1. INTRODUCTION TO WIRELESS COMMUNICATION

1. EXPLAIN NEED AND APPLICATIONS OF WIRELESS COMMUNICATION. (2013, 2017, 2018, 2019)

Wireless communication plays a vital role in modern society, ***enabling connectivity and information exchange without the constraints of physical cables.*** Here's an overview of the need and applications of wireless communication:

Need for Wireless Communication:

- **Mobility:** One of the primary drivers for wireless communication is the need for ***mobility. Users want to stay connected regardless of their location,*** whether they're on the move, at home, or in the office. Wireless technologies enable this ***seamless connectivity.***
- **Flexibility:** Wireless communication ***offers flexibility in deployment.*** It ***eliminates the need for extensive cabling infrastructure,*** making it ***easier and more cost-effective*** to set up communication networks in various environments, including ***rural areas, public spaces, and temporary locations.***
- **Scalability:** Wireless communication systems can easily scale to accommodate a growing number of users and devices. This scalability is crucial in scenarios such as ***large events, urban areas with dense populations, and expanding enterprise networks.***
- **Accessibility:** Wireless communication provides ***access to communication services in areas where wired infrastructure is impractical or unavailable.*** It helps to ***bridge the digital divide by extending connectivity*** to remote regions and underserved communities.

Applications of Wireless Communication:

- **Mobile Telephony:** Wireless communication forms the ***backbone of mobile telephony*** networks, ***enabling voice calls, text messaging, and data services*** on smartphones and other mobile devices.
- **Internet Access:** Wireless technologies such as ***Wi-Fi, LTE,*** and emerging standards like ***5G provide high-speed internet access to users in homes, businesses, and public spaces.*** This connectivity ***facilitates web browsing, online shopping, video streaming,*** and other internet-based activities.
- **IoT (Internet of Things):** Wireless communication is essential for connecting a vast array of IoT devices, including ***smart sensors, actuators, wearables, and home automation systems.*** These devices communicate ***wirelessly to collect data, monitor environments, and automate processes.***
- **Wireless Networking:** Wireless LANs (WLANs) enable flexible and convenient networking within ***homes, offices, and public hotspots.*** They ***support local connectivity between devices,*** allowing users to share resources, collaborate, and access network services without physical constraints.
- **Vehicle Communication:** Wireless communication is integral to modern automotive systems, facilitating ***vehicle-to-vehicle (V2V)*** and ***vehicle-to-infrastructure (V2I)*** communication for ***safety, navigation, and traffic management applications.***
- **Healthcare:** Wireless technologies enable ***remote patient monitoring, telemedicine consultations,*** and healthcare applications such as ***fitness trackers and medical implants.***

2. EXPLAIN MOBILE AND WIRELESS DEVICES. (2014, 2017, 2018)

Mobile and wireless devices encompass a diverse range of technologies, ***from simple sensors to powerful smartphones and laptops.*** These devices have evolved significantly over time, ***offering enhanced functionality, connectivity, and mobility.*** However, they also face challenges such as ***power consumption and interface design*** as technology continues to evolve.

Sensor Devices:

- Sensors are fundamental components in the Internet of Things (IoT) ecosystem, ***transmitting data wirelessly to other devices or systems.***
- They are ***often small, low-power devices designed to detect and transmit specific types of information,*** such as ***temperature, motion, or light levels.***
- As technology advances, sensors are becoming more sophisticated, with capabilities such as ***wireless connectivity, energy harvesting,*** and even ***onboard processing.***

Embedded Controllers:

- Many everyday appliances now include embedded controllers, which are essentially ***small computers that control the device's operation.***
- These controllers can range from simple microcontrollers performing basic functions to more complex systems with advanced features.
- By ***integrating wireless communication capabilities into appliances,*** manufacturers can enable features like ***remote monitoring, control, and automation.***

Pager Devices:

- Pagers were once popular communication devices for receiving ***short text messages, particularly in professions like healthcare and emergency services.***
- However, the ***widespread adoption of mobile phones and digital communication technologies has largely omitted the use of pagers*** in many regions.
- Pagers were ***limited in functionality compared to mobile phones,*** offering ***only one-way communication and basic text display capabilities.***

Mobile Phones:

- Mobile phones have ***undergone significant evolution*** since their inception, ***transitioning from basic voice communication devices to multifunctional smartphones.***
- Early mobile phones featured simple black-and-white displays and limited functionality, ***primarily focused on voice calls and short messaging.***
- Modern smartphones provides advanced features such as ***high-resolution colour displays, touchscreens, internet browsing, multimedia capabilities.***

Personal Digital Assistants (PDAs):

- PDAs emerged as handheld computing devices ***designed to assist users with personal organization and productivity tasks.***
- Early PDAs featured ***stylus-based input methods*** and ***basic software applications like calendars, contacts, and notes.***

- While standalone PDAs experienced a decline in popularity with the rise of smartphones, ***their functionality has been integrated into modern mobile operating systems.***

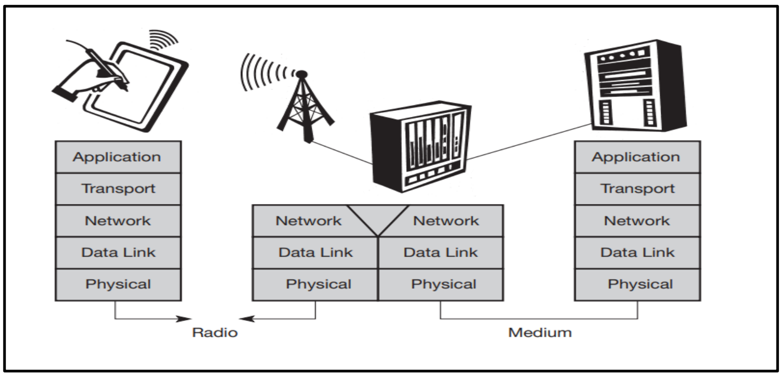
Pocket Computers:

- Pocket computers ***represent a bridge between PDAs and full-fledged laptops,*** offering ***enhanced computing capabilities in a portable form factor.***
- These devices typically feature ***compact keyboards, colour displays,*** and support for ***basic productivity applications*** like ***word processing and spreadsheets.***
- While pocket computers may not offer the same level of performance or software compatibility as traditional laptops, they provide users with ***greater mobility and*** convenience for ***on-the-go computing tasks.***

Laptop:

- Laptops are ***portable computing devices*** designed to offer similar functionality to desktop computers in a compact form factor.
- They typically offer ***integrated displays, keyboards, trackpads,*** and a ***variety of connectivity options.***
- Laptops vary in performance, ranging from budget-friendly models suitable for basic productivity tasks to high-end devices capable of demanding computing applications such as ***gaming and content creation.***

3. EXPLAIN REFERENCE MODEL USED FOR WIRELESS COMMUNICATION WITH SUITABLE DIAGRAM. (2012)



Shows a personal digital assistant (PDA) which provides an example for a ***wireless communication and portable device.*** This PDA ***communicates with a base station*** in the middle of the picture.

The ***base station consists of a radio transceiver (sender and receiver)*** and an ***interworking unit connecting the wireless link with the fixed link.*** The ***communication partner of the PDA, a conventional computer,*** is shown on the right-hand side.

figure shows the ***protocol stack implemented in the system according to the reference model.*** End-systems, such as the PDA and computer in the example, need a full protocol stack comprising the application layer, transport layer, network layer, data link layer, and physical layer.

Functions of each layer in detail in a wireless communication:

Physical Layer:

- Handles the ***actual transmission of data bits over the communication medium.***
- Responsible for tasks like ***selecting frequencies, generating carrier signals, and signal modulation.***
- Manages ***encryption*** for secure data transmission.

Data Link Layer:

- Manages ***data transfer between devices over the physical medium.***
- Responsible for ***framing data, error detection and correction.***
- Includes ***medium access control protocols*** for ***sharing the communication medium.***

Network Layer:

- ***Routes data packets across multiple networks from source to destination.***
- Provides ***addressing, routing,*** and ***handover management functionalities.***
- ***Determines the best path for data transmission*** based on ***network conditions and device locations.***

Transport Layer:

- Ensures ***reliable end-to-end communication between devices.***
- ***Segments data into smaller units,*** ensures ***reliable delivery, and handles reassembly.***
- Responsible for ***flow control, congestion control, and error recovery mechanisms.***

Application Layer:

- ***Contains user applications and services*** that utilize the communication infrastructure.
- Enables applications like ***web browsing, email, file transfer,*** and ***multimedia streaming.***

These layers work together to facilitate communication between devices, ***ensuring data confidentiality, integrity, availability, efficient transmission,*** and support for various applications and services.

2. WIRELESS TRANSMISSION

1. LIST THE MAIN PROBLEMS OF SIGNAL PROPAGATION? WHY RADIO WAVES DO NOT FOLLOW THE STRAIGHT LINE. (2019, 2019)

Problems of signal propagation

1. Diffraction: This phenomenon ***bends radio waves around obstacles like buildings, mountains, or even sharp corners.*** While it allows signals to reach shadowed areas, it can weaken the signal and ***cause multipath propagation,*** where the wave takes multiple paths, leading to ***interference and distortions.***

2. Reflection: Radio waves can bounce off surfaces like ***walls, water, and metal objects.*** Reflections can also ***create echoes and distort the signal,*** potentially causing ***ghosting or fading effects.***

3. Scattering: When radio waves encounter ***irregularities in the environment,*** like ***rain, snow, dust, or foliage,*** they get ***scattered in various directions, weakening the signal and reducing its range.***

4. Absorption: Certain materials, like ***water and concrete,*** absorb radio waves, ***attenuating their energy and limiting their travel distance.*** This is particularly ***noticeable at higher frequencies.***

5. Refraction: When radio waves pass through mediums with varying densities, like the atmosphere, ***their speed changes, causing them to bend.*** This is how signals can bounce off the ionosphere and ***travel long distances over the Earth's curvature.*** However, it can also lead to signal bending and focusing in unpredictable ways.

6. Interference: Radio waves from other sources, like other ***transmitters, power lines, or even electronics,*** can interfere with the desired signal, ***causing noise and reducing its clarity.***

Radio waves do not follow the straight-line cause:

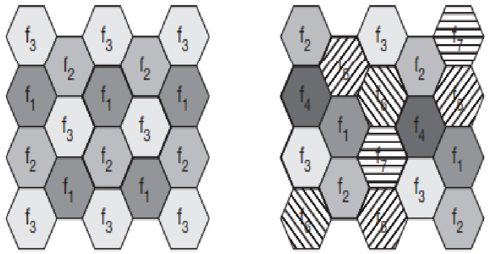
- when radio signals travel through empty space (like a vacuum), they move in straight lines, much like light does. This ***straight path between the sender and receiver is called "line-of-sight."*** Even though there's nothing in the way, the signal still loses strength as it travels farther. **This weakening follows a rule:** ***the farther the signal travels, the weaker it gets,*** and ***this weakening happens faster as the distance increases.***
- Now, when there's stuff in the way, like ***air, rain, fog, or even dust,*** it gets more complicated. These things can ***absorb or scatter the radio signal, making it weaker or causing it to change direction.*** For short distances, like in a local Wi-Fi network, this isn't usually a big problem. But for longer distances, like communicating with satellites or even just during heavy rain, it can be a big issue. ***Rain, for example, can soak up a lot of the signal, making it harder for the sender and receiver to talk to each other.***
- ***Different frequencies of radio waves behave differently too. Lower frequencies can pass through things better,*** like water, which is why ***submarines*** can communicate with long-wave radio. But ***higher frequencies,*** like those used by your phone, can ***get blocked more easily,*** even by something like a tree.

2. EXPLAIN CELLULAR SYSTEM IN WIRELESS COMMUNICATION. (2019, 2019, 2018, 2013)

Definition of Cellular System:

A cellular system is a ***telecommunications system*** that enables ***mobile communication over a network divided into geographical areas called cells.*** Each ***cell is served by a base station,*** and collectively, ***these cells cover a larger area,*** providing ***seamless wireless communication*** for users on the move.

Figure 2.41
Cellular system with three and seven cell clusters



Components of a Cellular System:

1. **Base Stations:** These are ***fixed transceiver stations located within each cell.*** They ***facilitate communication*** between ***mobile devices and the cellular network.***
2. **Mobile Devices:** These are the handheld devices used by subscribers to access the cellular network. Examples include ***smartphones, tablets, and feature phones.***
3. **Cell Sites:** Each cell contains one or more cell sites, which ***house the antennas and equipment necessary for wireless communication within that cell.***
4. **Switching System:** This system ***manages the connection between different cells*** and connects calls to the ***public switched telephone network (PSTN).***
5. **Control Equipment:** It includes equipment responsible for managing ***call handovers, cell selection, and other functions*** to ensure seamless communication ***as users move between cells.***

Working Principle:

1. **Cellular Division:** The geographical area is divided into smaller cells to ***accommodate a higher number of users and ensure efficient use of radio frequencies.***
2. **Frequency Reuse:** Frequencies allocated to one cell can be reused in distant cells ***without causing interference, maximizing spectrum utilization.***
3. **Handover:** When a mobile device moves from one cell to another, the network ***automatically transfers the call or data session to the new cell,*** ensuring ***uninterrupted communication.***
4. **Roaming:** Subscribers can ***access cellular services outside their home network's coverage area through roaming agreements*** with other cellular operators.

