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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Ares

Architecture de réseaux de services

Rhône-Alpes

THEME COM

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2. Overall Objectives

2.1. Overall Objectives

Keywords: *ad hoc networks, hybrid wireless networks, protocols, services deployment and administration.*

The goal of the *ARES* project is to model and to develop architectures and software support for hybrid wireless networks. Such networks rely on heterogeneous technologies including Personal Area Networks (PAN) and Wireless Area Networks (WAN) in infrastructure mode and/or in ad hoc mode (i.e. an infrastructureless mode); they connect people, but also an increasing number of devices. The main relevant issues concern the interoperability of different systems and protocols, and the optimization of radio, network and system resources for services deployment and provisioning. Considering the diversity and variability of the technical and environmental constraints, adaptation is a key to the success of hybrid networks.

ARES focuses on four main challenges: integrating different types of mobility, controlling cross-layer interaction, providing self-configurability, and supporting quality of service (QoS).

Cross-layer interaction involves both the radio transmission capabilities of the devices and the elementary services of the middleware environment. Radio transmission capabilities influence the performance of the network; their impact on the design of new protocols and the adaptation of existing protocols need to be studied by modelling and/or simulation. Despite middleware development is out of the scope of the project, we examine the impact of radio transmission on the specification of the basic services used by middleware, namely services discovery, global security, software deployment and terminal supervision.

The project does not cover the development of end-user applications based on context awareness. However, we consider existing usage scenarios, in order to derive specifications for the main services provided by a hybrid network. To advance the state of the art in network support for applications, we therefore develop a testbed and experiment with prototypes.

The activities of the project are organized in three areas:

- hybrid nework modelling;
- protocol design;
- services deployment and administration.

The four main challenges presented above are transversal to these research areas.

3. Scientific Foundations

3.1. Introduction

The *ARES* project deals with providing self-adaptation capabilities to network architectures: auto-configuration, auto-organization, dynamic adaptation and context discovery. We focus on interoperability aspects of wireless transmissions, protocols and services management, in a context of hybrid network. To do that, we merge standard protocols engineering with distributed system aspects. The modelling of wireless environment (propagation, MAC, mobility) is also a fundamental activity of the ARES project.

3.2. Hybrid networks modelling

Participants: Alexandre Caminada, Jean-Marie Gorce, Isabelle Guérin Lassous, Jialiang Lu, Philippe Mary, Pierre-François Morlat, Guillaume de la Roche, Katia Runser, Fabrice Valois, Guillaume Villemaud.

This scientific axis aims to propose a formal framework for the study and the evaluation of hybrid networks as defined in Section 2. The high complexity of such networks makes necessary the use of both a wide panel of different technics and several concepts of mobility.

While several solutions have been already proposed for some aspects of hybrid networks, the combination of all aspects is still challenging. Thus, adapting usual techniques used in conventional networks to the hybrid specificity, ensuring the scalability, and finding solutions as global as possible are very attractive goals. Both require a formal evaluation framework.

Models for hybrid networks have two goals: to give a better understanding of the behavior of these networks and to provide a framework for protocols design. Therefore, such models should be both simple, for tractability, and realistic, for efficiency. Finding a right balance between these antinomic requirements entails a careful identification of all the relevant parameters.

Modelling hybrid networks may be performed at different levels. It is obvious that hybrid networks aim to gather simultaneously several radio networks including different medium access techniques, mobile equipements having different mobility profiles, different traffic flows and network entities having different capacities. Taking into account all of these specific aspects is untractable, and in the modelling task it is firstly aimed to extract the set of relevant characteristics of hybrid networks. Moreover, it is crucial to work not only on usual radio interfaces but also on advanced technologies in order to anticipate future capacities. Modelling the interactions between the network layers (physical/data link, data link/network) is challenging as well as taking into account the dynamic feature of these networks. Finally, a framework for the performance evaluation of these networks should be proposed. This framework should integrate both realistic characteristics of environment and well-defined mobility and traffic models.

3.3. Protocols design

Participants: Isabelle Augé-Blum, Guillaume Chelius, Eric Fleury, Isabelle Guérin Lassous, Jialiang Lu, Nathalie Mitton, Thomas Noël, Tahiry Rafazindralambo, Cheikh Sarr, Fabrice Theoleyre, Fabrice Valois, Thomas Watteyne.

The second main topic addressed by the *ARES* project is devoted to the study of several IP (Internet Protocol) based protocols and their interactions in order to allow an hybrid framework, *i.e.* allowing simultaneously or at least in a complementary approach, the use of ad hoc aspects, PAN (Personal Area Network) and also the infrastructure of cellular networks. This definition of an hybrid architecture is a first step towards providing an ubiquitous Internet.

The generalization of the last hop as a wireless one increases drastically the use of IP during several mobility scenarios. It is likely that mobile users will expect similar levels of service quality as wireline users. In the Internet, IP packets are transmitted from one NIC (Network Interface Card) identified by its own IP address that defines the source IP address of the IP packet, to the final NIC also identified by its own IP address that defines the destination IP address of the IP packet. IP addresses play the role of both identifier and localization. The modification of one of the IP source or destination address leads to the breakdown of all current IP communications! To overcome this major problem, a new protocol named MIP (Mobile IP) was proposed.

However, in environments where mobile hosts change their point of attachment to the network frequently, the basic Mobile IP protocol tunneling mechanism introduces network overhead in terms of increased delay, packets loss and signaling. For example, many real-time wireless applications (e.g., voice-over-IP) would experience noticeable degradation of service with frequent handoff. Establishment of new tunnels can introduce additional delays in the handoff process causing packet loss and delayed delivery of data to applications. This delay is inherent in the round-trip incurred by Mobile IP as the registration request is sent to the home agent and the response sent back to the foreign agent. In order to handle this local movement (e.g., within a domain) of mobile hosts without interaction with the Mobile IP enabled Internet, micro-mobility protocols (Cellular IP, Hawaii, HMIP) based on hierarchical frameworks have been proposed. The cooperation of both MIP and Cellular IP leads to a structure where MIP handles the mobility of hosts between cellular networks whereas Cellular IP handles the mobility inside a cellular network.

We aim to add to this architecture the benefits of ad hoc networks since they will allow the covering of existing cellular networks to be extended. To fulfill our goal, we need to evaluate and optimize existing

protocols but also propose new architectures and protocols related to the specific context of hybrid networks. Architectural aspects appear to be fundamental in our approach since only a global and broad point of view allows all aspects of hybrid networks (ad hoc networks embedded in a cellular network) and heterogeneous capacities (different communication medium, computational power, memories, power life) to be taken into account.

3.4. Services deployment and administration

Participants: Stéphane Frénot, Samuel Galice, Noha Ibrahim, Véronique Legrand, Frédéric Le Mouël, Marine Minier, Dan Stefan, Stéphane Ubéda, Pierre Parrend, Yvan Royon.

The third axis of the *ARES* project is architecture centered. The aim is to study elementary services that an *ambient network* should provide on the top of an optimized network layer. This axis falls in the area of *middleware*. Therefore, system oriented studies are also needed. By the way, it is not among the goals of *ARES* to design new middleware architectures. We focus on the glue between network layer and existing middleware approaches, and on the design of elementary functionalities that should be useful in any middleware.

Again, our scientific foundation is driven by the two main concepts: self-configuration and self-organization elements of the ambient network. In this context, three main orientations have been defined:

- Components deployment: in a highly mobile and dynamic environment, context adaptation is a key feature of the success of a support for ambient network; this *context awareness* can not be obtained without an efficient software/driver components deployment. This is also necessary to reach the third dimension of mobility: mobility of the user between devices. In this area, services discovery is a needed functionality that should be studied in the context of hybrid networks.
- Components instrumentations: supervising terminals in a mobile environment is difficult; in *ambient networks* where there are no pre-existing authorities, standard procedures are usefulness. New management and control paradigms have to be developed. *ARES* has the objective to propose new supports for *Autonomous Management*, i.e. user centered solutions without any administrator.
- Global security support: security is a key feature of *ambient networks*; difficulties come from the lack of central administration. Again, new paradigms have to be proposed. *ARES* is focused on *spontaneous* trust management and is studying a global solution on the top of this basic property.

As part of the objective, an efficient use of the network capacities and an optimal management of radio constrainsts have to be considered. As we focus on hybrid environments, most effort will be spent in the interactions between autonomous mobile terminals and access networks: this is what we define as a gateway function.

4. Application Domains

4.1. Introduction

The *ARES* team is developing skills in the area of wireless technology. Models, methods and tools for understanding and managing wireless environments are part of the *ARES* objectives. The aim of *ARES* is to study and propose a global support for a wireless hybrid environment, *i.e.* a cellular environment where ad hoc capacities are used both to extend the communication range of the cellular network and to give peer-to-peer communication capacities to terminals without the help of any infrastructure. There is no specific application domain *ARES* is focused on. Therefore, *ARES* team is keeping in mind some useful cases that should be deployed on top of such network environments. Our vision is that a hybrid environment perfectly fits the communication requirement of ubiquitous environment and ambient networks.

4.2. Applications in ubiquitous networks

Ad hoc networks were originally designed for military purposes but now they are reemerging as the next generation of networks. In *ARES*, we believe that the strength of an ad hoc environment is its capacity to be self-established without previous knowledge. The mobile terminal must have a set of mechanisms allowing the device to be automatically integrated and configured as part of the ad hoc network. In the *ARES* view, we add to these mechanisms the automatic discovery of *gateways* allowing ad hoc nodes to access fixed networks - or the Internet, through multihop wireless communications.

Applications considered as target for the *ARES* studies and developments are concerned with smart devices in multiple environments such as vehicles, mobile phones and personal appliances. Spontaneous networks are built with ad hoc capacities where gateways to fixed networks are viewed only as specific nodes offering a special service: access to the Internet.

The *ARES* team is more interested in applications where self-organization and self-configuration are emphasized. In this area we are currently working on the notion of *intelligent gateway* where supervision and security are the major topics.

4.3. Applications in sensor networks

Miniaturization in micro-electro-mechanical systems (MEMS) has enabled the development of a new kind of networks: *sensor networks*. Sensor networks use small objects able to monitor their close environment such as obtaining a temperature, an air or water pollution level, to detect movements or vibrations, etc. These networks also use one or more monitoring stations (also called sink stations) responsible to collect information from sensors. Using a large number of small inexpensive sensors increases the dependability of surveillance and reconnaissance systems and also decreases the vulnerability of the system to failure. To forward their data (monitoring information, request, etc.), all these nodes use multihop wireless communication.

