Relationship based Reasoning

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ABSTRACT
Relationship plays a vital role in the development of ontology for a domain. Relationships are fundamental to semantics in ontology in order to associate concepts and their instances. Subsumption, Satisfiablity, Consistency and Instance Checking are carried out in reasoning. It is accomplished with the use of concepts (TBox) and instances (ABox). Relationship based reasoning is important and very complex to implement. It can be achieved only with the use of finding semantic similarity between relationships. This paper discusses how the effective reasoning can be attained with the use of relationship. It discusses about the advantages of relationship based reasoning.

Keywords
Reasoning, Relationship, Formal Relations, Material Relations

1. INTRODUCTION
Reasoning is crucial where the knowledge have not been explicitly specified. It should infer some knowledge from already known facts. Practically it is very difficult to specify complete knowledge about the particular domain in a system. Thus the reasoner should be designed to infer some logical consequences from some set of already known facts.

Machine learning and reasoning are challenging one in today's IT development world. Both can be achieved with the use of ontology as it makes the system to understand the common structure of the particular domain. For the valid reasoning with the available knowledge, the representation technology and its power to reason are vital. In this sequences, predicate logic to extended DL have been used. Due to the expressiveness of DL, it has been widely used. OWL ontology uses DL for representing semantic information.

Many reasoning systems have been developed for reasoning and querying Ontologies. Among many reasoners, Fact++ [1], Pellet [3] and Hermit [2] have been widely used with Protégé. Protégé is one of a tool to develop ontology for a particular domain. The important services provided by those reasoners are Subsumption, Satisfiablity, Consistency and Instance Checking. All the services mainly focus towards concepts and individuals.

However, relationship between concepts is an important one to consider for critical applications like chemical and biological domain where quite less number of people addressed these issues. It plays a vital role in the development of ontology. Without relations, it is meaningless. Various kinds of relations can represent between concepts. It includes general relations (formal) and specialized relations (material). Reasoning over formal relations can be easily achieved with any kind of reasoners. But, it is very difficult in case of material relations. Since, semantics differ from one relation to another relation and also there may be a chance of having more than one relation between concepts.

In this work, an attempt has been made to infer relationship exists between ancestor classes. For example, if Laus has "isaffectedby" relationship with Acid rain; Acid rain has "isacomponentof" relation with Sulpuric acid. Our system is to be developed to identify the relationship exist between Laus and Sulphuric acid. Generally, reasoning gives intellect over concepts and its instances. Our paper portrays how effective reasoning can be attained with the use of relationship. In addition, it converses the advantages of relations based reasoning.

Section 2 discusses about various work related to relationship based reasoning. Section 3 describes various kinds of relations, its importance, etc. Section 4 discusses about advantages of reasoning which is based on relationship. Section 5 concludes the paper.

2. RELATED WORK
Guizzardi and Wagner [7] proposed a foundational ontology in order to provide real world semantics and sound modeling guidelines using conceptual modeling. In this paper, they discussed about the graphical representations of formal and material relations.

Amit et el [13] discussed about various simple and complex relation. It is explained about what is captured, how they are represented, how they are identified, discovered or validated and exploited. These relationships may be based only on what is contained in or directly derived from data or may be based on information extraction, external and prior knowledge and user defined computations. They presented some recent techniques for discovering indirect (i.e., transitive) and virtual (i.e., user-defined) yet meaningful (i.e., contextually relevant) relationships. It is based on a set of patterns and paths between entities of interest. They insisted that relationships are fundamental to semantics – to associate words, terms and entities.

Barry Smith et el [14] described a methodology for providing consistent and unambiguous formal definitions of the relational expressions used in such Ontologies. It is designed to assist developers and users to avoid errors in coding and annotation. It supports interoperability and support automated reasoning.

Axiomatic formalization of a theory of foundational relations between individuals, universals and collections is provided by Bittner in [4].

Wen-fei and Xin-li [15] constructed many relationships between Thesaurus. It includes Genus-Species, Part-of, Population and Individual, Superior-subordination,

Synonymy, Similarity, Timing, Spatial, Contradiction relationship etc.

Gu, Wei, Mejino and Elhanan [12] designed an algorithm to detect incorrect assignments with the use of relationship. They identified classification errors, redundant and circular relationship assignment errors.

Only few researches are currently carried out based on relationship based reasoning. Next section describes the importance of relationship.

3. IMPORTANCE OF RELATIONSHIP

Ontology contains concepts, its attributes, relationship between concepts and its instances. Relationship is used to structure the concepts in the ontology. In ontology, all the concepts are hierarchically defined. Without relationship, ontology has no meaning. It helps the system to understand more about what the concept is. In addition, it is used to rank the documents in the information retrieval. It also represents the dependency between concepts in the domain [5].

Relationship has some of the basic characteristics like symmetry (symmetric, asymmetric, antisymmetric), transitivity (transitive, intransitive), reflexivity (reflexive, irreflexive). In addition, it has functional, inverse functional and ordering (total order, partial order and no order) characteristics. All the relations can't satisfy these characteristics. Most of the formal relations satisfy transitive relations. But materialized relations depend on semantics of the relation.

