TRENDS IN E-LEARNING SERVICES DELIVERY VIA CURRENT SATELLITE SYSTEMS

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ABSTRACT

This paper presents some of current trends of the development of next generation satellite systems as an access network within NGN converged networks by analyzing satellite e-learning (e-consulting and e-collaborative work) aspects. Attention is aimed on the interactive (two-way) broadband satellite services based on IP. This paper provides the non-specialist reader with an overview of the opportunities offered by recent developments in satellite technology for education. It includes an overview of current and expected services. It also provides a general guide for those interested in setting up and using such systems in an educational context in terms of the way in which they can and should be deployed.

Keywords: *e-learning, e-consulting, e-collaborative work, DVB, NGN, satellite systems, broadband*

1. INTRODUCTION

In recent years the explosive growth of Internet and, in parallel, the success of second-generation mobile cellular systems with an exponential number of users propose a new interesting trend [1-15].

The interoperation between satellite systems, the existing and future mobile communication systems and the existing terrestrial infrastructures, Internet first of all but also ISDN, ATM and NGN, introduces the needs of new multimedia hybrid services that span different network technologies. High speed and high quality multimedia services are therefore expected with different quality of service (QoS) requirements. New multimedia applications including high-speed Internet, IP multicast, distance education (e-learning) and telemedicine require higher and flexible data rate and two-way communications [7-9]. The interactive channel for multimedia satellite networks (ICMNS) was under standardization by ETSI with forward link based up to 45 Mb/s and a return link using a multifrequency-time division multiple access (MF-TDMA) scheme providing between 144 kbps and 2,048 Mbps [9-14].

Communications for E-learning services, a typical asymmetrical application, can be categorized as follows [1,4,7].:

1. Broadcast type communications, by which the students can received the lectures in wide areas also directly to own home,
2. Interactive communications: based on videoconference it allows two-way communication from students and teacher and vice versa. The students and the teacher can interact remotely such as they were in the same class-room. The teacher can control the students, can formulate questions or propose tests that must resolve on line,
3. Self-learning, in which the students can retrieve materials remotely.

The satellite Channel via satellite (DVB-RCS) standard industry has embraced the DVB return. This forms the specification for the provision of an interaction channel for satellite networks with fixed return channel terminals. DVB-RCS builds the platform for high-speed networks supporting all Internet broadband services and allows for cost efficient satellite transmit and receive links [9-10,14-15].

Network convergence is a multi-faceted phenomenon that means different things to different people. However, everyone agrees that this phenomenon is real, is happening and potentially impacts all businesses. By network convergence we mean the integration of several media applications (data, voice, video, images) onto a common packet-based platform provided by the Internet Protocol (IP). The global Internet is becoming such a true multi-service infrastructure. This environment of global Internet offers the new opportunities from viewpoint of services and applications inclusive of whole spectrum of e-services and application. E-learning, e-consulting and e-collaborative work obtain new dimension, new flexibility as well as from viewpoint of transport rate and as the possibility to enhance the multimedia level of e-learning, e-consulting and e-collaborative work and as from on line interactive approaches. Converged networks guarantee QoS. The effective and optimal converged technology use assumes new methods/methodologies and pedagogical approaches, which will be used for the e-learning, e-consulting and e-collaborative work. The difference approaches, methods and methodologies will be used for application of e-learning in respect of forms (face to face, distance, blended), levels (elementary school, secondary school, university, long life learning, self learning) and education purpose (retraining scheme, input course, courses for the new technology application [2,3,5-6].

The paper presents some of current trends of the development of next generation satellite systems as a access network within NGN converged networks by analyzing satellite e-learning aspects [12-15]. This paper provides the non-specialist reader with an overview of the opportunities offered by recent developments in satellite technology for education. It includes an overview of the current and expected services. It also provides a general guide for those interested in setting up and using such systems in an educational context in terms of the way in which they can and should be deployed.

