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Advancement in Satellite Communications

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ABSTRACT

Communication has revolutionized by the Satellites. Its importance and services to human race cannot be neglected. In general, it helps us to predict weather, storm warning and also provides communication services in many fields like telephone, mobiles, television etc. In satellites Communication between two parties can be done by various modulation techniques. For example: FDMA, TDMA, CDMA. This paper describes the history of satellite communications, its types and its technological trends in different areas especially mobile communications.

Key words : TDMA, FDMA, CDMA, Modulation,

1. INTRODUCTION

Communication plays a vital role in present era. There are means to communicate with each other out of which satellites have revolutionized communication. GEO, MEO, LEO are the three basic types of satellites. In general satellite communication is transferring of a signal between a sender and a receiver. Since transferring of a signals in done in space this type of communication can be termed as space communication. At first satellites were solely used for military purposes, surveillance, weather forecasting and earth imaging. For commercial satellite communications GEO satellites have become a major backbone. Approximately 2,000 artificial satellites orbiting Earth relay analog and digital signals carrying voice, video, and data to and from one or many locations worldwide. Satellite communication has two main components: the ground segment, which consists of fixed or mobile transmission, reception, and ancillary equipment, and the space segment, which primarily is the satellite itself. A typical satellite link involves the transmission or uplinking of a signal from an Earth station to a satellite. The satellite then receives and amplifies the signal and retransmits it back to Earth, where it is received and reamplified by Earth stations and terminals. Satellite receivers on the ground include direct-to-home (DTH) satellite equipment, mobile reception equipment in aircraft, satellite telephones, and handheld devices.

2. HISTORY OF SATELLITES

The Merriam-Webster dictionary defines a satellite as a celestial body orbiting another of larger size or a manufactured object or vehicle intended to orbit the earth, the moon, or another celestial body. Today's satellite communications can trace their origins all the way back to the Moon. A project named Communication Moon Relay was a telecommunication project carried out by the United States Navy. Its objective was to develop a secure and reliable method of wireless communication by using the Moon as a natural communications satellite. The first American satellite to relay communications was Project SCORE in 1958, which used a tape recorder to store and forward voice messages. It was used to send a Christmas greeting to the world from U.S. President Dwight D. Eisenhower. NASA launched the Echo satellite in 1960; the 100-foot (30 m) aluminised PET film balloon served as a passive reflector for radio communications. Courier 1B, built by Philco, also launched in 1960, was the world's first active repeater satellite. It is actually believed "communications" satellite was Sputnik1.

Figure:-1 Satellite

Put into orbit by the Soviet Union on October 4, 1957, it was equipped with an onboard radio-transmitter that worked on two frequencies: 20.005 and 40.002 MHz. Sputnik 1 was launched as a step in the exploration of space and rocket development. While incredibly important it was not placed in orbit for the purpose of sending data from one point on earth to another. Hence, it was not the first "communications" satellite, but it was the first artificial satellite in the steps leading to today's satellite communications. Telstar was the first active, direct relay communications satellite. Belonging to AT&T as part of a multi-national agreement between AT&T, Bell Telephone Laboratories, NASA, the British General Post Office, and the French National PTT (Post Office) to develop satellite communications, it was launched by NASA from Cape Canaveral on July 10, 1962, the first privately sponsored space launch. Relay1 was launched on December 13, 1962, and became the first satellite to broadcast across the Pacific on November 22, 1963.

During the 1960s and 1970s, advances in satellite performance came quickly and a global industry began to develop. Satellites were mainly used at first for international and long-haul telephone traffic and distribution of select television programming, both internationally and domestically.

In 1973 the Canadian Broadcasting Corporation began distributing its video programming to Canadian customers using Telesat's Anik A satellite. Then in 1975 HBO began distributing its video programming to US customers by satellite. The commercial and technical success of these ventures led to a greater use and acceptance of satellite broadcasting. By the 1990s, satellite communications would be the primary means of distributing TV programs around the world.

2.1 Geostationary Satellites

A geostationary satellite shown in figure-2 is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates (west to east). At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer. BGAN, the new global mobile communications network, uses geostationary satellites.

