Semantic Web Model for Design and Operation of Network Control Centre

Chaynika Taneja

Directorate of Management Information Systems and Technology
Defence Research and Development Organisation, New Delhi-110 105
E-mail: chaynika@hqr.drdo.in

ABSTRACT

The Semantic Web, which represents the next generation of the Web, will be characterised by machine-interpretable content, intelligent semantic agents, advanced searches and improved Web services. The underlying languages and technologies for Semantic Web are fast evolving. The paper discusses model of a network control centre created using OWL, a Semantic Web language.

Keywords: Ontology, Extra Markup Language, resource description format, Web ontology language, OWL, XML

1. WEB TO SEMANTIC WEB

The Web, at the time of its conception, was envisioned as an information space. It was meant to be a huge mesh of data, which would be used not only for human interactions but would involve machine participation[1] also. Today, the Web is no longer just a repository of data; it has become a provider of services[2]. However, the inherent structure of the Web and the formats used limit the role of the machines to only the extent of pasteing the encapsulated data to our computer screens[3].

The painstaking task of interpreting the data was left to humans only[4]. So although the plethora of information on the web was immensely meaningful, it could not be read by the machines because the structure of the web was not designed to be interpreted by the computer without any human intervention[5].This gave birth to the vision, which we now know by the name of Semantic Web. The Web would now be a collection of information capable of machine interpretation.

At this point, the semantics of information became more important than its syntactics. So the Semantic Web is merely an extension of the World Wide Web (WWW); the only improvement being that the semantic of the information is well-defined, making it easy to be interpreted and processed by a machine.

2. SEMANTIC WEB LANGUAGES

The WWW used Hyper Text Markup Language (HTML) as the markup language for coding information as text. Multimedia objects like images, etc., were interspersed within it and the resulting webpage was displayed through a Web browser[6]. However, HTML was semantically limited and lacked a rich vocabulary bank to read the meaning behind the text[7].With the coming of XML, data was liberated from these opaque, inextensible formats. It provided a way for encoding data in machine readable formats, thereby, laying the foundations of the Semantic Web applications[8]. The resource description format (RDF) is the language that Semantic Web uses to describe data (or resource) so that it can be conveniently read and manipulated by a computer program. It builds over the Extensible Markup Language (XML) providing the semantics. While XML is just a data format, RDF is a model[6]. Web Ontology Language (OWL) further extends the concept of the Semantic Web by describing additional vocabulary than just formal semantics. Its core idea is to enable efficient representation of ontologies[9]. OWL has three flavours, OWL Lite, OWL DL, and OWL Full, in order of increasing complexity and availability of features[6].

Figure 1 illustrates the relationship between the above technologies and their position in the Semantic Web architecture[6]. All these technologies, namely XML,
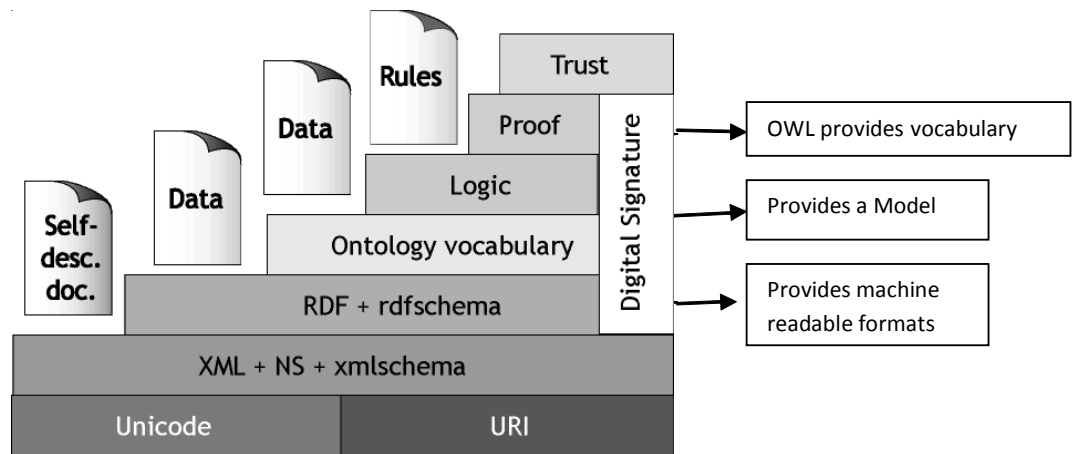
Figure 1. Semantic Web architecture.

