

NESSI Strategic Research Agenda

Vol. 1 Framing the future of the Service Oriented Economy

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Executive Summary

Information and Communication Technology (ICT) is an essential driving force for innovation and a core enabler of economic growth in the coming years. Enterprises in Europe (both private and public sector) are facing significant structural changes and will rely on software and services to support them in adapting effectively. This represents a new opportunity for Europe and the NESSI initiative embodies the strategic mechanism through which this opportunity can be seized and exploited globally. Application of innovative technologies will benefit all economic sectors, not just the software and ICT services industry. Globally competitive businesses and efficient public services will benefit all citizens.

Europe faces a period of potentially profound changes: in social attitudes, economic conditions and the business environment. This makes the ability to evolve continuously essential for the users of services, and therefore also for the technology used to deliver them. Technology must be an enabler of change rather than an inhibitor. Enlargement of the European Union and the changing nature of trade with the rest of the world puts a strong emphasis on a multicultural approach to business. This cannot be simply regarded as the need to use different languages, but rather there is a need to adapt more fully to the ways people behave and communicate in different countries and cultures.

The main focus of NESSI is that of *service*. There are many definitions of service used in different contexts. However, all are based on the same principle: a service consumer does not own the service and therefore need not be concerned with all the aspects generally associated with ownership such as infrastructure, technology, integration and maintenance. Instead he/she has only to choose a service which meets his business needs.

Businesses are increasingly concentrating on activities where they can gain a competitive advantage. Supporting capabilities can be obtained as services from specialist providers.

In this context NESSI *is about transforming the EU economy through Service Oriented business models*.

In order to promote and make real the transformation, NESSI is defined 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, as depicted in the following picture, foresees NESSI as a key element in the EU economy. It illustrates the three main constituent parts of the context of NESSI:

- ICT Technologies, represented by the **NESSI Framework**, where the services, the key elements of the ecosystem, are engineered;
- the **NESSI Landscape**, where the services as implemented by the NESSI Framework are applied to specific businesses and domains, and for cross-domain cooperation;
- the set of instantiation mechanisms based on regulations, rules and policies which, constituting the **NESSI Adoption**, make services real and thus usable by the consumers.

This document details the above mentioned assets and the research challenges required by each of them in order to reach the NESSI vision.

This document is the first volume in the series of volumes which constitute the NESSI Strategic Research Agenda. These are: Vol. 1 "Framing the future of the Service Oriented Economy" (the present document), which introduces the NESSI Holistic Model; Vol. 2 "Strategy to build NESSI", which, defining the NESSI set of solutions, describes principles, paths and evolution steps in the construction of NESSI; Vol. 3.x "NESSI Roadmap", which, in a series of documents dealing with different domains, plans the short, mid and long term phases in the execution of NESSI.

Table of Contents

1	Context.....	5
1.1	ICT as a means to achieve the Lisbon Objectives.....	5
1.2	Software and Services at the heart of the Knowledge economy.....	6
2	Vision	7
2.1	NESSI Holistic View.....	7
2.2	NESSI service perspective.....	10
3	Challenges	12
3.1	Reaching the Vision is THE Challenge.....	12
3.2	Driving the Paradigm Shift	12
3.3	Dealing with Complexity.....	13
3.4	The Tension of Trust.....	13
3.5	Keeping it OPEN.....	13
3.6	Transforming Vision into Reality.....	14
3.7	Building Active Support.....	14
4	Strategic Research Areas	15
4.1	NESSI Properties and Principles.....	15
4.1.1	Overall View	15
4.1.2	Trust	15
4.1.3	Dependability.....	16
4.1.4	Comprehensive View.....	17
4.1.5	Open Standards	18
4.1.6	Open Source	19
4.1.7	Process and System Quality	22
4.1.8	Connectivity	26
4.1.9	Federation	27
4.2	NESSI Landscape.....	28
4.2.1	Introduction.....	28
4.2.2	Business dynamics.....	29
4.2.3	Services Science and engineering	30
4.3	NESSI Framework	30
4.3.1	Overview.....	30
4.3.2	Semantic Layer.....	33
4.3.3	Service Integration Layer	34
4.3.4	Infrastructure Layer	36
4.3.5	Security.....	37
4.3.6	Interoperability.....	38
4.3.7	Management Services.....	40
4.4	NESSI Adoption.....	42
4.4.1	Overall Approach.....	42
4.4.2	Adopting NESSI.....	42
4.4.3	Systems Science	44
4.4.4	Architecture and Engineering	46
4.4.5	Regulatory Governance	48
4.4.6	A European “full scale” demonstration centre	48

5 Making it Happen..... 49

6 Acknowledgments 52

7 APPENDIX 53

7.1 Scenarios..... 53

7.2 NESSI-centric use case 54

7.3 Connected mobility use case 55

1 Context

1.1 ICT as a means to achieve the Lisbon Objectives

The President of the European Commission José Manuel Barroso has re-emphasised the importance of achieving the objective for Europe to become by 2010 *“the world’s most dynamic and competitive knowledge-based economy”*¹. The objectives set in Lisbon – higher growth, more and better jobs and greater social inclusion – are ambitious. At this moment in time, we are half-way through the ten year target period within which the Lisbon Objectives were to be achieved. The recent report from the High Level Group chaired by the former Dutch Prime Minister Wim Kok reported that progress has been slow.

In this context, Europe should launch new initiatives aiming at leadership in strategic areas on the way to the knowledge economy. Information and Communication Technologies (ICT) were identified as key factors in contributing to the Lisbon objectives, primarily by²:

1. Driving the transformation of the European economy towards a dynamic and competitive knowledge-based economy.

ICT plays a central role in boosting productivity and improving competitiveness. 40% of the productivity growth in the EU between 1995 and 2000 was related to ICT. ICT increasingly pervades all industrial and service markets as it irrepressibly integrates in all sorts of goods and services.

2. Creating more and better jobs.

ICT has grown from 4% of EU GDP in the early ‘90s to around 8%, and accounted for 6% of employment in the EU in 2000. It is one of the most innovative sectors, representing 18% of overall EU spending in Research and Development (R&D). It is also one of the most productive, with an annual productivity growth of 9% on average over the period 1996-2000.

The key role of ICT was confirmed at the Spring Council 2004³ as well as in the recent report from the High Level Group chaired by Wim Kok, which explicitly refers to *“making R&D a top priority and promoting the use of information and communication technologies”*⁴.

The dynamicity of ICT and the knowledge economy requires the establishment of a world-class communication software infrastructure to allow pan-European access by all relevant stakeholders, to facilitate interactions between industry, academia and citizens, and to make it easy to create, share and use knowledge in business, scientific and societal applications.

¹ Lisbon European Council: Presidency Conclusions (24/03/2000 – No. 100/1/00)

² “Challenges for the European Information Society beyond 2005” COM(2004) 757.

³ “Report from the Commission to the Spring European Council. Delivering Lisbon. Reforms for an Enlarged Union”, COM(2004) 29.

⁴ European Commission: Facing the challenge - The Lisbon strategy for growth and employment. Luxembourg: Office for Official Publications of the European Communities, 2004.

1.2 Software and Services at the heart of the Knowledge economy

ICT systems support and control many vital aspects of our lives. In many cases, they depend on fragile software and this brings to the fore the issue of software quality and reliability, which hence become of paramount importance to society as a whole.

At stake is a European market for software and services, a sector that employs more than one million European specialists and is expected to account for 215 B€ in revenues with an expected growth in 2005 around 4,4%. This figure, roughly 2% of the European GDP, represents 65% of the total European IT market value and 31.5% of the total European ICT market value.

However, these figures alone do not depict the importance of the European software and services industry. It is also important to consider the added value it brings at the social and economic level. From the economic point of view, it is obvious that ICT in general and software services in particular represent a primary asset for business operations and competitiveness for a vast majority of European production sectors. Research conducted in September 2004 on 197 European executives from various industrial sectors concluded that ICT is generally perceived as a critical factor in improving business processes and developing innovative and more competitive business strategies.

Pervasive connectivity, as already demonstrated by the rapid increase of broadband access and growth in mobile data, will radically change the nature of communications. Indeed, network traffic is moving to a decentralised environment driven by myriads of small autonomous systems with embedded programmable devices like sensors, smart tags, cameras and appliances on the fringes of converging fixed and mobile networks. These changes will open new opportunities for a range of industries to combine existing and new services and products in novel ways, hence creating totally new demands and challenges to the production, deployment and operation of software, systems and services.

These new services and their uptake by individuals and industries will be associated with a number of social, ethical and legal constraints. Software and services not only have to cope with these constraints, they are also instrumental in transferring the enforcement of regulations and laws from paper to electronic solutions. It is essential for Europe to retain its ICT capabilities that guarantee its control over such crucial assets as business methods, accounting procedures, privacy rules and intellectual property rights.

2 Vision

2.1 NESSI Holistic View

The innovation driver and core enabler of economic growth in the 21st century is Information and Communication Technology (ICT). The combination of the growing demand for software and services together with the structural forces affecting industry, represent a new opportunity for Europe. In this context, the NESSI initiative embodies the strategic mechanism through which Europe will seize this opportunity and exploit its global capability, not only to the benefit of the software and ICT services industry, but also to that of all economic sectors, and at the end of the day, to the benefit of all citizens.

Within ICT the IT services marketplace is today changing dramatically, due to a series of factors:

- private and public organisations require flexibility to keep up with the ever increasing pace of change caused by globalisation and technological innovation as well as the capacity to put in place new business models that distinguish their offering from their competitors;
- a continuing shift toward increasingly made-to-order solutions, which changes the balance of demand from products to services and from monolithic do-it-all applications to customised software solutions based on the composition and configuration of service components;
- A major shift toward mission-critical 24/24 running systems integrating with continually changing third-party systems such as in an Infoware;
- the broader uptake of ICT by end-users leads to new needs such as ubiquitous access, ease of use, personalisation and trusted transactional capabilities on all types of platforms, from embedded systems to distributed environments;
- the clear emergence of Open Source Software, which nourishes the dynamics of the ICT marketplace and creates a specific ecosystem that fosters opportunities by: increasing competition and choice, aligning with open standards, positioning software as a public good, improving technological self-reliance, increasing transparency while optimising costs.

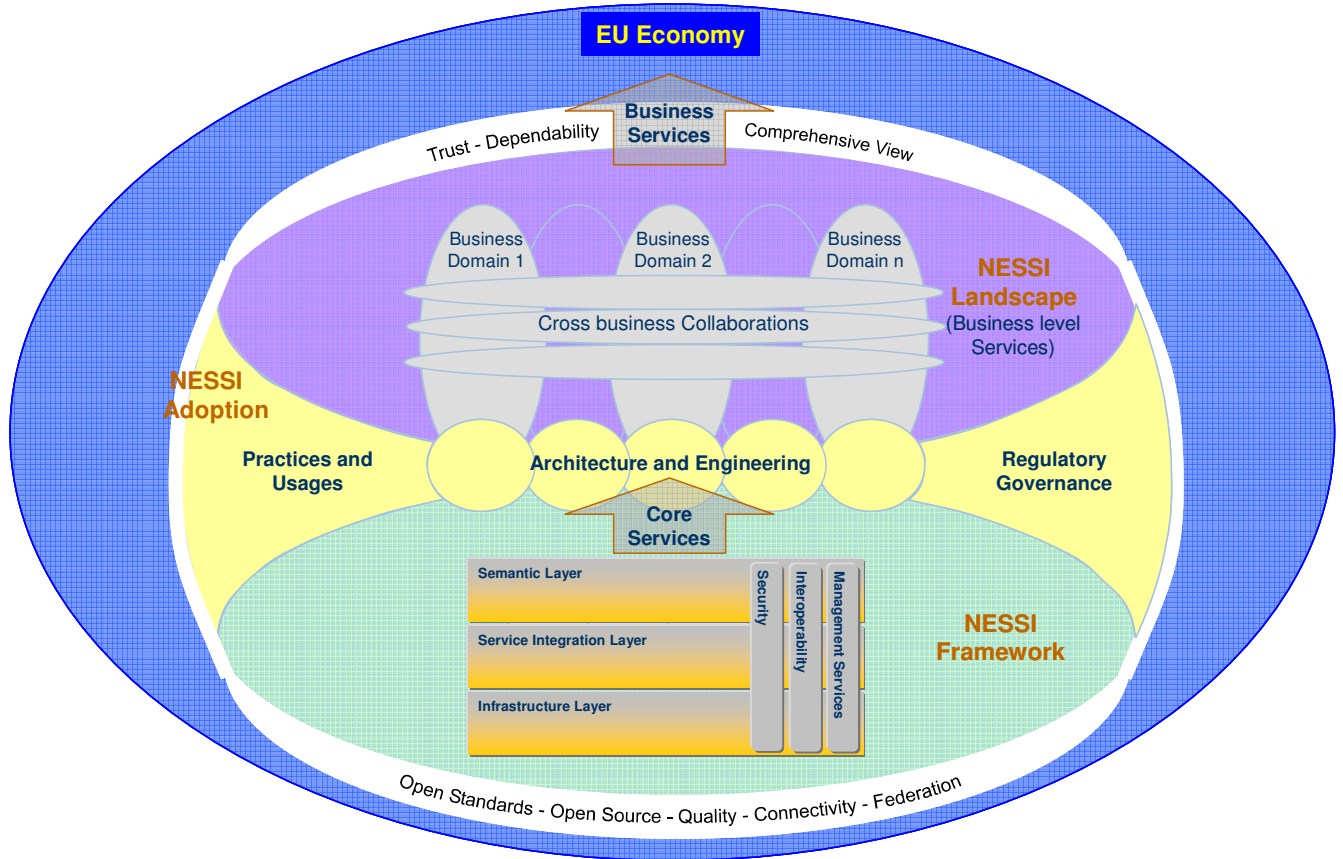
To address the above factors properly, the ICT industry in general, and the software and IT service industry in particular, need to step up to the task of developing innovative products and services. Although technology related aspects are important, it is crucial to address as well the sociological implications of building such systems, since the success of the initiative will be determined in a significant part by the acceptance of new technology by end users and communities.

NESSI aims at shaping a vision and building an ecosystem that together enable the emergence of a service-oriented economy in Europe. It is with this in mind that the NESSI SRA is based on a holistic model which embraces the whole service approach from the behaviour of large systems service-based to delivery of a simple service to end-users. This model, as depicted in the following picture, foresees the NESSI ecosystem as a key element in the EU Economy and architects it in three main constituent parts:

- ICT Technologies, represented by the **NESSI Framework**, where the services, the key elements of the ecosystem, are engineered;
- the **NESSI Landscape**, comprising an emerging service economy, where services are applied to specific businesses and domains as well as made cross-domain. The NESSI Landscape aims at enabling tight interactions between systems of agile service-oriented businesses in an always changing market;
- the set of instantiation mechanisms based on regulations, rules and policies, experiences and learning approaches constitute the **NESSI Adoption** element and makes services usable by consumers.

At the core of NESSI vision is **the provision of new approaches enabling the transformation of the European economy through service oriented business models.**

In the Appendix specific scenarios have been provided to illustrate the role NESSI can effectively play in real-life. In particular these scenarios describe the possible relationships between NESSI and other relevant ETPs such as Artemis and eMobility.



NESSI Framework

Future scenarios will be characterised by large distributed systems with many data collection points, operations, and computers that evolve data into knowledge and help humans coordinate the execution of complex tasks. Large amounts of data will be generated by sensors, transmitted via wireless channels to ground stations, and then moved through fast optical technology to powerful computational infrastructure. The results will be visualised on different devices according to the context of use. A crucial missing piece is a software infrastructure middleware facilitating a seamless and cost-effective composition of services in this new era of the Web. This software infrastructure should support pervasive and ubiquitous application scenarios where machines dissolve across the net into a set of special purpose and domain-specific appliances.

Core Services will be offered to private and public organisations to build systems that, enriched and empowered by the proper business models, will deliver the services the end-user will have at their disposal.

The availability of an open-source reference implementation, along with the systematic adoption of consolidated open-standards, gives Core Services the right characteristics for fast and pervasive adoption worldwide. Core Services can be adopted dynamically, enjoy much lower development cost, a higher level of exchangeability and interoperability, and lower cost of entry to the marketplace due to common trust, security and privacy methods, common ontologies and semantics.

NESSI Landscape

At the heart of the European service economy, the **NESSI Landscape** aims at enabling tight interactions between systems of agile service-oriented businesses in an always changing market.

By the use of Core Services it will be possible to build new systems which, incorporating the necessary business logic, will deliver the Business Services end-users will adopt to satisfy their information needs. This also enables enterprises and public sector organisations to supply services to their customers that are adapted to the local culture and context. It is expected that the current segmentation into separate business domains (such as Automotive, Healthcare, etc.) will be relaxed. In fact an event occurring in a specific location under specific circumstances might affect or need support from other systems in other places and other domains. Enabling flexible use of service components across different domains in cross-business collaborations is the goal of the interoperability standards and mechanisms which NESSI will make available.

It is expected that current business models can be made more dynamic and modular while retaining their specific semantics and business logic. In addition, an important aspect NESSI intends to explore is the way new business models, can be made possible by the adoption of NESSI framework technologies.

