CAPITULO 3: OPTIMIZACION DEL SISTEMA CELULAR

El objetivo principal de los sistemas de telefonía fija como de los de telefonía móvil es brindar la comunicación de voz entre sus clientes y los abonados de otras redes, en las mejores condiciones de calidad y economía.

El factor básico que diferencia la telefonía móvil de la fija es la forma de acceso al cliente, ya que intervienen varias condiciones como la movilidad geográfica, la distribución de carga de tráfico a lo largo del día, el fenómeno de la estacionalidad esporádica de abonados y la velocidad de crecimiento de las redes de telefonía móvil que en nada se parece a la telefonía fija.

La optimización del sistema celular involucra toda esta serie de conceptos que tienen interacciones muy complejas entre sí, y la modificación de cada uno de ellos impacta en el funcionamiento del sistema. Por otra parte está la rapidez con la que es necesario actuar para atender a unas condiciones de entorno variables, de forma que, en cada momento se proporcione al usuario una calidad de servicio prefijada.

En el proceso de la optimización intervienen todas las áreas del Departamento Técnico de las operadoras celulares, ya que todas realizan funciones particulares que en conjunto dan vida a las comunicaciones móviles.

En el presente capítulo se trata a la optimización desde el punto de vista de los parámetros que se manejan en la central celular, en donde los Ingenieros de Conmutación son los llamados a realizar este trabajo.

A continuación se presenta una introducción acerca de los conceptos que abarcan de manera general los procesos de optimización y que se deben tener en cuenta en la operación del sistema celular, luego de lo cual se procederá a explicar los ambientes en que se envuelve la comunicación celular y que son en los que se debe poner mayor atención al momento de realizar una optimización, como son: el *handoff*, el tráfico, la movilidad y la radio frecuencia.

3.1. CICLO DE CRECIMIENTO DEL SISTEMA

El proceso iterativo del sistema incluye la relación de varios factores, como el crecimiento de abonados, requerimientos de canales físicos y administración de radio frecuencia RF. Este ciclo es marcado por la necesidad de minimizar la interferencia de RF (vía pérdidas de las antenas, direccionalidad, sectorización de las celdas, etc.) mientras el sistema incrementa la capacidad en erlangs, tal como se indica en la figura 3.1. Los procesos para controlar la propagación de RF e incrementar la capacidad son muy dinámicos, lo que obliga a los operadores a tomar decisiones difíciles y convierte a la ingeniería en un proceso igual de dinámico y complejo.

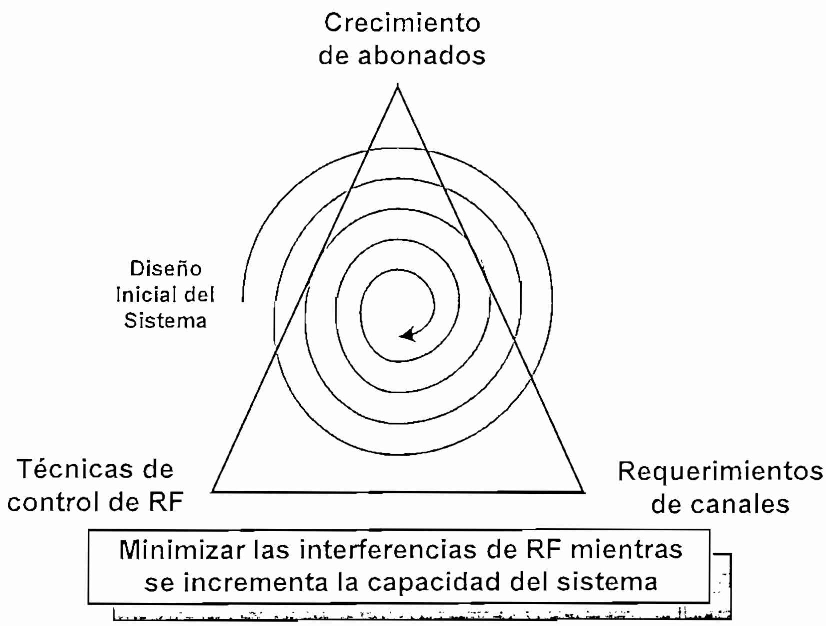


Fig. 3.1: Ciclo de crecimiento del sistema

3.2. CICLO DE OPTIMIZACION

Como en todo proceso que involucra la puesta en servicio de algún sistema en particular, el diseño primero es desarrollado sobre el papel para luego proceder a las pruebas de simulación. Por ejemplo, cuando se va a poner en servicio una celda, se simula su cobertura generando una señal de portadora en los posibles puntos donde se piensa poner la celda, una vez obtenidos estos resultados se los compara con la predicción teórica y se harán las respectivas modificaciones. Una vez realizadas las pruebas en vivo y cargado el tráfico, se procederán a hacer futuras optimizaciones si son requeridas.

Como un sistema va madurando (ciclo de crecimiento), el área geográfica que fue previamente optimizada deberá ser revisada debido a las interferencias en la celda o se tomarán otras acciones compensatorias como por ejemplo la inclinación de las antenas. Estas acciones se repiten en el ciclo de la optimización, el cual es mostrado en la figura 3.2.

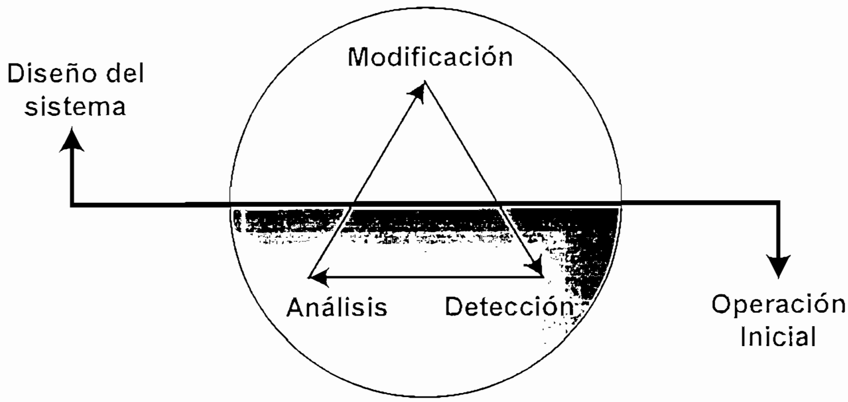


Fig. 3.2: Ciclo de optimización

Con el ciclo de crecimiento, la complejidad del sistema se incrementa de forma no lineal. Los procesos de optimización e ingeniería establecidos son esenciales para el mejoramiento, mantenimiento y rendimiento del sistema.

3.3. PERSPECTIVAS DEL RENDIMIENTO DEL SISTEMA

Hay dos perspectivas generales acerca del rendimiento del sistema que son aceptadas en telefonía celular: perspectiva de ingeniería y perspectiva del usuario final.

La perspectiva de ingeniería, toma aspectos relevantes que impactan el diseño del sistema que tienen correlación con el acceso al sistema que son la movilidad y la realización de las llamadas. De las dos perspectivas es la más comprensiva y la que más conceptos abarca. Ya que la perspectiva de ingeniería se enfoca en la identificación de las causas y efectos de las interacciones del sistema, esta perspectiva es la que más se toma en consideración cuando se realiza la optimización de un sistema celular.

La perspectiva del usuario final fue desarrollada, primeramente, para manejar la cuantificación del rendimiento de las llamadas como una relación con la experiencia del usuario final en el sistema. Algunas operadoras escogen el uso de esta perspectiva para identificar el índice del rendimiento del sistema. Las limitaciones de la perspectiva de usuario final en la identificación y ubicación de problemas en el sistema, reducen directamente la efectividad de esta perspectiva en los esfuerzos de optimización del sistema.

Algunas áreas donde existen diferencias notables entre estas perspectivas son las siguientes:

1. Fallas de proceso de llamadas (no hay detección de SAT sobre el canal de voz después de enviarse la designación de canal de voz inicial en el canal de control directo), son percibidas como:

    - Perspectiva de usuario final: bloqueo
    - Perspectiva de ingeniería: falla en la llamada.

    Si el bloqueo fue el problema, entonces añadiendo recursos adicionales se debería aliviar el problema. Caso contrario puede haber otras causas como mensajes recibidos que no son revisados efectivamente, inconsistencias entre los canales de voz y de control, un problema en la codificación de atenuación móvil del canal de voz o de control, o una falla puntual en el radio.

2. Completación de llamadas a una máquina o buzón de mensajes en lugar de un directorio de datos designado, son percibidos como:

   - Perspectiva de usuario final: intento de llamada infructuosa.
   - Perspectiva de ingeniería: llamada completada.

   Para cuantificar correctamente los eventos de fallas, todas las llamadas que no sufren fallas fuertes (por ejemplo, pérdidas de SAT de cualquier tipo) deben ser consideradas como una terminación desde la perspectiva de un canal de radio. Cuando un canal de tráfico es accesado a un tratamiento u otra entidad, la posibilidad de perder el SAT existe. Si la condición ocurre y la completación no es contada, entonces las estadísticas de caídas de llamadas serán erróneas para el sistema.

   El punto de vista del usuario final es válido como un punto de referencia, pero trabajado en paralelo con la perspectiva de ingeniería, por lo que esta actividad deberá ser tomada como un parámetro más no como fuente para el análisis del sistema.

3.4. CONCEPTOS DE FALLAS FUERTES VS LEVES

Una falla fuerte puede ser definida como un fenómeno indeseable en el cual una llamada válida no se ha tramitado o no se ha terminado apropiadamente. Las fallas fuertes incluyen un conjunto de eventos asociados con las medidas estándar de la industria tales como el recurso de bloqueo, sobrecarga del procesamiento, falla de enganche de la llamada, caídas de llamada y caídas por *handoff*. Hay dos clasificaciones para las fallas fuertes: de orden alto y de orden bajo.

Las fallas suaves crean degradación de las llamadas pero no necesariamente causan que la llamada se caiga prematuramente. Las fallas suaves son posibles debido al comportamiento de las llamadas y al acondicionamiento del usuario, éstos están relacionados con el control del sistema y el usuario final.

La figura 3.3 identifica los casos de identificación de fallas.

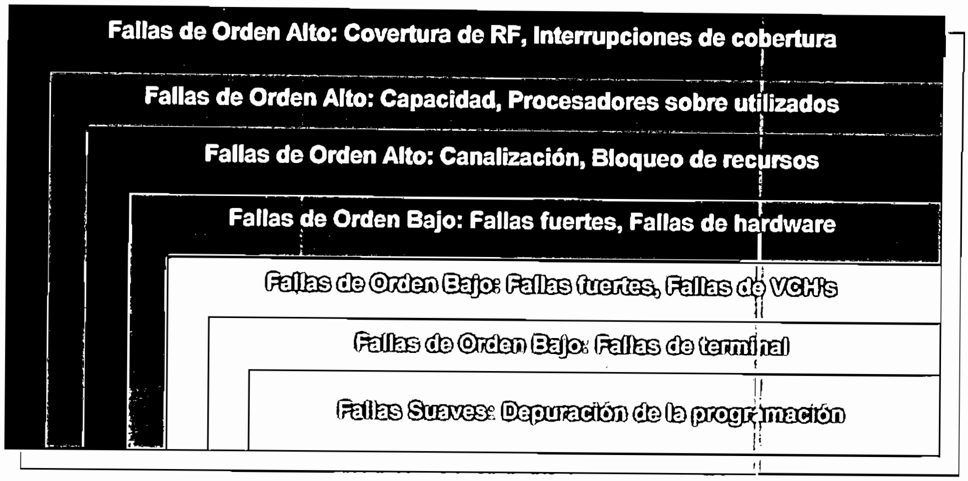


Fig. 3.3: Jerarquía de las fallas

3.5. DEPENDENCIAS FUNCIONALES Y ANOMALAS

Para la optimización, el ingeniero debe tomar en consideración varios niveles de dependencias funcionales con respecto a la operación del sistema. Estas dependencias comprenden los sucesos de flujo de llamadas y eventos de fallas, los efectos de actividades anómalas, y las interacciones complejas de RF.

Para manejar el rendimiento de una llamada, los ingenieros primero deben ser capaz de conocer el proceso básico del flujo de las llamadas ya explicados en los capítulos anteriores para establecer las acciones que se deban tomar según las condiciones que se presenten; además de entender las capacidades y limitaciones del sistema en la detección de los eventos de fallas. Por ejemplo, una caída de llamada es detectada vía la expiración del tiempo del SAT que ocurre en una llamada activa (activa es definida como un canal donde el SAT ha sido detectado previamente), donde la limitación de este método de detección puede ser vista si se ha dado una condición falsa del SAT. El sistema "piensa" que el intento de acceso o el *handoff* ha ocurrido cuando en realidad una falla se ha dado, causando erróneamente una falla en el establecimiento de la llamada o caída por *handoff* tomando esto como una caída de llamada (llamada establecida) cuando el SAT eventualmente no ha sido detectado.

Otro tipo de dependencias consiste de la interacción de cierto tipo de eventos de fallas sobre otras áreas del rendimiento del sistema. Entender las causas directas e indirectas de un problema son cruciales para resolver los problemas del sistema. Los eventos de falla pueden ser detectados, pero no significa que pueden ser tan fácilmente deducidos lo que es causa de riesgo de una anomalía.

Las interacciones complejas del sistema tales como la cobertura de RF y las dependencias de características deben ser entendidas si los análisis y técnicas de modificación del sistema son exitosos. Entender el concepto de área de cobertura efectiva y los impactos del trayecto directo en el acceso del sistema y del trayecto inverso en control de RF y el *handoff,* son requerimientos fundamentales en la valoración de los efectos de actividades anómalas o ajustes en los parámetros del sistema. La interacción de las características puede jugar un papel fuerte en la contribución de eventos anómalos o ayudar en el "enmascaramiento" de una causa de riesgo, por ejemplo, el nivel del canal de control seteado a un valor alto puede aliviar la respuesta dual pero puede limitar los intentos legítimos para el acceso al sistema.

Muchas de las anomalías detectadas en la operación del sistema celular tienen causas y efectos potenciales. Debido a estas interdependencias, no está por demás tener en cuenta las jerarquías mostradas en la figura 3.3 que pueden volver a una anomalía en un problema común, tal como podría ser un alto porcentaje de caídas de llamadas, el cual es realmente un problema complejo.

3.6. OPTIMIZACION DE PROCESOS

Las acciones resultantes de la detección y de la fase de análisis, dan como resultado la identificación de anomalías de distinta naturaleza que impactan en el funcionamiento del sistema. Algunas anomalías se las puede tolerar cuando se tienen limitaciones para poderlas resolver, como fallas graves en los equipos y no se dispone de los repuestos necesarios, o grados de falla donde intervienen los niveles superiores que generalmente son los fabricantes; aunque en general las anomalías que se presentan son resueltas por el propio personal técnico de las operadoras.

En el presente capítulo se va a describir de manera particular desde el punto de vista de los parámetros que se manejan en la Central Celular, los procesos más importantes y cuyo correcto funcionamiento depende el funcionamiento general de la red, por lo que requieren de un estudio constante para realizar un seguimiento de su comportamiento.

La optimización se analizará sobre los siguientes procesos:

- Procesos de *handoff.*
- Procesos de tráfico.
- Procesos de movilidad.
- Procesos de radio frecuencia.

3.6.1. OPTIMIZACION DE LOS PROCESOS DE *HANDOFF*

3.6.1.1. INTRODUCCION AL *HANDOFF*

Los sistemas celulares requieren un método lógico para que los usuarios móviles puedan cambiar de frecuencias de radios según como se estén moviendo a través de las diferentes áreas de cobertura. El *handoff* es el proceso de transferencia de la unidad móvil que está siendo servido por las diferentes estaciones bases.

El propósito principal del proceso de *handoff* es mantener la señal recibida desde el móvil a un nivel que no degrade la calidad de voz. La transferencia es disparada por mecanismos, los cuales están relacionados al nivel de señal recibida, calidad de la llamada, o la capacidad del sistema.

El *handoff* puede ser intra-partición, inter-partición o inter-sistema. Hay que anotar que el *handoff* puede ser también inter-modo, es decir entre AMPS y TDMA, en cada uno de los eventos. El término partición se refiere a un anillo, un sector, o cualquier grupo de canales en un área geográfica exacta de una celda.

Las razones principales para que se produzca el *handoff* son:

- Mantener la calidad de la señal y la configuración de las celdas
- Balance de tráfico entre particiones.
- Para propósitos de mantenimiento de canales de voz libres.

- ***Mantenimiento de la calidad de la señal y configuración de las celdas***

Ante todo la razón principal de ser del *handoff* es mantener la calidad de la señal y la configuración de las celdas, con una aceptable relación de carrier/interferencia (C/I) entre la unidad del usuario y la estación base, según como el usuario se mueva de partición a partición. Esto se debe a que las particiones no pueden usar la misma frecuencia de radio.

Para asegurar la calidad de la señal, el nivel de la señal desde el usuario es monitoreado por el canal de voz sirviente a la celda por medio de la calidad del indicador o medida de señal recibida (RSI - *Received Signal Indicator*), la tasa de bits errados (BER - *Bit Error Rate*) y la relación C/I. El indicador de señal recibida en la estación base es comparado en función del nivel bajo de umbral de *handoff* establecido (HTL - *Handoff Threshold Low*), debajo del cual la señal es considerada de pobre calidad y el *handoff* se encuentra listo para mirar a otro canal candidato de voz.

Ya que los caminos desde la celda al usuario y desde el usuario a la celda están típicamente diseñados para que las ganancias sean muy cercanas entre los dos, el nivel de señal recibida en la celda tiende a ser un indicador confiable del nivel de señal recibida por el usuario.

Como el usuario móvil viaja lejos de las diferentes particiones, el RSI decrece. Una vez que el nivel de señal cae por debajo del nivel bajo de umbral de *handoff*, la celda notifica al sistema que la llamada es una candidata para realizar *handoff*. El sistema pregunta a las particiones sirvientes circundantes (la partición en la cual está actualmente operando) y determina la mejor partición a la cual la llamada debería ser transferida. Cuando un canal de voz está disponible, la unidad móvil es instruida por la partición servidora a resintonizarse a una frecuencia residente en la partición señalada (partición a la cual el móvil será transferido). De este modo, el usuario es "entregado" y el nivel de señal es mantenido.

Las consideraciones que el sistema debe tomar para manejar la calidad de la señal en las transacciones de *handoff* son:

- El *handoff* debe ocurrir antes de que la degradación de la señal sea evidente al usuario.

- Las medidas de la calidad de la señal dêben ser promediadas durante un período de tiempo para minimizar el efecto de desvanecimiento de Rayleigh y otros efectos, caso contrario, el *handoff* puede ocurrir con excesiva frecuencia.

- El nivel de señal asociado con la partición señalada debe ser suficiente tal que en una llamada no se produzca el efecto "ping pong" entre particiones. Esto reduce los *handoffs* innecesariamente.

- Los cambios de nivel de potencia en el usuario deben ser tomados en cuenta.

- ***Balance de tráfico entre particiones***

La segunda razón de ser del *handoff* es balancear el tráfico entre particiones de modo que una condición de sobrecarga no sea experimentada en una partición. El método de balance de carga se conoce como *handoff* dirigido, donde se setea un umbral de ocupación de canales de voz. Este umbral es un porcentaje de no ocupación de los canales de voz.

- ***Mantenimiento del sistema***

La tercera razón es para mantenimiento del sistema. Un mantenimiento de *handoff* es iniciado cuando se va a realizar el *handoff* de una llamada a un canal de la misma partición. Por ejemplo, cuando un canal de localización es usado como backup del canal de control, un canal de voz será backup del canal de localización. Una llamada en ese canal de voz está en mantenimiento previo la conversión del radio a canal de localización. Otro ejemplo es que un canal de voz activo no responderá a una petición de ocupado a menos que se produzca un *handoff* a otro canal. Si el *handoff* no es satisfactorio, la llamada se caerá o se reintentará más adelante.

3.6.1.2. TIPOS DE *HANDOFF* POR DESTINO DESIGNADO

Hay diferentes tipos de *handoff*. El *handoff* es la condición que generalmente se refiere al proceso de transferencia a una llamada de un canal a otro.

La siguiente es una lista de tipos de *handoffs* descritos por el destino designado:

- *Handoff* interpartición / intercelda.
- *Handoff* intrapartición / intracelda.
- *Handover* intracelda o intersector.
- *Handoff* intersistema.

- ***Handoff interpartición / intercelda***

Un *handoff* interpartición / intercelda ocurre cuando una llamada es pasada a otra partición desde la partición sirviente. Se producen disparos de los niveles de señal de los usuarios necesarios para un *handoff*, entonces, las celdas vecinas son “empadronadas” como candidatas potenciales para las cuales el usuario puede hacer *handoff*.

- ***Handoff intrapartición / intracelda***

Un *handoff* desde el actual canal sirviente a otro canal en la misma partición es conocido como un *handoff* intrapartición / intracelda.

Una forma notable de *handoff* intrapartición es un modo de *handoff* de TDMA a AMPS, deseado para mejorar la calidad de voz de una llamada cuando un móvil en el modo TDMA está en un área pobre de cobertura (por ejemplo, con pobre relación C/I) sin particiones adyacentes elegibles para *handoff*. Bajo tales condiciones pobres de C/I, la calidad de voz analógica puede parecerle mejor al usuario que la calidad de voz digital, especialmente con vocoders VSELP.

- ***Handover intracelda o intersector***

Un *handoff* de un sector de una celda a otro sector de la misma celda es referido como un *handover*. Con algunos tipos de radios, el *handover* es disparado por el radio cuando la medida de señal recibida de un sector adyacente es más grande que la medida de señal recibida del sector actual. Los canales de localización no están envueltos en estos *handovers*.

- ***Handoff intersistema***

Un *handoff* de un sistema celular a otro sistema celular (por ejemplo, entre dos centrales celulares separadas) es referido a un *handoff* intersistema. Este tipo de *handoff* requiere el uso del protocolo IS-41.

3.6.1.3. DIAGRAMA GENERAL DEL FLUJO DE *HANDOFF*

A continuación se va a describir los flujos de llamadas de *handoff* usando el nivel de disparo por debajo del umbral para llamadas analógicas y digitales, respectivamente.

- ***Handoff Analógico***

En la figura 3.4 se presenta un diagrama de flujo que representa la operación básica del proceso de *handoff* analógico. Los canales de localización analógicos determinan los candidatos potenciales de *handoff*.

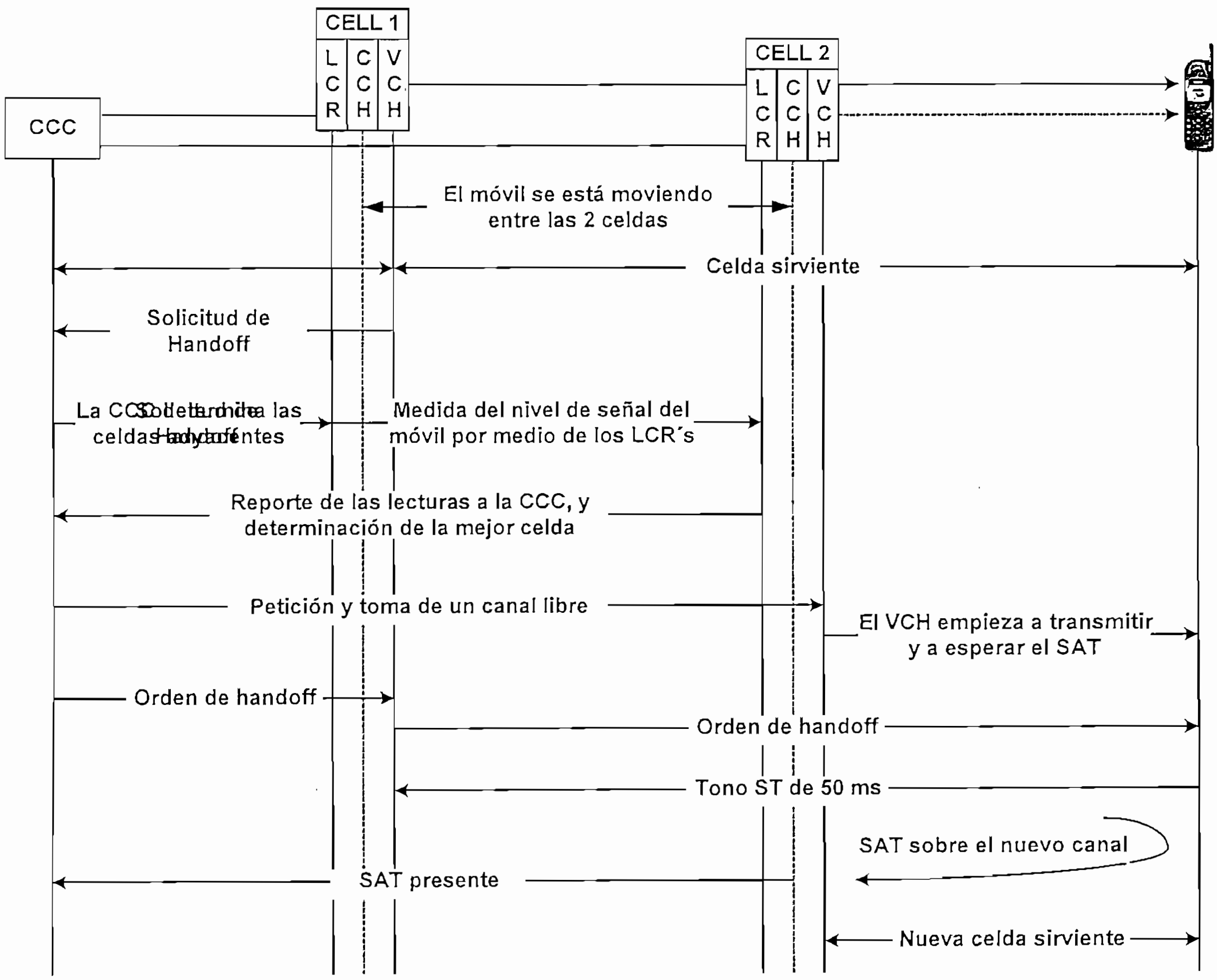


Fig. 3.4: Flujo de handoff analógico

Cuando el móvil está conectado a otro abonado (público o privado), como se lo explicó en el capítulo 2, el FVC emite dos mensajes: de *handoff* (fig. 2.21) y de nivel de potencia (fig. 2.22). Cuando se dispone de control dinámico de potencia, durante la conversación el canal de radio en la celda está monitoreando constantemente la señal del móvil RSI. Por lo que sí éste se aleja de la celda el RSI disminuye, y en cambio, si se acerca su RSI aumenta.

Los niveles de potencia para las estaciones móviles son medidos en dBW. La unidad AMPS del usuario debe ser capaz de reducir o incrementar la potencia por comando de la estación base que especifique el nivel de potencia de 0 a 7 (excepto 0 y 1 para los teléfonos portátiles). Al detectarse estas variaciones de señal, el mensaje de nivel de potencia enviado en el FVC es el que puede regular hasta ciertas instancias la potencia de salida del móvil.

Así mismo, el FVC juega su papel fundamental en el proceso de *handoff*. Una vez que el móvil ha alcanzado su valor máximo de potencia y el RSI sigue disminuyendo, el radio de la celda al detectar que la señal del móvil está por debajo del umbral establecido, le indica al cerebro de la central celular que existe un candidato para realizar el *handoff* (en modo AMPS no hay la capacidad de que el móvil provea de lecturas del RSI al transceiver de la celda). La central mediante su algoritmo patentado, revisa su base de datos y determina que celdas están adyacentes a la celda servidora, y emite una orden a los canales receptores de localización (LCR) de estas celdas que sintonicen el canal al qué está enganchado el móvil, midan la señal que ellos ven y reporten esos datos de vuelta a la central. Los canales de localización bajo condiciones normales pueden medir 6 ó 7 unidades móviles por segundo, y tienen la propiedad de poder sintonizarse a cualquier canal de voz y medir el RSI del móvil (39).

Una vez recibidas las lecturas de los diferentes LCR's, la central analiza estos valores y determina qué celda adyacente le está mirando al móvil con mejor potencia que la actualmente servidora, entonces se realiza la petición y toma de un canal libre de la nueva celda y se empieza a transmitir el SAT de ese canal.

En este punto, la celda sirviente envía el mensaje de *handoff* en el FVC mediante el método de silencio y ráfaga a la unidad móvil. El móvil recibe este mensaje y responde por medio de un tono de señal de 50 ms a la celda como acuse de recibo de la orden de *handoff*. El proceso sigue adelante y la conversación conmuta al radio de la nueva celda, el móvil se sintoniza al canal asignado, reconoce el SAT y responde al SAT en el RECC. Una vez recibido el SAT, la celda desconecta el antiguo canal de voz y habilita el audio del nuevo canal de voz.

- ***Handoff digital***

En cuanto al proceso de *handoff* digital (ver figura 3.5), los sistemas TDMA pueden basar sus medidas mediante el canal receptor de localización digital (DLR - *Digital Locating Receiver*) y también por el proceso denominado *handoff* asistido por el móvil (MAHO - *Mobile Assisted Handoff*) con/sin medidas del DLR .

El móvil recibe el mensaje de orden de medición de la señal en el DTCH (capítulo 2, fig. 2.34) por medio del canal de control asociado rápido (FACCH – equivalente al tono de señal de 50 ms en el *handoff* analógico), y continúa hasta recibir una orden de detener la medición. Una vez obtenidos los datos, el móvil reporta las medidas por medio de los mensajes de calidad del canal, transportados cada segundo en el canal de control asociado lento (SACCH).

Las mediciones realizadas consisten de la intensidad de la señal RSI y del BER del DTCH sirviente, además del RSI de la lista de celdas adyacentes. Para el canal de voz de servicio, se toman 25 muestras de 40 ms cada una (25 tramas TDMA), calculando los valores del RSI y el BER con el promedio de las muestras.

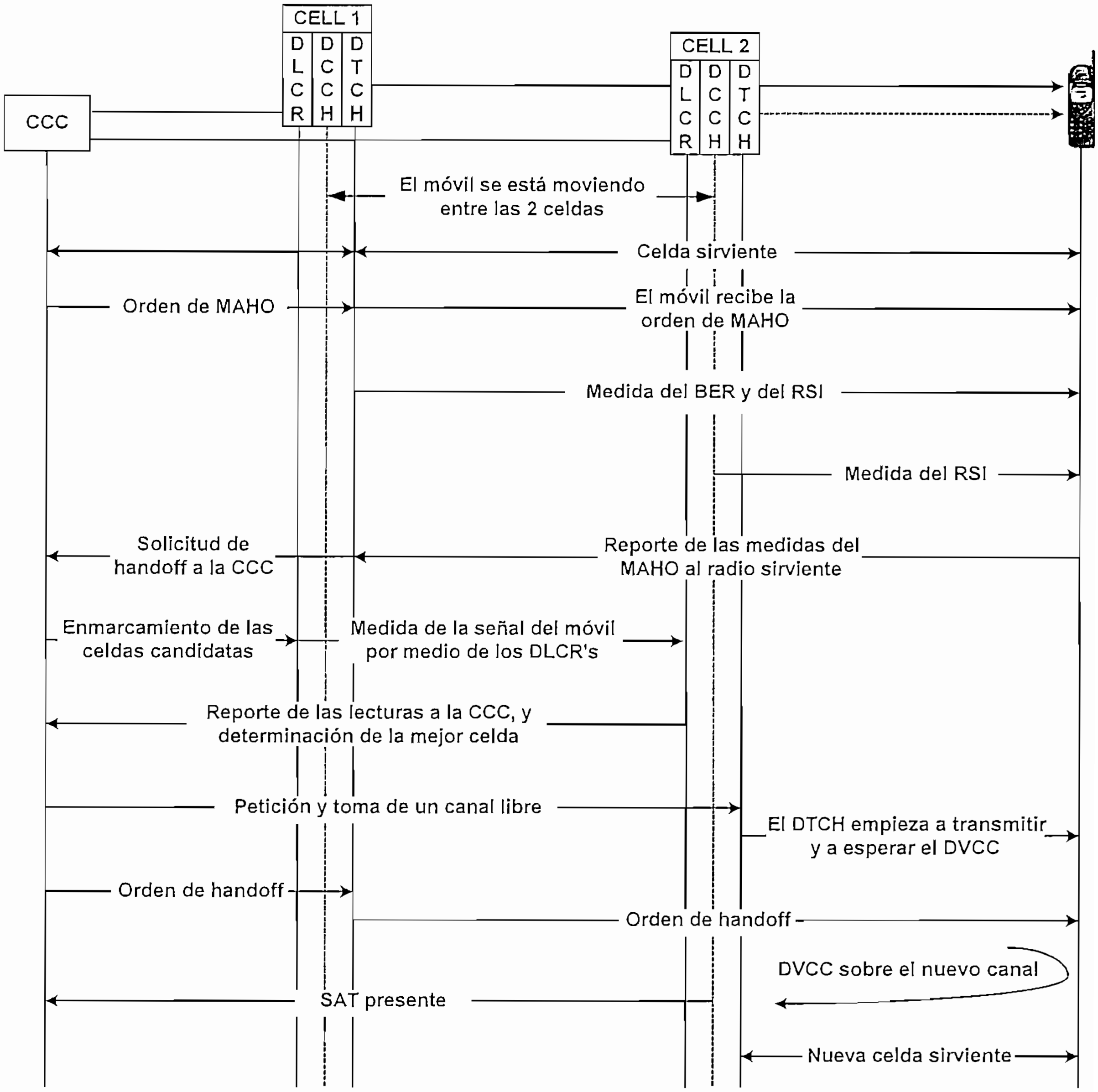


Fig. 3.5: Flujo de handoff digital

El MAHO es un método de medición del nivel, en el cual las propias unidades móviles monitorean el nivel o intensidad de la señal que reciben de su celda sirviente y de las celdas vecinas para determinar el instante en el que el *handoff* es necesario. En los intervalos libres del canal de conversación DTCH, el móvil puede monitorear la calidad con que llega la señal de hasta 12 celdas adyacentes, tal como se muestra en la figura 3.6.

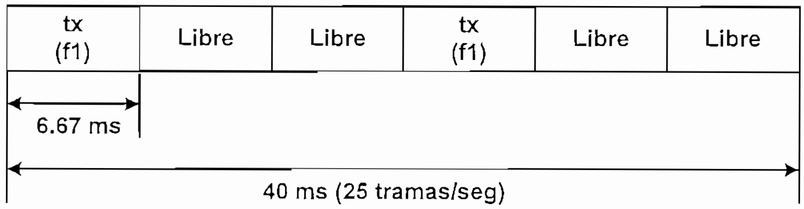


Fig. 3.6: Formato del monitoreo de señal

El MAHO tal como se lo define en el estándar IS-136, simplemente es un soporte para ayudar al proceso de *handoff*. Hay tres escenarios básicos para los *handoffs* digitales: sólo MAHO, MAHO con DLR y sólo DLR.

- ***Sólo MAHO:*** Las lecturas de RSI medidas en el móvil son comparadas para escoger la mejor celda. Como se mencionó anteriormente, máximo 12 son los canales del MAHO a ser medidos por el móvil.

- ***MAHO con DLR:*** Las lecturas son usadas para escoger 4 candidatos fuera de la lista de las celdas adyacentes. Después que los 4 candidatos son definidos, las lecturas de los DLR's son realizadas y sus medidas son usadas para escoger la mejor celda.

- ***Sólo DLR:*** Las lecturas son similares a los *handoffs* analógicos, ya que los canales de localización son usados para medir el nivel de señal vistos por las celdas adyacentes, y la mejor celda se encuentra basado en las lecturas de los DLR's. Para completar el *handoff* basado en sólo DLR, todas las celdas adyacentes preguntadas durante el proceso de *handoff* deben tener DLR's. Si se tiene deshabilitado el MAHO y no existe DLR en alguna celda, no es posible un *handoff* TDMA a esa celda.

Es importante explicar las condiciones en las cuales se da un *handoff* de TDMA a AMPS, ya que esta interacción se presenta sólo en los siguientes casos:

- Si las celdas analógicas adyacentes disponen de DLR's, usando las medidas de localización de estos canales un *handoff* TDMA a AMPS puede ocurrir, ya que las celdas pre-exploradas tienen DLR.

- Si no existieran DLR's en las celdas analógicas candidatas, por medio de las lecturas de la MAHO puede ocurrir un *handoff* de TDMA a AMPS, dado que en los parámetros de software de la central celular a la MAHO se la puede programar para que se entienda con los canales de control analógico o digitales.

- Si no existiera DLR's y el MAHO es deshabilitado, no será posible realizar el *handoff* de TDMA a AMPS.

3.6.1.4. LOGICA Y PROCESO DEL *HANDOFF*

Se puede decir que existen cinco etapas básicas para la operación del *handoff*:

- ***Medición:*** Son las condiciones físicas que envuelven al proceso de *handoff*. Las medidas del RSI, BER y la relación C/I son tomadas durante la etapa inicial del *handoff*.

- ***Disparo:*** El disparo determina si un *handoff* debería ser solicitado, por lo que la central realiza el pedido de lectura del RSI del móvil que necesita sufrir un *handoff* a todas las celdas que tienen la posibilidad de aceptar la llamada.

- ***Exploración:*** En la etapa de exploración se reúne la información para elegir las celdas candidatas que tienen condiciones para aceptar la llamada. La exploración se utiliza también para eliminar solicitudes inválidas.

- ***Selección:*** Las celdas candidatas son clasificadas y la mejor es seleccionada para que reciba al usuario que va a realizar el *handoff*.

- ***Ejecución:*** Cuando todos los estados anteriores han sido completados satisfactoriamente, el *handoff* es ejecutado

El más común de los procesos de *handoff* ocurre cuando el canal de voz sirviente a un móvil determina que el RSI del móvil ha disminuido de un umbral determinado. Midiendo los valores del RSI sobre los sectores o celdas adyacentes, la central celular lo que hace es localizar un mejor lugar para servir al usuario, y si uno puede ser encontrado, entonces el móvil es transferido a un canal de voz disponible y la llamada procede con interrupciones no muy evidentes.

Aunque el concepto de *handoff* es simple, el mismo tiene un número de parámetros sofisticados y algoritmos propios de cada central de conmutación celular que le permiten al operador controlar y optimizar su comportamiento.

NOTA: Para entender de mejor manera los procesos de *handoff*, en el anexo C se describen con más detalle los cinco estados del mismo.

En las celdas, cada canal de voz está provisto de un umbral que es utilizado para determinar cuando un proceso de *handoff* básico debería ser disparado, el cual fue mencionado en la parte de mantenimiento de la calidad de la señal y configuración de las celdas y se lo conoce como nivel bajo de umbral de *handoff* (HTL). Debido a esto los canales sirvientes realizan dos funciones principales en el proceso del *handoff*: medir el RSI del móvil durante toda la duración de la llamada (el RSI es medido en el cabal de voz de reversa), y soportar la ejecución del *handoff*.

Las medidas ayudan a suprimir la variabilidad inherente en las lecturas del RSI, y proveen más seguridad en la información que puede ser usada para deducir la distancia del móvil desde el centro de la celda y la calidad de la llamada.

3.6.1.5. AMBIENTE DEL *HANDOFF*

Uno de los aspectos a considerar en los parámetros del *handoff* es la movilidad del usuario, ya que bajo ciertas circunstancias algunos umbrales del *handoff* pueda que se los deba ajustar para permitir que el sistema tenga un tiempo adecuado para procesar una solicitud de *handoff* en ambientes de alta velocidad.

Los *handoffs* son disparados a un nivel de RSI específico como ya se lo explicó anteriormente, pero requieren de una cantidad de tiempo discreto para completarlo. El móvil tenderá a tener un nivel más bajo que el nivel presentado en el momento en que fue solicitado, y los móviles que viajan a velocidades altas pueden presentar niveles significativamente más bajos todavía. La figura 3.7 ilustra esta situación

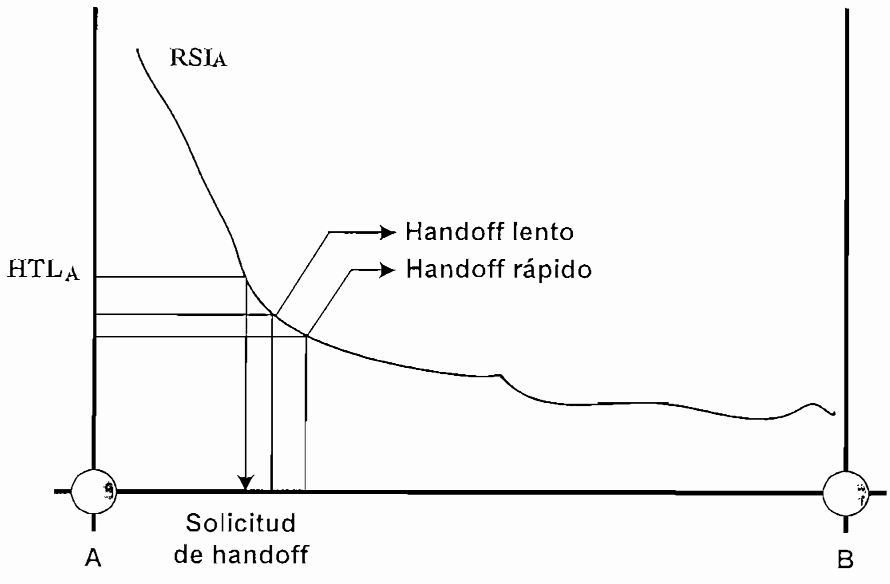


Fig. 3.7: Curva del nivel de handoff

Para tratar de obtener resultados normales de *handoff*, el operador debe tener el suficiente criterio para ingresar los valores de los umbrales que permitan "retrasar" un poco el *handoff* en ciertos casos como el de los móviles rápidos, especialmente en celdas pequeñas.

También se debe tomar en cuenta los efectos de las inherentes interferencias de radiofrecuencia, tanto en las llamadas analógicas como en digitales. Para tratar de evitar esto se realizan pruebas a los diferentes radios para mantener en óptima condición su funcionamiento. Las pruebas más comunes que se les realiza a los transceptores son las pruebas de canal que prueban la capacidad del radio de recibir y transmitir sólo la señal deseada, y las pruebas fuera del canal que prueban la capacidad del receptor para recibir una señal deseada en la presencia de señales no deseadas y la capacidad del transmisor de confinar las transmisiones al ancho de banda autorizado.

Un factor determinante para la calidad de la transmisión celular es trabajar constantemente en la reducción de interferencias, para lo cual se debe tratar de asegurar que la relación carrier/interferencia (C/I) se la mantenga en un valor de 17 dB o superior por toda el área de cobertura; para esto es muy importante que los radios tengan una buena sensibilidad de recepción. Una manera muy utilizada de medir la sensibilidad es por medio del SINAD, que es una relación que establece la calidad de la señal de comunicación, y que se la expresa de la siguiente manera (40)

$$SINAD = \frac{señal + ruido + distorsión}{ruido + distorsión} \qquad \text{(Ec. 3.1)}$$

Esta relación toma en cuenta el ruido generado durante el proceso de demodulación en el radio, y la distorsión del amplificador de audio en banda base. En los equipos de radio celular, una entrada de –116 dBm es equivalente a un SINAD de 12 dB, y si el radio está dentro de este rango como mínimo, se dice que tiene una sensitividad de recepción efectiva.

Los *handoffs* pueden ser controlados, además de la intensidad de la señal, por la relación C/I. La importancia de que el C/I sea mayor o igual a 17 dB, es que no sólo es útil para la calidad del *handoff*, sino también para realizar un adecuado reuso de frecuencias y reducir la interferencia cocanal. La mínima distancia en la cual se permite que la misma frecuencia sea reusada dependerá de algunos factores, tales como el número de celdas cocanales en la vecindad del centro de la celda, el tipo de contorno geográfico, la altura de la antena y la potencia transmitida a cada celda.

La distancia del reuso de frecuencia puede ser determinada por la siguiente expresión:

$$D = \sqrt{3N}R \qquad \text{(Ec. 3.2)}$$

Donde:

- N es el patrón de reuso de frecuencia (en el Ecuador N = 7).
- D es la distancia entre las celdas cocanales.
- R es el radio de la celda.

La interpretación gráfica de la ecuación 3.2 se lo presenta en la figura 3.8.

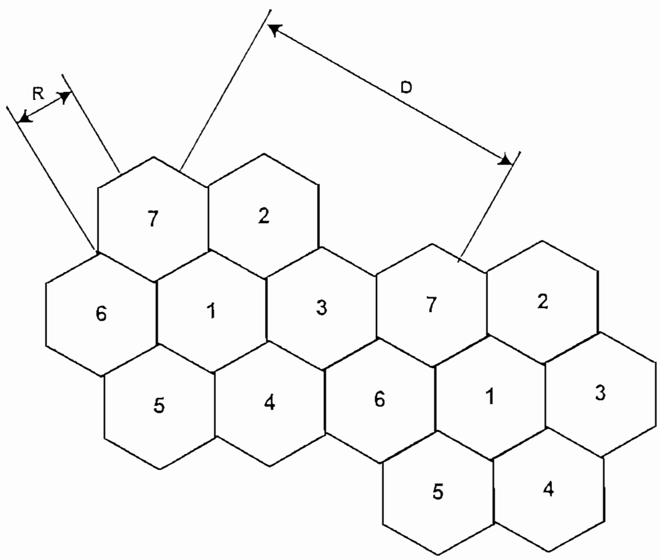


Fig. 3.8: Patrón de reuso de frecuencia N=7

Para encontrar el valor apropiado para D, la ubicación de cada móvil se asocia con su C/I recibido. Con el patrón N = 7 la relación D/R es igual a 4.5825, valor que va a gobernar la separación de dos celdas cocanales, ilustradas por la celda 7 de la figura anterior.

Un ejemplo práctico que puede producir interferencia cocanal son las "islas" de señal, las cuales por diferentes causas se escapan a la planeación de los ingenieros de radiofrecuencia. Las islas de señal cuando tienen una intensidad considerable de señal pueden crear las condiciones necesarias para que se produzcan llamadas desde las unidades móviles, que luego resultarán en caídas de las mismas debido a que las islas no tienen definidas celdas adyacentes para tener la posibilidad de realizar un *handoff* y salvar las conversaciones. En la figura 3.9 se presenta el caso de una isla de señal situada entre dos celdas adyacentes. Un móvil que se está desplazando de la celda A a la celda B atraviesa una isla proveniente de la celda C, la cual está reusando las frecuencias de la celda A. Las celdas A y C se encuentran separadas la distancia D que dicta la ecuación 3.2, a pesar de esto el móvil es medido por las dos celdas.

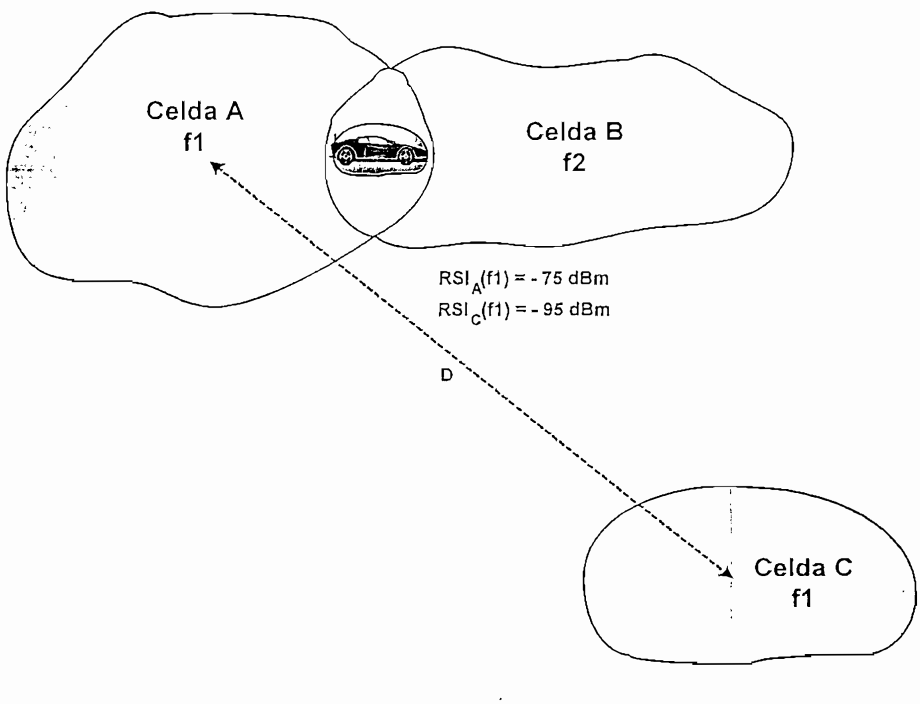


Fig. 3.9: *Posible interferencia cocanal*

Es necesario notar que la diferencia entre las medidas de las celdas A y C es de 20 dB, valor que es mayor al requerido por la relación C/I de 17 dB, asegurando la calidad de la llamada. Pero si esa diferencia hubiese sido menor que los 17 dB's se presentaría ruido e interferencia cocanal, y la llamada pasaría a un estado susceptible de caerse.

3.6.1.6. OPTIMIZACION DEL *HANDOFF*

La optimización del *handoff* es un proceso continuo, ya que la complejidad de los algoritmos de *handoff*, combinados con la variabilidad de la radio frecuencia y las variaciones entre los móviles, conducen a menudo a un proceso de ensayo y error que llevan a un consumo de tiempo ineficaz.

En la optimización se trata de eliminar las conjeturas, estableciendo un proceso general que se lo pueda aplicar a cualquier observación al funcionamiento del *handoff*. El propósito es tener claro el comportamiento del *handoff* para que desde una central de conmutación celular se conozcan los parámetros que puedan ser modificados, y cuando deben ser modificados.

Quienes intentan realizar la optimización del *handoff* tratan de asegurarse que las funciones del sistema cumplan con los criterios de la operadora. Pero a pesar de que las diferentes funciones difieran de una operadora a otra, los principios subyacentes siguen siendo los mismos, por lo que todos comparten una misma estructura en general: un ciclo continuo de medición, evaluación y modificación.

En la figura 3.10 se presenta un diagrama de flujo con los pasos más generales que se deben seguir en el momento de realizar el proceso de optimización del *handoff*.

Cada paso en la optimización es importante, y requiere una buena comprensión de los procesos que son optimizados y de los candidatos contra los cuales los procesos serán medidos. En un ambiente dinámico como es la telefonía celular, los trabajos realizados con seguridad deberán ser revisados posteriormente, por lo que la realización de la optimización nunca se puede decir que está realizado.

Uno de las tareas más difíciles en el proceso de la optimización es decidir dónde empezar, esto es, determinar el seteo inicial de los parámetros que controlan la operación. Lo ideal es escoger un conjunto de valores que cumplirán con los criterios del rendimiento, sin embargo cuando mejor es el seteo inicial, menos son los ciclos de optimización que serán requeridos para optimizar el sistema.

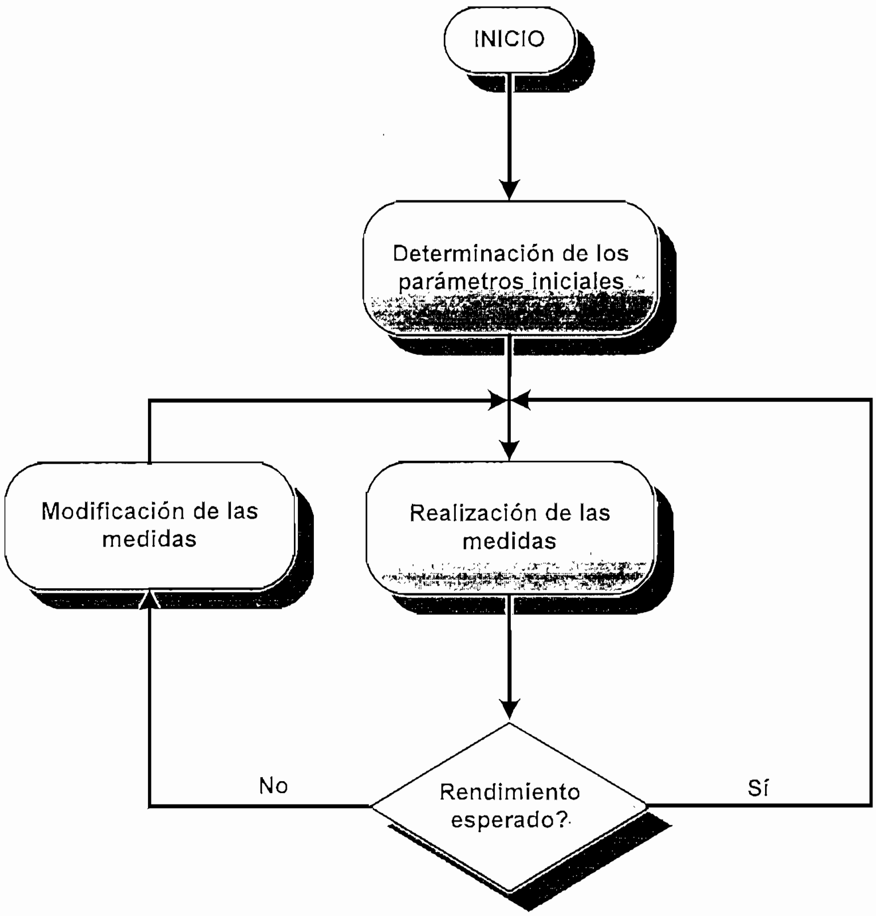


Fig. 3.10: *Proceso general para la optimización del handoff*

En el caso particular del *handoff* hay un gran número de parámetros que afectan su comportamiento y su rendimiento, algunos de los cuales son controlados desde la central celular, otros son recursos donde intervienen diferentes áreas de la operadora (transmisiones, planificación, etc.), y otros externos al sistema. Estos parámetros incluyen:

- Campos del software propio de la central y parámetros de oficina.

- Recursos físicos, tales como la ubicación de las celdas y su configuración.

- Consideraciones del móvil y el tipo de equipo del usuario.

- Efectos geográficos, debido al terreno, vegetación, edificios, autopistas y otros.

- Factores ambientales, con más incidencia la lluvia.

De los factores descritos, los últimos tres están más allá de la capacidad de los operadores para controlar y manipular, aunque deben estar enterados de cómo pueden afectar al proceso de *handoff*. Los ingenieros de conmutación tienen más influencia en los parámetros propios del sistema, a pesar de que se puede tener injerencia en las decisiones tomadas por otras áreas involucradas con la central. El enfoque principal es la optimización de los parámetros de la central, los cuales tienen un efecto determinante en el rendimiento.

En ausencia de cualquier otra información, muchos parámetros de *handoff* pueden ser seteados a los valores recomendados por los documentos de la propia operadora. Si los valores son seteados incorrectamente, el rendimiento del *handoff* puede sufrir de manera muy determinante, consecuentemente muchas operadoras intentan predecir cuales serán los valores adecuados para su sistema, basados en su mayoría en los análisis de propagación de radio frecuencia y medidas de campo, en lo posible antes de poner tráfico en las zonas involucradas.

Las medidas del rendimiento le proveen al operador de la información necesaria para determinar si su sistema se está comportando de acuerdo a lo esperado. Típicamente, los sistemas proveen abundantes datos acerca de lo que está pasando, el juego es decidir qué es importante y qué se puede ignorar. Para el *handoff*, muchas operadoras utilizan un conjunto bastante común de mediciones (aunque los métodos específicos de cálculo sean diferentes), entre las cuales se disponen los siguientes:

- Medidas exitosas de *handoff*, como tasas de caídas de llamadas y caídas de *handoff*.

- Medidas de la actividad del *handoff*, como solicitudes de *handoff* por llamada y reintentos por solicitud.

- Medidas de la actividad de los canales receptores de localización.

- Medidas de la eficacia del *handoff*, como ubicación de las fronteras, incremento en el RSI después del *handoff* y niveles de interferencia.

- Medidas de la calidad del *handoff*, como el ruido y los tiempos de silencio.

Esencialmente las medidas del rendimiento no tienen sentido si no se dispone de algún criterio para compararlas entre sí. Para cada medida el operador debe llevar un rastreo, debe tener un valor establecido para determinar si esa función en particular es realizada según lo deseado.

En muchos casos esto involucra elegir un número que represente un grado de servicio aceptable, como por ejemplo la tasa de caída de *handoffs*. Si la medida de este parámetro debe cumplir el 1%, el momento que el criterio está por debajo de este valor el sistema está funcionando bien, caso contrario requiere investigación y posibles ajustes.

En algunas circunstancias, se debe tener en cuenta que el valor absoluto de una medida puede ser no tan importante como la tendencia de la misma. De aquí que los pasos del ciclo comparen las medidas del rendimiento del sistema con los criterios establecidos por el operador. Si el sistema satisface o excede los criterios, no se necesita que se tomen acciones posteriores, y el ciclo de optimización empezaría nuevamente. Pero si algún aspecto del sistema no puede realizarse según lo esperado o deseado, entonces el operador debe determinar los cambios específicos que sean necesarios para que el funcionamiento del sistema se enmarque dentro de los parámetros investigados.

El determinar que el rendimiento del sistema no sea óptimo es bastante sencillo, decidir como mejorarlo es lo dificultoso. Diferentes problemas pueden afectar a algunas medidas, y un problema en particular puede afectar a algunas medidas. Un número de parámetros puede ser que se los tenga que modificar para alcanzar el efecto deseado, mientras el cambiar un parámetro en particular puede afectar todo el sistema.

Antes de que cualquier cambio sea realizado en el sistema, el operador debe determinar la raíz del problema, y además debe determinar el impacto en su totalidad de cualquier solución propuesta. Caso contrario, hay el riesgo de degradar el rendimiento del sistema en su totalidad, o en alguno de sus aspectos en particular.

Bajo ciertas circunstancias puede ser que no haya acción a seguir cuando suceda algún tipo de problema, generalmente cuando la solución planteada no es práctica como el requerimiento del aumento de canales a una celda o levantar más celdas en una zona en particular. Fuera de esto, una vez que la decisión ha sido tomada para modificar el comportamiento del sistema, el operador debe decidir hasta donde desea llegar. La obtención de los resultados darán las medidas propias de cada central, reforzando la necesidad de continuar con el ciclo de optimización.

Como se puede entender hasta el momento el proceso de *handoff* interactúa con los móviles, las celdas, la central y los aspectos de la radio frecuencia. Debido a esto, aunque el comportamiento del *handoff* es predecible, no se puede garantizar que todo el tiempo va a ser exitoso. La medida y la mejora de funcionamiento del *handoff*, entonces, se centra en la optimización de la operación del proceso sin cargar el sistema innecesariamente.

Los *handoffs* pueden fallar de diversas maneras, pudiendo esos problemas agrupar o generalizar en cuatro categorías:

- Localización del *handoff*, ya que no ocurre donde lo esperábamos.

- Ejecución del *handoff*, ya que no se completan correctamente.

- Calidad del *handoff*, ya que las llamadas no tienen buen audio antes, durante y después del *handoff*.

- Procesamiento del *handoff*, ya que los procesos están cargando al sistema.

- ***Localización del handoff***

Cuando un nuevo sistema es levantado o se realizan cambios a la configuración del mismo, ya sea en hardware o software (parámetros del sistema), uno de los aspectos principales del rendimiento del *handoff* que puede ser afectado es la ubicación de las fronteras, donde físicamente ocurrirá el *handoff*.

Puesto que el límite del *handoff* en cierto modo determina el área efectiva de cobertura de radio frecuencia de una celda, las localizaciones incorrectas del *handoff* pueden conducir a serios problemas de rendimiento, teniendo su consecuencia en el efecto conocido como arrastre de llamadas. El arrastre de llamadas significa que un móvil se mueve hacia el área de cobertura de otra celda antes de realizar el *handoff* (en el peor de los casos el *handoff* nunca ocurre). Este comportamiento altera el plan de reuso de frecuencias para el sistema y lleva a altas interferencias y caídas de llamadas; esta situación provoca de manera adicional el desperdicio de recursos, ya que la llamada dura tanto tiempo que los canales ocupados ocasionan bloqueo en las celdas.

El arrastre de llamadas se puede presentar bajo las siguientes circunstancias:

1. El *handoff* no es disparado a tiempo, causado porque el valor del HTL de la celda sirviente está seteado con valores bajos. Otra posible causa es que la tasa de muestreo del RSI de la celda sirviente programada en la central tenga un valor alto, por lo que hasta que se genere el disparo del *handoff* pasaría mucho tiempo y se produciría el arrastre de la llamada; la solución obvia es bajar los tiempos de muestreo del RSI.

2. La celda adyacente no es preguntada, lo cual es causado por varias razones. La primera causa obvia es que la celda adyacente no sea preguntada ya que no se encuentra ingresada en la programación de la celda sirviente, por lo que se debería añadirla inmediatamente. Otra posible causa es un seteo bajo de los valores involucrados con el proceso del *handoff*. También puede darse el caso de que la celda adyacente no se encuentre dentro del área de servicio móvil (MSA - *Mobile* Service Area) del usuario, por lo que habría que chequear las celdas adyacentes del MSA en la región de servicio móvil (MSR - *Mobile* Service Region) del usuario, y actualizar los valores para normalizar el sistema.

3. El disparo del *handoff* sin respuesta, lo cual es más bien un problema del hardware de la celda (las antenas en su mayoría), teniendo su causa en un insuficiente traslapamiento de las celdas.

4. La respuesta del LCR desde la celda adyacente no existe, cuya posible causa es que el RSI_B de la celda candidata no alcanza el mínimo criterio de *handoff*. También hay que considerar los casos en que por factores climáticos y de suelo, el móvil haya pasado a través de un corto silencio y haber sido capturado; para esto se puede usar dos opciones: aumentar el muestro y el factor del RSI, y segundo manejar un valor de compensación para el RSI conocido como histéresis.

5. También puede pasar que ya no se dispongan de canales en la celda adyacente, provocando bloqueo en la celda y que exista congestión. La mejor opción es aumentar la capacidad de la celda en radios para más

canales de voz (siempre y cuando el comportamiento de la celda lo justifique), o una solución más inmediata es reducir virtualmente el área de cobertura de la celda candidata.

- ***Ejecución del handoff***

Una vez que se ha determinado que el móvil debería hacer *handoff* y dónde debería hacer *handoff*, éste debería ocurrir con el menor impacto posible para el usuario. Debido a que los *handoffs* generalmente ocurren en los bordes de una celda, donde la comunicación entre la celda y el móvil son deterioran, existe un riesgo definido de interrumpir o perder la llamada con cada *handoff*.

Durante la ejecución del *handoff* se pueden presentar varios problemas, pero los más generales son:

1. Caída de llamadas durante los procesos de *handoffs*, generado por tiempos largos y que pueden ser superados con los criterios aplicados en la localización del *handoff*. También se puede presentar problemas de interferencia en el borde de la celda sirviente, por lo que primero se debería solicitar un *drive test* para evaluar la calidad de la llamada y medir los niveles de interferencia, y con estos resultados poder variar en la central los parámetros que puedan aportar con soluciones válidas, usar las relaciones de C/I o BER para realizar el *handoff* u obligar a un teléfono digital cambiarse de un DTCH a un AVCH cuando tenga niveles bajos de señal.

2. Efecto de ping pong debido a *handoffs* rápidos, ocasionado porque los tiempos de disparo son muy rápidos.

- ***Calidad del handoff***

Los usuarios de la red no están conscientes (y tampoco deben) de todo el escenario que existe detrás del establecimiento de una llamada y de los factores que intervienen para que su comunicación se mantenga en el sistema. El movimiento de la llamada mediante el *handoff* de un canal a otro, de una celda a otra, etc., puede resultar en cambios de las condiciones de radio frecuencia que afectan de manera sensible o audible en la llamada del suscriptor.

Aunque el usuario puede tolerar un cierto número de interrupciones durante la llamada, los ingenieros de conmutación como responsables del funcionamiento de la red deben maximizar la calidad percibida de las llamadas sin la necesidad de cargar al sistema con mensajería y exceso de actividad de procesamiento.

De igual manera, durante el *handoff* el usuario puede percibir ciertas falencias en el proceso. Las posibles causas que pueden afectar la calidad del *handoff*, se puede decir que en concepto son las mismas indicadas en la parte de localización y ejecución del *handoff*.

- ***Procesamiento del handoff***

Idealmente, el sistema debería ser capaz de determinar inmediatamente cuando un móvil sale de un área de cobertura de una celda, e instantáneamente identificar a cual celda está ingresando. En la realidad, el sistema solamente puede estimar la distancia del móvil desde la celda, y debe interrogar a las celdas circundantes para averiguar donde se encuentra el abonado.

En la red se debe cuidar el grado de servicio, por lo que se debe evitar una sobrecarga en el sistema debido al procesamiento del *handoff*. Se debe minimizar la mensajería innecesaria para que los canales involucrados puedan trabajar en lo posible dentro de los parámetros establecidos por cada fabricante.

A continuación se listan los posibles síntomas por los cuales se puede ver afectado el procesamiento del *handoff*:

1. Alto conteo de reintentos por muchas solicitudes de *handoff* innecesarios, que puede ser causado porque el HTL de la celda sirviente está muy alto, por lo que se debería comparar las solicitudes con los reintentos.

2. Tiempo de muestreo del RSI muy corto, por lo que se debería incrementar este tiempo para disparar el *handoff*.

3. Sobreflujo en el canal receptor de localización, debido a muchas solicitudes de RSI de las celdas adyacentes. Aunque la razón más a la vista sería el hecho de que no existan los suficientes LCR's en las celdas adyacentes, si son analógicos se deberían aumentar más canales y si son digitales se debería jugar con el MAHO para reducir el número de solicitudes existentes en los DLR's.

3.6.2. OPTIMIZACION DE LOS PROCESOS DE TRAFICO

3.6.2.1. FUNDAMENTOS DE TRAFICO

La ingeniería de tráfico establece básicamente un adecuado conjunto de canales de tráfico y troncales para soportar la actividad de llamadas. Se debe implementar procedimientos y pruebas para la funcionalidad de parámetros en la central celular para mejorar las técnicas de asignación de tipos de canales (analógicos, digitales o ambos), y evaluar el impacto del crecimiento de abonados con respecto a la capacidad de la red.

La capacidad de tráfico de un sistema celular es el máximo número de servicios que pueden ser soportados por el sistema y que pueden ser limitados por un componente o varios componentes.

El tráfico telefónico que fluye a través de los componentes de conmutación de la central celular varía básicamente de acuerdo al tiempo del día, días de la semana, de mes a mes, y días festivos. Esta variación va de niveles bajos a picos muy altos, por lo que para las operadoras que son capaces de ofrecer un buen servicio a precios razonables, es imperativo que se estudie el comportamiento del tráfico.

Con el estudio del comportamiento del tráfico se intenta cuantificar las variaciones, de tal modo que los ingenieros puedan estimar la cantidad y tipos de equipos a ser dimensionado en el sistema. La manera más común de hacerlo es recolectando información de las horas de más alto tráfico en el día, luego el número de muestras es promediada para después calcular el tráfico.

El tráfico es definido como el producto del número de llamadas durante un período de tiempo y su longitud promedia. También se debe hacer una distinción entre los términos densidad de tráfico e intensidad de tráfico; la densidad representa el número de llamadas simultáneas en un momento dado y la intensidad representa la densidad de tráfico promedio durante un período dado. La cantidad de densidad de tráfico usada en el cálculo del número de conmutadores solicitados es la intensidad de tráfico.

Otros términos que deben ser diferenciados son el tráfico cursado y el tráfico ofrecido, utilizados para la ocupación del tráfico verdadero. El tráfico cursado es el volumen de tráfico manejado actualmente y es tomado de los reportes de tráfico generados en la central, en tanto que el tráfico ofrecido es definido como la cantidad de tráfico cursado añadido la cantidad de tráfico perdido o bloqueado. Esto se lo puede ilustrar en el gráfico 3.11.

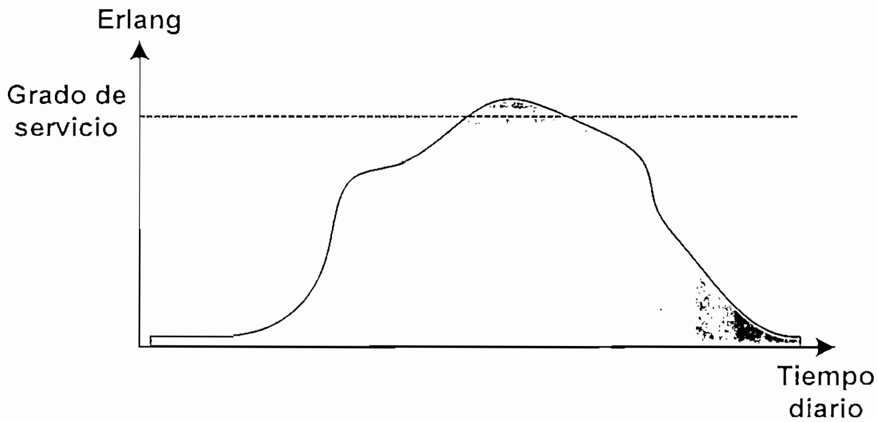


Fig. 3.11: Variación diaria del tráfico

Las variaciones de tráfico impactan al sistema en cualquier período de tiempo de ocupación de los recursos. Por lo que cuando se intenta dimensionar una central, algunas definiciones de períodos de tiempo del volumen de tráfico son necesarias. Las compañías operadoras hacen uso de varios tipos de muestras para caracterizar los períodos cuando hay sobrecarga en el tratamiento del tráfico, como son: hora ocupada (BH – *Busy Hour*), hora ocupada rechazada (BBH – Bouncing *Busy Hour*), día ocupado (BD – *Busy Day*) y día total (24-*hour*).

El tráfico generalmente es bajo durante la noche y se incrementa de manera rápida en las mañanas cuando las oficinas, los locales comerciales y las fábricas inician su actividad laboral. La intensidad de tráfico disminuye de manera gradual durante la hora de almuerzo y nuevamente se eleva en la tarde. Los patrones de incremento y disminución del flujo de tráfico se observan también durante el curso de la semana, por ejemplo, el promedio más alto de intensidad es en días hábiles (especialmente el día viernes) y las actividades más bajas, durante los fines de semana y vacaciones.

Sin tomar las previsiones del caso, el comportamiento del tráfico puede causar anomalías al sistema, las cuales son usualmente referidas a eventos inesperados o impredecibles que podrán trastornar la operación normal del sistema. Las anomalías más graves son las referentes a desastres naturales, pero otros tipos de anomalías ocurren cuando los usuarios reaccionan a ciertos acontecimientos planeados o no por las operadoras. Un ejemplo de esto, es las promociones de planes de tarifas celulares, que si son acogidas de muy buena manera, ocasionan que más suscriptores se adhieran a la compañía y esto puede ocasionar desborde tráfico para las capacidades actuales. Para prevenir este tipo de problemas, los proveedores del sistema deben tener algún tipo de plan de contingencia para evitar el bloqueo de llamadas, como disponer del hardware necesario para un crecimiento sostenido si las condiciones del mercado lo permiten.

- ***Unidades de tráfico***

La unidad básica del volumen de tráfico telefónico es el *call second*, que es el número de llamadas multiplicadas por su duración en segundos. Las medidas de volumen de tráfico son aplicables a la mayoría de las unidades de la central celular, tales como las troncales de voz o la matriz de conmutación, responsables de la duración global de la llamada o parte de una llamada.

La intensidad de tráfico se mide en erlangs, equivalente a un circuito en uso por hora o 3600 seg.; se le denomina erlang en honor al matemático danés A. K. Erlang, creador de la teoría de tráfico telefónico.

Una unidad derivada usada para la medición del tráfico es el CCS por hora (tiempo de llamadas por cien segundos de operación), que resulta de la suma del número de circuitos usados, proveídos de las troncales usadas que fueron muestreadas una vez cada 100 segundos (36 CCS equivale a 1 erlang).

Estas dos unidades de medida se las puede expresar de la siguiente manera:

$$Erlang = \frac{N^{o}\ llamadas \text{ x promedio de duración de llamada (seg.)}}{3600} \qquad \text{(Ec. 3.3)}$$

$$CCS = \frac{N^{o}\ llamadas \text{ x promedio de duración de llamada (seg.)}}{100} \qquad \text{(Ec. 3.4)}$$

Con un número determinado de abonados, los erlangs por usuario y el porcentaje de bloqueo permitido, es posible calcular el número de canales necesarios en una celda dada. Se va a suponer que se tiene 25 usuarios, cada uno habla un promedio de 12 minutos y el bloqueo permitido es del 2%; entonces se va a necesitar:

$$\frac{25\times 720}{3600} = 5 \text{ erlangs}$$

Con este resultado se puede acudir a la tabla de erlangs para saber cuántos radios son necesarios en la estación base para satisfacer a los 25 abonados. En el cuadro 3.1 se muestran algunos valores de porcentaje de bloqueo tanto para la capacidad analógica como digital de la celda, donde se puede observar que para los 5 erlangs con un bloqueo al 2% se necesitan 10 radios analógicos y 4 digitales.

Nº Radios	% de bloqueo Erlang-B					
	1%		2%		5%	
	AMPS	TDMA	AMPS	TDMA	AMPS	TDMA
1	0.0101	0.455	0.0204	0.602	0.0526	0.899
2	0.153	1.91	0.223	2.28	0.381	2.96
3	0.455	3.78	0.602	4.34	0.899	5.37
4	0.869	5.88	1.09	6.61	1.52	7.95
5	1.36	8.11	1.66	9.01	2.22	10.6
6	1.91	10.4	2.28	11.5	2.96	13.4
7	2.50	12.8	2.94	14.0	3.74	16.2
8	3.13	15.3	3.63	16.6	4.54	19.0
9	3.78	17.8	4.34	19.3	5.39	21.9
10	4.46	20.3	5.08	21.9	6.22	24.8
11	5.16	22.9	5.84	24.6	7.08	27.7
12	5.88	25.5	6.61	27.3	7.95	30.7

Cuadro 3.1: *Tráfico en erlangs*

Por lo tanto, al conocer el total de tráfico en erlangs es posible calcular el número de canales necesarios.

Otra unidad de tráfico que se puede utilizar se conoce como minutos de uso (MOU – *Minute Of Use*), el cual es equivalente a 60 segundos de llamada de uso, por lo que relacionando las tres unidades que se han revisado, se tiene lo siguiente:

- 1 erlang = 60 MOU = 36 CCS
- 1 MOU = 0.16 erlang = 0.6 CCS
- 1 CCS = 0.028 erlang = 1.67 MOU

- ***Grado de servicio (GOS - Grade of Service)***

El grado de servicio de una central se define como un componente de la calidad del servicio celular, probando la respuesta del sistema a las variaciones del tráfico mientras el resto de componentes estén libres de fallas y problemas internos.

Es una medida de la probabilidad de que una llamada ofrecida en una celda determinada no encontrará un canal de voz desocupado en el primer intento, es decir, que cualquier llamada será bloqueada (congestión en equipos o troncales). El grado de servicio se mide en porcentaje, por lo que existe la posibilidad de que un porcentaje del total de las llamadas durante una hora pico probablemente serán bloqueadas a través de problemas de congestión.

Típicamente el bloqueo móvil está entre 2% y 5%, mientras que en troncales de tierra el bloqueo es del 1%. Una tasa del 2% de bloqueo significa que un sistema será capaz de procesar al menos el 98% de los intentos de llamada. El bloqueo exacto de cada celda en el sistema, sin embargo, puede ser más o menos alto que el 2% en horas ocupadas.

El bloqueo es afectado por el número de solicitudes para obtener servicio a cualquier tiempo dado y la disponibilidad de infraestructura para obtener servicio. El número de circuitos de voz necesarios para una celda depende de la cantidad de tráfico en la hora ocupada, la tasa de bloqueo y el tipo de tráfico cursado. El tráfico puede ser determinado de algunas maneras: pronósticos de tráfico (rendimiento actual del sistema), herramientas de análisis de tráfico o datos recolectados desde registros propios de cada central celular sobre un período de tiempo.

Como se puede entender en el concepto del GOS, la ingeniería de tráfico debe tratar de no provocar ni sobredimensionamiento ni subdimensionamiento. El sobredimensionamiento trae demasiado costo al sistema (GOS = 0 %), recursos ineficientes, e ingreso de tráfico demasiado bajo para soportar los costos. En cambio el subdimensionamiento provoca bloqueo (GOS > 2%), bajo rendimiento técnico, calidad deficiente, y por ende aborto de abonados.

- ***Tablas de tráfico***

Se disponen de tres tablas de tráfico:

- Tabla Erlang-B
- Tabla Erlang-C
- Tabla de Poisson.

- ***Tabla Erlang-B***

La tabla Erlang-B es la más usada en los sistemas celulares. Esta tabla asume que las llamadas bloqueadas son liberadas, ya que las distribuye automáticamente hacia otra ruta. En otras palabras, los usuarios quienes no pueden conseguir un canal de voz esperan antes de intentarlo nuevamente después, haciendo desaparecer el bloqueo en su totalidad.

La expresión matemática para la tabla Erlang-B es:

$$P=\frac{\frac{A^N}{N!}}{\sum_{i=0}^{N}\frac{A^i}{i!}} \quad \text{(Ec. 3.5)}$$

Donde P es la tasa de bloqueo o GOS, N es el número de troncales o canales, y A es el tráfico llevado o la capacidad de tráfico en erlangs.

- ***Tabla Erlang-C***

La tabla Erlang-C es basada en la suposición que las llamadas que se encuentran bloqueadas son puestas en cola (con Erlang-B se pierden las colas) y son servidas tan pronto como un canal libre esté disponible.

La expresión matemática para la tabla Erlang-C es:

$$P=\frac{\frac{A^N N}{N!(N-1)}}{\sum_{i=0}^{N}\frac{A^i}{i!}+\frac{A^N N}{N!(N-1)}} \quad \text{(Ec. 3.6)}$$

- ***Tabla de Poisson***

La tabla Poisson está basada en la suposición que las llamadas bloqueadas son mantenidas. Comparada a la tabla Erlang-B, la tabla de Poisson es más conservadora; esto es, para el mismo número de tasa de bloqueo y canales, la capacidad de tráfico es menor.

La expresión matemática para la tabla de Poisson es:

$$P=1-e^{-A}\sum_{i=0}^{N-1}\frac{A^i}{i!} \quad \text{(Ec. 3.7)}$$

El cuadro 3.2 muestra los valores del tráfico usando estas tres tablas para 20 troncales a un GOS de 1%, 2% y 5%:

Nº Troncales	Erlang-B Tráfico en erlangs (A)			Erlang-C Tráfico en erlangs (A)			Poisson Tráfico en erlangs (A)		
	P = 1%	P = 2%	P = 5%	P = 1%	P = 2%	P = 5%	P = 1%	P = 2%	P = 5%
1	0.01	0.02	0.06	0.01	0.02	0.05	0.01	0.02	0.05
2	0.15	0.23	0.38	0.15	0.21	0.34	0.15	0.21	0.35
3	0.46	0.60	0.90	0.43	0.55	0.79	0.43	0.57	0.82
4	0.87	1.09	1.53	0.81	0.99	1.32	0.82	1.01	1.37
5	1.36	1.66	2.22	1.26	1.50	1.91	1.28	1.53	1.97
6	1.91	2.28	2.96	1.76	2.05	2.53	1.78	2.09	2.61
7	2.50	2.93	3.74	2.29	2.63	3.19	2.33	2.68	3.29
8	3.13	3.63	4.54	2.86	3.25	3.87	2.91	3.31	3.98
9	3.78	4.34	5.37	3.46	3.89	4.57	3.51	3.95	4.70
10	4.46	5.08	6.22	4.08	4.54	5.28	4.13	4.62	5.43
11	5.16	5.87	7.08	4.71	5.21	6.02	4.77	5.30	6.17
12	5.87	6.62	7.95	5.36	5.90	6.76	5.43	6.00	6.92
13	6.61	7.40	8.84	6.03	6.61	7.51	6.10	6.70	7.69
14	7.35	8.20	9.73	6.70	7.32	8.27	6.78	7.42	8.46
15	8.11	9.01	10.64	7.40	8.04	9.04	7.48	8.15	9.24
16	8.87	9.83	11.54	8.10	8.76	9.82	8.18	8.89	10.03
17	9.65	10.66	12.46	8.80	9.50	10.61	8.89	9.64	10.83
18	10.44	11.49	13.38	9.52	10.25	11.40	9.62	10.39	11.64
19	11.23	12.34	14.31	10.24	11.01	12.19	10.34	11.15	12.44
20	12.03	13.18	15.25	10.98	11.77	13.00	11.08	11.91	13.25

***Cuadro 3.2:** Muestra de tabla de tráfico*

Haciendo una comparación entre los tres casos, se ve que para un mismo número de troncales al 2% de GOS, con Erlang-B se tiene mayor capacidad de tráfico en erlangs.

3.6.2.2. DISTRIBUCION DEL TRAFICO

La eficiencia de una troncal es menor que la eficiencia de dos o más troncales, por lo que entre más troncales estén disponibles mayor es la eficiencia del sistema. Pero no se puede aumentar troncales de manera desmedida o limitar su número sin una comprensión de cómo afecta el flujo de tráfico a cada elemento del sistema celular en sí. Como se vio en el primer capítulo, la central celular se compone de varios procesadores que controlan los diferentes elementos de su arquitectura, los cuales tienen límites de ocupación propios de cada fabricante para su correcto funcionamiento, por lo que los Ingenieros de Conmutación deben hacer reportes continuos del funcionamiento de la red, y así prever que no se degrade el servicio telefónico celular brindado por la operadora.

Debido a esto se debe seguir muy de cerca el comportamiento del procesador principal; ya que coordina el procesamiento de llamadas, diagnósticos, mantenimiento, y demás procesos importantes para la central celular. Para los análisis respectivos se debe manejar apropiadamente el concepto de la capacidad en tiempo real del procesador central, entendiéndose como tiempo real el tiempo actual durante el cual la unidad de procesamiento central realiza sus funciones. El procesador está activo el 100% del tiempo, usualmente está realizando una combinación de actividades de procesamiento de llamadas y no llamadas. Sin embargo, si solicitudes de llamadas no son recibidas durante un período de tiempo el procesador se mantiene 100% activo en actividades de no llamadas, las cuales manejan las operaciones globales del sistema.

La ocupación del procesamiento de llamadas es una medida del porcentaje del tiempo real del procesador central asignado al proceso de las llamadas, usado durante un período de estudio caracterizado por los intentos de llamada en la hora ocupada de más alto tráfico (BHCA - *Busy Hour Call Attempt*). Para una central los intentos de llamadas incluyen las llamadas de móvil a móvil, de móvil a tierra, de tierra a móvil, envío de llamadas, interconexión IS-41, búsquedas fuera de tiempo y otras actividades. Las llamadas de voz completadas son sólo una parte del BHCA de una central típica inalámbrica. Desde el controlador de troncales digitales a la red telefónica pública conmutada, la capacidad es expresada en erlangs o en CCS's.

Como se mencionó anteriormente, el estudio del tráfico telefónico envuelve un intento de calificar las variaciones de los escenarios de llamadas, para establecer reglas y tendencias para su aplicación y pronóstico en el sistema telefónico optimizado. En una central el flujo de tráfico es el producto del número de llamadas durante un período de tiempo determinado y su longitud promedio, llamado también tiempo promedio de retención de la llamada (CHT – *Call Holding Time*).

