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Project-Team Ares

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Activity Report

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2. 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 focus 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 needs 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, Claude Chaudet, Dominique Dhoutaut, Jean-Marie Gorce, Isabelle Guérin Lassous, Jialiang Lu, 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: Claude Chaudet, Guillaume Chelius, Dominique Dhoutaut, Eric Fleury, Isabelle Guérin Lassous, Jialiang Lu, Nathalie Mitton, Thomas Noël, Tahiry Rafazindralambo, Cheikh Sarr, Fabrice Theoleyre, Fabrice Valois.

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: Nada Al Masri, Eric Fleury, Stéphane Frénot, Noha Ibrahim, Véronique Legrand, Frédéric Le Mouël, Dan Stefan, Yvan Royon, Stéphane Ubéda.

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 environments i.e. a cellular environment where ad hoc capacities are used both to extend the communication range of the cellular networks 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 currently work on the notion of *intelligent gateway* where superivsion 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 multi-hop 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 study such as topology control (addressing, localization, etc.), data communication (broadcasting, routing, gathering, etc.), architecture (hardware, system -OS-, network -communication stacks-, etc.), 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.

Any evaluation and design tool for wireless environment that combines network models and physical models should be addressed by the *ARES* team. Some results, even in terms of technology transfer, have already been obtained.

4.5. Middleware for the Grid

ARES team is developing skills in the area of Middleware for the GRID. The DARTS project aims at defining a middleware that manages services, services discovery and service supervision. That kind of middleware is both suited for ubiquitous environment and heterogeneous grid environment. We are currently defining a common middleware framework that is usable in both environments and that can be dynamically configured in order to present one of the two personalities.

5. Software

5.1. Advanced OSGi

Keywords: *OSGi*, *home gateway*.

Participants: Stéphane Frénot, Yvan Royon, Nada Al Masri, Dan Stefan.

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. That work has been presented in the UbiMob'2004 conference in Nice [24].
- 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. This architecture has been presented at the NOTERE 2004 conference [25].
- 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. This architecture is currently under development and has been presented at the DECOR2004 conference [23].

5.2. ANANAS

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

Participants: Guillaume Chelius, Eric Fleury.

AnaX, Ana4 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 allows the logical partitionning of an ad hoc network using channels. A channel is a maximal connected set of ad hoc nodes sharing a common channel value. Different routing protocol instances may be operated in the different channels, allowing routing optimizations depending on the channel properties. An ad hoc node may have several channel values and several or different interfaces bound to each channel. These values are manually or automatically configured, using an advertizing protocol or a MANET protocol. AnaX also introduces an addressing support to restrict the diffusion of information (broadcast or multicast) to a precise channel or to the whole ad hoc network. The software is available at http://sourceforge.net/projects/ananas.

5.3. Extension of OSPFv3 for auto-configuration

Keywords: *IPv6 auto-configuration*, *OSPF*, *SLA values*.

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 SLA values to links using a distributed protocol executed by the IPv6 routers. The RSM department of the ENST Bretagne and the project have published an Internet Draft for the Yokohama IETF meeting (draft-chelius-router-autoconf-00.txt) which extends OSPFv3 to establish and maintain a consensus on the automatic attribution of SLA values to the network links. Diffusion of SLA values in the OSPF area enables collision detection and avoidance while picking the SLA value for a newly created link. Implementation for this protocol is available for the Zebra application (http://citi.insa-lyon.fr/ gchelius/dslac/).

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 modelling. 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. An original multi-resolution algorithm has been implemented, speeding up the computation 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).

5.5. BRuIT

Keywords: *ad hoc networks*, *bandwidth reservation*, *interferences*.

Participants: Claude Chaudet, Isabelle Guérin Lassous.