A number of applications in many sectors exist for sensor networks. For example, commercial sector, transportation, manufacturing industry, agriculture, medicine or even military are sectors that will benefit greatly from increased surveillance. The *ARES* project is currently working with other resaerch group and compagnies in this area. Self-adaptive and self-organized are questions of active research, ranging from hardware to applications. Many topics must be studied such as topology control (addressing, localization, etc.), data communication (broadcasting, routing, gathering, etc.), architecture (hardware, system -OS-, network -communication stacks-, etc.), quality of services (response time, fiability, energy consumption, etc.) and applications (service lookup, distributed database, etc.).

4.4. Applications tools for wireless networks

The application domain concerned by tools that help in the evaluation, planning and simulation of wireless networks is part of the *ARES* goals both in terms of research tools and of technology transfer. Various aspects of the modelling of wireless environments need the design of specific tools for simulation and evaluation. Some of these tools are already being transferred to operational applications for wireless networks designers. The originality of the wireless tools designed by *ARES* comes from the merging of the network aspect (MAC layer and routing layer) with a good modelling of physical links.

5. Software

5.1. Advanced OSGi

Keywords: *OSGi, home gateway*.

Participants: Stéphane Frénot, Noha Ibrahim, Frédéric Le Mouël, Pierre Parrend, Yvan Royon.

OSGi is a specification for making dynamic Java environments. We are involved in the Oscar development community and we have provided many applications (called bundles) in this context. Our main objective is to provide a services management service on top of OSGi framework. Among these provided bundles are:

- osgiDev/osgiProv: (Formerly AWAP) this project aims at implementing the Device service discovery from the OSGi R3 specification. It's freely available at http://ares.insa-lyon.fr/~sfrenot/devel/osgidev/. The companion project osgiProv (http://ares.insa-lyon.fr/~sfrenot/devel/osgiprov) shows how to use the device manager service. The osgiDev service is now used in other third party projects around OSGi. For example it is used as the lower layer of the UPnP implementation provided by Domoware (Spanish team).
- tinyShell: the tiny shell is a lightweight user interface for managing the Oscar shell. This user interface was necessary to work on embedded devices such as iPaqs, since the current Swing-based user interface was too heavy to work on them. The tinyShell service has been tested on many flavours of OSGi gateways (Oscar, KnopflerFish). It is freely available on http://ares.insa-lyon.fr/~sfrenot/devel/tinygui.
- insaJmx / jmxosgi: the insaJmx service is a collection of services that enable services management inside OSGi. It is a layer that provides standard MBeans (Management Components) for managing OSGi. These services are providing a JMX agent, Standard and Dynamic MBean tools and http and RMI remote connector to remotely manage the gateways. The companion service jmxosgi is a collection of components that represent services deployed in the OSGi gateway. Both services are available on http://ares.insa-lyon.fr/~sfrenot/devel/insajmx and http://ares.insa-lyon.fr/~sfrenot/devel/jmxosgi.
- m-osgi is a OSGi extension which provides remote access to services. With M-OSGi every service that is deployed on the gateway is automatically remotely accessible. With this extension, services are available in a totally transparent way whether they are used locally or remotely. The idea is that the service is accessed contextually, which means that if the local CPU is overloaded we use a remote execution. On the contrary, if the network bandwidth is overwhelmed, we choose to run the service locally. Finally, the adaptation is dynamic since the service is dynamically adapted according to the computer load.
- p-osgi is an extension to OSGi that enables OSGi bundles delivery through a P2P network. Each gateway hosts part of the total number of bundles. Bundles are identified by their name and each name is associated with one gateway. When a bundle has to be deployed on one specific gateway, the P2P network automatically brings it.
- vosgi is an implementation of the virtual gateway paradigm. It enables to run OSGi platforms inside other OSGi platforms. The container platform is called the core gateway and the contained ones are called virtual gateways. Core gateway provides resource management and access control to services hosted in virtual gateways.

5.2. AnaX: Ad hoc Network Architecture

Keywords: *ad hoc network, heterogeneous network, hybrid network, multi-interfaces.*

Participants: Nicolas Boulicault, Guillaume Chelius, Eric Fleury.

AnaX, Ana4 (*a.k.a.* Ananas) and Ana6, is a network architecture for both ad hoc and hybrid networks which abstracts multi-hop multi-interfaces networks into a single ad hoc network. In the AnaX architecture, ad hoc and access networks are both considered as an unique ad hoc network (hybrid network) and as a multi-link subnet in terms of IP addressing. In other words, an IP address remains valid in the whole hybrid network and mobility does not lead to addressing modification. AnaX offers a support for vertical mobility, complete TCP/IP compatibility and logical network partitionning. The software is available at http://sourceforge.net/projects/ananas.

In 2005, the Ana4 Architecture has been the subject of an industrial transfer with several newly created compagnies (Kadya, Embeddia). It is also the subject of an informal collaboration with physicians in the context of the ACI IHR (high resolution seismic imaging network) project. The porting of the Ana4

architecture for Windows XP/CE is currently been achieved to complete the already supported list of OS. Several utility softwares (ad hoc traceroute, network monitoring...) have also been developped in order to offer a full easy-to-use software suite associated to the architecture.

5.3. NAP: No Administration Protocol

Keywords: *IPv6 router auto-configuration.*

Participants: Guillaume Chelius, Eric Fleury.

In collaboration with the ARMOR project, *ARES* has proposed a protocol extending the standardized IPv6 auto-configuration mechanisms. The basic IPv6 auto-configuration process is dedicated to hosts only; it allows retrieval of a 64 bits address prefix through ICMPv6 messages, the remaining 64 bits being determined from local information. We propose to dynamically and automatically attribute subnet values to links using a distributed protocol executed by the IPv6 routers. The RSM department of the ENST Bretagne and the project had initially published an Internet Draft for the Yokohama IETF meeting (draft-chelius-router-autoconf-00.txt) which extended OSPFv3 to establish and maintain a consensus on the automatic attribution of subnet values to the network links. This draft was updated in 2005 (draft-chelius-nemo-router-autoconf-00.txt) and the protocol, called NAP for *No Administration Protocol*, was further developped in particular to be integrated with other IPv6 auotconfiguration solutions such as DHCPv6 Prefix Delegation, DSTM or L2TP. Implementation for this protocol is available for the Zebra application (http://nap.dstm.info).

5.4. WILDE software

Keywords: *multi-resolution, optimization, wave propagation simulation, wireless network planning.*

Participants: Jean-Marie Gorce, Katia Runser, Guillaume de la Roche, Guillaume Villemaud.

In the context of network planning, we have developed a software in Java, implementing our propagation simulator described in Section 6. This software named WILDE (Wireless Design tool) is the heart of our developments concerning the radio link modeling. The simulator is based on a home-made propagation engine which implements a frequency-domain TLM method. This method is by now restricted to a 2D framework and the 3D framework is now under development. An original multi-resolution approach has been defined, speeding up drastically the computational time.
WILDE is the heart of WIPLAN, the software proposed by Sygmum (http://www.sygmum.com), our industrial partner for the development of a WLAN optimization tool.

For any information, contact Jean-Marie Gorce (Jean-Marie.Gorce@insa-lyon.fr).

6. New Results

6.1. Hybrid networks modelling

Keywords: *graph theory, modelling, performance evaluation, queueing theory, radio propagation.*

Participants: Alexandre Caminada, Jean-Marie Gorce, Isabelle Guérin Lassous, Jialiang Lu, Philippe Mary, Pierre-François Morlat, Guillaume de la Roche, Katia Runser, Fabrice Valois, Guillaume Villemaud.

This year again, the two research topics studied last year have been deeply investigated: the radio link characterization and the performance evaluation of WLANs. While each of these themes is using its own theories and models, they have to collaborate in order to propose a reliable and realistic overall modeling framework.

6.1.1. Radio physical layer analysis

6.1.1.1. Radio platform

Actual models of the radio link in network simulators are based on very simple models (circular, threshold based receivers, non additive interferences). The development of best models is a very challenging aim.

However,improving the physical layer of these simulators requires a perfect knowledge of the physical layer taking into account the exact radio layer implemented in wireless equipments. The only way to assess this exact implementation is a direct observation of received RF or baseband signals. The radio platform bought by INRIA Rhône-Alpes in 2004, exhibit attractive and efficient properties for this purpose, especially for WiFi based systems. This platform includes an arbitrary wave generator (AWG up to 6GHz) and a vectorial signal analyzer (up to 6GHz, with a 36MHz of bandwidth) both driven by the simulation software ADS (Agilent). This platform has been extended to offer the possibility to study 2×2 MIMO systems. This platform has been firstly defined to simulate a complete radio link, including coding, modulation and channel model and corresponding to many standards (802.11 series, GSM, UMTS, ...). The simulated signal can be emitted, through the AWG and received by the vectorial analyser. A full system can be thus tested over the true air medium. This platform offers also the possiblity to catch true RF signals, such as those emitted by conventional IEEE 802.11 or sensor network radio interfaces for instance. The use of this platform will allow to refine our physical layer models.

This year, this platform has been set and is now operative (see Fig.1). Radio link measurements are now conducted to assess the efficiency of the propagation engine simulator (see next paragraph) [44]. Furthermore, MIMO algorithms for WiFi have been evaluated with ADS. This would allow to prepare an experimental assessment of the future IEEE802.11n standard.

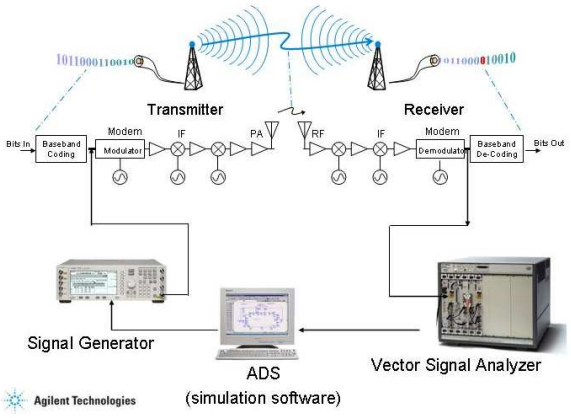

Figure 1. The radio platform includes a 2 channels VSA (vector signal analyser) and 2 synchronized AWG (arbitrary wave generators).

6.1.1.2. Propagation simulation in indoor environments

The simulation of propagation in indoor environments is a difficult task due to many reflection and diffraction effects. Empirical models fail to provide reliable predictions, while deterministic approaches are often too complex to be used. Among deterministic approaches, ray-tracing based methods are the most well known, because of their scalability in terms of complexity. These methods may indeed be very fast if only few reflexions are taken into account and diffraction effects are omitted. But they come with a lack of reliability. It is obvious that predictions may be more realistic while increasing the number of simulated reflected rays and if diffraction is introduced in the model. However, computational resource needs in this case drastically increase, and a tradeoff is mandatory between accuracy and efficiency. Among the deterministic approaches, ParFlow has been proposed by Chopard et al. (B. Chopard, P. Luthi and J.F. Wagen, A multi-cell coverage predictions : a massively parallel approach based on the ParFlow Method, IEEE Personnal, Indoor and Mobile

Radio Communications conference, 98) in the context of GSM base station planning. This technique is a time-domain discrete approach which accurately reflects the behavior of wave propagation but requires very high computation and time resources. Initially this method has been implemented in a parallel system to reduce the computation time.

