



A Formalised Ontology of Election

Ayorinde, I. T.
temiayorinde@yahoo.com

Akinkunmi, B. O.
ope34648@yahoo.com

Adenuga, A. O.
adebhayor@gmail.com

Dept. of Computer Science,
University of Ibadan,
Ibadan, Nigeria.

Abstract

Election is a formal decision-making process by which a group of people choose an individual to hold a public office. Elections have been the usual mechanism by which modern representative democracy operates. Though, election processes are open and assumed to be known to all categories of people involved in an election, this has not always been the case. Hence, this paper presents a formalised ontology of election processes that enhances a quick understanding of election processes. Based on the acquired knowledge of the domain, concepts and relations were identified and organized into classes, subclasses and instances. The classes were organized in taxonomical order. Object properties which defined the relationships among the domain classes were also created. Description logic (DL) was used for the formalisation of the axioms while Protégé 5.0. was used to implement it. Competency questions were used to evaluate the information in the knowledge base. The ontology was queried using the DL query tab of Protégé and it provided correct answers to the competency questions.

Keywords - Election processes, Formalised ontology, Description logic, Protégé 5.0

I INTRODUCTION

Election is a formal decision-making process by which a population chooses an individual to hold public office. There can be no democracy without free, fair and valid elections which open the door into a democratic culture and society [1]. The transparency and fairness of the electoral process, credibility of election authority and neutrality or partisanship of election management authority, among others, play a major role in the integrity of an election. Independent National Electoral Commission (INEC) is the electoral body that has the constitutional right in Nigeria to organise, undertake and supervise all elections to various political offices.

Ontology has been adapted in semantic web as formal encoding of the concepts, relations, objects and constraints within semantic model [2]. A formal ontology gives a formalised description of objects, properties of objects and relations among objects [3]. This provides the language with its definitions and constraints in the axioms. Ontology also represents information in a manner that this information can also be used by machines not only for displaying, but also for automating, integrating, and reusing the same information across various applications [4]. An ontology can be viewed as a declarative model of a domain that defines and represents the concepts existing in that domain, their attributes and the

relationships between them. It is typically represented as a knowledge base which then becomes available to applications that need to use or share the knowledge of a domain. The one common theme that unites all knowledge based systems is an attempt to represent knowledge explicitly via tools such as ontologies and rules rather than implicitly via code, the way a conventional computer program does [5]. A knowledge-based system is a computer program that reasons and uses a knowledge base to solve complex problems.

Description logic provides the means to model relationships between individuals in a domain of interest [6]. It is a family of logic-based knowledge representation languages that can be used to represent the terminological knowledge of an application domain in a structured way. The domain of interest in this study is election processes. Hence, this study develops a formalised ontology of election using description logic as its language of representation while Protégé 5.0 was used to implement it. The ontology provides a common understanding of the structure of election processes, enables the reuse of the domain knowledge and gives quick answers to queries.

II REVIEW OF RELATED WORKS

Ontology is a machine-understandable knowledge model, which is built by explicit specification of the real objects or abstract concepts and their relationships in a specific domain [7]. The term is borrowed from philosophy where ontology is a systematic account of existence [8]. It explained further that ontology should effectively communicate the intended meaning of the

defined terms and relationships. It should be coherent, clear, and designed to anticipate the uses of the shared vocabulary, i.e., built for pragmatics.

Describing a common, shared vocabulary allows researchers to share information through integration of data. Ontology plays a significant role to make these machine interpretable descriptions of basic concepts and relations among them. Ontology is developed so as to share a common understanding of the information among people or software agents, enable reuse of domain knowledge, make domain assumptions, separate domain knowledge from operational knowledge, and analyse domain knowledge. [2]. It also defines the concepts, relationships, and other distinctions that are relevant for modelling a domain and plays an important role in different aspects of information system development [9]. Ontology can help computers to extract and aggregate information originating from different data sources in an efficient manner [10].

Ontology provides a common framework for structured knowledge representation of domain knowledge. It gives the description of concepts and the relations that can exist between them. The concept is very important for data sharing and knowledge representation [11]. An ontology is a knowledge model that represents a set of concepts within a domain and the relationships among these concepts. Ontologies facilitate not only representation but also concept instantiation and instance-based reasoning within a domain [12].

Developing four stars election open data in rdf, an evidence from Taiwan election open data project was implemented with ontology and CSV files using Python automation [13]. In this work, paper documents were first converted to PDF to digitize the data from the handwritten paper and the PDF files into CSV files by doing OCR and manual inputting. Since ontology would be used to describe resources, properties, statements, and the relationship between entities, E-R (entity-relationship) diagrams were structured and transformed to ontology by using the Protégé OWL tool.

