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The Future Internet

Future Internet Assembly 2012: From Promises to Reality

Springer

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List of Editors

Federico Álvarez
Universidad Politécnica de Madrid, Spain
federico.alvarez@upm.es

Frances Cleary
Waterford Institute of Technology - TSSG, Waterford, Ireland
fcleary@tssg.org

Petros Daras
CERTH-ITI, Thessaloniki, Greece
daras@iti.gr

John Domingue
Knowledge Media Institute, The Open University,
Milton Keynes, UK
j.b.domingue@open.ac.uk

Alex Galis
Department of Electronic and Electrical Engineering,
University College London, UK
a.galis@ee.ucl.ac.uk

Ana Garcia
ENoLL, Brussels, Belgium
ana.garcia@enoll.org

Anastasius Gavras
Eurescom GmbH, Heidelberg, Germany
gavras@eurescom.eu

Stamatis Karnouskos
SAP Research, Karlsruhe, Germany
stamatis.karnouskos@sap.com

Srdjan Krco
Ericsson Serbia, Belgrade, Serbia
srdjan.krco@ericsson.com

Man-Sze Li
IC Focus, London, UK
msli@icfocus.co.uk

Volkmar Lotz
SAP Research, Sophia Antipolis, France
volkmar.lotz@sap.com

Henning Müller
Business Information Systems, University of Applied Sciences Western Switzerland, Sierre, Switzerland
henning.mueller@hevs.ch

Elio Salvadori
CREATE-NET, Trento, Italy
elio.salvadori@create-net.org

Anne-Marie Sassen
European Commission, Brussels, Belgium
anne-marie.Sassen@ec.eu

Hans Schaffers
ESoCE Net, Dialogic, Aalto University, Aalto, Finland
hschaffers@esoce.net

Burkhard Stiller
University of Zürich, Switzerland
stiller@ifi.uzh.ch

Georgios Tselentis
European Commission, Brussels, Belgium
georgios.tselentis@ec.eu

Petra Turkama
CKIR, Aalto University, Aalto, Finland
petra.turkama@aalto.fi

Theodore Zahariadis
Synelixis/TEI of Chalkida, Greece
zahariad@synelixis.com

Preface

This publication constitutes the 2012 edition of the yearly Future Internet Assembly book, which has been published since 2009.

The Future Internet Assembly (FIA) is a successful, unique, and bi-annual conference that brings together participants of over 150 projects from several distinct but interrelated areas in the EU Framework Programme 7.

They share scientific and technical results and discuss cross-domain research topics around the notion of creating new Future Internet technologies, applications, and services with a global view.

FIAs history started in spring 2008 in Bled, Slovenia, and the spring of 2012 saw the 9th FIA conference in Aalborg, Denmark. As with prior spring FIAs, the community has put together a book, which aggregates both representative results achieved in the Future Internet domain and the possibilities of what can be expected in the medium or short term.

In the FIA time line several key elements were required to ensure success. These are:

- Cross-domain considerations: on both core technical issues, such as FI architectures, FI services, FI experimentation, mobile FI, or Internet of Things, and on horizontal issues, such as socio-economics, privacy, trust, and identity.
- Engagement with application areas of the Future Internet and users: to move from FI technologies to sectors where innovation can be improved by Future Internet technologies.
- Provision of results that are applicable in day-to-day life.

Within the structure of the book, different topics are covered in a balanced and coherent manner.

The topics of the book have been organized into four chapters:

- Future Internet foundations cover core cross-domain technical and horizontal topics. Chapters within this section include architectural questions; mobile Internet, cloud computing, socio-economic questions; trust and identity; search and discovery; and experiments and experimental design.
- Future Internet technical areas are those technical domains that are associated to the Future Internet, mainly but not limited to networks, services, Internet of Things, content, and cross-area questions.
- Future Internet application areas consist of user areas and communities where the Future Internet can boost innovation. The chapters within this section cover smart cities, smart energy, smart health, smart enterprises, smart environment, smart transportation, logistics and mobility, smart manufacturing, smart agriculture, and tourism.
- Future Internet infrastructures cover experimentation and results in real infrastructures within the FI domain.

There were 40 submissions. Each submission was peer-reviewed by experts in the field and editors of the book. The committee decided to accept 20 papers. Introductions to the four chapters of the book and an invited introduction describing the FIA Roadmap are also provided.

