Multiple Access Techniques

Student Support Slides

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Communication Resource(CR)

- A CR represents the time and bandwidth that is available for communication signalling associated with a given system
- For efficient development of a communication system, it is important to plan out the resource allocation among system users, so that no block of time/frequency is wasted and so that the users can share the resource in equitable manner
- Multiplexing and Multiple Access refer to the sharing of a CR.
- There is a subtle difference between the two

Multiplexing

- Combining many signals into a single transmission circuit or channel.
- This technique is further extended to multiple access
- With multiplexing user requirements or plans for CR sharing are fixed or at the most slowly changing
- The resource allocation is assigned apriori
- And the sharing is usually a process that takes places within the confines of a local site e.g. a circuit board
- Multiplexing is provided by physical layer

Multiple Access

- Usually refers to/involves remote sharing of a resource such as in case of satellite communication
- With a dynamically changing multiple access scheme, a system controller must be aware of each user's CR need. The amount of time required for this information transfer, constitutes an overhead and sets an upper limit on efficiency of utilization of CR.
- Multiple access makes it possible for several transmitters connected to the same physical medium to share its capacity
- Multiple Access involves medium access control which is part of data link layer.

Allocation of Communication Resource

Three basic ways to increase the throughput(total data rate) of a CR are:

- Increase transmitter's EIRP(effective isotropic radiated power) or reduce system losses so that the received E_b/N_o is increased
- Provide more channel bandwidth
- Make allocation of CR more efficient

Allocation of Communication Resource

Methods of efficient resource allocation are:

- **FD**: Specified sub-bands of frequency are allocated
- **TD**: Periodically recurring timeslots are identified
- **CD**: Specified members are given orthogonal spread spectrum codes to use the full channel bandwidth
- **SD or multi beam frequency reuse**: Spot beam antennas are used to separate radio signals by pointing on different directions. It allows frequency reuse
- **PD or dual polarization frequency reuse**: Orthogonal polarization are used to separate radio signals, allowing for reuse of frequency band

Aim Multiplexing and Multiple Access

- Key to all multiplexing and multiple access schemes is that the various signals share a CR without creating unmanageable interference to each other in detection process.
- The allowable limit of such interference is that signals on one CR channel should not significantly increase the probability of error(P_e) in another channel.
- Orthogonal signals on separate channels will avoid interference between users

FDMA and TDMA

- FDMA and TDMA is to be covered from the Rappaport Book in Chapter 9
- For the time being, exclude the concept of Narrowband and Wideband systems.
- In layman terminology, narrowband systems are those which do have low data rates whereas wideband systems have high data rate.

Spread Spectrum Technique

A system is defined to be spread spectrum if it fulfills the following requirements

- Signal occupies a bandwidth much in excess (spread bandwidth)of minimum bandwidth necessary to send the information
- Spreading is accomplished by means of an orthogonal(unique) spreading signal, often called a code signal which is independent of the data
- At the receiver, dispreading(recovering the original data) is accomplished by correlation of the received spread signal with a synchronized replica of the spreading signal.

Spread Spectrum Technique

- So, each user is assigned a unique code sequence which its uses to encode its information-bearing signal
- The receiver, knowing the code sequence of the user, decodes a received signal after reception and recovers the original data.
- This is possible because of the cross-correlation between the code of the desired user and the codes of other users are small
- Because the bandwidth of the code signal is chosen to be much larger than the bandwidth of the information bearing signal, the encoding process enlarges the spectrum of signal and is therefore known as spread spectrum modulation

Benefits of Spread Spectrum Technique

- Interference suppression
- Protection against multipath interference
- Making the system a low probability of detection (LPD) or low probability of Intercept(LPI) communication system because spread signal seems buried in noise and has low power density
- Can be used for ranging or determination of position location
- Privacy
- **Multiple Access→ (we are focusing on this here):**spread spectrum technique be used for multiple access in order to share a communication resource among numerous users in a coordinated manner

Code Division MA

- Technique/Application used to provide Multiple Access is called CDMA
- Spreading of the transmitted signal gives CDMA its multiple access capability
- If multiple users transmit a spread spectrum signal at the same time and same frequency, the receiver will be to distinguish among the users provided each user has a unique code (chip) that has sufficiently low correlation with other codes

CDMA Techniques

- **Direct Sequence CDMA(DS-CDMA**):Also called DSSS(direct sequence spread spectrum).The information bearing signal is multiplied directly by a high chip rate spreading code

- **Frequency Hopping CDMA(FH-CDMA):**Also called FHSS(frequency hopping spread spectrum).The carrier frequency at which the information bearing signal is transmitted is rapidly changed according to the spreading code i-e hopping pattern is decided by the code

- **Time Hopping CDMA(TH-CDMA):**Also called THSS(time hopping spread spectrum).The information bearing signal is not transmitted continuously. Instead the signal is transmitted in short bursts where the times of bursts are decided by spreading code