WIDE Technical-Report in 2008

# The WIDE Nautilus6 Working Group Report 2007

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# The WIDE Nautilus6 Working Group Report 2007

Nautilus6 Working Group

## Abstract

*This report summarizes the activities realized within the WIDE Nautilus6 Working Group during the year 2007.*

## 1 Introduction

The WIDE [1] Nautilus6 Working Group [2] was established in fall 2002 to provide a better IPv6 mobility environment to the users. We concentrate our work on research, implementations and demonstrations on various topics around IPv6 and IPv6 mobility: host and network mobility, multihoming, seamless mobility, AAA, security, applications and operations.

## 2 Contributors

The following people have contributed to this report (in alphabetical order):


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- Antoine BOUTET (IRISA/INRIA Rennes, France)
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## 3 Implementation

### 3.1 NEPL

The NEMO Platform for Linux (NEPL) is a NEMO Basic Support [4] implementation for the GNU/Linux operating system. It has originally been developed as an extension to the Mobile IPv6 implementation for Linux (MIPL2 [5]) by the Helsinki University of Technology in cooperation with Nautilus6.

This year, the USAGI WIDE Working Group has released UMIP [6], an improved version of MIPL2 that aims at providing the necessary changes to run on the latest kernels while improving the software to respect the standards. Nautilus6 has thus proposed and continuously maintained NEPL for UMIP [7]. It is freely available as a patch, and several releases have been done this year. The latest one from November 2007 is available through the NEPL Howto that we also maintain [8]. Nautilus6 provides binary packages as well for Debian and Ubuntu available on our Mobile IPv6 package repositories (section 5.4).

Nautilus6 also proposes a Multiple Care-of Addresses registration (MCoA [9]) implementation for NEPL [10]. It brings multihoming features to NEPL, thus ensuring seamless and fault tolerant communication to a node running NEPL. This implementation is released as a patch also available through the NEPL Howto [8]. We recently released an updated version in November 2007.

NEPL and MCoA are used in a number of academical and industrial projects. The Nautilus6 operational Service operated in Keio University (Japan), Louis Pasteur University (France) and ENST-Bretagne (France) uses NEPL on their operational Home Agents (section 6) and in Homeguy, the Mobile IPv6 oriented Live-CD developed by Nautilus6 (section 5.3). The ANEMONE European testbed [11] uses NEPL and MCoA in their IPv6 mobility testbed. The French REMORA project [12] also uses both NEPL and MCoA as the core feature of their demonstration testbed. NEPL and MCoA have also been used within the WIDE project to provide reliable IPv6 connectivity during the WIDE Camp [13].

## 3.2 SHISA

SHISA is a Mobile IPv6/NEMO BS implementation built on top of BSD Operating Systems. This year, we started the activity to import the stack to the BSD mainline kernel. At the same time, we also tried to provide a practical usage example using the stack.

### 3.2.1 Merging Approach

The final goal of the SHISA development project is to integrate the developed stack into the BSD system so that every BSD users can utilize the IPv6 mobility function. SHISA was originally developed on top of the KAME IPv6 stack [14] for NetBSD 2.0 and FreeBSD 5.4. We ported SHISA to the NetBSD-current tree as the first step of porting effort. There are two reasons why we chose NetBSD as the first platform for the porting work. The first reason is that it supports various kinds of architectures. The mobility functions are useful especially when it is integrated to a moving entities such as PDAs and cars or trains, and so on. They usually use an architecture that runs with limited resources. NetBSD supports many such architectures that is suitable for embedded use, and we wanted to realize such small devices using our code. The other reason is the difference between the KAME tree (that was based on NetBSD 2.0) and the latest NetBSD is relatively small compared to other BSD variants that KAME supported. This makes it easier to port the SHISA code from KAME to NetBSD-current.

The first approach to the NetBSD developer was to have a presentation [15] in the Asia BSD Conference which was held in Tokyo in March 2007. In this conference, we introduced our IPv6 mobility architecture to the other BSD developers. In last April, one of our developer was registered as a NetBSD developer and was given access to the IPv6 network code to add IPv6 mobility functions. Currently we are following the latest NetBSD current code and preparing a patch file for the latest code.