2. SATELLITE COMMUNICATION

Satellite services can be at the disposal at any place on the Earth where there is direct visibility of the satellite. The direct visibility of the satellite is inevitable due to the type of radio wave propagation at frequencies used in satellite communication. Satellites with their typical feature of signal distribution together with current minimalization of costs are very suitable for the data distribution, television and radio programmes to thousands of viewers (e.g. terrestrial stations). The provision of communication services through satellite technology can be an alternative in regions without existing communication infrastructure or with weak terrestrial communication infrastructure of it can serve as a back-up in case of problems with primary communication system. For the satellite station installation on the user side only very little time is needed (ordinarily several minutes) and no slow planning is necessary. Satellite systems are rather resistant to natural disasters (e.g. earthquake) and in case of damage to the station it is possible to reestablish the operation in almost next to no time. Another advantage of the satellite technology is the possibility of the service providing on geographically vast areas, which also offers the possibility of mobile service providing. However, there are some disadvantages connected with the satellite service providing. The operation of the satellite communication system requires high initial costs. The satellite maintenance (space segment) is very complicated and quite often practically impossible. The satellite transmission through the links in many cases results in long time delay and sometimes the variation is noticeable as well. The quality of the satellite link is degraded by several factors (e.g. rain damping, depolarization, interference), which have to be taken into account in designing and operating of the satellite communication system [2,3,9,22-27].

The Fig. 1 shows the basic parts of the satellite communication system. The satellite communication system consists of the terrestrial and space segments.

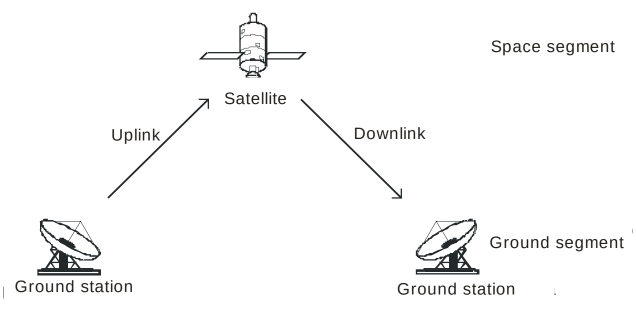

Fig. 1 The basic parts of the satellite communication system

The transmission link from the terrestrial station to the satellite is called up-link and the link from the satellite to the terrestrial station is called down-link.

The space segment consists of the satellite and all the terrestrial parts serving to satellite control and monitoring. The satellite is composed of *Payload*, which consists of antennas and electronics promoting signal transmission (communication subsystem) and *Platform*, which consists of subsystems enabling operation of the payload, e.g. an electrical energy supply, a driving system, a thermoregulatory system.

The terrestrial segment consists of all the terrestrial stations, which are usually connected to devices of the users. Some of the stations can function as both a transmitter and a receiver, some only either as a transmitter or a receiver. Depending on the mobility, we can talk of fixed, mobile and movable stations.

The basic parameters of the satellite system, which need to be taken into account in the communication services provision, are:

- The type of orbit,
- The frequency bandwidth used in communication,
- The type of coverage,
- The payload of the satellite,
- The access method.

The orbit is a trajectory on which the satellite moves in the balance of forces that affect it (e.g. the attractive force of the Earth's gravity and the gravity of other planets, centrifugal force originated by curvature of the satellite trajectory, the force originated by the solar radiation and aerodynamic force).

According to the height of the orbits the satellite systems can be divided into LEO, MEO, GEO and HEO (Fig. 2 and 3).

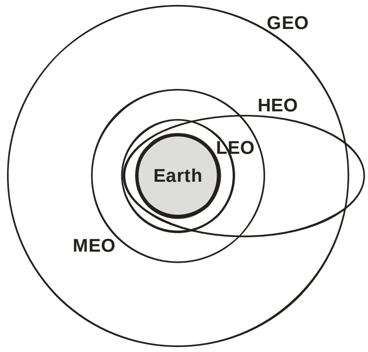

Fig. 2 The example of shapes and sizes of various types of orbits

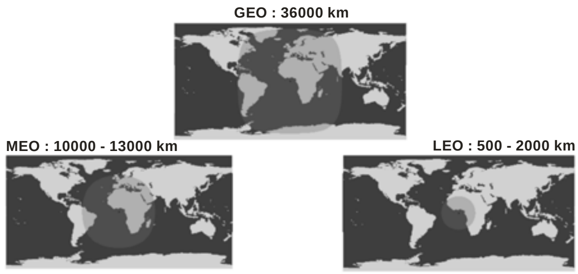

Fig. 3 The area of coverage and the height of orbits of individual satellite systems