NESSI Adoption

The fact that service-based systems will be implemented and deployed is not sufficient to have these systems efficiently adopted by citizens. Several barriers have to be addressed and to do so NESSI will develop its adoption strategies along three main axes:

- Entering the service economy, will require organisations not only to master service infrastructures, but also to reinvent their business models. NESSI will sustain the development of appropriate training programs and competence centres, helping organisations to change, to better architect and engineer their new systems, to adopt service-oriented business models.
- Ultimately, the long-term adoption of NESSI will be sustained by the development of expertise in knowledge domains relevant to a service-oriented economy in Europe. This will be achieved by setting-up corresponding education programs and promoting the development of open cross-disciplinary communities of experts in Europe.
- Compliance and evolution of regulations and governance procedures. At present it is true that for ICT, regulations represent an important source of requirements. The dynamicity of new service-based business models might require a different understanding since current regulations might appear in some cases to be too restrictive with respect to the fully adoption of the envisaged new models. In addition, the new service era might raise new issues (e.g. social, economical), unforeseen by regulators, and requiring new regulations. A current example of the relationship between technological and social issues is the capability of service-based systems to establish or maintain valid contracts on behalf of the organisations running them (eContracting).

NESSI Overall principles

The three main NESSI constituent parts all share important properties and principles. These are:

Trust – this is a fundamental principle on which the whole NESSI approach is based.

Dependability – as in current ICT practices, new services-based system will be implemented in such a way as to guarantee predictable functioning, and that their usage should not harm humans or the environment.

Comprehensive View – regardless of the complexity of its technologies, from the end-user point of view NESSI technologies will be perceived as utilities (e.g. electricity) without requiring specific knowledge to use them effectively.

Open Standards – this principle is at the core of the approach to wide adoption of NESSI technologies without creating barriers to business actors benefiting from NESSI results. It also represents an important contributor to the overall interoperability of service-based business applications.

Open Source – fostering Open Source development not only allows a widely adopted NESSI reference implementation to be built, but also increases market competitiveness and transparency.

Quality – The implementation of NESSI solutions as well as service-based systems will consider quality as a design-guide principle. At this level quality has to be considered as a twofold property: from one side it pertains to the quality of the delivered systems as such, from the other it pertains to all aspects related to Service Level Agreement (SLA) management (definition, implementation, and assurance). Indeed the adoption of a specific service by a specific consumer is not only guided by what the service does, but certainly also which are the SLAs at the basis to the service (costs, performance, availability, etc.).

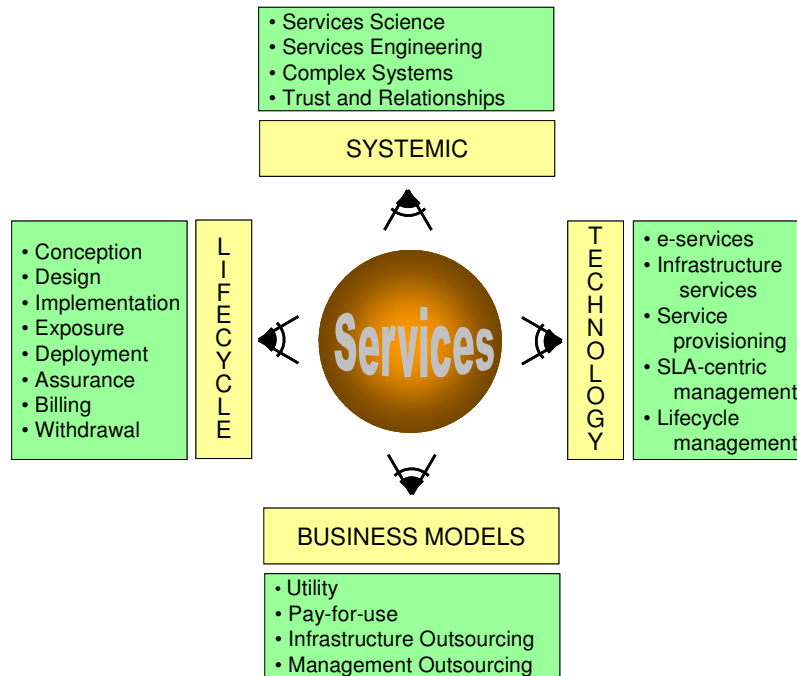
Connectivity – According to the “Comprehensive View” above and considering the size of the environment, needs in terms of flexibility, scalability and potential coverage in terms of geographical area, the whole infrastructure can be seen as a growing network made of a number of self-consistent instances able to interoperate in order to provide services to the users.

Federation – NESSI will not be built as a single instance or infrastructure. Multiple different instances of NESSI will be able to cooperate and collaborate as needed. In this context, scalability of NESSI-based solutions (from the very small to the very large) is a crucial property.

2.2 NESSI service perspective

The word “service” is used to characterise a wide variety of concepts. NESSI takes a broad view of services, although the emphasis is on services which rely on ICT.

In general terms, a service can be characterised by the fact the service consumer does not own the service, and by the existence of a service level agreement (SLA), either explicit or implicit, between a provider and a consumer. The SLA provides the shared context between different parties to a relationship based on the service. The relationships between provider and consumer can range from long-lived associations to dynamic single-use scenarios.



NESSI is a major component to sustain the transformation of the European economy to a Knowledge Economy, based on a full service-based model. NESSI is strongly connected with the domain of services science. Services science deals with the foundations of complex business services, which are seen as advanced business capability offered by businesses to their ecosystem consisting of customers, partners in the supply and demand chains, and to the end-consumers. In the ecosystem, complex services can be created and formed for transforming the production and distribution of goods and services. Lately there has been a significant trend in the marketplace: businesses are moving from centralised monolithic organisations to a networked collection of businesses, collaborating and sharing services (under contracts) in order to produce goods and new services faster and cheaper. Services science deals with understanding, defining, investigating, modelling and analyzing complex services that can be combined in multiple ways to offer better flexibility, agility and efficiency for business transactions and operations. The services being investigated not only include computational or system services but also labour, expertise, organisational, divisional services where mathematical and simulation techniques of optimisation and business performance play a strong role in enabling near optimal allocation of services to enable better production and distribution.

Services science relies on service engineering and complex systems engineering, which are both core to NESSI. Services engineering is a disciplined way of ensuring that services are created, instantiated, supported, invoked and gracefully dismantled based on complex requirements from businesses relating to services design, implementation and deployment. Services engineering provides the foundations and rigorous framework for enabling the formation and delivery of services. Complex systems engineering deals with the fundamental problem of understanding, designing and managing real-world complex services systems, working fluidly across disciplines. Increasing academic specialisation has tended to work against this, something that is often reflected in industrial research and development.

The service ecosystem supported by NESSI is both hierarchical and recursive. Services in NESSI can be approached using different views:

- Lifecycle view
 - conception/design
 - implementation
 - exposure
 - deployment

- assurance
- billing
- withdrawal
- Technology view
 - e-services
 - Infrastructure services
 - Service provisioning
 - SLA-centric management
 - Lifecycle management
- Business model view
 - Utility model
 - Pay-for-use model
 - Infrastructure Outsourcing model
 - Management Outsourcing model

3 Challenges

The benefits of reaching the objectives of the Lisbon agenda have already been articulated. While this section focuses on challenges, it must be clear that these challenges, however significant, are worth pursuing in light of the benefits the successful implementation of NESSI will provide to the European Society.

3.1 Reaching the Vision is THE Challenge

The formal mission assigned to a European Technology Platform is to build a research agenda, spelled out in a Strategic Research Agenda (SRA) document. While the formal mission of NESSI is therefore to define a Strategic Research Agenda in the space of software and services, Grid and infrastructure, and trust and dependability, completing this task in isolation will not provide the anticipated benefits to the European society. The holistic view of NESSI defines the context and motivation for what is captured in the NESSI SRA. Priority must be given to the various elements required to complete that vision, regardless of the nature of these elements. This means that NESSI success factors are found far beyond the confines of the technical research agenda for the NESSI Framework. NESSI, in particular, and the transformation of the EU economy more in general, will only succeed if all the elements spelled out in the holistic view are reached, including the technologies of the NESSI Framework, the business services of the NESSI Landscape, and the societal changes part of the NESSI Adoption. This calls for a multidisciplinary and multi-domain approach to the problem, starting with a holistic view which includes technology, people, and processes across the entire value chain. The NESSI initiative and its SRA form only part of the answer.

3.2 Driving the Paradigm Shift

Changing the EU Economy into “*the world’s most dynamic and competitive knowledge-based economy*” is much more than a simple evolution. It requires a paradigm shift in how to approach business engineering. Defining this new approach is a challenge. But the European economy will not stop for this transition to happen; this paradigm shift must be implemented in an evolutionary path.

Staying focused on the NESSI SRA, this paradigm shift translates into the evolution of products into services, and of implementations by development into implementations by composition and configuration. Users no longer want to deal with various kinds of products trying desperately to communicate and collaborate all together. They ask for a complete integrated set of services, accessible everywhere on all kinds of devices and fundamentally based on a pay-for-use model: in a word, services will be seen as **utilities**. In a similar fashion, pressured by the need to cope with rapid change and increasingly complex distributed environments, the majority of **new business software is now constructed by configuration rather than programming** (*Component Frameworks* and *Service Oriented Computing* are two examples

of this approach). There is a need for ways of producing applications by configuration and composition of loosely coupled services.

3.3 Dealing with Complexity

Complex systems, as characterised by the requirements of service oriented economies, are an integral part of our constructed world. As society comes to rely increasingly on these systems for all aspects of life, it would be reasonable if it is possible to claim a solid understanding as to how these can be specified, constructed, tested, and controlled. What could easily become an unwieldy situation must be kept in control. A fundamental problem in understanding, designing and managing real-world complex services systems is the need to work fluidly across disciplines. Increasing academic specialisation has tended to work against this, something that is often reflected in industrial research and development. With this respect NESSI wants to pursue a suitable funding environment established in which a mixture of disciplines can be brought together to improve our understanding of complex systems and their applications to services innovation.

In many cases the “wall of complexity” have been reached, therefore new concurrent multi-disciplinary approaches are needed: architecture, modelling and simulation, operational analysis, human factors and development tools. The implementation of core services will play there part as well, as virtualisation and abstraction are expected to be common across all technologies. Ultimately, the actual implementation will remain invisible to users as the interface will provide will be a unified, single-world view onto the business and infrastructure services.

There is a need to understand the emergent behaviours that will arise in sufficiently complex systems, initially to avoid them, and to ultimately exploit them.

3.4 The Tension of Trust

The new technological scenario will be characterised by large distributed systems with many data collection points, services, and computers that organise data into knowledge and help humans to coordinate the execution of complex tasks.

Even in situations where the component or service supplier is trusted, development errors may mean that the component or service is not dependable. Hence, the role of the architecture will be to promote trust by providing security properties that will limit the versatility of components and that will provide strong and validated mechanisms for protecting the system against hostile attacks.

Today’s systems and services are fragile, difficult to compose and maintain; this is a major barrier to build trusted applications, hence to the widespread adoption of service-oriented architectures. The highly connected model promoted by the initiative adds to the complexity of challenges, such as providing proper accountability mechanisms.

Nevertheless, trust is much more than an Information Technology issue. Trust implies complicated interdependencies and composition issues, spans security, systems, and social, legal and economic sciences: cyber security for computer networks, critical infrastructure protection, economic policy, privacy. Trust must be handled as a “holistic” interdisciplinary systems view of security, software technology, analysis of complex interacting systems, economic, legal, and public policy. “Absolute” trust will remain a worthy objective, but will always remain impractical as long as it will be tackled solely as a technical issue.

3.5 Keeping it OPEN

The NESSI initiative strongly believes in the creation of a world where all actors of the economy will benefit, where win-win relationships will by far outnumber win-lose situations. NESSI spells out strong principles in the area of open source and open standards, which are two foundations of the research programme. While these principles alone do not guarantee a level playing field, the bias for a

collaborative, inclusive approach combines with these principles to keep the NESSI initiative, as well as the world in which it is deployed, open and dynamic.

3.6 Transforming Vision into Reality

According to popular belief, Thomas Edison has said that “*vision without implementation is hallucination*”. This statement is very applicable to NESSI. While the NESSI vision is in line with the evolutionary trends of the EU economy, reaching its objectives of pervasive use and positive impact is extremely challenging. The involvement and commitment of all relevant players (industry, academia, and public institutions) to the coordinated definition and execution of the NESSI research agenda will require a realistic approach and constant focus. Timing and accuracy of decisions will prove to be critical success factors in the implementation of NESSI research agenda.

3.7 Building Active Support

Beyond a successful definition and implementation of our research agenda, the success of NESSI cannot be achieved without the existence of a strong community supporting the initiative, embracing its principles, and seeking a new way of approaching their individual role. Building this community has been captured in the NESSI Adoption section of the holistic model. More than for any other domain, NESSI cannot be successful in absence of this strong community.

As part of this community, relevant EU initiatives should adopt a “powered by NESSI” approach to fulfilling their mission.

4 Strategic Research Areas

4.1 NESSI Properties and Principles

4.1.1 Overall View

The instantiation of such a complex holistic model as identified by NESSI as well as the provision of new solutions for services as envisaged by the NESSI vision depend on a set of properties which are shared by all the components of the model and solid fundamental principles.

Users of NESSI depend on predictable and characterised behaviours of the services they use. Properties define the various dimensions of this expected behaviour. Achieving a given set of properties requires a systemic approach; all of the components described in the holistic view play their part. Just combining a group of components sharing a given property does not necessarily confer this property to the whole system; such a combination is actually neither required nor sufficient to confer this property to the aggregate. As a consequence, NESSI considers key properties in a systemic manner. There is a large set of properties applicable for services instantiated on a NESSI infrastructure; for the purpose of this document the core and most essential identified ones are: trust, dependability and "comprehensive view", which will be further detailed in the rest of this chapter.

Building a system as large and complex as what is described in the NESSI holistic view requires a structured approach, built on strong principles. This is not only required to deliver a functional system, but also, and maybe more importantly, to build a coherent system. These principles and common approaches are essential in achieving the set of properties supported by NESSI. The key principles identified are Open Standards, Open Source, Quality, Connectivity, and Federation. Each is described in more details in this chapter.

It is however important to note that some properties require more than a systemic approach, they also depend on a set of dedicated utility services and components. This is particular the case of trust, which is build by a combination of systemic approaches and a core set of security services. These dedicated components are described in the relevant sections of the NESSI holistic view.

4.1.2 Trust

Essential for the acceptance of any implementation in the NESSI context is that users and providers have trust in the results of the software, its usage, and the intentions behind it.

Properties such as trust are much more than only an Information Technology issue. Trust implies complicated interdependencies and composition issues, spans security, systems, and social, legal and economic sciences: cyber security for computer networks, critical infrastructure protection, economic policy, privacy. Trust must be handled as a "holistic" interdisciplinary systems view of security, software technology, analysis of complex interacting systems, economic, legal, and public policy and must be combined with active infrastructure management and decision support systems that allow ideally fully automated .decision if the risk associated with a service offered by a particular service provider is balanced with given trust, reputation values and the risk and impact in case of a failure for this service.

4.1.2.1 Objectives

For assuring trust technologies, methods and policies need to be developed for:

- Rules of conduct and legal guidelines for companies cooperating to provide software services,
- Measures to provide and guarantee a certain Quality of Service (QoS),
- Adaptation of services to various levels of privacy,

- Providing the necessary dependability, security, and safety.

4.1.2.2 Challenges

Trust has many facets and its provision has not only technical but also sociological, psychological, and economic aspects. Trust is influenced by the image an organisation has in public and with its customers; individual members of an organisation can have significant impact on its image.

Rules of conduct and legal guidelines for companies cooperating to provide SW services

Such rules encompass the legal basis for cooperation in NESSI, and also the openness of NESSI towards the general public. The possible attitudes, strategies and behaviour of industry and Open Source communities towards each other are included as well. The legal guidelines will encompass protection of (customer or other) data delivered from one service to another, respect of privacy regarding any data delivered from one service to another or accessible by one service from another.

NESSI plans to contribute to trust by supporting the offering of testbeds and certificates for software services that passes certain tests or adhere to certain rules. The definition of such testbeds, use cases, and rules is a major challenge.

Measures to provide and guarantee a certain Quality of Service (QoS)

Only a stipulated quality assurance will provide a basis for being able to trust. This quality assurance (for corresponding QoS) has to be put into place concerning both, the process and the technology.

Adaptations of services to various levels of privacy

The more services are provided by software, the more people will be worried about privacy. Personal data and data of companies and governmental organisations will be sent around networks by services, will be used by services and also forwarded to other services. Support to different levels of privacy need to be provided - services that have access to sensitive data may not be requested or even explicitly excluded by certain customers for certain purposes. Encapsulation of services working on sensitive data and their inclusion and exclusion from certain cascades of services need to be offered. The test beds mentioned above must offer tests of the presence of such inclusion and exclusion capabilities and about forwarding and storage of any private data. This is absolutely necessary to ensure trust in services.

The necessary dependability, security, and safety

These topics are described in sections 4.1.3 (Dependability) and 4.3.5 (Security). Trust requires that the services used are dependable, secure, and safe.

4.1.3 Dependability

The IFIP working group WG 10.4 on dependable computing and fault tolerance⁵ specifies: "... dependability, defined as the trustworthiness of a computing system which allows reliance to be justifiably placed on the service it delivers". The working group explains that dependability comprises characteristics such as reliability, availability, safety, and security.