### 3.2.2 Practical Usage

We also utilize the SHISA stack as an experimental network mobility router. The activity was done as a part of the Internet CAR Working Group [16] activity. The router is based on the Soekris platform. The router has two external network interfaces, one is a 802.11 wireless interface, the other is a PHS data communication interface. The router connects to the Internet through the wireless interface, whenever it is reachable to one of the known wireless access points that are pre-registered to the router. Otherwise, it connects to the Internet through the PHS interface. Currently, the PHS data communication service does not provide IPv6 access service. In this system, the router connects to the IPv4 Internet through the PHS interface first, and creates an IPv6 over IPv4 tunnel to get IPv6 connectivity.

The router is also equipped with another wireless network interface, which is used for direct communication with the neighbouring mobile routers. On the wireless interface, the OSPFv3 protocol is operated on top of the adhoc mode 802.11 network operation, and if two or more mobile routers are in the range of the wireless communication area, these routers become direct reachable entities. This shortcut path reduces the redundant communication path, which usually occurs when two mobile routers are communicating each other. In this case, the packets between the two routers are usually go through their home agents. Using the second wireless network interface makes route optimization when two routers are located closely.

The summary is reported as a conference paper [17] at the last Asia BSD Conference.

### 3.2.3 SHISA Project Summary

As an milestone of the SHISA development project, we have summarized our previous work on developing Mobile IPv6 stack on BSD systems in [18]. We implemented the IPv6 mobility stacks based on the IETF standard mobility specifications and released the stacks to accelerate the deployment of the IPv6 mobility technology. The first version of the stack (KAME Mobile IPv6) was implemented in the kernel, but the kernel stack design and its implementation had problems in extensibility and ease of development. We redesigned the stack moving the mobility signal processing code to user space. To keep the normal packet processing performance, the normal packet input/output processing code was kept in the kernel. The new stack (SHISA) can be easily extended to support new features. Thanks to this design, we could add NEMO BS, Multiple CoA Registration and IPv4 mobile network support to the SHISA stack easily. Also the SHISA stack will more readily attract third party development activities [19, 20] thanks to the user space implementation that is easier to develop than the kernel development. We made several experiments and demonstrations [21, 22, 23, 24] proving the applicability and stability of the SHISA stack, and to advertise the IPv6 mobility technology. We are now focusing on adapting the SHISA stack to the original BSD distributions so that the SHISA stack can be merged into these distributions.

## 3.3 DSMIPv6 for BSD

Dual Stack Mobile IPv6 (DSMIPv6) is an extension of Mobile IPv6 to support IPv4 care-of address and to carry

IPv4 traffic via bi-directional tunnels between mobile nodes and their home agents. Using DSMIPv6, mobile nodes only need the Mobile IPv6 protocol to manage mobility while moving within both the IPv4 and IPv6 Internet. This is an important feature for IPv6 mobility during its deployment phase because IPv6 access network is not widely deployed yet. We thus decided to develop DSMIPv6 implementation for SHISA, our open source Mobile IPv6 and NEMO implementation for BSD operating sysytems.

The DSMIPv6 implementation was designed to separate the signaling function and the forwarding function, and to minimize modifications on the existing kernel and user land programs. The binding management code is shared with both IPv4 and IPv6 mobility functions by using IPv4-mapped IPv6 address format. When care-of or home addresses are used, new or modified correspondent functions are called according to its address family. An IPv4 care-of address detection feature is also added to the user land programs.

By evaluating the implementation, it is confirmed that the DSMIPv6 implementation works in the all situations without adding remarkable header processing overhead. It is thus said that the specification is stable to forward IPv4/IPv6 packets address to their home addresses/mobile networks. The result was presented at [25].

### 3.4 DSMIPv6 for Linux

The Linux counterpart of the DSMIPv6 implementation is also being developped within the Nautilus6 Working Group, in collaboration with the USAGI Working Group. It is currently working with Linux Kernel 2.6.23 and umip-0.4 daemon codes provided by the USAGI git server.

The implementation itself is based on an old IETF draft (draft-ietf-mip6-nemo-v4traversal-04). It is split in kernel and userland parts according to what processing is required. On the userland side, separate functions are called according to the type of IP address (either v4 or v6) whenever specific handling is required, whereas on the kernel side much of the XFRM modular framework is reused for UDP encapsulation / decapsulation. This makes the code very lightweight and portable to more recent versions of the kernel and MIPL daemon code.

