DYNAMIC CONTROL ONTOLOGY FOR EFFICIENT GSM QUALITY OF SERVICE

***P. C. Bassey[1] and M. A. Raheem[2]**
[1]Department of Computer Science, University of Uyo, Uyo, Nigeria
[2]Department of Mathematics and Statistics, University of Uyo, Uyo, Nigeria

ABSTRACT

Inadequate information for effective control of GSM Quality-of-Service (QoS) is a problem that needs to be addressed as total dependence on the information from the providers' end might not give the true state of the problem encountered by the subscribers. Hence, there is need for feedback from the actual users of the services. This paper presents a dynamic ontological model as a necessary tool for effective control of GSM Quality-of-Service (QoS). Questionnaires were distributed to the subscribers of selected network providers: A, B, C and D. The collection of data took six weeks, spread over a period of three months, two weeks per month, that is from the first week of December 2009 to the last week of February, 2010. A Chi-Square test was performed on the data and results obtained form the basis for the model. This model is a three-tier dynamic architecture that used the subscribers' feedback mechanism as the measure for QoS. The work was aimed at serving as a guide to the government during its policy making. Telecommunication companies can also use the findings as they compete and take management decisions. Subscribers can use the work in their choice of network. The model is expected to assist in ensuring effective quality, affordability of telephone services, as well as the increased geographical spread of communication services in Nigeria.

Keywords: GSM Network Problems, Subscriber Feedback, Conceptualization, Network Efficiency, Knowledge Representation

1.0 INTRODUCTION

Telecommunication infrastructure remains one of the major issues affecting technology deployment required for growth and development in Nigeria (Awe, 2007). ***Telecommunication*** is taken from a combination of an ancient Greek word ***tele***, meaning "far off" and ***communication***, which means "the transfer of data." Telecommunication refers to the transfer of data from a transmitter (sender or source) to a receiver (sink) across a distance. GSM (Global System for Telecommunications networks) was formally known to be Groupe Speciale Mobile, is a mobile network system for communication.

The competition is getting fiercer by the day as the increasing numbers of operators have to compete desperately for the same potential subscribers (Ajala, 2005). The operators are fast realizing that they are in a highly competitive environment where subscribers can make or break them. Dissatisfaction by subscribers gives rise to a high rate of subscriber churn and low revenue for the operator. The performance of the network has a direct impact on the revenues. Mobile platforms also have their own set of challenges which includes: Bandwidth, Memory and CPU Availability, Storage Capacity, Connectivity Options and Issues, Security, User Interaction and Display (Zhdanova, 2008).

Due to this competition, the focus is gradually shifting from providing coverage to providing quality service. Nigerian Communications Commission (NCC) was established by Decree 75 of 1992 with the main objectives to include: creating a regulatory environment to facilitate the supply of telecommunications services and facilities; facilitating the entry of private entrepreneurs into the telecommunications market; and promoting fair competition and efficient market conduct among all players in the industry. Since the inauguration of NCC in July 1993, it has set out in bringing pressure to the operators to step up the quality of service (QoS) offered to Nigerians and had even gone a step further to award contracts to private companies to conduct comparative analyses of the quality of service offered by each of the operators. NCC is further threatening to sanction any operator that fails to pay attention to quality (Ajala, 2005). The average number of incoming calls during the peak period of the day in relation to the system's capacity and the average number of call congested daily were determined.

While availability has grown, this has not been matched by quality of service. It is not enough to have cheap lines and low cost bandwidth. Efficiency and accessibility of telecoms service should be paramount. Most operators have a lot of work to do in QoS especially in the areas of congestion and support. There are problems of congestion in Nigeria telecommunication industry with respect to GSM, such as difficulties in connecting subscribers and losing of resources by the service providers. Nigerian Communications Commission (NCC) may have to wield the big stick by sanctioning poor performers. We are still looking forward to obtain the key ingredient for the promotion of rapid socio-economic and political development of our nation as highlighted in the introductory section of the National Policy on telecommunication: *"The availability of an efficient, reliable and affordable telecommunications system is a key ingredient for promoting rapid socio-economic and political development of any nation" (Arzika, 2000).*

