



NETWORKED
EUROPEAN
SOFTWARE
& SERVICES
INITIATIVE

by



NESSI

Networked European Software & Services Initiative

Executive Summary

José Manuel Barroso, President of the European Commission, has re-emphasised the importance of the objective for Europe to become by 2010 *‘the world’s most dynamic and competitive knowledge-based economy’*. The objectives set in Lisbon in March 2000 – higher growth, more and better jobs and greater social inclusion – are ambitious, and Information and Communication Technologies (ICT) were identified as playing a key role in driving the transformation of the European economy.

Within the ICT area, the sector of software and IT services takes a significant share of the European economy. In 2004 it directly employed more than 1 million European professionals. Taking into consideration the added value of IT for economic sectors that utilise it, from banking and eGovernment to automotive, logistics and health, the actual share of software and IT services ranges between 5 and 6% of the European GDP. Moreover, the sector of software and IT services is a growth engine in that it stimulates the creation of high added-value, sustainable jobs. Over the last five years, 60% of the jobs created in Europe were highly skilled, and the increase of ‘high-knowledge’ employment was three times faster than the average growth in more traditional sectors.

Today however the IT services marketplace is changing dramatically, due to a series of factors:

- Businesses and the Public Sector, which require flexibility to keep up with the ever increasing pace of change caused by globalisation and technological innovation.
- 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 ad hoc service components and customised software solutions.
- The clear emergence of Open Source Software, which nourishes the dynamics of the ICT marketplace and creates an “eco-system” that fosters opportunities by: increasing options and competition, aligning to open standards objectives, positioning software as a public good, improving technological self-reliance, increasing transparency, minimising security risk while optimising costs.
- The broader uptake by end-users, which is gaining momentum, 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.

With this in mind, it is obvious that the IT sector is at the very heart of the Lisbon agenda, as it aims at delivering the benefits of the information society to people and organisations through services based upon innovative software infrastructures.

Promoted by thirteen major European ICT corporations, totalling almost a million jobs and about 300 B€ revenues, the NESSI Technology Platform aims to provide a unified view for European research in Services Architectures and Software Infrastructures that will define technologies, strategies and deployment policies fostering new, open, industrial solutions and societal applications that enhance the safety, security and well-being of citizens.

NESSI's Promoters






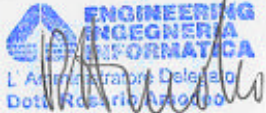




















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1. NESSI CONTEXT

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.

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, that hence becomes 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.

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.

However, figures alone do not depict the importance of the European software and services industry as well as will 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.

The pervasive connectivity, as already testified by the rapid increase of broadband access and growth in mobile data, will radically change the nature of communications. Indeed, the computer-dominated traffic is moving to a decentralised environment driven by myriads of small autonomous systems with embedded programmable devices like sensors, smart tags, cameras, handhelds and appliances on the fringes of the converging networks. This opens new opportunities for a large span 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 create a number of social, ethical and legal constraints. Not only have software and services to cope with these constraints, but they are also instrumental in transmuting regulations and laws from paper to electronic solutions. Therefore, it is key 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.

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.

2. SOFTWARE AND SERVICE FOR THE KNOWLEDGE ECONOMY: A VISION FOR 2020

The innovation driver and core enabler of economic growth in the 21st century is information and communication technology. This requires the ICT industry in general, and the software and IT service industry in particular, to step up to the task of developing innovative products and services that will help companies develop and adapt new business models that distinguish their offering from their competitors.

As a result, the perspective of the next 20 years can be envisioned as follows:

Globalisation as a reality.

In today's world, ICT should be one of the means on which Europe can capitalise to support economic growth and ensure higher value employment. We see a wealth of opportunities as software and IT drive the evolution of the Internet as a global knowledge and services eco-system. Doors to new markets are opened, and unlimited access to people, knowledge and services is provided, that otherwise would remain unknown.

