NESSI Strategic Research Agenda
NESSI Research Priorities for FP7
May 2009

A NESSI Roadmap series document

Public
Vol. 3.2 Revision 2.0
10 May 2009

Executive Summary

Information and Communication Technology (ICT) is playing a key role in driving the transformation of the European economy; it is both an essential driving force for innovation and a core enabler of economic growth.

Current facts and emerging trends show that there is a close interaction between the software and ICT service sector and its influence on productivity and innovation for nearly all areas of the European economy.

Today there is a clear trend towards employing flexible and agile approaches based on service models. This is happening throughout all sectors of the economy. At the same time citizens have become used to find information, to navigate to an address or to execute a financial transaction without buying a dictionary, using a map or going into a bank. But even more important, these transformations have gone along with a complementary social transformation. That is marked by the emergence of new ways of social interaction, community communication and problem solving leading to the co-creation of content, services and information up to the co-creation of software itself.

The vision, for the next coming ten years, is that 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.

This new global system is not any longer purely computer-based and not any longer existing with the purpose of exchanging information as we are used now; indeed in this system the ICT is there to dynamically and proactively serve in a natural, “normal”, as well as confident, way the everyday life of citizens and businesses of organisations: the so called “Internet of Services”. The main peculiarities of this system are: openness, trustworthiness, scalability, dynamicity and proactiveness, no central control and uncoordinated governance, and not full predictability.

Prominent amongst the research challenges immediately to be addressed, in order to move closer to creating the “Internet of Services”, are:

- Interaction with the service which is: permanent (always available), seamless (available through all modes of communication), transparent (hiding the details of the technology), trustworthy (confidence that the service can be relied upon), and adaptable across a wide range of applications.

- Management of services in a world which is open, dynamic, without centralised governance, and behaves in an unpredictable manner. This includes all the aspects of lifecycle management: operational management, service design, service development and deployment, and service delivery assurance.

To fully succeed, technology research cannot be performed without a clear understanding of the evolution of the applications serving business needs in real contexts. European society challenges that attract major research and development efforts are health and government, but other sectors such as transport or energy efficiency show that the list can well be extended and that service technologies are indeed fundamentally impacting many applied areas. Our recommendation is:

> *to address these challenges in a multi-facetted way through technology research, development and integration as well as research on holistic service systems and their influence factors, research on the user perspective and finally explorative large-scale and long-term test-bed activities that will drive a new quality of European services enabled by ICT*.

This document is intended for the wide ICT researchers community, as well as ICT stakeholders, and delineates the main priorities NESSI identifies as critical for the research initiatives to be launched in the next two years.

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1 Foreword

This document, part of the NESSI SRA Volumes series, is intended for the wide ICT researchers community, as well as ICT stakeholders, and delineates the main priorities NESSI identifies as critical for the research initiatives to be launched in the next two years with a particular aim for the execution of FP7 Work Program 2009-2010.

The document has been created using a fast-track process, parallel to the development of the NESSI Strategic Research Agenda. Its focus is specifically placed on the topics to be addressed in the short term and is a revision of the first version released on 29 February 2008. It is based on a number of contributions, such as position papers published to date, and inputs made by NESSI to the Future Internet Vision Document and Strategic Research Agenda issued by the x-ETPs group for what concerns Internet of Services.

New releases of this document, NESSI SRA Vol. 3.2, addressing topics for further calls of the FP7 Work Programme, are planned to be released corresponding to the FP7 calls schedule.

The structure of the NESSI SRA Volumes series is as follows:

- **Volume 1**: "*Framing the future of the Service Oriented Economy*", available at http://www.nessi-europe.eu, introduces the NESSI Holistic Model which defines NESSI in the context of a holistic approach to an ecosystem in which all the parties involved coexist and which can develop into a new economic model. This holistic model embraces the whole service area and foresees NESSI as a key element in the EU economy. It illustrates the three main constituents of the context of NESSI: *NESSI Framework*, *NESSI Landscape*, and *NESSI Adoption*.
- **Volume 2**: "*Strategy to build NESSI*", to be published, which defines the NESSI set of solutions and describes principles, paths and evolution steps in the construction of NESSI.
- **Volume 3.x**: "*NESSI Roadmap*", which is a series of documents dealing with different technological domains to plan the short, mid and long term phases in the execution of NESSI. This "NESSI input for FP7 – WP 2009-2010" document is part of Volume 3.x series.

2 Market Trends: more industrial sectors are adopting the service model paradigm

Information and Communication Technology (ICT) is playing a key role in driving the transformation of the European economy; it is both an essential driving force for innovation and a core enabler of economic growth. The Networked European Software and Services Initiative (NESSI) aims to create and evolve a unified agenda, based on a multidisciplinary approach, for European research in Services and their foundations. This agenda defines and promotes the wide adoption of technologies, strategies and deployment policies fostering new, open, industrial solutions and societal applications that enhance the safety, security and well-being of citizens.

In previous versions of the NESSI Strategic Research Agenda we already highlighted the close interaction between the software and ICT service sector and its influence on productivity and innovation for nearly all areas of the European economy. Since 2003, the GPD and ICT trends behave in a parallel way. This means that the ICT sector provides a significant contribution to the overall economy growth being 6% in 2007 of the worldwide GDP. In particular in Europe the growth rate of the telecommunication market is 8.2% while the growth rate of the IT sector in 2007 is of 4.8%. It is important to mention that in Europe the growth in services was of 8.9% in 2007 and that the IT sector growth was about 1% more in 2007 than in 2006 (*source ASSINFORM 2008*).

