



Shoubra faculty
of Engineering

4th year Communication



Advanced Electronic Systems

Part 2

Lecture 3

- **Communication satellite services (applications)**

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Satellite Applications: Communication Satellites

Satellite Applications

- Based on the intended applications, the satellites are broadly classified as:
 - **Communication satellites**
 - Navigation satellites
 - Weather forecasting satellites
 - Earth observation satellites
 - Scientific satellites
 - Military satellites.

Satellite Services

Main satellite services as defined by the ITU for the purpose of radio frequency allocations:

- Fixed satellite services (**FSS**): provide links for existing telephone networks, and for transmitting TV signals to cable companies
- Mobile satellite services (**MSS**): land mobile, maritime mobile, aeronautical mobile
- Broadcast satellite services (**BSS**): intended for direct broadcast.

Service type	Freq. bands for UL/DL	Usual terminology
Fixed satellite services (FSS)	6/4 GHz 8/7 GHz 14/12-11 GHz 30/20 GHz 50/40 GHz	C band X band Ku band Ka band V band
Mobile satellite services (MSS)	1.6/1.5 GHz 2/2.2 GHz 30/20 GHz	L band S band Ka band
Broadcasting satellite services (BSS)	2/2.2 GHz 12 GHz 2.6/2.5 GHz	S band Ku band S band



Communication Satellite

Introduction to Communication Satellites

- Satellite telecommunication is the most prominent one among other applications of satellites, both in terms of application potential and the number of satellites launched in each category.
 - The application areas of communication satellites mainly include **television broadcasting, international telephony and data communication** services.
 - Communication satellites act as repeater stations that provide either **point-to-point, point-to-multipoint or multipoint interactive services**.
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- **Telstar-1**, 1962, established the first intercontinental link between USA and Europe, providing telephony as well as television services.
 - To date more than 3000 communication satellites have been launched, out of which more than 1000 satellites were launched in the decade 2000--2010.
 - These electronic birds have tied the whole world together and made it look like a global village.

Communication Related Applications of Satellites

Satellite TV: Refers to the use of satellites for relaying TV programs from a point where they originate to a large geographical area. GEO satellites in **point-to-multipoint** configuration are employed for satellite TV applications.

Satellite Telephony: Satellites provide both long distance (especially intercontinental) **point-to-point** (trunk telephony) services as well as mobile telephony services, either to **complement or to bypass the terrestrial networks**.

Data communication services: including data and multimedia services such as data collection and broadcasting, image and video transfer, voice, internet, two-way computer interactions and database inquiries. Satellites in this case provide **multipoint interactive connectivity**,

Satellite versus Terrestrial Networks

Advantages of Satellites Over Terrestrial Networks

- Broadcast property -- wide coverage area.
- Wide bandwidth -- high transmission speeds and transmission capacity.
- Geographical flexibility -- independence of location: This makes them attractive to countries having difficult geographical terrains and unevenly distributed populations.
- Easy installation of ground stations. Once the satellite has been launched, installation and maintenance of satellite Earth stations is much simpler than establishing a terrestrial infrastructure
- Uniform service characteristics within their footprint. This overcomes some of the problems related to the fragmentation of service that result from connecting network segments from various terrestrial telecommunication operators.
- Immunity to natural disaster (e.g., floods, earthquakes,..etc)
- Cost aspects -- low cost per added site and distance insensitive costs.

Satellite versus Terrestrial Networks

Disadvantages of Satellites Over Terrestrial Networks

- Transmission delay. so, GEO satellites are not suited for certain applications like interactive media, which require small transmission delays.
 - Echo effects. The echo effect, in which the speaker hears his or her own voice, due to larger transmission delays (need echo suppressors)
 - Launch cost of a satellite. Although the cost of a satellite ground station is less than that of terrestrial networks and the cost of satellite services are independent of the distances involved, **the cost of launching a satellite is huge**.
- Current trends in the field of telecommunication favor space systems that **complement** terrestrial networks rather than maintaining their independence from them.