4.1.3.1 Objectives

Users of software services will require that these services are dependable. This means various things:

⁵ See <http://www.dependability.org/wg10.4/>

- Services do what they are supposed to do, according to their public specification, no more and no less.
- Services have no side effects on any other data (neither intended nor unintended).
- Services are secure from outside attacks or other misuses.
- Services offer their QoS according to the SLA.
- Authenticity - services are what they claim to be and from the indicated originator.

4.1.3.2 Challenges

Services do what they are supposed to do

A service must have the functionality that it claims to have. This can be assured by a certificate which may require passing certain tests. A service must also have the quality that is requested or expected by the user. Dependability comprises ways to ensure that defined Quality of Service (QoS) is delivered according to particular Service Level Agreements (SLAs). Ensuring this and providing a suitable certification scheme and technology is a major challenge.

Services have no side effects on any other data

The user must be sure that the data provided to a service is not used or stored for any other purpose than the one indicated by the user. Services must not allow any dealing with customer data unless users do wish that.

A service will use other services, each of which in turn may use others, etc. Thus, a service call will create a cascade of services. Such a cascade will leave traces somewhere in the servers of the networks used. Some kind of transaction mechanism for services has to be provided:

- Whenever a service S is executed and its execution has completed successfully, it has to be ensured that no customer data used by any service called by S directly or indirectly is still available except where S needs their availability as specified by the customer using S.
- Whenever such a service S cannot be completed, all changes made by S or any service S' called directly or indirectly by S shall be reversed to the state before S or S' were started.

Services are secure from outside attacks or other misuses

Certain applications will require different levels of security. We have to define such levels and identify what properties characterise them and have to support developing technologies for achieving them.

Services offer their QoS according to the SLA

This is described under the first list item, "Services do what they are supposed to do".

Authenticity - services are what they claim to be

A service has an identity and indicates its provider or originator. This identity must not be faked - it must be ensured that e.g. a service coming from a certain governmental institution really comes from there and not from some impostor. Corresponding methods for authentication have to be developed or adapted.

4.1.4 Comprehensive View

Business ecosystems such as the ones addressed through NESSI are very complex systems especially due to the fact they are built across many boundaries (e.g. cross-domain applications) and highly heterogeneous. This complexity must be hidden from users (which in this context includes service

providers) for who NESSI technologies should be perceived as utilities (e.g. electricity) without requiring specific knowledge to be used effectively.

One of the major challenges here will be to first come up with a complete virtualisation of resources and second to leverage them on the level of utilities as previously defined. With respect to this, NESSI plans to promote delegation mechanisms through which a demand for a “high-level” service coming from a user is put under the responsibility of the NESSI system to be properly and efficiently accommodated. The rationale behind it is to put the emphasis where the interest of the user lies: timely response to service request, and not to bother him/her with details such as HOW and BY WHOM the service demand was answered unless this is specifically required.

But if service demands can be captured and accommodated autonomously and intelligently by NESSI they also need to be satisfied “intelligibly”. This is just because “intelligence” at system level may not be perceived as immediately “intelligible” at user level. This is possibly even more pronounced at collective level.

If the term intelligibility was primarily introduced for voice communications and defined as the capability of being understood it is fully applicable to a broad range of various domains including the one of Semantic Web (where it is starting to be used). In the context of NESSI there is a plan to introduce and investigate it at the level of service description, construction and, probably most importantly, rendering to the user, in order to achieve what has been identified as “comprehensive view”.

We thus plan to not only focus on intelligent services but also to address services intelligibility since this is perceived as a key factor in the acceptance and wide adoption of NESSI Framework.

We can anticipate here that by working on intelligibility (with all the meaning attached to it: clearness, comprehensibility, ..) we will not only gain in user acceptance but also significantly contribute to the wide adoption of the NESSI Framework through generation of better trust and confidence, confidence being seen here as a human trait on which to play in order to develop trust in NESSI solutions (develop confidence to gain better trust).

4.1.5 Open Standards

In the context of the NESSI Strategic Research Agenda, the expression “open standard” refers to a class of publicly available specifications as defined in the “European Interoperability Framework” proposed by IDABC (Interoperable Delivery of European eGovernment Services to public Administrations, Businesses and Citizens <http://europa.eu.int/idabc>):

- The standard is adopted and will be maintained by a not-for-profit organisation, and its ongoing development occurs on the basis of an open decision-making procedure available to all interested parties
- The standard has been published and the standard specification document is available either freely or at a nominal charge. It must be permissible to all to copy, distribute and use it for no fee or at a nominal fee.
- Intellectual property -i.e. patents possibly present- of the standard is irrevocably made available on a royalty-free basis
- There are no constraints on the reuse of the standard.

Open standards provide vital benefits toward greater social and economic development like collaborative innovation, flexibility, interoperability, cost effectiveness and freedom of action.

Open standards are a key factor or a strategic driver for NESSI acceptance and wide adoption.

Based on broad participation and the availability of standard specifications, NESSI should create opportunities for enabling the transformation of European environment through the development of an open services ecosystem.

4.1.5.1 Objectives

As the expression of a consensus between actors within industries, open standards have a key role in fostering healthy and competitive IT ecosystems, bringing interconnectivity, interoperability, sharing information among hardware, software and IT services. In this respect they provide a tangible opportunity to achieve a full services integration and wider use linking together organisations, enterprises, administrations and citizens across networks, platforms and applications such as in critical sectors like healthcare, public safety and education.

Open standards are crucial means for achieving NESSI implementation and deployment objectives. Common standards are an important step in driving toward commercialisation and mass adoption of technology. In addition they facilitate the global scale interoperability not only of infrastructures but also of semantic, information and processes.

The NESSI Framework will be built on open standards which will allow industry, academia and public administrations to adopt technology rapidly and on a large scale, and to ensure cost effectiveness by increasing competition. NESSI implementation can be realised through a flexible and adaptable architecture along with commitment to open technology standards where they exist and when they are broadly supported by the market. This approach should increase technology options for implementation and use, broaden choice in procurement from a variety of technologies, allow citizens to choose how they want to access and receive services, and adapt to ever-changing requirements and procedures.

4.1.5.2 Challenges

NESSI will aim to play an active role in the various standardisation bodies working on open standards for software and services including, but not limited to, OMG, JCP, W3C, IETF, and OASIS. NESSI approach will be a catalyst for building consensus and innovative contributions to open standards. When no suitable standards body exists, or when existing bodies do not deliver open standards, the question of promoting, issuing or even creating alternative open standards should be addressed.

To ensure a high level of interoperability, compatibility test suites of open standards compliance need to be made available widely. To ensure unimpeded access to compatibility certification by all players, such compatibility test suites should be made available in open source on a royalty free basis. NESSI's scope embraces the development of tools, benchmarks and test suites required to ensure compliance with software standards and interoperability of subsystems.

NESSI will support open standards reference implementation via its European full scale demonstration centre. By their nature, open source products may act as reference implementations of developing standards.

In areas where *de jure* open standards are not available, NESSI should seek to publish specifications (e.g. formats, protocols, interfaces, languages) under conditions similar to those of open standards. Open source reference implementations of these specifications may be a way to encourage the emergence of *de facto* standards.

4.1.6 Open Source

The open source software (OSS) phenomenon is complex, and lends itself to analysis from multiple perspectives, these being software engineering, sociology and business/economics perspective. It is a new and possibly disruptive approach that may foster entrepreneurship and innovation, and could play a significant role in education and training. OSS supports a shift to a digital, knowledge-based economy,

prompted by new products and services and is expected to be a powerful engine for economic growth, increasing employment opportunities. This is particularly the case for European SMEs, where market opportunities are provided within the collaborative ecosystem that OSS engenders.

OSS is linked to open standards. It often entails copyright based protection of software intellectual property and typically engages a collaborative community which acts both in the role of code development and distribution. Open source development, by its very nature, supports open standards and promotes interoperability and interaction between systems. Open Source exerts commoditisation pressures on some segments of the software industry especially in operating systems, development tools and edge network servers. This commoditisation pressure may extend into the middleware stack at the core of service delivery platforms that can be built by the European secondary software sector (companies that develop software as an integrated part of their operations but which do not regard themselves as software companies).

From a broader business perspective, various parties are perusing several innovative business models and new business opportunities have emerged as a result of the OSS movement. Some organizations have begun to capitalize on this and have demonstrated some early limited success. It is uncertain if any of these business models are stable, will succeed, and will demonstrate an ability to scale in the long term but some do demonstrate potential and merit watching closely. Furthermore some sustainable open source business model may yet emerge. Over the last few years, the OSS model has matured in some spaces into a viable alternative or more often, complementary approach to proprietary software for many organizations in many different application areas.

4.1.6.1 Objectives

The business value of OSS comes from its role in preserving choice in a market characterised by growing monopolisation and in creating more independence at a time when innovation and competitiveness are crucial factors in the European economy. OSS may also offer savings (in terms of reduced total cost of ownership) for enterprise, government and public institutions. It also has the potential to improve transparency and increase the trust of the user and the citizen. The example of Gemeinden Sudtirol in Italy, which has successfully transitioned from a proprietary software environment to Linux on the Server and the Open Office suite on the desktop for public administration employees is a good example of demonstrable total cost of ownership savings and usability towards the citizen. In addition:

- OSS provides greater freedom of action and reduces vendor lock in and offers some protection against a vendor decommitting from a product or failing altogether;
- OSS can shift the expense of software (typically manifested as services) to be more time aligned to the benefits derived from software but may in fact be more expensive in the long term;
- OSS can provide an efficient mechanism to implement strategic standards;
- much of the value of open source may in fact be encapsulated in some commercial software that consumes it as componentry;
- OSS presents customers with options and reduces commercial vendors ability to extract monopolistic rent from its customers;
- OSS promotes choice allowing customers to choose between alternative be they commercial or open source based on best value for money.

NESSI wants to take a proactive approach to OSS which it is expected to bring benefits such as encouraging competition and developing the European software industry at grass roots level.

Further expected benefits are the wider availability and more independence for EU member states in being able to opt for quality software at the right price with appropriate interoperability and public open standards while avoiding vendor lock-in. NESSI fosters creativity and openness in software development which is regarded as a necessary foundation for the building of the European information society's

infrastructure. It is NESSI intention to encourage the development of very large scale, open and secure platforms at reasonable low cost.

European industry wishes focus and develop its strengths in the secondary software sector. OSS may have a particularly important role to play in service delivery platforms such as embedded systems in the automotive, consumer electronics, mobile systems, industrial control systems or utilities (e.g. telecommunications) sectors. It is widely acknowledged that OSS was a key enabling paradigm behind the explosive growth and adoption of the Internet. NESSI vision is to repeat this success model in Europe for the next generation service centric systems.

It is very important to acquire a more thorough understanding of OSS organisations, dynamics and mechanisms. This can only be achieved through a multi-disciplinary research approach taking into account the different dimensions. At this stage NESSI deems OSS to be an asset that Europe can leverage. NESSI aims are to drive European excellence in software rather than focusing on specific end-customer applications or new usage directions, thus maximising the added value and enabling cost reductions. With this respect NESSI will:

- Advance research in the OSS community and create OSS applications that can be harnessed widely by the European software industry;
- Ensure creation of competitive and robust business models in order to leverage open source and mixed open source and proprietary software, bringing more choice and better quality for the user and the citizen;
- Ensure the development of shared business platforms which are large scale, open and secure at low cost for sector and cross-sector use;
- Encourage education and training in OSS;
- Support the Europe software industry in using and participating in OSS.

4.1.6.2 Challenges

As stated above, research into open source communities and models is a multi-disciplinary activity encompassing, without being restricted to, sociology, economy, software engineering and legislation. Thus different types of expertise is necessary to develop future domain-specific or cross-domain services:

- OSS brings externalities that may have significant economic consequences. Apart from opportunities for cost containment in public expenditure and high quality public OSS-based information systems, the transition from a proprietary-based to a service-based software economy is an opportunity for local economic development that Europe should investigate, particularly to foster international cooperation including with BRIC (Brazil, Russia, India, and China) countries.
- The availability of COTS (Commercial Off The Shelf) software components has driven software development and is an important factor to consider for OSS. NESSI should organize a European library of OSS assets through an "OS COTS - based catalogue" e.g. key players, products, evaluation and return on experience, which is publicly accessible especially for SMEs. The definition of identification and characterization processes of OSS components could be specified. Implementation on a cooperative platform including the related services would be an additional advantage.
- The uptake of open source thinking by mainstream vendors is still impeded by the lack of quantitative understanding of its economic impact. The conceptual apparatus used to measure this impact may have to be developed as an evolution of traditional economical models which are often sector-specific. Amongst other new models, open source may be increasingly adopted for business ecosystems in a cross-activity or cross-sector approach. Open source is a straightforward way to perform dissemination of research results and technology transfer to industry. Active European based OSS communities may boost Europe's primary software industry and create in the market place alternative choices to mainly US proprietary software.

- The advent of open source promises to bring opportunities for innovative business models, some being already successfully practiced, others yet to be invented. Beyond the consumer/supplier relationship, which appears increasingly outmoded in the open source world, collective strategies may be developed. These will leverage network effects, yield economies of scale and cross-disciplinary synergies. Building new business and innovation ecosystems should be the target of these changes, with the goal of developing value and jobs in Europe.
- The OSS legal framework is still largely inspired from non-European countries. To accommodate its expansion and adoption in Europe by mainstream players, legal risks need to be clearly assessed and managed, taking into account the requirement for compatibility between open source licenses and European regulations in each member state, without jeopardising the fundamental values and principles of open source. Proper tracking of IPR will become increasingly important as complex software systems will be assembled from open source subcomponents. Integrators' and users' concerns about liability and legal risk management when using OSS or compounds of OSS and proprietary software will need to be addressed.
- The Open Source model is based upon external contributions made within a collaborative work environment. However better efficiency, safety and security must be guaranteed in these increasingly decentralised projects Geographically distributed teams, with new methods of development present new challenges. Success will depend on process model interoperability and open standards compliance accessible to open communities. A fresh European answer must be provided for next generation collaborative platforms for software development and management of distributed communities involving both research lab and industry. NESSI should investigate a modular, adaptable, extensible, robust and safe collaborative framework applicable to different project organisations, project maturities, processes with different levels of trustworthiness etc... on a large scale and with a unified perspective at European or international level.
- The issues of software quality, quality control & assurance are to date poorly covered by open source processes, although peer review of the code and the "many eyes" phenomenon provide some answers. The impact of transparent access to the code on safety, security, respect of privacy of systems based on open source needs to be assessed in detail. The relationship between process engineering methodology (extreme programming, co-design, concurrent engineering, workflow management, distributed development ...) and quality also needs to be explored.
- EU policy strategies need to be simplified or defined, to encourage the growth, deployment and support of OSS, where appropriate, taking into account competition and regulation rules, cultures and languages along with varied legislation. These should aim to enhance the market and technological conditions on a pan-European level in which openness enhances adoption of OSS platforms and applications and under which conditions OSS generates more efficient implementation of new technologies, thus enhancing productivity and the competitive advantage of European companies.

4.1.7 Process and System Quality

4.1.7.1 Objectives

All kinds of businesses rely more and more on software and services and the underlying infrastructure. Customers will only accept services if they have the expected and agreed quality. Errors in service behaviour may cause considerable damage, not only in terms of economic loss, but also in terms of environmental disasters including loss of human lives (e.g. errors in flight control software).

In general we can say that we need to assure that users get quality-agreed services so that they neither harm nor annoy them. From a business perspective it is also important to note that quality properties (often referred as Quality of Service - QoS) will be part of the contract between service consumers and providers in terms of Service Level Agreements (SLAs). Their definition, negotiation and monitoring are essential components of a service economy. Therefore, QoS characteristics such as safety, security,

privacy, and reliability are major aspects of systems and the services they deliver to customers. These qualities entail others, like maintainability, scalability, availability, manageability, and other performance properties. Typically these properties, as perceived by service consumers, involve the aggregate behaviour of all the constituent services and components. The derivation of aggregate behaviour from the properties of individual services or components requires study.

To ensure the expected QoS is delivered, we need guidelines that assist developers and provide criteria that help to determine if a particular service or piece of software is appropriate to deliver the expected QoS. These guidelines should consider the following major aspects:

- *Development processes*: Essential for the quality of products is not only what we develop but also how we develop. Increasingly, public administrations and industrial customers require a certain development process maturity from their suppliers. We need adequate process models (e.g. similar to the new V-model XT), guidelines, and assessment methods for mastering complex software systems and their provision as service-oriented utilities.
- *Development methods*: For coping with the complexity of software systems we need development methods that support distributed, heterogeneous development and verification and validation of the results. Existing development methods like AOP (Aspect-Oriented Programming) or MDD (Model-Driven Development) may be extended and new ones shall be created for achieving the necessary quality.
- *Tools*: Integrated development environments (IDE) are needed so that the new development methods can be applied, but also supporting cooperative development, verification and validation of the created systems.
- *Artefacts*: Business processes, software services, and all other created artefacts shall provide the necessary qualities. Business processes must have transaction characteristics to ensure correct completion. Self-diagnosis, adaptability to environments and for composing services are requirements on software and services to achieve the necessary quality objectives.

