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1 Executive Summary

The overall objective of work-package 3 of EMANICS is to encourage and support the integration and dissemination of scientific research and education through seminars, workshops, conferences, special summer- or winter-schools, and educational resource development.

In the reporting period between January and December 2009 this objective was achieved on one hand through the organization of a number of events, including the 3rd EMANICS summer school and the 3rd AIMS conference, three Dagstuhl seminars including the Seminar on Management of the Future Internet, the Seminar on Bandwidth on Demand, and the Seminar on Visualization and Monitoring of Network Traffic, as well as six scientific workshops including the P2P Management Workshop, the Joint EMANICS/AutoI/Self-NET Workshop on Autonomic Management, the IEEE IM Workshop on the Management of the Future Internet, the Workshop on Network Security, the Netflow Workshop, and the Joint EMANICS/SmoothIT Workshop on Economic Traffic Management. It is worth noting that all these events were very successful, with many participants from both industry and academia. [Mention industry participation, in particular network operators, regulators, and policy makers] Partially, reports about these successful events have even been accepted for publication in the Journal of Network and Systems Management.

On the other hand, EMANICS did financially support scientific dissemination through a number of 170 attendances to major conferences and workshops worldwide and the building of 5 new tutorials. EMANICS did also support the IEEE IM 2009 and the IFIP/IEEE Manweek 2009 conferences through the sponsorship of 5 travel grants for EMANICS members. In return, the EMANICS logo was put on the respective conference websites. In addition, EMANICS encouraged and supported the involvement of EMANICS members in leading a number of activities in the area of network and service management.

Finally, major progress has been made regarding the long-term establishment of AIMS and ISSNSM. In order to exploit the synergies between the two events, the AIMS steering committee has decided to colocate the summer school with AIMS 2010. Both events will be hosted by UniZH and will take place from June 21 to June 25. The general chair of AIMS 2010 will be Burkhard Stiller from UniZH.

2 Introduction

This deliverable reports on the events organized under the Work-Package 3 umbrella of EMANICS in the last phase (January - December 2009). Ten events are presented here:

- the Dagstuhl Seminar on Bandwidth on Demand, that took place in Dagstuhl, Germany, February 2009;
- the EMANICS P2P Management Workshop, that took place in London, UK, April 2009;
- the EMANICS/AutoI/Self-NET Workshop on Autonomic Management, that took place in London, UK, April 2009;
- the Dagstuhl Seminar on Visualization and Monitoring of Network Traffic, that took place in Dagstuhl, Germany, May 2009;
- the IEEE IM Workshop on the Management of the Future Internet, that took place in New York, USA, June 2009;
- the Autonomous Infrastructure, Management, and Security (AIMS), that took place in Twente, The Netherlands, July 2009;
- the International Summer School on Network and Service Management (ISSNSM), that took place in Munich, Germany, July 2009;
- the EMANICS Workshop on Network Security, that took place in Bremen, Germany, October 2009;
- the EMANICS Netflow Workshop, that took place in Bremen, Germany, October 2009;
- the EMANICS/SmoothIT Workshop on Economic Traffic Management, that took place in Zurich, Switzerland, November 2009;

In addition, the deliverable provides an overview of scientific dissemination activities performed since January 2009.

3 Dagstuhl Seminar on Bandwidth on Demand

The Dagstuhl Seminar on Bandwidth on Demand¹ took place February 8-11, 2009 in Dagstuhl, Germany. The co-chairs of the seminar from EMANICS were David Hausheer and Burkhard Stiller from University of Zurich.

3.1 Seminar Scope

The objective of this seminar was to bring together researchers and practitioners from different disciplines to discuss and develop partially technical, economic, and regulatory mechanisms for the provisioning of bandwidth on demand services. The key topics tackled by this seminar included (a) the technical design of scalable, robust, and cost-effective bandwidth allocation and provisioning schemes, including fully decentralized and market-based mechanisms such as auctions, (b) economic studies and modeling of market and business models in carrier and service provider networks, including cost and revenue models as well as game theoretical bandwidth on demand models, (c) resource allocation and provision in non-profit systems such as neighborhood wireless mesh networks and network testbed infrastructures like GENI or PlanetLab, (d), industrial developments of new technologies that facilitate or create impediments to bandwidth on demand, including network virtualization technologies and wireless mesh networks, as well as (e) legislative and regulatory issues related to the Telecom Act and in comparison to other commodities markets such as the electric grid, as well as legal issues of P2P trading infrastructures.

3.2 Programme

A total of 4 long and 17 short presentations were invited to the seminar. Additionally, 3 working groups were organized.

The detailed programme of the three-day seminar is shown below:

Monday, February 9, 2009:

09:00 Welcome and Intro

09:30 Session 1 - Technologies and bandwidth provisioning

- S. Urushidani: “Resource Allocation and Provision for BoD”
- A. Pras: “Management of Lambda-Connections in Optical Networks”

10:30 Coffee Break

11:00 Session 2 - Economic and legal studies, business models

- P. Antoniadis: “Resource allocation and provision in non-profit networks”

¹<http://www.dagstuhl.de/09072/>

- J. Dinger: “Techno-Legal Bandwidth on Demand Perspectives”

12:15 Lunch

13:30 Session 3 - 5 min statements of participants (part 1)

- G. Carle: “Multihoming in Heterogeneous Wireless Access Networks”
- G. Huitema: “Energy on Demand: Learning from the telecoms world”
- I. Hamchaoui: “Bandwidth on Demand: an ISP Point of View”
- Z. Despotovic: “Value of decentralized reputation management for BoD”

15:00 Coffee Break

15:30 Session 4 - All Brainstorming: What are BoD topics of interest?

16:00 Session 5 - Work groups: Determine technical, economic, legal aspects

18:00 Dinner

Tuesday, February 9, 2009:

09:00 Session 6 - 5 min statements of participants (part 2)

- B. Stiller: “RoD, BoD, CoD, ..., PoD, SoD, ... And XoD”
- M. Zitterbart: “Network virtualization providing Bandwidth on Demand”
- A. Androutsos: “Bandwidth Externalities & QoS Growth: A Long-run Economic Approach”
- Ch. Hoene: “Buying Bandwidth only if you need it”
- M. Waldburger: “Bandwidth on Demand Contract(s)”
- F. Beltran: “Analysis of aggregation strategies in BoD markets”

10:30 Coffee Break

11:00 Session 7 - 5 min statements of participants (part 3)

- D. Hausheer: “Virtual Networks on Demand”
- T. Braun: “QoS Support for Overlay Multicast”
- A. Farrel: “Convergence without Conflation - IETF Perspectives”
- B. Tuffin: “Self-managed inter-domain pricing: a discussion of possible approaches”
- P. Reichl: “The User Knows Best: A QoX-based View on *oD”
- G. Ruffo: “BoD: Opportunities and Challenges in the technological Jungle”
- H. Hartenstein: “Two Challenges: Wireless and As-a-service”

12:15 Lunch

13:30 Session 8 - Discussion: How should a BoD service look like?

15:00 Coffee Break

15:30 External visit and dinner

22:00 app. return time

Wednesday, February 10, 2009:

09:00 Session 10 - Feedback of Work Groups to Plenary (30 min each)

- Work Group 1: “BoD Applications and BoD versus BnD”
- Work Group 2: “Economic Mechanisms, Service Aspects, and Resource Management”
- Work Group 3: “Legal, Social, Ecological, ... Issues”

10:30 Coffee Break

11:00 Session 11 - Closing Discussion, result exploitation

12:15 Lunch

13:30 End of Seminar

3.3 Local Arrangements and Costs

The organizational and hosting costs of the seminar were of 0 Euros for EMANICS. Attendance to the seminar was upon invitation only. EMANICS supported 4 members of EMANICS with a travel grant of 700 Euros each for attending the seminar.

All presentation slides and seminar material has been made freely available to the public on the seminar web site.

3.4 Evaluation

In summary, the seminar was very successful. With 25 attendees it did lead to many fruitful discussions and scientific exchange.

A future BoD workshop is planned to be organized again in colocation with a large conference.

4 EMANICS P2P Management Workshop

The 2nd EMANICS Workshop on P2P Management² took place on April 27 and 28, 2009. This was a joint event between EMANICS and UK EPSRC PEERLIVE, and was organized by University College London, United Kingdom. The co-chairs of the workshop were George Pavlou and Marinos Charalambides from University College London, and David Hausheer from University of Zurich.

4.1 Workshop Scope

The objective of this workshop was to bring together researchers from the EMANICS, PEERLIVE and other communities to exchange ideas in the area of peer-to-peer (P2P) management. This event followed the first successful workshop which was hosted by the University of Zurich in March 2008.

The workshop addressed the application of P2P concepts for network and service management, the management of P2P networks, as well as fully decentralized and distributed management approaches.

4.2 Programme

A total of ten presentations were invited to participate in the workshop, which span over two days - it started with an afternoon session on the first day and finished with a morning session on the second day. The program included four presentations from EMANICS, two from PERLIVE and four from external researchers. Among the latter, was a presentation from an industrial participant.

The detailed programme of the two-day event was as follows:

Monday, April 27, 2009

13:45 Registration

14:15 Welcome, George Pavlou, Marinos Charalambides, University College London, David Hausheer, University of Zurich

14:30 Improving the Performance of P2P Streaming through an Overlay-operator Interface like ALTO/SIS, Fabio Hecht, University of Zurich

15:00 Answering Queries Using Cooperative Semantic Caching, Andrei Vancea, University of Zurich

15:30 Distributed Overlay Anycast Table using Space Filling Curves, Lawrence Latif, University College London

²<http://www.ee.ucl.ac.uk/nsrl/events/p2p-mgmt-ws>

- 16:00 Coffee break
- 16:30 Aspects of Autonomic Computing in Peer-to-Peer Systems, Kalman Graffi, Darmstadt University of Technology
- 17:00 MARL (Multi Agent Reinforcement Learning) in P2P Network Management, Ricardo Bagnasco, Technical University of Catalonia
- 17:30 Modular P2P Peer Sampling, Cyrus Hall, University of Lugano
- 18:00 End of first workshop day

Tuesday, April 28, 2009

- 09:15 Start of second workshop day
- 09:30 Exploiting KAD Vulnerabilities to Build an Efficient Honeypot Architecture, Thibault Cholez, Nancy University
- 10:00 Coffee break
- 10:30 A Sybilproof Indirect Reciprocity Mechanism for Peer-to-Peer Networks, Raul Landa, University College London
- 11:00 Embedding Identity in DHT Systems: Security, Reputation and Social Networking Management, Luca Maria Aiello, Turin University
- 11:30 Results of using a P2P Network to Deliver Content within the Enterprise, Chris Lloyd, Kontiki
- 12:00 Wrap-up and discussion
- 12:30 Lunch
- 13:30 End of workshop
- 20:00 Social event

4.3 Local Arrangements and Costs

The organizational and hosting costs of the workshop were of 3000 Euros for EMANICS. The workshop was open to non-EMANICS members and registration was free. Additionally, EMANICS members were supported with a travel grant of 700 Euros each for attending the workshop.

Presentation slides and workshop material has been made freely available to the public on the seminar web site.

4.4 Evaluation

In summary, the 2nd EMANICS Workshop on P2P Management was very successful. It received 31 registrations in total, with 32% of those coming from researchers not affiliated with EMANICS or PEERLIVE (industry, universities). It was a very interactive event with participants engaging in lively and fruitful discussions on the ideas and experimental results presented.

5 EMANICS/AutoI/Self-NET Workshop on Autonomic Management

The 2nd Workshop on Autonomic Management³ took place on April 28 and 29, 2009. This was a joint event between EMANICS, AutoI and Self-NET projects, and was organized by University College London, United Kingdom. The co-chairs of the workshop were George Pavlou, Marinos Charalambides and Alex Galis from University College London, and Nancy Alonistioti from the University of Athens.

5.1 Workshop Scope

The objective of this workshop was to bring together researchers from the EMANICS, AutoI, Self-NET and other communities to exchange ideas in the area of autonomic management. This event followed the first successful workshop which was hosted by the Technical University of Catalonia in May 2008.

The theme of the workshop focused on the role of autonomics in the management of the much debated Future Internet (FI). Presentations and discussions evolved around the management requirements of the FI as well as architectural, technological and design issues that need to be addressed so that autonomic management functionality can be realised.

5.2 Programme

A total of thirteen presentations were invited to participate in the workshop, which span over two days - it started with an afternoon session on the first day and resumed with two sessions on the following day. The program included four presentations from EMANICS, five from AutoI, two Self-NET and two from external researchers.

