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### **Management Summary**

The purpose of this deliverable is to report on the actions taken by the consortium members towards establishing a fully-functional, joint, European PhD programme that meets the high expectations of the network.

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# Chapter 1

## Introduction

The purpose of the T-SoE-1.1.2 task of the Virtual Campus WP SoE-1.1 is the development of a fully-functional, joint, European PhD programme that meets the high expectations of the network. To this end, particular actions have to be taken for establishing the foundations for such a programme and finally setting it off. Such actions include initial legal contracts and first steps towards achieving accreditation from relevant national and international bodies, the creation of the appropriate service and disciplinary-specific courses, seminars, and tutorials having a content which will be also influenced by the on-going research activities of the network, and the preparation of the appropriate proposal based on the realities at the involved universities (existing modules and curricula), aiming specifically at the mobility of PhD and master students between those universities.

To this end, by also relying on the very successful International Masters programme in Service Engineering (IMSE) and its current structure and already established procedures, a proposal was submitted to the EU under the Erasmus Mundus initiative for a joint, International, PhD programme in Service science and Engineering called IPSE. This proposal involved the network of partners of the IMSE programme, additional S-Cube partners, as well as other academic and industry partners. The courses offered included not only novel but also existing courses taught in IMSE or included in the S-Cube's learning unit. In addition, tutorials, seminars, as well as elective courses of different types (e.g., language, discipline-specific) were also offered. The programme had a specific structure and involved various boards and committees with particular administrative, management, and academic responsibilities, created from the subset or the whole consortium of partners. It also involved initial steps towards achieving accreditation for grading joint degrees.

Unfortunately, the proposal was rejected and the designated programme never set off. Thus, the goal of this deliverable is to highlight those points that need improvement/correction or must be incorporated so as to motivate the S-Cube partners to modify the existing proposal and re-submit it under the Erasmus Mundus initiative. To this end, the deliverable follows a research-oriented approach. As a result of a respective search performed by some S-Cube members, it first analyzes a set of other related joint PhD programmes (involving European universities) and highlights their main advantages and disadvantages. It then provides an overview of the IPSE proposal indicating its most important details. It finally highlights the main IPSE parts that have to be modified based on the reviewer comments, the content of the other related programmes, and further suggestions from the contributors of this deliverable.

The deliverable is structured as follows. Chapter 2 describes the basic arguments leading to the need of a joint, international PhD programme in service science and engineering. Chapter 3 provides an analysis of the related joint, European PhD programmes. Chapter 4 provides an overview of the IPSE proposal. Chapter 5 provides suggestions for improving the proposal and re-submitting it. Finally, Chapter 6 concludes this deliverable.

## Chapter 2

# The Need for a Joint, PhD Programme in Service Science and Engineering

Due to the advantages that service-orientation offers as well as the need for bridging the business to IT gap, enterprises start combining Business Process Management (BPM) and service technology so as to appropriately manage and optimize their business processes, which is a key ingredient for surviving in a dynamic business world where technology advances rapidly and the customer needs and behavior change. Moreover, enterprises start cooperating with other enterprises to obtain support for their core businesses as well as to create new innovative services and products. This gives rise to a special type of services, called business services, which are actually business processes that span the organizational boundaries and have to satisfy cross-organizational requirements. Through the offering of these business services, enterprises obtain value and economic growth and enter dynamic networks which are constantly evolving and changing so as to increase the value and profit of the partners involved based on the current business and technological settings, which include the deployment of better business service components.

These business services are not always automated but they can be composed from both human and software-based services. Moreover, they are usually linked to specific requirements and transactional properties that they must satisfy, while they might have to comply to organization policies as well as national and international laws. In addition, they may operate under different machines and hardware which can be in the administrative domain of different enterprises. Thus, the design and management of such services cannot rely on just one discipline but requires the examination and exploitation of various theories and methods that come from various disciplines, such as business and information management, software engineering, economics, and social sciences. To this end, there is a need for the introduction of a new discipline, called Service Science and Engineering, which will be devoted to the study, design, and implementation of service-based systems through following an inter-disciplinary approach. This discipline will seek to create value by applying scientific methodologies to design, create, and compose services as well as new knowledge through inter-disciplinary research.

Based on the above analysis, it is apparent that a service professional (service scientist or engineer) would have to possess cross-cutting skills from various disciplines, specific industry domain knowledge (as services may be applied to one or across various domains) as well as deep knowledge for all the activities involved in service management from service design to service adaptation and evolution. However, it has been observed that there is a shortage of people in Europe with these highly-demanding skills and background. These people could be exploited by the academia and industry in order to enhance innovation in Europe and make the European enterprises extremely competitive and profitable and allow them to grow substantially. In this way, more investments and better future employment opportunities will be developed in Europe. In addition, dedicated educational programmes in service research are missing that could be exploited so as to provide highly-skilled service scientists and engineers. Such programmes should not be offered by a single organization, due to the complexity of the inter-disciplinary nature of service research.

To this end, there is a need for a coordinated action to accelerate the education facilities offered to address the above challenges at the research and development level of the education sector through the development of a joint, multi-disciplinary, PhD programme in service science and engineering that will support academic excellence in services, by addressing not only technical but also business and social needs and opportunities, and drive the research, innovation, and growth in service economy.

## Chapter 3

# Related PhD Programs

As it was decided to enforce a research-oriented deliverable, the S-Cube partners performed research so as to discover which joint PhD programmes at the European level exist and report important information. The purpose was to show that although relevant, joint PhD programmes exist, none of them is either dedicated to services or covers appropriately all key service research areas. In this way, by also considering that the same results apply at the level of single PhD programmes, the need for a joint PhD programme in service science and engineering would certainly arise. Apart from reaching the above conclusion, another goal of the reporting was to unveil relevant characteristics of the programmes, such as the number of participating organizations (full and associative), the number of industry partners, the existence of joint or dual degrees, mobility paths, etc., so as to show commonalities as well as important omissions that should definitely be considered in the proposal of a novel, joint PhD programme.

The results of the performed research are summarized in Table 3.1. This table shows for each joint PhD programme its title, the organizations involved, duration, the research coverage of the key service research areas (designated by the respective research Work Packages in S-Cube), the names of the industry partners involved, if joint/dual degrees are issued, and which different mobility paths exist between the involved organizations.