Satellite Telephony

Satellite Telephony

- Satellites provide both long distance **point-to-point trunk telephony** services as well as **mobile telephony** services, either to **complement or to bypass** terrestrial networks. Potential users of these services include international business travelers and people living in remote areas.
- Single GEO satellites or a constellation of LEO, MEO and HEO satellites are used for providing telephony services.

Some satellite systems offering voice services:

- ✓ Intelsat
- ✓ Inmarsat
- ✓ Globalstar
- ✓ Iridium
- ✓ Ellipso
- ✓ Odyssey

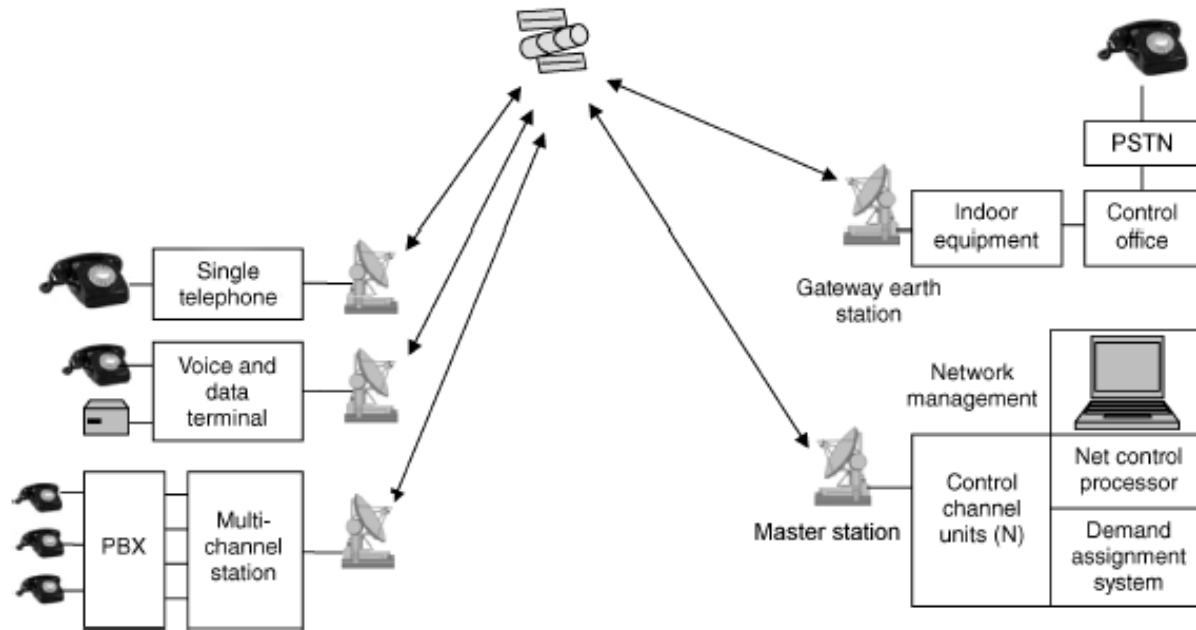


Figure 10.3 Satellite point-to-point telephone networks (PBX, private branch exchange; PSTN, public switched telephone network)

Steps in making a call through a satellite

1. The user lifts the receiver when he or she wants to make a call. This sends a request to the local Earth station, which in turn sends a service request to the master station.
2. If the master station is able to provide the satellite capacity, it sends a confirmation signal to the local Earth station, resulting in a dial tone in the telephone instrument.
3. The user then dials the destination number, which is transferred to the control station, which determines the destination Earth station and signals it that a connection needs to be established.
4. The destination Earth station then signals the called party of the incoming call by ringing that telephone instrument.
5. The satellite capacity is allocated to the connection and the telephone link is established once the called party lifts the handset.
6. Once the conversation is over, the calling party hangs up the receiver, hence indicating to the local Earth station to terminate the call.

