An Ontology of Geographic Supply Chain Management for Construction Industry: Modelling with RDF(S)

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Coursework 1 – Group A

1. Introduction

The construction industry is expanding globally and this has caused materials Supply Chain Management (SCM) to evolve over time to optimize production and materials management. The geographic location of materials suppliers and their distance from the construction site are factors that have a significant effect on the cost and quality of the construction [1]. "The ontology of material is a structured common dictionary of concepts within Semantic Web framework covers, substance, environment and process [2]. We investigated the principles, methods and tools for initiating, developing and analyzing the SCM ontologies. This study concerns the concrete linkages between ontology engineering techniques and supply chain management ontology as a particular type of application ontology. In order to further enhance the supply chain process in construction, the authors integrated GIS with SCM using Resource Description Framework (RDF) and Schemas for construction materials and suppliers.

2. Scenario

Researches have suggested integrating the Geographic Information System (GIS) with the Supply Chain Management to improve the effective collaborations. The Construction Specifications Institute (CSI) standardizes the divisions of construction materials and it vocabulary in English language, also called the MasterFormat. The ontology for material supply includes knowledge discovery of construction material, suppliers, manufacturers, warehouse etc.

The purpose of SCM ontology is to address challenging questions in the construction process. The extant literature does not inform us sufficiently about the concrete linkages between OE and SCM ontology. [3] The objective is to effectively share the common knowledge that exists in the SCM by defining the relationships and assumptions and build the theory and models for the construction industry. With the SCM ontology, we hope to bridge the gap among several entities involved in the domains. The ideal application is to locate construction materials and its supplier in a given geographic location. Designer, consultant firms, building

contractors, manufacturers and consumers searching for construction materials are the prospect users of this domain.

The ontology will achieve some of the significant requirement for the construction industry, For instance finding a supplier for a specific material that has certain attributes and having GIS location near to the construction site**.** This would certainly save cost and time and improve the quality of construction. The ontology is supposed to be used and maintain by all the parties involved in construction process, these includes but not limited to contractors, consultants, manufacturers, suppliers and consumers looking for construction related information on the web.

It is needed by the industry as in traditional SCM there is no effective mechanism to locate nearest suppliers of particular materials near to the construction sites. Ultimately, the materials may need to be imported, and results in delays and increase in the project cost.

3. Concepts

The concrete concept is to explore what knowledge the Longitude and Longitude of the world coordinates systems represents in terms of ontology and what these digits have relation to the things of the world. The RDF and ontology would describe what these numbers represents. For instance, what resource is available at a specific geodetic location? Is it a building, supplier, bridge, etc. The following table describes two resources and classifies them as Supplier and Bridge.

Longitude	**Longitude**	**isA**
35.454545543423	2.34454565656	Supplier
12.234344545563	10.3434545456	Bridge
25.234324543245	5.13434343412	University

Table1: Ontology - Geographic Information System for SCM

A construction site comprises of several **construction** projects supervised by a consultant firm, executed by **contractors** and **sub-contractors.** The CSI plays a significant role in standardizing the construction elements using **CSI divisions.** A division have several **sub-divisions** corresponds to construction **materials.** The **Managers** are mainly coordinating with engineers, consultants and the contractors. In project design, the critical stage is to explore the availability of required material and near to the geographic **locations**. However, certain materials need to be imported from other **city** or **countries.** Fig. 1, represents the

SCM components that are interlinked with the supplier geographic data and the web mapping service.