Broadband satellite networks are becoming an important segment of the global communication infrastructure, due to their wide geographical coverage and configuration flexibility. They provide seamless integration of applications and services that have traditionally been available via terrestrial networks. With respect to the latter, satellite networks present two main problems: the round trip delay (250-280 ms for geostationary satellites), which heavily affects the real-time transmissions, and the effects of the bad weather conditions in transmissions in the Ka frequency band. In fact, in the Ka band (18-31 GHz) and above, all the atmospheric effects due to clouds, oxygen, water vapor, turbulence and rain must be considered, but the combined effect of these factors is not easily statistically predictable. Fade countermeasure techniques must be developed for guaranteeing an acceptable quality of service of the transmitted data even in faded conditions [22-27].

Satellite broadband connectivity has never been considered seriously, as long as it did not allow for interactivity. However, nowadays satellites can provide interactivity via either the satellite return channel or by using a hybrid solution with narrow-band return path via a telephone line [2,5,7].

3. E-LEARNING SERVICES BASED ON TWO-WAY SATELLITE BROADBAND INTERNET CONNECTION

Broadband access for end-users is usually considered a 'wired' solution: fiber optic backbones, cable modems on coax, xDSL and ISDN on twisted copper. ADSL can only be provided up to a distance of between 4 and 6 km from the local telephone exchanges, depending on various factors. The cost to upgrade the existing copper network is very high. This means that many households, particularly those in rural and remote areas, will probably never be able to receive ADSL. Similarly, the cost of laying bi-directional cables for interactive TV and Internet means that cable distribution is also unlikely to be available to those living in small towns or in the countryside.

Satellite has the capability to reach everywhere, thus effectively removing local loop difficulties, especially in areas with poorly developed infrastructure. The subscriber requests (e.g. the click on a hyperlink in a web page) can still be routed through terrestrial telephone lines, but the downloaded data can now be routed via satellite directly to the Earth station of the end-user. The typical asymmetry of home and small business Internet use opens up the possibility of using a slow, small pipe in one direction and a fast, wide pipe in the other. The average user does not need in-bound high-bandwidth connectivity around the clock and needs even less out-bound high-bandwidth. So the hybrid of high-speed satellite for in-bound matched to a low-cost, low-speed request path may well be the most cost-effective solution. Using phone lines and a satellite downlink path means that you don't pay for more technology than you need.

Regular and high-quality access to educational resources, centers of excellence, leading experts and lively peer groups is a pre-requisite for the development of e-learning programmes, regardless of where you live or study. Such access depends to a certain extent upon the available networks, their speed and reliability and how much it costs to run them.

One key technology that holds great promise is satellite communication. Important innovations are taking place throughout the satellite industry that are leading us more and more along the path towards low cost two-way satellite services bypassing the need for expensive cabling. Such services can offer near instantaneous high-quality access to digital information. However, much needs to be done and understood about these kinds of services before they can play a more significant role in education environments. Issues of availability, reach, network design, cost and authorization, all have to be tackled and understood, both by potential service providers and potential users. It is important that the potential and implications of satellite communication are understood in the education world in order to influence the way in which services are made available and also to benefit early on from the exciting opportunities they offer.

To conclude, the advantages of two-way satellite Internet connectivity for end-users include:

- Reception is possible with a small antenna (one already in use to receive TV can, in many cases, be sufficient but may require adaptation),
- Connection is possible almost anywhere instantly within the footprint of the satellite, with no cabling work or delays dependent on terrestrial infrastructure, thus effectively solving the typical 'last mile' problem,
- Consumer equipment is relatively low cost,
- Internet connectivity can be combined with traditional broadcast technologies such as digital TV and radio, enabling content providers to select the most appropriate delivery means for particular content,
- In addition, multimedia push services via satellite, such as data broadcasting or information streaming, are extremely efficient. In these cases, there is no need for a return link via modem, so there is no additional cost for connectivity to the Internet.

