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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Ares

Architecture de réseaux de services

Grenoble - 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 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 infrastructure-less mode); they connect people through 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 through modeling and/or simulation. Despite middleware development is out of the scope of the project, we examine the impact of radio transmission on the specifications of the basic services used by middlewares, 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 an hybrid network. To advance the state of the art in network support for applications, we therefore develop testbeds and experiment with prototypes.

The activities of the project are organized in three areas:

- hybrid network modeling;
- 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 networks. To do that, we merge standard protocols engineering with distributed system aspects. The modeling of wireless environment (propagation, MAC, mobility) is also a fundamental activity of the ARES project.

3.2. Hybrid networks modeling

Participants: Ioan Burciu, Alexandre Caminada, Xavier Gallon, Jean-Marie Gorce, Nicolas Marechal, Philippe Mary, Benoit Miscopein, Pierre-François Morlat, Hervé Parvery, Guillaume de la Roche, Fabrice Valois, Guillaume Villemaud, Ruifeng Zheng.

This scientific axis aims at proposing 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. All 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 protocol 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.

Modeling hybrid networks may be performed at different levels. It is obvious that hybrid networks aim at gathering simultaneously several radio networks including different medium access techniques, mobile equipments having different mobility profiles, different traffic flows and network entities having different capacities. Taking into account all of these specific aspects is intractable, and in the modeling 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. Modeling 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, Elyes Ben Hamida, Nicolas Boulicault, Guillaume Chelius, Yu Chen, Eric Fleury, Karel Heurtefeux, Jialiang Lu, 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. Secured middlewares for dynamic environments

Participants: Fatiha Benali, Amira Ben Hamida, Denis Beras, Stéphane Frénot, Samuel Galice, Noha Ibrahim, Véronique Legrand, Frédéric Le Mouël, Marine Minier, Pierre Parrend, Yvan Royon, Jacques Saraydaryan, Stéphane Ubéda, Wassim Znaidi.

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. 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:

- Constrained middlewares: middlewares for dynamics systems like mobile phones, home gateways or sensor networks needs to be adapted to cope to these environments. Our activity aims at designing middleware layers that optimize some of their behaviors. We are specifically working on initial deployment size and resource consumption adaptation.
- Service deployment and administration: in a highly mobile and dynamic environment, service adaptation to the context 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. Moreover, 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. More over in fast dynamic systems component can join and leave regularly, we are working on ways to improve the control of their executions.

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 an 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. Application 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. 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. In 2006, the protocol proposal, 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).

5.2. Advanced OSGi

Keywords: *OSGi*, *home gateway*.

Participants: Denis Beras, Stéphane Frénot, Pierre Parrend, Yvan Royon.

OSGi is a specification for making dynamic Java environments. We are involved in the *Apache Felix*[1] 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.
- tinyShell: the tiny shell is a lightweight user interface for managing the *Felix* 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.

[1] *http://cwiki.apache.org/FELIX/index.html*

- 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.

5.3. SOMoM:Self-Organized Mobility Management

Keywords: *ad hoc and heterogeneous network*, *wireless multi-hops networks*.

Participants: Fabrice Theoleyre, Fabrice Valois.

During the last 3 years, we investigated self-organization paradigm in order to improve the behavior of ad hoc networks or hybrid networks. We introduced a self-organization based on a virtual backbone: some mobile nodes are elected to form a connected structure, collecting the traffic. Thus, the backbone must be continuously maintained and updated to remain efficient: the algorithms are proved to be self-stabilizing. The performances evaluation highlights properties of stability, robustness, etc. Thus, based on this self-organization, SOMoM was developed: it is a routing protocol allowing to create a multihops cellular network (*hybrid network*). SOMoM is conceived so that all the backbone nodes form a distributed routing cache. The routes passing through the backbone are more stable and the overhead required for the maintenance is reduced. Moreover, some information required for the self-organization are used by SOMoM to create a default route toward the access point (fig. 1). Inversely, the access point can initiate a route discovering to find a client in the ad hoc area: this mechanism occurs seldom and is cost-effective.

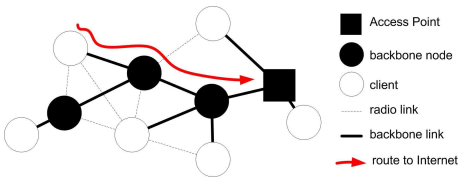

Figure 1. General behavior of SOMoM

The software is available at http://sourceforge.net/projects/somom. SOMoM can be used to extend, spontaneously, wireless networks over k hops. In practice, TCP flows are well-managed until k is lower than 4.

5.4. Wiplan software

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

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

Wiplan is a software including an Indoor propagation engine and a wireless LAN optimization suite, which as been registered by INSA Lyon. The heart of this software is the propagation simulation core relying on a original method, MR-FDPF (multi-resulution frequency domain parflow). The discrete ParFlow equations are translated in the Fourier domain providing a wide linear system, solved in two steps taking advantage of a multi-resolution approach. The first step computes a cell-based tree structure referred to the pyramid. In the second phase, a radiating source is simulated, taking advantage of the pre-processed pyramidal structure. 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. Extensive works have been done to make predictions more realistic. The network planning and optimization suite is based on a multi-criteria model relying on a Tabu solver.

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

5.5. WSim software

Keywords: *hardware platform emulation*, *hardware platform simulation*, *sensor network*.

Participants: Guillaume Chelius, Eric Fleury, Antoine Fraboulet.

In the context of researches in the field of sensor networks, we have developed in collaboration with Antoine Fraboulet (INSA Lyon) WSim, a full sensor node hardware simulator. It relies on cycle accurate full platform simulation using microprocessor instruction driven timings. The simulator is able to perform a full simulation of hardware events that occur in the platform and to give back to the developer a precise timing and performance analysis of the simulated software. WSim has been designed with respect to the following goals:

- WSim captures the behavior of the node application at a very low level, using the native code: instruction, bit, interrupt and byte radio level simulation and provides an accurate time control. The timing result of WSim has been validated with real-world systems (http://worldsens.net/) down to the clock cycle level;
- WSim is independent of any programming language and any OS since it runs the native code generated for the target microcontroller;
- WSim enables to run tuning tools on the application since many traces can be collected (execution trace, clock frequencies, interrupts, energy);
- WSim can monitor dynamic frequency scaling;
- WSim reflects the behavior of the network. At the same time, one may tune the degree of accuracy of the radio medium simulation;

For any information, contact Guillaume Chelius (Guillaume.Chelius@inria.fr) or refer to http://www.worldsens.net. WSim has been registered at the APP under IDDN 06-370012-00 and is commercialized by InsaValor.

5.6. WSNet software

Keywords: *sensor network*, *wireless network simulator*.

Participants: Guillaume Chelius, Eric Fleury.

Together with WSim and still in collaboration with Antoine Fraboulet, we have developed WSNet (http://wsnet.gforge.inria.fr), a modular event-driven wireless network simulator. Its architecture consists in different blocks that model characteristics and properties of the radio medium. During one simulation, the behaviour of a block is specified using a model which is a particular implementation of the block functionalities. Models are either provided with the simulator or developped by users.

WSNet has been designed to offer a wide range of radio medium modeling, from a basic "perfect" physical layer with no collision, no path-loss and a fixed radio range to a very precise one: Rayleigh fading, multiple radio resources (codes, frequencies), correlation factors between different radio frequencies and radio codes, additive interferences, complex radio modulations, complex antenna radiation patterns, *etc*. Given this range of models, it becomes possible and very simple to test a protocol in different radio environments and to dimension and optimize it by progressively increasing the radio modeling precision and complexity.

WSNet can be used in conjunction with WSim to simulate a whole sensor network with a very high accuracy. For any information, contact Guillaume Chelius (Guillaume.Chelius@inria.fr) or refer to http://wsnet.gforge.inria.fr. WSNet has been registered at the APP under IDDN 06-370013-00 and is commercialized by InsaValor.

6. New Results

6.1. Hybrid networks modeling

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

Participants: Ioan Burciu, Xavier Gallon, Jean-Marie Gorce, Nicolas Marechal, Philippe Mary, Benoit Miscopein, Pierre-François Morlat, Tahiry Rafazindralambo, Guillaume de la Roche, Fabrice Valois, Guillaume Villemaud, Ruifeng Zheng.

The two research topics studied last year have been deeply investigated: the radio link characterization and the performance evaluation of WLANs. Started in the framework of the ARC IRAMUS, the team also focused his work on modeling the behavior of sensor networks within a realistic environment.

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. Multi-$*$ system characterization and software radio development

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 but 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 Rhone-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 of studying 2 MIMO (Multiple Input Multiple Outpout) 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 analyzer. A full system can be thus tested over the true air medium. This platform offers also the possibility 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.

Last year, this operational platform has been used to evaluate the behaviour of multi-antenna systems in real conditions. This work has been done in collaboration with France Telecom R&D, Meylan, and will be extended in a near future toward an experimental assessment of the future IEEE802.11n standard. This year we extend this study to a case of a large band receiver with multi-mode and multi-channel capabilities [56], [57]. We have tested receiving simultaneously signals with two standards (802.11b and 802.11g) on two overlapping channels. In the case of strongly overlapping channels (and even though the same channel), the spatial interference rejection offered by the multi-antenna processing allows keeping good performances. Thus the principle of this multi-* receiver (multi-mode, multi-antenna and multi-channel) is confirmed as very promising.

In order to offer the possibility to test software radio implementation of those principles a complete demonstrator of a multi-* receiver is currently under development[16]. A large band front-end is developed by France Telecom and all digital processing parts are implemented on digital boards hosted in a multiprocessor computer. Two daughter boards consisting each of one FPGA and four DSPs are used for all steps of detection, selection, coarse and fine synchronization and demodulation of each standard on each selected channel, and all multi-branches processing will be performed on the PC. All steps of this very complex implementation are not yet completed. Another very important feature of future wireless interfaces is the capability of reducing both the final productive cost and the energy consumption. This can be efficiently done if dirty radio is authorized, namely, if usual constraints on the RF front-end can be relaxed. For this reason we have studied the impact of RF front-end impairments on performances of SIMO-OFDM receivers, in strong collaboration with Jacques Verdier, from INL, INSA Lyon. Our studies focused on OFDM techniques because this is the core technology of 802.11g and 802.11n. This is also the basis of future multiple access technologies referred to as OFDMA.

