Proceedings of the 5th WSEAS Int. Conf. on Signal Processing, Computational Geometry & Artificial Vision, Malta, September 15-17, 2005 (pp188-196)

Simulation for transmitting of MPEG-4 over Satellite Network

S.A.R. AL-HADDAD, MOHD WARDI AZIS, SALINA ABD SAMAD ADUWATI SALI,
ADZNAN JANTAN, ELSADIG AHMED, ABD RAHMAN RAMLI, WAN ZUHA WAN HASSAN
Department of Computer and Communication System Engineering
Faculty of Engineering, Universiti Putra Malaysia,
43400 UPM SERDANG, Selangor,
Malaysia
sar@eng.upm.edu.my

Abstract:- This project was carried out to study the several important effects for the transmission of video bit streams file over the satellite communication systems. This analyze will include the usage of different frequency and satellite altitude or distance of satellite from earth. There are several effects will be analyzed in this project, such as free space loss, propagation delay, transmission delay and coverage area of the satellite systems. The graph will be generated so the analyze can be done. The system will provide facilities like data processing which involves mathematical equations, data display, graph plotting and data from output graph. The system will bring us to the satellite performance analysis, which is important to maintain and improve the quality of the satellite services.

Keyword: -MPEG4, Video, bit streams file, Satellite, transmission delay, communication, and propagation delay

1 Introduction

Mobile satellite communication channels are characterized by long transmission delays, variations of these delays, high bit-error-rates, shadowing and the multipath effect that severely reduce the quality of video services. Error control techniques including feedback mechanism, error concealment methods, forward error correction technique and error resilience schemes are for achieving a high integrity video transmission over a mobile satellite channel. Furthermore, a low-delay and low-complexity video transcoding algorithm that fully interconnects to very low bit rate video communications standard; MPEG-4. This transcoder works as a gateway tool which links two-multimedia networks such as a mobile satellite network and a land-based network, with negligible processing delay and complexity.

Satellite network provide a broad coverage of spatially dispersed areas and remote locations easily, have broadcasting capability and are easy to install irrespective of geographical constraints. They also have intolerable detrimental impacts on the communications *Quality of Service* (QoS), particularly in video communications. Fixed satellite services have considerably high *bit-error-rate* (BERs) and significant long round-trip delays (500 ms for geostationary satellite communications). Moreover, mobile satellite channels are distorted by shadowing, the multipath effect and the delay variations incurred by the propagations effects [1]. The high BER, the shadowing and the multipath effect deteriorate the receive video quality severely, and the delay variations which cause jittering distorts the two-way video communications.

The main reason why MPEG-4 was chooses because its covers a wide range of applications, bit rates, resolutions, qualities and services. MPEG-4 has been developed in response to the growing interest of consumer electronic industries, telecommunication companies, broadcasters and computer enterprises as a new standard for the coding of audiovisual information in multimedia environments. The MPEG-4 standards are to provide a standard in order to cope with the requirements of current and future multimedia applications [2].

Because of the most multimedia applications possess an interactive character, MPEG-4 allows a facilitated access to both natural and synthetic video and audio data called content-based access. MPEG-4 using content-based functionalities makes it possible to access and interact with single objects of the coded scene. Further MPEG-4 offers two new functionalities referred to as robustness in error-prone environments and content-based scalability. These functionalities allow MPEG-4 encoded data to be accessible over a wide range of media and with a various quality in terms of temporal and spatial resolutions. Applications benefiting from these features are wireless communications and database browsing [2]. MPEG-4 also has a better coding efficiency, which improves the quality of coded video and audio. Possible applications of the MPEG-4 standard are Internet video, interactive video games, interactive storage media, content based image and video databases, interpersonal video communications (videoconferencing, videophone), wireless multimedia and others [2].