Advantages of Cellular Systems:

1. **Increased Capacity:** By dividing the coverage area into cells, cellular systems can accommodate a large number of users simultaneously.
2. **Improved Coverage:** Cells can be ***strategically placed to provide coverage even in remote or difficult-to-reach areas.***
3. **Better Call Quality:** The use of ***smaller cells reduces signal interference and improves call quality and reliability.***
4. **Mobility Support:** Cellular systems allow users to stay connected while moving within the coverage area ***without interrupting their communication sessions.***
5. **Scalability:** Cellular networks can ***easily scale up*** to accommodate growing subscribers.

In conclusion, ***cellular systems form the backbone of modern wireless communication,*** offering ***extensive coverage, high capacity, and seamless connectivity for mobile users.***

3. DRAW AND EXPLAIN FREQUENCY HOPPING SPREAD SPECTRUM. (2018, 2019)

In simple terms, "hopping" in the context of wireless communication means ***quickly switching between different frequencies.*** It's like hopping from one radio station to another on your car radio, but ***much faster and in a specific order.***

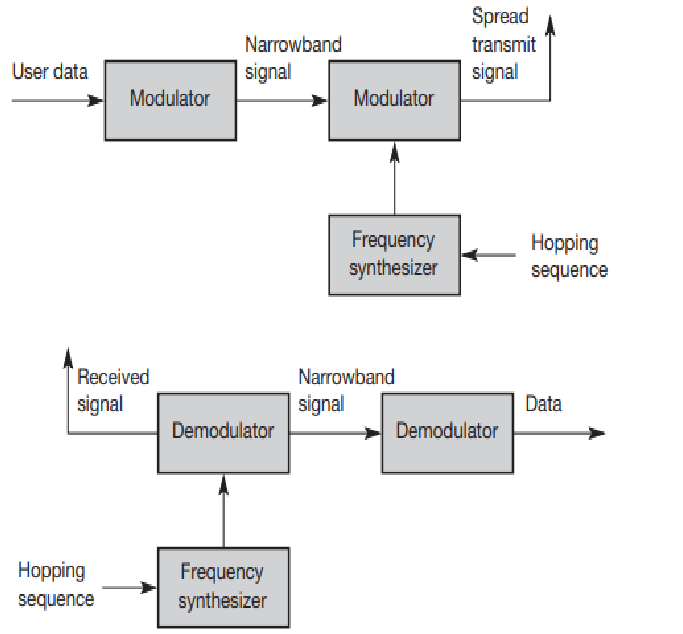
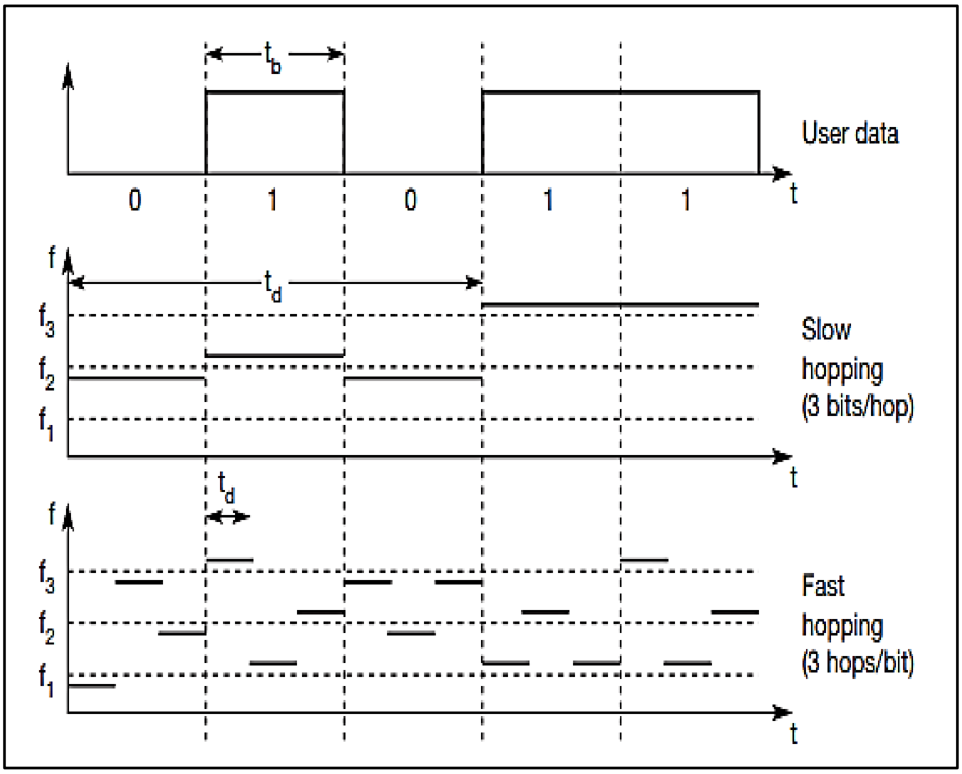


Figure 2.39 FHSS transmitter

Figure 2.40 FHSS receiver

Frequency Hopping Spread Spectrum (FHSS):

- FHSS involves ***dividing the available bandwidth into multiple smaller channels,*** each with its own frequency range. These ***channels are spaced apart to avoid interference.***
- The ***transmitter and receiver switch between these channels periodically according to a predetermined hopping sequence.*** This sequence ***determines the order and timing*** of channel changes.
- FHSS combines ***Frequency Division Multiplexing (FDM),*** where different channels carry different signals simultaneously, and ***Time Division Multiplexing (TDM),*** where different signals are ***transmitted at different times.***



Slow Hopping vs Fast Hopping:

- ***Slow Hopping:*** In slow hopping, the ***transmitter remains on one frequency for several bit periods before moving to the next frequency in the sequence. Slow hopping may be more susceptible to interference.***
- ***Fast Hopping:*** Fast hopping involves ***rapid frequency changes within a single bit period.*** This ***demands tight synchronization between the transmitter and receiver*** but provides ***better resilience against interference and fading*** by spending less time on any single frequency.

Receiver Operation:

- The ***receiver in an FHSS system must synchronize with the transmitter's hopping sequence*** to accurately ***decode the transmitted data.***
- It performs ***inverse operations of the modulation technique*** used by the transmitter to ***reconstruct the original user data.***
- Various ***filters are employed to manage interference and ensure precise demodulation*** and decoding of the received signal.

Example:
Bluetooth FHSS:

- Bluetooth technology utilizes FHSS, ***hopping between 79 channels within the 2.4 GHz ISM band at a rate of 1,600 hops per second.*** Each Bluetooth device follows a ***hopping sequence*** to coordinate communication with nearby devices.

In essence, FHSS offers a robust method for wireless communication by ***dynamically adapting to changing radio conditions, enhancing reliability, and mitigating interference.***

4. DRAW AND EXPLAIN DIRECT SEQUENCE SPREAD SPECTRUM. (2017, 2014)

Direct Sequence Spread Spectrum (DSSS)

Direct Sequence Spread Spectrum (DSSS) systems employ a technique where a ***user's bit stream is multiplied with a chipping sequence.*** This sequence is often referred to as a ***pseudo-random noise sequence*** because, when generated correctly, it appears like random noise.

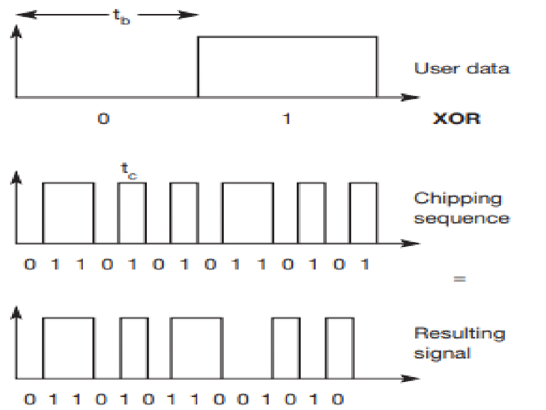


Figure 2.35
Spreading with DSSS

Definition: Direct Sequence Spread Spectrum (DSSS) is a ***spread spectrum technique*** used in wireless communication to ***spread the signal over a wider bandwidth than the original*** information signal.

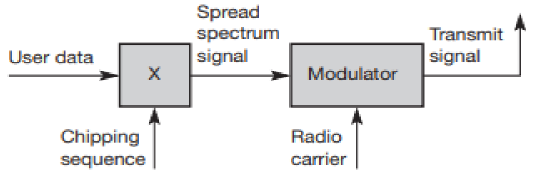


Figure 2.36
DSSS transmitter

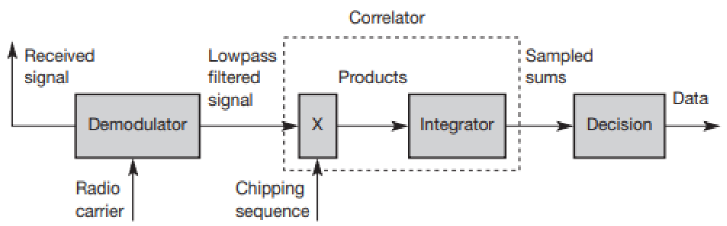


Figure 2.37
DSSS receiver

Key Features:

1. **Spreading the Signal:** DSSS ***multiplies the original data signal with a spreading code,*** which is a ***pseudo-random noise sequence of 1s and 0s, known as chip sequence.***
2. **Increased Bandwidth:** This ***multiplication spreads the signal across a wider bandwidth,*** but this increased bandwidth ***not synchronized with the same spreading code of original bandwidth.***
3. **Resistance to Interference:** DSSS offers robustness against interference because the ***spread signal is indistinguishable from noise, wider spread makes it harder to completely cover and disrupt the information.***

Receiver Operation:

1. **Correlation:** At the receiver, the ***incoming spread spectrum signal is multiplied again with the same spreading code,*** a process known as correlation.
2. **Data Retrieval:** ***Correlation effectively "undoes" the spreading,*** allowing the receiver to retrieve the original data signal.

Applications:

1. **Wireless LAN (Wi-Fi):** DSSS is commonly used in wireless LAN technologies such as ***IEEE 802.11b*** and some versions of ***IEEE 802.11g.***
2. **Cordless Phones:** Some types of cordless phones utilize DSSS for improved resistance to interference.
3. **Military Communications:** DSSS is employed in military communications systems due to its ***robustness against jamming and interference.***

In summary, DSSS ***spreads the signal over a wider bandwidth using a spreading code, enhancing resistance to interference*** and ***improving the reliability*** of wireless communication systems.

5. WHAT ARE THE MAIN REASONS FOR USING CELLULAR SYSTEMS? HOW SDM IS REALIZED FOR MULTIPLEXING. (2017)

Cellular systems offer several advantages that make them the preferred choice for mobile communications:

- **Increased Capacity:** Cellular systems can accommodate a large number of users by dividing the coverage area into smaller cells. Each cell has its own base station, allowing for efficient use of available frequency spectrum and reducing the likelihood of network congestion.
- **Improved Coverage:** By deploying multiple base stations across different locations, cellular systems provide better coverage compared to traditional broadcast systems. This ensures that users can maintain connectivity even while moving across different areas.
- **Quality of Service:** ***Cellular networks prioritize voice and data traffic,*** ensuring ***reliable and consistent communication*** for users. Additionally, ***technologies like handover and roaming enable seamless transitions between cells*** without interruption to ongoing calls.
- **Flexibility and Scalability:** Cellular systems can adapt to changing demand and usage patterns by adjusting parameters such as ***cell size, frequency allocation, and network resources.*** This scalability allows operators to efficiently manage network resources and accommodate future growth in subscriber numbers and data usage.
- **Improved Spectral Efficiency:** Cellular systems employ ***techniques such as frequency reuse, spatial division multiplexing, and interference management to maximize spectral efficiency.***

Here's how SDM is realized for multiplexing:

- **Three-Dimensional Coordinate System**: In SDM, the ***communication channels are represented in a three-dimensional coordinate system,*** which includes dimensions of ***code***

(c), time (t), and frequency (f). Each channel is associated with a specific combination of these dimensions.

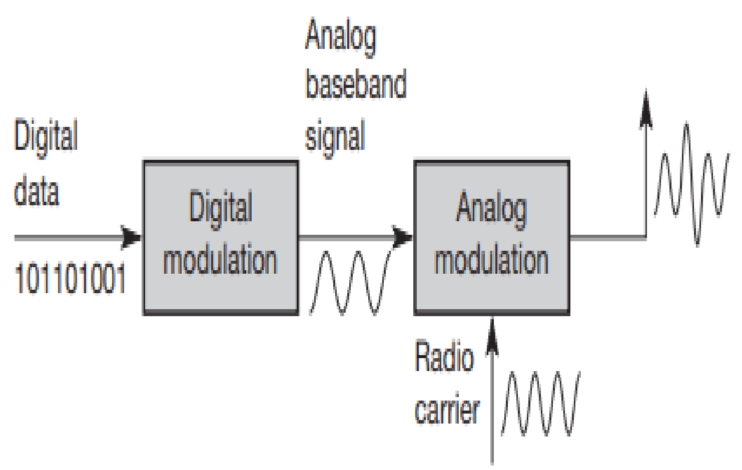
- **Separation of Channels:** The channels are ***mapped onto distinct "spaces"*** (s1, s2, s3, etc.), each ***representing a different physical area.*** These spaces are represented by circles, indicating the ***interference range of each channel.*** The goal is to separate the channels spatially to prevent interference between them.
- **Guard Space:** To ensure minimal interference, a guard space is maintained between the interference ranges of adjacent channels. This ***guard space helps prevent overlap and ensures clear separation between channels.***
- **Separate Senders:** In SDM, ***each channel is associated with its own transmitter or sender.***
- **Example:** ***FM Radio Stations:*** A practical example of SDM is seen in FM radio stations, where each station operates within a limited transmission range

6. EXPLAIN MODULATION WITH NEAT DIAGRAM. (2014, 2017)

Modulation is the ***process of encoding information onto a carrier signal for transmission.*** It changes one or more properties of the carrier signal, such as its ***amplitude, frequency, or phase,*** in accordance with the information being transmitted.

