GEO SATELLITES AND THEIR APPLICATIONS: SERVICE INTEGRATION OVER DVB SYSTEMS

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Abstract: The constant growth of GEO satellites as a medium of communication has underlined the question of service integration over such a system. Digital television over satellite experiences a real success, but paradoxically the Internet access via satellite seems an economic failure, preventing further service integration. In this paper, we propose a short overview of the current use of satellite for the Internet, and its drawbacks. Some perspectives are presented, underlining the need of relevant services. Then, three services and their integration on a satellite system are studied, concluding to the necessity of a relevant architecture, a system which makes the transition between present system and the next generation of satellite and which can thus propose a long-term protocol architecture. This paper presents a solution: a hybrid (transparent and regenerative) system. Eventually we will study the integration of different services over such a system, leading to a global architecture.

Keywords: IP; GEO satellite; DVB-S; DVB-RCS; Services Integration.

1. INTRODUCTION

Even if service integration is not a brand new idea (Integrated Service Digital Network [1]), it is still an area of research, since terrestrial operators fight to deliver over the same support access to the web, voice and television at lower prices: Ma Ligne TV, DSL-TV or Free Box are French examples of this integration. All these services are based on a high bandwidth medium and integrated via IP, which seems unavoidable today.

As GEOs experience a new success with digital television, several projects study it as a medium for IP (IBIS [2], GEOCAST [3], ...). Indeed its wide coverage, its broadcasting nature, its flexibility and its throughput are linked advantages contributing to its relevance for service integration.

However, high deployment costs and standardization issues have highly impaired investments. Our participation in a national project, DIPCAST [4] (DVB for IP multicast, RNRT project), has led us to a solution: architectures based on a hybrid (transparent and regenerative) satellite.

The study of IP over satellite and its recent evolution (chapter 2) will lead to the different services which could find advantages in satellite systems (chapter 3). After introducing the hybrid system (chapter 4), the efficient integration of these services in a satellite system will be the main topic of the last part of this paper (chapter 5).

2. IP OVER SATELLITES

In this part, we propose an overview of IP over GEO satellites solutions to introduce the link between GEO satellite technology and services.

Based on bent-pipe satellites, classical solutions are one-way systems that could use a terrestrial return-link (Public Switched Telephonic Network, ADSL, cable…) as illustrated in figure 1. Such an architecture suits well for one-way and highly broadcasting services, like Television, Near Video on Demand, or Pushing. However it is not really relevant to unicast and bidirectional services like an Internet access. Indeed IP over bent-pipe systems has missed its target as the high deployment of cable and ADSL solutions has prevented satellite development in urban areas. But the return-link issue explains also its economic failure since remote areas mostly have a PSTN access which highly impairs system capacities, throughput and does not match with popular applications like chatting, mail or peer-to-peer.

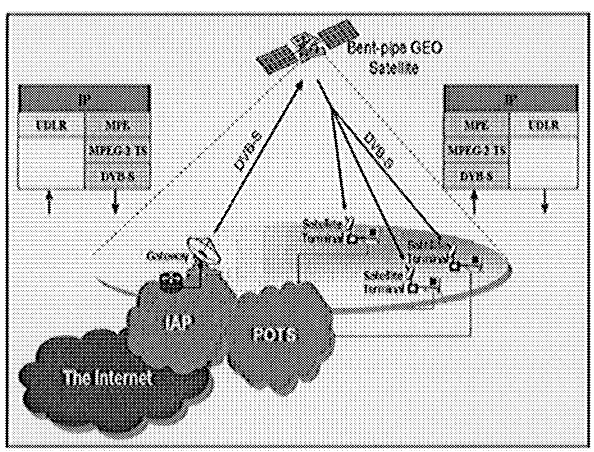

Figure 1. "Classical" architecture of IP over a bent-pipe system.

But GEO satellite domain has to tackle with another issue: standardisation [5]. For a long time, proprietary solutions have prevented satellites from reaching a larger public because of their specificities. Only digital television has been successful with its universal standard, DVB-S (Digital Video Broadcasting for Satellite). This standard recommends MPE (Multi Protocol Encapsulation) as the scheme for encapsulating and carrying IP datagrams over DVB-S [6]. However, if MPE seems at first glance one eligible solution, it seems not to fulfil its role well [7].