La forma de expresar las medidas de capacidad varía de acuerdo a cada operador, algunos prefieren usar los erlangs y otros el BHCA. De cualquier modo el sentido es el mismo, pero para efectos de comprensión, la relación 3.8 permite la conversión de erlangs a BHCA y viceversa.

$$Erlang = \frac{CHT \times BHCA}{3600} \qquad \text{(Ec. 3.8)}$$

El primer paso en la ingeniería de tráfico inalámbrico es determinar la carga de tráfico promedio (en un mercado específico) generado por un abonado durante la hora ocupada (erlangs por usuario). Conociendo cuan seguido un usuario usa su teléfono celular (tasa de llamadas) y el tiempo promedio de retención de la llamada, el promedio de la intensidad de tráfico por usuario en erlangs también puede ser calculado por la ecuación 3.8. Aunque se puede usar este método para calcular las predicciones de capacidad a partir de las suposiciones del comportamiento de la red, no se debe olvidar los registros que cada fabricante genera con la recopilación de la información de algún aspecto en particular del sistema que el operador quiera consultar. En todo caso, a continuación se va a presentar un ejemplo de cómo calcular las predicciones de capacidad en erlangs a partir de las suposiciones de tráfico, aplicable a cualquier elemento individual del sistema:

1. Obtener los erlangs por usuario, el tiempo de retención de llamada y el número total de usuarios. Una vez conocidos estos valores, obtener los erlangs totales del sistema mediante la aplicación lógica de la siguiente relación:

Erlangs del sistema = Erlangs por usuario x Nº de usuarios

2. Usando el grado de servicio deseado, y con el valor de los erlangs totales del sistema, se puede utilizar la tabla de tráfico Erlang-B para calcular el número de canales que satisfacen ese valor. Una vez determinado el número de canales de voz que se debe tener en la celda en cuestión para satisfacer la demanda de abonados que entra en el cálculo, se puede saber si se necesita o no aumentar más radios para cubrir la demanda de tráfico.

3. Otra manera de predecir los requerimientos de capacidad es utilizar los erlangs del sistema y el tiempo promedio de retención de las llamadas mediante la ecuación 3.8, para calcular el BHCA del sistema.

4. Comparando este valor del BHCA calculado con el valor del BHCA recomendado por cada fabricante, se puede determinar si la capacidad actual de troncales o líneas es suficiente para manejar los BHCA adicionales.

Como se puede observar es necesario realizar varias consideraciones cuando se realiza el análisis del estado actual del sistema, incluyendo aspectos como el manejo del mercado, ciclos de presupuesto y características asociadas con nuevas versiones de software; necesarios para el manejo del tráfico en este caso.

En los sistemas celulares el tráfico representa el área de más alto crecimiento. Los usuarios tienen las características de movilidad básica, y otros servicios verticales como son la transferencia de llamadas en estado de no-con*test*ación, transferencia de llamadas en estado de ocupado, transferencia de llamadas incondicional y la conferencia tripartita, que sumados a otras propiedades como el correo de voz, el roaming automático y la entrega de llamadas en general, ocasionan el aumento de mensajería en el sistema así como el tráfico en la red. La disponibilidad de estas características o servicios incrementan la demanda por usuario, y por lo tanto la demanda del sistema.

Por ejemplo, una llamada que podría haber sido enviada a un tratamiento de ocupado o sólo recibir el tono de timbrado si el usuario no con*test*a, puede ahora ser desviada a un servicio de correo de voz. El correo una vez que ha registrado el mensaje hará cola esperando una indicación para enviarlo al abonado correspondiente, aunque el usuario también llama al buzón para extraer sus mensajes. El número de llamadas resultantes desde el correo de voz y la transferencia de llamadas incrementa la demanda por usuario, impactando en la operación en tiempo real del módulo central de computación de la central celular.

El análisis de la capacidad de los elementos de la central trae consigo ciertos conceptos, como los tipos de capacidad en un sistema inalámbrico, los cuales son:

- La capacidad en tiempo real, que es la cantidad de tiempo disponible en el procesador de un nodo del sistema para la ejecución de tareas, incluyendo el procesamiento de llamadas y otras tareas tales como programación, auditorías, medidas operacionales y mantenimiento.

- La capacidad de la memoria, que es la cantidad de memoria requerida por el sistema, considerando el crecimiento de la base de datos de los usuarios, las características de cada abonado, equipamiento y nuevas características.

- La capacidad de mensajería, es decir, el rendimiento del procesamiento en un enlace de mensajes entre los componentes en el sistema.

- La capacidad en los canales, que es el número de canales disponibles en la red.

- La capacidad física, que es el número de terminaciones a un componente o a un grupo de componentes que dan acceso a la central.

Estos diferentes tipos de capacidades interactúan en la planeación de la operación de la red. El hecho de asegurar que las cargas de los procesadores están dentro de los rangos del fabricante, los controladores de las troncales de voz fijas y los controladores de las celdas estén manejando los BHCA adecuados dan las bases para realizar el análisis de la capacidad frente a la cobertura.

Una celda puede proveer de cobertura, capacidad o ambas. En el estado inicial de un sistema, las celdas son puestas para brindar cobertura continua en ciertas áreas. El número de celdas necesarias son determinadas por la calidad de cobertura que se quiere mantener a través del área servida. La calidad de la cobertura es normalmente especificada por el nivel de señal deseada y su factor de confiabilidad, lo que significa que en el 90% del área se debe tener un nivel de señal de por lo menos –80 dBm durante el 90% del tiempo (10)

En el estado avanzado del sistema, el tráfico en ciertas áreas se incrementa o se puede incrementar más allá de la capacidad del sistema, por lo que más celdas son añadidas para proveer capacidad adicional. Pero se debe considerar que esas celdas no extienden el área de cobertura existente, pero son necesarias para mantener el grado de servicio.

3.6.2.3. PLANIFICACION DEL TRAFICO

Para realizar la planeación del tráfico se requieren de varios elementos de consideración, los cuales se pueden resumir en los siguientes:

- Tendencias del impacto del mercado.
- Distribución de la demanda.
- Distribución del tráfico.
- Impacto de la distribución de las llamadas mixtas en el sistema.
- Anomalías del tráfico.
- Bloqueo de las troncales.
- Requerimientos del medio de transmisión.
- Condiciones de capacidad y cobertura.
- Criterios de ubicación de las celdas y varias tecnologías de servicio.
- Planeación intersistema.
- Sectorización o no de las celdas.

El crecimiento en sistemas estables es relativamente sencillo cuando es comparado con un sistema que tiene severas fluctuaciones en tráfico. Si el sistema soporta celdas en sitios rurales y metropolitanos, los pronósticos se los debería realizar por separado (por el área geográfica) para asegurar que el porcentaje de tráfico y el crecimiento de abonados proyectado no sea equivocado.

Las tendencias son un factor serio que pueden impactar (y de hecho lo hacen) los pronósticos de crecimiento de tráfico, las cuales se las puede definir como un cambio en el número de abonados o en la demanda por el servicio. Aunque esos factores pueden ser identificados o racionalizados, las consecuencias exactas que esas tendencias tendrán en el crecimiento de la red son difíciles de predecir. Sin embargo, los pronósticos deben tratar de coincidir con esos factores, y los planes de crecimiento deben ser formulados a pesar de la incertidumbre que puedan causar esos factores.

La competencia en el mercado celular (Conecel y Bellsouth), hace que ésta sea el factor impactante más grande en el crecimiento de un sistema específico, y la tendencia de crecimiento se hace más compleja cada día. Cada mercado será único, y por lo tanto, la ingeniería de tráfico debe considerar cualquier tendencia adicional que impacte el flujo de tráfico por las diferentes zonas geográficas (incluyendo las condiciones climáticas), y que pueden cargar tráfico visitante en unas áreas más que en otras.

Normalmente el pronóstico del tráfico envuelve proyecciones de crecimiento de tráfico del sistema celular por algunos años en el futuro. Esto hace que el dimensionamiento del tráfico sea un proceso retador, especialmente cuando no se cuenta con los datos necesarios. La información más importante con que se debe empezar el dimensionamiento es el número de subscriptores en las regiones de interés a los que se piensa servir y su distribución en el sistema, generalizando el significado de subscriptor como la persona o negocio que se adhiere al servicio celular para un móvil en particular.

La distribución de las llamadas mixtas es tan importante como la hora ocupada, el bloqueo, el GOS y la intensidad, cuando el tráfico es analizado y el sistema es optimizado. Como se explicó anteriormente, las llamadas pueden ser realizadas bajo seis tipos básicos de escenarios manejados por el procesamiento de llamadas:

- Móvil a fija.
- Fija a móvil.
- Móvil a móvil.
- *Handoff* de llamadas.
- Fija a tratamiento.
- Entrega de llamadas.

En la red el mayor porcentaje de llamadas se presenta de móvil a fija, seguido de fija a móvil, y por último de móvil a móvil.

Además de la consideración de la distribución mixta de llamadas, se debe considerar la aplicación mixta de tecnologías en los sistemas celulares. Como en el país se manejan las tecnologías AMPS y TDMA, cada proveedor del servicio debe decidir cuando migrar de AMPS a TDMA para ampliar la capacidad digital, o simplemente ampliar la capacidad analógica, dependiendo de las tendencias de tráfico mostrados en los reportes del rendimiento de la red.

Los radios en las celdas pueden funcionar de tres maneras: sólo digital, sólo analógico o ambos. En el modo sólo digital los radios funcionan en el modo TDMA-3 con tres canales de tráfico de voz por frecuencia del canal. En el modo sólo analógico, los radios funcionan en el modo AMPS con un canal de tráfico de voz por frecuencia del canal. Y por último, el modo ambos es el más conveniente para el sistema, ya que no se necesita aumentar el hardware de radios en la celda sino que simplemente se los redefiniría en la central según como se lo necesite, si como analógico o digital. Además, el mejoramiento de la capacidad de 3 a 1 que TDMA tiene sobre AMPS, hace que la decisión de implementar TDMA pueda impactar a la evolución del sistema, por ejemplo, supongamos que tenemos una celda omnidireccional que está alcanzado los límites de interferencia y capacidad. La solución obvia podría ser implementar la sectorización para dirigir mejor la cobertura y añadir celdas para cubrir la división de la misma, o retrasar los más que se pueda la división y añadir canales TDMA.

El crecimiento de los sistemas AMPS y TDMA, y los pasos que se pueden seguir son indicados en las figuras 3.12 y 3.13.

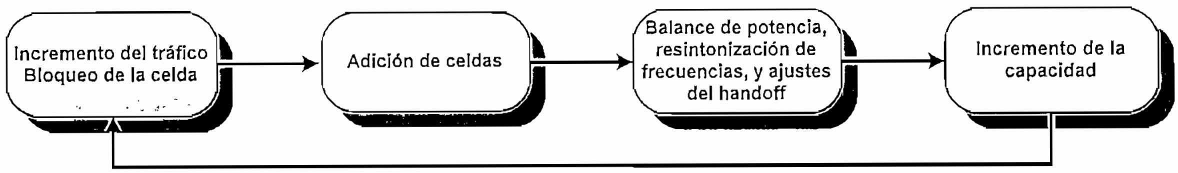


Fig. 3.12: Crecimiento del sistema AMPS

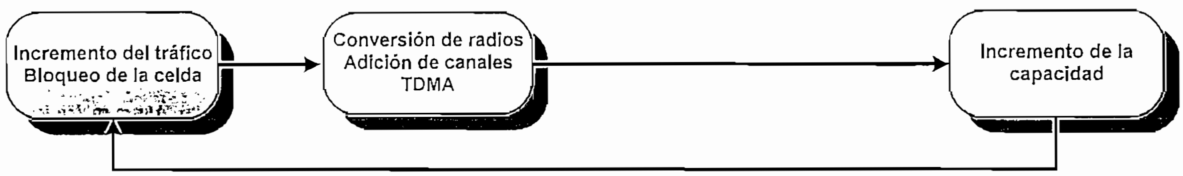


Fig. 3.13: Crecimiento del sistema TDMA

Un aspecto muy importante que no se puede dejar a un lado, es el aprovisionamiento para la red telefónica fija, la cual es una parte crucial de la planeación de toda operadora celular. Un buen porcentaje de las llamadas incluirá en la PSTN, ya sea de móvil a fija o de fijo a móvil. Cuando se realiza el aprovisionamiento se debería considerar la dirección de las troncales (unidireccionales o de doble vía), el tipo de señalización, el grado de servicio que se debe cumplir, y el número de PCM's que van a llevar los canales de voz y de señalización (en caso de ser SS7). Además, se debe considerar las troncales que se van a programar y enlazar con equipos periféricos (correo de voz, PBX, etc.) y con otras centrales de conmutación celular.

La aplicación de la direccionalidad de las troncales depende del servicio que se quiera brindar a los abonados, las cuales son ilustradas en la figura 3.14.

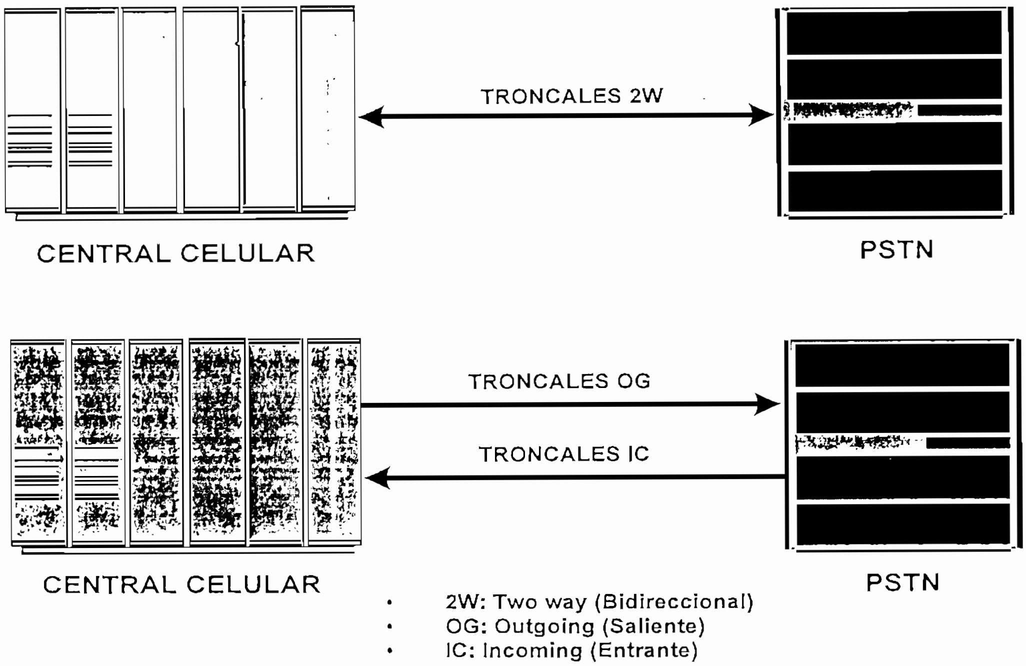


Fig. 3.14: Dirección de las troncales

Los medios de transmisión utilizados para llevar el tráfico de los enlaces de voz, y también los datos o señalización en las diferentes troncales, varían según las condiciones.

Otro elemento de planeación del tráfico son las celdas de cobertura. Generalmente, los sistemas son diseñados en cobertura en la primera fase, y en capacidad en las fases posteriores, ya que el plan de celdas del sistema tiene un impacto significativo en la distribución de tráfico del sistema. La ubicación de las celdas puede ser seleccionada bajo las siguientes premisas:

- Añadir nueva cobertura.
- Extender la cobertura.
- Incrementar capacidad.
- Combinación de anteriores criterios.

La nueva cobertura involucra la ubicación de celdas en la red "hexagonal" donde las demandas de cobertura son requeridas. Factores incontrolables, tales como terrenos accidentados, concentración urbana, etc., pueden determinar si las celdas son o no ubicadas en un arreglo hexagonal; ocasionando que la realización del plan de frecuencias sea cada vez más complicada.

Extender las celdas obedece a varios factores, especialmente a factores geográficos, al igual que la división de las mismas. La división de las celdas responde a dos propósitos: proveer cobertura adicional en edificios y proveer capacidad de tráfico adicional. Una celda dividida descargará el tráfico en celdas adyacentes y proveerá capacidad adicional mientras el GOS se mantendrá por debajo del nivel deseado, a pesar de que esto no es una tarea fácil, debido a que la adición de celdas trae consigo un reajuste del balance de los caminos de transmisión para mantener la intensidad de la señal a los usuarios.

Por último, y el mayor dolor de cabeza dentro de la planificación del sistema es la planeación de las frecuencias, la cual no es realizada directamente por el área de Conmutación (Central Celular) sino por el área de Planificación, pero no significa que los Ingenieros de Conmutación no deban tener claro el concepto de cómo se realiza este proceso, ya que el mismo tiene el mayor impacto en cuanto a calidad de servicio y afecta a todos los demás procesos de planificación.

La planeación de frecuencias se lleva a cabo para optimizar el uso del espectro de frecuencias y desarrollar un plan de reuso de frecuencias para hacer más eficiente el uso de los canales disponibles. Los planes de frecuencias no son sólo usados para el reuso de las mismas, sino para reducir los diferentes factores que afectan la calidad de las llamadas. Además tienen una gran influencia sobre el desempeño en general del sistema, ya que envuelven la agrupación de las celdas, la asignación de canales de voz, canales de localización y canales de control en un área de servicio determinada.

La interferencia de radio frecuencia es la mayor preocupación en los sistemas de comunicación inalámbrica. La medida de este tipo de interferencia es expresada como la relación carrier a interferencia (C/I), que puede ocurrir desde el mismo sistema o de otras fuentes. Básicamente se tiene dos tipos de interferencias:

interferencia por canales asociados o cocanales (C/I) e interferencia por canales adyacentes (C/A).

La interferencia cocanal es ocasionada cuando otro transmisor usa la misma frecuencia. Este escenario puede ocurrir con bastante facilidad en los sistemas celulares ya que las frecuencias se reusan varias veces. Cuando la distancia es más grande entre las celdas donde las mismas frecuencias están siendo reusadas (ver figura 3.9), es menor la probabilidad de que este tipo de problema ocurra. Otro aspecto que ayuda a reducir la interferencia es la reducción de la potencia del transmisor. Los usuarios que poseen equipos analógicos, perciben la interferencia cocanal en forma de *cross-talk*.

La interferencia adyacente se da cuando hay una sobrecarga de energía de un canal de mayor o menor número de frecuencia que el afectado, escenario que ocurre con mayor frecuencia ya que cada canal es reusado en algún lugar del sistema. En los equipos analógicos, el usuario percibe la interferencia de canal adyacente en forma de estática o ruido, y en los equipos digitales como robotización o silencios.

Como se mencionó en el capítulo I, el servicio celular está dividido en las bandas A y B. La autorización original de la FCC fue para 40 MHz del espectro que contenía 666 canales, luego se añadieron 10 MHz o 166 canales adicionales, los cuales son numerados a partir del 667 denominándose como espectro expandido. Con estas modificaciones, el espectro tiene un total de 416 canales, 395 canales de voz y 21 de control, cuyo espaciamiento es de 30 KHz; esto se puede apreciar en la figura 3.15.

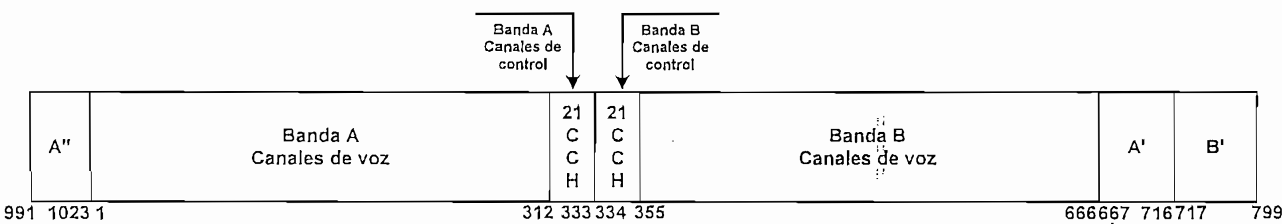


Fig. 3.15: *Distribución de frecuencias*

Por lo general los números de los canales son referidos como frecuencias, por lo que se puede establecer relaciones para convertir de números a frecuencias y viceversa. El cuadro 3.3 muestra las relaciones que son utilizadas para determinar la frecuencia que corresponde a un número de canal N dado.

Frecuencia (MHz)	Espectro normal	Espectro expandido
Transmisión	0.03N + 870	0.03(N – 1023) + 870
Recepción	0.03N + 825	0.03(N – 1023) + 825

Cuadro 3.3: *Relaciones de conversión*

Con esta información se puede estudiar la asignación de canales a las celdas de la red, para lo cual la planeación celular divide un área de servicio determinada en varias áreas de servicio más pequeñas. El patrón celular utilizado en el Ecuador es el arreglo de N = 7 celdas ya sean sectorizadas a 120° u omnidireccionadas. La sectorización se la realiza debido a interferencias, capacidad de canales y un mejor control de los patrones de cobertura.

El plan de frecuencias N = 7 divide todas las frecuencias disponibles en 21 grupos de frecuencias con un canal de control por grupo. Los grupos se reúnen como 1A, 1B, 1C, y así sucesivamente, y el número total de grupos de frecuencia por celda es igual a 3. Los grupos son asignados como N, N + 7 y N + 14, donde N es el número de celda en el *cluster* (N = 1, 2, 3, ..., 7), asignando de este modo los grupos 1A, 1B y 1C a la celda 1, 2A, 2B y 2C a la celda2, etc.; proporcionando 7 separaciones de canal dentro de la misma celda pero sin ninguna separación entre celdas. La adyacencia de los canales reaparece en el patrón de reuso de frecuencias, lo cual es común en los sistemas N = 7 que requieren utilizar más de un grupo de frecuencias por celdas.

Los cuadros 3.4 y 3.5 muestran los diferentes grupos de frecuencias para las bandas A y B.

Grupo	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	A1	B1	C1	D1	E1	F1	G1	A2	B2	C2	D2	E2	F2	G2	A3	B3	C3	D3	E3	F3	G3
	X1	X2	X3	X4	X5	X6	X7	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Z1	Z2	Z3	Z4	Z5	Z6	Z7
CCH	333	332	331	330	329	329	327	326	325	324	323	322	321	320	319	318	317	316	315	314	313
Espectro Normal	312	311	310	309	308	307	306	305	304	303	302	301	300	299	298	297	296	295	294	293	292
	291	290	289	288	287	286	285	284	283	282	281	280	279	278	277	276	275	274	273	272	271
	270	269	268	267	266	265	264	263	262	261	260	259	258	257	256	255	254	253	252	251	250
	249	248	247	246	245	244	243	242	241	240	239	238	237	236	235	234	233	232	231	230	229
	228	227	226	225	224	223	222	221	220	219	218	217	216	215	214	213	212	211	210	209	208
	207	206	205	204	203	202	201	200	199	198	197	196	195	194	193	192	191	190	189	188	187
	186	185	184	183	182	181	180	179	178	177	176	175	174	173	172	171	170	169	168	167	166
	165	164	163	162	161	160	159	158	157	156	155	154	153	152	151	150	149	148	147	146	145
	144	143	142	141	140	139	138	137	136	135	134	133	132	131	130	129	128	127	126	125	124
	123	122	121	120	119	118	117	116	115	114	113	112	111	110	109	108	107	106	105	104	103
	102	101	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82
	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61
	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40
	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19
	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
Espectro Expandido										716	715	714	713	712	711	710	709	708	707	706	705
	704	703	702	701	700	699	698	697	696	695	694	693	692	691	690	689	688	687	686	685	684
	683	682	681	680	679	678	677	676	675	674	673	672	671	670	669	668	667				
																			1023	1022	1021
	1020	1019	1018	1017	1016	1015	1014	1013	1012	1011	1010	1009	1008	1007	1006	1005	1004	1003	1002	1001	1000
	999	998	997	996	995	994	993	992	991												

Cuadro 3.4: *Plan de frecuencias N = 7 para la banda A*

Grupo	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	H1	I1	J1	K1	L1	M1	N1	H2	I2	J2	K2	L2	M2	N2	H3	I3	J3	K3	L3	M3	N3
	X1	X2	X3	X4	X5	X6	X7	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Z1	Z2	Z3	Z4	Z5	Z6	Z7
CCH	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354
Espectro Normal	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375
	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396
	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417
	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438
	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459
	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501
	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522
	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543
	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564
	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585
	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606
	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627
	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648
	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666			
Espectro Expandido						717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732
	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753
	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774
	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795
	796	797	798	799																	

Cuadro 3.5: *Plan de frecuencias N = 7 para la banda B*

Cuando se trata de arreglos omnidireccionales, la distribución de frecuencias de un *cluster* podría quedar como se muestra en el ejemplo de la figura 3.16.

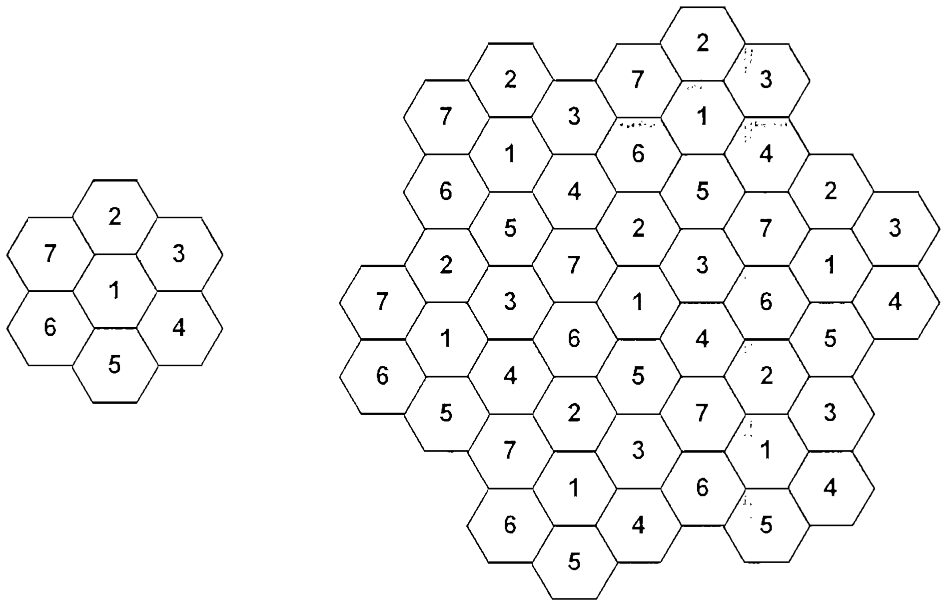


Fig. 3.16: Arreglo omnidireccional

El plan de frecuencias para las celdas sectorizadas divide a la celda en tres sectores de 120° cada uno. Este plan asigna un grupo de frecuencia por sector y tres grupos por celda. Similarmente, se asignan sólo un tipo de canal de control por sector o tres por celda. Esto se puede observar en el diagrama 3.17.

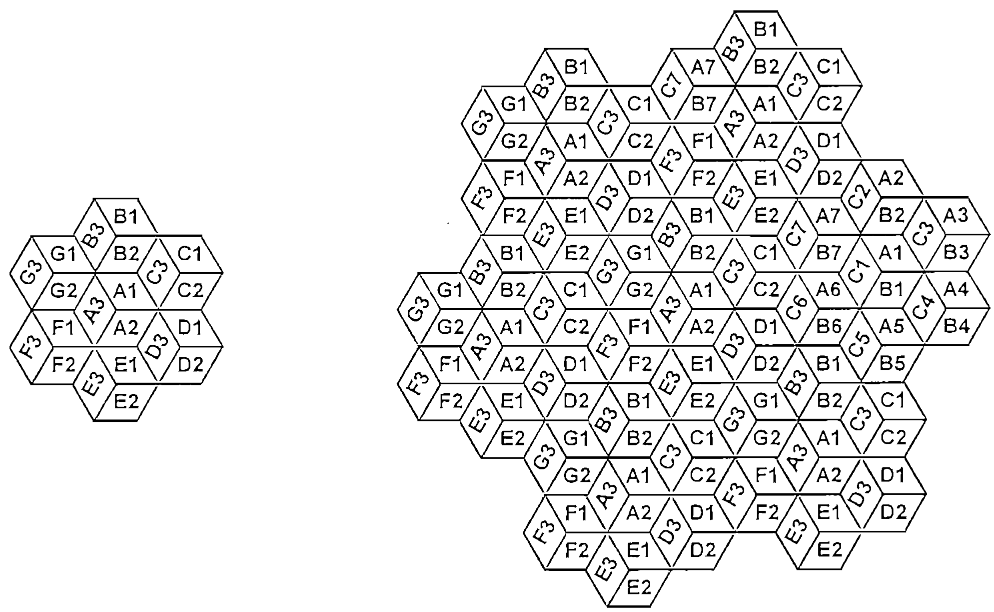


Fig. 3.17: Arreglo omnidireccional

Los planes de frecuencia raramente se implementan de acuerdo a los métodos teóricos en la mayoría de los sistemas celulares. Inicialmente la red puede implementarse con planes omnidireccionales o sectorizados, pero como resultado del crecimiento, eventualmente se tiende hacia un plan de frecuencias "improvisado" o personalizado que se adapta a la realidad de cada sistema.

Un plan de frecuencia personalizado responde a cualquiera o a la combinación de las siguientes razones:

- Crecimiento y densidad de tráfico no uniforme.
- Variación de las áreas geográficas.
- Variación de la altura de las antenas.
- Celdas de gran cobertura.
- División de los grupos de frecuencia.

La decisión de usar o no un plan de frecuencia estándar es tomado en un esfuerzo de minimizar las interferencias cocanal y de canal adyacente con la banda de frecuencia disponible. El plan de frecuencia personalizado puede optimizar el plan de celdas existentes a un mejor escenario, pero siempre y cuando se tenga el cuidado de que el plan soporte el crecimiento de nuevas celdas, sino éste requerirá de una resintonización regular de las frecuencias.

3.6.2.4. OPTIMIZACION DEL TRAFICO

Cuando se habla de la optimización del tráfico, lo que prácticamente se tiene que realizar es una redistribución de lo que ya está implementado en la red celular para dar cabida al crecimiento del sistema.

Las redistribuciones del tráfico toman en cuenta la carga de tráfico asimétrico y los mecanismos de *handoff* que pueden ser usados para redistribuir el tráfico dentro de un área geográfica.

- ***Redistribución del tráfico móvil***

La redistribución del tráfico móvil también tiene que ver con las posibles redefiniciones de las fronteras del *handoff*. La idea de redistribuir el tráfico móvil es reducir la carga de tráfico en una celda antes de que el bloqueo sea producido; esto provoca una ubicación de la llamada de manera más óptima. La redefinición de las fronteras del *handoff* toma ventaja del traslapo de las coberturas de radio frecuencia entre las celdas y altera el área de cobertura efectiva de las celdas; sin embargo, este método es efectivo solamente para usuarios no estacionarios y tiene un impacto pequeño sobre el tráfico tradicional.

La reducción de cobertura es mejor realizarla directamente alterando los patrones de cobertura de radio frecuencia. Cuando el control de propagación de radio frecuencia es limitado, la reducción de cobertura puede ser realizado variando los parámetros de *handoff* en la celda cargada y en sus adyacencias. Un control adicional existe cuando se utilizan los parámetros de pares de celdas para aislar las relaciones específicas de *handoff*. La combinación de los valores bajos de umbral de *handoff* bidireccionales y parámetros como la histéresis pueden efectivamente reducir el tráfico en una celda que está experimentando sobrecarga.

Los cambios de los parámetros en la central deberían ser realizados en etapas. Los esfuerzos de la primera etapa estarían dirigidos a jugar con los parámetros que intervienen en los procesos del *handoff*. Ya que la variación de estos parámetros serán realizados en celdas donde se tenga un alto estado de bloqueo, el éxito del procedimiento debe ser visto en un incremento en los intentos de *handoff* satisfactorios por la celda. Si los impactos de la redistribución del tráfico en la primera etapa no son suficientes, y las condiciones de radio frecuencia todavía lo permiten, la manipulación de los parámetros como la histéresis pueden proveer un efecto de reducción de cobertura más pronunciado. Estos parámetros pueden también causar actividad anómala del proceso de *handoff*, por lo que cualquier cambio debería ser monitoreado muy cuidadosamente.

Para asegurarse que los cambios ejecutados en la central no degraden el sistema, se debe solicitar al área de Planificación que se realicen pruebas de campo, también denominados *drive test's*, para poder asegurar que no se estén produciendo efectos como el del ping pong ni tampoco caídas de llamadas.

Algunas veces hay problemas con respecto a la cobertura o a la capacidad, especialmente en áreas relativamente pequeñas. Lo primero que se debe hacer es analizar los reportes de tráfico para ver el comportamiento de la celda bloqueada y de sus adyacentes para determinar si la presencia de bloqueo se debe a un evento en particular o realmente se ha venido presentando un crecimiento de tráfico en el tiempo de muestreo. Si después del análisis no queda más remedio que aumentar canales, se tiene que pasar al estudio de qué tipos de canales realmente se necesita, y lo más importante, si se dispone de la capacidad para hacerlo.

La idea de hacer una redistribución de tráfico en el sistema es tratar de evitar al máximo que se tenga bloqueo y aliviar las áreas congestionadas, ya que esto representa un costo alto a la empresa. La asignación de canales es el método apropiado para la distribución de los recursos requeridos para completar una conexión desde el móvil a la central, lo que también incluye el enlace de los canales de voz a los respectivos circuitos troncales.

Al observar los reportes de tráfico, éstos deben estar divididos en el tráfico de los canales analógicos y digitales de las celdas. Al presentarse bloqueo en alguna de estas dos divisiones comienza un análisis que puede resultar muy sencillo o que se puede complicar si no se tiene la visión de que tecnologías de teléfonos está soportando la red. Se pueden presentar tres casos de congestión de los canales de voz:

- Congestión digital.
- Congestión analógica.
- Congestión en general.

Con respecto a la parte digital, a los radios digitales de las celdas se los programa y se los carga para que sean capaces de atender a teléfonos digitales con codificador VSELP o con codificador EFRC (*Enhanced Full Rate Codec*). Ahora, el número de canales digitales que se ponga en la celda depende de lo proyectado por el área de Planificación. Como en el mercado celular los teléfonos digitales están tendiendo a utilizar EFRC debido a su mejor resistencia que VSELP, generalmente se pone una relación de canales de 2 a 1. Esto obliga a que en los Ingenieros de Conmutación discriminen correctamente el porqué se está presentando congestión en los canales digitales, sí por falta de canales VSELP o EFRC. Cómo saber esto, en la central se genera un reporte que ayuda a decidir qué tipos de canales se debe aumentar o convertir (de VSELP a EFRC o viceversa) para aliviar este tráfico, generalmente lo que se hace es tratar de equilibrar los porcentajes de bloqueo en los dos tipos de codificadores.

En el caso analógico, cuando está congestionado se podría decir que simplemente se tienen que aumentar más canales y punto, pero esto no siempre es así, y menos con la creciente demanda de teléfonos digitales. Un patrón típico de congestionamiento es que la parte analógica esté bloqueada y la parte digital "sobredimensionada", ante esto se debe tener cuidado de las decisiones tomadas para aliviar esta congestión. La mayoría de veces por lo que la parte analógica está bloqueada es que los teléfonos digitales al no poder acceder a un canal de voz que responda a sus características, éstos conmutan hacia los canales analógicos, y por ende bloquean la celda. El patrón de comportamiento de los teléfonos digitales es, si un teléfono VSELP se engancha a un canal digital VSELP tendría aún libres 2 canales más debido a la multiplexación de tiempo, pero estos canales sólo serán tomados por teléfonos VSELP y no por teléfonos EFRC, ocasionando que a pesar de que se dispongan canales digitales libres, éstos nunca sean tomados y se prefieran engancharse a los canales analógicos. Lo mismo ocurre al revés, cuando un teléfono EFRC engancha un canal EFRC, los otros dos canales virtuales sólo aceptarán EFRC y no VSELP. Entonces como se puede ver para aliviar la congestión analógica se debe considerar este escenario, ya que se podría solucionar sin aumentar canales analógicos sino simplemente redefiniendo de la manera adecuada los canales digitales.

En el caso del congestionamiento general de la celda podría ser porque el patrón de tráfico en la zona donde se encuentra la celda ha sufrido un cambio (se ha aumentado más construcciones, mayor número de abonados, mayor circulación de tránsito por esa zona, etc.), o podría ser también que existió feriado y la zona que cubre la celda es de interés para la población, sumándose un análisis más, que sería estudiar el comportamiento del tráfico de las celdas en fechas especiales y cómo se puede tomar las medidas preventivas para evitar el posible bloqueo en las áreas de cobertura involucradas.

- ***Redistribución del tráfico fijo***

La redistribución del tráfico fijo se la puede realizar por medio de rutas de desborde, es decir, el bloqueo algunas veces es desviado cuando un intento de llamada es transportado a una ruta alterna.

Lo primero que se debe discutir al momento de poner en servicio una conexión fija entre dos operadoras es el tipo de señalización que se va a utilizar, ya que esto trae consigo más o menos ventajas con respecto a la calidad de servicio y a la optimización de recursos. Además de esto se debe considerar el tipo de servicio que se va a brindar, ya que puede ser que sólo se necesiten troncales salientes, troncales o bidireccionales.

Con la señalización se gana, primero mayor velocidad en el establecimiento de una llamada. En la práctica se ve que con señalización R2 al momento de realizar una llamada desde un celular a un teléfono fijo, éste último timbra por primera vez luego de 6 o 7 segundos después de presionar la tecla de envío del móvil. En cambio con SS7, el tiempo de espera se reduce a 2 o 3 segundos. Otra ventaja es que se gana más troncales de voz por PCM, debido a que R2 utiliza un enlace de señalización por E1 y SS7 utiliza un enlace de señalización por todos los E1's, por lo que con SS7 se puede programar troncales de voz en los *slots* de tiempo 16 que en R2 son utilizados para señalización. Debido a todo esto es que hoy en día se está migrando todas las conexiones intercentrales de señalización por canal asociado a señalización por canal común.

La dirección de las troncales es importante en el proceso de la optimización del tráfico, ya que al programar destinos en la central se está obligando a que las llamadas se enruten por donde no sobrecarguen ni sobredimensionen al sistema. Las troncales bidireccionales son utilizadas en la conexión intercentrales, en cambio que las troncales unidireccionales son utilizadas entre diversos equipos periféricos y la central celular. Por ejemplo, la conexión de troncales entre el correo de voz y la central requiere que la mayoría de ellas sean salientes desde la central, debido a que generalmente los usuarios llaman al correo de voz y no al contrario, donde el correo de voz llama solamente a los usuarios que han solicitado este servicio adicional. Otro ejemplo puede ser la validación de usuarios en una plataforma de servicios especiales, donde se tendría el mismo número de troncales salientes y de troncales entrantes, utilizando las troncales salientes para enviar a la plataforma la información del usuario y las troncales entrantes para que la central reciba la autorización para que ésta termine de realizar el proceso del establecimiento de la llamada.

3.6.3. OPTIMIZACION DE LOS PROCESOS DE MOVILIDAD

La movilidad, al igual que los procesos presentados anteriormente, es una actividad que soporta algunas interacciones complejas que están relacionadas entre sí. La toma de decisiones acerca de cómo tratar el factor de la movilidad es responsabilidad de todo el equipo técnico de la operadora celular, ya que está basada sobre los ambientes dinámicos de radio frecuencia, selección de parámetros en la central celular y la disponibilidad de recursos. Este proceso asume que ciertas actividades ya han sido realizadas tales como las auditorías de las celdas, optimización de los procesos de *handoff*, diseños acertados de distribución de frecuencias, distribución de tráfico, etc.

Como en los demás procesos, serán tratados aspectos que afectan a la movilidad desde el punto de vista de las actividades de una central celular, pero para esto son necesarios ciertos conceptos que ayudarán a tener un criterio adecuado de los parámetros que son los que se debe manejar para realizar la optimización de la red dentro de los procesos de la movilidad.

Como se ha visto hasta ahora, los sistemas telefónicos fijos tienen la ventaja de saber las direcciones en donde sus clientes generan el tráfico. En cambio, en los sistemas celulares se debe investigar donde se encontrará después nuestro abonado, por lo que se debe analizar las tendencias pasadas de movilidad, comparar con las predicciones actuales y tratar de descubrir las tendencias futuras de posibles sobrecargas.

Como se vio anteriormente, la demanda de tráfico resulta del incremento en el número de usuarios móviles a medida que el sistema crece. Cada sistema tiene su conjunto de abonados, cuyos patrones de llamadas reflejan la cultura local y las condiciones empresariales, que sumados dan la perspectiva del comportamiento que van a tener en la red. Las diferencias de la movilidad de los abonados van a afectar en la frecuencia de los *handoffs* que van a ocurrir entre las celdas, y esto hace una gran diferencia en la capacidad de los sistemas inalámbricos, ya que la transferencia de llamadas entre las celdas genera un trabajo considerable en el sistema.

Para ayudar a la red móvil a funcionar bien en cuanto a la movilidad es necesario definir bien los parámetros de asignación de tonos de supervisión y códigos de color en todas las celdas existentes, con el fin de que el móvil no se pierda en el momento de generar una llamada. Otro factor muy importante es tratar de reducir al máximo las interferencias inherentes por el crecimiento de la red y el obligado reuso del espectro de frecuencias. Además se debe aprovechar las ventajas de cada tecnología (AMPS y TDMA) para que los usuarios obtengan el mejor servicio mientras estén moviéndose por todo el sistema.

3.6.3.1. ASIGNACION DE LOS TONOS DE SUPERVISION Y CODIGOS DE COLOR

Como se lo vio en el punto 2.1.3 del capítulo II, el SAT (tono de audio supervisión) consta de tres frecuencias, las cuales se transmiten en los canales de voz analógicos. La asignación del SAT se lo realiza bajo las premisas indicadas a continuación:

- Para la confirmación de las llamadas en los canales analógicos.
- Para supervisar el circuito de voz.
- Para la verificación de los *handoffs* desde los canales analógicos.

El mismo valor de SAT puede ser asignado a todos los canales de voz en el mismo grupo de canales de voz usados en las celdas, pero las consideraciones más comunes y lógicas en que se debe realizar la designación de los valores de frecuencia del SAT son las siguientes:

- Ninguna celda adyacente debe tener el mismo SAT.
- Las celdas que reusan los canales en los *clusters* adyacentes deben también tener distinto SAT, de manera que los tres valores deberían ser asignados de tal manera que la distancia de repetición entre las celdas que usan las mismas frecuencias de canales de voz y el SAT estén los más separadas posibles.

Esto se logra mediante la aplicación sistemática del plan de optimización propuesto, en el cual si se propaga por todo el sistema la manera en que se debe asignar los SAT's, se garantizará que los canales de las celdas tendrán valores diferentes. Siempre se debe tener presente que un plan de asignación de SAT conlleva a problemas en el procesamiento de las llamadas.

La asignación teórica de los tres valores de SAT's en un patrón de varias celdas con una distancia D de reuso de frecuencias de canales, podría dar una distancia de $\sqrt{3}D$ para el reuso combinado de las frecuencias de los canales de voz y las frecuencias de los SAT's, tal como lo ilustra el diagrama 3.18.

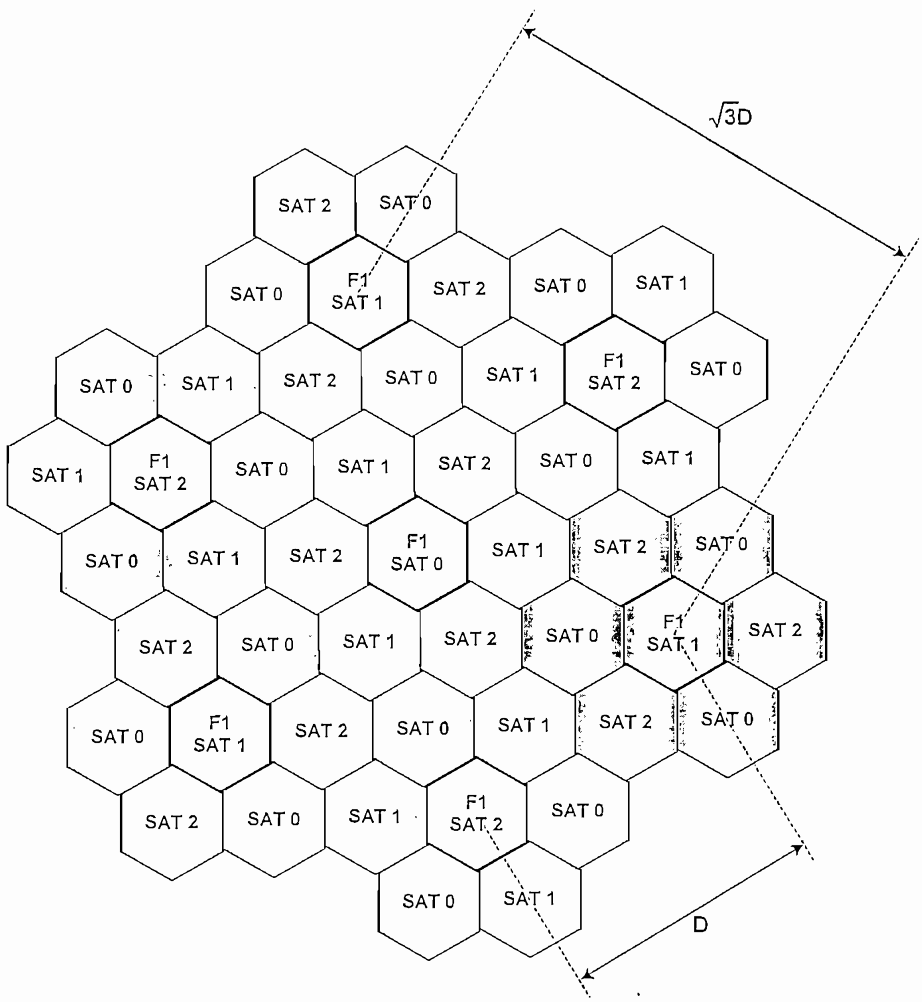


Fig. 3.18: Asignación de SAT's

La asignación del DCC (código de color digital) para los canales de control realiza una función similar a la de los SAT's. El DCC consta de cuatro valores diferentes como se indica en el cuadro 2.1 del capítulo II, y su distribución se lo realiza de la siguiente manera:

- Los canales de control de las celdas reusadas deben tener distintos valores de DCC.

- Los DCC's pueden asignarse a todos los canales de control de un *cluster*, los cuales deben alternarse los valores de DCC.

Los valores del DCC deben estar ubicados correctamente para evitar las condiciones de colisión, que ocurre cuando el móvil responde en un canal y es visto por más de una celda, ocasionando que el sistema se confunda y no distinga a qué celda el móvil está intentando responder o a donde desea enviar el mensaje.

Como se sabe, se dispone de 21 canales de control y de 4 valores para el DCC, por lo que se tiene una combinación de 84 únicos CCH-DCC, los cuales deben ser programados bajo los siguientes criterios:

- Distribuir uniformemente los canales de control. Por ejemplo, no utilizar el CCH F1 tres veces cuando el CCH F2 ha sido utilizado una vez.

- Distribuir uniformemente los DCC's a través de los canales de control. Por ejemplo, no utilizar la combinación CCH-DCC F1-0 tres veces cuando la combinación CCH-DCC F1-1 ha sido utilizada solo una vez.

- Dentro de un sistema, los intentos para aislar la duplicación de las combinaciones CCH-DCC debe ser tanto como sea posible.

- Luego de realizar la distribución de las combinaciones en la red, se debe realizar el análisis de los registros obtenidos por parte de la central celular para identificar los posibles problemas de cocanal, o problemas con la asignación de los DCC's.

El diagrama 3.19 muestra un ejemplo teórico de distribución de los valores del DCC.

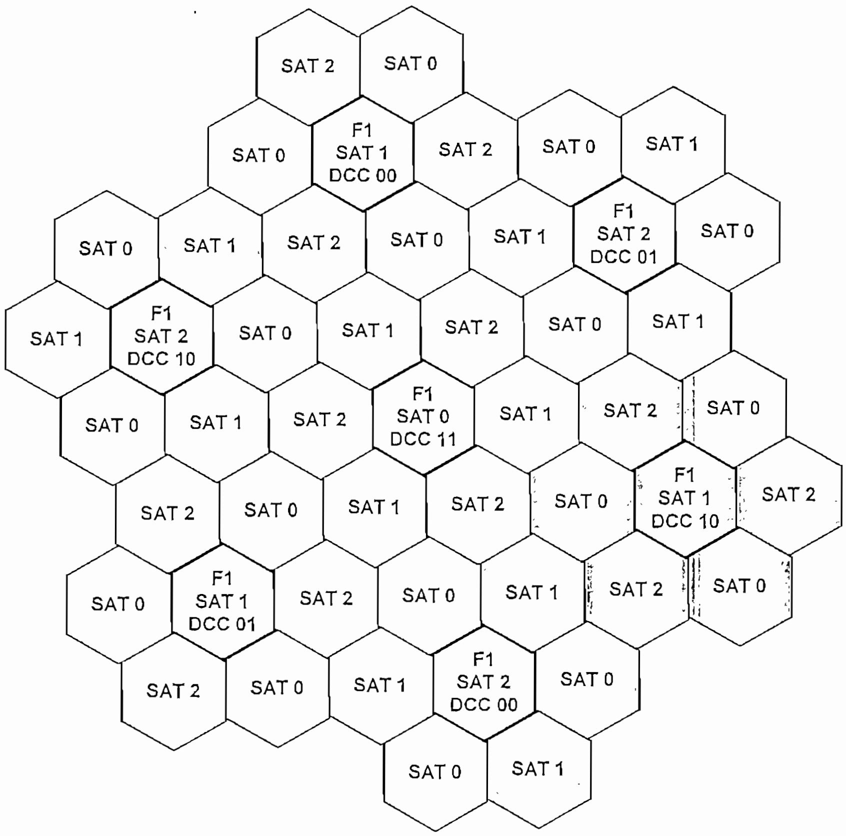


Fig. 3.19: *Distribución de los DCC's*

En los sistemas digitales, al igual que en los analógicos, se tienen códigos de color para supervisar los canales digitales de tráfico y de control. El DVCC (código de color de verificación digital) es el equivalente digital del SAT, el cual debe ser asignado para cada canal de voz, y es utilizado básicamente para lo siguiente:

- Verificación de la llamada sobre un DTCH.
- Supervisión del radio enlace digital.
- Verificación de los *handoffs* desde los DTCH's.

El DVCC es un campo de 8 bits, por lo que se disponen de 256 valores, aunque en realidad se utilizan 255 ya que el 0 no es usado, los cuales deberían ser asignados de manera que la repetición de éstos entre las celdas que usan las misma frecuencias de DTCH's y los mismos DVCC's sea lo más grande posible.

La manera en que se asignan los valores del DVCC es por medio de un parámetro base utilizado en la central para cada un grupo de 32 *clusters* o 224 celdas, este parámetro es conocido como DVCCB. Los 255 valores están divididos en los 32 grupos base (del 0 al 31), lo cual permite una fácil asignación a los 21 grupos de frecuencia en cada *cluster*, partiendo del DVCCB 0 para el grupo de frecuencia A1 hasta el DVCCB 20 para el grupo de frecuencia G3 y así sucesivamente.

Dentro de cada sector de una celda, cada *slot* de tiempo (0, 1 y 2) tendrá su propio y único DVCC, por lo que para saber que valor de DVCC tiene los canales de voz se debe cumplir con la siguiente relación[1]:

$$\text{DVCC} = \text{DVCCB} \bullet 8 + \#\ \textit{Slot}\ \text{de tiempo} \qquad \text{(Ec. 3.9)}$$

El cuadro 3.6 muestra un modelo de asignación de los valores del DVCC a través de los valores base.

Cabe recalcar que los arreglos del DVCC pueden ser variados fácilmente para los planes de frecuencias personalizadas por cada operadora.

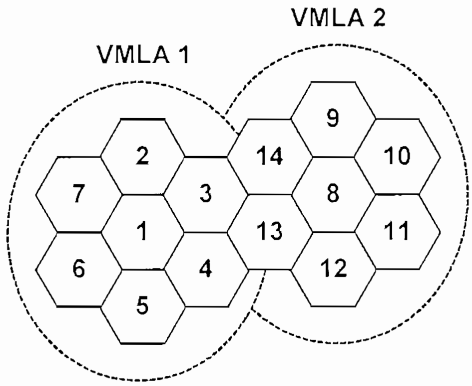
[1] Relación utilizada por Nortel.

Cluster	A1	B1	C1	D1	E1	F1	G1	A2	B2	C2	D2	E2	F2	G2	A3	B3	C3	D3	E3	F3	G3
1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9
3	10	11	21	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
4	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8
6	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
7	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
8	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7
9	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
10	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
11	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6
12	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
13	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
14	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5
15	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
16	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
17	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4
18	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
19	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
20	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2	3
21	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
22	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12	13
23	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1	2
24	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
25	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11	12
26	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0	1
27	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
28	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10	11
29	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	0
30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
31	22	23	24	25	26	27	28	29	30	31	0	1	2	3	4	5	6	7	8	9	10
32	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Cuadro 3.6: *Ejemplo de asignación de los DVCC's*

3.6.3.2. OPTIMIZACION DE LA MOVILIDAD EN EL SISTEMA

Para ofrecer un proceso de movilidad en los sistemas analógicos, se debe realizar en el papel y luego en el campo un diseño impecable en la asignación de DCC's y SAT's para no darle oportunidad al móvil de fallar en sus intento de acceso al servicio celular. Los criterios ya se los revisó en el anterior punto, por lo que realmente no amerita dar más detalles al respecto. Además de que los móviles analógicos en nuestro sistema no se aplican las búsquedas por zonas, por lo que la rebúsqueda de los datos de búsqueda del canal de control analógico es enviado a todas las celdas que está manejando la central celular para permitir frecuencia, traslapamiento de VMLA's, costo en tiempo real y la capacidad de los DCCH's. Las particiones pueden compartir el mismo número de registración con tal que pertenezcan al mismo VMLA. El gráfico 3.20 muestra dos VMLA's muy simples, con diferentes números de registración.

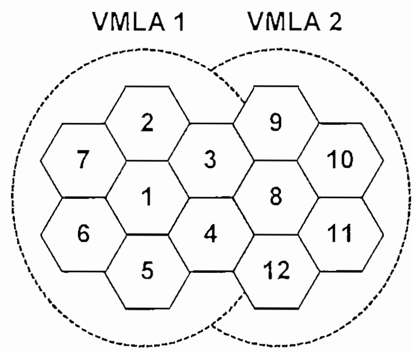


- **Las celdas de la 1 a la 7 tienen asignadas el NREG 1.**
- **Las celdas de la 8 a la 14 tienen asignadas el NREG 2.**

Fig. 3.20: *VMLA's básicos*

Cuando un móvil se registra primero en una partición, se le da una lista de todos los NREG's que pertenecen al VMLA donde se encuentra esa partición, esto incluye el NREG que está siendo emitido por la partición que se está registrando, la cual se la denominaremos NREG actual. Por ejemplo, en la figura 3.20 supongamos que al móvil que se está registrando en la celda 1 le es entregada una lista que contiene el NREG 1 (el NREG actual también es 1), la cual es almacenada en la memoria semipermanente del móvil. Cuando el móvil se mueve de la celda 1 a la 3, lee el NREG actual 1 emitido en la celda 3 y lo compara con el NREG almacenado en la memoria, como se da cuenta que aún sigue en el VMLA 1 la registración no es necesaria. Cuando el móvil se mueve de la celda 3 a la celda 13, lee el NREG actual 2 emitido sobre la celda 13 y lo compara con el NREG almacenado en la memoria, como el NREG no es igual al de su lista significa que el móvil ha cruzado a un nuevo VMLA y debe re-registrarse. Si la registración es satisfactoria, al móvil le es dado la lista de NREG que contiene el NREG 2 del nuevo VMLA para ser almacenado en su memoria.

Un VMLA puede contener una cantidad limitada de números de registración que le darán un número determinado de celdas a ese VMLA, las cuales no tendrán el mismo NREG. Esto da la flexibilidad de introducir un concepto muy utilizado en los VMLA's, que fue explicado en el ítem b del punto 2.3.5.3 del capítulo 2, el cual es el traslapamiento de las áreas virtuales, mostrado en la figura 3.21.



- **Las celdas de la 1 a la 5 tienen asignadas el NREG 1, y las celdas 3 y 4 el NREG 3.**
- **Las celdas de la 8 a la 12 tienen asignadas el NREG 2, y las celdas 3 y 4 el NREG 3.**

Fig. 3.21: *Traslapamiento de VMLA's*

Por ejemplo, un móvil que se esté registrando en la celda 5 será entregado la lista de NREG 1 y 3. En el momento que esté pasando a la celda 4 debe leer el NREG actual 2 emitido por ésta celda y lo compara con la lista en su memoria, lo iguala haciendo innecesario volver a registrarse ya que continúa en el VMLA 1. Cuando viaja a la celda 3 lee el NREG actual 2 emitido por ésta nueva celda y lo compara con su lista, al ver que no es igual se da cuenta que ha pasado a otro VMLA debiendo volver a registrarse. La lista del VMLA incluye los NREG's 2 y 3, por lo que si el móvil se regresara a la celda 4 no necesita re-registrarse ya que la celda 4 pertenece también al VMLA 2.

La cantidad de traslapamiento de VMLA, el cual puede ayudar a prevenir las continuas re-registraciones de los móviles a lo largo de su movimiento a través de las fronteras del VMLA, depende sobre todo de los patrones de movilidad y la planeación de radio frecuencia para el área en discusión. En áreas donde las re-

registraciones ocurren comúnmente, los VMLA's pueden ser configurados para traslaparse. Sin embargo, mientras el traslapamiento resuelve la continua re-registración de los móviles en las fronteras virtuales, esto puede causar otros problemas en el sistema, los cuales son:

- El traslapamiento de VMLA's requiere que algunas particiones pertenezcan a dos o más VMLA's, las cuales deben buscar los móviles a las particiones en el VMLA registrados actualmente, además de ser responsables de más VMLA's y de muchas más particiones. De este modo, el traslapamiento sustancialmente incrementa la carga de búsqueda de aquellas particiones compartidas y puede causar que sus canales de control digitales colapsen.

- El traslapamiento requiere VMLA's para tener más de un número de registración en sus listas, por lo que una partición pertenezca a más VMLA's más números de registración habrán en sus listas. Listas grandes de números de registración implican gran carga en los canales de control digitales debido a los mensajes de aceptación de registración, que contenidos en las listas también serán grandes. Se puede reducir la cantidad de registraciones en el VMLA por medio del traslapamiento, sin embargo, el costo por registración se vuelve alto debido a las listas grandes de números de registraciones, ocasionando en muchos casos que la situación de los canales de control pueda volverse peor si no se realiza un buen diseño. La mejor manera de prevenir las continuas re-registraciones es evitar poner las fronteras de los VMLA's en áreas de alta movilidad.

Con esta breve descripción de cómo se comportan los móviles en los VMLA's, se puede pasar a la tarea de la configuración de los mismos. La configuración varía de sistema a sistema, y requiere un conocimiento sobre la optimización de la red en general, ya que además envuelve una gran cantidad de datos a analizarse. El número de VMLA's, el tamaño, la forma y cuando un VMLA nuevo será añadido o cómo serán optimizados, son los puntos principales que deben ser considerados a la hora de proponer una configuración determinada.

Para empezar el proceso de configuración se debe contar con el plan de radio frecuencia y el trazado del área de servicio, datos proveídos por los ingenieros de Planificación. Luego se debe mirar las áreas dónde el tráfico es pesado y la movilidad es concentrada, agrupando esas áreas representativas en distintos conjuntos. Esto será la base de los futuros VMLA's.

Es fundamental el uso de las características del *handoff* de las celdas adyacentes para ayudarnos a refinar en el futuro la forma de estos VMLA´s preliminares. De manera general, para particiones con alta actividad de *handoff* deberían ser el corazón del VMLA y las adyacencias con baja actividad de *handoff* deberían ser utilizados para formar las fronteras del VMLA.

El tamaño del VMLA debería ser considerado por el tráfico de la búsqueda y registración, ya que son directamente proporcionales al número de miembros del VMLA. El tamaño del VMLA toma en cuenta los siguientes factores:

- Un sistema que tiene un alto porcentaje de terminaciones de llamadas móviles requiere un VMLA de tamaño pequeño.

- Un sistema que tiene una alta carga en movilidad requiere un VMLA de gran tamaño.

- La cantidad de *handoffs* disponibles en el sistema pueden ser usados para la configuración inicial del VMLA, relacionando el número de celdas por VMLA respecto a los *handoffs* por celda.

- La lista de celdas óptimas en una zona pueden ser usadas para los diseños iniciales.

- El balance del tráfico de búsqueda en el canal de control hacia delante y el tráfico de registración en el canal de reversa es necesario, ya que el tráfico en esas direcciones no debe exceder la capacidad del DCCH.

- El costo en tiempo real de la búsqueda y registración es una clave para determinar el punto óptimo del tráfico de estos dos factores.

Las razones principales por las cuales se debe guardar un balance entre el tráfico de la búsqueda y registración en el proceso de selección del tamaño y forma del VMLA son:

- Primero, la tasa de búsqueda es mayor y la frecuencia de registración es pequeña cuando un gran VMLA es usado en el sistema. La tasa de búsqueda es pequeña y la frecuencia de registración es grande cuando un VMLA pequeño es usado en el sistema.

- Segundo, la tasa de búsqueda es determinada por el porcentaje de terminaciones de llamada de un móvil para un VMLA en particular. La tasa de búsqueda es linealmente proporcional al porcentaje de terminaciones de llamadas móviles.

Para terminar de dar forma a la configuración de los VMLA's se debe tomar en consideración la reselección de parámetros necesarios para la verificación y la sintonización de las áreas virtuales. Cuando múltiples VMLA's son creados, el viaje de un móvil de un VMLA a otro será realizado en una registración basada en su ubicación, las cuales serán enganchadas en el nuevo VMLA por medio de los registros arrojados en la central celular. Debido a que estas registraciones crean tráfico en el R-DCCH, los datos programados en la central para las fronteras de las particiones entre los VMLA's deben ser llenadas tal que el móvil haga una transición limpia de un VMLA al próximo. Para asegurarse que efectivamente esté pasando lo que teóricamente se predijo, un recorrido de prueba es necesario para verificar los resultados obtenidos.

Una vez que los VMLA's han sido configurados y programados en la Central Celular, como después de todo proceso de optimización, se deben obtener los resultados de la implementación para saber si lo que se hizo no está causando efectos contraproducentes en el funcionamiento normal del sistema.

3.6.4. OPTIMIZACION DE LOS PROCESOS DE RADIO FRECUENCIA

El objetivo de describir los procesos de radio frecuencia es porque los demás procesos de optimización anteriormente explicados están totalmente ligados a la aplicación en el campo de las decisiones tomadas por los Ingenieros de RF. Como se puede ver, prácticamente este último punto tiene poco o nada que ver con las actividades que corresponden a los Ingenieros de Conmutación, pero no por eso es menos necesario que se tengan las ideas fundamentales para el momento en que se presenten alarmas en la Central Celular que tengan que ver con RF, se pueda entender lo que realmente significan y poder interpretarlas para comunicarlas al personal correspondiente.

La Ingeniería de RF incluye la discusión del plan de frecuencia, la configuración de las celdas, la selección del sitio, el área de cobertura, interferencia, sistema de antenas, balance de caminos, recorridos de prueba y estudios de propagación con su respectivo análisis. Cabe anotar que las pruebas de campo deberían ser realizadas en lo posible antes de finalizar la selección del sitio para determinar si ese sitio escogido será el más óptimo, además, una predicción de la cobertura de la celda también puede ser determinado con anterioridad.

3.6.4.1. AMBIENTE DE RF EN LOS SISTEMAS CELULARES

El ambiente de RF en los sistemas celulares empieza con la planeación de las frecuencias, cuyo propósito es prevenir las interferencias e incrementar la capacidad del sistema. En un plan de frecuencias se asigna canales específicos a celdas específicas, siguiendo un patrón de reuso el cual se reinicia con cada N grupo de celdas que conforman un *cluster*. N es el número de celdas en el patrón de reuso de frecuencias, y puede ir desde 1 hasta 12, además, N es críticamente importante ya que determina la capacidad del sistema y la interferencia.

Como se ha visto a lo largo de este capítulo, existen dos problemas en el diseño de los planes de reuso de frecuencias: se necesita conservar una proporción C/I de 17 dB para evitar interferencias de canales asociados o cocanales, y es deseable dividir los conjuntos de canales en el menor número de grupos de N posible para maximizar el número de canales por celda. Para tratar de asegurar de manera teórica que estos dos problemas sean superados se utiliza la relación indicada en la ecuación 3.2, donde se presenta la relación de N con respecto a D/R. La distancia D está entre las celdas con canales cocanales, es decir, indica que para una configuración celular que se repite, la celda central con señal C está rodeada por seis celdas interferentes (N = 7) distribuidas en forma similar con interferencia I.

En el modelo de N = 7 teóricamente se espera que las celdas interferentes estén alejadas a la misma distancia D de la celda central, que tengan el mismo radio R de cobertura y que transmitan a igual potencia. Aunque esto en realidad nunca se cumple, se va a asumir esas condiciones para sacar el valor más exacto de C/I que se debe cumplir para evitar las interferencias, por lo que se debe relacionar D/R con C/I. Para esto se debe tener en cuenta que en los ambientes de radio móvil las pérdidas en el camino de propagación son de 40 dB/dec (10), es decir, C cae a 40 dB/dec con respecto a R, e I de igual manera con respecto a D. Cumpliéndose que en un ambiente real de radio móvil se tenga las siguientes relaciones de pérdida de propagación (10):

$$C \, \alpha \, \mathrm{R}^{-\gamma} \text{ y } \mathrm{I} \, \alpha \, \mathrm{D}^{-\gamma} \qquad \text{(Ec. 3.10)}$$

Donde γ es el factor de pérdida en el camino de propagación de la señal.

Teniéndo en cuenta esto, se debe recordar que en la relación C/I al móvil realmente se va a tener involucradas a las interferencias de las celdas asociadas, por lo que se puede expresar esta relación como se indica en la ecuación 3.11.

$$\frac{C}{I} = \frac{C}{\sum_{i=1}^{K_I} I_i} \qquad \text{(Ec. 3.11)}$$

Relacionando la ecuación 3.10 en la 3.11, entonces la relación C/I al móvil en función de D/R puede ser expresada de la siguiente manera:

$$\frac{C}{I}=\frac{R^{-\gamma}}{\sum_{i=1}^{K_i} D_i^{-\gamma}}=\frac{1}{\sum_{i=1}^{K_i} (\frac{D_i}{R})^{-\gamma}} \qquad \text{(Ec. 3.12)}$$

Como se está analizando para el caso de N = 7, entonces K_i tendrá máximo un valor de 6 ya que es el número de celdas interferentes cocanales con este arreglo, por lo que la ecuación anterior quedaría como sigue:

$$\frac{C}{I}=\frac{1}{6(\frac{D}{R})^{-\gamma}}=\frac{1}{6}(\frac{D}{R})^{\gamma} \Rightarrow \frac{\mathrm{D}}{\mathrm{R}}=\left[6\left(\frac{C}{I}\right)\right]^{\frac{1}{\gamma}} \qquad \text{(Ec. 3.13)}$$

De esta ecuación se conoce que D/R es igual a 4.58 y que γ es igual a 4 (40 dB/dec), por lo que despejando C/I se tiene que da un valor de 18.66 dB que se debe cuidar, aunque en la práctica se debe tratar de asegurar un valor de 17 dB.

Con este análisis se puede entender de mejor manera el porqué se deben realizar los planes de frecuencia para tratar de cubrir las necesidades de tráfico evitando a toda costa la interferencia, por lo que algunos pasos que se debe tener en cuenta al momento de crear un plan son los siguientes:

- Analizar las predicciones de propagación o las medidas obtenidas para determinar una relación D/R apropiada para cada ambiente en el sistema celular.

- Usar la relación D/R para seleccionar el total reuso de frecuencias para N.

- Con el N seleccionado se debe asignar los canales específicos para cada celda, y luego los tonos de supervisión y colores de código.

- Evaluar los resultados y anticiparnos a posibles problemas.

- Revisar el plan de frecuencias para optimizar la relación C/I donde no fuera aceptable.

Aún con todas las recomendaciones dadas hasta el momento, las interacciones que intervienen en RF son bastante complejas y muy difíciles de calcular a medida que el reuso de portadoras se incrementan en el sistema. Debido a esto es muy importante el análisis de las interferencias, las cuales se debe tratar de evitar a toda costa en y durante la implementación del sistema celular. Básicamente se tiene dos tipos de interferencias que son el dolor de cabeza de todo ingeniero celular: la interferencia cocanal y la interferencia por canal adyacente, por lo que a continuación se va a realizar un breve análisis de cada una de ellas.

- ***Interferencia cocanal***

La interferencia cocanal, como se lo dijo anteriormente, ocurre cuando los canales de voz de una celda sirviente y/o el canal de control son usados también por otra celda en el sistema. El método del reuso de frecuencia es muy útil para incrementar la eficiencia del espectro de frecuencias, pero hay que poner mucho cuidado para evitar las interferencias. La determinación de las pérdidas en el sistema requiere identificar las zonas donde están ubicadas las celdas, ya que cada área está asociada a una pérdida en particular identificadas por los recorridos de prueba o por una mapa de estudio y reconocimiento físico.

En general, los factores del terreno afectan las pérdidas asociadas con la propagación y pueden provocar la presencia de señales indeseadas en forma de islas de cobertura. La forma del terreno juega un papel fundamental a la hora de dar el servicio, ya que mientras más irregular sea habrá más pérdidas, especialmente los terrenos que involucran laderas o montañas como es el caso de Quito; donde realizar los estudios de RF resulta una tarea muy agotadora por la geografía de la ciudad, sin contar con la diversidad de edificios existentes. Dependiendo de la calidad de los estudios previamente realizados, la implementación práctica de los mismos, previendo la altura adecuada de las celdas, poniendo mucha atención a los obstáculos que causan deformaciones en la propagación de la señal, los análisis futuros podrían ser menos pesados.

Debido a esto es importante conocer los modos básicos de propagación de un móvil. La primera es por espacio libre, donde no hay obstrucciones ni obstáculos y la señal disminuye en un valor de alrededor de 20 dB/dec. La propagación por reflexión puede incidir de manera constructiva o destructiva, ya que dependiendo del tipo de superficie la reflexión puede ser fina o difusa, y se presenta cuando existe una onda principal y una reflejada que está casi 180° fuera de fase (cuando la reflexión tiene un ángulo muy pequeño). Esta situación hay que tener en cuenta ya que la onda reflejada tiende a cancelar a la onda directa, reduciendo de manera considerable el nivel de señal recibida. La propagación por difracción en bordes, es otro modo básico de propagación, en la cual la señalización directa es bloqueada por obstrucciones.

Ahora, se debe aclarar que las señalizaciones de propagación reales nunca son tan simples como presenta la teoría, ya que incluye combinación de modos y cada señalización tiene su propia geometría que involucra más objetos de reflexión y absorción de los que puedan ser tratados matemáticamente. Entre las complicaciones reales se tiene las obstrucciones por ambientes con perturbaciones, el cual es el modo más común en las ciudades, ya que existe absorción y reflexión aleatorias ocasionando pérdidas adicionales y expansión de retardos de la señal. Otra complicación es la propagación de señalización múltiple, muy común en el ambiente celular y cuyas componentes de las señales llegan a amplitudes y fases aleatorias, por lo que los niveles de señal varían conforme se mueve el usuario provocando variaciones lentas que son causadas por el bloqueo y la proyección de sombras de objetos grandes como colinas o edificios, y desvanecimientos rápidos (desvanecimiento Rayleigh) causados cuando las señales recibidas desde muchas señalizaciones entran y salen de fase. Una complicación real muy difícil de tratar es la cobertura en edificios, ya que la atenuación de la señal dentro de éstos comparada con la señal de la *calle* puede ser más alta que 12dB. Esta atenuación se incrementará a lo largo de su interior debido a que los materiales, la geometría, el contenido y los múltiples ángulos son muy variables.

Con todo esto queda claro lo difícil que es mantener una buena relación C/I, además cabe mencionar que el grado en el cual el rendimiento del sistema es degradado es diferente entre los sistemas TDMA y AMPS. Por ejemplo, con un C/I de 17 dB, el canal analógico experimentará algún ruido detectable mientras que en un canal TDMA puede empezar a exhibirse una leve característica artificial asociada con la conversación.

Cuando el C/I se degrada a 14 dB, la calidad de voz de ambas llamadas analógica y digital se vuelve relativamente peor. En una llamada digital, la voz empieza a sonar mucho más artificial, con rompimientos en la conversación, lo cual es resultado de los excesivos silencios. En una llamada analógica se exhibirá una cantidad obvia de ruido de fondo. Aunque la voz es todavía comprensible, la calidad de la llamada cada vez es peor, pero conforme el C/I decrece la calidad de voz de una llamada digital se degrada más rápidamente que en una llamada analógica. La interferencia cocanal en un sistema TDMA se manifestará por sí mismo como un incremento en el BER además de otras interferencias en el sistema, de hecho, la degradación de las llamadas en un sistema TDMA es siempre asociada con un BER indeseable.

- ***Interferencia por canal adyacente***

Una señal celular no es totalmente independiente de las demás señales celulares en los canales inmediatamente arriba y abajo en frecuencia, por lo que la interferencia por canal adyacente ocurre cuando los canales de voz que están operando en una celda sirviente y/o los canales de control experimentan interferencia desde los canales próximos a ellos, los cuales están siendo usados por otra celda en el sistema, y al igual que en la interferencia cocanal no siempre es posible evitar que esto ocurra.

Todo estará bien mientras las señales en los canales adyacentes no sean más potentes que las señales que se intenta escuchar, y si se pone a analizar, siempre se va a tener canales adyacentes en todo el sistema por la asignación de canales en los *clusters* y cuando se está reusando los mismos; es más, en un mismo *cluster* es inevitable tener celdas con frecuencias adyacentes. En el caso que la señal adyacente sea más potente, esto puede causar ráfagas de estática cuando el desvanecimiento de Rayleigh debilite momentáneamente la señal verdadera, provocando que la llamada se termine sin ninguna razón aparente.

Debido a esto, la mejor manera de evitar la interferencia por canal adyacente es manteniendo la separación de 21 frecuencias o 630 KHz entre cada uno de los canales de la banda de frecuencias para los sistemas AMPS/TDMA (tal como lo dicta la FCC), lo cual se puede observar en los cuadros 3.4 y 3.5 donde se indican los planes de frecuencias para las bandas A y B. Si no se conserva la separación de 21 frecuencias se presentan pérdidas de inserción, haciendo que el canal interferido tenga menos potencia provocando que la llamada se caiga, sin que tenga nada que ver con las características del radio de la celda. Cuando se trata de problemas en los radios, es que generalmente no están bien sintonizados, produciendo que las ondas armónicas se vuelvan considerables comparadas con la onda principal, ocasionando que las armónicas interfieran a las frecuencias adyacentes de otros canales.

Cabe mencionar que en ningún caso se debe asignar canales adyacentes en la misma celda o sector. No se debe olvidar que las frecuencias se asignan de la siguiente manera: N, N + 7 y N +14.

El siguiente punto dentro del ambiente de RF es la cobertura de las celdas, donde un sistema celular debe ser diseñado para proveer un rendimiento adecuado en los canales directos y de reversa. La distancia sobre la cual la calidad de la señal puede ser soportada debería ser igual para los canales en ambos sentidos. La potencia del canal directo está determinada por los requerimientos de la cobertura de la celda, en cambio el canal de reverso debería tener un rango de pérdidas de camino igual o mejor para todos los usuarios. Esto hace que una parte importante de la Ingeniería de RF sea establecer una adecuada intensidad en la señal recibida al móvil y a la celda. Un punto teórico de inicio es tratar de asegurar que el contorno de cualquier celda en el sistema esté seteado entre 35 dBµV/m y 32 dBµV/m (46) dependiendo de las condiciones del área de servicio, pero en la realidad se obtienen valores de intensidad de campo más bajos y variables como por ejemplo 23 dBµV/m, los cuales para saber a qué valores en dBm corresponden se utiliza la siguiente relación:

$$P_r(dBm) = E(dB\mu / V) - 113dBm + 10\log(\frac{\lambda}{\pi})^2 \quad \text{(Ec. 3.14)}$$

Donde:

- P_r (dBm) = Potencia recibida
- E (dBµV/m) = Intensidad de campo
- λ = Longitud de onda

El corazón de la implementación de las nuevas celdas es la descripción del área de servicio, por lo que el área de cobertura debe estar especificada bajo los siguientes parámetros:

- El tamaño y la forma geográfica.

- Las características topográficas las cuales dan los mapas de RF requeridos.

- Las zonas donde los contornos de la señal especificada deben ser proveídas.

- Los sitios potenciales dónde estará la celda para proveer la cobertura requerida que soportará la red celular.

3.6.4.2. OPTIMIZACION DE RF

A pesar de que muchas de las actividades de RF vistas hasta el momento no son trabajo directo de los Ingenieros de Conmutación, los conceptos son de mucha utilidad para saber los datos, que son los que se deben programar en la central celular para aportar al correcto funcionamiento de los procesos de RF.

La versión de software de las centrales de conmutación contiene parámetros relacionados a RF. Si esos parámetros no son mantenidos apropiadamente o totalmente utilizados, ellos pueden perjudicar al rendimiento del sistema. Debido a esto, al igual que en todos los procesos que soporta la red, es necesario realizar auditorías permanentes del llenado de los parámetros en los campos correspondientes.

En el presente punto se va dar una descripción general de los parámetros utilizados en las centrales celulares para optimizar los procesos de RF. Las apreciaciones aquí realizadas sólo son recomendaciones básicas, ya que cada fabricante tiene su propio lenguaje para el ingreso o modificación de datos en sus centrales. Sin embargo antes de realizar cualquier cambio en los parámetros es de vital importancia obtener una foto del sistema para saber el estado del mismo, y un conjunto de registros y contadores que darán los datos sobre el rendimiento de la red celular. Esto proveerá una base inicial de lo enfrentado, además, después de que se haya aplicado algún cambio un recorrido de prueba a través de las áreas afectadas es necesario.

En RF primero se debe partir del hecho del tiempo mínimo que un móvil debe esperar entre los intentos de registración, el cual es importante que esté correctamente programado, ya que la central abre una ventana para mirar a los usuarios y evita que el sistema no mire a los abonados como perdidos. Si se pone tiempos muy largos podría ser que un abonado que perdiera la registración no se vuelva a activar, que se da generalmente porque está en un área de mala cobertura y la causa menos común, que sea problema del equipo en sí. Como todo extremo es malo, tampoco se deben asignar tiempos muy cortos, ya que abriría ventanas tan seguido que sobrecargaría al procesador principal con mensajes de registración innecesarios. Se debe tener claro que la registración es el paso que se toma para informar a la central de la identificación y ubicación de todos los móviles actualmente activos en las diferentes áreas de servicio móvil.

Ahora, para que el móvil responda a la registración, debe tener alguien que le pregunte. La encargada de realizar esta función es el campo denominado frecuencia con la que se envía los mensajes de orden de registración global o, lo que es lo mismo, la tasa de ocurrencia a la cual los mensajes de identificación son transmitidos a los móviles. En este campo se deben programar tiempos obviamente más cortos (un valor adecuado podría ser cada 10 segundos) para que la central se asegure que en el momento que abra la ventana de registración los móviles ya hayan recibido varias interrogaciones de reconocimiento por minuto.

Otros campos importantes son los que incluyen la información específica del control dinámico de potencia, los códigos de atenuación de potencia y los umbrales de *handoff*. Estos campos generalmente son umbrales, los cuales imponen techos o límites para que ciertos eventos ocurran con cierta frecuencia, o simplemente nunca ocurra para sobreguardar la calidad en el servicio celular.

Con respecto al *handoff*, se tiene un parámetro umbral conocido como *handoff* dirigido que especifica un límite a una celda seteando un porcentaje de ocupación de canales de voz, entonces, cuando el tráfico exceda ese límite la central intenta descargar la celda pasando las llamadas más alejadas hacia las celdas adyacentes. Si se trabaja con el *handoff* dirigido, entonces se debe setear un techo de señal con un valor razonable para reducir las interferencias de RF, para que la central tenga un control de los móviles que deben saltar de celda. Aunque en teoría suena agradable utilizar el *handoff* dirigido, en la práctica es muy complicado hacerlo, ya que los sistemas manejan un tráfico muy variable y las coberturas de las celdas son muy irregulares, ocasionando que se carguen innecesariamente a las celdas adyacentes.

Cuando se habla del control dinámico de potencia, se refiere a setear valores que deberían ser utilizados especialmente en ambientes donde el reuso de frecuencias es común, y donde los móviles operan muy cerca de las celdas de cobertura. Con el control dinámico de potencia el transceiver envía un mensaje de control de potencia al móvil proveyéndole la capacidad de controlarla autónomamente, esto basado en una ventana de operación de potencia con umbrales bajos y altos de nivel de señal. Esto permitirá al móvil transmitir a un nivel de potencia más bajo si físicamente se mueve hacia la celda, y a su vez también reducirá la oportunidad de que se produzca las interferencias cocanales y de canales adyacentes. Típicamente el seteo del control dinámico debería ser relativo al umbral bajo de *handoff* (HTL), por lo que se debe tener cuidado en la forma que se configuran los valores de la ventana de potencia, ya que si la ventana es muy alta puede crear interferencias y excesivos problemas de silencios cuando se esté operando cerca de la celda, y si la ventana es muy baja puede forzar al móvil a operar demasiado cerca al piso de ruido.

Los códigos de atenuación VMAC y CMAC son muy útiles especialmente para conservar la vida útil de los equipos móviles, ya que como todo equipo de transmisión, mientras más potencia transmita más desgaste tiene y su vida útil decrementa. Al setear estos campos se le obliga al canal de voz o al de control transmitir a una potencia determinada. Los valores de los pasos de potencia para los diferentes tipos de teléfonos se los puede revisar en el cuadro 2.3 del capítulo 2. En las celdas urbanas lo común es poner un valor de 2 para VMAC y CMAC (ayuda a proteger de la relación C/I), y en las celdas rurales el CMAC y el VMAC se programa con valores de 0 (ayuda a mejorar la cobertura del móvil). Algo que se debe tener en cuenta es que el VMAC no se lo debe programar con valores mayores al CMAC en una misma celda o sector, ya que esto provocaría excesivas llamadas con falla en el seteo.

Otro campo que se debe optimizar con respecto a los procesos de RF es el umbral de ruido, el cual permite administrar canales ruidosos libres y determinar su disponibilidad de uso. Este parámetro setea el nivel de señal en el cual un canal de voz libre está experimentando interferencia cocanal, si las medidas del canal libre están por encima del umbral de ruido, son puestos a la "cola" para su uso; y si están por debajo de este umbral remueve los canales de voz de la cola de ruido y los ubica en la cola de uso. En el momento que un canal de voz es detectado con interferencia cocanal, debe pasar un tiempo en que la central espera para saber si la interferencia es o no constante, caso contrario lo liberará, ese tiempo es otro campo que deber ser optimizado para no provocar casos extremos como congestión en la celda por no liberar a tiempo los canales con posibles problemas. Por experiencia práctica, los valores programados para el umbral de ruido pueden estar entre –102 dBm y –110 dBm, y el tiempo de guarda puede ser de 1 segundo.

