The FInES Paradigm Shift: From Resource Management and Planning to Enterprise Innovation Driver

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In this paper we address one of the key issues reported in the FInES (Future Internet Enterprise Systems) Research Roadmap[1], namely, the paradigm shift that the architectures of enterprise systems (ES) need to undergo in the next decade. Such paradigm shift is primarily motivated by a repositioning of the aims of enterprise systems that, the since their inception, have been conceived to support the management and planning of enterprise resources. Payroll, inventory management, and accounting have been the first application areas. Then, ES progressively expanded their functions and aims, but the underlying philosophy remained the same: supporting the value production in the day by day business, optimising operations and the use of resources, with look ahead capabilities (i.e., planning). In the recent period there has been a clear movement towards a progressive commoditization of such traditional ES functions. This movement is further facilitated by the evolution of infrastructures and technologies, starting from Cloud Computing and Future Internet, and, on top of those, the Software-as-a-Service (SaaS) paradigm that is progressively providing new ways for enterprises to conceive and realise their automation systems.

In essence, while the automation of enterprise management and planning functions will be increasingly easy to acquire, the business challenge in the future will be progressively shifted towards the support to enterprise innovation. But also innovation cannot remain as it has been: Future Internet, Web 2.0, Social Networking, and similar emerging forms of distributed, open computing will push forward new forms of innovation such as, and in particular, Open Innovation [Ches03]. The achievement of systematic innovation requires to orientate the research towards new, cross-domain fields, in particular promoting renewed synergies between business and ICT experts. Hence, on the ICT side, architectures and implementation technologies need to continue evolving along the lines already shown in the last period, having three grand challenges in mind.

The first grand research challenge (GRC) aims at surrendering the mastership of ES development, shifting it from ICT to business experts; this implies a step back for the former, accepting their ancillary role in the area of enterprise applications. But to do that, the ICT domain needs to push forward the release of ES development environments (ESDE) specifically conceived to be used by business experts. Such ESDEs will be able to separate the specification and implementation of (i) business logic from the (ii) specific business functions and, finally, their (iii) implementation. A central role will be played by Business Process Engineering, for the above point (i), and a new vision in the implementation of enterprise resources automation, for the last two points.

The second great research challenge concerns the architecture of the Future Enterprise Systems (FES) that need to deeply change with respect to the way the majority of enterprise software architectures appear today. A new paradigm is somehow already emerging nowadays, e.g., with the different articulations that Future Internet Systems (FIS) are assuming. In particular, we may mention, among others: the Internet of Services (IoS), Internet of Things (IoT), Internet of Knowledge (IoK), Internet of People (IoP). But these solutions need to further evolve towards a better characterisation in the business direction, allowing different aspects of the business reality (functions, objects, players, etc.) to acquire their networked identity, together with a clear and precise definition (i.e., science based) of their capabilities and mutual relationships. Furthermore, what is missing today is a unifying vision of the disparate business aspects and entities, supported by an adequate theory and then befitting technological paradigms. All possible entities composing an enterprise will have a digital image (a sort of 'avatar') that will be referred to

[1] http://cordis.europa.eu/fp7/ict/enet/documents/task-forces/research-roadmap/

as Future Internet Enterprise Resource (FInER) in this paper. So, the second grand research challenge consist in conceiving new, highly modular, flexible FInER based ES architectures.

Finally, there is a third grand research challenge, that of shifting the focus of the attention from the management and planning of business and enterprise resources to the innovation. This GRC requires, again, a strategic synergy between ICT and business experts. Then, from the ICT point of view, the need to develop a new breed of functions, tools, software packages, interface and user interaction solutions that are not available at the present time.

In this paper we intend to further elaborate on these challenges. In particular on the second GRC that concerns the conception and implementation of a new breed of ESs capable of offering to the business community software architectures characterised by a greater flexibility and evolvability, and a new paradigm for composing complex business artefacts starting from simpler ones. These software architectures will mirror the enterprise architectures. With this respect, a number of ICT solutions are already emerging: from Cloud Computing to Social Networking, from RFID to Service-oriented Computing, from Business Process Engineering to semantic technologies, from mashap to SaaS. An exhaustive analysis of the mentioned technologies is outside the scope of this short paper, below we will briefly outline the principles driving an innovation-oriented ES, based on FInERs.

1. An Architecture of a FInES

With the idea of a continuous innovation process going on in parallel to the everyday business activities, a FInES needs to integrate the two level: doing business and pushing forward innovation, constantly evolving along a loop similar to that represented in Fig. 1. From the architectural point of view, a FInES is seen as a federation of systems relaying on two major infrastructures for the advanced management of knowledge and interoperability. The figure reports four systems identified by the same numerals reported in the FInES Research Roadmap, but the prefix here is the letter 'S' to indicate the systems and 'I' to indicate the infrastructures (instead of 'RC' for research challenge). The macro-architecture is briefly described below along the line of what is reported in the cited research roadmap (where additional details can be found).

