NESSI Research Priorities for the next Framework Programme for Research and Technological Development FP8

Strategic Research Agenda Version May 2011

Executive Summary

This document is the May 2011 update of the NESSI Strategic Research Agenda (SRA) highlighting research priorities in the area of software and services. With the intention to provide this document as input for the definition of the next European Research Framework Programme FP8, the focus is on mid- and long-term research items with a time horizon up to 2020.

Information and Communication Technology (ICT) continues to play a growing role as general-purpose technology across all sectors of the economy and will play a key role to contribute to the solution of societal challenges as outlined by the Digital Agenda 2020. On the other hand, the ICT landscape will be influenced by major trends – people, devices, sensors, machines, and businesses get increasingly interconnected, huge amounts of data need to be managed, user behavior and life style are changing, and business and technology lifecycle are increasing their pace.

How can software and service technologies contribute best to solve the grand societal challenges? What is the impact of these trends on software and services? These were the main questions that guided the discussion within the NESSI community with the goal to identify the most relevant service characteristics in the future and to derive corresponding strategic research objectives. The resulting highest ranked objectives are (a) achieving interoperability of services, (b) extending and supporting the global accessibility and pervasiveness of services, (c) securing software and services and making them trustworthy, and (d) supporting fast business cycles and increasing productivity by software and services.

The discussion about the research objectives led to the proposal to extend the notion of service. Today, a service is provided by a single provider and the notion “service” denotes basically the software part that is needed to run a service. In the future, a service is increasingly shaped by the devices, machines, and sensors the service is based on, it will be influenced by the changing nature of enterprises in the future internet and new provider models in which for example communities play the role of the provider. Services will become a public commodity such as electricity and people will play the role of both service provider and consumer depending on their needs.

Detailed input on research items has been collected via an online survey and workshops. The received input has been prioritized and structured according to five technology areas: service usage, service engineering, service infrastructure, software engineering, and security, privacy and trust. These areas have to be combined into an integrated and multidisciplinary approach. Only with such an approach it is possible to come up with solutions to tackle the challenges of our society and to meet the requirements imposed by the major trends and the new notion of service. In addition, the need for a holistic approach – as taken by the NESSI open innovation environment – has to be emphasized; technological developments need to go hand in hand with socio-economic considerations to ensure that research is turned into successful innovations. These considerations as well as the fast technology cycles in the software and service area should be taken into account in the definition of corresponding research actions.

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1. Foreword

This document summarizes the results of the latest update of the NESSI Strategic Research Agenda (SRA).

NESSI – the Networked European Software and Service Initiative – is one of the so called European Technology Platforms (ETP). These ETPs are industry-led communities with the aim to bring together R&D key players including industry, SMEs, and academics, to identify joint research priorities, and to facilitate the translation of research results into innovations. NESSI is the ETP that facilitates joint research and innovation in Software and Services technologies.

The SRA is a major asset of NESSI and has its origin in the early days of NESSI. The work at that time started with a volume 1, "Framing the context", a volume whose main goal is to define the environment in which NESSI and, more generally, services are evolving. A second volume, "A Strategy to Build NESSI", introduced the systemic and technology foundation of NESSI. The systemic aspect touches on the human, economic and regulatory aspects, while the technology foundation relates to the creation of the NESSI Open Innovation environment and the underlying need for standards. Together these volumes also led to the creation of the NESSI research structure, providing the overall scope for the currently 18 NESSI Strategic and Compliant projects in which 136 member organizations are involved.

The 3rd volume is the one NESSI revises on an annual or biennial frequency, reflecting the NESSI research priorities and roadmaps. The latest edition was issued in May 2009. This document is therefore the 2011 update describing the research priorities for the mid- and long-term as seen by NESSI. All these documents as well as additional reports around the SRA topic are available from the NESSI website[1].

There are many driving forces encouraging this update. First of all, the NESSI membership survey conducted early in 2010 has shown that NESSI members consider the SRA as one of the main assets of NESSI providing a consolidated view on future research priorities based on the input given by the NESSI community. Secondly, the publication of the Digital Agenda for Europe, the advent of the Future Internet and the start of the preparation of the next European Framework Programme for Research (FP8) constitute another key driver for this SRA update. Thirdly, NESSI has completed a first set of activities – with the completion of some of its first research projects and the availability of major results as identified in the launch of the "inventory of results". This in parallel with a context evolution in which the speed of convergence and interaction are increasing between machines, devices and humans is bringing a considerable evolution in the services domain.
Building on these opportunities, NESSI entered into the process of updating its research agenda in September 2010.

[1] http://www.nessi-europe.com/

One major contribution of this update is to show why and how software and services technologies still require further research, to ensure that the underlying components of Future Internet and other applications are fully in line with the user needs – for example taking into account the increased deployments in the "cloud" that lead to totally new requirements both at business and technology levels but also additional strains and threats on critical issues such as trust and privacy. Further trends and factors influencing the research needs are outlined in more detail in chapter4 3 of this document.

