Grant Agreement N° 215483

Title:	*Completed Learning Unit Collection*
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Identifier:	*CD-SoE-1.1.5*
Type:	*Deliverable*
Version:	*1.0*
Date:	*19 November 2010*
Status:	*Final*
Class:	*External*

Management Summary

This document reports on the completed set of learning material collected as part of S-Cube's Spreading of Excellence (SoE) activities. WP-SoE 1.1 ("Virtual Campus") has the aim, amongst others, to make available various lectures and training programmes on research in and applications of software services, to be used in a joint Masters and PhD programme. As a further step towards this goal, this deliverable reports the learning material collected from S-Cube partners and a preliminary curriculum structure derived from the current material, existing curricula and student exchange programs.

The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013 under grant agreement n° 215483 (S-Cube).

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The S-Cube Deliverable Series

Vision and Objectives of S-Cube

The Software Services and Systems Network (S-Cube) will establish a unified, multidisciplinary, vibrant research community which will enable Europe to lead the software-services revolution, helping shape the software-service based Internet which is the backbone of our future interactive society.

By integrating diverse research communities, S-Cube intends to achieve world-wide scientific excellence in a field that is critical for European competitiveness. S-Cube will accomplish its aims by meeting the following objectives:

- Re-aligning, re-shaping and integrating research agendas of key European players from diverse research areas and by synthesizing and integrating diversified knowledge, thereby establishing a long-lasting foundation for steering research and for achieving innovation at the highest level.
- Inaugurating a Europe-wide common program of education and training for researchers and industry thereby creating a common culture that will have a profound impact on the future of the field.
- Establishing a pro-active mobility plan to enable cross-fertilisation and thereby fostering the integration of research communities and the establishment of a common software services research culture.
- Establishing trust relationships with industry via European Technology Platforms (specifically NESSI) to achieve a catalytic effect in shaping European research, strengthening industrial competitiveness and addressing main societal challenges.
- Defining a broader research vision and perspective that will shape the software-service based Internet of the future and will accelerate economic growth and improve the living conditions of European citizens.

S-Cube will produce an integrated research community of international reputation and acclaim that will help define the future shape of the field of software services which is of critical for European competitiveness. S-Cube will provide service engineering methodologies which facilitate the development, deployment and adjustment of sophisticated hybrid service-based systems that cannot be addressed with today's limited software engineering approaches. S-Cube will further introduce an advanced training program for researchers and practitioners. Finally, S-Cube intends to bring strategic added value to European industry by using industry best-practice models and by implementing research results into pilot business cases and prototype systems.

S-Cube materials are available from URL: http://www.s-cube-network.eu/

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1 Introduction

This deliverable is a report that describes jointly-defined courses and a curriculum structure with the aim to establish the foundations for joint European PhD and Master programmes and to provide learning material through the S-Cube Virtual Campus. This deliverable is the successor of CD-SoE-1.1.3 ("Initial learning programme and module collection", delivered in M24 of the project) and seeks to address the gaps highlighted in the preceding report in order for the planned programmes to reach their educational objectives.

In this opening section we present the context for learning material collection, in terms of its aims and relationship with other work packages (i.e., Section 1.1). We then provide the context of joint higher education curricula for European institutions in the field of services science in Section 1.2.

The remainder of this document is organized as follows. Section 2 presents the S-Cube joint curricula vision. Section 3 presents the learning material available, modules and introduces an initial structure for the curriculum. Section 4 summarizes and concludes this report. The description of the course material is given in Appendix A.

1.1 Workpackage Vision

As described in the S-Cube Description of Work[1], the Spreading of Excellence activities have the goal, amongst others, to disseminate S-Cube research results in the wider academic and scientific communities and to provide training material for researchers. These activities are shared between two work packages: SoE 1.1 and SoE 1.2. The purpose of WP-SoE-1.1 ("Virtual Campus") is, more specifically, to:

- Provide an infrastructure to support training for academic and industrial research.
- Provide a virtual community network facilitating communication and cooperation between students and researchers from various countries and backgrounds.
- Provide exposure to different academic approaches to Software Services and Systems research.
- Set up Software Services and Systems competence centres providing access to service-related expertise, technologies and knowledge to increase the take-up of service technologies.
- Collect and consolidate course material on Software Services and Systems research and applications.
- Structure and develop training and education programmes on the topic of service-oriented computing, including joint Master's and PhD programs.

This document, together with its preceding deliverable CD-SoE-1.1.3, relates to the final two points in the list above; they contribute to the structuring and development of training and education programmes by collecting, reviewing and reporting on available material shared by S-Cube partners. The documents also provide further input for the remaining deliverables in this workpackage that will jointly describe courses and the modules they contain:

> CD-SoE-1.1.7 ("Initial Masters programme") will describe the steps required to establish a joint European Master's programme;
>
> CD-SoE-1.1.8 ("Initial PhD programme") will describe the steps required to establish a joint European Ph.D. program.

Additionally, it must be noted that the course material collected until month 24 of the S-Cube NoE are described in more detail in deliverable SoE 1.2.6 ("Creation of course registries")

[1] http://www.s-cube-network.eu/

1.2 Joint European Higher Education Programmes

Currently, there is a drive towards cross-University and cross-country cooperation in European Higher academic institutions and beyond as demonstrated by the Bologna Process and the Erasmus Mundus programmes.