On this note, there is need for dynamic control ontology (DCO) for GSM quality-of-service to be made available for the emerging Semantic Web (Obrst, 2009). Ontology is the explicit and formal specifications of the terms in a domain and the relationship between them (Guarino, 1995). This terms or concepts of which their specification is formalized need to be shared thus providing a framework for communicating in a given application domain (Gimenez et al, 2008). We have several types of ontology including general ontology, domain ontology, task ontology and application ontology (Galton, 2009; Guarino, 1998) which may either be static or dynamic model. This research is aimed at creating a dynamic ontology for the control of the efficiency of the quality of service over network operators. The state of affairs in selected urban areas of Akwa Ibom State has been viewed and factors affecting efficiency of QoS prevalent in these zones are considered in our model. The need for this kind of model has been pointed out (Gimenez et al, 2008).

The model will be useful to subscribers who require effective service quality from their providers, providers who have the interest of their subscribers at heart and the government who is there to regulate and monitor the activities of these telecommunication industries, thereby facing out those with inefficiency in quality of service.

This paper is organized as follows. Section 2 highlights ideas from reviewed literatures. Section 3 presents the methods used, the identified factors, the data collected, which are categorised according to location and network type and the discussion on the results from the analysis of the data. Section 4 gives the conceptual framework or design of the dynamic control ontology for GSM QoS. Finally, we summarize and conclude in Section 5 by proposing the adoption of our DCO model and also state future trends for this work.

2.0 RELATED WORK

With the rapid advancement in media technologies and networks, distributed multimedia applications are expected to be deployed in an environment that is more dynamic and heterogeneous than ever before like the Semantic Web (Fernandez, 2006; Su et al, 2008). Semantic Web is different from the current Web – a collection of links and resources: machine readable, not machine understandable, semantically interpretable. Semantic Web is a collection an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Obrst, 2009). Effective QoS provisioning is more challenging as multiple end-to-end components are required. This paved way for the creation of several ontological models, some of which include three layer e-service ontology and an ontology that supports service publication and discovery (Bianchini et al, 2005). This is a way of representing knowledge. Knowledge representation has been defined as: a surrogate for real things, events, relationships; a set of ontological commit-ments, a model for a particular conception of the world; a partial theory of intelligent reasoning; a medium for efficient computation; and a medium of human expression (Obrst, 2009; Nilsson, 1997). This points out that we can model to include: objects in the real world; entities and relations; universals and particulars; and classes and instances/individuals (Konar, 2000). The SPICE project on mobile ontology creation and usage also saw the increasing need for domain ontology development and management for most kinds of knowledge driven applications. Here, multiple components that interact and exchange information or data in order to provide new and innovative services (Su et al, 2008). A formal approach for protocol information modeling and validation leveraging on ontological techniques where a protocol management system for representation of communication protocols and composition of protocol stacks is prototyped (Zhou et al, 2006). This formal approach is becoming widespread in the computer science community as several ontologies are being built like the CYC ontology for effective information systems (Guarino, 1998). Hence, ontology is the logical theory accounting for the intended meaning of formal vocabularies of the concepts in the world. Other location-sensitive applications like the APPLAUS require user's contribution to the system (Zhu and Cao, 2011). Users' activities for mobile service navigation have also been modeled using the task-ontology framework (Sasajima et al, 2006).

Quality of service can therefore be determined by the following variables: Rate at which difficulty occurs over time, rate of response over time, tariff rate and availability of communication channels (ETSI GS MOI 010, 2010). Since most of these problems involve entities and relationships in reality which is dynamic in nature, we therefore need a dynamic ontology (Grenon and Smith, 2004). Aside from telecommunication, other service oriented domains finds ontological models to be useful tools (InteGrail Report, 2010). This domain knowledge requires management, and this is one challenge of knowledge representation with ontologies and their incomplete knowledge representation (Brewster and O'Hara, 2004; Brewster and O'Hara, 2007). Sparseness is also identified as a problem for dynamic situations. This is shown in the REA framework of ontology for management contol systems and strategic planning as well as system dynamics (Church and Smith, 2007).

