INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team POPS

System & Networking for Portable Objects Proved to be Safe

Futurs

THEME COM

Activity Report

2007

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2. Overall Objectives

2.1. Introduction

Keywords: *Embedded operating system*, *POPS*, *ad hoc networks*, *exo-kernel*, *mobility*, *smart card*, *wireless networking*, *wireless sensor networks*.

The POPS research group studies solutions to improve programmability, adaptability and reachability of "POPS" (Portable Objects Proved to be Safe). The POPS family contains small and limited devices like smart cards, RFID tags (see Fig. 1) [55], wireless sensors (see Fig. 3) [47] or personal digital assistants. Such small devices are characterized by limited resources, high mobility, frequent disconnections, low-bandwidth communications, passive (no battery) or limited battery life and reduced storage capacity. Moreover, in spite of these constraints and because of the use in an untrusted environment, users and applications require high security level for POPS. The development of applications integrating POPS suffers from lack of "*reachability*" of such platforms. For instance, software development is penalized by exotic and limited operating systems. Indeed, POPS, such as smart cards, are difficult to program and high level of expertise is needed to produce software. Some efforts were taken recently with the advent of Java Cards [44], PalmOS or Windows CE. But Java Card offers a very small part of Java API and a typical application written in Java cannot be directly translated to Java Card. POPS mobility induces sudden and frequent disconnections, long round trip times, high bit error rates and small bandwidth. Hence, POPS systems have to adapt themselves to application requirements or modification of the environment.

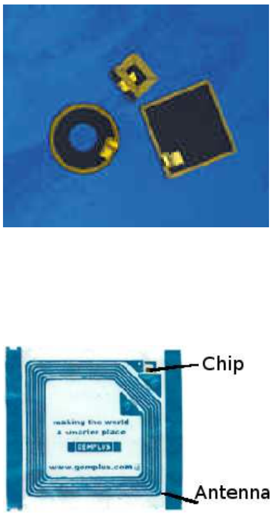


Figure 1. Example of RFID tags.

Indeed, the application should guide the system. Therefore, the POPS research group aims to propose a generic approach allowing any application to specialize the system according to its own needs and characteristics (See Fig. 2). Since POPS are limited in capacity, specializing the system for the application will allow to embed much less code and functionalities.

POPS research action takes advantage of its strong partnership with Gemplus/Gemalto since more than 17 years. This collaboration brings both partners (the POPS research group of LIFL and Gemplus/Gemalto) to high level of expertise in embedded operating system design and mobile networking which are our two main research activities.

2.1.1. *Embedded Operating Systems*

We focus our activities on "adaptability" and on "connectivity" of embedded platforms dedicated to POPS. From then on, our researches have evolved around the smart card. In fact, in the nineties (birth date of POPS research group) smart card was the only valuable and industrially deployed POPS. Smart card integration in database management systems, smart card integration in Corba (using the Card Object Adapter), open platform

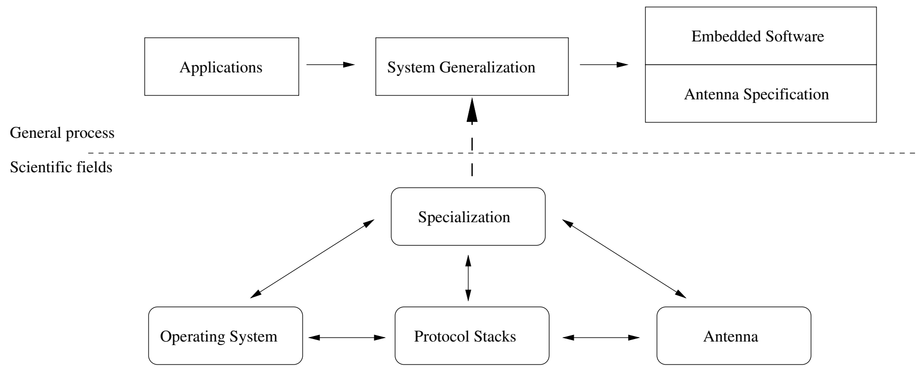


Figure 2. POPS' thematics and objectives.

for smart card (the first smart card virtual machine), have been milestones of the POPS research. More recently, we have focused our attention (according to our industrial inputs) on embedded operating system techniques, enabling "on-card" type checking and bytecode compression. Today, smart card manufacturers and other emerging POPS manufacturers have to deal with new technological 'lock-in' inside and outside the mobile object. Dedicated operating systems are now powerful enough to run dynamically downloaded applications in a safe way. Typically, Java Card loads and runs a Java-like bytecode. Nevertheless, "Java-like" means "non-Java". Embedded virtual machines do not support standard abstractions. And so, Java applications cannot be deployed in a limited embedded system. On the other hand, embedded applications do not limit their needs to the Java APIs. To overcome these limitations, we will focus on two complementary studies:

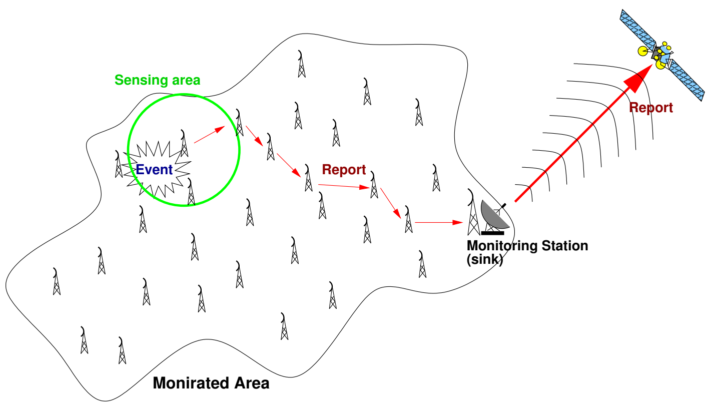
1. Firstly we study a new architectural way to embed a Java virtual machine. Conventional virtual machines are not operating systems but they overlap the abstractions proposed by the system. We plan to define a Java virtual machine designed to be the operating system (the virtual machine will manage the hardware itself).
2. Java is one of the possible hardware abstractions. However different applications require different abstractions: file-system, database systems, and so on. Camille OS is a smart card Exo-kernel enabling the download of different hardware abstractions in a safe way. In this way Camille ensure POPS "adaptability" to the applications requirements. Nevertheless some critical system extensions (enhanced IO protocols for example) need additional guaranties: real-time properties and hardware resources control.

2.1.2. Mobile Networking

POPS also have a non-conventional communication interface. Due to their mobility, they have transient and unpredictable communications with other entities. This fact motivates our focusing on the ad hoc network communication model which is the most flexible model.

Indeed wireless ad hoc networks [70], [45], [46], [43] cover a wide range of self-organized network types, including sensor, mobile ad hoc, personal area, and rooftop/mesh networks. The design of data communication techniques in multi-hop ad hoc networks has challenges at all layers of communication: physical, medium access control (MAC), network, transport and application layers. This research project concentrates on the network layer. The network layer problems can be divided into three groups: data communication, service access, and topology control problems. Data communication problems include routing, quality-of-service routing, geocasting, multicasting, and broadcasting. The protocols need to minimize the communication overhead (since bandwidth in wireless communication is typically limited) and power consumption by battery operated POPS. In service access problems, such as multi-hop wireless Internet (hybrid network, see Fig. 4), the

Event-driven model



On-demand model

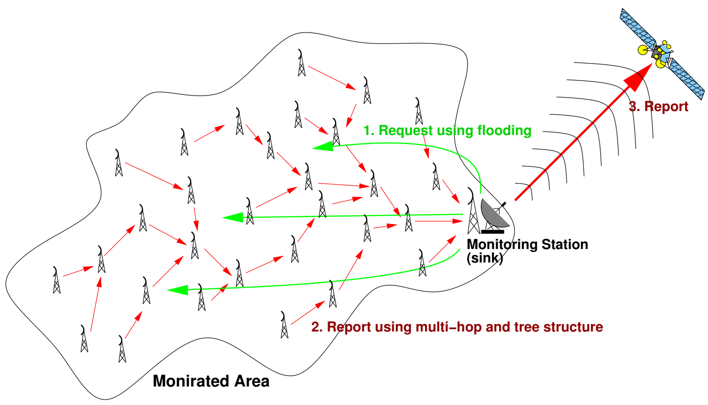


Figure 3. Example of a sensor network with event-driven and on-demand models.

goal is to provide or receive services from a fixed infrastructure with other hosts serving as relays if necessary. Topology control problems include neighbor discovery problem (detecting neighboring nodes located within transmission radius) and network organization problem (deciding what communication links to establish with neighboring nodes, sleeping period operations and adjusting transmission radii). Secure routing faces the following challenges: node selfishness, threats using modification of routing information, misrepresenting identity, fabrication of routing messages by one node, or between two malicious nodes (wormhole attack), and self-organized public-key management and authentication services. The main paradigm shift is to apply localized (or greedy) schemes as opposed to existing protocols requiring global information. Localized algorithms are distributed algorithms where simple local node behavior achieves a desired global objective. Localized protocols provide scalable solutions, that is, solutions for wireless networks with an arbitrary number of nodes, which is one of the main goals of this research project.

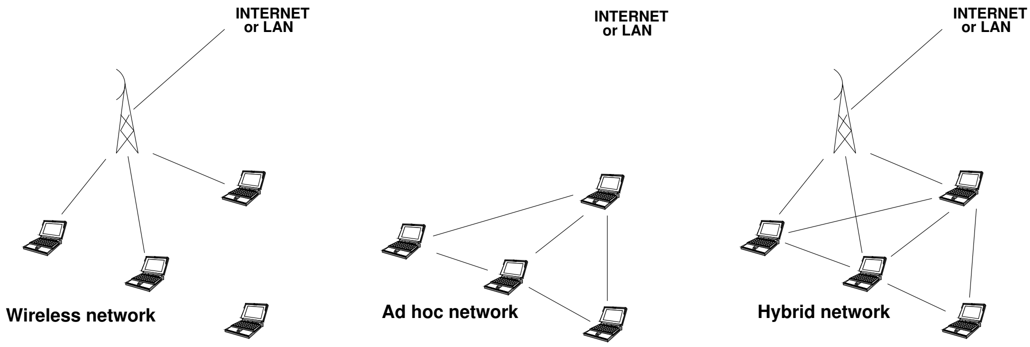


Figure 4. From wireless network to hybrid networks.

2.2. Highlights of the year

The JITS technology that was handed in by the POPS research team has won a prize from the JAX Innovation Award 2007 on 25th April 2007 in Germany. The JITS romization/customization tool was already awarded by the Java Card Forum Technology Contest in 2006, but the JAX Innovation Award give a prize to JITS architecture, including the on-board dedicated virtual machine. The JAX Innovation Award is intended to honour and recognise the most remarkable and outstanding contributions in the world of Java. These contributions can include products, open source projects, ideas, concepts, publications, or break-through technological innovations. The award places special emphasis on 'Innovation' as the key driver in the Java world.

3. Scientific Foundations

3.1. Scientific Foundations

Keywords: *Embedded operating system*, *POPS*, *ad hoc networks*, *exo-kernel*, *mobility*, *smart card*, *wireless networking*, *wireless sensor networks*.

The POPS research group investigates solutions to enhance programmability, adaptability and reachability of small objects designated as "POPS" (Portable Objects Proved to be Safe). The POPS set includes small devices like smart cards, RFID tags or personal digital assistant which are characterized by limited resources, high mobility and high security level in spite of untrusted environment. The development of applications integrating POPS suffers from lack of "*reachability*" of these platforms. Indeed, most POPS are not easy to program and high level of expertise is needed to produce software for such limited operating systems and devices. Moreover, POPS mobility induces sudden and frequent disconnections, long round trip times, high bit error rates and small bandwidth.

