Conceptual relations: From the General Theory of Terminology to knowledge bases

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Chapter 3. Conceptual Relations: from the General Theory of Terminology to Knowledge Bases

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Abstract. This chapter gives an overview of concept relations. They can be used to create terminological products, guarantee their quality and make their contents more accessible to the users. They facilitate the analysis, organization, and definition of concepts, help to establish connections between concepts and terms, to form and evaluate terms, and to identify term equivalents. This chapter first relates conceptual relations to concept formation, and discusses relevant aspects of terminological resources. Then an extensive typology of conceptual relations is compared to typologies with multidisciplinary backgrounds and purposes. Terminology work and terminological resources use often only basic relation types. However, ontologies, automatic term extraction, and advanced terminological knowledge systems benefit from a larger set of relation types.

Keywords: terminology, concept relation, relation, relation typology, semantic relation, concept, terminology work, terminology research

1. Introduction

In terminology work, concept relations are important to create terminological products and to make their contents accessible to the users. They are instrumental in the extraction of conceptual information, the analysis and organization of concepts, the definition of concepts, the specification of connections between concepts and terms, and term formation and evaluation. Furthermore, they are needed when presenting terminological information in vocabularies, databases, knowledge representation systems such as ontologies (see chapter by Montiel in this volume), and other resources such as terminological knowledge bases (see chapter by Meyer in this volume). They guarantee the quality of terminological products and facilitate knowledge transmission and acquisition.

The identification of relations between concepts and their organization in concept systems was a central element of the General Theory of Terminology developed by Eugen Wüster (see chapters by Candel and Humbley in this volume). It was the basis for compiling vocabularies for special fields, and was introduced as principles for terminology standardization (see chapter by Wright in this volume). What makes the role of concept relations even more relevant today is the need for terminology work in the digitalization and development of next-generation terminological

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products and conceptual knowledge systems as well as information extraction applications that are still on the horizon. In the 1990s, Meyer and her colleagues were looking forward to the next generation of terminological repositories that would contain "a richer and more systematically structured knowledge component than do conventional term banks and specialized dictionaries" (Meyer, Eck and Skuce 1997, 99; see also Skuce and Meyer 1990 and chapter by Meyer in this volume). However, this task has taken some time to develop and accomplish.

This chapter reviews sets of concept relations that can be used to develop terminological resources and to define methods to compile them, e.g., domain and task-specific relation typologies. This chapter is organized as follows. Section 2 relates concept relations to the process of concept formation. Section 3 discusses certain aspects of terminology resources where concept relations are relevant. Section 4 analyzes relation types based on Nuopponen (1994a, revised in 2005) to build on terminological literature and incorporate ideas from related studies. Section 5 presents the conclusions that can be derived from this chapter.

2. Concepts, characteristics and basics about concept relations

In Terminology, concepts are often defined as abstract units of thought or units of knowledge, consisting of characteristics (Figure 1), which correspond to one or more objects. Characteristics are abstractions of properties that are found or assumed to exist in real or imagined phenomena or objects (of reference) or which appear from their relationship with other phenomena.

Sager (1990, 22) describes concept formation as a "process of variously grouping and ordering the material and immaterial objects which we sense, perceive or imagine into abstract categories". Concepts thus become "constructs of human cognition processes which assist in the classification of objects by way of systematic or arbitrary abstraction" (ibid).

Figure 1 depicts the three levels, which are relevant to terminology work and research: (i) phenomena or objects (real world); (ii) ideas and concepts (cognition); and (iii) expression and communication (communication). The model is a simplification as many of the objects of reference exist only in people's minds.

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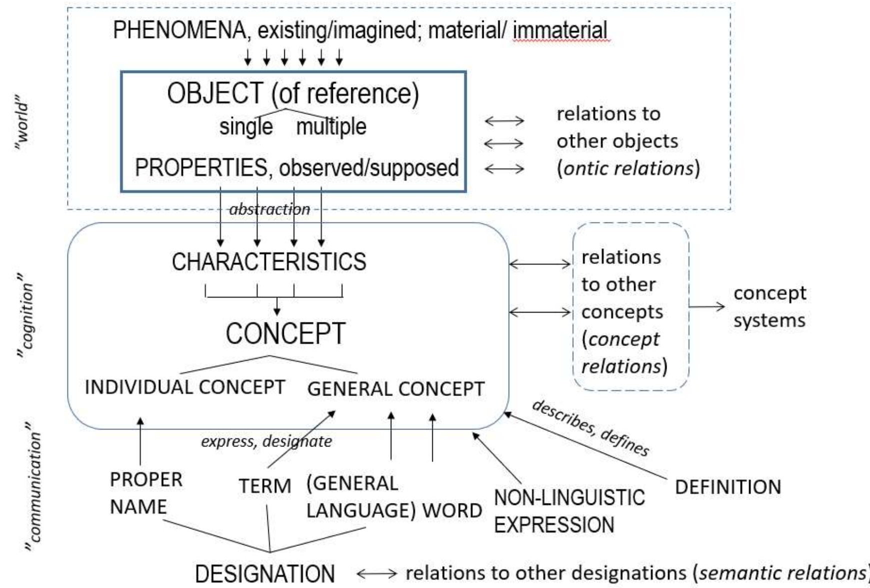

Figure 1. Concept formation

Abstraction leads to concept formation, which can be taken to an even higher abstraction level based on the shared characteristics of two or more concepts. This results in generic concept relations and systems (see Section 4.1). Moreover, in many cases, objects can be partitioned or segmented in phases or causes (Nuopponen 2007, 204). The concept relations stemming from the abstraction of these 'real life' connections can be classified as ontological concept relations (Wüster 1974, 95; Nuopponen 1994a, 84, 2018a, 457) (see Section 4).

Concept relations can be defined simply as relations between concepts (ISO 1087:2019, 4). They are different from relations between terms, i.e., linguistic designations for specialized concepts (see chapter by L'Homme in this volume) and from the relationships between terms and concepts. These distinctions are not always made, especially in multidisciplinary terminological studies. Often, the term *semantic relation* is used as a synonym for *concept relation*. This chapter focuses on relations between concepts, and thus the preferred term is *concept relation*. Relations are viewed here from the conceptual perspective regardless of which term is used in the sources.

3. Concept relations in terminological resources

As previously mentioned, concept relations are important elements in terminology work and compiling terminological resources. The development of new generations of terminological knowledge bases emphasizes the need to organize entries and knowledge, and to implement concept relations in term bases.

In systematic terminological vocabularies, entries are organized thematically or according to concept relations as in the vocabulary of terminology work ISO 1087:2019. In addition, the entries can be numbered in a way that make the hierarchical organization of concepts explicit. Concept relations can also be indicated in diagrams or tables depicting concept systems, information in definitions and explanations, references between entries, systematic lists in indexes, etc. (Nuopponen 2018a, 456).