The Bologna Process[2] aims to *"create a European Higher Education Area (EHEA) and to promote the European system of higher education worldwide"*. Within this process, institutions are encouraged to establish co-operation and form partnerships by sharing their knowledge for the development of curriculum to establish joint European educational degrees. The current Erasmus Mundus programme[3] (2009-2013) is a follow-on from a successful first phase (2004-2008) and has the aim of "*the enhancement of quality in European higher education*" and "*the promotion of the European Union as a centre of excellence in learning around the world"*. Under this topic, Erasmus Mundus supports higher education institutions involved in projects enhancing the profile and visibility of European higher education internationally.

Joint European education programmes involve two or more higher education partners in different countries contributing their knowledge, teaching and supervision capacities. They are compliant with the Bologna declaration and with the national laws of each participating institutions as well as European standards for quality assurance. They typically include periods of study abroad in partner institutions, and lead to the award of one or more legally recognized degrees upon completion of the programme. One such joint programme in the field of service science is the joint International Master in Service Engineering (IMSE[4]) organized by three members of the S-Cube consortium – namely Tilburg University, University of Stuttgart, and University of Crete. S-Cube associate member Tsinghua University (Peoples' Republic of China) is also an IMSE partner.

2 S-Cube Joint Curricula Vision

In partnership with the consortium's universities, S-Cube aims to derive a common graduate curriculum from existing curricula and student exchange programs to provide a foundation in Software Services and Systems to students from different scientific disciplines. Interdisciplinary, European PhD and Master's programmes, influenced by S-Cube research activities will be developed to offer both introductory and advanced courses for enrolled students. It is envisaged that students from other programmes will also be able to select elective modules from the joint curricula for their own course of study. The mobility of Masters and PhD students between the participating universities will be promoted, with each student being appointed a supervisor from one of S-Cube's partner institutions and offered the possibility to spend some of their research time in one of the network's universities.

2.1 Motivation

In the past few years, service science has emerged as a major research topic and has encountered a rapid growth in its uptake and application in a variety of domains. This progress has been fostered by several factors, for instance the natural evolution of computing paradigms towards software reuse and the backing of major IT providers, and also economic trends linked to the increasing expansion of companies - from national or regional markets to global commerce - thanks to the availability and evolution technology. As a result, there is a demand for highly skilled service professionals to support the drive towards service-oriented systems and to research, engineer and manage services and service networks. To address the need for research and education on the topic, S-Cube will develop joint curricula around service-oriented computing.

[2] http://www.ond.vlaanderen.be/hogeronderwijs/bologna/

[3] http://eacea.ec.europa.eu/erasmus_mundus/programme/about_erasmus_mundus_en.php

[4] http://www.erasmusmundus-imse.eu/

2.2 Objectives

The overall objective for the joint curricula, as described in the S-Cube Description of Work, is to foster the alignment and integration of European competencies and knowledge, to educate young researchers and to remove obstacles that prevent the exchange of ideas and integration of research (usually caused by differences in institutions and in background disciplines). More specifically, the aim of the joint curricula is to:

Contribute to a durable base and infrastructure for European service-based systems research and education.

Provide a solid background, a common view and an understanding of the main service-based systems technologies and applications for the next generation of SBA researchers.

Engage with and integrate diverse research communities, including Grid Computing, Service Oriented Computing and Software Engineering.

- Ensure that young researchers have the opportunity to work with S-Cube beneficiaries on Software Services and Systems.

2.3 Target audience and learning outcomes

The joint curricula targets European Master students, PhD Students, industry practitioners and young researchers with a background in Business Administration, Computer Science, Information Systems, or other related areas (e.g., Software Engineering or Grid Computing) who wish to gain a thorough grounding in Service-Oriented Computing and/or to specialize in related topics.

The goal of the programme is to provide participants with a comprehensive, up-to-date knowledge of service engineering theory and practice and to allow them to acquire skills, experiences and perspectives applicable to related academic and industrial professions from a European rather than national viewpoint. Upon completion of their curriculum of study, students are expected to be competent in services and service networks engineering, and to be aware of the latest developments in the rapidly evolving domain of service-oriented computing. In particular, the curriculum structure will cover principles, techniques and methods for engineering, adaptation and monitoring service-based applications, as well as for specifying, negotiating and assuring their quality. Mechanisms for the realization of the service-based systems, such as business process management, service composition and coordination, and service infrastructure, will also be addressed.

2.4 Structural overview and challenges

In terms of taught modules, the joint curricula will be organised around a set of compulsory, core modules (defined here as offering relevant, basic knowledge of service-oriented computing) and a set of elective, more specialised modules focused on specific parts of the programme of study. All S-Cube partners will contribute material to the joint programme of study. Anticipated challenges in the definition and implementation of the joint curricula will therefore be the agreement of a common specification for each programme, the integration of contributed material, and ensuring the consistency of the modules across the participating institutions. Other practical challenges in the implementation of the joint programmes in all partner institutions will relate to the integration of the course with existing work practices (due to variations in programme structures and lengths, holiday schedules and academic year length) and in the course assessment systems used in different institutions and countries. Finally, it is anticipated that there will be legal questions related to the recognition of the joint programmes both on a national and European scale.

