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Multi-Perspective Multi-Hierarchical Topic Maps

Ontology and a Method

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Multi-Perspective Multi-Hierarchical Topic Maps; Ontology and a Method

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Abstract. This paper presents our achievements in a project done in Department of Informatics, UiO. We present the motivation and the development of our project. Topic maps ware used in this project and we discussed their important property of being neutral towards hierarchies. We also discuss the nature of perspective relationships from a philosophical point of view, and how they can be represented in a topic map ontology. We then propose a method for building knowledge bases by collaboration of multiple experts, using the topic maps and the perspective relationships described.

1. Introduction

This paper presents our achievements on a project whose theme was user manuals. The initial project description for this project was written around the idea that the user manual for software libraries, which are built using paper based technology, is not very suitable for the user at all. We have chosen the programmer's manual for the High Level Architecture Run-Time Infrastructure implementation by US Defense Modeling and Simulation Office (DMSO), RTI1.3NG [15].

The first solution we considered was to identify some predetermined perspective points, or scopes, then to present the manual from those. We identified six scopes, and started working on a navigational structure which consisted of a combination of a scope navigation and a subject navigation. But in the process, the subject navigation turned out to be a hard problem, since it seems that any hierarchy on the subjects becomes only an imposed one, so we decided to represent it as a graph. As soon as we considered representing the subject structure in a graph, we moved into the direction of topic maps and semantic networks.

Semantic networks we didn't consider further, mostly because we came across a web site compiler called xSiteAble [16]. The xSiteAble is an open source tool for compiling a web site out of an XML description of a topic map, and unlike Omnigator of Ontopia [17], xSiteAble creates web sites also suitable for end-users.

The topic maps are neutral towards hierarchies letting the designer of the topic map use any combination of hierarchies emerging out of a more or less flat structure. Thus our decision of using topic maps provided a remedy of multiple hierarchies problem,

but our problem with the predefined scopes (perspective points) remained. The solution we devised was to encode the perspective relationships into the topic map itself, thereby using the navigational structures provided by the xSiteAble for browsing the topic map, and also generalizing the method we're going to propose to be implementable with any topic-map based tool. Thus we came up with the perspective relationships described in this paper.

One problem with xSiteAble is that it allows only binary relationships, and the philosophical nature of the perspective relationship suggests ternary and quadruple ones. Thus we also needed to come up with ways of reducing the ternary and quadruple relationships into sets of binary ones.

Using topic maps to represent the multiple perspectives has also implications for the collaborative work: whenever multiple experts are present for providing information on a subject matter, it's almost inevitable that different/contradictory explanations/perspectives for specific parts of the subject will arise. It is known that it's even hard to get one expert alone into explaining his/her expertise, which is a major issue in knowledge engineering, and cognitive psychology also covers some aspects of the problem. What is usually done in such situations is to attempt at persuading the experts at arriving at a shared definition usually through negotiations. These negotiations can be painful (both economically and psychologically), and usually precision is traded for accuracy and inclusion. So goes the saying "Camel is a horse designed by a committee." The method we present in the fourth section is aimed at this problem of building knowledge bases in a collaborative manner.

So the project started with the idea of building better software manuals, and I the course turned into an investigation of perspective relations and their representation using the topic maps, to be used as a collaboration tool for building knowledge bases.

2. Topic-Maps and Hierarchies

The concept of topic map has its roots in efforts to understand the essential semantics of back-of-book indexes in order that they might be captured in a form suitable for computer processing. Once understood, the model of a back-of-book index was generalized in order to cover the needs of digital information, and extended to encompass glossaries and thesauri, as well as indexes. The resulting core model, of typed topics, associations, and occurrences, has many similarities with the semantic networks developed by the artificial intelligence community for representing knowledge structures [9].

Another motivation for topic maps was the need to be able to merge indexes [10]. This was later extended to other forms of navigational aid: the electronic equivalents of not only printed indexes, but also tables of contents, glossaries, thesauri, cross references, etc. Common to all these applications is the attempt to provide access to information based on a model of the knowledge it contains. Topic maps became and ISO Standard in 1998.

