NESSI input for FP7[1]

1 Foreword

This document is submitted as input to the services of the European Commission in charge of drafting the FP7 work program. This document has been created using a fast-track process, parallel to the development of the NESSI Strategic Research Agenda. Focus is specifically placed on the topics to be addressed in the short term (first 2 calls of the FP7 work program).

This document is currently in DRAFT form and should be kept confidential between NESSI and the services of the European Commission. An updated version of this document might be released to the public at a later date.

[1] NOTICE:
The information in this document is provided "as is", and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and liability.

2 The Agenda of NESSI

The Services sector provides the majority of the European workforce with employment. As our economies have developed in terms of higher skills, the role of the services sector as a driver of economic growth has increased. 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. Services thus provide the growth engine and innovation base for the knowledge economy which is of critical importance for European competitiveness. The European Commission has again underlined how the knowledge economy is the key factor for Europe to become more competitive. The Lisbon Objectives set the goal of Europe becoming the world's most dynamic and competitive knowledge-based economy by 2010.

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

This research agenda starts with a fundamental change in our approach to computing technology, moving away from the physical view of data processing devices to the functional view of data transformation services. In this context, NESSI grand challenge is to

transform the Internet to service your life.

The idea is to have a service-oriented world based on a new generation of the Internet which is based on the following core properties:

- **Alive through services** – the service model enables to continuously improve the functionality available to users, making the system so responsive that it seems alive
- **Pervasive through trust** – the services are not only available everywhere, anytime, but are also pervasively trusted through the combination of strong end-to-end security and availability properties and a fully fledged collaboration between regulatory, technical and infrastructure environments.
- **Rich with knowledge** – the system supplies knowledge and expertise-based functions for the valorisation of business logic services and thus confers a competitive edge to the European economy
- **Invisible through ICT** – the system decouples provisioning and management of the infrastructure from use of services, which allows users and service providers to focus on the areas where they are best positioned to create value.

The following table captures everyday life experiences which are seen by users (enterprises, organizations and simple citizens) as limitations for the full implementation of a service-based economy as envisioned by NESSI. For each limitation the table shows the NESSI solution and than the corresponding research area. The colours on the left column point to the main elements on the NESSI Holistic Model as presented in NESSI SRA Volume 1 and briefly described in the next Section 3. **This table is not organized in order of priority**, as there is in fact no priority of research at this level of granularity.

Section 4 further details the identified research areas.

	Today Experience	NESSI Solution	Research Area
1	Dealing with computational resources is an unnecessary burden	Dematerialisation of IT and service-oriented utility	*Service-oriented utility infrastructure*
2	Evolving business processes is too long and costly to exploit new opportunities	Self forming/managing services, dynamic composition, automation of business process engineering	*Service and System Engineering*
3	Computers allow the input of data but not the expression of needs, Users are not in control of systems behaviour	Adaptation of service behaviour and interface to the users, semantic alignment	*Knowledge and behaviour representation*
4	Market evolution is locked-in by vendors	Open source, open standards and interoperability	*Openness*
5	Business processes are isolated and fragmented (private to organisation, discipline, …) forcing suboptimal individual solutions	Business processes interoperability, virtual organization support, focus on Inter-linking and multi-disciplinarity	*Business process collaboration*
6	Current Mechanisms to build trust between users and providers are not sufficient	Generate trust and confidence through policies, QoS, security, dependability, …	*Trust, security and dependability*
7	Old habits are always in the way	Boost the service economy through legal, social, cultural and scientific focused actions	*Linking technology to society*
8	NESSI is not available	Set-up and maintain an active NESSI community through building test-beds, creating centres of expertise, supporting vertical business areas	*Building NESSI*