As a first step, the NESSI vision was reviewed and updated. The result of this activity was presented during the ICT2010 conference in Brussels end of September 2010. The vision document was made publicly available at the NESSI website. This was the starting point for an online survey providing the opportunity to comment on this vision statement and to provide more detailed input on future research priorities. This survey was open for all NESSI members until beginning of November. The results of this survey were presented at a workshop during the ServiceWave2010 conference in Ghent mid December 2010. This workshop provided another opportunity to reflect on the interim results of the SRA update and to identify and to discuss further research priorities that should be taken into account for the final version of the SRA document. The complete draft version of the SRA update will be available from the NESSI website in May 2011.

2. Setting the scene – a few examples

Research in software and services is not new. Indeed, within the NESSI context, 4 years of research have taken place, and at the same time technological approaches such as the Future Internet have emerged, and while application domains such as e-Government, e-Health, or energy have opened the opportunity for piloting the usage of ICT within their own area.

With this background, the legitimate question is whether the software and services domain per se still requires specific support or whether the required evolutions can be taken care of in the application domains. This update of the NESSI SRA together with the NESSI inventory of results clearly highlights why and how the software and services domain remain as useful as ever, facing key challenges in ensuring that the application domains can benefit from a new generation of collaborating services.

Indeed, the application domains clearly open the door to efforts in integration, deployment, user involvement and cross-domain uptake. However, these evolutions can only occur by building on the underlying technology advances, with software and services being one of the key supporting domains. The NESSI results show major advances in secure services, front-ends potentially empowering users to create their own environments, underlying architecture and standards, open source and other support for cloud deployments. But the next examples will highlight some of the challenges that the real-world poses in the coming years, evolving from the current stage of advancement to the next one in terms of user and business adaptability.

From a technological view point, this evolution is one of convergence - when NESSI was defined in 2006, one of the major drivers was that of convergence of data, networks and services – with services identified as the key to ensure intelligent use of data. Today, this convergence has shifted to an entirely new dimension, across domains and user needs. This level of convergence requires that further innovation be delivered in the area of software and services, and the two examples below illustrate this convergence evolution to set the scene for the needs identified in this SRA update.

2.1. Moving to the next level of dynamic information

The convergence of Internet of Things, Internet of Services and Internet of Content empowers the development of new applications which take advantages of this convergence. For example, the combination of real time knowledge about things (e.g. goods in logistics) can be combined with real-time information about available service capabilities.

Assume a road accident involving a lorry. In such a scenario, the different goods transported can be identified and critical situations like the increase of temperature above a maximum or the danger to the environment and people can be recognized. Moreover, alternative transport capabilities available in the nearer surroundings can be identified, service level agreements can be negotiated and the actual logistic process can be adjusted. All the intervening bodies from civil protection to police forces, from health services to new lorries can operate in a fully informational and operating single environment of information, and therefore of action.

This situation highlights the power of convergence, but it will only be fully effective through a continuous adaptation of operational processes and facilitated by a continuous adjustment of future internet based applications. To facilitate this adjustment the stakeholders must be supported to understand and process the actual information about, e.g. alternative services offered, events generated by the Internet of Things and supported to decide continuously about adaptations, including support for (partial) automated adjustments of the applications themselves. In other words, the convergence of information that is already experienced in some cases today will only be effective, if it is supported all the way through to the convergence of operations.

This in turn requires the engineering applications for adjustment – a key shift in the focus of the software engineering methodologies. In addition to the traditional engineering activities, one has to focus on monitoring and adaptation activities and design and deploy an adaptation environment which aggregates, condenses real-time information about services and things, and supports the stakeholders in analyzing this information and in adjusting the applications across organisations, seamlessly supporting the action and operation phases.

This shift introduces two major elements – the need to support user adaptability, but also the need to support business adaptability, a term that represents the shift currently on-going within major industrial players that are re-organising traditionally separate domains, such as energy, transport, city infrastructure etc.

into single units reflecting the target level of integration. This in turn enables industrial players to handle the reality of so-called “cyber physical systems”, a terminology highlighting the difference between traditional embedded systems and a network of interconnected and interacting elements.

2.2. Enabling users to create new online services

This example focuses on the users of information and their needs in creating the level and integration of information that they require, leading to a level of user adaptability that cannot be delivered today.

