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Information Exchange Framework for Deregulated Electricity Market in Nigeria

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ABSTRACT

Nigeria electricity power sector is undergoing a major revolution. Competition is being introduced at the generation and distribution segments. The major changes will require considerable interactions between the Market Participants (MPs) in order to maintain the integrity and reliability of the whole power network. The interactions will involve massive exchange of information and data between the MPs. Exchange of information and data in the heterogeneous IT's environment of the MPs will be very difficult due to different information, data, files, databases and application or calculation models that will be used by the various MPs. Here we propose a framework based on Extensible Markup Language (XML) technology for data sharing and exchange of information in deregulated electricity market in Nigeria. XML-based information exchange and integration will provide excellent connectivity for diverse applications to be rolled out by the electricity MPs in support of network and market operations.

Keywords: *Deregulated Electricity Market, Information Exchange, XML, Message Passing, Electronic Data Interchange, Nigeria*

1. INTRODUCTION

The electricity industry in Nigeria has traditionally been a monopolistic market, where production of electricity required reliance on public monopoly suppliers subject to government regulation of prices and investment. Recently, Nigeria government has initiated a big reform of the electricity power sector. The reform involves basically the replacement of traditional vertically integrated electric power utility with a competitive market operation at the generation and distribution segments, and the handling over of the transmission system to a private organisation.

The drive towards liberalising energy markets in Nigeria is line with the global process of liberalisation and deregulation. Energy liberalisation in general, and electricity industry in particular is not something new, though for Nigeria the trend towards competitive electricity markets is recent. Countries such as the United States, many countries in Europe, Argentina, Chile, Australia, Japan and New Zealand have all deregulated their electricity and/or natural gas markets thereby opening them up to more competition [1, 2].

The general aims of the reform in Nigeria like deregulated electricity industries in other countries across the globe are to improve efficiency, to create a more competitive energy-producing industry, to attract new - outside - investors and also to divest the state of over-regulated, and often heavily indebted, electricity undertaking, providing welcome cash for the government that can be spent on social services [2, 3].

The regulatory reform and the restructuring of the electricity sector in Nigeria like other countries of the world are following the basic model previously applied to telephone industries. Potentially competitive segments (the generation) are being separated structurally or functionally from natural monopoly segments (the physical transmission of electricity). In contrast to telephone networks where a supplier makes a physical delivery of a product at point A, and it is then physically transported to a specific customer at point B, electricity network is characterised by uncontrollable network flows and there is generally no meaningful direct physical relation between the electric power produced by a specific generator connected to the network and a specific customer taking energy from the network [4, 5]. This creates significant challenges for accurately measuring and settling consumer and generator financial obligation in a competitive electricity market. This is in addition to many new MPs such as Independent Power Producers (IPP), distribution companies (Discos), etc. that will enter into new electricity market operation. Several MPs in the electricity market operation now desire information and data traditionally used only within a single utility.

The new electric utility organizations backed by the new Federal Government of Nigeria Electric Power Sector Reform Act (EPSRA) of 2005 [6] therefore need to exchange information and data with one another to support system planning functions including transmission planning, maintenance scheduling, and operations planning. The involvement of many entities in electricity market operation will require massive exchange of data and information not only for the security and reliability of the power network but also for settlement purposes. The heterogeneous nature of the IT's environments of the MPs poses a considerable difficulties in achieving these objectives. It is therefore necessary for utilities that want to exchange information to agree on data format, a suitable interface and protocol before they can transact business to each other IT systems. However, as the number of partners that want to exchange information increases, as will be obtained in Nigeria deregulated electricity market environment, the number of interfaces to be developed and protocols that will be used to exchange data also increases. The exchange of information will involve a large amount of MPs in many to many relationships. As the participants in the electricity market exchange data with one another, they need a powerful information infrastructure to automate their electricity business transactions [7].

Many countries where electricity deregulation has already taken place have developed efficient methodology for information exchange to overcome the interoperability problems. For example, the European Transmission System Operators (ETSO) set up ETSO Task Force 14 for the specification of Electronic Data Interchange (EDI) standards based on a general functional description of the electricity market and on existing examples in the deregulated market. Through the European information exchange (ebiX), the XML [8, 9] has been chosen as the unified standard for information exchange in the EU electricity market because of its advantages for document-level data exchange over the public Internet and within many private networks [10]. The Common Information Model (CIM) is an open standard for representing power system components developed by the Electric Power Research Institute (EPRI) in North America [11]. The essential structure of a power system model is defined in the CIM. XML has been adopted for encoding structured documents for exchanging the information defined by CIM [12].

