

## Problems and Solutions (Chapter 10)

1. What is meant by logical channel and how is the concept useful? Explain.

[Solution]

In wireless systems, channels refer to the wireless communications paths between wireless stations. They may be either physical or logical depending on the application. An RF channel is a physical channel, whereas control and traffic channels within the RF channel would be considered as logical channels. For example, in TDMA, a physical channel is used in time multiplex mode and a time-slot assigned to a user becomes a logical channel. Similar arguments can be given about the use of code in a CDMA system. Logical channels are used to carry user information and set up and control calls in the cellular networks.

2. How do you differentiate between different types of handoff? Explain.

[Solution]

Handoff can be classified into two different types: hard handoff and soft handoff. Hard handoff is also known as break before make and is characterized by releasing current radio resources from the prior BS before acquiring resources from the next BS. Both FDMA and TDMA employ hard handoff.

The feature of soft handoff is that two base stations are connected to the same mobile station during the handoff. Soft handoff can be used only in CDMA. In CDMA, the same channel is used in all the cells, if the code is not orthogonal to other codes being used in the next BS, the code could be changed. It is possible for an MS to communicate simultaneously with the prior BS as well as the new BS for some short duration of time, during the process of handoff.

3. Where does the MAC sublayer lie on the ISO-OSI layer hierarchy? What issues are handled in this sublayer?

[Solution]

MAC sublayer lies on the data link layer defined in ISO-OSI layer hierarchy. It handles the issue of how to enable multiple users access the media. It defines who can use the network medium, when multiple users are trying to access it simultaneously.

4. What is the role of different functional planes in GSM? Explain each one clearly.

[Solution]

The GSM system can be divided into five planes.

- (a) Physical plane: It provides to carry user information on all segments along the communication path and to carry signaling messages between entities.

- (b) Radio resource management (RR): It establishes stable connections between MSs and an MSC and maintains them despite user movements. The RR functions are mainly performed by the MS and the BSC.
  - (c) Mobility management (MM): The functions are handled by the MS (or SIM), the HLR/AUC, and the MSC/VLR. These also include performing needed security functions.
  - (d) Communication management (CM): It is used to set up calls between users and maintain and release resources. In addition to call management, it includes supplementary services management and short message management.
  - (e) Operation, administration and maintenance (OAM): It enables the operator to monitor and control the system at any time.
5. How are PCS systems different from conventional cellular systems like AMPS?

**[Solution]**

AMPS, the advanced mobile phone service, refers to the analog cellular system that is widely available today, operating at 800 MHz in North America (824 MHz - 849 MHz) for reverse link and 869 MHz - 894 MHz for forward link. This analog cellular system has been in place since 1983. AMPS has poor performance for data transfer.

The transition to digital began with the formation of Groupe Speciale Mobile, or GSM. Today, GSM stands for "global system for mobile communications". GSM was created in 1982 and the first commercial GSM systems went into operation in 1991. GSM standards are based on the TDMA digital technology, versus AMPS which uses analog systems.

PCS refers collectively to three new digital cellular services (GSM, TDMA, and CDMA) now operating in North America at 1900 MHz.

- TDMA (Time Division Multiple Access), also known as IS-136 or D-AMPS, is used by North American carriers such as AT&T Wireless, BellSouth, and Southwestern Bell to offer PCS services.
- CDMA (Code Division Multiple Access), also known as IS-95, is used by North American carriers such as AirTouch, BellAtlantic/NYNEX, GTE, Primeco, and Sprint PCS to offer PCS services.
- GSM, previously known as PCS 1900 or DCS 1900, originated in Europe but has since become an international standard and is deployed in North America today. GSM uses TDMA in its systems.

Sources:

- (1). <http://www.corecom.com/external/xphone/xphone2.html>

- (2). [http://popularmechanics.com/technology/telecom/1997/6/Next\\_Step\\_Digital\\_Cellular/print.phtml](http://popularmechanics.com/technology/telecom/1997/6/Next_Step_Digital_Cellular/print.phtml)

6. What are the important functionalities of SS7? Explain its use.

**[Solution]**

There are five major functionalities of SS7 as follows:

- (a) **Message Transfer Part (MTP):** It has three levels. The first is Signaling Data Link functions which define the physical, electrical and functional characteristics of the signaling link and physical interfaces. The second is Signaling Link functions which define the functions and procedures to ensure that message are reliably transmitted across a signaling link. The third is Signaling Network functions which define those transport functions and procedures that are common to and independent of individual signaling links.
  - (b) **Signaling Connection Control Part (SCCP):** It provides additional functions to the MTP, to support connectionless and connection oriented network services and Global Title Translation (GIT). It deals with signaling connections and also offers data transactions which occur without establishing a connection.
  - (c) **ISDN User Part (ISUP):** It offers two types of services, basic and supplementary. Basic services consist of those services employed in the process of setting up and tearing down a call. Supplementary services consist of those services of passing all messages that may be necessary to maintain and/or modify the call.
  - (d) **Transaction Capability Application Part (TCAP):** The primary service offered to an application is the packaging of data. TCAP is to format and present data in various standardized formats which allows it to be used in multi-vendor environments.
  - (e) **Operations, Maintenance and Administration Part (OMAP) and ASE:** OMAP defines messages and protocols that assist the administration of SS7 networks. Application Service Element (ASE) is a module or portion of a protocol in the application layer of the OSI protocol stack.
7. What are the similarities and the differences between AMPS and GSM? Explain clearly.

**[Solution]**

The major differences between AMPS and GSM is that AMPS uses analog technology while GSM uses digital technology. AMPS has poor performance for data transfer while GSM has higher data transfer. GSM features a subscriber identity module (SIM) smart card, which holds all of a subscriber's personal information (including his phone number) and phone settings, in AMPS only its HLR contain that data. AMPS and

GSM support roaming, but GSM allows for different system compatibility, hence a user can travel from one system to the other. Both systems use control channels to initiate calls, AMPS uses 21 control channels while GSM uses 3 control channels. AMPS is less secure than GSM.

8. How do you compare AMPS and GSM systems in terms of coverage area, transmitting power and error control? Explain.

[Solution]

AMPS requires less power at the MS and at the BS than GSM, yet GSM's power control attempts to minimize the radio transmission power of the MSs and the BTS, and thus minimize the amount of co-channel interference generated. AMPS instead has to rely on the digital color code (DCC) for that. AMPS has a cell radius from 1.5 – 25 km, yet GSM with its superior layout and hierarchical ordering offers better coverage because of its integration of a Location Area, PLMN and finally a GSM service area. GSM is highly adaptable across many digital cellular systems.

As far as error control is concerned, AMPS uses Reverse Control Channel or RECC and checks if it is busy or idle. For a single word transmission, following the seizure precursor, a single RECC message word repeats itself five times to increase the likelihood of correct reception at the receiver. The seizure precursor fields are used for synchronization and identification. For a multiple-word transmission following the seizure precursor, the first RECC message word repeats itself five times, then the second RECC message word is repeated five times. (from the textbook)

For GSM, each time slot burst is 156.25 bits and contains two 57-bit blocks, and a 26-bit training sequence used for equalization. A burst is transmitted in 0.577 ms for a total bit rate of 270.8 kbps, and is modulated using Gaussian minimum shift keying (GMSK) onto the 200 kHz carrier frequency. The 26-bit training sequence is of a known pattern that is compared with the received pattern in the hope of being able to reconstruct the rest of the original signal. Forward error control and equalization contribute to the robustness of GSM radio signals against interference and multi-path fading. The digital TDMA nature of the signal allows several processes intended to improve transmission quality, increase the mobile's battery life, and improve spectrum efficiency. These include discontinuous transmission, frequency hopping and discontinuous reception when monitoring the paging channel.

Source: <http://www.handytel.com/technology/gsm05.htm>

9. Why is a smart card needed in GSM, while it is not required in AMPS? Explain the logic behind this.

[Solution]

GSM systems worldwide, feature a subscriber identity module (SIM) smart card, which holds all of a subscriber's personal information (including his

phone number) and phone settings. The card can be switched from phone to phone, making the new phone receive all calls to the subscriber's number. The SIM card makes it possible to roam around the world where other GSM networks are operating. Any GSM phone becomes immediately programmed after plugging in the SIM card, thus allowing GSM phones to be easily rented or borrowed. SIM cards can be programmed to display custom menus for personalized service. All this information requires digital technology especially when digital transmissions provide for highly private conversations and complex authentication schemes that would allow the user to access certain privileges, something not found in the analog radio frequency modulation (FM) that is used in AMPS. AMPS system predates GSM, and hence functions more like a walkie-talkie almost exclusively for voice transmissions, hence the need for complex operations that require the usage of digital technology is not needed.

