A Conceptual Framework for an Ontology-Based Examination System

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***Abstract*— There is an increasing reliance on the web for many software application deployments. Millions of services ranging from commerce, education, tourism and entertainment are now available on the web, making the web to be the largest database in the world as of today. However, the information available on the web is syntactically structured whereas the trend is to provide semantic linkage to them. The semantic web serves as a medium to enhance the current web in which computers can process information, interpret, and connect it to enhance knowledge retrieval. The semantic web has encouraged the creation of ontologies in a great variety of domains. In this paper, the conceptual framework for an ontology-based examination system and the ontology required for such examination systems were described. The domain ontology was constructed based on the Methontology method proposed by Fernández (1997). The ontology can be used to design and create metadata elements required developing web-based examination applications and can be interoperate-able with other applications. Taxonomic evaluation and the Guarino-Welty Ontoclean techniques were used to assess and refined the domain ontology in other to ensure it is error-free.**

Keywords- semantic web; examination systems; ontology; knowledge bases.

I. INTRODUCTION

The world wide web is a huge library of interlinked and non-machine interpretable documents that are transferred by computers and presented to users. Thus, an information user semi-automatically connects and interprets the information.

The semantic web serves as a medium to enhance the current web in which computers can process information, interpret, and connect it to enhance knowledge retrieval. The semantic web is an XML-based ontological application that provides intelligent access to heterogeneous and distributed information. According to Berners-Lee [5] and [2], the Semantic web enable machine-readable metadata to be added to agents in order to efficiently facilitates useful tasks such as improved search, resource discovery, information brokering and filtering.

The semantic web has encouraged the creation of ontologies in a great variety of domains. Ontologies are being used as formal knowledge representation scheme and are used in designing and creating meta-data elements. It provides taxonomy for domain of discourse, and a set of constraints, relationships and rules between concepts in the taxonomy. Its use has enabled automated acquisition, retrieval and reuse of knowledge and improved software engineering activities through automated code generation, knowledge access etc. Ontology provides a sharable structure and semantics in knowledge management, e-commerce, decision-support and agent communication [6].

In this paper, we described the conceptual framework for an ontology-driven semantic web examination system. Succinctly, the paper described an ontology required for developing examination systems for the semantic web.

II. LITERATURE REVIEW

An examination according to [20] "is an educational activity well organized to test, measure and consequently evaluate the cumulative knowledge of students in their academic endeavours". It involved an agreed syllabus, same set of conditions and predetermined response time to same questions administered to student(s). [3] stated that "electronic examination system involves the conduct of examinations through the web or the intranet and it reduces the large proportion of workload on examination, training, grading and reviewing". Web-based examination is on the increase, most educational and professional institutions are progressively using the internet to deliver their services especially examinations to their customers.

The semantic grid uses open standards to enable distributed computers shares computing resources as well as information over the internet [22]. The application of semantic grid in education has provided huge opportunities for academic institutions especially universities to aggregate disparate information technology components to create a unified single system ([11], [9]. The semantic education grid involves development and deployment of large-scale distributed, open and comprehensive end-to-end infrastructure educational applications across academic institutions using web service and grid technology in other to enhance improved teaching and learning quality, and also to expand the global scope of educational services [15].

III. CONCEPTUAL FRAMEWORK

The semantic examination grid is the combination of the electronic examination and the semantic web technologies and is intended to be part of the large semantic education grid presented in Figure 1. It provides a convenient means of designing semantic based question banks that can handle large

set of questions while avoiding repetitions in the questions. It also offers an effective way of scheduling examination personnel to examination venues, periods and specific examinations.

An exam ontology which can be used or reused to develop web-based examination applications that would meet the outlined semantic requirements stated above was designed as a core component in the proposed semantic examination grid.

Web-based application developers who are interested in web-based examination delivery services would benefit from the exam ontology. The exam ontology provides a common vocabulary of examination administration with different levels of formality, the meaning of the terms and the relationships between them. The exam ontology is expected to provide common and shared knowledge about examination administration to web developers. It would also allow web-based examination applications to share information. It serves as knowledge bases which can be accessed in a language and platform independent manner to support e-examination. Figure 2 illustrates the conceptual framework for an ontology-driven semantic web examination system.

IV. OWL-DL EXAM ONTOLOGY

The exam ontology was constructed based on the Methontology method proposed by Fernández (1997) and covers five processes namely, specification, conceptualisation, formalisation and implementation and maintenance.

