INTEROPERABLITY REQUIREMENTS ELICITATION, VALIDATION AND SOLUTIONS MODELLING

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Abstract: This paper describes a methodology and a model-based approach for supporting the requirements elicitation and validation work in the ATHENA project. Numerous interoperability requirements have been gathered by four industrial partners and these requirements are validated against interoperability issues. The process of obtaining requirements from industrial users and developing solutions for them involves several communities such as the users, stakeholders and developers. A model-based methodology and approach are proposed to support the analysis of the requirements and for incorporating the different perspectives and views that are desired by everyone. An example from the telecommunications sector is used to illustrate the methodology and a matrix-based validation approach is supported using a model developed in the Metis modelling environment.

1 INTRODUCTION

Advances in technology have facilitated the use of technology in all aspects of life, from business to health care, from education to manufacturing as well as in our everyday lives. The role of ICT and communication are becoming increasing significant in our lives. Computers and systems no longer operate as single, isolated bits of technology used by a single operator. Rather, the trend has been for one system to communicate with another or depend on input from another and for people and businesses to share information and collaborate.

We live in a diverse world and this diversity is no doubt reflected in the technology that we use. We often find ourselves trying to transfer data across heterogeneous systems, attempting to get two incompatible devices to communicate or wondering how our business partners' concepts and terminology map to ours. Standardisation efforts have helped address some of these issues. However, there is still a long way to go before we are able to collaborate with our partners without facing interoperability problems.

Interoperability, in particular, technical interoperability is not a new issue. However, focus on areas such as e-business, e-government, e-health and e-learning has created a greater interest in interoperability. This is evident from the updated eEurope 2005 Action Plan where there is an emphasis on increasing interoperability in all these areas, (COM, 2004). Interoperability has been recognised as fundamental to achieving Australia's e-government aims, (Australian Government, 2003) and the National Institute of Standards and Technology in the US has estimated the cost of inadequate interoperability in some industries to be as much as $15 billion per year, (Gallaher et al., 2004). Thus, there is a global awareness on the significance of interoperability and a need to increase interoperability for improved business collaboration. One approach to address interoperability and produce solutions for interoperability problems is by identifying and

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analysing interoperability requirements that are posed by industry.

Two projects that are focussed on interoperability are EU Integrated Project 507849 ATHENA (Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Application), (ATHENA, 2004), and IST-508011 INTEROP Network of Excellence, (INTEROP, 2004). Both these projects conduct research on interoperability for networked enterprises. The INTEROP project focuses on theoretical research while the ATHENA project considers interoperability in industry by analysing the interoperability requirements from four different industry sectors and by developing solutions for interoperability.

The process of obtaining requirements from industrial users and developing solutions for them involves several communities such as the users, stakeholders and developers. The analysis of the requirements also involves several communities and numerous discussions. It is often difficult to keep track of the stages in this process and to take care of the knowledge that is created in this process that adds to the value of the solutions. One of the problems that have been identified during this process is fostering understanding among the different communities that are involved, (Christel and Kang, 1992). The facilitation of this process in itself poses interoperability problems! The requirements elicitation and validation processes are often seen in isolation by the solution developers and the views of the industrial user or the stakeholder are often overlooked. There is a need to consider the lifecycle of the requirement as a whole and take into account the views of the various communities that are involved in the different stages in the lifecycle.

This paper is based on research conducted in both the ATHENA and INTEROP projects. We propose the RAIS methodology and a model-based approach for eliciting and validating the interoperability requirements. The RAIS methodology takes into account the user and the stakeholders' views as well as the solution developer's view. The Active Knowledge Modelling (AKM) approach facilitates modelling and inter-relating the different views and visualising them from different perspectives, (Lillehagen, 2003). We focus on the requirements eliciting and validation work conducted in the ATHENA project using the modelling approach and how this approach can support modelling interoperability solutions that will be developed in the project.

The approach described in this paper provides a flexible way of analysing a large number of requirements (interoperability as well as other types of requirements) using model-based visualisation techniques. This is not a new method for requirements elicitation or validation. Rather, it is a complementary approach where existing requirements elicitation or validation methods can be used. This approach can then be used to provide visual support for the methods.

The rest of this paper is structured as follows: Section 2 describes the ATHENA project and interoperability requirements; Section 3 describes the RAIS methodology and the model for analysing and validating the interoperability requirements; Section 4 illustrates the methodology and the model with the help of an example and Section 5 discusses the advantages of this approach and our directions for continuing this work in the future.