Hence, POPS systems have to adapt themselves to applications requirements or modifications of their environment. In this context, we are conducting research in the two following connected areas:

- **Embedded Operating Systems**, focusing on operating systems and virtual machines scalability (in terms of memory, microchip performance and energy) where smart cards are our reference target. Our main activities deal with the scalability of Java abstractions (the "Java in the Small" sub-project) and efficient, extensible and safe hardware management (the "Camille NG" sub-project).
- **Mobile Networking**, focusing on communication protocols on wireless network architectures, in ad hoc or wireless LAN mode, using or not fixed infrastructure. Our protocols aim to ensure secure connectivity and QoS enhancement of dense large networks which are constituted of small devices with high mobility.

POPS software architecture has never stopped evolving. Since birth of smart cards (for instance) in the early eighties, we can distinguish four different generations of software architectures, from the rough, monolithic "smart card mask" to the ultra light "post-issuance" open kernel. Nevertheless, all software generations are still used today. A rough monolithic smart card OS is the only way (known by the industry) to product low-end/low-cost smart cards. "Post-issuance OS" like Java Card are sold for the high-end market.

The smart card example has shown that embedded software is a huge family. In fact, according to the limited capabilities provided by the hardware, an embedded application offers "limited" functionality. Nevertheless the omnipresence of the POPS (over 10^9 smart card around the world today) implies a great diversity of software. And the Subscriber Identification Module (SIM) inserted in our GSM, is very different from sensors used in wireless sensor networks. All of them are supported by a powerless hardware with limited resources (memory, CPU and energy). They all suppose the use of dedicated APIs and tools. They are built over dedicated underlying operating systems...

Supporting at the same time the whole set of abstractions used by each possible embedded application is obviously impossible. To overcome this technological lock our research group has proposed to embed the use of Exo-Kernel architecture [53]. Exo-kernel architecture consists in suppressing any abstraction consideration in the (Operating System) kernel design.

Basically if we consider the conception of a conventional file system, we can define three internal layers (see Fig. 5). In a conventional "monolithic OS" The bottom layer manages the hardware, allocating sectors, or flash memory pages, programming the burn of data, etc...The second layer implements basic software to simulate a virtual device easier to administrate and to use: "the file system". The top layer manages the software security by controlling the files access. In a μ-kernel, the 'kernel' of the operating system does not support a preferred abstraction but only manage (in a preferred way) the hardware and offer a safe and secure access for different abstractions implementations. In this way, μ-kernels allows the coexistence of multiple hardware abstractions. But recent results contest the performances of such OS architectures. In an operating system the performances of provided abstractions are greatly improved when they are correlated to the adequate hardware management. That's why Exo-Kernels architects claim that "the exo-kernel must offer a safe hardware exposition without any abstraction". Software applications must be able to access the hardware and manage it according to their own goals. It is the best way to ensure dynamic adaptability to the applications requirement.

We have proved the feasibility of this kind of kernel in a tiny device. However, it is an incomplete purpose because some hot OS topics can be loaded in a safe way. Safety is ensured statically, while the OS component is loaded. The Kernel Trusted Computing Base uses the "Proof Caring Code" principles [63]. Nevertheless,

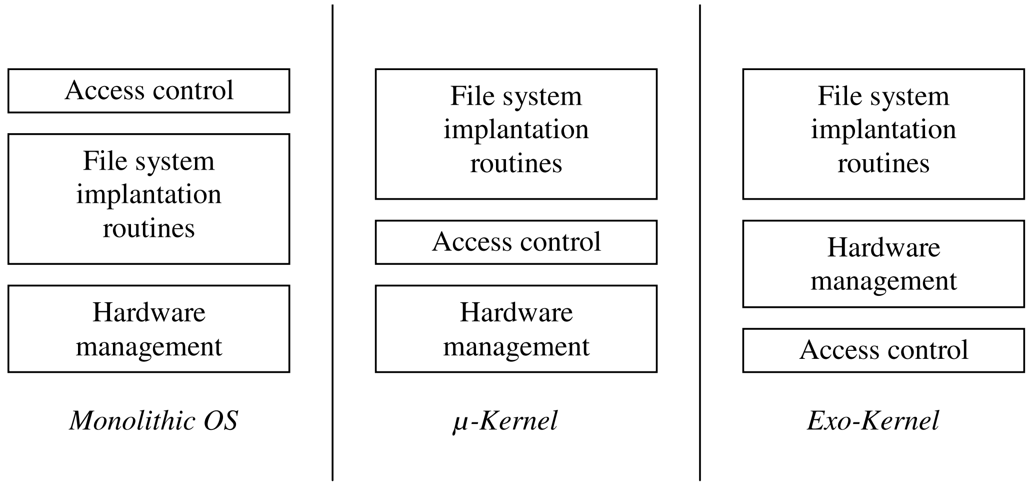


Figure 5. From monolithic OS to exo-kernel architecture.

the current Camille OS defines security in terms of confidentiality and integrity, not in term of availability. Problems are related to Real Time software and Resource Control. These goals are one of our next actions called Camille NG.

Smart card is probably one of the most limited devices in the POPS family. Important industrial efforts were made to invite Java developers to deploy Java software on cards. Nevertheless tiny operating systems like Java Card OS does not really satisfy Java developers. In this way, our work around Camille (supporting dynamic extensions of the embedded OS) looks insufficient. In fact Camille enables multiple hardware abstractions justified by multiples applications needs. However, real powerful abstractions, like those proposed by Java technologies, were clearly not deployed in POPS. To invite conventional software designer to deploy they work on POPS we propose to study new OS approach to deploy Java In The Small.

POPS also have non-conventional communication interfaces. Due to their mobility, they have transient and unpredictable communications with other entities. This fact motivates us to focus on the ad hoc network communication model which is the most flexible model.

The most suitable kind of network for POPS are wireless ad hoc networks which cover a wide range of self-organized network types. Ad hoc networks are multi-hop networks consisting of wireless autonomous hosts, where each host may serve as a router to assist traffic from other nodes. Wireless ad hoc networks cover a wide range of network scenarios, including sensor, mobile ad hoc, personal area, and rooftop/mesh networks. Sensors provide service to monitoring stations. Mobile ad hoc networks are pure infrastructure-less networks used in disaster relieves, conferences, hospitals, campus and battlefield environments, with laptops, palmtops, cellular phones or other devices serving as nodes. Rooftop/mesh networks provide high-speed wireless Internet access to homes and offices.

Nodes (hosts) in an ad hoc network can be static or mobile, and can switch between active and sleeping modes. The control is distributed, thus each POPS makes independent decisions following a common pre-established protocol. An ad hoc network may be linked to a fixed infrastructure (to receive or provide service) or can function on its own. Wireless networks of sensors are likely to be widely deployed in the near future because they greatly extend our ability to monitor and control the physical environment from remote locations and improve our accuracy of information obtained via collaboration among sensor nodes and online information processing at those nodes. Networking these sensors will revolutionize information gathering and processing in many situations (*e.g.* monitoring and reporting fires, chemicals, intruders etc.). Home or office appliances can be networked in a personal area network, with input from a fixed station or mobile human. Rooftop networks are static networks with nodes placed on top of buildings. They are applied in the mesh-networking approach, where the neighborhood is ‘seeded’ by the installation of a ‘neighborhood access point’ (NAP), a radio base-station connected to the Internet via a high-speed connection. Homes and offices within range of this NAP install antennas of their own, enabling them to access the Internet at high speed. Each of these homes and offices can also act as a relay for other homes and offices beyond the range of the original NAP. As the mesh grows, each node communicates only with its neighbors, which pass Internet traffic back and forth from the NAP. It is thus possible to cover large area quickly and cheaply. For providing fixed-wireless access, the mesh approach is technically superior to the traditional ‘point-to-multipoint’ radio approach. It requires much less power, offers multiple paths for choosing the fastest route, is robust and scales up easily. Ad hoc networks will make communication technology useful for people everywhere regardless of nature and availability of backbone infrastructures.

In a crowded environment, such as sport arena, phones could pass traffic from other phones to base stations in adjacent cells, thus boosting capacity. Reduced power also reduces the interferences when a call is multi-hopped to the same base station instead of being directly transmitted. Calls between users within the arena could be handled locally, without loading the cellular network.

Commercial developments of wireless networks have been so far basically limited to the single hop scenarios, with one link between a mobile node and the fixed infrastructure (*e.g.* cellular telephony), or between two mobile/wireless nodes (*e.g.* Bluetooth short range technology). Single-hop wireless networks already pose significant challenges due to limited bandwidth and battery power restrictions. A multi-hop wireless network can be modeled as a graph, with two nodes joined by an edge if and only if they are able to directly communicate with each other. The most popular model in literature is the model of a unit disk graph. In such a unit disk graph, a message sent by any node reaches simultaneously all its neighbors whose distance to the transmitting node is no more than the transmission radius, which is equal for all nodes. Variations of the model includes adding obstacles, having different transmission radii for each node, or introducing minimum and maximum transmission radii, where nodes closer than minimum radius receive message, farther than maximum radius, do not receive message, and uncertain reception in between the two radii.

The selections of best data communication protocols at the network layer are certainly affected by developments, current and future, on other layers below and above the network layer. For instance, the physical layer decides whether omni directional or directional antennas are used. If antennas are omni directional, which is a typical assumption, then a message sent by one node can be simultaneously received by all its neighbors (so called one-to-all model). Some recent developments exploit the use of directional ‘smart’ antennas, fixed narrow beam (reaching only one neighbor, one-to-one model), wide fixed beam, or variable angular size beam antennas (one-to-many models). The ultra-wideband (UWB) transmission involves transmitting very short pulses on a wide range of frequencies simultaneously at low power. Such pulses, less than billionth of a second long, pass unnoticed by conventional radio receivers, but can be detected by a UWB receiver. Information is encoded into streams of pulses, millions of which can be sent every second, by varying their polarity or their timing relative to an apparently random but pre-arranged schedule. UWB received a massive boost in February 2002, when it received limited approval for transmissions up to about ten meters. UWB is capable of data rate of over 100 megabits per second on such short distances. Work is well advanced on the standard to enable UWB devices to locate and communicate with each other. Ad hoc networking is expected to receive further boost after adopting UWB transmission. Infrastructure-less, ad hoc UWB networks are also called 5G.

The current ‘popular’ choices, or dilemmas, at the medium access control (MAC) layer is between IEEE 802.11 where all POPS communicate on the same channel, and the Bluetooth that uses frequency hopping and master-slave relations. The design of medium access layer for UWB transmission is under way. UWB supports existing 802.11, 802.15.3 and HiperLan MAC standards but they do not exploit position-aware information enabled by UWB.

The research on wireless ad hoc, sensor and local area networks is booming recently within both computer science and electrical engineering communities. Both ACM and IEEE organize symposia exclusively dedicated to ad hoc networks, now in the second and third years of existence. This is in addition to increasing number of papers on ad hoc networks at main events such as IEEE INFOCOM, ACM MOBICOM, IEEE ICC, IEEE Int. Symp. on Computers and Communications, IEEE Parallel and Distributed Symposium, and IEEE Int. Conf. Distributed Computing. Despite of the enormous interest in ad hoc networks (due to upcoming commercial applications), satisfactory solutions for some fundamental problems in their operation, such as routing, broadcasting, multicasting, and network organization, are still not found.

