### Attribute | Description
--- | ---
DC.Title | Enterprise Interoperability
DC.Subject | Basic Concepts, Definitions and Approaches, Enterprise Modelling for Interoperability, Ontology for Interoperability, Introduction to Architecture and Platforms for Enterprise, system Interoperability Business Interoperability (BI)
DC.Description | After the motivation phase and the COIN basic concepts are introduced, the base concepts of Enterprise Interoperability are explained. After describing the overall goals and essential terms for the Interoperability of enterprises, principles, methods and benefits of enterprise Interoperability are explained. Here we show key issue, definitions and approaches in manufacturing and industrial enterprise generally and how Interoperability is the ability of a system or a product to work with other systems based on various architectures and platforms or products without special effort from the user.
DC.Type | Collection
DC.Source | http://videolectures.net/coin_academia_training/
DC.Relation | IsPartOf COIN_ACADEMIA
DC.Coverage | 
DC.Creator | JSI
DC.Publisher | COIN IP FP7-ICT-2007-1
DC.Contributor | JSI
DC.Rights | Distributable
DC.Date | 
DC.Format | PDF, SWF, DOC, HTML
DC.Identifier | 
DC.Language | en
DC.Audience | researchers, business decision makers, engineers, students, scholars, general public
DC.Provenance | 
DC.RightsHolder | COIN IP FP7-ICT-2007-1
DC.InstructionalMethod | Explaining, teaching
DC.AccrualMethod | Updating
DC.AccrualPeriodicity | Irregular
DC.AccrualPolicy | Active
Date.Valid | 
Category | Basic
Background knowledge | Business processes, process modelling, organisation models, basic formalisms, collaboration and networking, social structures, formal models and modelling frameworks
Learning style | Conceptual
User | Scientific, Technical, Informative
UserLevel | Student, Postgraduate, Adult
Aim of the course:
In this course the learner will get basic knowledge on Enterprise Interoperability as an emerging scientific discipline. You will learn basic modes of Interoperability.

Course is composed of:
- reading the document – this document
- watching the video lecture on-line in KSC
- studying additional materials and presentations
- asking questions and debating in KSC

Disclaimer: The base for this course was taken from the ATHENA “Curriculum of the Interoperability Training Service” and has been updated to fit the purpose of the COIN D2.3.1. Training set-up and assessment deliverable.
1. Enterprise Interoperability

1.1 Introduction

Interoperability is the ability of a system or a product to work with other systems or products without special effort from the user is a key issue in manufacturing and industrial enterprise generally. It is fundamental to the production of goods and services quickly and at low cost at the same time as maintaining levels of quality and customisation. Interoperability is achieved if internal and external collaborators can interact on at least three levels: data, applications and business enterprise (through the architecture of an enterprise model and making allowance for the semantics of both partners). Not only a problem of software and IT technologies, it also implies support for communication and transactions between different organisations that must be based on shared business references. Today, a new and important consideration must be taken into account – economic business evaluation and the definition of dissemination policy.

In order to achieve enterprise interoperability as well as to improve collaborative operations (processes), and enhance the decision making regarding the collaborative operations, it is necessary that models are interchangeable and comprehensible for people involved in the business and organization processes. There are strengths, values, limitations and gaps of the application of enterprise modelling to achieve and to support interoperability between companies as well as succeed in reducing the throughput times, improving the process quality, reducing costs.

1.2 Overall goals and essential terms for the Interoperability of enterprises

In the ATHENA project were presented thematic groups of courses according to the classification in the IDEAS roadmap (IST-2001-37368), a follow-up to the European expert group on interoperability of enterprise software, i.e., Enterprise Modelling, Ontology, and Architectures & Platforms, complemented with three more areas also identified of relevance to organize the curriculum. In total they are six areas:

1) Enterprise modeling (EM)
2) Architectures and platforms (AP)
3) Product data exchange (PDE)
4) Ontologies (ONT)
5) Concepts of Interoperability (CI)
6) Business interoperability (BI)

1.2.1 Enterprise Modelling

Enterprise Modelling can be defined as the art of “externalising” enterprise knowledge, representing the enterprise in terms of its organization and operations, like processes, behaviour, activities, information. The goal is to make explicit certain facts and knowledge that adds value to the enterprise or that can be shared by business applications and users in order to improve the performance of the enterprise.

EM provides a methodology to describe the model of an enterprise at a certain level of abstraction allowing build the model of an enterprise according to various points of view, such as function, process, decision or economics.

One of the prime goals of EM is to support the analysis of an enterprise, and more specifically, to represent and understand how the enterprise works, to capitalise acquired knowledge and know-how for later reuse, to design a part of the enterprise, to analyse some aspects of the enterprise, to simulate
the behaviour of (some part of) the enterprise, to make better decisions about enterprise operations and organization, and to control, coordinate and monitor some parts of it.

