# Structuring Technical Guidelines in Fire Protection Engineering with Topic Maps

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ABSTRACT: Due to the federal structure of Germany and the continuous adaptation of engineering standards in the field of fire protection, there is a multiplicity of complex and heavily interrelated laws, technical guidelines, rules and regulations. This poses a challenge for all actors in the building planning process because for every trade structural fire protection aspects have to be considered.
In this paper, an approach based on the Topic Maps Standard to facilitate the planning-task related retrieval of fire protection regulations is described. As a result of this approach, the planner can query a term network with a text search or navigate through it in order to find the relevant information for his specific task. Considering fire protection as an example this contribution points out the aims, the requirements and an implementation approach for structuring and presenting of technical knowledge by use of semantic technologies.

## 1 INTRODUCTION

In the building planning process in Germany the structural fire protection is of great importance. For every trade of the building technical fire protection regulations have to be taken in account by the various involved planners.

Because of the federal structure of Germany, the fire protection regulations can differ in every federal state and even a local authority can enact special regulations. Furthermore, various private institutions and associations publish additional fire protection regulations which have to be observed by the building planners.

As a result, they are confronted with a multitude of laws, technical guidelines and rules concerning structural fire protection. To find the right regulations for a certain planning task, e.g. using printed media or full-text-search in electronic texts, is time-consuming and less effective.

In order to facilitate the retrieval of relevant passages in fire protection regulations, a network of terms describing the contents of the regulations and a link to them would be of great help. Firstly, the planer would get a quick overview of the used vocabulary and adjacent topics. Secondly, complementary fire protection rules which can be found in different regulations are bundled and linked to the same network terms.

In this paper an approach is presented using the ISO-Standard Topic Maps to structure the contents of fire protection regulations with a term network in order to facilitate the searching process in these documents for planners and engineers.

## 2 TECHNICAL GUIDELINES IN FIRE PROTECTION ENGINEERING IN GERMANY

This section will demonstrate the importance of structural fire protection in the building planning process and its influence on the characteristics of technical guidelines in the fire protection domain.

### 2.1 *Significance of fire protection in the planning process*

Fire protection planning in building design is a dominant aspect for the prevention of fire and for the protection of life and property in the case of fire. Therefore structural fire protection plays a major role in the building planning process and all trades of a building have to comply strictly with fire protection requirements. This fact implies that every planner, specialist in the field of a certain trade, also has to consider fire protection aspects, although not being an expert in this domain.

Furthermore, research in the field of fire protection engineering is leading to the development of progressive methods and to a frequent change of the state of the art in this domain.

Considering material damage, fire is one of the largest risks the insurance companies have to account for. Therefore, the association of property-

insurers publishes additional fire protection regulations which are - in general - stricter than the national and federal regulations. Furthermore, in addition to the different regulations of the federal states, other private institutions like the German Fire Protection Association (vfdb) also enact rules in structural fire protection.

All these aspects lead to characteristics concerning the structure of technical fire protection guidelines, rules and regulations. These characteristics will be pointed out in the following subsection.

### 2.2 *Characteristics of technical fire protection guidelines*

As mentioned above, a lot of different public and private institutions publish additional fire protection guidelines and regulations. As a result, there is a variety of different rules and regulations and their contents overlap, complete or replace each other. Furthermore, most fire protection rules do not only have an impact on a special trade but affect many trades of the building planning process. Thus, fire protection rules are generally not categorized by trades.

Nevertheless, all actors in the building planning process have to work with the complex fire protection guidelines and regulations which is time and cost consuming. Fire protection handbooks, best practice manuals, electronic full-text-search and indexing may support the planner in considering the important fire protection aspects, but for a particular planning task they are not sufficient to find the relevant regulations and rules. In order to augment the retrieval of fire protection regulations their complex contents can be structured by adding meta-information to them and by organizing the meta-information in a term network. This approach will be discussed in general and in detail in the next section.