BRuIT is a QoS protocol designed to provide accurate guarantees in mobile ad hoc networks. In ad hoc networks, where mobiles are supposed to perform QoS routing as well as admission control, it becomes critical for each mobile to have an accurate knowledge of transmissions in its neighborhood in order to provide accurate guarantees. BRuIT achieves this goal by periodically transmitting informations on the ongoing transmissions in the network and using this information for admission control.

We have implemented this protocol under the network simulator NS-2 and many optimizations and enhancements have been implemented in order to render this protocol more lightweight, more reliable, and to make it able to react to unpredictable changes in the resources availability. A linux version is being implemented and the source code will be made available soon. See http://ares.insa-lyon.fr/ cchaudet/Software.html.

5.6. Forwarding

Keywords: *IEEE 802.11*, *ad hoc networks*, *performance evaluation*.

Participants: Dominique Dhoutaut, Isabelle Guérin Lassous.

Forwarding enables the performance evaluation of the standard IEEE 802.11 in a real ad hoc context. *Forwarding* runs in user space and enables the transmission of unicasted or broadcasted packets in a well controlled manner. In order to characterize the effects of sole 802.11, we had to isolate them from those of others layers (routing and transport layers in particular). *Forwarding* gets its name from its ability to repeat

UDP packets depending on stated rules, thus creating stable multihop routes where controlled frames travel (each UDP packet translates in one frame, and there is no effects from TCP or others layers). Along with suitable results analysis tools, *forwarding* proved itself quite useful in understanding real behaviors of 802.11 in an ad hoc context and in pointing out some weak points of simulations. For any information contact Isabelle Guérin Lassous (Isabelle.Guerin-Lassous@inrialpes.fr).

6. New Results

6.1. Hybrid networks modelling

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

Participants: Alexandre Caminada, Claude Chaudet, Dominique Dhoutaut, Jean-Marie Gorce, Isabelle Guérin Lassous, Jialiang Lu, Guillaume de la Roche, Katia Runser, Fabrice Valois, Guillaume Villemaud.

This year, two research topics have been 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 modelling framework.

6.1.1. Characterization and impact of the radio interface

First of all we have focused our efforts on the radio propagation simulation and on the study of planning techniques for wireless LAN. These approaches are broad enough to offer for the future a way to simulate the behavior of hybrid networks. During this year we have focused our work on the simulation and the evaluation of the successful technology 802.11.

6.1.1.1. Radio platform

Actual models of the radio link in network simulators are based on very simple models. In order to improve these simulators and to allow a best fit between experiments and simulations, the knowledge of the implementation of the physical layer is mandatory. This implementation depends on the constructor, and the type of wireless cards. The only way to obtain this information is a direct observation of the transmitted signal. For this purpose, we have designed a radio platform. This platform has been bought by INRIA Rhône-Alpes in 2004. 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 a simulation software called ADS (Agilent).

This platform allows to simulate a complete radio link (including coding, modulation and channel model) and includes the possibility to observe the RF signals emitted by conventional IEEE 802.11 or sensor network radio interfaces. The use of this platform should allow to refine our models of the physical layer. During the next year we will focus our work on this platform in order to provide the interface to measure the properties of IEEE 802.11 bursts.

6.1.1.2. Propagation simulation in indoor environments

The simulation of propagation in indoor environments is a difficult task due to many reflexion 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 prediction may be more realistic if the number of reflexions increase and if diffraction is introduced in the modelling through an UTD approach. However, in this case, the computational resources needs may drastically increase, and therefore a tradeoff has to be defined 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. Last year (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. Then, the remaining computation load needed to compute the propagation of a source is drastically reduced.

Our approach is therefore able to perform accurate simulations. Concerning the simulator, this year, we have focused our efforts on three points: validation with experimental measurements, optimization of computation load and directivity of antennas.