Meyer et al. (1992), León-Araúz, Reimerink and García-Aragón (2013, 31) and Faber (this volume) emphasize that terminological knowledge bases should reflect the way that concepts are related to each other in the human mind. According to Meyer, Eck and Skuce (1997, 105), it is "very unfortunate that representations of concept systems are still quite rare in specialized dictionaries and terminological databases", something that is true even today. This is the kind of laboriously acquired subject-field knowledge, which Meyer, Eck and Skuce (1997, 99) see as valuable for users, but which generally "stays where it was first stored, namely in the terminologist's head" with only fragments included in definitions and examples. Marshman, Gariépy and Harms (2012, 47) agree that "the benefits of including terminological relations in many cases will outweigh the modestly increased workload, and that (as is the case with translation memories) the gradual accumulation of information will ultimately form a useful resource." What is needed is a termbase tool with a "structure that is adequate for storing the information and providing quick and multifaceted access" (ibid, 48).

One of the major benefits of making concept relations visible in terminological products is to enable knowledge transfer. In accordance with Meyer, Eck and Skuce (1997), Faber (2011, 10) states that "knowledge of conceptualization processes as well as the organization of semantic information in the brain should underlie any theoretical assumptions concerning the access, retrieval, and acquisition of specialized knowledge as well as the design of specialized knowledge resources." According to León-Araúz and Faber (2010, 17) the system thus becomes "a consistent resource in its different representational levels" because contextual constraints "structure knowledge in a similar way to how things relate in the real world, as well as in the human conceptual system".

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Concept relation information in terminological resources also has a didactic value (Picht and Draskau 1985, 92) since it helps the user to better understand terms, concepts, and their definitions (Nistrup Madsen, Sandford Pedersen and Erdman Thomsen 2001, 7). Understanding concepts in a specialized field helps language professionals to become familiar with a new domain and its language (Marshman, Gariépy and Harms 2012). Concept relation information and the visualization of concept systems also enable browsing without specific knowledge of a term or its exact orthographic form. This is evidently not the case of alphabetically organized glossary entries or a termbase interface with a simple search window.

4. Types of concept relations

Concepts can be related to each other in many ways, which is accurately explained by Sager (1990, 29):

> Inside subject fields concepts are also related either by their nature or by the real-life connections of the objects they represent. As in real life between objects, the kinds of relationships which exist between concepts are numerous and varied.

There are not only numerous types of concept relation, but also various ways to define and classify them. How concept relation types are distinguished from each other depends on the theoretical background or discipline and purpose or context of use or need (Nuopponen 2014, 2). This section shows how typologies can differ from one project to another. Firstly, Figures 2–4 present a concise overview of the proposals in Nuopponen (1994a, revised in 2005).[1]

[1] The figures include corresponding or similar relation types from the other typologies. The main distinction is made between generic (logical) and ontological relations, which cover all the other relation types. In the figures, the node *ontological relations*, which would cover all except generic relations, has been left out. The typology also integrates and builds on relation types from less recent terminological literature, e.g., Wüster (1971a, 1993[1974]), Dahlberg (1978, 1981), DIN 2330-1979, DIN 2331-1980, Arnzt and Picht (1989a) as well work in Philosophy, Linguistics, and Semantics. The typology functions as the core of Systematic Concept Analysis (see Nuopponen 2011), a method that includes also a satellite model in the form of a mind map as a tool for compiling and organizing concepts with the help of various types of relation (see Nuopponen 2016).

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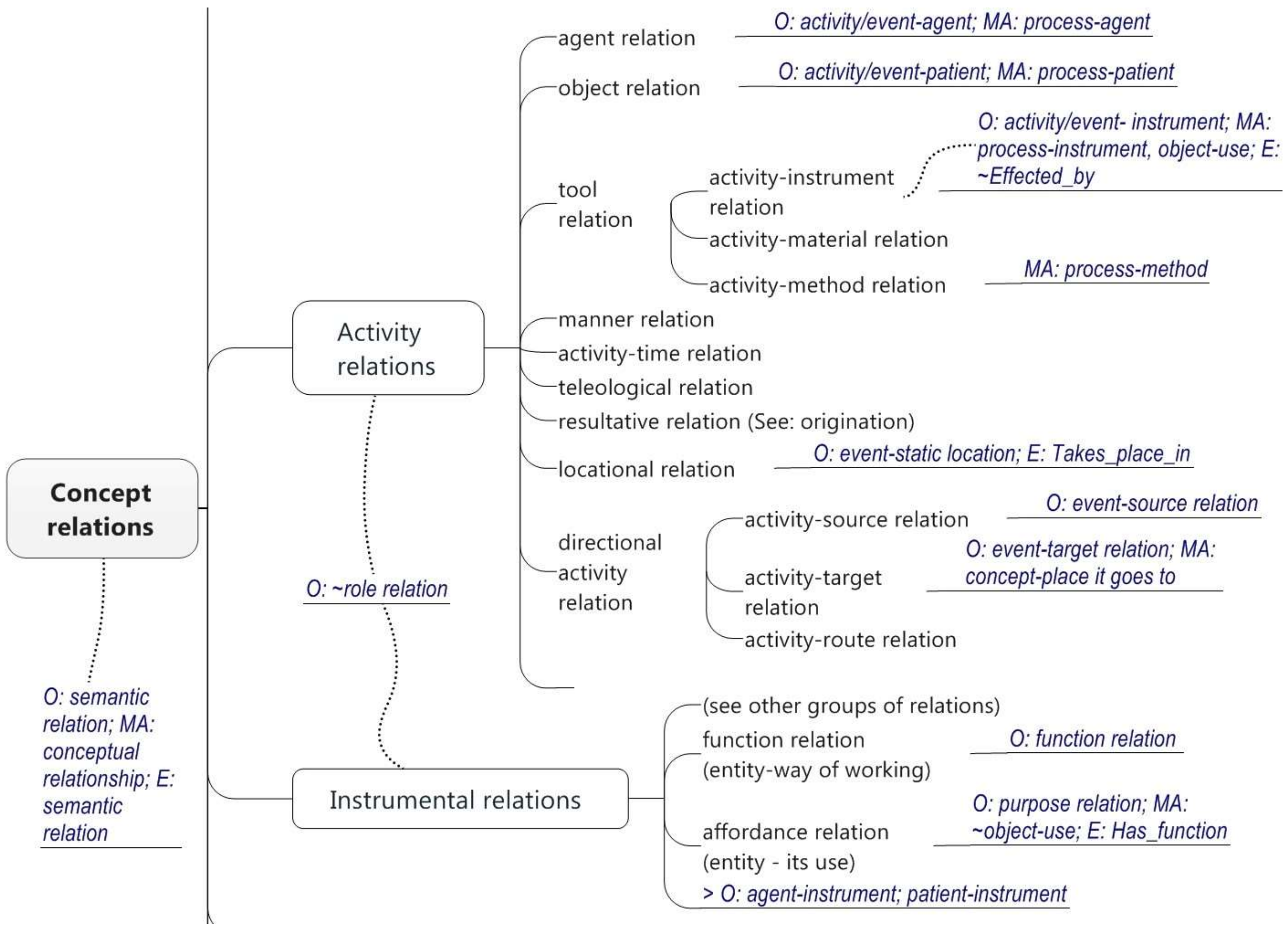

Figure 2. Concept relation typology: Generic and contiguity relations (Nuopponen 1994a, 2005)[2]

[2] Markings in the figures: O = OntoQuery, MA = Maroto and Alcina 2009, E = EcoLexicon; ~ = has similarities, > to be included.