2 ATHENA INTEROPERABILITY REQUIREMENTS

The ATHENA project defines interoperability as seamless business interaction across organisational boundaries. It distinguishes between technical interoperability and business interoperability. Research into technical interoperability is conducted by Action Line A projects while the Action Line B projects conduct research on business interoperability by analysing scenarios from four industry sectors; aerospace, automotive, furniture and telecommunications, see Figure 1. ATHENA emphasises on the mutual dependence of the technical and business aspects of interoperability in producing good solutions. In addition to providing interoperability solutions, one of the activities of Action line A projects has been to identify interoperability issues or problems concerned with interoperability which are used to validate against the requirements provided by the industrial partners in the Action Line B projects.

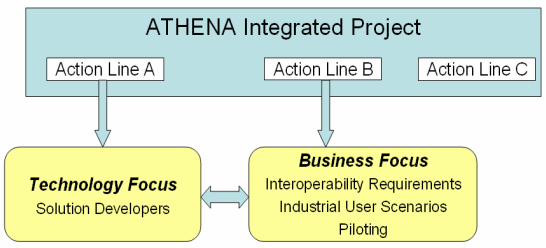

Figure 1: ATHENA Overview.

The ATHENA B4 project deals with interoperability requirements and one of the main tasks is to provide a way to easily validate the interoperability requirements by analysing them against the interoperability issues and the solutions.

2.1 Requirements Elicitation and Validation

Interoperability requirements from four industry sectors have provided a rich and diverse set of requirements. These requirements were derived by analysing different business scenarios, e.g. supply-chain management from the automotive industry and project portfolio management (PPM) from telecommunications. One of the main tasks that are currently being undertaken is the identification of requirements that are common to all these industries, similarities and differences in the requirements from the different sectors and using this information in the design of solutions.

A mapping approach has been defined for the validation of the requirements and solution against the interoperability issues to ensure that all the issues that have been identified have been addressed. This mapping approach also considers weighting to rank the impact of a particular issue on a requirement and the relevance of a solution to an issue.

Some important criteria in requirements validation that have been taken into account are:

1. Ensure that all requirements and interoperability issues are considered.
2. Ensure that all requirements and interoperability issues have proposed solutions.
3. Facilitate the analysis of the above two points, e.g. by supporting matrices to do this.
4. Ensure that requirements can be represented, viewed and analysed in different points of views and interests. e.g. the stakeholders' view or the users' view.

The large number of requirements that have been provided by the industrial users (~450) and managing and analysing them have been a challenge. The requirements are formulated in natural language and sorting or searching through them or identifying relationships among the requirements demands sophisticated techniques and technological support. The model-based approach supports the management of the large number of requirements and their relationships to the other aspects such as interoperability issues and solutions.

3 RAIS METHODOLOGY AND REQUIREMENTS MODEL

The RAIS methodology is described in Figure 2, where the different concepts that relate to the requirements and interoperability issues and how they relate (or influence) are illustrated, (ATHENA WDB4.6.2, 2005) and (INTEROP DTG6.1, 2005).

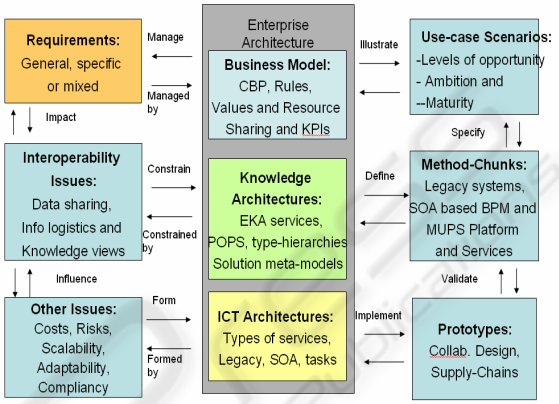

Figure 2: RAIS Methodology.

RAIS – Requirements, Architecture, Interoperability issues and Solutions, which are the main concepts of RAIS, bring together all the aspects of requirements engineering and analysis for the design and development of appropriate solutions. The main components are:

- **Requirements**: These are interoperability requirements obtained from the industrial users.
- **Architecture**: This is about the structure of entities, either systems or enterprises, their components, and how the components fit and work together to fulfill some purpose.
- **Interoperability Issue**: These are problems concerning interoperability extracted and elicited from analysis of business scenarios.
- **Solution**: These are the solutions that are designed by the ATHENA project as well as appropriate solutions that are available today.