## 3 TERM NETWORKS TO STRUCTURE THE CONTENTS OF TECHNICAL FIRE PROTECTION GUIDELINES

In the previous section the particularities of fire protection regulations and guidelines were pointed out. Due to their characteristics it is difficult and time-consuming for the planner to consult the regulations in order to comply with them. To make the search process in regulation documents more effective it is suggested to implement a network of fire protection terms based on meta-information of the contents of fire protection regulations. The requirements on the structure of such a term network will be analyzed in the next subsection. In order to implement the term network a metadata framework is needed. Therefore, Topic Maps (ISO 1999) and RDF (W3C 2004a) in combination with RDFS (W3C 2004b) could be – among others – deployed and will be compared to each other on the basis of the term network requirements. Finally, a brief description of the XTM Topic Maps Standard (TopicMaps.Org 2001) will be given. This metadata framework has been chosen to build the term network for technical fire protection guidelines with.

### 3.1 *Requirements on the term network for technical fire protection guidelines*

The term network could contain nodes which represent terms of the elements of structural fire protection and terms of elements of the building model (e.g., firewall, storey, fire area or emergency stairway). These terms could be assigned to paragraphs of the regulation documents which contain fire protection rules about the elements the terms stand for. An example could be the term “firewall” being assigned to a paragraph in which the fire resistance class of a firewall is defined. In the majority of cases the description of a paragraph by a single term is too general to get precise search results. Consequently, it should also be possible to assign two or even more terms to a particular paragraph. According to a paragraph in the fire protection regulations, a firewall of a central heating room located in the basement has to conform to a higher fire resistance class. The term-bundle “firewall” “central heating room” and “basement” could be assigned to this paragraph. As well as simple nexuses between terms, semantic connections - in form of verbs - should be possible to augment the expressiveness of the term network. One example of a semantic connection could be the expression “has a” between the term “emergency stairway” and the term “window”.

As planners of different disciplines have to consult fire protection regulations, they often use their own terminology and have their own discipline-specific perception in mind. In order to take this aspect into account synonyms should be represented in the term network.

The suggested term network can be implemented with different metadata frameworks. In the next subsection two of them will be compared taking into consideration the requirements pointed out in this section.

### 3.2 *Comparison of Topic Maps with RDF/RDFS*

In the wider context of semantic search, the metadata framework RDF in combination with ontologies, formulated in RDFS or OWL (W3C 2004c) is mainly applied in current research. The Resource Description Framework (RDF), standardized from W3C, is a very generic and minimalistic framework to describe metadata for the World Wide Web, yet very flexible at the same time. The framework focuses on the description of metadata which is machine-processable and which consists of only three

components: *resources*, *properties* and *statements*. The RDF-statement is structured in form of an English sentence with a subject (the *resource*), a verb (the *property*) and an object (the *value*). Different *resources* can also be linked by *properties*. As with RDF neither properties nor relationships between *properties* and other *resources* can be described, the schema language RDFS was developed. RDFS allows this description by providing classes and properties.

Referring to the requirements of the suggested term network, RDF/RDFS can be used to implement the network, because of its flexible generic nature. However, relationships between more than two terms can only be expressed with workarounds. Furthermore, an intuitive mechanism to assign elements of the network to particular passages in electronic regulation documents does not exist.

In addition to the metadata framework RDF/RDFS, the Topic Maps Standard, originally developed to merge back-of-the-book indexes, is also applied in the area of knowledge management. This ISO-Standard offers an intuitive description of knowledge structure and the possibility to assign information to this structure. A Topic Map can be described as a link network of metadata which is stored separately from the information resources but the elements of the network can be connected to the resources (Rath 2003) (Fig. 1).