An important study to allow tending to realistic software radio receivers is the definition of a large band and multi-mode RF front-end. A key point is the very high sample rate required to digitize large bandwidths, moreover when multiple bands are necessary. We are currently studying a double IQ architecture enabling a simultaneous demodulation of UMTS and WiFi complete bandwidths with an important decrease of needed sample rate. A patent is pending on this structure in collaboration with France Telecom.

Finally, in order to take the maximum benefit of such large band information, enhanced interference cancellation techniques have to be studied. Classical approaches are based on inter-standard interferences (ex. Multi-user with orthogonal codes) and co-channel utilisation. The adaptation of those techniques to heterogeneous signals on separated (but overlapping) channels shows very good potential in this software radio context [54], [55].

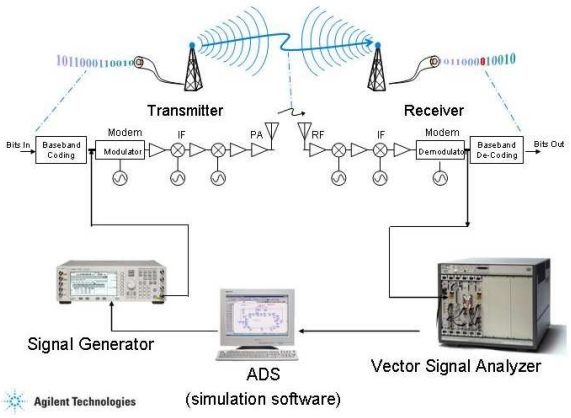

Figure 2. The radio platform includes a 2 channels VSA (vector signal analyser) and 2 synchronized AWG (arbitrary wave generators).

6.1.2. Reliable Propagation predictions in indoor environments , , ,

Simulating 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 reflections 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 artifacts 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, A complete and formal description of the theoretical method has been done.

6.1.3. Performance evaluation in hybrid networks

6.1.4. Wireless LAN behavior and optimization

The QoS of hybrid or mesh networks relies firstly on the design of the access network. 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.

Combining different criteria (coverage, interference minimization, throughput) appeared as a difficult task, especially for assessing the best trade-off between all constraints. Trade-offs aim at weighting constraints on the base of their relative importance. The existence of an exponentially large number of possible options makes the planning process difficult. 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.

6.1.5. Performance evaluation of 802.11 unfairness using process algebra

Analytical modelling and performance evaluation of 802.11 has been widely made using classical stochastic tools as Markov chains. Such models provide a framework to evaluate throughput, collision rate, etc. Nevertheless, if we need to investigate several protocols or several network topologies, new models should be proposed each time. More, the key problem is not to model a dedicated scenario but to solve it due to the space states constraints. In our point of view, stochastic process algebra are powerfull tools to deal with

wireless networks modelling because of the compositional approach and because of the use of the congruence paradigm of an algebra to reduce the space state. Thus, in these works, we use PEPA (Performance Evaluation Process Algebra): a stochastic process algebra dedicated to the study of communications systems. We have developed a new analytical generic model of wireless network in order to be able to deal with different network topologies (infrastructure, hidden terminals, 3 pairs, etc.), different backoff algorithms (BEB, DIDD, etc.), different trafic assumptions (saturated case, bursty trafic), different channel properties (ideal channel, fading, etc.), different medium access strategies (TDMA, CSMA, etc.). The goal is to provide a *tool-box* in order to study the classical performance parameters of ad hoc networks and a fairness index. This generic model should be useful to design new backoff strategies in order to improve both performance and fairness. In [63], [62], we have investigated the impact of a more realistic radio channel modeling. Three models was considered: *i)* an ideal physical layer, *ii)* the Gilbert-Elliot model and *iii)* correlated errors due to interferences. The trade-off between fairness and efficiency was studied in the case of the hidden terminal scenario. We show that the unfairness is less important when a more realistic radio channel model is used.

6.1.6. Wireless Sensor networks sensitivity to a real physical layer ,

The plethora of recent papers relative Wireless Sensor Networks (WSNs) allowed to provide the scientific community with several reference applications and few hard points. Energy consumption, radio resource sharing and transmission reliability are very important topics. In the frame of the ARC IRAMUS, we have worked on introducing realistic models in usual practical applications. The first problem investigated in collaboration with the INRIA project POPS, concerns the energy minimization of wide scale dense WSNs thanks to activating/sleeping protocols aiming at reducing the number of simultaneous active nodes. In many works, the radio link is assumed perfect, which means that the radio link between two nodes is switched (on/off model). In practice the radio link in a realistic environment is rather probabilistic. Thus, a radio link always experiences an error probability, which increases with the distance. This problem is even more important with fading and shadowing. We have firstly shown that introducing a realistic radio link (i.e. a PER is associated with each link) has a great effect on activating/sleeping algorithms. Realistic energy model have been presented in [74].

The last investigated issue concerns the connectivity of WSNs. Connectivity is an important feature because it warrants that all nodes are able to transmit their sensed information to a sink. We have introduced a realistic radio link (PER) taking into account realistic channels to enhanced the connectivity model. This work shown analytically that more than 50% of radio links may be 'unreliable', if a realistic channel is taken into account. This means that working with classical protocols (requiring reliable links) needs to suppress long-hop links virtually to achieve reliable transmissions. This however reduces drastically the energy efficiency of the WSN. On the opposite, this work shows that the use of opportunistic routing algorithms, able to exploit even unreliable links is a very challenging issue since these unreliable links often exist [6].

6.2. Protocols design

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

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6.2.1. Sensor networks

In the last quarter 2005, we launched a new and transversal activity inside the INRIA ARES project on sensor network. The mains goals are to gather the research efforts produce in the various research domains of ARES and to offer a common platform where our team may launch experimentations in situ. Our first work was the design of the node hardware. This one year investment done under the project named Worldsens[2] is now operational and we are able to test and deploy our own sensor applications. Note that this effort is done in a multidisciplinary collaboration, namely with the COMPSYS INRIA project and with the CEGELY laboratory.

[2] http://www.worldsens.net

In parallel to this hardware design and production, we have also invest in the development of a full integrated platform for the design, development, performance evaluation and profiling of applications for wireless sensor networks. A first main characteristic of Worldsens development platform is that once the design choices have been made, the simulation platform only handles the real application native code in order to test and validate the application at the instruction level. We do not want to impose to developers the task of rewriting their application in a particular description language or to transform low level parts of their code in order to be compliant with our simulation tools. In addition to this, we have designed our Worldsens simulation tools (WSim & WSNet) with respect to the following goals:

- Worldsens captures the behavior of the node application at a very low level, using the native code: instruction level, bit level and interrupt level.
- Worldsens reflects the behavior of the network. At the same time, one may tune the degree of accuracy from an ideal network layer where all transmitted packets are received to a network model taking into account collisions, SNR and radio propagation.
- In order to model the behavior of a global application, Worldsens handles large sensor networks, with hundred to thousand nodes.
- Worldsens handles precise timing in order to get the behavior of interruptions and byte level radio simulation.

In [32], [22] we present and demonstrate the use of the Worldsens platform in the process of a fast prototyping of wireless sensor network applications & protocols.

In the CAPNET project we propose to deploy large-scale secure ambient dynamic networks so that they can be analyzed and modeled based on data obtained in real-life situations. The several and in situ test beds deployed will be an opportunity to gather large amount of experimental data in order to conduct studies on such ambient dynamics networks. One test bed will be composed of more than 200 sensor nodes, distributed to students at INSA Lyon, in several departments. We ask them to carry them continuously in order to record not their location, but the interaction that a such dynamic network creates. Moreover, based on the knowledge of the underlying ambient networks, we will be able to deploy and test security mechanisms in order to guarantee the security of the data collected, to design strong privacy aware data gathering and also test the deployment of embedded ambient applications.

6.2.2. Activity scheduling in sensor networks , ,

We aim to save energy by scheduling periodic sensors' duty cycles. Different from existing works, we integrate two important tasks, collision avoidance and duty cycling, into one scheduling of sensors's activities. Our scheme consists of two parts: a *coloring scheme* that assigns a "color" to each sensor and a *color scheduling scheme* that associates each color with a schedule. Each sensor switches between sleep and active modes according to the schedule associated with its color. In the Infocom paper [23], we propose a novel coloring definition. Theoretical analyses and simulation results show that, if this coloring is used by collision avoidance schemes such as TDMA or CDMA, connectivity can be guaranteed by using much less colors than traditional colorings. Theoretical analyses and simulation evaluations are presented for our scheduling. As compared to handling collision avoidance and duty cycling separately, performances can be improved by integrating these two tasks into one carefully designed schedule of sensors' activities. In particular, in duty cycled dense networks, in order to reduce packet latency and save energy, it is desirable to guarantee the communication connectivity of links only in a sparse connected subgraph.

In order to support a dynamic WSN topology, we conduct some works on topology-transparent approaches to scheduling; these are independent of detailed topology information. Much work has been done on topology-transparent scheduling in which all nodes are active. In the IPDPS work [25], we examine the connection between topology-transparent dutycycling and such non-sleeping schedules. This suggests a way to construct topology-transparent duty-cycling schedules. We analyse the performance of topology-transparent schedules with a focus on throughput in the worst case. A construction of topology-transparent duty-cycling schedules based on a topology-transparent non-sleeping schedule is proposed. The constructed schedule achieves the maximum average throughput in the worst case if the given nonsleeping schedule satisfies certain properties.

Finaly, we consider sensor networks for monitoring tasks, where data of each stimulus is required to be collected by at least one of potentially multiple, mobile nodes, called sinks. In the ACM DIALM paper [24], we propose a backbone-based scheduling that achieves fast data dissemination. The proposed schedules can also be used for general communication that rely on backbone structures. Theoretical analyses are presented and we show that our scheme is asymptotically optimal for networks with certain properties. We also propose for loop-free routing protocols a scheme to update routing state, which handles sink mo- bility with a small overhead; the routing links updated are confined within those incident to sensor nodes in paths con- necting the old and new positions of sinks.

6.2.3. Dynamic interaction network analysis ,

Recent studies on sensor networks have shown that the duration of contacts and inter-contact are power-law distributed. While this is a strong property of these networks, we show in [30] that this is not sufficient to describe properly the dynamics of sensor networks. We present some coupled arguments from data-mining, random processes and graph theory to describe more accurately the dynamics with the use of a random model to show the limits of an approach limited to power-law contacts duration.

In a more anecdotic paper [47], we propose a new way to identify communities in evolving graphs like collaborative networks. We apply this approach on the Infocom co-authorship network to determine stable collaborations and evolving communities. We analyse the impact of the co-authorships relation topology on the formation of the program committee board of the conference.

