NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

Digital Satellite Communication System

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Student: Ayman Abu-Dayeh

Supervisor: Mr. izzet Agoren

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Abstract

Digital Satellite Communication one of the most rapidly emerging and developing technologies in the world today. We have seen a surprisingly huge interest from different research organizations and companies in this field and much has been contributed to this field in the past two decades. This term paper provides the TCP/IP with the topics and issues in Network Operation Center. We have been using Satellite since 1957. That satellite, called Sputnik however Communications via satellite is a natural outgrowth of modem technology and of the continuing demand for greater capacity and higher quality in communications.

Experience with satellite communications has demonstrated that satellite systems can satisfy many military requirements. They are reliable, survivable, secure, and a cost effective method of telecommunications. You can easily see that satellites are the ideal, if not often the only, solution to problems of communicating with highly mobile forces. Satellites, if properly used, provide much needed options to large, fixed-ground installations.

All the above schemes in satellite communication are different from the traditional communication used networks. Finally the paper discusses network operation centers (NOCs) with TCP/IP work.

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Introduction

In first chapter decades of its space program, the U.S. used satellites primarily for navigation and espionage. Today, however, satellites are an integral part of our telecommunications system and have many commercial applications. Most satellites serve one or more functions: Communications, Navigation, Weather and Environmental.

Experts generally classify satellites by the speed and distance of their orbital paths. Common types of satellites include geostationary satellites (GEOs), Low-earth orbiting satellites (LEOs), as well as Polar and Elliptical satellites.

In second chapter satellite communications has demonstrated that satellite systems can satisfy many military requirements. They are reliable, survivable, secure, and a cost effective method of telecommunications. You can easily see that satellites are the ideal, if not often the only, solution to problems of communicating with highly mobile forces. Satellites, if properly used, provide much needed options to large, fixed-ground installations.

In third chapter we will understand the roles of the many components of the TCP/IP protocol family; it is useful to know what you can do over a TCP/IP network. Then, once the applications are understood, the protocols that make it possible are a little easier to comprehend. The following list is not exhaustive but mentions the primary user applications that TCP/IP provides.

In forth chapter a basic understanding of sat networks is requisite in order to understand the principles of network security. In this section, we'll cover some of the foundations of sat networking, then move on to an overview of some popular networks. Following that, we'll take a more in-depth look at TCP/IP, the network protocol suite that is used to run the Internet and many intranets.

CF.APTER ONE

BACKGROUND OF SATELLITES AND OP~ITES

1.1 Satellite

1.1.1 History of Satellite

In 1957, the Soviet Union launched Sputnik, the first man-made satellite. In the first decades of its space program, the US used satellites primarily for navigation and espionage. Today, however, satellites are an integral part of our telecommunications system and ha.ve many commercial applications. Most satellites serve one or more functions:

- Communications
- Navigation
- Weather
- **Environmental**

The United States, who was behind the Russians, made an all-out effort to catch up, and launched Score in 1958, that was the first satellite with the primary purpose of communications.

1.1.2 Satellite Snecifications

- Each satellite will have one X-band and one Ka-band directional antenna.
- Each satellite will be stabilized about three axes, and will weigh approximately 2250 kg.
- Each satellite will have two solar panels (approximately 15 m long each) symmetrically located on either side. These panels will be capable of generating about 1700 watts for at least 10 years. When on the dark side of Mars, NiCd batteries will supply power. Internal heaters combined with thermal coating will provide temperature control.

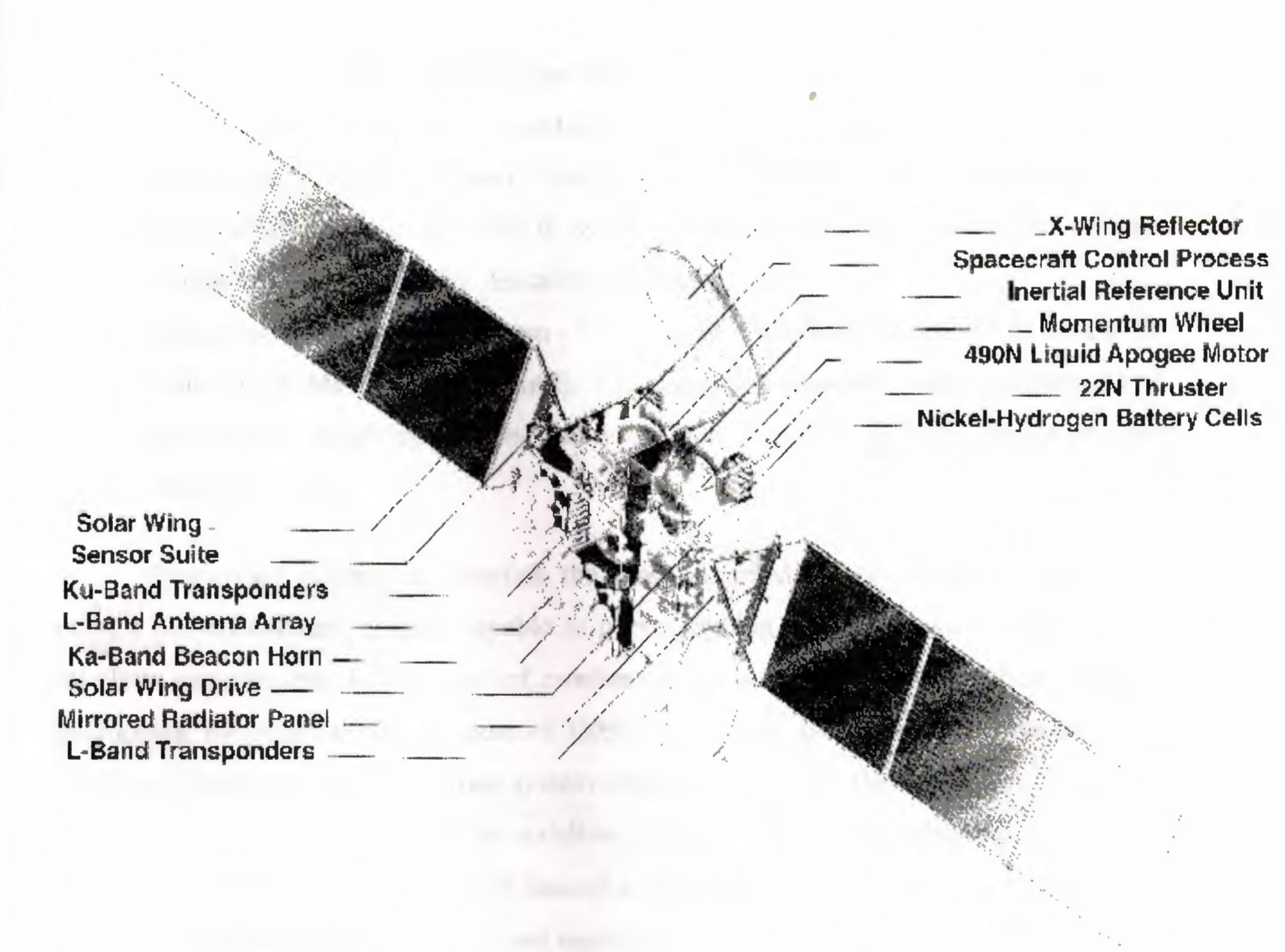


Figure 1.1 Satellite Specifications

1. 1.3 How Satellites Work

For a satellite to operate, three components are required:

- Communication capabilities with Earth - Communications antennae, radio receivers, and transmitters enable the satellite to communicate with one or more ground stations, called command centers. The ground station uplinks messages to the satellite, while the satellite downlinks messages back to Earth.
- A power source - Most contemporary satellites are battery-powered, taking advantage of solar recharging. Silver solar panels are prominent features on many

satellites. Other satellites have fuel cells that convert chemical energy to electrical energy, while a few utilize nuclear energy or heat generators. Small thrusters provide orientation (attitude), altitude, and propulsion control to modify and stabilize the satellite's position in space. Satellites also require energy to provide climate control onboard for delicate instruments.

- A bus (body) with control system - The body of a satellite, also known as the bus of a satellite, holds all of the scientific equipment and other necessary components of the satellite. Satellites combine many different materials to make up all of their component parts.

Specialized systems accomplish the tasks assigned to the satellite. These often include optical systems, sensors capable of photographing a range of wavelengths. Many satellites transmit data in the form of numbers to ground stations, which then calculate positioning information (in the case of GPS) or imaging (such as with environmental satellites). Designers can concentrate system complexity in either the satellite or the ground equipment. For example, when the satellite handles complex calculations, the ground station can be relatively simple. In the case of a "dumb pipe" where the satellite makes few, if any, calculations in space, the ground equipment must be more complex and thus more expensive.

1.1.4 [illegible]

The term "band" refers to the range of frequency at which a satellite communicates. Three commonly used bands in telecommunications are C-band, Ku-band, and Ka-band.

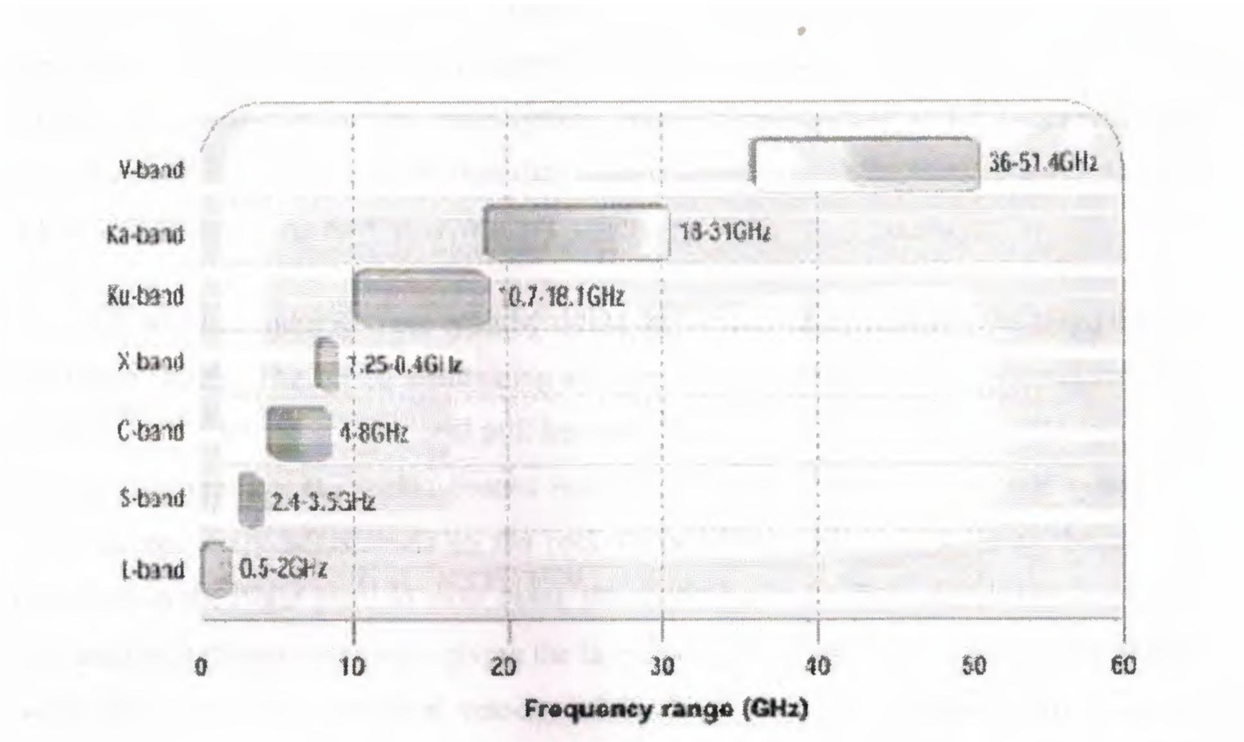


Figure 1.2 Satellite Frequency Bands

Bands: C; Kut and Ka

Satellite band Earth-to-space frequencies Space-to-Earth frequencies
C- 5.850 - 6.425 GHz 3.6 - 4.2 GHz
Ku- 12.75 - 13.25,13.75 - 14.8 GHz 10.7 - 12.75, 17.3 - 17.7 GHz
Ka- 27.5 - 30.0 GHz 17.7 - 21.2 GHz

C-band satellites, which use the range between 3.7 and 4.5 GHz, are able to reach several continents but require a receiver dish of about three meters in diameter. In contrast, Ku-band covers the range between 10.7 and 12.75 GHz. Television stations and other broadcasters that need to reach only one continent utilize the Ku-band. Ku-band requires a receiver dish that is significantly smaller than the one needed by C-band.

Ka-band operates in the range of 18 to 31 GHz. Many new multimedia companies utilize the Ka-band because it has sufficient bandwidth to support multimedia applications.

The wide range of frequencies allows data transmission at multiple frequencies simultaneously and allows for two-way broadband services. According to the Vision Group, the commercial use of these systems allows transmissions at 1.5 Megabytes per second, which is 150 times faster than data transmissions over phone lines. We recommend a Ka-band transmission for Cyber Wallet Launch vehicle.

All satellites today get into orbit by riding on a rocket or by riding in the cargo bay of the Space Shuttle. The key to maintaining a stable orbital position is to balance the velocity of the launch with the gravitational pull between the Earth and the satellite. After a rocket launches straight up, the rocket control mechanism uses the inertial guidance system to calculate necessary adjustments to the rocket's nozzles to tilt the rocket to the course described in the flight plan. In most cases, the flight plan calls for the rocket to head east because Earth rotates to the east, giving the launch vehicle a free boost. The strength of this boost depends on the rotational velocity of Earth at the launch location. The boost is greatest at the equator, where the distance around Earth is greatest and so rotation is fastest Once the rocket reaches extremely thin air, at about 120 miles (193 km) up, the rocket's navigational system fires small rockets, just enough to turn the launch vehicle into a horizontal position. The rocket then releases the satellite. At that point, the rockets fire again to ensure some separation between the launch vehicle and the satellite itself

1.1.S Spacecraft

The lvleteosat satellite system is an example of a very successful European endeavour. First: designed in the early 1970s, the first model was launched in 1977, and the same design is expected to be in use until at least the end of *1003*. The expected 26 years of operational service amply justifies the initial development effort. A few relatively minor design changes were introduced after Meteosat-3, and it is this updated satellite specification which is summarized below

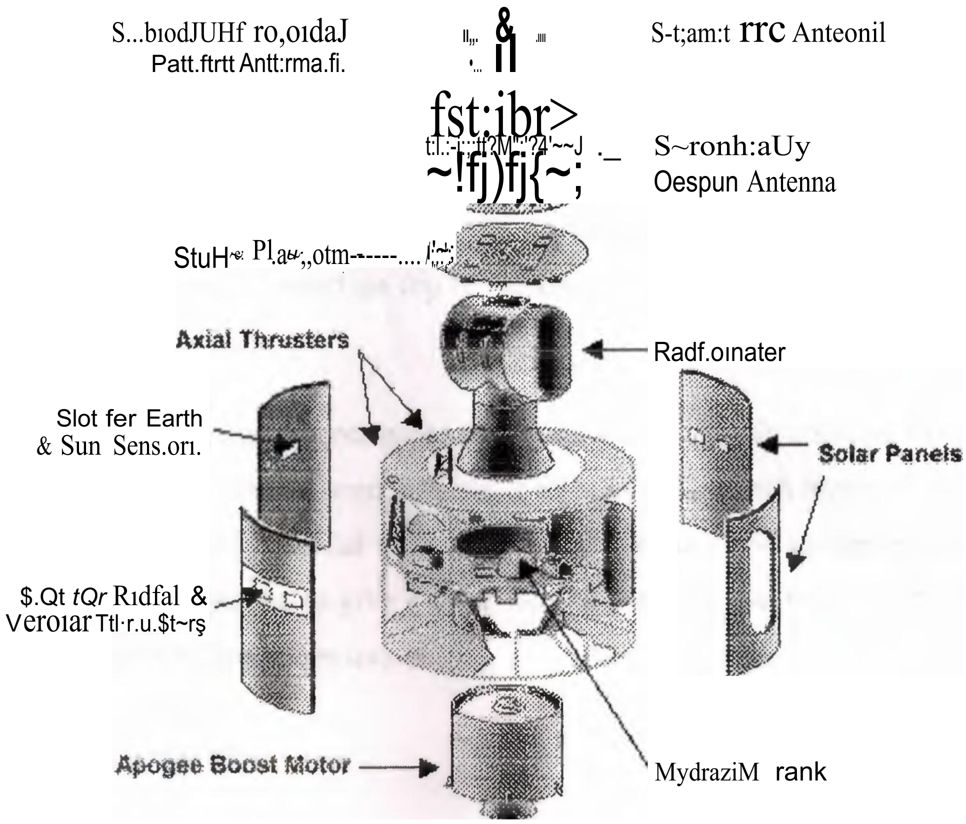


Figure 1.3 Spacecraft

Structure

The overall size of the satellite is 2.1 meters in diameter and 3.195 meters long. Its initial mass in orbit is 282 kg Additional to this dry mass is the hydrazine propellant used for station-keeping, amounting to approximately a further 40 kg at the beginning of life. In orbit, the satellite spins at 100 rpm a.round its ma.in axis, which is aligned nearly parallel to **the Earth's north-south axis.**