Related subtopics:
- Enterprise Modelling as a way to achieve Interoperability
- Enterprise Knowledge Modelling of Enterprises
- Cross-Organizational Business Processes - Interoperability Issues and Concepts
- Cross-Organizational Business Processes – Enabling Technologies and Tools

1.2.2 Architectures and Platforms (AP)

The interoperability in enterprise can be defined more simply as “the ability of enterprise Software and Applications to interact”. Consequently, the objective of AP for interoperability is to identify generic features, define generic principles and patterns to design interoperable solutions. These design principles and patterns should be independent of technologies and methodologies, and apply across industry sectors.

The main objective of Model-Driven Architectures (MDA) is to provide new and innovative solutions for the problem of sustaining interoperability through change and evolution, by providing dynamic and adaptive interoperability architecture approaches.

Service-Oriented Architectures (SOA) are being viewed as the next wave of technology to impact the computing landscape, by enabling the use of distributed components by allowing software vendors to provide not only applications to the market, but also a suite of services that can be utilised by a wider audience and paid for through an access or usage business model. SOA provides an integrated approach to enterprise architecture and application design, which places services at the heart of any enterprise architecture. Thus, SOA has the potential to provide decisive flexibility in business and IT design, and also offers flexibility in business strategy.

Related subtopics:
- Service-Oriented Interoperability (SOI)
- Planning and Specification of Interoperable Service-Oriented Solutions
- Implementing Interoperable Service-Oriented Solutions using Web Service and Agent Technologies
- Introduction to Model-Driven Interoperability (MDI)
- Principles of Model-Driven Interoperability.
- Driven Development of Interoperable Web Services, Agents and P2P Solutions

1.2.3 Product Data Exchange (PDE)

One of the difficulties enterprises face is the lack of interoperability of software applications to manage and progress in their business. Organizations are looking for new business relationships, and the exchange of information and documents with new partners often cannot be executed automatically or in and electronic format. This is primarily due to problems of incompatibility with the information representation adopted by the software applications they are working with.

Even within the same company, when a new software application is introduced, it is often impossible to integrate it with other application(s) already running. This means that although new IT capabilities are instigated by the company, the data flow is not automatic and paperless, and thus maintains a high rate of error in data exchange due to the human intervention.

Therefore, the interoperability problem complicates the major decisions of the information technology managers when looking for a new application, where the criteria for choice must be balanced between
1) an application that completely meets their needs; and 2) an application already compatible and ready to be integrated for electronic data exchange with the existing IT environment. Even when conformance in data format and access are achieved and verified, reliable interoperability of information semantics is, therefore, generally not.

The automatic understanding of the data exchanged has been identified as a task that is far from easy, sometimes leading to the development of very complex translators and interpreters. The use of different methodologies and the adoption of incompatible platforms and data structures have been identified as the major causes of this situation.

The endless possibilities for interconnection between parties willing to operate has driven companies to a scenario of near chaos, where solutions to this interoperability problem (often in the form of independent proposals) is becoming a priority. Looking at industrial companies, this problem has been identified as even greater because they additionally need to have a complete integrated and interoperable environment covering product life cycle, e.g., manufacturing and related business activities.

A conceptual model is an abstraction for computational realisation of a world of entities (e.g., physical, concept, relationship, method, constructor, fact, rule). It is through the realisation of such a model that information can flow appropriately between the parties in an interoperable environment. The conceptual data model is thus the basic enabler for seamless information transfer.

The aim is to push companies to become interoperable, by searching for the required integration and flexibility of their systems and enabling them to operate with any other party independently of the place where applications are located or the software architecture resides. Methodologies and solutions are needed to solve the interoperability problem found in industrial environments whenever product data exchange is required.

Related subtopics:
- Introduction to Dynamic Requirements Definition
- Standards to support Interoperability for Product Life cycle Management
- Frameworks for interoperability of product data in SME based environments

1.2.4 Ontologies (ONT)

Ontology reflects a view of a given segment of reality, and two communities (e.g., organizations) operating in the same business domain may have different views of the same matter. Experience shows that differences in the views of the business are the difficult part to be addressed when two Information Systems need to exchange data, and semantic differences are difficult to solve.

Related subtopics:
- Introduction to Semantics
- Ontology based support to Enterprise Interoperability
- Methods and Services for Ontology usage in Interoperable Environments

1.2.5 Concepts of Interoperability (CI)

At its most fundamental level, Interoperability can be described simply as the ability of IT systems and the business processes they support to exchange data and to enable the sharing of information and knowledge. Lack of interoperability today is costing the organizations large sums of money. Some investigations have concluded that 40% of ICT project costs in most major manufacturing industries can be attributed to solving interoperability problems. The Concepts of Interoperability area of study represents a starting point, a basis for initiating a study on the issues of interoperability.

