MSs from the BS. This message indicates either a transition up or transistion down in power. In open-loop power control at the BS, the BS decreases its power level gradually and waits to hear the frame error rate (FER) from the MS. If the FER is high, it increases its power level.

11.7 IMT-2000

The International Telecommunications Union-Radio communications (ITU-R) developed the 3G specifications to facilitate a global wireless infrastructure, encompassing terrestrial and satellite systems providing fixed and mobile access for public and private networks. IMT-2000 is a general name used for all 3G systems. It includes new capabilities and provides a seamless evolution from existing 2G wireless systems. The key features of the IMT-2000 system are as follows:

- High degree of commonality of design worldwide
- Compatibility of services within IMT-2000 and with fixed networks
- High quality
- Small terminal for worldwide use, including pico, micro, macro, and global satellite cells
- Worldwide roaming capability
- Capability for multimedia applications and a wide range of services and terminals

11.7.1 International Spectrum Allocation

In 1992 the World Administration Radio Conference (WARC) specified the spectrum for the 3G mobile radio system, as illustrated in Figure 11.34.

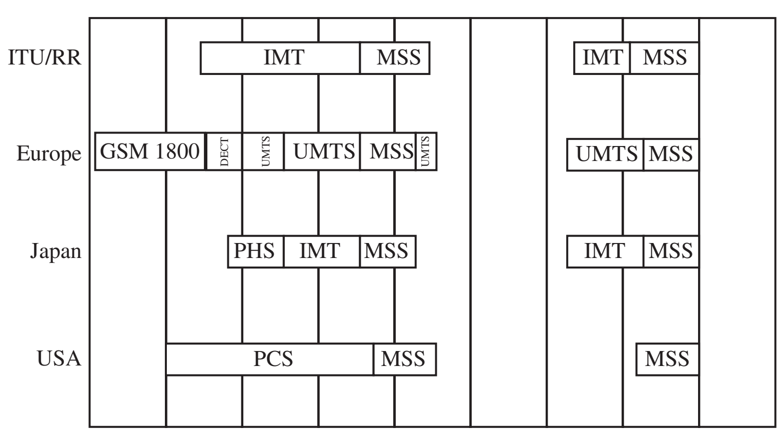

Figure 11.34
Spectrum allocation.

Europe and Japan followed the FDD specification. The lower-band parts of the spectrum are currently used for DECT and PHS (Personal Handyphone System), respectively. The FCC in the United States has allocated a significant part of the spectrum in the lower band to 2G PCS systems. Most of the North American countries are following the FCC frequency allocation. Currently no common spectrum is available for 3G systems worldwide.

11.7.2 Services Provided by Third-Generation Cellular Systems

The following services are provided by third-generation cellular systems:

- High bearer rate capabilities, including
  - 2 Mbps for fixed environment
  - 384 kbps for indoor/outdoor and pedestrian environment
  - 144 kbps for vehicular environment
- Standardization work
  - Europe (ETSI: European Telecommunications Standardization Institute) ⇒ UMTS (W-CDMA)
  - Japan (ARIB: Association of Radio Industries and Businesses) ⇒ W-CDMA
  - USA (TIA: Telecommunications Industry Association) ⇒ cdma2000 [11.6]
- Scheduled service
  - Service started in October 2001 (Japan's W-CDMA)

The radio interfaces for IMT-2000 as approved by the ITU meeting in Helsinki, Finland are shown in Figure 11.35.

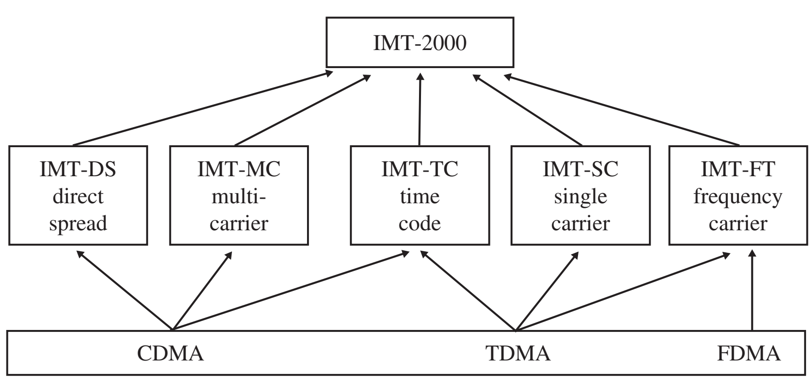

Figure 11.35 Approved radio interfaces.

