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A Multidisciplinary Framework for Concept Evolution: A Research Tool for Developing Business Models

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***Abstract* — The paper describes a new framework for multidisciplinary concept evolution (MCE). The impetus for systematizing the research concepts was a practical need to facilitate successful communication between different disciplines. The main benefit of the framework is that it aids the complex and dynamic process of conceptualization by highlighting abstraction, generalization, and ontology engineering as practical methods to implement concept evolution. One application of the framework is in solving complex business-related problems. The MCE framework can be utilized not only by researchers but also by other community stakeholders. Applying the framework to scientific disciplines may bring additional value to research as well as benefits to practical development endeavors.**

***Keywords* — Business models, multidisciplinary research, concept evolution, semantic interoperability.**

I.INTRODUCTION

A.General

The broad success of the Internet has led to the emergence of eBusiness (eB). Although eB has opened new possibilities for enterprises (especially for SMEs), its spreading popularity has partially influenced the tightening of competition in the global market environment. Facing limited resources, companies have tried to achieve economies of scale by establishing closer relationships with other companies in the form of business or enterprise networks. By networking, companies wish to save costs and achieve synergy effects in business-to-business (B2B) operations. This can be achieved, for instance, by using integrated information systems. These systems, which enable the distribution of network resources, are based on process thinking. This process view calls for a new "business thinking", which utilizes cross-organizational chains of business processes. This increases demands for mutual understanding and trust, which are prerequisites for implementing these cross-organizational business operations. Following jointly agreed procedures and contracts is one way of enforcing mutual and multilateral co-operation. However, the difficulties in combining different views and opinions still remain as a considerable obstacle in finding an agreement – even within a single company.

B.Background: Project Description

The demands of the modern business environment described above form the basis of work carried out in a research project focusing on integrating enterprise networks. The project, which embraces the interrelated research areas of business models, systems integration, and information security, seeks to analyse and model information, material and financial flows in the enterprise network, in an effort to combine all the individual results in a general model of integrated enterprise network.

Although they are all part of the common research problem, the focal points of these research areas are slightly divergent, yet complementary. Business models research aims to develop a new business network model which integrates processes in small and medium-sized enterprises (SMEs). The need to integrate the business processes has increased with the digitalization of B2B operations. The goal of systems integration research is to define an electronic business process collaboration prototype model. The developed business process integration model can then be used as a basis for service concepts and for a class of architectures offering a solution to B2B integration. Information security in this context is needed to implement business process integration safely.

C.Research Setting

The development of business-related models is in the scope of design sciences, as stated in March and Smith (1995). Design science attempts to create things that serve human purposes, whereas natural science tries to understand observable reality. Business models clearly serve human purposes. March and Smith (1995) continue with the four types of design science products: constructs, models, methods and implementations. They argue that as in natural science, there is a need for a basic language of concepts (i.e. constructs). These concepts make it possible to characterize

phenomena. March and Smith state that these constructs could be combined into higher level constructions (models) which are used to describe tasks, situations, or artefacts.

In accordance with the design science view, constructive research (CR) was chosen as the main research methodology, largely for practical reasons. CR is generally seen as a case-study method which aims to find solutions (constructions) to predetermined problems. If viewed as an applied research method, the essential feature of CR is the generation of new knowledge of the target area. According to Kasanen, Siitonen and Lukka (1993), finding a practically relevant research problem, obtaining a general and comprehensive understanding of the topic, and innovating and constructing a theoretically grounded solution are crucial steps in the constructive research approach (CRA). Although a relevant research problem can be discovered from a purely theoretical basis, it is more common to find actual research issues from premises of existing real-world business demands (Labro and Tuomela, 2003). In the final stages of the CRA, the developed construction should be evaluated and tested through an examination of its applicability and an illustration of its theoretical connections and research contribution (Kasanen et al., 1993).