Globalisation impacts both the creation and the uptake of software and services:

- In terms of creation, de-localised offices in the so-called BRIC⁵ countries enable to tap local talent, while granting local workforces access to the global marketplace of knowledge. In this way, software and IT dependant services can help create jobs, products and services that will boost European regional and national economies and bridge the digital divide within larger Europe, as well as address digital divide issues globally. Furthermore, services will be specified and created with a global perspective in mind since they will be nurtured in a globally accessible eco-system.
- Concerning uptake, services such as banking, insurance, air and maritime transport, healthcare, are being liberalised on a global scale. Software will have to adapt and accommodate users from diverse cultures. This is not simply a matter of changing the user interface language; the different ways of doing business have to be taken into account. In line with such changes demanded by the marketplace, software and services will come to interact through various business models. The Internet will evolve towards an eco-system where users will be networked, dynamically building and dismantling ad hoc partnerships without physically meeting. They will also utilise and eventually pay for services globally accessible within this eco-system. Flexible partnerships and commercial relationships will become ever more sophisticated, with contractual issues being managed entirely electronically.

Ubiquitous and invisible IT.

The advent of an ubiquitous telecommunication infrastructure has provided users with the full benefits of the telecommunication revolution, that has established a worldwide infrastructure mixing wired and wireless technologies. Communication has become the norm, and users do not identify which technologies and networks support it – they simply benefit from it and expect to enjoy a permanent link between them and the rest of the world. In this sense, telecommunication has become ubiquitous and invisible, while being at the heart of every day life.

In this continuum of connectivity, IT has to evolve so as to provide all users with a global, transparent tool in which they should only perceive the functionality of solutions, rather than the complexity of the technology underneath.

⁵ Brazil, Russia, India, China

Process innovation outranks product innovation.

Global competition and lower market entry barriers are forcing companies to find new ways to stand out against their competitors. Companies see their future business success depending more on adapting their business models – or the way their organisation operates – than on what their organisation actually does. Business model innovation is replacing product innovation as a primary driver for competitiveness. Managers all over the world see IT applications and services as the central element to enable flexibility for business process innovation.

From product to services.

In today's ICT market revenues are shifting from the sales of products to the provision of IT services. This shift is driven by consumers who want to benefit from solutions that address their needs, as seamlessly and as flexibly as possible, and by the increasing need of all industries to cut costs of operations and to make business processes more effective. A recent survey of 473 enterprise buyers by the Yankee Group of Boston⁶ showed that in 2005, 75% plan on investing in the technology and staff necessary to enable a service-oriented architecture. Gartner's worldwide IT Services Market Forecast, 2002-2007, expects today's 413 B€ worldwide IT services industry to grow to 560 B€ by 2007 – a compound annual growth of 6.3 %.

The current shift of the IT market will require a transformation of the IT sector. Europe has the potential to play a major role in this marketplace by capitalising on its global leadership in selected related areas (e.g., enterprise and societal applications), its strengths in correlated sectors (e.g., telecommunications, service providers and integrators), and its excellence and leadership in research in some of the related areas (e.g., Grids, ontologies and the semantic Web). This chance is bound to the further development of a strong and well focused presence in research and development in the related areas.

Creating a level playing field for smaller enterprises (SMEs).

Over the last 15 years the IT marketplace has been dominated by large software suppliers. SME's, either software developers or end-users, have had no alternative but to adopt proprietary standards. This is bound to change. Open source and open standards based solutions with service oriented architectures taking into account specifically European requirements shall provide smaller enterprises with new opportunities to drive their growth.

IT as a business catalyst.

