Tangled Web of Concept Relations. Concept relations for ISO 1087-1 and ISO 704

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Abstract. The paper discusses factors that are relevant when constructing a typology of concept relations for terminology work by focusing especially on *ISO 704:2009 Terminology work - Principles and methods* and *ISO 1087-1:2000 Terminology work - Vocabulary - Part 1: Theory and application* standards and their future revisions. At first prerequisites for a concept relation typology are discussed generally. The standards are then scrutinized as to how they introduce, define and classify concept relation types, and modifications are suggested. A concept relation typology is presented as an example of a comprehensive, generalizable and extendable typology.

Keywords: concept relation, conceptual relation, concept system, generic relation, associative relation, ISO 1087-1, ISO 704.

1 Introduction

The purpose of ISO 704:2009 *Terminology work - Principles and methods* is to standardize the elements which are essential for terminology work, to provide "a common framework of thinking and to explain how this thinking should be implemented" by practitioners and others involved in terminology work and terminology management. The ISO 1087-1 *Terminology work - Vocabulary - Part 1: Theory and application* has as its task to define the basic concepts in ISO/TC 37 standards. Both emphasize the meaning of concept relations and concept systems in terminology work. Concept systems in the standards have been scrutinized in [1] while the focus of this paper mainly lies on concept relations.

There is a growing number of researchers from terminology science and related fields (e.g. ontology research) interested in concept relations. However, the standards present a limited range of relation types, and there are some shortcomings in their definitions. This paper addresses these issues and suggests some modifications and possibilities to enhance the typology in future revisions. At first, some general prerequisites for a concept relation typology are taken up with reference to the research in concept relations. The term *typology* is chosen here instead of *(generic) concept system* in order to keep apart the object (concept relations and systems) and the metalanguage, which would easily collide in this case.

2 Prerequisites for a Concept Relation Typology

On the one hand, when comparing existing concept relation typologies, several factors influencing them can be distinguished. On the other hand, recent studies show the need for more developed and usable concept relation typologies. In the following, the observations based on these are formulated as prerequisites to be considered or aspects to be aware of when building a typology of concept relations.

1) The **theoretical background** influences the typology and terms utilized. Existing typologies can be traced e.g. to standardization, philosophy, classification studies, semantics, lexicology, ontology work etc. In terminology work and research, various modifications and combinations of these background typologies have been made. Instead of *concept relation* some authors use the term *semantic relation*.

2) A typology has usually a **target group**. The target group of the ISO standards primarily consists of field specialists and terminologists who participate in terminology work. Data modelling may utilize terminological concept relations as shown e.g. by [2], but information and data modelling are so far explicitly excluded from the ISO 704:2009. Widening the target group would mean that the different backgrounds have to be taken into consideration and an integrated methodology to be created. This would also include a shared typology of concept relations.

3) A typology is a tool made for a certain **purpose** [3]. Finding out and structuring concept systems of the field is emphasized as an important working method for terminology work. In addition to this, concept relations have a role in information dissemination, which is however lost, if the structural information is omitted from the final product as a data category [4,5]. Information on concept relations in terminology databases can help language professionals (e.g. translators, technical writers), subject-field learners, or even subject field specialists to familiarize themselves with language and concepts of the field [5]. A new generation of concept- and knowledge-oriented terminological databases (e.g. ecolexicon.ugr.es, www.coreon.com) is under development as shown by recent conference papers. More detailed typologies of concept relations are needed to enable navigation through concept relations (see e.g. [6,7]).

4) A typology must be **operationalizable** for the purpose. Forinstance, Wüster [8] created an extensive typology of relations, only part of which ended up in terminology work. At that time the only terminological products were printed glossaries and standards, why his typology remained a theoretical construct. A more simplified typology was adopted to the practical work, which is reflected in the ISO standards today. Costa and Roche emphasized in their paper at the LSP 2013 [9] that one of the main reasons for rethinking of the ISO conceptual principles is that they "cannot be operationalized" when considering e.g. computational representation of the conceptual system in computer aided translation, (multilingual) specialized dictionaries and content management systems, semantic search engine, knowledge mapping, e-Learning, etc.[9] They did not extend their discussion to concept relation part of the standards, but it is clear that the requirements for concept relation typologies for these purposes differ from those for traditional manual terminology work. The question is, if the scope of ISO 704 and 1087 should be widened to cover also the terminological needs of these purposes, which brings us again to the question of the target group.