2.0 Principles of MPEG-4 video

MPEG-4 aims to achieve its objectives by applying certain principles to the way data is represented. MPEG-4 relates to the components that comprise a multimedia scene as media objects. For example, a sound track, animation, video or images are all individual media objects. Media objects can be grouped together to form compound objects. These are the building blocks of multimedia scenes. But these media objects are only one part of an MPEG-4 stream. Additional information that governs how the objects are rendered on the screen and how they are transmitted over networks is also needed. For these purposes, MPEG-4 streams include Stream Description information and Coding information. The Screen Description information describes the relation between the media objects and how they are presented. The Coding information describes how the media objects are linked to the resources that are transmitting the media objects Fig.1 explains the way in which an audiovisual scene in MPEG-4 is described as composed of individual objects. The figure contains compound media objects that group primitive media objects together. Primitive media objects correspond to leaves in the descriptive tree while compound media objects encompass entire sub-trees. As an example: the visual object corresponding to the talking person and the corresponding voice are tied together to form a new compound media object, containing both the aural and visual components of that talking person.

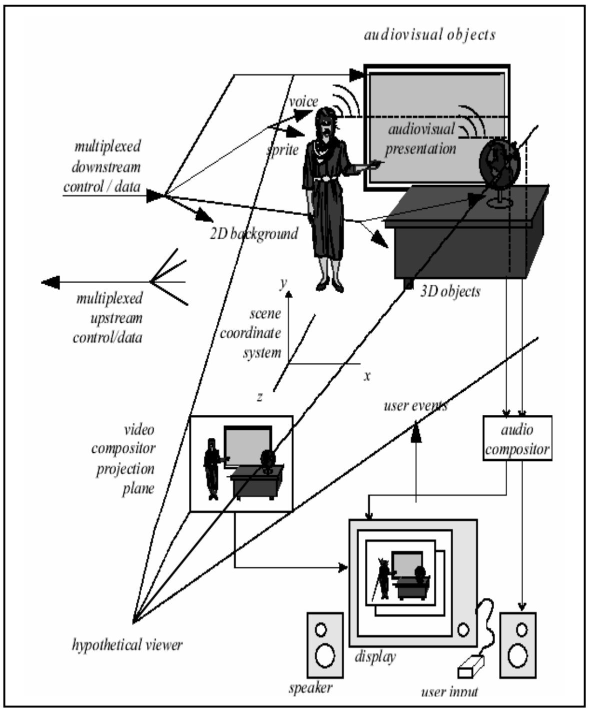

Fig.1: example of MPEG-4 scene

Such grouping allows authors to construct complex scenes, and enables consumers to manipulate meaningful (sets of) objects. More generally, MPEG-4 provides a standardized way to describe a scene, allowing for example to:

- place media objects anywhere in a given coordinate system;
- apply transforms to change the geometrical or acoustical appearance of a media object;

- group primitive media objects in order to form compound media objects;
- apply streamed data to media objects, in order to modify their attributes (e.g. a sound, a moving texture belonging to an object; animation parameters driving a synthetic face);
- change, interactively, the user's viewing and listening points anywhere in the scene.

2.1 Architecture of MPEG-4

The MPEG-4 Standards comprises several core parts:

- *MPEG-4 Systems*. This part of the standard describes scene description, multiplexing, synchronization, buffer management and protection of intellectual property.
- *Delivery Multimedia Integration Framework (DMIF)*. This part of the standard defines rich media streaming [see figure 2.2].
- *MPEG-4 Visual*. This part of the standard specifies the representation of natural and synthetic visual objects.
- *MPEG-4 Audio*. This part of the standard specifies the representation of natural and synthetic audio objects *(see fig. 2)* [3].

