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Project-Team Ares

Architecture de réseaux de services

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Activity Report

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2. Overall Objectives

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

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

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

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

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

The activities of the project are organized in three areas:

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

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

3. Scientific Foundations

3.1. Introduction

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

3.2. Hybrid networks modelling

Participants: Claude Chaudet, Dominique Dhoutaut, Jean-Marie Gorce, Isabelle Guérin Lassous, Houda Khedher, Katia Runser, Stéphane Ubéda, Fabrice Valois.

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

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

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

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

3.3. Protocols design

Participants: Claude Chaudet, Guillaume Chelius, Dominique Dhoutaut, Eric Fleury, Isabelle Guérin Lassous, Nathalie Mitton, Farid Naït-Abdesselam, Thomas Noël, Mahmoud Taïfour, Fabrice Theoleyre, Fabrice Valois.

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

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

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

We aim to add to this architecture the benefits of ad hoc networks since they will allow the covering of existing cellular networks to be extended. To fulfill our goal, we need to evaluate and optimize existing protocols but also propose new architectures and protocols related to the specific context of hybrid networks. Architectural aspects appear to be fundamental in our approach since only a global and broad point of view allows all aspects of hybrid networks (ad hoc networks embedded in a cellular network) and heterogeneous capacities (different communication medium, computational power, memories, power life) to be taken into account.

3.4. Services deployment and administration

Participants: Nada Al Masri, Eric Fleury, Stéphane Frénot, Véronique Legrand, Dan Stefan, Stéphane Ubéda.

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

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

- Components deployment: in a highly mobile and dynamic environment, context adaptation is a key feature of the success of a support for ambient network; this *context awareness* can not be obtained without an efficient software/driver components deployment. This is also necessary to reach the third dimension mobility: mobility of the user between devices. In this area, services discovery is a needed functionality that should be studied in the context of hybrid networks.

- Components instrumentations: supervising terminals in a mobile environment is difficult; in *ambient networks* where there are no pre-existing authorities, standard procedures are usefulness. New management and control paradigms have to be developed. *ARES* has the objective to propose new supports for *Autonomous Management*, i.e. user centered solutions without any administrator.
- Global security support: security is a key feature of *ambient networks*; difficulties come from the lack of central administration. Again, new paradigms have to be proposed. *ARES* is focused on *spontaneous* trust management and is studying a global solution on the top of this basic property.

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

4. Application Domains

4.1. Introduction

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

4.2. Applications in ubiquitous networks

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

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. We have also developed a specific *ambient application* called *WaveCar* which plays the role of an application model for our research activities. The WaveCar concept describes the way to manage (both from the user and the administrator point of view) multimedia contents in a personal vehicle [37].

4.3. Applications tools for wireless networks

The application domain concerned by tools that help in the evaluation, planning and simulation of wireless networks is part of the *ARES* goals both in terms of research tools and of technology transfer. Various aspects of the modelling a of wireless environments need the design of specific tools for simulation and evaluation.

Some of these tools are already being transferred to operational applications for wireless networks designers. The originality of the wireless tools designed by *ARES* comes from the merging of the network aspect (MAC layer and routing layer) with a good modelling of physical links.

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

5. Software

5.1. AWAP

Key words: *self-configuration*, *gateway*.

Participants: Dan Stefan, Stéphane Frénot.

AWAP aims at defining a wireless access point that can be remotely managed and that can give monitoring information about the underlying wireless network. In order to implement such a system we have chosen to use the OSGi gateway. This implementation is now currently available through the Oscar-OSGi distribution, and through our web site http://ares.insa-lyon.fr/~sfrenot/devel/awap/.

For the remote management of OSGi services, we have plugged the JMX framework on top of Oscar OSGi gateway. Our implementation enables one OSGi component to be dynamically instrumented by an MBean component in the JMX framework. The implementation and documentation are freely available on http://ares.insa-lyon.fr/~dan/jmx_osgi/index.html.

This last framework enables us to remotely manage a set of NWS elements. The main goal of this software is to remotely monitor the NWS elements and guarantee that every process is always alive. The implementation and documentation are freely available on http://ares.insa-lyon.fr/~dan/gasp/index.html.

5.2. ANANAS

Key words: *multi-interfaces*, *ad hoc network*, *hybrid network*.

Participants: Guillaume Chelius, Eric Fleury.

AnaX, Ana4 and Ana6, is a network architecture for both ad hoc and hybrid networks which abstracts multi-hop multi-interfaces networks into a single ad hoc network. In the AnaX architecture, ad hoc and access networks are both considered as an unique ad hoc network (hybrid network) and as a multi-link subnet in terms of IP addressing. In other words, an IP address remains valid in the whole hybrid network and mobility does not lead to addressing modification. AnaX allows the logical partitionning of an ad hoc network using channels. A channel is a maximal connected set of ad hoc nodes sharing a common channel value. Different routing protocol instances may be operated in the different channels, allowing routing optimizations depending on the channel properties. An ad hoc node may have several channel values and several or different interfaces bound to each channel. These values are manually or automatically configured, using an advertizing protocol or a MANET protocol. AnaX also introduces an addressing support to restrict the diffusion of information (broadcast or multicast) to a precise channel or to the whole ad hoc network. The software is available at http://sourceforge.net/projects/ananas.

5.3. Extension of OSPFv3 for auto-configuration

Key words: *IPv6 auto-configuration*, *OSPF*, *SLA values*.

Participants: Guillaume Chelius, Eric Fleury.

In collaboration with the ARMOR project, ARES has proposed a protocol extending the standardized IPv6 auto-configuration mechanisms. The basic IPv6 auto-configuration process is dedicated to hosts only; it allows retrieval of a 64 bits address prefix through ICMPv6 messages, the remaining 64 bits being determined from local information. We propose to dynamically and automatically attribute SLA values to links using a distributed protocol executed by the IPv6 routers. The RSM department of the ENST Bretagne and the project have published an Internet Draft for the Yokohama IETF meeting (draft-chelius-router-autoconf-00.txt) which extends OSPFv3 to establish and maintain a consensus on the automatic attribution of SLA values to the network links. Diffusion of SLA values in the OSPF area enables collision detection and avoidance while picking the SLA value for a newly created link. Implementation for this protocol is available for the Zebra application.

5.4. WILDE software

Key words: *wave propagation simulation*, *multi-resolution*, *wireless network planning*, *distributed code*.

Participants: Jean-Marie Gorce, Katia Runser.

In the framework of network planning, we have developed a project in JAVA, implementing our propagation simulator described in Section 6.1. This software named WILDE (Wireless Design tool) is the heart of our future developments concerning the radio link modelling. For any information, contact Jean-Marie Gorce (Jean-Marie.Gorce@insa-lyon.fr).