The Nigeria deregulated electricity market needs a similar and good information exchange methodology to enable effective take off of the competitive market operation. In this paper, we propose an XML-based information exchange framework for deregulated electricity market in Nigeria. The framework will offer an efficient and cost effective approach for full automation of information exchange between applications belonging to different MPs in the electricity market. It will solve the Business-to-Business (B2B) interoperability problems in electricity market operations. The major aim is to reduce paper work and to contribute to the improvement in efficiency of electricity business operations through the replacement of the costly process of data and information exchange that relies on conventional methods.

The rest of the article is organised as follows. Section two presents the motivation for using XML-based information framework. This is followed by definition of how to use XML for information exchange in section 3. The basic elements of the deregulated electricity market in Nigeria are presented in section 4. In section 5, the information exchange framework is presented. The article ends with the conclusions in section 6.

2. MOTIVATION FOR XML-BASED INFORMATION FRAMEWORK

The advancement in hardware, software, and communication equipment have revolutionised the way we transport, store, and manipulate large quantities of data. Internet and Web-based technologies have also experienced rapid advancement and general acceptance not only by the computer enthusiasts, but also by the business and consumer communities. The XML is at the forefront of efforts to replace paper-based business transactions not only between the big companies of the world but also transactions involving the small and medium enterprises. The XML standard [8, 9] makes transmitting data over the Web inexpensive and efficient. XML is a simple, very flexible text format derived from Standard Generalised Markup Language (SGML-ISO 8879). It describes a class of data called XML document and partially describes the behaviour of the computer programs, which process them. XML documents are made up of storage units called entities, which contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data and some of which form markup. Markup encodes a description of the document's storage layout and logical structure. XML provides a mechanism to impose constraints on storage layout and logical structure [8]. It lets applications communicate regardless of the programming model. XML is clearly the de facto way for electronic data interchange over the Internet. Because of the advantages of XML, a large number of XML-based languages have been developed for various purposes by many industries and researchers in non-electric utility sectors of the economy. Applications of XML include languages dedicated to exchange of data between particular software tools [13, 14], and vertical applications for particular industries [15]. The electricity market sector as earlier mentioned has also embraced the use of XML as format for information exchange.

3. DEFINING XML-BASED LANGUAGE

The use of XML requires the designing of domain-specific vocabulary and syntax. Unlike HTML that

defines a fixed vocabulary of tags for creating web pages, XML allows individual to define their own vocabularies usable by many applications. Figure 1(a) shows an example of an XML document that describes the contact information for a market participant in electricity market. Vocabulary used here includes the words "marketParticipant", "role", "contactPerson", "address", etc. Each XML-based applications needs to introduce a vocabulary like this. In the framework proposed here, the vocabulary items are drawn from Grid Code, Distribution Code, Metering Code and Market Rules.

An XML document must follow a specific syntax to make it well-formed. This document follows an XML syntax; a regular, hierarchical structure of elements and attributes. The construction beginning with <*marketParticipant*> and ending with <*/marketParicipant*> is an element, and the construction *contactPerson="Joseph Dada"* is an attribute. The document also shows that <*address*> element must be contained within <*marketParticipant*> element to make it conforms to application-specific syntax. In addition to the XML and application syntax, the sender and receiver of the XML document must also agree on and understand the meaning of *"contactPerson"*. This makes it essential to provide a precise specification of the vocabulary and syntax used in an XML document especially when communication between independent entities such as different MPs in Nigeria deregulated market is involved. XML provides specifications for both XML documents and XML schema or XML Document Type Definitions (DTD). A DTD or XML schema is a formal definition of a document. It specifies the element tags that can appear in the document, the attributes associated with each element, and the permitted structure of the elements. XML schema specifies the necessary vocabulary and syntax used for communication between independent parties as shown in Figure 1(b) for the example document shown in Figure 1(a). A receiver application can now use the XML schema to determine the validity of XML document it receives from sender application. The XML language as specified in an XML schema is now the basis of documents exchange between interested parties. The XML schema is usually generated from object-oriented model of domain vocabularies. The object-oriented model of the example XML schema using Unified Modelling Language (UML) [16] is shown in Figure 1(c). The figure basically shows the two classes and their attributes, which form the elements and attributes of the XML schema. Readers are advised to consult [16] for details of how to construct data models using UML.