At the heart of the topic model lies the concept of the topic. The topic can be anything about which anything whatsoever may be asserted by means whatsoever. Topics most often have three kinds of characteristics: they have names, occurrences

and roles in associations. In addition they can most often be described in a scope, meaning that topics can have different meanings in different scopes [11]. Garshol presents this another way – claiming that topics have names, i.e. something that describes the topic [12]. Topics have relationships between topics, which are called associations. Each topic in an association is said to play a role, and are defined by the role type. Topics also have occurrences, which are information resources to a relevant topic. Besides, topics may also have types.

Topic maps are neutral towards hierarchical structures. It doesn't support any particular hierarchical structure – but building a topic map, you can use any structure you want, including hierarchical structures. An hierarchical structure can be represented as a tree structure. In fact a 'meaningful tree' that divides into branches with every step down the hierarchy. Topic Maps are organized as ontologies, a network model, instead of a hierarchical model, and is much less rigid. Because the network of terms is stored in a separate semantic layer, there is no need to change existing systems [13].

Thus topic maps transcend the spatial organizational metaphors [14] and present a structure in which one "topic" can occur virtually in many places/context. Thus the flat graph structure is not flat per se, but it has a suitable structure to be navigated/processed with regard to multiple criteria.

3. Representing Multiple Perspectives Using Topic Maps

Perspectivism, which is usually mistaken for relativism, has roots all the way back to Leibniz's philosophy. In one of his lectures, Gilles Deleuze discusses the conditions that lead Leibniz to formulate what he calls the "first great theory in philosophy of perspective", and critically analyzes Leibniz's approach to provide an introduction for Leibniz's philosophy [1]. In the web site entitled "The Isms Book", Peter Saint-André defines the perspectivism as follows:

> **Perspectivism** (Idea in epistemology) — Perspectivism is the idea that judgments of truth and value depend on one's "perspective". This view is similar to contextualism and can be a valuable tonic to intrinsicism. However, some "radical" versions of perspectivism (for example some interpretations of Nietzsche's thought) come close to making perspectivism a virulent form of relativism. [Reference from nihilism.] [2]

This seems to be a somewhat accurate definition, but it definitely is not precise, and may miss the mark if one tries to work towards the details in the direction of this definition. Steve Palmquist points toward the differentiation between relativism and perspectivism in the 24th lecture in his book [3]. There are many essays and articles written on perspectivism, for two relatively introductory examples, see the essay by Brian Boeninger [4], which won the 1997 UCCS Philosophy Paper Contest, and the book by Steven Hales and Rex Welshon [5]. Karabeg also takes a perspectivist stance implicitly in his description of the polyscopic modeling [6], through his second, fourth and fifth postulates.

3.1 The Nature of Perspective Relationship

When we look into the nature of the perspective relations, it turns out that a perspective relation can be either a ternary (involving three topics) or a quadruple (involving four topics) relation. In the ternary case, the related are the perspective content, the perspective provider, and the perspective subject, or in other words the specified topic as in Figure 1. The semantics of the relation is that one person provides his/her own view on one subject, which constitutes the perspective content.

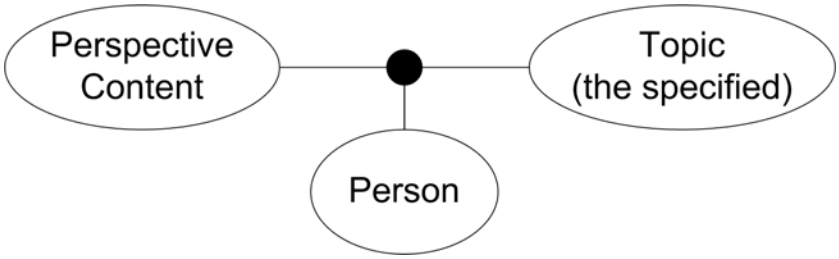

Figure 1 The ternary form of the perspective relationship.

In the quadruple case, the related are the ones in the ternary case, and one other topic which we name as the specifier topic as shown in Figure 2. The semantics for the quadruple relation is that from the point of one topic's subject (the specifier topic), the other topic (the specified topic) can be described. This observation that such a relationship exists is made by the person who is part of the perspective relationship and the explanation is in the perspective content topic.