We would like to acknowledge the hard work of the reviewers of the book, and the support provided by Easychair, which was used for the electronic submission and paper review.

Last but not least we would like to mention the European FP7 projects that financially supported the book publication: FIRESTATION, EFFECTS+, SESERV, and CONCORD (on behalf of the FI-PPP).

March 2012 Federico Álvarez

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Future Internet Foundations

Introduction

Burkhard Stiller
University of Zürich, CSG@IFI, Zürich, Switzerland
Alex Galis
University College London, U.K.
Theodore Zahariadis
Synelixis Ltd.

Since the Internet has reached a major standing in terms of being the medium and the infrastructure for information exchange, management and computation in the beginning of the 21st century, its usage is characterized by billions of users as well as by hundreds, even thousands of different applications and services. The diversity of these applications and the use of today's Internet outline a very successful approach and undisputedly determine the core pillar of the Information and Communication Technology (ICT) landscape and its societal challenges and opportunities. Such a success is deemed naturally positive, however, the scale of a distributed system typically determines as well the overall achievable performance, a degree of user satisfaction, and operational perspectives. Therefore, the operational and commercial dimensions of Internet communications and computation have turned into areas, which go well beyond the initial Internet's technology and its basics, including areas such as high reliability, full-fledged security, mobility support, or delay tolerance. While these technology-driven dimensions are being enriched by application-specific, provider-critical, and user-driven facets, the set of economic and societal factors of major importance are being addressed in work in the context of Future Internet, too. Thus, the need to re-think at least partially the Future Internet foundations is essential, especially to enable future networks and services as well as novel technology to be able to cope with those new demands.

In consequence, the addressing of relevant, important, and arising foundations of a Future Internet are crucial for a success of new infrastructures to come. As such the pure delivery of packets - one of the key design principles for a robust Internet – has to be extended with those principles, which have to guide future developments. In addition, the analysis of technology-to-economic relations in terms of inter-stakeholder operations is essential for a modern Future Internet Foundation, as the economic dimension of the information exchange has reached it technical limitations of today's Internet.

A particular key aspect is the study of system limits defining the constraints and freedoms in controlling the Future Internet. Limits can be determined by analyzing how the behaviour of the system depends on the parameters that drive the system. Some limits would lead to unexpected and significant behaviour changes of the system, for example the unpredictable boundaries or changes

in the scale of magnitude. Some other limits are determined by non-common behaviour interactions between the components of a system.

And as highly distributed and decentralized systems can interwork only, if the right standard is in place, the important paths to a systematic research to standardization approach are required. To address a third domain of relevance for the Future Internet (besides the technology itself and its economics) the societal aspect determines a highly relevant cross-disciplinary facet. In that sense the relations between technology, pervasiveness, and societal foundations require a carefully study and guidelines' work. Last but not least a number of detailed technical advances play an important role for Future Internet generations, such as combined development and run-time environments or interactive and the analytics of interaction and security solutions in an Internet.

Therefore, the content of the book section on "Future Internet Foundations" addresses selected topics in this field, and it could be classified as follows:

- Future Internet Basics: Design principles and tussle analysis
- Future Internet Standardization: Systematic approach and development path
- Future Internet Cross-disciplinary Facets: Technology, pervasiveness, and society
- Future Internet Technology Advances: Development and run-time environments as well as interaction and security solutions.

Following the review and selection process run for this FIA book, eight chapters were chosen covering some of the above research in Future Internet with two papers in each category. The following is a summary of main results of the "Future Internet Foundations" section of this FIA book.

The paper on "*Design Principles for the Future Internet Architecture*" by Dimitri Papadimitriou, Theodore Zahariadis, Pedro Martinez-Julia, Ioanna Papafili, Vito Morreale, Francesco Torelli, Bernard Sales, and Piet Demeester addresses very basic foundations of systems: design principles. Here, the authors consider design principles being a central role in the architecture of the Internet, which have driven and will drive most engineering decisions at a conception level and operational level. While the paper's content is based on the EC Future Internet Architecture (FIArch) Group results, it identifies those design principles, which are expected to govern the future architecture of the Internet.

