ASSIGNMENT 2 - MST2

Wireless Communication

Syllabus

1. Fading Channels and their characteristics- channel modelling, Digital.

Fading channels refer to the phenomenon where the quality of wireless signals fluctuates due to various factors such as multipath propagation, atmospheric conditions, and interference. This results in a loss of signal strength and an increase in errors, which can significantly affect the performance of wireless communication systems.

One of the main causes of fading channels is multipath propagation, where signals from a transmitter reach the receiver through multiple paths. These paths can have different lengths and may reflect off obstacles such as buildings or terrain, causing the signals to interfere with each other. This interference can result in constructive or destructive interference, depending on the phase and amplitude of the signals. As a result, the received signal can vary in strength and quality over time, leading to fading.

Fading channels are characterized by several parameters, including signal-to-noise ratio (SNR), coherence time, and Doppler spread. SNR refers to the ratio of signal power to noise power and is an important measure of signal quality. Coherence time refers to the duration over which a channel remains constant before changing due to fading. Doppler spread refers to the range of frequencies present in a signal due to the movement of the transmitter or receiver relative to each other.

Channel modelling in digital communication refers to the mathematical representation of the communication channel between a transmitter and receiver. The channel model is used to predict how the transmitted signal will be affected by various factors such as noise, interference, attenuation, and distortion. The goal of channel modelling is to optimize the design of communication systems by understanding the behaviour of the channel and developing techniques to mitigate its effects.

There are several types of channel models used in digital communication, including deterministic models, statistical models, and physical models. Deterministic models are based on the physical characteristics of the channel and provide an exact representation of the signal propagation. Statistical models use probability theory to model the random behavior of the channel, while physical models are based on empirical measurements of the channel.

Digital wireless communication relies on radio waves to transmit information between devices. These radio waves are transmitted at specific frequencies and can be modulated using various techniques such as amplitude modulation (AM), frequency modulation (FM), or phase modulation (PM). Digital modulation techniques, such as quadrature amplitude modulation (QAM) or phase-shift keying (PSK), allow for the encoding of digital information onto the carrier wave.

2. Signalling over a frequency non selective slowly fading channel.

Signalling over a frequency non-selective slowly fading channel refers to the transmission of information through a communication channel that experiences slow changes in its attenuation or gain. This type of channel is characterized by the fact that it affects all frequencies equally, which means that the received signal experiences a flat fading effect. To ensure reliable communication over such channels, various techniques have been developed to mitigate the effects of fading and improve the quality of the received signal.

One of the most commonly used techniques for signalling over a frequency non-selective slowly fading channel is diversity reception. This technique involves using multiple antennas at both the transmitter and receiver ends to improve the quality of the received signal. By combining signals from multiple antennas, diversity reception can reduce the impact of fading and improve the overall reliability of the communication link.

Another technique that is often used for signalling over such channels is equalization. Equalization involves compensating for the distortion introduced by the channel by applying an inverse filter to the received signal. This technique can be particularly effective when combined with diversity reception, as it can help to further reduce the impact of fading and improve the overall quality of the received signal.

3. Concept of diversity branches and signal paths.

Diversity branches and signal paths are concepts that are widely used in the field of wireless communication. In wireless communication, diversity refers to the use of multiple antennas or signal paths to improve the quality and reliability of the communication link. The basic idea behind diversity is to exploit the differences in the propagation environment of the wireless signals to improve the overall performance of the system.

There are several types of diversity branches and signal paths that are commonly used in wireless communication systems. Some of these include:

1. Space Diversity: In space diversity, multiple antennas are used at both the transmitter and receiver ends to improve the quality of the communication link. This type of diversity takes advantage of the fact that the propagation environment can vary significantly over different locations in space. By using multiple antennas, it is possible to select the antenna with the best signal quality at any given time, thereby improving the overall performance of the system.

2. Time Diversity: Time diversity involves transmitting multiple copies of a signal over different time intervals. This technique is based on the fact that fading and interference effects in wireless communication channels tend to be short-lived and unpredictable. By transmitting multiple copies of a signal over different time intervals, it is possible to increase the chances that at least one copy will be received correctly.

3. Frequency Diversity: Frequency diversity involves transmitting a signal over multiple frequency channels simultaneously. This technique is based on the fact that different frequency channels can experience different levels of interference and fading. By transmitting a signal over multiple frequency channels, it is possible to increase the chances that at least one channel will provide good quality reception.