4.1.7.2 Challenges

Challenges pertaining to the achievement of quality goals for service ecosystems can be divided into two main categories: challenges concerning the nature of QoS and challenges concerning the development and satisfaction of defined and agreed QoS, encompassing SLA definition, negotiation and monitoring.

Specifying, verifying, negotiating and monitoring Quality of services (QoS)

Firstly it is crucial to provide a clear (formalised) definition and specification of QoS. For each service, unambiguous ways of measuring and practically verifying desired aspects of its performance are required. An open research direction is to devise specification paradigms and models capable of representing the probabilistic nature of distributed processing. Some challenges are to:

- create specification models and languages that allow increased automation of the production and code-development process;
- achieve systems in which QoS guarantees can be specified and assured during unstable periods in which failures and recoveries take place.

In the area of QoS specification there is a need to support scenarios in which the user specifies overall quality properties at the application level where a system is composed of multiple components. The service provider needs to be able to translate user requirements into QoS constraints on the constituent components. Regarding such an approach some challenges are:

- performance monitoring of the overall system and composing services; the additional issue here is to understand the right level of granularity given to the monitoring party (e.g. consumer or provider); this encompasses monitoring the adherence to an agreed service level;

- provision of methodologies that guarantee overall system quality exceeding the guarantee of each individual composing service;
- defining a language containing measurable and simple parameters to express QoS metrics. Different implementations may coexist for the same type of service, each providing different service properties, e.g. messaging tools may have different reliability and ordering semantics. The challenge is for these separate specifications to be composable: a composable specification must describe the joint behaviour of integrated components, according to the agreed service level.

Secondly it is important to examine the validity of existing approaches for new domains and devise innovative paradigms that remain effective when there is a proliferation of networked applications that are far more scalable and dynamic than ever before. New kinds of application include:

- P2P resource sharing applications.
- Applications supporting high mobility of users, processes and applications such as dynamic virtual private networks and wireless networks.
- Grid services (scientific, enterprise, Internet, intranet desktop)
- Web services with QoS requirements. Emerging Web services standards, W3C recommendations and other initiatives are a step in this direction.

Thirdly it is an open challenge to understand aspects of all emerging network technologies especially in dynamic networks. These include mobile ad-hoc networks, storage networks, overlay networks, P2P networks and sensor networks. There is a need to consider issues concerning reliability, security, survivability, real time behaviour and other quality characteristics. Further, future R&D should devise methodologies that are suitable for these novel platforms. Regarding mechanisms that provide QoS several areas in which further development is necessary are:

- lifecycle cost: networked applications that provide QoS guarantees today can be difficult to develop and also hard and expensive to maintain. A separation of concerns is needed so that the same application can be deployed on different infrastructures and/or the same application can be deployed with different SLAs.
- end-to-end QoS: end-to-end requirements should be resilient to dynamic changes in the availability of underlying middleware and network resources. To this end, applications can be provided with monitoring and adaptation services from the supporting infrastructure, especially the middleware platform. Mechanisms that can deliver application-level QoS, taking a comprehensive view of available resources should be developed. As an example, improved network throughput can be achieved either by configuration of the network or by migration of application components to avoid the use of congested links. Resource sharing in heterogeneous multi-owner environments will be required.

QoS Development

One of the key challenges for middleware architectures aimed at supporting services that are composed and composable as well as adaptable, is to guarantee QoS levels in large scale open environments. Meeting the QoS requirements of applications is made harder in a ubiquitous computing environment where new and customised services are expected to be added into existing applications at an increasing rate.

In the general area of quality-assurance and dependable computing, recent years have exhibited maturity in understanding the foundations of fault tolerance mechanisms and produced evolutionary progress in the basic techniques. There is a deep understanding of the fundamental difficulties in coordinating multiple entities in a distributed environment and of maintaining consistency between replicated information. At the same time, the need for high availability and high levels of quality-assurance has grown both in mission-critical and business applications. Recent promising approaches, such as enhanced building blocks, performance enhancing mechanisms and paradigms, optimisation, end-to-end QoS, autonomic and self-stabilising computing, have been introduced. However maintaining QoS in distributed systems, especially

those allowing dynamic changes, is a key challenge in the specification, testing and implementation of service oriented systems.. A promising approach is the application of software product line engineering to service development. The increased quality a software product line offers, the usage of standardised processes and the explicit modelling of variability fits the requirements for service development very well.

According to the previously listed major aspects, the above main challenges can be further detailed as:

Development processes:

There are various different development processes, but they are often not compatible, so that they hamper cooperation between different organisations instead of fostering it. The phases, work products (documents, models, etc.) of process phases, process architecture, etc. are different and often not adaptable. The main challenges are:

- Process frameworks and architectures⁶
To derive organisation-, domain-, and country-specific processes having the necessary preconditions for cooperation between different partners
- Process meta models
To define process frameworks and process models supporting the derivation of organisation-specific processes and tailoring for particular projects, and as a starting point for standardisation efforts
- Process tailoring
For determining project-specific processes and the necessary environment for project management
- Partnering processes, adaptation and synchronisation of different processes
To enable the cooperative development over different organisations with different processes and cultures
- Quality guidelines
Process, business, and methodology maturity assessment for organisations.

Development methods:

Development methods and tools need more support for cooperative work, for the necessary traceability from requirements over architecture to implementation, and for sufficient verification and validation. The view on individual artefacts – sets of requirements, architecture, design models or implementation – as well as the overall view on related artefacts and on the interoperability of artefacts created in different stages of the development process needs more support. An important challenge is how to elicit, negotiate, document and validate the required qualities of service. This calls for new requirements engineering approaches that consider non-functional requirements in the context of service engineering. Tools are still often closed, isolated, and cannot exchange data and models. Thus major challenges are:

- Description and modelling of behavioural aspects (semantics) of all kinds of artefacts, including software services, software components etc.
- Methods that allow configuring components (of various kinds of artefacts, e.g. models, specifications, software components) to satisfy given requirements and consider given interfaces and their annotations.
- Methods to identify the best-fitting artefacts, comprising variability management, semantic analysis, etc.
- Consideration of quality goals for development and tests.

⁶ A process framework consists of process components (e.g., work products, roles, activities, etc.) that are used to construct project-specific processes; see e.g. <http://www.donald-firesmith.com/>

- Guidelines for considering certain qualities during development.
- Providing certain quality levels (e.g. particular security levels) – using the right development approaches, checks and tests. The development method could provide a system family, encompassing systems with varying levels of quality, using variability modelling.

Tools:

Challenges to be addressed in the area of tools include:

- Traceability support over various kinds of models
- Support for the development methods described above
- Automatic checking of certain qualities during development: Tools for static and dynamic analysis of services (or rather their specifications) and systems that are composed of these services are needed. As an example, tools for the automatic detection of undesired service interactions can contribute to assure the desired level of quality.
- Exchange of model data and models between tools (including product as well as process artefacts)
- Openness (this is a specific field for open source)
- Test environments
- Deriving tests from use cases
- Testing Quality of Service: Besides testing whether the functional requirements are met by a service or a system of services, the desired quality of service has to be evaluated by tools, too.
- Mapping quality goals to tests Test cases should be derived in a way that allows the evaluation of certain quality goals.

Artefacts:

- Annotations for all kinds of artefacts, including software services and software components that capture the behaviour (semantics) of such artefacts.
- Methods to automatically combine services, considering the behaviour of these services and the desired overall behaviour.
- Service level declaration and management – when services are deployed, information about guaranteed service levels is to be delivered at same time. This information is useful both for management issues and for self-deployment (in case of performance degradation).

4.1.8 Connectivity

NESSI as a whole is meant to be engineered following the utility industry paradigm (e.g. similar in user experience to telecommunications networks). Considering the size of the environment, needs in terms of flexibility and scalability, and potential coverage in terms of geographical area, we can imagine the whole infrastructure as a growing network made of a number of self-consistent instances able to interoperate in order to provide services to the users.

4.1.8.1 Objectives

NESSI will not be deployed as a platform on a single instance, but as a series of interconnected instances. Each single instance has thus to guarantee both the possibility to operate execution of services itself and interoperability/integration with other instances. Services and processes are being delivered to a number of different devices and platforms to fully support mobility. In this respect, a number of connectivity related issues has to be solved. In terms of 'end user access', each single instance will allow access by different kind of devices, supporting different connection types. Regarding connectivity among

different servers, the NESSI delivery platform can be imagined as a network of interconnected elements where each component supplies all features needed to allow secure access to hosted services by other entities, to access services on another instance, to manage pass-through (forwarding service requests to other instances) and roaming, to support session hand-over between instances and fail-over.

4.1.8.2 Challenges

In order to provide true connectivity at the service level NESSI should hide platform and device specific features so that it would enhance reuse of the same generic service descriptions as separate service configurations in various NESSI instances. In order to facilitate service level interoperability NESSI should also support the registration, search, discovery and binding of service provider and service consumer entities across several interconnected instances. Dependable service execution across instances requires end-to-end support for transactions i.e. individual service requests should comply with the classical transactional requirements over several interconnected NESSI service components and networks. Constant change of service demand and supply requires late binding mechanisms both for the vertical direction, e.g. component deployment API's, as well as for the horizontal service deployment, e.g. IDL-type interfaces. On the other hand, constant change of service component implementations needs configuration and version control and deployment over widely distributed solutions. Dynamic behaviour over interconnected entities is needed in order to enhance best available performance allocation of computing and memory resources e.g. to support nomadic users and computing at the network edge.

4.1.9 Federation

Since the implementation of NESSI infrastructure will presumably consist of a number of autonomous platforms, and given that these platforms should interoperate and cooperate in order to provide a unique virtual environment able to transparently supply services to the user in the most effective way, it is clear that such an environment must behave as a federation of service providers.

4.1.9.1 Objectives

The use of a federation paradigm implies that each single entity will exhibit predictable behaviour, and that trust relationships will be established and supported by appropriate mechanisms throughout the whole infrastructure.

Common behaviour rules will necessarily affect both the single instance operating criteria (to support, for example, the possibility of hosting services initially developed and operated by a different entity) and the management of relationships among all participants. In this respect it is important to underline the importance of developing tools and certification paths in order to verify compliance of each single entity with the NESSI infrastructure standards, considering that the presence of a single 'non compliant instance' in a federation can cause faults, problems in service availability, bad quality of service and/or security breaches.

Trust mechanisms will need to be put in place to cover all topics related to security and information needed for management of service deployment, management and accounting (e.g. billing, settlement, quality of service, health monitoring).

Finally, each entity should be able to expose information related to its own limitations/possibilities so that there will be the possibility, for example, to find the best instance where a service can be accessed/run or to verify possibility to either host a specific service or allocate resources for it.

4.1.9.2 Challenges

Definition of rules for operating a single platform instance and for interoperability among instances will include various topics in different domains such as (but not limited to) security, rights management and services management and accounting. Although standards are already present in some domains (e.g.:

SAML for security), there is still a lot of work to be done to allow management of enforcement and trust at the proper level of granularity. Additionally, in various domains there is no standard available at all.

Looking at security issues to be addressed we can identify lack of a standard to describe policies related to authentication and authorisation in a way that can be used by access management platforms (WS-Policy does not address this, and SAML needs to be improved), as well as the need to solve issues related to privacy (use of attributes from user profile, ...); in general. Typical identity and access management issues must be solved: certification of user identity, enforcement of security policies (context dependent), and management of user data.

Another important area to be addressed is Digital Rights Management. This includes topics such as content protection, management of rules both for handling, distribution and access of digital content/information, as well as enforcement mechanisms.

Speaking of service management and accounting, given that NESSI should allow appropriate management of service level, billing and settlement throughout the infrastructure, it is essential that each component keeps access, usage and performance information in a form that is seamlessly readable by all federation participants, granting rights to access the proper information on a selective basis, both in a batch way and in near real-time. This can be possible only by improving existing available models and by defining a set of new standards.

Again, standards are needed to let each member of a federation expose information related to its own capabilities and limitations in terms of service operations and management, as well as to manage identity of individual delivery platforms and service providers.

Considering the potential impact on the integrity of the whole NESSI infrastructure that can be caused whenever a single instance does not respect established behaviour rules, some sort of certification process has to be established to verify compliance of a new component before granting the right to become part of the platform. 'Perimetral' security mechanisms should avoid intrusion of non compliant servers in the federation. The certification process, in particular, should include a set of tools to be used both by providers in test phase and by a NESSI certification organisation in acceptance phase.

4.2 NESSI Landscape

4.2.1 Introduction

We are currently experiencing a fundamental shift in the structure of economies, businesses and social communities from information-rich organisations to services-rich businesses (profit or non-profit) in Europe and other parts of the world. With the help of IT, organisations and infrastructures are rapidly evolving into a web of intertwined services being offered across multiple technological, societal, governmental and business systems. The NESSI Landscape is not only focusing on an enabling technology framework for business services in Europe, but also on social and organisational services across Europe. The challenge is to enable a framework for services (business and IT) that will enable and foster the economy in Europe to migrate towards a services-rich model of many-to-many business transactions, collaboration and interactions.

Over the last decade, large and medium businesses (e.g. automotive, electronics, mobile communications, paper, media and others) in Europe have been transforming and migrating away from a centralised model of building products towards offering services. They are also moving to a less centralised model of integration and interaction with business ecosystems consisting of multiple partners, suppliers, retailers, dealers and others. The reason for these changes is to make more effective use of specialised skills and services and to benefit from reduced costs of supply-chain integration and value-chain services offered to end-consumers. Other factors contributing to the shift include globalisation and dependency on sourcing products and services across the world based on lower costs and specialisations.

The key enabler that has played a strong role in enabling the shift to happen faster has been IT and IT-led business innovations. In a first step, NESSI will leverage IT innovations and enable a framework for optimising basic technological and business processes, linking various operations and transactions at a global level, providing information and services from any point to any point of the world. The scenarios could include managing physical workflows to achieve optimal operations in, for instance, supply chain logistics and distribution of resources. Later, NESSI can enable the creation of a 'knowledge chain', linking thousands of business activities across multiple businesses for enabling product and services to be created and delivered.

In the near future, the rapid set-up of highly dynamic service-based ecosystems in the pursuit of new market opportunities such as cross-sector collaborative applications will require us to not only improve our understanding of business dynamics, but also to develop new business models for it. In this quest for a new generation of business models for service-based ecosystems, NESSI through the NESSI Landscape, will offer a unique place to learn from experience.

NESSI Landscape will indeed act as a place where a broad range of services will be made available and deployable in a variety of ways depending on context. It will also, more importantly, provide an opportunity to learn from their active use by individuals, organisations or agents. The rationale behind this applied approach is to first capture additional requirements from both technical and sociological perspectives and second to advance services science and service engineering to have those requirements properly addressed.

This may also have an impact at the design of NESSI "utilities" that will support NESSI Framework instantiation through NESSI Landscape and in accordance with NESSI Adoption. This will be achieved through "core services" such as delegation service, composition service(s), transformation service (from one representation scheme to another) and others. Composition services will support industries such as automotive and electronics that have evolved over the last decade into offering more services through their business ecosystem partners for their products in order to profit and increase their revenue and market share. In the end, consumers benefit from the services offered by the manufacturers and everyone involved in the supply chain. This translates to more revenue and better consumer satisfaction on behalf of service providers and product manufacturers.

4.2.2 Business dynamics

Business ecosystems are currently a hot topic, but there is very little research on what the success factors of thriving business ecosystems are. In particular, the concept of how to commercially exploit services provided via digital means in an ecosystem is not well understood. An applied approach – in which services are deployed in a variety of ways and then actively used by other businesses and citizens – will help to understand these new paradigms. This includes the necessity to not only focus on a technical but also a sociological dimension.

Current ecosystems have strong dependencies – e.g. in the classical software vendor mode, where the ecosystem is dominated and controlled by one central player, or in the industrial district style of ecosystem where there is a similar level of dominance by one larger player – e.g. the automotive sector (e.g. FIAT) or the clothing sector (e.g. BENETTON).

NESSI foresees ecosystems that are economically more independent and which can thrive across regional borders, rather than the traditional geographically located ecosystems with a centre of gravity around one specific economic activity.

While recent research and publications have explored the concept of the business ecosystem as dominated and regulated by a key player (so called Keystone), not enough research has been conducted into alternatives. The business ecosystem we foresee in NESSI is perceived to be more balanced than is the case in the Keystone scenario. However, in a peer to peer network or in a balanced ecosystem, there are challenges with regard to governance, commercial viability and sustainability over a longer period,

which require additional investigation. In addition legal and contractual questions with regard to services need to be addressed.

The topic of service provision and the interdependence of service providers and service consumers (which are often simultaneous parallel roles) and the underlying trust models and networks also require thorough investigation.

4.2.3 Services Science and engineering

In a recent workshop on the future of computing in business, the main theme was on the science of services. The aim was to understand, model and analyze the fundamental shifts in the world economy from manufacturing and information to a services based economy. Services science deals with the foundations of complex business services, which are seen as advanced business capability offered by businesses to their ecosystem consisting of customers, partners in the supply and demand chains, and to end-consumers. In the ecosystem, complex services can be created and formed for transforming the production and distribution of goods and services. Lately there has been a trend in the marketplace: businesses are moving from centralised monolithic organisations to a networked collection of businesses, collaborating and sharing services (under contracts) in order to produce goods and new services faster and cheaper. Services science deals with understanding, defining, investigating, modelling and analyzing complex services that can be combined in multiple ways to offer better flexibility, agility and efficiency for business transactions and operations. The services being investigated not only include computational or system services but labour, expertise, organisational and divisional services where mathematical and simulation techniques of optimisation and business performance play a strong role in enabling near optimal allocation of services to enable better production and distribution.

