SATELLITE COMMUNICATION

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<u>DHAKA-1207</u>

"Communication is the distinguishing mark of being human". So said Cicero, an ancient statesman and philosopher in Pre-Christian Rome. Indeed the level of development in communication can be regarded as an index of human civilization. Human being are the only species who can distinguish among some 40 basic speech sounds.

If we look into the history of human communication, we notice that communication explosion has oddurred only recently in the whole human history.

Some Milestones in Human Communication :

35,000 B.C.	Speculation that language existed.
22,000 B.C.	Pre-historic cave paintings.
3,000 B.C.	Early Egyptian hieroglyphics.
1,000 B.C.	Early Greek Script.
600 A.D.	Book Printing in China.
1,562 A.D.	First Monthly Newspaper in Italy.
1,827 A.D.	Photographs on Metal Plates.
1,835 A.D.	Telegraphs Introduced by Samuel Morse.
1,866 A.D.	Trans Atlantic Cable Completed.
1,876 A.D.	Telephone Invented by Graham Bell.
1,888 A.D.	Radiowaves Identified.
1,900 A.D.	Spech Transmitted via Radiowaves.
1,927 A.D.	A.T. & T Demonstrates T.V.
1,942 A.D.	First Electronic Computer.
1,947 A.D.	Transistor Invented.
1,957 A.D.	First Artificial Earth Sat. Launched.
1,969 A.D.	Man Lands on the Moon.
1,962 A.D.	First Com. Sat. Tester Launched.
1,970 A.D.	Micro Electronic Chips Coming into wide use.
1,975 A.D.	Fibre Optic Signal Transmission Highly Developed.

1,980 A.D. New Breakthroughs in Space Photography.
1,981 A.D. Space Shuttle Launched.
1,982 A.D. Major Advances in Digital Telephones.

Rapid Progress in Satellite Communication

It is needless to say that bulk of the information transmit is carried by electromagnetic waves. A fundamental concept in electrical communication is the bandwidth. The amount of information a telecommunication channel can carry is proportional to its bandwidth. It is actually the range of frequencies that a channel can transmit. If the lowest frequency in the range is f1 and the highest frequency is f2 then the bandwidth is f2-f1. Bandwidth used for various telecommunication links are shown.

Telephone	-	4 khz
TV	-	4600 khz.

Atmospheric Effects

The propagation of radio waves is largely influenced by the earth's atmosphere. Radiop waves in the lower frequencies from 3-30 khz are reflected by the D layer of the earth's ionosphere which was discovered in the beginning of this century by Sir Appleton and others.

It has been found that radio waves from 3 kz to 30 MHz can travel half way around the earth by being repeatedly reflected between the earth and the F layer. The ionosphere is largely created by the solar radiation and the electron density in the ionosphere varies a great deal between day and night and with solar activity. This can create havoc in the transmission of information through the atmosphere and research on ionosphere is continually taking place.

Tropospehreic scattering , reflection and ducting also affect radio propagation. Reflection affects frequencies between 30 MHz to 1000 MHz and ducting mostly affects frequencies above 1000 MHz. Forward scattering of radio energy is used as a mechanism for long distance communications especially at frequencies between 3 to 10 GHz. Large scale changes of refractive indices with height cause refraction of radio waves that can be quite significant at all frequencies at low elevation angles. Radio propagation above 3

GHz is strongly influenced by the presence of heavy rain and above 15 GHz, oxygen and water vapour in the atmosphere causes attenuation.

Telecommunication Satellites

In order to meet the increasing demands of communication, increasing bandwidth and consequently higher frequencies are necessary. This is done by microwave radio links operating in the region 3-30 GHz. Such waves travel in straight lines and hence operate only within the line of sight. Thus construction of relay tower at distances between 30-40 km are necessary. Over the Ocean, installation of submarine cables with repeaters are necessary, 3-30 GHz region of radio waves is not reflected by the ionosphere, it passes through the ionosphere and if some repeaters are placed high above the atmosphere, long distance communication is possible. It was suggested by Arthur Clerk as early as 1945 that three geostationary satellites placed over the equator could serve as a means of global telecommunication. With the launch of the 1st artificial earth satellite on 4 October, 1957, this idea became a reality. Right in 1958, a US satellite named SCORE was used to rebroadcast an on board tape recording of US President's Christmas message. After some experiments with ECHO and COURIER US launched its first non-geosynchronous experimental telecommunication satellite named TELSTAR in 1962 for telephone, television and facsimile transmission. The first experimental synchronous telecommunication satellite was SYNCOM launched in 1963 by NASA.

Satellite Dynamics

About three fourth of the expenditure in satellite communication goes in the spacecraft itself. The theory of launching an artificial satellite has been known since Newton's time. However, it is only with the development of powerfulrockets that this became a reality.