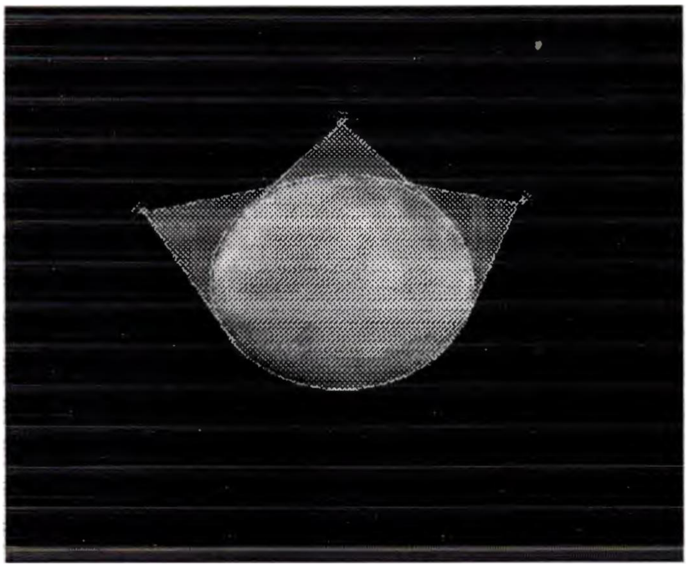
Meteosat is composed of a main cylindrical body, on top of which a drum-shaped section (diameter 1.3 m) and two further cylinders a.re stacked concentrically The main cylindrical body contains most of the satellite subsystems, including the radiometer. Its surface is made up of six panels covered with the solar cells which provide the electrical power. The panels also have cut-outs for sensors, thrusters and umbilical connectors.

The cylindrical surface of the smaller drum-shaped section, mounted on top of the 8/UHF platform, is covered with an array of radiating dipole antenna elements. Electronics within the drum activate the individual elements *in* sequence, in reverse order to the satellite spin sense. This subsystem constitutes an electronically-despun antenna whose function is to ensure that the main transmissions in S-band are always directed towards the Earth. The two cylinders mounted on top of the drum are toroidal pattern antennas for S-band and low UHF respectively.

An apogee boost motor containing solid propellant is initially attached to the bottom of the satellite at launch. This is used to boost it from its post-launch highly elliptical orbit into the required circular equatorial orbit. Following this burn, the apogee boost motor is jettisoned, leaving an opening to give a clear field of view for the radiative cooler which cools the radiometer infrared detectors.

1.1.6 Satellite **Network**

For our mission, constant connection must be maintained between the main base on Earth and the base on Mars, mainly because there will be people working on Mars and a constant monitoring of their progress and health conditions is an essential part of mission success. The worst-case scenario will be injury or death of one or more crewmernbers, and therefore the more we monitor them, the less chance of failing there is.



Figurel.5 Graphic Shows the Bask Schematics **of How** Satehites **Array Around Mars**

Satellite, *in* the middle on the picture will be the one right above the landing site and -the main base. The other two will be 645 degrees to either side. All the satellites will be in geosynchronous orbit, which *is* roughly $1.69*10^7$m above the surface ofMars..From this orbit, each satellite will be able to cover about 95% of its side of Mars (from 80.4 degrees South to 80.4 degrees North). The overall area being covered this way is about 60% of the planet and includes all the places our people and equipment could ever reach.

For the actual data transmissions, only the two outside satellites will be used. They are positioned in such way that. one of them will always be in contact with Earth. The third one will be used as a backup; *if* one of the others fails, it will be able to move to the failed satellite's position and replace it.

1.1.7 SatLink

Sat Link is rather like an international private circuit in the sky. It's designed for your exclusive use and is delivered directly to the location or multiple locations of your choice throng hroof-topdishes

1.1.8 SatStar

S~.t Star enables multiple locations to exchange information with a central site via a BT hub and small satellite dishes at each site.

1 1 0 Broadcast Doto... Service

Broadcast Data Service is a full-time private network offering one-way data communications from a central location to as many locations as required.

1.2 Orbits

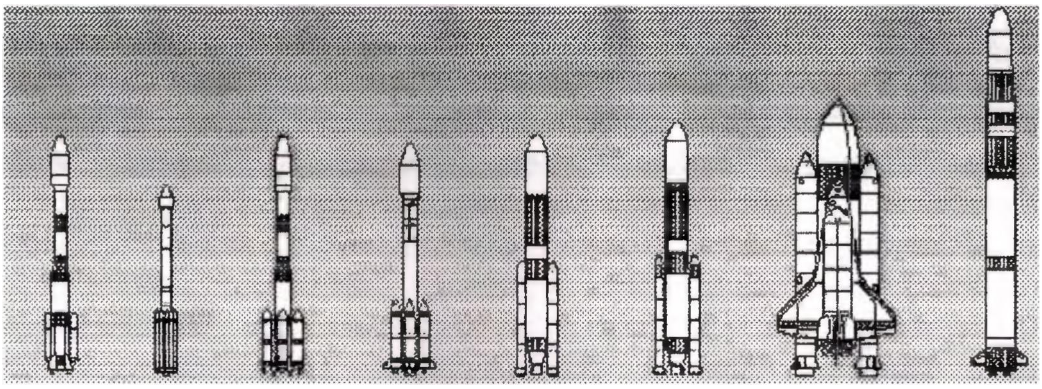


Figure L6 Orbits Space Shuttle

The direction a body travels *in* orbit can be direct, or prograde, in which the spacecraft moves in the same direction as the planet rotates, or retrograde, going in a direction opposite the planet's rotation. True anomaly is a term used to describe the locations of various points in an orbit. It is the angular distance of a point in an orbit past the point of peria psis, measured *in* degrees. For example, a spacecraft might cross a planet's equator at 10 degrees true anomaly. Nodes are points where an orbit crosses a plane. As an orbiting body crosses the ecliptic plane going north, the node is referred to as the ascending node; going south; it is the descending node.

To completely describe an orbit mathematically, six quantities must be calculated. These quantities are called orbital elements, or Keplerian elements. They are: (1) semi-major axis and (2) eccentricity, which are the basic measurements of the size and shape of the orbit's ellipse. Recall an eccentricity of zero indicates a circular orbit. The (3) orbit's inclination is the angular distance of the orbital plane from the plane of the planet's equator (cır from the ecliptic plane, if you're talking about heliocentric orbits), stated in degrees: an inclination of 0 degree. Means the spacecraft orbits the planet at its equator and in the same direction as the planet rotates. An inclination of 90 degrees indicates a polar orbit:, in which the spacecraft passes over the north and south poles of the planet. An inclination of 180 degrees indicates an equatorial orbit in which the spacecraft.moves in a direction opposite the planet's rotation (retrograde). The (4) argument of periapsis is the angular distance of periapsis from the ascending node. Time of periapsis passage (5) and the celestial longitude of the ascending node (6) are the remaining elements. Generally, three astronomical or radiometric observations of an object in an orbit: are enough to pin down each of the above six Keplerian elements.

1.2.1 Orbital Paths

Experts generally classify satellites by the speed and distance of their orbital paths. Common types of satellites include geostationary satellites (GEOs), Low-earth orbiting satellites (LEOs), as well as Polar and Elliptical satellites.

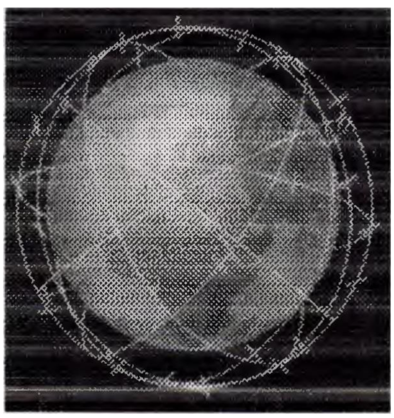


Figure **1.8 Orbital Paths**

1.2.1.1 GEOs

A satellite in a geostationary orbit circles the earth once every 24 hours, directly above the Equator. It stays above the same paint an Earth all the time. To maintain the same rotational period as the Earth, a satellite in geostationary orbit must be 22,237 miles above the Earth. At this altitude, a satellite's footprint extends over 42.4 percent of the Earth's surface at one time. Because the high-altitude satellite appears to remain fixed in one position, it requires na tracking to receive. its downlink signal. Direct Broadcasting, such as DirecTV and Echo Star, transmits from geostationary satellites; the mounting of the dishes, with simple antennas, allows them to point toward the fixed position of the satellite. Although the large footprint and simplicity of the antenna make GEOs attractive communication satellites, delay is a significant disadvantage. Because of the distance of the satellite to Earth, total delay of a signal can be up to 2 seconds (up and downlink).

1.2.1.2 LEOs

When a satellite circles close to Earth, it is in Low Earth Orbit (LEO). Satellites in LEO are just 200 - *500* miles (320 - 800 kilometers) high. Because they orbit so close to Earth, they must travel very fast so gravity will not pull them back into the atmosphere. Satellites in LEO speed along at 17,000 miles per hour (27,359 kilometers per hour). They can circle Earth in about 90 minutes. A Low-Earth Orbit is useful because its nearness to Earth reduces delay. Polar and Elliptical Orbit satellites are special subcategories ofLEOs.

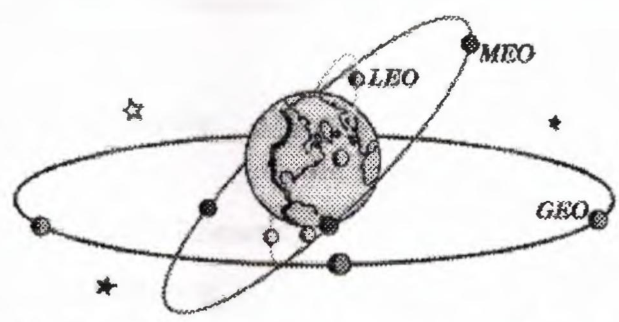


Figure 1.9 the LEO,GEO and MEO Orbits

- **Geosynchronous Orbits (GEO)**

GEO: (Intelsat, Satcom, Comsat, Anik, MSAT, Globis ..)

- Direct broadcast
- Fixed satellite services
- Inter satellite links

- **Mid Earth Orbit (MEO):**

MEO: (Odyssey, Navistar, Archemidis, Ellipse):

- Voice and data communications
- Radio determination and radio Navigation
- Reconnaissance

- **High Earth Orbit (HEO)**

HEO: (Molniya, Tundra):

- Communication services at high earth latitudes

- **Low Earth Orbit (LEO)**

LEO: (Iridium, Global Star Orbcomm):

- Voice and high speed data communications
- Rescue and search
- Remote sensing and monitoring
- Reconnaissance

Sun-Synchronous LEO-s (Tiros-N, Teledesic):

- Remote sensing and monitoring
- Reconnai ssance

~ Geostationary orbit

1.2.3.1 Sun-Synchronous Orbit

- . Because of the Earth's yearly orbit, the Sun appears to move in space, Relative to the fixed stars. The daily eastward turn is equal 0.98560.
- . The Earth oblatness causes the orbital plane ta rotate around the polar Axis, the phenomenon referred to as regression of the nodes.
- . In order this regression ta be positive (eastward) a satellite should be On a retrograde orbit, i > 900.

With the rate of regression of the nodes synchronized with a daily tum of the Earth around the Sun, the orbital plane completes one rotation around the Earth within one tropical year.

In sun-synchronized orbit the satellite will be at the s.ame latitude at the same local solar time each day. In .helio-centric coordinates the angle between the radius-vector pointing to the Earth and normal ta the orbital plane will remain constant

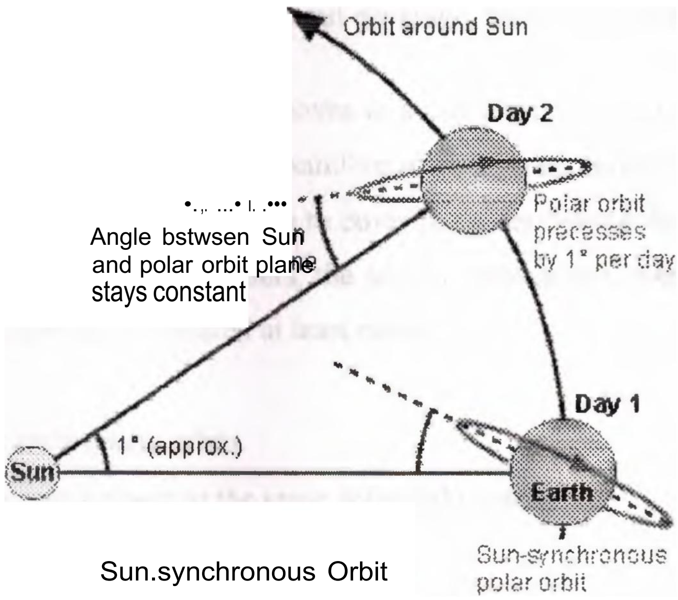


Figure 1..10 Sun-Synchronous Orbits

The orbit is designed to ensure that the angle between the orbital plane and the sun remains constant, resulting in consistent. lighting conditions. This is achieved by a careful selection of orbital parameters to produce a precession of the orbit equal to the apparent motion of the sun as seen from Earth orbit, i.e. about one degree eastward each day. The satellite's orbital plane must be inclined away from a true north-south polar orbit. With an inclination af 98.7° to the equatorial plane, the asymmetric gravitational pull of the Earth causes the orbit to process by the required amount. (Note that the satellite's motion is actually retrograde - it moves to the west, not the east.) A key feature is that, in each half of this orbit, the satellite always crosses a particular line of latitude at the same local solar time. The angle of the sunlight (in the daytime half) will therefore be consistent, only varying slowly as the seasons change in the course of a year.

The altitude of a satellite in polar orbit is a compromise between different requirements:

- High ground resolution and a short orbital period for frequent coverage - these result from a low orbit.
- A swath of observation that is wide enough such that successive orbital swaths overlap. This ensures complete ground coverage, and is favoured by a higher orbit.

As a result, a typical polar satellite moves in a circular orbit with an altitude of about 850 km and a period of 100 minutes. The satellite scans a swath about 3000 km wide an the Earth's surface, which is also wide enough to cover the poles despite the north-south orbital inclination af 8.7°. With these parameters, the satellite makes just over 14 orbits in a day, and every paint on the Earth is covered at least twice.

Advantages of sun-synchronous orbits:

- satellite cross a given latitude at the same solar light conditions
- may be designed to avoid the solar eclipse

Such features are important for monitoring and surveillance services.

