Satellite Networking Principals

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Contents

Lecture Objectives

- Refreshing fundmental data networking concepts
- Understand the concepts of satellite networks and internetworking with terrestrial networks.
- Know the different satellite services, network services and quality of service (QoS).
- Appreciate the differences between satellite networking and terrestrial networking issues.
- Describe the functions of network user terminals and satellite user earth terminals and gateway earth terminals.

1 Introduction to Satellite Networking

- The ultimate goal of satellite networking is to provide services and applications especially for special and niche markets that can not be reached due to practical obstacles such as geography.






1.1 Historical Development of Satellite Services

- **4 October 1957** → Sputnik by the USSR
- **August 1960** → the first experiment of an active relaying communications satellite Courier-1B by the USA.
- Similar to any communication services, voice and TV broadcast are among the first door-crasher services provided by satellite systems.
  - **April 1965** → Intelsat-1 marked the first commercial geostationary communication satellite. It provided 240 telephone circuits and one TV channel between the USA, France, Germany and the UK
  - 1967 → Intelsat-II satellites provided the same service over the Atlantic and Pacific Ocean regions.
  - 1968-1970 → Intelsat-III achieved worldwide operation with 1500 telephone circuits and four TV channels.
  - January 1971 → Intelsat-IV satellite provided 4000 telephone circuits and two TV channels
  - Intelsat-IVa provided 20 transponders of 6000 circuits and two TV channels
- Digital satellites boosts the capacity of the satellites
  - **1981** → Intelsat-V satellite achieved capacity of 12 000 circuits with FDMA and TDMA operations, 6/4 GHz and 14/11 GHz wideband transponders, and frequency reuse by beam separation and dual polarisation.
  - 1989 the Intelsat-VI satellite provided onboard satellite-switched TDMA of up to 120 000 circuits
  - 1998, Intelsat VII, VIIa and Intelsat- VIII satellites were launched.
  - 2000, the Intelsat-IX satellite achieved 160 000 circuits.
- **1999** Development of direct-to-home (DTH) broadcast
  - the first K-TV satellite provided 30 14/11-12 GHz transponders for 210 TV programmes with possible direct-to-home (DTH) broadcast and VSAT services.
- **1979** Development of satellite maritime communications
  - the International Maritime Satellite (Inmarsat) organisation was established to provide global maritime satellite communication
- 1990's Internet over satellite networks
  - As the human dependence on the Internet increases, the satellite is becoming an interinsic part of the Internet.
  - The role of satellites in high-speed networking will evolve according to the evolution of the terrestrial networks. Two main roles can be identified in two scenarios of the broadband network development:
    - **Initial phase** when satellites will compensate the lack of sufficient terrestrial high bit rate links mainly by interconnecting a few regional or national distributed broadband networks, usually called 'broadband islands'.
    - **Maturation phase** when the terrestrial broadband infrastructure will have reached some degree of maturity. In this phase, satellites are expected to provide broadcast service and also cost-effective links to rural areas complementing the terrestrial network. At this phase satellite networks will provide broadband links to a large number of end users through a UNI for accessing broadband networks. This allows high flexibility concerning topology, reconfiguration and network expansion. Satellites are also ideal for intercon- necting mobile sites and provide a back-up solution in case of failure of the terrestrial systems.

1.1.1 ITU Satellite Service Standardization

- For the purpose of bandwidth allocation, planning and management, the ITU Radiocommunication Standardisation Sector (ITU-R) defines three satellite services including
  - fixed satellite service (FSS) for communication between two fixed earth stations.

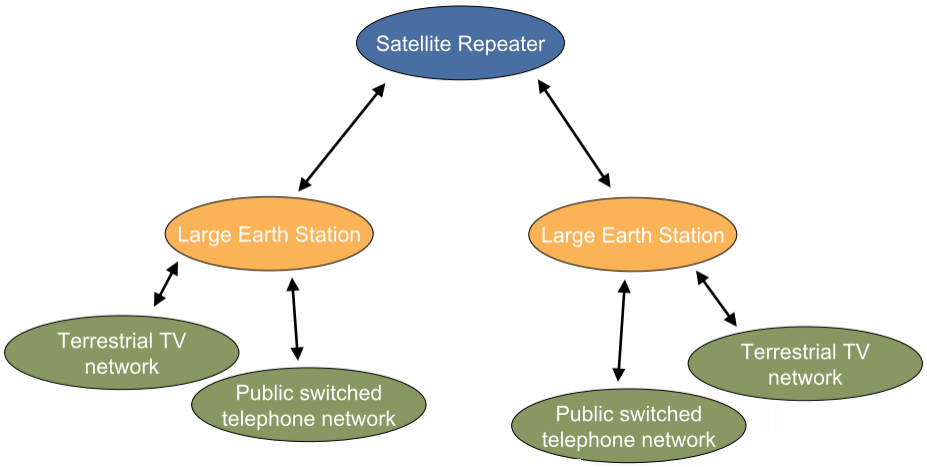

Figure 1: FSS Services

  - mobile satellite service (MSS) for communication involving a mobile earth station.
    - e.g. Iridium, Thuraya, Inmarsat
    - Video, data traffic to/from mobile terminals