3 The Strategy of NESSI

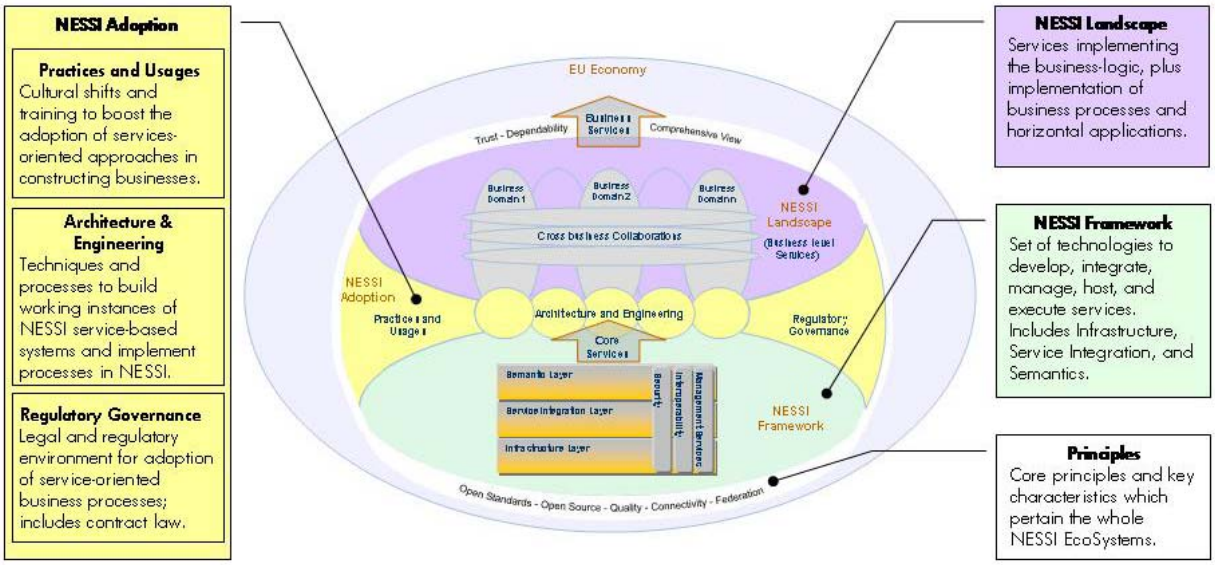
Transforming the Internet to service your life requires more than technology; this challenge can only be achieved through a balanced approach addressing simultaneously all angles of this transformation. NESSI models this transformation through a holistic view[2], in the context of an all-inclusive ecosystem in which the new economic models are developed. This view highlights the following areas:

- **NESSI Framework** ("*NESSI Core*"): Software, ICT Architectures and ICT Infrastructures where data evolves into knowledge, and which helps humans coordinate the execution of complex tasks. This focuses on facilitating a cost-effective provisioning and seamless composition of services, supporting pervasive and ubiquitous application scenarios.

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

- **NESSI Adoption** ("*The Art of NESSI*"): Socio-economic, human capital, public policy, and scientific foundations of the transformation to a European services economy, tightly coupled with the technology engineered in the NESSI Framework.
- **NESSI Landscape** ("*Powered by NESSI*"): Business services and business processes implemented and deployed using the technology defined in the NESSI Framework, leveraging the socio-economic models defined in the NESSI Adoption.

NESSI Holistic View



4 Initial Research Priorities

The following sections present the initial research topics identified for each of the NESSI research areas.

4.1 Service-oriented utility infrastructure

Objective: Build framework foundations to support the transformation to knowledge-based and service-oriented paradigms. The focus is to address the creation of new generation of infrastructures based on emerging concepts (e.g. SOKU – Service Oriented Knowledge Utilities to provide all the capabilities needed for the dynamic management of the services distributed across the available resources.

1) Service abstraction and virtualisation: (1) advanced mechanisms which support different levels of abstraction and virtualisation to employ resources and to enable provision of services as utilities including dynamic monitoring of SLAs internal to service containers together with dynamic service reallocation; (2) self adapting user interfaces, including device adaptation and accessibility; (3) reliable, multi-protocol dynamic binding, with endpoint virtualisation; (4) user device based ownership and management of profiles, service processes, histories and content; (5) any device as a service endpoint: evolution to complex and extremely distributed scenarios on very different scales of machines, starting from Grid based systems down to PDAs and RFIDs; (6) multi-scale challenges, including architectural (organizing and structuring systems at different scales using component-based middleware and software engineering) and algorithmic (P2P algorithms and systems).

2) Decision Support and Automation tools for IT Service Management and automation and decision support tools development that is aimed at improving the efficiency and effectiveness of IT service delivery and support. This includes the following aspects: IT Service and Resource Models -model IT

changes and their dependencies-, Risk and impact analysis -assess IT failure/changes risk and impact-, and IT Planning -how to better plan for IT services-

3) Technology bases for wide scale computing utility: new generation of operating systems for resources virtualisation, dynamic composition and allocation, including computing, storage and networking with the aim of data-centres virtualisation.