5.5. BRuIT

Key words: *bandwidth reservation*, *ad hoc networks*, *interferences*.

Participants: Claude Chaudet, Isabelle Guérin Lassous.

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

This protocol has been implemented under the network simulator NS-2 and many optimizations and enhancements have been implemented in order to render this protocol more lightweight, more reliable, and to make it able to react to unpredictable changes in the resources availability. Simulation code and tests should be finished by the end of 2003 and the source code will be made available. A linux version is to be released soon after. See http://citi.insa-lyon.fr/~cchaudet.

5.6. Forwarding

Key words: *performance evaluation*, *IEEE 802.11*, *ad hoc networks*.

Participants: Dominique Dhoutaut, Isabelle Guérin Lassous.

Forwarding enables the performance evaluation of the standard IEEE 802.11 in a real ad hoc context. *Forwarding* runs in user space and enables the transmission of unicasted or broadcasted packets in a well controlled manner. In order to characterize the effects of sole 802.11, we had to isolate them from those of others layers (routing and transport layers in particular). *Forwarding* gets its name from its ability to repeat UDP packets depending on stated rules, thus creating stable multihop routes where controlled frames travel (each UDP packet translates in one frame, and there is no effects from TCP or others layers). Along with suitable results analysis tools, *forwarding* proved itself quite useful in understanding real behaviors of 802.11 in an ad hoc context and in pointing out some weak points of simulations. The code is available at http://citi.insa-lyon.fr/~ddhoutau.

6. New Results

6.1. Hybrid networks modelling

Participants: Claude Chaudet, Dominique Dhoutaut, Jean-Marie Gorce, Isabelle Guérin Lassous, Houda Khedher, Katia Runser, Stéphane Ubéda, Fabrice Valois.

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

Three thematics have been emphasized: radio link characterization, the modelling of interactions required for adapted protocols and performance evaluation taking into account both mobility and traffic models. While each of these themes is using its own theories and models, they will have to strongly collaborate in order to propose a reliable and realistic overall modelling.

6.1.1. Characterization and impact of the radio interface

First of all we have focused our efforts on the radio propagation simulation and on the study of planning techniques for wireless LAN. These approaches are broad enough to offer a way to integrate in these simulators the behavior of hybrid networks. Finally, we have started an evaluation of the successful technology 802.11.

6.1.1.1. Propagation simulation in indoor environments

The simulation of propagation in indoor environments is a difficult task due to many reflexion and diffraction effects. Empirical models fail to provide reliable predictions, while deterministic approaches are often too complex to be used. Among deterministic approaches, ray-tracing based methods are the most well known, because of their scalability in terms of complexity. These methods may indeed be very fast if only few reflexions are taken into account and diffraction effects are omitted, but come with with a lack of reliability. It is obvious that prediction may be more realistic if the number of reflexions is increased and if diffraction is introduced in the modelling through an UTD approach. However, in this case, the computational resources may drastically increase, and therefore a tradeoff has to be defined between accuracy and efficiency. Among the deterministic approaches, ParFlow has been proposed by Chopard et al. (B. Chopard, P. Luthi and J.F. Wagen, A multi-cell coverage predictions : a massively parallel approach based on the ParFlow Method, IEEE Personnal, Indoor and Mobile Radio Communications conference, 98) in the context of GSM base station planning. This technique is a time-domain discrete approach which accurately reflects the behavior of wave propagation but requires very high computation and time resources. Initially this method has been implemented in a parallel system to reduce the computation time.

We have proposed in 2001 a new resolution scheme (FDPF for Frequency Domain ParFlow) to solve the discrete ParFlow equations in the Fourier domain. The problem is thus written as a wide linear system. In 2002, we have solved this system in two steps taking advantage of a multi-resolution approach. The first step computes a cell-based tree structure referred to the pyramid. This step is considered as a pre-processing phase since this computation does not require the knowledge of a source location. In the second phase, a radiating source is simulated, taking advantage of the pre-processed pyramidal structure.

This year, a new algorithm has been proposed to define an environment-based adaptive pyramidal structure avoiding artefacts near walls and other discontinuities [16]. More precisely, a new non regular pyramidal structure which fits the particular arrangement of the indoor environment has been presented. The use of a full-space discrete simulator instead of classical ray-tracing techniques is a challenge due to the inherent high computation requests. However, we demonstrate that the use of a multi-resolution approach allows some computations in a pre-processing phase to be performed, independently of source locations.

When these computations have been done, it is possible to test a source with a reasonable CPU charge, by using the pyramidal structure and by limiting the accuracy level of the results. The use of this algorithm in the context of WLAN planing is described below. Our approach is therefore able to perform accurate simulations. However several parameters have to be set in our simulator. More specifically, propagation parameters (refraction index and attenuation) of constitutive materials (walls, free-space, ...) have to be estimated. Instead of using 'true' values of these parameters, we rather use them to adapt our simulations to the reality. More precisely, these parameters can be defined as the degrees of freedom of the FDPF algorithm. To find the best set of parameters, an optimization process is used. It is aimed at minimizing the quadratic difference between the simulated values and actual measurements. This topic has been studied by a master's student.

Another aspect which has been studied in depth is the directivity of antennas. First of all, directive antennas should be taken into account in order to accuratel simulate real propagation. Moreover, the radio channel properties (angular and temporal spread) will be required for the performance evaluation of receiver techniques. It is fundamental that our simulator is able to process and investigate multipath phenomenon. For this purpose we have tested DOA (Direction Of Arrival) algorithms in our simulator. The more robust method was found to be a MUSIC-based technique, extended in 2 dimensions and allowing the different directions of arrival at all receiver positions in the simulator to be detected. This topic was studied by a master's student.

6.1.1.2. Wireless LAN planning

The performance of a WLAN is strongly influenced by the access points characteristics. That is why their number, their location and their emission power have to be determined with care during the planning stage of the network. The planning problem can be exposed in different ways according to the optimization goals that have been chosen. The traditional approach is to compute a coverage map that satisfies a simple constraint on the signal level based on a minimum threshold. Some more elaborated models introduce constraints of quality of service (as throughput or interference level) on the receiver locations. The evaluation of a solution (an access point configuration) relies on a propagation simulation that computes the coverage map. This simulation is often an expensive computational operation. The goal of the optimization algorithm is to determine a solution that satisfies the coverage constraints with a minimum number of propagation simulations. We have proposed a deterministic algorithm, that exploits both the pre-processing and the multi-resolution specificities of our propagation simulator. Its aim is to find out an access point distribution that provides an homogeneous coverage. A first approach considering a fixed emitting power level and a 2D problem has been proposed in [25]. From this study we want to test several optimization schemes, taking into account different goals (homogeneous coverage, fairness of resources, interference limited configurations, ...), and different algorithms (deterministic or stochastic methods), taking advantage of our multi-resolution algorithm. This is the topic of the PhD work of Katia Runser.