These four components help us to address the what-how dimensions of a system; e.g. *what* is desired and *how* the desire is achieved (Soderborg et al., 2003). In addition to these, it is possible to incorporate other aspects such as *who* desire the functionality, i.e. the stakeholders' view, or *where* in the business process is this relevant, i.e. the business and enterprise architecture view. By bringing these components together in a cohesive methodology, we

are able to see the dependencies among these concepts and how they influence and impact one another. This can be done by modelling the dependencies among these different concepts. We have used AKM technology and the Metis modelling environment, (Metis, 2005).

3.1 Modelling Concepts

In Metis, the notion of a metamodel is used to define the elements of a model. The main components of the RAIS methodology, requirement, architecture, interoperability issue and solution are represented as an entity-relationship model, see Figure 3, where the different components are represented as objects and can be related to one another. The relationships between the different objects are obtained by adapting the RAIS methodology to the mapping approach described in the project (ATHENA WDB4.6.1, 2005).

The main concepts and relationships are:

- An Interoperability issue *impacts* a Requirement.
- A Solution *fulfils* a Requirement.
- A Solution *solves* an Interoperability issue.
- A Solution *is relevant to* an Interoperability issue.
- An Architecture *structures* Requirements.
- An Architecture *impacts* an Interoperability issue.
- An Architecture *defines* a Solution.
- An Architecture *implements* a Solution.

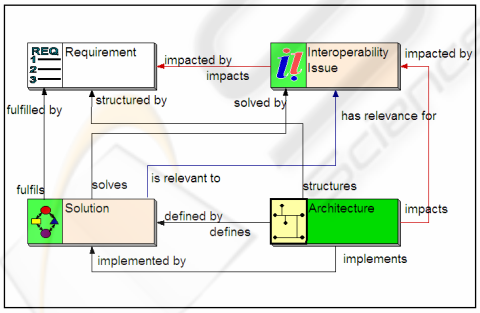

Figure 3: RAIS Metamodel.

3.2 Requirements Model

A Metis model of all the interoperability requirements is available from the ATHENA Dynamic Requirements Definition System (DRDS), (Solheim et al., 2005). The DRDS has a web-based front end for the user to provide the requirements and a database that could be used to generate a model in the Metis modelling environment for requirements elicitation, validation and visualisation.

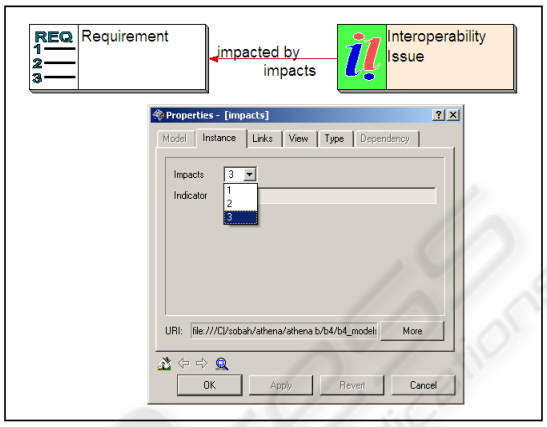

Figure 4: Weighting on Relationships.

In Metis, a requirement is represented as an instance of the object type requirement. We have enriched this model by modelling the interoperability issues and solutions and creating relationships between them to indicate correlations.

Weighting of correlations are implemented by defining a property on the relationship that indicates the impact of a correlation. For example, the impact of an interoperability issue may be low (=1 or yellow), medium (=2 or orange) or high (=3 or red), see Figure 4.

The mapping approach defined for validation of requirements uses matrices to analyse correlations of requirements and issues and solutions and issues. The model supports automatic generation of these matrices where a relationship between two objects or sets of objects (which represent the two axes of the matrix) is marked on the corresponding cell on the matrix. We have used numerical values as well as colour coding to support the visualisation of this.

4 EXAMPLE

In this paper, we focus on the interoperability issues identified by the telecoms sector by Intracom S.A., Greece and the interoperability requirements provided by them. Some of these interoperability issues are:

T4. Provision of (near) real-time aggregated views of key business information.

T7a. Legacy applications integration and interoperability

T7b. Model driven generation of interoperable custom and role-based workplaces

T8a. Communication / collaboration infrastructure integration / interoperability

T8b. Exchanged and/or shared data integration / interoperability

T8c. **D**istributed data and data access synchronization

While these issues have been identified by the telecoms sector, they are not confined to this particular industry sector alone. Some of these issues, such as "T7b, model driven generation of interoperable custom and role-based workplaces", are likely to be issues that are relevant to other industry sectors as well.

