ITEA
Roadmap
for Software-Intensive Systems and Services

3rd edition, February 2009

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Executive Summary

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We are pleased to introduce the third edition of ITEA's Roadmap for Software-Intensive Systems and services.

As the key strategy document, it develops the shared vision of the *technological direction* for the ITEA 2 programme that will be necessary to introduce a new approach for promising *applications and services.* Roadmap 3 (RM-3) will be used to guide the ITEA 2 programme, and is intended to cover the period 2008 to 2014 for software-intensive systems and services.

ROADMAP 3 STRUCTURE AND MOTIVATION

With the fantastic development of technology in recent years from only a few processors overall to several processors per person, very not many people remain interested in buying or thinking in terms of technologies. Humans or agents are only interested in using applications systems and services. Instead of being technology proactive, looking for services, such as in Roadmap 2, this time services are looking for humans, agents or machines. We are now moving rapidly from a world where users were looking for products or services to a world characterised by offer saturation where suppliers offer us a full range of services, with products being offered to sell services: the Polaroid model.

An extremely important aspect of this for society as a whole, and Public Policy in particular, is that it is possible to start from and steer towards *societal needs*.

For these reasons, the Roadmap was built in two steps:

1. First of all, it anticipates applications and services corresponding to dreams and scenarios elaborated by industry futurists; and
2. From this, enabling technologies are described. They belong to different groups of 'challenges' and could have various maturity levels. Their success could also depend on external events[1] called in this document 'rendezvous'. The bidirectional relations between application driven and technology push does not preclude work from being started or continued on technologies without direct applications and services domains in mind.

Application and services, as well as technologies, were categorised in five categories each, as shown in Figure ES-1.
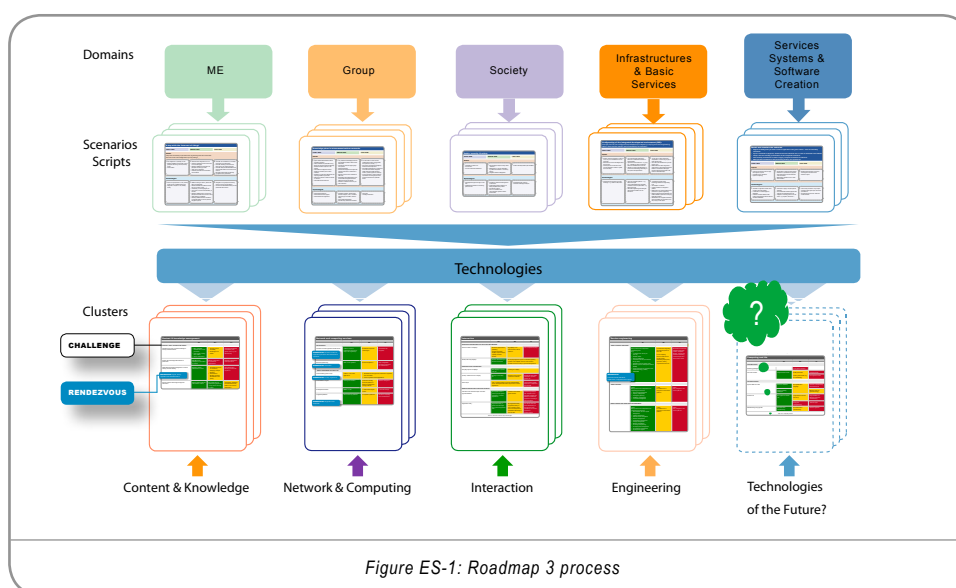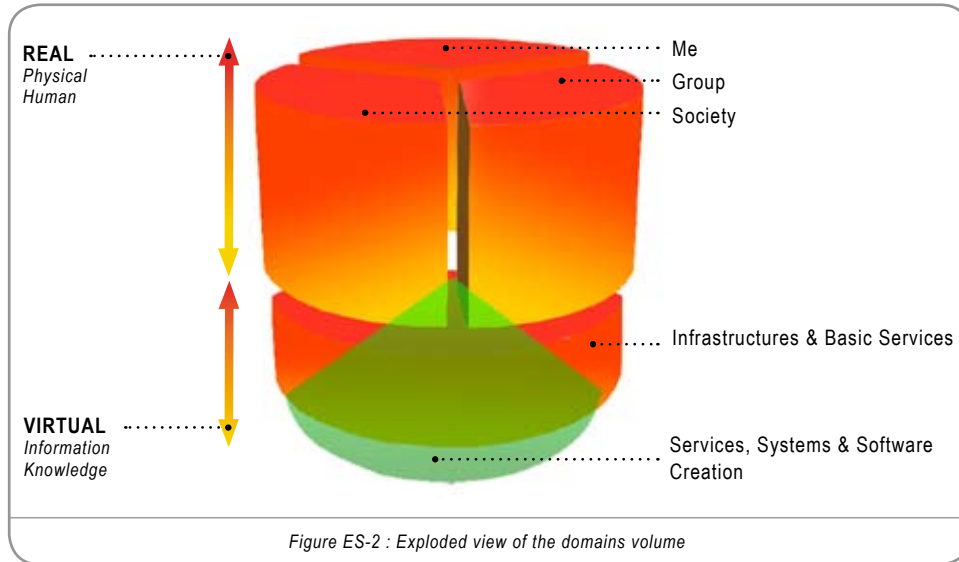