10. What is the function of ACSE and ROSE service elements? Explain clearly.

**[Solution]**

The ISO Association Control Service Element (ACSE), an application layer protocol in the OSI model, is to establish and release an application-association between two AEIs and to determine the application context of that association. The ACSE supports two modes of communication: connection-oriented and connectionless. For the connection-oriented mode, the application-association is established and released by the reference of ACSE connection oriented services. For the connectionless mode, the application-association exists during the invocation of the single ACSE connectionless mode service, A-UNIT-DATA .

The ISO Remote Operations Service Element Protocol (ROSE) is a protocol that provides remote operation capabilities, allows interaction between entities in a distributed application, and upon receiving a remote operations service request, allows the receiving entity to attempt the operation and report the results of the attempt to the requesting entity. The ROSE protocol itself is only a vehicle for conveying the arguments and results of the operation as defined by the application.

11. A cellular system employs CDMA scheme. Is it possible to use TDMA (instead of CDMA)? If not, why not; and if yes what may be the potential advantages? Explain clearly.

**[Solution]**

Yes, a TDMA scheme can replace a CDMA scheme if the appropriate modifications are considered. The potential advantages would be that we would have less complexity involved in the system. Smaller bandwidth allocation is needed and power control is not a problem as the near-far problem is greatly minimized. However, the number of users in a TDMA system is lower than in a CDMA.

12. One approach of using Walsh code in a CDMA system is to assign a code permanently to each subscriber. What are advantages, disadvantages, or limitations of such an approach?

[Solution]

Advantages of this scheme is that we can have the code encoded in the smart card, and hence the user can access it faster and achieve faster communications. The disadvantage comes at the security involved. If the same user keeps on using the same codes over and over, then a patient hacker can eavesdrop and eventually figure out the codes and can use them for malicious purposes. The limitations to this approach is that because these codes are orthogonal, then we are limited by the number of codes we can generate. Therefore, a user who is assigned a code and is not using it represents a wasted resource that can be used by another user.

13. In IMSI, why is a temporary ID used? Explain clearly.

[Solution]

The SIM stores an IMSI (International Mobile Subscriber Identity), a TMSI (Temporary Mobile Subscriber Identity) and a shared key  $K$ . The TMSI is a temporary identification number that is assigned during location update to protect the true identity of the caller. A shared key is permanent and is used to produce challenge-responses and session encryption keys. Hence, once the session is over, it is imperative to disassociate the user with the ID, otherwise it can be stolen and used to authenticate a hacker with intension of doing malicious work.

14. What is the rationale behind the traffic channel indicating the reverse control channel to be busy in AMPS?

[Solution]

In the traffic Channel, the rationale behind the busy control channel is to be able to reverse indicate to other MSs the status of shared control channel. This also avoids collision.

15. Why is the far-near Problem present in CDMA and not in FDMA?

[Solution]

CDMA requires tight power control as it suffers from near-far effect. In other words, a user close to the base station transmitting with the same power as a user farther away will drown the latter's signal. All signals must have more or less equal power at the receiver. While in FDMA all together different frequencies are used, this problem does not exist. The signals with different frequencies can not affect each other signals as the signals are distinct, which is not the case in CDMA where the same frequency is used to transmit 2 calls, each with a different code.

16. A large company consists of 10,000 employees and an infrastructure needs to be created to broadcast messages to all the employees. If an AMPS

system is to be used for such a broadcast, what may be the possible alternate scheme if:

- (a) All employees are located in the same city?
- (b) 50% employees are in one location, while remaining 50% in another place?
- (c) 25% of employees each are located in four different locations?
- (d) People are spread all over the world?

**[Solution]**

Assuming that by infrastructure, we mean that these employees's primary objective is to communicate with each other.

- (a) AMPS is capable of handling up to 100000 users per city so no special scheme is required, only one HLR needed.
- (b) If the two locations are adjacent then, we can have separate HLRs serving each region, with each HLR serving as the other VLR.
- (c) If the locations are adjacent then, we can have 4 HLRs serving each region, with each HLR serving as the other VLR.
- (d) In this case, it is extremely hard and expensive, as it would require a large number of BS to cover the whole earth and a large number of HLRs and VLRs. It is also possible that on some places on earth there would be no coverage.

17. How would you address Problem 10.16 if GSM scheme is to be employed?

**[Solution]**

Assuming that by infrastructure, we mean that these employees's primarily objective is to communicate with each other.

