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A Study on Satellite Communication Network

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Abstract: ***Satellite communication is one of the most popular next generation communication technologies for global communication networks in parallel to terrestrial communication networks .Today's world is a vast network of global communications systems, the role of satellite networks in global communications is growing at an unprecedented. Communications satellites are used for television, telephone, radio, internet, and military applications. Communication in the whole of the World is revolutionized with the advent of Satellites. GPS Navigation, Global telephony, Multimedia video and internet connectivity, Earth Imaging through Remote sensing satellites for resource monitoring, Telemedicine, Tele-education services etc. are other feathers in Satellite communication applications. Satellite communication system has entered transition from point-to-point high cost, high capacity trunks communication to multipoint-to-multipoint communication with low cost. Satellite Communication has served mankind in many ways e.g. to predict weather, storm warning, provide wide range of communication services in the field of relaying television programs, digital data for a multitudes of business services and most recent in telephony and mobile communication. It may not surprise world community, if satellite communication links may be used for voice and fax transmission to Aircraft on International routes in near future.***

In this paper satellite communication advancement, different application aspect present and future is discussed.

Keywords: Satellite communication, Internet, Space Segment, Ground Segment, Satellite Communications services.

I. INTRODUCTION

Satellites are man-made systems that operate in space (the broadest definition of "satellite" includes celestial bodies (such as the moon) orbiting around planets. In this research paper, the definition of "satellite" is limited to man-made spacecrafts only). Since the launch of the first satellite in 1957, people have found diverse applications for these systems and have made significant technical advances and innovations to improve their efficiency. Currently, millions of people around the world rely on satellites for telecommunication, navigation, weather forecast, military intelligence, space exploration, and scientific studies of the atmosphere and beyond[4].

This growth has been a global phenomenon as the economies of world have increased and improved a great extent requiring increased communication services for both business and consumer markets. In a satellite-based Internet system, satellites are used to interconnect heterogeneous network segments and to provide ubiquitous direct Internet access to homes and businesses. This article presents satellite-based Internet architectures and discusses multiple access control, routing, satellite transport, and integrating satellite networks into the global Internet. Satellites are specifically made for telecommunication purpose. They are used for mobile applications such as communication to ships, vehicles, planes, hand-held terminals

and for TV and radio broadcasting. Wireless communication uses electromagnetic waves to carry signals. These waves require line-of-sight, and are thus obstructed by the curvature of the Earth. The purpose of communications satellites is to relay the signal around the curve of the Earth allowing communication between widely separated points.[1] Communications satellites

use a wide range of radio and microwave frequencies. To avoid signal interference, international organizations have regulations for which frequency ranges or "bands" certain organizations are allowed to use. This allocation of bands minimizes the risk of signal interference.

Satellite Internet access is Internet access provided through communications satellites. Modern consumer grade satellite Internet service is typically provided to individual users through geostationary satellites that can offer relatively high data speeds, with newer satellites using K_a band to achieve downstream data speeds up to 50 Mbps[6].

