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Deliverable 1.2
Yearly report on vision and integration program

The EMANICS Consortium

Caisse des Dépôts et Consignations, CDC, France
Institut National de Recherche en Informatique et Automatique, INRIA, France
University of Twente, UT, The Netherlands
Imperial College, IC, UK
International University Bremen, IUB, Germany
KTH Royal Institute of Technology, KTH, Sweden
Oslo University College, HIO, Norway
Universidat Politecnica de Catalunya, UPC, Spain
University of Federal Armed Forces Munich, CETIM, Germany
Poznan Supercomputing and Networking Center, PSNC, Poland
University of Zurich, UniZH, Switzerland
Ludwig-Maximilian University Munich, LMU, Germany
University of Surrey, UniS, UK
University of Pitesti, UniP, Romania

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For more information on this document or the EMANICS Project, please contact:

Dr. Olivier Festor
Technopole de Nancy-Brabois — Campus scientifique
615, rue de Jardin Botanique — B.P. 101
F—54600 Villers Les Nancy Cedex
France

Phone: +33 383 59 30 66
Fax: +33 383 41 30 79
E-mail: <olivier.festor@loria.fr>

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Editor(s): Gabi Dreo Rodosek, Frank Eyermann, Matthias Goehner, Sameh Saad

E-mail: Gabi.Dreo@unibw.de,Frank.Eyermann@unibw.de, Matthias.Goehner@unibw.de, Sameh.Saad@unibw.de

Author(s) (in alphabetic order):

Gabi Dreo Rodosek, Frank Eyermann, Matthias Goehner, Ralf Koenig, Sameh Saad, Thomas Schaaf, Jürgen Schönwälder

WP1 members that provided teaching material

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V0.3	December 15	Gabi Dreo Rodosek	Objectives of the Common Course Program
V0.4	December 15	Matthias Goehner and WP1 members	Overview of teaching material of the EMANICS partners
V0.5	December 18	Frank Eyermann	Requirements Analysis for the integration tool
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1 Executive Summary

The establishment of a common long-term integration and research program among EMANICS partners requires a solid framework for collaboration and integration in the field of teaching as well as research activities. A precondition of such a framework is to achieve a common understanding of and the same level of knowledge about topics of network and service management. This can only be achieved through an *EMANICS common course program* for teaching integrated network and service management.

By developing such a common course program two goals have been targeted:

- To provide a pool of modules of teaching material (courses, labs, exercises etc.) in various presentation styles (slides, streams, etc.) accessible by every EMANICS partner;
- If all modules are taught within a course, a participant of such a course can acquire an *EMANICS certified degree* in order to achieve a standardized level of knowledge about integrated network and service management among EMANICS partners.

In the first step the available teaching material, provided by EMANICS partners, has been collected to provide a basis for the definition of the common course program. An analysis of the collected material has shown the diversity of the topics addressed, the different granularity as well as the different emphasis partners have put on specific issues. The starting discussions on the course structure have also shown that some common basic terminology has to be defined at first. Further discussions, as already reported in the previous deliverable, emphasized the necessity to develop a taxonomy for integrated network and service management.

Another objective of work package 1 is to evaluate the integration among EMANICS partners as well the visibility of EMANICS to other communities. The discussions between EMANICS partners have shown that the initially defined integration metrics needed to be refined, resp. changed, and that a lot of diverse opinions about the meaning resp. semantics of the metrics have been discussed. It was agreed that the further discussion needs to be tool supported which was realized through the implementation of EMIN (EManics Integration).

In order to identify new challenges and visions several documentations have been collected at the work package 1 web site. Furthermore, a joint EMANICS/NMRG workshop on future directions of network and service management research has been held in October in Utrecht. A summary of the identified challenges resp. observations is included in the deliverable as well.

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2 Introduction

Since collaboration and integration of teaching and research activities is one of the key objectives of EMANICS, and especially of work package 1, a precondition is to establish a common basis upon which a successful collaboration can take place. Among experts, it is necessary to agree on a common terminology and to develop a common taxonomy. For students and newcomers in the field of network and service management, it is necessary to develop a common course program in order to achieve the same level of knowledge.

The objectives of the program are thus as follows:

- The program should consist of modules. In case a partner needs to present resp. teach a specific topic, covered by a module, he can access the teaching material for this module.
- The common course program should include lectures, labs, exercises, etc. in various presentation styles (slides, streams, etc.). Labs infrastructure should also be shared (virtually) among partners. In other words, if students from one EMANICS partner have a routing configuration exercise, they can access for example the Cisco 6500 routers at CETIM.
- If all modules of the common course program have been passed successfully, an EMANICS certified degree should be issued. Students can study parts of the program at one institution, and another part at another EMANICS partner institution. Thus, such a structure of a common course program should foster also student mobility and exchange.
- A standardized EMANICS exam should be developed as well.

In the initial step the available teaching material has been collected and analyzed. Based upon the collected material and several discussions, an initial version of the common course program has been developed. Due to the intensive discussions already on the initial version, it is expected that a common agreement on the structure will require some more iterations.

Since the definition and a common understanding of metrics is always a challenging task (in various fields), it was not surprising that also the definition of integration metrics caused several intensive discussions. The basic integration parameters, as initially defined and also collected, have been questioned whether they really measure the level of integration in the adequate way. It was also agreed that several metrics can be interesting for specific institutions, and can be defined by themselves, but that a set of EMANICS common metrics and parameters needs to be defined as well.

In order to support such a discussion about the definition and the meaning of integration metrics, a Java-based tool EMIN has been developed. The objectives of EMIN are as follows:

- Support the definition and visualization of the integration metrics in a flexible way;
- Access already existing reporting data to avoid yet another reporting tool as much as possible;
- Automatic generation of integration and visibility graphs

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Since the identification of new challenges is also within the focus of WP1, some relevant documents have been collected on the WP1 web site ([5]-[10]) to start discussions. Furthermore, the University of Twente (UT) and the International University Bremen (IUB) jointly organized an NMRG/EMANICS workshop to discuss future directions of network and service management research. The workshop was held on October 19-20 in Utrecht (Netherlands) and hosted by SurfNet, the operator of the Dutch research network. The workshop was attended by 20 people representing researchers, operators, vendors and technology developers. The six attending EMANICS partners (UT, IUB, KTH, UniZH, HIO, INRIA) provided valuable input from the perspective of researchers active in this field.

As a preparation of the workshop, all attendees were asked to write up position statements in order to jump start discussions. After a discussion of the position statements, smaller groups were formed to work on a list of predefined questions. The answers produced by the smaller groups were subsequently presented and discussed in the whole auditorium.

The meeting web page

(http://www.ibr.cs.tu-bs.de/projects/nmrg/meetings/2006/utrecht/) has links to all received position statements, some slide materials, the questions for the various groups and the list of attendees. Meeting minutes can be found at http://www.ibr.cs.tu-bs.de/projects/nmrg/minutes/minutes-021.txt. The workshop participants generally felt that the event was useful and that further work should be undertaken to consolidate the workshop ideas and to produce a more structured workshop report. A summary of the observations is included in the deliverable.

2.1 *Purpose of the Document*

Deliverable 1.2 reports on the following three issues:

- The development of a common course program for integrated network and service management, including an overview of relevant teaching material within the Network of Excellence (NoE) as reported by partners. Based on an analysis of the reported teaching material and the discussions among partners about the objectives of such a common course program, an initial version has been developed. Since already the definition of the initial structure of the common course program caused a lot of discussions, it is expected that the common course program will go through various versions before an agreement will be reached.
- A description of EMIN, a developed Java-based tool to support the identification, discussion and visualization of integration metrics is included.
- A report on the joint EMANICS/NMRG workshop on future directions of network and service management research.

2.2 *Document Outline*

Chapter 3 addresses the common course program and identifies its relevant modules. In order to be able to determine the core elements of the program members of WP1 provided a rough structure of all lectures / courses concerning IT Management related topics. Section 3.1 outlines the motivation including the objectives as well as a rough description of the intention of the common course program. Furthermore, section 3.3 contains a detailed overview of teaching material by weighting the relevance of the pro-

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vided material with respect to the common course program. In Section 3.4 a rough outline of the initial version of the program is presented, followed by a more detailed description of the structure of its included modules in Sections 3.5 to 3.15. Finally, in Section 3.16 next steps concerning the improvement of the common course program are sketched. These include the identification and assignment of experts to the defined modules and further refinements of the content of the modules as well as the creation of presentation material as for example lecture slides, exercises, podcasts, etc.

Chapter 4 describes EMIN, a developed tool, to support the definition and implementation of integration metrics. After a requirement analysis, use cases describe the implementation and give hints how to use the tool.

In Chapter 5 a report on the joint EMANICS/NMRG Workshop is presented addressing future directions of network and service management research.

Bibliographic references in Section 7 and a list of abbreviations in Section 8 complement this work.

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3 Common Course Program

3.1 *Motivation for a Common Course Program*

In order to support a long term integration of the European teaching activities regarding network and service management, one major objective is the establishment of an EMANICS *common course program (CCP)* on the graduate level which is consistent within all universities of the EMANICS network. The underlying motivation of the program is to guarantee a way to uniformly transfer knowledge between the members of EMANICS. Therefore, the EMANICS common course program provides a kind of quality label in the domain of network and service management. Moreover, the program serves as an adequate basis for the comparability as well as the convertibility of grades and experiences within the NoE. Beside these aspects, another purpose is to facilitate the transfer of courses and researchers between participating institutions and universities within the EMANICS network.

3.1.1 Description of the Common Course Program

The common course program consists of a set of modules for several academic disciplines considering IT management related topics. A basic set of the identified modules of the program (cf. Section 3.4) can be considered as a kind of a core program, whereas some other modules representing very specific topics can be seen as optional elements of the CCP. A course resp. a lecture which integrates the full set of relevant modules of the CCP then could exhibit the quality label "*EMANICS certified network and service management course*". On the other hand, students participating in such a certified course could also receive a certificate such as "*EMANICS certified network and service management student*" which will be handled uniformly within the NoE. Hence, a student who has completed this certified course at any university within the NoE has satisfied the requirements of the common course program. Students, who have not yet completed this course, are able to study the rest of the modules at any other university within the EMANICS network. Such a common groundwork encourages not only the exchange of students between institutions, but enables the more efficient use of staff and skills.

Therefore, an important task of work package 1 includes the identification and collection of relevant course material e.g., lecture slides, seminar reports, lab course material as well as exercises with respect to the identified modules of the initial version of the common course program in order to establish a document pool. The document pool serves as a basis from which relevant course material can then be extracted. Besides, the created document pool serves as a useful means in order to maintain an information repository wrt. IT Management related courses each member within the NoE has access to.

3.1.2 Objectives of the CCP

- Identification of relevant teaching material not only focusing on lectures and courses but also on seminars, labs, exercises, etc.
- Harmonization of relevant teaching material in order to support a common level of knowledge and to provide a EMANICS-wide standard in the field of integrated network and service management for the students

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- Establishment of a teaching repository i.e., document pool on the EMANICS web-page comprising all relevant teaching material
- Support of various presentation media, e.g., lecture slides, podcasts, interactive exercises, etc.
- Providing a quality label for an “EMANICS certified network and service management course” which is uniform within the NoE

3.2 *Distinction to other Courses, Prerequisites for Students*

A prerequisite for students participating in the common course program is a basic knowledge of computer networks. Based upon the discussions so far, the program should be developed for graduate students. Further refinements of the prerequisites will be output of the ongoing discussions.

