Developing Domain Ontology for Nigerian History

Ibukun Afolabi*[1], Olawande Daramola[1], Timilehin Adio[1]

[1] Covenant University, Department of Computer and Information Sciences, Faculty of Science and Technology, PMB. 1023, Ota, Ogun State, Nigeria.

A B S T R A C T

Background: Nigeria, which is the most populous country in Africa, located in the West of Africa has a rich political and cultural history. Although, Nigeria has a valid history, the documentation of a significant portion of the historical information is vague and anecdotal because a lot of it is oral, which makes it susceptible to distortion. There is also poor electronic documentation, with a large chunk of history captured in print - history books, media report and museum artifacts. **Objective:** To develop a domain ontology for Nigerian history which is intended to provide viable support for sundry automation needs that require historical knowledge. **Results:** The NHO (Nigerian History Ontology) has been developed using a semi-automated approach that involved extraction of terms from textual sources and eventual conceptualization, modeling, and development using the Protégé Ontology Editor. The NHO (Nigerian History Ontology) developed ontology reveals a potential to competently support knowledge-based software endeavor. Also compared with Gold Standard ontology, it was found to be rich in content. **Conclusion:** We have presented the details of the process of developing a domain ontology for Nigeria history, which is the first of its kind in terms of focus (Nigeria), and perspectives (political, cultural). The NHO is a documentation of Nigerian historical knowledge for meaningful use, which makes the knowledge useful by both humans and software agents. It also provides an electronic archive of Nigerian history in a compact and easily accessible way.

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INTRODUCTION

History provides the logical thread that connects the events of old with human affairs in the present; it is a coherent and sequential account of past activities and occurrences that have shaped the course of a nation. History can also be defined as the academic discipline that uses a narrative to study and analyse a sequence of past events, the cause and effect of such events (Richard, 2001). The history of a nation is particularly important because it gives the citizens a sense of origin, and provides many opportunities for emerging generations to connect with their heritage.

Although Nigerian History is real the documentation of extant historical information is vague and anecdotal because a lot of it is oral, which makes it susceptible to distortion. There is also poor electronic documentation, since the history is captured largely in print - history books, media report -, and museum artefacts.
Also, historical information is scattered, occurring in bits and pieces some of which are difficult to access.
These historical facts exist in different forms with twists, and varying perspectives, which can be confusing.
There is also a lack of national initiative on culture preservation, which is making vital historical values of many Nigerian cultures tend to extinction.

Corresponding Author **Ibukun Afolabi Covenant University**, Department of Computer and Information Sciences, Faculty of Science and Technology, PMB 1023. Ota. Ogun State. Nigeria. 234-08021247616, ibukun.fatudimu@covenantuniversity.edu.ng

Ontology is a shared formal conceptualization of a domain that provides a veritable platform to tackle some of the existing threats to Nigerian history. This is because 1) ontology will serve as a standard vocabulary, which will foster a shared understanding of key concepts of Nigerian history; 2) It will enable effective reuse of historical knowledge; 3) create a platform to formalize historical information such that it becomes useful for man and systems; and 4) create a national knowledgebase of historical events that is capable of supporting sundry learning and professional purposes.

Despite the many benefits of domain ontology for Nigerian history, no such infrastructure exists at the moment. Few of the extant structures that seem close to a history ontology for Nigeria include archontology.org[1], which is a guide for the study of historical offices, consisting of different projects for different countries. There also exists the Geopolitical Ontology by the FOOD AND AGRICULTURE ORGANIZATION (FAO) of the United Nations (Iglesias-Sucasas et al., 2009). These two are grossly inadequate as domain ontology for Nigerian history in terms of structure and content.

The aim of this paper therefore is to provide a domain ontology for Nigerian history from both the political and cultural perspectives. Apart from affording a platform to search and retrieve information on Nigerian history, the ontology will provide the semantic support that is needed for development of knowledge-based applications, and processes, in several facets of the Nigerian national life such as education, health, agriculture, media and many more, in a manner akin to the Finnish national ontology initiative (Viljanen et al., 2009).

