



**HAL**  
open science

## Evaluation of ad-hoc and mobility architectures using satellite communications

Thierry Gayraud, Pascal Berthou

► **To cite this version:**

Thierry Gayraud, Pascal Berthou. Evaluation of ad-hoc and mobility architectures using satellite communications. 26th AIAA International Communications Satellite Systems (ICSSC 2008), Jun 2008, San Diego, United States. 3p. hal-00356844

**HAL Id: hal-00356844**

**<https://hal.science/hal-00356844>**

Submitted on 29 Jan 2009

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Evaluation of Ad-Hoc and Mobility Architectures using Satellite Communications

Thierry Gayraud<sup>1,2</sup> and Pascal Berthou<sup>1,2</sup>

<sup>1</sup>LAAS-CNRS, Université de Toulouse, Toulouse, France

<sup>2</sup>Université Paul Sabatier, Université de Toulouse, Toulouse, France

**Abstract—** In military or emergency scenarios (like Disaster Relief), the area where the terrestrial forces are located is not always easy to cover. In such an area, no infrastructure is available (never deployed or unavailable due to disaster for instance), persons are located in many locations, eventually structured in groups, but distant from one to another. The topology may also introduce difficulties (canyons, mountains, vegetation...). In such scenarios, communications in a group may be done using ad-hoc networks principle, but the communications from one group to another can be compared to the interconnection of ad-hoc networks. We propose in this paper to interconnect these terrestrial ad-hoc networks with a geostationary DVB-RCS system. This satellite network allows us not only to interconnect the groups, but also to provide them with an access to a very far headquarters and also to the Internet, thanks to the bidirectional link supported by these satellite systems. DVB-S/RCS systems, mobility protocols and ad-hoc network protocols are first presented separately. The global architecture is then defined. Each kind of architecture is evaluated alone. Finally, architectures performances are compared to each other and the results are discussed as a conclusion.

## I. Introduction

In order to offer an appropriate support to the variety of current and future data streamed applications, broadband satellite systems need to support mobility. Mobility is currently an important issue, leading researchers to propose various kinds of solutions. Many proposals already appeared in terrestrial networks, but mobility in a DVB-RCS satellite access network implies new constraints. Due to the delay of one satellite hop for instance, the hand over time seems to be too long for current multimedia distributed applications.

The studied scenarios depend on the type of mobility (user, terminal, session, network) or its “range” (micro-mobility/macro-mobility). In terrestrial networks, mobility solutions have been defined in MAC layers such as in 802.11 networks or at the IP layer using MobileIPv6, thanks to IPv6 services such as addressing, auto configuration and extension headers. The solution is different in each scenario. In this paper, these proposals will be presented and then considered in satellite network context.

The studied scenarios may also be solved by another kind of solutions related to ad-hoc networks solutions. These networks (AODV and OLSR for instance) are widely studied in IETF groups and many network protocols have been proposed to solve the problem. Another kind of problem has to be considered if the ad-hoc network cannot be considered as a connected set but is divided in many sub-networks. In that case, the question is how to interconnect these sub-networks to obtain the full connected ad hoc network as defined usually. In this paper, the way to interconnect these sub-networks using a satellite DVB-S/RCS system will be presented and evaluated.

To evaluate the definition and then the performance of our proposals, a realistic DVB-S/RCS satellite emulation testbed has been used. This testbed was first designed and implemented in IST SATIP6 project by LAAS and Thales Alenia Space. The new release of the testbed is now supporting also DVB-S2 and its features. This emulation platform was calibrated by experimentations done using real satellite systems implementing the same kind of terrestrial devices as our testbed. The user terminal is a device like a PC laptop, a PDA or a smartphone able to use various wireless network interface (Wi-Fi, Bluetooth, 3G,...) to connect to the closest ad-hoc sub-network. In each

group, one member is able to provide the group with a satellite link equipment (Satellite terminal + antenna) to connect to any other group.

Our first MIP6 experimental results based on multimedia applications traffic profiles have been obtained and analysed, using both UDP and TCP, in mesh or star topology in the new IST project Satsix. MIP6 has shown that it is able to maintain connections during the mobility phase, but induces much latency due to specific satellite constraints.