4.2.3.1 Services Engineering

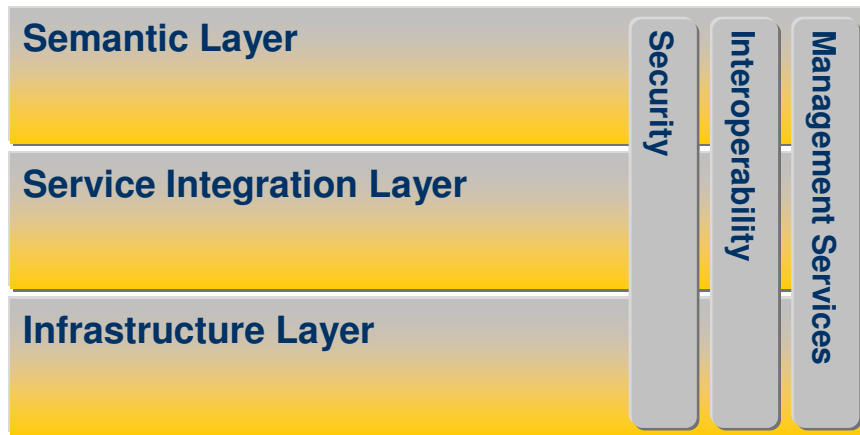
Services engineering is a disciplined way of ensuring that services are created, instantiated, supported, invoked and gracefully dismantled based on complex requirements from businesses on services design, implementation and deployment. Services engineering provides the foundations and rigorous framework for enabling the formation and delivery of services. This involves the execution strategy of defining, building and deploying business services for one or more businesses for wide use across the industrial supply-chains for enabling business transactions and consumer benefit. Services engineering assumes that business and IT requirements are captured and specified for enabling the creation and instantiation of new services. The engineering involves methodologies and tools for specifying complex services (using technologies such as Web Services or XML or ebXML), and building those services in a flexible manner for use by external third-party businesses or internal business divisions. The major areas of concern for services engineering include service definitions, interface design for labour, computing and organisation, interface instantiation, design of service units and components, deployment of services through one or more means (including hosting and delivery), management of services (hosted or otherwise), governance of services, services contracts for enabling business interaction and others.

4.3 NESSI Framework

4.3.1 Overview

Working towards achieving the initiative's objectives will be supported by an integrated roadmap of research and development covering different technology domains. The following rough taxonomic framework, which spans different levels of abstractions in software **infrastructure** and **system services**, from low-level infrastructure considerations (e.g. dealing with large-scale resource virtualisation) to high-level **semantic** considerations (e.g. supporting semantic ontologies, situations and intentions), is an illustration of the range of scientific and technical issues which the R&D promoted by NESSI will cover. The addressed domains are inter-related, and aim to support the NESSI holistic model where high-level services contextualise flexible low-level infrastructures.

The framework also addresses concerns that cross-cut these different levels of abstraction, covering general issues such as security, system and service management, and interoperability.



The NESSI approach is application domain independent, even if the outcome of the work on the roadmap could be configured and extended in domain specific platforms that could be re-combined in cross-domain platforms, creating a federation process. Autonomous capability will allow our solutions to adapt themselves to changes in the deployment environment conditions, in the business scenarios and in user requirements.

This roadmap should be supported by efficient software engineering methods to increase the productivity of the software development processes.

Infrastructure

The infrastructure domain aims at the virtualisation of resources across servers, storage, distributed systems and the network. Infrastructures have to be architected and implemented to be robust, fault-tolerant and secure. From a user's perspective, infrastructures must be transparent (almost invisible) during the entire lifecycle – allowing a plug-and-play approach to infrastructure usage as well as to Grid provisioning and operation of services.

New foundation core layers, including the development of Grid-aware network-oriented operating systems, are necessary to cope with new challenges in providing such an infrastructure. To support and enable the customers in migrating their applications to new virtualised infrastructure models, a structured methodology for application migrations is required.

Service Integration

In the NESSI vision, Service Oriented Architectures (SOA) will become the primary architecture for business systems of the near future. SOA provide means to create by configuration complex systems in a new modular way. This modularity will allow reusability of published services by other applications within a virtual organisation paradigm. In this context, the general problem of configuring and composing a set of services, at both the functional and the business levels, is a difficult one: dependable systems can only be built from reliable configuration. Therefore, the service integration platform also aims at providing tools and methods for configuration and composition in the same way as existing CASE tools provide support for programming.

Moreover, the platform shall also support dynamic reconfiguration, where software can be modified without stopping execution. The potential is great – for example, a system could adapt itself automatically

to reflect the culture or language of a client user. Equally, dynamic reconfiguration allows systems to evolve and extend without loss of service – thus meeting the demands for high availability.

Semantics

Semantics will be a key element for the transformation of information to knowledge. One way to build knowledge will be through advanced search engines that allow fast search in large unstructured data. Semantic Web technology based on ontologies will enable far more effective machine to machine communication about the nature and the manipulation of data they hold and actions based upon that data. On the business process level, business modelling provides the semantics that is required for business process management, process transformation and inter-company cooperation. In a knowledge-based economy, learning and knowledge management finally will have to converge to a work place utility.

Security and trust

Concern over security is possibly the most significant barrier to acceptance of IT services and digital services as a utility, becoming absolutely crucial in a more dynamic environment. Security and trust in a utility-driven world can only be achieved by an end-to-end perspective that is addressing all layers involved. An example is the consistent treatment of identity (of people, resources and processes) balanced with mechanisms for providing levels of privacy and anonymity where required by the legal or regulatory environment or by user wishes. Related to this is the need for a practical yet rigorous approach to trust in large distributed systems as well as models and mechanisms for secure and trusted inter-enterprise cooperation and cooperation in virtual organisations.

Point-to-point “Dynamic Trust” is an emerging future model for a highly networked world. It requires point-to-point authentication and trust, from any actor on the network to any other actor. It uses multiple overlapping or alternative technologies and assumes that all parties to transactions must identify and authenticate themselves, and prove their right to participate. Its rules-based security references individual and environmental circumstances, history, and current network and environmental status, plus additional application-level protections. This model corresponds most closely to a world heavily populated with intelligent wireless devices.

Management Services

We are using “service” in a broad sense, including network connectivity, computing hardware, application environments, data and information as well as application components. Central to the NESSI vision of a service oriented utility are automated and autonomic management techniques for efficient and effective management of large, dynamic systems. These will include:

- service lifecycle management to support identification of components, location, negotiation and reservation, orchestration, configuration, operational management, withdrawal and release of resources, accounting and settlement;
- trust and SLA or contract management that deal with aspects like the agreement of QoS provisioning mapped to SLAs, flexible QoS metrics and the management of QoS violation. In addition, common principles for defining unambiguous service level agreements associated with a measurement and audit methodology will be necessary in a commercial environment;
- managing of the complexity (including emergent properties) of global scale, distributed ICT so that performance can be predicted and controlled;
- mechanisms for controlled sharing of management information, end-to-end coordination and performance prediction and management.

Interoperability and open standards

Interoperability (using open standards) understood in its widest sense involves any kind of ICT at any level. It deals with aspects like interfaces between different systems, abstraction between layers, connectivity, standardised protocols, interoperability to support dynamic composition of services, business process interfaces, standards for inter-enterprise cooperation, and integration with sensors and other new devices.

Industry-developed open standards will constitute the key mechanisms to overcome the current interoperability problems that generate frustration and distrust in new technology.

With the introduction of service-oriented architectures and Web services, the software and IT services sector is taking a great leap forward. Development of these technologies and infrastructures parallels the demand from companies for achieving flexible business models that enable them to set themselves apart from competitors.

These technical considerations should be combined with the new economic situation produced by the rise of cheap software factories in developing countries at extremely low prices. Europe should ensure that the new service infrastructure supports the emergence of knowledge, a context in which jobs are created as high added-value opportunities, rather than pursuing a worldwide price-based competition.

Increasing the relative weight of added-value services with respect to the software-development process within IT companies is one of the ways that will support the job creation process. In this context, focusing on knowledge is the key to the future but also dealing with new business ecosystems and non technical issues on services adoption.

4.3.2 Semantic Layer

4.3.2.1 Objectives

The intention behind work anticipated for the semantic layer is to support increasing levels of automation in interactions between software systems and components. The Semantic Web initiative of W3C has focused on ways of finding information resources on the Worldwide Web (principally web pages) with relevance in a particular context. This represents a sound starting point but a broader scope is now required to support a broader range of resources (including services and service components) and the richer interaction patterns their effective use will involve.

The principal objective of this research activity is the ability to effectively describe computational infrastructure, software components, applications (exposed as services) and contents, to annotate resources with these descriptions and then to discover and use them without human intervention. Among the usage scenarios anticipated are composition of services, substitution of service components in response to failure or other performance issues and negotiation of service offerings. Ontology learning will facilitate automatic annotations from legacy applications and services which will allow them to exchange information without human intervention.

Semantics for web resources are typically described using ontologies which define basic concepts, relationships and axioms within a specific domain. A basic feature of any ontology is a taxonomy of terms which have an agreed meaning. At least at this level, there is and will continue to be, a large number of independently produced ontologies for different sectors, purposes and objectives. Techniques for interoperability will therefore be required.

It must be possible to associate descriptions (metadata) with resources and to advertise appropriate subsets of these descriptions via standard query interfaces. The realisation of the full value of a semantic approach to distributed resources depends on the ability to infer implicit information for automated decision support.

4.3.2.2 Challenges

The ultimate goal of semantics is to provide an intelligent framework for services, infrastructure and software in general. Automated coordination of service components, including applications, computational devices and infrastructure, towards a common end, requires that the functional and communication characteristics of each component can be expressed and reasoned about. Additionally, policies and usage conditions associated with each service component need to be described.

In terms of content, we need to address not only the existence of a huge amount of information (e.g. web content), but also annotation associated with this information. Semantic systems must be able to evolve with ontologies, infer implicit information from knowledge bases and deal with provenance, trust and proof.

In terms of processes, service-oriented applications will need to find services based not only on their behaviour, interaction and business properties but also on non-functional properties like security, privacy, trust and performance. Facilities to allow applications to be assembled from a selection of service components best meeting the needs of consumers should be available, taking into account the context and all relevant component characteristics. Self-healing systems will need to use similar functionality and should be able to substitute any malfunctioning components with similar ones.

The composition and execution state of a service will need to be represented to (human) users in an appropriate way. User intervention needs to be supported in a natural and intuitive way, which will require semantic representation of the user context. Interpretation of possibly ambiguous requests from human users and transforming these into service requirements is a particular challenge. The ability to map from a range of human languages to a set of well-defined concepts in context is necessary if the same services are to be provided to linguistically diverse communities.

The major research initiatives addressing this mixture of semantic content and infrastructure are Semantic Web Services and the Semantic Grid, which has a vision of: “a generically usable... infrastructure, comprised of easily deployed components whose utility transcends their immediate application, providing a high degree of easy-to-use and seamless automation and in which there are flexible collaborations and computations on a global scale”. This is expected to be achieved by using the emerging Semantic Web infrastructure to support Grid computing at all levels, from infrastructure to applications. In order to attain this level of automation, problems such as on-demand composition of services, dynamic ontology-driven discovery of services and contents, contextualised enactment of services and management facilities for the ontology life-cycle need to be addressed and solved.

4.3.3 Service Integration Layer

4.3.3.1 Objectives

As of today, service integration is usually accomplished through use of middleware that let users build composite services or execute business processes by proprietary engines that at most support standard service definitions (Web services) and basic standard transport protocols (http, JMS), used sometimes in conjunction with proprietary components (adapters, connectors). Interoperability between different implementations of these standards is not always easy, and a really effective higher level standard is still to come in Business Process Management.

The SOA wave is surfed by most software vendors, and consequently standards related to services integration and management are being continuously improved, but a lot has still to be done to allow for real services integration.

The service integration layer will have to address the crucial aspect of maximising reusability of service components to reduce costs and time-to-market. Technologies at this layer should support reusability in a reliable environment capable of managing dynamic configurability as well as autonomic and intelligent service composition. This not only concerns to the middleware that provides runtime execution support of,

and access to, the backend of services but also those technologies that are used to implement their user interface.

In order to be effective, dynamic configurability and intelligent/autonomic service composition require availability of context information, semantic description of services and of related characteristics, advanced features for fault management and health management (i.e.: self-healing Web services). In particular, the exploitation of applicable context information (client/resource location, user preferences, hardware/software characteristics of access devices, QoS requirements etc.) is essential to drive service composition and inter-working; context data are collected and aggregated by the underlying infrastructure layer. A major example of context awareness exploitation is the full support of ubiquitous computing, where both location-dependent and location-transparent services are provided to disparate platforms or devices, from phones and PDAs to desktop clients. This implies, for instance, support for multiple transport protocols and small footprint for execution on different terminal devices.

Open Source reference implementations of SOA standards have to be addressed as a key factor: Business Process Management and Execution engines capabilities should be enhanced to target human interaction, transactional execution, context awareness and adaptive algorithms. Extension and widespread adoption of standards related to management of Web services, on the other hand, will allow more effective, more resilient infrastructure management. Business Process Execution engines should also be extended to support advanced reasoning about causes of fault, and flexible recovery from errors during process execution.

Another critical issue is the evolution of technologies able to support developers in such complex runtime environments so that they can design and implement context-dependent services. This topic includes, but is not limited to, programming languages, Virtual Machines and middleware as well as development environments. The aim is to allow management of unplanned software evolution, such as either administrator-triggered or autonomous/dynamic (re)configuration and adaptiveness at runtime.

Last but not least, security (identity and access management) should be consistently managed throughout all supporting platforms and device providers.

4.3.3.2 Challenges

Apart from the need to improve transactional and human interaction support, standard process execution languages (e.g. BPEL) must target autonomous, intelligent, and dynamic composition of services based on currently applicable context, leveraging opportunities given by the semantic layer (such as description of service characteristics, SLA, ...). In order to make this happen, specific standardisation activities have to be addressed to manage context awareness at the proper level of abstraction. A relevant challenging aspect is the full support of user mobility (update of context information when clients change their access networks/terminals during service sessions).

Nevertheless, features related to dynamic deployment and dynamic configuration and reconfiguration of services become essential for middleware platforms, virtual machines and programming languages that can fully support unplanned software evolution in a continuous way. In the same direction, development environments should evolve to help programmers in their everyday activities.

As far as the development of self-healing services is concerned, technological aspects of Business Process Management Execution engines, as well as Web service composition strategies have to evolve. Specifically, suitable design techniques should be defined in order to support self-healing services, i.e. services able to diagnose possible wrong behaviours (causes of errors) and execute the consequent repair strategies. Moreover, infrastructures for the execution of intelligent fault handlers should be developed to support an advanced recovery from faults by investigating their causes, and not only their symptoms (as currently done in most frameworks).

Reuse of services will have to be addressed also through implementation of “services catalogues” and registry federation, that can be referenced both design time and runtime. Registries must include service contracting information (who can use what) and service level agreements, and have to support different aspects of virtualisation. In this respect, pursuing an effective semantic representation of relevant characteristics of services is a key challenge.

4.3.4 Infrastructure Layer

4.3.4.1 Objectives

Software and services are supported by an infrastructure of processing, storage and network resources. Today’s enterprise IT infrastructures typically consist of a large number of heterogeneous items of physical equipment which are deployed to meet the needs of specific software systems and are managed as discrete components or in small, isolated groups.

The increasing role of network connectivity in software-based systems offers considerable benefits in terms of improved scalability and resilience. The ability to consolidate computing and storage components into resource pools which can flexibly support multiple applications has the potential to simplify provisioning and improve resource usage. However, it also presents additional challenges, particularly in the management of large numbers of components in a coherent way.

Standardisation of components and their interfaces is required to simplify configuration and management. Virtualisation is an important aspect of this standardisation – hiding the variation between components from different vendors or based on different technology from the users of the services and systems they support.

There is a requirement for infrastructure middleware to provide appropriate interfaces for configuration, monitoring, and control of resources. The middleware should be capable of collecting heterogeneous information about service environments (interfaces of currently available resources and service components, network status, user preferences, terminal profiles etc) and of filtering and aggregating them to provide only data relevant to service managers in context. Awareness of service context is essential information to enable autonomous middleware-level decisions to be made without the need for explicit administrator intervention. Management information (configuration and monitoring) spans different levels of abstraction – from low-level hardware (e.g. discs, servers, routers and switches) through aggregations (storage volumes, virtual machines, virtual networks) and possibly to a virtual computing infrastructure which is capable of supporting many independent application environments on a shared physical infrastructure.

In addition to a consistent approach to interfaces, mechanisms to support partitioning of resources and isolation of independent applications are required.

Tools and techniques are required to help manage, predict and understand system-level properties, such as performance and reliability, in terms of the design and configuration of the various components involved and their interactions.

