

The Role of Modeling in Future Innovative Business and Community Information Systems

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Abstract: Future internet systems have a number of properties supporting new innovative business and community systems. Event-driven architectures (EDA) providing varied information to support collaborative decision-making enable more decisions to be made closer to the problem owner. The "Internet of Things" (IoT) enables the Internet to reach out into the real world of physical objects. Mobile and collaborative applications and services utilizing information processing and process support enabled by sensor data from a vast numbers of connected and cheap devices and directly and indirectly from humans in control of these devices will change a number of markets. Future innovative business and community information systems will need to take this situation into account, addressing technological, methodological and conceptual challenges. This paper will focus on the latter, discussing in particular the potential role of model-based techniques and how to assess and improve the quality of models and modelling approaches in this setting using the SEQUAL framework.

1 Introduction

ICT has over the last 30 years gone from obscure to infrastructure. All organizations are dependent on an application systems portfolio supporting its current and future tasks, and newcomers in any area are dependent on establishing a similar application portfolio quickly in a way that can evolve with changed business needs, technological affordances and expectations among co-operators, competitors and customers, these days especially to address a rising number of (in particular) mobile delivery channels.

Over these 30 years, one has regularly investigated how IT-systems are developed and used. In [LST78], results from a 1977 survey on distribution of work on IT in organizations were published. Somewhat surprisingly at that time, one found that almost half of the time was used on maintenance (i.e. changing systems that were already in production). Similar investigations have been done in Norway in 1993 [KS94], 1998 [HKS00], 2003 [KJS06], and 2008 [DK10]. For some areas, there are large differences for instance which programming languages that are used. Other areas are remarkably stable. As illustrated in Table 1, the split of the time use for development vs. maintenance is relatively similar to how it was 30 years ago. (In absolute terms a smaller proportion is used for both development and maintenance, since most of the time used by IT-departments these days are on user-support and keeping systems operational as we

see in the above part, the last two lines in the table show the numbers when we do only look at the relative distribution of development and maintenance time). Over the last 20 years the percentage of new systems that are in fact replacement systems, being installed basically to replace an old system, has stayed above 50%, rising slowly.

Table 1. Comparisons of maintenance figures across investigations

Category	Nor. 2008	Nor. 2003	Nor. 1998	Nor. 1993	Nosek/ Palvia [NP90]	Lientz/ Swanson 1977
Development	21%	22%	17%	30%	35%	43%
Maintenance	35%	37%	41%	40%	58%	49%
Other work	44%	41%	42%	30%	7%	8%
<i>Disregarding 'other work'</i>						
Development	34%	34%	27%	41%	38%	47%
Maintenance	66%	66%	73%	59%	62%	53%

One example of a notable change is *where* systems are developed, maintained and operate compared to 20 years ago. In 1993, 58% of the systems were developed by the IS-organization, and only one percent was developed *in* the user organization. In 1998, however, 27% of the systems were developed by the IS-organization and 27% as custom systems *in* the user organization. In 2003, 23% of the systems are developed in the IS-organization, whereas in 2008 only 12% were developed in the IS organization. The percentage of systems developed by outside firms is higher in 2008 (40% vs. 35% in 2003, vs. 22% in 1998 vs. 12 % in 1993). The percentage of systems developed based on packages with small or large adjustments is also increasing (41% in 2008 vs. 39% in 2003 vs. 24% in 1998 vs. 28% in 1993). The new category introduced in 1998, component-based development (renamed “use of external web services” in 2008) is still small (5% in 2008) although increasing (1.0 % in 2003, 0.4% in 1998). Whereas earlier the main way of developing systems where to do it in-house or using temporary consultants, outsourcing of all type of IT-developments has been on the rise over the last 10 years, although you also find examples lately on insourcing. In the 2008 investigation around a third of the IT-activity was outsourced (32.9% in private sector, 24.1 in public sector). Whereas only two of the respondents reported to have outsourced all the IT-activities, as many as 84% of the organizations had outsourced parts of their IT-activity. Whereas the public organizations have outsourced more of the development (40% in public, 29% in private) and maintenance (34% in public, 30% in private) than the private organizations, they have outsourced less of the operations (31% in public, 41% in private) and user support (21% in public, 29% in private). Other important aspects to take into account are the rise of new delivery models (e.g. OSS) not only for infrastructure applications, and the trend towards using cloud infrastructures for the operations of ICT-solutions.

