# Future Internet Enterprise Systems (FInES) Standardisation Task Force Report

## Working DRAFT (Second Edition)

**Editors**
Stephen Pattenden, Telemetry Associates Limited
Robert Young, Loughborough University
Martin Zelm, INTEROP-VLab (Rapporteur)

**Contributing projects, experts and initiatives**

| Project Name | Project URL | Contributor name | Organisation |
|---|---|---|---|
| BIVEE | http://www.bivee.eu | Dogac, Asuman,<br>Pattenden, Stephen | SDRC<br>Telemetry Associates Ltd |
| COIN | http://www.coin-ip.eu | de Sabbata Piero | ENEA |
| ENSEMBLE | http://www.ensemble-csa.eu | Lampathaki, Fenareti | NTUA |
| IERC | http://www.internet-of-things-research.eu/about_iot.htm | Guillemin Patrick | ETSI |
| MSEE | http://www.msee-ip.eu | Doumeingts, Guy<br>Chen, David<br>Zelm, Martin | I-VLab<br>University Bordeaux<br>I-VLab |
| SYNERGY | http://www.synergy-ist.eu | Young, Robert | Loughborough University |
| VDML-OMG | http://www.omg.org | Berre Arne | SINTEF |

**Additional contributing experts**

| Expert name | Organisation | Expert name | Organisation |
|---|---|---|---|
| Kosanke Kurt<br>Martin Richard | ISO TC184 SC5 WG1 | Shorter David<br>Michel Jean Jacques | CEN TC 310 WG1 |

# Table of Contents

# 1 Executive Summary

There is a clear need for both improved standards for interoperability and for improved mechanisms by which the valuable results of research programmes can be exploited through standardisation. There are many teams of researchers working in Cloud Computing, Internet of Things and Semantic Enterprise Interoperability and there is a significant need to understand how, given all this activity, to turn research outputs into standards and to use both to increase global compatibility and drive the market. It is clear that if existing barriers could be removed and replaced with Interoperable Services that could utilise any intelligent object ("Thing") in a fully interoperable way then there would be significant market growth and drives towards many solutions such as the issues raised by Climate Change, Energy use and the ageing population.

While this Standards report and the Future Internet for Enterprise Systems is not concerned with specific sectors, solving the issue of general interoperability and enabling easy and intuitive creation of services and applications is a prerequisite to resolving many issues in particular sectors. Despite significant research and standardisation activity, this aspiration is still a distant one.

This report, now in its second edition, has examined the correspondence between research in the area of the Future Internet Enterprise Systems and Standardisation. It goes on to analyse these correspondences, identifies problems and issues and makes recommendations for approaches to radically improve the links between RTD and standardisation in the areas relevant to FInES.

The report looks in depth at the standardisation efforts related with Cloud Computing, Internet of Things and Semantic Enterprise Interoperability. It covers the many initiatives, projects and organisations active in this area and the ramifications of these technologies and initiatives to the Future Internet. The Report looks at standards roadmaps of NIST and the European SIENA roadmap, at relevant groups such as ETSI and CCIF, many projects and identifies a wide range of issues. Further, the report reviews Conformance and Interoperability Testing Standards and Initiatives such as the CEN/ISSSS Global Interoperability Test Bed (GITB) project.

A common feature of much of this report is that it demonstrates that while the Business to Business (procurement and documentation) area is well developed both in research and in standardisation, the more general case for the Future Internet is not.

The overall conclusion of this report is that there is an ongoing need for strong links between Research in the area of the Future Internet and Standardisation and especially where these lead to resolving market barriers and enabling significant Enterprise and Industry led growth in GDP for Europe. From the analysis undertaken the report proposes three significant actions are needed:

1. To continue to require all projects to have a standardisation plan as this ensures a close relationship between projects and their relevant standardisation groups.
2. To research the requirements of an interoperability eco-system framework that can overcome the existing fragmentation of interoperability standards and enable inter-standard interoperability.
3. To provide a funding model that enables the exploitation of project results for standardisation but against standardisation timescales.

# 2 History

The first edition of the FInES Standardisation Task Force report was published in September 2010, the history is summarised in the table below. This second edition has received major contributions from those mentioned on the cover page that have significantly enriched the content of the report and are gratefully acknowledged.

The editing team has focused on analysing the domain of standardisation for FInES, on realigning the table of content and on revisiting the individual chapters with the intent to update the knowledge to the latest state of play in standards developments. One particular effort was to focus on new developments and to identify issues which can lead to requirements for new standards in the FInES domain.

History of the FInES Standardisation TF report

| FInES Standardisation TF Report | Editors | Published |
|---|---|---|
| First Edition | Azuman Dogac (Rapporteur), Stephen Pattenden, Martin Zelm | September 2010 |
| Second Edition – Working Draft for Comment | Martin Zelm (Rapporteur), Stephen Pattenden, Robert Young | March 2012 |
| Second Edition | Martin Zelm (Rapporteur), Stephen Pattenden, Robert Young | May 2012 (planned) |

# 3 Introduction

In a climate of profound uncertainty, standardisation has an even more critical role in providing a stable foundation to facilitate innovation and ultimately deliver choice for end users[1]. As the Internet of Things[2] gathers momentum and more and more intelligent “things” appear in the systems of B2B, B2C, M2M[3] transactions and most importantly B2M (Business or service to machines) transactions, the more pressing the necessity to formulate standard frameworks for overall interoperability and for standards to enshrine the work of FinES and its related projects.

As highlighted in the Sevenths Framework Work Plan, standardisation is recognised as an important research outcome and as a visible way to promote research results. Standards are considered by the EU as an important element in the field of international cooperation.[4]

This report assesses the progress in standardisation in areas of direct relevance to FInES, identifies key issues of importance for standardisation in these areas and evaluates these in the context of requirements for standardisation and convergence with FInES.

[1] COIN IP Contribution to FInES Cluster Position Paper by Sergio Gusmeroli, Claudia Guglielmina, Man-Sze Li, Andrew Faughy, Marco Conte, ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/enet/fpp-1st-contribution-coin_en.pdf

[2] Internet of Things: an early reality of the Future Internet, Workshop Report by Maarten Botterman

[3] B2B = Business to Business Services, B2C = Business to Consumers/customers Services, M2M = Machines/Devices to Machines/Devices Services

[4] http://ec.europa.eu/enterprise/sectors/ict/files/ict-policies/2010-2013_ict_standardisation_work_programme_1st_update_en.pdf

# 4 FInES Standardisation Objectives

The objectives of FInES Standardisation Task Force is to establish the requirements on interoperability, research and existing standardisation in the area of FinES, research outputs from existing projects and raise awareness on the needs, the available standards, and of the ongoing work in standardisation:

- Contact with Groups: To establish contacts with groups (ESOs - CEN, CENELEC, ETSI, IFIP, W3C, OASIS, I-VLab, IETF, ISO, IEC and ISO/IEC JTC1 and others) and projects working in the area of interoperability
- Collate relevant work: To collect and collate relevant RTD work and existing and relevant standards, ongoing work in progress in standardisation and identify areas that could be standardised in the future as current and planned RTD projects
- Barriers and concerns: To establish a base for FinES requirements on interoperability standardisation by identifying potential barriers and concerns.
- Knowledge Base: To inform, coordinate and advise both Standardisation (the ESOs and other EU Consortia and Fora) and RTD (the current and future FP7 and FP8 projects) of each others activities and content and ensure that through conferences, seminars and workshops an understanding is reached between the two areas
- Propose standardisation plans: To propose new approaches to improve the exploitation of FInES research outcomes through standardisation plans that overcome the identified barriers. This should include suggestions for projects to be prepared to support common RTD and standardisation work as well as potentially new future activities to be funded by the EU Commission.

# 5 The Areas Addressed by FInES

FInES is a cluster of several research projects with individual objectives addressing different research areas and trying to bring together very distinct domains like future socio-technical enterprise systems, Internet ICT technologies, semantic information exchange and software service methodologies. The FInES Research Roadmap intends to capture the whole cluster in its inherent complexity.

## 5.1 Structure of the FInES Standards Task Force Report

The FInES standardisation report largely focuses on the ”Enterprsie Systems” space and the “Platforms and Applications” space as identified in the FInES research roadmap. The major areas addressed being:

1. Cloud Computing: Today’s powerful x86 computer hardware was designed to run a single operating system and a single application. This leaves most machines vastly underutilised. Virtualisation, also termed as Infrastructure as a Service (IaaS) allows users to run multiple virtual machines on a single physical machine, sharing the resources of that single computer across multiple environments. Cloud computing, on the other hand, is covered by three models offering Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), which all involve the on-demand delivery of computing resources. There is indeed a need for a common, interoperable and open set of cloud computing standards: However, if every IaaS, PaaS or SaaS provider creates their own API, then customers and developers need to learn multiple different APIs in order to engage with each provider’s service. Strategies to overcome this issue while accommodating diversity are required and need to be addressed by FInES.

2. The Internet of Things: The visibility of things through the use of Radio-frequency identification (RFID) is often seen as a prerequisite for the Internet of Things and it is in this area of standardisation that this chapter focuses. However, the scope of the internet of things reaches far beyond this basic instantiation of the Internet of Things and can be said to extend to any object or any information that can be accessed using the Internet. Under such an extended scope the IoT includes anything held in the cloud, any object or device used in any environment and any information or application. Cloud related standards which have relevance to IoT are discussed in chapter 6 while interoperability related work is discussed in chapter 8.
3. Semantic Enterprise Interoperability: This is a vast area where expertise from prior standardisation efforts has the potential to be exploited, given appropriate methods, for future benefit. In order to manage the diversity of work in this area, this chapter of the report has been divided into the three key areas of frameworks for interoperability, ontologies and semantic languages. This includes semantic Interoperability of Electronic Business Documents for realising SaaS-U[5] as well as industrial automation ontologies and methods for interoperability assessment.
4. Analysis of existing and needs for future user oriented standards in FInES. Namely to identify and to develop selected new standards and approaches to standardisation in the area of Future Internet and Future Enterprise Systems.

In addition to the main report an annex provides some information concerning projects and initiatives that may be addressing similar standardisation areas since three Initiatives related to FInES are must be acknowledged. The IERC – European Research Cluster on the Internet of Things. the Internet-Science Network of Excellence and the work under FI-PPP FI-WARE. These are presented in ANNEX Chapter 12.

## 5.2 The FInES Research Roadmap

The FInES Research Roadmap[6] is divided in four categories, called spaces, namely the *Socio-economic Space*, the *Enterprise Space*, the *Enterprise Systems, Platforms and Applications Space* and the *Enabling Technology Space*.

The Socio-economic Space represents the larger context in which enterprises operate. It includes topics such as the social responsibility of enterprises, the impact on the environment, or the value system that goes beyond the pure economic dimension

The Enterprise Space is the space addressing the main characteristics of future enterprises, the emerging business and production models, new governance and organisation paradigms, new forms of cooperation: all geared towards a continuous innovation

The Enterprise Systems, Platforms, and Applications Space is specifically concerned with the ICT solutions and socio-technical systems aimed at supporting the emerging future enterprises that will largely operate over the Future Internet. The issues delineated in this space will be aligned with business needs and rationale identified for the future enterprises

The Enabling Technology Space is the knowledge space that concerns the ICT solutions, in particular Future Internet solutions, knowledge representation, cooperation and interoperability etc which will be evolving according to their own strategies, be it enabling solutions available ‘by default’ or solutions will need to be ‘solicited’ for the purpose of FInES.

[5] COIN IP Contribution to FInES Cluster Position Paper by Sergio Gusmeroli, Claudia Guglielmina, Man-Sze Li, Andrew Faughy, Marco Conte, ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/enet/fpp-1st-contribution-coin_en.pdf

[6] The FInES Research Roadmap, V1.2, 2011

## 5.3 Specific Definitions used in this report

The table below presents selected definitions of terms, which should clarify our understanding of their content.

| Term | Definition |
|---|---|
| Interoperability | Interoperability is the ability of two or more networks, systems, devices, applications or components to exchange information between them and use the information so exchanged. Source: IEEE/CENELEC CWA 50560, 2011) |
| Enterprise interoperability: | Enterprise interoperability is the ability of enterprises and entities within those enterprises to communicate and interact effectively (CEN/ISO 11354 EN IS Part 1, 2010) |
| Enterprise (System) 3.0 | Enterprise System (ES) 3.0 is increasingly characterised by user-generated business applications developed by business experts with enterprise engineering (rather than software engineering) methods and tools. ES mashup will be largely adopted, supported by suitable platforms and tools, starting from reusable components (from smart objects to services and apps) largely available over the Internet, (Source: FInES Position paper FP 8 orientations – final. 2011) |
| Future Internet Enterprise Systems (FInES) | A specific research area of the Information and Communication technology domain funded by the European Union through the 7th Framework Programme for Research and Development (also called FInES). It states that the full potential of the Future Internet is accessible to, relevant for, and put to use by European enterprises<br>including SMEs. The Internet thus becomes a universal business system on which new values can be created by competing as well as collaborating enterprises - incumbent as well as new - through innovation in a level playing field, with sustainable positive benefits for the economy, society and the environment. [Source: FInES Cluster Position Paper, 2009] |
| Internet of Things | The Internet of Things (IoT) is an integrated part of the Future Internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network. [Source: http://www.internet-of-things.eu/ ] |
| Cloud Computing | Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.(Peter Mell et all, NIST Special Publication 800-145, 2011) |
| Interoperability Service Unit (ISU) | The Interoperability Service Utility (ISU) is a concept created by the FInES community. It denotes the overall system that provides enterprise interoperability as a utility-like capability |

| | |
|---|---|
| | which can be invoked on-the-fly by enterprises in support of their business activities. That system comprises a common set of services for delivering basic interoperability to enterprises, independent of particular IT solution deployment. [Source: Enterprise Interoperability Research Roadmap, 2006 (Version 4.0) & 2008 (Version 5.0)] |
| Ontology | A lexicon of specialised terminology along with some specification of the meaning of terms in the lexicon. From ISO 18629-1 |
| Formal or heavyweight ontology | an ontology that provides an explicit representation of the meaning of terms, using a rigorous logical axiomatisation, in order to remove terminological and conceptual ambiguities. From IST Project 2001-33052 WonderWeb: Ontology Infrastructure for the Semantic Web |

# 6 Standardisation Efforts Related with Cloud Computing

## 6.1 Introduction

Cloud computing is a monetisation model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction[7]. Cloud computing has a range of characteristics[8] and various service models.[9,10] There are also many cloud computing providers each with their own proprietary APIs. Ideally, the cloud computing market should be fair and free of monopolies and vendor/customer lock-in situations: Open specifications with standardised protocols and data formats are needed. The expected benefits are:

- Applications able to run on any cloud node
- Applications able to migrate between cloud nodes
- Contingency planning/disaster recovery
- Scalability/elasticity
- Centralised and standardised security enforcement and monitoring (intrusions, secure configurations, vulnerabilities)
- Interagency billing of resources used will self-optimise growth of cloud nodes

Alongside existing Cloud Computing providers, we are likely to see multiple smaller providers delivering specific solutions or ranges on information or services. These can only prosper with standards for identifying what is on offer and how to find it.

