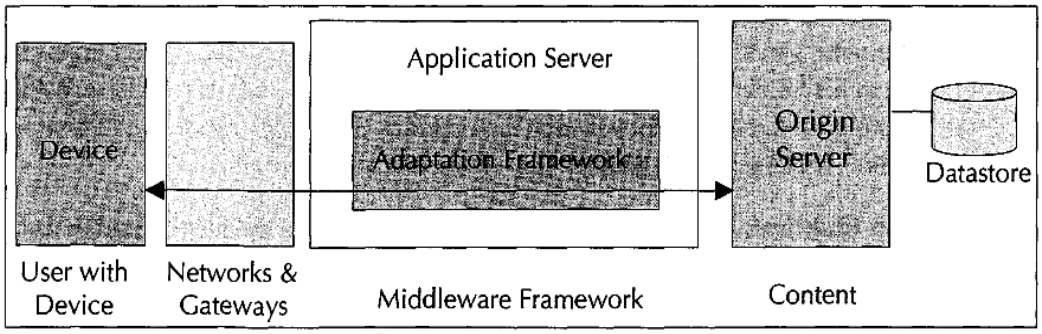
Q-1

a. Explain the role of network, gateway and middleware in mobile computing architecture. Draw the respective block diagram.

Answer:



Network: Whenever a user is mobile, he will be using different networks at different places at different time. Ex: GSM, CDMA, iMode, Ethernet, Wireless LAN, Bluetooth etc.

Gateway: This is required to interface different transport bearers. These gateways convert one specific transport bearer to another transport bearer.

Middleware: This is more of a function rather than a separate visible node. The middleware handles the presentation and rendering of the content on a particular device. Middleware also handles the security and personalization for different users.

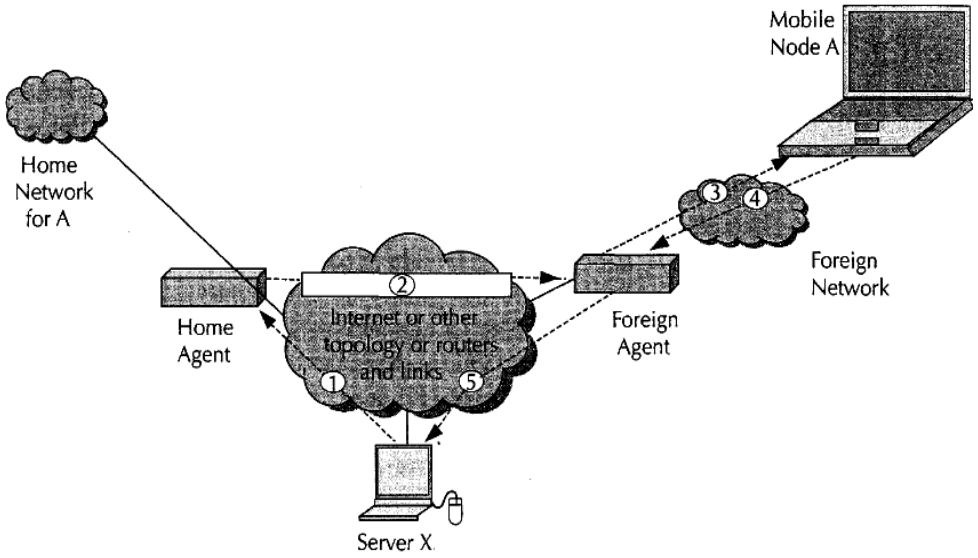
b. Explain co-channel interference. Mention methods to minimize co-channel interference.

Answer:

Time division multiplexing (TDM) is a flexible multiplexing scheme for typical mobile communications. A channel k_i is given the whole bandwidth for a certain amount of time, i.e., all senders use the same frequency but at different points in time. Guard spaces represent the time gaps, are to separate the different periods when the senders use the medium. If two transmissions overlap in time, this is called **co-channel interference**. To avoid this type of interference, the precise synchronization between different senders is necessary. For a receiver tuning in to a sender this does not just involve adjusting the frequency, but involves listening at exactly the right point in time. However, this scheme is quite flexible as one can assign more sending time to senders with a heavy load and less to those with a light load. To avoid any type of co-channel interference, two neighboring cells never use the same frequencies.

c. Explain the working mechanism of Mobile IP. Give an example for illustration.

