Report

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Date	Oct. 30 2018
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Abstract

There are several communication methods. And most of them are a focus on communication within the planet. Such as WIFI, LAN, and WAN are used to communicate in the Earth. Sometimes, these methods don't work because of obstacles. And the artificial satellite can be a solution to that problem. It is in the space, so transmit a data to the destination from the space, so it can avoid territorial obstacles. And the development of space drives Moon and Mars exploration. The last thing is the international space station. It is work global station on the space, it is a symbol of peace, and concentration of technology. Every work can be done based on the communication system, so I'll handle it.

History of Space development

There are many marvelous events in the history of space development. I pick the 4 biggest events to explain the history of space exploitation.

I think that the most important event is the launch of an artificial satellite. Before the launching, we just live on the Earth, and try to understand and just look at the sky through the telescope. However, after launching the satellite, we can move around in the space. So the first satellite, Sputnik 1, is launched by the Soviet Union on 4 October 1957 and initiated the Soviet Sputnik program. And after this moment, many countries began to develop space

The second event is the Moon Exploration Program. In 1969, project Apollo success to send a human to the Moon. Actually, Neil Armstrong is known as first moon visitor. And It also shows that if human want to do something, then anything can be done.

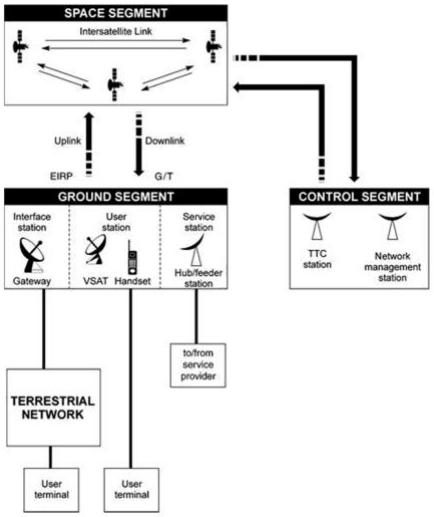
The third event is that construction of international space station. In the beginning, the USA built a space station for the military purpose, but after finishing cold-war, this station works as an international space hub. And this station is owned by Russian and USA, half for Russian and the other one for the USA. This structure proves that human can build and maintain huge building on the space. In the station, a few numbers of person stay, so it drove several other technologies, such as communication system and computer.

The fourth event is that Mars Exploration Program. There are many rovers which are a probe, for example, Viking (1976~1982), Mars Pathfinder & Sojourner (1997), Spirit & Opportunity (2004 ~), Phoenix (2008), and Curiosity (2012~). These rovers worked on Mars. And I'd like to talk about Curiosity because it is the most recent program and still work on Mars. As you know, Mars has a very tough environment. So It makes rover very hard to survive and communicate with Earth. However, curiosity works well and keep moving around Mars.
I think that all of the events require to improve communication system.

Communication system of Satellite

The Second World War stimulated the expansion of two very distinct technologies – missiles and microwaves. The expertise eventually gained in the combined use of these two techniques opened up the era of satellite communications.
The space era stated in 1957 with the launching of the first artificial satellite (Sputnik).[i]

The reduction in the cost of communication, the most outstanding feature is the variety of services offered by satellite communications systems. The increasing size and power of satellites has permitted a consequent reduction in the size of earth stations. [i]



An Overview of a satellite communication system and illustrate its interfacing with terrestrial entities. The satellite system is composed of a space segment, a control segment, and a ground segment.- The space segment contains one or several active and spare satellites organized into a constellation.
- The ground segment consists of all the traffic earth stations.
- the uplinks from the earth stations to the satellites
- the downlinks from the satellites to the earth stations.
- the intersatellite links, between the satellites.[i]

Uplinks and downlinks consist of radio frequency modulated carriers, while intersatellite links can be either radio frequency of optical. Carriers are modulated by baseband signals conveying information for communications purposes. [i]