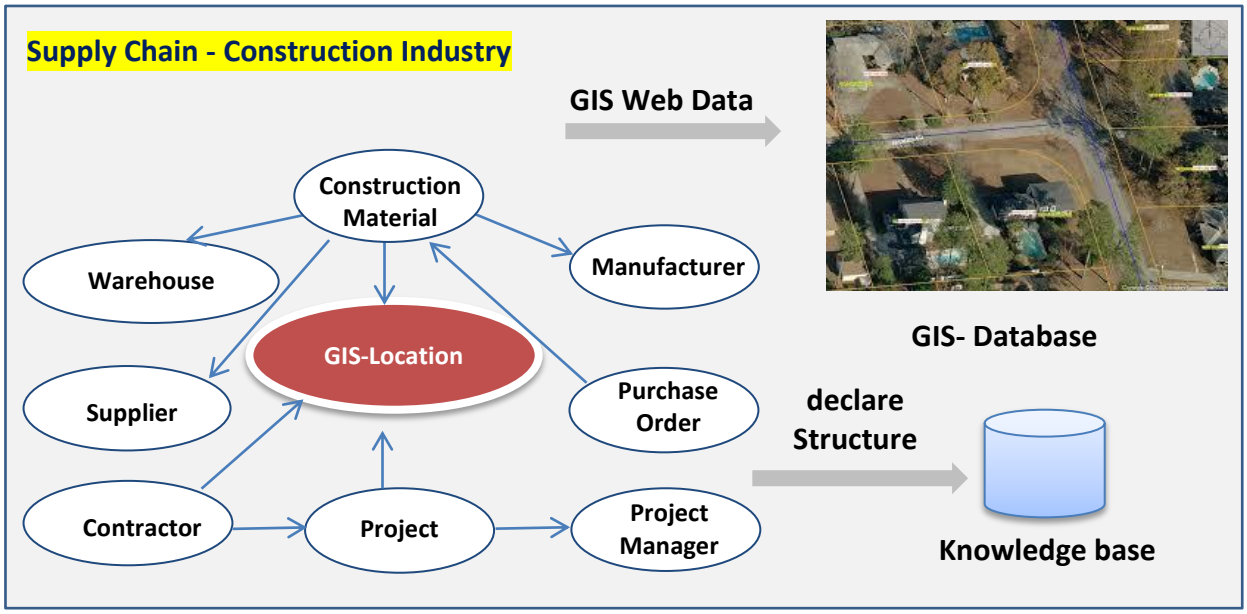


Figure 1: Supply Chain of Construction Material

4. Domain and scope of the SCM ontology

Representation of Construction material and Supply chain Management is the domain of the ontology. Our objective is to use this ontology for the applications that help mangers of the construction industry in decision making to helps them choosing good combinations of construction materials and buildings. The building material has an attribute "Toxiclevel" that defines the toxicity of paint, silicone and other construction materials. Naturally, the ontology would help managers or owners of the building, which combination of material is best for an specific type of construction.

5. Competency Questions

Although there can be a several competency questions, we have decided on the ones that we believe are the most significant.

1- What material is best for a particular kind of construction?

The relationship "**usingMaterial**" exists between the "**Residential**" and the **Material,** the material concept has a property **"hasToxicLevel"** can be used to determine the most toxic material used in the residential buildings.

2- **What are the projects in a locality done by a given contractor?**

The **contractor** is connected to **projects** using **"hasProject"** property and each project is connected to "**hasCountry**" property is helpful in to determining the project's location.

3- **Who are the contractor and consultant companies of a construction at a given location?**

The relationship **"hasContractor"** and **"hasConsultant"** will give the details regarding the companies and the Bridge instance also has a **hasLatitude"** and **"hasLongitude"** properties which will give the location details.

4- **What is the material specification u need to use on the project ?**

The ontology tells u based on location and standards information like the specification you require for a given project, what is the specification of the material you need to purchase. The best one can be chosen based on the best match to requirements to the properties like **"hasStandard", "hasToxicLevel", "isSuppliedBy"** etc.

5- **Who are the nearest suppliers of a specific material near a construction site?**

The relationship "**isSupplierof**" exists between the "**Supplier**" and the **Material**, the Supplier also sharing **"hasLatitude"** and **"hasLongitude"** properties**.** For instance a **Bridge** has a **hasLatitude"** and **"hasLongitude"** properties.

6. Initial Taxonomy

We enumerated the important terms for our scenario and scope. We have modeled an abstract relationship of supply chain in the construction industry. We have used singular names for the defining the classes and sub-class names.The chosen classes and their relationship are shown below in figures 2, 3, 4, 5, 6, 7 and the overall taxonomy can be found in Appendix A.

6.1.Define the classes and the class hierarchy

We have used top-to-down approach for the design and the initial taxonomy consists of **six** top level classes include **Construction**, **Material**, **Company**, **Standard**, **Location**

and **Person**. During the taxonomy hierarchy creation process we established classes several times and checked how different selections influenced the overall hierarchy. The classes and it hierarchy is defined using protégé 3.5 [4]

6.2.Reusing existing ontologies

Reusing the existing ontology is a good option for saving time and in merging different ontologies to extend the functionalities; we searched for "material", "supplier", "supply chain" in the DAML ontology library (http://www.daml.org/ontologies/). We found 1 "material", 4 "materials" and "4" construction ontologies at www.opencyc.com and www.cyc.com. However, they have a keyword for material, but no details available about construction materials and targeting the supply chain management ontology.

6.3.Multiply Inheritance

It is possible for a sub-class to have relation with more than one parent class, in designing the taxonomy of the construction class, the three middle level taxonomies has been defining three different kinds of constructions, i.e. "industrial", "building" and "infrastructure". The industrial further classified into "chemical" and "refinery" having two parent classes. i.e. "industrial" and "building". This states that both these construction types are industrial as well as buildings.