A number of needs can be identified in this landscape that must be addressed in future business information systems. We will in this article discuss these issues highlighting the

application and possible changed role of *modelling techniques*. In section 2 we describe the role of modelling in information systems development in general. In section 3 some traits of future business and community information systems are described, and section 4 describes a vision of the role of modelling in this landscape. Section 5 concludes the paper.

2 The Role of Modeling and Quality of Models

Conceptual modelling is usually done in some organizational setting. One can look upon an organization and its information systems abstractly to be in a certain state (the current state, often represented as a descriptive 'as-is' model) that are to be evolved to some future wanted state (often represented as a prescriptive 'to be' model). The state includes the existing processes, organization and computer systems. These states are often modelled, and the state of the organization is perceived (differently) by different persons through these models. This open up for different usage areas of conceptual models as described e.g. in [NK06], illustrated in Fig. 1:

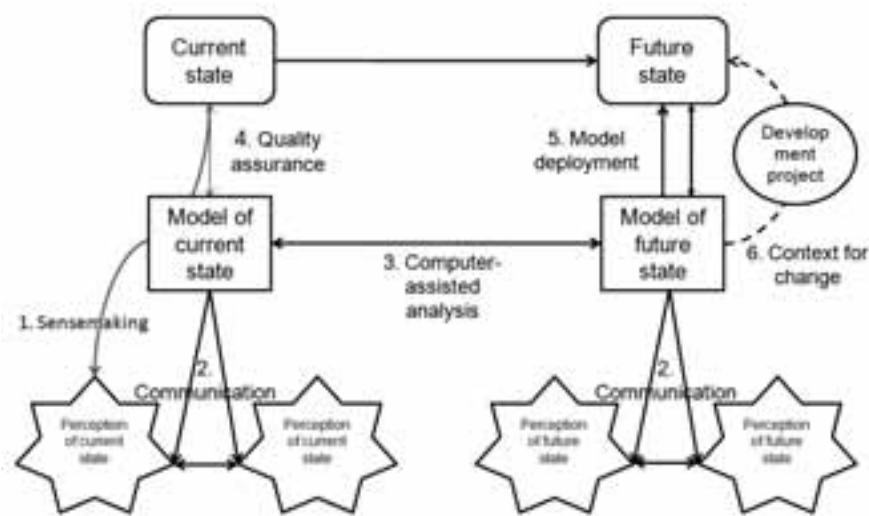


Figure 1: Application of conceptual modelling

1. Human sense-making: The model of the current state can be useful for people to make sense of and learn about the current situation as it is perceived.
2. Communication between people in the organization: Models can have an important role in supporting human communication [W11].
3. Computer-assisted analysis: To gain knowledge about the organization through simulation or deduction, often by comparing a model of the current state and a model of a future, hopefully better state.

4. Quality assurance, ensuring e.g. that the organization acts according to a certified process achieved for instance through an ISO-certification process.
5. Model deployment and activation: To integrate the model of the future state in an information system directly. Models can be activated in three ways:
 - a. Through people, where the system offers no active support.
 - b. Automatically, where the system plays an active role, as in an automated workflow system.
 - c. Interactively, where the computer and the users co-operate to bring the process forward [KJ02].
6. To give the context for a traditional system development project, without being directly activated.

SEQUAL is a generic framework for assessing quality of models [K12, KSJ06, KS03]. The framework has earlier been used for evaluation of modelling and modelling languages of a large number of perspectives, including data, object, process, enterprise, and goal-oriented modelling. Quality has been defined referring to the correspondence between statements belonging to the following sets:

- **G**, the set of goals of modelling.
- **L**, the language extension, i.e., the set of all statements that are possible to make according to the rules of the modelling languages used.
- **D**, the domain, i.e., the set of all statements that can be stated about the situation.
- **M**, the externalized model itself.
- **K**, the explicit knowledge relevant to the domain of the audience.
- **I**, the social actor interpretation, i.e., the set of all statements that the audience interprets that an externalized model consists of.
- **T**, the technical actor interpretation, i.e., the model as 'interpreted' by modelling tools.