The rest of this chapter is organized as follows. Section 3.1 analyzes the joint PhD programmes that are dedicated to service research, while Section 3.2 analyzes the joint PhD programmes in related fields. Finally, the last section provides an overall programme analysis and concludes this chapter.

### 3.1 Joint PhD Programmes in Service Research

As can be seen from Table 3.1, there are two joint PhD programmes dedicated to service research. The B·E·S·T programme (<http://www2.informatik.hu-berlin.de/top/best/doku.php?id=start>), launched in 2006 with 5 PhDs already awarded, focuses on the area of service technology with the aim to support the emerging paradigms of Programming-in-the-Large or Programming-in-the-world. Thus, it is expected that the programme has less focus on theoretical issues in service research. This programme involves three organizations, namely Humboldt-Universität zu Berlin (HUB), Eindhoven Technical University (ETU), and Universität Rostock. The duration of the offered PhDs is four years. No industry partners are involved in the programme. However, it is funded by third parties, including the Dutch NWO and STW, as well as the German Deutsche Forschungsgemeinschaft (DFG) and the German Ministry for education and research (BMBF). No joint degrees are issued but the PhD students have the opportunity to perform their PhD defense at both HUB and ETU so as to obtain double PhD degrees. Finally, mobility paths have been anticipated, as a PhD student at one program partner can visit another program partner to perform joint research.

The second joint PhD programme dedicated to service research is SOAMED, started at 2010 and currently involving 8 PhD students, which focuses on the area of Service-Oriented Architectures for the integration of software-based processes, exemplified by Health Care Systems and Medical Tech-

TITLE	ORGANIZATIONS INVOLVED	DURATION	RESEARCH COVERAGE	INDUSTRY PARTNERS	JOINT/DOUBLE DEGREES	MOBILITY PATHS
SOAMED PhD Program (Service-oriented Architectures for the Integration of Software-based Processes, exemplified by Health Care Systems and Medical Technology)	HU Berlin, TU Berlin, Charité, HPI Potsdam	2 years with option of prolongation	[ potentially: all ]			
B-E-S-T PhD program (Berlin - Eindhoven - Rostock Service Technology Program )	Humboldt-Universität zu Berlin, Eindhoven Technical University, Universität Rostock	4 YEARS	[ potentially: all - detailed information not available at the moment ]		double	Yes: from HU Berlin to ETU and vice versa.
Internet Technologies and Information Systems - combined MSc and PhD Program (Distributed systems and algorithms focus area)	Technische universitat Carolo-Wilelmina Zu Braunschweig, TU Clausthal University, Georg-August-Universität Göttingen, Leibniz Universität Hannover	4 YEARS	JRA 1.1: full, JRA 1.2: partial, JRA 1.3: partial, JRA 2.3: partial			
EMJD-DC Joint Doctorate in Distributed Computing	UPC BarcelonaTech - UPC, Spain (Co-ordinating institution) CATHOLIC UNIVERSITY OF LOUVAIN – UCL, Belgium TECHNICAL INSTITUTE – IST, Portugal ROYAL INSTITUTE OF TECHNOLOGY – KTH, Sweden	4 YEARS	JRA 1.1: partial, JRA 1.2: partial, JRA 1.3: partial, JRA 2.3: full	Telefonica Research (TID), Ericsson, Euranova, Peerialism.	double, with a view to implement a joint degree later on.	Yes: - any 2 of involved universities from different countries - additional mobility to

Table 3.1: The related, joint PhD programmes

nology. In this programme, four organizations are involved, namely Humboldt-Universität zu Berlin, Technical University of Berlin, Charité Medical University of Berlin, and HPI Potsdam. Based on the programme overview visualized at the programme's web site (<http://www.ki.informatik.hu-berlin.de/soamed-en/details>), it is stated that the programme aims at underpinning the currently pragmatically focussed service-oriented approach with theoretical foundations by integrating established as well as emerging software engineering procedures with the goal to decisively improve the concepts, methods, and tool support for service-oriented system construction. Thus, this PhD programme will potentially cover all key service research areas. The duration of the offered PhDs is two years with an option for prolongation. The programme is funded by the German Deutsche Forschungsgemeinschaft (DFG). As no other information is currently available, it is assumed that for this programme no industrial partners are involved, no joint degrees are issued, and no mobility paths have been foreseen.

Based on the above analysis, there definitely exist joint, PhD programmes dedicated to service research. As no additional information is provided, based on the programmes' available abstracts/overviews, these programmes potentially cover more or less all key service research areas, with the B · E · S · T programme having focus more on technological issues. However, concerning the other important details, both programmes do not involve industry partners and they do not issue joint degrees. Moreover, only one (B · E · S · T) from the two programmes allows for mobility paths. The absence of industry partners means that the PhD students will not have the opportunity to perform research and be acquainted with the demanding RTD environment of these partners. Moreover, the lack of relations with the industry leads to the situation where the students, after finishing their PhDs, will have to seek job opportunities in the industry on their own. The lack of joint degrees and mobility paths means that the research work of the PhD student will be recognized only by one organization. This is also true for the case of B · E · S · T, as while it allows for mobility paths, it enforces the PhD student to perform his/her defense in two organizations in order to obtain a double PhD degree. Finally, it must be noted that in both PhD programmes the teaching of service courses is not mentioned.

## 3.2 Related Joint PhD Programmes in other Fields

The rest of the programmes (i.e., Internet Technologies and Information Systems – ITIS – <http://www.itis-graduateschool.de/web/content/welcome-itis> and the Erasmus Mundus Joint Doctorate (EMJD) in Distributed Computing – EMJD-DC – <http://emjd-dc.eu/>) focus on specific research fields, such as distributed computing, and internet technologies, and offer some service-based courses. In addition, by inspecting the fourth column in Table 3.1, the key service research areas are not appropriately covered. In particular, only those related to “engineering and adaptation methodologies for service-based systems” (JRA-1) as well as “self-\* service infrastructure and service discovery mechanisms” (WP JRA-2.3) are partially covered in average (where “engineering principles, techniques, and methodologies” (WP JRA-1.1) and “self-\* service infrastructure and service discovery mechanisms” are fully covered by ITIS and EMJD-DC, respectively). In these PhD programmes, the duration of a PhD is four years long, while the consortium consists of four organizations. Concerning the rest of the relevant information, only EMJD-DC involves four industrial partners, it issues double degrees and will study pathways to the implementation of a joint degree. Moreover, it anticipates for mobility paths involving any two of the involved universities from different countries, while also additional mobility is allowed to industry in most projects.