Examples of constellation using sun-synchronous design:

- Tiros-N series (Television and Infrared Observational Satellites)
- Teledesic (Sponsored by Teledesic, Kirkland, Washington)

1.2.3.2 Molniya **Orbit**

- High eccentricity results in long stay-time at high latitudes
- Inclination of orbit by 63.40 or 116.60 stabilizes the position of apsidal

Line in orbital plane

- Harmonic ratio provides periodic repetition of satellite's position

6'10

- Molniya (Lightning in Russian) is a collective name for highly

Elliptical orbits inclined by 63.40 or 116.60 and having a periodic time composing harmonic ratio with the sidereal day.

Advantages:

- Provide high elevation angles at the areas situated at high latitudes

Disadvantages:

- require using steering Earth antennas for tracking the satellites
- complicated network design
- varying footprint size

Applications:

- Molniya orbits are used ta provide the direct broadcast and voice

Communications in densely populated territories of northern hemisphere.

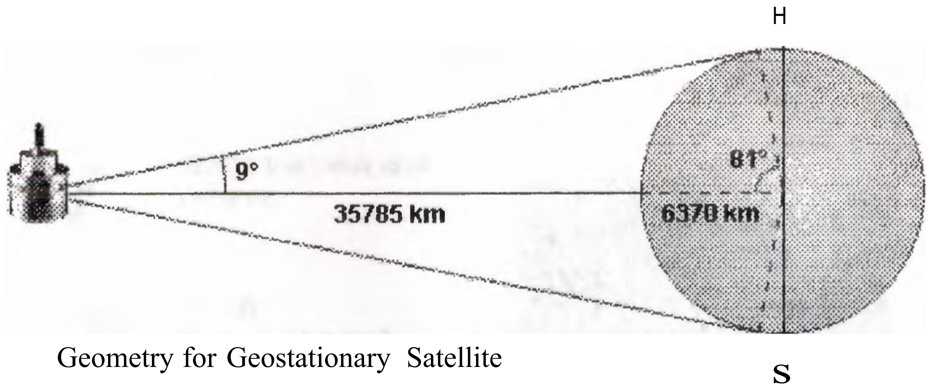
Examples of constellation using Moiniya designs:

- ELLIPSO-BOREALIS (Periodic Time - 3 hours)
- ARCHIMEDES (European Space Agency)
- TUNDRA (Periodic Time - 1 sidereal day)

The mean motion of satellite, 14.18 rev/day is not a whole number. The Satellite is not earth-synchronous.

1.2.3.3 Geostationary orbit

A gee-stationary orbit is an orbit of an Earth's satellite whose period of rotation is exactly equal to the period of rotation of Earth about it's polar axis (which is 23 hours, 56 minutes and 4.1 seconds) and whose trajectory is aligned with the Earth's equator.



Geometry for Geostationary Satellite

Figure 1.11 Geometry for Geostationary Satellite

The theoretical coverage area of a geostationary satellite extends to an angle of 81° from the sub-satellite point (the point on the Earth's surface directly beneath the satellite), corresponding to over 40% of the Earth's surface. In practice, the useful coverage is somewhat less than this. For an observer at latitude 81° the satellite would lie on the horizon, making communication difficult; a more realistic coverage value would be about 75°, From the point of view af a weather satellite, the distorted perspective introduced by the Earth's curvature limits the useful study of features to about 70° from the sub-satellite point, corresponding to about one third of the Earth's surface. For the quantitative derivation of meteorological products from Meteosat data, EUMETSAT imposes a further limit of 60°. Even so, it would need as few as three geostationary satellites ta provide coverage of all but the polar regions of the Earth (the latter are covered by satellites in polar orbit).

1.2.4 Launch Profile

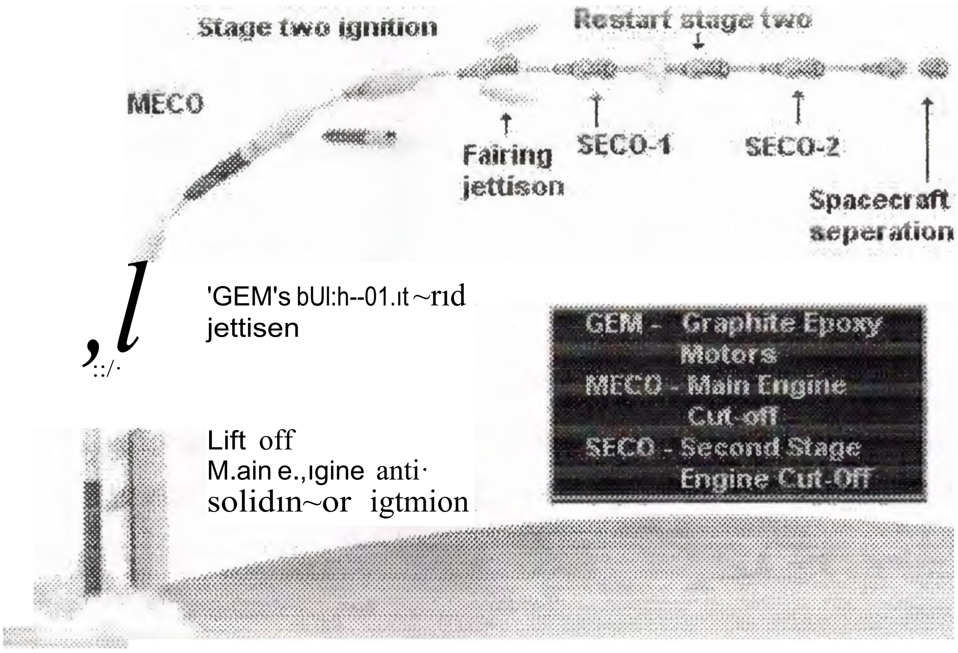


Figure 1.12 Launch Profile

1.2.5 Time Division Multiple Access (TDMA)

Overview.

The TDMA system is designed for use in a range of environments and situations, from hand portable use in a downtown office to a satellite user traveling at high speed on the freeway. The system also supports a variety of services for the end user, such as voice, data, fax, short message services, and broadcast messages. TDMA offers a flexible air interface, providing high performance with respect to capacity, coverage, and unlimited support of mobility and capability to handle different types of user needs.

. The Advantage ofTDMA

- *lt* economizes on bandwidth.
- It maintains superior quality of voice transmission over long distances.
- It is difficult to decode.
- It can use lower average transmitter power.
- *lt* enables smaller and less expensive individual receivers and transmitters.
- It offers voice privacy.

The Disadvantages of TDMA

One of the disadvantages of TDMA is that each user has a predefined time slot. However, users roaming from one cell to another are not allotted a time slot. Thus, if all the time slots in the next cell are already occupied, a call might well be disconnected. Likewise, if all the time slots in the cell in which a user happens to be in are already occupied, a user will not receive a dial tone.

Another problem with TDMA is that it is subjected to multipath distortion. A signal coming from a tower to a handset might come from any one of several directions. It might have bounced off several different buildings before arriving, which can cause interference.

1.2.6 Frequency Division Multiple Access (FDMA)

IDMA is basically analog's FDMA with a time-sharing component built into the system. FDMA allocates a single channel to one user at a time (Figurel.13) the transmission path deteriorates, the controller switches the system to another channel. Although technically simple to implement, FDMA is wasteful of bandwidth: the channel is assigned to a single conversation whether or not somebody is speaking. Moreover, *it* cannot handle alternate forms of data, only voice transmissions.

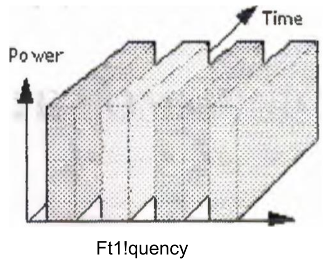


Figure 1.13 FDMA

- How TDMA, FDMA Works?

TDMA relies upon the fact that the audio signal has been digitized; that is, divided into a number of milliseconds-long packets. It allocates a single frequency channel for a short time and then moves to another channel. The digital samples from a single transmitter occupy different time slots in several bands at the same time as shown in Figure 1.14

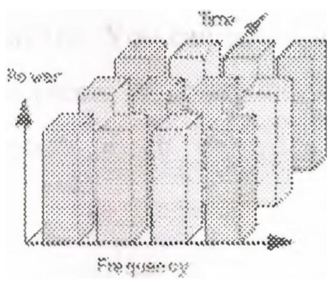


Figure 1.14 TDMA

The access technique used in TDMA has three users sharing a 30-kHz carrier frequency. TDMA is also the access technique used in the European digital standard, and the Japanese digital standard. The reason for choosing TDMA for all these standards was that it enables some vital features for system operation in an advanced cellular or PCS environment. Today, TDMA is an available, well-proven technique in commercial operation in many systems.

CHAPTER TWO

SATELLITE COMMUNICATION

2.1 History of Satellite Communications

The first regular satellite communications service was used by the Navy in 1960. The moon was used to bounce teletypewriter signals between Hawaii and Washington, D.C. During the early 1960s, the Navy used the moon as a medium for passing messages between ships at sea and shore stations. This method of communications proved reliable when other methods failed.

Experience with satellite communications has demonstrated that satellite systems can satisfy many military requirements. They are reliable, survivable, secure, and a cost effective method of telecommunications. You can easily see that satellites are the ideal, if not often the only, solution to problems of communicating with highly mobile forces. Sateliites, if properly used, provide much needed options to large, fixed-ground installations.

For the past fifty years, the Navy has used high-frequency (hf) transmissions as the principal method of sending messages. In the 1970s, the hf spectrum was overcrowded and "free" frequencies were at a premium. Hf jamming and electronic countermeasures (ECM) techniques became highly sophisticated during that period. As a result the need for new and advanced long-range transmission methods became apparent.

Communications via satellite is a natural outgrowth of modern technology and of the continuing demand for greater capacity and higher quality in communications.

In the past, the various military branches have had the resources to support their communications needs. Predicted usage indicates that large-scale improvements will have to be made to satisfy future needs of the Department of Defense. These needs will require greater capacity for long-haul communications to previously inaccessible areas. Satellite communications has the most promise for satisfying these future requirements

Military satellite communications technology was at a low level until 1965. At that time high quality voice transmissions were conducted between a satellite and two earth stations. That was the stepping stone to the Initial Defense Communications Satellite Program (IDCSP), which will be covered later in this chapter

2.2 Defense Communication Satellite Program (DCSP)

The Defense Communications Satellite Program (DCSP) was initiated by the Secretary of Defense in 1962. Phase I of the program was given the title Initial Defense Communications Satellite Program (IDCSP). The first satellite launch occurred in June 1966 when seven experimental satellites were placed into orbit. The final launch of this program consisted of eight satellites and occurred in June 1968.

2.3 Fundamental Satellite Communication System

A satellite communications system uses satellites to relay radio transmissions between earth terminals. The two types of communications satellites you will study are ACTIVE and PASSIVE. A passive satellite only reflects received radio signals back to earth. An active satellite acts as a REPEATER; it amplifies signals received and then retransmits them back to earth. This increases signal strength at the receiving terminal to a higher level than would be available from a passive satellite.

A typical operational link involves an active satellite and two or more earth terminals. One station transmits to the satellite on a frequency called the UP-LINK frequency. The satellite then amplifies the signal, converts it to the DOWN-LINK frequency, and transmits it back to earth. The signal is next picked up by the receiving terminal. Figure 2-1 shows a satellite handling several combinations of links simultaneously.

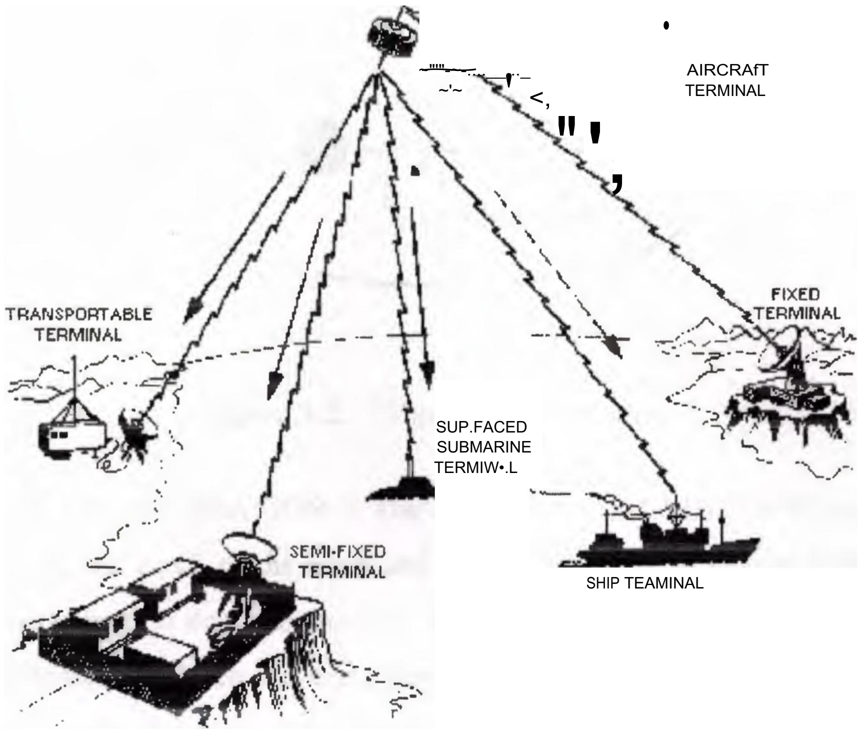


Figure 2.L - Satellite communications system.

2. 4 Orbit Descriptions

Orbits generally are described according to the physical shape of the orbit and the angle of inclination of the plane of the orbit. These terms aye discussed in the following paragraphs:

- PHYSICAL SHAPE. - All satellites orbit the earth in elliptical orbits. (A circle is a pecial case of an ellipse.) The shape of the orbit is determined by the initial launch parameters and the later deployment techniques used.
- PERIGEE and APOGEE are two, of the three parameters used to describe orbital data of a satellite. These are shown on figure 2-2. Perigee is the point in the orbit nearest to the center of the earth. Apogee is the point in the orbit the greatest distance from the center of the earth. Both distances are expressed in nautical miles.

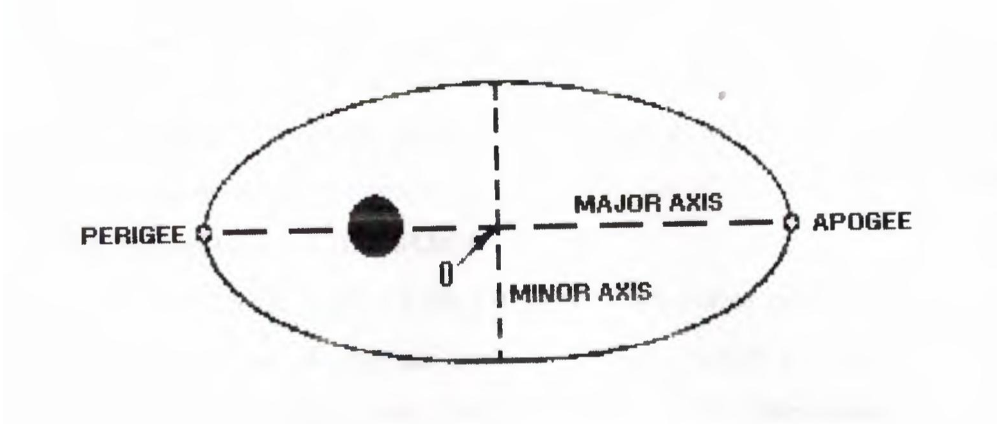


Figure 2.2. - Elliptical satellite orbit.

- ANGLE OF INCLINATION. - The ANGLE OF INCLINATION (angle between the equatorial plane of the earth and the orbital plane of the satellite) is the third parameter used to describe the orbit data of a satellite. Figure 2-3 depicts the angle of inclination between the equatorial plane and the orbital plane. Most satellites orbit the earth in orbital planes that do not coincide with the equatorial plane of the earth. A satellite orbiting in any plane not identical with the equatorial plane is in an INCLINED ORBIT.