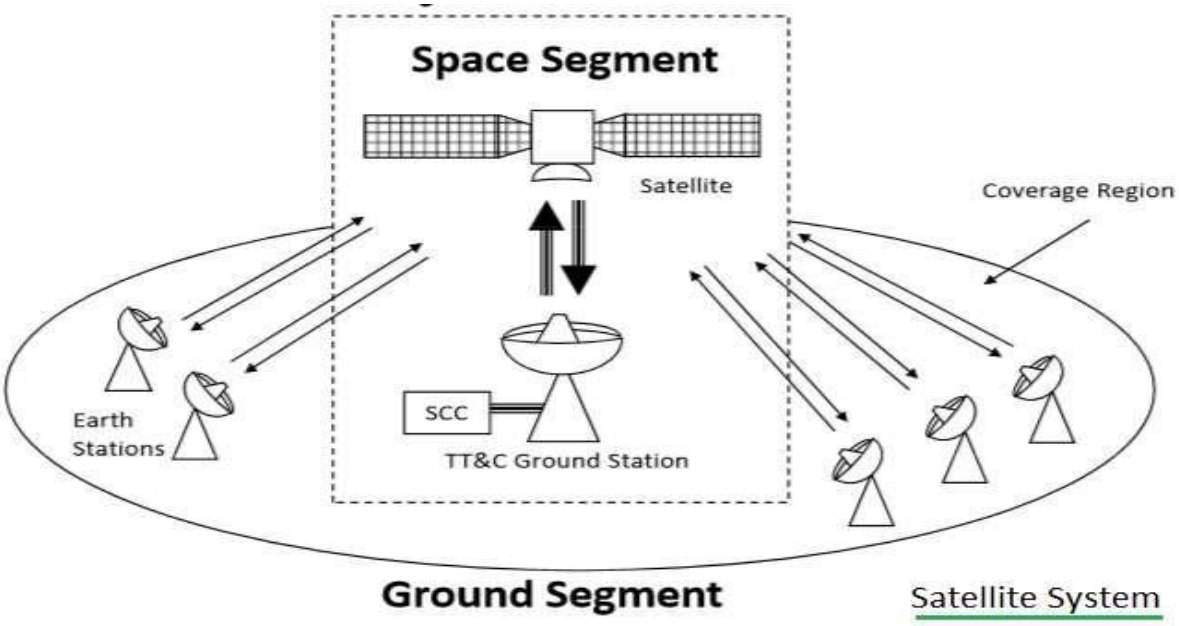
A satellite system, if properly designed, can cover the entire surface of the Earth, making it extremely appealing to aeronautical and maritime users, and to those in remote areas lacking terrestrial communication infrastructure. Even for the densely wired parts of the world, it Offers an alternative to the increasingly congested terrestrial links. A satellite network is inherently a broadcast system. It is particularly attractive to point-to-multipoint and multi-point-to-multipoint communications which are experiencing rapid development, especially in broadband multimedia applications. Satellite networks can serve as broadband access net-works, high-speed backbone networks connecting heterogeneous networks, or simply as communication links between users with fixed or mobile terminals[1].

A **communications satellite** is an artificial satellite that relays and amplifies radio telecommunications signals via a transponder; it creates a communication channel between a source transmitter and a receiver at different locations on Earth. Communications satellites are used for television, telephone, radio, internet, and military applications. There are over 2,000 communications satellites in Earth's orbit, used by both private and government organizations[1].

Satellite Communication utilization has become wide spread and ubiquitous throughout the country for such diverse applications like Television, DTH Broadcasting, DSNG and VSAT to exploit the unique capabilities in terms of coverage and outreach. The technology has matured substantially over past three decades and is being used on commercial basis for a large number of applications. Most of us are touched by satellite communication in more ways than we realize[7].

The potential of the technology for societal applications continue to fascinate ISRO and efforts are on to leverage the benefits of technology to the betterment of mankind. Important initiatives pursued by ISRO towards societal development include Tele-education, Tele-medicine, Village Resource Centre (VRC) and Disaster Management System (DMS) Programmes. The potential of the space technology for applications of national development is enormous[7].

II. Elements of Satellite Communications System



(FIG. 1)

Two major elements of Satellite Communications Systems are[4]:-

- Space Segment
- Ground Segment

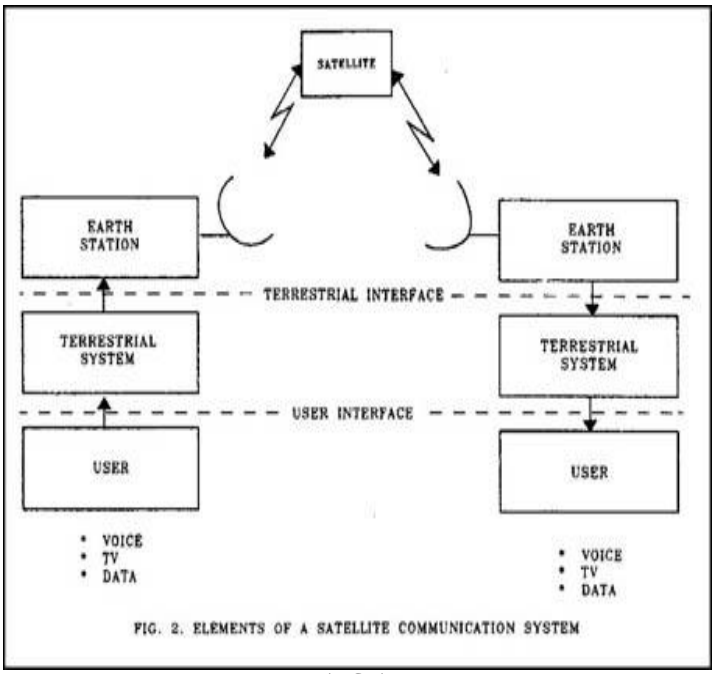
The Space Segment includes [4]:-

- Satellite
- Means for launching satellite
- Satellite control centre for station keeping of the satellite