The detailed programme of the two-day event was as follows:

Tuesday, April 28, 2009

13:45 Registration

14:15 Welcome, George Pavlou, Marinos Charalambides and Alex Galis, University College London

14:30 Keynote: Challenges in Distributed Management, Paul McKee, British Telecom

15:15 Autonomic Management of Service Clouds, Alex Galis, University College London

16:00 Coffee break

³<http://www.ee.ucl.ac.uk/nsrl/events/auto-mgmt-ws>

- 16:30 A Service Enabler Infrastructure for the Future Internet, Laurent Lefevre and Abderhaman Cheniour, INRIA
- 17:00 Self-management of Wireless Ad-hoc Networks, Antonis Hadjiantonis, University of Nicosia
- 17:30 Knowledge Management Requirements in Autonomic Network Management, Giannis Koumoutsos, University of Patras
- 18:00 End of first workshop day
- 20:00 Social event

Wednesday, April 29, 2009

- 09:15 Start of second workshop day
- 09:30 Information and Knowledge Management for an Autonomic Internet: Experience and Future Challenges, Steven Davy, Waterford Institute of Technology
- 10:00 Towards an Information Management Overlay for the Future Internet, Lefteris Marmatas, University College London
- 10:30 Coffee break
- 11:00 An Autonomous Management System for the AUTOI Approach, Javier Rubio Loyola, Technical University of Catalonia
- 11:30 In-network Management for the Future Internet, Alberto Gonzalez Prieto, KTH Royal Institute of Technology
- 12:00 Towards Self-healing in Wireless Sensor Networks, Themistoklis Bourdenas, Imperial College London
- 12:30 Lunch
- 13:30 Fusion of Self-management and the Future Internet, Andrej Mihailovic, Kings College London
- 14:30 Tools for Cognition in Self-managed Networks, Stan Wing Wong, Kings College London
- 15:15 Coffee break
- 15:45 Towards a Service-aware Future Internet and its Management, George Pavlou, University College London
- 16:30 Wrap-up and discussion
- 18:00 End of workshop

5.3 Local Arrangements and Costs

The organizational and hosting costs of the workshop were of 3000 Euros for EMANICS. The workshop was open to non-EMANICS members and registration was free. Additionally, EMANICS members were supported with a travel grant of 700 Euros each for attending the workshop.

Presentation slides and workshop material has been made freely available to the public on the seminar web site.

5.4 Evaluation

In summary, the 2nd EMANICS Workshop on Autonomic Management was a great success facilitating a better integration of the work and views in this area with a wider community. It received 43 registrations in total, with 20% of those coming from researchers not affiliated with the three European projects involved. Representatives from the EMANICS, AutoI and Self-NET projects had the opportunity to present their latest work, which led to fruitful discussions and assisted in identifying areas for potential collaboration.

6 Dagstuhl Seminar on Visualization and Monitoring of Network Traffic

The Dagstuhl Seminar on Visualization and Monitoring of Network Traffic⁴ took place May 17-20, 2009 in Dagstuhl, Germany. The co-chairs of the seminar from EMANICS were Aiko Pras (University of Twente) and Jürgen Schönwälder (Jacobs University Bremen). The co-chairs from the visualization community were Daniel A. Keim (University of Konstanz) and Pak Chung Wong (Pacific Northwest National Lab). Florian Mansmann (University of Konstanz) helped with producing this report.

6.1 Motivation

The seamless operation of the Internet requires being able to monitor and visualize the actual behaviour of the network. Today, IP network operators usually collect network flow statistics from critical points of their network infrastructure. Flows aggregate packets that share common properties. Flow records are stored and analyzed to extract accounting information and increasingly to identify and isolate network problems or security incidents. While network problems or attacks significantly changing traffic patterns are relatively easy to identify, it tends to be much more challenging to identify creeping changes or attacks and faults that manifest themselves only by very careful analysis of initially seemingly unrelated traffic pattern and their changes. There are currently no deployable good solutions and research in this area is just starting. In addition, the large volume of flow data on high capacity networks and exchange points requires to move to probabilistic sampling techniques, which require new analysis techniques to calculate and also visualize the uncertainty attached to data sets.

6.2 Seminar Scope

The aim of the seminar is to bring together for the first time people from the networking community and the visualization community in order to explore common grounds in capturing and visualizing network behaviour and to exchange upcoming requirements and novel techniques. The seminar also targets network operators running large IP networks as well as companies building software products for network monitoring and visualization. We believe that bringing experts from two usually separate fields together makes this seminar unique and we expect that the intensive exchange in a Dagstuhl seminar setting has high potential to lead to joint follow-up research.

The following research questions were suggested for discussion:

- What are suitable data analysis and visualization techniques that can operate in real-time and support interactive online operation?
- How can monitoring and visualization techniques be made scalable?

⁴<http://www.dagstuhl.de/09211/>

- How can distributed monitoring systems be self-organizing and adapt dynamically to changes in network and service usage?
- How can algorithms aggregate data within the network and trade accuracy of the measurement results against data collection overhead?
- What are suitable sampling techniques and how does sampled data impact data analysis techniques and data visualization?
- Which filtering, zooming, and correlation techniques can be applied in real-time?
- What are good techniques for visualizing unusual traffic patterns or very rare patterns?
- What are effective methods to detect and visualize intrusions, like (distributed) scan attempts and denial of service attacks?

While this item list was helpful as an orientation, not all of the items were actually covered during the seminar. Moreover, other concerns, such as NetFlow storage and retrieval, were emphasized in the presentations and discussions.

6.3 Participants

The seminar gathered 36 researchers from the following 10 countries:

Country	Number of participants
Australia	1
Brasil	1
France	1
Germany	16
Israel	1
Netherlands	5
New Zealand	1
South Korea	1
Switzerland	3
USA	6

Most participants come from universities or state-owned research centers (33) while 3 participants were employed by industry or industrial research centers.

6.4 Programme

Monday 2009-05-18

After the opening, the morning sessions featured the following keynote talks:

- Jack van Wijk, Eindhoven University of Technology: Network Visualization
- Harald Weikert, IsarNet: Network Traffic Visualization with IsarFlow
- Felix Wu, University of California at Davis: On Detection and Analysis of BGP Anomalous Dynamics

In the afternoon sessions, short talks of the participants presented the participants' research activities in the fields of networking and visualization:

1. Keith Andrews, TU Graz: The Usability of Information Visualisation Techniques for Network Monitoring
2. Nevil Brownlee, University of Auckland: Collecting and Analysing Traffic Flow Data
3. Isabelle Chriment, Université Henri Poincaré Nancy I: Measurements and Analysis of P2P Exchanges
4. Stephan Diehl, Universität Trier: Working Group Results "We have a hammer, find a nail"
5. Falko Dressler, Universität Erlangen: High-speed Monitoring and Intelligent data pre-selection for Attack Detection
6. Glenn A. Fink, Pacific Northwest National Lab: Cyber Analytics: Challenges and solutions for computer security
7. Carsten Goerg, Georgia Institute of Technology: Interactive Exploration of Typed Networks
8. Hans Hagen, TU Kaiserslautern: Visualization and Monitoring of Network Traffic
9. Simon Leinen, Switch Zürich: Visualizations in Network Operations and Management: What Works, What Doesn't, and What's Missing
10. Lars Linsen, Jacobs University Bremen: Cluster Visualization in Network Traffic
11. Florian Mansmann, Univeristy Konstanz: Monitoring and Intrusion Detection with NFlowVis
12. John McHugh, Dalhousie University: FloVis a visual paradigm for forensic network data analysis
13. Cristian Morariu, Univeristy of Zürich: Distributed Traffic Analysis
14. Stephen North, AT&T Research Florham Park: Network Visualization and Service Monitoring Research in a Large ISP
15. Adam Perer, IBM Haifa: Improving Exploration of Networks by Integrating Statistics and Visualization
16. Ramin Sadre, University of Twente: Three Remarks on Visualization

17. Taghrid Samak, DePaul University Chicago: Using Space-Filling Curves in Visualization of Network Traffic
18. Sebastian Schmerl, BTU Cottbus: Explorative Visualization of Log Data to support Signature Development and Forensic Analysis
19. Carsten Schmoll, FhG FOKUS Berlin: Fraunhofer FOKUS - interests in Visualisation
20. Jürgen Schönwälder, Jacobs University Bremen: Flow Pattern Analysis
21. Mike Sips, MPI für Informatik Saarbrücken: Exploring and Modeling the Local Behavior of Personal Machines
22. Anna Sperotto, University of Twente: Working with network data: visualizing data relations
23. Alexandru C. Telea, University of Groningen: Visualization of Large Network Structures: Bundled Edges or Node Link Layouts?

The evening session was reserved for demonstrations of research prototypes accompanied by cheese and wine.

Tuesday 2009-05-19

Four working groups were formed in order to inspire fresh and novel research. Thereby, particular care was taken that the groups are mixed in a way that each one contained experts of both fields. Each of the following questions was assigned to two working groups.

1. What could be applications of visualization in the area of network monitoring?
2. What visualization could be useful to solve networking problems?

After the 90 minutes discussions within the working groups, the results were shared and discussed with all participants of the seminar.

The social program of the event was scheduled on Tuesday afternoon. It included a wine tasting in the historic city Trier.

Wednesday 2009-05-20

The morning of the last day of the seminar was reserved for discussions, conclusions and the closing remarks of the organizers.

6.5 Conclusions

The Visualization and Monitoring of Network Traffic seminar was a fertile meeting in which researchers from diverse background met. It included industry and academia, senior and junior researchers, multi-national representation, and people coming from several disciplines. This diversity resulted in interesting and useful discussions, new understandings of the fundamental concepts and problems in the field, and in new collaborations on an array of problems which were not well defined or identified prior to this seminar.

Several work groups during the seminar not only generated new insights into specific topics in the field of visual network monitoring, but also initiated ongoing joint work, with group members continuing the work they started at the seminar. The seminar included multiple presentations and discussions. In particular, the largely disjoint research communities Networking and Visualization exchanged their methods and unsolved problems resulting in fruitful discussions and awareness of the respectively other field.

This seminar clearly illustrated the diversity, relevance, and fertility of the topics we presented and discussed. The intensity of the participants' involvement leads us to believe that the interactions fostered by the seminar will generate a lot of follow-up research, and eventually lead to practical use as well.

7 First IFIP/IEEE International Workshop on Management of the Future Internet (ManFI 2009)

The First IFIP/IEEE International Workshop on Management of the Future Internet⁵ took place June 5, 2009 at Hofstra University, Long Island, NY, USA. The co-chairs of the workshop from EMANICS were Gabi Dreo Rodosek and Iris Hochstatter from University of Federal Armed Forces Munich. The workshop was colocated with the IEEE Integrated Network Management Conference and followed the first EMANICS workshop on Vision and Management of the Future Internet which was held at AIMS 2008.

7.1 Workshop Scope

Recently, researchers in the networking area around the world have been investigating ways to solve the major problems that exist in the current Internet and designing a new Internet called the Future Internet, which has become a very hot topic, especially in the US, Europe, Japan and Korea. Network management is a very important area but it was an afterthought in the current Internet and thus managing the Internet is very cumbersome and difficult. As the researchers have just started architecting and designing the Future Internet, we also need to include the manageability from the beginning (i.e., in the design stage).

GENI and FIND in USA, FIRE, OneLab, Autol in Europe, NWGN in Japan, and FIF in Korea are the some of the major research initiatives for developing the Future Internet. Similarly, the researchers around the world also have started working on the Manageability of the Future Internet. GENI OMIS WG in US, 4WARD in Europe, and CASFI in Korea are good examples of such research projects. We believe that this topic will be a very hot one in the network management community at least for the next few years.

In total 20+ participants attended the workshop.

7.2 Programme

The programme of the one-day workshop included two keynotes, two paper sessions, a poster session, and a panel. A total of 8 presentations and 4 posters were invited to participate. The detailed programme can be found in the appendix of this deliverable.

7.3 Local Arrangements and Costs

EMANICS supported the workshop through travel grants of 3000 Euros in total for EMANICS members attending the workshop.

All workshop papers have been published in IEEE Xplore.