Un parámetro muy importante en RF es el umbral de señal en el canal de control de la celda en el cual se setea la posibilidad que un móvil pueda originar o no la llamada. Hay que tener presente que un mal seteo de este valor puede causar que las llamadas sean rechazadas. Para buscar un valor adecuado se tiene que tomar muy en cuenta la geografía de la ciudad, por ejemplo, para que los abonados se puedan comunicar en Quito que es una ciudad sumamente difícil en cuanto a la cantidad de obstáculos que presenta; es necesario programar un nivel "malo" de señal para las estadísticas, pero bueno para los usuarios ya que se les permite acceder al sistema a pesar de que registren niveles bajos de señal, permitiéndoles realizar llamadas especialmente en edificios y lugares cerrados donde la señal llega muy atenuada. Debido a este análisis en las celdas urbanas muchas veces se programa para que los usuarios puedan originar llamadas con niveles de –110 dBm, y en las celdas rurales no se les impone ninguna clase de restricción, ya que en esas zonas de cobertura muchas veces no les interesa la calidad de la llamada sino simplemente el poder comunicarse.

Otro aspecto importante con el que se debe trabajar en RF es la asignación de canales digitales en las celdas. En este punto la central celular contiene un campo en el cual se define el nivel mínimo de señal aceptable requerido para que una llamada sea asignada a un canal de voz digital, determinando si un móvil digital es asignado a un canal de voz analógico o digital. De igual modo, las condiciones de RF van a incidir en la decisión, pero la consideración que se hace es que en las celdas urbanas no se tiene definido un valor para que el teléfono móvil digital del usuario pueda acceder a los servicios digitales mientras pueda hacerlo, pero en las celdas semi-rurales y rurales la situación es diferente, ya que es preferible que los abonados se enganchen a un canal analógico que a un digital debido a que lo analógico es más resistente en lugares de mala señal. Debido a esto en las celdas rurales se programan con un valor mínimo de señal de alrededor de –102 dBm para preservar lo más que se pueda la calidad del servicio celular. Un criterio que se debe tener en cuenta es que el valor mínimo de señal de asignación de canal siempre debe ser mayor al umbral de señal en el canal de control de la celda.

De manera general, las recomendaciones realizadas en este punto, al ser implementadas y analizadas según los requerimientos de cada fabricante, serán de gran ayuda para brindar un servicio telefónico celular eficiente. Aunque, no está por demás mencionar la importancia de la adecuada optimización en los procesos de *handoff*, tráfico y movilidad; para que los procesos de RF aporten positivamente al rendimiento de la red y viceversa.

3.6.5. RESULTADOS DE LA OPTIMIZACION

Una vez que se han realizado los procesos de optimización, es una obligación analizar cada uno de los campos y parámetros que se han variado en la central celular con el fin de saber cual ha sido el impacto causado en el servicio, y en el caso de que fue afectado negativamente, inmediatamente volver a como se tenía programado antes de ejecutar los cambios.

El nivel proporcionado a los usuarios depende del grado de desarrollo de la red, para lo cual la red debe funcionar bajo parámetros o indicadores de calidad expresados en porcentajes, que dirán si se está o no cumpliendo con las regulaciones del servicio celular para el efecto.

Se debe tener presente que la calidad de servicio de cualquier sistema, realmente se mide por el grado de satisfacción de los usuarios que lo utilizan.

3.6.5.1. REGULACION DEL SERVICIO CELULAR

La regulación del servicio que brindan las operadoras celulares en el Ecuador está dictada por la Superintendencia de Telecomunicaciones en la norma técnica DDS/SDN/F.C-001/00 que estipula la calidad de servicio de telefonía móvil celular, de la cual se va a revisar las normas y parámetros de la calidad de servicio y la eficacia de la red.

a) Normas y Parámetros de la Calidad de Servicio

La evaluación de servicio se lo realiza a través de:

- La calidad de la prestación del servicio dada a sus abonados.

- La eficacia con la que satisface las necesidades y expectativas de los abonados.

Por tanto, es preciso medir los parámetros de calidad de servicio desde el punto de vista del abonado y establecer normas de funcionamiento en equilibrio con la capacidad tecnológica en los costos.

- ***Mediciones de la calidad de servicio***

El nivel de calidad de servicio proporcionado al abonado depende de:

- El grado de desarrollo de la red. En la presente norma se establecen los indicadores que permiten una supervisión de la calidad del servicio y que garantizan el cumplimiento de las diferentes normas de funcionamiento.

- La eficacia con que el personal de la operadora interviene para determinar las causas de cualquier degradación de la red y el tiempo de demora en restablecer la calidad de servicio a niveles admisibles.

Se hace necesario establecer los indicadores relacionados con estos dos aspectos.

- ***Indicadores para el desarrollo general de la red***

Los indicadores para aceptar una expansión aceptable de la red de telefonía móvil celular del país y la introducción de servicios y equipos nuevos son:

- Porcentajes de líneas disponibles en las centrales de telefonía móvil celular.

- Porcentaje de celdas que disponen de nuevos métodos de transmisión (grado de penetración de nuevas tecnologías).

- Porcentaje de solicitudes del servicio que no han podido ser atendidas.

- Números de teléfonos públicos por cada 1000 abonados.

- ***Indicadores de supervisión de la calidad de servicio***

Dentro de los indicadores de supervisión se tienen indicadores generales, relaciones del abonado con la empresa y relaciones del abonado con el servicio ofrecido.

Los indicadores generales son los señalados por los abonados y por los informes sobre alteraciones dados por las operadoras. Son indicadores de la satisfacción de los abonados respecto al servicio ofrecido. Estos son:

- Número de quejas de abonados por 100 abonados por mes.

- Porcentaje de abonados entrevistados que consideran satisfactorio el servicio ofrecido.

Las relaciones del abonado con la empresa son:

- Tiempo medio de espera de los abonados, para la instalación de un servicio.

- Porcentaje de tiempo de espera de los abonados, para la instalación que superan un tiempo t.

- Tiempo medio de espera de los abonados, para la reparación del servicio.

- Porcentaje de tiempo de espera de los abonados para la reparación que supera un tiempo t.

Las relaciones del abonado con el servicio ofrecido son:

- Establecimiento de la conexión que viene dado por la tasa de eficiencia (porcentaje de llamadas que reciben respuesta), y tiempo de espera para el establecimiento de una llamada.

- Retención de la conexión, concediéndose importancia particular a las llamadas de terminación prematura. Se pueden medir por informes de alteraciones señaladas por el abonado, e informes de alteraciones señaladas por el área de mantenimiento o de atención al público.

- Calidad de la conexión concediéndose importancia particular a la dificultad para hablar u oír durante la comunicación. Se puede medir por informes de alteraciones señaladas por el abonado, e informes de alteraciones señaladas por el área de mantenimiento o de atención al público.

- Integridad de la facturación, donde los indicadores por reclamos de los abonados son el porcentaje de los abonados que señalan errores de facturación y el porcentaje de quejas justificadas sobre la facturación.

b) Eficacia de la Red

Como se mencionó anteriormente, la calidad del sistema se refiere a la eficacia de la red, por lo que a continuación se va a explicar los parámetros mínimos de calidad que se deben cumplir y que expone la norma técnica DDS/SDN/F.C-001/00. Pero es importante anotar que cada operadora maneja parámetros propios de calidad adicionales que les permitirá saber que está pasando exactamente en cada etapa de su sistema.

- ***Intensidad de campo dentro del área de cobertura de la celda***

  El nivel de intensidad de campo mínimo en los límites de la celda será de 23 dBμV/m o –90 dBm para teléfonos portátiles de 0.6 W, y de 16 dBμV/m o –97 dBm para teléfonos móviles transportables de 3 W.

- ***Reutilización de frecuencias***

  La relación de portadora a interferencia C/I será:

  $\geq$ 24 dB para celdas analógicas.

  $\geq$ 17 dB para celdas digitales o combinadas (analógicas/digitales)

La medición se realizará en el área de cobertura en el límite de –90 dBm de una determinada celda; se medirá su propia señal y la señal proveniente de una celda no contigua que reutiliza la frecuencia.

- ***Grado de servicio y tiempo de ocupación del canal de control***

El porcentaje del tiempo de ocupación del canal de control no deberá exceder al 70% en la hora pico (promedio de horas pico de los días laborables de una semana).

- ***Grado de servicio del canal de voz***

Se calcula en las horas pico de los días laborables de una semana. El promedio del grado de servicio de la semana deberá ser menor o igual que el 2%, y esta medida se tendrá que realizar en cada celda.

- ***Grado de servicio de las troncales de la red telefónica pública***

El grado de servicio de las troncales hacia y desde la red telefónica pública se calcula siguiendo el mismo criterio del punto anterior. La probabilidad de pérdida será menor o igual que el 1%.

- ***Grado de servicio en las troncales del sistema celular***

Al igual que en el caso anterior, el grado de servicio de las llamadas no atendidas por bloqueo u ocupación en las troncales del sistema celular no deberá exceder el 1%.

- ***Bloqueo de llamadas transferidas por procesos de handoff***

El porcentaje promedio de llamadas no completadas por transferencias (*handoff*) fallidas no deberá exceder el 2%.

$$BLLT = \frac{Llamadas\_no\_completadas\_por\_handoff\_fallidos}{Total\_de\_intentos\_de\_handoff} * 100 \quad \text{(Ec. 3.15)}$$

Esta medida se tendrá que realizar a cada celda y en las horas pico de los días laborables de una semana.

- ***Grado de servicio del sistema***

En este grado de servicio se incluyen, el grado de servicio del canal de voz, el grado de servicio de los circuitos troncales, el bloqueo para *handoff*, el grado de servicio del canal de control, etc., por lo que el valor obtenido para este grado de servicio deberá ser menor o igual que el 5 %.

El grado de servicio del sistema se calcula aplicando la siguiente fórmula:

$$GOS = \frac{Número\_de\_llamadas\_no\_efectivas}{Número\_total\_de\_llamadas} * 100 \quad \text{(Ec. 3.16)}$$

Estas medidas deberán realizarse durante la hora más cargada (horas pico) de los días laborables de una semana, de la cual se debe obtener el promedio.

CAPITULO 4: CONCLUSIONES Y RECOMENDACIONES

1. Lo realizado en la presente tesis de grado, es una base teórica que servirá de consulta para futuros proyectos relacionados con telefonía celular, cuyo campo de estudio es muy extenso debido a que es un servicio relativamente nuevo, que en Ecuador se empezó a brindar aproximadamente desde el año 1994.

2. Un aspecto fundamental en toda red de comunicaciones es el tipo de señalización que se utiliza para la interconexión entre diferentes sistemas. En el presente trabajo se describen los dos tipos de señalización más comunes entre centrales: señalización número 7 y señalización R2. Actualmente las operadoras telefónicas fijas y celulares están utilizando cada vez más el sistema de señalización número 7, la cual presenta ventajas muy importantes con respecto a la señalización R2, que ha sido la señalización comúnmente utilizada en el país por las operadoras telefónicas fijas e inalámbricas. Entre las ventajas más sobresalientes de SS7 frente a R2, están la de una conmutación más dinámica y por ende un procesamiento de llamadas hasta un 70% más rápida, la de permitir la introducción de nuevas facilidades y servicios como la marcación 1-800 de las operadoras fijas, la de explotar las capacidades digitales de los teléfonos móviles IS-136 mediante la interconexión entre las operadoras y diversas plataformas de servicios adicionales (correos de voz, servicio de mensajería corta, etc.), entre sus principales ventajas.

3. La red telefónica celular es un sistema integral de comunicaciones, en el que todos los procesos interactúan entre sí. Debido a esto, en la presente tesis se trata de abarcar los tópicos más relevantes con respecto a los elementos que conforman el sistema celular, los cuales eran imprescindibles revisarlos para llegar a entender la estructura y funcionamiento de una oficina central de conmutación celular.

4. La importancia del presente trabajo radica en que la oficina de conmutación de telefonía móvil se encarga de coordinar la administración, mantenimiento y operación de la infraestructura telefónica celular. Los Ingenieros de Conmutación deben ser capaces de mantener el sistema funcionando constantemente, investigar y evaluar nuevas tecnologías que puedan ser implementadas en la red celular.

5. Una tarea básica, obligatoria y fundamental de todo Ingeniero de Conmutación es realizar el monitoreo diario de las alarmas generadas en la central, ya que permiten hacer un diagnóstico del comportamiento del sistema celular. Si se presentara algún inconveniente en el sistema, se debe dar aviso inmediato al personal de las áreas involucradas, para que éste sea resuelto inmediatamente y no se degrade la calidad del servicio.

6. Es fundamental que los Ingenieros de Conmutación de las operadoras celulares entren en un proceso constante de investigación, desarrollo, supervisión y mantenimiento de sus respectivas centrales, con el fin de encontrar nuevas herramientas y utilidades propias para aumentar el rendimiento de la red y la confiabilidad del servicio brindado al usuario final.

7. La comprensión de los conceptos expuestos en esta tesis, dan las bases para entender los principales procesos que inciden directamente en la calidad de las llamadas, logrando discriminar los efectos que la variación de los parámetros que controlan cada uno de estos procesos puedan provocar en el funcionamiento del sistema.

8. Es necesario aclarar que los procesos de optimización del sistema celular fueron realizados desde el punto de vista del trabajo que se realiza en las centrales celulares, por lo que es muy recomendable desarrollar otros proyectos de tesis de grado que topen la optimización desde el punto de vista de otras áreas, como son el área de transmisiones, el área de datos, el área de planificación, el área de desarrollo, etc.

9. Como se pudo observar en este documento, la central siempre está generando registros y contadores de cada evento que sucede en el sistema, por lo que es recomendable llevar estadísticas diarias y semanales de cada uno de los elementos que conforman la red, como por ejemplo: reportes del canal de control, reportes del canal de localización, reportes de los procesos de *handoff*, reportes del estado de las llamadas, reportes de la carga del procesador, reportes del tráfico, etc. Esto es de mucha utilidad para realizar un seguimiento constante de cómo está operando la central celular, además que se pueden realizar estadísticas mensuales y anuales del crecimiento de los abonados permitiendo realizar proyecciones del hardware que se necesitaría para dar soporte a más suscriptores.

10. Debido a que los sistemas celulares son altamente dinámicos, el proceso de optimización es un proceso continuo, el cual como se ha visto a lo largo del desarrollo del presente trabajo debe ir de un ajuste grueso a una sintonía fina para conseguir lograr el mejor desempeño de la red, y cumplir con los parámetros mínimos de calidad para satisfacción de los abonados celulares.

11. El proceso de optimización envuelve un alto grado de complejidad en las redes celulares, debido a que se tiene que considerar muchos factores como el ambiente de radio frecuencia, distancia de las estaciones radio bases, una distribución correcta del plan de frecuencias por parte de cada operador, y así evitar la presencia de interferencias que puedan degradar el servicio.

12. Los procesos de optimización descritos en esta tesis, ayudan a mantener el servicio celular dentro de los parámetros de calidad establecidos en las regulaciones dictadas por la Superintendencia de Telecomunicaciones para la telefonía celular. También es importante mencionar que para alcanzar niveles óptimos de calidad, las operadoras locales deben invertir en el hardware necesario para ampliar sus redes (tanto en cobertura como en capacidad de interconexión entre centrales); ya que en la realidad es notorio la presencia de congestión y de interferencias en determinadas zonas de

cobertura que se escapan de las manos de los Ingenieros Celulares por las limitaciones actuales de la telefonía celular en el Ecuador.

13. Es importante mencionar el impacto que tiene la implementación de nuevas estaciones bases celulares en la red celular, pues si no se dimensiona adecuadamente la cobertura y los parámetros que éstas manejarán, se afectará de manera grave a las celdas circundantes, sobre todo en las zonas urbanas donde se tiene un gran factor de reuso de frecuencias.

14. El crecimiento sostenido que presenta la telefonía celular lleva a pensar que se deben introducir nuevos sistemas que ofrezcan mejor calidad en sus operaciones, como son PCS, CDMA, etc. Pero esta situación de migración de tecnologías por parte de las operadoras locales no se dará, al menos en los próximos años, debido a que TDMA (la tecnología utilizada en el país) es todavía muy manejable para el mercado actual. Pero si llegado el caso, se tuviera que dar el salto hacia estas tecnologías, las condiciones económicas de las operadoras deberían ser las más adecuadas, ya que esto implicaría cambiar toda la infraestructura celular actual debido a la incompatibilidad entre tecnologías celulares, especialmente con CDMA.

15. Desde el punto de vista del autor de esta tesis, se ha cumplido el objetivo y los alcances propuestos en la misma, esperando que sea un aporte positivo para todos aquellos que deseen aprender algo más del mundo de las comunicaciones inalámbricas celulares.

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ANEXO A: RESUMEN DE LAS TECNOLOGIAS CELULARES EN EL MUNDO

En los cuadros a.1 y a.2 se presenta un resumen con las tecnologías celulares analógicas y digitales utilizadas en el mundo hasta el mes de diciembre de 1999, obtenido de la revista latinoamericana para las comunicaciones inalámbricas FRECUENCIA, en la edición Nº 15 de noviembre – diciembre de 1999.

TECNOLOGIAS CELULARES ANALOGICAS	
AMPS	Sistema avanzado de teléfonos móviles. Desarrollado por BellLasbs en los años setenta y utilizando comercialmente por primera vez en Estados Unidos en el año 1983. Opera en la banda de 800 MHz. Es actualmente el estándar celular más utilizado en el mundo.
C-450	Instalado en Sudáfrica durante la década de los años ochenta. Utiliza la banda de 450 MHz y es muy parecida al estándar. C-Netz. Actualmente conocida como Motorphone y opera por Vodacom S.A.
C-NETZ	La más antigua tecnología celular, se utiliza principalmente en Alemania y Austria. Utiliza 450 MHz.
COMVIK	Lanzada en Suecia en agosto del año 1981 por la red Comvik.
NAMPS	Sistema avanzado de teléfonos móviles de banda angosta. Desarrollado por Motorola como tecnología de transición entre la analógica y la digital. Posee una capacidad tres veces mayor a la de AMPS. Opera en el rango de 800 MHz.
NMT450	Teléfonos nórdicos /450. Desarrollada especialmente por Ericsson y Nokia para responder a los terrenos accidentados que caracterizan a los países nórdicos. Rango 25 Km. Opera a 450 MHz. Utiliza FDD FDMA.
NMT900	Teléfonos móviles nórdicos /900. Versión mejorada de NMT 450, desarrollada por los, países nórdicos para acomodar mayores capacidades y teléfonos portátiles. Posee un rango de 25Km. Utiliza Tecnología FDD FDMA.
NMT-F	Versión francesa de NMT900.
NTT	Telegrafía y Telefonía nipona. La vieja norma analógica estándar A de alta capacidad se conoce como HICAP.
RC2000	Radiocom 2000. Sistema francés lanzado en noviembre del año 1985.
TACS	Sistema de comunicaciones de acceso total desarrollado por Motorola. Es similar a AMPS. Se lo utilizó por primera vez en Estado Unidos, en el año 1985. En Japón se lo conoce como JTAC. Opera en el rango de frecuencia de 900 MHz.

Cuadro a.1: *Tecnologías celulares analógicas*

TECNOLOGIAS CELULARES DIGITALES	
AMPS	Nombre austríaco para redes GSM 900.
C-450	CDMA de banda ancha. Conocido como W-CDMA. Se lo utilizará en UMTS.
C-NETZ	Tecnología inalámbrica que utiliza tanto CDMA como TDMA para aplicaciones en celdas grandes en bandas con licencias o de celdas pequeñas en bandas sin licencias. Utiliza CDMA entre celdas y TDMA dentro de ellas. Está basada en la tecnología Omnipunto.
COMVIK	Acceso múltiple por división de códigos, Actualmente, existen diversas variaciones del CDMA, además de la N–CDMA originalmente inventada por Qualcomm, al comienzo conocida simplemente como CMDA, pero también conocida en los Estados Unidos. Como IS–95. Las últimas variantes son B-CDMA, W-CDMA y la CDMA/TDMA compuesta. Se caracteriza por una alta capacidad y radios pequeños de celdas. Utiliza tecnología de aspecto extendido y un esquema especial de codificación. Fue adoptada por una alta capacidad y radios pequeños de celdas. Utiliza tecnología de espectro extendido y un esquema especial de codificación. Fue adoptada por la TIA en el año 1993. Las primeras redes basadas en CDMA ya son operacionales. B–CDMA será la base para los servicios de tercera generación del estándar UMTS.
N-AMPS	La primera generación de CDMA para banda angosta (IS-95).
NMT450	La segunda generación de CDMA MoU para inclusión en UMTS.
NMT900	Estándar para los teléfonos inalámbricos digitales de segunda generación.
NMT-F	Teléfono inalámbrico digital de tercera generación percusor de la tecnología DECT.
NTT	AMPS digital, versión mejorada del AMPS, también conocida como IS –54. Utiliza una variante de TDMA. Fue diseñado para responder al problema de utilización mas eficiente de canales existentes: utiliza el mismo espaciamiento de canales, de 30 kHz, y las mismas bandas de frecuencias (824-849 y 869-894 MHz) que AMPS pero utilizar TDMA en vez de FDMA, IS- 54 incrementa el número de usuarios de 1 a 3 por canal
RC2000	Estándar digital inalámbrico conocido como GSM 1800. Esta es una versión diferente a las frecuencias de GSM. Los teléfonos GSM de 900 MHz no pueden ser utilizados en redes DCS 1800 a menos que sea de banda dual.
DECT	Teléfono inalámbrico digital europeo. Se inicio como el CT- 3 de Ericsson pero se desarrollo como el estándar para operaciones inalámbricas digitales europeas. Aspira ser un estándar mucho mas flexible que el CT2 ya que tiene más canales RF. También posee un mejor rendimiento con multimedios debido que se pueden concatenar los transmisores de 32 Kbits. Ericsson ha desarrollado un teléfono dual GSM/DECT.
E-NETZ	Nombre alemán para redes GSM 1800.
FDMA	Modulación por acceso múltiple por división de frecuencia.
GSM	Sistema global para comunicaciones móviles. El primer estándar

	digital europeo desarrollado para establecer compatibilidad celular en toda Europa. Su éxito se ha extendido a todas partes del mundo y ahora están operando más de 80 redes GSM. Opera en los 900 MHz.
PCS	Servicio de comunicaciones personales. La banda de frecuencias PCS es de 1850 a 19990 MHz, que abarca una amplia gama de nuevas normas celulares digitales como N–CDMA y GSM 900 de una sola banda y no pueden ser utilizados en redes PCS.
INMARSAT	Sistema satelital marítimo internacional. Utiliza algunos satélites geoestacionarios. Disponibles en versiones Inmarsat A, B, C y M.
IRIDIUM	Red satelital de telefonía y localización móviles, lanzada en noviembre del año 1998. Utiliza TDMA para los enlaces intersatelitales. Utiliza la banda de 2 GHz.
IS –54	Tecnología basada en TDMA utilizada por el sistema D-AMPS en los 800 MHz.
IS –95	Tecnología basada en CDMA utilizada en los 800 MHz.
IS- 136	Tecnología basada en TDMA
JS- 008	Estándar basado en CDMA para 1900 MHz.
N-CDMA	Acceso múltiple por división de códigos para banda angosta o simplemente CDMA en su versión original. También conocido en los Estados Unidos como IS–95. Desarrollada por Qualcomm y caracterizado por su alta capacidad y pequeño radio de celdas. Posee un interfaz de 1.25 MHz para espectro extendido. Utiliza las mismas bandas de frecuencia que AMPS y puede operar con AMPS empleando la tecnología de espectro extendido y un esquema especial de codificación. Fue adoptado por la TIA en el año de 1993. Las primeras redes basadas en CDMA ya operan
PACS-TDMA	Estándar basado en TDMA para 8 ranuras, utilizando principalmente para peatones. Derivado de las especificaciones de acceso inalámbricos de Bellcore para aplicaciones en bandas con licencia. Cuenta con el apoyo de Motorola.
PDC	Operaciones celulares digitales personales. Estándar japonesa basada en TDMA para las bandas de 800 y 15000 MHz.
PHS	Sistema personal portátil. Sistema Japonés. TDD–TDMA centrado que ofrece servicios de transmisión de datos a altas velocidades y una excelente claridad de voz. Es básicamente un sistema WLL con una cobertura limitada de 300m a 3 Km.
TDMA	Acceso múltiple por división de tiempo. El primer estándar digital estadounidense adoptado por la TIA en el año 1992. En la actualidad existen algunas variaciones.
TELECENTRE-H	Un sistema WLL de propiedad Krone con un rango de 30 Km, a 300-500 MHz y 800-1000 MHz. Utiliza las tecnologías FDD FDM/FDMA y TDM/TDMA.
TETRA	Acceso trans-europeo por radio troncalizado. Sistema PMR diseñado para transmitir voz y datos en vehículos, automotores públicos y particulares y en flotas de camiones. Permite efectuar roaming. Es un sistema muy nuevo, todavía no está completamente implementado.
ULTRAPHONE	Sistema WLL de IDC con un rango de 30 Km, a 350-500MHJz.

110	Utiliza las tecnologías FDD FDM/TDMA. Permite cuatro conversaciones simultaneas en cada espacio para canales (25kHz). Un sistema WLL típico de 24 canales puede operar con 95 circuitos de voz de duplexación completa en 1.2 MHz.
UMTS	Estándar universal para teléfonos móviles. La próxima generación de servicios celulares globales, que deberá comenzar a funcionar en el año 2004. Velocidades de transmisión de datos propuestas <2Mbps, utilizando combinaciones de TDMA y W-CDMA.
W-CDMA	Uno de los últimos componentes de UMTS, junto con TDMA y CDMA 2000. Posee un interfaz aéreo de 5 MHz y es la base de las velocidades de datos en anchos de banda más altos.
WLL	Circuitos locales inalámbricos. Sistemas limitados, normalmente utilizados en zonas remotas en donde es imposible utilizar líneas fijas. La mayoría de los sistemas WLL modernos utilizan tecnología CDMA.

Cuadro a.2: *Tecnologías celulares digitales*

ANEXO B: DESCRIPCION DE LAS CAPAS DEL CANAL DE CONTROL DIGITAL POR MEDIO DEL ESTANDAR PROVISIONAL IS-136.1-A

1. Terminology

AC	Authentication Center	IS-41
ACC	Analog Control Channel	IS-136.2
AG	Guard Time for Abbreviated RACH Burst	4.4.1
AGC	Automatic Gain Control	4.4.5
ARCH	Access Response Channel	2.3.2.2
ARM	ARQ Response Mode	5.2.5.2
ARQ	Automatic Retransmission Request	5.4
AVC	Analog Voice Channel	IS-136.2
BC	Begin Continue	5.2.2.2
BCCH	Broadcast Channel	2.3
BCN	Broadcast Channel Change Notification Flag	4.6 & 5.2.5.2
BER	Bit Error Rate	6.3.17
BI	Begin Indicator	5.2.2.1 & 5.2.2.2
BMI	Base Station, MSC and Interworking Function	IS-41
BP	Bit Position	4.4
BRI	Busy Reserved Idle	4.4.2.1
BT	Burst Type	5.2.1.1
BU	Burst Usage	5.1.2.5 & 5.2.5.2
CDVCC	Coded DVCC	IS-136.2
CEF	Candidate Eligibility Filtering	6.3.3.4.2
CI	Change Indicator	5.2.1.3 & 5.2.1.4
CLI	Continuation Length Indicator	5.2.2.1
CPE	Coded Partial Echo	4.4.2.2
CRC	Cyclic Redundancy Check	4.4.3.1
CSC	Customer Service Center	7.2
CSFP	Coded Superframe Phase	4.4.8
DCC	Digital Color Code	IS-136.2
DCCH	Digital Control Channel	2.1
DTC	Digital Traffic Channel	IS-136.2
DVCC	Digital Verification Color Code	IS-136.2
E-BCCH	Extended Broadcast Control Channel	2.3.3.2
EC	E-BCCH Change flag	4.6 & 5.2.5.3
ECL	E-BCCH Cycle Length	4.6
EHFC	Extended Hyperframe Counter	4.7
EHI	Extension Header Indicator	5.2.1
F-BCCH	Fast Broadcast Control Channel	2.3.3.1
FC	F-BCCH Change flag	4.6 & 5.2.5.3
FDCCH	Forward Digital Control Channel	2.3
FEC	Forward Error Correction	2.2
FILLER	Filler Data	5.2.5.2
FRNO	Frame Number	5.2.5.2

FRNO MAP	Frame Number Map	5.2.1.4
G	Guard Time	4.4.4
HF	Hyperframe	4.6
HFC	Hyperframe Counter	4.7
HLR	Home Location Register	IS-41
IDT	Identity Type	5.1.2.1 & 5.2.1.4
IE	Information Element	6.5
IRA	International Reference Alphabet (formerly IA5)	ITU Rec T.50 (1992)
ISOR	Ineligible for Service Offering Reasons	6.3.3.4.2
L2	Layer 2	(general)
L3	Layer 3	(general)
L3DATA	Layer 3 Data	5.2.1.4
L3LI	Layer 3 Length Indicator	5.2.1.4
LSB	Least Significant Bit	(general)
LTM	Long-Term MACA	6.3.17.1
LT_RSS	Long Term Received Signal Strength	6.3.17.1
MACA	Mobile Assisted Channel Allocation	6.3.17
MEA	Message Encryption Algorithm	5.2.1.4
MEK	Message Encryption Key	5.2.1.4
MIN	Mobile Station Identification Number	8.1.3
MM	Message Mapping	5.2.5.2
MRLQ	Monitoring Of Radio Link Quality	5.5
MS	Mobile Station	(general)
MSB	Most Significant Bit	(general)
NEB	Number of E-BCCH slots per Superframe	4.10.2
NFB	Number of F-BCCH slots per Superframe	4.10.2
NL	Neighbor List	6.4.1.2.1.1
NL3M	Number of Layer 3 Messages	5.2.1.4
NPS-DCCH	Non-Public Mode Search DCCH	6.3.3.1
NR	Number of Reserved slots per Superframe	4.10.2
NSB	Number of S-BCCH slots per Superframe	4.10.2
OLC	Overload Class	6.4.1.1.2.3
PACA	Priority Access and Channel Allocation	6.3.5
PAID	PCH Allocation ID	4.10
PCH	Paging Channel	2.3.2.1
PCON	Page Continuation	4.8 & 5.2.5.2
PDU	Protocol Data Unit	2.2
PE	Partial Echo	4.11.2 & 5.3.3.1
PEA	Partial Echo Assigned	5.2.1.4
PF	Paging Frame	4.7
PFC	Paging Frame Class	4.7
PFM	Paging Frame Modifier	4.7
PFN	Paging Frame Number	4.7
PI	Polling Indicator	5.2.1.3
PMSID	Permanent Mobile Station Identity	4.10
POF	Private Operating Frequency	6.3.3.1
PREAM	Preamble	4.4.5
PSP	Public Service Profile	6.3.21
PSS	Processed Signal Strength	6.3.3.2
R	Ramp Time	4.4.6
R/N	Received/Not Received	4.4.2.3
RACH	Random Access Control Channel	2.3.1

RDCCH	Reverse Digital Control Channel	2.3
RSS	Received Signal Strength	6.3.2.1
RSVD	Reserved	(general)
RTC	Reselection Trigger Conditions	6.3.3.4.1
S-BCCH	Short Message Service-Broadcast Control Channel	2.3.3.3
SAP	Service Access Point	5.1
SCF	Shared Channel Feedback	2.3.5
SF	Superframe	4.5
SFP	Superframe Phase	4.5
SMS	Short Message Service	(general)
SMSCH	Short Message Service Point-to-Point Channel	2.3.2.3
SPACH	SMS, PCH and ARCH	2.3.2
SSD	Shared Secret Data	6.3.12.1
STM	Short-Term MACA	6.3.17.1
STU-III	Secure Terminal Unit	IS-136.2
ST_RSS	Short Term Received Signal Strength	6.3.17.2
SYNC	Synchronization	IS-136.2
SYNC+	Additional SYNC for RACH Burst	4.4.10
TIR	Temporarily Ineligible for Reselection	6.3.3.4.3
TDMA	Time Division Multiple Access	4.4
UGID	User Group Identification	5.2.5.2
WER	Word Error Rate	6.3.17.4.1.1

2. General

2.1 Specification Scope

Four documents together comprise the specification information necessary for development of IS-136 based products.

- IS-136.1 (DCCH - Digital Control Channel. A collection of logical channels conveyed on radio bearer channels using $\pi/4$ – DQPSK modulation that are used for transmission of control information and short user data messages between the base and mobile stations.) - This document contains specification text for the DCCH air interface. Distinct sections for Layer 1, Layer 2, Layer 3 and higher layers descriptions are provided (i.e., a layered document).

- IS-136.2 - A modified TIA/EIA 627 standard with no major architectural changes to the document itself (i.e., unlayered approach maintained). This document addresses the air interface requirements for the Analog Control Channel (ACC), Analog Voice Channel (AVC) and Digital Traffic Channel (DTC - A collection of logical channels conveyed on radio bearer channels using $\pi/4$ – DQPSK modulation that are used for transmission of user information and related control messages between the base and mobile stations).

- IS-137 - modified EIA/TIA 628 standard. This document addresses the minimum performance requirements for mobile stations.

- IS-138 - modified EIA/TIA 629 standard. This document addresses the minimum performance requirements for base stations.

Other useful documents include:

IS-130	800 MHz Cellular Systems TDMA Radio Interface Radio Link Protocol 1
IS-135	800 MHz Cellular Systems TDMA Services Async Data and Fax
IS-41	Cellular Radio Telecommunications Intersystem Operations
IS-53	Cellular Features Description
IS-54	Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard
IS-641	800 MHz Cellular System, TDMA Radio Interface, Enhanced Full-Rate Speech Codec
ITU E.163	Numbering Plan for the International Telephone Service

ITU E.164	Numbering Plan for the ISDN Era
ITU E.212	Identification Plan for Land Mobile Stations
ITU F.69	The International Telex Service - Service and Operational Provisions of Telex Destination Codes and Telex Network Identification Codes 94/06
ITU I.330	ISDN Numbering and Addressing Principles
ITU I.334	Principles Relating ISDN Numbers/Subaddresses to the ISO Reference Model Network Layer Addresses
ITU T.50	International Alphabet No. 5
ITU X.121	International Numbering Plan for Public Data Networks
ITU X.213	Network Service Definition for Open Systems Interconnection for CCITT Applications
ITU X.25	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode and Connected to Public Data Networks by Dedicated Circuit 93/03
TIA/EIA 553	Mobile Station-Land Station Compatibility Specification
TIA/EIA 627	800 MHz Cellular System, TDMA Radio Interface, Dual-Mode Mobile Station-Base Station Compatibility Standard
TIA/EIA 628	800 MHz Cellular System, TDMA Radio Interface, Minimum Performance Standards for Dual Mode Mobile Stations
TIA/EIA 629	800 MHz Cellular System, TDMA Radio Interface, Minimum Performance Standards for Base Stations Supporting Dual Mode Mobile Station
TSB 50	User Interface for Authentication Key Entry

EIA Telecommunications System Bulletin No. 16, March 1985 -
Assignment of Access Overload Classes in the Cellular Telecommunications Services

2.2 Protocol Reference Model

The protocol reference model is provided for information purposes and is not intended to be exhaustive.

Figure 2 - 1 BMI - DCCH Protocol Reference Model

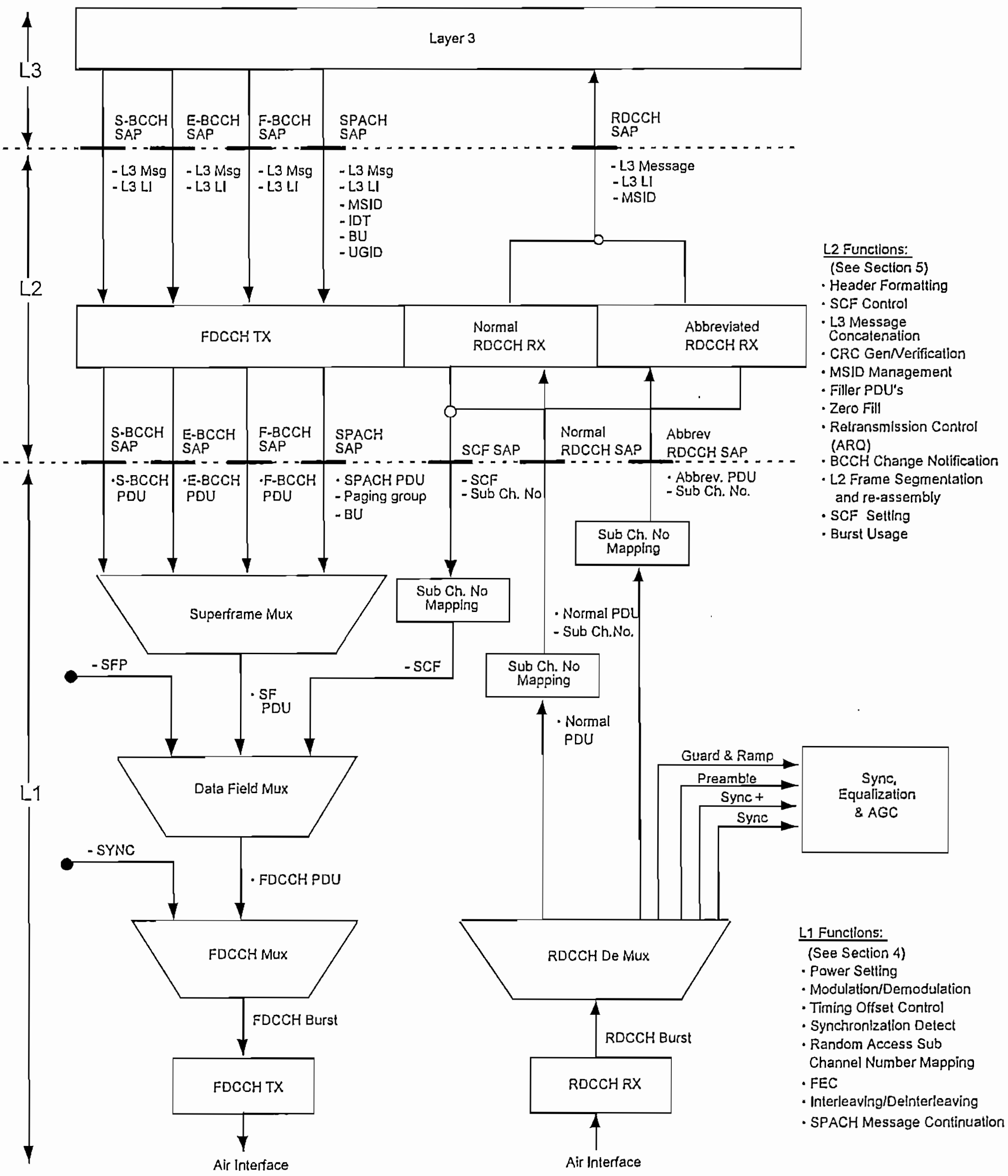
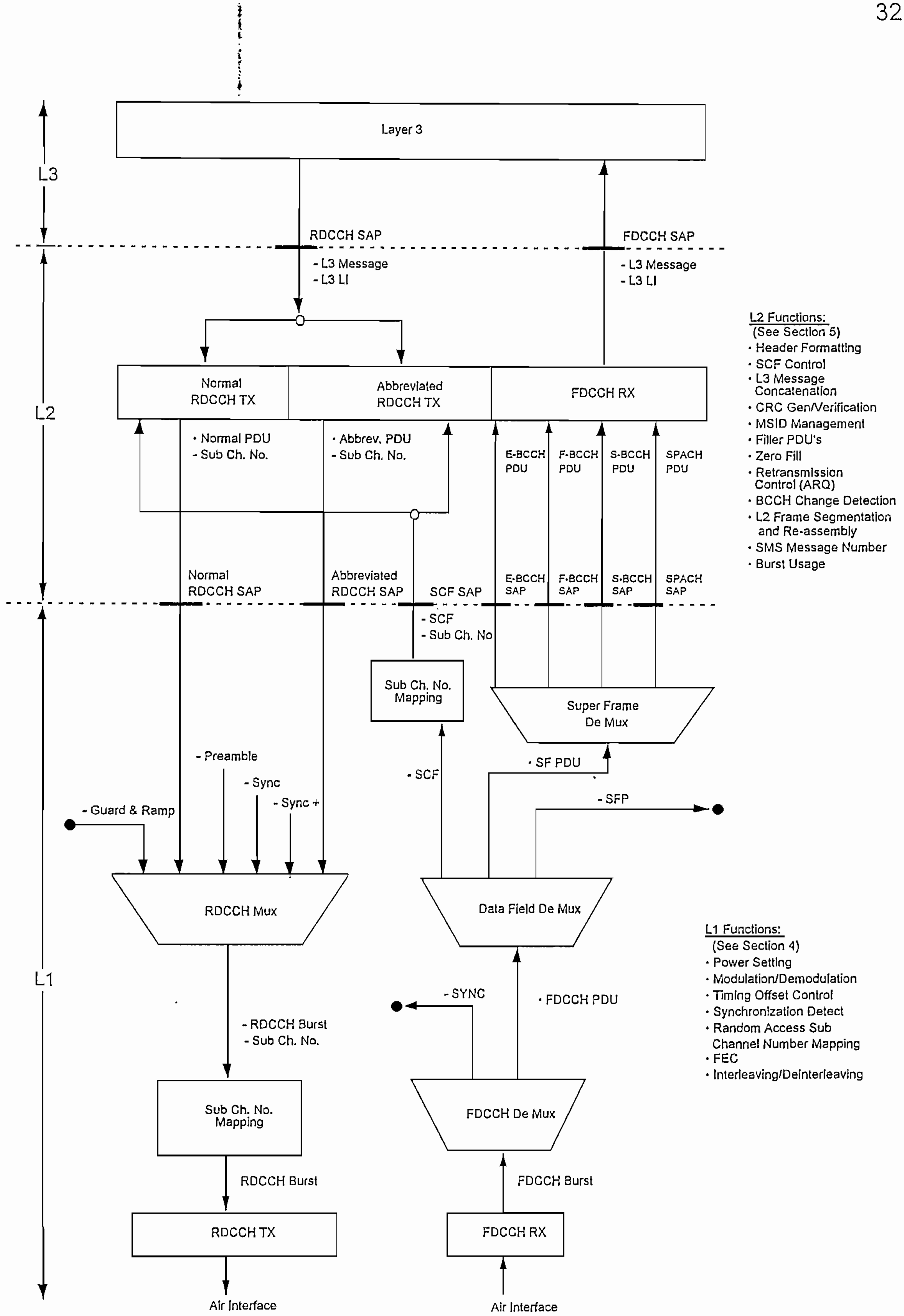


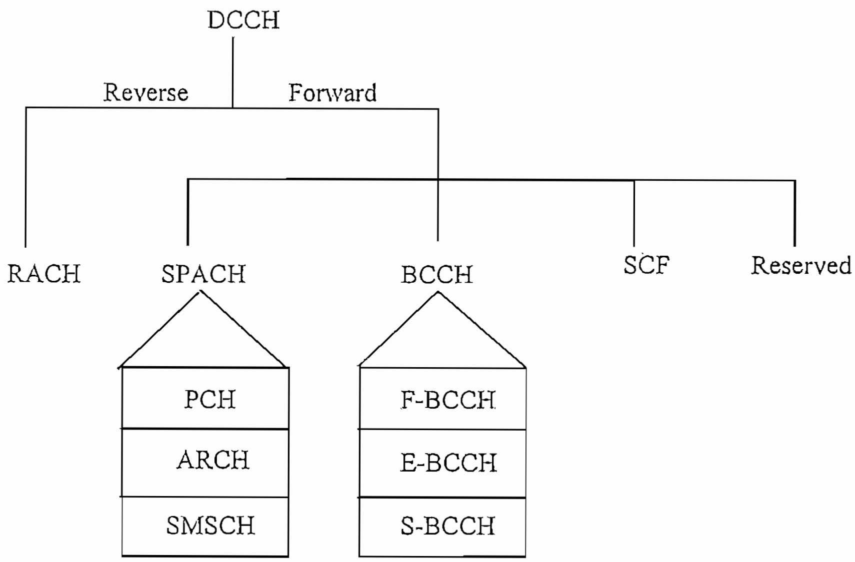
Figure 2 - 2 MS - DCCH Protocol Reference Model



2.3 Logical Channel Definition

The DCCH comprises the logical channels shown in Figure 2-3. The reverse DCCH (RDCCH) consists of a RACH. The forward DCCH (FDCCH) consists of SPACH, BCCH, SCF and Reserved slots.

Figure 2 - 3 Logical Channels



2.3.1 Random Access Channel (RACH)

A random access channel is used to request access to the system.

Attributes: Unidirectional (reverse), Shared, Point-to-Point, Acknowledged (Acknowledged using Shared Channel Feedback mechanism).

Note: Contention resolution and/or collision avoidance feedback is provided on the corresponding SCF channel.

2.3.2 SMS Point-to-Point, Paging and Access Response Channel (SPACH)

This logical channel is used to broadcast information to specific mobile stations regarding SMS Point-to-Point (SMSCH), paging (PCH) and to provide an access response channel (ARCH) as described below. The SPACH may be considered to be further subdivided in 3 logical channels SMSCH, ARCH and PCH, as described below.

Attributes: Unidirectional (forward), Shared, Point-to-Point, Acknowledged or Unacknowledged.

2.3.2.1 Paging Channel (PCH)

A logical channel subset of the SPACH dedicated to delivering pages and orders.

Note: SPACH ARQ Operation (see Section 5.4) is not supported on this channel.

Attributes: Unidirectional (forward), Shared, Point-to-Point, Unacknowledged.

2.3.2.2 Access Response Channel (ARCH)

A logical channel subset of the SPACH to which the mobile station autonomously moves to, upon successful completion of a contention or reservation based access on a RACH. The ARCH may be used to convey assignments to another resource or other responses to the mobile station access attempt.

Note: SPACH ARQ operation (see Section 5.4) is supported on this channel.

Attributes: Unidirectional (forward), Shared, Point-to-Point, Unacknowledged or Acknowledged.

2.3.2.3 SMS Channel (SMSCH)

A logical channel used to deliver Teleservice-related messages to a specific mobile station.

Note: SPACH ARQ operation (see Section 5.4) is supported on this channel.
Attributes: Unidirectional (forward), Shared, Point-to-Point, Unacknowledged or Acknowledged.

2.3.3 Broadcast Control Channel (BCCH)

The BCCH is an acronym used to refer to the F-BCCH, E-BCCH and S-BCCH logical subchannels.
These three logical channels are used, in general, to carry generic, system-related information.
The attributes of these three channels are: Unidirectional (forward), Shared, Point-to-Multipoint, Unacknowledged.

2.3.3.1 Fast Broadcast Control Channel (F-BCCH)

This logical channel is used to broadcast DCCH structure parameters and parameters that are essential for accessing the system.

2.3.3.2 Extended Broadcast Control Channel (E-BCCH)

The E-BCCH carries broadcast information that is less time critical than F-BCCH for the mobile stations. For the optional information, a message type and a length indicator are included.

2.3.3.3 SMS Broadcast Control Channel (S-BCCH)

This logical channel is used for the broadcast SMS service.

2.3.4 Reserved Channel

This logical channel is defined for future use only. Defining it now assures forward compatibility with the first generation IS-136 mobile stations.

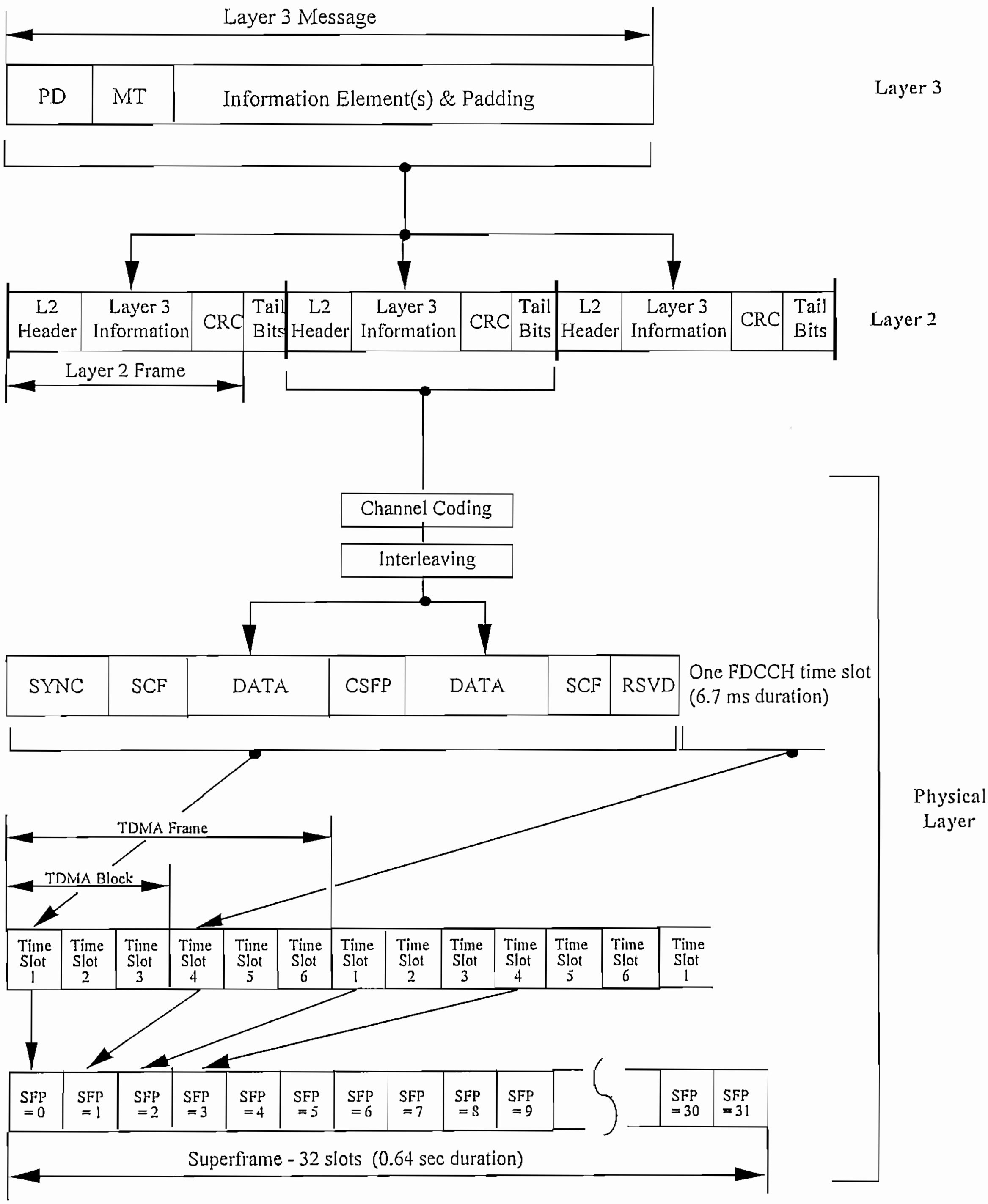
2.3.5 Shared Channel Feedback (SCF)

This logical channel is used in support of Random Access channel operation (see Section 5.3.3).

2.4 Layer 3 Message Mapping Through Layer 2 to Physical Layer

This description of message mapping is only included to aid in the understanding of the Standard and only shows one possible mapping sequence.
Figure 2-4 shows an example of how one L3 Message is mapped into several layer 2 frames, an example of a L2 frame mapping onto a time slot, and an example of time slot mapping onto a DCCH channel.
The length of a L3 Message is determined by a L3 Length Indicator which is carried as part of L2 header. The length of an L2 frame is fixed, determined by the specific logical channel. Tail bits are added to the L2 frames before channel encoding.
The length of the FDCCH time slots and RDCCH burst is fixed. There are two forms of RDCCH bursts which have different fixed lengths. Figure 2-4 assumes an FDCCH slot and a full-rate DCCH on the Physical Layer.
The mapping of assembled FDCCH slots into superframes is also shown in Figure 4-10. Two superframes are assembled into a Hyperframe according to Figure 4-11. The grouping of hyperframes into Paging frames is shown in Figure 4-12.

Figure 2 - 4 Message Mapping



2.5 Notes

1. Analog Voice Channel (AVC) and Analog Control Channel (ACC) operation is only supported in the 800 MHz hyperband.
2. Unless otherwise specified, all mobile stations and BMI shall set all bits that they are programmed to treat as reserved bits to 0 (zero) in all messages that they transmit. All mobile stations and BMI shall ignore the state of all bits that they are programmed to treat as reserved bits in all messages that they receive.
3. The capabilities of a mobile station shall be consistent across all hyperbands that it supports except for analog speech, which can only be supported in the 800 MHz hyperband.

4. All lines added or modified during the transition from IS-136 plus IS-136 Addendum are denoted by a single vertical change bar (|) in the right hand margin.

3. Optional Mobile Station Facilities

- Control Channel Reselection based on availability of services (i.e., Service Offering) on a candidate control channel (see Section 6.3.3.4)
- SOC/BSMC signaling.
- Reduction of scanning frequency for RSS measurements of neighboring cells (see Sections *6.3.3.1 and* 6.3.3.2).
- SMS SUBMIT (see Section 7.1.2.2).
- PFC 2 to PFC 8.
- Any type of number other than "unknown" as specified in the Type of Number field within the Address Info information element (see Section 6.5).
- Any Numbering Plan other than "unknown" as specified in the Numbering Plan field within the Address Info information element (see Section 6.5).
- When the Address Info indicates "Type of Number = unknown" and "Numbering Plan = unknown", the IRA encoding of the Address field is optional.
- Async Data and G3-Fax Service Mode.
- Support of User Group operation (see Sections 5.1.1.2, 5.2.5, 6.3.16 and 8.4). If supported, only a single User Group ID may be enabled at any point in time.
- Support of Subaddressing (see Section 6.3.13).
- Support of half-rate, double rate and triple rate operation on a Digital Traffic Channel (i.e., data, fax and/or vocoder rates other than full-rate). The capability to operate on a full-rate or half-rate DCCH with any valid Slot Configuration (see Table 4-3 in Section 4.10.1) is mandatory.
- Message Encryption on the DCCH.
- Digital operation in more than one hyperband.
- Analog Operation.
- Support of Delta Time on Digital Traffic Channel.
- Support of voice coders.
- STU-III.

4. Physical Layer

4.1 Radio Frequency Carrier Spacing and Designation

As per IS-136.2 (see Section 2.1.1.1).

4.2 Power Output and Modulation Characteristics

As per IS-136.2 (see Sections 2.1.2, 2.1.3.3, 3.1.2, 3.1.3.3.1 and 3.1.3.3.6).

4.3 Service Access Points

Layer 1 provides the following service access points (SAPs) to layer 2 both on mobile station and BMI side. Refer to Figures 2-1, 2-2 and 5-1 for the BMI, MS Protocol Reference models, and for the primitives on the mobile station and BMI sides from a layer 2 perspective.

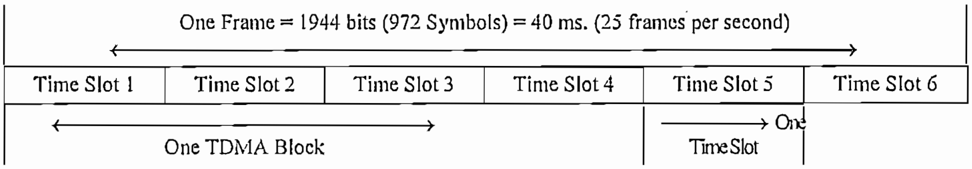
- F-BCCH SAP
- E-BCCH SAP
- S-BCCH SAP
- SPACH SAP

- SCF SAP
- Normal RDCCH SAP
- Abbreviated RDCCH SAP.

4.4 TDMA Frame Structure

The frame structure may be depicted as follows:

Figure 4 - 1 Frame Structure



A TDMA frame is 40 milliseconds long and consists of six equally sized time slots (1–6), each 162 symbols (324 bits) in length. A TDMA Block consists of half a TDMA frame (either slots 1 to 3 or slots 4 to 6).
The Bit Position (BP) of forward and reverse slots/bursts are numbered sequentially from 1 to 324.
In the forward direction, the first transmitted bit of the SYNC has BP = 1 and the last transmitted bit of the RSVD field has BP = 324. In the reverse direction, the first transmitted bit of the Guard has BP = 1. In the normal slot format, the last transmitted bit of the DATA field has BP = 324. In the abbreviated slot format, the last transmitted bit of the AG field has BP = 324.

Figure 4 - 2 Normal Slot Format MS → BMI on DCCH

G	R	PREAM	SYNC	DATA	SYNC+	DATA
6	6	16	28	122	24	122

Figure 4 - 3 Abbreviated Slot Format MS → BMI on DCCH

G	R	PREAM	SYNC	DATA	SYNC+	DATA	AG
6	6	16	28	122	24	78	44

Figure 4 - 4 Slot Format BMI → MS on DCCH

SYNC	SCF	DATA	CSFP	DATA	SCF	RSVD
28	12	130	12	130	10	2

Interpretation of the fields is as follows:

AG	-	Guard Time for Abbreviated RACH Burst
CSFP	-	Coded Super Frame Phase
DATA	-	Coded Information Bits
G	-	Guard Time
PREAM	-	Preamble
R	-	Ramp Time
RSVD	-	Reserved Field, set to 11
SCF	-	Shared Channel Feedback
SYNC	-	Synchronization
SYNC+	-	Additional Synchronization

4.4.1 AG

The AG (Abbreviated Guard) field denotes guard time for the abbreviated access burst format. The field is 22 symbols (44 bits) in length. During this time the mobile station shall maintain carrier off condition. Note that the first 3 symbols of AG consist of Ramp.

4.4.2 SCF

The SCF (Shared Channel Feedback) field is used to control accesses on the RACH and is comprised of the following:

- Busy/Reserved/Idle (BRI)
- Received/Not Received (R/N)
- Coded Partial Echo (CPE).

4.4.2.1 BRI

The BRI (Busy/Reserved/Idle) is a 6-bit field and is mapped into FDCCH slots as shown in Figure 4-5. Encoding of the BRI is described in Section 5.3.2.1.1.

Figure 4 - 5 Bit Mapping of the BRI Field

BRI_5	BRI_4	BRI_3	BRI_2	BRI_1	BRI_0
BP_{29}	BP_{33}	BP_{37}	BP_{313}	BP_{317}	BP_{321}

4.4.2.2 CPE

The CPE (Coded Partial Echo) is an 11-bit field and is mapped into FDCCH slots as shown in Figure 4-6. Encoding of the CPE is described in Section 5.3.2.1.3.

Figure 4 - 6 Bit Mapping of the CPE Field

d_6	d_5	d_4	d_3	d_2	d_1	d_0	$\bar{b}_3$	$\bar{b}_2$	$\bar{b}_1$	$\bar{b}_0$
BP_{30}	BP_{32}	BP_{34}	BP_{36}	BP_{38}	BP_{40}	BP_{314}	BP_{316}	BP_{318}	BP_{320}	BP_{322}

4.4.2.3 R/N

The R/N (Received/Not Received) is a 5-bit field and is mapped into FDCCH slots as shown in Figure 4-7. Encoding of the R/N is described in Section 5.3.2.1.2.

Figure 4 - 7 Bit Mapping of the R/N Field

R/N_4	R/N_3	R/N_2	R/N_1	R/N_0
BP_{31}	BP_{35}	BP_{39}	BP_{315}	BP_{319}

4.4.3 DATA

User data bits (coded information bits) are mapped onto the DATA field for transmission. In the forward direction, the field is 260 bits in length. In the reverse direction, the length of the DATA field is 244 bits for the normal slot format and 200 bits for the abbreviated slot format.

4.4.3.1 Channel Encoding

The logical channels BCCH, SPACH and RACH (normal and abbreviated) use a rate 1/2 convolutional encoding. The same encoding polynomials as for full-rate speech (see Section 2.1.3.3.3.4 of IS-136.2) are used. The first bit received from layer 2 is the left most bit in Figure 4-8 and shall be the first bit delivered to channel encoding. The last five bits sent to the channel encoder are set to zero (tail bits).

Figure 4 - 8 Partitioning of the Data Before Channel Encoding

L2 Header	L3 Information	CRC	Tail
← 109/101/79 →		16	5

The combined length of the L2 Header and L3 Information fields are as follows:

SPACH and BCCH: = 130-16-5 = 109

RACH (normal length): = 122-16-5 = 101

RACH (abbreviated length) = 100-16-5 = 79

4.4.3.2 Interleaving

For all channel types and burst lengths, all bits are sent within one burst (i.e., only intra-burst interleaving is performed). The output of the interleaver is sequentially mapped into the DATA fields, beginning with the first bit (leftmost bit) of the first DATA field (leftmost DATA field). The DATA field bits are transmitted over the air interface beginning with the first bit of the first DATA field.

4.4.3.2.1 Forward DCCH

The 260 encoded data bits are interleaved in a 13-row by 20-column matrix. The data bits are placed into a rectangular interleaving array as shown in the matrix below, where the bits have been numbered 0 - 259, corresponding to their order at the output of the encoder. The data bits are entered into the array column-wise. The bits are then transmitted row-wise using the following algorithm:

```
Do row = 0,2,4,6,8,10,12
    Do column = 0 to 19
        Transmit (array(row, column))
    End Do
End Do
Do row = 1,3,5,7,9,11
    Do column = 0 to 19
        Transmit (array(row, column))
    End Do
End Do
```

0	13	26	...	234	247
1	14	27	...	235	248
2	15	28	...	236	249
...	...	...	...	...	...
11	24	37	...	245	258
12	25	38	...	246	259

Thus, the bits are transmitted in the order of:

- 0,13,...,247 (row 0),

  .
  .
  .
- 12,25,...,259 (row 12),
- 1,14,.....,248 (row 1),

  .
  .
  .
- 11,24,...,258 (row 11).

4.4.3.2.2 Reverse DCCH

Normal Length Burst

The 244 encoded data bits are interleaved in a 12-row by 21-column matrix with a partial column of 4 bits in column 21. The data bits are placed into a rectangular interleaving array as shown in the matrix below, where the bits have been numbered 0-243, corresponding to their order at the output of the encoder. The data bits are entered into the array column-wise. The bits are then transmitted row-wise using the following algorithm:

```
Do row = 0,2
      Do column = 0 to 20
            Transmit (array(row, column))
      End Do
End Do
Do row = 4,6,8,10
      Do column = 0 to 19
            Transmit (array(row, column))
      End Do
End Do
Do row = 1,3
      Do column = 0 to 20
            Transmit (array(row, column))
      End Do
End Do
Do row = 5,7,9,11
      Do column = 0 to 19
            Transmit (array(row, column))
      End Do
End Do
```

0	12	24	...	228	240
1	13	25	...	229	241
2	14	26	...	230	242
3	15	27	...	231	243
...	...	...	...	...	N/A
11	23	35	...	239	N/A

Note: N/A means not applicable.

Thus, the bits are transmitted in the order of:

- 0,12,...,240 (row 0),
  - .
  - .
  - .
- 10,22,...,238 (row 10),
- 1,13,...,241 (row 1),
  - .
  - .
  - .
- 11,23,...,239 (row 11).

Abbreviated Length Burst

The 200 encoded data bits are interleaved in a 12-row by 17-column matrix with a partial column of 8 bits in column 17. The data bits are placed into a rectangular interleaving array as shown in the matrix below, where the bits have been numbered 0-199, corresponding to their order at the output of the encoder. The data bits are entered into the array column-wise. The bits are then transmitted row-wise using the following algorithm:

```
Do row = 0,2,4,6
      Do column = 0 to 16
            Transmit (array(row, column))
      End Do
End Do
Do row = 8, 10
      Do column = 0 to 15
            Transmit (array(row, column))
      End Do
End Do
Do row = 1,3,5,7
      Do column = 0 to 16
            Transmit (array(row, column))
```

```
        End Do
    End Do
    Do row = 9, 11
        Do column = 0 to 15
            Transmit (array(row, column))
        End Do
    End Do
```

0	12	24	...	180	192
1	13	25	...	181	193
...	...	...	...	...	...
7	19	31	...	187	199
8	20	32	...	188	N/A
9	21	33	...	189	N/A
10	22	34	...	190	N/A
11	23	35	...	191	N/A

Thus, the bits are transmitted in the order of:

- 0,12,...,192 (row 0),

  .
  .
  .
- 10,22,...,190 (row 10),
- 1,13,...,193 (row 1),

  .
  .
  .
- 11,23,...,191 (row 11).

4.4.4 G

The G (Guard) field provides guard time, and is 3 symbols (6 bits) in duration. During this time, the mobile station shall maintain carrier-off condition.

4.4.5 PREAM

The PREAM (Preamble) field allows the base station to perform automatic gain control (AGC) and to facilitate symbol synchronization before the subsequent data and burst synchronization portions of the received burst are reached. The field is specified by the following phase changes in radians:

| $-\pi/4$ | $-\pi/4$ | $-\pi/4$ | $-\pi/4$ | $-\pi/4$ | $-\pi/4$ | $-\pi/4$ | $-\pi/4$ |

4.4.6 R

The R (Ramp) field denotes a power ramp up or a power down interval, and is 3 symbols (6 bits) in duration.

4.4.7 RSVD

The RSVD (Reserved) is comprised of two bits set to 11.

4.4.8 CSFP

The CSFP (Coded Superframe Phase) field is used to convey information regarding the Superframe Phase (SFP) so that mobile stations can find the start of the superframe (see Section 4.5). The content in this field may also be used to discriminate between DCCH and DTC in that the CSFP of a DCCH and CDVCC of a DTC have no common codewords. This is accomplished by using the same basic coding method together with inverting the checkbits of all CSFP codewords before transmittal. The field is 12 bits in length.

The channel encoding of the SFP into CSFP is similar to how DVCC is handled in IS-136.2 (i.e., a (12,8) code). The LSB of SFP is d0. The bits d7, d6 and d5 are reserved and all set to zero (000). After the encoding, according to the IS-136.2 CDVCC process (see Section 1.2.5 of IS-136.2), the check bits b_3, b_2, b_1, b_0 are all inverted (and denoted $\bar{b}_3$, $\bar{b}_2$, $\bar{b}_1$, $\bar{b}_0$) before forming the resulting CSFP information. The bits are transmitted as follows:

Figure 4 - 9 CSFP Bit Allocation

d_7	d_6	d_5	d_4	d_3	d_2	d_1	D_0	$\bar{b}_3$	$\bar{b}_2$	$\bar{b}_1$	$\bar{b}_0$
BP_{171}	BP_{172}	BP_{173}	BP_{174}	BP_{175}	BP_{176}	BP_{177}	BP_{178}	BP_{179}	BP_{180}	BP_{181}	BP_{182}

4.4.9 SYNC

See IS-136.2, Section 1.2.4.

4.4.10 SYNC+

The SYNC+ field provides additional synchronization information to improve base station receiver performance.
The SYNC+ word is specified by the following phase changes in radians:

$\pi/4$	$-\pi/4$	$3\pi/4$	$-3\pi/4$	$-\pi/4$	$-\pi/4$	$-3\pi/4$	$3\pi/4$	$3\pi/4$	$\pi/4$	$\pi/4$	$-\pi/4$

4.4.11 Transmit Offset

At the mobile station, the offset between the forward and reverse slots/bursts shall always be 207 symbol periods as no time advance is applied on the DCCH (see Section 1.2.1 of IS-136.2).

4.5 Superframe

Each superframe (SF) on the FDCCH is comprised of an ordered sequence of logical channels as shown in Figure 4-10. The number of slots that can be supported for each logical channel is as shown in Table 4-1. It should be noted that the total number of slots per superframe is 32 for a full-rate DCCH and 16 for a half-rate DCCH.

Figure 4 - 10 Superframe Structure

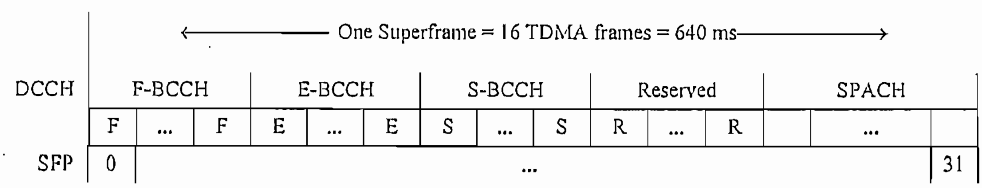


Table 4 - 1 Slot Allocations

	Full-Rate DCCH		Half-Rate DCCH	
	Min	Max	Min	Max
F-BCCH (F)	3	10	3	10
E-BCCH (E)	1	8	1	8
S-BCCH (S)	0	15	0	11
Reserved (R)	0	7	0	7
SPACH (Note 1)	2	28	2	12

Note 1: Some SPACH slots may be restricted from allocation as PCH Subchannels (see Sections 4.10.2 and 6.4.1.1.1.1).

The SFP increments every TDMA block. SFP starts at 0 on the first F-BCCH slot and counts modulo 32. For a half-rate DCCH only slots with even SFP numbers are used.
The first slot in a SF (SFP = 0) shall be allocated to the first F-BCCH slot (see Figure 4-10). If more than one DCCH is allocated on a given frequency, the start of the SFs must occur in the same TDMA block (i.e., SF synchronization is required).

4.6 Hyperframe

A Hyperframe consists of two superframes: one primary and one secondary. Every PCH in the primary Superframe is always repeated in the secondary Superframe. The SPACH information, excluding PCH information, may be different from SF to SF (see Figure 4-11).
The *F-BCCH* carries the same information in every Superframe on a given DCCH. The E-BCCH information may be different from SF to SF, as the information repeats after a certain period. The length of the E-BCCH cycle is indicated by the L2 ECL field.

Any change in the F-BCCH or E-BCCH information elements, except those in Section 6.5 indicated as non-critical, shall take effect in the next Hyperframe. If a change occurs, notification shall be provided by transitioning the L2 BCN flag in all SPACH slots in the preceding Hyperframe.
F-BCCH includes an E-BCCH change flag (EC), which transitions to indicate if the E-BCCH information has changed beginning with the current hyperframe.
F-BCCH also includes an F-BCCH change flag (FC), which transitions to indicate if the F-BCCH information has changed beginning with the current hyperframe.

Figure 4 - 11 Hyperframe Structure

Hyperframe 0										Hyperframe 1				
Superframe 0 primary					Superframe 1 Secondary					Superframe 2 primary				
F	E^0	S^0	R	$SPACH^i$	F	E^1	S^1	R	$SPACH^j$	F	E^2	S^2	R	$SPACH^k$

- F denotes F-BCCH
- E denotes E-BCCH
- S denotes S-BCCH
- R denotes Reserved

SPACH can be PCH, ARCH or SMSCH

If SPACH is equal to PCH, then $j = i$ and $k = i + 1$;

Else $j = i + 1$ and $k = i + 2$.

4.7 Paging Frame

There are two terms used in determining PF class:

- Assigned PF class
- Current PF class

A mobile station shall use PFC_1 (see Figure 4-12) as its Assigned PFC prior to initially registering. Once a mobile station has successfully registered on its serving BMI it shall continue using PFC_1 as its Assigned PFC unless the serving BMI assigns it a new PFC.
The highest PFC supported by the BMI is broadcast on the F-BCCH in MAX_SUPPORTED_PFC. If the MAX_SUPPORTED_PFC is less than its Assigned PFC, the mobile station shall set its Assigned PFC to MAX_SUPPORTED_PFC.
It should be noted that a mobile station having an Assigned PFC of N (where N is greater than 1) is also capable of supporting Paging Frame Classes PFC_1 through PFC_{N-1}.
If the Paging Frame Modifier (PFM) transmitted on the SPACH (see Section 5.2.5) is set to 0, the Current PFC, which is used to index paging frames, is equal to the Assigned PFC.

If PFM = 1 and PFM Direction = 1 (push out) then:

> A mobile station capable of supporting one PFC higher than its Assigned PFC shall set its Current PFC to its Assigned PFC + 1 as long as the MAX_SUPPORTED_PFC is not exceeded. If its Current PFC = PFC_8, it shall remain at PFC_8.

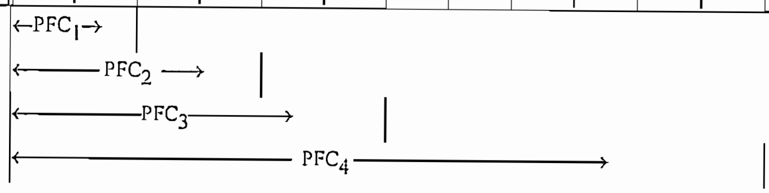
If PFM = 1 and PFM Direction = 0 (pull in) then:

> The mobile shall set its Current PFC to one PFC less than its Assigned PFC unless its Assigned PFC = PFC_1 in which case its Current PFC is not changed.

A Hyperframe counter (HFC) and Primary SF indicator are provided in the BCCH. Optionally, an Extended Hyperframe Counter (EHFC) may also be provided in the BCCH. The HFC counts modulo 12, and the EHFC counts modulo 8. The EHFC is required in order to support PFC > 5.

Figure 4 - 12 Paging Frame Classes 1, 2, 3, 4

HFC	0		1		2		3		4		5		6	
SF	0	1	2	3	4	5	6	7	8	9	10	11	12	13
PFC_1	p	s	p	s	p	s	P	S	p	s	p	s	p	s
PFC_2	p	s	-	-	p	s	-	-	p	s	-	-	p	s
PFC_3	p	s	-	-	-	-	P	S	-	-	-	-	p	s
PFC_4	p	s	-	-	-	-	-	-	-	-	-	-	p	s



HFC = Hyperframe Counter
SF = Superframe
PFC = Paging Frame Class
P = Primary PCHs
S = Secondary PCHs

The secondary PCH is always transmitted in the same hyperframe as the corresponding primary PCH. Examples of PCH assignment which are aligned to HFC = 0 are shown in Figure 4-12. It should be noted that for PFC greater than 1, alignment with any HFC value is possible.

The valid Paging Frame Classes are defined in Table 4-2.

Table 4 - 2 Paging Frame Classes Definition

PFC	PFN (Paging Frame Number) (Periodicity In HF)
1	1
2	2
3	3
4	6
5	12
6	24
7	48
8	96

A paging frame is therefore defined as the number of hyperframes over which a mobile station has a single instance of PCH allocation.

4.8 PCH Displacement

PCH Displacement is the process by which the BMI directs a mobile station to continue reading a number of SPACH slots after it first reads its assigned PCH Subchannel. Whenever a mobile station reads its assigned PCH Subchannel and determines that there is no message addressed to its MSID, it shall read the PCON bit carried in that slot. If the PCON bit is set to 0 the mobile station may sleep until the next occurrence of its assigned PCH Subchannel. When the BMI activates PCH Displacement (PCON = 1), the mobile station shall respond by reading additional SPACH slots as determined by the PCH_DISPLACEMENT parameter sent in the DCCH Structure message (see Section 6.4.1.1.1.1).

When PCH Displacement is activated on a full-rate DCCH, the mobile station shall read every other SPACH slot after its assigned PCH Subchannel until PCH_DISPLACEMENT additional SPACH slots have been read or it receives a page message addressed to its MSID. For the case where a mobile station has read the last SPACH slot in a primary superframe and PCH_DISPLACEMENT still requires additional SPACH slots to be read, it shall read the second SPACH slot in the next primary superframe. For the case where a mobile station has read the second to last SPACH slot in a primary superframe and PCH_DISPLACEMENT still requires additional SPACH slots to be read, it shall read the first SPACH slot in the next primary superframe.

When PCH Displacement is activated on a half-rate DCCH, the mobile station shall read every SPACH slot after its assigned PCH Subchannel until PCH_DISPLACEMENT additional SPACH slots have been read or it receives a page message addressed to its MSID.

The PCH Displacement process defined herein shall not be affected by the Number of Non-PCH Subchannel Slots parameter sent in the DCCH Structure message (see Section 6.4.1.1.1.1), i.e., any slots that have been restricted from allocation as PCH Subchannels shall still be read according to PCH displacement rules when PCON = 1.

An example of PCH Displacement activation on a full-rate DCCH for a mobile station having a PCH Subchannel corresponding to SFP = 27 is shown in Figure 4-13. The mobile station determines that there is no message addressed to its MSID in its PCH Subchannel,

PCON = 1 and the BMI has set PCH_DISPLACEMENT to 4. The mobile station proceeds to read SPACH slots corresponding to SFP = 29 and 31 in the first primary superframe without receiving a message addressed to its MSID. The mobile station continues to read SPACH slots corresponding to SFP = n + 1 and n + 3 in the second primary superframe without receiving a message addressed to its MSID. At the point where PCH_DISPLACEMENT additional SPACH slots have been read, the mobile station may sleep until the next occurrence of its assigned PCH Subchannel.
Note that each L2 Frame having a BU (see Table 5-7) set to Hard Triple Page, Hard Quadruple Page, Hard Penta Page or PCH Burst (see Section 5.2.5.1) sent in the primary superframe is repeated in the secondary superframe in the slot having the same SFP value. For this example a total of n-1 BCCH slots have been allocated.

Figure 4 - 13 PCH Displacement

Primary SF							Secondary SF		Primary SF						
BCCH	SPACH						BCCH	SPACH	BCCH	SPACH					BCCH
		X		X		X					X		X		
SFP	...	27	28	29	30	31				n	n+1	n+2	n+3	...	

4.9 SPACH Message Continuation

SPACH Continuation is the process by which the BMI sends a message over multiple SPACH slots. A mobile station shall respond to SPACH Message Continuation whenever it determines that a message addressed to its MSID has been sent by the BMI over multiple SPACH slots. A PCH message spanning more than 1 SPACH slot, when sent on a full-rate DCCH, shall be transmitted using every other SPACH slot (i.e., consecutive SPACH slots shall not be used). A PCH message spanning more than 1 SPACH slot, when sent on a half-rate DCCH, shall be transmitted using consecutive SPACH slots. An ARCH or SMSCH message spanning more than 1 SPACH slot shall be transmitted using consecutive SPACH slots unless interrupted (see Section 5.6).
The SPACH Message Continuation process defined herein shall not be affected by the Number of Non-PCH Subchannel Slots parameter sent in the DCCH Structure message (see Section 6.4.1.1.1.1), i.e., any slots that have been restricted from allocation as PCH Subchannels shall still be read according to SPACH Message Continuation rules.
An example of SPACH Message Continuation activation on a full-rate DCCH for a mobile station having a PCH Subchannel corresponding to SFP = 27 is shown in Figure 4-14. The mobile station determines that there is no message addressed to its MSID in its PCH Subchannel, PCON = 1 and the BMI has set PCH_DISPLACEMENT to 4. The mobile station proceeds to read the SPACH slot corresponding to SFP = 29 and receives the first slot of a three SPACH slot PCH message addressed to its MSID. The mobile station next reads the SPACH slot corresponding to SFP = 31 and SFP = n + 1 in the next primary superframe which contains the remainder of the PCH message.
Note that each L2 Frame having a BU (see Table 5-8) set to Hard Triple Page, Hard Quadruple Page, Hard Penta Page or PCH Burst sent in the Primary SF is always repeated in the Secondary SF in the slot having the same SFP value. For this example a total of n-1 BCCH slots have been allocated.

Figure 4 - 14 SPACH Message Continuation (PCH)

Primary SF							Secondary SF		Primary SF						
BCCH	SPACH						BCCH	SPACH	BCCH	SPACH					BCCH
		X		X		X					X				
SFP	...	27	28	29	30	31				n	n+1	n+2	n+3	...	

4.10 Mobile Station PCH Allocation

Each mobile station shall be allocated a specific PCH Subchannel, within its paging frame on a specific DCCH. The available PCH Subchannels and DCCHs can be identified by the DCCH parameters broadcasted on BCCH.

A mobile station may calculate its assigned PCH Subchannel using either its User Group ID (UGID) or its Permanent Mobile Station Identity (PMSID) which can be a MIN or an IMSI. If User Group operation is activated (see Sections 6.3.10 and 8.4) and the current DCCH supports User Group operation (see Service Menu in Section 6.4.1.2.2.4), the mobile station shall calculate its assigned PCH Subchannel using the UGID value as included in the User Group information element. Otherwise, the mobile station shall calculate its assigned PCH Subchannel using its PMSID determined as follows:

- If a mobile station has an IMSI (see Section 8.1.1) but does not have a MIN (see Section 8.1.3), then IMSI shall be used for PCH Subchannel determination purposes.
- If a mobile station has a MIN but does not have an IMSI, then MIN shall be used for PCH Subchannel determination purposes.
- If a mobile station has both a MIN and an IMSI, then whichever of the two it used for its last successful registration shall determine its PCH Subchannel.

- If a mobile station has both a MIN and IMSI but is precluded from registering on its serving BMI (see Section 6.3.7), then MIN shall be used for PCH Subchannel determination purposes.
- If a mobile station has both a MIN and an IMSI, and one has been rejected since its last successful registration, then the unrejected PMSID shall be used for PCH Subchannel determination purposes.
- Registrations made using TMSI do not affect the PCH Subchannel determination process.

A mobile station shall therefore only monitor a single PCH Subchannel as determined by either UGID or PMSID. If UGID is used to determine its assigned PCH Subchannel, a mobile station shall still search for PMSID or TMSI based MSID frames as well as User Group frames. If PMSID is used to determine the assigned PCH Subchannel, and User Group operation is activated, a mobile station shall search for either PMSID or TMSI based MSID frames as well as User Group frames.
The 16 least significant bits of the selected UGID or PMSID are referred to as PAID in Sections 4.10.1, 4.10.2 and 4.10.3.

4.10.1 DCCH Selection

Each mobile station is hashed to a DCCH in a cell according to its PAID, the number of DCCHs in the cell, and the number of slots allocated to the DCCHs. A hashing algorithm, which yields exactly one DCCH channel and slot assignment for a given PAID, is described in the following paragraphs. Note that this algorithm is provided to describe the requirements for DCCH selection but does not mandate a specific implementation. Any algorithm that selects the same DCCH channel and slot combination for a given PAID as this algorithm shall be considered to meet the requirements for DCCH selection.

The hashing process consists of three steps:

- The information required to perform DCCH selection must be computed or obtained from layer 3.
- An ordered list of DCCHs in a cell is assembled.
- Using its PAID, the mobile station selects the appropriate DCCH channel and slot from the ordered list.

This hashing algorithm requires that the following information be computed or obtained from the DCCH Structure and Control Channel Selection Parameters messages (see Sections 6.4.1.1.1.1 and 6.4.1.1.1.3):

- The total number of channels in a cell that contain a DCCH (NC). Nominally, NC is 1 (for the current DCCH.) However, if the optional information element Additional DCCH Information was provided, then NC is 2 + the value in the Number of Additional DCCH Channels field.
- The channel number (C_i; i = 1..NC) for every DCCH in the cell, including the current DCCH. For other than the current DCCH, C_i shall be obtained from the DCCH Channel field in the Additional DCCH Information information element.
- The slot configuration (S_i; i = 1..NC) and the number of slots (NS_i; i = 1..NC) for each channel C_i containing a DCCH. For the current DCCH, S_i is the value in the Slot Configuration information element. For other than the current DCCH, S_i is the value in the Slot Configuration field obtained from the Additional DCCH Information information element. In either case, NS_i is computed as follows:

$$NS_i = \begin{cases} 1, & \text{if } S_i = 0; \\ 2, & \text{if } S_i = 1; \\ 4, & \text{if } S_i = 2; \\ 6, & \text{if } S_i = 3. \end{cases}$$

- The total number of slots (NS) allocated to the DCCHs in the cell. NS shall be computed as follows:

$$NS = \sum_{i=1}^{NC} NS_i$$

Once all of the necessary information is available, the list of DCCH channel numbers, C_i; i = 1..NC, shall be sorted in ascending order. The slot configuration list, S_i; i = 1..NC, and number of slots list, NS_i; i = 1..NC, shall be similarly ordered so that the original relationship between channel C_i and its slot information lists, S_i and NS_i, is preserved.