➤ The call may involve connection through multiple satellites and cross-links.

Point-to-Point Trunk Telephone Networks

- One of the traditional applications of satellites includes **long distance**, especially **intercontinental trunk telephony services**, also referred to as thin-route satellite telephony services. These services are particularly useful for establishing connections between the companies headquarters and its remote offices, through gateway Earth stations.
- Trunk telephony services come under the domain of **fixed satellite services (FSS)**, mainly utilizing C and Ku bands. Generally, GEO satellites are utilized for providing these services. Intelast, Europestar, Eutelsat, PamAmSat are examples of some of the satellites used for the purpose.

Mobile Satellite Telephony

- One of the important services provided by **mobile satellite services (MSS)** is the **interactive voice communication to mobile users**. This service is referred to as mobile satellite telephony.

The satellite phones target **two specific markets**:

- Global mobile coverage: Satellites provide international business users with seamless global mobile services with a single mobile phone (in contrary to terrestrial networks which need roaming agreements that may be not available between some countries).
- Unserved regions: where the basic telecommunication services are not present.

Mobile Satellite Telephony (cont'd)

- MSS satellites launched in the periods 1980—1990 and 1990--1998 were GEO satellites (Generation-I and Generation-II), mainly providing telephony services to **relatively large mobile terminals**. Third generation mobile satellites, comprising constellations of LEO, MEO, HEO and GEO satellites, provide voice and multimedia services to **mobile and hand-held terminals**.
- These **third generation** mobile satellite services also **referred to as** global mobile personal communication services (**GMPCS**).
- GMPCS is a personal communication system providing **transnational, regional or global** two-way voice, fax, messaging, data and broadband multimedia services from a constellation of satellites accessible with small and easily transportable terminals.

Mobile Satellite Telephony (cont'd)

Table 10.1 Features of the various GMPCS systems

Types of GMPCS	Services offered	Frequency range	Terrestrial counterpart	Examples
Little LEO (data only GMPCS)	Data services like messaging in the store-and-forward mode	Below 1 GHz	Messaging services like paging and mobile data services	Orbcomm
Big LEO including LEO, HEO and MEO satellites (narrowband GMPCS)	Real time voice and data services	1–3 GHz	Cellular telephone	Iridium, Globalstar (LEO orbit), ICO constellation (MEO orbit) and Ellipso constellation (HEO orbit)
GEO (narrowband/broadband MSS)	Both store-and-forward and real time voice, data and video services	1.5–1.6 GHz and around 2 GHz	Cellular ISDN	Inmarsat, ACeS (Asia cellular satellite), APMT (Asia-Pacific mobile telecommunications), ASC and Thuraya satellite systems
Boadband GMPCS (broadband FSS)	Real time multimedia including voice and data	Above 10 GHz	Fibre optics	Sky Bridge Teledesic constellation



Satellite Television

Satellite Television

- Satellite television is the most widely used application area of communication satellites. It accounts for about 75% of the satellite market for communication services. Satellite television basically refers to the use of satellites for **relaying TV programs from a central broadcasting center to a large geographical area.**
- Satellites like GE and Galaxy in the US, Astra and Hot Bird in Europe, INSAT in India and JCSAT (Japanese communications satellite) and Superbird in Japan are used for TV broadcasting applications.
- Other means of television broadcasting include terrestrial TV broadcasting and cable TV services.
- Satellites can provide TV transmission services either **directly to the users** or **in conjunction with** the cable and **terrestrial** broadcasting networks.