The work by Alexandros Kostopoulos, Ioanna Papafili, Costas Kalogiros, Tapio Levä, Nan Zhang, and Dirk Trossen on "*A Tussle Analysis for Information-centric Networking Architectures*" highlights in an examination, based on the tussle analysis method, key interests of various stake-holders, which shall to be taken into account by future designers when deploying new content delivery schemes under the Information Centric-Network (ICN) paradigm. This is considered highly relevant, since key concepts of ICNs are expected to have significant impact on the Future Internet, especially by creating new challenges for all associated stakeholders.

The approach by Bernard Sales, Emmanuel Darmois, Dimitri Papadimitriou, and Didier Bourse on "*A Systematic Approach for Closing the Research to Standardization gap*" argues that standardization activities are recognized as one of

the tools to incubate research results and accelerate their transfer to innovative marketable products and services. But since a lack of research transfer via the standardization channel is visible in EU research, generally referred to as the research-to-standardization gap, this paper analyzes the root causes for this situation and proposes a research-focused pre-standardization as a supplemented methodology and its associated processes to aim at a systematic analysis of standardization aspects of research projects.

The paper on "*From Internet Architecture Research to Standards*" by Dimitri Papadimitriou, Bernard Sales, Piet Demeester, and Theodore Zahariadis argues that that the debate between architectural research driven by the application of the theory of utility and the theory of change is over. It highlights a "third path" which is based on identifying the actual foundational design principles of the Internet such as the modularization principle and by acknowledging the need for a all-inclusive architecture instead of (re-) designing protocols independently and expecting that their combination would lead to a consistent architecture at running time. The proposed path will in turn also partially impact how the necessary standardization work is to be organized and conducted, including both "problem-driven" and "architecture driven" work.

The work on "*SOCIETIES: Where Pervasive Meets Social*" by Kevon Doolin, Ioanna Roussaki, Mark Roddy, Nikos Kalatzis, Elizabeth Papadopoulou, Nick Taylor, Nicolas Liampotis, David McKitterick, Edel Jennings, and Pavlos Kosmides provides an overview of the vision, concepts, methodology, architecture, and initial evaluation of results toward the accomplishment of the goal to improve the utility of Future Internet services by combining benefits of pervasive systems with those of social computing. As such, the work in the SOCITIES Integrated project attempts to bridge different technologies in a unified platform, especially by allowing individuals to utilize pervasive services in a community sphere.

The lessons learned on "*Cross-Disciplinary Lessons for the Future Internet*" by Anne-Marie Oostveen, Isis Hjorth, Brian Pickering, Michael Boniface, Eric T. Meyer, and Cristobal Cobo are described in terms of socio-economic barriers related to the Future Internet. As the authors outline, these observations are derived from an on-line survey and a workshop organized by the Coordination and Support Action SESERV, which identified six key social and economic issues to be deemed most relevant by 98 representatives from FP7 Challenge 1 projects. Thus, the cross-disciplinary views (including social scientists, economists, policy experts, and other stakeholders) are expressed and seen by the Future Internet community itself. In turn, the paper presents strategies for some solutions to these challenges, which is complemented by an investigation on how relevant the European Digital Agenda is to Future Internet technologists.

The view on "*An Integrated Development and Runtime Environment for the Future Internet*", expressed by Amira Ben Hamida, Fabio Kon, Gustavo Ansaldi Oliva, Carlos Eduardo Moreira Dos Santos, Jean-Pierre Lorré, Marco Autili, Guglielmo De Angelis, Apostolos Zarras, Nikolaos Georgantas, Valérie Issarny, and Antonia Bertolino, sketched technological solutions for future ultra large

systems, addressing scalability and heterogeneity issues in order to leverage Service-Oriented Architectures to support a wider range of services and users. Thus, an architecture combining both a development and a runtime environment is defined, as undertaken in the CHOReOS project.

Finally, the work by James Davey, Florian Mansmann, Jörn Kohlhammer, and Daniel Keim on "*Visual Analytics: Towards Intelligent Interactive Internet and Security Solutions*" presents an introduction to Visual Analytics and its relevance to the Future Internet in particular the two facets, which are characterized by a vast and growing amount of data: content and infrastructure. It shows that emerging data visualization platforms for the web derive their value from the relevance of the data that is analyzed with them. This paper argues that targeted research in Visual Analytics can revolutionize the way in which humans interact with content in the Future Internet.