The rest of this paper is structured as follows. Section 2 presents the background and related work, Section 3 outlines the   requirements for the domain ontology of Nigerian History, while Section 4 explains the procedures for the ontology modelling and development. In Section 5, we evaluate the ontology, Section 6 describes the plan for the ontology maintenance while we discuss some plausible applications of the ontology in Section 7. The paper is concluded in Section 8 with a brief note and prospects of future work.

BACKGROUND AND RELATED WORK

Nigeria as a country gained independence on October 1, 1960. It is a federation of 36 states and one federal capital territory. Nigeria is located in Western Africa bordering the Gulf of Guinea between Benin and Cameroun. It covers a total area of 923,768 Sq km, Land Area: 910,768 Sq km and Water: 13,000 Sq km (Olaoye, 2012). It has an estimated population of 167million people and it is Africa's most populated country having over 250 tribes (Olaoye, 2012).

Politically, Nigeria, since independence in 1960, a central and regional government ruled the Country but this changed in 1966 when, a group of soldiers overthrew the government, and the military rule persisted until 1979 when Nigeria returned to civilian government rule. Shehu Shagari was elected as the President of the Second Republic. In 1983, President Shagari's government was deposed by a second coup headed by Gen. Muhamadu Buari. The military ruled continually changing from one military government to another until Nigeria returned to civil rule, with the election of   former military ruler Olusegun Obasanjo in 1999 as a democratically elected civilian president. Since then the country has enjoyed a stable democracy (Ogbeidi, 2012).

Culturally, the three main tribes of the country are Yoruba, Igbo, and Hausa.

- Yoruba people are believed to have split from the Igala (who live on the opposite side of the Niger's divergence) about 2000 years ago. The Yoruba paid tribute to a pantheon composed of an impersonal Supreme Deity, Olorun, and 400 lesser deities who perform various tasks. Oduduwa is regarded as both the creator of the earth and the ancestor of the Yoruba kings. According to one of the various myths about him, he founded Ife and dispatched his sons and daughters to establish similar kingdoms in other parts of what is today known as Yorubaland.

- The city of Nri is considered to be the foundation of Igbo culture (Griswold,2000). Nri and Aguleri, where the Igbo creation myth originates, are in the territory of the Umueri clan, who trace their lineages back to the patriarchal king-figure, Eri (Allo, 1997). Eri's origins are unclear, though he has been described as a "sky being" sent by Chukwu (God) (Allo, 1997; Uzukwu,1997). He has been characterized as having first given societal order to the people of Anambra (Uzukwu, 1997).

- Trade is the key to the emergence of organized communities in the sahelian portions of Nigeria. A string of dynastic Hausa states stretched across western and central Sudan. The most powerful of these states were Ghana, Gao, and Kanem, which were not within the boundaries of modern Nigeria but which influenced the history of the Nigerian Hausa states. By the 11th century some Hausa states - such as Kano, Jigawa, Katsina, and Gobir - had developed into walled towns engaging in trade, servicing caravans, and the manufacture of various goods (Allo, 1997).

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[1] http://www.archontology.org/nations/nigeria/00_1963_td_s.php

The excerpt of Nigerian history briefly narrated above, is mainly an oral mythology that has been passed down from generations to generations with little concrete electronic documentation. The need to preserve the valuable heritage of Nigerian history through organized representation of historical knowledge is the core motivation for developing the Nigerian History Ontology (NHO) in this work.