4. Combing methods: Selective diversity combing, switched combining, Maximal ratio combining, Equal gain combining.

Combing methods are used in signal processing to improve the quality and reliability of received signals. There are several types of combing methods, including selective diversity combing, switched combining, maximal ratio combining, and equal gain combining.

Selective diversity combing is a method that selects the best signal from multiple antennas based on a predetermined criterion. This criterion can be signal strength, signal-to-noise ratio, or any other metric that indicates the quality of the received signal. Once the best signal is selected, it is used for further processing.

Switched combining is another method that uses multiple antennas to improve signal quality. In this method, each antenna is sampled in turn, and the sample with the highest quality is selected for further processing. This process is repeated periodically to ensure that the best signal is always selected.

Maximal ratio combining is a method that combines multiple signals from different antennas using a weighted average. The weights are determined based on the quality of each signal and are adjusted dynamically to ensure that the best possible combination is achieved.

Equal gain combining is a simpler method that combines multiple signals by taking their average. This method assumes that all signals are of equal quality and therefore assigns equal weight to each signal.

5. Spread Spectrum Multiple access,

Spread Spectrum Multiple Access (SSMA) is a technique used in wireless communication to allow multiple users to share the same frequency band without interfering with each other. SSMA uses a spread spectrum modulation technique that spreads the signal over a wide frequency band, making it difficult for other signals to interfere with it.

In SSMA, each user is assigned a unique code that is used to spread the signal over a wide frequency band. The receiver uses the same code to despread the signal and recover the original data. This allows multiple users to transmit and receive data simultaneously on the same frequency band without interfering with each other.

One example of SSMA is Code Division Multiple Access (CDMA), which is used in many cellular networks. In CDMA, each user is assigned a unique code that is used to spread the signal over a wide frequency band. The receiver uses the same code to despread the signal and recover the original data. This allows multiple users to transmit and receive data simultaneously on the same frequency band without interfering with each other.

Space Division Multiple Access:

Space Division Multiple Access (SDMA) is a wireless communication technique that allows multiple users to transmit and receive data simultaneously in the same frequency band by exploiting the spatial dimension. It is a form of multiple access technology that uses the spatial domain to provide additional capacity in wireless networks. SDMA is based on the principle that each user has a unique spatial signature, which can be used to distinguish it from other users.

In SDMA, the available bandwidth is divided into multiple spatial channels, each of which is allocated to a different user. The number of channels depends on the number of antennas used at the transmitter and receiver ends. The transmitter sends different signals through each antenna, and the receiver uses its antennas to separate these signals and extract the information sent by each user.

One of the most common examples of SDMA is Multiple-Input Multiple-Output (MIMO) technology. MIMO uses multiple antennas at both the transmitter and receiver ends to create multiple spatial channels. Each channel can support a different user, allowing multiple users to transmit and receive data simultaneously in the same frequency band. MIMO technology has been widely adopted in modern wireless communication systems such as Wi-Fi, LTE, and 5G.

6. Packet Radio Protocols:

Packet Radio is a form of digital communication that uses radio frequencies to transmit data packets. It is widely used in Amateur Radio, emergency services, and military applications. Packet Radio protocols are the set of rules that govern the transmission and reception of data packets over the airwaves.

There are several types of Packet Radio Protocols, including:

1. AX.25: AX.25 is the most widely used Packet Radio Protocol. It was developed in the 1980s and is still in use today. AX.25 uses a 1200 baud Bell 202 modulation scheme to transmit data packets. It supports both connection-oriented and connectionless communication.

2. APRS: APRS (Automatic Packet Reporting System) is a protocol used for real-time tactical digital communications of information of immediate value in the local area. APRS is used by amateur radio operators to transmit location and status information, weather reports, and messages over the airwaves.

3. PACTOR: PACTOR is a protocol used for long-range digital communications over HF radio frequencies. It uses a proprietary modulation scheme that allows for reliable data transmission even under poor signal conditions.

4. WINMOR: WINMOR is a protocol designed for use with the Winlink 2000 system, which provides email and message transfer services over HF radio frequencies.

5. GPRS: GPRS (General Packet Radio Service) is a packet-switched protocol used for mobile data communication over cellular networks. It is commonly used for internet access on mobile devices.