6.1.1.3. Real experiments with 802.11b

Most of the studies about ad hoc networks are based on simulations using rather simple propagation models. The obtained performances of the tested protocols are often biased by these simplistic assumptions. In order to give more realistic models, we have focused on a well known existing technologie, the IEEE 802.11 standard and we have experimented it on actual ad hoc environment. We have conducted measurements in order to characterize the real behavior of computers equipped with 802.11b cards [12][13][2]. We have highlighted in particular the non-circular shape of the communication range of those cards (depending on the orientation, the range can be as much as two or three times larger) and the great instability in the effective packets losses due to the environment. We also measured the communication and interference ranges and observed the so called "grey zones problem" typical to ad hoc networks where more than one transmission speed are used. The impact of these physical phenomena on upper layers protocols (and especially the ad hoc routing and TCP layers) is indeed of prime concern, as the effective performances depend largely on them. All these measures should guide us in the choice of more realistic models.

6.1.2. Modelling interactions in hybrid networks

6.1.2.1. Interactions for quality of service in ad hoc netwoks

In an ad hoc network in which every node plays the same role, we should expect a fair sharing of the medium between the nodes. But bandwidth sharing indeed highly depends on network topology. The more mobiles contend for medium access in a geographic area, the less bandwidth will be available to each one. This is due to the fact that ad hoc networks usually rely on a radio medium which is shared. Unlike wired networks, radio networks require special mechanisms (code or frequency allocation, for example) to isolate one communication from one another, therefore neighbors have to share the same medium.

But, when using a CSMA/CA-like protocol (IEEE 802.11 e.g.), as long as the medium capacity is not exceeded, mobiles can use the medium according to their emissions. If a mobile has to emit twice as much traffic as its neighbors, it is free to do so. When the radio channel becomes saturated, medium share becomes unpredictable.

Considering all these facts, guaranteeing a quite fair medium share in a large network containing regions of different node densities requires the mobiles to limit their emissions. Otherwise, mobiles in sparser regions will keep the medium busy and imbalance in node degrees will result in imbalance in bandwidth allocation.

By exchanging simple information such as degree and allocated bandwidth, mobiles are able to apply a global allocation policy. For example, we should be able to maximize the network use (at the cost of a great unbalance), or on the opposite, to guarantee the exact same bandwidth to every node in the network, at the cost of a reduced global bandwidth.

We designed an algorithm that computes in a totally distributed manner an intermediate solution. The algorithm is a set of interactions between the neighbor mobiles that guarantees a minimum bandwidth to every node in the network while trying to minimize differences between neighbors allocations.

We have simulated this algorithm behavior on regular and random topologies. These results are given in [29]. The resulting allocation is generally below the optimal allocation in terms of global bandwidth allocation but is fairer. The results are similar to the fairest solution considering max-min fairness. Nevertheless, this algorithm still needs to be converted into a protocol by adding mobility and asynchronism in messages transmission.

6.1.2.2. Unfairness interactions in 802.11b based ad hoc networks

The IEEE 802.11 standard is primarily devoted to wireless networks with base stations. But this standard supplies an ad hoc mode that can be implemented with the service Distributed Coordination Function (DCF) of its MAC (Medium Access Control) layer. This service enables communications between mobiles within communication range without the use of fixed infrastructure. Therefore, the merge of this standard with an ad hoc routing protocol enables any communication between any pair of mobiles of the network.

The DCF mode is a random protocol, CSMA/CA like. Each potentiel emitter has to sense the radio medium. If the medium is free, it can transmit, otherwise it has to wait a random time. This random value is decremented as long as the medium is free. If the medium becomes busy, the mobile stops its counter and will use this value as soon as the medium will become free. This ensures that all the mobiles within communication range have the same chance to access the medium. However, this is no longer true in the context of multihop networks like ad hoc networks. Based on simulations and experimentations, we have detected different kinds of unfairness with 802.11b. All cases lead to a severe imbalance of the rates of the mobiles. Three different kinds of interactions have been shown [2]:

- one case is correlated to the hidden nodes problem and leads to many collisions on one pair of the communicating mobiles;
- one case comes from the use of EIFS in 802.11 that corresponds to a longer waiting before having the right to access the medium and that slows down the mobile touched by this EIFS;
- one case comes from the asynchronism of independant mobiles (not within communication range) that prevents the mobiles in competition with them to access the medium.

In some cases, the rate of some emitters is almost null. This phenomenon may have a strong impact on the performance of ad hoc networks and the associated protocols. These results show that adapted MAC protocols are a necessity.

6.1.3. Performance evaluation in hybrid networks

6.1.3.1. Traffic and mobility characterization in mobile networks

This year, we have focused our work on a global study of traffic and mobility characterization in mobile networks as GSM. This contribution was done during the Phd. of Mrs Houda Khedher who will defend her Phd during March 2004. The goal was to provide a new cellular network planning methodology that takes into account global information and more specifically local properties. Global information represents the flows exchange among cells while local properties are binded to the traffic characterization. This work is based on real-world performance measurements collected and recorded in normalized counters according to the OMC (Operation Maintenance Center) of a well-known telecommunication operator. In the global approach, we have done a detailed characterization of cells behavior. Behavior is characterized by the traffic intensity variation during the day and the week for different services area such as: highway, campus, downtown, popular and middle-class suburbs, manufacturing district. We have shown the impact of taking into account such precise informations on planning and cellular network performance. This study has allowed a mobility model well-adapted to cellular network with a mobility matrix between services area to be provided. Local approach deals with traffic characterization and traffic process. Because cellular network performances are impacted by both arrival and service process, it is necessary to define precisely such process. Using a classical Kolmogorov-Smirnov test, we have proposed a characterization of new call arrivals, handover arrivals and channel holding time for each services area mentioned above [17]. A characterization means the process and the process parameters. The next step will be to implement these results in a global simulator of cellular network wich takes into account more information to help telecommunications operator in cellular network planning. Because, ARES team focuses on hybrid networks, we think that the competences acquired should be helpful in order to model and to analyze hybrid network performance.

6.1.3.2. Performance evaluation of a 802.11b based ad hoc network

In order to evaluate the unfairness of 802.11 (as previously described), we modeled a particular scenario using discrete time Markov chains. The scenario consists in three pairs of mobiles contending for medium access. Each pair is composed of an emitter trying to saturate the radio channel (i.e. a frame is always ready to be transmitted) and a corresponding receiver. The three pairs are placed so that one pair interferes with the two others while the two others are independent.

