

# Research Network on Interoperability of Applications and Software for Networked Enterprises in the Valencian Region (INTERVAL)

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**Abstract:** Enterprise interoperability is a tool for enhancing the competitiveness of firms, and its importance is brought out by the fact one of the EC's strategic aims is to accomplish interoperability among European firms by the year 2010. Nevertheless, in the particular case of the Valencian Region (Spain), research into enterprise interoperability is still badly structured, fragmented, overlapping and, in many cases, practically non-existent. The INTERVAL project has been set up in an attempt to solve this problem. The scheme plans to carry out a series of initiatives aimed at integrating research activities and applying them to the complicated Valencian business sector. By so doing these companies would benefit from the application of knowledge created specifically for them and adapted to fit their characteristics. In this paper we present the details of the project, including its goals, aims, activities, results achieved, the methodology used to accomplish them, the economic and/or technological advantages, as well as possible applications and future lines of research.

## Introduction

The capacity of a firm to cooperate with other enterprises in economic, organisational and technological affairs is becoming a key tool for enhancing competitiveness.

Nevertheless, current management methods and enterprise technologies generally lack common conceptual approaches that solve the difficulties involved in structuring and interconnecting enterprises at the information, product and decision levels.

One of the areas in which research is being conducted with the aim of improving those methods and technologies is enterprise interoperability [CHE03]. Although different definitions of interoperability have been proposed, in this paper we shall be using the definition put forward by the Thematic Network IST-2001-37368 Interoperability Developments for Enterprise Applications and Software (roadmaps) IDEAS [IDE06]. This project, funded by the European Commission, defines interoperability as “the ability of a system or product to work with other systems or products without special effort on the part of the customer”.

In the particular case of the Valencian Region, however, research in the domain of interoperability is still badly structured, fragmented, overlapping and, in many cases, practically non-existent. In addition, there is no global vision of consistency or coordination among the different research centres, university laboratories or other bodies. This situation is not only applicable to research, but also to the areas of training and education.

On the other hand, it is important to note that the idiosyncrasy of Valencian industry, which is largely made up of firms belonging to a variety of extremely important industrial sectors, makes it impossible to draw on other studies and research works that have been conducted in other European regions. A specific process of analysis and development must therefore be carried out for this particular case.

The INTERVAL project was thus designed to address the problems of enterprise interoperability as a means of enhancing the future competitiveness of Valencian firms throughout the world, including SMEs. The project involves carrying out initiatives targeted towards integrating research activities and their applications within the complicated Valencian business sector. By so doing Valencian firms will be able to benefit from systems that have been adapted to fit their particular morphology, culture, customers, etc., and which facilitate and speed up cooperation and the exchange of information and knowledge.

Five organisations participate in the project: the *Universidad Politécnica de Valencia* (UPV), the *Universitat Jaume I de Castellón* (UJI), the *Instituto Tecnológico del Mueble, Madera, Embalajes y Afines* (AIDIMA - furniture trade association), the *Instituto Tecnológico de Alimentación* (AINIA - agro-food trade association) and the *Instituto Tecnológico de Informática* (ITI - ICT trade

association). It is important to note that these organisations had already taken part in several of the three most important European initiatives for promoting and researching on enterprise application interoperability, such as the ATHENA-IP project [ATH06], which is part of the European Union's 5<sup>th</sup> Framework Programme, and the INTEROP-NoE (Interoperability Research for Networked Enterprise Applications and Software, funded by the 6<sup>th</sup> Framework Programme of the EU FP6 508011) [INT06]. They therefore had some prior knowledge of the European scene as regards enterprise application interoperability and its possible application to Valencian firms. These organisations today belong to the virtual laboratory for research into enterprise interoperability, INTEROP-VLab, which has its origins in the INTEROP network of excellence and is made up of over 70 European and Asian organisations (enterprises, universities, research centres). Furthermore, in order to carry out some of the activities included within the INTERVAL project it was necessary to seek the collaboration of over 50 firms, which first worked together on collecting data and later to validate the results of the project.

Lastly, it is important to note that one of the objectives of the project is for it to act as a unifying element for the whole of the Valencian business community within the area of enterprise interoperability. An extensive programme of dissemination including seminars, meetings, conferences, and so forth will be implemented to this end.