According to OECD, other service sectors – including banking and insurance, telecommunication or energy supply – were second after ICT companies itself when it came to employing ICT specialists. This trend of employing the service model is nowadays expanding the traditional service industry as it is embracing new sectors. In fact, industrial automation itself is looking for new ways of engineering the production based on new flexible and agile approaches. Nevertheless all of these statistics cannot completely describe the transformative impact the adoption of the service model is having, even that, more limited, of ICT on service industries as well as on service provisioning combined with products – and finally on the transition of products into services.

Citizens have become used to find information, to navigate to an address or to execute a financial transaction without buying a dictionary, using a map or going into a bank. But even more important, this industry transformation has gone along with a complementary social transformation. That is marked by the emergence of new ways of social interaction, community communication and problem solving leading to the co-creation of content, services and information up to the co-creation of software itself.

There are several striking characteristic of this service transformation – that can be observed areas as diverse as governmental services, health care and personal mobility.

1. The service transformation is shaping around the service user and his/her needs. This extends the way services are currently developed and used. Soon users will only accept seamless, personalized and fully user-centric services.

2. Traditional mechanisms for providing the services and related business models are thereby transformed – some may become even obsolete as can be observed e.g. in the music and media industry.

3. New intermediaries are created – in return former intermediaries might vanish depending on their capabilities to adapt. This also goes along with new partnerships e.g. ICT companies entering into health care service provisioning.

4. The dividing line between the providers and consumers of a service is blurring – in community provided services this may even fade to exist.

Whereas these characteristics are not primarily technical, they have important ICT implications. The first is the need to integrate services and electronic devices seamlessly and to dynamically tailor services on the specific demands and conditions of the user. This goes along with the need to care (e.g. including prevention and defence) for increasingly exhaustive private and personal information. Secondly, this calls for an

interaction of service providers with other complementary providers as well as with the wider community of service participants and users.

On the other hand this shift is posing increasing demands on the manageability, scalability, performance and – new in discussion - energy efficiency of the distributed ICT environments supporting these services (ICT industry accounts for approximately 2 percent of global carbon dioxide (CO2) emissions, a figure equivalent to aviation, according to a 2007 estimate by Gartner, Inc. Despite the overall environmental value of IT, this is clearly unsustainable.).

Europe should aim to extend its successful leadership in mobile communication and computing to drive the necessary architecture and open standards as well as European centres of activity and information according to the new service paradigm. That should be based on a convergence of networks – being it mobile or fixed. The fact that many of the upcoming services are integrating mobile devices – from phones up to sensors or RFID - puts Europe in a natural leading position.

Moreover, Europe needs to preserve openness and prevent new types of market failures as well as off-shoring losses to other geographic regions that may arise in the new global service environment. There is already a fierce competition on key information elements such as electronic identities or geographical information up to the recent rise of providers of personal genetic data. Distributed and open approaches are still evolving in parallel, leaving a wide possibility for firms and organisations of all sizes to participate – including the large body of European small and micro sized businesses. Here, Europe is left with no other choice than to compete distinctively in this development.

Apart from those technological implications, European cultural diversity provides a fertile ground for complementary social developments and indeed European countries such as Finland or the Netherlands are already top on the list when it comes to digital community activities or contributions. However, still these mechanisms are poorly understood – in the same way as the user perspective and user interaction in many services.

Therefore, technology represents only one side of the NESSI challenge, the other is a more profound understanding of service systems and their implicit interaction between service participants and technology. Here, we also need to shed light on the real demands of service users and not only on the restrictions of how services are provided today. In addition, restrictions – some of them being rooted in history, legal requirements or regulatory context – need to be better understood.

Finally, a side effect of the society and economy centricity is that services need to be piloted in real usage situations and increasingly complex, integrated test-beds. This is – in the same way as service infrastructure development – a long-term activity. Here, forces should be combined so that new ICT and economical and societal process are studied together to understand whether the ICT solutions are suited to the changes occurring in the society and *vice-versa*.

European society challenges that attract major research and development efforts are health and government, but other sectors such as transport and mobility or energy efficiency show that the list can well be extended and that service technologies are indeed fundamentally impacting many applied areas. NESSI is addressing these challenges in a multi-facetted way through technology research, development and integration as well as research on holistic service systems and their influence factors, research on the user perspective and finally explorative large-scale and long-term test-bed activities that will drive a new quality of European services enabled by ICT.

3 A New perspective for the Internet

3.1 Towards "Future Internet"

The evolution of the way people use the Internet is transforming the concepts also behind the Internet itself: from a mechanism to exchange information to a "global" system made up not only of the needed networking infrastructure, but also of all the ICT stakeholders around it.

This new thing is still evolving and it will embrace also the usage context itself, i.e. the consumers and the providers of services in a unique and whole continuum where roles may continuously vary. We can think to this continuum as a complex interaction of billions of different devices, billions of actions, and billions of stakeholders all of them interacting also each other.