Solving the Markov chain shows that the central pair gets a medium share below 5% where it should expect one third of the bandwidth. Results of the Markov chain solving for different frame sizes and different protocol behaviors are gathered in [28][7].

The main problem we have to face is the size of the Markov chain to solve. A parallel computer is required to solve most of the configurations we tried. Therefore, we plan on applying optimization techniques (lumpability, e.g.) in order to reduce the size of the problem and apply this method to more complex systems.

6.1.4. Perspectives

All these works have provided some fundamental elements of the global modelling. During the next years, we will focus our work on collaborative aspects between these research topics and we would like to answer some of these questions:

- How could we define a suitable radio link model for ad hoc simulations? This implies a deep study of usual radio interfaces. We will focus this work on the IEEE 802.11b norm. We will have to define what is a good accuracy level for propagation modelling and how more realistic interference schemes could be defined.
- Is it possible to modify the radio interface in order to reduce unfairness situations? The use of MIMO techniques, multi-channels or smart antennas will be investigated.
- Starting from the three identified unfairness situations, how could a formal modelling using Markov chains improve the understanding of these problems?
- How could the use of traffic and mobility models be taken into account in the planning of the fix architecture of wireless LAN? Which rules can be established to define what is a good infrastructure in hybrid networks?

6.2. Protocols design

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

6.2.1. Architectural design

Based on the draft of ana6[1], describing an IPv6 Addressing Architecture Support for mobile ad hoc networks, we have developed further our view of a global architecture for an ad hoc network. The notion of IPv6

[1] http://www.dfn-pca.de/bibliothek/standards/ietf/none/internet-drafts/draft-chelius-adhoc-ipv6-00.txt

connector introduced allows several network interfaces to be virtualized into a single addressable object. A host may have several ad hoc connectors and an interface may be bound to several ad hoc connectors. The ad hoc connector defines a set of addresses which indistinctly identify all bounded interfaces. This notion of ad hoc connector is “simply” implemented in IPv6 by defining a third IPv6 local-use unicast address: ad hoc local addresses. Their validity is limited to an ad hoc network. They provide a basic identification support for ad hoc nodes that can be extended by other configuration mechanisms such as stateless global address attribution. In the IPv6 architecture scheme, an ad hoc network may be at the same time, a multi-link subnet and a multi-link multi-subnet. Considering the whole ad hoc network as a multi-link subnet is achieved by matching a particular multicast scope, the subnet scope, with the ad hoc network. To support the multi-link multi-subnet vision, the notion of logical ad hoc sub-networks, also called area, is introduced. A area is a connected set of ad hoc connectors sharing a common area value. A specific range of multicast addresses is associated to each area. It enables the restriction of multicast groups to a given area. An implementation of this IPv6 ad hoc framework is currently done under FreeBSD.

We have also conducted works on the design of a hybrid architecture. This work clarifies the design of an ad hoc network connected to a fixed wireless infrastructure and explores the different ways of handling handover. Research on mobile wireless networking has roughly been concentrated on two distinct areas. The first theme is concerned with seeking the way to extend the edge of the traditional network infrastructures with a last wireless hop. Wireless connectivity is provided by base stations and mobile users are able to switch between base stations while moving around. The second theme corresponds to the spontaneous self-organization of networks of devices. Research efforts put into integrating these two fields of wireless networking – wireless access to a fixed network and ad hoc networking – are increasing. The goal of our architecture is to provide connectivity to a global network infrastructure for an isolated ad hoc node. Our aim is to highlight the problems encountered while merging the two concepts and to propose several solutions. In order to increase the flexibility of the infrastructure networks, we consider wireless links between base stations in the access network [10].

6.2.2. Auto-organization

In order to be able to use ad hoc networks on a very large scale, flat routing protocol (reactive or proactive) is really not suitable. Indeed, both routing approaches become ineffective for large scale wireless ad hoc networks, because of link (flooding of control messages) and processing overhead (routing table computation). One well known solution to this scalability problem is to introduce a hierarchical routing by grouping geographically close nodes to each other in clusters and by using a "hybrid" routing scheme: classically proactive approach inside each cluster and reactive approach between clusters. Such an organization also presents numerous advantages such as more facility to synchronize stations in a group or to attribute new service zones.

In our work [33], we propose a novel metric suitable for organizing an ad hoc network into clusters and we propose a new distributed cluster head election heuristic for an ad hoc network. Our new metric does not rely on "static" parameters and thus our novel heuristic extends the notion of cluster formation. The proposed heuristic allows load balancing to insure a fair distribution of load among cluster heads. Moreover, we implement a mechanism for the clusterhead election that tries to favor their re-election in future rounds, thereby reducing transition overheads when old clusterheads give way to new ones. We expect from network organization to be robust towards node mobility.

We have also investigated gateway and address auto-configuration for IPv6 ad hoc networks. The particular nature of an ad hoc network makes it impossible to use the classical IPv6 mechanisms used in wired networks in order to propagate prefix information. We have specified a protocol (node behavior, information propagation, message format) which allows nodes in an ad hoc network to discover gateways and their associated IPv6 prefixes. One of the pair gateway/prefix is then used by each node in order to build an IPv6 global address and, when necessary, to maintain a default route towards the Internet. Specific mechanisms are included to act in response to topological changes and to avoid the diffusion of false information after nodes movements [36].

6.2.3. Virtual topology for hybrid networks

This work was initiated last February'03 with Fabrice Theoleyre, currently Phd. student in the *ARES* team.

We propose to organize an ad hoc network through a virtual topology. We consider a virtual topology as a hierarchical organization based on both backbone and clusters. Our proposition is to connect *better nodes* to structure a collaboration between them in order to provide services (as routing and mobility management) to the rest of the ad hoc network. Such an organization of *better nodes* is called virtual topology and is based on both virtual backbone and cluster. Because of heterogeneity, *better nodes* are the nodes which are more well-suited -due to their mobility, energy, neighborhood density, ... - to collaborate. We propose to integrate both backbone and clusters to offer control on the distributed topology. A cluster can be viewed as a service area and a way to group relatively close nodes. A backbone is used to concentrate control traffic about topology management, routing protocols, to connect clusters, etc. The advantages of virtual topology are:

- scalability: because MANets are limited by a high number of nodes, clusters can gather mobile nodes and backbone can concentrate flooding and routing packets in order to minimize the storm problem. Such a decomposition facilitates a local routing protocol restricted to the cluster only and a global routing protocol using backbone;
- to facilitate integration of MANets in a wireless/wired infrastructure using the root of the virtual backbone. It can be viewed as a spontaneous extension of a wireless infrastructure and offers a natural way to manage hybrid networks;
- to offer a framework to implement new services as mobility management, paging and localization services, native multicast support, etc.;
- to hide node neighborhood changes using a top-level view of MANets where less topology change occurs because we focus on the neighborhood change only for *better nodes* which are members of both backbone and clusters. Virtual topology stabilizes neighborhood and simplifies network heterogeneity and topology;
- because MANets are composed of heterogeneous nodes, virtual topology classifies *better nodes* as dominants and others as dominated. For example, dominants participate in virtual topology in order to minimize the energy consumption. It gives a hierarchy of node contribution.

