FLAMINGO

European Seventh Framework Network of Excellence

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WP3 — Interaction with Academia and Industry

Deliverable D3.4 — Third Year Report on Interaction with Academia and Industry

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Project funded by the European Union under the
Information and Communication Technologies FP7 Cooperation Programme
Grant Agreement number ICT-FP7 318488

Document Control

Title:	D3.4 — Third Year Report on Interaction with Academia and Industry
Type:	Public
Editor(s):	Filip De Turck
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Doc ID:	D3.4
Delivery Date:	2015-10-31
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Executive Summary

Joint research and dissemination activities are the pillars for project's interaction with academia and industry. The organization of major conferences, journals, interoperability labs, peer-to-peer interaction between researchers and industrial partners, joint work with other EU projects is beneficial for both the FLAMINGO consortium as well as for all external researchers in the area of network and service management. In the third year of the project the consortium carried out a number of tasks with respect to three objectives of this activity: organization of the scientific community, results dissemination to researchers within academia and industry, and achievement of scientific excellence. In this respect, the following achievements have been made:

- **Organization of scientific conferences.** The FLAMINGO consortium organized and participated to the three major conferences in the domain of Network Management in 2015 (IFIP/IEEE IM, IFIP AIMS and IFIP/IEEE CNSM). Furthermore, the FLAMINGO consortium also played an important role in establishing a new conference on Network Softwarization (IEEE NetSoft 2015), and will consolidate the scientific quality of this conference by organizing the important second edition (IEEE NetSoft 2016). In addition, the FLAMINGO consortium will organize the European Conference on Cyber Warfare and Security (ECCWS 2016).
- **Organization of scientific journals.** Members of the consortium served as editors for the major journals on Network Management. These journals include: IEEE Communications Magazine (ComMag), IEEE Transactions on Network and Service Management (TNSM), Journal of Network and Systems Management (JNSM) and International Journal of Network Management (IJNM). Furthermore, 4 special issues were organized in Y3 on very relevant topics studied within the FLAMINGO project.
- **Organization of a detailed questionnaire.** A questionnaire has been established in order to update the taxonomy of Network and Service Management conferences and identify emerging research topics. Participation from worldwide experts (both industry and academia) was actively sollicited.
- **Organization of the annual European AIMS conference.** The Autonomous Infrastructure, Management and Security (AIMS 2015) conference was organised by the FLAMINGO consortium at Ghent University in Belgium, June 22–25, 2015. The program was specifically tailored towards Ph.D. students from the network and service management community.
- **Organization of specific workshops and events that foster interaction between academia and industry.** During the course of the second year, the FLAMINGO consortium organized 23 specific workshops and events, which are all described in section 3 of this deliverable.
- **Organization of interoperability labs.** The two interoperability labs (NETCONF interoperability lab and OpenFlow testing lab) have been extended.
- **Integration of the European research landscape.** FLAMINGO organized and contributed to the Future Internet Cluster meetings, the NetFutures 2015 event, the NetWorld2020 event, the EUCnC 2015 conference, and collaborated with other on-going EU projects.
- **Organization of the FLAMINGO Scientific and Industrial Council.** The consortium organized the third meeting of the Scientific and Industrial Council.

Please refer to sections 2 through 6 for more detailed information on the progress and achievements made during the third year of the project.

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1 Introduction

WP3 is structured in five tasks, which all were active throughout the third year of the project with contributions by all project partners. The five tasks are listed below:

- Task 3.1 Organizing Scientific Excellence
- Task 3.2 Organization of Joint Workshops and Events
- Task 3.3 Setup of an Interoperability Lab
- Task 3.4 Integration of the European Landscape
- Task 3.5 Organization of a Scientific and Industry Council

Progress status and the achieved results for each task are detailed in Sections 2 through 6 of this deliverable. Table 1 below gives an overview of the objectives in the third year of the project and their status.

Objective	**Target Number**	**Achieved Number**
Conference organization	2	5
Journal organization	2	4
Special issue organization	2	4
Workshop organization	2	14
Specific events organization	2	12
netFutures contributions	1	1
Dagstuhl seminar organization	1	1
Organization of interoperability lab	1	2
EuCNC contributions	1	2
Future Internet cluster organization	1	1
Joint work with other EU projects	2	9
Scientific and industrial council establishment and meeting	1	1
Total number of activities	**20**	**56**

Table 1: Status of FLAMINGO WP3 objectives in Year 3.

2 Scientific Excellence: Organization and Achievements

In this section, we describe the actions undertaken to organize conferences and symposia in our research field, scientific journals, the IEEE Technical Committee on Network Operations and Management, IFIP Working group on Management of Networks and Distributed Systems, and the IFIP Technical Committee on Communication Systems. Furthermore, the activities on the IFIP Open digital library, conference ranking and the network and service management taxonomy are described.

2.1 Conferences and Symposia

The key conferences in the field of Network Management include: IFIP/IEEE International Symposium on Integrated Network Management (IM), IEEE/IFIP International Symposium on Network Operations and Management (NOMS), International Conference on Network and Service Management (CNSM) and International Conference on Autonomous Infrastructure, Management and Security (AIMS). During the third year of the FLAMINGO project the IFIP/IEEE IM, AIMS and CNSM conferences took place, while IEEE/IFIP NOMS 2016 will take place in April 2016, according to its biennial schedule. The FLAMINGO consortium contributed to all three conferences by taking part in the Steering, Organizing and Technical Program committees. Table 2 indicates the number and the role of FLAMINGO members involved in the organization for each of these conferences. More information on the contributing members is provided in the sections below.
Moreover, the FLAMINGO consortium played in important role in establishing and organizing the IEEE NetSoft conference, and is currently organizing the ECCWS 2016 conference.
The organized conferences are described in more detail below, in chronological order of conference dates.

Conference	SC	OC	TPC
NetSoft 2015	-	3	7
IM 2015	2	6	14
AIMS 2015	3	11	14
CNSM 2015	1	5	12

Table 2: Number and role (SC - Steering Committee; OC - Organizing Committee; TPC - Technical Program Committee) of FLAMINGO members in the main Network Management conferences in FLAMINGO Y3.

2.1.1 IEEE Conference on Network Softwarization, NetSoft 2015

The FLAMINGO consortium played an important role in establishing a new conference: the first IEEE conference on Network Softwarization (NetSoft 2015), organized in London, UK, April 13-17, 2015 and hosted by UCL. Prof. George Pavlou, UCL, served as General Chair. Since it is the first edition, the role of a finance chair was very important: Prof. Olivier Festor, INRIA, served as NetSoft 2015 Finance Chair. Furthermore, Prof. Filip De Turck served as NetSoft 2015 Patron Chair. Seven members of the FLAMINGO consortium participated in the IEEE NetSoft 2015 Technical Program Committee.
NetSoft 2015 is realized as part of the recently established IEEE Software-Defined Networks initiative of the IEEE Future Directions Committee. Due to the enormous current world-wide interest

in SDN and NFV, many participants from the various branches of industry, academic experts and students participated to the event.
NetSoft 2015 is the first of a series of IEEE annual events on SDN and NFV, and received a lot of coverage (websites, social media, publications, also in broader press). The theme of IEEE NetSoft 2015 was "Software-Defined Infrastructures (SDI) for Networks, Clouds and Services".
Due to the commitment and contributions by the mentioned FLAMINGO consortium members, the FLAMINGO logo and link to the FLAMINGO website was shown prominently on the official IEEE NetSoft 2015 website.
A total of 108 papers were submitted to the main technical track of IEEE NetSoft2015. Each paper received at least 3 reviews with an average of 4.5 reviews per paper. Paper acceptance was thoroughly discussed during a physical technical program committee meeting held in Paris, France on February 20, 2015. Final selection included 17 full papers (16%) for presentation during the plenary sessions and 31 short papers for presentation during the two parallel breakout sessions. In addition to the technical sessions, IEEE NetSoft 2015 also includes 3 keynote talks, 1 panel discussion, 7 software demonstrations, 3 tutorials and 3 workshops on 5G Soft Networks, Security in SDN, and Management of SDN respectively.
Prof. Olivier Festor (INRIA) organized a succesful workshop during NetSoft 2015 on Security Issues in SDN (IEEE SEC-SDN).

Location	Date	Technical Track Submissions	Accept. Rate	Total Submissions	On-site Participants
London, UK	April, 13-17	108	16%	176	165

Table 3: IEEE NetSoft 2015 conference statistics.

2.1.2 IFIP/IEEE International Symposium on Integrated Network Management, IM 2015

The consortium contributed to the organization of the IEEE/IFIP International Symposium on Integrated Network Management (IM 2015: `http://www.ieee-im.org/`), which is considered as one of the two flagship conferences in the domain of Network Management (IFIP/IEEE NOMS is the other, held in even years). IM 2015 took place in Ottawa, Canada, May 11-15, 2015 at the Ottawa Convention Centre.

The theme of IM 2015 was focused on *Integrated Management in the Age of Big Data* presenting recent, emerging approaches and technical solutions for dealing with Big Data as well as using it for management solutions.

The total number of technical track submissions was 206, whereas the total number of submissions was 375. The total submissions also include workshop paper submissions, dissertation submissions, demo paper submissions and experience paper submissions. The acceptance rate for the main conference track was 27.2%.

Location	Date	Technical Track Submissions	Accept. Rate	Total Submissions	On-site Participants
Ottawa, Canada	May, 11-15	206	27.2%	375	350

Table 4: IEEE/IFIP IM 2015 conference statistics.

FLAMINGO members contributed in the following roles of the organizational process of IEEE/IFIP IM 2015:

- Technical program committee co-chair – Remi Badonnel (INRIA),
- Publication co-chair – Filip De Turck (Ghent University - iMinds),
- Workshop co-chair – Burkhard Stiller (UZH),
- Dissertation digest co-chair – Olivier Festor (INRIA),
- Demonstration co-chair – Jürgen Schönwälder (JUB),
- Demonstration co-chair – Marinos Charalambides (UCL).

Many FLAMINGO members (14 in total) assisted the Technical Program Committee in ensuring the scientific quality of the conference. In particular, the IM 2015 Best Reviewer Award has been received by Burkhard Stiller (UZH).

Furthermore, the FLAMINGO Consortium was involved in the organization of the following events co-located with the IM 2015 symposium:

- the 8th IEEE/IFIP International Workshop on Management of the Future Internet (MANFI 2015), co-chaired by Filip De Turck (Ghent University - iMinds),
- the 36th Network Management Research Group (NMRG) Meeting, co-chaired by Olivier Festor (INRIA).

2.1.3 International Conference on Autonomous Infrastructure, Management and Security, AIMS 2015

The 9th International Conference on Autonomous Infrastructure, Management and Security (AIMS 2015) has taken place from June 22 to June 25, 2015, in Ghent, Belgium, hosted by the Ghent University and iMinds. AIMS 2015 followed the tradition of the previous events and included in the program, beside the main track, also keynotes, lab sessions, and a PhD Student Workshop. The focus of the conference organization was on strengthening the educational goals of the conference and its strong focus on PhD students and young researchers.
FLAMINGO members contributed in the following roles of the organizational process of AIMS 2015 conference:

- General chairs – Prof. Filip De Turck (iMinds) and Prof. Piet Demeester (iMinds),
- TPC chairs – Prof. Steven Latré (iMinds) and Dr. Marinos Charalambides (UCL),
- Ph.D. track TPC chairs – Dr. Jerome Francois (INRIA) and Dr. Corinna Schmitt (UZH),
- Lab Session chairs – Dr. Ricardo Schmidt (UT) and Dr. Tim Wauters (iMinds),
- Publication chair – Prof. Burkhard Stiller (UZH),
- Online Media chair – Maxim Claeys (iMinds),
- Local Arrangement chairs – Prof. Peter Van Daele (iMinds) and Davinia Stevens (iMinds).

Many FLAMINGO members (14 in total) assisted the Technical Program Committee in ensuring the scientific quality of the conference. Furthermore, the FLAMINGO Consortium organized the three hands-on Lab Sessions during AIMS 2015:

1. Lab Session 1: *Map-Reduce and Hadoop*, by Jerome Francois (INRIA)
2. Lab Session 2: *Deploying Network Function Virtualization Experiments on the Virtual Wall Test-bed*, by Niels Bouten (iMinds) and Rashid Mijumbi (UPC), Spain.
3. Lab Session 3: *Powering Monitoring Analytics with ELK Stack*, by Abdelkader Lahmadi (INRIA) and Frederick Beck (INRIA).

Two keynotes were given by FLAMINGO members: (i) Prof. Burkhard Stiller (UZH) gave a keynote talk on "Management of Big Data - The Areas of Conflict: Data Volume, Analysis Methods, and Protection", detailing a carefully crafted view on current trends and opportunities for the development of new big data management mechanisms, and (ii) Prof. Piet Demeester (iMinds) and Prof. Filip De Turck (iMinds) on "Current Trends in Network Research and Advice for Young Researchers", a list of 15 tips were given, motivated and illustrated to the young researchers, for successfully pursuing a career either in academia or a career in industry.

AIMS 2015 focused on "Intelligent Mechanisms for Network Configuration and Security". The technical program consisted of two main sessions – covering the topics of autonomic and decentralised management, and security, privacy and measurements – and included seven full papers, which were selected after a thorough reviewing process out of 22 submissions. Each paper received three or four independent reviews, followed by a shepherding process aimed at tutoring those 7 accepted papers through the preparation of the camera-ready paper version and to the paper presentation.

The AIMS PhD Student Workshop provides a venue for doctoral students to present and discuss their research ideas, and more importantly to obtain valuable feedback from the AIMS audience about their planned PhD research work. This year, the workshop was structured into two technical sessions covering management of future networks and security management. All PhD papers describe the current state of these investigations, including their clear research problem statements, proposed approaches, and an outline of results achieved so far. A total of 9 PhD papers were presented and discussed. These papers were selected after a separate review process out of 24 submissions, while all PhD papers received at least three independent reviews.

AIMS 2015 had 52 attendees, in line with previous editions. The attendees were mainly European researchers, but also a few researchers from Korea and Uruguay.

Location	Date	Technical Track Submissions	Accept. Rate	Total Submissions	On-site Participants
Ghent, Belgium	June, 22-25	22	31.8%	46	52

Table 5: IFIP AIMS 2015 conference statistics.

2.1.4 International Conference on Network and Service Management, CNSM 2015

The CNSM 2015 conference is held in Barcelona, Spain, November 09-13, 2015. FLAMINGO member Prof. Joan Serrat (UPC) is the General Chair of CNSM 2015. Additional FLAMINGO members involved in the organization of CNSM 2015 are Prof. Jürgen Schönwälder (JUB) as Technical

Program Co-Chair, Anna Sperotto (UT) as Workshop Co-Chair, Prof. Filip De Turck (iMinds) as Distinguished Experts Panel Co-Chair, and Dr. Corinna Schmitt (UZH) as Publication Co-Chair.

CNSM 2015 received 102 submissions from all over the world (Africa, Asia, Europe, North America and South America). All submitted papers underwent a rigorous review process with at least three reviews for every paper and a rebuttal phase. The technical program committee selected 18 papers as regular full papers, a very competitive acceptance ratio of 17.6%. Due to the high quality of the submitted papers, many good papers could not be selected to the main technical conference. The 14 best such papers were selected for the Mini-Conference program. In addition, 16 short papers are presented in two poster sessions. The topics covered this year include: fault management, cloud management, software defined networks, network function virtualization, security, autonomic management, management of quality of service/experience, measurements, and mangement of wireless and mobile networks.

Next to the main track, the second International workshop on Management of SDN and NFV takes place during the CNSM 2015 week. It is co-chaired by FLAMINGO member Dr. Marinos Charalambides (UCL). In addition, the International DMTF Academic Workshop on Datacenter and Cloud Management (DCM 2015) takes place during the CNSM 2015 week.

Location	Date	Technical Track Submissions	Accept. Rate	Total Submissions	On-site Participants
Barcelona, Spain	November, 9-13	102	17.6%	148	150

Table 6: IFIP CNSM 2015 conference statistics.

2.1.5 IEEE Conference on Network Softwarization, NetSoft 2016

In the first edition of the IEEE NetSoft conference (held in UCL, London) in 2015, FLAMINGO played an important role in the establishment of the conference (by serving as General Chair, Finance Chair, Patron Chair and taking care of the local arrangements). Due to the importance of the conference and its focus on future networks and management, the FLAMINGO consortium decided to strongly contribute to the consolidation of the conference and to make sure that the scientific quality of the conference is high. The following members of the FLAMINGO consortium contribute to the organization of IEEE NetSoft 2016:

- Prof. Filip De Turck (iMinds) – TPC Chair,
- Prof. Burkhard Stiller (UZH) – Workshop Chair,
- Prof. Olivier Festor (INRIA) – Tutorial Chair,
- Prof. Remi Badonnel (INRIA) – Publication Chair.

