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Interim report on standardization, interaction and cooperation

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Table of Contents

1 Introduction.....	6
2 Standardization.....	7

2.1 Description in JPA.....	7
2.2 IETF	7
2.2.1 Working Groups.....	7
2.2.1.1 ISMS.....	7
2.2.1.2 NETCONF	8
2.2.1.3 YANG	9
2.2.1.4 NSIS	9
2.2.1.5 PCN.....	9
2.2.2 IETF Meetings	10
2.2.3 Publications	11
2.2.3.1 Transport Subsystem for SNMP.....	11
2.2.3.2 Mapping SNMP Notifications to SYSLOG Messages.....	11
2.2.3.3 SNMP Traffic Measurement and Trace Exchange Formats.....	12
2.2.3.4 SNMP Context EngineID Discovery	12
2.2.3.5 DiffServ Resource Management	12
2.2.3.6 NSLP for Quality-of-Service Signaling.....	13
2.2.3.7 Load Control PCN	13
2.2.3.8 Pre-Congestion Notification Encoding Comparison	14
2.2.3.9 SMIng	14
2.2.3.10 SNMP Trace Analysis Definitions.....	14
2.3 IRTF.....	15
2.3.1 23 th NMRG meeting - Enschede	15
2.3.2 24 th NMRG meeting - Philadelphia.....	16
3 Interaction with industry.....	18
3.1 Description in JPA.....	18
3.2 Theta days	18
3.3 Other forms of interaction - Podcasts	19
4 Cooperation with other networks and projects	21
4.1 Description in JPA.....	21
4.1.1 Joint EMANICS/EuroFGI - EUNICE 2007 Summer School.....	21
4.1.2 Joint EMANICS/AGAVE Workshop on Management of Network Virtualisation	22
4.1.3 Joint EMANICS/COST IS605 Dagstuhl Seminar.....	22
4.1.4 NAVS November 2007 concertation meeting.....	23
4.1.5 IFIP TC6-WG6.6.....	23
4.1.6 Autonomic Communication Forum	23
4.1.7 Additional forms of cooperation	24
5 Conclusions.....	25
6 References	26
7 Abbreviations.....	28

Executive Summary

This document is the interim report of the activities undertaken in work-package 5 within the first nine months of second phase of the project.

In the second phase of EMANICS, the objectives of this WP are:

- to foster active participation of EMANICS members in standardization activities (IETF, IRTF),
- to establish and maintain interactions with industry, and
- to maintain and extend cooperation with other networks and projects (within Europe and worldwide).

The most important achievement of WP5 is its contribution to Internet standardization. In this nine months period, EMANICS partners contributed to 24 Internet-Drafts. This is even more than what was achieved in the previous period, and may make EMANICS one of the most successful NoEs to this respect. In addition, EMANICS partners are also very active within the “*Network Management Research Group*” (NMRG) of the “*Internet Research Task Force*” (IRTF).

EMANICS partners have had many bilateral interactions with industry and multiple forms of cooperation with related EU projects, such as Euro-FGI, AGAVE project and the COST IS605 action. EMANICS is also very active in running the key events and in organizing the top publications in our area.

1 Introduction

The title of work-package 5 is “standardization and technology transfer” for device, network and service management. The objectives of this work-package are:

- to foster active participation of EMANICS members in standardization activities, in particular within the IETF and IRTF,
- to establish and maintain interactions with industry, and
- to maintain and extend cooperation with other networks and projects (within Europe and worldwide).

To reach these objectives, three tasks have been defined:

- T5.1: Standardization,
- T5.2: Interaction with industry,
- T5.3: Cooperation with other networks and projects.

This document is the interim report produced after 27 months of the EMANICS project. It shows the activities undertaken within the first nine months of Phase 2. Note that, to make this deliverable self-contained, some text of the previous deliverable (D5.2) has been included in this deliverable.

Section 2 discusses standardization, Section 3 discusses the interaction with industry and Section 4 discusses the cooperation with other networks and research projects. Section 5 provides the conclusions. All meeting minutes, RFCs and Internet-Drafts can be downloaded from the EMANICS, IETF and NMRG websites; to keep the size of this deliverable reasonable, these have not been attached as annex.

2 Standardization

In the second phase of the EMANICS project several partners contributed to the IETF standardization process and joined the IRTF “Network Management Research Group” (NMRG) meetings. This chapter starts with summarizing the WP5 description, as contained in the JPA. Section 2.2 discusses the EMANICS contributions to the IETF standardization process and Section 2.3 gives an overview of EMANICS contributions to the IRTF-NMRG.

2.1 Description in JPA

An important goal of this NoE is to monitor and influence international standardization activities relevant to network management. Such activities take place within the IETF, IRTF, IAB, DMTF, TMF, ITU, W3C, OMG, OASIS and GGF. This work-package will actively sponsor efforts that strengthen the European presence and enhance the influence of European research on future international standards in this area. An explicit objective of EMANICS is to play a leading role in early standardization activities on Internet management, such as performed within the IRTF Network Management Research Group (NMRG). An outcome of that work will be research papers, internet-drafts and RFCs.

2.2 IETF

This section discusses the EMANICS contributions to the IETF standardization process. Section 2.2.1 gives an overview of the main IETF Working Groups to which contributions have been made; some of the text within that section is copied from the IETF WG pages (and was also already included in D5.2). Section 2.2.2 mentions the IETF meetings that have been attended and Section 2.2.3 lists the Internet-Drafts and RFCs to which contributions have been made.

2.2.1 Working Groups

EMANICS partners have contributed to several IETF WG, as well as a design team that most likely will become an IETF WG.

The remainder of this section will discuss the most important WGs / design teams EMANICS contributed too:

- Integrated Security Model for SNMP (ISMS)
- Network Configuration (NETCONF)
- The YANG data modeling language
- Next Steps in Signaling (NSIS)
- Congestion and Pre-Congestion Notification (PCN)

In addition, Jürgen Schönwälder (JUB) is member of the IETF MIB Doctors and joined the IETF Security Directorate.

ISMS

The *Integrated Security Model for SNMP* (ISMS) WG is co-chaired by Jürgen Schönwälder, who works at JUB and is member of the EMANICS NoE.