Related work

There has been different approaches to development of an ontology and these approaches are chosen according to the purpose of the ontology. In Sureka et al.,(2008), developed a domain-specific ontology from common-sense semantic network in order to target-specific sentiment analysis. They used an algorithm that was based on *ConceptNet* (a large semantic network of common sense knowledge) for extracting domain ontology. Cheng et al. created a domain ontology by using Corpus-Based Semantic Similarity to map document corpus in a domain similar to the domain of the ontologies (Cheng et al., 2008) and in Kietz et al., (2000), a domain ontology was extracted from a corporate Intranet using the multi-strategy approach in learning.

There are also few domain ontologies that have been developed for educational purposes, specifically for automated grading; Mesaric and Branimir, developed a domain ontology for higher education in economics. This ontology helped to solve the problem of taxonomic shortcomings in economics as an academic disciple. Their approach to ontology creation is based on(Mesaric & Dukic, 2007). Boyce and Pahl (2007), developed a domain ontologies for database course content. This followed a process called, Knowledge Engineering in Educational Technology (KEET). The KEET approach include the following steps: 1) enumerate important terms: 2) define the classes (concepts); 3) define the properties of classes; and 4) finally create instances of the classes.

Developing ontologies for preserving history, has also gained some attention. In 2009, Garbacz et al. built an axiomatic system that formally defines an ontology for the history of the administrative structure of the Catholic Church in Central-Eastern Europe in the so-called pre-statiscal period, i.e. roughly from XII to XIX century (Garbacz et al., 2009). Papyrus, is an history ontology that was created with the objective of being a means to model and represent concepts and entities that are of interest to history researchers. The ontology has been based on the International Committee for Documentation (CIDOC) Conceptual Reference Model focusing on the history of Science and technology(Crofts et al., 2006). There also exist, the FDR/Pearl Harbor Project corpus which has been annotated for a wide range of linguistic phenomena and entities, including persons, titles, dates, locations, organizations (military, government, civilian, enterprise), and semantic categories, represents one of the most significant collections of historical material concerning the history of America and the world in the twentieth century(Ide and Woolner, 2005).

Presently, the Geopolitical Ontology publicly released in 2002 by the Food and Agriculture Organization of the United Nations (FAO) is the closest semantic network of terms that relate to the Nigerian History domain. The ontology was expressed in the Web Ontology Language (OWL) and it included relationships between geopolitical and geographic entities (Bizer et al., 2009). The DBpedia ontology[2] also provides a good source of semantic network of contextual terms on Nigeria but it is quite general and lack concrete details on Nigerian historical information from both the political and cultural perspectives. A greater focus and details on historical information on socio-cultural and political aspects is particularly important for an ontology that is intended to support a variety of knowledge based automation tasks such as automated essay grading, e-Learning, information retrieval and so on. It is therefore essential to develop an ontology for Nigerian history that could play an important role in helping to leverage on historical facts for information processing for national development.

REQUIREMENTS FOR THE NHO

The Nigerian History Ontology (NHO) is a semantic representation of information on Nigerian Culture and political history mainly for the purpose of electronic learning support – e-learning, e-assessment, and information retrieval. The main users of the NHO include the following;

Knowledge Driven Application: software applications that needs to leverage on knowledge Nigerian History in order to realize their objectives. These could be Automatic Essay Scoring (AES) systems for history related subjects, question answering systems, expert systems using historical knowledge, automatic news generation, recommender systems and the likes.

Users: a person seeking for information on Nigerian history and wanting to know more about some concepts and their connection with Nigeria history. Example of these kinds of users includes history students, on-line learners and so on.

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[2] http://live.dbpedia.org/page/Nigeria

Domain Expert: is the person responsible for the   maintenance of the concepts and relationships in the NHO. The task of the expert includes matching of concepts to existing ontologies and updating the NHO as new knowledge evolves from events from the Nigerian scene.

Structuring and representation of knowledge is the main concern of knowledge engineering (Sowa, 2000). Ontologies are therefore key to achieving this purpose, this is why the NHO is required to capture semantics in form of reusable Annotations.