⁵<http://www.manfi.org/2009/>

7.4 Evaluation

In summary, the workshop was very successful, it was truly interactive with a lot of discussions. Details about the presented works, topics discussed, and outcomes can be found in the report about ManFI 2009 attached in the appendix of this deliverable. This report will be published in the March 2010 issue of the Springer Journal of Network Systems Management (JNSM)⁶. More material can also be found at the workshop website <http://www.manfi.org/2009/>

⁶<http://dx.doi.org/10.1007/s10922-009-9153-1>

8 Autonomous Infrastructure, Management, and Security (AIMS 2009)

This section reports on the 3rd International Conference on Autonomous Infrastructure, Management and Security (AIMS 2009) which was held at the University of Twente, The Netherlands, on June 30 - July 2, 2009⁷. The co-chairs of the conference were Aiko Pras and Ramin Sadre from the University of Twente. A copy of this report will be submitted for publication to the Journal of Network and Service Management (JNSM).

AIMS 2009 constitutes the 3rd edition of a single-track and standalone conference on management and security aspects of distributed and autonomous systems, which has taken place initially in Oslo, Norway in June 2007, followed by AIMS 2008 in Bremen, Germany. The AIMS 2009 conference consisted of normal conference paper sessions, a short paper session, two tutorials, a discussion panel, a keynote, and a PhD workshop. The latter provides a venue for doctoral students to present and discuss their research ideas in a wider audience. In this way, students obtain feedback about their results achieved so far, as well as about their future research plans.

The theme of AIMS 2009 was “Scalability of Networks and Services”, focusing on how scalable networked systems can be monitored, managed, and protected in an efficient and autonomous way. The research papers that have been accepted for presentation have approached this theme from different perspectives, covering topics such as network resource management, overlays and peer-to-peer networks, network configuration and optimization, and monitoring and visualization. The conference proceedings have been published in the Lecture Notes in Computer Science series [1].

AIMS 2009 was organized and supported by the EC IST-EMANICS Network of Excellence (#26854) and co-sponsored by IFIP WG 6.6 and the Strategic Research Orientation of the University of Twente on Dependable Systems and Networks (DSN).

The conference was followed by a meeting of the EMANICS WP2 participants on July 3rd.

8.1 Keynote

The opening keynote was given by Joe Sventek, who is the Professor of Communication Systems in the Department of Computing Science at the University of Glasgow, Scotland. He noted that there is a substantial body of work on cross-layer design in wireless networks. Most of these efforts are with regards to the passing of physical layer information to higher layers. The typical approach is for the network layer to exploit physical layer information when determining routes between nodes. As such, the network layer autonomously modifies the paths that packets take between nodes to account for signal strength, remaining battery power, and many other physical layer metrics. One can say that the physical layer informs the higher layers. There has been surprisingly little work in which the higher layers, especially the networking layer, inform the operation of the lower layers. There is no reason to believe that cross-layers design is not a two-way street, with each layer affecting/informing the other. In his talk, Prof. Sventek discussed recent

⁷<http://www.aims-conference.org/2009/>

work in which knowledge of routes at the network layer can be used to positively affect the operation of the MAC layer in resource-constrained, wireless networks.

8.2 Technical Paper Sessions

The technical paper sessions consisted of four full paper sessions and one session for short papers. A total number of 12 full papers and three short papers were selected for presentation at the conference. Details on the paper selection process and the Technical Program Committee (TPC) can be found in the conference proceedings [1]. The full papers covered the areas of

- Network Resource Management (three papers),
- Overlays and P2P Networks (three papers),
- Network Configuration and Optimization (four papers), and
- Monitoring and Visualization (two papers).

In order to highlight the most original (full paper) contribution, an AIMS 2009 best paper award was established. A best paper award committee was formed consisting of Burkhard Stiller (University of Zurich), Joan Serrat (Universitat Politècnica de Catalunya), and Ramin Sadre (University of Twente). The award was given to Cristian Popi (INRIA) and Olivier Festor (INRIA) for their paper titled “Flow Monitoring in Wireless MESH Networks”. In this paper, the authors presented a dynamic and self-organized flow monitoring framework in Wireless Mesh Networks. An algorithmic mechanism that allows for an autonomic organization of the probes plane was investigated with the goal of monitoring all the flows in the backbone of the mesh network accurately and robustly, while minimizing the overhead introduced by the monitoring architecture. For more details, please study the full paper published in the conference proceedings.

8.3 PhD Workshop

The PhD workshop was devoted to short presentations of PhD projects. The eight presentations [1] were selected from 15 short paper submissions in which PhD students gave a description of their research problem and the chosen approach, and outlined the results achieved. After each presentation, the student had to answer challenging questions from the senior conference participants, such as on the relevance of the project topic, the validity of the chosen approach, etc. The presentations led to lively discussions and most students appreciated very much the valuable feedback they had received from the audience.

8.4 Discussion Panel

The AIMS conference included a discussion panel on the “management” of PhD students. The panel was moderated by Aiko Pras (University of Twente). During 75 minutes, the moderator and the panel members Alva Couch (Tufts University), Jürgen Schönwälder (Jacobs University Bremen), Joan Serrat (Universitat Politècnica de Catalunya), and Burkhard Stiller (University of Zurich) discussed how PhD students are supervised at their universities, including topics such as admission and defense rules, financial aspects, etc. Especially the PhD students in the audience participated in the discussions.

8.5 Tutorials

AIMS 2009 comprised two free tutorials (75 minutes each) that were embedded into the technical program. The first tutorial was given by Frank Eyermann (Universität der Bundeswehr München, Germany) on the management of highly dynamic, infrastructureless radio networks. The tutorial made the participants familiar with the used technologies. Typical scenarios were used to explain the requirements to the network management, with a focus on military scenarios since they have the most and strongest requirements, such as red-black separation (separation of unclassified/already encrypted data and classified data). Concepts and solutions addressing the mentioned requirements were presented. The tutorial was concluded with naming some of the most prominent open problems and research challenges in the area.

The second tutorial, given by Jürgen Schönwälder from the Jacobs University Bremen, provided an introduction to IEEE 802.15.4 and IPv6 over 802.15.4 (6LowPAN). The tutorial started with the technical characteristics of the IEEE 802.15.4 standard, such as the radio characteristics, frame formats, and media access control. Then, IPv6 over 802.15.4 (6LowPAN) was presented, describing the motivation behind 6LowPAN as well as technical details such as the frame formats and fragmentation. Finally, the management of 6LowPAN networks was discussed, presenting the two approaches of SNMP and HTTP-like protocols.

8.6 Program Chairs

Aiko Pras is Associate Professor in the Departments of Electrical Engineering and Computer Science at the University of Twente where he is leading the DACS group. He received a Ph.D. degree for his thesis titled “Network Management Architectures”. His research interests include network management technologies, network monitoring and measurements, network security and web services. He has contributed to research and standardization activities as a founding member of the IRTF Network Management Research Group (NMRG) and as RFC author. He is chairing the IFIP Working Group 6.6 on “Management of Networks and Distributed Systems”, is editor of ComMag, associate editor of IJNM, and Editorial Advisory Board member for JNSM. He is Steering Committee member of the IFIP/IEEE NOMS and IM Symposia (NISC), Manweek, AIMS, E2EMon, as well as the EUNICE Consortium.

Ramin Sadre is a senior researcher at the DACS group of the University of Twente, the Netherlands. He holds a Ph.D. degree for his thesis on the decomposition-based analysis of queueing networks. He is WP7 leader within the European Network of Excellence on Management Solutions for Next Generation Networks (EMANICS). His research interests include the analytical performance evaluation of communication systems, traffic modeling, and the design of self-learning intrusion detection systems.

8.7 Conclusions

The AIMS 2009 event, which was attended by roughly 40 people, has been a great success. The goal of offering a highly interactive event has been met and the structure of a mixed program that includes technical paper sessions, a PhD workshop, a keynote talk, a discussion panel and tutorials has worked very well. In particular, participants appreciated that the conference provided the opportunity for true interactivity and feedback between the audience and the speakers.

The AIMS steering committee has decided that the next AIMS conference, AIMS 2010, is going to take place at the University of Zurich, from June 21 to June 25, 2010. People who are interested in participating at AIMS 2010 can subscribe to the AIMS mailing list⁸. More details are available on the AIMS 2010 website⁹.

⁸aims-announce@ifi.uzh.ch

⁹<http://www.aims-conference.org/2010/>

9 International Summer School on Network and Service Management (ISSNSM)

The 3rd Summer School on Network and Service Management¹⁰ took place July 13-17, 2009 at University of Federal Armed Forces Munich, Germany. It was organized by Gabi Dreo Rodosek, Iris Hochstatter, and Björn Stelte from University of Federal Armed Forces Munich.

The EMANICS summer school provided advanced classes on a comprehensive suite of advanced topics in network management and security. The courses were accompanied with practical hands-on labs in order to combine the theoretical background with some operational experience. The instructors are well known members of the academic and industrial community.

9.1 Content

Courses and associated practical labs were organized by instructors who are well known experts. The courses introduced technologies, which were later further studied by the students in a series of exercises of lab experiments.

The following three topics were covered in the summer school:

- Topic #1: IT Service Management
 - ISO/IEC 2000 (Michael Brenner, Thomas Schaaf)

ISO/IEC 20000 is an international standard for IT Service Management (ITSM). First published in 2005, it is experiencing increasing attention and acceptance by IT service providers, as well as developers of ITSM tools, products and systems. For IT service providers, being able to demonstrate ITSM capabilities through an ISO/IEC 20000 certificate is fast becoming a crucial factor for winning new contracts - or renewing old ones.

This session provided an introduction to ISO/IEC 20000, at which the McKinley airport simulation accompanies theoretical aspects of the framework. It explains the purpose and structure of ISO/IEC 20000, covers all sections of the standard and outline the most important requirements specified by it. At the end of the tutorial, attendees have understood the fundamentals of ISO/IEC 20000, its role in the context of IT Service Management, and the similarities and differences between ISO/IEC 20000 and ITIL. They are now familiar with the process framework of ISO/IEC 20000, its definition of an ITSM system, and have gained insights into how these concepts can be applied in an IT service provider organization. In addition, the course serves as a preparation for later personal certification (taking the ISO/IEC 20000 Foundation level exam is possible at various testing centers worldwide).

¹⁰<http://www.aims-conference.org/issnsm-2009/>

- Topic #2: Self-Properties

- Self-Properties (Michael Zapf)

Distributed systems have become more complex in recent years, due to the increased performance and capabilities of hardware and software which allows to form new structures like peer-to-peer overlays, ad-hoc networks, or to coordinate autonomous components to reach a common goal, as known from Grid technologies or software agents. Exploiting these new possibilities, however, also shows a downside: system designers, maintainers, and users gradually lose track on the activities and interactions within the system, and it becomes increasingly difficult to build stable systems of multiple, active, heterogeneous parts which shall cooperate in a given way.

Many approaches have been researched to cope with this dilemma, making use of the concept of self-organisation. Here, the structure and behaviour of a large group of individual autonomous components is created and maintained by internal rules, removing the human user from the control loop. That way, the user is relieved from the burden of keeping the complex system running and may concentrate on the actual task. Besides self-organisation, we can identify similar concepts like self-management which targets at maintaining the functionality of a system by itself, self-optimization which entails self-observation and re-configuration, or self-healing where systems detect failures by themselves and commit repair activities. All these and similar terms may be subsumed as "self-properties".

In this course an introduction and overview on the current research on self-properties was given, featuring:

- * Concepts and examples of self-properties
- * Research and industrial initiatives
- * Emergence Engineering
- * Self-optimization in Service-oriented Architectures
- * Planning in a self-organising team of soccer robots

- Topic #3: Security

- Malware detection with Machine Learning Methods (Thomas Stibor)

This session provided an introduction into Malware detection with Machine Learning Methods. The course topics were:

- * Operating mode of viruses
- * Theoretical detection methods of antivirus scanners
- * Machine learning methods (Support Vector Machines, Bayes, Neural Networks) for malware detection

- Anonymity: Tor and I2P (Jens Kubieziel)

This session provided an introduction into the network anonymity protocols TOR and I2P. It was presented how both protocols work, where specific weaknesses are and what attacks exist. After the theoretical part we an own anonymity network was built using the Tor software.

9.2 Schedule

The overall schedule for the week is shown below. The summer school started on Monday morning and closed on Friday afternoon.