An example of data exchange between applications that share a common XML schema is shown in Figure 2. The producer application generates an XML document based on the XML schema and the consumer consumes the XML document and sends an acknowledgement back to the producer. The sender can generate XML document either from the output of an application or database, while the receiver application can store the data from the XML document it receives into either a database or use it as input to an application. The consumer consumes the XML document and sends an acknowledgement back to the producer.

4. NIGERIA DEREGULATED ELECTRICITY MARKET

The Nigeria electricity supply industry is made up of single vertically integrated utility call Power Holding Company of Nigeria (PHCN) formally refers to as National Electric Power Authority (NEPA). PHCN is responsible for generation, transmission and distribution of electricity to various types of consumers – industrial, commercial and residential. The transmission system supplies bulk power from the generators to the distribution substations at high voltages (132 - 330KV), while the distribution system delivers power from these substations to the consumers' doorstep predominantly at various low voltages (33KV, 11KV, 415V and 220V). With the coming into force of the reform Act – EPSRA, the vertically integrated Nigeria power sector utility – PHCN has been separated into generation, transmission and distribution companies. The Act stipulates the functional unbundling of the Generation, Transmission and Distribution sectors. The unbundling of PHCN has resulted into 6 generation, one transmission and 11 distribution successor companies. Through the EPSRA, an enabling regulatory framework for private sector participation in the electricity industry in Nigeria has been provided [6]. The Act also provides the establishment of a regulatory body – National Electric Reforms Commission (NERC) to facilitate the privatisation of the successor companies as well as the gradual development of a competitive and privately managed electricity sector. The functions and responsibilities of the successor companies operating at the generation, transmission and distribution section are briefly described.

4.1 Generation Segment

The generation segment will comprise many generating companies (Gencos) responsible for operating the power stations, improving the generation capacity and making the necessary investments in line with the objectives of the Federal Government of Nigeria. The new 6-generation companies carved out of the existing power system consist of a mixture of both thermal and hydro power stations. In addition, independent power producers will also be licensed to participate in the competitive electricity market.

4.2 Transmission Segment

The only transmission company – Transmission and System Operating Company of Nigeria (TCN) as stipulated in the reform Act is now the operator of the high voltage network of the Nigerian electricity industry.

TCN is also responsible for overseeing the market operations involving the trading of the wholesale energy amongst market users. As operator of the grid, it is responsible for assuring the technical security and reliability of the interconnected system, and the technical quality of the electrical power supply, and for non-discriminatory access to and use of their transmission system as specified in the electricity Act.