The vision, for the next coming ten years, is that all electronic devices, human beings may think of, will have interaction capabilities with the aim of providing services to other devices or human beings within continuing changing scenarios according to different business needs and situations in a continuum which *de-facto* creates a new global system.

This new global system is not any longer computer based and not any longer existing with the purpose of exchanging information as we are used now, this system is there to dynamically and proactively serve in a natural, and "normal", way the everyday life of citizens and businesses of organisations. This new system is commonly known as the **"Future Internet"**. The main peculiarities of this system are:

- **openness**, to ensure all the organisations and individuals to have the possibility to take advantage of the available technologies offering and accessing any service;
- **trustworthiness**, to have it wide confidently adopted and used;
- **scalability**, to ensure all size of organisation and business to be served;
- **dynamicity and proactiveness**, as services should smoothly adapt to different scenarios when needed and providing convenient support before it is actually invoked;
- **no central control and uncoordinated governance**, as the complexity and the size of the system increases so that any new approaches to management are needed to extract business value from its executions;
- **not fully predictable**, as the multitude of items composing this new perspective ("billions of ...") does not allow the system to have a predictable global behaviour, nevertheless the behaviour expected at the point of interaction should be guaranteed.

Before reaching that level, several steps are needed. For the next five years (launched with FP7 Work Programme 2009-2010) of research as NESSI we intend to concentrate on the realisation of the so-called **"Internet of services"**. The goal is to guarantee that services are part of the new capabilities that the Future Internet will bring into the everyday life of citizens and businesses of organisations. In this perspective, the scope of "Internet of Services" is not limited to "electronic" services, i.e., to re-usable computational entities available on the Internet. It encompasses also non-electronic services that operate and execute in the real world and that citizens and organizations exploit in their lives and businesses. Indeed, even if these services are not necessarily "consumed" through the Future Internet, this system will be a key enabler for getting information about these services, for managing and monitoring, and so on. This aspect is clearly illustrated, for instance, in the "future health-care" and "future field working" example scenarios in the next section.

One key element that will play an important role is the intertwining of the "Internet of Services" with the "Internet of Things". Indeed, through the "Internet of Things" services will be embedded in the operation environment, and objects will become gateways to services.

In the context of the Internet of Services a key goal is to pursue the achievement of "Continuity of services". Continuity of services has two main and complementary perspectives: the service consumer and the service provider perspectives.

Service consumers look for the "Perfect interactivity". With "perfect" we mean here permanent (i.e. and interactivity that has no time limits), transparent (i.e. the service consumer is only concentrated on the benefits of the service he/she is using), seamless (i.e. the interaction is performed using the "typical" devices of the context), and trustworthy.

Service providers require new approaches to management where the central control principle is shifted to the simplicity of the approach to keep the consistency of each service.

3.2 Example scenarios

The Future Internet that NESSI is addressing will lead to next generation electronic services as well as new ways of creating, providing and consuming such services. Imagine the possibilities …

Imagine future retail …
You decide to open and run a new retail store. In order to evaluate a suitable location for the store you first run a simulation. All information to run the simulation is retrieved from different providers, i.e. census data from a public services authority, map data from a geographical information system, local market data from a research institute. Even though you pay for the simulation only based on the time that you use it, it is highly personalized and you have all data services automatically matched to your specific business domain as well as your geographic focus. In the store many logistics and retail processes will be automated using dynamic pricing according to daytime and weekday, dynamic ordering of goods or inventory management. Data is gathered from your products directly by reading their electronic identification. In regular intervals you will now use the simulation as a strategic planning tool for your daily business – matching the real-time information from your store with all necessary real-time information of the local market that you are doing business in.

Imagine future health-care ...
You are enjoying Paris as a tourist in your car and suddenly the unfortunate happens, an accident. The car automatically alerts the police and ambulance and reports the location of the accident. The closest available ambulance picks you up and transports you to the best suitable hospital based on the initial diagnosis. While you are being transported information is being shared between the ambulance and the hospital physicians and your medical records are being downloaded, analysed, translated into French, and sent to the hospital so after the first aid during transport the best medical treatment can be provided.

Imagine future field working ...
You are arriving at the impressive construction site that your company has been working on for the past two years in order to monitor the progress. Now your phone gives you detailed technical information such as pipe plans or electricity plans depending on exactly where you will be going in the building. You can mark problem areas and the areas are immediately marked in all construction plans. Your back-office has instant access in the same way as your colleagues in other areas of the building or the responsible subcontractors.

Imagine future service creation ...
You have been playing around with a business idea for a new electronic end customer service. Now you want to make it real. Now imagine that you do not have to run your own small sized data-centre for this or do extensive custom IT development but will be able to a large extent to compose your service out of existing basic services in the Internet. Luckily your business grows but you are not worrying about scalability or seasonal peaks as the execution of your services will happen somewhere in the Internet and you are billed only on actual usage.

Even though the above are just a few – non exhaustive – examples, several characteristics of the Future Internet that is largely based on services, shine through:

- The Future Internet will not only provide connectivity, it will also set the **Infrastructure Foundations** for providing services:
  - o High-speed connectivity based on various technologies;
  - o Shared and distributed sensors, computing and storage resources;
  - o Pooled massive computing resources to deliver basic services.

