Constructing a New Communication System by Integrating the GSM to the Satellites Infrastructure

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Abstract: - The current researches and industries are looking forward to integrate different technologies to get a global technology that offers all of the intended services in a simple way. In this paper, a new communications system is proposed to integrate the use of GSM over the available satellites infrastructures. The proposed communications system could be used to facilitates and get benefits of both systems (the GSM and Satellites) to achieve competitive services over the world. The proposed system is concentrated on a global communications system that served all over the world and gives some specialization and privacy for each country. Furthermore, this paper shows an algorithm on how to implement the GSM over satellite systems in an efficient, flexible, and cost-effective manner.

Key-Words: - GSM, GSM over Satellite, Mobile Communications, Satellite Communications.

1 Introduction

The first artificial satellite was placed in orbit by the Russians in 1957. That satellite, called Sputnik, signaled the beginning of an era. 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. The first satellite, Sputnik 1, was put into orbit around Earth and was therefore in geocentric orbit. By far this is the most common type of orbit with approximately 2456 artificial satellites orbiting the Earth. Geocentric orbits may be further classified by their altitude, inclination and eccentricity [1].

The commonly used altitude classifications are Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and High Earth Orbit (HEO). Low Earth orbit is any orbit below 2000 km, and Medium Earth Orbit is any orbit higher than that but still below the altitude for geosynchronous orbit at 35786 km. High Earth Orbit is any orbit higher than the altitude for geosynchronous orbit [2].

Internet, cellular mobile, satellite, phones and other communications systems construct the main foundations of globalization that make the wide world as a small village.

Satellites can be divided into five principal types: research, communications, weather, navigational, and applications. The growth of number of mobile users shown in Fig. 1 and indicates that it reached to 50% of the population during 2007. Consequently Fig. 2 shows the forecasting of population growth, and indicates that at 2020 the world population reaches about 7.6 billions, this means a huge number of mobile users. Recent years show a huge increment of world population, these needs more communications services, and so huge investments spend in this field to overcome these needs. This is an indication to find new media and systems to cover this growth [3] & [4].

However, the current researches and industries are looking forward to integrate different technologies to get a global technology that offers all of the intended services in a simple way. In this paper, a new communications system is proposed to integrate the use of GSM over the available satellites infrastructures. The proposed communications system could be used to facilitates and get benefits of both systems (the GSM and Satellites) to achieve competitive services over the world.

The proposed system is concentrated on a global communications system that served all over the world and gives some specialization and privacy for each country. Furthermore, this paper shows how to implement the GSM over satellite systems in an efficient, flexible, and cost-effective manner. In addition, since the laser inter-satellite communication is on the verge of becoming a reality [5] [6], it could be used with our proposed system.

The rest of this paper is organized as follows: Section 2 gives an overview of the geosynchronous communications satellites, section 3 presents the details of the proposed system, and section 4 illustrates the data transmission and frame format of the proposed system. In section 5, the communication algorithm for the proposed system has been explained, and finally, section 6 discusses and concludes the paper results.