In total, 14 members of the FLAMINGO consortium contribute as Technical Program Committee members of IEEE NetSoft 2016.
NetSoft 2016 will be held in Seoul, Korea, June 6-10, 2015. This conference is the flagship event established as part of the IEEE Software-Defined Networks (SDN) initiative of the IEEE Future Directions Committee. This cross-societies' initiative aims at creating the conditions for a pre-industrial exploitation and adoption of SDN/NFV paradigms in Telecommunications and ICT ecosystems, through a worldwide cooperation of leading technical experts in industry and academia.

NetSoft is the primary forum for publication and technical exchange of the latest research and innovation results in the area of Network Softwarization. The theme of NetSoft 2016 is “Softwarization of Networks, Clouds, and Internet of Things”.
The technical sponsors of NetSoft 2016 are the IEEE Communications Society, the IEEE Computer Society, the IEEE Signal Processing Society and the IEEE Consumer Electronics Society.
Similar to the first edition of Netsoft, the FLAMINGO logo will be shown on the official NetSoft 2016 website, together with a link to the FLAMINGO website.

2.1.6 European Conference on Cyber Warfare and Security, ECCWS 2016

The European Conference on Cyber Warfare and Security ECCWS (formally the European Conference on Information Warfare and Security ECIW) offers a forum for academics, researchers and practitioners working in this important field, whether at micro or macro levels. ECCWS is an established conference, organized for the 15th time in 2016, with focus on discussion, exploration and development of both theoretical and practical aspects of information warfare and security.
ECCWS 2016 is hosted by UniBWM in Munich and organized by Prof. Gabi Dreo Rodosek (UniBWM) as General Chair and Dr. Robert Koch (UniBWM) as Program Chair.

2.2 Journals

Over the course of last year FLAMINGO partners held different organizational and editorial roles in the main journals of the Network and Service Management field:

- IEEE Network and Service Management Series in Communications Magazine (ComMag),
  `http://www.comsoc.org/files/Publications/Magazines/ci/cfp/cfpcommagnetworkmanagementseries.html`
- IEEE Transactions on Network and Service Management (TNSM),
  `http://www.comsoc.org/tnsm/`
- Journal on Network and Systems Management (JNSM, published by Springer),
  `http://www.springer.com/computer/communication+networks/journal/10922`
- International Journal on Network Management (IJNM, published by Wiley),
  `http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-1190`

Table 7 shows the number of FLAMINGO members that contributed as editors to these journals in different roles over the course of FLAMINGO Y3.

Journal	Role				
	SE	**AEiC**	**EAB**	**AE**	**SIE**
ComMag	2	-	-	-	-
TNSM	-	-	-	4	2
JNSM	-	-	3	3	-
IJNM	-	2	-	6	4

Table 7: Number of FLAMINGO members in the major Network and Service Management journals. Journal role: SE - series editor, AEiC - associate editor-in-chief, EAB - editorial advisory board member, AE - associate editor and SIE - special issue editor.

2.2.1 IEEE Communications Magazine (ComMag)

Prof. Jürgen Schönwälder and Prof. George Pavlou serve as the two series editors of the IEEE Network and Service Management Series in IEEE Communications Magazine. Two times per year a series on Network and Service Management is published and the FLAMINGO project is explicitly acknowledged by the series editors.

2.2.2 IEEE Transactions on Network and Service Management (TNSM)

The following FLAMINGO members serve as associate editors for this journal: Prof. Olivier Festor, Prof. Filip De Turck, Prof. Burkhard Stiller and Prof. Aiko Pras.

2.2.3 Journal on Network and Systems Management (JNSM)

This journal has an Editorial Advisory Board with the following FLAMINGO members: Prof. George Pavlou, Prof. Olivier Festor and Prof. Aiko Pras. The following FLAMINGO members serve as associate editors: Prof. Jürgen Schönwälder, Prof. Filip De Turck and Prof. Burkhard Stiller.

2.2.4 International Journal on Network Management (IJNM)

Prof. Aiko Pras and Prof. Filip De Turck serve as associate-editor-in-chief and the following FLAMINGO members serve as associate editors: Prof. Olivier Festor, Prof. Jürgen Schönwälder, Prof. Burkhard Stiller, Prof. Joan Serrat, Prof. Gabi Dreo Rodosek and Prof. Rémi Badonnel.

2.3 Organization of Journal Special Issues

The following four special issues were organized by the FLAMINGO consortium in Y3:

2.3.1 IJNM special issue on Network Security

The University of Twente (UT), the Universität der Bundeswehr München (UniBwM) and the University of Zurich (UZH), in collaboration with CAIDA (UCSD, USA) organized a special issue of the International Journal of Network Management on the topic of “Measure, Detect and Mitigate-Challenges and Trends in Network Security”. Editors of this special issue have been Prof. Gabi Dreo Rodosek (UniBwM), Dr. Anna Sperotto (UT), Dr. Corinna Schmitt (UZH), Rick Hofstede (UT) and Dr. Alberto Dainotti (CAIDA). The special issue was published in September 2015.

Cybercrime has developed rapidly during the last decade, and recent years in particular have seen an unprecedented number of cyber attacks. Despite increased national and international efforts against cybercrime, cybercrime still has double-digit annual growth rates. As the number of services and systems connected to the Internet and migrating to cloud infrastructures increases, the ability to carry out attacks from a seemingly-safe distance attracts more criminals and has made e-Crime a multi-billion dollar market. Furthermore, recent trends highlight that attacks target not only end-hosts, but also the Internet infrastructure itself, with attacks aiming at impeding the functioning of the Domain Name System (DNS) and Internet backbones, for example.Network security is also gaining enormous political attention in times of mass surveillance, advanced persistent threats (APTs) and data leakages.

In this context, it is evident that the steps highlighted in this special issue, *measure*, *detect* and *mitigate*, become important. The dramatic trends in attack evolution call upon constant innovative solutions in each of these areas as well as in their synergistic combination. The goal of this special issue was twofold: presenting (1) contributions characterizing and measuring emerging network threats, as well as (2) cutting-edge detection and mitigation techniques that are effective against network attacks and insider activities in today's and future small-to-enterprise sized networks and network backbones.

A total of 14 papers was received for this special issue. Three papers were considered, at an early stage, as out of scope, and therefore did not go through the full review process. Of the 11 remaining papers, one was accepted after the first review round, five were rejected and five underwent a second revision. In both review rounds, the papers received three reviews on average. In total, 33 reviewers participated in the review process and based on their reviews, a final number of six papers was selected for publication. Two papers from FLAMINGO members were submitted to the special issue, and one of those was accepted for publication.

2.3.2 TNSM special issue on Management of SDN/NFV-based Systems

This special issue is organized by Prof. Filip De Turck (iMinds) for the IEEE Transactions on Network on Service Management (TNSM).
The special issue focuses on efficient management of software-defined virtualized telecommunication systems and datacenters. The guest editors for the special issue are: Jun Bi (Tsinghua University, China), Raouf Boutaba (University of Waterloo, Canada), Prosper Chemouil (Orange Labs, France), Filip De Turck (Ghent University-iMinds, Belgium) and Cedric Westphal (Huawei and University of California, Santa Cruz, USA).
Paper submissions were due December 2014. In total, 26 papers were submitted for this special issue. In order to allow a fast publication cycle, the special issue was split in two parts: Part I appeared in the March 2015 issue of TNSM and Part II appeared in the June 2015 issue. After extensive review and discussion, it was decided to publish four accepted papers in Part I of the special issue. The authors of the four papers were given the time to update their paper and take the reviewers' comments and suggestions into account. The selected papers address three critical topics that play a central role in the management of SDN/NFV-based telecommunication systems: efficient resource allocation and management of softwarized network functions, design of high-performance platforms to allow network function virtualization on commodity machines, and enabling efficient collaboration between providers in softwarized networks.
An additional set of four more papers have been accepted for Part II of the special issue, after a thorough revision by the authors to take into account the detailed comments from the reviewers. The four selected papers in Part II of the special address three very important topics for the efficient management of SDN/NFV-based telecommunication systems: (i) optimizations to flow-based software-defined networks to address the scalability and energy consolidation requirements, (ii) programming abstractions in wireless software-defined networks, and (iii) improved network virtualization to more efficiently support latency sensitive applications.
From the FLAMINGO consortium, 12 different members made strong contributions to the paper review process (multiple review cycles per accepted paper).

2.3.3 IJNM special issue on Advances in Management of Multimedia Services

University College London (UK) in collaboration with the University of Würzburg (Germany), NTT (Japan), the University of Missouri (USA), and the University of Antwerp (Belgium), has organized

a special issue of the International Journal of Network Management on the topic “Advances in Management of Multimedia Services”. The editors for this issue have been Dr. Marinos Charalambides (UCL), Dr. Thomas Zinner (University of Würzburg), Dr. Hiroshi Saito (NTT), Dr. Prasad Calyam (University of Missouri), and Steven Latre (University of Antwerp). The special issue has been published online in July 2015.

Based on important trends observed in the delivery of multimedia services, the special issue presents recent research that addresses challenges associated with key quality indicators, quality of experience (QoE) monitoring, and QoE control mechanisms. Ten papers were submitted for the special issue, and, after a thorough review process and discussion, three papers were published. The authors of these papers were given the time to update their paper and take the review comments and suggestions into account. The selected papers address topics that play a central role in the management of multimedia services: monitoring and measurement for determining the quality of multimedia sessions, and reconfiguration methods for improving their quality.

2.3.4 TNSM special Issue on Management of Softwarized Networks

This Special Issue of the IEEE Transactions on Network and Service Management (TNSM) focuses on Management of Softwarized Networks, including SDN/NFV-based systems and also Software-Defined Clouds, including edge clouds and Fog Computing.
The due date for paper submissions is February 15, 2016 and publication is scheduled for the September 2016 issue of TNSM.
Prof. Filip De Turck (iMinds) serves as the main editor of this special issue, together with Prosper Chemouil (Orange Labs, France), Raouf Boutaba (University of Waterloo, Canada), Christian Esteve Rothenberg (University of Campinas, Brazil), Kohei Shiomoto (NTT, Japan) and Minlan Yu (University of Southern California, USA).
Several members of the FLAMINGO consortium already confirmed to make strong contributions to the paper review process of this IEEE TNSM Special Issue.

2.4 Related Activities

The following eight activities were also performed by the FLAMINGO consortium in Y3, which are related to organizing the scientific community.

2.4.1 IEEE Communications Society Technical Committee on Network Operation and Management (IEEE CNOM)

CNOM is the IEEE Communications Society Technical Committee on Network Operation and Management. CNOM provides the Communications Society with a focus on network and service operation and management, and actively encourages the exchange of information on the operational and technical management aspects of public and private networks for voice, data, image, and video, and organizes and sponsors publications and discussions of these topics.

Prof. Filip De Turck (iMinds) serves as the CNOM Vice-Chair and represents FLAMINGO in CNOM.

2.4.2 IFIP Working Group 6.6 (WG 6.6 Management of Networks and Distributed Systems)

The IFIP Working Group (WG) 6.6 aims to facilitate cooperation between different organizations and individuals internationally in the areas of distributed operations and management, integrated

network management, systems management, and service engineering. It aims to be an effective conduit in the technology transfer between the academic and research communities, industry and the standard bodies.

Prof. Olivier Festor (INRIA) serves as the chair of IFIP WG 6.6, and Prof. Burkhard Stiller (UZH) as the co-chair of this IFIP WG 6.6.

2.4.3 IFIP Technical Committee 6 (TC6 - Communications Systems)

Technical Committee 6 (TC6 - Communications Systems) is an important Technical Committee within IFIP both in terms of its activity and of the revenue it generates for IFIP from publications and conferences. Currently, TC6 has ten Working Groups (WGs), the majority of which are concerned either with specific aspects of communications systems themselves or with the application of communications systems, one WG is concerned with communications in developing countries. TC6 meets twice a year, in Spring and Autumn (Fall), usually co-locating its meetings with a related conference.

Prof. Aiko Pras (FLAMINGO Coordinator) chairs IFIP TC6. The work of TC6 is largely concerned with managing and coordinating the WGs and with setting the strategies both for TC6 itself and for existing and future WGs.

2.4.4 IFIP Open Digital Library

Also in the third year of the FLAMINGO project IFIP TC6 continued its efforts regarding their Open Digital Library. As requested by the reviewers, FLAMINGO's third year annual report will clarify the objectives behind such Digital Library; this deliverable therefore focusses on the changes compared to the previous year.

First, the IFIP General Assembly embraced the Digital Library as developed by TC6 for all of IFIP. Therefore the URL was changed from `http://opendl.ifip-tc6.org` into `http://dl.ifip.org`. As already explained in D3.3 from last year, the library maintained by the University of Twente (with this year only limited support from FLAMINGO) will eventually migrate towards the INRIA HAL system.

Second, various new conferences in the area of network and service management, as well as networking in general, have published their 2015 papers in the Open Digital Library. Prominent examples are our flagship conference "Integrated Network Management" (IM 2015), including associated workshops such as MANFI 2015, IFIP Networking 2015, as well as CNSM 2015 (still to include at the time of writing this deliverable).

2.4.5 Network and Service Management Taxonomy

The FLAMINGO taxonomy (reported upon in D3.1) was fully implemented for the IFIP/IEEE IM 2015 symposium and for IEEE/IFIP NOMS 2016. A paper describing the FLAMINGO taxonomy is accepted for publication in JNSM (Springer Journal on Network and System Management).
During FLAMINGO Y3, a significant effort was performed to update the FLAMINGO Network and Service Management taxonomy. A taxonomy is very useful for a research community: it contains the topics of interest researchers can select when submitting a paper, these topics are then matched with the topics of expertise of the reviewers. It is important that this list of topics is kept

up to date to assure a good classification of the papers and a good match with the reviewers' expertise.
For this reason, a detailed questionnaire was organized and participation from experts (specialists in network and service management) was actively solicited by the FLAMINGO consortium. In total 154 experts participated to the questionnaire. The questionnaire was very interesting to have the experts' view on the key topics to be addressed (by the research community, not only their teams) during the next five years. These topics will be used for future Call-for-Papers of conferences and workshops in the network and service management community.
The questionnaire details, methodology, analysis of results, and updated taxonomy are presented in Appendices A-G of this deliverable: Appendix A describes the questionnaire contents, Appendix B present the taxonomy, which was used as a starting point for the questionnaire. This taxonomy was already an updated version compared to the FLAMINGO taxonomy reported upon in D3.1 (realized in FLAMINGO Y1), based on detailed discussions within the FLAMINGO consortium. Appendix C presents an analysis of the questionnaire outcome in terms of identified important and less important topics. Appendix D presents the study of new topics to be added to the taxonomy. A total of 202 topics were suggested. Appendix E presents a comparison of topics submitted to the main conferences in network and service management (IEEE/IFIP NOMS, IFIP/IEEE IM, and IFIP CNSM). Appendix F presents the updated FLAMINGO taxonomy. For completeness, Appendix G shows the full list of suggestions by the questionnaire participants.

The updated taxonomy is discussed in detail during a dedicated physical meeting with senior FLAMINGO members and also during a dedicated physical meeting with experts in network and service management. Furthermore, the updated FLAMINGO taxonomy will be presented and discussed during the CNOM and IFIP WG6.6 meeting co-located with CNSM in Barcelona, Spain.

A paper presenting the updated FLAMINGO taxonomy, the methodology and analysis of results being prepared for submission to the Journal on Network and Systems Management (JNSM).

The taxonomy is publicly available on the Simpleweb, the CNOM website and the FLAMINGO website.

2.4.6 IM 2015 Dissertation Session Organization

Prof. Olivier Festor (INRIA) organised the Dissertation sessions during IFIP/IEEE IM 2015, May 13-14 in Ottawa, Canada. The goal of the Dissertation sessions is to provide Ph.D. students in the area of network and service management the opportunity to present their Ph.D. work to a wide international audience and to give out an award for the best work. The assessment criteria for the award include the relevance of the work for network and service management, the potential of the thesis results for future engineering practice, the novelty and contribution of the work, as well as the quality of publications and software produced as part of the thesis.
From the 15 submitted Ph.D. dissertations, 8 were accepted for presentation during IFIP/IEEE IM 2015. Two FLAMINGO members presented their Ph.D. realizations:

- Ricardo Schmidt (University of Twente), *Measurement-Based Network Link Dimensioning*, with Ph.D. advisors: Prof. Aiko Pras (University of Twente) and Dr. Hans van den Berg (TNO, the Netherlands).
- Rashid Mijumbi (UPC), *Self-managed Resources in Network Virtualisation Environments*, with Ph.D. advisors: Joan Serrat (UPC), Juan Luis Gorricho (UPC).

The IFIP/IEEE IM 2015 Dissertation award was given to Amir Nahir (Technion, Israel) for his Ph.D. dissertation on *Resource Allocation and Management in Cloud Computing*, with Ph.D. advisors: Prof. Ariel Orda (Technion, Israel) and Prof. Danny Raz (Technion, Israel).

