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A Classification of Future Internet Enterprise Systems Projects

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Abstract. In a world where the technological progress has surpassed even the most imaginary predictions and the financial crisis presents unprecedented challenges for enterprises, Future Internet Enterprise Systems (FInES) can be an important enabler for boosting enterprise competitiveness, innovation and sustainability. This paper aims at investigating the landscape of projects in the domain of FInES in order to gain insight in the commonalities of their research directions. By synthesizing a classification basis along the FInES and the EISB (Enterprise Interoperability Science Base) dimensions, all completed and running projects have found their positioning in the classification scheme that has been also visualized in an interactive map. The features of a typical FInES project have been highlighted, leading to conclusions that highlight the need for constantly updating the projects' mapping to depict their advancements and for closer engagement and validation of results by the projects' members.

Keywords: Future Internet Enterprises Systems, FInES, EISB, Enterprise Interoperability, Scientific Areas, Classification, EU Projects

1.1 Introduction

In light of a rapidly changing world in which disruptive technologies and societal challenges have revolutionized the way people communicate, collaborate and innovate, the name of the game for enterprises has completely changed. The Internet has undoubtedly permeated and transformed all aspects of our economies and societies [9]. However, it was never designed for how it is now being used and is creaking at the seams [4]. To address the inherent limitations of the underlying internet, the Future Internet (FI) has gained significant research momentum. It is expected to be a holistic communication and information exchange ecosystem,

which will interface, interconnect, integrate and expand today's Internet, public and private intranets and networks of any type and scale, in order to provide efficiently, transparently, interoperably, timely and securely services (including essential and critical services) to humans and systems, while still allowing for tussles among the various stakeholders without restricting considerably their choices [3].

In this context, Future Internet Enterprise Systems (FInES) is one domain of the overall FI research field, supporting enterprise competitiveness through Internet technologies. Research in FInES primarily targets business value innovation in open paradigms, to be structurally embedded in future enterprise systems. The final outcome should be a new and sustainable infrastructure for enterprises at the European level, including SMEs and the manufacturing industry, a new generation of technologies in support of applying the Internet developments to the enterprise space ("Enterprise 3.0" and beyond), methods and tools to support knowledge sharing within business ecosystems (Clouds, Clusters, etc.) and new scientific foundations to produce FInES offerings that are rested on and subject to the rigour of science, according to the FInES Position Paper on FP8 orientations [6].

This paper aims at investigating the landscape of the FInES research projects along their advancements on Enterprise Interoperability and their contribution to meeting the FInES strategic directions. It proposes a classification framework and maps the projects to multiple facets which are also visualized in an interactive way [10]. In particular, the structure of the paper is as following: Section 2 outlines the methodology applied in the context of this paper giving way to Section 3 that identifies the FInES projects portfolio. Section 4 defines the various classification dimensions. Section 5 presents the findings upon mapping the projects leading to concluding remarks in Section 6.

1.2 Methodology

In the European Union, various approaches (i.e. 0, [14]) trying to classify project results have emerged in order to recognize their shared research directions. Such works are typically based on the distribution of questionnaires to the appropriate stakeholders, the conduction of interviews or online workshops and the aggregation of the results. Recently, though, more collaborative methods, which are, for example, based on folksonomies for collaboratively creating and managing tags to annotate and categorize content [13], have gained attention.

The approach adopted in this paper is guided by the following driving principle: a classification by external - to the project - observers should be initially conducted in an objective manner to the extent that this is possible. At a later stage, this initial classification will be extended to bring together a folksonomy in which the projects will try to position their scope and results with keywords they define and that will be then aligned with the existing classification keywords.