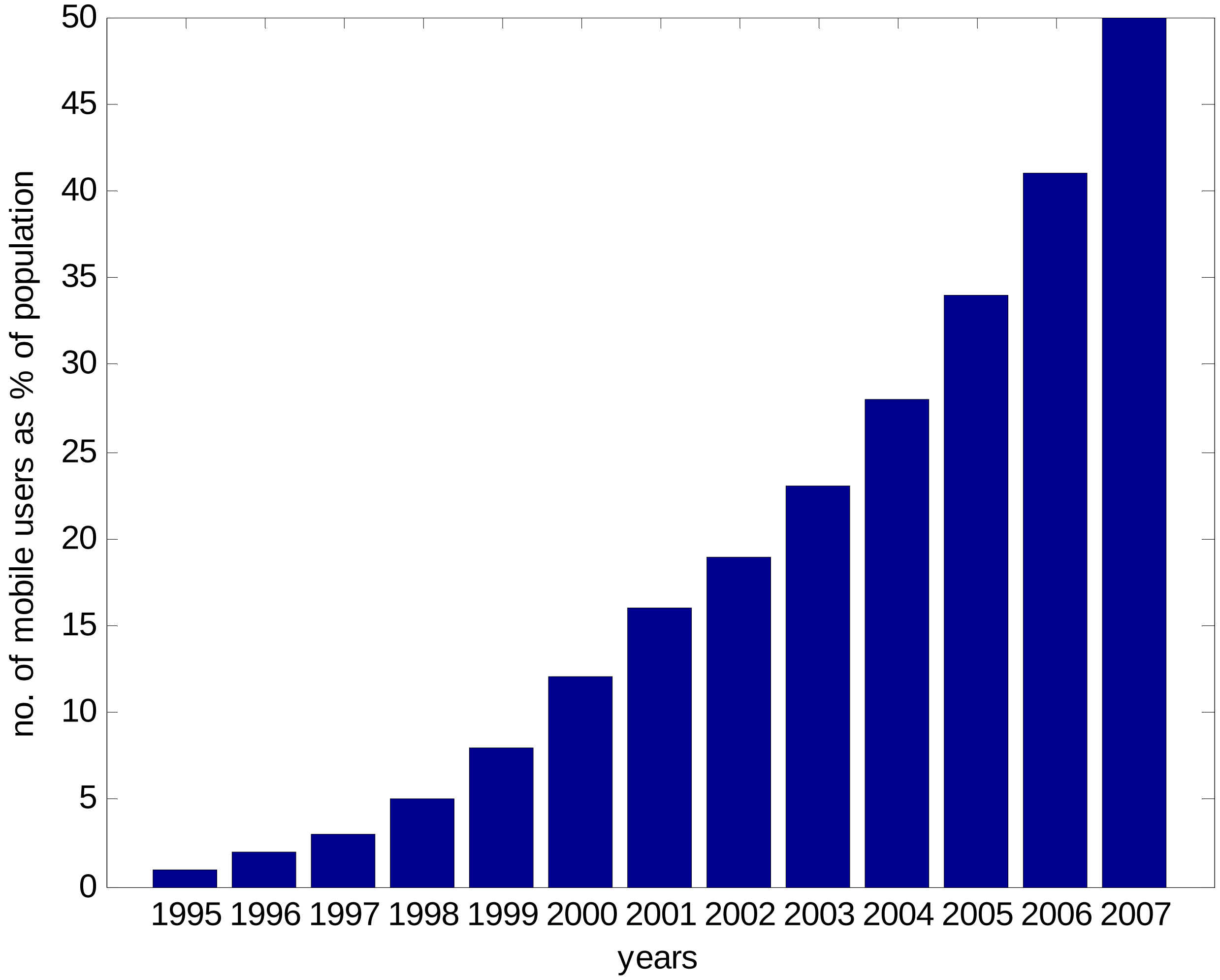

Fig. 1: Growth of mobile users

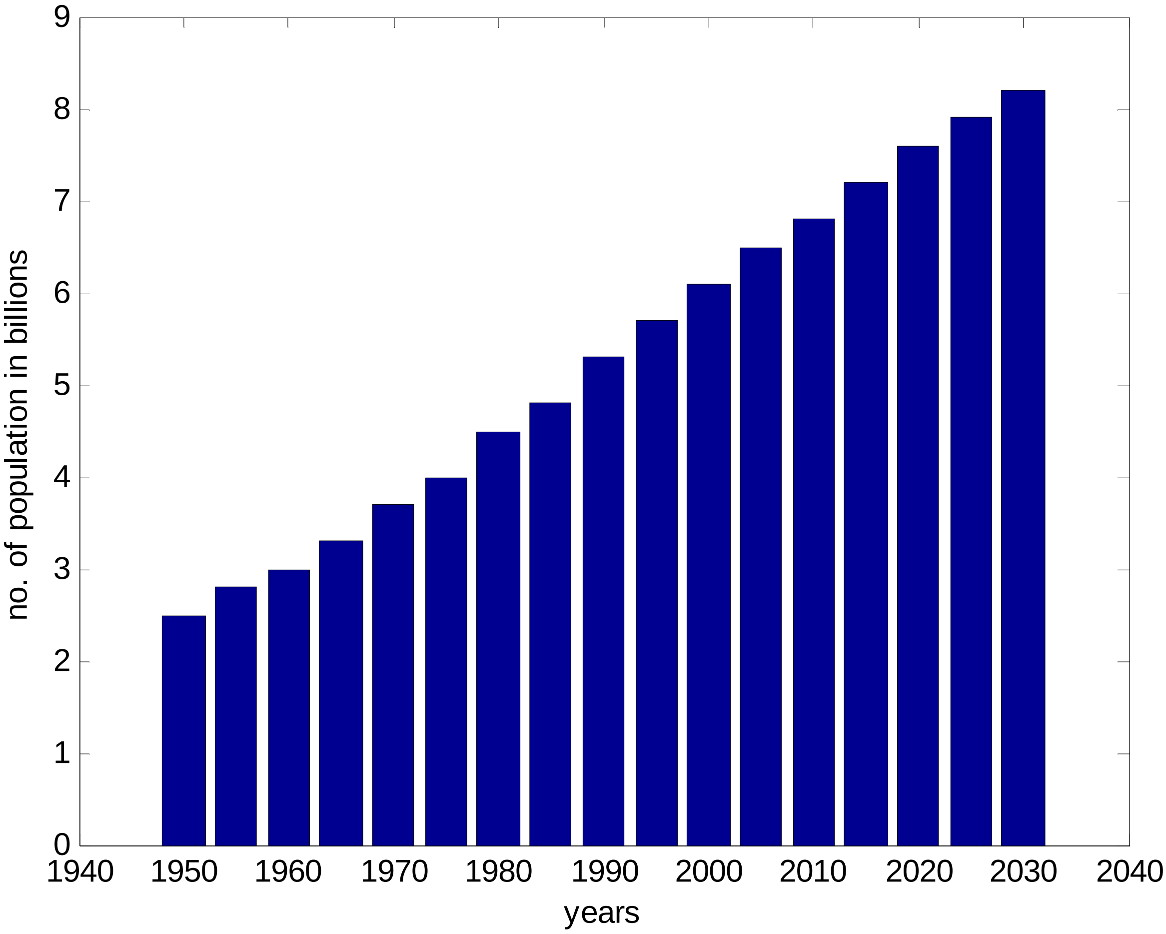

Fig. 2: Population growth

2 Geosynchronous Communications Satellites

In 1963, the necessary rocket booster power was available for the first time and the first geosynchronous satellite, Syncom 2, was launched by NASA. For those who could see it, the satellite was available 100% of the time, 24 hours a day. The satellite could view approximately 42% of the earth. However, a system of three such satellites, with the ability to relay messages from one to the other could interconnect virtually all of the earth except the Polar Regions as shown in Fig. 3. A circular geosynchronous orbit in the plane of the Earth's equator has a radius of approximately 42,164 km (from the center of the Earth). The one disadvantage of the geosynchronous orbit is that the time to transmit a signal from earth to the satellite and back is approximately ¼ of a second - the time required to travel 22,236 miles (35,786 km) up and 22,236 miles back down at the speed of light. For telephone conversations, this delay can sometimes be annoying. For data transmission and most other uses, it is not significant. In any event, once Syncom had demonstrated the technology necessary to launch a geosynchronous satellite, a virtual explosion of such satellites followed [7] [8].

During the last years, the number of commercial communications satellites in geosynchronous has been increased [9].