5) The typologies of relations are utilized in various **ways**. Previously, terminology work has been solely a manual effort, which is reflected in standards and textbooks. Both in manual analysis and computer aided extraction, generic and partitive relations are relatively easy to discover. Associative relations, however, make a vast class covering all other possible relations. In manual analysis, the vague set gives a freedom to include any relevant concepts to the vocabulary or database. In computer-aided terminology extraction, however, a set of predefined lexical relation markers may be needed depending on the approach taken.

6) Depending on the purpose, the typology can be **domain-dependent** or **independent**. It is challenging to achieve a generalizablility because many relation types are more or less domain-dependent [5,10]. Also domain-independency requires great adjustments when applying the typology to new domains [5]. On the other hand, the nature of the concept determines which relations are potentially activated, or seen from the opposite direction: the relation type determines what kind of concepts are involved [6].

7) It takes much effort to analyze more **complicated** relations than the basic generic and partitive relations. This is one of the reasons for why the manual terminology work is satisfied with a small amount of concept relations as [5] note. This is partly due to the lack of research - or rather lack of operationalization of the results - since as noted by [5] some of the more complicated relations such as causal and instrumental relations etc. have been covered. This has been basic research to find out how various types of relations appear in definitions and texts [5] or theoretical top-down classification [e.g. 11]. The basic problem is how to make the knowledge operational for practical purposes such as terminology work and standardization [cf. 9]. Some results also have more direct use for automatic extraction of terminological information. On the other hand, when systematically compiled and presented glossaries of a restricted thematic field have been scrutinized, generic and partitive relations are far from being the only relation types utilized to link the concepts together (see e.g. 12 on *transactional relations*).

On the basis of the discussion above the following prerequisites for creating a typology of concept relations could be summarized: theoretical background has to be considered, target group(s) and purpose(s) defined, it must be ensured that the typology is operational for the purpose and fits for its usage. For some purposes (e.g. ISO 704) a domain-independent and generalizable typology is needed than for the analysis of a certain field. The same goes for the continuum complexity-simplicity. In addition to these, there are **formal** requirements for a concept relation typology, such as unambiguousness and consistency as well as extensibility and flexibility. In the following, it is mostly these formal requirements function as criteria when the concept relations and their typologies in ISO standards are scrutinized.

3 Concept relations in ISO standards

While the standards define the basic concepts of terminology, the concept of *concept relation* does not get a definition. Instead of saying what the concept relations "are", ISO 704: 2009 (p. 8) states: "Concepts do not exist as isolated units of knowledge but always in relation to each other. Our thought processes constantly create and refine the relations between concepts, whether these relations are formally acknowledged or not." Under the heading "Types of concept relations", the reader would expect a further discussion on the nature of concept relations and criteria for subdividing them as well as on how the concept relations relate to object relations (ontical relations). Instead, the standard makes remarks on organizing concepts into concept systems and aspects that have to be kept in mind as to concept fields. *Concept systems* and *concept fields* are defined and introduced ten pages later in the document. Furthermore, the example on *mice* and *computer mouse* not being parts of the same subject field does not either belong to the topic of the chapter.

In general, the standard does not keep apart concept relations from concept systems. Concept relations are sometimes explained and exemplified by talking explicitly about concept systems as above, or by using the term *generic* or *partitive relation* when clearly talking about the respective concept system (e.g. "in a generic relation there may be several ways of subdividing a concept into subordinate concepts depending on the criteria of subdivision or type of characteristic chosen"; p. 11). The examples for *generic relation* and *partitive relation* exemplify the respective concept systems with detailed explanations and instructions for what to observe when structuring this kind of concept systems. There is a chapter for concept systems later on in the standard, which is now missing relevant content, because most of it has been already spread throughout the document [12].

3.1 Main relation types

Both standards distinguish between hierarchical and associative relations as the main division (see Fig. 1). The definitions of these two coordinate concepts take totally different approaches. The first one does not tell what the distinguishing characteristic is and how hierarchical relation can be distinguished from its coordinate concept. Instead, two different criteria for subdivision can be detected between the lines: *ability to build hierarchies* and *type of associative/thematic connection.*

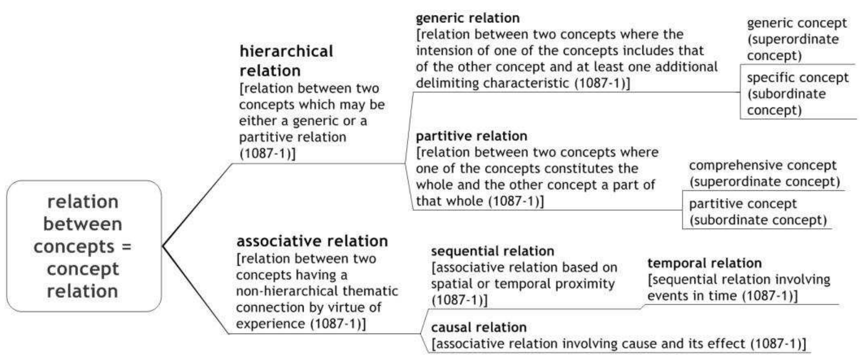

Figure 1. The main types of concept relations in ISO 1087-1:2000.