The functions of the ground segment are to transmit the signal to the satellite and receive the signal from the satellite. The ground segment consists of following [4]:-

- Earth Stations
- Rear Ward Communication links
- User terminals and interfaces
- Network control centre

Schematic block diagram showing the elements of Satellite Communications System is shown in fig. 2.



(FIG.2)

A. SPACE SEGMENT

The Space Segment Satellite itself is known as space segment and comprised of complex structure. It has some major subsystem like TTC system, Transponder, Fuel Tank called thrusters tank, Antenna system and Control system etc. Satellite transponder includes the receiving antenna to receive signals from ground stations, a broad band receiver, multiplexer and frequency converter which is used to reroute the received signals through high powered amplifier to downlink the ground stations. Satellite role is to transpond the received signal in other form of signal to be re transmitted to ground stations. For example of television broad cast where TV programs are up-linked to satellite, satellite transpond it and down linked over a wider region, so that it may be received by many different customers processing compatible equipment. Another use of satellite

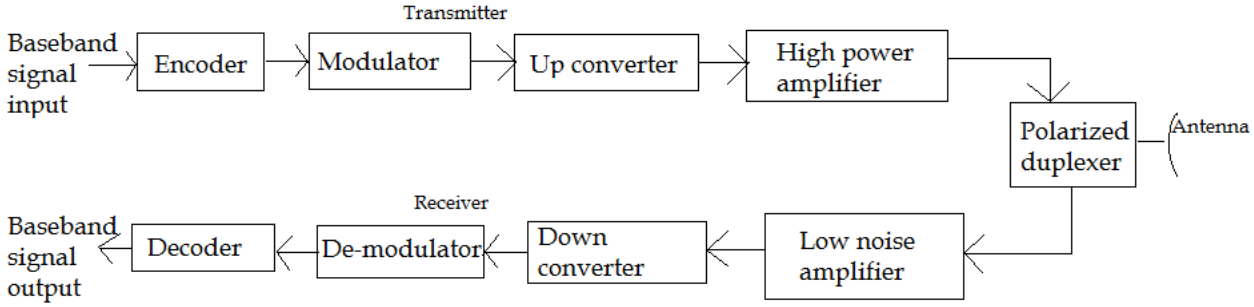
is observation wherein satellite is equipped with cameras, various sensors and it merely downlinks any information it picks up from its vantage point[2].

B. GROUND SEGMENT

The ground segment of satellite communications system establishes the communications links with the satellite and the user. In large and medium systems the terrestrial microwave link interfaces with the user and the earth station. However, in the case of small systems, this interface is eliminated and the user interface can be located at the earth station. The earth station consists of following [3]:-

- Transmit equipment.
- Receive equipment.
- Antenna system.

Fig. 4 shows the schematic block diagram of an earth station.



(FIG.3)

In the earth station the base band signal received directly from users' premises or from terrestrial network are appropriately modulated and then transmitted at RF frequency to the satellite. The receiving earth station after demodulating the carrier transmits the base band signal to the user directly or through the terrestrial link.

The baseband signals received at the earth stations are mostly of the following types.

- Groups of voice band analog or digital signals
- Analog or digital video signals.
- Single channel analog or digital signal
- Wide band digital signal.

In satellite communications, in early days FM modulation scheme was most frequently used for analog voice and video signal transmission. However, the trnd is now to use digital signals for both voice and video. Various digital modulation schemes like Phase Shift Keying (PSK) and Frequency Shift Keying (FSK) are adopted for transmission of digital signals[4].