Currently, we have proposed new distributed algorithms for construction and maintenance procedures where we take into account both backbone and clusters constraints simultaneously. Because *better nodes* are chosen on a weight metric, we have studied weight impact. We have therefore proposed a stability weight that takes into account node degree, mobility and energy available [34].

The next steps will deal with routing protocols over such virtual topology and with implementing mobility management as localization/paging strategies.

6.2.4. QoS in ad hoc networks

802.11 is the current technology that enables the communication between mobiles within communication range. Due to its success and its simplicity, researches on ad hoc networks often assume that 802.11 is the underlying technology. But several works (in which we have taken part) have shown some dysfunctions of 802.11 in the ad hoc context. This may have a strong impact especially on the QoS protocols in ad hoc networks that need to offer some guarantees. We have proposed different protocols that take into account the features and the anomalies of 802.11 in ad hoc networks. We have investigated the QoS notion at different levels: we have proposed two modifications of 802.11 to ensure a better fairness at the MAC level and we have designed a system for video transmission.

6.2.4.1. Protocols to solve unfairness in 802.11 based ad hoc networks

As mentioned in Section 6.1, we have characterized different ad hoc topologies where 802.11 has an unfair behavior. Bensaou et al. (Bensaou, B. and Wang, Y. and Ko, C. C, *Fair Medium Access in 802.11 Based Wireless Ad-Hoc Networks*, First Annual IEEE and ACM International Workshop on Mobile Ad Hoc Networking and Computing, 2000) have proposed a modification of 802.11 in order to reduce unfairness in some of these topologies. This protocol ensures a better rate per node but after a decrease of the global bandwidth. After a deep study of this protocol, we have shown that all the mobiles stabilize their contention window on the maximum value, which leads to a long wait before accessing the medium for each mobile. Then, the protocol drastically reduces the overall bandwidth. We have proposed a modification of Bensaou et al.'s protocol: we have introduced different rules that delay the changes in the contention windows size and we have modified the evolution of the contention windows. These modifications give to the mobiles a reasonable size to their contention window while ensuring a certain fairness between the mobiles. The overall bandwidth is thus increased [2].

6.2.4.2. A routing-aware adaptive medium access control protocol

In mobile wireless ad hoc networks, fair access to the shared wireless medium among different contending stations is a very important issue. Because each node in wireless ad hoc networks, in addition to its own packets, has to forward packets belonging to other nodes, selfish behavior may represent a significant advantage for a node to save its battery power and reserve more bandwidth for its own traffic. However, if a large number of nodes start to behave non cooperatively, the network may break down completely, depriving all users of services. In order to avoid the misbehavior of certain nodes and alleviate the bandwidth share unfairness among all the mobile nodes, we have described and evaluated a routing-aware adaptive medium access control protocol (RAMAC) in IEEE 802.11 based wireless ad hoc networks, which takes into account both a node's own and routed data traffic, and tries to give the same approximate bandwidth share to every mobile node to transmit its own traffic. Simulation results show that the proposed RAMAC scheme improves substantially the bandwidth share of the mobile nodes to use for their own traffic transmissions while participating in the routing service [24][23].

6.2.4.3. Video Transmission over IEEE 802.11 Wireless Networks

Video transmission over the Internet is becoming very popular with the majority of the applications transporting stored pre-encoded video from server to client. These new applications have strict timing and loss requirements, which the current deployment of the Internet is unable to guarantee. To enable quality streaming real time video, the application has to be rate adaptive and use feedback signaling to learn about the network condition in order to adjust its sending rate and match the available network bandwidth. In this work, we have presented solutions to the problem of transmission of real time MPEG-4 video application over IEEE 802.11 wireless networks based on a packet losses adaptation system. The system developed uses the concept of application-level framing (ALF). Because dealing with data loss is application-dependent, the application, rather than the transport layer, is the best capable of handling these losses appropriately. The main contributions of this work are: (1) an end-to-end congestion control algorithm which is capable of estimating available network bandwidth based on the packet loss information at the receiver; (2) a quality adaptation mechanism which adjusts the quality of the MPEG-4 video according to the available bandwidth in appropriate fashion. To demonstrate the performance, we have designed and implemented a framework that adapts for variations in packet loss and uses frame discarding scheme to assure a good quality perception. These mechanisms have been integrated into publicly available software to evaluate the quality perception of the video transmitted from a video server to a wireless terminal [22].

6.2.5. Multicast

Multicasting remains an efficient communication service. Using trees is evidently more efficient than brute force approach of sending the same information from the source individually to each of the receivers. However, trees have by definition an edge connectivity of 1, each path inside a tree appears as a critical path in terms of link failure. In a mobile ad hoc network environment, multicast tree structures are not reliable and must be readjusted as the connectivity changes among the multicast members and sources due to the mobility of nodes. In order to overcome this major tree's drawback, mesh oriented structures have been proposed: they exploit the robustness of mesh structures to handle frequent route failures and gain in stability at the expense of bandwidth and scalability.

To realize a tradeoff between robustness and scalability, we propose a new way of multicast routing in ad hoc networks, Dense Multicast Zone Routing (DMZ). Based on the dense zone notion (regions of the network where any multicast diffusion structure will be reduced to a local broadcast), DMZ creates a source-based forwarding structure reaching all dense zones. DMZ also monitors the robustness of the structure and thus is able to dynamically adapt the interdense zone structure in order to reach an acceptable robustness factor. The first argument for the use of dense zones is that it is not worth building complex structures to finally perform a simple broadcast. The second argument is that broadcast schemes may be more reliable than multicast ones [8][11][6].

6.2.6. Energy constraint

We have initiated a study on the energy consumption in wireless ad hoc network. There has been an increased awareness of energy efficient protocol need for battery-powered devices in recent years. Though the optimization of the sensor network lifetime must take place at each stage, we focus mainly on the sensing and communication levels. Indeed, data transmission and reception using a wireless medium appears to be a highly energy consuming process. More precisely, our work is focused on a specific communication pattern called broadcast, where data are distributed from a source node to each node of the network. Broadcast is a common and frequent process during a sensor network lifetime. It is useful for auto-organization, parameter/data dissemination, or control regulation. Conventional energy aware protocols manage the energy consumption by adjusting the transmission power of sensor nodes. Nodes are assumed to adapt their transmission power to the minimum required to sustain communication.