Formal relations [7] hold between two or more entities directly, without any further intervening individual. It includes is-a, part-of, subtype-of, subset-of, etc. Figure 1 shows the formal relations of the Pizza ontology.

Material relations [7] have its material structure. Examples include working-at, has-contact, is-connected-to, etc. It has temporal relations like transcribed-from, transcribed-to, processed-from, processed-into, etc and spatial interval like contains, overlaps, maximally-overlaps, adjacent to, starts, finishes, etc. [8]. Figure 2 shows material relations of the Pizza ontology.

Other general1-semantic relations exists are active relation, antonymy, synonymy, homonym, meronymy, entailment, pertainym and cause/effect relations, etc. Figure 3 shows some of the complex relationship.

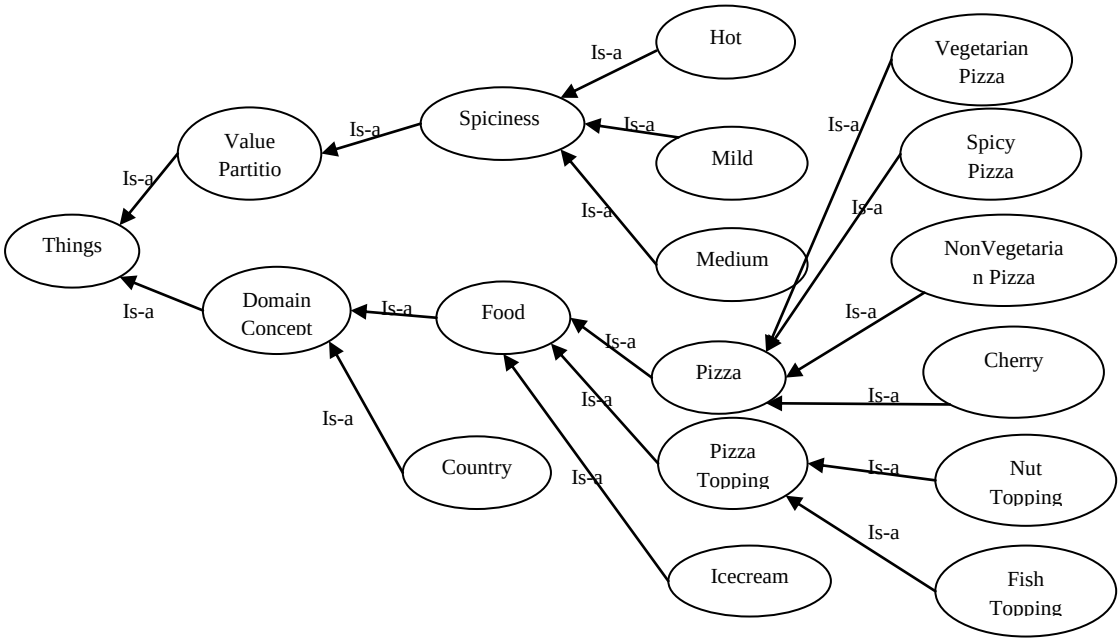

Fig.1: Formal relations

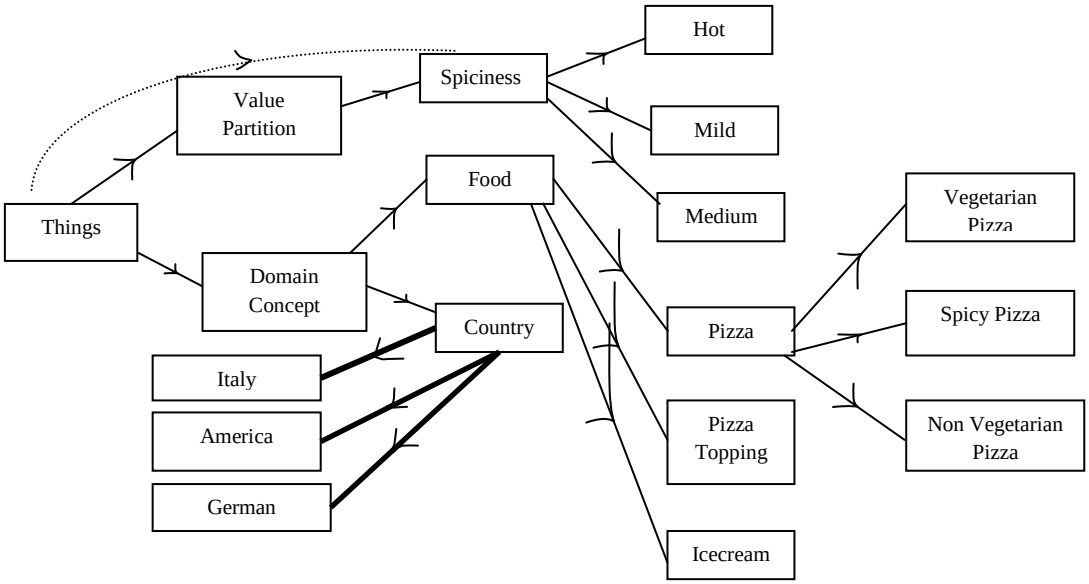

Fig.2: Material relations

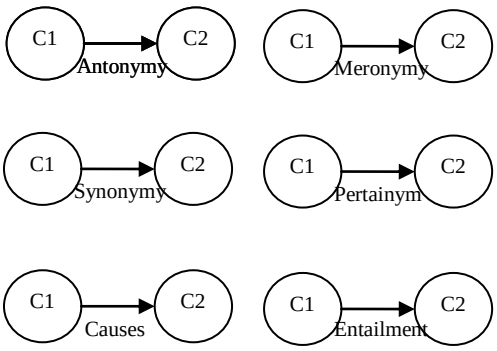

Fig. 3. Some of the Complex relationship

In OBO ontology [6], the relations like instance_of, part_of, located_in, contained, overlaps, adjacent_to, earlier, derives_from, has_participant and has_agent, etc are used between the concepts.

In GO ontology [9], few relations like is-a, part-of, has-part and regulates relation have been used. Reasoning over these relations has been performed. But it can be achieved with only formal relations.

ChEBI ontology [10] contains relations like is-a, is-part-of, is-conjugate-acid-of, is-conjugate-base-of, is_tautomer_of, is-enantiomer-of, has-functional-parent, has-parent-hydride and is-substituent-group- from. But reasoning can be performed only on concepts.

Next section deals about our approach to reason over materialized relations.

4. RELATIONSHIP BASED REASONING

Reasoners uses Tableaux algorithm to infer unknown information. It uses ABox and TBox for query answering. Subsumption and Satisfiablity can be achieved with the use of TBox. Consistency and Instantiation can be achieved with the use of Abox. Mainly reasoners concentrate on Concepts, a relationship and instances. But our work concentrates on Concepts, instances and many relationships.

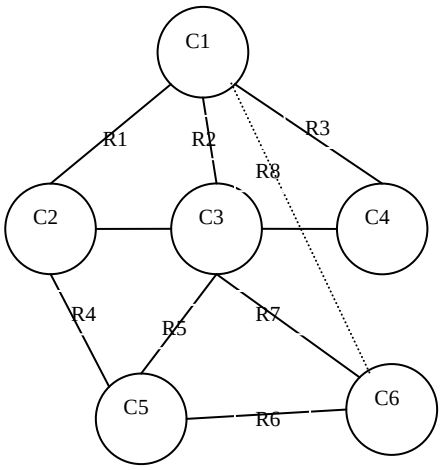

Fig.4: Representation of concepts and relations in ontology