4. Application Domains

4.1. Application Domains

Keywords: *Telecommunication*, *ambient computing*, *banking application*, *environment*, *military area*.

Application domain of our research activities is very wide since it concerns domains commonly addressed by smart object issues:

- individual authentication in information systems, like in banking system (bank smartcards), mobile phone system (SIM cards) or wireless networking (smartcard for Wi-Fi),
- adaptable and robust networking, like in infrastructure less communication system (military communication system or emergency communication system),
- ambient computing which uses intensively POPS,
- environment surveillance systems which can use wireless sensor networks.

5. Software

5.1. Java In The Small

Keywords: *Java-OS*, *embedded system*.

Participants: Alexandre Courbot, Gilles Grimaud, Kevin Marquet [Contact], David Simplot-Ryl.

Initial goal of Java was to allow high level software development on small devices. Eventually it found success and promotion with software deployment on the Web, and more recently as a solution for huge enterprise servers and massive parallel computing. Today small targets are still supported, but with dedicated (Java-like) APIs and VMs. These specific technologies dramatically restrain the context in which Java applications can be deployed.

JITS focuses on these technologies and on enhancements to allow the use of a real Java Runtime Environment and a Java Virtual Machine everywhere by targeting tiny devices such as SmartCards. These devices usually don't use a Virtual Machine layer over an OS, but expect the Virtual Machine to be the OS. This is possible thanks to the JVM features which can be presented as a specific hardware abstraction for most of them.

5.2. CAMILLE NG

Keywords: *Exo-kernel*, *embedded system*, *extensibility*, *real-time*.

Participants: Nadia Bel Hadj Aissa [Contact], Gilles Grimaud.

The Camille operating system (a dedicated exo-kernel) aims at supporting the various hardware resources used in smart cards, without specializing abstractions. The architecture principle is very similar to the MIT Exo-Kernel principles and concepts. The Camille OS provides the following three basic characteristics. Portability is inherited from the use of an intermediate code and by a limited set of hardware primitives. Security is ensured by a code-safety checking (which uses a PCC-like algorithm) at loading time. Extensibility is provided through a simple representation of the hardware that at the root of the system does not predefine any abstraction. Thus, applications have to build or import abstractions which match their requirements. The Camille split architecture is described in Fig. 6.

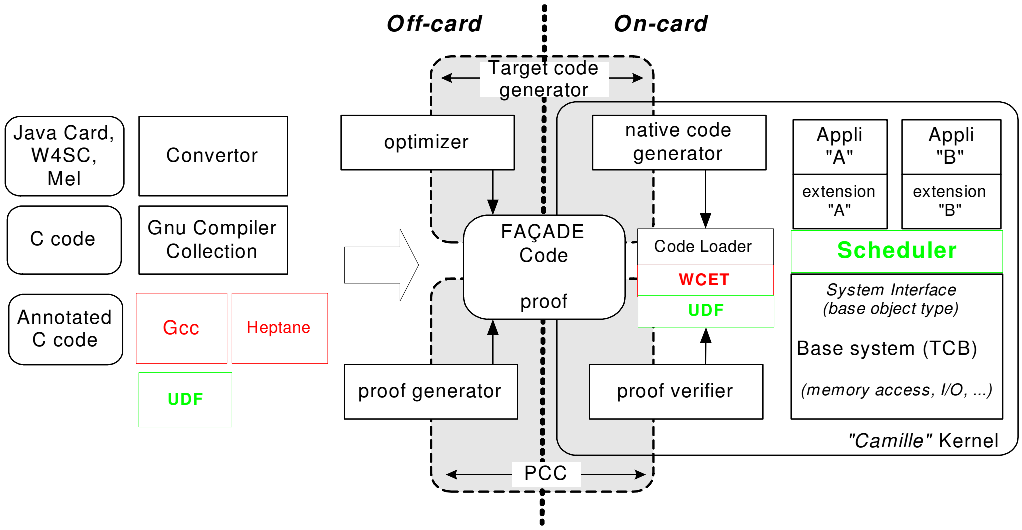


Figure 6. CAMILLE Architecture.

The usual downside of extensibility is performance. For some parts of the OS that require efficiency, Camille uses Just-in-Time techniques to compile intermediate code into native one. Increased performances also come from the exo-kernel approach that does not introduce abstraction penalties in the core of the OS. Because smart cards have limited computing power, additional hardware independent optimizations are also performed out of the card, while the source code is translated to FACADE. A more precise description of Camille, and experimental results as well can be found in [58]. The Camille prototype demonstrates the feasibility of an extensible smart card OS that has reasonable footprint: 17 KB of native code in which 3.5 KB for code verification, 8.5 KB for native code generation, and the rest for hardware multiplexing.

5.3. SimTag: a simulator for anti-collision protocol design for RFID Tags

Keywords: *RFID tags*, *anti-collision*.

Participant: David Simplot-Ryl.

SimTag is a simulator dedicated to anti-collision protocols. It includes protocols from ISO-18000-3 standard [56] and allows to test numerous parameters. It has been used by engineers from Gemplus/Gemalto and TagSys to tune their own protocols that are now included in standards.

SimTag can be found at the URI http://www.lifl.fr/POPS/SimTag/Index.

6. New Results

6.1. Activity Scheduling in Wireless Sensor Networks

Keywords: *Networked sensors*, *activity scheduling*, *energy conservation*.

Participants: Jean Carle, Antoine Gallais, François Ingelrest, David Simplot-Ryl.

In this context, wireless sensor networks are made up of lots of devices deployed over a distant or sensitive field to be monitored. Full coverage, energy efficiency, and connectivity are critical requirements of such a network. Energy consumption is balanced by taking advantage of the redundancy induced by the deployment of nodes. Some nodes are active while others are in sleep mode, thus using less energy. The area coverage problem is to determine a small number of sensors that still cover the same area as the whole network. The activity scheduling problem is a subclass of the area coverage problem where connectivity of the active nodes subset must also be provided, so that monitoring reports can reach the sink stations. Most of the results of this research activity appeared in [11].

There are several variants regarding the relation between sensing and transmission ranges. One common assumption is that sensing radius and communication radius are equal [2] or with a transmitting radius of at least twice of the sensing radius, allowing to automatically obtain the connectivity of the network in case of full area coverage. Our propositions [7], are for arbitrary ratio between sensing and transmission radii. More recently, in [25], we propose an overview of a localized algorithm for area coverage able to build connected active nodes sets. We also detail its behavior to show why it should be able to still provide good results under realistic physical layer conditions. Some tracks to still improve its resistance to message losses are also given.

In [26], we studied the impact of a realistic radio channel on activity scheduling and area coverage in sensor networks. Indeed, most of the previous work in this area has been studied within an ideal environment, where messages are always correctly received. In this paper, we follow the path opened in [60] by arguing that protocols developed with such an assumption can hardly provide satisfying results in a more realistic world. To strengthen this point of view, we replace the classic unit disk graph model by the lognormal shadowing model, and analyze some existing solutions. The results show that either the resulting area coverage is not sufficient or the percentage of active nodes, and thus energy consumption, is very high. To solve these problems, we present an original method, where a node decides to turn off when there exists in its neighborhood a covering set of nodes, and that this set is sufficiently reliable (i.e. the risk is lower than a given threshold). This reliability is based on link probabilities that may be obtained thanks to the signal-to-noise ratio of previous transmissions. We provide experimental results for a static threshold, and present some methods to dynamically compute the threshold based on the local density of nodes. These results show that our solution is very efficient as it preserves area coverage while minimizing the quantity of working nodes.

To increase reliability or security, a monitored area coverage of any point by more than one sensors (say k) may be required. Such k coverage minimizes the risk of possibly missed event or false alerts. By using such k-coverage, it can also be possible to correlate data to obtain data as pertinent as possible. In [13], we consider two formulations of the k-coverage problem. The first said that an area is k-covered if every physical point is covered by at least k active sensor nodes. In the second formulation, we consider that there exist k distinct set of sensor nodes so that each one fully covers the area. Many existing solutions first address the problem of 1-area-coverage and then try to generalize it to k by using the second formulation. To the best of our knowledge, none has ever ensured connectivity independently from the ratio of sensing and communicating radii. Moreover, proposed protocols never show to what extent they can be resistant. Indeed, many solutions lie in clustering or distributed protocols in which correct communication is crucial. Meanwhile, no study about the impact of message loss is ever conducted.

In [24], we propose a localized algorithm for multiple sensor area coverage able to build connected active nodes sets. We also show that a simple feature of the protocol, called the coverage evaluation scheme, can be enhanced to handle various k-area coverage problem definitions. Experimental results show that our coverage scheme is resistant to collisions of messages as k-area-coverage of the deployment area and connectivity of the active nodes set can still be ensured.

6.2. Efficient MAC Layer for RFID and Wireless Devices

Keywords: *MAC layer*, *RFID*, *Wireless communication*.

Participants: Farid Naït-Adbesselam, David Simplot-Ryl, Thomas Soete.

The IEEE 802.11 [59] standard for Wireless Local Area Networks (WLANs) employs a mechanism for Medium Access Control (MAC), named Distributed Coordination Function (DCF), which is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The collision avoidance mechanism uses the random backoff prior to each frame transmission attempt. The random nature of the back-off reduces the collision probability, but cannot eliminate completely these collisions. It is well known that as the number of contending stations increases, the number of collisions is also likely to increase and the performance of the 802.11 WLAN is significantly compromised. In [41], we propose a novel distributed MAC protocol, named Reduced Collision MAC (RC-MAC). In our algorithm, a station will access the channel by following a cyclic method. After a certain period of contention resolution, the stations will be simply organized in a cycle and each of them will access the channel while its turn comes. In this case, there is no more collision in the future and the bandwidth is used efficiently. Through extensive simulations, we show that RC-MAC achieves a significant increase in the overall performance compared to the standard 802.11 DCF.

The efficient use of energy in wireless sensor networks is critical issue as the battery of a sensor node, in most cases, cannot be recharged or replaced after deployment. In order to detect an event, a sensor node spends most of the time in monitoring its environment, during which a significant amount of energy can be saved by placing the radio in low power sleep mode when no reception and/or transmission of data is involved. In [38], we discuss the design of a new MAC protocol for wireless sensor networks whose goal is to extend the lifetime of the network by avoiding major energy waste causes, such as collisions, overhearing and idle listening, without compromising other network performance measures such as network throughput. The performance of the protocol is studied by simulation and is compared to that of the well known S-MAC protocol [72] which is design to save energy and to the IEEE 802.11 protocol [59] which is designed to maximize throughput.

In [20], we present evaluation performances of an anti-collision protocol for RFID tags. The protocol enables electronic markers, also known as smart labels or tags, to be identified. The principle of the protocol is the framed aloha [66] with an optimization of the frame length. The optimization of this length is based on an evaluation of the number of active tags. Besides its performances, a particularly interesting feature of the method is that it does not depend on factory parameters or uniqueness of the identifier and that it adapts itself to environmental conditions to ensure efficient identification.

6.3. Self-organization and Topology Control for Small Devices

Keywords: *Clustering*, *Hello Packets*, *hierarchy*, *multi-hop wireless communications*, *routing*, *self-organization*.

Participants: François Ingelrest, Fadila Khadar, Nathalie Mitton, David Simplot-Ryl.