An ontology for e-government public services was developed to cover the basic services that should be delivered to citizens and enterprises [14]. Such basic services include e-service composition, e-service cataloguing, change management and administrative responsibility.

POWER (Politics Ontology for Web Entity Retrieval) is an ontology of political processes designed for tracking politicians, political organisations and elections, both in mainstream and social media. Since politicians are frequently being mentioned in texts by their roles in the political scene, which may change rapidly over time, POWER was designed for tracking such complex and dynamic setting, with the purpose of making it a key resource to analytics applications in mining the media [15].

The Political Ontology article discusses the concept of political ontology, the status of ontological claims,

and ontological disputes in political analysis. It also highlights the consistent disparity between the often tacit and normalized analytical assumptions of existing mainstream approaches to political analysis and those which emerge from sustained ontological reflection [16].

The Cornucopia of Formal-Ontological Relations presents a new method for generating typologies of formal-ontological relations [17]. The guiding idea is that formal relations are those sorts of relations which hold between entities which are constituents of distinct ontologies. The authors provide examples of ontologies and show how these can be used to give a rich typology of formal relations in a way which also throws light on the opposition between three and four-dimensionalism.

An Ontology of Good Governance (A Political Theory Approach) was aimed at exploring the ontology of good governance from a political theory perspective. It analyzed the political nature of good governance using the theory of democracy. Classical approach to democracy as coined by political scientists were used [18].

III METHODOLOGY

Knowledge engineering process is adopted for the development of this formalised ontology. Necessary and required knowledge about election was acquired from domain experts and categorised into facts, relations and constraints. The axioms were formalised using description logic. Competency questions were used to evaluate the ontology.

A. Conceptualisation of the Domain

Based on the acquired knowledge of the domain, relevant concepts and relations were identified and organised into classes, subclasses and instances. The classes were organised in taxonomical order. The classes and salient subclasses that exist within the election ontology domain are:

Tenure, PoliticalMandate, Mandate, PoliticalParty, PartyName, PoliticalPartyID, PoliticalPartyStatus, PoliticalAssociation, PartyTicket, Candidate, Contestant, PartyTicket, ElectoralContest, Contest, Person, Election, PartyPrimary, PartyElection, ElectedOfficial, PersonRegister, VotersRegister, RegisteredVoter, NigerianAdult, NigerianCitizen, Persons, EligibleVoter, GeographicalArea, SpatialLocation, GeographicalCoordinates, Politically Significant Geographical Area (PSGArea), Wards, LocalGovernment, StateConstituency, FederalConstituency, SenatorialDistrict, PollingStation, PollingStationStatus, EligibleVoter, WardStatus, PollingCentre, LGStatus, StateStatus, LocalGovtArea, PoliticalOffice, LawMakerSeat, ExecutiveSeat, StateAssemblySeat, FederalRepSeat, SenatorialSeat, CouncillorSeat, StateAssembly, FederalReps, Senate, President, Governor, LGChairman, ElectionActor, Candidate, ElectionOfficials, PartyAgent, ElectionDayTask, Accreditation, Collation, Counting, Sorting, Voting, Time, Date, ResultAnnouncement,

CastBallot, TaskDate, Ballot, CastedBallot and NullBallot among others.

Object properties which defined the relationships among the domain classes and subclasses were also created, some of which are: hasStart, hasEnd, hasOccupancy, hasPeriod, hasLogo, hasName, hasID, hasINECRegistration, ofParty, forMandate, hasPartyTicket, IsMemberofParty, hasWinner, hasContestant, hasVoters, hasPrize, scheduledFor, hasOpponent, hasEntry, tookAction, hasAge, catersForVoters, hasConstitutionalStatus, hasWard, hasLGA, hasLG, hasSC, hasFC, seatBelongsTo, hasTaskTime, hasParticipant, hasSuccessorTask, hasVenue, hasPredecessorTask, hasBallotEntry, hasThumbEntry, takesAction and hasObject among others.

B. Definitions of Concepts, Roles and Axioms

This section defines the concepts, roles and axioms used in the formalization of the election ontology.