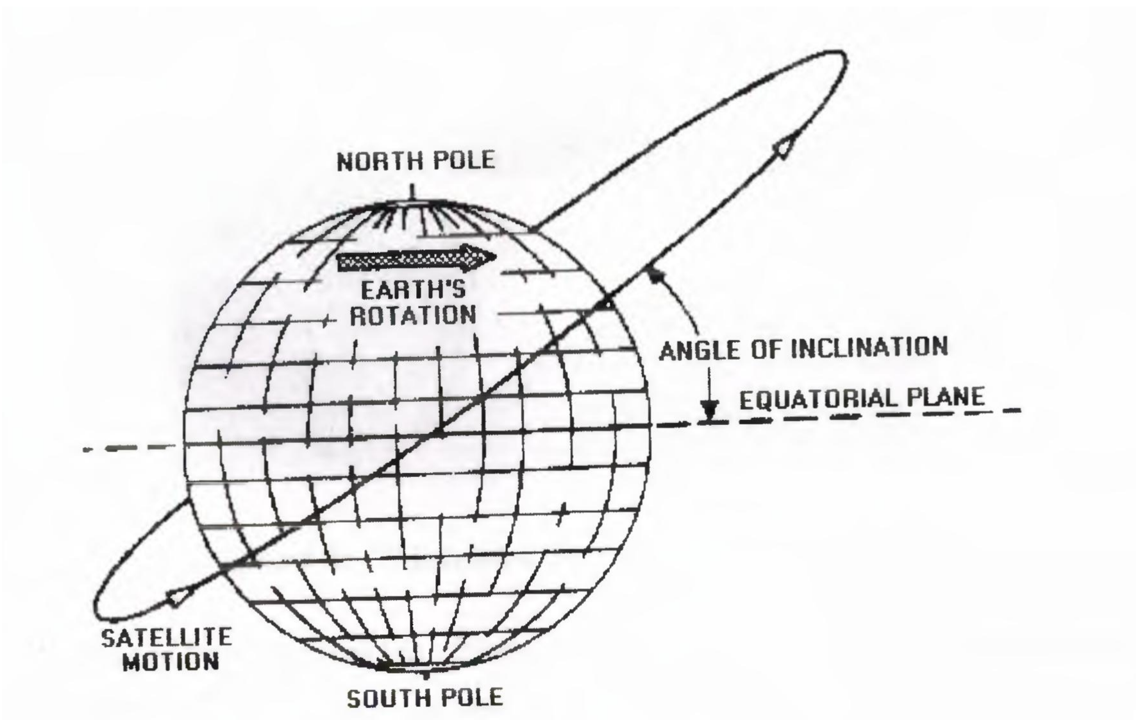


Figure 2.3. - Inclined satellite orbit.

- SPECIAL TYPES OF INCLINED ORBITS. - A satellite orbiting in a plane that coincides with the equatorial plane of the earth is in an EQUATORIAL ORBIT. A satellite orbiting in an inclined orbit with an angle of inclination of 90 degrees or near 90 degrees is in a POLAR ORBIT.
- SPECIAL TYPES OF CIRCULAR ORBITS. - We stated previously that a circular orbit is a special type of elliptical orbit. You should realize a circular orbit is one in which the major and minor axis distances are equal or approximately equal. Mean height above earth, instead of perigee and apogee, is used in describing a circular orbit. While we are discussing circular orbits, you should look at some of the terms mentioned earlier in this chapter. A satellite in a circular orbit at a height of approximately 19,300 nautical miles above the earth is in a synchronous orbit. At this altitude the period of rotation of the satellite is 24 hours, the same as the rotation period of the earth. In other words, the orbit of the satellite is in sync with the rotational motion of the earth. Although inclined and polar synchronous orbits are possible, the term synchronous usually refers to a synchronous equatorial orbit. In this type of orbit, satellites appear to hover motionlessly in the sky. Figure 2-4 shows how one of these satellites can provide coverage to almost half the surface of the earth.

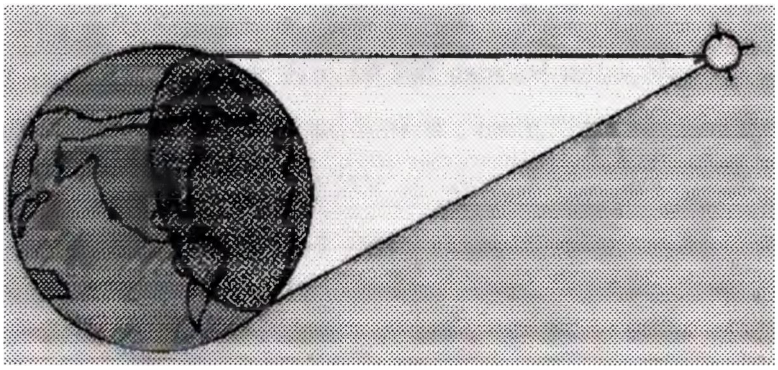


Figure 2.4. - Illumination from a synchronous satellite.

Three of these satellites can provide coverage over most of the earth (except for the extreme north and south polar regions). A polar projection of the global coverage of a three-satellite system is shown in figure 2.5.

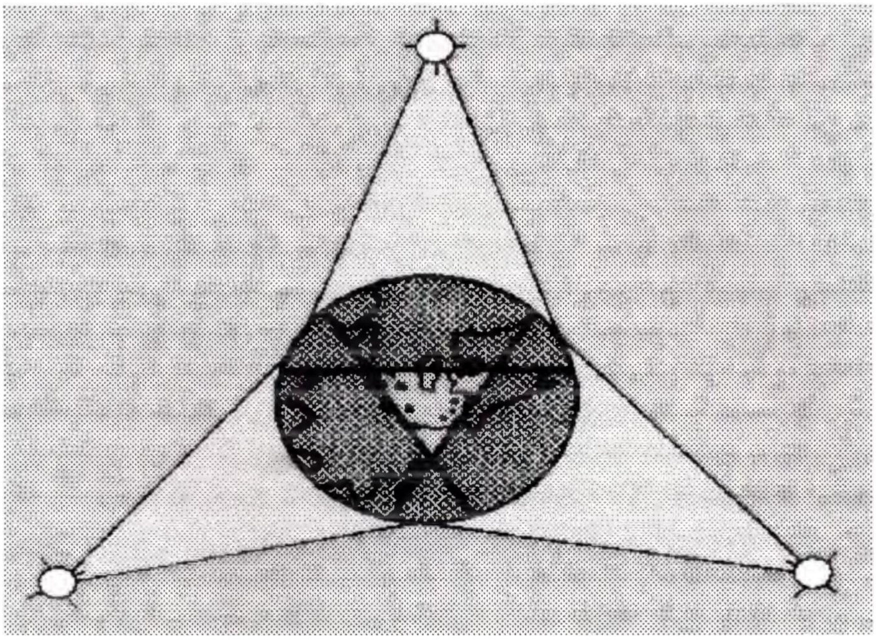


Figure 2.5. - Worldwide synchronous satellite system viewed from above the North Pole

A satellite in a circular orbit at other than 19,300 nautical miles above the earth is in a near-synchronous orbit. If the orbit is lower than 19,300 nautical miles, the period of orbit of the satellite is less than the period of orbit of the earth. The satellite then appears to be moving slowly around the earth from west to east. (This type of orbit is also called sub-synchronous.) If the orbit is higher than 19,300 nautical miles, the period of orbit of the satellite is greater than the period of orbit of the earth. The satellite then appears to be moving slowly around the earth from east to west. Although inclined and polar near-synchronous orbits are possible, near synchronous implies an equatorial orbit.

A satellite in a circular orbit from approximately 2,000 miles to 12,000 miles above the earth is considered to be in a MEDIUM ALTITUDE ORBIT. The period of a medium altitude satellite is considerably less than that of the earth. When you look at this altitude satellite, it appears to move rather quickly across the sky from west to east.

2. 5 Satellite Characteristics

Early communications satellites were limited in size to the diameter of the final stage of the rocket that was used for launching. Weight was determined by the thrust of the rocket motors and the maximum weight the rocket could lift into orbit.

As early as June 1960, two satellites were successfully placed in orbit by the same launch vehicle. With the development of mıltilaunch capability, added flexibility became available. We then had choices as to the size, weight, and number of satellites to be included in each launch.

Using our multilaunch capabilities, the Defense Satellite Communications System (DSCS) has placed larger and heavier satellites in synchronous equatorial orbits. Figure 2-6 is a drawing of a DSCS satellite. It shows each pair of transmit and receive dish antennas. A~ you can see, a large area of the earth can be covered using only one satellite.

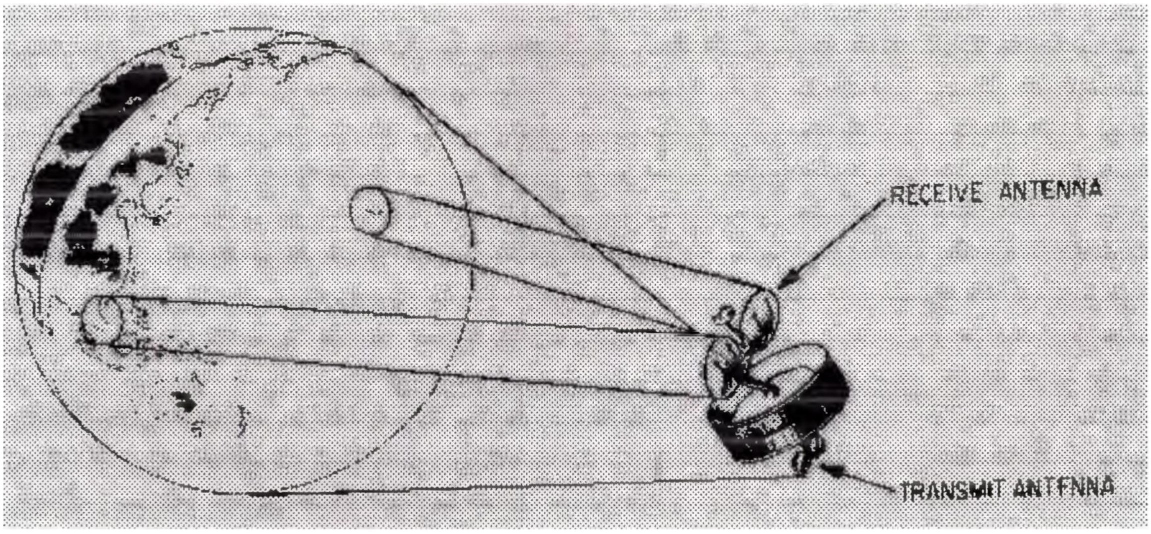


Figure 2.6. - DSCS satellite.

2.6 Satellite Power Sources

Early communications satellites were severely limited by the lack of suitable power sources. This severely limited the output power of the satellite transmitter. The only source of power available within early weight restrictions was a very inefficient panel of solar cells without battery backup. A major disadvantage of this type of power source is that the satellite has no power when it is in ECLIPSE (not in view of the sun). For continuous communications, this outage is unacceptable.

A combination of solar cells and storage batteries is a better prime power source. This is a practical choice, even though the result is far from an ideal power source. About ten percent of the energy of the sunlight that strikes the solar cells is converted to electrical power. This low rate is sometimes decreased even further. You find this when the solar cells are bombarded by high-energy particles that are sometimes found in space.

Early satellites had over 8,500 solar cells mounted on the surface of the satellite, which supplied about 42 watts of power. No battery backup was provided in these satellites.

Newer communications satellites have about 32,000 solar cells mounted on the surface of the satellite, and they supply about 520 watts. A nickel cadmium battery is used for backup power during eclipses.

Nuclear power sources have been used in space for special purposes, but their use stops there. Technology has not progressed sufficiently for nuclear power sources to be used as a power source.

2.7.1 Receivers by Satellite

All satellite communications earth terminals are equipped with specially designed highly sensitive receivers. These receivers are designed to overcome down-link power losses and to permit extraction of the desired communications information from the weak received signal. The terminals currently in use have specially designed preamplifiers mounted directly behind the antennas.

2.7.2 Transmitters by Satellite

All earth terminal transmitters generate high-power signals for transmission to the communications satellites. High-powered transmitters and highly directional, high-gain antennas are combined in this configuration. This is necessary to overcome up-link limitations and to ensure that the signals received by the satellite are strong enough to be detected by the satellite. Each transmitter has an exciter/modulator and a power amplifier. The modulator accepts the input signal from the terminal equipment and modulates an IF carrier. The exciter translates the IF signal to the up-link frequency and amplifies it to the level required by the power amplifier.

Transmitters used in earth terminals have output power capabilities that vary from lO watts to 20 kilowatts, depending on the type used and the operational requirements.

2.8 Role of Satellite Communication

In the context of a worldwide military communications network, satellite communications systems are very important. Satellite communications links add capacity to existing communications capabilities and provide additional alternate routings for communications traffic. Satellite links, as one of several kinds of long-distance links, interconnect switching centers located strategically around the world. They are part of the defense communication systems (DCS) network. One important aspect of the satellite communications network is that it continues in operation under conditions that sometimes render other methods of communications inoperable. Because of this, satellites make a significant contribution to improved reliability of Navy communications

- Mobile Satellite Communications Experiment

Means of communications with mobile bodies such as ships, air-planes and automobiles, etc. are solely depend on radio-wave.
But the conventional communications to the mobile bodies have limited application and are

not necessarily satisfactory in terms of quality and amount of information . Especially, small ships and airplanes, located on or over the open sea far from. land cannot help depending on inefficient microwave communications as they did before.

The development of satellite communications system for ships and airplanes facilitates not only outstanding improvement of navigation safety but also rendering new services such as remote medical services. Furthermore, the introduction of the system to the communications equipment easily carried by vehicles and men moving on the ground is very beneficial for the communication at mountaneous or isolated areas or at the time of disaster and emergency.

NASDA developed mobile communications experiment equipment called AMEX (aeronautical maritime experimental transponder) in corporation with the Communication Research Laboratory of the Ministry of Posts and Telecommunications and the Electronic Navigation Research Institute of the Ministry of Transportation.

Synthetic experiments on mobile satellite communications covering land, ocean and sky are presently conducted by the above mentioned two organizations utilizing Engineering Test Satellite-V (Kiku-S)

2.9.1 Advantages of Satellite Communication

Satellite communications have unique advantages over conventional long distance transmissions. Satellite links are unaffected by the propagation variations that interfere with hf radio. They are also free from the high attenuation of wire or cable facilities and are capable of spanning long distances. The numerous repeater stations required for line-of-sight or troposcatter links are no longer needed. They furnish the reliability and flexibility of service that is needed to support a military operation.

- Capacity

The present military communications satellite system is capable of communications between backpack, airborne, and shipboard terminals. The system is capable of handling thousands of communications channels.

- Reliability

Communications satellite frequencies are not dependent upon reflection or refraction and are affected only slightly by atmospheric phenomena. The reliability of satellite communications systems is limited only by the equipment reliability and the skill of operating and maintenance personnel.

- Vulnerability

Destruction of an orbiting vehicle by an enemy is possible. However, destruction of a single communications satellite would be quite difficult and expensive. The cost would be excessive compared to the tactical advantage gained. It would be particularly difficult to destroy an entire multiple-satellite system such as the twenty-six. random-orbit satellite system currently in use. The earth terminals offer a more attractive target for physical destruction. These can be protected by the same measures that are taken to protect other vital installations.

A high degree of freedom from jamming damage is provided by the highly directional antennas at the earth terminals. The wide bandwidth system that can accommodate sophisticated anti-jam modulation techniques also lessens vulnerability.

- Flexibility

Most operational military satellite earth terminals are housed in transportable vans. These can be loaded into cargo planes and flown to remote areas. With trained crews these terminals can be put into operation in a matter of hours. Worldwide communications can be established quickly to remote areas nearly anywhere in the free world.