- Experimental measurements allow to set in our simulator several parameters. More specifically, propagation parameters (refraction index and attenuation) of constitutive materials (walls, free-space, ...) have to be estimated. 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.
  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. 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 shown that our prediction error (RMSE) is about 6dB [32][33].
- The computation 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 an interface between the COLT procedures and the ATLAS BLAS library (http://math-atlas.sourceforge.net/). The computation load was then drastically reduced because the matrix inversion in J was slow down due to the memory management. The computation also depends on the way the multi-resolution is built. This problem has been extensively investigated [32].
- Another aspect which has been studied in depth is the directivity of antennas. Indeed directive antennas should be taken into account in order to accurately simulate real propagation of access points. For instance, some access points are using patch antennas which are front lobe of about 120° and a front to back ratio of about 20dB. We have developed a method allowing to simulate directive antennas from omnidirectional sources. For this purpose, the theory of smart antennas has been adapted. Starting from the theoretical directivity of any antenna, the amplitudes and phases of

elementary radiating sources of an antennas network are chosen to fit experimental and theoretical directivity charts. We have shown that a front-to-back ratio higher than 20dB is easily achieved for a main lobe of about 120°, which is enough to simulate accurately WiFi access point antennas. (This work was the subject of a Master thesis, which is going to be published as a technical report.)

6.1.1.3. Wireless LAN planning

The performance of a WLAN is strongly influenced by the access points characteristics. That is why their number, their location and their emission power have to be determined with care during the planning stage of the network. The planning problem can be tackled in different ways according to the optimization goals that have been chosen. The traditional approach is to compute a coverage map that satisfies a simple constraint on the signal level based on a minimum threshold. Some more elaborated models introduce constraints of quality of service (as throughput or interference level) on the receiver locations. The evaluation of a solution (an access point configuration) relies on a propagation simulation that computes the coverage map. This simulation is often an expensive computational operation. The goal of the optimization algorithm is to determine a solution that satisfies the coverage constraints with a minimum number of propagation simulations. We have proposed a deterministic algorithm, that exploits both the pre-processing and the multi-resolution specificities of our propagation simulator. Its aim is to find out an access point distribution that provides an homogeneous coverage. A first approach considering a fixed emitting power level and a 2D problem has been proposed in 2003. From this study we want to test several optimization schemes, taking into account different goals (homogeneous coverage, fairness of resources, interference limited configurations, ...), and different algorithms (deterministic or stochastic methods), taking advantage of our multi-resolution algorithm. This is the topic of the PhD work of Katia Runser. This year, we have focused our work on the definition of optimization criteria. We defined mathematically several criteria: radio coverage, QoS and localization performance. The coverage criteria is the easiest one, which reflects the need of a radio access everywhere, and has been defined last year.

The localization criteria is a new proposal. Indeed, the localization through a WiFi network is a challenging task. Many works in the literature have been devoted to the development of localization technics. All of these approaches are based on a triangulation from power received signals. Lot of efforts have been done to improve the robustness of localization. We propose two original points: firstly, we have shown that the use of our simulator to build the database of power received signals is efficient. This work was the subject of a Master thesis, which is going to be published as a technical report. Secondly, we propose to introduce the aim of localization in the network planning phase. It means that we propose to deploy the access points with regard to the expected localization accuracy. For this purpose we have defined a localization criteria based on a distance defined in the vectorial space of received powers. We have identified two main reasons of lack of accuracy in mobile localization: a lack of received signal in some areas and a similitude in the received power space of different areas. This has allowed us to define a localization criteria and we have proposed a way to optimize the infrastructure for the localization task. This work is actually under test.

6.1.2. Performance evaluation in hybrid networks

6.1.2.1. 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 [38][46][7].

We have modeled a particular scenario using discrete time Markov chains. As far as we know, this is the first theoretical study that models a multihop scenario where some mobiles are not almost never synchronized with 802.11 [12]. The scenario consists in three pairs of mobiles contending for medium access. Each pair is composed of an emitter trying to saturate the radio channel (i.e. a frame is always ready to be transmitted) and a corresponding receiver. The three pairs are placed so that one pair interferes with the two others while the two others are independent. Solving the Markov chain shows that the central pair gets a medium share below 5where it should expect one third of the bandwidth. Results of the Markov chain solving for different frame sizes and different protocol behaviors are gathered in. We have also evaluated this scenario by varying different parameters like packets size, fixed wait interval of 802.11 (DIFS and EIFS), etc. We have shown that a good tradeoff between equity in flows' rate and aggregrated throughput is difficult to reach.