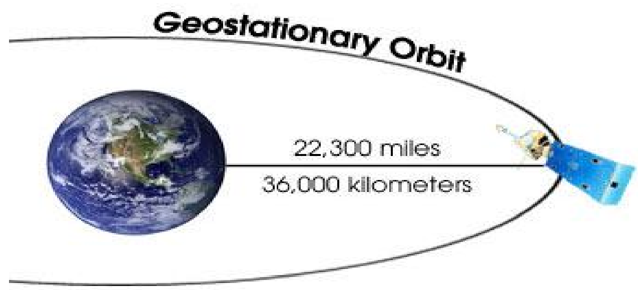

Figure:-2 Geostationary Satellite

A single geostationary satellite is on a line of sight with about 40 percent of the earth's surface. Three such satellites, each separated by 120 degrees of longitude, can provide coverage of the entire planet, with the exception of small circular regions centered at the north and south geographic poles. A geostationary satellite can be accessed using a directional antenna, usually a small dish, aimed at the spot in the sky where the satellite appears to hover. The principal advantage of this type of satellite is the fact that an earthbound directional antenna can be aimed and then left in position without further adjustment. Another advantage is the fact that because highly directional antennas can be used, interference from surface-based sources, and from other satellites, is minimized.

Geostationary satellites have two major limitations. First, because the orbital zone is an extremely narrow ring in the plane of the equator, the number of satellites that can be maintained in geostationary orbits without mutual conflict (or even collision) is limited. Second, the distance that an electromagnetic (EM) signal must travel to and from a geostationary satellite is a minimum of 71,600 kilometers or 44,600 miles. Thus, a latency of at least 240 milliseconds is introduced when an EM signal, traveling at 300,000 kilometers per second (186,000 miles per second), makes a round trip from the surface to the satellite and back.

2.2 Low Earth Orbit Satellites

A **low Earth orbit** (**LEO**) is generally defined as an orbit within the locus extending from the Earth's surface up to an altitude of 2,000 km. Given the rapid orbital decay of objects below approximately 200 km, the commonly accepted definition for LEO is between 160 - 2,000 km as shown in the figure 3.

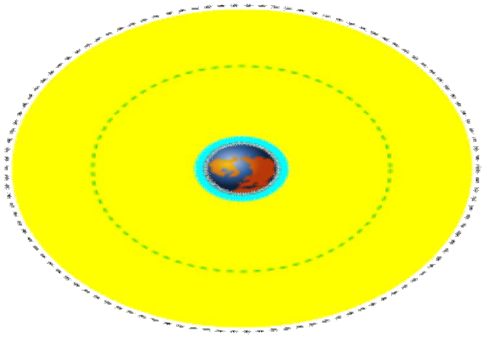

Figure:-3 Low Earth Orbit

Objects in LEO encounter atmospheric drag in the form of gases in the thermosphere (approximately 80–500 km up) or exosphere (approximately 500 km and up), depending on orbit height. Objects in LEO orbit Earth between the atmosphere and below the inner Van Allen radiation belt. The altitude is usually not less than 300 km for satellites, as that would be impractical due to atmospheric drag. The orbital velocity needed to maintain a stable low earth orbit is about 7.8 km/s, but reduces with increased orbital altitude.

2.3 Medium Earth Orbit Satellites

Medium Earth orbit (MEO), sometimes called intermediate circular orbit (ICO), is the region of space around the Earth above low Earth orbit (altitude of 2,000 kilometres (1,243 mi) and below geostationary orbit (altitude of 35,786 kilometres (22,236 mi). The most common use for satellites in this region is for navigation, communication,

The most common altitude is approximately 20,200 kilometres (12,552 mi)), which yields an orbital period of 12 hours, as used, for example, by the Global Positioning System(GPS). Other satellites in Medium Earth Orbit include Glonass (with an altitude of 19,100 kilometres (11,868 mi)) and Galileo (with an altitude of 23,222 kilometres (14,429 mi)) constellations. Communications satellites that cover the North and South Pole are also put in MEO. The orbital periods of MEO satellites range from about 2 to nearly 24 hours. Telstar 1 shown in figure 4, an experimental satellite launched in 1962, orbits in MEO.

Figure:-4 Telstar-1

3. DEVELOPMENTS IN SATELLITE COMMUNICATIONS

GEO(approx 35000 km), MEO(approx 10000 km), LEO(<1000 km) satellites were classified according to their altitudes, where as in advanced satellites these were again subdivided into many types depending on various of factors. LEOs can be further sub-divided into Big LEO and Little LEO categories. Big LEOs will offer voice, fax, telex, paging and data capability, whereas little LEOs will offer data capability only, either on a real-time direct readout ('bent pipe') basis, or as a store-and-forward service.