Answer:



- Server X wants to transmit an IP datagram to node A. The home address of A is advertised and known to X. X does not know whether A is in the home network or somewhere else.
- At the *A:s* home network, the incoming IP datagram is intercepted by the home agent. The home agent discovers that A is in a foreign network. A care-of-address has been allocated to A by this foreign network and available with the home agent. The home agent encapsulates the entire datagram inside a new **IP** datagram, with N.s care-of address in the **IP** header.
- At the foreign network, the incoming **IP** datagram is intercepted by the **foreign agent.** The foreign agent is the counterpart of the home agent in the foreign network.
- The IP datagram from A to X travels directly across the network, using X's IP address as the destination address.

d. Define the following:

(i) Mobile assisted handoff

(ii) Network controlled handoff

Answer:

(i) Mobile assisted handoff - In mobile assisted handoff, every mobile station measures the received power from surrounding base stations and continually reports the results of these measurements to the serving base station. A handoff is initiated when the power received from the base station of a neighboring cell

begins to exceed the power received from the current base station by a certain level or for a certain period of time.

(ii) Network controlled handoff - In real-time systems the base station measures RSSI and initiates the handoff through MSC. The MSC allocates a free channel in the incumbent call by testing the channel traffic conditions and uses multiplexing techniques. This method consumes more time, since the final handover decision is controlled by the base station.

e. Explain the advantages of WLAN.

Answer:

Advantages of WLAN

Mobility

Low Implementation Costs

Installation Speed and Simplicity

Network Expansion

Reduced Cost-of-Ownership

Higher User to Install Base Ratio

Reliability

Scalability

f. Mention any four advantages of indirect TCP in wireless protocols.

Answer:

Advantages of indirect TCP in wireless protocols:

1. TCP does not require any changes in the TCP protocol as used by the hosts in the fixed network or other hosts in a wireless network that do not use this optimization.

2. Due to the strict partitioning into two connections, transmission errors on the wireless link, i.e., lost packets, cannot propagate into the fixed network.

3. Without partitioning, retransmission of lost packets would take place between mobile host and correspondent host across the whole network. Now only packets in sequence, without gaps leave the foreign agent.

4. It is always dangerous to introduce new mechanisms into a huge network such as the internet without knowing exactly how they will behave.

5. An optimized TCP could use precise time-outs to guarantee retransmission as fast as possible.

g. Explain the role of security frameworks in mobile environment.

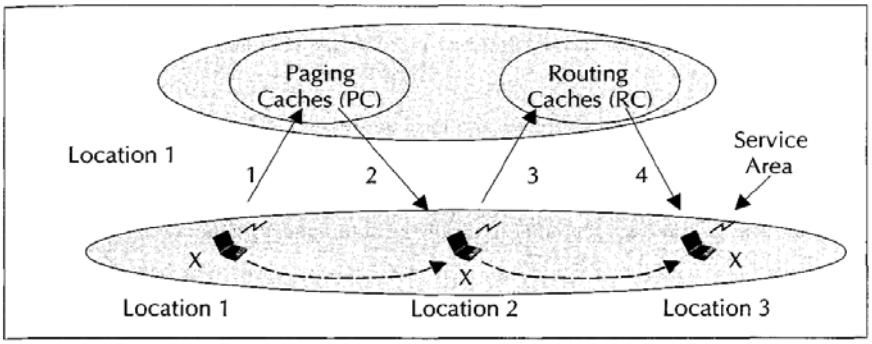
Answer:

Security frames works:
3GPP (3G Partnership Project) Security, mobile virtual private network, Smartcard Security, RFID Security, etc.

Q-2

a. Explain Paging Caches (PC) and Routing Caches (RC) in cellular IP. Explain how Cellular IP addresses the feature of high speed mobility.