Monday:	08:30 - 09:00	Welcome and registration
	09:00 - 17:30	ISO/IEC 20000
	18:30 - ...	Barbecue Get-together
Tuesday:	09:00 - 18:00	ISO/IEC 20000
Wednesday:	09:00 - 18:00	Self-Properties
Thursday:	09:00 - 15:00	Malware detection
	15:00 - ...	Excursion to Andechs
Friday:	09:00 - 12:30	Anonymity online

9.3 Instructors

- Michael Brenner (Leibniz Supercomputing Centre)

Michael Brenner received the Diploma (M.Sc.) degree and the Ph.D. degree in Informatics from the Ludwig-Maximilians-Universität, Munich, Germany. Until 2007 he was a research associate at the Ludwig-Maximilians-Universität Munich. He is currently employed at the Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities where he chairs the working group for IT Service Management. He is a member of the MNM team and has authored or co-authored various publications on topics related to IT Service Management. Dr. Brenner is an active instructor for various IT Service frameworks (ITIL, MOF, ISO/IEC 20000) and holds several advanced certifications in this field. He is a member of the Committee for the IT Certification of Persons as per ISO/IEC 20000 which defines a new (soon to be ISO 17024 accredited) training and personal certification scheme of IT Service Management according to ISO/IEC 20000. He also co-authors, with Thomas Schaaf, the official training materials for several courses of this qualification scheme.

- Thomas Schaaf (Ludwig-Maximilians-Universität)

Thomas Schaaf received the Diploma (M.Sc.) degree in Informatics from the Ludwig-Maximilians-Universität, Munich, Germany. He is currently a research associate at LMU Munich, specializing in Service Level Management issues, and pursuing his Ph.D. degree in Informatics. He is a member of the MNM team and has authored or co-authored several publications on topics related to IT Service Management. He is an experienced instructor for IT Service Management according to ITIL and ISO/IEC 20000 and holds various related advanced certifications. Together with Michael Brenner he is responsible for the development of training materials for various courses within the training and qualification scheme for IT Service Management according to ISO/IEC 20000.

- Michael Zapf (Universität Kassel)

Michael Zapf is a postdoctoral assistant at Universität Kassel since December 2004. He earned his Ph.D. degree at the University of Frankfurt in 2001 for his research on type systems for autonomous software agents, specifically in the area of mobile agents. His current interests are model-driven concepts for software engineering in complex systems of autonomous components. Dr. Zapf holds lectures at Universität Kassel on Internet services and technologies and autonomous software agents and has published articles on self-organisation concepts for engineering complex systems, engineering of system behaviour using Genetic Programming, and application of self-properties to web services.

- Thomas Stibor (TU München)

Thomas Stibor studied computer science at the Johann Wolfgang Goethe University in Frankfurt and afterwards received his PhD from the Technical University Darmstadt in the field of artificial immune systems and IT security. During his thesis he stayed at the University of Kent at Canterbury, England, for half a year. As a post-doc, he did research at the University of California at Davis, USA. Today, he is a researcher and teaches at the Technical University Munich, chair for security in computer science.

- Jens Kubieziel

Jens Kubieziel worked in the banking business and was responsible for treasury management and currency trading as well as training internal and external clients. Since 2000 he works in the IT-sector. First he trained customers of INTERSHOP Communications AG in using and extending its e-commerce software. From 2003 he holds lectures in different areas of system administrations, data protection and security. Kubieziel has written articles for german computer magazines and is the author of the book "Anonym im Netz – Techniken der digitalen Bewegungsfreiheit".

9.4 Evaluation

The summer school was evaluated by distributing an evaluation form to the participants. A total of 9 evaluation forms were returned. Below is the summary of the numeric data collected. All grades are given on a scale of 1 to 5 (1 being excellent and 5 poor).

Question	Grade
How do you rate the overall organization?	1.1
How do you rate the social programm?	1.1
How do you rate the rooms and infrastructure provided?	1.2
Did you have enough time to interact with other people?	1.1
How do you rate the selection of the topics?	2.3
How do you rate the selection of presenters?	2.0

Overall, most attendees were very happy. We asked who would attend a third incarnation of the summer school and 7/9 (78%) indicated they would attend ISSNSM in 2010. We

also asked free form questions concerning topics participants are specifically interested in, concerning things that can be improved in a future event, and we were asking which aspects of the summer school participants liked and which they disliked.

9.5 Conclusion

The summer school was attended by 23 persons and turned out again to be a highly interactive and successful event. The evaluation of the summer school was again very positive.

10 EMANICS Workshop on Network Security

The 1st EMANICS Workshop on Network Security¹¹ took place October 7, 2009 at Jacobs University Bremen, Germany. The co-chairs of the workshop were Jürgen Schönwälder from Jacobs University Bremen and Olivier Festor from INRIA.

10.1 Workshop Scope

As the Internet has grown from an academic network into a major utility, providing proper Internet security remains one of the major challenges. While cryptographic mechanisms are generally well understood, it often remains challenging to deploy and utilize them properly, taking into account operational constraints and the behaviour of humans. This workshop provides a forum for researchers and network operators to exchange new ideas to secure networks and novel techniques to analyze security properties and security incidents in operational networks.

The workshop is open to the public but the number of participants and presentation slots is limited. The workshop will have several sessions, each one consisting of around three short presentations followed by a discussion round.

10.2 Programme

We wanted the workshop to be an opportunity for people to exchange and discuss their experiences and ideas. To structure the discussions, the workshop was organized into several discussion topics. For each discussion topic, there were presentations introducing and highlighting different aspects of the topic, followed by a discussion round.

The detailed programme of the one-day workshop is shown below:

09:00 Welcome / Opening

09:30 Measuring Potentially Sensitive Statistical Data in the Tor Anonymity Network (Karsten Loesing, The Tor Project)

10:30 Coffee Break

10:45 Attacking Tor Users (Radu State, University of Luxembourg)

11:15 Automated Behavioral Fingerprinting (Jerome Francois, INRIA Nancy)

11:45 Discussion

12:00 Lunch Break

13:00 Playing with Honeypots (Gerard Wagener, University of Luxembourg)

¹¹http://emanics.org/component/option,com_openwiki/Itemid,144/id,security_workshop2009/

- 13:30 Detecting SPAM / PHISHING Using Flow Data (Anna Sperotto, Aiko Pras, University of Twente)
- 14:00 Discussion “Privacy in the Future Internet”
- 15:00 Leaving for an Excursion (Social Event)
- 19:30 Return from the Excursion (Social Event)

For the discussion round, a questionnaire was distributed in the morning. The condensed answers were then presented in the afternoon to steer the discussion. The excursion to the Climate House in Bremerhaven took the attendees of this workshop and the co-located NetFlow/IPFIX workshop on a trip around the globe following the 8th degree of longitude.

10.3 Local Arrangements and Costs

The organizational and hosting costs of the workshop were of 3000 Euros for EMANICS. The workshop was open to non-EMANICS members and registration was free. Additionally, EMANICS supported 16 members of EMANICS with a travel grant of 700 Euros each for attending the workshop.

Presentation slides and workshop materials has been made freely available to the public on the seminar web site.

10.4 Evaluation

In total 23 participants attended the workshop. The cozy atmosphere of the meeting room inspired many discussions and made the workshop a success. With 23 attendees from industry and academia, including leading personalities in their field of specialization as well as PhD students, the workshop did lead to many fruitful interchanges of ideas and also to some critical questions on how to position research efforts or discussions on the potential impact of new research directions.

11 2nd EMANICS Workshop on NetFlow/IPFIX Usage

The 2nd EMANICS Workshop on Netflow/IPFIX Usage¹² took place October 8, 2009 at Jacobs University Bremen, Germany. The co-chairs of the workshop were Ramin Sadre and Aiko Pras from University of Twente. The local organizer was Jürgen Schönwälder from the Jacobs University Bremen.

A detailed report on the workshop will be submitted to the Journal of Network and Systems Management (JNSM). A copy of that report, including a summary of the presentations, can be found in the appendix of this document.

11.1 Motivation and Workshop Scope

NetFlow is a protocol developed by Cisco Systems to monitor Internet traffic that flows in network elements [2]. A flow is a unidirectional stream of packets that pass through a network element, sharing a common set of attributes [3, 4]. In early versions of NetFlow, a flow was defined by a fixed set of seven fields: source and destination IP addresses, source and destination port numbers, protocol type, type of service and logical interface (ifIndex). Since NetFlow version 9, the definition of a flow is flexible and created via templates. IPFIX (IP Flow Information Export) is an effort of IETF (Internet Engineering Task Force) to create standard protocols to collect and export IP flows. IPFIX is under discussion in IETF since 2001, and in 2004 NetFlow version 9 was chosen to be the basis for the IPFIX specification [5]. Several improvements on NetFlow version 9 have already been added to IPFIX, including, for example, enterprise-defined fields [6] and bidirectional flow exporting functions [7].

For the second consecutive year, the European EMANICS Network of Excellence ran an one-day workshop about the usage of NetFlow/IPFIX in network management, aiming to provide a place where researchers and operators can discuss the latest development and exchange practical experiences. The first workshop edition [8] intended to discuss technologies to capture and analyze flow data, effects of sampling and aggregation techniques on the accuracy of analyzes, and applications that NetFlow/IPFIX can be used for. This second edition was divided into three sessions, addressing the following questions:

- What is the current stage of IPFIX standardisation and what are the challenges for adopting the protocol?
- What are the new applications of NetFlow/IPFIX?
- How is NetFlow/IPFIX used in practice?

11.2 Programme

The workshop was an opportunity for people to exchange and discuss their experiences and ideas. To structure the discussions the workshop was organized into several discus-

¹²http://emanics.org/component/option,com_openwiki/Itemid,144/id,netflow_workshop2009/

sion topics. For each discussion topic, there were short presentations (10-15 minutes) highlighting different aspects of the topic, followed by discussions.

The detailed programme of the one-day workshop is shown below:

09:00 Registration

09:30 Welcome

09:45 Topic: NetFlow/IPFIX in Practice

- Bandwidth Behavior of Large Flows (Ramin Sadre, UT)

10:15 Coffee Break

10:30 Topic: IPFIX Standardisation and Open Issues

- Latest Developments in IPFIX (Benoit Claise, Cisco Systems)
- IPFIX - Current Trends and Approaches for Secured Data Transmission (Carsten Schmoll, Fraunhofer FOKUS)
- SCRIPT: A Framework for Scalable Real-time IP Flow Record Analysis (Cristian Morariu, UZH)

12:00 Lunch Break

13:30 Topic: New Applications for IPFIX

- User Identification Through Network Flow Pattern Analysis (Nikolay Melnikov, JUB)
- Passively Detecting Remote Connectivity Issues Using Flow Accounting (Tim Kleefass, SWITCH)
- Extracting Performance Metrics from NetFlow in Enterprise Networks (Jochen Kgel, Universität Stuttgart/IKR)

15:00 Coffee Break

15:30 Topic: NetFlow/IPFIX in Practice

- Practical Experiences (Andreas Bourges, IsarNet)
- The SURFmap plug-in for NfSen (Rick Hofstede, UT)

16:30 End of Workshop

11.3 Local Arrangements and Costs

The organizational and hosting costs of the workshop were of 3000 Euros for EMANICS. The workshop was open to non-EMANICS members and registration was free. Presentation slides and workshop materials has been made freely available to the public on the seminar web site.

11.4 Evaluation

Like the first edition, the *2nd EMANICS Workshop on NetFlow/IPFIX Usage* was a success. Although the number of participants (27 in total) was lower than in the previous year, we were again able to attract many leading personalities in the field. All presentations generated high interactive discussions, resulting in valuable feedback for senior researchers and PhD students. A third edition of the workshop will be organized in 2010, probably in conjunction with the *IETF 78 Meeting*, which will take place on July 25-30, in Maastricht, The Netherlands. More information about the workshop, including slides and contact information of all presenters, can be found on the EMANICS website [8].

12 EMANICS/SmoothIT Workshop on Economic Traffic Management

The 2nd EMANICS/SmoothIT Workshop on Economic Traffic Management¹³ took place November 9-10, 2009 at University of Zurich, Switzerland in conjunction with the 4th GI/ITG KuVS Workshop on the Future Internet. The organizer of both workshops was Burkhard Stiller from University of Zurich.

12.1 Objectives

The topics “Future Internet” and “Economic Traffic Management” have seen a wide attention of networkers and economists. Triggered by FIND/GENI activities of the NSF both the EU in the 7th Framework as well as the German BMBF in its IT strategy for 2020 have addressed this topic. Although many discussions took place in such a research environment, the application of new ideas into test-beds and possibly industry shows an emerging demand today. These two combined workshops and their topics do cover the areas of technology, infrastructure, economic theory, and operations. Furthermore, methodological and architectural topics range from the incremental improvement of today’s Internet to a complete new start (clean slate approach).

The two main goals of the 4th GI/ITG Kommunikation und Verteilte Systeme (KuVS) Workshop on Future Internet and the 2nd Workshop on Economic Traffic Management (supported by the FP7 STREP SmoothIT and the FP6 NoE EMANICS) are to give scientists, researchers, and operators the opportunity to present and discuss their ideas in these areas as well as strengthening the cooperation in the field of an economic-technology interplay.