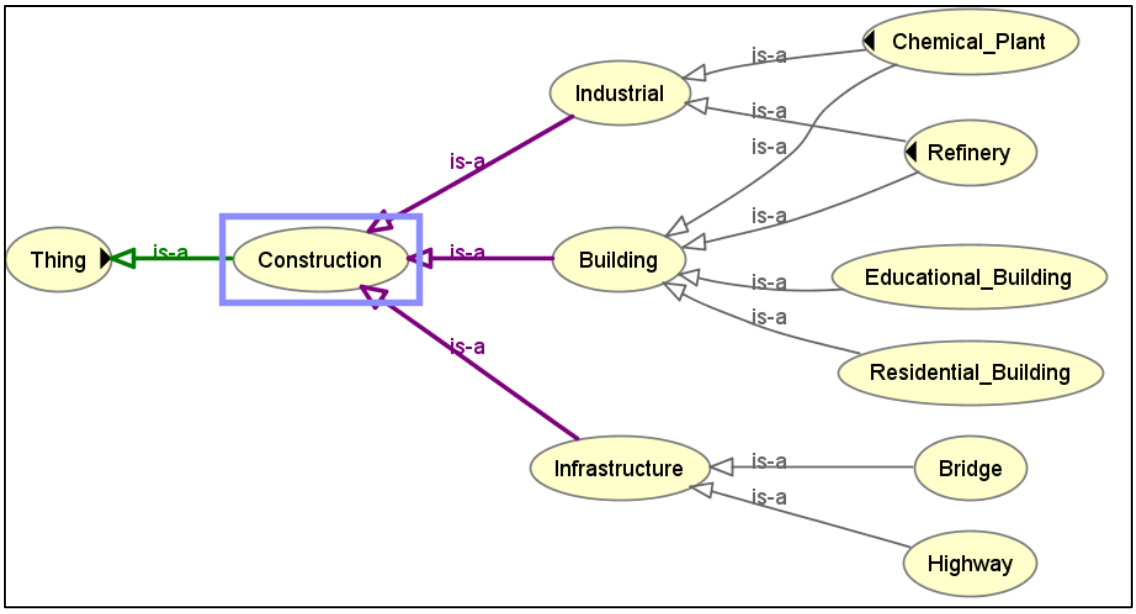


Figure 2: Taxonomy of Construction

6.4. Naming Convention

The material class is a container for other objects having similar features; the coating material and glass are the sub-classes of material class. For example, a class `Nano_Glass` actually represents all Nano_Glasses.

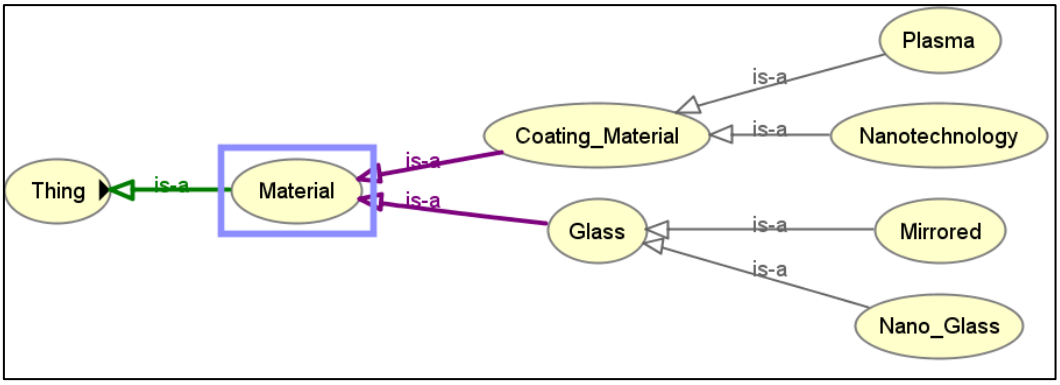


Figure 3: Taxonomy of Material

In construction industry the materials are categorized using different standard defining the, The Construction Specifications Institute (CSI) used in America and Canada, is an organization that keeps and changes the standardization of construction language as it pertains to building specifications [5]. BSI is British Standard Institute also for defining construction standards. .