Despite the asymmetry, this dichotomy has established itself in the principles of terminology work. However, if we want to define what *concept relation* is or to expand the amount of concept relations in the typology, this main division causes problems. Because hierarchical relations are restricted to generic and partitive by the standards, all the remaining relations are non-hierarchical by definition.

3.2 Hierarchical relations

As mentioned above, ISO 1087-1:2000 (p. 4) restricts hierarchical relations only to generic and partitive relations by. ISO 704:2009 (p. 8) makes it stipulative by adding "In this International Standard..". The category *hierarchical relation* seems somewhat superfluous, because most what is said about it in ISO 704:2009, is said about generic relations and generic concept systems. The metaphorical similarity between generic and partitive relations is that they are able to form hierarchies, which could, however, be applied even to further types of concept relations. After all, there are other relation types that fill (even better) the requirements for what generally is understood by 'hierarchy' e.g. in systems theory, organization theory, ecology etc. According to 704:2009 (p. 8), "in a hierarchical relation, concepts are organized into levels of superordinate and subordinate concepts. For there to be a hierarchy, there must be at least one subordinate concept below a superordinate concept."

What is common to generic and partitive concept systems is actually that they are **nested hierarchies**, i.e. superordinate concepts in a way or another "contain" or "consist of" the subordinate concepts. A generic superordinate concept contains the extension of its subordinate concepts; a partitive superordinate concept refers to a whole while its subordinate concept refers to a part in the whole. Also concept systems based on *locational relations* could be regarded as nested hierarchies, e.g. computer disc contains folders, they contain files and files contain data. The same goes for *material component relations*: butter contains butterfat that contains fatty acid. Examples of **not nested** hierarchies are military hierarchies and ecosystem's food chains [17]. In them the entities on the higher level do not contain or consist of the entities on lower level. The hierarchical relation between them and the corresponding concepts is based on some other criteria than containment. This type of concept relation appears in e.g. [13], where it is called *rank relation*. These tree relations mentioned above cannot be, however, included in neither of the main relation types in the standards because of the restrictions made in the definitions.

3.3 Types of generic and partitive relations

According to the standards, both generic and partitive relations are relations between super- and subordinate concepts in respective concept systems. E.g. ISO 704:2009 (p. 9) defines generic relation as a relation that "exists between two concepts when the intension of the subordinate concept includes the intension of the superordinate concept plus at least one additional delimiting characteristic". Even though ISO 704:2009 mentions coordinate concepts and horizontal series (e.g.

“Partitive relations, like generic relations, can be expressed as vertical and horizontal series”, p. 15), the relation typology does not cover the relation between the coordinate concepts or other types of relations in the concept systems. This has been solved e.g. in [11,13] by assigning the terms *generic relation* and *partitive relation* to wider concepts which cover also the relations between co-ordinate concepts (see Fig. 2). Respectively partitive concept relations could be partitive superordination and co-ordination. In ISO 704:2009 the concept systems formed by these relations are called *generic* and *partitive concept systems*. Thus it is motivated to call <u>all</u> the relations in them *generic* respective *partitive relations*.

Because ISO 704:2009 does not develop further the theoretical background of the concept relation typology, some problems appear in the definitions. The standard says forinstance that “..if the same concept is viewed as a comprehensive concept in a partitive relation, the individual concept can be subdivided into its parts” (p. 16). Here a distinction between the object and concept levels should be made clearer – it is not the concept that is subdivided into parts but the <u>object</u> that the concept represents (c.f. ISO 704:2009: 2). The definition in ISO 704:2009 also says that “A partitive relation is said to exist when the superordinate concept represents a whole, while the subordinate concepts represent parts of that whole. The parts come together to form the whole.” The “whole” here refers to the object that is being devided and not to the concept. Parts of the concepts are its characteristics. As to the typology of partitive relations, further types could be distinguished as has been done e.g. in Fig. 3, where they are divided into compound, partition, and set relations.