12.2 Program

Thus, after a reception of 27 extended abstracts (2 pages each), with 2-4 reviews per presentation a selection of 11 full presentations had been done. Due to the interest in diverging reviews for a number of further extended abstracts, 5 statement presentations had been selected, too. These presentations have been complemented additionally by 5 invited presentations, which originally included 1 presentation from the European Commission and 4 industrial presentations, from which finally Swisscom, Switzerland, Deutsche Telekom, Germany, and INTRACOM TELECOM, Greece did present.

The result of these presentations has been organized in 7 sessions, addressing a selected set of highly emerging aspects in Future Internet technologies, economics, and operations.

In more detail with respect to the invited presentations, Paulo de Sousa did present the story of the upcoming explosion of hyper-connected objects or “network of things”, which may yet test the Internet’s resilience and stability. In that respect he did face challenges seen by the Internet today, which are of technical, economic, political and social nature.

¹³<http://www.csg.uzh.ch/events/fi-etm>

The efforts of the European research approach are part of the 7th Framework Programme, and the next steps include a public-private partnership (PPP) on the Future Internet, which shall lead to a “network of objects and subjects”.

Furthermore, Stefan Burschka addressed trouble shooting in IP networks with traffic mining approaches. Based on traffic mining examples the need for effective tools and approaches has been visualized and results of such schemes have been discussed. Encryption guessing, social behavior, and feature evaluation over time have been touched as tasks for identifying unexpected traffic and its patterns.

Additionally, Gerhard Hasslinger did describe techniques for the distribution of popular content over the Internet via server-based and peer-to-peer overlays and outlines their impacts on traffic profiles. Current trends show a good basis for network wide traffic engineering including load balancing. Improvements are expected by shortening end-to-end paths and delays with a welcome side effect of reduced load on core interconnection links. In general, P2P file sharing contributes a relevant but no longer dominant traffic profile. As measured, the mean traffic volume per subscriber did not follow the growth in access speed.

Finally, Spiros Spirou did present a clear distinction of P2P caching techniques, covering internal (transparent and opaque) and external schemes. Based on the description of its operations and protocol needs, a comparison in terms of technical criteria has been done. The role of stakeholders complemented the view on caching demands. A concluding discussion motivated the need for different alternatives as well as the business and technology-driven demand for Content Distribution Networks, too.

Please refer to the appendix for the detailed program.

12.3 Local Arrangements and Costs

The organizational and hosting costs of the workshop were of 3000 Euros for EMANICS. The workshop was open to non-EMANICS members and the registration fee was 50 Euros. Additionally, EMANICS supported 3 members of EMANICS with a travel grant of 700 Euros each for attending the workshop.

12.4 Summary

The set of in total 19 presentations given, was successfully received by a registered audience of 36 participants, which included 13 each from Germany and Switzerland, 2 each from Greece, The Netherlands, and the U.K., and 1 each from Belgium, France, Korea, and Poland.

Good discussions raised in many areas and continued in coffee and lunch breaks. Topics discussed originated from the presentations given, and new application ideas, technology demands, and business views have been bashed and supported.

The program and available material can be accessed at the workshop web site.

13 Dissemination Management

EMANICS did support a number of 170 attendances to major conferences worldwide through travel grants of 700 Euros each in 2009.

In addition, EMANICS did support IEEE IM 2009, the International Symposium on Integrated Network Management which took place at Hofstra University, Long Island, NY, USA from June 1-5, 2009, through the sponsorship of 3 student travel grants, and IFIP/IEEE Manweek 2009, the 4th International Week on Management of Networks and Services which took place in Venice, Italy from October 26-30, 2009, with 2 student travel grants for EMANICS members:

Author	Affiliation	Conference	Title
Tiago Fioreze	UT	IM 2009	Self-Management of Hybrid Networks: Can We Trust NetFlow Data?
Iris Hochstatter	UniBwM	IM 2009	IM ManFI Workshop – Technical Program Committee
Peter Racz	UniZH	IM 2009	STACO An Accounting Configuration Architecture for Multi-Service Mobile Networks
Giovane Moura	UT	MANWEEK 2009	Optical Switching Impact on TCP Throughput Limited by TCP Buffers
Iris Hochstatter	UniBwM	MANWEEK 2009	

Moreover, EMANICS did financially support the building of the following tutorials:

Author	Affiliation	Title
Gabi Dreo	UniBwM	Introduction to Network Management
Helmut Reiser	LMU	ISO/IEC 20000 International Standard for IT Management
Juergen Schoenwaelder	JUB	NETCONF and YANG: Status, Tutorial, Demo
Juergen Schoenwaelder	JUB	Introduction to IEEE 802.15.4 and IPv6 over 802.15.4 (6LowPAN)
Frank Eyermann	UniBwM	Management of highly dynamic, infrastructureless radio networks

Finally, as outlined in the following tables, EMANICS did support with an amount of 6000 Euros the involvement of EMANICS members in leading activities in the area of network and service management.

Emanics member	Role	Journal / Event / Organization	Date
Jürgen Schönwälder	Editorial Board	IEEE TNSM	2009
Jürgen Schönwälder	Editorial Board	Springer JNSM	2009
Jürgen Schönwälder	Editorial Board	Wiley IJNM	2009
Jürgen Schönwälder	Chair	IRTF NMRG	2009
Jürgen Schönwälder	Chair	IETF ISMS	2009
Jürgen Schönwälder	Member	IETF Security Directorate	2009
Jürgen Schönwälder	WG Editor	IETF OPSAWG	2009
Jürgen Schönwälder	WG Editor	IETF NETMOD	2009
Jürgen Schönwälder	Steering Committee	AIMS	2009
Jürgen Schönwälder	Co-Chair	EMANICS Security Workshop	October 2009
Jürgen Schönwälder	Co-Chair	Dagstuhl Traffic Visualization Seminar	May 2009
Jürgen Schönwälder	Local Organizer	EMANICS NetFlow/IPFIX Workshop	October 2009
Jürgen Schönwälder	Co-Chair	Smart Grid Workshop 2010	2009
Jürgen Schönwälder	PC Member	DSOM 2009	2009
Jürgen Schönwälder	PC Member	AIMS 2009	2009
Jürgen Schönwälder	PC Member	ICCC CSWS 2009	2009
Jürgen Schönwälder	PC Member	ManFi 2009	2009
Jürgen Schönwälder	PC Member	NOMS 2010	2009
Gabi Dreo Rodosek	Editorial Board	Wiley IJNM	2009
Gabi Dreo Rodosek	Co-Chair	2nd DFN Forum Communication Technologies	May 2009
Gabi Dreo Rodosek	PC Member	IM 2009	June 2009
Gabi Dreo Rodosek	Co-Chair	ManFI 2009	June 2009
Gabi Dreo Rodosek	PC Member	AIMS 2009	July 2009
Gabi Dreo Rodosek	Co-organizer	ISSNSM 2009	July 2009
Gabi Dreo Rodosek	PC Member	Chinacom 2009	August 2009
Gabi Dreo Rodosek	PC Member	APNOMS 2009	September 2009
Gabi Dreo Rodosek	PC Member	DSOM 2009	October 2009
Gabi Dreo Rodosek	PC Member	MILCOM 2009	October 2009
Gabi Dreo Rodosek	PC Member	WCNC 2010	April 2010
Gabi Dreo Rodosek	PC Member	NOMS 2010	April 2010
Gabi Dreo Rodosek	Co-Chair	ManFI 2010	April 2010
Gabi Dreo Rodosek	Co-Chair	3rd DFN Forum Communication Technologies	May 2010
Gabi Dreo Rodosek	PC Member	Chinacom 2010	August 2010
Iris Hochstatter	PC Member	ManFI 2009	June 2009
Iris Hochstatter	Co-organizer	ISSNSM 2009	July 2009
Iris Hochstatter	PC Member	Chinacom 2009	August 2009
Iris Hochstatter	PC Member	WCNC 2010	April 2010
Iris Hochstatter	PC Member	ManFI 2010	April 2010
Iris Hochstatter	PC Member	Chinacom 2010	August 2010
Björn Stelte	Co-organizer	ISSNSM 2009	July 2009

Emanics member	Role	Journal / Event / Organization	Date
Joan Serrat	PC Member	IWCMC 2009	January 2009
Joan Serrat	PC Member	MUCS 2009	March 2009
Joan Serrat	PC Member	ChinaCom 2009	March 2009
Joan Serrat	PC Member	ISPA 09	April 2009
Joan Serrat	PC Member	IM 2009	April 2009
Joan Serrat	Key Note Speaker	ICNS 2009	April 2009
Joan Serrat	PC Member	ManFI 2009	March 2009
Joan Serrat	Panelist	FIA Prague	May 2009
Joan Serrat	Panelist	ManFI 2009	June 2009
Joan Serrat	Local Organizer	ICAC 2009	June 2009
Joan Serrat	PC Member	MACE 2009	June 2009
Joan Serrat	PC Member	AIMS 2009	July 2009
Joan Serrat	Panelist	AIMS 2009	July 2009
Joan Serrat	PC Member	DSOM 2009	October 2009
Joan Serrat	PC Member	LANOMS 2009	October 2009
Joan Serrat	PC Member	NGNM 2009	October 2009
Heinz-Gerd Hegering	Editor, Advisory Board	JNSM	2009
Heinz-Gerd Hegering	Editorial Board	IEEE NSM	2009
Heinz-Gerd Hegering	PC Member	IM 2009	June 2009
Heinz-Gerd Hegering	PC Member	AIMS	June/July 2009
Heinz-Gerd Hegering	PC Member	DMTF SVM	September 2009
Heinz-Gerd Hegering	PC Member	DSOM	October 2009
Heinz-Gerd Hegering	General Co-Chair	HPDC 2009	June 2009
Dieter Kranzlmler	Conference Chair	HPDC 2009	June 2009
Dieter Kranzlmler	Strategic Director	EGI_DS	2009
Dieter Kranzlmler	Area Director for Applications	OGF	2009
Helmut Reiser	PC Member	DFN-Forum	May 2009
Helmut Reiser	PC Member	AIMS	June/July 2009
Helmut Reiser	PC Member	ADVCOMP	October 2009
Helmut Reiser	PC Member	ETM Workshop	November 2009
Michael Schiffers	Local Chair and PC Member	HPDC 2009	June 2009
Michael Schiffers	PC Member	Upgrade-CN	June 2009
Thomas Schaaf	TPC member	BDIM 2009	June 2009
Michael Brenner	TPC member	BDIM 2009	June 2009
Vitalian Danciu	PC Member	DMTF SVM	June 2009
Mark Burgess	Editorial Board	Science of Computer Programming	2009
Mark Burgess	Associate Editor	Journal of the Computer Society of India	2009
Mark Burgess	Editorial Advisory Board	International Journal of Network Management	2009
Mark Burgess	Steering Committee	AIMS	2009
Mark Burgess	Steering Committee	USENIX/LISA	2009

Emanics member	Role	Journal / Event / Organization	Date
Emil Lupu	Tutorial and Keynotes Chair	AIMS 2009	July 2009
Emil Lupu	PC Member	AIMS 2009	July 2009
Emil Lupu	PC Member	IM 2009	June 2009
Emil Lupu	PC Member	DSOM 2009	October 2009
Morris Sloman	PC Member	IM 2009	June 2009
Morris Sloman	Steering Committee Member	IM 2009	June 2009
Morris Sloman	PC Member	DSOM 2009	October 2009
Aiko Pras	WG Chair	IFIP WG 6.6	2009
Aiko Pras	Series Editor	IEEE ComMag NSM	2009
Aiko Pras	Associate Editor	Kluwer IJNM	2009
Aiko Pras	Editorial Advisory Board	Springer JNSM	2009
Aiko Pras	Editorial Board	Wiley IJNM	2009
Aiko Pras	Editorial Board	IEEE Comm. Surveys	2009
Aiko Pras	Editorial Board	Springer JISA	2009
Aiko Pras	Steering Committee	IFIP/IEEE NOMS and IM	2009
Aiko Pras	Steering Committee	IFIP/IEEE ManWeek	2009
Aiko Pras	Steering Committee	IFIP/ACM AIMS	2009
Aiko Pras	Steering Committee	E2EMon Workshop	2009
Aiko Pras	Steering Committee	EUNICE	2009
Aiko Pras	PC Co-chair	Manweek 2009	October 2009
Aiko Pras	Co-organizer	EMANICS Netflow Workshop	October 2009
Aiko Pras	PC Co-chair	AIMS 2009	June 2009
Aiko Pras	Diss. Digest Co-chair	IM 2009	June 2009
Aiko Pras	TPC Co-chair	TMA 2009	May 2009
Aiko Pras	Co-organizer	Dagstuhl VisMon Seminar	May 2009
Aiko Pras	Co-organizer	Dagstuhl FI Management Seminar	January 2009
Aiko Pras	Organizing committee	NOMS 2010	April 2010
Aiko Pras	Organizing committee	IM 2009	June 2009
Aiko Pras	PC member	FI-ETM Workshop	November 2009
Aiko Pras	PC member	DSOM 2009	October 2009
Aiko Pras	PC member	MMNS 2009	October 2009
Aiko Pras	PC member	APNOMS 2009	September 2009
Aiko Pras	PC member	AIMS 2009	July 2009
Aiko Pras	PC member	ManFI 2009	June 2009
Aiko Pras	PC member	IM 2009	June 2009
Aiko Pras	PC member	IEEE ICC NGN	June 2009
Aiko Pras	PC member	EU FI Conference	May 2009
Aiko Pras	PC member	TMA 2009	May 2009
Ramin Sadre	Co-Chair	NetFlow Workshop	October 2009
Ramin Sadre	Program Co-Chair	AIMS 2009	June/July 2009
Ramin Sadre	TPC Member	ICIW 2009	May 2009
Ramin Sadre	TPC Member	W3-Workshop	November 2009