The implementation currently supports IPv4 Care-of Addresses to provide IPv6 connectivity in legacy IPv4-only access networks. It has been succesfully experimented during Spring 2007 and the results will be shown in a paper to be completed. Support for IPv4 Home Address is planned as well as interoperability testing with the SHISA implementation described previously as soon as compliance will be reached with latest version of the document (either draft or RFC).

## 4 Integration of IPv6 Mobility and IKEv2

This year we have focused our work on providing dynamic keying for Mobile IPv6 as defined in RFC4877 [26] on the Linux platform, using the racoon2 [27] implementation for IKEv2. This is the first step to achieve MIPv6 bootstrapping in AAA environments as defined by RFC 5026 [28].

### 4.1 Racoon2 modifications

We have made several modifications to the racoon2 implementation in order to make it compliant to the MIPv6 requirements. For example, when used with UMIP, racoon2 does not handle the SPD entries related to the MIPv6 messages, but it must be able to negotiate the security parameters (SA) for these entries. Another issue, the IKE session endpoints differ from the SA endpoints, which was also not supported by racoon2. The daemon must also be able to negotiate pairs of SA for asymmetrical traffic selectors (for example to protect BU in one way and BA in the other way.)

All these modifications have been released as patches (see next section for detail) and the racoon2 core team has plans to integrate it in their daemon. Nautilus6 also provides binary packages for Debian and Ubuntu available on the Mobile IPv6 package repositories (section 5.4).

### 4.2 Dynamic Keying HowTo

We have published a HowTo document [29] describing the installation and configuration of mip6d and racoon2 in order to achieve dynamic keying in MIPv6 and NEMO in Linux.

This document describes the steps to build the needed environment (kernel, mip6d and racoon2 with appropriate patches) and the configuration of each part. The authentication method is certificate-based.

### 4.3 New MIGRATE format

The current implementation of dynamic keying uses the MIGRATE message as defined in draft 03 [30] for the communication between the MIPv6 daemon and the IKEv2 daemon.

We have identified several problems with this interface. The SADB_X_EXT_PACKET message for example can not be efficiently implemented in Linux. Moreover, it requires the IKE daemon to parse the BU message to acquire the Care-of Address that must be used in the IKE exchange. This adds a lot of complexity. Another issue is that using the MIGRATE message to migrate the IKE session is not always suitable (see next section for detail). For example, if no tunnel-mode SA is defined, the IKE session would not survive movement.

Considering all these issues, we have written a new proposal for the interface between MIPv6 and IKEv2, based on the MIGRATE message. This new proposal has been submitted to the previous draft authors and will serve as a base for the release 05 of the document (not published yet). The main changes are: we do not use the SADB_X_EXT_PACKET extension anymore, but we have a new extension SADB_X_KMADDRESS in the MIGRATE message, to pass the IKE session endpoints from the MIPv6 daemon to the IKE or IKEv2 daemon. We also change a little bit the ordering of the events, issuing the first MIGRATE before sending the BU message.

This new solution has been implemented and works perfectly. It will be made available through the Nautilus6 package repository as soon as the new version of the draft is published at the IETF.

### 4.4 (K) flag

We have found another issue related to dynamic keying in the previous MIGRATE implementation. It is an interoperability issue.

RFC 3775 specifies a flag in BU and BA messages representing "Key Management Mobility Capability (K)". This flag represents the ability of the peer to move the IKE session endpoints when the MN moves.

We have submitted an Internet Draft [31] to detail the sequence of events that can happen when the flag is not used properly, as it is the case with the current racoon2 implementation (but fixed thanks to the new SADB_X_KMADDRESS extension). This document will serve as a base to propose a new clarification in the RFC 3775 that is being prepared in the MEXT IETF workgroup (RFC3775bis).

At the time of writing this document, it is not known whether the new proposal is accepted.

## 5 Operation Support

The Nautilus6 operational MIPv6 service is meant to provide a full featured IPv6 Mobility service to promote the use of mobility and as a playground for experimental protocols deployment. Our Operational service consists in different parts cooperating together as shown on Figure 1.