Several workshops organised by the ITU and projects like SATIPV6 [8] work in order to prevent future system from proposing proprietary solutions. IP satellite system must propose a standard interface to be interoperable. In such a context, several works present real opportunities for satellite systems:

- The DVB-RCS (DVB Return Channel for Satellite) standard proposes an air return link for satellite systems [9], allowing bidirectional offers (Tachyon [10]) for four years. Nevertheless it remains a new technology today, compared to ADSL offers, so prices are still quite expensive for final users (about 150 € per month and high installation fees for 512k/128k). But these solutions remain interesting for communities [11].
- ULE (Ultra Lightweight Encapsulation) seems an attractive solution to replace MPE [12] since it is specifically suitable for IP or Ethernet data.
- The next-generation of GEO satellites offers multi-spot solutions (spot-beams technology) and On-Board Processing (OBP) on-going revolution (multiplexer, switch [13] and maybe in a next step, router [14]).

The sum of these technologies could bring significant improvements, but involves a higher system cost and complexity. Therefore we have to clearly define when to use a satellite system, and what sort of system. Furthermore, such an evolution will take many years to be available, so there is a need for a long-term protocol architecture.

3. SERVICES OVER SATELLITES

To compete with terrestrial systems is not the goal of satellites, so services must be clearly analysed to know their relevance to satellite support since technology success is strongly linked to their proposed services. Thus several services (Internet access, VoD and networks interconnection) are detailed here, since these services may take advantage of GEO specificities.

3.1 Satellite Internet access

Internet access is a popular growing media of communication since mobiles and many applications are based on this service. Nevertheless satellites can not replace terrestrial media, because in the one hand it is still an expensive technology, and in the other hand, its characteristics are different. Satellite and Terrestrial Internet accesses are complementary: for Internet access in urban areas, terrestrial solutions remain cheaper and more suitable, but in remote areas where terrestrial access is reduced to 56kbits/s connections (village, small towns), or impossible (mountains, islands, boat, train, off-shore platform, desert...) satellites are a good option. Moreover satellites may play a key role in potential mobility for user terminals.

To characterise the Internet traffic or to enhance the performance of satellite Internet access are not the topic here. But we can analyse user needs. In traditional web navigation, users send a few data whereas the incoming flows are quite important. However, Internet access is undergoing changes with the rise of bidirectional applications like peer-to-peer [15], return-link has to propose a higher throughput than classical PSTN access.

GEO can support these different needs, with its DVB-RCS return-link. The multi-spot system can also be an economic advantage, reducing the waste of system capacity introduced by unicast communications. However, as DVB-RCS terminals are expensive for private users, this system is more suitable for access networks which can be based on a WiFi local network.

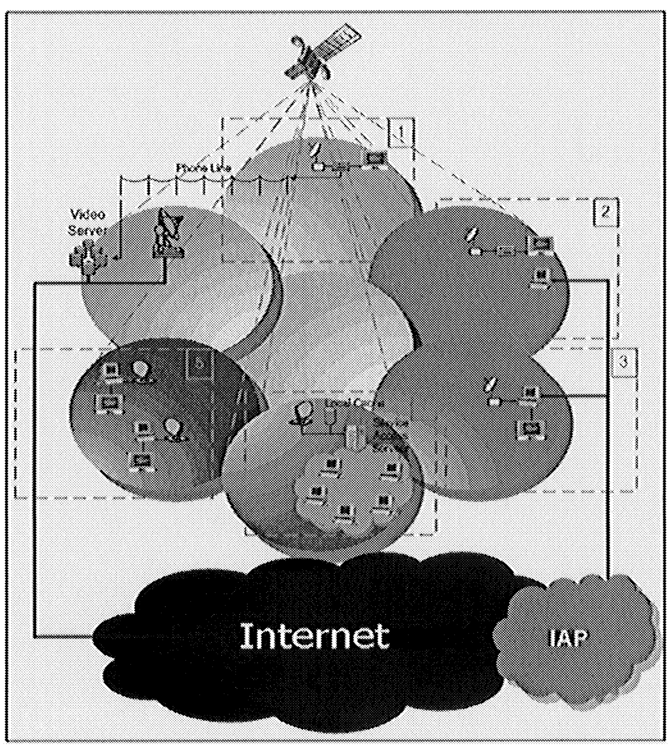

Figure 2. Different satellite architectures of VoD.

3.2 Video on Demand via satellite

Satellite systems are suitable for VoD services due to their advantages (i.e. high bandwidth, MPEG-2 compliant and natural broadcasting). Indeed satellites can broadcast the media, delivering it at the same time to several clients as it would have to only one, without any additional cost. However, such a process requires users to wait before the media is sent.

