

Topic Map Technology for Municipal Management Information Systems

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Abstract

Experience shows that data warehouse solutions and reporting systems widely-used in enterprises can support the information needs of municipal managers only to a certain degree. Their need for information need is generated, in part, by ad hoc press reports, citizen requests or actions of the political opposition. Regularly produced reports or figure based information do not often provide satisfactory answers to unpredictable questions.

The development of a management information system for the municipality in Stuttgart, Germany, concentrates on ad hoc information retrieval which is semantically supported by topic map technology. The article describes the characteristics of unstructured ad hoc information needs and shows on a conceptual level how topic maps can be developed as an instrument to support municipal management.

1. Introduction

Long before the E-Government-hype had reached its peak in Germany, public administrations became a new field of application for management information and decision support systems. Experience shows that data warehouse solutions and reporting systems widely-used in enterprises can support the information needs of city administrators only to a certain degree. A considerable part of the information needs of public administrations is generated ad hoc by press reports, inquiries made by citizens or actions of the political opposition and is therefore unpredictable.

The development of a management information system for the municipality in Stuttgart concentrates on situational information retrieval which is semantically supported by topic map technology.

In this article, the function and the development process of a topic map as a central feature of a municipal management information system will be described.

In the second section we provide a brief overview of the work of municipal managers and introduce KORVIS, the research project. A summary of our survey on information needs in the municipal management documenting the importance of unstructured and unpredictable information needs is described.

The third section of the paper deals with the topic map technology and its function within KORVIS. The description of the ontology modeling process makes up the main part of this section.

Finally, we provide an outline of our experiences with the development of a topic map for a municipal management information system.

2. Municipal Management Information

In 2001, the municipal management in Stuttgart, Germany, decided to plan and develop a management information system.

The central goal of their project was to integrate different information resources and support parliamentary working processes in the municipal council. In order to meet the information requirements and support the managerial work of administration managers and members of the municipal parliament, data and information about the characteristics of municipal management work and resulting information demands had to be collected.

Previous work on management information systems for municipal management [1] suggests that information requirements of mayors or council members can hardly be surveyed by structured objective methods. The research design for the survey on information needs in Stuttgart combined structured elements, such as interviews based on the critical success factors approach¹ [2], with less structured methods such as participant observation. As the management of a municipality is a considerably complex social organisation, the research project was based on the action research paradigm (cf. [3, 4]). Personal involvement of the researcher in the development process was essential to grasp the essence of municipal management.

¹ The critical success factors approach was developed by Rockart in 1979 in order to determine information needs of top managers. It is based on the assumption that "critical success factors are, for any business, the limited number of areas, in which results, if they are satisfactory, will ensure successful competitive performance of the organisation. As a result, the critical success factor are areas of activity that should receive constant and careful attention from management." [2]

2.1 Information Needs of Municipal Managers

The management of a municipality can be divided into two elementary groups: administration managers (the mayor of the municipality) and elected members of the municipal council. A major difference between these two groups is that members of the administration are professional municipal managers with expert knowledge in their administrative areas whereas council members are honorary politicians gainfully employed in other professions.

Council meetings, including their preparation and post processing, form the central part of the managerial work of municipal managers. Information requirements in connection with council work play an important role in the overall information needs of municipal managers. Some of the findings of the information needs survey conducted in Stuttgart are summarized below [5]:

1. User groups, politicians and administration managers need information on general trends and consequences of economic and social development. Almost all aspects of personnel planning in a municipality are influenced by demographic development. Requested information comprises, among other issues, requests for data on business activities, figures regarding employment and unemployment, the capital market etc..

2. Politicians are especially interested in facts and figures regarding their specific municipality or the district they represent. As elected officials, their actions are motivated not only by pragmatic thought and long range strategies but also by requests by citizens for attention to issues of public concern.

3. Both politicians and administration managers are interested in information on current incidents in their municipality. This category of information is of short-term interest. Plans for the removal of a statue in Stuttgart, for example, caused immense reaction in the press and citizen protest as the popularity of the statue had been underestimated. The situation created a demand for immediate information because whenever a representative appeared in public he was questioned about the incident.