The main quality types, illustrated in Fig. 2 are:

- Physical quality: The basic quality goal is that the externalized model **M** is available to the relevant social and technical actors for interpretation (**I** and **T**).
- Empirical quality deals with comprehensibility and predictable error frequencies when a model **M** is read or written by different social actors.
- Syntactic quality is the correspondence between the model **M** and the language extension **L**.
- Semantic quality is the correspondence between the model **M** and the domain **D**. This includes validity and completeness.
- Perceived semantic quality is the similar correspondence between the social actor interpretation **I** of a model **M** and his or hers current knowledge **K** of domain **D**.
- Pragmatic quality is the correspondence between the model **M** and the actor interpretation (**I** and **T**). One differentiates between social pragmatic quality (to what extent people understand the models) and technical pragmatic quality (to what extent tools can be made that can interpret the models).
- The goal defined for social quality is agreement among social actor's interpretations.
- The deontic quality of the model relates to that all statements in the model **M** contribute to fulfilling the goals of modelling **G**, and that all the goals of modelling **G**

are addressed through the model M . In particular, one include under deontic quality the extent that the participants after interpreting the model learn based on the model (increase K) and that the audience are able to change the domain D if this is beneficially to achieve the goals of modelling.

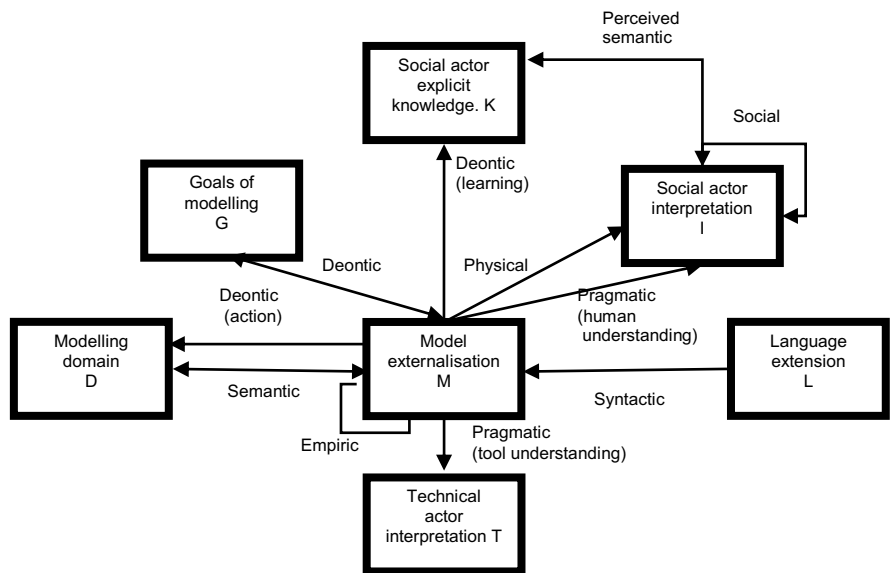


Figure 2: SEQUAL framework for discussing quality of models

3 Future Business and Community Information Systems

The future business environment must take into account a stronger integration across traditional organizational borders and countries. In the FiNES position paper [L11], a number of organizational trends are highlighted:

- *The disappearing boundaries of the enterprise*: Virtual teams, extended value chains, dynamic value networks and a range of digital ecologies [VZUM10] such as digital ecosystems will change the contours of the business world.
- *Everybody is an Enterprise*: The role of SMEs and especially micro enterprises and start-ups is expected to become even more important
- *The WhatYouSenseIsWhatYouGet (WYSIWYG) Enterprise*: With massive quantities of real-time information becoming available one can get new real-time enterprise applications.
- *A Knowledge Commons for Enterprises*: There is a need for an open and accessible “Knowledge Commons” facilitated by the Internet for all to freely, responsibly and legitimately exploit

- *The advent of intelligent virtual reality:* With increasing dematerialization blurring the physical with the virtual, enterprises are not only becoming digital, they are acquiring multiple roles, cyber presences and distinctive virtual identities

Combined with societal trends (e.g. demographic, legislative, financial, geo-political, and environmental) that demands change in current practice there is a number of issues that must be addressed in future business information systems to support these organizational and societal needs. Future business information systems will take advantage of in particular future internet to

- Be empowered by a new participative Web hosting a new wave of services and using user-friendly technologies;
- Create value by leveraging the Internet as the platform through which knowledge is manipulated dynamically, experienced in the business context and represented in a radically different way;
- Have the required capability that enables and supports collaboration with other enterprises, new dynamic relationships, discovery of partnerships, new opportunities and markets, and the management of the new risks involved
- Operate in a new set of business environments that provide support for quality measures, guarantees, persistence, safety, trust, arbitration and other mechanisms for reducing risks on both the customer and the provider side
- Become the WYSIWYG enterprise, where Web-based applications become as rich as the desktop.