3.0 MATERIALS AND METHODS

Thirty (30) questionnaires each were randomly distributed among the potential respondents at the three major cities (locations), on the selected weeks, which were chosen systematically for six weeks. A number of questions as contained in the sample questionnaires (see appendix), were then administered to the respondents. Note

that the actual company names were used but for privacy sake they have been replaced with A, B, C, and D and same is used consistently throughout this paper. The information gathered were thereafter pooled, with respect to the observed problems encountered majorly by the subscribers of the various GSM networks considered in this research. The observations based on the various problems were thereby cross-classified according to the network and location types with a view to examine if the problems as associated with the network type are independent of the locations where the various operators are based. Considering the fact that obtained data were:

(i) generated through questionnaires and
(ii) nominal in nature being counts of observations, which can only be classified; a Chi-Square test of association (independence) was observed to enable us determine if the problems (factors) with respect to the network types were associated with the locations (Duane, 2004).

3.1 Factors affecting QoS

Some of the examined factors include: High tariff, Irregular updates, Unavailability of communication channels, Difficulty in connectivity, Suspended calls, Recharging difficulties, SMS transmission difficulties, Slow response, Balance checking difficulty, and Unsuccessful calls and High tariff.

3.2 Presentation of Results

Data collected through the administration of questionnaires in three urban cities of Akwa Ibom State were analysed using the empirical test (as stated earlier), and the summary of results are shown in Figure 1.

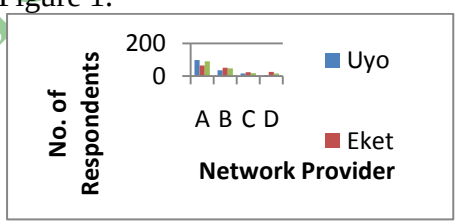

Figure 1: Bar Chart showing total number of Respondents in Operators across selected urban regions of Akwa Ibom State

The identified factors for inefficiency in GSM QoS are presented in tables 1 to 8 and the corresponding bar charts in figures 2 to 9:

Table 1: No Connectivity with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	85	53	84
B	33	42	44
C	24	23	18
D	5	26	15

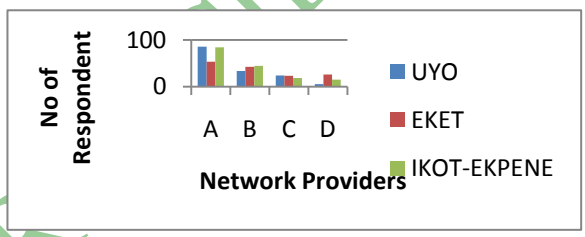

Figure 2: Bar Chart showing No Connectivity with respect to Network types across the Locations

Table 2: Recharging difficulty with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	33	44	39
B	9	35	17
C	4	9	6
D	1	12	7

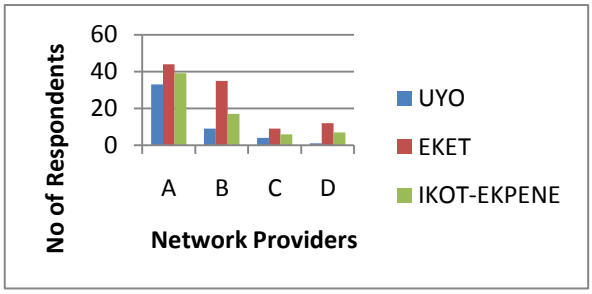

Figure 3: Bar Chart showing Recharging difficulty with respect to Network types across the Locations

Table 3: Balance check difficulty with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	36	35	41
B	12	28	18
C	47	8	7
D	1	9	6

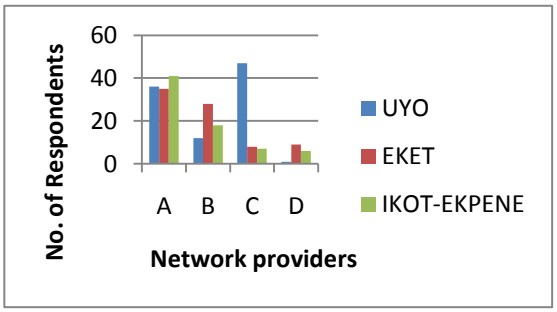

Figure 4: Bar Chart showing Balance check difficulty with respect to Network types across the Locations

Table 4: Suspended/Terminated calls Problem with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	49	44	58
B	18	34	27
C	11	12	10
D	1	14	8