2.4.7 Best Paper Awards

The paper *DNSSEC and Its Potential for DDoS Attacks: A Comprehensive Measurement Study* by Roland van Rijswijk-Deij, Anna Sperotto and Aiko Pras and published in the 2014 ACM Internet Measurement Conference (IMC 2014) has been recognized with the following awards:

- the *ACM IMC Community Contribution Award* at IMC 2014, awarded by the IMC TPC to the paper that has made an outstanding contributiong in terms of publicly released datasets.
- the *IRTF Applied Networking Research Prize 2015*, awarded for recent results in applied networking research that have the potential to provide a scientific foundation for possible IETF and IRTF work. This research will be presented at IETF-94, Yokohama November 1-6, 2015.

The AIMS 2015 best papers were awarded to two FLAMINGO papers (one by University of Twente and one by University of Zürich):

1. *How asymmetric is the Internet? A Study to Support the use of Traceroute* by Wouter de Vries, José Jair Santanna, Anna Sperotto, and Aiko Pras.
2. *Schengen Routing: A Compliance Analysis* by Daniel Dönni, Guilherme Sperb Machado, Christos Tsiaras, and Burkhard Stiller.

2.4.8 Student Travel Grants

During IFIP/IEEE IM 2015, the following Student Travel Grants were awarded to authors from the FLAMINGO consortium (based on their application and high ranking of their paper):

- Rashid Mijumbi (iMinds)
- Jeroen van der Hooft (iMinds)
- Jessica Steinberger (University of Applied Science - Darmstadt and University of Twente)
- Daniel van der Steeg (University of Twente)
- Olivier van der Toorn (University of Twente)

3 Organization of Specific Workshops and Events

In this section, the various specific workshops and events organized by the FLAMINGO consortium in Y3 (23 in total), are detailed in chronological order.

3.1 Contributions to Munich Science Days

In the beginning of November 2014 (08.-11.11.2015) the CODE Research Center participated with an own exhibition booth at the Munich Science Days[1]. On the one hand the idea behind this regularly event is to show recent research work done to the public. On the other hand it allows everyone to ask questions to researchers. The overall topic of the event from 2014 was “Digital Worlds”. This fits perfectly with the purpose of the Research Center CODE. On the last day of this event the spokesperson of the Research Center CODE Prof. Gabi Dreo Rodosek gave a keynote with the title “Cyber-Defense vor dem Hintergrund der NSA-Affaire”. The overall event was attended by 300 researchers to present their research and experts such as Ranga Yogeshwar, Harald Lesch and Wolfgang Heckl. In total, the event consisted of 30 presentations and 25 exhibition booths.

3.2 International Workshop on Management of SDN and NFV Systems, ManSDNNFV 2014

The first International workshop on Management of SDN and NFV (ManSDN/NFV), was established by the FLAMINGO consortium (founded by Prof. Filip De Turck and co-chaired by Dr. Marinos Charalambides, UCL). The first instance of the workshop was held in conjunction with CNSM 2014 in Rio de Janeiro Brazil, on November 21st. We received 21 submissions. All papers received a minimum of three reviews, with most receiving four reviews. Out of the 21 papers, 9 were accepted as full papers, which were presented orally, and 5 as short papers presented as posters. The proceedings included both the full and the short papers. The keynote talk was given by Prof. Danny Raz (Technion, Israel) on ”When NFV Meets SDN: A Short Circuit or Sparkling Fireworks?”. The workshop was a success and attracted significant interest from both industry and academia. Of special mention was the level of interaction among participants and presenters. The best paper award was given to A. Amokrane, J. Hwang, J. Xiao, and N. Anerousis for their paper “Software Defined Enterprise Passive Optical Network”.

Together with Dr. Marinos Charalambides, Prof. Dorgival Guedes (UFMG, Brazil), Dr. Liam Fallon (Ericsson, Ireland), and Dr. Toshio Tonouchi (NEC, Japan) served as workshop co-chairs.

3.3 FITCE event 2015 “Dematerializing ICT Networks”

On March 4th, 2015 an event was organized together with FITCE (Federation of Telecommunications Engineers of the European Union), in Ghent, Belgium. The theme of the event was “Dematerialising ICT networks: where do we stand and where are we going? — A view from academics and industry”. FITCE was founded in 1961 and regularly organizes events on relevant and upcoming topics in the telecommunication industry.
Prof. Filip De Turck (iMinds) contributed to the event and gave a talk on “SDN/NFV-based systems: status and challenges”, highlighting the FLAMINGO contributions and achievements in this area. The main technologies and enablers for SDN/NFV-based systems were detailed, together with the

[1] http://www.muenchner-wissenschaftstage.de/2014/

reason why network operators and service providers are eager to adopt the SDN/NFV principles. It was shown that efficient management of software-defined virtualized telecommunication systems and datacenters will be of key importance in the future and the key challenges for future research were addressed as well.
There were also talks from Alcatel-Lucent on “Transition from Clouds to NFV: a story about technology and innovation” and from Cisco on “SDN and NFV development acceleration and the importance of open platforms”. 75 attendees from industry and academia participated to the event and the discussions.

3.4 Organization of the “Connected Choices” Panel

On March 6th 2015, the Research Center CODE organized a panel with around 50 participants. The events started with a keynote from Melissa Hathaway (President of Hathaway Global Strategies, LLC) with the topic “Connected Choices: How the Internet Is Challenging Sovereign Decisions”. They keynote highlighted current problems and trend in the Future Internet in the next ten years. In addition, the presentation addressed the geopolitical interests of states to get connected to the Internet, since this builds the basis for further resources like, e.g. tax for Internet transactions or the control of data streams. These issues can only be addressed by the support of international standards and guidelines. In the following, a lively discussion about the Future Internet inspired by this keynote took place.

3.5 Organization of CODE Research Center Annual Meeting

From Wednesday 25 March to Thursday 26 March 2015 the CODE Research Center organized the Annual Meeting at the Universität der Bundeswehr Munich, where numerous well-known national and international representatives from politics, economy and authorities attended. The first day of the event started with eight keynotes by national and international representatives from politics, economy and research institutions. Afterwards an interesting panel discussion with the title “Orwell vs. Privacy - Wie viel Überwachung braucht der Staat?” took place. The following panelists participated to the discussion:

- Marc Bachmann, Bereichsleiter “Öffentliche Sicherheit”, BITKOM
- Dr. Thomas Daum, Flottillenadmiral, Abteilungsleiter Informationstechnik, Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr
- Dr. Alexander Duisberg, Rechtsanwalt, Co-Head der International IT Sector Group, Partner, Bird&Bird
- Peter Kestner, Partner, Deloitte
- Sebastian Schreiber, Senior Consultant, Geschäftsführer, SySS GmbH
- Helmut Ujen, Leitender Kriminaldirektor, KI 4 - Kompetenzzentrum Informationstechnische Überwachung, Bundeskriminalamt

The second day consisted of three keynotes and a five parallel workshops with highly relevant topics (Drone Defence - with Jamming and Spoofing, Industry 4.0 - How to secure production chains against industrial espionage?, New Problems in IT forensics, IT Security Act - The master stroke?, BigData). In the afternoon the results from the five workshops were presented. Please find below the keynote speakers which contributed to the events and made it therefore an interesting and valuable event to connect research and industry partners as well public authorities.

- Maurice Cashman, Director, Security Architecture, McAfee. Part of IntelSecurity
- Peter Dathe, Präsident, Bayerisches Landeskriminalamt
- Gabriele Korb, Stv. Amtschefin, Luftfahrtamt der Bundeswehr
- Dr. Burkhard Körner, Präsident Bayerisches Landesamt für Verfassungsschutz
- Andreas Könen, Vizepräsident, Bundesamt für Sicherheit in der Informationstechnik
- Heinz Lutz, Geschäftsleitung, Roschi Rohde&Schwarz AG
- Dr. Rolf Reinema, Head of Technology Field IT Security, Siemens AG
- Michael Sieber, Head of Unit Information Superiority, European Defence Agency
- Dr. Markus Zoller, CEO, RUAG Schweiz AG - RUAG Defence

The annual meeting was accompanied by a parallel technical exhibition from industry and research partners. Please find below the list of participating partners for the technical exhibition:

- Airbus Defence and Space
- Bayerisches Landeskriminalamt
- Bundeskriminalamt
- Codenomicon
- CounterTack
- Ectacom
- ESG
- General Dynamics - Fidelis Cybersecurity Solutions
- Giesecke & Devrient
- Hexis Cyber Solutions
- LRZ München
- McAfee. Part of Intel Security
- Rohde & Schwarz
- SAP
- Schönhofer
- Secunet
- Sicherheitsnetzwerk München
- VOICE e.V. - Bundesverband der IT-Anwender

3.6 IEEE Workshop on Security Issues in SDN (SEC-SDN)

FLAMINGO has co-chaired the IEEE International Workshop on Security issues in SDN — Sec-SDN 2015 which was held during the IEEE International Conference on Network Softwarization (NetSoft 2015) on April 17, 2015. Software Defined Networking emerged as a game changer and major business enabler for current vendors, operators and software developing companies. In the meantime, security in SDN is becoming crucial for the deployment and acceptance of SDN based networks and critical infrastructures and thus many current research efforts are addressing various pieces in this research landscape. With topics that range from deep packet inspection, data analytics for SDN and data plane virtualization, Sec-SDN 2015 provided support to academic and industrial researchers for scientific exchanges and high quality paper presentations related to the security issues in SDN. In addition to the technical track, this first edition of the workshop included a keynote on “Virtualized Software DPI” and a panel dedicated to “Increased software in the Network: Security Threats and Opportunities”.

3.7 FLAMINGO Participation to TMA PhD School 2015

FLAMINGO students have taken part to the PhD School of the Traffic Monitoring and Analysis workshop, held in Barcelona, April 21-22, 2015. The following posters have been accepted for presentation to the summer school, and the authoring PhD students have been invited to attend:

- “Determining the State of Security in the IPv6 Internet”, by L.Hendriks, A. Sperotto and A. Pras (UT)
- “DDoS Attack Mitigation using OpenFlow-based SDN”, by M.Jonker and A. Sperotto (UT)
- “Characterizing and Mitigating the DDoS as a Service Phenomenon”, by J. Santanna, A. Sperotto and A. Pras (UT).

3.8 International Workshop on Management of the Future Internet, ManFI 2015

The FLAMINGO consortium organized the International Workshop on Management of the Future Internet (ManFI 2015) with Prof. Filip De Turck (iMinds) as the main organizer. The workshop took place on May 11th, 2015 in Ottawa, Canada. More than 30 people from industry and academia attended and actively participated to the workshop.

The keynote was given by Dr. Anwar Haque, Bell Canada with the title “The Impact of new Services on the Management of Telecommunication Networks - Vision and Challenges”. The main technical track was divided in three topics, where interactive discussions were initiated by the session chairs, based on paper presentations:

- *Traffic Management*, with presentations from colleagues from Osaka University (Japan), NTT (Japan), Bosco Technologies Inc. (Japan) and McMaster University (Canada);
- *Fog Computing Management*, presented by researchers from Korea Advanced Institute of Science and Technology – KAIST (Korea), Liverpool John Moores University (UK), University of Hamburg (Germany), Ghent University - iMinds (Belgium), Alcatel-Lucent (Belgium), Dasan Networks Corp. (Korea), and University of La Rochelle, France;
- *SDN/NFV Management*, presented by researchers from University of Würzburg (Germany), iMinds (Belgium), Nokia (Germany), CREATE-NET (Italy), and Dell (USA).

Prof. Pieter Simoens (iMinds) served as a ManFI 2015 session chair. Next to Prof. Filip De Turck, Prof. Kazuhiko Kinoshita (Tokushima University, Japan) served as workshop co-chair.

3.9 International Workshop on Quality of Experience Centric Management, QCMan 2015

The FLAMINGO consortium organized the International Workshop on Quality of Experience Centric Management (QCMan 2015) with Prof. Filip De Turck (iMinds) as the main organizer. The workshop took place on May 11th, 2015 in Ottawa, Canada. More than 25 people from industry and academia attended and actively participated to the workshop.
The keynote was given by Prof. Tobias Hossfeld (University of Duisburg-Essen) with the title "QoE++: Shifting from Ego- to Eco-System?". The main technical track was divided in four topics. Interactive discussions were initiated by the session chairs based on paper presentations:

- *Network-assisted Video Streaming*, with presentations from researchers of University of Ghent-iMinds (Belgium) and Alcatel-Lucent (Belgium);
- *Video Streaming and QoE*, presented by colleagues from University of Duisburg-Essen (Germany), University of Würzburg (Germany), Beijing University of Posts and Telecommunications (China), and Technische Universitaet Muenchen (Germany);
- *Virtual Desktop Environments*, presented by researchers from University of Missouri-Columbia (USA);
- *Techniques to model and improve Quality of Experience of networked services*, by researchers from University of Duisburg-Essen (Germany), University of Zagreb (Croatia), Jerusalem College of Technology (Israel), University of Zilina (Slovakia), Athens University of Economics and Business (Greece), University of Maribor (Slovenia), National University of Ireland, Galway (Ireland), University of Pennsylvania (USA), Eindhoven University of Technology (the Netherlands), University of Debrecen (Croatia), and Budapest University of Technology and Economics (Hungary).

In order to further stimulate discussions amongst the participants, a panel was organized with the title "QoE Management in the era of Big Data, Clouds, and the IoT – Opportunities and Pitfalls". The following colleagues served as panelists: Prof. Phuoc Tran-Gia (University of Würzburg, Germany), Prof. Alberto Leon-Garcia (Toronto University, Canada), Prof. Steven Latré (iMinds, Belgium).
Next to Prof. Filip De Turck, Dr. Thomas Zinner (University of Würzburg, Germany) and Prof. Prasad Calyam (University of Missouri-Columbia, USA) served as workshop co-chairs.

3.10 IM 2015 Demo Session Organization

Dr. Marinos Charalambides (UCL) and Prof. Jürgen Schönwälder (JUB) organized the demonstration session during the IFIP/IEEE International Symposium on Integrated Network Management (IM 2015). 23 demonstration papers were submitted (2 pages in IEEE double column format) and after a peer review process (2 reviews per submission) 18 were accepted. The 4 papers rejected were either out of scope or promoting industrial products. Out of the 18 demos accepted 7 had a companion paper in the main IM track, 4 in the experience session and 1 in the mini-conference.

During the conference, the accepted demos were organised in three dedicated sessions (6 demos each) which were held on different days of the conference. The demonstrations came from students, academic researchers and faculty members, as well as industrial researchers, who used posters and live demos on machines to present their ideas. The three sessions generated a lot of discussion around the research prototypes and the emerging technologies presented. A best demo award was presented in the closing ceremony of IM 2015 and was given to P.H. Isolani, J. Wickboldt, C. Both, J. Rochol, and L.Z. Granville for "SDN Interactive Manager: An OpenFlow-Based SDN Manager". All demos were included in the electronic conference/workshops proceedings and made available via the Open Digital Library and IEEExplore.

3.11 FLAMINGO Demonstration during IM 2015

During the IEEE/IFIP International Symposium on Integrated Network Management (IM 2015), FLAMINGO partners have given the demonstration of a platform for the analysis and visualization of network flow data of android environments. This platform relies on a set of on-device probes to monitor network and system activities of these applications. The data are collected from these probes and parsed through generic and flexible collectors relying on Flume agents that we have adapted and extended. The collected data are then stored using a column oriented Hbase storage engine which is the Hadoop database. Finally, after being parsed, they are made available within the Elasticsearch engine to search and visualize them using the Kibana tool. This well attended demonstration took place during the dedicated session in the IM 2015 schedule, and the FLAMINGO acknowledgement was prominently mentioned.

3.12 IFIP/IEEE IM 2015 Workshops

Next to the organization of the already mentioned ManFI 2015 and QCman 2015 workshops, Prof. Burkhard Stiller organized the following workshops during IFIP/IEEE 2015 as workshop chair:

- IFIP/IEEE DISSECT 2015 (International Workshop on Security for Emerging Distributed Network Technologies)
- IFIP/IEEE BDIM 2015 (International Workshop on Business Driven IT Management)
- IFIP/IEEE CogMan 2015 (International Workshop on Cognitive Network Management)

Main focus of the workshops were interactive discussions between the researchers from academia and industry.

3.13 36th Network Management Research Group (NMRG) meeting

This meeting was organized by Prof. Olivier Festor (INRIA) on May 15th 2015 in Ottawa, Canada. There were two 30 minute presentations by FLAMINGO consortium:

- *Extending IP Flow-Based Network Monitoring with Location Information*, draft-irtf-nmrg-location-ipfix, by Abdelkader Lahmadi, INRIA.
- *The DDoS as a Service Phenomenon. Everyone can attack you at the press of a button!* by José Jair Santanna, Twente University.

Furthermore, the present FLAMINGO members contributed to the discussion during this NMRG meeting.

3.14 NDIX Relation Day for Internet Exchange Germany - the Netherlands

On June 11, 2015 Prof. Aiko Pras gave a presentation on the topic “Internet Security and Privacy” for the NDIX (Netherlands - Germany Internet Exchange) relation days, which took place in the FC Twente stadion in Enschede and addressed 250 people working in the Twente region on ICT and networking. The presentation showed some examples of recent NSA programs, such as HACIENDA. LANDMARK and PRISM. It gave some details of zero-day exploits, such as StuxNet and Heartbleed. In the second half of the presentation recent results of our FLAMINGO DDoS research were presented, and the audience was shown how easy and effective it is to perform large scale DDoS attacks using booters.