The main problem we have to face is the size of the Markov chain to solve. A parallel computer is required to solve most of the configurations we tried. This year, we have succeeded in reducing the size of the Markov chain for some packets size by identifying a unique absorbing sub-chain.

Most of the studies on ad hoc networks and on performance issues with 802.11 are based on simulations. The obtained performances of the tested protocols are often biased by the simplistic assumptions of the physical layer made by the simulators. Experimentations in real environment is thus mandatory. The Forwarding software enables such experiments in ad hoc context. This year, we have proposed a method to realize a global visualization of real experiments in ad hoc networks based on an *a posteriori* synchronization [22].Such global results could give, at any time of the experiment, which mobile sends which packet to which other mobile, which mobile receives which packet from which mobile, etc. Such information enable to know what precisely happens during experiments and can strongly help in understanding the evaluated protocols.

Last year, we experimented basic configurations in order to evaluate the capacity of a single 802.11 link, the share of the medium and the communication and interference range. If the tested networks were large, the communications were done on one-hop links and not multihop links. This year, we have experiment the rate offered by 802.11 on a multihop configuration constituted of a chain of mobiles [21]. This is the most basic configuration as soon as two mobiles not in commucation range wish to communicate. We show that the rate achieved on a four-hop chain is around 200kb/s with wireless cards at 2Mb/s and is very unstable. This is much less than the rate obtained with the NS2 simulator.

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 [9]. 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.

6.1.2.2. Performance evaluation of 802.11 unfairness using process algebra

Performance evaluation of 802.11 have 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. Using the compositionnal approach of Process Algebra, we have developped 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. 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.

6.1.2.3. Performance Evaluation of 802.11 in realistic environment

Stochastic models are widely used in the field of performance evaluation of wireless networks. Most of the existing performance models assume that the radio channel is ideal. It means that the interferences are not considered, the signal to noise is stable and determinist, i.e. the radio environment is not considered. As a result, deploying a real wireless LAN (especially in indoor environments) leads to quite different performance results. Hence we propose a method which integrates the real radio behavior in an analytical performance model. Taking advantage of our model, we are able to predict the performance (throughput, global capacity, etc.) of an indoor WLAN of 802.11b type, on the basis of the radio coverage knowledge (obtained with the radio planning tool WILDE). We have analyzed the following scenarios: a network with only one access point, a network with more than one access point and hidden terminal scenarios. As another part of our result, we have identified the impact of a slow rate station in the performance evaluation. Our work shows that the performance depends strongly on the quality of the radio environment. Some experimental results are also evaluated to confirm analytical results.

6.1.2.4. Model for traffic monitoring

Network measurements are 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 by the network and the active approach that generates explicit control packets in the network for measurements. One of the key point is to minimize the overhead in terms of hardware, software and maintenance cost and of additional traffic. We have performed a study on the problem of assigning tap devices for passive monitoring and beacons for active monitoring [39]. Minimizing the number of devices and finding optimal strategic locations is a key issue, mandatory for deploying scalable monitoring platforms. We propose new solutions based on an Integer Linear Programming formulation.

6.2. Protocols design

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

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6.2.1. Architectural design

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 [16][17] is now available under FreeBSD via sourceforge (http://sourceforge.net/projects/anax).