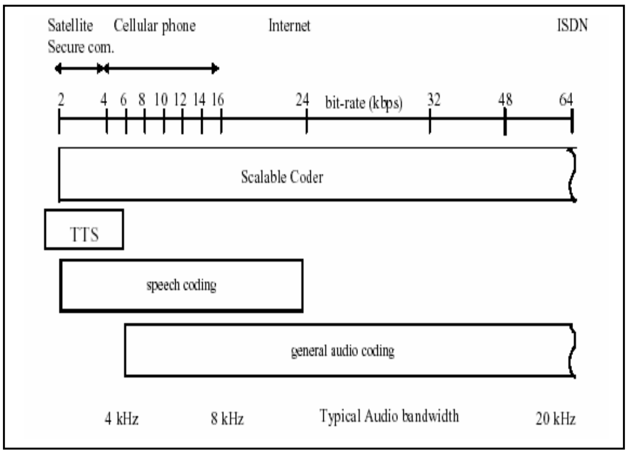

Fig. 2: Block Diagram of MPEG-4 Audio

2.2 Satellite

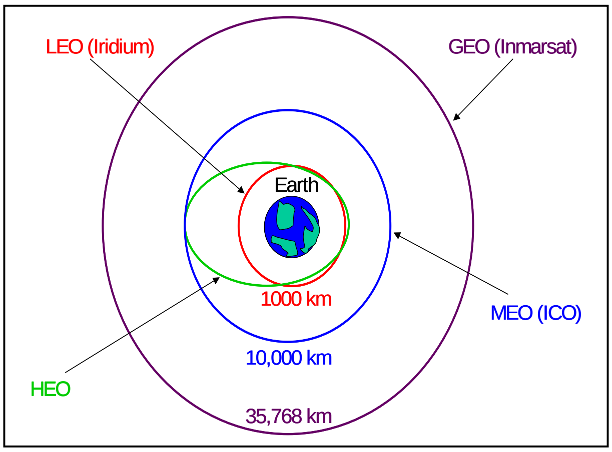

Fig. 3: Orbit of different satellite

Satellites can be classified according to their orbital altitude from earth. Accordingly, satellites have been conveniently classified in three categories:

- Low-Earth Orbit Satellites (LEO)
- Medium-Earth Orbit Satellites (MEO)
- Geosynchronous Satellites (GEO)

LEO satellites are normally military reconnaissance satellites that can pick out tanks or armored cars from 500 to 1000 miles above the earth. The typical round-trip propagation delay between earth and a LEO satellite is 20-30 msec due to the relatively short distance. In recent years, the use of LEO satellite networks has increased due to their ability to provide global coverage for mobile and personal communication users. The lower altitude of LEO satellites allows improved power budgets especially for handheld terminals where the transmitted power is especially constrained. Furthermore, the short propagation delays in LEO satellites allow real-time connections to use the satellite network.

The disadvantages of LEO satellites are the increased system complexity and the short line-of-sight (i.e., smaller coverage spot). LEO satellites constantly have to rotate around the earth to preserve their altitude. Thus, increased system complexity is required to manage the handover of a section of earth from one LEO satellite to another. Moreover, the earth stations must have mobile antennas to track the position of the satellite [4].

The summaries of *Low Earth Orbit* (LEO) satellite are as below [5]:

PRO:

- The transmission delay associated with LEO system is the lowest of all the other systems.
- Because of the relatively small size of the satellites developed and the smaller size of the ground equipment required, the LEO systems are expected to cost less to implement than the other satellite systems.

CONS:

- The small coverage area of a LEO satellite means that a LEO system must coordinate the flight paths and communications hand-offs a large number of satellite at once, making the LEOs dependent on highly complex and sophisticated control and switching systems.
- LEO satellites have a shorter life span than other systems. There are two reasons for this: first, the lower LEO orbit is more subject to the gravitational pull of the earth and second, the frequent transmission rates necessary in LEO systems means that LEO satellite generally have a shorter battery life than others.

2.3 Handover

Satellite handoff modeling is a key component of LEO satellite network simulations. It is difficult to predict exactly how handoffs will occur in future LEO systems because the subject is not well treated in the literature. In these satellite extensions, we establish certain criteria for handoffs, and allow nodes to independently monitor for situations that require a handoff. An alternative would be to have all handoff events synchronized across the entire simulation- it would not be difficult to change the simulator to work in such a manner.

There are no link handoffs involving geostationary satellites, but there are two types of links to polar orbiting satellites that must be handed off: GSLs to polar satellites, and crossbeam ISLs. A third type of link, interplanes ISLs, is not handed off but is deactivated at high latitudes [6].