### 3.2.1 EMJD-DC Joint Doctorate in Distributed Computing

As the EMJD-DC is funded by Erasmus Mundus, it obliges to the rules and policies of this programme. Thus, it is interesting to provide an overview of the most interesting details of EMJD-DC, which could be exploited for suggesting improvements for the IPSE EMJD proposal.

#### Programme Structure and Mobility Paths

Concerning EMJD-DC’s programme structure, there are many interesting features. First, all academic partners are involved in each individual student program. In particular, the PhD student is trained in two partner universities (A and B) and has to follow an obligatory research internship in another partner university (C). Moreover, a student’s progress is supervised by a 5-member committee, called progress committee, comprising the supervisor and co-supervisor from partner universities A and B, respectively, an internal rapporteur from partner university C, an external rapporteur from a university that does not belong to the consortium, and the committee chair (preferably from partner university D) that is responsible for ensuring that specific milestones and intermediate evaluations are met.

Another interesting programme feature is that each PhD student is obliged to follow both a research internship in the research laboratory of the internal rapporteur as well as an industrial one in an industrial partner associated to the project. Both internships last 3 months and are to be followed at the program’s summer breaks of the first and second year.

The student training involves 4 technical modules, at least two scientific modules, 2 language courses, and at least 3 skills/management modules. The technical and scientific modules are given during the first two years, while the language courses and the management modules are spread along the studies. Moreover, the management modules are linked to the internships as well as to the participation in the events organized by the EMJD-DC, such as the annual workshop called “Doctorate Days” in which all PhD students participate by presenting PhD proposals and on-going work reports and distinguished presenters give interesting keynote talks.

A significant feature of the programme structure is that specific deliverables must be provided by the students. In particular, the students must participate in one industrial and one research internship, they must attend at least two EMJD-DC workshops, provide early progress reports, and have at least 5 publications in related journals and conferences. Fewer publications can be accepted only in case they involve first-tier journals and conferences with high impact factors. Thus, as can be seen, there

are specific criteria apart from the delivery of the proposal and thesis reports and the successful thesis defense that must be satisfied so that a student is finally graduated.

Two milestones have been designated for assessing a student's progress and performing the appropriate actions for assuring the quality of the research results produced. In particular, in the first year, the student must prepare and deliver the PhD proposal, while in the second year, the student must produce and deliver an early progress report analyzing the main research issues being dealt with, the early research results, and the overall plan for the remaining work. These two reports are evaluated by the progress committee and in case that they are not satisfactory, the student will have to submit a new version of the proposal after six months but is assisted through the guidance of one member of the progress committee.

Finally, a specific mobility path has been designated by EMJD-DC for the PhD students. In particular, the PhD students pass their first year mostly in partner university A, where they are trained with 3 technical and 1 scientific module and they perform individual research that results in the preparation and submission of the PhD proposal. In addition, they have to attend the EMJD-DC workshop and move to an industry partner at the summer break to follow a specific internship. Similarly to the first year, in the second year, the students move to partner university B, where they are trained with 1 technical and 1 scientific module, while they perform individual research work that is reported in the early progress report. In addition, they have to attend the EMJD-DC workshop and move to the research laboratory of partner C at the summer break to follow a specific internship. In the third year, the students may reside either at partner A or B and mainly perform research work, while they can also attend the annual workshop. Finally, in the fourth year, the students reside at partner A where they complete their research work and finally defend their thesis.

## Student Admission Requirements and Fellowships

**Student Admission Requirements.** The applicant must prepare and upload all the appropriate documents at the EMJD-DC admission web site. The applicant must either hold a higher education degree in computer science or related areas of distributed computing or may be at the final year of a Master education. In the latter case, he/she must also upload a written statement from the degree administration office confirming the student's enrollment in the final year and his/her expected graduation/completion date. If the applicant is conditionally accepted in the programme, he/she must present the degree certificate to the Admissions Office before his/her enrollment.

The documents that must be uploaded by the students include: a) a proof of their English language proficiency (e.g., through tests), b) personal profile details (collected by the web-based application), c) a correctly certified copy of the Masters degree in original language and translated into English (if already graduated), d) a correctly certified copy of the transcript of records in original language and translated into English including all courses taken, e) a curriculum vitae including details on their academic career, contact details and photo, f) a copy of the passport or some other kind of identification in English, g) two letters of recommendation from professors of the most recently attended higher institution or from employers if relevant, h) publication list and patents in English if applicable, and i) the Candidate Application form.

The applicants that pass the first evaluation round may be interviewed in the second round in order to validate some information and examine the applicants' oral and presentation skills. However, no further information is provided about how the student selection is actually performed.

Please note that EMJD-DC defines specific deadlines for the application, selection, and the start of the academic year.

**Fellowships** Fees and other required participation costs differ between the partner universities. However, for PhD candidates selected for a fellowship for the EMJD-DC programme, participation costs and tuition fees will be provided for and thus waived. Moreover, the assigned (i.e., supervising) consortium

partners provide the fellowship holders with Employment Contracts including full social security cover and pension rights according to the national laws applicable to each student.

EMJD-DC offers 9 fellowships for each admission period which are splitted according to the types of fellowships that are allowed in an EMJD (see next chapter). Only candidates that have been accepted in EMJD-DC are eligible for a fellowship. Moreover, individuals that have already benefited from an EMJD fellowship cannot be granted a second grant. Finally, the scholarships are awarded exclusively for a full-time enrolment in the programme.

The candidates joining the program are supported in key aspects by the local International Student Offices at each university as well as by other local offices supporting academic and social activities). The support includes initial orientation, help with visa and other bureaucratic tasks, local language tuition, and specific accommodation for postgraduate students in all cases.