4.3.4.2 Challenges

There is a need for a consistent management architecture which can support multiple component technologies and vendors (storage, processing and network) and accommodate future product developments. Management systems must be capable of operating in an environment where there are multiple points of control, possibly requiring different levels of abstraction and the visibility of context information at different levels of aggregation. For instance, administrators of a corporate or campus network environment could be interested in fine-grained monitoring information about their local traffic, with a homogeneous interface independently of network equipment technologies and vendors. Alternatively, administrators of complex, context-dependent services, involving a large number of globally

distributed and heterogeneous service components might need a high-level summary view of the state of the service environment. The challenge is exacerbated by the fact that the delivery of innovative context-dependent applications may involve coordinated use of complex distributed infrastructures and software services operated by independent providers in an open and dynamic networked environment.

In general there will be incomplete sharing of management information between business domains. However, it must be possible for the users of the infrastructure to manage their own business processes effectively. One implication of this is that components and subsystems must operate with a high level of autonomy and be able to adapt their behaviour to a changing environment so that users can depend on defined levels of availability and performance.

Performance modelling and prediction which links the infrastructure level to the application level is an area where advances in understanding are required – both to be able to engineer systems effectively and to be able to diagnose and repair faults detected at application level.

A less technical issue that needs to be addressed is the need to involve system administrators directly in the definition of new management methods and processes, both to benefit from operational experience and to ensure acceptability. A system administrator's primary responsibility is to ensure security and reliable operation of the systems for which they are responsible. Confidence and trust in automated systems must be built before new approaches will be accepted, particularly for critical applications.

4.3.5 Security

4.3.5.1 Objectives

Concern over security is possibly the most significant barrier to acceptance of ICT and digital services as a utility becoming absolutely crucial in a more dynamic environment. Security has a crucial importance in the new Internet-based, distributed applications and eServices world:

- the lack of security is hindering their deployment,
- the failure to produce secure software systems represents in practice an insurmountable barrier to the widespread deployment of these services.

Key building blocks to achieve user trust include security, data protection and privacy. Balance between security and privacy should not be altered by technical development, usage and dependability of infrastructures, technologies and applications. The integration of the human user in the security chain, however, is one of the hardest problems in all security (and especially in all authentication) schemes.

4.3.5.2 Challenges

Enterprise security which ensures performance and interoperability, has historically been based on the “fortress” model: static and undifferentiated, difficult to change, location-specific, and reliant on very few mechanisms (strong walls and a locked gate). The “hard, crunchy” exterior protects a “soft, chewy” interior. Anyone outside the gate is suspect; anyone inside is trusted. Once you are past the gate, you can do whatever you like.

The emerging “airport” security model is more flexible and situational, with multiple zones of security based on role. “Gates” to zones can employ multiple overlapping technologies for identification, authentication, and access control, depending on the individual's role and the purpose of the zone. The result is a series of fortresses within the fortress.

Point-to-point “Dynamic Security” is the future model for a highly networked world heavily populated with intelligent wireless devices that massively interact and collaborate together without any *a priori* knowledge about their identity and/or capabilities.

It requires point-to-point security mechanisms, from any actor on the network to any other actor. It uses multiple overlapping or alternative technologies for secure identification of source and destination, including advanced PKI mechanisms, and assumes that all parties to transactions must identify and authenticate themselves, and prove their right to participate. The design and development of a trust model in open and dynamic environments raises several challenges. Trust is not absolute: an entity will never trust another party to do any possible action, instead, trust is context-dependent: a trustor trusts a trustee with respect to its ability to perform a specific action or provide a specific service within a context and this trust does not necessarily transfer to another context.

Security policies should refer individual and environmental circumstances, history, current network and environmental status, additional application-level protections and assurance of the communication path, in order to avoid tapping or fraudulent emissions. Technologies should also provide facilities to help humans to identify physical persons and objects in a specific environment and to associate them a proper trust level or range. More in details, many unsolved security and trust issues exist for eServices provisioning. Some issues of interest are:

- design of a security/trust ranking model widely accepted by the open community. A big problem in automating trust-based decisions is evaluating an appropriate trust level and in determining trust values;
- design of a risk management framework for security/trust management. The relationship between the level of trust and the degree of risk with respect to a service or an e-commerce transaction has been little explored and no well-established risk models for trust management exist to be currently adopted;
- engineering approach to security management. There are no accepted techniques or tools for specification and reasoning about security. There is a need for a high-level, abstract way of specifying and managing security, easy to integrate into applications and to use on any platform. Security decisions are currently hard-coded into an application, which adds complexity to the application design and difficulty to adapt it to security policy changes and which lacks flexibility when setting up new relationships;
- development of efficient and open mechanisms for protecting different types of data. For instance, at the infrastructure layer, there is the need for data identification, independently from semantics. Tools for source identification and integrity check are mandatory for a security framework. It may be possible to track the use of single data as a basis of a royalty payment system.

Another important challenge is to enforce the individual user's privacy preference protection, in order to avoid the propagation of confidential data among cooperating service providers, without the user's permission. The emerging model for privacy protection is based on the dynamic control and negotiation of the exchange of data between applications, given the user's stated preferences. Autonomous agents, representing the user, can be exploited to check the privacy management declarations exposed by the various service providers and decide whether they can be trusted or not.

4.3.6 Interoperability

4.3.6.1 Objectives

Increasing collaboration within and among enterprises and governmental bodies during their entire product and service provision life cycle is a global trend. Most of these organisations are transforming themselves into "networked organisations". These new collaboration concepts are especially relevant for SMEs. They adopt such concepts to extend and complete their service offerings so that they can compete with larger organisations.

Related IT systems and applications need to be interoperable in order to achieve seamless interaction across organisational boundaries and thus to realise networked organisations. Interoperability, defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged", needs to be addressed in respect of all layers of an enterprise (including ICT

Systems, Knowledge, Business and Semantics). In all sectors, tools and services should be based upon open standards and interoperable solutions to avoid lock-in to specific platforms or providers.

Currently, many organisations face significant difficulties related to lack of interoperability. For example, analysts such as Gartner and AMR tend to agree that company budgets for integration projects nowadays add up to 30-40% of companies' total IT budgets. This figure indicates that significant efforts are undertaken to achieve custom integration. The objective of NESSI's research in this area is to make interoperability a general feature of IT systems and applications, and work towards making the vision of "plug-and-do-business" where networked organisations can easily find, communicate, and do business with other organisations become reality.

4.3.6.2 Challenges

Interoperability is not only a property of ICT systems, but also concerns the processes and the business context of an organisation. Therefore, NESSI considers interoperation only meaningful, when all levels of an organisation are addressed. The diversity, heterogeneity, and autonomy of software components, application solutions, business processes, and the business context of an enterprise must be considered. This leads to four categories of challenges that should be addressed by interoperability research:

- 1) **Organisation (Business/Knowledge) area research challenges.** Interoperability at business level is the organisational and operational ability of an organisation to factually cooperate with other, external organisations, whether these organisations are enterprises or public institutions. Cooperation requires a certain degree of compatibility of *business procedures*; in order to understand the business compatibility of two organisations, it is necessary to understand the decisional model, the business model, and business processes. Interoperability at knowledge level should be seen as the compatibility of the skills, competencies, and knowledge assets of an enterprise with those of other, external organisations.
- 2) **Semantics and Ontologies area research challenges.** To overcome the semantic barrier, which emerges from different interpretations of syntactic descriptions, precise, computer-processable meaning must be associated with each relevant concept across the business, knowledge and ICT layers of a solution. It has to be ensured that semantics are exchangeable and based on a common understanding to be indeed a means to enhance interoperability. This can be achieved using an ontology and an annotation formalism for meaning. For specific research challenges on semantics, please refer to section 4.3.2
- 3) **ICT systems research challenges.** Interoperability at ICT Systems level should be seen as the ability of an ICT solution to allow an organisation to operate, make decisions and exchange information within and outside its boundaries. Interoperability at ICT Systems level touches various areas such as application logic, process logic, data logic and system protocols.
- 4) **Interoperability domain research challenges.** A number of different approaches exist in order to structure more holistic approaches to interoperability – including both standardised frameworks and industrial frameworks and architectures. The research challenges here are to identify an overall interoperability architecture and corresponding supporting frameworks that help to resolve the needs for interoperability.

4.3.6.3 Driving *ex-ante* Interoperability through Open Standards

NESSI is promoting "openness" as an essential step toward greater social and economic development. NESSI wants to be open to all the stakeholders including the citizens, open to the increasingly interconnected economies of nations and open to choose the best technology platform for their organisations.

To move toward openness, NESSI will adopt open standards for greater software interoperability and for vital benefits to be provided through the whole society like for instance:

- Collaborative innovation; community environments like OS make more and better innovations work across applications, platforms and networks in shorter time.
- Flexibility; increase technology options for citizens, users, and implementers to easily build information systems and adapt to ever-changing requirements and procedures.
- Interoperability; eliminate especially in critical public applications like health care, public safety and education.
- Cost effectiveness; avoid vendor lock-in, increase competition and drive lower prices.
- Freedom of action; obtain a level playing field and lessen risk so that no one company can pace, control or block technology; rather, an open community leads.

Open standards evolve and mature at different rates and to different levels of openness within a framework of necessary characteristics. These specifications must be:

- Published without restriction;
- Made freely available for adoption by the industry; those standards essential for software interoperable in e-services, and those essential to accommodate the open source community, should be royalty free.
- Controlled by an open industry organisation with a well-defined inclusive process for evolution of the standard
- Implemented by offerings available in the market; having various vendors who offer solutions enables choice for procurers and longevity for users.

NESSI stakeholders should prefer or give priority to open standards when they apply and consider provisions that:

- Address interoperability by referencing open standards, when they exist, and by seeking the benefits and goals of openness.
- Focus on services, not technology so that needs are defined independent of specific vendors, hardware platforms, operating systems, and programming languages in which the service is implemented.
- Ensure choice from a variety of technologies for governments to “plug and play” and for citizens to choose how they want to access and receive services.
- In addition, all stakeholders can promote open standards for software interoperability by:
 - Contributing user requirements to standards organisations
 - Encouraging major vendors to participate in technical committees of standard bodies and engaging in the evolution of such open industry specifications.

4.3.7 Management Services

4.3.7.1 Objectives

The complexity and difference in nature of the new envisaged service ecosystems will require specific mechanisms which, offered as service, enable the management of the whole deployed system and the framework needed to manage service-based systems delivery, deployment and execution.

Indeed, the complexity of functions and services involved in future networked software systems and their sheer scale require automated support to manage these systems. Systems should be as autonomous as

possible in their management and adaptation behaviour (e.g. dealing automatically with failures, resizing automatically for varying loads and variations in contract agreements, reconfiguring automatically for changing execution environments and operating conditions).

Two levels of management are considered:

- Managing the infrastructure used to implement the services. The major concerns are to ensure availability and performance of key elements that supply the service description, the messaging and the network. This encompasses management of network layer, XML messaging layer, service registries, and service implementations.
- Management of the services themselves.

4.3.7.2 Challenges

The stupendous complexity of functions and services involved in future networked software systems, and their sheer scale, precludes in the long term the involvement of humans in the detailed management of these systems. Instead, one should strive to build systems which are as autonomous as possible in their management and adaptation behaviour (e.g. they can deal automatically with failures, resize automatically in response to varying loads and variations in contract agreements, reconfigure automatically to make best use of execution environments and operating conditions). It is important to note that building autonomous systems is bound to require more semantic-level (e.g. behavioural) information from applications and services.

Thus main challenges in the management area are therefore related to achieving self-managed services. One of the challenges has to do with the fact that self-management cuts across concerns that are currently separate. This means that it affects the infrastructure used to build the services, the composition of services, etc. Therefore self-management should address the inherent recursive nature of services that are systems of systems and be able to work within systems and across systems (e.g. through cooperation of the different self-management entities). Additionally, there is the need to offer open management. This issue involves standardisation efforts and also research. One way to classify the challenges in self-management is to review the different “self-*” properties that should be attained such as:

- **Self-provisioning** - Provisioning of services and resources to run them under demand (e.g. resizing/shrinking the system as needed depending on load conditions, relevant SLAs, operating conditions, etc.).
- **Self-protection** - Reacting to attacks by increasing the level of protection as required.
- **Self-healing** - Repairing the service in case of failures in a non-intrusive way (i.e. without affecting the performance of running services) to maximise system availability and tolerate faults.
- **Self-optimisation** - Continuously monitoring and tuning the service to maximise the performance metrics defined by the administrator, e.g. services can re-deploy themselves on available infrastructure, or require more and different resources whenever they are aware that performance is below a defined service level.
- **Self-configuration** - Configuring the service automatically for the current load, workload, operating conditions, SLA, device in which they are deployed (e.g. intelligent deployment depending on the target device, phone, PDA, PC, cluster, etc.). In particular, deployment of services would occur in an ‘intelligent’ way, when needed and on the proper infrastructure. This means semantically appropriate devices. The concept here is that different devices not only have different supporting technology, but are also meant for different purposes (e.g. a PDA is not semantically equivalent to a mobile phone, or to a PC). In particular, deployment on a particular infrastructure or device can cause specific ‘revision’ of the service level guaranteed which in turn might require a new negotiation of service contractual terms.

4.4 NESSI Adoption

4.4.1 Overall Approach

The adoption of NESSI will follow a lifecycle typical to significant technology advances: the creation of the technology base together with the knowledge that will bring it to life followed by a mass adoption in order to benefit from its full value.

The overall approach regarding NESSI adoption will thus rely mainly on the following three steps:

- First the fully functional NESSI Open Framework will be made ubiquitously available, together with a methodology to instantiate it in specific domains.
- Second NESSI Landscape will start to be populated with intelligent domain and business services defined according to open industry standards (recommended by NESSI Consortium), and be made *de facto* accessible.
- Third NESSI adoption will focus on pragmatic issues to “glue” together NESSI Framework (more specifically its instances) and NESSI Landscape in order to form a new business services ecosystem dynamically (e.g. cross-sector collaborative applications) that will meet some specific demand.

The rationale behind this is to end up with a seamless continuum of tightly integrated services at not only syntactic and semantic levels but also and most importantly at a pragmatic level. It will also be to promote a new class of business services that will adapt and evolve in dynamic ecosystems rather than being designed and programmed. They will exhibit not only intelligent, autonomous behaviour but also “intelligible” behaviour from an end-user perspective. We can here anticipate that “intelligibility” of behaviour will be a key factor of acceptance by contributing to generate trust and confidence in these new service ecosystems.

NESSI success and mass adoption will also and especially result from the multidisciplinary and integrated approach that will be continuously promoted during its whole lifecycle. This will create a unique synergy among researchers coming from various disciplines and working together to significantly advance understanding and technology.

With respect to this a European “full-scale” research & demonstration centre will be set up to exchange and disseminate NESSI results and also to conduct joint trials with other EU instruments (e.g. ETPs, JETIs, ...).

4.4.2 Adopting NESSI

4.4.2.1 Objectives

NESSI has the ambitious objective of driving a major evolution in the way business gets done in Europe. To reach its goal NESSI will rely on existing assets (coming from various domains) and also promote the development of new ones. This means that NESSI will not neglect all of the work done to date in various sectors but will transform and federate it to advance, and possibly create, business models that will contribute to NESSI widespread adoption across Europe.

NESSI will thus induce a change in both scale and perspective that will speed up and support the transformation process of the whole EU economy. A change in scale first, since with NESSI, companies of all sizes will be able to implement their business processes through the composition of publicly available services, in full trust & confidence. A change in perspective second, allowing all businesses to focus on their areas of core competency and leveraging the knowledge of others for the rest. These two major changes will drive the EU economy to a new level of competitiveness through the possibility of dynamically creating, changing and adapting within a business ecosystem.

Adopting NESSI will also result from the unique facilities offered by the NESSI Framework together with NESSI Landscape to cope with new demands (business, societal, economic, and political) in a way which has not been possible before. This will be complemented by additional features coming from a special interest in NESSI on not only technical aspects but also social ones as represented by NESSI Adoption in the NESSI holistic view. By considering a business ecosystem primarily as a socio-technical system and thus promoting a multidisciplinary and integrated approach NESSI plans to:

- capture (either explicitly or implicitly) business models and the processes used in them,
- reflect on new and existing business models and their use to derive or infer requirements,
- propose NESSI solutions to cope with user needs and thus improve the performance of the business ecosystem. NESSI solutions will vary from recommendations, through standardisation to implementation of tools and service components. Most of these solutions, once assessed and fully validated, will be realised and made available through NESSI ETP test-bed platform,
- demonstrate and assess the effectiveness of NESSI solutions.