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

In the future, possible extensions of this work are open to investigation. In order to closely follow the reality of sensor networks, we are currently investigating the integration of discrete levels of energy in our mathematical model. These levels would replace the continuous range of possible transmitting powers we are currently using. Once again, the challenge is to adapt our continuous theory to a pseudo discrete case.

We have also investigated a new way of saving energy in mobile devices using IEEE 802.11 network interfaces to communicate, which is achieved by adding consecutive frames into a single one and gathering their headers. This mecanism focuses on IEEE 802.11 infrastructure networks [20][26].

In the same time, we are working on new models for energy consumptiom computation based on experimental results obtained from various networks interfaces (i.e. Bluetooth, IEEE 802.11a/b/g, etc.). Using these models, we can obtain the power consumption of the network interfaces according to the duration of the communications and the amount of data transfered to and from a device [21].

6.2.7. Perspectives

All these works have provided some fundamental elements on protocols design: multicast, QoS, and also practical implementation of an ad hoc architecture both in IPv4 and IPv6. Possible extensions of this work are open to investigations. During next years, we will focus our work on improving the results and finding new analytic results in order to increase the collaboration researches done on hybrid networks modelling in the *ARES* project. Open questions and future researches are:

- In order to closely follow the reality of sensor networks, we are currently investigating the integration of discrete levels of energy in our mathematical model. Once again, the challenge is to adapt our continuous theory to a pseudo-discrete case.

- Concerning the design of an efficient broadcast algorithm, improvements can be made in order to be more robust regarding random sensor dispatching.
- To develop and deploy the Dense Multicast Zone Routing above ana6 in order to have a large ad hoc testbed supporting a fully compliant IPv6 stack.
- We also intend to propose a way of routing in large ad hoc network using the density metric proposed in the the auto-organization scheme and thus perform node locating over such a hierarchy. We are currently investigating the use of purely distributed hash function in order to solve this key problem.
- To propose efficient QoS protocols, we intend to use results obtained from the modelling part and to integrate the QoS notion in more than one level of the network stack.

6.3. Services deployment and administration

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Key words: *Middleware*, *services instrumentation and administration*, *security*.

6.3.1. *Services oriented framework*

In the context of a hybrid network, a framework addressing the major challenges described in Section 3.4 needs to be services oriented to be generic. In those environments, interface of services and implementation of services have a different life cycle. That asynchronous association enables a framework to satisfy a client (through the interface access) even if the service implementation is not yet available. An automatic way to instrument and to allow remote management control of distributed services becomes mandatory. Based on all these strong requirements, *ARES* is addressing different services oriented environments: OSGi environment and J2EE environment.

For services deployment and administration, we also believe that the concept of federation of applicative nodes is a central piece for services deployment and administration. A federation is a set of heterogeneous nodes that can be remotely managed and that provides services either for their clients (in the pervasive domain) or for the community (in the GRID domain).

Each application domain provides its own problems and limitations, and *ARES* has defined two scenarii that characterize these two domains. The wavecar scenario describes a pervasive environment enabling the management of applications hosted on remote locations. A large scale administration architecture for services management has been defined [37] which enables remote management of applications (synchronization of data, services discovery and updates, ...).

For characterization of the GRID domain, we use the WILDE application (see Section 5.4) reengineered in terms of services that are deployed over different execution locations. The management architecture in that domain enables us to dynamically relocate a service implementation considering its consuming resource. Thus we can provision a node with new services as it becomes available to the network. Our architecture aims at defining the initial provisioning of frameworks, remote execution of services and adaptation to available environments.

6.3.2. *Services instrumentation*

In the context of services oriented applications addressed by *ARES*, hot plug services can be dynamically deployed or re-deployed. All management information attached to a service will also be automatically deployed for each new service. Inside each service, we need to systematically offer commands allowing the deployment, the configuration and the instrumentation in order to be able to remotely administrate every service.

This work has been done both for the OSGi environment [31] and the EJB environment [15].

We can identify two aspects in the supervision of systems: management and instrumentation. Instrumentation systems extract information from the resources of the supervised system. Management systems exploit this information and enable management operations over the instrumented resources. Management and instrumentation are then complementary for the supervision of systems.

Our first step was to define a unified instrumentation view of the application servers environment. For each application server we mainly identify three environment levels that affect the execution of components, and thus should be instrumented. These levels are the system low level (Network and OS), the application server level, and finally the components level. We define a global multi-layered instrumentation view which enables the application server to have a global view of its execution environment. Our motivation behind this instrumentation is to enable the deployment of components over application servers in the federation according to the nodes' characteristics such as the bandwidth utilization, CPU availability, memory usage, application server load, and available components services.

Instrumentation on each level is, however, handled independently from other levels. People interested in network and system domain developed their dedicated instrumentation systems. The Network Weather System (NWS), for example, is one of the instrumentation systems from academia. Other industrial instrumentation systems are vendor specific. At the application server level, JMX is the instrumentation proposal used by most AS vendors to implement the J2EE management specification presented in the JSR 77. Finally at the component level, few efforts are made in the area of application instrumentation like in the Application Response Measurement (ARM) and Application Instrumentation and Control AIC from The Open Group, these efforts however are not exploited for components and require manual insertion of the instrumentation code.

The architecture that we propose presents a unified instrumentation view for all nodes in a federation of application servers where each node presents the three environment levels. Having a unified instrumentation view, all nodes in the federation can be accessed for management in a standard manner. We use JMX for the implementation of this unified instrumentation view. For each level, we specify which elements should be instrumented according to the component requirements in order to enable the deployment management in the federation. Namely, from system low level the instrumentation view includes the CPU, memory, disk and bandwidth utilization. From the application server level the instrumentation view considers both standards AS services and additional specific services. The component level is depending on the platform.

6.3.3. Services performance evaluation

In the context of dynamic services oriented distributed plateform, there exists a central question before deploying a new service: are local resources sufficient to host a specific service? If the target service is defined in the context of *Grid environment* - i.e. the target service needs large CPU resource, the ARES project has proposed a predicting model.

We first assume that the service is proposed in the J2EE standard. Local resources are viewed as a federation of application servers and the deployment is proposed to this federation rather than on a specific server. A servers' federation is a collection of heterogeneous hardwares of different capacitie running a EJB container. Each server presents a specific behavior as more and more clients simultaneously access the system, but share a common administration policy. A client is exterior to the federation - should be a fix computer somewhere on the Internet or a mobile PDA, asking for a Grid service deployment.

In our approach a performance prediction mechanism is triggered before deployment [15]. An *EJB provider* has to evaluate its component on a dedicated server and the framework deduces performances on real production servers of the federation. Since EJB components are externally accessed through the Java RMI layer we have shown that the round robin behavior of RMI enables a simple CPU load prediction model that only relies on the total number of concurrent clients accessing the server. That standard result of the round robin queuing system enables us to build a simple deployment management mechanism on a federation of servers.