Related subtopics:
• Fundamentals in Interoperability
• The ATHENA Interoperability Framework
• Practices of Interoperability in SMEs

1.2.6 Business Interoperability (BI)

The Technical Interoperability is how software programs in different companies can interact and is the prerequisite for Business Interoperability, which is how different companies can align their business processes in order to do business electronically.

Business Interoperability, generally known as ‘Collaboration’, concerns itself with the semantics and agreements between companies acting in trading communities.

The courses in this area provide an introduction to business interoperability, and assist the students in determining the strategic business challenges relating to interoperability, providing a general model for determining the impact of interoperability on businesses, through the Business Interoperability Framework, Interoperability requirements for applications, Interoperability Impact Analysis Model and Policy Action Recommendations.

Related subtopics:
• Introduction to Business Interoperability
• Business Documents and Protocols

1.3 Enterprise Modelling of Collaborative Enterprises

Interoperability in the context of enterprise applications is the ability of a system or a product to work with other systems or products without special effort from the customer or user. The capability to interact and exchange information both internally and with external organisations (partners, suppliers, customers) is a key issue in the economic sector. It is fundamental in order to produce goods and services quickly and at lower cost, while ensuring higher levels of quality and customisation. Today, companies maximise flexibility and speed of response to changing market conditions, by focusing on core innovation and information centred activities, outsourcing capital and labour intensive activities to less advanced economies. They develop knowledge and links with other companies with which they can collaborate to provide the products and services that the market demands – the networked enterprise, or virtual organisation. Successful enterprises in this knowledge economy may be small, but are highly productive, focussed on innovation and capable of flexibly and rapidly sharing information and knowledge to participate in highly competitive networked enterprises. The issue of interoperability within the enterprise is therefore no longer limited to the interoperability between silos of systems within single companies, but has become one of interoperability throughout a value chain.

Seeking to achieve Interoperability among the partner companies in collaborative enterprises, we face three core challenges:

• **Heterogeneity**, incommensurable knowledge and information perspectives, systems and software infrastructures, working practices, etc. among the partner companies;
• **Need for Flexibility**, due to need for innovation, learning, change and exception handling;
• **Complexity**, the richness and uncertainties of interdependencies within and among partners, their activities, resources, skills and products.

Heterogeneity, need for flexibility, and complexity must be managed at different levels:

• **Knowledge**, approaches, methods and skills needed for innovation, problem solving and work performance, the shared language and frames of reference needed for communication, etc.
• **Process**, the planning, coordination and management of cooperative and interdependent activities and resources;
• **Infrastructure**, the information formats, software tools, and interoperability approaches of the
participating companies.

The resulting problem space is summarised in Table 1. Each level is elaborated below.

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Process</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heterogeneity</strong></td>
<td>Communication, establishing a common languages and meanings across companies and disciplines</td>
<td>Process diversity, negotiating different rules and procedures between the partners</td>
</tr>
<tr>
<td><strong>Complexity</strong></td>
<td>Integrate capabilities, form effective teams across different local cultures. Align views with contents and context among and between stakeholders and people.</td>
<td>Work management and planning, task assignment, coordination and monitoring of activities and tasks across projects, partners and networks, dealing with uncertain interdependencies among several concurrent activities.</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Learning, partners must be able to improve practice based on common experience from the Collaborative Enterprise</td>
<td>Supporting both structured and ad-hoc work (with evolving plans); Handling unforeseen exceptions</td>
</tr>
</tbody>
</table>

Table 1: Problem space for collaborative enterprise integration

1.3.1 Process Structure, Diversity, and Evolution

Unstructured creative activities are often most important for the competitiveness of an enterprise. Even in seemingly routine work, exceptions and uncertainties permeate the environment. Workers reflect upon and manage these problems in a sophisticated manner (Wenger, 1998). Most enterprise knowledge work can thus be regarded as knowledge intensive, creative and emergent as concerns the logical flows of procedure. On the other hand, most work processes also have routine activities and repetitive tasks. Based on the approach, methodologies, platforms and envisioned solutions (working environment), these activities and tasks when performed can yield very different flow patterns. Many companies have prescribed quality management procedures for administration, audit, approval etc. Systems must thus integrate support for ad-hoc and structured work (Haake & Wang, 1997; Jørgensen & Carlsen, 1999). Users must be supported in selecting a suitable degree of plan specificity for the current state of their process, balancing plan complexity with the need for guidance and control. In software engineering, researchers have defined process classification schemes, e.g. to select appropriate methodologies. Reflecting the wide diversity of processes, even within a single industry, up to 15 classification dimensions with 37400 process types have been proposed (Cockburn, 2003).
This number suggests that predefined ways of working cannot be constructed for all variants. Instead, base methodologies must be adapted and combined in the particular circumstances of each collaborative enterprise.