RDF and OWL together add semantics or meaning to the information on the Web, so that the computers can now process not just text but also meaning, resulting in more meaningful and relevant searches and applications.

3. OBJECTIVE

The objective of the study was to create a Semantic view of a network control centre (NCC). Most of the large organisations have a NCC or the Data Centre that acts as a central nervous centre of the network. It is the controlling node and is used to manage and monitor the health of the network. The intended model was a generic one and could represent any network centre. The paper also describes how the Semantic Web languages like RDF and OWL can be used to model any process, flow or framework and hence be made part of the Semantic Web dataset.

The ontology once defined becomes a resource on the web, enabling it to be accessed, interpreted and processed by Semantic Web applications. The Semantic Web heavily relies on ontologies to make data structured and hence makes it capable of machine understanding[10].

4. PROCESS FLOW

The steps required for creating the semantic view of the NCC are illustrated in Fig. 2.

5. EDITING WITH SEMANTIC WORKS

Altova's SemanticWorks 2011[11], a graphical RDF/OWL editor was used for the purpose of modelling. The ontology was created in the OWL DL, which is one of the flavours of OWL. However, the choice of the version of OWL may vary with the complexity of the ontology. The process begins with creating a RDF schema file, which was used to develop the information model, in this case "network_control_centre.rdf".
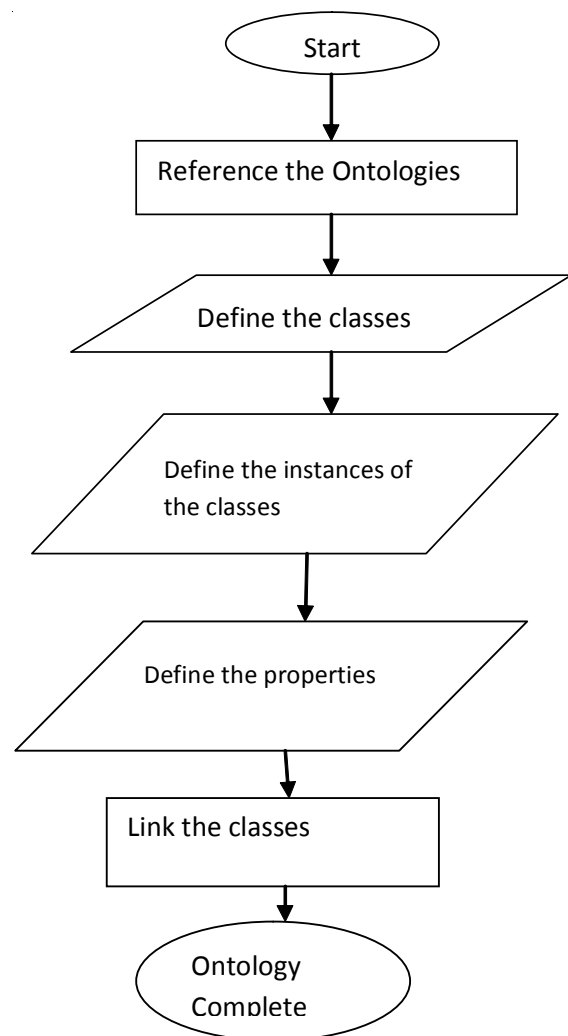

Figure 2. Flow chart of process flow.

5.1 Referencing the Ontology

The first step after creating the RDF Schema file is to reference some of the already existing ontologies, so that they can be used directly in the proposed model.

Prefixes for these ontologies were also created so that these can be conveniently used in the model being created.

Figure 3 shows the ontologies that are referenced in the RDF file. The prefixes are also defined, which can be used to directly refer to the ontology. The prefix 'cen' shown in the Fig. 3 refers to the NCC ontology that was intended to model.

