Satphone Systems Overview

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الخلاصة :

الهاتف الفضائي هو هاتف نقال يقوم بإنشاء قناة اتصال عبر أقمار صناعية ثابتة أو متحركة بالنسبة إلى الأرض عوضاً عن الشبكة العالمية للاتصالات GSM. وكون الهواتف الفضائية لا ترتبط بشبكات هاتف تخضع للدول، فهذا يسهل عمليات الاتصال في المناطق التي لا تتوفر فيها تغطية لخدمات الاتصالات اللاسلكية مثل المناطق القروية والصحراوية النائية وفي عرض البحار. وكذلك تستخدم هذه التقنية في المناطق المتأثرة بسبب الحروب أو بسبب بعض الظواهر الطبيعية مثل الزلازل والاعاصير والبراكين هذه الورقة تعرض فكرة مبسطة عن الاتصالات عبر الأقمار الاصطناعية من ناحية التقنية المستخدمة وجودة الخدمة بالمقارنة مع الاتصالات اللاسلكية الأخرى.

Abstract:

The satphone is a kind of mobile phone system which creates a communication channel via two kinds of satellites geostationary and low earth orbit which is completely different from global system for the mobile (GSM). Satellite phone networks are not controlled by local authorities of countries, so the communication service can be available in all areas where the GSM services are unavailable such as remote areas, deserts, and submarines. It can also be used in destroyed areas due to wars or natural phenomena such as Earthquakes, Hurricanes and Volcanoes.

The aim of this article is to provide a simple overview of the current satphone in terms of technology and quality of service compared with conventional wireless or cable telecommunications.

Key words: Satphone, Satellite, GSM

1. Introduction:

A satellite telephone, satellite phone, or satphone is a type of mobile phone that connects to orbiting satellites instead of terrestrial cell sites. They provide similar functionality to terrestrial mobile telephones; voice, short messaging service and low-bandwidth internet access are supported through most systems [1].

Satphones are complicated radio transmitters. Radios and cell phones use antennas on earth to send out a signal, either a radio broadcast or phone calls. Satphones send the signal to a satellite in orbit around the earth. The satellite then broadcasts the signal back to earth, to a “Ground Earth Station” or GES. From the GES the signal is sent to the proper communications service provider and to its destination, the receiver of the call. The GES acts as a gateway between your satphone, traditional cellular mobile phone networks, landline networks, and other satphones.

Transmitting information to the satellite in orbit is the “uplink.” Receiving information from the satellite is the “downlink.” This information can be data or voice. A phone’s signal can be intercepted anytime it has an active connection with the satellite: during the uplink or the downlink [1].

1- Cellular vs. Satellite :

The Sat-phone differs from cellular phone in many aspects including the used technology, handsets, service coverage and service cost.

a- Technology :

Cell phones are essentially two-way radios, communicating with a local tower that forms a "cell" which is a region of space covered by the transmitters on that tower. A "cellular network" consists of a wide range of these cells. Problematically, though, cell phone radios are relatively short range, and expansive networks require large numbers of these towers, which may be

prohibitively expensive or may require infrastructure that's not available.

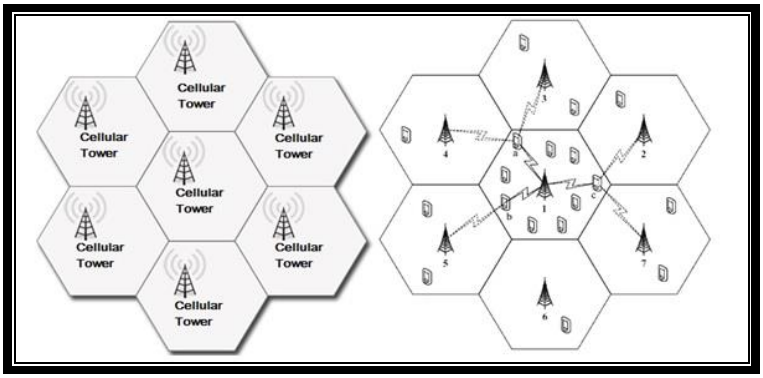

Figure1. Cellular Phone Technology .

Satellite phones communicate directly with a satellite orbiting the Earth. This allows satellite phones to receive a communications signal over a much wider area. A satellite phone can connect anywhere as long as it is covered by the satellite beam. The signal from the satellite phone transmits directly to the satellite, which then sends the signal to the nearest land-based earth station or teleport, which then transmits the signal to the receiving phone. The receiving phone can be a land line, cell phone or another satellite phone [2].