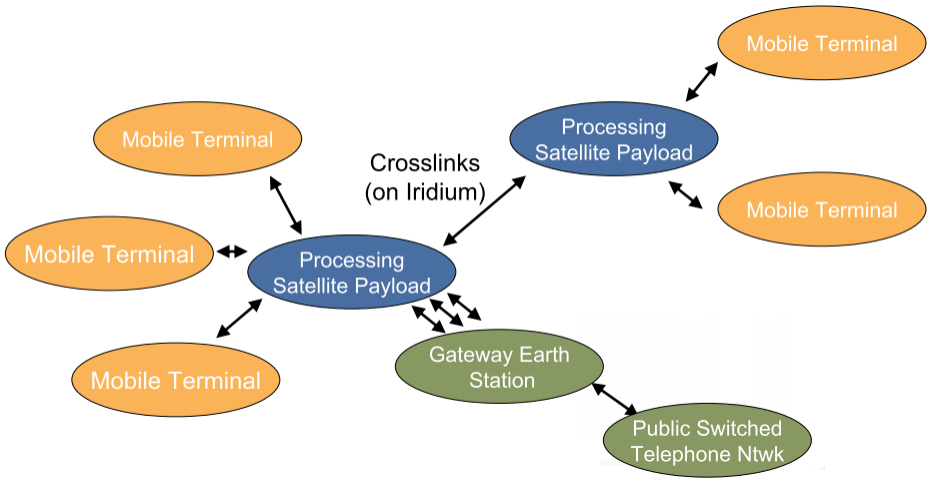

Figure 2: MSS Services

  - broadcasting satellite service (BSS) as in the case of TV broadcasting.

- To support the aformentioned services, three main roles can be played by satellites in communication networks
  - ***Access network*** in which satellites act as base station in the cellular system and users directly connect to the satellite to have access services such as telephony.
  - ***transit network*** in which satellites are used as intermediate nodes (may be just a bent-pipe or router). In this case, satellites are completely transparent to the end users.
  - ***broadcast network*** in which satellites provide very efficient broadcasting services including digital audio and video broadcast

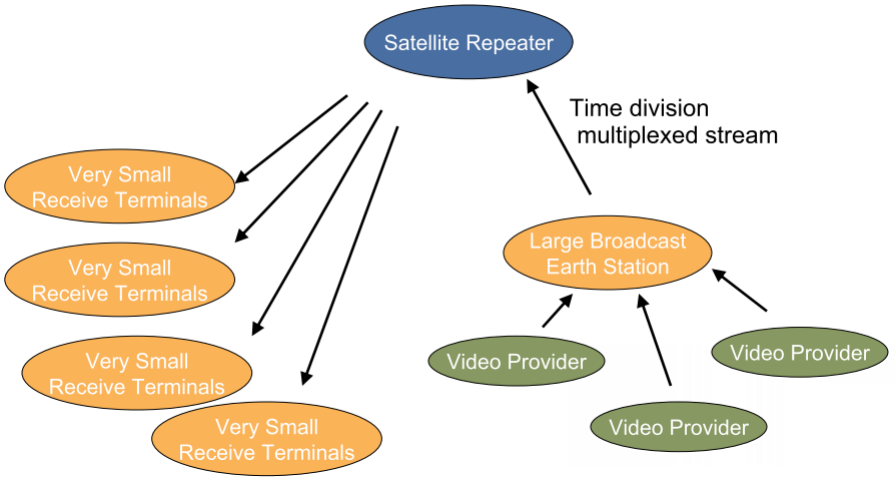

Figure 3: Broadcasting Services

2 Characteristics of satellite networks

- The satellite radio link imposes special characteristics that have a strong impact on designing satellite networks including large propagation delay, channel impairments, limited power and crowdness.

2.1 Large Propagation Delay

- For GEO satellites, the time required to traverse these distances – namely, earth station to satellite to another earth station – is in the order of 250 ms.
- Round-trip delay will be of 2 × 250 or 500 ms.
- These propagation times are much greater than those encountered in conventional terrestrial systems.
- This large delays impacts several applications especially interactive applications such as voice and data.

2.2 Channel Impairments

- Again to the large distances, losses in satellites systems are too high in comparison to conventional systems.
- For LOS microwave we encounter free-space losses possibly as high as 145 dB. In the case of a satellite with a range of 22 300 miles operating on 4.2 GHz, the free-space loss is 196 dB and at 6 GHz, 199 dB.
- From satellite to earth the link is power-limited for two reasons:
  - Interference avoidance in bands shared with terrestrial services, such as the popular 4-GHz band.
  - In the satellite itself, which can derive power only from solar cells. It takes a great number of solar cells to produce the RF power necessary; thus the downlink, from satellite to earth, is critical.

2.3 Limited Power

- power is limited for
  - user terminals requiring mobility
  - for units installed in remote places that rely on battery supply of power
  - for communication systems on board satellites that rely on battery and solar energy.
- The bandwidth and transmission power together within the transmission conditions and environment determine the capacity of the satellite networks.

2.4 Crowdness

- The equatorial orbit is filling up with geostationary satellites.
- Radio-frequency interference from one satellite system to another is increasing.

3 Course Project: Satellite Network Emulation or Simulation

- The objective of the project is to expose the students to the impact of of different system components on the preformance of o satellite systems.
- For example, one may be interested on investigating e of sas link error, or link delay on TCP performance. Others may be interested in the preformance of resource allocation starategies on the system performance. These issues can be investigated using network emulation or simulation.
- For Emulation, one can use traffic control (tc) commands in linux. Specifically, tc commands in linux a satllite link can be emulated using two computers to as client and server machines. Other, applications may be used to send and receive artificial traffic on these machines.
- For simulation, NS2 and NCTUns can be used to develop a simulation framework for satellite systems.
- Independent of your chosen tool,

References

[1] Zhili Sun, "Satellite Networking: Principles and Protocols," John Wiley & Sons Ltd, 2005

[2] TDMA-DAMA on NS2

[3] NCTUns