Besides its potential for content, Visual Analytics can play an important role in the network infrastructure of the Future Internet. Due to the amount of data available from networking devices, the inherent complexity of the network and the need to immediately react to failures or attacks, visual and computational support for tasks in this domain can significantly improve infrastructure planning and testing, as well as network monitoring and security. Strengthening the connection between Visual Analytics and the Future Internet would enable a more secure, reliable and scalable infrastructure.

Future Internet Application Areas

Introduction

Stamatis Karnouskos
SAP Research

Petros Daras
Informatics and Telematics Institute, CERTH

Henning Müller
University of Applied Sciences Western
Switzerland, Sierre (HES-SO)

Man-Sze Li
IC Focus

Hans Schaffers
Aalto University

1 Introduction

Applications are software systems perceived and utilized by their intended users to carry out a specific task. Applications are what users are actually using in their working environments and their daily lives, hence applications are the medium that enables them to interact with the rapidly advancing technologies. This implies that we should take the users' needs and aspirations as a point of departure for developing and introducing advanced applications. Therefore, it is extremely important to pay attention to the openness of the process of developing, testing and validating applications and to the involvement of users in that process.

Applications evolve as they depend on the capabilities provided by several real systems. For example, the end-user devices they run on as well as virtual resources they utilize e.g. for mash-up applications are depending on the distributed services that provide the functionalities needed by these applications. In the Future Internet (FI) era, the applications will enjoy both the advances we have seen on the hardware e.g. running on mobile devices such as smartphones with memory and CPU power that comparable to supercomputers a couple of decades ago, as well as on the software side, where virtualization of the infrastructure and real-time communication and computation on data is possible. Taking advantage of the rich information offered by various stakeholders as well as the FI platform core facilities, the FI applications are expected to be seamlessly adjusting to the user's needs and context, while in parallel hiding the complexity of the underlying infrastructure and the interactions with the other services and systems.

Some of the key Internet-based technologies underlying smart Future Internet applications include cloud computing, real-world user interfaces of cyber-physical systems and the semantic web. Cloud computing, a new way of delivering com-

puting resources, will have considerable impact as it is opening up new possibilities in virtualization of physical spaces. The rapid advance of Internet of Things technologies will enable us to sense the real-world and will empower a new class of applications that are able to receive real-time information from the physical surrounding and interact with it. For example, a new generation of location-aware applications and services and, on the longer term new types of spatial intelligence, will advance the end-user application capabilities while it will blend easily in a global ecosystem of web applications, social media and crowdsourcing. Finally, the semantic web is expected to facilitate the merging of data from different sources and presenting them in a meaningful way, thus bringing social media based collaboration and collective intelligence to a higher level.

As the Future Internet will be a very complex system of systems, the applications will be the entry point for many users to interact with it and enjoy its offerings. In such a complex and rapidly changing environment the application developer will have to deal with multiple heterogeneous information sources that will need to be integrated as well as an increasingly number of heterogeneous devices that will be used to interact with the user. To achieve this, we will witness further increase in the trend to go beyond monolithic applications towards composite ones that collaborate both with parts of the Future Internet infrastructure as well as with other services and apps. This collaborative way of interactions is expected to lead to emergent behaviours in the Future Internet that at the end will better serve the end-users.

Several challenges need to be mastered in order to empower the visions for highly sophisticated Future Internet Applications. The challenges are increasingly multi-domain (ranging from technical to social, design, economics etc.) while in parallel traditional issues such as security, trust, privacy, user-friendliness and rapid development will still need to be present from day 1 and not added as an aftermath. Complexity management, crowdsourcing, real-time analytics, knowledge capturing and communication, simulation are only some indicative aspects that will need to be investigated as they will impact the next generation of applications. Nevertheless the Future Internet applications are in the heart of emerging visions for a smarter world i.e. smart cities, smart energy, smart health, smart enterprises, smart environment, smart transportation, logistics and mobility, smart manufacturing, smart agriculture and tourism. Their existence has the challenging goal of enabling innovation by empowering the Future Internet users.

2 Papers in the Section Applications

Various papers collected in this section demonstrate aspects of the scope and width of advanced applications based on Future Internet technologies. The papers vary from offering the technology orientation of applications to demonstrating the importance of applications within various application contexts such as service marketplaces and social networking.