Using the sorted lists C_i, S_i, and NS_i, the algorithm to perform DCCH channel and slot selection is as follows:

```
SLOT_COUNT = 0
LOOP (i = 1..NC) over each channel containing a DCCH
     LOOP (j = 1..NSi) over each DCCH slot on this channel
```

```
            SLOT_COUNT = SLOT_COUNT + 1
            IF SLOT_COUNT = (PAID mod NS) + 1
            THEN
                the selected DCCH channel shall be Cj, and the DCCH rate and slot assignment for the
                selected DCCH shall be obtained from Table 4-3 using the current values of slot index (j)
                and Slot Configuration (Sj)
            END IF
        END LOOP
    END LOOP
```

Table 4 - 3 Selected DCCH Rate and Slot Assignment

Slot Index (j)	Slot Configuration (S_j)	Assigned Slots	Rate
1	0	1	half-rate
1	1, 2, or 3	1 and 4	full-rate
2	1, 2, or 3	1 and 4	full-rate
3	2 or 3	2 and 5	full-rate
4	2 or 3	2 and 5	full-rate
5	3	3 and 6	full-rate
6	3	3 and 6	full-rate

4.10.2 PCH Subchannel Selection

For its selected DCCH, a mobile station is assigned to a PCH Subchannel within the superframe according to the following algorithm:

Case 1: Half-rate

PCH_SUBCH = [[(PAID div NS) mod NP] + NB] * 2

NP = [(16-NB)-NNP]

Case 2: Full rate

PCH_SUBCH = [(PAID div NS) mod NP] + NB

NP = [(32-NB) - (NNP * 2)]

where:

PCH_SUBCH = SFP of assigned PCH Subchannel

NP = Number of PCH Subchannels per Superframe [NP > 0]

NB = NFB + NEB + NSB + NR

NFB = Number of F-BCCH slots per Superframe

NEB = Number of E-BCCH slots per Superframe

NSB = Number of S-BCCH slots per Superframe

NR =Number of Reserved slots per Superframe

NNP = value in Number of Non-PCH Subchannel Slots

NS = Number of Slots computed in Section 4.10.1

4.10.3 Hyperframe Selection

For its selected DCCH, a mobile station need only read its assigned PCH Subchannel in a hyperframe for which the following condition is satisfied:

[(PAID div NS) div NP] mod PFN = (HFC + EHFC * 12) mod PFN where: PFN = Paging Frame Number (1,2,3,6,12,24,48,96) corresponding to the PFC of the mobile station (see Section 4.7).

HFC = Hyperframe Counter (broadcast on BCCH)

EHFC = Extended Hyperframe Counter (optionally broadcast on BCCH). If EHFC is not present on the BCCH, a EHFC default value of 0 is used

NS = Number of Slots computed in Section 4.10.1

NP = Number of PCH slots computed in Section 4.10.2.

4.11 Subchanneling of the RACH

4.11.1 General

RACH subchanneling exists in order to allow sufficient processing time at both the mobile station and base station in conjunction with a random access event. In the interest of consistent performance, it is required that the SCF response time be the same for both a full-rate and half-rate DCCH. In order to accomplish this the full-rate DCCH has been defined to consist of six RACH subchannels, and the half-rate DCCH has been defined to consist of three RACH subchannels.

4.11.2 SCF Flags - RDCCH and FDCCH Burst Associations

The SCF flags are carried in FDCCH time slots and serve to indicate the BMI reception status of bursts sent previously on the RDCCH. The SCF flags are also used to indicate the availability status (i.e., Busy/Reserved/Idle) of their corresponding RDCCH bursts (see Section 5.3.2.1.1). A mobile station having an access pending reads SCF flags to determine when to begin its access attempt.

If a full-rate DCCH exists then its RDCCH bursts and FDCCH slots are multiplexed so as to create 6 distinct access paths as shown in Figure 4-15. Assuming that path 1 (P1) in the FDCCH indicates that the next P1 burst in the RDCCH is available (i.e., Idle) and is selected for an access attempt, a mobile station shall begin sending the first burst of its access at that time (64.8 ms after receiving the full P1 slot in the FDCCH). The mobile station shall then begin reading the SCF flags in the next P1 FDCCH slot (41.8 ms after completing transmission of its access burst) to determine the BMI reception status of its initial access burst.

It should be noted that the SCF information carried in any given FDCCH slot is completely independent of the layer 3 information carried therein as the SCF flags occupy bandwidth completely separate from that assigned for BCCH, PCH, ARCH or SMSCH purposes. It should also be noted that for RACH purposes, 6 distinct access paths will always exist for a full-rate DCCH and 3 distinct access paths will always exist for a half-rate DCCH. The access paths associated with one DCCH are completely distinct from those associated with any other DCCH (such that a mobile station assigned to a given DCCH will never make an access attempt using the access paths associated with any other DCCH).

Figure 4-16 shows the relationship between FDCCH SCF flags and RDCCH bursts. The arrows show the order of events associated with an access attempt. Thus, following the arrows from left to right on RACH subchannel P1, the BRI portion of the SCF flags first indicates the availability of the next P1 burst in the RDCCH. If a burst is transmitted in that RDCCH burst, then the mobile station reads the R/N portion of the SCF flags in the next P1 FDCCH slot to determine the BMI reception status of its transmitted burst. For the case of the first burst of a random access the mobile station also reads the PE portion of the SCF flags to determine whether or not its particular access was captured. The BMI sets the PE value to reflect the captured mobile station access. If the mobile station determines that its access was captured based on PE and that the R/N flag indicates received, it proceeds to send any additional bursts it has pending beginning in the next P1 burst in the RDCCH.

Figure 4 - 15 RACH Subchannels

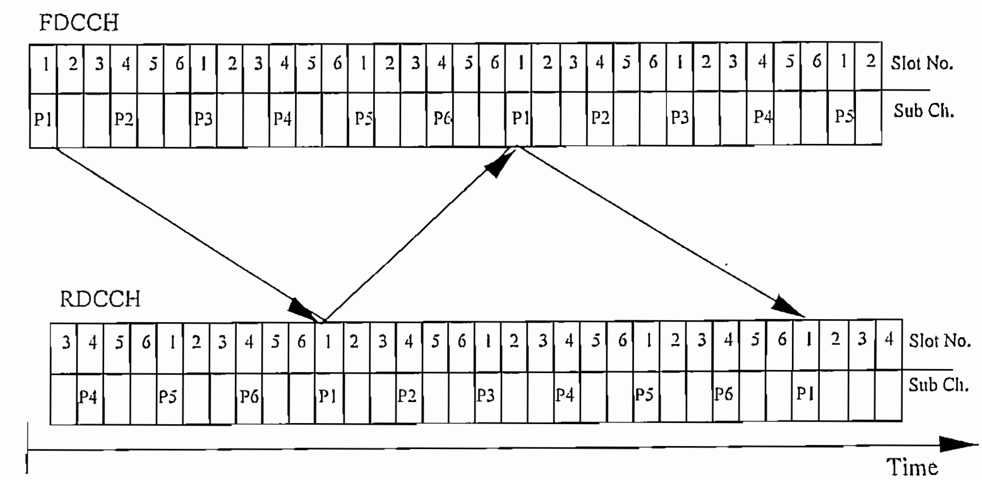
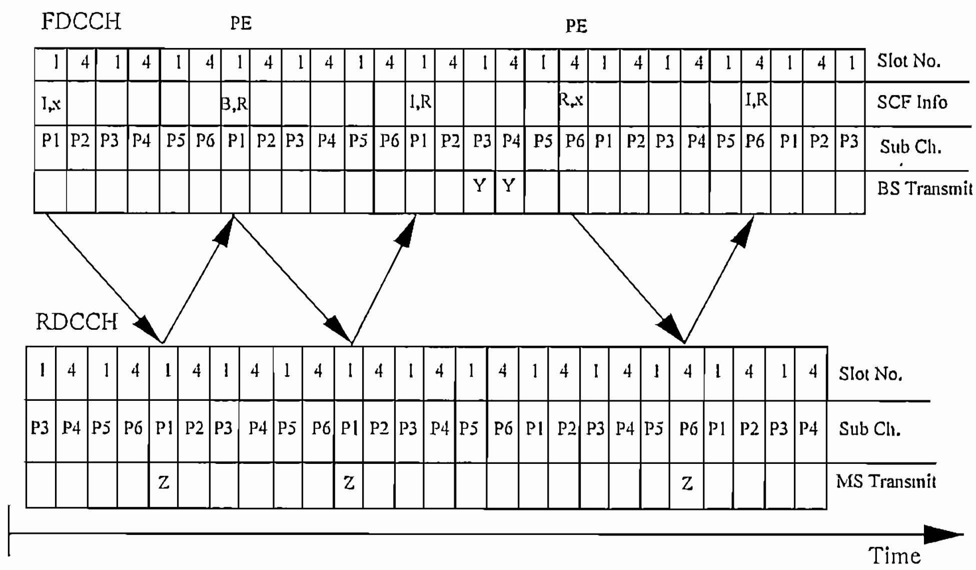


Figure 4-15 shows the RACH subchannels that are used in the case of a full-rate DCCH. For a half-rate DCCH only RACH subchannels P1, P3 and P5 are used.

In Figure 4-16 an example of a dialogue between a mobile station and the BMI is illustrated for the case of a full-rate DCCH. The mobile station makes a contention based access, transmitting a total of two bursts and checking the PE after sending the first burst. The mobile station transmits in the RDCCH bursts marked with a Z. The mobile station begins looking for an access response from the BMI (e.g., an ARCH message) after successfully completing an access. The BMI then responds with a message sent over two FDCCH slots (marked with a Y) within the expected time frame. Finally the mobile station makes a reservation based access (at the discretion of the BMI), sending a single burst message in the RDCCH. Relevant SCF flag values are also shown in Figure 4-16.

Figure 4 - 16 RACH Subchannel Dialogue



Notes:

1. "x" means "don't care".
2. "Z" means "transmit occasions for the mobile station".
3. "Y" means "base station response".
4. The first field of SCF info represents the BRI value and the second field represents the R/N value.

5. Layer 2 Operation

5.1 Service Access Points

The description of Service Access Points is included to aid the understanding of the structure of the standard and should not be regarded as mandatory for implementation on the mobile station or BMI side.

Layer 2 provides the following Service Access Points (SAPs) to layer 3. Refer to Figures 2-1, 2-2 and 5-1 for the BMI, MS Protocol Reference models, and for the layer 2 primitives on the mobile station and BMI.

MS Side:

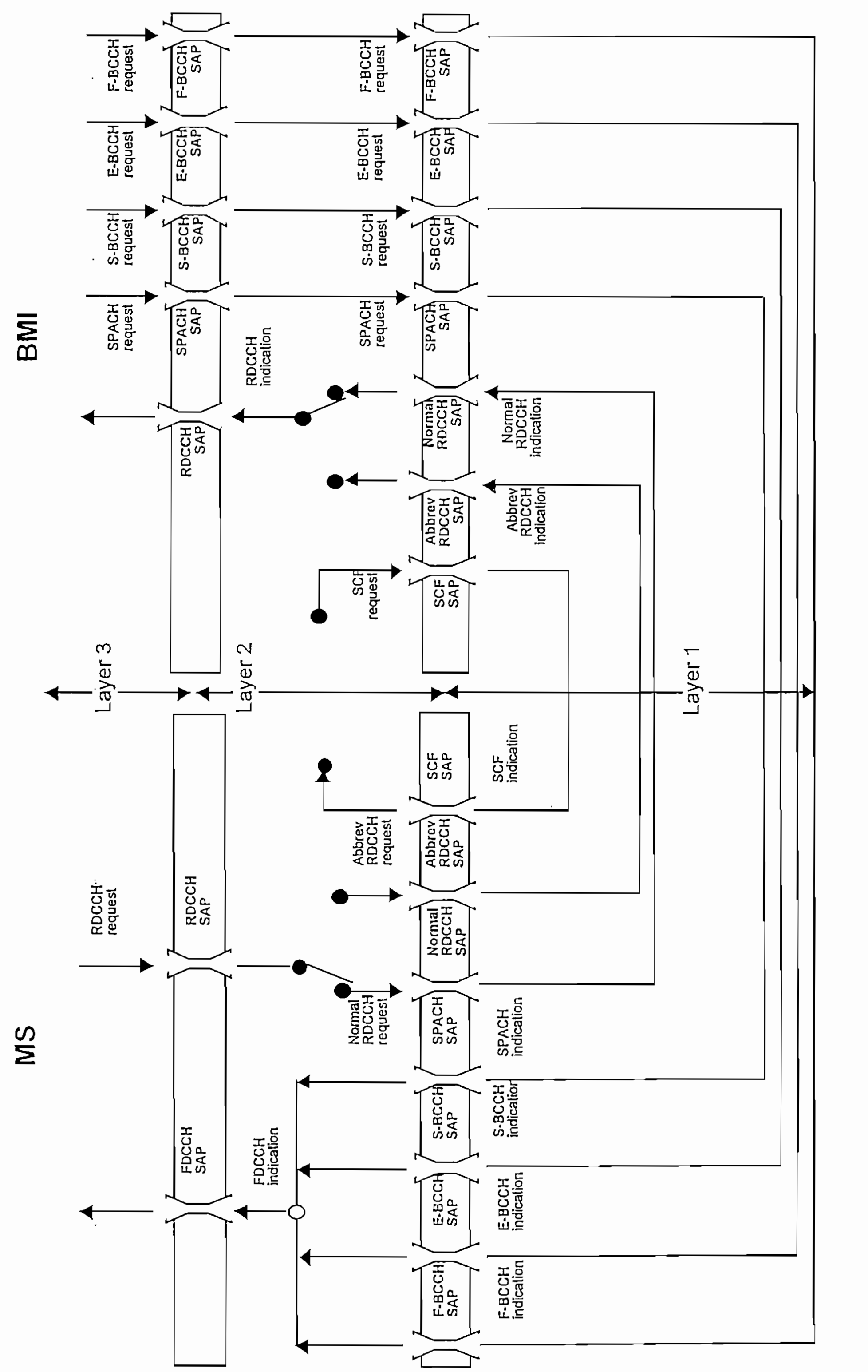
- A Forward DCCH Service Access Point (FDCCH SAP)
- A Reverse DCCH Service Access Point (RDCCH SAP).

BMI Side:

- A Fast Broadcast Channel Service Access Point (F-BCCH SAP)
- An Extended Broadcast Channel Service Access Point (E-BCCH SAP)

- A Broadcast Short Message Service Access Point (S-BCCH SAP)
- An SMS Point-to-Point, Paging and Access Response Channel Service Access Point (SPACH SAP)
- A Reverse DCCH Service Access Point (RDCCH SAP).

Figure 5 - 1 Primitives and SAP From a Layer 2 Perspective



5.1.1 MS Primitives

5.1.1.1 RDCCH Request

The RDCCH Request primitive is sent from layer 3 to layer 2 in order to initiate a mobile station access attempt on the RACH. This primitive contains the following information:

- One or more layer 3 messages reflecting the total number of coincidental layer 3 messages associated with an access attempt (see Section 6.4). All such layer 3 messages shall be concatenated at layer 2 using the number of layer 3 messages (NL3M) field to indicate the total number of concatenated messages. All concatenated layer 3 messages shall therefore be sent during the same access attempt.
- A Layer 3 Length Indicator (L3LI) for each layer 3 message included within the RDCCH Request primitive. Each instance of L3LI identifies the length, in octets, of its corresponding layer 3 message.
- A message encryption indicator (algorithm and key) used to identify the specific form of encryption applicable to all layer 3 messages that are subject to message encryption and included within the RDCCH Request primitive. Layer 3 messages included within the RDCCH Request primitive that are not subject to message encryption are therefore not affected by the status of the message encryption indicator (i.e., always sent without any message encryption applied).

Upon layer 2 determination of an access success/failure condition (see Section 5.3.3), layer 2 shall indicate the access success/failure status to layer 3.

5.1.1.2 FDCCH Indication

The FDCCH Indication primitive is sent from layer 2 to layer 3 whenever a mobile station correctly receives a layer 3 message that is either broadcasted or addressed to it on any of the following FDCCH channels:

- F-BCCH
- E-BCCH
- S-BCCH
- SPACH.

- F-BCCH and E-BCCH

  These channels provide no addressing at layer 2 and as such all received layer 2 frames shall be accepted and processed by a mobile station while in the DCCH Camping state (see Section 6.2.3). When a complete layer 3 message is recovered from received frames, layer 2 sends a FDCCH Indication primitive to layer 3 and includes the following information:

  - A layer 3 message as defined in Section 6.4.
  - A L3LI providing the layer 3 message length in octets.
  - A BCCH (F-BCCH/E-BCCH) message indication.

- S-BCCH

  For further study.

- PCH

  A mobile station listens to its assigned PCH Subchannel (see Section 4.10) while in the DCCH Camping, Registration Proceeding, Origination Proceeding, Terminated Point-to-Point Teleservice Proceeding, SSD Update Proceeding and the Originated Point-to-Point Teleservice Proceeding state. This SPACH channel provides addressing at layer 2 so that received layer 2 frames shall only be accepted and processed by a mobile station if the layer 2 address information matches its own (see Section 5.2.5).
  A mobile station having a valid TMSI (see Section 8.1.2.2) need only recognize a TMSI based MSID type. A mobile station not having a valid TMSI shall only recognize a PMSID based MSID type. The last successful registration made using a PMSID shall determine which instance of PMSID (MIN or IMSI) a mobile station will recognize.
  For the case of a received Hard Triple/Quadruple/Penta Page frame (see Section 5.2.5.1), a mobile station shall attempt to match its MSID against the MSIDs contained in the received layer 2 frame. If a matching MSID is found, layer 2 sends a FDCCH Indication primitive to layer 3 including the following indications:

- A PCH message indication.
- A Hard Page indication.

For the case of a received Single/Double/Triple/Quadruple MSID frame (see Section 5.2.5.1), a mobile station having a matching MSID shall process the received layer 2 frame(s). When a complete layer 3 message is recovered from received frames, layer 2 sends a FDCCH Indication primitive to layer 3 and includes the following information:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.
- A PCH message indication.
- An MSID indication.

For the case of a received User Group frame (see Section 5.2.5.1), a mobile station shall attempt to match its enabled User Group ID against the User Group ID contained in the received layer 2 frame. If a User Group match is found, layer 2 sends a FDCCH Indication primitive to layer 3 including the following information:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.
- A PCH message indication.
- A User Group indication.

- ARCH

A mobile station listens to the ARCH when expecting a response to certain access attempts. This SPACH subchannel provides addressing at layer 2 so that received layer 2 frames shall only be accepted and processed by a mobile station if the layer 2 MSID address information matches its own. A mobile station having a valid TMSI (see Section 8.1.2.2) need only recognize a TMSI based MSID type. A mobile station not having a valid TMSI shall only recognize a PMSID based MSID type. The last successful registration made using a PMSID shall determine which instance of PMSID (MIN or IMSI) a mobile station will recognize.
For the case of a received Single/Double/Triple/Quadruple MSID frame (see Section 5.2.5.1), a mobile station having a matching MSID shall process the received layer 2 frame(s). When a complete layer 3 message is recovered from received frames, layer 2 sends a FDCCH Indication primitive to layer 3 and includes the following information:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.
- An ARCH message indication.
- An MSID indication.

For the case of a received User Group frame (see Section 5.2.5.1), a mobile station shall attempt to match its enabled User Group ID against the User Group ID contained in the received layer 2 frame. If a User Group match is found, layer 2 sends a FDCCH Indication primitive to layer 3 including the following information:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.
- An ARCH message indication.
- A User Group indication.

- SMSCH

A mobile station listens to the SMSCH when it expects to receive a terminating Point-to-Point SMS message. This SPACH subchannel provides addressing at layer 2 so that received layer 2 frames shall only be accepted and processed by a mobile station if the layer 2 MSID address information matches its own. When a complete layer 3 message is recovered from received frames, layer 2 sends a FDCCH Indication primitive to layer 3 and includes the following information:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.
- An SMSCH message indication.

A mobile station having a valid TMSI (see Section 8.1.2.2) shall only recognize a TMSI based MSID type. A mobile station not having a valid TMSI shall only recognize a PMSID based MSID type. The last successful registration made using a PMSID shall determine which instance of PMSID (MIN or IMSI) a mobile station will recognize.

5.1.2 BMI Primitives

5.1.2.1 RDCCH Indication

The RDCCH Indication primitive is sent from layer 2 to layer 3, and is used to carry layer 3 messages received from a mobile station on the RACH.

The RDCCH Indication primitive includes the following protocol elements:

- One or more layer 3 messages as defined in Section 6.4.
- One or more L3LIs providing the layer 3 message length in octets.
- Mobile Station ID (MSID).
- Mobile Station ID Type (IDT), defining the MSID format, as defined in Table 5-2.
- A message encryption indicator (algorithm and key) used to identify the specific form of encryption applicable to the received layer 3 messages that are subject to encryption.

5.1.2.2 F-BCCH Request

The F-BCCH Request primitive is sent from layer 3 to layer 2, and is used to carry the layer 3 messages to be sent on the F-BCCH.

The F-BCCH Request primitive includes the following protocol elements:

- A layer 3 message as defined in Section 6.4.
- A L3LI providing the layer 3 message length in octets.

5.1.2.3 E-BCCH Request

The E-BCCH Request primitive is sent from layer 3 to layer 2, and is used to carry the layer 3 messages to be sent on the E-BCCH.

The E-BCCH Request primitive includes the following protocol elements:

- A layer 3 message as defined in Section 6.4.
- Layer 3 Length Indicator, providing the overall layer 3 message length in octets (L3LI). There shall be one L3LI per layer 3 message.

5.1.2.4 S-BCCH Request

For further study.

5.1.2.5 SPACH Request

The SPACH Request primitive is sent from layer 3 to layer 2, and is used to page mobile stations and send layer 3 messages to selected mobile stations on the PCH, ARCH or SMSCH.

The SPACH Request primitive includes the following protocol elements:

- Layer 3 messages, as defined in Section 6.4, may be included.
- If layer 3 messages are included, then L3LI shall also be included to provide the layer 3 message length in octets.
- Up to 5 MSIDs.
- One IDT defining the MSID format, as defined in Table 5-7.

- A Polling Indicator (PI) used to indicate whether or not an ARQ STATUS frame is required (see Table 5-7).
- The burst usage (BU) to discriminate if the SPACH Request is intended to be on the PCH, the ARCH or SMSCH.
- A message encryption indicator (algorithm and key) used to identify the specific form of encryption applicable to the received layer 3 message included in the SPACH Request primitive.

The ARQ transmission mode is not allowed on the PCH. Table 5-1 shows the restrictions regarding the transmission mode for different BU types:

Table 5 - 1 Layer 2 Transmission Mode Restrictions

	Layer 2 Acknowledged	Layer 2 Unacknowledged
BU = PCH	Not allowed	Allowed
BU = ARCH	Allowed	Allowed
BU = SMSCH	Allowed	Allowed
BU = Null	Not allowed	Allowed
BU = Hard Triple Page	Not allowed	Allowed
BU = Hard Quadruple Page	Not allowed	Allowed
BU = Hard Penta Page	Not allowed	Allowed

If this SPACH request has BU indicating PCH, ARCH or SMSCH, the maximum length of a layer 3 message to be sent is limited by the L3LI (i.e., 255 octets).

5.2 Protocols

The layer 2 protocols used for FDCCH operation are defined to support the sending of layer 3 messages on the SPACH (SMSCH, PCH and ARCH), F-BCCH, E-BCCH, and the S-BCCH. The layer 2 protocol includes support for an ARQ mode of operation for the SMSCH and ARCH.
The layer 2 protocol used for RDCCH operation is defined to support the sending of layer 3 messages on the RACH using Shared Channel Feedback (see Section 4.11.2). Because of the Shared Channel Feedback (SCF) defined for random access channel operation, no further ARQ capability is explicitly built into RACH layer 2 protocol.
The layer 2 protocol frames identified herein are always logically transmitted beginning with the left most bit of a frame and ending with the right most bit of a frame.

5.2.1 RACH Protocol

The RACH layer 2 protocol is used on the RDCCH where all TDMA bursts are used to carry RACH information. A RACH layer 2 protocol frame shall be constructed to fit within a 117/95 (normal/abbreviated) bit envelope (see Section 4.4.3.1). An additional 5 bits are reserved for use as tail bits resulting in a total of 122/100 (normal/abbreviated) bits of information carried within each RACH burst. The layer 2 protocol defined for RACH operates using the Shared Channel Feedback mechanism and as such supports only an ARQ like operation. Figures 5-3 through 5-16 below shows examples of possible RACH layer 2 frames. For a complete set of RACH layer 2 frames, see Annex C. A summary of the fields comprising layer 2 protocol frames for RACH operation are provided in Table 5-2. Multiple L3 messages may be sent in one transaction.
The Extension Header (see Figure 5-2) contains supplementary header information used to identify the Message Encryption Mode used. This header is present when the Extension Header Indicator (EHI) is set to 1. The EHI field is not present in the SPACH ARQ STATUS Frame. The position of the Extension Header, if present, follows immediately after the EHI field.

Figure 5 - 2 Extension Header

MEA =XX	MEK = XX	RSVD = 0
2	2	1

5.2.1.1 Normal Length Protocol Frames

When BMI broadcast information indicates that normal length bursts are to be sent during a mobile station access procedure, the following layer 2 frames are used. The size of the L3DATA field changes based on the size of MSIDs, the presence of the Extension Header and the number of layer 3 messages indicated by NL3M.

Figure 5 - 3 BEGIN Frame (MSID type TMSI)

BT	IDT	EHI=	MSID	NL3M	L3LI	L3DATA	CRC
= 000	= 00	0	= X..X	=000	= X..X	= X..X	= X..X
3	2	1	20	3	8	64	16

Figure 5 - 4 BEGIN Frame (MSID type MIN)

BT	IDT	EHI =	MSID	NL3M	L3LI	L3DATA	CRC
= 000	= 10	0	= X..X	=000	= X..X	= X..X	= X..X
3	2	1	34	3	8	50	16

Figure 5 - 5 BEGIN Frame (MSID type IMSI and Two Layer 3 Messages)

BT	IDT	EHI =	MSID	NL3M	L3LI1	L3LI2	L3DATA	CRC
= 000	= 11	0	= X..X	=001	= X..X	= X..X	= X..X	= X..X
3	2	1	50	3	8	8	26	16

Figure 5 - 6 CONTINUE Frame

BT	CI	L3DATA	CRC
= 001	= X	= X..X	= X..X
3	1	97	16

Figure 5 - 7 END Frame

BT	RSVD	L3DATA	FILLER	CRC
= 010	= 0	= X..X	= 0..0	= X..X
3	1	←——97——→		16

Figure 5 - 8 BEGIN and END Frame (MSID type MIN)

BT	IDT	EHI =	MSID	NL3M	L3LI	L3DATA	FILLER =	CRC
= 011	= 10	0	= X..X	=000	= X..X	= X..X	0..0	= X..X
3	2	1	34	3	8	←——50——→		16

Figure 5 - 9 SPACH ARQ STATUS Frame

BT	PEA	RSVD	FRNO MAP	FILLER	CRC
= 100	= X..X	= 00	= X..X	= 0..0	= X..X
3	7	2	26	63	16

5.2.1.2 Abbreviated Length Protocol Frames

When BMI broadcast information indicates that abbreviated length bursts are to be sent during a mobile station access procedure, the following layer 2 frames are used. The size of the L3DATA field changes based on the size of MSIDs, the presence of the Extension Header and the number of layer 3 messages indicated by NL3M.

Figure 5 - 10 BEGIN Frame (MSID type TMSI)

BT	IDT	EHI=	MSID	NL3M	L3LI	L3DATA	CRC
= 000	= 00	0	= X..X	= 000	= X..X	= X..X	= X..X
3	2	1	20	3	8	42	16

Figure 5 - 11 BEGIN Frame (MSID type MIN)

BT	IDT	EHI=	MSID	NL3M	L3LI	L3DATA	CRC
= 000	= 10	0	= X..X	=000	= X..X	= X..X	= X..X
3	2	1	34	3	8	28	16

Figure 5 - 12 BEGIN Frame (MSID type IMSI)

BT	IDT	EHI =	MSID	NL3M	L3LI1	L3LI2	L3DATA	CRC
= 000	= 11	0	= X..X	=001	= X..X	= X..X	= X..X	= X..X
3	2	1	50	3	8	8	4	16

Figure 5 - 13 CONTINUE Frame

BT	CI	L3DATA	CRC
= 001	= X	= X..X	= X..X
3	1	75	16

Figure 5 - 14 END Frame

BT	RSVD	L3DATA	FILLER	CRC
= 010	= 0	= X..X	= 0..0	= X..X
3	1	←75→		16

Figure 5 - 15 BEGIN and END Frame (MSID type MIN)

BT	IDT	EHI	MSID	NL3M	L3LI	L3DATA	FILLER =	CRC
= 011	= 10	= 0	= X..X	=000	= X..X	= X..X	0..0	= X..X
3	2	1	34	3	8	←28→		16

Figure 5 - 16 SPACH ARQ STATUS Frame

BT	PEA	RSVD	FRNO MAP	FILLER	CRC
= 100	=X..X	= 00	= X..X	= 0..0	= X..X
3	7	2	26	41	16

5.2.1.3 Frame Usage

BEGIN Frame

A BEGIN frame shall always be sent as the initial frame of a random access transaction requiring two or more frames for its completion. The length of the L3DATA field within a BEGIN frame is variable as it depends on the size of the MSID included within the frame, the presence of the Extension Header, and the number of concatenated layer 3 messages indicated by NL3M. Immediately following the NL3M field are a corresponding number of L3LI fields. If any required L3LI fields cannot fit entirely within the BEGIN frame it is padded with FILLER and the remaining L3LI fields are then included immediately prior to the L3DATA field in the subsequent CONTINUE or END frame. The L3DATA field(s) contains layer 3 message information and begins immediately after the L3LI field(s). One or more complete layer 3 messages may be carried within a BEGIN frame. Additional layer 3 message information which cannot fit within the BEGIN frame is carried in subsequent CONTINUE or END frames.

CONTINUE Frame

A CONTINUE frame shall always be sent as an intermediate frame of a random access transaction requiring three or more frames for its completion. The first CONTINUE frame sent during a RACH transaction is therefore always preceded by a BEGIN frame and the last CONTINUE frame sent is always followed by an END frame. As many CONTINUE frames as needed are sent to complete a multi-frame RACH transaction.

The first CONTINUE frame sent in support of a RACH transaction shall have its CI field set to 0. The mobile station toggles the CI field for every initial transmission of a CONTINUE frame. For any repeated transmission of a CONTINUE frame, the CI value remains the same as its value in the initial transmission of that frame.
The SCF information received in the FDCCH is used by the mobile station to determine whether or not any given CONTINUE frame needs to be resent. If the SCF indicates that a CONTINUE frame was incorrectly received by the BMI, the mobile station shall immediately resend that CONTINUE frame without changing the value of the CI field.

END Frame

An END frame shall always be sent as the last frame of a random access transaction requiring two or more frames for its completion.

BEGIN and END Frame

A BEGIN and END frame shall always be sent when a random access transaction requires only a single frame for its completion. One or more complete layer 3 messages may be carried within a BEGIN and END frame.

SPACH ARQ STATUS Frame

A SPACH ARQ STATUS frame shall be sent to report the partial or complete status of an ARQ based transmission received by the mobile station on the SPACH. A mobile station shall send a SPACH ARQ STATUS frame after receiving an ARQ Mode BEGIN or ARQ Mode CONTINUE frame on the SPACH where the PI field = 1 (see Table 5-7).
The FRNO MAP bit map field = 1 for received or = 0 for not received for each ARQ Mode CONTINUE frame received on the SPACH.

5.2.1.4 RACH Field Summaries

Table 5 - 2 RACH Layer 2 Protocol Field Summary

Field Name	Length (bits)	Values
BT = Burst Type	3	000 = BEGIN 001 = CONTINUE 010 = END 011 = BEGIN and END 100 = SPACH ARQ STATUS 101...111 = Reserved
RSVD = Reserved	½	Set to zero.
CI = Change Indicator	1	Starts at 0, toggles for every new transmitted frame. Stays the same for every repeated frame.
EHI = Extension Header Indicator	1	0 = Extension Header not present 1 = Extension Header is present
IDT = Identity Type	2	00 = 20-bit TMSI 01 = 24-bit TMSI 10 = 34-bit MIN 11 = 50-bit IMSI
MSID = Mobile Station Identity	20/24/34/50	20-bit TMSI 24-bit TMSI 34-bit IS-136.2 MIN 50-bit IMSI
NL3M = Number of Layer 3 Messages	3	000 = 1 layer 3 message 001 = 2 " " " 010 = 3 " " " 011 = 4 " " " ... ... 111 = 8 layer 3 messages
L3LI = Layer 3 Length Indicator (1 to 8 instances may be present)	8	Variable length layer 3 messages supported from 0 up to a maximum of 255 octets.
L3DATA = Layer 3 Data	Variable	Contains a portion (some or all) of the layer 3 message having an overall length as indicated by L3LI. The portion of this field not used to carry layer 3 information is filled with zeros.
PEA = Partial Echo Assigned	7	The 7-bit partial echo value used by a mobile station during an ARQ mode transaction (see Section 5.4.2).

MEA = Message Encryption Algorithm	2	00 = Reserved 01 = " 10 = " 11 = Reserved for SOC/BSMC specific signaling.

RACH Layer 2 Protocol Field Summary (continued)

MEK = Message Encryption Key	2	00 = Reserved 01 = " 10 = " 11 = Reserved for SOC/BSMC specific signaling
FRNO MAP = Frame Number Map	26	A partial or complete bit map representation of the receive status of an ARCH or SMSCH ARQ mode transaction (1 = Frame Received, 0 = Frame Not Received) (see Section 5.4.2)
FILLER = Burst Filler	Variable	All filler bits are set to zero.
CRC = Cyclic Redundancy Code	16	See Section 5.2.6.

5.2.2 F-BCCH Protocol

The F-BCCH layer 2 protocol is used whenever a TDMA slot is used to carry F-BCCH information. The first F-BCCH slot of a superframe must have its SFP value set to zero. All F-BCCH slots in a superframe assume a DVCC value of zero for the purpose of calculating the layer 2 CRC value (see Section 5.2.6). It should be noted that a full cycle of F-BCCH information (i.e., a set of layer 3 messages) always starts in the first F-BCCH slot of a superframe and is completed within the same superframe.
A single F-BCCH layer 2 protocol frame shall be constructed to fit within a 125-bit envelope (see Section 4.4.3.1). An additional 5 bits are reserved for use as tail bits resulting in a total of 130 bits of information carried within each F-BCCH burst. The layer 2 protocol defined for F-BCCH operation supports only unacknowledged operation. Figures 5-17 through 5-19 provide examples of possible F-BCCH frames. For a complete set of F-BCCH layer 2 frames, see Annex C. A summary of the fields comprising layer 2 protocol frames for F-BCCH operation are provided in Table 5-3.

Figure 5 - 17 F-BCCH BEGIN Frame (1 Complete Message)

BC = 0	FC = X	EC = X	L3LI = X..X	L3 DATA =X..X	BI = 0	FILLER = 0..0	CRC = X..X
1	1	1	8		1		16

Figure 5 - 18 F-BCCH BEGIN Frame (Two L3 Messages with the Second L3 Message continued)

BC = 0	FC = X	EC = X	L3LI =X..X	L3DATA = X..X	BI = 1	L3LI= X..X	L3DATA = X..X	CRC = X..X
1	1	1	8		1	8		16

Figure 5 - 19 F-BCCH CONTINUE Frame (Message Ending)

BC = 1	FC = X	EC = X	CLI = X..X	L3DATA = X..X	BI = 0	FILLER = 0..0	CRC = X..X
1	1	1	7		1		16

5.2.2.1 F-BCCH Frame Usage

BEGIN Frame

The BEGIN frame is used for starting the delivery of one or more L3 messages on the F-BCCH. If the opening L3 message is shorter than one frame, the Begin Indicator (BI) is added to the end of the L3DATA field to indicate whether or not an additional L3 message is started within the BEGIN frame. If BI = 0, the rest of the BEGIN frame is padded with FILLER. If BI = 1, a new L3 message is started in the BEGIN frame. If the L3DATA field ends on a frame boundary, there will be no BI bit and the end of the message is implied. If the L3DATA field ends with less than 9 bits remaining in the frame and another layer 3 message is to be sent, BI is set to 0, the rest of the frame is padded with FILLER, and the new layer 3 message is sent starting with a BEGIN frame.
Whenever there is no layer 3 information available for transmission, a BEGIN frame with L3LI = 0 and FILLER padding shall be sent.

CONTINUE Frame

The CONTINUE frame is used for continuation of a L3 message which is too long to fit into the previous frame. The CLI indicates how many bits of the frame belong to the continued message. If BI = 0, the rest of the CONTINUE frame is padded with FILLER. If BI = 1, a new L3 message is started in the CONTINUE frame. If the L3DATA field ends on a frame boundary, there will be no BI bit and the end of the message is implied. If the L3DATA field ends with less than 9 bits remaining in the frame and another layer 3 message is to be sent, BI is set to 0, the rest of the frame is padded with FILLER, and the new layer 3 message is sent starting with a BEGIN frame.
CLI makes it possible for mobile stations to receive any message starting in a CONTINUE frame even if the preceding frame was not received.

5.2.2.2 F-BCCH Field Summaries

Table 5 - 3 F-BCCH Layer 2 Protocol Field Summary

Field Name	Length (bits)	Values
BC = Begin / Continue	1	0 = Begin 1 = Continue
FC = F-BCCH Change	1	Toggles to indicate a change in the F-BCCH.
EC = E-BCCH Change	1	Toggles to indicate a change in the E-BCCH.
CLI = Continuation Length Indicator	7	Number of bits in the current L2 frame used to carry information from a previously initiated L3 message.
L3LI = Layer 3 Length Indicator	8	Variable length layer 3 messages supported from 0 up to a maximum of 255 octets.
L3DATA = Layer 3 Data	Variable	Contains a portion (some or all) of the layer 3 message having an overall length as indicated by L3LI. The portion of this field not used to carry layer 3 information is filled with zeros.
BI = Begin Indicator	1	0 = No additional layer 3 message present 1 = Additional layer 3 message present
FILLER = Burst Filler	Variable	All filler bits are set to zero.
CRC = Cyclic Redundancy Code	16	See Section 5.2.6.

5.2.3 E-BCCH Protocol

The E-BCCH layer 2 protocol is used whenever a TDMA burst is used to carry E-BCCH information. It should be noted that a full cycle of E-BCCH information (i.e., a set of layer 3 messages) need not be aligned to start in the first E-BCCH slot of a superframe and may span multiple superframes.
A single E-BCCH layer 2 protocol frame shall be constructed to fit within a 125-bit envelope (see Section 4.4.3.1). An additional 5 bits are reserved for use as tail bits resulting in a total of 130 bits of information carried within each E-BCCH burst. The layer 2 protocol defined for E-BCCH operation supports only unacknowledged operation. Figures 5-20 through 5-22 provide examples of possible E-BCCH frames. For a complete set of E-BCCH layer 2 frames, see Annex C. A summary of the fields comprising layer 2 protocol frames for E-BCCH operation are provided in Table 5-4.

Figure 5 - 20 E-BCCH BEGIN Frame (1 Complete Message)

BC = 0	ECL = X	L3LI = X..X	L3DATA = X..X	BI = 0	FILLER = 0..0	CRC = X..X
1	8	8		1		16

Figure 5 - 21 E-BCCH BEGIN Frame (Two L3 Messages with the Second L3 Message continued)

BC =0	ECL =X	L3LI =X..X	L3DATA =X..X	BI =1	L3LI =X..X	L3DATA =X..X	CRC =X..X
1	8	8		1	8		16

Figure 5 - 22 E-BCCH CONTINUE Frame (Message Ending)

BC =1	RSVD =0	CLI =X..X	L3DATA = X..X	BI =0	FILLER =0..0	CRC =X..X
1	1	7		1		16

5.2.3.1 E-BCCH Frame Usage

BEGIN Frame

The BEGIN frame is used for starting the delivery of one or more L3 messages comprising a full cycle of E-BCCH information on the E-BCCH. The first L3 message in an E-BCCH cycle shall always be the first L3 message carried within a BEGIN frame. If the opening L3 message is shorter than one frame, the Begin Indicator (BI) is added to the end of the L3DATA field to indicate whether or not an additional L3 message is started within the BEGIN frame. If BI = 0, the rest of the BEGIN frame is padded with FILLER. If BI = 1, a new L3 message is started in the BEGIN frame. If the L3DATA field ends on a frame boundary, there will be no BI bit and the end of the message is implied. If the L3DATA field ends with less than 9 bits remaining in the frame and another layer 3 message is to be sent, BI is set to 0, the rest of the frame is padded with FILLER, and the new layer 3 message is sent starting with a BEGIN frame.

Whenever there is no layer 3 information available for transmission, a BEGIN frame with L3LI = 0 and FILLER padding shall be sent.

CONTINUE Frame

The CONTINUE frame is used for continuation of a L3 message which is too long to fit into the previous frame. The CLI indicates how many bits of the frame belong to the continued message. If BI = 0, the rest of the CONTINUE frame is padded with FILLER. If BI = 1, a new L3 message is started in the CONTINUE frame. If the L3DATA field ends on a frame boundary, there will be no BI bit and the end of the message is implied. If the L3DATA field ends with less than 9 bits remaining in the frame and another layer 3 message is to be sent, BI is set to 0, the rest of the frame is padded with FILLER, and the new layer 3 message is sent starting with a BEGIN frame. CLI makes it possible for mobile stations to receive any message starting in a CONTINUE frame even if the preceding frame was not received.

5.2.3.2 E-BCCH Field Summaries

Table 5 - 4 E-BCCH Layer 2 Protocol Field Summary

Field Name	Length (bits)	Values
BC = Begin / Continue	1	0 = Begin 1 = Continue
ECL = E-BCCH Cycle Length	8	This field indicates the total number of L2 frames required for the current E-BCCH Cycle.
RSVD = Reserved	1	Reserved field set to 0.
CLI = Continuation Length Indicator	7	Number of bits in the current L2 frame used to carry information from a previously initiated L3 message.
L3LI = Layer 3 Length Indicator	8	Variable length layer 3 messages supported from 0 up to a maximum of 255 octets.
L3DATA = Layer 3 Data	Variable	Contains a portion (some or all) of the layer 3 message having an overall length as indicated by L3LI. The portion of this field not used to carry layer 3 information is filled with zeros.

BI = Begin Indicator	1	0 = No additional layer 3 message present 1 = Additional layer 3 message present
FILLER = Burst Filler	Variable	All filler bits are set to zero.
CRC = Cyclic Redundancy Code	16	See Section 5.2.6.

5.2.4 S-BCCH Protocol

For further study.

5.2.5 SPACH Protocol

The SPACH layer 2 protocol is used whenever a slot is used to carry Point-to-Point SMS, Paging, or ARCH information. A single SPACH layer 2 protocol frame shall be constructed to fit within a 125-bit envelope (see Section 4.4.3.1). An additional 5 bits are reserved for use as tail bits resulting in a total of 130 bits of information carried within each slot assigned for SPACH purposes. Figures 5-23 through 5-38 provides examples of possible SPACH headers and frames. For a complete set of SPACH layer 2 frames, see Annex C. A summary of the fields comprising layer 2 protocol frames for SPACH operation is provided in Table 5-7.

Figure 5 - 23 SPACH Header A

BU = XXX	PCON = X	BCN = X	PFM = X	RSVD = 0
3	1	1	1	1

Figure 5 - 24 SPACH Header B

BT = XXX	IDT = XX	MM = X	SRM = X
3	2	1	1

Figure 5 - 25 Extension Header

MEA = XX	MEK = XX	RSVD = 0
2	2	1

Figure 5 - 26 Null Frame

Header A (BU=000)	GA = X	FILLER = 0..0	CRC X.. X
7	1	101	16

Figure 5 - 27 Hard Triple Page Frame (34-bit MIN, PCH)

Header A (BU=101)	MSID1 = X..X	MSID2 = X..X	MSID3 = X..X	CRC = X..X
7	34	34	34	16

Figure 5 - 28 Hard Quadruple Page Frame (24-bit TMSI, PCH)

Header A (BU=110)	IDT = 01	MSID1 = X..X	MSID2 = X..X	MSID3 = X..X	MSID4 = X..X	FILLER = 0..0	CRC = X..X
7	2	24	24	24	24	4	16

Figure 5 - 29 Hard Penta Page Frame (20-bit TMSI, PCH)

Header A (BU=001)	MSID1 =X..X	MSID2 =X..X	MSID3 =X..X	MSID4 =X..X	MSID5 =X..X	FILLER =0..0	CRC =X..X
7	20	20	20	20	20	2	16

Figure 5 - 30 User Group Frame (PCH)

Header A (BU=111)	Header B (BT=111)	EHI =0	UGID =X..X	L3LI =X..X	L3DATA =X..X	FILLER =0..0	CRC =X..X
7	7	1		8			16

Figure 5 - 31 Single MSID Frame (PCH)

Header A (BU=111)	Header B (BT=000)	EHI =0	MSID1 =X..X	L3LI1 =X..X	L3DATA1 =X..X	FILLER =0..0	CRC =X..X
7	7	1		8			16

Figure 5 - 32 Single MSID Frame (ARCH)

Header A (BU=011)	Header B (BT=000)	EHI =1	Extension Header =X...X	MSID1 =X..X	L3LI1 =X..X	L3DATA1 =X..X	FILLER =0..0	CRC =X..X
7	7	1	5		8			16

Figure 5 - 33 Double MSID Frame (ARCH)

Header A (BU=011)	Header B (BT=001)	EHI =0	MSID1= X..X	MSID2= X..X	L3LI1 =X..X	L3LI2 =X..X	L3DATA1 =X..X	L3DATA2= X..X	FILLER =0..0	CRC =X..X
7	7	1			8	8				16

Figure 5 - 34 Double MSID Frame with Continuation (ARCH)

Header A (BU=011)	Header B (BT=001)	EHI =0	MSID1 =X..X	MSID2 =X..X	L3LI1 =X..X	L3LI2 =X..X	L3DATA1 =X..X	CRC =X..X
7	7	1			8	8		16

Figure 5 - 35 CONTINUE Frame (ARCH)

Header A (BU=011)	Header B (BT=100)	L3DATA1 =X..X	L3DATA2 =X..X	FILLER =0..0	CRC =X..X
7	7				16

Figure 5 - 36 Triple MSID Frame (ARCH, 1 L3 Message for 3 MSIDs)

Header A (BU=011)	Header B (BT=010, MM=1)	EHI =0	MSID1 =X..X	MSID2 =X..X	MSID3 =X..X	L3LI =X..X	L3DATA =X..X	CRC =X..X
7	7	1				8		16

Figure 5 - 37 CONTINUE Frame (ARCH)

Header A (BU=011)	Header B (BT=100)	L3DATA =X..X	FILLER =0..0	CRC =X..X
7	7			16

Figure 5 - 38 ARQ Mode BEGIN Frame (SMSCH)

Header A (BU=100)	Header B (BT=101)	EHI =0	MSID =X..X	PEA =X..X	RSVD =00	PI =X	ARM =X	L3LI =X..X	L3DATA =X..X	CRC =X..X
7	7			7	2	1	1	8		16

Figure 5 - 39 ARQ Mode CONTINUE Frame (SMSCH)

Header A (BU=100)	Header B (BT=110)	PEA =X..X	RSVD =00	PI =X	ARM =X	FRNO =X..X	L3DATA =X..X	CRC =X..X
7	7	7	2	1	1	5	79	16

5.2.5.1 Frame Usage

Frames usage requirements on the SPACH are as follows:

- Similar frame formats are used for all SPACH channels such that all frames will always have a common Header A. The content of Header A determines whether or not Header B is present in any given frame.
- Header A discriminates between hard (no L3 data provided) page bursts, PCH bursts, ARCH bursts and SMSCH bursts.
- Header B is used to define what burst type is used, what identity type is used, the SPACH response mode and whether or not the L3 data is sent to more than one mobile station.
- A Hard Triple Page frame containing three 34-bit MSIDs can be sent on the PCH (BU = Hard Triple Page).
- A Hard Quadruple Page frame containing four 20-bit or 24-bit MSIDs can be sent on the PCH (BU = Hard Quadruple Page).
- A Hard Penta Page frame containing five 20-bit MSIDs can be sent on the PCH (BU = Hard Penta Page).
- One or more L3 messages may be transmitted in one frame, or continued over many frames.
- In addition to Hard Triple, Quadruple and Penta Page frames, MSIDs are carried within frames where BU = PCH, ARCH or SMSCH with BT = Single MSID, Double MSID, Triple MSID, Quadruple MSID or ARQ Mode BEGIN (see Table 5-6).
- The mobile station identity type field identifies the format of the MSID or the UGID carried within a given SPACH burst. For the case of multiple MSIDs carried in a frame no mixing of MSID formats is allowed.
- For non-ARQ mode operation the L2 SPACH protocol supports sending a single L3 message to multiple MSIDs in addition to the fixed one to one relationship between MSIDs and L3 messages. The Message Mapping field (MM) is used to control this aspect of layer 2 frame operation.
- A value of all zeros shall be used to indicate an invalid instance of MSID.

Table 5 - 5 Possible Frame Formats

	SMSCH	PCH	ARCH	Can Be Continued
Single MSID	Y	Y	Y	Y

Double MSID	N	Y	Y	Y
Triple MSID	N	Y	Y	Y
Quadruple MSID	N	Y	Y	Y
Hard Triple Page (MIN)	N	Y	N	N
Hard Quadruple Page (TMSI)	N	Y	N	N
Hard Penta Page (TMSI)	N	Y	N	N
User Group	N	Y	Y	Y
CONTINUE	Y	Y	Y	Y
ARQ Mode BEGIN	Y	N	Y	Y
ARQ Mode CONTINUE	Y	N	Y	Y

Table 5 - 6 Possible Burst Type / Identity Type Combinations

Identity Type (IDT) / Burst Type (BT)	20-bit TMSI	24-bit TMSI	34-bit MIN	50-bit IMSI
Single MSID Frame	Yes	Yes	Yes	Yes
Double MSID Frame	Yes	Yes	Yes	No
Triple MSID Frame	Yes	Yes	No	No
Quadruple MSID Frame	Yes	No	No	No

SPACH Header A

The SPACH Header A contains burst usage information and flags for managing mobile stations in sleep mode. The BU field provides a high level indication of burst usage. The flags indicate changes in sleep mode configuration as well as BCCH information. This header is always present in all possible frame types.

SPACH Header B

The SPACH Header B contains supplementary header information used to identify the remaining content of the layer 2 frame as well as information about the layer 2 access mode (reservation or contention) to be used in the next access attempt made by the receiving mobile station. This header is present when Header A indicates a burst usage of type PCH, ARCH or SMSCH.

Extension Header

The Extension Header contains supplementary header information used to identify the Message Encryption Algorithm and Message Encryption Key used to encrypt the Layer 3 payload information. This header is only present when the EHI field is set to 1.

Null Frame

The Null frame is sent as necessary by the BMI when there is nothing else requiring transmission for any given SPACH burst.

Hard Triple Page Frame (34-bit MIN)

A Hard Triple Page is a single frame page message containing three 34-bit MINs.

Hard Quadruple Page Frame (20- or 24-bit TMSI)

A Hard Quadruple Page is a single frame page message containing four 20 or 24-bit MSID as determined by IDT.

Hard Penta Page Frame (20-bit TMSI)

Hard Penta Page is a single frame page message containing five 20-bit TMSIs.

User Group

The User Group frame is used in support of user group operation.
If a L3 message is too long to fit into a User Group frame then the remaining L3 information is carried using additional CONTINUE frames as necessary. If a complete L3 message does fit within a User Group frame it is padded with FILLER as necessary.

Single MSID Frame

The Single MSID frame is used for starting the delivery of ARCH or SMSCH L3 messages in non-ARQ mode. In addition, this frame may also be used for sending L3 PCH messages which are non-ARQ by definition.
If a L3 message is too long to fit into a Single MSID frame then the remaining L3 information is carried using additional CONTINUE frames as necessary. If a complete L3 message does fit within a Single MSID frame it is padded with FILLER as necessary.

Double MSID Frame

The Double MSID frame is used for starting the delivery of two ARCH messages in non-ARQ mode or two PCH L3 messages. The number of MSIDs is indicated in the BT field with the same IDT format used for both instances of MSID. If any required L3LI fields cannot fit entirely within the frame, the frame shall be padded with FILLER and the remaining L3LI fields are then included immediately prior to the L3DATA field in the subsequent CONTINUE frame. The L3DATA field(s) contains layer 3 message information and begins immediately after the L3LI field(s).

Note that for MM = 0, $L3LI_n$ and $L3DATA_n$ qualify the message intended for $MSID_n$.

Triple MSID Frame

The Triple MSID frame is used for starting the delivery of three ARCH L3 messages in non-ARQ mode or three PCH L3 messages. The number of MSIDs is indicated in the BT field with the same IDT format used for all instances of MSID. If any required L3LI fields cannot fit entirely within the frame, the frame shall be padded with FILLER and the remaining L3LI fields are then included immediately prior to the L3DATA field in the subsequent CONTINUE frame. The L3DATA field(s) contains layer 3 message information and begins immediately after the L3LI field(s).

Note that for MM = 0, $L3LI_n$ and $L3DATA_n$ qualify the message intended for $MSID_n$.

Quadruple MSID Frame

The Quadruple MSID frame is used for starting the delivery of four ARCH L3 messages in non-ARQ mode or four PCH L3 messages. The number of MSIDs is indicated in the BT field with the same IDT format used for all instances of MSID. If any required L3LI fields cannot fit entirely within the frame, the frame shall be padded with FILLER and the remaining L3LI fields are then included immediately prior to the L3DATA field in the subsequent CONTINUE frame. The L3DATA field(s) contains layer 3 message information and begins immediately after the L3LI field(s).

Note that for MM = 0, $L3LI_n$ and $L3DATA_n$ qualify the message intended for $MSID_n$.

CONTINUE Frame

The CONTINUE frame is used for continuation of L3 messages that are too long to fit into a single frame.

ARQ Mode BEGIN Frame

An ARQ Mode BEGIN frame shall always be sent to initiate an ARQ mode L3 message delivery on the SMSCH or ARCH. The ARQ Mode BEGIN frame contains only one MSID within its L2 header as well as a portion of the L3 message to be delivered to a mobile station. If the L3 message is too long to fit within a single ARQ Mode BEGIN frame then the remaining L3 information is carried using additional ARQ Mode CONTINUE frames as necessary. If the L3 message does fit within a single ARQ Mode BEGIN frame it shall be padded with FILLER as necessary.
The PEA field contains a BMI-assigned partial echo value that is used by the mobile station for the duration of the initiated ARQ mode transaction.

ARQ Mode CONTINUE Frame

One or more ARQ Mode CONTINUE frames shall be sent to complete an ARQ mode L3 delivery on the SMSCH or ARCH.
The FRNO field serves to uniquely identify each ARQ Mode CONTINUE frame sent in delivering a complete L3 message. The FRNO field value is incremented for each new ARQ Mode CONTINUE frame sent. When an ARQ Mode CONTINUE frame is resent because of incorrect frame reception at the mobile station, its FRNO field shall be unchanged from the value used when the frame was initially sent.

5.2.5.2 SPACH Field Summaries

Table 5 - 7 SPACH Layer 2 Protocol Field Summary

Field Name	Length (bits)	Values
BU = Burst Usage	3	000 = Null 001 = Hard Penta Page (20-bit MSID) 010 = Reserved 011 = ARCH Burst 100 = SMSCH Burst 101 = Hard Triple Page (34-bit MSID) 110 = Hard Quadruple Page (20 or 24- bit MSID) 111 = PCH Burst
PCON = PCH Continuation	1	0 = No PCH Continuation 1 = PCH Continuation
BCN = BCCH Change Notification	1	Transitions whenever there is a change in F-BCCH or E-BCCH information.
PFM = Paging Frame Modifier	1	0 = Use Assigned PFC 1 = Use one higher /lower than Assigned PFC

BT = Burst Type	3	000 = Single MSID Frame 001 = Double MSID Frame 010 = Triple MSID Frame 011 = Quadruple MSID Frame 100 = CONTINUE Frame 101 = ARQ Mode BEGIN 110 = ARQ Mode CONTINUE 111 = User Group Frame
IDT = Identity Type	2	00 = 20-bit MSID/UGID 01 = 24-bit MSID/UGID 10 = 34-bit MSID/UGID 11 = 50-bit MSID/UGID
MSID = Mobile Station Identity	20/24/34/50	20-bit TMSI 24-bit TMSI 34-bit MIN 50-bit IMSI
UGID = User Group Identity	20/24/34/50	20-bit Local UGID 24-bit SOC UGID 34-bit National UGID 50-bit International UGID
MM = Message Mapping	1	0 = One instance of L3LI and L3DATA per instance of MSID 1 = One instance of L3LI and L3DATA for multiple MSIDs.
L3LI = Layer 3 Length Indicator	8	Variable length layer 3 messages supported up to a maximum of 255 octets.
L3DATA = Layer 3 Data	Variable	Contains a portion (some or all) of the layer 3 message having an overall length as indicated by L3LI. The portion of this field not used to carry layer 3 information is filled with zeros.

SPACH Layer 2 Protocol Field Summary (continued)

Field Name	Length (bits)	Values
PEA = Partial Echo Assigned	7	The 7-bit partial echo value used by a mobile station during an ARQ mode transaction.
PI = Polling Indicator	1	Indicates whether or not the BMI is soliciting a response (ARQ STATUS Frame) from the mobile station. 0 = ARQ STATUS Frame not required 1 = ARQ STATUS Frame required.
SRM = SPACH Response Mode	1	Indicates how a mobile station is to respond once it has received all frames associated with a given SPACH message. 0 = Next access attempt made on RACH to be contention based. 1 = Next access attempt made on RACH to be reservation based.
EHI = Extension Header Indicator	1	0 = Extension Header not present 1 = Extension Header present
MEA = Message Encryption Algorithm	2	00 = Reserved 01 = " 10 = " 11 = Reserved for SOC/BSMC specific signaling
MEK = Message Encryption Key	2	00 = Reserved 01 = " 10 = " 11 = Reserved for SOC/BSMC specific signaling
RSVD = Reserved	½	Set to zero

ARM = ARQ Response Mode	1	Indicates how a mobile station is to respond once it has received an ARQ frame with PI set to 1. 0 = Send SPACH ARQ STATUS frame on contention basis. 1 = Send SPACH ARQ STATUS frame on reservation basis.
FRNO = Frame Number	5	Uniquely identifies specific frames sent in support of an ARQ mode transaction.
GA = Go Away	1	Indicates if the DCCH is barred (see Section 6.3.3.4.1). 0 = DCCH not barred 1 = DCCH barred
FILLER = Burst Filler	Variable	All filler bits are set to zero.
CRC = Cyclic Redundancy Code	16	See Section 5.2.6.

5.2.5.3 Broadcast Change Notification

Broadcast Change Notification is controlled by the BCN flag.

- If the Broadcast Change Notification (BCN) flag transitions in a PCH Subchannel, a mobile station in the DCCH Camping state (see Section 6.2.3) not having a MSID match for that PCH Subchannel shall ignore the PCON flag and proceed to read FC and EC information on the F-BCCH in the next hyperframe.
- If the BCN flag transitions in a SMSCH or ARCH slot, a mobile station in the DCCH Camping state (see Section 6.2.3) shall ignore the PCON flag and proceed to read EC and FC information on the F-BCCH in the next hyperframe.
- A mobile station that has left the DCCH Camping state (see Section 6.2.3) for call processing purposes may detect a BCN flag transition, but shall not respond to it until it returns to DCCH Camping state.
- A mobile station that has left the DCCH Camping state (see Section 6.2.3) for call processing purposes shall only respond to PCON = 1 if its current layer 3 state supports the reception of a FDCCH Indication primitive containing a PCH message.
- After reading FC and EC as a result of BCN notification, a mobile station shall read all current F-BCCH if it detects that the FC has toggled and all current E-BCCH if it detects that the EC has toggled.
- The E-BCCH information may be different from SF to SF as the information repeats after a certain period. It should be noted that for the proper operation of the BCN flag, the BMI shouldnot change F-BCCH or E-BCCH information more frequently than can be accommodated by mobile stations operating at the maximum PFC supported by the BMI .

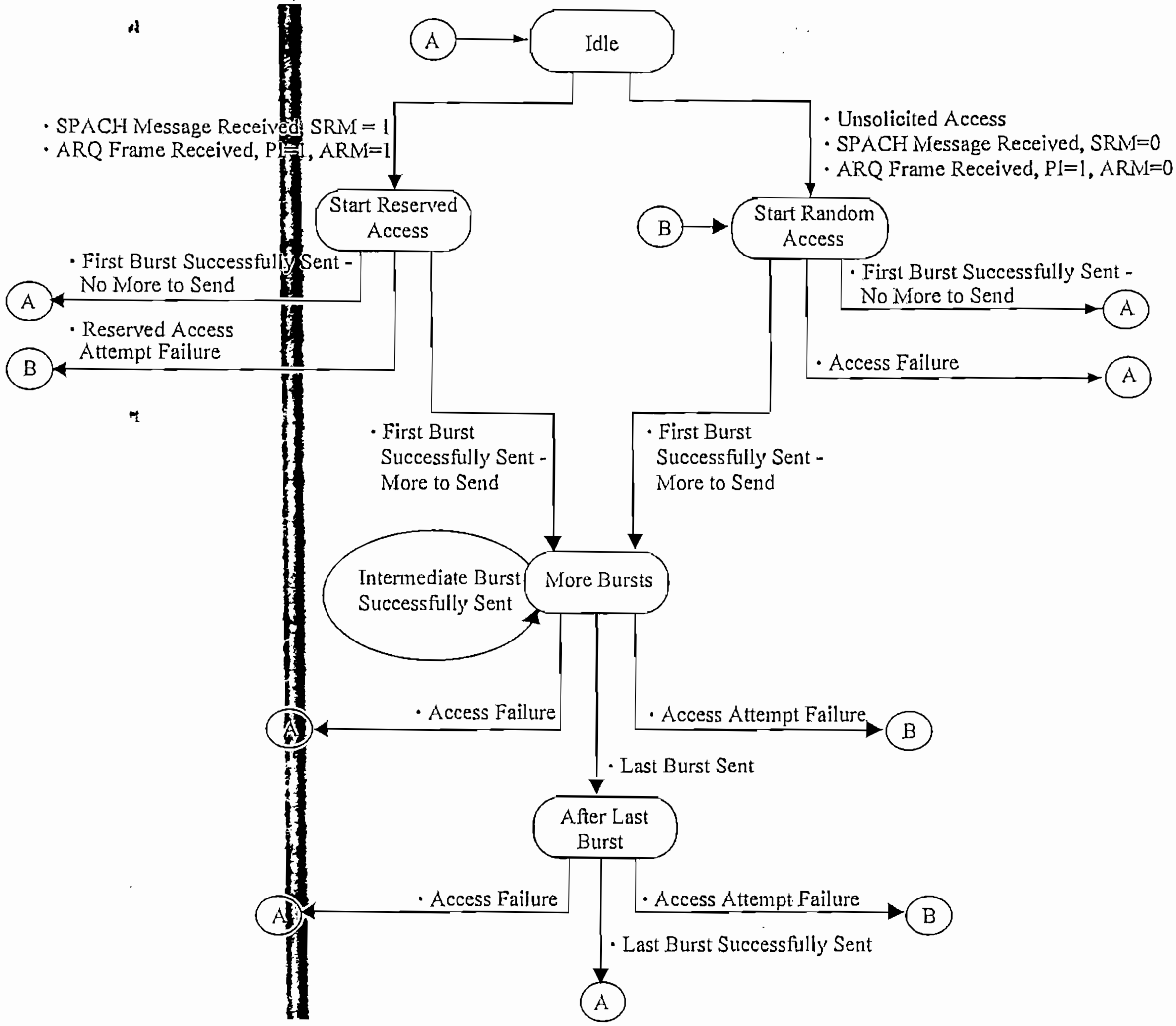
5.2.6 CRC Generation

The CRC polynomial is the same as that used for FACCH CRC encoding in IS-136.2 (see Section 2.7.3.1.1.3 of IS-136.2). Generally, the DVCC and the information bits are used when calculating the CRC as per IS-136.2. However, for the F-BCCH, the DVCC value is set to zero before calculating the CRC. For the E-BCCH, S-BCCH, Reserved, SPACH and RACH, the DVCC to be used for CRC calculation shall be as received in the DCCH Structure message. In addition, for the F-BCCH, E-BCCH, S-BCCH and Reserved slots (see Section 4.5) the one's complement of the calculated CRC shall be used in the interest of discriminating these slots from the SPACH slots.

5.3 Mobile Station Access on the RDCCH

5.3.1 States MS Side

Figure 5 - 40 Overview of MS States



5.3.1.1 Idle

The mobile station is considered to be in the Idle state whenever it is not attempting to make an access on the RACH.

5.3.1.2 Start Random Access

The Start Random Access state is entered under the following conditions:

- When the mobile station decides to make an unsolicited system access;
- When the mobile station is required to make a solicited system access as a result of successfully receiving a complete SPACH message with SRM = 0;
- When the mobile station is required to make a solicited system access as a result of an ARQ mode transaction where the mobile station receives an ARQ frame with PI = 1 and ARM = 0;
- When the mobile station is required to make a solicited system access as a result of receiving a R/N = Not Received after sending the first burst of a reserved access attempt.

5.3.1.3 Start Reserved Access

The Start Reserved Access state is entered under the following conditions:

- 100ms after a mobile station successfully receives the last L2 frame of a SPACH message where SRM=1 in all L2 frames used in sending the SPACH message and where the received SPACH message solicits a mobile station response on the RDCCH.

- Immediately after a mobile station successfully receives an ARQ Mode BEGIN frame or an ARQ Mode CONTINUE frame having PI=1 and ARM=1.

5.3.1.4 More Bursts

A mobile station is considered to be in the More Bursts state if, after successfully transmitting one or more bursts, there are one or more additional bursts pending for its access attempt.

5.3.1.5 After Last Burst

A mobile station is considered to be in the After Last Burst state if it has transmitted the last burst of its access attempt and is awaiting SCF feedback to determine the reception status.

5.3.2 Protocol Elements

5.3.2.1 Encoding of SCF Flags

5.3.2.1.1 BRI

The BRI flag is used to indicate whether the corresponding RDCCH RACH slot (see Section 4.11.2) is Busy, Reserved or Idle. Six bits are used for this flag and the encoded combinations are shown in Table 5-8:

Table 5 - 8 BRI Encoding Rules

	BRI_5	BRI_4	BRI_3	BRI_2	BRI_1	BRI_0
Busy	1	1	1	1	0	0
Reserved	0	0	1	1	1	1
Idle	0	0	0	0	0	0

5.3.2.1.2 R/N

The R/N flag is used to indicate whether the base received the corresponding RDCCH burst or not. Five bits are used for this flag and the encoded combinations are shown in Table 5-9:

Table 5 - 9 R/N Encoding Rules

	R/N_4	R/N_3	R/N_2	R/N_1	R/N_0
Received	1	1	1	1	1
Not Received	0	0	0	0	0

5.3.2.1.3 CPE

The CPE field is used to:

- Indicate which mobile station attempting a non-ARQ related contention based access has had its initial burst correctly received by the BMI. In this case, the BMI encodes the CPE using the 7 least significant bits of the MSID provided by the mobile station in its RACH access attempt.

- Indicate which mobile station attempting an ARQ related contention based access has had its initial burst correctly received by the BMI. In this case, the BMI encodes CPE using the PEA value included in the received SPACH ARQ STATUS Frame.

- Solicit a reservation based response from a mobile station having an access pending. For the ARQ mode transactions, the BMI encodes the CPE using the PEA value assigned to the mobile station. For non-ARQ mode transactions, the BMI encodes the CPE using the 7 least significant bits of the MSID used in the last message sent to the mobile station.

CPE encoding is similar to DVCC encoding (see Section 1.2.5 of IS-136.2). The d7 bit is omitted (set to zero) in the encoding process and not transmitted as part of CPE. Note that the LSB of the 7-bit value used in CPE encoding is denoted as d0 (see Section 4.4.2.2). CPE encoding results in the check bits b_3, b_2, b_1, and b_0, being inverted (denoted $\bar{b}_3$, $\bar{b}_2$, $\bar{b}_1$, $\bar{b}_0$) before forming the resulting CPE information.

Table 5 - 10 CPE Encoding Rules

Access Mode	CPE Assignment
Contention-ARQ	PEA
Contention-non-ARQ	7 LSBs of MSID
Reservation-ARQ	PEA
Reservation-non-ARQ	7 LSBs of MSID

5.3.2.2 Decoding of SCF Flags

5.3.2.2.1 BRI Decoding

Table 5-11 shows how the mobile station shall decode the received BRI flag according to Layer 2 state. Note that only the Layer 2 states relevant to BRI decoding are shown.

Table 5 - 11 BRI Decoding Rules

Layer 2 State	Busy	Reserved	Idle
Start Random Access	N/A	N/A	IF $\sum_{i=0}^{3} BRI_i < 2$ AND $\sum_{i=2}^{5} BRI_i < 2$
Start Reserved Access	N/A	IF < 3 bits differ from encoded Reserved value	N/A
More Bursts	IF < 4 bits differ from encoded Busy value	N/A	N/A
After Last Burst	IF < 4 bits differ from encoded Busy value	N/A	N/A

5.3.2.2.2 R/N Decoding

Table 5-12 shows how the mobile station shall decode the R/N flag according to the Layer 2 state. Note that only the Layer 2 states relevant to R/N decoding are shown.

Table 5 - 12 R/N Decoding

Layer 2 State	Received	Not Received
More Bursts After Last Burst Start Random Access Start Reserved Access	$\sum_{i=0}^{4} R/N_i \geq 4$	$\sum_{i=0}^{4} R/N_i < 4$

5.3.2.2.3 CPE

The mobile station interprets a received CPE value as correctly decoded if it differs by less than 3 bits from the correct CPE. This is referred to as PE match.

5.3.3 Random Access Procedures

The following procedures are used in making contention or reservation based access attempts. These procedures are subject to the Random Access parameters sent on the Access Parameters message on the F-BCCH, and are summarized in Table 5-13.

Table 5 - 13 Random Access Parameters

BCCH Parameter Names	Range of Parameters
Max Busy/Reserved	0, 1
Max Retries	0 - 7
Max Repetitions	0 - 3
Max Stop Counter	0, 1

5.3.3.1 Mobile Station Side

A mobile station can attempt an access on either a contention or reservation basis. An access shall only be attempted once a mobile station has read the Access Parameters information on the F-BCCH (see Section 6.4.1.1.1.2).
A random delay uniformly distributed between 0 and 6 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 3 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, is used by a mobile station after failing to read BRI = Idle during any given access attempt.

A mobile station is allowed a maximum of Max Retries + 1 access attempts before declaring an Access Failure. A given access attempt is considered to have failed if one of the following occurs:

- The mobile station does not decode BRI as Idle after one attempt (Max Busy/Reserved = 0) or 10 attempts (Max Busy/Reserved = 1).
- The mobile station does not find a PE match along with R/N = Received after sending the first burst of an access attempt.
- The mobile station does not successfully send any given burst after the number of retries indicated by Max Repetitions.
- The mobile station detects a total of Max Stop Counter + 1 consecutive occurrences of either of the following:
  - BRI ≠ Busy after sending an intermediate burst of an access attempt.
  - R/N = Not Received and BRI ≠ Busy after sending the last burst of an access attempt.

After failing its initial access attempt a mobile station shall proceed as follows:

- If Max Retries = 0 the mobile station shall consider the access to have failed.
- If Max Retries = 1 the mobile station shall wait a random delay uniformly distributed between 0 and 20 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 10 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, before making its next access attempt.
- If Max Retries > 1 the mobile station shall wait a random delay uniformly distributed between 0 and 6 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 3 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, before making its second access attempt and 0 and 20 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 10 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, before making its third or later access attempt.

Note that a mobile station shall still monitor its assigned PCH Subchannel when making a random access attempt for registration or origination purposes.

5.3.3.1.1 Start Random Access

When a mobile station is in the Start Random Access state it shall look for BRI = Idle on the FDCCH of its serving DCCH regardless of RACH subchanneling (see Section 4.11).
If a random access is a result of a multi MSID page, the mobile station shall first wait a random time delay between 0 and 6 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 3 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, before looking for BRI = Idle.
If a random access is a result of a Directed Retry (see Section 6.4.3.7), a forced Registration, a Page indicating User Group, Audit indicating User Group, or is attempted when the overload control status is enabled (see Section 6.2.3), the mobile station shall first wait

a random time delay between 0 and 31 TDMA blocks with a granularity of 1 TDMA block for a full-rate DCCH or between 0 and 16 TDMA frames with a granularity of 1 TDMA frame for a half-rate DCCH, before looking for BRI = Idle.
Upon finding a FDCCH slot with BRI ≠ Idle, the mobile station shall wait a random time delay (see Section 5.3.3.1) before looking at another BRI flag. If the mobile station does not decode BRI = Idle after one attempt (Max Busy/Reserved = 0) or 10 attempts (Max Busy/Reserved = 1), it shall consider the access attempt to have failed. Upon finding a FDCCH slot with BRI = Idle, a mobile station shall send the first burst of its access attempt.

After sending the first burst of an access attempt a mobile station shall then read the CPE field in the next FDCCH slot of its selected RACH subchannel of its serving DCCH and then proceed as follows:

- If a PE match does not occur the mobile station shall increment Rtr_ctr (see Figure 5-41) and then determine whether or not to make another access attempt based on Max Retries.
- If a PE match occurs and there are no more bursts to send the mobile station shall proceed as follows:
  - If R/N = Received, the mobile station shall consider the access attempt as successfully completed and enter the Idle state.
  - If R/N = Not Received and BRI = Busy, the mobile station shall increment Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Rep_ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.
  - If R/N = Not Received and BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Stop_ctr and Rep_ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.
- If a PE match occurs and there are more bursts to send the mobile station shall proceed as follows:
  - If BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Stop_ctr and Rep_ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.
  - If BRI = Busy and R/N = Received, the mobile station shall increment Burst_ctr, set Rep_ctr = 0 and Stop_ctr = 0, then enter the More Bursts state and invoke the More Bursts procedure (see Section 5.3.3.1.3).
  - If BRI = Busy and R/N = Not Received, the mobile station shall increment Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Rep_ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.

5.3.3.1.2 Start Reserved Access

When soliciting a reservation based access, the specific FDCCH slot selected by the BMI for sending CPE and BRI information is completely independent of which RACH subchannel the mobile station may have previously used. A mobile station in this state as a result of responding to SRM=1 (see Section 5.3.1.3) shall immediately begin looking at the FDCCH slots of all RACH subchannels in an effort to find a PE match. A mobile station in this state as a result of receiving an ARQ Mode BEGIN or ARQ Mode CONTINUE frame (see Section 5.3.1.3) shall, beginning with the FDCCH slot in which it received the ARQ frame, begin looking at the FDCCH slots of all RACH subchannels in an effort to find a PE match. In either case, the mobile station shall then proceed as follows:

- If the mobile station does not find a PE match along with BRI = Reserved within 8 TDMA blocks for a full-rate DCCH (4 TDMA frames for a half-rate DCCH) when attempting to send an ARQ STATUS frame on a reservation basis, it shall enter the Start Random Access state.
- If the mobile station does not find a PE match along with BRI = Reserved within 32 TDMA blocks for a full-rate DCCH (16 TDMA frames for a half-rate DCCH) when attempting to send a layer 3 message on a reservation basis, it shall enter the Start Random Access state.
- If the mobile station finds a PE match along with the BRI = Reserved within the expected time frame, it shall send the first burst of its access attempt using the next occurrence of the RACH subchannel associated with the FDCCH slot in which the PE match occurred.

If there are no more bursts to send, the mobile station shall respond to the SCF status of its first transmitted burst as follows:

- If R/N = Received, the mobile station shall consider the access attempt as successfully completed.
- If R/N = Not Received and BRI = Busy, the mobile station shall increment Rep_ctr and then determine whether or not to resend the first burst based on Max Repetitions. If more than Max Repetitions consecutive resends of the first burst have been made, the access attempt is considered to have failed

and Rtr_ctr is incremented. Otherwise, the mobile station shall set Stop_ctr = 0 and then continue the access attempt by sending the first burst.

- If R/N = Not Received and BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Stop_ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.

If there are more bursts to send, the mobile station shall respond to the SCF status of its first transmitted burst as follows:

- If BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and Rtr_ctr, and consider its access attempt to have failed. Note that the initialization of Stop_Ctr (see Figure 5-41) results in immediately declaring an access attempt to have failed when this condition occurs.

- If BRI = Busy and R/N = Received, the mobile station shall increment Burst_ctr, set Rep_ctr = 0 and Stop_ctr = 0, and then enter the More Bursts state and invoke the More Bursts procedure (see Section 5.3.3.1.3).

- If BRI = Busy and R/N = Not Received, the mobile station shall increment Rep_ctr and then determine whether or not to resend the first burst based on Max Repetitions. If more than Max Repetitions consecutive resends of the first burst have been made, the access attempt is considered to have failed and Rtr_ctr is incremented. Otherwise, the mobile station shall set Stop_ctr = 0, and then continue the access attempt by resending the first burst.

5.3.3.1.3 More Bursts

A mobile station having more bursts to send as part of its current access attempt shall first examine the SCF information associated with its previously sent burst and respond as follows:

- If R/N = Received and BRI = Busy, then the mobile station shall set Rep_ctr = 0 and Stop_ctr = 0, and shall send the next burst in the next occurrence of its RACH subchannel. If there are no more bursts to send, the mobile station shall enter the After Last Burst state and invoke the After Last Burst procedure (see Section 5.3.3.1.4).

- If R/N = Not Received and BRI = Busy, then the mobile station shall increment Rep_ctr and then determine whether or not to resend the current burst based on Max Repetitions. If more than Max Repetitions consecutive resends of the current burst have been made, the access attempt is considered to have failed and Rtr_ctr is incremented. Otherwise, the mobile station shall set Stop_ctr = 0 and then continue the access attempt by resending the current burst.

- If BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and then determine if it may resend the current burst based on Max Repetitions or Max Stop Counter. If more than Max Repetitions consecutive resends of the current burst have been made, or Max Stop Counter +1 occurrences of this condition have been experienced, the access attempt is considered to have failed and Rtr_ctr is incremented. Otherwise, the mobile station shall continue the access attempt by resending the current burst.

5.3.3.1.4 After Last Burst

After sending or resending the last burst of its access attempt, a mobile station shall respond to SCF information received on its associated RACH subchannel as follows:

- If R/N = Received, the mobile station shall consider the access attempt to be successfully completed and then immediately begin looking for its expected ARCH and/or SMSCH response (as indicated by the RDCCH Request primitive that precipitated the current access attempt).

- If R/N = Not Received and BRI = Busy, then the mobile station shall increment Rep_ctr and then determine whether or not to resend the last burst based on Max Repetitions. If more than Max Repetitions consecutive resends of the current bust have been made, the access attempt is considered to have failed and Rtr_ctr is incremented. Otherwise, the mobile station shall set Stop_ctr = 0 and then continue the access attempt by resending the last burst.

- If BRI ≠ Busy, the mobile station shall increment Stop_ctr, Rep_ctr and then determine if it may resend the last burst based on Max Repetitions or Max Stop Counter. If more than Max Repetitions consecutive resends of the last burst have been made, or Max Stop Counter + 1 occurrences of this condition have been experienced, the access attempt is considered to have failed and Rtr_ctr is incremented. Otherwise, the mobile station shall continue the access attempt by resending the last burst.

If a mobile station decides to resend the last burst it shall proceed as follows:

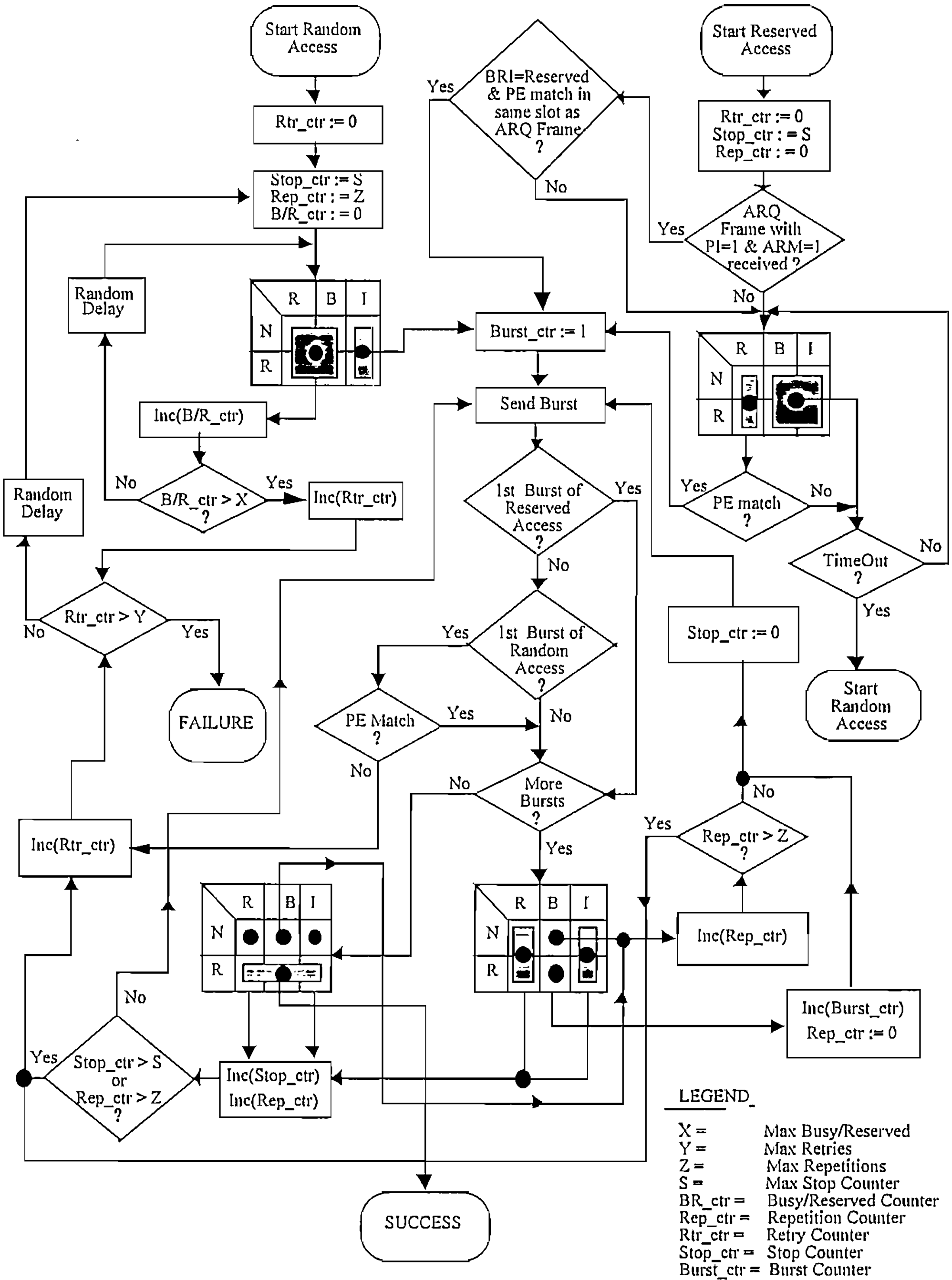
- The mobile station shall immediately begin looking for its expected ARCH/SMSCH response starting with the next FDCCH slot (i.e., the FDCCH slot following the FDCCH slot from which it read SCF information that resulted in its decision to resend the last burst).
- If the mobile station receives its expected ARCH/SMSCH response prior to successfully resending its last burst, it shall consider the access attempt to be successfully completed.