When benchmarked, the *client* has a characterization of the EJBs' consumption in terms of CPU. Depending on the targeted machine in the application servers federation, the response time of its EJB should be predicted and a hosting contract could be negotiated between the *client* and the federation. The aim of the contract is to guarantee an execution time for a specific cost.

The work has been conducted in the context of a large project called DARTS (Deployment and Administration of Resources, Treatment and Services) founding by the French ministry of research (ACI GRID).

6.3.4. Hybrid security model

Since security is a major challenge of *ambient networks*, *ARES* has proposed a global view of security management and to study specific aspects according to hybrid environment. A global security approach needs components in various places of the architecture. This work is far from being complete and the proposed model has to be improved. Therefore, the proposition addresses most aspects of the security management.

Trust is an important element of any security architecture, particularly in such an environment where the active compromise of nodes is a real threat. Many existing studies on specific ad hoc security management assume a pre-existing trust relationship [19]. This assumption can be acceptable in a large range of potential applications - such as the military context - but does not correspond to the most common scenarios that one would come across in everyday life. In ambient networks, whether comprised of devices having ad hoc capabilities or not - the term used to define security is context awareness. “Ambient awareness is the process of a personal computing device in acquiring, processing and - in the background, possibly unattended by the user - acting upon application-specific contextual information, taking the current user preferences and state of mind into account” [2].

The *ARES* proposed architecture is based on three main concepts:

- Imprinting model: the imprinting procedure is a strongly secure way to link a device with a user; this operation supposes physical contact in a secure environment; during this operation, verification of the integrity of the terminal should be done; everything needed to set up security management process has to be deployed on the terminal during this operation. Investigation has been conducted in this direction. An external secure key with computational capacity is used in our model to deploy on the terminal a *seed of trust* which is a merging of secure data and cryptographic tools. An *imprinting station* - a fix terminal connected to the Internet should be used at this moment to complete information coming from the key with information obtained from a trusted server (user profile, pre-existing history of the user, huge size data and so on).
- Cryptographic identification: in the *ARES* view of a hybrid environment, every terminal receives an unique identification therefore, we suppose that verification of this ID can not be done during interaction between terminals by a trusted third party because the Internet may be unreachable at the moment of interaction and also because no central server is supposed in this model; cryptographic identity generation scheme has to be used by terminals to prove their ID has not be usurped (doing so, the terminal also proves it is accepting the model).
- Trusted Ambient Community: we propose a trust management scheme matching this definition of context awareness [32]. 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 will take advantage of any encountered access points to contact fixed servers. We believe that trust cannot be attributed to a Boolean value, but must entail various levels of trust belonging to various levels of offered services. 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 merge of context awareness and recommendation schemes. The basic mechanism is based on the notion of *node history*, which is used to build a specific shared secret. Then, nodes aggregate when exchanging data and services into an ambient community, which is the ultimate level of organization.

[2] P. Jonker and al., *Philosophies and technologies for ambient aware devices in wearable computing grids*, Elsevier Computer communications, 26, 2003

6.3.5. Perspectives

We are currently working on an OSGi extension supporting our service oriented distributed platform. Our approach offers a large flexibility and allows us to deploy an instrumentation framework of distributed services applications.

Our future work in this area is to design a more ambitious framework and to propose a *peerware* (using JXTA) that will enable to connect several OSGi platforms. Using such a paradigm, our approach still provides a global remote management of all OSGi platforms. The underlying idea that we are currently implementing is to use a middleware concept to exchange information based on a peer-to-peer approach.

Our performance evaluation scheme has also to be improved in various ways, and adapted and included in the global services oriented distributed platform. First, other parameters have to be benchmarked, namely the network bandwidth consumption. There exist also jobs to do in the area of sincerity control mechanism: since the EJB provider indicates which of the EJB methods consumes the most, there can be errors if this is not the case. Each federation member needs to trigger a sincerity control mechanism that verifies that every EJB component stays in its negotiated values.

The global security architecture is essentially defined for an ubiquitous environment rather than for a Grid domain. Therefore, the model should also be compared with existing security models in the context of the GRID. In pervasive computing, the architecture is open to a variety of possible security threats for which currently there is no global solution. Trust management is a key issue, its implementation being not only a technological problem but also a philosophical problem. We will study various policies for trust establishment. An ideal solution for a trust management architecture would therefore need to be flexible in order to be easily adaptable to any context - perhaps incorporating the possibility of the coexistence of various trust policies within the same architecture.

8. Other Grants and Activities

8.1. Regional initiatives

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

Altophone The European regulatory authorities are about to change the laws that deal with the proscription of cell phone silencers, towards the acceptance of intelligent systems. The French Telecommunications Regutator (ART France[3]) has initiated the law number 2001-624 (July 17, 2001) which deals with a restriction mode for GSM cell phones in order to block incoming and outcoming calls in selected areas (courts, museum, amphiteatre of university, ...) and to authorize only emergency calls. This project was done with Altophone SA which owned international patents on architectures of jamming and filtering radio-mobiles communications.

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

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

SeeWan The regional incubator CREALYS supports the creation of a start-up which aims to propose tools for planning wireless LAN. The CITI contributes to this project under an agreement between the region Rhone-Alpes, INSA Lyon (CITI) and the contractors. Our team is charged to provide the heart of the software, i.e. the propagation engine, while the start-up should develop the user interface and define the end-user needs for such an application.

8.2. National initiatives

SAFARI The SAFARI project[4] aims to design, to combine and to carry out a framework of protocols and softwares required for the transparent access, the automatic configuration, the services integration and adaptation into a IPv6 network in ad hoc configurations with wired accesses. The added value of this project is the design of new protocol and software solutions based on existing standards (IPv6, multicast, proxies, active networks, etc.) and adapted to the dynamic features of the network infrastructure and of the services demand and continuity. The different partners of the project are FTR&D, ALCATEL, INRIA, LIP6 (Paris 6 University), LRI (Paris Sud University), LSIIT (Strasbourg University), LSR-IMAG (Institut National Polytechnique de Grenoble), SNCF and the École Nationale Supérieure des Télécommunications.

GASP The goal of the project is to propose a portable approach for the application development in an ASP (Application Service Provider) process with a Data Grid distributed architecture. GASP's (Grid ASP) main idea is to port industrial applications on software developed by our research projects and to reuse existing, portable and " standard " software. GASP contains 10 sub-projects which will last 24 months. After studying the state of the art and defining the specifications of each different component, the software architecture of the middleware will be developed and evaluated. Then, the middleware will be validated on the two target applications: digital simulation of electronic components and the digital models of ground. Meanwhile, a hierarchical version of the agents will be carried out on VTHD (Vraiment Très Haut Débit) and the supervision, safety, authentification and accounting aspects will be added to the product. The last task will consist in passing in industry the resulting software architecture after validation on our applications.