Answer:



Cellular IP uses two parallel structures of mappings through Paging Caches (PC) and Routing Caches (RC). PCs maintain mappings for stationary and idle (not in data communication state) hosts; whereas, RC maintains mappings for mobile hosts. Mapping entries in PC have a large timeout interval, in the order of seconds or minutes. RCs maintain mappings for mobile hosts currently receiving data or expecting to receive data. For RC mappings, the timeout are in the packet time scale. While idle at location 1, the mobile host X keeps PCs up-to-date by transmitting dummy packets at a low frequency. Let us assume that the host is mobile and moved to location 2 without transacting any data. The PC mapping for X now points to location 2. While at location 2, there are data packets to be routed to the mobile host X, the PC mappings are used to find the host (step 2). As there is data transmission, the mapping database to be used will be the RC

b. A city has an area of 2,600 square miles and is covered by a cellular system using a 7-cell reuse pattern. Each cell has a radius of 6 miles and the city is

allocated 40 MHz of spectrum with a full duplex channel bandwidth of 60 kHz. The Grade of Service (GOS) is assumed to be 2% for an Erlang B system is specified. If the offered traffic per user is 0.03 Erlangs, compute (i) the number of cells in the service area (ii) the number of channels per cell and (iii) the traffic intensity of each cell.

Answer:

(i) Given:

Total coverage area = 2600 miles

Cell radius = 6 miles

The cell coverage area 2.5981 *R^2= 2.5981 * 6 * 6 = 93.5316 sq.ms.

Hence, the total number of cells are Nc = 2600 /93.5316=27.7 or 28 cells

(ii) The total number of channels per cell (C)

= allocated spectrum / (channel width * frequency reuse factor)

= 40,000,000/(60,000 * 7) = 95.2 or 95 channels/cell

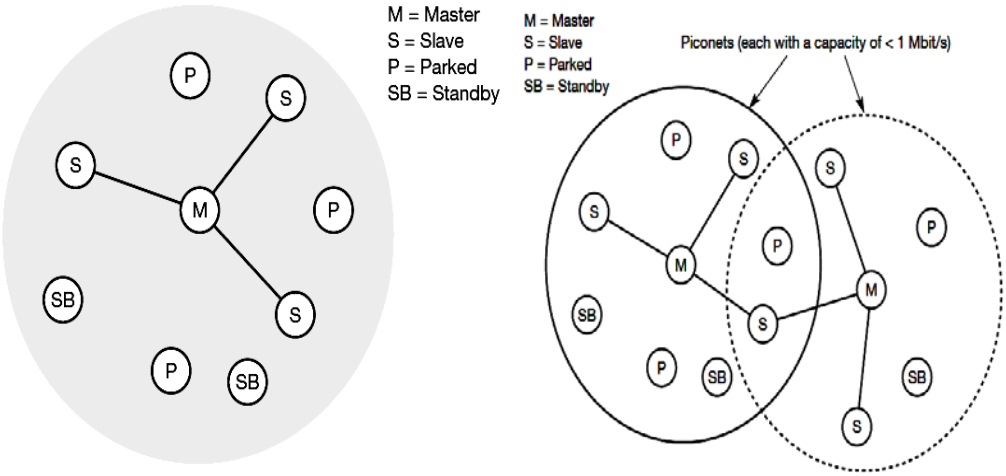
(iii) Here:

C= 95 and GOS = 0.02

The traffic intensity per cell A = 84 Erlangs/cell

c. Explain the functioning of piconets and scatternets in Bluetooth technology.

Answer:



A piconet is a collection of Bluetooth devices which are synchronized to the same hopping sequence. Figure shows a collection of devices with different roles. One device in the piconet can act as master (M), all other devices connected to the master must act as slaves (S). The master determines the hopping pattern in the piconet and the slaves have to synchronize to this pattern. Each piconet has a unique hopping pattern. If a device wants to participate it has to synchronize to this. Two additional types of devices are shown: parked devices (P) cannot actively participate in the piconet. Devices in stand-by (SB) do not participate in the piconet. Each piconet hasexactly one master and up to seven simultaneous slaves.

The scatter net consists of two piconets, in which one device participates in two different piconets. Both piconets use a different hopping sequence, always determined by the master of the piconet. If a device wants to participate in more than one piconet, it has to synchronize to the hopping sequence of the piconet it wants to take part in. If a device acts as slave in one piconet, it simply starts to synchronize with the hopping sequence of the piconet it wants to join. After synchronization, it acts as a slave in this piconet and no longer participates in its former piconet.

