INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Team MADYNES

Management of Dynamic Networks and Services

Lorraine

THEME 1B

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1. Team

MADYNES is a project of the LORIA (UMR 7503) laboratory, common with CNRS, INRIA, Henri Poincaré University - Nancy 1, Nancy 2 University and the Lorraine National Polytechnical Institute (INPL). This report covers the team activity from November, 1st 2002 to October, 31st 2003.

Head of the project team
Olivier Festor [Research Director - INRIA]

Vice-head of the project team
Isabelle Chrisment [Assistant Professor, ESIAL - UHP]

Administrative Assistant
Josiane Reffort [Project assistant, Nancy 1 University - UHP]

INRIA Staff
Radu State [Researcher - INRIA]

University Staff
Laurent Andrey [Assistant Professor, Nancy 2 University]
Laurent Ciarletta [Assistant Professor, ENSMN - INPL, since 1/10/2003]
Jacques Guyard [Professor, ESIAL - UHP]
Emmanuel Nataf [Assistant Professor, Nancy 2 University]
André Schaff [Professor, Director of ESIAL]

Guest Researchers
Rachida Dssouli [Professor, Concordia University, Montréal, CA (july-august 2003)]

Project technical staff
Isabelle Astic [INRIA, 6Net & VTHD++ contract until august 31th, 2003]
Abelkader Lahmadi [INRIA, VTHD++ contract]

Ph.D. Students
Mouna Benaissa [MEN grant UHP-Nancy 1, in cooperation with the CRAN lab., 3rd year]
Nizar Ben Youssef [Industrial Funding, UHP-Nancy 1, 1st year]
Guillaume Doyen [MEN grant, UHP-Nancy 1, 1st year]
Hassen Sallay [Region/Industry co-funded grant, UHP-Nancy 1, 3rd year]

Student Interns
Rémi Badonnel [DEA Informatique & ESIAL, UHP, France]
Adnane Ben Halima [ENSI, Tunis, Tunisia]
Laurent Berroyer [Maîtrise IUP GEII - Nancy, France (2 months)]
Mohamed Salah Bouassida [DEA Informatique UHP, France]
Vincent Cridlig [DEA Informatique & ESIAL, UHP, France]
Clément Dony [IUT- Charlemagne, Département SRC, Verdun, France (2 weeks)]
Pierre Humbert [DEA Informatique & ESIAL, UHP, France]
Ouadi Lakchine [ENSIAS, Rabat, Moroco]
Hanane Oumina [INPT, Rabat, Moroco]
Romain Recourt [IUT- Charlemagne, Département Informatique, Nancy, France (2 months)]
Clément Ridoret [Maîtrise IUP GEII - Nancy, France (2 months)]
Amal Tati [ENSIAS, Rabat, Moroco]
Benjamin Zores [DEA Informatique & ESIAL, UHP (2 months)]

2. Overall Objectives

Key words: *automated management*, *management frameworks*, *mobile device management*, *network management*, *service management*, *dynamic environments*, *service configuration*, *provisioning*, *monitoring*, *security*,

benchmarking, *telecommunications* .

The goal of the MADYNES research team is to design, validate and deploy novel management and control paradigms and software architectures that are able to cope with the growing dynamicity and the scalability issues induced by the ubiquitous Internet.

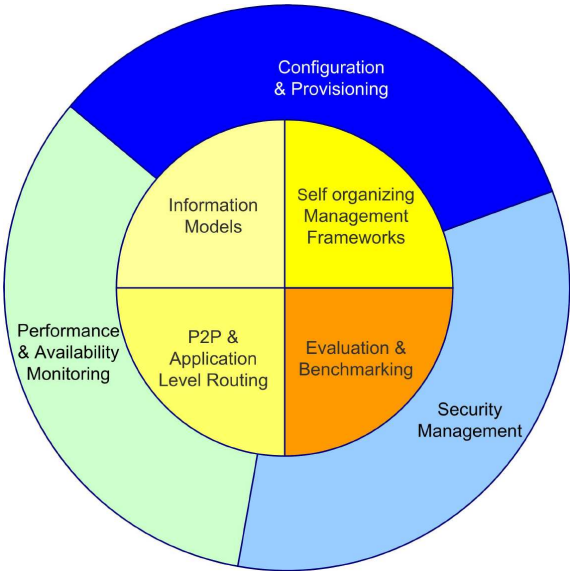

Figure 1. The MADYNES research themes

Therefore, the project develops activities in the following areas (see Figure 1 for details):

- **Autonomous Management** (inner circle of figure 1):
  - the design of models and methods enabling self organisation and self-management of networked entities and services,
  - the design and evaluation of management architectures based on peer-to-peer and application level routing principles together with novel approaches to the representation of management information,
  - the modelling and benchmarking of management infrastructures and activities.
- autonomous management is instantiated within **Functional Areas** (outer circle of Figure 1):
  - the security plane where we focus on new key management protocols and security of the management plane,
  - the service configuration and provisioning plane where we aim at providing solutions for the automation of processes ranging from service subscription to service deployment and service activation,
  - performance and availability monitoring.

The next generation Internet is the main application field of our research. Its architecture and the services that it is planned to support offer all dynamic and scalability features that we address in the two complementary research directions of the project.

3. Scientific Foundations

3.1. Evolutionary needs in network and service management

The foundation of the project is the ever increasing need for automated monitoring and control within networked environments. This need is mainly due to the increasing dependency of both people and goods towards communication infrastructures as well as the growing demand towards higher quality in the offered services. Because of its strategic importance and crucial interoperability requirements, the management models were constructed in the context of strong standardisation activities (by organisations like IEEE, IETF, ISO, ITU-T, TMF or DMTF) over the last 15 years. This led to the design of most of the paradigms used in today's deployed approaches. These paradigms are the Manager/Agent interaction model, the Information Model paradigm and its container, together with a naming infrastructure called the Management Information Base. In addition to this structure, five functional areas known under the FCAPS[1] acronym are associated to these standards.

While these models were well suited for the specific application domains for which they were designed (telecommunication networks or dedicated protocol stacks), they all show the same limits. Especially they are unable to:

1. deal with any form of dynamicity in the managed environment,
2. master the complexity, operating mode and heterogeneity of the emerging services,
3. resist to scale of new networks and service environments.

The above three limits are observed in all five functional areas of the management domain and represent the major challenges when it comes to enable effective automated management and control of the devices, networks and services in the next decade.