More specifically, *I-Search: A Unified Framework for Multimodal Search and Retrieval* focuses on novel approaches for multimodal search allowing for easy

retrieval of diverse media types simultaneously e.g. 3D objects, images, audio and video. These technologies show a high potential value for enabling Internet-based applications in various important sectors, which are characterized by an overwhelming amount of content and could further serve for providing generic enablers to FI-WARE in terms of accessing varied content.

Supporting content, context and user awareness in Future Internet applications presents the general idea of delivering complex services in a distributed networking environment to end-users. The main feature of the proposed idea is that the process of complex services delivery is aware of the content being delivered, the context of the services delivery and that the delivered services are personalized for each separate end-user.

Towards Trustworthy Marketplaces for Services and Apps in the Future Internet presents the concept of trusted service marketplaces playing a key role for the future Internet of Services. Such service marketplaces impose new demands and requirements to trust and security and the paper proposes an approach and vision to address these demands.

Semantically Enriched Services to Understand the Need of Entities describes the evaluation of the proposed "Net-Ontology" aiming to improve network communication with semantics. The paper addresses intermediate network layers and contains an experimental evaluation and a promising comparison against the current TCP/IP stack.

Using Future Internet Infrastructure and Smartphones for Mobility Trace Acquisition and Social Interaction Monitoring focuses on the social networking context of Future Internet applications, which is of high relevance to smart city environments. The authors discuss a system for producing traces for a new generation of human-centric applications, utilizing technologies such as Bluetooth and focusing on human interactions. Two deployments in human-centric environments are described, one in an office environment and one in an exhibition/conference environment. The paper demonstrates the growing interaction between technology development and user interaction,

3 Conclusions

The Future Internet will be information driven and rely on services to empower the interactions among its stakeholders at multiple layers which will be facilitated via the applications. This calls for open information exchange and a new generation of highly sophisticated applications customized to end-user needs. Many of the papers in this volume are dealing with several central schemes of the Internet: content of an increasingly unstructured nature such as images and mixed media, needs to navigate this content using the user context such as location and other sensors and trust in the information that is received and being transmitted. All these application domains will change the way people interact and the way that living spaces are being created, highlighting the impact of the Future Internet on the lives of most of us.

Future Internet Application Areas: Smart Cities
Introduction

Srjdan Krco
Ericsson

Cities are complex, dynamic environments, catering for the needs of a large number of citizens and businesses ("users of city services"). The number of people living in the cities globally is continuously increasing, we are witnessing emergence of mega cities and the need for a sustainable development of such environments is more than evident.

The smart cities concept is not new. A number of cities around the world are using "smart" designation aiming to show that they have already done something in that regard or are planning to do so (this ranges from deploying optical infrastructure across a city to introduction of e-government services or some other, mainly ICT based, improvements making the city services more efficient or quality of life of the citizens better). With the recent technological advances in the domains of Internet of Things, M2M, big data, and visual analytics and leveraging the existing extensively deployed ICT infrastructure, the smart cities has attracted a lot of interest over the last few years.

Combining these technologies has made it possible to improve a range of the city services, from the public transport domain and traffic management to the utility services like water and waste management and public security and safety. All these services are intrinsically connected and interweaved. Therefore, for a city to develop in a sustainable and organized manner it is crucial to coordinate such developments and make it possible for smart services to leverage each others' functionality. The city governments will have a crucial role in these endeavors, from the overall city planning perspective as well as creation of the regulation and legislation framework for smart city service developers and providers.

The content of this area includes three chapters covering smart cities from three different perspectives: social, legislation and safety.

The "Towards a Narrative-Aware Design Framework For Smart Urban Environments" chapter is focusing on smart cities from both technical and social perspectives. The chapter describes a new narrative-aware design framework for the smart cities which combines quantitative sensor-generated data (Internet of Things installations) as well as qualitative human generated data (human storytelling) through participatory web platforms, in an always-on networked world. Three levels are identified in the framework: "data and stories", "analysis and processing" and "services and applications". Examples of narrative-aware urban applications based on the design framework are given and analyzed.

The "Urban Planning and Smart Cities: Interrelations and Reciprocities" chapter analyses the smart city's contribution in the overall urban planning and

vice versa. It highlights and measures smart city and urban planning interrelation and identifies the meeting points among them. The chapter starts with the urban planning principles based on the European Regional Cohesion Policy, and then identifies the key smart city attributes and characteristics. Finally, analysis of the way these domains influence each other and impact development of each domain is given.