A glossary of terms to be included on the ontology, their natural language definition and their synonyms and acronyms was first developed. The terms were classified into one or more taxonomies of concepts, where a concept is an abstraction for one or more terms.

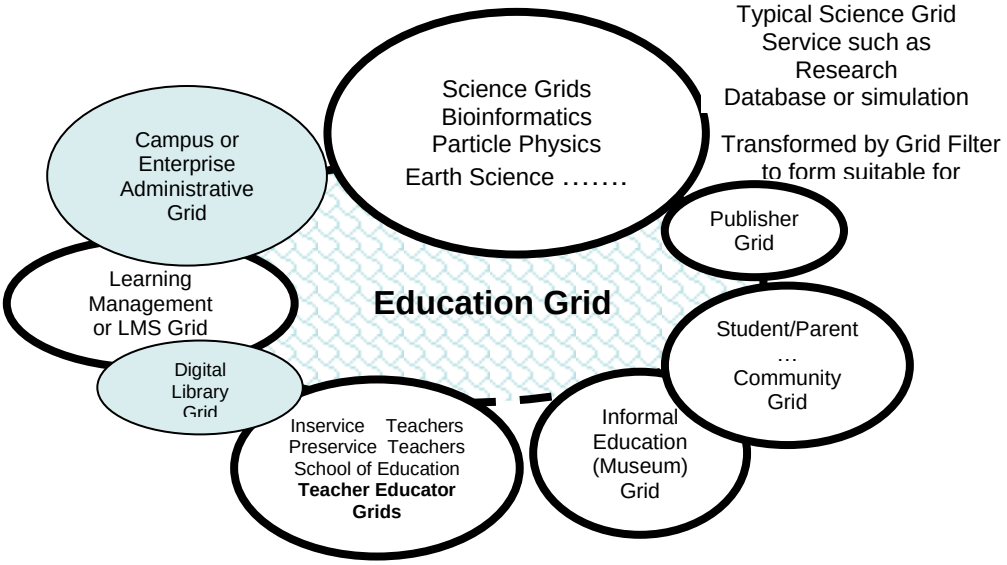

Figure 1: The Semantic Educational Grid as Grid of Grids

Figure 3 illustrates the concepts inherent in the exam ontology using hierarchy of classes by classifying taxonomy with UML. As described in figure 3, ExamAdmin is the parent class in the exam ontology. This parent class is further break down into eight other child classes namely ExamType, ExamFormat, ExamMedia, ExamMaterials, ExamPolicy, ExamTerm, ExamPersonel and ExamMalpractices. Each of these child classes is further sub-divided into child classes and so on as shown in figure 3. This class hierarchy of concepts and relations makes the contents of the exam ontology more manageable and facilitates integration of additional concepts when required in the future. Also, it enables precise and powerful search results when the exam ontology is implemented in a hierarchical application.

