Objectives, structure and contents of the discipline

Architectures for Integration of Systems (AIS) - ENGLISH
Arquitecturas para Integração de Sistemas (AIS) - PORTUGUÊS

Mestrado Integrado em Engenharia Electrotécnica e Computadores

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1 Objectives of the discipline Architectures for Integration of Systems (AIS)

The Architectures for Integration of Systems (AIS) discipline aims to generate insights in the field of Interoperability. Its portfolio of lessons has been designed drawing upon many years of recognized academic, research and industrial experience at the leading edge of interoperability for Enterprise Software and Applications, intending to cover identified knowledge needs.

AIS objective is to prepare the students facilitating their understanding on the whys and hows of today’s common problems at the application and business levels, which are directly or indirectly caused by interoperability difficulties. A further goal is to provide the necessary skills to develop research and technical solutions for interoperability problems.

Thus, students will get knowledge and resources that will increase their ability to execute and drive interoperability solutions, addressing an international perspective, intending to soften the impact of international competition and growing globalization.
2 Organization of the AIS discipline per learning themes and lessons

Twenty one lessons are the components of the AIS discipline, organized into six main learning themes representing specialized clusters of lessons for the AIS discipline. These lessons are prepared to be delivered in a semester of 15 weeks, with a delivery of 4 hours per week of theoretical and practical sessions.

The AIS lessons are:

- **Concepts of Interoperability (CI)**
  - CI1 - Fundamentals in Interoperability
  - CI2 - The ATHENA Interoperability Framework
  - CI3 - Practices of Interoperability in SMEs

- **Enterprise Modelling (EM)**
  - EM1 - Enterprise Modelling as a way to achieve Interoperability
  - EM2 - Enterprise Knowledge Modelling of Enterprises
  - EM3 - Cross-Organizational Business Processes – Enabling Technologies and Tools
  - EM4 - Cross-Organizational Business Processes – Advanced Interoperability Issues

- **Ontologies (ONT)**
  - ONT1 - Introduction to Semantics
  - ONT2 - Ontology based support to Enterprise Interoperability
  - ONT3 - Methods and Services for Ontology usage in Interoperable Environments

- **Architectures & Platforms (AP)**
  - AP1 - Introduction to Service-Oriented Interoperability (SOI)
  - AP2 - Planning and Specification of Interoperable Service-Oriented Solutions
  - AP3 - Implementing Interoperable Service-Oriented Solutions using Web Service and Agent Technologies
  - AP4 - Introduction to Model-Driven Interoperability (MDI)
  - AP5 - Principles of Model-Driven Interoperability.
  - AP6 - Model-Driven Development of Interoperable Web Services, Agents and P2P Solutions

- **Product Data Exchange (PDE)**
  - PDE1 - Introduction to Dynamic Requirements Definition
  - PDE2 - Standards to support Interoperability for Product Life cycle Management
  - PDE3 - Frameworks for interoperability of product data in SME based environments

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1 Tradição do termo português *tema didáctico.*
Business Interoperability (BI)

- BI1 - Introduction to Business Interoperability
- BI2 - Business Documents and Protocols

2.1 Learning theme: Concepts of Interoperability (CI) – 3 lessons

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 learning theme of study represents a starting point, a basis for initiating a study on the issues of interoperability.

The Concepts of Interoperability learning theme is composed of 3 lessons:

CI1 - Fundamentals in Interoperability
The lesson endows the students with the basis and scope of Interoperability.

CI2 - The ATHENA Interoperability Framework
The lesson gives an overview of the objectives and structure of the ATHENA Interoperability Framework (AIF) and provides an example of how this framework can be used to derive ATHENA Interoperability Profiles (AIP) that provide solutions to specific interoperability problem scenarios.

CI3 - Practices of Interoperability in SMEs
The lesson will give a general overview of the specific requirements of SMEs regarding interoperability issues at business, technical and organizational level.

CI1 - Fundamentals in Interoperability is the introductory lesson that provides the basics to the students for understanding the problem related to the lack of interoperability between systems.

The CI2 lesson will enable participants to understand the objective and structure of an Interoperability Framework and how to apply it to solve a particular interoperability problem scenario. This lesson presents results and methodologies reached in enterprise modelling and business process management, ICT service-oriented architectures and development platforms and semantic annotation and ontology-based reconciliation.

The goal of the CI3 lesson is to present the structural and qualitative differences of interoperability requirements of SMEs compared to those of larger enterprises. It analyses typical interoperability scenarios in OEM-SME relationships and networks of SMEs.

CI1 - Fundamentals in Interoperability

This lesson looks at the basics of interoperability for enterprise software and applications as it exists today, and provides a clear and straightforward understanding of its principal concepts. Focusing on Enterprise Modelling, Ontologies, Architectures and Platforms domains, this lesson also delves into aspects of Business Interoperability and Product Data Management. During the lesson, typical interoperability problems found in organizations are presented, and solutions proposed.