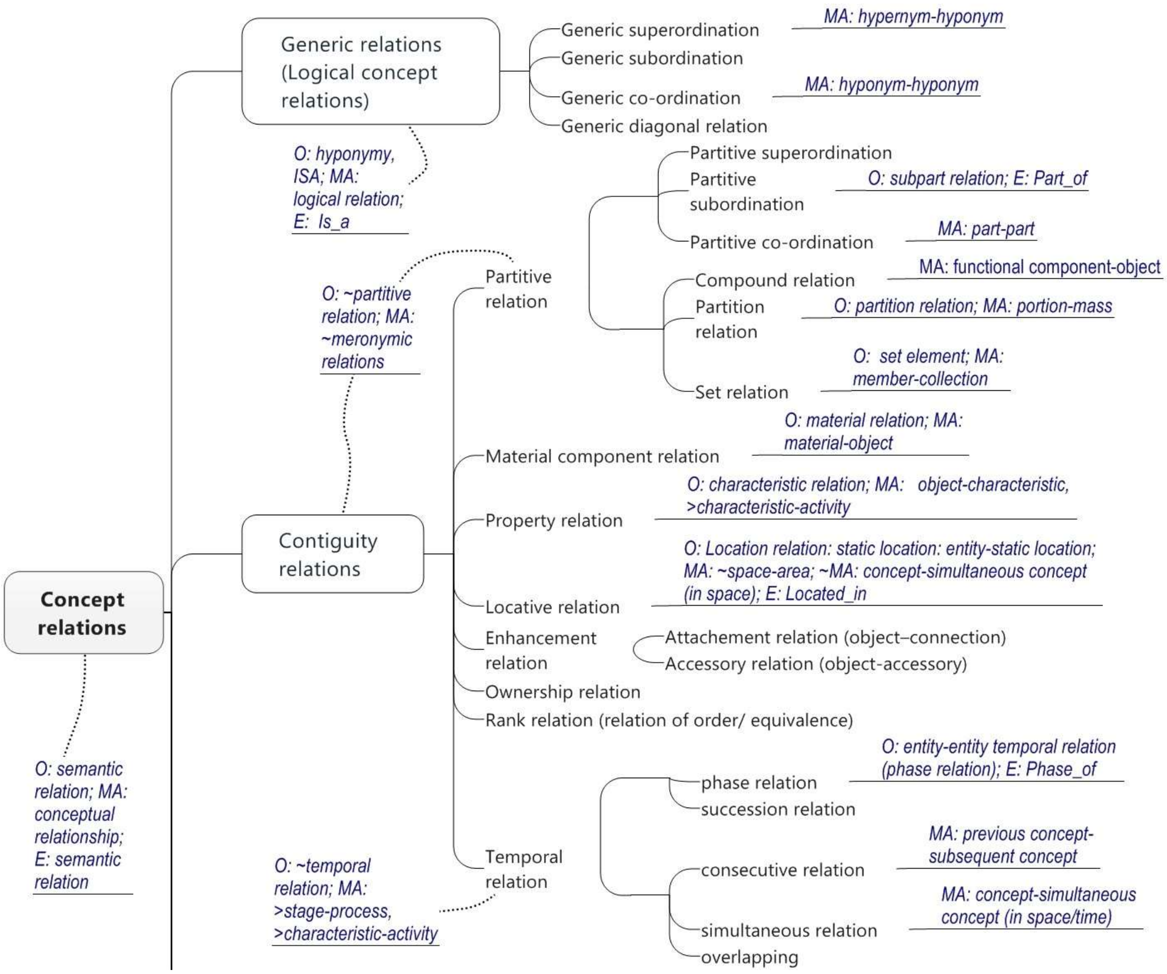

Figure 3. Concept relation typology: Activity and instrumental relations (Nuopponen 1994a, 2005)

The relations in our typology are defined and complemented with relation types from three multidisciplinary terminology projects. These projects base their relation inventory on the empirical analyses of relations in specific domains. The typology in Figures 2-4, in contrast, seeks to create an overall classification of concept relations that would be applicable to all domains and languages. We are aware that some of these relations types overlap with the ones presented in Figures 2-4, but our descriptions of specific relations (Sections 4.1 to 4.7) also refer to these typologies.

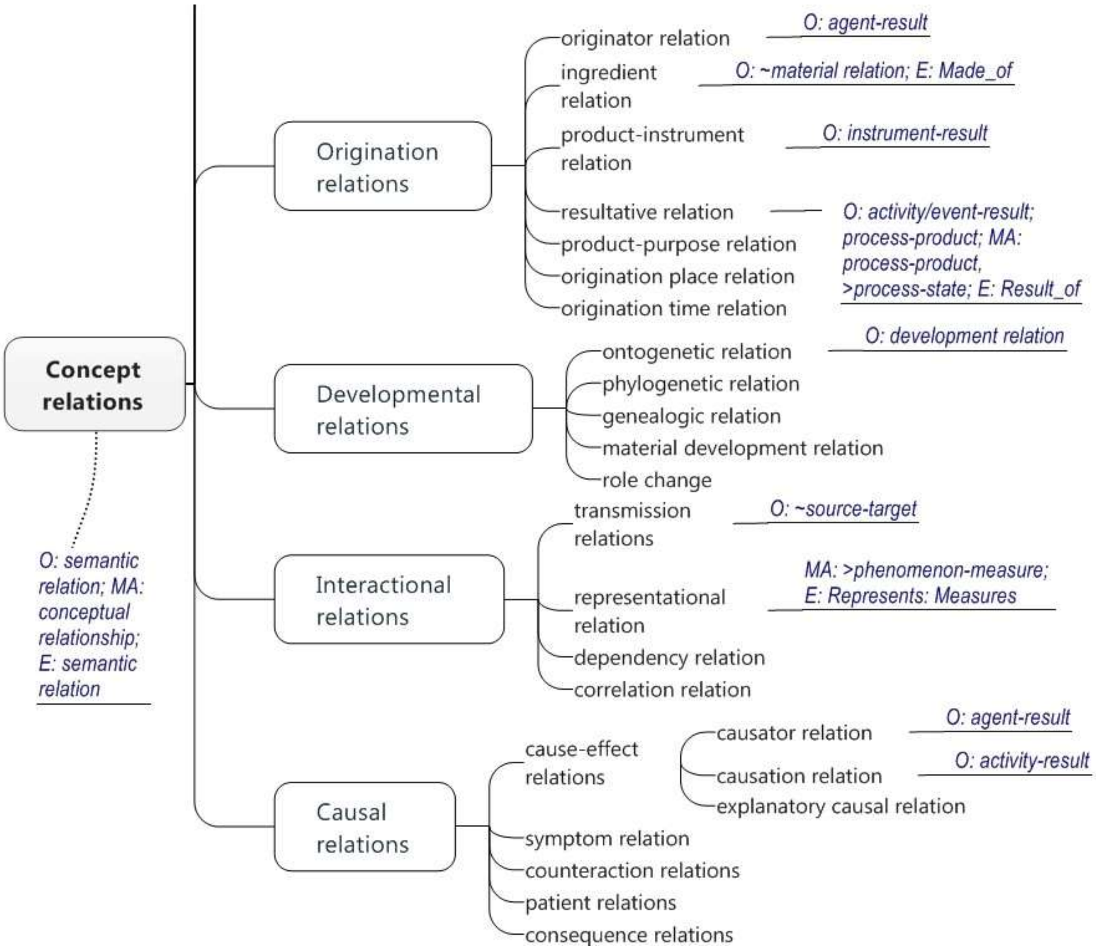

Figure 4. Concept relation typology: Origination, developmental, interactional and causal relations (Nuopponen 1994a, 2005)

Table 1 lists the relation types of the other typologies and the different labels used in them. Table 1 first shows the 2004 version of the OntoQuery typology.[3] The OntoQuery (ontology-based querying) project described by Nistrup Madsen et al. (2001) integrates terminological methods in ontology work, why their relation typology combines relations used previously in both terminology (e.g., Nuopponen 1994a) and ontology work. Consequently, they use the terminology from both fields, while the term *semantic relations* for concept relations comes from the latter one.