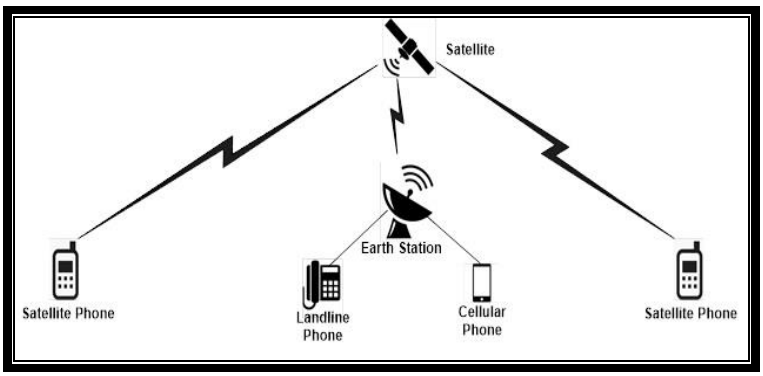

Figure 2. Satellite Phones Technology.

b- Handsets :

Satellite phone handsets tend to be larger than their cellular counterparts, and may have prominent antennas designed to improve communication with the satellite. In the early days of satellite phones, this difference was pronounced , the first satellite phones weighed up to 16 ounces, and this bulk provided only 2 hours of talk time. Later phones, like their cellular counterparts, have grown smaller; modern satellite phones may be nearly indistinguishable from short-range cell devices. In other respects, using a satellite phone is relatively similar to using a cell phone, which means newer phones support Internet connectivity, and many satellite services support "text messaging," or SMS [2].

c- Global Coverage and Applications :

An issue with cellular networks is that a tower cell has a relatively short range, and wide cellular networks require a large number of towers to cover cities, which may be very expensive or require infrastructure that is not readily available. It is not cost effective for the cellular providers to put up cell towers in rural areas or in many third world countries where there is low usage. It is also impossible to place towers out in the ocean or in very remote or mountainous regions, making your cellular phone worthless for communications when not close to a cell tower. Although most cities and urban areas now have access to cellular networks, this still represents only a fraction of the Earth's surface. Figure 3 shows the area covered by a cellular network. The areas not covered by the tower cells do not have cellular signal, and cellular phones cannot be used to communicate in these areas without coverage.

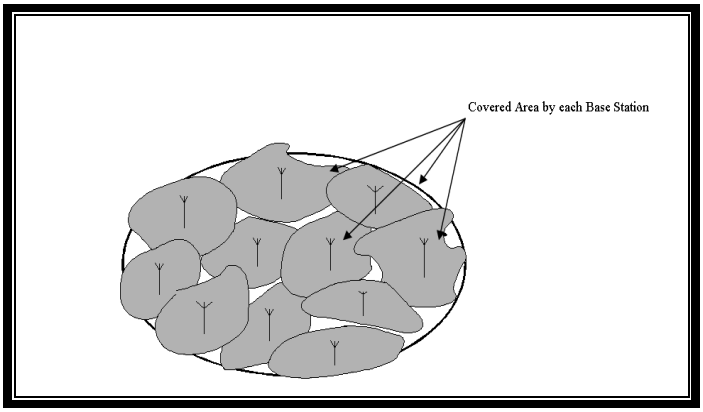

Figure 3 Cellular Phone Coverage Area .

Unlike cellular phones, Satellite signals are transmitted far above the earth and do not rely on towers, making them very useful in remote areas. This is why satellite phones are more useful than cellular phones to those who are travelling to isolated and remote areas. Figure 4 shows satellite coverage beams over very wide areas. Any satellite phone located anywhere inside a satellite coverage beam can communicate with other phones, regardless of how remote the location, whether at land, air, or sea.

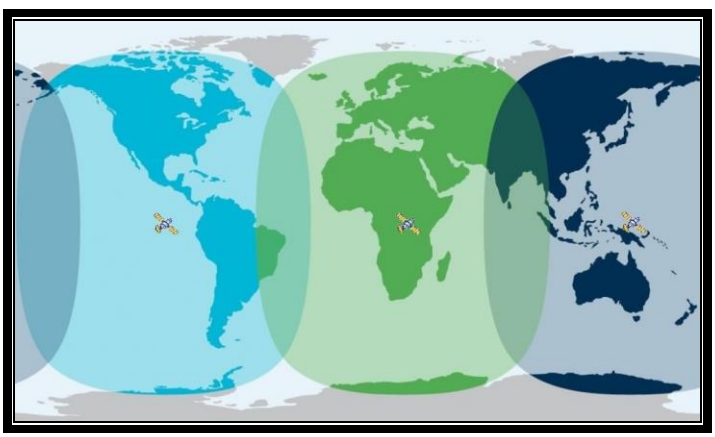

Figure 4 Satphone Coverage Area.