Let's focus on digital modulation, ***which translates digital data (0s and 1s) into an analogue signal (baseband signal)*** suitable for transmission over a ***medium that only allows for analogue transmission.*** There are three basic methods for this translation: ***Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), and Phase Shift Keying (PSK).***

Figure 2.21 Modulation in a transmitter



- **Amplitude Shift Keying (ASK):** In ASK, the ***amplitude of the carrier signal is varied to represent different digital symbols.*** A ***high amplitude may represent one symbol (e.g., 1)*** while a ***low amplitude may represent another symbol (e.g., 0).***
- **Frequency Shift Keying (FSK):** FSK modulates the frequency of the carrier signal to represent digital symbols. One frequency may represent one symbol, while another frequency represents the other symbol.
- **Phase Shift Keying (PSK):** PSK modulates the phase of the carrier signal to represent digital symbols. Different phase shifts correspond to different symbols.

After digital modulation, an ***analogue modulation is applied to shift the centre frequency of the baseband signal up to the desired radio carrier frequency.*** This analogue modulation is necessary for wireless transmission due to several reasons:

- **Antennas:** Antennas must be of a practical size, which is determined by the wavelength of the signal. For example, handheld devices require antennas of a few centimetres in length, achievable with higher carrier frequencies.
- **Frequency Division Multiplexing (FDM):** Analog modulation enables FDM, where multiple signals are transmitted on different carrier frequencies. This allows for efficient use of available bandwidth.
- **Medium Characteristics:** The characteristics of the transmission medium, such as path-loss and reflection, depend on the wavelength of the signal. Different applications require different carrier frequencies to achieve desired transmission characteristics.

As for digital modulation, three different basic schemes are known for analogue modulation: amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM).

These modulation schemes are implemented in a radio transmitter, where digital data is first modulated into an analogue baseband signal using digital modulation techniques. The baseband signal is then further modulated onto a carrier signal using one of the analogue modulation schemes

7. DRAW AND EXPLAIN SPACE DIVISION MULTIPLEXING AND FREQUENCY DIVISION MULTIPLEXING. (2013, 2018, 2018)

Multiplexing Techniques in Communication Systems

Multiplexing plays a vital role in communication systems by ***enabling the transmission of multiple signals over a single communication channel simultaneously.*** This significantly ***increases the channel's capacity and allows for efficient sharing of resources.*** Two key multiplexing techniques are:

1. Space Division Multiplexing (SDM):

- **Concept:** SDM focuses on ***physically dividing the transmission medium*** (e.g., airwaves, cable) into ***separate, independent channels.*** Each channel then acts as a ***dedicated pathway for transmitting a single signal.***
- **Analogy:** Imagine a ***highway with multiple lanes.*** Each lane allows for independent traffic flow, increasing the overall capacity compared to a single-lane highway.
- **Applications:**
    - **Cellular networks:** Base stations ***employ multiple antennas to create separate channels for different users within the same cell,*** enabling them to communicate concurrently.
    - **Fibre optic communication:** ***Multiple optical fibres can be bundled together in a single cable,*** with each fibre carrying a distinct signal.

- **Satellite communication:** ***Satellites can utilize multiple beams to communicate with different users on Earth*** simultaneously.

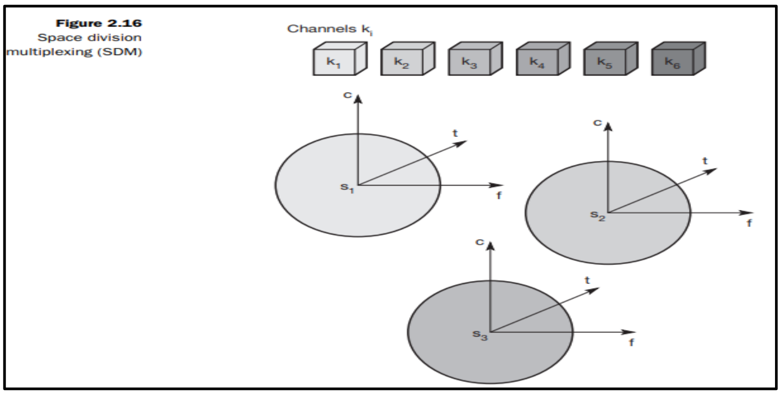


Figure 2.16 Space division multiplexing (SDM)

2. Frequency Division Multiplexing (FDM):

- **Concept:** In frequency division multiplexing (FDM), the ***available broad band is divided into multiple smaller sub-bands, each with its own bandwidth.*** Different signals can be carried on these sub-bands simultaneously with minimal interference, as long as the sub-bands are carefully allocated to avoid overlap in frequency.

- **Analogy:** This is similar to dividing a radio dial into different radio stations, each broadcasting on a specific frequency.

- **Applications:**
  - **Radio broadcasting:** Different ***radio stations are assigned distinct frequencies*** on the AM or FM band to avoid interference.
  - **Cable television:** Multiple channels are transmitted on ***different frequency bands*** within the cable network.
  - **Wi-Fi:** Wi-Fi channels ***utilize separate frequency bands*** to ensure smooth communication between multiple users sharing the same network.

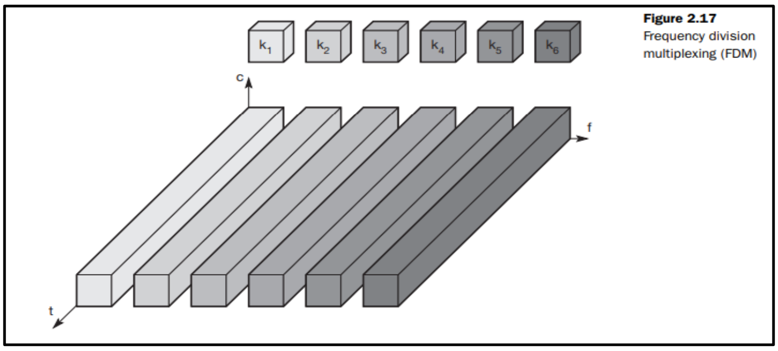


Figure 2.17 Frequency division multiplexing (FDM)

In short, Both SDM and FDM are essential techniques for ***maximizing the capacity of communication channels and enabling efficient resource sharing.*** Choosing the appropriate technique depends on various factors, such as the ***available resources,*** the ***type of signals being transmitted,*** and the ***desired level of channel utilization.***

3. MEDIUM ACCESS CONTROL:

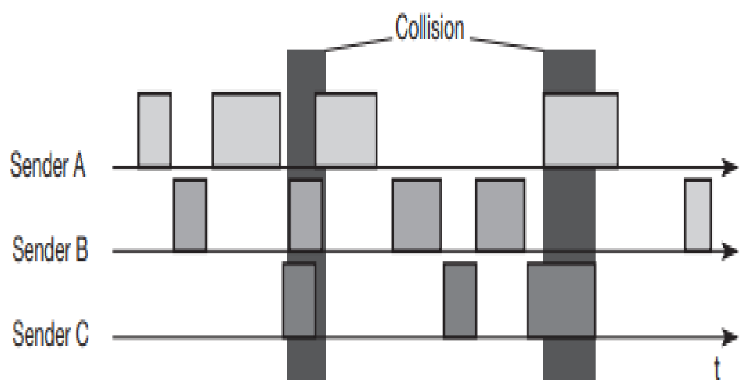
1. DESCRIBE CLASSICAL AND SLOTTED ALOHA. (2019, 2018)

The ALOHA protocol, developed at the ***University of Hawaii in the 1970s,*** is a ***random-access protocol*** used for ***sharing a single communication channel among multiple users.*** It's one of the ***earliest methods for sharing a common communication channel*** in a network.

In ALOHA, multiple users can transmit data packets over the shared channel ***without any centralized control or coordination.*** Each user transmits data whenever it has information to send, ***without checking if the channel is busy or if other users are transmitting.***

If two or more users transmit at the same time, a ***collision occurs, and the data packets become corrupted.*** ALOHA then employs a ***simple retransmission strategy,*** after a random time, interval, the sender attempts to transmit the data packet again.

Figure 3.5 Classical Aloha multiple access



Classical Aloha is a ***random-access protocol*** used in wireless communication systems where ***base stations can access the medium (i.e., transmit data) at any time without coordination*** or control from a central arbiter.

key points about Classical Aloha:

- **Uncoordinated Access:** Stations in ***Classical Aloha can access the medium at any time without synchronization*** or ***coordination with other stations.***
- **Random Transmission:** ***Stations transmit data packets independently, without waiting for predefined time slots or synchronization signals.*** They attempt to ***transmit whenever they have data ready.***
- **Collision Detection:** Since there's no coordination, collisions can occur when multiple stations transmit simultaneously. ***Collisions corrupt the transmitted data.***
- **No Collision Resolution:** Classical Aloha lacks mechanisms to resolve collisions. It ***relies on higher layers of the protocol stack to detect collisions*** and ***handle retransmissions,*** if necessary.
- **Throughput:** In Classical Aloha, the ***best performance or maximum data transfer rate (throughput) is achieved when the network is about 18% full.*** This is based on the assumption that ***data packets arrive randomly,*** following a pattern called a ***Poisson distribution.***

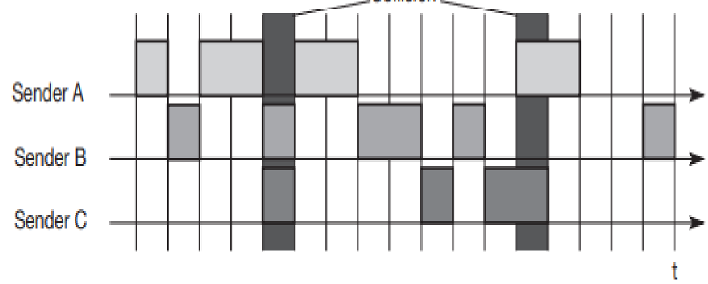


Figure 3.6 Slotted Aloha multiple access

Slotted Aloha is an improvement over the classical Aloha scheme that ***introduces time slots for transmission.*** Here's how Slotted Aloha works:

key points about Slotted Aloha:

- **Introduction of Time Slots:** In Slotted Aloha, the ***transmission time is divided into discrete time slots of equal duration. All stations must be synchronized to these time slots.***
- **Synchronized Transmission:** ***Stations can only begin transmitting at the start of a time slot.*** This ***synchronization helps avoid collisions*** that occur when stations attempt to transmit at arbitrary times.
- **Uncoordinated Access:** Similar to Classical Aloha, access to the medium is still uncoordinated. Stations decide independently whether to transmit in a particular time slot.
- **Increased Throughput:** By introducing time slots, Slotted Aloha effectively ***doubles the maximum achievable throughput compared to Classical Aloha.*** Under the same assumptions, ***Slotted Aloha can achieve up to 36% throughput.*** The ***use of time slots reduces the probability of collisions and improves the efficiency of the protocol.***

Aspect	Classical ALOHA	Slotted ALOHA
Time Division	Time is not divided into slots.	Time is divided into equal-sized slots.
Frame Structure	Frames can start at any time.	Frames must start at the beginning of a slot.
Collision Handling	Collisions may occur randomly at any time.	Collisions only occur at the start of each slot.
Efficiency	Lower efficiency due to random collisions.	Higher efficiency due to synchronized slots.
Throughput	Lower throughput due to collisions.	Higher throughput due to reduced collisions.
Implementation	Simpler implementation.	More complex implementation due to slot timing.
Synchronization	No synchronization required.	Requires synchronization for slot timing.
Performance Predictability	Performance is less predictable.	Performance is more predictable.
Scalability	Less scalable for high loads.	More scalable for high loads.
Examples	Traditional ALOHA.	Slotted ALOHA.