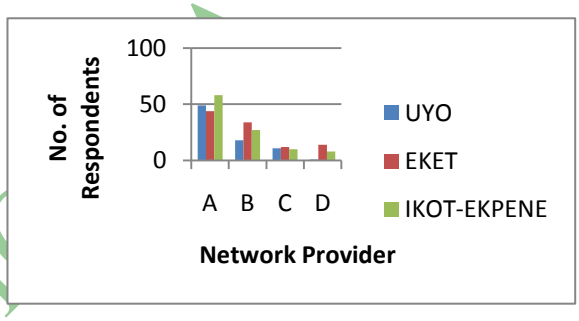

Figure 5: Bar Chart showing Suspended/Terminated calls Problem with respect to Network types across the Locations

Table 5: Problem of Unsuccessful calls with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	61	50	62
B	20	37	31
C	11	13	9
D	1	9	8

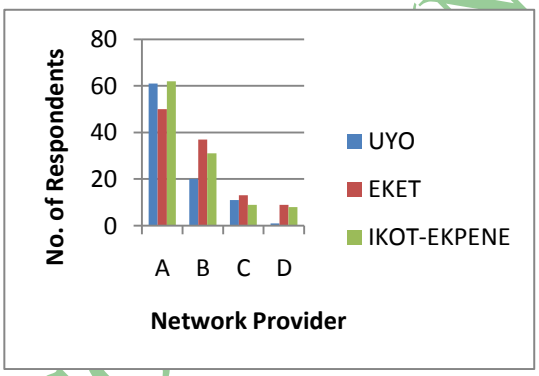

Figure 6: Bar Chart showing Problem of Unsuccessful calls with respect to Network types across the Locations

Table 6: Poor SMS Access with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	33	44	39
B	9	35	17
C	4	9	6
D	1	12	7

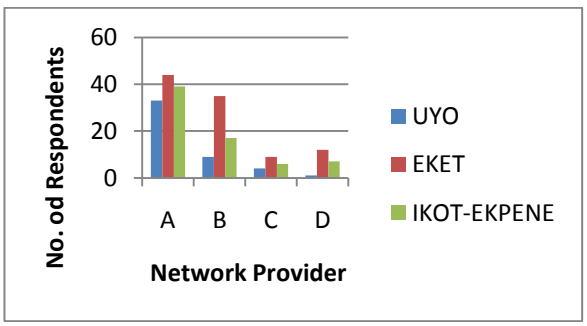

Figure 7: Bar Chart showing Poor SMS Access with respect to Network types across the Locations

Table 7: High Tariff Problem with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	58	43	59
B	21	31	26
C	13	6	11
D	3	9	7

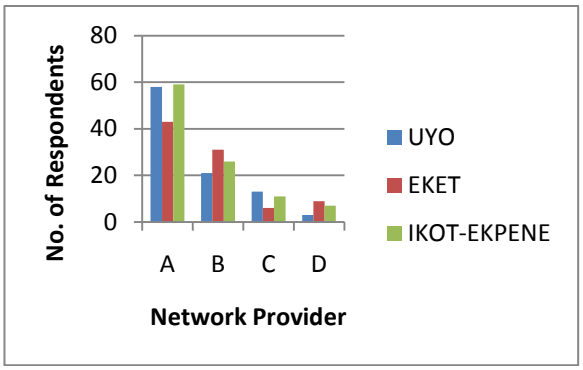

Figure 8: Bar Chart showing High Tariff Problem with respect to Network types across the Locations

Table 8: Poor Response Problem with respect to Network types across the Locations

Provider	Uyo	Eket	Ikot-Ekpene
A	65	53	79
B	22	39	32
C	15	17	12
D	3	11	10

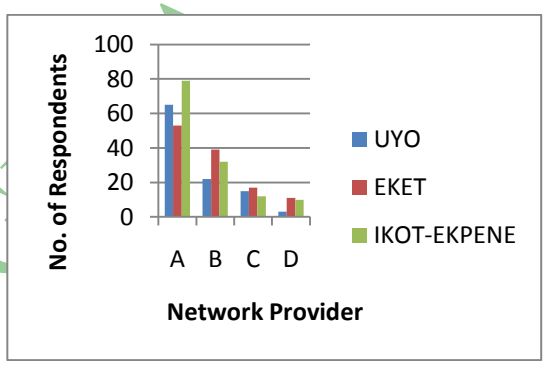

Figure 9: Bar Chart showing Poor Response Problem with respect to Network types across the Locations

Meanwhile, the following hypotheses were tested:

H_o: i^{th} problem with respect to the network types is independent of (not associated with) the location types. Against

H_1: the i^{th} problem with respect to the network types is not independent of (associated with) the location types.

where i^{th} problem(factor) includes : 'No connectivity,' 'Recharging difficulty,' 'Balance Check difficulty,' 'Suspended/ Terminated calls problem,' 'Unsuccessful calls,' 'Poor SMS access,' 'High Tariff charging,' and 'Poor Response.'