We have proposed in 2001 a new resolution scheme (FDPF for Frequency Domain ParFlow) to solve the discrete ParFlow equations in the Fourier domain. The problem is thus written as a wide linear system. In 2002, we have solved this system in two steps taking advantage of a multi-resolution approach. The first step computes a cell-based tree structure referred to the pyramid. This step is considered as a pre-processing phase since this computation does not require the knowledge of a source location. In the second phase, a radiating source is simulated, taking advantage of the pre-processed pyramidal structure. In 2003, a new algorithm has been proposed to define an environment-based adaptive pyramidal structure avoiding artefacts near walls and other discontinuities. More precisely, a new non regular pyramidal structure which fits the particular arrangement of the indoor environment has been presented. Using of a full-space discrete simulator instead of classical ray-tracing techniques is a challenge due to the inherent high computation requests. However, we have shown that the use of a multi-resolution approach allows the main computation load to be restricted in a pre-processing phase. Concerning the simulator, two points have been investigated: validation with experimental measurements and optimization of computational load.

- To improve the predictions, a calibration process has been proposed and extensively studied [2], [44]. Experimental measurements are used to set several parameters to fit the model with measures. These parameters are the refraction index and the attenuation coefficient of constitutive materials (walls, free-space, ...). Instead of using 'true' values of these parameters, we rather use them to adapt our simulations to the reality. More precisely, these parameters can be defined as the degrees of freedom of WILDE (the friendly name of MR-FDPF).
  To find the best set of parameters, an optimization process has been defined. This process is settled in three part: measurements, fit between measures and simulations, test and select the best parameters set. The measures have been obtained from a wide set of measurements from 5 access points, with for each one more than 300 receiving points. The fit between measures and experimental values is evaluated by the use of a RMS criteria. In order to find the best set of parameters, a search algorithm has been implemented. The algorithm we used, DIRECT, performs a tradeoff between local and global search. In this way, we have evaluated the influence of each parameter for which the simulations fit the measurements. In practice, we found that standard parameters values (*i.e.* the refraction index of air for free propagation, index of concrete for walls, ...) allows a good fit between measures and simulations (see Figure 2). Because the time needed to find all of these parameters is wide enough, we propose a more efficient optimization principle which resumes only to find a scaling factor. In this work we show that our prediction error (RMSE) is about 6dB [44], [2]. Main errors were observed for low level signal. In this case the setup used for measurements (WiFi card plugged in a laptop) revealed a lack of accuracy. The remaining question is to evaluate if this error is due to the model or to the measurements. We are now conducting measurements with the radio platform to increase the path-loss range up to 60dB.
- The computational load is concentrated on the pre-processing phase and consists in successive matrix inversions up to a size of about 1000x1000. The first version of WILDE used the COLT library (http://hoschek.home.cern.ch/hoschek/colt/), developed at the CERN, for matrix computation. We have developed a JNI interface between the COLT procedures and a BLAS library (http://math-atlas.sourceforge.net/). The computational load then drastically reduced because the matrix inversion in JAVA was slow down due to the memory management.
  The computational load also depends on the way the multi-resolution is built. This problem has been extensively investigated [59], [52], [28]. Furthermore,the matrix computational load associated with each block has been reduced by using symmetries between sub-blocks. Then, the remaining computational load needed to compute the propagation of a source is drastically reduced and falls

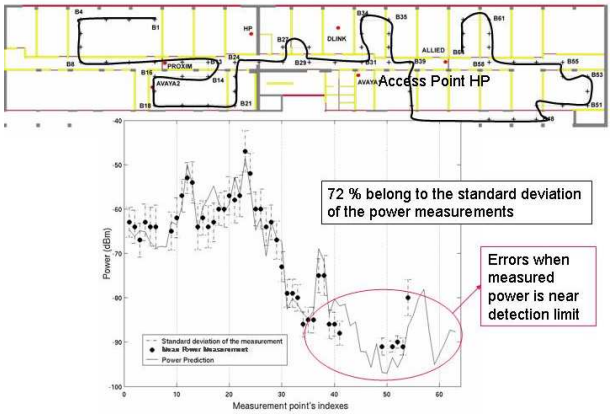

Figure 2. experimental measurements are compared to simulated values. Main errors are concentrated in areas where the signal level is low.

under $O(N^2 \cdot log(N))$ for an environment of $N \times N$ pixels. This is equivalent to the complexity of an elementary single ray based approach such as MWM (multi wall model).
These improvements made possible to compute a full coverage at the true frequency (2,4GHz) over a wide size floor ($25m \times 100m$) on a standard computer (with 2,5GB RAM) in 30mn and 45s respectively for the pre-process and the propagation (see Figure 3).

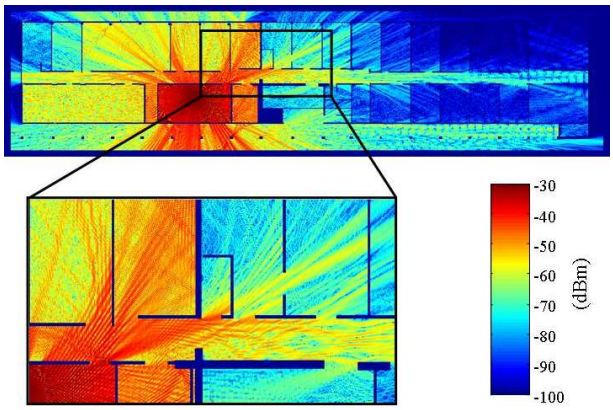

Figure 3. This figure exhibits the radio field prediction at a resolution of 2cm in a floor of 25m x 100m.

6.1.1.3. Assessment of multi-antennas systems

The capacity of both radio access and *ad hoc* networks is limited by interferences. The potential of multi-antennas system is very attractive but suffers the lack of experimental setups and the high increase of complexity. In the framework of a collaboration with FT R&D, Meylan, we started a study on multi-antennas

receivers for 802.11 based systems. This works focused on OFDM based systems and time-domain (TD) and frequency-domain (FD) equalizers have been first compared. FD algorithms albeit natural for OFDM signals, may appear inefficient if the radio channel spreads more than expected, *i.e.* if the length of the channel impulse response becomes longer than the cyclic prefix of the OFDM signal. It is of course possible to increase further the cyclic prefix but reducing the available throughput. On one hand a TD equalizer is more robust, but on the other hand the complexity of the equalizer is much more high. An efficient approach would consist in a combination of both technics while reserving TD equalization for long-term channel coefficients. These algorithms are tested in the radio platform on simulated and real 802.11g signals.

6.1.2. Performance evaluation in hybrid networks

6.1.2.1. Wireless LAN planning

The QoS of hybrid or mesh networks relies firstly on the design of the access network [2]. The access network planning should take into account the properties of the environment (propagation) and should model the interferences between mobiles and access (AP) nodes. Then, the QoS can be assessed. The location of APs and their emission power have to be determined with care during the network planning stage. The planning problem can be tackled in different ways according to the optimization goals that have been chosen. The traditional approach computes coverage maps and selects a configuration satisfying a unique constraint on the signal level, based on a minimum threshold. The evaluation of a solution (APs configuration) relies then only on a propagation simulation computation. This simulation is often an expensive computational operation but severely reduced by the use of WILDE.

This year, we have proposed some more efficient criteria than the only coverage requirement. These criteria are service oriented since they take into account the aim of the wireless access network. The first proposed criteria concerns the throughput of the network. Using a Markov chain based analytical evaluation of the throughput of a WLAN cell, the mean throughput per node is computed for each possible mobile over the environment and a global criteria is defined allowing to maximize the mean throughput. However, in this model, interferences between adjacent cells are not taken into account. To overcome this limit, a complementary constraint has been added in the problem, which aims to reduce the number of interfering signals in each cell. Keeping the number of interferer lower than 2 or 3 makes possible an efficient frequency planning over APs reducing drastically the level of interfering signals.

Location criteria have been also studied. Many works in the literature have been proposed to develop location system based on the WiFi technology. All methods are based on triangulation techniques, requiring a reference database of possible locations. This database is often built from a time-consuming measurement campaign and has to be made each time the APs are moved or modified. On the opposite, the use of simulation results as a reference database allows to modify as soon as needed the APs configuration to improve the location accuracy. We have proposed a location criteria aiming to minimize the location error of mobile nodes, by optimizing the APs configuration.

From this study, the complexity of combining different criteria appeared as a difficult task, especially to determine the best trade-off between all constraints. Trade-offs must be made based on the relative importance of one objective against another. The planning process is also complicated by the existence of an exponentially large number of possible options. For this purpose we focused our work on multi-objective resolution algorithms. In a multi-objective approach, the constraints are considered each one independently. All possible solutions are evaluated with respect to all objectives and are compared in a vectorial space of size N, N being the number of constraint. A solution is a member of the Pareto front if no other solution has been found which is better in all objectives The Pareto front is defined as the set. We have adapted our Tabou algorithm in a multi-objective framework. Then the combination of several criteria has been investigated.

6.1.2.2. Performance evaluation of a 802.11 based ad hoc network

This performance study has been dealed according to different approaches. A classification of the different performance issues with 802.11 and 802.11b in an ad hoc context has been done. Theoretical analysis of some scenarios that present performance issues have been proposed. An experimental evaluation of some

topologies has also been carried out. The goal of these experimentations is twofold: to validate and invalidate the proposed models and the theoretical analysis and to offer statistics on the technology 802.11 for the works on characterization of the radio interface (Section 6.1.1).

The performance issues presented by 802.11 (and also 802.11b) in wireless multihop networks can be classified in three main categories:

- The configurations that lead to long-term unfairness issues in which some flows suffer from starvation while other flows capture the whole channel bandwidth.
- The configurations that result in short-term fairness issues where the frames are emitted by burst.
- The configurations that result in an overall throughput decrease. In these situations, a part of the network capacity is not used and wasted.

Most of the basic topologies that present such issues have been identified and more complex topologies have been analyzed [6].