It was then decided to study and evaluate other solutions. Using Adhoc networking protocols, it was shown that our architecture developed in Satsix project was able to interconnect ad-hoc subnetworks in order to gather all terminals in one large Ad-hoc network. Unfortunately this solution is not able to reduce the hand over delay in mobility context. Of course the number of satellite/earth hops introduces delay, but also in AdHoc networks, route computing is optimized when routing signaling is increased. In our solution increasing signaling is not always possible as the bandwidth of ad hoc networks is often limited. The main problem of our proposal occurs when one node goes from one subnetwork to another one. In that case, the handoff may rise up to 3.5 s, because the adhoc protocol packets are crossing several times the earth/satellite link (up and down).

A comparison of the 2 techniques based on experimental results is then presented. These 2 solutions are not today easy to deploy as they are still under development. From the satellite link point of view, any one of these 2 solutions is not more difficult to implement than the other one. Their performances are related to the number of satellite hops they need according to the studied scenario.

The first part of this paper describes DVB-RCS satellite systems, mobility features and ad-hoc networking. The second part deals with mobility and ad-hoc networking in a DVB-RCS satellite system. The third part gives the results of our experimentation of

- MIP6,
- Adhoc protocol OLSR

on our DVB-RCS emulation testbed and the evaluation results of relevant scenarios. The last part concludes the paper with a comparison of these 2 techniques and the future work resulting from our proposals evaluation.

## **II. Presentation of the components of the architectures**

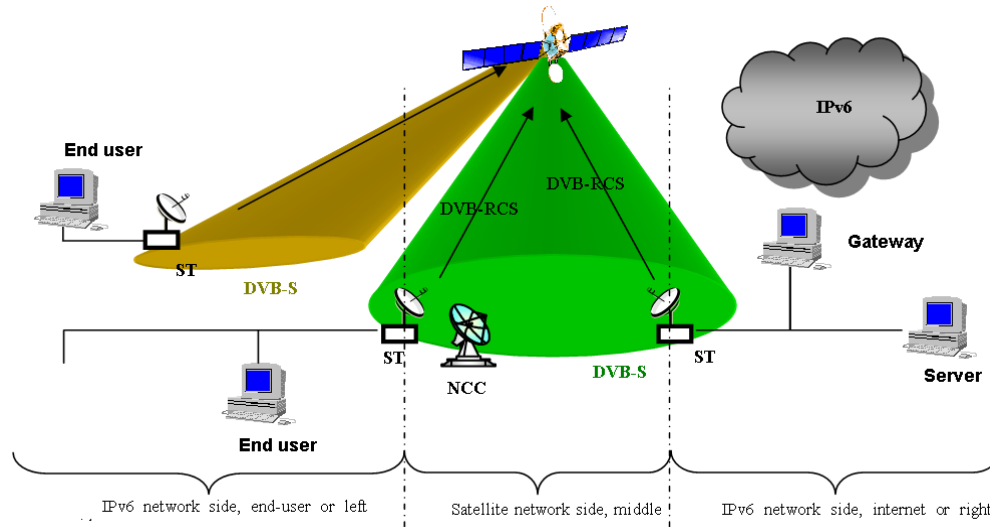
### **A. DVB-RCS systems architectures**

Initiated in 1993, the international European DVB Project published, in the end-nineties, a family of digital transmission specifications, based upon MPEG-2 (Motion Picture Expert Group) video compression and transmission techniques. Data are transported within MPEG-2 transport streams (MPEG2-TS) which are identified through DVB Service Information Tables. Adapted for satellite systems, DVB-S defines one of the most widespread formats used for Digital TV over the last years and still nowadays. However, DVB-S Satellite Terminals can only receive frames from the satellite. The need for a return link rapidly becomes essential so as to support emerging Internet services via satellite. Two main alternatives can be retained: UDLR (UniDirectional Link Routing) which emulates a cheap bidirectional solution through a terrestrial return link and DVB-RCS, which provides expensive but full bidirectional satellite architecture.

The return link access scheme in DVB-S/RCS systems is MF-TDMA. The return link is segmented into portions of time and frequency ("super-frames"). The entire satellite system control, especially STs synchronization and resource allocation, is performed by the NCC. It periodically broadcasts a signaling frame, the TBTP (Terminal Burst Time Plan), which updates the timeslot allocation within a super-frame between every competing ST. This allocation can be dynamically modified on STs demand thanks to a bandwidth on demand protocol called Demand Assignment Multiple Access (DAMA).