4.2 Service and System Engineering

Objective: Build engineering and management foundations to support the transformation to knowledge-based and service-oriented implementation of business processes. Focus on dynamic composition, engineering automation, and management of complexity for both services and business processes.

1) Autonomic and adaptive properties of services: (1) adaptability and learning mechanisms for dynamic context identification and composition to inherit, merge and federate standard context descriptions together with light weight rule engines supporting dynamic intelligent, on-demand service discovery and composition and deployment; (2) Methods for self-monitoring, -stabilization and -healing of service components for dynamic (re)boot, (re)configuration and (re)deployment supporting adaptation to rapid changes in the environment.

2) Advanced service discovery mechanisms and policies: Research and development to advance technology in the areas of: (1) description of service functionalities and properties covering SLA issues like service level guarantees, limitation of use, accountability, configuration to enable dynamic services composition and reallocation, flexible reconfiguration of business processes on all levels of granularity; (2) dynamic, distributed indexing methods to provide efficient and scalable content based service discovery and routing using different structural levels of data descriptions for service content and demand and their perfect or approximate matching; and (3) semantics based service discovery, composition and federation.

3) Autonomic properties of systems: New transaction approaches and modelling need to be investigated to evolve from the traditional concept of transaction to a new concept in the context of a service-based economy. Critical issues are a) transaction management for wide scale composite services across multiple domains with undefined latencies, low quality connections and compact encodings; b) back up and recovery mechanisms to manage widely distributed state-full transactions.

4) Service management and sustainability: (1) Model based definition of business services including service composition and resource dependency relations. Methods and tools for design-time and run-time analysis and testing of composite services; (2) service monitoring, usage tracking, enabling collection of accounting info, tracking of service level realisation under arbitrary loads, alarm mechanisms for various hazards in service operations; (3) enabling policy driven service deployment by providing generic mechanisms for policy descriptions for varying resource constraints and loads.

5) Software and system engineering to support service-based business processes: integrating recent advances on system engineering (especially complex system engineering and cognitive system engineering) while focusing on the peculiarity of this type of systems to capture both *intrinsic* and *extrinsic* parameters (or design principles) that enables and supports (through methodology, tooling, …) the design of effective and efficient technological support to business ecosystems that will face challenges attached to them (e.g. governance, commercial viability and sustainability, dependability, security & trust …).

6) Lifecycle management for service-based systems: process that fully addresses the continuum from (coalition) formation to disbanding going through operation in a context sensitive manner while preserving QoS and offering the capacity to cope with unexpected events; business ecosystems that encourage emergence of knowledge and process from a collaborative perspective and thus tend to be more trained or evolved than programmed and configured.

7) Technology for networked and cooperating business ecosystems: embedding local (domain specific) business ecosystems in surrounding intelligent ICT Infrastructure for enabling their cross vertical integration, evolution and task/services provision in everyday environments.

4.3 Knowledge and behaviour representation

Objective: Research and build the technology to remove or alleviate the communication barriers between human beings and computers. Focus is on leveraging existing research in human-to-computer interaction to bring a new dimension to service-oriented paradigms.

1) Advanced human interaction with services: advanced declarative abstract user interface definition languages together with: corresponding runtime environments to support multimodal/multidevice interaction with services; development tools for user interface development by composition and configuration.

2) Human computer-mediated interaction and collaboration: investigate, demonstrate and assess the potential of computer-mediation (or agent-mediated) techniques to alleviate, for example, cognitive workload or sustain team work effectiveness. Focus would thus be here on human-agent collaborative interaction modelling and how this could be first automated or semi-automated and second on how this automation could be leveraged from several perspectives (interaction, visualisation, decision, …) according to various contexts.

4.4 Openness

Objective: Encourage increased competition in the industry beyond software, improve the functionality, the value and the trust of the services to be built interoperable and end-to-end through the largest as possible variety of technologies to choose from, based on a new generation of open services architectures, software infrastructures, open standards and the “community-based” model.

1) New generation of Open Standards for interoperability: A new generation of open standards is needed to allow Europe at large (e.g. business, industry, research, government, education, environment) to interoperate more efficiently through massive services to be instantiated and assembled dynamically whichever the structure, behaviour and location of software.

