Modern Telecommunication Systems
Lecture 8

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Satellite Communication

- A satellite is simply any body that moves around another (usually much larger) one in a mathematically predictable path called an orbit.
- A communication satellite is a microwave repeater station in space that is used for telecommunication , radio and television signals.
- There are about 750 satellite in the space, most of them are used for communication.

History of Satellite Communication

- The first man made satellite with radio transmitter was launched in 1957.
- First true communication satellites (Telstar I & II) were launched in July 1962 & May 1963.
- 10/1964 Syncom 2: First GEO satellite, 7.4/1.8 GHz (one TV-channel or several 2-way telephone connections
- 1987 TVSAT: First DBS-satellite (Direct Broadcast Satellite, Television-broadcasts directly to home).

Satellite Communication System

- Communication satellites are not originators of information to be transmitted.
- Satellites are relay stations for earth sources.
- The transmitting station sends the information to the satellite, which in turn retransmits it to the receiving station.
- The satellite in this application is what is generally known as a repeater.

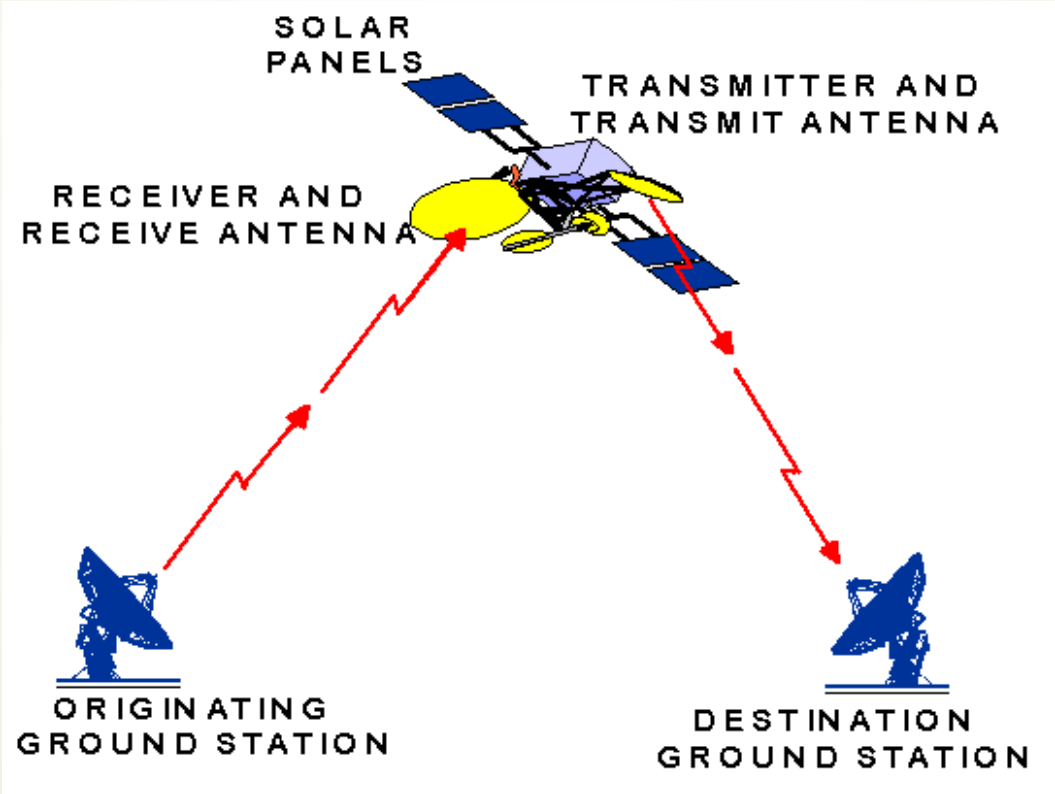
Satellite Communication System

- Repeaters and Transponders
  - An earth station transmits information to the satellite.
  - The satellite contains a receiver that picks up the transmitted signal, amplifies it, and translates it on another frequency.
  - The signal on the new frequency is then retransmitted to the receiving stations back on earth.

Satellite Communication System

- Repeaters and Transponders
  - The original signal being transmitted from the earth station to the satellite is called the uplink.
  - The retransmitted signal from the satellite to the receiving stations is called the downlink.
  - The transmitter-receiver combination in the satellite is known as a transponder.

Satellite Communication System



Satellite Communication System

- Repeaters and Transponders: Frequency Allocations
  - Most communication satellites operate in the microwave frequency spectrum.
  - The microwave spectrum is divided up into frequency bands that have been allocated to satellites as well as other communication services such as radar.
  - The most widely used satellite communication band is the C band.
  - The C band uplink frequencies are in the 5.925- to 6.425-GHz range and the downlink frequencies are in the 3.7- to 4.2-GHz range.