2. DESCRIBE FREQUENCY DIVISION MULTIPLE ACCESS WITH NEAT DIAGRAM. (2019, 2018)

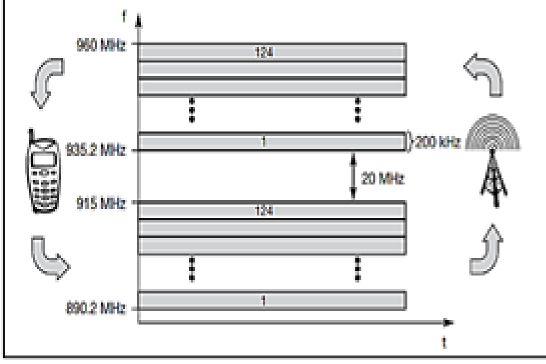


Figure 3.3
Frequency division multiplexing for multiple access and duplex

Frequency Division Multiple Access (FDMA) is a technique used in communication systems to enable ***multiple users to access the communication medium simultaneously*** by ***allocating different frequency bands to each user.*** Here's a clear description of FDMA along with a neat diagram:

Description:

1. **Basic Principle**: FDMA is based on the concept of Frequency Division Multiplexing (FDM), where the ***available frequency spectrum is divided into multiple non-overlapping frequency bands,*** each ***allocated to a different user*** or ***communication channel.***
2. **Frequency Allocation**: In FDMA, ***each user or communication channel is assigned a specific frequency band within the overall spectrum.*** This allocation can either be fixed, where ***each user maintains its frequency band at all times,*** or dynamic, where ***frequency bands may change over time based on demand.***
3. **Pure FDMA vs. FDMA with TDMA**: Channels can either remain on their assigned frequencies continuously (pure FDMA) or change frequencies according to a predetermined pattern, often combined with Time Division Multiple Access (TDMA). This is particularly useful for ***mitigating narrowband interference.***
4. **Duplex Communication**: FDMA is often ***used in conjunction with Frequency Division Duplexing (FDD) for duplex communication,*** where ***simultaneous transmission and reception occur on separate frequency bands.*** This enables communication in both directions without interference.
5. **Example**: In a mobile phone network based on the GSM standard, the frequency allocation follows a ***fixed scheme*** regulated by national authorities. For instance, all uplinks may use a certain frequency range, while all downlinks use another. Each user is assigned specific frequencies for uplink and downlink communication, creating duplex channels.
6. **Bandwidth Allocation**: Each channel in FDMA has a specific bandwidth allocated to it. For example, ***in GSM, each channel may have a bandwidth of 200 kHz.***

FDMA allows for ***efficient utilization of the available frequency spectrum by dividing it into distinct frequency bands,*** enabling multiple users to communicate simultaneously without interference. ***Each user's communication is segregated by frequency,*** ensuring reliable and interference-free transmission.

3. EXPLAIN THE CONCEPT OF MULTIPLE ACCESS WITH COLLISION AVOIDANCE. (2018, 2014)

Multiple Access with Collision Avoidance (MACA) is a protocol ***designed to address the hidden terminal problem*** in wireless communication networks. Here's how MACA works:

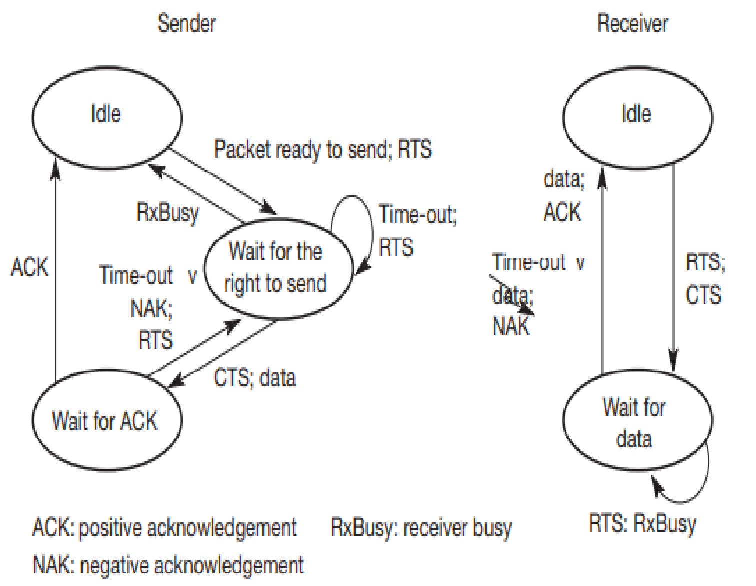


Figure 3.12
Protocol machines for multiple access with collision avoidance

- **Request to Send (RTS):** Before initiating transmission, a station (e.g., station A) ***sends an RTS frame to the intended receiver*** (e.g., station B). The ***RTS includes information such as the sender's and receiver's identities*** and the ***length of the future transmission.*** This ***RTS is not heard by other stations,*** such as station C.
- **Clear to Send (CTS):** Upon receiving the RTS, the intended receiver (station B) responds with a CTS frame, ***acknowledging the RTS.*** The CTS also contains information about the sender (station A), the receiver (station B), and the duration of the future transmission. ***Unlike the RTS, the CTS is heard by all stations within range,*** including station C.
- **Medium Reservation:** Upon receiving the CTS, station C knows that the ***medium will be occupied for the duration indicated in the CTS,*** therefor station C refrains from transmitting data to station B during this time. This ***reservation of the medium prevents collisions at station B during data transmission.***
- **Collision Resolution:** This is a ***way to avoid data loss*** when two or more stations try to send data at the same time. They first send small messages called RTS to ask for permission to send data. If two RTS messages collide, they are not heard by the receiver. The ***receiver then sends a message called CTS to only one station that it heard,*** and tells the others to wait. This way, ***only one station can send data at a time.***

Sender Machine State:

- Idle until data request.
- Issues RTS.
- Waits for CTS.
- Sends data.
- Waits for ACK.
- Retry or idle based on ACK/NAK.

Receiver Machine State:

- Idle awaiting communication.
- Receives RTS.
- Sends CTS if idle.
- Receives data.
- Processes data.
- Sends ACK.
- Returns to idle.

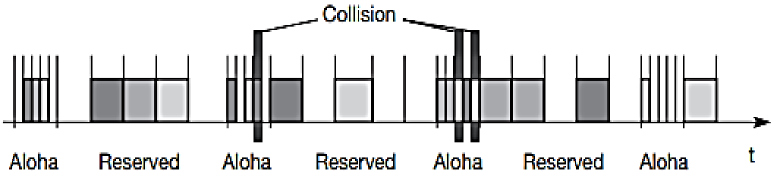
4. EXPLAIN ACCESS METHOD DAMA-PRMA. (2019)

Access Method in Wireless Communication

In wireless communication, with ***multiple devices trying to transmit data over a shared channel,*** collisions can occur if they all transmit simultaneously. An ***access method is a set of rules that devices follow to take turns and avoid collisions.*** It's like having a traffic light system for data transmission, ***ensuring order and reducing wasted attempts.***

Demand Assigned Multiple Access (DAMA)

Figure 3.7
Demand assignment multiple access with explicit reservation



Now, let's talk about DAMA. Imagine a busy highway where cars can't just jump into traffic. DAMA works similarly.

- **Two Modes:** DAMA has two phases: ***contention and transmission.***
- **Contention Phase (Like a Reservation Lane):** During this phase, ***devices compete for slots in the upcoming transmission period using a slotted Aloha scheme.*** Collisions can happen here, but they ***only affect short reservation requests, not actual data.***
- **Transmission Phase (The Highway):** Based on successful reservation requests, devices are assigned specific slots in the transmission period. Collisions are highly unlikely here because each device has a designated slot.
- **Centralized Control:** A ***central entity manages the reservation process*** and ***transmits a reservation list dictating which device gets which slot.***

Packet Reservation Multiple Access (PRMA)

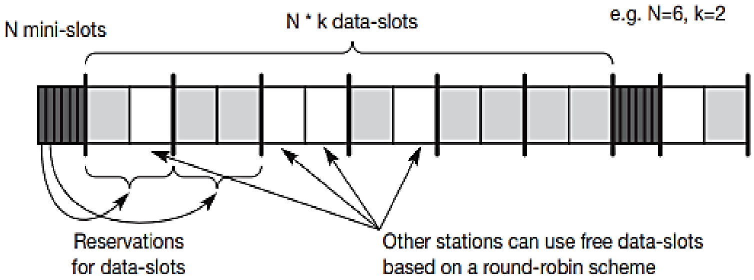


Figure 3.9
Reservation TDMA access scheme

Here, reservations are a bit more implicit, like reserving a seat by leaving your bag on it.

- **Frame Structure:** ***PRMA uses a frame with multiple time slots.*** The base station (like a bus driver) ***broadcasts the status of each slot (occupied or free)*** at the beginning of every frame.
- **Implicit Reservation:** ***Devices use Aloha only for free slots, avoiding collisions with already occupied ones.***
- **Success and Failure:** If multiple devices compete for a free slot, a collision occurs. The ***base station re-broadcasts the status, indicating the failed reservation attempt.***
- **Guaranteed Data Rate:** Once a device successfully reserves a slot, all future slots in that frame are implicitly reserved for it, guaranteeing a data rate.

DAMA vs. PRMA

- **Reservation Style:** DAMA uses ***explicit reservation (requesting a slot),*** while PRMA uses ***implicit reservation (occupying a free slot).***
- **Collision Points:** DAMA allows collisions during reservation, while PRMA only allows collisions in free slots, protecting ongoing transmissions.

4. TELECOMMUNICATION SYSTEMS

1. DRAW SYSTEM ARCHITECTURE OF GSM AND EXPLAIN. (2018, 2019, 2019)

The GSM system has a hierarchical architecture consisting of three main subsystems: **Radio Subsystem (RSS), Network and Switching Subsystem (NSS), and Operation Subsystem (OSS).**

The ***RSS handles wireless transmission between mobile stations and base transceiver stations.*** The NSS manages core network functions such as call ***switching, subscriber data storage, and authentication.*** The OSS oversees ***network operation and performance monitoring.***

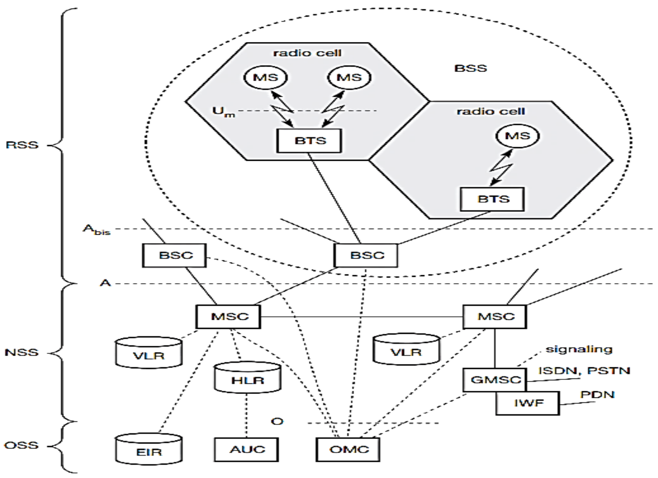


Figure 4.4
Functional architecture of a GSM system

The GSM network can be broken down into three main parts:

1. **Radio Subsystem (RSS):** This handles the radio communication between ***mobile station and the base stations.*** It consists of:
    - **Mobile stations (your phone)**
    - **Base Station Subsystem (BSS):**

      This manages the radio connections and includes:

- **Base station controllers (BSC)** - ***manages multiple cell towers.***
- **Base transceiver stations (BTS)** - the ***actual cell towers that your phone talks to.***

2. **Network and Switching Subsystem (NSS):** This is the brain of the system, ***keeping track of users and calls.*** It ***connects the wireless network to regular phone lines and lets you switch between cell towers while on a call.*** Key parts include:
    - **Mobile switching centre (MSC)** - ***routes calls and manages connections***
    - **Databases:**
        - **Home location register (HLR)** - ***stores information about each user*** (phone number, location, etc.)
        - **Visitor location register (VLR)** - keeps track of phones currently using a specific cell tower
3. **Operation Subsystem (OSS):** This ***monitors and maintains the network for security and performance.*** It includes:
    - **Operation and maintenance centre (OMC)** - ***monitors the network for problems*** and keeps things running smoothly.
    - **Authentication centre (AUC)** - ***verifies the identity of phones*** on the network to prevent unauthorized use.
    - **Equipment identity register (EIR)** - keeps track of which phones are allowed on the network ***(prevents stolen phones from working).***

2. EXPLAIN LOCALIZATION AND CALLING IN GSM WITH NEAT DIAGRAM. (2014, 2019)

Localization in the context of the GSM system refers to the ***process of determining the current geographical location of a mobile station (MS) within the network.*** This is essential for various network functionalities, including ***routing calls to the appropriate MSC (Mobile Switching Centre)*** and ensuring ***seamless service provision such as roaming.***

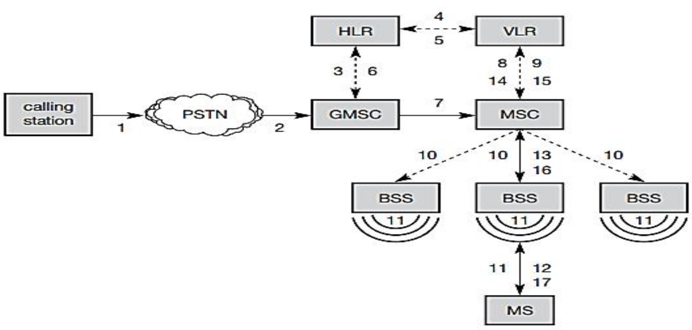


Figure 4.8
Mobile terminated call (MTC)

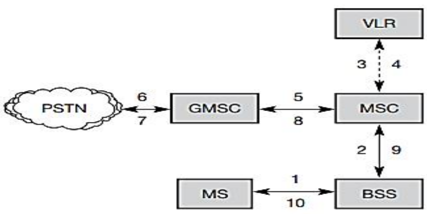


Figure 4.9
Mobile originated call (MOC)

Here's how the process works:

- **Periodic Location Updates:** Even when a user is not actively using their mobile station, the GSM system periodically updates the user's location. This ensures that the ***system always knows where the user is within the network.***
- **HLR (Home Location Register):** The HLR is a ***database that contains subscriber information, including the current location (location area) of the user.*** It ***doesn't store precise geographical coordinates*** but rather the location area.
- **VLR (Visitor Location Register):** The VLR is responsible for users currently within its coverage area. It ***informs the HLR about location changes*** when a mobile station moves into a new location area.
- **Location Area Update:** When a mobile station moves into a new location area ***(covered by a different VLR),*** the ***HLR sends all necessary user data to the new VLR.***
- **Roaming:** ***Moving between different VLRs while maintaining uninterrupted services is called roaming.*** It can occur within one provider's network, between providers in one country ***(national roaming),*** or between different countries ***(international roaming).***