2.5 Topics covered

As mentioned above, IMSE has defined a successful services science curriculum. The course material and the initial curriculum structure presented in Section 3.3 of this deliverable are driven by S-Cube's research agenda and the partners' expertise and is aligned with the structure and content of IMSE. It is expected that the upcoming work on structuring the study programmes (i.e., CD-SoE-1.1.7) will

examine and emulate other courses' structure, including IMSE, if appropriate. Assuming the legal and logistic aspects of implementing such joint curricula have been overcome, the programmes of study will encompass topics from all of S-Cube's Joint Research Activities (JRA) work packages (WPs):

- **Activity JRA-1: Engineering and Adaptation Methodologies for Service-based Systems**, has the goal of providing an integrated set of principles, techniques and methodologies for the engineering, adapting and monitoring hybrid service-based applications, and for guaranteeing the end-to-end quality provision and SLA conformance. JRA-1 comprises the following WPs:
  - WP-JRA-1.1 defines principles, techniques and methodologies for engineering hybrid service-based applications exploiting knowledge from fields outside of service-oriented systems engineering.
  - WP-JRA-1.2 defines novel principles, techniques and methodologies for cross-layer monitoring of service-based systems.
  - WP-JRA-1.3 defines principles, techniques and methodologies for specifying, negotiating and assuring end-to-end quality provision and SLA conformance with respect to quality characteristics across functional layers and across the chain of service providers and consumers.
- **Activity JRA-2: Realisation Mechanisms for Service-based Systems** is concerned with three service technology layers: business process management, service composition and coordination and service infrastructure. This activity aims to devise novel mechanisms achieving the technological innovation required for the functional SBA layers, and to develop seamless sophisticated interoperation mechanisms to guarantee that all three layers operate in harmony. The JRA-2 activity is divided between the following workpackages:
  - WP-JRA-2.1 provides Business Process Management concepts for service implementation. These concepts are focussed on business models, business transaction monitoring and better collaboration and decision-making within integrated Agile Service Networks.
  - WP-JRA-2.2 investigates Adaptable, Coordinated Service Compositions and concentrates on service composition and coordination for adaptable service-enabled business processes in multiple domains, taking into account stakeholders needs, QoS characteristics of processes and key performance indicators.
  - WP-JRA-2.3 defines Self-* Service Infrastructure and Service Discovery Support policies, monitoring and redeployment techniques for self-adaptive and self-healing services, and develops various registry support mechanisms.

3 Learning Material and Modules

In the Virtual Campus workpackage deliverable preceding this one, CD-SoE-1.1.3, we reported a collection of learning materials and compared the initial set of materials gathered against the preliminary list of topics based on S-Cube's JRA WPs (described above). This comparison revealed imbalances in the material available relative to the number of topics addressed in JRA WPs. In particular, the courses around service engineering theme lacked comprehensive material on service monitoring, adaptation and deployment. The material on composition and coordination models, approaches and verification and the material on business process modelling and integration was also limited. Finally, the elements of technical foundations, tools and infrastructure for services were not addressed in depth.

In the work since producing CD-SoE-1.1.3, we have sought to address these gaps by introducing new course material to ensure better coverage and alignment with S-Cube research framework. In particular, we have focused on introducing courses around the themes of BPM, infrastructure and middleware, as the extent of the gaps found around these topics was considerable. Based on the experiences of the consortium and the contributed material, we were also able to address issues in the Service Engineering theme. However, the content of the learning material around particular areas such as service adaptation and monitoring and composition and coordination, we feel, can still be enriched with additional material and new, specialized courses. We hope to address these gaps and further enrich the content by incorporating new material collected during the next phases of the project.

3.1 Content of the Learning Material

The overall list of course material covered in this deliverable is given in Table 1[5]. The description of the course material pertaining to Software Services and Systems are documented in Appendix A using templates adapted from SoE-1.1.2 ("Organisational structure for virtual campus") that succinctly describes the course/module content, its aims, pre-requisites (where appropriate) and relevant Integrated S-Cube Knowledge Model (CD-IA-1.1.3) terms. More detailed specifications for the courses that have been collected are available in deliverable SoE-1.2.6 ("Creation of course registries"). The template proposed in SoE-1.1.2 will be implemented if and where appropriate for the description of fully-fledged courses.