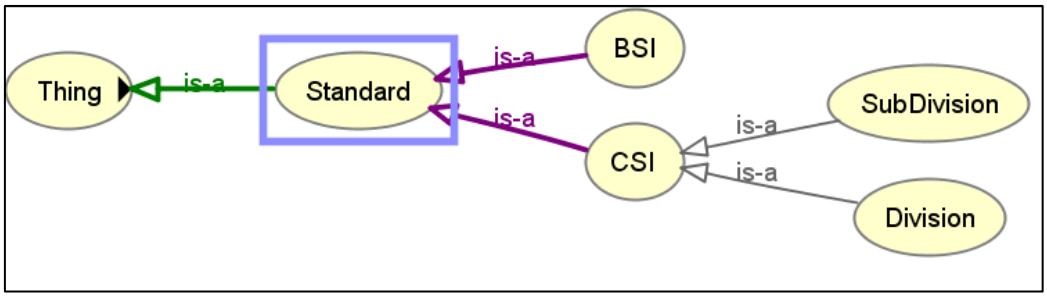


Figure 4: Taxonomy of Construction Standards

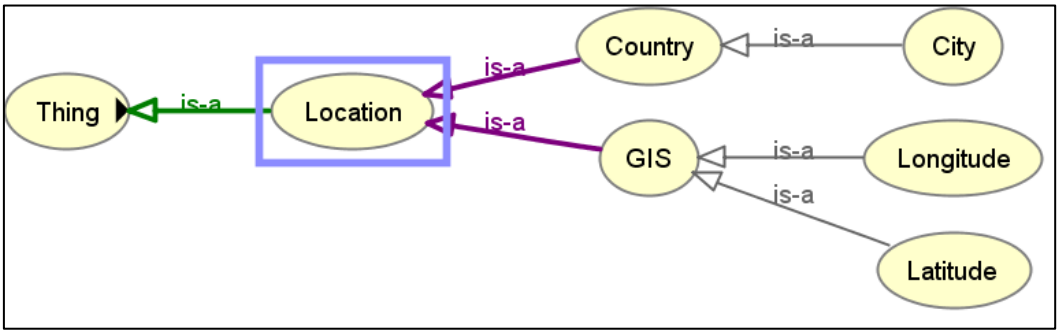


Figure 5: Taxonomy of GIS Locations

6.5. Taxonomy of Company

The class company has sub-classes like contractors, consultants, designers, suppliers, manufacturers. Due to the limitation of number of classes, some of the third level classes are ignored. In construction industry there could be tens of classes of company.

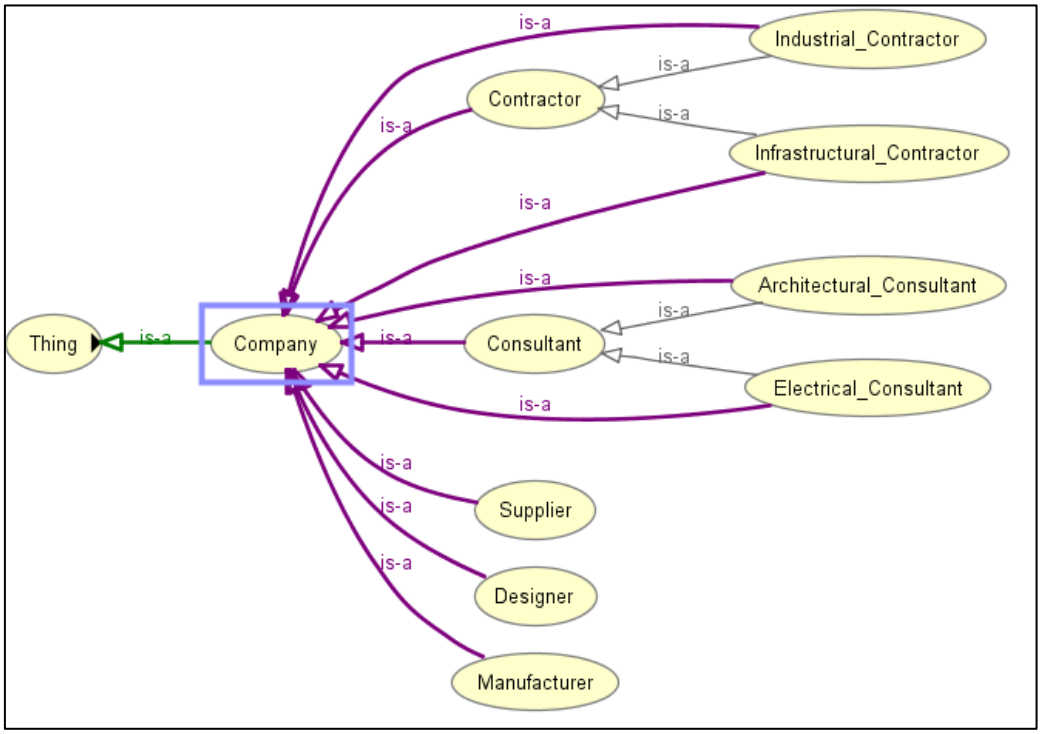


Figure 6: Taxonomy of Company in Construction

The Managers sharing is-A employee with person, on the other hand an owner is also sharing the same relationship. Similarly there could be several sub-classes, but for the task ontology of supply chain, this is just to demonstrate the ontology relationships.

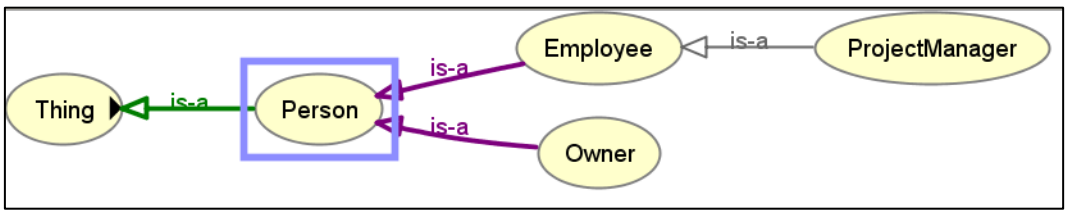


Figure 7: Taxonomy of Person

7. Instances

The following instance diagram represents a scenario where the RDF is defined a triples of nodes and edges. The following instance illustrates A **manufacture** is manufacturing "**Nano-Glass"** has coating **Nano-TiO2** which is produced by **Chemical Plant_1**. Though, the supplier of a specific construction material based on certain attributes could be located regionally.