## 6.2 Existing Roadmaps

### 6.2.1 NIST Cloud Computing Standards Roadmap

NIST defines cloud computing as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers,*

7 http://groups.google.com/group/cloudforum/web/nist-working-definition-of-cloud-computing

8 NIST Special Publication 800-145, *The NIST Definition of Cloud Computing*, http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf

9 NIST Special Publication 800-145, *The NIST Definition of Cloud Computing*, http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf

10 http://cloud-standards.org/wiki/index.php?title=Cloud_standards_overview

*storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"*[11].

NIST foresees a Federal Cloud Infrastructure[12]. The Federal government identifies minimal standards and architecture to enable agencies to create or purchase interoperable cloud capabilities:

- Agencies would own cloud instances or 'nodes'
- Nodes would provide the same software framework for running cloud applications
- Nodes would participate in the Federal cloud infrastructure
- Federal infrastructure would promote and adopt cloud architecture standards (non-proprietary)
- 'Minimal standards' refers to the need to ensure node interoperability and application portability without inhibiting innovation and adoption thus limiting the scale of cloud deployments

NIST Cloud Computing Reference Architecture and Taxonomy Working Group has also provided "NIST cloud computing reference architecture" that depicts a generic high-level conceptual model for discussing the requirements, structures and operations of cloud computing[13]. It contains a set of views and descriptions that are the basis for discussing the characteristics, uses, and standards for cloud computing, and relates to a companion cloud computing taxonomy.

In July 2011, The NIST Cloud Computing Standards Roadmap Working Group surveyed the existing standards landscape for security, portability, and interoperability standards/models/ studies/use cases, etc., relevant to cloud computing[14]. In support of this action an inventory of standards relevant to Cloud Computing has also been compiled[15]. Using this available information, current standards, standards gaps, and standardisation priorities are identified.

In the NIST Roadmap, the cloud computing standards are divided into three categories:

- Cloud Computing Standards for Interoperability: The standards in this category are divided into two groups: Standards for Self-Service Management Interfaces that are served to Cloud Consumers to control the use of the cloud service by starting, stopping, and manipulating virtual machine images and associated resources; and Standards for Functional Interfaces which are the interfaces provided to client applications for their functional purpose. The functional interfaces for IaaS are very much tied to the architecture of the CPU that is being virtualised. This is not a cloud-specific interface and the de facto CPU architectures are used for this purpose. The functional interface of a PaaS offering is a runtime environment with a set of libraries and components to which the application is written which could be offered in different programming languages. For SaaS offering, the functional interface is the same as the application interface of the software itself, there are many different standards used for this purpose (to achieve interoperability between what is essentially a Web server and the user's browser) which are not cloud-specific such as IP (v4, v6), TCP, HTTP. SSL/TLS, HTML, XML, REST, Atom, AtomPub, RSS, and JavaScript/JSON. Apart from these, there are standardisation efforts that are specifically initiated to address interoperability issues.[16]

---

11 http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf

12 http://csrc.nist.gov/groups/SMA/ispab/documents/minutes/2008-12/cloud-computing-standards_ISPAB-Dec2008_P-Mell.pdf)

13 http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf

14 NIST Cloud Computing Standards Roadmap (NIST Special Publication 500-291), http://www.nist.gov/manuscript-publication-search.cfm?pub_id=909024

15 http://collaborate.nist.gov/twiki-cloud-computing/bin/view/CloudComputing/StandardsInventory

16 NIST Cloud Computing Standards Roadmap (NIST Special Publication 500-291), http://www.nist.gov/manuscript-publication-search.cfm?pub_id=909024

- Cloud Computing Standards for Portability:[17] One of the main focus of Portability standards for cloud computing have been workload portability. These standards aims to provide portable meta-data model for the distribution of virtual machines (systems) to and between virtualisation and cloud platforms to enable the portability of such packaged workloads on any cloud computing platform. Another aspect of portability in the cloud environment is that of storage and data (including metadata) portability between clouds, for example, between storage cloud services and between compatible application services in SaaS and PaaS layers.

Cloud Computing Standards for Security: These standards aim to ensure the confidentiality, integrity, and availability of information and services hosted over the cloud.[18]

### 6.2.2 The SIENA European Roadmap

The first iteration of the SIENA European Roadmap[19] on Grid and Cloud Standards for e-Science and Beyond was released at Cloudscape III in March 2011. The document gives insight into e-Infrastructure requirements and technology, as well as the invaluable role that standardisation and interoperability have for the successful application of distributed computing. The importance of international co-ordination is also highlighted with important links to the US National Institute of Standards and Technology (NIST) helping to build coordination on the development of standards for Cloud computing. Finally, the roadmap sets out a number of recommendations including the undertaking of determined and targeted efforts to discourage fragmentation, and to encourage and participate in the development of an adequate set of structures - both organisational (e.g. governance, single sign on, etc.) and technical (e.g. open standards, security, software, etc.) to ensure the interoperability of future European e-infrastructures for research and e-government.

SIENA European Roadmap on Grid and Cloud Standards for e-Science and Beyond also includes use cases and position papers collected for the Cloudscape III event, serving primarily as a sample of the cloud computing landscape. The challenges highlighted were discussed at Cloudscape III and were fed into the second iteration of the Roadmap released in October 2011.

## 6.3 Relevant groups

### 6.3.1 European Telecommunications Standards Institute (ETSI)

The European Telecommunications Standards Institute (ETSI)[20] produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies. ETSI is officially recognised by the European Union as a European Standards Organisation. The high quality of ETSI work and open approach to standardisation has helped to evolve into a European roots - global branches operation with a solid reputation for technical excellence. ETSI is a not-for-profit organisation with more than 700 ETSI member organisations drawn from 62 countries across 5 continents world-wide.

ETSI's Grid Technical Committee was renamed TC Cloud[21] in 2010 to better reflect the development of Grid and Cloud technology and the widening role of the Committee. The goal of TC Cloud is to address issues associated with the convergence between Information Technology (IT) and telecommunications in scenarios where connectivity goes beyond the local network. This

---

17 NIST Cloud Computing Standards Roadmap (NIST Special Publication 500-291), http://www.nist.gov/manuscript-publication-search.cfm?pub_id=909024

18 NIST Cloud Computing Standards Roadmap (NIST Special Publication 500-291), http://www.nist.gov/manuscript-publication-search.cfm?pub_id=909024

19 SIENA European Roadmap on Grid and Cloud Standards for e-Science and Beyond http://www.sienainitiative.eu/ (is a CSA under INFRA-2010-3.3: Coordination Actions

20 ETSI: http://www.etsi.org

21 http://portal.etsi.org/CLOUD

includes not only Cloud computing but also the emerging commercial trend which places particular emphasis on ubiquitous network access to scalable computing and storage resources.

TC Cloud focuses on interoperable applications and services based on global standards, and the validation tools to support these standards. Evolution towards a coherent and consistent general purpose infrastructure is envisaged. This will support networked IT applications in business, the public sector and academic and consumer environments.

The technical scope of TC Cloud is broad. It includes resource and service access, protocols and middleware, and security. The Committee's approach is to complement existing activities in ETSI and other standards development organisations. Networking with such bodies, and with other relevant stakeholders, will help to build the consensus necessary to produce technical specifications and reports. This will enable ETSI to propose a roadmap to interoperable Information and Communications Technologies (ICT) Cloud standards.

Inputs to a recent Cloud Computing ETSI Workshop "Standards in the Cloud: a transatlantic mindshare" can be found at http://docbox.etsi.org/Workshop/2011/201109_CLOUD/

ETSI technical committee GRID (now TC CLOUD) works in collaboration with:

- ETSI TISPAN, ETSI MTS
- ETSI PLUGTESTS™ Service
- OGF (Open Grid Forum)
- Especially the GGF SCRM-CG group (Standards Development Organisations Collaboration on Networked Resources Management) coordinating the standardisation efforts of:
  - Distributed Management Task Force (DMTF)
  - Organization for the Advancement of Structured Information Standards (OASIS)
  - Storage Networking Industry Association (SNIA)
  - Tele Management Forum (TMF)
  - Internet Engineering Task Force (IETF),
  - International Telecommunication Union Telecommunication Standardization Sector (ITU-T)
  - World Wide Web Consortium (W3C)
- DG INSFSO F2, F3 unit
- NESSI European Technology Platform

### 6.3.2 The Cloud Computing Interoperability Forum (CCIF)

CCIF [22] was formed in order to enable a global cloud computing ecosystem whereby organisations are able to seamlessly work together for the purposes for wider industry adoption of cloud computing technology and related services. A key focus will be placed on the creation of a common agreed upon framework / ontology that enables the ability of two or more cloud platforms to exchange information in an unified manor.

CCIF is an open, vendor neutral, not for profit community of technology advocates, and consumers dedicated to driving the rapid adoption of global cloud computing services. CCIF aims to accomplish this by working through the best practices / reference architectures for the purposes of standardised cloud computing use open forums (physical and virtual) focused on building community consensus, exploring emerging trends, and advocating.

Unified Cloud Interface Project[23] is an attempt to create an open and standardised cloud interface for the unification of various cloud API's as shown in Figure 1. The aim is to create a singular programmatic point of contact that can encompass the entire infrastructure stack as well as emerging cloud centric technologies all through a unified interface. In this vision for a unified

[22] http://www.cloudforum.org/
[23] http://code.google.com/p/unifiedcloud/

cloud interface the use of the resource description framework (RDF) is an ideal method to describe a semantic cloud data model (taxonomy & ontology).

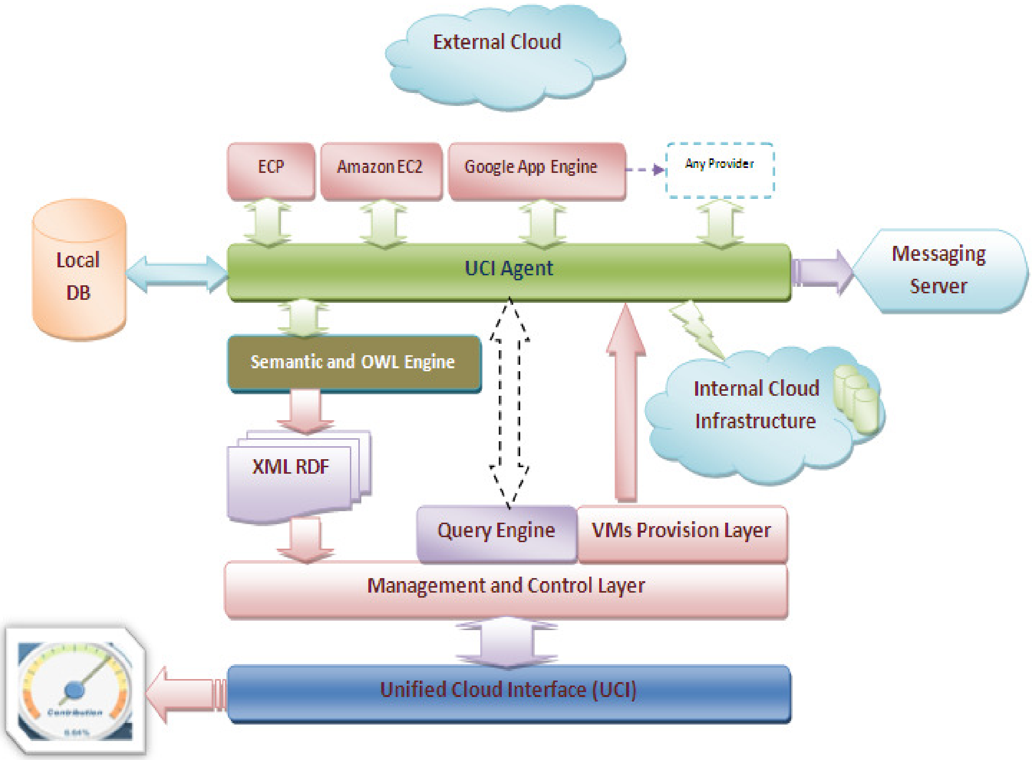



Figure 1. Unified Cloud Interface[24]

### 6.3.3 OMG Cloud Standards Coordination working group

OMG hosted "Cloud Standards Summit"[25] on July 13, 2009. As a part of this initiative, OMG announced[26] a collaboration with leading technology Standards Development Organisations (SDOs) to coordinate and communicate standards for Cloud computing and storage. Organisations expected to participate in this round-table style collaboration include: the Distributed Management Task Force (DMTF), the Open Grid Forum (OGF), the Storage Networking Industry Association (SNIA), Open Cloud Consortium (OCC) and the Cloud Security Alliance (CSA). To support this collaboration a public working group has been established, *Cloud Standards Coordination working group*, as an outgrowth of the already existing Standards Development Organization Collaboration on Networked Resources Management (SCRM) working group. The organisations involved have created a wiki[27] to describe each organisation's standards and efforts in this space. Each SDO has representatives that keep the wiki up to date.

In the overview of the standards coordination activities given by the group[28], the cloud interfaces are categorised as “Management Interfaces”, and “Functional Interfaces” as in NIST Roadmap.