Today, there are approximately 150 communications satellites in orbit, with over 100 in geosynchronous orbit. One of the biggest sponsors of satellite development was Intelsat, an internationally-owned corporation which has launched 8 different series of satellites (4 or 5 of each series) over a period of more than 30 years. Spreading their satellites around the globe and making provision to relay from one satellite to another, they made it possible to transmit 1000s of phone calls between almost any two points on the earth. It was also possible for the first time, due to the large capacity of the satellites, to transmit live television pictures between virtually any two points on earth [10] [11].

Low earth orbit satellite systems are designed to provide global communication for multimedia services, including voice, video and data. In design of LEO systems, the choice of satellite altitude is an important consideration, which has a significant impact on system performance [12]. The delay of the propagation signal is very important voice signal and it must be with the range of 200 mille-seconds, and this range is available and achievable with LEO satellite [13].

3 The Proposed System

The worldwide popularity of cellular mobile has driven operators to deploy services in most metropolitan areas and, increasingly, into smaller areas. Often the terrestrial infrastructure is not sufficient to reach these locations and satellite is the only viable way to extend the service into these regions. Furthermore, the daily exposure to GSM electromagnetic fields has raised public concern of possible adverse health effects to people living in the near of base station antennas [14]. However, the proposed communication system will overcome this problem since there are no electromagnetic fields.

The implementation of cellular mobile over satellite is in common use in many regions of the world. While cellular mobile is inherently satellite friendly and it is easy to implement in a simple way, so there are more approaches which can lead to significant bandwidth, and therefore cost, reductions.

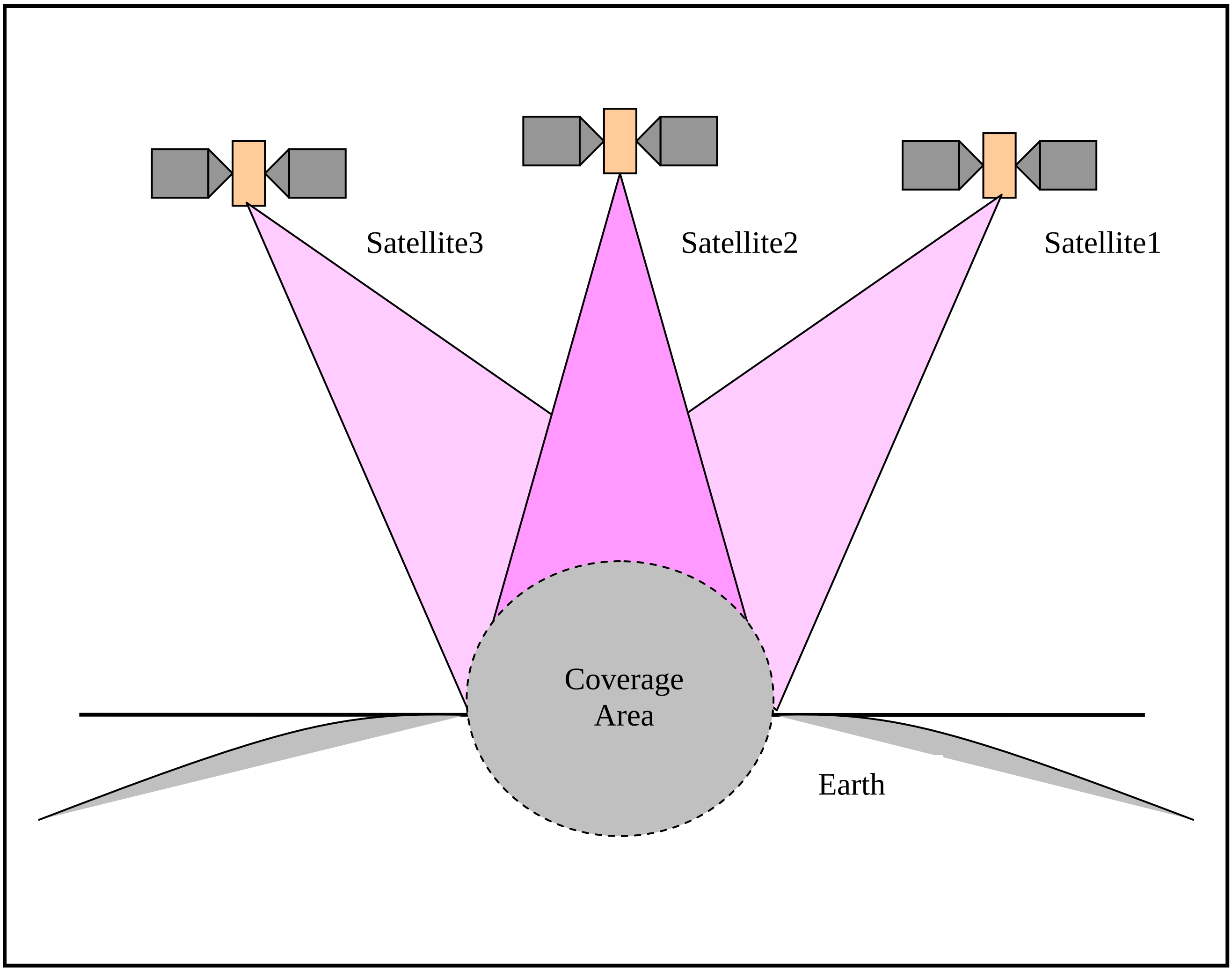

Fig. 3: The envelope of three satellites

The proposed system divides the world into areas that each area contains on a number of countries and can be covered by one geosynchronous satellite, so it is possible to assume that 24 satellites can be cover all the areas of the world (as in Geographic Information System). The proposed system as shown in Fig. 4 can be divided into two parts; the first one is the Global Extra Communication System (GECS), that concern with the satellite communication between users outside of areas and countries. GECS depends on geostationary satellite through Earth Stations (ESs), where the communications of each area goes through a GateWay (GW) unit that makes security and privacy for each country as well as identifies the authority and legality for each user. The second one is the Local Intra Communication System (LICS), that concern with the mobile communication between users inside of areas and countries. LICS depends on mobile communication systems networks through Base Stations (BSs), where the communications through of each area goes through a central center that dominant all the internal communications and operates as a pre-filter link to the gateway to achieve the external communications.