MADYNES addresses these challenges by focusing on the design of management models that rely on inherently dynamic and evolving environments. The project is centered around two core activities. These activities are, as mentioned in the previous section, the design of an autonomous management framework and its application to the standard functional areas: security, configuration and performance.

3.2. Autonomous management

3.2.1. Models and methods for a self-management plane

Self organisation and automation is a fundamental requirement within the management plane in today's dynamic environments. It is necessary to automate the management processes and enable management frameworks to operate in time sensitive evolving networks and service environments. The automation of the organization of devices, software components, networks and services is investigated in many research projects and has already led to several solution proposals. While these proposals are successful in several layers, like the IP auto-configuration or the service discovery and binding facilities, they did not enhance the management plane at all. For example, while self-configuration of IP devices is commonplace, no solution exists that provides support to the SNMP plane to configure itself (e.g. finding the manager to which an agent has to send traps or organizing the access control based on the locality or any other context information). This area represents a major challenge in extending current management approaches that they become self-organized.

Our approach relies on a bottom-up effort which consists in identifying those parameters and framework elements (manager data, information model sharing, agent parameters, protocol settings, ...) that need dynamic configuration and self-organisation (like the address of a trap sink). For these parameters and their instantiation in various management frameworks (SNMP, Netconf, WBEM, ...), we investigate and elaborate novel approaches enabling fully automated setup and operation in the management plane.

[1] Fault, Configuration, Accounting, Performance and Security

3.2.2. Design and evaluation of P2P-based management architectures

Over the last years, several models emerged and gained wide acceptance in the networking and service world. Among them, the overlay networks together with the P2P paradigms appear to be very promising. Since they rely mainly on fully decentralised models, the offer excellent fault tolerance and have a real potential to achieve great scalability. Mainly deployed in the content delivery and the cooperation and distributed computation disciplines, they seem to offer all features required by a management framework that needs to operate in a dynamic world. This potential however needs an in depth investigation because these models also have many characteristics that are unusual in management (e.g. fast and uncontrolled topology evolution or advanced trust relationships environments rather that fully secured frameworks).

Our approach within this research effort complements the bottom-up approach followed in the activity presented before. Here a complete redesign of a management framework is done given the characteristics of the underlying P2P and overlay services. Among the topics of interest we study the concept of management information and operations routing within a management overlay as well as the distribution of management functions in a multi-manager/agent P2P environment. The functional areas targeted using the P2P model are network and service configuration and distributed monitoring. The models are to be evaluated against highly dynamic frameworks such as ad hoc environments (network or application level) and mobile devices.

3.2.3. Integration of management information

Representation, specification and integration of management information models forms a foundation of network and service management and remains an open research domain. The design and specification of new models is mainly driven by the emergence of new protocols, services and usage patterns. These need to be managed and exposed through well designed management information models. Integration activities are driven by the multiplication of various management approaches (e.g even within one standardisation body, often several information models and management approaches co-exist). To enable automated management, these approaches need to inter-operate which is not the case today.

The MADYNES approach for the problem of management information modelling and representation aims to:

1. enable application developers to establish their management interface in the same workspace, with the same notations and concepts as the ones used to develop their application,
2. foster the use of standard models (at least the structure and semantics of well defined models),
3. design a naming structure that allows management information request routing in an overlay management plane and
4. evaluate new approaches to the integration especially based on management ontologies and semantic information models.

3.2.4. Modelling and benchmarking of management infrastructures and activities

The impact of a management approach on the efficiency of the managed service highly depends on three factors:

- the distribution of the considered service and the associated management tasks,
- the management patterns used (e.g. monitoring frequency, granularity of the management information considered),
- the cost in terms of resources these considered functions have on the managed element (e.g. method call overhead, management memory footprint).

While the first factor was investigated in several research projects so far, none of the other two were investigated at all. The lack of such benchmarking data and models simply make an objective evaluation of operational cost of a management approach impossible. This may be acceptable in backbone networks where

processing and communication resources can be tuned very easily (albeit sometimes at a non negligible cost). This is not true in constrained environments like in battery and processing limited devices or in bandwidth limited wireless networks for which the lack of a management cost models is a serious concern.

MADYNES addresses this problem from multiple viewpoints: communication, patterns and processing and/or memory resources consumption. Our goal is to provide management patterns combining several management technologies if needed so as to optimise the resources consumed by the management activity imposed by the operating environment. Therefore, we establish *abacuses* for management frameworks and in parallel we collect data on current management practice. These data will form the core of the "Constraints-based management tuning activity" that we are working on and can be used for rigorous comparison among distribution and processing of management activity.

3.3. Functional Areas

3.3.1. Security: key management protocols and security of the management plane

Securing the management plane is vital. While several proposals are already integrated in the existing management frameworks, they are rarely used. This is due to the fact that these approaches are completely detached from the enterprise security framework. As a consequence, the management framework is "managed" separately with different models which represents a huge overhead. Moreover the current approaches to security in the management plane are not inter-operable at all, multiplying the operational costs in a heterogeneous management framework.

The primary goal of the research that needs to be undertaken in this activity is the design and validation of a security framework for the management plane that will be open and capable to integrate the security services provided in today's management architectures. Management security interoperability is of major importance in this activity.

Our activity in this area aims at designing a generic security model in the context of multi-party / multi-technology management interactions. Therefore, we develop research on the following points:

1. Abstraction of the various access control mechanisms that exist in todays management frameworks. We are particularly interested in extending these models so that they support event-driven management which is not the case in most of them today.
2. Extention of policy and trust models to ease and ensure coordination among managers towards one agent or a subset of the management tree. Provisional policies are of great interest to us in this context.
3. Evaluation of the adequacy of key distribution architectures to the needs of the management plane as well as selecting reputation models to be used in the management of highly dynamic environments (e.g. multicast groups, ad hoc networks).

A strong requirement towards the envisioned generic model is that it needs to be instantiated (with potential restrictions) into standard management platforms like SNMP, WBEM or NETCONF and to allow interoperability in environments where these approaches coexist and even cooperate. A typical example of this is the security of an integration agent which is located in two management worlds.

3.3.2. Automation of service configuration and provisioning

Configuration covers many processes which are all important to enable dynamic networks. Within our research activity, we focus on the operation of tuning the parameters of a service in an automated way. This is done together with the activation topics of configuration management and the monitoring information collected from the underlying infrastructure. Some approaches exist today to automate part of the configuration process (download of a configuration file at boot time within a router, on demand code deployment in service platforms, ...). While these approaches are interesting they all suffer from the same limits, namely:

1. They rely on specific service life cycle models (e.g. the activation process is different in OSG*i*, in MeXe or in J2EE client provisioning).