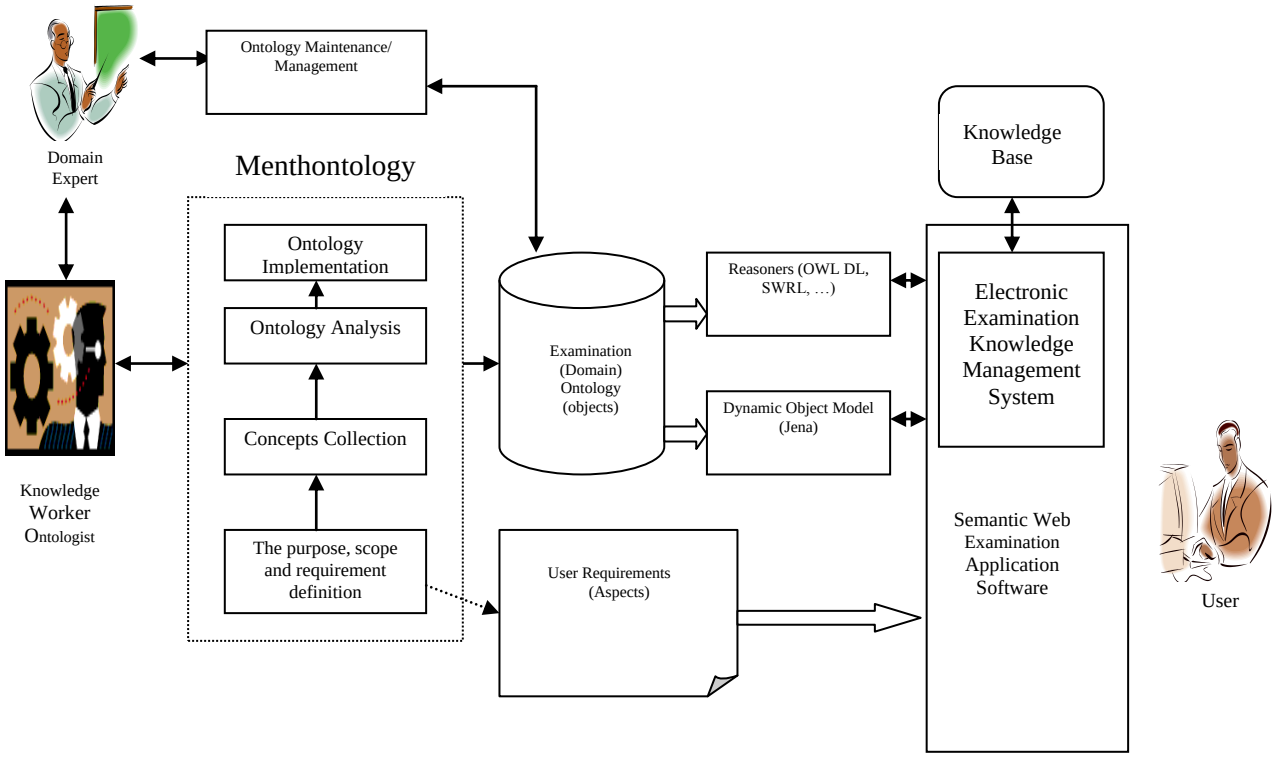

Figure 2: An ontology-driven semantic web examination application

The ontology relation diagram designed for the exam ontology is illustrated in Figure 4. The ontology relations defined the ad hoc relations between concepts in the domain ontology and also with concepts in other ontologies. Relations are determined by their names and the source and target concepts.

V. IMPLEMENTATION

Figure 5 shows how the various classes in the exam ontology relate to each other within the Protégé_4.0_alpha application. Unlike the class diagram, the protégé class hierarchy shows the various sub-classes and relations that were added to the parent class in the exam ontology. For instance, ExamPersonnel is a sub-class to ExamAdmin as relation of

ExamAdmin(ExamPersonel). The figure 6 below shows the OWL visualization of a section of the examination ontology which covers the sub-class "ExamPersonnel". The classification of people who are concerns with the administration of examinations would facilitate effective scheduling of personnel to examination venues, subjects and even to supervise other personnel. An instance of any sub-class could be created such as Supervisor, Venue, Invigilator, Question, etc .

The examination ontology was developed with formal semantic flavour in order to improve access to information stored on the web. The examination ontology was designed as a web application which can be integrated with other applications to provide access to information. The sample output of the examination ontology is displayed in the web browser of figure 7 to describe an instance of sub-class supervisor.

The browser output is divided into three parts namely content, all resources and ontology. The content part shows the semantic link to the exam ontology, the resources, classes, and objects and data type properties.

The various classes and attributes are displayed in the all resources part. Each resource is semantically related to the other relevant resources. The ontology part displays how the various classes are represented in the ontology.

For instance, the sub-class "Supervisor" displayed in figure 7 is a sub-class of ExamPersonnel" which in turn is a sub-class of ExamAdmin. The output reveals that the sub-class "Invigilator" is a disjoint class to the sub-class displayed which implies that an individual cannot belong to these two sub-classes at the same time.

The relationship between the sub-classes is also displayed along with other information. For instance, the relationship between "Invigilator" and "Supervisor" is shown in figure 8, which means that there is an individual named "Tony Chris" who belongs to the set of invigilators and who is being supervised by another individual named "Okechukwu Adams".