d- Cost :

The primary downside of satellite phones is their cost, both to acquire the phone and to use it. Satellite phone companies have to deploy their own expensive technology; each satellite costs tens of millions of dollars. Initially, the cost of making voice calls from a satellite phone varies from around $0.15 to $2 per minute, while calling them from landlines and regular mobile phones is more expensive. Costs for data transmissions (particularly broadband data) can be much higher. Rates from landlines and mobile phones range from $3 to $14 per minute with Iridium, Thuraya and Immersed being some of the most expensive networks to call. The receiver of the call pays nothing, unless they are being called via a special reverse-charge service.

Making calls between different satellite phone networks is often similarly expensive, with calling rates of up to $15 per minute. Calls from satellite phones to landlines are usually around $0.80 to $1.50 per minute unless special offers are used. Such promotions are usually bound to a particular geographic area where traffic is low. Despite the high cost of calls, it is very important to consider the purpose of a satellite phone and its usefulness in an emergency situation compared to cellular phones. In an emergency situation or when you have no other means of staying in touch, a satellite phone is the most viable option.

2- Satellite phone networks :

When the user initiates a call on a satellite capable handset, the nearest satellite picks up the call and authenticates the users through the nearest gateway on the earth. If the destination phone is part of the public switched telephone network (PSTN), the call is routed to the nearest gateway and consecutive PSTN. If the destination phone is another satellite handset, the call routing occurs through satellites only, which increases transmission efficiency and quality.

There are three types of satellite communication systems which differ in terms of orbit and signal strength. These satellite systems are Low earth orbit (LEO) satellites, Medium earth orbit (MEO) satellites, and geosynchronous earth orbit (GEO) satellites.

a. **Geosynchronous satellites :**

Geostationary Earth Orbit (GEO) satellites are deployed 35,786 km above the equator line [10]. These satellites are called geostationary as, at this altitude, the satellites move synchronously with earth (i.e., a GEO satellite completes a circular movement around the earth in 24 hours). Consequently, the satellite position and coverage area are stationary relative to a fixed location or observer on earth. At this altitude, a GEO satellite covers almost one-third of the earth's surface (not including the polar area), requiring only three satellites to cover the whole earth (Fig. 1). Although a small number of GEO satellites are needed for global coverage. The amount of bandwidth available on these systems is substantially higher than that of the low Earth orbit (LEO) systems [3]. GEO systems exhibit some significant disadvantages for communication networks. The user terminals and satellites consume alot of power, and the propagation delay for real-time communications is very high in these systems[3].

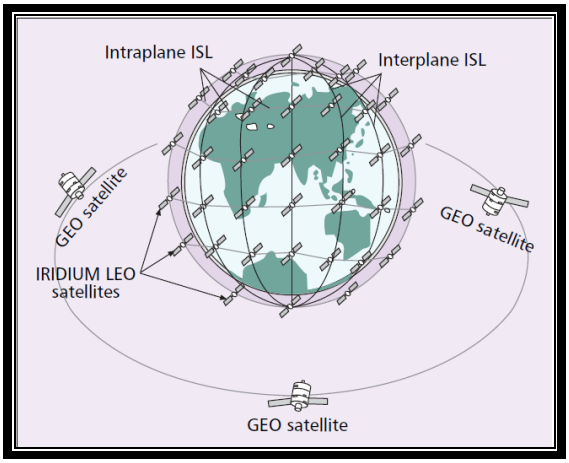

Figure 5 GEO Satellite Coverage.

Another disadvantage of geostationary satellite systems is that in many areas—even where a large amount of open sky is present—the line-of-sight between the phone and the satellite is broken by obstacles such as steep hills and forest. The user will need to find an area with line-of-sight before using the phone. This is not the case with LEO services: even if the signal is blocked by an obstacle, one can wait few minutes until another satellite passes overhead, but a moving LEO may drop a call when line of sight is lost[3].