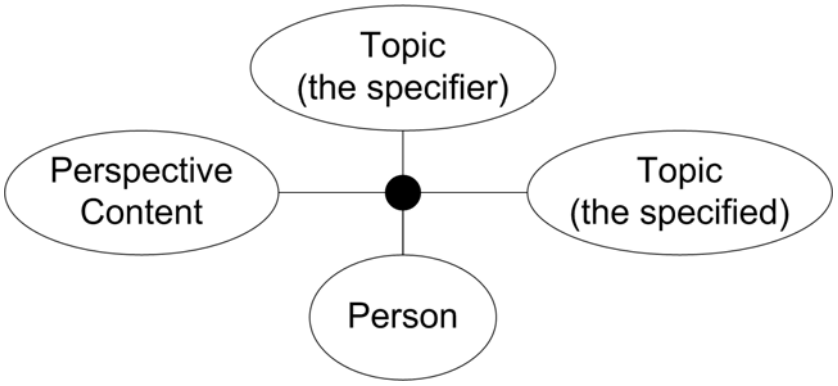

Figure 2 The quadruple form of the perspective relationship.

The topic for the perspective content has one distinguishing property that it is specific to a relationship: semantically, two different perspective relationships may share any person, specifier (if exists) or specified topics, but not the perspective content topic. One unique perspective content topic should exist per each perspective relationship in a topic map.

One of the things that should be stressed about the quadruple form of the perspective relationship is that because of the possibility of the specified topic and the specifier topic being of the same nature, a situation which we don't observe in the ternary case, the quadruple perspective relation is directed with respect to two of its constituents: the specifier and the specified. Thus, in one perspective relation, a topic A might act as the specifier in a relationship having some other topic B as the specified, while in another relationship this specified topic B might act as the specifier and A might become the specified. Giving concrete examples to this case is not easy, but the informational approach to physics and physical approach to information illustrates the point.

There are also the cases that the perspective provider might want to provide perspectives with regard to multiple topics, multiple specifier topics, or perspectives having multiple topics as the specified topics, or both multiple specifier topics and multiple specified topics. Our answer to such an argument that the nature of the perspective relation is still either ternary or quadruple, but in such a case the relation involves a set of specifier topics and/or a set of specified topics. One way to represent such sets in topic maps would be to introduce a set membership relation into the ontology and one set topic, which can be used as the specifier or the specified topic of a perspective relation as defined in this paper.

3.2 Reducing the Perspective Relationship to a Set of Binary Relationships

Not every tool for topic-maps provide support for ternary or higher dimensional relationships. Since the tool that was decided to be used in the project that caused this work be done was supporting only binary relationships, we derived forms of perspective relationship reduced to a set of binary relationships. It turns out that for both forms, the ternary or the quadruple, there are two major ways of establishing this reduction: fully connecting all the related topics or reifying the perspective relation.

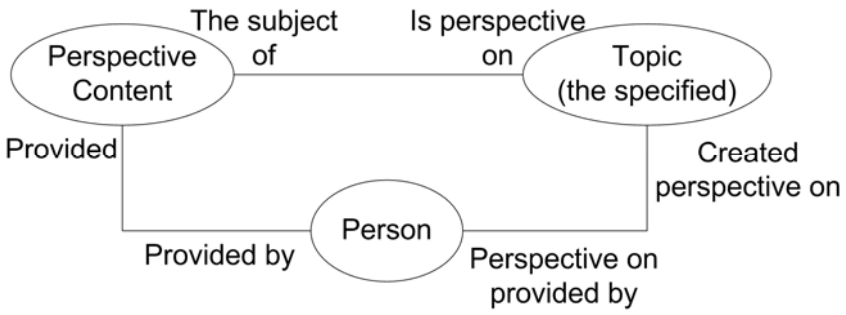

Figure 3 Fully connected reduction of the ternary form of perspective relation.

For the ternary case, the fully connecting solution ends up in three binary relations involved, as shown in Figure 3. In the relation between the perspective content and the specified topic, the perspective content topic is the perspective on the specified topic, and the topic is the subject of the perspective content, and in the tool we used,

the links of these topics appear in each other's web pages under the headings of "Is perspective on", in the page of the topic serving as the perspective content, as shown in Figure 4, and "The subject of perspective", in the page of the specified topic, as shown in Figure 5. The other two relations are similar, and have similar appearances in the respective web pages. For the relation between the specified topic and the person, and the relation between the person and the perspective content the situations are similar as shown in Figure 4, Figure 5, and Figure 6.