6.2.4. Self-Organization with a virtual topology for hybrid networks , , ,

Two approaches of mobile ad hoc networks can be considered: the classical one where the network is viewed as flat and a more recent one where the network is structured through a logical view. In this work, the logical view is associated to a virtual topology: a virtual topology is defined 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 investigated the behavior and the key properties of such self-organization. We have also introduced robustness and how to use this work to develop a mesh network in mobile ad hoc network. In 2005, self-stabilization and analytical properties was investigated. 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. The main objective was to provide layer 3 protocols taken into account this self-organization. A routing protocol (called VSR, *Virtual Structure Routing*) was proposed and a mobility management protocol too (SoMoM, *)Self-Organized Mobility Management*. These works highlighted the benefit provided by the use of a self-organisation. In 2006, intensive performance evaluation studies have been done in order to characterize how a routing protocol based on self-organization is more efficient than the classical flat approach (OLSR, DSR) or the hierarchical one (CBRP). In [14], VSR appears to be a good trade-off between pro-active and reactive protocols.

One another question is: because a self-organisation is based on *better* nodes which are more solicited for the network, bottlenecks can appear and, thus, the network capacity can decreased. We refer to the network capacity as a flow problem. An analytical framework to study the capacity in mobile ad hoc networks an hybride one have been developed. The input of this model is the network topology, the routes provided by a routing protocol (OLSR for flat networks, VSR for structured one). The output provided upper and lower bounds. The main result is: in case of ad how network, the capacity is not affected by a self-organisation scheme but the capacity decreases strongly in case of hybride network.

Currently, we experiment the self-organisation scheme and the mobility management protocol using the mesh networks of the CITI laboratory. The software is available at http://sourceforge.net/projects/somom. The application is spontaneous extension of wireless networks [67].

6.2.5. Autonomic mechanisms for wireless sensor networks

This work is financed and supported by France Telecom R&D under CRE No 46128746 with PACIFIC team since November 2004. This research project funded the PhD thesis of Jia-Liang Lu. Mr Lu did his first year of his Ph.D. in the CITI laboratory and the two last year in the ILAB Team, FTRD Beijing, China.

The goal is to provide autonomic mechanisms for wireless sensor networks in order to allow spontaneous deployment without human intervention, without centralized control. We refer to autonomic mechanisms as self-* protocols. Self-* can be associated to self-configuration in order to configure the nodes Id. without human intervention. This mechanism provided also duplicated address detection protocol. Self-* is also associated to self-organisation where we provide a logical view of the network: the topology provided is a connected backbone. This self-organisation can be used for data-dissemination and/or data-aggregation. Finally, self-* also refer to self-healing in order to maintain active the self-organisation scheme. We provide an integrate self-configuration / self-organisation scheme. A patent is associated to this mechanism.

The initial version of the self-organisation scheme (note LEGOS [51]) allows to structure a wireless sensors network around a tree. Several extensions was proposed to build a mesh network. Based on this self-organisation scheme, the main paradigm of the communication protocols in WSN was studied. We first propose a join process to self-organise and self-configure the node's identity [49], [50]. We also investigated the impact of a structured network on the data-dissemination issue and the sink mobility management [52].

6.2.6. 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 [10]. 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.

6.2.7. Solution to the performance anomaly of IEEE 802.11

In the widely used 802.11 standard, the so called performance anomaly is a well known issue. Several works have tried to solve this problem by introducing mechanisms such as packet fragmentation, backoff adaptation, or packet aggregation during a fixed time interval. We propose a novel approach solving the performance anomaly problem by packet aggregation using a dynamic time interval, which depends on the busy time of the wireless medium. Our solution differs from other proposition in the literature because of this dynamic time interval, which allows increasing fairness, reactivity, and in some cases efficiency. In this work, We propose an analytical evaluation of our protocol in the classical scenario where all stations are within communication range and a detailed simulation-based evaluation. We evaluate our protocol in terms of efficiency and of

fairness on many configurations not limited to one hop networks. We also compare our solution to three different approaches that belong to the three main classes of solutions solving the performance anomaly.

6.2.8. Real-time communication in wireless sensor network

The goal of this work is to propose new protocols for real-time communication in wireless sensor networks. Critical applications 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.

Our first results let us define a new MAC protocol 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. 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), and extending our protocol to three dimensions, by proposing a hard real-time cross-layer protocol.

6.2.9. Neighbor discovery

In wireless multi-hop networks, hello protocols are a basic service on which several high level protocols are based (e.g., routing). However, their study usually rely on simplistic models which do not take into account problems stemming from low layers, such the physical layer. For example, radio interferences may impact the protocol performance and robustness. In [38], we have considered three models in which interferences and collisions are handled in very different way. Simulations have been performed and have shown the impact of these models on the graph of connectivity obtained during the neighbor discovery process. This quantitative study has highlighted the importance of the radio channel modelling when designing and evaluating communication protocols.

In the second part of the work, we have computed the analytical link probability success between two neighbors as well as the expected number of nodes that correctly receive a hello packet. The analytical analysis have confirmed the simulation results. Finally, we have appled these results to the dimensioning of a hello protocol parameters in the context of the Capnet project. A method has been proposed to choose the protocol parameter values in order to respect constraints on the neighbor discovery process and to minimize the protocol energy consumption.

6.2.10. Data dissemination

In wireless sensor networks, sensors usually operate on an n-to-1 communication paradigm, where the collected data are transmitted from the sensors towards a static sink. In [39], we have studied the problem of data dissemination and data collection using mobile sinks. In such a context, the difficulty for sensor nodes is to efficiently track the sink and report the requested data to the sink location. As flat architectures and flooding-based protocols do not scale, overlaying a virtual infrastructure over the physical network has often been investigated as an interesting strategy for an efficient data dissemination in wireless sensor networks. This virtual infrastructure acts as a rendez-vous area for queries and data reports.

Our main contribution is an analytical comparative study of a variety of virtual infrastructures topologies (e.g., square, random line, central line, random point, ...). The latter are evaluated in terms of communication cost, path stretch and network lifetime, in the worst and average cases. In addition, realistic simulations are performed for different protocols and scenarios. From this study, two tradeoffs have emerged. First, using a large virtual infrastructure may reduce the dissemination cost, as the nodes become closer to the rendez-vous area. The network lifetime is also preserved as the traffic is better distributed. However, large rendez-vous area increases the cost of data lookup. In addition, such a virtual infrastructure may reduce the protocol reliability and robustness as it concentrates the traffic over a small rendez-vous area. Hence, the solution to this problem is to adapt the protocol and its structure to the sensor network application.

6.2.11. Energy-efficient self-organization in Wireless Sensor Networks

Self-organization and WSN constraints. As WSNs are expected to be composed of several tens of thousands of nodes and generally do not enjoy planned roll-outs, it is essential that communication is set up without human intervention. We agree with C. Bettstetter defining self-organization as "*the emergence of system-wide functionality from simple local interactions between individual entities*". Whereas it may have different definitions depending on the application, in this work, this system-wide functionality is routing, which is facilitated by local interactions based on virtual coordinates.

The 1hopMAC protocol: preamble sampling and avoiding neighborhood tables. Approximately 80% of a node's energy is used by the radio module, when this module is on. When the radio module is active, it can be either sending/receiving a message, or idle listening to the medium (without receiving any message). Current nodes have an idle listening power close to the power used for sending/receiving. This means that the only way of reducing power consumption is to turn off the node's radio as much as possible. This, in turn, increases the network's lifetime.

In 2006, we have proposed the 1hopMAC protocol. The main contributions of this protocol are (1) it is based on micro-frame preamble sampling which yields ultra-low power consumption when the network sits idle, and (2) it avoids nodes maintain neighborhood tables. Routing protocols need to know which nodes are neighbors of the current node. Traditionally, this information is contained in neighborhood tables which are constructed and maintained pro-actively. 1hopMAC replaces this proactive approach by a reactive one, in which nodes learn about their neighbor on-demand. This is particularly interesting for low-power, low-throughput and long-lasting wireless multi-hop networks, such as WSNs.

In 1hopMAC, neighbor nodes send ACK messages to the current node after their back-off timer expires. In the initial proposal, this back-off timer was directly proportional to the node's metric (e.g. it's distance to the sink node when using geographic routing). When neighbor nodes had close metrics, ACK messages could collide. We recently proposed to modify the way the neighbor node calculated the back-off time as a function of the its metric. Instead of being proportional, a polynomial function was proposed, lowering the collision probability of the ACK messages by 40%.

Centroid Virtual Coordinates - A Novel Near-Shortest Path Routing Paradigm Having nodes know their physical location is costly in hardware and/or energy. We thus consider nodes do not know their real coordinates, and instead use virtual ones. Virtual coordinates are not related in any way to the node's real position and are entirely randomly generated within each node at initialization. Geographic routing protocols run on top of these virtual coordinates. The basic idea behind a geographic routing protocol is to elect as next hop the neighbor node closest to destination. Here the "closest" node is the node with smallest Euclidian distance between its virtual coordinates and the destination's.

At initialization, each node chooses its virtual coordinates randomly in a predefined range. At each hop, the current node updates its virtual coordinates with the average of its neighbors', virtually placing the current node at the center of gravity of its neighbors. We call this updating process the centroid transformation.

We call virtual graph the connectivity graph when placing the nodes at their virtual coordinates. We have analytically proven that (1) the virtual graph converges to a state where the virtual coordinates of all node are aligned, and (2) the virtual coordinates of the nodes align in the correct order. This means that a geographic routing protocol using these virtual coordinates discover paths with near-shortest lengths in number of hops. This analytical study is confirmed by extensive simulation.

Analytical and simulation results show that our solution performs better (both in the energy consumed and robustness) than solutions requiring real coordinates.

Cross-layer design. The layered approach has been introduced in traditional wired networks because it clearly separates the different tasks the communication stack needs to perform. This leaves the user the possibility to build his stack, assembling interchangeable layer blocks. Yet, this approach has some drawbacks for WSNs. This is mainly attributed to the low-energy nature of the nodes. In a fully layered approach, a given layers has a very abstract view of lower layers, and a situation can arise in which for example the radio module of the

radio is constantly on (which is an issue of the physical layer), whereas the node is scheduled in such a way that there is no data to transmit or receive (which is an issue of the MAC layer). Energy is thus lost at the interface between layers. To alleviate this effect, cross-layering is used.