Fig.4 shows an ontology which contains concepts C1,C2,C3,C4,C5 and C6 and relations R1,R2,R3,R4,R5,R6,R7 and R8. Relations from R1 to R7 are represented in the ontology itself. But, end user needs to know about R8. Even, it is not explicitly defined, our proposed system discover its relationship though it is very complex.

In our work, People ontology [11] is used. It contains 60 classes, 14 relationships and 22 instances. Taxonomy classification, consistency checking and instance classification have been performed in People ontology.

Description Logic for People ontology as follows:

Classes

Thing

adult

adult ⊑ ¬ young

animal

animal ⊑ ∃ eats Thing

animal_lover

animal_lover ≡ person ⊓ ≥ 3 has_pet Thing

bicycle

bicycle ⊑ vehicle

bone

brain

broadsheet

broadsheet ⊑ newspaper
broadsheet ⊑ ¬ tabloid

bus

bus ⊑ vehicle

bus_company

bus_company ⊑ company

bus_driver

bus_driver ≡ person ⊓ ∃ drives bus

car

car ⊑ vehicle

cat

cat ⊑ animal
cat ⊑ ¬ dog

Reasoning can be carried over concepts and relations. For example,

dog_owner and leaf

It displays classes which it belongs to. But it doesn't explicitly reason how it was related.

To solve this problem, a method has been proposed to find the semantics of the relations and correlation between the relationships. This method returns

Dog_owner ***is a*** *person. Person* ***eats*** *animal and animal* ***eats*** *leaf* or *dog_owner* ***is a*** *person and he* ***eats*** *leaf* or *leaf is* ***eaten-by*** *person and dog-owner is a person.*

Our method also finds what kind of properties exists with the combination of various relations. It can be achieved with the use of semantic similarity.

It is very useful in Chemical domain. The person wants to know about "if Sulpuric Acid heated and cooled what will happen". Existing reasoner should not infer about this query. But our proposed method infers the information from already known facts and provides it to the user.

5. CONCLUSION

Reasoning is not only important to answer queries over ontology classes and instances. It is very important to maintain high quality Ontologies and to integrate and align multiple Ontologies. Without relationship, it is very difficult to accomplish. Since relationship provides semantics to the ontology. Ontology contains only concepts, properties and instances; it provides only 50% of the knowledge about the particular domain. Our method concentrated mainly on relationship and explained how effective reasoning can be achieved with the use of relationship.

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