2.9.2 Satellite Limitations (Disadvantages)

Limitations of a satellite communications system are determined by the technical characteristics of the satellite and its orbital parameters. Active communications satellite systems are limited by two things. Satellite transmitter power on the down links and receiver sensitivity on the up links. Some early communications satellites have been limited by low-gain antennas.

- Power

The amount of power available in an active satellite is limited by the weight restrictions imposed on the satellite. Early communications satellites were limited to a few hundred pounds because of launch-vehicle payload restraints. The only feasible power source is the inefficient solar cell. (Total power generation in the earlier satellites was less than 50 watts.) As you can see, the rf power output is severely limited; therefore, a relatively weak signal is transmitted by the satellite on the down link. The weak transmitted signal is often reduced by propagation losses. This results in a very weak signal being available at the earth terminals. The level of signals received from a satellite is comparable to the combination of external atmospheric noise and internal noise of standard receivers. Special techniques must be used to extract the desired information from the received signal. Large, high-gain antennas and special types of preamplifiers solve this problem but add complexity and size to the earth terminal. (The smallest terminal in the defense communication systems network has effectively an 18-foot antenna and weighs 19,500 pounds.) Development of more efficient power sources and relaxation of weight restrictions have permitted improved satellite performance and increased capacity.

- Receiver Sensitivity

Powerful transmitters with highly directional antennas are used at earth stations. Even with these large transmitters, a lot of signal loss occurs at the satellite. The satellite antenna receives only a small amount of the transmitted signal power. A relatively weak signal is received at the satellite receiver. This presents little problem as the strength of the signal received on the up link is not as critical as that received on the down link. The down-link signal is critical because the signal transmitted from the satellite is very low in power. Development of high-gain antennas and highly sensitive receivers have helped to solve the down-link problem.

- Availability

The availability of a satellite to act as a relay station between two earth terminals depends on the locations of the earth terminals and the orbit of the satellite. All satellites, except those in a synchronous orbit, will be in view of any given pair of earth stations only part of the time. The length of time that a nonsynchronous satellite in a circular orbit will be in the ZONE OF MUTUAL VISIBILITY (the satellite can be seen from both terminals) depends upon the height at which the satellite is circling. Elliptical orbits cause the satellite zone of mutual visibility between any two earth terminals to vary from orbit to orbit. These times of mutual visibility are predictable. Figure 2-7 illustrates the zone of mutual visibility.

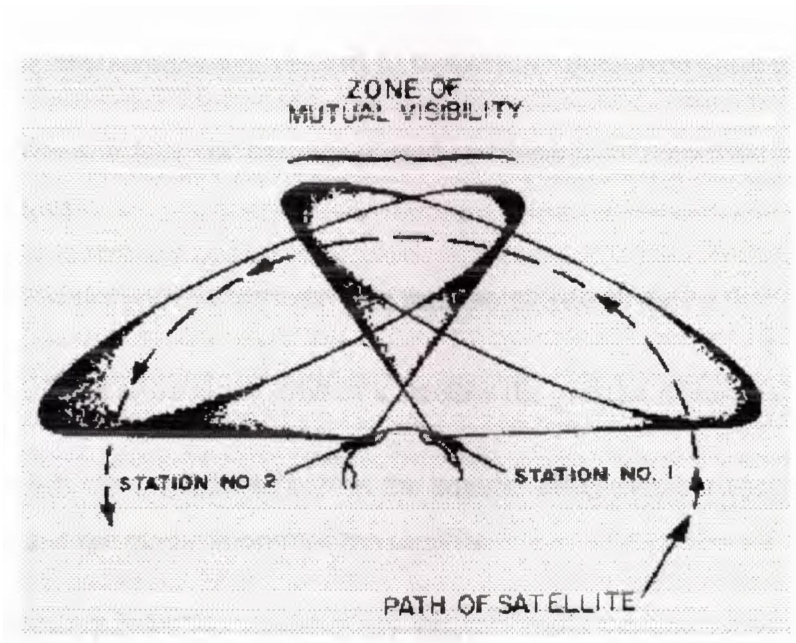


Figure 2.7. - Zone of mutual visibility.

FREQUENCY CONTROL. - The frequency of a radio signal received from a satellite is not generally the exact assigned down-link frequency. This variation depends upon the type of orbit of the satellite. The greatest frequency variations in signals from satellites occur in medium altitude circular or elliptical orbits. The smallest frequency variations occur in signals from satellites in near-synchronous or synchronous orbits.

- Tracking

When a particular satellite has been acquired, the earth terminal antenna will track that satellite for as long as it is used as a communications relay. Several methods of tracking are in actual use; however, we will explain PROGRAMMED TRACKING and AUTOMATIC TRACKING.

2.10 Summary

Now that you have completed this chapter, a short review of what you have learned will be helpful. The following review will refresh your memory of satellite communications, equipment, and theory.

The UP LINK is the frequency used to transmit a signal from earth to a satellite.

The DOWN LINK is the frequency used to transmit an amplified signal from the satellite back to earth.

PERIGEE is the point in the orbit of a satellite closest to the earth.

APOGEE is the point in the orbit of a satellite the greatest distance from the earth.

The ANGLE OF INCLINATION is the angular difference between the equatorial plane of the earth and the plane of orbit of the satellite.

INCLINED ORBITS are orbits where there is some amount of inclination. These include equatorial and polar orbits ..

A POLAR ORBIT is an orbit that has an angle of inclination of or near 90 degrees.

An ECLIPSE is when the satellite is not in view or in direct line of sight with the sun. This happens when the earth is between them.

An EPHEMERIS is a table showing the pre calculated position of a satellite at any given time.

SATELLITE-SUN CONJUNCTION is when the satellite and sun are close together and the noise from the sun prevents or hampers communications.

A SATELLITE ECLIPSE is an eclipse where the rays of the sun don't reach the satellite. This prevents recharging of the solar cells of the satellite and decreases the power to the transmitter.

The ZONE OF MUTUAL VISIBILITY is where the satellite can be seen by both the up- and down-link earth terminals.

CHAPTER THREE ,

ANALYSIS OF TCP/IP

3.1 Overview of TCP/IP

To understand the roles of the many components of the TCP/IP protocol family, it is useful to know what you can do over a TCP/IP network. Then, once the applications are understood, the protocols that make it possible are a little easier to comprehend. The following list is not exhaustive but mentions the primary user applications that TCP/IP provides.

3.2 TCP/IP History

The architecture of TCP/IP is often called the Internet architecture because TCP/IP and the Internet as so closely interwoven. In the last chapter, you saw how the Internet standards were developed by the Defense Advanced Research Projects Agency (DARPA) and eventually passed on to the Internet Society.

The Internet was originally proposed by the precursor of DARPA, called the Advanced Research Projects Agency (ARPA), as a method of testing the viability of packet-switching networks. (When ARPA's focus became military in nature, the name was changed.) During its tenure with the project, ARPA foresaw a network of leased lines connected by switching nodes. The network was called ARPANET, and the switching nodes were called Internet Message Processors, or IMPs.

3.3 The Sample Network

Here we have design a dedicated TCP/lP network. The sample network relies on several servers, although many networks have only one. Also, the several different types of servers to show you how they can be configured, where as most real networks are not this diverse. All the machines are connected over an Ethernet network. In all, the sample network has four servers and three clients.

Each of the seven machines on the network has its own name and IP address. For this sample network, the IP address mask has been randomly chosen as 147.120.

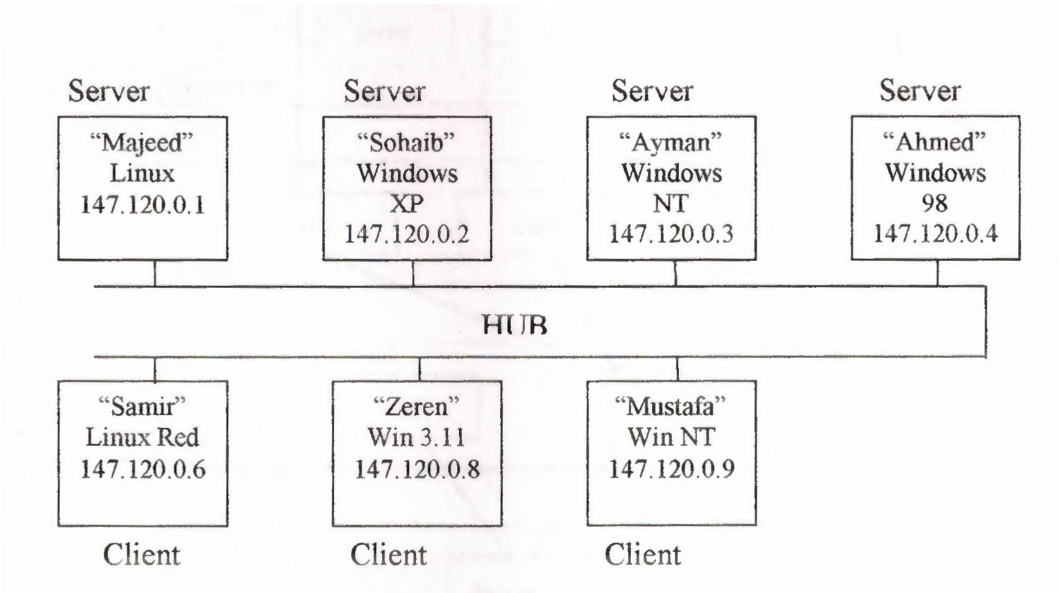


Figure 3.1 Sample TCP/IP Network

3.4 TCP/IP Protocols

This chapter discusses the protocols available in the TCP/IP protocol suite. The following figure shows how they correspond to the 5-layer TCP/IP Reference Model. This is not a perfect one-to-one correspondence; for instance, Internet Protocol (IP) uses the Address Resolution Protocol (ARP), but is shown here at the same layer in the stack.

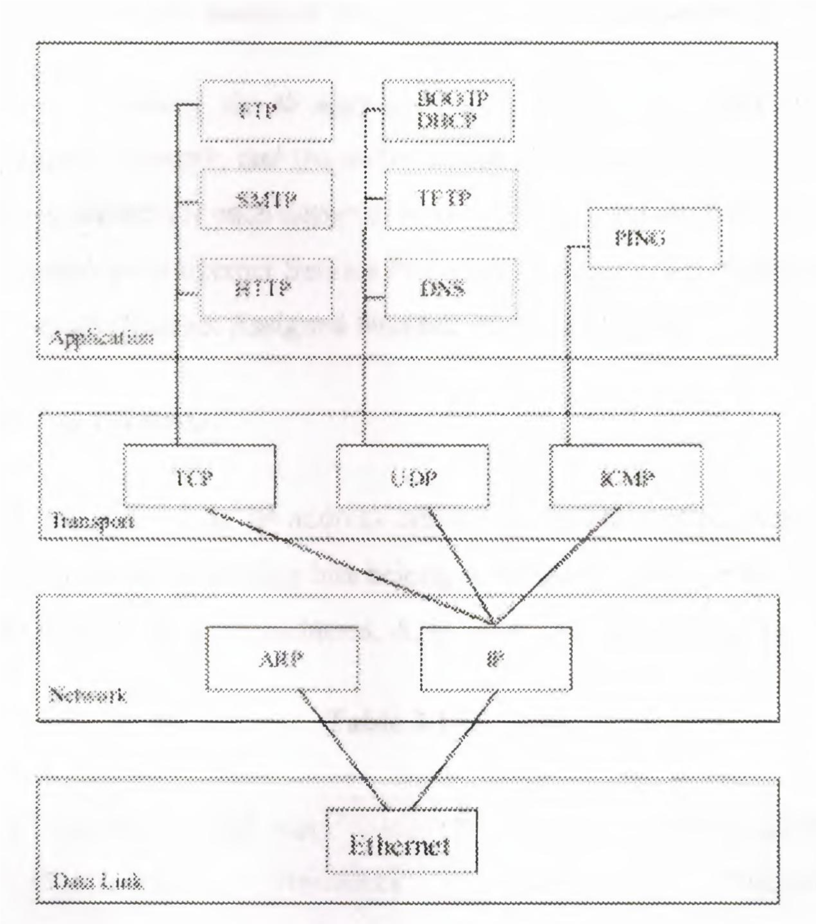


Figure 3.3. TCP/IP Protocol Flow

3.5 IP

IP provides communication between hosts on different kinds of networks (i.e., different data-link implementations such as Ethenet and Token Ring). It is a connectionless, unreliable packet delivery service. Connectionless means that there is no handshaking, each packet is independent of any other packet. It is unreliable because there is no guarantee that a packet gets delivered; higher-level protocols must deal with that.

3.5.1 IP Address

IP defines an addressing scheme that is independent of the underlying physical address (e.g, 48-bit MAC address). IP specifies a unique 32-bit number for each host on a network. This number is known as the Internet Protocol Address, the IP Address or the Internet Address. These terms are interchangeable. Each packet sent across the internet contains the IP address of the source of the packet and the JP address of its destination.

For routing efficiency, the JP address is considered in two parts: the prefix which identifies the physical network, and the suffix which identifies a computer on the network. A unique prefix is needed for each network in an internet. For the global lnternet, network numbers are obtained from Internet Service Providers (ISPs). ISPs coordinate with a central organization called the Internet Assigned Number Authority (IANA).

3.5.2 IP Address Classes

The first four bits of an IP address determine the class of the network. The class specifies how many of the remaining bits belong to the prefix (aka Network ID) and to the suffix (aka Host ID). The first three classes, A, Band C, are the primary network classes.

Table 3.1 IP Classes

Class	First 4 Bits	Number Of Prefix Bits	Max # Of Networks	Number Of Suffix Bits	Max # Of Hosts Per Network
A	0xxx	7	128	24	16,777,216
B	10xx	14	16,384	16	65,536
C	110x	21	2,097,152	8	256
D	1110	Multicast			
E	1111	Reserved for future use.			

When interacting with mere humans, software uses dotted decimal notation; each 8 bits is treated as an unsigned binary integer separated by periods. IP reserves host address 0 to denote a network. 140.211.0.0 denotes the network that was assigned the class B prefix 140.211.

3.5 .3 Net masks

Net masks are used to identify which part of the address is the Network ID and which part is the Host ID. This is done by a logical bitwise-AND of the IP address and the net mask. For class A networks the net mask is always 255.0.0.0; for class B networks it is 255.255.0.0 and for class C networks the net mask is 255.255.255.0.

3.5.4 Subnet Address

All hosts are required to support subnet addressing. While the IP address classes are the convention, IP addresses are typically sub netted to smaller address sets that do not match the class system. The suffix bits are divided into a subnet ID and a host ID. This makes sense for class A and B networks, since no one attaches as many hosts to these networks as is allowed. Whether to subnet and how many bits to use for the subnet ID is determined by the local network administrator of each network.

If sub netting is used, then the net mask will have to reflect this fact. On a class B network with sub netting, the net mask would not be 255.255.0.0. The bits of the Host ID that were used for the subnet would need to be set in the net mask.

Although the individual subscribers do not need to tabulate network numbers or provide explicit routing, it is convenient for most Class B networks to be internally managed as a much smaller and simpler version of the larger network organizations. It is common to subdivide the two bytes available for internal assignment into a one byte department number and a one byte workstation ID.

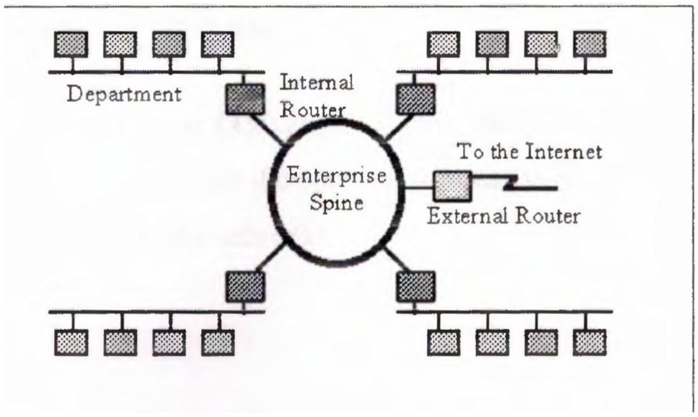


Figure 4-4 Subnet Address

The enterprise network is built using commercially available TCP/IP router boxes. Each router has small tables with 255 entries to translate the one byte department number into selection of a destination Ethernet connected to one of the routers. Messages to the PC Lube and Tune server (130.132.59.234) are sent through the national and New England regional networks based on the 130.132 part of the number. Arriving at Yale, the 59 department ID selects an Ethernet connector in the C& IS building. The 234 selects a particular workstation on that LAN. The Yale network must be updated as new Ethernets and departments are added, but it is not effected by changes outside the university or the movement of machines within the department.