What seems already clear is that the CCP should only contain network and service management related content. *E.g.,* the above mentioned prerequisites will not be part of the CCP.

3.3 *Overview of the Relevant Teaching Material per EMANICS partner*

In order to be able to identify the core elements of the common course program, the members within the NoE provided a rough structure of all lectures / courses concerning IT Management related topics. To be able to cover a large range of various teaching material, not only relevant lectures and courses have been taken into account but also seminars, lab courses as well as exercises. Lectures where management related topics are only partly sketched have also been reported.

Furthermore, the EMANICS partners were asked to provide additional information which chapters and sections are of relevance from their point of view in order to obtain a subjective perception. The relevance of the respective chapter or section of a course has been annotated with stars by the EMANICS partners which reflect the relevance of the teaching material (*** = of major relevance ** = important and * = of minor relevance only). This information has also been taken into consideration when defining an initial version of the modules. Currently, the provided teaching material differs wrt. to the level of detail, the size of the lectures, the form of the presentation slides as well as the language in which the teaching material is made available. In the first step, the provided material has been included in the deliverable as sent by each EMANICS partner. In the next steps a harmonization of the teaching material in order to obtain a uniform basis which facilitates the use of relevant material has to be approached.

The overview begins with a summary of relevant teaching material per institution and then contains a detailed description of the content in form of a table of contents. The presented information has been extracted from the emails of the EMANICS partners and therefore differs in the form of the presentation (e.g., listings, textual descriptions, etc.).

3.3.1 Oslo University College (HIO), Norway

Overview of relevant courses:

- Network and system administration
- Computer and information security

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- Networking: technologies and principles
- Intrusion detection and firewall security
- Analytical system administration
- Social and ethical aspects of systems
- Network infrastructure and security lab
- High performance computing services
- Supercomputers and virtual operating systems

Network and System Administration I

Content:

- Introduction and review
- Human-Computer system components
- Mapping out the LAN
- Formalizing policy and management models
- OS installation
- Predictability
- User management and ethics
- Configuration management
- Application level services
- Web services
- Principles of security
- Managing Security and Backup
- Firewalls and TCP/IP Security
- Local Area Network from scratch
- Summary and outlook

Computer and Information Security

Content:

- What is security?
- Trust and Risk Analysis
- Basic Information Security
- Identity & Authentication
- Protocols & Data Integrity
- Access control
- Security models
- Object orientation

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- Software security I
- Software security II
- Encryption
- Internet security
- Intrusion detection
- Site security and ISO17799

Networking: technologies and principles

Content:

- Communication networks and networking: an overview
- Physical aspects of communications
- Data link layer and Local Area Networks
- Internet protocol overview
- Switching and
- forwarding in networks
- Forwarding in datagrams and virtual circuits
- Routing in the Internet
- IP Routing practices: RIP vs. OSPF
- Autonomous Systems and Border Gateway Routing
- Wide Area Network principles and architectures
- Quality of service, resource allocation, traffic shaping
- Designing a complete network
- Misc, Network Address Translation, IPv6 and IPSec

Intrusion detection and firewall security

Content:

- TCP,UDP,IP and network communication in general
- Firewalls and some architectures
- Network Filtering rules and IPtables syntax
- Other firewall functions
- Host signature and packet signature based IDS
- Intrusion Detection Using Snort
- Anomaly Detection
- Honeypots
- Mitnick Attack, analysis
- Forensic evidence

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- Penetration testing
- Research and overview

Analytical System Administration

Content:

- Philosophy of science
- Observation, data collection and uncertainty
- From the discrete to the continuous
- Configuration management
- Simple systems
- Business models
- Diagrams and graphs of systems
- A model of human-computer systems
- Integrity Information and Noise
- Arrivals and queues
- Workflow and scalability models
- Decision making
- Game theory
- Summary and conclusions

Social and ethical aspects of systems

The aim of this course is to make you reflect on social, cultural and ethical issues surrounding society and its use of information technology. The course contains two sections: the first is on how computer technology changes society and the second on how to work as a computer professional. The overall aim of the first section is to increase the student's awareness of the implications computer technology have on the development of our society. They should realize the responsibility they have as computer professionals to give realistic information about technological possibilities and limitations to the public. They should know pro and con arguments of major issues related to the use of computers and the Internet, and be able to argue orally and in writing. They should be able to ethically evaluate the products of their future employer, whether they work in business, research or education with databases, Internet, programming, numerical modeling or network administration.

Network infrastructure and security lab

The aim of this course is to give students substantial experience in using networking equipment in a realistic environment. Students should become proficient at handling hardware and software configuration, as well as learn debugging skills.

Experiments carried out in the lab must be documented as scientific experiments and written up in clear, concise English. Presentation skills will contribute to the grade, as well as documentation of analytical ability and systematic work practice.

The rough plan for your own development is like this:

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1. Start by learning about the tools of the lab.
2. Reproduce some familiar scenarios.
3. Progress to asking your own questions.
4. Troubleshooting and analysis.

You will be graded on performance, reporting, tidiness and safety. In particular, in your reports we will be looking for three main things:

- An ability to communicate and explain your work to users at all levels of technical ability.
- A critical and enquiring mind that asks relevant and forward looking questions.
- Documentation of your work that allows you and others to reproduce precisely what you claim in your reports.

High Performance Computing Services

This new course aims to teach students about high volume service and data centre design.

- Introduction: Technologies
- Server Rooms and Data Centres
- Queuing theory I
- Queuing theory II
- Parallelism and Job Scheduling
- Server Traffic Characteristics
- Load Balancing I
- Load Balancing II
- Performance tuning
- Deployment and Configuration Management with cfengine I
- Deployment and Configuration Management with cfengine II
- Monitoring: SNMP, gmond, Ganglia, etc
- ITIL Service Management Practices

Supercomputers and virtual operating systems

This course is given in collaboration with IBM Norway. It will be available to a limited number of students and is designed to fill a specific need for the computing industry: experience and understanding of supercomputers and virtual operating systems. Specific attention is given the IBM operating systems zOS (OS/390) and VM that are widely deployed.

The course is suitable for students enrolled on the Master's degree program, and for students planning to work in banking and large commerce organizations. The course will have a strong practical flavor, building on notions from Operating Systems and Unix, and will pay special attention to comparing and contrasting the differences in architecture between common operating systems on PC hardware and IBM eServer zSeries

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computing. This should offer a different and deeper perspective on computing in a world that is dominated by disposable Intel hardware.

Content:

- Architecture and design principles
- Address spaces, data space and hyperspace
- Dispatching, interrupts, supervisor mode, etc.
- Job and task control
- I/O processing in the z/OS and OS/390
- Workload management
- Storage management concepts
- Unix system services
- Networking, SNA and its relation to TCP/IP
- Security concepts
- Virtual Machines
- VM operating systems
- Virtual linux instances
- Clustering

3.3.2 Imperial College (IC), United Kingdom

Currently at the Imperial College there are no courses relating to systems and network management. The following two courses are the most relevant within the research domain of distributed systems.

Overview of relevant teaching material:

- Distributed Systems
- Distributed Systems Management

Distributed Systems (**)

Content:

- Overview of Distributed System Architecture: motivation, system structures, architecture, ODP Reference model and distribution transparencies, design issues.
- Interaction Primitives: message passing, remote procedure call, remote object invocation
- Software Structures and components: composite components, Darwin architecture description language, first & third party binding.
- Interaction Implementation: message passing, RPC, concurrency and threads, heterogeneity of systems and languages.
- Security: threat analysis, security policies - military (Bell Lapadula) vs commercial models; access control concepts, identification, authentication, authorization and delegation; authorization policy: access matrix, access rules and domains, firewalls;

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access control lists, capabilities, secret and public key encryption, digital signatures, authentication, Kerberos; web security; security management.

Distributed Systems Management: SNMP, monitoring and event generation, domains & policy. (***)

Content:

- Time Service: Issues related to time synchronization, Cristian, Berkley and NTP clock synchronization algorithms; Logical time synchronization.
- Peer-to-Peer Systems: What is P2P; P2P structures; P2P Middleware; Overlay routing; Case studies – Gnutella, Freenet, Tapestry.

3.3.3 INRIA, France

Overview of relevant teaching material:

- Network and service management
- Advanced management algorithms and models

Network and service management

Content:

- Introduction to network management (management plane, fcaps, ...)
- SNMP (ASN.1, SMIv1, SMIv2, SNMP protocol v1, v2, v3)
- LDAP
- Open Source management tools
- NAGIOS
- MRTG like components
- Syslog
- Cfengine
- Management in the Java World : JMX
- OSI based management (Netconf etc.)

Advanced management algorithms and models

Content:

- Closed loop management
- Event correlation algorithms
- Advanced algorithms
- Study of recent papers on the area of network and service management

3.3.4 University of Zurich (UniZH), Switzerland

Overview of relevant teaching material:

- P2P Systems and Application

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- Protocols for multimedia communication

P2P Systems and Application

Content:

- Lecture Organization
- Introduction and Application Areas
- P2P Generations, Past and Future
- Distributed Hash Tables
- Grids and P2P
- Web Services and P2P, Google WS Demo
- P2P Search and Scalability
- Hybrid P2P Systems
- Market Management of P2P Systems
- Decentralized Accounting
- Mobile und Collaborative P2P Systems
- Challenge Task Presentations
- P2P Business Applications

Protocols for multimedia communication

The lecture protocols for multimedia communication covers IT management related aspects as for example QoS management und resource management.