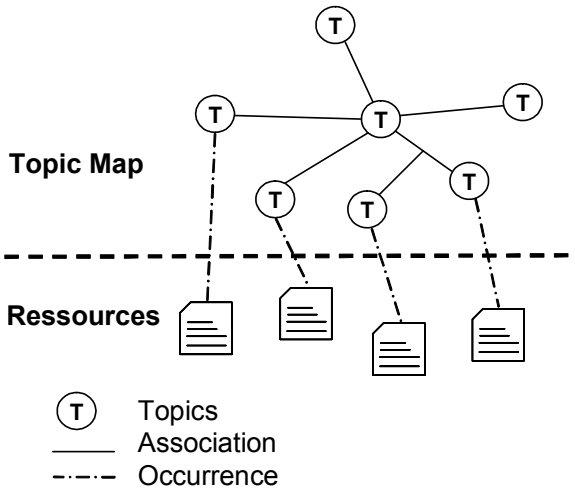


Figure 1. Elements of Topic Maps

Topic Maps mainly consist of *topics*, *associations* and *occurrences*. The *topics* represent objects from the real world in the broadest sense, e.g. building components. The *associations* can interlink two or more *topics*. The information (e.g., a book, a hyperlink, a document) to the *topic* is assigned by *occurrences*. Additionally, the element *scope* makes it possible to express the view of different planners in the same Topic Map, so that synonyms or different terminologies in the fire-protection domain can be represented. Consequently, the Topic Maps Standard focuses on representing knowledge for the perspective of humans (Pepper 2002) and includes an intuitive, rich but also flexible data model. Therefore, the term network will be modeled using the XTM Topic Maps Standard whose elements and structure will be briefly presented in the next subsection.

### 3.3 *Elements and structure of XTM Topic Maps*

In this section, a short introduction to XTM Topic Maps based on Pepper (2000) will be given. The core elements will be mainly explained. They will be used later in the fire protection term network. A comprehensive description of all elements of the data model is out of the scope of this paper.

The following remarks refer to the XML Topic Maps language which differs from an older standard called HyTM which is rarely used in nowadays.

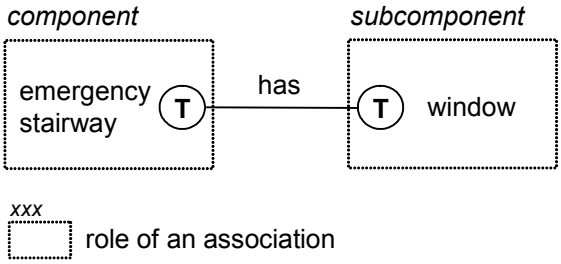


Figure 2. Associations in Topic Maps

The most important element of the subject-centric standard is the *topic* itself. It has a name and can be a representation of any physical or non-physical subject. In case of the developed term network it is used to model the fire protection terms. *Topics* can also have one or more *topic types* which allow modeling hierarchical relations like a “firewall” being “building component”. The *topics* can be interlinked by *associations*. An *association* does not have an implicit direction but can be determined by either the human reader or by the role that the two *topics* have in the *association*. In Figure 2, the direction of the *association* is fixed because it is obvious for the human reader that a component can have a subcomponent but not vice versa. Among *associations* between two *topics*, n-array *associations* can also be modeled with Topic Maps.

Using the described elements, a network of metadata can be built expressing coherences between the different contents of fire protection regulations. The connection of the network to the electronic resources is realized by *occurrences*. *Occurrences* are available to assign *associations* and *topics* to the underlying information resources (electronic documents). Another important element in Topic Maps is the *scope*. *Topics*, *associations* and *occurrences* can have two or more *scopes* allowing for multiple contexts. Existing synonyms in the different regulations and technical guidelines treating fire protection issues can be represented by *scopes* for the names of the *topics* in the term network.

It is also possible to assign the characteristics (names, *associations* and *occurrences*) of a *topic* to *associations* and *occurrences* using the technique of reification. This means, creating a *topic* which does not represents a subject of the real world but rather an element in the Topic Map itself. As a result, the characteristics of this *topic* also belong to the Topic Map element (*association* or *occurrence*) it reifies.

In the presented approach, this technique is mainly used to name *associations* and to assign not only *topics* to paragraphs of electronic documents but is also used to assign *associations* to the electronic resources.

The next section shows how a term network structuring fire protection regulations can be built on the basis of Topic Maps and with use of an implemented editing tool.

## 4 BUILDING THE TERM NETWORK WITH TOPIC MAPS

In the last section, possible metadata frameworks to implement the term network for fire protection regulations were discussed and the Topic Maps Standard was chosen because of his flexible and intuitive design and its focus to offer a human-oriented knowledge representation. In the next subsection the structure and the creation of the term network and the implemented editing tool, which supports the creation, will be described. Furthermore, the creation process of the term network will be illustrated.