Following the CRA stages from the standpoint of design science and surveying the existing theories and concepts, it became evident that there are severe distinctions in the conceptualizations between each research area. It was seen a necessity among researchers to find a ground-level consensus of at least the essential concepts like: business process, business modelling, electronic commerce, B2B integration, trust etc. Additionally, the complexities in selecting the concepts in the scope of the research and the challenges in communicating the definitions thereof between the different parts of the research, acted as a driving force for developing a formal framework for multidisciplinary conceptualization.

D.Structure of the Paper

The next section explains how the challenges introduced by complex cross-disciplinary concept semantics led to the idea to develop a generic framework for multidisciplinary concept evolution (MCE). After this, the practical methods of concept evolution and the notion of emergence of meaning are briefly illustrated. Building on these findings, a proposal for how the framework can be utilized in solving complex business-related problems is then described, followed by a concluding discussion about the usefulness of the developed model.

II.CHALLENGES OF MULTIDISCIPLINARY CONCEPTUALIZATION

The above issue of concept diversity experienced in the project can be illustrated, for example, by using terminology adapted from the well-known methodology of formal concept analysis (Wille, 1982), which uses a mathematical notion of lattices to represent the relation between concepts (or objects) and their properties (or attributes). The philosophical background of formal concept analysis (FCA) lies in the definition of *concept* (of a given context) as a unit of thoughts consisting of two parts, the *extension* and the *intension*. The extension covers all objects belonging to this concept and the intension comprises all attributes valid for all those objects (Wagner, 1973). In relation to business network research, the initial assumption of a shared concept context can now be formulated using the practical guideline for FCA (Wolff, 1993): the extent of the topmost concept, i.e. the most general super-concept of the combined research domain, should always be the set of all concepts; its intent does not contain any properties (in the mentioned context of the project's research domain). However, the added complexity of the domain of the discourse, caused mainly by the projects multidisciplinary approach and the diverging views in each research area about details of the concepts of each domain, required a more sophisticated treatment of concept semantics.

Additionally, the overlapping nature of the concept descriptions is exemplified in how the three research areas had in many cases inconsistent concept definitions: on the one hand, there were concepts that had a uniform (or nearly identical) name but they still referred to a completely different (real-world) entity, or they had a contradictory meaning between research views; and on the other hand, some concepts with unrelated names appeared to be identical in their definitions or referred to the same underlying entity.

In the context of the initial project's collective research area, these findings about the complex interplay of closely interconnected and at the same time divergent views of three overlapping domain concepts (business models, information security and systems integration) prompted us to discover an intrinsic layered structure of concept composition, which is illustrated in Figure 1. Three overlapping areas of concepts can thus be distinguished: (S) a single-topic layer; the concepts appearing in only one research domain, (D) a dual-composite layer; concepts that fall within the intersection of two research domains, and (M) a multi-composite layer; a set of concepts that fall within the intersection of all research domains.

By means of generalization, an extension of the described model is also depicted on the right side of the diagram. Here it can be seen that the overlapping nature of cross-disciplinary conceptualizations presents itself as a multi-layered structure, where each layer contains a certain set of domain concepts (originating from one or several domains) according to their interconnectedness (that could present itself as a similarity or as relevance, but also as dissimilarity or even as being conflicting) with the other domain's perception of the entity represented. Using this kind of

semi-analytical abstract modelling in each research area individually (or in collaboration), the domain concepts can be categorized and related not only according to their "internal" properties but also along their "external" relations to other research views.

extent that metamodelling can be used as an informal description that is robust enough to present the essential building blocks of the proposed practical research framework.