Emanics member	Role	Journal / Event / Organization	Date
Burkhard Stiller	Co-organizer	Dagstuhl FI Management Seminar	January 2009
Burkhard Stiller	Co-organizer	Dagstuhl BoD Seminar	February 2009
Burkhard Stiller	Editorial Board	Wiley IJNM	2009
Burkhard Stiller	Editorial Board	Springer JNMS	2009
Burkhard Stiller	Editorial Board	Netnomics	2009
Burkhard Stiller	Chair	TCCC	2009
Burkhard Stiller	Chair	Econ@Tel COST Action	2009
Burkhard Stiller	TPC Co-chair	ICQT 2009	May 2009
Burkhard Stiller	PC Member	IM 2009	May 2009
Burkhard Stiller	PC Member	Networking 2009	May 2009
Burkhard Stiller	PC Member	ICC 2009 CSS	June 2009
Burkhard Stiller	PC Member	ICC 2009 AHSNET	June 2009
Burkhard Stiller	PC Member	IWQoS 09	July 2009
Burkhard Stiller	PC Member	NGI 09	July 2009
Burkhard Stiller	PC Member	ManFI 2009	June 2009
Burkhard Stiller	PC Member	ChinaCom 2009 AIS	August 2009
Burkhard Stiller	PC Member	AIMS 2009	June 2009
Burkhard Stiller	PC Member	NEW2AN 2009	September 2009
Burkhard Stiller	PC Member	IEEE LCN 2009	October 2009
Burkhard Stiller	PC Member	Eunice Workshop	September 2009
Burkhard Stiller	PC Member	SSS P2P	November 2009
Burkhard Stiller	PC Member	SASO	September 2009
Burkhard Stiller	PC Member	SPIRIT 2009	October 2009
Burkhard Stiller	PC Member	MMNS 2009	October 2009
Burkhard Stiller	PC Member	KuVS FI Workshop	May 2009
Burkhard Stiller	PC Member	GridEcon Workshop	August 2009
Burkhard Stiller	PC Member	DSOM 2009	October 2009
Burkhard Stiller	PC Member	IWSOS 2009	December 2009
David Hausheer	PC Chair	Dagstuhl BoD Seminar	February 2009
David Hausheer	PhD Workshop Chair	AIMS 2009	June 2009
David Hausheer	PC Member	ManFI 2009	June 2009
David Hausheer	PC Member	IEEE WETICE COPS 09	June 2009
David Hausheer	PC Member	FMN 2009	June 2009
David Hausheer	PC Member	FI Conference	May 2009
David Hausheer	PC Member	AIMS 2009	June 2009
David Hausheer	PC Member	P2P 2009	September 2009
David Hausheer	PC Chair	EMANICS P2P Workshop	April 2009
David Hausheer	PC Member	FI-ETM Workshop	November 2009

14 Conclusions and Future Events

In this report we have presented the conference, summer school, and workshop organizations and scientific dissemination activities performed in the network since January 2009. All organized events so far have been very successful.

During the reporting period the network was also very active in scientific dissemination management through the support of major events and activities worldwide and the support of 5 new tutorials.

Finally, major progress has been made regarding the long-term establishment of AIMS and ISSNSM. In order to exploit the synergies between the two events, the AIMS steering committee has decided to collocate the summer school with AIMS 2010. Both events will be hosted by UniZH and will take place from June 21 to June 25. The general chair of AIMS 2010 will be Burkhard Stiller from UniZH. The organizer of ISSNSM 2010 still has to be determined. An amount of 6000 EUR for the long-term establishment of AIMS and ISSNSM has been allocated to UniZH.

15 Acknowledgement

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A Appendices

Attached to this deliverable are the following documents:

- Detailed agenda of the ManFI workshop
- Report on the First IFIP/IEEE International Workshop on Management of the Future Internet (ManFI 2009) to be published in the JNSM December 2009 issue
- Detailed agenda of the FI-ETM workshop
- Report on the 2nd EMANICS Workshop on Netflow/IPFIX Usage (to be submitted to JNSM)



in conjunction with the 11th IFIP/IEEE International Symposium on Integrated Network Management (IM2009)

June 5, 2009 at Hofstra University, Long Island, NY, USA

<http://www.manfi.org>

- 08:45 - 09:00 Welcome Address
- 09:00 - 09:45 Keynote 1
 The State of the Art in Network Management for the Future Internet
John Strassner (Waterford Institute of Technology, Ireland)
- 09:45 - 10:30 Keynote 2
 In-Network Management: A new Paradigm for Managing the Future Internet
Marcus Brunner (NEC Laboratories Europe, Germany)
- 10:30 - 11:00 Coffee Break and Poster Session
- 11:00 - 12:40 Paper session 1
 Future Internet: Management Challenges and Paradigms
Chair: Iris Hochstatter (Universität der Bundeswehr München, Germany)
- Towards Management of the Future Internet
Sung-Su Kim (POSTECH, Korea), Young J. Won (POSTECH, Korea), Mi-Jung Choi (Kangwon National University, Korea), James Won-Ki Hong (POSTECH), Korea, John Strassner (Waterford Institute of Technology, Ireland)
- Challenges for Federated, Autonomic Network Management in the Future Internet
Brendan Jennings (Waterford Institute of Technology, Ireland), Rob Brennan (Trinity College Dublin, Ireland), William Donnelly (Waterford Institute of Technology, Ireland), Simon N. Foley (University College Cork, Ireland), Dave Lewis (Trinity College Dublin, Ireland), Declan O'Sullivan (Trinity College Dublin, Ireland), John Strassner (Waterford Institute of Technology, Ireland), Sven van der Meer (Waterford Institute of Technology, Ireland)
- A Viewpoint of the Network Management Paradigm for Future Internet Networks
Javier Rubio-Loyola, Joan Serrat, Antonio Astorga (Universitat Politècnica de Catalunya, Spain), Andreas Fischer, Andreas Berl, Hermann de Meer (University of Passau, Germany), Giannis Koumoutsos (University of Patras, Greece)
- Service-Oriented Testbed Infrastructures and Cross-Domain Federation for Future Internet Research
Thomas Magedanz, Florian Schreiner, Sebastian Wahle (Fraunhofer Institute for Open Communication Systems (FOKUS), Germany)



- 12:40 - 14:00 Lunch
- 14:00 - 15:40 Paper session 2
- Future Internet: Selected Management Aspects
Chair: Joan Serrat, (Universitat Politècnica de Catalunya, Spain)
- Understanding IPv4 Prefix De-aggregation: Challenges for Routing Scalability
Roque Gagliano (Latin America and Caribbean Regional Registry (LACNIC), Uruguay), Eduardo Grampin, Javier Baliosian (University of the Republic of Uruguay (UdelaR), Uruguay), Xavier Masip-Bruin, Marcelo Yannuzzi (Technical University of Catalonia (UPC), Spain)
- Troubleminer: Mining network trouble tickets
Amélie Medem, Marc-Ismael Akodjenou, Renata Teixeira (LIP6 Laboratory, France)
- A Formal Approach for the Inference Plane Supporting Integrated Management Tasks in the Future Internet
Martín Serrano, John Strassner, Mícheál Ó Foghlú (Waterford Institute of Technology, Ireland)
- Dynamic QoE Optimisation for Streaming Content in Large-Scale Future Networks
Jeroen Famaey, Bart De Vleeschauwer, Tim Wauters, Filip De Turck, Bart Dhoedt, Piet Demeester (Ghent University, Belgium)
- 15:40 - 16:00 Coffee Break and Poster Session
- 16:00 - 17:50 Panel session
- Why is Managing the Future Internet Being Ignored?
Chair: James Won-Ki Hong (POSTECH, Korea)
- Panelists:
- Joan Serrat (Universitat Politècnica de Catalunya, Spain)
 - Lisandro Zambenedetti Granville (UFRGS, Brazil)
 - Marcus Brunner (NEC Europe Ltd., Germany)
 - Spiros Spirou (Intracom Telecom, Greece)
 - Yoshiaki Kiriha (NiCT, Japan)
- 17:50 - 18:00 Closing Session

Posters

- The Internet tipping point: driving the transition to a new architecture?
Ewan Sutherland (University of Namur, Belgium)
- Automated Network Services Configuration Management
Miguel Lopes, Antonio Costa, Bruno Dias (University of Minho, Portugal)
- Economic Traffic Management
Spiros Spirou (Intracom Telecom, Greece), Burkhard Stiller (University of Zurich and ETH Zurich, Switzerland)
- The Role of AI Planning in the Management of Future Internet
Feng Liu (Ludwig-Maximilians-University of Munich, Germany)

Is the Management of the Future Internet Ignored? – A Report on ManFI 2009

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²Division of IT Convergence Engineering, Pohang University of Science and Technology (POSTECH), Pohang, Korea

Abstract This report summarizes the presentations and discussions at the 1st IFIP/IEEE International Workshop on Management of the Future Internet (ManFI 2009). This report provides a broad, high-level view of key requirements, challenges, strategies and R&D results associated with the current state-of-the-field in Future Internet management.

Keywords Future Internet, Network Management, Architectures, Automation

1 Introduction

Acting on the rising popularity of Future Internet (FI) research, the first IFIP/IEEE International Workshop on Management of the Future Internet (ManFI 2009) was intended as a forum to bundle those FI activities and provide up-to-date results that focus on the management aspects of the FI. The workshop took place on June 5, 2009, at Hofstra University, Long Island, NY, USA, in conjunction with the 11th IFIP/IEEE International Symposium on Integrated Network Management (IM 2009). ManFI 2009 was organized by POSTECH Korea and the Universität der Bundeswehr München, and co-sponsored by the IST Network of Excellence for the Management of Internet Technologies and Complex Services (EMANICS), which is sponsored by the European Commission.

Recently, researchers in the networking area around the world have been investigating ways to solve the major problems that exist in the current Internet. This design activity is referred to the “Future Internet”, which has become a very hot topic, especially in the US, Europe, Japan and Korea. Network management is a very important area; however, it was not one of the original design goals of the current Internet. Rather, it emerged as a “necessary means” to enable functionality provided by the Internet to grow. As a result, managing the current Internet is still very cumbersome and difficult. The purpose of this workshop is to encourage researchers to include manageability at the *beginning* of architecting the Future Internet.

The ManFI 2009 program featured two keynote addresses and presentation of eight full and four short papers. It concluded with a panel session. All submitted papers were reviewed by at least three members of the technical program committee.

2 Keynote addresses

John Strassner (Chairman of the Autonomic Communications Forum, director of autonomic research at the Telecommunications Software and Systems Group, and Professor at POSTECH) delivered the first keynote on the state of the art in network management for the Future Internet. He discussed shortcomings of the current Internet and its management problems and then compared the three approaches to the Future Internet: incremental,

evolutionary, and revolutionary. Within those categories, he gave an extensive overview of current initiatives and projects from Europe, the US and Asia. These included the GENI [1] and FIND [2] programs of the US; the Situated Autonomic Computing [3], 4WARD [4], Autonomic Internet (AutoI)[5]; and Internets of the Future [6] of Europe; and the Future Internet Forum [7] of Asia. John pointed out that new network architectures are designed following an information-centric approach, which leads to new key management requirements, such as security and trustworthiness in a distributed environment and the need to involve management functionality at modeling and design phases. Key problems include the lack of a scalable knowledge representation that can be used to unite management data from heterogeneous devices and technologies, the lack of support for translating needs to different constituencies, and a brief look into how Future Internet architectures could be designed to overcome these problems.