3.15 FLAMINGO Participation to the TERENA 2015 conference

FLAMINGO has taken part in the TERENA 2015 conference, held in Porto, 15-18 June, 2015 with the poster ad associated lightning talk: “Determining the State of Security in the IPv6 Internet”, by L.Hendriks, A. Sperotto and A. Pras (UT).

The TERENA 2015 conference attracted 600 industry participants.

3.16 EuCNC 2015 Workshop on Management of Network Function Virtualization

Prof. Filip De Turck contributed to the workshop and discussions, together with two presentations from FLAMINGO members:

- *Benefits of NFV-based Multimedia Delivery* by Niels Bouten (iMinds)
- *Management and Control Functionality in Software Defined Networks* by Daphne Tuncer (UCL)

More details on the workshop organization and the FLAMINGO contributions are described in section 5.5 below.

3.17 Workshop on Multimedia Streaming in Information Centric Networks (MuSiC)

On July 3, 2015 a workshop was organized in Turin, Italy by Prof. Hermann Hellwagner (Klagenfurt University, Austria) with strong contributions by Prof. George Pavlou (UCL) and Stefano Petrangeli (iMinds). The main aim of the workshop was to bring together the Multimedia Systems/Communications research community and the Information-Centric Networking research community. These two communities barely interacted in the past. Multimedia communications researchers still mostly think and operate in the context of IP networks, while ICN researchers mainly discuss key networking aspects, not focusing on the requirements, challenges and opportunities of real-time multimedia data delivery/streaming (even though there are a few notable exceptions). Yet, recent intense discussions on the IRTF mailing list on video delivery and QoS/QoE and several publications indicate increased interest of ICN experts in multimedia communication.
The workshop provided a forum to bring the two communities together, and resulted in vivid discussions and intense exchange and learnings at the intersection of the two areas. Prof. George Pavlou (UCL) gave a keynote talk on “Information Centric Networking support for Multimedia Services: Overview, Current State and Challenges” and Stefano Petrangeli (iMinds) presented the FLAMINGO views on “SVC-Based Adaptive Streaming in Information Centric Networks”.

3.18 Organization of Workshop with SURFsara, the Netherlands

On July 9, 2015, the FLAMINGO consortium organized an one-day workshop with SURFsara[2] in Amsterdam, the Netherlands (hosted by SURFsara). Ricardo de Oliveira Schmidt, from the University of Twente, served as the main organizer. The goal of the workshop was twofold: (1) disseminate the FLAMINGO results to researchers and operators at SURFsara, a subsidiary of SURF (collaborative organization for ICT in Dutch higher education and research) and a major provider and facilitator of high performance computing and data infrastructure for science and industry; and (2) learn from SURFsara their main challenges on networking and their vision.

There were 17 participants, being 14 from the FLAMINGO consortium and the 3 experts from SURFsara (including Walter Lion, group leader on supercomputing and senior consultant at SURFsara). SURFsara presented their infrastructure, services and challenges on high performance computing and data storage. SURFsara also took the workshop participants for a tour through their dependencies including the supercomputer. From FLAMINGO, 6 presentations were given, namely

- "Decision Support System for Distribution Centers and Temporary Storages of Supply Networks", by Peter Hillmann, from the Universität der Bunderswehr München;
- "Towards Cloud-Based Compositions of Security Functions for Mobile Devices", by Jerômé François, from INRIA;
- "How Asymmetric is the Internet?", by Wouter de Vries, from the University of Twente;
- "Adaptive Video Streaming Delivery", by Stefano Petrangeli, from Ghent University, iMinds;
- "Tussel Analysis and Two-way authentication for constrained devices", by Corinna Schmitt, from the University of Zurich;
- "DNS Measurement Infrastructure", by Mattijs Jonker, from the University of Twente.

After each presentation, there were interactive discussions about further opportunities of collaboration between SURFsara and FLAMINGO, and also among FLAMINGO consortium partners. Very interesting and valuable feedback was provided by all members in the audience.

3.19 IRTF NMRG Workshop on Flow-Based Network Management

Giving continuity to the tradition, the IRTF NMRG Workshop was organized within the IETF 93 meeting in Prague, Czech Republic, on July 24, 2015. This year the workshop was named "Workshop on flow-based network management" and was organized by Ricardo de Oliveira Schmidt from the University of Twente, and Ramin Sadre from the Université Catholique de Louvain.

The workshop had a great attendance, with a peak of more than 30 people in the audience. There were nine presentations, authored by universities and institutions from all over Europe. Two of these were authored by FLAMINGO partners, namely:

- "TinyIPFIX for Efficient Data Transmission in Wireless Sensor Networks", by Corinna Schmitt from the University of Zurich;

[2] https://www.surf.nl/en/about-surf/subsidiaries/surfsara/

- "Towards botnet detection: What botnet characteristics can be detected in real-life network environments by using flow data?", by Christian Dietz, from the Universität der Bundeswehr München.

The other presentations were:

- "Hardware Accelerated L7 Monitoring at 100 Gbps", by Lukáš Kekely, from CESNET;
- "Interactive Monitoring, Visualization, and Configuration of OpenFlow-Based SDN", by Pedro Isolani, from Federal University of Rio Grande do Sul;
- "Flow data storage and retrieval utilizing big data approach", by Martin Zadnik, from CESNET;
- "Characterizing the IPv6 security landscape by large-scale measurements", by Luuk Hendriks, from University of Twente;
- "Automaton models can be applied for fingerprinting and classifying network participants", by Cristian Hammerschmidt, from University of Luxembourg;
- "Distributed Anomaly Detection Based on Flow Information", by Carlos Garcia, from TU Darmstadt;
- "Challenges for flow-based management – implications from draft-unify-nfvrg-devops", by Catalin Meirosu, from Ericsson Research.

The workshop program and the slides of all presentations are publicly available online at the IETF 93 meeting website[3]. A report on the workshop is being prepared for submission to the Journal of Network and Services Management (JNSM), with explicit FLAMINGO acknowledgement.

3.20 Organization of the "Capture the Flag" event

At the end of October (23./24.10.2015) the CODE Research Center will organize a "Capture the Flag" event at the Universität der Bundeswehr München. To goal of this event - the first CTF at the Universität der Bundeswehr München - is to identify people with strong interests and knowledge in solving IT and IT security related tasks. Therefore, challenges with various level of difficulty will be available to be solved by the teams. A team consists of two to four participants, which have to be defined in advance.

3.21 International Workshop on Management of SDN/NFV Systems, ManSDNNFV 2015

Following the success of the first International workshop on Management of SDN and NFV, referred to as ManSDN/NFV, the FLAMINGO consortium organized the second ManSDN/NFV workshop, which will be held in conjunction with CNSM 2015 in Barcelona, November 13th. The event, which is co-chaired by Dr. Marinos Charalambides (UCL), received 23 submissions (2 more than last year) and the program is currently being decided. Like its predecessor, the workshop is expected to attract significant interest from both industry and academia and to have a highly interactive nature.

Together with Dr. Marinos Charalambides, Dr. Alberto E. Schaeffer-Filho (UFRGS, Brazil), Prof. David Hausheer (Technische Universitaet Darmstadt, Germany) and Dr. Diego López (Telefónica, Spain) serve as workshop co-chairs.

[3] https://www.ietf.org/proceedings/93/nmrg.html

3.22 Dagstuhl Seminar 16012: Global Measurements: Practice and Experience

The Dagstuhl Seminar “Global Measurements: Practice and Experience” will take place from January 4th to January 7th, 2016 in Schloss Dagstuhl. The seminar, a follow-up of Dagstuhl Seminar 13472 “Global Measurement Frameworks” that took place in November 2013, aims at discussing the practical experience gained with global measurement frameworks and it will look at the experience gained with metrics, data processing technologies, and data analysis methods. Prof. Jürgen Schönwälder (JUB) serves as the main organizer from the FLAMINGO consortium, the coordination of the seminar is done by Vaibhav Bajpai, also a FLAMINGO consortium member from Jacobs University Bremen.

3.23 IEEE/IFIP NOMS 2016 workshops on Future Internet Management

Prof. Filip De Turck serves as Workshop Chair of the IEEE/IFIP Network Operations and Management Symposium (NOMS 2016). In total seven different workshops will be organized during NOMS 2016. Two workshops already existed before and will organize a next edition during NOMS 2016:

- IEEE/IFIP DISSECT 2016 (International Workshop on Security for Emerging Distributed Network Technologies)
- IEEE/IFIP ManFi 2016 (International Workshop on Management of the Future Internet, with main theme: efficient management of SDN/NFV-based systems)

Five new workshops are established with contributions from the FLAMINGO consortium:

1. IEEE/IFIP PASC 2016 (International Workshop on Platforms for Smart City Management)
2. IEEE/IFIP UMITS 2016 (International Workshop on Management of Intelligent Transportation Systems)
3. IEEE/IFIP AnNet 2016 (International Workshop on Data Analytics for Network and Service Management)
4. IEEE/IFIP 5GMan 2016 (International Workshop on Management of 5G Networks)
5. IEEE/IFIP ManFIoT 2016 (International Workshop on Management of Fog Computing and Internet of Things)

The interaction between industry and academia is strongly stimulated for all these workshops, and many interesting areas for managing future networks are covered in these workshops.

4 Interoperability and Testing Labs

The NETCONF interoperability lab, described in some detail in the deliverables D3.2 and D3.3, has been maintained in the third year of the FLAMINGO project by installing software updates and maintaining the underlying virtual machine infrastructure. During the third year, the focus has been on the design and implementation of the OpenFlow testing lab.

4.1 OpenFlow Testing Lab

The OpenFlow testing lab allows us to study how OpenFlow switches and controller reacts to attacks or anomalous traffic.

4.1.1 Background

SDN (Software-Define Networking) paradigms have deeply impacted the network management community by paving the ways to more centralized and so more controlled management. Indeed, the main principle consists in splitting the control plane and the data plane. Hence, a SDN-enabled switch is only a specialized device in forwarding data traffic according to a number of rules specified by a remote controller. OF (OpenFlow) is a de facto standard in the SDN world and Figure 1 highlights a standard use case. In that case, when a packet from X to y arrives at the switch, the switch informs the controller (*PacketIn*), which decides how to forward such a packet and all the successive ones belonging to the same flow, i.e. sharing some common headers (IP addresses, ports, etc.). The controller thus installs a new rule into the flow table of the switch (*FlowMod*), e.g., to forward the packet on port of the switch, and then request the switch to forward the packet (*PacketOut*). There are also other modes of functioning, for example by installing pro-actively flow table entries without any *PacketIn* messages as trigger.

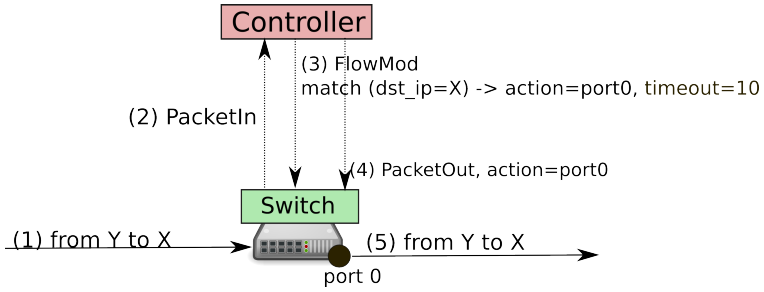


Figure 1: OpenFlow overview

4.1.2 Objectives

As highlighted in the previous sections, the controller plays a central role in OF. While the ONF (Open Networking Fundation) specifies a protocol and capabilities, some of them are optional. Hence, all OF controllers do not bring the same level of capabilities. More than that, they are quite sensitive components as the entire network can be affected by an abnormal behavior of a controller. They thus have to be resistant to attacks and anomalies. In FLAMINGO, we are particularly interested to test OF controllers under attack scenarios like DoS (Denial-of-Service). The final testing platform is depicted in Figure 2.

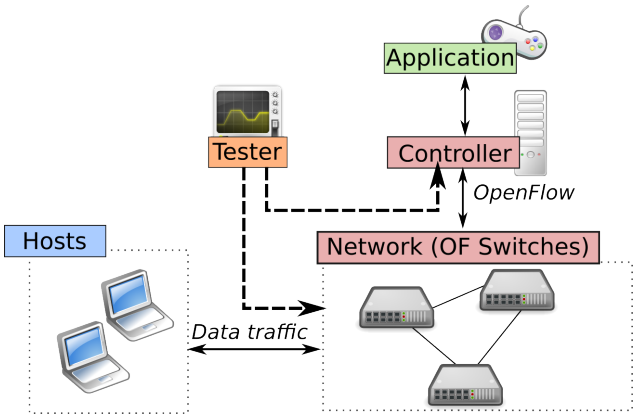


Figure 2: OpenFlow testing platform

As shown in Figure 2, the OF controller can be be attacked through different communication channels:

- the Northbound API is specific to each controller which can expose its own capabilities. We thus decided to exclude this one from our research as we want to be able to support any other controller and run our tools.
- the Southbound API forwards OF traffic and make this channel a good candidate for carrying OF-level attacks independently of the controller.
- the data plane can also be used to impact the controller as the data traffic may entail OF traffic. It is a side-effect attack.

4.1.3 Testbed Construction

The contribution in year 3 was focused on the construction of a dedicated tesbed. As a malfunctioning controller can impact the controlled devices, i.e., the switches, it is important to have a full testbed with a controller, switches and connected hosts in the network. Also, we want to leave the possibility of changing the switches because a controller may not be considered as impacted by an attack while the switch can be. For example, a DoS may consist in injecting faked flow tables rules to the switches through the controller (either by spoofing the switches for sending *packet_in* messages or by sending crafted traffic on the data plane level). The controller may support the load and will flood the switch with *flow_mod* messages. Hence, in that case, the controller transparently carries the attack to the switch.

With such an approach, we keep our testbed open to change the controller or the switches in Figure 2. As switches might be virtual machines but also real hardware, a physical testbed has been constructed.

It is composed of:

- 4 TP-Link TL-WR1043ND routers
- 5 Raspebery-Pi machines playing the role of network hosts used to generate traffic between them
- 1 controller hosted in a desktop PC

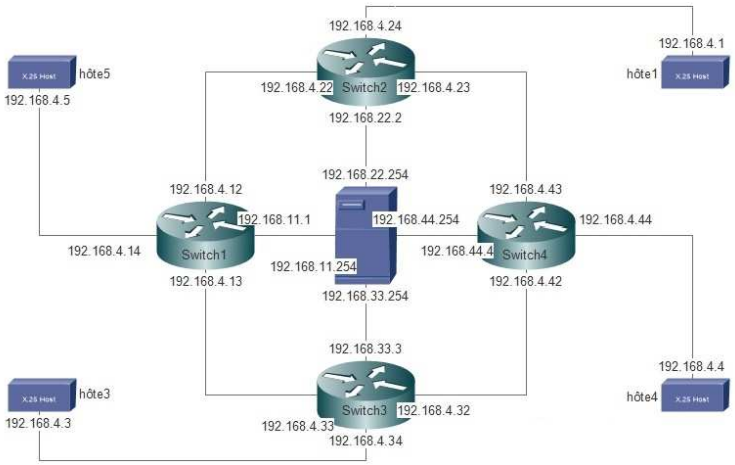


Figure 3: Testbed topology

The initial topology for preliminary test is shown in Figure 3.

Initial tests have been performed using the OpenDaylight controller[4].

4.1.4 Future Plans

Because the testbed is now set up, the next year will be dedicated to design and develop the testing tool represented in Figure 2 as the tester to assess the behavior of different controllers when this tool is used.

[4] https://www.opendaylight.org/

5 Integration of European Research Landscape

During FLAMINGO Y3, the consortium organized and contributed to the Future Internet Architecture Cluster meetings, the NetFutures 2015 event, the NetWorld2020 event, the EUCnC 2015 conference, and collaborated with 9 other on-going EU projects.

5.1 Future Internet Architecture Cluster

The Future Internet Architecture Cluster takes care of the coordination between the ongoing Future Internet projects. The projects belong to the FP7, H2020 and 5G-PPP work programs. At the time of writing, 24 Future Internet projects are taking part in the Future Internet Cluster. Prof. Filip De Turck chairs the Future Internet Architecture Cluster since August 2014. Prof. Thomas Michael Bohnert serves as deputy chair of the Future Internet Architecture Cluster.

The Future Internet Architecture Cluster organizes joint coordination meetings and represents the ongoing Future Internet projects. The main realizations of the Future Internet Architecture Cluster are the editorial role for delivering joint position papers (with contributions from all participating projects, the position papers will be used as input for the upcoming calls for H2020 project proposals), contributions to workshops, the organization of the coordination meetings and contributions during the Net Tech Future coordination meetings. These main contributions are presented in more detail below.
Moreover, the FLAMINGO consortium maintains the website of the Future Internet Architecture Cluster: `http://fi-cluster.futureinternet.eu/`.