2) Core standards leverage: Future software and service technologies and applications need to leverage core standards, such as W3C, OASIS, OMG, especially those enabling large scale service-oriented infrastructures, services management and operations and utility services enabling seamless integration, perennial technology development and large spectrum services instantiation.

3) New generation of licences: A new generation of licences, including OSS documentation, is needed: to be conformant to European regulations and national laws; to define intelligent decision models and associated IP rights and obligations management to assess the compatibility of OS licences; to integrate in the software development cycle the mandatory traceability to define, track the legal status of collaborative software and/or compose and design methodologies to be implemented in software development platforms as well as prototype software to demonstrate their feasibility and usefulness.

4) Next Forge Generation based on context-aware collaborative environments: The aim is to conceive and design framework core services for the development of cooperative applications through objects sharing in interactive applications (co-design, software development, cooperative edition, workflow, synchronization, etc.) distributed on a large-scale network. Particular care shall be given to study of basic cooperation concepts, building blocks and models definition and modelling of distributed cooperating activities.

5) Interoperation between open and closed source software components: identify the most important issues concerning interoperability of open source software; build interoperability test-beds providing test-suites and integration components which support Open Source and proprietary code in component-based systems

4.5 Business process collaboration

Objective: Provide innovative and advanced service-based solutions devoted to the rapid set-up of highly dynamic and reliable service-based ecosystems that will enable to seize new and emerging market opportunities (e.g. cross-sector collaborative applications). Advance research capabilities on business dynamics and sciences attached to it (especially Services Science) while consolidating and federating existing research effort and giving orientations for the future in the field. Advance engineering (e.g. Service Engineering) capabilities to cope with inherent complexity attached to this type of systems. Promote (also standardize) a new breed of services called "intelligent services" able to join a socio-technical environment like Business Ecosystem while proposing some unique and advanced features (e.g. context-awareness) for a broad range of application domains (from vertical to cross-vertical domain collaborative applications). Assess the impact of services landscape design at both open framework and adoption level.

1) Service-centric systems building environments, enablers for software and system construction by configuration rather than by programming, e.g. for service composition and orchestration: (1) IDEs to decouple programming from transport and binding related issues; service policies management (properties) and enforcement (static binding); (2) evolution of Business Process Management (design, execution engines) through new generation of business enacting workflow languages, standards for human interaction and context description, rule engines to manage intelligent algorithms.

2) Collaborative business process management: advance tools and techniques to support paradigm change: moving from business process management to collaborative business process management. Design and develop new mechanisms to autonomously or semi-autonomously acquire/model (possibly standardize) collaborative processes from various perspectives (business but also cultural, environmental, …) and that could be used at run-time to increase the performance of the whole business ecosystem (e.g. automated reasoning to not only implement and deploy complex business processes but also infer or derive them through activity monitoring techniques).

3) Collaborative Business Innovation: Research business architectures and designs based on cross-community collaboration. Focus on gaining competitiveness through rapid response to business challenges and horizontal integration of business operations.

4) Virtualisation of enterprises, new working environments: Multi-disciplinary research on the enablers and impact of the societal, policy, and legal changes associated with the transformation to a European services economy. Focus will be on restructuring businesses through virtualisation of enterprises and on the modernisation of working environments, including self-employment and tele-work.

5) Architecting and engineering the new organisations: A fundamental problem in understanding, designing and managing real-world complex services systems is the need to work fluidly across disciplines. New concurrent multi-disciplinary approaches are needed: structure, modelling and optimisation, operational analysis, human factors (multiculturalism) and support tools.

6) Services science for Business Ecosystems: advance service science to deal with new requirements of next generation of business ecosystems; investigate and model complex services that can be combined in multiple ways to offer better flexibility, agility and efficiency for (potentially cross-vertical domain) business transactions and operations; cover the whole spectrum of services requested from domain specific to non domain specific; encourage formalization and simulation techniques; demonstrate and assess relevance and performance from various viewpoints (e.g. socio-technical aspects).