[24] http://code.google.com/p/unifiedcloud/
[25] http://www.omg.org/news/meetings/GOV-WS/css/index.htm
[26] http://cloud-standards.org/wiki/index.php?title=Press_Release
[27] http://cloud-standards.org.
[28] http://cloud-standards.org/wiki/index.php?title=Cloud_standards_overview

The standard and test bed groups which are active in developing standards for these two categories of interfaces are listed as:

- Cloud Security Alliance Group (CSA)
- Distributed Management Task Force (DMTF)
- Storage Networking Industry Association (SNIA)
- Open Grid Forum (OGF)
- Open Cloud Consortium (OCC)
- Organization for the Advancement of Structured Information Standards (OASIS)
- TM Forum
- Internet Engineering Task Force (IETF)
- Internet Telecommunications Union (ITU)
- The European Telecommunications Standards Institute (ETSI)
- Object Management Group (OMG)

The group has summarised the standardisation activities of these SDOs in Cloud Management Interfaces and Cloud Functional Interfaces through the matrices presented in Figure 2

| | SaaS | PaaS | IaaS | DaaS |
|---|---|---|---|---|
| Provisioning | OMG | OMG | OGF/OMG/ DMTF | SNIA/ OMG |
| Metering and Billing | | | | SNIA |
| Security | | | OGF/DMTF/ CSA | SNIA (IETF) |
| Privacy | | | | |
| Quality of Service | | | DMTF | SNIA |
| Identity | | OASIS | | |

Figure 2. Standardisation of Cloud Management[29]

| | SaaS | PaaS | IaaS | DaaS |
|---|---|---|---|---|
| Client Application Interface | | | | |
| Development Platform | OMG | OMG | OMG | OMG |
| Virtual Machine Interface | | | DMTF | |
| Data Storage Interface | | | | SNIA |

Figure 3. Standardisation of Functional Interfaces[30]

### 6.3.4 The Open Cloud Consortium (OCC)

[29] http://cloud-standards.org/wiki/index.php?title=Cloud_standards_overview
[30] http://cloud-standards.org/wiki/index.php?title=Cloud_standards_overview

The Open Cloud Consortium (OCC)[31]:

- Supports the development of standards for cloud computing and frameworks for interoperating between clouds;
- Develops benchmarks for cloud computing;
- Supports reference implementations for cloud computing, preferably open source reference implementations;
- Manages a testbed for cloud computing called the Open Cloud Testbed;
- Sponsors workshops and other events related to cloud computing.

The current working groups include:

- The Open Science Data Cloud (OSDC) Working Group**:** This is a working group that manages and operates a large data cloud for scientific data.
- Project Matsu: This working group is developing a cloud that can assist at times of natural disasters by providing an elastic capability to process geospatial data.
- OCC Virtual Network Testbed: The OCC Virtual Network Testbed is a wide area distributed testbed for virtual networking.
- The Open Cloud Testbed Working Group: This working group manages and operates the Open Cloud Testbed..

### 6.3.5 The Open Cloud Computing Interface (OCCI)

OGF[32] is a leading development organisation for open standards in the area of distributed networking, computing and storage with an emphasis on technologies for large-scale distributed computing. The Open Grid Forum (OGF) has launched the Open Cloud Computing Interface Working Group (OCCI-WG)[33]. Its aim is the rapid development of a clean, open API for cloud infrastructure delivered on-demand. The OCCI comprises a set of open community-led specifications delivered through the OGF. OCCI is a general-purpose set of specifications for cloud-based interactions with resources in a way that is explicitly vendor-independent, platform-neutral and can be extended to solve a broad variety of problems in cloud computing. OCCI provides a protocol and API design components, including a fully-realised ANTLR grammar, for all kinds of cloud management tasks. The work was originally initiated to create a remote management API for IaaS model based services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and monitoring. It has since evolved into a flexible API with a strong focus on integration, portability, interoperability and innovation while still offering a high degree of extensibility. The current release of the Open Cloud Computing Interface is suitable to serve many other models in addition to IaaS, including e.g. PaaS and SaaS.

OCCI has been used by two European Union FP7 projects, RESERVOIR[34] (Resources and Services Virtualisation without Barriers) and SLA@SOI[35], in order to enable the interoperation of the cloud infrastructures developed in these two projects. Also in SLA@SOI project, the development of an OCCI implementation (BSD License) on top of Apache Tashi[36] has been carried out.

### 6.3.6 Distributed Management Task Force (DMTF)

Distributed Management Task Force (DMFT) is actively developing standards in the Cloud Computing domain. The Open Virtualization Format (OVF) has been published as a DMTF

31 http://www.opencloudconsortium.org/index.html)
32 http://www.ogf.org/
33 http://occi-wg.org/
34 http://www.reservoir-fp7.eu/
35 http://www.sla-at-soi.eu/
36 http://incubator.apache.org/tashi

standard, and in August 2010, the Cloud Management Working Group was established under DMTF.

Open Virtualization Format (OVF)[37] is developed by Distributed Management Task Force (DMTF) and is a hypervisor-neutral, efficient, extensible, and open specification for the packaging and distribution of virtual appliances composed of one or more virtual computer systems. It aims to facilitate the automated, secure management not only of virtual machines but the appliance as a functional unit. OVF is a common packaging format for independent software vendors (ISVs) to package and securely distribute virtual appliances, enabling cross-platform portability. By packaging virtual appliances in OVF, ISVs can create a single, pre-packaged appliance that can run on customers' virtualisation platforms of choice.

#### 6.3.6.1 Cloud Management Working Group (CMWG)

The Cloud Management Working Group CMWG [38] is developing a set of prescriptive specifications that deliver architectural semantics as well as implementation details to achieve interoperable management of clouds between service requestors/developers and providers. This WG is proposing a resource model that at minimum captures the key artefacts identified in the Use Cases and Interactions for Managing Clouds document produced by the Open Cloud Incubator[39]. It produced "Cloud Infrastructure Management Interface (CIMI)"[40] document which is currently a "Work In Progress Draft". It defines a logical model for the management of resources within the Infrastructure as a Service domain.

#### 6.3.6.2 Cloud Auditing Data Federation Working Group

A cloud provider's ability to produce and share specific audit event, log and report information on a per-tenant basis is essential. DMTF's CADF WG[41] will develop open standards for federating cloud audit information, which will instill customers with greater trust in cloud hosted applications. These reports and logs will include information needed to classify and tag events as relevant to particular compliance control domains and frameworks (such as ISO 27002, PCI DSS, COBIT, etc.).
The CADF will develop specifications for federating audit event data including interface definitions and a compatible interaction model that will describe interactions between IT resources for cloud deployment models. The CADF is also working closely with the DMTF Cloud Management Working Group (CMWG) to reference their resource model and interface protocol work.

### 6.3.7 Storage Networking Industry Association (SNIA) Cloud Storage Technical Work Group

The SNIA[42] has created the Cloud Storage Technical Work Group[43] for the purpose of developing SNIA Architecture related to system implementations of Cloud Storage technology. The Cloud Storage TWG:

- Acts as the primary technical entity for the SNIA to identify, develop, and coordinate systems standards for Cloud Storage.
- Produces a comprehensive set of specifications and drives consistency of interface standards and messages across the various Cloud Storage related efforts.

[37] http://cloud-standards.org/wiki/index.php?title=Open_Virtualization_Format_(OVF)
[38] http://dmtf.org/sites/default/files/CloudManagementWGCharter.pdf
[39] http://www.dmtf.org/standards/cloud
[40] http://dmtf.org/sites/default/files/standards/documents/DSP0263_1.0.0a.pdf
[41] http://dmtf.org/sites/default/files/DMTF_Cloud_Auditing_Data_Federation_Charter%20v1.0.8.pdf
[42] http://www.snia.org/home
[43] http://www.snia.org/cloud

- Documents system-level requirements and shares these with other Cloud Storage standards organisations under the guidance of the SNIA Technical Council and in cooperation with the SNIA Strategic Alliances Committee

SNIA published the Cloud Data Management Interface (CDMI)[44] as an architecture standard which defines the functional interface that applications will use to create, retrieve, update and delete data elements from the Cloud. As part of this interface the client will be able to discover the capabilities of the cloud storage offering and use this interface to manage containers and the data that is placed in them. In addition, metadata can be set on containers and their contained data elements through this interface. This interface is also used by administrative and management applications to manage data (apply software data services), containers, accounts, security access and monitoring/billing information, even for storage that is accessible by other protocols. The capabilities of the underlying storage and data services are exposed so that clients can understand the offering.

### 6.3.8 IEEE Cloud Computing Initiative

IEEE has launched the Cloud Computing Initiative[45], the first broad-based project for the cloud to be introduced by a global professional association. It includes the sponsoring of standards, conferences, publications, and educational activities. The effort is kicking off with the approval of two new standards development projects, IEEE P2301™, Draft Guide for Cloud Portability and Interoperability Profiles, and IEEE P2302™, Draft Standard for Intercloud Interoperability and Federation.

IEEE P2301[46] provides profiles of existing and in-progress cloud computing standards in critical areas such as application, portability, management, and interoperability interfaces, as well as file formats and operation conventions. With capabilities logically grouped so that it addresses different cloud audiences and personalities, IEEE P2301 provides an intuitive roadmap for cloud vendors, service providers, and other key stakeholders.

IEEE P2302[47] defines topology, functions, and governance for cloud-to-cloud interoperability and federation. Topological elements include clouds, roots, exchanges (which mediate governance between clouds), and gateways (which mediate data exchange between clouds). Functional elements include name spaces, presence, messaging, resource ontologies (including standardised units of measurement), and trust infrastructure. Governance elements include registration, geo-independence, trust anchor, and potentially compliance and audit. The standard does not address intra-cloud (within cloud) operation, as this is cloud implementation-specific, nor does it address proprietary hybrid-cloud implementations.

### 6.3.9 Organization for the Advancement of Structured Information Standards (OASIS)

OASIS[48] drives the development, convergence and adoption of open standards for the global information society. OASIS sees Cloud Computing as a natural extension of SOA and network management models. The OASIS technical agenda is set by members, many of whom are deeply committed to building Cloud models, profiles, and extensions on existing standards, including:

- Security, access and identity policy standards -- e.g., OASIS SAML, XACML, SPML, WS-SecurityPolicy, WS-Trust, WS-Federation, KMIP, and ORMS.
- Content, format control and data import/export standards -- e.g., OASIS ODF, DITA, CMIS, and SDD.

---

44 http://snia.org/sites/default/files/CDMI_SNIA_Architecture_v1.0.1.pdf
45 http://standards.ieee.org/news/2011/cloud.html
46 http://standards.ieee.org/develop/project/2301.html
47 http://standards.ieee.org/develop/project/2302.html
48 http://www.oasis-open.org/

- Registry, repository and directory standards -- e.g., OASIS ebXML and UDDI.
- SOA methods and models, network management, service quality and interoperability -- e.g., OASIS SCA, SDO, SOA-RM, and BPEL.

In relation to Cloud Computing, OASIS hosts two specific technical committees:

- OASIS Identity in the Cloud (IDCloud) TC[49]**:**The OASIS IDCloud TC works to address the serious security challenges posed by identity management in cloud computing. The TC identifies gaps in existing identity management standards and investigates the need for profiles to achieve interoperability within current standards. It performs risk and threat analyses on collected use cases and produces guidelines for mitigating vulnerabilities.
- OASIS Symptoms Automation Framework (SAF) TC[50]**:** Cloud computing, in particular, exacerbates the separation between consumer-based business requirements and provider-supplied IT responses. The SAF facilitates knowledge sharing across these domains, allowing consumer and provider to work cooperatively together to ensure adequate capacity, maximise quality of service, and reduce cost.

### 6.3.10 Cloud Security Alliance

The Cloud Security Alliance (CSA)[51] is a not-for-profit organisation with a mission to promote the use of best practices for providing security assurance within Cloud Computing, and to provide education on the uses of Cloud Computing to help secure all other forms of computing. It provides a Security Guidance Document [52] which covers key areas of focus in cloud computing and provides advice for both Cloud Computing customers and providers within 15 strategic domains. CSA provides the Cloud Security Alliance Controls Matrix (CM)[53] which is specifically designed to provide fundamental security principles to guide cloud vendors and to assist prospective cloud customers in assessing the overall security risk of a cloud provider. CSA also provides a report[54] on “Top Threats to Cloud Computing”, to present the needed context to assist organisations in making educated risk management decisions regarding their cloud adoption strategies. Finally, as of October 2010, CloudAudit[55] initiative is officially a part of the Cloud Security Alliance. The goal of CloudAudit is to provide a common interface and namespace that allows cloud computing providers to automate the Audit, Assertion, Assessment, and Assurance (A6) of their infrastructure (IaaS), platform (PaaS), and application (SaaS) environments and allow authorised consumers of their services to do likewise via an open, extensible and secure interface and methodology.

## 6.4 Project Contributions

### 6.4.1 FP7 Project SLA@SOI

Cloud computing uses the concept of service level agreements to control the use and receipt of resources from and by third parties. Service Level Agreements (SLA)s commonly include segments to address: a definition of services; performance measurement; problem management; customer duties; warranties; disaster recovery; termination of agreement. Any SLA management strategy considers two well differentiated phases: the negotiation of the contract and the monitoring of its fulfillment in run-time. Thus, SLA Management encompasses the SLA contract definition (the QoS (quality of service) parameters), SLA negotiation, SLA monitoring and SLA

[49] http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=id-cloud
[50] http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=saf
[51] https://cloudsecurityalliance.org
[52] http://www.cloudsecurityalliance.org/guidance/csaguide.pdf
[53] http://www.cloudsecurityalliance.org/guidance/CSA-ccm-v1.00.xlsx
[54] https://cloudsecurityalliance.org/topthreats/csathreats.v1.0.pdf
[55] http://www.cloudaudit.org/

enforcement according to defined policies. The main point is to build a new layer upon the cloud able to create negotiation mechanism between providers and consumer of services.

SLA@SOI is a FP7 project[56] researching aspects of multi-level, multi-provider SLAs within service oriented infrastructure and cloud computing. An essential part of an SLA-aware infrastructure is a scalable and self-sufficient monitoring system capable of monitoring large distributed systems, in real-time. The monitoring system must support two mutually exclusive perspectives arising from the Service Level Agreement, namely the customer's perspective and the infrastructure/service provider's perspective. The former is interested in the SLA alone, while the latter needs to be able to optimise the utilisation of the infrastructure. To help process and manage the volume and variety of monitoring data, a multi-layer monitoring architecture has been proposed by Infrastructure Management[57].

### 6.4.2 FP7 Project Reservoir

Reservoir project[58] enables the delivery of better services for businesses and eGovernment with energy-efficiency and elasticity by increasing or lowering compute based on demand. RESERVOIR has defined a Reference Architecture for a next generation of Infrastructure as a Service (IaaS) Clouds capable of dealing with new requirements such as service-orientation (services managed as a whole, automating the services provisioning and scalability, and guaranteeing Service Level Agreements), separation between infrastructure and services, use of Open/Standard specifications, virtualisation technology independent, support for site federation, which allows private, public and hybrid Clouds, security and isolation reinforcement and use of utility computing business models. The RESERVOIR Framework is implemented as a blueprint enabling CTOs and CIOs from business and government to build on-demand infrastructure services, reducing investment and operational costs, increasing energy efficiency and elasticity while ensuring security and Quality of Service.