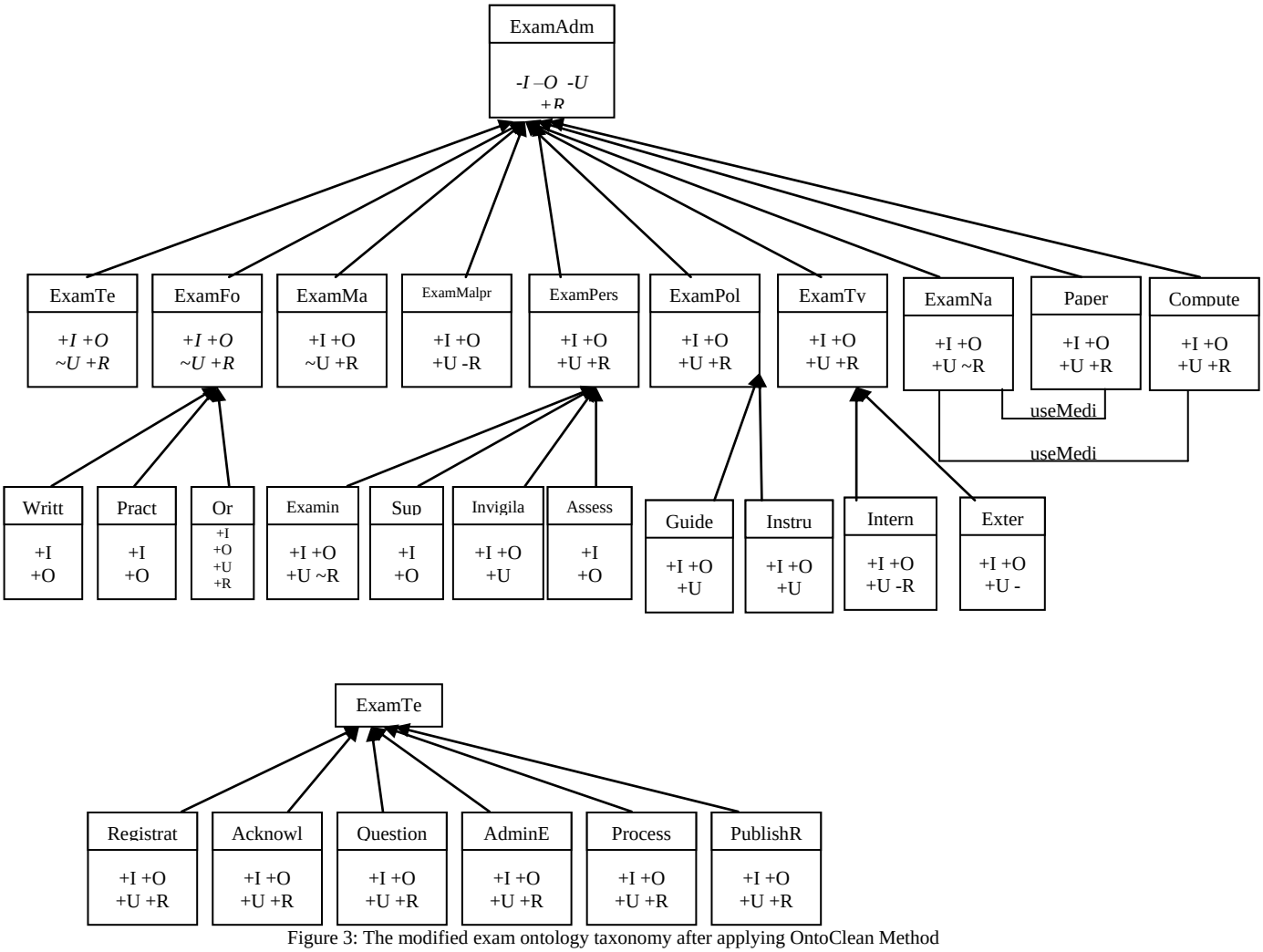

Figure 3: The modified exam ontology taxonomy after applying OntoClean Method

VI. CONCLUSION

In this paper, we have described an examination ontology based which was developed based on the methontology ontology development technique proposed by Fernández. The relevant concepts which characterize the domain of discourse were identified, appropriately defined along with their binding relationships and slots, and were classified based on the inherent concepts they described. The concepts were presented using a tree-like class hierarchy which shows the relationship between the super-class concept and the sub-class concepts. The ontology was developed with Protégé_4.0_alpha which is based on the OWL-DL. The consistency check and computation of the inferred ontology was done with FaCT++ reasoner and the validity of the ontology was confirmed. The exam ontology was developed to provide a knowledge base for the semantic examination grid. Information regarding a specific examination - persons, questions, date – can be obtained with ease referencing. The ontology was designed with a view to permit integration of additional concepts in the future and at different levels of content granularity. The exam ontology is interoperable which can be reused or integrated into electronic examination applications to facilitate efficient information access and retrieval.