A number of partly related needs can be identified in this landscape that must be addressed in future business and community information systems:

- The support of end-to-end engineering process (including full life-cycle support)
- Integration across organizations and nations
- Systems being provided by ecosystems of providers
- Event-oriented systems utilizing the internet of things

We will below go into more detail on each of these areas, discussing in particular the application of modelling techniques.

3.1 The support of end-to-end design and engineering process (including full life-cycle support of products)

Even with the shift to a service economy, manufacturing and engineering remains important for the economy. On the other hand we witness new trends such as sustainable manufacturing and mass customization. Consequently, the manufacturing industry is facing significant changes.

The key enabler for coping with these changes will be IT, due to its strong impact on innovation and productivity. Current IT for manufacturing is characterized by scattered data formats, tools and processes dedicated to different phases in the product lifecycle. Moreover, the flow of information is closely aligned to the product lifecycle i.e., information from the design phase goes into the manufacturing phase, but not in the

opposite direction. In addition, user feedback is often neglected in design. Due to the diversity of tools and data formats, manufacturing struggles to cope with new trends in this area. For example, both the trend to mass customization and the demand for increased sustainability require a tight integration of the design, manufacturing and usage phases of a product, which is currently not in place. What is missing is an integrated, holistic view on information, persons and processes across the full product lifecycle. As experiences of the past show, a tight integration of all tools used throughout a product lifetime is not feasible. A model-based approach to address this in a more federated manner is the application of AKM (Active Knowledge Modeling) [LK08].

3.2 Integration across organizations and nations

Over the last 10 to 15 years the number of varying organizational forms has increased a lot, from strictly structured supply-chains to loosely structured communities of interest. Co-operation across traditional organizational boundaries is increasing, as outsourcing and electronic business is enabled by the Internet and IT in general. When such co-operation moves beyond the buying and selling of goods and well-defined services, there is a need for a flexible infrastructure that supports not only information exchange, but also knowledge creation and sharing.

An extended enterprise (EE) (also often termed virtual enterprise) is defined as a dynamic networked organization, being developed ad-hoc to reach a certain goal based on the resources of several existing co-operating enterprises [KJ04]. The EE-partners often comes from different countries, using different languages and having different cultural background. The EE-partners wants to harvest knowledge from the EE to be reused in the originating organization, or in other EE's. An approach that needs to be extended to support this situation is process-support environment like workflow modelling and BPM [HVLAK10]. Based on globalization trends, also other challenges pop up. [KDS08] provides an example of the needs when a multi-national company is to coordinate their local business units in order to serve other multi-national companies in an integrated fashion. As reported in [KDS08] there was in this case a need to standardize the processes of the company's national branches in order to build a common image of the organization (both inward and outwards), and to support the certification of the cross-national processes of their multi-national customers, but at the same time adhere to national and cultural rules and expectations for how to do business. Similar examples from other businesses (e.g., car rental industry) are presented in [A11]. Such aspects are not only of importance in business, but also in the public administration area. Public administrations and service providers face growing challenges linked to the application of new IT-solutions and are forced to rethink traditional administrative structures and functions and adapt their services to meet new societal demands with reduced budgets. In the public sector there is increasing emphasis in particular in Europe on cross-department and cross-national applications, to increase reuse of solutions across traditional borders [AVJK11], as described for instance in the last EU Ministerial Declaration on eGovernment [EU09]. For instance, even in small countries like Norway and the Netherlands, there are around 430 local municipalities which in principle execute variants of the same processes [A11, AVJK11] which are different due to political, historical and demographic reasons.

