



Information Society  
Technologies



<b>Title:</b>  <b>Deliverable D6.2</b> <b>First Year Public Trial and Evaluation Report</b>	<b>Document Version:</b>  1.6
--	-------------------------------------

<b>Project Number:</b> IST-2001-37613	<b>Project Acronym:</b> 6POWER	<b>Project Title:</b> IPv6, QoS & Power Line Integration
--	-----------------------------------	---

<b>Contractual Delivery Date:</b> 31/07/2003	<b>Actual Delivery Date:</b> 18/06/2003	<b>Deliverable Type* - Security**:</b> R – PU
---	--	--

\* Type: P - Prototype, R - Report, D - Demonstrator, O - Other

\*\* Security Class: PU- Public, PP – Restricted to other programme participants (including the Commission), RE – Restricted to a group defined by the consortium (including the Commission), CO – Confidential, only for members of the consortium (including the Commission)

<b>Responsible and Editor/Author:</b> Antonio F. Gómez Skarmeta	<b>Organization:</b> UMU	<b>Contributing WP:</b> WP6
--	-----------------------------	--------------------------------

**Authors (organizations):**  
Jean-Mickael Guérin (6WIND), Emilio García (ASSA), Pedro Ruiz (ASSA), Jordi Palet (Consulintel), Alvaro Vives (Consulintel), Chano Gómez (DS2), Daniel Martínez (UMU), Juan José Pujante (UMU).

**Abstract:**  
  
Description of the Madrid 2003 Global IPv6 Summit demonstrations.

**Keywords:**  
  
IPv6, Power Line Communication.

# Revision History

The following table describes the main changes done in the document since its creation.

<b>Revision</b>	<b>Date</b>	<b>Description</b>	<b>Author (Organization)</b>
v0.1	29/04/2003	Document creation	Daniel Martínez (UMU) Juan José Pujante (UMU)
v1.1	29/04/2003	Minor review and modifications Added Videophone demo	Emilio García (ASSA) Pedro M. Ruiz (ASSA)
v1.2	30/04/2003	Network map change. Added Network requirements. Table of Contents updated. New sections	Juan José Pujante (UMU) Antonio F. Skarmeta (UMU)
v1.3	26/05/2003	Added information about 6WIND and prefix delegation	Jean-Mickael Guérin (6WIND)
v1.4	26/05/2003	Added Consulintel related information	Alvaro Vives (Consulintel)
v1.5	16/06/2003	Added section for Home Gateway Added photographs of GIS2003	Daniel Martínez (UMU) Juan José Pujante (UMU)
v1.6	18/06/2003	Final Review	Jordi Palet (Consulintel)

# Executive Summary

This document describes the trials shown at Madrid Global IPv6 Summit, 12<sup>th</sup>-15<sup>th</sup> May 2003. In this trial, further results of the 6POWER Project were shown.

# Table of Contents

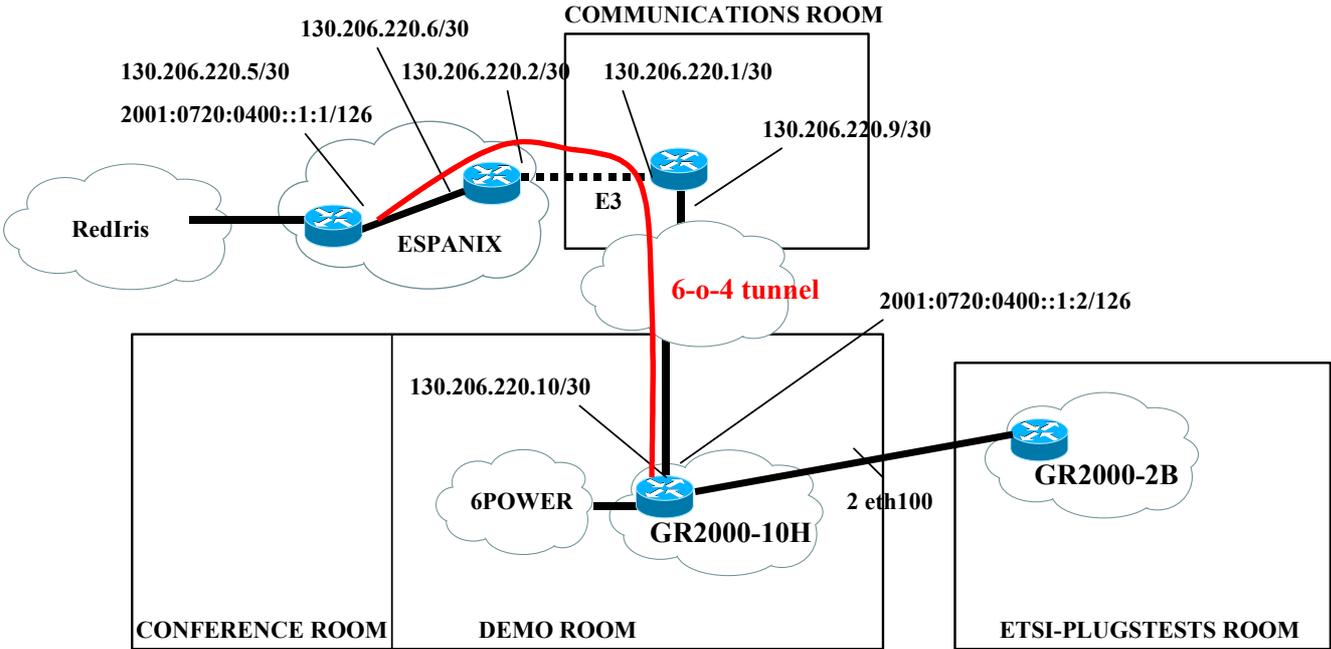
<b>1.</b>	<b><i>Trial Description</i></b> .....	<b>6</b>
<b>2.</b>	<b><i>Network Map</i></b> .....	<b>8</b>
<b>3.</b>	<b><i>Videophone Application</i></b> .....	<b>10</b>
<b>4.</b>	<b><i>Prefix Delegation and RADIUS</i></b> .....	<b>11</b>
<b>5.</b>	<b><i>Rough Description of the Tests</i></b> .....	<b>12</b>
5.1	<b>PC 1: Streaming Video Server</b> .....	<b>13</b>
5.2	<b>PC 2: Videophone Client</b> .....	<b>14</b>
5.3	<b>PC 3: Videophone Application</b> .....	<b>15</b>
5.4	<b>Laptop 1: QoS Broker and PDP</b> .....	<b>16</b>
5.5	<b>Laptop 2: Streaming Video Client</b> .....	<b>17</b>
5.6	<b>Router 1 (Delegating router)</b> .....	<b>18</b>
5.7	<b>Router 2 (Requesting router)</b> .....	<b>19</b>
<b>6.</b>	<b><i>Description of the demos</i></b> .....	<b>20</b>
6.1	<b>Videophone Demonstration</b> .....	<b>20</b>
6.2	<b>Prefix Delegation and RADIUS</b> .....	<b>20</b>
6.3	<b>Streaming Video Server</b> .....	<b>21</b>
6.3.1	<b>Overview</b> .....	<b>21</b>
6.3.2	<b>Innovations of the Demonstration</b> .....	<b>21</b>
6.3.3	<b>How IPv6 improves the environment</b> .....	<b>21</b>
6.4	<b>NAT-PT Demonstration</b> .....	<b>21</b>
6.5	<b>Home Gateway Demonstration</b> .....	<b>22</b>
<b>7.</b>	<b><i>Evaluation of Project Components</i></b> .....	<b>24</b>
7.1	<b>Scenario 1: No Interference</b> .....	<b>24</b>
7.2	<b>Scenario 2: Interfering Traffic (no reservation)</b> .....	<b>24</b>
7.3	<b>Scenario 3: Interfering Traffic (reservation)</b> .....	<b>25</b>
<b>8.</b>	<b><i>Summary and Conclusions</i></b> .....	<b>27</b>