7) Services engineering for Business Ecosystems: Advance services engineering to better cope and sustain the emergence of the service-based economy where services are applied to specific businesses and domains as well as made cross-domain (not limited to cross-business but also cross-cultural, cross-societal, …); promote use of existing services while developing new breeds such as intelligent services able to perceive, reason (learn) and act in a more proactive way either in isolation or in coalition in order to cope with change in their living environment (Business, IT, …);

promote and instrument (standardized) formal description of services much more amenable to automation since not limited to purely syntactic aspects but also addressing semantic (possibly also pragmatic) ones; assess the effectiveness of the approach to first build-up systems that are configured rather than programmed and second trained and/or evolved systems rather than configured (exhibit features ranging from context awareness, compose-ability, granularity till self-management and/or intelligent/intelligible mediation with humans).

4.6 Trust, security and dependability

Objective: Weave in NESSI the security and dependability properties required to build trust and confidence of the various stakeholders in both NESSI and the business processes "powered by NESSI". The approach addresses all angles of the NESSI Holistic model: technology focus in infrastructure and services, societal focus in use and adoption, and ecosystem focus in business processes and services hosted on NESSI. This area includes mechanisms and services to build end-to-end trust, security and dependability, including adaptation of existing research artefacts to wide-scale and pervasive deployment across Europe as well as engineering service-oriented systems with strong end-to-end trust, security and dependability characteristics.

1) Widespread and large-scale deployment of Privacy Enhancing Technologies (PETs): Technology research and development to provide components and architectures that make the deployment and use of PETs possible, easy, and attractive across a wide range of interactions and relationships between consumers/citizens and public/commercial entities, with a focus on the infrastructure/services side of such relationships. The overall PETs deployment research context also includes the definition of attractive business and regulatory models for infrastructure providers and others systems using PETs, as well as social factors research.

2) Strong identity management: Technology research and development to make the wide-scale deployment of strong identity and authorization management solutions attractive from both a usability and economic standpoint. Includes (1) Identity management capabilities; (2) Policy based security and trust; (3) Federated identity management; and (4) Small footprint strong authentication methods.

3) Service definition and assurance: Mechanisms and architectures to adequately define, negotiate, apply and evaluate levels of services for trust and dependability, including (1) SLA management (definition, assurance, eContracting …) and metrics; (2) QoS (Constant update of runtime QoS with metrics from service management); (3) eNegotiation; and (4) proactive and reactive service behaviour monitoring, including real time impact analysis of problems, policy based alerting and autonomic adjustments.

4) Trusted certification tools for services: Research and define certification tools for services, to be linked with the technologies and standards of the service platform (such as Web Services standard trust-related (WS policy, trust, privacy). Also includes rights management (content/information and service usage).

5) Inherently Stable and Safe Architectures: Research, identify, and document principles and architectures that confer a high degree of stability, predictability, and trust to infrastructures and related deployed systems when considered from an end-to-end perspective. Also includes an analysis of those elements most contributing to a lack of reliability.

6) Openness as a foundation for systems security: Study, identify gaps, and define adequate development processes and policies, including certification mechanisms, to seize the opportunity to turn Open Source and Open Standards into a foundation for system security.

7) Holistic Management of Trust: Multi-disciplinary research on the holistic approach to the management of trust and security. Focus is on the complicated interdependencies and composition issues, spanning security, systems, social, legal and economic sciences.

8) Trust & Confidence, Data Privacy Policies: Research and technology development that is aimed at making the deployment and use of privacy enhancing technologies possible, easy and attractive.

Social factors research, to ensure that the resulting approach is understandable, useable and attractive to individual citizens and consumers. It will be essential for business and citizens to develop data privacy policies which ensure a balanced level of privacy protection while allowing for new services business models to prosper.

9) Privacy vs. Adaptability: in the context of wider adoption of service-based systems self-adaptability techniques with respect to market and human beings requirements, such as personalisation and user profiling, new business ecosystems shall be built keeping as untouchable the basic democratic rights of modern societies such as privacy.

4.7 Linking technology to society

Objective: Cope with the socio-economic, human capital, and scientific foundations of the transformation to a European services economy. Driving services innovation and competitiveness requires investments and changes complementary to technology-oriented research and development.

1) Legal framework for Services: Identify the legal barriers to the development of a services economy today and develop an Internal Market legal framework that will enable rather than hamper the creation of a future services economy. Focus is on supporting innovative business models based on cross-border establishment and movement of services within the EU and creating fresh opportunities for firms to develop new, often ICT-related, services to meet emerging global demands.