1. Party, Tickets and Mandates

Definition 1

A Tenure has a start date and an end date.

$$\text{Tenure} \equiv = 1\text{hasStart.Date} \sqcap = 1\text{hasEnd.Date} \sqcap (\text{hasStart,hasEnd}). \leq$$

Definition 2

Political mandate is a mandate that has a political office to be occupied within a time interval

$$\text{PoliticalMandate} \equiv \text{Mandate} \sqcap = 1\text{hasOccupancy.PoliticalOffice} \sqcap = 1\text{hasPeriod.Tenure}$$

Definition 3

Political Party Identity is an Identity consisting of a party logo and a party name.

$$\text{PoliticalPartyID} \equiv \text{ID} \sqcap \exists\text{hasLogo.PartyLogo} \sqcap \exists\text{hasName.PartyName}$$

Definition 4

Political Party is a group of people that has been registered with INEC as a Political Party.

$$\text{PoliticalParty} \equiv \text{PoliticalAssociation} \sqcap$$

$$\text{hasID.PoliticalPartyID} \sqcap$$

$$\exists\text{hasINECRegistration.PoliticalPartyStatus}$$

Definition 5

A nomination belongs to a Political Party and for a particular election.

$$\text{PartyTicket} \equiv = 1\text{ofParty.PoliticalParty} \sqcap$$

$$= 1\text{forMandate.PoliticalMandate}$$

Definition 6

A Candidate is a person that has the ticket of one political party for an election.

$$\text{Candidate} \equiv \text{Contestant} \sqcap$$

$$= 1\text{hasPartyTicket.PartyTicket}$$

Axiom 7

Only a member of a party can have the Party's ticket.

$$\text{hasPartyTicket} \circ \text{ofParty} \sqsubseteq \text{IsMemberOfParty}$$

Axiom 8

No nomination can be held by more than one Person.

$$\text{PartyTicket} \sqsubseteq \text{PartyTicket} \sqcap$$

$$\forall((\text{inv hasPartyTicket}), (\text{inv hasPartyTicket})). =$$

2. Electoral Contests, Primaries and Elections

Definition 9

An electoral contest is a contest in which there are many contestants and voters, and has one winner among the contestants.

$$\text{ElectoralContest} \equiv \text{Contest} \sqcap$$

$$\geq 1\text{hasContestant.Person} \sqcap$$

$$= 1\text{hasWinner.Person} \sqcap$$

$$\exists(\text{hasWinner,hasContestant}). = \sqcap$$

$$\geq 1\text{hasVoters.Person}$$

Definition 10

An Election is an electoral contest among candidates that have party tickets vying for the same mandate and the election is scheduled for a date before the start of the mandate's tenure.

$$\text{Election} \equiv \text{ElectoralContest} \sqcap$$

$$\exists \geq 1\text{hasContestant.Candidate} \sqcap$$

$$= 1\text{hasPrize.PoliticalMandate} \sqcap$$

$$(\text{hasContestant} \circ \text{hasPartyTicket} \circ \text{forMandate} = \text{hasPrize}) \sqcap$$

$$= 1\text{scheduledFor.Date} \sqcap$$

$$\exists(\text{scheduledFor,hasPrize} \circ \text{hasPeriod} \circ \text{hasStart}). \text{Before}$$

Definition 11

A party primary is a electoral contest in which all contestants belong to the same Party and the prize is a party ticket.

$$\text{PartyPrimary} \equiv \text{ElectoralContest} \sqcap$$

$$\forall(\text{hasContestant} \circ \text{IsMemberofParty}). = \sqcap$$

$$= 1\text{hasPrize.PartyTicket}$$

Definition 12

A party election is an electoral contest in which all contestants are of the same party and the prize is a party office.

$$\text{PartyElection} \equiv \text{ElectoralContest} \sqcap$$

$$\forall(\text{hasContestant} \circ \text{IsMemberofParty}). = \sqcap$$

$$= 1\text{hasPrize.PartyOffice}$$

Axiom 13

The winner of a contest can only emerge from the contestants.

$$\text{hasWinner} \sqsubseteq \text{hasContestant}$$

Role-Definition 14

When two different candidates have party tickets for the same election, they are opponents

$hasOpponent \equiv hasPartyTicket . forMandate .$

$inv(hasPartyTicket . forMandate) \sqcap \neg =$

Definition 15

Elected official is a candidate that was nominated for an election and also won the election or returned unopposed.

$ElectedOfficial \equiv Person \sqcap$

$\exists(hasPartyTicket . forElection \sqcap$

$inv hasContestant \sqcap$

$(inv hasWinner \sqcup \neg \exists hasOpponent . Candidate) . Election$

3. Registers and Voters

Definition 16

A Person Register is a list with many entries, each of which is an identifier for persons.