The earth stations are ground segment of satellite communication. Earth Station has two fold roles. In case of uplink or transmitting station terrestrial data in the form of base band signals is passed through a base band processor, an up converter, a high powered amplifier and through parabolic dish antenna up to an orbiting satellite. In case of down link or receiving station vice versa job performed and ultimately converting signals received through the parabolic antenna to base band signal[2].

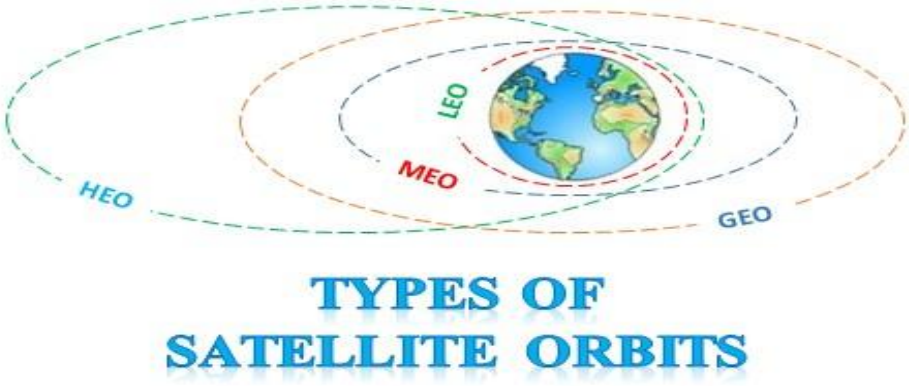
The network operations and control centre for the communications network monitors the network operations by different users, distribution of different carriers within a transponder and allocation of bandwidth & EIRP of different carriers. Proper functioning of Network operations and control centre is essential where the number of users in the network is large. Network

operations & control centre is also responsible for giving clearance to the ground system in respect of antenna radiation pattern, EIRP etc [4].

III. Categories of Satellites based of Satellites Locations

Based on the location of the orbit, satellites can be divided into four categories:

1. GEO (Geo-stationary earth orbit)
2. MEO (medium earth orbit)
3. LEO (Low earth orbit) and
4. HEO (Highly elliptical orbit)



(FIG.4)

A. Geo-Stationary Earth Orbit –

These satellites have almost a distance of 36,000 km to the earth. E.g. All radio and TV, whether satellite etc, are launched in this orbit.

B. Medium Earth Orbit-

Satellite at different orbits operates at different heights. The MEO satellite operates at about 5000 to 12000 km away from the earth's surface. These orbits have moderate number of satellites.

C. Low Earth Orbit-

LEO satellites operate at a distance of about 500-1500 km.

D. Highly Elliptical Orbit-

This orbit is made for satellites that do not revolve in circular orbits, only a very few satellite are operating in this orbit.

IV. Satellite Communications Services

Different Satellite Communications services are classified as one way link and two way link. One way link from transmitter Tx to receiver Rx on earth's surface is shown in fig.5.[4]

Examples of satellite services where the transfer of information takes place through one way link are:

- Broadcast Satellite Service (Radio, TV, Data broadcasting)
- Data Collection Service (Hydro meteorological data collection)
- Space operations service, (Tracking, Telemetry, Command)

- Safety services (Search & Rescue, Disaster Warning)
- Earth Exploration Satellite Service (Remote Sensing)
- Meteorological Satellite Service (Meteorological data dissemination)
- Radio Determination Satellite Service (Position location)
- Reporting Service (fleet monitoring)
- Standard frequency and time signal satellite service
- Space Research Service.

In two-way Satellite Communications link the exchange of information between two distant users takes place through a pair of transmit and receive earth stations and a satellite. Fig.6 shows the elements of two-way link