In Web 1.0 companies directly stored or provided data to pages and portals and where business and consumer users had to use those specific pages to access this information through what can be described as ‘hard-coded’ services. With the so-called Web 2.0 came the advent of ideas and standards that enabled not only this data to be exposed but the individual services to be exposed and reutilised by others. The concept of mashup emerged which described the composition of these varied services to provide new services of increasing functionality and which in turn could be the basis for further services. There has been much investment via the EU/FP7 in projects such as SOA4All, as well as commercially, in mashup technologies and service editors which have attempted to eliminate the difficulty of this service composition that exists even for the development community and which has led, in reality, to significantly less services openly available than expected. Despite many aspects being seemingly in place the service world is a long way from the reality of the App-Store world where there is an impression that a wider class and population can create Apps.

The real challenge is to move from this technological approach to a user oriented approach – moving from a data oriented model to a “user needs” approach. This creates significant service challenges to provide innovations which can merge the services of websites and other areas together in a seamless way; for example, by allowing consumer and SME users to drag operable web pages together to visually form new service web sites whilst behind the scenes the service technologies automatically knit together the various individual services. Service research is delivered into the world of the service prosumer – where the user can be both a consumer and a provider, to himself or even to others.

3. The context of the SRA update – trends and the research challenges in the Software and Services landscape

The SRA update reviewed the main challenges to be addressed by software and services and trends impacting future software and services. The discussion within the NESSI community finally led to a prioritization of future service characteristics and related research topics to be covered within the NESSI core technology areas.

3.1. Main challenges to be addressed by software and services

The latest report on Europe's digital competitiveness[2] states that Information and Communication Technology (ICT) is one of the key drivers for economic growth basically through the investment in ICT and the achieved productivity gains mainly in the IT sector. In the future, its importance will increase even further through its growing role as a general-purpose technology across all sectors of the economy such as transportation, energy, or healthcare. Analyst reports[3] say that smart machine-to-machine solutions will drive this new wave of growth. Almost 200 million Internet-enabled devices used for connecting machines have been shipped in 2010. There will be more than 800 million of those devices shipped in 2014 with an annual growth rate of 44%[4]. Overall, this will lead to an increasingly connected world of smart objects, people, and businesses enabling improvements in efficiency and productivity. Services in those machine-to-machine scenarios will be implemented no longer by software mainly, but will be shaped significantly by the machines, devices and sensors the services will be based on.

The increased cross-sector adoption of ICT is also promoted by the Digital Agenda 2020[5] with the aim to establish a digital single market and to address the grand societal challenges such as the climate change, the aging population or the rising healthcare cost. The agenda stresses the point that the Internet has accelerated economic competition at a global scale. There is the danger that Europe is lagging behind its competitors, if a number of obstacles cannot be overcome such as the fragmented digital market, the lack of interoperability, or the rising cybercrime and risk of low trust: services need to be accessible on any device and interoperable across borders and trust in using them needs to be facilitated to establish a single digital market; services have to be based on standards and open platforms to achieve their interoperability; new forms of cybercrime need to be addressed, personal data and privacy need to be protected, and the Internet has to be considered as a critical information infrastructure for the European economy.

Research can contribute to overcome such obstacles and to improve the efficiency and productivity across sectors.

3.2. Highlights of the previous version of the NESSI SRA

The previous version of the NESSI SRA was based on the vision that for the next coming years "*all electronic devices human beings may think of will have interaction capabilities enabling new services within continuing changing scenarios according to different business needs and situations in a continuum which de-facto creates a new global system.*" Which impact that will have for the software and service area has been summarized into two main headlines – the service transformation and the future Internet.

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[2] Source: Europe's Digital Competitiveness Report 2010, http://ec.europa.eu/information_society/digital-agenda/documents/edcr.pdf

[3] Source: Harbor Research, The Emergence of Smart Business, 2010

[4] Source: Forrester, The M2M Market is a blossoming opportunity, March 2010

[5] http://ec.europa.eu/information_society/digital-agenda/index_en.htm

The way how and the extent to which services are used and the emergence of social networks and community-based collaborations has triggered a transformation of services. This transformation is characterized by

- emphasizing that users will demand more and more seamless, personalized and fully user-centric services;
- the changing mechanisms for providing services and the transformation of related business models;
- the introduction of new business roles and the entrance of new key players into different sectors such as eHealth, eEnergy or Media;
- the blurring line between provider and consumer of a service.

The new global system is given by the Future Internet – an Internet that serves in a more dynamic and proactive way its users in their everyday life. This Future Internet has to be open, scalable, and trustworthy and there should be no central control and uncoordinated governance. Due to its complexity it will not be fully predictable in its overall behavior.

The software and service aspects of the Future Internet are covered by the so called Internet of Services. It should be emphasized that the Internet of Services is closely intertwined with the Internet of Things to embed services in their deployment environment given by networked machines, sensors, and devices. Moreover, software and services technology will be a key in the provision of Internet of Content and Knowledge, including the new and emerging media industry taking advantage of the Internet.