$PersonRegister \equiv List \sqcap \exists 1 \geq hasEntry . IDfor . Person$

Definition 17

A Voters' Register is a Person-Register for which the only entries are identifiers for each of duly Registered Voters.

$VotersRegister \equiv PersonRegister \sqcap$

$(hasEntry \circ IDfor = RegisteredVoter)$

Definition 18

A Registered Voter is a Nigerian Adult who took the action of registering to vote.

$RegisteredVoter \equiv$

$NigerianAdult \sqcap \exists TookAction . RegisterToVote$

Definition 19

A Nigerian Adult is a Nigerian citizen who is at least 18 years of age.

$NigerianAdult \equiv NigerianCitizen \sqcap hasAge \geq 18$

Where $NigerianCitizen \sqsubseteq Persons$

Note: We restrain ourselves from defining who a Nigerian citizen is as doing so is outside the scope of this work.

Definition 20

An Eligible Voter is a Nigerian Adult who has an entry on the Voter's Register.

$EligibleVoter \equiv$

$NigerianAdult \sqcap$

$\exists inv IDfor . inv hasEntry . VotersRegister$

4. Spatial Locations and Constitutional Geography

Definition 21

Geographical Area is a spatial location that has geographical coordinates.

$GeographicalArea \equiv SpatialLocation \sqcap$

$\exists hasCoordinates . GeographicalCoordinates$

Axiom 22

Politically Significant Geographical Area (PSGArea) is a subclass of Geographical Areas which has subclasses Wards, Local Governments, State Constituencies, Federal Constituencies, Senatorial Districts, States and Territories

$PSGArea \sqsubseteq GeographicalArea$

$Ward \sqsubseteq PSGArea$

$LocalGovernment \sqsubseteq PSGArea$

$StateConstituency \sqsubseteq PSGArea$

$FederalConstituency \sqsubseteq PSGArea$

$SenatorialDistrict \sqsubseteq PSGArea$

$State \sqsubseteq PSGArea$

Definition 23

Polling Station is a spatial location within a ward that has the electoral status of a polling station and caters for no more than 500 voters who are all eligible voters.

$PollingStation \equiv SpatialLocation \sqcap$

$GeogWithin . Ward \sqcap$

$\exists hasElectoralStatus . PollingStationStatus \sqcap$

$\leq 500 CatersForVoter . EligibleVoter$

Definition 24

Ward is a geographical area that has an electoral status and must have more than one polling centre

$Ward \equiv GeographicalArea \sqcap$

$\exists hasElectoralStatus . WardStatus \sqcap$

$\geq 1 hasPollingCentre . PollingCentre$

Definition 25

Local Government is a geographical area that has electoral status which is a local government status and at least one ward

$LocalGovernment \equiv PSGA \sqcap$

$= 1 hasConstitutionalStatus . LGStatus \sqcap$

$\geq 1 hasWard . Ward$

Definition 26

State is a geographical area that has electoral status which is a state status and more than one local government

$State \equiv GeographicalArea \sqcap$

$= 1 hasConstitutionalStatus . StateStatus \sqcap$

$\geq 1 hasLGA . LocalGovtArea$

Definition 27

State Constituency is a politically significant geographical area that has electoral status and has more than one local government

$StateConstituency \equiv PSGArea \sqcap$

$\exists hasConstitutionalStatus . SCStatus \sqcap$

$\geq 1 hasLG . LocalGovernment$

Definition 28

Federal Constituency is a politically significant geographical area that has an electoral status and contains at least one state constituency.

$FederalConstituency \equiv PSGArea \sqcap$
 $\exists hasConstitutionalStatus.FCStatus \sqcap \geq$
 $1hasSC.StateConstituency$

Definition 29

Senatorial district is a politically significant geographical area that has such an electoral status and contains at least one federal constituency.

$SenatorialDistrict \equiv PSGArea \sqcap$
 $\exists hasConstitutionalStatus.SDStatus \sqcap$
 $\geq 1hasFC.FederalConstituency$

5. Political Offices and Seats

Definition 30

Political office is delineated into two, lawmaker seat and executive seat

$PoliticalOffice \equiv LawmakerSeat \sqcup ExecutiveSeat$

Definition 31

A lawmaker seat can be State house of assembly seat, federal house of assembly seat or senatorial seat or local government councillorship.