Figure ES-1: Roadmap 3 process

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[1]   Categories of Software Technologies as well as the relation to business models, regulation, legislation and acceptance by society and public

THE APPLICATIONS AND SERVICES DOMAINS

Today, and even more tomorrow, the vision of the world may be very different with services looking to us inducing a new concept for application models (Figure ES-2).

REAL
Physical Human

Me
Group
Society

Infrastructures & Basic Services

Services, Systems & Software Creation

VIRTUAL
Information Knowledge

Figure ES-2 : Exploded view of the domains volume

The world of applications and services is described as:

a. A cylinder with three segments representing the three applications and services providers aiming at users: *Me*, *Group* and *Society*. The three domains have a large zone for contacts and exchange between them:
   - **Me:** Individual entity – person, device or machine – achieving and controlling its individual goal and offering/ using services to/from others;
   - **Group**: Collection of *Me* or *Groups* co-operating towards achieving a common goal, each member contributing to that goal complying with group-controlled rules; and
   - **Society**: Assembly of actors/stakeholders achieving high-level societal or commercial objectives regulated by widely-accepted rules covering all member of an overall community.

These domains exist of course in the real world but the systems and services are in the virtual – digital – world, shown by the changing colours. However, the border between the real and virtual world is not sharp, so a gradient is used to show the transition between them. The Roadmap identifies the implications of these two facets of the same digital reality. In general, services are considered to cross both worlds and can be indistinguishably agent, business, customer, machine, peer, etc.

The fact that the IT world is evolving towards a situation of saturation, in which services look for users, is of course the basic motivation for this categorisation.

b. In addition to the three main application domains *Me*, *Group* and *Society*, we have the 'pure' software and information technology domains that enable the existence of all these services. We split these into two transversal application domains, namely the *Infrastructures and Basic Services* (IBS) domain, and the *Services, Systems and Software Creation* (SSSC) domain.

- **Infrastructures & Basic Services**: Distributed adaptive services, generic support services and framework services used to compose services, applications and systems dynamically; and
- **Services, Systems & Software Creation**: A range of activities and software tools required to help actors/ persons/agents engaged in designing, implementing, verifying, maintaining and modifying software-intensive products and/or systems and services.

The *Infrastructures and Basic Services* domain is placed in Figure ES-2 as a cylinder below the three applications domains, since it would support all three of them. The *Services, Systems & Software Creation* domain is represented as a cone within all the other four domains, starting at the transition from real to virtual, and going to the bottom of the *Infrastructures and Basic Services* domain to reflect the increase in construction activities.

These two domains are complementary. *IBS* make it possible to run relevant services for *Me*, *Group* or *Society* domains. It is the 'virtual space aether', which makes information technology possible in the first place. Now, services, systems and software must be created mostly by humans to run on this infrastructure, this is the *SSSC* domain. Obviously, services, systems and software creation and the infrastructure are linked, and so some description of common trends and evolutions is required.

For each of the domains, actors are identified and their contributions to the domain described in each chapter. By actors, RM-3 means agent, business, customer, machine or product as well as services interacting between themselves. The interaction could be person or machine centric – consumer to consumer (C2C) or machine to machine (M2M) – as well as heterocentric, such as business to consumer (B2C) or service to agent (S2A) for agent, business, consumer and machine or service.