[3] Other relations are discussed in other articles related to this project.

Maroto and Alcina (2009) present a typology which is based on Sager (1990) and enhanced with the meronymic relationships in Winston, Chaffin and Herrman (1987). The authors are interested in how concept relations should be stored in a conceptual database so that this information can be used in knowledge retrieval. The third typology is the inventory of relation types from EcoLexicon-related research (e.g., León-Araúz and Faber 2010). Their typology is based on corpus studies where relations are often named with the most frequent or typical lexical pattern for each relation type, e.g., *is_a, part_of* (see chapter by Faber in this volume).

Table 1. Concept relation typologies

OntoQuery: Andreasen et al. (2004, 205): Semantic relations	- **Hyponymy** (ISA) - **Location relation:** dynamic location (source SRC: source-target /event-source relation; target relation: source-target /event-target relation); static location (event-static loc./entity-static loc.) - **Purpose relation** - **Event relation**: event-source / event-target relation/ event-static loc./entity-static loc./ event-agent / event-patient/ event-theme/ event-instr. /event-result relation - **Function relation** (entity-way of working) - **Partitive relation**: subpart relation; partition	relation; material relation; set-element - **Causal relation** - **Role relation**: agent relation (event-agent/ agent-patient/ agent-theme/ agent-result relation/ etc.); patient relation; theme relation; instrument relation; result relation (All the roles are combined with each other) - **Measurement relation** - **Characteristic relation** - **Temporal relation**: time-entity; entity-entity temporal relation (phase relation; development relation)
Maroto and Alcina (2009): Conceptual relationships	- **Logical relations**: hypernym-hyponym; hyponym-hyponym - **Meronymic relationships**: functional component-object; member-collection; portion-mass; material-object; stage-process; characteristic-activity; space-area; part-part - **Sequential relationships**: concept-simultaneous concept (in space); concept-place it goes to;	concept-simultaneous concept (in time); previous concept-subsequent concept - **Argumental and circumstantial relationships**: process-agent; process-patient; process-product; cause-effect; process-instrument; process-method; object-use - **Other relationships**: phenomenon-measure; object-characteristic; associative relationship
EcoLexicon: Semantic relations	Is_a; Part_of; Phase_of; Made_of; Delimited_by; Located_in; Takes_place_in; Result_of; Causes;	Affects; Has_function; Effected by; Represents; Measures

In Nuopponen (2005, 128–129, 2014), the upper-level hierarchy consists of logical (generic) and ontological relations as reflected in Wüster (e.g., 1993 [1974], 360–361, 1985, 9, 12). Terminological literature generally distinguishes between hierarchical and non-hierarchical relations. Generic and partitive concept relations are regarded as hierarchical and all the other types

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of relations as non-hierarchical (e.g., ISO 704:2009; ISO 1087:2019). Non-hierarchical relations are also referred to as *associative*, which is sometimes a synonym for *ontological relations*. However, they are not identical since associative relations include all ontological relations except for partitive ones (see Nuopponen 2014, 5-8). On the other hand, associative relations are sometimes referred to as *undefined relations*, when there is no matching relation at hand (Nistrup Madsen et al. 2001, 18; Maroto and Alcina 2009; Table 1). In the following, the relations are organized as depicted in Figures 2-4, where the upper-level node *ontological relation* has been omitted.

4.1. Generic relations

In terminology literature, the most frequently mentioned relations are generic relations, also known as *logical relations*. According to ISO 1087:2019, generic relations are relations between a generic concept and a specific concept (e.g., 'software' – 'application software'), where the intension of the latter includes the intension of the former and at least one additional delimiting characteristic. The generic concept in the generic super-/subordination is called a *superordinate concept* whereas the more specific concept is the *subordinate concept*. The set of subordinate concepts on the same level of abstraction are known as *coordinate concepts* (e.g., 'system software' – 'application software' in Figure 5). (see ISO 1087:2019; ISO 704:2009; Nuopponen 2018b, 458–459).[4]

In the EcoLexicon project, for instance, they examine an alternative way of distinguishing between different types of generic relations, based on the type of characteristic. Since EcoLexicon generated different types of generic relations at the same level, it was necessary to reduce noise, information overload, and redundancy (Léon Araúz et al. 2016, 76,). Gil-Berrozpe, León-Araúz and Faber (2016) analyzed *rock* and found the following subdivisions for specific concepts: formation-based, composition-based, location-based, state-based, attribute-based, function-based, and shape-based hyponymy.

This kind of specification of generic relations can be domain-dependent, and for each field, classification must be done separately. Instead of distinguishing between different types of generic relations, this is usually done by finding types of characteristic that function as criteria for subdivision (Bowker 1997a, chapter in this volume; ISO 704:2009, 11–13; Nistrup Madsen and

[4] The counterparts in semantic relations are hyponymy/hyperonymy, hyperonym, hyponym and co-hyponyms (see Murphy and Koskela 2010).

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Erdman Thomsen 2008, 3). Subdivision is thus based on characteristics, (e.g., size, origin, purpose, formation, composition, location, state). For instance, computer software can be organized according to purpose (e.g., ‘application software’ and ‘system software’) or to the domain of execution (e.g., ‘desktop application’, ‘server software’, ‘embedded software’, etc.) (Figure 5).