The requirements and the interoperability issues from this sector have been modelled and the correlations between them have been established. A screen shot of this model is shown in Figure 5.

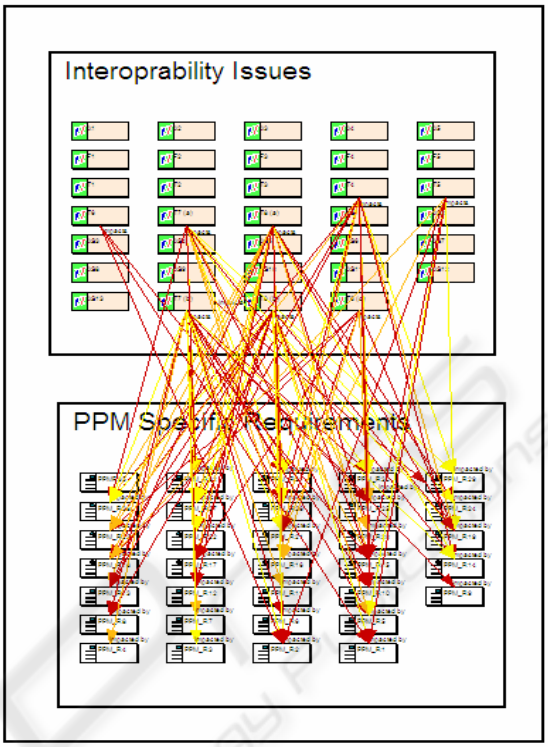

Figure 5: Requirements and Interoperability Issues.

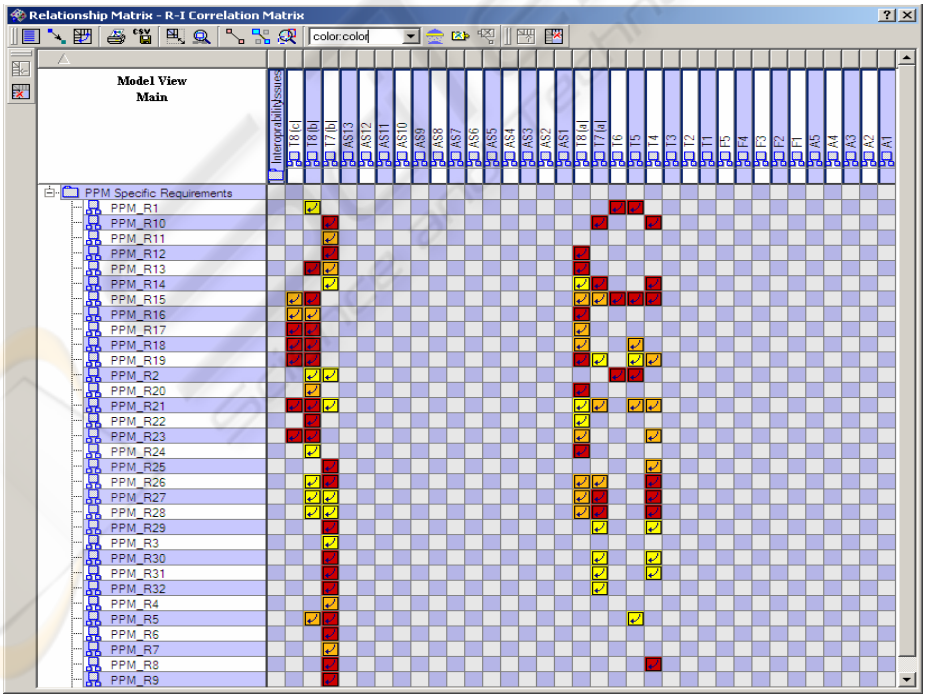

Figure 6: Requirements and Interoperability Issues: Correlation Matrix.