11.7.3 Harmonized 3G Systems

A harmonized 3G system based on the Operators Harmonization Group (OHG) [11.5] recommendation is required to support the following:

- High-speed data services, including Internet and intranet applications
- Voice and nonvoice applications
- Global roaming
- Evolution from the embedded base of 2G systems
- ANSI-41 (American National Standards Institute-41) and GSM-MAP core networks
- Regional spectrum needs
- Minimization of mobile equipment and infrastructure cost
- Minimization of the impact of intellectual property rights (IPRs)
- The free flow of IPRs
- Customer requirements on time

A diagram representing the terrestrial component of the harmonization efforts for IMT-2000 is shown in Figure 11.36.

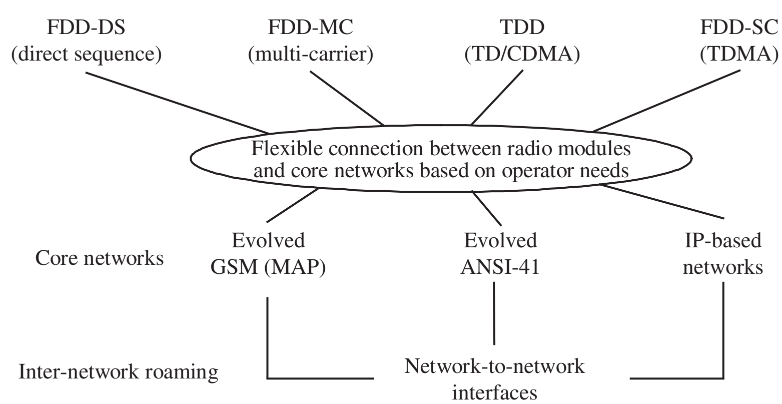

Figure 11.36 Modular IMT-2000 harmonization.

11.7.4 Multimedia Messaging Service (MMS)

The multimedia messaging service (MMS) [11.7] is an open industry specification developed by the WAP forum for the 3rd Generation Partnership Program (3GPP). The service is a significant enhancement to the current SMS service which allows only text. MMS has been designed to allow rich text, color, icons and logos, sound clips, photographs, animated graphics, and video clips and works over the broadband wireless channels in 2.5G and 3G networks. MMS and SMS are similar in the sense that both are store-and-forward services where the message is first sent to the network which then delivers it to the final destination. But unlike SMS, which can be sent only to another phone, the MMS service can be used to send messages to a phone or may be delivered as an email.

The main components of MMS architecture are:

- MMS Relay—Transcodes and delivers messages to mobile subscribers.
- MMS Server—Provides the "store" in the store-and-forward MMS architecture.
- MMS User Agent—An application server gives users the ability to view, create, send, edit, delete, and manage their multimedia messages.
- MMS User Databases—Contain records of user profiles, subscription data, etc.

The content of MMS messages is defined by the MMS conformance specification version 2.0.0, which specifies SMIL 2.0 (synchronization multimedia integration language) basic profile for the format and the layout of the presentation.

Although MMS is targeted toward 3G networks, carriers all over the world have been deploying MMS on networks like 2.5G using WAP, and it helps in generating revenue from existing older networks.

Some of the possible application scenarios are as follows:

- Next-generation voicemail—Makes it possible to leave text, pictures, and even video mail.
- Immediate messaging—MMS features "push" capability that enables the message to be delivered instantly if the receiving terminal is on and avoids the need for "collection" from the server. This "always-on" characteristic of the terminals opens up the exciting possibility of multimedia "chat" in real time.
- Choosing how, when, and where to view the messages—Not everything has to be instant. With MMS, users have an unprecedented range of choices about how their mail is to be managed. They can predetermine what categories of messages are to be delivered instantly, stored for later collection, redirected to their PCs, or deleted. In other words, they posses dynamic ability to make ad hoc decisions about whether to open, delete, file, or transfer messages as they arrive.
- Mobile fax—Using any fax machine to print out any MMS message.
- Sending multimedia postcards—A clip of holiday video can be captured through the integral video cam of a user's handset or uploaded via Bluetooth from a standard camcorder, then combined with voice or text messages and mailed instantly to family members and friends.