Marcus Brunner (Network Laboratories, NEC Europe Ltd.) dedicated his keynote to the European Future Internet research perspectives and more specifically to the in-network management approach of the 4WARD project. He pointed out that today's approach to Internet management as an add-on does not work well for self-management, and is thus not sufficient for future management needs. Self-management functions need to be designed as an integral part of new network components, and the in-network management approach will enable self-management to be implemented with reduced integration costs and shortened service deployment cycles.

3 Technical Paper Sessions

Out of all submissions, we chose eight contributions for presentation as full technical papers. In the morning paper session, four papers dealing with Future Internet management challenges and paradigms were presented. The afternoon session featured four papers dealing with selected management aspects of the Future Internet. In addition, four short papers were chosen for poster-style presentations.

Accepted papers represented the latest results in research and development in the management of the Future Internet, and covered topics including architectural aspects of the management of the Future Internet, shortcomings of current management of the Internet, surveys of Future Internet research activities and how they approach management, automation of management functionality, and more. In the following, we provide a brief overview of the contributions of each paper and the discussions that evolved:

- Sung-Su Kim (POSTECH, Korea) presented “Towards Management of the Future Internet”. He summarized representative programs from Europe (4Ward, AutoI, and ANA [7]) and the US (CONMan [8] and DMNGI [9]), and discussed their common design requirements such as architecture, protocol, market aspects, and automation of management functionality. He also pointed out that none of these projects addressed new management techniques or ways of representing management data, and pointed out why these were needed for the FI.
- Brendan Jennings (Waterford Institute of Technology, Ireland) presented “Challenges for Federated, Autonomic Network Management in the Future Internet”. This paper described the Federated Autonomic Management of End-to-end systems (FAME) project, and pointed out that new management systems will need to support federation of behavior. Difficulties in achieving this vision include negotiation and delegation of governance, common knowledge, end-to-end service level monitoring, translating business requirements to network implementation, and coordination of service-aware distributed management.

- Javier Rubio-Loyola (Universitat Politècnica de Catalunya, Spain) presented “A Viewpoint of the Network Management Paradigm for Future Internet Networks”. He described the autonomies management approach taken by the European AutoI project, and focused on the context-awareness to trigger autonomic behavior to adapt the system to changes in the environment. Functional layers are used to simplify the management of networks. He used a ubiquitous multimedia streaming service as a use for illustrating these principles.
- Thomas Magedanz (Fraunhofer Institute for Open Communication Systems, Germany) et al. discussed “Service-Oriented Testbed Infrastructures and Cross-Domain Federation for Future Internet Research”. They suggested an approach called the Network Domain Federation (NDF) that discusses the architecture of the federated testbed of the PanLab II European project. Different combinations of services and resources are provided by federating different testbeds using an innovative object-oriented approach. The architecture has been implemented using standard protocols like SPML, HTTP, and SIP.
- Marcelo Yannuzzi presented “Understanding IPv4 Prefix De-aggregation: Challenges for Routing Scalability”. A characterization of the IP prefix de-aggregation factor has been analyzed, and the management requirements were shown as applied to the LISP testbed. LISP is a solution for routing table size problems, and their overlay-based approach can satisfy the proposals for LISP. Finally, they will use the results from this study to understand how to better migrate existing IPv4 networks to IPv6.
- Amélie Medem (LIP6 Laboratory, France) presented “Troubleminer: Mining Network Trouble Tickets”. Text processing techniques are used to mine the textual description of trouble tickets automatically, which generates vectors of keywords. Based on those vectors, an n-ary tree is constructed for classifying the trouble tickets. Experiments have been carried out with the datasets from the Abilene and Switchlan networks. One of the findings is that more than half of all trouble tickets correspond to maintenance activities.
- Martín Serrano (Waterford Institute of Technology, Ireland) presented “A Formal Approach for the Inference Plane Supporting Integrated Management Tasks in the Future Internet”. This paper started by reviewing the Knowledge Plane of Clark, et al., and then explained the motivation for extending this work into the Inference Plane by Strassner, et. al. He explained how the Inference Plane could accommodate business-aware service management, and then showed how the Ontology for Support and Management (OSM) project could be used to define and manage many of the semantic structures required to formalize and represent knowledge. This in turn can facilitate interoperability between management systems by enriching their information or data models with associated semantics.
- Jeroen Famaey (Ghent University, Belgium) presented “Dynamic QoE Optimisation for Streaming Content in Large-Scale Future Networks”. He focused on the description of a set of algorithms aiming at optimizing the process of streaming multimedia content in a scalable and fully distributed end-to-end architecture. The algorithms help select the most appropriate content servers and codecs (plugins), considering bandwidth limitations and maximizing QoE. Experimental results based on simulations have been used to assess the approach.

The high volume of very interesting discussions and feedback to the presenters emphasized the forward-looking character of this workshop. For example, many of the workshop participants asked diverse questions, ranging from implementation experience to experimental methodology to open speculation concerning future work and alternatives.

4 Short Paper Session

Four selected short papers were presented as posters:

- Ewan Sutherland (University of Namur, Belgium) presented “The Internet tipping point: driving the transition to a new architecture?” The focus of this paper was to find a guide for future design and implementation by learning from past experience. The effect of changes that the clean-slate approach will cause was analyzed and discussed in detail.
- Miguel Lopes (University of Minho, Portugal) presented “Automated Network Services Configuration Management”. The presented framework works in cooperation with an automated and distributed monitoring system that together build an automated network service replication mechanism enabling to work with independent software and hardware implementations.
- Spiros Spirou (Intracom Telecom, Greece) presented “Economic Traffic Management”. He proposed an autonomous and cooperative traffic management and explained how various actors in several scenarios expressed their goals and incentives. Economics-inspired methods were applied, and rules for local interactions of actors that maximized incentives were described for achieving global traffic management.
- Feng Liu (Ludwig-Maximilians-Universität München, Germany) presented “The Role of AI Planning in the Management of Future Internet”. He proposed to apply the hierarchical task network (HTN) planning approach to facilitate the task decomposition operation and knowledge representation, which are important building blocks of Future Internet management. He explained his approach by comparing it with traditional planning.

5 Panel: Why is Managing the Future Internet Being Ignored?

The last session of the ManFI 2009 workshop was dedicated to a panel session with the theme “Why is Managing the Future Internet Being Ignored?” Chaired by James Won-Ki Hong (POSTECH, Korea), the four panelists Joan Serrat (Universitat Politècnica de Catalunya, Spain), Lisandro Zambenedetti Granville (UFRGS, Brazil), Spiros Spirou (Intracom Telecom, Greece), and Yoshiaki Kiriha (NiCT, Japan) debated a wide range of topics with each other and the participants of the workshop.

Joan started the discussion by stating his opinion that management of the Future Internet is not being ignored but, instead, is being re-thought. The limitations of the current Internet have created a pressing need for new approaches. Joan stated that a new Internet should rely on autonomic communications principles with embedded self-management capabilities.

Lisandro focused on the importance of network virtualization on different layers. He related important management questions to technology and business aspects. Two popular examples were “How can one manage physical/virtual routers?” and “What’s the cost of managing network virtualization?” He also indicated the importance to interact with other communities dealing with similar issues.

Yoshiaki presented the role of future management technologies from activities in Japan, where the FI is motivated by the networking community; consequently, it is called New Generation Network (NWGN). It is envisioned that societal and business changes will transform society from a competitive to a collaborative society. Five future network-oriented research goals have been formulated: delivery of added value delivery for different stakeholders, creation and management of trusted heterogeneous networks, global sensor

clouds that provide complex behavior from aggregating simple entities, realizing network autonomicity, and transforming approaches to consider “green” networks.

Spiros gave some figures on Future Internet management funding by the European Union, which led to comparisons with other regions. In Europe, FI management has only been included in project funding recently, which shows the increasing importance of continuing research in management, while the US and Japan have no funding devoted to FI management.

The discussions then covered a large range of topics, including e.g. the design philosophy behind the Future Internet and business cases for virtualization. Another major issue in FI management will be security, which like management, must be designed in from the start and which is difficult to do in a fashion so that is accepted by all stakeholders. This lack of acceptance is caused by many diverse factors, ranging from the current view of many companies that network management is a cost (as opposed to profit) center, which discourages industry from investing in its research.

6 Concluding Remarks

All technical papers were published with the papers from the other IM 2009 workshops by IEEE:

IFIP/IEEE International Symposium on Integrated Network Management Workshop Proceedings

June 1-5, 2009, Hofstra University, NY, USA

IEEE Catalog Number: CFP0958G-CDR

ISBN: 978-1-4244-3924-9

Further, the workshop materials (e.g., program and presentations) are available online at: <http://www.manfi.org>

Many contributed to the success of the ManFI 2009 workshop. We would like to thank the authors and all speakers for presenting their work, sharing ideas and the openness for discussions. We gratefully acknowledge the work of the technical program committee members in the process of selecting the best papers and the IM 2009 workshop chairs for their organizational support. Many thanks go to all workshop participants, who helped to make ManFI 2009 a rich and pleasant first event in – hopefully – a series of workshops on management of the Future Internet.

Acknowledgements

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Authors

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**4th GI/ITG KuVS Workshop on The Future Internet and
2nd Workshop on Economic Traffic Management (ETM)**

- Preliminary Program -

Monday		November 9, 2009		Affiliation	Presentation
10.30	Welcome	B. Stiller	UZH	CH	-
11.00	Session 1 <i>Invited Presentations: Hyperspace and Interconnection</i>				
	<i>IP1</i>	P. de Sousa	European Commissi	BE	From the Internet to the Hyperspace: A Network Story
	<i>IP2</i>	M. Meulle	Orange France Telecom Group	FR	Business Issues and the Connectivity of the Inter-domain IPv6 Internet
12.00	Lunch	-			
13.30	Session 2 <i>Virtualization and P2P</i>				
	<i>P1</i>	C. Werle, L. Völker, R. Bless	Univ. of Karlsruhe	DE	Attachment of End Users to Virtual Networks
	<i>P2</i>	Z. Bozakov, A. Galatis	Univ. of Hannover	DE	Performance and Migration Evaluation of Virtual Software Routers
	<i>P3</i>	S. Oechsner, F. Lehrieder, T. Hoßfeld, D. Staehle, F. Metzger, K. Pussep	Univ. of Würzburg, Univ. of Darmstadt	DE	Economic Traffic Management for BitTorrent-Based P2P Networks
15.00	Coffee Break	-			
15.30	Session 3 <i>Peer Selection Schemes</i>				
	<i>P4</i>	S. Soursos, S. Spirou, M. Makidis, M.A. Callejo Rodriguez,	INTRACOM TELEKOM., TID	GR	BGP-based Locality Promotion for Cooperative Management of Overlay Traffic
	<i>P5</i>	M. Kantor, W. Krzysztofek, R. Stankiewicz, P. Cholda, Z. Dulinski	AGH	PL	Impact of BGP Routing Asymmetry on the Optimal Choice of Peers
	<i>P6</i>	E. Agiatzidou, G. D. Stamoulis	AUEB	GR	Collaboration between Peering ISPs for Economic Management of Overlay Traffic
17.00	End of Day 1	-			
17.50	Take off to Social Event				
18.30	Social Event				
21.30	Return				
Tuesday		November 10, 2009		Affiliation	Presentation
9.00	Session 4 <i>Invited Presentations: Broadband and P2P</i>				
	<i>IP3</i>	S. Burschka	Swisscom	CH	Traffic Mining, feel the packets, be the packets
	<i>IP4</i>	G. Haßlinger	Deutsche Telekom	DE	Traffic Management on Network Provider Platforms for Broadband Internet Access
	<i>IP5</i>	S. Spirou	INTRACOM TELEKOM	GR	Two Schools of P2P Caching
10.30	Coffee Break	-			
11.00	Session 5 <i>Short Presentations (Statements)</i>				
	<i>SP1</i>	M. Charalambides, J. Rubio-Loyola, G. Pavlou, J. Serrat	UCL	UK	Business-driven DiffServ QoS Management
	<i>SP2</i>	S. Mies, O. P. Waldhorst	Univ. of Karlsruhe	DE	Next Steps in Overlay Construction on Dynamic Heterogeneous Networks
	<i>SP3</i>	M. Waldburger, T. Schaaf, B. Stiller	Univ. of Zürich, LMU	CH	An Approach to an Automated Determination of Legal Parameters in SLAs
	<i>SP4</i>	R. Strijker, M. Cristea, C. de Laat, R. Meijer	Univ. of Amsterdam	NL	Framework for Programmable Network Control
	<i>SP5</i>	J. An, S. Pack	Korea Univ.	KOR	Catching Three Rabbits: Hybrid Channel Access with Network Coding in Wireless Networks
12.30	Lunch	-			
13.30	Session 6 <i>Intrusion and Spam Detection</i>				
	<i>P7</i>	S. Schmerl, M. Vogel, H. König	Brandenburg Univ. of Tech.	DE	Cooperating Intrusion Detection Overlay Structures
	<i>P8</i>	W. van Wanrooij, A. Pras	Univ. of Twente	NL	Detecting Spam using Blacklists
14.30	Coffee Break	-			
15.00	Session 7 <i>Monitoring and Provisioning</i>				
	<i>P9</i>	R. Holz, D. Haage	University of Tübingen	DE	CLIO/UNISONO: Practical Distributed and Overlay-Wide Network Measurement
	<i>P10</i>	C. Morariu, P. Racz, B. Stiller	Univ. of Zürich	CH	Experimental Results of Distributed Traffic Monitoring
	<i>P11</i>	M. Chamania, A. Jukan	Univ. of Braunschweig	DE	The Role of Transport Service Provisioning for Future Networks: Pressing Issues
16.30	Wrap-up	B. Stiller			
17.00	End of Day 2	-			