Thanks to this introduction, Figure 1 gives a good overview of DVB-S/RCS satellite networks architecture, compliant with the architecture adopted within the ETSI BSM [3] group and the DVB-RCS standards. It consists in a geostationary satellite network with onboard switching capabilities, Ka MF-TDMA (Multiple Frequency Time Division Multiple Access) uplinks and Ku TDM (Time Division Multiplexed) downlinks. The satellite is regenerative meaning that only a single hop is needed to interconnect two end users. Satellite Terminals (RCST) provide single PC or LANs with the access to the network, while Gateways (GWs) allow the connection with Internet core networks. The uplink access from each RCST is managed through DVB-RCS interfaces.

On the left is represented the end-user side of the platform. On the right is shown the provider/enterprise/Internet side of the platform. We distinguish also between the satellite network side (in the middle) and the IP network sides (on left and right ends), interconnected by RCSTs.



**Figure 1 : DVB-S/RCS architecture**

So, the 3 main components in the satellite network side (middle) are the Satellite, the Return Channel Satellite Terminals (RCST) and the Network Control Center (NCC)

## B. Mobility in terrestrial networks

Most of current users of networks and Internet access are interested in mobility support. In terrestrial networks, the main difficulty comes from the IP addressing used in Internet. Designed to enable the connection of fixed terminals, addressing is related to the terminal location. Unfortunately, a mobile terminal is often changing from one network to another one. So, if the initial IP address is used in the new network, it will not work.

This problem may be solved differently according to the kind of mobility to be concerned. Let us consider the following taxonomy:

- o User terminal move only:
  - o Discrete mobility: the terminal only moves from the network to another one, it is shut down before leaving the first network and will be restarted after being connected to the new one.
  - o Continuous mobility: The terminal moves from a network to another one, the terminal power is kept on and the current session are kept available and active during the terminal move.
- o Network equipment move also: the network is able to move also and its connection point to Internet may change.

In this paper, only the continuous mobility is considered because it is focused on user terminal move only. Please note also that discrete mobility is simply done by auto-configuration of the moving terminal.

Two sub-cases of continuous mobility may also be defined:

- o micro-mobility: the terminal stays in the same IP network, going from one Wi-Fi cell to another one);
- o macro-mobility: the terminal moves from one IP network to another, staying in the same IP AS (Autonomous System).

In micro mobility scenarios, upper layer connections often are stopped during handovers even if the terminal is still connected to the same access network. Hierarchical mobility has then been proposed to avoid delays in connection due to layer 2 handoffs. In this scheme, a second level of mobility management is introduced and changes from one WiFi network to another one for instance is solved in a new level called regional level introducing an "local anchor point".

In macro mobility scenarios, the handover introduced by network changes cannot be avoided. But different kind of anticipated changes can be introduced. The main idea consists of using a registrar in order to know where the mobile terminal is going to connect after moving. In that case, mobility is anticipated and the delay is reduced, setting up the connection changes before the old one is over.

It is then clear that the best solution to a mobility scenario is related to the kind of mobility to be used. It is also proven that the kind of mobility depends also upon the underlying technology used in the scenario. The solutions given above were designed and applied in terrestrial networks. Using satellite systems, transmission delays are very important for instance and terminal moves have high impacts as they need to communicate through the satellite segment to update the terminal connections. A dedicated study is needed to include efficiently satellite access networks in mobility scenarios as it will be shown in the next section.

### **C. Ad-hoc networking**

Another way to implement mobility has to be used if there is no infrastructure available in the user area. In that case, the communication from one node to another one is relayed by other nodes, working as usually does a router in classical networks.

This kind architecture is highly dynamic and routing messages from sender to the receiver is not easy as the routes are changing very quickly. Specific routing algorithms and protocols have been designed and evaluated to provide the user with connectivity to the network hop by hop if necessary.

2 main groups are known today to implement these features, one is proactive the second is reactive, depending on how and when the route is computed. The reference in these categories are AODV and OLSR. As they are well known it is possible to find an implementation of these algorithms. We decided to focus mainly on OLSR because the available release at that time was the most interesting for us.

When a node moves, it may lose its connectivity. The handover is here due to the time needed to recompute the route for instance.

## **III. Mobility Architectures and Ad Hoc Architectures : their emulation test beds**

### **A. Mobility Implementation in DVB-S/RCS systems**

#### *1. MIPv6 description*

Mobile IPv6 (MIPv6) first provides the mobile user and his correspondents with a direct communication, avoiding communication resets during user moves, as described in RFC 3775 [2].