7. Pure ALOHA.

Pure ALOHA is a type of random-access protocol used in computer networks. It was developed in the 1970s by Norman Abramson at the University of Hawaii. Pure ALOHA allows network nodes to transmit data whenever they have data to send, without checking if the channel is busy or not. This can lead to collisions, where two or more nodes transmit at the

same time and their signals interfere with each other, resulting in lost data.
Pure ALOHA is a slotted protocol, which means that time is divided into discrete slots, and each transmission takes up one slot. When a node has data to send, it waits for the beginning of the next slot and then transmits its data. If a collision occurs, the node waits for a random amount of time before trying again.

Pure ALOHA was later improved upon with the development of Slotted ALOHA, which divides time into slots and requires nodes to wait until the beginning of a slot before transmitting. This reduces collisions and improves efficiency.

One example of Pure ALOHA in action is in satellite communication systems, where there is often a delay between when a signal is transmitted and when it is received. Pure ALOHA can be used in this context because it allows nodes to transmit whenever they have data to send, without waiting for confirmation that the previous transmission was successful.

8. Slotted ALOHA.

Slotted ALOHA is a random-access protocol used in computer networks. It is a modification of the original ALOHA protocol, which was developed in the 1970s for satellite-based communication systems.

In Slotted ALOHA, the time is divided into discrete slots, and each slot corresponds to a unit of data transmission. The transmission of data packets occurs only at the beginning of each time slot. If two or more devices attempt to transmit data simultaneously, a collision occurs, and the packets are lost. In such cases, the devices wait for a random period before attempting to retransmit their packets.

Slotted ALOHA has several advantages over the original ALOHA protocol. Firstly, it reduces the probability of collisions by ensuring that all transmissions occur at the beginning of each time slot. Secondly, it simplifies the process of collision detection and resolution. Thirdly, it allows for higher network throughput by maximizing the utilization of available bandwidth.

One example of Slotted ALOHA in action is in RFID (Radio Frequency Identification) systems. In RFID systems, tags containing information are attached to objects or products, and these tags communicate with readers using radio waves. Slotted ALOHA is used in RFID systems to ensure that multiple tags do not transmit data simultaneously and cause collisions.

9. AMPS and ETACS.

AMPS and ETACS:
AMPS (Advanced Mobile Phone System) and ETACS (Extended Total Access Communication System) are both analog cellular network systems that were introduced in the 1980s. These systems were used for mobile communication before the advent of digital cellular networks like GSM, CDMA, and LTE.

Types of AMPS:

There are two types of AMPS: Narrowband Advanced Mobile Phone Service (NAMPS) and Wideband Advanced Mobile Phone Service (WAMPS). NAMPS operates on a frequency band of 800 MHz, whereas WAMPS operates on a frequency band of 1900 MHz

Example of AMPS:

An example of AMPS is the Motorola Dyna TAC 8000X, which was the first commercially available cell phone. It was introduced in 1983 and operated on the AMPS network.

Types of ETACS:

ETACS is divided into two types: ETACS-A and ETACS-B. ETACS-A operates on a frequency band of 900 MHz, whereas ETACS-B operates on a frequency band of 800 MHz

Example of ETACS:
An example of ETACS is the Mitsubishi MT-30, which was introduced in 1985. It operated on the ETACS network and was one of the first mobile phones to be commercially available in Japan.

Difference between AMPS and ETACS: The main difference between AMPS and ETACS is the frequency band they operate on. AMPS operates on a frequency band of 800 MHz or 1900 MHz, whereas ETACS operates on a frequency band of 800 MHz or 900 MHz Another difference is that AMPS has two types, NAMPS and WAMPS, whereas ETACS has two subtypes, ETACS-A and ETACS-B.

10. United States digital cellular (IS-54 & IS 136)

Digital cellular technology in the United States refers to the IS-54 and IS-136 standards that were developed by the Telecommunications Industry Association (TIA) in the late 1980s and early 1990s. These standards were the first digital cellular technologies used in the United States and were designed to replace the analog cellular systems that were prevalent at the time.

IS-54, also known as North American Digital Cellular (NADC), was introduced in 1991 and was based on Time Division Multiple Access (TDMA) technology. It allowed for three voice channels to be transmitted simultaneously on a single 30 kHz channel, providing better spectral efficiency than analog cellular systems. Some examples of IS-54-based systems include Ameritech's Digital AMPS (D-AMPS) and Pacific Bell's PCS 1900.