Self-organization for a network is the spontaneous emergence of a macroscopic organized structure due to the collective interactions among a large assemblage of single nodes. In ad hoc networks, self-organization is of several kinds. on one hand, it can refer to the construction of a logical structure of clusters. On another hand, it can refer to individual mechanisms which help the network to organize routing like adaptation of frequency for instance. In the first case, self-organization relies on a specific partition of the network, called *clustering*: the terminals are gathered into clusters according to some criteria, each cluster is identified by a special node called *cluster-head*. Many clustering algorithms have been proposed in the literature, of all kinds : 1-clusters [57], [48], [50], [51]. As far as we know, only two of them let clusters adapt to the underlying topology [64], [62] and produce unbounded clusters. This makes them more robust towards the topology changes.

Nevertheless, to the best of our knowledge, none of these layer-3 protocols, either for routing or clustering, have taken into account the importance of the reliability of these neighborhood tables on which they all rely. Indeed, even in a static environment, some HELLO packets may be lost because of collisions and delay occurring at the MAC layer level. Therefore, the choice of the MAC layer, the HELLO packet frequency and the time data are kept in memory have importance in order to provide the nodes with a view of their neighborhood as close to the physical one as possible. So, neighborhood tables are not always reliable and since layer-3 protocols mainly rely on them, routing or *clustering* results are also impacted.

In [40], we are interested in investigating the impact of realistic MAC and physical layers over a network self-organization. Indeed, all these protocols always rely on the neighbor discovery obtained through the Hello protocol. In [40], we analyze how the parameters of the HELLO protocol, the choice of the MAC layer protocol and the metric used for clustering may overcome or worsen the effects of the propagation errors. To do so, we chose to study two clustering algorithms proved self-stabilizing which only differ by the metric used: DDR [64] and the density-based algorithm [62]. We study their behavior over two different MAC layer approaches: IEEE 802.11[1] and MadMac [65]. We provide a theoretical analysis based on stochastic geometry and queue theory to establish the more suitable parameters for the HELLO protocol (HELLO message frequency and data lifetime). We show theoretically and by simulation that these parameters can strongly impact the behavior of the studied clustering protocol. We highlight that in a network without data communications, changing the MAC protocol does not affect the chosen parameters of the HELLO protocol, contrarily to the metric used for self-organizing the network, which can help to smooth down the link failures occurring at the MAC layer.

In [30], we are interested in studying how nodes may dynamically adjust the frequency of HELLO messages. Indeed, because of mobility, neighborhood tables have a limited lifetime and must be regularly updated. However, finding the correct frequency is not obvious: if it is too low (*i.e.* with regards to the speed of hosts), then tables quickly become obsolete. On the contrary, if it is too high, then tables will be up to date but a high part of the available bandwidth will be wasted to the detriment of data traffic. There obviously exists a trade-off between these behaviors, but finding the optimal one is not trivial. Moreover, this trade-off actually depends on network characteristics (*e.g.* density, speed) that may evolve over time, and a constant frequency is then not the best choice. An efficient HELLO protocol should thus be adaptive. A straightforward solution might be to let nodes know their speed and choose the correct frequency based on this information, but of course there is no easy and cheap way for a node to determine its speed. We propose a turnover based adaptive HELLO protocol (TAP), which enables nodes in mobile networks to dynamically adjust their HELLO messages frequency depending on the current speed of nodes. To the best of our knowledge, all existing solutions are based on specific assumptions (*e.g.* slotted networks) and/or require specific hardware (*e.g.* GPS) for speed evaluation. One of the key aspects of our solution is that no additional hardware is required since it does not need this speed information. TAP may be used in any kind of mobile networks that rely on HELLO messages to maintain neighborhood tables and is thus highly relevant in the context of ad hoc and sensor networks. In our solution, each node has to monitor its neighborhood table to count new neighbors whenever a HELLO is sent. This *turnover* is then used to adjust HELLO frequency. To evaluate our solution, we propose a theoretical analysis based on some given assumptions that provides the optimal turnover when these assumptions hold. Our experimental results demonstrate that when this optimal value is used as the targeted turnover in TAP, the HELLO frequency is correctly adjusted and provides a good accuracy with regards to the neighborhood tables.

In [31], we focused on the construction of small connected dominating sets, where all nodes are either dominant or neighbor of a dominant node. As a basis for our work, we used a heuristic given by Dai and Wu in [52] for constructing such a set. Their approach, in conjunction with the elimination of message overhead by Stojmenović, has been recently shown to be an excellent compromise with respect to a wide range of metrics. In this paper, we presented an enhanced definition to obtain smaller sets in the specific case where 2-hop information is considered. In our new definition, a node u is not dominant if there exists in its 2-hop neighborhood a connected set of nodes with higher priorities that covers u and its 1-hop neighbors. This new rule requires the same level of knowledge used by the original heuristic: only neighbors of nodes and neighbors of neighbors must be known to apply it. However, it takes advantage of some topological knowledge originally not taken into account, that may be used to deduce communication links between 1-hop and 2-hop neighbors. We provided the proof that the new set is a subset of the one obtained with the original heuristic. We also gave the proof that our set is always dominating for any graph, and connected for any connected graph. Two versions were considered: with topological and positional information, which differ in whether or not nodes are aware of links between their 2-hop neighbors that are not 1-hop neighbors. An algorithm for locally applying the concept at each node was described. We finally provided experimental data that demonstrates the superiority of our rule in obtaining smaller dominating sets. A centralized algorithm was used as a benchmark

[1] http://www.ieee802.org/11/

in the comparisons. The overhead of the size of connected dominating set is reduced by about 15% with the topological variant and by about 30% with the positional variant of our new definition.

In the chapter [12], we consider localized algorithms, in opposition to centralized algorithms, which can be used in topology control for wireless networks like ad hoc or sensor networks. The aim of topology control can be to minimize energy consumption, or to reduce interferences by organizing/structuring the network. We focus this chapter on neighbor elimination schemes which consist in removing edges from the initial connection graph.

Among the common problems studied in ad hoc and sensor networks is broadcasting. In such communication, a message is sent from a given host to all the other ones in the network. Applications of this process are numerous: route discovery, synchronization... The simplest and most widely used approach to broadcast is blind flooding, where each node that receives the packet for the first time forwards it to its neighborhood. This method obviously ensures a total coverage of the network, provided that the latter is connected. However, as mobile objects rely on a battery, it is mandatory for the broadcast protocol to be energy efficient. Blind flooding causes redundancy of packets, resulting in unnecessary collisions and especially huge waste of energy. Optimization of broadcasting is generally done by reducing the quantity of needed relaying nodes, or by limiting the transmission power at each host. Of course, all these optimizations must preserve the reliability of the protocol.

As power adjustment is a mechanism of prime importance for energy preservation, we studied localized broadcasting methods based on the concept of optimal communication range. To further reduce energy savings, we studied a well-known centralized and very efficient protocol named BIP (Broadcast Incremental Power) [71], which constructs an efficient spanning tree rooted at a given node. Its efficiency is due to its consideration of the coverage obtained thanks to a single omnidirectional transmission, instead of considering all links separately. It offers very good results in terms of energy savings, but its computation is centralized and it is a real problem in ad hoc or sensor networks. Distributed versions have been proposed, but they all require a huge transmission overhead for information exchange. Other localized protocols have been proposed, as our previously presented TR-LBOP and TR-DS protocols [61], but none of them has ever reached the performances of BIP. We thus proposed and analyzed in [16] an incremental and localized version of this protocol, named LBIP for Localized BIP. In our method, the packet is sent from node to node based on local BIP trees computed by each node in the broadcasting chain. Local trees are constructed within the k-hop neighborhood of nodes, based on information provided by previous nodes, so that a global broadcasting structure is incrementally built as the message is being propagated through the network. Only the source node computes an initially empty tree to initiate the process. Discussion and results are provided where we argue that $k = 2$ is the best compromise for efficiency. We also discuss potential conflicts that can arise from the incremental process. We finally provided experimental results showing that this new protocol obtains very good results for low densities, and is almost as efficient as BIP for higher ones. LBIP is currently the most efficient localized broadcasting known scheme.

In [32], we present a way for broadcasting based on a topology control. We indeed present a way of controlling topology in wireless ad hoc networks while using a realistic physical layer. We first define the notion of connectivity in probabilistic physical layer. In a λ-connected network, all transmissions between any two devices has a probability of being done correctly greater or equal to λ. We then propose a topology reduction that preserves λ-connectivity. This topology reduction can be used to broadcast data.

A chapter for the *Handbook of Computer Networks* [15] has been written, where we describe two broadcast protocols which were demonstrated to be the best ones. In this chapter, we considered only the case where all nodes have fixed and same transmission range, which is common assumption in most literature. The two selected protocols are reliable: a protocol is reliable if it guarantees that the packet will be delivered to all nodes connected to the source, assuming ideal MAC layer. These two protocols are based on neighbor designating and self-pruning paradigms. In the (neighbor designating) multipoint relay (MPR) protocol, list of neighbors that should retransmit the packet is included in the message, so that all 2-hop neighbors are covered. In the (self-pruning) connected dominating sets (CDS) based broadcast protocol, a subset of nodes is selected so that other nodes are neighbors to at least one node from the set. We also describe the neighbor elimination scheme

(NES) as an additional mechanism to increase performance of both approaches. We provided experimental comparison of these key algorithms which demonstrates that the NES can greatly improve the performance of any underlying protocol. We also showed very competitive performance of localized schemes compared to a greedy centralized scheme.

6.4. Networking Issues in Wireless Networks

Keywords: *Routing*, *georouting*, *multi-hop wireless communications*.

Participants: Essia Hamouda Elhafsi, Nathalie Mitton, David Simplot-Ryl.

Sensor networks are specialized ad hoc networks composed of a large number of self organizing nodes/devices. They are used in a wide range of applications, such as monitoring, security, and data-gathering. These applications have two challenging issues in common i. e., energy savings and position-awareness. Through this collaboration, we wish to address these two key issues to efficiently deploy sensor networks. Nodes, in sensor networks, rely on batteries with limited capacity, thus the most important criteria when designing communication protocols is to optimize their energy consumption to extend the life of the sensor device and extend the reliability of the underlying network. In this framework, routing protocols based on geographic information of the sensors have been proposed as a viable alternative to existing routing protocols for wireless ad hoc networks in order to reduce the overhead of maintaining routing tables in the sensors and to avoid the cost (energy consumption) of flooding and route discovery.

However, none of the above cited papers consider or optimize the energy consumption in their proposed algorithms. Xu et al., in [67], compute the optimal transmission radius that minimizes the total power consumption for a routing task in sensor network. In Cost-Over-Progress Routing [68], the authors propose an energy-efficient geographic routing. Therefore, we presented ORouting [23], a localized energy efficient greedy routing scheme. ORouting computes its routing path by locally selecting the next hop node based on its orthogonal distance to the direction of the source/destination pair. Moreover, in its routing decision, ORouting is biased towards its neighbors in the forward direction towards the destination. We compare ORouting to several routing protocols. We show, through simulation, that our protocol improves significantly energy consumption and achieves a high percentage of successful routings.

However, such a solution requires that the sensors be aware of their geographic (physical) position which can be obtained by equipping all the sensors with costly GPS devices. An approximate solution may be obtained by equipping only a few designated sensors (called landmarks) with GPS devices and let the remaining nodes infer their positions. However, even such an expensive alternative may not be a reliable solution since GPS reception might be obstructed by static obstacles i. e., nodes may be deployed indoors. A cheaper alternative is to consider the problem of inferring nodes location in sensor networks in which no node is aware of its physical location. Proposed solutions such as in [49], [54] are aimed at routing by deriving and using virtual coordinates. However, none of the above cited papers consider or optimize the energy consumption in their proposed algorithms.