$LawmakerSeat \equiv StateAssemblySeat \sqcup$
 $FederalRepSeat \sqcup SenatorialSeat \sqcup$
 $Councillorship$

Definition 32

$StateAssemblySeat \equiv LawmakerSeat \sqcap$
 $hasConstituency.StateConstituency \sqcap$
 $SeatBelongsTo.StateAssembly$

Definition 33

$FederalRepSeat \equiv Lawmaker \sqcap$
 $hasConstituency.FederalConstituency \sqcap$
 $SeatBelongsTo.FederalReps$

Definition 34

$SenatorialSeat \equiv LawmakerSeat \sqcap$
 $hasConstituency.SenatorialDistrict \sqcap$
 $SeatBelongsTo.Senate$

Definition 35

An executive seat is either a president or governor.

$ExecutiveSeat \equiv President \sqcup Governor \sqcup LGChairman$

Rule 36

Election actors. The main actors in an election are the candidate, political party, voters, election officials and party agents.

$ElectionActor \equiv Candidate \sqcup PoliticalParty$
 \sqcup
 $Voter \sqcup ElectionOfficials \sqcup PartyAgent$

6. Election day Actors, Tasks and Routines

An accreditation is an election day task in which eligible voters participate and are the only people who may be accredited.

$Accreditation \equiv ElectionDayTask \sqcap$
 $\geq 1(hasParticipant \sqcap Accredits).EligibleVoter \sqcap$
 $\exists hasVenue.PollingBooth \sqcap$
 $hasSuccessorTask.Voting \sqcap$
 $(Accredits \sqsubseteq hasParticipant)$

Definition 39

Voting is an election day task which participants constitute a subset of eligible voters that have been accredited in an accreditation task that took place on the same day.

$Voting \equiv ElectionDayTask \sqcap$
 $\geq 1hasParticipant.(EligibleVoter \sqcap$
 $takesAction.CastBallot) \sqcap$
 $hasVenue.PollingBooth \sqcap$
 $hasSuccessorTask.Counting \sqcap =$
 $1hasPredecessorTask.Accreditation \sqcap$
 $(hasParticipant \sqsubseteq$
 $hasPredecessorTask \circ Accredits) \sqcap$
 $(taskDate = hasPredecessorTask \circ taskDate)$

Definition 40

Ballot here is referred to the ballot paper that has not been thumb printed.

$Ballot \equiv = 1Designatedfor.Election \sqcap$
 $\geq 1hasBallotEntry.Entryfor.Person \sqcap$
 $(Designatedfor \circ hasContestant = hasBallotEntry) \sqcap$
 $(hasThumbedEntry \sqsubseteq hasBallotEntry)$

Definition 41

Cast Ballot is the action of voting

$CastBallot \equiv Action \sqcap$
 $= 1inv takesAction.EligibleVoter \sqcap$
 $(hasActionDate = Designatedfor \circ Scheduledfor) \sqcap$
 $(hasActionTime, inv (hasParticipant.takesAction) \circ)$
 $hasTaskTime).Within \sqcap$
 $= 1 hasObject.CastedBallot$

Definition 42

Casted Ballot refers to the ballot paper that has thumb entry.

$CastedBallot \equiv Ballot \sqcap$
 $(NullBallot \sqcup (= 1 hasThumbedEntry.Entry))$

Definition 44

Null ballot is one that has no thumb entry or a voter has voted for two candidates.

$NullBallot \equiv Ballot \sqcap$
 $\neg \exists hasThumbedEntry.Entry \sqcap$
 $\geq 2 hasThumbedEntry.Entry$

C. Assertional Facts (ABOX)

Various facts about the election ontology were extracted as follows:

Fact 1

A voter votes for candidates
 $votesFor(Voter, Candidates)$

Fact 2

Political party nominates Candidates
nominates(PoliticalParty, Candidates)

Fact 3

A candidate is a member of a political party
hasMembership(Candidate, PoliticalParty)

Fact 4

A political party can be identified by political party identities which are party logo and name
hasIdentity(PoliticalParty, PoliticalPartyIdentity)

Fact 5

Polling stations are located in wards
locatedIn(PollingStation, Ward)

Fact 6

State comprises of local governments
comprisesOf(State, Local Government)

Fact 7

It is only election officials that are eligible to operate voting machine
operates(ElectionOfficial, VotingMachine)

Fact 8

Election officials are the ones that counts ballot
counts(ElectionOfficial, ballot)

Fact 9

Political parties conducts primary elections
conducts(PoliticalParty, PrimaryElection)

Fact 10

A voter owns voter's card
hasOwnership(Voter, VotersCard)

Fact 11

Party agents witnesses election
hasWitness(PartyAgent, Election)