A Typical Satellite TV Network

- Satellite television employs GEO satellites acting as **point-to-multipoint** repeaters receiving a certain telecast from the transmission broadcasting center and retransmitting the same after frequency translation.
- Satellites can provide TV programs either directly to the users (**direct-to-home television**) or indirectly, where the satellite feeds the signal to a central operator who in turn transmits the programs to the users through **cable networks** or **terrestrial broadcasting networks**

- The **uplink** section comprises:
 - Programming source
 - Broadcasting center
 - Main broadcasting satellite.
- The satellite **downlink** comprises:
 - Main broadcasting satellite
 - TV receiving network

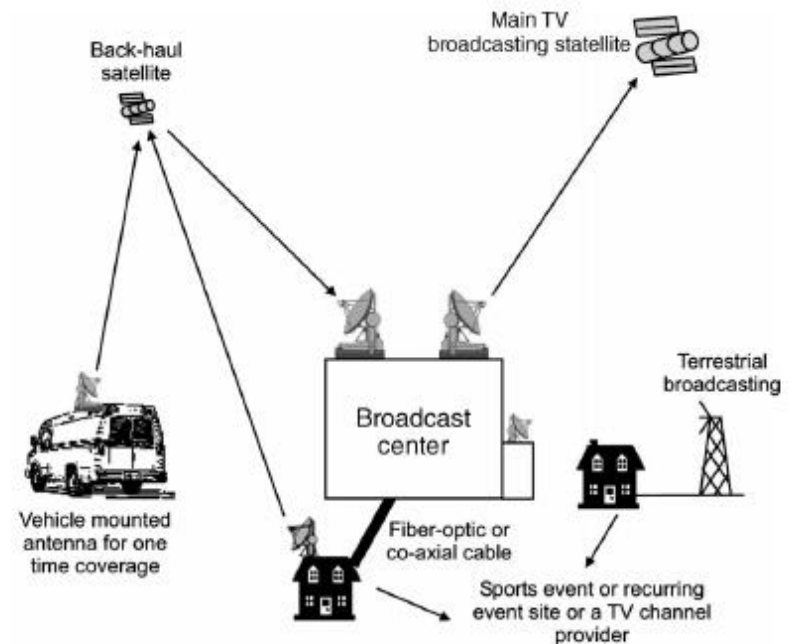


Figure 10.4 Uplink section of satellite TV networks

A Typical Satellite TV Network (cont'd)

Uplink transmission:

- The programming source provide various TV programming signals, like TV channels, sports coverage, news coverage or local recorded TV programs, **to the broadcasting center** either **through terrestrial means**, like using the line-of-sight microwave communication and the fiber optic cable, **or using satellites referred to as back-haul satellites**.
- As an example, for one-time events like various news events, a vehicle-mounted Earth station generally operating in the Ku band is driven to the site and then the programs are transmitted to the main broadcast center using a back-haul satellite.
- The broadcasting center is the hub of the satellite TV system and it **processes and beams** the signal to the main broadcasting satellite. Generally, the signals are transmitted using analogue techniques in the C band or using a digital format employing various **compression** techniques in the Ku band. The signals are also generally **encrypted** before transmission to prevent unauthorized viewing

A Typical Satellite TV Network (cont'd)

Downlink transmission:

- The satellite downlink comprises the main broadcasting satellite and the TV receiving network. In fact, the main broadcasting satellite is common in both the uplink and the downlink sections.
- The receiver network in the case of **satellite distributing programs to the terrestrial broadcast network** comprise various terrestrial broadcasting centers that receive the satellite signal and transmit them to the users in the VHF and the UHF bands using terrestrial broadcasting. The user end has directional Yagi antennas to pick up these signals.
- In the case of **satellite distributing programs to a cable operator**, the downlink section comprises the cable—TV head ends and the cable distribution network.
- For **DTH services**, receive-only satellite dishes are mounted at the user's premises to receive the TV programs directly from the satellite.

Satellite-Cable Television

- **Cable TV** refers to the use of coaxial and fiber optic cables to connect each house through a point-to-multipoint distribution network to the head end distribution station (e.g., various houses in a large building). The head ends receive programming channels from either a local broadcasting link or through satellites.
- The use of satellites to carry the programming channels to the cable systems head ends is referred to as **satellite--cable television**. The head end in this case consists of various receive-only Earth stations with the capability of receiving telecast from two to six satellites.