3.3.5 Universidat Politechnica de Catalunya (UPC), Spain

Overview of relevant teaching material:

- Network and service management

Network and Service Management

Content:

1. Network management based in the client/server approach **(***)**
   - Study case: Management of a web server
   - Management technology: WBEM

1.1 Problem scope and scenario description

1.2 Introduction to the WBEM architecture
   - Functional architecture
   - Management of a server based on WBEM

1.3 Object oriented modeling and CIM
   - Basic concepts

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- Class design
- UML and MOF for CIM
- Introduction to the CIM Core model

1.4 Management of an Apache server
- Configuration management
- Monitoring

2. Network and service management based in the manager/agent approach **(***)**
- Study case: management of mobile services in a GPRS/WLAN environment
- Management technology: TMN/OSI

2.1 TMN and the management model of OSI/ITU-T
- TMN models
- The OSI management architecture
- GDMO and ASN.1 principles
- Common information services and protocol (CMIS/CMIP)

2.2 Introduction to SNMP

2.3 Specification of the interfaces in an Operation System
- X interface for management of mobile services
- Q interface for management of a WLAN access point

3. Introduction and comparison of other management techniques **(**)**

3.1 Distributed management based on CORBA

3.2 Use of Web services for network management

3.3 Use of P2P technologies in the management of networks and services

3.3.6 University Twente (UT), The Netherlands

Overview of relevant teaching material:

- Internet management and measurements

Internet Management and Measurements

Content:

1. Introduction
- About this course
- Ad-hoc approaches to network management
- Network management standards
- Intro to SNMP

2. Structure of Management Information (SMI)
- SMIv1, SMIv2

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- SMIng

3. Management Information Bases (MIBs)
   - Introduction
   - Relation between MIBs
   - MIB-II
   - SNMPv2 MIB
   - Interfaces MIB
   - IP MIB
   - TCP MIB
   - UDP MIB
   - Host resources MIB
4. Simple Network Management Protocol (SNMP)
   - SNMP version 1
   - SNMP version 2
   - SNMP version 3
5. Advanced topics
   - Remote monitoring (RMON)
   - Distributed management (Disman)
   - Extensible agent technology (Agentx)
   - New approaches: COPS-PR and NetConf
   - New approaches: Web-services for management
   - Tools: ntop
   - Alternative approaches: TMN

3.3.7 University of Federal Armed Forces Munich (CETIM), Germany

Overview of relevant teaching material:

- Lecture: Network and service management
- Lecture: IT Security
- Labs: Computer Networks with exercises with HP ProCurve and HP OpenView Network Node Manager
- Lecture: Computer Networks I and II (Quality of Service in IP Networks)
- Seminars: Grid Computing

Network and Service Management

Content:

1. Network scenarios and their complexity

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- virtual private networks
- Intranet/Extranet Service Areas: Terminology and classification
- Intranet/Extranet Service Areas: 3 example projects

2. Requirements and function areas of management
3. Management architecture and their models **(***)**
   - Introduction
   - Management architecture
   - Models
     - Information model
     - Functional model
     - Communication model
     - Organizational model
4. OSI Management and TMN **(**)**
5. Internet (SNMP) management **(***)**
6. Management tools and management platforms **(**)**
   - Stand-alone test and monitoring tools
   - Quality management: Service-Level-Management (Problems and Approaches)
   - Problem management: Trouble-Ticket-Systems
   - Customer Service Management: Concepts and Implementation
   - Network management platforms, switch and router management
   - System management platforms
   - Integration of tools
7. Enterprise management **(**)**
8. Paradigm shift to IT service management

3.3.8 Ludwig Maximilian University Munich (LMU), Germany

Overview of relevant teaching material:

- Lecture: Network and systems management
- Lecture: Components to build up computer networks
- Lecture: IT security
- Lecture: Design and realization of e-Business and internet applications
- Lecture: Computer networks I – fundamentals and basic concepts
- Lecture: Computer networks II: Quality of Service and Multimedia Communication
- Seminar: Process-oriented IT service management
- Lab course: IT security

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- Lab course: Computer networks

Lecture: Network and systems management

Content:

1. Basics of distributed systems
   - Architectures (OSI, Internet, DCE, CORBA)
   - Resources (media, components, services)
2. Network and system management **(***)**
   - Requirements, formation of concepts, scenarios
   - Management disciplines and management dimensions
3. Management architectures: **(***)**
   - Introduction
   - Requirements for an integrated management
   - Models of a management architecture
4. OSI Management and TMN **(***)**
   - SMI, GDMO, CMIS/CMIP, SMF
   - Telecommunications management Network
5. Internet Network management **(***)**
   - Internet-MIBs and SMI (info model)
   - SNMP (communication model
6. CORBA as a management architecture **(*)**
7. DMTF Desktop management Architecture **(*)**
8. WEB-Based management (WBEM, JMAPI) **(**)**
9. Management platforms **(**)**
10. Integration of agents, architecture crossings, development tools **(**)**
11. Management tools: **(***)**
    - Well-chosen examples
    - Independent test and supervision tools
    - Trouble ticket systems
    - Documentation systems
    - SLA tools
12. Management scenarios: **(***)**
    - Well-chosen examples
    - Components management, system management and application management
13. Enterprise management, service management **(***)**

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- Questions
- Solution attempts
- ITIL, eTOM

Lecture: Components to build up computer networks

Content (excerpt):

…

3. LAN components
   - Basics to the construction of LANs
   - LANs according to IEEE 802.3 (Ethernet)
   - Wireless LANs
   - Bluetooth
   - Power over Ethernet (PoE)
   - LAN components
   - Switches
   - Router
   - Structure of network components
   - Management of LAN components **(***)**

…

Lecture: IT security

Content (excerpt):

...

2. Basics
   - OSI Security Architecture and safety management **(***)**
   - Formation of concepts
   - Security versus Safety

…

Lecture: Design and Realization of E-Business and Internet-Applications

Content:

1. Introduction / overview
2. Web access and internet security **(*)**
   - Firewalls, security services, proxies
   - DNS, e-mail
3. Virtual private networks **(*)**
   - Technologies and usage (mainly IPSec-based)

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- Network technologies, functionality and usage mainly based on MPLS

4. Case studies **(***)**

- Invitations of tenders, requirement analysis, solution design, etc.

- Special requirements, realisation, data center infrastructures, operational management, etc.

5. Wireless LANs and UMTS **(*)**

6. IT processes and IT service management **(***)**

7. System management and Customer Self Care **(***)**

8. Identity management **(***)**

Lecture: Computer networks I - Fundamentals and Basic Concepts

Content (excerpt):

...

9. Layer 7 (Services and applications)

9.1 Internet services

9.1.1 Overview

9.1.2 DNS

9.1.3 Mail

9.1.4 WWW

9.2 Internet management **(***)**

9.2.1 Overview, FCAPS

9.2.2 MIB concept

9.2.3 SNMP

…

Computer networks II: Quality of Service and Multimedia Communication

Content (excerpt):

…

2. Mechanisms for QoS support **(**)**

2.1 From planning phase to resource reservation (resource management, negotiating service quality alternatives, mapping and scaling of service quality, admission control, reservation process)

2.2 Service qualities in the treatment phase Traffic Shaping with Leaky Bucket/Token Bucket/(r, T) smoothing, error treatment, service quality changes)

3. QoS possibilities with ATM **(*)**

3.1 SDH / SONET (overview and architecture, topology, hierarchy layers, multiplex structure, ATM over SDH)

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3.2 ATM overviews (purposes, reference model, network structure and interfaces, cell switching)

3.3 ATM layers (cell construction, cell model, channels and Paths, traffic and service parameters, service classes, overload control, OAM-Flows)

3.4 ATM adaptation layers (AAL-Sublayers, AAL models, signaling)

…

Seminar: Process-oriented IT service management

Content:

1. ITIL **(***)**
   - Introduction to IT Service Management (ITSM) and managing ITSM processes
   - ITIL Service Support processes
   - Service Delivery processes
   - optional for students: ITIL Foundation certification
2. Other ITSM standards (Overview and Introduction) **(***)**
   - BS15000 / ISO 20000
   - eTOM
   - Microsoft Operations Framework
3. ITSM process awareness using Airport simulation game **(**)**

Lab course: IT Security

Content:

1. TCP/IP and network services **(*)**
   - IP addresses and net masks
   - Address Resolution Protocol (ARP)
   - Configuration of network interfaces
   - Configuration of the static routes
   - TCP/UDP basics
   - DNS and BIND
2. Attack Scenarios - Wiretapping network traffic **(*)**
   - Viruses and worms
   - Security scanner and password cracker
   - Rootkits
   - Denial of Service tools
3. Securing a network **(*)**
   - Reconfiguration of the net topology
   - Static packet filter firewalls (using iptables)

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- Dynamic packet filter firewalls (using iptables)
- Network Address translation
- Anti-Spoofing

4. Cryptographic methods **(*)**
   - Encryption (especially IPSec)
   - Checksums (several)
   - Signatures (GNUPG)
   - Certificates
5. Securing services and protocols **(*)**
   - SSH vs. telnet
   - E-mail and WWW (sendmail and apache)
   - Virtual private Networks (OpenSwan/StrongSwan)
6. Application level services: **(*)**
   - Application Level Gateways
   - Circuit Level Gateways (esp. SOCKS)
   - Advanced Proxy usage (e.g., squid as reverse proxy)
   - Intrusion Detection Systems (snort and tripwire)

Lab course: Computer networks

Content:

1. IP networks based on Ethernet
   - Classical Ethernet (10BASE-5) on the oscillograph
   - IP Address Configuration **(*)**
   - DNS and DHCP configuration **(*)**
   - Firewall configuration
2. ATM: Basics in ATM and Packet Analysis
   - Quality of Service Management on ATM permanent and switched VCs **(**)**
   - Classical IP over ATM and LAN Emulation on ATM
3. Network Management **(***)**
   - OSI management model
   - SNMP and MIBs, SMI
   - Working with HP OpenView (maps, triggers, alarms)

3.3.9 International University Bremen (IUB), Germany

Overview of relevant teaching material:

- Lecture: Network and protocols

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- Lecture: Distributed systems
- Lecture: Advanced networking
- Lecture: Advanced distributed systems
- Seminar: Networks and distributed systems

Network and Protocols (undergraduate course)

Content:

- Fundamental Principles (Checksums, Retransmissions, Timeouts, Congestion)
- Local Area Networks (IEEE 802)
- Internet Network Layer (IPv4/IPv6)
- Internet Routing (RIP, OSPF, BGP)
- Internet Transport Layer (UDP, TCP)
- Firewalls and Network Address Translators
- Abstract Syntax Notation One (ASN.1)
- External Data Representation (XDR)
- Augmented Backus Naur From (ABNF)
- Domain Name System (DNS)
- Electronic Mail (SMTP, IMAP)
- Document Access and Transfer (HTTP, FTP)
- Operations and Management (SNMP) **(***)**
- Remote Procedure Calls (ONC RPC)

Distributed Systems (undergraduate course)

Content:

- Systems:
  - Middleware Systems (CORBA, JAVA RMI, Web Services)
  - Distributed File Systems (NFS, CIFS, AFS)
  - Peer-to-Peer File Sharing (Gnutella, Bittorrent)
- Algorithms:
  - Time and Clocks
  - Mutual Exclusion, Election, Voting
  - Atomic Multicasts and Virtual Synchrony
- Security:
  - Cryptography, Authentication, Key Exchange **(*)**
  - Secure Internet Protocols (TLS, IPsec, SSH, PGP)
  - Access Control (DAC, RBAC) **(*)**

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Advanced Networking (graduate course)

Content:

- Internet Multicasting (DVMRP, OSPF, PIM)
- Internet Quality of Service (Flows, Shaping, RSVP, DiffServ, Policy) **(**)**
- New Internet Transport Protocols (SCTP, DCCP)
- Multimedia Transport and Signaling (RTP, SIP)
- Mobility (MIPv4, MIPv6, Link-Layer Handovers)
- Domain Name System Extensions (SRV, ENUM, DDDS)
- Label Switching (MPLS, LDP, RSVP-TE)
- Measurement, Modeling, Simulation **(**)**

Advanced Distributed Systems (graduate course)

Content:

- Dependability and Fault Tolerance **(*)**
- - Security and Trust **(*)**
- Algorithms (Robust and Self-stabilizing Algorithms) **(*)**
- Peer-to-Peer Systems (Can, Chord, Pastry, Tapestry)
- System Monitoring and Configuration **(***)**

Seminar: Networks and Distributed Systems

3.3.10 KTH, Royal Institute of Technology (KTH), Sweden

Overview of relevant teaching material:

- Management of networks and networked systems

Management of Networks and Networked Systems (advanced undergraduate and graduate)

Content:

1. Introduction
2. SNMP-A Management Protocol and Framework
3. Distributed Management
4. Internet QoS Management
5. Performance Management for Web Services
6. Policy-based Management
7. Traffic Measurements for IP Operations

3.3.11 University of Surrey (UNIS), United Kingdom

Overview of relevant teaching material:

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- Network & service management & control

Network & Service Management & Control

Content:

- Network and service management and control principles. The management functional areas (fault, configuration, accounting, performance security). Layered management architectures.
- Technology evolution in management and control, protocol and distributed computing based approaches.
- The manager-agent model: managed objects, structure of management information, the management information base, management services and protocols, communication and awareness principles.
- The Open Distributed Processing model: principles of distributed processing, distribution transparencies, trading, viewpoints, request brokers, generic ODP platform services.
- The Internet Simple Network Management Protocol (SNMP). OSI Systems Management (OSI-SM) and CMIS/P.
- The OMG Common Object Request Broker Architecture (CORBA).
- Examples and problems using SNMP, CMIS/P and CORBA.
- Hierarchical management models, the TMN architecture, methodologies and principles. Virtual Private Network Management in ATM/MPLS and IP.
- Introduction to Traffic Engineering (TE), configuration/provisioning cycle, off-line/dynamic TE. Expected utilisation optimisation, load balancing, TE objectives. The limitations of shortest-path routing. MPLS-based TE through explicit paths. IP-based TE through link weight setting. Configuration via SNMP.
- Inter-domain Internet structure. Border Gateway Protocol (BGP) principles for dynamic TE. Inbound and Outbound TE, how BGP can be used to influence them. Off-line inter-domain TE through egress router selection. Configuration via SNMP.
- Quality of Service (QoS). Service Level Agreements and Specifications (SLAs/SLSs). Management system architectures for intra- and inter-domain QoS. QoS-aware intra- and inter-domain TE.
- The Intelligent Network (IN) conceptual model and architecture.

3.3.12 Univeristy of Pitesti (UPI), Romania

Overview of relevant teaching material:

- Computer networks
- Computer security
- Advanced networking and communication

Computer networks

Content:

- Computing Basics **(*)**

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- Basic Networking **(*)**
- Digital Bandwidth **(*)**
- General Model of Communication **(*)**
- The OSI Reference Model **(*)**
- Comparison of the OSI Model and the TCP/IP Model **(**)**
- Local Area Networks **(*)**
- Basic LAN Devices **(*)**
- Evolution of Network Devices **(*)**
- Basics of Data Flow Through LANs **(*)**
- Building LANs **(**)**
- Wide Area Networks **(***)**
- Layer 1: The physical layer
- Layer 2: The data link layer
- Layer 3: The network layer
- Layer 4: The transport layer
- Layer 5: The session layer
- Layer 6: The presentation layer
- Layer 7: The application layer

Computer security

Content:

- Computer Security (basic principles, security goals, Program security, Operating system security, Windows 2000 Security, Trusted operating systems, Common Criteria, Cryptographic Traffic Analysis Prevention, Database Security); **(**)**
- Cryptology (Steganography, Basic cryptology, Symmetric cryptography, Hashes and message digests, Asymmetric cryptography, Secret Sharing and Key Escrow); **(**)**
- Network Security (Cryptographic authentication & PKI, Network Cryptographic Protocols, Authentication website, Cryptographic protocols and practice, Network & distributed system security, Electronic mail security, IP Security Option, Firewalls and protocol vulnerabilities); **(***)**
- Other Topics in Security (Security QoS, Security administration, Legal and ethical issues); **(*)**
-

Advanced Networking and Communication

Content:

1. Review of basic concepts: **(*)**
   - concepts taught in Computer Networks

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- basic programming techniques: sockets, threading, cryptography, HTTP and SOAP programming

2. Communication fundamentals, basic elements of: **(**)**
   - compression
   - error detection and correction
   - random processes
   - queuing theory
   - information theory
3. Advanced Networking **(***)**
   - IPv6, Mobile IP, DNS
   - Wireless communications and protocols, wireless LAN, cellular networks
   - Traffic fragmentation, reliable transport, routing algorithms,
   - Mapping the internet: traceroute maps vs AS maps from Routeviews and RIS
   - Measurement and Management RTFM, IPFIX, SNMP, etc.
4. Modern application level communications **(***)**
   - HTTP system drivers
   - Web services protocol level addressing and routing
   - Web services protocol level security: authentication, authorization, digital encryption, digital signatures, secure conversations
   - Message workflows

3.4 *Rough Outline of the CCP*

Based on the performed survey (cf. Section 3.3) within the Network of Excellence with respect to the identification of relevant courses, lectures, seminars and exercises regarding IT Management related topics, a first version of the rough structure of the common course program, organized in separate modules has been identified. It was agreed that the common course program should be organized in modules.

In this context a module can be seen as the basic building block of the common course program. Another objective within work package 1 was the discussion about the content of each module. The following contains a rough outline of the current version of the common course program wrt. the modules which are further refined within the following subsections along with a detailed presentation of the overall structure of each module.

Rough outline of the CCP:

Module 1: Terminology

Module 2: Management scenarios

Module 3: Management principles

Module 4: Examples of management architectures: OSI management and TMN

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Module 5: Examples of management architectures: Internet management

Module 6: Selected management protocols

Module 7: Example of other management architectures and techniques

Module 8: Algorithmic approaches

Module 9: Management platforms and management tools

Module 10: Process-oriented IT service management

Module 11: Management automation and self-management

3.5 *Module 1: Terminology*

Structure of module 1:

1. **Terminology**
   1.1. Definition of key terms

3.6 *Module 2: Management scenarios*

Structure of module 2:

2. **Management scenarios**
   2.1. Selected management scenarios
      2.1.1. Help desk support
      2.1.2. Nomadic systems
      2.1.3. DNS management
      2.1.4. Meta directory application
      2.1.5. Event correlation
      2.1.6. Management of MPLS enabled networks
      2.1.7. Management of switched campus networks
      2.1.8. Management of VoIP services
      2.1.9. LAN management at a university
      2.1.10. WAN management at a global NSP
      2.1.11. Web Hosting Service Management of a national Hosting provider
      2.1.12. Management of a national peering point (e.g., DE-CIX)
      2.1.13. Hierarchical systems management in a distributed enterprise
      2.1.14. Management of a Grid environment (e.g. D-Grid)
   2.2. Selected case studies of management scenarios
      2.2.1. e.g., BMW Extranet
      2.2.2. e.g., T-Systems
      2.2.3. etc.

3.7 *Module 3: Management principles*

Structure of module 3:

3. **Management principles**
   3.1. Classification
      3.1.1. Centralized management
      3.1.2. Distributed management
      3.1.3. Cooperative management

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3.2. Models
3.2.1. Information model
3.2.1.1. Description / terminology
3.2.1.2. Properties of a managed object
3.2.1.3. Definition of concrete management information
3.2.1.4. Information model vs. data model
3.2.2. Functional model
3.2.2.1. Description
3.2.2.2. Network management functions according to OSI
3.2.2.3. Function model – delegation
3.2.2.4. FCAPS
3.2.2.4.1. Fault management
3.2.2.4.2. Configuration management
3.2.2.4.3. Accounting management
3.2.2.4.4. Performance management
3.2.2.4.5. Security management
3.2.2.5. Further management functions
3.2.2.6. etc.
3.2.3. Communication model
3.2.3.1. Description
3.2.3.2. Management communication
3.2.3.3. Aspects of the communication model
3.2.3.4. etc.
3.2.4. Organizational model
3.2.4.1. Description
3.2.4.2. Roles and connections of the entities
3.2.4.3. Models of cooperation

3.8 *Module 4: Examples of management architectures: OSI management and TMN*

Structure of module 4:

4. Examples of management architectures: OSI management and TMN
4.1. OSI management
4.1.1. Overview
4.1.1.1. Object oriented
4.1.1.2. ASN.1 template language
4.1.2. OSI communication model
4.1.2.1. Systems management, layer management, layer operation
4.1.2.2. CMIS/CMIP (scooping, filtering)
4.1.3. OSI organizational model
4.1.3.1. Manager / agent
4.1.3.2. Domains and policies
4.1.4. OSI functional model
4.1.4.1. Systems Management Functional Areas SMFAs
4.1.4.2. System Management Functions SMFs
4.2. Telecommunications Management Network (TMN)
4.2.1. Functional architecture
4.2.2. Physical architecture
4.2.3. Information architecture

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4.2.4. Logical layered architecture

3.9 *Module 5: Examples of management architectures: Internet Management*

Structure of module 5:

5. Examples of management architectures: Internet Management
- 5.1. Overview
- 5.2. Internet information model (SMI and MIB)
  - 5.2.1. SNMPv1-SMI and SNMPv2-SMI
  - 5.2.2. Standardized MIBs
    - 5.2.2.1. MIB-II
    - 5.2.2.2. SNMPv2 MIB
    - 5.2.2.3. Interfaces MIB
    - 5.2.2.4. IP MIB
    - 5.2.2.5. TCP MIB
    - 5.2.2.6. UDP MIB
    - 5.2.2.7. Host resources MIB
  - 5.2.3. Manufacturer specific MIBs
    - 5.2.3.1. Examples
- 5.3. Internet communication model
  - 5.3.1. Simple Network Management Protocol (SNMP)
    - 5.3.1.1. Introduction
    - 5.3.1.2. SNMP operations
    - 5.3.1.3. SNMP message encoding
    - 5.3.1.4. Security aspects
    - 5.3.1.5. SNMP version 1
    - 5.3.1.6. SNMP version 2
    - 5.3.1.7. SNMP version 3
- 5.4. Internet functional model
  - 5.4.1. RMON-MIB
  - 5.4.2. RMON2-MIB
  - 5.4.3. Internet function model extensions

3.10 *Module 6: Selected management protocols*

Structure of module 6:

6. Selected management protocols
- 6.1. Syslog
- 6.2. Netconf (IETF)
- 6.3. IPFIX
- 6.4. EPP

3.11 *Module 7: Example of other management architectures and techniques*

Structure of module 7:

7. Example of other management architectures and techniques

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7.1. CORBA
7.1.1. Object management architecture
7.1.2. Object model and interface definition language (IDL)
7.1.3. Object request broker and inter ORB protocols
7.2. WBEM
7.3. CIM
7.4. P2P-Technologies
7.5. Management using Web Services and Management of Web Services

3.12 *Module 8: Algorithmic approaches*

Structure of module 8:

8. Algorithmic approaches
8.1. Event correlation
8.2. Distributed monitoring and data aggregation
8.3. Network Discovery mechanisms
8.4. Intrusion detection
8.5. Policy specification, translation, analysis and conflict detection
8.6. Machine reasoning
8.7. Dependency modeling
8.8. Bayesian networks
8.9. Petri nets
8.10. Planning and scheduling

3.13 *Module 9: Management platforms and management tools*

Structure of module 9:

9. Management platforms and management tools
9.1. Classification of tools
9.1.1. Criteria for classification of the tools
9.1.2. General classification scheme
9.2. Independent test and monitoring tools
9.2.1. ping
9.2.2. traceroute
9.2.3. ntop
9.2.4. wireshark
9.2.5. dig
9.2.6. whois
9.2.7. tcpdump
9.2.8. tcp-wrapper
9.2.9. cacti
9.2.10. rdd
9.2.11. netcat
9.2.12. iperf
9.2.13. rancid
9.2.14. scli
9.2.15. nmap
9.3. Network management platforms
9.3.1. Architecture of a management platform

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9.3.1.1. Communication modul
9.3.1.2. Information modul
9.3.1.3. Graphical user interface
9.3.1.3.1. Tasks
9.3.1.3.2. Functions
9.3.1.3.3. Fundamental principles
9.3.1.3.4. Views
9.3.1.4. Basic applications
9.3.1.4.1. Status monitor
9.3.1.4.2. Treshold monitor
9.3.1.4.3. Event management
9.3.1.4.4. Configuration management
9.3.1.4.5. Topology management
9.3.1.4.6. Performance monitor
9.3.1.5. Platform based network management products
9.3.1.5.1. e.g., HP OpenView Network Node Manager
9.3.1.5.2. e.g., Tivoli NetView
9.3.1.5.3. etc.
9.3.1.6. Platform based system management products
9.3.1.6.1. e.g., HP OpenView: VantagePoint Operations, Service Activator
9.3.1.6.2. e.g., IBM Tivoli Enterprise
9.3.1.6.3. e.g., CA Unicenter TNG/TND
9.3.1.6.4. e.g., Nagios
9.4. Quality management (QoS-Tools)
9.5. Security management
9.6. Configuration management
9.6.1. An example tool: CFEngine
9.7. Trouble Ticket Systems (TTS)
9.7.1. Problem aquisition
9.7.2. Fault management
9.7.3. Aquisition of symptoms
9.7.4. Requirements of TTS tools
9.7.5. Examples of TTS
9.7.5.1. Commercial products
9.7.5.1.1. BMC Remedy Action request System
9.7.5.1.2. HP Service Desk
9.7.5.2. Public domain products
9.7.5.2.1. OTRS
9.7.6. Standardization efforts
9.8. Fault diagnosis and error recovery

3.14 *Module 10: Process-oriented IT Service Management*

Module Summary:

Providing IT services to customers with better, guaranteed quality has been the aim of many diverse efforts, undertaken under the common denominator "IT Service Management". Lately, more organizational approaches to this issue have been gaining popularity, especially the guidelines of the IT Infrastructure Library (ITIL, 10.2). Both the

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ISO/IEC 20000 standard (10.3) as well as the Microsoft Operations Framework (MOF, 10.4) highly base on the ITIL contents.

While ITIL has been developed and published by the British Office of Government Commerce (OGC) and in this respect can be seen as a collection of best practices, the Enhanced Telecom Operations Map (eTOM, 10.5) is a research effort in the context of the NGOSS (New Generation Operations Systems and Software, 10.5.1) project on behalf of the Tele Management Forum (TMF). As a research-driven approach, eTOM is based on a core information model called SID (10.5.4).

Cobit (Control Objectives for Information and Related Technology, 10.6) is an IT governance framework striving for similar goals as ITIL does, but providing a much more narrow focus on control requirements and business risks, complementary applicable to ITIL.

All of the presented approaches follow the principles of process-orientation which basically means that the control of activities and operations in IT Service Management (ITSM) within an IT organization takes place in the context of dedicated management processes.

The learning targets of module 10 are to be aware of the challenges in ITSM and business alignment of IT operations, to know the principles of process-orientation adapted to the management of IT and IT service operations, to gain a survey on state-of-the-art technologies and concepts in ITSM and to know the differences and interrelationships between the most important approaches.

Structure of module 10:

10. Process-oriented IT Service Management

- 10.1. Introduction & Overview
  - 10.1.1. Process Modelling
  - 10.1.2. Best Practices
  - 10.1.3. Maturity Models
- 10.2. IT Infrastructure Library (ITIL)
  - 10.2.1. Introduction & Structure
  - 10.2.2. Best Practices for Service Support
    - 10.2.2.1. Service Desk
    - 10.2.2.2. Incident Management
    - 10.2.2.3. Problem Management
    - 10.2.2.4. Configuration Management
    - 10.2.2.5. Change Management
    - 10.2.2.6. Release Management
  - 10.2.3. Best Practices for Service Delivery
    - 10.2.3.1. Service Level Management
    - 10.2.3.2. Financial Management for IT Services
    - 10.2.3.3. Capacity Management
    - 10.2.3.4. IT Service Continuity Management
    - 10.2.3.5. Availability Management
  - 10.2.4. Other ITIL Sets
    - 10.2.4.1. Security Management
    - 10.2.4.2. ICT Infrastructure Management
    - 10.2.4.3. Planning to Implement Service Management
    - 10.2.4.4. Application Management

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3.15 *Module 11: Management Automation and Self-Management*

Module Summary:

Having learnt in former modules about selected management protocols, students recognize that current management protocols mainly support monitoring (reading status values from managed systems) and execution (usually assigning values to parameters of managed systems). This is how a management station typically communicates with the managed systems, the actual creative part of the task (analyzing and recognizing situations, planning for changes, reasoning about how to adapt to circumstances like failures, bottlenecks, security incidents) is mostly done by human operators.

This module introduces students to management automation targeting at closed-loop management, which - for some cases - allows an automatic execution of the tasks formerly assigned to humans.

After evaluating goals and risks of management automation, the visions and concepts of IBM's Autonomic Computing Initiative are introduced.

The main part of this module presents mechanisms and techniques associated with automating management tasks mostly at the level of resources and services. In this section, adaptive systems and control theory mainly address self-optimization, fault-tolerant and highly available systems address self-healing, and robust and resilient systems address self-protection. The applicability of management automation to real world examples is shown by reconsidering selected scenarios from module "Management Scenarios".

A section on human factors concludes these modules, showing how humans and machines can cooperate to carry out systems and network management tasks, including delegation of tasks, mutual control and trust.

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The module "Algorithmic approaches" is recommended to detail the algorithmic foundations for implementing management automation.

Structure of module 11:

11. Management Automation
- 11.1. Terms and Definitions
- 11.2. Automation objectives and risks
- 11.3. Autonomic Computing Initiative by IBM
  - 11.3.1. Architecture of an Autonomic Element
  - 11.3.2. MAPE-K feedback control loop
  - 11.3.3. Self-CHOP capabilities
  - 11.3.4. Deriving management actions from business objectives
- 11.4. Mechanisms and techniques for management automation
  - 11.4.1. Adaptive systems and control theory
  - 11.4.2. Fault-tolerant and highly available systems
  - 11.4.3. Robust and resilient systems
- 11.5. Human factors in management automation
  - 11.5.1. Task Analysis and Human-Machine Function Allocation
  - 11.5.2. Levels of autonomy: From assistant systems to autonomous Systems

3.16 *Further Steps*

The initial version of the common course program will be improved through various discussions. After an agreement about the structure has been reached, the identified relevant modules need to be realized by

- Identifying existing teaching material that can be used without any modifications;
- Improving existing material with small modifications;
- Developing new material.

For the realization of step 2 and 3, experts will be asked to provide the necessary input in their field of expertise.

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4 EMIN (EManics INtegration)

Another main objective of the NoE is to improve the collaboration of the European network management experts and their respective institutions. Keeping track of the amount of collaboration is a valuable indicator in order to proof the success of the NoE.

In order to support the definition on the one hand and the discussion of the already defined metrics on the other hand, work package 1 developed a software tool. The tool called *EMIN* supports the definition and evaluation of metrics. EMIN displays for each partner an integration graph, showing the degree of integration with weighted links.

4.1 *Requirements*

The requirements for EMIN are derived from [2] and defined based on the discussions of the work package 1 team. The requirements can be grouped into general requirement and functional requirements.

4.1.1 General requirements

General requirements are all requirements which do not directly relate to a function of the software.

The first general requirement is that EMIN should be easy and intuitive to use. Reporting and controlling takes already quite some time and therefore it should not be necessary to spent more time on reading manuals or other documentation. The use of standard technologies in a well known environment is one way to address this requirement.

This requirement also includes that the heterogeneity of nowadays operating systems is taken into account. It should be able to use the tool on any of the current operating systems, thus putting no additional burden on the user in order to find the “right” system. Furthermore, the installation of client software has to be as simple and quick as possible.

The access to EMIN data has to be controlled. It has to be ensured, that only authorized persons can read, insert and edit data; access to EMIN data for people who are not member of EMANICS has to be avoided.

For EMANICS members it should be possible to edit the permissions on a fine-grained level. The following four access profiles have been identified:

- Read data of the own affiliation
- Insert and edit data of the own affiliation
- Read all data in EMIN
- Edit all data in EMIN

A concurrent access of several users at the same time has to be possible.

EMIN should access all existing data about reported integration and research activities to omit to have yet another reporting tool.

4.1.2 Functional requirements

This section lists the requirements for detailed functions of EMIN.

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The overall task of EMIN is to provide means to insert and edit integration data. This data is structured according to the quantitative metrics defined in [1] in Section 5.1. There seven metrics, called indicators, are defined. Table 1 cites from [1] for convenience.

Indicator	Unit	Description
Joint projects in EMANICS	Number	This indicator counts the number of subtasks of the work packages in which the partners participate
Joint published papers	Number	Papers which are composed by at least 2 partners and have been published
Visits	Days	Duration of a meeting of at least two EMANICS partners
Joint PhD Committees	Number	The number of inter-organizational supervision of Ph.D. or master thesis
Student exchanges	Days	The duration of students staying at the institution of a partner
Other tasks	Person days	Other common tasks within EMANICS which are not sub-tasks of WP7, WP8 and WP9, *e.g.*, Virtual Lab, joint software development or common activities with industry
General collaboration	Person days	Person-days spent in collaborations which already have been established before the EMANICS project started, *e.g.*, common industry projects, exchange programs

Table 1: Integration indicators

Discussions have been raised if the metrics are ambiguous, so that different people may select completely different numbers to denote the same thing. When defining the metrics, indicators have been selected, which should be fairly easy and objective to count- even after some time has passed by.

The last two metrics “Other tasks” and “General collaboration” are rather unspecific, but needed to be introduced in order to a have metrics which catch “the rest”. If each case would have been handled with its own metric, the list would be too long and too confusing. Special attention has to be put on those both metrics.

As a requirement from this discussion, the tool has to support the user as much as possible. Where one partner already reported collaboration, this should be visible to the other involved members, when they report their collaboration.

EMIN should be able to calculate the indexes named in the previous deliverable. These are

- the Bilateral Collaboration Index (BCI) and
- the Collaboration Index (CI).

This calculation also requires defining the weights for each metric. For this, no common criteria exist and a consensus on these weights will be very hard to achieve. Therefore it

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should be able for every user to adjust the weights himself. But still a reference value is necessary in order to compare results.

The main benefit of EMIN should be the visualization of the reported data for each institution, especially the BCI. Means to display the progress of collaboration over time should be possible. The memory effect as described in 0[1], Appendix A has to be implemented.