In VCap [49], the authors propose a geographic routing where nodes are not aware of their locations but this algorithm is not energy-aware. We proposed VCost [22], an energy-efficient geographic routing where nodes are not aware of their exact location. Like in VCap, nodes use virtual coordinates extracted from the distance in number of hops they are from at least 3 landmarks. Since there are several ways to define virtual coordinates, we tested several kinds of virtual coordinates, all gotten from a distance in number of hops from landmarks. From these virtual coordinates, they perform an energy-efficient routing in a COP fashion, but based on the virtual coordinates.

To perform such a cost over progress routing, nodes need to compute virtual coordinates and distances. Since there are different ways of computing such coordinates (number of hops like in VCap, centered coordinates like in Glider, etc) and such distances from virtual coordinates (Hamming, Euclidean, etc), we compared the performances of the routing protocol by using each of them. It appears that the most efficient way was VCost where the virtual coordinates were the number of hops from the nodes to the different landmarks and the distances used were the Hamming distances computed over the virtual coordinates.

We compare the performance of our proposed method to the one of several geographic routing algorithms and show that our algorithm is efficient in terms of energy saving and hit rate (success rate of a message to reach its destination).

Proposed solutions such as in [69][22] are aimed at routing by deriving and using virtual coordinates. Using virtual coordinates as in [69] infer that several nodes may have the same coordinates and thus the routing is not guaranteed delivery. To palliate this drawback, another way of assigning virtual coordinates has been proposed in [21] with guaranteed delivery. For it, virtual coordinates are assigned to nodes by constructing a tree of labels. It is a collision free, distributed labeling algorithm based on hop counting, which embed a spanning tree of the underlying network. The Routing with Position Trees (RTP) is a guaranteed delivery, non-flooding, efficient implicit routing protocol based on Position Trees. In [21], we study experimentally the statistical properties of memory requirements and the routing efficiency of the RPT and it appears that RTP outperforms existing virtual coordinates based routing schemes regarding memory requirements and guaranteed delivery, nevertheless it is not energy efficient, which is the goal of our future works.

Nevertheless, there are many ways to define virtual coordinates and many ways to use them. In [42], nodes determine their $[x, y]$ position in a virtual space based on a random or pseudo-random process. Then, nodes use these coordinate to route information with geographical-inspired routing protocols. At the bootstrap, only the sink knows its real coordinates. Every other node first chooses virtual coordinates at random and then make them change as the centroid of its neighbors. Only the sink never changes. Yet, node coordinates tend to stabilize. A centroid routing is then applied over these coordinates. In order to avoid loops, messages need to embed their identity of each node it goes through.

6.5. Security for Mobile Devices

Keywords: *Access control*, *Networked sensors*, *Security*, *Selfishness*.

Participants: Michael Hauspie, Farid Naït-Abdesselam, David Simplot-Ryl, Isabelle Simplot-Ryl, Thomas Soete.

Routing protocols is a now well explored area in mobile ad hoc networks when considering a network composed of cooperative and well behaving nodes. However, in civilian applications, the fact that every nodes are routers belonging to different authorities lead to potential security threats.

In such context, malicious nodes could try to cheat in their interaction with peers on network. A first cheat action would be to not participate to routing by not forwarding any packet. This cheating form is called selfishness, where nodes try to maximize their own welfare for example to save some battery power. Even non malicious nodes may yield to temptation to avoid cooperation since the cost of the participation to network functionalities may be very high for individual nodes: a simple estimation says than when the average number of hops from source to destination is 5 in an ad hoc network then 80% of the energy spent by a node to send packets is dedicated to packet forwarding for other nodes. In [17], [33], we conduct a survey on the state-of-art work in this field.

For instance, several algorithms exist in the literature to prevent such selfishness, mostly based on reputation mechanism and virtual currency mechanism. The idea is most of the time either to reward cooperating nodes or to punish misbehaving nodes. Virtual currency mechanisms are more robust to attacks. Moreover, they could easily be adapted to network using directional antennas whereas reputation mechanisms are mostly based on monitoring communication of other nodes.

Another particularly severe attack on routing protocols in ad hoc networks is the so-called wormhole attack in which two or more colluding attacking nodes record packets at one location, and tunnel them to another location for a replay at that remote location. When this attack targets specifically routing control packets, the nodes that are close to the attackers are in effect shielded from finding any alternative routes to the remote location with more than one or two hops, and thus all the routes will be directed to the wormhole established by the attackers. In optimized link state routing protocol (OLSR), if a wormhole attack is launched during the propagation of link state packets, the wrong link information will propagate throughout the network, leading to routing disruption. In [39], we devise an efficient method to detect and avoid wormhole attacks in the OLSR protocol. This method tries first to infer links that may potentially lead to wormhole tunnels. The proper wormhole detection will then be applied to suspicious links by means of an exchange of encrypted probing packets between the two supposed neighbors (endpoints of the wormhole). The proposed solution has several advantages since it does not require any time synchronization or location information and shows high detection rate under various scenarios.

6.6. Secured Mobile Code for Small Devices

Keywords: *Mobile code*, *System software components*, *code safety*, *secured software*.

Participants: Nadia Bel Hadj Aissa, Dorina Ghindici, Gilles Grimaud, Isabelle Simplot-Ryl.

Small devices are often dedicated to highly sensible applications like payment or human health and are most of the time plunged in an hostile environment. Thus the need of safety and security properties is major in this field. Most of classical safety and security properties rely on the fact that all the system is known during conception phase. Nevertheless, small devices also evolve to more flexible architectures and can now be updated or customized after deployment, or even load new applications, so the properties cannot be established relying on a global knowledge of the applicative code nor the environment. Mobile code is deployed from potentially untrusted sources on small devices that most of the time have not enough computational resources to verified themselves the required propertied on the loaded applications.

To secure the system, we propose two ways: to enforce some security properties by the design of the system itself, and to verify other properties that depends on applications.

For the first point, we present in [14] an extensible system for small secure embedded devices. We advocate the use of a typed intermediate language as a transformation of various high level languages. We present an extensible type system that unifies in a unique hierarchy some type systems from various source languages and ensures integrity and confidentiality. To increase execution efficiency and use flexibility, we propose a dynamic binding mechanism that allows the programmer to describe the bindings of his code without breaking the type system. We also design the whole type system so that future addition of new kinds of objects has as little impact as possible.

To ensure applications properties, small devices may rely on certificates issued from third parts or verify the properties themselves. The first solution require some centralized infrastructure while the second one is restricted by the limited resources of such devices. To maximize the autonomy of ubiquitous systems, we propose solutions that allow small devices to verify mobile code properties using some kind of "light" PCC. The mobile code is pre-analyzed and sent with proof annotations that are verified when the code is loaded on the device. We have applied this method to verification of information flow and have proposed in [27] an embedded verifier that can be used in smart cards.

In [19], we focus our study on the computation of the worst case execution time of an embedded application while there is no way to make previous assumptions on the CPU configuration available on the smart card had to be faced differently. In this paper, an evaluation of a distributed WCET computation method is presented. A low-level analysis on an ARM7TDMI CPU core is also described. We explain how the global WCET of a dynamically loaded application is extracted. Experimental results show a small overestimation compared to the observed execution time for a PIN- based authentication applet. Hardware-dependent WCET computation can also take advantage of the typing information related to the intermediate language. Improvement in the performance evaluation is up to 81,22%.

We propose in [18], a way to unify the approaches with the notion of contract.

6.7. Software Customization for Small Devices

Keywords: *JVM optimization*, *JavaOS*, *memory management*.

Participants: Alexandre Courbot, Gilles Grimaud, Kevin Marquet.

In a first time we have studied the smart card and small device evolution to refine our vision of the new technological lock for dedicated operating system. This case-study is a central element allowing us to concentrate our effort on real innovations rather than on inapplicable results. It was made possible by an effective and efficient partnership with the industry. The quality of this preliminary work is now attested by our significant technological transfer and by the success of our accepted patents.

Since the last year we have started some additional works on memories management. In a first hand, java platforms provided a homogeneous memory abstraction based on objects allocation an automatic garbage collection. In another hand, embedded hardware provides a large diversity of RAM (Internal and External) EEPROMs, FlashROM, and so one with a lot of specificities. In an embedded virtual machine the memory manager have to fit the hardware and existing work on Object Oriented memory management failed when we apply them on EEPROM for example. A first lock is related to the garbage collection over heterogeneous memories (ROM and RAM for example). We promote a DSL – i.e. Domain Specific Language – linked with some dedicated frameworks and algorithms that deal efficiently with this diversity and in this way we permits a real benefit of the embedded memories without wasting time of the software engineer in charge of development for a dedicated device.

Garbage collection techniques have been the focus of numerous research works. In particular, their efficiencies and properties have been measured and discussed for years, concerning their use on computers. Today, virtual machines are increasingly considered for constraints devices such as smart cards, sensors, or personal digital assistants (PDAs). These small devices have a specific hardware configuration. In particular, the memories used can be very different of the RAM (e.g. EEPROM, Flash memory, different types of RAM, etc.). Although garbage collection has been widely studied in the past decades, existing works do not take into account the specifics of such memories. In [37] we presents a fine complexity study which takes into account the properties of the memories, especially their read and write access speeds. Firstly, we presents the literal expressions of the complexities of each garbage collector algorithms, and we check the our complexity study with some experimental validations. The paper finally present results extracted from this work.

In [36], we firstly present results showing that the memory manager (especially the garbage collector) must be adapted to the type of memory it is in charge of. Then, we propose a flexible memory management solution that addresses this issue by assigning a different memory manager to each memory. Each manager can use the allocation and garbage collection schemes adapted to the physical properties of the memory it is in charge of. In order to minimize interactions between memory managers during allocations and garbage collections, we use a special component in charge of placing objects into the different memories. Thereby, our solution brings the benefits of automatic data reclamation to devices with heterogeneous memory spaces.

Finally, We propose an object memory management where the placement of an object in a given generation is based on different properties. This approach is supported by a domain specific language allowing to write powerful and flexible placement policies. These placement policies completely describe the placement, in the different memories, of the objects handled by the virtual machine. In [34] we have discussed the Domain Specific Language and the expected benefits and in [35] we have prompted the applicability of our solution for Java Environments and the soundness of the approach for software engineering in terms of separation of concerns; dealing with memories issues is no more an issue for embedded application designers.

7. Contracts and Grants with Industry

7.1. Gemplus/Gemalto partnership

Participants: Alexandre Courbot, Gilles Grimaud [Scientific responsible], Kevin Marquet, David Simplot-Ryl.

Since its creation, POPS has been supported by Gemplus/Gemalto within the framework of a partnership agreement that lasts since 16 years. Gemplus/Gemalto has been continuously supported the POPS research activities though fundings and the sharing of experiences and problems between POPS and Gemplus/Gemalto Labs researchers.

POPS has been a provider of innovative technologies for Gemplus/Gemalto thanks to several major patents (including those for a secure interpreter, a database card, a loader-linker of code, or communication protocols for tags), and thanks to thesis and projects such as: the card interpreter CAVIMA (1991), the “blank card” model (1991 and 1995), the CQL card and its integration in ODBC (from 1991 to 1994), a 32-bit RISC architecture for smart cards (1996), a programmable open card and its integration in object-oriented systems (1996), the language for the GemXplore 98 cards (1997), the integration of smart cards in transactional systems (1999), optimized communication protocols for tags (from 1999 to 2001 with Gemplus/Gemalto Tags), the card system CAMILLE (2000), or the card with multiple execution contexts.