- **ACeS:** This small regional operator provides voice and data services in East Asia, South Asia, and Southeast Asia using a single satellite.
- **Inmarsat:** The oldest satellite phone operator, founded in 1979. It originally provided large fixed installations for ships, but has recently entered the market of hand-held phones in a joint venture with ACeS. The company operates eleven satellites. Coverage is available on most of the Earth, except Polar Regions.
- **Thuraya:** Established in 1997, Thuraya's satellites provide coverage across Europe, Africa, the Middle East, Asia and Australia.
- **MSAT / SkyTerra:** An American satellite phone company that uses equipment similar to Inmarsat, but plans to launch a service using hand-held devices in the Americas similar to Thuraya's.
- **Terrestar:** Satellite phone system for North America
- **ICO Global Communications:** A satellite phone company which has launched a single geosynchronous satellite which is not yet active.

b. Low Earth Orbit :

LEO telephones utilize LEO (low Earth orbit) satellite technology. The advantages include providing worldwide wireless coverage with no gaps. LEO satellites orbit the Earth in high speed, low altitude orbits with an orbital time of 70–100 minutes, an altitude of 640 to 1120 kilometers (400 to 700 miles), and provide coverage cells of about (at a 100-minute orbital period) 2800 km in radius (about 1740 mi). Since the

satellites are not geostationary, they move with respect to the ground. At least one satellite must have line-of-sight to every coverage area at all times to guarantee coverage [3].

A number of LEO satellite systems (like Iridium, and Globalstar) [2] have been proposed to overcome the disadvantages of GEO systems in high-speed data and voice communications. In contrast to GEO systems, LEO satellite systems have a number of advantages, such as efficient bandwidth usage, lower propagation delays, and lower power consumption in the user terminals and satellites [2].

However, in contrast to GEO satellite systems, the coverage area of a LEO satellite is not stationary. This is due to the asynchronous movement of the satellite relative to Earth, resulting in the handing over of a satellite between ground stations as it passes over different areas of the Earth. The mobility management in LEO satellite systems is thus more challenging than in GEO systems.[4],[5]

Depending on the positions of both the satellite and terminal, a usable pass of an individual LEO satellite will typically last 4–15 minutes on average; thus, a constellation of satellites is required to maintain coverage (as is done with Iridium, Globalstar, and others).

Two such systems both based in the United States, started in the late 1990s, but soon went into bank rupcy after failing to gain enough subscribers to fund launch costs. They are now operated by new owners who bought the assets for a fraction of their original cost and are now both planning to launch replacement constellations supporting higher bandwidth. Data speeds for current networks are between 2200 bit/s and 9600 bit/s using a satellite handset.

- **Globalstar**: A network covering most of the world's landmass using 44 active satellites. However, many areas are left without coverage since a satellite must be in range of an Earth station. Satellites fly in an inclined orbit of 52 degrees, so polar regions cannot be covered.

The network went into limited commercial service at the end of 1999.

- **Iridium**: A network operating 66 satellites in a polar orbit that claims coverage everywhere on Earth. Commercial service started in November 1998. In 2001, service was re-established by Iridium_Satellite LLC. Radio cross-links are used between satellites to relay data to the nearest satellite with a connection to an Earth station.

In some LEO satellite systems (for example, Iridium), satellites communicate among themselves using Inter Satellite Links (ISL). As shown in Figure 1, ISLs are of two types: intraplane ISLs, which connect satellites within the same orbit; and interplane ISLs, which connect satellites in adjacent orbits .

c. **Medium Earth orbit** (**MEO**) :

Sometimes called intermediate circular orbit (ICO), is the region of space around the Earth above low Earth orbit (altitude of 2,000 kilometres (1,243 mi)) and below geostationary orbit (altitude of 35,786 kilometers (22,236 mi)).
The most common use for satellites in this region is for navigation, communication, and geodetic/space environment science. The most common altitude is approximately 20,200 kilometers (12,552 mi)), which yields an orbital period of 12 hours, as used, for example, by the Global Positioning System (GPS). Other satellites in Medium Earth Orbit include Glonass (with an altitude of 19,100 kilometers (11,868 mi)) and Galileo (with an altitude of 23,222 kilometers (14,429 mi)) constellations. Communications satellites that cover the North and South Pole are also put in MEO.

d. Comparison Between Satellite Systems ;

The Major differences between LEO, MEO & GEO satellite systems can be summarized as follows:

Table 1 A Comparison between Satellite Systems.