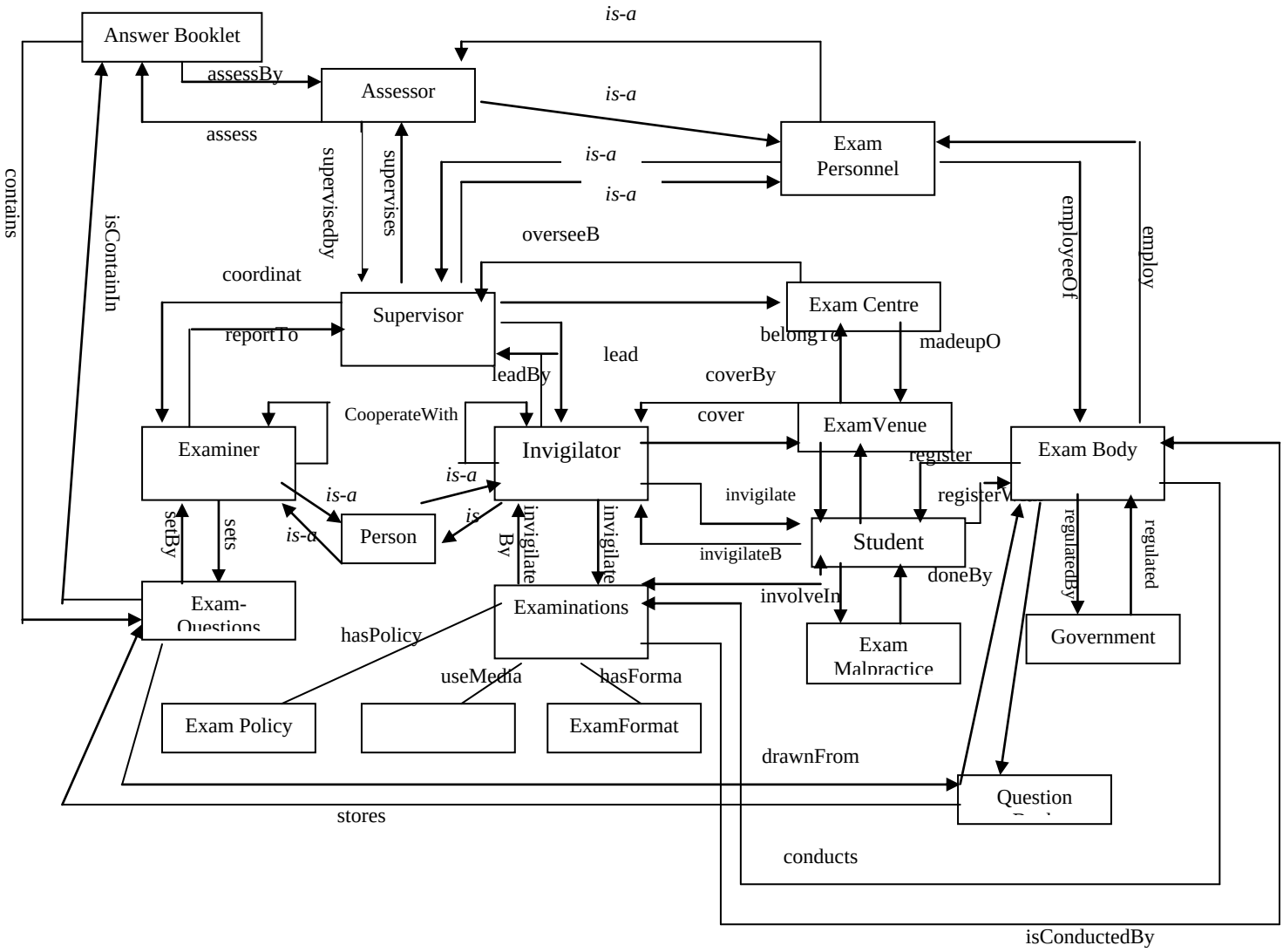

Figure 4. Diagram of Binary Relations *in (KA)*

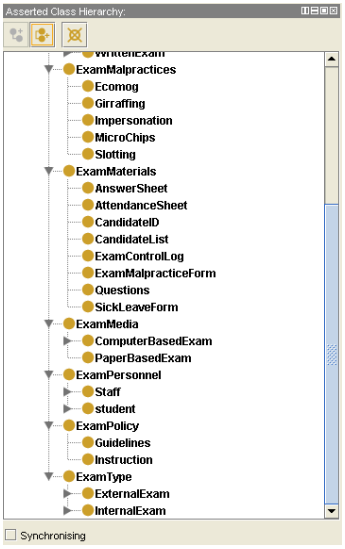

Figure 5: Protégé_4.0_alpha class hierarchy of exam ontology

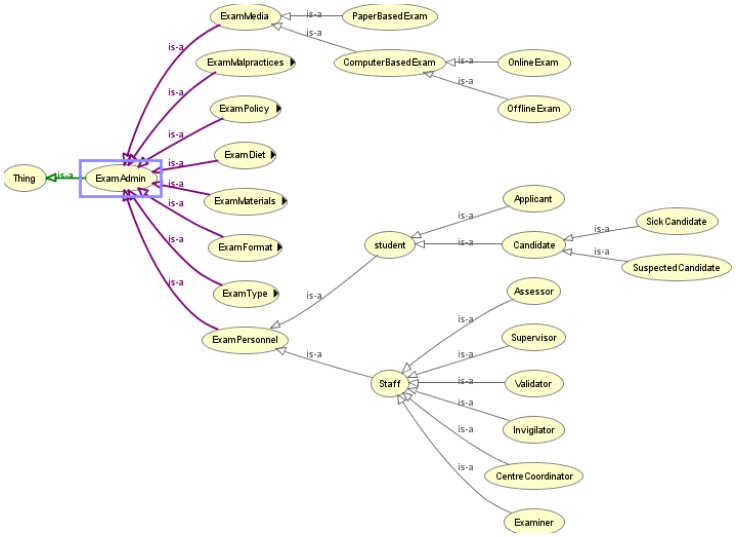

Figure 6: OWL visualization of sub-class "ExamPersonnel" in the exam ontology