A mobile station that considers its access attempt to have failed (after attempting to resend the last burst) shall immediately stop looking for its expected ARCH/SMSCH response.

5.3.3.1.5 MS Random Access Flow Chart

Figure 5 - 41 Random Access Flow Chart

Figure 5-41 is provided for overview purposes and is not intended to be exhaustive.



5.4 SPACH ARQ

5.4.1 MS ARQ States

5.4.1.1 ARQ Idle

The mobile station is considered to be in the ARQ Idle state whenever it is not engaged in an ARQ mode transaction.

5.4.1.2 ARQ Active

The mobile station is considered to be in the ARQ Active state whenever it is engaged in an ARQ mode transaction.

5.4.2 MS ARQ Procedure

5.4.2.1 Start ARQ Mode

When a mobile station receives an ARQ Mode BEGIN frame with a MSID matching its own, it shall enter the ARQ Active state and proceed as follows:

- PEA shall be stored for ARQ Mode transaction identification purposes. PEA uniquely identifies a mobile station ARQ transaction. The PEA specifies a unique instance of an ARQ.
- The number of pending ARQ Mode CONTINUE frames shall be calculated based on the received L3LI.
- Initialize FRNO MAP by setting all bit positions of this map to 0. The FRNO map is 26 bits long and supports ARQ mode transactions up to 27 ARQ frames long (1 BEGIN and 26 CONTINUE). Bit positions in FRNO MAP correspond to the ordered sequence of CONTINUE frames (see Section 5.2.5) and are set to 1 upon correctly receiving the corresponding CONTINUE frame. The left most bit position of FRNO MAP corresponds to the CONTINUE frame received with FRNO = 0, and the right most bit position of FRNO MAP corresponds to the CONTINUE frame received with FRNO = 25.
- The portion of the L3 message carried in L3DATA shall be stored.
- If PI = 1 and ARM = 1, the mobile station shall send an ARQ STATUS frame on a reservation basis (see Section 5.3.3.1.2).
- If PI = 1 and ARM = 0, the mobile station shall send an ARQ STATUS frame on a contention basis (see Section 5.3.3.1.1).
- A mobile station in the process of responding to PI = 1 shall be capable of receiving additional ARQ Mode CONTINUE frames.
- When an ARQ STATUS frame is sent, it shall reflect the status of the ARQ Mode transaction at the time the mobile station received an ARQ frame with PI = 1.
- If the ARQ STATUS frame is successfully sent, the mobile station shall proceed as follows:
    - If one or more ARQ Mode CONTINUE frames are determined to be pending, invoke the ARQ Mode Continuation procedure (see Section 5.4.2.2).
    - If no ARQ Mode CONTINUE frames are determined to be pending, terminate the current ARQ mode transaction, and enter the ARQ Idle state.
- If the ARQ STATUS frame is not successfully sent the mobile station shall terminate the ARQ mode transaction, and enter the ARQ Idle state.
- If PI = 0, the mobile station shall proceed as follows:
    - If one or more ARQ Mode CONTINUE frames are determined to be pending, invoke the ARQ Mode Continuation procedure (see Section 5.4.2.2).
    - If no ARQ Mode CONTINUE frames are determined to be pending, terminate the current ARQ mode transaction, and enter the ARQ Idle state.

5.4.2.2 ARQ Mode Continuation

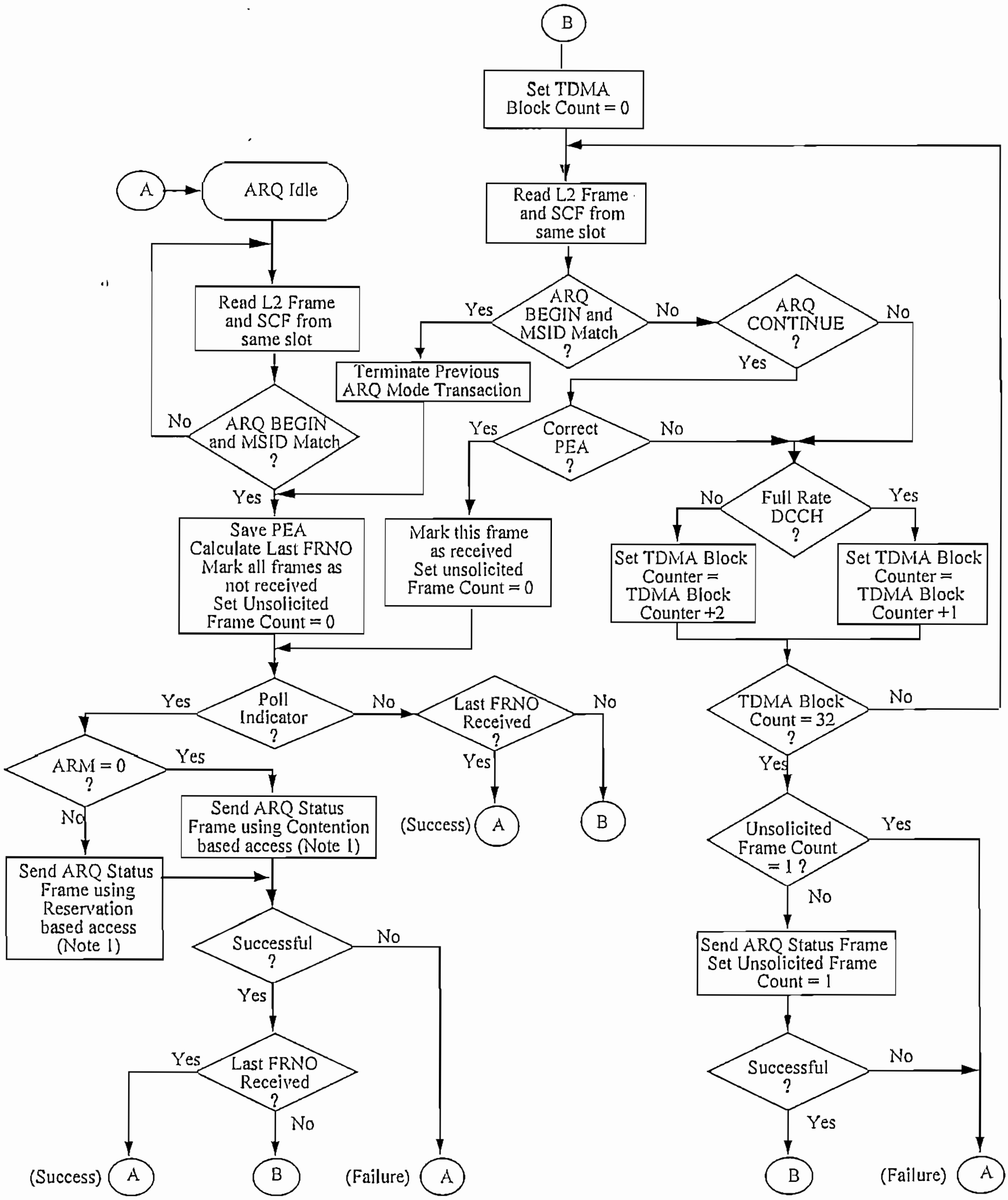
If an ARQ Mode CONTINUE frame with matching PEA value is not received within 32 TDMA blocks after a previously received ARQ Mode BEGIN frame, ARQ Mode CONTINUE frame or within 32 TDMA blocks after successfully sending an ARQ STATUS frame, the mobile station shall attempt to send an unsolicited ARQ STATUS frame to the BMI.
If the unsolicited ARQ STATUS frame is not sent successfully (see Section 5.3), the mobile station shall terminate the ARQ mode transaction and enter the ARQ Idle state.

If an ARQ Mode CONTINUE frame is not received within 32 TDMA blocks after successfully sending an unsolicited ARQ STATUS frame, the mobile station shall terminate the ARQ mode transaction, and enter the ARQ Idle state.
If an ARQ Mode BEGIN frame with an MSID matching its own is received while executing this procedure, the mobile station shall terminate its current ARQ mode transaction and start a new ARQ mode transaction by re-entering the Start ARQ Mode procedure (see Section 5.4.2.1).

If an ARQ Mode CONTINUE frame with matching PEA value is received within 32 TDMA blocks, the mobile station shall proceed as follows:

- The received FRNO shall be marked as received within the FRNO MAP.
- The portion of the L3 message carried in L3DATA shall be stored.
- If PI = 1 and ARM = 1, the mobile station shall send an ARQ STATUS frame on a reservation basis (see Section 5.3.3.1.2).
- If PI = 1 and ARM = 0, the mobile station shall send an ARQ STATUS frame on a contention basis (see Section 5.3.3.1.1).
- A mobile station in the process of responding to PI = 1 shall be capable of receiving additional ARQ Mode CONTINUE frames.
- When an ARQ STATUS frame is sent, it shall reflect the status of the ARQ Mode transaction at the time the mobile station received an ARQ frame with PI = 1.
- If the ARQ STATUS frame is successfully sent, the mobile station shall proceed as follows:
    - If more ARQ Mode CONTINUE frames are determined to be pending, remain in this procedure.
    - If no more ARQ Mode CONTINUE frames are determined to be pending, terminate the current ARQ mode transaction and enter the ARQ Idle state.
- If the ARQ STATUS frame is not successfully sent the mobile station shall terminate the ARQ mode transaction and enter the ARQ Idle state.
- If PI = 0, the mobile station shall proceed as follows:
    - If one or more ARQ Mode CONTINUE frames are determined to be pending, remain in this procedure.
    - If no ARQ Mode CONTINUE frames are determined to be pending, terminate the current ARQ mode transaction and enter the ARQ Idle state.

Figure 5 -42 ARQ MS - Side



Note 1: A mobile station in the process of responding to a PI = 1 shall be capable of receiving additional ARQ Mode CONTINUE frames.

5.5 Monitoring of Radio Link Quality (MRLQ)

5.5.1 Measurement Procedure and Processing

In order to estimate the radio link quality, the mobile station shall measure the Word Errors based on CRC check failure and update the MRLQ counter based on the first slot read in the Paging Frame.

For MRLQ purposes only, a mobile station having an Assigned PFC (see Section 4.7) higher than 1 may, whenever it deems appropriate, reduce the interval between MRLQ Word Error measurements and remain at the reduced interval as long as necessary to ascertain the quality of the radio link. However, the interval between MRLQ Word Error measurements shall not be less than one hyperframe.
The mobile station shall initialize the MRLQ counter to 10 upon entering the DCCH Camping state (see Section 6.2.3). Each MRLQ updating shall increase the MRLQ counter by 1 if the CRC check was successful. A CRC check failure shall decrease the MRLQ counter by 1. Note, however, that the MRLQ counter may be updated, at most, once per Hyperframe. The MRLQ counter shall be truncated to the value of 10, i.e., its value shall never exceed 10.

5.5.2 Radio Link Failure Criteria

Whenever the MRLQ counter reaches 0, a Radio Link Failure is declared (see Section 6.3.3.4.1). The mobile station shall then perform a Control Channel Reselection (see Section 6.3.3).

5.6 SPACH Message Interruption

SPACH message transmissions are subject to the following rules:

General Rules:

- A mobile station shall be required to continue an interrupted ARCH or SMSCH message if the interruption did not result in an MSID or UGID match.
- A mobile station in the process of receiving an ARQ mode transaction shall not abort that process if interrupted by a non-ARQ frame with a matching MSID or UGID.
- A mobile station in the process of receiving an ARQ mode transaction shall abort that process if interrupted by a new ARQ mode transaction with a matching MSID or UGID.
- A mobile station in the process of receiving a non-ARQ mode transaction shall not abort that process if interrupted by a PCH frame with a matching MSID or UGID.
- A mobile station expecting or in the process of receiving an ARCH or SMSCH message shall still monitor its assigned PCH Subchannel for PCH messages and respond to PCON = 1 according to PCH displacement (see Section 4.8).
- The duration of a single instance of an ARCH or SMSCH message interruption on a full-rate DCCH shall not exceed 32 logically consecutive Layer 2 SPACH frames.
- The duration of a single instance of an ARCH or SMSCH message interruption on a half-rate DCCH shall not exceed 16 logically consecutive Layer 2 SPACH frames.
- The total number of interruptions during any given ARCH or SMSCH message is not limited.
- A mobile station shall not be required to retain more than 36 Layer 2 frames.
- Tables 5-14 and 5-15 summarize the full set of SPACH interruption rules.

PCH Message Transmission Rules:

- A BMI in the process of transmitting a multi-slot PCH message shall complete the message transmission without interruption according to SPACH Message Continuation (see Section 4.9).

ARCH Message Transmission Rules:

- A mobile station expecting or in the process of receiving an ARCH message shall also be capable of receiving and responding to PCH messages.
- A BMI in the process of transmitting a non-ARQ ARCH message shall not begin transmitting a new ARCH or SMSCH message to any mobile station until the transmission of its current non-ARQ ARCH message is complete.
- A BMI in the process of transmitting an ARQ ARCH message shall not begin transmitting an ARQ ARCH message with an identical PEA value to any mobile station until the transmission of its current ARQ ARCH message is either completed or aborted.
- A mobile station in the process of receiving an ARQ ARCH message may be interrupted by one or more instances of a non-ARQ ARCH message; by one or more instances of Null frames, Reserved frames, hard pages, PCH messages, or SMSCH messages or by one or more instances of ARQ messages having a different PEA value.

SMSCH Message Transmission Rules:

- A mobile station expecting or in the process of receiving an SMSCH message shall also be capable of receiving and responding to PCH messages.

- A BMI in the process of transmitting a non ARQ SMSCH message shall not begin transmitting a new SMSCH or ARCH message to any mobile station until the transmission of its current non ARQ SMSCH message is complete.

- A BMI in the process of transmitting an ARQ SMSCH message shall not begin transmitting an ARQ SMSCH message with an identical PEA value to any mobile station until the transmission of its current ARQ SMSCH message is either completed or aborted.

- A mobile station in the process of receiving an ARQ SMSCH message may be interrupted by one or more instances of a non-ARQ SMSCH message; by one or more instances of Null frames, Reserved frames, hard pages, PCH messages, or ARCH messages; or by one or more instances of ARQ messages having a different PEA value.

Table 5 - 14 BMI SPACH Interruptions

Current BMI Message Being Transmitted	Interruptions Allowed				
	PCH	Non-ARQ ARCH	ARQ ARCH	Non-ARQ SMSCH	ARQ SMSCH
PCH	N	N	N	N	N
Non-ARQ ARCH	Y	N	N	N	N
ARQ ARCH	Y	Y	Y (Note 1)	Y	Y (Note 1)
Non-ARQ SMSCH	Y	N	N	N	N
ARQ SMSCH	Y	Y	Y (Note 1)	Y	Y (Note 1)

Note 1: The BMI may initiate multiple parallel ARQ mode transactions using distinct PEA values. If the BMI initiates another ARQ mode transaction to the same mobile station, it shall abort the current ARQ mode transaction for that mobile station.

Table 5 - 15 Mobile Station Response to SPACH Message Interruption

Current BMI Message Being Received	Interruptions Allowed				
	PCH	Non-ARQ ARCH	ARQ ARCH	Non-ARQ SMSCH	ARQ SMSCH
PCH	N	N	N	N	N
Non-ARQ ARCH	Y (Note 1)	N	N	N	N
ARQ ARCH	Y (Note 1)	Y (Note 1)	Y (Note 2)	Y (Note 1)	Y (Note 2)
Non-ARQ SMSCH	Y (Note 1)	N	N	N	N
ARQ SMSCH	Y (Note 1)	Y (Note 1)	Y (Note 2)	Y (Note 1)	Y (Note 2)

Note 1: If the interrupting message is addressed to the mobile station receiving the current BMI message, the mobile station shall not abort its current message.

Note 2: If the interrupting message is addressed to the mobile station receiving the current BMI message, the mobile station shall abort its current message.

6. Layer 3 Operation

Terminology used in Sections 6.2 and 6.3 is as follows:

- "FDCCH Indication primitive received containing a PCH message" refers to PCH messages that are delivered on the mobile station allocated PCH Subchannel. The possible layer 3 messages that can be delivered on this PCH Subchannel are specified in Section 6.4.3. In addition, Hard pages (see Section 5.2.5) are considered to be PCH messages.

- "FDCCH Indication primitive received containing an ARCH message" refers to ARCH messages that are delivered on the ARCH subchannel. The possible layer 3 messages that can be delivered on this subchannel are specified in Section 6.4.3.

- "FDCCH Indication primitive received containing an SMSCH message" refers to SMSCH messages that are delivered on the SMSCH subchannel. The possible layer 3 messages that can be delivered on this subchannel are specified in Section 6.4.3.

- "FDCCH Indication primitive received containing a BCCH message" refers to messages that are delivered on the F-BCCH, E-BCCH and S-BCCH channels. The possible layer 3 messages that can be delivered on these channels are specified in Sections 6.4.1.

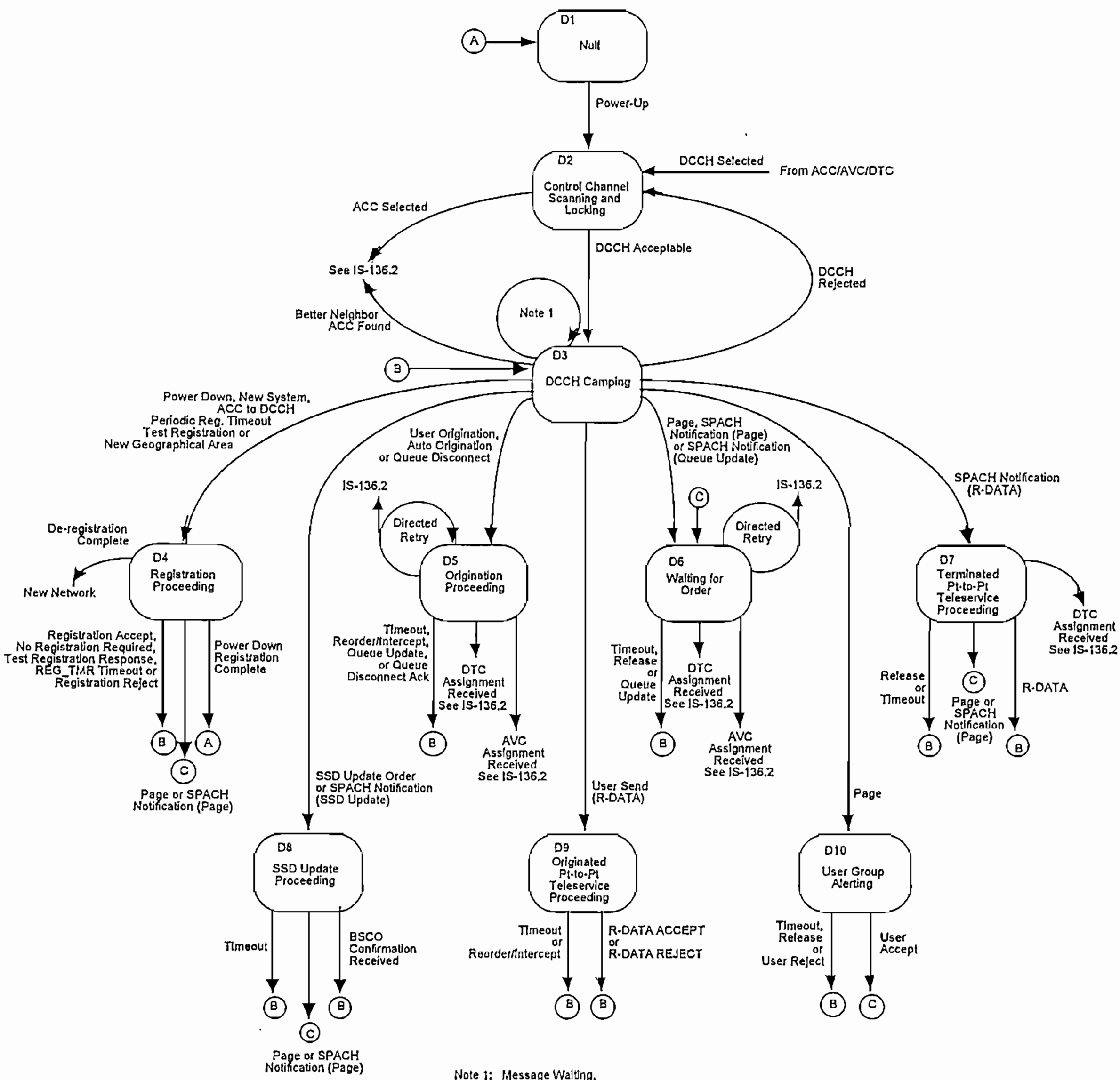
- "Layer 2 Access Success Indication" indicates that the requested layer 3 message(s) have been successfully transmitted on the RACH (See Section 5.3 and 5.1.1.1).

- "Layer 2 Access Failure Indication" indicates that the requested layer 3 message(s) have not been transmitted on the RACH due to an Access Failure (See Sections 5.3 and 5.1.1.1).

6.1 Mobile Station State Diagram

Figure 6-1 is provided for overview purposes and is not intended to be exhaustive.

Figure 6 - 1 Mobile Station State Diagram



Note 1: Message Waiting,
Unique Challenge Order,
User Alert,
Parameter Update,
Capability Request,
Better Neighbor DCCH Found,
Cell Barred,
Audit Order,
SPACH Notification (Queue Disconnect),
SPACH Notification (Mobile Assisted Channel Allocation), or
Queue Update

6.2 Mobile Station State Descriptions

6.2.1 Null State (D1)

The layer 3 entity within a mobile station shall be in the Null state if it is powered down. When a power up occurs a mobile station shall enter the Control Channel Scanning and Locking state (see Section 6.2.2).

6.2.2 Control Channel Scanning and Locking State (D2)

The layer 3 entity within a mobile station shall be in the Control Channel Scanning and Locking state when it is in the process of selecting a candidate service provider. While in this state, a mobile station may at any time determine that an analog control channel (ACC) is the preferred service provider in which case it shall enter the Initialization task (see Section 2.6.1 of IS-136.2).
If a mobile station attempts to find service on a DCCH, it may search for a candidate DCCH following the recommendations provided in the DCCH Scanning and Locking procedure (see Section 6.3.1). If a mobile station finds a candidate DCCH, it shall execute the Control Channel Selection procedure (see Section 6.3.2).
If the candidate DCCH satisfies the criteria described in the Control Channel Selection procedure, the mobile station shall enter the DCCH Camping state (see Section 6.2.3). Otherwise, the mobile station shall search for another candidate DCCH or ACC.
If a power down condition occurs while in this state, the mobile station shall attempt to return to the serving control channel it last used during its current power cycle and send a Power Down Registration if required by that control channel.

6.2.3 DCCH Camping State (D3)

Upon entering this state from Control Channel Scanning and Locking state or for the first time on the current DCCH as a result of control channel reselection, a mobile station shall always make an initial reading of a full cycle of F-BCCH and E-BCCH. A mobile station in this state shall not make an access attempt until it has completed its initial reading of a full cycle of F-BCCH. After completing its initial reading of F-BCCH, a mobile station will leave this state in order to process any of the following transactions:

- An originated call
- A terminated call
- A registration
- An SSD Update
- A Terminated Point-to-Point Teleservice
- An Originated Point-to-Point Teleservice
- A User Group call

The layer 3 entity within a mobile station shall be in the DCCH Camping state as long as it is logically connected to the best DCCH according to the control channel (re)selection rules. While in this state the mobile station shall respond to the following conditions as indicated:

ACC Service Preferred:

- This condition exists whenever a mobile station determines that an ACC is the preferred service provider. Whenever this condition is detected, the mobile station shall enter the Initialization task (see Section 2.6.1 of IS-136.2).

Radio Link Failure:

- This condition exists whenever the MRLQ counter (see Section 5.5) reaches zero on the current DCCH. Whenever this condition is detected, the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

Cell Barred:

- This condition exists whenever the layer 2 Go Away flag is set (see Section 5.2.5) or the Cell Barred information element indicates barring (see Section 6.4.1.1.1.2) on the current DCCH. Whenever this condition is detected, the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

Server Degradation:

- This condition exists whenever $C\_RESEL_{current} < 0$ (see Section 6.3.3.4.2) AND $Short\_RSS_{current} \leq Long\_RSS_{current}$ (see Section 6.3.3.3). Whenever this condition is detected, the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

Priority System Condition:

- This condition exists whenever a mobile station or a mobile station user decides to acquire service on a DCCH supporting a Network Type, SID, PSID or RSID determined to be of higher priority relative to the current DCCH (see Section 6.3.15 and 6.3.19). Whenever this condition is detected, the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

Service Offering:

- This condition exists whenever the mobile station decides to evaluate the services offered by other DCCHs (see Section 6.4.1.1.2.4). Whenever this condition is detected the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

Periodic Evaluation:

- This condition exists whenever the mobile station decides to evaluate the signal strength performance of other DCCHs. This condition shall occur at least once every SCANINTERVAL (see Section 6.3.3.1) when the Full_reselect_data_indicator is set (see Section 6.3.3.3). Whenever this condition is detected the mobile station shall invoke the Control Channel Reselection procedure (see Section 6.3.3) using the results obtained according to the Signal Strength Measurements procedure (see Section 6.3.2.3). The Neighbor List entries acquired on the current DCCH, Private Operating Frequencies (see Section 6.3.21) and/or a DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) shall serve as candidates for cell reselection.

FDCCH Indication primitive received containing a BCCH message:

- The BCCH Update procedure (see section 6.3.18) shall be invoked.

PER_TMR Timeout:

- The Registration procedure (see Section 6.3.7) shall be invoked.

PER_TMR_indicator is set:

- The mobile station shall reset the PER_TMR_indicator and then invoke the Registration procedure (see Section 6.3.7) indicating a PER_TMR timeout.

REREG_TMR Timeout:

- The Registration procedure (see Section 6.3.7) shall be invoked.

REREG_TMR_indicator is set:

- The mobile station shall reset the REREG_TMR_indicator and then invoke the Registration procedure (see Section 6.3.7) indicating a REREG_TMR timeout.

TMSI_TMR Timeout:

- The Registration procedure (see Section 6.3.7) shall be invoked.

REGID Increment:

- Whenever the mobile station increments its value of REGID, the Registration procedure (see Section 6.3.7) shall be invoked.

Queued_Orig_indicator is set:

- Whenever this condition is detected the mobile station shall provide the user with an appropriate indication of the queued originated call condition.

Auto Origination:

- This condition exists whenever a mobile station has entered this state for the first time on the current DCCH as result of control channel reselection and Queued_Orig_indicator is set. Whenever this condition is detected the mobile station shall re-attempt the queued originated call by invoking the Origination procedure (see Section 6.3.5).

Power Up:

- This condition exists whenever a mobile station enters this state without having successfully registered during its current power cycle. Whenever this condition is detected, the mobile station shall invoke the Registration procedure (see Section 6.3.7).

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

FDCCH Indication primitive received containing a PCH message:

- The Termination procedure (see Section 6.3.4) shall be invoked.

User Origination:

- This condition exists whenever a mobile station decides to initiate an originated call. Whenever this condition is detected the Origination procedure (see Section 6.3.5) shall be invoked.

Queue Disconnect:

- This condition exists whenever Queued_Orig_indicator is set and the mobile station decides to abort its queued originated call. Whenever this condition is detected the Origination procedure (see Section 6.3.5) shall be invoked.

MS Originated SOC Message Delivery:

- This condition exists when a mobile station decides to invoke SOC Message Delivery, the SOC Message Delivery message sent on the F-BCCH or E-BCCH indicates that MS Originated SOC Message Delivery is supported and the BMI is broadcasting a SOC/BSMC Identification message that has a SOC supported by the mobile station. Whenever this condition is detected, the specific action taken is beyond the scope of this specification.

MS Originated BSMC Message Delivery:

- This condition exists when a mobile station decides to invoke BSMC Message Delivery and the BMI is broadcasting a SOC/BSMC Identification message that has a BSMC supported by the mobile station. Whenever this condition is detected, the specific action taken is beyond the scope of this specification.

MS Originated SMS:

- The Originated Point-to-Point Teleservice procedure (see Section 6.3.6) shall be invoked.

De-registration Condition:

- This condition exists whenever a mobile station decides to either acquire service or discontinue service on a control channel that does not provide intersystem support (see Reg-Info Map IE in Section 6.4.1.1.1.4). Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

Non-Public Mode Search Condition:

- This condition exists whenever a mobile station user decides to initiate a search for non-public mode service. Whenever this condition is detected, the Non-Public Mode Search procedure (see Section 6.3.19) shall be invoked.

Test Registration Condition:

- This condition exists whenever a mobile station or a mobile station user decides to initiate a Test Registration (see Section 6.3.20) on its current DCCH. Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

User Group Activation/Deactivation Condition:

- This condition exists whenever a mobile station user decides to activate, deactivate or modify User Group operation. Once User Group operation has been activated for a given User Group domain (see Section 8.4.1), this condition will only exist when User Group operation is to be deactivated or modified for that User Group domain. Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

System Transition Condition:

- This condition exists whenever a mobile station is registered on a SID, PSID or RSID and desires to acquire service on a different SID, PSID or RSID independent of a change of DCCH (see Section 6.3.8, 6.3.14, 6.3.15 and 6.3.19). Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

VMLA Transition Condition:

- This condition exists whenever the Present RNUM information element received by a mobile station (see Section 6.4.1.1.1.4) is not part of the RNUM list stored in its semi-permanent memory. Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

ACC to DCCH Transition Condition:

- This condition exists whenever a mobile station is attempting to acquire service on a DCCH and its last successful registration was on an ACC during its current power cycle. Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

Hyperband Transition Condition:

- This conditions exists whenever a mobile station is attempting to acquire service on a DCCH and its last successful registration during its current power cycle was in a different Hyperband. Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

Forced Registration Condition:

- This condition exists whenever one of the following occurs:
  - A mobile station determines that the FOREG flag (see Section 6.4.1.1.1.4) has transitioned from disabled to enabled.
  - Immediately after power up, a mobile station determines that the FOREG flag is enabled.

  Whenever this condition is detected, the Registration procedure (see Section 6.3.7) shall be invoked.

All other conditions shall be ignored.

6.2.4 Registration Proceeding (D4)

The layer 3 entity within a mobile station shall be in the Registration Proceeding state after it has sent a Registration or a Test Registration message to the BMI but has not yet received a response. Upon entering this state as a result of sending a Registration message, the mobile station shall store its Assigned PFC in temporary memory and then set its Assigned PFC and current PFC to PFC_1, regardless of the setting of PFM and PFM Direction (see Section 4.7). The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- If this state was entered as a result of a De-registration condition, the mobile station shall start DEREG_TMR and then remain in the Registration Proceeding state.

- If this state was entered as a result of a Power Down condition, the mobile station shall enter the Null state (see Section 6.2.1).
- Otherwise, the mobile station shall stop REREG_TMR (if running), start REG_TMR and remain in the Registration Proceeding state.

Layer 2 Access Failure Indication:

- If this state was entered as a result of a De-registration condition, the mobile station shall restore its paging frame class from temporary memory and then do one of the following:
  - Return to DCCH Camping state.
  - Proceed to acquire service on the new network.
- If this state was entered as a result of a Power Down condition, the mobile station shall enter the Null state (see Section 6.2.1).
- Otherwise, the mobile station shall restore its Assigned PFC from temporary memory and then return to DCCH Camping state.

REG_TMR Timeout:

- If the mobile station has resent its registration up to the maximum of 5 times it shall return to the DCCH Camping state. Otherwise, it shall set REREG_TMR timer to a random time uniformly distributed in the interval 16 to 40 superframes with a granularity of 1 superframe, and then enter the DCCH Camping state.

DEREG_TMR Timeout:

- The mobile station shall do one of the following:
  - Reset DEREG_TMR, resend its Registration with a De-registration indication a maximum of one time and remain in the Registration Proceeding state.
  - Proceed to acquire service on the new network.

FDCCH Indication primitive received containing an ARCH message:

- If a Registration Accept message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall invoke the Registration Success procedure (see Section 6.3.10).
- If a Registration Reject message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall invoke the Registration Reject procedure (see Section 6.3.11).
- If a Test Registration Response message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall update its PSID/RSID list accordingly, stop REG_TMR and then return to the DCCH Camping state.
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other ARCH message is received, the mobile station shall ignore it and remain in Registration Proceeding state.

FDCCH Indication primitive received containing a PCH message:

- If a Page message, a hard page or a SPACH Notification message indicating Page is received and the mobile station determines that it should respond according to the Subaddressing Procedures (see Section 6.3.13), the mobile station shall stop REG_TMR or DEREG_TMR (whichever is running), restore its paging frame class from temporary memory and then invoke the Termination procedure (see Section 6.3.4).
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other PCH message is received the mobile station shall ignore it and remain in the Registration Proceeding state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.5 Origination Proceeding (D5)

The layer 3 entity within a mobile station shall be in the Origination Proceeding state after it has done one of the following:

- Sent an Origination message but has not yet received a response from the BMI.
- Sent a Queue Disconnect message but has not yet received a response from the BMI.

The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- The mobile station shall start ORIG_TMR and then remain in the Origination Proceeding state.

Layer 2 Access Failure Indication:

- If a Directed Retry message was received while in this state, the mobile station shall proceed as follows:
  - Invoke the Reselection Criteria procedure (see Section 6.3.3.4).
  - If a DCCH is selected, the mobile station shall formulate the Origination message with the Last Try bit set to the value of the Last Try bit received in the last received Directed Retry message, issue an RDCCH Request primitive containing the Origination message along with any other coincidental messages required and remain in the Origination Proceeding state.
- Otherwise, the mobile station shall stop ACCESS_TMR and then return to DCCH Camping state.

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the Origination Proceeding state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the Origination Proceeding state.

ORIG_TMR or ACCESS_TMR Timeout:

- The mobile station shall stop ORIG_TMR or ACCESS_TMR (whichever is running) and then return to the DCCH Camping state.

FDCCH Indication primitive received containing an ARCH message:

- If a Digital Traffic Channel Designation message is received, the mobile station shall determine if the message is intended for this mobile station in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for this mobile station, it shall stop ORIG_TMR and ACCESS_TMR, update the parameters as received in the message, reset PER_TMR_indicator and REREG_TMR_indicator, invoke the Registration Update procedure (see Section 6.3.8) and then enter the Confirm Initial Traffic Channel task (see Section 2.6.5.2 of IS-136.2). It should be noted that if the channel designation was received as a result of a Directed Retry access, then CAND_1 (see Section 6.3.3.4.3) becomes the current DCCH and all broadcast parameters read on CAND_1 shall be considered as current by the mobile station.
- If an Analog Voice Channel Designation message is received, the mobile station shall determine if the message is intended for this mobile station in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for this mobile station, it shall stop ORIG_TMR and ACCESS_TMR, update the parameters as received in the message, reset PER_TMR_indicator and REREG_TMR_indicator, invoke the Registration Update procedure (see Section 6.3.8) and then enter the Confirm Initial Voice Channel task (see Section 2.6.4.2 of IS-136.2). It should be noted that if the channel designation was received as a result of a Directed Retry access, then CAND_1 (see Section 6.3.3.4.3) becomes the current DCCH and all broadcast parameters read on CAND_1 shall be considered as current by the mobile station.

- If a Directed Retry message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall proceed as follows:
    - Stop ORIG_TMR.
    - Invoke the Reselection Criteria procedure (see Section 6.3.3.4).
    - If a DCCH is selected, the mobile station shall formulate the Origination message with the Last Try bit set to the value of the Last Try bit received in the Directed Retry message, issue an RDCCH Request primitive containing the Origination message along with any other coincidental messages required and remain in the Origination Proceeding state.
- If a Reorder/Intercept message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop ORIG_TMR, store the cause code and then proceed as follows:
    - If the cause code = Unknown MSID and the mobile station has a permanent MSID (MIN or IMSI) that has not been previously rejected since its last SID based registration (New System), the mobile station may resend an RDCCH Request primitive containing its previous Origination using the alternate MSID and remain in the Origination Proceeding state.
    - Otherwise the mobile station shall stop ACCESS_TMR and then return to the DCCH Camping state.
- If a Queue Update message is received the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it the mobile station shall proceed as follows:
    - Stop ORIG_TMR and ACCESS_TMR.
    - Set Queued_Orig_indicator.
    - Invoke the Registration Update procedure (see Section 6.3.8).
    - If the MACA_LIST and/or the MACA_LIST (Other Hyperband) information elements are included in the Queue Update message the mobile station shall perform STM measurements on the current DCCH and the indicated MACA channels according to the STM Measurements procedure (see Section 6.3.17.4.2). These MACA channels are distinct from those indicated on the BCCH and are only reported on as a result of receiving a SPACH Notification indicating Mobile Assisted Channel Allocation (see Section 6.3.4).
    - Update the parameters as received in the message and then return to the DCCH Camping state.
- If a Queue Disconnect Ack message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it the mobile station shall stop ORIG_TMR and ACCESS_TMR, reset Queued_Orig_indicator, update the parameters as received in the message and then return to the DCCH Camping state.
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other ARCH message is received, the mobile station shall ignore it and remain in the Origination Proceeding state.

FDCCH Indication primitive received containing a PCH message:

- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other PCH message is received, the mobile station shall ignore it and remain in the Origination Proceeding state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.6 Waiting for Order (D6)

The layer 3 entity within a mobile station shall be in the Waiting for Order state after it has done one of the following:

- Sent a SPACH Confirmation message in response to a SPACH Notification Indicating Page but has not yet received a response from the BMI.
- Sent a SPACH Confirmation message in response to a SPACH Notification Indicating Queue Update but has not yet received a response from the BMI.
- Sent a Page Response in response to a Page but has not yet received a response from the BMI.

The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- If this access included a SPACH Confirmation message sent in response to a SPACH Notification Indicating Page, the mobile station shall start SPACH_TMR and remain in the Waiting for Order state.
- If this access included a SPACH Confirmation message sent in response to a SPACH Notification Indicating Queue Update, the mobile station shall start WAFO_TMR and remain in the Waiting for Order state.
- Otherwise, the mobile station shall start WAFO_TMR and remain in the Waiting for Order state.

Layer 2 Access Failure Indication:

- If a Directed Retry message was received while in this state, the mobile station shall proceed as follows:
  - Invoke the Reselection Criteria procedure (see Section 6.3.3.4).
  - If a DCCH is selected the mobile station shall formulate the Page Response message with the Last Try bit set to the value of the Last Try bit received in the last received Directed Retry message, issue an RDCCH Request primitive containing the Page Response message along with any other coincidental messages required and remain in the Waiting for Order state.
- Otherwise, the mobile station shall stop ACCESS_TMR (if running) and then return to the DCCH Camping state.

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the Waiting For Order state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the Waiting For Order state.

WAFO_TMR, SPACH_TMR or ACCESS_TMR Timeout:

- The mobile station shall stop WAFO_TMR, SPACH_TMR or ACCESS_TMR (whichever is running) and then enter the DCCH Camping state.

FDCCH Indication primitive received containing an ARCH message:

- If SPACH_TMR is running and a Page message is received the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a Page Response message (see Section 6.4.4) along with any other coincidental messages required, stop SPACH_TMR, start ACCESS_TMR and then remain in the Waiting for Order state.
- If WAFO_TMR is running and a Queue Update message is received the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it the mobile station shall proceed as follows:
  - Stop WAFO_TMR.
  - Set Queued_Orig_indicator.
  - If the MACA_LIST and/or the MACA_LIST (Other Hyperband) information elements are included in the Queue Update message the mobile station shall perform STM measurements

on the current DCCH and the indicated MACA channels according to the STM Measurements procedure (see Section 6.3.17.4.2). These MACA channels are distinct from those indicated on the BCCH and are only reported on as a result of receiving a SPACH Notification indicating Mobile Assisted Channel Allocation (see Section 6.3.4).

- Update the parameters as received in the message and then return to the DCCH Camping state.

- If WAFO_TMR is running and a Digital Traffic Channel Designation message is received the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it the mobile station shall stop WAFO_TMR and ACCESS_TMR (if running), update the parameters as received in the message, reset PER_TMR_indicator and REREG_TMR_indicator, invoke the Registration Update procedure (see Section 6.3.8) and then enter the Confirm Initial Traffic Channel task (see Section 2.6.5.2 of IS-136.2). It should be noted that if the channel designation was received as a result of a Directed Retry access, then CAND_I (see Section 6.3.3.4.3) becomes the current DCCH and all broadcast parameters read on CAND_I shall be considered as current by the mobile station.

- If WAFO_TMR is running and an Analog Voice Channel Designation message is received the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it the mobile station shall stop WAFO_TMR and ACCESS_TMR (if running), update the parameters as received in the message, reset PER_TMR_indicator and REREG_TMR_indicator, invoke the Registration Update procedure (see Section 6.3.8) and then enter the Confirm Initial Voice Channel task (see Section 2.6.4.2 of IS-136.2). It should be noted that if the channel designation was received as a result of a Directed Retry access, then CAND_I (see Section 6.3.3.4.3) becomes the current DCCH and all broadcast parameters read on CAND_I shall be considered as current by the mobile station.

- If WAFO_TMR is running and a Directed Retry message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall:

  - Stop WAFO_TMR.

  - Invoke the Reselection Criteria procedure (see Section 6.3.3.4).

  - If a DCCH is selected the mobile station shall formulate the Page Response message with the Last Try bit set to the value of the Last Try bit received in the Directed Retry message, issue an RDCCH Request primitive containing the Page Response message along with any other coincidental messages required and remain in the Waiting for Order state.

- If WAFO_TMR is running and a Release message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop WAFO_TMR and ACCESS_TMR, store the cause code and then return to DCCH Camping state.

- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other ARCH message is received, the mobile station shall ignore it and remain in Waiting for Order state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.7 Terminated Point-to-Point Teleservice Proceeding (D7)

The layer 3 entity within a mobile station enters the Terminated Point-to-Point Teleservice Proceeding state after it has sent a SPACH Confirmation in response to a SPACH Notification indicating R-DATA but has not yet received a response from the BMI. The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- The mobile station shall start PPT_TMR and remain in the Terminated Point-to-Point Teleservice Proceeding state.

Layer 2 Access Failure Indication:

- Enter the DCCH Camping state (i.e., Teleservice Delivery Aborted).

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the Terminated Point-to-Point Teleservice Proceeding state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the Terminated Point-to-Point Teleservice Proceeding state.

PPT_TMR Timeout:

- Enter the DCCH Camping state (i.e., Teleservice Delivery Aborted).

FDCCH Indication primitive received containing a SMSCH message:

- Stop PPT_TMR
- If an R-DATA message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall proceed as follows:
  - If the R-DATA message is acceptable to the mobile station, it shall respond in the required time window (see Table 6-15) by sending a R-DATA ACCEPT message with the same R-Transaction Identifier present in the R-DATA message and then enter the DCCH Camping State (see Section 6.2.3).
  - If the R-DATA message is not acceptable to the mobile station, it shall respond in the required time window (see Table 6-15) by sending a R-DATA REJECT message with the same R-Transaction Identifier present in the R-DATA message, and with the mandatory R-Cause information element and then enter the DCCH Camping State (see Section 6.2.3).
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other SMSCH message is received, the mobile station shall ignore it and remain in the Terminated Point-to-Point Teleservice Proceeding state.

FDCCH Indication primitive received containing an ARCH message:

- If a Digital Traffic Channel Designation message is received, the mobile station shall determine if the message is intended for this mobile station in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop PPT_TMR, update the parameters as received in the message, reset PER_TMR_indicator and REREG_TMR_indicator, invoke the Registration Update procedure (see Section 6.3.8) and then enter the Confirm Initial Traffic Channel task (see Section 2.6.5.2 of IS-136.2).
- If a Release message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop PPT_TMR, store the cause code and then enter the DCCH Camping state.
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other ARCH message is received, the mobile station shall ignore it and remain in the Terminated Point-to-Point Teleservice Proceeding state.

FDCCH Indication primitive received containing a PCH message:

- If a Page message, a hard page or a SPACH Notification message indicating Page is received and the mobile station determines that it should respond according to the Subaddressing Procedures (see Section 6.3.13), the mobile station shall stop PPT_TMR then invoke the Termination procedure (see Section 6.3.4).
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other PCH message is received, the mobile station shall ignore it and remain in the Terminated Point-to-Point Teleservice Proceeding state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.8 SSD Update Proceeding (D8)

The layer 3 entity within a mobile station shall be in the SSD Update Proceeding state after it has:

- sent a SPACH Confirmation in response to a SPACH Notification Indicating SSD Update but has not yet received a response from the BMI; or
- sent a Base Station Challenge Order in response to an SSD Update Order but has not yet received a response from the BMI; or
- sent an SSD Update Order Confirmation.

The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- If the access included a SPACH Confirmation message, the mobile station shall start SPACH_TMR and remain in the SSD Update Proceeding state.
- If the access included an SSD Update Order Confirmation, the mobile station shall enter the DCCH Camping state.
- Otherwise, the mobile station shall start SSDU_TMR and remain in the SSD Update Proceeding state.

Layer 2 Access Failure Indication:

- Terminate this procedure and then enter the DCCH Camping state.

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the SSD Update Proceeding state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the SSD Update Proceeding state.

SSDU_TMR or SPACH_TMR expires:

- Terminate this procedure and then enter the DCCH Camping state.

FDCCH Indication primitive received containing an ARCH message:

- If SPACH_TMR is running and a SSD Update Order is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop SPACH_TMR, send a Base Station Challenge Order in the required time window (see Table 6-15) and then remain in SSD Update Proceeding state.
- If SSDU_TMR is running and a Base Station Challenge Order Confirmation is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop SSDU_TMR, set SSD-A and SSD-B according to Section 6.3.12.9, issue an RDCCH Request primitive containing an SSD Update Order Confirmation (see Section 6.4.4.16) in the required time window (see Table 6-15) and remain in the SSD Update Proceeding state.
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other ARCH message is received, the mobile station shall ignore it and remain in the SSD Update Proceeding state.

FDCCH Indication primitive received containing a PCH message:

- If a Page message, a hard page or a SPACH Notification message indicating Page is received and the mobile station determines that it should respond according to the Subaddressing Procedures (see Section 6.3.13), the mobile station shall stop SSDU_TMR or SPACH_TMR (whichever is running), and then invoke the Termination procedure (see Section 6.3.4).
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other PCH message is received, the mobile station shall ignore it and remain in the SSD Update Proceeding state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.9 Originated Point-to-Point Teleservice Proceeding (D9)

The layer 3 entity within a mobile station shall be in the Originated Point-to-Point Teleservice Proceeding state after it has sent an R-DATA message but has not yet received a response from the BMI. The mobile station shall respond to the following conditions as indicated:

Layer 2 Access Success Indication:

- The mobile station shall start PPT_ORIG_TMR and remain in the Originated Point-to-Point Teleservice Proceeding state.

Layer 2 Access Failure Indication:

- Enter the DCCH Camping state (i.e., Teleservice origination aborted).

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the Originated Point-to-Point Teleservice Proceeding state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the Originated Point-to-Point Teleservice Proceeding state.

PPT_ORIG_TMR Timeout:

- If this is the first PPT_ORIG_TMR timeout, the mobile station shall do one of the following:
  - Repeat the R-DATA transmission by invoking the Originated Point-to-Point Teleservice procedure (see Section 6.3.6).
  - Enter the DCCH Camping state.
- If this is the second PPT_ORIG_TMR timeout, the mobile station shall enter the DCCH Camping state.

FDCCH Indication primitive received containing an SMSCH message:

- If an R_DATA ACCEPT or R_DATA REJECT message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it and has the same R-Transaction Identifier as the one sent in R-DATA message, the mobile station shall stop PPT_ORIG_TMR, activate DELAY_TMR according to the R-DATA Delay information element if present and then enter the DCCH Camping state.
- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).
- If any other SMSCH message is received, the mobile station shall ignore it and remain in the Originated Point-to-Point Teleservice Proceeding state.

FDCCH Indication primitive received containing an ARCH message:

- If a Reorder/Intercept message is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop PPT_ORIG_TMR and then proceed as follows:

  - If the cause code = Unknown MSID and the mobile station has a permanent MSID (MIN or IMSI) that has not been previously rejected since its last SID based registration (new System), the mobile station may resend an RDCCH Request primitive containing its previous R-DATA using the alternate MSID along with any other coincidental messages required and remain in the Originated Point-to-Point Teleservice Proceeding state.

  - Otherwise the mobile station shall return to the DCCH Camping state.

- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other ARCH message is received, the mobile station shall ignore it and remain in the Originated Point-to-Point Teleservice Proceeding state.

FDCCH Indication primitive received containing a PCH message:

- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other PCH message is received, the mobile station shall ignore it and remain in the Originated Point-to-Point Teleservice Proceeding state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.2.10 User Group Alerting (D10)

The layer 3 entity within a mobile station shall be in the User Group Alerting state once it has received a Page indicating User Group from the BMI and is awaiting a user accept indication at the mobile station. The mobile station shall respond to the following conditions as indicated:

PER_TMR Timeout:

- Set the PER_TMR_indicator and remain in the User Group Alerting state.

REREG_TMR Timeout:

- Set the REREG_TMR_indicator and remain in the User Group Alerting state.

UGA_TMR Timeout:

- Terminate user alerting and return to the DCCH Camping state.

FDCCH Indication primitive received containing an ARCH message:

- If a Release message indicating MSID or UGID is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall stop UGA_TMR, terminate user alerting and then enter the DCCH Camping state.

- If a SOC Message Delivery or BSMC Message Delivery is received, the mobile station shall determine if the message is intended for it according to the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall process this message (the specific action taken is beyond the scope of this specification).

- If any other ARCH message is received, the mobile station shall ignore it and remain in the User Group Alerting state.

User Accept Indication:

- The mobile station shall stop UGA_TMR, terminate user alerting, issue an RDCCH Request primitive containing a Page Response message (see Section 6.4.4) along with any other coincidental messages required, start ACCESS_TMR and then enter the Waiting for Order state (see Section 6.2.6).

- If the mobile station desires to activate message encryption on an AVC or DTC, the Message Encryption Mode information element shall be included in the Page Response message. The mobile station uses the Message Encryption Algorithm Map and Message Encryption Key Map information elements provided in the Service Menu message to make its message encryption selection.

User Reject Indication:

- The mobile station shall stop UGA_TMR, terminate user alerting and then enter the DCCH Camping state.

Power Down:

- This condition exists as a result of a mobile station decision to power down. The mobile station shall terminate user alerting, stop all timers and then invoke the Registration procedure (see Section 6.3.7).

All other conditions shall be ignored.

6.3 Procedures

6.3.1 DCCH Scanning and Locking

The mobile station may scan all RF channels while searching for a DCCH, and several strategies may be adopted to speed mobile station determination of DCCH allocation. Some recommendations are provided below.

One approach a mobile station may use to scan for an acceptable DCCH is provided in Annex D. The reference model presented in this annex includes the following DCCH search strategies: (1) search based on historic information on DCCH allocation, (2) obtain DCCH locator information from the CDL field of a DTC (see IS-136.2, Section 1.2.6), (3) read the Control Channel Information message on the ACC overhead message train (see IS-136.2, Section 3.7.1.2.5), (4) utilize neighbor list entries when a DCCH is found, and (5) conduct a band search for a DCCH as a last resort. The probability block structure described in Section 6.3.1.1 may be used by a mobile station to segment the search for a DCCH when conducting a band search. It is not recommended, however, that a mobile station utilize searching for a DCCH by probability blocks until all other search strategies have been exhausted. In the absence of any other information, the mobile station shall search any given probability block in ascending order of channel number. If a mobile station receives DCCH locator information, it shall take precedence over the channel block probability scheme described herein.

It is recommended that a mobile station use historic information whenever possible to reduce DCCH acquisition times. The mobile station may store DCCH allocation information to assist in the location of control channels at mobile station power-up. For example, a mobile station may store the DCCH allocation of its home system. It may also store information on the last DCCH of operation prior to power-down. If a mobile station is authorized to operate on autonomous systems, it may also store DCCH information associated with any given autonomous system (see Section 6.3.21).

If DCCH information is given upon release from an analog voice channel or digital traffic channel (see IS-136.2, Sections 3.7.2.1 and 3.7.3.1.3.2.6), then the mobile station shall use this information to scan for a DCCH if digital service is the preferred service.

If in the course of searching for a DCCH, a mobile station identifies a DTC, it is recommended that the mobile station decode the CDL field (see IS-136.2, Section 1.2.6). If the CDL value is non-zero, the mobile station shall examine the indicated channel numbers in an attempt to find a DCCH.

To accommodate international application, several system configurations are supported as indicated in Regulatory Configuration (see Section 6.4.1.2.1.2).

6.3.1.1 General Recommendation for Digital Control Channel Assignments

Radio spectrum may be divided into one or more frequency bands reflecting the number of operators supported in a geographic area. To aid the mobile station in searching for a DCCH, any given frequency band is comprised of 16 probability blocks. Probability blocks are assigned a relative order of probability regarding their potential for DCCH support (see Tables 6-1 through 6-8). The ranking of probability blocks is only a relative measure of probability and shall not be interpreted as an absolute probability for finding a DCCH. Furthermore, since DCCH allocation is at the discretion of the cellular operator, who may choose not to partition DCCHs according to probability blocks, it is recommended that a mobile station search by probability blocks only after all other strategies for finding a DCCH have been exhausted, especially in existing 800 Mhz cellular operations.

6.3.1.1.1 Regulatory Configuration Identifier = 0

For this RCI, the Regulatory Configuration message is used to define the number of channel groups and their associated boundaries. Each defined channel group shall be divided into 16 probability blocks where block size is determined by the number of channels in the frequency band Div 16.

The size of the 16th probability block is the number of channels in the frequency band Div 16 + the number of channels in the frequency band Mod 16.

The relative probability of blocks listed in descending order of probability is as follows: block 8,9,7,10,6,11,5,12,4,13,3,14,2,15,1,16.

For example, if RCI = 0 on an 800 MHz DCCH and if three service providers were to operate with equal spectrum allocation, then the RF Channel Allocation values for the 800 MHz hyperband would be as follows:

Field	Value
Parameter Type (RF Channel Allocation)	1
Number of Channel Groups	3

Channel Group	1 222
Channel Group	223 444
Channel Group	445 666

For example, if RCI = 0 on an 800 MHz DCCH and if four service providers were to operate with equal spectrum allocation, then the RF Channel Allocation values for the 800 MHz hyperband would be as follows:

Field	Value
Parameter Type (RF Channel Allocation)	1
Number of Channel Groups	4
Channel Group	991 175
Channel Group	176 383
Channel Group	384 591
Channel Group	592 799

For example, if RCI = 0 on a 1900 MHz DCCH and if four service providers were to operate with equal spectrum allocation, then the RF Channel Allocation values for the 1900 MHz hyperband would be as follows:

Field	Value
Parameter Type (RF Channel Allocation)	1
Number of Channel Groups	4
Channel Group	2 500
Channel Group	501 1000
Channel Group	1001 1500
Channel Group	1501 1998

6.3.1.1.2 Regulatory Configuration Identifier = 1

For 800 MHz TDMA systems in North America, a mobile station that prefers System A and follows the recommended probability blocks shall begin searching for a DCCH according to Table 6-1. A mobile station that prefers System B and follows the recommended probability blocks shall begin searching for a DCCH according to Table 6-2.

Table 6 - 1 Recommended A Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	1 - 26	A	26	4
2	27 - 52	A	26	5
3	53 - 78	A	26	6
4	79 - 104	A	26	7
5	105 - 130	A	26	8
6	131 - 156	A	26	9
7	157 - 182	A	26	10

8	183 - 208	A	26	11
9	209 - 234	A	26	12
10	235 - 260	A	26	13
11	261 - 286	A	26	14
12	287 - 312	A	26	15
13	313 - 333	A	21	16 (Lowest)
14	667 - 691	A'	25	3
15	692 - 716	A'	25	2
16	991 - 1023	A"	33	1 (Highest)

Table 6 - 2 Recommended B Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	334 - 354	B	21	16 (Lowest)
2	355 - 380	B	26	15
3	381 - 406	B	26	14
4	407 - 432	B	26	13
5	433 - 458	B	26	12
6	459 - 484	B	26	11
7	485 - 510	B	26	10
8	511 - 536	B	26	9
9	537 - 562	B	26	8
10	563 - 588	B	26	7
11	589 - 614	B	26	6
12	615 - 640	B	26	5
13	641 - 666	B	26	4
14	717 - 741	B'	25	3
15	742 - 766	B'	25	2
16	767 - 799	B'	33	1 (Highest)

For 1900 MHz TDMA systems in the United States, a mobile station that follows the recommended probability blocks shall begin searching for a DCCH according to its preferred band as indicated in Tables 6-3, 6-4, 6-5, 6-6, 6-7 and 6-8.

Table 6 - 3 Recommended 1900 MHz A Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	2 - 31	A	30	16 (Lowest)
2	32 - 62	A	31	15
3	63 - 93	A	31	14
4	94 - 124	A	31	13
5	125 - 155	A	31	12
6	156 - 186	A	31	11
7	187 - 217	A	31	10
8	218 - 248	A	31	9
9	249 - 279	A	31	8

10	280 - 310	A	31	7
11	311 - 341	A	31	6
12	342 - 372	A	31	5
13	373 - 403	A	31	4
14	404 - 434	A	31	3
15	435 - 465	A	31	2
16	466 - 498	A	33	1 (Highest)

Table 6 - 4 Recommended 1900 MHz B Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	668 - 698	B	31	16 (Lowest)
2	699 - 729	B	31	15
3	730 - 760	B	31	14
4	761 - 791	B	31	13
5	792 - 822	B	31	12
6	823 - 853	B	31	11
7	854 - 884	B	31	10
8	885 - 915	B	31	9
9	916 - 946	B	31	8
10	947 - 977	B	31	7
11	978 - 1008	B	31	6
12	1009 - 1039	B	31	5
13	1040 - 1070	B	31	4
14	1071 - 1101	B	31	3
15	1102 - 1132	B	31	2
16	1133 - 1165	B	33	1 (Highest)

Table 6 - 5 Recommended 1900 MHz C Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	1501 - 1531	C	31	16 (Lowest)
2	1532 - 1562	C	31	15
3	1563 - 1593	C	31	14
4	1594 - 1624	C	31	13
5	1625 - 1655	C	31	12
6	1656 - 1686	C	31	11
7	1687 - 1717	C	31	10
8	1718 - 1748	C	31	9
9	1749 - 1779	C	31	8
10	1780 - 1810	C	31	7
11	1811 - 1841	C	31	6
12	1842 - 1872	C	31	5
13	1873 - 1903	C	31	4
14	1904 - 1934	C	31	3
15	1935 - 1965	C	31	2
16	1966 - 1998	C	33	1 (Highest)

Table 6 - 6 Recommended 1900 MHz D Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	502 - 511	D	10	16 (Lowest)
2	512 - 521	D	10	15
3	522 - 531	D	10	14
4	532 - 541	D	10	13
5	542 - 551	D	10	12
6	552 - 561	D	10	11
7	562 - 571	D	10	10
8	572 - 581	D	10	9
9	582 - 591	D	10	8
10	592 - 601	D	10	7
11	602 - 611	D	10	6
12	612 - 621	D	10	5
13	622 - 631	D	10	4
14	632 - 641	D	10	3
15	642 - 651	D	10	2
16	652 - 665	D	14	1 (Highest)

Table 6 - 7 Recommended 1900 MHz E Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	1168 - 1177	E	10	16 (Lowest)
2	1178 - 1187	E	10	15
3	1188 - 1197	E	10	14
4	1198 - 1207	E	10	13
5	1208 - 1217	E	10	12
6	1218 - 1227	E	10	11
7	1228 - 1237	E	10	10
8	1238 - 1247	E	10	9
9	1248 - 1257	E	10	8
10	1258 - 1267	E	10	7
11	1268 - 1277	E	10	6
12	1278 - 1287	E	10	5
13	1288 - 1297	E	10	4
14	1298 - 1307	E	10	3
15	1308 - 1317	E	10	2
16	1318 - 1332	E	15	1 (Highest)

Table 6 - 8 Recommended 1900 MHz F Band DCCH Allocation

Block Number	Channel Number	Band	Number of Channels	Relative Probability
1	1335 - 1344	F	10	16 (Lowest)
2	1345 - 1354	F	10	15
3	1355 - 1364	F	10	14
4	1365 - 1374	F	10	13
5	1375 - 1384	F	10	12

6	1385 - 1394	F	10	11
7	1395 - 1404	F	10	10
8	1405 - 1414	F	10	9
9	1415 - 1424	F	10	8
10	1425 - 1434	F	10	7
11	1435 - 1444	F	10	6
12	1445 - 1454	F	10	5
13	1455 - 1464	F	10	4
14	1465 - 1474	F	10	3
15	1475 - 1484	F	10	2
16	1485 - 1498	F	14	1 (Highest)

6.3.1.1.3 Regulatory Configuration Identifier = 2

Subject to further study.

6.3.1.1.4 Regulatory Configuration Identifier = 3

Subject to further study.

6.3.1.2 Means to Identify a DCCH

The IS-136.2 DTC, TIA/EIA 627 DTC and the FDCCH slots have similar format. However, there are several ways to distinguish a DCCH from a DTC using the information in:

- The CSFP and CDVCC Fields

  The IS-136.2 DTC, TIA/EIA 627 DTC and the FDCCH slot format have structural commonality which allows for distinguishing a DCCH from a DTC. Because of the differences in the channel coding of DVCC and SFP, there are always 4 bits out of 12 which are different in every pair of CDVCC (see Section 1.2.5 of IS-136.2) and CSFP (see Section 4.4.8) codewords regardless of which CDVCC or CSFP codeword is transmitted by a base station. Bit errors introduced due to radio channel impairments may, however, change the extent to which transmitted codewords differ once they are received by a mobile station.
  Secondly, the CDVCC content is fixed from slot to slot on a DTC whereas the content of the CSFP changes in a predictable fashion from slot to slot on a DCCH.
- The DATA Field

  The channel coding and interleaving employed on a DTC (both IS-136.2 and TIA/EIA 627) is different from that employed on a DCCH regardless of the DTC service.
  It should be noted that a mobile station can perform DCCH discrimination based on CSFP alone and therefore can avoid channel decoding of the DATA field until the beginning of a superframe is received. The beginning of a superframe is comprised of one or more F-BCCH slots which have a DVCC value of zero used for CRC calculation purposes.
- The SACCH and RESERVED Fields

  The IS-136.2 SACCH and RESERVED fields have different functionality on a DCCH. Hence, these fields may also be used to distinguish between a DCCH and DTC but the techniques are less straightforward.

6.3.2 Control Channel Selection

The Control Channel Selection procedure is executed in order to allow a mobile station to determine whether or not a given candidate control channel is acceptable for camping purposes. Upon finding a candidate control channel not marked as ineligible, a mobile station shall proceed to execute the Signal Strength Aspects Determination procedure (see Section 6.3.2.1) and the Service Aspects Determination procedure (see Section 6.3.2.2).

6.3.2.1 Signal Strength Aspects Determination

The mobile station uses the following criteria to determine whether or not a candidate DCCH is suitable from a signal strength perspective:

1) $C\_SEL_{cand} > 0$ dBm AND

2) ($MS\_ACC\_PWR_{cand} \leq 4$ dBm AND Mobile_Station_Power_Class = 4) OR $MS\_ACC\_PWR_{cand} \geq 8$ dBm

where:

C_SEL_{cand} is: RSS_{dBm} - $RSS\_ACC\_MIN_{dBm}$ - $MAX(MS\_ACC\_PWR_{dBm} - P_{dBm}, 0_{dBm})$ for the candidate control channel. C_SEL is set to a negative value if requirement 2 above is not met.

RSS is the received signal strength, averaged over the last 5 measurements. The minimum time between 2 consecutive measurements shall be 20 milliseconds. See Section 6.3.2.3 for signal strength measurement accuracy.

RSS_ACC_MIN is a parameter broadcasted on the F-BCCH Control Channel Selection Parameters message. It is the minimum received signal level required to access the cell.

MS_ACC_PWR is a parameter broadcasted on the F-BCCH Access Parameters message. It is the maximum nominal output power that the mobile station may use when initially accessing the network.

P is the maximum nominal output power of the mobile station as defined by its power class (see Section 2.1.2.2 in IS-136.2).

Mobile_Station_Power_Class as per IS-136.2, Table 2.1.2.2.1-1.

If the candidate DCCH does not fulfill the signal strength requirements above the mobile station shall mark it as ineligible, terminate this procedure and remain in the Control Channel Scanning and Locking state (see Section 6.2.2).
If the candidate DCCH does fulfill the signal strength requirements above the mobile station shall enter the Service Aspects Determination procedure.

6.3.2.2 Service Aspects Determination

A mobile station shall apply the following criteria to determine whether or not a candidate DCCH is suitable from a service perspective:

- The mobile station shall read the DCCH Structure and Control Channel Selection Parameters messages sent on the candidate DCCH and use the Additional DCCH Information information element (if included) to determine its assigned DCCH according to the Mobile Station PCH Allocation procedure (see Section 4.10). If its assigned DCCH is not the candidate DCCH, the mobile station shall mark the candidate DCCH as ineligible and re-enter the Signal Strength Aspects Determination procedure, using its assigned DCCH as the candidate DCCH.

- Otherwise, the mobile station shall read the Access Parameters message sent on the candidate DCCH. If the candidate DCCH is identified as Barred according to the Cell Barred information element sent in the Access Parameters message, the mobile station shall proceed as follows:

  - Mark the candidate DCCH as ineligible.

  - If a time is specified in the Cell Barred information element it shall remain ineligible for the time specified.

  - Terminate this procedure and remain in the Control Channel Scanning and Locking state.

- Otherwise, if the Initial Selection Control flag sent in the Control Channel Selection Parameters message of the candidate DCCH is set, the mobile station shall proceed as follows:

  - The mobile station shall first attempt to find an alternate control channel (other than the candidate DCCH initially selected) not marked as ineligible. If an alternate control channel is available the mobile station shall re-enter the Signal Strength Aspects Determination procedure using the alternate control channel as a candidate DCCH. Note that any alternate control channel found to have its Initial Selection Control flag set shall be marked as ineligible.

  - Otherwise, the mobile station shall complete this procedure using the candidate DCCH initially selected prior to considering any alternate control channels (if any were considered).

- Otherwise, the mobile station shall read the System Identity message sent on the candidate DCCH. If the candidate DCCH is not marked with a Network Type (see Section 8.3.2) that the mobile station subscribes to, the mobile station shall mark the candidate DCCH as ineligible, terminate this procedure and remain in the Control Channel Scanning and Locking state.

- Otherwise, the mobile station may declare the candidate DCCH as acceptable for camping purposes, enable Service Offering based reselection by setting RTC5_status = 1 (see Section 6.3.3.4.1 and 6.3.3.4.3), terminate this procedure and enter the DCCH Camping state (see Section 6.2.3).

6.3.2.3 Signal Strength Measurements

Signal strength measurements shall be made with an absolute accuracy determined according to Figure 6-2.

The relative accuracy, defined as the error in dB, between the difference of the two estimated RF levels and the difference between the corresponding RF input levels, is ±3dB in the range -105 to -85dBm of estimated RF levels. In addition, if the estimated RF levels spans a wider range, from -105 to -75dBm, the relative accuracy shall be ±5dB.

Over the temperature range -30°C to +60°C, the absolute and relative accuracies shall hold.
The signal strength encoding shall be made according to Table 6-9 with encoding increasing monotonically with received RF signal strength.

Figure 6 - 2 Absolute Signal Strength Accuracy

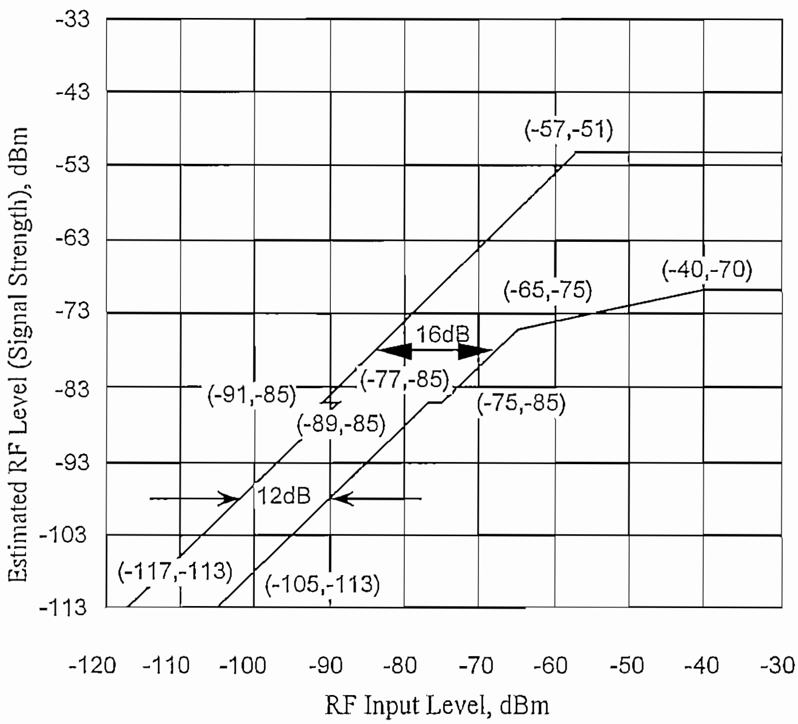


Table 6 - 9 RSS Encoding and Quantization

Bit Pattern	RSS Value
00000	-113 dBm or less
00001	-111 dBm
00010	-109 dBm
00011	-107 dBm
.	.
.	.
.	.
11110	-53 dBm
11111	-51 dBm or greater

6.3.3 Control Channel Reselection

The Control Channel Reselection procedure is executed in order to allow a mobile station to determine whether or not a given candidate control channel is better than its current DCCH with respect to selection criteria. While in DCCH Camping state, the mobile station shall:

- execute the Control Channel Locking procedure (see Section 6.3.3.1),
- execute the Reselection Criteria procedure (see Section 6.3.3.4).

6.3.3.1 Control Channel Locking

The following information elements are included in the Control Channel Selection Parameters message sent on the F-BCCH, in the Neighbor Cell message and in the Neighbor Cell (Multi Hyperband) message sent on the E-BCCH and are used in determining the interval of signal strength measurements (measurement_interval) for the serving DCCH , NL entries, Private Operating Frequencies (see Section 6.3.21) and any DCCH identified as a result of Non-Public Mode Search (see Section 6.3.19) as follows:

- SCANINTERVAL: This information element represents the basic measurement_interval in Hyperframes to be used for each frequency identified as requiring signal strength measurements.
- HL_FREQ: There is one instance of this information element for each entry in the NL. HL_FREQ is used to modify the SCANINTERVAL for each entry in the NL as follows:

  If HL_FREQ = HIGH, measurement_interval for the associated NL entry is SCANINTERVAL.

  If HL_FREQ = LOW, measurement_interval for the associated NL entry is twice SCANINTERVAL. However, a mobile station may choose to measure all frequencies as if they have HL_FREQ set to HIGH.

Whenever there is a change in either the SCANINTERVAL or the NL contents, the mobile station shall compute measurement_interval for each entry in the NL. The measurement_interval for the serving DCCH, Private Operating Frequencies (POFs) and any DCCH identified as a result of Non-Public Mode Search (NPS-DCCH) shall always be set to SCANINTERVAL. A mobile station's Current PFC shall not influence the computation of measurement_interval.

The mobile station shall measure the signal strength of the serving DCCH, POFs, NPS-DCCH and all viable NL entries each time their associated measurement_interval lapses and process the results according to the Reselection Criteria procedure (see Section 6.3.3.4). A NL entry is considered viable if:

- It is in a Hyperband supported by the mobile station.
- It has a Network Type supported by the mobile station.
- It uses a form of modulation supported by the mobile station (i.e., FSK, and/or π/4-DQPSK).

As an example, for the case where SCANINTERVAL = 0 and the NL contains 8 entries having HL_FREQ = 1 and 8 entries having HL_FREQ = 0 the following would result:

- For the serving DCCH, measurement_interval = 1 Hyperframe.
- For NL entries having HL_FREQ=1, measurement_interval = 1 Hyperframe.
- For NL entries having HL_FREQ=0, measurement_interval = 2 Hyperframes.
- The total number of signal strength measurements made per Hyperframe will then be 1 + 8 + 8 * 1/2 = 13 (including the serving DCCH).

6.3.3.2 Optional Enhancements

If the value of the Scanning Option Indicator information element sent in the Control Channel Selection Parameters message is set to 0, a mobile station shall not support any optional enhancements to measurement_interval. If the value of the Scanning Option Indicator information element is set to 1, a mobile station has the option of increasing measurement_interval (see Section 6.3.3.1) for one or more of the NL entries. There are three conditions that a mobile station can detect and respond to by increasing measurement_interval. A mobile station may increase measurement_interval for any given NL entry multiple times should more than one of these conditions be coincidental. The three conditions that may result in a mobile station increasing measurement_interval for one or more NL entries are as follows:

1. If the time since the last control channel reselection is greater than one hour, then the mobile station is allowed to increase measurement_interval for all NL entries by a factor of 2.
2. The mobile station shall first make 25 signal strength measurements on the serving DCCH and NL entries in order to produce a valid processed signal strength (PSS) value. The algorithms used to produce PSS values shall consist of either a linear average (current meas. + 24 previous meas. divided by 25) or an exponential average ((current meas./25) + previous PSS * 24/25). If the change in PSS on the serving DCCH is less than 7 dB over the last 5 minutes AND the change in PSS on all NL entries is less than 7 dB over the last 5 minutes, a mobile station is allowed to increase measurement_interval for all NL entries by a factor of 2.
3. If the difference between PSS on the serving DCCH and PSS for a NL entry is less than 10 dB over the last 5 minutes, a mobile station is allowed to increase the measurement_interval for that NL entry by a factor of 2.

As soon as a condition is no longer valid, the mobile station shall revoke the corresponding increase in measurement_interval for all affected NL entries. Whenever Reselection Trigger Conditions RTC_1, 2, 3, 4, 5 and 7 occur (see Section 6.3.3.4.1) a mobile station shall immediately terminate all optional enhancements to measurement_interval made for all NL entries.

6.3.3.3 Signal Strength Measurement and Processing

The mobile station shall keep a running average of the last five signal strength measurements (Long_RSS) for each measured frequency. Additionally, the mobile station shall keep a running average of the last two signal strength measurements of the current DCCH (Short_RSS). Both of these values shall be used for control channel reselection (see Section 6.3.3.4). The interval of signal strength measurements for any given frequency is determined by measurement_interval (see Sections 6.3.3.1 and 6.3.3.2).
The accuracy of signal strength measurements shall be as defined in Figure 6-2. The granularity and range of Long_RSS and Short_RSS values shall be as specified in Table 6-9.
Upon camping on a control channel the Full_reselect_data_indicator is reset. After collecting 5 signal strength measurements for each viable Neighbor List entry, the Full_reselect_data_indicator is set to show that valid average Long_RSS values are available and Neighbor list control channels can be considered for reselection purposes.
The mobile station shall also collect 5 signal strength measurements for the POFs and NPS-DCCH it has identified as requiring measurements before the POFs and NPS-DCCH can be considered for reselection purposes. A mobile station may take into account the fact that POF signal strength measurements may be subject to discontinuous base station transmissions (see IS-136.2, Section 3.1.2).

6.3.3.4 Reselection Criteria

The reselection criteria is comprised of 3 distinct and sequential procedures:

- The Reselection Trigger Conditions procedure (see Section 6.3.3.4.1) identifies the conditions for which the mobile station will invoke the Candidate Eligibility Filtering (see Section 6.3.3.4.2).
- The Candidate Eligibility Filtering procedure specifies the criteria for the eligibility and filtering of candidate control channels.
- The Candidate Reselection Rules procedure (see Section 6.3.3.4.3) uses the candidates identified by the Candidate Eligibility Filtering procedure to determine if a control channel reselection will take place.

6.3.3.4.1 Reselection Trigger Conditions (RTC)

The following Reselection Trigger Conditions are listed in descending order of precedence and may result in control channel reselection:

RTC1: Radio Link Failure Condition:

Whenever this condition is detected (see Section 6.2.3) the mobile station shall invoke the Candidate Eligibility Filtering procedure immediately.

RTC2: Cell Barred Condition:

Whenever this condition is detected (see Section 6.2.3) the mobile station shall invoke the Candidate Eligibility Filtering procedure immediately. If this condition is a result of the Cell Barred Information Element received in the Access Parameters message, the mobile station shall mark its current DCCH as "barred" for the time period indicated therein.

RTC3: A Server Degradation Condition:

Whenever this condition is detected (see Section 6.2.3) the mobile station shall invoke the Candidate Eligibility Filtering procedure immediately.

RTC4: Directed Retry Condition:

This condition exists whenever a mobile station receives a Directed Retry message (see Section 6.2.5 and 6.2.6). Whenever this condition is detected the mobile station shall invoke the Candidate Eligibility Filtering procedure immediately.

RTC7: Priority System Condition:

Whenever this condition is detected (see Section 6.2.3) and the mobile station has camped on its current DCCH for a time period greater than that defined by the DELAY Information Element sent in Control Channel Selection Parameters message (see 6.4.1.1.1.3), the mobile station shall invoke the Candidate Eligibility Filtering procedure. If the mobile station has not camped on its current DCCH for a time period greater than that defined by DELAY it shall remain in the DCCH Camping state.

If a mobile station receives a PCH message while responding to this condition, it shall terminate the Control Channel Reselection procedure and enter the Termination procedure (see Section 6.3.4).

RTC5: Service Offering Condition:

Whenever this condition is detected (see Section 6.2.3) while SERV_SS ≠ 0 (see Section 6.4.1.2.1.1) and RTC5_status =1 (see Sections 6.3.2.2 and 6.3.3.4.3.3), the mobile station may optionally invoke the Candidate Eligibility Filtering procedure. If SERV_SS = 0 or RTC5_status = 0 the mobile station shall remain in the DCCH Camping state.

If a mobile station receives a PCH message while responding to this condition, it shall terminate the Control Channel Reselection procedure and enter the Termination procedure (see Section 6.3.4).

RTC6: Periodic Evaluation Condition:

Whenever this condition is detected (see Section 6.2.3) and the mobile station has camped on its current DCCH for a time period greater than that defined by the DELAY Information Element sent in Control Channel Selection Parameters message (see 6.4.1.1.1.3), the mobile station shall invoke the Candidate Eligibility Filtering procedure. If the mobile station has not camped on its current DCCH for a time period greater than that defined by DELAY, it shall remain in the DCCH Camping state.

If a mobile station receives a PCH message while responding to this condition, it shall terminate the Control Channel Reselection procedure and enter the Termination procedure (see Section 6.3.4).

6.3.3.4.2 Candidate Eligibility Filtering (CEF)

Invoking the Control Channel Reselection procedure results in the determination of the measurement_interval for each control channel frequency identified as requiring signal strength measurements (see Sections 6.3.3.1 and 6.3.3.2). The set of candidate control channels to be considered for reselection may be a subset of the control channel frequencies being measured and is determined as follows:

- For RTC1, RTC2, RTC3, RTC5, RTC6 and RTC7, the set of candidate control channels is determined by the mobile station using all viable NL entries, POFs and/or NPS-DCCH identified whenever the corresponding reselection trigger condition is initiated (see Section 6.2.3).
- For RTC4, the set of candidate control channels is determined by the mobile station as follows:
  - If one or more instances of the Retry Channel information element are included in the Directed Retry message (see Section 6.4.3.7), the mobile station shall only consider the control channels specified therein as the set of candidate control channels.
  - Otherwise, the viable NL entries in Neighbor Cell or the Neighbor Cell (Multi Hyperband) message (see Sections 6.4.1.2.1.1 and 6.4.1.2.2.10) marked as valid for directed retry according to the Directed Retry Channel field, shall be considered as the set of candidate control channels.

In addition, the set of candidate control channels to be considered for reselection shall exclude all control channels for which sufficient signal strength measurements have not been made (see Section 6.3.3.3). If the set of candidate control channels contains one or more entries, the mobile station shall invoke the applicable CEF filtering procedure according to the RTC condition as indicated in Table 6-10. Otherwise, the mobile station shall invoke the Candidate Reselection Rules procedure (see Section 6.3.3.4.3).

Table 6 - 10 CEF to RTC Mapping

RTC	CEF
RTC1	CEF1
RTC2	CEF2
RTC3	CEF2
RTC4	CEF3
RTC5	CEF4
RTC6	CEF5
RTC7 (Note 1)	CEF2 or CEF4

Note 1: If RTC7 occurs when SERV_SS = 0, CEF2 shall be invoked. Otherwise CEF4 shall be invoked.

CEF1: IF ($C\_RESEL_{candidate} > 0$)

THEN this Control Channel is eligible for reselection.

ENDIF

CEF2: IF ($C\_RESEL_{candidate} > 0$ AND $T_{candidate} > DELAY_{candidate}$ AND $CELLTYPE_{candidate}$ = PREFERRED AND $Long\_RSS_{candidate} > SS\_SUFF_{candidate}$)
(criteria 1)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($C\_RESEL_{candidate} > 0$ AND $T_{candidate} > DELAY_{candidate}$ AND C_RES2 > 0
AND
($CELLTYPE_{candidate} \neq$ NON_PREFERRED
OR $Long\_RSS_{current} < SS\_SUFF_{current}$))
(criteria 2)

THEN this Control Channel is eligible for reselection.

ENDIF

ENDIF

CEF3: IF ($C\_RESEL_{candidate} > 0$ AND $CELLTYPE_{candidate}$ = PREFERRED AND $Long\_RSS_{candidate} > SS\_SUFF_{candidate}$)
(criteria 1)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($C\_RESEL_{candidate} > 0$)
(criteria 2)

THEN this Control Channel is eligible for reselection.

ENDIF

ENDIF

CEF4: IF ($C\_RESEL_{candidate} > 0$ AND $T_{candidate} > DELAY_{candidate}$)

THEN SWITCH ($CELLTYPE_{candidate}$)

CASE PREFERRED:

IF ($Long\_RSS_{candidate} > SS\_SUFF_{candidate}$ + SERV_SS OR C_RES2 > SERV_SS)
(criteria 1)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($Long\_RSS_{candidate} > SS\_SUFF_{candidate}$ - SERV_SS AND $DCCH_{candidate} \neq$ ISOR)
(criteria 2)

THEN this Control Channel is eligible for reselection.

ELSE

IF (C_RES2 > - SERV_SS AND $DCCH_{candidate} \neq$ ISOR)
(criteria 3)

THEN this Control Channel is eligible for reselection.

END IF

END IF

END IF

CASE NON_PREFERRED:

IF ($Long\_RSS_{current} < SS\_SUFF_{current}$ - SERV_SS AND C_RES2 > SERV_SS)
(criteria 4)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($SS\_SUFF_{current} + SERV\_SS > Long\_RSS_{current} > SS\_SUFF_{current} - SERV\_SS$ AND $C\_RES2 > - SERV\_SS$ AND $DCCH_{candidate} \neq ISOR$)
(criteria 5)

THEN this Control Channel is eligible for reselection.