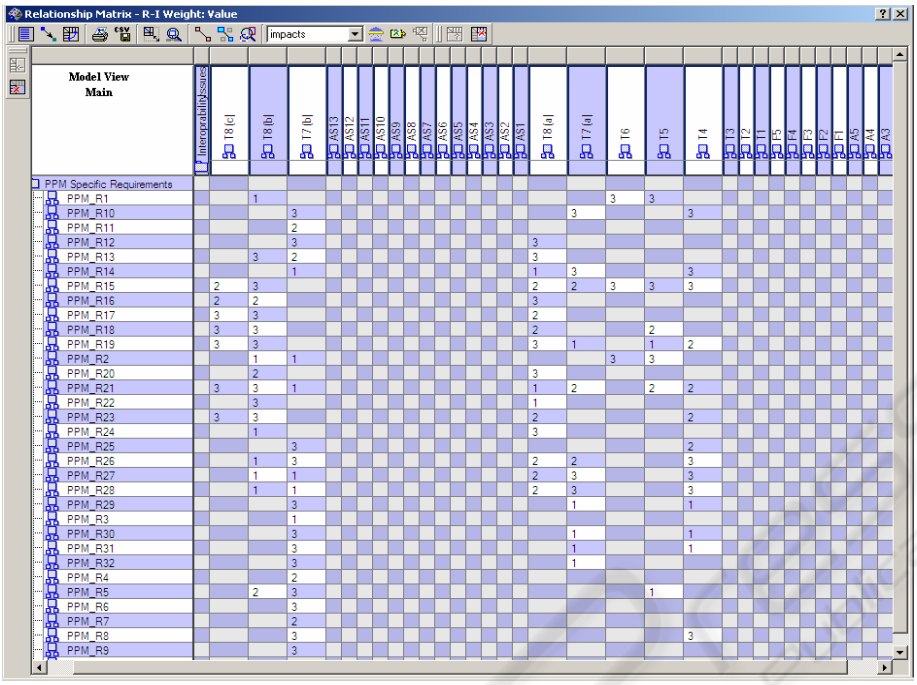

Figure 7: Impact of Interoperability Issues on Requirements.

4.1 Validation Matrices

A matrix of the requirements against interoperability issues is shown in Figure 6 and Figure 7. (Note that although identifiers of requirements and interoperability issues have been displayed on the matrices in the figures, it is also possible to display their names and descriptions.) The matrix shown in Figure 6 shows the correlations between the requirements and interoperability issues and the colour code used to indicate the level of the impact is shown in the cell corresponding to each correlation. This is for quick, visual assessment of the impact of issues on requirements. The level of impact can also be shown as a quantitative value (Figure 7) or as a qualitative value (low, medium, high).

By observing the matrix, it is possible to have an overview of the requirements–issues landscape. A correlation indicates that there is an impact. The values or the colours on the matrix indicate the level of the impact. And most importantly, it will indicate if there are no requirements that address a specific issue or the other way around:

- An interoperability issue that does not have a relationship to a requirement or does not impact any requirement indicates that new requirements must be considered so that this issue is addressed and will be considered in the development of solutions.
- A requirement that is not impacted by an interoperability issue indicates that it must be verified if this requirement is really an interoperability requirement.

Matrices can also be generated for the other elements in the model. For example, a matrix can be generated to validate the solutions against interoperability issues and to assess the relevance of each solution for an interoperability issue. The solutions can be existing solutions, based on state of the art, or new solutions developed by the ATHENA project. A matrix of existing solutions against interoperability issues will identify problem areas where innovative new solutions can be proposed by ATHENA. Similarly, a matrix containing both existing and new solutions can be used to identify solutions developed by ATHENA where the solution may be an improvement or an alternative to an existing solution.

4.2 Selective Viewing

One of the advantages in using a visual modelling environment is the possibility to do selective viewing of the data. For example, select one interoperability issue and see the requirements or solutions that are related to this issue. For example, the issue “T7b, model driven generation of interoperable custom and role-based workplaces” impacts several requirements. A selective view of

this generated from the model is shown in Figure 8. A matrix of this view can also be generated and this is shown in Figure 9.

This capability is particularly important when there are several communities involved in the work. For example, the industrial users are interested in identifying the issues and ensuring that there are requirements addressing all these issues. Solution developers are interested in ensuring that they provide solutions to relevant issues as well as meet the requirements from the industrial users. The stakeholders are interested in seeing the benefit that is achieved by adopting a particular solution. For example, in a situation where there are two alternative solutions that meet their needs, they will select the one that is most beneficial for them.