The goal of the ISMS working group is to develop a new security model for SNMP that integrates with widely deployed user and key management systems, as a supplement to the USM security model. For this integration the working group will define a standard

method for mapping from AAA-provisioned authorization parameter(s) to corresponding SNMP parameters.

In order to leverage the authentication information already accessible at managed devices, the new security model will use the SSH protocol for message protection, and RADIUS for AAA-provisioned user authentication and authorization. However, the integration of a transport mapping security model into the SNMPv3 architecture should be defined such that it is open to support potential alternative transport mappings to protocols such as BEEP and TLS. The ISMS WG covers the following work items [1]:

- Specify an architectural extension that describes how transport mapping security models (TSMs) fit into the SNMPv3 architecture.
- Specify an architectural extension that describes how to perform a mapping from AAA-provisioned user-authentication and authorization parameter(s) to *securityName* and other corresponding SNMP parameters.
- Specify a mapping from RADIUS-provisioned authentication and authorization parameter(s) to *securityName* and other corresponding SNMP parameters.
- Specify a mapping from locally-provisioned authentication and authorization parameter(s) to *securityName* and other corresponding SNMP parameters.
- Define how to use SSH between the two SNMP engines
- Specify the SSH security model for SNMP.

NETCONF

The goal of the NETCONF working group is to produce a protocol suitable for network configuration, with the following characteristics [3]:

- Provides retrieval mechanisms which can differentiate between configuration data and non-configuration data.
- Is extensible enough that vendors will provide access to all configuration data on the device using a single protocol.
- Has a programmatic interface.
- Uses a textual data representation, that can be easily manipulated using non-specialized text manipulation tools.
- Supports integration with existing user authentication methods.
- Supports integration with existing configuration database systems.
- Supports network wide configuration transactions (with features such as locking and rollback capability).
- Is as transport-independent as possible.

The NETCONF protocol uses XML for data encoding purposes, because XML is a widely deployed standard which is supported by a large number of applications. XML also supports hierarchical data structures. The NETCONF protocol should be independent of the data definition language and data models used to describe configuration and state data. It should be possible to transport the NETCONF protocol using several different protocols. The group will select at least one suitable transport mechanism, and define a mapping for the selected protocol(s).

YANG

YANG is a data modeling language used to model configuration and state data manipulated by the NETCONF protocol, NETCONF remote procedure calls, and NETCONF notifications. Today, the NETCONF protocol RFC 4741 lacks a standardized way to create data models. Instead, vendors are forced to use proprietary solutions. In order for NETCONF to be a interoperable protocol, models must be defined in a vendor-neutral way. YANG provides the language and rules for defining such models for use with NETCONF [6].

Until now, work on YANG is performed by a special design team. Currently a WG description for an IETF WG is being written and most likely the design team will be transformed into an IETF-WG for a NETCONF data modeling language.

NSIS

The *Next Steps in Signaling Working Group* is responsible for standardizing an IP signaling protocol with QoS signaling as the first use case. The working group concentrates on a two-layer signaling paradigm. The intention is to re-use, where appropriate, the protocol mechanisms of RSVP, while at the same time simplifying it and applying a more general signaling model [4].

The NSIS WG develops a transport layer signaling protocol for the transport of upper layer signaling. In order to support a toolbox or building block approach, a two-layer model will be used to separate the transport of the signaling from the application signaling. This allows for a more general signaling protocol to be developed to support signaling for different services or resources, such as NAT & firewall traversal and QoS resources. The initial NSIS application will be an optimized RSVP QoS signaling protocol. The second application will be a middle box traversal protocol. An informational document detailing how Differentiated Services can be signaled with the QoS Signaling protocol will be made.

Security is a very important concern for NSIS. The working group will study and analyze the threats and security requirements for signaling. Compatibility with authentication and authorization mechanisms such as those of Diameter, COPS for RSVP and RSVP Session Authorization will be addressed.

PCN

The Congestion and Pre-Congestion Notification (PCN) working group develops mechanisms to protect the quality-of-service of established inelastic flows within a DiffServ domain when congestion is imminent or existing. These mechanisms operate at the domain boundary, based on aggregated congestion and pre-congestion information from within the domain. The focus of the WG is on developing standards for the marking behavior of the interior nodes and the encoding and transport of the congestion information. To allow for future extensions to the mechanisms and their application to new deployment scenarios, they are logically separated into several components, namely, encoding and transport along forward path from marker to egress, metering of congestion information at the egress, and transport of congestion information back to the controlling ingress. Reaction mechanisms at the boundary consist of flow admission and flow termination. Although designed to work together, flow admission and flow termination are independent mechanisms, and the use of one does not require or prevent the use of the other. The WG may produce a small number of informational documents that describe how specific quality-of-service policies for a domain can be implemented using these two mechanisms [5].

2.2.2 IETF Meetings

In Phase 2, the following IETF meetings took place:

- 69th IETF, July 2007; Chicago, USA,
- 70th IETF, December 2007; Vancouver, Canada,
- 71th IETF, March 2008; Philadelphia, USA,
- YANG design team Meeting; September 2007, Stockholm.

The 69th IETF meeting, which was held in July 2007 in Chicago, was attended by Georgios Karagiannis (UT). At that meeting he provided presentations at the PCN and NSIS WGs, and participated at the TSVWG working group.

Although no EMANICS participants attended the 70th IETF meeting (December 2007, Vancouver), slides of the IRTF-NMRG / EMANICS meeting, which was held shortly before the IETF meeting, were presented at OPSAREA meeting by the OPSAREA leader, Dan Romanescu [32].

The 71th IETF meeting was organized between March 9-14, 2008, in Philadelphia, USA. Two EMANICS partners participated: Jürgen Schönwälder (JUB) and Georgios Karagiannis (UT). Jürgen Schönwälder chaired the ISMS WG meeting, and contributed to a number of other WGs, such as OPSAWG and NETCONF. He also participated at the CANMOD BOF meeting. At the Philadelphia IETF meeting, it was decided that the NETCONF data modeling requirements discussion is over. There is now work going on to draft a charter for a NETCONF data modeling language working group, and the YANG specifications are likely becoming the basis of this IETF effort. The details need to be further discussed, and rough consensus within the IETF has to be reached. However, it is likely that the first IETF YANG data modeling language meeting will take at the 72nd IETF meeting, which will take place in Dublin end of July.