Research on wireless networks has roughly been concentrating on two distinct themes. The first one tries to extend the edge of infrastructure networks by the integration of a last wireless hop. The radio connectivity is provided by base stations. The second theme concerns infrastructureless and auto-organized wireless networks (mobile ad hoc networks). Research efforts aiming at merging cellular wireless and ad hoc networks have recently increased. Hybrid networks, the extension of a cellular network using ad hoc connectivity, offer obvious benefits. On one hand, they extend the cellular network coverage area using ad hoc connectivity and on the other hand they provide a global Internet connectivity to ad hoc nodes. However, deployment of a wired infrastructure network induces costs and constraints. They can be reduced if we replace the wired infrastructure network by a fully wireless one, also known as a wireless mesh network. The infrastructure network becomes a collection of static wireless nodes (mesh routers) acting both as base stations and infrastructure routers. Infrastructure communications become wireless and multihop. As the wireless medium slightly differs from the wired one (pervasive medium, non isolated links, higher latency and lower bandwidth), the design of classical micro-mobility protocols must be rethought and if necessary modified.

In our work [14], we study the architecture as well as the mobility notification strategies that can be used in hybrid networks. Several strategies for mobility notification frame transmission are compared and in particular, we compare the consequences of transmitting control packets in unicast, broadcast and ackowledged broadcast (a transmission mode we developped for mesh networks) and show that contrary to wired networks, adding reliability to the 802.11b MAC level does not increase robustness in the upper routing layer. We also addressed the optimizations related to the ARP protocol and studied the impact of interface queue length on data packet delivery. Finally, we propose and compare several mechanisms to reduce the routing overhead induced by the micro-mobility protocol (e.g. Cellular IP) in the wireless mesh network: we study the introduction of nack mechanisms in Cellular IP for explicit route destruction as well as a variable frequency `route update` emission policy.

6.2.2. Auto-organization

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 have proposed a novel metric suitable for organizing an ad hoc network into clusters and we have proposed a new distributed clusterhead election heuristic for an ad hoc network. Our new metric does not rely on "static" parameters and thus our novel heuristic extends the notion of cluster formation. The proposed heuristic allows load balancing to insure a fair distribution of load among cluster heads. Moreover, we have implemented a mechanism for the clusterhead election that tries to favor their re-election in future rounds, thereby reducing transition overheads when old clusterheads give way to new ones. We expect from network organization to be robust towards node mobility. Based on our previous density metric suitable for self-organizing multihop wireless networks, we have peformed analytical analysis [43] based on stochastic geometry in order to characterize the average density of nodes, the number of clusterheads as a function of the node density. We have also conducted studies on the self-stabilization [44] of our self-organization algorithm in order to show the robustness of our density metric.

We have gone on in the investigation of gateway and address auto-configuration for IPv6 ad hoc networks in conjunction with the ana6 architecture. The particular nature of an ad hoc network makes it impossible to use the classical IPv6 mechanisms used in wired networks in order to propagate prefix information. We have specified a protocol (node behavior, information propagation, message format) which allows nodes in an ad hoc network to discover gateways and their associated IPv6 prefixes. One of the pair gateway/prefix is then used by each node in order to build an IPv6 global address and, when necessary, to maintain a default route towards the Internet. Specific mechanisms are included to act in response to topological changes and to avoid the diffusion of false information after nodes movements [20].

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 form services areas, one leader, the clusterhead, managing its zone. 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;
- To optimize the information flooding.

Because nodes are mobile, we introduce a protocol constructing and maintaining such a topology [34]. The whole structure is built in choosing optimal nodes to act as leaders. This decision is taken according to a stability weight. Major improvements were done in reducing overhead for construction and maintenance of this virtual topology and in creating redundancy in the backbone for disconnection minimization. The Access Point constitutes a single point of failure in the Internet interconnection. Thus, a solution integrating several Access Points in the hybrid network was proposed: one backbone is constructed per AP. Besides, a solution to interconnect these backbones was also presented [35].