Fact 12

A voter cast votes in a polling station
castVote(Voter, PollingStation)

Fact 13

Accredited election observers are allowed to observe election
observes(ElectionObserver, Election)

Fact 14

Ballot are sorted by election officials
sortedBy(ballot, ElectionOfficial)

Fact 15

Candidates contest for political office
contestFor(Candidates, PoliticalOffice)

Fact 16

Election officials announces election result

announces(ElectionOfficial, ElectionResult)

Fact 17

Political offices are occupied by election winner
hasOccupancy(PoliticalOffice, ElectionWinner)

A. Some Competency Questions

A few of the competency questions used to query the ontology are given below:

1. Who are the major actors involved in an election?
2. Who can occupy an executive seat and a Senatorial seat?
3. Which positions do candidates contest for?
4. How can a political party be identified?
5. Who nominates candidates for elections?
6. What are the processes involved on election day?
7. Who is an eligible voter?
8. Where can voters cast their votes?
9. What defines a constitutional geographical area?
10. What defines an election winner?

IV IMPLEMENTATION

This ontology was implemented with Protégé 5.0 and queried using the DL query tab of the Protégé with Hermit Reasoner of version 1.3.8. Answers to the competency questions were used to evaluate the ontology as discussed below.

1. Competency question: "Who are the major actors involved in an election?"

The answer to the competency question given above is shown in Fig. 1 below. The ontology returns candidate, political party, voters, election officials and party agents as its answer.

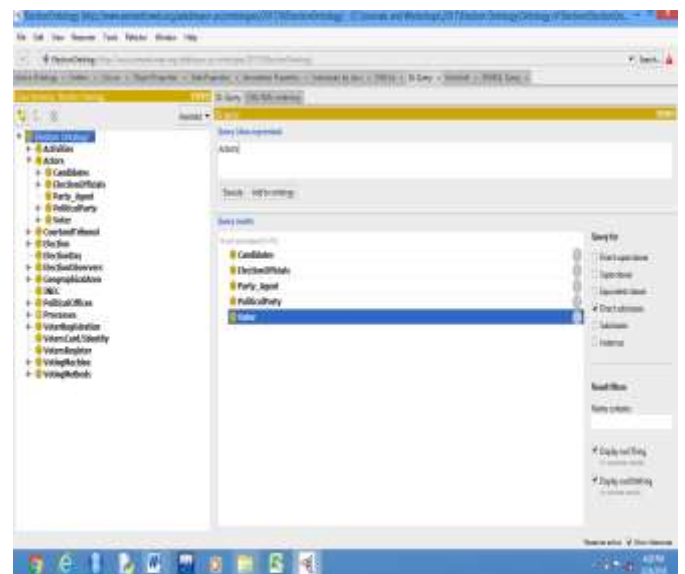


Fig. 1: Answer to the competency question: "Who are the major actors involved in an election?"

2. Competency question: "Which political positions are for the lawmakers?"

Fig. 2 shows the answer to this query and it returns Senatorial seat, federal house of representative and state house of assembly seats.

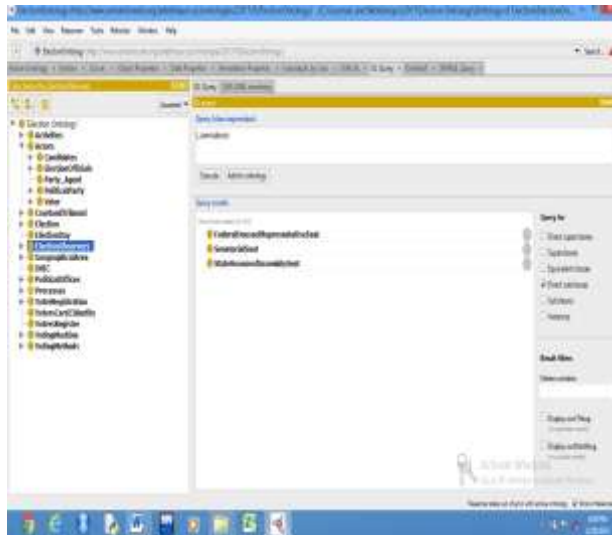


Fig. 2: Answer to the competency question: “Which political positions are for the lawmakers?”

3. Ontograph for both executive and lawmakers offices

The ontograph in Fig. 3 helps to see the various political offices at a glance showing the major classes and the subclasses.