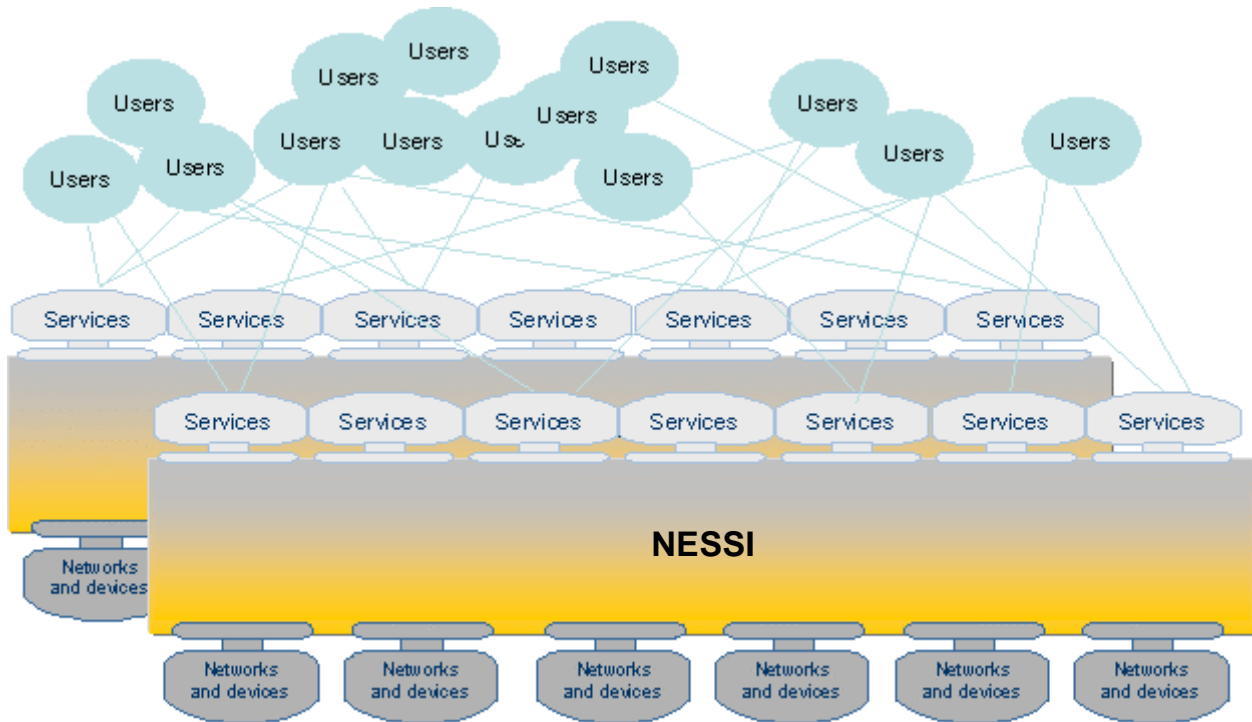
Currently software automates the flow of goods, capital and information. Its role should expand to accelerate and integrate business processes becoming a key enabler for a successful global economy.

In this vision, NESSI envisages the wide adoption of services offered through networks and devices as a distributed system which in turn provides virtualisation.

This scenario will be characterised by large distributed systems with many data collection points, services, 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, then moved through fast optical technology to powerful computational infrastructure and 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

⁶ Yankee Group News Release 27 Sept 2004

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.



As an outcome of this scenario, services that are developed according to consolidated open standards will be adopted dynamically, for they will have enjoyed much lower development cost, higher level of exchangeability and interoperability, lower entry cost on the marketplace due to common trust, security and privacy methods, available ontologies and semantics. These approaches also enable enterprises and public sector organisations to supply services to their customers that are adapted to the local culture and specificity.

At the core of our vision is the provision of new approaches enabling to compose services intelligently and to deliver them efficiently.

3. MISSION

Driving innovation is the newfound responsibility of the software and IT services sector. For the first time in history, software and IT services can and must make an essential contribution to granting companies and public administrations of any size the flexibility they need to apply innovative business models including the provision of improved end user services. The software and IT services sector is the capstone of this evolution as no other industry holds as much potential for innovation, disposes of as many resources, creates as much value and affects as many other industries .

As such the *NESSI* mission is

to develop a visionary strategy for software and services driven by a common European Research Agenda, where innovation and business strength are reinforced by:

- providing European Industry and the Public Sector with efficient services and software infrastructures to improve flexibility, interoperability and quality;
- mastering complex software systems and their provision as service oriented utilities;
- establishing the technological basis, the strategies and deployment policies to speed up the dynamics of the services eco-system ;
- developing novel technologies, strategies and deployment policies that foster openness, through the increased adoption of open standards and open source software as well as the provision of open services;
- fostering safety, security and the well-being of citizens by means of new societal applications, enhanced efficiency of industry and administrations, and competitive jobs;

hence transforming the European economy into a knowledge based economy and enabling the European software and IT services industry to attain a stronger global position.