Table 1: Course Material

ID	Course Title	Described in *Appendix A*
101	*Service Oriented Architectures*	*Table 3*
102	*Business Process Integration*	*Table 4*
103	*Business Processes, Online Communities and Business Transformation*	*Table 5*
104	*Web Services*	*Table 6*
105	*Service Management and Clouds*	*Table 7*
106	*Messaging*	*Table 8*
107	Advanced Internet Computing	Table 9
108	Service Oriented Design	Table 10
109	Introduction to Model-Driven Engineering	Table 11
110	Web Services in the Semantic Web	Table 12
111	A QoS Ontology and a Semantic QoS Metric Matching Algorithm	Table 13
112	QoS-Based Web Service Discovery	Table 14
113	Software Quality & Processes	Table 15
114	Quality Assurance for Service-based Systems: From Software Engineering to Service Engineering	Table 16
115	Human Provided Services in Mixed Service-Oriented Systems	Table 17
116	Applying Social Network Analysis Techniques to Software Engineering	Table 18
117	Introduction to the Analysis of Computational Systems through Abstract Interpretation	Table 19
118	Service-Centric Systems and Requirements Engineering	Table 20
119	Quality of Service Optimization in Web Services	Table 21
120	Design of Dependable Service-based Processes	Table 22
121	Service-based Software Development	Table 23
122	A Framework for Proactive Dynamic Service Discovery	Table 24
123	Web Services Business Process Execution Language (WS-BPEL)	Table 25
124	Aspects and BPEL	Table 26
125	Agile Service Networks	Table 27
126	Introduction to Grid Computing	Table 28

[5] *The material introduced in this deliverable (as additions to the list given in CD-IA-1.1.3) are highlighted in italic.*

3.2 Learning Modules

With respect to the workpackage goal of initiating curriculum development, this section introduces an initial clustering of the learning material presented in Table 1 into 'modules' each containing a logical collection of relevant courses around a particular topic area. The classification is based on the S-Cube Research Framework and planned Joint Research Activities (JRA). The following paragraphs briefly describe the modules, which are later associated with relevant course material and listed in Table 2.

- *Business Process Management*: This module focuses on business process definition, deployment, execution, monitoring, analysis and evolution as well as related enabling technologies (e.g. BPEL).
- *Service Engineering and Design*: This broad topic covers the phases of service development and SBAs lifecycle such as requirements engineering, design, construction, deployment and provisioning, monitoring, and adaptation.
- *Service Composition*: This specific module covers general aspects of service composition and coordination while taking into account several factors such as QoS characteristics of processes and key performance indicators.
- *Quality Definition, Negotiation & Assurance*: This particular topic focuses on techniques on end-to-end quality provision and SLA conformance with respect to quality characteristics across functional layers. Topics relevant to the quality of service engineering processes are also covered.
- *Service Networks*: This module covers specific topics around service networks focusing on the notion of service economies, service value, service systems and innovation.
- *Infrastructure and Middleware*: This topic focuses on the technical foundations – software and hardware – including the notions of cloud and grid computing.

Table 2: Modules and Courses

Modules	Courses
Business Process Management	103 Business Processes, Online Communities and Business Transformation 102 Business Process Integration 123 Web Services Business Process Execution Language (WS-BPEL) 124 Aspects and BPEL
Service Engineering & Design	108 Service Oriented Design 101 Service Oriented Architectures 121 Service-based Software Development 109 Introduction to Model-Driven Engineering 107 Advanced Internet Computing 118 Service-Centric Systems and Requirements Engineering 110 Web Services in the Semantic Web 120 Design of Dependable Service-based Processes 115 Human Provided Services in Mixed Service-Oriented Systems 117 Introduction to the Analysis of Computational Systems through Abstract Interpretation
Service Composition	107 Advanced Internet Computing 123 Web Services Business Process Execution Language (WS-BPEL) 101 Service Oriented Architectures 102 Business Process Integration 104 Web Services 108 Service Oriented Design 124 Aspects and BPEL

Modules	Courses
Quality Definition, Negotiation & Assurance	119 Quality of Service Optimization in Web Services 112 QoS-Based Web Service Discovery 111 A QoS Ontology and a Semantic QoS Metric Matching Algorithm 113 Software Quality & Processes 114 Quality Assurance for Service-based Systems: From Software Engineering to Service Engineering
Service Network	125 Agile Service Networks 103 Business Processes, Online Communities and Business Transformation 116 Applying Social Network Analysis Techniques to Software Engineering
Infrastructure and Middleware	126 Introduction to Grid Computing 106 Messaging 104 Web Services 105 Service Management and Clouds 112 QoS-Based Web Service Discovery 122 A Framework for Proactive Dynamic Service Discovery

3.3 Initial Programme Structure

As an initial basis for establishing joint European PhD and Master programmes, we have drafted a preliminary curriculum structure based on the currently available learning material and module classification given above, as well as similar programmes discussed in Section 1.2. This curriculum structure and the module classifications given above are subject to change as the activities for upcoming SoE deliverables (e.g., for CD-SoE-1.1.7) and the work to establish joint Master's and PhD programmes continue.

The preliminary curriculum structure for the target audience (discussed in section 2.3) is based on a 2-year course. Our initial roadmap for the selection of courses (core and optional) and their dependencies is as follows:

> ***1st Year***: The first year will focus on infrastructure and middleware, programming models to realise software services and the analysis and design of software services to realise global business processes. The courses in the *Infrastructure and Middleware* theme (e.g., Web Services, Messaging, Service Management and Clouds) form the core content for the *first semester* of the year. In the *second semester* students could be offered a wide selection of courses from *Service Engineering & Design* and *Service Composition* modules (e.g., Service Oriented Architectures, Advanced Internet Computing, WS-BPEL, Service Oriented Design).
>
> ***2nd Year***: In the second year, we propose a shift in emphasis from foundations towards business process management, the socio-economic analysis of service-enabled processes in service networks and the quality management of service-based applications. Following this approach, the *third semester* in the second year will offer core courses from the BPM module (e.g., Business Process Integration, Business Processes, Online Communities and Business Transformation). The *fourth semester* of this proposed programme offers a collection of courses from *Service Networks* and *Quality Definition, Negotiation & Assurance* modules (e.g., Agile Service Networks, Quality of Service Optimization in Web Services).