- Massive computing tasks, high demanding in energy and full scalability, will arise from next generation services. The Future Internet will facilitate access to computing resources, application platforms and applications hosted or operated by dedicated Cloud Computing providers. The access shall happen via services of these providers (Cloud Services). Be it internet-based services, software as services, infrastructures or platforms as services, cloud computing services will provide a more scalable, robust, flexible, cost and energy efficient alternative to today's IT.

- The Future Internet will provide, besides classical information services, access to ***things*** and their characteristics. It will also allow interacting with these things. In return things can also become active and trigger actions over the Internet ("**Internet of Things**").

- The Future Internet will not only allow access to services based on technical characteristics such as IP-location or web service identifiers but also based on contextual information (e.g. using geographical context or business context). Services can be searched, identified and composed into business process components. This will allow business processes to be flexibly adapted ("**Internet of Services**").

- The Future Internet will enable secure and dynamic formation, participation and management of social and business networks which could be massive in size and/or ad hoc in nature ("**New Collaborative Community Networks**").

- The Future Internet will set the foundations for a trustworthy service infrastructure, which is secure by design providing means to exchange critical, protected and sensitive data between countries, public and private organisations, and individuals. This sharing will be safe, secure, complete, immediate, but also compliant with standards, legislations and/or regulations which apply: ("**end-to-end Trust**").

3.3 Advancements over FP7 WP 2007-2008

The Work Programme 2009/2010 is an important mean to progress beyond what already promoted by the previous one by:

- encouraging integrated research framework (e.g. Future Internet),

- instilling research topics (either fully new or in continuity of existing ones) in synergy with the ones already proposed,

- promoting federating research challenges,

- enabling cross-fertilization among research areas, and

- promoting integration, consistency and coherence across multiple projects even launched on different research programmes.

As a result of Call 1 NESSI has launched a number of strategic projects addressing different and complementary research areas. Those projects were carefully designed and built to:

1. materialize the NESSI Vision around the key notion of the "Open Service Framework" (NEXOF), and

2. significantly contribute to NEXOF's implementation.

As such the NESSI Strategic Projects, granted by the EC (FP7 Call 1) and at National level, are the first wave of NESSI Strategic projects aiming at addressing some of the highest priorities in view of the strategic goals of NESSI. These projects are:

- **EzWEB**, addressing the definition of a reference architecture and implementation of an open platform supporting the retrieval, combination (mash-up) and utilization of front-end layer components in a next-generation, global Service-Oriented Architecture;

- **MASTER**, addressing the provision of methodologies and infrastructures that facilitate monitoring, enforcement, and audit of quantifiable indicators on the security of a business process, and that provide manageable assurance of security levels, trust levels and regulatory compliance of highly dynamic service-oriented architectures in centralised, distributed (multi-domain), and outsourcing contexts;

- **RESERVOIR**, addressing the definition and introduction of a powerful ICT infrastructure for the reliable and effective delivery of services as utilities. This infrastructure will support the setup and deployment of services on demand, at competitive costs, across disparate administrative domains, while assuring quality of service;

- **SLA@SOI**, addressing the definition of a holistic approach for the management of service level agreements (SLAs) and to implement an SLA management framework that can be easily integrated into a service-oriented infrastructure (SOI);

- **SOA4ALL**, addressing the definition and implementation of a comprehensive framework and infrastructure that integrates four complimentary and revolutionary technical advances (Web principles, Web 2.0, Semantic Web, and Context management) into a coherent and domain independent service delivery platform.

In addition to the above projects there is **NEXOF-RA** which is the NESSI Strategic Project in charge to define the Reference Architecture of NEXOF leveraging research results and open contributions from the NESSI Strategic Projects and any interested party (research projects/initiatives, organizations, individuals).

At the time of writing this document, Call 1 projects, such as the ones above, have started and are running almost one year. From their early steps and first results it is evident that there are still gaps to be filled to not only achieve the whole NEXOF as defined in NESSI SRA Vol. 2, but also to provide significant advancements towards the “Internet of Services”. In this respect this document delineates the critical research priorities which, beyond what already proposed for the FP7 WP 2007-2008, are indicated of critical importance for the next coming two years. In summary, such advancements for each NESSI research area are:

- **Service-oriented utility infrastructure**: from adaptation of ICT infrastructures as a whole to differentiating specific aspects for Hardware, Middleware and new programming models ranging from flexible allocation of resources to energy efficiency, and from new composite system designs to harmonized virtualisation;
- **Service and System Engineering**: (i) extending the notion of systems to hybrid-systems and embedding in Service Engineering advanced practices such as construction and management situational based, quality-of-experience based systems, including their semantic enrichment; (ii) from suitable platforms to fulfil future trends and challenges for different levels of the automation pyramid to the vertical integration between different layers of the automation pyramid;
- **Adaptive interactions**: from service adaptation to embedding intelligence, situational-driven personalisation and educating principles into hybrid service-based systems user interfaces;
- **Business process modelling**: from modelling to building business processes composing IT services;
- **Reference Architecture and Implementation**: Define architectures which are independent of business domain, business size and technologies and build reference implementation to serve the large adoption based on those architectures;

- **Service Pervasiveness**: from software pervasiveness to the materialisation of services ubiquitously available;
- **End-to End Trust, Security, Privacy and Resilience**: from trust and confidence through policy statements to automated policy enforcements, from manual audits to automated E2E assurance and accountability, from organization-centric trust management schemes to trustworthy infrastructures, services and intuitive user-centric security, from add-on and partial security solutions to built-in E2E security;
- **Systemic foundation for a Service Economy**: from the definition of Services Sciences research area to build systemic foundations for a Service Economy;
- **Services in the industrial domain**: from suitable platforms to fulfil future trends and challenges for different levels of the automation pyramid to the Vertical Integration between different layers of the automation pyramid.
- **Building NESSI**: build specific collaborative service-based business systems for targeted application domains (e.g. industry automation, education).