These five applications and services domains are totally immersed in an environment more and more influenced by major societal impact such as but not just limited to:

- Health;
- Ageing population;
- Urbanisation;
- Environment;
- Knowledge;
- Security and safety;
- Globalisation; and
- On the move.

This total immersion will directly affect the way applications and services are developed and proposed to customers. Conversely, this will give rise to many new market opportunities. The importance of sociologists in analysing these impacts is key.

In each of the applications and services domains, the societal issues will be developed; the part related to health, shown in a section below, is a good first example; it shows that domains are not independent 'silos'.

For each of the domains, after a short definition to illustrate the coverage, a template summarises identified sub-categories with for each the definition used to characterise it. And, in the document, a scenario is elaborated from each characteristic or from a combination of them that illustrates a large but perhaps not totally exhaustive list of technologies developed in Chapters 6 to 10.

THE CATEGORIES OF SOFTWARE TECHNOLOGIES

In each technology chapter, the main challenges are identified and, for each, a few main generic technologies have been expressed and their development positioned roughly in time – short, mid or long term – within the time frame of RM-3.

Today, however, the success of a new technology or even a nice combination of technologies – not only based upon software but also hardware often associated and synchronised with external conditions such as the 'Rendezvous'; regulation being typical – can no longer be transformed into a business achievements by themselves. The success will come from the applications and services that can be generated from them by marketing effort and by the way technology appears mandatory but must remain transparent.

In a specific chapter entitled *Technologies of the Future?,* the Roadmap team proposes a few new directions that could have a major influence on the software industry as well as on software applications and services. Indeed, the future could show breakthroughs and big changes, as well as continuing development. It is necessary to prepare for this.

Figure ES-3: Enabling technology
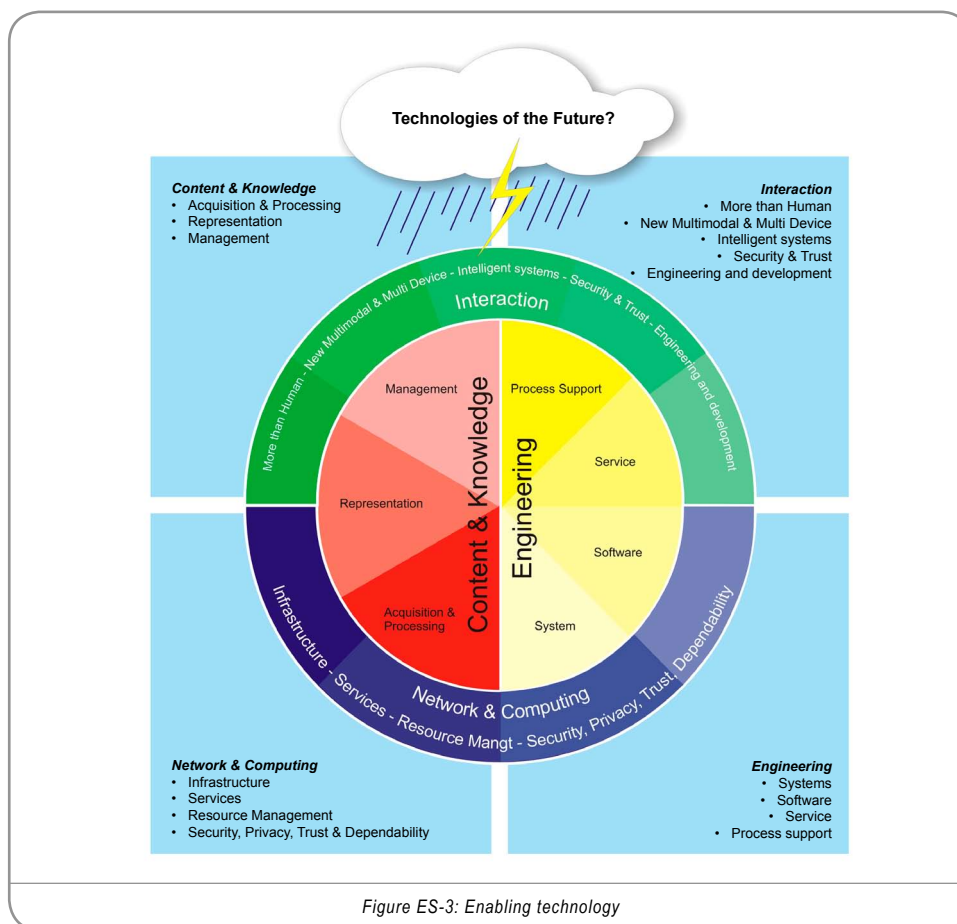
Each technology cluster is detailed in challenges and sub-challenges. In the main document the 'Rendezvous' concept illustrates external conditions which could influence the success of a specific technology while in several cases, back-up solutions are investigated.