Some of the main achievements carried out by RESERVOIR project in relation to Cloud Computing Standards can be summarised as follows:

- Spearheading and establishing the Open Cloud Computing Interface Working Group (OCCI) within the Open Grid Forum (OGF). Implementing current specifications.
- Extending the Open Virtualization Format (OVF) standard used for describing the virtual machine landscape and their elasticity rules. The OVF standard has been developed by the industry-led standards body, Distributed Management Task Force, Inc. (DMTF).

One of the open source spin-outs of Reservoir project is the OpenNebula platform, which is the most advanced open-source Cloud Management Tool toolkit for building private, public and hybrid clouds, offering unique features for Cloud management and providing the integration capabilities that many enterprise IT shops need for internal Cloud. OpenNebula has been enhanced to address the requirements of business use cases from leading companies in the context of RESERVOIR. OpenNebula implements the most of the standard cloud interfaces: Amazon Web Services (AWS); the Open Cloud Computing Interface (OCCI) specifications developed by the Open Grid Forum and VMware vCloud, it also leverages the ecosystems being built around these interfaces.

[56] http://sla-at-soi.eu/

[57] Hierarchical Monitoring Services for Efficient Distributed System Management, http://sla-at-soi.eu/?p=523

[58] http://www.reservoir-fp7.eu/

## 6.5 Summary of issues

Interoperability, security and portability have been identified as the key areas where significant standardisation effort is required to support cloud computing. Indeed the sheer number of projects and initiatives associated with delivering cloud computing solutions is likely to render an interoperable Cloud Computing solution very difficult. This is without including the “clouds” of major commercial providers such as Amazon, Apple and Microsoft (and many others). Governments are also working to utilise cloud computing for disseminating information as part of their e-inclusion strategies. Overall, the Cloud Computing environment is confusing.

Several organisations including Cloud Security Alliance, Open Cloud Manifesto and NIST state that there is a need to define standards for cloud computing[59]. According to a survey led by IDC Enterprise Panel in August 2008, among the challenges/issues of the cloud model adoption, security is the major concern worrying the users.

When interoperability standards are not available, the number of proprietary implementations is increasing. This raises the issue that proprietary implementations cannot be examined against privacy and security aspects. Hence, there is a need for interoperability standards in cloud computing to include security and privacy.

In addition to the above issues of security and portability, there needs to be work that will enable any user to utilise any cloud facility as appropriate. This will require detailed analysis of how information, applications and services are stored, identified and discovered under any cloud computing solution and the development of cloud normalisation services which will allow any user to utilise or provide the information in the cloud space as a monetised resource.

It is possible that this work could be one of the tasks of FInES or the Network of Excellence in Internet Science (EINS) project, as it seeks to understand and normalise aspects of the Future Internet in regard to Enterprise systems. Additionally, a project to analyse, understand and promote the interoperable information cloud environment could be established where monetised information could be bought and sold from the cloud computing domain by users and providers of all sorts. The establishment of such an ecosystem could have major benefits for all cloud computing providers; for those who supply information and those who need to access and buy it.

# 7 Standards for the Internet of Things

## 7.1 Introduction

There are many definitions for the Internet of Things but in general it can be said to refer to uniquely identifiable objects and their virtual representation in an internet-like structure[60]. The visibility of things through the use of Radio-frequency identification (RFID) is often seen as a prerequisite for the Internet of Things and it is in this area of standardisation that this chapter focuses. However, the scope of the internet of things reaches far beyond this basic instantiation of the (RFID) Internet of Things and can be said to extend to any object or any information that can be accessed using the Internet. Under such an extended scope the IoT includes anything held in the cloud, any object or device used in any environment and any information or application. The necessity of unique identity, discoverability, describability are prerequisites and under a broadened scope the ability to initialise, customise, manage and operate such objects or things as appropriate (with particular attention being paid to IPR, Access Rights, safety, security and unintended consequences) become realisable across the whole realm of the Future Internet.

Issues related to semantic interoperability are covered in the next chapter.

---

[59] http://www.cloudsecurityalliance.org/

[60] http://en.wikipedia.org/wiki/Internet_of_Things

## 7.2 Relevant groups

### 7.2.1 Global Standards One (GS1)

Global Standards One (GS1)[61] is a not for profit association dedicated to the design and implementation of supply chain standards and solutions. Its family of standards focuses on different aspects of supply chain integration such as electronic products codes, product information synchronisation and electronic document standards. GS1 was formed in early 2005 by the European Article Number and the Uniform Commercial Code organisations when they joined together. EAN and UCC were two organisations that heavily contributed to the adoption and proliferation of barcodes.

In a GS1 Network, the trading partners share three different types of data:

- Master data (identical for all same articles)
- Transactional data (describing a business transaction), and
- Event data describing an event for all individual items with serialised item numbers. An event can be a read (observation) made by a company internally or a read made with the help of sensor equipment like temperature

All these data are (primarily) communicated via electronic means, defined according to the following four GS1 Standards:

- EPC (Electronic Product Code): EPC is an extension to the GTIN barcode naming conventions in that it includes unique product identity.
- EPCglobal Network[62]: Event data is communicated and registered with the help of the EPCglobal Network. EPCglobal drives the development of the Electronic Product Code (EPC) related with RFID standards.
- The Global Data Synchronization Network (GDSN)[63]: Master data is communicated with the help of the global data synchronisation network (GDSN). The Global Data Synchronization Network (GDSN) enables product data and location information synchronisation so that trading partners have consistent item data in their respective systems.
- Electronic business messaging: GS1 eCom[64] is the part addressing the transactional data is communicated with the help of the standard for electronic business messaging in this family of standards. In GS1 eCom, there are two distinct categories: the earlier eCom standards that are based on Electronic Document Interchange (EDI), called EANcom and the newer generation GS1 XML[65] which is designed using XML Schema.

### 7.2.2 EPCglobal Network

The EPCglobal Network[66] is a part of Global Standards one whose
standards are designed to improve visibility. Visibility is one of the key components of the roadmap towards the creation of the Internet of Things vision[67].

61 GS1. Global Standard One. http://www.gs1.org/.
62 EPCglobal. Electronic Product Code Global. http://www.gs1.org/productssolutions/epcglobal/
63 GDSN. GS1 Global Data Synchronisation Network. http://www.gs1.org/productssolutions/gdsn/.
64 GS1 eCOM, http://www.gs1.org/productssolutions/ecom/
65 GS1 XML. Global Standard One XML. http://www.gs1.org/productssolutions/ecom/xml/.
66 EPCglobal. Electronic Product Code Global. http://www.gs1.org/productssolutions/epcglobal/
67 Internet of Things: an early reality of the Future Internet, Workshop Report by Maarten Botterman

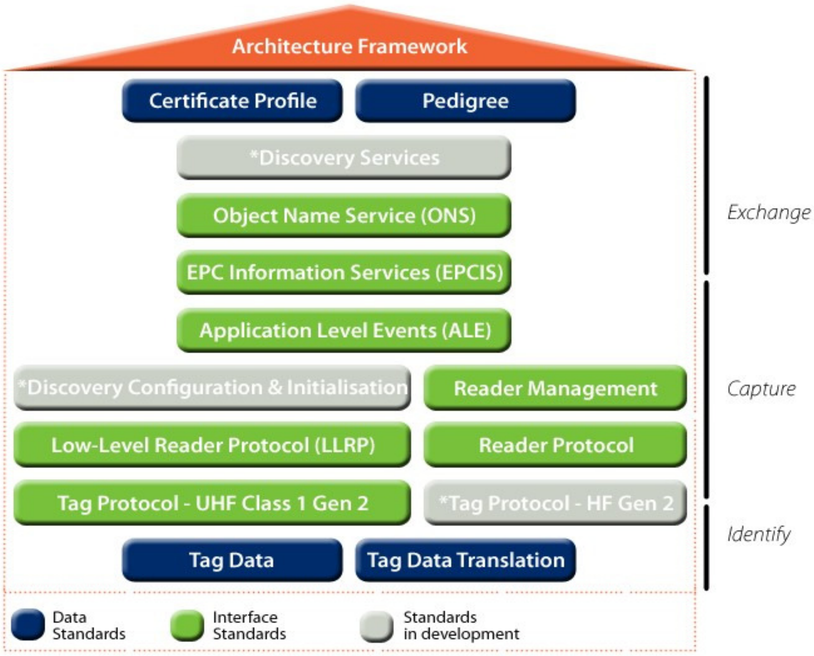



Figure 4. EPCglobal Network Architecture

The EPCglobal Network architecture is based on the following principles as shown in Figure 4:

- A unique number (the EPC) to identify each individual instance of a product within the supply chain.
- This unique number is held in an RFID-tag that is attached to that object.
- As this object moves through the supply chain, it is detected by RFID readers at different locations and the information is passed to filtering and collection EPC middleware (Application Level Event (ALE)).
- This middleware aggregates information, removes duplicates, applies appropriate filters and in turn passes filtered information to enterprise systems.
- When IT systems require more information about an object, they use the EPC code from the object's tag or other EPC Manager Numbers to query the Object Naming Service (ONS) or the Discovery Service (DS).
- The ONS will return the Internet address of the EPC Information Services (EPC IS) server of the source, which holds information about the object in question
- A comparison can be made with the Internet Domain Name Service (DNS), which translates domain names into their IP-addresses
- The EPC Discovery Service (EPC DS) will return the Internet addresses of the EPC Information Services (EPC IS) servers of all parties where that particular EPC code has been (www.epcglobalinc.org)
- This can be compared to a search engine on the Internet
- The EPC Discovery Service (DS) will be used if a company does not know where data of a specific EPC resides

## 7.3 Project Contributions

### 7.3.1 FP7 iSURF Project

iSURF Project is enabling the collaborative supply chain planning across multiple domains for a flexible and dynamic environment and especially to facilitate European SMEs participation to collaborative supply chain planning process. The iSURF Project contributes to standards related to the visibility of things through its following objectives:

- Provide an open source smart product infrastructure for SMEs in order to enable SMEs to acquire the supply chain visibility information in real time from the distributed RFID devices. The iSURF smart product infrastructure provides the SMEs with the capabilities of gathering product information through RFID devices, filtering and aggregating the collected data and putting them into a business context. This smart product infrastructure is based on EPCGlobal[68] standards.
- Support the architecture with a Global Data Synchronization[69] Service Utility which conforms to the GS1[70] standard in order to ensure the accuracy and reliability of master data used in the supply chain by developing standard based open platform for SMEs.
- Ensure the security and privacy of both the real time visibility data gathered through RFID devices and the planning and forecasting messages exchanged across enterprises. The necessary identity management, security and privacy mechanisms for sharing visibility data gathered through RFID devices and for exchanging the planning data between supply chain partners are be based on the OASIS standards such as XACML[71] and SAML[72].

## 7.4 Summary of issues

The work presented in this chapter focuses only on the visibility of things. There are new standards initiatives at the early stages of discussion for the development of M2M communication standards[73] and to agree the scope of standardisation work required through the International Telecommunications Union's IoT Global Standards Initiative.[74]
These standardisation efforts and requirements need to be understood in relation to FInES role in IoT and may require liaison with a number of the dominant groups involved/

The major issue in respect to IoT is that the "traditional" RFID vision of the Internet of Things is now only a relatively limited subset of the whole IoT ecosystem which now effectively covers any object that can be accessed by any internet (or internet like) methodology. This is leading to convergence of the IoT with Cloud Computing and the Interoperability of such systems becomes increasingly important. There are many issues as to the wide diversity of identity and naming systems for objects and of strategies for discovery of such objects but it can be reasonably asserted that a world where services and applications can discover and use objects (which may be information, applications, devices and device drivers - as well as RFID devices - and using a wide selection of naming conventions, discovery methods and working under different protocols) will be more efficient in its use of resources and open the way for a vast range of new, innovative and value added services for business in the area of Enterprise Systems and generally. All of these services are amenable to monetisation and can deliver value to the provider, supplier and consumer increasing the overall value of FInES and its standardisation efforts.

The fact that the issues of interoperability in IoT are very similar to those in Cloud Computing implies that a unified approach to interoperability for the Future Internet as applied to Enterprises and Enterprise Systems will be required. It is possible that this work could be one of the tasks of the NoE in Internet Science as it seeks to understand and normalise aspects of the Future Internet in regard to Enterprise systems. Alternatively, work to develop an Interoperability

---

68 EPCglobal. Electronic Product Code Global. http://www.gs1.org/productssolutions/epcglobal/
69 GDSN. GS1 Global Data Synchronisation Network. http://www.gs1.org/productssolutions/gdsn/.
70 GS1. Global Standard One. http://www.gs1.org/.
71 http://www.oasis-open.org/committees/xacml/
72 http://www.oasis-open.org/committees/security/
73 http://www.theinternetofthings.eu/content/major-standards-development-organizations-agree-global-initiative-m2m-standardization
74 http://www.itu.int/ITU-T/newslog/Internet+Of+Things+Standards+Work+Plan.aspx

Ecosystem or a project to analyse, understand and promote the interoperable information cloud environment, could be established where monetised information was bought and sold from the cloud computing domain by users and providers of all sorts. The establishment of such an ecosystem could have major benefits for all users of the Internet of Things and those who need to access, buy and sell through it.

# 8 Standards and Semantic Enterprise Interoperability

## 8.1 Introduction

There are a very large number of groups involved in standardisation which have an impact on enterprise interoperability. Because of this, this chapter is presented against three categories of inputs; Frameworks, Ontologies and Languages, rather that attempting to discussing the contribution of each standardisation group individually. These are presented in the sections below following an initial overview section.

## 8.2 Overview of Enterprise Interoperability Standards

Standardisation is carried out by European and international standardisation organisation as well as by industry consortia. There exist several standards that can support particular aspects of interoperability like unifying process model representation (CEN/ISO 19440), harmonising information representation (ISO 10303), or enable capturing of software capabilities (ISO 16100). Framework for structuring interoperability concerns, barriers and approaches for solutions (ISO/CEN 11354) are also being standardised. Table 1 provides an overview on existing standards and work in progress performed in CEN and ISO.