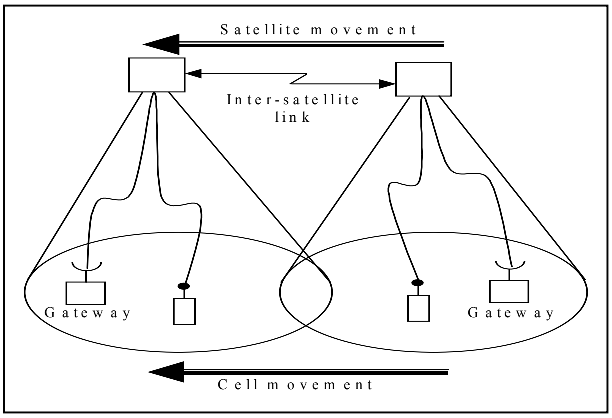

Fig. 4: Handover when moving to other cell

Research in LEO satellite has been providing successful handover to users as they transition from one satellite's coverage area to the coverage area of another. In an analytical model has been proposed for modeling handovers of the users between satellites that are in the same orbital plane [7]. However, only uplink access has been considered (single hop scenario) and rerouting on the LEO constellations, which might needed due to these handovers, has been ignored.

In handovers between the satellites in adjacent orbital planes are also considered for a single hop scenario [8]. However, multi-hop communications is necessary in mobile satellite networks since different satellites might cover different users. The multi-hop satellite routing problem has been addressed in with an emphasis on setting up routes between pairs of satellite to minimize the re-routing frequency [9]. The need for re-routing arises from the fact that, often, no user pair can be serviced by the same satellite end nodes for the complete call duration. In route optimization was performed for the routes between two satellites [9]. Realistically, the optimizations is needed for the route between two ground terminals, since the handover between the ground terminals and the satellite results in changing satellite nodes for the connections.

From figure 4, LEO satellite takes less than two hours to orbit the Earth, which means that a single satellite is "*in view*" of ground equipment for a only a few minutes. As a consequence, if a transmission takes more than the few minutes that any one satellite is in view, a LEO system must "*hand off*" between satellites in order to complete the transmission. In general, this can be accomplished by constantly relaying signals between the satellite and various ground stations, or by communicating between the satellites themselves using "inter-satellite links."

LEO systems are designed to have more than one satellite in view from any spot on Earth at any given time, minimizing the possibility that the network will loose the transmission. Because of the fast-flying satellites, LEO systems must incorporate sophisticated tracking and switching equipment to maintain consistent service coverage. The need for complex tracking schemes is minimized, but not obviated, in LEO systems designed to handle only short-burst transmissions [10].

2.4 Propagation delay

The data transmitted by the sources in satellite communication system is subject to propagation delay. The main cause of propagation delay is the large distances in space compared to typical terrestrial links. The atmosphere also causes delay in data transmission. Large distances and other factors between a ground station and a GEO result in a typical Round Trip Time (RTT) of 260ms. Similarly, data transfer between a ground station and LEO results in RTT of 10-30ms and with MEO in about 100ms [11].

For a LEO satellite the round-trip delay is 20–25 ms, which is comparable to that of a terrestrial link. Since LEO satellites are closer to the Earth's surface, the necessary antenna size and transmission power level are much smaller; but their footprints are also much smaller. A constellation of a large number of satellites is necessary for global coverage. The lower the orbit altitude, the greater the number of satellites required. In addition, since satellites travel at high speeds relative to the Earth's surface, a user may need to be handed off from satellite to satellite as they pass rapidly overhead. Therefore, steer able antennas are crucial to maintain continuous service [12].

3.0 The calculations

There are a few calculation involve such as Free Space Loss, Propagation Delay, Transmission Delay and Coverage Area.

3.1 Free space loss

Free space loss [13] is calculated using the formula as below:

$$\text{Free Space Loss} = 20 \log [4\pi R / \lambda]$$

$$\lambda = c / f$$

Where: c = speed of light
f = frequency
R = satellite altitude / distance

For free space loss, the parameter that can be change is the frequency and satellite altitude. These parameters are used in order to get the expected graph. There are many other parameters that include in the consideration such as acceptance angle, waiting time, handover and delay.

3.2 Propagation delay

Propagation delay [14] is calculated using the formula as below:

$$\text{Prop. Delay} = \frac{\text{Satellite Altitude}}{\text{Speed of Light}}$$

For this formula, the only parameter that can be change is the satellite altitude because the speed of light is fixed that is 3 x 10^8 m/s. The satellite altitude for LEO satellite systems is between 320 km to 800 km.