4.3 Editing the Model

One of the activities during the elicitation and validation process is changing or updating the information in the model. For example, we might want to have additional correlations, delete a correlation or change the value of the impact. The matrices can be used to change the correlations or edit the relationships as shown in Figure 9. It is easier and more efficient to conduct an analysis on a selective view of the information and then use the menus available on the matrices to make changes. For example, we might want to have a correlation between the requirement PPM17 and interoperability issue T7b. Similarly, we might want to change the value of impact on a particular correlation. These changes can be easily achieved using the matrix, e.g. establish a new correlation between a requirement and an interoperability issue, delete an existing correlation and change the value of the impact of the correlation.

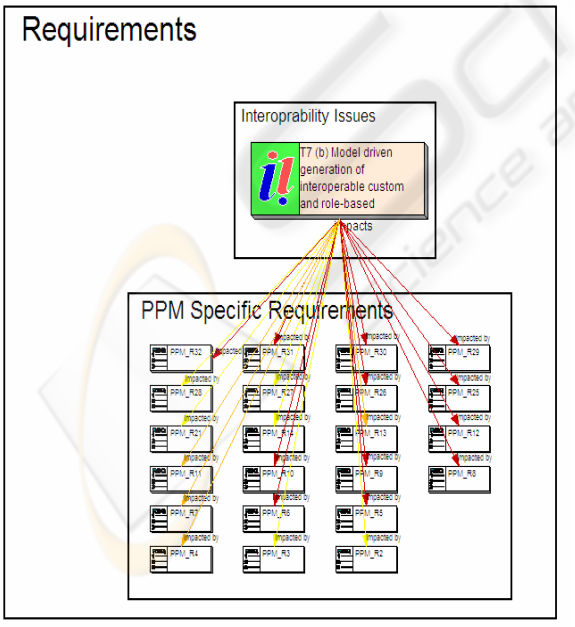

Figure 8: Requirements impacted by one Interoperability Issue.

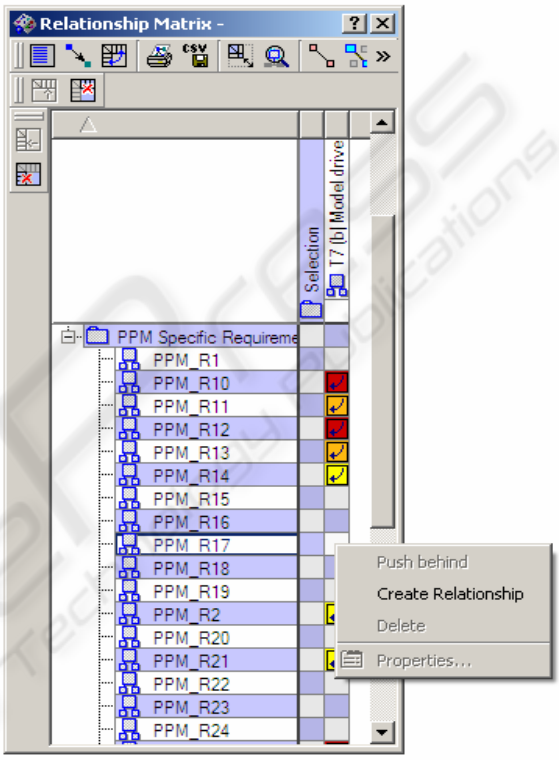

Figure 9: Matrix to show impact of one Interoperability Issue.

5 DISCUSSION AND FUTURE WORK

This paper describes a methodology and a model-based approach for supporting the requirements elicitation and validation work in the ATHENA project. Numerous interoperability requirements have been gathered by four industrial partners and these requirements are validated against interoperability issues. The analysis of these requirements supports the design and development of solutions. The use of matrices has been identified as a means to support the validation of requirements.

The model-based approach facilitates easy viewing of the relevant concepts and provides enhanced visualising capabilities such as automatically generated matrices, selective views and colour coding on relationships to indicate a level or a degree of an impact or relevance. The model supports easy extension of the concepts as well as easy integration of work done in the other parts of the project. It also supports easy and efficient changing or updating of the model contents during the validation work.

We are currently enhancing our model with requirements and interoperability issues for the other industrial users in the project and mapping the solutions that have been developed in the ATHENA project against the interoperability issues. We plan to extend the model by adding new concepts such as the classification structure of the requirements which will further support the elicitation process and the identification of common requirements among the different industries. Another important view that we plan to implement is that of the stakeholder and the business value. This is particularly important in the design and validation of solutions, which is the next phase of our work.

In the future, we see these interoperability requirements, issues and solutions utilised by industry as well as other sources as a means of quickly assessing their interoperability problem(s) and finding or designing solutions in a fast and efficient manner.

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