In addition to the core courses offered in each semester, we expect students to select optional (elective) courses among a wide selection of topics in diverse learning modules and courses listed in above sections. The core and elective courses will also be accompanied with seminar courses (on services science), summer schools (e.g., the SSAIE Summer School[6]), industry internships and/or thesis/dissertation work.

[6] *SSAIE (Service and Software Architectures, Infrastructures and Engineering) Summer School: http://www.ssaie.eu/*

4 Summary and Conclusion

This deliverable has report the learning material provided by S-Cube partners for use in the SoE-1.1 (Virtual Campus) work package to help establish the foundations of joint European PhD and Master programmes. Overall, the material collected spans much of the service lifecycle and provides elements for solid foundations on Service-oriented Systems' architecture, design and execution, while providing context on the environments in which these systems are expected to be engineered and operated. Concepts, principles, approaches and techniques for service requirements elicitation, service description, discovery and quality assurance were contributed as well as insights into engineering, analysis and design techniques and the human actors of such systems. Concepts around business processes were also contributed, which included their modelling, integration, technical and managerial infrastructure and others that in all cover a wide spectrum of aspects of business process management. Basic concepts on the areas of SBA lifecycle such as analysis, construction, composition, deployment, etc., as well as concepts relevant to service infrastructure and management are also outlined. In this deliverable we also introduced an initial curriculum structure towards programmes together with modules and corresponding courses. We are expecting to further enrich the material to address a wider and deeper knowledge around software services. The structuring and enhancements are expected to continue during the work on the establishment of joint programmes to be reported in the upcoming deliverables.

Appendix A – Description of the Learning Material

The following tables describe the learning material based on the template. Although a particular learning material is associated with relevant S-Cube JRA work packages, it is common that the material covers crosscutting aspects and concepts pertaining to multiple themes and JRA work packages.

Table 3: Service Oriented Architectures

Learning module	Service Oriented Architectures
Author	Tilburg
Related WP	WP-JRA-1.1
Description	The Internet-based economy is gearing towards the real world of fully automated business processes. Automated services have emerged as the next generation of Web based technology for exchanging information over the Internet and promise to revolutionise the process of developing and deploying distributed software applications. Service Oriented Architecture is a logical way of analyzing and designing a software system to provide services to either end-user applications or to other services distributed in the Internet, via published and discoverable interfaces. The objective of this course is to present the principles and fundamental underpinnings of Web Services and Service Oriented Architectures, concentrating on service analysis and design. The topics covered include: Service Oriented Architectures; Web Services Analysis, Design, Description & Discovery; Event-based Processing; UMM, UML for Services; SOA Patterns, etc.
Prerequisites	N/A
Knowledge model terms	Web Service; Service; Software Service; Service-Based Application; Web Service Composition Model; Service Composition Life-Cycle; Service Deployment; Service Composition; Service Orchestration; Service Choreography; Service Discovery; Quality of Service Level; Service Specification; Service Description; Service Analysis

Table 4: Business Process Integration

Learning module	Business Process Integration
Author	Tilburg
Related WP	WP-JRA-2.1
Description	This module focuses on integrating business processes that flow within and between enterprises. The course addresses how enterprises collaborate, what coordination mechanisms, and technologies are necessary to achieve collaboration and how these factors are reflected on the business processes of an enterprise. The module contains an in-depth and integrated coverage of both business and technical issues including definitions, principles and strategy. It focuses on how enterprises transform their structure and processes in order to collaborate with each other by integrating their business processes. The aspects include: Business Models, Business Relationships and Processes; Business Technology Infrastructure, Supply Chains, Business Modelling, E-Business Integration.
Prerequisites	N/A

Knowledge model terms	Process; Business Process; Business Activity; Service; Workflow; Business Policies; Business Process Integration; Business Process Modelling, Business Process Execution; Business Process Analysis, Monitoring and Auditing; Business Transaction; Business Process Optimization; Enterprise Application Integration; Process Model; BPM Software Suite

Table 5: Business Processes, Online Communities and Business Transformation

Learning module	Business Processes, Online Communities and Business Transformation
Author	UoC
Related WP	WP-JRA-2.1
Description	Living in an era of radical change leveraged by service technologies and the Internet, the way firms do business and the way they are organized and managed are changing beyond recognition. The virtual and networking organizations discussed in this module may be partly a vision of the future, and partly already exist at the moment. Trends are emerging that indicate the contours of the organization of the future and a business environment of which networks (clouds) and services will be the very fabric. Needless to say, services oriented computing is one of the major drivers of these trends. A profusion of information reaches us in all kinds of ways. The technology that makes this possible is developing at a dizzying pace, and the boundaries between all kinds of information carriers are becoming increasingly blurred. The most important question facing firms now is what all that information, intelligence and technology means in terms of their business strategies for a sustainable competitive position, for products and services, their customers, their sales markets and their partners in business chains. The module revolves around those themes, and is based on the evolving insights from visionary sources, as well as practical examples from early adopters. Challenges facing early adopters that are discussed include: Trust management, Identity Management, Privacy Management, Compliance, Social networks, online communities (Web2.0) and their relationship to business processes, Human resources deployment and redeployment strategies.
Prerequisites	N/A
Knowledge model terms	Process; Business Process; Service; Business Policies; Business Process Analysis, Monitoring and Auditing; Social Network Analysis