3.3 Transmission delay

Transmission delay is calculated as the following equation:

$$\text{Delay} = \frac{1}{c}\left[\left((R+h)^2 - R^2\cos^2\theta\right)^{\frac{1}{2}} - R\sin\theta\right]$$

Where: R = radius of earth
θ = elevation angle
c = speed of light
h = distance from earth

3.4 Coverage area

The *coverage area*, A, of a single satellite system is given as below:

$$A = 2\pi R^2(1-\cos\theta)$$

Where: R = radius of the earth
θ = earth central angle

The earth central angle, θ, is calculated using the equation below where *R* is radius of the earth, *E* is the minimum elevation angle and *h* is the satellite altitude **[14].**

$$\theta = \left[\cos^{-1}\left(\frac{R\cos E}{R+h}\right)\right] - E$$

4.0 Result and discussion

4.1 Free space loss vs. frequency

The graph shows the numerical result of free space loss versus frequency. We can see that the free space loss experiences significant decreases as frequency increases. This is because during the transmission of video over satellite, when we using low frequency, the possibility of transmission will be loss is high compare to when we use the high frequency. Normally, frequency for uplink is greater than frequency for downlink. This is because, more power frequency is needed to transmit the data to the satellite located hundred kilometers from the earth but it is only need low frequency to download to earth.

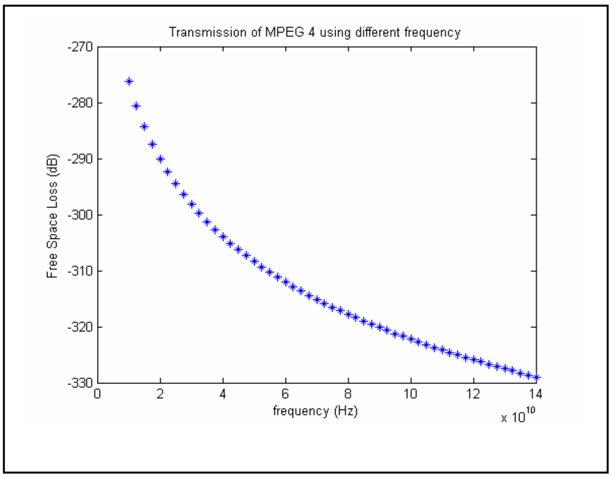

Fig. 5: free space loss vs. frequency

4.2 Free space loss vs. distance

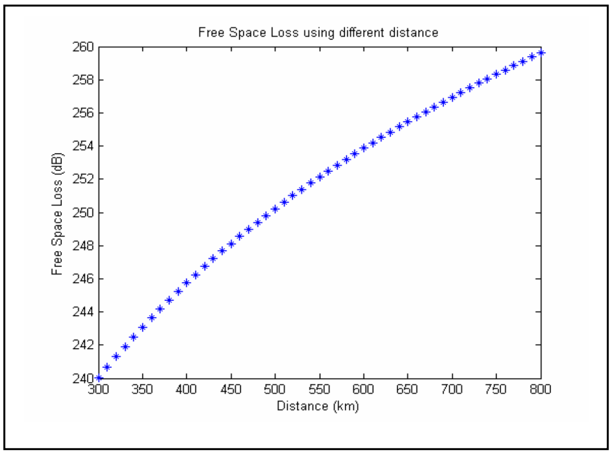

Fig. 6: free space loss vs. distance

If we refer to equation in 3.1, we can see that if we change the satellite altitude or distance, the free space loss also will change. Since LEO satellite systems operates in the distance between 320 to 800 kilometers, so the distance must be choose is as low as possible in order to minimize the free space loss.

4.3 Propagation delay vs. altitude

Referring to fig. 7, it shows the graph for propagation delay versus satellite altitude or distance from the earth. As we can see, the propagation delay (in dB) increases steadily as the satellite altitude increases. This phenomenon shows that, the higher satellite altitude from earth, the higher propagation delay occur during the transmission. Since LEO satellite system has the altitude between 300 km to 800 km, the propagation delay is still small compare to other satellite systems such as MEO or GEO that have the satellite altitude more than thousand kilometers.