Some of the main disadvantages include:

- Satellite Internet is generally more expensive than terrestrial access solutions, at least in regions where they are available,
- The outdoor unit (antenna and cabling) are more prone to vandalism and weather conditions,
- Bandwidth availability is somewhat limited,
- Requires professional support,
- Not the ideal technology for videoconferencing.

Satellites have been used to provide a telecommunication highway and for TV broadcasting since the start of the space age. The role of satellites will change in the medium and long terms, opening up new roles and markets, including Broadband Internet access, first for business users, then for the general consumer, via transparent satellites, and in the longer term, with regenerative satellites; as an add-on to future UMTS networks, satellites will provide high capacities on the forward channel for multicasts (S-DMB system); collective satellite mobile systems will provide high bit rate communications on trains, aircraft and ships; and satellites will provide accurate handset location functions for use by location-based services.

4. BASICS TRENDS IN BROADCAST / MULTICAST SERVICES DELIVERY VIA THE SATELLITE DIGITAL MULTIMEDIA BROADCASTING SYSTEM

The Satellite Digital Multimedia Broadcasting System (SDMB) architecture (Figure 4) combines geo-stationary satellites and terrestrial repeaters to provide mobile network operators with a cost-effective solution that increases the point-to-multipoint transfer capacity over their whole mobile network coverage [2,6,7,12,15,20]. Being effectively a content delivery network oriented towards the mobile users, the system features inherent broadcast and multicast transfer capability over a wide coverage, favoring content distribution to large, spatially distributed audiences.

The expected system will operate in the IMT2000 frequency band allocated to Mobile Satellite Systems (MSS), which is directly adjacent to the IMT2000 allocated to the terrestrial mobile network. The use of dedicated radio resources enables the SDMB system to carry the most cumbersome traffic and consequently contribute to the reduction of the mobile network congestion.

Satellite systems are also expected to play a significant role in 3G services delivery to end customers. At first, it is important to select the most suitable services, which can be delivered by satellite efficiently. Multimedia services deployed for mobile terminals will be a subset of all fixed network multimedia services. This is mainly due to limitations that are intrinsic to mobile networks with respect to fixed networks (available bandwidth, quality of service, etc.). Services, which are most efficiently delivered by S-UMTS, are those where the satellite network capabilities are more suitable and advantageous compared to those of terrestrial mobile networks [5,11,18].

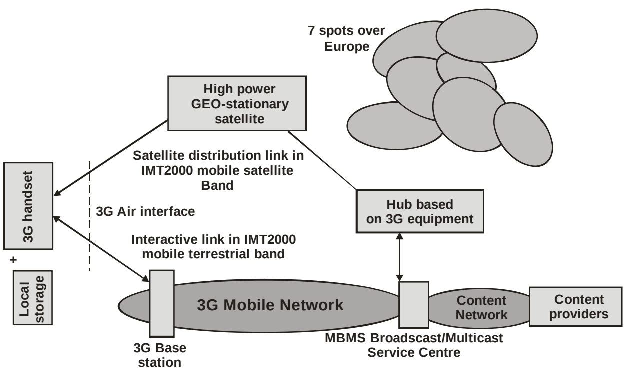

Fig. 4 The SDMB system architecture

All services targeted by the SDMB systems share the content delivery concept, in that they deliver the same content to many users. However, the network services within Mobile Digital Broadcast Satellite (MoDiS) [6-8] have been divided into two categories, content delivery and peer-to-peer (P2P) services, with regard to the originating point of the content: the originating point for the content delivery service is the content server and for 2P is the end terminal. P2P in SDMB, is not the same as in the Internet. The P2P term is used to indicate applications where the users are not only receivers of information, as in the content delivery service, but can also produce and send content to their peers.