Now, let's discuss the process of calling a GSM subscriber:

The calling process involves the following steps:

1. **Dialling:** The calling party dials the phone number of the called party.
2. **Call Setup:** The ***MSC receives the dialling request, queries the HLR to determine the current location of the called party.***
3. **Connection:** The MSC ***sets up a connection between the calling party's and called party's base stations.***
4. **Conversation:** Voice or data communication occurs between the calling and called parties.
5. **Call Termination:** Either party ends the call.
6. **End Call:** The ***MSC terminates the call and releases resources.***

This process ensures that the ***call is properly routed to the GSM subscriber regardless of their current location within the network.***

3. DRAW AND EXPLAIN DECT SYSTEM ARCHITECTURE (2012, 2013, 2018, 2018, 2019)

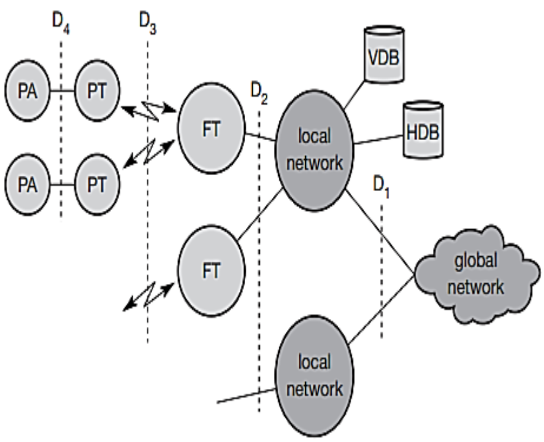


Figure 4.18
DECT system architecture reference model

DECT, which stands for Digital Enhanced Cordless Telecommunications, is a ***digital cellular network system widely used for cordless communication.*** Let me explain the DECT system architecture according to the provided information:

System Architecture:

1. **Global Network Interface (D1)**: The DECT system interfaces with external networks such as ISDN, PSTN, PLMN (e.g., GSM), or PSPDN to provide services like ***data transportation and address translation.*** This interface ***connects the local DECT network to the outside world.***

2. **Local Networks**: Within the DECT context, l***ocal networks provide telecommunication services locally.*** These networks can include ***private branch exchanges (PBXs), LANs*** following ***IEEE 802.x standards,*** or other similar networks. Local networks handle functions like ***switching, call forwarding,*** and ***address translation.***

3. **Home Database (HDB) and Visitor Database (VDB)**: These ***databases support mobility within the DECT system.*** Similar to ***Home Location Register (HLR) and Visitor Location Register (VLR)*** in GSM systems, HDB and VDB store user data and handle functions related to user ***mobility and call routing.***

4. **DECT Core Network**: The ***core network comprises the Fixed Radio Termination (FT) and the Portable Radio Termination (PT).*** FT and PT ***handle layers one to three of the OSI model*** at the ***fixed network side and mobile network side,*** respectively. They primarily provide ***multiplexing services*** for communication within the DECT system.

5. **Portable Applications (PA)**: Portable Applications can be implemented on DECT devices to provide additional functionalities beyond basic communication services. These applications ***enhance the versatility and usability of DECT devices.***

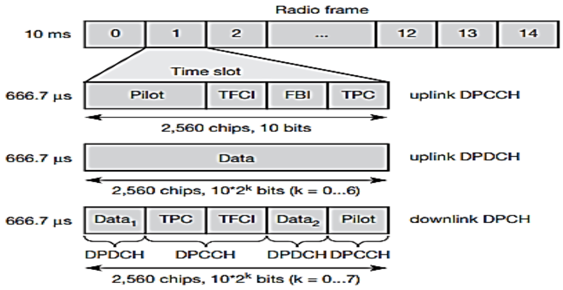
Overall, the DECT system architecture ***facilitates cordless communication by integrating local and global networks,*** supporting ***mobility,*** and providing essential services for seamless communication within the DECT system.

4. DRAW AND EXPLAIN UTRA-FDD (W-CDMA) FRAME STRUCTURE. (2014)

UTRA stands for Universal Terrestrial Radio Access, which is a ***standard for third-generation (3G) mobile telecommunications systems.*** Specifically, UTRA-FDD (Frequency Division Duplex) is a mode of UTRA that ***utilizes Wideband Code Division Multiple Access (W-CDMA) with direct sequence spreading.***

In UTRA-FDD, ***uplink and downlink transmissions occur on separate frequency bands.*** For instance, in Europe, the ***uplink transmission from mobile stations typically occurs between 1920 and 1980 MHz,*** while the ***downlink transmission from base stations occurs between 2110 and 2170 MHz.***

Figure 4.28
UTRA FDD (W-CDMA) frame structure



The frame structure of UTRA-FDD, depicted in Figure 4.28, ***consists of 15 time slots.*** Unlike other systems like GSM, where ***time slots are used for user separation,*** in UTRA-FDD, time slots primarily support ***periodic functions.*** Each ***radio frame in UTRA-FDD comprises 38,400 chips*** and has a ***duration of 10 milliseconds (ms).*** Within each frame, ***time slots consist of 2,560 chips,*** which approximately equals ***666.6 microseconds (µs).***

Key components of the UTRA-FDD frame structure include:

1. **Dedicated Physical Data Channel (DPDCH):** This channel ***carries user or signalling*** data. The ***spreading factor of the DPDCH can vary between 4 and 256,*** leading to different data rates ranging from ***15 kbit/s to 960 kbit/s per slot.***

2. **Dedicated Physical Control Channel (DPCCH):** Each ***connection in layer 1 requires one DPCCH.*** This channel ***conveys control data for the physical layer,*** including ***channel estimation, transport format combination identifier (TFCI), signalling for handover,*** and ***transmit power control (TPC).***

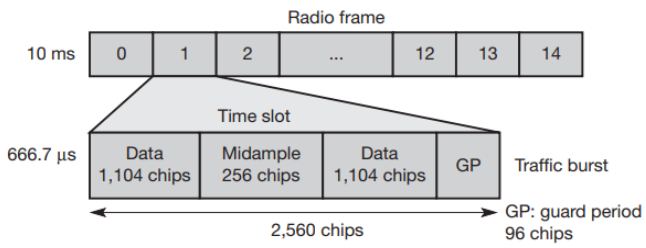
3. **Dedicated Physical Channel (DPCH):** The ***downlink multiplexes control and user data. Spreading factors between 4 and 512 are available,*** with various burst formats defined. The data rates for data channels within a DPCH range from ***6 kbit/s to 1,872 kbit/s.***

In addition to these channels, a ***Physical Random-Access Channel (PRACH)*** is used ***on the uplink*** for ***medium access coordination.***
Overall, UTRA-FDD (W-CDMA) frame structure ***efficiently facilitates uplink and downlink transmissions,*** providing ***high-speed data connectivity*** and enabling ***mobile telecommunications services.***

5. EXPLAIN UTRA-TDD. (2013, 2017)

UTRA-TDD, the second mode within the Universal Terrestrial Radio Access (UTRA) system, ***separates uplink and downlink transmissions in time.*** It utilizes a frame structure akin to FDD, ***comprising 15 slots with 2,560 chips per slot, resulting in a 10 ms radio frame duration.*** The ***chipping rate is 3.84 Mchip/s.***

Figure 4.29
UTRA TDD (TD–CDMA) frame structure



To cater to diverse user data rate requirements, the TDD frame can be ***configured symmetrically or asymmetrically,*** allowing for various combinations of ***uplink and downlink slots.*** The ***frame can feature one or multiple switching points from uplink to downlink,*** although at least one slot must be allocated for each direction.

The ***system can dynamically adjust the spreading factor (1, 2, 4, 8, 16) to accommodate desired data rates.*** Using a specified burst type, ***data rates ranging from 414 kbit/s to 6,624 kbit/s are attainable,*** assuming all slots are utilized for data transmission.

In TDD, ***all stations employ the same scrambling codes, necessitating tight synchronization.*** Spreading codes are available only once per slot, limiting simultaneous sending stations to a maximum of 16. A ***guard period (GP) at the end of each slot aids in synchronization.***

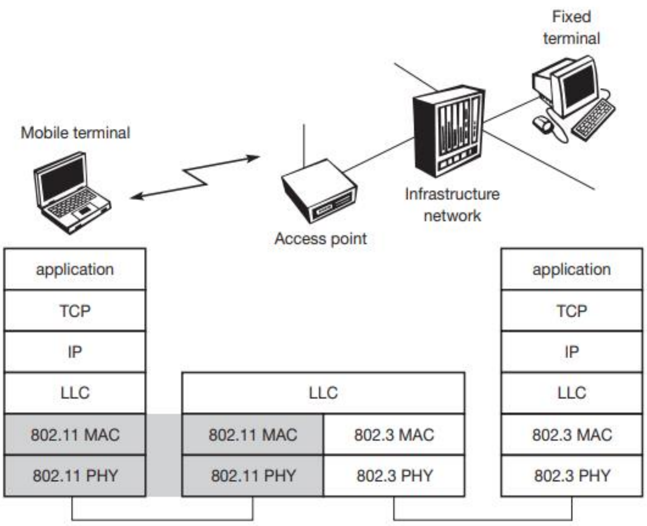
UTRA-TDD ***occupies 5 MHz bandwidth per channel,*** similar to UTRA-FDD, but with ***lower licensing costs.*** However, ***coverage per cell is lower than FDD, and user equipment movement must be controlled to optimize performance,*** resembling characteristics of WLANs.

Overall, UTRA-TDD offers ***flexibility in resource allocation and cost-effectiveness,*** albeit with limitations in coverage and mobility support compared to FDD.

6. EXPLAIN PROTOCOL ARCHITECTURE AND BRIDGING OF IEEE 802.11. (2012, 2014, 2017)

The protocol architecture of IEEE 802.11, which ***governs wireless local area networks (LANs),*** encompasses ***several layers and functionalities*** to ensure ***efficient and reliable communication.*** Here's an explanation of its components:

Figure 7.5
IEEE 802.11
protocol architecture
and bridging



1. Physical Layer (PHY):

The physical layer deals with the actual transmission of data over the wireless medium.

It is subdivided into two sublayers:

- **Physical Layer Convergence Protocol (PLCP):** Responsible for tasks like ***modulation, encoding, and decoding of signals.***
- **Physical Medium Dependent Sublayer (PMD):** Handles the specifics of the physical medium, such as ***frequency bands and modulation techniques.***

2. Medium Access Control (MAC) Layer:

The ***MAC layer governs access to the wireless medium,*** ensuring that multiple devices can share the same channel without causing interference.

It performs tasks such as ***medium access, fragmentation of user data, and encryption.***

It includes functions like ***carrier sense*** and provides a ***common interface (SAP) for accessing the PHY layer.***

3. Logical Link Control (LLC) Layer:

Situated above the MAC layer, ***LLC handles the differences in medium access control layers required for different media types.***

It ***ensures compatibility between the higher layers (application, TCP, IP) for both wired and wireless nodes.***

4. Management Layers:

IEEE 802.11 standard also specifies management layers for ***configuration, control, and maintenance of the wireless network.***

- **MAC Management:** Supports functions like ***association and re-association of stations with access points, authentication, encryption, synchronization, and power management.***
- **PHY Management:** Handles tasks such as ***channel tuning and maintenance of PHY Management Information Base (MIB).***
- **Station Management:** Responsible for higher-layer functions, such as ***control of bridging and interaction with the distribution system*** in the case of an access point.

Overall, the protocol architecture of ***IEEE 802.11 ensures seamless integration with existing wired LAN standards (such as IEEE 802.3 Ethernet)***, allowing applications to operate across both wired and wireless networks with minimal differences perceived by end-users.

7. EXPLAIN BASIC STRUCTURE OF IEEE 802.11 MAC PACKET STRUCTURE. (2013, 2018, 2019)

The IEEE 802.11 MAC (Media Access Control) packet structure comprises various elements that ***facilitate wireless communication.*** Here's a breakdown of its basic structure:

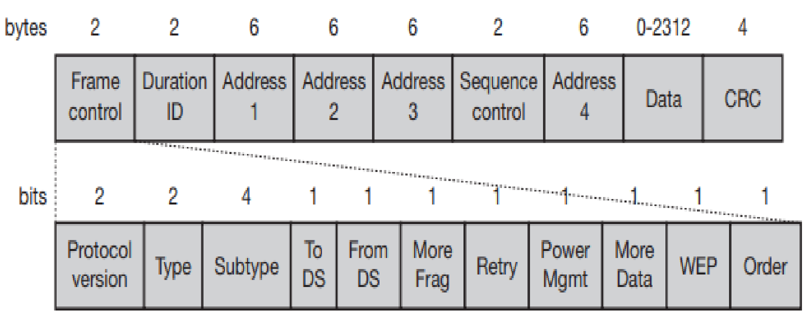


Figure 7.16
IEEE 802.11 MAC packet structure

1. **Frame Control:** The initial ***2 bytes hold essential information about the frame,*** including the ***protocol version, frame type (management, control, or data), and subtype.***

2. **Duration/ID:** Specifies the ***duration of medium occupancy*** or contains an identifier if the value is above a certain threshold. Used for setting ***NAV (Network Allocation Vector)*** during processes like ***RTS/CTS (Request to Send/Clear to Send) and fragmentation.***

3. **Address Fields (1 to 4):** Four fields ***holding MAC addresses*** (48-bit each) for ***source, destination, and potentially other entities involved in the communication,*** depending on the ***Distribution System bits.***

4. **Sequence Control:** ***Prevents frame duplication*** by assigning a sequence number to each frame.