Gemplus/Gemalto and POPS have also gained benefits from this partnership through National or European projects in which they participate altogether: CASCADE (IST 4th framework), CESURE (RNRT), COMPiTV (RNTL), RESET (IST 5th framework), and INSPIRED (IST 6th framework).

At that present time, their partnership is mainly focused on embedded operating system research activities (JITS, Camille, and OS customization).

7.2. European FP6 IST IP “Wirelessly Accessible Sensor Populations” (WASP) 2006-2009

Participants: Jean Carle, Gilles Grimaud, Michael Hauspie, Fadila Khadar, Nathalie Mitton, David Simplot-Ryl [contact].

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 organization of the nodes, towards the information distribution and a selection of applications. The emphasis in the project lays in the self-organization 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:

- A consistent chain of energy-sensitive software components.
- Sets of cross optimized software stacks.
- Benchmarks and a set of measurements on energy- and code- efficiency.
- Rules for the design of configurable sensor nodes.
- A prototype implementation in one of the three chosen business areas.

List of participants: Philips Research Eindhoven, Philips Forschung Laboratorium, IMEC, CSEM, TU/e, Microsoft Aachen, Health Telematic Network, Fraunhofer IIS, Fokus, IGD, Wageningen UR, Imperial College London, STMicroelectronics, INRIA, Univ of Lille, Ecole Polytechnique Federale Lausanne, Cefriel, Centro Ricerce Fiat, Malaerdalen University, RWTH Aachen, SAP, Univ of Paderborn

7.3. European FP7 ICT IP “Advanced Sensors and lightweight Programmable middleware for Innovative Rfid Enterprise applications” (ASPIRE) 2008-2010

Participants: Nathalie Mitton, David Simplot-Ryl [INRIA representative].

ASPIRE will research and provide a radical change in the current RFID deployment paradigm through innovative, programmable, royalty-free and privacy friendly middleware. This new middleware paradigm will be particular beneficial to European SME, which are nowadays experiencing significant cost-barriers to RFID deployment.

European networked enterprises in general and SME in particular are still reluctant to adopt RFID, since they perceive RFID as unprofitable or too risky. This is largely due to the fact that the adoption of RFID technology incurs a significant Total Cost of Ownership (TCO). ASPIRE will significantly lower SME entry costs for RFID technology, through developing and providing a lightweight, royalty-free, innovative, programmable, privacy friendly, middleware platform that will facilitate low-cost development and deployment of innovative RFID solutions. This platform will act as a main vehicle for realizing the proposed swift in the current RFID deployment paradigm. The ASPIRE middleware platform will take into account innovative European developments in the area of ubiquitous RFID-based sensing (i.e., physical quantities sensing (temperature, humidity, pressure, acceleration), mobile sensing) towards enabling novel business cases that ensure high ROI (Return on Investment). The ASPIRE RFID middleware paradigm, as well as the unique and novel characteristics of the ASPIRE middleware platforms are thoroughly described in this proposal.

List of participants: Aalborg University - CTiF (Danemark), INRIA-ObjectWeb (France); INRIA-POPS (France), Université Joseph Fourrier - Grenoble University - LIG Laboratory (France), Research and Education Laboratory in Information Technologies - Athens Information Technology (Greece), Melexis technologies SA (Switzerland), Open Source Innovation Ltd (United Kingdom), NORMAPME European Office of Crafts, Trades and SMEs for Standardisation (Belgium), Dimitropoulos - VICOP LTD (Greece), Pole Traceability Valence PV (France), Instituto Telecomunicações (Italy).

7.4. ANR RNRT “SurVeiller Prévenir” (SVP) 2006-2009

Participants: Jean Carle, Gilles Grimaud, Fadila Khadar, Nathalie Mitton [contact], David Simplot-Ryl.

This project is a RNRT project (Réseau National de la Recherche en Télécommunications http://www.telecom.gouv.fr/rnrt/).

The SVP project (SuperVise and Protect) proposes to study the realization and the experimentation of an integrated pervading architecture in order to make easier the conception, the deployment and the optimal exploitation of supervising and protecting services over different kinds of dynamic networks. Its main goal is to develop and deploy an environment able to embed a great amount of dynamic and communicating entities, each dedicated to a specific service.

In order to propose a generic architecture, the project aims to study the basic technological blocks needed to the development of supervising and preventing applications : interconnection between sensor nodes (localization, positioning, addressing, routing, etc) and providing of advanced functions (sensor network and data management and scheduling).

To validate our process, the project aims to develop and deploy two platforms of experiment in vivo and scenarios application software different and additional in term of coverage of problems. The first one is based on a process of quantification of the physical activity of the users by a non intrusive wireless biometric device for aspects of optimization of the resources. The second scenario is that of the seaport, notably the Autonomous Harbor of The Havre for aspects of positioning and localization in an complex radio environment.

List of participants: ANACT, APHYCARE, CEA Leti, INRIA POPS, INRIA ARES, INRIA R2D2, INRIA PARIS, LIP6, LPBEM, Institut Maupertuis, Thales.

7.5. ANR RNRT "Réseaux hétérogènes Intelligents pour Situations de Risques" (RISC) 2007-2010

Participants: Jean Carle [contact], David Simplot-Ryl, Michael Hauspie, Nathalie Mitton.

This project is a RNRT project (Réseau National de la Recherche en Télécommunications http://www.telecom.gouv.fr/rnrt/).

The RISC project (Réseaux hétérogènes Intelligents pour Situations de Risques) focuses on heterogeneous networks in the context of civil safety. The goal is to study and define the communication from physical to network layer process in a crosslayer optimization. This network is heterogeneous since it contains mobile and static nodes, with variable bandwidth. Furthermore, some nodes have the ability to monitor the environment. This heterogeneity comes from realistic deployment where different kind of nodes must operate in the same global network. For example, in safety operation context, mobile nodes are human with portable radio in the field of operations, fixed nodes correspond to radios infrastructure link to external world (i.e. headquarters). Sensors are also used to support current action: Static sensors are used to monitor the environment. Mobile sensors could be placed on human to monitor either environmental constants or human biological constants during operation.

The project is organized around two axes:

- Research and implementation of innovative technical methods taking into account heterogeneity of the network and in-use constraints.
- Crosslayer optimization which guaranty significant improvement for the performances. In the context of mobile ad hoc wireless environment, heterogeneity tighten up the need of crosslayering methods.

List of participants: CRESTIC, ENST Paris, ETIS, LIFL, RTS Electronics, Thales Communication.

7.6. ANR RNTL "Mesure de performances et caractéristiques de plates-formes embarquées Java-Card" (MESURE) 2006-2008

Participants: Gilles Grimaud [contact], Kevin Marquet, Hervé Meunier, David Simplot-Ryl.

This project is a RNTL project (Réseau National de recherche et dinnovation en Technologies Logicielles http://www.rntl.org/).

The MESURE project is a pre-competitive project which aims at developing a set of tools to measure performance of microchip cards (smart cards). The open platforms used today in big mobile phone, payment, and electronic documents (IDs, passports) applications are built on open Java Card platforms.

The main objective of the project is to offer to the whole smart-card industry a tool to measure products. Today, such a tool does not exist in the industrial landscape, despite some tools developed internally by the designers and some important users. The existing tools are proprietary, really specific and not one is accepted by the whole industry.

The expected results by the end of the MESURE project are :

- The possibility for the smart-card industry to use a tool which can measure the performances and evaluate the characteristics of the Java platform.
- Having the opportunity to compare on criteria other than the price and the reliability.
- The definition of a point of reference which products can be compared to, performance wise.

List of participants: CNAM-CEDRIC (P. Paradinas), USTL-LIFL (G. Grimaud), Trusted Labs (E. Vétillard).

7.7. "Infrastructure pour le COMmerce du futur" (ICOM) 2007-2009

Participants: Nathalie Mitton [contact], David Simplot-Ryl.

This project is lead in the framework of the competitiveness cluster of trade industry of Nord-Pas de Calais PICOM (Pôle des Industries du COMmerce). Trade industry are being in constant evolution. The massive apparition of the Internet, the increasing exigence of quality of service, the ubiquitous and pervasive informatics shatter the traditional trade practices, their economical and organizational models.

ICOM (Infrastructure pour le COMmerce du futur) aims at helping enterprises regarding a fast and easy deployment of new applications using new technologies and infrastructures from ubiquitous informatics. It will provide a smart infrastructure which hides the heterogeneity of identifiers (RFID, NFC, bar code) and manages data storage and request routing to provide scalability.

List of participants: Athos Origin (H. Jost), Auchan (B. Courouble), Décathlon (E. Lecointe), La Poste (J. Estienne), La Redoute (F. Gitton), INRIA-ASAP (A. Vianna), INRIA-ADAM (L. Duchien), INRIA-POPS (N. Mitton), GS1 (S. Cren), ORANGE France (D. Dufresne).

7.8. ANR RNRT “Very large open wireless sensor networks” (SenseLab) 2008-2010

Participants: Nathalie Mitton, David Simplot-Ryl [contact].

The purpose of the SenseLab project is to deploy a very large scale open wireless sensor network platform. SenseLab’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. Ambient and sensor networks have recently emerged as a premier research topic. Sensor networks are a promising approach and a multi-disciplinary venture that combines computer networks, signal processing, software engineering, embedded systems, and statistics on the technology side. On the scientific applications side, it covers a large spectrum: safety and security of buildings or spaces, measuring traffic flows, environmental engineering, and ecology, to cite a few. Sensor networks will also play an essential role in the upcoming age of pervasive computing as our personal mobile devices will interact with sensor networks dispatched in the environment.

The SenseLab 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.

When deployed, SenseLab would be a unique scientific tool for the research on wireless sensor networks.

List of participants: INRIA-ARES (E. Fleury), INRIA-ASAP (M. Bertier), INRIA-POPS (D. Simplot-Ryl), Thales Communication S.A. (V. Conan), UPMC-LIP6 (M. Dias di Amorim), ULP-LSIIT (T. Noel).

7.9. ACI Sécurité Informatique “models and Protocols for SEcuRity in wireless Ad hoC networks” (SERAC) 2004-2007

Participants: Farid Naït-Abdesselam [contact], David Simplot-Ryl, Thomas Soete.

The ACI Project SERAC, funded by the French Ministry of Education and Research, conducts research activities on security in the context of Mobile Ad Hoc Networks. The area of security in ad hoc networks steel partly or not completely explored. High level security requirements for ad hoc networks are basically identical to security requirements for any other communication systems, and include the following services: authentication, confidentiality, integrity, non-repudiation, access control, and availability. However, similar to wireless communication systems (like GSM), which have additional challenges for the implementation of aforementioned services when compared to fixed networks, ad hoc networks can be viewed as an even more extreme case, requiring even more sophisticated, efficient and well designed security mechanisms.

List of participants: USTL-LIFL (F. Naït-Abdesselam), INRIA-CODE (D. Augot), INRIA-HIPERCOM (P. Mühlethaler) and GET (J. Leneutre, A. Cavalli).

7.10. Regional project “Indoor Communications” (COM’DOM) 2005-2007

Participants: Gilles Grimaud, Michael Hauspie, François Ingelrest, Hervé Meunier, Farid Naït-Abdesselam [contact], David Simplot-Ryl, Thomas Soete.