OBJECTIVES
This lesson is designed as an introduction to AIS.

CONTENT
1. What is Interoperability
2. Interoperability Problems
3. Business Impact of interoperability problems
4. Proposed solutions
   a. Enterprise Modelling in the Context of Collaborative Enterprises
   b. Cross-Organizational Business Processes
   c. Knowledge Support and Semantic Mediation Solutions
   d. Interoperability Framework and Services for Networked Enterprises
   e. Planned and Customisable Service-Oriented Architectures & Model-Driven and Adaptive Interoperability Architectures
   f. Dynamic Requirement Definition & Piloting

**CI2 – The ATHENA Interoperability Framework**

The aim of this lesson is to present the students with the overall objective and structure of the ATHENA Interoperability Framework (AIF). The different requirements for process vs. product-based interoperability will be explained, as well as the life-cycle services needed for supporting an interoperability project.

A use-case example will demonstrate how to instantiate the AIF to an ATHENA Interoperability Profile (AIP) for solving a specific interoperability problem scenario.

**OBJECTIVES**

The lesson will enable participants:

To understand the objective and structure of the ATHENA Interoperability Framework and how to apply it to solve a particular interoperability problem scenario.

It presents the conceptual level of the AIF, which defines a reference architecture and methodology for interoperability; the technical level, which defines the technical interoperability infrastructure and supporting tools; and the applicative level, which comprises guidelines, handbooks and best practices, will be explained.

**CONTENT**

1. What is the ATHENA Interoperability Framework (AIF)?
2. AIF structure
   a. Process based interoperability
   b. Product based interoperability
   c. Conceptual level
   d. Technical level
   e. Applicative level
3. ATHENA Interoperability Profiles (AIP) – solutions to interoperability scenarios
4. Life-cycle services for interoperability projects
5. Application of an AIP to an interoperability problem scenario (use-case example)
CI3 - Practices of Interoperability in SMEs

The lesson will give a general overview of the specific requirements of SMEs regarding interoperability issues at the business, technical and organizational levels. It will present a common problem scenario (carrier-shipper interaction when consuming logistics services) that illustrates the needs and requirements related to the transparent and automated integration of services, data and process mapping, configuration of business processes and the provision of predefined and configurable adapters. A conceptual solution to the interoperability challenges stated in the common problem scenario will be presented, as well as guidelines and best practices for applying generic solution approaches, tools and methodologies.

OBJECTIVES

The lesson will enable participants:

- To understand the specific interoperability requirements of SMEs
- To use the an Interoperability Framework for elaborating customised solutions to interoperability issues in SME environments

CONTENT

1. SME-specific interoperability requirements
   a. Major differences to larger organizations
2. An example problem scenario
   a. Relations with other SME business scenarios (e.g. Procurement)
3. Conceptual solution to the problem scenario
4. How to build a conceptual solution using the AIF

2.2 Learning theme: Enterprise Modelling (EM) – 4 lessons

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.

The students will progress beyond the current state-of-the-art, by improving current approaches for EM-driven execution, and will thus contribute to improving organizational and process interoperability. Furthermore, it will provide methodologies to model the level (or maturity) of the interoperability of enterprise’s applications and processes.

These lessons will improve early user involvement with scaled methodologies, tools and dynamic involvement of end users to perform model-supported daily business. Also, they will engage in the further development of a unified Enterprise Modelling language to enable the exchange of enterprise models. The development of a collaborative business process modelling methodology will open new ways to externalise the dynamic dependencies between participants and processes, and to support the execution of these complex processes amongst networked enterprises.
The four lessons in the EM learning theme are:

**EM1 - Enterprise Modelling as a way to achieve Interoperability.** The lesson provides an overview of methods for achieving interoperability between businesses through enterprise modeling.

**EM2 - Enterprise Knowledge Modelling of Enterprises.** The lesson provides an overview of methods for applying collaborative information and knowledge technology for interoperability.

**EM3 - Cross-Organizational Business Processes – Enabling Technologies and Tools.** Learn about the technologies, tools, and standards that enable interoperability of cross-organizational business processes

**EM4 - Cross-Organizational Business Processes - Interoperability Issues and Concepts.** This lesson covers the essentials about the concepts to support Cross-Organizational Business Processes

The overall goal of the EM1 and EM2 lessons is to provide an overview in the development of methodologies, core languages and architectures from EM. These lessons address models, model generated workplaces, services and execution platforms for establishing collaborative on-demand extended enterprises and networked organizations, sharing results and knowledge to improve common understanding and enable better performance and quality results.

EM3 and EM4 provide studies about solutions that enable execution of Cross-Organizational Business Processes (CBPs). The notion of business processes has received increasing recognition as the “glue” between originally disjointed activities within an enterprise. Business process systems, including workflow management systems, have demonstrated the applicability of this concept within the boundaries of the enterprise. We envisage that this concept provides a significant opportunity in the cross-organizational context.