AN EXAMPLE OF THE IMPACT ON SOCIETAL ISSUES: HEALTH

The societal impact 'health' is a generic of a real global and cross-cutting problem that should be handled from all three application domains: *Me*, *Group* or *Society*. It has been selected by the team for insertion in the introduction to illustrate the fact that the same topic can be viewed by users from different facets. This section describes the topic of health – defined

by the World Health Organisation (WHO) as: "the state of complete physical, mental and social well-being, not merely the absence of disease or infirmity" – for persons over their whole life, from conception to grave in a cross-domain context. Citizens are supported towards self-management in keeping healthy through prevention and avoiding relapses after a chronic disease has been treated. Healthcare professionals are supported in giving the optimal care in screening, diagnosis, treatment and post-event follow-up.

Healthcare institutes working at the frontline in the health area are starting to adopt an approach called the 'care cycle'. The essence is that the complete care process is focused on the patient and his or her specific disease. This is in sharp contrast with most approaches to date, which are organised around disease and function, through which the patient needs to navigate. To support such a care-cycle approach, technologies are involved inside and outside the hospital to prevent, diagnose, treat and monitor diseases.

In practice, people go through more than one care cycle during their lives and sometimes are in more than one care cycle in parallel, where information from one care cycle, either in the past or parallel in time, might be relevant in another care cycle. Health-management systems should cope with this complexity.

This may take a person through different stages of support from self-management, to informal care and professional care, depending on the state of health or severity of the situation. This will be applicable particularly to assisted living for the elderly and support for chronically ill people.

IMPORTANT THOUGHTS ON SOFTWARE-INTENSIVE SYSTEMS AND SERVICES

The way the digital world[2] can enhance the real world is a topic that deserves some further exploration. The increasing amount of software together with the presence of the Internet is pushing a global convergence of previously isolated domains. A new scenario is emerging in which the digital component is increasing. This has important implications as the convergence process is creating some sort of global digital world – without geographical boundaries – in which different innovation rules, not yet fully understood, apply.

In general, a 'world' can be defined in terms of the entities, the rules defining their interactions and environment in which they evolve.

	ENTITIES	LIFE AND INTERACTION	ENVIRONMENT	INNOVATION POTENTIAL
Real world	Physical: real life objects	Defined by physical laws – some still unknown	Physical space	Strongly limited (time, space …)
Digital world	Immaterial needing specific transducer for representation: digital data structures	Definable by software logic	Execution environment	Limits unknown – constrained by the execution environment and some basic physical laws such as speed of light and size of molecules

An exponential expansion of the execution environment – i.e. computing, communications and storage – will lead the digital world to demonstrate its innovation potential as a consequence of differentiating attributes of the digital entities when compared with the real ones.

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2)   In this section, 'virtual' is often associated with digital which is a mathematical representation of the world; virtual is here either the digital model of the real world or a pure software logic.

The expansion of the execution platform makes more visible the differentiating attributes of the digital entities and their strengths for easy:

- Creation and modification – with digital entities too;
- Replication;
- Distribution – removing space limitation;
- Adaptability;
- Increasing added value through combination – from data to information to knowledge; and
- Speed of evolution and processing – removing time limitations.

Furthermore, we develop two interrelated directions of thought that are very important to consider when defining a successful business strategy. This is particularly true for companies proposing software tools, and software infrastructure realisations to the market:

1. The economy behind software and software-intensive services and systems; we characterise the various kinds of software and related business models.

   Business models for software, usually for the category 'software as a product', might vary quite a lot; some examples are:

   - Free software: software made available free of charge, often to knowledgeable users;
   - Open-source software: software made available free of charge to users and developers. Developers are often requested to make improvements available free of charge, but sometimes for commercial use, some license fee is requested;
   - Selling or licensing the software commercially;
   - Services around the software such as testing, packaging, documentation and support: for commercial software, this is often included in the licensing agreement; for open-source software, this is often offered as a service. In some cases commercial software is transformed into open-source software to relieve the company from a maintenance burden and concentrating on services around the product; and
   - Software as a service has its own business model of offering software to users, relieving the users – individuals, SMEs or large companies – from operational responsibilities and optimises total cost of ownership.

