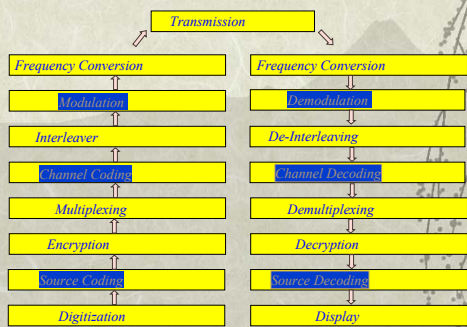


# Satellite Communication

Lecture # 11

# Channel Characteristics

## The sequence of signal processing and transmission



## Signal processing and transmission

- Digitisation *higher reliability, low cost, less susceptible to noise*
- Source Coding *to reduce bit rate for transmission*
- Encryption *for communications privacy*
- Multiplexing *for efficient transmission of multiple channels*
- Channel Coding *for error free transmission*
- Interleaving *for robust error correction*
- Modulation *imparting baseband information to a carrier*
- Frequency Conversion *to operate at radio frequencies*

## MULTIPLEXING AND MULTIPLE ACCESS TECHNIQUES

## Multiplexing and Multiple Access

- For the majority of data communications that take place, there is a requirement for several users to **share a common channel** resource at the same time.
- For multiple users to be able to share a common resource in a managed and effective way requires some form of **access protocol** that defines when or how the sharing is to take place and the means by which messages from individual users are to be identified upon receipt. These sharing process come to be known as **multiplexing** and **multiple access** in digital communications.

## Multiple Access and Multiplexing

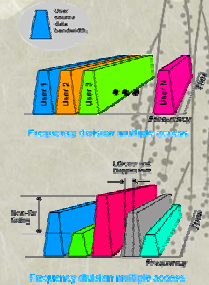
- ❖ **Multiple Access:** is the ability for several earth stations to transmit their respective carriers simultaneously into the same satellite transponder
- ❖ **Multiplexing:** is the reversible operation of combining several information-bearing signals to form a single, more complex signal.

## Multiple Access and Multiplexing

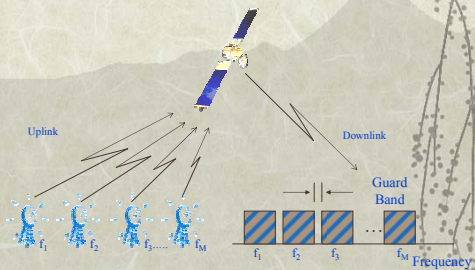
Multiple Access at radio frequency		Multiplexing at baseband
TDMA	-	TDM
FDMA	-	FDM
CDMA	-	CDM

## FDMA

- ❖ Used extensively in the early telephone and wireless multi-user communication systems
- ❖ If a channel, such as a cable, has a transmission bandwidth  $W$  Hz, and individual users require  $B$  Hz to achieve their required information rate, then the channel in theory should be able to support  $W/B$  users
- ❖ Near-Far problem



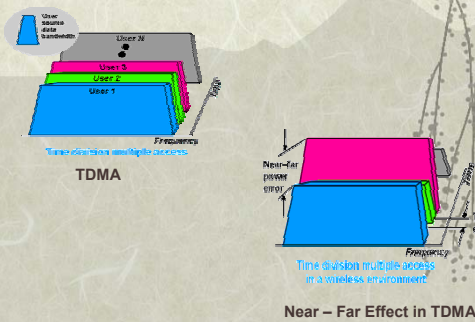
## Frequency Division Multiple Access; FDMA



## TDMA

- ❖ The basic principle behind **time division multiplexing** is that the user has access to a modem operating at a rate **several times** that required to support his own data throughput, such that he can send his information in a time slot that is shorter than his own message transaction. Other users can then be assigned similar time slots on the same channel. Clearly if the data rate on the channel is  $w$  bits/second, and each individual user requires only  $b$  bits/second, then the system can support  $w/b$  simultaneous users.
- ❖ In TDM systems, users are assigned a time slot for the duration of their call whether they require it or not.