We propose a cross-layered communication system composed of the 1hopMAC protocol at layer 2, and the geographical routing protocol on top of virtual coordinates at layer 3. The "metric" used at 1hopMAC is a modified Euclidian distance between the node's virtual coordinates and the destination's. This results in a novel communication stack which has the following properties:

- No node needs to know its real coordinates;
- it supports having **multiple sinks**;
- the resulting communication architecture is **simple and robust**;
- topological **changes are rapidly absorbed**;
- it **guarantees delivery**, even with a realistic transmission model;
- it is ultra-lower power, enabling the deployment of long lasting WSNs.

6.3. Middlewares for dynamic environments

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

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Our activity is divided in three axes: Constrained Middlewares, Service deployment and administration and Global security model.

6.3.1. Constrained environments

We are still working on optimising the OSGi/Java stack to be embeddable in small devices.

We first selected a reference platform. The NLSU2 from Linksys is a SAN device that enables the sharing of data stored on USB keys. The device contains an 266MHz Arm based board, an Ethernet connexion and two USB ports. It has 8MB of flash and 32 MB of SDRAM and it mainly corresponds to current home gateway systems. We hardly work on this platform to get a running an operational Linux operating system (SlugOSBe). We tried various setups and finally selected a big endian glibc based system. The base operating system costs 4 MB.

Our goal is now to run an OSGi/Java stack on this kind of equipment. The main problem is to deal with the CLASSPATH size of the Java Virtual Machine. The current size is about 9MB of classes that cannot fit on the device. We designed a light space disk OSGi execution environment. This is divided in two parts.

- The first idea is to enable a remote installation of standard classes. This means that we modified the standard classloader mechanism in order to remotely load used classes and defined them at runtime in the virtual Machine. The idea is to boot the device with a minimal classpath archive that contains the strict elements to boot and get an active network stack. Then all remaining classes are downloaded from the network. We provide a patch file for the jamvm virtual machine that enable this. Needed local class footprint is 860 ko.
- The second element is to avoid the local cache of bundle when using OSGi. In the standard OSGi behavior when a user installs a bundle, it is firstly downloaded on the equipment and stored on a local cache. Then it is available for bootstrapping and its classes can be instantiated.
  The ROCS (Remote OSGi Cache Storage) provides the bundle classes and resources through a RMI remote access. Bundle is stored by a server and classes/resources are transparently accessed by the ROCS API.

Thus locally, we only install the META structure of bundles (version specifications, directory structure, bundle location origin) but it contains neither classes nor resources. In this way a bundle consume less than 10KB on the local flash memory.

This activity is presented in MUSE internal deliverable B3.6.

6.3.2. Services deployment and administration

6.3.2.1. MOSGi extension to JamOM

The MOSGi framework is still provided in Felix project. Around it, we build new tools. Among them there is a load prediction tool called JaMoM (Java Management of Management).

JaMoM makes an evaluation of management probe on remote gateway. The problem we address concerns the CPU load implied by management. For instance if a manager wants to provide some kind of Quality of Services (QoS) he should know the load of a remote gateway and its variation. The problem is at which rate can he ask the gateway ? If he asks continuously he has an accurate information but the remote equipment load will raise dramatically. If he asks once a day he will have an inaccurate value, a negligible CPU load, but the end-user can wait half a day if his system is in failure. In order to find the best balance between a good QoS and a adequate implied load, we design the JaMoM tool.

The tool is able to make a CPU cost evaluation for every remote probe that can be queried. We show that all probes react in a same manner: the load implied increase linearly with the frequencies of requests. We also show that if you monitor N different probes the resulting load is the sum of the corresponding loads. We design the framework that allows a manager to set all monitoring frequencies for all managed probes he wants to observe. Those settings can be converted by JaMoM into a CPU load prediction.

6.3.2.2. Automatic Negotiated Integration of Services

Proposals have been done in service integration in pervasive environments. Existing approaches are currently application-centric, with a pre-definition of the service orchestration in the application (such as BPEL), or user-centric with a dynamic on-demand composition meeting the user's requirements. These different approaches require to know the existing services: at least their interfaces, and often their different provided quality. We address the problem of integrating totally unknown services that we dynamically discover in a pervasive environments.

We have first defined the integration as having four steps: the translation that describes the integration intention; the generation that produces the different integration possible plans; the evaluation that decides of the plan to apply; and the execution that runs the integration plan. We have conducted a classification of existing systems according to these phases.

In the classification, no system perfectly reaches automatic, flexibility, dynamism and contextual properties. Therefore, we propose a middleware-centric approach that automatically integrates the services as soon as discovered, and creates all possible compositions (even if not relevant ones). Our framework, called ANIS - Automatic Negotiated Integration of Services, enables service composition at run-time and in a semantic way. Services are composed through a specific integrable interface that implements various contextual behaviors. Negotiation over non-functional properties can be conducted, to allow a flexible and viable composition of services, adapted to the pervasive environments. ANIS matches all the services available in the environment and based on a definition of compatibility, integrates services together. We propose two different techniques to realize the integration: Redirection, i.e. calling interfaces and replication, i.e. copying implementations of services. Once the new services deployed in the environment, they are analyzed based on semantics and user criteria to eliminate the not relevant ones.

Automatic technical integration has been published in [44]. Contextual technical integration has been published in [45]. Preliminary ideas for the integration decision have been published in [46].

6.3.2.3. Contextual Service Loading

Devices such as mobile phone or PDA are constrained in term of available memory. Two approaches exist to optimize this memory use: using small dedicated systems, with data format and compression to save memory; or using more generic systems with optimizations consisting in well-choosing the elements to load to memory.

In this work, we concentrate on optimizing the loading. Several systems propose a just-in-time loading mechanism, such as Java p2p class loading. However, these mechanisms do not allow to anticipate future elements to load and do not take into account available elements in the environment that do not need to be loaded and can be remotely access.

We propose AxSeL, A contextual Service Loader. The service paradigm offers the grouping of classes in a semantically relevant entity, a service. The service paradigm also allows to express dependencies between services. Service discovery protocols also provide a way to remotely access environment's services instead of loading them.

Based on these three interesting service's properties (semantic, dependencies, context discovery), we build on each device a service graph and run dynamically and incrementally a specific colouring algorithm, matching device constraints and service properties. This colouring algorithm finally decides to load (or garbage) a service, to remotely access a service or to generate a null service (an empty service preventing the crash of an application and that will be replaced by the relevant one as soon as available).

Architecture of AxSeL system has been published in [40], and currently the system is under development.

6.3.2.4. Global Results

We published a general view of our management activity in [11]

Yvan Royon defended is Phd Thesis on Thursday the 13th, december 2007. Here is a summary:

The home gateway market evolves towards new business models. Today's model, called triple play, brings Internet connectivity to our homes, along with two additional services: telephony and video over IP. These three services are managed by a single business entity: the access provider.

Constructors and operators propose a replacement model, called multi-play, which opens the market to multiple voice and video providers. This allows end-users to access more content and to choose between competing service plans.

A third business model then becomes possible. Since the market is open to multiple business actors, and since home gateways become more and more powerful, why should we limit services to voice and video? An increasing number of other services exist, such as health care, support for the disabled, home automation and telesecurity. The notion of service must be broadened, and the home gateway must be enhanced to be able to host any kind of service. We call this model multi-service.

Technical novelties with multi-service home gateways are that they support deploying, executing and managing several software modules that come from different providers. This translates into specific needs in terms of execution isolation, remote management, deployment infrastructure, and programming model.

Execution isolation is a compromise between the level of isolation and the impact on performance. Since home gateways have limited hardware resources, performance and complexity are key factors. They need a level of isolation that allows to separate software modules based on their providers. When choosing how this separation is enforced, we create variants in the business model; for instance, some modules, such as a video codec or a web server, may or may not be shared among service providers.

Each provider manages his own services. Similarly, variants are possible: one is that each provider chooses his own management technology, another is that the access provider dictates one.

The deployment infrastructure must scale, both service-wise and user-wise, and propose update mechanisms. Variants lie in life cycle management granularity, e.g. pausing services may or may not be possible.

Lastly, the programming model impacts decoupling between modules, their reusability, and their time-to-develop.

To implement these four families of needs on resource-constrained targets, we focused on two execution environments, which allow different aforementioned variants: Java/OSGi and C/Linux.

OSGi boasts a clean, service-oriented programming model, and already manages deployment and life cycle of modules. However, it lacks multi-user features and the related isolation mechanisms.

GNU/Linux offers many tools for isolation and module deployment. However, it needs a tight integration and a unified management of such tools.

Therefore, we propose to fill these lacking features on these two environments, so they can conform to the multi-service model.

6.3.3. Trust framework 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 built upon the notion of node history (often called credentials), 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 2006, 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 History Extraction (CHE) protocol. The trust decision is based on the use of informations cryptographically proved, to reduce this risk. Roughly, smart devices record past interactions between autonomous nodes in a *history* (after a bootstrap phase); to interact, nodes first search previous common met nodes in their histories; then, they mutually authenticate; and finally, they prove, using a security protocol presented here, that these common interactions really took place. If the number of such common interactions is sufficient that is, upper a certain threshold, then the interaction may occur.

The security protocol proposed is based on the notion of cryptographic ID first introduced by A. Shamir, adapted to elliptic curves by D. Boneh and M. Franklin for the cipher and used by Chen, Zhang and Kim for a signature without a trusted PKG (Private Key Generator). The main advantages to use elliptic curve identity based cryptography is the gain in size and in computational time in adequacy with small devices used in ambient networks such as PDAs or smart phones. Moreover, user's public key being or being derived from his identity, there is no requirement of public key directories. Also, key distribution being far simplified, this make ID-based cryptosystems advantageous over the traditional Public Key Cryptosystems (PKCs). We have performed a security analysis of this protocol regarding the most usual attacks known against ad hoc network.

In 2007, we have implemented our protocol on several platforms (including PDAs) and have studied its performance considering the lack of resources in the ad hoc context. Especially, we have tried to limit the required number of exchanges between the parties and propose some optimal bounds for the choices of the implied parameters using first a probabilistic evaluation on the required size of the history taking into account our threshold and secondly performing some simulations to adapt the security policies according our approaches.

Currently, we work with economists to prove the relevance of our approach in the "real" world using experimental economic games. We have developed the game that will be used in the experiments that are planed for the beginning of 2008.

6.3.4. Symmetric Cryptography

The ARES project is also working on the traditional aspects of cryptology under two main aspects: constructions and attacks for block ciphers and stream ciphers in the context of the ANR RAPIDE (see RAPIDE project).