2. We also show that, while maturing, the economy organises itself around 'ecosystems', characterised by provider-customer relationships based on more or less generic platforms, which group some infrastructure and basic services with a set of tools, and around which a wide service creation and provision economy can be built.

While maturing, software markets organise themselves as a complex set of actors mutually providing and using software components, called an 'ecosystem'. These ecosystems can be organised around a single actor, in general at the end of the food chain, or around a category of such actors – e.g. from the same industrial branch.

However, at their maturity, they are often organised around a 'platform', which brings together an execution platform and tools for developing applications on this platform. The execution platform can include some hardware. The existence and wide adoption of this platform creates a vast market for applications, services and components sold to end users.

CONCLUSION
The ten chapters of this document are a contribution to the effort made by several ITEA 2 founding companies to deliver a major revision of the Roadmap (Version 3) in line with the ITEA 2 programme launched in 2006.

Trying to extract some generic conclusions covering these several chapters representing such an important effort will of course be partial but the team proposes four main directions:

1. Even if Moore's law may remain valid for a few more years from the technological point of view, some other factors might limit its applicability. For example, the investment cost to develop and manufacture next-generation technologies could become so high that only a very few consortia can afford it and, as a consequence, the number of available semiconductor production factories will be very limited; the industrial risk will then turn out to be very high and probably unacceptable for high-end products. Are there solutions to bypass or avoid this difficulty?

2. Large systems and systems of dynamically-configured systems, aimed at addressing very high complexity and/or accommodating a multitude of various 'users', need specific attention. How do we proceed from experimental set-up to deployment and then full scale that fulfils all possible and necessary 'illities' with a maximum of updated societal constraints? Put in general terms, we have a fundamental *system design* issue.

3. The software industry is different from many other industries because the investment cost is mainly based upon up-to-date human competence, and so seems limited – indeed, it is very high. The potential success of a product, system or service relies only on the people who have the capacity to formulate, define, design, develop, update, maintain and support the systems, manage the project and train the users. Do we have today a sufficient number of such specialists in Europe and what about our future needs?

4. The move toward a full information and knowledge society gives the software industry, or industries using software as one of their tools, a very challenging position to contribute largely to understanding the new societal requests and to propose innovative and solvent practical solutions. Will that be the leverage to the future?

RECOMMENDATIONS FOR THE PROGRAMME

After more than ten years of existence, the ITEA Programme launched to serve the European industry with the proactive and efficient support of public authorities belonging to the EUREKA countries has demonstrated its ability and flexibility to organise projects over time by mapping the projects in clusters, the result of which have been visible in the market some years later.

This evidence can be illustrated by several industrial successes from large industry as well as from SMEs. A document describing in more details a list of such marketing successes will be published by the ITEA 2 office. The merit of having several entities, large industries, SMEs, research centres and academia putting in common their experience and knowledge during the pre-competitive phase of a project shows by these examples that it does not preclude them from competing aggressively later in the market with products or services coming from their previous common efforts. This spirit has also been the foundation of the Competitiveness Centres ('Pôles de compétitivité') as they exist today in France, the Netherlands or, slightly differently, Germany and Spain.

For the future, with the experience that ITEA has acquired, it should be very helpful to continue such mapping of projects for an identified end-to-end goal and ecosystem to show and share year after year with the ITEA open community the gaps which are detected while at the same time being able to justify the overlap that could also be documented.

At the same time, a project could also be a new research and pre-development area; it is the goal for ITEA 2 – as an industry-driven programme – to detect and promote such new directions that could be the basic foundations for a future success. One example deals with expansion of the realm of software and services to new areas. We know that when translated into service markets, Moore's law relies on a virtuous mutual financing scheme between infrastructure – all required hardware, basic software and networking – and services. Booting up this loop requires that future competitors on services agree and find a way to initiate the building of the infrastructure. This issue comes back recurrently in each new domain opened by technological advances, such as today in embedded systems, ambient intelligence and the Internet of things. Basically, European industry needs the analysis and organisation capability to be at the forefront of these evolutions when they occur.

THE ROADMAP 3 WORKING GROUP TEAM

The process to create this Roadmap was based on consensus. The ITEA 2 companies nominated experts to the core team elaborating the document. All in all, more than 75 specialists and young talents in various industries and from major European universities and large research centres contributed to the development and validation of this document.

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