3.4 Associative relations

Similarly to partitive relations, the definitions of the associative relations do not keep clearly apart the object and concept level, e.g. “Some associative relations exist when dependence is established between concepts with respect to their proximity in space or time.” (ISO 704:2009: 17) Again, it is not the concepts that have a spatial or temporal contact but the <u>objects</u>. As associative relations ISO 1087-1:2000 mentions sequential, causal and temporal relations while ISO 704:2009 does not give any typology for associative relations but plenty of examples. Instead of isolated examples, the standard could present some kind of classification or a more developed typology – eventually as an annex. There is a need for one when we look at the new developments of terminological data bases. Forinstance, León Araúz et al. [6, p. 32] say that terminological knowledge bases are restricted to these basic relations, “whereas conceptual dynamism can only be fully reflected through non-hierarchical ones”, which relate to “movement, action and change, which are directly linked to human experience and perceptually salient conceptual features”.

5 Concept Relation Typology

Even though it is a challenge to compile a typology, there are some existing ones to start with e.g. the one introduced in [11], which is taken here as an example. The typology has been later on revised in various articles, e.g. in [13] and [14]. It has incorporated relation types presented by other authors [e.g. 8,15,16]. On the one hand, the typology presents an overall upper level division for relation types, and on the other hand, it gives examples of the relation types on the lower level of abstraction.

The main division is made into generic (syn. logical) and ontological relations, where ontological are divided into contiguity (in space or time) and influence (causal, developmental, activity, origin and interactional) relations. Influence relations have a causal component and are overlapping with each other in some degree. A distinction between causal and purely temporal concept relations is made, and purely causal concept relations are separated from other relations which include causal components. [11]

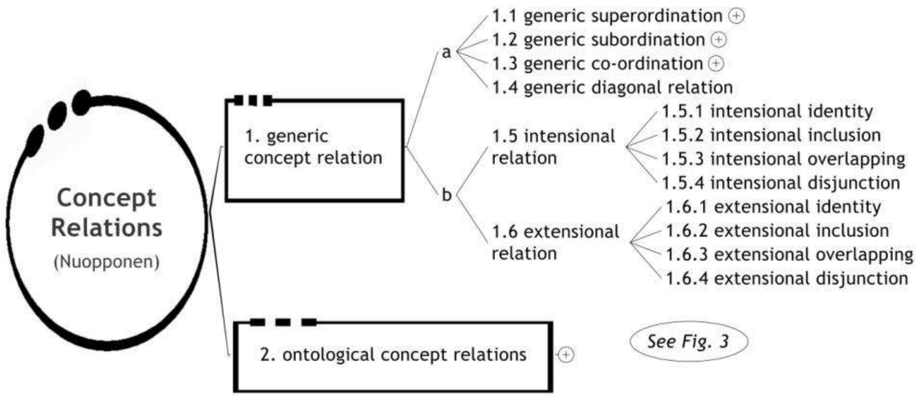

Fig. 2. Concept relation typology [1, 11, 13, 14]

As mentioned earlier, generic concept relations are divided into four subtypes which are those between concepts in higher and lower, lower and higher, or same level of abstraction as well as between concepts in other positions on different levels of abstraction in the same concept system (see Fig. 2). The typology takes also another approach to generic relations, and compares the intension and extension of concepts (see Fig. 2). These distinctions are useful when analysing concepts and comparing e.g. different languages or on different fields. The following types of relations are presented in [11,13]:

- intensional relation (based on similarity and differences in concept characteristics): intensional identity (concepts have same intension i.e. same characteristics); intensional inclusion (intensionally wider/narrower concept, both have same characteristics, one of them has additionally one or more): intensional overlapping (concepts have a set of same characteristics, both have one or more additional characteristics); intensional disjunction (concepts do not have any common characteristics);
- extensional relation (based on similarity and differences in concept extensions i.e. subordinate concepts or objects): extensional identity (concepts have the same ex-

tension); extensional inclusion (both have same extension, one has one or more subordinate concepts/objects in addition); extensional overlapping (concepts share a set of subordinate concepts/objects, both have one or more in addition); extensional disjunction (two concepts do not share any subordinate concepts/objects).