4. Another important task of municipal managers is the control of administrative work and the operational implementation of decisions. Information about the current financial situation, current spending and the development of municipal projects is required by all.

The analysis of characteristic elements of municipal managers' information requirements suggests that they can be grouped into two super categories:

- predictable information needs that occur regularly or are related to the specific subject area of a municipal manager, and

- information needs that are generated by the situation at hand and are related to unpredictable occasions or current events.

If asked for an estimation of the relative proportion of predictable and unpredictable information requirements, interestingly enough, the stated proportion of unpredictable information needs parallels the hierarchic position of a municipal manager. This means, the information needs profile of top municipal managers (e.g. the mayor) is dominated by unpredictable information requirements. An interview partner stated that his information needs could not be pressed into static patterns; for the management of a municipality the size of Stuttgart, he needed to know basically everything.

2.2 Regular Information Needs versus Ad Hoc Information Needs

The conducted survey on information needs in Stuttgart shows that unpredictable information requirements are characteristic for different user groups in a municipality. Press reactions on a particular council decision, for example, can generate the need to derive supporting arguments from as many different information sources as possible. Council debates on investment proposals are also prepared on a broad information basis ranging from statistic projections to legal aspects.

The importance of unpredictable and unstructured information requests depends on the hierarchical position of a municipal manager [5]. The frequency of occurrence of politically-motivated events cannot be predicted. This causes, in turn, spontaneous information demands generated by the necessity to react on the actions of others. Not only are politicians' information needs spontaneous, in comparison to chief officers whose needs are confined to the specific domain of their task, the information requirements of the mayor of a municipality are extremely diverse. Similarly, the information demands of politicians cannot be reduced to specific subject ressorts but are rather defined by actual plans of their own political faction, reactions to plans of other factions, requests of citizens, or reactions on proposals of administration managers.

The differentiation of structured and unstructured information needs was proposed earlier by Groffmann [6], who observed a connection between the grade of structure of information requirements and the grade of innovation of someone's daily work. The more daily work is dominated by routine tasks, the more important are regular or predictable information requests for overall information needs. Contrastingly, if daily work is dominated by highly innovative tasks, information needs will also be dominated by unstructured and unpredictable information demands.

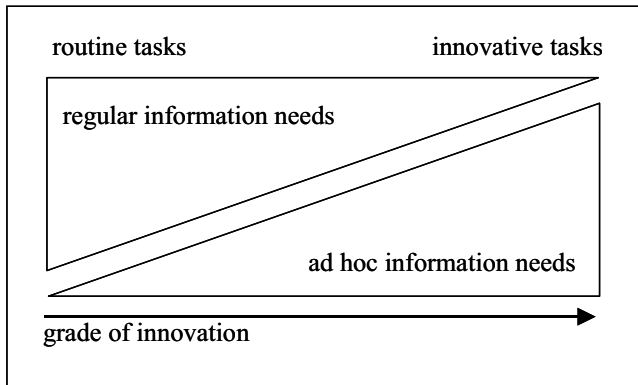


Figure 1. Information needs [6]

In the case of municipal managers, the proportion of political work seems to be responsible for the extent to which unstructured information requirements occur in the information needs profile. Political work can in fact be described as highly innovative; political strategies are expected to be new and innovative to be successful.

The management information system for Stuttgart is intended to support the information needs of politicians and administration top managers. For both user groups, a high proportion of unstructured information needs is characteristic. If unstructured ad hoc generated information requests are to be supported, classical management information systems with reporting tools are inappropriate and inadequate. Sophisticated search supporting instruments are more likely to meet these information needs.

2.3 KORVIS

KORVIS (Kommunales Rats- und VerwaltungsInformationsSystem; municipal council and administration information system) is a cooperation project of Stuttgart, the regional capital of Baden-Württemberg in Southern Germany, and the Department for Information Systems at the Technische Universität München. The project aims at integrating different information resources and combining them in order to deliver user group specific information portals.