Also Jürgen Schönwälder attended some design team meetings on a management data language for the network configuration protocol NETCONF, which is currently standardized by the IETF. This team consists of active IETF members from organizations like Ericsson, Juniper, tail-f, and Jacobs University. The team is working on several Internet-Drafts defining a NETCONF data modeling language and a set of reusable data type definitions. This work has been called “YANG” [6].

An overview of EMANICS participation to IETF meetings is provided in Table 1.

Meeting	Name	Organization	Role
69 th IETF	Georgios Karagiannis	UT	Editor of Internet-Drafts
71 th IETF	Jürgen Schönwälder	JUB	ISMS co-chair Editor of Internet-Drafts
71 th IETF	Georgios Karagiannis	UT	Editor of Internet-Drafts
71 th IETF	Gijs van den Broek	UT	
YANG meeting	Jürgen Schönwälder	JUB	Design team member

Table 1: EMANICS participation to IETF meetings

2.2.3 Publications

In the first nine months of the second Phase of the EMANICS project, 24 Internet-Drafts were co-authored by EMANICS partners. These documents fall into the following categories:

- Transport Subsystem for SNMP
- Mapping SNMP Notifications to SYSLOG Messages
- SNMP Traffic Measurement and Trace Exchange Formats
- SNMP Context EngineID Discovery
- DiffServ Resource Management
- InterDomain-QOSM
- NSLP for Quality-of-Service Signaling
- Load Control PCN
- Pre-Congestion Notification Encoding Comparison
- SMIng
- SNMP Trace Analysis Definitions

A short description of these drafts, which is copied from their introductory sections, can be found in the next subsections.

TRANSPORT SUBSYSTEM FOR SNMP

The following versions of the Internet-Draft “*Transport Subsystem for the Simple Network Management Protocol (SNMP)*” were produced by EMANICS partners in this phase of the EMANICS project:

- D. Harrington, **J. Schönwälder**: *Transport Mapping Security Model (TSM) - Architectural Extension for the Simple Network Management Protocol (SNMP)*, draft-ietf-isms-tsm-09, July 2007
- D. Harrington, **J. Schönwälder**: *Transport Subsystem for the Simple Network Management Protocol (SNMP)*, draft-ietf-isms-tsm-10, September 2007
- D. Harrington, **J. Schönwälder**: *Transport Subsystem for the Simple Network Management Protocol (SNMP)*, draft-ietf-isms-tsm-11, November 2007
- D. Harrington, **J. Schönwälder**: *Transport Subsystem for the Simple Network Management Protocol (SNMP)*, draft-ietf-isms-tsm-12, February 2008

This document describes a Transport Subsystem, extending the Simple Network Management Protocol (SNMP) architecture defined in RFC 3411. It describes a subsystem to contain transport models, comparable to other subsystems in the RFC3411 architecture. As work is being done to expand the transport to include secure transports such as SSH and TLS, using a subsystem will enable consistent design and modularity of such transport models. This document identifies and discusses some key aspects that need to be considered for any transport model for SNMP. It also defines a portion of the Management Information Base (MIB) for managing models in the Transport Subsystem.

MAPPING SNMP NOTIFICATIONS TO SYSLOG MESSAGES

In this phase of the project, EMANICS partners produced the following Internet-Draft:

- **V. Marinov, J. Schönwälder**: *Mapping Simple Network Management Protocol (SNMP) Notifications to SYSLOG Messages*, draft-marinov-syslog-snmp-01.txt, February 2008

This draft defines a mapping from Simple Network Management Protocol (SNMP) notifications to SYSLOG notifications.

SNMP TRAFFIC MEASUREMENT AND TRACE EXCHANGE FORMATS

The following versions of the Internet-Draft “*SNMP Traffic Measurements and Trace Exchange Formats*” were produced by EMANICS partners in this period:

- **J. Schönwälder**: *SNMP Traffic Measurements and Trace Exchange Formats*, draft-irtf-nmrg-snmp-measure-02.txt, December 2007
- **J. Schönwälder**: *SNMP Traffic Measurements and Trace Exchange Formats*, draft-irtf-nmrg-snmp-measure-03.txt, February 2007
- **J. Schönwälder**: *SNMP Traffic Measurements and Trace Exchange Formats*, draft-irtf-nmrg-snmp-measure-04.txt, March 2007

The Simple Network Management Protocol (SNMP) is widely deployed to monitor, control and configure network elements. Even though the SNMP technology is well documented, it remains relatively unclear how SNMP is used in practice and what typical SNMP usage patterns are. This Internet-Draft proposes to carry out large scale SNMP traffic measurements in order to develop a better understanding how SNMP is used in real world production networks. It describes the motivation, the measurement approach, and the tools and data formats needed to carry out such a study.

SNMP CONTEXT ENGINEID DISCOVERY

In this phase the following versions of the Internet-Draft “*Simple Network Management Protocol (SNMP) Context EngineID Discovery*” were produced by EMANICS partners

- **J. Schönwälder**: *Simple Network Management Protocol (SNMP) Context EngineID Discovery*, draft-ietf-opsawg-snmp-engineid-discovery-01, January 2008
- **J. Schönwälder**: *Simple Network Management Protocol (SNMP) Context EngineID Discovery*, draft-ietf-opsawg-snmp-engineid-discovery-02, February 2008

The Simple Network Management Protocol (SNMP) version three (SNMPv3) requires that an application knows the identifier (snmpEngineID) of the remote SNMP protocol engine in order to retrieve or manipulate objects maintained on the remote SNMP entity. This document introduces a well-known localEngineID and a discovery mechanism which can be used to learn the snmpEngineID of a remote SNMP protocol engine. The proposed mechanism is independent of the features provided by SNMP security models and may also be used by other protocol interfaces providing access to managed objects.