1.3.2 Knowledge, Communication and Learning

Inter-organisational and multi-disciplinary cooperation requires not only information exchange, but also knowledge sharing. Effective teams must form across local cultures. Common frames of reference are established through working together, so support systems must allow the meaning of terms, plans and artefacts to evolve. In communities of practice, this learning process is called negotiation of meaning (Wenger, 1998). Later called participative peripheral learning (Wenger and Lave, 2001) spiralling from abstract conceptual plans and architectural views through horizons of concretised and refined knowledge, until we share adequate inter-dependent views to start working together and even be able to pro-actively share knowledge in visual collaborative views. A collaborative enterprise platform, the MPCE (Modelling Platform for Collaborative Enterprises), as described in D.A1.5.1, must also support new approaches to work execution and management. Tasks must be assigned to whoever is qualified and available; task execution must be monitored for re-engineering and re-assignment across the collaborative enterprise (Lillehagen 2002).

Lack of integration into everyday work practice is a reported shortcoming of knowledge management (KM), enterprise modelling and process improvement (Davenport & Prusak, 1993). KM too often becomes the domain of outside experts that lack a full understanding of the complexities of work and the local language of the work community (Senge 1991, Lillehagen 1994, Wenger, 1998). Work performers become sources of information to KM activities, not active participants and contributors. Standardisation and codification, rather than local innovation, organisational and social learning, become the focal points of KM. Failure rates above 50% are common (Lawton, 2001). Knowledge Management has to exploit visual collaborative scenes (Lillehagen CE 2002). The gap between what people say and what they do, makes it difficult to use enterprise models and other official accounts of work as input to KM (Argyris & Schön, 1978). This is further explained by the horizons and layers of knowledge acquisition, encoding and representation and the proximity to the action of the encoder (Lillehagen CE 2002). Still some knowledge cannot be articulated and will remain tacit, such as alternative actions, feelings and possible experimentation. Most descriptive views in industry are just for the presently needed solution while they are used, subject to an ongoing elaboration and interpretation. Innovation and learning demand that modelling infrastructures be open and must support Reflective Views, Recursive knowledge processes, Repetitive tasks and Replicable meta-models (Lillehagen CE 2002). Models and model views are never complete, but adequate for our purpose and ambition, but they must be consistent, coherent, compliant and co-managed for interoperability of models, meta-models and model elements. This is why the Enterprise Knowledge Architecture (EKA) structures and services are mandatory.

1.3.3 Infrastructure Integration and Customisation

The unique nature of each collaborative enterprise, and the dynamic set of partners, seldom makes it economically viable to integrate information systems through developing new software interfaces. Standardisation today (Chen & Vernadat, 2003) requires that a whole domain is static and well understood, and is thus seldom appropriate for knowledge work. We are encoding too much of enterprise semantics and logic from enterprise knowledge spaces into application software. Consequently, we need an open, model-supported and model-driven infrastructure for collaborative concurrent modelling and execution, supporting shared understanding, work management and learning, and allowing interoperability to emerge from work, rather than being a prerequisite for cooperation. Such flexibility is seldom offered by the tools currently available for collaborative enterprise integration, like e-business frameworks, workflow management, enterprise resource planning, etc. (Alonso et al., 1999). Consequently, flexibility, exception handling and learning are important research topics in all these disciplines.

Simplicity invites use, while complicatedness prohibits use. But in order to achieve simplicity we must
understand and master complexity, which must not be confused with complicatedness. Software that offers a wide range of functionality often becomes incomprehensible and complicated to use. Consequently, only a small portion of the available services is utilised. This condition is known as *featuritis*. We thus need role and task specific user interfaces, emphasising what is needed in the current context. Interfaces and semantics should also adapt to the local needs of each project. Enterprise models, articulating who performs which tasks when and why, are powerful resources for such adaptation.

Systems should also adapt to the skills and preferences of each individual. Where experts should be given freedom to exercise skilled judgment, novices need detailed guidance. Personalisation fosters a sense of ownership, motivating active participation. Studies have shown that personal templates and configurations spread informally through the organisation, improving processes and disseminating knowledge in an emergent manner (Trigg & Bødker, 1994).
2. Reference Materials


http://videolectures.net/iesa08_berlin/

INTEROP-VLab official repository of public deliverables in the Enterprise Interoperability domain

http://interop-vlab.eu/
3. **Suggested readings**