2. They offer proprietary interfaces and protocols for their use.

These two basic limits highly impact service dynamics in a heterogeneous environment.

We follow two research directions in the topic of configuration management. The first one aims to establish an abstract life-cycle model of either a service, a device or a network configuration and to associate to this model a generic command and programming interface. This is done in a way similar to what is followed in the area of call control in initiatives such as Parlay or OSA.

In addition to the investigation of the life-cycle model, we work on technology support for distributing and exchanging configuration management information. Especially, we investigate policy-driven approaches for representing configuration and constraints while we study XML-based protocols (in conjunction with the theme 1 of MADYNES) for coordinating their distribution and synchronisation. Off and online validation of configuration data is also part of this effort.

3.3.3. Performance and availability monitoring

Performance management is one of the most important and deployed management function. It underlies almost any service, and becomes crucial for any service which is bound to a service level agreement describing the expected service delivery level. Performance management needs models, metrics, associated instrumentation, data collection and aggregation infrastructures as well as advanced data analysis algorithms.

Today, a programmable approach for end-to-end service performance measurement in a client server environment exists. This approach, called Application Response Measurement (ARM) defines a model including an abstract definition of a unit of work and related performance records and offers an API enabling application developers to easily integrate measurement within their distributed application. While this approach is very interesting, it is only a first step in the automation of performance management.

We are investigating two specific aspects. First we are working on the coupling and possible automation of performance measurement models with the upper service level agreement and specification levels. Second we are working on the mapping of these high level requirements to the lower level of instrumentation and actual data collection processes available in the network. More specifically we are interested in providing automated mapping of service level parameters to monitoring and measurement capabilities as well as automated deployment and/or activation of performance measurement sensors based on the mapped parameters. This activity also incorporates self-instrumentation (and when possible on the fly instrumentation) of software components for performance monitoring purpose.

4. Application Domains

4.1. Mobile, Ad hoc and constrained networks

The results that emerge from MADYNES can be applied to any dynamic infrastructure that contributes to the delivery of value added services. While this is a potentially huge application domain, we focus at the network level on the following environments:

1. mobile devices and IPv6 networks,
2. multicast services,
3. ad hoc and sensor networks.

All these selected application areas exhibit different dynamicity features. In the context multicast services we focus on key distribution, monitoring and accounting. On *ad hoc* and dynamic networks we are investigating the provisioning, monitoring, configuration and performance management issues.

Concerning Mobile Devices, we are interested in their configuration, provisioning and monitoring. Ipv6 work goes on in Information Models and, combined with SNMPv3, on self-configuration of the agents.

Value added services such as VPNs and/or voice, video, security services are of interest to the team too.

4.2. Dynamic Service Infrastructures

At the service level, dynamics is also increasing very fast. We apply the results of our work on autonomous management on infrastructures which support dynamic composition and for which self-instrumentation and management automation is required.

The target service environments are:

- the Fractal service composition framework,
- the Open Services Gateway initiative (OSG*i*),
- Web Services and,
- peer-to-peer infrastructures.

5. Software

5.1. MADYMAX

Participants: Olivier Festor, Radu State [Correspondent], Benjamin Zores.

We have designed and implemented a management toolkit for SyncML device management. Our work is twofold: we provide the community with experience around this recently proposed management protocol and we offer a possibility to evaluate the performance and target deployment and usage of this management standard. Before MADYMAX was released, no freely available implementations did exist to allow these tasks to be performed.

Our toolkit fits into the global SyncML device management framework. Its functionality starts at the processing of high level device information models and ends at device-specific functional management agents.

The main objective of our toolkit is to automate the development of management agents for the SyncML device management framework. Based on user-specified management interfaces, management agents can be extended to support new management objects. This extension can be done at run-time (in case of Java based service management), or at compile-time (in the case of device specific native management).

Based on an initial prototype of the SyncML representation protocol [20], we redesigned and implemented the framework with all services in Java [32]. The toolkit is registered within the APP and is freely distributed under an open source (LGPL) license. It is available on the team's web site.

5.2. SMIng agent toolkit

Participants: Olivier Festor, Emmanuel Nataf [Correspondent].

We have designed and implemented a management toolkit for SMIng[2] specifications and their mappings onto network (SNMP) and policy (COPS-PR[3]) management. We provide a reference implementation that is needed to the IETF standardisation process toward homogeneous management solutions.

Our toolkit provides an operational architecture where policy rules and network information can be integrated in order to manage networks and services with policy rules or to use network management information for policy rules choice. Starting from SMIng specifications of policies, together with networks and services information models, we provide a solution that generates the agent interfaces working on two sides; one on the network side where the agent acts as a proxy and a Policy Decision Point (PDP). The second side is a manager for whoom the generated agent provides a uniform SMIng-oriented API to management applications. It is presented in [7]. The common use of policy and network management information is illustrated by an application on mobility management [13].

The software package is freely distributed under an open source (LGPL) license and is available on the team's web site.

[2]Structure of Management Information - next generation
[3]Common Open Policy Service - Provisioning

6. New Results

6.1. Provisional policies for secure management of multi-homed devices

Participants: Isabelle Chrisment, Olivier Festor, Radu State [Correspondent].

The current approaches for network management are based on the static pre-configuration of the management plane. Management agents and managers share a common knowledge about the underlying management information model and the access to the management objects. These approaches have some important shortcomings, among which important configuration complexity as well as limited adaptability to network dynamics due to network or user mobility.

We proposed a new management paradigm based on several key issues. Firstly, the classical client-server interaction is extended towards a more powerful vision in which managers can perform management actions if and only if other management platforms agree. Management tasks are performed within a given context (spatial, temporal or management data driven) and taken into account by a context-aware management plane. We defined a framework based on provisional policies, in which policies concerning the management plane can be specified. These policies regulate access to management objects, allowing to model context-related information and additional manager interactions. We have shown how the already existing SNMPv3 management protocol can be transparently extended to implement our approach [30][10].

6.2. P3P formalisation and evaluation

Participants: Vincent Cridlig, Olivier Festor, Jacques Guyard [Correspondent].

Writing and evaluating policies is a recurrent problem in todays networked environments. Most of these policies addressing security and privacy are expressed and processed in rule-based frameworks. We studied one of the policy languages currently used in Web privacy, namely P3P (the Platform for Privacy Preferences). We addressed the use of a formal approach to specify and generate an evaluation environment for P3P-based privacy policy specifications using the ELAN framework. The outcome of the work was a formalisation in ELAN of the APPEL and P3P languages [3].