In close synergy with all the indicated priorities an additional major advancement will come from a transition from research on services as such to a research which puts and operates services in relationship with their context of use.

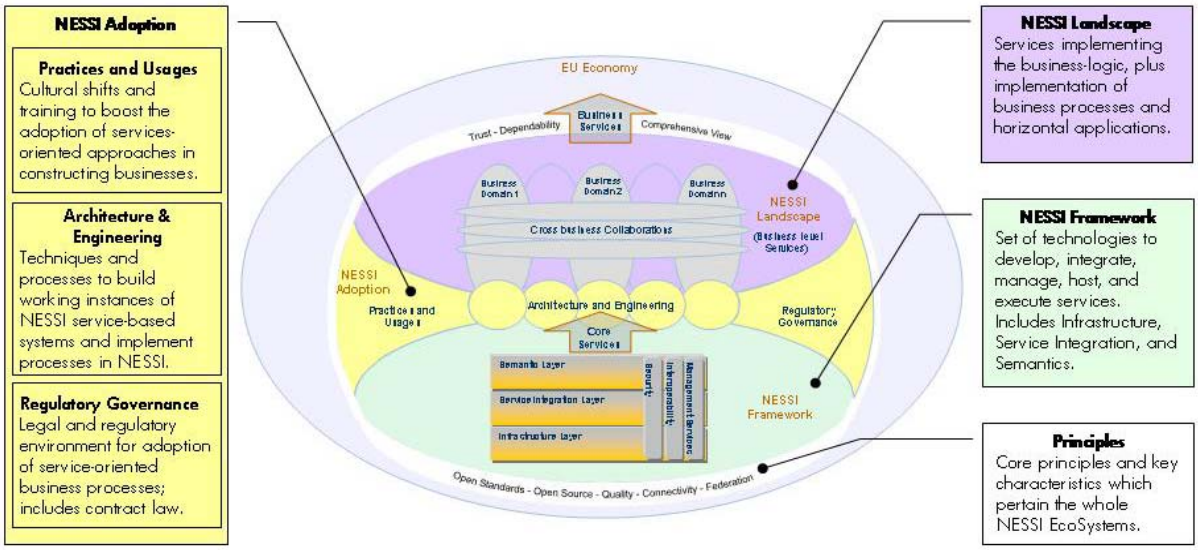
Through advancements provided by NESSI Strategic and Compliant Projects and further research initiatives which shall address research priorities as the ones indicated in this document we do expect NESSI to not only deliver an Open Service Framework applicable to a broad range of domains, but also to significantly contribute to the Future Internet.

4 The Strategy of NESSI

Transforming the Internet to service our lives requires more than technology; this challenge can only be achieved through a balanced approach addressing simultaneously all angles of this transformation. NESSI models this transformation through a holistic view[1], in the context of an all-inclusive ecosystem in which the new economic models are developed. This view highlights the following areas:

- **NESSI Framework** ("*NESSI Core*"): Software, ICT Architectures and ICT Infrastructures where data evolves into knowledge, and which helps humans to coordinate the execution of complex tasks. This focuses on facilitating a cost-effective provisioning and seamless composition of services, supporting pervasive and ubiquitous application scenarios.
- **NESSI Adoption** ("*The Art of NESSI*"): Practices and usages, architecture and engineering, and regulatory governance which constitutes major enablers and scientific foundations for the complete transformation of the European economy into a fully operational services economy. Such enablers and foundations are tightly coupled with the technology engineered in the NESSI Framework.
- **NESSI Landscape** ("*Powered by NESSI*"): Business services and business processes implemented and deployed using the technology defined in the NESSI Framework, leveraging the socio-economic models defined in the NESSI Adoption.
- **NESSI Principles** ("*Guided by NESSI*"): core principles and key characteristics which permeate the whole NESSI Ecosystem.

NESSI Holistic View



[1] This view is described in details in "NESSI Strategic Research Agenda, Volume 1: Framing the future of the Service Oriented Economy", available at http://www.nessi-europe.com

5 Research Priorities for 2009-2010

5.1 Highlights of research priorities

The following table captures driving objectives for the full implementation of a service-based economy as envisioned by NESSI. For each objective the table summarises research priorities in turn assigned to a specific research area. The colours on the left column point to the main elements on the NESSI Holistic Model, briefly described in the previous Section 4; they are: green for the "NESSI Framework" element, purple for the "NESSI Landscape" element, and yellow for the "NESSI Adoption" element.

This table **does not suggest any order of priority**, as there is in fact no priority of research at this level of granularity.