### 4.1 *Structure and creation of the term network*

The structure of the suggested term network is simple and adapted to the contents of the regulation texts for which it should serve as a metadata layer. The network contains only few elements which are:

- *topics* with names (for fire protection terms)
- typed *associations* between two *topics* (to link two terms with a verb)
- untyped *associations* between more than two *topics* (to bundle multiple fire protection terms)

Each of these elements can be assigned to one or more particular paragraphs in fire protection regulation texts which should be available in html-format (Fig. 3). The connection of network elements with the underlying electronic documents is realized by *occurrences* which contain the URLs of the specific part of the document (e.g., one paragraph).

As in Germany fire protection regulations often differ for each federal state, *scopes* are used to specify the *occurrence* which connects a network element to the electronic resource (Fig. 5).

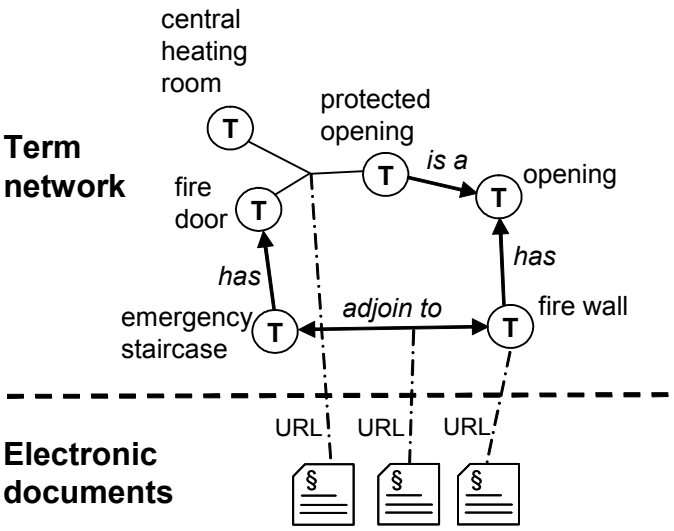

Figure 3. Structure of the term network

Additionally, the *scope* for an *occurrence* is used to attach further characteristics to the referenced regulation paragraph e.g., for which building type (e.g., fire proof doors in hospitals) the paragraph is valid.

A single term which is connected to a particular regulation passage only allows a very general metadata description of what the specific paragraph is about. Connecting two terms with one verb and assigning this "phrase" to a paragraph gives a more differentiated description of its content. One example could be a paragraph containing requirements of windows in safe staircases which will be assigned to the *association* "has" which connects the *topics* "safe staircase" and "window". In addition, through the connection of more than two *topics* by an untyped *association* it is possible to describe complex assertions of paragraphs. To cite an example, a particular paragraph in one regulation contains special fire protection requirements for partition walls in assembly rooms which are located on the ground floor. This paragraph could be assigned to the bundle of *topics* (inter-linked with untyped *associations*) "partition wall", "assembly room" and "ground floor". Furthermore, it is possible that in two regulations - treating the same fire protection aspect - different terms are used, like "fire protection wall" and "fire wall". This means that each *topic* can have a list of synonyms expressed with the Topic Maps element *scope*.

The last examples show that the application of fire protection rules depends on many aspects like building type, occupancy, location etc. Due to this complexity the term network has to reflect these technical correlations as accurately as possible to assure that the planner finds the right fire regulations for his specific planning task. This is the reason for creating the term network manually by a fire protection expert.

As this expert generally does not have skills in abstract knowledge representation standards an editing tool with a graphical user interface was imple-

mented which encapsulates the used Topic Maps Standard and is geared to the linguistical needs of the field of structural fire protection.

The next subsection demonstrates how to create term network elements and how to assign them to the electronic information source.

### 4.2 *Annotation of an exemplary fire protection regulation paragraph*

In this subsection it is shown, based on a concrete paragraph, how fire protection regulations in the form of electronic documents can be structured with the term network by using the Topic Maps Standard. A regulation for staircases in residential buildings with more than five storeys contains the following passage:

*The staircase which is located inside the building may only be accessible by a separate anteroom.*

This fire protection rule should prevent that - in case of fire - smoke can easily reach the inside of the staircase which serves as fire rescue path. This rule only exists for the federal state Hessen.