The COM’DOM project, funded by the region Nord Pas de Calais, conducts research for designing high data rate radio interface, operating at the 60 GHz frequencies, for high speed wireless communications in wireless ad hoc networks. At the same time it focuses in designing a coupled radio-fiber optics switches to extend indoor connectivity of a wireless ad hoc networks. Beside, the hardware conception and development, researchers involved in this project think in the design of new medium access protocol suitable for smart antennas, as well as the design of new routing and optimization protocols for ad hoc networks.

List of participants: USTL-LIFL (F. Naït-Abdesselam) and USTL-IEMN (N. Rolland).

7.11. Regional Project “MOdèles et InfraStructures pour Applications ubIQUitairES” (MOSAIQUES) 2005-2007

Participants: Alexandre Courbot, Gilles Grimaud [contact], David Simplot-Ryl, Isabelle Simplot-Ryl.

Proliferation of hardware and software sensors and others pervasive technologies, motivates the Mosaiques studies on software context-awareness. Context-based software conception and deployment seems the most natural substrate for theses technologies, because it provides the right separation of concerns. However, context-aware software needs to be supported by efficient, distributed, extensible and scalable software technologies. In Mosaiques we studies different ways to overcome theses technological locks.

Combining methodological principles (first axis), dedicated infrastructure supports (second axis), and adaptability validation (last axis) will satisfy the required ability to perform execution of a pervasive software environment over heterogeneous ubiquitous computing supports. In this context the POPS contribution is related to extensible and scalable software infrastructure for constrained devices.

List of participants: USTL-LIFL (L. Duchien), UVMH-LAMIH (S. Lecomte), USTL-TRIGONE (A. Derycke), INRETS Lille (C. Gransard), École des Mines de Douai (N. Bouraqadi).

7.12. ARC “CApacité des Réseaux radio MAillé (CARMA)” 2007-2009

Participants: Nathalie Mitton [contact], David Simplot-Ryl, Marie-Émilie Voge.

Wireless mesh network deployment is a major technological and economic stake and a decisive step toward a ubiquitous network. Mesh networks meet multi hop wireless communications very well studied in the context of ad hoc networks, when having the same target of coverage if a given area as a sensor network and the same needs of controlling from a telecommunication operator having to offer a guaranteed quality of service.

The goal of CARMA is to study and analyze the capacity of such mesh networks, major criterion of QoS. Then, it is mandatory to combine complementary theoretical approaches (deterministic bounds, stochastic tools, graph theory, etc) to develop methods and tools for modeling and evaluating the capacity provided by a mesh network. Then, we will aim at optimizing this capacity to enhance the network behavior. To do it, CARMA turns toward cross-layer approaches to approach the optimal behavior and provide a efficient deployment suitable and adaptive to applications. CARMA aims for it at providing communication protocols acting simultaneously at the MAC layer and the routing aspects. At last, protocols will be validated through theoretic tools, simulations and experiments.

List of participants: INRIA - ARES (G. Chelius, F. Valois), INRIA - MASCOTS (D. Coudert, H. Rivano) and LSR - DRAKKAR (A. Duda, F. Theoleyre).

7.13. CNRS national platform "Sensor and Self-Organized Networks" (RECAP)

Participants: Jean Carle [contact], Antoine Gallais, Julien Graziano, Michael Hauspie, Francois Ingelrest, Fadila Khadar, Nathalie Mitton, David Simplot-Ryl [contact].

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

Self-adaptive and self-organized are questions of active research in a number of different research communities, ranging from hardware to applications. Many topics must be study such as topology control (addressing, localization, etc.), data communication (broadcasting, routing, gathering, etc.), architecture (hardware, system -OS-, network -communication stacks-, etc.), applications (service lookup, distributed database, etc.). The RECAP project is a CNRS national platform which aims to support research activities in this area. RECAP is organized in four sub-projects: Applications, Data Communication, Topology Control, and System Architecture.

List of participants: CITI INSA Lyon (E. Fleury), LAAS (M. Diaz), LIFL (J. Carle), LIP6 (M. Dias de Amorim), IRISA (P. Quinton), LSIIT (T. Noël), LSR (A. Duda).

7.14. ACI Sécurité Informatique CLADYS 2004-2007

Participants: Farid Naït-Abdesselam [contact], Thomas Soete.

Mobile ad hoc networks are able to provide fast and efficient network deployment capabilities in a wide variety of scenarios where a fixed networking infrastructure is not possible. These types of networks offer new challenging security problems due primarily to their wireless network interface, allowing easy eavesdropping and injection of messages, and to their distributed infrastructure-less topology. The security in mobile ad hoc networks has been analyzed individually at different layers of the communication protocols. In this project we are investigating a cross layer approach to provide a novel global assessment of the network by analyzing the risk and vulnerabilities across communication protocol layers under different kind of adversarial settings. However, there is an inherent trade-off between the performance of a network and its security . In this work we explore possible evaluations of security threats versus the cost of prevention and reaction to such threats. We consider different kind of adversaries with different capabilities. We are investigating the effect of these capabilities on the different layers and the network as a whole. Such a study will help identify the importance of layered security in this infrastructure-less wireless setting.

The network assumptions are fundamental for the type of security mechanism we can deploy. Ideally the communication and security properties we want the network to have under any type of adversarial setting are: access control, availability, and end to end message integrity, authenticity, and confidentiality. However, not all of these properties are easily achieved. Some properties even have mutual conflicting goals: providing integrity, authenticity and confidentiality incur in extra computation and bandwidth from the network, which can produce a decrease in network performance, functionality and ultimately, it can affect its availability. Therefore, due to the limited resources in ad hoc networks, the tradeoff between improved security, vulnerability and network performance need to be closely examined and taken into consideration in this project. Much of the efforts will be toward the study of cross layer interactions for detecting attacks and to provide intrusion detection and tolerance, along with graceful degradation designs for network survivability.

List of participants: USTL (F. Naït-Abdesselam), UVSQ J. Ben-Othman, ENST J. Leneutre, Univ. Avigno A. Benslimane.

7.15. ANR SESUR 2007 “Securing Flow of INformation for Computing pervasive Systems” (SFINCS) (2008-2010)

Participants: Dorina Ghindici, Gilles Grimaud, Isabelle Simplot-Ryl [project leader].

The upsurge of a globally interconnected network of devices have had a deep impact on the environment, habits and even typology of computing devices end-users. These advances changed our behaviour in a lot of beneficial ways but also gave way to new threats that feed decades-old fears about liberty. Preserving privacy and security are thus more than ever at the heart of service users and providers concerns.

In an open, heterogeneous and highly concurrent context, enforcing private and business data confidentiality requires, beyond basic access control, fine-grained control over data usage by the various actors. This problem is known from the litterature as information flow control. Information flow analysis has been actively investigated for several years, leading to a rich theory. This problem has usually been tackled from a type-checking or static analysis viewpoint. However, it appears that this rich theory has been scarcely applied in the industry.

The SFINCS project aims at studying application of this theory on practical use-cases to identify bottlenecks that prevent wider industrial adoption of information flow control techniques. To this end, project SFINCS brings together complementary partners: From case studies provided by industrial partners, academic partners shall enrich information flow theory to take into account practical issues preventing thorough analysis of ubiquitous software systems. Provided case studies come from distance selling services and mobile telephony and thus will provide a wide array of the diverse problems encountered in the enforcement of needed security and privacy properties.

This project addresses varied problems:

- Sofware engineering and programming problems, like analysis of programs using shared libraries through public APIs or external streams (eg. XML),
- Theoretical problems about information analysis, like tracking information in arrays or collections,
- Security engineering problems, like expressing of security rules or selective authorisation of information leaking through safe channels (eg. using cryptography).

List of participants: LIFL (G. Grimaud, I. Simplot-Ryl), LIF, Univ. of Provence (J.-M. Talbot), VERIMAG (Laurent Mounier, Michael Périn, Yassine Lakhnech, Pascal Lafoucarde), NORSYS/SI3SI (Pascal Flamant, Arnaud Bailly), Trusted Labs (Anthony Ferrari, Erci Vétillard).

7.16. International Relationship

We have research activities with international partners as:

- Edgar Chavez, Univ. Morelia, Mexico,
- Ivan Stojmenović, Univ. Ottawa, Canada.
- Issa Traoré, Univ. of Victoria, Canada.

Isabelle Simplot-Ryl is member of the Creol project (CREOL: A formal framework for reflective component modelling) of the University of Oslo funded by the Research Council of Norway through the strategic programme IKT-2010.

7.17. Visits and Invitations of Researchers

- Prof. Ivan Stojmenović from the University of Ottawa was invited in Lille for two month in May and June 2006.
- Prof. David Simplot-Ryl, and Isabelle Simplot-Ryl were visiting professors at the University of Ottawa in August 2007.

8. Dissemination

8.1. Editorial Activities

- **David Simplot-Ryl** is managing editor of *Ad Hoc & Sensor Wireless Networks: An International Journal (AHSWN)* (Old City Publishing), associate editor of *International Journal of Computers and Applications (IJCA)* (ACTA Press), member of editorial board of *International Journal of Wireless and Mobile Computing (IJWMC)* (Inderscience) and of editorial board of *International Journal of Parallel, Emergent and Distributed Systems (IJPEDS)* (Taylor & Francis). He is guest-editor of a special issue of *Journal of Computer Communications* (Elsevier) on "Sensor-Actuator Networks (SANETs)" in 2007.

8.2. Organization Committees and Program Committees (Conferences, Workshops, Schools)

- **Jean Carle** was program committee member of several international events such as :
  - *3rd International Conference Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) 2007*, (Melbourne, Australia, December 3-6).
  - *3rd International Workshop on Localized Communication and Topology Protocols for Ad hoc Networks (LOCAN 2007* (Pisa, Italy, Monday, October 8th).
  - *1st International Workshop on Peer to Peer Networks (PPN´07)* (Vilamoura, Algarve, Portugal, November 26th).
  - *8th ACIS International Conference on Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing (SNPD2007)* (Qingdao, China, July 30 - Aug 1).
  - *IADIS International Conference on Applied Computing 2007 (IADIS AC 2007)* (Salamanca, Spain, February 17-20).
- **Gilles Grimaud** is involved in the program committee of international events:
  - *Design and Implementation of Programming Languages (PLDI'07)* (San Diego, CA, USA, June 10-13).
  - *Principles and Practice of Programming in Java 2007 (PPPJ'07)* (Lisbon, Portugal, September 4-7).
- **Michaël Hauspie** is a program committee member of:
  - *IADIS International Conference on Applied Computing 2007 (IADIS AC 2007)* (Salamanca, Spain, February 17-20).
- **Nathalie Mitton** is a program committee member of:
  - *4th IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS-2007)* (Pisa, Italy, October 8-11, 2007).

- *1st ACM Workshop on Sensor Actor Networks (SANET 2007)* (Montreal, Canada, Sept. 10, 2007).
- *9eme Journées doctorales en Informatique et Réseaux (JDIR 2008)* (Villeneuve d'Ascq, France, Jan. 16-18, 2008).

She is a member of the shadow committee member of

- *3rd International Conference on emerging Networking EXperiments and Technologies (CoNext 2007)* (New York, USA, December 10-13, 2007).

She is publicity chair:

- *4th IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS-2007)* (Pisa, Italy, October 8-11, 2007).
- *1st ACM Workshop on Sensor Actor Networks (SANET 2007)* (Montreal, Canada, Sept. 10, 2007).