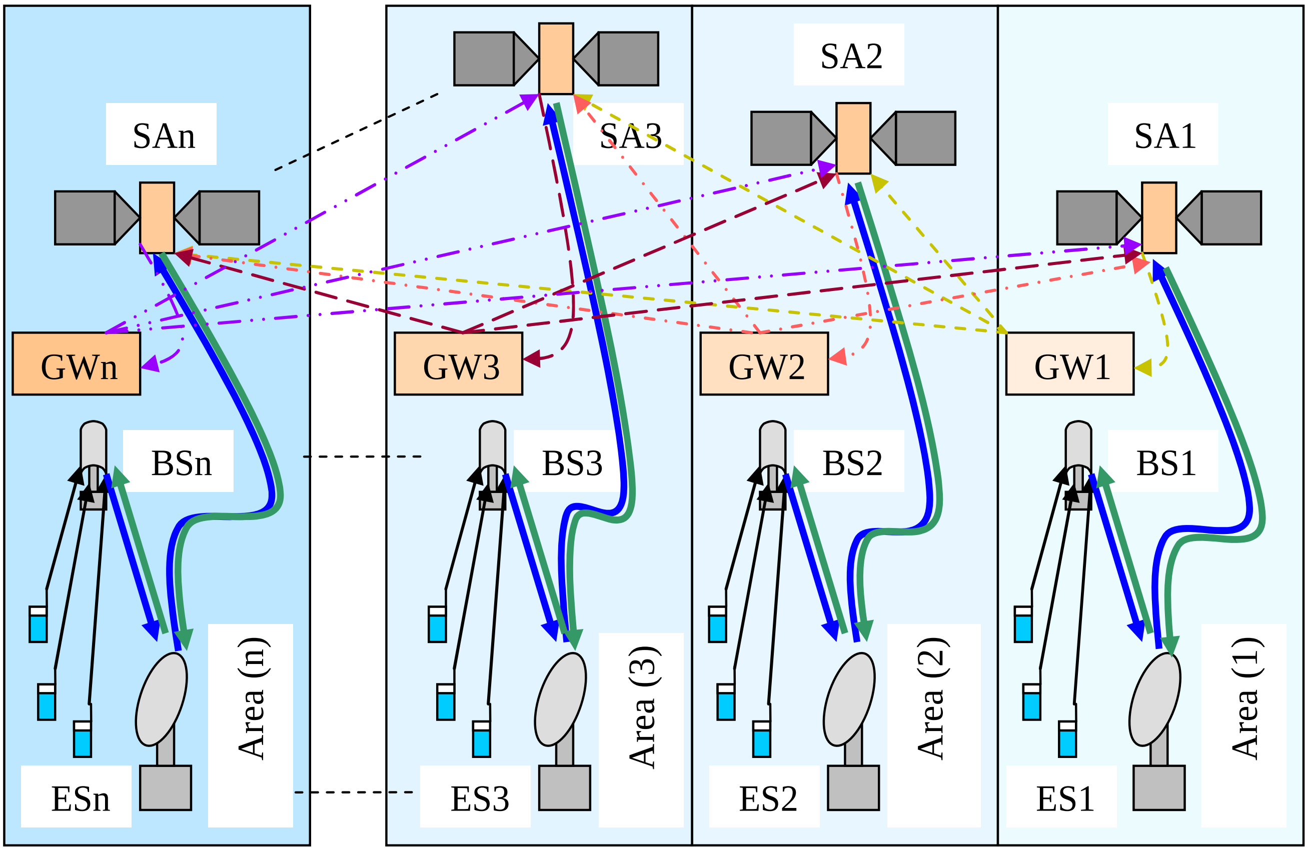

Fig. 4: The architecture of the proposed system

The local operation (internal access) starts when a signal is transmitted to a local subscriber, so this operation passes through a mobile network, then to the nearest base station, then to the indicated subscriber. The global operation (external access) starts when a signal is transmitted to a global subscriber, so this operation passes through a satellite network to the area gateway of the source subscriber, then via inter-satellite links passes to the area gateway of the destination subscriber, then to the indicated subscriber.

4 Data Transmission and Frame Format

Geosynchronous system has large bandwidth that supports multimedia services including voice, data, and video services, in addition of other services. The main problem of geosynchronous is the delay time that occurs due to large signal propagation. To overcome this problem, the length of the transmitted frame is chosen as minimum as possible (one byte). The global system is divided into 24 areas and each area divided into a number of countries depending on the coverage of the satellite, in total of 192 countries. Therefore it must be 192 fixed addresses for all countries, and that are indicated by geosynchronous satellites. The international transmitted data are encapsulated by internal mobile network and then encapsulated by external satellite network and directed to the destination country (one of 192).

Base Transceiver Station (BTS) is the equipment which facilitates the wireless communication between user equipments (UE) and the network. Typically a BTS will have several transceivers which allow it to serve several different frequencies and different sectors of the cell. A BTS is controlled by a Base Station Controller (BSC) via the Base station Control Function (BCF). A number of BSCs are served by an MSC. The Mobile Switching Center (MSC) is the primary service delivery node for GSM, responsible for handling voice calls and SMS as well as other services. The outdoor communications are transmitted via a global mobile service switching center (GMSC), which is a gateway used to interconnect two satellites.