### **3.3 Overall Analysis and Conclusions**

At the global level, it can be deduced that half of the PhD programmes involve only German universities by exploiting the funding of German third-parties, such as the German Deutsche Forschungsgemeinschaft (DFG). This means that students that desire to obtain a dual PhD degree related to service research have more opportunities to go to Germany and than to any other European country. This conclusion is also strengthened by observing that 9 out of the 14 organizations that are involved in the programmes examined are situated in Germany while the rest are situated in different European countries (Spain, Sweden, Netherland, Portugal, and Belgium). Moreover, only one joint PhD programme, which is not dedicated to service research, is funded by Erasmus Mundus. In addition, no joint degrees are issued by any of the programmes. Finally, in most of the programmes, the duration of the PhD is four years long.

According to the omissions/deficiencies of the two joint, PhD programmes in service research analyzed in Section 3.1, it is apparent that there is a need for a novel and more flexible joint, PhD programme that corrects these deficiencies and clearly covers all key service research areas not only through the research performed but by also offering the appropriate lessons/modules that are needed for diffusing the required knowledge to students which may not have the appropriate background on services. Such a PhD programme could be funded by Erasmus Mundus based on the various advantages and opportunities that EJMD brings about (see Section 3.2.1), enabling the correction of the above deficiencies, and on the fact that no other truly related programme already exists at the European level and involves universities and research organizations (with close connections with universities) from many different European countries already constituting research excellence centers in service science and engineering.

## Chapter 4

# The IPSE proposal

Based on the analysis of the previous chapter, it is apparent that there is a need for a joint PhD programme in service research that involves many organizations, both in research and industry, from many European countries but also countries from other continents, which covers all key service research areas and offers service courses enabling students (even those originating from different but related disciplines) to obtain the appropriate skills and knowledge in order to fulfill all their PhD commitments. This need was recognized by the members of S-Cube, which prepared and submitted an EMJD proposal for a joint, international PhD programme in service science and engineering called IPSE. This chapter provides an overview of this proposal by highlighting the most important proposal details.

The purpose of IPSE was to deliver an interdisciplinary, international Doctoral programme in service science and engineering with a special focus on engineering aspects of services. It was formed as a logical continuation of the IMSE programme. It aimed at preparing MSc students with a background on Business Information Systems, Computer Science, or Service Engineering (e.g., IMSE graduates) to become the new breed of cross-disciplinary service scientists and engineers with capabilities to perform autonomous research on the cross-junction of software service systems and business management. Table 4 shows a summary of all the related information of IPSE.

The related information of IPSE has been categorized in specific units, which are analyzed in the following sections of this chapter.

### 4.1 Key research areas

IPSE concentrated on three interrelated key research areas that span across the involved organizations' competencies. These research areas were the following: a) **Service Analysis and Design** dedicated to examining novel, objective methods for the development and creation of services, b) **Service Development, Deployment, and Monitoring** dedicated to the development and deployment of fully-functioning service-based systems, which respect both functional and non-functional requirements, as well as the monitoring of these systems so as to detect violations of these requirements and trigger the appropriate adaptation actions, and c) **Service Evolution and Management** dedicated to the adaptation of service systems, in sight of requirements and system context changes or infrastructural failures, and their graceful evolution when these changes or failures become permanent.

Through the introduction of the above research areas, the IPSE student would obtain the appropriate skills and knowledge across the whole life-cycle of a service-based system in order to perform autonomous research and develop innovative tools, mechanisms, and methods that advance the state-of-the-art in service management and evolution.

As can be seen from Table 4, IPSE did not fully cover all key service research areas relevant to S-Cube. In particular, three research areas are partially covered, namely "Monitoring and Adaptation Principles, Techniques and Methodologies for Service-Based Systems" (WP JRA-1.2), "End-to-End

TITLE	International PhD programme on Service Engineering (IPSE)
S-CUBE PARTNERS INVOLVED	Tilburg University, The Netherlands; University of Stuttgart, Germany; University of Crete, Greece; University of Duisburg-Essen, Germany; Lyon University, France
NUM OF FULL PARTNERS	6: The 5 S-Cube Partners and the SAPIENZA University in Rome, Italy
NUM OF ASSOCIATE PARTNERS	4: Carnegie Mellon University, USA; Tsinghua University, China; RMIT, Melbourne, Australia; University College, London, UK
NUM OF INDUSTRY PARTNERS	7: Software AG, Germany; ForthNet, Greece; PriceWaterhouseCoopers, The Netherlands; HP Research Labs, England/USA; IBM EMEA, Israel; Thales, The Netherlands; Shell, The Netherlands/UK
DURATION	3 YEARS
RESEARCH COVERAGE	JRA-1.1: Full, JRA-1.2: Partial, JRA-1.3: Partial, JRA-2.1: Full, JRA-2.2: Full, JRA-2.3: Partial
MOBILITY PATHS	All PhD candidates start in year 1 at Tilburg University in the Netherlands, after which they (may) move to a core partner-A (in Germany, France, Italy or Greece) to follow specialized courses associated to the track to which they were assigned. The students will stay at this location for the duration of phase three, after which they move to the second core partner-B (in another country) for further specialization during phase 4 of the programme. In phase three and four PhD students may go outside the EU for one semester to one of the associated academic partners in Australia, China, England or the
ACCREDITATION PROCESS	Partners award graduates with a joint degree. The national legislations of the core partners involved require an accreditation process to be completed before a joint doctoral degree can be issued.
FELLOWSHIPS	A specific number is funded. The consortium strives to equally distribute the number of scholarship among the partners.
COURSES IN THE LEARNING UNIT THAT ARE NOT COVERED BY THE PROPOSAL	Monitoring and Analysis of Service Based Applications; Unconventional Models for Services (Infrastructure); Self-* Infrastructures; Service Quality Overview; Service Quality Definition and SLA Negotiation; Quality Assurance and Quality Prediction; Aspects and BPEL; Introduction to the Analysis of Computational Systems through Abstract Interpretation; Human Provided Services in Mixed Service-Oriented Systems; Agile Service Networks; Introduction to Model-Driven Engineering; Quality of Service Optimization in Web Services; Agile Service Networks; A Framework for Proactive Dynamic Service Discovery; Messaging; Introduction to Grid Computing
COURSES IN THE PROPOSAL THAT ARE NOT COVERED BY THE LEARNING UNIT	Research Methods; Designing Networked Organizations and Inter-organizational Systems; Workflow Analysis & Design; Advanced Workflow Management; Advanced Information Management; Data Management; Formal methods for software and services; Human Computer Interaction; Digital Economics; Internet Knowledge Management and Innovation; Business Intelligence; Supply Chain Management; Logics: semantics, algorithms and applications to services; Graph model for Web services; Formal Methods in Software Engineering
COURSES IN THE IMSE THAT ARE NOT COVERED BY THE PROPOSAL	Enterprise Architecture; Business Process Management; Designing Networked Organizations and Inter-organizational Systems; Message-Based Applications; Datawarehousing and Analytics; Service Management and Clouds; Infrastructure Technologies for Large Scale Service-Oriented Systems; Multicore Architecture Programming; Distributed Systems; Mobile Networks and Computing; Cybersecurity
COURSES IN THE PROPOSAL THAT ARE NOT COVERED BY IMSE	Research Methods, Designing Networked Organizations and Inter-organizational Systems, Advanced Workflow Management; Advanced Web Services; Advanced Information Management; Data Management; Formal methods for software and services; Human Computer Interaction; Business Process and Service Networks Simulations; Business Processes, Online Communities and Business Transformation; Internet Knowledge Management and Innovation; Business Intelligence; Supply Chain Management; Semantic Web services; Security specification and enforcement for web services based applications; Logics: semantics, algorithms and applications to services; Graph model for Web services; Software Engineering II (Level 2); Software Quality Assurance; Formal Methods in Software Engineering; Requirements Engineering II
CREDIT SYSTEM TYPE	ECTS
JOINT/DOUBLE DEGREES	Joint