**EM1 – Enterprise Modelling as a way to achieve Interoperability**

The lesson will give a general overview of the discipline of Enterprise Modelling and its current state of the art, before focusing on approaches and methodologies for establishing Enterprise Modelling practices in an organization. After exposing some of the reasons for the lack of interoperability, the lesson discusses interoperability issues, at both the business and technical level, which can be mitigated or solved by applying Enterprise Modelling practices. The last part of the lesson comprises a more detailed description of different solution approaches concerning model driven system architecting and engineering, exchange, collaborative development and execution of Enterprise Models; and the model based generation of adaptive workplaces.

**OBJECTIVES**

The lesson will enable participants:

- To understand what Enterprise Modelling is and what its current methods and tools are
- To understand the reasons for lack of interoperability and how Enterprise Modelling addresses these interoperability problems

**CONTENT**

1. What is Enterprise Modelling?
2. What are the current methods and tools for Enterprise Modelling?
   a. Frameworks and Architectures
   b. Industry Initiatives, Standardisation Bodies and Organizations
   c. Languages for Enterprise Modelling/Model Interchange
   d. Methodologies
   e. Modelling Platforms, Infrastructures and Tools
   f. Execution Platforms, Infrastructures and Tools
3. Enterprise Modelling establishment methodology
a. Collaboration processes and Maturity Assessment (EIMM)
b. Deducing modelling approach

4. What interoperability problems are addressed by Enterprise Modelling?
   a. Reasons for lack of interoperability
   b. Business and technology level interoperability issues

5. How does Enterprise Modelling address these interoperability issues?
   a. Systems architecting and engineering driven by enterprise models
   b. Collaborative Enterprise Modelling platform (MPCE)
   c. Active knowledge modelling and model execution platforms and infrastructures
   d. Model-driven, user-composed solution platforms and services, including Model-Generated Workplaces

**EM2 - Enterprise Knowledge Modelling of Enterprises**

The lesson provides an approach and an overview of methods for applying collaborative Information and Knowledge Technology (IKT), develops industrial solutions and achieves interoperability between businesses through Enterprise Modelling based on an integrated modelling and task execution platform.

The lesson starts with an introduction to Enterprise Modelling in general, outlining the problems of business and IT interoperability, and the underlying reasons for these problems. The main part of the lesson describes Enterprise Modelling approaches to industrial use-case pilots seeking to overcome these problems. This part is communicated using practical industrial examples. Specific interoperability issues in industry are addressed as illustrated in the contents below. The distinction between general Enterprise Modelling and Enterprise Knowledge Modelling is emphasised from concepts to practical user interaction. The lesson is focused on one of two practical examples, to be decided in the class.

**OBJECTIVES**

The lesson will enable students:

- To understand knowledge management problems, their causes, effects and solutions
- To apply Enterprise Knowledge Modelling to realise the values of interoperability
- To demonstrate new ways of applying IKT technology, achieving interoperability
- To develop and govern IT infrastructure and interoperability through operational enterprise knowledge architectures

**CONTENT**

1. What is Enterprise Modelling?
   a. Enterprise Knowledge Modelling - emphasis on knowledge aspects

2. What are the current methods and tools for Enterprise Modelling?
   a. State of the art in supporting industrial modelling
   b. Contrasting approaches – benefits of knowledge modelling

3. What interoperability problems are addressed by Enterprise Modelling?
   a. Business and technology level interoperability issues
   b. Reasons for lack of interoperability

4. How does Enterprise Modelling address these interoperability issues?
   a. Business value models
b. Enterprise Modelling establishment methodology

c. Systems architecting and engineering driven by enterprise models

d. Collaborative Enterprise Modelling platform

e. Active knowledge modelling and model execution platforms and infrastructures

f. Model-driven, user-composed solution platforms and services, including model-generated workplaces

5. Examples from industrial application areas (choice of audience):

 a. SME networks
 b. Product and portfolio management
 c. Supply chain management
 d. Collaborative product design

6. Questions and Answers, and conclusions

**EM3 - Cross-Organizational Business Processes – Enabling Technologies and Tools**

This lesson presents technologies to model and execute cross-organizational business processes. The students will learn how the modelling and enactment of cross-organizational business processes can be addressed, and its related technologies and standards.

**CONTENT**

1. Concepts for modelling and enacting CBPs
2. CBP modelling tools
3. CBP enactment engine

**EM4 - Cross-Organizational Business Processes – Advanced Interoperability Issues**

The lesson presents advanced interoperability issues in Cross-Organizational Business Processes (CBPs). It presents the requirements that have to be addressed when an organization seeks to make their business processes interoperable.

**OBJECTIVES**

The students will learn about interoperability issues that are addressed by Cross-Organizational Business Processes. They will gain an overview of requirements that are imposed by enterprises that wish to interoperate, and will learn about the concepts that have been developed nowadays to model and execute CBPs.