- These Earth stations then transmit signals over a typical cable distribution network to a large number of houses known as **subscribers**, who **pay a monthly fee** for the service.

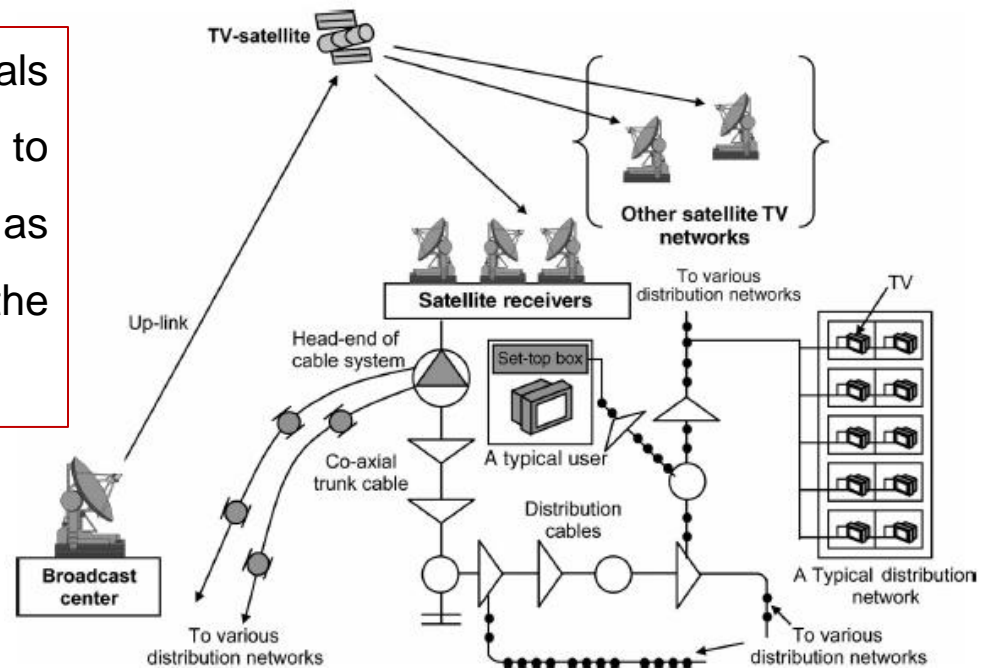


Figure 10.5 Satellite cable television

Satellite-Local Broadcast TV Network

- Here the satellite distributes programming to **local terrestrial broadcasting stations**. The broadcasting stations use powerful antennas to transmit the received signals to various users within the line-of-sight (50--150 km) using UHF and VHF microwave bands. The users receive these TV signals using directional antennas like Yagi antennas, reflector antennas or dipole antennas.
- Sometimes, a **combination of both the satellite-cable TV and the satellite-local broadcast TV networks** is used for distributing TV programs to the users. As an example, one of the possible configurations is where the satellite sends the signals to the local broadcasting stations, which in turn broadcast them to the cable operators.

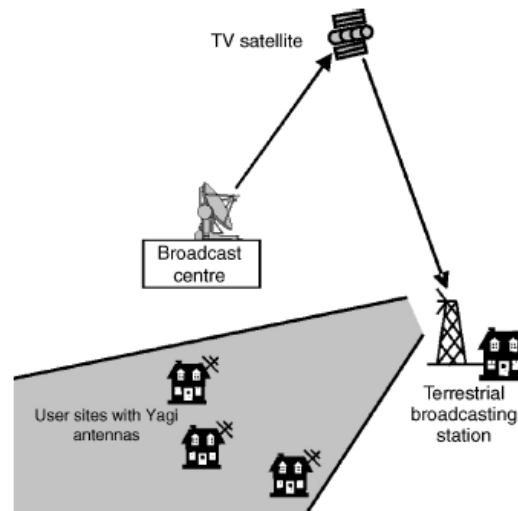


Figure 10.6 Typical satellite local-broadcast TV network

Direct-to-Home Satellite Television

- Direct-to-home (DTH) satellite television refers to the direct reception of satellite TV programs by the end users from the satellite through their own receiving antennas.