We implemented the evaluation environment in a software component which returns the appropriate behaviour from a remote resource, a P3P policy and user APPEL preferences. This environment is being integrated in the Mozilla browser [2].

This work was extended with the ELAN formalisation of another policy language of the management community namely Ponder developed at Imperial College [22].

6.3. Secure Multicast in ad hoc networks

Participants: Mohamed Salah Bouassida, Isabelle Chrisment [Correspondent], Olivier Festor.

The multicast model appears as a way to optimise communications used by multimedia applications (audio, video conferences,...) involving several participants. But, group communications makes well-known security issues more complex. It involves some specific features which can influence the security architecture: group size and scalability, multicast application type, duration of group life, heterogeneity of group members.

On the other side, ad hoc networks offer dynamic characteristics in space and time ; these networks create themselves spontaneously and do not rely on any predefined infrastructure. Therefore, ad hoc networks present other interesting challenges for securing group communication.

To address these challenges, we have proposed an extension of the BAAL approach to adapt it within ad hoc environment [21]. The BAAL protocol was specified in our research team to manage and distribute the group key within wired networks.

6.4. QoS conscious Web Service orchestration & automated instrumentation

Participants: Laurent Andrey [Correspondent], Rémi Badonnel, Olivier Festor.

As a framework which allows composition, we studied the management of Web Services. In particular, we looked at how the dynamic composition of such services can be combined with performance management. Therefore, we defined an extension of the Business Process Execution Language for Web Services (BPEL4WS) language together with a set of algorithms enabling the services to be dynamically combined to optimise the overall service quality as described in the associated service level agreement. The proposed BLEL4WS extensions are quality of service (QoS) constraints that can be associated to simple activities, structured activities or even among activities. An XML Schema was defined to express the constraints in a user friendly way.

These constraints, together with the BPEL4WS description of an activity, are exploited within an operational framework which uses performance monitoring to rank service providers and to dynamically combine instances of web services to meet the QoS constraints of an activity. This intelligent QoS Broker was implemented within the Axis framework and deployed within the MADYNES network [18].

Components models and frameworks are good candidates to ease the development, assembly and deployment of complex disitributed systems. We made a first investigation on the features that should be provided in a component framework to make the designed applications manageable. Two questions guided our work:

- how to use knowledge about components architecture to automatically ellaborate some management functions. For example, we investigated how to get an activation mechanism for a container from the basic contained components,
- what can be provided into component-based frameworks to ease the interaction and/or integration with existing management frameworks like SNMP or JMX.

We developped a demonstrator which illustrated our work on the last point. It is based on the Fractal component model developped by FT R&D Grenoble (DTL/ASR) coupled with JMX, the Java extention for application management. This work has been presented at the “Fractal Workshop” (29 january 2003, Inria Rhône-Alpes, Montbonneau).

6.5. Multicast accounting

Participants: Olivier Festor [Correspondent], Ouadie Lakchine, Hassen Sallay.

Multicast is one of the services which offers great dynamics and thus represents a real challenge to management solutions. In the area of accounting, we improved the existing approaches in two ways. First, we enhanced the existing cost allocation algorithms by introducing the notion of dynamics in their processing, i.e. the support of dynamic join and leave of participants within a given multicast session. This extension was applied to the cost allocation strategy called Equal Link Split Download (ELSD) as defined by Herzog. We demonstrated that the proposed extension to support dynamics called D-ELSD can be deployed efficiently so as to scale well and such that the proposed strategy maintains the fairness properties of the initial ELSD [8].

The proposed model was implemented into an active network architecture developed within the group called AMAM. It builds upon the FLAME environment (designed in a previous cooperation with Alcatel) and integrates the various plug-gins necessary to perform the accounting activities on several multicast sessions [27].

We also demonstrated that the proposed distribution model for cost allocation and monitoring can be used to support key distribution and multicast security efficiently [9].

6.6. Management of peer-to-peer overlays

Participants: Guillaume Doyen, Olivier Festor [Correspondent], Emmanuel Nataf.

The dynamic nature of peer-to-peer networks highly impacts the way monitoring is performed on their elements and on the service they offer. In a first attempt to define a performance monitoring framework for peer-to-peer networks, we investigated the use of a standard method based on the Application Response Measurement framework from the Open Group. This model was extended through its integration within JMX and applied to an instant messaging service [4].

In parallel to the application level performance monitoring activity, we worked on the instrumentation and management of the JXTA framework. We designed an initial management environment that offers dynamic topology discovery of peered nodes together with statistical data collection on communication channels among peers [31].

6.7. Information modelling and integration

Participants: Olivier Festor, Guillaume Doyen, Emmanuel Nataf [Correspondent], Radu State.

SMIng (Structure of Management Information Next Generation) is an effort undertaken by a set of researchers within the IRTF NMRG team to try to enhance the information modelling framework within the IETF.

The first effort we undertook was to validate the framework based on our experience in previous management information modelling approaches (namely OSI GDMO/GRM). When used in combination with the Common Open Policy Service (COPS), we identified the need to extend COPS in order to be able to fill a SMIng-based management information base. This analysis was performed on an implementation of a SMIng-based agent framework developed within MADYNES.

We also used the SMIng framework in two application domains: one for policy-based management and SNMP-based monitoring of an active network environment (FLAME) [7] and one for the specification of provisional policies [13]. In both cases we showed how the framework and the unified notation can ease the design of information models and associated management agents and applications.

We also have addressed the integrated management of Mobile IP and mobile networks based on a extension of Mobile IP. We propose an extension of the CIM Information Model towards the modelling of management information requested by this type of mobility. Our approach provides a framework for managing the mobile infrastructure as well as the integration of security management (firewall configuration) into the management plane [14]. This work was done in cooperation with Alex Petrescu (Motorola Labs, Paris). The management of mobile devices using the proposed framework was also addressed in this collaboration [15].

6.8. QoS management in Ad Hoc networks

Participants: Mouna Benaissa, Olivier Festor, Hanane Oumina, André Schaff, Radu State [Correspondent].

Although extensive research in the area of ad-hoc networks has already been done, very few of it has addressed the management of ad-hoc network infrastructures. Ad-hoc networks are typical examples of network-wide and user-wide dynamic networks. The requirements for the management plane in such networks are new and challenging with respect to existing management approaches. The interactions among managed entities and manager-side applications must be established (and maintained) dynamically. A mobile node, joining an ad-hoc network must first bootstrap the management plane and next cooperate for the global management of the considered network. Existing proposals in the network management research community do assume that a-priori manager-agent relationships are established. The ad-hoc network landscape invalidates these assumptions.