## Goals of the project

One result of the Thematic network IST IDEAS was that it was decided that any work aimed at interoperability research should stress the need to integrate three key thematic components: ontologies, to identify the interoperability semantics in the enterprise; enterprise modelling to define interoperability requirements and to aid the implementation of solutions [DUC04]; and a set of enabling architectures and technologies to provide implementation solutions.

Thus, the INTERVAL project aims to extract value from the sustainable integration of these thematic components and to develop industrially significant new knowledge. The project's role is to create the conditions of a technological breakthrough to prevent the firm's investment from being simply dragged along by the incremental evolution of the offers in Information Technologies. All these requirements can be transformed into the **5 main goals** of the project:

**Goal 1. Relevance:** to set up a stable enduring Valencian research community that focuses on the interoperability of enterprise software applications.

**Goal 2. Impact:** to create the conditions for an innovative and competitive technology transfer by providing an enterprise-based conceptualisation of interoperability.

**Goal 3. Integration:** to fit together the 3 key components of knowledge (Ontologies, Enterprise modelling and Architectures and technologies), as well as to prepare a stable and enduring virtual centre based on enterprise interoperability that reaches the highest possible number of research and industrial stakeholders.

**Goal 4. Organisation and Management:** to structure the activities and be flexible enough to adjust the strategy and the work schedule throughout the year the project is to last and to lay the foundations for it to be continued beyond that time.

**Goal 5. Excellence of the participants:** to ensure that the integration process is achieved quickly, by basing the project on a consortium of key researchers and exploiting the experience gained during the Thematic Networks of the 5<sup>th</sup> and 6<sup>th</sup> Framework Programmes.

## Work schedule

The project is organised in seven work packages. The tables below shows the aims of each work package, the tasks that each work package can be broken down into, the results obtained until now and the methodology employed, the technological and/or economic advantages obtained, possible applications and the tasks are being undertaken now.

<b>Task 1: Integration of the knowledge map into enterprise interoperability</b>
<p><b>Aims</b></p> <p>To describe the state of the art and current structure of research in the domain of interoperability within the Valencian Region.</p> <p>To define a preliminary unifying framework and organise these research elements in order to provide a map of research on interoperability.</p> <p>To produce a knowledge map to show: (i) complementarities in the research conducted within the V-Lab Network; (ii) shortages that exist among members; and (iii) the research domains that must be reinforced in the INTERVAL Network.</p>
<p><b>Results obtained</b></p> <p>Report on the current state of research on interoperability within the Valencian Region.</p> <p>Production of a Knowledge Map for each of the partners and the overall INTERVAL Network so as to gather all the information and knowledge together in one single organisational structure.</p> <p>Analysis of the different knowledge maps in order to determine the current situation (AS-IS) and to define the desired future situation (TO-BE).</p> <p>A methodology and action development plan to perform the transition from the AS-IS state to the TO-BE state.</p> <p>Creation of the Extended Knowledge Map in Enterprise Interoperability of the Valencian Region (MCEIECV), including new bodies and organisations.</p>
<p><b>Methodology employed</b></p> <p>The method employed to carry out the task was based on the use of the INTEROP integrated taxonomy and the INTEROP-VLab<sup>1</sup> Knowledge Map, as well as on bibliographical searches (publications and projects) that were carried out to</p>

<sup>1</sup> <http://www.interop-vlab.eu/>

determine the state of the domain. Furthermore, the state of enterprise interoperability in the traditional sectors of the Valencian Region was also researched.

**Technological and/or economic advantages obtained**

Connection of the research network to other Valencian organisations in order to foster research and acquisition of interoperable solutions.

Improvement of the vision and structure of Valencian research activities in the area of enterprise interoperability.

Structuring of knowledge within the Valencian Region into the three key components of enterprise interoperability: Enterprise modelling, Ontologies and Architectures.

Presentation of the current state of research on enterprise interoperability within the Valencian Region.

Integration of Valencian organisations that are outside the Network into the research.

Development of the recommendation plan targeted towards future activities in the field of interoperability.