IS-136, also known as Digital AMPS (D-AMPS) or TDMA Single Rate (TIA/EIA IS-136.1), was introduced in 1995 and was an improvement over IS-54. It offered better call quality, improved battery life, and more efficient use of bandwidth. It also allowed for six voice channels to be transmitted simultaneously on a single 200 kHz channel. Examples of IS-136-based systems include AT&T's Digital OneRate and Sprint's PCS Voice.

The main difference between IS-54 and IS-136 is that IS-136 uses a different modulation scheme called Gaussian Minimum Shift Keying (GMSK), which provides better spectral efficiency and allows for more channels to be transmitted on a single frequency band. Additionally, IS-136 supports more advanced features such as text messaging, caller ID, and call waiting.

Wireless Communication

MST-2

1 (a): Mention the various multiple access schemes used in wireless communication?

Ans: Multiple Access Schemes are used in wireless communication to allow multiple users to share the same frequency band simultaneously. There are several types of Multiple Access Schemes used in wireless communication, including:

1. Frequency Division Multiple Access (FDMA): This technique involves dividing the available frequency band into several smaller frequency bands, each of which is assigned to a specific user. FDMA is commonly used in analog cellular networks.

2. Time Division Multiple Access (TDMA): In this technique, the available frequency band is divided into time slots, and each user is assigned a specific time slot during which they can transmit their data. TDMA is commonly used in digital cellular networks.

3. Code Division Multiple Access (CDMA): CDMA uses a unique code to identify each user, allowing multiple users to transmit data simultaneously over the same frequency band. CDMA is commonly used in 3G and 4G cellular networks.

4. Orthogonal Frequency Division Multiple Access (OFDMA): OFDMA divides the available frequency band into several subcarriers, each of which can be assigned to a different user. OFDMA is commonly used in Wi-Fi and 4G LTE networks.

5. Space Division Multiple Access (SDMA): SDMA uses multiple antennas at both the transmitter and receiver to create multiple spatial channels, allowing multiple users to transmit data simultaneously over the same frequency band.

6. Polarization Division Multiple Access (PDMA): PDMA utilizes the polarization properties of electromagnetic waves to create multiple channels for communication.

1 (b): What is guard space?

Guard space is a term used in satellite communication to refer to the frequency spectrum allocated for the transmission of military and government signals. It is a portion of the electromagnetic spectrum that is reserved for exclusive use by authorized personnel and agencies. Guard space is essential for ensuring the security and reliability of military communications, as it helps prevent interference from unauthorized users.

The allocation of guard space varies depending on the country and region, but generally, it falls within the range of 240 MHz to 400 MHz. In the United States, guard space is divided into two bands: UHF (Ultra High Frequency) and VHF (Very High Frequency). The UHF band ranges from 225 MHz to 400 MHz, while the VHF band ranges from 138 MHz to 174 MHz.

1 (c): What are the advantages of GSM system over analogy cellular system?

The Global System for Mobile Communications (GSM) is a digital cellular technology that has replaced the analog cellular systems. The advantages of GSM over analog cellular systems are numerous and significant.

Firstly, GSM offers better voice quality than analog cellular systems. The digital nature of GSM allows for clearer and more reliable voice transmissions, which reduces the likelihood of dropped calls and interference. Additionally, GSM supports advanced features like call waiting, conferencing, and caller ID, which were not possible with analog cellular systems.

Secondly, GSM provides better security than analog cellular systems. GSM uses encryption to protect voice and data transmissions from eavesdropping and interception. This encryption makes it difficult for unauthorized parties to access sensitive information transmitted over the network.

Thirdly, GSM is more efficient in its use of radio spectrum than analog cellular systems. This efficiency means that more users can be accommodated on the same amount of radio spectrum, which results in lower costs for both operators and consumers.

1 (d): What is AMPS?

AMPS stands for Advanced Mobile Phone System, which was the first analog cellular system widely used in North America. It was developed by Bell Labs and first deployed in the United States in 1983. AMPS uses Frequency Division Multiple Access (FDMA) to divide the frequency band into multiple channels, allowing multiple users to access the network simultaneously.

AMPS was a significant improvement over the previous mobile phone systems, which were limited to a small number of users and had poor call quality. With AMPS, users could make and receive calls from anywhere within the coverage area, which was divided into cells that were served by a base station.

AMPS was eventually replaced by digital cellular technologies such as CDMA and GSM, which offered better call quality and higher capacity. However, AMPS played an important role in the development of mobile phone technology and paved the way for modern cellular networks.