5.2 Future Internet Architecture Cluster meeting during NetFutures 2015

The NetFutures event replaces the formed FIA event, and was organised by iMinds and the European Commission, March 25-26, 2015 in Brussels. The NetFutures event attracted over 700 attendees. The theme of the event was “Born to Scale”.
During the event a meeting of the Future Internet Architectures Cluster was held, organized and chaired by Prof. Filip De Turck (iMinds). During the meeting, results of two recently finished cluster projects (eCousin, Leone) were presented by the project coordinators. Next, the new cluster projects (BEBA, ENDEAVOUR, NEAT, POINT, reTHINK, RIFE, UMOBILE) presented their objectives and viewpoints, followed by discussions.
In order to stimulate discussions on synergies between the ongoing projects, a discussion session was organised on “SDN/NFV and Network Apps — a view from the cluster”. A few short presentations from the projects were given, followed by an open and lively discussion between the project representatives. The position paper by the Future Internet Cluster (with editors Prof. Filip De Turck, Prof. Thomas Michael Bohnert and Dr. Antonio Cimmino) was discussed and disseminated to the project representatives of the Future Internet projects. Next, the preparation of a short paper with a joint vision on the topic of “SDN/NFV and Network Apps” was discussed.
The next meeting of the Future Internet Architecture Cluster is planned to be co-located with NetFutures 2016, Brussels, Belgium, April 2016.

5.3 Collaboration with Related European Research Projects

In FLAMINGO Y3 the following collaborations with European research projects took place by the different partners:

JUB collaborated with researchers from the FP7 project Leone and the Marie Curie Innovative Training Network (ITN) METRICS. The Leone project ended in February 2015 and focused on a network management framework that integrates a very large number and diversity of sources of information about the network and its performance, including measurements focussed on the quality of experience perceived by the end users in a world of highly distributed and increasingly meshed applications. The METRICS project aims to study the factors that influence our understanding of the performance of the global Internet. The result of the collaboration was a joint proposal to organized a Dagstuhl Seminar "Global Measurements: Practice and Experience". The seminar will take place in January 2016.

UCL has been collaborating with FP7 FUSION on decentralised cloud management. A joint paper with the title "Self-Tuning Service Provisioning for Decentralized Cloud Applications" had been submitted to IEEE TNSM as a result of this collaboration. During the reporting period the review comments received were addressed and the paper was submitted for another round of reviews. In addition, UCL has been collaborating with a UK EPSRC project on knowledge-centric networking (www.ee.ucl.ac.uk/kcn-project/), which is between three UK institutions. The architecture of the project for knowledge generation and dissemination has been influenced by the distributed management framework developed in the context of WP6.

UT continued its collaboration with the mPlane project (as collaborating institution) and the Mobile Cloud Networking (MCN) project. UT has collaborated with the MCN project in the context of cloud networking, which resulted, for example, in the positioning paper "OpenFlow-based Link Dimensioning" in Supercomputing 2014. In addition, UT is also collaborating with the STREP project SALUS. SALUS aims at investigating security and interoperability aspects in next generation PPDR communication infrastructures. The collaboration with SALUS has yielded publications such as "A first look at HTTP(S) intrusion detection using NetFlow/IPFIX" (IM 2015), "Real-time DDoS attack detection for Cisco IOS using NetFlow" (IM 2015) and "Unveiling flat traffic on the Internet: An SSH attack case study". Finally, UT is collaborating with the Dutch NWO project D3 – Distributed Denial-of-Service Defense: protecting schools and other public organizations. The goal of the project is to investigate detection and mitigation of DDoS attacks on public organizations.

UniBwM collaborated in Y3 with national research projects SVFUA and fit4sec. The aims of the first is to provide a key-management and key-exchange as well as encrypted communication in radios environments. The latter project develops an information system to identify trending topics for technology scouting.

iMinds collaborated in Y3 with the EU projects Fed4FIRE and Unify and the national project V-FORCE. Fed4FIRE establishes a cloud-based experimentation platform for large experiments. FLAMINGO experiments were conducted on the Fed4FIRE platform and feedback was incorporated in the platform design and implementation. Joint work with Unify is defined on resilient deployment of virtualized functions in large scale scenarios. The V-FORCE project focuses on high-bit rate multimedia content and intelligent delivery over telecommunication networks.

UPC has been collaborating until its date of completion in August 31th within the FedSM project in the elaboration of a lightweight standard for IT Service Management called FitSM. The impact expected of this standard is very high looking at the expectation and interest show by relevant parties as well as because its sustainability has been assured thanks to the transfer of rights to a non profit organization called ITEMO of which UPC and the other creators of the standard are also forming part.

UZH collaborated with the EU Project SmartenIT and the FLAMINGO standardization activity by UZH is part of the external liaison with the SmartenIT project. This liaison covers work and development of Socio-economic-aware Design of Future Networks by Tussle Analysis and authorization/authentication solutions for constraint devices.

5.4 Networld2020 event, Brussels

On December 3, 2014, the NetWorld2020 Annual Event took place in Brussels. The event theme was “The future of telecommunication networks”. A lot of attention was devoted to the 5G PPP initiative, and also activities beyond 5G were addressed. The priorities of the 5G PPP Association for the Horizon2020 Workprogramme 2016-17 were presented. Four parallel sessions were organised on selected topics where experts presented their view. These sessions were intended to stimulate discussion. The results from these discussions are used by the NetWorld2020 Expert group and the 2016-17 Workprogramme.
The four organized sessions were:

1. Requirements from vertical sectors on 5G systems: experiences gained from experimentation in the FI-PPP
2. From“Signal Strength” and unpredictable QoE to“Service Leve” and customer choice
3. Testbeds, experiments, demonstrations in 5G PPP
4. Challenges towards trusting the network and the Cloud

Prof. Filip De Turck respresented the FLAMINGO consortium and participated to the event. He served as expert in the second session and presented his view on “Efficient context-aware user-centric media delivery with service guarantees”. The session was moderated by Dr. Terje Tjelta, Telenor research, Norway. The other experts in this session were Prof. Markus Fiedler, Blekinge University, Sweden and Dr. Hakon Lonsethagen, Telenor research, Norway.

5.5 Contributions to EuCNC 2015

The EuCNC 2015 (European Conference on Networks and Communications) took place in Paris, France from June 29 until July 2, 2015. Three FLAMINGO representatives were present (Filip De Turck, Niels Bouten and Daphne Tuncer) and provided two presentations. Furthermore, the FLAMINGO consortium contributed to the discussions on collaborations on the topics of “Orchestration and Programmability” and “Infrastructure Virtualization and Management” during the workshop on “Network Function Virtualization and Programmable Networks”.
The FLAMINGO consortium submitted a workshop proposal and joined forces with 8 ongoing EU research projects to establish the workshop on “Network Function Virtualization and Programmable Networks”. More specifically, the following projects contributed to the workshop organnization:

- FP7-T-NOVA: Network Functions as-a-Service over Virtualized Infrastructures
- FP7-UNIFY: Unifying cloud and carrier networks
- FP7-FLAMINGO: NoE on Network and Service Management
- FP7-NETIDE: An integrated development of environment for portable network applications
- FP7-MCN: Mobile Cloud Networking
- H2020 VITAL: VIrtualized hybrid satellite-TerrestriAl systems for resilient and fLexible future networks
- H2020 ACINO: Application Centric IP/Optical Network Orchestration

- H2020-5Gx: 5G exchange
- H2020-SESAME: Small Cells coordination for Multi-tenancy and Edge services

Interesting keynotes and presentations were given by the participants. The workshop was well attended and a discussion took place afterwards, generating some interesting ideas for future work on elastic resource provisioning at infrastructure level and service level. The envisaged scenarios and prototype setups of the different projects were discussed and aligned.

6 FLAMINGO Scientific and Industry Council

This work package organizes the FLAMINGO Scientific and Industrial Council (SIC) and its meetings. These meetings take place on a yearly basis and provide perfect opportunities for FLAMINGO partners to get feedback on their past research, and receive directions for future activities.

6.1 Members

The Scientific and Industrial Council is composed of top industrial and scientific researchers that have a recognized track-record in the area of network and service management, both from an industrial and scientific perspective. The following people take part in the FLAMINGO Scientific and Industrial Council:

- Marcus Brunner, Swisscom, Switzerland - Former IEEE CNOM chair, expert in standardization and clear view on network and service management from an industry point of view;
- Morris Sloman, Imperial College London, UK - Top researcher of the network management research community, high H-index (46), Editor-in-Chief of IEEE Transactions on Network and Service Management;
- Claudio Bartolini, HP, USA - Expert in IT service management and clear view on challenges for the industry;
- Lisandro Granville, UFRGS, Brazil - Current IEEE CNOM chair, active researcher and clear view on the network and service management challenges from academic point of view;
- Alex Clemm, Cisco, USA - Senior Principal Engineer, regular author of books and research articles;
- Raouf Boutaba, Waterloo University, Canada - Steering Committee Chair of the main network management conferences (NOMS/IM/CNSM), Top Researcher with high H-index (39) in network and service management research community;
- Rolf Stadler, KTH, Sweden - Top researcher of the network management research community, regularly publishes papers with lots of citations;
- Axel Clauberg, DT, Germany - Vice President, IP & Optical Technologies, large experience in various aspects of network management for three decades;
- Prosper Chemouil, Orange, France - Program Director on Future Networks at Orange Labs Networks, specifically involved in new networking paradigms like information-centric, programmable and autonomic networking and standardization.

6.2 Council Meeting in Barcelona on November 11, 2015

This section describes the meeting agenda and confirmed participants. The meeting minutes and planned actions will be provided soon after the meeting.

6.2.1 Agenda

1. Online educational material
    - Highlight successful material (youtube, wikipedia)
    - Discuss plans for last year
2. Contributions to the academic community
    - General summary of activities
    - Survey and Taxonomy update
    - IFIP open access repository
3. Contributions to standards
    - IETF contributions
    - IRTF contributions
    - ITU contributions
4. Research on Network and Service Monitoring
    - Overview and highlights
    - Discussion of directions for last year
5. Research on Automated Configuration and Repair
    - Overview and highlights
    - Discussion of directions for last year
6. Research on Economic, Legal, and Regulative Constraints
    - Overview and highlights
    - Discussion of directions for last year

6.2.2 Participants

The following participant confirmed to be present the entire time during the council meeting:

- Aiko Pras (UT, the Netherlands)
- Alex Clemm (Cisco, USA)
- Raouf Boutaba (UWaterloo, Canada)
- Rémi Badonnel (INRIA, France)
- Filip De Turck (iMinds, Belgium)
- Jürgen Schönwälder (JUB, Germany)
- Morris Sloman (ICL, UK)

- Rolf Stadler (KTH, Sweden)
- Prosper Chemouil (Orange, France)
- Axel Clauberg (Deutsche Telekom, Germany)
- Burkhard Stiller (UZH, Switzerland)
- Claudio Bartolini (HP, USA)
- George Pavlou (UCL, UK)

Prof. Aiko Pras chairs the council meeting.

7 Summary

This deliverable details the activities in the third year of the FLAMINGO project to organize the scientific network management community, to disseminate the results of FLAMINGO to researchers within academia and industry, and to achieve scientific excellence. The following activities were successfully undertaken during the third year:

- The three major international conferences on network and service management (IM, AIMS, CNSM) were organized with a large contribution from the FLAMINGO consortium;
- The FLAMINGO consortium played an important role in establishing a new conference: the first IEEE conference on Network Softwarization (NetSoft 2015), organized in London, UK, April, 2015 and hosted by UCL;
- The FLAMINGO consortium organizes the main European Security conference, European Conference on Cyber Warfare and Security (ECCWS), held in Munich, Germany.
- The four main journals on network and service management (ComMag, TNSM, JNSM, IJNM) were organized with large contributions from the FLAMINGO consortium;
- Four journal special issues were organized by the FLAMINGO consortium on currently very relevant topics.
- 14 workshops were organized by the FLAMINGO consortium with specific focus on new and emerging topics in the domain of Future Internet management;
- Specific actions were undertaken to improve scientific quality of conferences and journals: disseminating the FLAMINGO network and service management taxonomy and conference ranking;
- 12 specific events were organized to foster interaction between academia and industry;
- The FLAMINGO consortium contributed to the EuCNC 2015 conference held in Paris, 2015.
- A Dagstuhl seminar is organized by the FLAMINGO consortium;
- A new OpenFlow Testing Lab has been established;
- The FLAMINGO consortium makes regular contributions to the Future Internet Cluster and works jointly with other EU projects (e.g. Leone, mPlane, SmartenIT, Fusion, MCN, Salus, Fed4Fire, Unify, FedSM);
- A meeting of the Scientific and Industry Council with top industrial and scientific researchers that have a recognized track-record in the area of network and service management, is organized.

Abbreviations

AIMS	Autonomous Infrastructure, Management and Security
CESNET	Czech Republic's National Research and Education Network
CNSM	International Conference on Network and Service Management
DoS	Denial-of-Service
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFIP	International Federation for Information Processing
IJNM	Wiley International Journal of Network Management
IM	IFIP/IEEE Symposium on Integrated Management
JNSM	Springer Journal of Network and Systems Management
NAT	Network Address Translation
NETCONF	Network Configuration Protocol
NMS	Network Management System
NOMS	IEEE/IFIP International Symposium on Network Operations and Management
OF	OpenFlow
SDN	Software-Defined Networking
SSH	Secure Shell
TLS	Transport Layer Security
TNSM	IEEE Transactions on Network and Service Management

A FLAMINGO Questionnaire Description

The questionnaire was formalized as an online survey, available at `http://goo.gl/forms/QBZ0QejVUE`, and has been distributed across a large number of international members of academia and industry.

At the start of the questionnaire, demographical information about the participants is collected, as shown in Figure 4. This information includes the level of experience, both in research and in network and service management specifically, the background (academia or industry) and geographical location of the current employment (continent). Participation can either be done anonymously or named. The participants were given the opportunity at the end of the questionnaire to enter their email address in order to be informed on the results of the taxonomy review.

For each of the 7 categories of topics, covered by the taxonomy, the participants of the questionnaire are asked to indicate which topics should be addressed by the network and service management research community during the next five years (2015-2020), on a scale from 0 (highly irrelevant topic) to 5 (highly relevant topic). Given the broad range of topics presented in the taxonomy, the participants are given the possibility to not express an opinion. Finally, shortcomings in the taxonomy can be identified in an optional text area. A screenshot of the resulting survey for category (1) is shown in Figure 5.

Before the questionnaire was distributed externally, the members of the FLAMINGO consortium internally reviewed the questionnaire to indicate any possible shortcomings or ambiguities. After this internal review, the questionnaire was finalized and distributed among FLAMINGO partners, CNOM members and industry partners with the request to further distribute the questionnaire among their respective personal contacts in academia and industry.