5.2 Defining Classes

The next step is to define the classes, which can be created by clicking new in the 'Classes' tab. The next step is to describe the classes by going the detail view of each class and by providing additional information about the class like its sub-class, parent class, its predicates, etc. The classes defined for the NCC ontology are illustrated in Fig. 4.
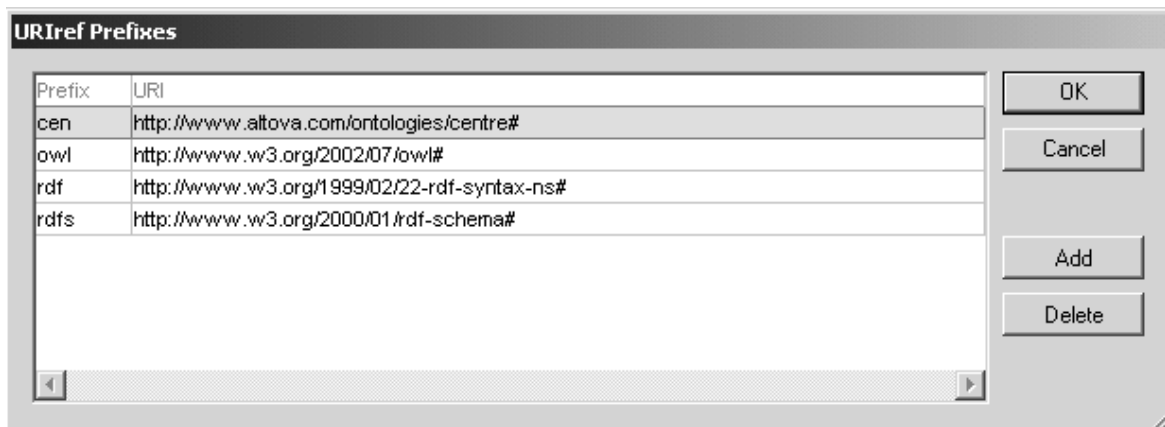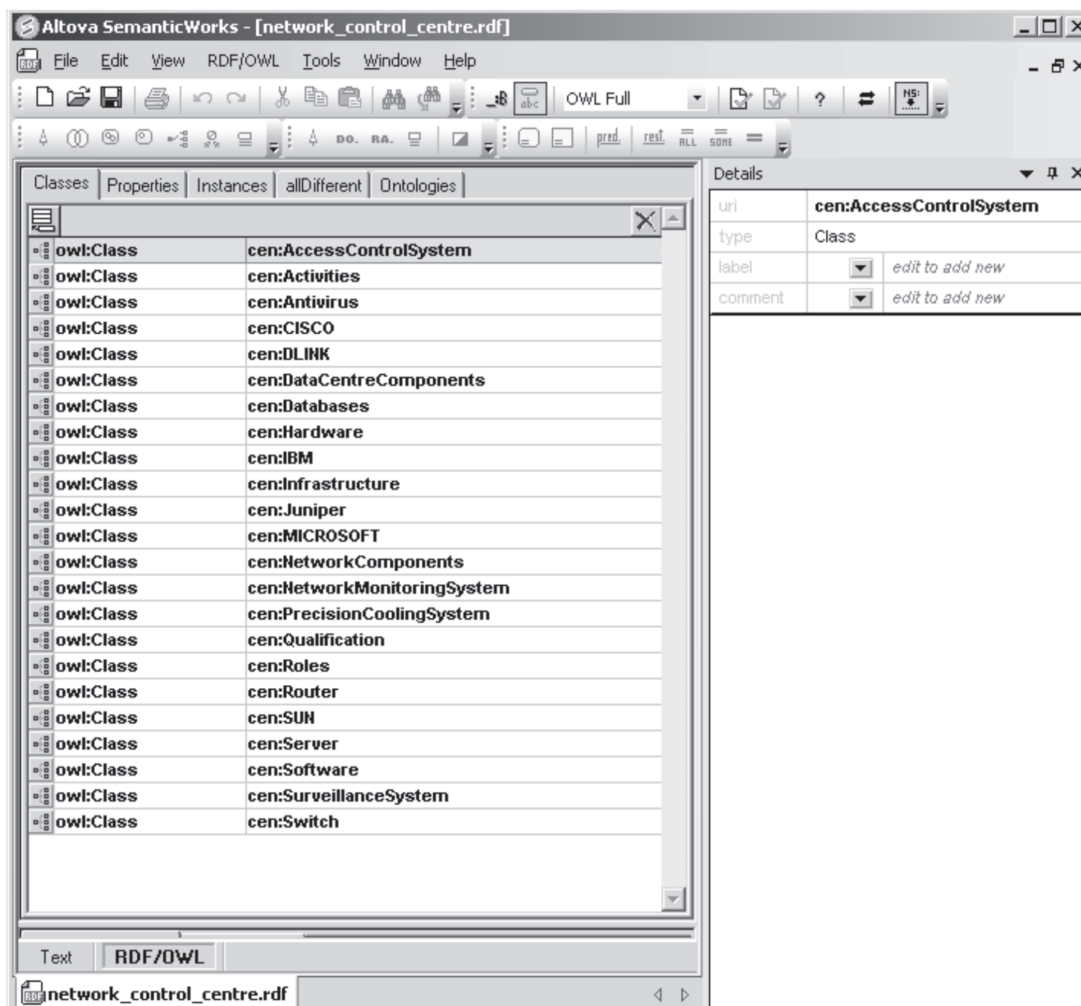