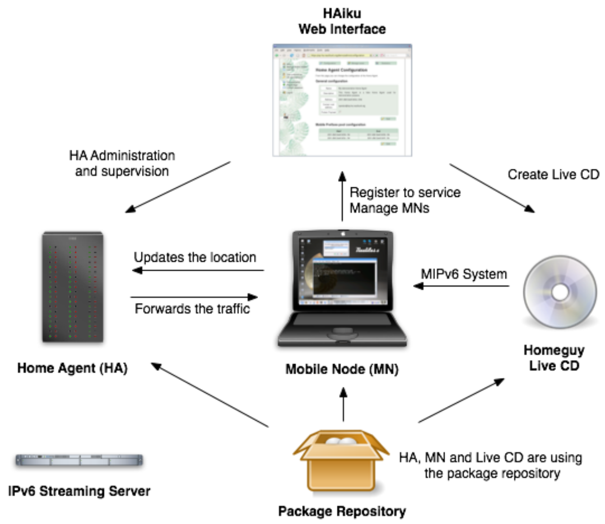


**Figure 1. Interaction in Operational service**

### 5.1 HAiku

We have released a simple and intuitive web interface called HAiku [32] which goal is to simplify the procedures involving the administrators and the users of a Home Agent. It is developed within the operational activity and initially designed for our public operation (section 6), however we want to make a tool adapted to all Home Agents. The first public release has been made in May 2007 and gave full support for Mobile IPv6 support and static keying with IPsec. This version let the users register to a Home Agent and create Mobile Nodes with the static security bindings managed by the software. A live CD with Mobile IPv6 support (section 5.3) and customized for each created Mobile Nodes is also available to help in using the service. On the administrative side, operators can manage the list of registered users and disable temporarily or delete users' accounts. They have also a basic control on the configuration of the Home Agent.

The version 0.2, released in October added among others the support for NEMO and the support for protecting all the traffic between the Mobile Node and the Home Agent. This version also added the possibility to send a mail from the interface to registered users and display Home Agent statistics retrieved thanks to SONAR.

The upcoming version 0.3 adds the support for Dynamic Keying and rails migrations.

Our work on HAiku has led to modification on existing software to add features needed for an operational use. One of these change was to add the capability to the MIPv6 daemon to dynamically reload its configuration. Until then, it was not possible to authorize a new node to register with the Home Agent without restarting the daemon. This was unacceptable for our operational service and we made it possible to reload the configuration without closing existing bindings.

Another change was to provide the support for nested configuration files to avoid doing change on the fly on the

MIPv6 daemon configuration file. We made it possible to use one main configuration file for the daemon and one file for each Mobile Node. The main configuration file doesn't change and we create or delete additional files for Mobile Node management. This is a clean way to proceed.

### 5.2 SONAR

SONAR [33] is first designed to be a set of free tools to build a statistics repository containing detailed information of mobile nodes. Users can send statistics information about their mobility system to a statistics repository by using these tools. The repository shows the history and analysis results of the collected data. The analysis includes classification of mobility, MIPv6/NEMO protocol evaluation, network access technologies benchmark and correlation between L2 and L3 technologies.

In 2007 we developed the home agent client and use its output to produce live statistics and monitoring of the Home Agent through HAiku interface (section 5.1). Preliminary tests and experiment have been covered in a paper [34].

The mobile node client (mobile host and mobile router) is available for Linux, FreeBSD and NetBSD. The home agent client is available for Linux and NetBSD.

### 5.3 Homeguy

We developed Homeguy [35] to be used jointly with our operational Home Agent but it soon proved to be also a very elegant way to install a full Mobile IPv6 distribution in a matter of minutes. Homeguy is a complete Operating System on CD-ROM with Mobile IPv6 capability that can be installed easily on hard drive. It is based on latest Ubuntu (currently gutsy) and has support for Mobile Host or Mobile Router. We bundled many Mobile IPv6 related software including implementations or networking tools, multimedia software, administration scripts, etc. We release a beta version of Homeguy in October and the 1.0 at the end of the year 2007.

### 5.4 Packages repositories

One of the difficulties of Mobile IPv6 deployment is the lack of packaged solutions. We started to package Mobile IPv6 related software for Debian and Ubuntu in order to facilitate the development of Homeguy (section 5.3). The need was motivated by the fact that setting up a complete Mobile IPv6 environment required to build a new kernel with MIPv6 extension enabled, build daemons, patch software, etc. We decided to provide our packages publicly to spread the use of Mobile IPv6 technology. Today, our Debian and Ubuntu packages repository containing software that had no binary packages yet or that had to be modified to support mobility are widely used and are a great help for those who want to setup MIPv6 environment.