END IF

END IF

CASE REGULAR:

IF ($C\_RES2 > SERV\_SS$)
(criteria 6)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($C\_RES2 > - SERV\_SS$ AND $DCCH_{candidate} \neq ISOR$)
(criteria 7)

THEN this Control Channel is eligible for reselection.

END IF

END IF

END CASE

END IF

CEF5: IF ($C\_RESEL_{candidate} > 0$ AND $T_{candidate} > DELAY_{candidate}$)

THEN SWITCH ($CELLTYPE_{candidate}$)

CASE PREFERRED:

IF ($Long\_RSS_{candidate} > SS\_SUFF_{candidate} + SERV\_SS$ OR $C\_RES2 > SERV\_SS$)
(criteria 1)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($Long\_RSS_{candidate} > SS\_SUFF_{candidate}$ AND $DCCH_{candidate} \neq ISOR$)
(criteria 2)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($C\_RES2 > 0$ AND $DCCH_{candidate} \neq ISOR$)
(criteria 3)

THEN this Control Channel is eligible for reselection.

END IF

END IF

END IF

CASE NON_PREFERRED:

IF ($Long\_RSS_{current} < SS\_SUFF_{current} - SERV\_SS$ AND $C\_RES2 > SERV\_SS$)
(criteria 4)

THEN this Control Channel is eligible for reselection.

ELSE

IF ($Long\_RSS_{current} < SS\_SUFF_{current}$ AND $C\_RES2 > 0$ AND $DCCH_{candidate} \neq ISOR$)
(criteria 5)

THEN this Control Channel is eligible for reselection.

END IF

END IF

CASE REGULAR:

IF (C_RES2 > SERV_SS)
(criteria 6)

THEN this Control Channel is eligible for reselection.

ELSE

IF (C_RES2 > 0 AND $DCCH_{candidate} \neq$ ISOR)
(criteria 7)

THEN this Control Channel is eligible for reselection.

END IF

END IF

END CASE

END IF

where:

$C\_RES2 = C\_RESEL_{candidate} - C\_RESEL_{current} + RESEL\_OFFSET_{candidate}$

C_RESEL = C_SS unless the power requirement is not met, in which case C_RESEL is set to a negative value. C_SS and the power requirement are defined as follows:

$C\_SS = Long\_RSS_{dBm} - RSS\_ACC\_MIN_{dBm} - MAX(MS\_ACC\_PWR_{dBm} - P_{dBm}, 0_{dBm})$.

The power requirement is :

($MS\_ACC\_PWR_{cand} \leq 4$ dBm AND Mobile_Station_Power_Class = 4) OR $MS\_ACC\_PWR_{cand} \geq 8$ dBm

where:

RSS_ACC_MIN is a parameter broadcasted on the F-BCCH Control Channel Selection Parameters message (see Section 6.4.1.1.1.3), on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or the E-BCCH Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10). It is the minimum received signal level required to access the control channel.

MS_ACC_PWR is a parameter broadcasted on the F-BCCH Access Parameters message (see Section 6.4.1.1.1.2), on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or the E-BCCH Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10). It is the maximum nominal output power that the mobile station may use when making its initial access attempt on the control channel.

P is the maximum nominal output power of the mobile station as defined by its power class (see Section 2.1.2.2 in IS-136.2).

Mobile_Station_Power_Class as per IS-136.2, Table 2.1.2.2.1-1.

T is a timer which starts when $C\_RESEL_{candidate}$ becomes greater than 0. T is reset when $C\_RESEL_{candidate}$ becomes less than or equal to 0.

DELAY is a parameter broadcast on the F-BCCH Control Channel Selection Parameters message (see Section 6.4.1.1.1.3), on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or on the E-BCCH Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10).

RESEL_OFFSET is a parameter broadcast on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or on the E-BCCH Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10).

CELLTYPE is a parameter broadcast on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or the Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10). It takes the values REGULAR, PREFERRED, or NON_PREFERRED.

SS_SUFF is a parameter broadcast on the F-BCCH Control Channel Selection Parameters message (see Section 6.4.1.1.1.3), on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or the Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10).

Long_RSS is the averaged received measured signal strength (see Section 6.3.3.3).

SERV_SS is a service signal strength offset broadcast on the E-BCCH Neighbor Cell message (see Section 6.4.1.2.1.1) or on the E-BCCH Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10).

6.3.3.4.3 Candidate Reselection Rules

All candidate control channels marked as temporarily ineligible for reselection (TIR) while in this procedure shall continue to be marked as TIR until this procedure is terminated. In addition, candidate control channels marked as ineligible for service offering reasons (ISOR) while in this procedure may continue to be marked as ISOR after termination of this procedure. The mobile station shall then invoke the CAND_1 Determination procedure (see Section 6.3.3.4.3.1) in an attempt to mark a reselection candidate as CAND_1.

6.3.3.4.3.1 CAND_1 Determination

If the Candidate Eligibility Filtering procedure (see Section 6.3.3.4.2) identifies one or more candidates as eligible for reselection, the mobile station shall apply the following rules in determining which reselection candidate to mark as CAND_1:

- If one or more candidate control channels are eligible as a result of CEF1 (see Section 6.3.3.4.2), then the control channel with the maximum C_RESEL (see Section 6.3.3.4.2), that has not been marked as TIR, shall be marked as CAND_1.

- If this procedure is invoked as a result of CEF2 or CEF3 (see Section 6.3.3.4.2), then the mobile station shall proceed as follows:

  - If one or more candidate control channels have been declared eligible according to criteria 1 then the control channel with the maximum C_RES1 (C_RES1 = Long_RSS - SS_SUFF), that has not been marked as TIR, shall be marked as CAND_1.

  - Otherwise, if one or more candidate control channels have been declared eligible according to criteria 2, then the control channel with the maximum C_RES2 (see Section 6.3.3.4.2), that has not been marked as TIR, shall be marked as CAND_1.

- If this procedure is invoked as a result of CEF4 or CEF5 (see Section 6.3.3.4.2), then the mobile station shall proceed as follows:

  - If one or more candidate control channels have been declared eligible according to criteria 1 or 2, then the control channel with the maximum C_RES1, that has not been marked as TIR, shall be marked as CAND_1.

  - Otherwise, if one or more candidate control channels have been declared eligible according to criteria 3, then the control channel with the maximum C_RES2, that has not been marked as TIR, shall be marked as CAND_1.

  - Otherwise, if one or more candidate control channels have been declared eligible according to criteria 4 or 5, then the control channel with the maximum C_RES2, that has not been marked as TIR, shall be marked as CAND_1.

  - Otherwise, if one or more candidate control channels have been declared eligible according to criteria 6 or 7, then the control channel with the maximum C_RES2, that has not been marked as TIR, shall be marked as CAND_1.

If the Candidate Eligibility Filtering procedure (see Section 6.3.3.4.2) did not identify any candidates eligible for reselection as a result of RTC2 or RTC3 (see Section 6.3.3.4.1), then the mobile station may mark, as CAND_1, a control channel that has C_RESEL > 0 and that has not been marked as TIR, with the following priority:

- The control channel having a CELLTYPE = PREFERRED with the greatest C_RES1 value shall be marked as CAND_1 if one is available.

- Otherwise, the control channel having the greatest C_RES2 value shall be marked as CAND_1.

If the mobile station does not identify a CAND_1, it shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4). Otherwise, the mobile station shall invoke the CAND_1 Examination procedure (see Section 6.3.3.4.3.2).

6.3.3.4.3.2 CAND_1 Examination

If a candidate control channel has been marked as CAND_1, the mobile station shall proceed as follows:

- If CAND_1 is an ACC and the trigger condition is Directed Retry, the mobile station shall enter the Directed Retry task (see 2.6.3.14 of IS-136.2). If the mobile station returns from the Directed Retry task because the corresponding DCC on the DCCH NL is not equal to the DCC received on CAND_1 the mobile station shall proceed as follows:

  - Mark CAND_1 as TIR.

  - Set Long_RSS and Short_RSS for that candidate control channel to -113 dBm.

- If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure (see Section 6.3.3.4.3) to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 is an ACC, the mobile station shall enter the Initialization task (see 2.6.1 of IS-136.2). If the mobile station returns from the Initialization task because the corresponding DCC on the DCCH NL is not equal to the DCC received on CAND_1 the mobile station shall proceed as follows:

  - Mark CAND_1 as TIR.

  - Set Long_RSS and Short_RSS for that candidate control channel to -113 dBm.

  - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 is a DCCH and the trigger condition is Directed Retry, the mobile station shall read the Registration Parameters, System Identity, Access Parameters and the Overload Class (if broadcasted) messages sent on the selected DCCH. If the DVCC received on CAND_1 is equal to the corresponding DVCC on the DCCH NL and an access is allowed according to CAND_1 overload control, the mobile station shall return to the invoking procedure.

- Otherwise, if CAND_1 is a DCCH and the trigger condition is Directed Retry, if the mobile station is unable to make an access due to CAND_1 overload control it shall proceed as follows:

  - Mark CAND_1 as TIR.

  - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 is a DCCH, for any trigger condition the mobile station shall read the DCCH Structure message sent on the selected DCCH. If the corresponding DVCC on the DCCH NL is not equal to the DVCC sent on CAND_1 the mobile station shall proceed as follows:

  - Mark CAND_1 as TIR.

  - Set Long_RSS and Short_RSS for that candidate control channel to -113 dBm.

  - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 is a DCCH and is identified as Barred according to the Cell Barred Information Element broadcast in its Access Parameters message, the mobile station shall proceed as follows:

  - Mark CAND_1 as TIR.

  - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 has been declared eligible as a result of RTC5-CEF4 criteria 2, 3, 5 or 7 or RTC6-CEF5 criteria 2, 3, 5 or 7 (see Sections 6.3.3.4.1 and 6.3.3.4.2) and the mobile station determines that CAND_1 does not offer the desired service offerings, Network Type, SID, PSID or RSID, the mobile station shall mark CAND_1 as ISOR and then do either of the following:

  - Terminate the Control Channel Reselection procedure and remain in the DCCH Camping state.

  - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).

- Otherwise, if CAND_1 has been declared eligible as a result of RTC5-CEF4 Criteria 1, 4 or 6, or RTC6-CEF5 Criteria 1, 4 or 6 (see Sections 6.3.3.4.1 and 6.3.3.4.2) and the mobile station determines that selecting CAND_1 would render it inoperable (e.g., a mobile station desiring to make speech calls would not be able to make speech calls), the mobile station shall mark CAND_1 as ISOR and then do either of the following:
    - Terminate the Control Channel Reselection procedure and remain in the DCCH Camping state.
    - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).
- Otherwise, if CAND_1 is a DCCH, for any trigger condition the mobile station shall read the DCCH Structure and the Control Channel Selection Parameters messages sent on CAND_1 and use the Additional DCCH Information information element (if included) to determine its assigned DCCH according to the Mobile Station PCH Allocation procedure (see Section 4.10). If its assigned DCCH is not CAND_1, the mobile station shall mark CAND_1 as TIR, use its assigned DCCH as the candidate DCCH and proceed as follows:
    - If this candidate DCCH is included in the neighbor list of the mobile station's current DCCH and is marked as eligible, it shall be marked as CAND_1 and the mobile station shall invoke the Suitable CAND_1 Found procedure (see Section 6.3.3.4.3.3).
    - Otherwise, if this candidate DCCH is not included in the neighbor list of the mobile station's current DCCH it shall be measured according to the Signal Strength Aspects Determination procedure (see Section 6.3.2.1). If it fulfills the signal strength requirements of the Signal Strength Aspects Determination procedure it shall be marked as CAND_1 and the mobile station shall invoke the Suitable CAND_1 Found procedure (see Section 6.3.3.4.3.3).
    - Otherwise, the mobile station shall proceed as follows:
        - Mark CAND_1 as TIR.
        - If there are any remaining candidate control channels that are marked as eligible, the mobile station shall restart the Candidate Reselection Rules procedure to determine the suitability of the remaining candidate control channels for reselection purposes. Otherwise, the mobile station shall invoke the Suitable CAND_1 Not Found procedure (see Section 6.3.3.4.3.4).
- Otherwise, a suitable CAND_1 exists and the mobile station shall invoke the Suitable CAND_1 Found procedure (see Section 6.3.3.4.3.3).

6.3.3.4.3.3 Suitable CAND_1 Found

Upon finding a suitable CAND_1 the mobile station shall proceed as follows:

- If CAND_1 is a DCCH the mobile station shall proceed as follows:
    - If CAND_1 has been declared eligible as a result of RTC5-CEF4 (see Sections 6.3.3.4.1 and 6.3.3.4.2), the mobile station shall mark its current DCCH as ISOR.
    - The mobile station shall enable Service Offering based reselection by setting RTC5_status = 1.
    - If CAND_1 has been declared eligible as a result of RTC6-CEF5-Criteria 1, RTC6-CEF5-Criteria 4 or RTC6-CEF5-Criteria 6 (see Sections 6.3.3.4.1 and 6.3.3.4.2) and CAND_1 is marked as ISOR, the mobile station shall disable Service Offering based reselection by setting RTC5_status = 0.
    - CAND_1 is declared as the mobile station's current DCCH and all broadcast parameters read on CAND_1 shall be considered as current by the mobile station.
    - The mobile station shall then terminate this procedure and remain in the DCCH Camping state.
- If CAND_1 is an ACC the mobile station shall proceed as follows:
    - If CAND_1 has been declared eligible as a result of RTC5-CEF4 (see Sections 6.3.3.4.1 and 6.3.3.4.2), the mobile station shall mark its current DCCH as ISOR.
    - The mobile station shall enable Service Offering based reselection by setting RTC5_status = 1 and reset Queued_Orig_Indicator.
    - CAND_1 is declared as the mobile station's current ACC and all overhead information read on CAND_1 shall be considered as current by the mobile station.

6.3.3.4.3.4 Suitable CAND_1 Not Found

If a control channel has not been selected as CAND_1 after considering all candidates identified by the Candidate Eligibility Filtering procedure (see Section 6.3.3.4.2), or because no candidates were identified by the Candidate Eligibility Filtering procedure or because ACCESS_TMR timeout occurs the mobile station shall proceed as follows:

- For RTC1, RTC2, RTC3 and RTC7 the mobile station may terminate the Control Channel Reselection procedure and enter the Control Channel Scanning and Locking state. Note that for RTC3 the mobile station is prohibited from making an access on its current DCCH.
- For RTC4, the mobile station shall stop ACCESS_TMR, ORIG_TMR or WAFO_TMR (if any are running), terminate the Control Channel Reselection procedure and then enter the DCCH Camping state (see Section 6.2.3).
- For RTC5 or RTC6, the mobile station shall terminate the Control Channel Reselection procedure and remain in the DCCH Camping state (see Section 6.2.3).

6.3.4 Termination

When this procedure is invoked, the mobile station shall determine which of the following PCH messages has been received and respond in the required time window (see Table 6-15) as indicated below. If the mobile station is required to send a message as a result of executing this procedure, it shall be sent on the same DCCH where the mobile station received the PCH message.

Page or Page indicating Hard Page (see Section 5.1.1.2):

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall proceed as follows:
  - If the Service Code is acceptable, the mobile station shall issue an RDCCH Request primitive containing a Page Response message (see Section 6.4.4) having a Service Code indicating the desired service, along with any other coincidental messages required (see Section 6.7), start ACCESS_TMR, and then enter the Waiting for Order state (see Section 6.2.6).
  - If the Service Code is not acceptable, the mobile station shall issue an RDCCH Request primitive containing a Page Response message (see Section 6.4.4) having a Service Code = Service Rejected, along with any other coincidental messages required (see Section 6.7) and return to (or remain in) the DCCH Camping state.
- It should be noted that the default Service Code (see Section 6.5) associated with a Hard Page received on an 800 MHz DCCH is "Analog or Digital Speech - Digital Preferred". The default Service Code associated with a Hard Page received on a 1900 MHz DCCH is "Digital Speech Only".
- If the mobile station desires to activate message encryption on an AVC or DTC, the Message Encryption Mode information element shall be included in the Page Response message. The mobile station uses the Message Encryption Algorithm Map and Message Encryption Key Map information elements provided in the Service Menu message to make its message encryption selection.

Page indicating User Group:

- The mobile station shall determine if the message is intended for it in accordance with User Group Addressing Procedures (see Section 6.3.16). If the message is intended for it and the Service Code is acceptable, the mobile station shall start the UGA_TMR and then enter the User Group Alerting state (see Section 6.2.10).

Audit Order indicating User Group:

- The mobile station shall determine if the message is intended for it in accordance with User Group Addressing Procedures (see Section 6.3.16). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing an Audit Confirmation message (see Section 6.4.4.1), along with any other coincidental messages required (see Section 6.7).
- The mobile station shall check the Forced Re-Registration flag of the Audit Order. If enabled the mobile station shall invoke the Registration procedure (see Section 6.3.7). Otherwise, the mobile station shall remain in the DCCH Camping state.

Audit Order:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing an Audit Confirmation message (see Section 6.4.4.1) along with any other coincidental messages required (see Section 6.7).

- The mobile station shall check the Forced Re-Registration flag of the Audit Order. If enabled, the mobile station shall invoke the Registration procedure (see Section 6.3.7). Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating Page:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15) message and then enter the Waiting for Order state (see Section 6.2.6). Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating SSD Update:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15) and then enter the SSD Update Proceeding state (see Section 6.2.8). Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating R-DATA:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall proceed as follows:

    - If a mobile station has received the Service Menu message indicating that no point-to-point teleservices are supported, or the Service Menu message has not been received, the mobile station may ignore this message.

    - Otherwise, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15) along with any other coincidental messages required (see Section 6.7) and then enter the Terminated Point-to-Point Teleservice Proceeding state (see Section 6.2.7).

  Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating Queue Update:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it and Queued_Orig_indicator is set the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15), reset Queued_Orig_indicator and enter the Waiting for Order state (see Section 6.2.6). Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating Queue Disconnect:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it and Queued_Orig_indicator is set the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15), reset Queued_Orig_indicator and remain in the DCCH Camping state. Otherwise, the mobile station shall remain in the DCCH Camping state.

SPACH Notification indicating Mobile Assisted Channel Allocation:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it and Queued_Orig_indicator is set, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4.15) along with a MACA Report (see Section 6.4.4.6) based on MACA channels provided in the most recently received Queue Update message (see Section 6.4.3.25), and remain in the DCCH Camping state. Otherwise, the mobile station shall remain in the DCCH Camping state.

Queue Update:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it and Queued_Orig_indicator is set the mobile station shall proceed as follows:

- If the MACA_LIST and/or the MACA_LIST (Other Hyperband) information elements are included in the Queue Update message the mobile station shall perform STM measurements on the current DCCH and the indicated MACA channels according to the STM Measurements procedure (see Section 6.3.17.4.2).

- Update the parameters as received in the message and remain in the DCCH Camping state.

SSD Update Order:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a Base Station Challenge Order (see Section 6.4.4.3) along with any other coincidental messages required (see Section 6.7) and then enter the SSD Update Proceeding state (see Section 6.2.8).

Unique Challenge Order:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall formulate a Unique Challenge Order Confirmation according to the Unique Challenge-Response procedure (see Section 6.3.12.6), issue an RDCCH Request primitive containing the Unique Challenge Order Confirmation (see Section 6.4.4) and remain in the DCCH Camping state.

Message Waiting:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4) and remain in the DCCH Camping state.

User Alert:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4) and remain in the DCCH Camping state.

Parameter Update:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall examine the Request Number information element. If the Request Number information element is different from the last Request Number information element received on the current DCCH, the mobile station shall increment $COUNT_{S-p}$, otherwise the mobile station shall not increment $COUNT_{S-p}$. The mobile station shall then issue an RDCCH Request primitive containing a SPACH Confirmation (see Section 6.4.4) and remain in the DCCH Camping state.

Capability Request:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station shall issue an RDCCH Request primitive containing a Capability Report (see Section 6.4.4) and remain in the DCCH Camping state.

SOC Message Delivery:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station processing of this message is beyond the scope of this specification.

BSMC Message Delivery:

- The mobile station shall determine if the message is intended for it in accordance with the Subaddressing Procedures (see Section 6.3.13). If the message is intended for it, the mobile station processing of this message is beyond the scope of this specification.

Other Message:

- If any other message is received or the mobile station determines that a received message is not intended for it according to the Subaddressing Procedures (see Section 6.3.13) or the User Group Addressing Procedures (see Section 6.3.16), the mobile station shall remain in the DCCH Camping state.

6.3.5 Origination

If an emergency call is being attempted the mobile station shall disregard the overload control status and proceed as follows:

- Formulate an Origination message (see Section 6.4.4) in accordance with the Subaddressing Procedures (see Section 6.3.13).
- The mobile station shall then issue an RDCCH request primitive containing an Origination message along with any other coincidental messages required (see Section 6.7), start ACCESS_TMR and then enter the Origination Proceeding state (see Section 6.2.5).

For non emergency calls the mobile station shall first examine the overload control status (see Section 6.3.18). If it is enabled the mobile station shall re-read the Overload Class message on the F-BCCH and check the overload control bit corresponding to its internally stored Overload Class. If its corresponding overload control bit is disabled, the mobile station shall remain in DCCH Camping state. Otherwise, if a Queue Disconnect condition exists (see Section 6.2.3) the mobile station shall proceed as follows:

- Formulate a Queue Disconnect message (see Section 6.4.4) in accordance with the Subaddressing Procedures (see Section 6.3.13).
- The mobile station shall then issue an RDCCH request primitive containing a Queue Disconnect message along with any other coincidental messages required (see Section 6.7), start ACCESS_TMR and then enter the Origination Proceeding state (see Section 6.2.5).

Otherwise, if a User Origination condition or an Auto Origination condition exists (see Section 6.2.3) the mobile station shall proceed as follows:

- Reset Queued_Orig_indicator.
- Formulate an Origination message (see Section 6.4.4) in accordance with the Subaddressing Procedures (see Section 6.3.13).
- If the mobile station desires to activate message encryption on an AVC or DTC, the Message Encryption Mode information element shall be included in the Origination message. The mobile station uses the Message Encryption Algorithm Map and Message Encryption Key Map information elements provided in the Service Menu message to select its message encryption mode.
- The mobile station shall then issue an RDCCH request primitive containing an Origination message along with any other coincidental messages required (see Section 6.7), start ACCESS_TMR and then enter the Origination Proceeding state (see Section 6.2.5).

6.3.6 Originated Point-to-Point Teleservice

When this procedure is invoked the mobile station shall proceed as follows:

- If DELAY_TMR is running, the mobile station shall remain in the DCCH Camping state.
- If the overload control status (see Section 6.3.18) is enabled the mobile station must re-read the F-BCCH and check whether the overload control bit corresponding to its internally stored Overload Class is enabled. If its corresponding overload control bit is disabled the mobile station shall remain in the DCCH Camping state.
- The mobile station shall then examine the R-DATA Message Length information element received in the Access Parameters message (see Section 6.4.1.1.1.2) which indicates the maximum R-DATA message length the mobile station is authorized to send on the RACH. If the message length is greater than the maximum R-DATA message length authorized by the BMI, the mobile station shall remain in the DCCH Camping state.
- If the R-DATA message contains an SMS SUBMIT (see Section 7.1.2.2) and the SMS SUBMIT is not supported by the BMI (see Section 6.4.1.1.2.4) then the mobile station shall terminate this procedure and remain in the DCCH Camping state.

  Otherwise the mobile station shall do the following:

  - Formulate an R-DATA message (see Section 6.4.4.9).
  - Initiate transmission of the R-DATA message by sending an RDCCH Request primitive to layer 2 containing this message along with any other coincidental messages required (see

Section 6.7) and enter the Originated Point-to-Point Teleservice Proceeding state (see Section 6.2.9).

6.3.7 Registration

When this procedure is invoked the mobile station shall proceed as follows:

- If REG_REJECT_TMR is running, and the system the mobile desires to register on matches the system associated with this timer (see Section 6.3.11), the mobile station shall remain in the Camping state.
- If a mobile station determines that a registration is necessary as a result of this procedure, and the Overload Control status is enabled (see Section 6.3.18), the mobile station shall first reread the Overload Control message on the F-BCCH and check whether the overload control bit corresponding to its internally stored Overload class is enabled. If its corresponding overload control bit is disabled and a De-registration or Power down condition does not exist (see Section 6.2.3), the mobile station shall set REREG_TMR to a random time uniformly distributed in the interval 16 to 40 superframes with a granularity of 1 superframe and remain in DCCH Camping state.
- If the mobile station is in its home SID area, REGH is disabled and a Power Down condition does not exist, the mobile station shall remain in the DCCH Camping state.
- If the mobile station is not in its home SID area, REGR is disabled and a Power Down condition does not exist, the mobile station shall remain in the DCCH Camping state.
- If the current DCCH supports message encryption (see Service Menu in Section 6.4.1.2.2.4) and the mobile station desires to activate DCCH message encryption, the Message Encryption Mode information element shall be included if a Registration message is sent as a result of this procedure. The mobile station uses the Message Encryption Algorithm Map and Message Encryption Key Map information elements provided in the Service Menu message to make its DCCH message encryption selection. Once DCCH message encryption has been activated (see Section 6.3.10), subsequent registrations shall only include the Message Encryption Mode information element to deactivate or modify DCCH message encryption.
- The mobile station shall then examine the list of conditions below to see if it must send a registration message. The conditions are in priority order so that if more than one of the conditions are fulfilled only one registration message is sent. If a mobile station does send a registration message it shall use a MSID selected according to MSID Management rules (see Section 8.1.4.1).

  If a Test Registration condition exists (see Section 6.2.3) and the Non-Public Registration Control broadcast information (see Section 6.4.1.1.1.4) indicates that Test Registrations are allowed, the mobile station shall formulate a Test Registration message, issue an RDCCH Request primitive containing this message and then enter the Registration Proceeding state (see Section 6.2.4).

  Otherwise, if a Power Down condition exists (see Section 6.2.3) and the PDREG flag sent in the Registration Parameters message is enabled, the mobile station shall formulate a Registration message with a Power-down indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

  Otherwise, if a De-registration condition exists (see Section 6.2.3) and the DEREG flag sent in the Registration Parameters message on the current DCCH is enabled, then the mobile station shall proceed as follows:

  - Formulate a Registration message with the Registration Type information element set to De-registration.
  - The C-Number information element may optionally be included in the Registration message in order to provide the BMI with network address information specific to the network it has decided to acquire service on. The network support for C-Number is beyond the scope of this specification.
  - Issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state.

  Otherwise, if a De-registration condition exists and the DEREG flag is disabled, the mobile station shall not send a Registration message on the current DCCH prior to acquiring service on the new network.
  Otherwise, if a Power Up condition exists (see Section 6.2.3) and the PUREG flag sent in the Registration Parameters message is enabled, the mobile station shall formulate a Registration message with a Power-up indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the

Registration Proceeding state (see Section 6.2.4). If the Reg-Info Map information element is present in the Registration Parameters message, and indicates that a SID Report is requested, then the mobile station shall include the SID Report information element in the Registration message. If a Power Up condition exists and the PUREG flag sent in the Registration Parameters message is disabled, the mobile station shall clear the Power Up condition and return to the DCCH Camping state.

Otherwise, if a User Group Activation/Deactivation condition exists (see Section 6.2.3) and the current DCCH supports User Group operation (see Section 6.4.1.2.2.4), the mobile station shall formulate a Registration message with a User Group indication, include the User Group information element, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a System Transition condition exists (see Section 6.2.3) and the SYREG flag sent in the Registration Parameters message is enabled, the mobile station shall formulate a Registration message with a New System indication, include the Selected PSID/RSID information element if appropriate, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4). If the Reg-Info Map information element is present in the Registration Parameters message, and indicates that a SID Report is requested, then the mobile station shall include the SID Report information element in the Registration message.

Otherwise, if a VMLA Transition condition exists (see Section 6.2.3) and the LAREG flag sent in the Registration Parameters message is enabled, the mobile station shall formulate a Registration message with a Location Area indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a Forced Registration condition exists (see Section 6.2.3), the mobile station shall formulate a Registration message with a Forced indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if the mobile station entered this procedure in response to an Audit Order (see Section 6.3.4), it shall formulate a Registration message with a Forced indication, issue an RDCCH Request primitive containing this message, an Audit Confirmation message and any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a PER_TMR Timeout condition exists (see Section 6.2.3), the mobile station shall formulate a Registration message with a Periodic indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a REREG_TMR Timeout condition exists (see Section 6.2.3), the mobile station shall formulate a Registration message with an indication reflecting that of its previous registration attempt, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a TMSI_TMR Timeout condition exists (see Section 6.2.3),, the mobile station shall formulate a Registration message with a TMSI Timeout indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if an ACC to DCCH Transition condition exists (see Section 6.2.3) the mobile station shall formulate a Registration message with an ACC to DCCH indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, if a Hyperband Transition condition exists (see Section 6.2.3) the mobile station shall formulate a Registration message with a New Hyperband indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required (see Section 6.7), and then enter the Registration Proceeding state (see Section 6.2.4).

Otherwise, the mobile station shall invoke the Periodic Registration Determination procedure (see Section 6.3.9). If a registration is not necessary the mobile station shall remain in DCCH Camping state.

6.3.8 Registration Update

If the mobile station has received a REG Period information element on its current DCCH but not the REGID Parameters information element it shall reset its PER_TMR to (REGPER + 1) * 94 superframes.

If the mobile station has received a REG Period and a REGID Parameters information element on its current DCCH and REGID_PER > 0, it shall set NXTREG = REGID + ((REGPER + 1) * 94 / REGID_PER) and store NXTREG in semi-permanent memory.

If the mobile station has received a REG Period and a REGID Parameters information element on its current DCCH and REGID_PER = 0, it shall set NXTREG = REGID + ((REGPER + 1) * 94) and store NXTREG in semi-permanent memory.

If the mobile station has received a SID information element on its current DCCH it shall store SID in semi-permanent memory.

After performing these updates the mobile station shall terminate this procedure and return to the Invoking procedure.

6.3.9 Periodic Registration Determination

If the mobile station has received a REG Period and a REGID Parameters information element on its current DCCH and REGID_PER > 0, it shall use the following algorithm to review NXTREG to determine if REGID has cycled through zero:

- If NXTREG is greater than or equal to REGID + ((REGPER + 1) * 94 / REGID_PER) + 5, then NXTREG shall be replaced by the greater of 0 or NXTREG – 2^{20}.
- Otherwise do not change NXTREG.
- If REGID is greater than or equal to NXTREG the mobile station shall formulate a Registration message with a Periodic indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required and then enter the Registration Proceeding state.

If the mobile station has received a REG Period and a REGID Parameters information element on its current DCCH and REGID_PER = 0, it shall use the following algorithm to review NXTREG to determine if REGID has cycled through zero:

- If NXTREG is greater than or equal to REGID + ((REGPER + 1) * 94) + 5, then NXTREG shall be replaced by the greater of 0 or NXTREG – 2^{20}.
- Otherwise do not change NXTREG.
- If REGID is greater than or equal to NXTREG the mobile station shall formulate a Registration message with a Periodic indication, issue an RDCCH Request primitive containing this message along with any other coincidental messages required and then enter the Registration Proceeding state.

Otherwise, the mobile station shall terminate this procedure and return to the Invoking procedure.

6.3.10 Registration Success

If the current registration is as a result of a De-registration Condition (see Section 6.2.3) the mobile station shall stop DEREG_TMR, reset Queued_Orig_indicator and then proceed to acquire service on the new network.

Otherwise, the mobile station shall stop REG_TMR, invoke the Registration Update procedure and then proceed as follows:

If a list of RNUM values is provided in the Registration Accept message the mobile station shall set its RNUM list in semi-permanent memory according to the received list.

If a list of RNUM values is not provided in the Registration Accept message received in response to a registration sent due to a VMLA Transition Condition, the mobile station shall set its RNUM List to the value of the RNUM field sent in the Registration Parameters message.

If a TMSI is assigned to a mobile station in the Registration Accept message, the mobile station shall start TMSI_TMR (see Section 8.1.2 for TMSI administration).

If a User Group ID supported by the mobile station is allocated in the Registration Accept message, the mobile station shall consider User Group operation activated and begin monitoring a PCH Subchannel based on the allocated UGID (see Section 4.10). If a User Group was de-allocated in the Registration Accept message, the mobile station shall consider User Group operation deactivated and begin monitoring a PCH Subchannel based on PMSID (see Section 4.10).

If a mobile station receives a Registration Accept message containing a PFC Assignment information element, it shall set its Assigned PFC to that value (see Section 4.7). If the Registration Accept message does not contain a PFC Assignment information element, the mobile station shall restore its Assigned PFC from temporary memory (see Section 6.2.4).

Upon receiving a Registration Accept message in response to a Registration message that requested the activation of DCCH message encryption, the mobile station shall consider DCCH message encryption as activated according to the selected message encryption algorithm, domain and key. The Registration Accept message may itself be encrypted if identified as a message subject to encryption according to the selected domain. Once activated, DCCH message encryption shall remain activated until one of the following occurs:

- The mobile station deactivates DCCH message encryption via a Registration message.
- The mobile station determines that the current DCCH does not support its activated DCCH message encryption.
- The mobile station receives a Registration Reject message with Cause = Requested Message Encryption Mode Temporarily Denied.

If the PSID/RSID Available information element is included in the Registration Accept message the mobile station shall store the SID and the list of PSID/RSIDs in semi permanent memory and overwrite PSID/RSID values it may have received in a previous Registration Accept message in that SID area and delete the associated PSID/RSID Alphanumeric Names.
If the current registration is as a result of a Power Up Condition (see Section 6.2.3), a System Transition Condition (see Section 6.2.3) or an ACC to DCCH Transition Condition (see Section 6.2.3), the mobile station shall reset Queued_Orig_indicator.
The mobile station shall then consider itself registered for service on the selected system (SID, PSID or RSID) and enter the DCCH Camping state. If the mobile station has registered for service on a PSID/RSID, it shall update PSID/RSID in semi-permanent memory.

6.3.11 Registration Reject Procedure

If the current Registration Reject message was received as a result of a registration sent with a De-registration indication, the mobile station shall store the reject cause, reset Queued_Orig_indicator and then do one of the following:

- Resend its Registration with a De-registration indication a maximum of one time and remain in the Registration Proceeding state.
- Stop DEREG_TMR. The mobile station may then proceed to acquire service on the new network.

Otherwise, the mobile station shall stop REG_TMR, store the reject cause, still consider itself registered for service (if currently registered), and then proceed as follows:

If the cause code = Unknown MSID and the mobile station has an alternative permanent MSID (MIN or IMSI) that has not been previously rejected during the current registration attempt, the mobile station shall resend its previous Registration using the alternate MSID and then remain in the Registration Proceeding state (see Section 6.2.4).

If the cause code = PSID/RSID Removal the mobile station shall remove from memory the PSID or RSID that it attempted to register on, regardless of how the PSID or RSID was acquired. The mobile station shall restore its Assigned PFC from temporary memory (see Section 6.2.4) and then return to the DCCH Camping state.

Otherwise, the mobile station shall set REG_REJECT_TMR timer based on the Reject Time information element of the Registration Reject message (see Section 6.4.3.15). If the Reject Time information element is not present in the Registration Reject message, the mobile station shall set REG_REJECT_TMR to 2048 superframes. The mobile station shall store the Mobile Country Code, SOC, SID, PSID or RSID, as appropriate, of the system which rejected its registration. If the mobile station is not currently registered, it shall continue to use PFC_I as its Assigned PFC and then return to DCCH Camping state. If the mobile station is currently registered, it shall restore its Assigned PFC from temporary memory (see Section 6.2.4) and then return to the DCCH Camping state.

6.3.12 Authentication

The term Authentication refers to the process during which information is exchanged between a mobile station and the BMI for the purposes of enabling the base station to confirm the identity of the mobile station. In short, a successful outcome of the authentication process occurs only when it can be demonstrated that the mobile station and base station possess identical sets of Shared Secret Data (SSD).
The following DCCH Authentication procedures are equivalent to the ACC Authentication procedures described in IS-136.2.

6.3.12.1 Shared Secret Data (SSD)

SSD is a 128-bit pattern that is generated in the mobile station using the SSD_Generation_Procedure, stored in the mobile station (in semi-permanent memory) and readily available to the BMI. As depicted in Figure 6-3, SSD is partitioned into two distinct subsets. Each subset is used to support a different process.

Figure 6 - 3 Partitioning of SSD

Contents	SSD-A	SSD-B
Length (bits)	64	64

Specifically,

SSD-A is used to support the Authentication procedures, and

SSD-B is used to support voice privacy and message confidentiality.

SSD is generated according to the procedure specified in Appendix A.

6.3.12.2 Random Challenge Memory (RAND)

$RAND_S$ is a 32-bit value held in the mobile station. It is a value received on the BCCH, and is used in conjunction with SSD-A and other parameters, as appropriate, to authenticate mobile station originations, terminations, registrations, SPACH Confirmations and R-DATA messages.

6.3.12.3 Call History Parameter ($COUNT_{S-p}$)

The Call History Parameter is a modulo-64 count held in the mobile station. $COUNT_{S-p}$ is updated at the mobile station upon receipt of a Parameter Update Order message on a DCCH or a Parameter Update Order message on the DTC or AVC.

6.3.12.4 MIN1 and MIN2

The 24-bit parameter referred to as MIN1 in the Authentication procedures is derived as indicated in Section 8.1.4.2.
The 8-bit parameter referred to as MIN2 in the Authentication procedures is derived as indicated in Section 8.1.4.2.

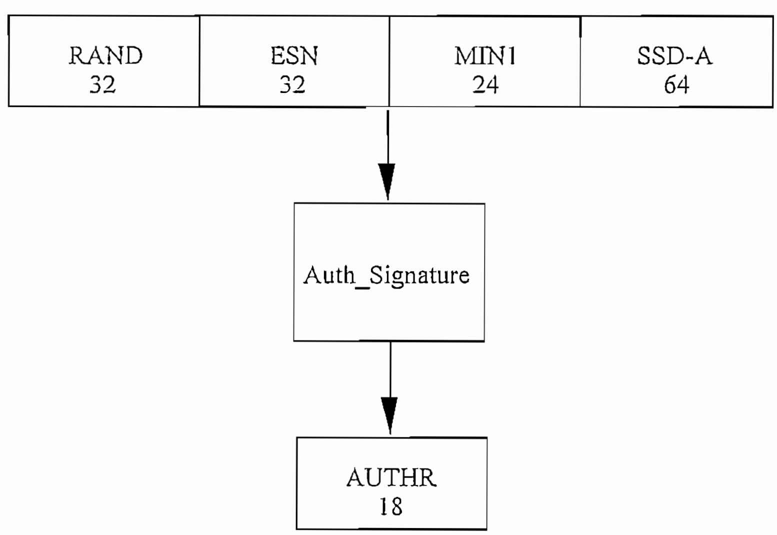
6.3.12.5 Authentication of Mobile Station Registrations

When the AUTH or AUTH Map information element indicates that the Authentication message for Registrations is required (see Section 6.4.1.1.1.2), and the mobile station attempts to register, the following authentication-related procedures shall be performed:

- In the mobile station:
  - Initialize the authentication algorithm (Auth_Signature) as illustrated in Figure 6-4.
  - Execute the Auth_Signature procedure (see Appendix A).
  - Set AUTHR equal to the 18 bits of Auth_Signature algorithm output.
  - Send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{S-p}$ to the BMI via the Authentication message.
- At the BMI:
  - Compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MSID/ESN.
  - Compute AUTHR as described above, except use the internally stored value of SSD-A.
  - Compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If any of the comparisons by the BMI fail, the BMI may deem the registration attempt unsuccessful, initiate the Unique Challenge-Response procedure (see Section 6.3.12.6), or commence the process of updating the SSD (see Section 6.3.12.9).

Figure 6 - 4 Computation of AUTHR for Authentication of Mobile Station at Registrations



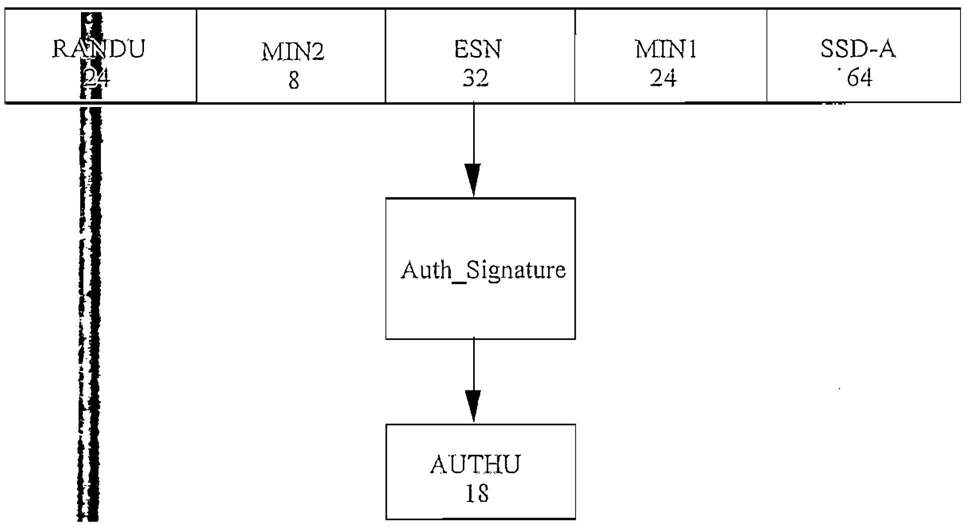
6.3.12.6 Unique Challenge-Response Procedure

The Unique Challenge-Response procedure is initiated by the BMI and is carried out as follows:

- At the BMI:
  - A 24-bit, random pattern referred to as RANDU is generated and sent to the mobile station via the Unique Challenge Order message.
  - Initialize Auth_Signature as illustrated in Figure 6-5.
  - Execute the Auth_Signature algorithm (see Appendix A).
  - Set AUTHU equal to the 18 bits of the Auth_Signature algorithm output.
- At the mobile station:
  - Compute AUTHU as described above using the received RANDU and its internally stored values for the remaining input parameters.
  - Send AUTHU to the BMI via the Unique Challenge Order Confirmation message.

Upon receipt of the Unique Challenge Order Confirmation from the mobile station, the BMI compares the received value for AUTHU to that generated/stored internally. If the comparison fails, the BMI may deny further access attempts by the mobile station, drop the call in progress, or initiate the process of updating the SSD (see Section 6.3.12.9).

Figure 6 - 5 Computation of AUTHU for Unique Challenge-Response Procedure



6.3.12.7 Authentication of Mobile Station Originations

When the AUTH or AUTH Map information element indicates that the Authentication message for Originations is required (see Section 6.4.1.1.1.2), and the mobile station attempts to originate a call, the following authentication-related procedures shall be performed:

- In the mobile station:
  - Initialize Auth_Signature as illustrated in Figure 6-6.

    If there were at least six digits dialed, then the last six dialed digits shall comprise the DIGITS input parameter. If there were less than six digits dialed, then the DIGITS input parameter shall be populated as follows:

    - MIN1, which is derived according to Section 8.1.4.2, shall be used to initially fill the DIGITS input parameter;
    - the least significant 4 bits of the DIGITS input parameter are replaced by the last dialed digit;
    - the next least significant 4 bits of the DIGITS input parameter are replaced by the second last dialed digit;

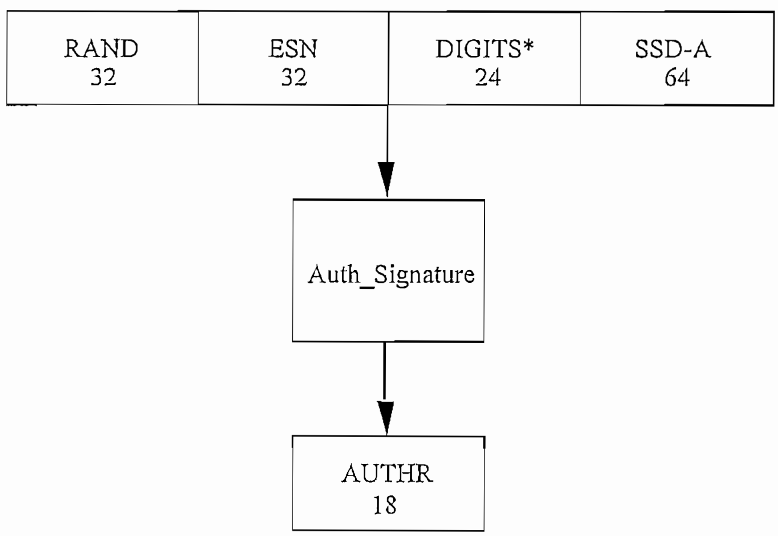
- continue replacing 4-bit segments of the DIGITS input parameter in this manner until all dialed digits have been included.

- Execute the Auth_Signature algorithm (see Appendix A).
- Set AUTHR equal to the 18 bits of the Auth_Signature algorithm output.
- Send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{s-p}$ to the BMI via the Authentication message.

- At the BMI:
  - Compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MSID/ESN.
  - Compute AUTHR as described above, except use the internally stored value of SSD-A.
  - Compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If the comparisons at the BMI are successful, the appropriate channel assignment procedures are commenced. Once the mobile station is assigned to a digital traffic channel or an analog voice channel, the BMI may, at the discretion of the System operator, issue a Parameter Update Order message to the mobile station. Mobile stations confirm the receipt of Parameter Update Orders by sending a Parameter Update ACK.
If any of the comparisons by the BMI fail, the BMI may deny service, initiate the Unique Challenge-Response procedure (see Section 6.3.12.6), or commence the process of updating the SSD (see Section 6.3.12.9).

Figure 6 - 6 Computation of AUTHR for Authentication of Mobile Station Originations



* Last 6 digits transmitted by the mobile station.

6.3.12.8 Authentication of Mobile Station Terminations

When the AUTH or AUTH Map information element indicates that the Authentication message for Page Responses is required (see Section 6.4.1.1.1.2), and the Termination procedure determines that a Page Response is required (see Section 6.3.4), the following authentication-related procedures shall be performed:

- In the mobile station:
  - Initialize Auth_Signature as illustrated in Figure 6-7.
  - Execute the Auth_Signature algorithm (see Appendix A).
  - Set AUTHR equal to the 18 bits of the Auth_Signature algorithm output.

- Send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{S-p}$ to the BMI via the Authentication message.

- At the BMI:

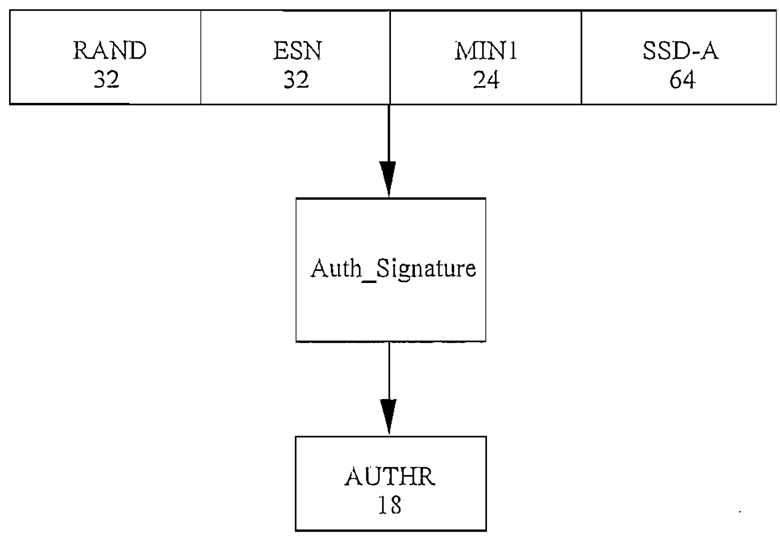
  - Compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MSID/ESN.

  - Compute AUTHR as described above, except use the internally stored value of SSD-A.

  - Compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If the comparisons at the BMI are successful, the appropriate channel assignment procedures are commenced. Once the mobile station is assigned to a digital traffic channel or an analog voice channel, the BMI may, at the discretion of the System operator, issue a Parameter Update Order message to the mobile station. Mobile stations confirm the receipt of Parameter Update Orders by sending Parameter Update ACK.

Figure 6 - 7 Computation of AUTHR for Authentication of Mobile Station Terminations



If any of the comparisons by the BMI fail, the BMI may deny service, initiate the Unique Challenge-Response procedure (see Section 6.3.12.6), or commence the process of updating the SSD (see Section 6.3.12.9).

6.3.12.9 SSD Update

Updating the SSD involves the application of SSD_Update_Procedure (Appendix A), initialized with mobile station specific information, random data and the mobile station's A-key.

The A-key is:

- 64 bits long;

- assigned to the mobile station;

- stored in the mobile station's permanent security and identification memory; and

- is known only to the mobile station and its associated HLR/AC.

Note 1: The last item in the above list is intended to enhance the security of the mobile station's secret data by eliminating the need to pass the A-key itself from BMI to BMI as the subscriber roams. As a consequence, SSD updates are carried out only in the mobile station and its associated HLR/AC, not in the serving BMI. The serving BMI obtains a copy of the SSD computed by the HLR/AC via intersystem communication (see EIA/TIA IS-41) with the mobile station's HLR/AC.

Note 2: Since the SSD Update procedure involves multiple transactions and can be started on one channel and completed on another channel, call processing and signaling text above and beyond that normally included in this portion of the document has been included here for the sake of added clarity.

An A-key must be entered into the mobile station. See TSB 50, "User Interface for Authentication Key Entry" for details. In addition to TSB 50 procedures, the A-Key may be entered into the mobile station via Over-Air-Activation (see Section 7.2).

More specifically, updating the SSD in the mobile station proceeds as follows (refer to Figure 6-8):

- At the BMI:
    - Send an SSD Update Order, with the RANDSSD field set to the same 56-bit random number used in the HLR/AC computations, to the mobile station via the SSD Update Order message.
- In the mobile station:
    - Upon receipt of the SSD Update Order, initialize SSD_Generation_Procedure as illustrated in Figure 6-9.
    - Execute the SSD_Generation_Procedure algorithm (see Appendix A).
    - Set SSD-A_NEW equal to the 64 most significant bits of the SSD_Generation_Procedure algorithm output, and SSD-B_NEW to the 64 least significant bits of the SSD_Generation_Procedure algorithm output.
    - Select a 32-bit random number, RANDBS, and send it to the BMI in a Base Station Challenge Order message.
    - Re-initialize Auth_Signature as illustrated in Figure 6-10.
    - Execute the Auth_Signature algorithm (see Appendix A).
    - Set AUTHBS equal to the 18 bits of the Auth_Signature algorithm output.

Figure 6 - 8 SSD Update Message Flow

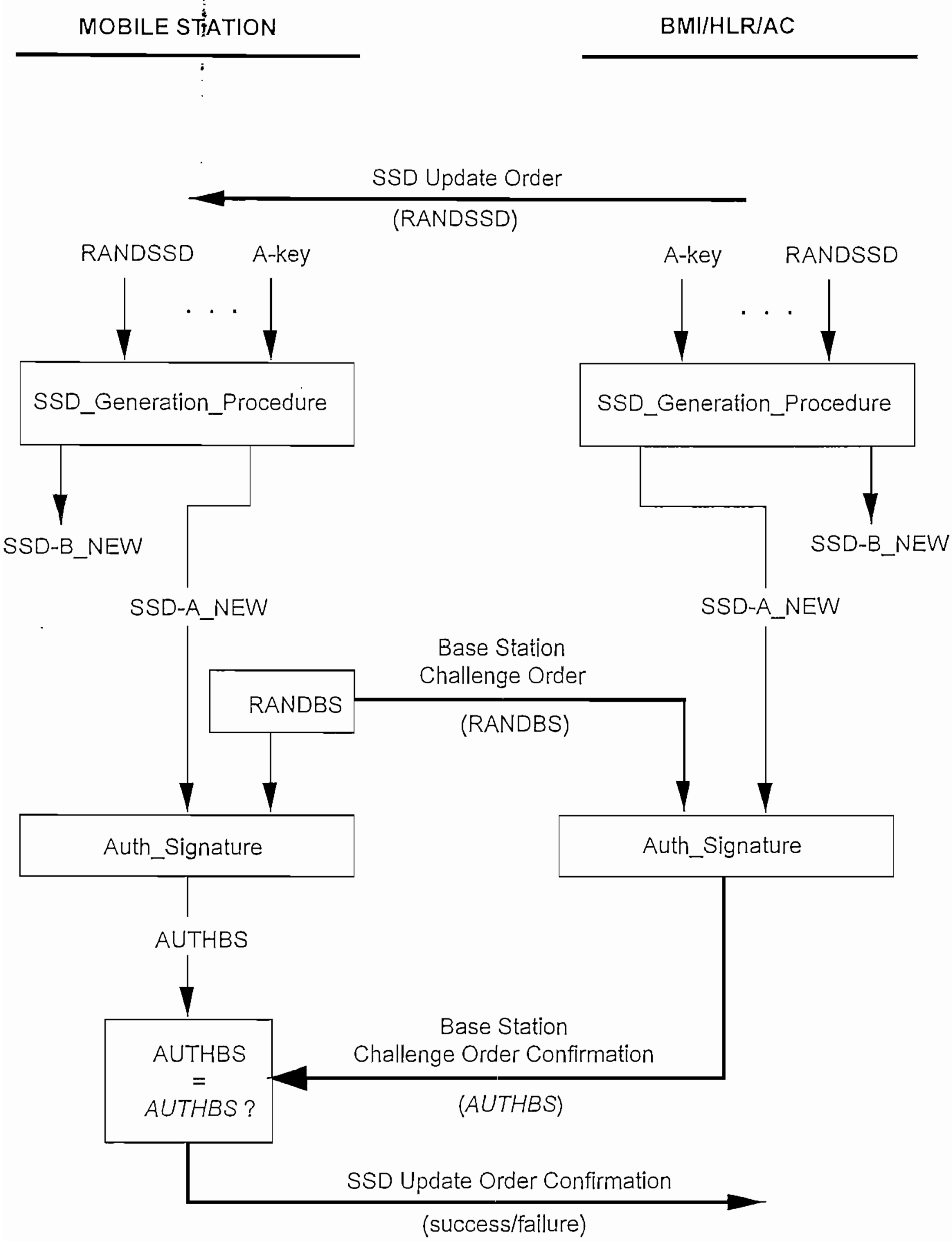


Figure 6 - 9 Computation of Shared Secret Data

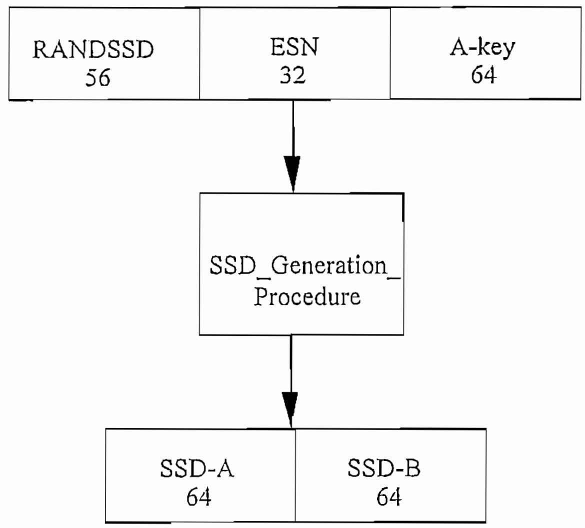
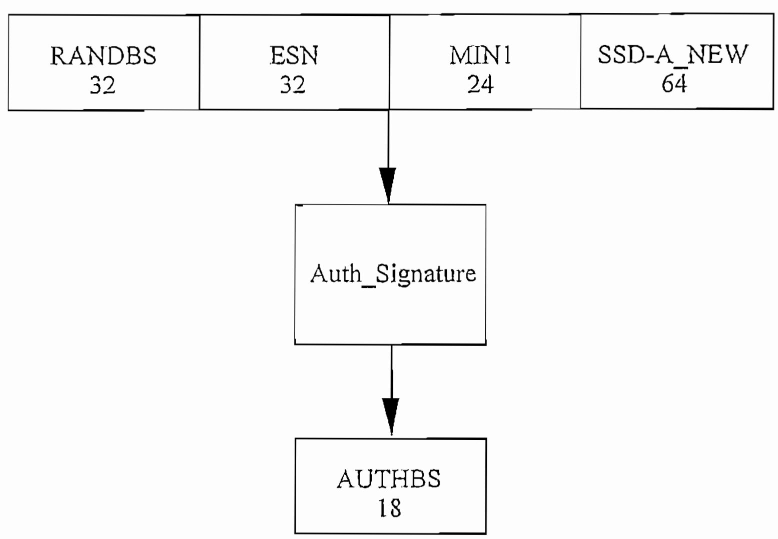


Figure 6 - 10 Computation of AUTHBS



- In the BMI:
  - Upon receipt of the Base Station Challenge Order, initialize Auth_Signature as illustrated in Figure 6-10, where RANDBS is set to the value received in the Base Station Challenge Order.
  - Execute the Auth_Signature algorithm (see Appendix A).
  - Set AUTHBS equal to the 18 bits of the Auth_Signature algorithm output.
  - Acknowledge receipt of the Base Station Challenge Order by including AUTHBS in the Base Station Challenge Order Confirmation message.
- In the mobile station:
  - Upon receipt of the Base Station Challenge Order Confirmation, compare the AUTHBS received to that generated internally.

- Acknowledge receipt of the SSD Update Order as follows:
  - If the comparison at the mobile station is successful, set SSD-A and SSD-B to SSD-A_NEW and SSD-B_NEW, respectively and send an SSD Update Order Confirmation message to the BMI with the SSD Update Status information element set to SSD Update Successful.
  - If the comparison at the mobile station fails, discard SSD-A_NEW and SSD-B_NEW and send an SSD Update Order Confirmation message to the BMI with the SSD Update Status information element set to SSD Update Failed due to AUTHBS mismatch.

In the BMI, if the SSD Update Order Confirmation received from the mobile station indicates a success, set SSD-A and SSD-B to the values received from the HLR/AC (see EIA/TIA IS-41).

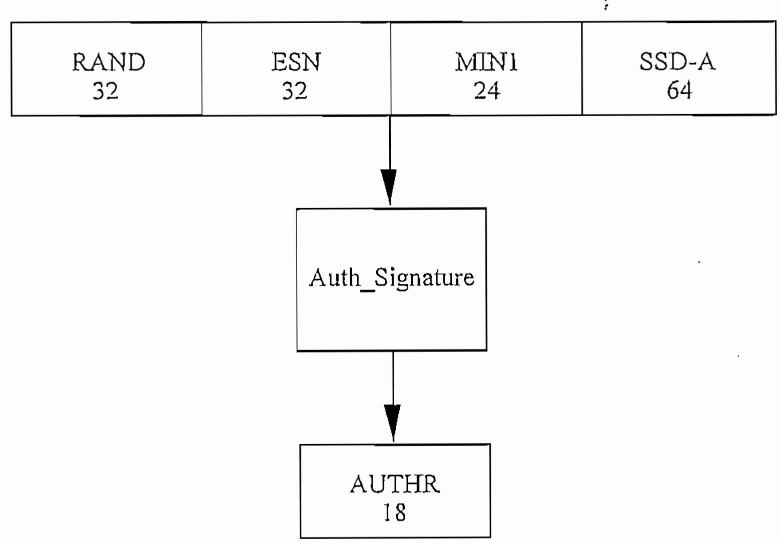
6.3.12.10 Authentication of Mobile Station R-DATA Messages

When the AUTH or the AUTH Map information element indicates that the Authentication message for R-DATA Messages is required (see Section 6.4.1.1.1.2), and the mobile station attempts to send an R-DATA Message, the following authentication-related procedures shall be performed:

- In the mobile station:
  - Initialize the authentication algorithm (Auth_Signature) as illustrated in Figure 6-11.
  - Execute the Auth_Signature procedure (see Appendix A).
  - Set AUTHR equal to the 18 bits of Auth_Signature algorithm output.
  - Send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{S-p}$ to the BMI via the Authentication message.
- At the BMI:
  - Compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MSID/ESN.
  - Compute AUTHR as described above, except use the internally stored value of SSD-A.
  - Compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If any of the comparisons by the BMI fail, the BMI may deem the R-DATA Message transmission attempt unsuccessful, initiate the Unique Challenge-Response procedure (see Section 6.3.12.6), or commence the process of updating the SSD (see Section 6.3.12.9).

Figure 6 - 11 Computation of AUTHR for Authentication of Mobile Station R-DATA Messages



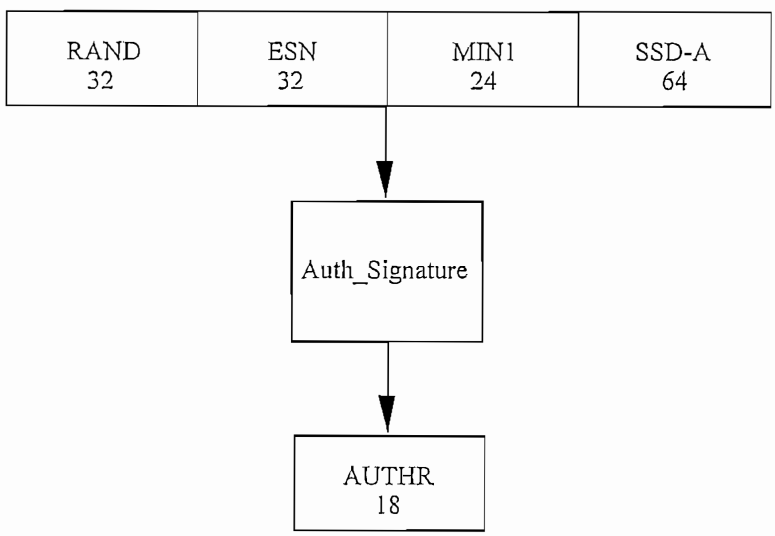
6.3.12.11 Authentication of Mobile Station SPACH Confirmations

When the AUTH or AUTH Map information element indicates that the Authentication message for SPACH Confirmations is required (see Section 6.4.1.1.1.2), and the mobile station attempts to send a SPACH Confirmation in response to a SPACH Notification indicating R-DATA, the following authentication-related procedures shall be performed:

- In the mobile station:
  - Initialize the authentication algorithm (Auth_Signature) as illustrated in Figure 6-12.
  - Execute the Auth_Signature procedure (see Appendix A).
  - Set AUTHR equal to the 18 bits of Auth_Signature algorithm output.
  - Send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{S-p}$ to the BMI via the Authentication message.
- At the BMI:
  - Compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MSID/ESN.
  - Compute AUTHR as described above, except use the internally stored value of SSD-A.
  - Compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If any of the comparisons by the BMI fail, the BMI may deem the SPACH Confirmation transmission attempt unsuccessful, initiate the Unique Challenge-Response procedure (see Section 6.3.12.6), or commence the process of updating the SSD (see Section 6.3.12.9).

Figure 6 - 12 Computation of AUTHR for Authentication of Mobile Station SPACH Confirmations



6.3.12.12 Auth_Signature, SSD_Update and SSD_Generation Procedures Algorithm

For details refer to Appendix A. Appendix A, and its associated documents, contain information which is governed under the U.S. International Traffic and Arms Regulation (ITAR) and the Export Administration Regulations. TIA will act as the focal point and facilitator for making such information available. Procedures for distribution of this information are contained in the Technology Transfer Control Plan which is available from TIA.

6.3.13 Subaddressing Procedures

The sections below describe the procedures governing the use of Subaddresses as applicable to Call Control.

6.3.13.1 BMI to Mobile Station Subaddressing

The BMI may include the Called Party Subaddress information element in applicable messages only when the Subaddressing Support flag in the Access Parameters is enabled (see Section 6.4.1.1.1.2) and the target mobile station supports subaddressing. If the Called Party Subaddress information element is present, the mobile station shall compare the contents of the information element with any subaddress information the mobile station has. If there is a Subaddress match, the mobile station shall continue to process the message in accordance with the procedures defined for the message received. If no Subaddress match exists, the mobile station shall discard the message and remain in its present state.

If the Called Party Subaddress information element is not included in a message received from the BMI by a mobile station that has subaddressing capability, the MSID of UGID of the message received shall be the only addressing information used to determine if the mobile station shall respond.

6.3.13.2 Mobile Station to BMI Subaddressing

The mobile station shall not include the Called Party Subaddress or Calling Party Subaddress information element(s) in applicable messages when the Subaddressing Support flag in the Access Parameters is disabled (see Section 6.4.1.1.1.2).

If the Subaddress Support flag is enabled, the following applies:

SPACH Message:

- If the mobile station is responding to a SPACH message that included Subaddress information, the mobile station shall include this subaddress information in any associated response.
- If the mobile station is responding to a SPACH message that does not include a Subaddress information, it shall send a response that may include the Subaddress information.

RACH Message:

- The mobile station may include Subaddress information in a RACH message. The BMI shall attempt to complete the call regardless of the presence of subaddress information.

  The Subaddress information can only be used by the network in a call completion if all parts of the network involved in the call setup support the use of Subaddress information.
- BMI forwarding of Subaddress information to other nodes or terminals in the network is for further study.

6.3.14 Non-Public System Registration

During any given power cycle (i.e., between mobile station power up and power down), a mobile station is only allowed to make a single registration attempt using the Registration message on private or residential systems for which it does not have a PSID or RSID match, if such registrations are allowed according to Non-Public Registration Control (see Section 6.4.1.1.1.4). If such a registration is attempted it shall be sent immediately after camping on and reading at least a full cycle of F-BCCH on a DCCH that supports such registration. A mobile station may, however, attempt to register as often as necessary on a private or residential system for which it does have a PSID or RSID match. If a mobile station receives a Registration Reject, it shall not re-register on that private or residential system for the time period indicated by the Registration Reject. If a mobile station receives a Registration Accept that includes the PSID/RSID available information element, it shall retain knowledge of the corresponding Mobile Country Code, SOC, SID and PSID or RSID as appropriate over multiple power cycles (see Section 8.3.4 and 8.3.5).

6.3.15 Non-Public Reselection Based on System Priority

A mobile station shall always attempt to reselect to a DCCH supporting a higher priority Network Type or a higher priority SID, PSID, or RSID (as determined by the mobile station's Network Type ranking list and SID, PSID and RSID ranking list), when a DCCH supporting a higher priority Network Type, SID, PSID, or RSID is available for reselection. This is accomplished by the mobile station declaring a Priority System Condition (see Section 6.2.3) whenever it determines that a higher priority DCCH is available. Mobile stations shall therefore be capable of ranking Network Types according to user preference. The default Network Type ranking in a mobile station, from highest to lowest, shall be Residential, Private, then Public. Optionally, a mobile station may be capable of ranking individual SIDs, PSIDs, or RSIDs.

If a mobile station has reselected to a DCCH serving more than one system on which the mobile station is authorized to operate on, then the mobile shall first attempt to register on the SID, PSID or RSID with the highest priority as determined by ranking of Network Type or SID, PSID and RSID. If a mobile station determines that a higher ranking SID, PSID or RSID is available on the current DCCH, then the mobile station shall declare a System Transition Condition (see Section 6.2.3).

6.3.15.1 Autonomous System Reselection

After acquiring service on a public, private or residential system, a mobile station may autonomously initiate an attempt to search for and acquire service on another system (see Section 6.3.3.4.1). When attempting to acquire service on a private or residential system, a mobile station shall only attempt to register using a Registration message according to Section 6.3.14.

6.3.15.2 User Initiated System Reselection

After acquiring service on a public, private or residential system, a mobile station user may initiate an attempt to search for and acquire service on another system (see Section 6.3.3.4.1). When attempting to acquire service on a private or residential system, a mobile station shall only attempt to register using a Registration message according to Section 6.3.14.

6.3.16 User Group Addressing Procedures

The sections below describe the procedures governing the use of User Group Addressing as applicable to Call Control. PCH Subchannel allocation (see Section 4.10) requires that only a single instance of UGID may be active at any point in time.

6.3.16.1 Local User Group Addressing

Local User Group Addressing utilizes the 20-bit Local UGID (see Section 5.2.5.2). An address match for Local UGIDs exists when:

- User Group operation is activated (see Sections 6.3.7 and 8.4), and
- The Local UGID of the received frame matches a Local UGID assigned to the mobile station (see Section 5.1.1.2).

6.3.16.2 SOC User Group Addressing

SOC User Group Addressing utilizes the 24-bit SOC UGID (see Section 5.2.5.2). An address match for SOC UGIDs exists when:

- User Group operation is activated (see Sections 6.3.7 and 8.4), and
- The SOC UGID of the received frame matches a SOC UGID assigned to the mobile station (see Section 5.1.1.2).

6.3.16.3 National User Group Addressing

National User Group Addressing utilizes the 34-bit National UGID (see Section 5.2.5.2). An address match for National UGIDs exits when:

- User Group operation is activated (see Section 6.3.7 and 8.4), and
- The National UGID of the received frame matches a National UGID assigned to the mobile station (see Section 5.1.1.2).

6.3.16.4 International User Group Addressing

International User Group Addressing utilizes the 50-bit International UGID (see Section 5.2.5.2). An address match for International UGIDs exits when:

- User Group operation is activated (see Section 6.3.7 and 8.4), and
- The International UGID of the received frame matches an International UGID assigned to the mobile station (see Section 5.1.1.2).

6.3.17 Mobile Assisted Channel Allocation

6.3.17.1 General

When the mobile station is in the DCCH Camping state, two Mobile Assisted Channel Allocation (MACA) specific functions may be performed:

- Long-Term MACA (LTM). The mobile station generates a report that includes word error rate (WER), bit error rate (BER), and paging frame received signal strength (LT_RSS) measurements for its serving DCCH (see Section 6.3.17.4.1).
- Short-Term MACA (STM). The mobile station generates a report that includes Short Term Received Signal Strength (ST_RSS) measurements for the serving DCCH and, optionally, other channels (see Section 6.3.17.4.2).

6.3.17.2 MACA Broadcast Information

The Mobile Assisted Channel Allocation message may be broadcast on the BCCH and contains the following information:

- MACA_STATUS: No MACA, LTM, STM, or both LTM and STM.
- MACA_LIST and MACA LIST (Other Hyperband): The BMI sends a list of up to 15 channels, other than current DCCH, which the mobile station shall measure. If the number of channels is greater than 8, the mobile station shall measure and report on channels other than the current DCCH according to Table 6-12.
- MACA_TYPE: What type of access shall include LTM or STM information, if any, as part of MACA reports. Note that MACA reports are sent coincidentally with the RACH messages listed in Table 6-12.
- MACA_8_CONTROL: MACA_8_CONTROL shall be included in the Mobile Assisted Channel Allocation message if the number of entries in the information element MACA_LIST is greater than 8.

Table 6 - 11 General MACA Operation Control

MACA STATUS	MACA TYPE			
	1XXX	X1XX	XX1X	XXX1
00	MACA Disabled	MACA Disabled	MACA Disabled	MACA Disabled
01	LTM for Audit Confirmation	LTM for Page Response	LTM for Origination	LTM for Registration
10	STM for Audit Confirmation	STM for Page Response	STM for Origination	STM for Registration
11	LTM & STM for Audit Confirmation	LTM & STM for Page Response	LTM & STM for Origination	LTM & STM for Registration

Table 6 - 12 MACA Operation Control For More Than 8 Channels

MACA TYPE	MACA_8_CONTROL	
	0	1
1XXX (Audit Confirmation)	Include measurements from all channels in MACA_REPORT	Include measurements from all channels in MACA_REPORT
X1XX (Page Response)	Include measurements from first 8 channels in MACA_REPORT	Include measurements from all channels in MACA_REPORT
XX1X (Origination)	Include measurements from first 8 channels in MACA_REPORT	Include measurements from all channels in MACA_REPORT
XXX1 (Registration)	Include measurements from all channels in MACA_REPORT	Include measurements from all channels in MACA_REPORT

6.3.17.3 MACA Report Information Contents

MACA reports contain the following information (see Section 6.4.4.6):

1. What type of MACA report is being made (LTM, STM, or both).
2. Whether or not a MACA report is based on a full measurement interval.
3. The measurement results for the selected MACA report.

6.3.17.4 Procedures

6.3.17.4.1 LTM Measurements

6.3.17.4.1.1 LTM Measurement Units

The mobile station shall report Channel Quality and LT_RSS, where Channel Quality is defined as WER and BER measurements. LT_RSS is based on signal strength measurements made in units of dBm.

6.3.17.4.1.2 LTM Measurement Time Interval

Individual LTM measurement shall be made once per Paging Frame according to the Current PFC (see Section 4.7). A mobile station uses the Full Measurement Indicator to inform the BMI whether or not a MACA report is based on a Full Measurement Interval (see Section 6.3.17.4.1.3).

6.3.17.4.1.3 LTM Measurement Techniques

6.3.17.4.1.3.1 BER and WER Measurement Techniques

The mobile station will determine an estimate of bit error information by monitoring the correctness of the data stream at the input to the channel decoder. The Word Error Rate (WER) is estimated by monitoring the correctness of the DCCH Layer 2 CRC. The mobile station BER and WER information will be derived using the following algorithm.

1. Upon entering the DCCH camping state or selecting a new DCCH, the mobile station shall clear the content of AVE_BER_SUM (average bit error summation buffer) and AVE_WER_SUM.

2. The contents of buffer AVE_BER_FR is cleared at the beginning of each L2 frame decode. As each DCCH L2 frame is decoded, the number of bit errors divided by the number of bits over which the measurement was performed is accumulated in AVE_BER_FR. If the DCCH L2 Frame decode resulted in a Word Error, the WER_FR is set to 1.

3. At the completion of each DCCH L2 frame decode, the content of AVE_BER_FR is added to the content of AVE_BER_SUM, the content of WER_FR is added to the content of AVE_WER_SUM until 32 DCCH L2 Frames of any type have been measured.

4. A Full Measurement Interval has been reached when 32 DCCH L2 frames have been measured.

5. For Paging Frames after 32 DCCH L2 frames have been measured, a new AVE_BER_FR and WER_FR are calculated according to the procedure in item 2. The new AVE_BER_SUM and AVE_WER_SUM are calculated by multiplying the old AVE_BER_SUM and AVE_WER_SUM by the ratio (31/32) respectively, and adding the result to the new value of AVE_BER_FR and WER_FR respectively.

6. When a MACA Report is generated and a Full Measurement Interval has been reached, BER and WER values sent in the MACA Report shall be obtained by dividing AVE_BER_SUM and AVE_WER_SUM by 32.

   When a MACA Report is generated and a Full Measurement Interval has not been reached, BER and WER values sent in the MACA Report shall be set to zero. The reported bit error rate is encoded using the current AVE_BER values (in percent) as given in Table 2.4.5.1-1 of IS-136.2. The reported Word error rate is encoded using the field WER (in percent) of the information element LTM Measurement, see Section 6.5.

6.3.17.4.1.3.2 LT_RSS Measurement Technique

The mobile station signal strength information will be derived using the following algorithm. All calculations are in dB.

1. Upon entering the DCCH camping state or selecting a new DCCH, the mobile shall clear the contents of buffers LT_RSS_SUM (LT_RSS summation buffer).

2. The content of buffer LT_RSS_FR is cleared at the beginning of each DCCH L2 Frame decode. As a DCCH L2 frame is received, one signal strength measurement will be taken and the result stored in the LT_RSS_FR buffer.

3. At the completion of the sampling process, the content of LT_RSS_FR buffer will be added to the content of LT_RSS_SUM buffer until 32 DCCH L2 frames have been measured.

4. Once the LT_RSS for 32 DCCH L2 frames have been measured, which defines a Full Measurement Interval, the average will be taken by dividing the content LT_RSS_SUM by 32. This value is then stored in the LT_RSS_AVE buffer.

5. For Paging Frames after 32 DCCH L2 frames have been measured:

   a. Once the signal strength measurement is stored in LT_RSS_FR, the content of LT_RSS_AVE is subtracted from LT_RSS_SUM.

b. The content of LT_RSS_FR is then added to the content of LT_RSS_SUM.

c. A new LT_RSS_AVE value is determined by dividing LT_RSS_SUM by 32 and storing the result in LT_RSS_AVE.

6. The value of LT_RSS contained in the MACA Report Message is derived by encoding the value contained in the LT_RSS_AVE buffer as defined in Table 6-9, (see Section 6.3.2.3), according to RSS Value. This encoding function is performed when the MACA Report Message is generated.

The LT_RSS requirements regarding absolute accuracy, relative accuracy and the temperature range are as specified for Signal Strength in Section 6.3.2.3.

6.3.17.4.2 STM Measurements

6.3.17.4.2.1 STM Measurement Units

The mobile station shall report ST_RSS based on Signal Strength measurements made in units of dBm.

6.3.17.4.2.2 STM Measurement Time Interval

Each instance of ST_RSS reported to the BMI shall be based on a minimum of 4 signal strength measurements for each frequency (see Section 6.3.17.4.2.3). The minimum time between two consecutive signal strength measurements on the same frequency shall be 20 ms. The maximum time between two consecutive measurements on the same frequency shall be 500 ms.

6.3.17.4.2.3 STM Measurement Techniques

Averaging of signal strength measurements (s_i) is done in dBm units. For each instance of ST_RSS, the averaged signal strength is calculated as $(s_1 + s_2 + ... + s_n)/n$ where $n \geq 4$. The MS may make the measurements continuously or prior to an access. Upon entering the DCCH camping state or selecting a new DCCH all existing s_i for all instances of ST_RSS shall be discarded. If the ST_RSS is not derived according to intervals specified in this section for the current DCCH and all of the frequencies specified in the MACA_LIST, then the STM Measurements information element shall not be included in the MACA Report (see Section 6.4.4.6).
The encoding of the averaged signal strength measurements into ST_RSS is as defined in Table 6-9 , see Section 6.3.2.3, according to RSS Value.
The ST_RSS requirements regarding absolute accuracy, relative accuracy and the temperature range are as specified for Signal Strength in Section 6.3.2.3.

6.3.18 BCCH Update

When this procedure is invoked the mobile station shall determine which of the following BCCH messages have been received and invoke the Control Channel Selection, Control Channel Reselection or Registration procedures as necessary according to changes in message content.

DCCH Structure:

- Update parameters per the received message and ensure that the mobile station is listening to the proper PCH Subchannel (see Section 4.10).

Access Parameters:

- Update parameters per the received message.

Control Channel Selection Parameters:

- Update parameters per the received message and ensure that the mobile station is listening to the proper PCH Subchannel (see Section 4.10).

Registration Parameters:

- Update parameters per the received message.
- If the received message includes the REG Period information element but does not include the REGID Parameters information element and PER_TMR is not running, the mobile station shall set PER_TMR to (REGPER + 1) * 94 superframes.
- If the received message includes both the REG Period information element and the REGID Parameters information element the mobile station shall stop PER_TMR if running. If REGID_PER > 0, the mobile station shall maintain the value of REGID either by continuously monitoring it on the F-BCCH or by automatically incrementing it every REGID_PER superframes. If REGID_PER = 0, the mobile station shall not increment REGID.

System Identity:

- Update parameters per the received message.

Overload Class:

- Update parameters per the received message and set the overload control status to enabled. The overload control status shall be set to disabled if this message is not present on the current DCCH.

Mobile Assisted Channel Allocation:

- Update parameters per the received message.
- The Mobile Assisted Channel Allocation procedure shall be invoked as necessary (see Section 6.3.17).

Mobile Assisted Channel Allocation (Multi Hyperband):

- If multi hyperband operation is supported, then the mobile station shall update the parameters per the received message and invoke the Mobile Assisted Channel Allocation procedure as necessary (see Section 6.3.17).

Neighbor Cell:

- Update parameters per the received message.

Neighbor Cell (Multi Hyperband):

- If multi hyperband operation is supported then the mobile station shall update the parameters per the received message.

Regulatory Configuration:

- Update spectrum band configuration and probability block information per the received message.

Alternate RCI Info:

- Update parameters per the received message.

BSMC Message Delivery:

- Mobile station processing of this message is beyond the scope of this specification.

Emergency Information Broadcast:

- Update parameters per the received message and alert the mobile station user.

Neighbor Service Info:

- Update parameters per the received message.

Neighbor Service Info (Multi Hyperband):

- If multi hyperband operation is supported then the mobile station shall update the parameters per the received message.

Service Menu:

- Update parameters per the received message.

SOC/BSMC Identification:

- Update parameters per the received message.

SOC Message Delivery:

- Mobile station processing of this message is beyond the scope of this specification.

Time and Date:

- Update parameters per the received message.

6.3.19 Non-Public Mode Search

While camping on a DCCH, a mobile station user may decide to initiate a Non-Public Mode Search Condition in order to search for service with an alternate system (SID, PSID, or RSID) on the current DCCH and/or other DCCHs. Two possible procedures are defined for Non-Public Mode Search: New PSID/RSID Search and Manual System Search.

6.3.19.1 New PSID/RSID Search

When the user invokes this procedure, the mobile station shall proceed as follows:

1. Collect one signal strength measurement on each frequency in the current band (see Tables 6-1 to 6-8).
2. Make a list of up to 24 channels with the strongest signals.
3. Tune to the strongest channel in the list.
4. Determine if this channel contains a DCCH. If the channel contains a DCCH, read the F-BCCH and determine if the DCCH is marked with a non-public Network Type (Private and/or Residential) enabled in the mobile station. If this is the case, then mark the DCCH as DCCH_1. If the channel does not contain a DCCH, or if the DCCH is not marked with a non-public Network Type enabled in the mobile station, then go to Step 10.
5. If Test Registrations are allowed on DCCH_1, according to the Non-Public Registration Control information element, then formulate a Test Registration message for all PSIDs/RSIDs supported on DCCH_1 and wait for a Test Registration Response on DCCH_1. If Test Registrations are not allowed on DCCH_1, then go to Step 10.
6. Upon receiving a Test Registration Response message, generate a list of the PSIDs/RSIDs for which an "accepted" indication is provided. Mark an appropriate PSID/RSID in the "accepted" list as SYS_1. If an accepted indication is not indicated for any PSIDs/RSIDs supported on DCCH_1, then go to Step 10.
7. Display the PSID/RSID Alphanumeric Name of the SYS_1 non-public system. Details of the display are beyond the scope of this standard. The user has the option to choose or skip this non-public system.
8. If the user chooses SYS_1 then proceed as follows:
   - If SYS_1 is a PSID or RSID already stored in the mobile station, update the stored PSID/RSID Alphanumeric Name.
   - If SYS_1 is a PSID or RSID not already stored in the mobile station, then store the PSID or RSID and the PSID/RSID Alphanumeric Name along with the associated SID/SOC/MCC.
   - If the mobile station is currently registered on SYS_1, then the mobile station shall terminate this procedure and remain in the DCCH Camping state.
   - If DCCH_1 is the current DCCH , then the mobile station shall declare a System Transition Condition (see Section 6.2.3).
   - If DCCH_1 is not the current DCCH, then the mobile station shall add DCCH_1 to the list of channels identified as requiring measurements (see Section 6.3.3.1). The mobile station shall then, after an appropriate delay required for channel measurement purposes (see Section 6.3.3.3), declare a Priority System Condition (see Section 6.2.3) using DCCH_1 as the only reselection candidate. The CELLTYPE for DCCH_1 shall default to PREFERRED until otherwise determined. In addition, the mobile station shall determine the MS_ACC_PWR, RSS_ACC_MIN, SS_SUFF and DELAY (see Section 6.3.3.4.2) for DCCH_1 prior to invoking or while executing the Control Channel Reselection procedure (see Section 6.3.3)
9. If the user does not choose SYS_1 then proceed as follows:
   - If the PSID/RSID marked as SYS_1 is the last PSID/RSID in the "accepted" list for DCCH_1, then go to step 10.
   - Otherwise, mark another PSID/RSID in the "accepted" list for DCCH_1 as SYS_1 and go to step 7.
10. If this is the last channel in the list, then end the procedure. Otherwise, the mobile station shall tune to the next strongest channel in the list and go to Step 4.