There are different satellite architectures for VoD as shown in fig. 2:

- 1. One way delivering data to a DVB system. User can select media through a phone call.
- 2-3. One way delivering data to a DVB system or card. User selects media through his Internet access.
- 4. Users are grouped into a service network with a local cache fed by a DVB-S/RCS system. Users can ask local application servers for a media. If not in cache, it is downloaded through the bidirectional link.
- 5. A bidirectional satellite link is used by a private user.

However a bidirectional satellite system for VoD may be a commercial failure since VoD does not need an important return-link, and bidirectional systems are more expensive. Moreover the VoD service is insufficient for itself and must be seen as a complementary service to another one [16]. Therefore solutions 4 and 5 must propose other services to be interesting.

For these reasons solutions 1, 2 or 3 seem the best suitable offers. These services can be multicast ones, or in NVoD configuration, the video provider can wait until having enough clients to broadcast the data. In order to know when and where to send the video, the provider must know how many clients want it, and where they are distributed among the different spots.

3.3 Network interconnection via satellite

These service requirements are highly different from the two services previously described, since in private network interconnection, the QoS of the link is primordial. Terrestrial technologies can not really guarantee delay and bandwidth (except with a leased line) whereas satellite systems can connect two VPN with only two hops (bent-pipe system) or one hop (OBP). So a satellite system can guarantee a throughput, a delay and a jitter, since the data only pass through the satellite system.

Because of DVB-S system cost, the interconnection with DVB-RCS terminals seems more interesting. The choice between the bent-pipe system and the OBP one depends on the user needs: time dependant applications like voice over IP may require a low delay and so OBP suits better (about 250ms instead of 500ms), whereas bent-pipe systems may be enough if applications are not too delay regarding.

3.4 Requirements for service deployment

The study of these different services underlines two major points: on the one hand, bent-pipe systems are relevant for some services. On the other hand, each service requires a specific system. The following chapter will present a solution to fill the gap between bent-pipe systems and next-generation ones as to propose a long-term solution.

4. THE HYBRID SYSTEM: A BRIDGE BETWEEN BENT-PIPE AND OBP SATELLITES

Today systems are classically bent-pipe ones, but the next-generation of GEO is clearly opening the age of on-board intelligence. However since evolution is a slow process especially in satellite domain, we propose an architecture of transition, called a hybrid system

The basic idea is the presence of two distinctive payloads (fig.3): a transparent one (bent-pipe) and a regenerative one (OBP). Such a hybrid system may deal with any satellite configuration for a long time.

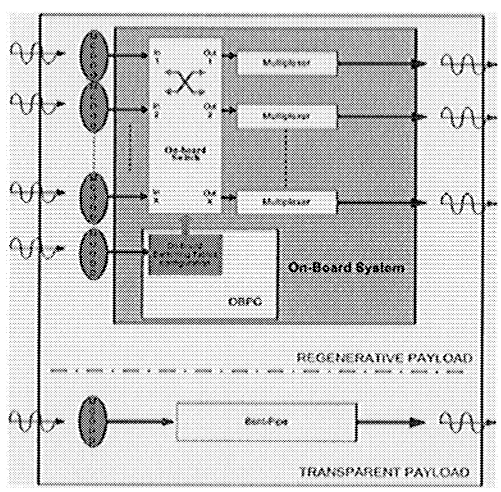

Figure 3. The two payloads of a hybrid satellite system.

The bent-pipe part of the system is divided into two parts: a DVB-S hub and a DVB-RCS hub to repeat DVB-S as DVB-RCS signals.

The regenerative part is divided into several spots interconnected by a switch (or later a router). Two solutions have been compared for DVB-RCS system, one based on ATM cells [7] and one based over MPEG-2 TS. Even if the ATM solution has some advantages like QoS management, the MPEG-2 TS support has been selected since more suitable. Indeed, it allows to have the same type of containers for DVB-S and DVB-RCS, and so to ease the on-board switching and multiplexing, whereas an ATM solution induces two distinctive processing and a higher overhead on downlink streams (fig.4).