Our research for the management of ad-hoc networks focused on extending the concepts of policy based management to an ad-hoc networking environment. Our approach is based on extending the IETF-proposed COPS (Common Open Policy Service) towards an ad-hoc environment. Our extension proposes the use of management policies based on radio-level information together with an underlying signalling protocol (BRUIT) designed within the ARES team in Lyon. The novelty of our work resides in proposing a bootstrapping method for the COPS protocol, and the integration of layer 2 network related policies in the management plane. A first implementation of the management framework is available in the team [28].

This work was performed in cooperation with the ARES team within a larger framework offered by the RNRT project SAFARI.

At the application, level, we continued our experiment with the CRAN laboratory on the performance monitoring of interactive audio application in ad hoc networks [1]. This work will be completed in December 2003.

6.9. P2P-based management

Participants: Laurent Ciarletta, Olivier Festor [Correspondent], Pierre Humbert, Radu State.

One of MADYNE's goals is to investigate the use of P2P models as possible candidates for supporting management tasks over highly dynamic environments. In 2003, we initiated these investigations through two different studies.

The first one was to evaluate the impact of P2P systems in the context of device management. There, we proposed the combined use of a JXTA and JMX framework to dynamically configure mobile nodes [11][12].

The second study we made concerning the use of P2P systems for management was to study their usability to dynamically configure distributed firewalls. The P2P environment used in this evaluation is the ActiveXML technology developed within the GEMO Team at INRIA. The benefit of the proposed management architecture is that it combines the dynamics of self-organising P2P overlays with the simplicity of XML and the support of Web Services (these features come from Active XML). Hence, a management application together with its parameters is defined as an Active XML service together with an XML document. In the context of the firewall configuration framework, the document contains the set of policies that are applied to one entity. These policies are updated among the firewalls using the active XML communication and organisation facility. An implementation of the framework was done on Linux using the Daxfi firewall [24].

6.10. IPv6 management and security

Participants: Isabelle Astic, Adnane Ben Halima, Olivier Festor [Correspondent], Abdelkader Lahmadi, Romain Recourt.

As part of the 6Net project we continued our work on the design and adaptation of management techniques for Ipv6 networks. In this context, we finalised our algorithm for topology discovery in IPv6-based local area networks [17]. This algorithm has been implemented and deployed on the LORIA IPv6 testbed [19]. In parallel, we did enhance the back-office of our IPv6 management framework by distributing the management tasks among several servers and improve the usability of the various management interfaces [29][16].

Within VTHD++, we made several performance studies on IPsec combined with Ipv6. These studies which were performed through nation wide deployment and intensive testing of various IPsec implementations, enabled the identification of several interoperability leaks in the implementations (between 33% and 58% successful interoperability hits in the tested scenarios and configurations).They also confirmed that the performance is equal in IPv4 and IPv6 when IPSec is enabled [25][6][26].

7. Contracts and Grants with Industry

7.1. SAFARI

Participants: Isabelle Chrisment, Olivier Festor [Correspondent], Radu State.

From : february 2003
To : january 2006
Participants : France Télécom (leader), ALCATEL, INRIA (ARES, HIPERCOM, MADYNES), LIP6, LRI, LSIIT, LSR-IMAG, SNCF and ENST.

SAFARI is an RNRT precompetitive research project. The goal of the project is to design, setup and deploy a communication suite enabling transparent access, automated configuration, service integration and adaptation within an IPv6 ad hoc network that maintains connectivity with the Internet.

The MADYNES contributions to this project are:

- the design of a policy-based approach for bandwidth reservation in the ad hoc part of the network,
- the design of a monitoring architecture enabling dynamic reconfiguration and supporting transient connectivity of monitored and monitoring nodes,
- the design of a key distribution architecture dedicated to secure a multicast service within the hybrid network.

7.2. OSS-CR

Participants: Laurent Andrey [Correspondent], Olivier Festor, Radu State.

From : september 2003

To : august 2004

Participants : IRISA/ENS Cachan & INRIA/SARDES (leader), LAAS, LIP6, LORIA/MADYNES

OSS-CR (Observation et Supervision des Systèmes Complexes, Répartis et Dynamiques) is a specific action sponsored by two of the Thematic Networks of the CNRS: embedded and complex systems and distributed systems. This specific action addresses one of the foundation of self management namely the inference of a global state for a distributed system based on observers. Its goal is to identify and propose directions and solutions for generation, deployment and operation of distributed monitoring environments in highly dynamic environments and to propose novel approaches to self-instrumentation of systems and event correlation.

The MADYNES contributions to this action are in the area of benchmarking the cost of instrumentation in Java-based distributed applications.

7.3. IST-6Net

Participants: Isabelle Astic, Olivier Festor [Correspondent], Abdelkader Lahmadi.

From : january 2002

To : december 2004

Participants : CISCO (leader), IBM, European NRENs, 12 universities and labs.

6NET (Large-scale International Ipv6 Pilot Network) is an IST project with 30 participants. The project aims at deploying and operating a native IPv6 backbone throughout Europe to experiment all IPv6 services in an inter-domain environment on a large scale.

The MADYNES contribution to this project is the evaluation of management algorithms in the context of IPv6 and the evolution of Open Source management platforms to support IPv6.

Within 6Net, we designed a new topology discovery algorithm for IPv6 Local Area Networks. We implemented the IPv6 MIB-2 on the net-snmp framework and ported several environments on IPv6 (NAGIOS, NTOP, Looking glass services).

7.4. VTHD++

Participants: Isabelle Astic, Olivier Festor [Correspondent], Abdelkader Lahmadi.

From : january 2002

To : april 2004

Participants : France Telecom R&D, INRIA, ENST, ENST-Bretagne, INT, Eurecom and IMAG

VTHD++ is an RNRT funded project. The main goals of the project are to prove that:

- IP can offer value added services like QoS and security on very high speed networks (2,5 Gb/s in the backbone) while preserving the simplicity of network usage and operation, i.e. complexity needs to be addressed in edge devices,
- IPv6 can maintain and even improve the performance of IP networks while preserving the compatibility with IPv4.