Even in its present informal state, this cross-domain

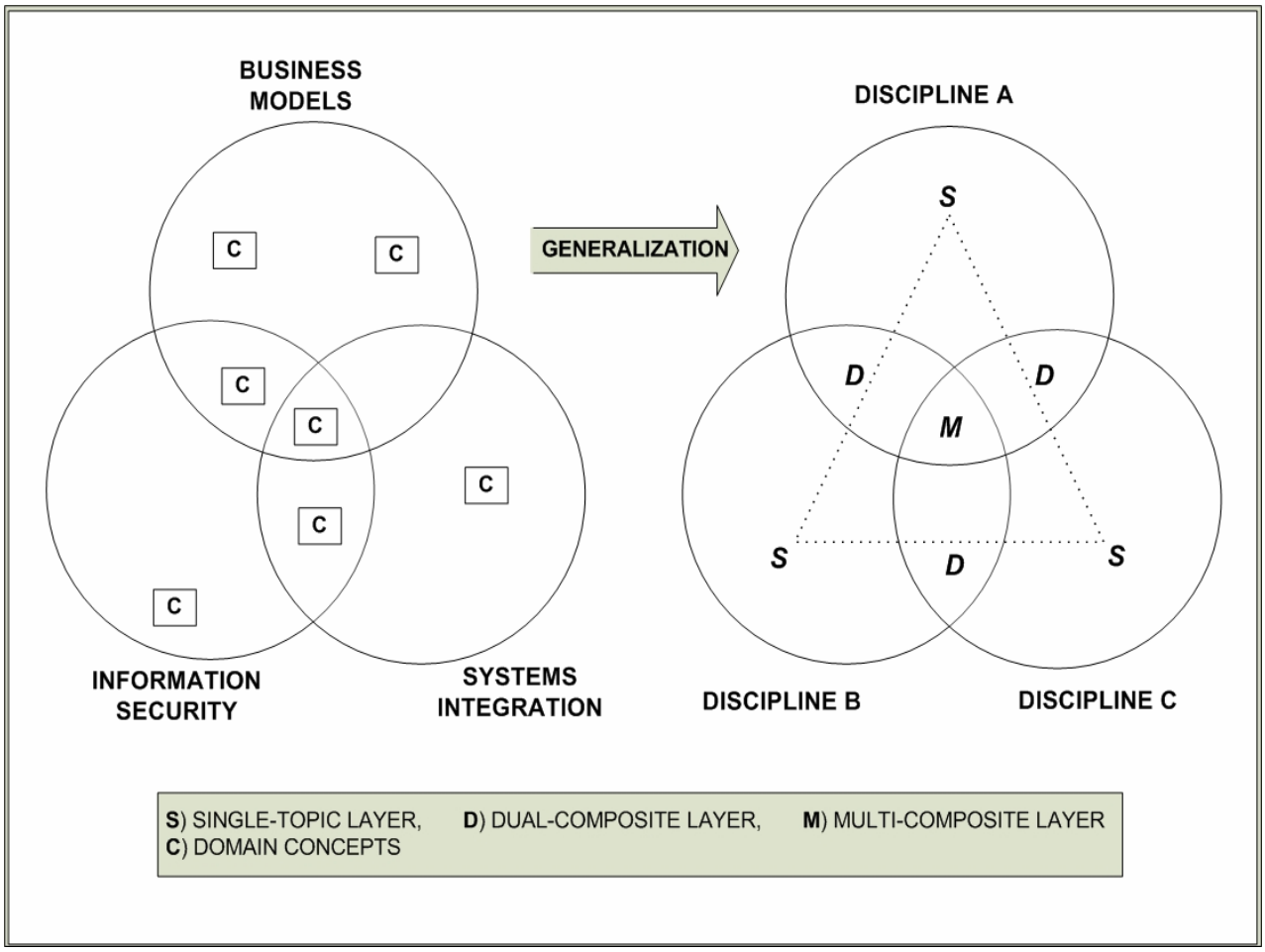

Figure 1: Layered composition of domain concepts

It can be claimed that this way of thinking differs from the more traditional conventions used in multidisciplinary research, which have shown a tendency to only try to connect, combine or converge the already existing concept models of different disciplines in an attempt to build a coherent representation of the whole.