Virtual structures are often based on an election process, the decision being taken usually according to the node degree or its identifier. We discuss about the assets to use a more sophisticated weight, representing the capacity of a node to be a leader, member of the virtual topology. Such a weight was shown to allow to create significantly stabler topologies than a weight based on the degree or the identifier. Moreover, our structure creates a hierarchy between leaders and clients. Thus, the nodes which don't take part in the virtual topology can sleep to spare their energy. Such a solution is very efficient, with a very limited impact on performances, and presents better performances when the decision of sleeping is taken according to our stability weight [36].

The next steps will deal with routing protocols based on self-organization networks instead of flat one and in implementing mobility management as localization/paging strategies inspired by cellular networks.

6.2.4. QoS in ad hoc networks

6.2.4.1. Evaluation of the BRuIT protocol

This year, we have proposed enhancements and evaluations of BRuIT [11], 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 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 of over-detected neighbors reaches 40 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.

6.2.4.2. Dynamic bandwidth allocation

In the BRuIT protocol, the allocated bandwidth for the best-effort flows was primarily static. This solution often leads to a sub-optimal use of the network resources as soon as there are few priviledged traffics. An alternative is to allocate bandwidth to best effort traffic according to the properties of the network, i.e. the topology and the bandwidth available to each mobile. This assignment is done so that no saturation appears on any mobile. Finding such a solution while maximizing at the same time the overall used bandwidth in the network is equivalent to a fractional packing problem. Algorithms solving this problem are essentially sequential and difficult to adapt to a distributed setting. Moreover, such solutions maximize the total used bandwidth without guaranteeing any fairness among the mobiles. Not providing a minimum amount of bandwidth for each mobile in the network may lead to serious imbalance and to a bad use of the network. We have proposed a distributed algorithm to allocate bandwidth to each mobile according to the topology of the network and the available bandwidth on each mobile for ad hoc networks [13]. The algorithm guarantees a non null minimum bandwidth to each mobile. With this algorithm, each mobile computes the bandwidth it can use in order to avoid saturating its capacity or its neighbors'. With such an algorithm, congestion is less likely to appear in the network. We have simulated this algorithm behavior on regular and random topologies. The resulting allocation is generally sub-optimal in terms of global bandwidth allocation but is fairer. The results are similar to the fairest solution considering max-min fairness.

6.2.4.3. A managed bandwidth reservation framework for ad hoc networks

We have coupled the BRuIT protocol to an authorization framework implemented within the management plane using a policy-based approach. The policy based management approach for network emerged as a scalable solution towards the management of large networks. It is based on pushing more intelligence in the network using a set of policies for its management. Existing work on policy based management approaches for ad hoc networks is relatively modest. Our approach for extending policy based management architectures in ad hoc network is based on integrating radio level information and ad hoc routing protocols within the management plane. The management plane architecture is based on an extension of the COPS framework within an ad hoc network. This extension is centered around two major principles. Firstly, radio level parameters are included as core building blocks of management policies. These parameters and an additional signaling support are provided by the BRuIT component. Secondly, the classical policy management framework is adapted to the case of a dynamic infrastructure. This is done by extending the simple device architecture with a self-configuration layer. This layer is responsible to dynamically bind PEPs to PDPs. A partial implementation of our architecture was developed in Java (based on the JCAPI-COPS API developed at UQAM) [10].

6.2.5. Energy constraint

We have initiated a study on the energy consumption in wireless ad hoc network. There has been an increased awareness of energy efficient protocol 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 [18][41] 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.

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 [25].
- 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 [23].

- 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. A part of the project (JMX instrumentation) is presented in [24].

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 model 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 flux. 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.

7. Contracts and Grants with Industry

Altophone The European regulatory authorities are about to change the laws that deal with the proscription of cell phone silencers, towards the acceptance of intelligent systems. The French Telecommunications Regutator (ART France[1]) has initiated the law number 2001-624 (July 17, 2001) which deals with a restriction mode for GSM cell phones in order to block incoming and outcoming calls in selected areas (courts, museum, amphiteatre of university, ...) and to authorize only emergency calls. This project was done with Altophone SA which owned international patents on architectures of jamming and filtering radio-mobiles communications.