In order to effectively classify projects across multiple dimensions, the following steps have been undertaken:

1. Investigation of the FInES Portfolio in order to identify the ongoing and completed projects.

2. Creation of a Knowledge Base for the projects based on desk-research. During this step, the public results of each project are retrieved and studied in order to familiarize with their scope and main directions.
3. Elaboration on the appropriate sources for the classification criteria.
    - For the FInES (Future Internet Enterprise Systems) dimension, the relevant research categories and topics have been recognized on the basis of the European Commission documents (Work Programmes and the corresponding Calls related to the FInES domain) [2], [11]. It was decided that the FInES Research Roadmap 2010 [5] should not be used, since it is mainly concerned with future R&D objectives, while the purpose of the proposed classification is to study the current landscape (at present time) [7].
    - For the EISB (Enterprise Interoperability Science Base) dimension, the relevant scientific areas have been proposed by focusing on the real object of observation, which is the "Enterprise", and by analyzing it in its core components to identify the interoperability needs within them. The existing interoperability layers (i.e. organizational interoperability, semantic interoperability, technical interoperability) have not been reused, as there is no consensus reached among researchers, the various layers define in high level the necessary stack for interoperable systems and often are interconnected among themselves.
    - For the Generic dimensions, criteria like the Consortium Partners, Number of Countries represented, and Funding Scheme, that can be easily retrieved from the projects' websites have been selected.
4. Synthesis of a classification basis with the research categories and topics, as well as with the scientific areas.
5. Definition of a common glossary in order to ensure common understanding of the key underlying terms. Such a glossary can be constantly updated as it is maintained in a wiki.
6. Mapping of projects on the FInES and EISB dimensions after careful study of the Knowledge Base.
7. Visualization of results with the help of the debategraph functionalities.
8. Ongoing online deliberation of the classification results with the corresponding projects.

1.3 FInES Projects Portfolio

During the last decade, the European Commission has funded research in the areas of Enterprise Software, Enterprise Interoperability and Collaboration applicable to enterprises. More than 30 projects spanning the FP5, FP6 and FP7 Framework Programmes, as well as the CIP programme, involving research institutes, industrial players and SMEs across Europe, have been implemented or are still ongoing. The following figure depicts the overall FInES Cluster projects portfolio.

Fig. 1.1: FInES Cluster projects

1.4 Classification Dimensions

1.4.1 FInES Dimension

As far as the classification along the FInES dimension is concerned, the identified topics together with the main category they belong to are presented in the following table:

Table 1.1: FInES-related Classification

Category	Topics
Virtual Enterprise Environments	Distributed, adaptive and interoperable virtual enterprises Real-time management of volatile manufacturing assets Internet-based, user-centric collaboration and sharing for the networked enterprise Virtual worlds and Mixed-reality powered enterprises Innovative dynamic composition of business services
Factories of the Future	Holistic modelling and simulation of full complex products and processes Efficient and sustainable lifecycle management of products and services New manufacturing business models and practices
Collection and Distribution of Intelligence and Knowledge	Advanced collective intelligence Ambient intelligence Automated resource search and discovery Semantically-enriched, context-aware and reusable business knowledge Real-time and highly dispersed knowledge management

Category	Topics
	Visual analytics
Internet of Things	Integration of virtual and physical worlds Distributed networked devices Open protocols and standardization Smart objects
Software Architecture and Services	Interoperability Service Utility (ISU) Service Management and Engineering Multi-channel Service Delivery Open, federated Service Architectures and Platforms Cloud Computing Advanced Software Engineering
Trust security and Identity Management	Trust, Identity Management and privacy enhancing policies Trust policies for managing and assessing risks Trustworthy and secure end-to-end service infrastructures Trustworthy ubiquitous network infrastructures

1.4.2 EISB Dimension

Enterprise Interoperability is defined as the capacity of two or more enterprises, including all the systems within their boundaries and the external systems that they utilize or are affected by, in order to cooperate seamlessly, over a sustained period of time to pursue a common objective [8].

In order to classify and reuse knowledge in the domain in a systematic way within an Enterprise Interoperability Science Base (EISB), twelve scientific areas [12] have been defined by focusing on the real object of observation, which is the "Enterprise", and by analyzing it in its core components to identify the interoperability needs within them. An Enterprise, as defined in [15] is "…an organization designed to provide goods, services, or both to consumers." The main ingredients of such a system are the following: Infrastructures, Data, Processes, Policies and People.