The expert, who creates and maintains the term network will add the *topics* "emergency staircase" and "anteroom" to it (in case they do not exist yet) and will connect the two *topics* with the *association* "adjoins to". Then he will assign this *association* to the cited paragraph with an *occurrence* which contains the hyperlink to the html-document of the paragraph text. Furthermore, he will add the *scope* "Hessian" and the *scope* "residential building with more than five storeys" to this *occurrence*.

Up to this point, the term network is created and linked to the different electronic documents which contain the fire protection regulation texts. In order to utilize the term network to facilitate the retrieval of specific regulation paragraphs it has to be put to the disposal of the building planner. The user interface of the term network will be discussed in the next section. Furthermore, an implemented search tool using the term network will be presented.

## 5 THE TERM NETWORK AS A SEARCH INSTRUMENT FOR FIRE PROTECTION REGULATIONS

In the previous sections, it was described how the content of the different complex fire protection regulations and technical guidelines in Germany can be structured by a term network expressed in the Topic Maps Standard. In the following subsection the requirements for a representation of the term network to the user, bearing in mind the application domain, will be discussed. Finally, an implemented search tool using the term network will be presented.

### 5.1 *Requirements for the user interface of the term network*

Due to the complexity of fire protection rules and because of the fact that building planners in general do not have expert knowledge in the fire protection domain, they are not well acquainted in fire protection terminology and the complex structure of regulation documents. That is why the network of fire protection terms should be graphically presented to them. A graphical user interface – for which Topic Maps are predestinated – allows the planner to navigate in the term network if he does not know the exact technical terms for the subject he is searching for. Even if he knows the exact term the network representation shows adjacent subject areas which can also be of interest to him. However, there should be a mechanism to present only the specific area of interest of the term network to the planner. Otherwise he could not find the *topics* he is searching for because of an overloaded representation.

The mentioned aspects have been considered for the implementation of the search tool "Fire Protection Navigator". This software tool will be introduced in the following subsection, referring to the regulation paragraph of subsection 4.2.

### 5.2 *Application examples*

The search tool "Fire Protection Navigator" is presented using the following scenario to demonstrate the advantages of a search in regulation documents with Topic Maps:

*An architect who has to plan a residential building with six storeys in Hesse wants to integrate emergency staircases which are located inside the building. He does not know which fire protection rules he has to comply with for these staircases.*

In order to find relevant regulations, he uses the "Fire Protection Navigator" which offers him a graphical network of fire protection terms which are associated to the regulation documents.

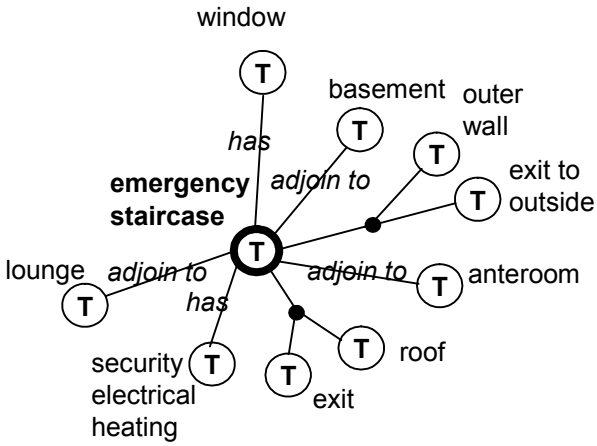


Figure 4. Graphical representation of the term network

In order to choose the relevant section of the network for his question, he may use a free-text search

field. He enters the word “emergency staircase” in the field. As a result, the specific section of the network is displayed (Fig. 4).

The architect could now choose the *topic* “emergency staircase” and would get a long list of regulation paragraphs which are linked to this term. As this list also contains paragraphs of other federal states he could filter these paragraphs by constraining the search to documents which are only valid to “Hesse” and to the type “residential building” as it is demonstrated in Figure 5.