We participate in the IPv6 study part of this project. Especially, we contribute to:

- the design, deployment and execution of multi-site IPSec performance and interoperability tests,
- the provision of distributed application environments supporting IPv6,
- the management of IPv6 environments with:
  - the sharing of our experience in Ipv6 management tools,
  - the extension of our looking-glass components.

8. Other Grants and Activities

8.1. International relationships and cooperations

We maintain several international relationships, either through a formal cooperation or on an informal basis.

MADYNES was the coordinator of a Network of Excellence proposal in the area of Network and Service Management within the first call of the 6th framework. The proposal, called MAUI, was led by Olivier Festor. and did integrate 38 research laboratories around Europe, both academic and industry. The proposal was ranked 3rd after the final hearings in the "Broadband for all" thematic priority and is today on a waiting list for possible funding. If not funded within this call, the proposal will be enhanced and resubmitted in a future call.

We cooperate now for several years (2 years before MADYNES was actually created) with Concordia University in Montreal, Canada. This cooperation was targeting the test of IPv6 related protocols. This cooperation, which was funded by the "Fonds France-Canada pour la Recherche", was successfully completed in July 2003 during the 2 months stay of Professor Dssouli within MADYNES. We are currently working on establishing a new formal cooperation in the area of P2P services and their management.

We also maintain an informal cooperation with the team of Aiko PRAS at the University of Twente, The Netherlands. This cooperation is instantiated mainly through our joint participation to the IRTF Network Management Research Group and through joint organisation of network management events. Aiko Pras will co-chair with Olivier Festor and Alexander Clemm the IFIP/IEEE International Symposium on Integrated Network Management in 2005. Olivier Festor together with Aiko Pras and Juergen Schönwälder co-edit a special issue of IEEE Communications Magazine on XML-based management in july 2004. Pierre Humbert spent 3 months at Twente in 2003.

We hosted students from several engineering schools and universities in Morocco (ENSIAS, INPT) and Tunisia (ENSI) for their master thesis degree training period.

8.2. National initiatives

In addition to the cooperation with the various partners within national funded RNRT projects, we are involved in both the steering committee of the Internet Next Generation summer school (Olivier Festor) and the G6 French IPv6 research and experience association (Astic Astic). We also participate to the CNRS pluridisciplinary network (RTP) on communication networks and the OSS-CR specific action (see the contracts section for details)

Olivier Festor served in 2003 as an expert for the RNRT commission 4: Software for telecommunications. He is also member of the board of the ING-RHDM summer school which was held in Porquerolles in may 2003.

Isabelle Chrisment and Olivier Festor participated to the 3 days kickoff workshop of the INRIA activity on Dynamic Networks in September 2003. MADYNES is involved in this coordination and joint research effort led by Philippe Jacquey (HYPERCOM) and Eric Fleury (ARES).

8.3. Guest Researchers

In 2003, Professor Rachida Dssouli from Concordia University, Montréal Canada, spent 2 months (June, July) within the MADYNES research team. During her stay, she worked on the models and infrastructures for IPv6 testing [33]. This was done in the context of a bilateral cooperation we started with Canada in year 2000.

9. Dissemination

9.1. Program committees and conference organisation

Isabelle Chrisment is member of the program committee of CFIP'2003 SAR'2003 (which she co-chaired with Pr. Dssouli), and WSTI'2003. She is also member of the program committee of NOTERE'2004. Isabelle Chrisment organized the second French workshop on network security architectures (SAR'2003). The event which took place in Nancy from June 30 to july 4 was attended by 48 researchers.

Radu State is member of the program comittee of SAR'2003 and IFIP/IEEE DSOM'2003.

Olivier Festor is member of the following program committees : IFIP/IEEE Distributed Systems: Operations and Management (DSOM), IFIP/IEEE Network Operation and Management Symposium (NOMS), IFIP/IEEE International Symposium on Integrated Management (IM), ING-RHDM Summer school, Colloque Francophone sur l'Ingénierie des Protocoles (CFIP), Colloque Francophone sur la Gestion de Réseaux et de Services (GRES), (Mobile Ad hoc Networks workshop (MadNet), Des Nouvelles Architectures de Communication (DNAC), NOTERE.

Olivier Festor is also member of the Board of Editors of the Journal of Systems and Network Management and reviewed 36 papers for several international conferences and journals in 2003. He served as an expert in telecommunications for the "Fond de recherche sur la nature et les technologies" from the Québec Governement and the "National Sciences and Engineering Research Council of Canada".

André Schaff is member of the program committee of CFIP'2003 and NOTERE'2004.

9.2. Teaching

There is a high demand on networking courses in the various universities to which the LORIA belongs. This puts high pressure on the MADYNES members which are all in charge of numerous courses in this domain. Especially the team professors and assistant professors ensure more than the required amount of teaching obligation in their respective institutions: IUT, DEUG, bachelor, master, ESIAL and École des Mines de Nancy engineering school or DEA. Below we only enumerate the courses that are directly related to our research activity.

Within the DEA degree, TRS (Telecommunications, Networks and Services) specialisation, Isabelle CHRISMENT is in charge of the course entitled *Advanced Internet Protocols*; Olivier FESTOR is in charge of the course entitled OVERLAY NETWORKS AND SERVICE INFRASTRUCTURES This course is shared with Pr. Francis LEPAGE from the CRAN.

Isabelle CHRISMENT is managing the Telecommunications and Networks specialisation of the 3rd year at the ESIAL[4] engineering school. She also teaches the networking related courses in this cursus. Olivier FESTOR and Emmanuel NATAF are in charge of the *Network and Service Management* course and Radu STATE teaches network security and wireless communications at the masters degree level.

André Schaff is the Director of the ESIAL Engineering School.

9.3. Tutorials, invited talks, panels

Olivier Festor and Radu State gave a course on the management of dynamic networks and services at the Concordia Institute for Service Engineering - Summer school 2003: Telecommunications Service Engineering

[4] *Ecole d'Ingénieurs en Informatique et ses Applications de Lorraine*

and Network Management in august 2003 [5]. The same course was given as a tutorial at the CFIP'2003 Conference in October 2003 in Paris.

Olivier Festor and Radu State gave a tutorial on the Evolution of network and service management at ECOTEL'2003 in Antibes, France in December 2002 [34].

Olivier Festor gave a one hour tutorial on the Research challenges in network and service management at the CNRS RTP 01 Communication Networks meeting in St Jean-de Luz in February 2003.

Radu State gave a tutorial entitled "Network Management in Beyond 3G networks" networks and their management at the WINS'2002 workshop on Wireless Networking and Security, Izmir, Turkey in December 2002. He also participated to the IRTF NMRG meeting in Heidelberg, October, 20th 2003. There he gave a tutorial on the SyncML framework and the MADYNES implementation.