### 5.5 IPv6 streaming server

We have set up an IPv6 streaming server within Nautilus6 to face the lack of IPv6 content. Video playlists are served by a web server in IPv6 and we have configured Homeguy to have direct access to these media. This is very useful to test your IPv6 connectivity and visually experience network handovers.

### 5.6 Global HAHA

Global HA to HA (Global HAHA) protocol is an extension of Mobile IPv6 and NEMO to remove their link layer dependencies on the Home Link and distribute the home agents at IP layer. In this mechanism every home agents are connected as a mesh topology using IP over IP tunnel and advertise the same home prefix to the Internet. A Binding Update message sent from a mobile node will be thus routed to the nearest home agent based on the routing information. All the traffic from the mobile node to other Internet nodes is received by the nearest home agent and then forwarded to the final nodes. All the traffic to the mobile node from the Internet nodes is received by the home agent that is nearest to the sending nodes and forwarded to the mobile node.

We are now preparing the experimental Global HAHA network on the actual IPv6 Internet. Currently, three home agents are placed at IIJ (Japan), WIDE (San Francisco) and WIDE (Keio University). Each home agent (or upstream router of the home agent) are advertising the same prefix used for the home network prefix using the BGP routing protocol. Next year we will have some experiments related to home agent distribution/redundancy technique using this live experiment network.

## 6 Public Operation

### 6.1 K2

Nautilus6 operates a Home Agent in K2 campus (Shin-Kawasaki, Japan) that has been made available publicly for any personal or scientific use at [36] in April 2007 and provides IPv6 mobility to more than eighty registered users. This Home Agent is running the latest stable version of HAiku (section 5.1) and Homeguy (section 5.3), and is the main Home Agent of Nautilus6 operational service.

A test Home Agent is also available and has features to be included in main service. It runs development version of HAiku and Homeguy. K2 moreover hosts an IPv6 streaming server (section 5.5), the Debian and Ubuntu package repositories (section 5.4) and the documentation of the Operational service.

### 6.2 Louis Pasteur University

The Louis Pasteur University Network and Protocols team [3] operates a Mobile IPv6 Home Agent as part of the Nautilus6 operational service. This Home Agent is located in Strasbourg, France. Thirteen users (mainly academics) subscribed to the service. We also use this Home Agent for educational purposes amongst the Louis Pasteur University students.

This Home Agent currently runs HAiku 0.1 (section 5.1) though we plan to upgrade the service to HAiku 0.2 for the beginning of year 2008.

The Network and Protocols team also participated to the publication of the HAiku installation documentation on the GNU/Linux operating system.

### 6.3 ENST-Bretagne and IRISA/INRIA Rennes

The University campus called Beaulieu in Rennes, France has both GPRS and Wi-Fi connectivity.

An outdoor Wi-Fi access has been deployed on the campus in order to provide an IPv6 access which can be viewed as Wi-Fi hotspots (Figure 2). The outdoor Wi-Fi coverage is represented by the red areas in the above figure. These access points are completely managed by the project, thus we can set up configurations to answer specific needs. The IPv6 prefix advertised by an access point depends on the localization on the campus.

The blue areas are the indoor coverage of the project. However, this coverage is not yet operational for the demonstration. Moreover, the campus is fully covered with a GPRS access. As this GPRS network only provides currently IPv4 connectivity, an IPv6 over IPv4 tunnel is set up in the ANEMONE testbed.

### 6.4 INRIA Rocquencourt

Mobile Adhoc Network (MANET) routing protocol and NEMO basic support protocol are considered key technologies for vehicle networks. Cooperation between MANET and NEMO (MANEMO) brings several benefits especially for route optimization and multihoming. We made a real field vehicle communication environment with NEMO and MANET. By switching from NEMO to MANET, routes between vehicles are optimized and network performances improved in terms of latency and bandwidth. Experiments result shows that network performances are further improved with simultaneous utilization of NEMO and MANET. Network performances were shown on a web site