Q-3

a. Describe the working mechanism and communication metrics of base station controller and base transceiver system in mobile communication system.

Answer:

Base station controller (BSC) - The BSC basically manages the BTSs. It reserves radio frequencies, handles the handover from one BTS to another within the BSS, and performs paging of the MS. The BSC also multiplexes the radio channels onto the fixed network connections at the A interface.

Base transceiver station (BTS) - A BTS comprises all radio equipment, i.e., antennas, signal processing, amplifiers necessary for radio transmission. A BTS can form a radio cell or, using sectorized antennas, several cells, and in GSM is connected to MS via the Um interface (ISDN U interface for mobile use), and to the BSC via the Abis interface. The Um interface contains all the mechanisms necessary for wireless transmission (TDMA, FDMA etc.). The Abis interface consists of 16 or 64 kbit/s connections. A GSM cell can measure between some 100 m and 35 km depending on the environment (buildings, open space, mountains etc.) but also expected traffic.

b. Explain the features of location management.

Answer:

Identification: Location management must provide the means to identify all entities of the network. Radio cells, WATM networks, terminals, and switches need unique identifiers and mechanisms to exchange identity information. This requirement also includes information for a terminal concerning its current location (home network or foreign network) and its current point of attachment.

Transparency of mobility: A user should not notice the location management function under normal operation. Any change of location should be performed

without user activity. This puts certain constraints on the permissible time delay of the functions associated with location management.

Security: To provide a security level high enough to be accepted for mission-critical use (business, emergency etc.), a WATM system requires special features. All location and user information collected for location management and accounting should be protected against unauthorized disclosure. This protection is particularly important for roaming profiles that allow the precise tracking of single terminals.

Efficiency and scalability: The performance of all operations should be practically independent of network size, number of current connections and network load. The clustering of switches and hierarchies of domains should be possible to increase the overall performance of the system by dividing the load.

c. Give the advantages of borrowing channel allocation and dynamic channel allocation in the assignment of frequencies to cell clusters.

Answer:

The fixed assignment of frequencies to cell clusters and cells respectively, is not very efficient if traffic load varies. For instance, in the case of a heavy load in one cell and a light load in a neighboring cell, it could make sense to 'borrow' frequencies. Cells with more traffic are dynamically allotted more frequencies. This scheme is known as **borrowing channel allocation (BCA),** while the first fixed scheme is called **fixed channel allocation (FCA)**. FCA is used in the GSM system as it is much simpler to use, but it requires careful traffic analysis before installation. A dynamic channel allocation (DCA) scheme has been implemented in DECT. In this scheme, frequencies can only be borrowed, but it is also possible to freely assign frequencies to cells. With dynamic assignment of frequencies to cells, the danger of interference with cells using the same frequency exists. The 'borrowed' frequency can be blocked in the surrounding cells.

Q-4

a. Write notes on the following:

(i) Hidden and Exposed terminals

(ii) Near and Far terminals

Answer:

(i) Hidden and Exposed terminals: If for two mobile A and B, the transmission range of A reaches B, but not C. The transmission range of C reaches B, but not A. Finally, the transmission range of B reaches A and C, i.e., A cannot detect C and vice versa. A starts sending to B, C does not receive this transmission. C also wants to send something to B and senses the medium. The medium appears to be free, the carrier sense fails. C also starts sending causing a collision at B. But A cannot detect this collision at B and continues with its transmission. A is hidden for C and vice versa. While hidden terminals may cause collisions, the next effect

only causes unnecessary delay. Now consider the situation that B sends something to A and C wants to transmit data to some other mobile phone outside the interference ranges of A and B. C senses the carrier and detects that the carrier is busy (B's signal). C postpones its transmission until it detects the medium as being idle again. But as A is outside the interference range of C, waiting is not necessary. Causing a 'collision' at B does not matter because the collision is too weak to propagate to A. In this situation, C is exposed to B.