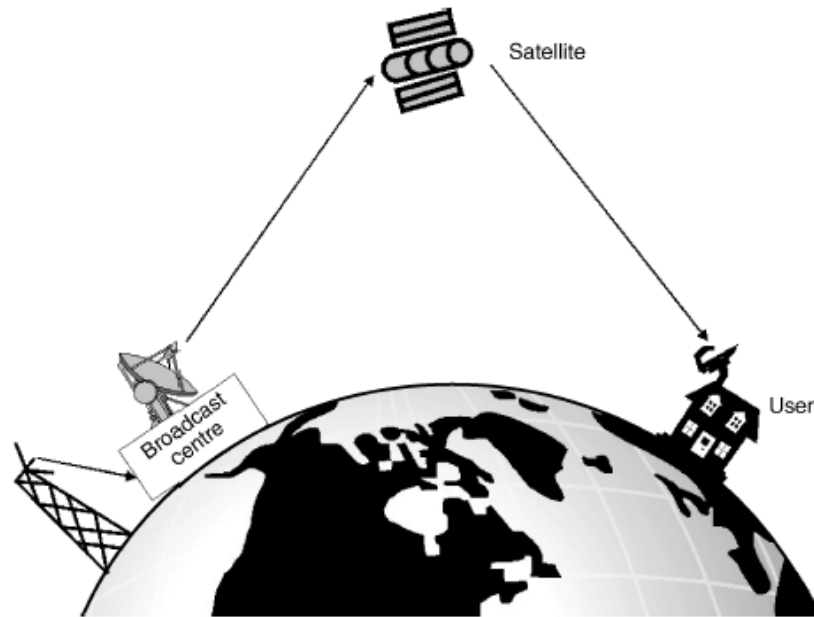


Figure 10.7 Direct-to-home satellite television



Satellite Data Communication

Satellite Data Communication Services

- Data communication via satellites refers to the **use of satellites** as a communication channel **to transmit data** between two computers or data processing facilities located at different places.
- Data communication services are provided either by GEO satellites or by a constellation of LEO, MEO or HEO satellites. GEO satellites provide broadcast, multicast and point-to-point unidirectional or bidirectional data services through special networks called **VSAT networks**.

Satellite Data Broadcasting

- Satellite data broadcasting refers to the use of satellites in **point-to-multipoint or multipoint interactive** configurations for the transmission of information in **digital form**.
- **International organizations** having offices in remote areas make use of satellite broadcasting services for data collection and broadcasting, image and voice transfer, two-way computer interactions and database inquiries between these remote stations and the main head center.

Satellite Data Broadcasting (cont'd)

- Point-to-multipoint broadcast services refer to unidirectional data transmission from a **single uplink** to a large number of remote receiving points within the coverage area of the satellite (i.e. **unidirectional**)
- A multipoint interactive network is similar to the point-to-multipoint network except for the fact that the remote terminals in this case also have the transmitting capability (i.e., **bidirectional**)