**CONTENT**

1. Interoperability Issues
2. Requirements for modelling and executing CBPs
3. Concepts for Modelling CBPs
4. Concepts for Enacting CBPs

2.3 **Learning theme: Ontologies (ONT) – 3 lessons**

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.

The Ontologies learning theme is composed of 3 lessons:
ONT1 - Introduction to Semantics  

The lesson is an introduction to semantics, both informal, meaning natural language definitions, and formal, e.g., the Web Ontology Language, OWL.

ONT2 - Ontology based support to Enterprise Interoperability  

The lesson gives an overview of the objectives and structure of the main concepts and issues in Ontology based support to Interoperability. It provides some examples on how this can be used to seek solutions to the general interoperability problem.

ONT3 - Methods and Services for Ontology usage in Interoperable Environments  

The lesson shows how to use the Semantic Suites to manage ontologies, and to achieve better enterprise knowledge integration, as well as inter-operability between enterprises. It is a more in-depth continuation of ONT2.

The ONT1 lesson will give the basic understanding about semantics to the students, with a special emphasis on the semantic annotation needs in the interoperability reaching process.

The ONT2 lesson gives an overview of the objectives and structures of the main concepts and issues about Ontology based support to Interoperability, and also provides some examples on how this can be used to address the solutions to general interoperability problems. Semantic annotation will be used to associate a formal meaning to enterprise models and, in particular, to information structures and Business Processes in order to realise a semantic interoperability platform.

A study about the development of methods and tools for enterprise ontology management is provided by the ONT3 lesson, with a focus on supporting enterprise knowledge integration and interoperability for enterprises and software applications. This is based on the building of an ontology environment aimed at supporting the integration of the different sorts of knowledge that can be found in an enterprise.

ONT1 – Introduction to Semantics  

This introduction to semantics is organized into three units: Semantics, Writing Definitions and the Semantic Web. Semantics can be either informal, that is, in the form of natural language definitions, or formal, that is, expressed using a language with a formal logical foundation.

Using a terminology database as an example, the first unit discusses informal semantics and shows the importance of definitions. It also discusses WordNet as being at the border between the informal and formal. The second unit is dedicated to imparting the skills needed to write good definitions. The third unit explains the basics of the Semantic Web technologies: RDF, RDFS and OWL. They are explained by relating them to databases and to strategies for writing natural language definitions.

OBJECTIVES  

The objectives of this lesson are to enable the student to explain and handle both informal and formal semantics. After working through the lessons, the student will be able to:

- Discuss the range of meaning of semantics
- Explain the importance of definitions of terms; example terms are: ‘work’, ‘cell phone’
- Apply and explain strategies for writing definitions
- Explain the basics of the Semantic Web technologies RDF, RDFS and OWL, and relate them to informal semantics

CONTENT  

The lesson consists of three units:

1. Semantics
2. Writing Definitions
3. Semantic Web Technology

**ONT2 - Ontology based support to Enterprise Interoperability**

The aim of this lesson is to present the students with the goal and structure of Knowledge Support and Semantic Mediation Solutions. Both the conceptual level of the Ontology based support to Interoperability, which defines the approach applied for interoperability using ontology, and the technical level, which defines the technical and semantic interoperability infrastructure and supporting tools are covered in this lesson. Some examples on how these tools can be used to seek solutions to the general interoperability problem are provided.

**OBJECTIVES**

The lesson will enable participants to understand the objective and structure of a Semantic Suite and how to apply it to solve some generic interoperability problems.

**CONTENT**

1. Introduction
2. Interoperability Issues – Semantic viewpoint
3. Requirements
4. State-of-the-art
   a. Methods of Ontology building and maintenance
   b. Technologies
   c. Tools
5. Concepts
6. Methodology adopted in the ATHENA approach
7. Architectures & Tools
8. Conclusion

**ONT3 – Methods and Services for Ontology usage in Interoperable Environments**

This lesson explains, in more depth than ONT2, how to use a Semantic Suite. Effective use of the suite requires an understanding of the individual tools and their respective function. Instructional examples will be used to illustrate the role and function of each tool in the suite.

**OBJECTIVES**

The aim of this lesson is to enable students to understand the use of a Semantic Suite to solve interoperability problems at the semantic level. This involves creating, maintaining and using ontologies, annotations to resources and reconciliation rules.

**CONTENT**

1. Introduction
2. The Semantic Suite, an Overview
3. Ontologies
   a. The Ontology Management System
   b. Methods of Ontology building and maintenance
4. Annotations
   a. Principles of Annotation; Types of Annotation
b. The Annotation Tool

5. Reconciliation Rules
   a. The Reconciliation-Rules Generator
   b. The Reconciliation Engine
   c. Debugging

6. The Semantic Search Engine

7. Conclusion

2.4 Learning theme: Architectures and Platforms (AP) – 6 lessons

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.