Table 4.1: Overview of the IPSE Proposal

Quality Assurance and SLAs” (WP JRA-1.3), and “Self-\* Service Infrastructure and Service Discovery Support”. This conclusion can be derived by also inspecting columns 11-14 of Table 4 which show respectively:

1. which courses from S-Cube’s learning unit collection are not covered by IPSE
2. which IPSE courses are not covered by the S-Cube’s learning unit collection
3. which IMSE courses are not covered by IPSE
4. which IPSE courses are not covered by IMSE

In particular, the courses that are missing in IPSE but are part of IMSE or the S-Cube’s learning unit collection relate to monitoring and analysis of service-based systems, quality assurance, prediction, and optimization, self-\* infrastructures, and service discovery. On the contrary, the IPSE courses that are missing from IMSE or the S-Cube’s learning unit collection map to service-related research fields, such as formal methods, human-computer interaction, workflow management, information and data management, business intelligence, and supply-chain management.

## 4.2 IPSE Consortium

The consortium of IPSE consisted of 6 full/core academic partners, from which 5 were S-Cube members, namely Tilburg University, University of Stuttgart, University of Crete, University of Duisburg-Essen, and Lyon University. It also consisted of 4 associate academic partners situated in China, USA, Australia, and UK, as well as 7 industrial partners (big companies as well as SMEs) situated in Germany, Greece, The Netherlands, UK, USA, and Israel. The consortium was carefully constructed so that each partner is a major national, European, or international player in service science and engineering and has complementary capabilities and skills in the key research areas selected.

The role of the IPSE academic partners was to enable and guarantee the access to research equipment and prototype implementations, the exchange of knowledge and research results, the resource (researchers and PhD students) mobilization, and the joint supervision of the IPSE PhD students.

The associate academic partners had an active role in the IPSE programme with the duty to bring in specific knowledge and expertise, not only by contributing lectures and courses but by also providing advices on further developments in the field and exchanging their experience obtained from their own programmes and international collaborations.

On the other hand, the role of associate industry partners was to provide internships and practical guidance to the PhD students allowing them to work in a highly competitive environment and pursue research challenges that are of high business priority. Such a practical guidance would not only be offered during the internship but also during the SSAIE Summer School on Service Computing (<http://www.summersoc.eu>) where the IPSE PhD students will attend lectures provided by service professionals in service science and engineering and obtain feedback for the work that they present from the summer school participants, which are other PhD students as well as young researchers and professionals from leading academic, research and industrial organizations across Europe and around the world. Last but not least, the industry partners provide a link to the business world and can offer employment opportunities to the IPSE graduates.

## 4.3 Programm Structure and Mobility Paths

Each key research theme/area in IPSE is addressed in a coherent and well-structured manner and serviced by at least three partners, while the integration among partners is grounded on the S-Cube Research Roadmap. Moreover, so as to ensure cross-fertilization and coherence, one partner from each research theme serves as a logical linking pin with the other research themes.

IPSE offers a three year PhD programme, which is organized in four phases, where three from these phases directly correspond to the key research themes. In the first year, the PhD students mostly attend lessons. In the first semester (Phase 1), they follow basic courses in service science and engineering provided from one specific core partner. In the second semester (Phase 2), they (may) move on to core partner *A* (if it is different from the one of the first semester / Phase 1) and they attend specialized courses according to the programme track in which they were selected, while they also prepare and finalize their PhD proposal. The programme tracks correspond to the key research themes of IPSE. In the second year (Phase 3), the PhD students focus on conducting research and producing specific research results according to their proposal. Finally, in the third year (Phase 4), the candidates move on to core partner *B* for further specialization, where they consolidate the research results of their work, write papers that are accepted in high-quality conferences and journals, as well as finalize their PhD thesis and defend it.

It must be noted that core partners *A* and *B* should be situated in different European countries, they should service the same research track as the one selected for the PhD student, while both constitute those core partners that issue the joint or dual degree of the student. Moreover, members from these partners constitute the two-party supervising committee of a PhD student. In addition, during Phase 3 and 4, PhD students have the opportunity to spend one semester outside Europe in one from the 4 associated academic partners.

Table 4.2 shows for each key research theme the courses offered (their code and description) by the respective IPSE partners. Please note that some elective courses were also offered by the IPSE partners that concerned seminars, the SSAIE summer school, general research methodology courses, discipline-specific courses, as well as language courses for enabling the students to learn the language of the partner's hosting country.

A final remark concerns that all partner universities have adopted the ECTS credit system. This is actually a requirement imposed by the EMJD programme. To this end, students with marks between A and D pass the course and earn credits, while students with lower marks (E and F) fail to pass the course.

## 4.4 Student Selection, Costs, and Scholarships

### 4.4.1 Student Selection

In IPSE, the students apply for joining the PhD programme through an electronic submission system. The information submitted is checked by the admission office of the coordinating partner. This office may contact the applicant in order to obtain missing or incomplete information.