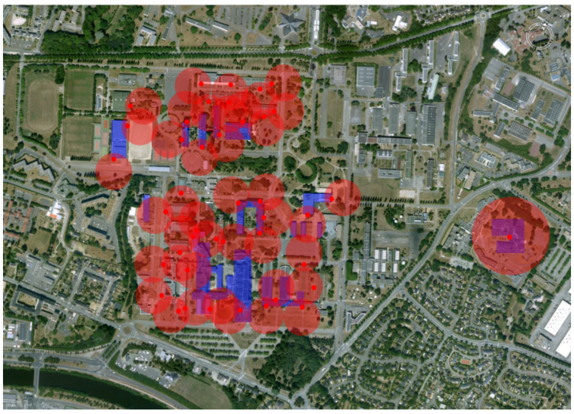

**Figure 2. Overview of indoor and outdoor testbed in Rennes**

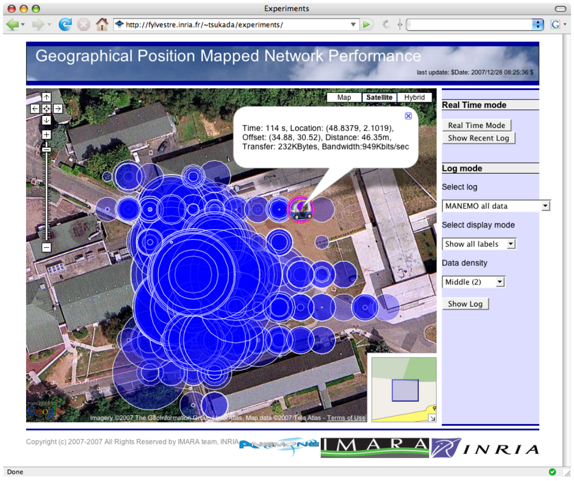


**Figure 3. Geographical Position Mapped Network Performance**

in real time and mapped at locations using GPS information. Figure 3 is the screen shot of the website.

## 7 Demonstrations

### 7.1 Ubiquitous Network Symposium

We had a demonstration at the Ubiquitous Network Symposium, which was held in Akihabara (Tokyo) on November 29th and 30th 2007.

The purpose of the demonstration was to show our work on the MIPv6 and IKEv2 interaction mechanism (Figure 4 is the poster used at the demonstration to show the purpose in Japanese). We demonstrated a working implementation of RFC 4877 [26], where we had NEMO (NEPL implementation, section 3.1) using IKEv2 (racoon2 [27]) to dynam-

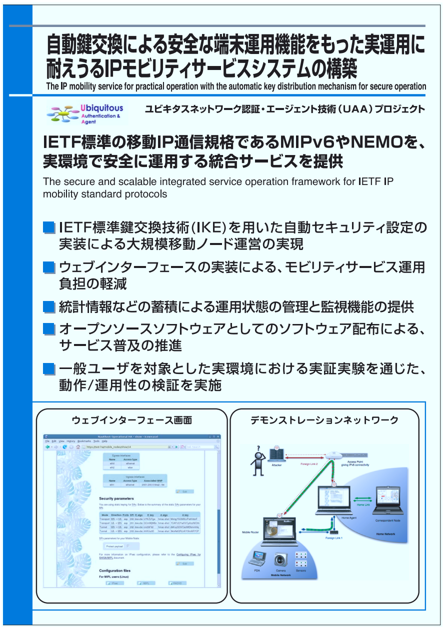


**Figure 4. UNS demonstration poster**

**Figure 5. UNS demonstration testbed**

ically establish the security associations parameters used to protect NEMO signaling and optionally tunneled traffic. The protection of traffic payload between the Home Agent and a Mobile Router was the main focus of the demonstration.

The demonstration testbed (Figure 5) was set as described in Figure 6.

We had two mobile routers registered to a home agent running our HAiku interface. One Mobile Router was using IPsec to protect all traffic tunneled to the Home Agent, the other Mobile Router was protecting only the signaling messages (BU, BA, ...). In the mobile networks (Figure 7) attached to these routers, we had IPv6 cameras and other sensors. A correspondent node in the home link was displaying