Table 2. Generic concept relations

Generic (logical) concept relations	**Relation participants**	**Examples**
Generic super/subordination	superordinate (higher level of abstraction), subordinate concept (lower level of abstraction)	
a) direct generic super/subordination	super- and subordinate concepts on subsequent abstraction levels	’software’ – ‘application software’
b) indirect generic super/subordination	super- and subordinate concepts on a different abstraction level further away	’software’ – ‘text processing software’
Generic co-ordination		
a) direct generic co-ordination	co-ordinate concepts on the same level and below same direct superordinate concept and same criteria of division	‘application software’ – ‘system software’
b) indirect generic co-ordination	co-ordinate concepts on the same level, but under different direct superordinate concepts or criteria of division	‘application software’ – ‘server software’
Generic diagonal relation	other pairs of concepts on different abstraction levels in the same concept system	‘system software’ – ‘text processing software’

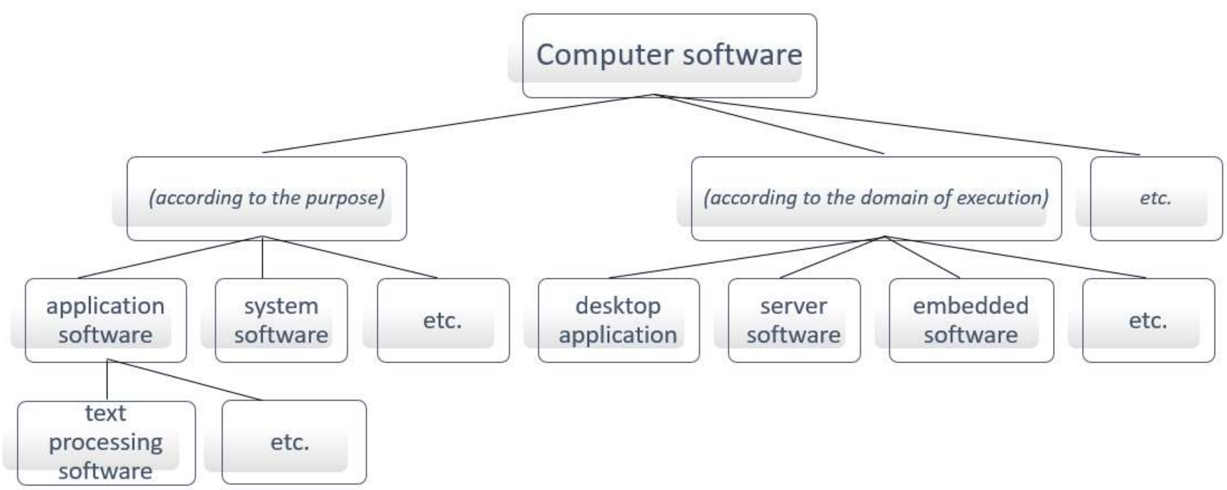

Figure 5. A fragment of a generic concept system for computer software

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4.2. Contiguity relations

Contiguity relations are dealt with here as a group even though they are different relation types. Although most of them are generally classified as partitive relations, here a more detailed classification is made.

Table 3. Contiguity relations

Relations of contiguity	**Based on relationships between**	**Example**
partitive relations:	a whole and its parts (whole-part, part-part)	
- compound relation	a whole and its functional/constituent part	'house' – 'door'
- partition relation	a whole and the part "where the nature of the part is the same as that of the whole"	'cake' – 'slice'
- set relation	a whole and a group of similar things forming part of it	'forest' – 'tree'
material component relation	a whole and components which can be extracted from it	'wine' – 'alcohol'; 'olive' – 'olive oil'
property relation	an object and its property	'wool' – 'thermal resistance'
locative relation	an object and the place where it appears, is to be found in, is kept in (container – contained)	'furniture'– 'room'; 'auditory information' – 'echoic memory'
enhancement relation	an object and another object that can be attached to it, not an essential part (object – accessory /attachment)	'e-mail' – 'attachment'; 'car' – 'spare tyre'; 'camera' – 'USB cable'
ownership relation	an owner and something owned	'car owner' – 'car'
rank relation	objects that are evaluated and ordered according a certain type of property (order or equivalence)	'president' – 'vice president'; 'gold medal' – 'silver medal
temporal relations:	actions or objects with contact in time (consecutive, overlapping or simultaneous)	
- phase relation	- phases/stages in a process/event/action	'drafting' – 'rewriting' – 'editing' etc.
- succession relation	- a series of persons or things that follow one after another	'starters' – 'main course'

4.2.1. Partitive relation

Partitive (concept) relations are based on dividing a whole into parts (e.g., 'car' – 'steering system'), which explains why they are sometimes called *part-whole relations*. In addition to relations between whole and part concepts, partitive relations include *part-part* relations that are based on parts of the same whole (e.g., 'steering wheel' – 'steering column'). Since they thus create hierarchies in a way that is reminiscent of generic relations, they are also classified as hierarchical (e.g., ISO 1087:2019; ISO 704:2009). Analogically, the concepts are often called *super-, sub-* and *co-ordinate concepts* in both of them even though the nature of the relations is totally different (ISO 704:2009, 8). The superordinate concept in partitive relations is also called *comprehensive concept* as opposed to *partitive concept* (ibid. 13).[5]

Based on Cruse's (1986, 162) division of canonical and facultative meronyms, Nuopponen (1994a, 161; 2005, 132) also distinguishes between canonical or facultative partitive super- and subordination in partitive concept systems. This means that an entity needs the part (canonical superordination; e.g., 'car' – 'tyre') or can exist without the part (facultative superordination; e.g., 'hotel' – 'restaurant'); the part cannot exist without the whole (canonical subordination; e.g., 'finger' – 'hand'), or does not necessarily need the part (facultative subordination; e.g., 'tree' – 'forest')." (Nuopponen 1994a, 161–164, 2005, 132; see also Winston et al. 1987).

Partitive relations can be divided into the compound relation (*sub-part relation*) ('bicycle' – 'wheel'), partition relation ('bread' – 'slice'), and set-element relation ('firm' – 'employer') (Nistrup Madsen et al. 2001, 7). Maroto and Alcina (2009, 236) define the partition relation (*portion–mass*) as a relationship "between a part and the whole where the nature of the part is the same as that of the whole", (e.g., 'specimen' – 'material'). The set-element relation (*member-collection*) is described as a relationship that is "established between parts that have space proximity or social connection with respect to the whole, no matter the function they fulfil or the fact that they are situated structurally in a specific way", (e.g., 'mosaic' – 'tesserae' [piece of mosaic]) (ibid).

4.2.2. Material-component relation

Another type of contiguity relation is the relation based on an entity and a material that forms a part of it or can be extracted from the object, e.g., 'wine' – 'alcohol'; 'olive' – 'olive oil'; 'egg' – 'cholesterol'. This relation is different from partitive relations and treated as a separate type of contiguity relations (Nuopponen 1994a, 91, 108–110; 2005) (cf. Nistrup Madsen et al. 2001, 7; Maroto and Alcina 2009, 236; see also the ingredient relation in Section 4.4). Nevertheless, this distinction is not relevant when analysing concepts that refer to abstract phenomena (e.g., 'friendship' – 'trust').

[5] The counterpart in semantic relations is called *meronymy* and the term is sometimes used to refer to partitive concept relations, too (Maroto and Alcina 2009, 237). This type of semantic relation has been dealt with quite extensively in Cruse (1986) and Murphy (2003).

4.2.3. Property relation

The property relation is based on the relationship between an object and its properties, e.g., 'wool' – 'thermal resistance'; 'virus' – 'contagious'. The object can be of any type (e.g., material, activity, entity). The properties could also be anything (e.g., form, performance, purpose, color, ability etc.). Maroto and Alcina (2009, 236) exemplify the *object-characteristic* relationship with 'ceramic floor tile' – 'water absorption'. In some domains, such as Chemistry and Law, property concepts are important. However, in other fields and contexts, they are not always regarded as concepts and given a designation, but rather specified with longer descriptions.