If a mobile station receives a PCH message while responding to a Non-Public Mode Search Condition, it shall terminate this procedure and enter the Termination procedure (see Section 6.3.4).

6.3.19.2 Manual System Search

When the user invokes this procedure, the mobile station shall proceed as follows:

1. Search the current DCCH and neighboring DCCHs (including Private Operating Frequencies if they exist) for all candidates that support one or more of the following:
   - PSIDs
   - RSIDs
   - preferred SID

   that the mobile station subscribes to.

2. Display the PSID/RSID Alphanumeric Name of each PSID or RSID supported by the candidate control channels that match a PSID or RSID stored in the mobile station, and the Alphanumeric System ID of the preferred SID.

3. Mark as DCCH_1 the candidate control channel supporting the SID, PSID, or RSID matching the Alphanumeric System ID or PSID/RSID Alphanumeric Name selected by the user. If more than one candidate control channel supports the selected PSID, RSID, or SID, then the candidate with the highest signal strength shall be marked as DCCH_1. If no SID, PSID, or RSID is selected by the user, then terminate the procedure.

4. If DCCH_1 is the current DCCH, then the mobile station shall proceed as follows:
   - If the selected SID, PSID, or RSID is the same as the SID, PSID, or RSID with which the mobile station is registered, then this procedure is terminated and the mobile station remains in the DCCH Camping state on the current DCCH.
   - Otherwise, if the selected SID, PSID, or RSID is different than the SID, PSID, or RSID with which the mobile station is registered, then a System Transition Condition is declared (see Section 6.2.3) and this procedure is terminated.

5. If DCCH_1 is not the current DCCH, then the mobile station shall add DCCH_1 to the list of channels identified as requiring measurements (see Section 6.3.3.1). The mobile station shall then, after an appropriate delay required for channel measurement purposes (see Section 6.3.3.3), declare a Priority System Condition (see Section 6.2.3) using DCCH_1 as the only reselection candidate. The CELLTYPE for DCCH_1 shall default to PREFERRED until otherwise determined. In addition, the mobile station shall determine the MS_ACC_PWR, RSS_ACC_MIN, SS_SUFF and DELAY (see Section 6.3.3.4.2) for DCCH_1 prior to invoking or while executing the Control Channel Reselection procedure (see Section 6.3.3)

If a mobile station receives a PCH message while responding to a Non-Public Mode Search Condition, it shall terminate this procedure and enter the Termination procedure (see Section 6.3.4).

6.3.20 Test Registration

Test Registrations may be initiated automatically by the mobile station in order to update a PSID/RSID Alphanumeric Name for a PSID or RSID stored in the mobile station (see 6.3.20.1), or may be initiated as a part of the Non-Public Mode Search procedure (see Section 6.3.19). During any given power cycle, a mobile station is allowed to make multiple Test Registration attempts on private or residential systems, regardless of whether it has a PSID or RSID match, if such registrations are allowed according to Non-Public Registration Control (see Section 6.4.1.1.1.4). If a mobile station receives a Test Registration Response containing a "not accepted" indication according to the PSID/RSID Map (see Section 6.5), it shall not attempt to register with the "not accepted" PSID or RSID on that DCCH, using the Registration message, for the duration of its current power cycle or until an "accepted" indication is received via Test Registration Response. The PSID/RSID Alphanumeric Name of a PSID/RSID shall not be displayed for any PSID/RSID for which a "not accepted" indication is received. It should be noted that test registrations are not intended to trigger IS-41 transactions.

6.3.20.1 Alphanumeric Updating

The mobile station may automatically send a Test Registration message in an attempt to acquire or update the PSID/RSID Alphanumeric Name. The mobile station shall only send an automatic Test Registration if it is camped on a DCCH that supports a PSID or RSID for which an alphanumeric update is desired, if Test Registrations are allowed on that DCCH according to Non-Public Registration Control. The mobile station shall only select those PSIDs/RSIDs it has marked for alphanumeric updating when populating the PSID/RSID Map for the Test Registration message. Upon receiving a Test Registration Response message from the BMI, the mobile station shall retain knowledge of the PSID/RSID Alphanumeric Name for the numeric PSIDs or RSIDs that were selected in the PSID/RSID Map, and for which an "accepted" indication was received. If an Alphanumeric System ID information element is received in a Test Registration Response, the mobile station shall update its Alphanumeric System ID accordingly. The PSID/RSID Alphanumeric Name shall be retained over multiple power cycles of the mobile station until updated or deleted (see Section 6.3.10). The Alphanumeric System ID shall be retained over multiple power cycles of the mobile station until updated.

6.3.21 PSP and POF Determination

An autonomous system is a microsystem of Network Type Private and/or Residential that shares frequencies with the cellular network in an operator's SID area. The number of authorized autonomous systems, and their geographic locations, are controlled by the cellular operator. However, there may be a large number of autonomous systems per SID area, and the specific frequencies used by any autonomous system may be dynamic. These factors make it impractical for the cellular network BMIs to include the DCCHs of autonomous systems as neighbor list entries. Normal reselection procedures based solely on neighbor list entries must therefore be supplemented for mobile stations searching for autonomous systems.

A mobile station shall store two sets of frequencies for each autonomous system's PSID/RSID it retains in memory. The first set of frequencies correspond to control channels that have been assigned to the cellular network BMIs in the general vicinity of the autonomous system. These frequencies, along with their corresponding DVCC or DCC and SID/SOC/MCC are termed the Public Service Profiles (PSPs) for the autonomous system. The second set of frequencies represent potential operating frequencies of the autonomous system and are termed the Private Operating Frequencies (POFs). A mobile station shall allow for the storage of a minimum of four PSPs and four POFs per autonomous system PSID or RSID. The procedure for a mobile station to initialize and update PSPs and POFs is described later in this section.

Each time a mobile station camps on a DCCH, the frequency and DVCC of each stored DCCH PSP shall be compared to the frequency and DVCC of the current DCCH. If both the frequency and DVCC of any of the stored PSPs match the frequency and DVCC of its current DCCH, then a candidate autonomous system is considered as identified and the mobile station proceeds to examine the supplementary PSP information as follows:

- If the SID/SOC/MCC associated with the PSP under consideration corresponds to the PSID/RSID of the candidate autonomous system, the mobile station declares a PSP match.
- Otherwise, the mobile station declares a PSP mismatch for the PSP under consideration.

Each time a mobile station tunes to the strongest or second strongest dedicated analog control channel while performing the Initialization task (see IS-136.2, Section 2.6.1) or optionally the Idle task (see IS-136.2, Section 2.6.2), the frequency, SID and DCC of each stored ACC PSP shall be compared to the frequency, SID and DCC of this ACC. Note that a mobile station that chooses to search for PSP matches or make POF measurements in the Idle state while on an ACC may be subject to missed pages. If both the frequency, SID and DCC of any of the stored PSPs match with the frequency, SID and DCC of the strongest or second strongest dedicated analog control channel, the mobile station declares a PSP match. Otherwise, the mobile station declares a PSP mismatch for the PSP under consideration.

When a PSP match is declared while on a DCCH, the mobile station shall add the POFs of the associated autonomous system to the list of channels identified as requiring measurements (see Section 6.3.3.1). The mobile station shall then, after an appropriate delay as required for channel measurement purposes (see Section 6.3.3.3), declare a Priority System Condition (see Section 6.2.3) and use the POFs as the list of reselection candidates. The CELLTYPE for these reselection candidates shall default to PREFERRED until otherwise determined. In addition, the mobile station shall determine the MS_ACC_PWR, RSS_ACC_MIN, SS_SUFF and DELAY (see Section 6.3.3.4.2) for the POFs prior to invoking or while executing the Control Channel Reselection procedure (see Section 6.3.3). When a PSP match is declared while on an ACC, the mobile station may determine that a DCCH is the preferred service provider, and enter the Control Channel Scanning and Locking State (see Section 6.2.2), using the associated POFs as candidates.

A mobile station shall allow for manual initialization of PSPs and POFs for each PSID/RSID corresponding to an autonomous system via NAM programming. A mobile station shall also allow for automatic initialization of PSPs and POFs upon initial selection of an autonomous system as follows:

- Whenever a mobile station camps on a DCCH supporting a PSID/RSID that matches a PSID/RSID stored in its memory (see Sections 8.3.4 and 8.3.5), and the Public bit of the Network Type is set to zero, the mobile station shall update the PSPs and POFs stored for the corresponding PSID/RSID.
- To update the PSPs, the mobile station shall store the first four neighbor list entries received within the Neighbor Cell message (see Section 6.4.1.2.1.1) or the Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10), that have a CELLTYPE of NON_PREFERRED. The mobile station shall first examine the Neighbor Cell List (TDMA) information element in an attempt to find 4 neighbors having a CELLTYPE of NON_PREFERRED. If four neighbors are not found in the Neighbor Cell List (TDMA) information element, the mobile station shall proceed to examine the Neighbor Cell List (Other Hyperband) and then the Neighbor Cell List (Analog) information elements for additional neighbors.
- To update the POFs, the mobile station shall store the first four neighbor list entries received within the Neighbor Cell message (see Section 6.4.1.2.1.1) or the Neighbor Cell (Multi Hyperband) message (see Section 6.4.1.2.2.10), that have a CELLTYPE of PREFERRED or REGULAR. The mobile station shall only examine the Neighbor Cell List (TDMA) information element in an attempt to find 4 neighbors having a CELLTYPE of PREFERRED or REGULAR.
- Whenever the mobile station stores a new set of PSPs or POFs for a given autonomous system, it shall delete the old PSPs or POFs for that autonomous system.

6.4 Layer 3 Message Set

The section below describes the Layer 3 messages. In all messages below the information element at the top of the tables shall be regarded as the first when delivered to layer 2. In the information elements the most significant bit (the leftmost bit in the tables) is the first bit when delivered to layer 2. The information element descriptions are found in Section 6.5 in alphabetical order. All specified lengths are in bits unless otherwise specified. The following coding rules apply to this section:

- The opening 2 bits of a message is the Protocol Discriminator (PD). When PD = 00, the supported layer 3 message set is as specified in this section.

- The opening 4 bits of an optional Information Element (IE) within a message shall be a Parameter Type, which uniquely identifies the optional information element within the message being sent. In the interest of future compatibility, the following rules apply for the Parameter Type Codes:

  - If a mobile station or BMI reads an optional IE that has an unrecognized parameter type code defined as comprehension required, it shall ignore the IE as well as the remainder of the received message. In this case the receiving end shall still treat the message along with all recognized optional IEs received up to that point within the message as valid.

  - If a mobile station or BMI reads an optional IE that has an unrecognized parameter type code defined as comprehension not required, it shall ignore the IE and proceed to attempt to read the next IE in the message.

Table 6 - 13 Parameter Type Coding

Parameter Type	Code
Reserved	0000
Optional Information Element-Comprehension required	0001-0110
Extension	0111
Optional Information Element-Comprehension not required	1000-1110
Reserved for future expansion	1111

Auxiliary Parameter Type Coding for Parameter Type Code 0111

Auxiliary Parameter Type	Code
Reserved	0000
Optional Information Element – Comprehension required	0001-1110
Reserved for future expansion	1111

- An optional IE shall be identified by its associated Parameter Type field. If optional IEs are included in a message their order of inclusion shall reflect their top to bottom order of appearance within the messages defined by this standard.

- When a new revision of this standard results in the definition of additional optional IEs for a given message, they shall be added following the last optional IE currently defined for the message.

- Information elements having parameter type codes 1000 through 1110 require an 8-bit length indicator field (indicating the remaining number of octets in the information element) immediately following the parameter type field.

- Information elements having a Parameter Type code of 0111 require an Auxiliary Parameter Type field immediately following the Parameter Type field.

- Mandatory information elements shall not use Parameter Type, and shall be positioned in the order depicted within a message.

- The length information of a variable length information element is contained within the information element description, unless otherwise specified.

- The maximum length of a layer 3 message is 255 octets with the exception of the F-BCCH which is further limited by the number of F-BCCH slots allocated per Superframe (see Section 4.5).

- Layer 3 messages shall be padded with trailing 0 (zeros) as necessary to the nearest octet boundary.

- In the interest of backward compatibility, a received layer 3 message shall still be accepted if its length exceeds the maximum length the receiving end is capable of understanding, i.e., the receiving end discards any layer 3 information it is incapable of understanding.

- Mandatory messages and information elements are denoted by an 'M'.

- Optional messages and information elements are denoted by an 'O'.

- Messages that contain information elements defined by different revisions of IS-136 are provided with a "Rev" column to clearly indicate the revision of IS-136 for which each information element was defined. Messages that have only Rev 0 information elements do not have a revision column included.

6.4.1 BCCH Messages

BCCH Messages	Subchannels		
	F-BCCH	E-BCCH	S-BCCH
DCCH Structure	M		
Access Parameters	M		
Control Channel Selection Parameter	M		
Registration Parameters	M		
System Identity	M		
Overload Class	O		
Mobile Assisted Channel Allocation (Note 1)	O	O	
Mobile Assisted Channel Allocation (Multi Hyperband) (Note 1 & 3)	O	O	
Neighbor Cell		M	
Neighbor Cell (Multi Hyperband) (Note 2)		O	
Regulatory Configuration		M	
Alternate RCI Info		O	
BSMC Message Delivery	O	O	
Emergency Information Broadcast		O	
Neighbor Service Info		O	
Neighbor Service Info (Multi Hyperband)		O	
Service Menu (Note 1)	O	O	
SOC/BSMC Identification (Note 1)	O	O	
SOC Message Delivery	O	O	
Time and Date		O	

Note 1: This message may only be sent on one Subchannel.

Note 2: If this message is not present, a mobile station capable of multi hyperband operation shall use the Neighbor Cell message for Control Channel Reselection purposes.

Note 3: If this message is not present, a mobile station capable of multi hyperband operation shall use the Mobile Assisted Channel Allocation message for MACA purposes.

6.4.1.1 F-BCCH Messages

The F-BCCH carries broadcast information necessary for the mobile stations to find the structure of the DCCH and other essential BMI information. The full set of F-BCCH shall begin and end within the same Superframe (see Section 5.2.2). The set of layer 3 messages defined for transmission on the F-BCCH is as follows.

6.4.1.1.1 Mandatory F-BCCH Messages

6.4.1.1.1.1 DCCH Structure

This message shall always be sent first. The format of the DCCH Structure message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Number of F-BCCH	4.5	M	3
Number of E-BCCH	4.5	M	3
Number of S-BCCH	4.5	M	4
Number of Reserved Slots	4.5	M	3
Hyperframe Counter	4.7	M	4
Primary Superframe Indicator	4.5	M	1

Slot Configuration	4.10.1	M	2
DVCC	5.2.6	M	8
MAX_SUPPORTED_PFC	4.7	M	3
PCH_DISPLACEMENT	4.8	M	3
PFM_DIRECTION	4.7	M	1
Number of Non-PCH Subchannel Slots	4.10	M	2
Extended Hyperframe Counter	4.7	O	7
CBN_High		O	20
Non-Public Probability Blocks (Note 1)	6.3.1	O	9 – 24

Note 1: If present, this information element shall not be included in the Neighbor Cell message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Extended Hyperframe Counter	0001
CBN_High	0010
Non-Public Probability Blocks	0011

6.4.1.1.1.2 Access Parameters

The format of the Access Parameters message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
AUTH (Note 1)		0	M	1
S		0	M	1
RAND	6.3.12	0	M	32
MS_ACC_PWR	6.3.2.1	0	M	4
Access Burst Size	4.4, 5.2.1	0	M	1
Max Retries	5.3.3.1	0	M	3
Max Busy/Reserved	5.3.3.1.1	0	M	1
Max Repetitions	5.3.3.1	0	M	2
Max Stop Counter	5.3.3.1.4	0	M	1
R-DATA Message Length	6.3.6.2.1	0	M	3
Cell Barred	6.2.3, 6.3.2.2	0	M	5
Subaddressing Support	6.3.13	0	M	1
Delay Interval Compensation Mode		0	M	1
AUTH Map (Note 2)		A	O	10

Note 1: The Authentication procedure shall be executed as identified in the Common Cryptographic Algorithms document if AUTH = 1, regardless of the presence of the AUTH Map information element.

Note 2: In the absence of this information element, the mobile station shall use the AUTH information element in order to determine whether or not to include the Authentication message as part of its access attempt. This information element shall not be present if AUTH = 0.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
AUTH Map	0001

6.4.1.1.1.3 Control Channel Selection Parameters

The format of the Control Channel Selection Parameters message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SS_SUFF	6.3.3.4.2	M	5
RSS_ACC_MIN	6.3.2.1	M	5
SCANINTERVAL	6.3.3.1	M	4
Initial Selection Control	6.3.2.2	M	1
DELAY	6.3.3.4.1	M	4
Scanning Option Indicator	6.3.3.2	M	1
Additional DCCH Information	4.10.1	O	20 – 111

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Additional DCCH Information	0001

6.4.1.1.1.4 Registration Parameters

The format of the Registration Parameters message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
REGH	6.3.7	0	M	1
REGR	6.3.7	0	M	1
PUREG	6.3.7	0	M	1
PDREG	6.3.7	0	M	1
SYREG	6.3.7	0	M	1
LAREG	6.3.7	0	M	1
DEREG	6.3.7	0	M	1
FOREG	6.3.7	0	M	1
Capability Request		0	M	1
Present RNUM (Note 1)	6.3.7	0	O	14
REG Period (Note 2)	6.3.7	0	O	13
REGID Parameters	6.3.7	0	O	28
Non-Public Registration Control	6.3.7, 6.3.14	0	O	6
Reg-Info Map (Note 3)	6.2.3, 6.3.7	A	O	8

Note 1: This information element shall be included if the LAREG = 1.

Note 2: This information element shall be included whenever REGID Parameters is included. REG Period may be included even if REGID Parameters is not included.

Note 3: If this information element is not included, IS-41 based intersystem communications shall be assumed and a SID Report shall not be required in a Registration message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Present RNUM	0001
REG Period	0010

REGID Parameters	0011
Non-Public Registration Control	0100
Reg-Info Map	0101

6.4.1.1.1.5 System Identity

The format of the System Identity message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SID	8.3.1	M	15
Network Type	8.3.2	M	3
Protocol Version		M	4
PSID/RSID Set (Note 1)	8.3.4, 6.3.2, 6.3.3	O	37 + 17 * N
Mobile Country Code	8.3.3	O	14
Alphanumeric System ID		O	12-132

Note 1: This information element shall be included if the Network Type indicates that Private or Residential network are supported.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
PSID/RSID Set	0001
Mobile Country Code	0010
Alphanumeric System ID	1000

6.4.1.1.2 Optional F-BCCH Messages

6.4.1.1.2.1 BSMC Message Delivery

This message is used to carry BSMC specific signaling information whose content is beyond the scope of this specification. The format of the BSMC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
BSMC		M	8
Custom Control		M	1 – 512

6.4.1.1.2.2 Mobile Assisted Channel Allocation

This message is used to order the mobile station to report radio measurements on certain channels. It contains information regarding the channels the mobile station shall measure and when to report the measurements for mobile assisted channel allocation. The format of the Mobile Assisted Channel Allocation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6

MACA_STATUS	6.3.17	M	2
MACA_TYPE	6.3.17	M	4
MACA_8_CONTROL	6.3.17	O	5
MACA_LIST	6.3.17	O	19 to (19 + 11*N) (Note 1)

Note 1: The total number of channels included in the MACA_LIST information element shall not exceed 15.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
MACA_8_CONTROL	0001
MACA_LIST	0010

6.4.1.1.2.3 Overload Class

This message is used to regulate the extent of accesses made on the RACH as a result of mobile stations invoking the Origination, Registration or Originated Point-to-Point teleservice procedure. The format of the Overload Class message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
OLC	6.3.5, 6.3.6, 6.3.7	M	16

6.4.1.1.2.4 Service Menu

The service menu provides a list of services supported by the BMI. The format of the Service Menu message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
Voice Privacy Mode Map		0	M	4
Data Privacy Mode Map		0	M	4
Voice Coder Map		0	M	6
Message Encryption Algorithm Map		0	M	8 – 40
Message Encryption Key Map		0	M	4
Menu Map		0	M	10
FACCH/SACCH ARQ Map		0	M	1
User Group Map		0	M	1
SMS Map		0	M	2
IRA Support		0	M	1
OATS Support		A	M	1

Note: In the absence of this message, the mobile station shall assume the following services:

- No Voice Privacy
- No Data Privacy
- VSELP coded digital speech on a full-rate DTC
- No Message Encryption
- Analog speech
- No ARQ support on the FACCH/SACCH
- No User Group support

- No SMS CMT support
- No IRA support
- No OATS support

6.4.1.1.2.5 SOC / BSMC Identification

This message is used to identify the SOC and BSMC value associated with the BMI. The format of the SOC/BSMC Identification message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
SOC	Annex B	0	M	12
BSMC	Annex B	0	M	8
ALT_SOC_LIST	Annex B	A	O	28*S+8

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
ALT_SOC_LIST	0001

6.4.1.1.2.6 SOC Message Delivery

This message is used to carry SOC specific signaling information whose content is beyond the scope of this specification. The format of the SOC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SOC	Annex B	M	12
Custom Control		M	1 – 512

6.4.1.1.2.7 Mobile Assisted Channel Allocation (Multi Hyperband)

This message is used to order a multi hyperband capable mobile station to report radio measurements on certain channels. It contains information regarding the channels the mobile station shall measure and when to report the measurements for mobile assisted channel allocation. A mobile station capable of multi hyperband operation that is capable of supporting at least one channel included in the MACA_LIST (Other Hyperband) information element shall consider information elements included in this message as taking precedence over corresponding information elements included in the Mobile Assisted Channel Allocation (MACA) message (see Section 6.4.1.1.2.2).

The format of the Mobile Assisted Channel Allocation (Multi Hyperband) message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
MACA_STATUS	6.3.17	M	2
MACA_TYPE	6.3.17	M	4
MACA_8_CONTROL	6.3.17	O	5
MACA_LIST	6.3.17	O	19 to (19 +11*N) (Note 2)
MACA_LIST (Other Hyperband) (Note 1)		O	21 to (21 + 11*P) (Note 2)

Note 1: Up to one instance of this information element may be sent for each unique hyperband that is different from the hyperband of the current DCCH. At least one instance of this information element shall be present in this message.

Note 2: The total number of channels included in this message is determined as follows:

- If the MACA_LIST information element is included in this message, then $((N+1) + \sum ((P+1)_i, i=1 \text{ to } 3)) \leq 15$.
- If the MACA_LIST information element is not included in this message, then $(\sum ((P+1)_i, i=1 \text{ to } 3)) \leq 15 - K$, where K is the number of channels included in the MACA_LIST information element if present in the Mobile Assisted Channel Allocation message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
MACA_8_CONTROL	0001
MACA_LIST	0010
MACA_LIST (Other Hyperband)	0011

6.4.1.2 E-BCCH Messages

The E-BCCH carries broadcast information that is less time critical than F-BCCH for mobile stations. Any given E-BCCH message may occur more than once in an E-BCCH cycle.
The set of messages in the E-BCCH may span several Superframes before a repetition occurs. Any given E-BCCH message may begin and end in different Superframes (see Section 5.2.3). The set of E-BCCH messages is as follows.

6.4.1.2.1 Mandatory E-BCCH Messages

6.4.1.2.1.1 Neighbor Cell

The format of the Neighbor Cell message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SERV_SS	6.3.3.4.2	M	4
Non-Public Probability Blocks (Note 1)	6.3.1	O	9 - 24
Neighbor Cell List (TDMA)	6.3.3	O	(9 + 57 * N) to (9 + 77 * N) (Note 2)
Neighbor Cell List (Analog) (Note 3)	6.3.3	O	9 + 49 * M (Note 2)

Note 1: If present, this information element shall not be included in the DCCH Structure message.

Note 2: The total number of channels included in the Neighbor Cell List (TDMA) and Neighbor Cell List (Analog) information elements shall not exceed 24.

Note 3: This information element shall not be included if the DCCH is in the 1900 MHz Hyperband (see Section 6.4.1.2.2.10).

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Non-Public Probability Blocks	0001
Neighbor Cell List (TDMA)	0010
Neighbor Cell List (Analog)	0011

6.4.1.2.1.2 Regulatory Configuration

The format of the Regulatory Configuration message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
RCI		M	2
RF Channel Allocation (Note 1)		O	32 - 1418

Note 1: This information element shall not be present when RCI is non-zero.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
RF Channel Allocation	0001

6.4.1.2.2 Optional E-BCCH Messages

6.4.1.2.2.1 BSMC Message Delivery

This message is used to carry BSMC specific signaling information whose content is beyond the scope of this specification. The format of the BSMC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
BSMC		M	8
Custom Control		M	1 - 2024

6.4.1.2.2.2 Emergency Information Broadcast

This message provides emergency information to all mobile stations. The format of the Emergency Information Broadcast message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Text Message Data Unit		M	8 - 2016
Signal (Note 1)		O	16

Note 1: In the absence of this information element the user alerting is mobile station specific.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Signal	0001

6.4.1.2.2.3 Mobile Assisted Channel Allocation

Same as Section 6.4.1.1.2.2.

6.4.1.2.2.4 Service Menu

Same as Section 6.4.1.1.2.4.

6.4.1.2.2.5 SOC / BSMC Identification

Same as Section 6.4.1.1.2.5.

6.4.1.2.2.6 SOC Message Delivery

This message is used to carry SOC specific signaling information whose content is beyond the scope of this specification. The format of the SOC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SOC	Annex B	M	12
Custom Control		M	1 - 2020

6.4.1.2.2.7 Time and Date

The format of the Time and Date message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Time from Jan 1, 1980		M	32
Time Zone Offset		M	12

6.4.1.2.2.8 Neighbor Service Info

This message provides information regarding services supported by a TDMA neighbor and is formatted as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
TDMA Service Info (Note 1)		O	20 to (20 + 11 * N)

Note 1: This information element shall be included only if the Neighbor Cell List (TDMA) information element is present in the Neighbor Cell message. The list of TDMA Service Map fields in this information element shall be in the same order as the list of channels included in the Neighbor Cell List (TDMA) information element.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
TDMA Service Info	0001

6.4.1.2.2.9 Alternate RCI Info

This message provides information regarding a DCCH associated with a regulatory configuration different from that of the current DCCH and is formatted as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SID	8.3.1	M	15

CHAN (Note 1)		M	11
RCI		M	2
Mobile Country Code	8.3.3	O	14
Hyperband Info (Note 2)		O	6

Note 1: This information element identifies a DCCH associated with a regulatory configuration of type RCI on the hyperband given by Hyperband Info.

Note 2: In the absence of this information element, the same Hyperband as the current DCCH shall be assumed.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Mobile Country Code	0001
Hyperband Info	0010

6.4.1.2.2.10 Neighbor Cell (Multi Hyperband)

This message is used to convey neighbor cell information to mobile stations capable of multi hyperband operation. A mobile station capable of multi hyperband operation that is capable of supporting at least one neighbor DCCH included in the Neighbor Cell List (Other Hyperband) information element shall consider information elements included in this message as taking precedence over corresponding information elements included in the Neighbor Cell Message (see Section 6.4.1.2.1.1).

The format of the Neighbor Cell (Multi Hyperband) message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SERV_SS		M	4
Neighbor Cell List (TDMA)	6.3.3	O	(9+57*N) to (9+77*N) (Note 1)
Neighbor Cell List (Analog)	6.3.3	O	9 + 49*M (Note 1)
Neighbor Cell List (Other Hyperband) (Note 2)	6.3.3	O	(11+57*P) to (11+77*P) (Note 1)

Note 1: The total number of channels included in this message is determined as follows:

- If all optional information elements are included in this message, $(N+M+\sum (P_i, i=1 \text{ to } 3)) \leq 24$.
- If the Neighbor Cell List (TDMA) information element is included and the Neighbor Cell List (Analog) information element is not included, then $(N + \sum (P_i, i=1 \text{ to } 3)) \leq (24 - K)$, where K = number of channels included in the Neighbor Cell List (Analog) information element if present in the Neighbor Cell message.
- If the Neighbor Cell List (Analog) information element is included and the Neighbor Cell List (TDMA) information element is not included, then $(M + \sum (P_i, i=1 \text{ to } 3)) \leq (24 - K)$, where K = number of channels included in the Neighbor Cell List (TDMA) information element if present in the Neighbor Cell message.
- If both the Neighbor Cell List (TDMA) and Neighbor Cell List (Analog) information elements are not included, then $\sum (P_i, i=1 \text{ to } 3) \leq (24 - K)$, where K = total number of channels included in both the Neighbor Cell List (TDMA) and Neighbor Cell List (Analog) information elements if present in the Neighbor Cell message.

Note 2: Up to one instance of this information element may be sent for each unique hyperband that is different from the hyperband of the current DCCH. At least one instance of this information element shall be present in this message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Neighbor Cell List (TDMA)	0001
Neighbor Cell List (Analog)	0010
Neighbor Cell List (Other Hyperband)	0011

6.4.1.2.2.11 Neighbor Service Info (Multi Hyperband)

This message provides information regarding services supported by a TDMA neighbor and is formatted as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
TDMA Service Info (Note 1)		O	20 to (20+11*N)
TDMA Service Info (Other Hyperband) (Note 2)		O	22 to (22+11*P)

Note 1: This information element shall be included only if the Neighbor Cell List (TDMA) information element is present in the Neighbor Cell (Multi Hyperband) message. The list of TDMA Service Map fields in this information element shall be in the same order as the list of channels included in the Neighbor Cell List (TDMA) information element.

Note 2: One instance of this information element shall be included for each instance of Neighbor Cell List (Other Hyperband) included in the Neighbor Cell (Multi Hyperband) message. If multiple instances of this information element are present, then they shall be included in the same order as the corresponding instances of the Neighbor Cell List (Other Hyperband) information elements. The list of TDMA Service Map fields in this information element shall be in the same order as the list of channels included in the corresponding Neighbor Cell List (Other Hyperband) information element.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
TDMA Service Info	0001
TDMA Service Info (Other Hyperband)	0010

6.4.1.2.2.12 Mobile Assisted Channel Allocation (Multi Hyperband)

Same as Section 6.4.1.1.2.7

6.4.1.3 S-BCCH Messages

Use of the S-BCCH is reserved for future study.

6.4.2 Reserved Slots Messages

The Reserved slots are for future use.

6.4.3 SPACH Messages

The SPACH carries mobile specific information and may span several FDCCH slots which may be part of different Superframes. The set of layer 3 messages defined for transmission on the SPACH is as follows:

SPACH Messages	Subchannels		
	SMSCH	PCH	ARCH
Analog Voice Channel Designation			X
Audit Order		X	
Base Station Challenge Order Confirmation			X
BSMC Message Delivery	X	X	X

Capability Request		X	
Digital Traffic Channel Designation			X
Directed Retry			X
Message Waiting		X	
Page		X	X
Parameter Update		X	
Queue Disconnect Ack			X
Queue Update			X
R-DATA	X		
R-DATA ACCEPT	X		
R-DATA REJECT	X		
Registration Accept			X
Registration Reject			X
Release			X
Reorder/Intercept			X
SOC Message Delivery	X	X	X
SPACH Notification		X	
SSD Update Order		X	X
Test Registration Response			X
Unique Challenge Order		X	
User Alert		X	

6.4.3.1 Analog Voice Channel Designation

This message is used to assign the mobile station to an analog voice channel in the 800 MHz Hyperband. The format of the Analog Voice Channel Designation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
MEM		M	1
SCC		M	2
VMAC	IS-136.2	M	4
CHAN	IS-136.2	M	11
Protocol Version		M	4
Subaddress		O	20 - 180
DTX Support (Note 1)		O	6
Display		O	12 - 668

Note 1: In the absence of this information element, the mobile station shall default to DTX Not Supported.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001
DTX Support	0010
Display	1000

6.4.3.2 Audit Order

The BMI sends this message in order to solicit an audit confirmation from the mobile station. The format of the Audit Order message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Forced Re-registration		M	1
Debug Display Allowed		M	1
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.3 Base Station Challenge Order Confirmation

This message is a response to the Base Station Challenge Order and contains the authentication algorithm output. The format of the Base Station Challenge Order Confirmation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
AUTHBS	6.3.12.9	M	18
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.4 BSMC Message Delivery

This message is used to carry BSMC specific signaling information whose content is beyond the scope of this specification. The format of the BSMC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
BSMC	Annex B	M	8
Custom Control		M	1 - 2024
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.5 Capability Request

This message is sent by the BMI in order to query the capabilities of a specific mobile station. The format of the Capability Request message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.6 Digital Traffic Channel Designation

This message is used to assign the mobile station to a digital traffic channel. The format of the Digital Traffic Channel Designation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
DVCC	IS-136.2	M	8
DMAC	IS-136.2	M	4
CHAN		M	11
ATS		M	4
SB		M	1
Protocol Version		M	4
Time Alignment		M	5
Delay Interval Compensation Mode		M	1
Voice Mode (Note 1)		O	10
Subaddress		O	20 - 180
Message Encryption Mode (Note 2)		O	13
Hyperband Info (Note 3)		O	6
Display		O	12 - 668

Note 1: This information element may be present for a Speech Call. If not included, the Voice Mode shall default to VSELP voice coder and No Voice Privacy.

Note 2: If the Message Encryption Mode information element is not included, Message Encryption Mode shall default to No Message Encryption.

Note 3: In the absence of this information element, the same Hyperband as the current DCCH shall be assumed.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Voice Mode	0001
Subaddress	0010
Message Encryption Mode	0011
Hyperband Info	0100
Display	1000

6.4.3.7 Directed Retry

This message is used to force a mobile station to reject this DCCH and re-attempt to access an alternate control channel from its neighbor list. The format of the Directed Retry message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Last Try	6.2.5, 6.2.6, 6.3.5	M	1
RCF and AUTH (Note 1)		O	6
DTX Support (Note 1)		O	6
Retry Channel (Note 2)		O	17 per instance
Subaddress		O	20 - 180

Note 1: This information element shall be included for Directed Retry to an ACC only.

Note 2: Up to 6 instances of this information element may be included. The channel identified in this information element shall also be included in either the Neighbor Cell message or the Neighbor Cell (Multi Hyperband) message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
RCF and AUTH	0001
DTX Support	0010
Retry Channel	0011
Subaddress	0100

6.4.3.8 Message Waiting

This message is used to inform the mobile station that it has messages waiting. The format of the Message Waiting message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Message Waiting Info		M	14 - 164
Subaddress		O	20 - 180
Display		O	12 - 668

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001
Display	1000

6.4.3.9 Page

This message is used to inform the mobile station that an attempt to set up a mobile station terminated call is underway. The format of the Page message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6

Service Code		M	4
Called Party Subaddress		O	20 - 180
Signal (Note 1)		O	16
Calling Party Number Presentation Indicator		O	8
Calling Party Number		O	20 - *
Calling Party Subaddress		O	20 - 180
Display		O	12 - 668
Called Party		O	20 - *

Note 1: This information element shall be included for the case of a Page message sent to a User Group.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Called Party Subaddress	0001
Signal	0010
Calling Party Number Presentation Indicator	0011
Calling Party Number	1000
Calling Party Subaddress	1001
Display	1010
Called Party	1011

6.4.3.10 Parameter Update

This message is used to inform the mobile station to update its internal call history parameter that is used in the authentication process (see Section 6.3.12.3). The format of the Parameter Update message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Request Number		M	4
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.11 R-DATA

This relay message is used to carry point-to-point teleservice layer messages (e.g., SMS CMT, see Section 7.1 or OATS, see Section 7.2). The format of the R-DATA message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
R-Transaction Identifier		M	8
R-Data Unit		M	16 - *
Teleservice Server Address (Note 1)		O	20 - *

User Destination Address (Note 2)		O	20 - *
User Destination Subaddress (Note 2)		O	20 - 180
User Originating Address (Note 2)		O	20 - *
User Originating Subaddress (Note 2)		O	20 - 180
User Originating Address Presentation Indicator (Note 3)		O	8

Note 1: Included in the event that the Teleservice Server sending the short message has included its address in a MS Terminated short message.

Note 2: Included according to the rules and procedures of the teleservice supported by the R-DATA message. The point code and subsystem number shall only be used in the Teleservice Server Address information element.

Note 3: Included to identify presentation restriction and screening related to the User Originating Address.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Teleservice Server Address	0001
User Destination Address	0010
User Destination Subaddress	0011
User Originating Address	0100
User Originating Subaddress	0101
User Originating Address Presentation Indicator	0110

6.4.3.12 R-DATA ACCEPT

This relay message is used to acknowledge and accept the R-DATA message. The format of the R-DATA ACCEPT message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
R-Transaction Identifier		M	8
R-DATA Delay (Note 1)		O	8
Subaddress		O	20 - 180

Note 1: This information element is only included when this message is sent on the SMSCH.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
R-DATA Delay	0001
Subaddress	0010

6.4.3.13 R-DATA REJECT

This relay message is used to acknowledge and reject the R-DATA message. The format of the R-DATA REJECT message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6

R-Transaction Identifier		M	8
R-Cause		M	8
R-DATA Delay (Note 1)		O	8
Subaddress		O	20 - 180

Note 1: This information element is only included when this message is sent on the SMSCH.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
R-DATA Delay	0001
Subaddress	0010

6.4.3.14 Registration Accept

The format of the Registration Accept message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
PFC Assignment	4.7, 6.3.10	0	O	7
RNUM List	6.3.10	0	O	10 - 510
MSID Assignment	6.3.10	0	O	6,26,30
User Group	6.3.10	0	O	6,28,32,42,58
PSID/RSID Available	6.3.10	0	O	25 - 280
Display		0	O	12 - 668
Directory Address		0	O	20 - *
Directory Subaddress		0	O	20 - 180
Subaddress		A	O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
PFC Assignment	0001
RNUM List	0010
MSID Assignment	0011
User Group	0100
PSID/RSID Available	0101
Subaddress	0110
Display	1000
Directory Address	1001
Directory Subaddress	1010

6.4.3.15 Registration Reject

The format of the Registration Reject message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6

Cause	6.3.11	M	4
Reject Time (Note 1)	6.3.11	O	12
Subaddress		O	20 - 180
Display		O	12 - 668

Note 1: In the absence of this information element, a reject time of 2048 Superframes shall be assumed (see Section 6.3.11).

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Reject Time	0001
Subaddress	0010
Display	1000

6.4.3.16 Release

This message is used when the BMI clears a mobile station terminated call. The format of the Release message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Cause		M	4
Signal		O	16
Subaddress		O	20 - 180
Display		O	12 - 668

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Signal	0001
Subaddress	0010
Display	1000

6.4.3.17 Reorder/Intercept

This message is used when the BMI rejects an Origination or a R-DATA message sent by the mobile station. The format of the Reorder/Intercept message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Cause	6.2.5, 6.2.9	M	4
Tone Indicator		M	2
Subaddress		O	20 - 180
Display		O	12 - 668

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

Display	1000

6.4.3.18 SOC Message Delivery

This message is used to carry SOC specific signaling information whose content is beyond the scope of this specification. The format of the SOC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SOC	Annex B	M	12
Custom Control		M	1 - 2020
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.19 SPACH Notification

This message is used to provide a mobile station with a Notification or to inform the mobile station that BMI intends to deliver a message on the ARCH or the SMSCH. The format of the SPACH Notification message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SPACH Notification Type	6.3.4	M	6
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.20 SSD Update Order

This message causes the mobile station to execute the authentication algorithm. The format of the SSD Update Order message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
RANDSSD	6.3.12	M	56
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.21 Test Registration Response

This message is used to inform the mobile station whether it is likely to receive service upon registration. The format of the Test Registration Response message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
PSID/RSID Map		M	16
Subaddress		O	20 - 180
Alphanumeric System ID		O	12 - 132
Alphanumeric PSID/RSID List		O	12 - 1924

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001
Alphanumeric System ID	1000
Alphanumeric PSID/RSID List	1001

6.4.3.22 Unique Challenge Order

This message causes the mobile station to execute the authentication algorithm. The format of the Unique Challenge Order message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
RANDU	6.3.12	M	24
Subaddress		O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.23 User Alert

This message is sent to activate user alerting at a mobile station. The format of the User Alert message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Signal (Note 1)		O	16
Subaddress		O	20 - 180
Display		O	12 - 668

Note 1: In the absence of this information element, a mobile station shall assume standard pitch, cadence and duration as defined in the Signal information element.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Signal	0001
Subaddress	0010
Display	1000

6.4.3.24 Queue Disconnect Ack

This message is used to inform the mobile station that its request to disconnect its queued call has been received by the BMI. The format of the Queue Disconnect Ack message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		A	M	2
Message Type		A	M	6
Subaddress		A	O	20-180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.3.25 Queue Update

This message is used to inform a mobile station that its originated call attempt has been queued by the BMI or to provide a currently queued mobile station with updated queue information. The format of the Queue Update message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		A	M	2
Message Type		A	M	6
Queue Position		A	O	8
Subaddress		A	O	20 - 180
MACA_LIST (Note 1)		A	O	19 to (19 + 11*N)
MACA_LIST (Other Hyperband) (Note 1, Note 2)		A	O	21 to (21 + 11*P)
Display		A	O	12 - 668

Note 1: The total number of channels that may be included in this message is determined as follows: $((N+1) + \sum ((P+1)_i, i=1 \text{ to } 3)) \le 15$.

Note 2: Up to one instance of this information element may be sent for each unique hyperband that is different from the hyperband of the current DCCH.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Queue Position	0001
Subaddress	0010
MACA_LIST	0011
MACA_LIST (Other Hyperband)	0100

Display	1000

6.4.4 RACH Messages

The RACH carries mobile station specific information and may span several RDCCH slots (see Section 5.2.1). The set of layer 3 messages defined for transmission on the RACH is as follows:

RACH Messages	Subchannel RACH
Audit Confirmation	X
Authentication	X
Base Station Challenge Order	X
BSMC Message Delivery	X
Capability Report	X
MACA Report	X
Origination	X
Page Response	X
Queue Disconnect	X
R-DATA	X
R-DATA ACCEPT	X
R-DATA REJECT	X
Registration	X
Serial Number	X
SOC Message Delivery	X
SPACH Confirmation	X
SSD Update Order Confirmation	X
Test Registration	X
Unique Challenge Order Confirmation	X

6.4.4.1 Audit Confirmation

The format of the Audit Confirmation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
PFC Minus One		M	3
Selected PSID/RSID (Note 1)		O	8
User Group (Note 2)		O	28,32,42,58
Subaddress	6.3.13	O	20 - 180
Display (Note 3)		O	12 - 668

Note 1: Selected PSID/RSID if it is currently registered on a Private or Residential system served by this DCCH.

Note 2: This information element shall be included for the case of an Audit Confirmation sent as a result of a User Group Audit.

Note 3: May be included only if the Audit Order message Debug Display Allowed flag is set.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Selected PSID/RSID	0001

User Group	0010
Subaddress	0011
Display	1000

6.4.4.2 Authentication

The format of the Authentication message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
COUNT	6.3.12	M	6
RANDC	6.3.12	M	8
AUTHR	6.3.12	M	18

6.4.4.3 Base Station Challenge Order

The format of the Base Station Challenge Order message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
RANDBS	6.3.12	M	32
Subaddress	6.3.13	O	20 - 180

If the S bit is set in the Access Parameter message on the BCCH, the mobile station shall also include the Serial Number message.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.4.4 BSMC Message Delivery

This message is used to carry BSMC specific signaling information whose content is beyond the scope of this specification. The format of the BSMC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
BSMC	Annex B	M	8
Custom Control		M	1 - 2024
Subaddress	6.3.13	O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.4.4.5 Capability Report

The format of the Capability Report message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
Protocol Version		0	M	4
SCM		0	M	5
Software Vintage		0	M	6
Firmware Vintage		0	M	6
Model Number		0	M	4
Manufacturer Code	2.3.2, IS-136.2	0	M	8
MAX_SUPPORTED_PFC	4.7	0	M	3
SOC Support (Note 1)		0	M	1
BSMC Support		0	M	1
Async Data Support		0	M	1
G3-Fax Support		0	M	1
SMS Broadcast Support		0	M	1
Subaddressing Support		0	M	1
Supported Frequency Bands		0	M	8
IRA Support		0	M	1
User Group Support		0	M	1
800 MHz Analog Speech Support (Note 2)		0	M	1
Half-Rate DTC Support		0	M	1
Double Rate DTC Support		0	M	1
Triple Rate DTC Support		0	M	1
STU-III Support		A	M	1
Subaddress	6.3.13	A	O	20 - 180
Voice Coder Map Info (Note 3)		A	O	10
ALT_SOC_Support (Note 4)		A	O	16

Note 1: This information element corresponds to the SOC identified in the SOC information element in the SOC/BSMC Identification message. Since only one SOC can be supported at a time, this information element must be set to zero if the mobile station includes the ALT_SOC_Support information element in this message.

Note 2: A mobile station that supports analog operation in the 800 MHz hyperband shall also support digital operation (DCCH and DTC) in the 800 MHz hyperband.

Note 3: When this information element is not present, the default voice coder shall be VSELP.

Note 4: This information element corresponds to a SOC identified in the ALT_SOC_LIST information element of the SOC/BSMC Identification message. This information element shall not be included if the value of the SOC Support information element in this message is set to 1.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001
Voice Coder Map Info	0010
ALT_SOC_Support	0011

6.4.4.6 MACA Report

The format of the MACA Report message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
LTM Measurement	6.3.17	O	16
STM Measurement	6.3.17	O	8+(N+1)*5
STM Measurement (Other Hyperband) (Note 1)		O	14 - 93

Note 1: One instance of this information element shall be included for each instance of MACA_LIST (Other Hyperband) included in the Mobile Assisted Channel Allocation (Multi Hyperband) message. If multiple instances of this information element are present, then they shall be included in the same order as the corresponding instances of the MACA_LIST (Other Hyperband) information elements.

Parameter Type Code for Optional Information Elements

Parameter Type	Code
LTM Measurement	0001
STM Measurement	0010
STM Measurement (Other Hyperband)	0011

6.4.4.7 Origination

The format of the Origination message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Protocol Version		M	4
Emergency Call	6.3.5	M	1
Called Party Number (Note 1)		M	16 - *
Last Try	6.2.5	M	1
SCM	IS-136.2	M	5
Service Code		M	4
Voice Mode (Note 2)		O	10
Data Mode (Note 3)		O	16
Message Encryption Mode		O	13
Bandwidth (Note 4)		O	7
Calling Party Number Presentation Indicator		O	8
Calling Party Number		O	20 - *
Called Party Subaddress		O	20 - 180
Calling Party Subaddress		O	20 - 180

Note 1:

- If the Service Code indicates G3-Fax or Async Data, this information element provides authentication related information. In this case, a 6-digit random number is generated by the mobile station and encoded TBCD.
- When Authentication is required (the AUTH or AUTH Map information element indicates that the Authentication message for Originations is required - see Section 6.4.1.1.1.2), this information element shall be encoded TBCD.

Note 2:

- This information element shall not be included if the Service Code indicates Analog Speech only.

- This information element may not be included if the Service Code indicates Digital Speech Only or Analog or Digital Speech. If not included, the Voice Mode shall default to VSELP voice coder and no Voice Privacy.
- If multiple instances of this information element are present, they shall be included in descending order of user preference.

Note 3:

- This information element shall be included if the Service Code indicates ASYNC Data or G3-Fax.
- This information element shall not be included if the Service Code indicates Speech.

Note 4:

- This information element shall not be included if the Service Code indicates Analog Speech only.
- This information element may not be included if the Service Code indicates Digital Speech Only or Analog or Digital Speech. If not included, the Bandwidth shall default to Full-Rate Digital Traffic Channel Only.
- This information element shall be included if the Service Code indicates ASYNC Data or G3-Fax.

Parameter Type Code for Optional Information Elements

Parameter Type	Code
Voice Mode	0001
Data Mode	0010
Message Encryption Mode	0011
Bandwidth	0100
Calling Party Number Presentation Indicator	0101
Calling Party Number	0110
Called Party Subaddress	1000
Calling Party Subaddress	1001

If the AUTH or AUTH Map information element indicates that the Authentication message for Originations is required (see Section 6.4.1.1.1.2), the mobile station shall also include the Authentication message when sending an Origination.
If the S bit is set in the Access Parameter message on the BCCH, the mobile station shall also include the Serial Number message.

6.4.4.8 Page Response

The format of the Page Response message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Protocol Version		M	4
Last Try	6.2.6	M	1
SCM		M	5
Service Code		M	4
Voice Mode (Note 1)		O	10
Data Mode (Note 2)		O	16
Message Encryption Mode		O	13
Bandwidth (Note 3)		O	7
User Group (Note 4)	6.3.4	O	28,32,42,58
Subaddress	6.3.13	O	20 - 180

Note 1:

- This information element shall not be included if the Service Code indicates Analog Speech only.
- This information element may not be included if the Service Code indicates Digital Speech Only or Analog or Digital Speech. If not included, the Voice Mode shall default to VSELP voice coder and no Voice Privacy.

- If multiple instances of this information element are present, they shall be included in descending order of user preference.

Note 2:

- This information element shall be included if the Service Code indicates ASYNC Data or G3-Fax.
- This information element shall not be included if the Service Code indicates Speech.

Note 3:

- This information element shall not be included if the Service Code indicates Analog Speech only.
- This information element may not be included if the Service Code indicates Digital Speech Only or Analog or Digital Speech. If not included, the Bandwidth shall default to Full-Rate Digital Traffic Channel Only.
- This information element shall be included if the Service Code indicates ASYNC Data or G3-Fax.

Note 4:

- This information element shall be included for the case of a Page Response sent as a result of a User Group Page.

Parameter Type Code for Optional Information Elements

Parameter Type	Code
Voice Mode	0001
Data Mode	0010
Message Encryption Mode	0011
Bandwidth	0100
User Group	0101
Subaddress	0110

If the AUTH or AUTH Map information element indicates that the Authentication message for Page Responses is required (see Section 6.4.1.1.1.2), the mobile station shall also include the Authentication message when sending a Page Response.
If the S bit is set in the Access Parameter message on the BCCH, the mobile station shall also include the Serial Number message.

6.4.4.9 R-DATA

This relay message is used to carry point-to-point teleservice layer messages (e.g., SMS CMT, see Section 7.1). The format of the R-DATA message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
R-Transaction Identifier	6.3.6	M	8
R-Data Unit	6.3.6	M	16 - *
Teleservice Server Address (Note 1)	6.3.6	O	20 - *
User Destination Address (Note 2)		O	20 - *
User Destination Subaddress (Note 2)		O	20 - 180
User Originating Address (Note 2)		O	20 - *
User Originating Subaddress (Note 2)		O	20 - 180
User Originating Address Presentation Indicator (Note 3)		O	8

Note 1: Included in the event that the Teleservice Server destination address is different from the one in the mobile station subscription profile.

Note 2: Included according to the rules and procedures of the teleservice supported by the R-DATA message.

Note 3: Included to identify presentation restriction and screening related to the User Originating Address.

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Teleservice Server Address	0001
User Destination Address	0010
User Destination Subaddress	0011
User Originating Address	0100
User Originating Subaddress	0101
User Originating Address Presentation Indicator	0110

If the AUTH or AUTH Map information element indicates that the Authentication message for R-DATA Messages is required (see Section 6.4.1.1.1.2), the mobile station shall also include the Authentication message when sending an R-DATA Message.
If the S bit is set in the Access Parameter message on the BCCH, the mobile station shall also include the Serial Number message.

6.4.4.10 R-DATA ACCEPT

Same as Section 6.4.3.12.

6.4.4.11 R-DATA REJECT

Same as Section 6.4.3.13.

6.4.4.12 Registration

The format of the Registration message is as follows:

Information Element	Reference	Rev	Type	Length
Protocol Discriminator		0	M	2
Message Type		0	M	6
Registration Type	6.3.7	0	M	4
SCM		0	M	5
Protocol Version		0	M	4
C-Number	6.3.7	0	O	20 - *
PFC Request	4.7	0	O	7
Message Encryption Mode		0	O	13
Selected PSID/RSID		0	O	8
User Group (Note 1)	6.3.7	0	O	6,28,32,42,58
Subaddress	6.3.13	0	O	20 - 180
SID Report (Note 2)	6.3.7	A	O	23

Note 1: This information element shall be included by a mobile station to request User Group operation.

Note 2: This information element shall be included by a mobile station if a Registration message is sent as a result of a Power Up condition or a System Transition condition (see Section 6.3.7) and the Reg-Info Map information element in the Registration Parameters message indicates that a SID Report is requested.

Parameter Type Code for Optional Information Element

Parameter Type	Code
C-Number	0001
PFC Request	0010
Message Encryption Mode	0011
Selected PSID/RSID	0100
User Group	0101
Subaddress	0110
Extension	0111

Auxiliary Parameter Type Code for Parameter Type Code 0111

Auxiliary Parameter Type	Code

SID Report	0001

If the AUTH or AUTH Map information element indicates that the Authentication message for Registrations is required (see Section 6.4.1.1.1.2), the mobile station shall also include the Authentication message when sending a Registration.

If the S bit is set in the Access Parameter message on the BCCH, the mobile station shall also include the Serial Number message.

6.4.4.13 Serial Number

The format of the Serial Number message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
ESN	8.2	M	32

6.4.4.14 SOC Message Delivery

This message is used to carry SOC specific signaling information whose content is beyond the scope of this specification. The format of the SOC Message Delivery message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SOC	Annex B	M	12
Custom Control		M	1 - 2024
Subaddress	6.3.13	O	20 - 180

Parameter Type Code for Optional Information Element

Parameter Type	Code
Subaddress	0001

6.4.4.15 SPACH Confirmation

The format of the SPACH Confirmation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
Confirmed Message Type		M	6
Subaddress	6.3.13	O	20 - 180

If the AUTH or AUTH Map information element indicates that the Authentication message for SPACH Confirmations is required (see Section 6.4.1.1.1.2) and the mobile station is responding to a SPACH Notification indicating R-DATA, the mobile station shall also include the Authentication message when sending a SPACH Confirmation.
If the S bit is set in the Access Parameter message on the BCCH and a SPACH Notification indicating R-DATA was received, the mobile station shall also include the Serial Number message.

Parameter Type Code for Optional Information Element

Parameter Type	Code
Subaddress	0001

6.4.4.16 SSD Update Order Confirmation

The format of the SSD Update Order Confirmation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
SSD Update Status	6.3.12.9	M	2
Subaddress	6.3.13	O	20 - 180

Parameter Type Code for Optional Information Element

Parameter Type	Code
Subaddress	0001

6.4.4.17 Test Registration

This message is sent by the mobile station to the base to inquire whether it is likely to receive service should it attempt to register on any given PSID/RSID. The format of the Test Registration message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
PSID/RSID Map		M	16
Subaddress	6.3.13	O	20 - 180

Parameter Type Code for Optional Information Element

Parameter Type	Code
Subaddress	0001

6.4.4.18 Unique Challenge Order Confirmation

The format of the Unique Challenge Order Confirmation message is as follows:

Information Element	Reference	Type	Length
Protocol Discriminator		M	2
Message Type		M	6
AUTHU	6.3.12.6	M	18
Subaddress	6.3.13	O	20 - 180

Parameter Type Code for Optional Information Element

Parameter Type	Code
Subaddress	0001

6.4.4.19 Queue Disconnect

This message is sent to the BMI whenever a mobile station requests that its queued originated call be disconnected. The format of the Queue Disconnect message is as follows:

Information Element	Reference	Rev	Type	Length

Protocol Discriminator		A	M	2
Message Type		A	M	6
Subaddress		A	O	20 - 180

Parameter Type Codes for Optional Information Elements

Parameter Type	Code
Subaddress	0001

6.5 Information Element Description

The following coding rules apply to all information element descriptions:

- Elements of type "flag" shall have the values of:

  0 = Disable (off, false)

  1 = Enable (on, true)

- Changes in F-BCCH and E-BCCH information elements not designated as non-critical shall trigger a transition of the BCN flag in the SPACH.
- Changes to the content of information elements designated as non-critical may or may not trigger a transition of the BCN flag in the SPACH at the discretion of the BMI.
- All specified lengths are in bits unless otherwise noted.
- Unless identified by one of the above types, all information elements are sent as binary data (type "value").

800 MHz Analog Speech Support

This information element indicates whether or not the mobile station supports analog speech in the 800 MHz hyperband.

Value	Function
0	800 MHz Analog Speech Not Supported
1	800 MHz Analog Speech Supported

Access Burst Size

This information element informs the mobile station of which burst size to use on the RACH (see Section 4.4) according to the following table:

Value	Function
0	Use normal length bursts on the RACH
1	Use abbreviated length bursts on the RACH

Additional DCCH Information

This optional information element contains information regarding additional DCCH frequencies in this cell and their relation to the current DCCH.

Field	Length
Parameter Type	4
Number of Additional DCCH Channels (Note 1) (N - 1)	3
DCCH Channel Info (Note 2)	13 per instance

Number of Additional DCCH Channels - The number of additional DCCH channels in this cell is 1 plus the value in this field.
DCCH Channel Info - This field consists of two subfields: DCCH Channel and Slot Configuration. The value in DCCH Channel, which is encoded according to Table 2.1.1.1-1 in IS-136.2, is a channel in this cell on which at least one DCCH resides. The Slot Configuration field, which is encoded in the same manner as the Slot Configuration information element described in Section 6.5, indicates the number of slots assigned to DCCHs on the channel in the DCCH Channel field.

Field	Length
DCCH Channel	11
Slot Configuration	2

Note 1: All DCCHs provided in this optional information element, plus the current DCCH, together define the entire set of DCCH channels allocated to a multi-channel DCCH. Each DCCH in the set shall therefore, via broadcast information, identify the same set of DCCH channel.

Note 2: The number of instances sent equals 1 + the value in the Number of Additional DCCH Channels field.

Address Info

This field is used in the definition of the C-Number, Called Party, Called Party Number, Calling Party Number, Teleservice Server Address, User Destination Address and User Originating Address.

Field	Length (code)
Length of Address Info content (N) (in octets) (Note 1)	8
Type of Number	3
Numbering Plan Identification	4
Address Encoding	1
Address (Note 2)	8 per instance

Note 1: The minimum value for N is 1 because Type of Number, Numbering Plan Identification and Address Encoding fields shall always be included.

Note 2: Up to N-1 instances of this field may be sent.

The Type of Number field is coded as follows:

Code	Description (Note 1)
000	Unknown (Note 2)
001	International Number
010	National Number
011	Network Specific Number (Note 3)
100	Subscriber Number
110	Abbreviated Number
111	Reserved for Extension
All other codes are reserved	

Note 1: For the definition of "international, national and subscriber number", see ITU (formerly CCITT) Recommendation I.330.

Note 2: The Type of Number "unknown" is used when the user or the network has no knowledge of the Type of Number, e.g., international number, national number, etc. In this case, the Address field is organized according to the network dialing plan, e.g., prefix or escape digits might be present. Both the BMI and mobile station shall support type of number "unknown".

Note 3: The Type of Number "network-specific number" is used to indicate administration and service number specific to the serving network.

The Numbering Plan Identification field is coded as follows:

Code	Description
0000	Unknown (Note 1)
0001	ISDN/telephony numbering plan (ITU Recommendations E.164 and E.163)
0011	Data numbering plan (ITU Recommendation X.121)
0100	Telex numbering plan (ITU Recommendation F.69)

0110	Land Mobile numbering plan (ITU Recommendation E.212)
1001	Private numbering plan
1100	Destination Point Code and Subsystem Number (Note 2)
1110	Internet Address
1111	Reserved for extension
All other codes are reserved	

Note 1: The numbering plan "unknown" is used when the user or the network has no knowledge of the numbering plan. In this case the Address field is organized according to the network dialing plan; e.g., prefix or escape digits might be present. Both the BMI and mobile station shall support Numbering Plan Identification "unknown".

Note 2: If the Numbering Plan Identification field indicates that the number is a Destination Point Code (DPC) and Subsystem Number (SSN), then the Address Encoding field shall be treated as "reserved" and set to 0, and the encoding of the Address field is binary, with the most significant bit of the DPC being sent first and the least significant bit of the SSN being sent last.

The Address Encoding specifies the encoding of the address field.

- TBCD (Address Encoding = 1) or alternatively,
- IRA, as specified by Tables 5 and A-1 of ITU Recommendation T.50 (1992) (Address Encoding = 0). In this case, the most significant bit of each instance of Address field is set to 0.

In the interest of bandwidth efficiency, TBCD is strongly recommended when addressing information can be encoded using TBCD. Both BMI and mobile station shall support TBCD address encoding.
If a Numbering Plan Identification different than unknown is used and requires using a specific address encoding then this coding shall be indicated properly in the Address Encoding field.

The Address field, when encoded using TBCD, contains 2 digits per instance as follows:

Field	Length
Digit 1	4
Digit 2	4

TBCD coding of Digit 1 and Digit 2 is as follows:

Binary Value	Digit
0000	Filler (Note 1)
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	0
1011	*
1100	#
All other values reserved	

Note 1: When the number of digits is odd, 1 Filler digit is added in Digit 2 of the last Address field.

The purpose of this information element is to supply an Alphanumeric PSID/RSID to the user. The ordering of the Alphanumeric PSID/RSID list reflects the ordering of the PSID/RSID Set sent on the System Identity message. The information contained in this information element is coded in IRA characters.

Field	Length
Parameter Type	4
Length of Alphanumeric PSID/RSID List (in octets)	8
PSID/RSID Alphanumeric Name (Note 1)	4 - 124 per instance

Note 1: Up to 16 instances may be sent. If an odd number of instances are sent, then 4 bits of filler shall be inserted after the last instance.

The PSID/RSID Alphanumeric Name field is coded as follows:

Field	Length
Length of PSID/RSID Alphanumeric Name (N)	4
Display Character (Note 1)	8 * N

Note 1: N characters are present up to a maximum of 15. The encoding of a single character in Display Character field is IRA according to ITU Recommendation T.50 (1992) Tables 5 and A-1. The most significant bit of each octet of Display Character is set to 0. The BMI shall not provide display characters (i.e., N = 0) for those instances of PSID/RSID indicated as Not Accepted within a Test Registration Response message.

Alphanumeric System ID

The purpose of the Alphanumeric System ID information element is to supply an alphanumeric system ID to each user. The information contained in this information element is coded in IRA characters.

Field	Length
Parameter Type	4
Length of Alphanumeric System ID in octets (N)	8
Display Character (Note 1)	8 * N

Note 1: N characters are present up to a maximum of 15. The encoding of a single character in Display Character field is IRA according to ITU Recommendation T.50 (1992) Tables 5 and A-1. The most significant bit of each octet of Display Character is set to 0.

ALT_SOC_LIST

This information element contains information regarding the optional alternate SOCs supported by the BMI.

Field	Length
Parameter Type	4
Number of Alternate SOCs (S)	4
SOC (Note 1)	12
SOC PSID/RSID Map (Note 1, 2)	16

Note 1: The SOC and SOC PSID/RSID Map are sent as a pair. There may be 1-16 instances of these paired information elements. The number of pairs are 1 plus the value in the Number of Alternate SOCs field.

Note 2: The SOC PSID/RSID Map field indicates which PSIDs/RSIDs are associated with its paired SOC value. The bit map ordering of the SOC PSID/RSID Map field corresponds to the ordering of the PSIDS/RSIDs identified within the PSID/RSID Set information element of the System Identity message.

The SOC field is coded according to the SOC information element.

The SOC PSID/RSID Map field is coded as follows:

Value	Function
XXXX XXXX XXXX XXX1	1st PSID/RSID Supported
XXXX XXXX XXXX XXX0	1st PSID/RSID Not Supported

...	...
1XXX XXXX XXXX XXXX	16th PSID/RSID Supported
0XXX XXXX XXXX XXXX	16th PSID/RSID Not Supported

ALT_SOC_Support

The ALT_SOC_Support information element indicates which alternate SOC that the mobile supports.

Field	Length
Parameter Type	4
SOC	12

Async Data Support

This flag indicates whether or not the mobile station supports Async Data operation.

ATS

This information element defines the assigned time slot.

Value	Function
0001	Full-rate Digital Traffic Channel on time slots 1, 4
0010	Full-rate Digital Traffic Channel on time slots 2, 5
0011	Full-rate Digital Traffic Channel on time slots 3, 6
1001	Half-rate Digital Traffic Channel on time slot 1
1010	Half-rate Digital Traffic Channel on time slot 2
1011	Half-rate Digital Traffic Channel on time slot 3
1100	Half-rate Digital Traffic Channel on time slot 4
1101	Half-rate Digital Traffic Channel on time slot 5
1110	Half-rate Digital Traffic Channel on time slot 6
0100	Double full-rate Digital Traffic Channel on time slots 1, 4 and 2, 5
0101	Double full-rate Digital Traffic Channel on time slots 1, 4 and 3, 6
0110	Double full-rate Digital Traffic Channel on time slots 2, 5 and 3, 6
1111	Triple full-rate Digital Traffic Channel on time slots 1, 2, 3, 4, 5, 6
All other values are reserved	

AUTH

This flag indicates whether or not the mobile station shall send the Authentication message along with a Registration, Origination, Page Response, SPACH Confirmation message due to a SPACH Notification indicating R-DATA or R-DATA (see Section 6.3.12).

AUTH Map

This information element is used to determine whether or not a mobile station shall include the Authentication message as part of its access attempt.

Value	Function
000 000	Authentication message not required
XXX XX1	Authentication message for Registrations required
XXX X1X	Authentication message for Originations required
XXX 1XX	Authentication message for Page Responses and SPACH Confirmations required (Note 1)
XX1 XXX	Authentication message for R-DATA Messages required
All other bit map positions are reserved.	

Note 1: The inclusion of the Authentication message is limited to the case where a SPACH Confirmation is sent in response to a SPACH Notification including R-DATA.

AUTHBS

This information element contains the output from the Authentication procedure (see Section 6.3.12).

AUTHR

This information element contains the output response of the authentication algorithm for originations, registrations, and terminations.

AUTHU

This information element contains the output response of the authentication algorithm for unique challenge orders (see Section 6.3.12).

Bandwidth

This information element identifies the digital traffic channel bandwidth requirements for the requested call.

Field	Length
Parameter Type	4
Bandwidth	3

Value	Function
000	Half-Rate Digital Traffic Channel Only
001	Full-Rate Digital Traffic Channel Only
010	Half-Rate or Full-Rate Digital Traffic Channel - Full-Rate Preferred
011	Half-Rate or Full-Rate Digital Traffic Channel - Half-Rate Preferred
100	Double Full-Rate Digital Traffic Channel Only
101	Triple Full-Rate Digital Traffic Channel Only
All other values are reserved	

BSMC

This information element identifies the assigned manufacturer's code (see Annex B). The BSMC value of 0 is reserved. If the mobile station receives this BSMC value, it shall consider it as an unknown base station manufacturer code.

BSMC Support

This flag indicates whether or not the mobile station supports the BSMC sent on the SOC/BSMC Identification message sent on the BCCH.

C-Number

This information element allows the mobile station to provide the BMI with network address information in conjunction with a registration of type De-registration. The maximum length of this information element is network-dependent.

Field	Length
Parameter Type	4
Address Info	16 - *

Called Party

This information element identifies the called party associated with a mobile station terminated call.

Field	Length
Parameter Type	4
Address Info	16 - *

Called Party Number

This information element identifies the called party associated with a mobile station originated call. The maximum length of this information element is network-dependent.

Field	Length
Address Info	16 - *

Called Party Subaddress

This information element identifies the subaddress of the called party of a call. The maximum length of this information element is 180 bits.

Field	Length
Parameter Type	4
Subaddress Info	16 - 176

Calling Party Number

This information element identifies the calling party's network address. The maximum length of this information element is network-dependent.

Field	Length
Parameter Type	4
Address Info	16 - *

Calling Party Number Presentation Indicator

If present this information element identifies the presentation restrictions and screening related to the Calling Party Number information element.

Field	Length
Parameter Type	4
Presentation Indicator	2
Screening Indicator	2

The Presentation Indicator field is coded as follows:

Code	Function
00	Presentation Allowed
01	Presentation Restricted
10	Number Not Available
11	Reserved

The Screening Indicator field is coded as follows:

Code	Function
00	User-provided, not screened
01	User-provided, verified and passed
10	User-provided, verified and failed
11	Network-provided

Calling Party Subaddress

This information element identifies the subaddress of the calling party of a call. The maximum length of this information element is 180 bits.

Field	Length
Parameter Type	4
Subaddress Info	16 - 176

Capability Request

This flag indicates whether or not a mobile station shall also include a Capability Report message whenever it sends a New System registration, a Forced registration or a Power-Up registration (see Section 6.3.7).

Cause

This information element indicates the cause for a Registration Reject, Release or Reorder/Intercept.

Code	Cause
0000	Unknown MSID
0001	Congestion
0010	RSS too low
0011	Unknown
0100	Operator Determined Barring
0101	User Group Release
0110	User Group Barred
0111	Requested Service Code Not Supported
1000	Requested Service Code Not Available
1001	Authentication Failure
1010	Addressing Information Not Supported
1011	Requested Message Encryption Mode Temporarily Denied
1100	Unknown UGID
1101	PSID/RSID Removal
1110	Voice Codec Not Available
1111	Reserved

CBN_High

This non-critical information element contains information to support message encryption on the forward and reverse DCCH and DTC.

Field	Length
Parameter Type	4
CBN_High	16

CBN_High is incremented every 192 SFs when the Extended Hyperframe Counter cycles to 0. Proper operation of CBN therefore requires that the optional Extended Hyperframe Counter information element be included in the DCCH Structure message.
Note that the modulo count of 192 SFs are derived using the following:

$$\text{SF count} = 2 * 12 * \text{EHFC} + 2 * \text{HFC} + \text{Primary SF indicator}.$$

Aside from SOC/BSMC specific signaling, the use of this information element is for further study.

Cell Barred

This non-critical information element specifies whether or not a cell is barred for access and the Number of 100 SFs the cell can be considered barred. The barring period is set according to one plus the value of the Number of 100 SFs field.

Field	Length
Cell Barred	1
Number of 100 SFs	4

CELLTYPE

This information element provides a relative distinction by an operator to bias mobile station control channel reselection decisions in order to insure traffic flows according to an operator's desires.

Value	Function
00	REGULAR
01	PREFERRED
10	NON-PREFERRED
11	Reserved

CELL_SYNC

This flag indicates whether or not a candidate DCCH is superframe synchronized with the current DCCH. If this flag is enabled the maximum time offset between superframes sent on the candidate DCCH and current DCCH shall be no more than 7.5 symbols, i.e., a mobile station shall expect to find synchronization on a candidate DCCH within +/- 7.5 symbols relative to its current DCCH superframe.

CHAN

For the 800 MHz hyperband, channel number is defined in Table 2.1.1.1.1-1 of IS-136.2. For the 1900 MHz hyperband, channel number is defined in Table 2.1.1.1.2-1 of IS-136.2.

Confirmed Message Type

This information element is always set to the value of the SPACH Notification Type information element included in the SPACH Notification message used to solicit a SPACH Confirmation response from a mobile station.

COUNT

This information element consists of the mobile station call history parameter, used for the Authentication process (see Section 6.3.12).

Custom Control

This information element consists of binary data as specified by the SOC/BSMC protocol currently in use.

Data Mode

This information element identifies the mode to be used for the requested Data/Fax Call. The Data Mode fields are further defined in IS-130.

Field	Length
Parameter Type	4
PM_D	3
SAP	1
Acked Data	1
CRC	2
Data Part	3
RLP	2

The PM_D field is coded as follows:

Value	Function
000	No Data Privacy
001	Data Privacy Algorithm A
All other values are reserved	

The SAP field is coded as follows:

Value	Function
0	SAP 0 only
1	SAP 0 and 1

The Acked Data field is coded as follows:

Value	Function
0	Acknowledged data, unacknowledged data, or both
1	Unacknowledged data only

The CRC field is coded as follows:

Value	Function
00	16-bit Cyclic Redundancy Check
01	24-bit Cyclic Redundancy Check
10	No Cyclic Redundancy Check
11	Reserved

The Data Part field is coded as follows:

Value	Function
000	See IS-135
001	STU-III (Standard to be determined)
All other values are reserved.	

The RLP field is coded as follows:

Value	Function
00	RLP1
01	RLP2
All other values are reserved.	

Data Privacy Mode Map

This information element identifies the forms of data privacy supported by the BMI.

Value	Function
0000	No Data Privacy Supported
XXX1	Data Privacy Algorithm A Supported
1XXX	Reserved for SOC/BSMC Specific Signaling
All other bit map positions are reserved	

Debug Display Allowed

This flag indicates whether or not the mobile station is allowed to include a Display information element in the Audit Confirmation message.

DELAY

This information element is used for Control Channel Reselection purposes (see Section 6.3.3).

Code	Value (Superframes)
0000	0
0001	15
0010	30
0011	45
0100	60
0101	75
0110	90
0111	105
1000	150
1001	195
1010	240
1011	285
1100	330
1101	375
1110	420
1111	Reserved

Delay Interval Compensation Mode (DIC)

This flag is used to control the application of the DIC mode in the mobile station. When received in the Access Parameters message, the domain of DIC application shall be the DCCH. When received in the Digital Traffic Channel Designation message, the domain of DIC application shall be the DTC.

DEREG

This flag indicates whether or not De-registration is enabled.

Directed Retry Channel

This flag determines whether or not the associated Neighbor List channel is to be considered for Directed Retry purposes.

Directory Address

When the mobile station is served by a system not networked to its home system, it may be assigned a directory address different than that used in its home system. The purpose of this information element is to transport the assigned directory address to the mobile station user. The maximum length of this information element is network-dependent.

Field	Length
Parameter Type	4
Address Info	16 - *

Directory Subaddress

The Directory Subaddress is transmitted in conjunction with the Directory Address. The purpose of this information element is to convey the assigned directory subaddress (extension number) to the mobile station user.

Field	Length
Parameter Type	4
Subaddress Info	16 - 176

Display

This information element is used to supply Display information that may be displayed to the mobile station user. The information contained in this information element is coded in IRA characters. If a mobile station receives this information element with a length exceeding the maximum length that it supports, the information element should be truncated.

Field	Length
Parameter Type	4
Length of Display info in octets (N)	8
Display Character (IRA) (Note 1)	8 per instance

Note 1: N characters are present up to a maximum of 82. The encoding of a single character in Display Character field is according to ITU Recommendation T.50 (1992) Tables 5 and A-1. The most significant bit of each octet of Display Character is set to 0.

DMAC

This information element indicates the power level to be used on the assigned digital traffic channel. The coding is according to IS-136.2, Table 2.1.2.2-1.

Double Rate DTC Support

This information element indicates whether or not the mobile station supports double rate DTCs.

Value	Function
0	Double Rate DTCs Not Supported
1	Double Rate DTCs Supported

DTX Support

This information element is used to indicate DTX capabilities supported on the analog voice channel.

Field	Length
Parameter Type	4
DTX	2

The DTX field is coded as follows:

Values	Function
00	DTX Not Supported
01	Reserved
10	DTX Supported - up to 8 dB attenuation
11	DTX Supported - no limit on attenuation

DVCC

This information element is as defined in IS-136.2 except that a DVCC value of 0 may be used by a DCCH.

Emergency Call

This flag is used to indicate whether or not an origination is an emergency call. If this flag is set, it indicates an emergency call and the Called Party Number is ignored by the BMI.

ESN

This information element identifies the Electronic Serial Number of the mobile station (see Section 8.2).

Extended Hyperframe Counter

A non-critical information element used to support paging frame classes higher than 5. This counter ranges from 0 to 7 and is incremented each time the modulo 12 HFC wraps around to 0. If this counter is not broadcast, a default value of 0 shall be assumed by the mobile station. No discontinuities in the value of this counter shall occur as a result of a Broadcast Change Notification (see Section 5.2.5.3).

Field	Length
Parameter Type	4
EHFC	3

FACCH/SACCH ARQ Map

This information element identifies whether or not the BMI supports FACCH/SACCH ARQ mode on its IS-136 digital traffic channels.

Value	Function
0	FACCH/SACCH ARQ Not Supported
1	FACCH/SACCH ARQ Supported

Firmware Vintage

This information element is used to identify the mobile station's firmware vintage (specific to a mobile station vendor).

Forced Re-Registration

This flag indicates if the mobile station is required to initiate a Registration attempt with Registration Type set to Forced.

FOREG

This flag indicates whether or not forced registration is enabled.

G3-Fax Support

This flag indicates whether or not the mobile station supports G3-Fax operation.

Half-Rate DTC Support

This information element indicates whether or not the mobile station supports half-rate DTCs.

Value	Function
0	Half-Rate DTCs Not Supported
1	Half-Rate DTCs Supported

HL_FREQ

This information element is used to determine the frequency of channel measurements.

Value	Function
0	Low
1	High

Hyperband

This information element provides frequency band information as follows:

Value	Function
00	800 MHz
01	1900 MHz
All other values are reserved	

Hyperband Info

If present, this information element is used to specify the Hyperband associated with the specified channel.

Field	Length
Parameter Type	4
Hyperband	2

Hyperframe Counter

This information element is a non-critical counter used to identify which hyperframe is currently being broadcast. This counter ranges from 0 to 11. No discontinuities in the value of this counter shall occur as a result of a Broadcast Change Notification (see Section 5.2.5.3).

Initial Selection Control

This flag is used to discourage a mobile station executing the Control Channel Selection procedure (initial selection) from selecting a DCCH for camping purposes.

IRA Support

This information element indicates whether or not a mobile station or BMI supports IRA address encoding in the Address Info information element.

Value	Function
0	IRA Encoding Not Supported
1	IRA Encoding Supported

LAREG

This flag indicates whether or not the mobile station is to register when the present RNUM of the current DCCH is not part of its RNUM list used to define its location area.

Last Try

If a mobile station receives a Directed Retry message and attempts a new access on another DCCH, it shall set the Last Try flag in the Origination or the Page Response message to the value of the Last Try flag received in the Directed Retry message. Otherwise the mobile station shall set the Last Try flag to disabled at system access.

LTM Measurement

This information element provides the Channel Quality and LT_RSS of the current channel in the MACA report.

Field	Length
Parameter Type	4
WER	3
VER	3
LT_RSS and Full Measurement Indicator	6

The WER field is coded as follows:

Code	Estimated WER
000	0 %
001	> 0 - 2%
010	> 2 - 4%
011	> 4 - 8%
100	> 8 - 16%
101	> 16 – 32%
110	> 32 – 64%

111	> 64%

BER shall be encoded using Table 2.4.5.4.1.1-1 in IS-136.2.
The LT_RSS and Full Measurement Indicator field is defined as follows:

Field	Length
LT_RSS	5
Full Measurement Indicator	1

LT_RSS shall be encoded using Table 6-9 in Section 6.3.2.3, according to RSS Value.

The Full Measurement Indicator is a flag indicating whether the associated measurement is based on a full measurement or not.

MACA_8_CONTROL

This information element, together with MACA_TYPE and MACA_STATUS, determines the number of channels reported.

Field	Length
Parameter Type	4
Banana	1

The Banana field is coded as follows:

Value	Function
0	Page Response and Origination restricted to 8 channels other than current DCCH, see Table 6-12.
1	No MACA Report restrictions

MACA_LIST

This information element contains information regarding the channels, other than the current DCCH, the mobile station shall measure for mobile assisted channel allocation.

Field	Length
Parameter Type	4
Number of MACA Channels (N)	4
CHAN (Note 1)	11 per instance

Note 1: N + 1 instances of this field are included up to a maximum of 15.

MACA_LIST (Other Hyperband)

This information element contains information regarding the channels other than the current DCCH. A mobile station that is not capable of performing measurements on a channel specified in this list shall report a RSS value of 00000 for that channel.

Field	Length
Parameter Type	4
Hyperband	2
Number of MACA Channels (P)	4
CHAN (Note 1)	11 per instance

Note 1: P + 1 instances of this field are included up to a maximum of 15.

MACA_STATUS

This information element determines which MACA function combinations are enabled.

Value	Function
00	MACA Disabled
01	MACA LTM Enabled
10	MACA STM Enabled
11	MACA LTM and STM Both Enabled

MACA_TYPE

This information element determines when MACA reporting is to take place.

Value	Function
1XXX	Report MACA at Audit Confirmation
X1XX	Report MACA at Page Response
XX1X	Report MACA at Origination
XXX1	Report MACA at Registration

Manufacturer Code

This information element indicates the manufacturer of the mobile station. For administrative purposes, it is anticipated that the same value used in IS-136.2, Section 2.3.2 will be used for this field.

Max Busy/Reserved

This information element identifies the maximum number of times that BRI ≠ Idle can be detected during any given access attempt before layer 2 declares an access attempt failure (see Section 5.3.3).

Value	Function
0	1 BRI ≠ Idle Allowed
1	10 BRI ≠ Idle Allowed

Max Repetitions

This information element identifies the maximum number of times a specific burst within any given access attempt may be sent on the RACH before layer 2 declares an access attempt failure (see Section 5.3.3).

Value	Function
00	0 Repetition Allowed
01	1 Repetition Allowed
10	2 Repetitions Allowed
11	3 Repetitions Allowed

Max Retries

This information element identifies the maximum number of access attempts that layer 2 can make before it considers the access to have failed (see Section 5.3.3).

Value	Function
000	1 Access Attempt Allowed
001	2 Access Attempts Allowed
010	3 Access Attempts Allowed

011	4 Access Attempts Allowed
100	5 Access Attempts Allowed
101	6 Access Attempts Allowed
110	7 Access Attempts Allowed
111	8 Access Attempts Allowed

Max Stop Counter

This information element identifies the maximum number of times that either of the following conditions can be detected for any given burst of an access attempt before layer 2 declares an access attempt failure (see Section 5.3.3):

- BRI set to Reserved or Idle after sending an intermediate burst of an access attempt.
- R/N set to Not Received along with BRI set to Reserved or Idle after sending the last burst of an access attempt.

Value	Function
0	1 Occurrence Allowed
1	2 Occurrences Allowed

MAX_SUPPORTED_PFC

This information element identifies the maximum paging frame class supported by a DCCH or a mobile station.

Value	Function
000	PFC_1 is the only PFC supported
001	PFC2 is the maximum supported Paging Frame Class
010	PFC_3 is the maximum supported Paging Frame Class
011	PFC_4 is the maximum supported Paging Frame Class
100	PFC_5 is the maximum supported Paging Frame Class
101	PFC_6 is the maximum supported Paging Frame Class
110	PFC_7 is the maximum supported Paging Frame Class
111	PFC_8 is the maximum supported Paging Frame Class

MEM

This information element indicates whether or not message encryption algorithm A and message encryption domain A (see Message Encryption Algorithm Map information element) are enabled on the assigned voice channel.

Value	Function
0	Message Encryption Algorithm A and Domain A Disabled
1	Message Encryption Algorithm A and Domain A Enabled

Menu Map

This information element identifies the services supported by the BMI.