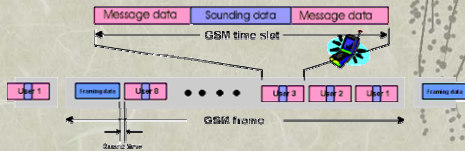
## TDMA



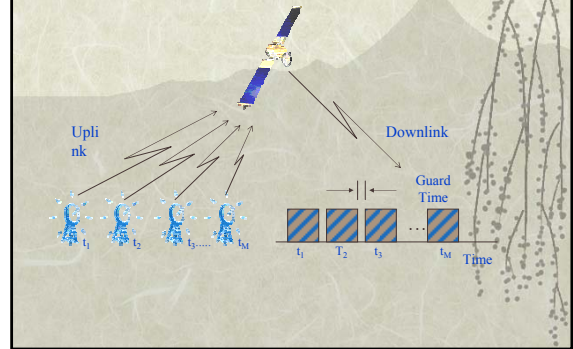
## Example of a TDMA system

- ❖ The GSM digital cellular system is a very good example of a TDMA

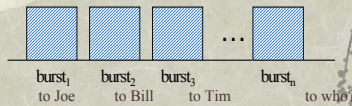
GSM TDMA data and frame structure



## Time Division Multiple Access; TDMA

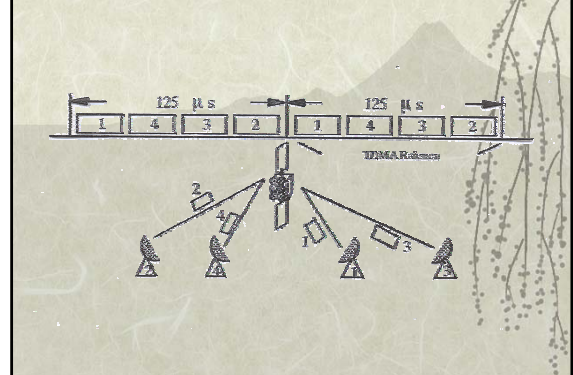


## Time Division Multiplexing



a coherent stream of data

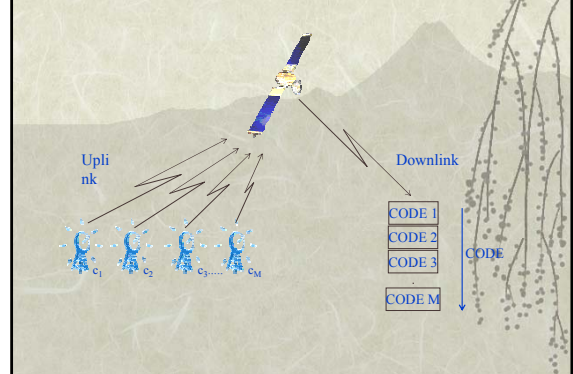
## Time Division Multiple Access; TDMA

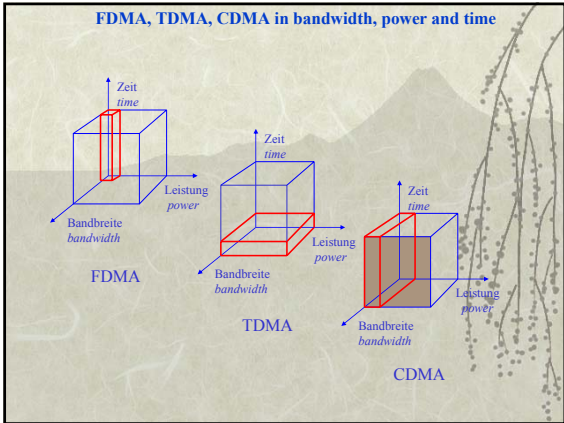
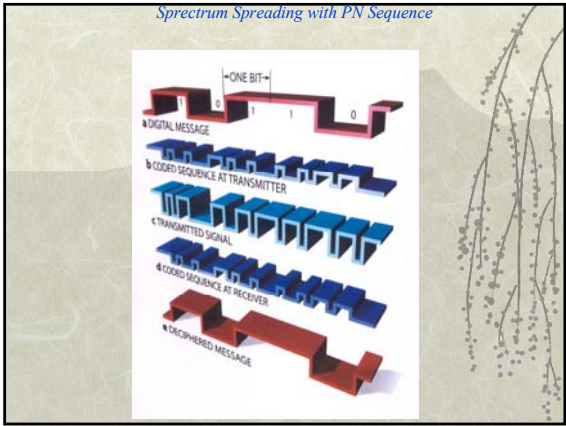
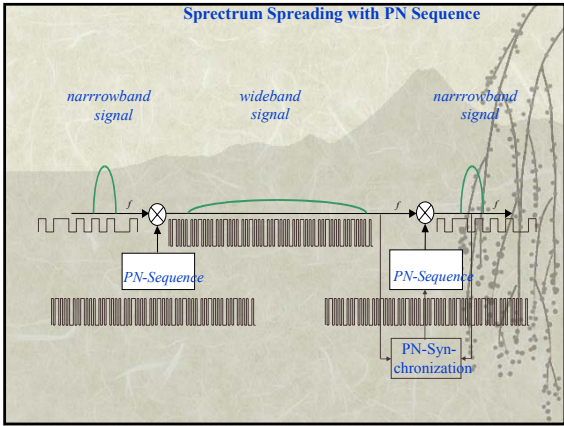