The NHO should also make the knowledge that is represented in it explicit as knowledge, because it will be consumed by learners, since knowledge is central for learning. For the content developer or domain expert the NHO will be a central ingredient for the development of learning content.

Finally the ontology is required to be extensible without having to change the underlying model and assumptions. This will make provision for it to be comprehensive in future because there will be need to add new concepts to the ontology. Also, the ontology should be able to answer some competency questions such as being able to do the following:
   i)   relate a specific place (city, town, locations) with history, e.g. What is Abuja?
   ii)   relate a specific person (ruler, king, politician, position) to history , e.g. Who is Obasanjo?
   iii) provide definite answers to questions that pertain to persons, cultures, and places in history, e.g. example, where did Yoruba race originate?
   iv)   relate specific dates and events with history, e.g. what happened on October 1, 1960?
These set of competency questions influenced the conceptualization, modelling and development of the NHO

ONTOLOGY MODELLING AND DEVELOPMENT

The core idea of the approach to developing the NHO is based on the prescriptions in, (Boyce and Pahl, 2007; Noy and McGuinness, 2000), which is outlined as follows.
- Determine the scope of the ontology by answering questions such as, which domain are we interested in? What will the ontology be used for? Who will use the ontology etc. The next step is to decide the source for the ontology i.e. domain experts, documents or existing ontology.
- Select relevant textual information using information extraction process to extract all the keyword and key phrases that exist in them.
- Build the ontology using the following steps: 1) Extract important terms from text: 2) define the concept taxonomies, relations, attributes, instances, axioms and functions: 3) create an application interface through which the ontology can be accessed for the purpose of querying. These steps have been captured in Figure 1.

According to Figure 1, the first step, which is to determine the scope of the ontology has been detailed in Section 3 of this paper. The source of the ontology is domain document, and the process of selecting credible documents form the second step of the development process. This includes the selection of the relevant Nigerian historical documents such as History text books, journals, and credible online resource material.

The third step is to extract the important terms using an information extraction tool called AnalogX keyword Extractor.[3]
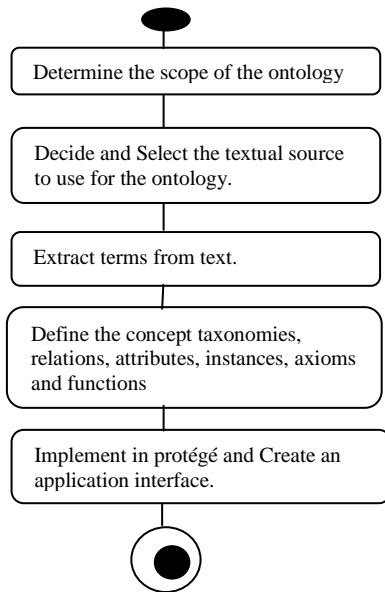
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[3] www.analogx.com

Figure 1: Activity workflow for creating the ontology

Relevant terms were selected from the document corpus using the information extraction process which includes the following; filtration and stemming. In the filtration process, the textual documents are filtered by removing the unimportant words from documents content. Such unimportant words include: articles, pronouns, determiners, prepositions and conjunctions, common adverbs and non-informative verbs. After the filtration process, the extracted words are stemmed which is the process that removes a word's prefixes and suffixes (such as unifying both infection and infections to infection). The main concepts and properties are them selected from the extracted keywords and organized into concepts and properties hierarchically into categories; The approach used to define the class hierarchy is a top-down development process which starts with the definition of the most general concepts in the domain and subsequent specialization of the concepts by identifying relevant subconcepts (Noy and McGuinness, 2000).

The concepts that are included in the Nigerian History ontology (NHO) are those that are considered relevant from the political and cultural perspectives. The conceptualization of the classes in the NHO derives from asking some salient questions such as: Who is a Nigerian? This is defined is several aspects such as:
Where is he from? What does he do? What relationships does he have?
It is in attempting to provide answers to these questions that we identified the concepts currently included in the NHO.