The information situation of the municipal management three years ago can be described as follows: Stuttgart has several separate information systems where statistical data, georeferenced data, council documents, budgetary information, information on the administrative structure and organisational units etc. are stored. Following a request for information, several information systems must be accessed requiring expertise in handling these systems in order to achieve an exhaustive result. Each of these systems has its own user interface, its own logical structure and uses specific expert vocabulary, such as the statistical information system.

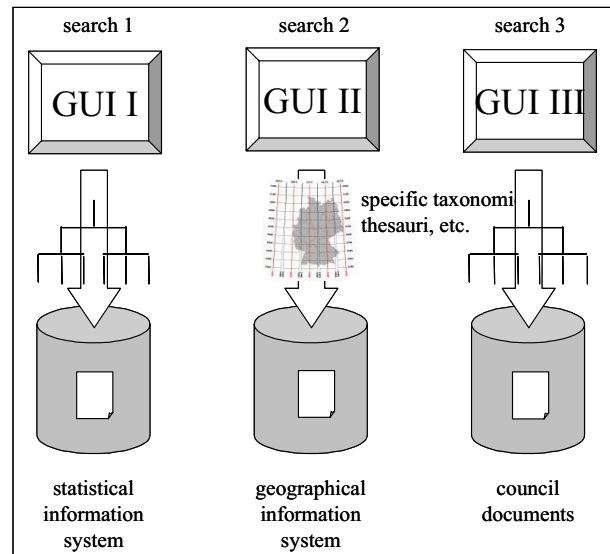


Figure 2. Information situation in Stuttgart

One must be aware of possible connections between findings in one information system and data stored in another. If, for example a council debate on the traffic situation surrounding the building of a nursery school is to be prepared, the seeker of information must search statistical information on traffic patterns in the specific area, stored in the statistical information system, as well as maps on accident hot spots, stored in the geographic information system. The data themselves do not provide these kinds of links.

The vision for KORVIS is to deliver a complete information overview containing all information and data related to a specific research topic. One central information portal and research interface will translate information requests into the different classification schemes of the connected information systems and collect data and information from various sources. The topic map offers the possibility to research information sources on a meta level, reveal unexpected relationships, and limit research results to a manageable amount.

In order to reveal relationships between documents and data stored in different information systems, the information objects in KORVIS will be annotated with meta data.

3. Topic Maps

Stocks of information and data have grown rapidly in recent years. Yet information seeking has become more difficult and time consuming.

In order to simplify information organisation and the retrieval of specific data in huge stocks of data, increasingly sophisticated indices and thesauri have been developed.

Information seekers are now confronted with various systematics of information and data organisation which require specific knowledge on structure and key words. Topic maps were designed to support information seekers in this situation. Like geographical maps, they provide an overview of the 'information topography' of an information source: for example of information objects and their interrelatedness. The use of topic maps aims at accelerating research processes and improving the quality of the result.

The basic idea of the topic map concept is to represent documents on a meta layer by a virtual element called 'topic' [7]. Topics themselves are related to other topics using so called 'associations'.

Thus topic maps can build a netlike structure which differs from other classification methods in several ways.

Common information classification methods are based on the tree paradigm [8]. They define root categories which are divided into several branches or subcategories. This approach seems to work quite naturally with structured domains where the differentiation of topics and subtopics is obvious. By using a tree-like classification structure, several abstraction levels can be introduced and properties of items can be inherited along branches. Thus the tree-paradigm allows a clearly structured classification of information resources. For unstructured information areas, however, hierarchy classification often fails. Topic maps provide a more flexible classification method which allows hierarchical classification as well as net-like structures.

3.1 Topic Map Technology

Based on the international standard ISO/IEC JTC1/SC34, topic maps provide a notation to represent the structure of information resources. Topic maps consist of topics and relationships between topics [8].