# Table of Figures

<b>Figure 1-1:</b>	<b>Madrid 2003 GIS Venue Networks .....</b>	<b>6</b>
<b>Figure 1-2:</b>	<b>Madrid 2003 GIS WAN connectivity .....</b>	<b>7</b>
<b>Figure 2-1:</b>	<b>6POWER Network Map .....</b>	<b>8</b>
<b>Figure 2-2:</b>	<b>Part of the 6POWER Booth at GIS2003.....</b>	<b>9</b>
<b>Figure 3-1:</b>	<b>Snapshot of the Videophone Application.....</b>	<b>10</b>
<b>Figure 6-1:</b>	<b>Quality Profiles in the Videophone Application.....</b>	<b>20</b>
<b>Figure 6-2:</b>	<b>Home Gateway Demonstration at GIS2003 .....</b>	<b>22</b>
<b>Figure 7-1:</b>	<b>Bandwidth and Losses with Interference .....</b>	<b>25</b>
<b>Figure 7-2:</b>	<b>Bandwidth .....</b>	<b>26</b>
<b>Figure 7-3:</b>	<b>Interarrival Jitter .....</b>	<b>26</b>

# 1. TRIAL DESCRIPTION

This document describes the trials shown at Madrid Global IPv6 Summit 12<sup>th</sup>-15<sup>th</sup> May 2003 (GIS2003), organized by Consulintel. This event had delegates and speakers from over 35 countries, and several IST projects were present. Also both IPv6 and IPv4 connectivity was provided with an upstream of 34 Mbps, from the Summit venue. This means that the IPv6 Madrid Summit was a good choice for a public trial from both the technical and dissemination point of view.



Delegated IPv4 prefix: 130.206.14.0/23

Delegated IPv6 prefix: 2001:0720:1501::/48 (Demo)

2001:0720:1500:0100::/62 (Delegates network)