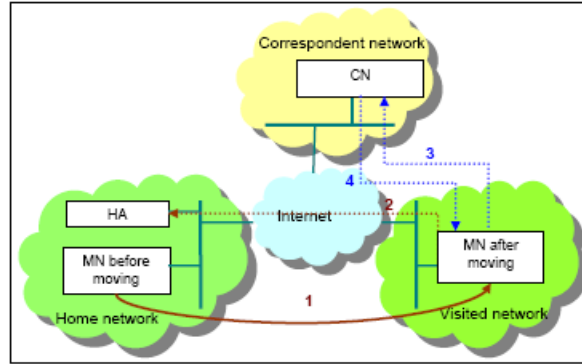
Many entities are involved in MIPv6 :

- the mobile terminal (called MN : Mobile Node) mainly located in the home network, and moving into a visited network
- the Home Agent (HA), located in the home network of the mobile,
- the correspondent terminal (called CN : Correspondent Node) part of the correspondent network.

MN is an IPv6 terminal, able to move from one network to another one, CN is an IPv6 terminal communicating with MN. HA is a network device managing mobility.

The main idea in MIPv6 is that the mobile will be reachable anywhere at any time using the home address (HoA) it has received from its home network.

Routing is done as usually if the MN is located in its home network. But if the mobile node is in a visited network, thanks to IPv6 auto-configuration, the new MN address is called Care-of Address (CoA) compliant with the visited network addressing. At the beginning of the arrival in a new network, traffic sent to MN is first rerouted by its HA from its home network. The route optimization process will allow as fast as possible to use direct communication between MN and CN. All these steps are shown Figure 2.

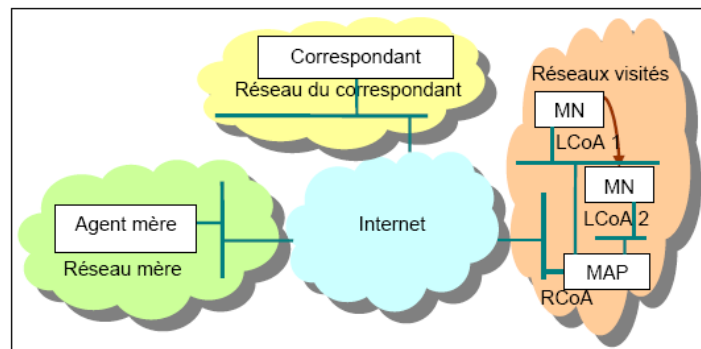


**Figure 2 : Communication steps as MN moves (with route optimization)**

## 2. HMIPv6 (Hierarchical Mobile IPv6)

MIPv6 is really inefficient if the terminal often changes its access point to Internet. Each time the terminal moves, each time messages have to be exchanged between MN and HA. If the distance between MN and HA is high compared to the moving distance of the terminal, then the update is implemented by several messages exchanged from MN and HA, introducing high delays due to the transmission delays between HA and MN.

This problem may be avoided using HMIPv6, introducing the concept of a local anchor point, it is able to manage well the short local moves of the terminal inside of an IP domain. HMIPv6 is described in RFC4140 **Erreur ! Source du renvoi introuvable.** HMIPv6 designed the MAP (Mobility Anchor Point), a router located in the visited network. It is used as a kind of “local home agent”.



**Figure 3 : HMIPv6 principle**

When the mobile node is connected to a visited network, MN is given a temporary address given by a local router. This address is called LCoA (Link Care-of Address). Another temporary address is assigned by the MAP to the mobile; this address is called RCoA (Regional Care-of Address). MN is known by its HA using its unique RCoA. This address will change only if the MN moves to another region. If not, a move from a sub network to another one only needs to change the LCoA. This change done by the MAP is transparent to the HA and CN, thanks to the MAP functionality.

## 3. SIP

SIP (Session Initiation Protocol) protocol is now one of the most important protocols in the Next Generation Networks. SIP defines a URI (Uniform Resource Indicator) such as (sip:gayraud@laas.fr), Session Layer Address. This URI is not linked to the network address (IP address). It allows also the localization of the mobile user.

SIP architecture includes several logical functions such as:

- **Localization Server (LS)** to locate the user agent (UA) mapping one public URI to a set of local URI (sip:gayraud@helios.laas.fr) related to one terminal.
- **Registrar Server (RS)** to provide a database in which the location of the user is stored and modified each time it is needed if the user is moving.