	Objective	NESSI Research Priorities	Research Area
1	Provide a flexible infrastructure to support the networked economy	Advanced infrastructure technologies in • Hardware (flexible allocation, virtualization, advanced storage, energy efficiency) • Operating Systems (merge physical- and virtual-machines execution with service-oriented application execution at OS level) • Desktop Virtualization (access private/secure desktops from anywhere, over the web,) • Middleware (new composite system designs, harmonized virtualization) • Related programming models • Related power-aware software design methods • Transparent deployment of cloud services	*Service-oriented utility infrastructure*
2	Provide coherence to the composition of uncoordinated services across all layers and all providers	• Modelling, Construction and Management of hybrid service-based systems (situational, spontaneous, goal-based) • Mapping quality of experience of the services to non-functional properties of components • Refining semantics to become appropriate across hybrid service-based systems • Product Line Engineering applied to services	*Service and System Engineering*
	Provide solutions to support the challenges of the Industrial Domain	• Suitable platforms to fulfil future trends and challenges for different levels of the automation pyramid • Vertical Integration between different layers of the automation pyramid	

	Objective	NESSI Research Priorities	Research Area
3	Add the dimensions of knowledge and reasoning to the interaction between user and (business and societal) services	• Social and business intelligence service provision • Knowledge- and situational-driven personalization of interfaces and services • Embodiment of intelligent access to services • Embodiment of educating principles in services	*Adaptive interactions*
4	Pave the way towards the collaborative executable enterprise	• Dynamic formation, formalization management and interaction of business processes implemented through services • Support for long-term and transactional business collaboration • Support for event-orientation	*Business process modelling*
5	Define open architectures for intranet- to internet-scale service delivery	Harmonize SOA and SOI architectures to support all kinds of • business and provisioning models • applications and hardware environments • stakeholders	*Reference Architecture and Implementations*
6	Materialize the ubiquitous service availability	• Turn devices into enablers of services by embodying SOA principles into embedded systems • Link collaborative devices to services	*Services pervasiveness*
7	Secure, reliable, resilient, compliant and trustworthy (hybrid) service-based systems	Implementing Privacy, Identity Management and Trust in service-based systems and in the FI society through: • A chain of trust across all levels and trust zones achieving security by design • Security by Design • Embed user-centric intuitive security mechanisms • Protection against threats • Enabling users to understand security, privacy and trust	*End to end Trust, Security, Privacy and Resilience*

	Objective	NESSI Research Priorities	Research Area
8	Ensure social, economical, legal and cultural viability	• Make services accessible to all • Multidisciplinary research to build a theory describing the relationship between organizations and social networks in regards to hybrid service-based systems • Support emerging business models for innovation • Understanding OS community collaborative processes • Understanding OS business models and the impact on the Service Economy	*Systemic foundation for a Service Economy*
9	Provide the business context for services in hybrid service-based systems	• Build the specific collaborative service-based business systems for targeted application domains • Identify specific and generic parts supporting services in hybrid service-based systems	*Building NESSI*

The following sections detail the research priorities for each research area.

5.2 Service oriented utility infrastructure

Objective: Provide a flexible infrastructure to support the networked economy.

(1) Advanced infrastructure technologies in (i) hardware which needs to be virtualised and able to be allocated flexibly, encouraging efficient hardware utilisation, in turn enabling energy efficiency; (ii) middleware which needs to be designed on a multi-tier model, with virtualization at each layer and the ability to replace components at each layer without disturbing the whole stack, (iii) reliable, high-performance and low latency cloud services that make the virtualized resources available over the Internet and (iv) related programming models need to support flexible middleware and application software, and for loosely-connected parallel execution environments.

5.3 Service and Systems Engineering

Objective: Provide coherence to the composition of uncoordinated services across all layers and all providers.

(1) Modelling, construction and management of hybrid service-based systems (situational, spontaneous and goal-based) including: (i) the management of increasing complexity and variability of requirements; (ii) product line engineering approaches for services; (iii) evolvability of services and systems; (iv) the migration approach to help users to move from one technology to the other; (v) modernize existing legacy code base to become service-centred; (vi) release planning; (vii) spontaneous creation of applications from pre-existing services; (viii) semantic- and goal-based

automatic service discovery and composition (ix) smart repositories to support the automation of required on-the-fly discovery and composition of services.

(2) Mapping quality of experience of the services to non-functional properties of the components based on advanced service lifecycle approaches including engineering, deployment, composition, provisioning, management and decommissioning that support transparent knowledge tracking, feedback loops, prediction and simulation, allow for a clear separation of concerns between different stakeholders (business vs. IT, developers, providers, customers, …) and support the full variety of scenarios. Research on non-functional properties for services including: (i) how to define, describe, develop and evaluate these non-functionals, including privacy issues; (ii) enforcement, monitoring and management of non-functional properties; (iii) mapping of quality of experience to non-functional properties, taking into account how to define and describe these properties according to different usages and contexts (including social and cultural aspects) and the need for negotiation in Service Level Agreement (including trust-related notions); (iv) defining a system by tuning QoE through end-user control panel.

(3) Refining semantics to become appropriate across hybrid service-based systems. (i) The semantic approach for services uses ontologies to fully describe goals and both functional and non-functional characteristics. (ii) The semantic approach for processes requires: declarative choreography languages; semantic business process descriptions; improved maintenance and updating; improved reasoning.