4.2 *Design*

4.2.1 Architecture

For EMIN a Web-based architecture with a database server has been chosen. This architecture presents the user only static HTML content, thus requiring only a standard Web browser on client side. This ensures that a maximum of devices and operating systems are supported. The heterogeneity is therefore not a problem.

This architecture brings also another advantage for the users. An installation of client components is not necessary. Users can directly access the tool over a provided URL.

All scripting is performed on the server, thus no client side scripting is necessary. As only static HTML pages are sent to the client, the tool is usable with even very conservative security settings. Yet a graphics display is needed to display the integration graphs.

In order to store the data persistently a database is used as a backend. Next to the reported data the database also stores user profiles. The persistent storage is necessary to be able to display the development of integration through time in terms of a history function.

4.2.2 Authentication and authorization

As identified in the requirements, the access to EMIN and the data has to be controlled, i.e., users have to be authenticated and authorized in order to work with the tool.

Several possibilities exist how to authenticate a user, which mainly differ in security and the effort on the user side. As the security requirements of EMIN are not high, still a strong authentication is necessary, it was decided to use centrally administered user accounts consisting of name and password. The user has to enter these credentials before entering EMIN. For convenience, a possibility to change the password is included in EMIN.

The access profiles shown below are realized as roles. Four roles can be directly derived from the requirements. Two more are added for the management of EMIN:

- *Reader*: Is allowed to read data of the own affiliation
- *Editor*: Is allowed to insert and edit data of the own affiliation
- *ReaderAll*: Is allowed to read data of all institutions
- *EditorAll*: Is allowed to edit and insert data for all institutions.
- *Useradmin*: Can create and delete user accounts
- Roleadmin: Can assign roles to users.

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Those roles are used for authorization. In order to determine the permissions of a user with the roles *Reader* or *Editor*, his affiliation is also used.

4.2.3 Data model

The data model of EMIN is depicted in Figure 1. The data stored can be classified in two categories: administrative data and metric data.

Administrative data comprises:

- the list of EMANICS partners (table *partners*),
- the user accounts (table *accounts*),
- the roles (table *roles*) and
- what user has which roles (table *rolemapping*).

The columns of the tables should be self-explaining. For the table *partners* the column *name* should denote the full name, *e.g.*, University of the Federal Armed Forces, Munich, and *shortname* the EMANICS' abbreviation, *e.g.*, CETIM. The column *pwHash* of the table *accounts* stores the stores the SHA-1 hash of a user's password. No clear text

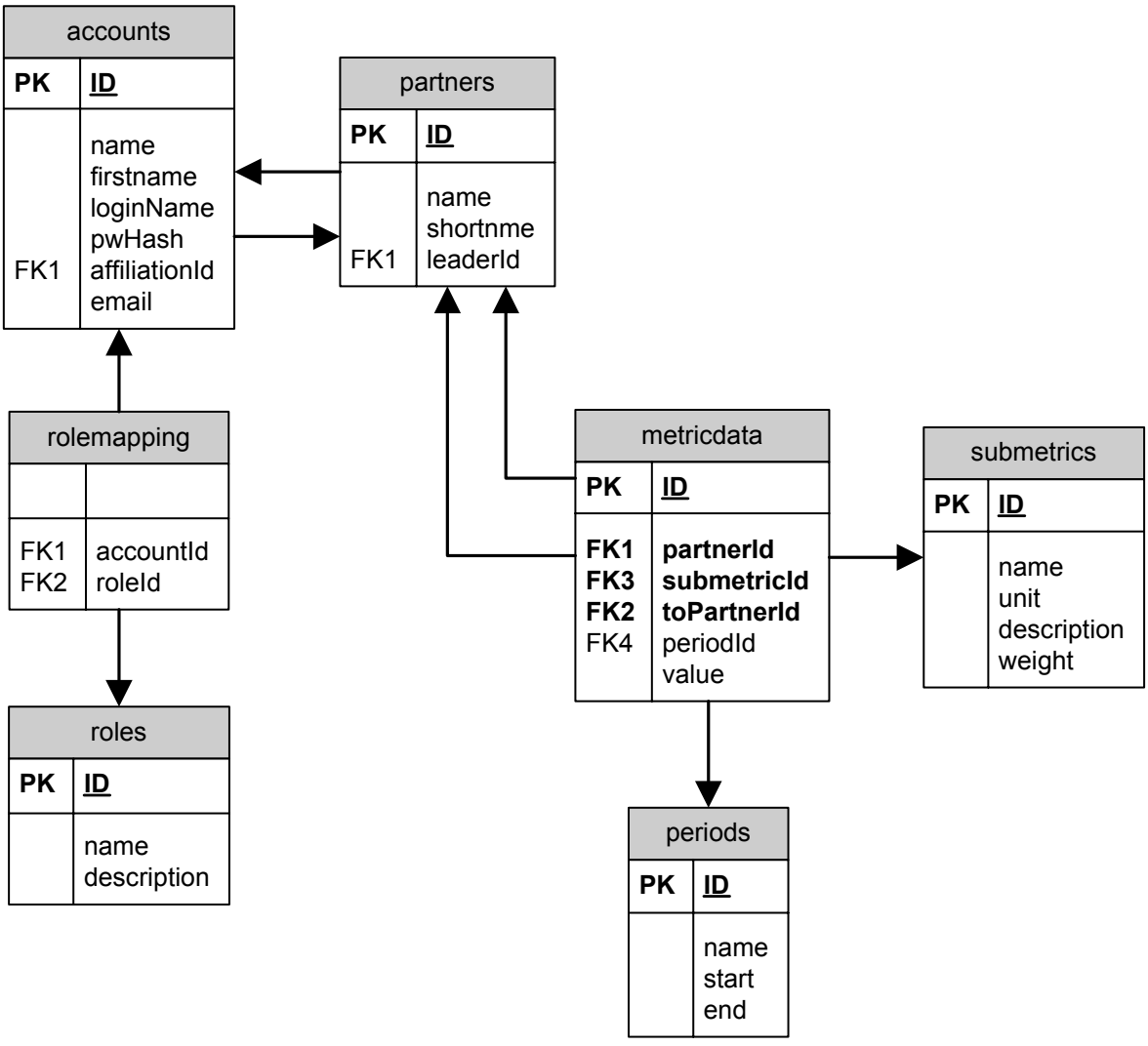

Figure 1: Data model of emin

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of passwords is stored in EMIN.

The table *accounts* and the table *partners* are linked twice. On the one hand, each user is associated with one partner institution (*accounts.affiliationId = partners.id*). On the other hand, each institution has one responsible person for EMANICS (*partners.leaderId = accounts.Id*).

Accounts and *roles* have an n:m relationship. This is modelled by a third table *rolemapping*. For each user for each role an entry with the corresponding *accountId* and *roleId* is stored.

The second type of data is the **metric data**. It comprises:

- the list of metrics (table *submetrics*)
- the reporting periods (table *periods*) and
- the reported data from the EMANICS partners (table *metricdata*).

There are two relationships between *metricdata* and the *partners* table. EMIN records bilateral integration, thus somebody always reports collaboration of his institution with another institution. *Metricdata.partnerId* stores the ID of the institution of the one who reports (*metricdata.partnerId = partners.ID*), to*PartnerId* stores the ID of the Institution a collaboration is reported with (*metricdata.toPartnerId = partners.ID*).

The field *periodId* relates an entry with a reporting period, listed in the table periods (*metricdata.periodId = periods.ID*).

Each entry of *metricdata* holds a relationship to one of metrics listed in the table *submetrics* (*metricdata.submetricId = submetrics.ID*). The column *value* of the table *metricdata* stores the reported value for the chosen metric. In the table *submetrics*, the column *weight* stores the default weight, used when calculating the BCI.

4.3 *Functions*

This section presents the most important use cases for EMIN. The following actions are described:

- Login procedure
- List all reports
- Create a new report
- Display one report
- Edit one report
- Evaluate one report

4.3.1 Login

Every user needs to authenticate with name and password. The default web page of EMIN is index.html which presents the user a form to fill in his credentials. If an unauthenticated user tries to access any other web page, he is redirect to a web page to fill in his credentials. After successfully authenticating, the user is in the logged-in state.

Figure 2 shows this process graphically. Figure 3 shows a screenshot of the login screen.

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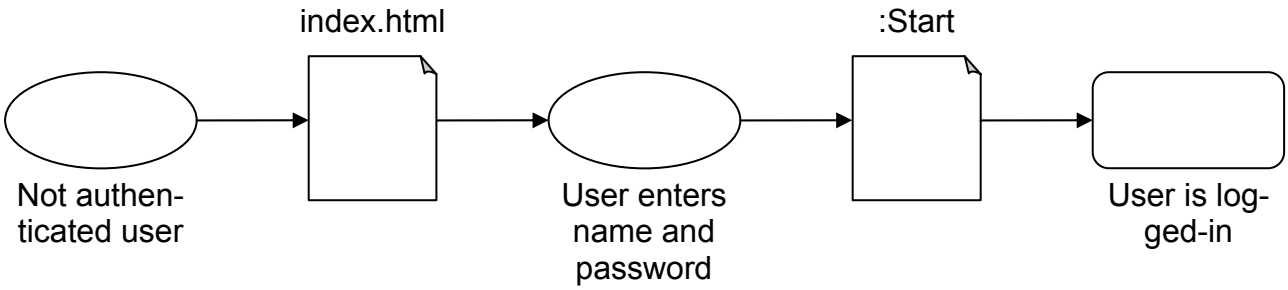

Figure 2: Login procedure

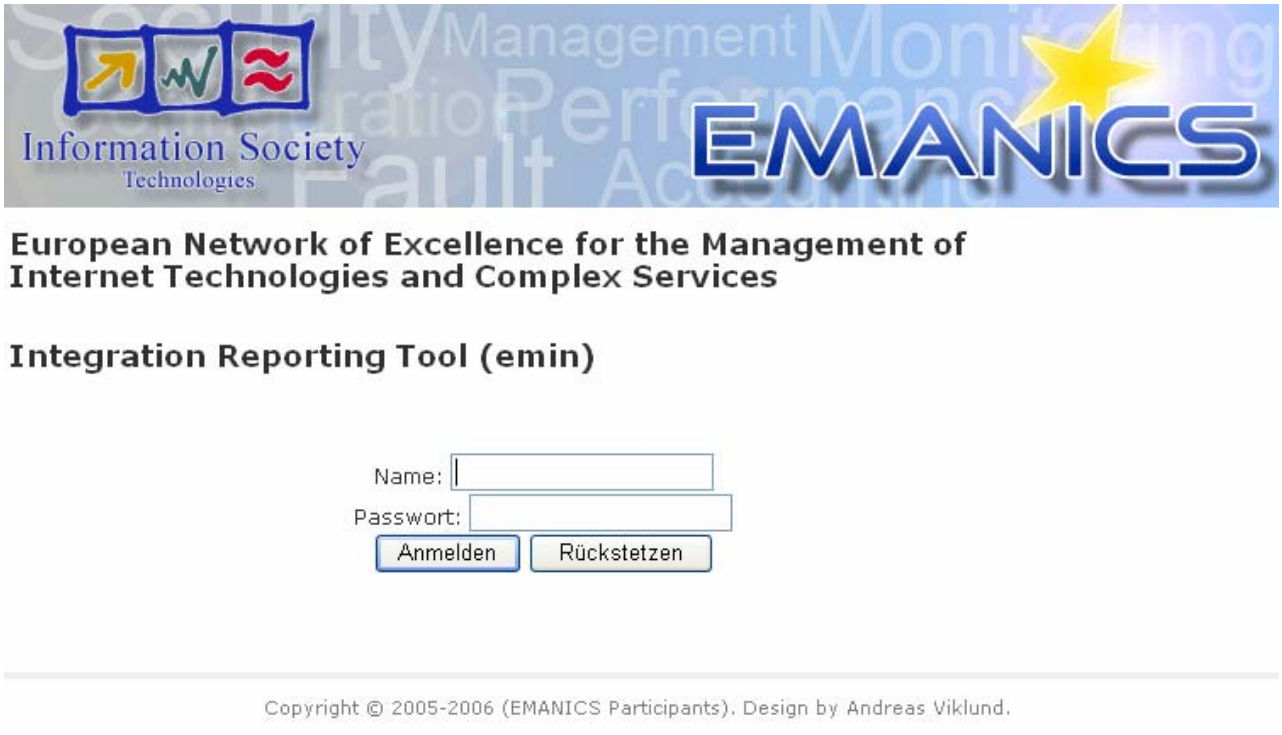

Figure 3: Screenshot of login screen

4.3.2 List all reports

EMIN maintains a list with all reports that have been entered so far. This list is the starting point for many other functions of EMIN. A link to this list is always accessible in the menu bar and on the bottom of most web pages of EMIN. Figure 4 show the process to reach the list of reports.