11.7.5 Universal Mobile Telecommunications System (UMTS)

Network Reference Architecture

The latest UMTS architecture is shown in Figure 11.37. It is partly based on the 3G specification, while some 2G elements have been kept [11.8]. UMTS Release'99 architecture inherits a lot from the global system for mobile (GSM) model on the core network (CN) side. The MSC basically has very similar functions both in GSM and UMTS. Instead of circuit-switched services for packet data, a new packet

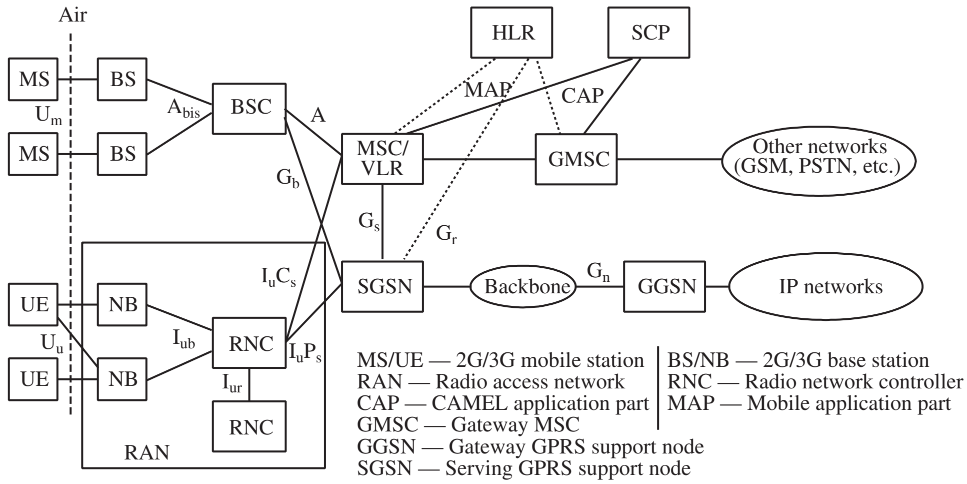

Figure 11.37 UMTS network architecture.

node, packet data access node (PDAN), or 3G serving general packet radio services (GPRS) support node (SGSN) is introduced. This new element is capable of supporting data rates up to 2 Mbit/s. CN elements are connected to the radio network via the I_u interface, which is very similar to the A-interface used in GSM. The major changes in the new architecture are in the radio access network (RAN), which is also called UMTS terrestrial RAN (UTRAN). There is a totally new interface called I_{ur}, which connects two neighboring radio network controllers (RNCs). This interface is used for combining macrodiversity, which is a new WCDMA-based function implemented in the RNC. BSs are connected to the RNC via the I_{ub} interface [11.9]. Throughout the standardization process, extra effort has been made so that most of the 2G core elements can smoothly support both generations, and any potential changes are kept to a minimum. In 2G, the RAN is separated from the CN by an open interface, called "A" in circuit-switched (CS) and G_b in packet-switched (PS) networks. The former uses time division multiplex (TDM) transport, while packet data are carried over frame relay. In 3G, the corresponding interfaces are called I_u C_s and I_uP_s. The circuit-switched interface will utilize ATM, while the packet-switched interface will be based on IP.

UTRAN Architecture

UTRAN consists of a set of radio network subsystems (RNSs) [11.5]. as shown in Figure 11.38. The RNS has two main elements: Node B and a RNC. The RNS is responsible for the radio resources and transmission/reception in a set of cells.

A RNC is responsible for the use of and allocation of all radio resources of the RNS to which it belongs. The responsibilities of the RNC include

- Intra-UTRAN handoff
- Macrodiversity combining and splitting of the I_{ub} datastreams

- Frame synchronization
- Radio resource management
- Outer loop power control
- Serving RNS relocation
- UMTS radio link control (RLC) sublayers function execution

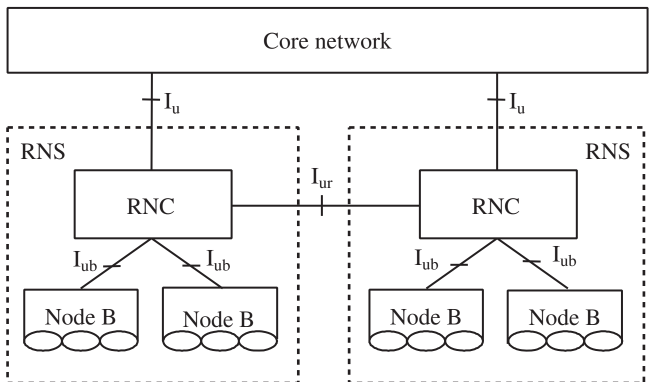

Figure 11.38
UTRAN architecture.