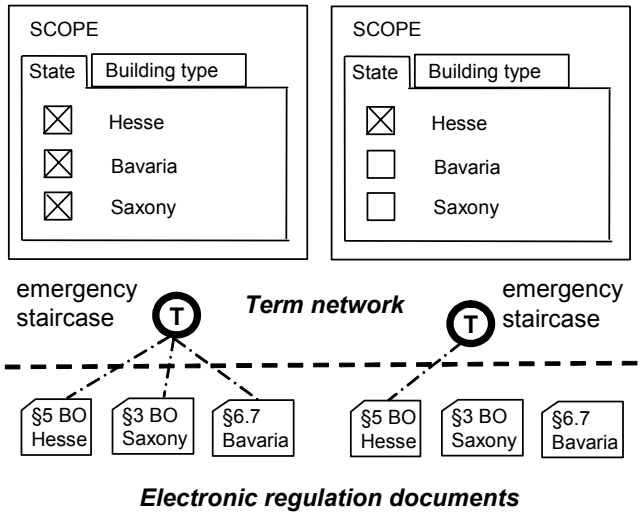


Figure 5. The effect of scopes for occurrences

As a result he would find most of the relevant paragraphs but not the one of subsection 4.2, because in this paragraph the word “staircase” and not “emergency staircase” is used although the fire protection rule is actually also related to emergency staircases which are located inside the building. But due to the network representation of the fire protection terms the architect recognizes that there are staircases which have anterooms. Thus, he clicks on the *association* “adjoin to” which connects the *topics* “emergency staircase” and “anteroom”. As a result he gets the link to the important Hessian paragraph stating that in this case the emergency staircases must obligatorily have an anteroom.

The fire protection navigator is implemented in Java using the Topic Maps library TM4J (Ahmed 2003) and the graphics library TOUCHGRAPH (Shapiro 2005).

## 6 RELATED WORKS

In the domain of knowledge management in civil engineering, two big research projects on the level of the European Union have principally to be mentioned. Within the scope of the e-Cognos project (Bourdeau et al. 2001) an extensive multilingual ontology for the construction domain was developed in the DAML+OIL (Horrocks et al. 2001) ontology language. This ontology can serve together with implemented services to create, to capture, to index and to retrieve disseminated knowledge in the construction sector.

One of the aims of the European FUNSIEC-project (Lima et al. 2004) is the development of an Open Semantic Infrastructure for the European Construction Sector (OSIEC). In order to realize this aim FUNSIEC reverts to existing norms and ontologies like IFC and e-Cognos. These projects focus on the integration of information resources of the whole construction domain and follow a generic approach including European wide standardizations while the approach of this paper is to cover the needs of a specific field in the construction domain. In order to structure fire protection regulations in (Rueppel 2002) and (Meissner et al. 2004), first approaches of a rule based expert system have been introduced. This system allows for validation of fire protection concepts. Admittedly, only hard fire protection rules can be analyzed by the system.

## 7 CONCLUSIONS

In this paper, the complexity of regulations and technical guidelines of fire protection is pointed out. The fire protection rules in Germany are disseminated over different regulations, they are not categorized by building trades and they are often interwoven. As a result, it is difficult and time consuming for the planners of a building to find all relevant fire protection rules for a particular planning task.

In order to offer a semantic search in regulation documents to the planner a network of fire protection terms was introduced which serves as a metadata layer whose elements are connected to the underlying electronic resources. The term network is based on the ISO-Standard Topic Maps whose advantages to RDF/RDFS for this special use case were pointed out. The creation of the term network has to be done manually by fire protection experts to guarantee exact search results. They are supported in this task by an implemented editing tool which encapsulates the abstract data model of Topic Maps.

Furthermore, it was decided to support the planner in his search with a graphical user interface. The visualization allows the planner to navigate in the network and finally to display the electronic documents which are assigned to the network elements. As a result, the planner may realize connections between different fire protection rules easier. Furthermore, the network offers extra information about adjacent subjects of interest to him which was demonstrated within a previous example.

In order to structure the contents of different electronic resource types (databases, documents etc.) and in order to structure larger knowledge bases, an ontology-driven approach should be preferred because of its higher expressiveness and better valida-

tion mechanisms. But to realize a quick gain for the retrieval of documents in a limited knowledge base of a special construction domain Topic Maps can be a possible practice-oriented alternative to highly formal ontology approaches.

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