3.2.1 Discussion of Results

Considering the eight problems under discourse, we had four cases where H_o was rejected to include Problem of no connectivity with respect to zone and network type, Balance check difficulty, Suspended/Terminated calls, Suspended/ Terminated calls, Poor SMS access and four where H_o was accepted to include Recharging difficulty with respect to zone and network type, Unsuccessful calls, High Tariff, Poor Response.

The various problems experienced by the various network users were classified in a way to examine the effect or influence of the various major locations where the network providers are operating on the efficiency of the services rendered to the users. In each case however, the various locations (Ikot Ekpene, Uyo and Eket) were cross-classified with the various network providers (A, B, C, D), the Chi-square test of association was observed. By implication, not rejecting H_o (null-hypothesis) simply indicates that the location type has no significant association with or influence on each of the following problems: Recharging difficulty, Unsuccessful calls, High Tariff and Poor Response. Meaning, these problems could rather be traced to the provider's service inefficiency. The percentages of these problems are summarized in Table 9.

Table 9: Network type Induced Problems

Network/ Problems	Recharging Problem (%)	Unsuccessful calls (%)	High Tariff (%)	Poor Response (%)
A	46.4	69.2	64	78.8
B	46.2	66.7	59.1	75.9
C	32.8	56.9	51.7	70.5
D	43.5	39.1	41.3	52.2

In all, A users encounter problems of recharging, unsuccessful calls, high tariff and poor response more as compared with any other network providers. Whereas, rejecting H_o (null-hypothesis), implies that the following problems: No connectivity problem, Difficulty in checking balance, suspended/terminated calls and Poor SMS access traceable to the various network types are influenced by or are associated with the operational locations of the network providers. Table 10 gives the summary of their percentages.

Table 10: Location Induced Problems

Location/ Problems	No Connectivity (%)	Account Check (%)	Suspended/ Terminated Calls (%)	Poor SMS (%)
Uyo	95.5	62.3	63.5	55.2
Eket	95.3	48.5	60.9	42.0
Ikot Ekpene	87.3	43.6	51.3	20.1

These domain knowledge obtained from the result of the analysis are concept-ualized in the next section.

4.0 CONCEPTUALIZATION OF THE DOMAIN KNOWLEDGE

Figure 10 gives the conceptual framework of the identified concepts from the domain knowledge. This follows the principles on building an ontology as highlighted in the literature (Guarino, 1997; Uschold and Gruninger, 1996).

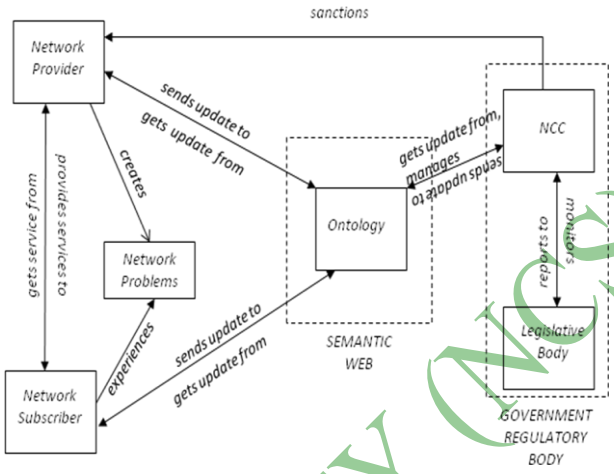

Figure 10: Conceptual Framework of GSM Quality of Service Ontology

From the conceptual framework shown in figure 10, one can intuitively picture the entities and the sub-entities (Casati et al, 1998), as obtained from the domain knowledge to include: Net-Problems (net-type-induced-problems, location-induced problems), Net-Beneficiary (net-providers, net-subscribers) and Net-regulatory-body (legislative-body, NCC). All these entities interrelate in one way or the other. The relationships among these entities include:

- provides-service,
- experiences-problem,
- creates-problems,
- gets-service-from,
- sends-update-to,
- manages,
- gets-update-from,
- monitors,
- reports-to and sanctions.