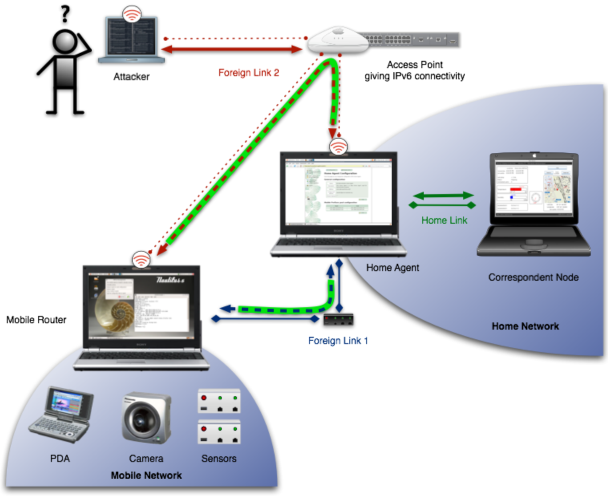


**Figure 6. UNS demonstration principles**

**Figure 7. Mobile Network**

pictures from the cameras. The routers could move between a wired network and a wireless network, which was used to represent a non-controlled and insecure environment. A spy computer (Figure 8) was listening to all wireless traffic and running a custom version of driftnet – a tool that can extract pictures from TCP streams and display these pictures – that was able to capture in IPv6 and tunneled traffic. When the mobile router without protected payload was moving to the wireless network, the spy computer was able to capture and display the pictures sent by the camera. When the mobile router with tunnel protection was moving, the spy computer failed to display the camera pictures.

This demonstration helped people to visualize the role of IPsec protection for the tunneled traffic. When using IPv6 mobility, and NEMO in particular, the mobile router may traverse insecure networks, especially in the case of ubiquitous networking. In situations where the exchanged data requires confidentiality (sensors data for example), it

Figure 8. Spy computer

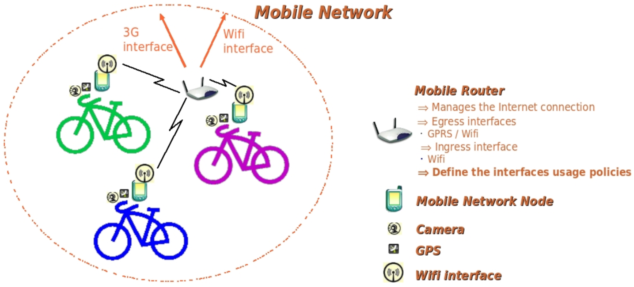


Figure 9. The overview of E-bike 2007

is mandatory to use IPsec to protect the exchanges on the insecure path. This protection is transparent to the peers.

The demonstration was also a good opportunity to show some tools we have developed in Nautilus6 in action, the HAiku web interface and the Homeguy Linux distribution. People were interested to hear that they could experiment quite easily with IPsec in their own testbed thanks to our packages repositories for Debian and Ubuntu Linux distributions.

### 7.2 Tour de France 2006

A demonstration of the IPv6 mobility protocols was set during the Tour de France event in summer 2006. This demonstration has been reported in the 2006 Nautilus6 WIDE report and further analyzed in a paper published in 2007 [37].

### 7.3 E-bike 2007, Advantages of Flow Bindings

Three bicycles equipped with user terminals evolved on the university campus named Beaulieu in Rennes, France. All user terminals were connected to the IPv6 Internet via a mobile and multi-interfaced router with Network Mobility Basic Support protocol shown as Figure 9. This protocol included for the first time the Flow Bindings support in order to optimize the different network accesses. This demonstration shows why it is important to install flow policies on an embedded mobile network in order to distribute and filter applications according to the connectivity of the mobile network. As a demonstration, a web interface were prepared for all the attendants shown in section 7.5. More details are appeared in some documents [38, 39].

### 7.4 ANEMONE Promotion day

ENST-Bretagne, INRIA Rennes and INRIA Rocquencourt made a demonstration in ANEMONE project [1] promotion day on 14th December 2007. There were more than 90 attendants.

Two Citroen C3 move through an itinerary across the university campus (Beaulieu) where both GPRS and Wi-Fi connectivity is available. Each access network has its own characteristics in terms of price, bandwidth, latency, etc. Occupants are equipped of user terminal (i.e. Tablet PC, PDA) and have a Wi-Fi Internet connectivity via the Mobile Router embedded in each vehicle. They benefit from the ANEMONE services such as Video on Demand and can communicate with the audience thanks to instant messaging and Voice over IP. Web interface were prepared for all the attendants shown in section 7.5.

### 7.5 Web interface for Demonstration

A web interface based on PHP and Javascript application allows anyone from the Internet to monitor and follows the demonstrations without the need to install any software or system. The web server receives all information of each mobile network component. This web interface displays a description of each components, the localization and the itinerary followed by the mobile network, the pictures from the cameras, the data from the different sensors, and several parameters on each network interface of the mobile network components during the trip.