4.2.4. Locative relation

Locative relations are based on the contact between an object and its location, site, habitat, environment or container (e.g., 'fish' – 'lake'/'water'; 'book' – 'bookshelf'; 'tea' – 'teapot'; 'visual information' – 'iconic memory'). León-Araúz and Faber (2010, 13) consider this relation type "relevant when the location of a physical object is an essential characteristic for its description". They distinguish it from the partitive relation and exemplify the latter with 'river bed'. Since a river cannot exist without a bed, there is thus a partitive relation. If these two relations converge, the *part_of* relation overrides the *located_in* relation (ibid). Another example is 'computer case' since the central processing unit (CPU) is located in the case. The CPU is thus not part of the case but both are parts of the computer configuration.

Maroto and Alcina (2009, 236) define *space-area* as a relation that is "established between a spatial area and the specific localizations inside that area", e.g., 'visible area' – 'radiation field'. Moreover, other relation type classes include location, linked to the relations of activity (Section 4.3), origination (Section 4.4), and transmission (Section 4.6). However, they involve a more dynamic location, a location where something happens.

4.2.5. Enhancement relation

The enhancement relation connects two objects, one of which can be attached to the other without being its actual part (Nuopponen 2005). It is not always distinguishable from (facultative) partitive relations. The question here is the difference between *part-of* (e.g., 'mobile phone' – 'camera') and *accessory-of* (e.g., 'mobile phone' – 'protective case'). Dictionaries define 'accessory' as "an object or device that is not essential in itself but adds to the beauty, convenience, or effectiveness of something else" (Merriam-Webster 2020). A distinction could be made between relations referring to (a) an object and its accessories (*accessory relation*); and (b) an object and a connected object (*attachment relation*).

4.2.6. Ownership relation

The ownership relation is sometimes impossible to distinguish from the partitive relation, but it may become relevant in certain cases, such as in 'car owner' – 'car' and in other cases where ownership is an essential characteristic (e.g., 'copyright owner' – 'copyright'; 'building cooperative' – 'real estate'). The relation often involves concepts referring to persons, groups of people or legal entities, and an object belonging to them.

4.2.7. Rank relation

The rank relation is based on comparison, rating, or ranking phenomena according to a property, such as importance, efficiency, value, or size. A classic example is the different levels in the military, e.g., 'sergeant' – 'corporal' – 'private'. Furthermore, concepts in a taxonomy may be related to each other with rank relations, e.g., 'species' – 'genus' – 'family' – 'class'. Examples from academic education include 'Bachelor of Arts' – 'Master of Arts' – 'Doctor of Philosophy'. The concepts on the same level are 'ranked' equally, e.g., 'Master of Arts' – 'Master of Science'. The rank relation is the original hierarchical relation). Various fields have their own hierarchies and principles upon which hierarchies are built. They also have their own terminology as well as meta-concepts, which terminological methods could apply to further specify this relation type (Nuopponen 1994a, 94–95, 186–187, 2011, 13).

4.2.8. Temporal relation

Temporal relations are based on contact in time and should be distinguished from contact in space. Depending on the concepts connected, they could be subdivided into phase relations or successor relations. In the first case, concepts represent a sequence of phases of events, actions, or processes (e.g., 'drafting' – 'rewriting' – 'editing' etc.). In successor relations, the concepts refer to persons, things, or time periods that follow one another in succession, (e.g., 'former president' – 'president'; 'starters' – 'main course'; 'Monday' – 'Tuesday' – etc.). In both cases, these relations could be subdivided into consecutive, overlapping (intertwining), and simultaneous (Nuopponen 1994a, 176–182; 2007, 204). Therefore, they could also be classified as sequential as in ISO 1087:2019. In addition to the relations between each of the phases, and relations “between two activities or entities that concur”, Maroto and Alcina (2009, 236) distinguish relations between an activity as a whole and its phases. This can be compared to the spatial whole-part relation.

Temporal relations are an essential element in concept systems with relations of activity (Section 4.3), origination (Section 4.4), and cause (Section 4.7). For instance, in concept systems based on activity relations, temporal relations combine different activities such as the phases of a process or a multiphase activity. Figure 6 shows a sequence of three phases that represents the analysis of concepts for different phases of an activity or a process, different stages in the production of a product, or different “links” in a causal chain.

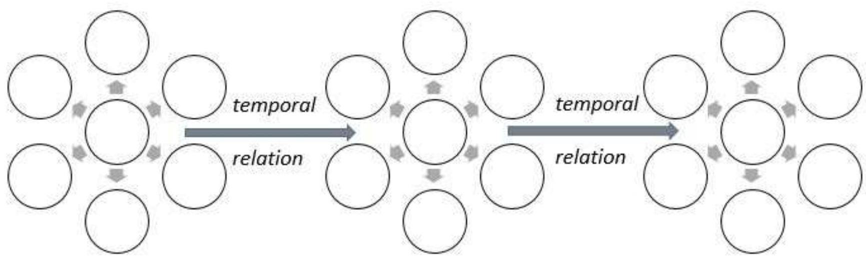

Figure 6. Temporal relations as connectors

4.3. Activity relations

Activity relations are a set of concept relations, where one of the related concepts represents an activity (e.g., ’fishing’, ‘gardening’, ‘elections’, ‘terminology work’, ‘meteorology’). The other related concept refers to the entity performing the activity (agent), the object of the activity, and the tools, materials and methods used (Table 4). Additionally, it may refer to the purpose, location, and direction of the activity. Each question may further result in a broad generic concept system, such as tool concepts where a set of instruments, materials, methods etc. are listed and specified (Nuopponen 1994a, 105; 2006, 85–86; 2011, 11–12). Different sequential activities can be connected by temporal phase relations as shown in Figure 6.

The ‘agent’ concept refers to the entity that performs the activity. It can be “a person, a group, or an organization that intentionally carries out some activity or contributes to it, or takes part in it” (Nuopponen 2006, 85). In the EcoLexicon project, activity and agent also play a central role (e.g., Faber 2015, 23). Here a distinction is made between purposeful, goal-oriented action (agent relation) and a causal activity, where the 'causing agent' may often be a "natural agent" (see Section 5.7).

An 'object' in this context is something that is affected by the activity, or that undergoes an activity, such as 'fishing' – 'fish', 'interior design' – 'interior', 'nursing' – 'patient', or 'cognitive science' – 'cognition'. A 'tool' in this context is understood very generally as anything that is used to perform an activity or to carry out an action ('cleaning'), e.g., equipment (or instrument) ('mop'), material ('detergent'), and method ('green cleaning'. The manner of doing something can also be regarded as a tool or can be taken separately (Nuopponen 2006, 86–87, 2018b).