The result of this collaboration is the proposition of a cell phone silencer concept based on the idea of changing the access control parameters on the channel BCCH and developing other intelligent methods, also based on changing parameters on the common downlink channels; intelligent in the way that they keep people from using their cellular phones in places where this is not desired, but let pass emergency calls and calls originating from privileged phones. The network provider has the control over all silencers within its network. This is done by smoothly modifying the Radio Resource Layer in a way that does not irritate other GSM devices not taking advantage of this feature. The overall system can be applied to any regular cell phone.

Seewan The regional incubator CREALYS supports the creation of a start-up which aims to propose tools for planning wireless LAN. The CITI contributes to this project under an agreement between the region Rhone-Alpes, INSA Lyon (CITI) and the contractors. Our team is charged to provide 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).

8. Other Grants and Activities

8.1. Regional initiatives

SICOM In the project, *ARES* is proposing news approaches including access to information through mobile devices. Both Personal Area Network (communication between medical devices and data devices in a local area), wireless LAN (in medical area) and 2G wireless access have been studied. *ARES* has also proposed a global security architecture for this environment. SICOM is a project founded by the Regional Council (Rhône-Alpes).

8.2. National initiatives

SAFARI The SAFARI project 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 dynamic features of the network infrastructure and of the services demand and continuity. The different partners of the project are FTRD, 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.

[1] http://www.art-telecom.fr

ACI DARTS DARTS proposes the development of software components allowing both a fast deployment and services administration on federations of servers allowing access to resources and processing capacity. A federation of servers is a collection of entry points to the global execution space. A server offers access to several users by federating resources; it collaborates with other servers to combine services or to delegate queries. DARTS concentres on the server functionality and its experimental works is based on Java technologies: J2EE (EJB, JMX).

ACI Blanche The CITI of INSA Lyon is the head of a "White Incitative Concerted Action (ACI blanche)" which deals with the wireless LAN planning problem. This project is done in collaboration with the Hipercom project of INRIA, and started in January 2001, for a total period of 3 years. The aim is to develop a prototype for the help of wireless LAN planning. The originality of this project lies in its transverse approach. Indeed, we deal both with radio coverage constraints and planning problems constrained by quality of service goals (throughput, error rate, handover management). The key issues are the radio coverage simulation, protocols adaptation and the simulation of ad hoc networks.

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 domain for such large scale systems are sensor networks, P2P systems and grid platform.

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 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 will be 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.

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. The kick-off meeting of DYNAMO is scheduled for January 27th 2005.

8.4. Visiting scientists

Janez Žerovnick visited the *ARES* project twice in July. He is a professor at the University of Maribor in Slovenia. He worked with Claude Chaudet and Isabelle Guérin Lassous on adaptative bandwidth allocation in ad hoc networks. The collaboration has resulted in one paper accepted in international conference in 2004 and one paper submitted to an international journal.

9. Dissemination

9.1. Leadership within scientific community

Guillaume CHELIUS is:

- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);

Éric FLEURY is:

- co-head of the CITI Lab and vice-head of the ARES project;
- the leader of the CNRS TAROT action (Techniques Algorithmiques Réseaux et d'Optimisation pour les Télécommunications);
- a member of the steering committee of the RTP (Réseau Thématique Prioritaire) *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;
- 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 VISON (*Vers un Intranet Sécurisé et Ouvert au Nomadisme*);
- 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;
- President of the PhD examining board of Christophe JELGER (Rennes). Reviewer and member of the PhD examining boards of: Arnaud TROEL (Rennes), Ayman EL-SAYED (Grenoble), Mounir BENZAID (Paris-Sud), Shiyi WU (Nice), Christian DETRÉ (Evry), Joel CORRAL (Rennes). Member of the examining board of Jean-Loup GUILLAUME (Paris 7) and Erwan ERMEL Paris 6).

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).