NESSI operates in the context of a wide continuum of information and communication technologies, and envisages close collaboration with other global research initiatives.

4. STRATEGIC DRIVERS

A number of strategic drivers influence the achievement of a world-leading Knowledge economy through IT.

European dimension.

In order to allow ICT actors to deliver complete solutions to end-users – and thus to drive the relevance of the research for the whole European industry – *NESSI* reflects the entire value chain of the new knowledge-based economy with a focus on excellence and relevance of its members. To this end, it will include technology providers, integrators, solution and service providers, leading edge end-users and SMEs. It will actively stimulate interest in policy, academia, industry and the user community so as to attract new members.

In the continuum of information technology *NESSI* is ideally positioned to cooperate with other European Technology Platforms to maximise the outcomes of the research effort in the ICT field.

Furthermore, the current level of synchronisation between academic research agendas and industrial needs is not satisfactory. The decoupling of business and research agendas is a primary reason for the difficulties the European industry has to exploit research results. The open approach of *NESSI* will be sustained by bringing European research institutes and universities in support. This will provide *NESSI* with the necessary scientific foundation and stimulate new research-innovation-industrialisation cycles.

ICT Simplification.

The effective use of software and IT services by European business has become more complex over time. Quickly changing standards, tools and their interoperability, require continuous monitoring. This increased effort contrasts with the lower and slower investment in IT in Europe. Empirical evidence suggests that Europe's productivity gap with the US is to a large extent due to its weaker investment in ICT. In addition, European performance is affected by the higher proportion of SMEs, which lag behind larger enterprises in terms not only of ICT infrastructure deployment but also of sophistication of ICT usage.⁷

The hasty adoption of new software technologies and services during the “Internet bubble” era has seen the emergence of complex, over-provisioned, proprietary hardware and software infrastructures. This situation constrains most of today's enterprise ICT budgets to the management and maintenance of the current installed base, rather than allowing innovative investments in ICT. A complex ICT landscape also limits business flexibility and manageability, and thus *structurally* limits the enterprises' ability to take up future innovations. ICT simplification will allow ICT capacity to be optimised across, and accessed by the entire organisation.

Structuring software systems through open standards-based services and the use of virtualisation in the provisioning of ICT will simplify the management of enterprises' IT and enable automation. This structuring will be eased by the fact that many of the required components already exist within most enterprises and public administrations.

Adopting a citizen perspective.

European citizens should directly benefit from the growth of the Knowledge economy in their role as employees or employers, as consumers of government and commercial services.

⁷ “Challenges for the European Information Society beyond 2005” COM(2004) 757.

A higher uptake of Knowledge economy information technologies by citizens, students, professionals would offer general productivity gains. Moreover, it would also allow people with special needs to more fully participate in society, be it to learn, to work, or to interact with communities.

Quality of life, bridging the digital divide and access of the citizen to a better life through ICT are central to European policies. This has to be the starting point of analysis for any evolution of the ICT market. Access to advanced internet services has social and societal advantages; it also implies a larger economic impact of any new evolutionary development.

A connected citizen uses software in many varieties, since it is at the heart of the most knowledge intensive added value in products and services as diverse as eHealth, eGovernment, eCommerce, banking, insurance, homeland security.

A truly multicultural approach.

In the design, testing and implementation of ICT, user needs – which are frequently citizen needs in the European public service context – must be taken into account at a much earlier stage and to a wider extent than has been the norm up to now. The true diversity of a multicultural approach is not only reflected at the level of multilingual interfaces, but as importantly at the level of different ways of interacting.

Business and administrative process flexibility.