Table 4. Activity relations

Activity relations	**Based on relationships between**	**Examples**
agent relation	activity and its performer	'research' – 'researcher'
object relation	activity and its object	'research' – 'research question'
tool relation	activity and tools used for it: (instrument, material, method)	'research' – 'research method'
- activity-instrument (equipment) relation	activity and instrument / equipment	'research' – 'software'
- activity-material relation	activity and material utilized	'research' – 'research material'
- activity-method relation	activity and method utilized	'research' – 'qualitative method'
manner relation	activity and the manner/way to do it	'research' – 'objectivity'
activity time relation	activity and time for it	'research' – 'research leave'
teleological relation	activity and its purpose	'research' – 'research result'
locational relation	activity and the place	'research' – 'university'
directional activity relation	activity and directions for it:	
- activity-source relation	activity and its starting point	'marathon' – 'starting line'
- activity-target/goal relation	activity and its end point	'marathon' – 'finish line'
- activity-route relation	activity and its route	'marathon' – 'marathon course'

In certain activities, time is a relevant factor. For example, studies are carried out during the academic year and semesters. In scuba diving, 'bottom time', 'dive time' and 'surface time' are important concepts. Activities also have a purpose. For instance, scuba diving is performed because of leisure, recreation, or as a profession (commercial purposes, scientific purposes, etc.) (Nuopponen 2006, 88). If the purpose is to produce something, the relationship between the activity concept and product concept is a resultative relation (e.g., 'programming' – 'software'), which can be borrowed from the origination relation (product – activity) (cf. Section 4.4). Place or location here is where the activity is performed, e.g., ‘opera (performance)’ – ‘opera house’ (cf. Section 4.2.4). For certain activities, it is possible to distinguish a route (e.g., ‘cycling’ – ‘cycle lane’), or a source and a target (location) (e.g., for ‘source language’ and ‘target language’ in translation).

Instrumental relations could also be taken as a relation class of their own since apart from the activity and origination relations (Section 4.4), there are other relations involving instruments. Maroto and Alcina (2009, 236) include the *object-use* relation in their classification, where object refers to the instrument and use to the use or function “to which it is devoted”. These relations could also encompass those referring to the possible uses of a tool (affordance). Faber, León-Araúz, and Prieto Velasco (2009, 11) include the *has-function* relation, which may link both artificially created objects or processes and natural entities “for human profit”. Furthermore, they mention relations such as *functions*, *measures*, *studies*, *represents*, e.g., “a hydrograph represents rate of water flow” (ibid).

Another group of relations that has been taken as separate in the OntoQuery project are the role relations (Nistrup Madsen et al. 2001, 18–24; Andreasen et al. 2004, 205; see Table 1).[6] In Table 4, the activity concept is the core concept and the others are directly linked to it (see Nuopponen 2011, 11–12; 2006). However, from the perspective of role relations, all the concepts in a concept system of activity have connections between them (e.g., activity/event-agent, agent-patient, agent-instrument, and agent-result) (Andreasen et al. 2004, 205). This would apply more widely to all relation types since concepts can take certain roles (e.g., agent, patient), similar to semantic roles. The EcoLexicon knowledge base, for instance, applies roles, and relates each concept type to other concepts by a set of conceptual relations (Faber, León-Araúz and Prieto Velasco 2009, 8).

4.4. Origination relations

Concept relations of origination exist between concepts that refer to a concrete or abstract object and those that refer to its origin (Table 5). The main concept is the first one. Related concepts refer to the producer/maker/creator/etc., material or ingredients of the object, instrument, manufacturing

[6] The typology is partly based on the activity relations in Nuopponen (1994a, 105, 205; 2005), but includes some further relation types and takes a different angle to the concepts involved.

method, process or activity, place of origin, and time of origin as well as purpose of the product (Nuopponen 1994a, 107–110, 205; 2011, 9).

A distinction is made between ingredient, material component and partitive relations. The ingredient relation is based on materials or ingredients that are used to make something, e.g., ‘bread’ – ‘flour’, ‘yeast’, ‘salt’ and ‘water’, whereas the material components (see Section 4.2.2) of bread would be those in its chemical or nutritional composition e.g., ‘bread’ – ‘gluten’, ‘acrylamide’, ‘carbohydrates’. The relation ‘bread’ – ‘crust’ is partitive (Section 4.2.1). Both artificial and natural objects can be analyzed as to the materials that they are made of (see Faber, León-Araúz and Prieto Velasco 2009, 10), which materials they can be reduced to, or which functional parts they can be broken into.

Table 5. Origination relations

Origination concept relations	**Based on relationships between**	**Examples**
originator relation	object and its originator, creator, producer	‘bread’ – ‘baker’
ingredient relation	object and ingredients it is made of	‘bread’ – ‘flour’, etc.
product-instrument relation	object and a tool or a method used to produce it	‘bread’ – ‘oven’
resultative relation	object and the activity of producing it	‘bread’ – ‘baking’
product-purpose relation	object and purpose of its production or creation	‘bread’ – ‘food’
origination place relation	object and its place of origin	‘bread’ – ‘bakery’
origination time relation	object and time of its production or creation	‘bread’ – ‘baking time’

In the EcoLexicon project, the product-instrument relation (*effected-by*) is “especially meaningful in those domains where human interaction plays an essential role, as is the case of environmental contexts” (Faber, León-Araúz and Prieto Velasco 2009, 10). Furthermore, the authors find the resultative relation (*result-of*) relevant when processes or entities are derived from other processes. This could also be treated as a temporal relation between successive phases (Section 4.2.6). In addition, Maroto and Alcina (2009, 236) add a state as a product of a process (*process–state*). As in causal relations, a distinction could be made between objects, processes, and states as products. Purpose here is to be distinguished from the purpose of an action/activity (teleological relation) (Section 4.3) and from causal relations (Section 4.7).

The origination-place relation differs from the location relation (Section 4.2.2) since it involves concepts that refer to a product and the place or location where it is made or where it originates from. In contrast, the latter is based on the connection between an object and the place where it is located. Similar to the origination-place relation is the relation that León-Araúz and

Faber (2010) call *takes_place_in*. Their example "littoral drift *takes_place_in* the sea" refers to a natural phenomenon, which otherwise activates various types of causal relation.

4.5. Developmental relations

Developmental relations are based on objects that go through stages in various types of process (Table 6). The concepts in these relations may refer to stages of individuals (ontogenetic relation), species (phylogenetic relation), generations (genealogic relation), or materials (material development relation, e.g., 'water' – 'ice'). An additional relation is the role-change relation based on the changing or developing roles of the same individual. Except for sequential connections, there are also simultaneous, co-occurring, co-influencing and co-existing phenomena, which activate even more complex concept relations and entire concept systems (Nuopponen 1994a, 101–103, 196–204; 2011, 10). In various fields, especially in Biology, there are systems and principles for creating this type of concept system.

Table 6. Developmental concept relations

Developmental concept relations	**Based on relationships between**	**Examples**
ontogenetic relation	development phases/ stages/ stages of individual	'child' – 'adult'; 'infancy' – 'adolescence'; 'puberty' – 'adolescence'
phylogenetic relation	development stages of a species	'grey wolf' – 'domesticated dog'
genealogic relation	generations	generations in a family tree
material development relation	development stages of a material	'water' – 'ice'; 'flour' – 'dough' – 'bread'
role change relation	changing roles of the same individual	'presidential candidate' – 'president elect' – 'president'

4.6. Interactional relations

Interactional concept relations are based on the interplay between the objects of reference. Each type of interplay has its own relational properties and can activate networks of several concepts. Interaction is also included in many other relation types.