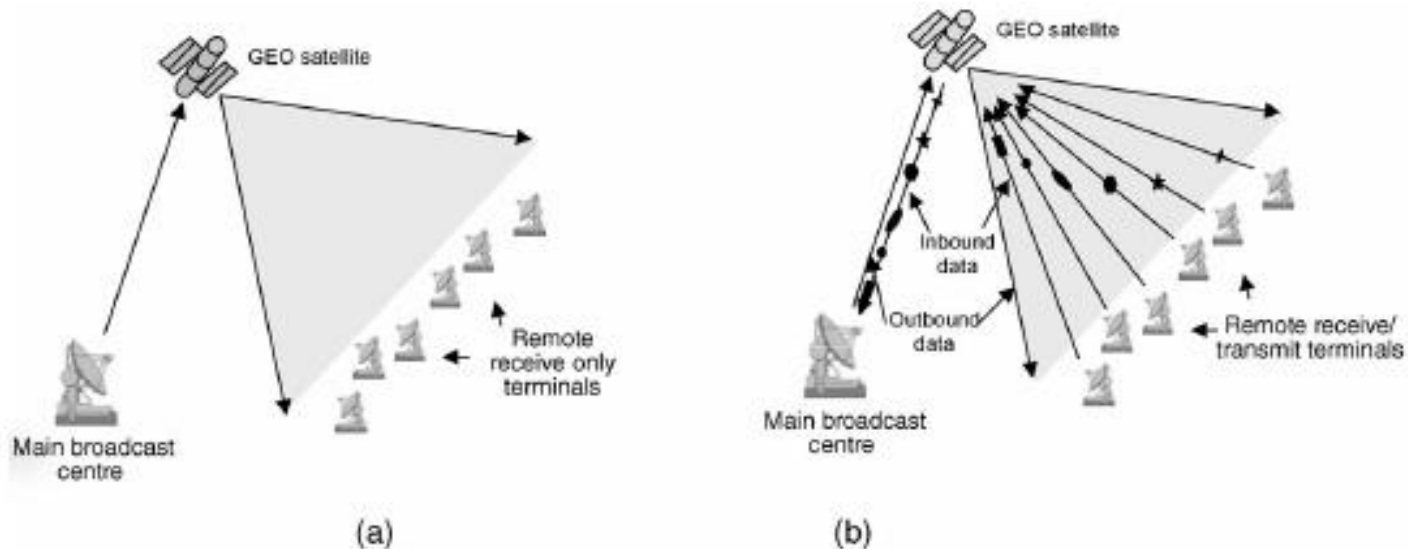


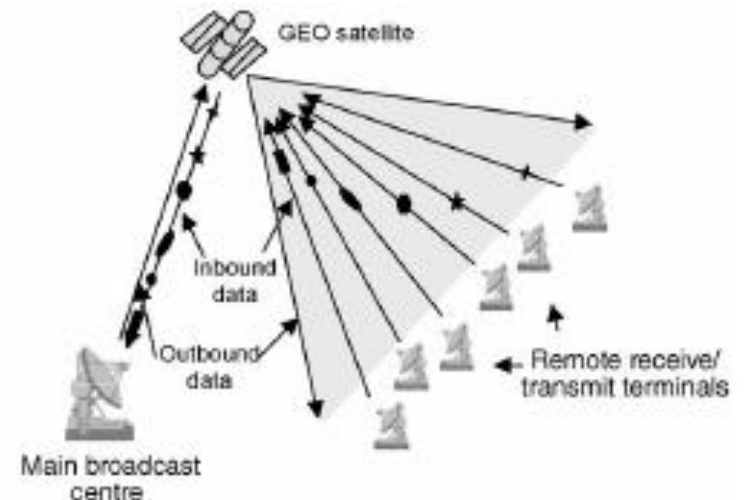
Figure 10.9 (a) Typical point-to-multipoint network (b) Typical multipoint interactive network

Satellite Data Broadcasting (cont'd)

Multipoint interactive network:

- In general, the amount of data transmitted from the central station to the remote terminals (**outbound direction**) far **exceeds** the data transmitted from the remote terminals to the central station (**inbound direction**). Hence these networks are **asymmetrical** in form, having higher data rates in the outbound direction as compared to the inbound direction.

Interactive data communication is the foundation of most corporate and government networks.



VSATs (Very Small Aperture Terminals)

- VSATs, are used for providing:
 - one-way or two-way data broadcasting services
 - point-to-point voice services
 - one-way video broadcasting services.
- VSAT networks are ideal for centralized networks with a central host and a number of geographically dispersed terminals (e.g., banking institutions with branches all over the country, reservation and airline ticketing systems, etc.
- VSATs advantages: wide geographical area coverage, high reliability, low cost independence from terrestrial infrastructure, flexible network configurations, etc.
- However, VSATs **suffer** from a **major problem of delay** between transmission and reception of data (around 250 ms) due to the use of GEO satellites.