Jean-Marie GORCE is:

- elected representative with the council of the Telecomunications Department of INSA-Lyon;
- an expert for the CMIFM (Comité mixte inter-universitaire franco-marocain) for the evaluation and the follow-up of scientific projects in telecommunications;
- 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 one PhD examining board: Landaabalo Agba, examinator, university of Limoges.

Isabelle GUÉRIN LASSOUS is:

- co-chair of the confrence AlgoTel 2004 (6e Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications);
- 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 SPECIF committee that allocates PhD awards;
- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- a member of three PhD examining boards: Claude Chaudet, supervisor, INSA de Lyon; Anelise Munaretto, Paris 6; Mohamed Essaïdi, Nancy I;
- a member of the INRIA Rhônes-Alpes committee of computer resources (CUMI).

Stéphane UBÉDA is:

- elected representative with the council of the Telecomunications Department of INSA-Lyon;
- a member of six PhD examining boards: David Carsenat, Limoges; Malika Boulkenafed, Paris 6; Rola Naja, ENST Paris; Nicolas Enderlé, ENST Paris; Claude Chaudet, supervisor, INSA Lyon, Guillaume Chelius, supervisor, INSA Lyon; and of one Habilitation Thesis examining board: Thomas Noël, Strasbourg.

Fabrice VALOIS is:

- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- 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 organized the TAROT meeting at the INSA of Lyon (14-15 october 2004).
- Nathalie MITTON organized the ACI Pair-à-Pair meeting in Lyon (21-22 october 2004) .
- Stéphane UBÉDA and Fabrice VALOIS are program chair of the winter school ECOTEL'04 (*Ecole d'hiver des Télécommunications* about *Wireless networks* organized in Tunisia (2-9 december 2004).

9.3. Teaching activities

DEA DISIC - INSA DE LYON

- Isabelle Guérin Lassous and Stéphane Ubéda gave a course on *Ad Hoc Networks* (20h);
- Jean-Marie Gorce and Fabrice Valois gave a course on *Networks Planification* (20h).

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 gives a course on *Internet New Generation* (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, 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;
- Jean-Marie Gorce and Guillaume Villemaud gave a course on Antennas for professional formation (14h);
- all the members supervised engineer projects.

MOTOROLA

- Stéphane Frénot gave a training course on OSGi development to the MOTOROLA Mobile Phone Software division (2 days).

9.4. Miscellaneous

9.4.1. Defended PhDs

- Guillaume Chelius, *Architectures et communications dans les réseaux spontanés sans-fil*, 26 april 2004, jury: Serge Fdida, Eric Fleury, Andrew Herbert, Philippe Jacquet, Catherine Rosenberg, Stéphane Ubéda;
- Claude Chaudet, *Autour de la réservation de bande passante dans les réseaux ad hoc*, 28 september 2004, jury: André-Luc Beylot, Michel Diaz, Isabelle Guérin Lassous, Philippe Jacquet, David Simplot-Ryl, Stéphane Ubéda.

9.4.2. On going PhDs

- Nada Al Masri, *Administration et fédération de serveurs d'applications*, INSA de Lyon;
- Noha Ibrahim, *Intégration automatique de services par négociation avec les applications*, INRIA;
- Jialiang Lu, *Mécanismes d'auto-configuration de réseaux d'objets communicants*, INRIA;
- Philippe Mary, *Innovative approaches for MIMO antennas in embedded systems*, INSA de Lyon;
- Nathalie Mitton, *Auto-organisation et réseaux ad hoc*, INRIA;
- Tahiry Rafazindralambo, *Etude de la capacité dans les réseaux radio multi-sauts*, INRIA;
- Guillaume De La Roche, *Prédiction du lien radio dans les environnements indoor*, INSA de Lyon;
- Yvan Royon, *Modèles d'administration de passerelles domestiques*, INRIA;
- Katia Runser, *Planification de réseaux sans fil*, 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.

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