In the SDMB system, all the services come under the push service category since there is no one-to-one correspondence between the single user request (via Internet) and the delivery of content. Push services deliver their contents one-way to mobile phones based on end user subscription criteria or criteria determined by an operator. Push messages can include information like headline news, mail arrival notifications, alarming, weather forecasts, stock quotes, and advertisements.

5. SDMB APPLICATIONS

5.1. Push-and-store applications

On-demand-content, such as MP3 audio, video clips, movies, mobile games and entertainment are potential applications for mobile users in particular when broadband bearers with wide coverage are available. ‘WebCasting’ may be the base application for an Internet user. The desire of a mobile user is to have the same quality and functionality for Web Browsing as on a stationary PC. Mobile devices offer usually reduced bandwidth and fewer browser functions than a powerful home-PC system. A realistic goal in mobile environment is to integrate a small web browser that is able to display HTML pages to the user and offers as much Web-typical functionality as possible.

Entertainment-related applications include pre-stored audio on demand (music and radio) and video on demand (movies, video clips) as well as software delivery (games, ring tones, animated images).

Infomation-related applications refer to the distribution of regional or national information of common interest to the mobile users cache. The user navigates through the applications without a return channel. The content may be filtered and pre-selected according to the users preference, the location and the situation before it is presented to the user. The information transmitted can be categorized into two information classes and they are listed below.

“Basic” information (text): Traffic information, tourist information, finance, news, public information (security, ...), job offers, weather forecast, horoscope, classified adds.

“Rich” information (audio, video, image & text): sport (video clip showing a goal during a football game), video document for news, Personalised information portal: based on DMB cache and filtering capabilities.

Webcasting is another important application. A significant number (i.e. top 1000) of Internet pages is transmitted via the broadcast satellite link to the end users’ cache. Missing pages can be delivered on request via the cellular mobile network. This combination ensures a quick Internet access also in a vehicular environment with the possibility of access to individual sites not included in the top 1000. The result is a service that offers mobile access to fixed ISP services with near-wireline transmission quality and functionality. It includes full Web access to the Internet as well as streaming video/audio capabilities. Possible variations of the application include the replication of famous sites, also in-car, shopping gallery sites, mobile professional portals [2,6,12, 15-21].

5.2. Streaming applications

Typical examples are audio and video broadcasting/multicasting of live events (e.g., sports events etc.), access to a live web-camera, or “web-TV”, real time data update. The data rate for the transmission of video files depends on the display size of the terminal and on the frame rate of the video system (picture size and quality). The European PAL-Norm uses 768 times 576 pixels with 50 frames per second, which means about 25 Mbit/s to provide an optimal TV quality, which is definitily too high for mobile communication. To reduce the data rate, the video signals are compressed and encoded. MPEG-4 encoding will be preferred in this context [7,8,12,15].

5.3. SDMB peer-to-peer applications

The combination of a number of application components can create a powerful tool to fulfil most of the user requirements within the mobile environment. Session management and stream synchronization will enable a moderated and smooth collaboration environment. Examples of such applications components are listed below:

- Chat (several users form a group and exchange written messages),
- Whiteboard (a common “drawing” area is used by a group of participants, every participant sees changes caused by other users, pictures could be loaded and displayed within the whiteboard),
- File transfer,
- Location-based information based on user location provided to the server via a location detection technique registered or all of the users and according to user location,
- Application sharing (an application executed on a server or on a client PC is controlled by one user at time, all participating users may interact with the application if they have a token, changes are visible to all participants),
- Streaming of music and/or video clips,
- Streaming of live video generated at a video server or from a mobile device to a group of users.

Based on the review of current services delivered by SDMB systems we can say, that the most of those are very suitable for E-learning purpose [7, 15-18].

6. ARCHITECTURE OF CONVERGED TECHNOLOGIES AND NGN USING SATELLITE NETWORKS AS AN ACCESS LAYER

The platform of converged technologies is based on integration of various network architectures (telecommunication networks and IP (Internet Protocol) networks), for purpose of efficiency network resource utilization, decrease in cost, creation universal network environment supported processes delivering variety multimedia services and applications [7,12,15]. Conceptual model in Figure 5 defines this network platform.