(4) Product Line Engineering applied to services. (i) Guidance and decision criteria for dividing an application into a set of services. (ii) Orchestration and composition of services for different customer environments. (iii) Variability of applications and service runtime environment e.g. regarding hardware platform, footprint, reliability, level of dynamism (binding at design time / start-up / runtime), communication protocol, etc.

Objective: Provide Solutions to support the challenges of the Industrial Domain

(1) Suitable platforms to fulfil future trends and challenges for different levels of the automation pyramid, in particular for the control level (Embedded System) and the Corporate level (Enterprise System): (i) The size and complexity of embedded systems, especially of their SW-portions, is growing fast. The capabilities to easily integrate with other systems are becoming more and more important. Thus the demand for better modularization and flexibility of SW used there is growing. The challenge is to support service delivery and service providers also on lower layers of the automation pyramid. (ii) New trends for enterprise systems (e.g. Software as a Service, Cloud Computing, Internet of Services and Web 2.0) become more and more important to address challenges like cost-effective scalability, ease of deployment and flexible service & software delivery. These trends have to be evaluated regarding their practical relevance for readiness necessary enhancements or adaptation for industrial use.

(2) Vertical Integration between different layers of the automation pyramid: Industrial solutions consist often of multiple systems which span over multiple levels of the automation pyramid. This requires flexible and still simple integration capabilities between software applications and platforms used in different levels of the pyramid. The fact that those systems are delivered often by several companies requires integration to be loosely coupled and standard-based. Suitable concepts, techniques, technologies to address this challenge have to be elaborated.

5.4 Adaptive Interactions

Objective: Add the dimensions of knowledge and reasoning to the interaction between users and (business and societal) services.

(1) Social and business intelligence service provision, including (i) integration and composition of different service technologies, (ii) creation of a social and business intelligence platform to support effective monitoring, collaboration and decision making processes in service provision.

(2) Knowledge- and situational-driven personalization of interfaces and services, including (i) methods and tools to integrate human beings thinking into services technologies (e.g. Web 2.0, mash-up, Web 3.0), (ii) process- and context-sensitive information delivery for knowledge workers and interactions for community networks, (iii) methods and tools to support situational interfaces and reasoning intelligence, and (iv) an object-oriented, service-based, semantic-powered, GUI-delivered personal Interface for the Information Society with full awareness support of identity trust, context, devices and networks.

(3) Embodiment of intelligent access to services, including (i) new methodologies and tools to support acquisition of knowledge and learning from reasoning, which could develop intelligence managed on the user side with native hardware/software interface integration.

(4) Embodiment of educating principles in services, including (i) new methodologies and tools to support the learning and acquisition of solutions build on business process modelled knowledge so knowledge could be equally used as "a software solution" or as "digital encyclopaedia", and managed at the user side with native hardware/software interface integration.

5.5 Business process modelling

Objective: Pave the way towards the collaborative executable enterprise.

(1) Dynamic formalization, management and interaction of business processes implemented through services. This necessitates (i) the transition from business processes to IT applications: modelling of functional and non-functional properties, modelling of mediators to support negotiation; supporting round-trip management of business processes, supported by simulation of end-to-end business processes based on a multi-model approach; (ii) executable enterprise engine i.e. an application engine capable of running modelled enterprise architectures being used as "teaching applications" through a full featured interface (the personal interface for the IS).

(2) Support for long-term and transactional business collaboration. Here (i) long-running activities are orchestrated and controlled in terms of operational goals and compliance regulations, business rules etc (represented in the form of unconventional atomicity criteria); (ii) business interactions are conducted in an "all or nothing" manner according to formalised rules, procedures and standardised communications in applications that require complete end-to-end operational integration, e.g. manufacturing, logistics and distribution.

(3) Support for event orientation. Here (i) the events flowing through the IT layers of an enterprise are monitored, event patterns detected, complex events generated and business process steps triggered in real-time; (ii) underlying service and SW architectures take into account event-orientation and proper techniques are applied to describe event patterns and to model event engines which are adaptable and scalable to business requirements.

5.6 Reference Architecture and Implementations

Objective: Define open architectures for intranet- to internet-scale service delivery.

(1) Harmonize service architectures (SOA) and infrastructure architectures (SOI) to advance the structure of multi-tier, federated and Internet scale architectures, support all kinds of business models, applications and hardware environments and provide transparent and integrated access for all relevant stakeholders (architects, engineers, operators, consumers, etc.). The points of focus include: (i) dynamically manage the complexity linked to the continuous emergence of innovation in software and hardware; (ii) dynamic operational support to uncoordinated governance; (iii) support compliance between different emerging ICT solutions; (iv) design for resilient service architectures for guaranteed delivery; (v) integration of dependable building blocks (e.g. fault prevention); (vi) support the creation of domain specific platforms; (vii) provide scalable, reliable, fast service architectures for enterprises of any size, acting in any domain, and adopting heterogeneous technologies.

5.7 Service Pervasiveness

Objective: Materialize the ubiquitous service availability.