Table 1. Standards relevant for an integrated/unifying approach (Ref. IFIP WG5.8)

| *Standard id* | *Name/Description* |
|---|---|
| CEN/ISO 11354 | Framework for Enterprise Interoperabilitty |
| CEN/ISO 19440 | Constructs for enterprise modelling |
| ISO 18629 | Process specification language(multi-part set of standards) |
| ISO 15531 | Industrial manufacturing management data (MANDATE) |
| ISO 10303 | Standard for Product data representation and exchange (STEP) |
| ISO 13584 | Parts Library (PLIB) |
| ISO 15289 | Content of systems and software life cycle process information products |
| ISO 15926 | Integration of life-cycle data for process plants including oil and gas production facilities |
| ISO 18876 | Integration of industrial data for exchange, access, and sharing (IIDEAS) |
| ISO 15745 | Framework for Application Integration |
| ISO 16100 | Manufacturing software capability profiling for interoperability |
| ISO 22745 | Open Technical Dictionary |
| ISO 8000 | Data Quality |

Some selected standardisation efforts on enterprise interoperability with focus on the business /user stakeholders, outside ISO – some of them open standards developed by industry consortia-are listed below in Table 2. In this overview, we are not considering (industry) sector specific standards.

Table 2. Standards relevant for an integrated/unifying approach outside of ISO

| *Organisation* | *Name/Description* |
|---|---|
| CEN-ISSS EBIF | CEN eBusiness Interoperability Roadmap |
| UN/CEFACT | UN/CEFACT e-Business framework |
| ISA/IEC | Enterprise-Control System Integration |
| OMG | Service Driven Architecture (SOA), Business Process Modelling Notation (BPMN) |
| OASIS | ebXML Business Process Specification |
| OAGi | Open Applications Group Integration Specification (OAGIS) |

Table 3 capture relevant standardisation groups involved in the development of these standards and also identifies their related aims. This raises it own interoperability issues as many of the standards developed by these groups, while extremely useful in their own right, are not interoperable across the range of standards within their own domains of interest.

Table 3. Examples of standardisation groups

| Body | Aims |
|---|---|
| CEN TC310 | Advanced Automation Technologies and their Applications |
| ISO TC 184/SC4 | Development and dissemination of standards for industrial data |
| ISO TC 184/SC5 | Development and dissemination of standards for interoperability and integration of enterprise systems |
| Organisation for the Advancement of Structured Information Standards (OASIS) | Development and use of open standards for information |
| Object Management Group (OMG) | Development of standards to aid enterprise integration |
| World Wide Web Consortium (W3C) | Development and maintenance of standards for information representation and sharing on the Web |
| ISO/IEC JTC1 SC32 WG2 | International standards for metadata and related technologies |

The work towards enterprise interoperability standards across these groups can be viewed from three perspectives: frameworks for interoperability; information and process ontologies; and languages for interoperability. Standardisation progress on these three are described in turn in the following subsections of this report.

## 8.3 Interoperability Frameworks

There exist quite a number of interoperability frameworks. Comparing architectural frameworks addressing enterprise interoperability, there is one unique fundamental property in this standard CEN/ISO 11354, namely the dimensions of interoperability barrier and interoperability concern. Other frameworks do not identify the interoperability problems explicitly, but define areas of solutions. Another difference is in the way of addressing interoperability. Table 4 lists a number of non-commercial, not national nor sector specific, selected interoperability frameworks.

Table 4. Interoperability Frameworks

| **Organisation** | *Name/Description* |
|---|---|
| ISO 15745 | Framework for Application Integration |
| CEN/ISO 11354 | Requirements for establishing manufacturing enterprise process interoperability |
| ATHENA FP6 IP | BIF: Business Interoperability Framework[75] |
| CEN-ISSS EBIF | CEN eBusiness Interoperability Roadmap |
| UN/CEFACT | UN/CEFACT e-Business framework |
| OMG | Service Driven Architecture (SOA) |
| iDABC[76] | European Interoperability Framework for Pan-European eGovernment Services |
| CENELEC | CWA50560:2010 Interoperability Framework Requirements Specification |

### 8.3.1 Framework for Enterprise Interoperability (CEN/ISO 11354)

The standard is mainly based on several inputs from European R&D projects carried out in the enterprise interoperability domain. At first a thematic network - IDEAS (Interoperability Development of Enterprise Applications and Software) - was launched with the objective to elaborate a roadmap for interoperability Then two important initiatives relating to interoperability development - ATHENA (Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications) Integrated Project and INTEROP (Interoperability Research for Networked Enterprises Applications and Software) Network of Excellence (NoE) have been implemented.
Based on ATHENA IP and INTEROP NoE, two organisations were created after the completion of the two projects to continue the development of enterprise interoperability: VLab (Virtual Laboratory) from INTEROP NoE, and EIC (European Interoperability Centre) created by ATHENA IP[77]

The needs for enterprise interoperability refer to the ability of enterprises (or part of them) to interact through the exchange of information and other entities such as material objects, energy, etc. Interoperability is a necessary support to allow business collaboration to happen. Enterprise interoperability can apply to both inter- and intra-enterprise needs and includes the concepts of extended enterprise, virtual enterprise and sub-systems of one enterprise. Interoperability is considered as a generic concept, and it is therefore assumed that common problems of interoperability failure and solutions to overcome them can be identified and developed for any particular enterprise.

The multiple-part standard preEN CEN/ISO 11354 defines a Framework for Enterprise Interoperability and specifies processes and underpinning metadata. These data need to be in place to establish or to enable enterprise interoperability solutions for Manufacturing Enterprise Processes (MEP) and their models. The framework establishes a base for interoperation in unified, integrated and federated environments of manufacturing enterprises, named interoperability approaches.

Further, four interoperability *concerns* are identified Data, Service, Process, and Business: Data are used by services, including Web services. Services are employed by processes to realise business of the enterprise. From another point of view, the goal of an enterprise is to run its business. To realise the business, one needs processes. Processes employ services that in turn need data to perform activities. This context is illustrated in Figure 5

75 ATHENA Deliverable D.B3.1, 2007
76 http://europa.eu.int/idabc
77 D. Chen, D. Shorter: *Framework for Manufacturing Process Interoperability-CEN/ISO 11354*, Standards Workshop at the I-ESA 2008 , http://www.interop-vlab.eu/

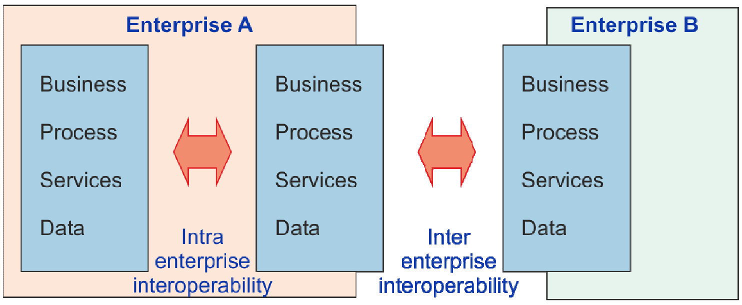



Figure 5. Categories of interoperability concerns (Source ATHENA 2007)

Finally, an interoperability barrier viewpoint is identified to capture the incompatibilities and mismatches that obstruct the sharing and exchanging of information and other entities. Three categories of barriers are defined, conceptual, technological and organisational.

The framework is designed with the above mentioned three viewpoints addressing *approaches concerns* and *barriers* of interoperability and shall express the needs of the stakeholder who is concerned with interoperability issues. Figure 6 shows the Framework for Enterprise Interoperability

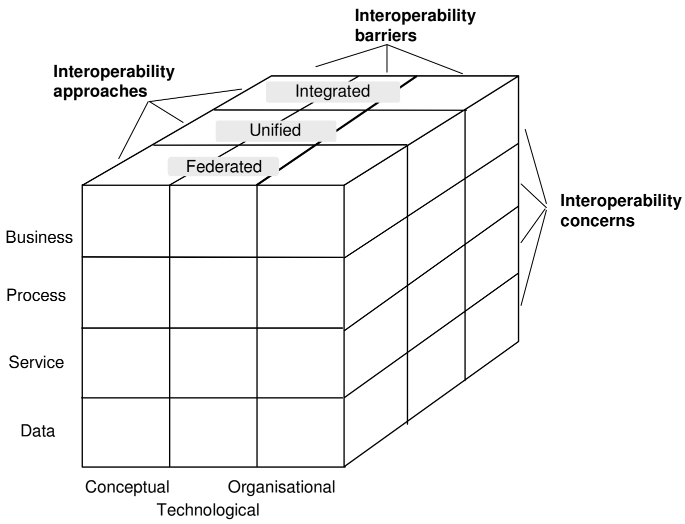



Figure 6. Framework for Enterprise Interoperability

The framework describes the different categories of interoperation and their particular requirements. It is concerned with the operational interworking of MEPs, including the interoperability of their supporting software applications. It focuses on enabling the communication rather than defining the communication itself, and is thus independent of specific technologies. Further details of the framework, components and relationships are presented in the Annex.

The standard is originating from the European projects ATHENA and INTEROP. Part 1 of the standard – Framework for enterprise interoperability - has been at least partly supported by the INTEROP project, part 2 - Maturity Model for Enterprise Interoperability - has been started as a new work item after project completion. The work is carried out by CEN TC310 WG1 and by ISO TC 184 SC 5 WG1

### 8.3.2 CENELEC CWA50560:2010 IFRS[78]

Although it was prepared within the scope of the Smart House, the Interoperability Framework Requirement Specification (initially prepared by TAHI[79] and standardised under CWA50560:2010 IFRS) is an effort to standardise the prerequisites for any form of interoperability – the things that must be presented and known by users for interoperability to be possible. Conformance to the standard requires:

- Discovery – the ability of any object (device, system, service, information, application) to be discoverable
- Unique ID – the necessity of any object to have a unique ID (or an ID which is unique relative to a Unique ID, Location or Address) and that this ID can be used to deliver;
- Description – the necessary description of the object whether held locally by the object or under some form of dictionary
- Access rights and controls – As appropriate any object must maintain rights to who can access it and what can be carried out on the object if access is allowed. (In many cases the sector or ownership of the object will constrain particular actions or use by particular entities). Access rights include a requirement for an object (as appropriate) to ensure that safe operation be maintained and carries a particular requirement for flagging these requirements to applications which may seek to operate the object
- Configuation – As appropriate, the ability of the object to be configured – managed or operated

Additionally, the CWA (IFRS) presents a hierarchy of “Levels” of Interoperability which should be transferable to any Interoperability metric. Its levels are shown in Table 5 below and provides an example of work under consideration for standardisation in this area.

Table 5, Hierarchy of Interoperability levels

| | | |
|---|---|---|
| | **Level 0** | A single system of supplier-defined structure built from devices using a single HBES specification and locally defined interoperability verified by the supplier for one or more application domains. No assurance of coexistence is provided. |
| | **Level 1** | A Level 0 system operating across one or more application domains Verified coexistence is required. |
| | **Level 2** | Multiple Level 1 systems that interwork to exchange information and interoperate across specification and application domains verified by the suppliers using conformance specifications agreed by each HBES specification used. |
| | **Level 3** | As Level 2, and the interoperability is verified with respect to international standards applicable to the HBES specifications used in the system. |
| **CONFORMS TO IFRS** | **Level 4** | As Level 3, but conforming to IFRS so that the applications and devices can be installed, managed and changed during the operation of the system by a qualified installer. |
| | **Level 5** | As Level 4, and changes of application and devices will be done automatically. |
| | **Level 6** | As level 5, and with remote management, diagnostics and maintenance. (automatic installation, operation and support). |

Levels 0 – 3 are representative of the state of the domain for systems that are designed and engineered for a specific purpose. Implementers of these systems are able to rely on a well defined hierarchy of system, user and business requirements in conjunction with known technical

78 See CWA50560:2010 IFRS

79 TAHI (The Application Home Initiative) exists to grow the market of products and services for connected home-based users under the scope of the Smart House. Since the majority of people are customers and end users of FInES have homes, it is seen that the work of TAHI is relevant to FInES. see http://www.theapplicationhome.com/

requirements when deriving their solutions. This CWA states no conformance requirements for such systems – it relies on interoperability agreements made by the suppliers and installers and these may be ISs. The classification by levels is used as an informal reference to understand their capabilities.
For applications that are now being proposed and for open systems of the future, the situation is entirely open: there is no set of overarching, general, open user requirements from which system and technical solutions and interoperability requirements are derived. Interoperability must exist throughout the lifetime of the system, surviving changes, additions and upgrades, while offering backwards compatibility. Levels 4 – 6 represent systems that have this interoperability requirement. CWA50560:2010 defines the conformance requirements for systems that claim compliance with Levels 4 – 6.

Areas of new work required for IFRS include developing and trialling methodologies for using the IFRS in other environments and creating conformance and certification systems.

### 8.3.3 New area of work

#### 8.3.3.1 Need for a standard metric to measure enterprise interoperability

The fact that interoperability can be improved means that it can be measured. Although many enterprise interoperability solutions have been developed in the past, there is still not a generally agreed metric system to allow measuring various degrees of enterprise interoperability. Some interoperability maturity models have been proposed to evaluate interoperability from maturity point of view. A standard project from CEN has been proposed to define a maturity model for enterprise interoperability. Besides of maturity, other complementary metrics are needed. A generally agreed enterprise interoperability metric standard is required to put EI research and development on a more rational and scientific basis. The approach given by CWA50560:2010 IFRS in Section 8.3.2, is one possible way of measuring the level or metric of Interoperability.

However, as with Clouds and IoT, there are many ways of defining and working towards interoperability. It is entirely too easy to attempt a "full" interoperability solution in a limited sector or subsector based approach which may come in at levels 2 or 3 on the IFRS hierarchy. This is not the "universal" interoperability (Level 6) that is really needed. The question is; "What are the absolute prerequisites for interoperability to be possible within the whole domain of internet connected objects and then how are these prerequisites classified and under what ontologies. The next question then becomes how can an infrastructure or framework be constructed which supports such an interoperability and can be made both to work and be acceptable to all subordinate interoperability solutions. Again this is a problem for the NoE in Internet Science.