4.4.2.2 Challenges

Hereafter a few of the necessary capabilities seen here as key enablers for the adoption of NESSI are described:

- **Service description.** New ways to address and describe intelligent business services are required to accomplish the NESSI Vision. In particular the formalism we are aiming at will allow the realisation of brokering and search mechanisms that support users, companies and also intelligent agents, in finding the appropriate service providers. It will also bring additional autonomy and intelligence at service level in order to develop context awareness and react appropriately to it (i.e. intelligently and intelligibly).
- **Open & Applied approach** in which services are shared and deployed in a variety of ways and then are actively used by other businesses and citizens in order to build a common understanding of what we can get out of NESSI systems (what works and what doesn't work and most importantly why). To meet the objective of this ETP, the NESSI framework needs to be ubiquitously available and to give access to a wide variety of services. This is an essential condition to the creation of a new business ecosystem, significantly more dynamic and competitive than is the case today.
- **Service construction.** Dynamic composition of services (out of simple and complex service components) driven by current demands (individuals, organisations, markets) and flexibly adapting to changing needs and context. Indeed as research progresses, it will become possible to build publicly accessible information systems which support the dynamic creation of business processes from the composition of services. These processes will be engineered with the support of knowledge-based systems, and will be instantiated by composing services found through service location mechanisms integrating underwriting functions. Utility computing mechanisms will be used to provision these services and the infrastructures they need to operate.
- **Selection process of appropriate service providers** based not only on the offered functional and performance capabilities but also on "softer" non-functional characteristics such as trustworthiness and reputation,
- **Relations between the collaborating partners (stakeholders)** defined in the form of electronic contracts that must be negotiable in an easy, reliable and automated way,
- **Ubiquitous availability:** from everywhere using a wide variety of devices and supporting a wide variety of business models,

- Constant/continuous monitoring, assessment and management of the quality of a service (QoS) of the rendered business ecosystem, provided at various levels of granularity. This must be applied not only e.g. on agreed QoS metrics but also on characteristics that are more difficult to quantify, such as trust, reputation and the level of security that can be assured by particular service providers.
- Support and accommodate consumer demands for services (whenever, wherever and whoever they are: individuals, organisations, ...). This will need to work through automated but fully traceable decision processes. It includes the support of users that are intermittently connected, have varying environments and access network quality and in general changing context. This is fully in line with the paradigm shift which has already been anticipated: moving from “often disconnected” to “always connected” and for which NESSI may be able to make a significant contribution from the service-oriented perspective.
- Guaranty of security and reliability in the ecosystem, in a highly distributed setting.

This mass adoption of NESSI requires an evolution in European business practices:

- industry sectors need to define common business models and identify common business services (ordering, invoicing, payment, shipping, ...);
- legal frameworks regulating business interactions, such as contract law, may need to be adapted to remove artificial barriers to the use of the framework;
- regulated industries, such as finance, insurance and accounting, need an updated set of regulations;
- certain core services, notably in the domain of trust, reputation, and underwriting, might have to be regulated or provided by public institutions;
- business educational programs must be updated to incorporate the new business dynamics;
- positive public actions, including research, focusing on removing barriers to the adoption of this framework, can significantly accelerate the creation of this new business ecosystem. It is our intention to create a complementary research agenda in support of this objective;
- an open development process making full use of OSS and open standards can be the foundation and cornerstone of a service ecosystem in Europe and foster the mass adoption of NESSI.

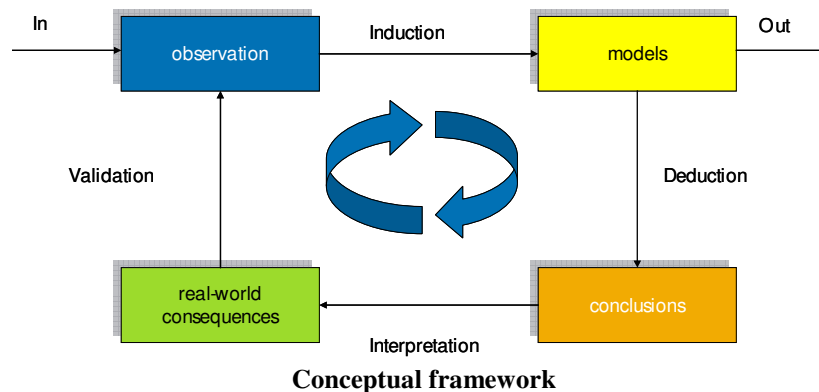
4.4.3 Systems Science

4.4.3.1 Objectives

Complex systems are an integral part of our constructed world. As we come to rely increasingly on these systems for all aspects of our lives we must be able to claim a solid understanding as to how these can be specified, constructed and controlled. With a few exceptions this is not possible. This failure to understand, and hence design and manage complex systems is very evident in the large numbers of high profile information systems failures that can be observed every year. In an ever more competitive world – whether it is between businesses or nation states, an inability to comprehend, design for and then deliver effective complex systems is unsustainable. Systems and Services Science are of strategic interest to Europe.

A fundamental problem in understanding, designing and managing real-world complex systems is the need to work fluidly across disciplines. Increasing academic specialisation has tended to work against this – often reflected in industrial research and development as well. Combining disciplines as diverse as

psychology, mathematics and engineering is difficult. Factors such as language, funding models, publication practices and problem sets all mitigate against the necessary mixture of disciplines coming together to improve our understanding of complex systems, their applications and their limitations.



A conceptual framework for articulating our objectives in systems and services sciences is shown in the above picture. Achieving this closed loop shifts everything from the scale of a global Information Technology Outsourcing (ITO) deal to a dynamically constructed online billing solution for a small-medium enterprise (SME) into the realm of predictable engineering based on sound science. This is the core problem we need to tackle and whether participants are motivated by a desire to develop cost effective, repeatable complex systems, to ground academic research or to seek out new problems, disciplines must be fused in a constructive and creative way. The primary purpose is to advance the development and integration of the sciences that underpin the successful analysis, design and control of complex systems characterised by the requirements of services. Grounding these problems in the area of services research - prime examples of large, complex and economically significant systems - makes both industrial and academic sense.

4.4.3.2 Challenges

In academic, government, and industrial contexts, the range of analytic, design and management disciplines that must be integrated appears daunting. As has been observed, it is quite difficult to maintain even mutual respect between mathematicians at one (apparent) end of the spectrum, and social scientists at the other. At the same time both are necessary to the success of this programme and both must be engaged if this work is to deliver long term value to government and industrial sponsors.

The challenges can be seen in two contexts; firstly there are technical issues – the representation and analysis of complex systems, leading to disciplined engineering practices that can integrate the ‘soft’ sciences of sociology with the ‘hard’ grounding of mathematics, embracing management sciences and engineering en route. Secondly we must engage in the necessary social engineering of the community of systems research and development groupings that will enable appropriate conversations to take place. Both are necessary. This requires active encouragement through technical meetings, funding, and some equivalents to the ‘grand challenges’ that have inspired the computer science community to develop high performance computing systems.

It is essential that governmental bodies be engaged in this endeavour. As instigators and consumers of some of the largest and most complex systems projects, their sensitivity to success will make them highly attractive partners.

Amongst the many potential research, development and delivery problems that could become part of this group of projects, NESSI will focus on the following:

- 1) Developing the underlying theories of systems and services sciences – all science ultimately depends on solid foundations, observation, explanation, prediction and experiment. This requires a combination

of appropriate experimental work, mathematical tools for representation and analysis and engineering practices based upon both. Engineering (in all of its forms from mechanical to electrical) provides a model for the repeatable and reliable application of mathematics and science, and we propose that this should be repeated for systems and services.

- 2) Dealing with socio-technical integration of services: the interfaces between 'hard' and 'soft' technologies, as well as abilities to reason between the 'why' and the 'what' are poorly understood. Specifically we propose projects that examine:
 - a) Composing people, processes and technologies – how can we treat systems that have social requirements, driving organisations, driving processes which in their turn drive information systems provision?
 - b) Relationship management; dealing with systems of systems – the grounding of management science approaches to 'systems' in concrete and reusable forms that have a rational mathematical basis.
- 3) Development, validation and maintenance of direct relationships between the economic, financial, human and technical properties of the systems under discussion.
- 4) Developing rigorous, composable, reusable and comprehensible systems modelling tools – there are many approaches to systems analysis which are difficult to compare and contrast. A shared understanding, with appropriate tools and representation standards will enable purchasing organisations to make rational and repeatable choices between providers.
- 5) Educating and training of personnel across industry – all industries need to be able to train to recognised standards, both for their own benefit and that of their customers. In the area of systems sciences, the establishment of appropriate training and the recognition of the validity of qualifications is neither agreed upon nor well articulated. This activity will establish both.
- 6) Integrating modelling methods for systems of discrete components with methods that model large scale dynamics.
- 7) Developing the scientific infrastructure to support systems and services sciences as an academic discipline – initiatives including the cross industry Centre for Systems and Services Sciences (CS3) point the way to the effective development of both social and technical infrastructure. Specifically it is essential that there is support for the following:
 - a) Organisation of regular hybrid industrial-government-academic research meetings and colloquia;
 - b) Publication of advances in the area of Systems and Services Sciences through a refereed journal;
 - c) Identification and encouragement of pre- and near-competitive research
 - d) Establishment of a 'dating agency' for academic, government and industrial partnerships;
 - e) Establishment of systems and services sciences as a recognised research discipline;
 - f) Establishment and championing standards in systems analysis, specification, development and management in process and training;
 - g) A body that can act as a validator of expertise of competence in systems and services sciences;
 - h) A body that can act as a repository for sample and standard problem sets and research results.

4.4.4 Architecture and Engineering

4.4.4.1 Objectives

The scope covered by the NESSI Technology Platform is large and complex. The research agenda supports innovative approaches, and aims at pushing beyond the limits of what has been achieved by research in software and services so far. Yet, the program must remain pragmatic: the ultimate goal is to exploit the results of the research to build dynamic service eco-systems, including the comprehensive infrastructures on which they are based. An instance of the NESSI Technology Platform must be a seamless continuum of tightly integrated services, where IT is both ubiquitous and invisible.

This objective can only be reached if the objective of building this seamless continuum is considered from the start of the research. At the same time, the goal of fostering innovation and the mere dynamics of research preclude the specification of a complete framework of standards upfront. Reaching a balance between mandates, guidelines, recommendations, and choices in the area of design principles, architectures, interfaces, and standards is a key to the success of the whole program.

Instances of the NESSI Technology Platforms will be created by combining a large variety of technology components. These components will be selected from the full spectrum formed by the mature open-source offerings on one end and the artefacts produced by the NESSI research programs on the other. Relevant results of other European research programs, as well as state-of-the-art solutions coming from research institutions or the software industry worldwide are included in this space. These components are inter-dependent in the NESSI Technology Platform. An early determination of the key characteristics of these components will significantly contribute to the effectiveness of the NESSI research. The characteristics of the protocols used in the service integration layer is a good example of key structuring decisions that must be made and communicated early in the program.

The NESSI framework is designed and engineered to support a wide variety of application domains, and must behave with the performance, cost, security, and reliability characteristics optimised for each of these domains. The core framework must allow domain-specific extensions while retaining cross-domain capabilities.

4.4.4.2 Challenges

The NESSI vision and strategic research agenda identify foundation principles on which the program is structured. This is only a foundation, though. Many additional layers of detail are required to build a coherent system.

- Engineer a reflective middleware platform for composable and dynamically adaptable services that will entirely hide the underlying resources from the user or application and will achieve a seamless continuum of tightly integrated services
- Rely on and advance service science. In the future, services must be autonomous, platform-independent entities that can be described, published, discovered, and dynamically assembled for developing massively distributed, interoperable, evolvable systems. Description formalisms and tooling are needed to achieve this vision and make it happen. Not only to use existing services of wide variety and granularity but also to federate them and develop new ones with advanced features.
- Propose a new and innovative approach to Service engineering. Software engineering techniques require better quality and more efficient methodologies for safety critical systems with a clean scientific foundation (e.g. formal approach) to allow the construction of powerful, flexible, scalable complex systems. For instance they will need to assess and support the highly dynamic and unpredictable environmental aspects (heterogeneity, security, trust, QoS, change ...), the contexts surrounding them and to adapt to changes. This directly relates to service description and construction through mechanisms such as composition.
- Promote a new approach to requirements engineering which considers both functional and non-functional requirements. This is especially true for QoS where NESSI will aim at addressing how to elicitate, negotiate, formalise, document, and validate the required qualities of service at various levels. This is also true in process and system quality assurance and especially testing.
- Advance open software development methods that establish and maintain a link between requirements, design and implementation throughout the development and maintenance lifecycle.

4.4.5 Regulatory Governance

NESSI is about transforming the EU economy through service oriented business models to help in achieving the Lisbon goals. Transformation is about change and Europe faces a period of potentially profound changes: in social attitudes, economic conditions and the business environment. This transformation is crucial to maintain and improve Europe's prosperity and enhance the standard of living for our citizens.

However, it is important to understand that when changing business models and strategy, in order to drive growth through innovation, all the systems involved will have to embrace this transformation. Society begins to understand how to use new technology in an effective way and there is pressure for it to be widely deployed. This may be hindered by laws and established practices which were appropriate for earlier times with different technological capabilities. Changing regulations can take a long time. There are laws in Europe that were appropriate for the manufacturing era of the last century and which are not designed for a services economy.

With the Better Regulation initiative the European Commission has already started to address these obstacles and to simplify burdensome and strict regulatory frameworks. Following a broad consultation of Member States and stakeholders, the Commission proposes to repeal, codify, recast or modify 222 basic legislations and over 1,400 related legal acts in the next three years. In this context NESSI will help to identify what the key regulatory barriers to the services sector are.

Even though some parts of the regulatory framework may appear to be unnecessarily restrictive and burdensome, in general legislation has its 'raison d'être' especially also to create trust and security among users. This is specifically true for policy and legal matters related to data protection, liability etc. NESSI will give input to these areas which are closely linked to the discussion of new and emerging business models.

4.4.6 A European "full scale" demonstration centre

While the NESSI initiative seeks to advance generic software technologies, the relevance of the initiative for the European citizens and economy can be better understood by the fact that it is focused – even driven by – consideration of demanding, sector-specific scenarios (e.g. eGovernment, eHealth, eSecurity, ...).

In order to design, build and run these scenarios and to demonstrate NESSI capabilities enhancements, a European "full scale" research and demonstration centre (compliant with the SRA) will be set up both physically and virtually in one or several connected locations in Europe in order to run and assess on a test-bed platform, proofs of concepts and demonstrators based on NESSI technologies and solutions.

The NESSI European "full-scale" research and demonstration centre will be established as a general purpose environment in which a mixture of disciplines can be brought together to develop a shared understanding on dynamic business ecosystems and how they can be specified, constructed, tested and controlled. The rationale behind the creation of the NESSI Centre is to break the "wall of complexity", (already reached in many cases) by creating new and multiple synergies among various relevant communities in order to understand the emergent behaviours that will arise in sufficiently complex systems, initially to avoid them, and to ultimately control and exploit them.

This NESSI research and demonstration centre will be able to host industrial partners and academics related to the SRA fields in order for them to:

- share their research, technology and project portfolios. Also to share various perspectives.

- set up an integrated research framework together with a shared roadmap. Also start to create and sustain synergy between communities ranging from research community (e.g. synergy between semantic community and SOA community) to application community
- implement NESSI ETP through its various constituents
- disseminate their results
- demonstrate and assess (qualitatively and quantitatively) all or part of NESSI Technology Platform from various perspectives (e.g. societal or economical impact) this on Operational and Business Cases.

The NESSI European full-scale research and demonstration centre will be multifaceted, covering the following aspects:

- Research & Technology,
- Development (engineering),
- Experimentation & Innovation
 - demonstrate the potential of NESSI resulting technology in a broad range of application domains and from various perspectives (e.g. business, societal, economic, cultural, environmental, ...) such as its capacity to answer needs that haven't been yet answered, or even try to satisfy fully new emerging needs and learn/evolve (autonomously or semi-autonomously) from that.
 - be the place where scenarios spanning the interests of a number of European Technology Platforms (NEM, ARTEMIS, eMobility...) could be explored
- Dissemination,
- Training & education

The NESSI Centre will ultimately act as a **Transformation Centre** enabling the NESSI Vision to be first accomplished, second benchmarked and improved, and finally widely adopted.

5 Making it Happen

In addition to proposing and developing new and innovative technologies, NESSI will bring forward proposals for improving the coordination of the European research instruments and for fostering efficient innovation environments.

Coordinating European research resources

To implement its Strategic Research Agenda (SRA) and to achieve coordination and consistency of existing RTD European instruments, NESSI will put forward a synergetic approach focussing mainly on the upstream part of the NESSI SRA.

Use will be made primarily of the regular instruments in the four Specific Programmes envisaged for FP7, in particular:

- **Cooperation:** collaborative research projects, Networks of Excellence, coordination of national programmes (ERA-NET) and international cooperation under the thematic priority ICT;

- **Ideas:** foundational research funded via the European Research Council (ERC);
- **People:** Marie Curie Fellowships for training and public-private mobility of researchers;
- **Capacities:** research infrastructures for promoting the development of world-class Centres of Excellence in Europe; research at universities and institutes for (groupings of) SMEs.

To benefit from EU financial support through these instruments, NESSI members will participate in the normal Calls for Proposals of FP7.

In addition, Centres of Excellence may envisage applying for EU Structural Funds, as well as loans from the European Investment Bank (EIB) in combination with the new Risk Sharing Facility foreseen in FP7. Furthermore, the new EU Competitiveness and Innovation Programme (CIP) may provide opportunities for SMEs.

NESSI innovation environment

NESSI policies, procedures and processes will establish a new holistic approach to research, technology development, innovation and skill creation in a distributed industrial context of “eco-alliances” and “cooperation”.

Creating new industrial eco-systems

By facilitating a more effective relationship between research and product development, NESSI will accelerate the pace of innovation. In order to achieve these objectives, NESSI will launch a series of action plans to consolidate this eco-systems.

Promotion of Open Standards

Contributions to standardisation are currently fragmented over many bodies and consortia, many of which are dominated by major US companies.