- **Proxy Servers (PS)**, to relay requests from the UA, using the LS and RS in order to find the best URI in all the available URIs.

SIP is able to better manage the move of the user because it is designed to anticipate the move of the user. When it is detected that the MN is now in a new network, then the auto-configured MN sends a new message to its « partners » called **re-INVITE** giving its new SIP address. The receiver sends back an ACK, and then the communication is able to restart normally. Here, the application is able to see that the address has changed. Detailed explanations are available in

## B. The Satellite System Emulation

This emulation testbed comes from the IST project Satip6. It was then enhanced in a second step by a joint work of LAAS and Alcatel Alenia Space. In order to have the most modular platform and so preserves room for future evolution (DVB-S2, ULE), stringent requirements were fixed before the development phase.

At first, the aim was to take advantage of a linux system (Fedora Core 2) which natively supports Ipv6 and a wide panel of IPv6 applications (*Apache* as HTTP Server, *Mozilla* as HTTP Client, *Vsftpd* as FTP Server, *Gnomemeeting*, *SIPCommunicator* for Videoconferencing, *VideoLanClient* for Video streaming).

The main blocks in the testbed are:

- The *satellite carrier* package is responsible for the different satellite carriers emulation on top of Ethernet (DVB-RCS, DVB-S and Signaling Channels) and the simulation of typical satellite bit errors and delay
- The *DVB-S/RCS* package implements a framing structure compliant with the DVB-S/RCS standards. and fills DVB-RCS frames with ATM-like cells coming from the AAL5 layer. In order to achieve proper QoS, this layer manages synchronization and queues according to the authorizations a DAMA algorithm delivers.
- The *DAMA* package implements the DAMA algorithms used to manage the satellite resources allocation at layer 2
- The *IP Dedicated* package implements an AAL5 like layer which is responsible for segmentation and reassembly functionalities and for a specific tagging mechanism targeted towards IP. It also implements a dynamic address resolution protocol in order to use that mechanism.
- The *IP QoS Package* implements common mechanisms to enable differentiation at this level. It treats packets incoming from IP network and forwarded on the DVB-DCS uplink according to a committed QoS behavior and is in charge of discriminating, regulating and scheduling this traffic in to 3 classes of Service (Real-Time, non Real-Time and Best Effort).

## C. Traffic Generation and Measurement

The main goal of this traffic generation tools is to reproduce multimedia traffic and to study the Satellite network impact on the data transmission. The use of real applications is mostly interesting to evaluate the quality the user perceives but is not sufficient to obtain metrics to adjust some algorithms or mechanisms used in Satellite network. A set of traffic generation tools (FLOC+FLORE+FLAN) have been developed to analyze traffic characteristics from real applications, replay traffic traces and measure statistics.

FLOC (FLOw Capturer) is a piece of software used to capture all data transmitted by all connections from a multimedia communication. FLOC creates a tcpdump filter from the 4-tuple (source IP, destination IP, source port and destination port) from which the capture of traffic will be done. FLOC stores captured traces in a file.

FLORE (FLOw REplayer) tool is composed of a server that transmits traffic from information of the trace file, and a client that receives multimedia replayed data. Both are NTP synchronized at millisecond near. During multimedia data arrival, the client creates an output trace file per connection, containing statistics like the arrival time (with the departure time), the sequence number, the size, the delay and the inter packet delay.

FLAN (Flow Analyzer) analyzes statistics from FLORE output files and provides graphics such as the throughput for each initial and replayed captured multimedia connection, the end to end replayed transmission delay, the sequence number evolution, the packet delay following its size, the inter packet delay and also evaluation of loss rate for each connection distinguishing isolated loss and burst losses.

## D. Mobility implementation in the satellite system test bed

The previous section has introduced the main components of different proposals to provide users with mobility support.