**Possible applications**

Applications are based on: (i) A wider vision and improved present knowledge about the state of research in enterprise interoperability in Valencia, which is a big advantage because it can be used as an important source of resources for developing new projects or implementing interoperable solutions in different organisations; and (ii) gathering relevant information so as to be able to identify organisations that work in the same research domain and to add their knowledge to the knowledge map, thus making it explicit to any interested party.

**Current tasks**

Current lines of research include: (i) a detailed analysis of overlaps, complementarities, collaborative results and cooperation on projects, by defining an extended taxonomy; (ii) a study of the evolution of the Extended Knowledge Map by updating the different knowledge domains of the existing organisations; and (iii) including new organisations within the Valencian Region that are in some way related with enterprise interoperability.

**Task 2: Framework for enterprise interoperability**

**Aims**

To establish a thorough state of the art of the empirical techniques and methods for (1) deriving specifications of information system and developing complete software tools from business process models and enterprise models.

To help define a systematic method for deriving the specification of an information system from business process and enterprise models [OMG03].

**Results obtained and methodology employed**

1. A report that includes the main standards, reference architectures, general frameworks, languages and R&D projects related with the enterprise model.

2. Review and critical analysis of the different methods that have been proposed in the literature for generating models of information systems from enterprise models. The analysis detects the main shortcomings and proposes suitable procedures to put them to rights.

3. Original method for deriving the specification of an interoperable information system based on enterprise models. The method, called MDI, proposes a hierarchy of models based on the MDA approach and employs the UML modelling language and model fragmentation to achieve an automatic transformation among them, until the application code is obtained.

**Methodology employed**

On the one hand, we analysed the information obtained from different publications such as international journals indexed in the ISI, papers presented at high-impact international congresses, and so on. On the other hand, and at the same time, we also participated in different national and international R&D projects related with enterprise modelling and interoperability. Furthermore, throughout the project different meetings were held to discuss the progress of the model-directed interoperability (MDI) model, to illustrate it with examples of real applications and to summarise and set out the results in the form required by the MDI method.

**Technological and/or economic advantages obtained**

Increased productivity and diminished software development times and costs, since the software can be generated more quickly and with fewer human resources.

Solutions to the problem of model interoperability on both the horizontal (models created in different departments or firms) and vertical levels (computation-independent models, platform-independent computer models, platform-specific computer models).

Eliminate software validation errors, since working with enterprise models makes it easier to define the requirements that the application must satisfy in a comprehensive, unambiguous manner.

Development of applications that are complete, secure and easy to implement for organisations that wish to interoperate.

**Possible applications**

On the one hand, the study and critical analysis of the state of the art in enterprise modelling and the transformation of models will allow (1) the research community to propose new lines of work in order to correct the main shortcomings that are detected, and (2) developers to utilise the collected knowledge as a training tool.

On the other hand, the method that is proposed for deriving the specification of an interoperable information system from enterprise models is essentially of use to software development firms, which will find it useful as a procedure that will enable them to improve productivity and lower times and costs.

**Current tasks**

Current lines of work involve the full application of the method to different enterprises in order to validate and improve results and to generate case studies.

**Task 3: Integration based on the ontology, enterprise model, and architectures and platforms****Aims**

To map the common practices within the domain of interoperability and its three key components in enterprises in the Valencian Region.

To detect the shortcomings of current approaches.

To establish a set of solutions to resolve the problems that are detected and to promote the implementation of an interoperability based on the three components.

**Results obtained**

1. A study on the map of current practices in the three dimensions of interoperability (ontologies, enterprise modelling and architectures) within the firms and public organisations in the Valencian Region, and description of existing weaknesses and strengths.

2. Definition of a set of solutions which make it possible to cover the deficiencies detected in the map of common practices; these solutions are based on a global approach that is grounded in the three components.