Table 6: Web Services

Learning module	Web Services
Author	USTUTT
Related WP	WP-JRA-2.3; WP-JRA-1.1; WP-JRA-2.2
Description	This module deals with the technologies and basic mechanisms behind service-based applications both, from a requester and a provider perspective. It introduces the fundamental architectural styles in this area (REST and SOA) and their relationships to standards like HTTP, SOAP, WSDL, etc. Basics SOA concepts such as virtualization and loose coupling are introduced. The architecture and basic features of the Service Bus are also discussed. Topics include; Application Server (JEE,...), Messaging and Loose Coupling, The Web as a Middleware Platform, Web Protocols (HTTP, SMTP,…), Dominant Architectural Styles (REST, SOA), QoS at the Message Level (SOAP, WS-TX/BA), Service Descriptions (WSDL, Policy), Service Discovery (UDDI, MEX,…), Virtualization (Service Bus, Grid, Cloud,…),

	Service Composition (Orchestration, Coordination, Choreography).
Prerequisites	N/A
Knowledge model terms	Web Service; Service; Software Service; Service-Based Application; Web Service Composition Model; Stateless Service; Stateful Service; Service Composition Life-Cycle; Service Deployment; Service Composition; Service Orchestration; Service Choreography; Service Discovery; Quality of Service Level; Service Specification; Service Description; Enterprise Service Bus

Table 7: Service Management and Clouds

Learning module	Service Management and Clouds
Author	USTUTT
Related WP	WP-JRA-2.3
Description	Through this module, students will gain an understanding of the data center economics and the technical and business drivers for cloud computing, They will understand foundational technologies as well as what drives affinity of work loads for cloud computing. They will also be able to assess the choices of delivery models an IT organization faces. The topics covered include: • Principles of Service Management • Virtualization • Data Center Economics • Cloud Management Platforms • Operational Support Services • Business Support Services • Layers of Cloud Services • Infrastructure Services • Software Platform Services • Application Services • Public and Private Clouds • Cloud Federation and Integration • Security and Clouds • Application Patterns for Clouds
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Service; Software Service; Service-Based Application

Table 8: Messaging

Learning module	Messaging
Author	USTUTT
Related WP	WP-JRA-2.3
Description	After attending the lecture, students understand the problem of application integration as origin for Web Service technology, and the generic principle for solving this problem, which is based on the use of Message-Oriented Middleware. The architecture of MOM is clear, as well as details about the MQI and JMS. The relevant patterns used to solve the integration problem are mastered. Topics covered include; RPC and Tight Coupling, MOM Architecture and Interfaces (MQ, JMS), Categories of Integration Pattern, Endpoints, Messages, Channels, Routing, Transformations, Management, Messaging and Web Services.
Prerequisites	N/A
Knowledge model terms	Web Service

Table 9: Advanced Internet Computing

Learning module	Advanced Internet Computing
Author	TUW
Related WP	WP-JRA-1.1
Description	The module discusses theoretical foundations, technologies, architectures, standards and examples of recent developments regarding Internet Computing and their applications, focusing on Service-oriented Computing and Web services. Topics covered include SOC and SOA, Enterprise Application Integration and Middleware, Web services foundations, architectures and standards (SOAP, WSDL, UDDI), Web services Composition and Workflows (e.g., BPEL, WS-Coordination, WS-Transaction, BPML, WSC)
Prerequisites	Good programming knowledge in Java
Knowledge model terms	Service; Software Service; Service-Based Application; Service Registry; Service Provider; Web Service; Stateless Service; Stateful Service; Service Deployment; Service Level Agreement; Service Orchestration; Service Choreography; Business Activity

Table 10: Service Oriented Design

Learning module	Service Oriented Design
Author	VUA
Related WP	WP-JRA-1.1
Description	This module presents advanced design techniques applicable to large service-oriented and software systems. The lectures present innovative software and service-oriented design techniques, and emphasis is given among others to service identification and SOA design and migration. Topics covered include software services and their key aspects, concepts of SOA, service discovery, service composition, service modelling, QoS and SLAs, and key differences between system development and service-oriented development.
Prerequisites	N/A
Knowledge model terms	Service; Software Service; Service Design; Service Discovery; Service Composition; Enterprise Service Bus; Service Orchestration; Service Choreography; Service Composition; Service Analysis

Table 11: Introduction to Model-Driven Engineering

Learning module	Introduction to Model-Driven Engineering
Author	INRIA
Related WP	WP-JRA-1.1
Description	This module introduces modelling as a way to master the complexity of modern software development and presents concepts and principles of model-driven engineering. Topics introduced include: UML and Model Driven Engineering, object-oriented meta-languages, model transformation techniques, software product lines (SPL), and aspect oriented model driven engineering.
Prerequisites	N/A
Knowledge model terms	Model-Driven Service Composition