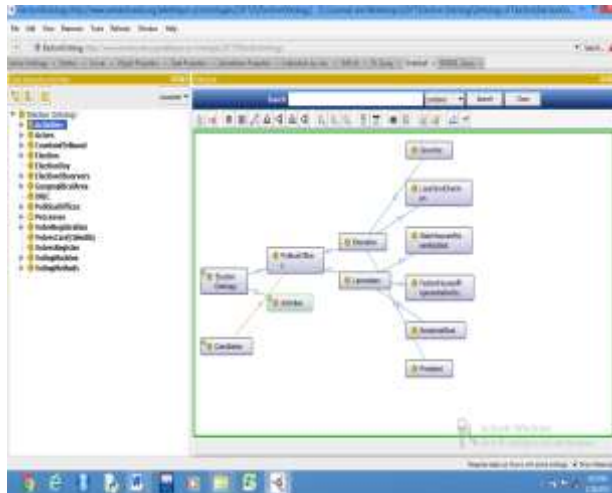


Fig. 3: An ontograph for the various political offices

4. Answer to the competency question: “Where does a voter cast vote on election day?”

Fig. 4 gives the answer to the above query as Polling Station.

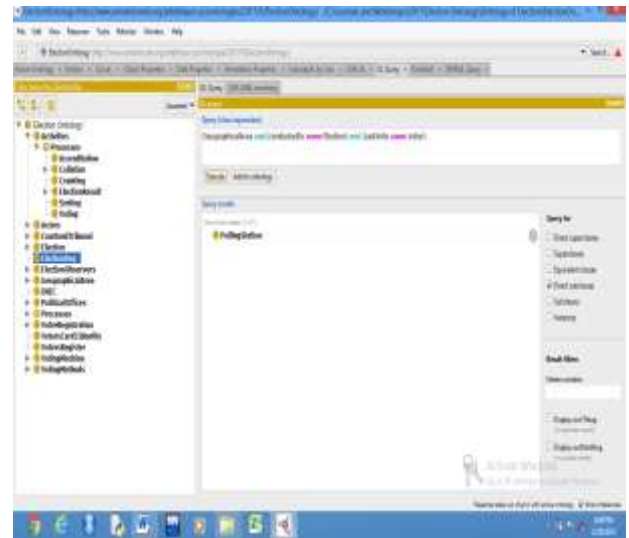


Fig. 4: Answer to the competency question: “Where does a voter cast vote on election day?”

5. Competency question: “In which geographical areas are elections conducted?”

Fig. 5 shows the answer to the above competency question and it returns federal constituency, state constituency, local government, state, senatorial district and ward.

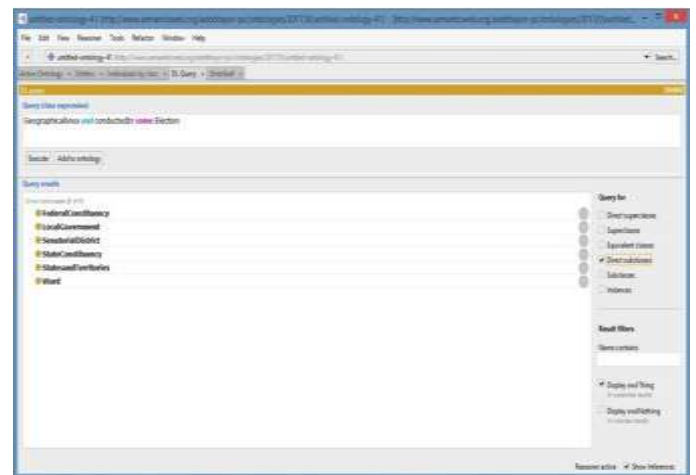


Fig. 5: Answer to the competency question: “In which geographical areas are elections conducted?”

V. CONCLUSION

Election is central to the stability and development of democracy. Hence, the formalised election ontology developed in this study should act a guide and easily accessible information on the processes of election for the electorate and even INEC officials who may want to do contrary to what is expected of them during an election.

ACKNOWLEDGMENT

We appreciate the efforts of our reviewers who gave the insight into the area we needed to improve on the paper. Their comments were very helpful in restructuring the arrangements and contents of the work.