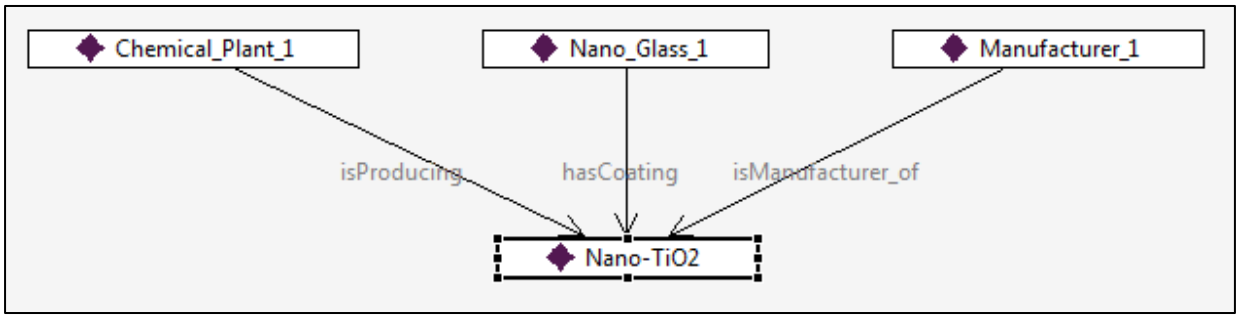


Figure 8: Relationships of a coating material

In this instance, **Peter** is employed at **Consultant_1** that has latitude and longitude location and supervising a **Residential_1** Project.

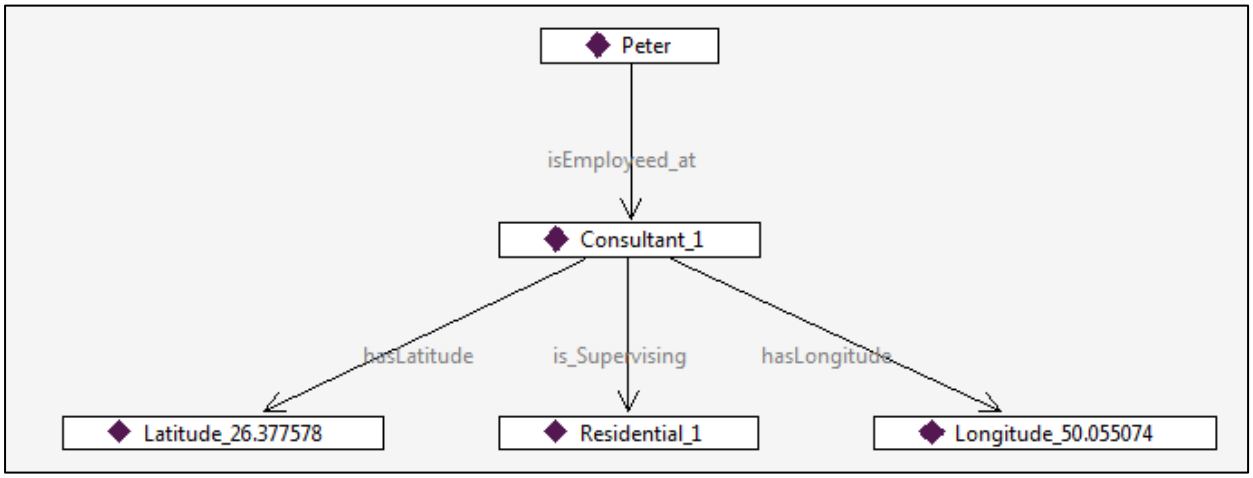


Figure 9: Relationships and properties of a Consultant

This instance showing "**John**" is the owner of the building "Residential_1" which was designed by "**Designer_1**" by constructed by "Contractor_1" under the supervision of "**Consultant_1**"