The main objectives of NESSI in the area of standards are:

- to favour open architectures in a context still dominated by proprietary solutions;
- to define and to promote a cross-sector approach.

Regulations, safety, security and digital trust certifications

In most application areas, the design, implementation and operation of software, systems and related ICT services are constrained by European or international regulations concerning safety, security, digital trust, and environment. These regulations have strong impact on the costs of the design and engineering processes, especially for software. Being able to produce certified software systems at acceptable cost is a major factor in competitiveness for several European industries. In this context, NESSI will:

- develop awareness regarding these regulations and their impact, and forge links with the regulation authorities to overcome regulatory barriers to the introduction of the new NESSI technologies - particularly in safety critical contexts - and to accelerate harmonisation across Europe and internationally, so as to overcome market fragmentation.
- stimulate the creation of independent European certification bodies when necessary. Moreover, in this area opportunities for European universities, Research Institutes and SMEs will be investigated.

Open Source policy

NESSI will also promote and facilitate the creation of “Open Source Business Ecosystems” which will increase the market reach and the availability of software services and applications but also the efficiency of business transactions and processes especially for SMEs.

NESSI will exploit this potential by:

- setting-up a European infrastructure to host and support OSS initiatives relevant to NESSI vision and priorities including the validation, certification and supply of OSS components.
- promoting whenever appropriate the creation of “Open Source Eco-Systems” for the dissemination and commercialisation of the software technologies and associated services produced by NESSI projects.

Industry-Academia Collaboration

NESSI will actively facilitate productive engagement and interdisciplinary working between industry and academia in several ways - not just through its collaborative research programme, but through innovative infrastructural mechanisms for coupling academia and industry in research and development, and through engagement of industry and academia in joint education and training initiatives.

Education and Training

NESSI will facilitate productive engagement of industry and academia to match the pace of evolution of educational systems and curricula to the rapid evolution in technologies.

NESSI will overcome the gap between the theory of academic education and the practice and pragmatism of industrial applications. NESSI will facilitate the development of new combinations of skills so that hardware designers will be able to appreciate the possibilities or limitations of software, and vice-versa. NESSI will break down the present distinctions between system architects, hardware and software engineers, and promote a more holistic approach to system and service design.

In addition, NESSI will:

- develop courseware, establish graduate study programmes and industrial “summer schools”, and a Distinguished Lecturer Programme.
- support, recognise and promote the definition of curricula dedicated to NESSI technologies and engineering.
- Establish NESSI Chairs within leading European universities.

International Cooperation

The International Collaboration policy of NESSI is based on NESSI strengths and on “win-win” concepts.

NESSI will help Europe to develop “brain magnet” capabilities to draw participation of the best brains in this area throughout the world .To this end, NESSI will develop and communicate its Vision and Strategic Research Agenda globally. The creation of Centres of Excellence, and the increasing international visibility through communication, the web-site, Annual International conference, will be among the tools to foster this collaboration. The added value of collaboration will become visible through:

- the opening of new markets, such as Asia, based on existing strengths; and fostering NESSI standards as a worldwide basis;
- compensation for weaknesses in specific areas where there is no European equivalent;
- mutualisation of resources for the development of non-differentiating (business-wise) technologies;

- completion of the resources available to research ecosystems.

Each particular collaboration will pursue a specific aim of one of these kinds.

6 Acknowledgments

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7 APPENDIX

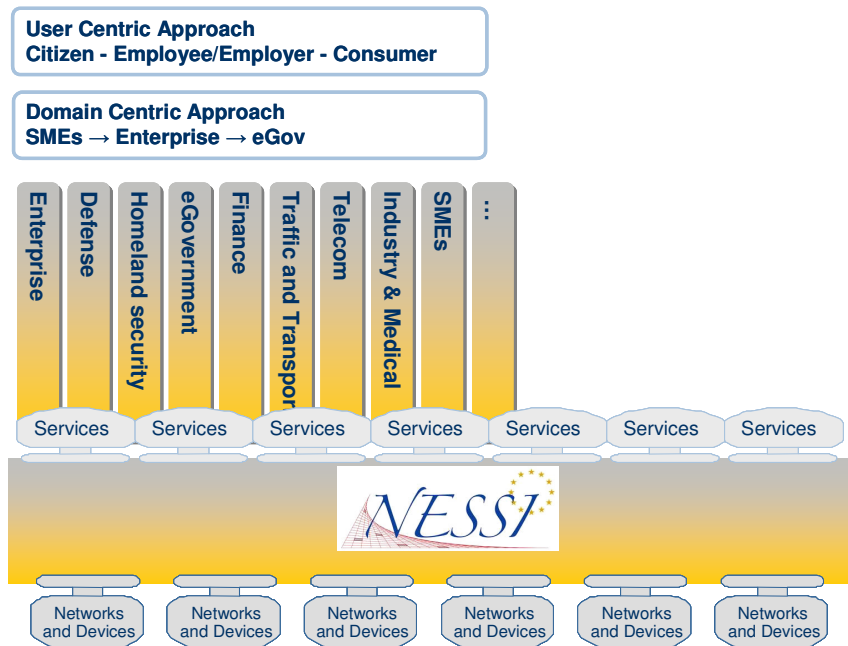
7.1 Scenarios

While the NESSI initiative seeks to advance generic software technologies, the relevance of the initiative for the European citizens and economy can be better understood by the fact that it is focused – even driven by - consideration of demanding, sector-specific scenarios.

In this light the role of application scenarios is crucial not only to keep the solutions identified and implemented on the right track, but also to ensure that software pervasiveness and NESSI generality is correctly pursued.

For instance NESSI will address important issues such as:

- What would be a “generic” e-Gov platform? And what activities would it generate?
- How to allow e-Vote for all European countries?
- How to implement the Schengen Network System?
- How can interoperability be implemented, e.g. between different administrations even belonging to different countries? This implies issues such as how to allow mobility of citizens all over Europe, and how to coordinate different actors when responding to unlikely disastrous events?
- How to support the emergence of business ecosystems such as industrial districts? logistic systems?
- How can secure information exchange be provided, e.g. between industrial partners?
- How to coordinate local regions’ public administrations work and productivity of SMEs?
- How to support strict food policies to protect European citizens’ health?
- What would be a “healthcare” platform?
- How to govern (manage, control, maintain, etc.) complex civil infrastructures, such as hospitals and airports, where many different kinds of electronic devices, often unmanned, cooperate to realise the overall infrastructure mission?
- How to let different control systems cooperate? E.g. how to accommodate city-rail traffic with respect to car traffic allowing car drivers to know the exact situation?



7.2 NESSI-centric use case

The Story

Pumps4Cars Ltd is a medium size supplier for automotive water pumps. Their primary customer (a car OEM) is looking for a new high performance pump for a new series of sports cars. As the specification is outside the current product portfolio of Pumps4Cars, the request is popping up at the Product Management. As Pumps4Cars wants to extend its product offering in the high performance segment, Product Management initiates further exploration.

After some research Pumps4Cars engineering identifies that this high performance pump requires a new design based on a new material that Pumps4Cars has never used before: diamond coated ceramics.

To start the prototype manufacturing of this new product, Pumps4Cars is checking the availability of this material with it's key suppliers.

As none of the current suppliers has the material available, a new procurement process is started to identify potential new suppliers. Shortly after this a number of offers arrive which are ranked according to the needs of Pumps4Cars

... to be continued with scaling up, hosting, integration of external services, ...

Relation to NESSI

Pumps4Cars provides a "new parts tender" e-service where its customers provide can ask Pumps4Cars for price and availability of new products based on specifications provided. An internal "bid management service" is mapping incoming requests to the product portfolio and availability. If a product is requested that is outside the specifications of the existing product portfolio, the request is forwarded to further human intervention and decision making.

Pumps4Cars engineering runs an engineering knowledge management system that is combining and semantically mapping between knowledge from various engineering disciplines to provide them with innovative engineering approaches.

The Pumps4Cars supply chain system is connected with it's key suppliers and allows them to check availability of products.

The procurement process is initiated by calling a "bid request" service of market place service provider. Incoming bids are analyzed and ranked according to various criteria.

7.3 Connected mobility use case

The following scenario, we can name “A seamless travel through Europe” shows some of the NESSI characteristics and interconnection with other platforms.

The Story

It's Friday and Alberto has got a message through his PDA while he is celebrating a meeting with one of his main customers in Amsterdam. His electronic assistant/agent notifies him that it would be possible to get an earlier flight back to Madrid if he is able to get on a taxi in twenty minutes at the front of the building where the meeting takes place. This doesn't surprise Alberto because data about the meeting venue and the return flight ticket currently booked is available to his electronic assistant. He knows that it was aware that the ticket can be changed without charge and has probably started a process some minutes ago that consists in checking whether earlier flights still have seats available and there is a taxi service to drive him to the airport on time. The meeting was close to its end since actions and conclusions have already been reviewed and a date for the next meeting has just about agreed. Therefore, Alberto confirms his assistant that he will go with the change. While he is saying goodbye to his customers, Alberto's assistant confirms the flight reservation change and orders the taxi. Communication with both the flight reservation service and the taxi service has been carried out electronically.

During the trip to the airport, Alberto's assistant has asked him whether he would like to check what gifts he can buy to his wife and children in the duty free shops of the airport. It has made this suggestion because this is something that Alberto typically decides to do in his frequent travels abroad. It is also aware of his buying preferences and has access to a record of previous purchases in this specific airport duty free area. Alberto confirms he would like to, so the assistant first performs a search in shops of the duty free asking for special offers as well as prices for products or services (e.g., sending flowers) it knows may be of interest to Alberto. When it gathers the responses from all shops he shows the information to Alberto so that he can made his final choice.

Relation to NESSI

The electronic assistant/agent has weakened up because it's been alerted that the meeting Alberto is attending is about to finish. It's able to recognise that Alberto is still at the meeting by matching its current coordinates with coordinates of the meeting venue. The NESSI infrastructure provides the means for discovering the current location of Alberto in case that his PDA is not equipped with a GPS system.

The semantics associated to the context (the fact that Alberto has a return flight ticket that may be changed without charge but it will make sense only if he gets on time to the airport on time for an earlier flight) point to the process execution program that would orchestrate the services that have to be called in order to change the flight. Research on process execution languages as well as the architecture/implementation of generic virtual assistants that are able to interpret programs written in these languages is under the scope of NESSI. Also it is the way to characterise business process semantically so that they can be dynamically discovered and offered to the user based on the context. The ability to run these agents on small devices such as a PDA, however, would fall within the scope of Artemis.

In our example, the process execution program executed by the assistant would first check if there are earlier flights available by means of connecting to the airline reservation service. If is the case, it will next check if there is a taxi service that guarantees to drive Alberto to the airport on time for boarding. NESSI defines the software middleware that will be used to invoke services by the assistant as well as the container where service requests are received and dispatched. If the assistant runs on the PDA, this middleware makes usage of wireless protocols defined by the eMobility platform. Registry of airline flight reservation services is provided by the NESSI infrastructure.

In the process execution program run by the

assistant, the taxi service to be invoked is not predefined (only its interface). The assistant will look for available taxi services based on the context (i.e., what's the city) and will perform the necessary brokering to find one that guarantees arrival to the airport on time. How to integrate semantic- and context-aware brokering schemas in process execution languages as well as the runtime infrastructure needed to support brokering is under the scope of NESSI.

Interaction with the duty free area of the airport is driven through a process that will be also proposed to Alberto based on the context. NESSI provides the infrastructure to execute such process, which will orchestrate services exported by shops in the duty free area. Each duty free shop is able to provide its own semantic-driven search engine which will enable to search based on preferences of the user rather than specific product or service names. Research on how this searching services could be easily integrated and configured for each shops' catalog offering is under the scope of NESSI.

Buying in the duty free area implies interaction with electronic payment services. This interaction will take place through the infrastructure provided by NESSI which will take care of critical aspects like identity management, confidentiality and trustworthiness. There are Service Level Agreements (SLAs) between payment services and duty free shops. The NESSI infrastructure should help to monitor and guarantee such SLAs.

When Alberto arrives to the airport it is just about 20 minutes before his flight takes off but he doesn't need to check-in. Info about his flight, including the boarding gate, has been downloaded to his PDA which will work as a boarding pass during his stay in the airport. The PDA automatically connects with equipments in all control security gates he has to cross in order to enter the boarding area. When he arrives to the boarding gate assigned to his flight, an employee of the duty free area is waiting to give him the gifts he had bought through his assistant which took care of providing info about the boarding gate number to the duty free system. It is five minutes before the call for boarding so Alberto has even time to call his wife and tell her that, this time, he will be back on time for dinner.

At the airport, connection between the electronic boarding pass holder in the PDA and the equipments in all control security gates is carried out through the NESSI infrastructure. The infrastructure deals with all aspects related to identity management and confidentiality of the exchanged information.

Software running in the equipments located at control security gates interacts with remote security systems that are able to check police records, etc. This communication also takes place through the NESSI infrastructure.

The final mobile phone call that Alberto made to his wife was not carried through the NESSI infrastructure.

Veronique is manager of one of the shops in the

Another area in NESSI has to do with driving

duty free area. She feels very happy because this year they are really doing well and will surpass the selling target in more than 20%. He recognises that this has a lot to do with the deployment of the infrastructure that now is enabling shops like her to offer and sell goods electronically. She feels rather proud of having support this decision when it was a novel experience and benefits were not so obvious in a first approach. It's amazing how many travellers who didn't buy anything before, have now become regular customers of his shop. The duty free area started with just two assistants dealing with orders that arrived electronically, but now they have to employ three additional ones to response the increasing demand from customers.

Veronique is now pushing forward the idea of connecting the shops of the same chain so that demand that cannot be satisfied can be forwarded to shops in the duty free area of destination airports. This time, she feels sure about the idea, because now, more than ever, she knows that making the experience of buying more easy and grateful to final customers will finally bring the benefits.

Next day, Alberto and his family got the car to start their planned trip to Galicia, in the north part of Spain. Some days ago, Alberto and his wife defined a plan for the whole weekend assisted by a local tourist integrated information system called Destination Management System (DMS). The system creates a special package for them integrating the offer from selected hotels, restaurants, entertainment resorts and museums.

Car travel data were also prepared by Alberto some days ago but he made some minor last-minute adjustments during his flight back to Madrid.

Before starting the journey, this travel data are downloaded to the car computer. The car computer learns who sits where and adjusts vehicle instruments, entertainment, air condition etc. to the family members' preferences, e.g. by loading the latest Harry Potter to the video and audio channels of the kid on the back seat.

The navigator calculates the best routes during the whole trip, not only for the travel from Madrid to Asturias and the return back home but also for the several travels across the region that Alberto

research on the ASP (Application Service Provider) space. Several duty free shops may use the same ASP application which implements the B2C interface and is able to integrate with the disparate backend applications and databases associated to each shop. Research on this area is also within the scope of NESSI.

NESSI would also focus on providing the technology that enables that different delegations of a company with presence in many countries can interact with each other to provide a single global service.

NESSI provides the technological framework capable of supporting B2B integration within an environment basically fragmented, dispersed and not much digitalised as the one described for tourism, in which information, the primary key of competitive advantage, is difficult to recover and integrate.

NESSI will cover research in orchestration and dynamic integration of semantically described services, run time e-contracting techniques and semantic-driven decision support systems.

The car has lots of embedded systems and a lot of the technology; what the technology inside the car can offer has been described elsewhere. What NESSI shall provide is the infrastructure for connecting the embedded units in the car to other mobile and ground-based communication channels of roadside controllers, toll stations, police, tourist information, repair stations, etc. The NESSI infrastructure will do the connection to services that offer mapping of national and local traffic signs and regulations (e.g. about parking rules) to the language and signs used by

and his wife planned for the weekend. It uses inputs and ground-based traffic computer information and suggests some route changes because of accidents or bad weather conditions on the road. The car automatically recognises toll stations and sends the credit card number so that no stops at toll stations are necessary. Similarly, police checks can mostly be avoided because the data are sent to police requesting them. All these features can be set or reset by the users, at their own discretion; so, if they do not want their data being delivered to certain places, they just restrict the receiver list.

While driving, diagnostic programs regularly check the proper functioning of the car. During the travel back to Madrid, a problem is detected and Alberto is informed. The closest repair station is identified, their availability checked and also the availability of spare parts. Since Alberto wants the car to be repaired before the problem becomes serious, he tells the car to make an appointment with the repair station and get the required spare parts. The repair concerned software, so the repair software was downloaded and installed while Alberto and his family are having lunch in a restaurant close to the repair station.

the driver. It offers the basis for translation services for the translation of news, weather, traffic, and touristy information. These services will be called automatically by the embedded systems in the car. The road controllers will send information about any detected accidents, traffic jams, obstacles in the road, etc. to the cars' computers, which in turn will use the translation services ordered before. Similarly, the toll stations will use banking services running on the NESSI infrastructure for deducting the road toll from the drivers' bank account, using security services provided by the infrastructure that prevents unauthorised access to these data. The NESSI infrastructure allows the car to call services for connecting to repair stations and software download from the manufacturer. These services call other services, for payments, identification of spare parts, etc.

The embedded systems in the car are in the focus of the Artemis platform, the communication is part of the eMobility platform. NESSI provides the basis for the services that bring the benefit of the functionality to the user.