This web interface has been used during the demonstration E-Bike 2007 and ANEMONE Promotion Day to allow the audience to follow the demonstration. The screen shots of the web interface appear in Figure 10 for E-Bike 2007 and Figure 11 for the promotion day of ANEMONE project.

[1] http://www.anemone.irisa.fr/event/

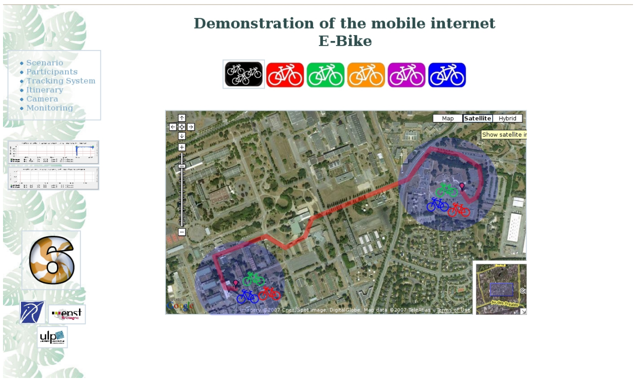


**Figure 10. Web interface for E-bike 2007 demonstration**

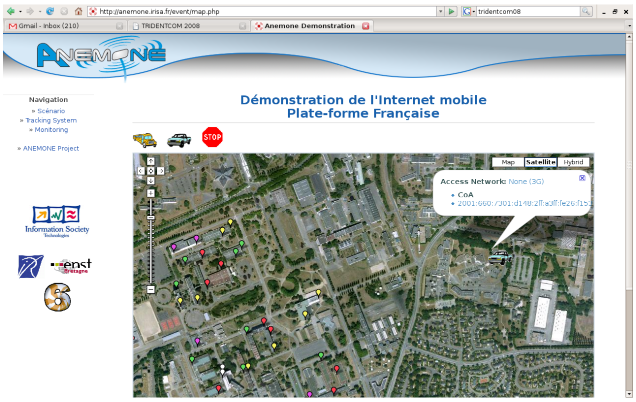


**Figure 11. Web interface for ANEMONE promotion day**

## 8 Conclusion

This year, we worked on IPv6 mobility implementation, IPv6 mobility operation support technology and demonstration activity to accelerate IPv6 mobility deployment. In the implementation activity, we worked on NEPL and SHISA implementations which provides the base IPv6 mobility stacks for Linux and BSD respectively (section 3.1 and 3.2). We also worked on the DSMIPv6 technology that is a kind of interoperability technology between IPv4 to IPv6 mobility for both Linux and BSD (section 3.3 and 3.4).

To realize the actual deployment of the IPv6 mobility technology, operation technologies are important as well as implementation activities. We have started public home agent service that is open to every users worldwide in Japanese, and two other public services open to academic users in France (section 6). We have been also working on operation support technologies. The web interface (HAiku) for the home agent server eases the load of the operators and the Live-CD system (Homeguy) eases the difficulty of mobile users who are not well trained on installing Mobile IPv6 stack on the laptop PCs. The pre-packaged mobility related software will also help experienced users to make their Linux operating system mobility enabled (section 5).

On the security area, we focused on the integration effort of IKEv2 and Mobile IPv6 this year. As a result of this activity, we have published a working implementation based on racoon2 (the open source Internet key exchange daemon program), and have proposed some issues and solutions of the current IKEv2/Mobile IPv6 integration techniques being discussed at the IETF (section 4).

We had several demonstration activities this year. At the Ubiquitous Network Symposium 2007, we demonstrated the technology of IKEv2 and Mobile IPv6 interaction (section 7.1). We improved our E-Bike demonstration testbed to support flow binding technology to effectively utilize multiple network connections (section 7.3). At the ANEMONE promotion day, we demonstrated mobile cars equipped with the GPRS and Wi-Fi connections running in the university campus of Beaulieu connected to the Internet seamlessly using the ANEMONE platform (section 7.4).

## 9 Next Steps

We have developed several core software that will help IPv6 mobility deployment. We have also shown that these software work well at many events such as conferences and exhibitions. The next steps are to make these software easily available to normal users. For example, the Mobile IPv6/NEMO BS stacks have to be integrated to the Linux and BSD's main trees so that every users of these operating systems can use mobility technology by default. We also have many other supportive software, for example HAiku, SONAR, IKEv2 integration patch, and other mobility related software. These software will help mobile service providers and we will keep working on these activities.

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