3.3. Review of trends and expected characteristics and research objectives

The 2011 update of the NESSI SRA confirmed basically the overall trends as described in the previous version and showed that certain aspects gained further momentum as described and forecasted in reports[6] and by initiatives such as the Future Internet PPP or the Digital Agenda 2020.

NESSI has reviewed those initiatives and market forecasts and has identified the main factors influencing the software and services area. These factors have been grouped into four main trends:

- *The connected world*. People, devices, sensors, machines, and business get increasingly interconnected in the Future Internet. In 2020, there will be around 3 billion Internet users and trillions of those devices, sensors, and machines.
- *Explosion of digital information*. The amount of structured and unstructured data is increasing at an annual rate of 57%.
- *Changing life style*. People spend more time online. They not only consume services, but produce increasingly content and even applications. They

[6] ITU, The world in 2009: ICT Facts and Figures, http://www.itu.int/ITU-D/ict/material/Telecom09_flyer.pd
IDC, Digital Marketplace Model and Forecast, 2009
Gartner, Four Business Model Scenarios for higher education, ID Number: G00167364, 2009
Informa Telecoms & Media, Global Mobile Forecasts to 2014, January 2010
Forrester, The M2M Market Is A Blossoming Opportunity, March 2010
IDC - Digital Universe Decade – Are you ready? , May 2010
Gartner – Next Generation Communications Consumers, Worldwide, 2020, 2010
IDC, The Internet Reaches Late Adolescence
ITRS International Technology Roadmap for Semiconductors http://www.itrs.net

expect that services will be accessible from everywhere and that they are pervasive and personalized.

- *Fast business and technology cycles*. Internet commerce is growing at an annual rate of 18%. New services can be easily deployed and can replace older ones at a faster pace. Falling prices of storage and processing power and increased performance will enable services to rely on huge amount of stored information, and to become faster and to operate in real-time.

"The connected world" and "The fast business and technology cycles" have been considered by the NESSI members in a recent survey as the most influential ones for future software and services (see Figure 1). This view is backed by analyst reports[7] stating that connected solutions in the machine-to-machine area are maturing and experiencing robust growth during the next years, but also saying that there is still some way to go before end-to-end solutions are available without significant tailoring.

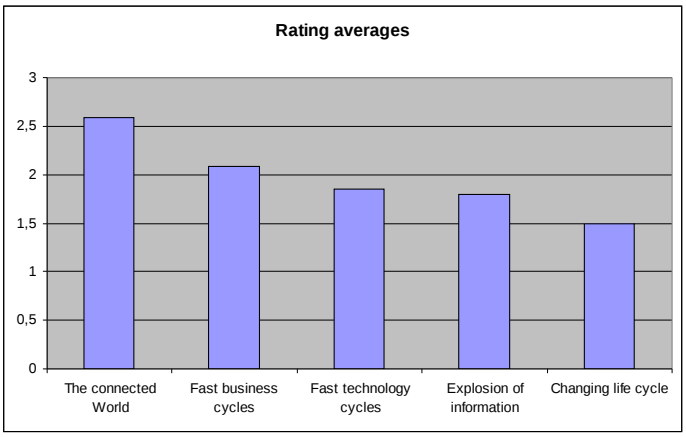

Figure 1: Trends influencing software and services

These trends as well as the challenges mentioned in section 3.1 – i.e. improve productivity, achieving interoperability, extend global accessibility, and improve trust and security – can be considered as the main drivers impacting the characteristics of future software and services such as:

- *Interoperability*. Services should be easily composed; they should be able to interwork and exchange information via open platforms and standardized interfaces.
- *Security and trustworthiness*. Services must be secure, protect privacy and generate trust and confidence.
- Global accessibility and pervasiveness. Services ought to be accessible everywhere, at any time and on any devices.
- *Smartness and adaptability*. Services should be able to adapt to context and user needs.
- *Resource-efficiency*. Services should contribute to reducing energy consumption and apply green-IT.
- *Real-timeliness*. Services should act and react increasingly in real-time.

[7] Harbour Research, The Emergence of Smart Business

- *Self-X**. Services should deal in an autonomic and self-controlled way – self-healing, self-composing, self-managed, etc.

A survey among NESSI members has prioritized the interoperability, security and trust, as well as the global accessibility as the most important characteristics (Figure 2). This is in-line with the view that the trends around the connected world are considered to be most influential for future services. In addition, the survey has emphasized the important role of services to support innovation and new business models as well as the ability of software and services to deal with fast business and technology lifecycles.

The findings resulting from the review of the trends and characteristics of services provided the guidance for the discussion about which topics still needs research, where the gaps are, and how to prioritize the identified research items.