- (a) If all the employees are located in the same city, then very small cells have to be used in order to accommodate them all where cell splitting will occur. The density would be very high.
- (b) Larger cells would be used if compared to the ones used if all employees were in one place. The density would be average.
- (c) Even larger cells would be used if compared to the ones used in the previous Problem. The density would be low.
- (d) In this case, the GSM can make use of its compatibility across systems and even makes use of satellite systems to accommodate its users over all places over the world.

18. Repeat Problem 10.17 for IMT2000 system.

**[Solution]**

Assuming that by infrastructure, we mean that these employees's primarily objective is to communicate with each other.

For IMT2000 it does not matter whether the employees are in the same city, 2 different locations, 4 different locations or all over the world. IMT2000 includes pico, micro, macro and global satellite cells.

19. Search the various Web sites and find why does IS-41 message transfer use X.25?

**[Solution]**

TIA IS-41 is an Inter/Intra Cellular Network Communication Protocol which was developed to support interoperability between differing cellular networks. The protocol provides functionalities for automatic roaming, specifically roamer validation, call delivery, feature portability, adjacent market handoff, continuous subscriber service, and feature transparency.

X.25 is the primary method readily available in the early stages of IS-41 deployment since it has low complexity. X.25 make the packet switch separate from the message content. An X.25 network transfers data via packet switching. With this method, information is taken from many different users and combined into discrete data packets. These data packets are then forwarded to the Packet Data Network (PDN).

SS7, Signaling System Number 7, is the backbone of the IS-41 intersystem operations network for AMPS based networks in North America and around the world. It provides interconnect among most cellular carriers, and is being used extensively in PCS systems. Routing in an SS7 network can be based on either the physical address of a network element (point code) or on a global title translation. In this later case, a phone number, credit card number or other logical address is used as routing information. The capabilities of packet switching and flexible addressing make SS7 most suitable for telecommunication networks. The only drawback is the cost of interconnection, and for this (and some historical) reasons, some smaller carriers will continue to interface to IS-41 networks using X.25, relying on protocol conversion to access the SS7 backbone network.

20. What is fundamental principle and use of spread spectrum?

**[Solution]**

In the spread spectrum transmission technique, the frequency spectrum of a data-signal is spread using a code uncorrelated with the signal. As a result, the bandwidth occupancy is much higher then required.

Spread Spectrum uses wide band, noise-like signals. Spread Spectrum signals use fast codes that run many times the information bandwidth or data rate. These special "Spreading" codes are called "Pseudo Random" or "Pseudo Noise" codes. They are called "Pseudo" because they are not real Gaussian noise.



Spread Spectrum transmitters use similar transmitting power levels to narrow band transmitters. Because Spread Spectrum signals are so wide, they transmit at a much lower spectral power density, measured in Watts per Hz, than narrowband transmitters. This lower transmitted power density characteristic gives spread signals a big plus. Spread and narrow band signals can occupy the same band, with little or no interference. This capability is the main reason for all the interest in the Spread Spectrum today

A number of advantages are:

- Low power spectral density. As the signal is spread over a large frequency-band, the Power Spectral Density gets very small, so other communications systems do not suffer from the interference problem. However the Gaussian Noise level is increasing.
  - Interference limited operation. In all situations the whole frequency-spectrum is used.
  - Privacy due to unknown random codes. The applied codes are - in principle - unknown to a hostile user. This means that it is hardly possible to detect the message of another user.
  - Applying spread spectrum implies reduction in multi-path effects.
  - Random access possibilities. Users can start their transmission at any arbitrary time.
  - Good anti-jam performance.
21. Explain with an example, how in CDMA two signals encoded using two different codes being transmitted in the same bandwidth reach the destination without interference with each other.

[Solution]

T-mobile and Cingular are SMS service providers in Cincinnati area. Short Message Service is a mechanism of delivery of short messages over the mobile networks. It is a store and forward way of transmitting messages to and from mobiles. The message (text only) from the sending mobile is stored in a central short message center (SMS) which then forwards it to the destination mobile station. This means that in the case that the recipient is not available, the short message is stored and can be sent later. One major performance measure of SMS is the delay incurred in delivering SMS.

22. What is the future of SMS services and how do you compare with paging? Explain clearly.

[Solution]

The next step in the evolution of SMS, which requires substantial changes in the network infrastructure, is the Multimedia Messaging Service (MMS)

that allows a combination of text, sounds, images and video. MMS will support pictures and interactive video. It will be possible, for example, to send mobile greeting cards and visiting cards using MMS. Paging has similarity with SMS. But SMS is from a mobile user to another mobile user, and is transported by appropriate signaling.