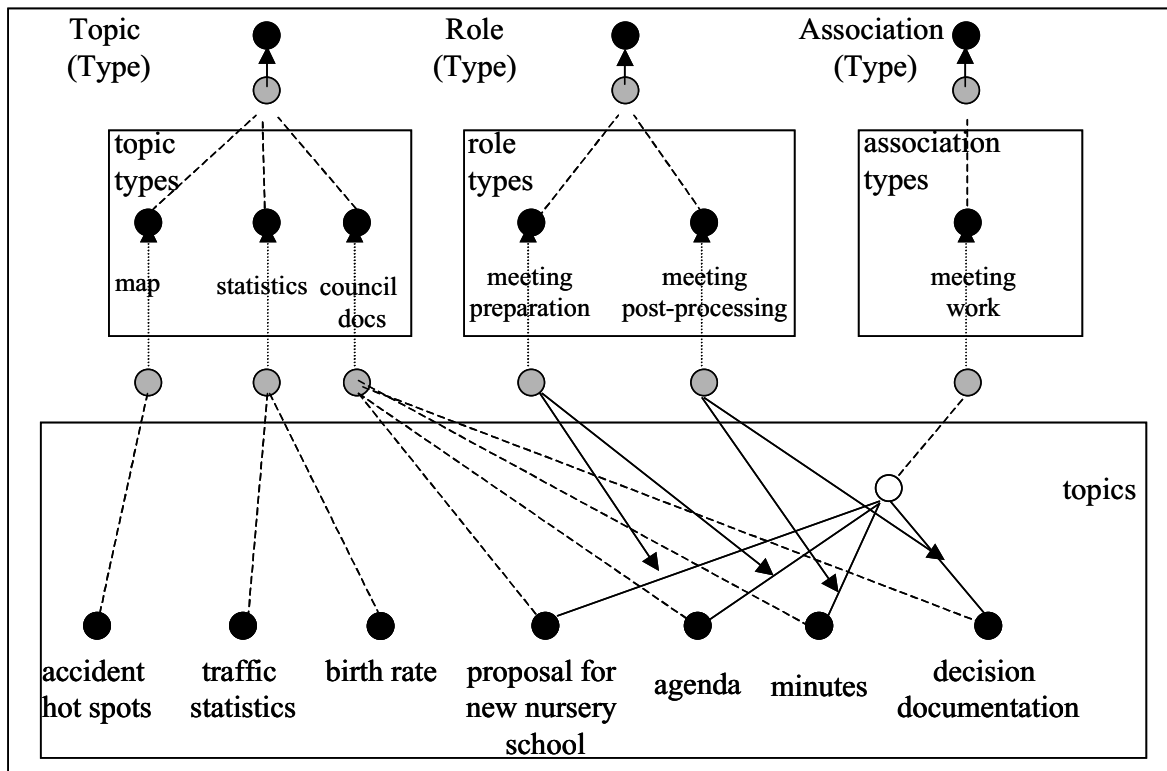


Figure 3. Building elements of topic maps (based on [9])

The three building elements of topic maps are (see Figure 3):

1. **topics** and topic types,
2. **topic associations**, association types and association role,
3. **topic occurrences** and occurrence role types.

Topics represent real world objects which can be either physical objects (a nursery school) or abstract concepts (a decision). Similar topics can be grouped to topic types. One topic may be assigned 'zero', 'one' or 'n' types [7]. Links from topics to external information resources, such as sets of data or documents in a data base, are called topic occurrences. Associations describe the relationship between two or more topics. Each of the related topics is assigned an association role which describes the part of each topic in a relationship in greater detail. In contrast to topics, associations are assigned only one association type.

3.2 Topic Maps in KORVIS

The topic map concept has been chosen for KORVIS as an instrument to integrate different information resources and make relationships between information objects accessible.

The first step was to define the information resources which needed to be integrated. The survey on information needs conducted at the beginning of the project revealed that it is hardly possible to exclude any information system in Stuttgart from the integration due to the unstructured or ad hoc type of information needs. Information needs are generated from a variety of situations necessitating access to diverse information sources.