Motion of a artificial satellite is the same as that of a planet around the sun or that of a natural satellite like the moon around the earth. Its dynamics has been worked out by illustrious theoretical physicists like Newton, Largrange, Laplace, Gauss, Hamilton and others. To a first approximation, orbit of an artificial satellite around the earth follows the laws of Kepler's planetary motion. However, the orbits are subject to perturbation by atmospheric drag, non-homogeneity of the earth, radiation pressure etc. If the height of the orbit is less than 200 miles above the earth surface the satellite cannot stay in the orbit for long. Its height is gradually reduced and it eventually burns up in the atmosphere.

A satellite orbit can be inclined with earth's equator or parallel to it. The time period of motion of a satellite depends on its height above the earth's surface. For example if the height is 200 miles, the time period is about 90 minutes. For a particular height, 22,300 miles, the time period is 24 hours. If such a satellite is placed above the equator and its motion is in the same direction as that of the earth, then there will not be any relative motion between the satellite and the earth. If a point on the surface of the earth is in the line of sight of the satellite once, it will remain so for all time. Such a satellite is called geostationary synchronous satellite and is generally used for telecommunication purposes.

Geostationary synchronous satellites are not most commonly used for communication purposes. It is not very easy to place a satellite in geostationary orbit. This is done in two stages. First the satellite is placed in a transfer orbit and then by a velocity increment, placed in the desired geostationary orbit.

The satellite. may change its orbit occasionally due to atmospheric drag, radiation pressure etc. and this need to be corrected and the satellite must have the necessary fuel otherwise it will be out of operation soon.

Power in the satellite is provided by solar arrays with arrangement storage battery during eclipses, a communication satellite has been found to be cheaper and more reliable. It also provides communication to hitherto inaccessible places.

The communication system in a sat consists of receivers, amplifiers and transmitter. The satellite uses different frequencies for receiving and transmitting otherwise the powerful transmitting signal will interfere with the weak incoming signal.

The equipment which receives a signal, amplifies it, changes its frequency and retransmit it is called a transponder.

The frequencies used are : 6/4 14/12 30/20 GHz.

Earth Station

An earth station performs two basic functions. They transmit and receive all forms of communication via satellite and process the communication with the terrestrial system in the countries in which they are located.

These are three different types of earth station in use :

Standard A	:	30 meter or larger diameter parameter parabolic antena.
Standard B	:	11 meter antenna.
Standard C	:	14-19 meter antenna.

An International Satellite Organization named INTELSAT has been established with Washington as its headquarters. It serves now 165 countries with more than 70 developing countries. It has a total capacity of 64,000 voice channels plus 17 TV channels. 300 earth stations exist outside US. In US 12,000 annual space segment utilization charge has come down from US$32,000 in 1965 to US$ 4,680 in 1982.

Bangladesh is a member of INTELSAT and operates two earth stations one at Betbunia at Hill Chittagong and another at Taliababad near Dhaka.

A list of the communication satellites in operation is given below :

COMMUNICATION SATELLITE SYSTEMS

Satellite	Launched date
ANIK A-1	1972
ANIK A-2	1973
WESTER-2	1974
SATCOM 4	1974
ANIK A-3	1975
SATCOM-1	1975
SATCOM-2	1976
COMSTAR D1	1976

COMSTAR D2	1976
ANIK B	1978
COMSTAR D3	1978
WESTER 3	1979
SBS	1980
SBS-2	1981
SATCOM 3R	1981
COMSTAR D4	1981
SATCOM-5	1982
ANIK C-1	1982
ANIK D-1	1982
WESTER-4	1982
WESTER-5	1982
SBS-3	1982
WESTER-1	1983
SATCOM IR	1983
GALAXY	1983
ANIK C-2	1983
TELSTAR 301	1983
ADVANCED WESTER	1983
GALAXY-2	1983
SATCOM 2R	1983
WESTER-6	1983
INSAT	1983
ANIK D-2	1984
TELSTAR 303	1984
AMSAT	1984
SPACNET	1984
GSTAR-1	1984
GSTAR-2	1984
TELSTAR-302	1984
SPACENET-2	1984
ANIK-3	1985
SATCOM-6	1985
MEXAT	1985
SATCOR (COLUMBIA)	1985
BRAZILSAT	1985
STC-1 (TY)	1985
FASS-1	1987
FASS-2	1987
ARABSAT	-
PALAPA	-

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2. James Martin : Communication Satellite Systems Prentice Hall Inc., 1978.

3. M.P.M. Hall : Effects of Tropospherre on Radio Communication Peter Peregrin Ltd., 1979.

4. INTELSAT Annual Report, 1983.

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