Since the satellite footprint decreases in size as the orbit gets lower, LEO and MEO systems require larger constellations than GEO satellites in order to achieve global coverage and avoid data delays. Less energy is, however, generally required for LEO and MEO satellite communication because of the shorter average distance between transmitter and satellite. Some systems implement several high-gain antennas to generate ‘spot beams’ and so reduce the requirement of the mobile to have a complex antenna and/or high output power.

3.1 Little Leo’s

ARGOS:- The **Advanced Research Global Observation Satellite** was launched on 23 Feb 1999 from SLC-2W, Vandenberg AFB, CA, atop a Boeing Delta II (7920-10). Construction of the spacecraft bus and integration of the satellite's nine payloads was accomplished by Boeing at their Seal Beach, CA facility. The program was funded and led by the DoD's Space Test Program as mission P91-1 the first mission contract let in 1991. The nine payloads were research and development missions by nine separate researchers. Many experiments were done such as

- **CERTO -** Coherent Electromagnetic Radio Tomography Experiment
- **CIV -** Critical Ionization Velocity Experiment.
- **ESEX -** Electric Propulsion Space Experiment.
- **EUVIP -** Extreme Ultraviolet Imaging Photometer Experiment.
- **GIMI -** Global Imaging Monitor of the Ionosphere Experiment.
- **SPADUS -** Space Dust Experiment.

The first of the Argos-2 satellites NOAA-K (NOAA-15) was launched in May 1998 and now is operating as operational, replacing NOAA-D (NOAA-12) as the morning satellite and this was launched in September 2000. Later in March 2002 NOAA-M (NOAA-17) was launched.

ORBCOMM:- These satellites are low earth orbit communications satellites, operated by the United States satellite communications company Orbcomm. As of January 2013, 45 such satellites have orbited Earth, with 44 still continuing to do so. These were launched to test equipment and communication techniques used by the other satellites. The first three CDS satellites, Orbcomm-X, CDS-1 and CDS-2, were launched before any operational satellites, in order to validate the systems to be used in the operational constellation. Orbcomm-X, also known as Datacomm-X, was launched in 1991. It carried communications and GPS experiments. Initially, the spacecraft was reported healthy, but communication was lost after just one orbit.

Orbcomm-1 satellites make up most of the current Orbcomm constellation. 36 were built, of which 35 were launched, and one more, Orbcomm FM-29, was rebuilt as TacSat-1 for the United States military

Orbcomm Quick Launch (QL) satellites are satellites which were intended to replenish the constellation. The first five such satellites were launched in 2008, with one more planned, but never launched. The satellites are based on the CDS-3 satellite, which was launched on the same rocket as the first five QL spacecraft. The sixth will be launched as a secondary payload to a Russian Government satellite, also on a Kosmos-3M. Orbcomm holds options for two further satellites. The satellites experienced a power system anomaly, and Orbcomm filed an insurance claim on the satellites for $50 million. Orbcomm reported in 2011 that the last remaining Quick Launch satellite had failed.

Orbcomm Generation 2 (**OG2**) satellites are intended to supplement and eventually replace the current first generation constellation. Eighteen satellites have been ordered, and are planned to be launched in three groups of six between 2010 and 2014. Orbcomm has options for a further thirty OG2 spacecraft. The satellites will be launched by SpaceX on the Falcon 9 launch system. Originally, they were to launch on the smaller Falcon 1e rocket. The first of these satellites was launched on 7 October 2012 as secondary payload on a SpaceX Falcon 9 flight.

STARSYS:- This system was to have been broadly similar to Orbcomm, except that it offered bent pipe mode only, thus limiting its usefulness to coastal areas. Further work on the system, in which the operators of the Argos system were closely involved, has been suspended because of difficulties in securing financial backing. The FCC licence was returned in late 1997.