3.3 Systems being provided by ecosystems of providers

As described in the introduction, the trend for a long time has been that systems are developed and evolved further and further away from the core users of the system. Rather than being provided by distinct entities, we see a development in the direction of systems to a larger degree being supported by *virtual communities* of human/organizational actors, co-working on partially shared digital artefacts [BDLV09]. The term '*digital ecosystem*' is being used to generalize such communities, emphasizing that their actors constantly interact and cooperate with other actors in both local and remote ecosystems. Such systems are characterized by self-organization, scalability and sustainability, providing both economic and social value as a specialization of the more generic concept digital ecologies. Examples are communities for Open Source (OSS) and Creative Commons, Knowledge Commons, social media networks, or voluntary groups of citizens or academics.

However, the existing digital ecosystems have limited scope, various degree of transparency, insufficient capabilities for search and evaluation of useful, high quality artefacts from the huge and ever-evolving Internet, and none does fully support a wide range of shared artefacts from a wide range of actors. There are two main variants of digital ecosystems; *content ecosystem* and *software ecosystems*. *Content ecosystems* are networks that deal with creation and sharing of artistic and intellectual artefacts. The impact of IT on participative and democratic processes and on creativity is already here, and will continue to grow with the increasing diffusion of web-based social networking and user generated content and services. *Software ecosystems* are defined as "*a set of businesses functioning as a unit and interacting with a shared market for software and services, together with relationships among them. These relationships are frequently underpinned by a common technological platform and operate through the exchange of information, resources, and artefacts*" [JFB09].

3.4 Event-oriented systems utilizing the internet of things (IoT)

What previously was termed convergence (between the telecommunications world, IT, media, and later also the power systems in what is now popularly called smart grids) is now emerging in practice, propelled by several simultaneous trends.

1. The continuing miniaturization of computing resources making it possible to perform computing at some level everywhere, by any device.
2. The availability of high-bandwidth access to computing resources in an increasing number of places.
3. The infrastructure being built up for utilizing remote computing resources (these days often presented under the term 'cloud computing')
4. More power-efficient solutions. Many battery-operated devices can last more than a year, and passive solutions used by RFID and NFC (Near Field Communication) are powered by the readers. Parasitic energy harvesting devices that extract small amounts of energy from the environment can power sensors where normal power solutions are not economically or practically available.

The emergence of the IoT will lead to a world in which countless everyday objects are interconnected and have their own computational power. These active and interactive objects will be able to monitor and change their environment via sensors and actuators, and to interact and collaborate with each other and with the people around them. Although more accessible, to quickly produce innovative applications and services for this setting is not an easy task. Information systems need to combine transaction-orientation with event-orientation, using event-driven architecture (EDA) [CS09] reflecting the nature of IoT applications. These applications are characterized by being:

- Collaborative, that is including numerous active components that behave concurrently, running on distributed devices, and collaborates to provide a desired functionality.
- Event-driven and reactive, that is continuously reacting on a large number of events from the physical environment, from users and from other parts of the system.
- Dynamic and adaptive, meaning that the applications, associations and collaborations are dynamically established and configured depending on the current context at run-time. The information gathered is often used to support human decision-making rather than to only automate a predefined process. Interaction with human users is essential both to use the systems efficiently, and to effectively improve the systems over time through capturing the experiences from the use of the system.

4 Quality of Models for Future Business and Community Information Systems

There are two main scenarios for the future use of modelling. What we term the steady state scenario, where modelling continues to be a somewhat esoteric activity for a limited number of experts is of course one possibility. The more optimistic view in the light of the above is that abstractions techniques such as modelling is taken into use in an increasing number of areas, to make it possible to at all be able to manage the development. One striking aspect is that the number and variety of stakeholders that will need to relate to models of some sort will increase. Given the increased educational level in most countries, it is not unlikely that also more people will be able to relate to these types of abstractions, given that one of the thing that you are exposed to in a master study of most types, is training to deal with abstractions. Looking at the sets in SEQUAL, we can thus foresee the following under this scenario:

- G: The same list of goals and applications of modelling that is described in Section 2 will still be relevant, but emphasis on less formal, interactive approaches will increase to be able to support the more federated landscape needed to address future IT-driven environments.
- D: The range of relevant domains is increasing, also within what can be classified as the 'same' system, given that systems to an increasing degree ranges across and is expected to integrate a number of areas.