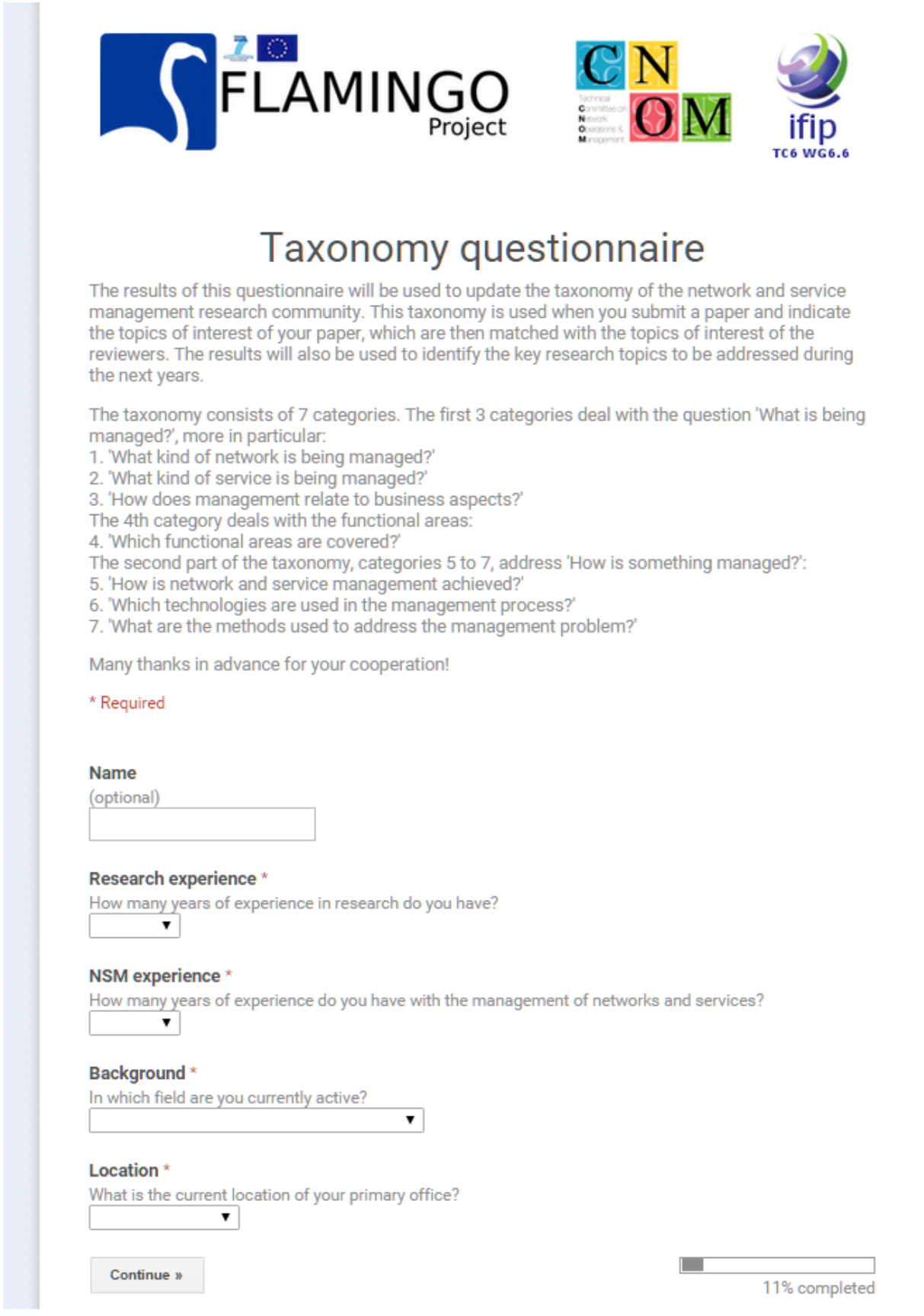
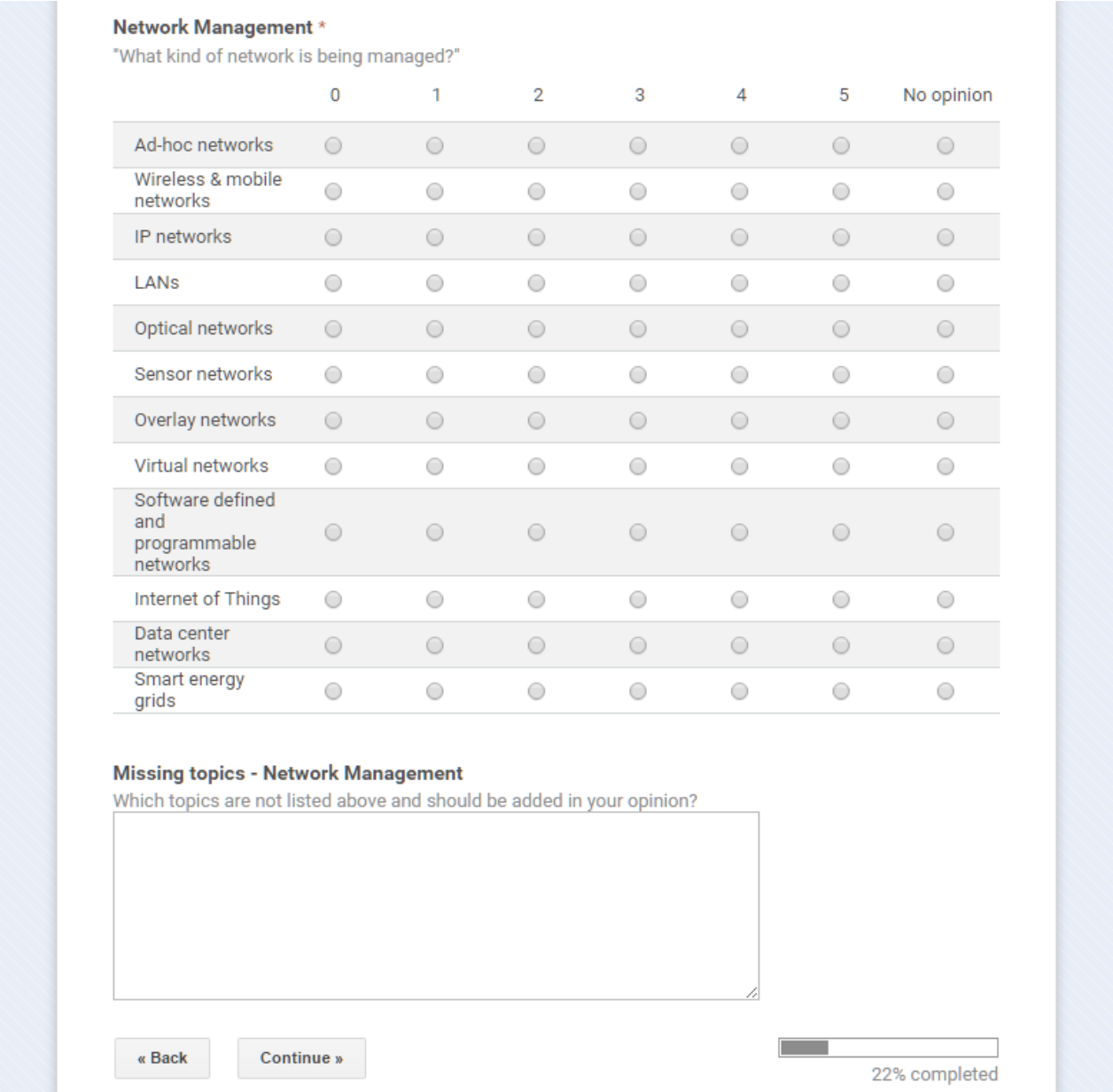


Figure 4: Screenshot of the taxonomy questionnaire - demographical information collection



Network Management *

"What kind of network is being managed?"

	0	1	2	3	4	5	No opinion
Ad-hoc networks	○	○	○	○	○	○	○
Wireless & mobile networks	○	○	○	○	○	○	○
IP networks	○	○	○	○	○	○	○
LANs	○	○	○	○	○	○	○
Optical networks	○	○	○	○	○	○	○
Sensor networks	○	○	○	○	○	○	○
Overlay networks	○	○	○	○	○	○	○
Virtual networks	○	○	○	○	○	○	○
Software defined and programmable networks	○	○	○	○	○	○	○
Internet of Things	○	○	○	○	○	○	○
Data center networks	○	○	○	○	○	○	○
Smart energy grids	○	○	○	○	○	○	○

Missing topics - Network Management

Which topics are not listed above and should be added in your opinion?

« Back Continue »

22% completed

Figure 5: Screenshot of the taxonomy questionnaire for the network management category.

B Original FLAMINGO Taxonomy

The topics in the taxonomy are organized in 7 categories. The first 3 categories deal with the question 'What is being managed?', more in particular:

1 'What kind of network is being managed?'

2 'What kind of service is being managed?'

3 'How does management relate to business aspects?'

The 4th category deals with the functional areas:

4 'Which functional areas are covered?'

The relationship between these 4 categories is illustrated in Figure 6.

The second part of the taxonomy, categories 5 to 7, address the question 'How is something managed?' (illustrated in Figure 7):

5 'How is network and service management achieved?'

6 'Which technologies are used in the management process?'

7 'What are the methods used to address the management problem?'

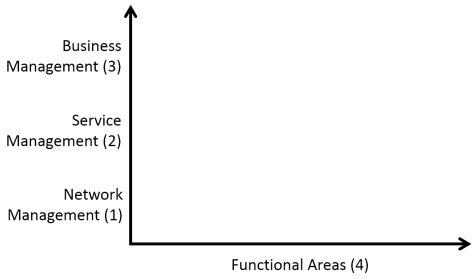


Figure 6: Taxonomy categories - What is being managed?

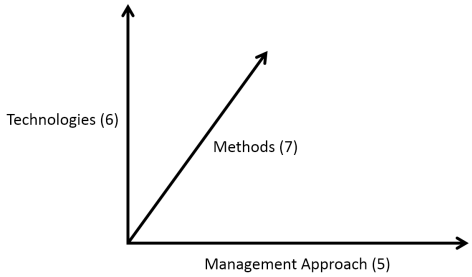


Figure 7: Taxonomy categories - How is something managed?

Based on internal discussions in the FLAMINGO consortium, a few changes were made to this taxonomy to be used as input for the questionnaire. These changes cover both moving some topics to another category to increase uniformity of the taxonomy and to better fit the semantics of the categorization described above and adding new emerging topics. No topics were removed by the changes.

The following topics were moved to another category:

- The topic **Internet of Things** is moved from category *6. Technologies* to category *1. Network Management*.
- The topic **QoE-Centric Management** is moved from category *2. Service Management* to category *5. Management Approaches*.

- The topic **Resource Provisioning & Management** is moved from category *2. Service Management* to category *6. Technologies*.
- The topic **Service Discovery, Migration & Orchestration** is moved from category *2. Service Management* to category *6. Technologies*.

The following emerging topics were added to the category:

- The topic **IoT Services** was added to category *2. Service Management*.
- The topic **Security Services (IDS, DDoS detection and prevention, etc.)** was added to category *2. Service Management*.
- The topic **Regulatory Perspective** was added to category *3. Business Management*.
- The topic **Economic Aspects** was added to category *3. Business Management*.
- The topic **Software Defined Networking** was added to category *6. Technologies*.
- The topic **Network Function Virtualization** was added to category *6. Technologies*.

The resulting taxonomy, used as input to the questionnaire, is shown below.

1. Network Management

- Ad-Hoc Networks
- Wireless and Mobile Networks
- IP Networks
- LANs
- Optical Networks
- Sensor Networks
- Overlay Networks
- Virtual Networks
- Software Defined and Programmable Networks
- **Internet of Things**
- Data Center Networks
- Smart Energy Grids

2. Service Management

- Multimedia Services (e.g., Voice, Video)
- Data Services (e.g., Email, Web)
- Hosting (Virtual Machines)
- Grid Services

- Cloud Services
- **IoT Services**
- **Security Services (IDS, DDoS detection and prevention, etc.)**

3. Business Management

- Legal Perspective
- **Regulatory Perspective**
- Ethical Issues
- **Economic Aspects**
- Process Management

4. Functional Areas

- Fault Management
- Configuration Management
- Accounting Management
- Performance Management
- Security Management
- SLA Management
- Event Management

5. Management Approaches

- Centralized Management
- Distributed Management
- Autonomic and Self Management
- Policy-Based Management
- Federated Network Management
- Pro-Active Management
- Energy-Aware Network Management
- **QoE-Centric Management**

6. Technologies

- Protocols
- Middleware

- Mobile Agents
- P2P
- Grids
- Data, Information, and Semantic Modeling
- **Service Discovery, Migration and Orchestration**
- **Resource Provisioning**
- **Software Defined Networking**
- **Network Function Virtualization**
- Cloud Computing
- Human-Machine Interaction
- Operations and Business Support Systems (OSS/BSS)

7. Methods

- Control Theories
- Optimization Theories
- Economic Theories
- Machine Learning and Genetic Algorithms
- Logics
- Probabilistic, Stochastic Processes, Queuing Theory
- Simulation
- Experimental Approach
- Prototype Design
- Monitoring and Measurements
- Data Mining and (Big) Data Analytics

C Evaluation of Questionnaire Results

C.1 Participants from Industry

In total 49 internationally respected people from industry participated to the questionnaire. They can be classified in 5 groups, as shown in Table 8.

Table 8: Five groups of participants from industry.

Industry Group	**Number of Participants**
Network provider	12
Network equipment provider	16
Cloud system provider	3
Software application provider	7
Other	11
Total	*49*

Table 9 and Table 10 respectively show the geographic distribution and the distribution of the level of experience, both in research and in the management of networks and services, of the participants from industry. We are most thankful for the industrial participants' inputs.

Table 9: Geographic distribution of the participants from industry.

Continent	**Percentage**
Asia	8.16%
Europe	65.31%
North America	26.53%

Table 10: Distribution of the level of experience of the participants from industry.

Experience	**Research**	**NSM***
0 - 5 years	8.16%	12.24%
5 - 10 years	20.41%	20.41%
10 - 15 years	20.41%	20.41%
15 - 20 years	20.41%	16.33%
20+ years	30.61%	30.61%

*Network and Service Management

C.2 Participants from Academia

In total 105 internationally respected people from academia in the network and service management research field participated in the questionnaire. Table 11 and Table 12 respectively show the geographic distribution and the distribution of the level of experience, both in research and in the

management of networks and services, of the participants from academia. We are most thankful for the academic participants' inputs.

Table 11: Geographic distribution of the participants from academia.

Continent	Percentage
Asia	3.81%
Europe	80.00%
North America	8.57%
South America	7.62%

Table 12: Distribution of the level of experience of the participants from academia.

Experience	Research	NSM*
0 - 5 years	15.24%	27.62%
5 - 10 years	23.81%	26.67%
10 - 15 years	20.95%	18.10%
15 - 20 years	17.14%	11.43%
20+ years	22.86%	16.19%

*Network and Service Management

C.3 Aggregation of questionnaire input

To analyze the results of the questionnaire, the input is aggregated per topic for both academia and industry. The results below denote the average rating given to each of the topics in the taxonomy (on a scale from 0 to 5), its standard deviation and the number of abstentions, expressed as a percentage of the number of participants. Table 13 depicts the results.

Table 13: Summarized results of the taxonomy questionnaire.

Topic	Academia			Industry		
	Avg.	Stdev	Abst. [%]	Avg.	Stdev	Abst. [%]
1. Network Management						
Ad-hoc networks	2.9	1.39	4.76	2.81	1.56	12.24
Wireless & mobile networks	4.25	1.04	0	4.24	1.23	0
IP networks	3.48	1.2	1.9	3.94	1.19	2.04
LANs	2.46	1.2	1.9	2.91	1.21	4.08
Optical networks	3.28	1.16	6.67	3.31	1.28	8.16
Sensor networks	3.85	1.2	0.95	3.5	1.45	10.2
Overlay networks	3.37	1.19	4.76	3.49	1.22	8.16
Virtual networks	4.31	0.9	2.86	4.27	1.05	2.04
Software defined and programmable networks	4.6	0.77	1.9	4.44	1.13	2.04
Internet of Things	4.48	0.96	2.86	4.04	1.3	2.04

Data center networks	3.84	1.12	1.9	3.88	1.14	2.04
Smart energy grids	3.87	1.21	4.76	3.07	1.58	12.24
2. Service Management						
Multimedia services (e.g., voice, video)	3.86	1.28	0.95	3.52	1.38	2.04
Data services (e.g., email, web)	2.86	1.24	0.95	3.13	1.47	2.04
Hosting (virtual machines)	3.75	1.08	1.9	3.88	1.25	0
Grid services	2.93	1.31	5.71	2.78	1.28	8.16
Cloud services	4.32	0.85	0.95	4.38	0.99	4.08
IoT services	4.41	0.97	0.95	3.94	1.37	4.08
Security services (IDS, DDoS detection and prevention, etc.)	4.34	0.92	3.81	4.32	1.04	4.08
3. Business Management						
Legal perspective	3.27	1.24	11.43	3	1.48	16.33
Regulatory perspective	3.27	1.28	8.57	3.31	1.35	8.16
Ethical issues	2.95	1.34	4.76	2.98	1.41	8.16
Economic aspects	4.05	0.98	3.81	4.09	1.3	4.08
Process management	3.51	1.17	10.48	3.57	1.15	14.29
4. Functional Areas						
Fault management	4.02	0.95	1.90	4.06	1.06	2.04
Configuration management	3.95	0.99	0.95	4.10	1.10	2.04
Accounting management	2.93	1.37	4.76	2.87	1.33	6.12
Performance management	4.16	0.87	0.95	4.06	1.03	0.00
Security management	4.36	1.04	1.90	4.29	1.13	2.04
SLA management	3.65	1.20	2.86	3.72	1.30	4.08
Event management	3.36	1.18	7.62	3.77	1.22	10.20
5. Management Approaches						
Centralized management	3.03	1.40	0.95	3.63	1.30	2.04
Distributed management	4.07	1.09	0.95	4.00	1.15	2.04
Autonomic and self management	4.20	1.04	0.00	4.25	1.3	2.04
Policy-based management	3.65	1.00	0.95	3.92	1.15	2.04
Federated network management	3.80	1.10	4.76	3.59	1.23	10.20
Pro-active management	3.81	1.07	10.48	3.64	1.31	10.20
Energy-aware network management	3.67	1.14	0.95	3.47	1.38	8.16
QoE-centric management	3.65	1.21	2.86	3.62	1.37	8.16
6. Technologies						
Protocols	3.58	1.26	2.86	3.60	1.35	4.08
Middleware	3.42	1.16	4.76	3.49	1.31	8.16
Mobile agents	2.73	1.48	2.86	2.82	1.50	10.20
P2P	2.59	1.34	2.86	2.41	1.50	10.20
Grids	2.32	1.29	8.57	2.15	1.48	16.33
Data, information, and semantic modeling	3.54	1.10	0.95	3.88	1.47	12.24
Service discovery, migration and orchestration	3.80	1.01	2.86	3.93	1.24	6.12
Resource provisioning	3.89	0.88	0.95	3.91	1.23	4.08
Software defined networking	4.45	0.75	0.00	4.19	1.17	4.08
Network function virtualization	4.37	0.85	0.00	4.46	1.03	6.12

Cloud computing	4.05	1.03	0.00	4.17	1.19	4.08
Human Machine interaction	3.11	1.32	6.67	3.18	1.42	8.16
Operations and Business Support Systems (OSS/BSS)	2.97	1.19	15.24	3.83	1.43	14.29
7. Methods						
Control theories	3.58	1.08	8.57	3.53	1.47	8.16
Optimization theories	3.96	0.96	4.76	3.70	1.31	6.12
Economic theories	3.20	1.07	10.48	3.21	1.33	4.08
Machine learning and genetic algorithms	4.10	1.00	2.86	3.89	1.25	6.12
Logics	3.17	1.20	11.43	3.05	1.24	18.37
Probabilistic, stochastic processes, queuing theory	3.59	1.10	1.90	3.47	1.31	8.16
Simulation	3.71	1.01	0.95	3.30	1.07	6.12
Experimental approach	4.14	0.92	0.95	3.84	1.09	8.16
Prototype design	3.94	1.05	0.95	3.96	1.01	6.12
Monitoring & measurements	4.27	0.85	0.00	4.13	0.98	2.04
Data mining and (big) data analytics	4.47	0.84	0.00	4.13	1.24	4.08

C.4 Important topics

This section selects the most important topics, both for industry and academia, and compares them. An important topic is defined as a topic that received the maximum rating (i.e. 5) from at least 50% of the participants.