Figure 3. Creating the prefixes.

Figure 4. Defining the classes.

5.3 Defining Instances

Instances of classes are defined and associated once their classes have been defined. This is done by creating the new instances in the Instances Tab and linking these to their parent classes. Figure 5 demonstrates this step.

5.4 Defining Properties

Properties characterise the classes. Once the classes and instances are defined, defining the properties is the next step. In the 'Properties' Tab of the main window, click new property and create the required properties. The domain and range of each properties is suitably pointed out in the details view. Figure 6 lists some of the properties of the model discussed here.

6. NETWORK CONTROL CENTRE MODEL

The virtual NCC may represent any division/working unit of an organisation/establishment. The ontology has been divided into two parts. Both the workflow as well the infrastructural aspects have been modelled. However, the
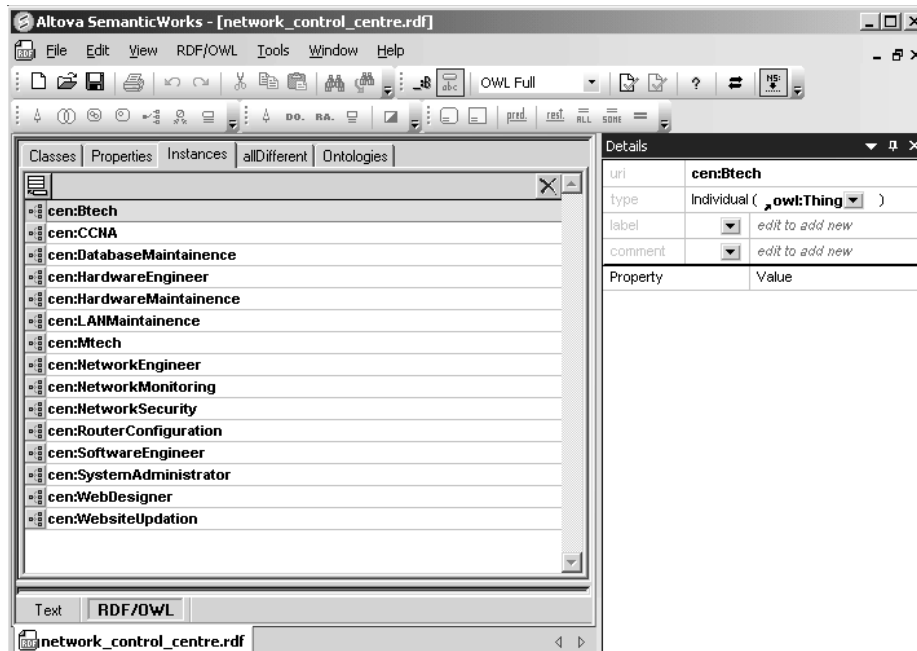