Parameter	LEO	MEO	GEO
Satellite Height	500-1500 km	5000-12000 km	35,800 km
Orbital Period	10-40 minutes	2-8 hours	24 hours
Number of Satellites	40-80	8-20	3
Satellite Life	Short	Long	Long
Propagation Loss	Least	High	Highest
Gateway Cost	Very Expensive	Expensive	Cheap

3- Satphone Security :

Although communication between satellites and the user segment is standardized and documented by ETSI, no details about the actual cryptographic algorithms used for voice encryption are disclosed. However, when a call is established after setting up an appropriate channel the satellite initiates authentication by sending a request to the phone. This request contains a random number R which is sent to the phone's SIM card where a specific secret key S is stored. Given (R, S), the SIM card derives a session key K and an authentication token. After authentication, encryption is switched on and all subsequent frames on the relevant channel are encrypted by a stream cipher.[6]

5. Satellite Systems :

There are three different types of satellite systems. Which are described as follows:

a. INTELSAT :

The INTELSAT (International satellite communication system) Organization was established in 1964 to handle the myriad of technical and administrative problems associated with a world wide telecommunication system. The international regions served by INTELSAT are divided into the Atlantic Ocean region (AOR), the Pacific Ocean Region (POR), and the Indian Ocean region (IOR). For each region, satellites are positioned in geo-stationary orbit above the particular Ocean,

where they provide a transoceanic telecommunication route. In addition to providing Trans oceanic routes, the INTELSAT satellites are used for domestic services within any given country and regional services between countries. Two such services are vista for telephony and
Intelnet for data exchange

b. DOMSAT :

Domestic satellites are used to provide various telecommunication services, such as voice, data, and video transmission (T.V channels), within a country. Satellite cell phones allow global trevellers and those in remote areas to avoid landlines and terrestrial cell phone services entirely. Satellite cell phones relay your call to a satellite and down through a hub to the end-user. This means that most of the earth's geographical area is now accessible by a satellite cell phone! Third party providers of satellite cell include Satcom Global, Roadpost Satcom, Online Satellite Communications, and others.

c. SARSAT :

SARSAT (Search and rescue system) is one type of Polar orbiting satellites. Polar-orbiting satellites orbit the earth in such a way as to cover the north and south polar-regions. Infinite number of polar satellite orbits is possible. Polar satellites are used to provide environmental data and to help locate ships and aircrafts in distress .

6. Cost of Satellite Phone:

While it is possible to obtain used handsets for the Thuraya, Iridium, and Globalstar networks for approximately US$200, the newest handsets are quite expensive. The Iridium 9505A, released in 2001, sold in March 2010 for over US$1,000. Satellite phones are purpose-built for one particular network and cannot be switched to other networks, the price of handsets varies with network performance. If a satellite phone provider encounters trouble with its network, handset prices will fall, then increase once new satellites are launched. Similarly, handset prices will increase when calling rates are reduced. Among the most expensive satellite phones are BGAN terminals, often costing several thousand US dollars. These phones provide broadband Internet and voice communications.

Satellite phones are sometimes subsidized by the provider if one signs a post-paid contract but subsidies are usually only a few hundred US dollars or less. Since most satellite phones are built under license or the manufacturing of handsets is contracted out to OEMs, operators have a large influence over the selling price. Satellite networks operate under proprietary protocols, making it difficult for manufacturers to independently make handsets

7. The Use of Satellite Phone in Disasters :

Most mobile telephone networks operate close to capacity during normal times, and large spikes in call volumes caused by widespread emergencies often overload the systems when they are needed most. Examples reported in the media where this has occurred include the 1999 Izmir earthquake, the September 11 attacks, the 2006 Hawaii earthquake, the 2003 Northeast blackouts, Hurricane Katrina, the 2007 Minnesota bridge collapse, the 2010 Chile earthquake, the 2010 Haiti Earthquake, and the Dawson College shooting. Reporters and journalists have also been using satellite phones to communicate and report on events in war zones such as Iraq and Syria. Terrestrial cell antennas and networks can be damaged by natural disasters. Satellite telephony can avoid this problem and be useful during natural disasters. Satellite phone networks themselves are prone to congestion as satellites and spot beams cover a large area with relatively few voice channels.

8. Conclusion

A comparison between cellular phone system and satellite phone in terms of the technology, coverage area, and cost is presented in this review paper, With the success of cellular phone system was believed that satellite phone system and technology would be able to provide phone access in area of world that were not at that time accessible to terrestrial cellular phone system.

The most common issue of satphone systems compared with cellular phone systems is the high cost of calls and low security system, as a result, the developments, researches and work on satphones will continue for their positive point for providing communication facility in any location on the earth at reasonable cost. The world countries will continue dealing with

both systems satphone and cellular one, and continue work to reduce the cost of satphone systems like what has happened to the TV broadcasting via satellites service.

Despite high cost call, it is very important to consider the purpose of a satellite phone and its usefulness in an emergency situation compared to cellular phones. In an emergency situation or when you have no other means of staying in touch, a satellite phone is the most viable option.

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