The lessons in this learning theme addresses the MDA and SOA concepts and implementations, which demonstrates the relevance of the service oriented and model driven approaches for solving interoperability problems while boosting the performance of the organizations, lowering their operational costs, increasing the control over their work, and improving their flexibility. With them, learn about MDA and SOA and understand how they can help in designing new interoperable software solutions for inter-organization interaction, as well as how they can be used in re-architecting existing legacy solutions.

The Architectures and Platforms learning theme is composed of six lessons:

**AP1 - Introduction to Service-Oriented Interoperability (SOI)** Learn about service-oriented architecture (SOA) and its application in developing interoperable enterprise software systems.

**AP2 - Planning and Specification of Interoperable Service-Oriented Solutions** Learn about service-oriented architectures and how they can help in designing new interoperable software solutions for inter-organization interaction, as well as how SOA can be used in re-architecting existing legacy solutions.

**AP3 - Implementing Interoperable Service-Oriented Solutions using Web Service and Agent Technologies** Learn about agent technologies and how they can be integrated in and enhance service-oriented architectures.

**AP4 - Introduction to Model-Driven Interoperability (MDI)** Learn about model-driven architecture (MDA) and its application in developing interoperable enterprise software systems.

**AP5 - Principles of Model-Driven Interoperability** Learn about model-driven interoperability, metamodelling, domain-specific languages, and model mappings and transformations.
AP6 - Model-Driven Development of Interoperable Web Services, Agents and P2P Solutions

Learn about model-driven specification and realisation of interoperable Web service, agents and P2P software solutions.

The AP1, AP2 and AP3 lessons are concerned with the development of service-oriented solutions that can be planned and subsequently customised during deployment. This is intended to provide better industry-focused solutions that can be better adapted for deployment into client environments.

The objective of the AP4, AP5 and AP6 lessons is to give the state of the art in the model-driven field, by applying platform independent architecture specifications, and dynamic and autonomous federated architecture approaches, including the use of agent technologies.

AP1 - Introduction to Service-Oriented Interoperability (SOI)

According to W3C, a service-oriented architecture (SOA) specifies a set of components whose interfaces can be described, published, discovered and invoked over a network. SOA aims to promote software development in a way that leverages the construction of dynamic systems that can easily adapt to volatile environments and be easily maintained, as well. The decoupling of system constituent parts enables the re-configuration of system components according to the end-user’s needs and the system’s environment. Furthermore, the use of widely accepted standards and protocols that are based on XML and operate above internet standards (HTTP, SMTP, etc.) enhances interoperability. The lesson presents the ATHENA Service-Oriented Interoperability (SOI) Framework, which provides guidelines for how to integrate enterprise software systems in a service-oriented architecture (SOA).

OBJECTIVES

The lesson will enable participants to learn about the ATHENA SOI Framework and gain a basic understanding of how to integrate enterprise software systems using SOA principles. The lesson aims to increase awareness of how SOA can be applied to solve interoperability issues. The lesson AP2 explores the SOI framework in more detail.

CONTENT

The lesson will cover the following topics:
1. Interoperability
2. Service-oriented architecture (SOA)
3. Service-oriented interoperability (SOI)

AP2 - Planning and Specification of Interoperable Service-Oriented Solutions

This lesson focuses on service-oriented architectures and principles for service integration. The lesson will present core technical information regarding service-oriented architectures that allows business technical staff with general technical background to understand and further develop existing applications (and their required extensions) for effective delivery in an inter-organizational interaction.

OBJECTIVES

This lesson aims to describe different integration patterns, integration strategies for service integration, and describe service-oriented architectures (SOAs) for legacy and enterprise integration.

The lesson describes how Web services technologies can be used in developing SOAs.

CONTENT

The lesson will cover the following topics:
1. ATHENA Service-Oriented Interoperability (SOI) Framework
2. Service-Oriented Integration Patterns
3. Service-Oriented Integration Strategies
From the very beginning an important feature of agent theories and technologies was to use such theories and technologies as a software engineering approach to system design. With the idea of wrapper agents, agent technologies have sought to achieve integration of legacy systems. The FIPA standards strive for interoperability amongst agents in multi-agent systems. However, aside from the notion of integrating legacy systems, agent technologies can also contribute to interoperability of software systems in a broader sense. There are other major trends in software design, such as Service-Oriented Architectures (SOA), the Model-driven Architectures (MDA) proposed by the Object Management Group (OMG), and Peer-to-Peer (P2P) Computing, all of which support interoperability. Important issues to address are, how agent technologies fit into this landscape and what they can contribute, in contrast to the competing technologies.

OBJECTIVES

The aim of the lesson is to demonstrate how agent technologies can be integrated with SOAs. It turns out that a special class of agents, i.e. BDI (Belief, desire, intention) agents, is especially suited to achieving this integration. BDI models are powerful vehicles for doing Web service composition that fit nicely with the MDA approach to the design of SOAs. With this, BDI agents can contribute significantly to enhance a service-oriented environment with aspects of autonomy and self-organization.