The bottommost layer of this conceptual model (user layer) presents complete package of terminal equipments which can be used individually or to form their suitable configurations or to combine various technologies in e-learning process, e-consulting and e-collaborative work with a view to achieve an optimal platform for e-learning.

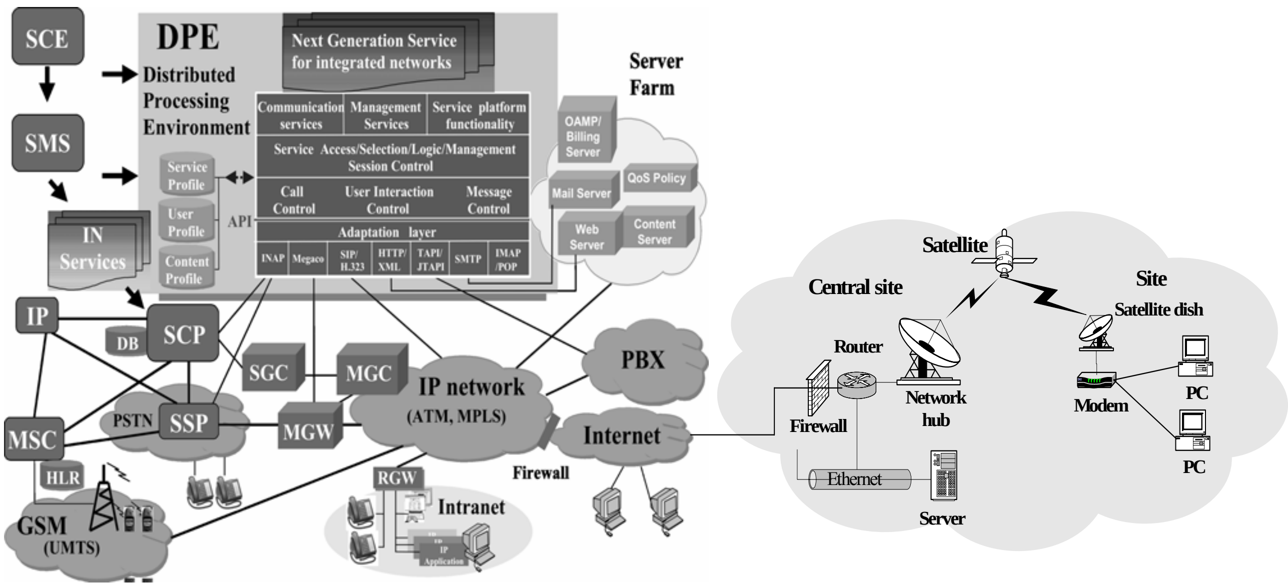

Fig. 5 The Conceptual model of NGN

The next layer of the conceptual model of convergent technologies and NGN is an Access layer which common e-learning user understands as network infrastructure for interconnection to complex ICT infrastructure for access security to required resources of e-learning, e-consulting or e-collaborative work (access to various applications servers, e-learning portal, LMS (Learning Management System) platform, databases, service provider and e-learning applications, etc.).

Core Packet Network layer and Call Control layer mean for user of e-learning services and applications only ICT infrastructure which creates conditions for transmission and delivering e-learning services in required form and quality.

On Application/Content layer of the conceptual model of converged technologies and NGN are implemented individual multimedia services and applications. Call Control layer covers access process to multimedia services and their applications as well as all delivering ones process.

For ubiquitous wide area and global access, satellite systems are relatively easy to deploy and are capable of providing large capacity access. The economics of satellite delivery are very compelling with respect to other terrestrial based broadband access technologies like DSL, cable modem, or fixed wireless.

7. CONCLUSIONS

In this paper we described some current trends of the development of next generation satellite systems as an access network within NGN converged networks by analyzing satellite e-learning services (e-consulting and e-collaborative work) aspects. The attention was devoted to describing of new services delivered by satellite digital mobile broadcasting systems regarding E-learning application that can make use these services.

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BIOGRAPHIES

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