**Methodology employed**

The implementation of Interoperability and its three key components in the Valencian Region was mapped by referring to existing publications, consulting other partners in the project and conducting a survey in associated firms. This made it

possible to define existing strengths and weaknesses.
<p><b>Technological and/or economic advantages obtained</b></p> <p>Creation of a map of common practices within the domain of interoperability in the enterprises in the Valencian Region, which served as a reference point to follow up their future evolution.</p> <p>Determination of the strengths and weaknesses of the current situation in the domain of enterprise interoperability, its consequences and the definition of a set of solutions aimed at promoting enterprise interoperability with a greater added value that allows more effective and efficient productive systems to be attained.</p>
<p><b>Possible applications</b></p> <p>The current map of enterprise interoperability in Valencian enterprises will enable firms in the ICT sector to match their services to the needs of this field, while at the same time enabling the public administrations to better adapt the initiatives they develop to foster it.</p> <p>The proposed solutions will make it possible to draw up an action plan to resolve the weaknesses detected in Valencian enterprises, and putting them into practice will allow new lines of business to be created in training, consulting and support for interoperability solutions.</p>
<p><b>Current tasks</b></p> <p>Current lines of work focus on: a) putting the set of proposed initiatives into practice, and b) monitoring the evolution of enterprise interoperability in Valencian firms.</p>

<p><b>Task 4: Use cases</b></p>
<p><b>Aims</b></p> <p>To investigate and understand the advantages and disadvantages of the different interoperability architectures that currently exist.</p> <p>To coordinate future research for the creation of new architectures.</p> <p>Exchange use cases, requirements and pilot studies.</p>
<p><b>Results obtained and methodology employed</b></p> <p>1. Study of Interoperability Architectures: From the study of interoperability architectures it can be deduced that if firms are to be interoperable, their systems need to be ready to exchange and integrate information, regardless of the format the documents may be in.</p> <p>2. Compilation of practical use cases: Practical cases which adopt alternative ways to use the architectures mentioned above are proposed. With this proposal, all the information and knowledge from the different members is summarised and arranged in one single organisational structure, in order to attain a more optimal vision.</p>
<p><b>Methodology employed</b></p> <p>On the one hand, a study of the different interoperability architectures was carried out and, on the other, the problems affecting interoperability in the different sectors involved were also identified. Finally, use cases were developed for each sector, except the food sector.</p>
<p><b>Technological and/or economic advantages obtained</b></p> <p>Increased productivity and lower times and costs in detecting and solving interoperability issues.</p> <p>Resolution of the problems of model interoperability at both the intra-firm and inter-firm levels.</p>
<p><b>Possible applications</b></p> <p>The aim is to help future Valencian researchers in their search for information when it comes to proposing architectural solutions for solving interoperability problems. Moreover, use cases become highly applicable because they focus on ensuring that their future use as a reference within the domain of interoperability is as clear and concise as possible.</p>

<p><b>Current tasks</b></p> <p>Current lines of work consist in developing the use case for the food sector under AINIA guidance and in expanding the range of current use cases by including ontologies.</p>
<p><b>Task 5: Dissemination and communication</b></p>
<p><b>Aims</b></p> <p>To structure the Valencian virtual laboratory to allow communication and dissemination of results to the External Network.</p> <p>To increase awareness about the technology for achieving organisational interoperability with special emphasis on Enterprise Modelling, Ontologies and Architectures and platforms.</p> <p>To define a common Network strategy for disseminating and evaluating joint research findings.</p> <p>To identify and assess the application interoperability requirements with users and standardisation bodies.</p>
<p><b>Results obtained</b></p> <ol style="list-style-type: none"> <li>1. Web portal for communicating results and publications produced within the framework of the project. This communication structure is complemented with bulletins from the centres that are taking part in the project.</li> <li>2. Dissemination of the potential advantages and strengths to be gained by using interoperability based on the three dimensions through conferences, papers and the publication structure.</li> <li>3. Definition of a strategic framework to perform the dissemination and communication of the work carried out in the field of interoperability by all participants so as to maximise the number of recipients and the strength of the message.</li> </ol>
<p><b>Methodology employed</b></p> <p>A web portal was created for the project and to help make the project more widely known, it was complemented with bulletins produced by the participating Institutes. Additionally, articles have been published in journals, workshops have been held and papers have been presented at congresses on the area of interoperability.</p>
<p><b>Technological and/or economic advantages obtained</b></p> <p>Dissemination of the results obtained in order to increase awareness of the importance of enterprise interoperability in the day-to-day undertakings of Valencian organisations. This awareness must be used in the training of students within this field, as well as in the process of developing enterprise applications. Important transmission of the project at both regional and European levels.</p>
<p><b>Possible applications</b></p> <p>Setting up the dissemination network, consisting of the web portal (<a href="http://interval.interop-vlab.es">http://interval.interop-vlab.es</a>) and the bulletins from the Institutes that are participating in the project, will make it possible to continue with the dissemination initiatives that are already under way.</p> <p>The publications to date have served to create a body of knowledge on enterprise interoperability on a general level and, more specifically, in the Valencian Region.</p>
<p><b>Current tasks</b></p> <p>Current work consists in maintenance of the web portal and continuing to publish material in journals and congresses on the subject of Interoperability. At the same time, congresses and workshops centred on both business and scientific issues will also be held.</p>
<p><b>Task 6: Methodology to implement services and develop assimilation initiatives</b></p>
<p><b>Aims</b></p> <ul style="list-style-type: none"> <li>◆ To develop a methodology to implement interoperability services and to</li> </ul>