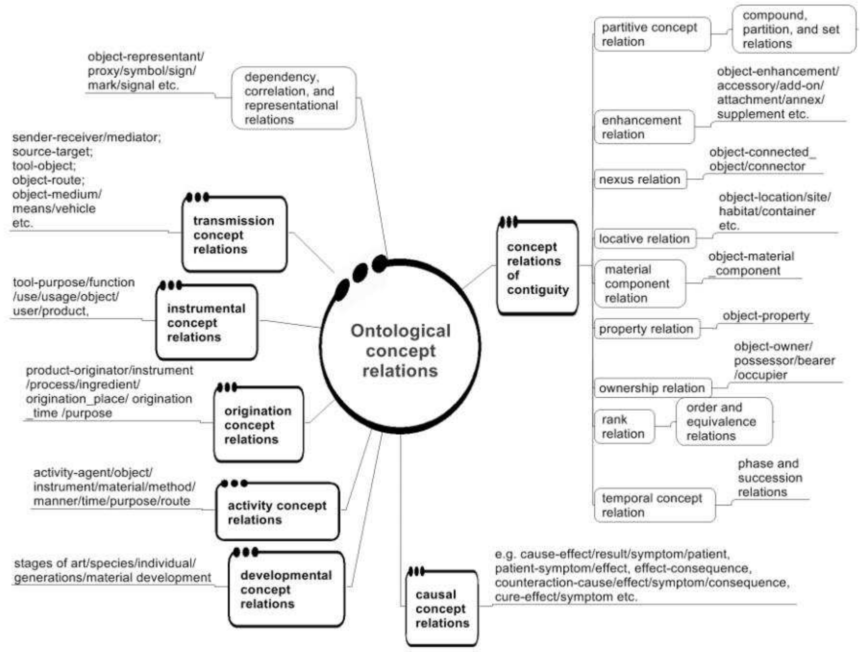

Fig. 3. Ontological concept relations [1,11,13,14]

In the Fig. 3, the original hierarchy of ontological concept relations [1994] has been flattened on both ends to make the typology of ontological concept relations more operationalizable. The typology allows a wide variety of very specific relations and relation types to be subordinated to the relevant category. New relation types can be added; e.g. when reviewing the typology for this paper, a new relation called *nexus relation* was added (Fig. 3). It is based on connection between objects that are not parts and wholes in relation to each other, nor attachments or locations. An example could be *mobile device–Internet.*

Further modifications have been made here to add more flexibility to the lower level relation types. Instead of listing subtypes of relations, only examples of possible “concept roles” or ”relation participants” have been listed. The complete typology includes also relationships between the two concepts also from the opposite direction, e.g. sender–receiver and receiver–sender relation. Sometimes it may be important to separate this type of information. Additionally, parallel or simultaneous relations are often involved, e.g. when we deal with concepts referring to multiple, alternative or alternating senders or receivers, which reminds the generic coordination and sometimes overlaps with it when e.g. a classification of concepts for various senders or receivers is made in a transmission concept system.

6 Discussion

There is a need to revise concept relation typologies for terminology work. New applications for the principles of terminology work and fast pace of digitalization of “everything” emphasizes the need for more developed terminological tools. The concept relation typology presented in ISO standards is restricted to a few core relation types, and their definitions and treatment are not quite unambiguous or consistent. They may be operationalizable for manual terminology work but also there a more extended typology could be fruitful. As shown here, even the most basic relation types are quite complicated when we take a closer look at them.

Domain-dependency poses challenges to create a typology that is general enough to fit for concept analysis of various fields. On the one hand, fields may have their own frequent relation types on the micro level, which cannot be easily generalized or operationalized in other fields. On the other hand, a too abstract relation type causes also problems by being too vague and difficult to locate in specific fields. Especially when working with corpora and automatically extracting concept relations, it may be a daunting task to trace back to the concept relations and concept systems. Same relations may be expressed in myriads of ways, e.g. “is a” is only one way to express generic relation, and on the other hand, the same expression may refer to several other relation types (e.g. “can be divided into”).

The typology presented in Chapter 5 has been tested over the years in a multitude of fields and remodeled according to the problems encountered. However, several of the more complicated relation types still need more detailed analysis in order to make the typology to work properly as an analysis tool. Also when we consider needs for other than terminologists and manual terminology work, more testing and adaptation needs to be done.

Many of these questions and challenges are to be considered when remodeling and enhancing a concept relation typology for ISO standards – or for any other purpose: which theoretical background and terminology to lean on, for which target group, purpose and context the typology is meant, how to operationalize the new typology, how to handle the complexity and domain-(in)dependency of relations, how to ensure comprehensiveness, flexibility and extendibility of the typology, etc. Above all the typology must also be unambiguous and consistent even though the relations encountered may feel like a tangled web.

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