3.5.5 Directed Broadcast Address

IP defines a directed broadcast address for each physical network as all ones in the host ID part of the address. The network ID and the subnet ID must be valid network and subnet values. When a packet is sent to a network's broadcast address, a single copy travels to the network, and then the packet is sent to every host on that network or subnetwork.

3.5 .6 Limited Broadcast Address

If the IP address is all ones (255.255.255.255), this is a limited broadcast address; the packet is addressed to all hosts on the current (sub) network. A router will not forward this type of broadcast to other (sub) networks.

3.6 IP Routing

Each IP datagram travels from its source to its destination by means of routers. All hosts and routers on an internet contain IP protocol software and use a routing table to determine where to send a packet next. The destination IP address in the IP header contains the ultimate destination of the IP datagram, but it might go through several other IP addresses (routers) before reaching that destination.

Routing table entries are created when TCP/IP initializes. The entries can be updated manually by a network administrator or automatically by employing a routing protocol such as Routing Information Protocol (RIP). Routing table entries provide needed information to each local host regarding how to communicate with remote networks and hosts.

When IP receives a packet from a higher-level protocol, like TCP or UDP, the routing table is searched for the route that is the closest match to the destination IP address. The most specific to the least specific route is in the following order:

- A route that matches the destination IP address (host route).
- A route that matches the network ID of the destination IP address (network route).
- The default route.

If a matching route is not found, IP discards the datagram.

IP provides several other services:

- Fragmentation: IP packets may be divided into smaller packets. This permits a large packet to travel across a network which only accepts smaller packets. IP fragments and reassembles packets transparent to the higher layers.
- Timeouts: Each IP packet has a Time To Live (TTL) field, that is decremented every time a packet moves through a router. If TTL reaches zero, the packet is discarded.
- Options: IP allows a packet's sender to set requirements on the path the packet takes through the network (source route); the route taken by a packet may be traced (record route) and packets may be labeled with security features.

3.7 ARP

The Address Resolution Protocol is used to translate virtual addresses to physical ones. The network hardware does not understand the software-maintained IP addresses. IP uses ARP to translate the 32-bit IP address to a physical address that matches the addressing scheme of the underlying hardware (for Ethernet, the 48-bit MAC address).

There are three general addressing strategies:

1. Table lookup
2. Translation performed by a mathematical function
3. Message exchange

TCP/IP can use any of the three. ARP employs the third strategy, message exchange. ARP defines a request and a response. A request message is placed in a hardware frame (e.g., an Ethernet frame), and broadcast to all computers on the network. Only the computer whose IP address matches the request sends a response.

3.8 The Transport Layer

There are two primary transport layer protocols: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). They provide end-to-end communication services for applications.

3.8.1 UDP

This is a minimal service over lP, adding only optional check summing of data and multiplexing by port number. UDP is often used by applications that need multicast or broadcast delivery, services not offered by TCP. Like IP, UDP is connectionless and works with datagram's.

3.8.2 TCP

TCP is a connection-oriented transport service; it provides end-to-end reliability, resequencing, and flow control. TCP enables two hosts to establish a connection and exchange streams of data, which are treated in bytes. The delivery of data in the proper order is guaranteed.

TCP can detect errors or lost data and can trigger retransmission until the data is received, complete and without errors.

3.8.2 ..1 TCP Connection/Socket

A TCP connection is done with a 3-way handshake between a client and a server. The following is a simplified explanation ofthis process.

- The client asks for a connection by sending a TCP segment with the SYN control bit set.
- The server responds with its own SYN segment that includes identifying information that was sent by the client in the initial SYN segment.

- The client acknowledges the server's SYN segment.

The connection is then established and is uniquely identified by a 4-tuple called a socket or socket pair:

(Destination IP address, destination port number)(Source IP address, source port number)

During the connection setup phase, these values are entered in a table and saved for the duration of the connection.

3.8.2.2 TCP Header

Every TCP segment has a header. The header comprises all necessary information for reliable, complete delivery of data. Among other things, such as IP addresses, the header contains the following fields:

Sequence Number - This 32-bit number contains either the sequence number of the first byte of data in this particular segment or the Initial Sequence Number (ISN) that identifies the first byte of data that will be sent for this particular connection.

The lSN is sent during the connection setup phase by setting the SYN control bit. An ISN is chosen by both client and server. The first byte of data sent by either side will be identified by the sequence number ISN + 1 because the SYN control bit consumes a sequence number. The following figure illustrates the three-way handshake.

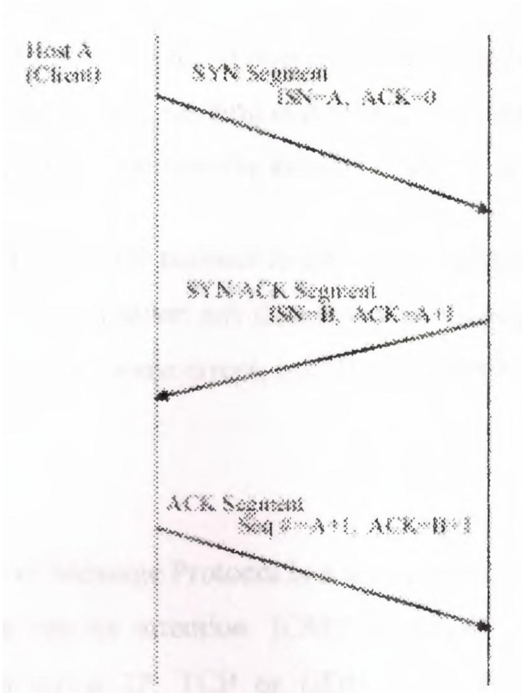


Figure 4-5. Synchronizing Sequence Numbers for TCP Connection

The sequence number is used to ensure the data is reassembled in the proper order before being passed to an application protocol.

Acknowledgement Number - This 32-bit number is the other host's sequence number + 1 of the last successfully received byte of data. It is the sequence number of the next expected byte of data. This field is only valid when the ACK control bit is set. Since sending an ACK costs nothing, (because it and the Acknowledgement Number field are part of the header) the ACK control bit is always set after a connection has been established.

The Acknowledgement Number ensures that the TCP segment arrived at its destination.

Control Bits - This ô-bit field comprises the following I-bit flags (left to right):

- URG - Makes the Urgent Pointer field significant.
- ACK - Makes the Acknowledgement Number field significant.
- PSH - The Push Function causes TCP to promptly deliver data.
- RST - Reset the connection.
- SYN - Synchronize sequence numbers.

Window Sizes - this 1ô-bit number state how much data the receiving end of the TCP connection will allow. The sending end of the TCP connection must stop and wait for an acknowledgement after it has sent the amount of data allowed.

Checksum - This 16-bit number is the one's complement of the one's complement sum of all bytes in the TCP header, any data that is in the segment and part of the IP packet. A checksum can only detect some errors, not all, and cannot correct any.

3.8.3 ICMP

Internet Control Message Protocol is a set of messages that communicate errors and other conditions that require attention. ICMP messages, delivered in IP datagrams, are usually acted on by either lP, TCP or UDP. Some lCMP messages are returned to application protocols.

A common use of ICMP is "pinging" a host. The Ping command (Packet INtemet Groper) is a utility that determines whether a specific IP address is accessible. It sends an ICMP echo request and waits for a reply. Ping can be used to transmit a series of packets to measure average round-trip times and packet loss percentages.

3.9 The Application Layer

There are many applications available in the TCP/IP suite of protocols. Some of the most useful ones are for sending mail (SMTP), transferring files (FTP), and displaying web pages (HTTP). These applications are discussed in detail in the TCP/IP User's Manual.

Another impoıtant application layer protocol is the Domain Name System (DNS). Domain names are significant because they guide users to where they want to go on the Internet.

- DNS

,

The Domain Name System is a distributed database of domain name and IP address bindings. A domain name is simply an alphanumeric character string separated into segments by periods. It represents a specific and unique place in the "domain name space." DNS makes it possible for us to use identifiers such as zworld.com to refer to an IP address on the Internet. Name servers contain information on some segment of the DNS and make that information available to clients who are called revolvers.

'3.10 Summary

The TCP/IP protocol was developed by the people who actually use it from day to day. This is usually the best way of doing things when it comes to computers and the internet. Any minority who try to govern and control the internet will most likely fail. This was the case with the OSI reference model. The ISO who developed it assumed that they know what's best because they have experience in developing standards for things. This was not the case with OSI, it was almost successful but it didn't quite make it main stream. This is because the people who use the internet will always end up making the choice when it comes to computing standards. It could be a standard from a small company or from a large company like Microsoft who developed the successful DirectX.

I have come to the conclusion that the TCP/IP was the best protocol for the job. The simple reason for this is that the people who developed it were committed to their task and were not going to give up till they were successful. Another factor is that they had the public backing and the public are the ones that will end up using it.

CHAPTER FOUR

NETWORK OPERATION CENTER (NOCs)

4.1 Introduction to Networking

A basic understanding of sat networks is requisite in order to understand the principles of network security. In this section, we'll cover some of the foundations of sat networking, then move on to an overview of some popular networks. Following that, we'll take a more in-depth look at TCP/IP, the network protocol suite that is used to run the Internet and many intranets.

Once we've covered this, we'll go back and discuss some of the threats that managers and administrators of computer networks need to confront, and then some tools that can be used to reduce the exposure to the risks of network computing.

- What is Network?

A " network" any set of interlinking lines resembling a net, a network of roads ‖ an interconnected system, a network of alliances." This definition suits our purpose well: a computer network is simply a system of interconnected computers. How they're connected is irrelevant, and as we'll soon see, there are a number of ways to do this.

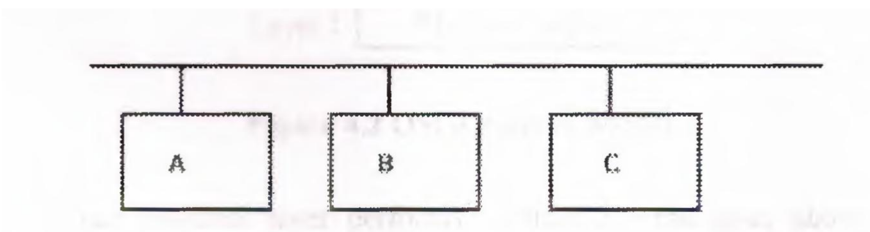


Figure 4.1: A Simple Local Area Networ

4.2 Open Systems Interconnection Reference Model (OSI/ISO)

The open systems interconnection (OSI) reference model is the basis of commercially available network service architectures. Other network protocols developed independently conform loosely to the model. The transport control protocol/interface program (TCP/IP) is an example. For more information on TCP/IP.

The OSI reference model is a convenient framework for networking concepts. Basically, data are added to a network by a sender. The data are transmitted along a communication connection and are delivered to a receiver. To do this, a variety of networking hardware and software must work together.
Industry standards have been or are being defined for each layer of the reference model. Two standards are defined for each layer: one specifies the interface to the services provided by the layer, and the other specifies the protocol observed by the services in the layer. Users of a service interface standard should be able to ignore the protocol and any other implementation details of the layer.
The OSI reference model divides networking functions into seven layers, as shown in Figure 4.2..

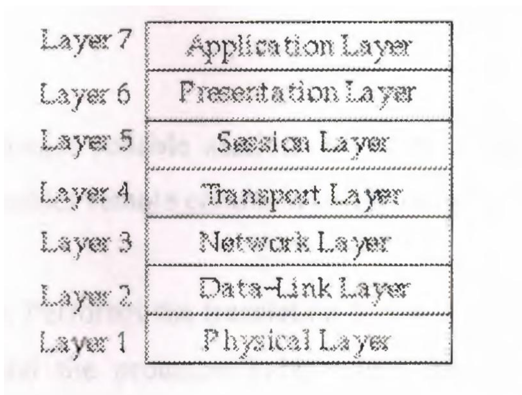


Figure 4.2 OSI Reference Model

Each protocol layer performs services for the layer above it. The ISO definition of the protocol layers provides designers some freedom of implementation. For example, some applications skip the presentation and session layers to interface directly with the transport layer.

- Layer 1:

Physical Layer: The hardware layer of the model. It specifies the physical connections between hosts and networks, and the procedures used to transfer packets ~ hPtwPPn mı:H·.hinpc;:

- Layer 2:

Data-Link Layer: manages the delivery of data across the physical network. It describes how the internet protocol (IP) should use existing data link protocols, such as Ethernet/802.

- Layer 3:

Network Layer: This layer is responsible for machine-to machine communications. It determines the path a transmission must take, based upon the receiving machine's IP address. Besides message routing, it also translates from logical to physical addresses.

- Layer 4:

Transport Layer: Controls the flow of data on the network and assures that received and transmitted data are identical. TLI, TCP/LP, or the user datagram protocol (UDP) may be used to enable communications between application programs running on separate machines.

- Layer 5:

Session Layer: Manages reliable sessions between cooperating applications. The interface at this layer enables remote communication using function call semantics.

- Layer 6:

Presentation Layer: Performs the translation between the data representation local to the computer and the processor-independent format that is sent across the network.

- Layer 7:

Application Layer: At this top layer are the user-level programs and network services. Some examples are telnet, ftp, tftp, and the domain name service (DNS).

4.3 Satellite via Internet Connection Network

Multi-computer families are a growing trend. People upgrade to new computers because the 'old' one isn't powerful enough to run the latest applications in video editing, photo editing or games. The older computer still works fine for the kids' homework, school reports and browsing so it is kept along with the new one. The availability of broadband internet connections is also increasing as are the number of households with broadband. These two trends have, in turn driven the growth of a third trend - the home network. A home network allows the broadband connection to be shared by all the networked computers, eliminating much of the conflict over who gets to use the Internet. Formerly the network was only found in businesses but many companies that manufacture the hardware elements of a network recognized the trend toward home networks early and began marketing their products to the home consumer. A trip to your local computer store will reveal a dazzling array of products for a home network that can be overwhelming. Among the most common questions asked in the DSLR Satellite foıum concern sharing the satellite connection. Frequently new owners have been offered conflicting or erroneous information by the companies or dealers that sell the service regarding whether the Satellite connection can be shared.

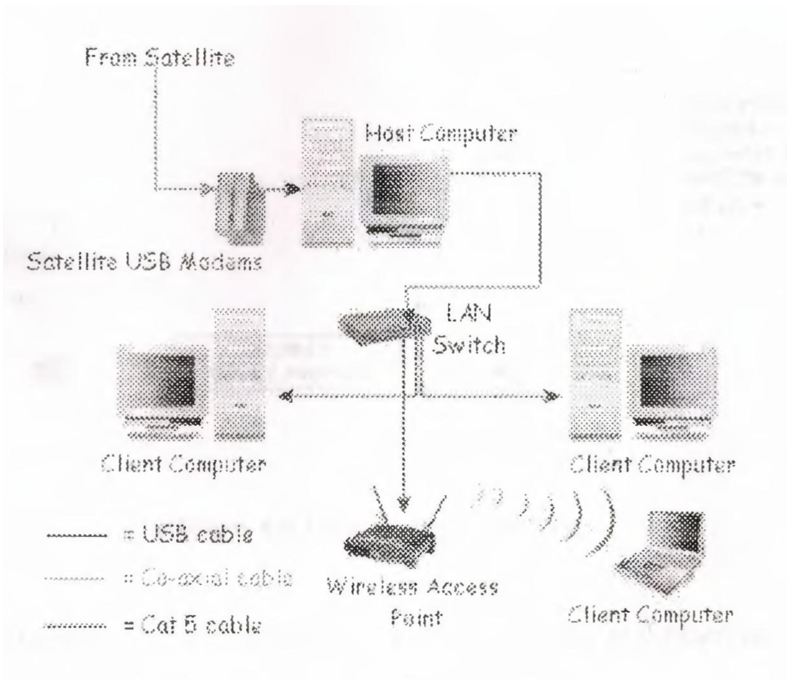


Figure 4.3 Internets via Satellite

If they then go to a computer store and ask about sharing their broadband connection they are very likely to be given further erroneous information by the store personnel who are unaware of the particular requirements of this connection. Forum members decided to develop this document to assist the new Satellite Internet user to:

1. Establish a working home network
2. Share their Satellite Internet connection

This document is designed to assist the computer user who has never even opened their computer's case to get a network up and running and to share their satellite connection.