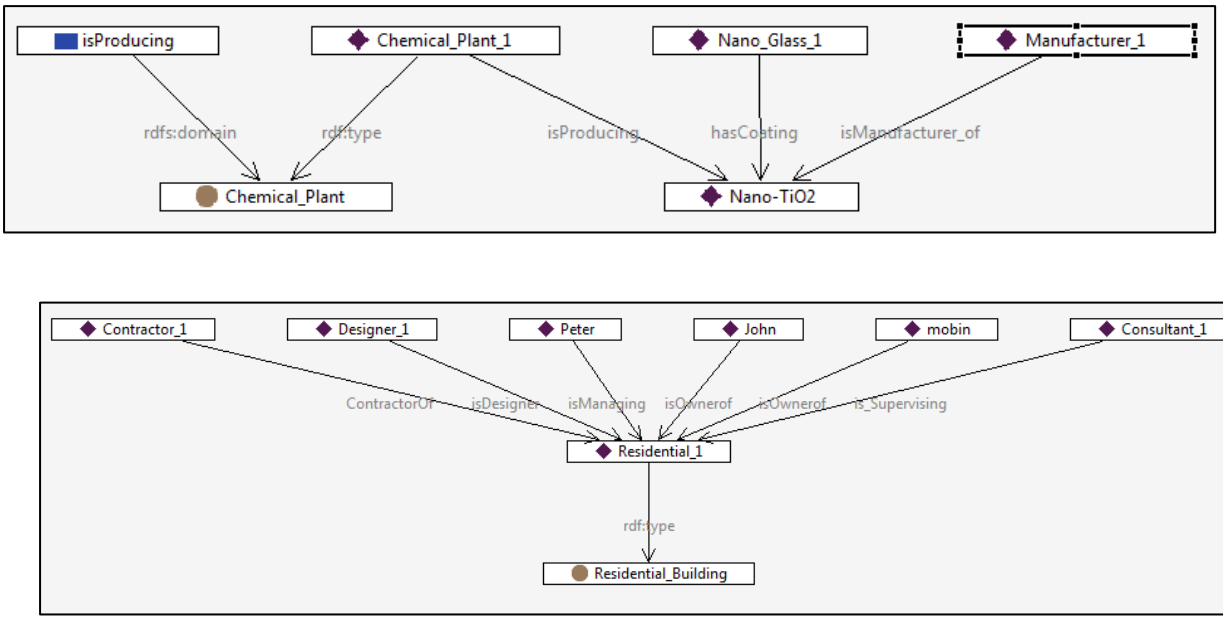


Figure 10: Multiple relationships and properties of various instances

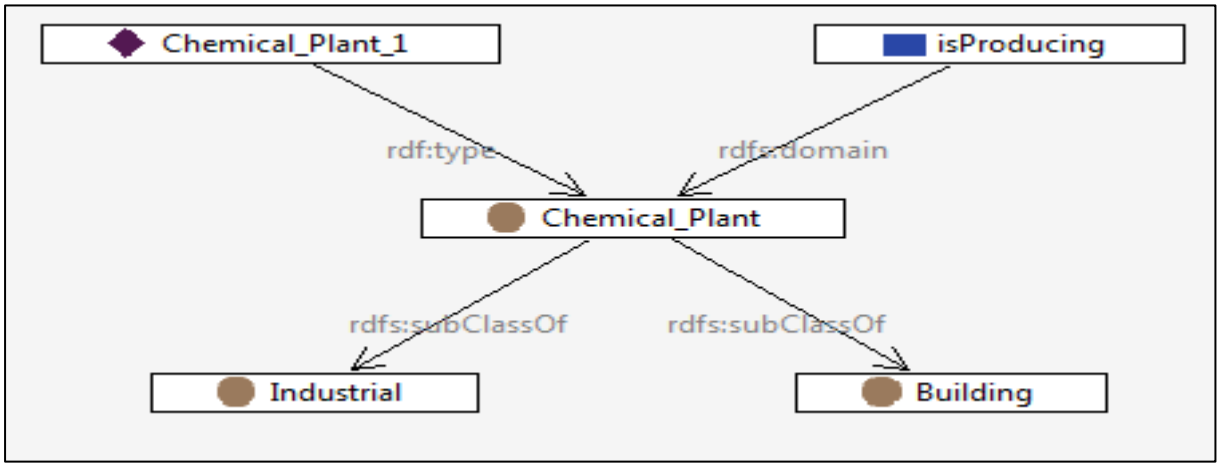


Figure 11: Relationships and properties of a Chemical Plant

The following instance demonstrates **Highway_32** was constructed by **"contractor_2"**