Figure 1-1: Madrid 2003 GIS Venue Networks

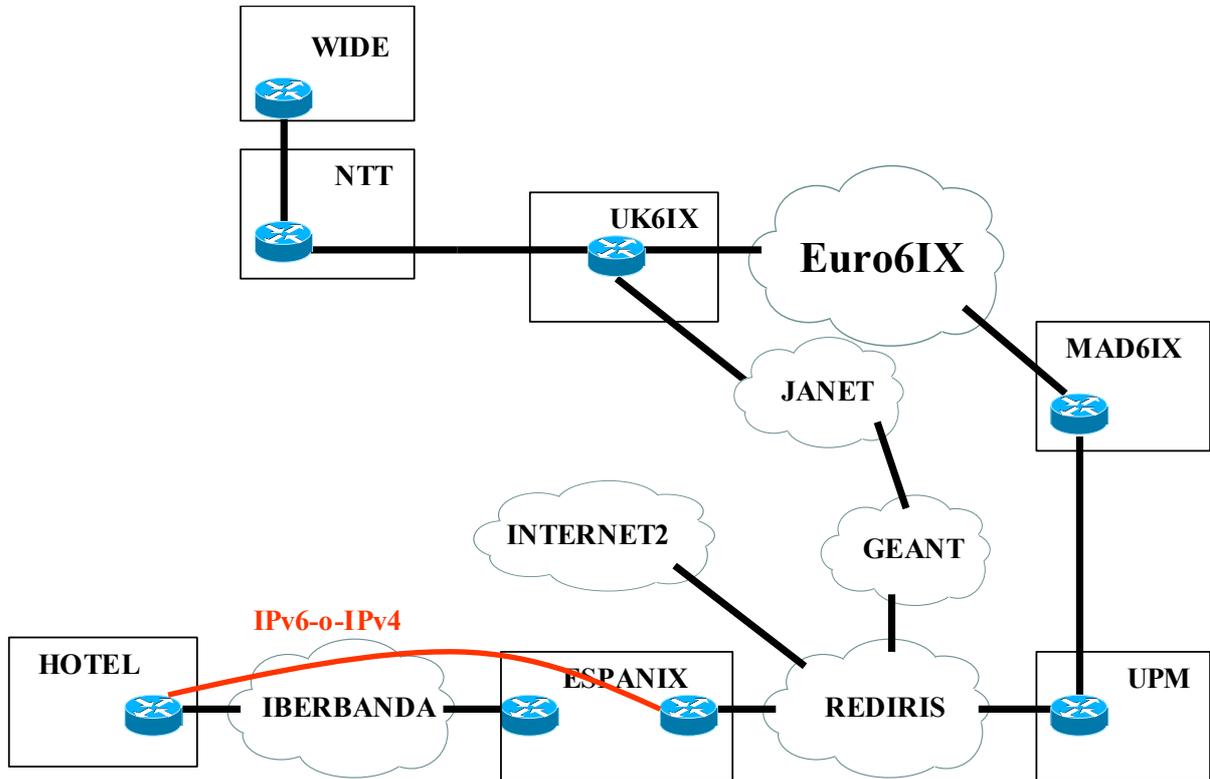
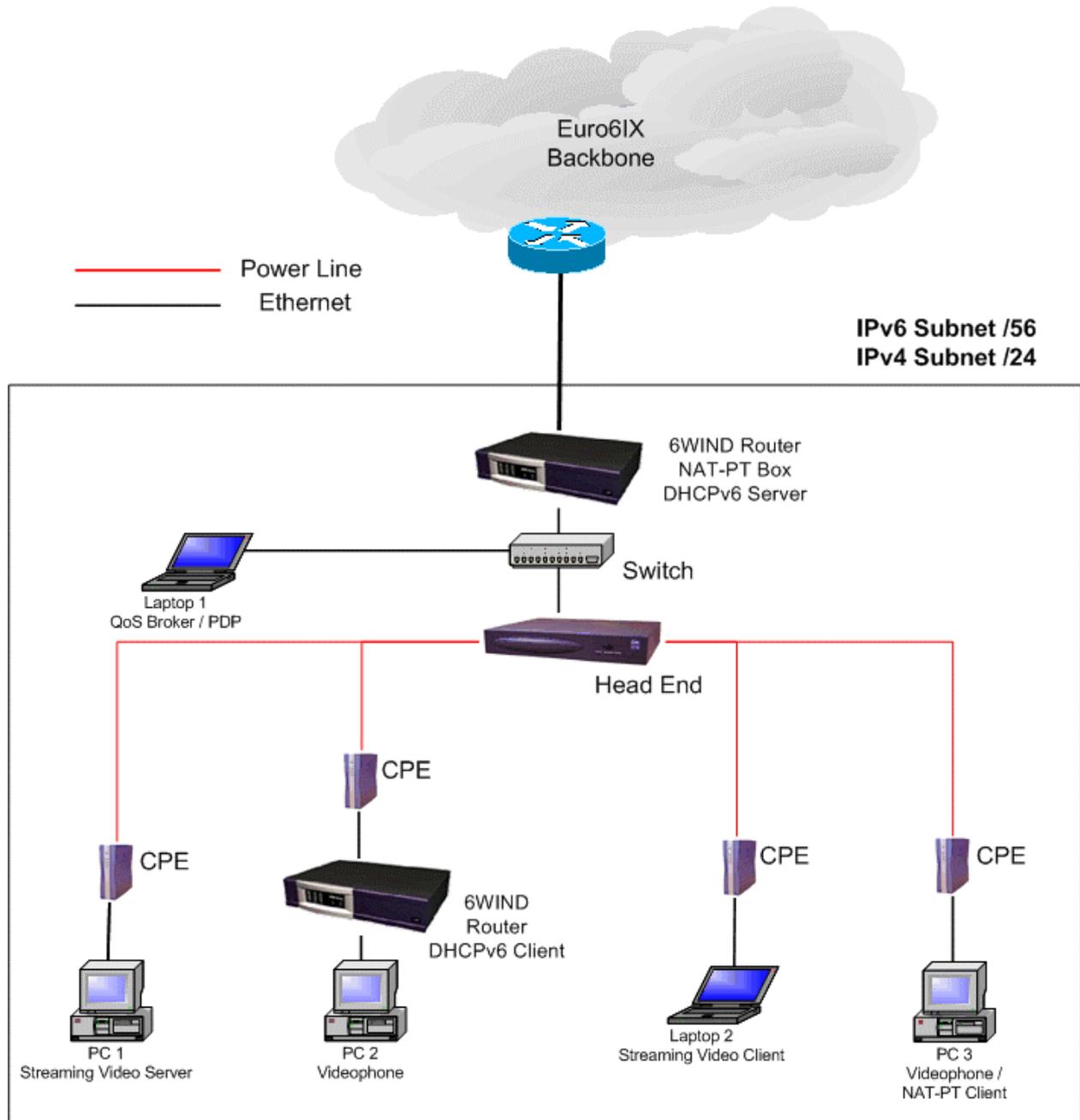


Figure 1-2: Madrid 2003 GIS WAN connectivity

In this trial, further results of the 6POWER Project were shown, comprising interaction between IPv6 applications and services with power line communication. Some of tests being shown were local, whereas others were remote.