## 8.4 Information and process ontologies

There are many definitions for what an ontology is and this can add to potential confusion when we consider ontologies for enterprise interoperation. A useful definition of an ontology is the one specified in the Process Specification Language standard (ISO 18629-1, 2004) and quoted as: "An ontology is a lexicon of specialised terminology along with some specification of the meaning of terms in the lexicon.". The beauty of this definition is that it leaves open the basis for the method of specification of the terms in the ontology. It is this basis that largely determines the level of interoperability that can be expected from the ontology.

Formalisms for specifying the meaning of terms in an ontology can broadly be categorised as following either lightweight or heavyweight approaches. The lightweight approach makes the fundamental assumption that the terms defined in an ontology can readily be understood without any logical semantic checks being used. For examples information models defined in EXPRESS or in UML can be considered to be lightweight ontologies. On the other hand, heavyweight ontologies are developed from expressive ontology languages such as OWL or Common Logic, that are able to capture the meaning of terms in computational form. Heavyweight ontologies thus provide a preferred route towards interoperability across systems. However, one of the problems for interoperability across standards is the lack of interoperation across the multiple languages used in standardisation

There are several aspects that impact on the development of standards for ontologies and their use in order to achieve enterprise interoperability. Of particular relevance are (1) the importance of foundation ontologies, (2) new areas of work such as the consolidation of international standards in industrial automation and (3) the languages exploited to specify and support ontology development and mapping. Each of these are discussed below.

### 8.4.1 Foundation and Domain Ontologies

Foundation ontologies, sometimes called upper or top-level ontologies, formally prescribe a set of meta-concepts that describe abstract and generic intuitions. A useful definition of foundation ontologies has been acknowledged by Sanchéz-Alonso and García-Barriócanal[80] as:

> *"Upper ontologies include definitions of concepts, relations, properties, constraints and instances, as well as reasoning capabilities of these elements. They are limited to generic, high level, abstract concepts that are general enough to address a broad range of domains, not including concepts specific to given domains."*

Table 6 summarises examples of foundation ontologies and some of their interesting features. The importance of foundation ontologies in supporting enterprise interoperation is noteworthy. This is because they provide a basis and domain-independent structures for enabling the consistent development of domain ontologies. Domain ontologies may be regarded as being specialised conceptualisations, e.g., domain ontologies for production engineering, business, medicine and finance.

Table 6. Examples of foundation ontologies

| Foundation Ontology | **Features** |
|---|---|
| Basic Formal Ontology (BFO) | BFO comprises a number of sub-ontologies. The concepts 'SNAP' and 'SPAN' describe foundation theories for intuitions regarding objects and events. SNAP and SPAN are elaborations that use primitive lexicon, defined terms, axioms and definitions to define the interpretation of concepts in BFO. |
| Cyc's upper ontology | Developed within the Cyc project, this upper ontology contains about 3000 terms classified under 43 topical groups such as 'fundamentals', 'spatial relations', etc. |
| Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) | DOLCE is a proposed foundation ontology library which prescribes, in FOL, structures for modelling ontologies. DOLCE acknowledges the concepts 'endurant' and 'perdurant' to refer to things that endure and unfold through time respectively. |
| General Formal Ontology (GFO) | GFO consists of a three-tier meta-ontological architecture with an abstract top level, abstract core level and a basic level. GFO acknowledges the concepts 'Presential' and 'Occurent' to refer to things that endure and unfold through time respectively. |

80 Sanchéz-Alonso, S. and García-Barriócanal, E., 2006. Making use of upper ontologies to foster interoperability between SKOS concept schemes. *Online Information Review*. 30(3): 63-77

| | |
|---|---|
| Highfleet's Upper Level Ontology (ULO) | User ontologies are instantiated from formally defined types of 'Universal' (i.e., meta-concepts) using KFL as ontology language. All user-defined classes need to be categorised as being either of 'abstract' or 'concrete' entity types. Abstract entity types cannot be located in some place while concrete entity types can. |
| Open Knowledge Base Connectivity (OKBC) ontology | OKBC has been formalised in KIF and provides a protocol for various knowledge representation systems such as Ontolingua and Protégé |
| Suggested Upper Merged Ontology (SUMO) | SUMO has been developed by the IEEE Suggested Upper Merged (SUO) working group in the SUO-KIF language. A SUMO-CL version is available and has been formalised by Kojeware Corporation using the CLIF syntax. |
| WordNet | A top-level ontology that describes semantic constructs used in natural language processing. A lexicon in WordNet comprises nouns, verbs, adjectives, adverbs and function words. |

The development, agreement upon and use of foundation or core concept ontologies are significant for FInES as such ontologies provide a strong basis for cross-domain sharing of knowledge. An example of work in this area is provided by the UN/CEFACT Core Component Technical Specification and OASIS Semantic interoperability Support for Electronic Business Document Interoperability (SET) TC which are applied to the interoperability of electronic documents exchanged in eBusiness applications.

The essence of UN/CEFACT Core Component Technical Specification[81] is to design documents from standard, re-usable building blocks, called *Core Components*. The ultimate aim is to make the *Core Components* available from a single common repository for discovery and reuse in designing the business documents. The purpose of OASIS SET TC[82] is to provide standard semantic representations of electronic document artifacts based on UN/CEFACT Core Component Technical Specification (CCTS) and hence to facilitate the development of tools to support semantic interoperability. Note that, by conforming to a standard ontological representation and hence having all the document schema ontologies in a common pool, the users of the Harmonized Ontology only need to create a document schema ontology if it is not already in the Harmonized Ontology and benefit from all the existing connections when they do so.

## 8.4.2 New Areas of Work

### 8.4.2.1 Industrial Data Integrated Ontologies and Models (IDIOM)

IDIOM is described as an architecture for facilitating the representation and sharing of industrial data through the exploitation of tools and methodologies, which reflect current best practices in industry[83]. IDIOM is an effort from ISO TC184/SC4 and focuses on the potential of approaches, such as natural language dictionaries, process models, data models, but more importantly ontologies, to address the capture of richer structures with more formal semantics and also as a route towards the future development of ISO standards in industrial automation. Of particular

81 UN/CEFACT Core Components Technical Specification, http://www.unece.org/cefact/ebxml/CCTS_V2-01_Final.pdf

82 OASIS Semantic Support for Electronic Business Document Interoperability (SET) Technical Committee, http://www.oasis-open.org/committees/tc home.php?wg abbrev=set

83 Price, D., Leal, D. and Barnard Feeney, A., 2010. IDIOM architecture specification. Future SC4 Architecture PWI deliverable version 02. This document follows Resolution 785 from the ISO TC184/SC4 meeting in June 2009, Parksville, Canada

relevance to interoperability is how IDIOM identifies OWL and CL as possible ontology specification languages for the representation of semantics. Significantly, this approach aims to maximise the value of the extensive range of standards that already exist within ISO TC184 SC4.This is an important step forward towards having sets of ISO enterprise standards that are interoperable.

#### 8.4.2.2 Consolidation of ISO Standards in Industrial Automation

It has been recognised that the textual definitions of similar terms across a number of ISO standards in industrial automation can be varied [84]. As a consequence of this, subjective interpretation of concept meanings can occur and, therefore, there is a need for being able to formally capture the semantics of these terms to enable their verification and checking for their consistency. This is fundamental for the interoperability of systems that are developed based on standards-based definitions.

As a means of illustrating the consolidation and verification of the meaning of concepts, pilot implementations have been carried out to research the value of representing the semantics of production-centric concepts, defined in ISO standards, using the OWL and CL approaches[85]., emphsising the need for significant further work in this area. Another related effort focusing on the ontology-driven definition of ISO concepts is the SemanticSTEP work being done under the S-TEN project[86]. These show the value of formal ontologies for interoperability across standards. The significant difference in capability between OWL and CL are also highlighted.

#### 8.4.2.3 Reference Ontologies

Another area of relevance for the progression towards improved standards for ontologies in enterprise interoperation is concerned with the development of reference ontologies for particular business domains. These ontologies are different from foundation ontologies in the sense that they capture theories about specific areas that are generally validated and agreed by a large community of experts for specific business domains. Reference ontologies are not application-specific but offer a basis for specialisation to heterogeneous application ontologies that can then support interoperation across suit a range of focused applications.

For enterprise interoperation, reference ontologies can for example, encompass concepts in product lifecycle management. Examples of current similar ontologies are the MAnufacturing Semantics ONtology [87] which is a proposal for a common semantic definition for the manufacturing domain. Another example is the manufacturing core ontology which has been developed in the context of the Interoperable Manufacturing Knowledge Systems (IMKS) project[88]. This ontology supports the specialisation of application-specific models as well as the provision for verification mechanisms to enable knowledge sharing across design and manufacturing applications. Other acknowledged reference ontologies include the Foundational Model of

---

[84] Michel, J.J., 2005. Terminology extracted from some manufacturing and modelling related standards. CEN/TC 310 N1119R2.

[85] Chungoora, N., Cutting-Decelle, A.-F., Young, R.I.M., Gunendran, A.G., Usman, Z., Harding, J.A. and Case, K., 2011. Towards the ontology-based consolidation of production-centric standards. *International Journal of Production Research*. DOI:10.1080/00207543.2011.627885.

[86] S-TEN Project: Intelligent Self-describing Technical and Environmental Networks SemanticSTEP. [Online] Retrieved from http://www.s-ten.net/

[87] Lemaignan, S., Siadat, A., Dantan, J.-Y., Semenenko, A., 2006. MASON: a proposal for an ontology of manufacturing domain. In: *Proceedings of the IEEE Workshop on Distributed Intelligent Systems: Collective Intelligence and its Applications (DIS'06)*.

[88] Interoperable Manufacturing Knowledge Systems http://www.lboro.ac.uk/departments/mm/research/product-realisation/imks/index.html

Anatomy (FMA)[89] and the Common Anatomy Reference Ontology (CARO)[90] developed to suit the biomedical field.

Each business domain within FInES could potentially benefit from its own reference ontology as a primary support for interoperability bearing in mind that many future applications will lie across business domains and therefore will need ways of translation from one ontology to another.

#### 8.4.2.4 Issues on Ontologies

The major issue is not that there are ontologies with different means of managing their descriptions of objects, rather it is in finding the correct ontologies for the object whose description that is required. This is almost a state where we need a hierarchy of ontologies or even an ontology of ontologies where the description and operational parameters of each subservient ontology is held. Once this is in place it can be possible to search out the correct description for the object under consideration. However, a major issue may be that in many ontologies the same object may be held with either subtly different descriptions or else very different descriptions but yet the specific object holds the same name but exists in a different domain as something different.

In order for machines to be able to find the information about objects that they may need there will need to be a range of strategies that enable the correct description to be found.

As in the case of interoperability, there are likely to be basic rules that can allow any ontology to be characterised and therefore used by systems. This will be especially important where applications or service need to work across multiple enterprise areas. In such cases M2M communication which entails the devices at each end of the communication to work together reliably is a major challenge. The basic rules should form part of a standard for working enterprise interoperability to level 6 of the IFRS (See CWA50560:2010 IFRS in Section 8.3.2).

## 8.5 Specification Languages

For the purpose of this section, an ontology specification language is regarded as one that is used for representing the structures behind consensual information and knowledge. There are multiple ontology specification languages most of which broadly fall into three main categories: (1) ontology markup languages (i.e., Semantic Web languages), (2) schematic languages and (3) general ontology languages (see Figure 8).

89 Rosse, C. and Mejino Jr., J.L.V., 2003. A reference ontology for biomedical informatics: the foundation model of anatomy. *Journal of Biomedical Informatics*. 36: 478-500.

90 Haendel, M.A., Neuhaus, F., Osumi-Sutherland, D., Mabee, P.M., Mejino, J.L.V., Mungall, C.J. and Smith, B., 2008. CARO – the common anatomy reference ontology. In: Burger, A., Davidson, D. and Baldock, R., (eds). *Anatomy ontologies for bioinformatics: principles and practice*. Computational Biology. 6(4): 327-349.

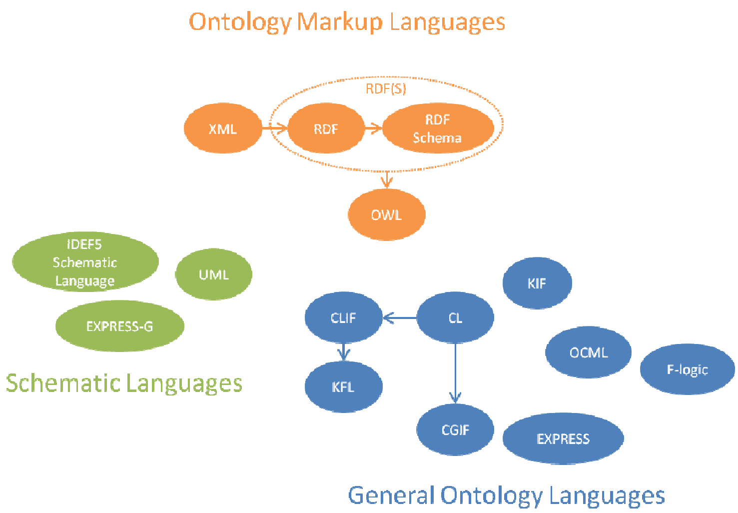


Figure 8. Identifications of examples of ontology specification languages.

Ontology markup languages such as the Resource Description Framework (RDF) and the Web Ontology Language (OWL) have their syntax based on the eXtensible Markup Language (XML) and are Description Logic-based. Description Logics (DL) are a subset of First Order Logic (FOL) and are optimised to ensure decidability for inference engines. Schematic languages offer a diagrammatic basis for defining and designing ontologies. On the other hand, general ontology languages are largely FOL-based and offer the potential for developing expressively-encoded ontologies. Examples include the Knowledge Interchange Format (KIF) and Common Logic (CL) (ISO 24707, 2007).

Table 7 summarises the various ontology specification languages in terms of their descriptions, their underlying basis, in regard to the lightweight and heavyweight methods, and the main contributors who have supported the development of these languages. It is important to note that the appropriateness of an ontology specification language is dependent on the interoperability requirements that need to be met in any particular enterprise interoperability situation. In FInES the most likely relevant languages are likely to be RDF, OWL and CL.