Legend:	IPx	Invited Presentation no. X	25 min presentation and 5 min Q&A, discussions
	Px	Presentation no. X	20 min presentation and 10 min Q&A, discussions
	SPx	Short Presentation no. X (Statement)	10 min presentation and 8 min Q&A, discussions

Location: CSG@IFI, University of Zürich, Binzmühlestrasse 14, CH-8050 Zürich, Switzerland

Travel and Hotel Infos: <http://www.csg.uzh.ch/travel-info>

Report of the Second Workshop on the Usage of NetFlow/IPFIX in Network Management

**Idilio Drago · Rafael R. R. Barbosa ·
Ramin Sadre · Aiko Pras**

Received: date/ Accepted: date

Abstract Following the success of the *First Workshop on the Usage of NetFlow/IPFIX* [9] in 2008, the European EMANICS Network of Excellence organized a second edition in October 2009 at Jacobs University Bremen. This report summarizes the workshop and presents its main conclusions.

Keywords NetFlow · IPFIX · EMANICS

1 Introduction

NetFlow is a protocol developed by Cisco Systems to monitor Internet traffic that flows in network elements [2]. A flow is a unidirectional stream of packets that pass through a network element, sharing a common set of attributes [3,4]. In early versions of NetFlow, a flow was defined by a fixed set of seven fields: source and destination IP addresses, source and destination port numbers, protocol type, type of service and logical interface (ifIndex). Since NetFlow version 9, the definition of a flow is flexible and created via templates. IPFIX (IP Flow Information Export) is an effort of IETF (Internet Engineering Task Force) to create standard protocols to collect and export IP flows. IPFIX is under discussion in IETF since 2001, and in 2004 NetFlow version 9 was chosen to be the basis for the IPFIX specification [7]. Several improvements on NetFlow version 9 have already been added to IPFIX, including, for example, enterprise-defined fields [1] and bidirectional flow exporting functions [11].

For the second consecutive year, the European EMANICS Network of Excellence runs an one-day workshop about the usage of NetFlow/IPFIX in network management, aiming to provide a place where researchers and operators can discuss the latest development and exchange practical experiences. The first workshop edition [9] intended to discuss technologies to capture and analyze flow data, effects of sampling and aggregation techniques on the accuracy of analyzes, and applications that NetFlow/IPFIX can be used for. This second edition was divided into three sessions, addressing the following questions:

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- What is the current stage of IPFIX standardisation and what are the challenges for adopting the protocol?
- What are the new applications of NetFlow/IPFIX?
- How is NetFlow/IPFIX used in practice?

This report presents an summary of all presentations of the workshop, along with their main conclusions.

2 IPFIX Standardisation and Open Issues

In the first session, the status of IPFIX standardisation was discussed, together with some other issues that impact the practical implementation of the protocol. The session was opened with a presentation about the current status of IPFIX in IETF. As in the previous workshop edition, Benoit Claise (Cisco Systems) gave an overview about the history of IPFIX and the main differences between IPFIX and NetFlow Version 9. In addition, he compared IPFIX with PSAMP (Packet Sampling), showing that those protocols are complementary. He finished presenting a summary about current work in IETF:

- The *IPFIX File Format* specification, which defines a format for storing IPFIX data, has been completed.
- There are three drafts about network management under discussion: *Definitions of Management Objects for IP Flow Information Export*, *Definitions of Managed Objects for Package Sampling*, and *Configuration Data Model for IPFIX and PSAMP*.
- There is still work in progress related to *IPFIX Structured Data*, *Mediation Function* and *IPFIX Export per SCTP Stream*.
- New items have been added to the charter: *Flow Anonymization*, *Flow Selection* and *IPFIX Benchmarking*.

Claise's talk raised discussions about open issues in IPFIX deployment - some of them detailed in subsequent presentations.

Carsten Schmoll (Fraunhofer FOKUS) proposed a solution for securing IPFIX data transmission. Network flow data must be treated as confidential, since it contains information that can be used during attacks. His solution covers two major threats:

1. Anonymity disclosure: NetFlow/IPFIX records contain information about active flows, addresses of involved nodes, and traffic patterns in the network. That information can be used by attackers to identify users' behavior or reveal details about the network structure, easing attacks against other network elements.
2. Attacks against the measurement system: Applications that depend on network flow data can be affected if the measurement structure is damaged. For example, unprotected collectors are vulnerable to *flooding attacks*, that can disrupt accounting systems.

Schmoll proposed exporting encrypted data (using IPFIX), and decrypting it only when strictly necessary. His solution can use a different encryption key for each collector device, allowing exporting devices to decide which collectors will decrypt a portion of data. All communication for key exchanging is protected by standard TLS (Transport Layer Security), and all ordinary security measures - like protection by firewalls and access control policies - are recommended. A comprehensive evaluation of the effectiveness of his approach, however, is still to be performed.

Cristian Morariu presentation targeted at the bottlenecks in handling NetFlow/IPFIX data. Since NetFlow/IPFIX meters are normally installed in high-speed networks, the structure for transporting and processing that data must be prepared for heavy workloads. Bottlenecks can occur, for example, if NetFlow/IPFIX data arrives at a collector device in rates higher than the writing speed of the storage hardware, if the bandwidth available in the network is not sufficient, or if the time required to process an NetFlow/IPFIX record is longer than the inter-arrival time of those records. These bottlenecks are normally addressed on the metering point, by sampling packets or flows before exporting any data. However, some applications require high accurate measurements, and both sampling approaches may impact that.

Morariu proposed a new architecture suitable for scenarios in which sampling is not recommended. His solution, based on the peer-to-peer protocol Kadmillia, aims to increase the amount of flows that can be processed, distributing the workload across several network nodes. Furthermore, his solution is more robust, since peer-to-peer networks provide redundancy and avoid single points of failures. Although a prototypical implementation already exists, new evaluations are needed to ensure its feasibility.

3 New Applications for IPFIX

In the second session, new applications for NetFlow/IPFIX were discussed. The session was opened by Nikolay Melnikov (Jacobs University Bremen), who is researching methods for identification of users, based on network flow analysis. Each user has its individual browsing style, that generates patterns on data collected by NetFlow/IPFIX monitoring systems. Melnikov's goal is to identify users automatically, comparing unknown NetFlow/IPFIX records to known examples of users' flow signature. Even though this research is still in early stages, first results are promising: using cross-correlation as proximity measure, the duration distribution of flows from four volunteering users could be differentiated. Next steps of his research include the creation of more features from original data and the selection of the most discriminative features, among others. All those tasks, however, depend on the availability of data from new volunteers.

Tim Kleefass (SWITCH/University of Stuttgart) presented a new application for NetFlow/IPFIX data, that can help network operators to identify remote connectivity issues. Network operators need to know problems before their customers notice them, even when those problems are not directly connected to their services or products. As an example, all traffic going to YouTube was lost for several minutes in 2008, due to a wrong configuration created by a telecommunication company in Pakistan – users all around the world were affected, without knowing exactly who caused the problem. Kleefass proposed to compare the number of flows passing edge routers of a network to and from a remote location. Using those totals, he updates a connectivity matrix every 5 minutes. In case of remote connectivity issue, those numbers will be unbalanced, showing an abnormal situation. Some applications that have unbalanced traffic in normal situations, like Skype, must be filtered out to avoid false alarms. Using logs from Swiss research and educational network (SWITCHlan), Kleefass showed that this approach successfully identifies outages in remote Internet locations.

Jochen Kögel (Universität Stuttgart) closed this session, presenting how NetFlow/IPFIX data can be used to extract performance metrics in enterprise networks. As described in RFC3917 [10] and RFC5472 [12], quality of service monitoring is one

target application of IPFIX, but a comprehensive research of what can be extracted from IPFIX data is lacking. Kögel presented methods to extract RTT (Round Trip Time) and delay from flow data. The RTT can be extracted from a single router if all traffic (in both directions) are routed through it. In that case, the RTT will be the difference between starting time of a pair of related flows (request/response flows). Delay estimation, on the other hand, requires information from several routers on the path between end nodes. The delay can be calculated based on the starting time of the same flow collected at different points (assuming that all equipments have synchronized clocks). Experiments showed good results, comparing the calculations with active measurements.

4 NetFlow/IPFIX in Practice

The other presentations discussed the following aspects of the current usage of NetFlow/IPFIX: real-world experiences of a NetFlow tool-vendor, a new visualization tool for NetFlow data, and an analysis of bandwidth behavior of network flows.

Andreas Bourges (IsarNet) reported some experiences of using NetFlow from a tool-vendor's perspective. In the first part of his presentation, the monitoring tool IsarFlow was described. Its capabilities include bandwidth monitoring, application discovery, anomaly detection and others. Emphasis was given to the approach implemented to deal with the large amount of collected data. The second part of his presentation focused on how IsarNet's clients are using NetFlow. In their experience, customers typically use the tool to find out:

- Which protocols are causing the high load on a given link?
- Which IP addresses are causing the high load on a given link?
- Which TCP flags and port numbers are being used for communication between end nodes?
- What settings are used by a given protocol?

Most of their customers are still using NetFlow version 5, however the demand for version 9 is increasing. Bourges argued that Flexible NetFlow has several interesting features, but version 5 is enough to meet their customers requirements. Moreover, the deployment of Flexible NetFlow faces a dilemma: tool vendors need that customers hardware/software infrastructure supports this new version before they start providing products to it; however, customers are not willing to upgrade their infrastructure if there is no application that supports Flexible NetFlow.

Rick Hofstede (University of Twente) proposed a novel way to visualize flow data, that combines geographic information and network traffic data. He implemented a plug-in for NfSen [8], which interfaces with IP2Location [6] and Google Maps API [5], creating a web application that displays geographic information about the network traffic. His tool provides zoom levels that allow to distinguish between various aspects of network information, while keeping an intuitive interface.

Ramin Sadre (University of Twente) presented his analysis of bandwidth behavior of large flows. This study was motivated by the interest of network management in those flows. For example, if packet switching/optical networks are available, large flows can be moved from IP to optical level, optimizing network efficiency. The objective of his research is to go beyond the aggregated information provided by NetFlow records, such as start/end time and transmitted bytes, and analyze how flows behave during their lifetime. Two research questions were presented:

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- Have large flows, in general, a constant throughput?
 - What do we know about the (overall) throughput of a flow, after observing it for some time (e.g. 5 minutes)?

The study was based on data collected at the University of Twente in 2007. At this stage of his research, only flows with more than 100MB were considered. Sadre concluded that most flows in his data set have a constant throughput, but there are some large deviations. Furthermore, more precise throughput estimation is achieved as the observing time of a flow gets longer.

5 Conclusions

Like the first edition, the *2nd EMANICS Workshop on NetFlow/IPFIX Usage* was a success. All presentations generated high interactive discussions, resulting in valuable feedback for researchers. A third edition of the workshop will be organized in 2010, probably in conjunction with the *IETF 78 Meeting*, which will take place on July 25-30, in Maastricht, The Netherlands. More information about the workshop, including slides and contact information of all presenters, can be found on the EMANICS website [9].

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