Concerning this topic and especially the stream cipher aspect, the stream ciphers SOSEMANUK (software profile) and the second version of the stream cipher DECIM (hardware profile) have been chosen as Phase 3 candidate by the European Network of Excellence ECRYPT (work package eSTREAM).

Moreover, With the new class of attacks called algebraic attacks, it becomes dangerous to use LFSR (Linear Feedback Shift Register) as a transition function in a stream cipher dedicated to software and hardware purposes. Some other constructions oriented hardware using FCSRs have been recently proposed for the ECRYPT call for stream cipher primitives [35]. A FCSR (Feedback with Carry Shift Register) is a binary automaton with carries. All the results concerning the complexity, the provided period comes from the 2-adic theory. This year, we have demonstrated a theoretical upper bound on the number of steps required to reach the main cycle of the graph of an FCSR (considered as optimal or not). For a FCSR with n main bit cells, this bound is equal to $n + 4$.

Notice also that two algorithms (Hardware Profile) based upon FCSRs and called F-FCSR enter in the Phase 3 of the eSTREAM project. Thus, the previous constructions based on FCSRs were dedicated to hardware applications. Based upon the good properties of FCSRs, we have designed a new family of software oriented stream ciphers called X-FCSR family. The core of the system is composed of two 256-bits FCSRs. We proposed two versions: X-FCSR-128 and X-FCSR-256 which output respectively 128 and 256 bits at each iteration. We study the resistance of our design against several cryptanalyses. These stream ciphers achieve a high throughput and are suitable for software applications (6.3 cycles/byte).

Concerning block ciphers design and cryptanalyses, we have found a new weakness on the block cipher Rijndael-256 designed by V. Rijmen and J. Daemen. Rijndael-256 use plaintext blocks of length 256 bits under keys of lengths 128, 192 or 256 bits. We have built an efficient distinguisher between 4 inner rounds of Rijndael-256 and a random permutation of the blocks space, by exploiting the existence of semi-bijective properties induced by the cipher. We could extend this distinguisher to three attacks against 7, 8 and 9 rounds versions of Rijndael-256. The best studied cryptanalysis works against 9 rounds of Rijndael-256 under a 192-bit key and requires $2^{128} - 2^{119}$ chosen plaintexts and 2^{188} encryptions.

Currently, we work on a new design for a software oriented block cipher that uses a parallel and byte-oriented structure. We have studied a particular round function and especially its resistance regarding traditional attacks. We are studying now a good key schedule algorithm for this block cipher.

6.3.5. Privacy preservation in ambient networks

The ARES project is also working on the notion of Privacy preservation in ambient networks through the ARC PRIAM (see PRIAM project). Including lawyers, we are currently working on the particular implications of the privacy notion taking into account the the social and legal aspects. We currently work on a model that include a privacy audit in the context of ambient networks where a constant connexion with a central authority could no more be considered.

6.3.6. Intrusion detection , ,

The detection aims at detecting plans of global behaviours generated by attackers, user faults and system failures. The role of the global view will be to take into account all types of events to find "how it happened". The high level detection also takes into account alerts raised by the lower level components i.e. intrusion detection alerts, behaviour alerts and all events that were not handled or detected by lower level of detection.

The high level mechanisms will sort alerts not based on raw events but on activities. This allows regrouping all events according to scenarios. An event is often defined as a subset of a scenario. The correlation process associates an event to a scenario, the precision of the original meaning of an alert is very important.

To sum up, the centralization of event raises a new problematic to translate input raw events into enriched alerts. Several mechanisms are required:

- extraction of the knowledge included in event,,
- structure of this event,
- gathering of all events (coming from different sources) that represent the same event,
- gathering of all events that represent the same activities but that are different steps of this activity,
- gathering of all activities that belong to the same plan or scenario.

In this domain, various work have been done the last two years.

Normalization F.Bénali Nevertheless, the centralization, which gathers a huge amount of alerts, is much too difficult to be handled manually and requires automation. In other words, the centralization of all types of events/alerts raises three major issues which can be improved by high level mechanisms. First of all, two events raised by two different sources but meaning the same are often represented by two different event messages (due essentially to their proprietary description language): at the scale of the IS, that increases incredibly the number of different events. Secondly, some events have different granularity levels. Thus, the analyst receives several events for a single monitored activity. Thirdly, a quantitative problem occurs: many equivalent normalized events represent the same activity several times: the analyst should receive only one alert associated to several raw events.

This process translates a raw event message described in a pseudo-natural (and unstructured) expression into a normalized one. For this, we use a classification based on linguistic rules. For instance, a first detection source (linux) expresses the user login with " Authentication succeeded " and a second source (Netscreen) expresses the same login with "user login". Normalization aims at assigning them the same expression like "authentication_activity_ login_success"

The first step is the design of the Action Ontology issued from the Action Theory by Davidson. An action is expressed by five essentials concepts: Intention of agent, Movement used by agent, Tyep of agent, Target that is aimed by agent, and the result expected by agent. All event observed in the log system have their one and single one equivalent in the action ontology.

Event correlation The correlation process gathers alerts according to rules taking into account the normalized alerts (without a-priori similarities). The semantics of the alerts allows improving the efficiency of the correlation process and simplifying the rules definition. In case of explicit correlation, these rules are pre-defined by the security expert. In other cases, scenarios may be discovery by learning machines which learn from expert knowledge. In the first step, the correlation engine is a semantics rule based one. We use Bayesian networks to modelling of scenario.

Diagnosis The alert enrichment is required by mechanism that aims at helping the human analyst decision by enhancing the alerts and finding the origin of these ones. The diagnosis is administrator and/or threshold-triggered when the accuracy of the raised alert is not sufficient. The global diagnosis is composed of two major components: characterization and investigation which are inter-related (Investigation can launch the Characterization one) The input of the global diagnosis may be an IDMEF alert or an IODEF incident. The diagnosis process is triggered by a trust level evaluation process .The evaluation process affected to the alert trust level weights in order to analyse the accuracy (not enough information) of the alert thanks to semantics-based techniques. The semantics and some attributes of the input alert is checked according to criteria such as WHO, WHERE, HOW, WHAT and WHY questions. If this information is not available, the characterization process is triggered to look for this information.

7. Contracts and Grants with Industry

7.1. Contracts and Grants with Industry

Exaprotect The ARES project is involved in a strong collaboration with the Exaprotect Compagny including two PhD students. The focus of this work is the imporvement of network intrusion detection system (IDS). Network-based computer systems play an always increasing vital roles in our society but are full of security flaws on many levels. Finding and fixing all the flaws - by formal methods, is not technically feasible. If such a defense drastically reduces the threat it can not canceled all corruptions, especially the one from insider attacks. An IDS is used to detect all types of malicious network traffic and computer usage that can't be detected by a conventional firewall. By monitoring and analyzing system behavior, IDS are suppose to detect violations of security policy. This monitoring can be done at many different levels in the systems. Although their main weakness is certainly the absence of global vision. Classical IDS have only a local and very specific view of the system. Moreover, the majority of classical IDS use signature detection prohibiting the detection of unknown attacks. The goal of our work is to enforce this global vision of the system for an IDS. To do so we first extend the domain of monitored events to events not directly involved in security achievement. The second problem addressed isthe introduction of a behavior analysis.

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 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, 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.

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).

Worldsens Under the Worldsens label, InsaValor is commercializing the WSim and WSNet softwares that are partly developed in the *ARES* project together with sensor nodes that are developped by the *ARES* project and the CITI & CEGELY laboratories (INSA Lyon). InsaValor is an organization associated to the INSA Lyon and responsible for ensuring the transfer and development of the research activities carried out in the INSA Lyon research laboratories.

8. Other Grants and Activities

8.1. Regional initiatives

CAPNET The CAPNET project is a BQR project funded by the INSA 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 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 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

ARC CARMA The CARMA INRIA ARC (*Capacité des Réseaux Maillés*) is focused on the capacity of wireless mesh networks, main criteria to reach an acceptable level of quality of service in such networks. Several approaches are studied together (deterministic bounds, stochastic theory, graph theory, etc.) in order to develop new methods and tools suited to evaluate the capacity provided by a wireless mesh network. How to optimize this capacity is the second step of this project. Currently, a cross-layer is privileged in order to take into account the physical properties of the radio channel, the MAC behavior and the routing protocol. A testbed will be used to validate the tools developped.

ARC FRACAS The FRACAS INRIA ARC (Fiabilité des Réseaux Autonomes de Capteurs et Applications à la Sécurité) aims at studying the foundations and the limitations of an auto-configured middleware for tolerance of failures and malicious attacks in large scale networks and particularly large scale sensor networks. This ARC proposes to address this topic in two steps. The first step, a fundamental one, is to model communications, failures and at tacks in sensor networks and to study/adapt the available methods for algorithms proof and validation to the sensor network context. The second step, a practical one, is to design and implement the services that have to be offered by the middleware.

ARC MALISSE The purpose of the MALISSE INRIA ARC (Malicious sensors) is to study sensor networks and their applicability to a wide range of applications when they should be able to support reliably a number of key functionalities, even in the presence of malicious sensors. Obviously such algorithms need to be themselves adapted to sensor networks and more specifically should take into account sensors reduced resources. Obviously, identifying the potential attacks in such a network is an important step of this research. Expected outcomes should be both theoretical (algorithm design and proofs) and practical (simulation and implementation) in order to fully validate the proposed solutions .

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.

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).

ANR SETIN RAPIDE This project has just began in november 2006 and works for 4 years. Marine Minier is responsible of the work package "MACs construction". The aim of the ANR project RAPIDE is to construct, to study and to evaluate some new stream ciphers built upon a non linear transition function (such as FCSR (Feedback with Carry Shift Register or De Bruijn sequences for example) or to better evaluate the properties of the filtering function to discard known attacks, especially the algebraic ones. This project also focuses on the construction of MAC (Message Authentication Code) from stream cipher operations.

ARESA The ANR RNRT ARESA project is focused on the design of embedded systems and Wireless Sensor Networks in the case of different scenarios as: environmental monitoring and smart buildings. The goal of the ARESA project is to:

- Explore new event-driven and asynchronous software and hardware architectures, tailored to extremely low power consumptions;
- propose new communication and organisation protocols, which are optimised in terms of energy consumption and robustness;
- find new application protocols that are designed for data fusion and aggregation;
- study new network structures which facilitate auto-configuration and auto-organisation;
- provide tools of modelling and validation, which also take into account the physical environment and the interaction thereof with the wireless sensor nodes;
- validate the developed concepts, protocols and mechanisms by means of a testbed.