Olivier Festor was invited as a panelist at the IFIP/IEEE DSOM'2003 event in Heidelberg, Germany in October 2003. The panel topic was "Self-managing distributed systems".

Olivier Festor presented the MADYNES vision of autonomous management at the Alcatel-INRIA research cooperation board, in march 2003.

Laurent Andrey presented his work on component instrumentation and management "componentization" at the Fractal Workshop in January 2003 at Inria Rhône-Alpes in Montbonneau, France.

The multiple project and collaboration meetings have also seen participation from one or several members of the MADYNES Team. For all conferences in which a paper from the team was published, a team member attended and presented the work.

9.4. Habilitation and Ph.D. Commissions, recruitment commissions

Team members did participate to the following Ph.D. commissions:

- Van Le, Ph.D. in computer science from Université de Franche Comté - Besançon. Title: *GRIDSEC: une architecture sécurisée pour le GRID Computing*. Commitee: Laurent Philippe (préssident du jury), Thomas Ludwig (rapporteur), André Schaff rapporteur, Isabelle Chrisment (examinatrice), Frédéric Desprez (examinateur), Hervé Guyennet (directeur de thèse), september 2003.
- Laurent Ciarletta, Ph.D. in computer science from Université Henri Poincaré - Nancy. Title: *Contribution à l'évaluation des technologies de l'informatique ambiante*. Commitee: Jean-Claude Derniame (président du jury), Andrzej Duda (rapporteur), Guy Pujolle (rapporteur), André Schaff (directeur de thèse), Isabelle Chrisment (co-directrice de thèse), november 2003.
- Mauro Sergio Pereira Fonseca (LIP6), Ph.D. in computer science from Université Pierre et Marie Curie - Paris 6. Title: *Architectures basées sur les politiques et SLAs pour la gestion et le contrôle des services et réseaux multi-domaines émergeants*. Commitee: Guy Pujolle, Olivier Festor, Raouf Boutaba, Manoel Camillo Penna, Francine Krief, Nazim Agoulmine, september 2003.
- Hend Koubaa Ph.D in computer science from Université Henri Poincaré - Nancy 1. Title: *Localisation de services dans les réseaux ad-hoc*, Commission: Frédéric Alexandre (référent), Andrzej Duda, Eric Fleury, Philippe Jacquey (rapporteur), André Schaff, Stéphane Ubéda (rapporteur), March 2003.

MADYNES members were members of the following Habilitation Degree commission:

- Eric Fleury, HDR from INSA Lyon and University Claude Bernard - Lyon 1. Title: *Communications de Groupe: du parallélisme au ad hoc*, Commission: Andrzej Duda, Serge Fdida (rapporteur), Philippe Jacquey (rapporteur), Stéphane Ubéda, Olivier Festor (rapporteur) december 2002.

Isabelle Chrisment is an elected member of the recruitment committee in computer science at the Henri Poincaré - Nancy 1 University (27th section) and a nomminated member at the Louis Pasteur University in Strasbourg.

Olivier Festor is a nomminated member of the recruitment commitee in computer science at the Louis Pasteur University in Strasbourg, the Henri Poincaré - Nancy 1 University and at the French National Polytechnical in Lorraine (all three memberships in the 27th section).

Jacques Guyard is member of the recruitment committee in computer science at Henri Poincaré - Nancy 1 University (27th section).

Emmanuel Nataf is an elected member of the recruitment committee in computer science at the University of Nancy2 (27th section).

André Schaff is the elected president of the recruitment committee in computer science at Henri Poincaré - Nancy University (27th section). He is also member of the recruitment committee of the Franche-Comté University (Besançon) and the Louis Pasteur University in Strasbourg. He is also member of the Doctoral board in computer science in Nancy.

10. Bibliography

Publications in Conferences and Workshops

[1] M. BENAISSA, V. LECUIRE, F. LEPAGE, A. SCHAFF. *Analysing End-to-End Packet Delay and Loss in mobile ad hoc networks for interactive audio applications.* in « Workshop on Mobile Ad Hoc Networking and Computing - MADNET 2003, Sophia-Antipolis, France », C. BONNET, editor, pages 27-33, Mar, 2003.

[2] V. CRIDLIG, O. FESTOR, J. GUYARD, P.-E. MOREAU. *A Formal Approach to P3P Privacy Policies Evaluation.* in « 9th Open European Summer School and IFIP Workshop on Next Generation Networks - EUNICE 2003, hungary, Budapest », Sep, 2003.

[3] V. CRIDLIG, O. FESTOR, J. GUYARD, P.-E. MOREAU. *Formalisation et évaluation de politiques P3P.* in « Colloque Francophone sur l'Ingénierie des Protocoles 2003 CFIP2003 », Oct, 2003.

[4] G. DOYEN, N. EMMANUEL, F. OLIVIER. *Management of Peer-to-Peer Networks Applied to Instant Messaging.* in « IFIP/IEEE International Conference on Management of Multimedia Networks and Services - MMNS'2003, Belfast, Northern Ireland, UK », series Lecture notes in Computer Science, volume 2839, Springer, N. A. ALAN MARSCHALL, editor, pages 449-461, Sep, 2003, Proc. 1st End-to-End Measurement Workshop.

[5] O. FESTOR, R. STATE. *Management of Dynamic Networks and Services.* in « Concordia Summer Workshop on Services Engineering and Network Management, Concordia Institute for Information Systems Engineering (CIISE) Concordia University, Montréal, Canada », aug, 2003, http://www.loria.fr/publications/2003/A03-R-183/A03-R-183.ps.

[6] A. LAHMADI, I. ASTIC, O. FESTOR. *Evaluation des implémentations IPsec pour IPv6 : intéropérabilité et performances.* in « 2ème Rencontre Francophone sur Sécurité et Architecture Réseaux - SAR'2003, Marrakech, Maroc », Jul, 2003.

[7] E. NATAF, O. FESTOR, G. DOYEN. *An SMIng-centric proxy agent for integrated monitoring and provisioning.* in « The 8th IFIP/IEEE International Symposium on Integrated Networkd Management - IM'2003, Colorado

Springs, Colorado, USA », Kluwer Academic Publishers, J. S. GERMÀN GOLDSZMIDT, editor, pages 491-503, Mar, 2003.