UTRAN Logical Interfaces

In UTRAN, the protocol structure is designed so that the layers and planes are logically independent of each other and, if required, parts of protocol structure can be changed in the future without affecting other parts. The protocol structure contains two layers: the radio network layer (RNL) and the transport network layer (TNL). In the RNL, UTRAN-related functions are visible, whereas the TNL deals with transport technology selected to be used for UTRAN but without any UTRAN-specific changes. A general protocol model for UTRAN interfaces is shown in Figure 11.39. Here RANAP is radio access network application protocol.

Channels

Three types of channels are defined in UMTS: transport, logical, and physical channels. Transport channels are described by how the information is transmitted on the radio interface. Logical channels are described by the type of information they carry. On the other hand, physical channels are defined differently for FDD and TDD. For FDD, a physical channel is identified by its carrier frequency, its access code, and the relative phase of the signal in the uplink (either the In-phase or Quadrature component). Similarly, TDD identifies a physical channel by its carrier frequency, access code, relative phase for the uplink, and the time slot in which it is transmitted.

Transport Channels

Transport channels are the services offered by the physical layer to the higher layers. A general classification of transport channels is into two groups:

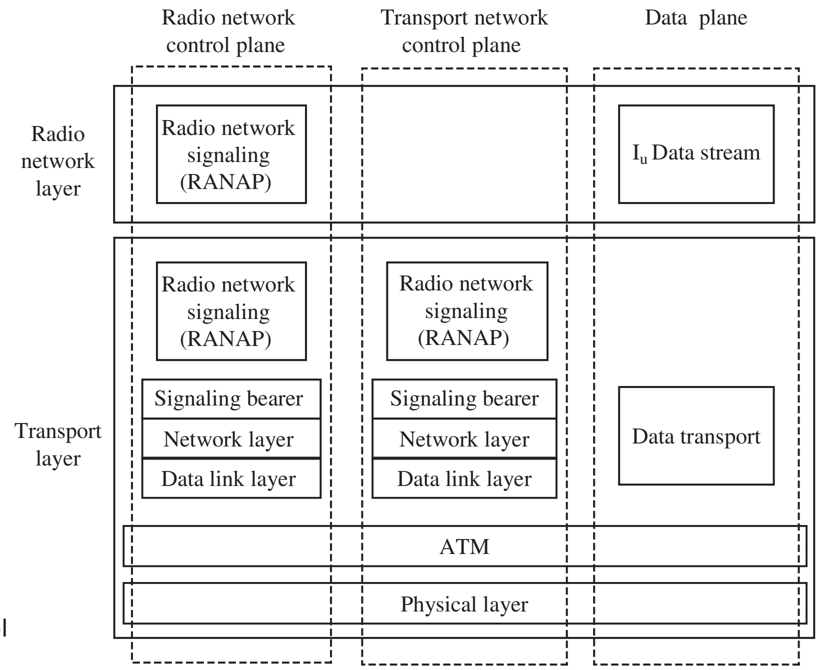

Figure 11.39
General protocol model for UTRAN interfaces.

1. Common transport channels (where there is a need for in-band identification of the UEs when particular UEs are addressed)
2. Dedicated transport channels (where the UEs are identified by the physical channel, i.e., code, time slot, and frequency)

In the following text, we describe the transport channels in detail:

- **Common transport channel types**:
  - **Random access channel (RACH)**: A contention-based uplink channel used for transmission of relatively small amounts of data (e.g., for initial access or non–real-time dedicated control or traffic data).
  - **ODMA (Opportunity driven multiple access) random access channel (ORACH)**: A contention-based channel used in relay link.
  - **Common packet channel (CPCH)**: A contention-based channel used for transmission of bursty data traffic. This channel exists only in FDD mode and only in the uplink direction. The common packet channel is shared by the user equipment (UE or MS) in a cell, and therefore is a common resource. The CPCH is fast power controlled.
  - **Forward access channel (FACH)**: Common downlink channel without closed-loop power control used for transmission of relatively small amount of data.