Private sector enterprise or public administration business processes – integrated end-to-end across the organisation and with key partners, suppliers and customers – that can respond to any customer demand, market opportunity or external threat, constitute a key requirement for a competitive economy. In a flexible environment, business and ICT are synchronised to capitalise on change with the primary benefits of simplicity, agility and value. These environments support component-based business models that reside on horizontal end-to-end business processes and in which every business change corresponds to an ICT infrastructure change. The new imperative for ICT is to transparently support these business designs with a services-oriented open infrastructure that allows applications, processes and defined components to be mixed and matched at will. The ability for efficient integration, i.e., the ability to connect people, processes and information fast and easily is critical as only this will give rise to enterprise computing at every employee's fingertips any time, anywhere, so that change can be enacted in real time.

New business services require an increased scale of system interconnection. The interconnection and global integrity of large numbers of independent and autonomous systems, from different companies and organisations, pose new challenges and require new technological solutions. These new business process compositions will be made possible through interoperability standards.

Embracing open source as a model.

Open Source has emerged as a viable and credible model for developing high-quality software components and solutions. The Open Source model creates new opportunities for a large number of providers, including SMEs, as it fosters competition that benefit end-users and corporations through the decrease in cost of ownership.

Open Source leverages community development and fosters collaborative work, building flexible, reusable and reconfigurable solutions, scaling across different environments through an open development process. Therefore it is a major enabler of innovation having, by nature, a fast feedback cycle between developers and users and allowing building on the expertise of wide communities of developers.

Open Source generates a positive industrial impact through business value and community alignment, and close co-operation between companies and Open Source projects, ensuring a sustained value-added process, leveraging network effects and economy of scale, enhancing value to all involved parties.

Open Source is an effective approach to developing and consolidating emerging open standards promoting interoperability, protecting investment for end-user and enterprises.

Open Standards adoption and development.

Today we have fragmented research in software engineering, service engineering, and grid architectures. There is a lack of coherence in addressing next generation systems, including distributed operating systems. Europe is largely absent in important standards debates. All large software and software-intensive companies are involved in shifting global alliances, using the organisations W3C⁸, OASIS⁹, IETF¹⁰, GGF¹¹ and others to further their industrial strategies, but only a few of them are genuine European players. We need to bring the interests and aspects of European businesses into the standards definition. There is a continuing need for wide consultation and input on standards - many of the ongoing changes to, for example, WSDL¹², SOAP¹³, and BPEL4WS¹⁴ are strongly influenced by the existing platforms of the vendors involved. General standards development is too slow, so we need fast consolidation of quasi- (de facto) standards; moreover developing a new product capable of competing with such platforms requires investments that no individual company can afford. That can only be done on a trans-national level: no country or company is strong enough, in isolation, to pursue the ambitious *NESSI* vision.

SME-friendly eco-systems.

Structuring of digital landscapes through open standards-based services will give rise to a new “open service” market. On the consumer side services can be procured based on any criteria (functionality, quality, cost) and from any source desired (established player vs. new market entrant, large standard provider vs. small specialised provider). On the provider side, this will open the service market and provide new opportunities particularly for specialised SMEs and companies that can build on regional strengths (language, culture, local market conditions). This will in turn allow for a stronger multi-cultural adaptiveness of software and digital services to accommodate users from diverse cultures in a society in which business tends to be international.

⁸ World wide Web Consortium

⁹ Organisation for the Advancement of Structured Information Standards

¹⁰ Internet Engineering Task Force

¹¹ Grid Global Forum

¹² Web Service Definition Language

¹³ Simple Object Access Protocol

¹⁴ Business Process Execution Language for Web Services

5. RESEARCH AREAS

5.1. Key Evolution Elements and Trends

The past 10 years have seen remarkable changes. For business systems, the dominant development paradigm is no longer based around programming but around reuse. Systems are developed by assembling and integrating COTS¹⁵, hand-written code, configured ERP systems, etc. Under pressure from 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).

The *NESSI* vision introduces a new technological scenario, characterised by large distributed systems with many data collection points, services, 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, then moved through fast optical technology to powerful computational infrastructure and the results are 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 dissolving into the net into a set of special purpose and domain specific appliances.

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 raise of cheap software factories in third 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.