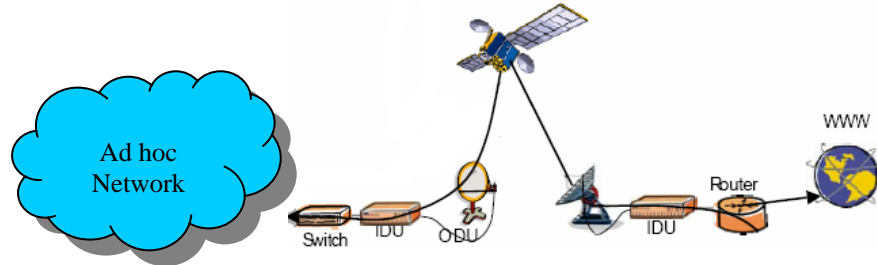
Concerning MIPv6, the protocol stack has to be available in MN and CN. The HA has to be located in the satellite access network. The usual location is close to the NCC, in the terrestrial segment belonging to the satellite service provider.

In HMIPv6 case, the new component MAP is deployed in the satellite access terminal (ST).

If SIP solution is used, then the specific servers (RS, LS) are located in the terrestrial segment belonging to the satellite service provider and the proxy servers (PS) are located in each ST.

#### E. Ad hoc protocol implementation in the satellite system test bed

In the adhoc networking architecture, all the components are able to route packets. They are shown just below.



**Figure 4 - Ad hoc networking architecture**

All the computers belonging to the adhoc network are connected to the satellite system by an Ethernet switch. The switch is programmed to switch from one configuration to another to simulate that the computer is moving. All the STs and all the users terminals implement a stack with a patch of OLSR for instance. No change is requested in the satellite or in the right part (ground segment) to connect to Internet or ISP. So deployment is quite easy.

### IV. Emulation and Evaluation Results

#### A. Mobility results

If we consider all the mobility moves done by the MN, a mobility scenario is always a set of elementary moves given in Table1 below.

	Scenario Number	MN goes from...	To...
Macro-mobility	1a	Home Network	Visited Network
	1b	Visited Network	Home Network
	2a	Home Network	Correspondent Network
	2b	Correspondent Network	Home Network
	3	Visited Network 1	Visited Network 2
	4a	Visited Network	Correspondent Network
	4b	Correspondent Network	Visited Network
	Micro-mobility	5	Subnetwork (behind ST1)

**Table 1 – Elementary moves in mobility scenarios**

So the evaluation of mobility has to be done from these elementary moves and then allows the reader to calculate the values related to the mobility case he wants to evaluate.

The results presented in this section were obtained first using theoretical evaluation and in a second step, these results were obtained from the evaluation platform and tools described previously in order to confirm these results.

- **Evaluation results**

Handoff delays are evaluated using the following equation:

$$T(\text{Handoff}) = T(\text{Layer 2}) + T(\text{Layer 3}) + T(\text{Messages restart}), \text{ if :}$$

- T (Layer 2) is due to synchronization, authentication and association delays. This duration is very short related to the over values and will be ignored later.
- T (Layer 3) is the time needed to obtain the new address, including the time to receive a Router Advertisement (RA) and to use DAD (Duplicate Address Detection). In a usual configuration, inter-RA delay is 50ms. As shown in **Erreur ! Source du renvoi introuvable.**,  $T(\text{DAD}) = 1500 \text{ ms}$ . So,  $T(\text{Layer 3}) = 1550 \text{ ms}$ .



- T (Messages restart) is the duration from the stop of the old connection to the restart of the new connection, due to the move of the terminal, introducing the main timing differences between the different proposals (MIPv6, HMIPv6 and SIP).

If the satellite propagation time is not considered, then the propagation time of a SIP message is shown to be 50ms. If the satellite propagation time is considered, then the propagation time of a SIP message from one network behind a satellite terminal to another network behind another satellite terminal is equal to 300 ms. A MIPv6 message is shorter than a SIP message and it was shown that this propagation time going through the satellite network is 275ms.

Considering the message sequence to be used in the different scenarios, the interruption times related to the different moves of the user terminal can be calculated.