Figure 11 gives the control ontology of the GSM QoS. The concepts: entities, sub-entities and their relationships are represented in the ontology as shown in Figure 11.

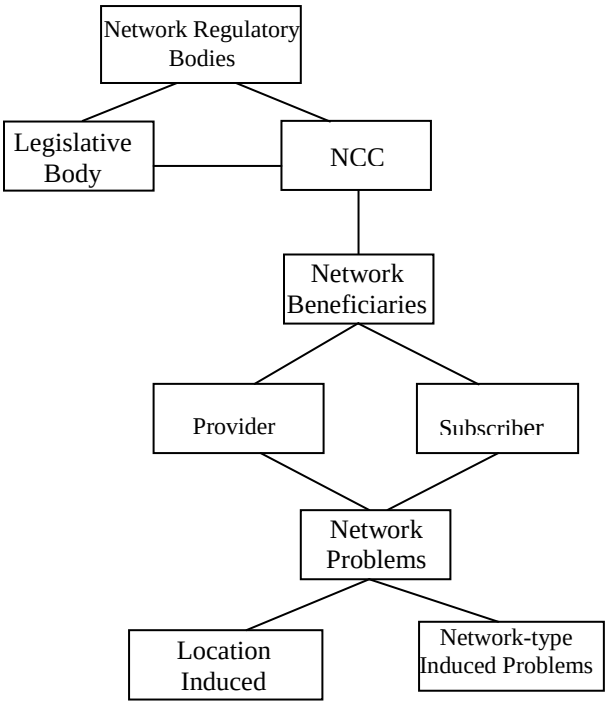

Figure 11: Control Ontology for GSM QoS

From the ontological diagram in Figure 11, we have that the ontology as proposed for the semantic web follows three-tier architecture. Figure 12 depicts the architecture of the dynamic control ontology for GSM QoS.

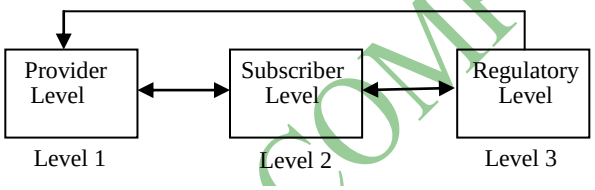

Figure 12: Architecture of the DCO for GSM QoS

From the architectural diagram in figure 12, level 1 of the ontology is managed and controlled by the network providers, that is, this level hosts the various network providers sending updates to DCO as input and managing the updates on services over changing time. The subscribers at level 2 use the updates and report the state of affairs of the quality of service of the network providers. These reports get to level 3 and serve as control measures for the regulatory body. The resulting ontological model is shown in figure 13.

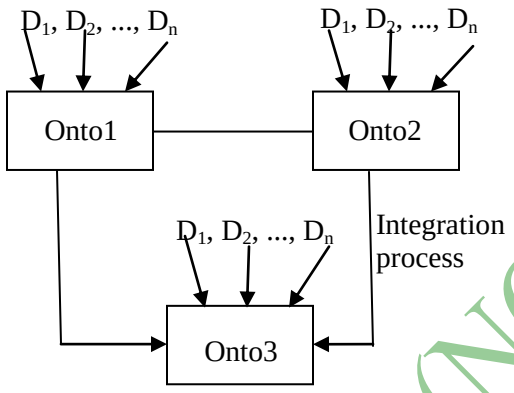

Figure 13: GSM Dynamic Ontology

From Figure 13, Onto1, Onto2 and Onto3 are different ontologies at the different levels of the architecture. During integration, there is need for mapping as Onto1 is merged with Onto2 to give the heterogeneous ontology for knowledge consistency (Ding and Foo, 2002). Onto3 is the resulting ontology from the integration process of Onto1 and Onto2. Onto3 can be managed and controlled for reuse and knowledge sharing (Boley and Guarino, 1996; Uschold et al, 1998). D1, D2, ..., Dn represent the various duration and instances of occurrence of events or processes affecting quality of service. Temporal properties like this have been modelled (Allen, 1984). The dynamic nature of the ontology is handled by the various durations by which change in processes occur.