The IPSE candidates should have completed a graduate programme before the actual start of the PhD programme. The most highly-qualified candidates are selected based on their previous academic performance and their research capabilities according to the assessment of the following criteria: English test, admission test, relevant previous degrees, transcripts, resume, reputation of the home institution, motivation letter (including track(s) preference), recommendation letters (two), and written work (papers/Master thesis). The admission of the selected candidates is finally judged based on a final interview which has the purpose to verify the skills and academic qualifications of the candidate.

The selection of the candidates is performed by the Academic committee, in which all partners are represented. This committee must also select the research track that will be followed by the selected PhD students according to their motivation letter and skills in such a way that the best candidates are selected for each track. The selected candidates are informed by the coordinating partner and must answer positively or negatively about their participation in the programme in a specific time frame.

It must be noted here that based also on the restrictions of the EMJD programme, the students should come from a European or a third country (outside EU). In the latter case, the students should not be residents or have carried out their main activity (e.g., studies, work) for more than 12 months over the last five years in a European country. The only exception concerns third-country students that have successfully obtained an Erasmus Mundus masters scholarship in order to follow an EMMC.

Table 4.2: The distribution of IPSE lessons offered by each core partner to the IPSE research themes

Research Theme	Core Partner	Course Code	Course Description
Analysis and Design	UOC	CU01	Digital Economics
	UOC	CU02	Introduction to Service Networks Science and Engineering
	UOC	CU03	Business Process and Service Networks Simulations
	UOC	CU04	Business Processes, Online Communities and Business Transformation
	UniDue	EDU01	Software Engineering II
	UniDue	EDU02	Software Quality Assurance
	UniDue	EDU03	Formal Methods in Software Engineering
	Tilburg	TU01	Service Oriented Analysis and Design
	Tilburg	TU03	Business Process Integration
	Tilburg	TU06	Seminar Services Science
	Tilburg	TU07	Workflow Analysis & Design
Development, Deployment, and Monitoring	USTUTT	US01	Advanced Workflow Management
	USTUTT	US02	Advanced Web Services
	USTUTT	US03	Advanced Information Management
	USTUTT	US05	Study Project
	Sapienza	SA01	Service oriented architectures
	Sapienza	SA02	Data Management
	Sapienza	SA03	Elective in Software and Services
	Sapienza	SA04	Formal methods for software and services
	Sapienza	SA05	Human Computer Interaction
	UOC	CU02	Introduction to Service Networks Science and Engineering
UOC	CU04	Business Processes, Online Communities and Business Transformation	
UOC	CUOp01	Business Intelligence	
Service Evolution and Management	Tilburg	TU02	IT and Service Governance
	UCBL	UL01	Semantic Web services
	UCBL	UL02	Security specification and enforcement for web services based applications
	UCBL	UL03	Logics: semantics, algorithms and applications to services
	UCBL	UL04	Graph model for Web services
	UniDue	EDU02	Software Quality Assurance
	UniDue	EDU03	Formal Methods in Software Engineering
Elective Courses	UOC	SC01	The Services and Software Architectures Infrastructure & Engineering Summer School
	Tilburg	TU04	Research Methods
	Tilburg	TU06	Seminar Services Science
	USTUTT	US04	Seminar Services Science
	Sapienza	SA06	Seminars in Software and Services

#### **4.4.2 Participation Costs**

The participation costs were the same for both EU and third-country PhD students. Two types of participation were accommodated with specific costs each. The first type concerned a full-time participation, while the second concerned a part-time participation and corresponded to less cost per student with respect to the former type. The costs for each participation type included training and courses, access costs to research facilities and reimbursement for several cost-related activities, such as travelling costs and Summer School visits.

Please note that PhD candidates that apply for a part-time programme are not entitled to an Erasmus Mundus grant.

#### **4.4.3 Student Scholarships**

According to EMJD restrictions, a specific number of fellowships is funded. Scholarships are separated into two types according to the country of origin of the student (EU and third countries). The IPSE consortium will equally distribute the number of scholarships among the partners.

### **4.5 Degree Types and Accreditation Process**

The PhD candidates that successfully fulfill the full programme of study will be granted a joint degree. This degree is granted by the core (supervising) partners on which the candidate has passed Phases 2-4 of the programme which serve the particular research track followed by the student. Please note that the national legislations of the core partners involved require an accreditation process to be completed before a joint doctoral degree can be issued. To this end, in case the accreditation process is not completed before the completion of the programme, the candidates will be granted with double degrees from the two core, supervising partners.

## Chapter 5

# Reviewer Comments and Improvement Suggestions

Unfortunately, the IPSE proposal was rejected for various reasons. To this end, the goal of this chapter is to report the most significant reviewer comments as well as suggest not only ways of addressing them but also some improvement directions, by considering the best features of other related joint PhD programmes, which could be exploited for optimizing and possible re-submitting the proposal.

Please note that it is not in the scope of the deliverable to propose a novel proposal as first of all the existing proposal is already both complete and appropriate and just requires small improvements, as it will also be seen from the reviewer comments. Secondly, it is not suitable for a project deliverable to include the description of a full proposal that will be submitted in a specific programme of the EU.

### 5.1 Reviewer Comments and Their Addressing

**1<sup>st</sup> Comment** Emphasis is given more on doctoral training (courses), and scientific quality and research methodologies were not sufficiently discussed.

**1<sup>st</sup> Comment Addressing** This comment stresses that while the research areas were appropriately separated, and a sufficient number of courses were offered for each research area so that PhD students obtain a set of skills that will enable them to build innovative service-based systems, the proposal does not explain how the student will perform his research in such a way that the research results produced will be of high scientific value and especially the way he/she will be guided in order to select the appropriate research methodology that is more suitable based on the research topic that he has selected. To this end, it would have been appropriate in the specific part of the proposal to which the reviewers refer to analyze the scientific quality assurance procedure to be settled for ensuring the quality of the research results produced by the candidates and that the candidates follow specific research methodologies that are the most suitable for their research topic. For the latter, it would have been helpful to provide a list of types of research topics with the corresponding most suitable research methodology (or even alternative ones).