DIFFSERV RESOURCE MANAGEMENT

The following Internet-Draft has been produced in this phase:

- A. Bader, L. Westberg, **G. Karagiannis**, C. Kappler, T. Phelan: *RMD-QOSM - The Resource Management in Diffserv QOS Model*, draft-ietf-nsis-rmd-11, August 2007
- A. Bader, L. Westberg, **G. Karagiannis**, C. Kappler, T. Phelan: *RMD-QOSM - The Resource Management in Diffserv QOS Model*, draft-ietf-nsis-rmd-12, November 2007

This document describes an NSIS QoS Model for networks that use the Resource Management in Diffserv (RMD) concept. RMD is a technique for adding admission control and preemption function to Differentiated Services (Diffserv) networks. The RMD QoS Model allows devices external to the RMD network to signal reservation requests to edge

nodes in the RMD network. The RMD Ingress edge nodes classify the incoming flows into traffic classes and signals resource requests for the corresponding traffic class along the data path to the Egress edge nodes for each flow. Egress nodes reconstitute the original requests and continue forwarding them along the data path towards the final destination. In addition, RMD defines notification functions to indicate overload situations within the domain to the edge nodes.

NSLP FOR QUALITY-OF-SERVICE SIGNALING

The following Internet-Drafts have been produced in Phase I:

- J. Manner, **G. Karagiannis**, A. McDonald: *NSLP for Quality-of-Service Signaling*, draft-ietf-nsis-qos-nslp-15, July 2007
- J. Manner, **G. Karagiannis**, A. McDonald: *NSLP for Quality-of-Service Signaling*, draft-ietf-nsis-qos-nslp-16, February 2008

This specification describes the NSIS Signaling Layer Protocol (NSLP) for signaling QoS reservations in the Internet. It is in accordance with the framework and requirements developed in NSIS. Together with GIST, it provides functionality similar to RSVP and extends it. The QoS NSLP is independent of the underlying QoS specification or architecture and provides support for different reservation models. It is simplified by the elimination of support for multicast flows. This specification explains the overall protocol approach, design decisions made and provides examples. It specifies object, message formats and processing rules.

LOAD CONTROL PCN

Three Internet-Drafts have been produced for Pre-congestion notification:

- L. Westberg, A. Bader, D. Partain, **G. Karagiannis**: *LC-PCN - The Load Control PCN solution*, draft-westberg-pcn-load-control-01, August 2007
- L. Westberg, A. Bader, D. Partain, **G. Karagiannis**: *LC-PCN - The Load Control PCN solution*, draft-westberg-pcn-load-control-02, November 2007
- L. Westberg, A. Bader, D. Partain, **G. Karagiannis**: *LC-PCN - The Load Control PCN solution*, draft-westberg-pcn-load-control-03, February 2008

There is an increased interest of simple and scalable resource provisioning solution for Diffserv network. The Load Control PCN (LC-PCN) addresses the following issues:

- ◆ Admission control for real time data flows in stateless Diffserv Domains
- ◆ Flow termination: Termination of flows in case of exceptional events, such as severe congestion after re-routing.

Admission control in a Diffserv stateless domain is a combination of:

- ◆ Probing, whereby a probe packet is sent along the forwarding path in a network to determine whether a flow can be admitted based upon the current congestion state of the network
- ◆ Admission control based on data marking, whereby in congestion situations the data packets are marked to notify the egress node that a congestion occurred on a particular ingress to egress path.

The scheme provides the capability of controlling the traffic load in the network without requiring signaling or any per-flow processing in the core routers. The complexity of Load Control is kept to a minimum to make implementation simple.

PRE-CONGESTION NOTIFICATION ENCODING COMPARISON

The following Internet-Drafts have been produced in this phase:

- K. Chan, **G. Karagiannis**: *Pre-Congestion Notification Encoding Comparison*, draft-chan-pcn-encoding-comparison-01, November 2007
- K. Chan, **G. Karagiannis**: *Pre-Congestion Notification Encoding Comparison*, draft-chan-pcn-encoding-comparison-02, February 2008
- K. Chan, **G. Karagiannis**: *Pre-Congestion Notification Encoding Comparison*, draft-chan-pcn-encoding-comparison-03, February 2008

A number of mechanisms have been proposed to support differential Quality of Service for packets in the Internet. DiffServ is an example of such a mechanism. However, the level of assurance that can be provided with DiffServ without substantial over-provisioning is limited. Pre-Congestion Notification (PCN) uses path congestion information across a PCN region to enable per-flow admission control to provide the required service guarantees for the admitted traffic. While admission control will protect the QoS under normal operating conditions, an additional flow termination mechanism is necessary to cope with extreme events (e.g. route changes due to link or node failure).

In order to allow the PCN mechanisms to work it is necessary for IP packets to be able to carry the pre-congestion information to the PCN egress nodes. This document explores different ways in which this information can be encoded into IP packets. This document does not choose the encoding but provide guidance and recommendation based on different criteria.

SMING

The following SMIng related Internet-Draft has been produced by EMANICS partners:

- **J. Schönwälder**: *Protocol Independent Network Management Data Modeling Languages - Lessons Learned from the SMIng Project*, draft-schoenw-sming-lessons-01, September 2007

A data modeling language for network management protocols called SMIng was developed within the IRTF-NMRG over a period of several years. This memo documents some of the lessons learned during the project for consideration by designers of future data modeling languages for network management protocols.

SNMP TRACE ANALYSIS DEFINITIONS

The following Internet-Drafts on SNMP trace analysis definitions have been produced by EMANICS partners. Development of these drafts took place within WP7:

- **J. van den Broek, J. Schönwälder, A. Pras, M. Harvan**: *SNMP Trace Analysis Definitions*, draft-schoenw-nmrg-snmp-trace-definitions-00, January 2008
- **J. van den Broek, J. Schönwälder, A. Pras, M. Harvan**: *SNMP Trace Analysis Definitions*, draft-schoenw-nmrg-snmp-trace-definitions-00, February 2008

The Network Management Research Group (NMRG) started an activity to collect traces of the Simple Network Management Protocol (SNMP) from operational networks. To analyze these traces, it is necessary to split potentially large traces into more manageable pieces that make it easier to deal with large data sets and simplify the analysis of the data.

This document provides some common definitions that have been found useful for implementing tools to support trace analysis. This document mainly serves as a reference

for the definitions underlying these tools and it is not meant to explain all the motivation and reasoning behind the definitions. Some of this background information can be found in other research papers.