The proposed system depends on the LEOs satellites to overcome the adequate delay that is with the limit of 200 msec. The distribution of satellites depends on the compensation between two main factors that are the area and the population density of each country, so we suggest 256 satellites are available to overcome the coverage of all countries as shown in Fig. 5. The global mobile frame is encapsulated via the satellite frame before transmitted consist of identification of satellite (Sat. ID), destination (Des. ID), and source (Sou. ID) as well as starting byte and end byte, four byte of trailer and 1500 byte of payload as illustrated in Fig. 6.

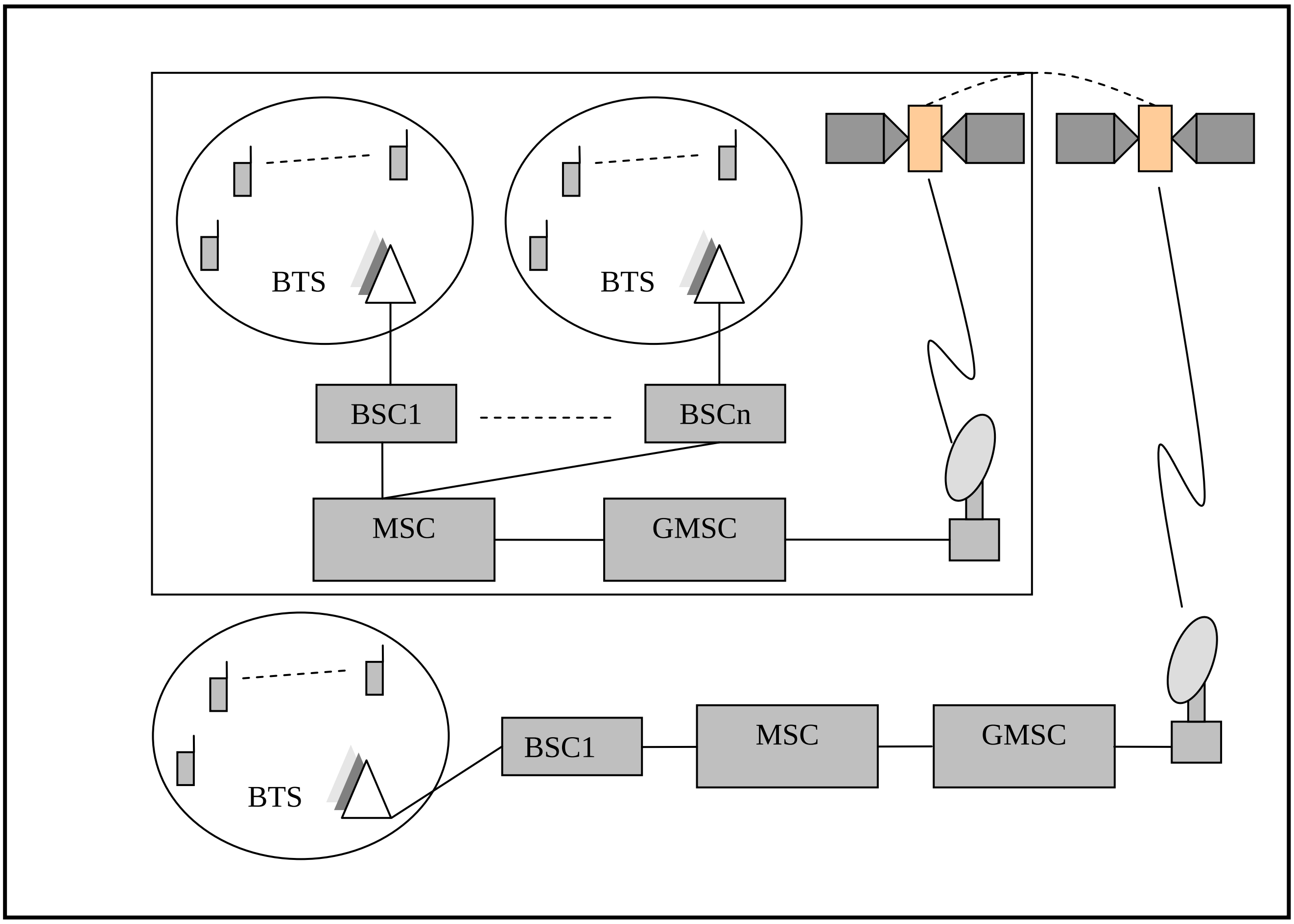

Fig. 5: The architecture of Mobile over Satellite system destination

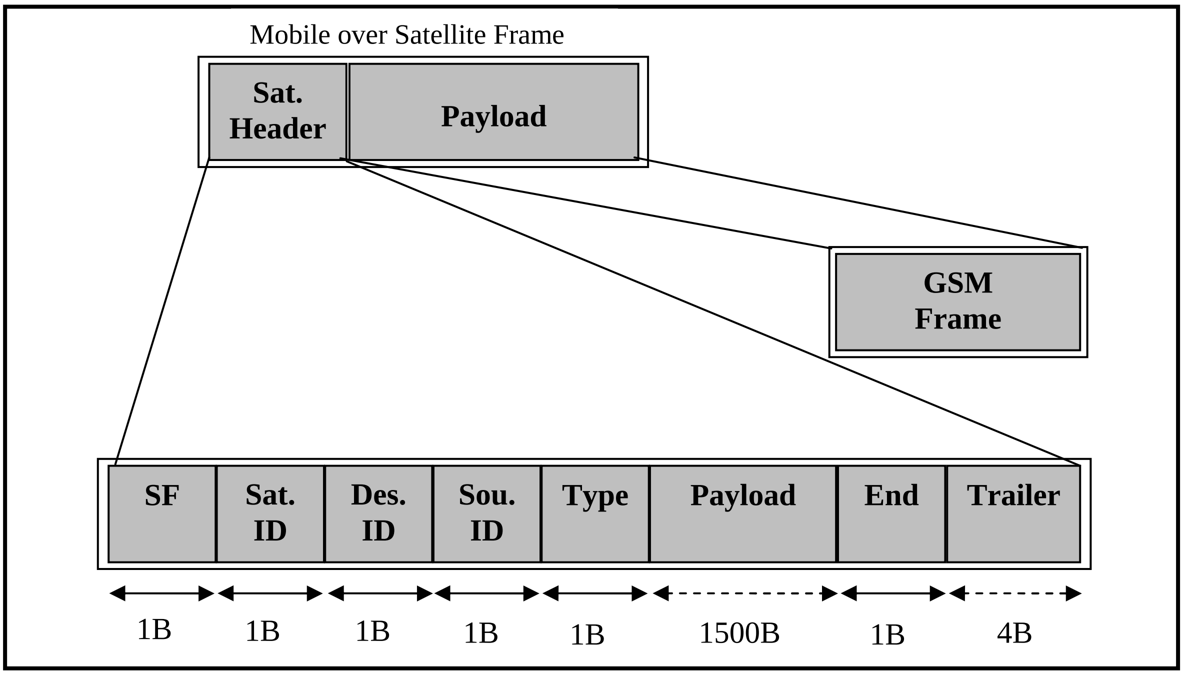

Fig. 6: The composite frame structure of the proposed system

5 Communication Algorithm for the Proposed System

The proposed system can perform the operation through the following algorithm. As a first step of this algorithm, the authentication process should be carried out. The authentication process is based on a challenge-response method in which the authentication key is available in the authentication centre and the SIM card of the given mobile device.

The authentication canter selects a random number of length 128 bits and calculates a signal response value (SR^*) using the well-known A3 authentication algorithm. Whereas, on the mobile device side, the mobile calculates the SR value using the following: the same selected random number (of size 128 bits), the authentication key which is already available in the SIM card, and the well-known A3 authentication algorithm. Finally, to give an access to the service, the HLR (or VLR if the mobile is located in a foreign zone) have to check that the SR* and the SR are identical, otherwise, the access is denied [15]. Figure 7 illustrates the authentication process.

Figure 8 illustrates where the main elements of the authentication process located inside the GSM network.