Within this group, transmission relations are based primarily on the relationship between a sender that sends something to a receiver. The classical communication model underlies this model, but it can be applied to many other fields and types of transmission (Nuopponen 1994a, 214–218). A transmission process may additionally involve one or more intermediaries, a path, and a tool (Table 7). Examples of this type of relation are sender-receiver, sender-intermediary, sender-object etc. (Nuopponen 2007, 207–209). Transmission is a type of activity and together with activity relations, they model most of the activity types.

The representational relation is based on the relation between an entity and another entity representing it (e.g., *concept – term*, *people – parliament*). Dependency relations are based on various types of economic, legal, and other connections that may exist when someone or something is determined or conditioned by another (e.g., *employer – employee*), and the persons involved are mutually dependent on each other.

Table 7. Interactional relations

Interactional relations	**Based on relationships between:**	**Examples**
transmission relation:	participants or objects in a process where something is transferred from one party to another	
- sender-receiver - source-object - sender-intermediary - intermediary-object - intermediary-receiver - tool-object - object-route - object-target	- the ones who send and receive - sender/source of the object and the object - sender and the mediator - mediator and the object to be send - mediator and receiver - tool used to transmit and the object - object and the path - object and the receiver	concepts in communication process, business transaction, or digital communication, etc.
representational relation	an object and its representation	'senator' – 'constituency'; 'term' – 'concept'; 'place name' – 'place'
dependency relation	someone or something that is determined or conditioned by another and this other	'employer' – 'employee'; 'lender' – 'borrower
correlation relation	two phenomena, when one changes, the other also changes	variables that vary or occur together; demand – price

The example 'adhesive' – 'adherent' in Maroto and Alcina (2009, 236) for the relationship *concept-simultaneous concept (in space)* also exemplifies a type of dependency.

The correlation relation is a reciprocal one between two entities, which means that when one changes, the other also changes (e.g., 'price' – 'demand').

4.7. Causal relations

As mentioned in the previous sections, the activity, origination, developmental, and interactional relations include causal components whereas the causal relation includes temporal components. As Marshman, L'Homme and Surtees (2008b, 145) point out, "the close interconnection of this relation with others, such as temporal succession and association, often poses challenges for its evaluation".

Causality is a complex phenomenon, and in addition to 'cause' and 'effect', various other types of concepts are involved (Table 8). These refer to different types of cause (agent, action/event, circumstances, etc.), effect (resulting events, states, products) as well as patients, symptoms, consequences and countermeasures and cures. The concept system becomes even more complex when co-ordinate, parallel, or alternative concepts (e.g., alternative treatments for a disease) are taken into account (Nuopponen 2008).

Causal concept relations have been addressed in terminological research more extensively for instance by Marshman (2002), Marshman et al. (2008a,b), Nuopponen (1994b; 2008), and Pasanen (2019).

Table 8. Causal relations

Causal concept relations	**Based on relationships between**	**Examples**
causator relations (agentive causal relation): causal agent – resulting event, state, product	causing agent and the effect	'SARS-CoV' – 'COVID-19'
causation relations (producing causal relation): producing cause – resulting event, state, product	causing action and the effect	'SARS-CoV infection' – 'COVID-19'
explanatory causal relations (circumstantial relation): explanatory cause – resulting event, state, product	circumstances needed and the effect	'exposure to SARS-CoV' – 'COVID-19'
symptom relations: effect – symptom, symptom – cause	effect and its symptoms; symptom and its causes	'COVID-19' – 'loss of smell'
counteraction relations: counteraction – cause, effect, consequence, symptom, patient	preventing or curing measures and causes, effects, consequences, symptoms or patients they are addressing	'COVID-19' – 'vaccination'
patient relations: patient – cause, effect, consequence, symptom	affected and cause, effect, consequence, or symptoms for it	'respiratory tract' – 'COVID-19'
consequence relations: cause/effect – consequence	consequences and their cause or effect leading to them	'COVID-19' – 'memory loss'

5. Conclusion

In this chapter, concept relations were characterized, based on a selection of typologies. After defining the relevance of conceptual relations in Terminology, their meaning for terminology work and terminological resources were discussed. The last part of the chapter focused on four typologies of conceptual relations. Nuopponen (1994a, 2005), which is the most extensive, was used as a basis for comparison. The inventories of conceptual relations in OntoQuery, Maroto and Alcina (2009), and EcoLexicon provided definitions, additions, and modifications as well as possible new perspectives and directions for future development.

Since all of these typologies vary from one publication to another, not all of the relation types in them could be covered in this chapter. Nuopponen's typology is the result of a theoretical study whose goal is to create a general concept system for conceptual relations. Accordingly, it is a top-down process, which takes existing typologies and relation descriptions, including Wüster's, as the point of departure. It has also been tested in various fields. The other typologies of conceptual relations mentioned in this chapter are from multidisciplinary research projects, which have a specific goal and which pertain to a certain specialized domain. Consequently, the sets of relation types were finally narrowed down to those that were relevant to their project. With the help of these domain-specific studies, we were able to pinpoint some lacunae as well as the need for the further division of certain relation.

Our review shows that although typologies of conceptual relations differ, they also have many features in common. The distinctions can be explained by different approaches and disciplines, which not only contribute their own terms and concepts but also their own concept systems. Interdisciplinary terminology in this case comes from semantics, ontology and corpus studies. When definitions and examples are scrutinized, beyond the superficial terminological differences (e.g., *concept relation* vs. *semantic relation*), few differences can be truly observed. Because of the different concept systems, however, inventories of conceptual relations are not fully identical though there are many similarities. Shared characteristics can be found at the lowest level of abstraction, whereas the greatest differences reside in the way that the relations are grouped and in how the top-level classification is structured.

The top-level division in the typology by Nuopponen is based on generic (syn. logical) and ontological relations. Accordingly, ontological relations are divided into contiguity (in space or time), activity, origination, developmental, interactional, and causal relations. In addition, instrumental and role relations comprise groups of their own. The most common relation types, such as generic, partitive, temporal and causal, are well described and scrutinized in research reports and Terminology handbooks. Nevertheless, many of the previously mentioned relation types need to be looked into closer and studied in future research projects and method

Nuopponen, Anita: Conceptual relations : From the General Theory of Terminology to knowledge bases. https://doi.org/10.1075/tlrp.23.03nuo

development. A step in this direction is the international ISO 704 standard, which is in the process of expanding its set of relation types (see chapter by Wright in this volume).

Concept relations have been regarded as important elements in the theory and methods of Terminology since the very beginning. In many ways, they are needed now more than ever, because concept relation information is crucial not only for terminology work but also for other purposes of knowledge transfer. There is a need for terminological and conceptual clarity in regard to specialized knowledge transfer. There is also a growing body of research focused on how concept relations are expressed in texts since an infinite amount of digital text is available. To access and organize specialized knowledge, ontology work has foregrounded concept relations. The development of various types of query system emphasizes the need to analyze context and syntax with a view to finding related concepts. For example, artificial intelligence systems are finding and producing a lot of data. The analysis of these data has highlighted the need to classify and organize it. In this type of endeavor, terminology, concept relations and field-specific conceptual systems are extremely relevant.

NOTE: The references are in the list of references of the whole publication.

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