5. **Data:** Carries the actual payload data, with a ***maximum size of 2,312 bytes,*** transferred transparently between sender and receiver.

6. **Checksum (CRC):** A ***32-bit*** checksum ***ensures frame integrity,*** a standard practice across 802.x networks.

The ***Frame Control field, crucially, determines the frame's purpose and operation,*** including its version, type, and subtype. Other subfields in the Frame Control include flags indicating characteristics like ***fragmentation, retry status, power management mode, and presence of more data to send.***

Furthermore, the 'to DS' and 'from DS' bits within the Frame Control field ***differentiate between transmissions within mobile stations, between mobile stations and access points, and between access points over a Distribution System.*** These ***bits control the interpretation of the four address fields,*** ensuring ***proper routing and identification of communication entities.***

Overall, the IEEE 802.11 MAC packet structure ***provides a standardized framework for wireless communication,*** accommodating various types of frames and ensuring ***efficient and reliable data transfer.***

8. DRAW AND EXPLAIN ARCHITECTURE OF AN INFRASTRUCTURE BASED 802.11/ DRAW AND EXPLAIN INFRASTRUCTURE AND AD-HOC NETWORKS. (2013, 2019, 2019)

Wireless networks can be structured in two fundamental system architectures: ***infrastructure-based and ad-hoc.*** Here's an explanation of both:

Infrastructure-Based Architecture:

In this architecture, ***wireless stations (STAs) are connected to access points (APs).*** ***Stations have access mechanisms to the wireless medium*** and establish radio contact with the AP.

Stations and APs within the same radio coverage form a ***Basic Service Set (BSS).***

Multiple BSSs, connected via a distribution system, form an ***Extended Service Set (ESS)*** which extends the coverage area.

The ESS has its own identifier called the ***Extended Service Set Identifier (ESSID),*** which separates different networks.

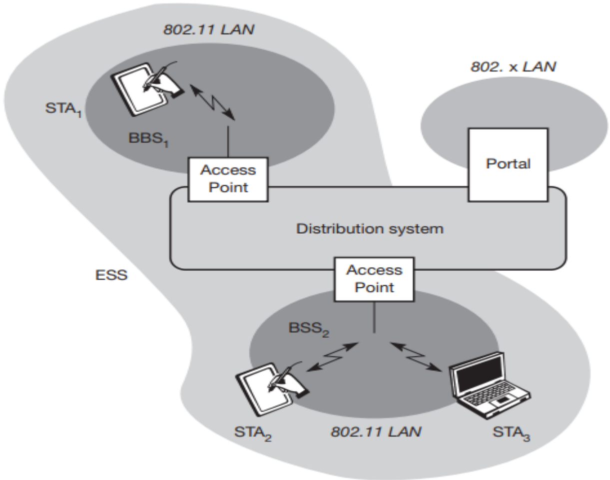


Figure 7.3 Architecture of an infrastructure-based IEEE 802.11

The ***distribution system connects wireless networks via APs to other LANs,*** acting as an ***interworking unit.***

The distribution system architecture is ***not specified in IEEE 802.11*** and can consist of various network types such as bridged ***IEEE LANs.***

APs support ***roaming, synchronization within a BSS, power management, and medium access control*** to support time-bounded services.

Ad-Hoc Architecture:

In this architecture, ***stations form independent Basic Service Sets (IBSS) without the need for APs.***
Stations within the same IBSS communicate directly with each other ***using the same radio frequency.***

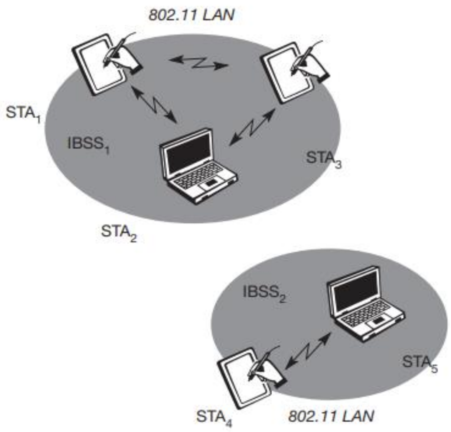


Figure 7.4 Architecture of IEEE 802.11 ad-hoc wireless LANs

Multiple IBSSs can be formed based on the distance between them or by ***using different carrier frequencies.***

IEEE 802.11 does not specify special nodes for ***routing, forwarding data, or exchanging topology information within ad-hoc networks.***

Overall, ***infrastructure-based architectures provide centralized connectivity through APs and distribution systems, whereas ad-hoc architectures enable decentralized peer-to-peer communication between stations without the need for infrastructure components like APs.***

9. EXPLAIN FORMING OF BLUETOOTH PICONET WITH SUITABLE DIAGRAM. (2014, 2017, 2019)

The formation of a Bluetooth piconet involves several key steps to synchronize devices and establish communication:

Channel and Frequency Usage: Bluetooth operates on ***79 channels within the 2.4 GHz band,*** with ***1 MHz carrier spacing.*** Each device employs ***frequency hopping spread spectrum (FHSS) with 1,600 hops per second*** in a pseudo-random manner, facilitating interference mitigation and network separation.

Piconet Concept: A piconet is a ***collection of Bluetooth devices synchronized to the same hopping sequence.*** Within a piconet, ***one device acts as the master (M), while all other connected devices act as slaves (S).*** The master dictates the hopping pattern, and slaves synchronize to it. ***Each piconet has a unique hopping pattern.***

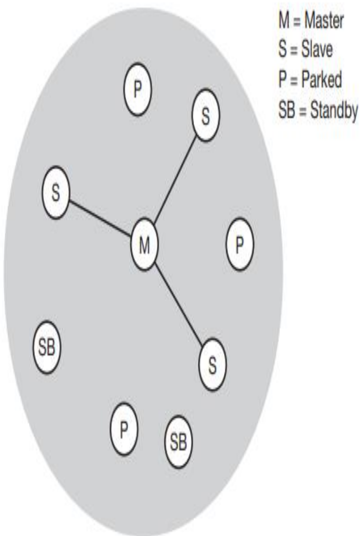
Device Roles: Additional device roles include ***parked devices (P), which are inactive but known and can be reactivated quickly,*** and ***stand-by devices (SB), which do not participate in the piconet.*** A ***piconet can have one master and up to seven simultaneous slaves,*** with ***more than 200 devices capable of being parked.***

Piconet Formation: The formation of a piconet involves the ***master sending its clock and device ID. All Bluetooth devices have the capability to be either master or slave.*** The ***unit initiating the connection automatically becomes the master,*** and other devices become slaves. The hopping pattern is determined by the device ID, with the master's clock dictating the phase in the hopping pattern.

Address Assignment: ***Active devices within the piconet are assigned a 3-bit active member address (AMA),*** while ***parked devices use an 8-bit parked member address (PMA).*** Devices in stand-by mode do not require an address.

Overall, the formation of a Bluetooth piconet involves ***synchronization of devices, assignment of roles and addresses,*** and sharing of resources within the piconet's hopping sequence and channel bandwidth.

Figure 7.41 Simple Bluetooth piconet



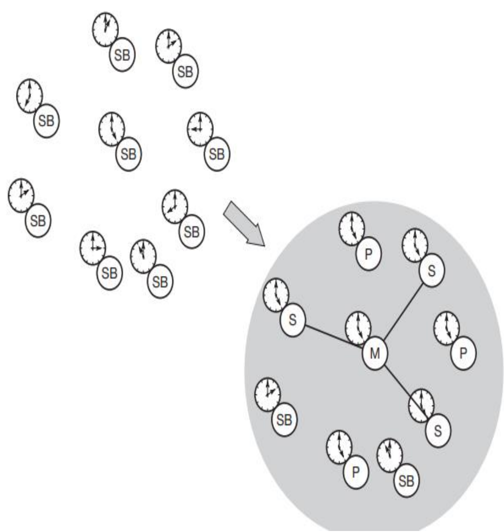


Figure 7.42 Forming a Bluetooth piconet

10. EXPLAIN MOBILE ORIGINATING CALL. (2018)

The process of performing a mobile originated call (MOC) within the GSM network is comparatively simpler than a mobile terminated call (MTC). Here's how it works:

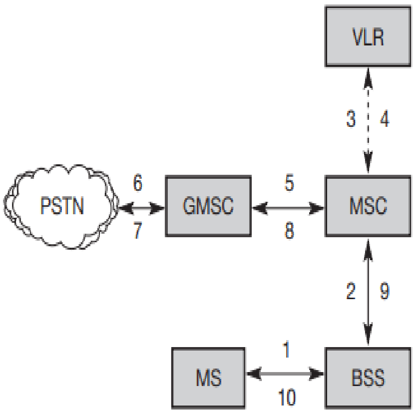


Figure 4.9
Mobile originated call (MOC)

Initiation by the Mobile Station (MS):

- The ***mobile station transmits a request for a new connection.***
- The ***Base Station Subsystem (BSS) forwards this request to the Mobile Switching Centre (MSC).***

Verification and Resource Availability Check by MSC:

- The ***MSC checks if the user is allowed to set up a call with the requested service.***
- It also checks the availability of resources within the ***GSM network and the Public Switched Telephone Network (PSTN).***

Connection Setup:

- If all resources are available, the MSC establishes a connection between the ***mobile station and the fixed network.***

Message Exchange between MS and BTS:

- During connection setup, various messages are exchanged between the mobile station and the Base Transceiver Station (BTS) to ensure proper ***authentication, encryption setup, and channel assignment.***

Alerting and Connection Establishment:

- Once the setup is completed, if someone is calling the mobile station, it responds with 'alerting' indicating that the MS is ringing, and with 'connect' when the user presses the connect button.
- Similar actions happen in reverse if the MS has initiated the call.
- After connection acknowledgment, both parties can exchange data.

Closing the Connection:

- Closing the connection involves a user-initiated disconnect message from either side.
- This is followed by releasing the connection and freeing the radio channel.

5. WIRELESS ATM

1. EXPLAIN WATM SERVICES. (2012, 2017)

ATM (Asynchronous Transfer Mode): ATM is a ***cell-based switching and multiplexing technology*** that was ***developed for high-speed data communication in broadband networks.*** Here are the key aspects of ATM:

1. **Cell Switching**: In ATM, data is divided into small, ***fixed-size cells (53 bytes),*** consisting of a ***5-byte header and a 48-byte payload.*** These ***cells are transmitted over virtual circuits,*** which are ***logical connections established between the source and destination.***
2. **Asynchronous Multiplexing:** ATM supports the transmission of different types of traffic ***(voice, video, data)*** over the same network by ***multiplexing cells from different sources onto a single physical link.*** This is done asynchronously, meaning that cells from different sources can be interleaved without any specific timing relationship.
3. **Virtual Circuits:** ATM uses ***virtual circuits, which are end-to-end connections established between the source and destination.*** These virtual circuits are identified by unique ***virtual path identifier (VPI) and virtual channel identifier (VCI)*** values in the cell header.
4. **Quality of Service (QoS):** ATM provides different levels of QoS by assigning ***different traffic classes to different virtual circuits.*** This allows ***time-sensitive applications like voice and video to be prioritized*** over non-time-critical data traffic.
5. **Connection-Oriented:** ATM is a connection-oriented technology, meaning that a ***virtual circuit must be established before data can be transmitted.*** This allows for ***efficient resource allocation and QoS guarantees.***
6. **Scalability:** ATM is designed to be highly scalable, supporting data rates from a few ***megabits per second (Mbps)*** up to ***gigabits per second (Gbps).***

WATM (Wireless Asynchronous Transfer Mode):

WATM is an extension of ATM technology to wireless networks. ***It aims to bring the benefits of ATM, such as high bandwidth, low latency, and QoS guarantees, to wireless communication systems.*** Here are the key aspects of WATM:

1. **Wireless ATM Adaptation Layer (WATM-AL):** WATM introduces a new adaptation layer called the Wireless ATM Adaptation Layer (WATM-AL). This layer is responsible for adapting the ***ATM cell stream to the wireless environment,*** handling issues like ***error control, retransmission,*** and ***efficient use of the wireless medium.***
2. **Wireless ATM Terminals:** WATM involves the use of Wireless ATM Terminals, which are ***devices capable of establishing ATM connections over wireless links.*** These ***terminals can be mobile or fixed*** and can ***communicate with base stations or access points*** that are connected to the ATM network.
3. **Mobility Support:** WATM supports mobility by enabling seamless handover of ATM connections between different wireless access points or base stations as the terminal moves. This ***ensures uninterrupted communication and maintains the QoS requirements of the ongoing connections.***

4. **Integration with ATM Networks:** WATM is ***designed to integrate seamlessly with existing ATM networks,*** allowing wireless terminals to access the same services and applications as wired ATM devices.