[8] H. SALLAY, O. FESTOR. *A Highly Distributed Dynamic IP Multicast Accounting and Management Framework.* in « IFIP/IEEE International Symposium on Integrated Network Managament - IM'2003, Colorado Springs, Colorado, US », pages 45-58, Mar, 2003.

[9] H. SALLAY, A. LAHMADI, O. FESTOR, I. CHRISMENT. *Extension de l'architecture active AMAM pour le support des services de sécurité multicast.* in « Colloque Francophone sur la Gestion de Réseaux Et de Services - GRES'2003, Fortaleza, Ceara, Brésil », Feb, 2003, http://www.loria.fr/publications/2003/A03-R-072/A03-R-072.ps.

[10] R. STATE, O. FESTOR, I. CHRISMENT. *Context Driven Access Control to SNMP MIB objects in multi-homed environments.* in « 14 th IEEE International workshop on Distributed Systems : Operations and Management - DSOM'2003, Heidelberg, Germany », Oct, 2003, http://www.loria.fr/publications/2003/A03-R-119/A03-R-119.ps.

[11] R. STATE, O. FESTOR. *A management platform over a peer to peer service infrastructure.* in « 10th IEEE International Conference on Telecommunications - ICT'2003, Tahiti, Papeete », Feb, 2003.

[12] R. STATE, O. FESTOR. *Management of Wireless Dynamic Infrastructures.* in « 8th IEEE Symposium on Computers and Communications - ISCC'2003, Kiris-Kemer, Turkey », IEEE, pages 1373-1379, Jul, 2003.

[13] R. STATE, E. NATAF, O. FESTOR. *A SMIng based Policy Access Control for SNMPv3.* in « 6th IEEE International Conference on High Speed Networks and Multimedia Communications - HSNMC'03, Estoril, Portugal », Jul, 2003.

[14] R. STATE, A. PETRESCU. *Security Management of Extended Mobility.* in « 2ème rencontre francophone sur Sécurité et Architecture Réseaux - SAR'2003, Nancy, France », Jun, 2003.

[15] R. STATE. *Wireless Terminal Management Architectures - Short Paper - Poster.* in « The 8th IFIP/IEEE International Symposium on Integrated Network Management - IM'2003, Colorado Springs, Colorado, USA », Mar, 2003.

Internal Reports

[16] I. ASTIC. *Le Back Office IPv6.* Rapport Intermédiaire, RNRT - Projet VTHD++, Aug, 2003.

[17] I. ASTIC, O. FESTOR, A. SCHAFF. *Recherche dynamique de topologie pour les réseaux IPv6.* Rapport de recherche, number 4706, INRIA, Jan, 2003, http://www.inria.fr/rrrt/rr-4706.html.

[18] R. BADONNEL. *Composition de services et supervision : application aux Web Services.* Stage de DEA, Jun, 2003, http://www.loria.fr/publications/2003/A03-R-182/A03-R-182.ps.

[19] A. BEN HALIMA. *Visualisation de topologie pour les réseaux IPv6.* stage de fin d'étude d'ingénieur, Jul, 2003.

[20] L. BERROYER. *Couche de communication SyncML pour le Device Management.* Stage Microthese IUP Maitrise, Feb, 2003.

[21] M. S. BOUASSIDA. *Sécurité Multicast et Réseaux Ad Hoc.* Stage de DEA, LORIA, Jun, 2003, http://www.loria.fr/publications/2003/A03-R-184/A03-R-184.ps.

[22] V. CRIDLIG. *Formalisation et évaluation des politiques de sécurité et de respect de la vie privée en ELAN.* Stage de DEA, Jul, 2003.

[23] O. FESTOR, I. CHRISMENT, L. ANDREY, J. GUYARD, E. NATAF, A. SCHAFF, R. STATE. *Proposition de Projet MADYNES : Supervision des réseaux et services dynamiques.* Rapport de recherche, Sep, 2003, http://www.loria.fr/publications/2003/A03-R-020/A03-R-020.ps.

[24] P. HUMBERT. *Impact des modèles Web-Services sur les architectures de supervision de réseaux.* Stage de DEA, Jun, 2003, http://www.loria.fr/publications/2003/A03-R-181/A03-R-181.ps.

[25] A. LAHMADI, I. ASTIC, O. FESTOR. *Etude et tests d'interopérabilité des différentes implémentations d'IPsec sous IPv6.* Rapport Intermédiaire, Consortium VTHD++, Jan, 2003.

[26] A. LAHMADI, O. FESTOR. *Impact sur les performances de la sécurisation d'IPv6 par IPsec dans un réseau Gigabit.* Rapport de fin de contrat, Consortium VTHD++, Jul, 2003.

[27] O. LAKHCHINE. *Implémentation de l'architecture AMAM à l'aide des réseaux actifs.* Projet de fin d'études d'ingénieurs, LORIA, Jun, 2003.

[28] H. OUMINA. *La conception et la réalisation d'un agent de supervision à base de politiques pour le protocole BRuIT.* Stage fin d'etudes, Jun, 2003.

[29] R. RECOURT. *Extension du site de supervision du pilote IPv6 Renater II.* Stage de deuxième année de DUT Informatique, IUT Charlemagne - Nancy II, Jun, 2003, http://www.loria.fr/publications/2003/A03-R-080/A03-R-080.ps.

[30] R. STATE, O. FESTOR, I. CHRISMENT. *Context Driven Access Control to SNMP MIB objects in multi-homed environments.* Rapport de recherche, Mar, 2003, http://www.loria.fr/publications/2003/A03-R-042/A03-R-042.ps.

[31] A. TATI. *Extension des modèles de communication sur JXTA.* Stage de fin d'etudes, LORIA, May, 2003.

[32] B. ZORES. *Conception et Implémentation d'un Toolkit Agent SyncML.* Stage 2ème année ESIAL, Sep, 2003, http://www.loria.fr/publications/2003/A03-R-120/A03-R-120.ps.

Bibliography in notes

[33] A. BENHARREF, R. DSSOULI, Z. BERBICH, I. CHRISMENT. *Formal Specifications, TTCN and executable test cases for main IPv6 protocols.* in « International Workshop on Communication Software Engineering - IWCSE'2002, Marrakech, Morocco », dec, 2002.

[34] O. FESTOR, R. STATE. *Supervision et contrôle des réseaux et services : retour vers le futur.* in « Cinquième Ecole d'Hiver des Télécommunications - ECOTEL'2002, Golfe Juan, France », dec, 2002, http://www.loria.fr/publications/2002/A02-R-550/A02-R-550.ps.