- **Downlink shared channel (DSCH)**: A downlink channel shared by several UEs carrying dedicated control or traffic data.
- **Uplink shared channel (USCH)**: An uplink channel shared by several UEs carrying dedicated control or traffic data, used in TDD mode only.
- **Broadcast channel (BCH)**: A downlink channel used for broadcast of system information into an entire cell.
- **Paging channel (PCH)**: A downlink channel used for broadcast of control information into an entire cell allowing efficient UE sleep mode procedures. Currently identified information types are paging and notification. Another use could be UTRAN notification of change in BCCH information.

■ **Dedicated transport channel types**:

- **Dedicated channel (DCH)**: A channel dedicated to one UE used in uplink or downlink.
- **Fast uplink signaling channel (FAUSCH)**: An uplink channel used to allocate dedicated channels in conjunction with FACH.
- **ODMA dedicated channel (ODCH)**: A channel dedicated to one UE used in relay link.

Logical Channels

Two types of logical channels are defined: traffic and control channels. Traffic channels (TCH) are used to transfer user and/or signaling data. Signaling data consists of control information related to the process of a call. Control channels carry synchronization and information related to the radio transmission. UTRAN logical channels are described in Figure 11.40.

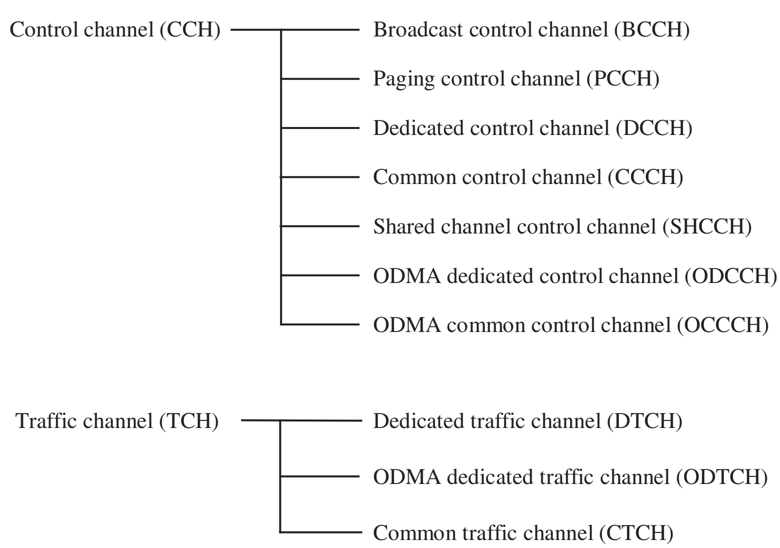

Figure 11.40 Logical channels in UTRAN.

- **Control channels**:
  - **Broadcast control channel (BCCH)**: A downlink channel for broadcasting system control information.
  - **Paging control channel (PCCH)**: A downlink channel that transfers paging information. This channel is used when the network does not know the location cell of the UE, or the UE is in the cell-connected state (utilizing UE sleep mode procedures).
  - **Common control channel (CCCH)**: Bidirectional channel for transmitting control information between network and UEs. This channel is commonly used by the UEs having no RRC connection with the network and by the UEs using common transport channels when accessing a new cell after cell reselection.
  - **Dedicated control channel (DCCH)**: A point-to-point bidirectional channel that transmits dedicated control information between a UE and the network. This channel is established through the RRC connection setup procedure.
  - **Shared channel control channel (SHCCH)**: Bidirectional channel that transmits control information for uplink and downlink shared channels between the network and UEs. This channel is for TDD only.
  - **ODMA common control channel (OCCCH)**: Bidirectional channel for transmitting control information between UEs.
  - **ODMA dedicated control channel (ODCCH)**: A point-to-point bidirectional channel that transmits dedicated control information between UEs. This channel is established through the RRC connection setup procedure.

- **Traffic channels**:
  - **Dedicated traffic channel (DTCH)**: A DTCH is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.
  - **ODMA dedicated traffic channel (ODTCH)**: An ODTCH is a point-to-point channel, dedicated to one UE, for the transfer of user information between UEs. An ODTCH exists in relay link.
  - **Common traffic channel (CTCH)**: A point-to-multipoint unidirectional channel for transfer of dedicated user information for all or a group of specified UEs.

Physical Channels

All physical channels follow four-layer structure of superframes, radio frames, subframes, and time slots/codes. Depending on the resource allocation scheme, the configurations of subframes or time slots are different. All physical channels need guard symbols in every time slot. The time slots or codes are used as a TDMA component so as to separate different user signals in the time and the code domain.