## 2. NETWORK MAP

The following figure depicts the trial network layout. This corresponds to the elements that were locally installed at the Madrid Global IPv6 Summit. In addition to this network, there were other elements installed at the University of Murcia offering IPv6 services to be used remotely.



**Figure 2-1: 6POWER Network Map**

Network requirements:

- **IPv6 Prefix:** It is required an IPv6 prefix with length 56. The 6200 router will extend this prefix to length 60 and delegate it to the 6100 router via DHCPv6. The 6200 router will also advertise this prefix with length 64.
- **IPv4 Subnet:** It is required an IPv4 subnet for NAT-PT operations and IPv4 addressing.

Figure 2-2 shows part of the actual test-bed installed at Madrid:



**Figure 2-2: Part of the 6POWER Booth at GIS2003**

### 3. VIDEOPHONE APPLICATION

A new SIP-enabled version of the videophone application will be used in the trials to demonstrate effectiveness of our policy-based QoS provision mechanisms.

Extensions to the basic videophone software include among others:

- Basic SIP support, and SIP proxy communication capabilities.
- Possibility to manage and configure different QoS requirements, which are informed inside the SIP messages to the QoS broker.
- Improved internal capabilities management to achieve higher performance.
- Basic capability adaptation functions.
- Session logging facilities to gather performance metrics like bandwidth, jitter, packet losses, etc.

The videophone application will be used to connect through the PLC network. Interference traffic will be generated by the Streaming server, which will serve us to compare the performance of the application with and without establishing QoS reservations. The session logging facilities will be used to obtain quantitative metrics of the performance.

A snapshot of this new version of the software is depicted in Figure 3-1.



Figure 3-1: Snapshot of the Videophone Application

## 4. PREFIX DELEGATION AND RADIUS

This demo shows the prefix delegation mechanism and the interaction between the delegating router and an IPv6 RADIUS server. Upon a request for an IPv6 prefix from the customer's CPE, the delegating router (6WINDEdge 6200 series) asks to the RADIUS server over IPv6 in order to get the prefix subscribed by the customer.

When the DHCPv6 server receives a solicitation from a client, he checks if he has a configuration for him, watching the configuration file parsing result, more precisely the host's configuration list. He is using the client duid to identify him at this point.

If he finds one, he sends a reply to the client, containing the prefix he found in the configuration file. If he can't find any, he tries to authenticate the client using the RADIUS server. He checks if the duid of the client can match any id in the hosts file parsing result. If the duid couldn't match the hosts file, the DHCPv6 server tries with the link-local address.

If one id matched the hosts file, he gets the associated login, and tries to authenticate to the RADIUS server. If the authentication is valid, a new client configuration is created using RADIUS-acquired information, and added to the hosts configuration list (to avoid another authentication to the RADIUS server, we keep this client configuration in memory). A new binding is added, and the server replies to the client, including the RADIUS-acquired prefix. Default lifetime of this prefix is infinite, but it can be overridden with the default prefix lifetime statement.

## 5. ROUGH DESCRIPTION OF THE TESTS

### Objectives of the Trial:

- Show the new prototype of the SIP-enabled Videophone application from Agora, together with an improved prototype of the QoS Broker, that includes a better management of the QoS as well as the usage of the COPS protocol.
- Show the usage of NAT-PT to allow IPv6 clients to access IPv4 networks.
- Show IPv6 autoconfiguration of CPE routers by mean of DHCPv6 prefix delegation mechanism controlled by an IPv6 radius server.
- Offer a streaming video service over the PLC network. This will be also useful to demonstrate the correct operation of the QoS reservations.
- Allow the remote control of Home Automation devices through an OSGi Framework secure server.
- Evaluate the performance of the whole setup.

### Number of PCs:

- 3 PCs
  - PC 1: Streaming Video Server
  - PC 2: Videophone application
  - PC 3: Videophone application
- 2 Laptops
  - Laptop 1: QoS Broker and PDP
  - Laptop 2: Streaming Video Client
- 2 Routers (6WINDGate)
  - Router 1: DHCPv6 server, NAT-PT
  - Router 2: DHCPv6 client

### Additional Remarks:

- There is a PC installed at the University of Murcia running the OSGi Framework and another one running an IPv6 RADIUS server.

## 5.1 PC 1: Streaming Video Server

### Scenario Leader

Consulintel – Jordi Palet

### Demonstration Scenario on PC1

- Streaming video server.

### Client Requirements

- 1 PC (Pentium II, 400 MHz, 128 MB RAM or higher features).
- PC provided and installed by Consulintel.
- Operating System – Windows 2003 (Windows .NET).
- Windows Media Server series 9.
- Windows Media Encoder series 9.
- USB web cam.
- 1 CPE connected to 6POWER's network HE.

### Server Requirements

- DNS domain name to access the different streams.