REFERENCES

- [1]. Sagay, I. E., (2008), 'Election Tribunals And The Survival Of Nigerian Democracy' A Lecture Delivered At The Launching Ceremony Of The Osun Defender On Tuesday 26th February, 2008 At The Muson Centre, Lagos
- [2]. Noy, N. F. and McGuinness, D. L. (2000). *Ontology Development 101: A Guide to Creating Your First Ontology*. Stanford University, Stanford, CA, 94305. Retrieved on June 28, 2017 from http://protege.stanford.edu/conference/2004/slides/Ontology101_tutorial.pdf
- [3]. Uschold, M. and Gruninger, M. (1996). *Ontologies: Principles, Methods and Applications*. *Knowledge Engineering Review* 11(2): 93 – 155.
- [4]. Jain, V., Singh, M. (2013). *Ontology Development and Query Retrieval using Protégé Tool*. I.J. Intelligent Systems and Applications, 2013, 09, 67-75 Published Online August 2013 in MECS (<http://www.mecs-press.org/>) DOI: 10.5815/ijisa.2013.09.08
- [5]. Smith, R. G., (1985), *Knowledge-Based Systems Concepts, Techniques, Presented at the Canadian High Technology Show*, Lansdowne Park, Ottawa, May 8, 1985
- [6]. Baader, F., Ghilardi, S. and Lutz, C. (2008). LTL over Description Logic Axioms. *Proceedings, Eleventh International Conference on Principles of Knowledge Representation and Reasoning* (2008)
- [7]. Hilal, S. M. (2012). *Design and Development of a Mineral Exploration Ontology*. Thesis, Georgia State University, 2012. http://scholarworks.gsu.edu/geosciences_theses/49_ Retrieved on July 16, 2016.
- [8]. Gruber, T. R. (1993). A Translation Approach to Portable Ontology Specifications. *Knowledge Acquisition* 5 (2): 199-220.
- [9]. Pundt, H. and Bishr, Y. (2002). 'Domain ontologies for data sharing – an example from environmental monitoring using filed GIS,' *Computer and Sciences V* 28, p. 95-102.
- [10]. Zhong, J., Aydina, A., McGuinness, L., (2009). *Ontology of fractures*. *Journal of Structural Geology* v. 31, p. 251-259
- [11]. Saripalle, R. K. (2004). *Current Status of Ontologies in Biomedical and Clinical Informatics*. University of Connecticut, Storrs. Retrieved April 04, 2016, from University of Connecticut: <http://www.engr.uconn.edu/~steve/Cse300/saripalle.pdf>
- [12]. Riano, D., Real F., Lopez-Vallverdu, J. A., Campana, F., Ercolani, S., Mecocci, P., Annicchiarico, R. and Caltagirone, C. (2012). An ontology-based personalization of health-care knowledge to support clinical decisions for chronically ill patients. *Int. Journal of Biomedical Informatics*. 45(3): 429-446, Jun 2012. DOI: [10.1016/j.jbi.2011.12.008](https://doi.org/10.1016/j.jbi.2011.12.008). Also published in the *JBI Virtual Issue on Computer-interpretable Clinical Guidelines* (Ed. Mor Peleg), 2013.
- [13]. Chien, C., Hung, C., Day, M., Lin Y. and Yang, C. (2016). *Developing Four Stars Election Open Data in RDF: Evidence from Taiwan Election Open Data Project*. *Proceedings of The 3rd Multidisciplinary International Social Networks Conference on Social Informatics 2016*, Data Science 2016
- [14]. Vassilakis, C. and Lepouras, G. (2006). *An Ontology for e-Government Public Services*. *Encyclopedia of E-Commerce, E-Government and Mobile Commerce*, 865-870 (2006). (Department of Computer Science and Technology, University of Peloponnese). Retrieved February 5, 2017 from: [hci- vr.dit.uop.gr/papers/%5BBB02%5D_OntologyE-GovServices.pdf](http://hci-vr.dit.uop.gr/papers/%5BBB02%5D_OntologyE-GovServices.pdf)
- [15]. Moreira S., Batista D., Carvalho P., Couto F.M., Silva M.J. (2011) *POWER - Politics Ontology for Web Entity Retrieval*. In: Salinesi C., Pastor O. (eds) *Advanced Information Systems Engineering Workshops. CAiSE 2011. Lecture Notes in Business Information Processing*, vol 83. Springer, Berlin, Heidelberg.
- [16]. Hay C. (2011). *Political Ontology*. From The *Oxford Handbook of Political Science*. Edited by Goodin R. E.
- [17]. Smith B. and Grenon P. (2004). *The Cornucopia of Formal-Ontological Relations*. *Dialectica* Vol. 58, No 3, pp. 279-296
- [18]. RAIU C. (2015). *An Ontology of Good Governance: A Political Theory Approach*, *Romanian Journal of Economics*, Institute of National Economy, vol.40(1(49)), pages 154-169.