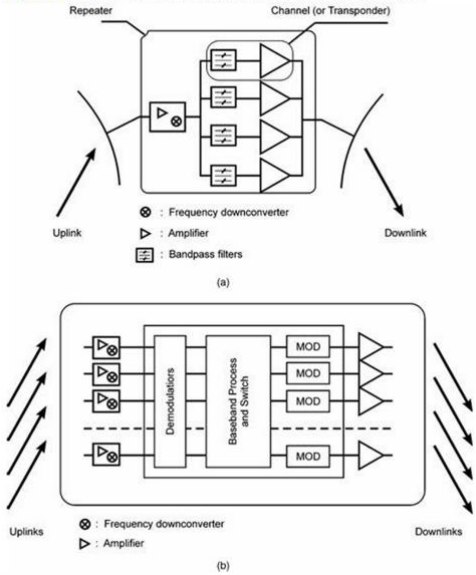
In a satellite system, several stations transmit their carriers to a given satellite, therefore the satellite acts as a network node. [i]

The space segment
The satellite consists of the payload and the platform. The payload consists of the receiving and transmitting antennas and all the electronic equipment which supports the transmission of the carriers. The two types of payload organization are illustrated
- Transparent / Regenerative i

The ground segment
Consists of all the earth stations; these are most often connected to the end-user's terminal by a terrestrial network or, in the case of small stations, directly connected to the end-user's terminal. [i]

The part of the system in the sky is termed the 'space segment'. The signal takes a finite time to travel up to the satellite and back down to earth (referred to as satellite delay) and is around 250 ms.[ii]

Figure 1.2 Payload organisation: (a) transparent and (b) regenerative.



Apollo 11 communication system

The Apollo program, known as Project Apollo, was the third United States human spaceflight program to carried out by the National Aeronautics and Space Administration (NASA).[iii]

The lunar module (LM) communications system was to provide essential communications between the LM and the Manned Space Flight Network (MSFN) on earth, between the LM and the command and service module when the latter was in lunar orbit, and between the LM and the extravehicular crewmen on the lunar surface.[iv]

Manned Space Flight Network (MSFN)
- The ground communications network that support communications links between the control center and the vehicles. We now refer to these assets as the Ground and Space Network.[v]

Very High Frequency (VHF)
- A frequency band used by the Lunar Module for communications. We now call the specific frequencies used by the LM, Ultra-High Frequency (UHF). They are the same set of frequencies used by the shuttle program.[v]

Extravehicular Activity (EVA)
- Any activity done by an astronaut or cosmonaut outside a spacecraft beyond the Earth's appreciable atmosphere.[vi]

Ranging
- The determination of the distance to a target based upon subcarrier, turnaround tones (S Band and VHF)[v]

S Band System: A tracking and communication system developed for the Apollo program by NASA and Jet Propulsion Laboratory (JPL). It operated in the S band portion of the microwave spectrum, unifying voice communications, television, telemetry, command, tracking and ranging into a single system to save size and weight and simplify operations.[vii]

S Band System	Voice & Data link between LM & MSFN
	Ranging Data between LM & MSFN
VHF System	Voice & Data link between LM & CSM
	Voice & Data link between LM & EVA
	Ranging Data between LM & CSM
Radio Frequency Systems Usage	During Earth Line of Sight
	During No Earth Line of Sight
	During EVA Operations

Curiosity communication system

Curiosity is a car type rover which is designed to expedition Gale Creator on Mars as part of NASA's Mars Science Laboratory mission. Curiosity's mission is to determine whether the Red Planet ever was, or is, habitable to microbial life.[viii]

Curiosity has three antennas that serve as both its "voices" and its "ears." They are located on the rover equipment deck (its "back"). Most often, Curiosity sends radio waves through its ultra-high frequency (UHF) antenna (about 400 Megahertz) to communicate with Earth through NASA's Mars Odyssey and Mars Reconnaissance Orbiters. Using orbiters to relay messages is beneficial because they are closer to the rover than the Deep Space Network (DSN) antennas on Earth and they have Earth in their field of view for much longer time periods than the rover does on the ground.[ix]