2.3 IRTF

In the first nine months of the second phase of the EMANICS project two Internet Research Task Force (IRTF) Network Management Research Group (NMRG) [7] meetings were organized. The IRTF-NMRG is chaired by Jürgen Schönwälder (JUB). Table 2 gives an overview of the EMANICS participation to these IRTF-NMRG meetings.

Meeting	Name	Organization	Role
Enschede	Aiko Pras	UT	Organizer
Enschede	Jürgen Schönwälder	JUB	NMRG chair
Enschede	Lisandro Granville	UT	
Enschede	Krzysztof Nowak	PSNC	
Enschede	Gijs van den Broek	UT	
Enschede	Olivier Festor	INRIA	
Enschede	Sameh Bel Haj Saad	INRIA	
Philadelphia	Jürgen Schönwälder	JUB	NMRG chair
Philadelphia	Georgios Karagiannis	UT	
Philadelphia	Gijs van den Broek	UT	

Table 2: EMANICS participation to IRTF-NMRG meetings

2.3.1 23th NMRG meeting - Enschede

The 23th NMRG meeting took place November 8-9, 2007 at the campus of the University of Twente, Enschede, Netherlands. The following text, which is partially copied from the original meeting minutes and which can be found on the NMRG website, summarizes the meeting results. The results of this meeting were also presented by the area director at the OPSAREA meeting of the 70th IETF meeting, which took place in Vancouver, Canada, from December 2-7. The slides of this presentation can be downloaded from [32].

PERFORMANCE OF SNMP OVER SSH/TLS/DTLS

Jürgen Schönwälder gave a brief introduction into the motivation behind SNMP over secure transports and the ISMS work done in this space. He then discussed some technical aspects of running SNMP over SSH, TLS, and DTLS and finally showed some measurements done with a prototype implementation. Since there are some inconsistencies and shortcomings in the data set, the measurements need to be repeated. Once that has happened, a detailed paper about this work will be submitted.

A VISUALIZATION TOOL FOR SNMP TRACES

Lisandro Zambenedetti Granville presented a tool being developed by one of his students which (a) provides a Web-based front-end to the functionality provided by the snmpdump

tool and (b) creates visualizations such as topology graphs, MIB object usage graphs, and traffic intensity graphs. It is unclear whether this work continues once the student involved has finished his assignment.

SNMP TRACE ANALYSIS AT PSNC

Krzysztof Nowak reported about some SNMP traces they have collected and analyzed. His presentation was based on the material that can also be found in EMANICS deliverable D7.2. There were some discussions concerning the nature of the data sets.

Poznan is collecting more traces and creating ideas to do further analysis, for example concerning reaction time to network events detected by SNMP management systems.

DETECTING PERIODIC AND APERIODIC SNMP TRAFFIC

Gijs van den Broek briefly explained the problem of separating periodic from aperiodic traffic. After a discussion how people would approach the problem, the work done in Twente was presented by Gijs. This led to a detailed discussion about assumptions made by several definitions. It became clear that some assumptions are unavoidable.

DEFINITIONS

The second day focusses solely on the discussion of common definitions for SNMP trace analysis work.

First, it was recognized that the flow definition used in the IM paper (although not spelled out well in the paper) is consistent with the session definition introduced by Gijs.

Next, it was recognized that the term session using by Gijs can be misleading since for example ISMS uses the term session to refer to SSH or TLS connections. Since the term sequence can also be misleading, it was decided to use the term "slice" since this term nicely fits that model that we split flows into slices and has no other meaning in the SNMP context.

After some extensive discussion concerning potential definitions of these terms, an initial set of definitions was drafted by JS and GB and presented at the end of the meeting.

It was agreed to continue work towards a consistent set of definitions that are needed for the trace analysis work done at the University of Twente (periodic/aperiodic traffic) and at the Jacobs University Bremen (table retrieval algorithms). The definitions will be put into an ID with the final goal to progress them in the NMRG towards RFC publication. The research groups will then use these definitions in the research papers they are working on.

2.3.2 24th NMRG meeting - Philadelphia

The 24th NMRG meeting was held in Philadelphia, USA on March 14, 2008, in conjunction with the 71th IETF meeting. Two EMANICS partners participated: Jürgen Schönwälder (JUB) and Georgios Karagiannis (UT). In addition, Gijs van den Broek, who is a M.Sc. student at the UT, also participated. In total there were about 20 participants to this meeting and interestingly several agenda items were closely related to EMANICS work (see also the meeting minutes).

One of these items was the work on SNMP trace analysis definitions, which was introduced by Gijs van den Broek. This work is directly related to EMANICS WP7, and is thus a good example of collaboration between the EMANICS research WPs and WP5. After his

presentation, there were several questions about how the definitions would work with some of the less common things that have been seen in management traffic, such as responses appearing on a different interface from the corresponding request, interleaved table walks, and how the slice definition excludes event-directed polling.

Another item was the “network management research classification”, which was presented by Georgios Karagiannis. This classification is currently under development within EMANICS WP1, and is therefore another good example of EMANICS work being presented to (pre-)standardization groups. The goal of the work is to define a taxonomy for organizing network and systems management research topics. The plan is to incorporate this taxonomy into the JEMS system (<https://submissoes.sbc.org.br/>), and use it for future conferences (such as NOMS, IM, DSOM) and to classify research efforts in IRTF. The meeting observed that taxonomies are rarely perfect, but can be useful nonetheless. Although there were several questions and comments, the general conclusion was that this work is being useful, and that the challenge is to limit its size.

At the NMRG meeting also the status of the “SNMP Traffic Measurements” draft was summarized (by Bert Wijnen). Also this work is a direct outcome of previous EMANICS WP7 work. Since the previous round of comments has been responded to, the next step is to formally ask the IRTF chair to ask for review in the IRSG, before moving to RFC.

Finally Jürgen Schönwälder presented a report on the IAB review. He noted that there is a desire to increase participation by operators. To that end, co-location of meetings with nanog might help. Another concern of the IAB is that some of the NMRG's work is showing up in academic publications rather than RFCs, limiting the visibility of the work. Consequently there is a desire to consider republication of some papers as RFCs. Finally, Jürgen noted that he hopes to step down as chair, and that consequently there is a need for new co-chairs.