We have also experimented different ad hoc configurations that have been pointed out in the literature for presenting some performance problems with IEEE 802.11 MAC protocol [18]. We have focused on fairness issues and show that some problems identified by simulation are real and should be considered while others are softened and some are even nonexistent due to either radio propagation or to implementation choices made by manufacturers. The communication and the carrier sense areas are not constant like in simulations and are affected by the environment. Thus, independent mobiles share the medium at some periods or one of the concurrent transmissions can be correctly received. More successful communications are then possible even for the mobiles penalized. We have also serious hints that with the used cards, the EIFS was not triggered and a DIFS was used in place. The fairness issues caused by this mechanism are therefore nonexistent. Finally, the experiments on the hidden terminals configurations reveal that the short-term unfairness is not as serious as expected since the average burst size is about 4 frames long. Moreover, the number of successful received packets is surprisingly high when the RTS-CTS are not activated.

6.1.2.3. Performance evaluation of 802.11 unfairness using process algebra

Performance evaluation of 802.11 has been widely made using stochastic models. Such models provide a framework to evaluate channel access rate, throughput, CSMA/CA behavior, etc. Nevertheless, each study should propose a new model according to the study objectives and finally the key problem is not to model a dedicated scenario but to solve it due to the space states constraints. Using the compositional approach of a dedicated process algebra for performance evaluation, we have developed a new (semi-)generic model which is able to be used for many performance evaluation of 802.11. The key contribution is to propose a model for a mobile node using 802.11 and the interactions between nodes are described using a model of the medium [30]. Such model is necessary to model medium sharing and medium contention. This model is used to study unfairness behavior of 802.11 in the context of mobile ad hoc networks.

6.1.2.4. Model for wireless multihop radio networks

In this work, we formalize the relation $\mathbb{P}(N_d = n)$ between the hop distance and the euclidian distance in 1-dimensional and 2-dimensional discrete networks. We provide closed formulas for the mean hop distance between two arbitrary nodes depending on their euclidian distance in both discrete and continuous networks. More generally, we also formally prove that results computed in discrete networks induce boundaries in continuous ones. Moreover, as the step of the discrete network is decreased, discrete results converge towards continuous ones. This phenomena justifies the methodology consisting in considering discrete networks to study properties that are hardly tractable in continuous networks. This formal analysis [54] allows to better understand the behavior of geographical routing process and we conducted additional work on investigating the optimal radio range that minimizes the energy globally consummed by a geographical routing process. (see Section 6.2)

6.1.2.5. Model for traffic monitoring

Network measurement is essential for assessing performance issues, identifying and locating problems. Two common strategies are the passive approach that attaches specific devices to links in order to monitor the traffic that passes through the network and the active approach that generates explicit control packets in the network for measurements. One of the key issues in this domain is to minimize the overhead in terms of hardware, software, maintenance cost and additional traffic.

We study the problem of assigning tap devices for passive monitoring and beacons for active monitoring. Minimizing the number of devices and finding optimal strategic locations is a key issue, mandatory for deploying scalable monitoring platforms. We present a combinatorial view of the problem from which we derive complexity and approximability results, as well as efficient and versatile Mixed Integer Programming (MIP) formulations [19].

6.2. Protocols design

Keywords: *MAC, architecture, auto-organization, energy, hybrid networks, quality of service.*

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6.2.1. Architectural design

We are still working on ad hoc architecture and we have performed several industrial transfers. Based on the draft of ana6 (http://www.dfn-pca.de/bibliothek/standards/ietf/none/internet-drafts/draft-chelius-adhoc-ipv6-00.txt), describing an IPv6 Addressing Architecture Support for mobile ad hoc networks, we have developped further our view of a global architecture for an ad hoc network. The notion of IPv6 connector introduced allows several network interfaces to be virtualized into a single addressable object. A host may have several ad hoc connectors and an interface may be bound to several ad hoc connectors. The ad hoc connector defines a set of addresses which indistinctly identifies all bounded interfaces. This notion of ad hoc connector is simply implemented in IPv6 by defining a third IPv6 local-use unicast address: ad hoc local addresses. Their validity is restricted to an ad hoc network. They provide a basic identification support for ad hoc nodes that can be extended by other configuration mechanisms such as stateless global address attribution. In the IPv6 architecture scheme, an ad hoc network may be at the same time, a multi-link subnet and a multi-link multi-subnet. Considering the whole ad hoc network as a multi-link subnet is achieved by matching a particular multicast scope, the subnet scope, with the ad hoc network. To support the multi-link multi-subnet vision, the notion of logical ad hoc sub-networks, also called area, is introduced. A area is a connected set of ad hoc connectors sharing a common area value. A specific range of multicast addresses is associated to each area. It enables the restriction of multicast groups to a given area. An implementation of this IPv6 ad hoc framework is now available under FreeBSD via sourceforge (http://sourceforge.net/projects/anax).

In [3], [12], [13] we consider the problem of interconnecting several hosts in a spontaneous hybrid and heterogeneous network, *i.e.* an environment where wired and multi-hop wireless technologies are used. Dealing with issues raised by such hybrid networks and addressing all challenges listed in MANet may require a departure from classical solutions available in the literature. To enable a full multi-hop connectivity without raising problems/inconsistencies regarding IP compatibility, we propose Ana4 (*a.k.a.* Ananas), a 2.5 layer architecture suitable for hybrid heterogeneous networks. In these articles, we present the architecture and implementations of Ana4 in the context of ad hoc and mesh networks as well as application fields where Ana4 is already used. We also present experimental measurements that show good performances with respect to a full IP solution (IP routing) and similar 2.5 approaches like MPLS.

6.2.2. Auto-organization in large scale networks

In order to be able to use ad hoc networks on a very large scale, flat routing protocol (reactive or proactive) is not really suitable. Indeed, both routing approaches become ineffective for large scale wireless ad hoc networks, because of link (flooding of control messages) and processing overhead (routing table computation).

One well known solution to this scalability problem is to introduce a hierarchical routing by grouping geographically close nodes to each other in clusters and by using a "hybrid" routing scheme: classically proactive approach inside each cluster and reactive approach between clusters. Such an organization also presents numerous advantages such as more facility to synchronize stations in a group or to attribute new service zones.

Last year, we proposed a way to "structure" the network by gathering nodes into groups called "clusters". Such a structure may then allow to apply classical routing schemes inside and between clusters. We studied it analytically and by simulation. This year, based on this structure and its different features, we have proposed different efficient algorithms for several functionalities. First, we have introduced a way to apply an efficient broadcasting scheme over it. This scheme allows either a broadcasting confined in a cluster or in the whole network. It has revealed to outperform existing broadcasting solutions for multi-hop wireless networks regarding energy savings, latency and robustness [39], [14], [15], [16], [33], [55], [61].

Then, we have introduced a way to route messages over this structure according to its special features. Indeed, clustering a network aims to allow a hierarchical routing. In relative works, hierarchical routing means applying a pro-active routing protocol inside clusters and a reactive one between clusters. However, as most of clustering schemes in the literature, our clustering scheme provides a constant number of clusters for an increasing number of nodes. Thus, applying a pro-active routing protocol inside the clusters lead to the same scalability problems than flat architectures. Therefore, we have proposed to apply the reverse approach for hierarchical routing, which means: a reactive routing protocol inside clusters (which would not generate too much latency since cluster radius was proved to be upper bounded by a constant) and a pro-active routing protocol between clusters (as the number of clusters is constant, the size of routing tables is in $O(1)$).

Nevertheless, this hierarchical routing approach needs a localization protocol to allow nodes to know in which cluster is the node they need to talk to [37]. It is actually an indirect routing. Therefore, we have also introduced a localization scheme which also takes advantage of the characteristics of the underlying cluster structure. It combines scalable advantages of DHT (Distributed Hashed Tables) and Interval Routing. This localization scheme has a time complexity in $O(1)$ and requires a memory size in $O(1)$ on nodes. Thus, globally, our indirect routing requires low memory size ($O(1)$), has a low time complexity ($O(1)$) and provides routes with a low stretch factor.

We are also conducting works that focus on problems of fault tolerance and scale in distributed system [34], [35]. Such systems motivate designs that autonomously recover from transient faults and spontaneous reconfiguration. Self-stabilization provides an elegant solution for recovering from such faults. We present complexity analysis for a family of self-stabilizing vertex coloring algorithms in the context of wireless networks. Overall, our results show that the actual stabilization time is much smaller than the upper bound provided by previous studies. Similarly, the height of the induced DAG is much lower than the linear dependency to the size of the color domain (that was previously announced). Finally, it appears that symmetry breaking tricks traditionally used to expedite stabilization are in fact harmful when used in networks that are not tightly synchronized.

6.2.3. Self-Organization with a virtual topology for hybrid networks

This work was initiated in February'03 with Fabrice Theoleyre, currently Phd. student in the *ARES* team. This section deals with self-organization of ad hoc networks through a virtual topology. We consider a virtual topology as a hierarchical organization based on both backbone and clusters. The backbone constitutes a spine carrying control traffic, disseminating information in the network. The clusters provide services areas with a leader (the clusterhead). This structure has several major goals:

- To hierarchize the nodes in creating leaders and clients;
- To distribute roles taking into account the natural heterogeneity of hybrid networks;
- To create a logical view above the physical view;
- To introduce stability in a volatile environment.

In the first part of this work (year 2004), we have investigated the behavior and the key properties of such self-organization. We have also introduced robustness and how to use this work to developp a mesh network in mobile ad hoc network.
In 2005, self-stabilization property was investigated [46]. The goal was to demonstrate that it is always possible to provide a virtual topology despite the radio environment and the mobility effect. We have also shown that a local change only implies a local reconstruction on the virtual topology.
Based on this virtual topology as a way to organize a spontaneous networks, the question is: how self-organization paradigms deal with network behavior? More precisely, how routing and location protocols can use the virtual topology we have introduced? A new routing protocol based on this self-organization is proposed (called VSR, Virtual Structure Routing [48], [49]). A proactive routing protocol is used inside the clusters and a reactive routing protocol is used of inter-cluster data request. The inter-cluster routing protocol uses the virtual backbone for route requests. In our proposition, a route between a source and a destination is a list of cluster id rather a list of nodes id. The important stability of the cluster topology provides more stable routes. Performance evaluation of this new *self-organized* routing protocol was done using OPNET Modeler network simulator. This proposition is compared with AODV (reactive routing protocol), OLSR (pro-active one) and CBRP (hierarchical one). Performances highlight the benefit of using self-organization mechanisms before to use a routing protocol. A similar approach was used to develop a location protocol dedicated for hybrid networks [47].
Currently, we are studying the trade-off between network capacity and self-organization [42]. Testbeds of self-organization protocol are scheduled using the mesh networks of the CITI.