### Network Requirements

- Connectivity to 6POWER's IPv6 network.
- 10/100 Mbps Ethernet.
- Required bandwidth 100 Mbps (To allow several clients and several local demos simultaneously and try to stress the PLC network).
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by Consulintel – 1 Person for PC1.

### Further Requirements

None.

## 5.2 PC 2: Videophone Client

### Scenario Leader

UMU – Antonio F. Gómez Skarmeta

ASSA – Pedro M. Ruiz

### Demonstration Scenario on PC2

- Videophone application.

### Client Requirements

- 1 High Performance PC.
- PC provided and installed by UMU.
- Operating System – Linux Red Hat 7.3.
- Videophone application from Agora.
- Video Capture Card.
- Sound Card.
- Microphone.
- Speakers.
- Proper DNS configuration for NAT-PT.

### Server Requirements

- SIP Proxy (functionality provided by the QoS Broker).

### Network Requirements

- Connectivity to IPv6 network/Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- PLC Bandwidth Requirements: 300 Kbps – 1.5 Mbps (according to QoS).
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by UMU – 1 Person for PC 2.

### Further Requirements

None.

## 5.3 PC 3: Videophone Application

### Scenario Leader

UMU – Antonio F. Gómez Skarmeta

ASSA – Pedro M. Ruiz

### Demonstration Scenario on PC 3

- Videophone application.
- NAT-PT functionality.

### Client Requirements

- 1 High Performance PC.
- PC provided and installed by Agora.
- Operating System – Linux SuSE 7.3.
- Videophone application from Agora.
- Video Capture Card.
- Sound Card.
- Microphone.
- Speakers.

### Server Requirements

- SIP Proxy (functionality provided by the QoS Broker).

### Network Requirements

- Connectivity to IPv6 network/Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- PLC Bandwidth Requirements: 300 Kbps – 1.5 Mbps (according to QoS).
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by Agora – 1 Person for PC 3.

### Further Requirements

None.

## 5.4 Laptop 1: QoS Broker and PDP

### Scenario Leader

UMU – Antonio F. Gómez Skarmeta

### Demonstration Scenario on Laptop 1

- QoS Broker application.
- COPS Policy Decision Point (PDP).

### Client Requirements

- Laptop provided and installed by UMU.
- Operating System – Linux Red Hat 7.3.
- QoS Broker application.
- COPS PDP application.
- Net-SNMP with IPv6 support and DS2 module.

### Server Requirements

### Network Requirements

- Connectivity to IPv6 network / Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- IPv4 Address needed: Yes
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by UMU – 1 Person for Laptop.

### Further Requirements

None.

## 5.5 Laptop 2: Streaming Video Client

### Scenario Leader

UMU – Antonio F. Gómez Skarmeta

### Demonstration Scenario on Laptop 2

- Usage of streaming video service.

### Client Requirements

- High performance Laptop.
- Laptop provided and installed by Agora.
- Operating System – Windows.
- Windows Media Player.

### Server Requirements

- Streaming Video server.

### Network Requirements

- Connectivity to IPv6 network/Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by Agora – 1 Person for Laptop.

### Further Requirements

None.

## 5.6 Router 1 (Delegating router)

### Scenario Leader

6WIND – Jean-Mickael Guérin

### Demonstration Scenario on Router 1

- DHCPv6 server functionality (Delegating Router).
- IPv6 RADIUS client functionality.
- NAT-PT functionality.

### Network Requirements

- Connectivity to IPv6 network/Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personnel

- Provided by 6WIND – 1 Person for Router 1.

### Further Requirements

None.

## 5.7 Router 2 (Requesting router)

### Scenario Leader

6WIND – Jean-Mickael Guérin

### Demonstration Scenario on Router 2

- DHCPv6 client functionality (Requesting Router).

### Network Requirements

- Connectivity to IPv6 network / Euro6IX backbone.
- 10/100 Mbit/s Ethernet.
- IPv4 Address needed: No
- IPv6 Address needed: Yes

### Demonstration Personal

- Provided by 6WIND – 1 Person for Router 2.

### Further Requirements

None.

## 6. DESCRIPTION OF THE DEMOS

### 6.1 Videophone Demonstration

The test-bed in which this demonstration took place is the one described in Section 2. The videoconference was set-up between two Videophones, installed in PC 2 and PC 3, both connected through the PLC network.

The videoconference application has been modified to bring the user the possibility of selecting one among three levels of quality (profiles), which are shown in Figure 6-1.

Quality Profile	Audio	Video			Estimated average bandwidth (Kbps)	
	Codec	Codec	Frames per second	Size		Quality
<b>LOW</b>	GSM	MJPEG	15	SQCIF	66	350
<b>MEDIUM</b>	G.711 a-law	MJPEG	16	QCIF	70	700
<b>HIGH</b>	PCM	MJPEG	16	CIF	60	1800

**Figure 6-1: Quality Profiles in the Videophone Application**

Moreover, the selection of the quality of the transmission is reflected when the call is established using SIP. That way, the QoS Broker (Laptop 1, which also acts as a SIP Gateway in all the process) is informed about the amount of bandwidth that will be required to maintain the selected quality. The QoS Broker, which is aware of the actual topology of the network, will act over the PLC elements, to guarantee the final Quality of Service.

Due to the high bandwidth available in the PLC network, all tests were conducted using the HIGH Quality Profile. As a result of each tests, measurements of bandwidth used by the application, jitter and losses were taken. They will be shown at next section, Evaluation of Project Components.