Figure 12: Relationships between a contractor and project

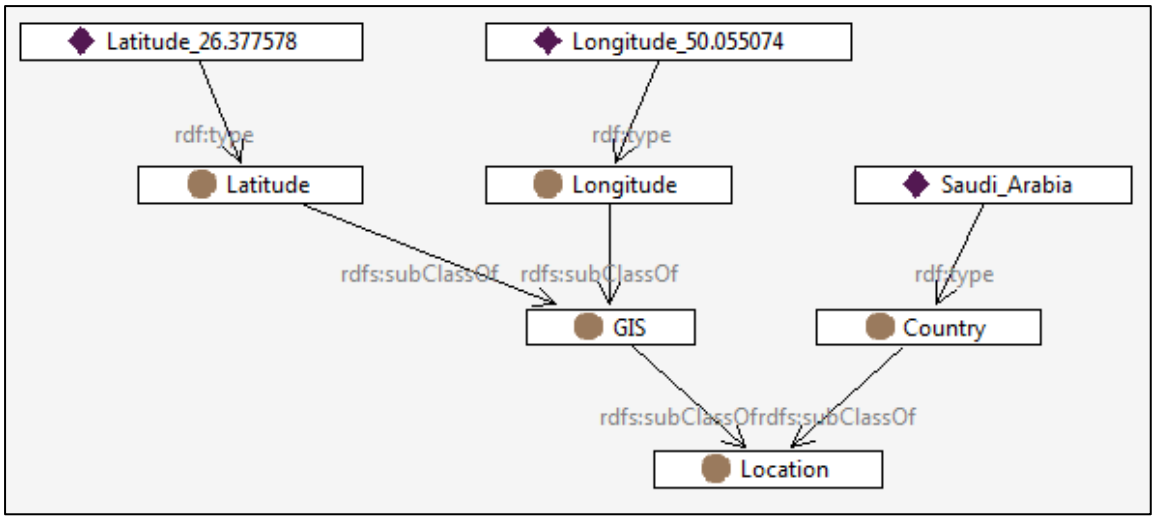


Figure 13: Relationships and properties of Location instance

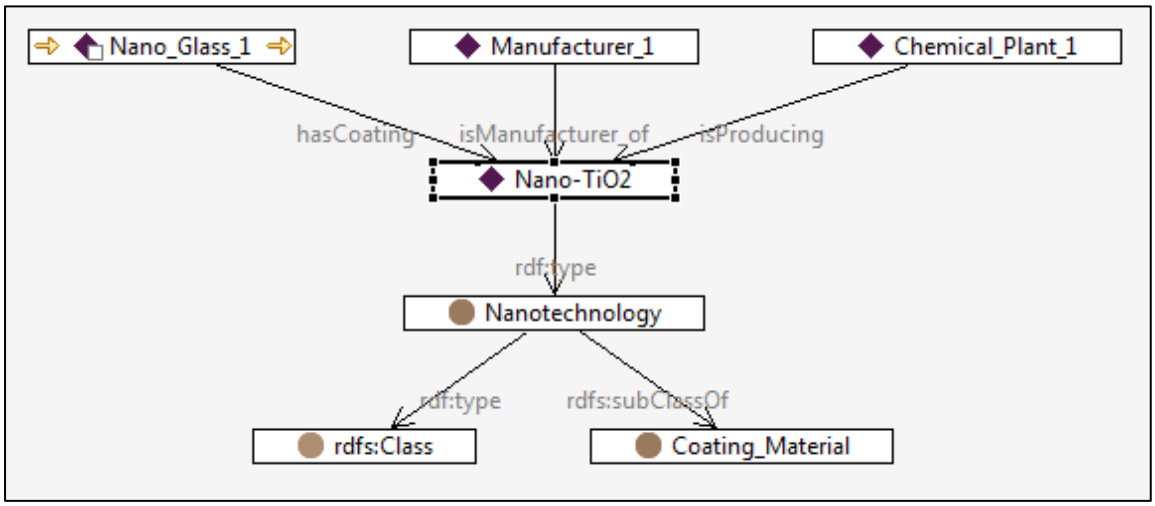
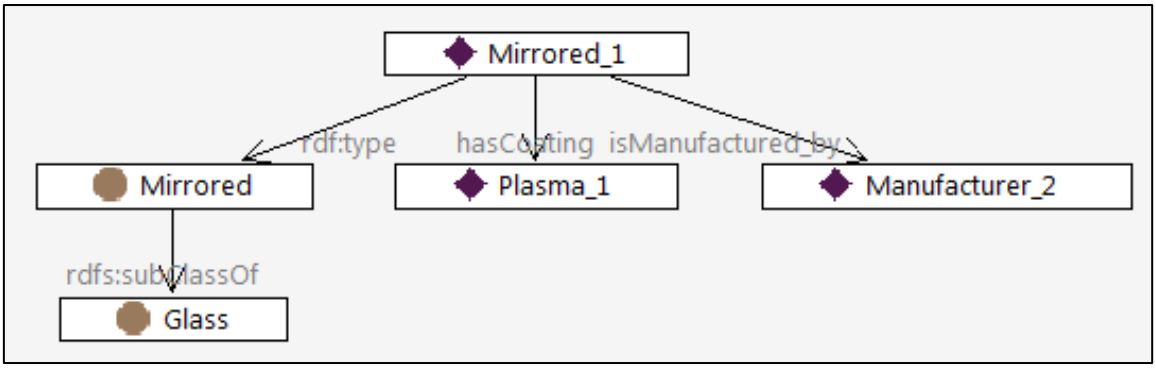


Figure 14: Relationships and properties coating Material



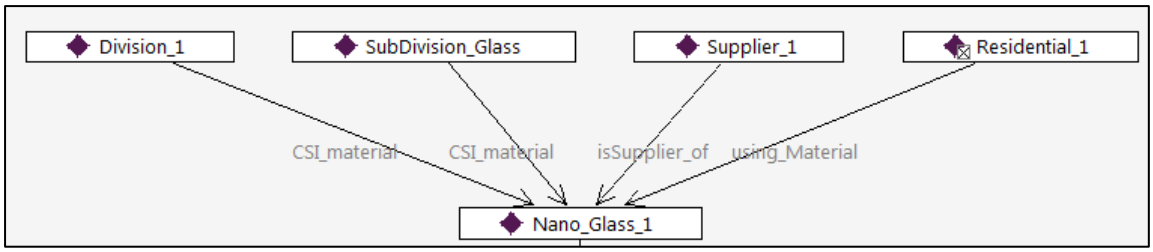


Figure 15: Detailed Relationships and properties coating Material

8. Conclusion

Our task was to create ontology for supply chain management on construction industry. To achieve this goal we created several class hierarchies on different kind of methods and ontology design based on the created class hierarchy and checked how changes on model affect the overall picture of the model. Detailed Protégé file including all the relationships, properties and classes is as attachment. As the main target we're trying to improve interaction among distinctive participants of a construction project. In order to make the ontology work we defined all the important participants and their responsibilities and relationships. The created ontology is an abstract model that was design by the requirements of the coursework.