6.2.4. Self-configuration and self-organisation in communicating objects netwokrs

This work is financed and supported by France Telecom R&D under CRE No 46128746 with PACIFIC team. This research project is also the PhD thesis of Jia-Liang Lu.
The goal is to identify the key mechanisms to deploy communicating objects networks or sensor networks in an autonomous way. So, self-configuration, self-organization and self-healing are the main topics we study. During the first year of this PhD. thesis, a global overview of these topics was done for France Télecom R&D. So, three reports were produced:

- Chapter 1: *Communicating objects: Taxonomy and Survey*
- Chapter 2: *Survey of Self-configuration: Addressing, Communication and Service*
- Chapter 3: *Survey of Self-organization: Towards an efficient network*

Currently, a new approach combining self-configuration and self-organization is studied.

6.2.5. MAC protocols for ad hoc networks

The IEEE 802.11 MAC layer is known for its unfairness behavior in ad hoc networks. Introducing fairness in the 802.11 MAC protocol may lead to a global throughput decrease. It is still a real challenge to design a fair MAC protocol for ad hoc networks that is distributed, topology independent, that relies on no explicit information exchanges and that is efficient, *i.e.* that achieves a good aggregate throughput.

We have proposed a new MAC protocol based on 802.11, called MadMac, that provides more fairness than 802.11 while maintaining a good aggregated throughput in ad hoc networks [64]. MadMac is based on two main mechanisms. The first mechanisms is: a station divides its throughput by 2 at the MAC layer if it detects an activity from one or more stations. This division is done by introducing a extra waiting time before transmitting a new packet. The second mechanisms tries to fine tune this extra waiting time according to the activity/collision experiences by the station. These mechanisms are only based on information provided by the 802.11 MAC layer and its behavior is not probabilistic.

We have compared MadMac with 802.11 from fairness and efficiency points of view. These comparisons have been carried out in many basic scenarios that are known to lead to fairness issues and in more complex

topologies. Results, from these simulations, show that, in most of the cases, MadMac provides a better fairness and maximizes the aggregate throughput when unfairness is solved.

Future works would be to investigate other ad hoc topologies like random topologies, and to propose an analytical evaluation of MadMac in order to make it fairer and efficient.

6.2.6. QoS in ad hoc networks

6.2.6.1. Evaluation of the BRuIT protocol

This year, we have proposed enhancements and evaluations of BRuIT [22], a bandwidth reservation protocol for ad hoc networks we designed in 2000/2001. BRuIT (Bandwidth Reservation under InTerferences) takes into account influence of distant emitters on medium availability. The goal is to consider the carrier sensing area. Some experiments showed that with IEEE 802.11b interface cards, the carrier sensing area radius is about twice the communication range. Therefore, in the first version of BRuIT, each mobile takes the decision to accept or reject a flow according to the bandwidth used in its one-hop and two-hop neighborhood. But twice the transmission range is not equivalent to two hops. We have evaluated both the average number of undetected jammers, *i.e.* nodes that are within two times the transmission range but that are not reachable by at most n hops long path for different n values, and over-detected neighbors, *i.e.* nodes that are reachable in at most n hops but that are not within two times the transmission range. Results show that there is a clear gain from considering one-hop neighborhood to two-hops. The number of undetected neighbors is reduced by about 35 % and the number of over-detected neighbors is null. Increasing n does not result in a significant gain, for example, considering three- hops neighborhood only reduces the number of undetected neighbors by 10 % compared to two-hops while the number of over-detected neighbors reaches 40 % of the total number of considered jammers. Therefore, considering more than two hops makes the evaluation less accurate and that's why BRuIT keeps on considering these informations for resources availability evaluation.

In order to evaluate BRuIT, we have compared it by simulation with AODV a best-effort reactive routing protocol. BRuIT and AODV are similar in the route research process, therefore such a comparison shows the cost of providing guarantees. The simulation results show that this protocol enhances the network usage by not overloading the medium at the cost of longer routes and a larger establishment time. Nevertheless, the load is better balanced in the network, therefore network capacity is not overloaded. This results in more stable routes and less control traffic as almost no reconstructions are needed.

6.2.6.2. Evaluation of the available bandwidth

In this work, we try to propose a more accurate mechanism to evaluate the available bandwidth than the one used in the BRuIT protocol. Such an evaluation is necessary to provide an efficient QoS protocol to manage bandwidth in ad hoc networks.

The available or residual bandwith of a link is the maximum throughput that can be injected on a link without degrading the close communications. Therefore, we have proposed a new technique to estimate the available bandwidth to wireless nodes and by extension on one-hop links in IEEE 802.11-based ad hoc networks [10], [45]. Our technique exploits the fact that both sender and emitter can estimate channel occupancy by monitoring their vicinity. It provides a non-intrusive estimation meaning that it does not generate any additional traffic to perform the evaluation. We have also developped a protocol based on this technique which periodically broadcasts node information on it's one hop neighborhood, so the receiver is able to compute its available bandwith with the sender.

We show by simulations that our technique provides an accurate and scalable estimation of the available bandwidth on wireless links in many ad hoc configurations. However, there are some topologies in which this technique does not give accurate estimates mainly due to phenomena like collisions, but we have proposed some improvements to adapt to these constraints.

6.2.7. Energy constraint

We have initiated a study on the energy consumption in wireless ad hoc networks. There has been an increased awareness of energy efficient protocols need for battery-powered devices in recent years. Though the optimization of the sensor network lifetime must take place at each stage, we focus mainly on the sensing and

communication levels. Indeed, data transmission and reception using a wireless medium appears to be a highly energy consuming process. More precisely, our work is focused on a specific communication pattern called broadcast, where data are distributed from a source node to each node of the network. Broadcast is a common and frequent process during a sensor network lifetime. It is useful for auto-organization, parameter/data dissemination or control regulation. Conventional energy aware protocols manage the energy consumption by adjusting the transmission power of sensor nodes. Nodes are assumed to adapt their transmission power to the minimum required to sustain communication.

In classical energy model, the amount of energy required to transmit data is proportional to the number of emitted bits and depends on both the communication range and the distance power gradient. Note that regarding this model, reception of a message is not a low cost operation and can not be neglected in comparison to the transmission cost. Indeed, the amount of energy needed for a reception is of the same order of magnitude as the one needed for transmission and is also proportional to the number of received bits. In consequence, as opposed to all the existing work done, energy aware protocols should not only try to reduce communication ranges but should also minimize the number of transmission and reception operations for each message. Our work focuses on the determination of minimum-cost (*i.e.*, minimum energy consumption) broadcast and sensing schemes. Our main contribution [23], [7] is to take into account both the transmission and reception costs and to derive analytical bounds to the minimum energy broadcast and minimum energy sensing problems.

We are also investigating the optimal radio range that minimizes the energy globally consummed by a geographical routing process. In a first step, we consider a common radio range for all nodes. In a second step, we derive a distributed algorithm which attributes variable radio ranges to the sensor nodes. Considering a geographical greedy routing protocol and a uniform distribution of nodes in the network area, we analytically evaluate the energy cost of a multi-hop communication. This cost evaluation corresponds to the asymptotic behavior of the routing protocol and turns out to be very accurate with regard to the results obtained by simulations. We show that this cost is function of the node intensity and we use this result to deduce the optimal radio range. We evaluate this range considering two energy consumption models, the first one considering the energy consumed by transmission operations only and the second one considering both transmission and reception operations. These results can be used in two ways. First, the range of the nodes can be tuned in advance as a function of the expected intensity of nodes during an off-line planning. Second, we propose an adaptative algorithm where nodes tune their powers with regard to an on-line evaluation of the local node intensity. This work is based on the previous modelling and analysis of the behavior of multi hop wireless path [54].

6.2.8. Real-time communication in wireless sensor network

This work has started in February 2005 with Thomas Watteyne, who is currently a Phd. student in the *ARES* team. Our goal is to propose new protocols for real-time communication in wireless sensor networks. Critical applications sometimes need to know guarantee and bounded response times after detecting a given event. For those applications, the underlying communication network needs to guarantee a given quality of service, mainly in terms of transmission delays and fault tolerance.

To our knowledge, only few works have so far dealt with hard real-time, where no message can reach its destination late. Only one protocol proposes a hard real-time MAC protocol, but with hard to meet assumptions on the nodes placement and their embedded components (radios need to use multiple frequencies, nodes have to be grouped in hexagonal cells with a router node in the middle...).

Our first results let us define a new MAC protocol [51] which guarantees timeliness constraints in the Worst Case, for a one dimensional wireless sensor network. Application examples include highway car accident monitoring, production chain surveillance, and railway train tracking. Having only a one-dimensional network frees ourselves from routing considerations, in order to focus on the MAC layer. In our protocol, run-time has two modes. Reliable collision-free communication is guaranteed during the run-time *protected mode*. A second mode, called *unprotected mode* is used when collisions are not likely. It is prone to collisions but provides a near optimal transmission speed of the alarm messages toward the sink node. After initialization, the network's run-time starts in unprotected mode. In case of collision, the network switches into a protected mode. The sink

decides when to switch back to unprotected mode. Our protocol provides both bounded worst case times and good average times thanks to the switching between those two run-time modes.

Our current work focuses on comparing our real-time protocol's performances with other more classical protocol's (where in case of collision alarms are retransmitted after a random waiting time). Future work include extending our protocol to three dimensions, thus proposing a hard real-time routing protocol.

6.3. Services deployment and administration

Keywords: *Middleware, security, services instrumentation and administration.*

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In this axis we have provided some new results around the OSGi platform and we have started new activities.

6.3.1. OSGi extensions

The OSGi service platform has the overall objective of providing an open framework for services development deployment and management. In this context, we have proposed many improvements to the initial specification in order to see the home gateway more like a federated entity than a sole execution environment.

- M-OSGi is an extension that enables a remote communication with every service deployed on the gateway. This extension transforms the home gateway into a node in the Grid domain. Each home gateway offers resources that can be remotely accessed and exploited.
- P-OSGi is an extension that enables the dissemination of installable components over a P2P overlay. This P2P overlay is made of the different home gateways available. This approach avoids the central repository of available resources since they are spread over the P2P overlay.
- JMX-OSGi: JMX is a standard way of managing Java applications. We have globally integrated JMX inside OSGi. The term globally refers to the fact that we have provided a solution that solves every step of the supervision/management architecture. We have a specific JMX agent inside every OSGi home gateway. This agent manages our specific components that represent the OSGi gateway, the services, the bundles and the Java classes that are available on one specific node. Finally we have defined a specific remote console which supervises the different active gateways.

6.3.2. Current investigations

Our current activity is twofold: continuing to provide management solutions for the OSGi framework and virtual machines for embedded devices and middleware of middlewares.