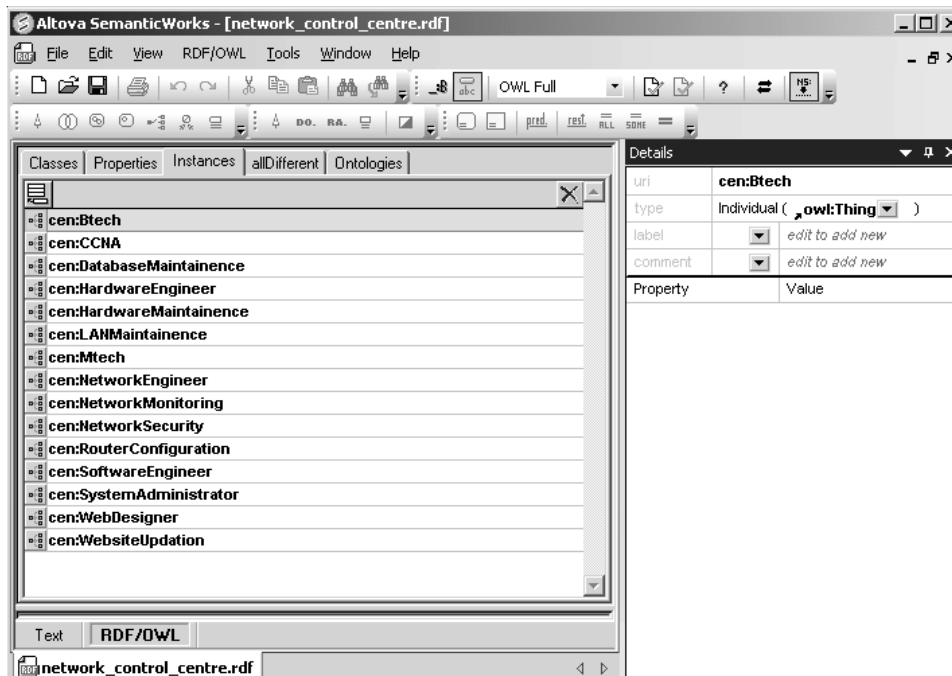**Figure 5. Defining instances of the classes.**

Figure 6. Defining properties.

scope of the tool and the languages is not limited to these and may be extended to model other entities as well like objects, concepts, flows, structures, hierarchies, etc.

6.1 Workflow Modelling

To begin with, a workflow modelling of the network was attempted. Various activities that are carried in a NCC, the roles or designations of the personnel carrying out the jobs, their qualifications, etc., were modelled. Figure 7 shows the graphical representation of the ontology. The activities class has a predicate one of, which implies that Activities can be any of the following classes:

⌘ LAN maintenance

⌘ Website updation

⌘ Network security

⌘ Database management

⌘ Router configuration

The property, 'DoneBy' has the domain as one of the Activities and range as any of the following classes:

⌘ Network engineer

⌘ System administrator

⌘ Web designer

Another property 'ShouldBe' has its domain as any of the roles defined above and range as any of the following:
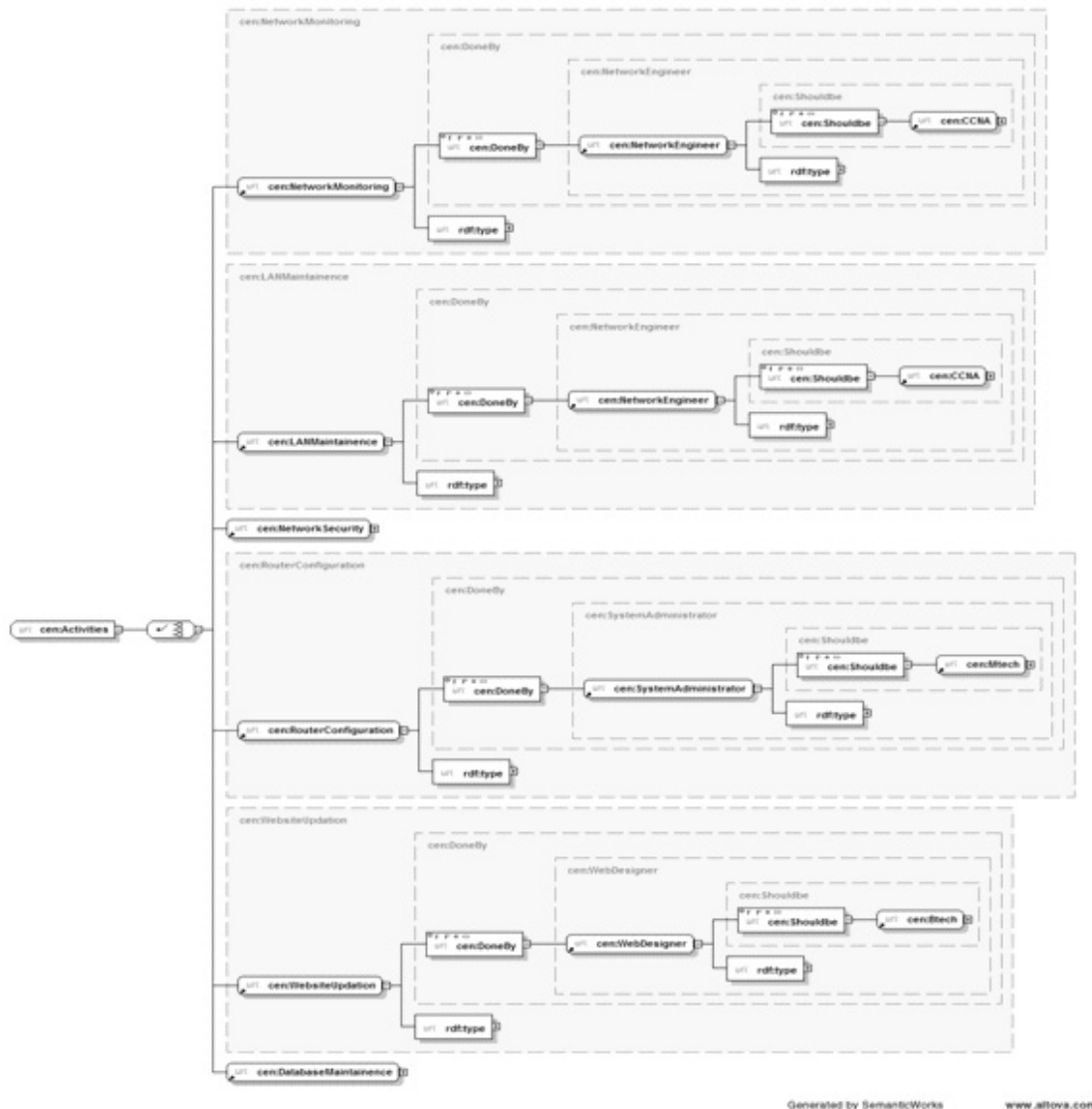
⌘ BTech