4.3.1 Uplink via Telephone Line (One-Way Connection)

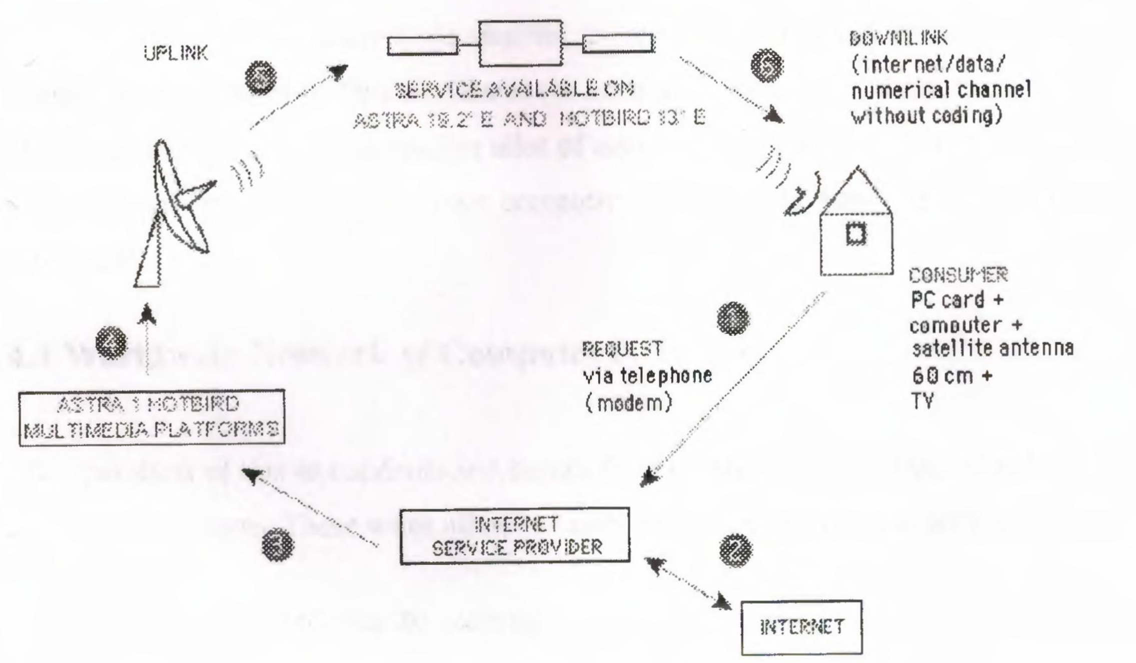


Figure 4.4 One-Way Connection

Data is sent via a telephone line to the internet service provider and received via a satellite.

4.3.2 Uplink and Downlink via Satellite (Two Way connection)

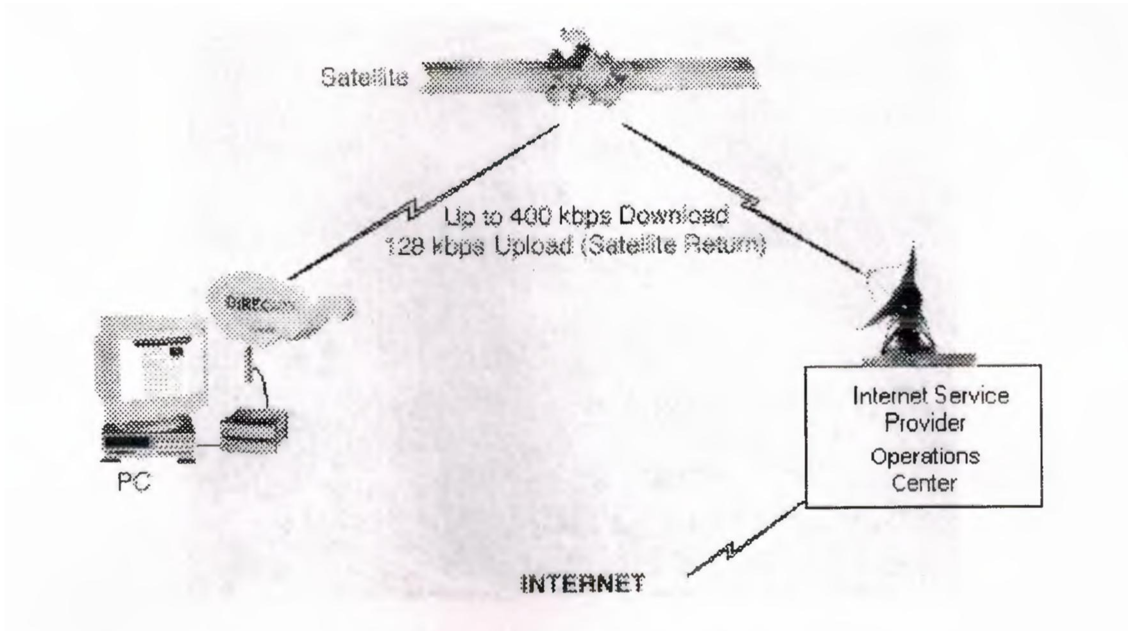


Figure 4.5 Two Way connection

Unlike one-way internet via satellite, 2-way offers download and upload capabilities straight through the dish. This eliminates the need for a phone line, the achievability heal of other systems. If you send or receive allot of data on a regular basis, this solution will save you hours of time. Freeing up your computer and allowing you to use your time more efficiently.

4.4 Worldwide Network of Computer Networks

You can think of this as hundreds and hundreds of computers connected around the world with plain-old wires. These wires allow the computers to communicate with each other.

- Networks started over 20 years ago....

As the technology progressed more reliable networks were created. Local Area Networks (LANs) connect computers together.

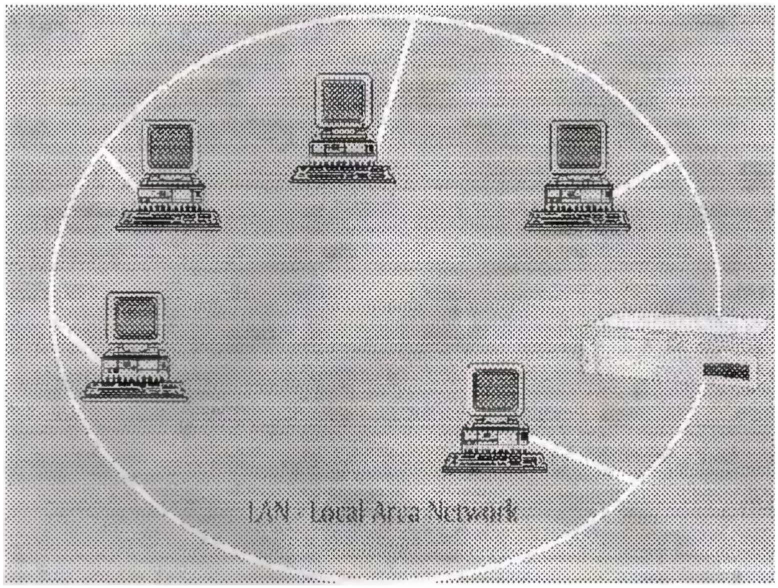


Figure 4.6 Local Area Network

LANs can connect to each other to form larger networks called Wide Area Networks (WAN) which span large geographic areas.

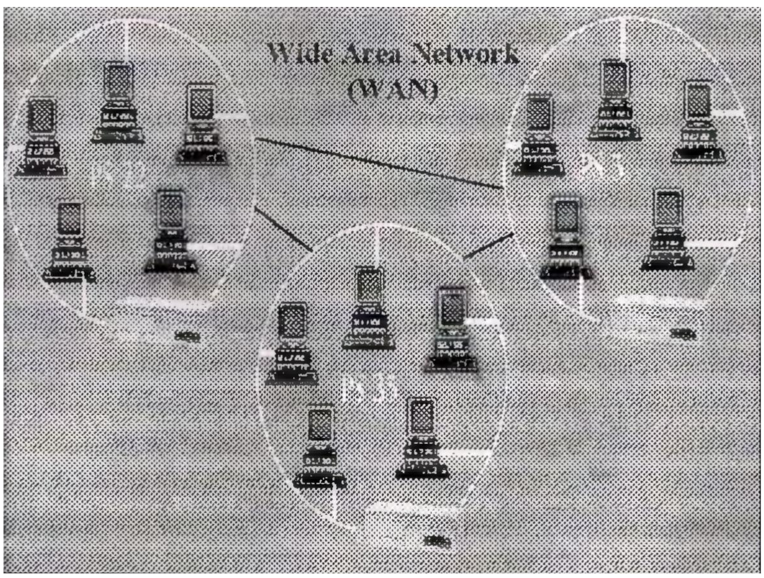


Figure 4.7 Wide Area Network

Local Area Networks and Wide Area Networks became so powerful that more and more of them began to connect to each other. Over the last 10 years, hundreds of thousands of these networks have connected up around the world to form the Internet.

A common language (TCP/IP) was introduced for communicating between computers.

- Over 6.6 million host computers (60 million users) currently connected to the Internet.
- By October 1999, host computers estimated to reach 105 million. This will result in around 1 billion users world wide.

In order to retrieve information from any of the millions of computers connected to this world wide network all you need is the Internet address for that computer. On the World Wide Web (WWW) this is called a URL (Uniform Resource Locator). For example, to retrieve the WWW site for the Stevens NJNIE web site,

4.5 Network security

Network security is a complicated subject, historically only tackled by well-trained and experienced experts. However, as more and more people become "wired", an increasing number of people need to understand the basics of security in a networked world. This document was written with the basic computer user and information systems manager in mind, explaining the concepts needed to read through the hype in the marketplace and understand risks and how to deal with them.

Some history of networking is included, as well as an introduction to TCP/IP and internetworking. We go on to consider risk management, network threats, firewalls, and more special-purpose secure networking devices.

This is not intended to be a " frequently asked questions" reference, nor is it a " hands-on" document describing how to accomplish specific functionality.

It is hoped that the reader will have a wider perspective on security in general, and better understand how to reduce and manage risk personally, at home, and in the workplace.

4.6 Network Operations Center (NOCs)

Each of the Network Operation Centers (NOC) features high level security, raised flooring, climate-control, UPS power supply, fire suppression system as well as multiple redundant connections to major backbones such as UUNET, Level3, Genuity, Sprint and Verizon. Each NOC is also equipped with backup batteries and diesel generators, Cisco routers and switches; and is staffed 24x7 by qualified system administrators and engineers. All servers are secured in a state of the art Smart POP; monitored by both on hand technicians, IP cameras and door security via Hand geometry reader; OC3C connections are physically diverse and Sonet protected; dual power feeds backed up with UPS, Rectifiers, Batteries and Generator to ensure our customers have near zero down time.

All movement 24 hours a day to further secure and protect the equipment.

4.7 Network Operation Center Features

- Environment

  Precision-controlled air conditioning systems protect and cool mission-critical servers and equipment in the Network Operations Center. The facility is controlled by YorkTM quad-compresser / dual-blower redundant systems. These systems provide a virtually dust-free and particle-free computing environment, with temperature, humidity, and air-quality regulation.
- Security

  Restricted access to the Network Operations Center is monitored by qualified personnel 24 hours a day, every day. Visitors and clientele are only allowed on-site if escorted by Network Operations Center staff. The entire Network Operations Center is monitored, ensuring prompt response and thorough coverage to fire or security alarms. All Network Operations Center customers are supplied with advanced firewall, encryption, intusion detection and other security measures. The premises are protected by a full digital video surveillance system of the Network Operations Center, with full on-site and off-site recording.

- Failsafe Power Supply

The Network Operations Center currently has 800amps 480v (3200amps 110v) 3-Phase power. The facility is backed up and protected by UPS (Uninterruptible Power Supply) systems on each individual rack, as well as an APC Silcom™ 500KVA system for facility-wide enterprise coverage. In a very rare case of utility outage, the Cummins™ 250KW deisel generator staıts automatically, taking over for the UPS systems and supplying all necessary power for the facility. The generator inteıfaces to the power grid thıu a Cutler-Hammer™ automatic transfer panel. The generator is powered by a 500 gallon fuel tank, capable of running without refueling for approximately 80 hours.

- 24x7x365 Monitoring

The Network Operations Center uses industry-standard SNMP (Simple Network Management Protocol) and provides round-the-clock monitoring of all hardware, including routers, switches, 'UPS systems, and servers. The Network Operations Center also monitors power, environmental factors (such as temperature and humidity), generator status, and network connectivity. All critical services/ports are monitored, including FTP, HTTP, SMTP, HTTPS, SSH, TELNET, and POP3. Also provided is network monitoring of the Local Area Network, Internet connectivity (all routers, switches, and wiring), and the Internet backbone via :MR.TG. Close and constant communication with upstream backbone providers ensures that our customers have constant access to high-performance Internet connections. Failure on any monitoring service results in audible alarms, LAN messages, and alerting through a staff paging system. We also offers remote cold boot hardware for dedicated server and co-location clients, with private, password protected, web based access.

- Hardware

  The Network Operations Center utilizes ONLY top name brand hardware. The facility is centered on a Cisco'>' GSR 12008 Border Router w/Hot Swap, with Cisco™ 7200VXR Series Routers serving as core routers, connecting via Gigabit Ethernet to the Hewlett Packard™ Procurve™ 4108GL primary switches. Hewlett Packard™ Procurve™ managed switches comprise the power and stability of the network, operating at 1OOmbps switched Ethernet speeds. Hardware utilized in the facility is comprised of the following brands: Intel™, Asus™, Abit™, AMD™, 3ComTM, Hewlett Packard™, Adaptec™, Cisco™, Tekram™, Kingston™, Micron™, Crucia1n1, IBM™, Maxtor™, Western-Digital™, Seagate™, Quantum'», FujitsuTM, DatatelTM, Belk inTM, & Lucent''>'. APCTM, Tripp-LiteTM, Compaq'?", & Power wareTM UPS Systems provide the power backups, along with a Cummins™ generator system. Facility monitoring is provided by a Panasonicw \VD-500 Digital Video System over Sony™ CCTV cameras.

- Software

  The Network Operations Center utilizes the Linux operating system on all Edmunds Enterprises' servers. Linux is a highly configurable system, and well known for speed and stability. Linux servers have been documented to remain operating for up to one year at a time without even requiring a reboot. The Apache™ Web Server nicely compliments the Linux Operating System. All servers are directly supported by the knowledgeable and dedicated staff of Edmunds Enterprises which has established a long reputation for Linux expertise and customer service. Servers are continually enhanced with the latest version of popular applications and development tools as well as security updates.

4,8 What Type of Network - Hardware Decisions

In order to share an Internet connection, you must first establish a network (LAN) and get your computers 'talking' to each other. The first decision you will be required to make is what kind of network will work for your situation. There are several types to choose from, each with their own strengths and weaknesses. You'll need to make this decision before you purchase anything.