Table 12: Web Services in the Semantic Web

Learning module	Web Services in the Semantic Web
Author	UoC
Related WP	WP-JRA-1.1
Description	This module describes technologies to support a machine-interpretable web, and mainly deals with the issue of describing Semantic Web Services. Topics presented include the concept of ontologies as a tool for the creation of enriched WS descriptions and ontology technologies.
Prerequisites	N/A
Knowledge model terms	Semantic Web Services; Web Service; Service Description

Table 13: A QoS Ontology and a Semantic QoS Metric Matching Algorithm

Learning module	A QoS Ontology and a Semantic QoS Metric Matching Algorithm
Author	UoC
Related WP	WP-JRA-1.1
Description	Various QoS ontologies have been proposed in the literature that can be used to describe the QoS capabilities of a Web Service and the QoS requirements of Web Service requesters. In this presentation, OWL-Q, one of the richest of such QoS ontologies, is presented. Its usage is highlighted by the proposal of a novel semantic QoS metric matching algorithm that can be used in QoS-based WS discovery algorithms in order to increase their precision and recall.
Prerequisites	Basic knowledge of standard WS and Semantic Web technologies
Knowledge model terms	Software Service; Web Service; Semantic Web Services; Quality of Service Characteristic

Table 14: QoS-Based Web Service Discovery

Learning module	QoS-Based Web Service Discovery
Author	UoC
Related WP	WP-JRA-1.1
Description	In this module, novel algorithms for QoS-based Web Service matchmaking and selection are analyzed, and an empirical evaluation conducted on specific implementations of these algorithms, that use different constraint solving techniques, is presented.
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Software Service; Web Service; Service Discovery; Quality of Service Characteristic

Table 15: Software Quality & Processes

Learning module	Software Quality & Processes
Author	Lero
Related WP	WP-JRA-1.3

Description	This module presents concepts and principles relating to software quality and processes. Topics introduced include: product quality, focusing specifically on a framework for Total Quality Management; advantages and disadvantages of implementing and improving processes within the software organization; implementation of process thinking, process focus and process discipline; implementation of the effective software process; and software process quality measurements.
Prerequisites	N/A
Knowledge model terms	Process; Software Process; Software process model; Quality of Service Dimension; Capability Maturity Model; Capability Maturity Model Integration; Key Performance Indicator

Table 16: Quality Assurance for Service-based Systems: From Software Engineering to Service Engineering

Learning module	Quality Assurance for Service-based Systems: From Software Engineering to Service Engineering
Author	UniDue
Related WP	WP-JRA-1.3
Description	This module motivates the need for quality assurance of service-based systems and provides an introduction to the three major classes of approaches for analytical quality assurance in service-based applications: Testing, Monitoring, and Static Analysis.
Prerequisites	Basic background in engineering processes and techniques
Knowledge model terms	Software Quality Assurance; Software Service; Service-Based Application; Service; Failure; Fault; Error; Static Analysis; Testing; Monitoring

Table 17: Human Provided Services in Mixed Service-Oriented Systems

Learning module	Human Provided Services in Mixed Service-Oriented Systems
Author	TUW
Related WP	WP-JRA-1.1
Description	This lecture presents the challenges and interactions in mixed systems. It further describes the Human -Provided Services (HPS) framework, which supports interactions between humans, interactions with services, and enables humans to publish their skills and capabilities as Web services. Finally, this lecture presents trust challenges and mechanisms to address them in the context of mixed systems, which participants flexibly join and leave, with highly dynamic interactions that are often influenced by the role and reputation of collaboration partners.
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Service; Software Service; Service-Based Application; Web Service; Human Computer Interaction; Activity; Context

Table 18: Applying Social Network Analysis Techniques to Software Engineering

Learning module	Applying Social Network Analysis Techniques to Software Engineering
Author	Lero

Related WP	WP-JRA-2.1
Description	This lecture presents an approach to the use of Social Network Analysis techniques in software engineering and demonstrates how social networks paradigms can support designing IT-enabled business processes and the steps involved in the process.
Prerequisites	N/A
Knowledge model terms	Business Process; Social Network Analysis; Business Process Measurement; Business Process Analysis, Monitoring and Auditing; Key Performance Indicator

Table 19: Introduction to the Analysis of Computational Systems through Abstract Interpretation

Learning module	An Introduction to the Analysis of Computational Systems through Abstract Interpretation
Author	UPM
Related WP	WP-JRA-1.1
Description	This lecture pertains to program analysis techniques applicable to several levels of Service-Oriented Applications, for instance to ensure their properties (e.g. correctness, robustness) or to analyze and synthesize service orchestration: checking functional properties, resource consumption etc. The topics presented include: concept of abstract interpretation; program analysis methods; abstract interpretation approaches and issues; abstract domains; abstract interpretation for logic programs.
Prerequisites	N/A
Knowledge model terms	Service analysis