Figure 5 shows a screenshot of a list of reports. On the upper left the main menu is visible. In the middle you can see the reports, with commands “Evaluate”, “Display” and “Edit”. See Section 4.3.4, 4.3.5 and 4.3.6 respectively for a description of the commands. On the bottom the fields necessary to create a new report are displayed (see Section 4.3.3).

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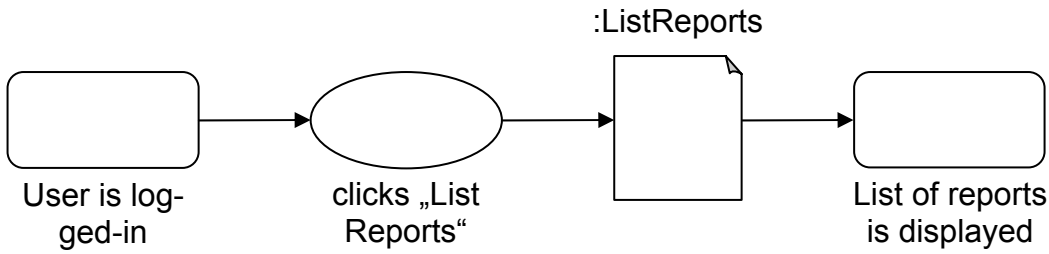

Figure 4: List all reports

Figure 5: Screenshot of lists of reports

4.3.3 Create a new reports

New reports can be created after choosing a period and an institution for which to create the report. If the permissions of a user do not allow him to create new reports, the respective buttons are not displayed. Likewise, if a user is only allowed to enter data for one institution, he should not be displayed a field to choose an institution.

Figure 6 shows this process. Start point is the list of reports. For the final state, the user is displayed a message, whether the previous actions have been successfully performed.

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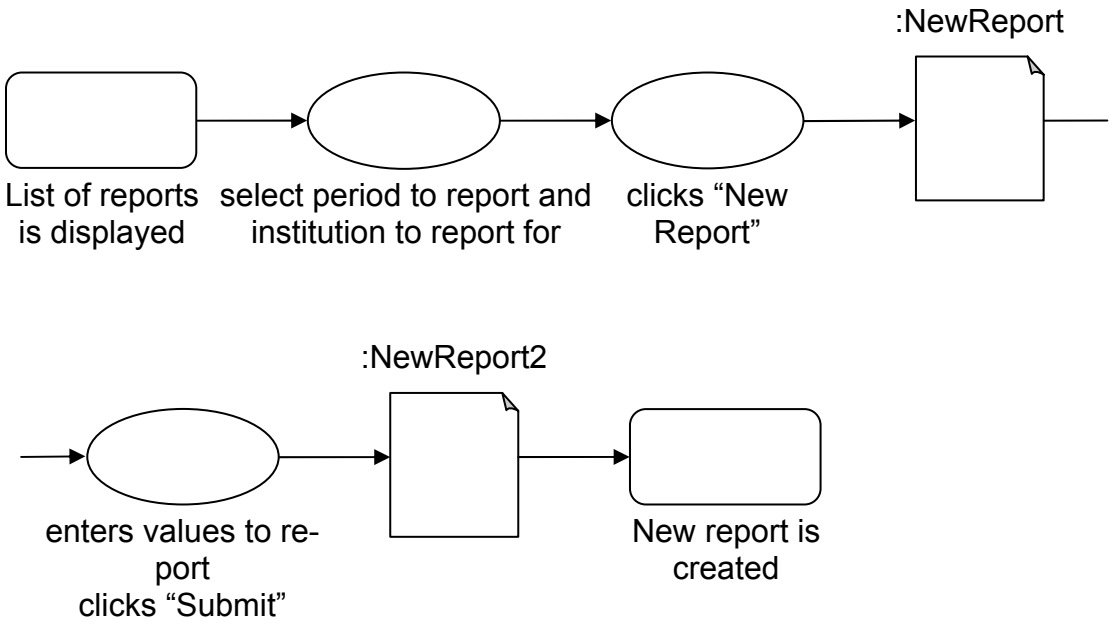

Figure 6: Create a new report

4.3.4 Display one report

Displaying one report is quite simple. When listing the reports, for each report a button “Display” is shown. This can be pressed in order to perform the action. See Figure 7 for a graphical representation of the process.

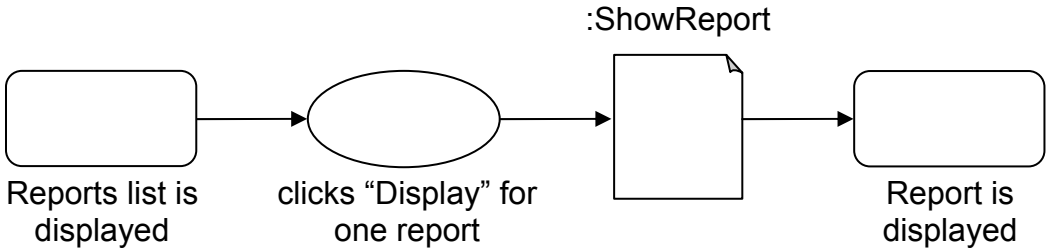

Figure 7: Display one report

4.3.5 Edit one report

The editing of a report can be started with the “Edit” button in the list of reports. This will display a table with all reported values, which can be changed. The submit button will store changed values in the database. For each institution for each period only one report is possible. This means, if a report was sent before end of a period and a new event should be reported, the report of this period has to be changed rather than creating a new one.

Figure 8 shows the process of editing a report. Figure 9 shows a screenshot of the report editing tableau. Here, values can be changed, but also empty values can be filled. After pressing submit, a page is displayed, showing the status of the operation (success or failure).

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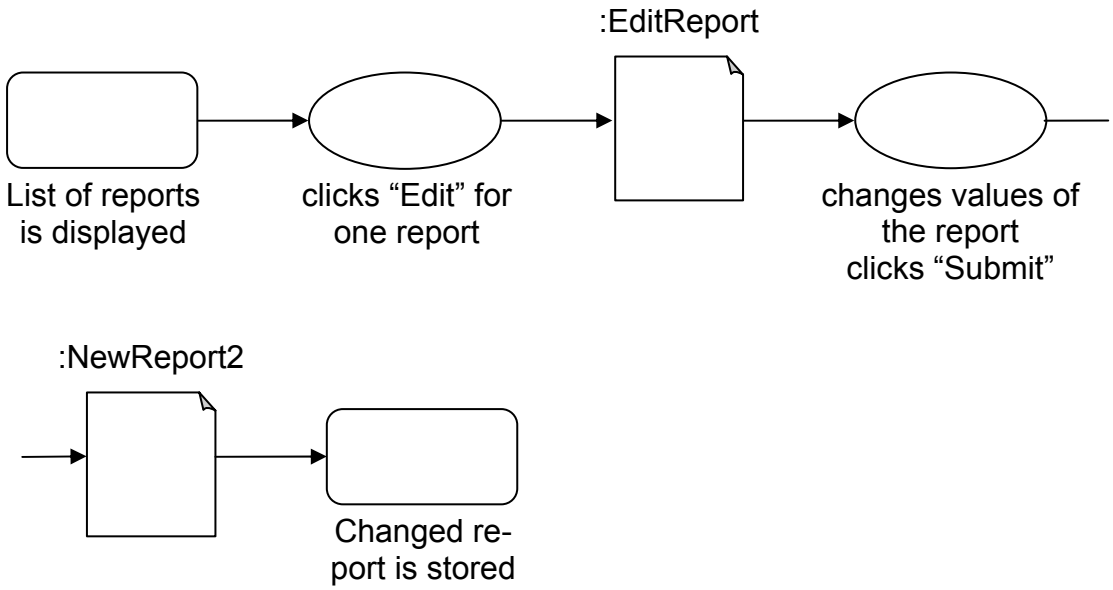

Figure 8: Edit one report

	INRIA	UT	IC	IUB	KTH	HIO	UPC	PSNC	UniZH	LMU	UniS	UniP
Projects (Number)	1.0											
Papers (Number)									1.0	1.0		
Visits(Days)												
PhD Committees (Number)									1.0			
Student exch.(Days)					28.0				1.0			
Other tasks (Person days)												
General collaboration (Person days)												

Figure 9: Screenshot of report editing tableau

4.3.6 Evaluation of one report

The evaluation of the reported data is the main task of EMIN. So far, EMIN can display an integration graph per report. See Section 4.4 for a discussion, which extensions to EMIN are planned for future.

Figure 10 shows the use case. After pressing “Evaluate” in the list of reports, the collaboration indexes and the integration graph are shown with default weights. Additionally, the page also gives the possibilities to adjust the weights, and to redraw the page.

The image of the integration graph is rendered on the server, thus no installation of Java or scripting techniques are necessary on the client.

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Figure 11, Figure 12 and Figure 13 show screenshots of the evaluation page. Please note the default weights are still arbitrary values and have therefore no meaning. The screenshots have been taken on a German system, therefore the submit button is in German “Anfrage senden” This text will always change to the system’s (to be more precise, to the browser’s) language.