(1) Turn devices into enablers of services by embodying SOA principles into embedded systems and link collaborative devices to services through (i) supporting the evolution of the "device" concept from a service point of view in its role as "enabling a service"; (ii) self-organisation, self-protection, and self-management for services; (iii) ensuring security and privacy in the context of future services; (iv) real-time SOA for embedded systems (predictability, footprint, performance); (v) capitalizing on opportunities created by the combination of separate contexts related to different "devices" when these cooperate; (vi) and providing advanced network functionality to support services.

5.8 *End-to-end Trust, Security, Privacy and Resilience*

Objective: Secure, reliable, resilient, compliant and trustworthy (hybrid) service-based systems

(1) Provide a chain of trust across all levels and trust zones in various contexts: (i) from infrastructure to user, between Service and ICT providers, trust establishment without identities, trust generation and reputation mechanisms, protected computing, (ii) address accountability, in security and dependability context (the traceability of actions performed on a service or a system), (iii) enforcement of trust and security policies based on monitoring of all service related actions for all service stakeholders (service requestor, service provider, hosting environment) without hindering performance, (iv) to allow users to trust that a service is performed as expected no matter how many levels separate the party requesting the service from the service provider, and (v) compliancy to policies, laws and regulations.

(2) Embed user-centric intuitive security mechanisms. User perceives everything about an application or service through its interface, whether it is the quality of service, its responsiveness, performance, or the security and trustworthiness of the service/system. The research topics should be based on a threat model for these interfaces and ability to correctly model systems based on user behaviour. By formalizing unexpected (unusable) behaviour of users, security mechanisms and actions can be included in the design phase to further tighten security.

(3) Security by Design. Service-based systems and Future Internet (not limited to FI of Services) calls for further advancement in security engineering and in architecture paradigms from a security perspective (e.g. Secure SOA+EDA) to achieve built-in security by design. This includes approaches and mechanisms to ensure and balance confidentiality, integrity and availability of information and knowledge in the context of Future Internet..

(4) Protection against threats: Means for proactive identification and protection from arbitrary attacks such as Denial of Service and Intrusion detection.

(5) Privacy, Identity Management and Trust in service-based systems and in the FI society:
   a. Privacy management: this includes research topics such as: User-centric privacy, identity, and trust management, Privacy evidence creation, Privacy of online communities, Multi-level security and privacy for the Future Internet, Federation of Privacy policy, Resilient Privacy, Privacy Standards to let consumers make informed decisions about the services they access, Anonymity and privacy preservation at large of mobile users.

   b. Identity Management: Research topics include user-centric approach to identity management to improve security of online service provision, design of user interaction for identity management, expressing trustworthiness of identity management to users and privacy-enhancing identity management, logs tools required for forensic purposes (but not limited to), methodologies and interfaces for managing multiple identities and credentials

including delegation, separate identity management, access right framework based on semantic.

c. Trust: the overall challenge is to make non-functional requirements such as trustworthiness part of the FI design and construction in order to achieve end to end security and trust. Research priorities include: Trust analysis, management and monitoring as well as End-to-End verification of trust, security, and dependability properties.

(6) Enabling users to understand security, privacy and trust: service consumers have to be educated in order to make informed decisions so as to be tuned as real FI user (so security-, privacy- and trust-aware when making decision using FI).

5.9 Systemic foundation for a Service Economy

Objective: Ensure social, economical, legal and cultural viability.

(1) Make services accessible to all; e.g. cost effectiveness, operational effectiveness in addition to traditional attractiveness.

(2) Develop a counterpart to the classical theory of the organisation that takes account of networks of relationships (among people and technology) within organisations and across organisations (networks of business collaboration, of social collaboration, and of human interactions), and particularly as these affect innovation in services. The approach used should include a multi-disciplinary effort (anthropological, social scientific, economic, computational, management, and other) for tackling the challenges of understanding services and deriving principles for harnessing services for providing value effectively.

(3) Support emerging business models through (i) services for the marketplace (e.g. accountability, charging and payments), (ii) SOA as a incubator for IT industrialisation, (iii) agile methods and technologies, (iv) specific support for the open source community, and (v) collaboration, which can be based on loose coupling and self-organisation, ad-hoc processes for collaborative, creative and un-structured tasks, virtual organisations, open source communities (as best practice example), balance of workload, as well as synergy between communication and data services to support the virtual enterprise and supply chain relationship.

5.10 Building NESSI

Objective: Provide the business context for services in hybrid service-based systems.

(1) Build specific collaborative service-based business systems for targeted application domains e.g. (i) industry automation, which seeks total integration in the value chain linking enterprise resource planning to manufacturing execution to process control to automation control to field services, and considering aspects like multi-domain optimisation, rule-based systems to capture engineering knowledge, configuration for flexible missions, management of the enterprise knowledge creation through the integration of different processes, technologies, tools and connecting them to enterprise business goals, or (ii) education, making learning and training services accessible life and wide long improving skill/competencies acquisition and employability.

(2) Identify specific and generic parts supporting services in hybrid service-based systems, including (i) Support to individuals and non-professional services systems builders as well as (ii) an SME reference enterprise architecture providing an integrated organizational corpora of processes and procedures built as a full enterprise architecture (cf. model built by Zachman) of reference for the SME and the NGO covering the integral business management, business direction assistance, implementation of value chain or value network processes and design, implementation, deployment and outsourcing of IT services.