The leader of the project is FTRD and the consortium is composed by: LSRINPG, TIMAINPG, VERIMAGUJF Grenoble, Coronis Systems.

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.).

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. This project is founded by ANR/RNRT.

LISE It is well known that defining in an unambiguous, comprehensive and understandable way the expected behaviour of software products or systems integrating a variety of components is quite a challenge, not to mention the use of such definition as a basis for a liability agreement. Taking up

this challenge is precisely the objective of LISE: the project will study liability issues both from the legal and technical point of views with the aim to put forward methods to (1) define liability in a precise and unambiguous way and (2) to establish such liability in case of incident.

It should be clear that LISE addresses long term objectives though, and a number of difficulties need to be overcome to reach them, both on the legal and on the technical side. Actually, it is the firm belief of the LISE partners that these difficulties cannot be solved without a tight collaboration between researchers in law and ICT, with substantial new results to be expected on both sides. To achieve this goal, LISE involves experts from both disciplines and the project will be organized to maximize interactions between the communities (both within the project and outside).

In contrast with previous work on forensics, the project will take a top-down approach (starting with the definition of liability and deriving sufficient and acceptable execution traces). The outputs of the project will concern the definition of liability as well as it establishment in case of incident.

SensLab The purpose of the SensLab project is to deploy a very large scale open wireless sensor network platform. SensLab's main and most important goal is to offer **an accurate and efficient scientific tool** to help in the design, development, tuning, and experimentation of real large-scale sensor network applications. The SensLab platform will be distributed among 4 sites and will be composed of 1,024 nodes. Each location will host 256 sensor nodes with specific characteristics in order to offer a wide spectrum of possibilities and heterogeneity. The four test beds will however be part of a **common global test bed** as several nodes will have global connectivity such that it will be possible to experiment a given application on all 1K sensors at the same time.

8.3. European initiatives

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.

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.

MOSAR IP project MOSAR (Mastering hOSpital Antimicrobial Resistance and its spread into the community) . Infections caused by antimicrobial-resistant bacteria (AMRB) account for an increasing proportion of healthcare-associated infections, particularly in high-risk units such as intensive care units and surgery; patients discharged to rehabilitation units often remain carriers of AMRB, contributing to their dissemination into longer-term care areas and within the community. The overall objective of MOSAR is to gain breakthrough knowledge in the dynamics of transmission of AMRB, and address highly controversial issues by testing strategies to combat the emergence and spread of antimicrobial resistance, focusing on the major and emerging multi-drug antimicrobial resistant microorganisms in hospitals, now spreading into the community. Microbial genomics and human response to carriage of AMRB will be integrated with health sciences research, including interventional controlled studies in diverse hospital settings, mathematical modelling of resistance dynamics, and health economics. Results from MOSAR will inform healthcare workers and decision-makers on strategies for anticipating and mastering antimicrobial resistance. To achieve these objectives, MOSAR brings together internationally recognized experts in basic laboratory sciences, hospital epidemiology, clinical medicine, behavioural sciences, quantitative analysis and modelling, and health economics. MOSAR brings together 11 institutions recognized for their leadership in these areas, from 10 EU Member or Associated States, as well as 7 SMEs to develop and validate high-throughput automated molecular tools for detection of AMRB. A high level of co-ordination will be obtained through a professionally IT-supported and rigorous management structure, to achieve optimal synergy of the components of MOSAR. We aim to develop and validate rapid testing for AMRB and initiate the clinical trials during the first 18 months of the project, and then to build on the infrastructure to execute the joint research programme.

MUSE II is an European project inside the FP6 Work intiative. is the follow up of MUSE I project. inside the FP6 Work intiative. Alcatel is the prime contractor. MUSE II will start by the begining of 2006.

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.

WASP IP IST project WASP (Wirelessly Accessible Sensor Populations). An important class of collaborating objects is represented by the myriad of wireless sensors, which will constitute the infrastructure for the ambient intelligence vision. The academic world actively investigates the technology for Wireless Sensor Networks (WSN). Industry is reluctant to use these results coming from academic research. A major cause is the magnitude of the mismatch between research at the application level and the node and network level. The WASP project aims at narrowing this mismatch by covering the whole range from basic hardware, sensors, processor, communication, over the packaging of the nodes, the organisation of the nodes, towards the information distribution and a selection of applications. The emphasis in the project lays in the self-organisation and the services, which link the application to the sensor network. Research into the nodes themselves is needed because a strong link lies between the required flexibility and the hardware design. Research into the applications is necessary because the properties of the required service will influence the configuration of both sensor network and application for optimum efficiency and functionality. All inherent design decisions cannot be handled in isolation as they depend on the hardware costs involved in making a sensor and the market size for sensors of a given type. Three business areas, road transport, elderly care, and herd control, are selected for their societal significance and large range of requirements, to validate the WASP results. The general goal of the project is the provision of a complete system view for building large populations of collaborating objects. The system incorporates networking protocols for wireless sensor nodes to hide the individual nodes from the application The tangible results of the project are: (1) A consistent chain of energy-sensitive software components, (2) Sets of cross optimised software stacks, (3) Benchmarks and a set of measurements on energy- and code- efficiency, (4) Rules for the design of configurable sensor nodes, and (5) A prototype implementation in one of the three chosen business areas The consortium consists of six industrial partners, one SME, six large research institutes and six universities. All of them have a proven experience with WSNs. The impact on European industry and research comes from the provision of an European alternative to the wireless sensor nodes originating in the US. The WASP results will be well suited for adoption by SMEs. The consortium defines an active programme to approach the appropriate SMEs and to familiarise them with the WASP results.

8.4. Visiting scientists

Yu Chen arrived in September 2005 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

DisMO4wNET Katia Jaffrès-Runser obtained a Marie-Curie outgoing fellowship from European community. She's going to spend 2 years at the Stevens Institute of Technology, New-Jersey, USA within the team of Dr Christina Comanisciu, and she will come back for one year in the ARES project. This project is managed by Jean-Marie Gorce.

Tiny6 This project will bring together French and Asian scientists who have developed well-recognized skills either in sensor networks or IPv6 fields. Sensor network is a generic name covering different technologies. Most of them have not been standardized yet and remain prototypes. From this diversity of sensor network technologies and considering the broad experience obtained on IPv6, this project has at 3 main objectives: Sharing knowledge between partners, exchanging students and accessing experimental platforms available at other partners' laboratories. Developing common material courses that can be taught in our different Universities. Specifying and implementing a minimal IPv6 stack adapted to the diversity of Sensor network behaviors.

STIC Tunisie The INRIA ARES project has a join research program with the MEDIATRON research team (Prof. Sami Tabbane, Tunisia) about mobile ad hoc networks. There are two goals: first to provide realistic mobility models and second, to model radio propagation for indoor environment. The final objective is to provide realistic input parameters in order to study mobile ad hoc networks.

WIDE-STIC ASIA WIDE and CNRS has launched a collaboration on the mobility and measurement topics. This project is supported by the French and Japanese governments and will continue for two years. We exchange researcher, research information, technical results between the two countries.

- PRA France-Chine Both LIAMA (sino-french computer sciences lab) and ARES are involved in a join project about the use of the declarative networking paradigm in order to specify localized and distributed protocols for wireless sensor networks. This project is a part of a more important and more ambitious project called Ubiquest where Orange Labs Beijing and BUPT (Beijing University of Post and Telecommunications) are also implied. The PRA funding supports only travel and short missions.

9. Dissemination

9.1. Leadership within scientific community

Isabelle AUGÉ-BLUM is:

- Elected representative with the council of the Telecomunications Department of INSA Lyon;
- a member of the group STRQdS (Systèmes temps réel et Qualité de Service);
- a member of the ARC INRIA Iramus (Radio Interface for Multihop Networks).

Guillaume CHELIUS is:

- Co-leader of the MAE Stic-Asie Tiny6 project in collaboration with ENST Bretagne, France Telecom, Korean Telecom and the Seoul National University;
- the leader of the multi-laboratory CAPNET project (BQR project sponsored by the INSA 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 –until September 2007–
- Vice-head of the ARES project;
- Co-chair of the Networking group ResCom (http://rescom.asr.cnrs.fr/) of the CNRS GDR ASR;
- 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;
- the leader for the INRIA Rhône-Alpes of the IP IST project WASP;
- the leader for the INRIA Rhône-Alpes of the IP project MOSAR;
- Head 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;
- elected representative with scientifique council of INSA Lyon –Until September 2007–;
- elected representative with the council of the Telecomunications Department of INSA Lyon –Until September 2007–;
- reviewer and/or member of several PhD examining boards
- coordinator for ENS Lyon, UCBL and INSA Lyon of the research cluster ISLE Rhône-Alpes (Computer, Signal and embeded systems)
- elected representative of the specialists committee in computer science (CS section 27) of INSA Lyon –Until September 2007–;
- elected representative of the specialists committee in computer science (CS section 27) of Lille;
- Reviewer of PhD examining boards of: Erwan LE MERRER, Pascal PONS, Jérémie LEGUAY;
- Reviewer of the HDR examining board of Matthieu LATAPY.

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 Felix Project (OSGi open-source implementation);
- a member of one PhD examining board for: Vincent Cridlig,Emanuel Bouix, Guillaume Doyen. examinator, university Henri Poincaré, Nancy 1;
- INRIA representative within MUSE II european projects;
- PMC member of apache felix project (OSGi V4 implementation platform).

Jean-Marie GORCE is:

- 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 ACI Sécurité Fragile (Failure Resilience and Application Guaranteed Integrity in Large-scale Environments);
- 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.

Véronique LEGRAND is:

- a member of the "ACI sécurité" KAA project
- a head of OPPIDUM project (French security program sponsored by Ministère des Finances) on intrusion detection domain and log behaviour detection.
- a member of SERBER project (BQR project sponsored by the INSA Lyon) on the security defender platform.
- a member of European project (Deserec and Red) on the dependability and security systems.

Frédéric LE MOUËL is:

- Elected representative with the council of the Telecommunications Department of INSA Lyon.
- Member of the INRIA ARC PRIAM project (Privacy Issues and Ambient Intelligence).
- Member of the French Ministerial ACI KAA project (Key Authentication Ambient).
- Leader for the INRIA Rhône Alpes of the European IP AMIGO project (Ambient intelligence for the networked home environment). Leader of the task 3.4 on "Programming and deployment framework for Amigo services".
- Reviewer of the PhD examining board of Frederic Van Quickenborne (University of Ghent, Belgium).
- Member of EuroSys (European ACM-SIGOPS Chapter), ASF (French ACM-SIGOPS Chapter), OUGF (OSGi User Group France).