2. Draw and explain the GSM architecture in detail.

GSM (Global System for Mobile Communications) is a standard used for mobile communication networks. It was developed by the European Telecommunications Standards Institute (ETSI) and is used in many parts of the world. The GSM architecture consists of several components that work together to provide mobile communication services.

The GSM architecture can be divided into three main parts: the Mobile Station (MS), the Base Station Subsystem (BSS), and the Network Subsystem (NSS).

1. Mobile Station (MS)
The MS is the user's mobile phone or device. It consists of two parts: the Mobile Equipment (ME) and the Subscriber Identity Module (SIM). The ME includes the hardware and software that make up the phone or device, while the SIM contains information about the user's account, such as their phone number and other authentication data.

2. Base Station Subsystem (BSS)
The BSS is responsible for managing communication between the MS and the network. It consists of two main components: the Base Transceiver Station (BTS) and the Base Station Controller (BSC). The BTS is responsible for transmitting and receiving radio signals to and from the MS, while the BSC manages multiple BTSs and handles tasks such as call setup and handover.

3. Network Subsystem (NSS)
The NSS is responsible for managing communication between different networks, as well as providing additional services such as voice mail and SMS messaging. It consists of several components, including the Mobile Switching Center (MSC), Home Location Register (HLR), Visitor Location Register (VLR), and Authentication Center (AuC).

- The MSC is responsible for routing calls between different networks, as well as managing call setup, handover, and other functions.
- The HLR stores information about each subscriber's account, including their phone number, SIM card information, and current location.
- The VLR stores temporary information about subscribers who are currently within its coverage area, such as their current location and status.
- The AuC is responsible for authenticating subscribers and ensuring that only authorized users can access the network.

3. Explain the packet radio: Pure ALOHA and Slotted ALOHA?

Packet radio is a form of wireless communication that involves the transmission of data in small packets between two or more radio stations. The data is broken up into packets, which are then transmitted over the airwaves and reassembled at the receiving station.

Pure ALOHA is a packet radio protocol that was developed in the early 1970s at the University of Hawaii. It is a random access protocol, which means that any station can transmit at any time, regardless of whether or not another station is currently transmitting. This can lead to collisions, where two or more stations transmit at the same time and their signals interfere with each other. When a collision occurs, the stations involved must wait for a random amount of time before attempting to transmit again.

Slotted ALOHA is a variant of Pure ALOHA that was developed to reduce collisions and improve efficiency. In Slotted ALOHA, time is divided into discrete slots, and stations are only allowed to transmit at the beginning of each slot. This helps to reduce collisions because stations are less likely to transmit at the same time. However, it also reduces efficiency because some slots may be unused if no station has data to transmit.

Packet radio has been used for a variety of applications, including amateur radio, emergency communications, and military communications. It has also been used in space exploration, with NASA using packet radio to communicate with its spacecraft.

4. Compare the performance of TDMA, FDMA and CDMA technique.

TDMA, FDMA, and CDMA are all techniques used in wireless communication systems to divide the available bandwidth among multiple users. Each technique has its own advantages and disadvantages, which affect its performance in different scenarios.

Time Division Multiple Access (TDMA) is a technique that divides the available frequency band into time slots and assigns each user a specific time slot for transmission. TDMA is widely used in cellular networks, such as GSM (Global System for Mobile Communications). TDMA offers high spectral efficiency, as multiple users can share the same frequency band by using different time slots. It also provides good call quality and low latency since each user has a dedicated time slot for transmission. However, TDMA suffers from synchronization issues, as all users must be synchronized to the same time slot. It also requires complex scheduling algorithms to allocate time slots efficiently.

Frequency Division Multiple Access (FDMA) is a technique that divides the available frequency band into sub-bands and assigns each user a specific sub-band for transmission. FDMA is used in analog communication systems such as FM radio and television broadcasting. FDMA offers good voice quality and is less susceptible to interference than other techniques. However, it is less spectrally efficient than TDMA or CDMA since each user occupies a separate frequency band.

Code Division Multiple Access (CDMA) is a technique that uses unique codes to distinguish between different users sharing the same frequency band. CDMA is used in cellular networks such as 3G and 4G LTE. CDMA offers high spectral efficiency since multiple users can share the same frequency band without interfering with each other by using different codes. It also provides good call quality and low latency since each user has a dedicated code for transmission. However, CDMA requires complex signal processing algorithms to decode the signals from different users accurately.