9. References

[1] Mansour N. Jadid and **Mobin M. Idrees**, "A Geographic Interactive Supply Chain Management System for Construction Projects". *Proceedings of the World Congress on Engineering and Computer Science* 2013 Vol II WCECS 2013, 23-25 October, 2013, San Francisco, USA.

[2] S. Fazal, *GIS Basics*, 1st ed. 2008., Dept. of Geography at Aligarh University, Aligarh, Uttar Pradesh.

[3] Andreas S.,Joerg L., Supply chain management ontology from an ontology engineering perspective" Computers in Industry, Volume 65, Issue 6, August 2014, Pages 913–923

[4] Ontology in Protégée, http://protege.stanford.edu/ [Accessed ,23 Feb 2016]

[5] Construction Specifications Institute
https://en.wikipedia.org/wiki/Construction_Specifications_Institute [Accessed ,28 Feb 2016]

Appendix A: The Overall taxonomy of all classes.

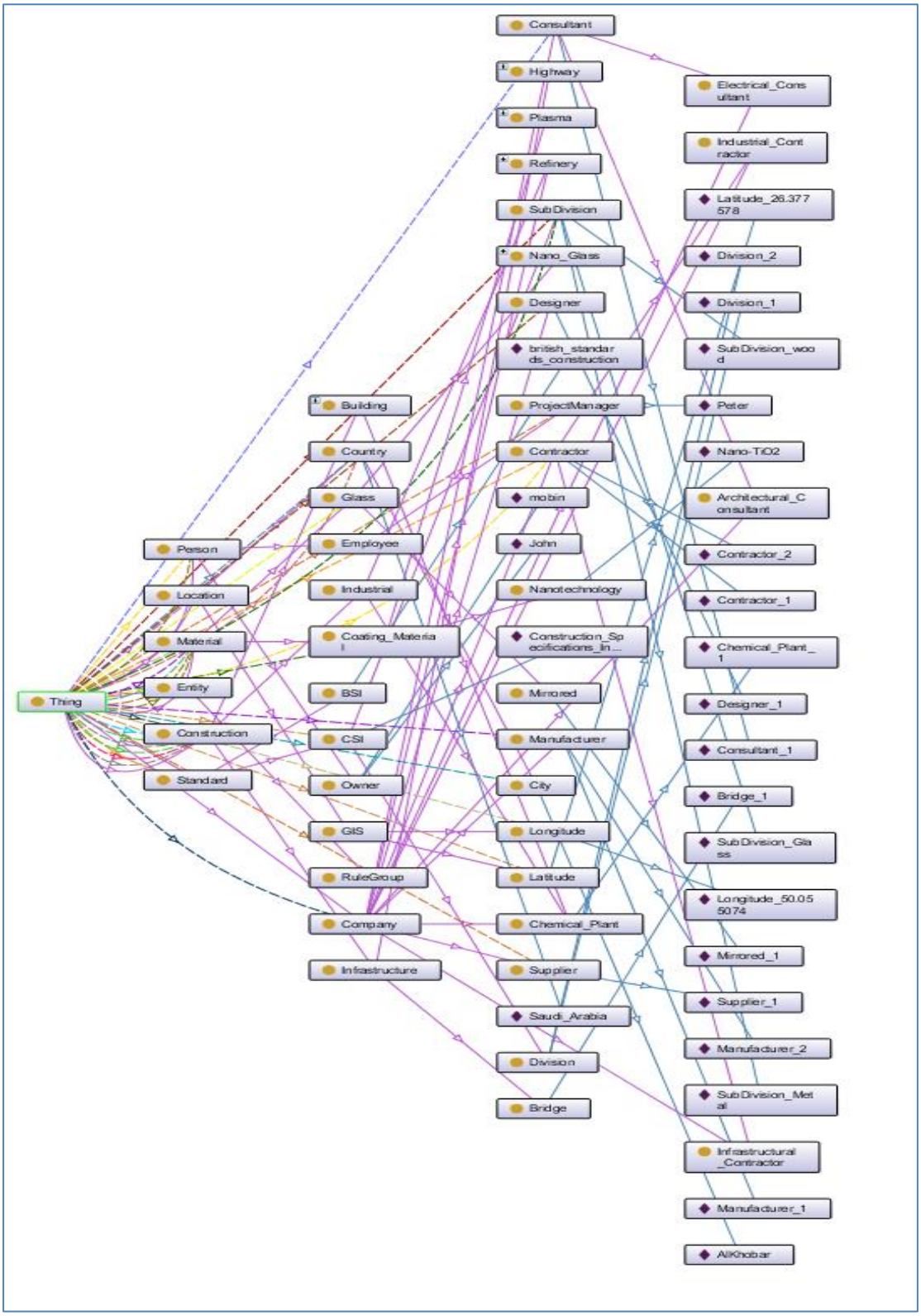


Figure 16: Overall Taxonomy