To implement the NHO, the protégé ontology editor was used. The graphic user interface (GUI) that enables a user to query the ontology from a desktop was developed using the Java NetBeans and Jena ontology API.

Description of the components of the NHO
Person: The design of the concept *Person* is based on the categories provided by Bizer et al., (2009) and some addition based on the Nigerian History domain, It contains the following subconcepts, *Artist, Athlete, Politician, Ruler* and *Citizen*. The *Ruler* concept contains three further subconcepts which includes, *Military_Ruler, Civilian_Ruler, Interim_Ruler.*
Ethnic_ group: the concept *Ethnic_group* describes a social group of people who identify with each other based on common ancestral, cultural, social, or national experience.
Date: the Date concept is used to capture the time a significant event occur in history.
Kingdom: The Kingdom concept is used to describe a monarchy ruled by a king of queen.
Political Party: This concept is used to capture a political organization that typically seeks to influence, or entirely control, government policy.
Religion: The design of the concept *Religion* contains the following sub concepts, *Christianity, Islam* and *Traditional Beliefs.*
Geo_Political_Zone: This concept is made up of 6 sub concepts, *South East, South South,South West,North Central,North East* and *North West.*

Village: This concept is used to describe a form of community for societies that practice subsistence agriculture and some non-agricultural societies.

Other concepts include Continent, Country, Nation, Security, Tribe and University.
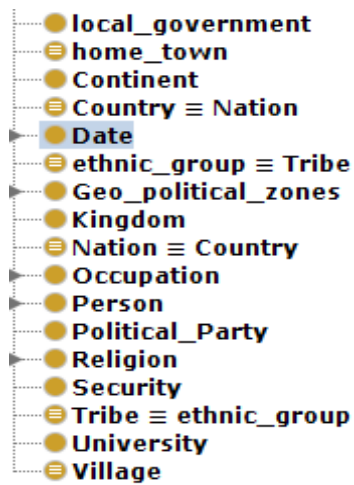
- 🟠 **local_government**
- 🔘 **home_town**
- 🟠 **Continent**
- 🔘 **Country ≡ Nation**
- 🟠 **Date**
- 🔘 **ethnic_group ≡ Tribe**
- 🟠 **Geo_political_zones**
- 🟠 **Kingdom**
- 🔘 **Nation ≡ Country**
- 🟠 **Occupation**
- 🟠 **Person**
- 🟠 **Political_Party**
- 🟠 **Religion**
- 🟠 **Security**
- 🔘 **Tribe ≡ ethnic_group**
- 🟠 **University**
- 🔘 **Village**

Figure 2:Main Concepts of the NHO

Figure 2 is the protégé implementation of the main concept in the Nigerian History Ontology (NHO). The Owlviz of the concept described above is presented in Figure 3.

Exploring Ontology Constructs

This section is a description of the main constructs used to represent the Nigeria History Ontology. When exported to RDF(S) ontology is codified using the following constructs.

rdfs:label: Used to store the general or popularly known name used to refer to the concept or individual. For example the individual *NTA* is labelled *Nigerian Television Authority, Obasanjo is also labelled OBJ*

rdfs: DefinedBy: Used to store the definition of the term. For example the concept Religion can be defined as "Religion is an organized collection of beliefs, cultural systems, and world views that relate humanity to an order of existence".

rdfs: Comment: Captures the further explanation on the term or individual. For example, the concept *Religion* can be further explained as *"Many religions have narratives, symbols, and sacred histories that are intended to explain the meaning of*
life and/or explain the origin of life or Universe."

owl:equivalentClass: Used to equate similar concepts in meaning for example *Ethnic_groups* is equated to *Tribe*.

*owl:sameAs:*Used to equate similar individuals.

rdfs:subClassOf **:** Used to break down general concepts to the type of classes that make them up.