Table 7. Examples of ontology specification languages

| Ontology Specification Language | Description | Basis | Contributor |
|---|---|---|---|
| **XML** | eXtensible Markup Language provides the syntax for the stack of Semantic Web languages | Lightweight | World Wide Web Consortium (W3C) |
| **RDF, RDF Schema, RDF(S)** | Resource Description Framework is used for modelling information to be deployed as Web resources | Lightweight | World Wide Web Consortium (W3C) |
| **OWL** | Web Ontology Language is a markup language to develop ontologies for the Semantic Web | Heavyweight | World Wide Web Consortium (W3C) |
| **IDEF5 Schematic Language** | Integration DEFinition Schematic Language is used to design ontologies | Lightweight | Knowledge Based Systems, Inc. |
| **UML** | Unified Modelling Language is an object-oriented graphical notation to model information | Lightweight | Object Management Group |
| **EXPRESS-G** | Diagrammatic notation for information | Lightweight | ISO 10303 |

| | | | |
|---|---|---|---|
| | models | | |
| **EXPRESS** | A language for modelling product data | Lightweight | ISO 10303 |
| **F-Logic** | Frame Logic is an object-oriented approach to FOL used for deductive and object-oriented databases | Heavyweight | Stony Brook University, University of Mannheim |
| **OCML** | Operational Conceptual Modelling Language is a language that supports the definition of 1st and 2nd order axioms | Heavyweight | Knowledge Media Institute, The Open University |
| **KIF** | Knowledge Interchange Format provides a syntax for FOL which can be understood by computers | Heavyweight | DARPA knowledge sharing effort |
| **CL** | Common Logic is described as a framework for a family of languages which are logic-based | Heavyweight | ISO/IEC 24707 |
| **CGIF** | Conceptual Graph Interchange Format is a dialect of CL used for representing conceptual graphs | Heavyweight | ISO/IEC 24707 |
| **CLIF** | Common Logic Interchange Format is the KIF-like syntax used in CL | Heavyweight | ISO/IEC 24707 |
| **KFL** | Knowledge Frame Language is based on an extended implementation of CLIF called ECLIF | Heavyweight | Highfleet, Inc. |

### 8.5.1 New Area of Work

#### 8.5.1.1 Ontology Integration and Interoperability (OntoIOp)

OntoIOp is a new working item which has been proposed to ISO TC37/SC3 by OASIS. The aim of this effort is to support the specification of a formal language for enabling distributed knowledge representation in ontologies with the added benefit of achieving interoperability across ontologies, services and devices. The Distributed Ontology Language (DOL) to be developed in OntoIOp is intended to accommodate mapping mechanisms between ontologies as well as translation mechanisms between ontology languages. Again mapping methods between ontologies are likely to be of great significance for FInES and standard methods by which these can be developed will be important.

#### 8.5.1.2 Value Delivery Modelling Language

OMG is expanding their focus from technical standards to methods that can be used by business leaders and managers. Thus there is a growing interest in business ecology and cross boundary collaborations. Excellent progress is being made in developing a modeling language that supports the following views: Value Networks, Value Chain, Business Model, REA (resources, events, activities). It also holds strong possibility of supporting other views as well such as system dynamics.

One of several innovations in the modeling language addresses the sometimes puzzling and conflicting ways people describe capabilities. We are taking the position that capabilities and functions can simply be modeled as value networks. This then leaves resources and assets to be handled as they are in VNA (Value Network Analysis) by associating them to the roles that control them through either use (if consumable) or application (if they are assets that are not consumed such as intangible assets).

## 8.6 Summary of issues

The issues in Semantic Interoperability for Enterprises can be viewed from the perspective of frameworks, ontologies and languages. While there are many frameworks, they are needed in order to understand and measure the capability of enterprises to interoperate. The applicability of key frameworks and relationships need to be understood.

There are a huge number of lightweight ontologies that contribute to their individual specific areas of interoperation. However, when combined into the necessary sets of standards needed by an enterprise they are not cross-compatible and require new, heavyweight ontologies and mapping methods to support interoperability (or alternately an ontology of ontologies). There is substantial value and expertise captured in many of these specific standards that needs to be extracted or developed within interoperable solutions. Strategies to do this and normalise the task of searching for the correct description under the correct ontology need development.

The variation in languages used to define ontologies also creates interoperability problems and there is a need to both match these to interoperability requirements and look towards interoperability methods between ontology languages[91].

Because of this diversity of approaches by a large number of frameworks, ontologies and languages, work is needed urgently to find ways for any application or use of information that may be discovered and resolved under these approaches and in any of the ontologies or languages used. Such resolution, must be via an open and generic process and may use applications which can translate from one framework, ontology or language into another or to the base used by the application or service.

It is thought that there should be a process for such a service or methodology which would need to be monetised in order to become viable and development of this should be part of the work on developing an Enterprise Interoperability Ecosystem under FInES. Among other issues that will need resolution, will be how needs for translation applications or drivers to make objects inclusive in a particular environment can be made visible as a value proposition so that developers can identify the need of solutions and deliver applications and processes satisfying the need. However, general Interoperability is a prerequisite for this and this work should lead to the specification and establishment of an overall Interoperability Ecosystem.

# 9 Conformance and Interoperability Testing Standards and Initiatives

Interoperability and Conformance testing involves checking whether the applications conform to the standards so that they can interoperate with other conformant systems. It is clear that only through testing, correct information exchange among applications can be guaranteed and products can be certified.

Currently, there are testing tools, test suites and testing committees which individually address specific individual standards. However, integrated testing frameworks which are capable of handling testing activities across all aspects of interoperability are necessary for conformance and interoperability validations. Moreover, ensuring correctness of produced data or a business result according to operational semantics of the real life use case is another motivation for testing activities. In fact, this is as crucial as achieving plug-and-play interoperability. Therefore, test frameworks should extend the automation of testing to cover the real life semantics of the business cases.

---

[91] Could this be something similar to the OSI 7 Layer stack?

An excellent example of this is the CEN CWA16408:2012 Testing Framework for Global eBusiness Interoperability Test Beds (GITB) and can be found on the CEN Website.

The work on GITB was motivated by the increasing need to support testing of eBusiness scenarios as a means to foster standards adoption, achieve better compliance to standards and greater interoperability within and across the various industry, governmental and public sectors.

Although eBusiness scenarios are widely adopted by users in these sectors, it is still cumbersome for them to reach interoperability of eBusiness implementations and to achieve conformance with standards specifications. More advanced testing methodologies and practices are needed to cope with the relevant set of standards for realizing comprehensive eBusiness scenarios (i.e. business processes and choreography, business documents, transport and communication protocols), as well as Test Beds addressing the specific requirements of multipartner interactions.

GITB is intended to increase the coordination between the manifold industry consortia and standards development organizations with the goal to increase awareness of testing in eBusiness standardization and to reduce the risk of fragmentation, duplication and conflicting eBusiness testing efforts. It thereby supports the goals of the European ICT standardization policy[92,93,94,95] to increase the quality, coherence and consistency of ICT standards and provide active support to the implementation of ICT standards.

**Vision**

The long-term objective is to establish a shared and Global eBusiness Interoperability Test Bed (GITB) infrastructure to support conformance and interoperability testing of eBusiness Specifications and their implementation by software vendors and end-users.

**Objectives**

The GITB project aimed to:

- develop the required global Testing Framework, architecture and methodologies for state-of-the-art eBusiness Specifications and profiles covering all layers of the interoperability stack (business processes, business documents, transport and communication);
- support the realization of GITB as a network of multiple Test Beds, thereby leveraging existing and future testing capabilities from different stakeholders (for example standards development organizations and industry consortia, Test Bed Providers, and accreditation / certification authorities);
- establish under EU support and guidance, a setup of a comprehensive and global eBusiness interoperability Test Bed infrastructure in a global collaboration of European, North American and Asian partners.

GITB focused on the architecture, methodology and guidelines for assisting in the creation, use and coordination of Test Beds. It is not intended to become an accreditation/certification authority or to impose a particular Test Bed implementation.

---

92 COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL AND THEEUROPEAN ECONOMIC AND SOCIAL COMMITTEE A strategic vision for European standards: Moving forward toenhance and accelerate the sustainable growth of the European economy by 2020 COM(2011)311 final

93 Proposal for a Regulation of the EU Parliament and of the Council on European Standardisation" COM (2011)315 final dated 1 June 2011.

94 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52010DC0245R(01):EN:NOT

95 http://ec.europa.eu/information_society/digital-agenda/publications/index_en.htm

# 10 Analysis of General Requirements for Standards and convergence in FInES

The previous chapters have outlined a large number of candidate standards for The Cloud, Semantic Interoperability, The Internet of Things, Enterprise Interoperability, relevant Ontologies and Specification Languages. Furthermore, it has been observed that often useful specifications developed by RTD are lost to standardisation because they are part of the final output of the Project process and neither time nor money is available to introduce them to standardisation.

Another issue is that many standards supporting interoperability are developed by both Standards Development Organisations (SDOs) and industry consortia, building both on research results and commercial development. However, because there is no coordination between the different organizations, these standards provide neither a coherent nor a sufficient set of solutions for the complexity of the Future Internet or for complex business and enterprise systems.[96]

The European Commission recommends in their recent White paper, titled '*Modernising ICT Standardisation in the EU - The Way Forward*[97] the following measures:

- To allow for a more integrated approach in ICT standardisation and the use of ICT standards and specifications;
- To strengthen collaboration and cooperation in ICT standards development, both Europe-wide and globally.
- To strengthen competitiveness of industry and fair competition by fostering the implementation of standards and specifications;

Many of the results of this consultation have been included in the *"2010-2013 ICT Standardisation Work Programme for industrial innovation"*[98]

To emphasise the first bullet above, the editors of this report note that many of the technology, techniques and methods used by the wide range of FInES related standardisation work (covered in the previous sections) tend to utilise similar approaches and similar solutions. Unfortunately, even where they do basically the same thing, they are not interchangeable and they are not usually interoperable with one another, even where they consist of "interoperability" frameworks.

It is considered therefore that there should be work undertaken to deliver a normalised or standard view of the various methods of using the existing standards such that the multiple but different systems can work interoperably together. It is noted that even between the various flavours of the Cloud, the Internet of Things and Enterprise Interoperability the same necessities arise. Any system or application must be able to discover what it needs, it must be able to identify what its discovered object is (device, information, application, etc..), it must be able to find out from that identification what it has discovered, the description of what the object does and how it does it and what ontology model and interoperability framework it uses.

Once a system or application, has made these discoveries, it has the information it needs to utilise that, or similarly any object (regardless of underlying flavouring). However, it needs to reach out to obtain the tools it needs to work with that object (unless that object lies within its own particular "flavour set"). It is the process of "reaching out to find resources" and creating a system

96 K. Kosanke, R. Martin: Enterprise and Business Process – How to interoperate? The Standards View, Standards Workshop at the I-ESA 2008, http://www.interop-vlab.eu/

97 http://ec.europa.eu/enterprise/policies/european-standards/files/ict/policy/standards/whitepaper_en.pdf

98 http://ec.europa.eu/enterprise/sectors/ict/files/ict-policies/2010-2013_ict_standardisation_work_programme_1st_update_en.pdf

where there is a reward for providing the resources that may need to be a subject of the definition and design of the “Interoperability Ecosystem”.

One of the observations made is that the various standards and specifications reported on in Chapters 6-8 are in many cases the result of many man years effort and much expenditure in their development. The owners of the Intellectual Property (IP) are not going to rewrite their work to make it interoperable with some new standard. Often their IP will often be aimed at a specific sector or niche in the market and making changes would be unnecessary. However, in a converging environment, it will be necessary to share resources across sectors and utilise objects working under multiple and different systems. The result of this is that we will need some form of “Interoperability Ecosystem” where the means are provided to enable such applications to utilise any object in any system provided that it has the right and security clearance to do so.

Therefore, one suggestion for future work of this report is to look at The Cloud, Semantic Interoperability, The Internet of Things, Enterprise Interoperability, relevant Ontologies and Specification Languages and seek to understand the commonalities, the ways in which they may be categorised, the methods used and how they could be integrated into an “Interoperability Ecosystem”. Before this work can undertake a serious integration, there must be a detailed analysis of all the relevant systems from Chapters 6-8 to understand how they work in isolation. From this analysis, we may be able to begin to create the structure of an environment where there is general interoperability or an Interoperability Ecosystem.

This work could be a strand of the NoE in Internet Science and could be promoted as almost pure research in the first instance or it could be work set up by FInES as a project or more general approach. However, once the initial, “how to approach the problem” work has been done, then an ecosystem can be created where services and applications can be constructed from all sorts of objects regardless of which underlying system they belong to and utilised in a practical environment using real information, applications and enterprise interoperability.

It is suggested that this work could be made a subject of the next call under FP8.

## 10.1 Future Work seen as necessary

### 10.1.1 The Basics for Interoperability in FInES

Time and again the conclusion of a chapter or sub chapter has been along the lines of “In this area, there have been lots of attempts to resolve the problem and there have been many successful solutions”. However, there are now many successful solutions doing approximately the same thing but in different ways. The general methods are similar but the details are different.

Unfortunately, in many cases, the specific solutions have considerable traction in terms of numbers of users and expenditure on their creation and they have to be regarded as fixed points. Therefore, any method of federation, must accept and acknowledge the status quo if specific solutions and find ways of interfacing or interoperating with them.

It is useful to understand that if the IoT is extended to include applications (apps, drivers, bridges, etc.) and any “thing” is reduced to Identity, Description and Discovery, then there will be a basis for building an ecosystem where everything can work together. The Core Project of the FI PPP are undertaking significant work in this area and this will need to be assessed.

The recommendation of this report is that FInES should devote resources towards tackling this issue. However, a completely federated solution that can accept any extant solution in any of the standards and specifications areas covered in sections 6 – 8 is a major area for thought and R&D. This is work that needs doing urgently. It is certainly work that is also relevant to FI-WARE, IERC, the European Research Cluster on the Internet of Things, http://www.internet-of-things-research.eu (former CERP-IoT).

and to the NoE in Internet Science. Therefore, FInES must set up liaisons and collaboration with these bodies. Ultimately though the work needs scoping from an Enterprise perspective since it has to include all the stakeholders and ensure as well as being able to use the Interoperability Ecosystem they all receive a benefit from their activity in contributing to the ecosystem.

Looking beyond the basics, it is noted that many projects are beginning to look at systems where the environment of the project and its subject is virtualised and taken into a virtual environment that models the real world and where experimentation and change may be applied and modelled distinctly from activities in the real world and when virtually proven can be reintroduced as reliable change in the real world. Other areas are the ability to use virtual models that can drive many different facets of industrial production, but be tools for marketing, planning and compliance with specifications.