Figure 4 The web page for the perspective content in a ternary perspective relation example.

Figure 5 The web page for the specified topic in a ternary perspective relation example**.**

Figure 6 The web page for the person in a ternary perspective relation example.

For the quadruple form of the perspective relationship, we end up with six different binary relationships after reducing to a fully connected structure, as shown in Figure 7. The quadruple reduction structure includes the reduction pattern of the ternary form, which occurs between the specified topic, the person topic and the perspective content topic, and the addition of the specifier topic and its related links. The web pages showing the topics that participate in a quadruple perspective relationship, in a fully connected manner, in the tool used in the project for demonstration of concept is given in Figure 8, Figure 9, Figure 10, and Figure 11.

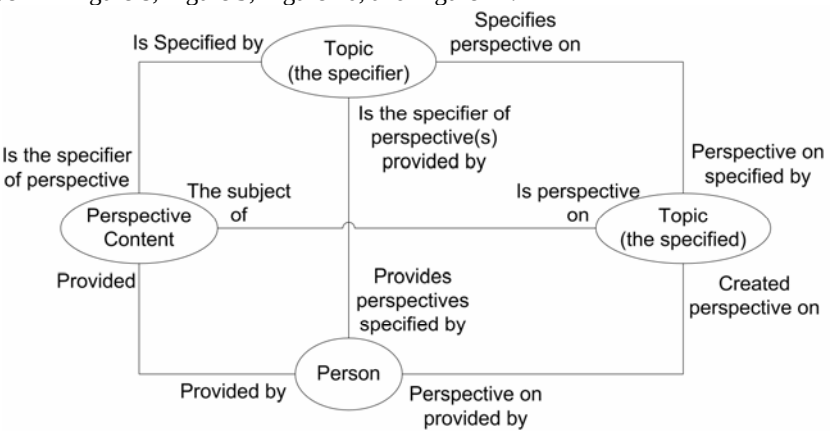

Figure 7 The fully connected reduction of the quadruple form of the perspective relation.

Figure 8 The web page for the perspective content in a quadruple perspective relationship example.

Figure 9 The web page for the person in a quadruple perspective relationship example.

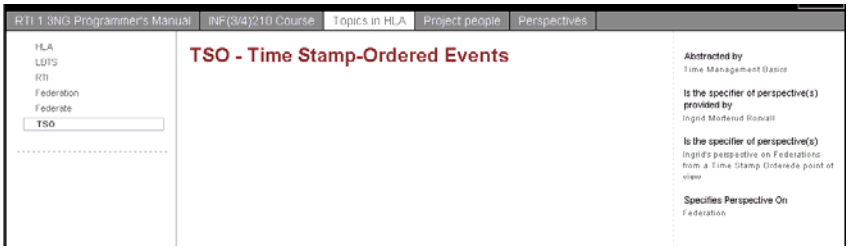

Figure 10 The web page for the specifier topic in a quadruple perspective relationship example.

Figure 11 The web page for the specified topic in a quadruple perspective relationship example.

The other way of reducing the perspective relationship to a set of binary relationships is to reify the perspective relationship as shown in Figure 12 and Figure 13. But the reified relation topic lacks content, thus the contents of the perspective content topic, which is specific to a perspective relation, can be moved into the reified relationship topic, as shown in Figure 14 and Figure 18. Examples to how these reified relationships might appear in web pages for the topics are shown in Figure 15, Figure 16, and Figure 17 for the ternary case; and in Figure 19, Figure 20, Figure 21, and Figure 22 for the quadruple case.