⌘ MTech

⌘ CCNA

Figure 7. Workflow modelling.

Now that the ontology has been defined, Statements like the following can be derived from it. "RouterConfiguration is an activity that is DoneBy a SystemAdminitrator who Should Be an MTech qualified personnel."

6.2 Infrastructure Modelling

The ontology defining the infrastructural aspects of NCC is explained here. The parent class 'Infrastructure' is the union of two classes 'NetworkComponents' and 'DatacentreComponents'. Let us now go down the hierarchy and analyse the 'NetworkComponents' class which is further a union of two classes 'Hardware' and 'Software'.

Software Class

✂ Union of classes:

    Antivirus

    Databases

    Network Monitoring System

✂ Predicate: Developed by with Range {IBM, Microsoft, CISCO}

These details are specified while describing the class in the details view.

Hardware Class

✂ Union of classes:

    Router

    Switch

    Server

✂ Predicate: Manufactured by with Range {Cisco, Dlink, Juniper, Sun, IBM}

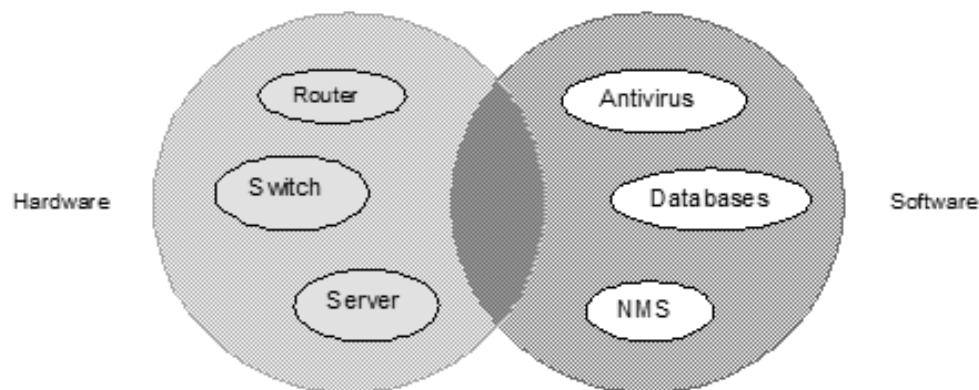The relationship between the various classes described above can be visualised by the Class Diagram

in Fig. 8. The complete ontology of infrastructural modeling has been graphically depicted in Fig. 9

7. INFERENCES DRAWN ON THE MODEL

This process is what forms the basis of Semantic Web applications and makes the whole Web a huge virtual relational database through which information can be extracted through the process of querying. If one considers the Workflow model in Fig. 7, one can derive the following reasoning "If X performs Network Monitoring in the Network Control Centre, It can be inferred that X is a CCNA". As is evident from the OWL ontology, since X performs network monitoring, he/she must be a Network Engineer, and hence should be CCNA qualified. The Semantic Web agent will do this reasoning in the background and give the user this result thus making in an intelligent agent. This is a simplified version of the actual processing that runs behind any Semantic Web application.