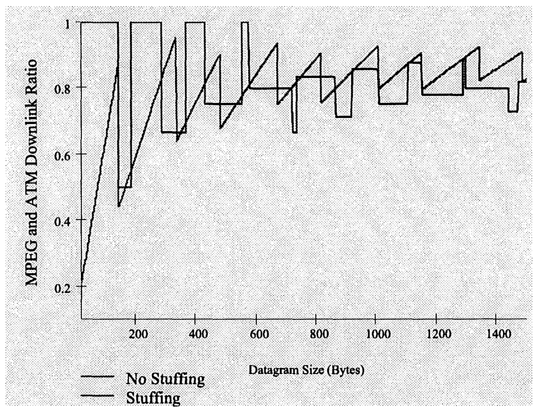

Figure 4. MPEG-2 TS encapsulation over ATM encapsulation ratio on a return downlink.

However, instead of MPE, we propose to integrate the ULE solution in this architecture for its relevance and better performances [17].

Table 1. Hybrid system characteristics

		Forward-link	Return-link	
			RCST⇨Gateway	*RCST⇨RCST*
Bent-pipe mode	*Min. delay*	250 ms	250 ms	500 ms
	QoS management	Access control		
	Diffusion Mode	Broadcast over the whole coverage		
OBPmode	*Min. delay*	250 ms	250 ms	250 ms
	QoS management	Access control and on-board policy		

This system proposes two kinds of characteristics (table 1). Compared to the bent-pipe mode, the OBP option offers a shortest delay in RCST/RCST communication. Moreover, its multi-spot functionalities allow saving system capacity. Considering a service level agreement, the terminal or gateway which are routers, select the system mode according to a QoS tagging of the specific stream. The mode is differentiated at access level by PID and at physical level, by frequency. The tagging process is a common mechanism not fixed here since we hope such a system could be included in larger QoS architectures. This study will be highly explained in a future paper.

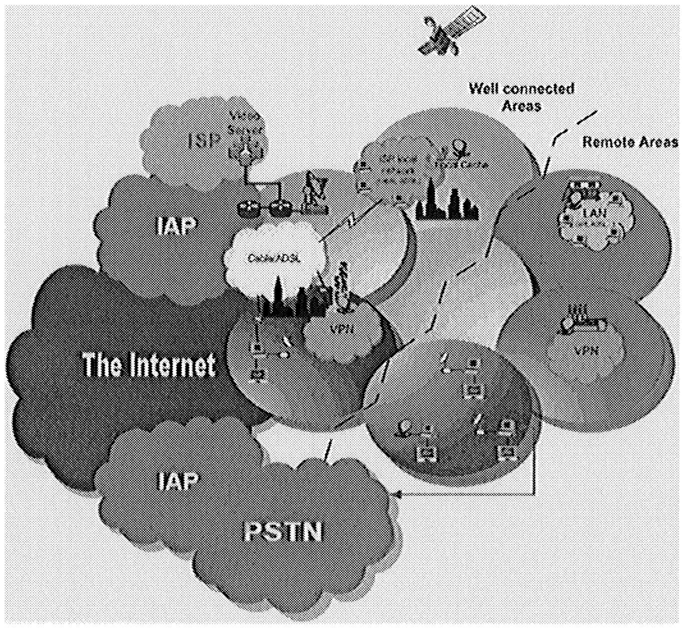

Figure 5. Integration of services over the same hybrid satellite system.

5. SERVICE INTEGRATION OVER A HYBRID SYSTEM

As services have their own needs, implying a different system to support them (chapter 3), and the hybrid option offers two specific modes, the hybrid system may be an efficient tool for service integration.

As illustrated in figure 5, the proposed architecture does not exclude terrestrial links. This architecture is divided into two areas: well connected areas, which are urban areas, and remote areas with mostly a PSTN access.

5.1 Internet access over a hybrid system

Internet access over this architecture is reserved for remote areas. Two services can be proposed. On the one hand a standard bent-pipe forward link (512kbit/s-2Mbit/s) with a terrestrial return link based on UDLR protocol [18] and PSTN (56kbit/s) for classical Internet access (web navigation, FTP...). On the other hand, a standard bent-pipe forward link with a bent-pipe return link (128kbit/s-1Mbit/s) for new bidirectional applications on the Internet and future multicast applications.

In unicast communication, the management of the several spots may save system capacity. However a relevant balance must be found between the cost of OBP use and the saving of throughput.

5.2 VoD over a hybrid system

For VoD, a satellite return link is unnecessary (part 3.2). The type of forward link is strongly linked to user requests. As proposed in table 2, the system mode and cost is set according to the number of requests for a media, when they want it and where the clients are.

Such a service is often cheap and can be deployed in remote areas as in well-connected areas like a complementary service.

