Satellites for Global and Mobile Communications

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Communications satellites play a vital role in linking people throughout the world, to form what is commonly referred to as the global village. A typical satellite communication system involves the transmission of a signal from an Earth station to a satellite. The satellite then amplifies the signal and retransmits it back to Earth, where it is received by terminals such as satellite phones, TV receivers, aircraft, and other fixed or mobile devices.

This article outlines the key communications services provided by satellites: telephony, data communications, and TV broadcasting. However, satellites enable a much wider variety of global and mobile communications applications such as distance learning, news gathering, navigation and tracking. Another key area of application of satellites is military communications.

Communication Satellites

The possibility of using satellites for communication was proposed by Sir Arthur C. Clarke in a paper published in 1945 entitled, *Extra-Terrestrial Relays: Can Rocket Stations Give World-wide Radio Coverage?*. He calculated that a satellite at an altitude of 35,786 km above the Earth's surface would be moving at the same speed as the Earth's rotation, and thus would remain in a fixed position relative to a point on Earth. Accordinaly an antenna fixed on the ground can be pointed to a satellite 24 hours a day. Clarke showed in his paper that three satellites in such an orbit would be able to provide radio coverage to the entire world.

It took several years for the technologies that made satellite communications practical to evolve. The first artificial satellite, Sputnik 1, was launched successfully by the Soviet Union on October 4, 1957. The Echo 1, an aluminum-coated balloon that simply reflected signals from the ground, developed by NASA and the Bell Labs was launched on August 12, 1960. The U.S. National Aeronautics and Space Administration's (NASA) ambitious satellite technology programs helped advance global satellite communications industry in leaps and bounds. The potential application of satellites for development and their ability to reach remote regions led other countries to build and operate their own national satellite systems subsequently.

Today, approximately 2,000 communications satellites orbit the Earth, relaying signals carrying voice, video, and data to and from one or many locations worldwide. Of these approximately 42% occupy the geostationary orbit proposed by Sir Clarke and 47% occupy low earth orbits (LEO). A smaller percentage of satellites operate in medium earth orbits (MEO) and elliptical earth orbits.

Frequency Bands

The frequency bands used in satellite communications are designated as L-, S-, C-, X-, Ku-, Ka-, and V-bands. The lower frequency ranges (L-, S-, and C-bands) need large antennas to communicate. The Padukka satellite station which was Sri Lanka's only link with the rest of the world at the time was commissioned in 1976, operated in the C-band with an antenna of 30m diameter. The higher frequency bands (X-, Ku-, Ka-, and V-) can use dishes of much smaller size (e.g. 45cm diameter). This makes the Ku- and Ka-bands ideal for TV broadcasting direct to homes, broadband data communications, and mobile applications.

The primary commercial frequency bands currently in use are the C-band (4-6 GHz) and the Ku-band (11-14 GHz). Over the next several years, the Ka-band is expected to increase to support evolving broadband services.

Regulation

The International Telecommunication Union (ITU), an agency of the United Nations, regulates satellite communications. The ITU, receives and approves applications for use of orbital slots for satellites, and is responsible for assigning frequencies to various applications in various regions of the world. Each country's telecommunications regulatory agency enforces these regulations and awards licenses to users of various frequencies. In Sri Lanka, this body is the Telecommunications Regulatory Authority (TRCSL).

Satellite Telephone Services

Satellite telephony provides services directly to handheld phones. These are used in telephony applications over sparsely populated territory or over oceans, where fixed or mobile terrestrial networks are not feasible or economical. The phone connects with an orbiting satellite, in the same way as a mobile phone connects with a base station. Though early satellite phones were large in size, with large retractable antennae, they are evolving to become almost indistinguishable from cellular phones. Satellite phone systems are also able to provide low-bandwidth data connectivity to user devices. The per-minute cost of satellite phone calls currently range between US$ 1.25 and 2.00.

•*Geostationary Systems*

Some satellite phone systems use geostationary satellites. The system cost is relatively low as each satellite covers a large area. However, the disadvantages are that line-of-sight between the phone and the satellite is usually required and the poor quality of services at latitudes beyond 700 . Another disadvantage is that it takes over a quarter of a minute for a signal to reach a satellite and be relayed back to earth.

Well known geostationary satellite phone systems include Inmarsat, Thuraya, ACeS and Terrestar. Inmarsat, the oldest satellite phone operator's core business is to provide fixed installation for ships. It operates 11 satellites, providing coverage to most parts of the world, except in the polar regions. The company has been in the news in recent times, for its role in the search for the lost Malaysian Airlines aircraft. AceS provides a regional service in South Asia, while Thuraya provides coverage over Europe, Africa, the Middle East, Asia and Australia. Geostationary systems are able to provide low-rate data services from 60 to 512 kbits per second in addition to voices.