<p>carry out initiatives aimed at helping SMEs assimilate them.</p> <ul style="list-style-type: none"> <li>◆ To test the methodology in different use cases.</li> <li>◆ To assess the results of the implementation.</li> </ul>
<p><b>Results obtained</b></p> <ol style="list-style-type: none"> <li>1. A methodology that defines the steps to be taken in developing services. This considers aspects such as investment capacity, the needs of the enterprise and of the organisations it interacts with, the firm's culture of technology, the users' predisposition towards the new technologies, and so forth. The methodology includes assimilation initiatives that will help the target organisations incorporate the services that are developed for them.</li> <li>2. Description of the players, requirements, level of implementation of the ICTs and level of maturity in interoperability of the use cases that are analysed.</li> </ol>
<p><b>Methodology employed</b></p> <p>To develop the methodology, first previously developed methodologies were analysed in order to determine the aspects that had not been considered in this field. The procedures carried out by the participants in developing services were then studied, and the aspects that were common to all participants and those that were not were both analysed to determine whether they should be included in the methodology or not.</p>
<p><b>Technological and/or economic advantages obtained</b></p> <ul style="list-style-type: none"> <li>- Definition of the methodology for implementing services and the development of assimilation initiatives, which will be used as a tool to promote the integration of interoperable systems in SMEs in the Valencian Region.</li> <li>- Applying the methodology in practical cases allows firms to appreciate the real benefits to be gained from incorporating this type of systems and services into their processes.</li> </ul>
<p><b>Possible applications</b></p> <p>This methodology can be applied by developers to ensure services are carried out properly, but it can also be applied by firms in order to gain a complete overview of the process and to monitor its evolution.</p>
<p><b>Current tasks</b></p> <p>Current work consists in applying the methodology in new practical cases in order to assess its effectiveness more thoroughly, and to optimise or extend it depending on the results from these tests.</p>

<p><b>Task 7: Management of the INTERVAL node</b></p> <p><b>Aims</b></p> <p>To match the aims of the Network to the Global INTEROP-VLab network.          To define and fine tune the rules of the Network.          To solve problems.          Accreditation of new participants.          External relations.          Collective definition and planning of the tasks to be carried out in the project.          Monitoring the performance of the tasks.          To guarantee the quality of the documents produced within the framework of the project, as well as ensuring that they are generated on time.</p> <p><b>Results obtained</b></p>
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<p>Definition of the alignment matrix of the general objectives of the INTEROP-VLab and the INTERVAL Network, and description of the specific aims of the Network.  A description of the <i>main results of the INTERVAL Network project</i>, which makes it possible to quickly identify the goals that are being pursued and achieved with this project.  Definition of a contingency plan of potential risks.  Identification of calls for research projects related with the domain of enterprise interoperability.  Operative management of the initial tasks of the INTERVAL project.  Monitoring the tasks carried out as part of the INTERVAL project.  Management of the activities for finishing and closing the project.</p>
<p><b>Methodology employed</b>  Monitoring and ensuring the project was executed properly was achieved through a collaborative website. Follow-up and control templates were defined and had to be filled in by the different participants, and meetings were held periodically to address a variety of aspects concerning the project.</p>
<p><b>Technological and/or economic advantages obtained</b>  The advantages obtained are focused on ensuring efficient and effective project management.</p>
<p><b>Possible applications</b>  Possible applications are related to the project management, with special attention to the following points:  Monitoring and updating objectives in order to follow up the evolution and trends within the field of enterprise interoperability.  Definition of the resources needed and the initiatives that are required to achieve the aims.  Effective management so as to be able to respond swiftly and efficiently to any problem that may arise.  Monitoring and identification of calls for R&amp;D projects in order to develop proposals.  Task control in order to carry out an exhaustive follow-up of the overall performance of the project, special attention being paid to the more awkward aspects.  Ensuring the Network works.  Disseminating the results so that they can further the scientific and business communities' knowledge within the domain of interoperability.</p>
<p><b>Current tasks</b>  Current lines of work as far as the management of the INTERVAL node is concerned are based on the current structure used to execute this project. Constant, fluent communication is essential for efficient and effective management. The network uses resources related with the ICTs for its communication, as well as face-to-face meetings in which there is an agenda and the different points are discussed by those present at the meeting. Hence, the tendency is to continue with this culture of collaborative work, and to introduce improvements whenever necessary.</p>