- The Wired or 10/100 Ethernet Network also known as "Fast Ethernet" to distinguish it from the older lOBaseT Ethernet (which will also work fine.) This network requires cable to connect all elements of the network. Advantage: Secure, reliable and has the fastest file transfer and is relatively inexpensive. Disadvantage: wires. If the computers are some distance apart you'll either have wires strung through the house or you have to figure out how to fish wires through the walls, attic, basement or crawl space.
- The Wireless Network also known as Wi-Fi or 802.11b. This relies on radio signals broadcast from an Access Point to reach the networked computers. Advantage: No or few wires. Disadvantage: Slower file transfer rate, works best with a clear line of sight between the Access Point and the computers receiving the signal. Distance and objects blocking the signal will reduce the speed of the network. Recently new WiFi5, (802.1 la) equipment has come out that allows substantially faster file transfer speeds. Be careful what you purchase as 802.1 la does not talk to 802.1 lb.
- Phone Line Network also known as HomePNA.

Advantage: makes use of existing phone wires and jacks to carry the network communications.

Disadvantage: You have to have phone jacks located where your computers are located or you have to add them and wire them. Slower than the 10/100 Ethernet but about the same speed as the current Wireless networks speeds.

- Power Line Networking

This relies on existing electrical wiring in the home to carry the network data. Advantage: No new wires - while not every room in the home will have a phone jack, all will have electrical outlets. Also, by necessity, computers will be located near electrical outlets. It doesn't require a card to be installed in the computer. Disadvantage: Slower than

Fast Ethernet for file transfer. There are competing standards. It can be very slow using the older technology. It uses large wall devices to access an electrical outlet

Recent advances may have ironed out some of the disadvantages that this type of network had so this may merit a second look.

- Network Architecture

Our network consists of three major segments: the ground network in California, the satellite link across the Pacific Ocean, and the ground network in Hawaii.

The ground network in California connects Caltech with)PL, the site of the ACTS ground station. This segment was established as part of Pacific Bell's extant CalREN fiber optic network and has proved to be the most reliable portion of our network.

The satellite connection was made available to us through a grant from NASA as part of the Gigabit Satellite Network (GSN) testbed program. NASA's Advanced Communications Technology Satellite (ACTS) was built to explore new modes of high speed data transmission at rates up to OC-12 (622 Mbit/sec). The 20-30 GHz frequency band has been employed for the first time by a communications satellite, with extensive rain fade compensation.

The ground network in Hawaii, which connects Keck observatory with the other ACTS ground station at Tripler Army Medical Center in Honolulu has been somewhat more complex in its evolution. This was primarily due to the relative inexperience of GTE Hawaiian Telephone and a lack of prior infrastructure in Hawaii. This segment initially consisted of a combination of underwater fiber, microwave antennae, and buried fiber. The higher bit error rates (BER) of the non-fiber segment produced noticeable instability in the end-to-end network. Fortunately, in January of 1997 this poıtion of the ground network in Hawaii was upgraded to optical fiber. The improved performance for high-speed data transfers of the final all-fiber network was immediately apparent.

In order to support standard higher-level (IP) networking protocols, we installed an Asynchronous Transfer Mode (ATM) network over this infrastructure. The transfer of 53-byte ATM cells is performed by hardware switches throughout the network, at speeds of

OC-1 (51 Mbit/sec) and above. Several vendors have supplied the ATM switches and Network Interface Cards (NICs), providing a stringent test of compatibility in the relatively new ATM environment. Although we have encountered several interoperability problems, none have been serious, and the ATM and telephone vendors have been extremely helpful.

In order to facilitate reliable data transfer, as well as to allow the use of the wealth of software tools already available, we are running the standard IP protocols over ATM using a pseudo-standard implementation known as " Classical IP". This enables the use of the standard network-based applications that are in widespread use on the Internet. Tools such as ftp and telnet are part of every observing ıun, as are additional special-purpose applications, such as an audio conferencing tool (rat) and a shared whiteboard tool (wb).

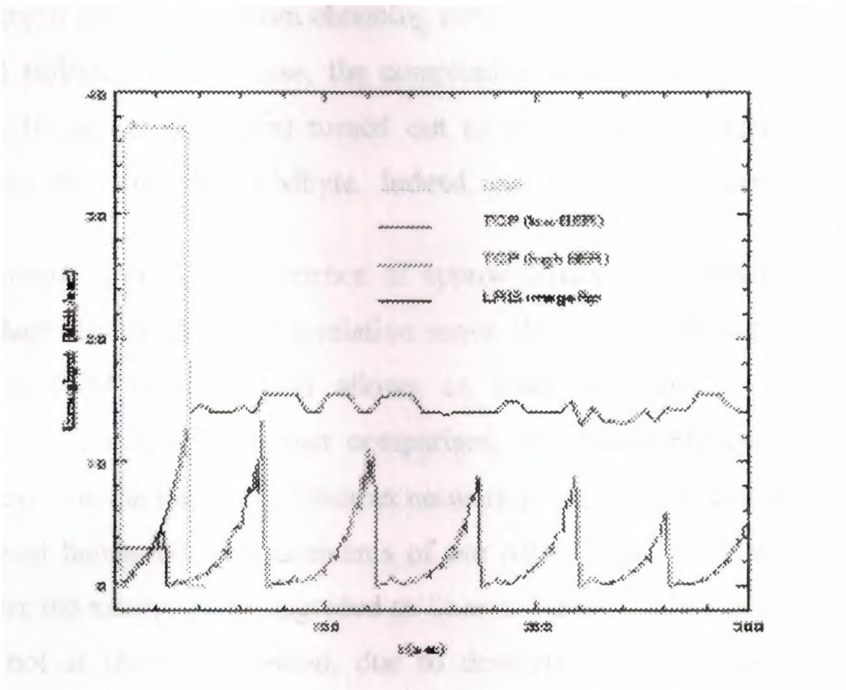


Figure 4.8 Bandwidth test results between Keck Observatory and the Caltech campus in Pasadena, California, over the ACTS satellite network. TCP exhibits a remarkable dependence on the bit error rate.

- Network Performance

The most important impact of a satellite component on a high-speed network is the relatively large delay introduced by the round-trip signal travel time to the satellite. In our network, this travel time is approximately 0.55 seconds, which corresponds to 3.5 Mbytes of data at OC-1 speeds (51 Mbit/sec). The problem has to do with the connection-oriented nature of TCP/IP: TCP sends a very specific amount of data, known as a "window", after which time it expects an acknowledgment from the other end of the connection. However, this window size is often very small; the default value for workstations running the SunOS operating system is only 4 Kbytes.

Fortunately, this problem is well-known in the high-speed networking community. Networks such as ours are known as "long fat networks" (LFN; see RFC 1323). In the case of the SunOS operating system (to which we are constrained by legacy control software at Keck), we obtained the TCP-LFN package from Sun Consulting, which purpoıts to suppoıt the RFC 1323 extensions. Unfortunately, a number of limitations of SunOS conspire to prohibit one from obtaining extremely large window sizes, regardless of the TCP-LFN software. ln our case, the compiled-in kernel limit of 2 Mbytes of Mbuf memory (i.e., IP packet wrappers) turned out to be the major constraint, limiting our window size to no more than 1 Mbyte. Indeed, our final tuned network delivered the expected maximum TCP/IP performance of approximately 15 Mbit/sec ([illegible] of OC-1). Although perhaps disappointing in a relative sense, this bandwidth is far in excess of Tl Ethernet speed (1.44 Mbit/sec) and allows an 8 Mbyte image to be transferred in approximately 5 seconds. As a further comparison, this bandwidth exceeds by 50% that which is available on the local area Ethernet network at the Keck Telescope itself. Figure 2 illustrates typical bandwidth measurements of our network for UDP and TCP, the latter before and after the network was upgraded to fiber in Hawaii. While network performance was perhaps not at the level desired, due to developing infrastructure in Hawaii and idiosyncrasies within the operating system, issues of network reliability had far greater impact on our remote observing operation. The experimental and limited nature of the ACTS program created a number of difficulties which one would almost certainly not face if using a more developed and/or commercial satellite system. The impact of the reliability issue is that at least one observer must be sent to Hawaii to use the telescope, in case of ACTS-related problems.

- Conclusions

This experiment has explored the data requirements of remote observing with a modern research telescope and large-format detector arrays. While the maximum data rates are lower than those required for many other applications (e.g., HDTV), the network reliability and data integrity requirements are critical. The former issue in particular may be the greatest challenge for satellite networks for this class of application. We have also experimented with the portability of standard TCP/IP applications to satellite networks, demonstrating the need for alternative TCP congestion algorithms and minimization of bit error rates.

Reliability issues asi we have demonstrated that true remote observing over high-speed networks provides several important advantages over standard observing paradigms. Technical advantages include more rapid download of data and the opportunity for alternative communication facilities, such as audio- and videoconferencing. Scientific benefits include involving more members of observing teams while decreasing expenses, enhancing real-time data analysis of ,m~n. ations by persons not subject to altitude-related conditions, and providing facilities, expertise, and personnel not normally available at the observing site.

Due to the limited scope of the ACTS project, future work from the standpoint of Keck Observatory will be concerned with establishing a more permanent remote observing facility via a ground-based network. At least two projects are under way in this direction: remote observing from the Keck Headquarters in Waimea, from where up to 75% of observing is now performed every month, and remote observing from multiple sites on the U.S. mainland using a slower T1 ceanection (Conrad et al. 1997, SPIE Proc. 3112). Trial tests of this latter approach over the ln!ı≥nıPr have been extremely promising

4.9 Summary

The "Internet Saten:!e Project ill develop and deploy advanced Internet services and technologies over satellite intn.~mrr,ıre for purposes of enhancing research, instruction and learning in a diverse set of institutions of higher education.

Conclusion

The "Internet Satellite Project" will develop and deploy advanced Internet services and technologies over satellite infrastructure for purposes of enhancing research, instruction and learning in a diverse set of institutions of higher education.

I have come to the conclusion that the TCP/IP was the best protocol for the job. The simple reason for this is that the people who developed it were committed to their task and were not going to give up till they were successful. Another factor is that they had the public backing and the public are the ones that will end up using it.

Digital Satellite Communication one of the most rapidly emerging and developing technologies in the world today. We have seen a surprisingly huge interest from different research organizations and companies in this field and much has been contributed to this field in the past two decades. This term paper provides the TCP/IP with the topics and issues in Network Operation Center. We have been using Satellite since 1957. That satellite, called Sputnik however Communications via satellite is a natural outgrowth of modern technology and of the continuing demand for greater capacity and higher quality in communications.

GLOSSARY OF TERMS

A

Address
A label associated with a quantity of data that indicates to where it should be sent.

Aloha
The basis of the access technique used for TOMA systems.

AOR
Atlantic Ocean Region. A group of orbital positions for satellite serving Europe, Africa and the Americas.

.Apogee
The point in a satellite's orbit at which it is furthest from the Earth.

B

Bandwidth
The range of frequencies over which a system operates or is capable of operating.

Baseband
The information signal, prior to modulation onto a carrier frequency.

Beamwidth
The angle at which radiation spreads out from an antenna as it propagates. The power from the signal smoothly tapers at the edges of the beam, for beam width calculations the points where the radiation is at half its peak value, or its peak value -3dB is taken as the edge of the beam of radiation.

itrate
The number of bits a system conveys each second in bits per second (bps).

roadcas
A transmission sent to a number of receives simultaneously.

D

Digital
A system of representing information as a series of distinct values that are suitable for representation as integer numbers.

G

Gain
A measure of how much larger an amplifiermakes a signal.

Gateway
A, typically large, Earthstation used to provide access to a satellite link where it is not appropriate to provide a terminal on the customer's premises (Sole User Terminal, or VSAT)

Geostationary, Geosynchronous
Refers to a satellite in the Clarke Orbit

Gigahertz (GHz)
1000000000 cycles per second

H

Hertz(Hz)
Unit of frequency, lHz = one cycle per second.

HPA
High Power Amplifier. The final stage of amplification before uplinking a signal to the satellite.

I

IBS
INTELSAT Business Services, a tariff for satellite capacity based on standard terminals.

IDPS
Instrument Data Processing System

INMARSAT
International Maritime Satellite Organisation

INTELSAT
International Telecommunications Satellite Organisation

Internetworking
The process of connecting networks together. The largest example of this is the Internet.

IOR
Indian Ocean Region, a group of orbital positions for satellite serving Europe, Africa and Asia

Interference
Another form of noise, this time generated by other transmitters

IP address
The Address of a host on the internet or a private IP network

IP subnet
A collection of IP hosts directly connected with one-another and sharing the same initial digits in their IP addresses.

IRO
Integrated Receiver Decoder; the i r device translates signals from the satellite to be suitable for presentation to a TV

ISDN
tntegrated Services Digital Network a ;,~!:;lie. circuits switched data network based on n x 64kbit/s connections

Isotropic antenna
Hypothetical omni-directional antenna a reference for calculating the gain of real antennas

ISP
Internet Service Provider, provides an access point to the Internet

T
J

JPL
Jet Propulsion Laboratory

k

Ka-band
The frequency range from 18-31GHz

kbitls
1000 bits per second

kHz
1000 Hz

Ku-band
The frequency range from 11 GHz to 17GHz

L

L
local Area Network

L-Band
The frequency range 0.5GHz to 1.5GHz

Leased Line
A private circuit for data communications.

LEO
Low Earth orbit Satellite

M

Mbit/s
1000000 bits per second

MEO
Medium Earth Orbit

MHz
1000000 cycles per second

Microwave
An electromagnetic signal with a wavelength measured in mm.

Modem
MOdulator-DEModulator; used to modify a carrier such that it represents the data to be sent and recovers that data when receiving.

Modulation
The process of converting data into a form suitable for transmission by using it to modify some characteristic of a carrier.

MUX
Multiplexor

N

NASA

National Aeronautics and Space Administration

O

Online
Data that is available on demand, though not instantaneously.

Orbital period
The time to complete one orbit, 24 hours for a geostationary system.

Orbital slot
The longitude of a geostationary satellite.

R

Receiver
Device that converts the signal from the satellite into a form suitable to be sent to the modem for de-modulation.

Router
A device to connect IP and other subnets

S

SAR

Synthetic Aperture Radar

SASS

Sea sat Satellite Scatter meter

STDN

Spaceflight Tracking Data Network

Satellite
Any object in orbit around another. In the context of communications, a geostationary satellite is an artificial satellite carrying a communications payload (amplifiers, frequency translators, etc.) and acting as a radio relay station to facilitate communications between two points on the Earth's surface.

Spin Stabilisation
A system to stabilise the satellite by rotating its body

Star network
A network where all communication is between a central site and several remote stations. The central site installation is usually large and specialist to give cost savings in the remote site equipment.

Synchronous transmission
A system where all timing is derived from a single clock source.

T

TCP/IP
Transmission Control Protocol / Internet Protocol; a protocol used in the Internet to

provide reliable communications over potentially unreliable links.

TDM/TDMA
Time Division Multiple: x / Time Division Multiple Access; a system commonly used in large star topology networks.

TDMA
Time Division Multiple Access: A method by which a number of sites can share a single carrier frequency by transmitting at different times. As the sites do not always co-ordinate their transmissions sometimes two or more sites will transmit simultaneously (a collision). A reliable communications protocol is used to recover the lost data when this occurs.

U

Uplink
The signal from the Earth to the satellite, also the act of sending such a signal.

URL
Uniform Resource Locator

V

VIRR
Visual and Infrared Radi

VSAT
Very Small Aperture Terminal, a satellite antenna and associated equipment. The antenna will normally be between 1.2 and 2.4m in diameter.

W

WAN
Wide Area Network

X

X.21
A common standard for s[illegible] a connections using balance voltage-differential signals over a cable.

.C25

A mature protocol, defined by the ITU and used in satellite systems and public data networks, to provide reliable data communications over packet switched networks.

y

YPOL

Signals that are linearly and vertically polarised

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