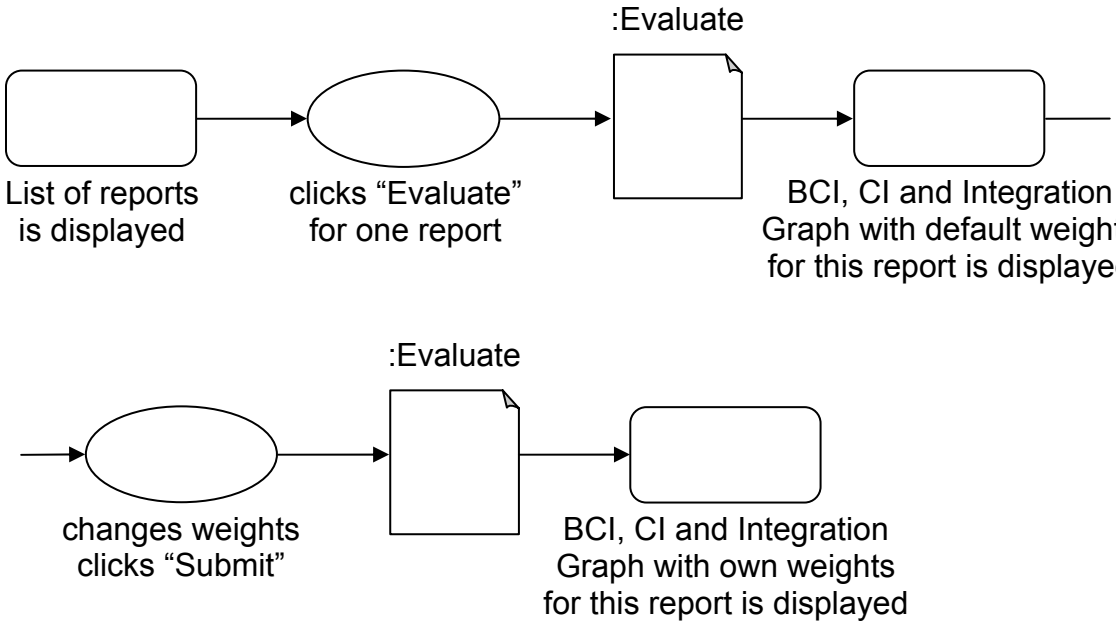

Figure 10: Evaluate one report

	INRIA	UT	IC	IUB	KTH	HIO	UPC	PSNC	UniZH	LMU	UniS	UniP	CI
BCI (with default weights)	8.0 (1.0)	0 (0)	0 (0)	0 (0)	8.400001 (140.0)	0 (0)	0 (0)	0 (0)	9.0 (12.0)	5.0 (2.0)	0 (0)	0 (0)	**30.400002 (155.0)**

Figure 11: Calculation of the Collaboration Indexes

Chose different weights

Metric	Value
Projects	8.0
Papers	5.0
Visits	1.0
PhD Committees	3.0
Student exch.	0.3
Other tasks	1.0
General collaboration	1.0

Anfrage senden

Figure 12: Mask to adjust weights

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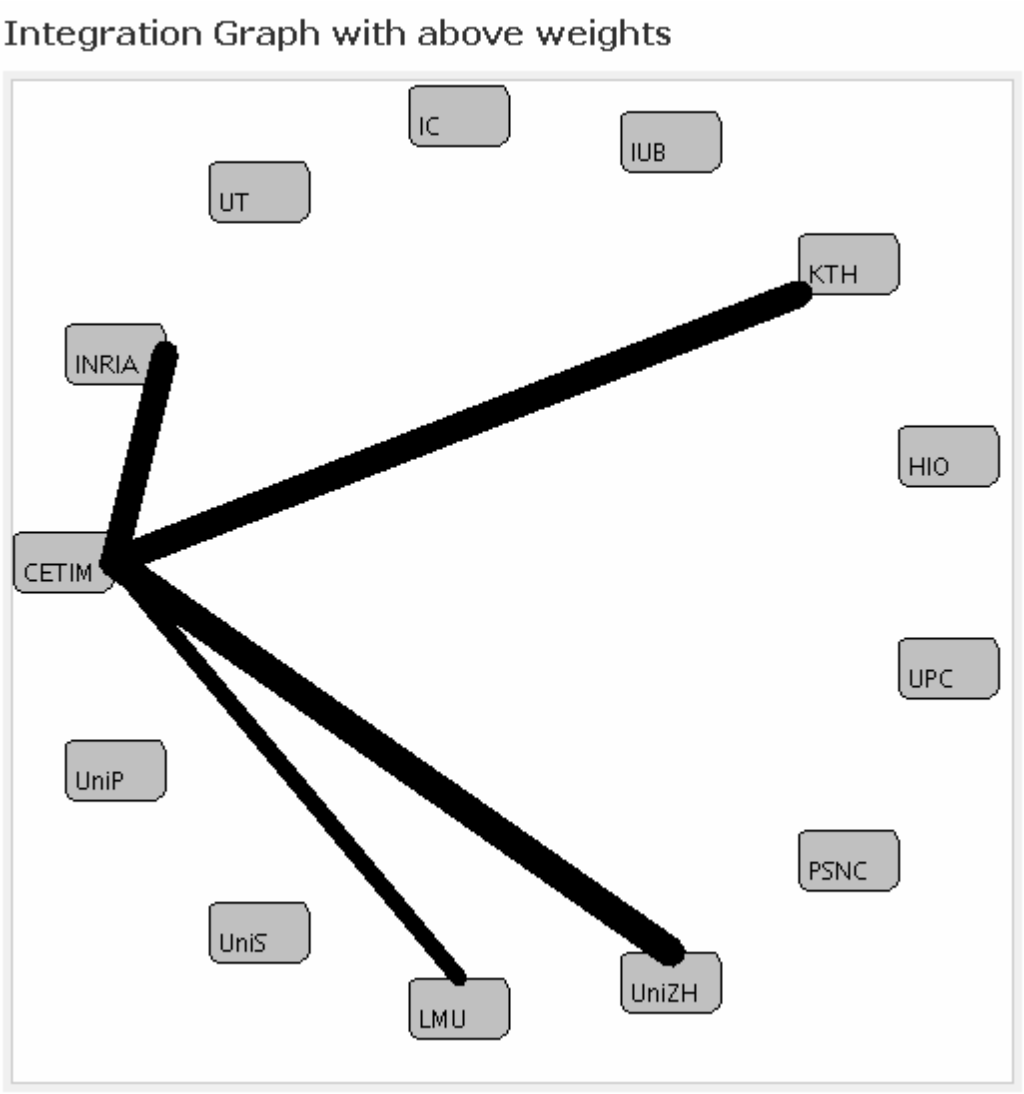

Figure 13: Sample Integration Graph

4.4 *Outlook*

In the current state EMIN has all functions implemented necessary to report the metrics and to store them in a database. This includes the authentication and the role-based authorization.

Yet, the user interface needs some improvements in a next step. Especially the layout of the web pages needs to be revised and links to go back to the main menu or the list of reports are not consistently placed.

New features need to be implemented to perform further evaluations. In the current version the evaluation of a single report is implemented (see Figure 12). New evaluations which can visualize the collaboration within the whole Network of Excellence) and not only of one single institution) need to be implemented. Furthermore, the visualization of the evolution of the collaboration over the different time periods would be beneficial.

Last but not least, the definition of weights for calculating the Bilateral Collaboration Index (BCI) is still open. A consensus is necessary in order to compare collaboration results.

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5 Report on the Joint EMANICS/NMRG Workshop on Future Directions of Network and Service Management Research

In October 19-20, a workshop was held in Utrecht (Netherlands) to discuss future directions of network and service management research. The goal of the workshop was to identify promising future direction of network and service management research that are felt worthwhile to explore in a timeframe of the next 5 years.

As a preparation of the workshop, all attendees were asked to write up position statements. This was intended to jump start the discussion. However, going through the position statements still took more time than expected since several position statements immediately triggered some lively discussions. After completing the presentation of the position statements, three smaller groups were formed: a group of operators, or group of researchers, and a group of vendors. Every group was tasked to answer a collection of prepared questions. The answers produced by the smaller groups were subsequently presented and discussed in the whole auditorium.

While it is impossible to provide a detailed summary, the key observations are the following:

1. It was agreed that more research is needed on monitoring. Especially aspects such as scalability, accuracy, data correlation, aggregation, and interpretation need more research in the face of very high capacity networks. It was observed that there is a need to move to statistical approaches and that there is a need to develop techniques to better deal with inconsistent and incomplete data sets.
2. Research is needed on understanding what modeling of behavior means. Reproducible and/or stabilizing behavior was considered particularly important. Some questions raised during the discussion were: How to specify behavior? How to design systems that exhibit reproducible behavior? How to encourage implementation of similar behavior?
3. Research is needed on effective data presentation and visualization mechanisms that hide complexity without losing semantics of data.
4. Research is needed to investigate fully distributed approaches for network and service management. It is necessary to investigate the relationships between centralized and fully distributed approaches. P2P technology is considered to play an enabling role in this area, but distributed algorithms in general are important related research fields.
5. Research is needed on self-* (self-organizing, self-healing, ...) technologies for network management. It was noted that self-* does not necessarily imply distribution nor does distribution imply self-* properties. In this context, it is important to investigate how self-* mechanisms differ from traditional approaches for automation, such as control loops.
6. Research is needed to investigate probabilistic approaches for management that can deal with some amount of uncertainty, namely uncertainty in management goals and also uncertainty in the input that is to not rely on the assumption that everything is deterministic and that the manager has permanent access to all data.

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The meeting web page http://www.ibr.cs.tubs.de/projects/nmrg/meetings/2006/utrecht/ has links to all received position statements, some slide materials, the questions for the various groups and the list of attendees.

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6 Conclusions

The establishment of a common long-term integration and research program among EMANICS partners requires a solid framework for collaboration and integration in the field of teaching as well as research activities. Such a framework needs not only to support the collaboration among experts to challenge new visions in network and service management. It has also to support the achievement of the same knowledge level among students and newcomers to this field. The first issue is addressed through the development of taxonomy for network and service management, common terminology resp. ontology of management. The second one is addressed by developing an EMANICS common course program.

Deliverable 1.2 reports on three issues:

- Development of an EMANICS common course program, including an overview of the currently available teaching material in this field among EMANICS partners;
- Development of EMIN, a developed Java-based tool to support the definition, discussion, and evaluation of integration and visibility metrics and indexes that measure and visualize the integration among EMANICS partners;
- Report on actions taken to identify new challenges and visions of network and service management.

The idea of an EMANICS certified degree – which can be obtained by a student who passes an exam, including all modules of the course program – has been discussed in order to achieve a standardized level of knowledge. The course program consists of modules which support also student mobility since some modules can be studies at one partner institution and the other part at another EMANICS partner. Besides, a pool of teaching material can be provided to EMANICS partners.

Since metrics and their meanings always cause a lot of discussions, it was not surprising that also the proposed integration metrics – to measure the integration and collaboration among EMANICS – were discussed intensively as well. In the first step several metrics - as defined in the project - has been collected and reported on the WP1 web site. However, it was felt that more meaningful and precise integration and visibility metrics need to be developed. To support, however, the discussion about the metrics, a Java-based tool has been developed.

The objective of identifying new challenges in network and service management has been approached by collecting relevant material as well as preparing a joint EMANICS / NRMG workshop of leading experts from providers, industry and research to discuss and identify the directions and open issues.

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8 Abbreviations

BCI Bilateral Collaboration Index

CI Collaboration Index

CCP Common Course Program

EMIN EMANICS Integration reporting tool

NoE Network of Excellence

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9 Acknowledgements

This deliverable was made possible due to the large and open help of the WP1 team of the EMANICS NoE. Many thanks are owed to all.

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