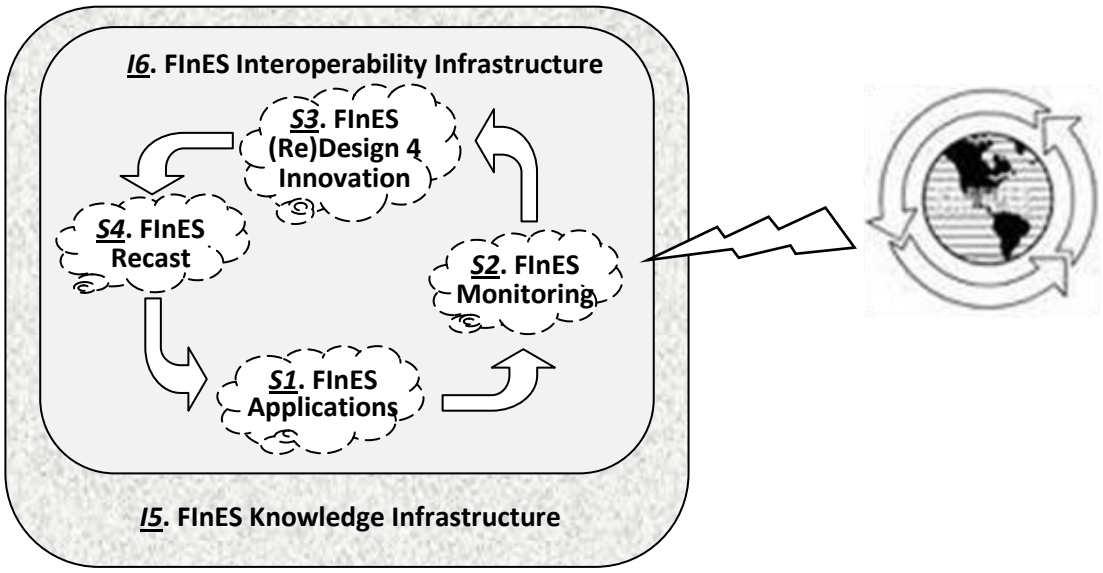

Fig. 1 - FInES Macro-architecture

S1 – FInES Open Application System

This system is devoted to the business operations for the day by day business and value production, with planning capabilities. In terms of functionalities it is similar to an ERP as we know it today, but its architecture is inherently different, since it is built with a clear separation of the business logic and enterprise strategies on the one hand and the business functions and operations on the other. The former are defined by business experts mainly using Business Process Engineering methods and tools, the latter are offered by a vast library of FInERs, both developed internally, ad hoc, and acquired from external providers.

S2 – FInES Open Monitoring System

This system is dedicated to the constant monitoring and assessment of the activities of S1, to keep under control the health of the enterprise, its performances, both internally (HR, resources, productivity, targets, etc.) and with respect to the external world (markets, competitors, etc.). Furthermore, the external world is also systematically watched to keep under control the general trends (e.g., cost and availability of natural resources, raw materials, financial markets, etc.) and to identify new opportunity of innovation (new methods, tools, technologies, but also new markets, new alliances, etc.). The S2 is able to maintain also a number of alerts and alarms to notify both opportunities of innovation but also threats and critical situations. For this system it is particularly important a constant open communication with the rest of the world, as exemplified in the figure.

S3 – FInES Re-design System

This system is mainly used by business expert to identify the areas where it is necessary / suitable to intervene to innovate the enterprise, and therefore its FInES components (FInERs) and architecture. The S3 offers a collection of tools aimed at supporting the expert to precisely identify where to intervene and what kind of interventions they intend to achieve. Such a varied and rich gamut of tools include BP engineering environments, recommendation systems, simulators, advanced enterprise 'probes', and various dashboards. All such tools are essential to support the business experts in their redesign activities that is, and will remain, largely a 'brain intensive' job.

S4 – FInES Recast System

This system has the critical task of implementing the new specifications identified and released by S3. The activities of S4 can be seen roughly divided in two phases. The first phase is focused on the identification and acquisition of the new components that will be used in the second phase. We will consider that such components will essentially be FInERs, both found on the market or developed ad hoc. The second phase is the reconfiguration of the existing version of FInES with the new FInERs. In many cases, the FInERs will be acquired together with a new real world enterprise resource and it will have advanced capabilities of self adapting in the FInES. For instance, having acquired a new drilling machine, when it is positioned in the shop floor of the enterprise, it will connect to the Internet, present itself, and upload to the right 'master controller' all the needed information (e.g., its characteristics), with a sort of "plugh 'n work" mechanism (similarly to what happens today with a new peripheral in your computer). Updating a FInES is a particularly delicate job, since the changes need to be achieved without stopping the business activities.