CONTENT

The lesson will cover the following topics:

1. Service-Oriented Computing
2. Agents and Complex Systems
3. BDI Agents and their integration into a SOA
4. Middle-Agents (e.g., Matchmakers, Brokers, Routers)
5. Multi-agent Communication, Coordination, and Collaboration
6. FIPA Communication Standards
7. Integration of FIPA Standards in a SOA

AP4 - Introduction to Model-Driven Interoperability (MDI)

Model-driven development (MDD), and in particular OMG’s Model Driven Architecture (MDA), is emerging as the state-of-the-art practice for developing modern enterprise applications and software systems. The MDD paradigm provides us with a better way of addressing and solving interoperability issues when compared to earlier non-modelling approaches.

The lesson presents a Model-Driven Interoperability (MDI) Framework, which provides guidelines on how MDD can be applied to the development of interoperable enterprise software systems.

OBJECTIVES

The participants will learn about the ATHENA MDI Framework and will gain a basic understanding of how MDD can be applied to solve interoperability issues. The lesson AP5 explores the MDI framework in more detail.

CONTENT

The lesson will cover the following topics:
1. Model-Driven Architecture (MDA)
2. Model-Driven Interoperability (MDI)

**AP5 - Principles of Model-Driven Interoperability**

This lesson focuses on principles and processes of how to apply model-driven development approaches to solving software interoperability problems. The lesson teaches how to develop metamodels using MOF technology, and how to build your own domain-specific languages and UML profiles. It further teaches how to develop your own model mapping and transformations using QVT technologies.

The lesson aims to provide guidelines on practical and correct use of these technologies in the development of interoperable software systems, using examples of how to apply metamodelling, UML profiles and model transformation centres around the platform independent model for SOA.

**OBJECTIVES**

This lesson aims to be a method engineering lesson that will teach the students how to develop and/or configure their own model-driven development methodologies and tools for software interoperability. Participants will gain an understanding of the use of metamodelling, domain-specific languages, and model mappings and transformations, and domain-specific languages in a software engineering development and integration process.

**CONTENT**

The lesson will cover the following topics:

1. Model-Driven Interoperability (MDI) Frameworks
2. Metamodelling, Domain-Specific Languages (DSLs) and UML Profiles
3. Model Mappings and Transformations
4. Method Engineering for Interoperability

**AP6 - Model-Driven Development of Interoperable Web Services, Agents and P2P Solutions**

The lesson teaches how to build platform independent models for service-oriented architecture (PIM4SOA) that we can use to analyse, specify and develop interoperability software solutions.

A PIM4SOA model is a basis for model transformation and code generation. The lesson teaches how to refine a PIM4SOA into specific system realisations such as Web services (XSD, WSDL and BPEL), agents and P2P solutions using for example transformation tools.

**OBJECTIVES**

The objective of this lesson is to teach students how to develop interoperable Web services, agents and P2P solutions in a service-oriented environment.

**CONTENT**

The lesson will cover the following topics:

1. Model-Driven and Adaptive Interoperability Infrastructures
2. PIM4SOA Modelling and UML Profiles
3. From PIM4SOA to Web Services
4. From PIM4SOA to Agent Systems
5. From PIM4SOA to Peer-2-Peer (P2P)
2.5 Learning theme: Business Interoperability (BI) – 2 lessons

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 lessons in this learning theme 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.

**BI1 - Introduction to Business Interoperability** The lesson gives an overview of the concepts and effects of business interoperability. It focuses on effects at the strategic management level.

**BI2 - Business Documents and Protocols** Learn about the concepts that have been developed in ATHENA to support modelling and handling of business documents and business protocols.

The BI1 lesson explains the various effects of interoperability at the business level, covering not only direct effects, such as lower transaction costs, but also strategic aspects, such as the readiness for new organizational forms.

The BI2 lesson presents the concepts and tools that have been developed in ATHENA to support an efficient handling of business documents.

**BI1 – Introduction to Business Interoperability**

The notion of interoperability is mostly associated with technical means of designing and organizing IT systems and applications in a way that they are capable of exchanging and using information. What lacks is a clear analytical framework to identify business opportunities that can be leveraged by interoperability concepts, and to investigate the business value of planned or completed investments in interoperability.

This lesson explains the various effects of interoperability at the business level. To provide a complete analysis approach, not only direct effects, such as lower transaction costs, but also strategic aspects, such as the readiness for new organizational forms, are covered in the lesson.

**OBJECTIVES**

This lesson is designed as an introduction to Business Interoperability and will be complemented by two other lessons that focus on training of “Impact Assessment” and “Networked Organisations”.

The main objectives of the lesson are:

- To give an introduction to Business Interoperability
- To explain different effects of interoperability on businesses
- To illustrate the interrelations between these effects
- To demonstrate the strategic impact of business interoperability

**CONTENT**

1. Direct interoperability effects
2. Interoperability and emerging forms of networked organizations
3. Interoperability and competition
4. Interoperability and macroeconomic effects
The lesson presents the concepts and tools to support an efficient handling of business documents. Furthermore, extension to the concepts and tools for cross-organisational business processes (see lessons EM3 and EM4) that enable an efficient handling of business protocols are introduced. Selected standards and related business content are presented.