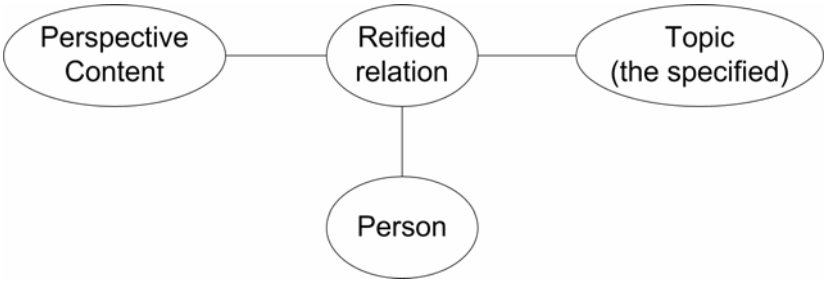

Figure 12 The reduction of ternary perspective relationship by reification.

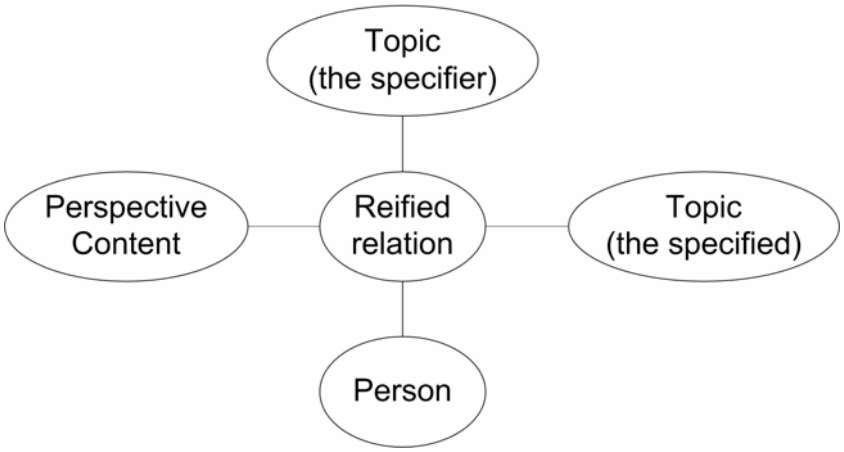

Figure 13 The reduction of quadruple form of perspective relationship by reification.

Figure 14 The reduction of ternary perspective relationship by reification, after moving the contents of the perspective content into the reified relation topic.

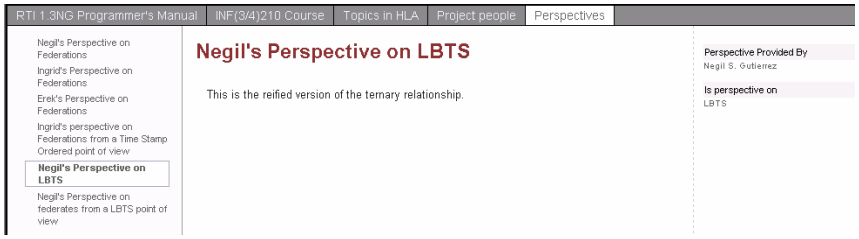

Figure 15 The web page for the perspective content which serves as the reified relationship in the example for reduction of the ternary form of perspective relationship by reification.

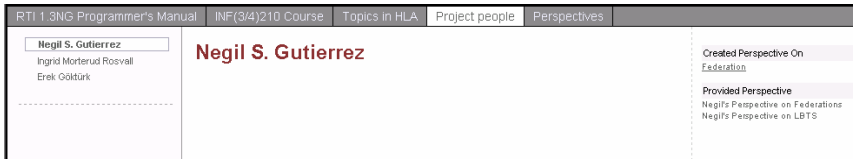

Figure 16 The web page for the person in the example for reduction of the ternary form of perspective relationship by reification.

Figure 17 The web page for the specified topic in the example for reduction of the ternary form of perspective relationship by reification.

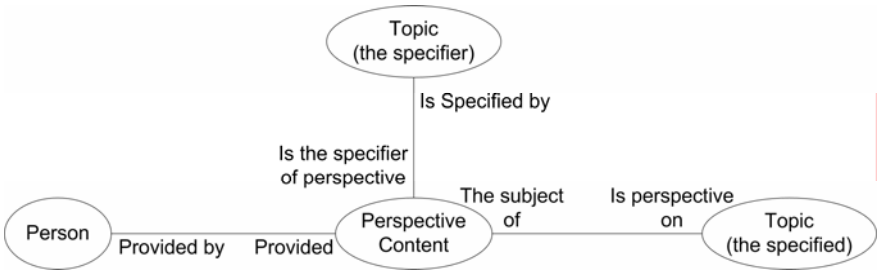

Figure 18 The reduction of quadruple form of the perspective relationship by reification, after moving the contents of the perspective content into the reified relation topic.