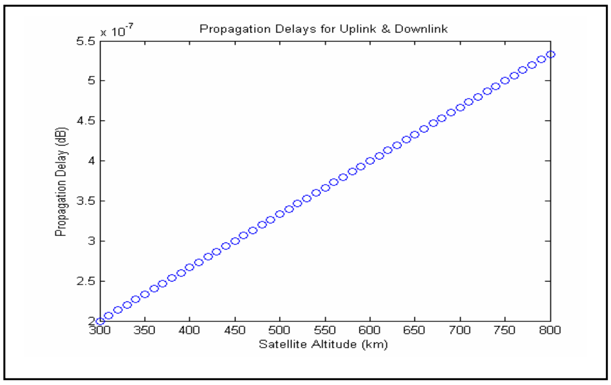

Fig. 7: propagation delay vs. altitude

From equation in chapter 3.2, it also shows whenever the incremental/decremental of the satellite altitude, it will influence the incremental/decremental of the propagation delay. The other parameter which is speed of light, it not influence the calculation since it has the fixed value.

4.4 Transmission delay vs. distance

From fig. 8, it shows graph for transmission delay versus the distance from the earth. The transmission delay (in dB) increases steadily as the distance from earth increases. From the graph, we can conclude that the higher distance of satellite from earth, the higher transmission delay occurs. Compare to other satellite systems, this transmission delay for LEO satellite systems still low since it operates in distance 320 km to 800 km. This result seems to be same as graph propagation delay versus satellite altitude. It is obvious that delay increases as *h* (distance between satellite and earth) increases.

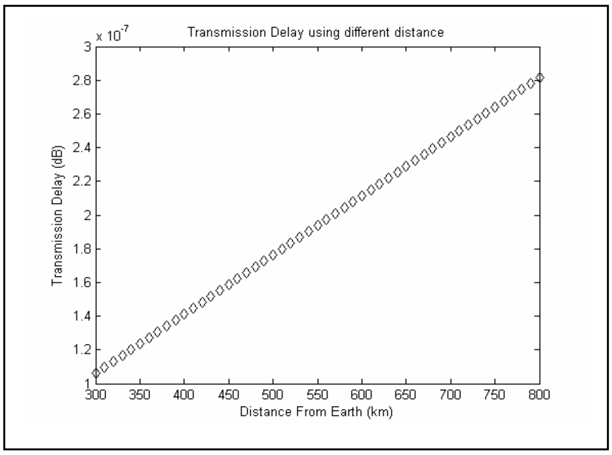

Fig. 8: transmission delay vs. distance

Referring to equation in chapter 3.3, it obviously shows that increasing the distance between satellite and earth will increase the transmission delay

4.5 Coverage area vs. altitude

Referring to figure 9, it shows the graph for coverage area versus satellite altitude. The graph show that the increasing of coverage area when the increasing of satellite altitude. This is because, the higher satellite altitude, the spotbeam for its coverage also become bigger. In order to cover the larger scale of coverage area, the satellite altitude must me as high as possible but must not greater than LEO satellite altitude because we want to avoid the higher transmission delay and propagation delay as well as free space loss.

Equation in 3.4 will show the detail of considerate parameter in the formula. Since the radius of the earth, elevation angle and earth central angle are fixed, the only parameter change is the satellite altitude

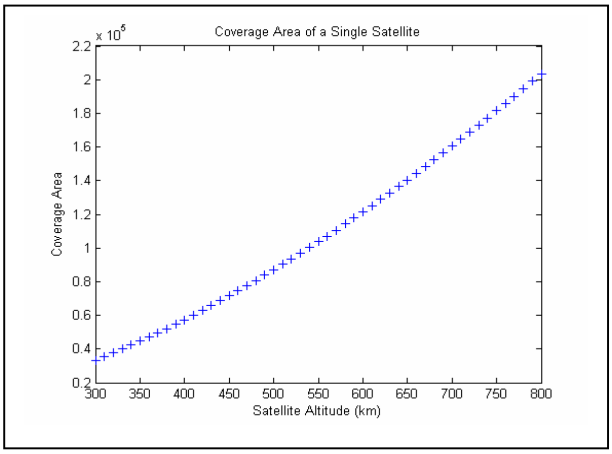

Fig. 9: coverage area vs. altitude

.