### 6.2 Prefix Delegation and RADIUS

The new feature is provided by the integration of two functionalities: DHCPv6 delegating prefix function and IPv6 RADIUS client. The advantage is the use of both a standard mechanism for prefix delegation like DHCPv6 and a standard protocol for customer databases access like RADIUS. It should increase IPv6 deployment by reusing existing user databases on RADIUS servers.

IPv6 brings customers routers auto-configuration thanks to the prefix delegation mechanism and integration with RADIUS server provides a transparent access to existing servers on ISP networks.

The test of this scenario consists in two steps: first, log into the 6100 router and check that the prefix delegation has been successful; this can be done by using the “show interface” command. Second, we must check that PC 2 has correctly learned the advertised prefix and that it has successfully formed an IPv6 address from it; using the “ifconfig” command can easily do this. The “route” command can also be used to check that the IPv6 routes have been successfully installed too.

## 6.3 Streaming Video Server

### 6.3.1 Overview

The demonstration tries to show the audio/video streaming over IPv6 by mean of an IPv6 player (Windows Media Player Series 9.0). The streaming server is located at the Eurov6 booth and connected to the 6POWER network using PLC technology.

In addition of a normal High Quality Video/Audio streaming, another goal is to show a preliminary use of IPv6 QoS functionalities for this kind of streaming services.

All this traffic will go through PLC network, from the streaming server to the streaming client located at the 6POWER stand. With this test we can show the capacity of the PLC network, which is able to support up to 45 Mbps.

### 6.3.2 Innovations of the Demonstration

The use of audio/video streaming over IPv6 using PLC as network access.

### 6.3.3 How IPv6 improves the environment

- The IPv6 protocol allows the use of a wide range of available addresses.
- The IPv6 protocol provides address autoconfiguration to the clients.
- The IPv6 protocol allows QoS facilities that improve the network performances.

## 6.4 NAT-PT Demonstration

The tests that were made for checking the correct operation of NAT-PT were:

- Ping6 an IPv4 host, for example, typing “ping6 www.google.com”. The ping response appears to be coming from an IPv6 address, although www.google.com is an IPv4-only host. The same way, the ping request that arrives to www.google.com appears to be coming from an IPv4 address, although it really comes from our IPv6-only node PC 2.
- Access to an IPv4-only web page from a web browser. The same procedure is used here, and the IPv4-only web page appears on the browser of PC 2.
- Use the “dig” command to query about an IPv4 host. The response will be an IPv6 address.

For example, the ping6 test works like this:

- The user at PC 2 types “ping6 www.google.com”.
- The 6200 router queries the IPv4 DNS at 155.54.95.19 for the IPv4 address of www.google.com (216.239.51.99).
- The ping request is sent over the public interface of the 6200 router, carrying the IPv4 source address of this interface, 130.206.14.210.

- The request arrives to 216.239.51.99, and a response is sent back to 130.206.14.210.
- When the response arrives to the 6200 router, its source address is changed to an IPv6 one (taken from the prefix 2001:800:40:2c80::/96), and the destination address is set back to that of PC 2.
- PC 2 receives the ping6 response, apparently coming from an IPv6 host, but really coming from www.google.com (216.239.51.99).

## 6.5 Home Gateway Demonstration

This demo shows how home devices can be securely and remotely controlled via a services gateway. The scenario consists of a local part installed at the Madrid trial, and a remote part located in Murcia. There is a PC in the remote part, which is running the OSGi Framework to control two devices: a lamp and the TICA device. The OSGi server offers a secure web interface from which both devices can be controlled, that is, the lamp can be switched on and off, and the TICA can be commanded to open or close a door. All of this operation could be watched in real time from Madrid, by means of a web cam installed in Murcia. Figure 6-2 shows this demo running at Madrid GIS2003.



**Figure 6-2: Home Gateway Demonstration at GIS2003**

The image from the web cam (which shows the remote part installed at UMU) refreshes every second, so that the user can easily monitor the status of the home devices being managed. Moreover, the web interface is also ready for watching the web cam picture on a PDA.

The OSGi Framework not only serves as an entry point for the home devices, but also as a protocol aggregator / translator. Home devices can be managed by a variety of third-party home control protocols like X10, EIB, BatiBus, etc. The usage of a home gateway makes all the devices manageable from a common entry point (the web interface), leaving to the OSGi Framework the task of actually communicating with the devices, using whatever protocols are

needed in each case. As an example, the home gateway that shown in Madrid was used to manage an X10 lamp and the custom TICA device made by the UMU, both from the same web interface as seen above.

Home control is secured by using HTTPS and a smartcard reader. The OSGi web interface has been secured at UMU by wrapping it with a secure Tomcat web server, so that it not only provides a server-side certificate, but also requests a client-side certificate. This has been done to reflect that no one can control the home devices but the actual owner of the house.

## 7. EVALUATION OF PROJECT COMPONENTS

The evaluation at GIS2003 was based on the performance and reliability of the Videophone application, running on IPv6-over-PLC with broker-based QoS management. Three scenarios were identified for taking bandwidth, losses and jitter measurements:

- Scenario 1: Only Videophone traffic is present in the PLC network. No QoS reservation is made.
- Scenario 2: Here, the streaming video server and client are used to inject interfering traffic in the PLC network. However, there is still no QoS reservation.
- Scenario 3: Videophone traffic has a QoS reservation, while streaming video traffic is used again to saturate the PLC link.

The following sections present the results of the tests made in each one of these scenarios.