(ii) Near and Far terminals: If two mobiles A and B are both sending with the same transmission power. As the signal strength decreases proportionally to the square of the distance, B's signal drowns out A's signal. As a result, C cannot receive A's transmission. Now think of C as being an arbiter for sending rights (e.g., C acts as a base station coordinating media access). In this case, terminal B would already drown out terminal A on the physical layer. C in return would have no chance of applying a fair scheme as it would only hear B. The near/far effect is a severe problem of wireless networks using CDM. All signals should arrive at the receiver with more or less the same strength. Otherwise (referring again to the party example of chapter 2) a person standing closer to somebody could always speak louder than a person further away. Even if the senders were separated by code, the closest one would simply drown out the others. Precise power control is needed to receive all senders with the same strength at a receiver.

b. Explain features of Mobile Transaction Processing.

Answer:

A transaction in mobile environment is different than the transactions in the centralized or distributed databases in the following ways:

- The mobile transactions might have to split their computations into sets of operations, some of which execute on a mobile host while others execute on stationary host.
- A mobile transaction shares its states and partial results with other transactions due to disconnection and mobility.
- The mobile transactions require computations and communications to be supported by stationary hosts.
- When the mobile user moves during the execution of a transaction, it continues its execution in the new cell. The partially executed transaction may be continued at the fixed local host according to the instruction given by the mobile user. Different mechanisms are required if the user wants to continue the transaction at a new destination.
- As the mobile hosts move from one cell to another, the states of transaction, states of accessed data objects, and the location information also move.

c. Explain the concept of session mobility in mobile computing environment.

Answer:

Session Mobility - A user session should be able to move from one user-agent environment to another. Example could be a user was using his service through a CDMA (Code Division Multiple Access) IX network. The user entered into the basement to park the car and got disconnected from his CDMA network. User goes to home office and starts using the desktop. The unfinished session in the CD MA device moves from the mobile device to the desktop computer.

Service Mobility - User should be able to move from one service to another. Example could be a user is writing a mail. To complete the mail user needs to refer to some other information. In a desktop PC, user simply opens another service (browser) and moves between them using the task bar. User should be able to switch amongst services in small footprint wireless devices like in the desktop.

Q-5

b. Explain the authentication process in mobile applications.

Answer:

Authentication is based on the SIM, which stores the individual authentication key Ki, the user identification IMSI, and the algorithm used for authentication A3. Authentication uses a challenge response method: the access control AC generates a random number RAND as challenge, and the SIM within the MS answers with SRES (signed response). The AuC performs the basic generation of random values RAND, signed responses SRES, and cipher keys Kc for each IMSI, and then forwards this information to the HLR. The current VLR requests the appropriate values for RAND, SRES, and Kc from the HLR. For authentication, the VLR sends the random value RAND to the SIM.

c. Explain location dependent and location independent computing models.

Answer:

At a low level, there are location dependent primitives that require a programmer to know the current site of a mobile agent in order to communicate with it. If a party to such communications migrates, then the communicating program must explicitly track its new location.

At a high level, there are location independent primitives that allow communication with a mobile agent irrespective of its current site and of any migrations of sender or receiver. Location independent primitives may greatly simplify the development of mobile applications, since they allow movement and interaction to be treated as separate concerns. Their design and implementation, however, raise several difficult issues. A distributed infrastructure is required for tracking migrations and routing messages to migrating agents. This infrastructure

must address fundamental network issues such as failures, network latency, locality, and concurrency; the algorithms involved are thus inherently rather delicate and cannot provide perfect location independence. Moreover, applications may be distributed on widely different scales (from local to wide-area networks), may exhibit different patterns of communication and migration, and may demand different levels of performance and robustness; these varying demands will lead to a multiplicity of infrastructures, based on a variety of algorithms.

Q-6

a. Explain the functioning of home Location Register (HLR), Visiting Location Register (VLR) and Mobile Switching Center (MSC).

Answer:

Home location register (HLR): The HLR is the most important database in a GSM system as it stores all user-relevant information. This comprises static information, such as the mobile subscriber ISDN number (MSISDN), subscribed services (e.g., call forwarding, roaming restrictions, GPRS), and the international mobile subscriber identity (IMSI). Dynamic information is also needed, e.g., the current location area (LA) of the MS, the mobile subscriber
roaming number (MSRN), the current VLR and MSC.