- **Farid Naït-Abdesselam** is a program committee member of several international events:
  - *IADIS International Conference on Applied Computing 2007 (IADIS AC 2007)* (Salamanca, Spain, February 17-20, 2007),
  - *First International Workshop on Next Generation Networks for First Responders and Critical Infrastructures (NetCri07), in conjunction with 26th IEEE International Performance Computing and Communications Conference* (New Orleans, Louisiana, USA, April 11-13, 2007),
  - *Second International Workshop on eSafety and Convergence of Heterogeneous Wireless Networks (eSCo-Wi'07)*, in conjunction with the *26th IEEE International Performance Computing and Communications Conference* (New Orleans, Louisiana, USA, April 11-13, 2007),
  - *IEEE International Conference on Communications (IEEE ICC 2007)* (Glasgow, Scotland, UK, June 24-28, 2007),

- **David Simplot-Ryl** is general co-chair of:
  - *International Workshop on Interactive Multimedia & Intelligent Services in Mobile and Ubiquitous Computing 2007 (IMIS-07)*, (Seoul, Korea, April 26-28, 2007), general co-chair,
  - *3rd International Workshop on Localized Communication and Topology Protocols for Ad hoc Networks (LOCAN 2007)*, (Pisa, Italy, 2007, October 8, 2007), organized in conjunction with the *4th IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS-2007)*,
  - *4th Workshop on Wireless Ad hoc and Sensor Networks (WWASN2007)*, (Toronto, Canada, June 25, 2007) a full day workshop held in conjunction with the *The International Conference on Distributed Computing Systems (ICDCS 2007).*
  - *2nd International Workshop on Interactive Multimedia & Intelligent Services in Mobile and Ubiquitous Computing 2007 (IMIS-08)*, (Busan, Korea, April 24-26, 2007), steering committee.
  - *5th Workshop on Wireless Ad hoc and Sensor Networks (WWASN2008)*, (Beijing, China, June 17-20, 2008) organized in conjunction with the *The International Conference on Distributed Computing Systems (ICDCS 2008).*

  He is program chair, vice-chair or co-chair of:

  - *1st ACM Workshop on Sensor Actor Networks (SANET 2007)*, (Montreal, Canada, September 10, 2007), organized in conjunction with *ACM MobiCom 2007*,

- *4th IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS 2007)*, (Pisa, Italy, October 8-11, 2007), vice program chair,
- *1st ACM Workshop on Convergence of RFID and Wireless Sensor Networks and their Applications (SenseID 2007)*, (Sydney, Australia, November 6, 2007), organized in conjunction with the *5th ACM Conference on Embedded Networked Sensor Systems (ACM SenSys 2007)*,
- *10ème Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel 08)* (Saint Malo, France, May 14-16, 2008).
- *7th International Conference on Ad-hoc Networks and wireless (ADHOC-NOW 2008)*, (Nice, France, September 10-12, 2008).

He is award chair of:

- *4th International Conference on Ubiquitous Intelligence and Computing (UIC-07)*, (Hong-Kong, China, July, 11-13, 2007

He was publicity chair of:

- *1st IEEE International Workshop: from Theory to Practice in Wireless Sensor Networks (t2pWSN'2007)*, (Helsinki, Finland, June 18, 2007) organized in conjunction with the *IEEE Internation Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2007)*,
- *The 2007 International Workshop on Intelligent Systems and Smart Home*, (Niagara Falls, Canada, August 28-September 1, 2007), organized in conjunction with the *5th International Symposium on Parallel and Distributed Processing and Applications (ISPA07)*.

He is member of several program committees:

- *1st International Conference on New Technologies, Mobility and Security (NTMS'2007)*, (Paris, France, April 30-May 3, 2007),
- *International Workshop on Service, Security and its Data management for Ubiquitous Computing (SSDU-07)*, (Nanjing, China, May 22-25, 2007) in conjunction with *PAKDD 2007*,
- *International Workshop on Wireless Sensor Networks*, (Marrakesh, Morocco, June 4-8, 2007) in conjunction with *NOTERE 2007 (New Technologies of Distributed Systems NOuvelles TEchnologies de la REpartition)*,
- *2nd International Conference on Body Area Networks (BodyNets 07)*, (Florence, Italy, June 11-13, 2007),
- *1st IEEE International Workshop: from Theory to Practice in Wireless Sensor Networks (t2pWSN'2007)*, (Helsinki, Finland, June 18, 2007) organized in conjunction with the *IEEE Internation Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2007)*,
- *2nd International Conference on Digital Telecommunications (ICDT 2007)*, (Silicon Valley, USA, July 1-6, 2007),
- *8th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2007)*, (Montréal, Canada, September 9-14, 2007),
- *3rd International Workshop on Wireless and Sensor Networks Security (WSNS'07)*, (Pisa, Italy, October 8, 2007), organized in conjunction with the *4th IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS-2007)*,
- *32nd IEEE Conference on Local Computer Networks (LCN 2007)*, (Dublin, Ireland 15-18 October 2007).

- *2nd International Workshop on Trustworthiness, Reliability and services in Ubiquitous and Sensor neTworks (TRUST 2007)*, (Taipei, Taiwan, December 10-13, 2007) in Conjunction with *EUC 2007*.
- *3rd International Conference on Mobile Ad-hoc and Sensor Networks (MSN 2007)*, (Beijing, China, December 12-14, 2007),

- **Isabelle Simplot-Ryl** is a program committee member of several international events:
  - *5th International Conference on Ubiquitous Intelligence and Computing (UIC 08)*, (Oslo, Norway, June 23-25, 2008).
  - *Eighth Smart Card Research and Advanced Application IFIP Conference (CARDIS 2008)*, (Ehgam, UK, September 2008).
  - *2nd International Workshop on Interactive Multimedia & Intelligent Services in Mobile and Ubiquitous Computing 2008 (IMIS 2008)* (Busan, Korea, April 24-26, 2008), in conjunction with MUE2008.
  - *9^e^ Journées Doctorales en Informatique et Réseaux (JDIR'08)*, (Lille, Janvier 2008).
  - *32nd IEEE Conference on Local Computer Networks (LCN 2007)*, (Dublin, Ireland 15-18 October 2007).
  - *2nd International Symposium on Smart Home (SH-07)*, (Jeju Island, Korea, December 7-8, 2007).
  - *International Workshop on Interactive Multimedia & Intelligent Services in Mobile and Ubiquitous Computing (IMIS-07)*, (Seoul, Korea, April 26-28, 2007), in conjunction with MUE2007.
  - *IADIS International Conference Applied Computing (Applied Computing 2007)* (Salamanca, Spain, February 17-20, 2007).

  She is Workshop Co-chair of:
  - *1st International Workshop on Formal Verification and Validation of Uniquitous Systems (ForVUS 2008)*, (Busan, Korea, April 24-26, 2008), in conjunction with *MUE2008*.
  - *First International Colloquium on Foundations of Mobile Systems Security And Reliability (MOSAR 2008)*, (Nice, September 2008), in conjunction with *ADHOC-NOW 2008*.

8.3. Invited Talks and Seminars

- **David Simplot-Ryl** gave a number of invited talks:
  - Broadcasting and area coverage in ad hoc and sensor networks *First Research Workshop on Wireless Computing and Sensor Networks (WCSN)*, (Havana, Cuba, April 2007).
  - RFID and Sensor Networks *First Research Workshop on Wireless Computing and Sensor Networks (WCSN)*, (Havana, Cuba, April 2007).
  - Beyond Smartcards and RFID: Smart Sensors. *Smart University, Ubiquitous computing: State of the art and challenges for the software infrastructure* (Sophia Antipolis, France, 2007).
- **Isabelle Simplot-Ryl** gave an invited talk:
  - Cooperation and security in ad hoc networks. *First Research Workshop on Wireless Computing and Sensor Networks (WCSN)*, (Havana, Cuba, April 2007).

8.4. Teaching

- **Jean Carle** is director of a vocational degree in computer sciences (licence professionnelle). He is also in charge of lecture in Mobile Networking for master degree in computer science, of lectures in *Networking and Data Communication* to under degree in computer science (IUT 1^{st} and 2^{nd} year) and in *Algorithm* to under degree in computer science (IUT 1^{st} year).
- **Gilles Grimaud** is in charge of lectures in *Embedded Systems* for research master (DEA), of lecture in *Security of Networks and Systems* for professional master (DESS), of lecture in *Operating Systems Architecture* for master of computer science (maîtrise), and of lecture in *Networking* in computer science degree (licence).
- **Michaël Hauspie** is director of vocational degree in computer science (licence professionnelle) and in charge of lectures in *Software engineering*, *Networking* and *Operating Systems* in under degree in computer science and vocational degree in computer science (IUT 1st and 2nd year/licence professionnelle). He also gives lectures in *Algorithms for wireless networks* in research masters in telecommunications.
- **Nathalie Mitton** is in charge of lecture in *Mobile Networking* for research master (DEA), and in *Transmission and Protocols* for vocational degree in computer science (licence professionnelle).
- **Farid Naït-Abdesselam** was responsible of numerous lectures in *Network engineering* and *Mobile Networking* for research and professional masters in computer science (DEA, DESS, ENIC).
- **Isabelle Simplot-Ryl** is head of the computer science department of the IUT-A. She is in charge of lectures in systems programming to under degree in computer science and vocational degree in computer science (IUT 2nd year/licence professionnelle), and of Lectures in Security in master.

8.5. Miscellaneous Scientific Animation

- **David Simplot-Ryl** was referee or examiner for several PhD thesis and Habilitation thesis:
  - Abdelmalik Bachir (LIG, IMAG, directed by Prof. Andrzej Duda),
  - Arnaud Casteigts (LABRI, Univ. Bordeaux 1, directed by Prof. Serge Chaumette),
  - Julien Montavont (LSIIT, Louis Pasteur University, directed by Prof. Thomas Noel),
  - Tahiry Razafindralambo (CITI, INSA Lyon, directed by Prof. Isabelle Guérin-Lassous),
  - Fabrice Valois (CITI, INSA-Lyon, habilitation thesis),
  - Adrien Van den Bossche (LATTIS, Univ. Toulouse II, directed by Prof. Thierry Val).
- **Gilles Grimaud** is a member of the steering committee of French Chapter of ACM SigOps. He is also is a member of the IFIP Working group 8.8 (SmartCards) and a member of the CSE of Lille university and Valenciennes University.
- **David Simplot-Ryl** is a member of the working group of OFTA (Observatoire Français des Technologies Avancées) on Ambient Computing directed by Valérie Issarny. He is member of the scientific committee of GDR ASR of CNRS.
- **Nathalie Mitton** is a co-initiator and a steering committee member of the "1^{st} International workshop on Mobility, Algorithms, Graph Theory In dynamic Networks (IMAGINE 2007)"
- **The POPS team** organizes the "$9^{èmes}$ Journées Doctorales en Informatique et Réseaux" which will hold at Villeneuve d'Ascq from January 16th to January 18th 2008.

9. Bibliography

Major publications by the team in recent years

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[2] J. CARLE, D. SIMPLOT-RYL. *Energy Efficient Area Monitoring by Sensor Networks*, in "IEEE Computer", vol. 37, 2004, p. 40–46.

[3] J. CARTIGNY, D. SIMPLOT-RYL. *Border Node Retransmission Based Probabilistic Broadcast Protocols in Ad-Hoc Networks*, in "Telecommunication Systems", vol. 22, n^{o} 1-4, 2003, p. 189–204.

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