•*Low Earth Orbit Systems*

LEO satellites orbit the earth at high speed, the low altitude orbits (640-1120 km). The orbital period is 70-100 minutes. Thus, LEO satellite systems need to use a constellation of satellites in several orbital planes to provide their services. The constellation architecture ensures that every location in the service area is covered by at least one satellite at all times. A usable pass of an individual LEO satellite will typically last 4–15 minutes. The service must be handed over from one satellite to the next to ensure continuity. Examples of LEO systems are *Iridium* with a constellation of 66 satellites and *Globalstar* with 44. The data rates that LEO systems are able to provide are lower than those offered by geostationary systems.

Emergency Communications

Satellite phones have helped disaster relief operations, saving thousands of lives over the years. Cellular systems and other terrestrial infrastructure can be among the first casualties of a disaster. Satellite systems operate independently of the local communications infrastructure. Hence they are ideally suited for communications during and after disasters, where other forms of communications have been disrupted. In effect, satellite systems are able to provide instant critical infrastructure in disaster situations such as

earthquakes, tsunamis and cyclones. Ambulances and fire trucks can also communicate with each other and with coordinating centers, and exchange important data by taking advantage of the data and positioning capabilities of the portable satellite phone. Disaster warning systems as well as disaster relief personnel usually have satellite systems as a back-up mechanism in their communications networks.

Satellites for Data Communications

Satellites facilitate the transfer of data through very small aperture terminal (VSAT) networks. A VSAT is a two-way satellite ground station with a dish antenna that is smaller than 3 m. An organization can set up a private network between its head office and remote branches using a VSAT service provider. The organization may configure the network in either a star topology or a mesh topology. In the star topology, the organization would operate a central uplink site called a network operations center (NOC), to transport data back and forth to each remote station via satellite. In the mesh configuration, each station may relay data via satellite to another station by acting as a hub, without the need for a NOC. VSAT service providers may provide such a service to multiple client organizations, with each organization having virtually its own private network while sharing the service provider's infrastructure with others.

With VSAT services, communications facilities similar to those available at the corporate office may be extended to their remote stations. Users in remote offices can make telephone calls, access the Internet and use common business applications to successfully run their operations even in isolated or harsh environments.

Bandwidth (or equivalently, data rates) available to the user is an important consideration in satellite data services. Today's popular social networking applications, as well as audio/video entertainment are bandwidth intensive tasks. Broadband satellite service providers adopt a wide range of technologies, and thus the available bandwidth also varies widely. Top ranking service providers offer download speeds in the range of 10-15 Mb/s. To keep this in perspective, original speeds offered just 15 years ago in the satellite Internet industry averaged 500kb/s download and 250kb/s upload. These speeds are expected to increase dramatically over the coming years. For interactive applications such as gaming and videoconferencing, upload speeds are also crucial. Current upload speeds range from about 400 kb/s to 5 Mb/s.

Broadcasting via Satellite

Satellite broadcasting services deliver radio and television directly to the consumer's fixed or mobile receivers. Direct-broadcast satellite (DBS) is a term used to refer to satellite television broadcasts intended for home reception. DBS is also known by the ITU as Broadcasting Satellite Service (BSS).
The inherent broadcast capability was what Sir Arthur C. Clarke foresaw as the potential of satellites in his article in 1945. Nearly 20 years later, the first TV broadcast via satellite happened at the 1964 Olympic games held in Tokyo. The games were telecast to the United States using Syncom 3, the first geostationary communication satellite, and from there to Europe using Relay 1.

Early satellite television was broadcast in C-band. Today's digital broadcast satellite transmits in the Ku- band. Digital technology provides better picture and sound quality, and makes more efficient use of the frequency band compared to older analog technology.
A DBS service provider obtains content from different sources, and beams a broadcast signal to a geostationary satellite. The satellite receives this and re-broadcasts it back to earth. The viewer's receiver picks up this signal, processes and displays it on a standard TV receiver.

The current standard for DBS is DVB-S2 (Digital Video Broadcasting - Satellite - Second Generation). It is based on and improves upon the previous DVB-S standard. DVB-S2 supports standard TV, high-definition TV (HDTV) and interactive TV services. DVB-S2 standard was developed in parallel with HDTV and H.264 (MPEG-4 AVC) video codec standards.

In a relatively short span of time, satellite communications technology has developed from the experimental to the sophisticated and powerful. Global and mobile communications forms, the underlying threads linking the world into a single global village, and despite competition from optical fiber, satellite communication remains the most general medium to achieve this.
With increasing video, voice, and data traffic, the satellite communications industry foresees a vast range of new applications that will drive the demand for its services. A key feature that is required to meet these demands is increased bandwidth. Communications satellites are evolving to have more onboard processing capabilities, more power, and larger-aperture antennas that will enable satellites to handle more bandwidth. These types of advances are essentially required by satellite communications service providers in order to remain competitive with alternate forms of communications such as optical fiber, cable and terrestrial microwave radio. In parallel developments ground equipment is evolving to be more sensitive, more energy efficient and small in size to further encourage novel applications.

Cost still remains a prohibitive constraint for widespread adoption of satellite services. Many of the current services are relatively new, arriving in the past 15-20 years. As such, considerable costs of research, development and testing still reflect in the service costs. As the technology matures, the price of services is expected to go down significantly, as has happened in other areas of communications.

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