Visitor location register (VLR): The VLR associated to each MSC is a dynamic database which stores all important information needed for the MS users currently in the LA that is associated to the MSC (e.g., IMSI, MSISDN, HLR address). If a new MS comes into an LA the VLR is responsible for, it copies all relevant information for this user from the HLR. This hierarchy of VLR and HLR avoids frequent HLR updates and long-distance signaling of user information.

Mobile services switching center (MSC): MSCs are high-performance digital ISDN switches. They set up connections to other MSCs and to the BSCs via the A interface, and form the fixed backbone network of a GSM system. Typically, an MSC manages several BSCs in a geographical region. A gateway MSC (GMSC) has additional connections to other fixed networks, such as PSTN and ISDN.

b. Compare fixed channel allocation and dynamic channel allocation schemes.

Answer:

The fixed assignment of frequencies to cell clusters and cells respectively, is not very efficient if traffic load varies. For instance, in the case of a heavy load in one cell and a light load in a neighboring cell, it could make sense to ‘borrow’ frequencies. Cells with more traffic are dynamically allotted more frequencies. This scheme is known as borrowing channel allocation (BCA), while the first fixed scheme is called fixed channel allocation (FCA). FCA is used in the GSM system as it is much simpler to use, but it requires careful traffic analysis before installation. A dynamic channel allocation (DCA) scheme has been implemented in DECT.

c. Explain data dissemination process and broadcasting process in information management of mobile computing devices.

Answer:

Wireless data dissemination allowed the user to tune and access and process desired information from anywhere in the world. Accessing data from wireless channel is a very useful facility because it allows users to get desired data through many computationally enabled devices such as cellular phones, PDAs, other new devices. If it is assumed that there is an abundance of wireless channels, then servers can continue to *push* all data users can ever need on these channels and users can *pull* whatever they require. Since, wireless channels are always in more demand, the task of data dissemination technology develops ways to satisfying users' data demand with limited wireless resources Data broadcast is predominately user-independent. The users are *passive* in that they can only read what is contained in a broadcast. While this model fits well into some types of data dissemination (such as local traffic information), it is not general enough for many different types of applications.

Q-7 Write short notes from any <u>THREE</u> of the following.

(i) Wearable Computing

(ii) Pervasive Computing

(iii) Reduced User Interfaces

(iv) Power Management in wireless systems

Answer:

(i) Wearable Computers: Wearable computers are those computers that may be adorned by humans like a hat, shoe or clothes, the wearable accessories. Wearable computers need to have some additional attributes compared to standard mobile devices. Wearable computers are always on; operational while on move; hands free, context aware (with different types of sensors). Wearable computers need to be equipped with proactive attention and notifications. The ultimate wearable computers will have sensors implanted within the body and supposedly integrate with the human nervous system.

(ii) Pervasive Computing is a technology that pervades the users' environment by making use of multiple independent information devices (both fixed and mobile, homogeneous or heterogeneous) interconnected seamlessly through wireless or wired computer communication networks which are aimed to provide a class of computing / sensory / communication services to a class of users, preferably transparently and can provide personalized services while ensuring a fair degree of privacy / non-intrusiveness.

(iii) Reduced User Interfaces –

- Reduced number of commands required to be known to the user for a given level of productivity.
- Reduced number of clicks or keystrokes required to carry out a given operation.
- Allows consistent behavior to be pre-programmed or altered by the user.
- Reduces the number of options to be on screen at one time (i.e. "clutter").

(iv) Power Management – The key idea is that the system only delivers the performance that is strictly required, thereby avoiding superfluous power consumption. When designing according to this concept, there are two aspects to consider: the technique itself that introduces the awareness, and the power management strategy that exploits it. Shutdown-based power management has been explored for hard disks, displays, and communication modules, among others. For processors, it has been incorporated in the kernel of real-time operating systems (RTOS). However, a breakthrough came with the development of dynamic voltage scaling (DVS), a technique for digital circuits that is more effective than shutdown. The reason is the convex nature of the power–speed curve, which comes about by varying the operating voltage. Numerous DVS-based power management strategies have been proposed to harness this potential.

Text Books

1. Jochen Schiller, Mobile Communications, Pearson Education

2. William Stallings, High-Speed Networks and Internets, Performance and Quality of Service, Pearson Education