An additional discovery was made when it was realized that formalizing and further developing this kind of a representation could serve as a metamodel. As such, the developed framework can be seen as an explicit model of constructs and rules needed to build specific models within a domain of interest. Thus, the described conceptualization schema could further be developed in accordance with the practices of metamodelling as, for example, in the specifications under the Model Driven Architecture (MDA) by the Object Management Group (OMG; Model Driven Architecture). The following sections focus on advancing the construct in the direction of metamodelling only to the

conceptualization schema could already be used in the initial research project in combining and harmonizing the whole concept domain in such a way that the different concept definitions and descriptions are also conserved.

III.CONCEPT EVOLUTION AND THE EMERGENCE OF MEANING

This section describes the essential constructs and practices that need to be incorporated into the previously described preliminary metamodel for it to be useful in actual research. The main goal here is to present the building blocks of a framework for multidisciplinary concept evolution (MCE).

The fundamental functional requirement of a practical design tool in this context is that researchers should be able to use it to generate a coherent, formally expressive and mutually accepted representation of strongly inter-connected research domain concept semantics. This kind of compilation of knowledge is here called *the general and shared body of meaning*. In accordance with the dictionary definition (Oxford English Dictionary), the emphasis here is on the emergence of an understanding about the significance, purpose or the underlying truth of the observed and analyzed conceptualizations. The justification for introducing meaning to this discussion lies in the insight that it is a valuable notion in tackling autonomy and heterogeneity issues (for example, in the dynamic integration of information systems) and to enable solutions to general problems in social, pragmatic, semantic and syntactic interoperability (Ouksel, 1999, Open Systems Framework for Social Interaction). Also the important community view is included in the framework by recognizing that the quality of the generated repository of meaning is ultimately evaluated by its ability to convey the necessary knowledge in an appropriate form to resolve conflicts, uncertainties and misunderstandings between the *stakeholders* or agents participating in the real-world phenomena being studied.

It is proposed here that mostly the operational requirements can be fulfilled by applying (i) *abstraction*, (ii) *generalization* and (iii) *ontology engineering* (particularly ontology mapping) to enable the emergence of meaning. However, before these methods or operations are detailed, the novel idea of *concept evolution* is defined as the concrete activities performed by the researchers that give rise to a higher-level representation emerging from the initially constructed conceptualization.

As illustrated in Figure 2, all the mentioned metamodel components, the overall description of the listed practical methods and the basic ideas about semantic interoperability, in combination with the given functional requirements, together constitute the main building blocks of the MCE framework.