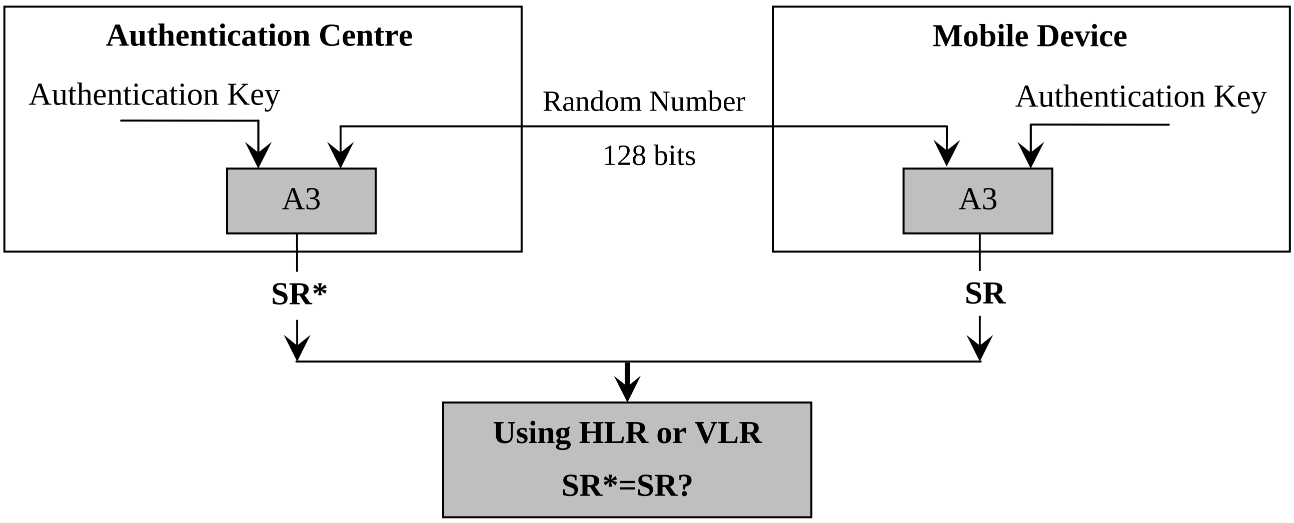

Fig. 7: The Authentication Process

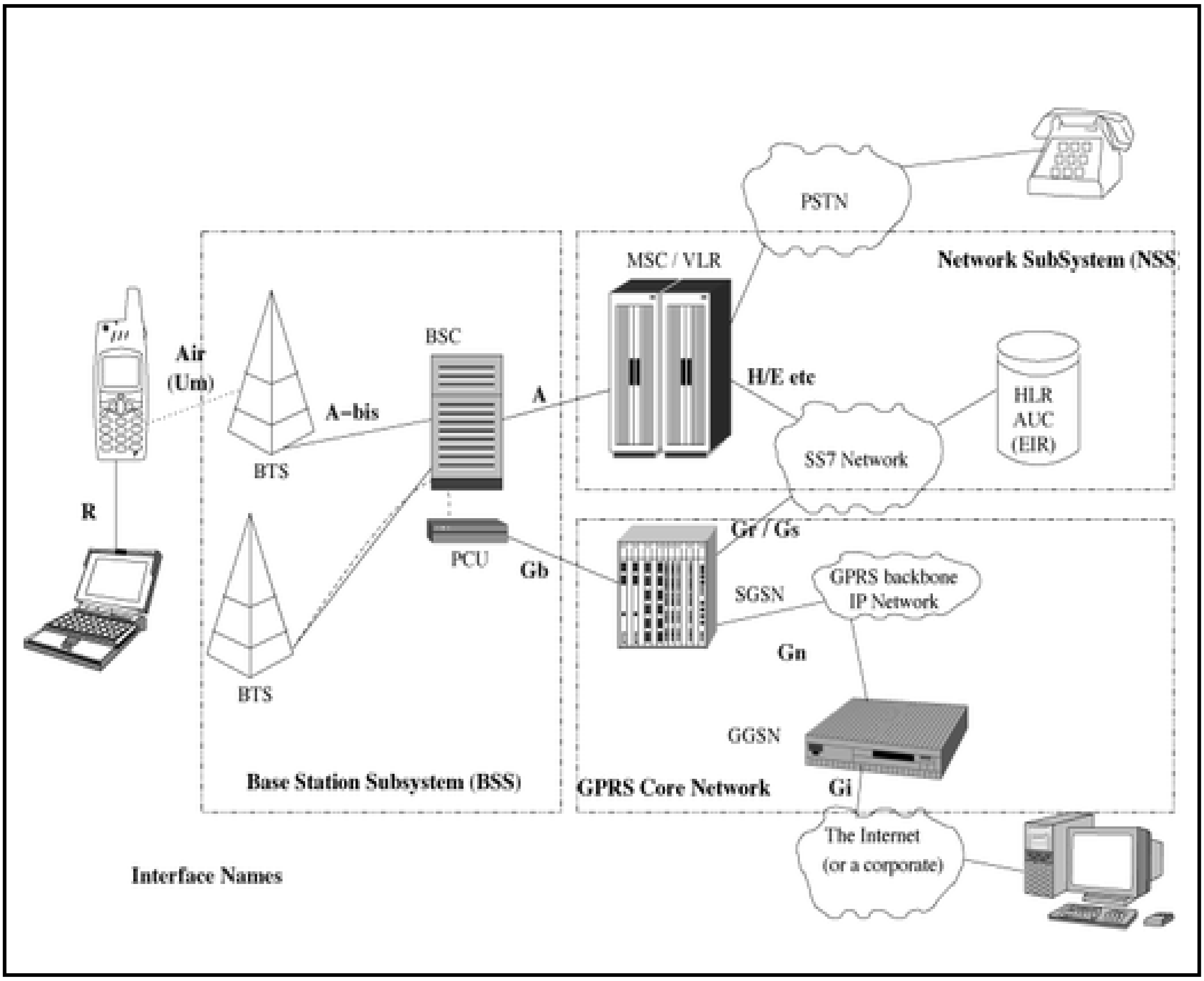

Fig. 8: The Structure of a GSM Network (key elements) [16]

The rest of the algorithm - see Figure 9 for the full algorithm - is constructed by three branches as the following:

First branch is related to the traditional communication approach between mobiles within the same provider. This approach starts with the mobile request and after authentication it goes through channel allocation in the BSC then to MSC_x and when the communication is on the same provider, the way take place to the indicated destination through BSC and BTS.

Second branch is related to the traditional communication approach between mobiles with different providers. This approach starts as the previous one but goes through $GMSC_1$ when the external call (local but not the same provider) is selected and there is no need for satellite link. Then goes to the destination mobile through PSTN, $GMSC_2$, MSC_y, BSC, and BTS.

Third branch is related to new communication approach between mobiles with different PSTN. This approach starts as the second one but it is selected when the communication occurs through satellite link. Then, the information passes through to the sending satellite base station, satellite channel allocation, frame encapsulation, and indicated satellite(s). The information received by the receiving satellite base station to destination mobile through $GMSC_3$, MSC_z, BSC, and BTS.