### 7.1 Scenario 1: No Interference

The first scenario is the simplest, where a point-to-point communication is performed between the two Videophones (PC 2 and PC 3) and no other traffic is present at that moment in the network.

The results were as expected, and they will serve as reference for the other scenarios.

### 7.2 Scenario 2: Interfering Traffic (no reservation)

The point of this scenario is testing the performance of the videoconference service when some traffic is crossing the network, thus sharing the total available bandwidth.

This traffic, considered for the purposes of the test as interference, was introduced from PC 1 to Laptop 2, at a rate of roughly 20 Mbps. The maximum theoretical bandwidth of the PLC network was 18 Mbps (due to asymmetrical considerations), so the quality of the videoconference was degraded, as it is shown in Figure 7-1.

Between  $t = 30$  s and  $t = 80$  s the interference traffic nearly saturates the link, causing packet loss in the videoconference (at a rate of more than 90%) and nearly no images being displayed at each Videophone. This effect is clearly seen when compared with the usual performance when interfering traffic is not present and bandwidth is about 2000 Kbps (actual oscillations are due to the different size of the frames transmitted, inherent to MJPEG video encoding).

Even when the interference has disappeared, after  $t = 80$  s, some losses are present, they are minimal and do not affect significantly the performance of the application, as the bandwidth shows.

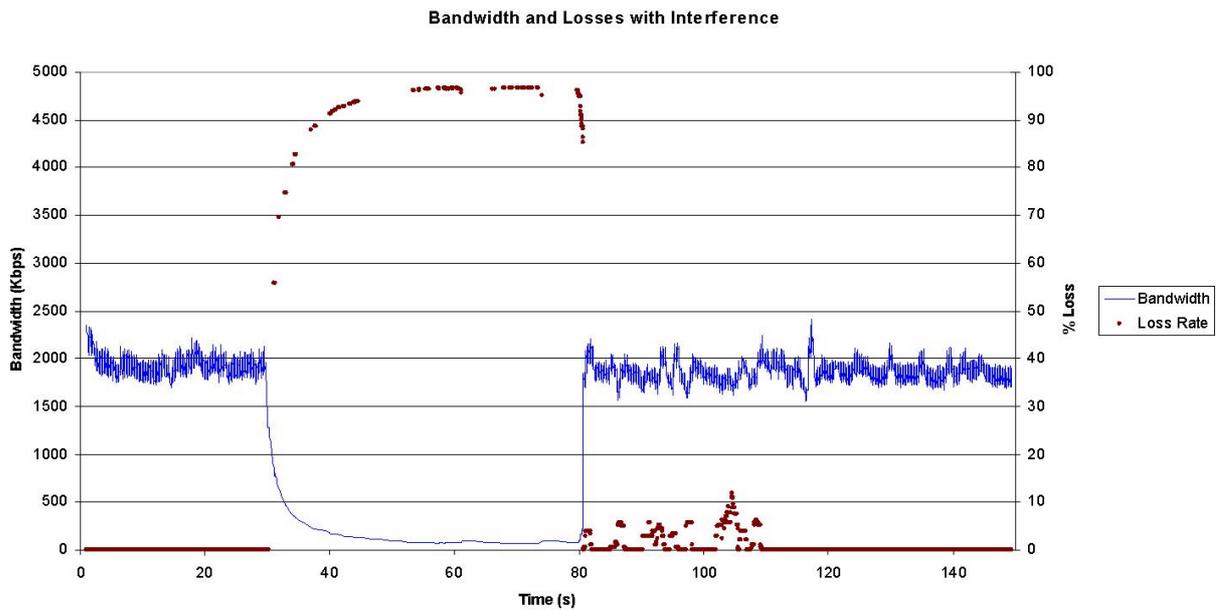


Figure 7-1: Bandwidth and Losses with Interference

### 7.3 Scenario 3: Interfering Traffic (reservation)

To cope with this kind of aggressive scenarios, where real-time bandwidth-sensitive applications must fight with other not so sensitive services (such as HTTP, FTP or even streaming), a QoS Broker was introduced in the topology, Laptop 1 in the scheme. As it was said before, it also performed as a SIP Gateway, so it intercepted, processed and retransmitted the SIP packages used to establish the session. These packages contained the relevant information about the bandwidth to be used (1800 Kbps), so the QoS Broker performed the adequate reservations. The result was the one depicted in Figure 7-2.

The blue line represents the actual bandwidth for this scenario, were the interference is present, but a resource reservation has been made. The yellow line corresponds to the bandwidth obtained from scenario 1, where no interference was present. It can easily be seen that the interference affected in no way the bandwidth available to the Videophones, and the only oscillations are due to the MJPEG encoding (as mentioned before).