As a consequence, a considerable number of information systems based on different classification methods and requiring different degrees of user expertise needed to be integrated. The topic map is intended to build the bridge between source systems.

For a start, the project management decided to concentrate on those information systems which are most important for council work. These included:

- the council information system CUPARLA,
- the decision management system,
- the geographic information system,
- the intranet,
- file services containing the budgetary plan.

The information objects stored in these systems already contained implicit or explicit relationships to other information objects within the same information system and to external information objects.

The topic map exposes these relationships and aids their accessibility for navigation. Further, the topic map reveals their semantic content (i.e. the nature of the

relationship between two information objects using graphical or verbal display instruments is described).

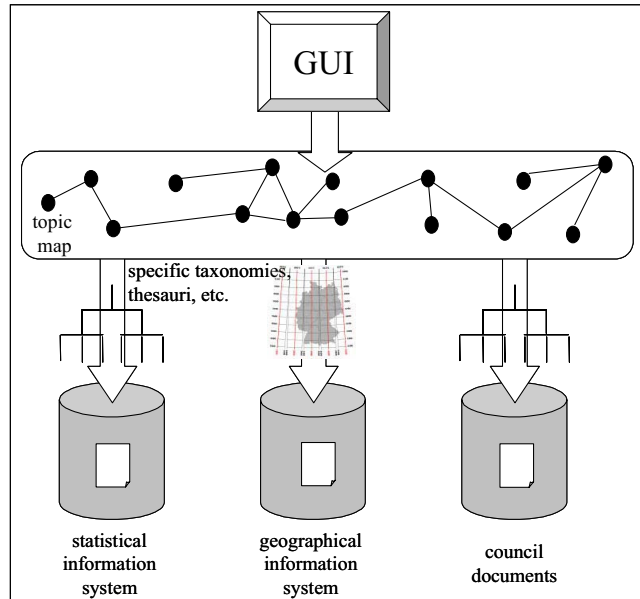


Figure 4. The topic map as a bridge over different information resources

3.3 Development Strategy

3.3.1 topic map development

In contrast to other classification methods based on taxonomies or thesauri, topic maps are built on the basis of an ontology representing "a catalog of types and things that are assumed to exist in a domain of interest"[10]. Using a common ontology for knowledge and information organisation helps to bridge intraorganisational gaps between different specialist departments or subject areas.

The development of a topic map for a municipality, however, poses several challenges. First of all, there is little documentation on the development (modelling) process of topic maps. Widhalm states that the topic map development process consists of seven phases: analysis, design, implementation, storing, publication, use and administration [7]. Research on topic maps concentrates on technical implementation. Conceptual questions like what steps are taken to define topics and associations, what level of abstraction makes sense for modelling, how can information needs be translated into an ontology etc. are sparsely addressed.

There are proposals for development strategies for a semantic web which might be applied to topic maps as well. Davies describes interviews and group meetings as an initial measure to gain insight into the ontology used by the future user group [11]. He also introduces more

technical approaches using text analysis tools to develop a first sketch of an ontology [11].

Conducting interviews and group meetings to make an organisation's ontology explicit is time consuming and affords considerable effort for preparation and post processing. Most interview partners are experts in their domain and the ontology used in that particular domain; rarely are they xml or topic map experts at the same time. Translating technical terms related to topic maps and the modelling process itself is an inevitable pre-requisite for a modelling workshop.

Technical approaches to topic map development are less time consuming but text analyses as a resource of topics and associations cannot provide more than a raw sketch of a topic map. The basic principle of text analyses is the statistical evaluation of the co occurrence of terms. Frequently used terms are suggested as topics and if two topics co-occur, an association between the two topics can be suggested using statistical methods. An automatically generated topic map doesn't contain information on associations and the deduction of associations based on statistics doesn't necessarily represent the ontology of an organisation.