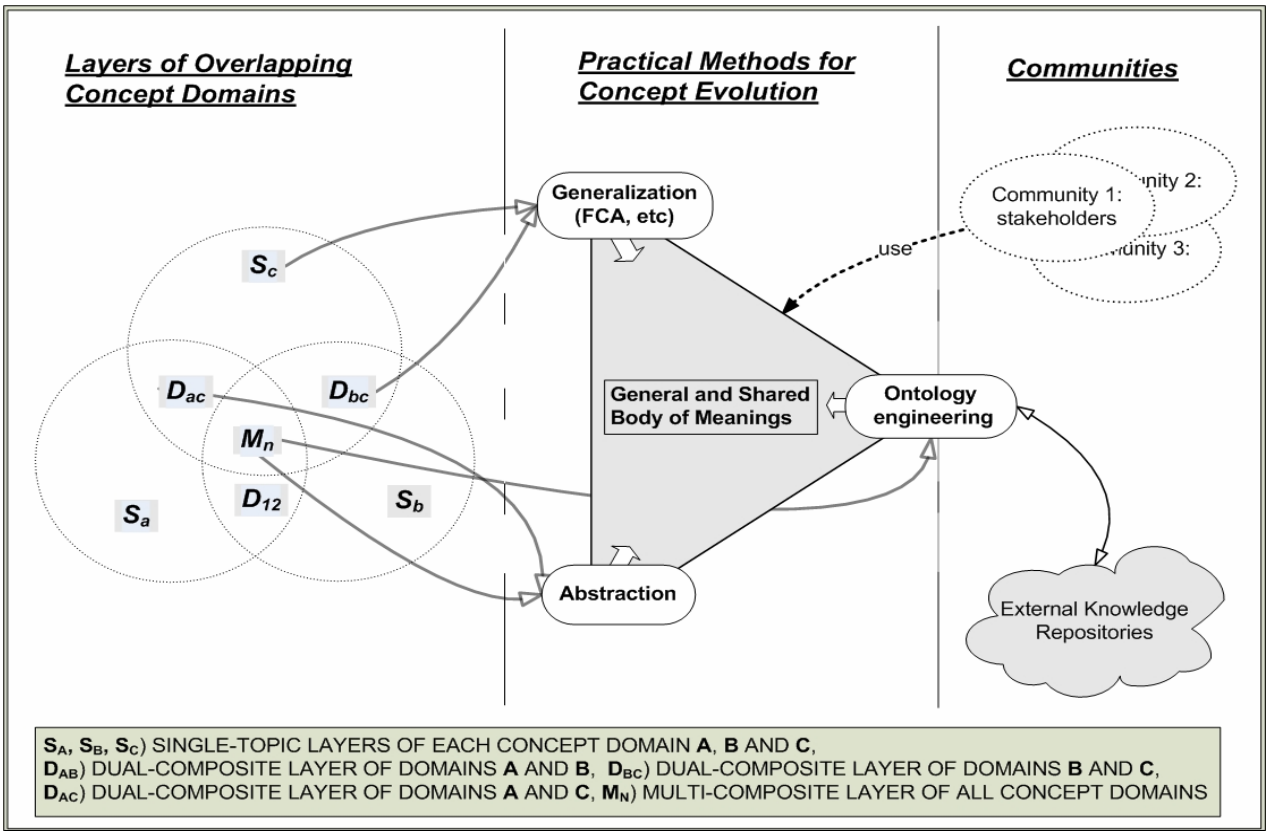

Figure 2: Concept evolution and emerging meaning

As stated before, the MCE framework identifies the following practical methods to aid in the complex and dynamic process of concept evolution:

i. *generalization*: used here in the same sense as in the well-known object-modelling and set-theory paradigms: inheritance (is-a relation), subsume/supersume, object attribute relations and associations; for example, Formal Concept Analysis (FCA).

ii. *abstraction*: seen here as a creative cognitive process, during which subjective interpretations are made (with the participation of domain specialists and experts, in addition to researchers) about the phenomena being researched and the initial concepts used. Abstraction (as the common-sense meaning suggests) can help the emergence of novel concepts by reducing the level of detail and by enabling higher-level representations.

iii. *ontology engineering*: based on the definition of *ontology* as appropriate for the Semantic Web initiave and as specified in the OWL specification by the World Wide Web Consortium (W3C; Web Ontology Language). Ontology mapping (Kalfoglou and Schorlemmer, 2005) is an especially useful practice here mainly in providing formal descriptions and tools to glue research-originated conceptualizations together. Additionally, it can also be used to relate or link evolving concepts and meanings to various *external knowledge repositories*. These repositories lie outside the actual research domain proper and may include things like: related existing ontologies, knowledge repositories, vocabularies, dictionary definitions, taxonomies, standards and enabling technology recommendations, generally accepted naming conventions, code lists, etc.

More formally these operations (i.e. the practical means of concept evolution) can now be expressed as a mapping (or a function), the domain of which consists of the sets (S_i, $D_{i,j}$, .., $M_{i,j,k,..}$) of overlapping domain area conceptualizations (not the individual concepts), and whose range is the constituents and the representations of meaning (m_i).