The NASA Deep Space Network (DSN) is an international network of antennas that provide the communication links between the scientists and engineers on Earth to the missions in space and on Mars.[x] The rover communication system includes a low data-rate direct-to/from-Earth X-Band transceiver as well as a high data-rate UHF-band transceiver for communication with Mars orbiters for data relay with Earth.[xi]

The Curiosity sends a message as two methods. First, it sends messages directly to the DSN station. Second, it sends a data using Mars Reconnaissance Orbiter and Mars Odyssey. Using the orbiter spacecraft brings two benefits. The first orbiter is close compared with DSN. Second, that have Earth in their field. [xii]

Rover uses radio waves as a transmission medium. The radio waves to and from the rover are sent through the orbiters using UHF antennas. All three orbiters active at Mars were at positions where they could receive transmissions from the Mars Science Laboratory spacecraft during its entry, descent, and landing. Two orbiters recorded Mars Science Laboratory data from the Mars Science Laboratory spacecraft, holding it onboard, and sending it to Earth hours later. The rover had two antennas that were used to communicate with the Earth. The low-gain antenna was omnidirectional and was used when the spacecraft was near the Earth. Because it radiated in all directions, the low-gain antenna did not need to be pointed at the Earth to enable a communications link. The medium-gain antenna was a directional antenna that had to be pointed toward the Earth for communications but had more power to communicate when the spacecraft was farther away from the Earth. When the rover speaks directly to Earth (from the surface of Mars), it sends messages via its high-gain antenna (HGA). [xiii]

The data rate direct-to-Earth varies from about 500 bits per second to 32,000 bits per second. The data rate to the Mars Reconnaissance Orbiter is selected automatically and continuously during communications and can be as high as 2 million bits per second. The data rate to the Odyssey orbiter is a selectable 128,000 or 256,000 bits per second. Between 100 and 250 megabits of data can be transmitted to an orbiter. That same 250 megabits would take up to 20 hours to transmit directly to Earth! The rover can only transmit direct-to-Earth for a few hours a day due to power limitations or conflicts with other planned activities, even though Earth may be in view much longer than the other things.[xiv]

International Space Station Communication System

The International Space Station (ISS) is a space station, or habitable artificial satellite, in low Earth orbit.[xv]

The ISS is a challenging adventure that is unique in that it requires a large number of Radio Frequency (RF) Systems to operate in a close proximity. These systems range from items critical to ISS operations communications and control.[xvi]

Radio communications provide telemetry and scientific data links between the station and Mission Control Centers. As a result, the ISS is equipped with internal and external communication systems used for different purposes.[xvii] Ultra-high frequency (UHF) radio is used by astronauts and cosmonauts conducting extravehicular activities (EVAs). UHF is used by other spacecraft that dock to or undock from the station to receive commands from Mission Control and ISS crewmembers.[xviii] Automated spacecraft are fitted with their own communications equipment. The ISS is equipped with about 100 IBM/Lenovo ThinkPad and HP ZBook 15 laptop computers. The laptops have run Windows 95, Windows 2000, Windows XP, Windows 7, Windows 10 and Linux operating systems.[xix] The operating system used for key station functions is the Debian Linux distribution. The migration from Microsoft Windows was made in May 2013 for reasons of reliability, stability, and flexibility.[xx]

IIS use as followed frequency for communication.

	Frequencies
Worldwid downlink for voice	145.80
Worldwid packet uplink/downlink	145.825
Region 1 voice uplink	145.20
Region2 & 3 voice uplink	144.49
Worldwide uplink for cross band voice repeater	437.80

Conclusion

When I start this research, I imagine that the evolution of technology in space communication, because on earth, many technologies grow very fast. But, after finishing research, I realize that they improve their machine very slowly. I think that in this area, the most important point is surviving. So, they try to choose old but can know parts drawback very well.

Second I focus on the system. I'd like to check that whether each of cases, such as the moon, mars, space which is near the earth, use a similar method to communicate with others. Those systems use radio wave as a transmission medium. That means every transmission idea is limited by radio character. And it could be explained that each transport method is seen similar.

So, I think that this work is very good for me to understand communication in space.

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