Table 1.2: EISB-related Classification

Scientific Area	Definition
Data Interoperability	The ability of data (including documents, multimedia content and digital resources) to be universally accessible, reusable and comprehensible by all transaction parties (in a human-to-machine and machine-to-machine basis), by addressing the lack of common understanding caused by the use of different representations, different purposes, different contexts, and different syntax-dependent approaches.
Process Interoperability	The ability to align and connect processes of different entities (enterprises), in order for them to exchange data and to conduct business in a seamless way.
Rules Interoperability	The ability of entities to align and match their business and legal rules for conducting legitimate automated transactions that are also compatible with the internal business operation rules of each other.
Objects	Objects interoperability refers to the networked interconnection of

Scientific Area	Definition
Interoperability	everyday objects. Devices or hardware components interoperability can be seen as a particular case of the object interoperability domain.
Software Interoperability	Software Interoperability refers to the ability of an enterprise software application to work with other enterprise software application.
Cultural Interoperability	The degree to which knowledge and information is anchored to a unified model of meaning across cultures.
Knowledge Interoperability	The ability of two or more different entities to share their intellectual assets, take immediate advantage of the mutual knowledge and utilise it, and to further extend them through cooperation.
Services Interoperability	The ability of an entity to seamlessly and automatically discover, aggregate and utilise a service that belongs to another entity.
Social Networks Interoperability	The ability of enterprises to utilise social networks for collaborations and interconnection purposes, by aligning part of their internal structure and functions to the characteristics of the social networks.
Electronic Identity Interoperability	The ability of different eID systems to collaborate in order to automatically authenticate entities and to pass on security roles and permissions to eID holders, regardless the system that they originate from.
Cloud Interoperability	The ability of cloud services to be able to work together with both different cloud services and providers, and other applications or platforms that are not cloud dependant.
Ecosystems Interoperability	The ability of instant and seamless collaboration between different ecosystems, ecosystems and independent entities, entities within the ecosystems and the ability of different independent entities to formulate virtual structures for specific purposes.

1.5 Classification Findings

Upon classifying the various projects in multiple dimensions, it can be easily concluded that the major percentage of the FInES projects (over 74 percent) is classified in three categories: “Virtual Enterprise Environments”, “Software Architectures and Services”, and “Collection and Distribution of Intelligence and Knowledge”.

Table 1.3: All projects Participation Percentage in FInES Categories

FInES Categories	Participation Percentage
Virtual Enterprise Environments (VEE)	20,48 %
Factories of the Future	6,02 %
Collection and Distribution of Intelligence and Knowledge	17,47 %
Internet of Things	9,04 %
Software Architectures and Services	36,75 %
Trust, Security and Identity Management	10,24 %

As far as the EISB dimension is concerned, the following table indicates that research targeting on specific scientific areas, such as Data Interoperability, Process Interoperability, Software Systems Interoperability and Services Interoperability, was more intense in the past. With completed projects having delivered significant results in such areas, other scientific areas, such as Knowledge Interoperability, Social Networks Interoperability, Cloud Interoperability and Ecosystems Interoperability, are currently being investigated by ongoing projects.

Table 1.4: FInES Cluster Projects in the EISB dimension

Interoperability Categories	Completed Projects	Ongoing Projects
Data Interoperability	19,51 %	14,74 %
Process Interoperability	12,20 %	8,42 %
Rules Interoperability	2,44 %	3,16 %
Objects Interoperability	2,44 %	6,32 %
Software Systems Interoperability	14,63 %	5,26 %
Cultural Interoperability	3,66 %	3,16 %
Knowledge Interoperability	9,76 %	10,53 %
Services Interoperability	18,29 %	14,74 %
Social Networks Interoperability	1,22 %	4,21 %
Electronic Identity Interoperability	1,22 %	4,21 %
Cloud Interoperability	2,44 %	9,47 %
Ecosystems Interoperability	8,54 %	11,58 %
None of these	3,66 %	4,21 %

It needs to be noted that the projects ACCESS-ICT, DEN4DEK, ICT VENTURE GATE and YMIR, most of which are focusing on making research results appealing to venture capitalists, have no relevance to any of the aforementioned categories and topics and for that reason they are not calculated in the participation percentage.