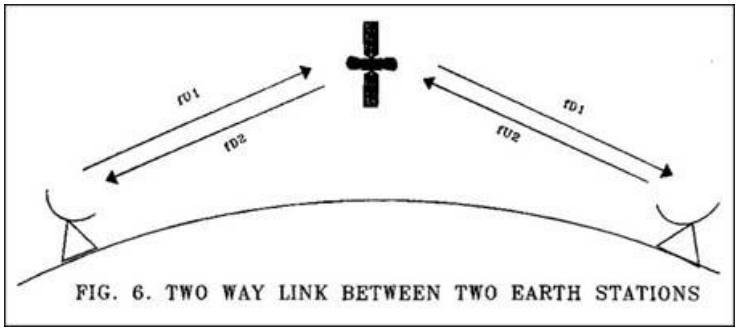


FIG. 6. TWO WAY LINK BETWEEN TWO EARTH STATIONS

Examples of two-way satellite services are[4]:-

- Fixed Satellite Service (Telephone, telex, fax, high bit rate data etc.)
- Mobile Satellite Service (Land mobile, Maritime, Aero-mobile, personal communications)
- Inter Satellite Service.
- Satellite News Gathering (Transportable and Portable)

A new class of two-way fixed satellite network service known as Very Small Aperture Terminal (VSAT) service has became very popular among business and closed users group communities.

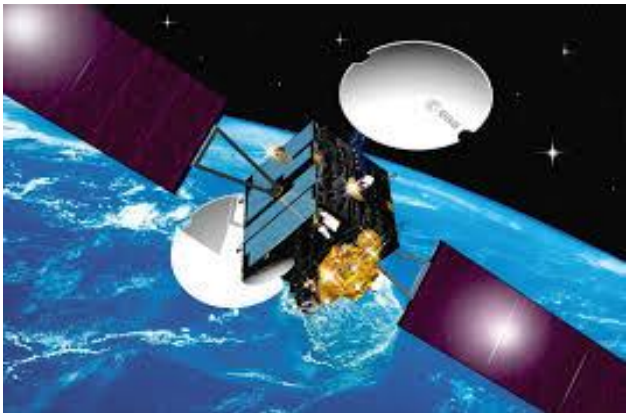
SAT networks are operated in two different configurations i.e. Mesh and Star. While in Mesh configuration a VSAT terminal can communicate with another VSAT terminal in a single hop connection, Star network involves two hops via satellite and the hub station.

Satellite Communication has a wide range of services. Applications are in numerous and broadly classified as follows[3]:

- In communication such as T.V. telephony, data transfer such as mail and internet etc. are mostly done through different communication satellites these days.
- Remote sensing and Earth observation can be done with the help of lower Earth Orbits (LEO) Satellite.
- Metro logical applications such as whether survey to study different layers and amount of ozone's content in the atmosphere.
- Military applications like short distance local communication from any camp to another, to study the location of the enemy etc.

V. ADVANTAGES AND DISADVANTAGE OF SATELLITE COMMUNICATION

A. Following are the **advantages of Satellite Communication[3]**:



- Point to multipoint communication is possible whereas terrestrial relay are point to point, this is why satellite relay are wide area broadcast.
- Circuits for the satellite can be installed rapidly. Once the satellite is in position, Earth Station can be installed and communication may be established within some days or even hours.
- During critical condition each Earth Station may be removed relatively quickly from a location and reinstalled somewhere else.
- Mobile communication cab is easily achieved by satellite communication because of its flexibility in interconnecting mobile vehicles.
- As compared to fibre cable, the satellite communication has the advantage of the quality of transmitted signals and the location of Earth Stations. The sending and receiving information independent of distance.

B. Following are the **disadvantages of Satellite Communication[3]**:

- With the Satellite in position the communication path between the terrestrial transmitter and receiver is approximately 75000 km long.
- The time delay reduces the efficiency of satellite in data transmission and long file transfer, which carried out over the satellites.
- Over-crowding of available bandwidth due to low antenna gains is occurred.
- High atmosphere losses above 30 GHz limit the carrier frequency.
- Satellite has been constructed for years. More over satellite design and development requires higher cost.
- Redundant components are used in the network design. This includes more cost in the installation.
- In the case of LEO/MEO, large number of satellites is needed to cover radius of earth. Moreover satellite visibility from earth is for very short duration which requires fast satellite to satellite handover. This makes system very complex.

VI. CONCLUSION

In this paper satellite communication advancement in the satellite communication, present and future applications are discussed. It is lone attempt to bring brief sketch about satellite communication applications. Satellite networks promise a new era of global connectivity, but also present new challenges to common Internet applications. Satellites very important for

modern communications. A detail study of applications is still to carry out at length. Details study of frequency reuse in satellite and mobile cellular is matter of research in our future works.

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