3.2 BIG LEO'S

IRIDIUM:- These satellites provides voice and data coverage to satellite phones, pagers and integrated transceivers over Earth's entire surface. Iridium Communications Inc. owns and operates the constellation and sells equipment and access to its services. The constellation consists of 66 active satellites in orbit, and additional spare satellites to serve in case of failure.[1] Satellites are in low Earth orbit at a height of approximately 485 mi (781 km) and inclination of 86.4°. Orbital velocity of the satellites is approximately 17,000 mph (27,000 km/h). Satellites communicate with neighboring satellites via K_a band inter-satellite links. Each satellite can have four inter-satellite links: two to neighbors fore and aft in the same orbital plane, and two to satellites in neighboring planes to either side. The satellites orbit from pole to pole with an orbit of roughly 100 minutes. This design means that there is excellent satellite visibility and service coverage at the North and South poles, where there are few customers.

GLOBALSTAR:- This is a low Earth orbit (LEO) satellite constellation for satellite phone and low-speed data communications, somewhat similar to the Iridium satellite constellation and Orbcomm satellite systems. Globalstar is the world's largest provider of mobile satellite voice and data services. Globalstar offers these services to commercial and recreational users in more than 120 countries around the world. It include mobile and fixed satellite telephones, simplex and duplex satellite data modems and satellite airtime packages. Many land based and maritime industries make use of the various Globalstar products and services from remote areas beyond the reach of cellular and landline telephone service. Global customer segments include: oil and gas, government, mining, forestry, commercial fishing, utilities, military, transportation, heavy construction, emergency preparedness, and business continuity as well as individual recreational users. Globalstar data solutions are used for a variety of asset and personal tracking, data monitoring and "Supervisory Control and Data Acquisition" or SCADA applications.

3.3 GEOS

INMARSAT:- It provides telephone and data services to users worldwide, via portable or mobile terminals which communicate to ground stations through eleven geostationary telecommunications satellites. Inmarsat's network provides communications services to a range of governments, aid agencies, media outlets and businesses with a need to communicate in remote regions or where there is no reliable terrestrial network. he company is listed on the London Stock Exchange and is a constituent of the FTSE 250 Index as of December 2011. There are three types of coverage related to INMSAT .

- **Global beam coverage**

Each satellite is equipped with a single global beam that covers up to one-third of the Earth's surface, apart from the poles. Overall, global beam coverage extends from latitudes of −82 to +82 degrees regardless of longitude.

➢ **Regional spot beam coverage**

Each regional beam covers a fraction of the area covered by a global beam, but collectively all of the regional beams offer virtually the same coverage as the global beams. Use of regional beams allow user terminals (also called mobile earth stations) to operate with significantly smaller antennae. Regional beams were introduced with the I-3 satellites. Each I-3 satellite provides four to six spot beams; each I-4 satellite provides 19 regional beams

➢ **Narrow spot beam coverage**

Narrow beams are offered by the three Inmarsat-4 satellites. Narrow beams vary in size, tend to be several hundred kilometers across. The narrow beams, while much smaller than the global or regional beams, are far more numerous and hence offer the same global coverage. Narrow spot beams allow yet smaller antennas and much higher data rates. They form the backbone of Inmarsat's handheld (GSPS) and broadband services (BGAN). This coverage was introduced with the I-4 satellites. Each I-4 satellite provides around 200 narrow spot beams.

THURAYA:- It is an international mobile satellite services provider based in the United Arab Emirates. The company claims to operate in more than 160 countries across Europe, the MiddleEast, North,Central and EastAfrica, Asia and Au stralia. With more than 350 roaming partners worldwide, Thuraya is the only mobile satellite operator that offers GSM roaming services over mobile networks. They have sold in excess of 650,000 satellite handheld phones since launching in 2001.[5] Thuraya offers the only dual mode satellite phone, the Thuraya XT-DUAL, a handset that features both GSM and satellite capabilities. In addition, Thuraya provides the Thuraya IP data modem, a secure and rapidly deployable satellite broadband solution offering connection speeds up to 444 kbit/s standard IP.

In 2013, the company launched the Thuraya SatSleeve, the world's first satellite adaptor for the iPhone. The application provides users with easy and affordable access to mobile communication services delivered over Thuraya's satellite network. In 2014, Thuraya launched the SatSleeve for Android, building on the company's reputation for being an innovator of mobile satellite phones. With the SatSleeve, Thuraya is extending its experience to address the prevalent BYOD trend in enabling consumers to use their own smartphones and apps in areas outside of terrestrial networks and into Thuraya's network.

4. CONCLUSION

In this paper an attempt has made to describe the essentials of satellite communications. Apart from the listed, there are many services already existed in this present era. By looking at the advancement rate in this field in near future we see the usage of satellites in every field.

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