8.3. Ministry Grant

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

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

[4] http://www.telecom.gouv.fr/rnrt/projets/res_02_04.htm

8.4. European initiatives

MUSE MUSE is an European project inside the FP6 Work intiative. Alcatel is the prime contractor. MUSE will be starting by the end of 2003.

The overall objective of MUSE is the research and development of a future low cost, full service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen. The proposed project integrates studies in the following areas:

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

The concepts of MUSE will be validated for three end-to-end deployment scenarios:

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

The expected impacts and results are:

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

8.5. Visiting scientists

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

9. Dissemination

9.1. Leadership within scientific community

Éric FLEURY is:

- the leader of the CNRS TAROT action (Techniques Algorithmiques Réseaux et d'Optimisation pour les Télécommunications);
- a member of the steering committee of the RTP (Réseau Thématique Prioritaire) *Réseau de communication* of the CNRS;
- a member of the project VISON (*Vers un Intranet Sécurisé et Ouvert au Nomadisme*);
- a member of three PhD examining boards: Julien Cartigny, Lille; Yon Dourisboure, Bordeaux I; Hend Koubaa, supervisor, Nancy I.

Stéphane FRÉNOT is:

- elected representative with the council of the Telecomunications Department of INSA-Lyon;

Jean-Marie GORCE is:

- elected representative with the council of the Telecomunications Department of INSA-Lyon;
- an expert for the CMIFM (Comité mixte inter-universitaire franco-marocain) for the evaluation and the follow-up of scientific projects in telecommunications;
- a member of the Research group (GDR) ISIS (Information, Signal, Images and Vision) of CNRS.

Isabelle GUÉRIN LASSOUS is:

- the leader of the research field *ad hoc networks* in the CNRS Specific Action (AS) Dynamo (Structural Analysis and Algorithmic in Dynamic Networks);
- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- a member of the INRIA committe that allocates the INRIA post-doctoral grants;
- a member of one PhD examining board: Dominique Dhoutaut, supervisor, INSA de Lyon;
- a member of the INRIA Rhônes-Alpe committee of computer resources (CUMI).

Farid NAIT-ABDESSELAM is:

- a member of G6 (group of IPv6 experimentation in France) and the leader of the IPv6 interconnection in Lyon;
- a member of the group RHDM (High-speed and Multimedia Networks).

Stéphane UBÉDA is:

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

Fabrice VALOIS is:

- a member of the group TAROT (Techniques Algorithmiques, Réseaux et d'Optimisation pour les Télécommunications);
- a member of the specialists committee (section 27) of the INSA-Lyon;
- elected to the Telecommunication department committee of the INSA-Lyon.

9.2. Conferences, meetings and tutorial organization

Claude CHAUDET and Guillaume CHELIUS organized the TAROT meeting at the INSA of Lyon (16-17 october 2003).

9.3. Teaching

DEA DISIC - INSA DE LYON

- Eric Fleury and Isabelle Guérin Lassous gives a lecture on *Ad hoc Networks* (20h);
- Jean-Marie Gorce and Fabrice Valois give a lecture on *Networks Planification* (20h).

ECOLE CENTRALE DE LYON

- Isabelle Guérin Lassous give a lecture on *Mobile Networks* (10h).

UNIVERSITÉ LYON I

- Isabelle Guérin Lassous gives practical exercises on *Graphs and Automats* to second-year students in DEUG (27h).

INSA DE LYON

- Stéphane Frénot, Jean-Marie Gorce, Farid Nait-Abdesselam, Stéphane Ubéda and Fabrice Valois are professor/teaching assistants at the INSA de Lyon;
- Eric Fleury gives lectures on *Mobility principles* and *Multicast* (20h);
- Isabelle Guérin Lassous gives a lecture on *Ad hoc Networks* to the fourth-year students (6h);
- all the members supervise engineer projects.

9.4. Conference and workshop committees, invited conferences

Eric FLEURY is:

- a member of the program committee of Wireless, Mobile and Ad Hoc Networks (WMAN 2003) conference:
- a member of the program committee of DIALM 03 workshop (Discrete Algorithms and Methods for Mobile Computing and Communications);
- a member of the program committee of AlgoTel 2003 (Algorithmique des Télécommunications);
- a member of the program committee of the special issue *Réseaux et protocoles* of the journal TSI (Techniques et Science Informatiques).

Jean-Marie GORCE is:

- a member of the technical committee of the "journées scientifiques francophones 2003 en Electronique, Télécommunication, Informatique", 20-22 décembre 2003, Tozeur, Tunisie.

Isabelle GUÉRIN LASSOUS has been invited:

- to give a talk at the colloquium *OPTIMISATION ET TELECOMS* of the LIX at the Ecole Polytechnique.

Stéphane UBÉDA is:

- is a member of the program committee of International Workshop on Wireless Ad Hoc Networking 2004, Japan.

Fabrice VALOIS is:

- a member of the program committe of the national conference AlgoTel 2003 (Algorithmique des Télécommunications).

9.5. Miscellaneous

9.5.1. Defended PhDs

- Dominique Dhoutaut, *Etude du standard 802.11 dans le cadre des réseaux ad hoc : de la simulation à l'expérimentation*, 11 december 2003, jury: Stéphane Amarger, Andrzej Duda, Isabelle Guérin Lassous, Philippe Jacquet, Guy Pujolle, François Spies, Stéphane Ubéda.

9.5.2. On going PhDs

- Nada Al Masri, *Administration et fédération de serveurs d'applications*, INSA de Lyon;
- Claude Chaudet, *Qualité de service dans les réseaux locaux sans fil*, INSA de Lyon;
- Guillaume Chelius, *Intégration et support pour les réseaux hybrides*, INSA de lyon;
- Nathalie Mitton, *Auto-organisation et réseaux ad hoc*, INRIA
- Katia Runser, *Planification de réseaux sans fil*, INRIA
- Fabrice Theoleyre, *Gestion de la mobilité dans les réseaux hybrides*, INSA de Lyon.

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[2] D. DHOUTAUT. *Etude du standard 802.11 dans le cadre des réseaux ad hoc : de la simulation à l'expérimentation*. Ph. D. Thesis, INSA de Lyon, December, 2003.

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[11] G. CHELIUS, E. FLEURY, F. VALOIS. *Adaptive and Robust Ad hoc Multicast Structure.* in « 14th IEEE International Symposium on Personal, Indoor and Mobile Radio Communication (PIMRC 2003) », IEEE, Beijing, China, September, 2003.

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