Table 2. VoD request and system modes

Service Characteristics for a single media			**System Mode**	**Cost**
User Requests	*User Positions*	*Emission time*		
1	1 spot	instant	OBP	expensive
1	1 spot	delay	wait for requests	-
numerous	several spots	delay	OBP	cheap
numerous	every spot	delay	Bent-pipe	very cheap

5.3 Network interconnection over a hybrid system

More concerned by QoS, network interconnection services on this system can be dual: VPNs may use a static bent-pipe DVB-RCS link for standard traffic, and then lease an OBP connection to have better delays and QoS for specific applications (like VOIP, teleconferencing, shared applications).

6. CONCLUSION

This paper has presented our on-going work over satellite architectures and their relevance to several services. After presenting the IP over satellite context, a first glance is given at a few services which seem especially relevant to satellite systems. These services present their own characteristics and imply specific satellite architectures. We propose a solution which integrates in the same satellite a bent-pipe payload and a regenerative payload: a hybrid system. Such a system makes it possible to integrate different services as detailed in the last part of our work. Eventually, this system proposes a flexible architecture relevant to actual services. Moreover, its on-board-processing possibility allows the system to be ready for future applications, like multicast ones, and then to make the bridge between present satellites and next generation satellites.

The satellite system is considered in this study as a complement to the terrestrial technology and as a good alternative when terrestrial is not available. This work is included in a global scheme: the study and design of an architecture which makes the transition between the present system and the next generation one. The work underway consists then in a more precise evaluation of this architecture, which seems one imperative step towards a perennial system.

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REFERENCES

[1] G. Dicenet, "Le RNIS : techniques et atouts", ed. Masson, Collection CNET, 1990

[2] S. Chacón, J.L. Casas, A. Cal, R. Rey, J. Prat, J. de la Plaza, G. Monzat, P. Carrere, C. Miguel, F. J. Ruiz, "Networking over the IBIS System", IST Mobile & Wireless Telecommunications Summit, 2002.

[3] Z. sun, M.P. Howarth, H. Cruickshank, S. Iyengar, L. Claverotte, "Networking Issues in IP Multicast over Satellite", International Journal of Satellite Communications and Networking 2003.

[4] DIPCAST, RNRT project, http://www.dipcast-satellite.com.

[5] R. Goodings, "IP over Satellite: Standardisation activities in ETSI/TC-SES",ITU Workshop on Satellites in IP and Multimedia, 2002.

[6] "Digital Video Broadcasting ; Implementation guidelines for Data Broadcasting", ETSI TR 101 202 v1.1.1, 2003

[7] J. Fasson, E. Chaput, C. Fraboul, "IP Multicast Architectures over Next-Generation GEO Satellites", VTC spring 2004, 2004.

[8] SATIP6 project, IST-2001-34344, http://satip6.tilab.com

[9] "Digital Video Broadcasting ; Interaction Channel for satellite distribution systems", ETSI EN 301 790 v1.3.1, march 2003

[10] Tachyon commercial web page, http://www.tachyon.net

[11] R. Tran Van Lieu, "Le Haut débit", 01 Réseaux n°138, april 2004

[12] G. Fairhurst, "Ultra Lightweight Encapsulation (ULE) for transmission of IP datagrams over MPEG-2/DVB networks", draft-fair-ipdvb-ule-02.txt, 2004

[13] J. Farserotu, R. Prasad, "A Survey of Future Broadband Multimedia Satellite Systems, Issues and Trends", IEEE Communications Magazine vol 36 issue 6 p 128-133, 2000

[14] D. M. Elwatt, "Cisco Shoots For The Stars Satellite. Company uses off-the-shelf Cisco router in space; networks could extend to the cosmos", informationweek.com, 2003

[15] S. Sen, J. Wang, "Analyzing Peer-To-Peer Traffic Across Large Networks", IEEE/ACM Transactions on Networking, vol. 12 n°2 p 219-232, april 2004

[16] K.C. Neel, "VOD: Satellite Killer or Bundle Filler?", CableFAX's CableWORLD, http://www.cableworld.com , march 2004

[17] M. Montpetit, M. Schmidt, G. Fairhurst, B. Collini-Nocker, H. Linder, H. Tork, IP over DVB: Study of Encapsulation and Protocol Performance, Final Report, 2004.

[18] E. Duros, W. Dabbous, H. Izumiyama, Y. Zhang, "A Link Layer Tunneling Mechanism for Unidirectionnal Links", RFC3077, march 2001.