**2<sup>nd</sup> Comment** More information should be provided regarding previous contracts of consortium members and more details should also be provided regarding skills in order to assess PhD supervision. The scientific competencies and the transferable skills should be well elaborated. The expertise of the staff involved is very appropriate to the proposed scope, but there is not sufficient information on PhD supervision.

**2<sup>nd</sup> Comment Addressing** Apart from stating the roles for each partner and their core competencies in terms of specific research areas of services, it would also have been appropriate to state the partner

participation in previous programmes, the scientific quality of the personnel that would be involved and their skills, statistical information about partner publications and (previous as well as current) PhDs, information about employment of the partners' PhD graduates in the academia and industry, as well as particular mechanisms and skills that could be transferred and exploited in IPSE especially for PhD supervision.

**3<sup>rd</sup> Comment** Complementarity of the consortium should be more coherent with the stated programme objectives.

**3<sup>rd</sup> Comment Addressing** This comment reveals that there is a gap with respect to the IPSE objectives that is not covered by any IPSE partner. Indeed, by inspecting the part of the proposal where the IPSE partner competencies are explained, it can be seen that most competencies directly relate to key areas in service research but not to any particular discipline, such as information technology, economics, or social sciences. However, by carefully examining the courses offered by the partners and by also knowing, at least for the S-Cube partners, their competencies in particular disciplines, it can be inferred that the consortium complementarity is coherent with respect to the stated multi-disciplinary objectives of the programme.

**4<sup>th</sup> Comment** The role of the non academic partner is restricted to internships and the advisory board; however internships are not integrated in the programme. A much higher involvement of non-academic partners in the doctoral programme and management would add strength.

**4<sup>th</sup> Comment Addressing** For the internship integration problem, we envisage that apart from the research internships that can be exploited in Phases 3 and 4, also industrial internships could be exploited. In this way, the PhD students will have the opportunity to work in a competitive environment, obtain practical experience, and exploit real input as well as industry-specific tools (which could require spending a lot of money for buying and subsequently exploiting them) in order to apply their research and complement the functionality of the research prototypes developed.

The non-academic partners were already involved in the IPSE governance board providing assistance and guidance to various issues, such as the determination of major elements of the research strategy and shaping of the three key research themes. However, industry partners could also be involved in other committees or boards to enforce a much higher involvement and add strength to the IPSE programme. For instance, they could be involved in the programme board, which has the duty to assess the programme quality and adapt it through enforcing improvements both in content and processes. In addition, they could involve specific staff with academic positions in the committees for the selection of the PhD students, their supervision, and the defence of their PhDs. In this way, candidates will be selected by also considering criteria such as development and collaboration skills, and students are not only supervised by experts in industry but also their work is guaranteed to produce research results that have high impact in industry. Moreover, we envision that another committee could be created by the industry partners with the main role to guarantee the employment of the IPSE graduates through absorbing them in their RTD teams or suggesting them to other industry organizations (which may have particular vacancies) with which they are linked. The IPSE proposal was suggesting the creation of an industry advisory board for external quality assurance. This board would have the duty to align the IPSE programme with the latest developments and trends in RTD in the international business environments. These two committees could be unified in an industry advisory and graduate employment board. Finally, we imagine that there can be specific work plans for IPSE students that wish to be employed in the industry, which will determine the exact timing for the initiation of the student's industry internship and the participation of a specific industry partner (through its staff member involved in academia) in the student's supervising and defense committee.

**5<sup>th</sup> Comment** All students will have one full year of courses, mostly at the MSc level, which limits the research period to 2 years, and this should have been justified. The mobility is very well organized and appropriate to the project, but internships are not integrated in the mobility scheme. The joint supervision and monitoring procedure is appropriate to ensure a good quality of the outcomes.

**5<sup>th</sup> Comment Addressing** For addressing the reviewer concerns, we envision two alternative solutions. The first solution distinguishes between the type of graduated students that participate in the PhD programme. For IMSE graduates and graduate students with service engineering background, we foresee one semester with special courses (along with the preparation of the research proposal) and a pure research period of 2.5 years. For the other type of graduates, in the first semester of the first year, the candidate will have to pass both basic as well as specialized courses and in the second semester of the same year he/she will have to prepare the research proposal as well as start the research work. Alternatively, the second solution extends the programme to four years, leaves the first year period the same, and adds one year of pure research. However, the EMJD fellowship for any type of students covers them for only three years. So, this means that additional funding should be found for the students, e.g., from the partner participation in European projects.

Concerning the internship integration in the mobility scheme, the first solution leaves space for one internship, either research or industrial. However, inspired by the EMJD-DC solution, the internships can last three instead of six months. So, in this way, there will be time to follow both internships. The second solution allows sufficient time space for both types of internships. However, it must be noted that EMJD dictates that for third-country students, their fellowship will not cover more than one semester of internship. Thus, either the internship time is reduced in three months or one of the internships (e.g., the industrial one) is funded through other means (e.g., by the industry partner).

**6<sup>th</sup> Comment** The Consortium Agreement describes task and responsibility for each partner, and all partners intend to continue the programme after the EU funding period, by using national or local funding. However they do not provide a clear sustainability plan.

**6<sup>th</sup> Comment Addressing** The IPSE proposal already foresees subsistence through national or local funding, funding from EU projects in which IPSE partners will participate, as well as exploitation of the bonds with the associate partners to obtain funding from their respective national science foundations. In addition, it plans to pursue actions for increasing the enrollment of self-paying students.

In this deliverable, it is envisioned that the industry partners as well as other industry organizations (which could be contacted) could also play a significant role in obtaining additional funding. In particular, the industry partners/organizations could fund a specific amount of scholarships, especially for students that would be involved in the internships offered and could be employed by the partners after their graduation. Moreover, they could also pay for obtaining the IPR of innovative service products produced in terms of the PhD thesis of IPSE graduates.

## 5.2 Other Improvement Suggestions

Apart from suggesting ways of addressing the reviewer comments, some other parts of the proposal could also be improved. First, by inspecting the core service-related competencies of the partners, it can be observed that the first two key research themes are very well covered but this does not hold for the third research theme (Service Evolution and Management). Moreover, by considering the layers of a service-based system, it can be noticed that the infrastructure layer and the research issues that brings about is not appropriately covered (see also Section 4.1). Thus, for the sake of completeness, it could be beneficial to incorporate a very small number (e.g., one or two) of additional core partners which

could provide additional, complementary competencies so as to perfectly cover the key research areas designated, without significantly increasing the requested amount of funding.