2) Understanding SME needs: Research to understand the specific needs of SMEs in a services economy are and how they will cope with the rapid changes that occur from the implementation of new business models. Concrete proposals on public policies and legal changes to maximize the growth associated with a strong involvement of SMEs.

3) Systems and Services Science: Create a new field of science, addressing the evolution from information rich organizations to services rich businesses through the combination of diverse technological, societal, governmental and business systems. The challenge is to understand, theorize, model and validate complex services (Business and IT) that will enable a better grasp and understanding of ecosystems of business and social collaboration and interactions. Specific topics to address include: (1) theory and formal methods for systems and services sciences, (2) tools and methods for modelling systems and services, (3) mathematical modelling technologies for systems and services, (4) design principles and methodologies for advanced simulation and emulation tools for modelling technologies, (5) experimental and socio-economic scientific methodologies, (6) integration of contributing disciplines, (7) mechanisms for delivery into businesses.

4) Approaches and processes for architecting and engineering services and systems: New development approaches for services and systems like e.g. AOP and variability management together with adequate processes for such development, especially collaboratively across different kinds of organisations (big and small industry, research institutes), different disciplines and domains, different countries, and different cultures.

5) Balanced Intellectual Property Approach: Identify required changes in IP laws and policies across Europe to encourage incremental innovation in services, while preventing over-protection that would work against the public interest and against the collaborative aspects of innovation. Focus is on avoiding artificial barriers to entry or other distortions in the fairness and openness of the new services economy.

6) New skills and cultural approach: Adapt education and training policies to rapidly changing requirements for new skills. Analyse what skills are needed for the services economy and develop a strategy on how to best implement changes in the existing education system to transform schools and universities accordingly. Create a new discipline focusing on Services Science Management and Engineering (SSME), which will bring together ongoing work in computer science, operations research, industrial engineering, business strategy, management sciences, social and cognitive sciences, and legal sciences to develop the skills required in the services-led economy of the 21st

Century. SSME students and faculty should explore the current and future processes of business, as well as its human, technological and strategic elements.

7) Shaping the future of Business Ecosystems: advance understanding on business dynamics in order to pave the way towards the next generation of Business Ecosystems (i.e. far from being dominated and regulated by a key player as today's systems, economically more independent, thriving across regional borders, addressing properly legal and contractual questions although not limited to those); identify research issues (e.g. success factors for business ecosystems, commercial exploitation of services provided via digital means,) that need to be tackled in order to propose and deliver innovative solutions; promote a socio-technical approach – in which services may be deployed in a variety of ways and then actively used by other businesses and citizens – to address new paradigms.

4.8 Building NESSI

Objective: Provide the necessary support mechanisms to create and feed a strong NESSI community. Focus includes the creation of testbeds, poles of expertise, as well as support provided to vertical areas so they implement their new service-oriented applications on the NESSI framework.

1) Poles of expertise and reference implementations (open- or closed- source) in the context of a European network of test-beds that will pave the way to the transformation of the European Economy through service-oriented business models. This includes:
   - Provide an explicit and comprehensive basis for the development and test of NESSI compliant services business and public applications. This in turn will ensure the availability of multiple, end-to-end, interoperable services in a fair and competitive global marketplace.
   - Accelerate the adoption of the expanded functionality of the "NESSI conformant services" facilitating cross-border interoperability and optimal exploitation/reuse.
   - Provide a controlled environment in which to verify the correctness, effectiveness and efficiency of open standards.
   - Provide the initial implementation which can respond to various applicability criteria across a variety of vertical initiatives.
   - Form the basis of a future NESSI conformance test suites and certification framework.
   - Facilitate rapid development, the communication/glue between the NESSI Holistic View core ingredients under OS-ware perspectives.
   - Provide different proof of concept implementations of the open NESSI architecture with software reference platforms (re)framed to support a massive services deployment.

2) Requirements Gathering: series of coordinating actions to collect user requirements both directly from user communities and through vertical business initiatives. This also includes a gap analysis addressing barriers to adoption.

3) Coordination with verticals ("Powered by NESSI"): horizontal strategy coupled with a series of coordinating actions to effectively drive the adoption of the NESSI platform as foundation for the vertical business initiatives. The list and priority of vertical initiatives is to be determined.