*owl:disjointWith***:** Used to handle complex classes**.** For example, all concepts under the concept *Person, Geo_political_zone*, and *Religion* are codified as *disjoint*. The NHO consist of a *Geo_political_zone* class that has six disjoint subclasses namely: *South East, South South, South West, North Central, North East, North West.*
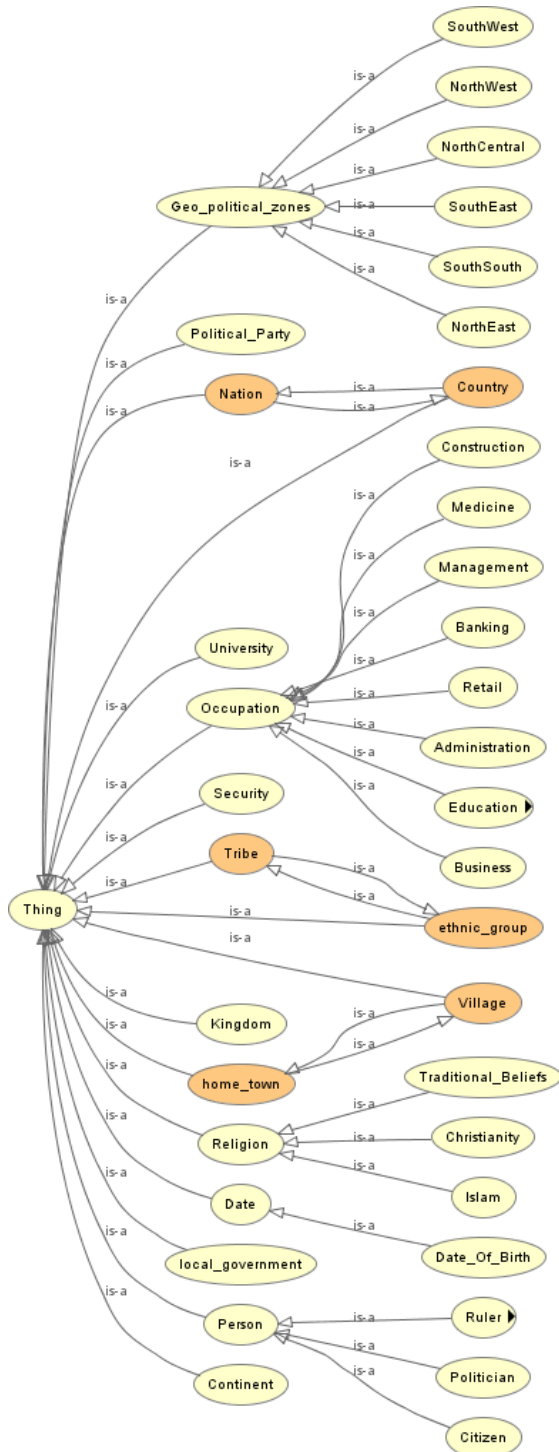
Figure 3: OwlViz presentation of the main concepts

The NHO contains relevant Object properties, such as *HasSynonymn, HasAsExample, isSuccessorOf, isPredecessorOf, SpatiallyInfers, isRelatedTo, BelongsTo, FriendOf, PartOf, Has* all of which define relationships between concepts in the ontology.

HasSynonym: This is used to indicate that a single concept may have one or more names. It uses a 1:N relationship.

HasAsExample: This is used to indicate that the concept being linked to is an instance or example of the concept from which the link emanates. It also uses a 1:N. For example, Chief MKO Abiola can also be referred to as Are Ona Kakanfo or M.K.O., and therefore the ontology specifies that:

Chief_MKO_Abiola *HasSynonym* Are_Ona_Kakanfo

It also manages historic changes using the following object properties, *isPredecessorOf* and *isSuccessorOf*, (Iglesias-Sucasas et al., 2009). The *isPredecessorOf* and *isSuccessorOf* are symmetrically inverse properties that

are used to identify which Person, ethnic group or kingdom were the predecessor/successor of another. For example, President GoodLuck Jonathan is the successor of President Musa Yaradua, and therefore the ontology specifies that:

Goodluck_Janathan *isSucessorOf* Musa_Yaradua; which also   connote that Musa_Yaradua *isPredecessorOf* Goodluck_Janathan

Knowledge Reuse: In developing the NHO, the reuse of the existing resources was considered. According to Noy and McGuinness (2000) this is the second step of the knowledge engineering methodology. Although ontologies in the specific domain of Nigerian history does not exist, we were able to find concepts that pertain to historical information on Nigeria included in some publicly available ontology. We considered concepts from the Dbpedia ontology[2], to ensure that the concepts of the NHO align with such publicly available, and standard ontology.

As of now, NHO contains 40 concepts categorized into 15 top-level concepts and 10 object properties. The maximum depth of the concept hierarchy is 2. Table 1 presents some metrics on the Nigeria History Ontology. All concepts and individuals have definition and further explanation where necessary.

Table 1 Nigeria History Ontology

Metrics	Values
Number of concepts	40
Number of ObjectProp	10
Subconcept axioms	23
Equivalent concepts axioms	5
Disjoint concept axioms	6
Object property range axioms	10
Object property domain axioms	10
Object property inverse axioms	1
Number of individuals	417

EVALUATION OF THE ONTOLOGY

A desktop application interface was developed for the NHO. This is to enable a prospective user   seeking information on Nigerian history to access such information with accuracy. The application was implemented using the Java programming language (NetBeans IDE). It gives the user opportunity of searching for specific terms and answering specific (What, Where, Which) questions that pertain to persons, places, events, and dates, in Nigeria's history. The NHO is specified using   OWL DL; ontology management and reasoning was facilitated by using the Jena API and the pellet OWL DL reasoner 3.1[4] respectively.

We tested the capability of the NHO to respond to user queries by posing instances of the competency questions from the application interface. For example, in response to the sample competency question, *What is Abuja?* The application implements an algorithm module that uses methods from the Jena API, and the Pellet reasoner to query the NHO for details on Abuja, and then gives the output shown as shown in Figure 4.
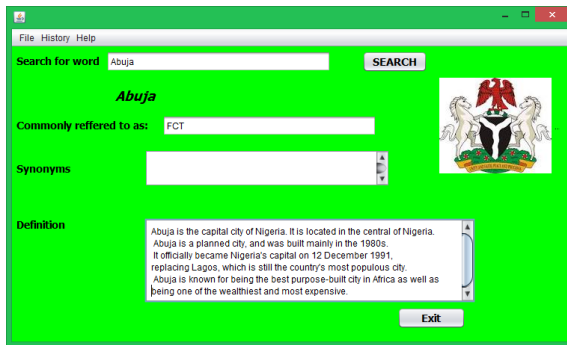
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[4] http://www.mindswap.org/2003/pellet/download.shtml

Figure 4.

Evaluating the Alignment of the Nigerian History Ontology (NHO) with a Standard Ontology.

Table 1 and Table 2 show the measure of alignment of the concepts of the NHO with the concepts in the DBpedia ontology. According to Table 1, *Person* concept in Nigerian History does not contain the subconcepts *Artist* and *Athelete*. This is because NHO is focused mainly on the cultural and political History of Nigeria. On the other hand, the Nigerian History Ontology contains the following additional subconcepts under Person, Citizen and Ruler.

In Table 2, *Date, Geo-Political Zones, Kingdom, Nation, Occupation, Political Party, Religion, Security, Tribe, University, Village* are the new concepts introduced into the NHO which are not contained in Dbpedia.

Table 2 Alignment between subconcepts of *Person* in Nigerian History and Dbpedia (Bizer et al., 2009).