I5 – FInES Knowledge Infrastructure

The FInES knowledge infrastructure (FKI) is inherently different from what is considered a Knowledge Management System today. In fact, rather than storing actual content, FKI is a meta-knowledge system, since the actual knowledge is fully distributed within and outside the enterprise. Inside the enterprise, the

knowledge is mainly stored and maintained by the FInERs components. Despite the 'fuzzy boundaries' of an enterprise, it is possible to (in principle) identify the relevant knowledge, externally produced and maintained, with respect to the 'internal knowledge'. FKI will maintain a complex, networked structure, conceived as an evolution of the Linked Open Data[2] of today, as a sort of hyperconnected, semantic directory aimed to support searching and inferencing over the indexed knowledge. To be effective, providing advanced semantic services, such a networked infrastructure needs to be connected to a federation of ontologies, both locally (to the enterprise) and globally maintained.

I6 – FInES Interoperability Infrastructure (FII)

A FInES is characterised by a great variety of components, services, tools, platforms, resources, produced by different providers and acquired in different moments. Furthermore, its inherent need for a continuous evolution requires a powerful, sophisticated infrastructure capable to accept, accommodate, and support the seamless cooperation for such a great gamut of components. The key aspect here is the capacity of "plug 'n work" for new resources, in particular FInERs, in similar way to the "plug 'n play" of today peripherals in a PC. This crucial facility can be achieved when the FInERs have a standard way of introducing themselves, providing to the FII all the (operational, but also semantic) details necessary to the full integration of the new component in the FInES. Then the newly acquired FInER will be integrated and made visible to the rest of the FInES and, once 'plugged in', operationally capable of providing its services, as well as acquiring the services it needs for its duties.

2. The new frontier for components: the FInER approach

Zooming in the systems illustrated in Figure 1, we can see that component-oriented engineering has been pushed to an extreme. Such an approach is fully applied throughout the FInES both horizontally (i.e., for different classes of applications and functions) and vertically (at different levels of granularity). But the most relevant aspect is the large role played by a new breed of components: FInERs (Future Internet Enterprise digital Resources), i.e., business and enterprise entities that have a double nature: a business nature, since they are understood and recognised by business people as constituent parts of the enterprise, and an ICT nature, since a FInER has a digital image characterised by 4 aspects: a unique identity, a processing capability, a memory, and a networking capability. Apart from the identity that is defined according to a precise, universally accepted standard (such as URI, IPv6, or ENS[3]), the other three ICT features can greatly vary, from very simple FINERs (e.g., a pen) capable simply of providing their identity (along with its sort, date of production, and few more details) when solicited, to very complex FInERs. The latter are fully aware of their nature, components, capabilities, and are able to carry out complex interactions with other FInERs, enacting articulated business processes, self-monitoring their own activities, as well as the evolution of the context, and making decisions when necessary.

FInERs can be concrete, tangible entities, such as a drilling machine or an automobile, or intangible, such as a training course, a business process, or a marketing strategies. FInERs are conceived to interact and cooperate among themselves, in a more or less tight way (alike to real world business entities do). We distinguish loose cooperation, when each FInER has a clear autonomous identity and can participate in different orchestrations, to tight cooperation, to integrated assemblies. The last case is the extreme where a FInER can exist only if all its parts are present and operational (and viceversa). A complex organization, such as an enterprise, is itself a FInER.

[2] http://esw.w3.org/SweoIG/TaskForces/CommunityProjects/LinkingOpenData

[3] ENS: Entity Name System, proposed by the OKKAM project (www.okkam.org)

As a first categorization of FInERs, is recapped in the following list:

- **Enterprise**, being the 'key assembly' in our work.
- **Gov organization**, seen in its interactions with the enterprise.
- **People**, a special class of FInERs for which avatars are mandatory.
- **Tangible** entity, from computers to aircrafts, to buildings and furniture.
- **Intangible** entity, for which a digital image is mandatory.

For a more extensive description of FInERs please refer to the mentiond FInES Research Roadmap.

3. Conclusions

At the beginning of the 80s, the SUN had a visionary catchphrase, summarised in the sentence 'The Network is the Computer'. As it happens with early intuitions, it took too long to happen and now few remember this foretelling. Actually, current ICT achievements show that this is going to be fully achieved in a short term to go. The next prophecy we propose is "the Enterprise is the Computer", meaning that an enterprise, with all its FInERs deployed and operational, will enjoy a fully distributed computing power, and the idea of a computer as we know it today will be absolutely marginal. But moving from the SUN's vision of 30 years ago to the FInES vision is not a natural evolution, it is a disruptive change, from both a technological point of view and a business perspective. In particular, in the latter, business people will be involved in building and maintaining large computing solutions simply interacting with a familiar (though technological enhanced) business reality. Along this line, the (in)famous business / IT alignment problem will simply disappear, since the gap has been solved at its roots.

We are aware that the vision presented in this paper is a long term one, however, we believe that it will advance progressively and in the next years we will see an incerasing integration of technologies that today are still loosely connected (e.g., IoT, IoS, Multi-Agent Systems, Cloud Computing, Autonomic Systems) and, in parallel, some key areas of the enterprise that will start to benefit of the FInES approach.

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