3 Interaction with industry

3.1 Description in JPA

One of the tasks of this work-package is to interact with industry to collect network management requirements and to transfer knowledge. As part of this effort, EMANICS has defined the so-called theta day instrument for industry. Two kinds of theta days exist: national and international. It is expected that most days will be of the first kind; although these days may be organized by single EMANICS partners, they will be open to other EMANICS partners. The duration of a theta day may vary from half a day to multiple days. The results of a theta day will be reported to all WP5 members.

3.2 Theta days

Since the organization of international, multi-day events is quite time consuming, it was decided to organize such events in collaboration with other projects. These events will therefore be reported in the next section.

In the second phase of the project many EMANICS partners organized national, half or one day interaction events with industry. Some of these events were specifically organized under the EMANICS umbrella, while others were organized in other ways. In all cases, however, the EMANICS project was explained to industrial partners and some work performed within EMANICS was presented.

An overview of the recent Theta days is presented in Table 3.

When	EMANICS	Other partner	Topic
2007-10	LMU	LRZ & Fujitsu-Siemens	Workshop "Virtualization"
2007-10	LMU	LRZ & Fujitsu-Siemens	Several topics on IT management
2007-10	LMU	TUM & Siemens AG	Management of virtual IT solutions
2008-01	HIO	University of Amsterdam	Promise theory
2008-01	HIO	Elsevier	Release party - Handbook of Network & System Administration
2008-01	JUB	Juniper, Ericsson & Tail-f	YANG design team telechats
2008-01	UniBW	Giesike & Devrint	Identity management
2008-01	UT	KPMG	Network security
2008-01	UT	TNO	Management of sensor networks
2008-01	UT	NFI	Trace collection and analysis
2008-02	HIO	Norsk Hydro	cfengine presentation
2008-02	JUB	BITKOM / Bundesumweltamt	Green information technology
2008-02	UniZH	KiVS Meeting Heidelberg	Future Internet trends and projects in Germany
2008-02	UniZH	SWITCH	Discussion about EMANICS and traffic traces

Table 3: Overview of Theta days

When	EMANICS	Other partner	Topic
2008-02	UT	Pine	Trace anonymization
2008-02	UT	Quarantainenet, Vodafone & KPMG	Network security
2008-02	UT	Brazilian Research Network	Future Internet
2008-03	JUB	Juniper, Ericsson & Tail-f	YANG design team meeting
2008-03	JUB	Various participants	71st IETF meeting
2008-03	JUB	Various participants	24th NMRG meeting
2008-03	UniBW	Ricoh	DokuTRENDS 2008 - print job approval by biometry
2008-03	UniZH	University of Toronto	Distributed & grid accounting (WP8)
2008-03	UniZH	University of Toronto	P2P incentives (WP9)
2008-03	UPC	Belfast - EASE	Joint paper policy model
2008-03	UT	Various participants	71st IETF meeting
2008-03	UT	Various participants	24th NMRG meeting
2008-03	UT	Telematics Institute	Self-management of sensor networks
Ongoing	INRIA	Alcatel/Bell labs	Autonomic management
Ongoing	KTH	Ericsson Research, Stockholm	Auto-configuration
Ongoing	UPC	ACF	Teleconference

Table 3: Overview of Theta days

3.3 Other forms of interaction - Podcasts

In addition to face to face meetings, EMANICS partners have also created a number of Podcasts in which the results of EMANICS research, tutorials, as well as keynotes at the world leading conferences in our field are being presented to industry and academia. The creation of these Podcast has been discussed within deliverables of WP4, and are available (amongst others) via iTunes. Below a short overview of the Podcasts that have been created in the previous phase [35].

REPORT OF THE IRTF-NMRG

A first podcast summarizes the results of the joint IRTF-NMRG and EMANICS Workshop on Challenges in Network Management research. The podcast has been recorded at the plenary IETF meeting on March 22, 2007, in Prague. The title is: *Key challenges in Network Management research*, the presenter is Aiko Pras (UT)

IM 2007 OPENING SESSION

The following podcasts have been recorded at the opening session of the 10th IFIP/IEEE Integrated Management Symposium (IM 2007), which was held May 21-25, 2007, in Munich, Germany:

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- Opening by Prof. Faerber, member of the academic senate of the University of Federal Armed Forces, Munich
 - Opening by Alexander Keller, IBM T.J. Watson Research Center, USA
 - Opening by Prof. Heinz-Gerd Hegering, Leibniz Supercomputing Center, Germany
 - Opening by Hans Spitzner, Bavarian Vice-Minister of Economic Affairs, Infrastructure, Transport and Technology
 - Keynote by Ulrich Pfeiffer, Regional CTO, Software Global Business Unit, HP

NOMS 2006 DISTINGUISHED EXPERT PANEL ON VOIP MANAGEMENT

The following podcasts have been recorded at the 2006 IEEE/IFIP Network Operations and Management Symposium on April 6, 2006, in Vancouver, Canada.

- VoIP Management - Does the Emperor have any clothes on?. Intro by Aiko Pras (University of Twente)
- Provider challenges in VoIP?. By Magda Nassar (AT&T).
- Applications and Trends in Wireless Consumer Networking. By Alexander Gelman (Panasonic).
- VoIP Management. By Amy Pendleton (Nortel).
- VoIP Management - The Emperor Has No Clothes On. By Henry Sinnreich (Pulver.Com).
- Closing discussion between panelists and audience.

SNMP RELATED PODCASTS

The following SNMP related podcasts are now available for industry and academia:

- Management standards
Overview and history of the ISO, ITU-T, IETF and DMTF management standards. It presents CMIP/CMIS, TMN and SNMP, and discusses the main differences between these approaches.
- Introduction to SNMP
Goals, principle operation, structure and standards.
- Structure of Management Information
SMI Versions 1 and 2. After an introduction it discusses scalar objects (naming, instances, definition) and table objects (definition). Textual conventions and notification types are introduced too.
- Introduction to MIBs
This tutorial starts with an example, discusses the difference between MIB definition and instance, and the modular structure of MIBs. It gives the list of current IETF hardware MIBs, transmission MIBs, network MIBs, transport MIBs, application MIBs and vendor specific MIBs. It concludes with naming of MIB modules.
- MIB-II
The standard Management Information Base: MIB-II. After an introduction it discusses the status of the MIB-II, the original design goals, its basic structure and relationship to the TCP/IP layers, and the various groups (system, IF, AT, IP, ICMP, TCP, UDP, EGP, Transmission and SNMP).