The discussion about the SRA touched also more fundamental aspects about how the notion of services will have to be changed very likely in the future and with that also the related research. Today, the notion of a service is referring basically to the software part that is needed to implement and run a service. A service running in an increasingly interconnected environment comprising different devices, machines, and sensors is shaped by and relies heavily on those devices and machines. In other words, a service is constituted not only of the software part anymore, but also constructed based on these hardware devices. Another dimension is given by who is providing a service. Today, in most cases there is a single service provider responsible to run a service. Already in case of a composed service, there might be more than one provider involved. And we might also have the case that a community is providing a service. The notion of a service would need to be extended in order to cover all those scenarios resulting at the end also into new research issues.

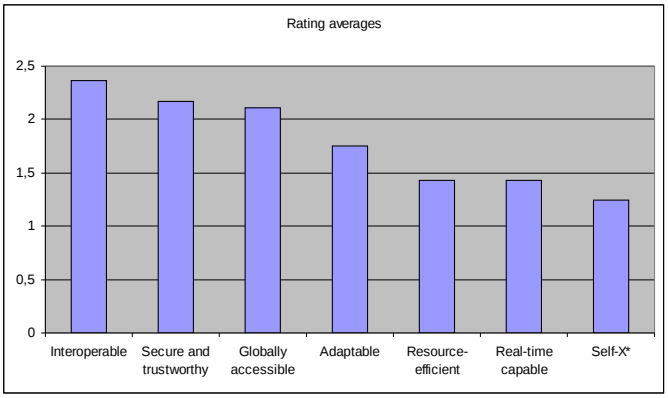

Figure 2: Important characteristics of future Software and Services

3.4. The core technology areas of NESSI

The main technological foundation for services is captured by NESSI's core technology areas:

- *Service usage*. This area is looking at technologies and the ways how user can interact with services, what is needed to improve and to optimize the usage of services.
- *Service infrastructure*. This area is looking at the infrastructure needed to run services. This includes for example cloud computing as well as technologies helping to reduce resource consumption.
- *Security, privacy and trust*. This area is dedicated to methods and technologies to provide secure and trusted services as well as privacy protection.
- *Service engineering*. Methods, approaches and technologies needed to design and implement services are covered in this discipline.
- *Software engineering*. All technologies which help to develop high-quality, reliable, and maintainable software in a cost-efficient way have to be considered here.

It is quite obvious that these five technology areas should not be treated as disciplines of their own and in isolation of each other. In many cases a multidisciplinary and integrated approach across all the areas is needed to get a successful and innovative service solution. For example, a service is perceived as a trusted service only if the service frontend provides transparency on how the service is dealing with personal information, supported by corresponding service and software engineering mechanisms guaranteeing a secure, correct and robust service execution, taking into account that the service is running perhaps in a cloud.

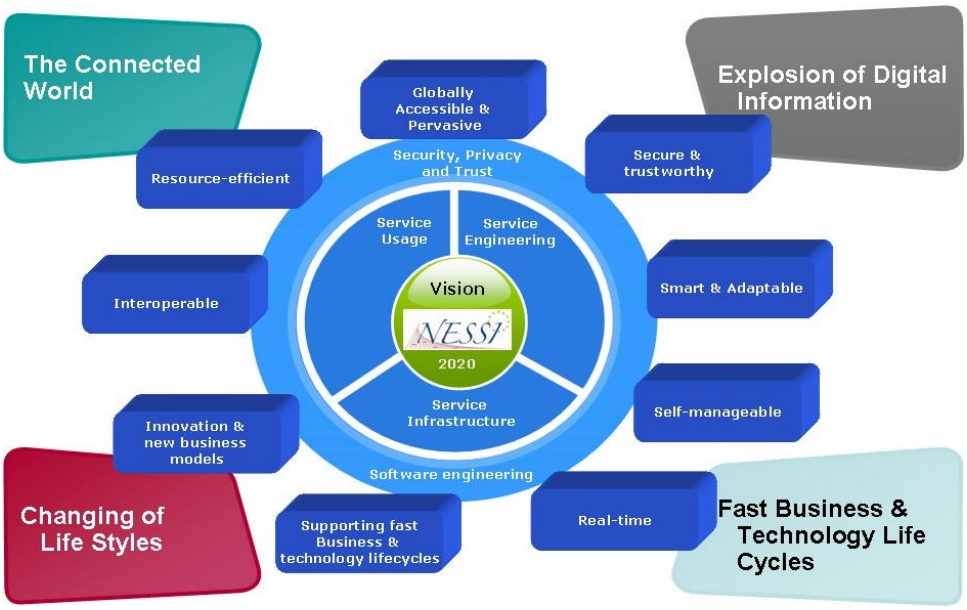

Figure 3: Trends and requirements impacting NESSI's core technology areas and future Software and Services

It also has to be noted that these five technology fields should not limit the thinking about what is needed for software and services in the future. It is important to be open-minded and to consider extending existing areas or even

to come up with new ones. This openness is especially important when developing a future-oriented technology and research strategy. For example, the application of software and services across different sectors such as health care, energy, or transportation may call for a new approach to research and technology to release full innovation potential. Also an extended notion of service as described in the previous section will make it necessary to adopt a more open view.