Table 14 lists topics considered important to both industry and academia. In total, 10 important topics were selected.

Table 14: Topics considered important (i.e., $\geq 50\%$ of the participants gives maximum rating) by both industry and academia.

Topic	**Academia**		**Industry**	
	Avg.	**=5 [%]**	**Avg.**	**=5 [%]**
1. Network Management				
Wireless & mobile networks	4.25	53.33	4.24	61.22
Virtual Networks	4.31	52.38	4.27	51.02
Software defined and programmable networks	4.60	70.48	4.44	71.43
2. Service Management				
Cloud services	4.32	51.43	4.38	57.14
Security services (IDS, DDoS detection and prevention, etc.)	4.34	52.38	4.32	55.10
3. Business Management				
4. Functional Areas				
Security management	4.36	60.00	4.29	57.14

5. Management Approaches				
Autonomic and self management	4.20	53.33	4.25	65.31
6. Technologies				
Software defined networking	4.45	57.14	4.19	53.06
Network function virtualization	4.37	58.10	4.46	63.27
7. Methods				
Data mining and (big) data analytics	4.47	61.9	4.13	53.06

For most of the identified topics, such as *Virtual Networks* and *Software defined and programmable networks*, the average rating for industry and academia are similar. However, for others there is a significant bias towards one of the groups. *Wireless and mobile networks*, *cloud services*, *autonomic and self management* and *network function virtualization* are very important for industry, while *software defined networking* and *data mining and (big) data analytics* are more important for academia. Furthermore, Table 15 shows two topics that are important to academia, but not to industry. Please note that categories that don't include such topics are not listed.

Table 15: Topics considered important (i.e., $\geq 50\%$ of the participants gives maximum rating) by academia but not by industry.

Topic	**Academia**		**Industry**	
	Avg.	**=5 [%]**	**Avg.**	**=5 [%]**
1. Network Management				
Internet of Things	4.48	67.62	4.04	48.98
2. Service Management				
IoT services	4.41	60.95	3.94	42.86

From the results of the questionnaire, no topics could be identified that are considered important to industry, but not to academia.

C.5 Less important topics

This section identifies the less important topics, both for industry and academia, and compares them. A topic is defined to be less important when at least 30% of the participants has given it a rating of 2 or below.

Table 16 lists topics considered to be less important by both industry and academia. In total, 9 less important topics were selected.

Table 16: Topics considered less important (i.e., $\geq 30\%$ of the participants gives a rating of 2 or below) by both academia and industry.

Topic	Academia		Industry	
	Avg.	$\leq$2 [%]	Avg.	$\leq$2 [%]
1. Network Management				
Ad-hoc networks	2.90	33.33	2.81	32.65
LANs	2.46	50.48	2.91	38.78
2. Service Management				
Data services (e.g., email, web)	2.86	38.10	3.13	42.86
Grid services	2.93	34.29	2.78	40.82
3. Business Management				
Ethical issues	2.95	34.29	2.98	30.61
4. Functional Areas				
Accounting management	2.93	36.19	2.87	36.73
5. Management Approaches				
6. Technologies				
Mobile agents	2.73	40.00	2.82	32.65
P2P	2.59	42.86	2.41	40.82
Grids	2.32	46.67	2.15	46.94
7. Methods				

Table 17 shows a list of topics that are considered to be less important by academia, but not by industry. In total 1 topic was identified. Please note that categories that don't include such topics are not listed.

Table 17: Topics considered less important (i.e., $\geq 30\%$ of the participants gives a rating of 2 or below) by academia but not by industry.

Topic	Academia		Industry	
	Avg.	$\leq$2 [%]	Avg.	$\leq$2 [%]
5. Management Approaches				
Centralized management	3.03	35.24	3.63	20.41

From the results of the questionnaire, no topics could be identified that are considered to be less important by industry, but not by academia.

D New Topics to be added to the FLAMINGO Taxonomy

This section discusses the new topics that were extracted from the questionnaire. First, we discuss the number of participants that responded to the question ”Which topics are not listed and should be added in your opinion?”. Second, the number of newly identified topics per category are discussed. Third, the set of most frequently suggested topics (based on their occurrence) is extracted. Finally, other comments from questionnaire participants are discussed per topic.

Each of the questionnaire participants was given the opportunity to suggest new topics for every category that, in their opinion, should be included in the taxonomy. This was done by adding a text field in which the participants could enter a number of topics as they pleased. Some of the participants did not enter new topics, but rather comments on the existing topics. Not every participant filled out this text field, Table 18 shows an overview per category of the number of participants (both in absolute numbers and relative to the total number of participants) that entered one or multiple topics in this field.

Table 18: Number of participants that filled in the missing field per category

Category	**Participants [#]**	**Participants [%]**
1. Network Management	52	33.77
2. Service Management	29	18.83
3. Business Management	16	10.39
4. Functional Areas	17	11.04
5. Management Approaches	16	10.39
6. Technologies	15	9.74
7. Methods	15	9.74

As already mentioned, this field was used by many participants to enter multiple topics. Table 19 gives an overview of the number of new topics per category that were identified from the questionnaire. For some cases the number of topics is lower than the number of responses, as already mentioned, not all the responses in the missing field were identifying new topics, some of the respondents also used this field to suggest other changes to the existing topics. We examined the list of topics and identified identical or overlapping topics and came up with a list of unique newly identified topics. Table 19 also shows the number of unique topics that were identified.

Table 19: Number of new topics proposed per category

Category	**# of topcis**	**# of unique topics**
1. Network Management	71	35
2. Service Management	38	29
3. Business Management	13	9
4. Functional Areas	27	22
5. Management Approaches	17	14
6. Technologies	25	18
7. Methods	11	10

Next, the topics that were identified as missing by two or more participants were selected. Table 20 gives an overview per category of the most important set of newly identified topics. The new topics that were identified will be presented and discussed during the taxonomy meeting which will be organized at the International Conference on Network and Service Management (CNSM) 2015 in Barcelona. The topics that, in our opinion, are most likely to be added to the taxonomy are already marked in bold.

Table 20: New topics identified during questionnaire

Topic	Number of participants
1. Network Management	
Information-centric networks	6
Network Function Virtualization	6
Home networks	5
Security (in virtual networks / clouds) and privacy	5
Content Distribution networks	4
(Wireless) Mesh networks	3
Opportunistic/Social networks	3
Vehicular networks	3
Body area networks	2
Cellular networks / 5G networks	2
Cloud networks	2
Cognitive (radio) networks	2
Enterprise networks	2
Hybrid networks (mixture of networks i.e. wired + wireless)	2
Factory networks (Industry 4.0)	2
Inter-domain networks	2
Non-IP networks	2
2. Service Management	
Service Integration and Management	4
Industry 4.0 services	3
Big data management (e.g. online stream processing)	2
Information networking services	2
Personalized and context-aware services	2
Service assurance	2
3. Business Management	
Privacy management	5
4. Functional Areas	
Data mining / Management of network data	3
Monitoring and measurement management	2
Optimisation management	2
Privacy management / security management	2
5. Management Approaches	
Hierarchical management	3
Cognitive management	2
6. Technologies	
Machine learning technologies / data mining	5
(Distributed) (Big) data analytics	4

7. Methods	
Artificial Intelligence	2

Below is the full list of filtered and aggregated topic proposals that were made by the questionnaire participants.

Table 21: Long list of new topics identified during quesstionnaire

topic	Number of participants
1. Network Management	
Information-centric networks	6
Network Function Virtualization	6
Home networks	5
Security (in virtual networks / clouds) and privacy	5
Content Distribution networks	4
(Wireless) Mesh networks	3
Opportunistic/Social networks	3
Vehicular networks	3
Body area networks	2
Cellular networks / 5G networks	2
Cloud networks	2
Cognitive (radio) networks	2
Enterprise networks	2
Hybrid networks (mixture of networks i.e. wired + wireless)	2
Factory networks (Industry 4.0)	2
Inter-domain networks	2
Non-IP networks	2
Critical communications networks	1
Financial networks	1
Fixed access networks (e.g. G.fast, DSL, GPON, ?)	1
Future networks (i.e. RNA, XIA, RINA)	1
Internet of Everything	1
IPv6 networks	1
IPX networks	1
Large scale monitoring networks (e.g. RIPE ATLAS)	1
Large scale sensor aggregation networks	1
Nanoscale networks	1
Fault tolerant networks	1
P2P networks	1
Public safety networks	1
Satellite networks	1
Self-organizing networks	1
Transportation networks	1
User and device networks	1
Wide Area Networks	1

2. Service Management	
Service Integration and Management	4
Industry 4.0 services	3
Big data management (e.g. online stream processing)	2
Information networking services	2
Personalized and context-aware services	2
Service assurance	2
Analytics services	1
Business-crucial services	1
Commercial services	1
Container services	1
Cyber-physical interconnection services	1
Cybercrime services (ransomware, botnets, phishing)	1
DevOps services	1
Enabling services (backbone networks, interoperability)	1
Financial services	1
Healthcare related services	1
Management as a Service	1
Micro-services (Google Cloud Platform, ..)	1
Network services	1
Privacy management	1
Quality of Experience	1
Real-time services	1
Resource management	1
Robotic services	1
Service lifecycle management	1
Social network services	1
Storage services	1
Virtual networking services (NaaS)	1
Web applications	1
3. Business Management	
Privacy management	5
Economic incentives management	1
Environmental aspects	1
Explicit links and impact on the management OPEX	1
Geographical data protection issues	1
Human aspects	1
Integration between the OSS and BSS	1
Service auditing	1
User/customer management	1
4. Functional Areas	
Data mining / Management of network data	3
Monitoring and measurement management	2
Optimisation management	2
Privacy management / security management	2
Configuration deployment	1
Contingency management	1
Cross-(conventional-)layer management	1
Experience management	1

Fulfillment	1
Holistic/Cross-functional management	1
Instrumentation	1
Inter-area concepts (How do the areas interact?)	1
Isolation management	1
Non-functional areas management (including accessibility, availability, certification, configurability, compiance, extensibility, interoperability, maintainability, operability, performance, privacy, resilience, reliability, robustness)	1
Orchestration management	1
Power management	1
Resource management	1
Service assurance	1
State management	1
Sustainability management	1
Topology management	1
Virtual asset management (patch and compliance)	1
5. Management Approaches	
Hierarchical management	3
Cognitive management	2
Adaptive management	1
Distributed management	1
Hybrid management	1
In-network management	1
Integrated management	1
Intent-based network management	1
Locality-aware management	1
Pre-emptive management	1
Probabilistic management	1
Reactive management	1
Unified management framework	1
Verification of management	1
6. Technologies	
Machine learning technologies / data mining	5
(Distributed) (Big) data analytics	4
Controller and management platforms	1
Fog and edge networking	1
Machine-Machine interaction for autonomous systems	1
Management data flow pre-processing	1
Management of e2e services	1
Metadata-driven architecture	1
Model-driven architectures	1
Monitoring	1
More efficient control loops (FOCALE)	1
Network slice management	1
Orchestration of services	1
Predictive analytics	1
Process virtualization technologies	1
Programmable networks	1

Remote collectors	1
Service lifecycle management	1
7. Methods	
Artificial Intelligence	2
Cognitive computing	1
Control mechanism evaluation	1
Data analytics	1
Formal proof	1
Graph theory	1
Monitoring	1
Reliability theory	1
Self-X methods	1
Virtualization	1

E Comparison to Conference Submission Topics

In Table 22, we present the percentage of submitted (including rejected) and accepted (inside parenthesis) papers in all editions of NOMS, IM, and CNSM from 2010 to 2015, according to our updated taxonomy's specific, individual topic areas, as described in Appendix B. The percentages are obtained by dividing the number of submitted/accepted papers that address a topic by the total number of submitted/accepted papers of each edition.

Table 22: Submitted/accepted papers at NOMS, IM, and CNSM.

Topic	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)
1. Network Management						
Ad-Hoc Networks	5.56 (2.65)	3.25 (1.95)	5.46 (4.02)	2.37 (1.42)	4.61 (2.63)	1.61 (0.65)
Wireless & Mobile Networks	14.02 (6.88)	11.69 (5.84)	16.95 (10.92)	12.32 (5.21)	19.74 (11.84)	15.48 (10.97)
IP Networks	15.87 (11.38)	8.77 (6.17)	5.75 (2.87)	1.90 (0.47)	8.55 (5.92)	4.84 (2.58)
LANs	1.32 (0.53)	0.65 (0.65)	2.30 (1.44)	1.42 (0.95)	1.32 (1.32)	1.61 (1.29)
Optical Networks	1.06 (0.53)	1.62 (0.65)	2.30 (1.72)	1.90 (0.47)	1.97 (0.66)	1.61 (0.97)
Sensor Networks	6.08 (1.85)	1.95 (1.30)	6.90 (4.60)	2.37 (1.90)	5.92 (2.63)	3.87 (1.29)
Overlay Networks	3.44 (1.59)	1.30 (0.97)	2.59 (1.15)	2.37 (2.37)	2.63 (1.32)	3.23 (2.58)
Virtual Networks	3.70 (2.12)	1.95 (1.30)	4.60 (3.16)	6.64 (5.69)	7.89 (5.26)	11.94 (9.68)
Software Defined and Programmable Networks	0.53 (0.26)	0.97 (0.32)	3.16 (2.87)	6.16 (4.74)	12.50 (8.55)	22.90 (15.16)
Internet of Things	0.26 (0.00)	0.00 (0.00)	0.86 (0.86)	1.42 (0.47)	0.66 (0.66)	3.23 (2.26)
Data Center Networks	2.12 (1.59)	1.95 (1.30)	12.64 (10.34)	8.53 (8.06)	1.97 (0.00)	4.52 (3.87)
Smart Grids	0.53 (0.26)	0.32 (0.32)	0.57 (0.57)	0.95 (0.95)	0.66 (0.00)	0.97 (0.32)
2. Service Management						
Multimedia Services (e.g., Voice, Video)	9.26 (6.61)	5.84 (3.57)	7.18 (4.02)	4.27 (2.84)	2.63 (1.32)	9.03 (6.77)
Data Services (e.g., Email, Web)	4.50 (2.65)	6.17 (3.57)	2.01 (1.44)	0.47 (0.47)	1.97 (1.32)	0.97 (0.97)
Hosting (Virtual Machines)	3.97 (2.91)	4.22 (3.25)	9.48 (8.05)	6.16 (6.16)	5.26 (3.29)	1.94 (1.94)
Grid Services	2.12 (1.06)	0.97 (0.32)	0.57 (0.57)	0.00 (0.00)	0.66 (0.00)	0.00 (0.00)
Cloud Services	2.65 (2.12)	2.60 (1.95)	10.34 (8.91)	12.32 (9.00)	13.82 (9.21)	12.26 (8.39)
IoT Services	0.26 (0.00)	0.00 (0.00)	0.86 (0.86)	1.42 (0.47)	0.66 (0.66)	3.23 (2.26)
Security Services	14.55 (7.41)	9.09 (5.84)	12.64 (9.77)	16.59 (11.37)	15.13 (9.21)	13.55 (8.71)
3. Business Management						
Legal Perspective	0.53 (0.00)	0.32 (0.32)	0.57 (0.29)	0.47 (0.47)	0.66 (0.00)	0.32 (0.00)
Regulatory Perspective	0.53 (0.26)	0.65 (0.32)	0.29 (0.29)	0.95 (0.95)	0.00 (0.00)	0.00 (0.00)
Ethical Issues	0.53 (0.00)	0.32 (0.32)	0.57 (0.29)	0.47 (0.47)	0.66 (0.00)	0.32 (0.00)