Nigerian History	Dbpedia.org
	Artist
	Actor
	MusicalArtist
Politician	Athlete
Citizen	Politician
Ruler	
Civilian	
Ruler	
Interim	
Ruler	
Military	
Ruler	

Table 3 Alignment between concepts in Nigerian History and Dbpedia.

Nigerian History	Dbpedia.org
Continent	Continent
Country	Country
Date	
ethnic group	ethnic group
Geo Political Zones	
Kingdom	
Nation	
Occupation	
Person	Person
Political Party	
Religion	
Security	
Tribe	
University	
Village	
Home town	
Local government	

MAINTENANCE OF THE ONTOLOGY

A domain ontology for national history must evolve progressively with new information in order to retain its relevance. Hence, there is need to continually update such an ontology. In order to maintain the NHO, a plan that adopts a Web 2.0 approach to ontology update has been adopted (Hepworth , 2007). The Web 2.0 are services (or user processes) built using the building blocks of the technologies and open standards that underpin the Internet and the Web. They include blogs, wikis, and multimedia sharing services, content syndication, podcasting and content tagging services. Our idea is to allow users or willing contributors to upload useful contents via a wiki page, which we shall verify at the backend before use. This approach will be used to continually update the ontology in order to make it evolve consistently with respect to emerging national developments. The immediate plan is to carry out update quarterly, but this will be reduced to shorter periods as we make further progress in the ongoing project. The ontology update process typically involves extracting new concepts from information sources – which is a partially automated procedure as explained in Section 4, and then to create the ontology using the concepts and define all identified meaningful concepts relationships.

APPLICATION OF THE NHO

The advent of the Nigerian History Ontology (NHO) will be beneficial by offering semantic-based support for different types of automation needs where access to historical information on Nigeria is desirable. Some of the plausible applications of the ontology that can be envisioned in the immediate future are discussed as follows:

i)   **E-Learning Support**: the existence of the ontology will provide a viable online resource for educating persons on the history of Nigeria, by providing a potent vocabulary of Nigeria history.

ii) **Automating Essay Grading**: The NHO will provide the semantic knowledge support for automatic assessment of essays on history. This will be particularly useful in teaching history and related courses to very large population of students.

iii) **Media News Generation**: Ontologies have been used successfully to generate current news that has close ties with historical information about people, places, and events (Bontcheva & Wilks, 2004). The NHO will help media practitioners in Nigeria and beyond to access accurate instances in the archives of Nigerian that have bearing current events as occasion demands.

iv) **Knowledgebase for Sundry applications**: The ontology will provide a knowledgebase infrastructure that many software applications that require intelligent reasoning on aspects of Nigerian history can reference. Such as question answering systems, recommender systems, expert systems, e-tourism applications, intelligent planning systems and the likes.

v)   **Culture Preservation**: The ontology will serve as an electronic archive, national memory of notable events in the history of Nigeria, which will help to preserve the values and culture.

CONCLUSION

Ontologies are becoming increasingly important as knowledge based resource for man and machines. The developed ontology, NHO will offer significant support for many automation needs that pertain to the national life of Nigeria. The composition of the NHO engenders different types of relationships, and a wide range of semantic connection between the terms in the Nigerian history domain. The components of the NHO will continue to grow as more knowledge are captured in the ontology.

In conclusion, this paper has been able to present the details of the process of developing a domain ontology for Nigeria history, which is the first of its kind in terms of focus (Nigeria), and perspectives (political, cultural).. The NHO is a documentation of Nigerian historical knowledge for meaningful use, which makes the knowledge useful by both humans and software agents. It also provides an electronic archive of Nigerian history in a compact and easily assessable way.

In future work we shall improve the scope of the ontology to capture more aspects of the Nigerian History such as elections, education, economy, trade and many more. We shall also develop specific software applications that will leverage the NHO in practical problem solving in areas such as news generation, automatic essay grading, E-learning, recommender systems, intelligent dialog systems, and more. We also plan carry out more elaborate evaluation of the ontology.

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