Figure 19 The web page for the perspective content which serves as the reified relationship in the example for reduction of the quadruple form of perspective relationship by reification.

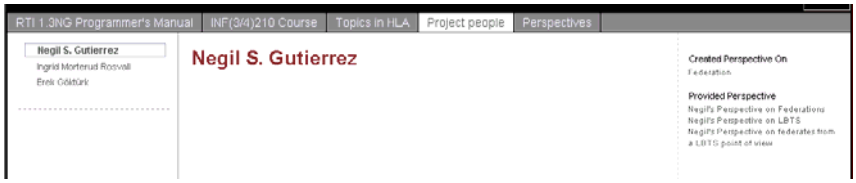

Figure 20 The web page for the person in the example for reduction of the quadruple form of perspective relationship by reification.

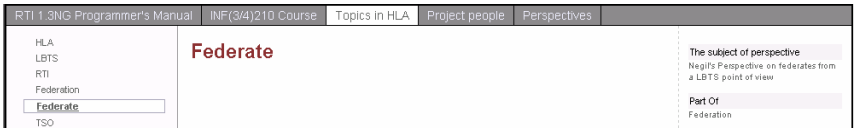

Figure 21 The web page for the specified topic in the example for reduction of the quadruple form of perspective relationship by reification.

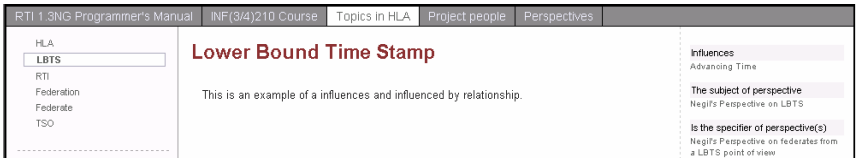

Figure 22 The web page for the specifier topic in the example for reduction of the quadruple form of perspective relationship by reification.

4. The Case Study and A Proposal for a Method

The case we used to study these concepts was building of a electronic manual related to the High Level Architecture (HLA). The HLA is a standard framework for building composable simulations, emphasizing the reuse of previously developed ones. The HLA consists of rules, a specification for documentation of the interfaces of component simulations, and the specification of services to be provided to the component simulation implementers. The manual we used was the programmer's manual of one specific implementation of the software library that provides these services, the HLA RTI1.3NG. For an overview of HLA, see [18].

We started by taking the ready-made programmer's manual and turned the table of contents to a topic map with the hierarchy suggested by the structure of chapters, sections and sub-sections. This served as a starting point, and also acted as a navigational index structure into the perspectives and the core topics: people with experience on the paper version still find the same structure on the resulting web site, and they would also have links to further information. It's very difficult to structure the core concepts, thus the manual also served as the first attempt at structuring the topics identified through the manual itself.

So the second step in our method was to identify the core concepts that are to be turned into a topic, just by going through the text of the manual and extracting terminology (usually in noun form) either specific to the manual's subject, or very key to the subject's operation/understanding, to be turned into topics with empty contents. This idea of identification of ontological elements from natural language descriptions is also found in software engineering (Abbott's method for object identification from natural language descriptions [7,8]). The natural language method is probably not the only method for identification of topics, and any other technique would also fit into this step.

In our case study, we three authors then assumed the role of experts who is supposed to provide content for the material, and observed that in creation of new

perspective relations and perspective content topics the interaction between the experts can be reduced to none at all, with some software controlling access to the topic map representation and allowing the experts only to edit their own perspective relations and their corresponding perspective content topics. At this stage there should also be a way for experts to introduce new topics into the list of topics identified in the second step, and our considerations for such entries are that they should be infrequent, meaning there should not be a huge number of new topics proposed by the experts if the manual is written good enough, and a person assuming the role of mediator/arbitrator for such requests might turn out to be of use.

Then in the last step, now that the experts explained the topics they want to, it's possible for an authority, say the whole group of experts, some other person or a mixture, to analyze the perspective topics to come up with shared definitions that are to constitute the contents or explanations of the topics for which various perspectives are provided for. We suggest at this point keeping the original perspective topics as well so that the discrepancies and similarities, discovered in the last step or missed, will be also visible to the final user/consumer of the information.