Economic Aspects	5.56 (3.70)	1.95 (1.30)	2.59 (1.72)	3.32 (2.37)	4.61 (1.97)	3.23 (2.26)
Process Management	10.85 (5.56)	6.17 (3.90)	5.75 (4.60)	4.74 (3.32)	4.61 (1.97)	2.90 (1.94)
4. Functional Areas						
Fault Management	11.64 (7.14)	5.84 (2.92)	10.06 (6.32)	12.32 (9.00)	5.92 (3.95)	10.00 (5.48)
Configuration Management	8.47 (5.82)	7.79 (5.19)	10.63 (7.18)	4.27 (3.32)	11.18 (6.58)	13.23 (9.03)
Accounting Management	1.06 (0.79)	3.25 (2.60)	1.72 (0.57)	1.42 (0.95)	1.97 (0.66)	0.32 (0.32)
Performance Management	16.40 (11.90)	12.34 (9.09)	18.97 (15.52)	11.37 (8.06)	27.63 (17.76)	16.45 (12.58)
Security Management	14.55 (7.41)	9.09 (5.84)	12.64 (9.77)	16.59 (11.37)	15.13 (9.21)	13.55 (8.71)
SLA Management	3.70 (1.85)	5.84 (2.27)	6.32 (5.46)	1.90 (1.90)	8.55 (6.58)	2.58 (1.94)
Event Management	2.91 (1.32)	2.27 (1.62)	1.44 (0.86)	0.47 (0.47)	4.61 (1.97)	1.94 (1.29)
5. Management Approaches						
Centralized Management	1.32 (1.06)	1.62 (1.30)	4.31 (3.16)	1.90 (0.95)	1.97 (1.97)	3.55 (2.58)
Distributed Management	11.64 (7.14)	7.79 (4.87)	10.34 (6.61)	5.69 (5.21)	9.21 (4.61)	4.84 (2.90)
Autonomic and Self Management	14.81 (9.79)	9.42 (6.17)	16.38 (11.21)	9.00 (6.64)	13.82 (9.21)	8.06 (5.81)
Policy-Based Management	8.47 (5.03)	6.17 (3.25)	6.90 (4.60)	3.79 (2.84)	9.87 (5.92)	2.58 (1.94)
Federated Network Management	3.97 (2.91)	1.62 (1.30)	0.57 (0.57)	3.32 (2.37)	0.66 (0.00)	1.29 (0.65)
Pro-Active Management	0.00 (0.00)	0.32 (0.32)	0.29 (0.00)	0.95 (0.47)	1.32 (0.66)	1.29 (0.97)
Energy-Aware Network Management	3.17 (2.12)	4.22 (2.60)	6.61 (5.17)	6.64 (5.21)	2.63 (2.63)	3.55 (1.29)
QoE-Centric Management	0.53 (0.00)	0.97 (0.97)	0.57 (0.29)	2.37 (1.90)	0.66 (0.00)	4.19 (3.23)
6. Technologies						
Protocols	7.14 (3.17)	2.92 (1.95)	4.02 (3.16)	12.32 (7.58)	9.87 (4.61)	10.00 (6.13)
Middleware	2.65 (1.85)	2.92 (1.30)	6.32 (4.02)	2.37 (1.90)	5.26 (3.95)	1.29 (0.32)
Mobile Agents	0.79 (0.26)	0.65 (0.00)	0.86 (0.57)	0.47 (0.47)	2.63 (1.97)	2.58 (0.65)
P2P	6.61 (4.50)	2.60 (1.30)	5.46 (2.87)	1.90 (1.42)	2.63 (1.32)	2.58 (1.61)
Grids	0.26 (0.26)	0.97 (0.65)	0.86 (0.57)	0.00 (0.00)	0.66 (0.00)	0.00 (0.00)
Data, Information, and Semantic Modeling	10.05 (5.03)	9.09 (5.84)	8.91 (7.18)	6.64 (3.79)	8.55 (4.61)	8.06 (4.84)
Service Discovery, Migration, and Orchestration	1.85 (1.32)	0.32 (0.32)	4.89 (4.02)	6.64 (5.21)	3.29 (1.97)	3.87 (2.58)
Resource Provisioning	3.97 (2.65)	2.27 (2.27)	5.17 (3.74)	19.43 (15.17)	0.66 (0.66)	12.90 (10.32)
Software Defined Networking	0.53 (0.26)	0.97 (0.32)	3.16 (2.87)	6.16 (4.74)	12.50 (8.55)	22.90 (15.16)
Network Function Virtualization	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	2.63 (1.32)	5.81 (3.87)
Cloud Computing	5.56 (3.17)	8.12 (3.90)	8.33 (6.03)	24.17 (20.38)	13.82 (9.87)	11.94 (8.06)
Human-Machine Interaction	1.32 (1.32)	0.65 (0.65)	0.00 (0.00)	0.47 (0.47)	0.00 (0.00)	0.97 (0.32)

OSS/BSS	1.59 (0.26)	0.32 (0.32)	1.44 (0.57)	1.90 (0.95)	0.66 (0.66)	1.94 (1.61)
7. Methods						
Control Theories	1.85 (1.32)	0.32 (0.00)	2.30 (1.15)	0.00 (0.00)	1.97 (1.32)	0.97 (0.32)
Optimization Theories	2.65 (1.85)	0.65 (0.32)	8.33 (5.75)	0.95 (0.95)	9.21 (4.61)	12.58 (10.32)
Economic Theories	1.06 (0.53)	0.97 (0.32)	2.01 (1.44)	0.47 (0.47)	1.32 (1.32)	2.26 (1.61)
Machine Learning and Genetic Algorithms	1.59 (0.53)	2.60 (1.95)	4.31 (3.16)	6.64 (3.79)	5.92 (3.29)	7.74 (5.81)
Logics	0.00 (0.00)	0.32 (0.00)	0.86 (0.57)	0.47 (0.47)	0.66 (0.66)	0.00 (0.00)
Probabilistic, Stochastic Processes, Queuing Theory	1.59 (1.59)	0.32 (0.32)	3.45 (2.59)	1.90 (1.42)	5.92 (3.29)	5.81 (4.19)
Simulation	3.44 (2.65)	3.25 (2.92)	5.75 (3.74)	9.48 (6.16)	14.47 (9.87)	20.97 (14.19)
Experimental Approach	2.38 (1.32)	1.62 (1.30)	6.03 (4.31)	9.95 (7.11)	13.16 (9.87)	28.06 (20.32)
Prototype Design	0.53 (0.26)	1.62 (1.62)	1.72 (0.86)	0.47 (0.00)	3.29 (2.63)	10.65 (6.77)
Monitoring and Measurements	4.23 (3.17)	4.22 (2.92)	5.75 (4.89)	10.90 (8.06)	9.87 (4.61)	11.94 (8.06)
Data Mining and (Big) Data Analytics	0.79 (0.79)	1.30 (1.30)	0.86 (0.86)	7.11 (6.64)	1.97 (1.97)	7.74 (5.16)

F Updated FLAMINGO Taxonomy

Based on the analysis made in Appendices C,D and E, we propose an updated version of the taxonomy to serve as a starting point for discussion during the physical meeting which will be organized in November at the CNSM 2015 in Barcelona.

In total, 10 changes to the taxonomy are proposed as listed below.

- Add the topic **Information-Centric-Networks** to category *1. Network Management*.
- Add the topic **Network Function Virtualization** to category *1. Network Management*.
- Add the topic **Home Networks** to category *1. Network Management*.
- Add the topic **Personalized and Context-aware Services** to category *2. Service Management*.
- Add the topic **Privacy Management** to category *3. Business Management*.
- Add the topic **Hierarchical Management** to category *5. Management Approaches*.
- Add the topic **Cognitive Management** to category *5. Management Approaches*.
- Remove the topic **Grid Services** from category *2. Service Management*.
- Remove the topic **Mobile Agents** from category *6. Technologies*.
- Remove the topic **Grids** from category *6. Technologies*.

The resulting proposed taxonomy is shown below.

1. Network Management

- Ad-Hoc Networks
- Wireless and Mobile Networks
- IP Networks
- LANs
- Optical Networks
- Sensor Networks
- Overlay Networks
- Virtual Networks
- Software Defined and Programmable Networks
- Internet of Things
- Data Center Networks
- Smart Energy Grids
- Information-Centric-Networks

- Network Function Virtualization
- Home Networks

2. Service Management

- Multimedia Services (e.g., Voice, Video)
- Data Services (e.g., Email, Web)
- Hosting (Virtual Machines)
- Cloud Services
- IoT Services
- Security Services (IDS, DDoS detection and prevention, etc.)
- Personalized and Context-aware Services

3. Business Management

- Legal Perspective
- Regulatory Perspective
- Ethical Issues
- Economic Aspects
- Process Management
- Privacy Management

4. Functional Areas

- Fault Management
- Configuration Management
- Accounting Management
- Performance Management
- Security Management
- SLA Management
- Event Management

5. Management Approaches

- Centralized Management
- Distributed Management
- Autonomic and Self Management

- Policy-Based Management
- Federated Network Management
- Pro-Active Management
- Energy-Aware Network Management
- QoE-Centric Management
- Hierarchical Management
- Cognitive Management

6. Technologies

- Protocols
- Middleware
- P2P
- Data, Information, and Semantic Modeling
- Service Discovery, Migration and Orchestration
- Resource Provisioning
- Software Defined Networking
- Network Function Virtualization
- Cloud Computing
- Human-Machine Interaction
- Operations and Business Support Systems (OSS/BSS)

7. Methods

- Control Theories
- Optimization Theories
- Economic Theories
- Machine Learning and Genetic Algorithms
- Logics
- Probabilistic, Stochastic Processes, Queuing Theory
- Simulation
- Experimental Approach
- Prototype Design
- Monitoring and Measurements
- Data Mining and (Big) Data Analytics

G Full List of Suggestions by Questionnaire Participants

Next to suggesting missing topics, many participants also used the field to express other comments concerning the taxonomy. Below are a number of selected comments made by the participants per category:

1. Network Management

- The term ”ad-hoc networks” is less and less used. I suggest you take it out. These days, people use instead ”Sensor networks” or ”Wireless and mobile networks”, which are already included in this list.
- The term ”overlay networks” is less and less used. Most people associate it with P2P, which does not ”sell” anymore. I suggest you take it out.

2. Service Management

- I suggest you delete the term ”Grid services”, which does not ”sell” anymore and is no longer used. The papers of the Grid community now talk about ”cloud services”.
- Integration of services on top of heterogeneous control planes into management policies

3. Business Management

- These issues should be part of multi-disciplinary research and not of the NSM only. A category indicating this integration might be useful.
- I recommend changing the section heading ”Business Management” into ”Non-technical Management Aspects”. Many people would argue that ethics should not be subsumed into business.
- Difference between legal and regulatory?

4. Functional Areas

- It makes no sense to break management into these functional areas anymore!
- SLA management should be moved to section ”Service management”.
- In general, making general statements along an FCAPS taxonomy like above is may be not so conclusive in the end.

5. Management Approaches

- Proactive management is not a separate approach, and not an own area. Given that most approaches are indeed reactive, isn’t autonomic management by definition pro-active?
- Change energy-aware to metric-aware (optimizing CPU utilization, ?)
- Maybe you need to add the time dimension: online vs planning
- Probably ”Security-aware Management” and its relationship to QoE should be considered.

6. Technologies

- These are approaches, not a technology?
- The terms ”Mobile agents”, ”P2P”, and ”Grids” no longer ”sell”. I suggest you delete them.

7. Methods

- Why machine learning *and* genetic algorithms? I'd definitely split (and genetic algorithms is a niche IMHO already included in optimization). I also assume statistical inference is included in Machine Learning, and for probability you refer to queueing and processes (otherwise my rating would have been much higher there)
- No one uses the term ”Economic theories”. I recommend renaming it to ”Game theory”.
- Change genetic algorithms into the more generic title ”evolutionary algorithms”. This could include swarm intelligence and memetic algorithms.

Below is a detailed overview of all comments and suggestions that were expressed by the participants.

1. Network Management

- Split software defined and programmable networks
- In my honest opinion, the above table of networks has a deep problem with some terms, in particular wireless/mobile networks, sensor networks, ad-hoc networks, and Internet of things. These terms sometime overlap but can differ highly. For example, I strong believe that the management of mobile network will tremendously change while still this area is a very well researched due to changes in the underlying infrastructure or business model. Sensor/ad-hoc and even Internet-of-Things are typically infrastructure-less and often be considered self-organising rather than managed.
- The names on the list already imply a specific mindset. E.g. Internet of Things is not really ”a network”, while ”ad-hoc networks” is very different from ”self-organized networks”. So your questionnaire does put some bias on the answers
- A second table with special aspects of NM would be best: dealing with Performance, Interoperability, Security, ... with regard to table above.
- Data Center Networks is including Big data? in that case nothing is missing
- The term ”ad-hoc networks” is less and less used. I suggest you take it out. These days, people use instead ”Sensor networks” or ”Wireless and mobile networks”, which are already included in this list.
- The term ”overlay networks” is less and less used. Most people associate it with P2P, which does not ”sell” anymore. I suggest you take it out.
- Community networks: I'd not include in the list as otherwise it becomes too broad, but is an interesting borderline case of a network that is multi owned but would benefit from centralized management (how to? a nice research question)
- Hybrid IT and Bimodal IT concepts - how do traditional IT governance methodologies work together with FastIT/Agile/DevOps practices?

2. Service Management

- I suggest you delete the term ”Grid services”, which does not ”sell” anymore and is no longer used. The papers of the Grid community now talk about ”cloud services”.
- The influence of ”let’s encrypt more” on network and service management
- I find it odd that ”traditional” OAMP is not listed. This implies that OAMP functions will be implemented differently for each type of service, which perpetuates our already broken siloed architecture.
- Integration of services on top of heterogeneous control planes into management policies

3. Business Management

- These issues should be part of multi-disciplinary research and not of the NSM only. A category indicating this integration might be useful.
- I recommend changing the section heading ”Business Management” into ”Non-technical Management Aspects”. Many people would argue that ethics should not be subsumed into business.
- I recommend renaming ”Process management”, which is not used at all, to ”Business Process Management”, which is widely used.
- Softwarization and Digitization are disrupting many businesses (Uber, Amazon, booking.com, Airbnb, Nike, Garmin, to name a few examples): how does this affect business management, what strategies are required to succeed in a Bimodal IT environment?
- Difference between legal and regulatory?
- I think that the latter two topics can be easily embraced by industry and academia. However, the first three, while important, are much harder for industry and academia to do research on.
- I think most of the topics here reported as ”business” are mostly orthogonal to research and in general have scarce influence on it. They are however very important for what concerns the deployment and impact that research has on society and need to be tackled by appropriate institutions.

4. Functional Areas

- Developing of new taxonomy of functional areas.
- Interworking between players (I don’t know if this is a functional area, but it raises some specific management issues.
- It makes no sense to break management into these functional areas anymore!
- I recommend deleting ”SLA management” and ”Event management”, which are not separate functional areas.
- SLA management should be moved to section ”Service management”.
- FCAPS is valid but sounds dated.

- Rename SLA management to SLAs and Service Level Management
- Rename Configuration Management to Orchestration, Fulfillment, Configuration Management
- I'm not convinced that this taxonomy should remain separate, as it encourages implementers to keep the above functional areas separate from the applications that they are applied to.
- In general, making general statements along an FCAPS taxonomy like above is may be not so conclusive in the end.

5. Management Approaches

- Proactive management is not a separate approach, and not an own area. Given that most approaches are indeed reactive, isn't autonomic management by definition pro-active?
- Change energy-aware to metric-aware (optimizing CPU utilization, ?)
- Maybe you need to add the time dimension: online vs planning
- Probably "Security-aware Management" and its relationship to QoE should be considered.

6. Technologies

- These are approaches, not a technology?
- The terms "Mobile agents", "P2P", and "Grids" no longer "sell". I suggest you delete them.

7. Methods

- Why machine learning *and* genetic algorithms? I'd definitely split (and genetic algorithms is a niche IMHO already included in optimization). I also assume statistical inference is included in Machine Learning, and for probability you refer to queueing and processes (otherwise my rating would have been much higher there)
- No one uses the term "Economic theories". I recommend renaming it to "Game theory".
- The term "Logics" should be changed to "Logic". Few people in our research community will be familiar with the different types of logic.
- I have no idea what is meant by "experimental approach" or by "prototype design", sorry. Note that economic theory can be tied into both control and optimization.
- Change genetic algorithms into the more generic title "evolutionary algorithms". This could include swarm intelligence and memetic algorithms.

These suggested topics are taken into consideration during the dedicated taxonomy meetings, organized by the FLAMINGO consortium in Barcelona 9-13 November, 2015. For instance, followings suggestions - amongst others - will be discussed in detail with the experts: change 'Genetic algorithms' in 'Evolutionary algorithms', update 'Economic Theories' to 'Economic Models and Game Theory', change 'Process Management' to 'Business Process Management'.