4. Research Priorities for NESSI's core technology areas

The table below provides an overview about the identified research priorities (see section 4.1 to 4.5) and how they relate to corresponding research objectives as outlined in section 3.3 and the challenges (see section 3.1).

Challenges	Research objectives	Research priorities
• Deliver sustainable economic and social benefits • Lack of interoperability • Fragmented digital markets • Rising cybercrime and risk of low trust	Support fast business cycles	• Priority 3.1-2: service usage in a fast changing business world • Priority 3.4-1: engineering for future service platforms • Priority 3.4-2: Community based service engineering • Priority 3.4.3: Engineering complex and adaptive heterogeneous services • Priority 3.5.1: Productivity in software engineering • Priority 3.5.2: New ways to increase software performance and energy-efficiency
	Improved service interoperability	• Priority 3.2-1: SLA handling in heterogeneous service scenarios • Priority 3.2-2: Management for single hybrid and multi cloud scenarios
	Extend global accessibility and pervasiveness	• Priority 3.1-1: Personalized, intuitive, and seamless service usage
	Secure services and improved trust	• Priority 3.3-1: Service usability • Priority 3.3-2: Identity and trust management • Priority 3.3-3: Internet cyber security • Priority 3.3-4: Security by design

4.1. Research priorities in the Service Usage area

Services offering a rich user experience will gain a better reputation and will attract more customers. Users will act not only as consumers when accessing services, but also increasingly as producers of those services and service-based applications. People will compose services out of other services and those services can federate with each other. Frontends need to be optimized for services running in the cloud to support global and seamless accessibility of services. User interfaces and service frontends have to adapt on a regular basis to the newest technologies that provide enhancements towards a better user experience.

Research Priority 3.1-1: Personalized, intuitive, and seamless service usage

- Develop automatic knowledge-, context- and situation-driven personalization of interfaces and services, allowing services to adapt to the needs of individual users and to anticipate their wishes;
- Make the Web an intuitive structure of information, services, things, catalogues and interaction mechanisms, with context-aware frontends and through innovative multimedia user interfaces based on virtual and augmented reality and 3D internet;
- Investigate Human Computer Interaction and develop User Centered Design methodologies to improve the usability of services in terms of QoS and QoE;
- Develop methods and tools to manage fast technology cycles, allowing services to improve the user experience in a continuous way;
- Address security and privacy concerns by frontend design and usage principles to increase the level of trust in services.

Research Priority 3.1-2: Service usage in a fast changing business world

- Empower end-users to create services and service front-ends;
- Provide support for new business models, where the barriers between producer and consumer roles will blur and may be simultaneous;
- Advance semantic interoperability to achieve seamless composition of heterogeneous services;
- Understand and optimize long-term usage and reputation of services by investigating data analytics and self management mechanisms built into services;
- Support end users in case of failures of services running in complex scenarios of composed and federated services.

4.2. Research priorities in the Service Infrastructure area

Well-managed services will attract more users and will be more competitive. Improvements and optimizations of SLA handling will be achieved by adopting an integrated approach, looking across different layers of the software stack underpinning the services, and considering the network infrastructure and the devices and sensors which are required by services used in machine-to-machine

(M2M) scenarios. Clouds will be increasingly interconnected, providing a powerful service infrastructure with mechanisms such as cloud federation, cloud aggregation and cloud brokerage. These mechanisms and the resulting multi-cloud scenarios raise a number of research issues such as trust, risk, self-healing, and legal compliance.

Research priority 3.2-1: SLA handling in heterogeneous service scenarios

- Optimize SLA mechanisms by adopting an integrated end-to-end approach across different layers, including services, network infrastructures, devices and sensors;
- Adopt an extended view on handling SLAs, considering not only QoS related aspects, but also aspects such as security, privacy and interoperability, and investigate their impact on QoE;
- Investigate high-availability and recovery, including failover, backup, and disaster recovery mechanisms for complex service infrastructures.

Research priority 3.2-2: Management for single, hybrid and multi cloud scenarios

- Advance standardized and open approaches for managing cloud resources, including computing, storage and network resources, in a coherent way;
- Develop integrated, application-aware management mechanisms able to address application-specific resource management logic;
- Integrate energy-aware infrastructure management and use of Green-IT;
- Identify common cloud components and their implementation as standardized building blocks;
- Implement monitoring techniques which allow insights into the cloud in a controlled manner to verify the compliance with a given SLA.