Topic maps should reflect an organisation's individual ontology as precisely as possible to ease the search for information. In contrast to standardized key word catalogues, topic maps ought to grasp typical terms and relationships between information objects. Creating an ontology which reflects the specific needs and characteristics of an organisation, or in this case of a municipal administration, is quite time-consuming and demands considerable 'manual work'. Although sophisticated tools to support the work exist, the main work of modelling the topic map cannot be done automatically.

Another challenge arises from the fact that an organisation's ontology includes a considerable amount of tacit knowledge [12]. Thus it is not easy to make an ontology explicit. Domain experts must be instructed on how to express their knowledge to create an underlying ontology which is as explicit as possible. During this process, topic map developers must be astute to catch hints which relate associations to topics.

3.3.2 Development strategy for Stuttgart

First attempts to develop a conceptual model of a topic map for Stuttgart were influenced by the idea that a development team consisting of technical experts and domain experts (employees of Stuttgart) would be able to create a topic map in a series of group meetings. The results of the survey on information needs could provide additional input. After several meetings it became clear that such a linear strategy would not be successful: The technical experts had the impression that they could not make themselves understood by the domain experts and

the domain experts did not know how to express themselves in terms of topic maps. Further, the experiences with 'manual' ontology modeling showed that the budget for KORVIS could not afford a purely 'hand-made' topic map.

The development strategy for the topic map in KORVIS presented here was designed to meet these challenges.

Evaluation of information needs: The results on information needs collected at the beginning of the project were re-analyzed looking for hints on **information habits** of future users, the **task structure** of specific user groups and **information resources** of central importance.

Information habits describe the way people work with information resources, which combinations of sets of data or documents are of interest, and if relationships between types of documents can be identified (i.e.: "if I read a document of type A I always look at a document of type B, too"). In this project, information habits in connection with council documents could be identified. Council members sought author information for one type of council documents and for other types of documents they preferred to know the organizational unit responsible for the implementation. This explanation of information seeking behaviors provided valuable insight on topics and their associations.

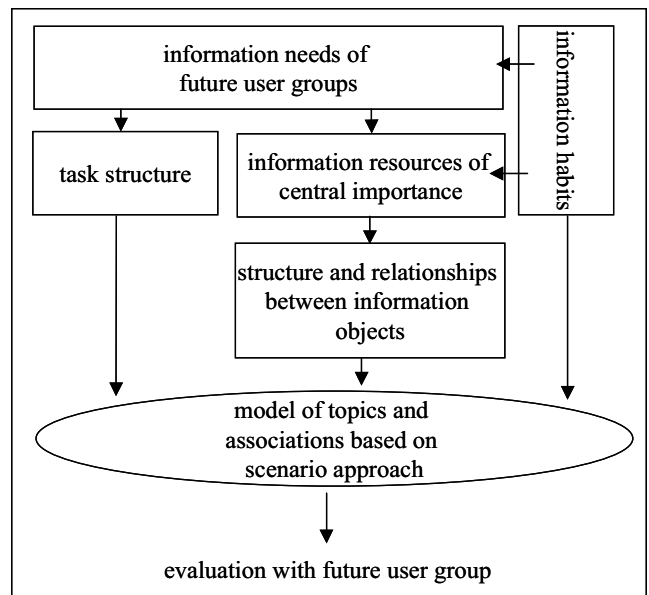


Figure 5. Development strategy

In addition to providing insight into topics and associations, the evaluation of information needs and knowledge of the task structure of municipal managers helped to identify which information resources were most important for the preparation and post-processing of council meetings. Not surprisingly, most information systems store council documents and related information

objects (the decision management system combines council decisions and project management tools). Thus, the implementation of decisions can be controlled via

milestones and reports on the progress of the implementation.