WATM services encompass various functionalities to support ***mobility and provide seamless connectivity within ATM networks.*** Here's an explanation of these services:

ATM Mobility Extension Service (AMES):

- AMES ***facilitates mobility within ATM networks*** for different equipment and applications.
- It ***ensures that wireless devices receive equivalent services as wired terminals, allowing users to rearrange devices without losing network access or compromising service quality.***

Personal Cellular System (PCS) Access Service:

- WATM offers PCS access services, enabling PCSs like ***GSM, IS-95, and UMTS*** to utilize the mobility capabilities of fixed ATM networks.
- ***Public services*** provided to users include ***multimedia telephony, symmetric services offering speech and low bit-rate video with medium mobility, as well as asymmetrical services for real-time online data transfer such as web browsing, email, and file downloads.***
- ***Private services*** may include ***high-quality multimedia telephony*** and ***specialized data transfer services*** for specific applications.

Satellite ATM Services (SATM):

- SATM offers a wide range of services including ***TV, interactive video, multimedia, internet, and telephony via satellites.*** SATM's main ***advantage lies in its ubiquitous wide-area coverage, serving remote, rural, and urban areas.***
- SATM ***supports direct user access*** where devices like ***mobile phones or terminals with antennas connect directly to the ATM network via satellite.*** Additionally, ***SATM enables fixed access services*** where entire networks, such as those in schools or remote areas, can connect to a satellite through a ***mobile switch.***

2. DRAW AND EXPLAIN WATM REFERENCE MODEL. (2012, 2013, 2017, 2018, 2019, 2019)

The **Wireless ATM (WATM)** reference model ***outlines the architecture for enabling wireless mobile access to an Asynchronous Transfer Mode (ATM) network.*** Here's an explanation of the components and their functions within this reference model:

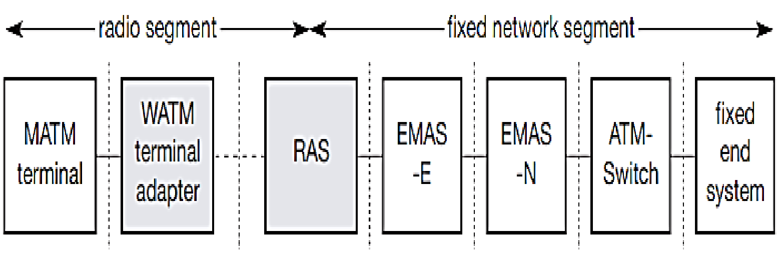


Figure 7.28
Example of a generic WATM reference model

- **Mobile ATM (MATM) Terminal:** This represents the ***wireless device seeking access to the ATM network.*** MATM terminals, such as ***laptops equipped with ATM adapters for wired access, utilize a WATM Adapter to gain wireless connectivity with the ATM network.***
- **WATM Terminal Adapter:**
  The WATM Terminal Adapter ***facilitates wireless access*** by providing the ***necessary transceiver components.***
- **WATM Radio Access System (RAS):**
  The ***RAS consists of radio transceivers responsible for establishing wireless communication with MATM terminals.*** It ***acts as an intermediary between the wireless terminals and the ATM network.***
- **Enhanced Mobility ATM Switch (EMAS-E):**
  The EMAS-E is a mobility-enhanced ATM switch that ***handles mobility-related functions within the network.*** It connects to the ***RAS and interfaces*** with other mobility-aware switches.
- **Mobility Aware Switches (EMAS-N):**
  These switches, also mobility-aware, are ***part of the fixed mobility support network.*** They ***facilitate seamless mobility management within the ATM network and ensure uninterrupted service as mobile devices move between access points.***
- **Standard ATM Switches:** The standard ATM switches are ***part of the conventional ATM network and do not inherently support mobility functions.***
- **Fixed End System:** This ***represents the communication partner within the network,*** which may be a wired. It ***communicates with MATM terminals through the fixed network segment.***

3. EXPLAIN HANDOVERS IN WATM. (2013)

Handover in a Wireless ATM (WATM) environment is a critical aspect, particularly due to the ***stringent quality of service (QoS) requirements and the connection-oriented nature of ATM technology.***

Unlike ***connectionless protocols*** such as ***mobile IP or IEEE 802.11 with IAPP,*** which ***focus on packet rerouting without guaranteeing specific traffic parameters,*** WATM must ensure seamless handover while ***maintaining connection quality and adhering to QoS requirements.***

Several ***key requirements and challenges*** associated with handover in WATM networks have been identified:

Handover of Multiple Connections:

- ***WATM must support handover for multiple connections simultaneously,*** as ***ATM technology allows end-systems to maintain numerous connections concurrently.***
- This involves ***rerouting all connections*** after handover, potentially leading to ***resource constraints or QoS degradation. Terminals may need to prioritize connections or accept lower-quality service for some connections to maintain overall performance.***

Handover of Point-to-Multi-Point Connections:

- WATM handover should seamlessly support point-to-multi-point connections, a ***significant advantage of ATM technology.*** However, the complexity of ***managing such connections may face certain limitations or restrictions.***

QoS Support:

- Handover procedures should aim to ***preserve the QoS parameters of all connections during the transition.*** However, ***due to resource limitations, maintaining consistent QoS for all connections may not always be feasible.***
- ***QoS renegotiation mechanisms and prioritized connection dropping*** may be necessary to optimize handover performance.

Data Integrity and Security:

- WATM handover processes should ***minimize cell loss, avoid duplication or reordering of cells,*** and ***ensure the security*** between terminals and the ***network remain intact throughout the handover process.***

Signalling and Routing Support:

- WATM networks must provide mechanisms for identifying ***mobility-enabled switches, radio adjacent switches, and rerouting partial connections*** within the handover domain to ***ensure seamless transition.***

Performance and Complexity:

- Handover functionality in WATM systems should ***strive for simplicity to minimize complexity and processing overhead.***
- Modifications to ***mobility-enabled switches should be kept minimal to avoid disrupting network performance,*** while ***terminal-side handover code should be lightweight*** to conserve battery power in mobile devices.

4. EXPLAIN LOCATION MANAGEMENT FOR WATM. (2014, 2019)

Location management in a Wireless ATM (WATM) environment is ***essential for seamlessly supporting mobility*** while ensuring ***security, efficiency, and scalability.***

It ***encompasses various functions aimed at tracking the current position of mobile terminals, providing them with permanent addresses,*** and ensuring security features such as ***privacy, authentication, and authorization.***

Several ***key requirements and considerations*** for effective location management in WATM networks have been identified:

Transparency of Mobility:

- Location management functions should ***operate seamlessly in the background without requiring user intervention.*** Any ***change in the terminal's location should be handled automatically, enabling transparent roaming*** between different domains and networks based on different technologies.

Security:

- To ensure the security and privacy of user information, robust security measures must be implemented. This includes ***protecting location and user data against unauthorized access or disclosure,*** especially for roaming profiles that enable precise tracking of terminals.
- ***Authentication of users, terminals, and access points,*** as well as ***encryption of communication channels,*** are crucial for maintaining security in WATM networks.

Efficiency and Scalability:

- With the potential for millions of users, location management systems in WATM networks must be highly scalable and efficient.
- Distributed servers for ***location storage, accounting, and authentication*** should be able to handle the network's size and load effectively. ***Clustering of switches and hierarchical domain structures*** can help distribute the load and enhance overall system performance.

Identification:

- All entities within the network, ***including radio cells, terminals, and switches,*** require ***unique identifiers and mechanisms for exchanging identity information.***
- Terminals should have both ***permanent and temporary addresses.***

Inter-working and Standards:

- Location management functions in WATM networks ***must interoperate with existing ATM functions from the fixed network, ensuring compatibility with routing protocols and other location management schemes such as Mobile IP.***
- Standardization of protocols for database ***updates, registration, and other operations is crucial for enabling mobility across provider network boundaries*** while allowing for proprietary enhancements within administrative domains.

6. MOBILE NETWORK LAYER

1. EXPLAIN IP PACKET DELIVERY TO AND FROM THE MOBILE NODES / EXPLAIN MOBILE NODE, CORRESPONDING NODE, FOREIGN AGENT AND CARE OF ADDRESS OF MOBILE IP (2019, 2019, 2018, 2018, 2013)

To explain the IP packet delivery to and from mobile nodes (MN) using the example network depicted in Figure.

let's break down the process with the help of entities and terms:

Packet Delivery to MN (From Correspondent Node CN):

- **Correspondent Node (CN):** Initiates the packet transmission with the ***MN's IP address as the destination.***
- **Internet Routing:** The packet is routed through the internet to the router responsible for the MN's home network based on standard routing mechanisms.

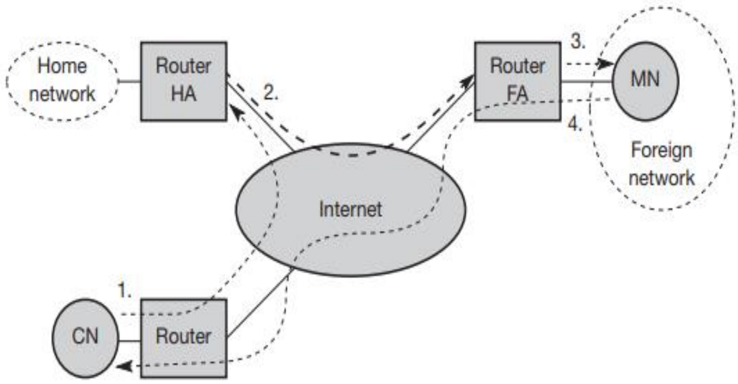


Figure 8.2
Packet delivery to and from the mobile node

s

- **Home Agent (HA):** Recognizes that the MN is not in its home network and ***intercepts the packet.***
- **Encapsulation and Tunnelling:** Instead of forwarding the packet as usual, the HA encapsulates and tunnels it to the Care-of-Address (COA), adding a ***new header with the COA as the destination and HA as the source.***
- **Foreign Agent (FA):** Receives the encapsulated packet and performs decapsulation, removing the additional header.
- **Delivery to MN:** Forwards the original packet with CN as the source and MN as the destination to the MN.
- **Mobility Concealment:** MN receives the packet with unchanged sender and receiver addresses, concealing its mobility.

Packet Delivery from MN (To Correspondent Node CN):

- **MN:** Sends the packet with its fixed IP address as the source and CN's address as the destination.
- **Foreign Network Router (with FA):** Acts as the default router and forwards the packet within the foreign network.
- **Internet Routing:** The packet is routed through the internet to reach the CN, following standard routing procedures.

In summary, the ***delivery of IP packets to and from*** mobile nodes involves ***interception, encapsulation, tunnelling, and decapsulation processes,*** ensuring seamless communication while concealing the mobility of the mobile nodes.

2. EXPLAIN TRADITIONAL TCP IN DETAIL. (2019, 2014, 2017, 2018)

Traditional TCP, also referred to as TCP designed for wired networks, is a fundamental concept in understanding ***reliable data transfer across the internet.*** Let's break it down step-by-step, along with its prerequisite concepts:

Prerequisite Concepts:

1. **Network Layers:** The ***internet functions through a layered model,*** with each layer handling specific tasks. TCP operates at the **Transport Layer**, which is ***responsible for reliable data delivery between applications on different devices.***

2. **Packets and Segments:** Data travels through the network in smaller units called packets. TCP groups data into its own units named **segments** and ***adds sequence numbers for proper reassembly at the receiver's end.***

Understanding Traditional TCP:

1. **Connection Establishment (Three-way Handshake):** Before data transfer, TCP initiates a connection using a ***three-way handshake.*** The sender sends a ***SYN (Synchronize) packet,*** the receiver responds with a ***SYN-ACK (Synchronize Acknowledgement) packet,*** and finally, the ***sender acknowledges the receiver's SYN with an ACK (Acknowledgement) packet.*** This establishes a connection and synchronizes the sequence numbers.
2. **Reliable Data Delivery:** Traditional TCP prioritizes reliable data delivery. Here's how it achieves this:
   - **Sequencing:** Each ***segment has a unique sequence number,*** ensuring the receiver can order them correctly.
   - **Acknowledgements (ACKs):** The receiver sends ACKs for received segments, informing the sender.
   - **Retransmissions:** If an ACK isn't received within a timeout period, the sender assumes packet loss and retransmits the missing segment.
3. **Flow Control:** TCP prevents overwhelming the receiver with data. It uses a **congestion window**, notified by the receiver, that ***specifies the number of bytes the sender can transmit before waiting for an ACK.*** This ***window size adjusts dynamically*** based on network conditions.
4. **Congestion Control:** Traditional TCP employs mechanisms to avoid overwhelming the network during congestion. Here are two key points:
   - **Slow Start:** Initially, the ***sender transmits cautiously, gradually increasing the transmission rate*** based on received ACKs.
   - **Congestion Window Adjustment:** ***Upon detecting packet loss*** (due to congestion), the ***congestion window shrinks,*** reducing the transmission rate.

Traditional TCP vs. Modern TCP Variants:

It's important to note that ***traditional TCP is primarily designed for wired networks.*** Modern variants of TCP exist to address the challenges of wireless networks, such as ***frequent handoffs and varying bandwidth.*** These variants often employ additional techniques for better performance in such environments.

3. DRAW AND EXPLAIN AGENT DISCOVERY FOR MOBILE IP. (2014)

Agent discovery is a process in Mobile IP (Internet Protocol) that ***enables a mobile node (MN) to discover foreign agents (FAs) within a visited network.*** Foreign agents are routers that ***assist in routing packets to and from the mobile node when it is away from its home network.*** Agent discovery is crucial for mobile nodes to maintain seamless communication while roaming.

Agent Advertisement:

In Agent Advertisement, foreign agents periodically broadcast advertisement messages on the local network, informing mobile nodes of their presence and availability to provide services.