4.3. Research priorities in the Security, Privacy and Trust area

The overall objective of this area is to provide the foundations for secure, reliable, resilient, compliant and trustworthy service-based systems. Security has to be an inherent part of the system design and infrastructure. Users and application developers installing appropriate security require easy to use interfaces and need to be aware of potential security issues. Privacy is highly context dependant and is based on trust. Therefore the concept of trust needs to be understood, how trust is created and how it can be managed. Further research priorities cover specific security challenges imposed by the Internet: managing digital identities and the resulting privacy issues, new ways of network security monitoring and analysis, and security considerations in specific areas such as M2M, cloud based services and infrastructures, and mobile network connectivity.

Research priority 3.3-1: Security Usability

- Easy to use (zero-configuration, security by default), more standardized and understandable security interfaces;
- Research on user behaviour for developing user-centric intuitive security mechanisms.

- Easy, on the fly user self-assessment of services before using it by measuring if a particular service fulfils a particular set of security, privacy and trust criteria.
- Tools and approaches to raise security awareness, and education enabling users to understand security, privacy and trust.
- Security as a Service based on cloud technology, and corresponding solutions for managed security services with improved usability.
- Security usability from an administrator's point of view, e.g. policy based security management of services and visualisation/analysis of monitoring information.

Research priority 3.3-2: Identity and Trust Management

- Support for identity management federation solutions able to scale up to Internet size serving billions of users, devices and ID providers, designed in an open way and attracting as many stakeholders (e.g. service providers) as possible;
- Adaptation, parameterization and testing of European eID security and privacy policies;
- Trust analysis, management and monitoring, including end-to-end verification of trust, security, and dependability properties in complex scenarios of composed and federated services;
- Mechanisms to enable trusted federations, for example in cloud infrastructures.

Research priority 3.3-3: Internet cyber security

- Risk management and mitigation of vulnerabilities on the entire service lifecycle, moving from system-based to more business-based risk analysis;
- New ways for system-wide security monitoring and analysis at all levels from networking up to services, by deploying innovative methodologies such as proactive protection, detection, analysis, and automatic mitigation; this also requires research on the collection and analysis of heterogeneous information from multiple sources;
- Use of cloud technology to facilitate collaboration among network operators, service providers and governments on security issues such as pro-active defence against massive DDOS using cloud federation;
- Supporting simultaneous compliance to multiple business domains such as eHealth, eGovernment, or eEnergy;
- Devise security mechanisms and controls for the Internet of Content (e.g. managed data distribution services), Internet of Things (e.g. M2M communication), and the underlying network infrastructure (e.g. mobile networks).

Research priority 3.3-4: Security by Design

- Research on security-oriented development environments and their coupling to a broad range of system families (e.g. service-based, internet-based, cloud-based).
- Approaches and mechanisms to ensure and balance confidentiality, integrity and availability of information and knowledge;

- Security test environments, defining widely accepted assurance levels and common guidelines supporting product integrity protection;
- Dynamic and context-aware adaptation of security mechanisms ("just-in-time security");
- Designing and implementing robust systems so that performance alters to counter attacks.

4.4. Research priorities in the Service Engineering area

Service Engineering is in many respects an immature engineering discipline. There are still many notions and concepts that need to be explored to actually understand the fundamental aspects of services - be they atomic or composed or something else. The notion of a service itself is changing from a software-centric view to a more comprehensive view including the environment and the deployment scenario, where a community might be the service provider and not a single entity anymore. M2M services are an example, where devices and sensors are an essential part of service provision. Service Engineering is not only about putting the service in place and make it running, but it is also about dealing with security and trust issues, the QoS and QoE aspects, etc. Thus it is a multi-disciplinary approach that will contribute significantly to shaping the business models and processes for the more advanced and challenging services ahead of us.

Research priority 3.4-1: Engineering for Future Service platforms

- Exploiting context models and context-driven adaptation;
- Purpose-built, cloud based development frameworks and platforms for rapid service creation and deployment;
- Embedded services for direct machine execution and enhanced service composition and orchestration by any device;
- New methods and techniques for the design of flexible and open service frameworks able to cope with fast business and technology cycles;
- Understand and optimize long-term service usage and reputation of a service (monitoring service usage, autonomic context and requirements capture, …).

Research priority 3.4-2: Community-based service engineering

- New concepts and Internet-based tools to support a collaborative style of distributed service development considering the principles of open innovation.
- Standardized components, platforms, and tools to facilitate open service development.
- Frameworks and environments for community-based service provisioning.

Research Priority 3.4-3: Engineering complex and adaptive heterogeneous services

- Automated negotiation of service level agreements and service contracts;
- Defining a coherent lifecycle for adaptable and evolvable service compositions with continuous quality assurance after deployment;

- Approaches to determine end-to-end QoS, considering QoS levels offered by constituent services and taking into account the characteristics of the technology layers;
- Adaptation mechanisms and techniques to proactively avoid critical problems and thus prevent costly repair activities;
- Engineering models for services operating on huge amount of data, which is created by mobile users and sensors and collected in clouds and Internet applications.