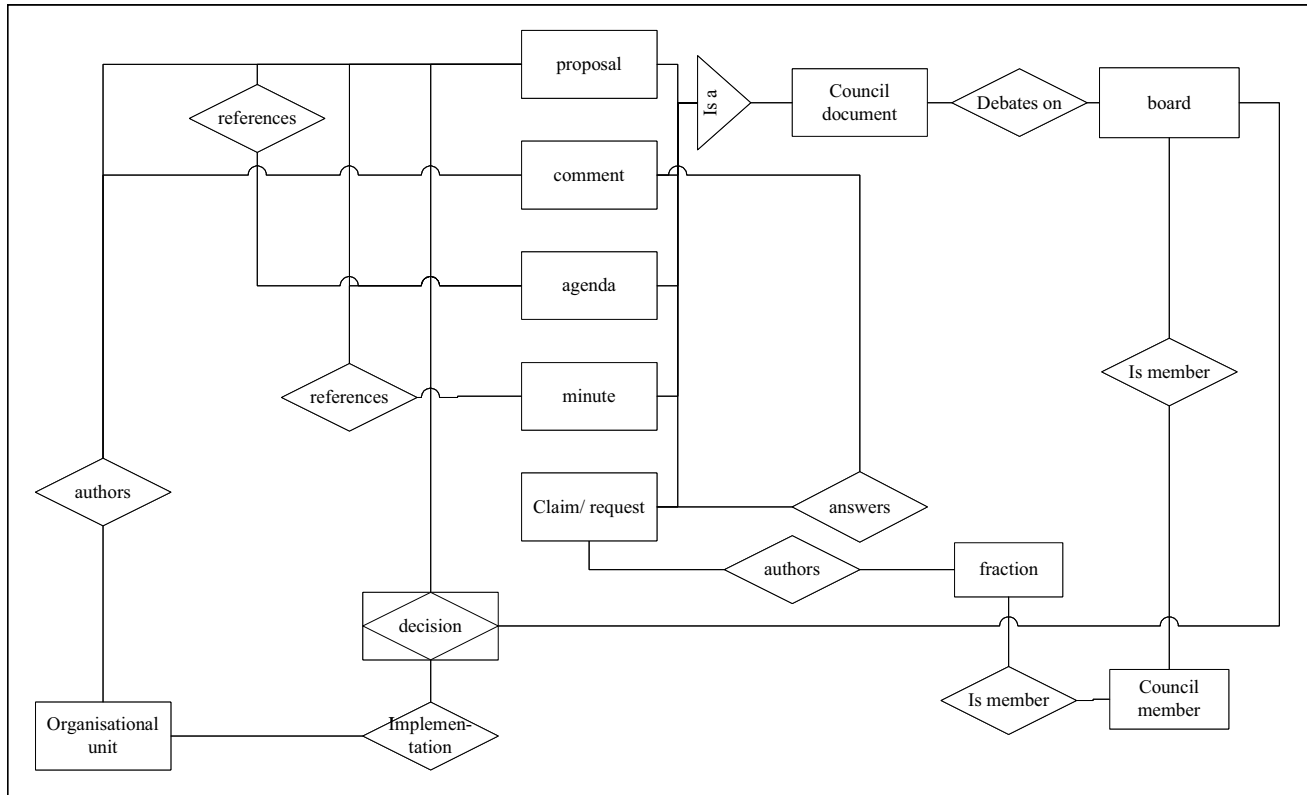


Figure 6. Relationships between information objects

Some of these information systems already provide links from information objects stored internally to information objects in other information systems. The decision management system for example provides links between the decision document, minutes of meeting discussions, the organisational unit responsible for the implementation and other information objects. The relationships between council documents and other related information objects (rudimentarily modeled in figure 6) is prescribed by the structure of council work. It can be seen as condensed domain knowledge and provides whole sets of topics and associations.

The reuse of relationship structures was the second element of the topic map development strategy in Stuttgart. Relationship structures are not only provided by information systems, but by documents or sets of documents as well. The catalogue of administrative services for Stuttgart provided associations between organizational units and administrative services and between administrative services and their legal basis. As associations already existed between organizational units and other topics derived from the council information systems, the topic map could be widened substantially

and gaps between unconnected topics could be filled. The reuse of given structures is an efficient way to add further topics and associations to the topic map: using one relationship structure, such as the services catalogue, a huge set of new topics and associations can be obtained.