It must also be said that this method resembles quite a lot to the waterfall model in software engineering, as shown in Figure 23, and as in the waterfall model, our model also acknowledges the possibility of transitions in the backward direction as well. Suitability of other models, such as the spiral model, is an interesting open question.

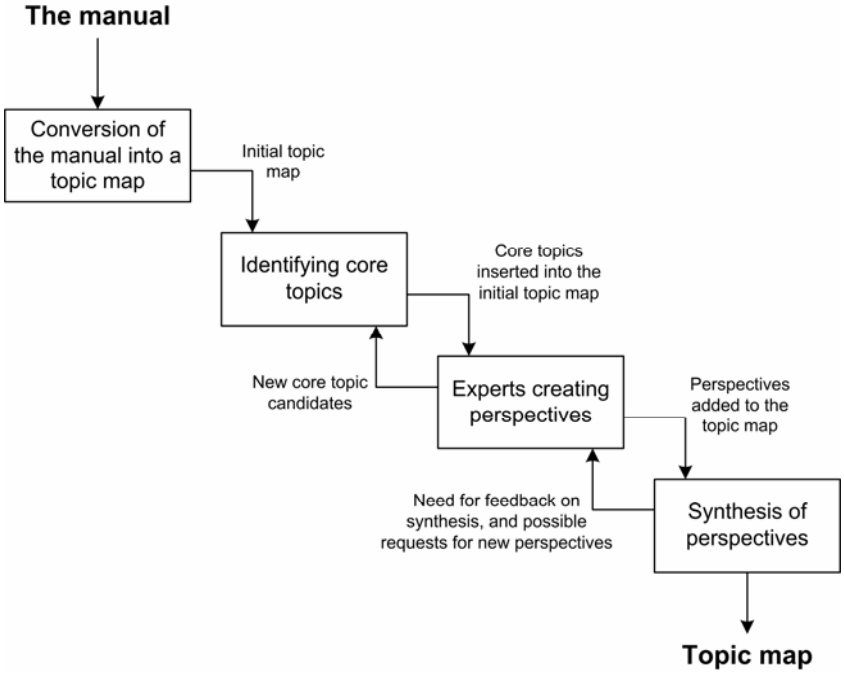

Figure 23 The model for building a knowledge base using topic maps as the representational tool, guided by a manual.

5. Conclusion

In this paper, we discussed one important property of topic maps being neutral towards hierarchies, that is topic maps are good for representing multiple intermingled hierarchies, and then described the nature of perspective relationships and how they might be represented in a topic map: the ontological and semantic implications. Finally we proposed a method for collaboratively building a knowledge base using topic maps with multiple perspective relations.

It must be noted that the different ways of reducing the perspective relationships have pros and cons. Although the fully connected reduction enables the user to move from any one constituent of the relation to any other, it results in quite a number of binary relationships and even might become confusing at times. On the other hand, the reduction by reification causes navigational difficulties, since some of the relationships between the constituent topics become two levels deep, but result in a very straightforward representational structure.

By adding perspective relations to a topic map ontology, the topic maps can be used as a collaboration tool for multiple experts building a knowledge base. Having room for all the perspectives can prevent conflicts between ideas from different experts, thus it may sort of bring order to the managemental chaos by separating the expertise explanation gathering and synthesis of material coming from different experts stages in knowledge engineering. So our proposal for the method is for avoiding the camel becoming the result.

We acknowledge that our discussion in this paper lacks a comparison of our method to the concept of scopes in topic maps, but our first impression is that our method of incorporating the perspectives into the topic map in terms of topics and relations, that is as a part of the ontology, not as another type in it, provides a better view of available perspectives to the user.

The aim of the project in the initial project proposal was about building better manuals, which would transcend the paper based technology, and we believe we managed to make progress towards this aim by the ontological definition of perspective relationships and the method we came up with. It must also be stressed that the main end product of our work is not the web site for the programmer's manual for HLA RTI implementation by DMSO which is not complete and which only served as a demonstration, but the concepts we discussed in this paper.

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