4 Cooperation with other networks and projects

4.1 Description in JPA

This work-package is also responsible for the identification and liaisons establishment with professional organizations, complementary NoEs, and national and European projects in the area of network management. Information exchange will be in two directions: projects in the area of EMANICS may take advantage of the knowledge that is available within EMANICS, and EMANICS will learn from these projects new requirements and results. Cooperation with professional organizations will focus on IFIP WG6.6 (Management of Networks and Distributed Systems) and IEEE CNOM. In the next period collaboration with other European projects will focus on the COST 605 (Econ@Tel) project; such collaboration could take the form of a joint workshop.

4.1.1 Joint EMANICS/EuroFGI - EUNICE 2007 Summer School

As a joint activity, EMANICS and EuroFGI organized the 13th EUNICE Open European Summer School and IFIP TC6.6 Workshop on Dependable and Adaptable Networks and Services. This workshop took place between July 18-20, 2007 at the University of Twente, the Netherlands. This Summer School is sponsored by IFIP TC6.6, IEEE ComSoc and the Netherlands Organization for Scientific Research (NWO). Proceedings are published as part of the Springer LNCS series. The number of participants was 64.

The main goal of the EUNICE Summer School is to give young researchers, and particularly Ph.D. students, the opportunity to present their work at an international level. The EUNICE Summer School also seeks to offer comprehensive and inspiring invited talks from experienced experts in the field, providing a context for discussions on ongoing research and new challenges. The EUNICE Summer School is an initiative of the European University Network of Information and Communication Engineering, or EUNICE Network for short. Although the summer school events are organized by the member institutions taking turns, submission to and participation in the events are open to researchers outside the EUNICE Network.

The 13th EUNICE Summer School returned to Enschede, The Netherlands, where it was hosted earlier in 2000. Back in 2000, the theme of the summer school was 'Innovative Internet Applications.' Much has changed since then: wireless network technologies have become a constantly growing part of the Internet infrastructure, and increasingly smaller and more powerful computing devices with flexible connectivity open the possibility of new services and applications. The EUNICE 2007 theme, 'Dependable and Adaptable Networks and Services,' linked to this change and how it affects and is affected by research in the field of information and communication technology. One of the main challenges in the next decade will be to make the Internet and the services that are provided on top of it more dependable and adaptable. Research on this theme is needed for fixed, wireless and ad-hoc networking, ubiquitous communication and computing, sensor networks, and context-awareness. While individual mobile applications with context-aware and personalized features emerged, at the same time many challenges for network and service architectures were imposed concerning integration, interoperability, management, provisioning, reliability and security. On the one hand research has to make available a sound understanding of these applications and their supporting service and network architectures. On the other hand, research should produce service and network infrastructure solutions to be able to provide the necessary quality of service for the envisioned applications [34].

4.1.2 Joint EMANICS/AGAVE Workshop on Management of Network Virtualisation

As a joint activity, EMANICS and AGAVE organized a joint workshop on *Management of Network Virtualisation*. This very successful workshop took place on November 6th, 2007, in Brussels. Speakers from both projects, as well as a number of invited speakers, presented their work.

The workshop focussed on discussing the latest developments in network virtualisation: an increasingly important topic for today's networks as well as the future Internet.

Network virtualisation serves several goals. On the one hand service differentiation may be achieved through the provisioning and management of virtual network resources. Virtual networks may support certain service features/requirements in terms of packet transfer characteristics, robustness and resilience to failures and congestion. On the other hand, the network provider may use virtual networks to facilitate network management, e.g. through load balancing of traffic, or partitioning of network resources. Virtual networks may span a single provider domain but may also extend across multiple providers to provide end-to-end virtual Internets. The workshop addressed architectures, business models and network management solutions for network virtualisation as well as specific mechanisms to implement and operate virtual networks.

The slides of the presentations can be downloaded from[33].

4.1.3 Joint EMANICS/COST IS605 Dagstuhl Seminar

In January 2008 UniZH organized a Dagstuhl Perspectives Seminar on "Telecommunication Economics". This seminar can be seen as a joint interaction between EMANICS WP8 and the COST Action IS605.

The goal of this Perspectives Workshop on "Telecommunication Economics" was to discuss and develop a strategic research and training outline among key people/organizations in order to enhance the competence in the field of telecommunication economics and respective network management tasks for integrated Internet and telecommunication networks. The view on respective guidelines and recommendations to relevant players (end-users, enterprises, operators, regulators, policy makers, and content providers), especially focusing on the provision of new converged broadband, wireless, content delivery networks to people and enterprises was the core.

The main objective of this Workshop was to allow business partnering to drive networking services and their sustainable provisioning for consumers and enterprises alike. This included in more specific detail the following four areas:

- The support of engineering leadership gained in mobile, broadband, digital TV, and wire-line communications, and selected media fields, by new sustainable business models in a fully deregulated and diversified demand framework.
- The study and identification of business opportunities throughout the value chain, especially for enterprises, content, and specialized services.
- The contribution to a strategy relative to socio-economic needs by increasing the motivation for deployment of cost effective and flexible solutions using networks and content.

- The provisioning of guidelines and recommendations for utilizing different types of technologies and quantify necessary actions. These results will potentially supply regulators and standardization bodies with analysis and guidelines for creating conditions for fast growing competitive mobile, broadband, and content markets while speeding up business.

4.1.4 NAVS November 2007 concertation meeting

EMANICS members also participated at the 9th Networked Media (NAVS) Concertation Meeting, which took place in Brussels on 13-14 November 2007. On the first day EMANICS members organized the Standards and Interoperability session, for which they invited Vic Hayes, who has been chairman of the IEEE 802.11 (WLAN) standardization efforts for more than 10 years. His message was that, to be successful, researchers should actively participate for many years within standardization organizations; it is not sufficient to just bring an idea to a standardization organization and hope that they will standardize it within 1 or 2 years. On the second day of the NAVS meeting, together with members from AGAVE, a report was presented of our joint workshop on Management of Network Virtualisation.