Such virtual systems are effectively made up of multiple systems that have been converged together in a manageable, virtual and holistic picture of the real world which reflects the real world actions. Such environments are likely to require all the tools delivered by the standards and specifications outlined in previous chapters and will rely on their convergence in a repeatable and efficient manner. An Interoperability Ecosystem must be able to call on any tool or application or device or information to be able to function which is non trivial both in scope and execution.

### 10.1.2 Coordination Action or other mechanisms

The COPRAS Coordination Action completed in early 2007 laid down a series of recommendations for the dissemination and standardisation outputs of projects under FP6 and FP7. However, in the absence of a project actually being in force, despite the good words about standardisation inserted into every STREP and IP, it is noted that in general the standardisation outputs from EU projects have not been maximised. This is often despite the fact that in order for the participants to exploit their project work, they need the supporting standards in place. The FInES STF considers that there should be a follow on to the COPRAS Coordination Action charged with actively extracting standardisation outputs from projects and as necessary assisting project with the standardisation process. One such action could be to request a formal standardisation plan in each new project proposal and provide the means for delivering resultant standards into the appropriate standards body.

Thus, it is considered that steps should be taken to ensure that there is maximum harmonisation of the large set of existing and developing standards in the area of the Future Internet and relevant other areas of EU projects, for Interoperability of services and things/devices and which ensures a dialogue between the standardisation environment and the RTD environment.

This may consist of a project or ongoing framework that should be designed to influence research with respect to standardisation and influence standardisation by disseminating the work of projects. The project should ensure that all current and future projects under the life of the CA must have links and outputs into standardisation and where insufficient resources have been allowed for this, that activities are established to overcome such shortfalls. The project should hold knowledge dissemination events that attract both the research and the standardisation communities In particular it should look towards a more general Interoperability Framework that covers the Future Internet more directly that existing work.

It is recommended that whatever is put in place has a mandate:

- to have an ongoing lifespan to ensure continuity,
- to work closely with projects in order to influence and extract their standardisable specifications and methods,
- to be funded to ensure that it can continue the process beyond the end of EU projects,
- to liaise and work closely with the ESOs to determine which standards committees and working groups should receive and normalise the work.

(It is possible that funds should be drawn from both DG INFSO and DG ENTR with their responsibility for Standardisation).

### 10.1.3 FP7 Research and FInES: Interrelationships for Standardisation

It is evident that the aspirations of FInES and its Standardisation of work related to the Future Internet as applied to Enterprises (FInES) has significant overlaps with the activities in key related FP7 areas of research as detailed in the Annex chapter 12. Our understanding is that the relationship will be as shown in Figure 9 below:

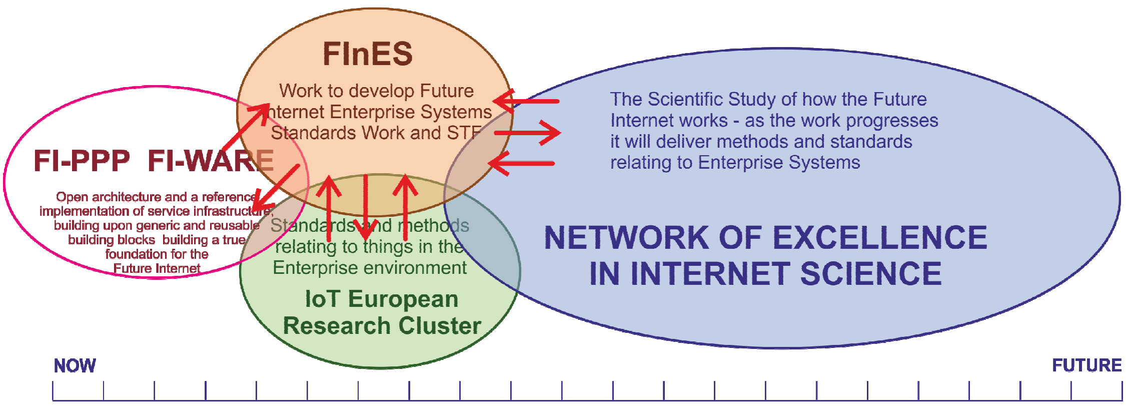



Figure 9. Relationship between activities in NoE-IS, IERC-IOT and FInES Standardisation

It is expected that outputs from both NoE and IoT will produce standards and new methods of managing Enterprise Systems. However, it should be noted that much of the work of FI-WARE and IERC (IERC-European Research Cluster on the Internet of Things) is likely to be relevant to FInES Standardisation. It should also be noted that Figure 9 has a time dimension. The FI-WARE, project under FI-PPP, is delivering its Open Architecture now. Much of what FInES and IERC lie in the near future and the standards output lags the project timescales. The NOE Internet-Science has only just started and it should be a project into which FInES can request the really intractable problems in developing the Future Internet. It is possible that the concept of an Interoperability Ecosystem should be one of those problems.

In the meantime, we should be creating liaisons between FInES and FI-WARE[99], IERC[100] and NoE in Internet Science[101]. Information on these can be found in Annex Chapter 12

99 See: http://www.fi-ware.eu/
100 See: http://www.internet-of-things-research.eu/index.html
101 See: http://www.internet-science.eu/

# 11 Conclusions

This report has drawn together and analysed work from standardisation of relevance to FInES, key inputs from FInES projects into standardisation, as well as identifying other research clusters that may have significant inputs to make towards related future standardisation. The following conclusions have been drawn against the original objectives of the report:

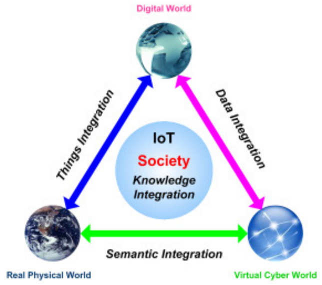
1. The understanding provided in this report has been drawn from a wide range of FInES experts who are closely associated with standards development. It is clear that this has given us good coverage of the related standards and standardisation groups, and enabled a effective understanding of the breadth and depth of the issues to be provided. However, given the extensive range of standardisation efforts that exist there will inevitably be some gaps in the coverage presented.
2. In clarifying the broad range of standardisation efforts that are underway is it has been important to identify an appropriate way of collating relevant work in order to better understand the standardisation gaps and issues for the future. This has been achieved by classifying standardisation efforts against Cloud Computing, Internet of Things, Semantic Enterprise Interoperability as well as conformance and interoperability testing. While there are many potential overlaps across these areas, the use of this classification has helped to demonstrate the wide range of effort that has been undertaken and to provide a useful basis for the analysis presented in chapter 10.
3. It is clear that a major barrier to successful interoperability standardisation is the lack of inter-standard interoperability. The extensive range of standardisation work that is currently undertaken is broadly focused on key localised problems that do not fit within a clearly specified interoperability framework.
4. There is a need to research the requirements of an interoperability eco-system framework within which this broad and growing range of standards can be positioned and exploited. It is clear that until some such approach is in place efforts to improve interoperability will continue to be fragmented.
5. Nonetheless it is clear that the current requirement on projects to have a standardisation plan has a positive effect in maintaining a close relationship between projects and their relevant standardisation groups.
6. It is also clear that a barrier to maximising the exploitation potential of research project results is the imbalance between the timescales for project completion and the timescales for full standardisation.
7. There is a need to identify a way to tap into a detailed understanding of the results beyond the traditional end point of a project. More effective standardisation outcomes from FInES projects requires a new funding model which enables the exploitation of project results for standardisation but against standardisation timescales. A Coordination Action similar to that described in chapter 10.1.2 should be of significant value.
8. It is noted that there is relevant activity under FI-PPP FI-WARE, IERC-IOT and the Network of Excellence in Internet-Science where work is being undertaken of probable relevance to FInES. It is recommended FInES establishes liaisons with these groups.

# 12 Annex: Relationship with other Internet work and or Clusters

It should be noted that the work of Standardisation in FInES and the general work of FInES has a relationship with work in other areas. Foremost of these are

## 12.1 IERC-European Research Cluster on the Internet of Things

Internet of Things (IoT) is an integrated part of Future Internet including existing and evolving Internet and network developments and could be conceptually defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network.



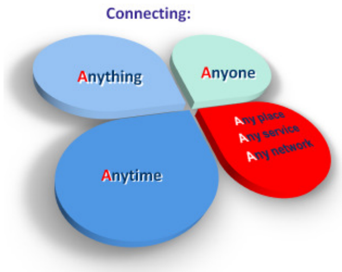




Figure 9. Scope of IERC-IoT

In the IoT, “smart things/objects” are expected to become active participants in business, information and social processes where they are enabled to interact and communicate among them-selves and with the environment by exchanging data and information “sensed” about the environment, while reacting autonomously to the “real/physical world” events and influencing it by running processes that trigger actions and create services with or without direct human intervention.

Services will be able to interact with these “smart things/objects” using standard interfaces that will provide the necessary link via the Internet, to query and change their state and retrieve any information associated with them, taking into account security and privacy issues IoT has the potential to enhance Europe's competitiveness and will be an important driver for the development of an information based economy and society. A wide range of research and application projects in Europe have been set up in different application fields. Communication between these projects is an essential requirement for a competitive industry and for a secure, safe and privacy preserving deployment of IoT in Europe.

The IERC - IoT European Research Cluster - European Research Cluster on the Internet of Things is bringing together EU-funded projects with the aim of defining a common vision and the IoT technology and development research challenges at the European level in the view of global development. The rationale for IoT is to address the large potential for IoT-based capabilities in Europe - coordinate/encourage the convergence of ongoing work on the most important issues - to build a broadly based consensus on the ways to realise IoT in Europe.

There should be standardisation input from IERC-IOT into FInES Standards.

## 12.2 The Network of Excellence in Internet Science

The Network of Excellence in Internet Science aims to strengthen scientific and technological excellence by developing an integrated and interdisciplinary scientific understanding of Internet networks and their co-evolution with society, and also by addressing the fragmentation of European research in this area. Its main objective is to enable an open and productive dialogue between all disciplines which study Internet systems from any technological or humanistic perspective, and which in turn are being transformed by continuous advances in Internet functionality.

The network brings together over thirty research institutions across Europe that are focusing on network engineering, computation, complexity, networking, security, mathematics, physics, sociology, game theory, economics, political sciences, humanities, and law, as well as other relevant social and life sciences. The network's main deliverable will be a durable shaping and structuring of the way that this research is carried out, by gathering together a critical mass of resources, gathering the expertise needed to provide European leadership in this area, and by spreading excellence beyond the partnership. The network is funded under the European Commission's Seventh Framework Programme: Information and Communication Technologies.

Its main goals are:

1. Coordinate the investigation, from a multi-disciplinary perspective, of specific important Internet-related topics at the intersection between humanistic sciences (social life, economy, law and regulation), technological sciences and environmental concerns (including energy), such as privacy and identity, reputation, virtual communities, security and resilience, network neutrality.
2. Lay the scientific and methodological foundations for the development of an Internet Science, based i.a. on Network Science and Web Science, aiming at understanding the co-evolution of Internet and Societies and in particular the impact of the "network effect" on human societies and organisations, as for technological, economic, social and environmental aspects.

NoE in Internet Science (EINS) sees its challenges as:

The various disciplines which contribute to "Internet Science" inevitably talk different languages and use different design and analysis tools. To establish an effective and productive dialogue between these different disciplines, the network will identify incentives to create collaboration opportunities. The key elements of Internet Science are:

- Multidisciplinary Convergence. As a platform, the Internet can enable integration of the various sciences that have made the greatest sustained contribution to human progress; however, their differing perspectives can also lead to missed opportunities and unanticipated consequences.
- Observability. The Internet generates unprecedented amounts of data on all sorts of human behaviour, and at the same time makes possible their integration with analytic and computational facilities.
- Constructive Experimentation. The global reach, discretionary connectivity and openness of the Internet, combined with the potential for generating 'subnets' and human-machine complexes, provides an ideal test bed for technological, socioeconomic and cybernetic experiments to complement the natural experiments provided by the observability and diversity of the Internet.

A key outcomes of the Network of Excellence in Internet Science will be:

- A set of scientific methodologies, deeply rooted in methods for understanding complex systems arising in biology, physics, economics and (other) social sciences;

- A set of emergence theories and system design methodologies that draw on work in various communities such as computer science, media design, political science and economics, and that recognises their implications for how designed artefacts are used.
- A set of empirical and experimentation methodologies that provide evidence, which can be used to test hypotheses, feed back into design and quantify or calibrate factors that range from individual end users' regulatory and legislative concerns to technological uncertainties and choices.

There is a strong need for liaison between FInES and NoE IS since FInES is now encountering Internet issues that need solutions at the basic level if we are to establish a working Interoperability Ecosystem which can serve and reward all the stakeholders in it.

## 12.3 FI-Ware –the Future Internet Core Platform

The goal of the ongoing European FI-WARE[102] project is to introduce an innovative infrastructure for cost-effective creation and delivery of services, providing high QoS and security guarantees. FI-WARE is designed to meet the demands of key market stakeholders across many different sectors, e.g., healthcare, telecommunications, and environmental services. FI-WARE unites major European industrial actors.

The key deliverables of FI-WARE will be an open architecture and a reference implementation of a novel service infrastructure (middleware), building upon generic and reusable building blocks developed in earlier research projects – building a true foundation for the Future Internet

FI-WARE is based on the following main foundations: Service Delivery Framework – the infrastructure to create, publish, manage and consume FI services across their life cycle, addressing all technical and business aspects. Cloud Hosting – the fundamental layer which provides the computation, storage and network resources, upon which services are provisioned and managed. Support Services – the facilities for effective accessing, processing, and analyzing massive streams of data, and semantically classifying them into valuable knowledge. IoT Enablement – the bridge whereby FI services interface and leverage the ubiquity of heterogeneous, resource-constrained devices in the Internet of Things. Interface to Networks – open interfaces to networks and devices, providing the connectivity needs of services delivered across the platform. Security – the mechanisms which ensure that the delivery and usage of services is trustworthy and meets security and privacy requirements.

The project intends develop Open Specifications of these Generic Enablers, together with a reference implementation of them available for testing. It is also intended to allow new organisations and consortia to contribute to these enablers under occasional open calls[103]. This way, it is aimed to develop working specifications that influence Future Internet standards.

[102] http://www.fi-ware.eu

[103] The FI-WARE project has reserved a portion of the project budget to fund specific tasks to be carried out by a new beneficiary or beneficiaries which will join the consortium after start of the project. These later-joining beneficiaries are selected by means of a series of competitive Open Calls. See http://www.fi-ware.eu/open-call/