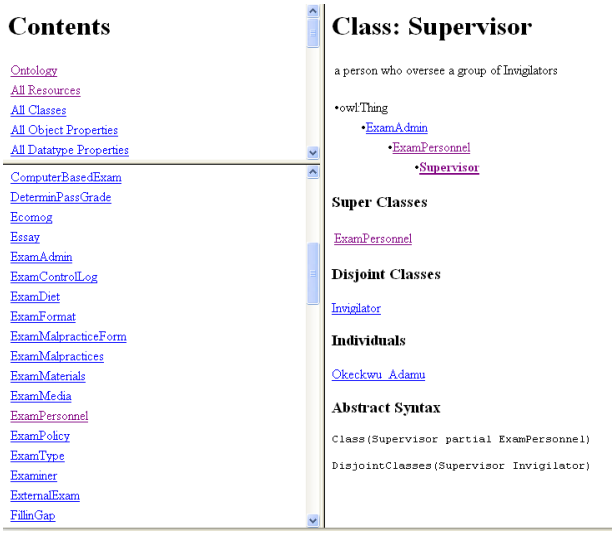

Figure 7: web browser of sample output of the exam ontology

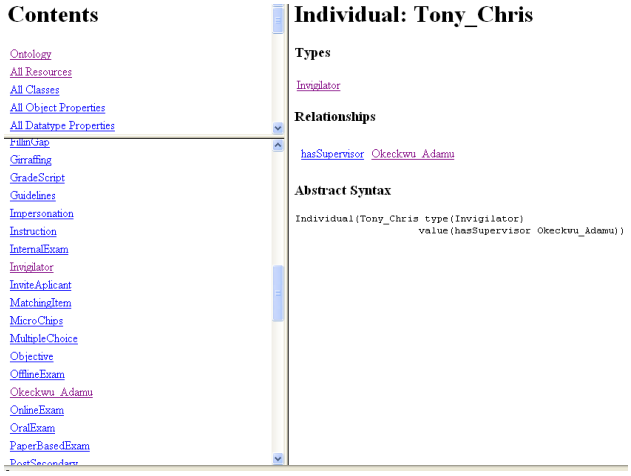

Figure 8: an instance of sub-class "Invigilator" and its relationships

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