VSAT Network

- **The ground segment** of a typical VSAT network consists of a **high performance hub Earth station** and a large number of **low performance terminals**, referred to as **VSATs**. VSATs can be simpler and smaller in design, thus enabling the VSAT networks to be extremely economical and flexible
- **The space segment** comprises of GEO satellites acting as communication links between the hub station and the VSAT terminals.

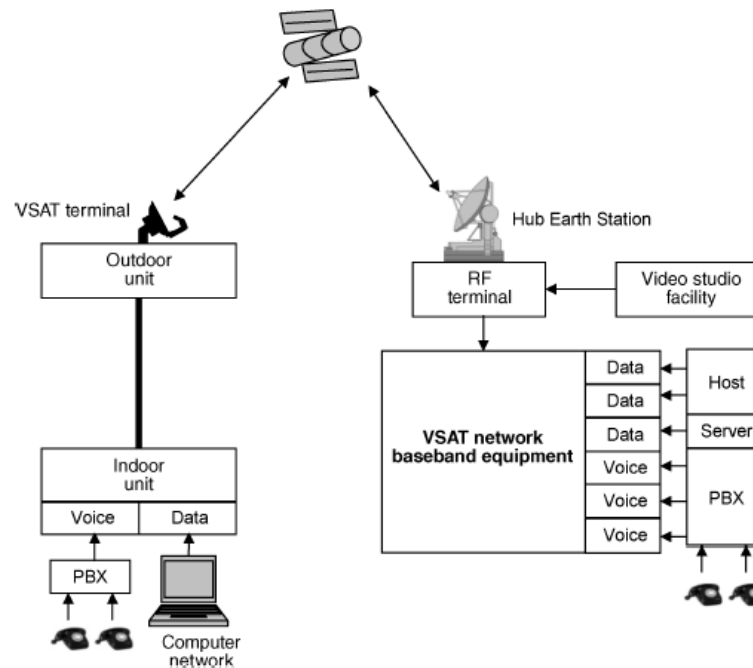


Figure 10.10 A typical VSAT network

VSAT Network (cont'd)

The Hub Earth station:

- The hub station is usually a **large, high performance** Earth station comprising an outdoor antenna (with a diameter of between 6 to 9 metres) for transmission, RF terminals for providing a **wide band uplink**, base band equipment comprising modems, multiplexers and encoders, a control center for managing the network and various kinds of interfacing equipment to support a wide variety of terrestrial links.
- These terrestrial links **connect** the **hub station** to the head office or to the **data processing center**, from where the data has to be broadcasted.
- In the **case of bidirectional** networks, the outdoor antenna is also configured for reception of signals and the RF equipment comprises **several narrowband downlink channels** for reception from various remote VSAT terminals.

VSAT Network (cont'd)

VSAT terminals:

- VSAT terminals **are smaller and simpler** in design as compared to the hub center and comprise an outdoor antenna (0.5 to 2.4 m in diameter), an RF terminal comprising an LNB (low noise block) for reception and base band equipment. They **also comprise an up-converter and power amplifier for uplinking** in the case of **bidirectional** networks.
- VSAT networks employ either C band or Ku band frequencies for transmission and reception. **Ku band** VSAT networks have **smaller antenna diameters** as compared to C band networks.

VSAT Network (cont'd)

- Data transmission through VSATs, as mentioned earlier, is generally **asymmetrical** in nature because the amount of **outbound data** to be transmitted far **exceeds the inbound data**.
- Hence, VSAT networks generally support **data, video and voice services** in the **outbound direction** and **only data and voice services** in the **inbound direction**. However, some VSAT networks offer compressed digital video services in the inbound direction also.



Thanks for attention