Summing up the benefits of using the framework, researchers are able to identify and analyse concepts from all relevant research areas and to categorize them into different classes. The framework also makes it possible to generate hierarchical concept schemas and to classify varying concept descriptions and definitions. Additionally, from the perspective of information system design, the framework is useful in providing at least a semi-formal (i.e. possibly machine processable) model of the domain of interest. It must be noted, however, that the practical use of the MCE framework in a variety of research situations still requires, for one thing, the specification of a formal method of utilizing the basic ideas and constructs discussed here.

IV.MCE FRAMEWORK IN THE CONTEXT OF NEW BUSINESS MODELS

When applying the MCE framework to a business context, an examined business-related phenomenon forms a starting point for utilization. When it is examined from the viewpoints of different business stakeholders and researchers, the outcome is a collection of different concept domains, which paradoxically are not compatible with each other. This diversity of concept domains has traditionally led to deviating views on research issues, because the target phenomena is interpreted and described in subjective conventions. The MCE framework makes it possible to achieve general and shared meanings for concepts of focused phenomenon. These meanings can be adopted by all the research areas in question, and can further be used to form subjective constructs that share their conceptual definitions. This is a crucial aspect in designing or formulating new business models. Business phenomena are typically complex, involving features from different disciplinary backgrounds.

In this research project the specific business-driven phenomenon is an integration of business processes, which is expected to lead to a new business model (integrated enterprise network). As Figure 3 illustrates, by processing the initial concepts “business process”, “integration” and “business network” in the MCE framework, a common set of meanings is attained. This collection is then used in the next (construction building) phase of the CRA as a valuable resource to aid in the creation of new solutions (constructs) for the described research problem. Developed constructs can further be combined into new business models. For example, a secure integration of business processes in an integrated business network demands a combination of constructs from different research areas. A prerequisite for this is that there exits general, shared meanings for the concepts of all related research areas.

One of the important consequences of applying the MCE framework to business process integration research issues is the insight that the study of information security should at least now be accepted as an important area of modern business. Because of the fact that information security is a business issue, not a technical issue (adapted: von Solms, 1999), a failure in designing and implementing it has evident effects on the ability of enterprises and networks to function. A severe information security incident can lead to growing insecurity and erosion of trust, which dissolves a network’s capability to function. Information security is more than a technical issue: it is also an organizational issue. Additionally, systems integration research should also be added to the list of business issues (Anderson, Longley, Kwok, 1994), and should thus be investigated in parallel to other research areas. A modern business relies heavily on information systems, which can be interconnected by the means of systems integration. IT is also one of the key enabling forces in networking development, because it enables a cost-effective way for enterprise interoperability. In contrast, as a standalone research approach, systems integration mainly provides the functional service view as an infrastructure for implementing business operations at the organizational level.

These distinct conceptualizations inflict difficulties in communication between different stakeholders. However,