OBJECTIVES

The students shall learn about methods and tools to efficiently handle business documents. This includes modelling, storage, retrieval, transformation and mapping.

CONTENT

1. Concepts for modelling and efficient handling of business documents
2. Concepts for modelling and enacting business protocols

2.6 Learning theme: Product Data Exchange (PDE) – 3 lessons

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 an 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.

The Product Data Exchange learning theme is composed of 3 lessons:

**PDE1 - Introduction to Dynamic Requirements Definition**  Learn about the definition of dynamic requirements by understanding the current business problems.

**PDE2 - Standards to support Interoperability for Product Life cycle Management**  Standards cartography, comparison, integration for product data exchange, sharing and retention for Product Life Cycle management

**PDE3 - Frameworks for interoperability of product data in SME based environments**  Methodologies and solutions to contribute to the solution of the interoperability problem found in industrial environments whenever product data exchange is required.

The PDE1 lesson is about dynamic requirement definition activity. This activity aims to provide a method and system to dynamically capture, analyse, manage and respond to requirements coming from user-scenarios concerning interoperability issues, and to support the maximum number of functional, support, organizational and commercial processes adapted to the wider set of industrial sectors.

Several standards and de facto standards exist for data modelling and representation. The goal of the PDE2 lesson is to provide a detailed description of the different standards that can support product data exchange, sharing and retention in a PLM strategy, and how they contribute to the interoperability of involved enterprise applications.

Business process interoperability plays a crucial role in achieving business integration. The PDE3 lesson concerns with the complexity of interactions between enterprises and teams of human beings, that requires sound methods to re-engineer business processes. The piloting of how the Business Process helps in achieving the bottom line business integration is of paramount importance. Technology testing is the primary step towards exploitation and implementation, as they are vehicles for facilitating collaboration and consensus building amongst stakeholders, as well as catalysts for building critical mass and commitment.

**PDE1 - Introduction to Dynamic Requirements Definition**

The lesson presents the methodology to deal with the Dynamic Requirements Definition (DRD) in current business environments. The lesson will show how the methodology allows the users to extract the specific requirements (related to the problem domain) from the description of the business scenario and the presentation of the interoperability issues.

**OBJECTIVES**

The lesson will teach participants to:

- About the DRD Methodology
- How to extract requirements
- How to describe interoperability problems
- How to propose a business scenario

**CONTENT**

The lesson will cover the following topics:

1. Interoperability Issues
2. Dynamic Requirement Definition
3. Methodology Dynamic Requirement analysis
**PDE2 - Standards to support Interoperability for Product Life cycle Management**

The lesson provide a cartography of standards supporting the learning theme of product data exchange, sharing and retention that support interoperability of enterprise application in the context of Product Life Cycle process operationalisation, providing a categorisation based on the interoperability framework: Enterprise, Knowledge, Information System, Ontologies.

**OBJECTIVES**

The goal of the lesson is to provide a detailed description of the different standards that can support product data exchange, sharing and retention in a PLM strategy, and how they contribute to the interoperability of involved enterprise applications.

**CONTENT**

1. STEP application protocols, XML vocabulary, Given domain ontology, XMI profiles, standardised process, standardised process or workflow modelling language (XPDL, PSL…)
2. Associated technologies as Express, XML schema, MDA, MOF.
3. Associated actors and stakeholders
4. Their advantages, drawbacks, differences, complementarities to support effective interoperability
5. The different types of mappings and the different ways to implement them (e.g. XSLT, Express-X, MOF, EAIS)
6. The different ways to integrate them

**PDE3 - Frameworks for interoperability of product data in SME based environments**

Different technologies and standards to support interoperability between systems are available today. Several Application Protocols and dedicated models have been developed to cover the main industrial application activities, from design to production and business. Most of these models were designed and developed using standard methodologies and techniques.

In spite of the large number of existing and emerging standards for enterprise data exchange, most of these have been developed in isolation, using divergent methodologies. Therefore, enterprises are facing a major problem regarding the explosion in the number of heterogeneous interfaces and data models their software applications need to handle. This is an important problem considering the effort required to develop each translator and the unpredictable number of existing incompatible platforms.

The ideal situation would be one where all applications could be easily integrated, independently of the platforms in use, as if all platforms were equal, interoperating in flexible and configurable enterprise environments. Using frameworks that do not waste the effort spent on the development of the independent standard models would give flexibility to the construction of new integrated models and avoid “yet another model”.

This lesson identifies the typical situation of the interoperability problem found in industrial environments whenever product data exchange is required. It proposes methodologies and solutions that contribute to a solution of this problem.

**OBJECTIVES**

To alert the students about the typical interoperability problem found in industrial environments whenever product data exchange is required, and inform them about suitable methodologies and platforms that can aid in solving this problem.