- Management solution for OSGi framework: OSGi is a model for managing home gateways. Despite the fact that it's the only current solution, it still needs improvements. The model is centered on a single operator that has full access to the gateway. We are currently working on making private service spaces inside the home gateway, each service space is on the responsibility of a specific service provider.
- Virtual Machines for embedded devices: Java virtual machines trend is to have big execution environments. In the home environment, each gateway has a small amount of memory and CPU cycle are scarce. Current xDSL modem have 4Mb of memory and 8Mb of hard drive. Putting virtual machines on these environments is a real challenge.
- Middleware of middlewares: the OSGi framework is a middleware that can be used in many different environments. In our previous studies we have applied OSGi concepts in both ubiquitous and grid environments. We are currently investigating solutions for providing middlewares that can be used as foundation for building other middlewares. For instance we use OSGi as the bottom layer of a globus-like implementation. We are currently working on extracting common behaviors of Java oriented middlewares in order to define some kind of middleware of middlewares.

6.3.3. Trust model managment for mobile devices

The *ARES* project is currently working on trust models for mobile communicating smart devices (see the KAA project). An initial model we proposed is a trust management scheme matching this definition of context awareness. The solution does not make any assumptions concerning the presence of any fixed infrastructure (the terminal can be in full ad hoc mode), while the proposed architecture could take advantage of any encountered access points to contact fixed servers. We believe that trust cannot be a attributed Boolean value (trusted terminals versus compromised terminals), but must entail various levels of trust belonging to various levels of offered services. For example, a smart device equipped with a web cam can probably offer the ad hoc routing service to most of the nodes in its environment as long as the behavior of the nodes is not suspicious. The same device could allow terminals attributed with slightly more trust to access the video flow. And the same terminal will probably require a strong level of trust before allowing a foreign node to access the web cam's configuration interface. Trust is created starting from a low level and grows during the establishment of what we term an ambient community. We propose an architecture based on self-organized communities of terminals with simple mechanisms to accept nodes in an existing ambient community, to establish the appropriate levels of trust, and also to reject or detach a suspicious node. Our solution is a mixture of context awareness and recommendation schemes. The basic mechanism is based on the notion of node history, which is used to build a specific shared secret. Then, nodes aggregate when exchanging data and services into an ambient community, which is the ultimate level of organization.

In 2005, we have proposed a novel cryptographic scheme to be included in the KAA framework. More precisely, the scheme is the basic foundation of the *Common Knowledge Exchange (CKE)* protocol. The CKE mecanism will derive a trust value from the intersection of recorded interactions in the past of each device. In this first draw, we reduce the notion of knowledge to the notion of history of interactions. Moreover, semantic values may be added to this notion of history. The CKE protocol is used to prove the existence of common past encountered nodes in the history of two nodes that never met before.

The CKE protocol is using the notion of cryptographic ID first proposed by Shamir in 1984 and adapted on the elliptic curves by Boneh and Franklin. The main advantages to use this form of cryptography is the gain in size and in computational time in adequacy with the small devices used in the ambient network such as PDAs or mobile phones. The security analysis has been carefully written in order to be certain of the framework we propose. Therefore formal proofs of the protocol need to be written.

7. Contracts and Grants with Industry

7.1. Contracts and Grants with Industry

Sygmum The regional incubator CREALYS helped the creation of a start-up aiming to propose tools for wireless LAN planning and QoS management. The CITI contributes to this project under an agreement between the Rhône-Alpes council, INSA Lyon (CITI) and the contractors. Our team is involved in the development of the heart of the software, *i.e.* the propagation engine, while the start-up should develop the user interface and define the end-user needs for such an application. The start-up is now created and is named Sygmum (see http://www.sygmum.com). This company proposes a software optimization tool, WIPLAN, which embed our propagation engine WILDE. This project is now continuing under an agreement between Sygmum and INSA Lyon (CITI) via INSAVALOR. This contract supports the PhD thesis of Guillaume de la Roche by a government agreement (CIFRE).

Sygman The regional incubator CREALYS supports the creation of a local start-up which aims to propose tools to monitor and control mobile services for GRPS/EDGE and 3G networks. Rather to use a mobile trace to monitor the cellular network behavior only, the proposition of Sygman is to monitor simultaneously both mobile application and radio environment in order to provide user-oriented investigation and performance measures. The CITI laboratory contributes to this project under an

agreement between the region Rhône-Alpes, INSA Lyon (CITI) and the contractors. Our team is charged to provide the methodology of application monitoring in cellular networks. The start-up will be created in 2006 January (see http://www.sygman.com).

France Télécom R&D The project *ARES* has several contracts with FT R&D:

FT R&D, Grenoble *ARES* has three contacts with FT R&G Grenoble (Meylan). First, *ARES* and France Telecom R&D, Meylan have contracted a collaboration in the field of multi-mode multi-antennas terminal design. This project aims to evaluate the potential of multi-antennas systems put into a multi-standard environment. The heart of the work concerns interference cancelation in an aware framework. The key point is to show how a multi-antennas terminal can exploit the spatial diversity to cancel multi-standard interferers. The efficiency should be assessed by simulations and with a demonstrator, in wLAN and *ad hoc* contexts.

Second, France Telecom R&D under CRE No 46128746 with PACIFIC team financed a work on self-configuration and self-organisation in communicating objects networks. This research project is also the PhD thesis of Jia-Liang Lu. The goal is to identify the key mechanisms to deploy communicating objects networks or sensor networks in an autonomous way. So, self-configuration, self-organization and self-healing are the main topics we study.

Finally, an agreement has been established between France Telecom R&D and INSA de Lyon (CITI Laboratory) through INRIA. This contract supports the PhD thesis of Thomas Watteyne by a government agreement (CIFRE). The contracts goal is to study and optimize wireless sensor network initialization mechanisms, from an energy point of view.

FT R&D, Caen This CRE (*Contrat de Recherche Externalise*) with FT R&D concers the study of addresses and routeurs autoconfiguration mechanisms in IPv6 SOHO netwoks. The goal is to develop a protocol suite enabling a full zero-configuration solution for IPv6 home networks. This project in in collaboration with ENST Bretagne and IMAG.

FT R&D, Lannion France Telecom R&D under CRE No 46128746 with the SPONTEX project financed a work on rates optimization in 802.11 based ad hoc networks. The goal of this project is to propose optimizations of 802.11 in a multihop context from a fairness and efficient points of view.

Alcatel R&D The main focus of this contract is to address the concern of operators to lower their operational expenses (OPEX). Since networks are converging towards IP technology, we focus on this protocol and more specifically to its latest version: IPv6. More specifically we are interested in self-configuration of intelligent routers with respect to several of their key features: address and routing, security. This project in in collaboration with ENST Bretagne.

Embedia Those who communicate messages are always in search of attractive ways to carry their information more effectively. When placing outdoor advertising campaigns, 30-second television commercials on large screens (14.69ft x 11.02ft), displaying advertisements, video footage and general information on buildings and walls in busy metro, market, restaurant and/or nightlife districts, the main problem is to carry the messages and update the information. The key idea was to use Ana4 to build a “video billboard mesh network” in order to perform content delivery and network management without deploying a wired network. It’s always more easy to get a power supply on outside building wall than a RJ45 like plug. This project is in partnership with a newly created company which is an interactive communications solutions provider and creates an innovative state-of-the-art link between businesses and their consumers and its patented solution delivers interactive multimedia content directly to end-user devices.

Kadya In many industrial contexts (logistics, objects and people monitoring, security...) it may be essential to localize precisely objects or people in real time, whether they are situated indoor or outdoor. In this goal, Kadya, a newly created company, is working on providing a location solution based upon cheap and light emitting radio tags, monitored by a set of listening stations. Each station collects data emitted by the tags through a proprietary radio protocol, and retransmits them through a mesh network to a server which analyzes the radio data to calculate the position of each radio tag. Ana4 is used to provide the illusion of a one hop IP network, allowing use of DHCP and broadcast operations for the listening stations. Moreover, the system is easily extensible as any additional station can be placed in the mesh network without the need for any configuration as the multi-hop connectivity is achieved by Ana4 and the IP configuration by DHCP. Furthermore, Ana4 allows the use of IP broadcasting over the network to monitor the system.

8. Other Grants and Activities

8.1. Regional initiatives

IHR The IHR project is the third test bed using Ana4. The ambitious goal of the IHR project is to develop a new seismic tool that would allow seismic investigation at scales comprised between one kilometer and few hundreds of meter. The geological targets are those potentially dangerous areas: fault zone, volcanoes, land-slides, valley with site-effect. A new equipment has been recently delivered. The new seismic network consists of thirty nine channels data-loggers equipped with six vertical sensors plus one component sensor. These spider-like mesh networks are connected to each others by network links (wire when possible and/or wireless) that allow a limited crew to control and tune the 270 channels. The deployed seismic network is heterogeneous and scientists on the field encounter several pure networking problems when they try to manage this spider network. How to configure the wireless network, the wire backbone network? How to deal with IP sub networks... Ana4 offers a simple solution. Due to the Ana4 support for multiple interfaces, the ad hoc network is spread over both the wireless and wire links, hiding the complex and heterogeneous topology to the end user. Auto-configuration is also made straight-forward as the retrieval of an IP address is possible even if nodes are several hops away from the DHCP server.

CAPNET The CAPNET project is a BQR project funded by the INSA de Lyon and gathering several laboratories of the institution: CITI, CEGELY, LAI, STOICA. Its research program aims at developing a new theoretical framework and the computational tools necessary for modelling and understanding large-scale ambient dynamic networks. In this optic, CAPNET will setup a real testbed in the Télécom department of INSA de Lyon and provide the opportunity to gather a complete map of all interactions of a given population, *(*i.e.) the students of the department. This testbed will be created by providing SensorLogger to each of four hundred students at the INSA de Lyon. SensorLoggers have the ability to periodically logg their neighbourhood, *i.e.* all other SensorLoggers present within their radio range.

Through this testbed, the CAPNET project will be able to collect very valuable data on energy consumption in sensor networks, user mobility and interaction. Analysis of these data will lead to fundamental advances in the understanding and modeling, and thus will provide valuable models for the design of energy efficient architectures as well as applications and protocols based on user mobility. Advances will be made in our own research fields (routing, localization, positioning, and mobility modelling) as well as orthogonal fields (e.g., sociology).

8.2. National initiatives

SAFARI The SAFARI project (http://www.telecom.gouv.fr/rnrt/rnrt/projets/res_02_04.htm) aims to design, to combine and to carry out a framework of protocols and softwares required for the transparent access, the automatic configuration, the services integration and adaptation into a IPv6 network in ad hoc configurations with wired accesses. The added value of this project is the design of new protocols and software solutions based on existing standards (IPv6, multicast, proxies, active networks, etc.) and adapted to the dynamics features of the network infrastructure and of the services demand and continuity. The different partners of the project are FTR&D, ALCATEL, INRIA, LIP6 (Paris 6 University), LRI (Paris Sud University), LSIIT (Strasbourg University), LSR-IMAG (Institut National Polytechnique de Grenoble), SNCF and the École Nationale Supérieure des Télécommunications.