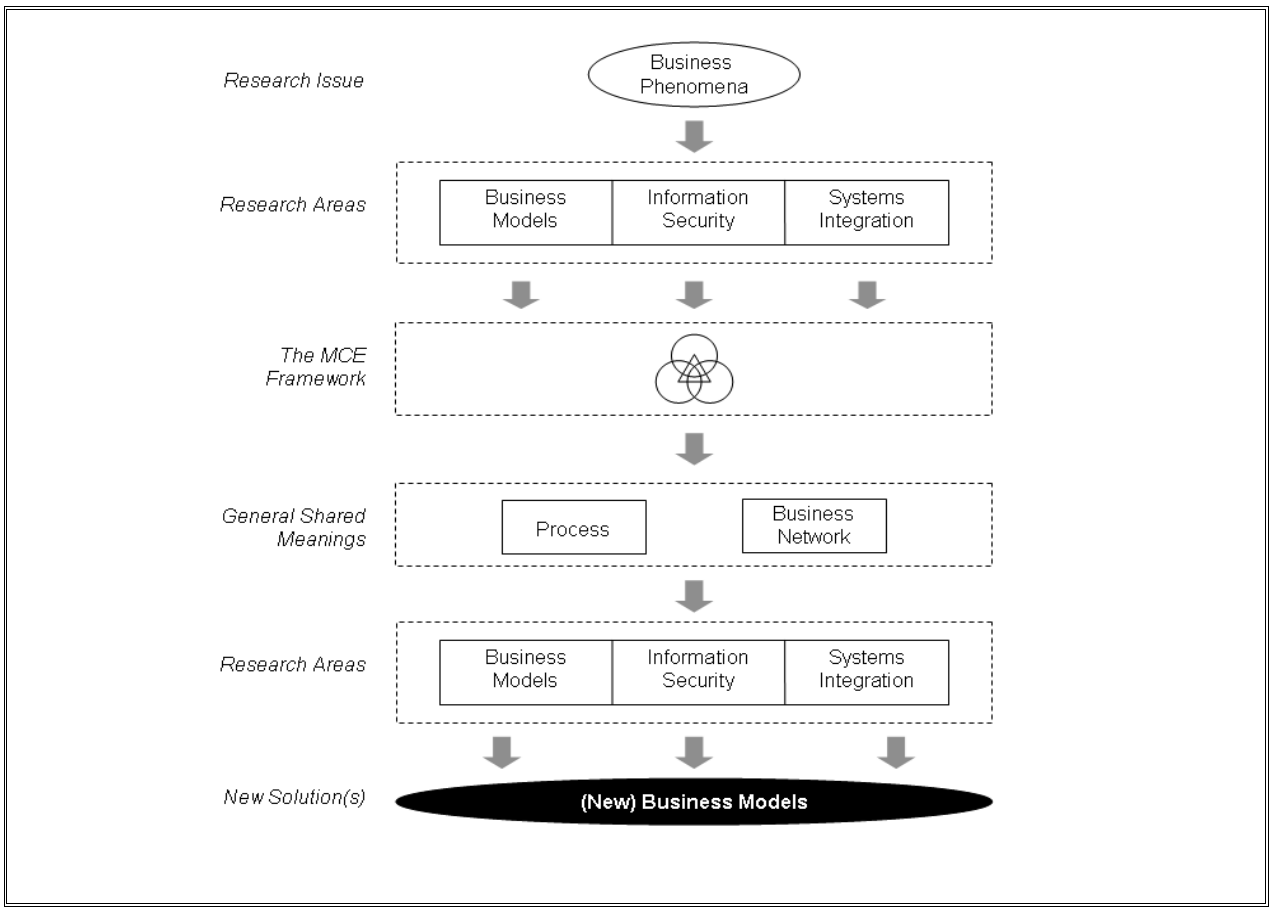

Figure 3: MCE framework used in business models related context

the issue of understanding is actually very pragmatic. For instance, in a real-world business context it is apparent that a company's IT director and marketing director understand each other - especially if they aim to build a new solution for the company's sales system. They might use the same words, which could actually mean completely different things. The issue of understanding becomes even more important when dealing with network of organizations (companies). When communicating between enterprises, it is more difficult to repair misunderstandings due to less face-to-face communication. Also, it is common knowledge that conceptual differences are greater between organizations than within one particular organization. Of course, these organizational-level conceptual differences are manifested through its employees and can often be experienced in B2B negotiating situations. The MCE framework can be applied to this kind of situation also. Then the issue is not to pool meanings from different disciplines, but to harmonize meanings from different viewpoints.

It is important to note that, once created, the MCE framework can be utilized not only by researchers but also by other (business) stakeholders, who view it from their own perspectives. They can pick only those concepts and meanings from the created collection that serve their own purposes. Even in the case of a single enterprise, there are multiple shareholder positions – for instance, management, shareholders, employees, creditors etc. And as a pragmatic example, it is in the interest of a company's management to ensure the information they communicate to other stakeholders is understood properly. If shared definitions of concepts and meanings are used, then it is more likely that the information is decoded and conveyed in the way it was intended.