Figure 1 shows the interdependencies among the activities of the project.

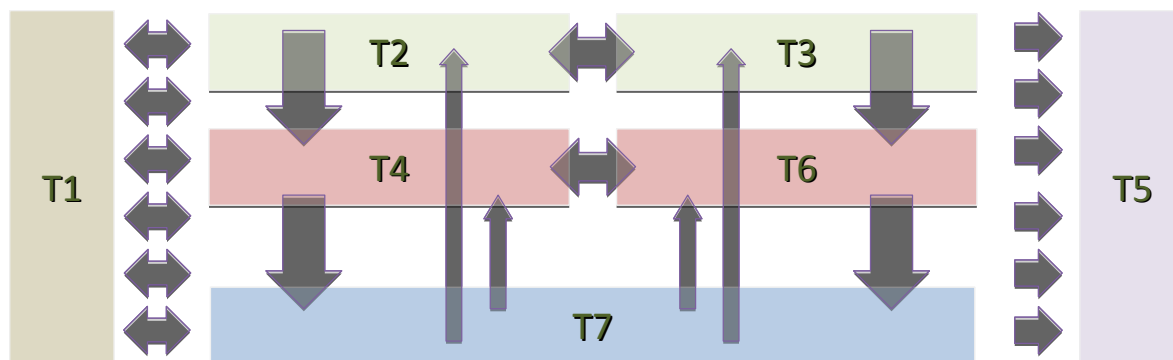


Figure 1. Interdependencies among the different tasks in the INTERVAL project

## CONCLUSIONS

Unlike many other regions, the potential of the Valencian Region lies in the diversity and complementarity of its industrial sectors, with their different cultures, methods of working and technologies. Within this context, interoperability is definitely a strategic instrument with which to facilitate collaboration and cooperation among Valencian firms and to make them more competitive.

Nevertheless, the benefits and advantages that Valencian firms could obtain by introducing enterprise application interoperability are not widely known. Within this framework then, the INTERVAL project will act as a meeting ground for the whole Valencian business community in the area of enterprise application interoperability, thus making it possible to:

- ◆ Set up a stable and enduring Valencian research community focused on enterprise application interoperability, using this project as an instrument of research cooperation and dissemination.
- ◆ Promote the virtual laboratory for research on enterprise application interoperability in the Valencian Region, thereby fostering the maximum dissemination of the project towards all Valencian research institutes and organisations.
- ◆ Integrate the three key components of knowledge in interoperability (Ontologies, Enterprise modelling and Architectures) and to control a stable and enduring virtual centre based on enterprise interoperability that reaches the highest possible number of research and industrial stakeholders.
- ◆ Create a shared interoperability-based culture in research and educational centres and in industry by training in and dissemination of everything that has to do with interoperability. In the long term, this culture will have an important influence on the way enterprise applications are developed, since it will

promote the production of applications that are ready for interoperability and which can be easily integrated and adapted to a particular context in the enterprise.

Finally, as there are no similar initiatives in Spain, the project is open to the participation of other Spanish interested organizations. However, there are similar initiatives in other European regions carry out by entities that belongs to the V-Lab network.

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