5.0 Conclusion

This project has been designed using MATLAB 7.0 Programming Language to develop and analyze a graph on the project entitled *Transmission of MPEG 4 Over Satellite Network*. From the project, we know that there are many effects that influence the transmission of video bitstreams file. Those effects that are involved are such as free space loss, transmission delay, propagation delay and coverage area.

For free space loss, we can conclude that by using the high frequency, we can reduce this loss but this reducing only can be success if the distance between satellite and earth station is near. Besides, in order to reduce the transmission delay and propagation delay, the distance or satellite altitude also must be as low as possible, so the reducing of these delay will success. Furthermore, we also want the coverage area for this satellite is as large as possible because the higher satellite altitude, the larger spotbeam that we can get. But this satellite altitude must no greater than LEO satellite system whereas we also can increase the transmission delay, propagation delay and the free space loss.

In the software development, MATLAB offers many more features and it is more multifaceted than any other calculator. MATLAB is a tool for making mathematical calculation. It is a user-friendly programming language with features more advanced and much easier to use than other computer language such as Pascal, C or C++. It provides a rich environment for data visualization through its powerful capabilities.

Based on the overall result, the aims of this project have been achieved. However, for the future development, maybe it could be done with other video bitstreams file format such as MPEG-7 or H.264.

References:

[1] Evans BG (ed.). *Satellite Communications Systems* (2nd edition). Peter Peregrinus Ltd: Exeter, England, 1991

[2] Microsoft (2004), *4Stream MPEG4*, Microsoft Corporation, http://www.4stream.de/frames/main/mpeg4.htm

[3] Microsoft (2004), *White Paper MPEG4*, Microsoft Corporation, http://www.inspot.com/users/gitano/LaurentW/MPEG4White20Paperv-2lw.html

[4] AKYILDIZ and JEONG (1997), *Satellite Systems*, Prentice Hall.

[5] Microsoft (2004), *Introduction to Global Satellite Systems*, Microsoft Corporation, http://www.compassroseintl.com/pubs/Intro_to_sats.html

[6] Microsoft (2004), Nikos Drakos, CBLU, University of Leeds, February 19th, 1998. http://www.isi.edu/nsnam/ns/doc-stable/node166.html

[7] F. Dosiere, T. Zein, G. Maral and J.P. Buotes. "A model for a Handover Traffic in Low Earth Orbit (LEO) Satellite Networks for Personal Communications," *International Journal of Satellite Communications*, 11: 145-149, 1993

[8] E. Del Re, R. Fantacci and G. Giambene. "Handover Request Queuing in Low Earth Orbit Mobile Satellite Systems," *Proceedings of the 2nd European Workshop on Mobile/Personal Satcoms*, p.p. 213-232, 1996.

[9] M. Werner, C. Delucci, H. J. Vogel, G. Maral and J. J. De Ridder. "ATM-Based Routing in LEO/MEO Satellite Networks with Inter satellite Links," *IEEE Journal on Selected Areas in Communications*, 15(1): 69-82, Jan. 1997.

[10] Microsoft (2004), *Introduction to Global Satellite Systems,* Microsoft Corporation, http://www.compassroseintl.com/pubs/Intro_to_sats.html

[11] Alexander Keller, Munich University of Technology, "Towards CORBA-based Enterprise Management: Managing CORBA-based Systems with SNMP Platforms", *Proceedings of the Second International Enterprise Distributed Object Computing Workshop*, EDOC'98, San Diego, CA, USA: Munich Network Management Team, November 1998.

[12] Yurong Hu and Victor O. K. Li, The University of Hong Kong, "Satellite-Based Internet: A Tutorial," *IEEE Communications Magazine*, March 2001.

[13] Leon W. Couch, II, *Digital And Analog Communication System,* 6^{th} edition Prentice Hall

[14] Stephen R. Pratt, Richard A. Raines, Carl E. Fossa Jr., and Michael A. Temple, *An Operational and Performance Overview of the IRIDIUM Low Earth Orbit Satellite System,* Department of Electrical and Computer Engineering, Air Force Institute of Technology.