Satellite Communication System

- Frequency bands used in satellite communication:

BAND	FREQUENCY
P	225–390 MHz
J	350–530 MHz
L	1530–2700 MHz
S	2500–2700 MHz
C	3400–6425 MHz
X	7250–8400 MHz
Ku	10.95–14.5 GHz
Ka	17.7–31 GHz
Q	36–46 GHz
V	46–56 GHz
W	56–100 GHz

Satellite Subsystems

- All satellite communication systems consist of two basic parts, the satellite or spacecraft and two or more earth stations.
- The satellite performs the function of a radio repeater or relay station.
- Two or more earth stations may communicate with one another through the satellite rather than directly point-to-point on the earth.

Satellite Subsystems

- The heart of a communication satellite is the communication subsystem.
- This subsystem is a set of transponders that receive the uplink signals and retransmit them to earth.
- A transponder is a repeater that implements a wideband communication channel capable of carrying many simultaneous communication transmissions.

Satellite Subsystems

Communication Subsystems

- The main payload on a communication satellite is the communication subsystem that performs the function of a repeater or relay station.
- An earth station takes the signals to be transmitted, known as baseband signals, and modulates a microwave carrier.
- The three most common baseband signals are voice, video, or computer data.
- Most modern satellites contain at least 12 transponders.

Satellite Subsystems

Communication Subsystems: Multichannel Configurations

- Virtually all modern communication satellites contain multiple transponders.
- This permits many more signals to be received and transmitted.
- Each transponder operates on a separate frequency, but its bandwidth is wide enough to carry multiple channels of voice, video, and digital information.
- The two multichannel architectures used with communication satellites are broadband and fully channelized.

Satellite Subsystems

Power Subsystem

- Today virtually every satellite uses **solar panels** for its basic power source.
- Solar panels are large arrays of photocells connected in various series and parallel circuits to create a powerful source of direct current.
- A key requirement is that the solar panels always be pointed toward the sun.
- Solar panels generate a direct current that is used to operate the various components of the satellite and to charge secondary batteries that act as a buffer.

Satellite Subsystems

Telemetry, Command, and Control Subsystems

- All satellites have a telemetry, command, and control (TC&C) subsystem that allows a ground station to monitor and control conditions in the satellite.
- The telemetry system is used to report the status of the onboard subsystems to the ground station.
- A command and control system permits the ground station to control the satellite.
- Most satellites contain a small digital computer that acts as a central control unit for the entire satellite.

Satellite Subsystems

Applications Subsystems

- The applications subsystem is made up of the special components that enable the satellite to fulfill its intended purpose.
- For a communication satellite, this subsystem is made up of the transponders.
- An observation satellite may use TV cameras or infrared sensors to pick up various conditions on earth and in the atmosphere. This information is then transmitted back to earth by a special transmitter designed for this purpose.

Ground Stations

- The ground station, or earth station, is the terrestrial base of the system.
- The ground station communicates with the satellite to carry out the designated mission.
- The earth station consists of five major subsystems:
  - The antenna subsystem
  - The receive subsystem
  - The transmit subsystem
  - The ground control equipment (GCE) subsystem
  - Power subsystem

Ground Stations

Antenna Subsystems

- All earth stations have a relatively large parabolic dish antenna that is used for sending and receiving signals to and from the satellite.
- Earth station dishes were 80 to 100 ft or more in diameter, however, with higher power transmission, antennas as small as 18 inches in diameter are used.
- The antenna in an earth station must be steerable. That is, it must be possible to adjust its azimuth and elevation so that the antenna can be properly aligned with the satellite.

Ground Stations

Receive Subsystems

- The downlink is the receive subsystem of the earth station.
- It usually consists of very low noise preamplifiers that take the small signal received from the satellite and amplify it to a level suitable for further processing.
- The signal is then demodulated and sent on to other parts of the communication system.

Ground Stations

Receive Subsystems: Receiver Circuits

- The purpose of the receive subsystem is to amplify the downlink satellite signal and translate it to a suitable intermediate frequency.
- The IF signal is then demodulated and demultiplexed as necessary to generate the original baseband signals.

Ground Stations

Receiver Ground Control Equipment

- The receiver **ground control equipment (GCE)** consists of one or more racks of equipment used for demodulating and demultiplexing the received signals.
- The down converters provide initial channelization by transponder, and the demodulators and demultiplexing equipment process the 70-MHz IF signal into the original baseband signals.
- Other intermediate signals may be developed as required by the application.