Second, the training of the students can be more precise by explicating particular requirements, such as the amount of technical, scientific, and management modules and the time that these modules must be exercised to students. This could be complemented by the proposition of specific course plans for different tracks and topic types, so that the student has from the very first moment and based on his track a clear view of the courses he/she should pass. Moreover, particular courses should be taught by all core partners. For instance, by also considering the first reviewer comment, it is apparent that course TU04 “Research methods”, dealing with the various stages of a research process, should be taught to all PhD students so that they are acquainted with the appropriate steps that must be performed during their research.

Third, based on EMJD-DC programme structure, the progress committee can be considered as an obligatory feature that must be exploited not only for including additional experts (e.g. from other core or associate partners) in the supervising committee of a student, offering their experience and advanced skills, but also for guaranteeing the quality of the research results produced and the smoothness of the students’ progress. The definition of specific milestones (even more from those defined in EMJD-DC) also allows to better control the student progress and to take particular actions for ensuring that the student is on the right track. In special cases, which should also be appropriately defined, the actions should include the ability to change track and research topic (e.g., if research results are not as expected) as well as to obtain an extension of one year in the student PhD program (e.g., when the research topic changes, for maternity reasons, or depending on the impact of research topic and the amount of research and development work to be performed for fulfilling the PhD, etc.).

Fourth, IPSE should explicitly state all the deliverables that must be delivered or fulfilled by the PhD student in order to be graduated. These deliverables should include: a) a specific number of courses to be passed for each course type, b) progress reports (three monthly are already designated by IPSE but they are not explicitly stated in the program structure nor their timing is explicitly specified), c) the PhD proposal, d) at least one internship must be followed, e) obligatory participation in the SSAIE Summer School where the student should present his proposal or on-going research work, f) the number of publications (conference and journal) which should be greater than a specific minimum, g) the PhD thesis, h) successful PhD defence, and i) one or more administrative reports (useful for internal evaluation, see eleventh improvement suggestion).

Fifth, similarly to the fourth reviewer comment about the role of the industry partners, the role of the associate partners could also be leveraged. In particular, apart from participating in the Academic Advisory Board and offering research internships, the associate partners could be involved in the academic, and supervisory committee, in the programme board and in the committees that select and supervise the PhD students. Apart from fulfilling the duty to promote IPSE, they could also search for further funding in order to offer more fellowships and attract more students. Moreover, they could also enable the issuing of joint degrees with the other two core partners of a specific track when a student follows their research internship and is supervised and examined by at least one of their staff members.

Sixth, particular documents, such as the degree certificate and the transcript, that are uploaded in the electronic submission/admission system by the applicant must be officially stamped and signed. In addition, they should be both in original and in officially certified translations in English. Moreover, some additional documents should be uploaded apart from those already mentioned in the IPSE proposal, such as a copy of the passport or some other kind of identification in English, and a list of patents. Finally, the recommendation letters should be from professors of the most recently attended higher education or even from employers.

Seventh, IPSE should define specific deadlines for the admission, selection, participation confirmation, the sending of the official letters of admission, and the start of the academic period.

Eighth, the selection criteria could additionally include collaboration and development capabilities as well as research and employment history (participation in European/international/national projects and

involved duties, position of work and size and reputation of company).

Ninth, IPSE promises to provide specific services to the students, including support for administrative procedures, housing facilities by some partners as well as assistance in finding a proper accommodation for the rest of the partners, and social integration activities. These services must be complemented by orientation activities: introduction to the university at the moment of admission with electronic documents and web links to relevant information, orientation day and other activities for all foreign students, as well as organization of one day visit to the research laboratories of the hosting partner university.

Tenth, IPSE dictates that a contract and required work permit will be arranged by the host institution (i.e., the institution where a candidate currently resides) to secure a candidate's position with respect to the national legislation of the country where he is currently working. However, it must be explicitly guaranteed that the (employment) contracts include full social security cover and pension rights according to the national laws applicable to each student. Moreover, depending on the candidate nationality and the countries involved in the planned mobility periods, a pre-contract must be provided for assisting in the process of obtaining the specific work permit and visas. In addition, irrespectively of the national health insurance regulations and services and the limitations depending on the student nationality, it would be appropriate to provide a common extended health insurance scheme for doctorate students, which includes all mobility periods and internships, through the coordinating organization in collaboration with the international offices at each university.

Eleventh, IPSE designates a specific set of mechanisms for internal evaluation. These mechanisms should additionally include institutional/partner evaluation through considering various information, such as:

- course and supervision evaluations
- student administrative reports provided after the end of each mobility/internship period evaluating the fulfillment of the student expectations, the adequacy of the services and of the hosting institute facilities, etc.
- statistical information per partner about the number of PhD students supervised, the number and quality of the accepted publications of the supervised students, the student participation in the courses, the number of collaborations with other partners (e.g., through the supervision of PhD students, the participation of other (non-supervising) partners in the PhD defense committee of supervised students, the number of PhD students that failed or changed research topic or theme, etc.
- scientific quality and performance of the participating staff

## Chapter 6

# Conclusions

This deliverable has justified the need for a joint, European PhD programme in service science and engineering. The existing joint European PhD programmes are not adequate as they either focus on different research fields or they present specific deficiencies. The IPSE proposal in the Erasmus Mundus initiative intended to close this gap by also correcting the deficiencies highlighted. However, it was rejected. To this end, the deliverable presented an overview of IPSE, analyzed some of the reviewers comments, and proposed ways of addressing them as well as further suggestions for improvement.

It is now in the discretion of the S-Cube partners to rely on the existing proposal and make the appropriate adjustments and actions that will lead to the establishment of a fully-functional, joint European PhD programme in service science and engineering. Such a programme will produce a novel generation of service professionals (service scientists or engineers) through the appropriate training for fostering cross-cutting skills from various disciplines and the diffusion of specific industry domain as well as deep knowledge for all the service management and evolution activities. These service professionals will pave the way for a more innovative and competitive Europe which will lead the research in service science and engineering, will enable the industry to capitalize on the innovative technology so as to grow and become more profitable, and will provide additional employment opportunities as well as advanced social services to its citizens.