Marine MINIER is:

- Head of the ACI sécurité project KAA (Key Authentication Ambiant);
- A member of the ANR SETIN project RAPIDE (nov. 2006 - nov 2010); responsible of the work package “MACs construction”.

Stéphane UBEDA is:

- The head of the CITI research Lab;
- elected representative of the specialists committee in computer science (CS section 27) of INSA Lyon;
- reviewer and/or member of the PhD examining boards of: Samuel Galice, Tahiry Rafazindralambo, Yvan Royon, Guillaume De La Roche.
- member of HDR examination of: Isabelle Chrisment, Fabrice Valois, Jean-Marie Gorce.

Fabrice VALOIS is:

- The leader of the team Protocols of the ARES project since September 2006;
- the scientific leader of a contract with FT R&D about *Self-configuration and self-organisation of wireless sensors networks*. Two teams of FTRD are involved: PACIFIC project (Grenoble) and ILAB Beijing (China);
- a member of the ARC INRIA Iramus (Radio Interface for Multihop Networks);
- in charge for the CITI Lab of the ANR RNRT ARESA (Wireless Sensors Networks project) project;
- the scientific leader of the INRIA STIC Tunisia project N°06/I15 about more accurate models for mobile ad hoc networks including both mobility models and radio propagation one;
- a member of the french research group Rescom;
- an elected member of the specialists committee in computer sciences (section 27) of the INSA Lyon.

Guillaume VILLEMAUD is:

- Elected representative with the council of the Electrical Engineering Department of INSA Lyon;
- A member of the research group (GDR) ISIS (Information, Signal, Images and Vision) of CNRS;
- A member of the ARC INRIA Iramus (Radio Interface for Multi-hop Networks);
- The scientific leader of a contract with FT R&D about Multi-antenna multi-mode software defined radio receiver;
- the scientific leader of a contract with ELA Medical about Antenna Diversity for Medical BaseStation;
- Member of the PhD examination board of Christophe DALL’OMO (Limoges);

9.2. Conferences, meetings and tutorial organization

Isabelle BLUM is:

- PC member of WWSN 2007, International Workshop in Wireless Sensor Networks in conjounction with NOTERE 2007 (New Technologies of Distributed Systems);

Guillaume CHELIUS is:

- PC member of Networks, in conjunction with the 34th International Colloquium on Automata, Languages and Programming (ICALP 2007);
- co-chair of AlgoTel 2007, the 9th francophone conference on algorithms for telecommunications (AlgoTel 2007);
- PC member of Mobile Ad-hoc and Sensor Networks 2007;

Guillaume DE LA ROCHE is:

- PC member of Eucap 2007, European Conference on Antennas and Propagation ;

Eric FLEURY is:

- PC member of COMSWARE 2008 (International Conference on COMmunication System softWAre and MiddlewaRE);
- PC member of Autonomic 2007 (First International Conference on Autonomic Computing and Communication Systems);
- PC member of EuroPar 2007 (Local chair of topic Mobile and ubiquitous computing at EuroPar 2007;
- PC member of LAACS 2007 (The 2nd Latin American Autonomic Computing Symposium;
- PC member of the IFIP International Conference on Embedded And Ubiquitous Computing;
- PC member of the 4th European Conference on Universal Multiservice Networks;
- PC member of SANET 2007 (the First ACM Workshop on Sensor Actor Networks);
- PC member of SENSORCOM 2007 (International Conference on Sensor Technologies and Applications);
- General co chair of the IEEE InternationalWorkshop on Theorymeets practice inWireless Sensor
- PC member of Networks 2007;
- PC member of WWSN 2007: PC member of the International Workshop in Wireless Sensor Networks in conjounction with NOTERE 2007 (New Technologies of Distributed Systems);
- PC member of Networks, in conjunction with the 34th International Colloquium on Automata, Languages and Programming (ICALP 2007);
- PC member of the Joint ACMWorkshop on Foundations of Mobile Computing, in conjunction with the Twenty-sixth Annual ACM SIGACT-SIGOPS Symposium on Principles of Distributed Computing (PODC 2007);

Stéphane FRÉNOT is:

- a member of the following technical program committees:
  - SERA (2008)
  - NOMS (2007-2008)
  - Notere (2006-2008)
  - Workshop SIPE (2007-2008)
  - Workshop AmbiSys (2008)
  - Workshop Anis (2008)

Jean-Marie GORCE is:

- PC member of Chinacom, 2007, the Second International Conference on Communications and Networking in China, Signal Processing track;)

Frédéric LE MOUËL is:

- a member of the following technical program committees:
  - Co-organizer and Chairman, with Stéphane Frénot, of IEEE SIPE'2007, 2nd IEEE International Workshop on Services Integration in Pervasive Environments in conjunction with IEEE ICPS'2007, Istanbul, Turkey.
  - PC member of UCS'2007, International Symposium on Ubiquitous Computing Systems, Tokyo, Japan, chairman of the 'Middleware' track.
  - PC member of MAI'2007, 1st Workshop on Middleware-Application Interaction in conjunction with EuroSys'2007, Lisbon, Portugal.
  - PC member of FuncAAL'2007, International Workshop on Functional Architectures for Assisted Living Services in conjunction with Pervasive'2007, Ontario, Canada.
  - PC member of OCM-SI'2007, 6ème atelier sur les Objets, Composants et Modèles dans l'ingénierie des Systèmes d'Information, en conjonction avec INFORSID'2007, Perros-Guirec, France.

Marine MINIER is:

- PC member WCC07, (International Workshop on Coding and Cryptography), Versailles, France, April 2007.
- PC member ISPA 2007 (The Fifth International Symposium on Parallel and Distributed Processing and Applications), Canada, 2007

Stephane UBEDA is:

- PC member of Home Networking Conference 2007;
- member of the *GRES 2007*;
- Editor of an Hermes collection in wireless communications.

Fabrice VALOIS is in the following program committees:

- ISSNIP07, 3th International Conference on Intelligent Sensors, Sensor Networks and Information Processing, Melbourne, Australia, December 2007.
- PE-WASUN'07, ACM International Workshop on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks, Chiana, Crete Island, Greece, October 2007.
- SensorCom'07, IEEE International Conference on Sensor Technologies and Applications, Valencia, Spain, October 2007
- WiMob'07, 3rd IEEE International Conference On Wireless and Mobile Computing, Networking and Communications, New York, USA, October 2007
- IWCMC'07, ACM International Wireless Communications and Mobile Computing Conference, Ad Hoc and Sensor Networks Symposium, Honolulu, Hawaii, August 2007
- Algotel'07, Rencontres Francophones sur l'Algorithmique pour les Télécommunications, Ile d'Oléron, France, May 2007

Thomas WATTEYNE is:

- Publicity chair of the First International Conference on Simulation Tools and Techniques for Communications, Networks and Systems 2008.
- IEEE Region 8 Electronic Communications Coordinator;
- IEEE Region 8 Student Activities Committee Awards and Contests Coordinator;
- member of the IEEE Wireless Communications Technical Committee (WTC);
- Web Chair for the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) 2008, Cannes, France, 14-18 September, 2008;
- Web Chair for Second International Conference on Body Area Networks (BodyNets) 2007, Florence, June 11-13, 2007;
- PC member IEEE International Conference on Communications (ICC) 2009, Wireless Networking Symposium;
- PC member Second International Conference on Sensor Technologies and Applications (SENSORCOMM) 2008;
- PC member Workshop on Radio Resource Management in Wireless Mesh Networks (RRMinMesh) 2008, held in conjunction with the 6th ACS/IEEE International Conference on Computer Systems and Applications (AICCSA);
- PC member 7th IFIP Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net) 2008;
- PC member IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) 2008, Mobile and Wireless Networks track;
- PC member IEEE International Conference on Communications (ICC) 2008, Wireless Networking Symposium;
- PC member First International Conference on Sensor Technologies and Applications (SENSORCOMM) 2007;
- PC member International Wireless Communications and Mobile Computing Conference (IWCMC) 2007, Ad Hoc and Sensor Networks track;
- PC member Fourth Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON) 2007;
- PC member IEEE Vehicular Technology Conference (VTC) 2007 Spring, Ad-hoc and Sensor Networks track;

Jean-Marie Gorce, Guillaume Villemaud, Thomas Watteyne, Isabelle Auge-Blum are co-organizers, with Jean Carle (LIFL), and Mischa Dohler (France Telecom R&D) of the workshop IRAMUS in Val Thorens, January, 24-26, 2007.

9.3. Teaching activities

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

- Jean-Marie Gorce gave a course with Mischa Dohler (FT R&D) on *Physical Layer for future wireless networks* (20h);
- Frédéric Le Mouël and Stéphane Frénot gave a course on Pervasive and Peer-to-Peer Systems (20h) in MASTRIA Mater program.
- Marine Minnier gave a course on security for adhoc networks.
- 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 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);
- Guillaume Chelius and Fabrice Valois gave a course on *Autonomic Computing* (20h);
- Stéphane Ubéda and Fabrice Valois gave a course on *Theoretical tools for networks performance evaluation* (20h).
- Fabrice Valois gave a course on *Self-organisation in radio multi-hop networks* at Ecole Polytechnique de Montréal, Québec, Canada.

INSA LYON

- Eric Fleury, Stéphane Frénot, Jean-Marie Gorce, Véronique Legrand, Marine Minier, Frédéric Le Mouël, Stéphane Ubéda, Fabrice Valois and Guillaume Villemaud are professors/teaching assistants at the INSA Lyon;
- all the members supervised engineer projects;
- Isabelle Augé-Blum, Eric Fleury, Stéphane Frénot, Jean-Marie Gorce, Marine Minier, Frédéric Le Mouël, Stéphane Ubéda, Fabrice Valois and Guillaume Villemaud are professors/associate professors at the INSA Lyon in the departments: Computer Science, Electrical Engineering, Telecommunications;
- 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.

OTHERS.

- Jean-Marie GORCE gave a talk called on "Physical layer modeling in wireless networks" at the Stevens Institute of Technology, New-Jersey, USA and at the *Ecole polytechnique de Montréal*, Québec, Canada.
- Guillaume CHELIUS gave lectures in the Research Master INSA/ Université Lyon 1 INSA Lyon, a joint Master ENST Bretagne - ITAM (Mexico), in the Telecommunication department of the INSA Lyon and at the ENS Lyon.