**CONTENT**

1. Interoperability of product data in industrial environments: Problems and challenges
2. The role of Application Protocols. The ISO TC184/SC4 standards
3. Methodologies and platforms for interoperability of product data in industrial environments
4. Industrial case study
3 Types of delivery and typical calendar

AIS discipline supports three types of delivery:

1. delivery that is bound by place and time, such as classroom training and instructor-led training, as it is planned to be delivered in the regular classes at the Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa.

2. delivery that is bound by time only, such as instructor-led, synchronous Virtual Classroom sessions, where a tutor guides the learner through a session over the Internet, as it is the case of the deliveries to the ITC Euromaster - European Master in Construction Information Technology (http://euromaster.itcedu.net/).

and

3. delivery that is independent of time and location, such as Web-based courseware that the learner can access anytime, anywhere, as it is the case when a student accesses to the AIS discipline portal in MOODLE at http://moodle.fct.unl.pt, and accesses directly to the available AIS e-Learning material.

The various delivery types support different requirements concerning knowledge transfer. The most basic delivery method is classroom training, which requires the physical presence of participants at the location where the training takes place. This type of training is particularly suitable for contents that impart a substantial understanding of the subject and require intensive interaction with the instructor concerning further inquiry, practical exercises or collaboration between lesson participants.

Virtual Classroom training does not provide the direct contact that traditional classroom training offers. However, its advantage is the locality independence. Participants do not have to travel to the training location, but can participate via their local internet access. Nevertheless, communication is not completely broken and participants can communicate with their instructors via the internet. Now, with Bologna, this seems to be an appropriate approach to save many costs and resources avoiding mobility overheads.

Finally Web-based training using e-Learning material offers the highest flexibility. This kind of delivery is best adapted to those willing to consolidate the knowledge acquired during a lesson, or for those that for some reason could not attend the class. Although the effort for the development of e-Learning material is very high, the costs related to this delivery method are comparatively low and there is no requirement for trainers during the delivery. This is an excellent mean to complement the classroom or virtual classroom activities, having the students the opportunity to study alone anytime and anywhere.

3.1 Typical calendar for delivery in classroom

<table>
<thead>
<tr>
<th>Week</th>
<th>Num. TP</th>
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<th>Theoretical work subject</th>
<th>Practical work subject</th>
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<tr>
<td>1-2</td>
<td>2</td>
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<td>-Presentation of the discipline</td>
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<td>-Concepts of Interoperability (CI)</td>
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<td>oCI2 - The ATHENA Interoperability Framework</td>
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<td>oCI3 - Practices of Interoperability in SMEs</td>
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<td>Presentation of 4 real case studies.</td>
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<td>Requirements analysis for interoperability, using the presented case studies.</td>
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<td>(from now on, the following practical works will be developed under the learning theme of the corresponding theoretical lesson, using as a basis the analyzed case studies)</td>
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<td>Learning theme: Enterprise Modelling (EM)</td>
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| 3-5 | 3 | 3 | oEM1 - Enterprise Modelling as a way to achieve Interoperability   
|    |   |   | oEM2 - Enterprise Knowledge Modelling of Enterprises           
|    |   |   | oEM3 - Cross-Organizational Business Processes – Enabling Technologies and Tools   
|    |   |   | oEM4 - Cross-Organizational Business Processes – Advanced Interoperability Issues   |
|   |   |   | Learning theme: Ontologies (ONT) |
| 6-7 | 2 | 2 | oONT1 - Introduction to Semantics           
|    |   |   | oONT2 - Ontology based support to Enterprise Interoperability   
|    |   |   | oONT3 - Methods and Services for Ontology usage in Interoperable Environments   |
|   |   |   | Learning theme: Architectures & Platforms (AP) |
| 8-10 | 3 | 3 | oAP1 - Introduction to Service-Oriented Interoperability (SOI)   
|    |   |   | oAP2 - Planning and Specification of Interoperable Service-Oriented Solutions   
|    |   |   | oAP3 - Implementing Interoperable Service-Oriented Solutions using Web Service and Agent Technologies   
|    |   |   | oAP4 - Introduction to Model-Driven Interoperability (MDI)   
|    |   |   | oAP5 - Principles of Model-Driven Interoperability.   
|    |   |   | oAP6 - Model-Driven Development of Interoperable Web Services, Agents and P2P Solutions   |
|   |   |   | Learning theme: Product Data Exchange (PDE) |
| 11-13 | 3 | 3 | oPDE1 - Introduction to Dynamic Requirements Definition   
|    |   |   | oPDE2 - Standards to support Interoperability for Product Life cycle Management   
|    |   |   | oPDE3 - Frameworks for interoperability of product data in SME based environments   |
|   |   |   | Learning theme: Business Interoperability (BI) |
| 14-15 | 2 | 2 | oBI1 - Introduction to Business Interoperability   
|    |   |   | oBI2 - Business Documents and Protocols   |
| Total | 15 | 15 |