V.CONCLUSIONS

The development of the MCE framework prompted a research project aimed to develop new business models. It was discovered that the project's multidisciplinary research environment brought a need to harmonize concepts of different research areas. This finding encouraged researchers to develop the framework as a research tool that would make it possible to combine and harmonize concept domains. Using the framework, researchers are able to identify and analyze concepts from all relevant research areas and to categorize them into three classes: concepts appearing in only one research domain, concepts that fall within the intersection of two research domains and a set of

concepts that fall within the intersection of all research domains. The framework identifies abstraction, generalization, and ontology engineering as practical methods to implement the process of concept evolution.

The MCE framework is a generic tool that can be used in developing pooled interdisciplinary conceptualizations. As a discipline-neutral tool, it can be applied in several research areas, for instance, in developing new business models. Future research is needed to study the detailed practical value of the framework in other practical disciplinary and non-disciplinary areas. Depending on these results, applying the framework to other research areas may bring additional value to both the research itself and further development of the framework, as well as possible practical benefits.

REFERENCES

[1] Anderson, A., Longley, D. & Kwok, L, "Security modelling for organisations." Proceedings of the 2nd ACM Conference on computer and communications security, 1994, ACM Press, pp. 241-250.

[2] Hara, N., Solomon, P., Kim, S.-L., and Sonnenwald, D., "An emerging view of scientific collaboration: Scientists' perspectives on collaboration and factors that impact collaboration." *Journal of the American Society for Information Science and Technology*, Vol. 54, No. 10, 2003, pp. 952-965.

[3] Jemison, D.B., "The importance of an integrative approach to strategic management research." *Academy of Management Review* 1981, Vol. 6, No. 4, 1981, pp. 601-608.

[4] Kasanen, E., Lukka, K. and Siitonen, A., "Constructive approach in business studies." *Finnish Journal of Business Economics XL*, 1991.

[5] Kalfoglou, Y. and Schorlemmer, M., "Ontology Mapping: The State of the Art." *Semantic Interoperability and Integration*. Dagstuhl Seminar Proceedings, IBFI, Scloss Dagstuhl. 2005.

[6] Labro, E. and Tuomela, T.-S., "On bringing more action into management accounting research: process considerations based on two constructive case studies." *European Accounting Review* 2003, pp. 409-442.

[7] March, S. & Smith, G., "Design and natural science research on information technology." *Decision Support Systems* 15, 1995, pp. 251-266.

[8] Solms von, B. and Solms von, R., "The 10 deadly sins of information security management." *Computers & Security* 23, 2004, pp. 371-376.

[9] OMG, Model Driven Architecture (MDA), Object Management Group (OMG), <http://ww.omg.com/mda> 20.2.2006

[10] Ouksel A., "A framework for a scalable agent architecture for cooperating heterogeneous knowledge sources", in Klusch, M. (ed.) *Intelligent Information Age: Cooperative, Rational and Adaptive Information Gathering in the Internet*, Springer, p. Chapter 5, 1999.

[11] Orlikowski, W. J., Baroudi, J.J., "Studying information technology in organizations: Research approaches and assumptions." *Information Systems Research* 2, No 1, 1991, pp. 1-28.

[12] Oxford English Dictionary, <http://dictionary.oed.com> 17.2.2006

[13] Wagner H., Begriff. *Handbuch philosophischer Grundbegriffe* pp. 191-209, München, Kösel, 1973.

[14] Wille, R., "Restructuring lattice theory: an approach based on hierarchies of concepts", in Rival, I. (ed.) Ordered Sets, pp. 445-470, Dordrecht-Boston, Reidel, 1982.

[15] Wolff, C. E., "A first course in formal concept analysis - how to understand line diagrams", in Faulbaum, F. (Ed.) *SoftStat'93, Advances in Statistical Software* 4, 1993, pp. 429-438.

[16] W3C, Web Ontology Language (OWL) Overview, World Wide Web Consortium (W3C), <http://www.w3.org/TR/owl-features/> 20.2.2006