Value	Function
00000 00000	No Services Supported
XXXXX XXXX1	30kHz Analog Speech Supported
XXXXX XXX1X	Half-Rate Digital Speech Supported

XXXXX XX1XX	Full-Rate Digital Speech Supported
XXXXX X1XXX	Half-Rate Data Supported
XXXXX 1XXXX	Full-Rate Data Supported
XXXX1 XXXXX	Double Rate Data Supported
XXX1X XXXXX	Triple Rate Data Supported
XX1XX XXXXX	STU-III Supported
All other bit map positions are reserved	

Message Encryption Algorithm Map

This information element identifies the message encryption algorithms, domains and keys supported by a DCCH or a DTC.

Field	Length
Domain Map	8
Encryption Algorithms (Note 1)	4 per instance

Note 1: The Domain Map field identifies the number of instances and ordering of the Encryption Algorithms field. One instance of Encryption Algorithms will be present for every bit position in the Domain Map that is set to 1. The ordering of instances will reflect the Domain Map scanned from left to right (e.g., if only Domain A is supported then the only instance of Encryption Algorithms will be associated with Domain A).

The Domain Map field is coded as follows:

Code	Function
0000 0000	No Domains Supported
XXXX XXX1	Domain A Supported (Note 2)
All other bit map positions are reserved	

Note 2: Domain A consists of those portions of FACCH/SACCH messages and Analog Voice Channel messages identified as being subject to encryption according to Appendix A.

For Domain A the Encryption Algorithms field is coded as follows:

Code	Function
0000	No Message Encryption Algorithms Supported
XXX1	Algorithm A Supported (see Appendix A)
1XXX	Reserved for SOC/BSMC Specific Signaling
All other bit map positions are reserved	

Message Encryption Key Map

This information element identifies the message encryption keys supported by the BMI.

Value	Function
0000	No Message Encryption Keys Supported
XXX1	Message Encryption Key A Supported
1XXX	Reserved for SOC/BSMC Specific Signaling
All other bit map positions are reserved	

Message Encryption Mode

This information element identifies the selected message encryption algorithm, key and domain.

Field	Length

Parameter Type	4
MEA	3
MED	3
MEK	3

The MEA field is coded as follows:

Value	Function
000	No Message Encryption
001	Message Encryption Algorithm A
All other values are reserved	

The MED field is coded as follows:

Value	Function
001	Message Encryption Domain A
All other values are reserved	

The MEK field is coded as follows:

Value	Function
001	Message Encryption Key A
All other values are reserved	

Message Type

This information element identifies the function of messages. Unassigned codes are reserved.

F-BCCH Messages	Code (binary-dec)
Access Parameters	00 0001 - 1
BSMC Message Delivery	00 0010 - 2
Control Channel Selection Parameters	00 0011 - 3
DCCH Structure	00 0100 - 4
Mobile Assisted Channel Allocation	00 0101 - 5
Mobile Assisted Channel Allocation (Multi Hyperband)	10 1001 - 41
Overload Class	00 0110 - 6
Registration Parameters	00 0111 - 7
Service Menu	00 1000 - 8
SOC Message Delivery	00 1001 - 9
SOC/BSMC Identification	00 1010 - 10
System Identity	00 1011 - 11

E-BCCH Messages	Code (binary-dec)
BSMC Message Delivery	00 0010 - 2
Emergency Information Broadcast	*00 1100* - 12
Mobile Assisted Channel Allocation	00 0101 - 5
Mobile Assisted Channel Allocation (Multi Hyperband)	10 1001 - 41
Neighbor Cell	00 1101 - 13

Neighbor Cell (Multi Hyperband)	10 0111 - 39
Neighbor Service Info	00 1110 - 14
Neighbor Service Info (Multi Hyperband)	10 1000 - 40
Regulatory Configuration	00 1111 - 15
Alternate RCI Info	10 0110 - 38
Service Menu	00 1000 - 8
SOC Message Delivery	00 1001 - 9
SOC/BSMC Identification	00 1010 - 10
Time and Date	01 0000 - 16

SPACH Messages	Code (binary-dec)
Analog Voice Channel Designation	01 0001 – 17
Audit Order	01 0010 – 18
Base Station Challenge Order Confirmation	01 0011 – 19
BSMC Message Delivery	00 0010 – 2
Capability Request	01 0100 – 20
Digital Traffic Channel Designation	01 0101 – 21
Directed Retry	01 0110 – 22
Message Waiting	01 0111 – 23
Page	01 1000 – 24
Parameter Update	01 1001 – 25
Queue Disconnect (Note 1)	10 1010 – 42
Queue Disconnect Ack	10 1011 – 43
Queue Update	10 1100 - 44
R-DATA	01 1010 - 26
R-DATA ACCEPT	01 1011 - 27
R-DATA REJECT	01 1100 - 28
Registration Accept	01 1101 - 29
Registration Reject	01 1110 - 30
Release	01 1111 - 31
Reorder/Intercept	10 0000 - 32
SOC Message Delivery	00 1001 - 9
SPACH Notification	10 0001 - 33
SSD Update Order	10 0010 - 34
Test Registration Response	10 0011 - 35
Unique Challenge Order	10 0100 - 36
User Alert	10 0101 - 37

Note 1: A corresponding SPACH message is not defined - this message type is allocated for SPACH Notification purposes only.

RACH Messages	Code (binary-dec)
Audit Confirmation	00 0001 - 1
Authentication	00 0010 - 2
Base Station Challenge Order	00 0011 - 3
BSMC Message Delivery	00 0100 - 4
Capability Report	00 0101 - 5
MACA Report	00 0110 - 6
Origination	00 0111 - 7
Page Response	00 1000 - 8

Queue Disconnect	01 0011 –19
R-DATA	00 1001 – 9
R-DATA ACCEPT	00 1010 – 10
R-DATA REJECT	00 1011 – 11
Registration	00 1100 – 12
Serial Number	00 1101 – 13
SOC Message Delivery	00 1110 – 14
SPACH Confirmation	00 1111 – 15
SSD Update Order Confirmation	01 0000 – 16
Test Registration	01 0001 – 17
Unique Challenge Order Confirmation	01 0010 – 18

Message Waiting Info

This information element indicates the type and number of messages waiting.

Field	Length
Number of values	4
Type and Number of Messages Waiting (Note 1)	10 per instance

Note 1: From 1 to 16 instances of this field may be sent, providing that the Type of Messages is different for all instances. The number of instances is Number of Values + 1.

The Type and Number of Messages Waiting field is defined as 2 subfields as follows:

Subfield	Length
Type of Message Waiting	4
Number of Messages Waiting	6

The Type of Message Waiting subfield indicates the type of messages associated with the Number of Messages Waiting subfield, and is coded as follows.

Value	Function
0000	Voice Messages
0001	SMS Messages
0010	G3-Fax Messages
0100 to 0111	User Specific Messages
All other values are reserved	

The Number of Messages Waiting subfield indicates the number of messages waiting associated with the Message Waiting Type subfield, and is coded as follows.

Value	Function
000000	No Message
000001	1 Message
...	...
111110	62 Messages
111111	Unknown Number of Messages (One or More)

Mobile Country Code

This information element indicates the Mobile Country Code of the current DCCH.

Field	Length
Parameter Type	4
Mobile Country Code (MCC)	10

The MCC is the equivalent of the Mobile Country Code defined in ITU (formerly CCITT) Recommendation E.212. The MCC values are defined in annex A of E.212. The following values are extracted from E.212 and are provided as information only. If other MCC values are required, refer to Annex A of E.212 for a complete list of MCC values.

Code (decimal)	Country
302	Canada
310	United States of America
311	United States of America
312	United States of America
313	United States of America
314	United States of America
315	United States of America
316	United States of America
334	Mexico

The 3 decimal digits of the MCC are expressed as the corresponding decimal number ($000 <= d_i d_j d_k <= 999$) coded in 10 binary bits using a normal decimal to binary conversion (0 to 999).

Model Number

This information element identifies the mobile station model number (specific to an mobile station vendor).

MSID Assignment

This optional information element contains information specifying the MSID the mobile station shall use.

Field	Length
Parameter Type	4
IDT	2
MSID	20/24

The IDT field is coded as follows:

Code	Value
00	20-bit TMSI
01	24-bit TMSI
10	Reserved
11	Reserved

MS_ACC_PWR

This information element identifies the maximum nominal output power that the mobile station shall use when accessing the BMI (see Section 2.1.2.2 of IS-136.2 for tolerances). The MS_ACC_PWR is also used when determining criteria for control channel selection and reselection.
For 800 MHz TDMA systems in North America, a mobile station shall associate the power levels listed below with the broadcasted value of MS_ACC_PWR.

Code	Value (in dBm)
0000	36
0001	32
0010	28
0011	24
0100	20

0101	16
0110	12
0111	8
1000	4
1001	0
1010	-4
All other codes are reserved	

For 1900 MHz TDMA systems in the United States, a mobile station shall associate the power levels listed below with the broadcasted value of MS_ACC_PWR.

Code	Value (in dBm)
0000	30
0001	30
0010	28
0011	24
0100	20
0101	16
0110	12
0111	8
1000	4
1001	0
1010	-4
All other codes are reserved	

Neighbor Cell

This field provides neighbor DCCH specific information as follows:

Field	Length
CHAN	11
Protocol Version	4
DVCC	8
RESEL_OFFSET	7
SS_SUFF	5
DELAY	4
HL_FREQ	1
CELL_SYNC	1
CELLTYPE	2
Network Type	3
Directed Retry Channel	1
MS_ACC_PWR	4
RSS_ACC_MIN	5
PSID/RSID Indicator	1
PSID/RSID Support Length	0 or 4
PSID/RSID Support (Note1)	0 or 1 – 16

Note 1: The PSID/RSID Support field indicates which PSIDs/RSIDs are supported by a neighbor DCCH. The bit map ordering of the PSID/RSID Support field corresponds to the ordering of the PSIDS/RSIDs identified within the PSID/RSID Set information element of the System Identity message. The indicated PSIDs/RSIDs, if SOC specific, are associated with the SOC information element of the SOC/BSMC Identification message.

Neighbor Cell List (Analog)

This optional information element contains information regarding the analog channels the mobile station shall measure with regards to the Control Channel Selection and Reselection procedures. This information element always specifies analog neighbors in the 800 MHz hyperband.

Field	Length
Parameter Type	4
Number of Analog Neighbor Cells (M)	5
Analog Neighbor Cell (Note 1)	49 per instance

Note 1: Up to "M" instances of this field may be sent.

The Analog Neighbor Cell field is coded as follows:

Field	Length
CHAN	11
Protocol Version	4
Digital Color Code (DCC) (as defined in IS-136.2)	2
RESEL_OFFSET	7
SS_SUFF	5
DELAY	4
HL_FREQ	1
CELLTYPE	2
Network Type	3
Directed Retry Channel	1
MS_ACC_PWR	4
RSS_ACC_MIN	5

Neighbor Cell List (Other Hyperband)

This optional information element contains information specifying the digital channels the mobile station may measure in order to acquire service in an alternate frequency band.

Field	Length
Parameter Type	4
Hyperband	2
Number of Neighbor Cells (P)	5
Neighbor Cell (Note 1)	57 - 77 per instance

Note 1: Up to "P" instances of this field may be sent.

Neighbor Cell List (TDMA)

This optional information element specifies the digital channels the mobile station shall measure with regards to the Control Channel Selection and Reselection procedures.

Field	Length
Parameter Type	4
Number of TDMA Neighbor Cells (N)	5
Neighbor Cell (Note 1)	57 - 77 per instance

Note 1: Up to "N" instances of this field may be sent.

Network Type

This information element identifies which Network Types are supported on a control channel. See Section 8.3.2 for Network Type definitions.

Network Type	Code
Public	1XX
Private	X1X
Residential	XX1

Non-Public Probability Blocks

This information element indicates whether or not each channel probability block for a given system configuration contains a DCCH for a non-public system in its current service area.

Field	Length
Parameter Type	4
Non-Public Map Length (N)	4
Non-Public Block Map (Note 1)	1 – 16

Note 1: The length of this field is N plus 1 long.

The Non-Public Block Map field indicates which probability blocks within a band are likely to contain Non-Public service. The ordering of the bits in this field reflects the ordering of the probability blocks of a band in that the least significant bit is associated with the first probability block of a band. If a bit in this field is set to 1, then the associated probability block in the band is likely to support Non-Public service. If a bit in this field is set to 0, then the associated probability block is not likely to support Non-Public service.

For example, if the 1st, 2nd, 3rd and 5th probability blocks of a band are likely to support Non-Public service, the values of Non-Public Map Length and Non-Public Block Map shall be:

Non-Public Map Length = 0100

Non-Public Block Map = 1 0111.

If the 3rd and 16th probability blocks of a band are likely to support Non-Public service, the values of Non-Public Map Length and Non-Public Block Map shall be:

Non-Public Map Length = 1111

Non-Public Block Map = 1000 0000 0000 0100.

Non-Public Registration Control

This information element informs the mobile station whether or not a Registration attempt is allowed independent of having a PSID or RSID match (see Section 6.3.14), and whether or not the Test Registration is allowed.

Field	Length
Parameter Type	4
Non-Public Registration Control	2

The Non-Public Registration Control field is coded as follows:

Value	Function
X1	PSID/RSID match independent registration allowed
1X	Test Registration allowed
00	PSID/RSID match independent registration and Test Registration not allowed (Default case if information element not sent)

Number of E-BCCH

This information element identifies the number of contiguous dedicated E-BCCH slots per superframe. Set to 1 plus the value in this field.

Value	Function
000	1 E-BCCH slot per superframe
001	2 E-BCCH slots per superframe

010	3 E-BCCH slots per superframe
011	4 E-BCCH slots per superframe
100	5 E-BCCH slots per superframe
101	6 E-BCCH slots per superframe
110	7 E-BCCH slots per superframe
111	8 E-BCCH slots per superframe

Number of F-BCCH

This information element identifies the number of contiguous dedicated F-BCCH slots per superframe. Set to 3 plus the value in this field.

Value	Function
000	3 F-BCCH slots per superframe
001	4 F-BCCH slots per superframe
010	5 F-BCCH slots per superframe
011	6 F-BCCH slots per superframe
100	7 F-BCCH slots per superframe
101	8 F-BCCH slots per superframe
110	9 F-BCCH slots per superframe
111	10 F-BCCH slots per superframe

Number of Non-PCH Subchannel Slots

This information element identifies the number of SPACH slots that may not be allocated to mobile stations as PCH Subchannels. For a half-rate DCCH, the following values apply:

Value	Function
00	All SPACH slots are eligible to be allocated as PCH Subchannels
01	The last SPACH slot cannot be allocated as a PCH Subchannel
10	The last two SPACH slots cannot be allocated as PCH Subchannels
11	The last three SPACH slots cannot be allocated as PCH Subchannels

For a full-rate DCCH, the following values apply:

Value	Function
00	All SPACH slots are eligible to be allocated as PCH Subchannels
01	The last two SPACH slots cannot be allocated as a PCH Subchannel
10	The last four SPACH slots cannot be allocated as PCH Subchannels
11	The last six SPACH slots cannot be allocated as PCH Subchannels

Number of Reserved Slots

This information element identifies the number of dedicated Reserved slots per superframe.

Number of S-BCCH

This information element identifies the number of contiguous dedicated S-BCCH slots per superframe.

OLC

This non-critical information element determines whether or not a mobile station can make an Origination, Registration or Originated Point-to-Point Teleservice. The mobile station must examine the value of the OLC bit map corresponding to its internally stored access overload class assignment. If its bit in the OLC bit map is enabled, the mobile station shall continue with its access attempt. Otherwise, it shall not make an access attempt.

The values of the Overload Class bit assignments are:

Value	Function
XXXXXXXXXXXXXXX1	Uniform distribution assigned to normal subscribers
XXXXXXXXXXXXXX1X	Uniform distribution assigned to normal subscribers
XXXXXXXXXXXXX1XX	Uniform distribution assigned to normal subscribers
XXXXXXXXXXXX1XXX	Uniform distribution assigned to normal subscribers
XXXXXXXXXXX1XXXX	Uniform distribution assigned to normal subscribers
XXXXXXXXXX1XXXXX	Uniform distribution assigned to normal subscribers
XXXXXXXXX1XXXXXX	Uniform distribution assigned to normal subscribers
XXXXXXXX1XXXXXXX	Uniform distribution assigned to normal subscribers
XXXXXXX1XXXXXXXX	Uniform distribution assigned to normal subscribers
XXXXXX1XXXXXXXXX	Uniform distribution assigned to normal subscribers
XXXXX1XXXXXXXXXX	Test Mobile Stations
XXXX1XXXXXXXXXXX	Emergency Mobile Stations
XXX1XXXXXXXXXXXX	Reserved
XX1XXXXXXXXXXXXX	Reserved
X1XXXXXXXXXXXXXX	Reserved
1XXXXXXXXXXXXXXX	Reserved

Any combination of bits are allowed to activate many OLCs at once.
For more information, refer to EIA Telecommunications Systems Bulletin No. 16 (March 1985), "Assignment of Access Overload Classes in the Cellular Telecommunications Services".

PCH_DISPLACEMENT

This information element identifies the number of additional SPACH slots the mobile station shall read when PCON is set.

Value	Function
000	0 additional SPACH slots read
001	1 additional SPACH slot read
010	2 additional SPACH slots read
...	...
111	7 additional SPACH slots read

PDREG

This flag indicates whether Power Down registration is turned on or off.

PFC Assignment

This information element identifies the Paging Frame Class that a mobile station may be assigned at registration.

Field	Length
Parameter Type	4
PFC Minus One	3

The PFC Minus One field is coded as follows:

Code	Value
000	Paging Frame Class 1
001	Paging Frame Class 2
010	Paging Frame Class 3

011	Paging Frame Class 4
100	Paging Frame Class 5
101	Paging Frame Class 6
110	Paging Frame Class 7
111	Paging Frame Class 8

PFC Minus One

This information element is used to indicate the current PFC of a mobile station.

Code	Value
000	Paging Frame Class 1
001	Paging Frame Class 2
010	Paging Frame Class 3
011	Paging Frame Class 4
100	Paging Frame Class 5
101	Paging Frame Class 6
110	Paging Frame Class 7
111	Paging Frame Class 8

PFC Request

This information element identifies the Paging Frame Class requested by a mobile station.

Field	Length
Parameter Type	4
PFC minus one	3

PFM_DIRECTION

This information element defines whether the layer 2 PFM flag is a pull-in (reduce the Paging Frame Class by one) or a push-out flag (increment the Paging Frame Class by one).

Code	Description
0	Pull-in (Decrease Paging Frame Class one unit)
1	Push-out (Increase Paging Frame Class one unit)

Present RNUM

This information element contains the registration number that is used to define a particular mobile station's Virtual Mobile Location Area (VMLA).

Field	Length
Parameter Type	4
RNUM	10

Primary Superframe Indicator

This non-critical information element indicates whether or not the current superframe is the primary superframe within a hyperframe.

Value	Function
0	Primary

1	Secondary

Protocol Discriminator

This information element is used to identify the layer 3 protocol used for the message being sent.

Value	Function
00	IS-136
All other values are reserved	

Protocol Version

This information element identifies the Protocol Version supported:

Value	Function
0000	EIA-553 or IS-54-A
0001	TIA/EIA 627
0010	IS-136 Rev 0
0011	Permanently Reserved
0100	IS-136 Rev A
All other values are reserved	

For optimal interoperability both the mobile station and BMI should restrict their functionality to the lowest common denominator of the PV of the BMI and PV of the mobile station for point-to-point operation.

PSID/RSID Available

This information element indicates the PSID/RSIDs for which a mobile station will receive service in the current SID area.

Field	Length
Parameter Type	4
Number of PSID/RSID (Note 1)	4
PSID/RSID	17 per instance

Note 1: The number of PSID/RSID in this set is 1 plus the value of this field.

The PSID/RSID field is structured as follows:

Field	Length
PSID/RSID Type Indicator	1
PSID/RSID Value	16

The PSID/RSID Type Indicator subfield is coded as follows:

Value	Function
0	PSID Indication
1	RSID Indication

When the PSID/RSID Value subfield contains PSID information, values are assigned as follows:

Value (hex)	Function

0000	Unused
0001-2FFF	SID Specific PSIDs
3000-CFFF	SOC Specific PSIDs
D000-DFFF	Nationwide PSIDs
E000-EFFF	International PSIDs
F000-FFFF	Reserved

See Section 8.3.4 for additional information regarding PSID.

When the PSID/RSID Value subfield contains RSID information, values are assigned as follows:

Value (hex)	Function
0000	Unused
0001-FFFF	SOC Specific RSID

See Section 8.3.5 for additional information regarding RSID.

PSID/RSID Indicator

This field indicates whether or not the PSID/RSID related mapping fields are present for the associated DCCH neighbor. Specifically, if the PSID/RSID Indicator value is set to 1, the PSID/RSID Support Length and PSID/RSID Support fields are present. If set to 0, the PSID/RSID Support Length and PSID/RSID Support fields are not present.

PSID/RSID Map

This information element is included in the Test Registration message to indicate which private/residential systems have been queried by the mobile station. This information element is included in the Test Registration Response message to indicate the private/residential systems on which the mobile station may receive service. The ordering of the PSID/RSID Map reflects the ordering of the PSID/RSID Set sent on the System Identity message.

Value	Function
XXXX XXXX XXXX XXX1	1st PSID/RSID Selected/Accepted
XXXX XXXX XXXX XXX0	1st PSID/RSID Not Selected/Not Accepted
...	...
1XXX XXXX XXXX XXXX	16th PSID/RSID Selected/Accepted
0XXX XXXX XXXX XXXX	16th PSID/RSID Not Selected/Not Accepted

PSID/RSID Set

A DCCH serving one or more private/residential systems shall use this information element to identify the PSID/RSID of each private/residential system that it is serving.

Field	Length
Parameter Type	4
SOC	12
Number of PSID/RSID (N)	4
PSID/RSID (Note 1)	17 per instance

Note 1: N + 1 instances of this field are present up to a maximum of 16.

The PSID/RSID field is structured as follows:

Field	Length
PSID/RSID Type Indicator	1
PSID/RSID Value	16

The PSID/RSID Type Indicator subfield is coded as follows:

Value	Function
0	PSID Indication
1	RSID Indication

When the PSID/RSID Value subfield contains PSID information, values are assigned as follows:

Value (hex)	Function
0000	Unused
0001-2FFF	SID Specific PSIDs
3000-CFFF	SOC Specific PSIDs (Note 1)
D000-DFFF	Nationwide PSIDs
E000-EFFF	International PSIDs
F000-FFFF	Reserved

See Section 8.3.4 for additional information regarding PSID.

When the PSID/RSID Value subfield contains RSID information, values are assigned as follows:

Value (hex)	Function
0000	Unused
0001-FFFF	SOC Specific RSID (Note 1)

See Section 8.3.5 for additional information regarding RSID.

Note 1: PSIDs/RSIDs in this range shall at minimum be associated with the SOC information element included in the SOC/BSMC Identification message. PSIDs/RSIDs in this range may also be associated with additional SOCs if the ALT_SOC_LIST information element is included in the SOC/BSMC Identification message.

PSID/RSID Support

This field is only present when the PSID/RSID Indicator field is set to 1. When present, the length of this is determined by adding 1 to the value of the PSID/RSID Support Length field.

The PSID/RSID Support field indicates which PSID/RSID values identified in the PSID/RSID Set information element of the System Identity message of the current DCCH are supported by the DCCH neighbor under consideration. The ordering of the bits in this field reflects the ordering of the PSID/RSID Set sent in the System Identity message in that the least significant bit is associated with the first PSID/RSID listed in the PSID/RSID Set. If a bit in this field is set to 1, then the associated PSID/RSID entry in the PSID/RSID Set is supported by the neighbor cell under consideration. If a bit in this field is set to 0, then the associated PSID/RSID entry in the PSID/RSID Set is not supported by the DCCH neighbor under consideration.

For example, if 16 PSID/RSIDs are listed in the System Identity message and the neighbor cell supports the 1st, 2nd, 3rd and 5th PSID/RSIDs in the PSID/RSID Set, the values of PSID/RSID Support Length and PSID/RSID Support shall be:

PSID/RSID Support Length = 0100

PSID/RSID Support = 10111.

If 16 PSID/RSIDs are listed in the System Identity message and the neighbor cell supports 3rd and 16th PSID/RSIDs in the PSID/RSID Set, the values of PSID/RSID Support Length and PSID/RSID Support shall be:

PSID/RSID Support Length = 1111

PSID/RSID Support = 1000000000000100.

PSID/RSID Support Length

This field is only present when the PSID/RSID Indicator field is set to 1. When present, this field is always 4 bits long and is used to determine the length of the PSID/RSID Support field.

PUREG

This flag indicates whether or not power up registration is enabled.

Queue Position

This information element is used to convey user queue position information.

Field	Length
Parameter Type	4
Queue Position	4

The Queue Position field is coded as follows:

Value	Function
0000	Reserved
0001	1st in queue
0010	2nd in queue
...	...
1111	15th in queue

R-Cause

This information element is used to qualify a R-DATA REJECT message.

Field	Length
Cause	7
Reserved	1

Cause Description	Direction	Code	
		Decimal	Binary
Unassigned (unallocated) number	B → MS	1	000 0001
No Route to Transit Network	B → MS	2	000 0010
Call barred	B → MS	10	000 1010
Short message transfer rejected	B → MS	21	001 0101
Memory capacity exceeded	MS → B	22	001 0110
Destination out of service	B → MS	27	001 1011
Unidentified subscriber	B → MS	28	001 1100
Facility rejected	B → MS	29	001 1101
Unknown subscriber	B → MS	30	001 1110
Network out of order	B → MS	38	010 0110
Temporary failure	B → MS	41	010 1001
Congestion	B → MS	42	010 1010
Resources unavailable, unspecified	B → MS	47	010 1111
Requested facility not implemented	B → MS	69	100 0101
Invalid short message transfer reference value	B → MS	81	101 0001
Invalid message, unspecified	B → MS	95	101 1111
Mandatory information element error	both	96	110 0000
Message type non-existent or not implemented	B → MS	97	110 0001
Message not compatible with short message transfer state or message type non-existent or not implemented	B → MS	98	110 0010
Information element non-existent or not implemented	both	99	110 0011
Invalid information element contents	both	100	110 0100

Message not compatible with the short message transfer state	both	101	110 0101
Protocol error, unspecified	both	111	110 1111
Interworking, unspecified	B → MS	127	111 1111
All other values are reserved.			

R-DATA Delay

This information element is used to control the period between R-DATA message transmissions on the RACH.

Field	Length
Parameter Type	4
DELAY	4

The DELAY field is coded as follows:

Code	Value (Superframes)
0000	0
0001	15
0010	30
0011	45
0100	60
0101	75
0110	90
0111	105
1000	150
1001	195
1010	240
1011	285
1100	330
1101	375
1110	420
1111	Reserved

R-DATA Message Length

This information element identifies the maximum length of an R-DATA message that a mobile station may send on the RACH.

Value	Function
000	No R-DATA message on RACH
001	31 octet R-DATA message on RACH allowed
010	63 octet R-DATA message on RACH allowed
011	127 octet R-DATA message on RACH allowed
100	Reserved
101	Reserved
110	Reserved
111	Limited only by layer 2 format

R-Data Unit

This information element contains the Higher Layer Protocol Data Unit and is mandatory in an R-DATA message.

Field	Length
Length Indicator in (N) (in octets)	8
Higher Layer Protocol Identifier	8
Higher Layer Protocol Data Unit	8 * (N – 1)

It should be noted that the value of N is variable as it ultimately depends on the total octet demands placed upon the IS-41 SMSDeliveryPointToPoint message which is length limited to 254 octets. The IS-41 SMSDeliveryPointToPoint message is translated by the MSC into an IS-136 R-DATA message and vice versa. The demands placed upon the contents of an SMSDeliveryPointToPoint message consist of the following:

- Various information elements included in an R-DATA message which are translated into their SMSDeliveryPointToPoint message information element equivalents.
- Various information elements included in an SMSDeliveryPointToPoint message which are specific to the IS-41 MAP layer (i.e., are not derived from the content of an R-DATA message).

The Higher Layer Protocol Identifier field is coded as follows:

Value	Function
0000 0000	Network Specific
0000 0001	Point-to-Point SMS (see Section 7.1)
0000 0010	Reserved for Cellular Paging Teleservice
0000 0011	OATS (See Section 7.2)
1000 0000	Reserved for Carrier Specific Teleservices
...	"
1111 1111	"
All other values are reserved	

R-Transaction Identifier

This information element is used to associate a R-DATA ACCEPT or a R-DATA REJECT message to the R-DATA message being acknowledged.

RAND

This information element identifies the random number stored by a mobile station for use in selected authentication processes.

RANDBS

This information element identifies the random number generated by the mobile station that is used in the SSD Update procedure.

RANDC

This information element identifies the number used to confirm the last RAND received by the mobile station. It is used in selected authentication processes.

RANDSSD

This information element identifies the random number generated by the BMI that is used in the SSD Update procedure.

RANDU

This information element identifies the random number generated by the BMI that is used in the Unique Challenge Response procedure.

RCF and AUTH

This information element of type flag indicates whether or not the mobile station is to read Control Filler information and send Authentication information when making an access on an ACC as a result of a Directed Retry received on the DCCH.

Field	Length
Parameter Type	4

RCF	1
AUTH	1

The RCF field is encoded as follows:

Value	Function
0	Do Not Read RCF
1	Read RCF

The AUTH field is encoded as follows:

Value	Function
0	Authentication Disabled
1	Authentication Enabled

RCI

This information element identifies a particular radio frequency system allocation, together with recommended DCCH allocation, as defined in this standard.

Value	Function
00	Allocation described in Section 6.3.1.1.1
01	Allocation described in Section 6.3.1.1.2
10	Allocation described in Section 6.3.1.1.3
11	Allocation described in Section 6.3.1.1.4

REG Period

This information element identifies the registration periodicity in number of 94 superframes. REGPER values are coded from 0 to 511 indicating 94 to 48128 superframes (approximately 1 minute to 8.5 hours).

Field	Length
Parameter Type	4
REGPER	9

REGPER	Value
00000 0000	94 Superframes
00000 0001	188 Superframes
00000 0010	282 Superframes
...	...
11111 1110	48034 Superframes
11111 1111	48128 Superframes

Reg-Info Map

This information element provides additional information to be used in the registration process.

Field	Length
Parameter Type	4
Reg-Info Map	4

The Reg-Info Map field is coded as follows:

Value	Function
XXX1	IS-41 Based Intersystem Communications Supported
XX1X	SID Report Requested
X1XX	Reserved
1XXX	Reserved

REGH

This flag indicates whether or not a home mobile station is allowed to register.

REGID Parameters

This non-critical information element contains information on the current REGID value and the time between stepping REGID. REGID is a system clock ranging from 0 to 1048575. REGID_PER indicates how often REGID is incremented and is expressed in superframes. REGID_PER ranges from 0 to 15 superframes. The value 0 indicates the REGID is not incremented.

Field	Length
Parameter Type	4
REGID	20
REGID_PER	4

Registration Type

This information element identifies the type of registration the mobile station is making according to the following table:

Value	Function
0000	Power down
0001	Power up
0010	Location Area
0011	Forced
0100	Periodic
0101	Deregistration
0110	New System
0111	ACC to DCCH
1000	TMSI Timeout
1001	User Group
1010	New Hyperband
All other values are reserved.	

REGR

This flag indicates whether or not a roaming mobile station is allowed to register.

Reject Time

This information element is used by the system to indicate to a mobile station the interval of time when it will be allowed to register again (see Section 6.3.11).

Field	Length
Parameter Type	4

Lower time boundary in 100 SF	4
Upper time boundary in 100 SF	4

The Lower Time Boundary in 100 SF field and the Upper Time Boundary in 100 SF field are defined as follows:

Value	Function
0000	0 SF
0001	100 SF
...	...
1101	1300 SF
1110	1400 SF
1111	Until MS power down (Note 1)

Note 1: If this value is used for both time boundaries, or if it is used only for one, the mobile station shall consider that no re-registration is allowed until mobile station power down.

The mobile station finds the re-registration time according to the following:

REG_REJECT_TMR = Lower time boundary in 100 SF + RANDNO * (Upper time boundary in 100 SF - Lower time boundary in 100 SF)

where:

- RANDNO is a random number uniformly distributed between 0.1 and 1 generated by the mobile station, with a granularity not greater than 0.1
- REG_REJECT_TMR is the time at which mobile re-registration is allowed.

Request Number

This information element is used in a Parameter Update message to allow the mobile station to recognize duplicate Parameter Update messages.

RESEL_OFFSET

This information element is used to increase/decrease the preference of a new candidate cell being considered for control channel reselection.

Code	Value (dB)
0000000	-128
0000001	-126
...	...
0111110	-4
0111111	-2
1000000	0
1000001	2
...	...
1111110	124
1111111	126

Retry Channel

This information element is used to specify a channel to be considered for directed retry purposes. The channel identified in this information element shall also be included in the Neighbor Cell message or the Neighbor Cell (Multi Hyperband) message.

Field	Length
Parameter Type	4
Hyperband and CHAN	13

The Hyperband and CHAN field is further comprised of 2 subfields as follows:

Subfield	Length
Hyperband	2
CHAN	11

RF Channel Allocation

This information element indicates an RF channel allocation for system configurations that are not described in this standard.

Field	Length
Parameter Type	4
Number of Channel Groups (N)	6
Channel Group (Note 1)	22 per instance

Note 1: Channel Group is an ordered pair indicating the first/last RF Channel Numbers assigned to the Channel Group. N + 1 instances of this field are provided.

The Channel Group field is defined as follows:

Field	Length
First Channel	11
Last Channel	11

RNUM List

This information element contains the registration number that is used to define a particular mobile stations Virtual Mobile Location Area (VMLA).

Field	Length
Parameter Type	4
Number of RNUMs	6
RNUM (Note 1)	10 per instance

Note 1: Up to 50 instances may be sent.

RSS_ACC_MIN

This information element is used for the cell (re)selection process. It is the minimum received signal strength required to access the cell.

Code	Value (dBm)
00000	$-\infty$
00001	-111
...	...
11110	-53
11111	-51

S

This flag indicates whether the mobile station sends the Serial number message along with a Registration, Origination, Page Response, SPACH Confirmation due to a SPACH Notification indicating R-DATA, R-DATA or Base Station Challenge Order.

SB

This flag defines whether the mobile station shall use the shortened burst initially on the assigned digital traffic channel as follows:

0 = do not send shortened burst.

1 = send shortened burst

SCANINTERVAL

This information element identifies the basic interval, in Hyperframes, between consecutive signal strength measurements. The basic interval is set to 1 plus the value of this field.

Value	Function
0000	1 Hyperframe interval
0001	2 Hyperframes interval
...	...
1110	15 Hyperframes interval
1111	16 Hyperframes interval

Scanning Option Indicator

This flag is used to control whether or not a mobile station can apply the optional enhancements (see Section 6.3.3.2) to the signal strength measurement interval applicable to NL entries. If set to 1, a mobile station may apply the optional enhancements. If set to 0, the mobile station shall not apply the optional enhancements.

SCC

This information element defines the SAT color code to be used on the assigned analog voice channel.

Bit Pattern	SAT Frequency
00	5970 Hz
01	6000 Hz
10	6030 Hz
11	Reserved

SCM

This information element denotes the power class, transmission capability and bandwidth of the mobile station (see IS-136.2).

Selected PSID/RSID

This information element indicates which private/residential system in the PSID/RSID Set the mobile station is attempting to register on or is registered on. In the absence of this information element, the registration attempt shall be considered to be intended for the SID.

Field	Length
Parameter Type	4
Selected PSID/RSID	4

The Selected PSID/RSID field is coded as follows:

Value	Function
0000	1st PSID/RSID in Set
...	...
1111	16th PSID/RSID in Set

Service Code

This information element indicates the requested service.

Code	Function
0000	Analog Speech Only
0001	Digital Speech Only
0010	Analog or Digital Speech - Analog Preferred
0011	Analog or Digital Speech - Digital Preferred
0100	Async Data
0101	G3 Fax
0110	Service Rejected
0111	STU-III
All other codes are reserved	

SERV_SS

This information element is used in the control channel reselection process.

Code	Value (in dB)
0000	Service Offering Reselection Trigger Condition not allowed (see Section 6.3.3.4.1)
0001	2
...	...
1110	28
1111	30

SID

This information element provides a digital identification associated with a cellular system where each system is assigned a unique number (see Section 8.3.1).

SID Report

This information element identifies the SID on which a mobile station last successfully registered (SIDs-p, see Sections 6.3.7 and 9.0).

Field	Length
Parameter Type (Extension)	4
Auxiliary Parameter Type	4
SIDs-p	15

Signal

This information element conveys alerting information to a mobile station user.

Field	Length
Parameter Type	4
Pitch	2
Cadence	6
Duration	4

The Pitch field is coded as follows:

Value	Function
00	Medium Pitch (standard)
01	High Pitch

10	Low Pitch
All other values are reserved	

The Cadence field is coded as follows:

Value	Function
000000	No Tone: Off
000001	Long: 2.0 s on, 4.0 s off (standard)
000010	Short-Short: 0.8 s on, 0.4 s off, 0.8 s on, 4.0 s off
000011	Short-Short-Long: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.8 s on, 4.0 s off
000100	Short-Short-2: 1.0 s on, 1.0 s off, 1.0 s on, 3.0 s off
000101	Short-Long-Short: 0.5 s on, 0.5 s off, 1.0 s on, 0.5 s off, 0.5 s on, 3.0 s off
000110	Short-Short-Short-Short: 0.5 s on, 0.5 s off, 0.5 s on, 0.5 s off, 0.5 s on, 0.5 s off, 0.5 s on, 2.5 s off
000111	PBX Long: 1.0 s on, 2.0 s off
001000	PBX Short-Short: 0.4 s on, 0.2 s off, 0.4 s on, 2.0 s off
001001	PBX Short-Short-Long: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.8 s on, 1.0 s off
001010	PBX Short-Long-Short: 0.4 s on, 0.2 s off, 0.8 s on, 0.2 s off, 0.4 s on, 1.0 s off
001011	PBX Short-Short-Short-Short: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.4 s on, 0.8 s off
001100	Pip-Pip-Pip-Pip: 0.1 s on, 0.1 s off, 0.1 s on, 0.1 s off, 0.1 s on, 0.1 s off, 0.1 s on, 0.1 s off.
All other values are reserved	

The Duration field is coded as follows:

Value	Function
0000	1 Cycle of Cadence
0001	2 Cycles of Cadence
...	...
1110	15 Cycles of Cadence
1111	Continuous Repeating of Cadence (Standard)

Slot Configuration

This information element identifies the number of slots dedicated to DCCH on this frequency according to the following table:

Value	Function
00	One half-rate DCCH on slot 1
01	One full-rate DCCH on slots 1 and 4
10	One full-rate DCCH on slots 1 and 4, and One full-rate DCCH on slots 2 and 5
11	One full-rate DCCH on slots 1 and 4; One full-rate DCCH on slots 2 and 5, and One full-rate DCCH on slots 3 and 6

SMS Broadcast Support

This flag indicates whether or not the mobile station supports SMS Broadcast operation.

SMS Map

This information element identifies the extent to which the BMI supports the CMT teleservice.

Value	Function
00	CMT Teleservice Not Supported
X1	SMS SUBMIT Supported (see Section 7.1.1.2.1, 7.1.1.1.2, 7.1.1.1.3, 7.1.1.3, 7.1.1.4)
1X	SMS DELIVER Supported (see Section 7.1.1.1.1, 7.1.1.2.2, 7.1.1.2.3, 7.1.1.3, 7.1.1.4)

SOC

This information element identifies which operator is providing service. If the mobile station receives a reserved SOC value, it shall consider it as an unknown system operator code. See Annex B for SOC allocation. The SOC specific PSIDs/RSIDs identified within the PSID/RSID Set information element of the System Identity message are, at minimum, associated with the SOC value identified by this information element.

Value (hex)	Function
000	Reserved / Unknown
001 - 7FF	National SOC
800	Reserved / Unknown
801 - FFF	International SOC

SOC Support

This flag indicates whether or not the mobile station supports the SOC identified by the SOC information element of the SOC/BSMC Identification message.

Software Vintage

This information element is used to identify the mobile station Software Vintage (specific to an mobile station vendor).

SPACH Notification Type

This information element contains the message type identifying the message that the BMI intends to deliver to the mobile station. The valid values for SPACH Notification Type shall be limited to the Message Type associated with Page, SSD Update, R-DATA, Queue Update, Queue Disconnect and Mobile Assisted Channel Allocation.

SSD Update Status

This information element is used to indicate the success, or reason for failure of an SSD Update Order from the mobile station perspective according to the following table:

Value	Function
00	SSD Update Successful
01	SSD Update Failed due to AUTHBS mismatch
10	Reserved
11	Reserved

SS_SUFF

This information element identifies the minimum signal strength deemed sufficient for a candidate control channel to be considered for control channel reselection. SS_SUFF is used, in some instances, to control cell reselection using an absolute threshold.

Code	Value (dBm)
00000	$-\infty$
00001	-111

...	...
11110	-53
11111	-51

STM Measurement

This information element is used to send the measured signal strength of the MACA channels.

Field	Length
Parameter Type	4
Number of values (N)	4
ST_RSS (Note 1)	5 per instance

Note 1: N + 1 instances of this field are provided. The first instance shall be the ST_RSS for the current DCCH. Other instances shall be ordered according to the sequence they appear in the Mobile Assisted Channel Allocation message (see Section 6.4.1.1.2.2).

ST_RSS shall be encoded using Table 6-9 according to RSS Value.

STM Measurement (Other Hyperband)

This information element is used to provide the measurement status of MACA channels not included in the STM Measurement information element.

Field	Length
Parameter Type	4
Report Map Length (N)	4
Report Map (Note 1)	1 - 15
ST_RSS (Note 2)	5 per instance

Note 1: This field is N bits long where N indicates the number of MACA channels present in the corresponding MACA_LIST (Other Hyperband) information element. The left most bit of this field corresponds to the first MACA channel in the corresponding MACA_LIST (Other Hyperband) information element.

Note 2: One instance of this field shall be included for each bit position set to 1 in the Report Map field. ST_RSS shall be encoded using Table 6-9 according to RSS Value.

STU-III Support

This flag indicates whether or not the mobile station supports STU-III operation.

Value	Function
0	STU-III Not Supported
1	STU-III Supported

Subaddress

This information element identifies the subaddress of a called or calling party.
The maximum length of this information element is 180 bits.

Field	Length
Parameter Type	4
Subaddress Info	16 - 176

Subaddress Info

This information element identifies the subaddress of a called or calling party.

Field	Length
Length of Subaddress Info content (N) (in octets) (Note 1)	8
Reserved	3
Odd/Even Indicator	1
Type of Subaddress	3
Reserved	1
Subaddressing (Note 2)	8 per instance

Note 1: The minimum value for N is 1 because Odd/Even Indicator, Type of Subaddress fields shall always be included.

Note 2: Up to N-1 instances of this field may be sent.

The Type of Subaddress field is coded as follows:

Code	Description
000	NSAP (ITU Recommendation X.213 or ISO 8348 AD2)
010	User-specified
All other values are reserved	

The Odd/Even Indicator field is coded as follows:

Code	Description
0	Even Number of Address Signals
1	Odd Number of Address Signals

Note: The Odd/Even Indicator is used when the Type of Subaddress is user-specified and the coding is BCD.

The Subaddressing field is defined as follows:

The NSAP address shall be encoded using the preferred binary encoding specified in ITU (formerly CCITT) Recommendation X.213 or ISO 8348 AD2.
When the AFI = 50 (encoded in BCD as 0101 0000), IRA characters are encoded as specified in Tables 5 and A-1 of ITU Recommendation T.50 (1992) or ISO 646 with the eighth bit set to zero. When AFI = 51 (encoded in BCD as 0101 0001), ASCII characters are encoded as specified in ANSI X3.4 with the eighth bit set to zero.
For a user-specified subaddress, the field is encoded according to the user specification, subject to a maximum length of 20 octets. When interworking with ITU (formerly CCITT) Recommendation X.25 networks, BCD coding should be applied.

Subaddressing Support

This flag is used to identify whether or not a BMI or a mobile station supports subaddressing.

Supported Frequency Bands

This information element indicates the frequency bands supported by the mobile station with Digital Traffic Channels.

Value	Function
XXXX XXX1	800 MHz A & B Bands Supported
XXXX XX1X	1900 MHz A Band Supported
XXXX X1XX	1900 MHz B Band Supported
XXXX 1XXX	1900 MHz C Band Supported
XXX1 XXXX	1900 MHz D Band Supported
XX1X XXXX	1900 MHz E Band Supported
X1XX XXXX	1900 MHz F Band Supported
1XXX XXXX	Reserved

SYREG

This flag indicates whether or not the mobile station is to register when it enters a new system identification area.

TDMA Neighbor Count

This information element identifies the number of TDMA Service Map instances present in the Neighbor Service Info message. Set to 1 plus the value in this field.

TDMA Service Info

This information element provides service attribute information for TDMA neighbors.

Field	Length
Parameter Type	4
TDMA Neighbor Count (N)	5
TDMA Service Map (Note 1)	1 or 11 per instance

Note 1: N + 1 instances of this field are present.

TDMA Service Info (Other Hyperband)

This information element provides service attribute information for Other Hyperband TDMA neighbors.

Field	Length
Parameter Type	4
Hyperband	2
TDMA Neighbor Count (P)	5
TDMA Service Map (Note 1)	1 or 11 per instance

Note 1: P + 1 instances of this field are present.

TDMA Service Map

This information element provides service information for one or more TDMA neighbors.

Field	Length
Service Map Indicator	1
Service Map	0 or 10

The Service Map Indicator field is used to indicate if the Service Map field is present. The Service Map Indicator is coded as follows:

Value	Function
0	Service Map not present
1	Service Map present

The Service Map field, when present, provides service information and is coded as follows:

Value	Function
00 0000 0000	No Services Supported
XX XXXX XXX1	Analog Speech
XX XXXX XX1X	Digital Speech
XX XXXX X1XX	G3 Fax
XX XXXX 1XXX	Async Data
XX XXX1 XXXX	Voice Privacy
XX XX1X XXXX	Data Privacy
XX X1XX XXXX	Message Encryption
XX 1XXX XXXX	User Group
X1 XXXX XXXX	Point-to-Point SMS

1X XXXX XXXX	Reserved

Teleservice Server Address

This information element identifies the Teleservice Server Address for the message being sent.

Field	Length
Parameter Type	4
Address Info	16 - *

Text Message Data Unit

This information element contains the message to be broadcast.

Field	Length
Length Indicator (N) (in octets)	8
Encoding Identifier	5
Reserved	3
Short Message Character (Notes 1, 2)	8

Note 1: As many instances as (N - 1) could be sent (providing that N > 1).

Note 2: The Text Message Data Unit is encoded as specified by the Encoding Identifier as follows:

0 0 0 0 1 IRA, as specified by Tables 5 and A-1 of ITU Recommendation T.50 (1992)

0 0 0 1 0 User specific

All other values are reserved.

If the Encoding Identifier indicates IRA, the most significant bit of each octet of Short Message Character is set to 0.

Time Alignment

This information element indicates the absolute timing offset (see Section 2.1.3.3.5.1 of IS-136.2) from standard offset reference (SOR) position (see Section 1.2.1.1. of IS-136.2).

Description	Code
Timing offset = SOR	00000
Timing offset = 1 unit from SOR	00001
Timing offset = 2 units from SOR	00010
Timing offset = 3 units from SOR	00011
...	...
Timing offset = 28 units from SOR	11100
Timing offset =29 units from SOR	11101
Timing offset = 30 units from SOR	11110
Maintain current timing offset	11111

Time from Jan 1, 1980

This information element is a non-critical sequential time counter in seconds elapsed since January 1, 1980, 00:00 hour, 0 seconds using Greenwich Mean Time as the reference point.

Time Zone Offset

This information element is used to identify the time zone offset in minutes relative to Greenwich Mean Time (GMT).

Field	Length
Direction	1

Minutes	10
Daylight Savings Indicator	1

The **Direction** field is coded as follows:

Value	Function
0	Subtract specified minutes from GMT
1	Add specified minutes to GMT

The **Minutes** field is coded as follows:

Value	Function
00000 00000	0 Minutes
00000 00001	1 Minute
...	...
10110 10000	720 Minutes (12 Hours)
All other values are reserved	

The **Daylight Savings Indicator** field is coded as follows:

Value	Function
0	Standard Time
1	Daylight Savings Time

Tone Indicator

This information element is used to indicate the type of tone to be generated by the mobile station.

Value	Function
00	Reorder (See Section 7.4 of IS-137)
01	Intercept (See Section 7.4 of IS-137)
All other values are reserved	

Triple Rate DTC Support

This information element indicates whether or not the mobile station supports triple rate DTCs.

Value	Function
0	Triple Rate DTCs Not Supported
1	Triple Rate DTCs Supported

User Destination Address

This information element is used to identify the user destination address of a short message.
The maximum length of this information element is network-dependent.

Field	Length
Parameter Type	4
Address Info	16 - *

User Destination Subaddress

This information element is used to identify the subaddress of the destination user of a short message. For the definition of subaddress, see ITU Recommendations I.330 and I.334.

Field	Length
Parameter Type	4
Subaddress Info	16 – 176

User Group

This information element identifies the User Group ID that a mobile station has requested or has been allocated.

Field	Length
Parameter Type	4
User Group Status	2
User Group Type (Note 1)	0,2
User Group ID (Note 1)	0,20,24,34 or 50

Note 1: Only present if the User Group Status = 00.

The User Group Status field is coded as follows:

Value	Function
00	Preferred User Group ID allocation request/Allocated User Group ID
01	Unspecified User Group ID allocation request
10	De-allocate MS from currently allocated User Group ID
11	Reserved

The User Group Type field is coded as follows:

Value	Function
00	20-bit Local UGID
01	24-bit SOC UGID
10	34-bit National UGID
11	50-bit International UGID

User Group Map

This information element identifies whether or not the BMI supports User Group operation.

Value	Function
0	User Groups Not Supported
1	User Groups Supported

User Group Support

This information element indicates whether or not the mobile station supports User Group operation.

Value	Function
0	User Group Operation Not Supported
1	User Group Operation Supported

User Originating Address

This information element is used to identify the user originating address of a short message.
The maximum length of this information element is network-dependent.

Field	Length
Parameter Type	4
Address Info	16 - *

User Originating Address Presentation Indicator

The purpose of this information element is to identify the presentation restrictions and screening related to User Originating Address or the originating MSID.

Field	Length
Parameter Type	4
Presentation Indicator	2
Screening Indicator	2

The Presentation Indicator field is coded as follows:

Value	Function
00	Presentation Allowed
01	Presentation Restricted
10	Number not Available
11	Reserved

The Screening Indicator field is coded as follows:

Value	Function
00	User-provided, not screened
01	User-provided, verified and passed
10	User-provided, verified and failed
11	Network-provided

User Originating Subaddress

This information element is used to identify the subaddress of the originating user of a short message. For the definition of subaddress, see ITU (formerly CCITT) Recommendations I.330 and I.334.

Field	Length
Parameter Type	4
Subaddress Info	16 – 176

VMAC

This information element indicates the power level to be used on the assigned analog voice channel. The coding is according to IS-136.2, Table 2.1.2.2-1.

Voice Coder Map

This information element identifies the types of voice coders supported by the BMI.

Value	Function

00 0000	No Voice Coders Supported
XX XXX1	VSELP Voice Coder Supported
XX XX1X	Alternate Voice Coder Supported (see IS-641)
1X XXXX	Reserved for SOC/BSMC Specific Signaling
All other bit map positions are reserved	

Voice Coder Map Info

This information element identifies the types of voice coders supported by the MS.

Field	Length
Parameter Type	4
Voice Coder Map	6

The Voice Coder Map field is coded according to the Voice Coder Map information element.

Voice Mode

This information element identifies the mode to be used for the requested Voice Call.

Field	Length
Parameter Type	4
VC	3
PM_V	3

The VC field is coded as follows:

Value	Function
000	No Voice Coder
001	VSELP Voice Coder
010	Alternate Voice Coder (see IS-641)
110	Reserved for SOC/BSMC Specific Signaling
All other values are reserved	

The PM_V field is coded as follows:

Value	Function
000	No Voice Privacy
001	Voice Privacy Algorithm A
100	Reserved for SOC/BSMC Specific Signaling
All other values are reserved	

Voice Privacy Mode Map

This information element identifies the forms of voice privacy supported by the BMI.

Value	Function
0000	No Voice Privacy Supported
XXX1	Voice Privacy Algorithm A Supported
1XXX	Reserved for SOC/BSMC Specific Signaling
All other bit map positions are reserved	

6.6 Layer 3 Timers

The time values associated with layer 3 timers are expressed in superframes in Table 6-14. When a timer is started, it shall be reset to its initial value.

Table 6 - 14 Procedure Timers

Name	Possible Values (in superframes)
ACCESS_TMR	25 (Origination) 15 (Page Response)
DELAY_TMR	0 – 420
DEREG_TMR	10
ORIG_TMR	20
PER_TMR	(REGPER + 1) * 94
REG_TMR	25
REREG_TMR	16 – 40
REG_REJECT_TMR	0 – 2048
SMS_ORIG_TMR	20
PPT_TMR	25
SPACH_TMR	10
SSDU_TMR	10
TMSI_TMR	67500
UGA_TMR	40
WAFO_TMR	10

The mobile station layer 3 entity shall respond to the messages listed in Table 6-15 within the time window specified in the same table. The time window starts when the last bit of the last burst of a layer 3 message is received by a mobile station and extends up to the time when the mobile station is ready to send the first bit of the first burst of the access containing the layer 3 response.

Table 6 - 15 Time Windows

Message Received by Mobile Station	Time Window (in Superframes)
Audit Order	1
Base Station Challenge Order Confirmation	2
Capability Request	1
Message Waiting	1
Page	1
Parameter Update	1
R-DATA	1
SPACH Notification	1
SSD Update Order	1
Unique Challenge Order	1

6.7 Layer 3 Message Concatenation

Table 6.7-1 summarizes messages which may be concatenated and sent during a single access attempt made by a mobile station. The primary purpose of an access attempt and the first message sent is indicated at the top of each column. The AUTH, AUTH Map, S, MACA_TYPE and Capability Request information elements in Section 6.5 indicate the conditions under which the secondary messages (Authentication, Serial Number, MACA Report and Capability Report) are concatenated with the primary message.

Table 6 - 16 Layer 3 Message Concatenation

Secondary Messages	Primary Messages						
	Audit Confirm	BS Chall. Order	Origination	Page Response	Registration	R-DATA	SPACH Confirm

Authentication	N	N	Y	Y	Y	Y	Y
Serial Number	N	Y	Y	Y	Y	Y	Y
MACA Report	Y	N	Y	Y	Y (Note 1)	N	Y
Capability Report	N	N	N	N	Y	N	N

Note 1: MACA Report is not required for a Power Down Registration.

ANEXO C: ESTADOS DEL PROCESO DE *HANDOFF*

c.1. MEDICION

Los canales sirvientes realizan dos funciones principales en el proceso del *handoff*. El primero es medir el RSI (*Received Signal Indicator*) del móvil durante toda la duración de la llamada (el RSI es medido en el canal de voz de reversa), y segundo soportar la ejecución del *handoff*. Las medidas ayudan a suprimir la variabilidad inherente en las lecturas del RSI, y proveen más seguridad en la información que puede ser usada para deducir la distancia del móvil desde el centro de la celda y la calidad de la llamada.

c.2. DISPARO

Cada canal de voz está provisto con un valor de umbral para cada llamada, el cual se utiliza para determinar cuando el *handoff* debería ser disparado. Como se lo mencionó en la parte de mantenimiento de la calidad de la señal y configuración de las celdas, este umbral se conoce como nivel bajo de umbral de *handoff* (HTL), y es derivado de la configuración de las diferentes celdas y de las características del móvil en las llamadas. La figura c.1 ilustra el comportamiento del HTL.

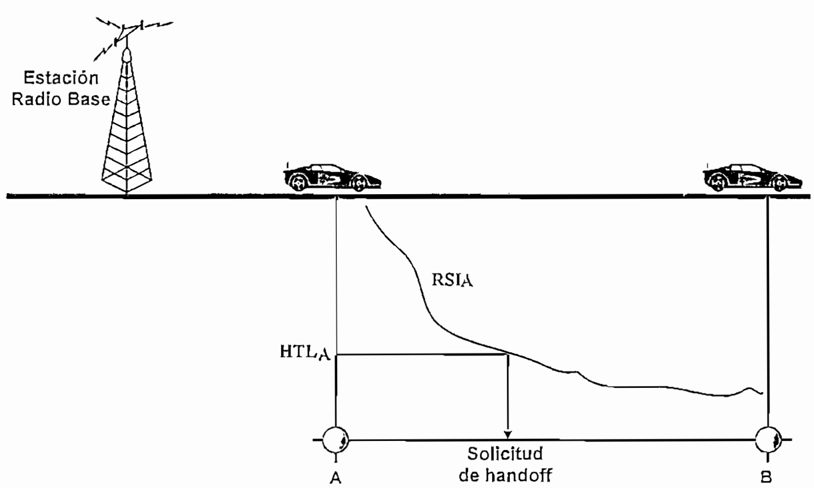
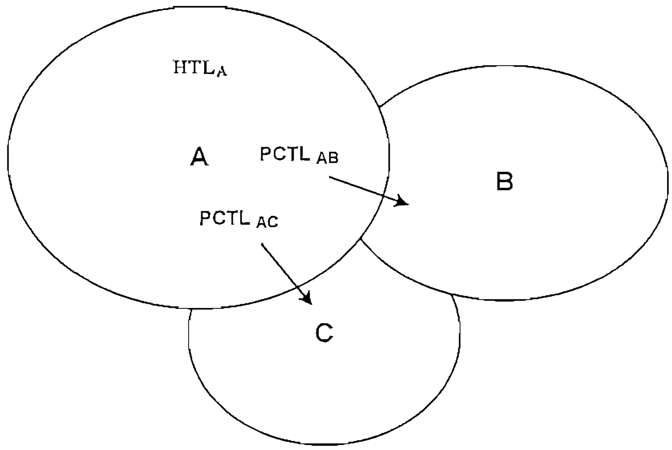


Fig. c.1: Diagrama del HTL

La frontera entre cualquier par de celdas está definida por un factor conocido como el nivel bajo de umbral de un par de celdas (PCTL), el cual determina el RSI al que un móvil que se encuentra lo suficientemente lejos de la celda sirviente, es considerado como candidato a realizar un *handoff*.

Puesto que el radio del canal de voz no puede determinar la dirección que sigue el móvil, debe accionar el *handoff* en el punto más cercano donde podría apagarse por el nivel de señal. Por esta razón el valor del HTL para una celda se define como el máximo valor de los factores PCTL con las celdas adyacentes, tal como se indica en la figura c.2.



$$HTL_A = \text{máx}\,(PCTL_{AB}, PCTL_{AC}, \ldots, PCTL_{AN})$$
$$RSI_A < HTL_A$$

Fig. c.2: Nivel bajo de umbral de un par de celdas

c.3. EXPLORACION

Una vez que la central celular recibe la solicitud de *handoff*, debe entonces determinar donde se está moviendo el móvil, y si una celda adyacente puede servir mejor a la llamada.

Ya que la información de la dirección no está disponible, la central sondea las celdas adyacentes y solicita que se realicen las medidas de RSI. Cualquier celda que cumpla con el criterio mínimo responderá a la solicitud de medida con una respuesta del canal receptor de localización (LCR) bajo condiciones normales.

Para que una celda sea considerada como adyacente para una petición de *handoff*, debe cumplir los siguientes requisitos:

- Ser ingresada en el software de la central que indique los procesos de *handoff*.
- La celda debe estar dentro de la región de operación de la central celular.
- Las medidas del RSI de la celda deben estar por debajo del PCTL establecido entre la celda sirviente y las celdas adyacente. En el ejemplo de la figura c.2 si RSI_A cae por debajo de $PCTL_{AB}$ solamente la celda B empieza a realizar las mediciones del nivel de RSI_B, lo mismo ocurre con la celda C si el RSI_A cae por debajo del $PCTL_{AC}$.

Básicamente el PCTL asegura que el móvil que se encuentre lo bastante lejos de la celda sirviente, tenga (posiblemente) acceso al área de cobertura de la celda adyacente. Cuando la celda ha pasado la verificación de que es adyacente, la central debe determinar si el móvil se encuentra servido de mejor manera que la celda anterior. Se debe mencionar que es deseable que el móvil no dispare otro *handoff* inmediatamente (a pesar de que esto no siempre sucede) después del primero, en otras palabras, el móvil debería ser pasado a una celda donde su RSI esté por encima del HOTL de esa celda. Si esto no es posible, entonces al menos el *handoff* no debería intentarse de regreso a la celda original, por lo que el RSI del móvil debe estar por encima del umbral del PCTL definido en la dirección de reversa.

Bajo estas circunstancias, puede darse el caso de que se permita al móvil pasar a una celda con una lectura de RSI más baja. Esto ocurre algunas veces en donde se tienen escenarios de coberturas de macroceldas/microceldas donde las medidas del RSI en las macroceldas siempre tienen un valor más alto. Para facilitar el *handoff* dentro de las microceldas se puede cambiar el criterio para una señal más fuerte, reemplazando los parámetros respectivos en la programación de la central celular.

Una celda adyacente es eliminada como un posible candidato para el *handoff* a menos que cumpla con al menos uno de los tres criterios de RSI indicados a continuación, lo que implica el mínimo RSI enviado al LCR:

- El RSI de una celda adyacente es más grande que su RSI actual.

- El RSI de una celda adyacente es más grande que el HOTL de la celda adyacente.

- El RSI de una celda adyacente es más grande que el umbral del PCTL desde la celda adyacente a la celda sirviente actual.

La central envía una solicitud de medida del RSI a cada celda adyacente candidata conteniendo el SAT y el canal a ser medido, y también el mínimo nivel RSI requerido. Cualquier medida del RSI en una celda adyacente que no exceda este mínimo valor no es reportada por el LCR.

Los receptores de localización toman las medidas de las particiones adyacentes, cuyas lecturas son cortas en duración (comparables a las medidas de los canales de voz), debido al alto volumen de mensajería presente en el sistema. Para asegurar que la variabilidad en las medidas no vaya en contra de la lógica del proceso y decisión del *handoff*, al criterio del RSI se agregan valores de compensación de histéresis.

Generalmente nacen dos tipos de valores de histéresis, ya que el error esperado en comparación a dos valores de RSI es más grande en comparación a un umbral de RSI establecido. De esta reflexión, matemáticamente el valor mínimo aceptable de RSI para una partición adyacente es el menos de los siguientes casos:

- $RSI_A + PCHIST_{AB}$
- $PCTL_{BA} + HIST_B$
- $HTL_B + HIST_B$

A continuación se va a proceder a ejemplificar cada uno de los casos anteriores ya que es importante tener claro el panorama para realizar la optimización de los procesos de *handoff*.

- ***Caso 1 - $RSI_B > RSI_A + PCHIST_{AB}$***

Se va a suponer que se tiene un móvil que se está moviendo entre dos celdas homogéneas, como se muestra en la figura c.3.

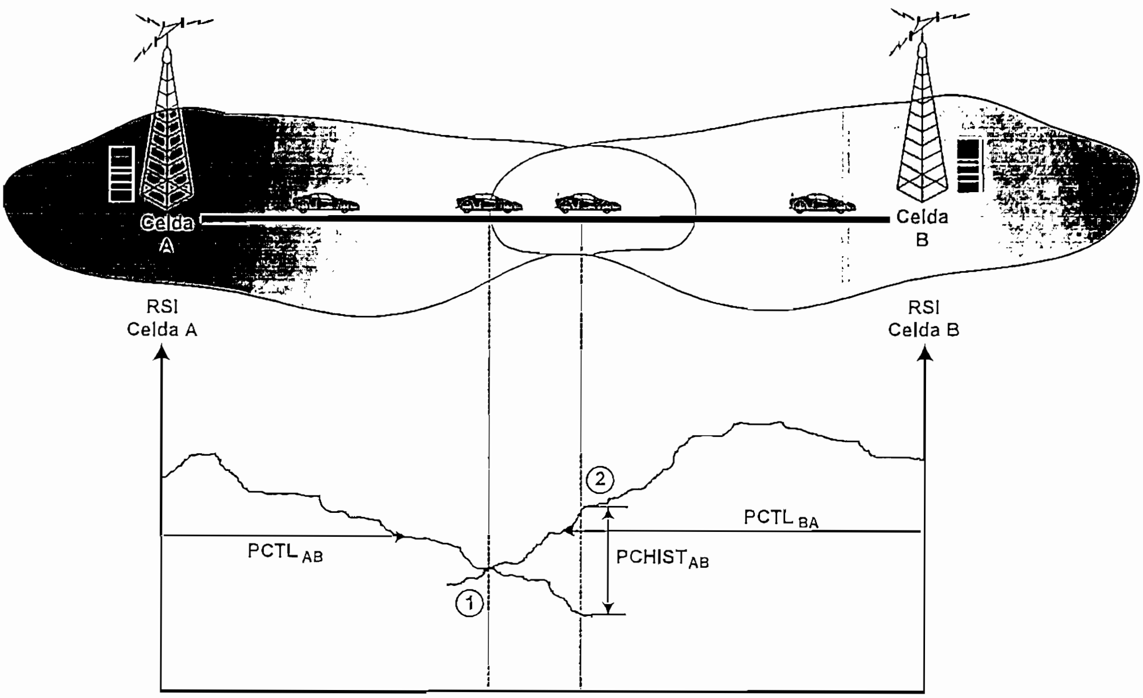


***Fig. c.3:** Primer caso de handoff*

Como se puede observar en la figura c.3, en la celda sirviente el umbral HTL_A es igual al factor $PCTL_{AB}$, y conforme el móvil se va alejando de la celda A el nivel de RSI_A va disminuyendo. En el momento en que el móvil se acerca al punto 1 se puede decir que el RSI_A es comparable al RSI_B, pero todavía no ocurre el *handoff*, el móvil estaría ingresando al límite del *handoff*:

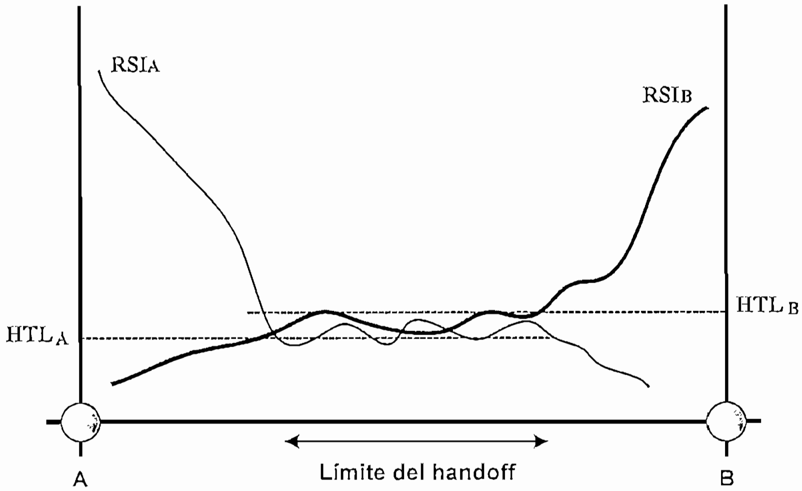


Fig. c.4: *Límite del handoff con posible efecto de ping pong*

En este punto, el móvil es mejor servido por la celda B que por la celda servidora ya que prácticamente se encuentra en la frontera de esta celda, pero debido a diferentes factores que están fuera del alcance de los operadores celulares como es los fenómenos físicos, climáticos, de radio frecuencia, desvanecimiento, etc., las medidas del RSI son susceptibles a errores.

Como se mencionó anteriormente, se introduce el parámetro de histéresis PCHIST que define un incremento mínimo en el RSI solicitado, y lo que hace es retrasar el *handoff* forzando la medida requerida en la celda candidata para que sea más fuerte, además de evitar el efecto del ping-pong en determinados puntos de las fronteras de las celdas. Esto ocasiona que los *handoffs* de la celda B a la celda A ocurra en un lugar diferente que el *handoff* de la celda A a la celda B, tal como se muestra en la figura c.5

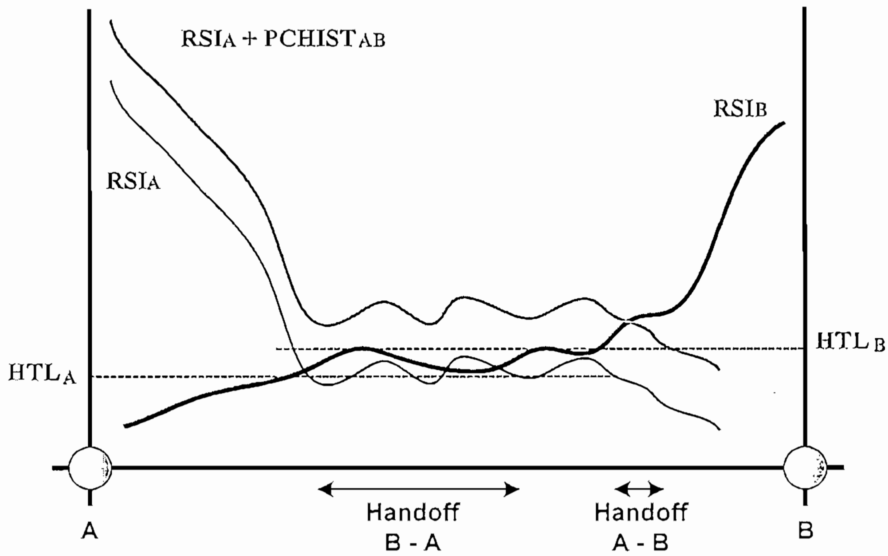


Fig. c.5: Límite del handoff con ajuste de histéresis

Con este retraso programado en la central celular, conforme el móvil se acerca al punto 2 va a sucederse el *handoff*, ya que justamente en este punto se va a presentar una pequeña área de sobrecobertura en donde se tiene el siguiente nivel de señal:

$$RSI_B \geq RSI_A + PCHIST_{AB} \qquad \text{(Ec. c.1)}$$

Una vez que el móvil ha cruzado al área plena de cobertura de la celda B, se han cumplido las condiciones para el proceso del *handoff*, siendo RSI_B mayor a HTL_B y al factor $PCTL_{BA}$, que además será igual al umbral HTL_B.

- ***Caso 2 - $RSI_B > PCTL_{BA} + HIST_B$***

En este caso se va a ejemplificar el ambiente de macroceldas/microceldas. Las microceldas son una opción para aliviar la carga de tráfico a las macroceldas, además de dar cobertura dedicada en los lugares donde la macrocelda no puede satisfacer las necesidades de ciertos lugares. Esto se ilustra en la figura c.6.

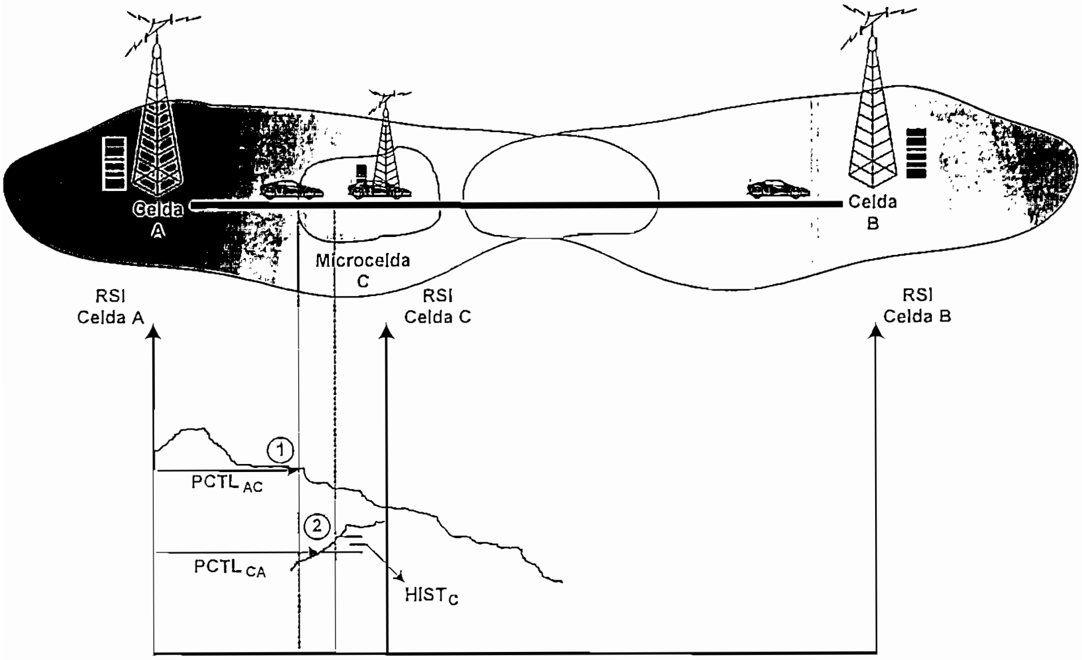


Fig. c.6: *Segundo caso de handoff*

Las características principales de las microceldas son que cubren áreas dedicadas, por lo que la potencia es muy baja. Debido a esto el móvil podría pasar de la celda A a la celda B sin realizar ningún *handoff* con la microcelda C, pero esto no es lo que se desea, ya que uno de los objetivos de la microcelda es ayudar a la celda A en el manejo del tráfico cursado.

Cuando el móvil se encuentra alrededor del punto 1, empiezan las lecturas del RSIM cuyo valor es menor que el RSIA, lo cual es posible ya que el manejo de éstos parámetros son programados en la central celular, que controlan la funcionalidad de los *handoffs* en situaciones específicas como en el caso de las microceldas.

El punto 2 es el lugar donde finalmente ocurre el *handoff*, y en el que el parámetro de histéresis juega un papel importante en el tipo de *handoff* que se está analizando. Como se trata de un móvil que está ingresando hacia un área de cobertura con menor nivel de señal que el de la celda sirviente, hay que añadir el valor de la histéresis $HIST_C$ con un valor adecuado respecto al umbral de un par de celdas ya programadas en la central. Este juego de valores hará que se incremente el valor del factor $PCTL_{CA}$ para evitar que el proceso de *handoff* pueda fallar, cumpliéndose la siguiente relación del nivel de señal:

$$RSI_C > PCTL_{CA} + HIST_C \qquad \text{(Ec. c.2)}$$

Se debe jugar de una manera muy cuidadosa con el valor de $HIST_C$ ya que si está mal elegido se puede producir un efecto de ping pong y el móvil regrese a su celda original.

- *Caso 3 - $RSI_B > HTL_B + HIST_B$*

En este caso se deben cumplir ciertas condiciones cuando los móviles se están moviendo por celdas asimétricas, lo que se puede observar en el diagrama c.7.

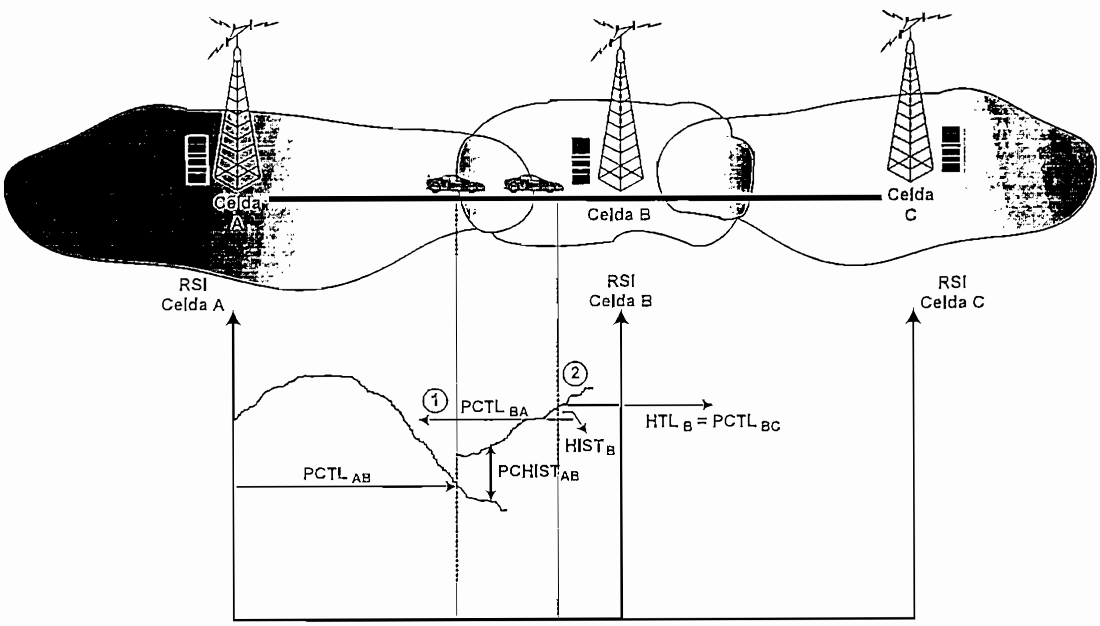


Fig. c.7: Tercer caso de handoff

En la figura c.7 cuando el móvil está acercándose al punto 1, el RSI_A es menor que el factor $PCTL_{AB}$ y es aquí donde se da comienzo a la lectura del RSI_B. Mientras el usuario sigue su trayectoria se puede observar que se cumple la condición del primer caso de *handoff*, donde el RSI_B es mayor que la suma de los parámetros RSI_A y $PCHIST_{AB}$.

En el momento que el móvil pasa de las fronteras del *handoff* y se acerca al punto 2 el RSIB es igual al $PCTL_{BA}$ añadido el parámetro $HIST_B$. Por lo que al producirse el *handoff* se cumple con la tercera relación, donde el valor del umbral HTL_B será igual al parámetro $PCTL_{BC}$, y la medida de señal del móvil en la celda B es:

$$RSI_B > HTL_B + HIST_B \quad \text{(Ec. c.3)}$$

c.4. SELECCION

La selección de la celda a la que se va a realizar el *handoff* se complica cuando se disponen más de una celda candidata, y el móvil tiene que decidir a qué celda pasar, obviamente bajo el criterio de la celda que le ofrece el mejor nivel y con el menor número de reintentos de solicitud de *handoff*. Las respuestas del RSI son seleccionadas basadas en que podría pasar si el móvil estuviera pasando a una celda candidata, por lo que los criterios de selección son esencialmente los mismos que para los establecimientos de los RSI's mínimos aceptables.

En ciertos sistemas, una ruta de tráfico pesado puede cortar o cruzar a través de las "esquinas" de las celdas, lo que produciría *handoffs* cortos o inmediatos y posteriormente volvería a pasar a la siguiente celda. A veces estos tipos de *handoffs* no son importantes y se podría buscar la manera de evitar esto, esencialmente cuando se tiene poca diferencia de dB's. Para esto en las centrales de conmutación se puede programar un factor que se conoce como predisposición (PDISP), el cual es un mecanismo que le ayuda al móvil segregar las celdas candidatas y realizar *handoffs* directos.

La figura c.8 ilustra un supuesto caso de *handoff* directo.

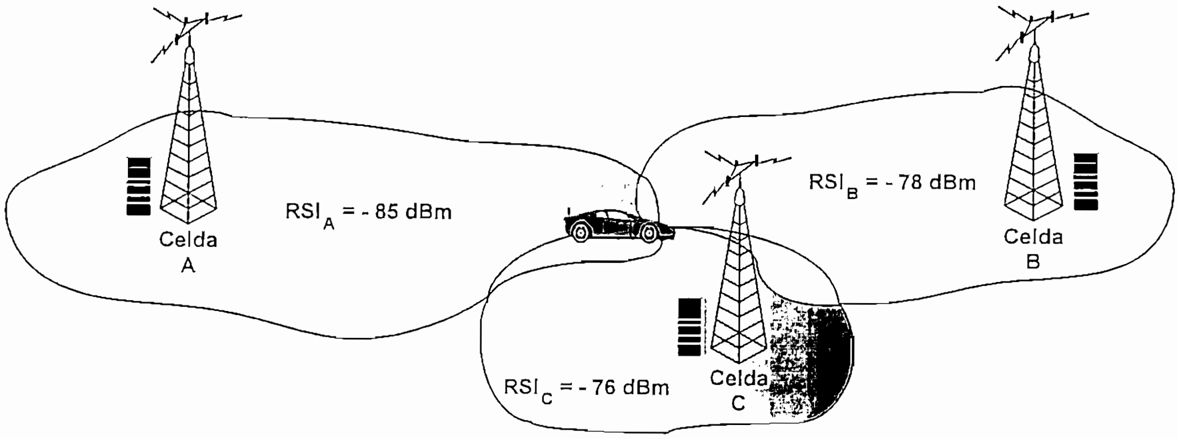


Fig. c.8: *Selección de celdas candidatas*

En la figura se muestra un móvil que está viajando de la celda A a la celda B, pero al pasar por la esquina de C el usuario haría un *handoff* rápido entre A y C; y luego entre C y B. Lo que se desea es un *handoff* directo entre las celdas A y B, por lo que bajo este escenario se introduce el PDSIP, teniendo algunas posibilidades como las que se indican en el siguiente cuadro:

CELDA	RSI	PDISP	RSI TOTAL
A	-85	0	-80
B	-78	3	-75
C	-76	0	-76

Cuadro c.1: *Elección de la celda B para realizar el handoff*

Como se puede observar, aplicando el PDISP al RSI medido el operador puede influir en el mecanismo de selección, permitiendo a las celdas moverse a posiciones más altas o bajas en la lista haciendo que la misma se vea más o menos atractiva que sus celdas vecinas y afecte la dirección del *handoff.* Graficando la figura c.8 de otra manera se tendría:

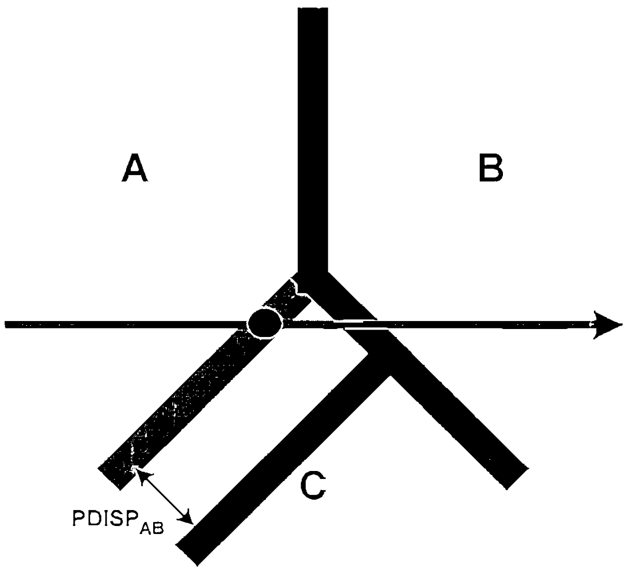


Fig. c.9: *Factor PDISP*

Para este caso se puede sacar la siguiente relación:

$$RSI_B > RSI_C - PDISP_{AB}$$

A pesar de esto, es importante recalcar que el PDSIP puede tener valores positivos o negativos.

c.5. EJECUCION

Una vez que la celda elegida es identificada, la ejecución del *handoff* es idéntica para todos los tipos de *handoff*. La central setea un nuevo canal de voz en la celda seleccionada, ordena al móvil resintonizarse a ese canal y liberar los viejos recursos. Esto se lleva a cabo de tal manera que se minimice los trastornos en la llamada, lo que minimiza las oportunidades de falla.