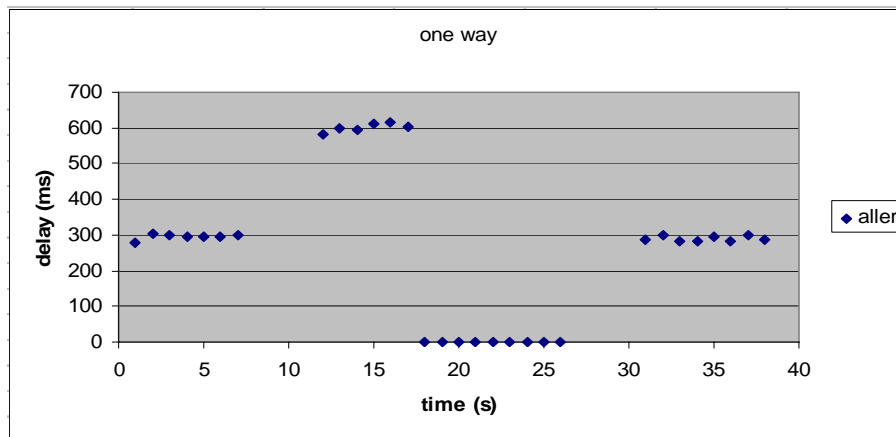
	SIP		MIPv6 avec RO et RRT	HMIPv6
	no ACK	with ACK		
Scenario 1a	<b>2.15s</b>	2.75s	3.20s	-
Scenario 2b	0.65s	1.25s	0.65s	-
Scenario 4a	<b>1,65s</b>	1,75s	2.15s	-
Scenario 5	2.15s	2.75s	3.20s	<b>1.60s</b>

**Table 2 – Interruption duration (RO=Route Optimisation, RRT=Return Routability Test)**

Table 2 shows clearly that using SIP allows theoretically a better or equal interruption delay in the three first studied scenarios. In the micro mobility scenario, the better delay is obtained with HMIP. So, to optimize the delay, a hybrid solution has to be designed in future work.

• **Emulation results**

The first measurements have been done using « pings » to evaluate the round trip time MN-CN. In this scenario, MN goes first from its home network to the network of CN and then comes back.



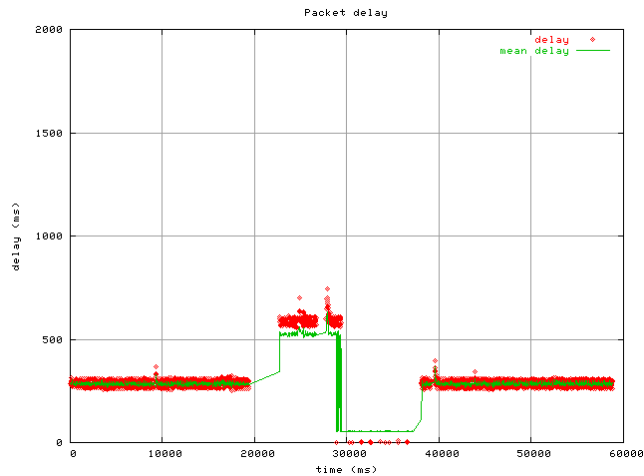
**Figure 5 – Ping measurements between MN and CN (RTT)**

Figure 5 shows 5 different steps:

1.  $T \leq 11s$ : RTT is around 600 ms, due to 2 satellite hops to go from MN to CN.
2.  $12s \leq T \leq 14s$ : packets are lost, the MN is moving.
3.  $15s \leq T \leq 17s$ : 3 pings are shown with a RTT around 1200 ms, due to 4 satellite hops, before route optimization is activated (MN to HA + HA to CN + CN to HA + HA to MN).
4.  $18s \leq T \leq 27s$ : MN and CN are communicating directly; the RTT is very short (around 0.200 ms).
5.  $28s \leq T \leq 33s$ : MN is back in home network; RTT is around 600ms, with 2 satellite hops.

Next experiment is made using Gnomemeeting traffic so that the following figure is obtained.

The time measured here are only one way trip so they are around half from the previous one (RTTs).



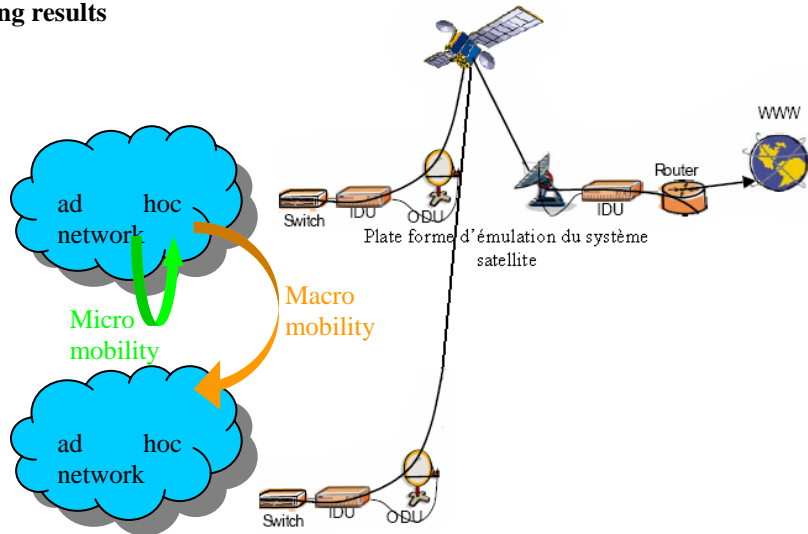
**Figure 6 – End to End delay using Gnomemeeting videoconférence**

The 5 steps identified previously using ping mechanism may be seen also here.