4.5. Research priorities in the Software Engineering area

ICT is transforming the way we work and live and it is a key driver for economic growth and productivity across all sectors. Software and software engineering is contributing to this transformation, for example by developing feature-rich and more intuitive service frontends and user interfaces improving the usability of services. Higher level programming languages and frameworks help to reduce development time, facilitate the integration of systems, and improve software quality. Sophisticated software development environments, including extensive testing and verification support, lead to more secure, trustworthy, and reliable software and enable the creation of more powerful and innovative services and applications. Software engineering has to come up with enhanced and new approaches to cope with the ever increasing complexity of new and heterogeneous services, to sustain productivity in developing software, to deal with changing runtime environments given by virtualized platforms and multicore processors, and to satisfy the increasing demand for high-performance and real-time software.

Research Priority 3.5-1: Productivity in software engineering

- Design patterns, techniques and tools for specific application domains, together with domain-specific application frameworks and platforms for efficient construction of software and service systems and extensive testing and verification support;
- Domain-specific and aspect-oriented approaches to raise the abstraction level of modelling and programming languages and to support fault management;
- Software engineering processes and tools to support the maintenance, evolution and portability of legacy code into new runtime environments such as distributed and virtualized platforms and multicore-based computing systems.

Research Priority 3.5-2: New ways to increase software performance and energy-efficiency

- New algorithms and programming paradigms resulting in better performance by exploiting parallel processing capabilities;
- Software models, languages, and tools to support parallel modelling and programming and enabling its widespread use within the software engineering community – for example to apply principles of data locality, and find new ways of synchronisation and scheduling.
- Engineering energy-aware software to improve power-efficiency of software systems and services.

5. The SRA as part of the NESSI holistic approach

Already in the early days of NESSI, it was pointed out that a holistic approach needs to be taken in steering research programs and when heading for innovations. Such an approach is based on technologies as covered by the NESSI core technology areas, but has to take into account also socio-economic aspects such as business models and processes and their implementation across several business domains, regulatory governance, standards, open source, trainings, adoption of best practices, etc.

NESSI is committed to such a holistic approach and reinvigorate it with its newly launched Open Innovation Environment ensuring and facilitating coherent research plans and activities, increasing the visibility of research results, and contributing to the take up of software and service solutions across different business domains.

The SRA contributes to this holistic approach. It describes the fast changing business and technology environment of software and services and summarizes the common understanding of the NESSI community about what are the critical research topics that should be addressed by joint research activities in the timeframe up to 2020. As such the SRA is intended to serve as input to the preparation of the new European Research Framework Programme FP8.

6. ANNEX

6.1. Contributors

Editor: Josef Urban (Josef.Urban@nsn.com), Nokia Siemens Networks

Contributing experts and organizations:

Name	Company	Name	Company
Adrian Waller	Thales	Marquart Franz	Siemens
Alberto Roman	Terremark	Manuel Carro	Universidad Politécnica de Madrid / IMDEA Software Institute
András Boros	Nokia Siemens Networks	Michael Montag	Nokia Siemens Networks
Andreas Metzger	Paluno (The Ruhr Institute for Software Technology)	Michel Cezon	INRIA
Bjørn Skjellaug	SINTEF	Miguel Jimenez	Universidad Politéncica de Madrid
Clara Pezuela	Atos Origin	Narcis Avellana	Sensing & Control Systems S.L.
Colin Upstill	IT Innovation Centre	Nuria De-Lama Sanchez	Atos Origin
Daniel Gidoin	Thales	Pablo Chacin	Polytechnic University of Catalonia
David Garcia Munoz Hita	ITELNET Consulting S.L	Pascal Bisson	Thales
David Luigi Fuschi	University of Reading	Paul Constantinescu	SIPS Design SRL
Dimitris Dranidis	CITY College	Pepe Fuster	AuraPortal (Aura Difusión)
Dimitrios Kourtesis	SEERC - South East European Research Centre	Per Håkon Meland	SINTEF
Elmar Husmann	IBM	Pierre de Leusse	AGH UST
Frédéric Gittler	HP	Philippe Leleu	Thales
Ignacio Caño Luna	Spanish National Institute for Communication Technologies (INTECO)	Philippe Thiran	University of Namur
Javier Soriano	Universidad Politécnica de Madrid	Rémi Raffard	Orange France Telecom
Jennifer Pérez	Universidad Politécnica de Madrid	Ricardo Goncalves	UNINOVA

Name	Company	Name	Company
Jordi Torres	BSC - UPC Barcelona Tech	Stefano De Panfilis	Engineering Ingegneria Informatica
Juan Bareño	Atos Origin	Stuart Campell	TIE Kinetix
Klaus Pohl	Paluno (The Ruhr Institute for Software Technology)	Véronique Pevtschin	Engineering Ingegneria Informatica

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