## CDMA

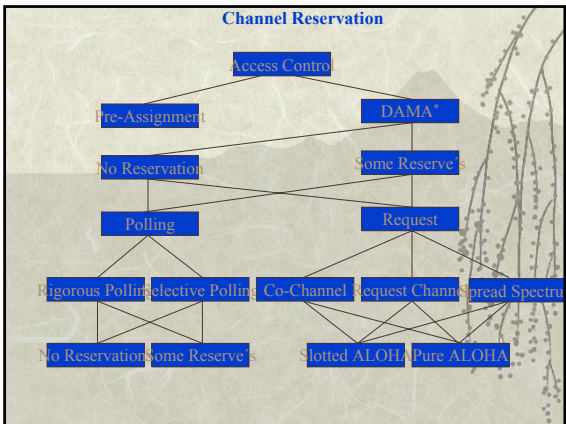
- ❖ In recent years, the interference immunity of CDMA for multi-user communications, together with its very good spectral efficiency characteristics, has been seen to offer distinct advantages for public cellular-type communications.
- ❖ There are two very distinct types of CDMA system, classified as direct sequence CDMA and frequency hopping CDMA. Both of these systems involve transmission bandwidths that are many times that required by an individual user, with the energy of each user's signal spread with time throughout this wide channel. Consequently these techniques are often referred to as spread spectrum systems.

## Code Division Multiple Access; CDMA





## Channel Coding & Modulation



### Channel Reservation

<i>Pre-Assignment</i>	<i>Resource is leased permanently</i>
<i>Demand Assignment</i>	<i>Resource is allocated on demand</i>
<i>Reservation</i>	<i>Reservations are possible</i>
<i>Polling</i>	<i>Polling of subscribers if they . . .</i>
<i>Rigorous Polling</i>	<i>Polling of all registered subscribers</i>
<i>Selective Polling</i>	<i>Polling according to statistics</i>
<i>Request</i>	<i>Subscriber requests resource from system</i>
<i>Request Channel</i>	<i>Request on separate request channel</i>
<i>Co-Channel Request</i>	<i>Request on communications channel</i>
<i>Spread Spectrum</i>	<i>Request per spread spectrum carrier</i>
<i>Pure Aloha</i>	<i>Request at random in time</i>
<i>Slotted Aloha</i>	<i>Request at random but in time slots</i>

### Channel Coding

- ❖ Every communication system operates in a noisy environment
- ❖ To develop a robust system one may choose:
  - Transmit signals with higher power
  - Repeat every signal
  - Repeat only erroneous signals
  - Apply forward error correction

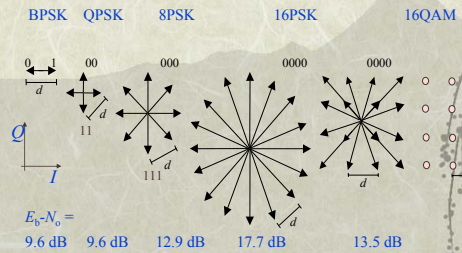
### Modulation Techniques

How can signals be employed to transmit information?

Sine Waves: Information is in amplitude, phase, or frequency

Pulses: Information is in amplitude, phase, position or pulse width

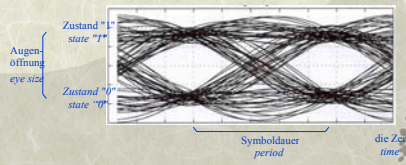
### Modulation Techniques



$E_b/N_0$  vs BER

BER	BPSK	QPSK	8PSK	16PSK	16QAM	32QAM	64QAM
$10^{-1}$	-1.0	-1.0	2.5	7.3	2.2	5.1	
$10^{-2}$	4.3	4.3	7.7	12.4	7.3	8.9	
$10^{-3}$	6.8	6.8	10.1	14.9	9.8	10.9	
$10^{-4}$	8.4	8.4	11.8	16.5	11.4	12.3	
$10^{-5}$	9.6	9.6	12.9	17.7	12.6	13.4	
$10^{-6}$	10.5	10.5	13.9	18.7	14.5	17.2	19.0
$10^{-7}$	11.3	11.3	14.7	19.4	14.3	14.8	
$10^{-8}$	12.0	12.0	15.3	20.1	15.0	15.5	
$10^{-9}$	12.6	12.6	15.9	20.7	15.6	16.0	
$10^{-10}$	13.1	13.1	16.4	21.2	16.1	16.5	
$10^{-11}$	13.5	13.5	16.9	21.6	16.5	16.9	
$10^{-12}$	13.9	13.9	17.3	22.1	16.9	17.3	
$10^{-13}$	14.3	14.3	17.7	22.4	17.3	17.7	
$10^{-14}$	14.7	14.7	18.0	22.8	17.7	18.0	
$10^{-15}$	15.0	15.0	18.3	23.1	18.0	18.3	

### The Baseband Eye Pattern



several periods of the running signal superimposed on the oscilloscope  
the eye size is a measure of the quality of the signal

*Questions?*