The focus on knowledge for IT is based on a set of key evolution elements such as:

- Advanced technologies that pave the way for the “**aware** computer”, including the basics of semantics, self-awareness and awareness of its context (tackling semantic grid, physical locations through advanced GIS, architectures and infrastructures like INSPIRE and GMES).
- Advanced technologies that pave the way to “**trust**” built on privacy, identity and dependability.
- **Ubiquitous** computing, including virtualisation, utility computing, pervasive connectivity, ambient intelligence, etc.
- Advanced technologies that pave the way to “**alive** software”, including adaptive algorithms, reconfiguration, component engineering, variability management and dynamic grid.
- Advanced technologies for **user-centric** engineering, including requirements and service engineering, usability techniques, vertical down-streaming on user markets with specific needs, like eGov, Health, etc.

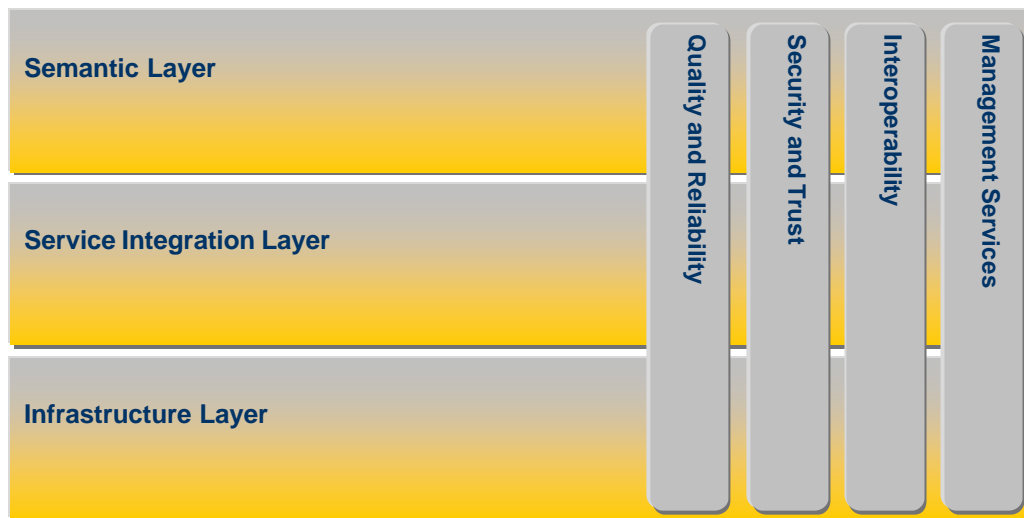
This five point schema of **aware**, **trust**, **ubiquitous**, **alive** and **user-centrality** will be revised continuously and shall constitute the basis for *NESSI's* Strategic Research Agenda.

¹⁵ Components Off The Shelf

5.2. Technology Domains

Working towards achieving the initiative's objectives will be supported by an integrated roadmap of research and development in the technology domains of **infrastructure** (mainly software related, Grid services and similar), **service integration** and **semantics**. These domains are inter-related, and aim to create the holistic framework where high-level services contextualise flexible low-level infrastructures.

Cross-domain aspects (quality and reliability, security and trust, interoperability, management services) will drive this holistic approach.



NESSI's 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. Autonomic 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 (including Grid) and the network. Infrastructures have to be architected and implemented to be robust, fault-tolerant and secure. From a users' 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.

Trust and security.

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. 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.

Quality and reliability.

Business processes execution and the correct functioning of devices are increasingly reliant on software. As a result, poor software design or software errors may cause catastrophic damage, not only in terms of economic loss but in terms of human lives (e.g. software errors in flight control software). Tools that help to improve software development processes, measure quality, and predict reliability, will be required and must deal with the globally distributed systems and services of the future.

This concerns end-to-end quality and reliability of services.

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. Key towards our 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 SLA¹⁶ contract management that deal with aspects like the agreements of QoS¹⁷ provision mapped on SLA contracts, flexible metrics of QoS indicators, and the management of QoS violation. In addition, common principles for defining unambiguous service level

¹⁶ Service Level Agreement

¹⁷ Quality of Service

agreements alongside 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 among 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.