The third element of the development strategy in Stuttgart is the scenario approach. Narratives describing working scenarios are frequently used as an interview technique [13] or as an instrument for knowledge management [14]. Their ability to transport a rich context connected with the narrated scenario makes them also very valuable for requirements engineering since they can form a communication medium for developers and futures users. Scenarios are used in connection with abstract concepts like semantic web or topic maps which are difficult to understand for most domain experts [10].

The initial modeling attempts for the topic map showed that communication about topic map elements and the translation of information needs into topics and associations was quite difficult. In order to find a common language for technical experts and domain experts, working scenarios were used to describe typical situations which generated specific information needs. Based on

these real life scenarios, domain experts were able to describe important information topics and associations between topics using actual examples. Technical experts were able to pose questions in order to specify statements on the nature of associations and so on.

Virtual characters like the council member 'Schütterle' or the mayor 'Pfleiderer' were invented to represent different user groups. Using the survey on information needs, a description of the characters was created based on their daily routines. Domain experts were presented descriptions of working situations of council member Schütterle or other virtual characters and asked to describe information search patterns or working patterns in terms of topics and related topics. One example scenario described council member Schütterle (a member of the board for environmental and technical issues) preparing for the next board meeting. The starting point for his preparation was the agenda for an upcoming debate. The agenda is one type of council document which already has links or topic map diction "associations" to other information objects. The agenda for each board or council meeting contains links to all the documents, proposals or administration statements which are to be discussed in the meeting. These documents are an important information source for council work. Since the relationships between the different types of council documents are prescribed by rules and therefore explicit, it was especially interesting to learn about their relationship to other information objects.

In the scenario, Schütterle looks at the agenda for tomorrow's meeting and opens the proposal for a building project. Here the scenario description ends and domain experts are asked to consider which information objects Mr. Schütterle would require to prepare for a discussion about a building project.

The domain experts in the topic map development team are administration employees who are responsible for information systems or specific subject areas and therefore have considerable experience with information requests from municipal managers. Most likely, they would suggest a city map showing the location of the proposed building project and a construction plan as information objects which might interest Mr. Schütterle. The information objects identified as important in connection with a proposal for a building project are modeled as topics with associations to the topic building project. In the next step, the technical experts define preconditions referring to necessary meta information for the implementation of the modeled associations. They used the working scenario to illustrate technical aspects and necessities of topic maps based on concrete examples and not abstract concepts.

4. Experiences

The support of unstructured ad hoc information needs is a key factor for the management of information systems in Stuttgart. Obtaining information of relevance is seen as key by many users. Municipal managers have shown considerable reluctance towards the modeling of their individual informational needs into information profiles necessary for the design of management reporting systems. Frequently uttered statements were: "We do not know what information will be important tomorrow, that depends on xy-development"; "How will information managers know, what is relevant for our decisions?"; "Who (are they) to tell me, what kind of information I need?". An exact description or definition of information needs appeared to be difficult perhaps propelled by the fear of revealing too many details about personal or party fraction strategies. As a consequence, the management information system design concentrates on instruments that react to, such as search support instruments, rather than predict information needs.

Although the concept of topic maps is difficult to convey to people lacking technical background, on an abstract level the introduction of the first prototype of a topic map supported search engine was quite successful. After brief remarks on topics, relationships and the implementation of these concepts to improve search results, the test candidates were able to use the new instrument and provide input on improvements. The topic map enabled users to search for information in several systems simultaneously for the first time and showed relationships between information objects of values to the users.

The modeling process to enlarge the topic map is ongoing. The elements of the development strategy, especially the scenario approach, now support cooperation between technical and domain experts. The reuse of existing structures and links has helped to bring the idea of a topic map for Stuttgart within an affordable range.

For KORVIS, many research questions remain unanswered. These include:

How can the topic map concept be conveyed in user group courses of more than three test candidates so that they are able to provide substantial feedback for further improvement? Can the scenario approach be used here as well?

To what extent and where can automatic instruments like text mining and statistical evaluation support the generation of topics and associations?

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