Ground Stations

Transmitter Subsystems

- The uplink is the transmitting subsystem of the earth station.
- It consists of all the electronic equipment that takes the signal to be transmitted, amplifies it, and sends it to the antenna.
- In a communication system, the signals to be sent to the satellite might be TV programs, multiple telephone calls, or digital data from a computer.
- Signals modulate a carrier, are amplified, and sent to an antenna via waveguides, combiners, and diplexers.

Ground Stations

Transmit Ground Control Equipment

- The transmit subsystem begins with the baseband signals, which are first fed to a multiplexer, if multiple signals are to be carried by a single transponder.
- The multiplexer output is then fed to a modulator.
- In analog systems, a wideband frequency modulator is normally used.
- In digital systems, analog signals are first digitized with PCM converters. The resulting serial digital output is then used to modulate a QPSK modulator.

Ground Stations

Power Subsystems

- Most earth stations receive their power from the normal ac mains. Standard power supplies convert the ac power to the dc voltages required to operate all subsystems.
- Most earth stations have backup power systems that take over if an ac power failure occurs.
- The backup power system may consist of a diesel engine driving an ac generator, which automatically starts when ac power fails.
- Smaller systems may use **uninterruptible power supplies (UPS),** which derive their main power from batteries.

Ground Stations

Telemetry and Control Subsystems

- The telemetry equipment consists of a receiver and the recorders and indicators that display the telemetry signals.
- The signal may be received by the main antenna or a separate telemetry antenna.
- A separate receiver on a frequency different from that of the communication channels is used for telemetry purposes.

Ground Stations

Telemetry and Control Subsystems

- In some satellite systems where communication is not the main function, some **instrumentation** may be a part of the ground station.
- Instrumentation is a general term for all the electronic equipment used to deal with the information transmitted back to the earth station.

Ground Stations

Very Small-Aperture Terminal

- A **very small-aperture terminal (VSAT)** is a miniature low-cost satellite ground station.
- These units are extremely small and mount on the top or side of a building and in some versions even fit into a suitcase.
- Costs range from a few thousand dollars to no more than about $6000 today.
- They can be installed very quickly by plugging them in and pointing the antenna.

Ground Stations

Very Small-Aperture Terminal

- The most common application of VSATs today is in connecting remote company or organization sites to a main computer system.
  - Gas stations and retail stores use VSATs as point-of-sale (PoS) terminals to transmit sales transaction information to the home office, check customer credit cards, and relay inventory data.
  - Tollbooths using Speed Pass and other radio-frequency identification (RFID) of vehicles for tolls use VSATs.
  - The set top box receiver used by consumers for Direct Broadcast Satellite (DBS) TV reception is a **receive-only (RO) VSAT.**

Advantages of SC

- The advantages of satellite communication over terrestrial communication:
  - The coverage area of a satellite is greater than that of a terrestrial system, an entire country or region can be covered with just one satellite.
  - Higher Bandwidths are available for use.
  - Superior Reliability- Satellite communication can operate independently from terrestrial infrastructure.
  - LEO and MEO satellite types have lower propagation delay and lower losses and can be used for global coverage.

Disadvantages of SC

- The disadvantages of satellite communication are:
  - Cost involved in launching satellites into orbit is too high.
  - Satellite bandwidth is gradually becoming used up.
  - There is a larger propagation delay in satellite communication than in terrestrial communication.

Satellite Applications

- Communication: The main application for satellites today is in communication. Communication satellites act as relay stations in the sky and permit reliable long-distance communication worldwide.
- Direct Broadcast Satellite (DBS) service: This is a TV signal distribution system designed to distribute signals directly to consumers.
- Satellite Cell Phones. Satellite-based cellular telephone service is under development. The proposed new systems use low-earth-orbit satellites to perform the relay services to the main telephone system or to make connection directly between any two cellular telephones using the system.

Satellite Applications

- Digital Satellite Radio: One of the newest satellite applications is in digital satellite radio or the digital audio radio service (DARS).
  - This service provides hundreds of channels of music, news, sports, and talk radio to car portable and home radios.
  - It provides full continuous coverage of the station you select wherever you are in the United States.
  - Its digital transmission techniques ensure high-quality stereo sound that is immune to noise.
  - The satellites transmit other information such as song title and artist, type of music, and other data, which are displayed on a LCD screen.

Satellite Applications

- Surveillance satellites can look at the earth and transmit what they see back to ground stations for a wide variety of purposes, including military intelligence, meteorological applications, and mapping.
- Satellite navigation systems can provide global coverage unavailable with land-based systems satellites.

End Of Slides