SVP The SVP project addresses the understanding, the conception, and the implementation of an integrated ambient architecture that would ease the optimization in the deployment of surveillance and prevention services in different types of dynamic networks. The main objective is to develop an environment which is able to accommodate a high number of dynamic entities completely dedicated to a specific service. The different partners of the project are: CEA, ANACT, APHYCARE, INRIA, UPMC/LIP6, LPBEM, Thalès. Thi sproject is founded by ANR/RNRT.

ACI Sécurité KAA The KAA project (Knowledge Authentication Ambient) is dedicated to trust models elaboration for autonomous smart communicating devices. KAA is a collaborative research project involving research teams in computer science, mathematical modelling and social sciences. Smart devices are dynamic groups of objects which can act together cooperatively even if they are fully strangers. With a wide use of smart communicating devices, we are facing both technical and social challenges. The KAA project proposes to look for human society trust management mechanisms and to derive a technological trust model. Such a model will lead naturally to a decentralized approach that can tolerate partial information albeit one in which there is an inherent element of risk for the trusting entity. Mathematical models (dynamic graphs and stochastic models, and also models from particles interactions) will be useful to study the dynamic of the proposed models as well as performance evaluations both in term of technological constraint (CPU, bandwidth) and security efficiency (risk evaluation).

ACI sécurité FRAGILE The purpose of this ACI (http://www.lri.fr/~fragile/) is to characterize the large-scale systems as distributed systems, in order to estimate the extent to which failure tolerance can be guaranteed in various characteristic contexts, and, in case such a guarantee is possible in theory, to propose an implementation which takes into account requirements of the context of execution. The application domains for such large scale systems are sensor networks, P2P systems and grid platform.

RECAP The RECAP project is a CNRS national platform composed of the CITI laboratory, LAAS laboratory, the LIP6 laboratory and the LIFL laboratory. It aims at supporting research activities in the area of self-adaptive and self-organized networks. It addresses many topics such as topology control (addressing, location, etc.), data communication (broadcasting, routing, gathering, etc.), architecture (hardware, system -OS-, network -communication stacks-, etc.), applications (service lookup, distributed database, etc.).

IRAMUS *ARES* heads an INRIA Cooperative Research Initiative called IRAMUS (Radio Interface for multi-hop networks). This action aims to propose new trends in the two following axes: realistic modeling and simulation of the MAC-PHY layers for *ad hoc* and sensor networks. The solutions are intended to be integrated in standard network simulators.

Assessment of the PHY-MAC interface in different applicative scenarii. Indeed, low rate sensor networks or high rate *ad hoc* networks do not require the same constraints on the PHY-MAC layers.

ACI PairAPair ARES contributes as an associated member to the ACI “masse de données” PairAPair. The purpose of this ACI (http://gyroweb.inria.fr/pairapair/) is to study a global approach fot P2P systems: model, conception, analysis, implementation of P2P protocols.

8.3. European initiatives

MUSE II MUSE II is the follow up of MUSE I project (see later). inside the FP6 Work intiative. Alcatel is the prime contractor. MUSE II will start by the begining of 2006.
We represent INRIA within this project. We are involved in two activities :

- designing constrained java virtual machine for xDSL Modems.
- designing an overall end to end security framework for OSGi application management.

MUSE MUSE is an European project inside the FP6 Work intiative. Alcatel is the prime contractor. MUSE startied by the end of 2003.
The overall objective of MUSE is the research and development of a future low cost, full service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen. The proposed project integrates studies in the following areas:

- Access and edge network architectures and techno-economical studies.
- Access and edge platforms.
- First mile solutions (DSL, optical access, fixed wireless access).
- Networking of the access network with home gateway and local networks.
- Lab trials.

The concepts of MUSE have been validated for three end-to-end deployment scenarios:

- Migration scenario featuring a hybrid access network of ATM and packet (Ethernet, IP) network elements and CPE with embedded service awareness and application enablers.
- Non-legacy scenario showing access nodes, various first mile solutions, and CPE that are optimized for native Ethernet and IPv6 throughout the home and access network.
- FTTx scenarios integrating new concepts for access technologies - VDSL, optical access, and feeders for wireless services -, and service-aware CPE.

The expected impacts and results are:

- Consensus about the future access and edge network by major operators and vendors in Europe.
- Pre-standardization work and joined position in standardisation bodies.
- Proof of concept demonstrators and lab trials by operators.

AMIGO AMIGO (Ambient Intelligence for the networked home environment) is an European project (IP project) inside the FP6 Work intiative. Philips is the prime contractor. AMIGO has started since september 2004. The aim is to research and develop open, standardized, interoperable middleware and intelligent user services for the networked home environment, which offers users intuitive, personalized and unobtrusive interaction by providing seamless interoperability of services and applications.
AMIGO will focus on the usability of a networked home system by developing open, standardized, interoperable middleware. The developed middleware will guarantee automatic dynamic configuration of the devices and services within this home system by addressing autonomy and composability aspects. The second focus of the Amigo project will be on improving the end-user attractiveness of a networked home system by developing interoperable intelligent user services and application prototypes. The Amigo project will further support interoperability between equipment and services within the networked home environment by using standard technology when possible and by making the basic middleware (components and infrastructure) and intelligent user services available as open source software together with architectural rules for everyone to use. The AMIGO project is a huge step towards general introduction of the networked home and towards Ambient Intelligence by solving the main technological issues that endanger the usability of a networked home system, as well as creating clear end-user benefits by introducing intelligent user services and attractive prototype applications.

AEOLUS AEOLUS (Algorithmic Principles for Building Efficient Overlay Computers) is an IP project that has been started since September, 1st, 2005. The university of Patras (Greece) is the prime contractor. The goal of this project is to investigate the principles and develop the algorithmic methods for building an overlay computer that enables an efficient and transparent access to the resources of an Internet-based global computer. In particular, the main objectives of this project are:

- To identify and study the important fundamental problems and investigate the corresponding algorithmic principles related to overlay computers running on global computers.
- To identify the important functionalities such an overlay computer should provide as tools to the programmer, and to develop, rigorously analyze and experimentally validate algorithmic methods that can make these functionalities efficient, scalable, fault-tolerant, and transparent to heterogeneity.
- To provide improved methods for communication and computing among wireless and possibly mobile nodes so that they can transparently become part of larger Internet-based overlay computers.
- To implement a set of functionalities, integrate them under a common software platform in order to provide the basic primitives of an overlay computer, as well as build sample services on this overlay computer, thus providing a proof-of-concept for our theoretical results.

COST 295 The main objective of the COST 295 (European Cooperation in the Field of Scientific and Technical Research (http://cost.cordis.lu/)) named DYNAMO for Dynamic Communication Networks – Foundation and Algorithms–, is to structure the community of researchers working on fundamental aspects of Dynamic Communication Networks.

8.4. Visiting scientists

John Mullins is visiting the *ARES* project since october 2006. He is professor at the *Ecole Polytechnique de Montreal* (CA). He is currently included in the security sub-team of the Middleware axis of the *ARES* project. He is working in the area of model checking.

Yu Chen arrived in September on a postdoctoral position. She did her PhD in Texas A&M University, College Station, TX, U.S.A. Her current research focuses on the development of distributed services for wireless ad hoc networks, including mobile ad hoc networks and sensor networks. She works on protocol design that provides certain levels of reliability and theoretical analysis of the designed protocol for scenarios of interest.

8.5. International initiatives

Easy The PAI STAR Easy project aims in promoting at the IETF and increasing the impact and attractivity of the solutions proposed by the project partners, *i.e.* (*ARES* ENST Bretagne, Korean Telecom and Seoul National University (South Korea), in the fields of full IPv6 networks autoconfiguration and radio link optimizations in IPv6 mobile networks. Through the organization of two Franco-Korean workshops, one that was held in october 2005 and that will be held in march 2006, the project must also help in gathering the works performed by all partners and in developping a common solutions to the addressed íssues.

- Eric Fleury, Stéphane Ubéda and Fabrice Valois have done a travel to China in order to meet France Telecom R & D and local universities and research centers (Tsinghua University of Beijing, Beijing JiaoTong University, Chinese Academy of Sciences, Shanghai Jiao Tong University). The goal was to identify research teams in the area of sensor networks which could collaborate in a joint project with France Télécom R & D and INRIA *ARES* Ànother meetings are also scheduled for 2006.

9. Dissemination

9.1. Leadership within scientific community

Guillaume CHELIUS is:

- A member of the PAI STAR Easy project in collaboration with ENST Bretagne, France Telecom, Korean Telecom and the Seoul National University;
- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- the leader of the multi-laboratory CAPNET project (BQR project sponsored by the INSA de Lyon) on sensor networks;
- the WP2 leader of the national CNRS platform on sensor and auto-organized networks (RECAP).

Éric FLEURY is:

- Co-head of the CITI Lab and vice-head of the ARES project;
- co-chair of the Networking group of CNRS GDR ASR;
- the leader of the CNRS TAROT action (Techniques Algorithmiques Réseaux et d'Optimisation pour les Télécommunications);
- a member of the steering committee of the Expert Group on Networking (Comité d'Experts Réseau de communication) of the CNRS;

- an expert for the OFTA (Observatoire Français des Technologies Avancées) for the ambiant computing group;
- representative for the French part of the european project COST 295;
- the leader for the INRIA Rhône-Alpes of the project FRAGILE of the ACI Sécurité;
- a member of the steering committee of the CNRS National platform on sensor network RECAP. He is also in charge for the CITI lab of the sensor platform founded by the CNRS;
- in charge for the CITI Lab and INRIA Rhône-Alpes of the SAFARI project;
- a member of the CNRS group ING (Internet Nouvelle Génération);
- a member of the project PairAPair of the ACI Masse de Données;
- elected representative of the specialists committee in computer science (CS section 27) of INSA-Lyon;
- elected representative with the council of the Telecomunications Department of INSA-Lyon;
- rerviewer and member of the PhD examining boards of: Michael Hauspie (Lille), Aubin Jarry (Nice), Pavel Hadam (Grenoble), Françoise Sailhan (Paris VI), Amina Meraihi Naimi (Versaille), Jean Lorchat (Strasbourg) and Alexandre Guitton (Rennes);
- reviewer and member of the the HdR examining boards of: Bertrand Ducourthial (Université de Technologie Compiègne) and Julien Bourgeois (l'Université de Franche-Comté);
- member of the HdR examining board of Isabelle Guerin Lassous.