Table 20: Service-Centric Systems and Requirements Engineering

Learning module	Service-Centric Systems and Requirements Engineering
Author	CITY
Related WP	WP-JRA-1.1
Description	This tutorial introduces web services and service- centric systems and explores their impact on requirements engineering processes, techniques and tools. Topics presented include: Web services, service-centric systems, service-oriented architectures, requirements engineering tools and techniques, and tools and techniques for specifying and publishing web services with functional and quality features, discovering web services compliant with early requirements, specifying service-level agreements from requirements, and service monitors based on requirements.
Prerequisites	N/A
Knowledge model terms	Service; Software Service; Service-Based Application; Web Service; Requirements Engineering; Requirement; Requirements Analysis

Table 21: Quality of Service Optimization in Web Services

Learning module	Quality of service optimization in web services
Author	POLIMI

Related WP	WP-JRA1.3
Description	This module discusses techniques to evaluate quality in service compositions. It presents the motivating needs for quality in SOA, introduces the concepts of QoS optimization and quality-driven compositions, and provides an analysis of optimization techniques. Re-optimization criteria at run time are illustrated. Triggers for rebinding, possible causes for failure and their handling, and available tool support are presented.
Prerequisites	Knowledge of BPM
Knowledge model terms	Quality Definition, Negotiation and Assurance (KM-QA); Quality negotiation and agreement (contract establishment); Optimization; Process; Quality of Service Constraint; Rebinding; Cost Model

Table 22: Design of Dependable Service-based Processes

Learning module	Design of dependable service-based processes
Author	POLIMI
Related WP	WP-JRA1.1
Description	This module discusses service-based processes dependability and illustrates techniques for improving process dependability. A definition of data quality is provided along with causes of poor data quality, assessment and measurement. Service adaptation requirements are then introduced and an algorithm for selecting adaptation strategies at design and at run time is illustrated. Finally a methodology to improve Web Service dependability is presented.
Prerequisites	Knowledge of BPM
Knowledge model terms	Service Based Application Construction; Service Specification; Adaptation; Adaptable Service-Based Application; Adaptation Requirements and Objectives; Data-Related Quality; Evolution; Adaptation Strategy; Design for Adaptation; Dependability; Self-Healing; Process; Context; Cost Model

Table 23: Service-based Software Development

Learning module	Service-based software development
Author	CITY
Related WP	WP-JRA-1.1
Description	This module presents a framework for service-based software development. An overview of the framework introducing its goal, processes and prescribed use of a query language to specify service request is provided. Algorithms for similarity analysis and distance measures are presented, and a Conference Travel SBA example is used to illustrate the concepts introduced.
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Service; Software Service; Service-Based Application; Service Based Application Construction; Service Discovery

Table 24: A Framework for Proactive Dynamic Service Discovery

Learning module	A framework for proactive dynamic service discovery
Author	CITY

Related WP	WP-JRA-1.1
Description	This module provides a motivation for proactive service discovery and presents an overview of a service discovery framework and its architecture. Service discovery queries and a corresponding query language are presented and illustrated. Different execution modes for dynamic service discovery are then introduced. Finally, an evaluation of the framework is provided.
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Service; Software Service; Service-Based Application; Service Discovery

Table 25: Web Services Business Process Execution Language (WS-BPEL)

Learning module	Web Services Business Process Execution Language (WS-BPEL)
Author	USTUTT
Related WP	WP-JRA-2.2
Description	This lecture deals with the standard service composition language, WS-BPEL, and describes the major usages of the language its relation to the Web service stack. Language features are explained in detail: activity types, partner interaction, correlation, variable usage, and advanced concepts such as dead-path elimination, scopes, fault and compensation handling, abstract processes etc.
Prerequisites	Basic knowledge of standard WS technologies
Knowledge model terms	Web Service; Service Composition; Workflow; Process; Business Process; Fault; Activity

Table 26: Aspects and BPEL

Learning module	Aspects and BPEL
Author	USTUTT
Related WP	WP-JRA-2.2
Description	This lecture deals with the flexibility of service compositions. It introduces a classification of process flexibility approaches and presents then a specific approach, which utilizes aspect-oriented programming techniques for increasing the flexibility of WS-BPEL service compositions.
Prerequisites	Basic background in Web Services, BPEL, Aspect-oriented programming.
Knowledge model terms	Web Service; Service Composition; Workflow; Process

Table 27: Agile Service Networks

Learning module	Agile Service Networks
Author	UoC
Related WP	WP-JRA-2.1
Description	This lecture introduces the notion of service economies, service value, and concepts of service systems as dynamic, human-centered value-correlation systems. It then presents an overview of existing research on service value system. Finally, it presents an approach to define the value of a value network and mappings to processes, people and services.
Prerequisites	N/A

Knowledge model terms	Agile Service Network; Value Network

Table 28: Introduction to Grid Computing

Learning module	Introduction to Grid Computing
Author	SZTAKI
Related WP	WP-JRA-2.3
Description	This module introduces concepts and principles of Grid Computing and the relationship between grids and SOA. The topics presented include: notion of grid computing, motivations for use, infrastructure and middleware, grid service compositions creation and execution, and execution of legacy applications as grid services.
Prerequisites	N/A
Knowledge model terms	Grid; Grid Workflow; Stateless Service; Stateful Service