Broadcasting Advertisement Messages: Foreign agents broadcast Agent Advertisement messages at regular intervals on the local network.

1. **Contents of Advertisement Messages:** These messages contain information such as the ***IP address of the foreign agent, its capabilities,*** and other parameters necessary for mobile nodes to establish communication.
2. **Reception by Mobile Nodes:** Mobile nodes within range of the foreign agent receive these advertisement messages.
3. **Selection of Foreign Agent:** Based on the information received in the advertisement messages, the mobile node selects a suitable foreign agent to register with for routing its traffic while in the visited network.

Agent Solicitation:

In Agent Solicitation, the mobile node actively seeks foreign agents by sending solicitation messages onto the local network. Here's how it works:

1. **Sending Solicitation Messages:** When a mobile node enters a visited network, it sends out Agent Solicitation messages onto the local network.
2. **Contents of Solicitation Messages:** These messages request foreign agents present in the network to respond with their information, including their IP address and capabilities.
3. **Response by Foreign Agents:** Foreign agents present on the local network receive the solicitation messages and respond with advertisement messages containing their information.
4. **Reception by Mobile Node:** The mobile node receives the advertisement messages from foreign agents and selects a suitable agent to register with for routing its traffic.

4. EXPLAIN INDIRECT TCP. (2012)

Indirect TCP (I-TCP) was developed as a ***solution to address the challenges of using traditional TCP over wireless links without altering the existing TCP protocol*** used in fixed networks. Here's a breakdown of how I-TCP works:

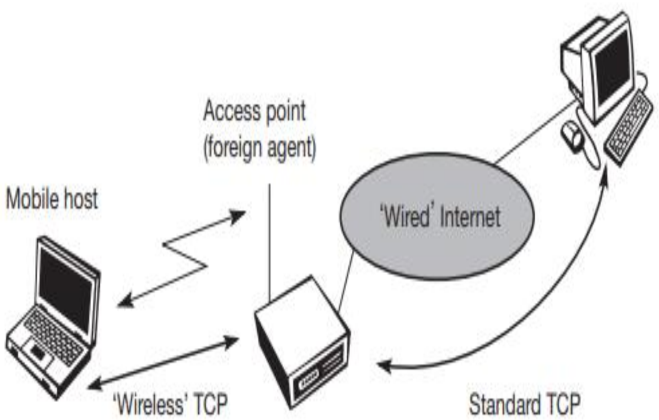


Figure 9.1
Indirect TCP segments a TCP connection into two parts

Segmentation of TCP Connection:

- I-TCP divides a TCP connection into two parts: ***fixed part and wireless part.*** In the fixed network, standard TCP is utilized between the fixed computer and the access point, ***ensuring compatibility with existing systems.***
- However, between the access point and the mobile host, a specialized TCP variant, adapted for wireless links, is employed. This ***segmentation allows for optimization of the wireless segment without requiring changes to the TCP protocol*** used in the fixed network.

Proxy Functionality:

- The ***access point acts as a proxy,*** terminating the standard TCP connection from the fixed host and initiating a separate TCP connection with the mobile host.
- This proxy behaviour ***ensures seamless communication between fixed and mobile hosts without any modifications to TCP*** at the fixed end.
- The foreign agent, typically involved in mobile IP, ***facilitates this proxying and manages the mobility*** of the mobile host.

Transparent Operation:

- From the perspective of the correspondent host in the fixed network, there is ***no awareness of the wireless link or the segmentation of the connection.***
- The ***foreign agent acts as an intermediary, relaying data between the fixed and mobile hosts in both directions.***
- ***Packet loss on the wireless link is detected and handled locally by the foreign agent,*** ensuring reliable data transport without impacting the fixed network.

Handover Support:

- During handovers, where the mobile host moves between access points or foreign agents, I-TCP requires several actions to maintain connectivity.
- This includes ***redirecting packets using mobile IP, transferring buffered data from the old proxy to the new one,*** and migrating the socket state to the new foreign agent.
- These measures ensure continuity of the TCP connection without disruption, ensuring a ***seamless experience for both fixed and mobile hosts.***

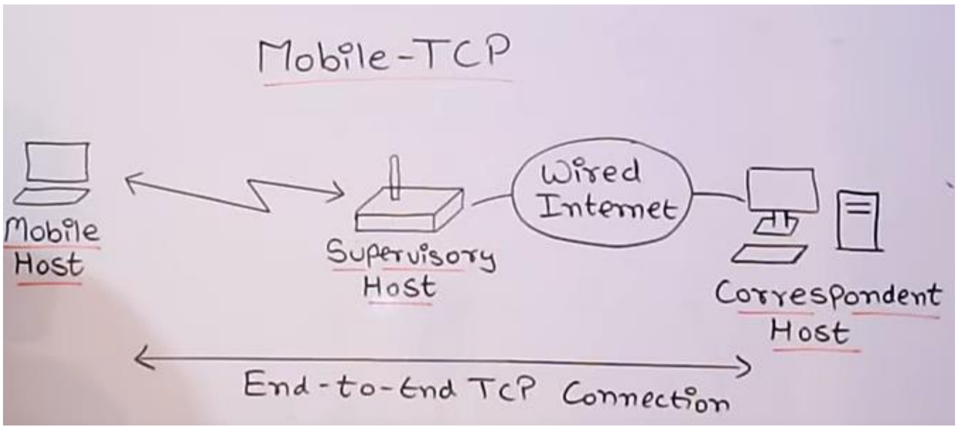
In summary, ***I-TCP enables efficient communication between fixed and mobile hosts by segmenting the TCP connection and employing proxy functionality at the access point.*** This approach maintains compatibility with traditional TCP in fixed networks while optimizing performance over wireless links.

5. EXPLAIN MOBILE TCP. (2012, 2014, 2017, 2018)

Mobile TCP (M-TCP) was developed to address the challenges of using standard TCP over wireless links, especially in scenarios with ***frequent disconnections or high bit error rates.***

Goals of M-TCP:

M-TCP aims to maintain the end-to-end semantics of TCP, ***improve overall throughput, reduce delay, ensure efficient handovers, and prevent the sender window from shrinking due to bit errors or disconnections*** without resorting to congestion control mechanisms.



Segmentation of TCP Connection:

- Similar to I-TCP, M-TCP segments the TCP connection into two parts**: the standard host-supervisory host (SH) connection** and **the SH-mobile host (MH) connection**.
- An unmodified TCP is used on the standard SH connection, while an optimized TCP variant is employed on the SH-MH connection.

Supervisory Host Functionality:

- The supervisory host ***monitors packets sent to the mobile host and the acknowledgments returned from it.***
- If the supervisory host detects a disconnection, it ***sets the sender's window size to 0, forcing the sender into a persistent mode.***
- This prevents unnecessary retransmissions and slow start mechanisms. ***Upon detecting connectivity again, the supervisory host restores the sender's window size to its previous value,*** allowing the sender to resume full-speed transmission.

Advantages of M-TCP:

- Maintains TCP end-to-end semantics.
- ***Avoids unnecessary retransmissions, slow starts, or connection breaks during disconnections by setting the sender's window size to 0.***
- Automatic ***retransmission of lost packets without buffering*** at the supervisory host.

Disadvantages of M-TCP:

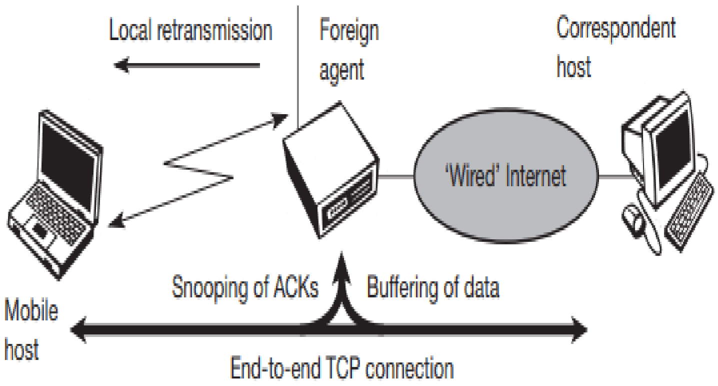
- ***Propagates packet loss on the wireless link to the sender,*** as the supervisory host does not act as a proxy.
- ***Requires modifications to the mobile host protocol*** and network elements like ***bandwidth managers.***

In summary, M-TCP offers advantages such as ***maintaining TCP semantics and efficient handling of disconnections,*** but it also introduces challenges such as ***susceptibility to packet loss*** and the ***need for additional network elements.***

6. DESCRIBE SNOOPING TCP WITH THEIR ADVANTAGES. (2018)

Snooping TCP is an enhancement to TCP that ***preserves end-to-end TCP semantics while buffering data close to the mobile host for fast local retransmission in case of packet loss.*** This enhancement is implemented primarily at the foreign agent in the Mobile IP context.

Figure 9.3
Snooping TCP as a transparent TCP extension



Mechanism of Snooping TCP:

- **Packet Buffering:** The ***foreign agent buffers all packets*** destined for the mobile host.
- **Packet Snooping:** The ***foreign agent monitors the packet flow in both directions*** to identify acknowledgements.
- **Fast Retransmission:** If a packet loss is detected (either by not receiving an acknowledgement or receiving a duplicate ACK), the foreign agent quickly retransmits the packet from its buffer.
- **Negative Acknowledgements (NACK):** When the ***foreign agent detects a missing packet in the sequence, it sends a NACK to the correspondent host,*** prompting immediate retransmission.

Advantages of Snooping TCP:

- **Preservation of End-to-End Semantic:** Snooping TCP ***ensures that neither the correspondent host nor the mobile host have an inconsistent view of the TCP connection,*** maintaining end-to-end semantic integrity.
- **Transparency:** The ***correspondent host does not require modifications,*** and ***most enhancements are implemented at the foreign agent,*** simplifying implementation.
- **Seamless Handover:** There is no need for state handover when the mobile host moves to another foreign agent. Any remaining buffered data can be retransmitted to the new care-of address without disruption.
- **Automatic Fallback:** If the enhancements cease to function, the approach automatically reverts to standard TCP, ***ensuring compatibility and fallback mechanisms.***

In summary, snooping TCP offers advantages in ***preserving end-to-end semantics and transparency,*** but it may face ***challenges in isolating wireless link issues and interacting with encryption schemes.*** Despite these drawbacks, snooping TCP provides a valuable enhancement for mobile TCP performance in certain network contexts.

EXPLAIN THREE DIFFERENT RANGES FOR THE SIGNAL PROPAGATION. WHAT ARE THE EFFECTS OF SIGNAL PROPAGATION? (2023)

Signal propagation refers to the ***process by which electromagnetic signals travel from a sender to a receiver through a medium, such as air, water, or a vacuum.*** In wireless communication networks, signal propagation plays a crucial role in determining the ***quality and reliability of communication between devices.***

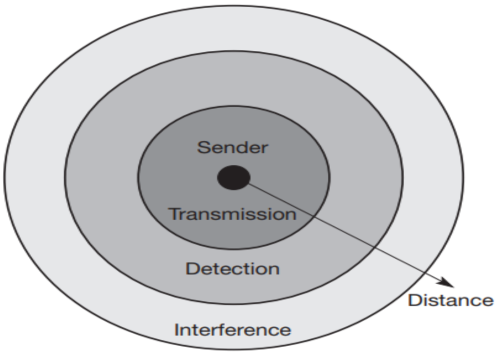


Figure 2.11
Ranges for transmission, detection, and interference of signals

Three different ranges for signal propagation are:

1. **Transmission Range**: This range ***represents the maximum distance*** within which a sender can transmit signals, and a receiver can successfully receive them with a ***low error rate.*** In other words, communication is possible within this radius, ***allowing the receiver to detect and decode the transmitted signals.***

2. **Detection Range**: Within this range, the ***transmitted signals can be detected by a receiver, but the error rate is too high to establish reliable communication.*** Although the receiver can detect the presence of signals, the r***eceived power may not be sufficient to distinguish them from background noise*** effectively.

3. **Interference Range**: In this range, the ***transmitted signals may interfere with other transmissions,*** even though they cannot be detected by a receiver. The signals may contribute to the overall ***background noise, potentially disrupting other communication channels*** without being identifiable themselves.

The effects of signal propagation include:

1. **Path Loss**: As signals travel through a medium, they experience ***attenuation or loss of power*** due to factors such as ***distance, obstacles, and absorption by the medium.*** Path loss results in a decrease in signal strength as the distance between the sender and receiver increases.

2. **Reflection, Refraction, and Scattering**: Signals may be reflected off surfaces, refracted as they pass through different mediums with varying densities, or scattered by objects smaller than their wavelength. These phenomena can cause signals to follow ***multiple paths of propagation,*** leading to ***signal distortion and interference.***

3. **Delay Spread**: Signals traveling along different paths may arrive at the receiver with varying delays due to differences in path lengths. This delay spread causes the original signal to

spread out in time, resulting in ***inter symbol interference (ISI)*** and reducing the reliability of communication.

4. **Fading**: ***Fading refers to variations in the received signal power over time or space,*** caused by factors such as ***multipath propagation, movement of transmitters or receivers, and changes in the environment.*** Fading can be ***short-term or long-term.***

Overall, signal propagation effects can significantly impact the performance and reliability of wireless communication systems, necessitating the use of sophisticated techniques such as ***equalization, diversity reception, and power control*** to mitigate their adverse effects.