4.1.5 IFIP TC6-WG6.6

In September 2007, at the Borovez, Bulgaria meeting of IFIP TC6, Aiko Pras (UT) and Olivier Festor (INRIA) took over the chair / vice-chair positions of IFIP WG6.6. The aims of IFIP WG6.6 is to facilitate cooperation between different organizations and individuals internationally in the areas of distributed operations and management, integrated network management, systems management, and service engineering. To be an effective conduit in the technology transfer between the academic and research communities, industry and the standard bodies. The scope of WG 6.6 is Operations and Management paradigms and technologies for novel and complex systems and networks continuously evolving over different levels of abstraction such as element, network, service, and business level. The Operations and Management encompass different function areas such as configuration, fault, accounting, performance and security. This includes new technologies such as autonomic computing, distributed and policy based management as well as already established management protocols and information models. The scope of the working group encompass the operation and management of existing networked systems including enterprise networks and multi-provider networks as well as emerging ad-hoc and sensor networks, Grids, peer-to-peer networks and interplanetary networks.

4.1.6 Autonomic Communication Forum

In 2007 Joan Serrat (UPC) became co-chair of the Policies Experts Group of the Autonomic Communication Forum (ACF). The ACF organizes teleconference meetings on a monthly basis and at least twice a year phase-to-phase meetings. Phase-to-phase meetings are open to companies and individuals and the aim is to present the evolution of activities of the different Experts Groups and Working Groups within the ACF. Among the participants up to now there are representatives from Telefonica, Whitestein Technologies, Hitachi, IBM, HP, Motorola and Intel. The first phase-to-phase meeting where Joan Serrat participated took place in March 2007 at the EU premises with the attendance of at least the above company representatives and two EU officers. The second took place in San Jose (CA) in November 2007. As co-chair of the Policies Experts Group Joan Serrat had the opportunity to present in these meetings his current projects in the field of policy based management, which are

part of EMANICS WP9. As the most tangible result of this activity a joint paper with Motorola and others will be presented at the EASe 2008 workshop in Belfast, April 2008.

4.1.7 Additional forms of cooperation

EMANICS partners have established strong contacts with the main universities and industries world-wide, and play a leading role in the world of network and service management. This becomes apparent by the fact that EMANICS partners became member of the IM/NOMS Steering Committee, have organized some of the main conferences in our field (like IM'07) and hold positions in the top journals in our field:

- IEEE Communications Magazine: editors
- Transactions on Network and Service Management: editorial board members
- Journal on Network and Systems Management,: editorial (advisory) board members
- International Journal on Network management: associate editor and editorial board members.

5 Conclusions

WP5 is currently structured into three tasks:

- T5.1: Standardization
- T5.2: Interaction with industry
- T5.3: Cooperation with other networks and projects

Within Internet management standardization, EMANICS partners hold strong positions within IETF WGs and the IRTF-NMRG. In this nine months period, 24 Internet-Drafts were (co-)authored by EMANICS partners. The chairs of the IETF-ISMS and the IRTF-NMRG are EMANICS members. EMANICS partners contributed to several IETF WGs, in particular the Integrated Security Model for SNMP (ISMS), Network Configuration (NETCONF), Next Steps in Signaling (NSIS), Congestion and Pre-Congestion Notification (PCN) as well as the YANG design team, which is in the process of becoming a new IETF WG. EMANICS members have organized two IRTF-NMRG meetings, are members of the IETF MIB Doctors and the IETF Security Directorate.

EMANICS partners have interacted with industry primarily in the form of many short meeting on a bilateral basis. In addition, most EMANICS partners have interacted with industry at various events, like conferences and workshops (for example within panels).

EMANICS partners had multiple forms of cooperation with related EU projects, such as:

- the Euro-FGI NoE: joint organization of the EUNICE 2007 Summerschool,
- the AGAVE project: joint workshop on the management of virtual networks,
- the COST IS605 action: joint Dagstuhl Seminar on “Telecommunication Economics”.

In addition, EMANICS contributed to the fall 2007 NAVS meeting, and took over the chair and co-chair positions of the IFIP WG6.6 and the Policy WG of the ACF. EMANICS members are also very active in running the key events and organizing the top publications in our area.

The general conclusion is that WP5 is running well and made very strong contributions to the IETF and IRTF.

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7 Abbreviations

AAA	Authentication, Authorization, and Accounting
ACF	Autonomic Communication Forum
BGP	Border Gateway Protocol
CETIM	University of Federal Armed Forces Munich
COPS	Common Open Policy Service
DiffServ	Differentiated Services
DSOM	Distributed Systems, Operations and Management
HIO	Oslo University College
IETF	Internet Engineering Task Force
INRIA	Institut National de Recherche en Informatique et Automatique
IRTF	Internet Research Task Force
ISMS	Integrated Security Model for SNMP
JEMS	Journal and Event Management System
JUB	Jacobs University Bremen
JPA	Joint Programme of Activities
KTH	Royal Institute of Technology
LMU	Ludwig-Maximilian University Munich
MIB	Management Information Base
MPLS	Multi-Protocol Label Switching
NETCONF	Network Configuration
NGN	Next Generation Network
NMRG	Network Management Research Group
NOMS	Network Operations and management Symposium
NSIS	Next Steps in Signaling
PDB	Per Domain Behavior
PSNC	Poznan Supercomputing and Networking Center
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RMON	Remote Monitoring
RSVP	Resource Reservation Protocol
SCTP	Stream Control Transmission Protocol
SLA	Service Level Agreements
SLS	Service Level Specifications
SMI	Structure of Management Information
SNMP	Simple Network Management Protocol
SSH	Secure SHell
TIC	Technologies de l'Information et de la Communication
TLS	Transport Layer Security
TMSM	Transport Mapping Security Model
TSVWG	Transport Area Working Group
UniS	University of Surrey
UniZH	University of Zürich
upc	Universitat Politècnica de Catalunya
UPI	University of Pitesti
UT	University of Twente
VoIP	Voice over IP
WG	Working Group