- K: In many areas one need to deal with a more varied set of stakeholders, with a more varied set of skills and knowledge. Not only do you need to align IT-experts with 'business'-experts, but also people across a large range of business expertise, being used to express their knowledge in a wide variety of notations.
- L: Using domain specific modelling, the possibilities of tailoring the language to fit the domain, and the knowledge of the stakeholders have increased. To bring more people into (semi-) formal modelling these possibilities will have to be exploited to a larger degree. Thus rather than having a consolidation of modelling languages like the one we saw in object-oriented design with UML, there will be an increasing number of variants of modelling languages. We will also see a mix of richer media components being integrated with the more traditional "box and arrow"-conceptual modelling notations, thus supporting also richer meta-meta models defining and limiting the type of constructs to include in models in the first place.
- T: An increasing number of tools will be available to extract model information from raw data, e.g. in the area of process mining [A11]. In addition, tools for meta-meta modelling and meta-modelling will be more common.
- M: Models will be pervasively available being coordinated in a federated manner. Models will be across meta-levels in an increasing degree (compared to the models in traditional software engineering being primarily on the type level). Models, in particular interactive models will have a larger value in themselves, acting to a larger extend as knowledge commons and open models (<http://www.openmodels.at/>).

We believe the core dimensions of SEQUAL will be relevant also for models as used for future systems. On the other hand, a number of specializations might be envisaged. We will briefly discuss some main aspects here.

- Physical quality: Rather than being based on central repositories, more distributed, federated storage of model fragments must be available, utilizing standard interchange formats and supporting model mash-ups.
- Empirical quality: Support for empirical quality will be more built in, e.g. in tools that build up models from raw data in process mining, thus integrating information visualization tools and modelling tools utilizing generic knowledge on good visualization tactics to a larger degree. Note that different meta-meta models can induce the need for rethinking guidelines for achieving empirical quality [NK09].
- Syntactic quality: Syntactic quality can be looked upon as trivial in a sense, since adherence can be enforced. On the other hand, one often sees that one extend languages with new aspects in an (not always conscious) attempt to turn semantic problems into syntactic problems. New tools based on meta-modelling makes this easier to do, and then makes it even more important to do right in the sense that one do not end up with too restricted languages for the different islands of modelling.
- Semantic quality: The federated approach needed for modelling will bring new challenges as for how we look upon the semantic quality of the overall model. Whereas semantic quality in smaller domains would be followed up much as before (i.e. looking at the feasible (perceived) completeness and validity), one would to a larger degree need to be able to live with inconsistencies across federations. In

connection to this, it would be important to be able to identify those aspects of the models across domains that need to be consistent.

- Pragmatic quality: Given that more types of stakeholders are involved, this is of increasing importance. Different techniques can be used for different types of stakeholder, supporting multiple views for different stakeholder types on the same model to ensure individual comprehension.
- Social quality: This will be important in smaller communities, and in interfaces between communities, but less needed across federation. Note on the other hand that since different stakeholder groups might see different views of the overall model, possibly visualized in radically different ways, the effort to assure that they comprehend the models equally will potentially have to increase, as seen in e.g. [KDS08].
- Deontic quality: Models will be more important, in particular in organized conduct across traditional organizational boundaries and needs to be handled in a more professional manner [W11].

5 Concluding Remarks

From the above descriptions, we see that the technical challenges and opportunities with the future internet gives new challenges and opportunities for business information systems on many levels, all of which give new challenges and opportunities for model-based techniques such as BPM, MDA, enterprise modelling, value modelling and AKM. In a way many of the core problems are not new, e.g. how to deal with event-based systems have been investigated in the conceptual modelling area for quite some time. Even if the use of modelling need to be extended and improved, general categories underlying discussions on quality of models as described in [KSJ06, K12] remains relevant, although need to be adapted to e.g. quality of interactive models [KJ02,LK08].

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SESSION 6

Information Retrieval and Modelling

**Christian Hentschel, Johannes Hercher, Magnus Knuth, Johannes Osterhoff,
Bernhard Quehl, Harald Sack, Nadine Steinmetz, Jörg Waitelonis, Haojin Yang**

Open Up Cultural Heritage in Video Archives with Mediaglobe190

Mario Kubek, Herwig Unger

Detecting Source Topics by Analysing Directed Co-occurrence Graphs202

Gerald Eichler, Roland Schwaiger

Creation and Management of Community-specific Knowledge Domain Taxonomies212