1.  $T \leq 20$  s, MN is in home network and CN is in a different network, behind 2 different satellite terminals and the delay is around 250 ms (1 satellite hop).
2.  $20s \leq T \leq 23s$ : MN is moving; communication is suspended.
3.  $23 s \leq T \leq 29s$ , delay is around 520 ms, route optimization is not already set (2 satellite hops: CN  $\rightarrow$  HA  $\rightarrow$  MN).
4.  $29s \leq T \leq 37s$ , MN and CN are in the same network and the delay is close to 0 s.
5.  $37s \leq T \leq 60s$  s, MN is back in its home network and as the communication restarts, the delay is around 250 ms.

Emulation results are shown to confirm the theoretical calculation, with additional delays and jitters, as expected. So the conclusion given by emulation testbed experiments is quite the same as the previous one, even if we consider MIP, HMIP or SIP.

### B. Adhoc networking results



**Figure 7 – Micromobility/Macromobility in a DVB-RCS system**

The adhoc networking emulation test bed is shown Figure 6. Performance has been evaluated in two cases : micro and macro mobility.

In micro mobility, the handoff duration D is equal to the duration of the connection stop plus the duration of going through the satellite system, or the mean duration + the duration of the satellite link interruption, so:

$$D = 0.431 \text{ sec} + 0.5\text{sec} = 0.931\text{sec}.$$

In macro mobility, the handoff duration D is equal to the duration of the connection stop in the adhoc network + the duration of IPv6 from ST1 to ST2 going through the satellite system + the duration of the satellite link interruption, so:

$$D = 0.891 \text{ s} + 4.7 \text{ s} + 0.5 \text{ s} = 6.091\text{s}.$$

### C. Discussion

So it is proved that using MIPv6 or adhoc networking can be used to enhance user service. The handoff duration is increased, but most of the applications are able to work even if the delays are high. Of course, these results have to be seen as first results without optimization related to the satellite impact on the architecture. Future work may be proposed in that way.

### V. Conclusion

A comparison of the 2 techniques based on experimental results has been presented. These 2 solutions are not today easy to deploy as they are still under development. From the satellite link point of view, any one of these 2 solutions is not more difficult to implement than the other one. Their performances are related to the number of satellite hops they need according to the studied scenario.

The next steps now are to improve performance of our proposals, to reduce handoff delays and to save the QoS of the communications still working during user mobility.

As a future work according to these results, a hybrid solution may be the right solution to support efficiently, TCP and UDP connections, and real time or non real time applications in such a context.

### References

- <sup>1</sup>IST SATIP6 Project (Contract IST-2001-34344), <http://satip6.tilab.com>
- <sup>2</sup>IST Satsix Project (Contract IST IP 026950), <http://www.ist-satsix.org>
- <sup>3</sup>D. Johnson, C. Perkins & al. "Mobility Support in IPv6", RFC 3775, June 2004.
- <sup>4</sup>ETSI TR102157 v1.1.1. ETSI TC SES; Broadband Satellite Multimedia; IP Interworking over satellite; Performance, Availability and Quality of Service, July 2003
- <sup>5</sup>H. Schulzrinne and E. Wedland. "Application-layer mobility using SIP", ACM SIGMOBILE, Vol. 4, Number 3, July 2000, pp.47-57.
- <sup>6</sup>N. Nakajima, A. Dutta, S. Das and H. Schulzrinne. "Handoff Delay Analysis and measurement for SIP based mobility in IPv6", Personal Communication Systems and Wireless LANs (ICC 2003), May 2003.
- <sup>7</sup><http://www.olsr.org>
- <sup>8</sup>Qi Wang and Mosa Ali Abu-Rgheff, "Signalling analysis of cost-efficient mobility support by integrating mobile IP and SIP in all IP wireless networks", International Journal of Communication Systems, 2006.