9.4. Miscellaneous

9.4.1. Visits

- Fabrice Valois was invited professor at Ecole Polytechnique de Montréal, Québec, Canada, between March and June 2007.

9.4.2. Defended Habilitations

- Fabrice Valois, *Auto-organisation de réseaux radio multi-sauts*, Nov 19th 2007, Jury: Andrzej Duda, Catherine Rosenberg, David Simplot-Ryl, Serge Fdida, Jean-Michel Fourneau, Isabelle Guérin-Lassous, Stéphane Ubéda
- Jean-Marie Gorce, *Contribution à la modélisation et l'optimisation des systèmes radio ambiants en réseau*, Nov 29th 2007, jury: Pierre Duhamel, Inbar Fijalkow, Guillaume Gellé, Isabelle Guérin-Lassous, Samuel Pierre, Alain Sibille, Stéphane Ubéda.

9.4.3. Defended PhDs

- Cheikh Sarr, *Resource estimation for quality of service in ad hoc networks*, July 17th 2007, Jury: Eric Fleury, Khaldoun Al Agha, Thomas Noël, Isabelle Guérin-Lassous, Claude Chaudet, Bertrand Ducourthial, Guillaume CHELIUS.
- Tahiry Rafazindralambo, *Performance Issues in Multi-Hop Wireless Networks*, Dec 3rd 2007, Jury: aurent Reynaud, Isabelle Guerin-Lassous, Serge Fdida, David Simplot, Andrzej Duda, Stéphane Ubeda.
- Yvan Royon, *Multi-service, multi-user java-based environments*, Dec 13th 2007, Jury: Olivier Festor, Gilles Muller, Stéphane Frénot, Gilles Grimaud, Stéphane Ubeda, Didier Donsez.
- Samuel Galice, *Cryptographic protocols for ad hoc networks*, Nov 30th 2007, Jury: Valérie Issarny, Khaldoun Al Agha, Isabelle Chrisment, Daniel Le Métayer, Marine Minier, Stéphane Ubéda.

- Guillaume De La Roche, *MR-FDPF Method for the Simulation of 802.11 Radio Propagation in Indoor Environments.*, Dec 12th 2007, Jury : Lionel Pichon, Rodolphe Vauzelle, Alexandre Caminada, Yves Lostanlen, Jean-Marie Gorce, Stéphane Ubéda.

9.4.4. On going PhDs

- Fatia Benali, *Alert languages for information security system*;
- Amira Ben Hamida, *Minimal autoextensible middleware for deployment in a pervasive environment*;
- Elyes Ben Hamida, *Domain-Specific Languages for sensor network MAC protocols*;
- Ioan Burciu, *Wide Band agile R/F transceiver*;
- Hajer Chamekh, *Semantic deployment of services in a pervasive environment*;
- Karel Heurtefeux, *Self-organization of Wireless Sensor Networks*;
- Noha Ibrahim, *Automatic Integration of Services in Pervasive Environments*;
- Jialiang Lu, *Impact of self-* on communicating object networks*;
- Philippe Mary, *Innovative approaches for multi-antenna processing in the context of multiple radio interfaces*;
- Nicolas Marechal *Distributed optimizations of the network connectivity in sensor networks*;
- Benoit Miscopein, *MAC protocol for UWB*;
- Pierre-François Morlat, *Study of SIMO and MIMO terminals in an ad hoc or sensor network context*;
- Pierre Parrend, *Security Models, Home Gateways, Components*;
- Jacques Saraydaryan, *Intrusion detection by behavior and statistical analysis*;
- Thomas Watteyne, *Energy-Efficient Self-Organization for Ad-Hoc Networks*;
- Fei Yang, *Real time communications in Wireless Sensor Networks*;
- Ruifeng Zhang, *Realistic Modeling and Simulation of the PHY layer in Multi-hop Sensor Networks*.
- Wassim Znaidi, *security in wireless sensor networks*.

10. Bibliography

Year Publications

Books and Monographs

[1] F. LE MOUËL, S. FRÉNOT (editors). *Proceedings of the 2nd IEEE International Workshop on Services Integration in Pervasive Environments (SIPE'2007)*, IEEE Press, Istambul, Turkey, July 2007, http://ares.insa-lyon.fr/sipe07/.

Articles in refereed journals and book chapters

[2] G. DE LA ROCHE, K. JAFFRÈS-RUNSER, J.-M. GORCE. *On predicting Indoor WLAN coverage with a fast discrete approach*, in "International Journal of Mobile Network Design and Innovation", vol. in press, 2007.

[3] A. FRABOULET, T. RISSET. *Master Interface for On-Chip Hardware Accelerator Burst Communications*, in "Journal of VLSI Signal Processing", to appear, accepted for publication, 2007.

[4] S. GALICE, M. MINIER, S. UBÉDA. *The KAA Framework : A History-Based Trust Establishment in Ambient Networks*, in "International Journal on Intelligent Control and Systems", To appear, 2008.

[5] J.-M. GORCE, K. JAFFRÈS-RUNSER, G. DE LA ROCHE. *A Deterministic Approach for Fast Simulations of Indoor Radio Wave Propagation*, in "IEEE Trans on Antennas and Propagation", vol. 55, n^{o} 3,2, 2007, p. 938-948.

[6] J.-M. GORCE, R. ZHANG, H. PARVERY. *Impact of Radio Links Unreliability on the Connectivity of Wireless Sensor Networks*, in "Eurasip JWCN", vol. in press, 2007.

[7] K. JAFFRÈS-RUNSER, J.-M. GORCE, S. UBÉDA. *Mono- and Multiobjective Formulations for the Indoor Wireless LAN Planning Problem*, in "Journal of Computers and Operations Research. Special Issue on Telecommunications Network Engineering", vol. in press, , doi:10.1016/j.cor.2007.02.011, 2007.

[8] P. MARY, M. DOHLER, J.-M. GORCE, G. VILLEMAUD, M. ARNDT. *BPSK Bit Error Outage over Nakagami-m Fading Channels in Lognormal Shadowing Environments*, in "IEEE Communication Letters", vol. in press, 2007.

[9] T. RAZAFINDRALAMBO, I. GUÉRIN-LASSOUS, L. IANNONE, S. FDIDA. *Dynamic and Distributed Packet Aggregation to Solve the Performance Anomaly in 802.11 Wireless Networks*, in "Computer Networks Journal, Elsevier Ed.", To appear, 2008.

[10] T. RAZAFINDRALAMBO, I. GUÉRIN-LASSOUS. *Increasing Fairness and Efficiency using the MadMac Protocol in Ad Hoc Networks*, in "Ad hoc journal, Elsevier Ed.", To appear, 2008.

[11] Y. ROYON, S. FRÉNOT. *Multiservice Home Gateways: Business Model, Execution Environment, Management Infrastructure*, in "IEEE Communications Magazine", vol. 45, October 2007, p. 122-128.

[12] F. THEOLEYRE, F. VALOIS. *A Self-Organization Structure for Hybrid Networks*, in "Ad hoc journal, Elsevier Ed.", to appear, accepted for publication., 2007.

[13] F. THEOLEYRE, F. VALOIS. *Structure virtuelle pour une auto-organisation dans les réseaux ad hoc et hybrides*, in "Annales des Télécommunications", vol. in press, 2007.

[14] F. THEOLEYRE, F. VALOIS. *VSR: a routing protocol based on a structure of self-organization*, in "Studia Informatica - Special Issue on Wireless Ad Hoc and Sensor Networks", to appear, accepted for publication., 2007.

[15] F. THEOLEYRE, F. VALOIS. *Chapter 5: 'Self-organization of ad hoc networks'*, in "Wireless Ad Hoc and Sensor Networks", ISBN: 978 1 905209 86, ISTE Ltd (Hermès Science Publications/Lavoisier Company), April 2007.

Publications in Conferences and Workshops

[16] L. ALAUS, G. VILLEMAUD, P.-F. MORLAT, J.-M. GORCE. *Preamble Detection Methods in a Multi-Antenna, Multi-Standards Software Defined Radio Architecture*, in "EuCAP 2007, Edinburgh, Scotland", 2007.

[17] F. BENALI, V. LEGRAND, S. UBÉDA. *An Ontology for the Management of Heteregenous Alerts of Information System*, in "The 2007 International Conference on Security and Management (SAM'07), Las Vegas, USA", June 2007.

[18] C. BRYCE, M. DEKKER, S. ETALLE, D. LE MÉTAYER, F. LE MOUËL, M. MINIER, J. MORET-BAILLY, S. UBÉDA. *Ubiquitous Privacy Protection*, in "Proceedings of the 5th Workshop on Ubicomp Privacy in conjunction with the 9th International Conference on Ubiquitous Computing (UbiComp'2007), Innsbruck, Austria", Position Paper, September 2007.

[19] Y. BUSNEL, M. BERTIER, E. FLEURY, A.-M. KERMARREC. *GCP: Gossip-based Code Propagation for Large-scale Mobile Wireless Sensor Network*, in "ACM EuroSys 2007, Lisbon, Portugal", (Poster), March 2007.

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[21] H. CHAMEKH, F. LE MOUËL. *An Ontology-based Approach to Semantically Deploy Services in Pervasive Environments*, in "Proceedings of the 2nd IEEE International Workshop on Services Integration in Pervasive Environments (SIPE'2007) in conjunction with the IEEE International Conference on Pervasive Services (ICPS'2007), Istambul, Turkey", July 2007.

[22] G. CHELIUS, A. FRABOULET, E. FLEURY. *Worldsens: a fast and accurate development framework for sensor network applications*, in "The 22nd Annual ACM Symposium on Applied Computing (SAC 2007), Seoul, Korea", ACM, March 2007.

[23] Y. CHEN, E. FLEURY. *A distributed policy scheduling for wireless sensor networks*, in "INFOCOM", 2007.

[24] Y. CHEN, E. FLEURY. *Backbone-based Scheduling for Data Dissemination in Wireless Sensor Networks with Mobile Sinks*, in "Fourth ACM SIGACT-SIGOPS International Workshop on Foundations of Mobile Computing, Portland, Oregon, USA", (co-located with ACM PODC 2007), ACM, 2007.

[25] Y. CHEN, E. FLEURY. *Topology-Transparent Duty Cycling for Wireless Sensor Networks*, in "IEEE International Parallel & Distributed Processing Symposium (IPDPS 07), Long Beach, California, USA", IEEE, 2007.

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