Stéphane FRÉNOT is:

- A member of the specialists committee (section 27) of the INSA-Lyon;
- a co-Founder of the OSGi French User Group;
- a member of ObjectWeb Consortium;
- an active member in Oscar Project (OSGi open-source implementation).
- a member of one PhD examining board: Guillaume Doyen, examinator, university Henri Poincaré, Nancy 1;
- INRIA representative within MUSE I and MUSE II european projects;
- PMC member of apache felix project (OSGi V4 implementation platform).

Jean-Marie GORCE is:

- Elected representative with the council of the Telecomunications Department of INSA-Lyon;
- the leader of the IRAMUS ARC of INRIA;
- a member of the Research group (GDR) ISIS (Information, Signal, Images and Vision) of CNRS;
- a member of the specialists committee (section 61) of the INSA-Lyon;
- a member of the specialists committee (section 61) of UCB Lyon 1 university;
- a member of a PhD examining board: Katia Runser, INSA Lyon.

Isabelle GUÉRIN LASSOUS is:

- The leader of the team Protocols of the ARES project;
- a member of the specialists committee (section 27) of the ENS Lyon;
- a member of the hearing committee of INRIA Rhône-Alpes;
- a member of the SPECIF committee that allocates PhD awards;

- a member of the CNRS TAROT action (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- the INRIA scientific leader of the european project AEOLUS (Algorithmic Principles for Building Efficient Overlay Computers);
- the INRIA scientific leader of a contract with FT R&D, "Bandwidth problems in multihop wireless networks";
- a member of the ARC INRIA Iramus (Radio Interface for Multihop Networks);
- a member of the ACI Sécurité Fragile (Failure Resilience and Application Guaranteed Integrity in Large-scale Environments);
- a member of the project RNRT SAFARI (Ad Hoc/Wired Services: Development of an integrated network architecture);
- a member of four PhD examining boards: Géraud Allard (Paris 6), Hakim Badis (Paris XI - reviewer), Mohammad Hossein Manshaei (Nice) and Julien Ridoux (Paris 6);
- a member of the INRIA Rhônes-Alpes committee of computer resources (CUMI).

Frédéric LE MOUËL is:

- The leader of the task 3.4 "Programming and deployment framework for Amigo services" of the European Amigo project;
- a member of the French Ministerial KAA project;
- elected representative with the council of the Telecomunications Department of INSA-Lyon;
- a member of EuroSys (European ACM SIGOPS) and ASF (French ACM SIGOPS);
- a member of the OSGi French User Group.

Stéphane UBÉDA is:

- Elected representative with the council of the Telecomunications Department of INSA-Lyon;
- a member of seven PhD examining boards: Allard Géraud (University Paris 6) Rabah Merahi (ENST), Almasri Nada (INSA de Lyon), Runser Katia (INSA de Lyon), Tournier Jean-Charles (INSA de Lyon), Khedher Houda (INSA de Lyon), Trezentos Daniel (Université Rennes I); and of three Habilitation Thesis examining board: Isabelle Christment (Henri Poincaré University), Laurent Viennot (Paris 7 University), Jean-Philippe Babeau (INSA de Lyon - Université Lyon I).

Fabrice VALOIS is:

- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- a member of one PhD examining board: Mlle Houda Khedher, examinator, Ecole Supérieur des Télécommunications de Tunis, Tunisie;
- a member of the specialists committee (section 27) of the INSA-Lyon.

Guillaume VILLEMAUD is:

- a member of one PhD examining board: Christophe Dall'omo, invited, university of Limoges.

9.2. Conferences, meetings and tutorial organization

Guillaume CHELIUS is:

- Co-president of the Algotel 2005 organizing comitee (Giens, France, 2005);
- co-organizer of the first CNRS RECAP workshop on sensor networks (Nice, France, 2005);
- submission and publication chair of the international Intersense 2006 conference;
- organization chair of the international FAWN 2006 workshop held in conjunction with the IEEE PerCom 2006 conference.

Eric FLEURY is:

- General chair of FAWN 2006;
- General chair of CFIP 2006;
- PC member of WWASN2006, InterSense 2006, Spaswin 2006 and MSN 2005.

Isabelle GUÉRIN LASSOUS is:

- Co-chair of the conference WONS 2006 (Third Annual Conference on Wireless On demand Network Systems and Services), Les Ménuires, France, January 2006, ares.insa-lyon.fr/wons2006;
- program chair of the conference MedHocNet 2005 (4th Annual Mediterranean Ad Hoc Networking Workshop), Île de Porquerolles, France, June 2005, med-hoc-net2005.lri.fr;
- a member of the following program committees: Seventh ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2006), Firenze, Italy, Second International Workshop on Sensor Networks and Systems for Pervasive Computing (PerSeNS 2006), Pisa, Italy, IEEE International Workshop on Foundations and Algorithms for Wireless Networking (FAWN 2006), Pisa, Italy, 2nd ACM International Workshop on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN 2005), Montréal, Canada, International Conference on Mobile Ad-hoc and Sensor Networks (MSN 2005), Wuhan, China, International Workshop on Localized Communication and Topology Protocols for Ad hoc Networks (LOCAN 2005), Washington, USA, First International Workshop on System and Networking for Smart Objects (SANSO 2005), Fukuoka, Japan, 2nd International Workshop on Practical Aspects of High-level Parallel Programming (PAPP 2005), Atlanta, USA, 1st International Workshop on Sensor Networks and Systems for Pervasive Computing (PerSens 2005), Kauai Island, Hawaii, 7e Rencontres Francophones sur les aspects Algorithmiques de Télécommunications (Algotel 2005), Presqu'île de Giens, France

- Jean-Marie Gorce, Guillaume Villemaud, Hervé Parvery, Jacques Verdier organized, with Agilent Technologies, a workshop on "Analyse et traitement de signaux pour les radiocommunications »", at INSA de Lyon from July, 5 to July, 7 2005.
- Stéphane Ubéda is the program chair of the Communication Network track of International Conference on High Performance Computing - HiPC'2006.
- Fabrice Valois is a program committee member of the EPEW'05 workshop (2nd European Performance Evaluation Workshop, Versailles, 1-3 Sept. 05, France)

9.3. Teaching activities

MASTRIA OF THE UNIVERSITY LYON 1, INSA DE LYON, UNIVERSITY LYON 2, ECL

- Eric Fleury is the chair of the master in Networking, Telecommunications and Services inside the Master of research MastRIA of the University Lyon 1, INSA de Lyon, University Lyon 2, ECL;
- Eric Fleury gave a course on *Internet New Generation* (20h);
- Stephane Frénot gave a course on *Open application servers design* (20h);
- Isabelle Guérin Lassous, Marine Minier and Stéphane Ubéda gave a course on *Wireless and Mobile Networks* (20h);
- Jean-Marie Gorce and Fabrice Valois gave a course on *Networks Planning* (20h).

ECOLE CENTRALE DE LYON

- Isabelle Guérin Lassous gave a course on *Mobile Networks* (10h).

INSA DE LYON

- Eric Fleury, Stéphane Frénot, Jean-Marie Gorce, Marine Minier, Frédéric Le Mouël, Stéphane Ubéda, Fabrice Valois and Guillaume Villemaud are professors/teaching assistants at the INSA de Lyon;
- Isabelle Guérin Lassous gave courses on *Ad hoc Networks* (6h) and *QoS in the Internet* (2h) to the fourth-year students;
- all the members supervised engineer projects.

ENSEIRB

- Stéphane Frénot gave a training course on OSGi development to Bordeaux engineering school.

ING 2005

- Stéphane Frénot gave a tutorial on OSGi and P2P deployement at ING'2005 winter school in Etaple Le Touquet, France.

- Guillaume CHELIUS gave a lecture called "Introduction to ad hoc routing: unicast, broadcast & multicast" during the First Franco-Mexican school on Telecommunications (Mexico City, Mexico), September 2005;
- Frédéric Le Mouël gave a lecture on "Pervasive Information Systems" in the Research Master in Computer Science of the University of Jendouba, Tunisia and of the BUAP University, Puebla, Mexico (2x20h).

9.4. Miscellaneous

9.4.1. Visits

- Guillaume CHELIUS has been a visiting scientist in the NPA team of the LIP6 laboratory from January 2005 to June 2005;
- Guillaume CHELIUS has been a visiting scientist in the the LNCC (Petropolis, Brasil) laboratory from September 2005 to December 2005;

9.4.2. Defended Habilitations

- Isabelle Guérin Lassous, *Autour de la notion de bande passante dans les réseaux radio multisauts*, 7 december 2005, jury: Claude Castelluccia, Marco Conti, Serge Fdida, Eric Fleury, Philippe Jacquet, Yves Robert.

9.4.3. Defended PhDs

- Nada Al Masri, *Administration et fédération de serveurs d'applications*, 25 march 2005, jury: Olivier Festor, Laurent Philippe, Michel Riveil, Gérard Vandôme, Stéphane Frénot, Stéphane Ubéda.
- Katia Runser, *Méthodologies pour la planification de réseaux locaux sans fil*, 27 october, 2005, jury: Alexandre Caminada, Jean-Marie Gorce, Xavier Lagrange, David Simplot-Ryl, Stéphane Ubéda, Rodolphe Vauzelle.

9.4.4. On going PhDs

- Noha Ibrahim, *Intégration automatique de services par négociation avec les applications*, INRIA;
- Jialiang Lu, *Mécanismes d'auto-configuration de réseaux d'objets communicants*, INRIA. Between November, 2005 and October, 2007, Jia-liang Lu will be in Beijng (China) in order to work with FTRD in the ILAB research team.
- Philippe Mary, *Approches innovantes du traitement d'antennes multi-capteurs dans un système embarqué contraint comportant des interfaces radio multiples*, INSA de Lyon;
- Nathalie Mitton, *Auto-organisation et réseaux ad hoc*, INRIA;
- Pierre-François Morlat, *Etude de terminaux SIMO et MIMO en contexte ad-hoc et réseaux de capteurs*, INRIA;
- Pierre Parrend, *Modèle de sécurisation de machines virtuelle contraintes*, INSA de Lyon.
- Tahiry Rafazindralambo, *Etude de la capacité dans les réseaux radio multi-sauts*, INRIA;
- Guillaume De La Roche, *Prédiction 3D du lien radio dans les environnements indoor*, INSA de Lyon;
- Yvan Royon, *Modèles d'administration de passerelles domestiques*, INRIA;
- Cheikh Sarr, *Evaluation des ressources dans les réseaux radio multi-sauts*, INSA de Lyon;
- Fabrice Theoleyre, *Gestion de la mobilité dans les réseaux hybrides*, INSA de Lyon;
- Thomas Watteyne, *Energy-efficient self-organization of ad-hoc networks*, INSA de Lyon.

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[2] K. RUNSER. *Méthodologies pour la planification de réseaux locaux sans-fil*, Ph. D. Thesis, INSAL, October 2005.

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