With regard to the Generic dimension, the countries represented in the projects consortia mainly originate from the European Union. The highest participation in such projects comes from Germany, UK, Spain, Italy and France. The majority of the projects are Specific Target Research Projects (STREPs), few projects are funded as Integrated Projects (IPs) and even less appear under Coordination and Support Action (CSA) or Network of Excellance (NoE) funding.

Finally, taking into account the classification conducted, the main features that can be found in a “typical” European FInES project are depicted in the following table.

Table 1.5: The typical FInES project

Number of Partners	Eleven to twelve partners
Universities and Educational Institutes Contribution	1/3 of the partners
Number of countries represented	Six to seven different countries
Funding Scheme	Specific Target Research Project (STREP)
FInES Dimension: Number of Categories and Topics addressed	Two to three different categories; Five to six different topics
EISB Dimension: Number of Scientific Areas covered	Three to five different scientific areas

The classification results have been depicted in an interactive way with the help of debategraph, a visualization tool that facilitates experts think through complex topics by building and sharing dynamic, collaboratively-editable and ratable maps of subjects from multiple perspectives. Figure 1.2 indicatively recognizes the projects that are related to the "Data Interoperability" aspects.

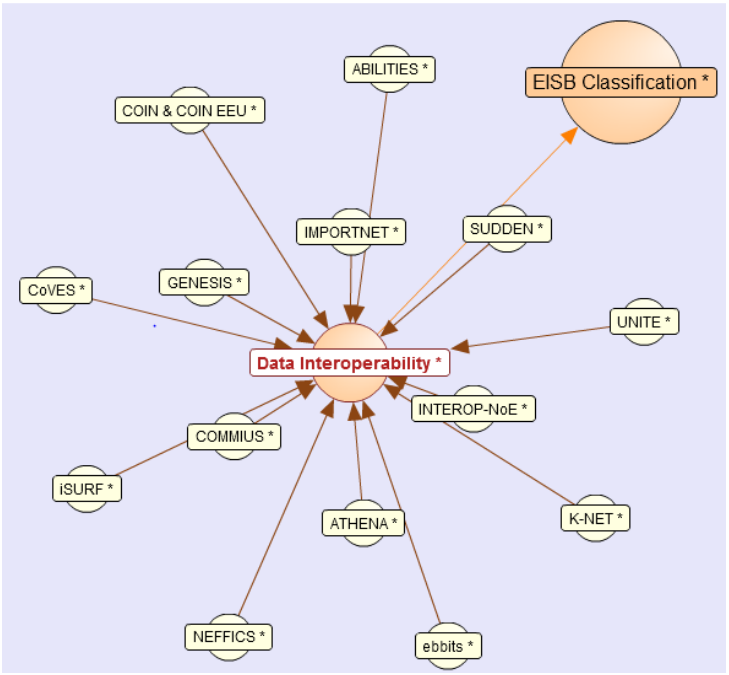

Fig. 1.2: Visualizing the FInES Cluster projects classification [10]

1.6 Conclusions and Further Steps

FInES (Future Internet Enterprise Systems) represents a highly dynamic landscape in which approaches and solutions constantly evolve in order to catch the realm of technology and markets for the benefit of enterprises. In order to map the FInES underlying projects along multiple dimensions, it is well-acknowledged that the design of a consistent representation of the FInES territory and the emerging paths in space and time cannot be static, but need to be constantly revisited to depict the latest advancements.

In general, a classification of projects based on the publicly available material, as the proposed approach in this paper, proved a particularly difficult task during the elaboration of the classification criteria and during the actual mapping of the projects. However, it has eventually offered a consistent mapping of the projects in an objective enough way in order to identify the progress of the projects towards the Enterprise Interoperability and the FInES domains.

Future steps along this work involve: (a) the creation of an online folksonomy on the top of the proposed classification that will provide the various stakeholders the opportunity to describe more precisely and with their own keywords the areas into which their project dives, (b) augmenting the projects base and continuation of the correlation analysis in order to identify important "hidden" aspects of FInES, and (c) incorporation of necessary indicators and metrics for performing impact analysis of the FInES projects.

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