The "The Safety transformation in the Future Internet domain" chapter is dealing with the public safety as one of the major concerns for governments and policy makers in smart cities. The chapter presents an introduction to Internet of things, Intelligent Video Analytics and Data Mining Intelligence as three fundamental pillars of the Future Internet infrastructure in the public safety domain.

Future Internet Infrastructures

Introduction

Federico Alvarez
Universidad Politécnica de Madrid, Madrid, Spain
Elio Salvadori
CREATE-NET, Trento, Italy
Anastasios Gavras
Eurescom, Heidelberg, Germany

One of the most important aspects of the Future Internet is to leverage existing investments in advanced infrastructures for testing and experimentation of novel Future Internet technologies and speed up their introduction into the market.

A large number of advanced infrastructures are available in regions such as Europe ranging from national or European level to many regional or city-level initiatives promoting innovative FI concepts such as smart-cities, smart-grids and e-health.

Europe has the potential to deliver massive capacity for Future Internet developments by leveraging the abundance of advanced infrastructures (current infrastructure, future infrastructure, pilot experiments, testbeds, and experimental facilities) but the fragmentation and lack of interoperability and understanding of capacities hinder those development at large scale.

The Future Internet Research and Experimentation (FIRE) initiative (www.ict-fire.eu) in Framework Programme 7 created a research environment for investigating and experimentally validating revolutionary ideas towards new paradigms for Future Internet architecture by bridging multi-disciplinary long-term research and experimentally driven large scale validation. FIRE invested significant effort in familiarising the ICT research community with the methodology of experimental driven research as a necessary research tool in the ICT related science disciplines.

In some cases it is difficult to define what is an ICT infrastructure. The definition of infrastructures done in the project INFINITY (www.fi-infinity-eu) is the following:

An infrastructure is an structured and organised collection of physical and/or logical elements offering an ICT platform with the functionality to facilitate large scale experimentation and testing for Future Internet projects and applications and service developments.

Such a platform may consist of ICT-based services which could be generic or more specific to a given domain (e.g. energy, transport, health, environment, tourism, health. . .).”

In consequence, ICT based infrastructures are one of the chapters which this book is addressing.

Following the review and selection process run for this FIA book, four chapters were chosen. The following is a summary of main results of the "Future Internet Foundations" section of this FIA book.

The paper on *"FSToolkit: Adopting Software Engineering practices for enabling definitions of federated resource infrastructures"* by Christos Tranoris, and Spyros Denazis describes the present the Federation Scenario Toolkit (FSToolkit) that enables the definition of resource request scenarios, agnostic in term of providers. This work adopts Software Engineering practices considering the concepts of modeling and meta-modeling to define a resource broker and to specify scenarios by applying the Domain Specific Modeling (DSM) paradigm. FSToolkit is developed for experimentally driven research for validating through testing-scenarios new architectures and systems at scale and under realistic environments by enabling federation of resources.

The work by Leonidas Lymberopoulos, Mary Grammatikou, Martin Potts, Paola Grosso, Attila Fekete, Bartosz Belter, Mauro Campanella and Vasilis Maglaris *"NOVI Tools and Algorithms for Federating Virtualized Infrastructures"* addresses the efficient approaches to compose virtualized e-Infrastructures towards a holistic Future Internet (FI) cloud service and aspires to develop and validate methods, information systems and algorithms that will provide users with isolated slices, baskets of resources and services drawn from federated infrastructures.

The paper "*Next Generation Flexible and Cognitive Heterogeneous Optical Networks Supporting the evolution to the Future Internet*" by Ioannis Tomkos, Marianna Angelou, Ramón J. Durán Barroso,Ignacio de Miguel, Rubén Lorenzo, Domenico Siracusa, Elio Salvadori, Andrzej Tymecki, Yabin Ye and Idelfonso Tafur Monroy describes the new research directions in optical networking to further advance the capabilities of the Future Internet. They highlight the latest activities of the optical networking community and propose concepts of flexible and cognitive optical networks including their key expected benefits..

The work by Marc Pallot, Brigitte Trousse, Bernard Senach "*A Tentative Design of a Future Internet Networking Domain Landscape*" presents a tentative FI domain landscape populated by Internet computing and networking research areas where still open questions such as visualzsing the conceptual evolution and articulating the various FI networking and computing research areas and identifying appropriate concepts populating such a FI domain landscape are developed.

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