Note that the regulatory is directly managing this level of ontology and if possible level 2 of the ontology as well. From the DCO, answers to competency questions can be obtained. They include:

- Is the problem general over all locations?
- Does the problem persist over time?
- Is the problem peculiar to a certain network?
- Does the provider carry out routine maintenance check on the network?
- Is the network efficient?

Answers to these questions will assist to enhance the control of the GSM quality of service to the desired level of efficiency.

5.0 CONCLUSION AND ACKNOWLEDGEMENT

5.1 Conclusion

Oftentimes, people rate the service quality based on the number of subscribers, but this research is a deviation as a number of factors that can be considered to determine the most preferred network operator within the research area are highlighted. This work shows that the network with highest number of subscribers may or may not be the most preferred network in terms of efficiency.

Our ontological model of the GSM QoS will function well and efficiently in any web-based information system. The goal of the model is to enable friendliness, fastness, and accuracy of a more dynamic information system as the vision of the Semantic Web moves to actualisation. Users of the proposed GIS services information system will appreciate the model and see it as a well thought out companion system.

The proposed model will help Government through its policy and the Telecommunication companies as they compete and take management decisions. Strategies that will ensure effective quality and affordability of telephone services, as well as the increased geographical spread of communications service in Nigeria were highlighted.

Further research should give the formal representation the DCO ontology to actualize the possible answers to the competency questions and how to authenticate the updates through this feedback mechanism to the ontology, ensuring that only credible subscribers pose their challenges to the ontology.

5.2 Acknowledgement

We acknowledge the contribution of Hon. Imo S. Udo and Ebenezer E. John whose effort towards the administration of the questionnaires led to the success of this work, since there was need for the questionnaires to be administered at the same time throughout the different locations. Our sincere gratitude goes to Dr. O. F. W. Onifade for painstakingly going through this manuscript with useful comments.

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8.0 APPENDIX
RESEARCH QUESTIONNAIRE

Dear respondent, this survey is intended to obtain your views on the quality of services rendered by various GSM providers. This will assist in improving the quality of services offered by the network providers. Your kind contribution/cooperation will be highly appreciated.
Please tick where necessary.

SECTION A: Demographic Data

Occupation: Civil/Public Servant □ Self Employed □ Private Establishment □ Unemployed □ Others (Specify).....

Sex: Male □ Female □

Age: Below 18 □ 18 and above □

Area of residence: ……

SECTION B:

(1) Have you subscribed to any network? Yes ¶ No ¶
(2) Which of the following networks have you subscribed to? A¶ B ¶ C ¶ D ¶ Others:¶ ……
(3) Which of the networks is mostly preferred by you? A ¶ B ¶ C ¶ D ¶ Others:¶ ……
(4) Is your provider charging too high while you make call. Yes ¶ No ¶
(5) How often do you encounter problems of no connectivity in a day? Rarely ¶ Often¶ Never¶
(6) How do you rate the service quality? Excellent¶ Good ¶ Average ¶ Poor¶
(7) Do you have any avenue of channeling your problems to your provider? Yes¶ No¶
(8) How quick do you get the response from the provider? Immediate ¶ Delayed¶ Never¶
(9) Have you been receiving updated information concerning new services by your provider? Yes¶ No¶
(10) Do you experience difficulties in checking your account balance? Yes¶ No¶
(11) If Yes, how often? Regularly ¶ Rarely ¶ Sometimes¶
(12) Have you experienced problems recharging your phones since last week? Yes¶ No¶
(13) If Yes, how many times? Once ¶ Twice ¶ Others¶ ……
(14) Do you have problems in checking your balance? Yes¶ No¶
(15) How many times daily/weekly do you experience suspended/terminated calls? No time ¶ Once ¶ Twice ¶ Others (specify)¶ ……
(16) Do you make/receive night calls? Yes¶ No¶
(17) If you make/receive night call, do all calls go through? Yes¶ No¶
(18) How many unsuccessful calls did you have a day? None ¶ One ¶ Two ¶ Others (Specify)¶ ……
(19) Have you been experiencing problems in sending /receiving SMS effectively for the last one week? Yes¶ No¶
(20) If Yes, how many times? One¶ Two¶ Others (Specify)¶ ……
(21) What do you think can be done to improve the quality of services rendered by these network providers? ……