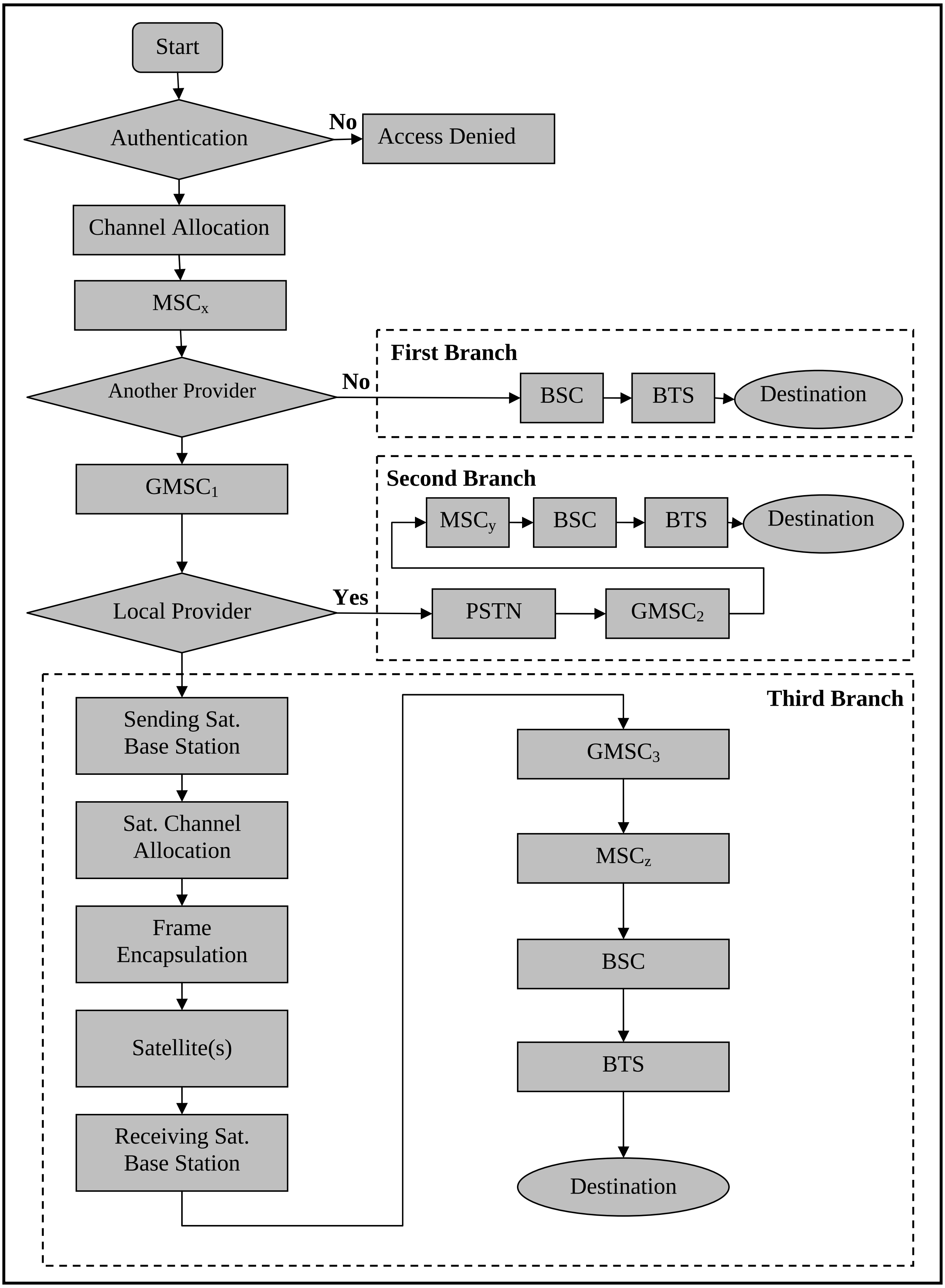

Fig. 9: Proposed communication system algorithm

6 Conclusion

The current researches and industries are looking forward to integrate different technologies to get a global technology that offers all of the intended services in a simple way. In this paper, a new communications system has been proposed to integrate the usage of GSM over the available satellites infrastructures. The proposed communications system could be used to facilitates and get benefits of both systems (the GSM and Satellites) to achieve competitive services over the world. The proposed system has been concentrated on a global communications system that served all over the world and gives some specialization and privacy for each country. Furthermore, this paper showed how to implement the GSM over satellite systems in an efficient, flexible, and cost-effective manner.

The proposed integrated communication system will overcome a set of problems, such as, coverage area, handovers, mobility, bandwidths, and health concern. The proposed system can serve all countries over the world without any limitation taking into account the privacy of each country. However, the only problem that can be raised from the proposed system is the compensation and synchronization between the numbers of satellites that float via the space.

However, the implementation of mobile communications over satellite systems leads to a global efficient and flexible system that offers huge number of adequate services over the world. The proposed system contains numbers and address of calls and information which allows each user to select those corresponding transmissions. The synchronization between satellites including coverage area, handover and frame format must be well-designed to overcome all of the raised problems.

As a future work, the proposed system could be implanted using the GPRS, EDGE, and 3G mobile systems instead of 2G (GSM2) mobile systems.

References:

[1] D. A. Vallado, *Fundamentals of Astrodynamics and Applications*, Microcosm Press, 2007.

[2] M. Ken, Types of Satellites, EzineArticles, Online: *http://ezinearticles.com/?Types-of-Satellites&id=408061*, accessed on May 08, 2008.

[3] United Nations, the world at six billon, Online: *http://www.un.org/esa/population /publications/sixbillion/sixbilpart1.pdf*, accessed on May 08, 2008.

[4] Texas Instruments Incorporated, The next billion mobile phone user, Online: *http://focus.ti.com/pdfs/wtbu/ti_emergingmarkets.pdf*, accessed on May 5, 2008.

[5] M. S. Mazalkova, The system transfering between laser-satellites, *WSEAS Transactions on Communications*, Vol. 7, No. 7, 2008, pp. 152-159.

[6] M. Reyes-Ayala, E. A. Andrade-Gonzalez, J. A. Tirado-Méndez, H. J. Aguil, Analysis of Non-Linear Response in DS-CDMA Satellite Systems, *WSEAS Transactions on Communications*, Vol. 7, No. 4, 2008, pp. 235-241.

[7] L. Nagy, Satellite Communications, Online: *http://ctd.grc.nasa.gov/rleonard/*, accessed on May 8, 2008.

[8] D. Hart, Satellite Communications, Online: *http://www.cse.wustl.edu/~jain/cis788-7/ftp/ satellite_nets.pdf*, accessed on May 8, 2008.

[9] R. D. Briskman, *IEEE Transactions on Broadcasting*, Vol. BC-33, No. 1, 1987, pp. 27-30.

[10] International Telecommunications Union, *ITU Handbook on Satellite Communications*, 3rd ed., Wiley InterScience, 2002.

[11] D. Roddy, *Satellite Communications*, 4th ed., McGraw-Hill Professional, 2006.

[12] B. Gavish and J. Kalvenes, The impact of satellite altitude on the performance of LEOS based communication systems, *Wireless Networks*, Vol. 4, No. 2, 1998.

[13] N. Blefari-Melazzi, M. Femminella and F. Pugini, A Layer 3 Movement Detection Algorithm Driving Handovers in Mobile IP, *Wireless Networks*, Vol. 11, No. 3, 2005.

[14] M. Ibrani-pllana, L. Ahma, E. Hamiti and R. Sefa, Human exposure assessment in the vicinity of 900 MHz GSM base station antenna, *WSEAS Transac tions on Communications*, Vol. 7, No. 4, 2008, pp. 229-234.

[15] J. Schiller, *Mobile Communications*, 2nd Ed., Addison Wesley, 2003.

[16] Wikipedia, GSM, online: *http://en. wikipedia.org/wiki/GSM*, accessed on: May 9, 2008.