8. CONCLUSION

As the Web evolves and inches towards the utopia called the Semantic Web, more and more languages and tools will be developed by Web developers and researchers in this field. However, the widespread acceptance of the concept, its understanding and contribution from everyone is what will make this dream of Semantic Web come true. The paper is an attempt in this direction. It tries to demystify the concept using a model, which is applicable to almost every setup or organisation.

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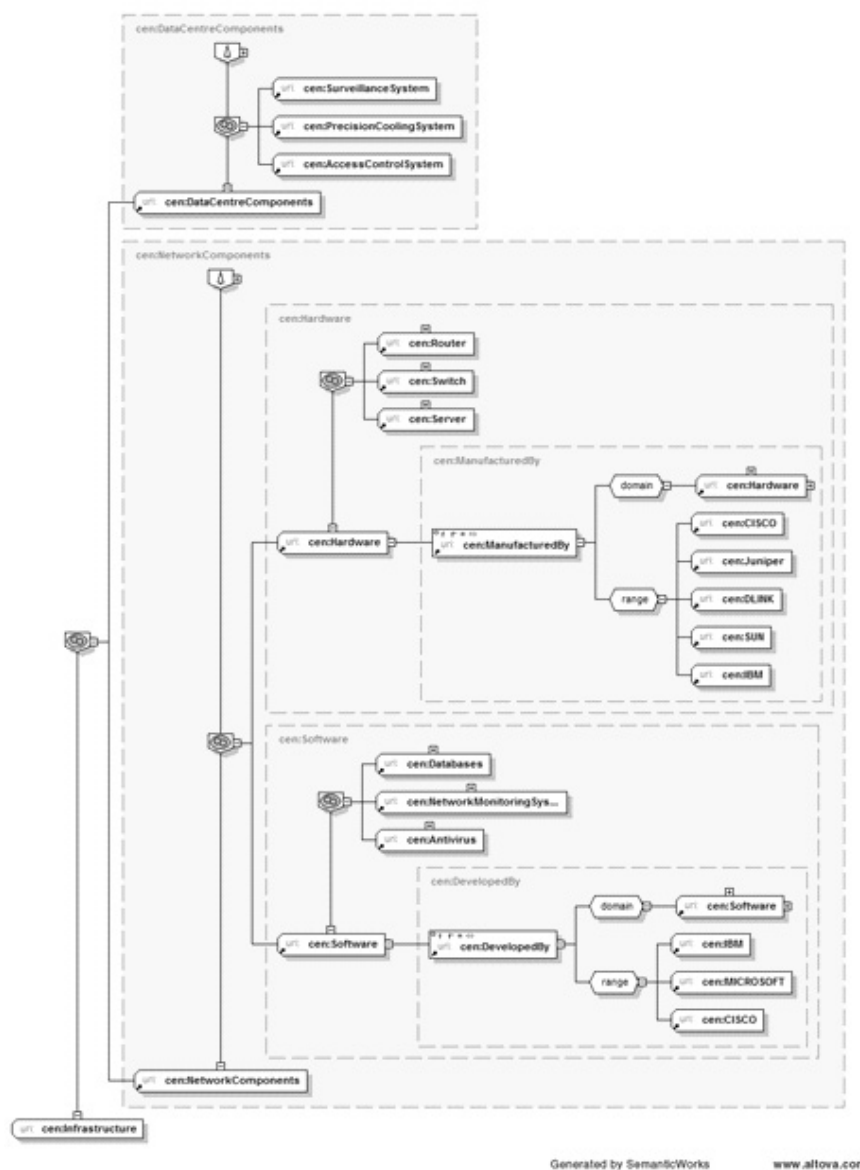
Figure 8. Class diagram illustrating the relationship between classes.

Figure 9. Infrastructural modelling.

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About the Author

Ms Chaynika Taneja is working as a Scientist in the DMIST, DRDO HQ, New Delhi. She holds a Bachelor's degree in Electronics and Communication from NIT, Kurukshetra. Her areas of interests include networking, web hosting and security, biometrics and Semantic Web.