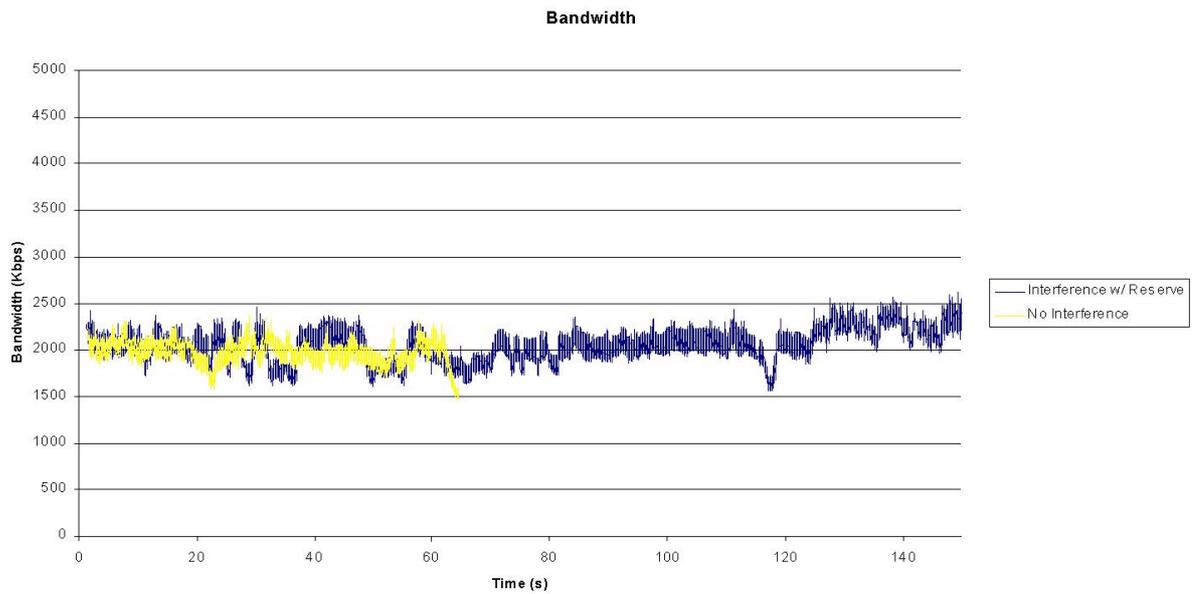


Figure 7-2: Bandwidth

In contrast, Figure 7-3 shows that the jitter was affected by the presence of the reservation and the interfering traffic, although so lightly that it could be easily compensated by buffering techniques at each end.

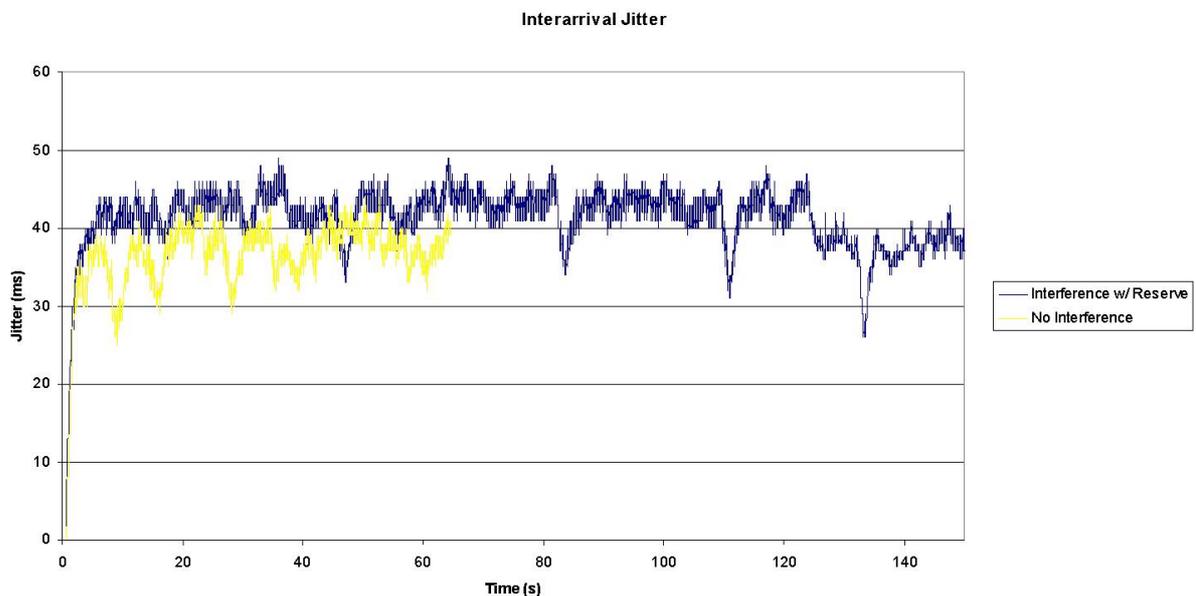


Figure 7-3: Interarrival Jitter

As a result of this demonstration, it became clear that the mechanisms of bandwidth control and QoS are essential if real-time services are to be used with some guarantees in this kind of networks.

## 8. SUMMARY AND CONCLUSIONS

At the sight of the results, we can state that IPv6 over PLC is a promising field, featuring the performance, reliability and availability needed for final IPv6 users. The tests run show that already developed PLC technology is capable of bringing broadband IPv6 access to the homes, and once the second generation of PLC chips are available (with a transmission capacity over 200 Mbps), PLC will be able to compete with other solutions such as xDSL or cable lines.

Prefix delegation and NAT-PT demos show that the overall architecture is both scalable and backwards compatible with IPv4-only areas, which makes the deployment of a PLC network easier; besides, home automation and streaming video demos show that valuable services can already be offered to the end users at home.

Those present at the Madrid 2003 Global IPv6 Summit showed a great interest in the technologies being exhibited, particularly in the 6POWER project, as was later reflected in the press.

People feel PLC technology as something nearer than other technologies like Bluetooth or WLAN, since it is based on the normal power lines and sockets that we use in everyday life, and so they feel more comfortable with it.

This, together with its proven capabilities, makes us think that the IPv6-over-PLC solution will be well accepted enough to become pervasive in a short period of time.