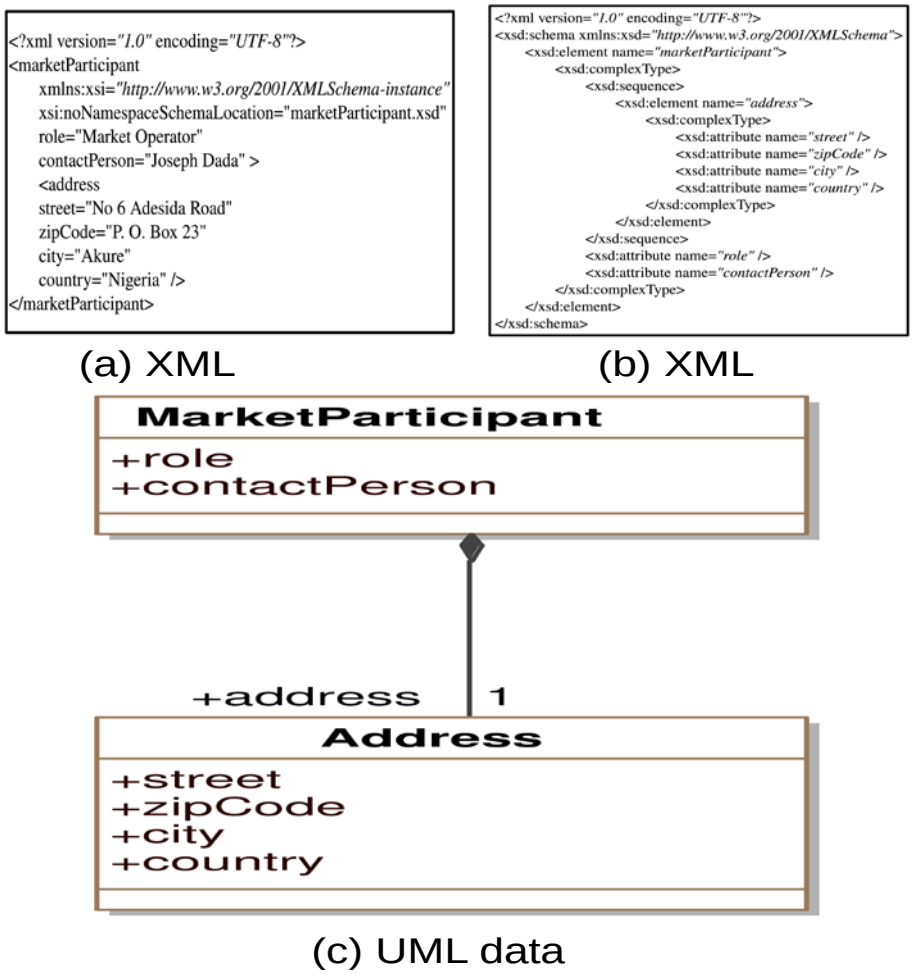

Figure 1: Example of XML document and its schema, and UML data model of the schema elements and attributes

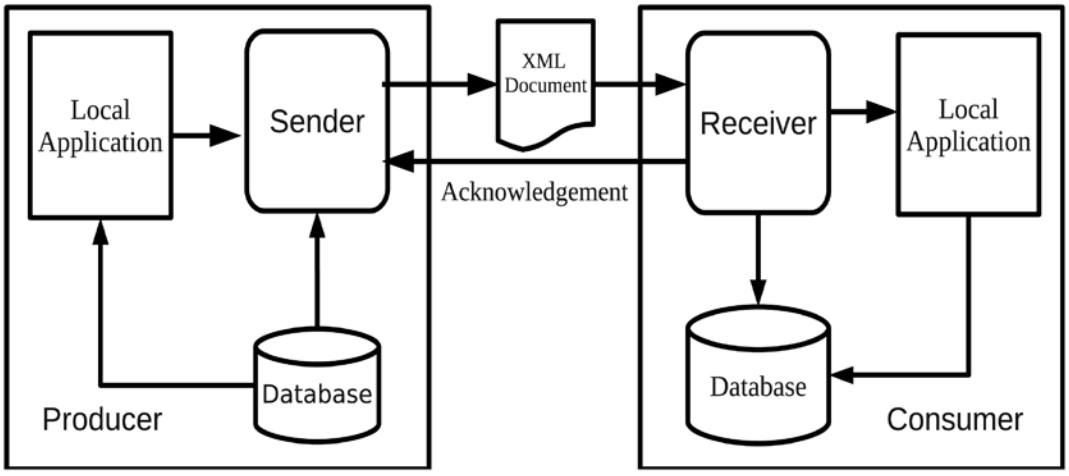

Figure 2: Example of data exchange between producer and consumer based on XMLtechnology.

4.3 Distribution Segment

Many regional Discos will manage the distribution segment. Each of the Discos will be restricted to the coverage of specific geographical zones in Nigeria. A distribution company has the responsibility of distribution of electrical power to the consumers in their coverage areas. The Discos are commercially and administratively responsible for their coverage areas. The details of the roles to be performed by the Discos are clearly specified in the Distribution Code [17].

4.4 Grid Code, Distribution Code, Metering Code and Market Rules

To fulfil the non-discriminatory access to the transmission system, the competitive segments will operate in accordance with the Market Rules [18], the Metering Code [19] and Grid Code [20]. The competitive segments will be overseen by the Market Operator and System Operator under the regulatory supervision of the Nigeria Electricity Regulatory Commission (NERC).

The Grid Code, which has been published will facilitate an efficient production and supply of electricity for all users of the transmission system and TCN itself, without any act of discrimination between users or class of users as well as facilitates competition in the generation and supply of electricity in Nigeria. It contains day-to-day operating procedures and principles governing the development, maintenance and operation of an effective, well coordinated and economic transmission system for the Nigeria electricity sector [20]. The Grid Code also provides guidelines for operation of the national grid in a technically efficient manner that will greatly minimise the incidence of system collapses, which is very common in Nigeria presently.

The Market Rules will ensure that Discos meet their obligations to Gencos for power purchased, which in turn will enable the Gencos to maintain their plant and expand their available capacity to meet the massive demand from Nigerians. To address the concern of investors in the generation sector about the credit worthiness of the Discos, the Nigerian Bulk Electricity Trading Plc (NBET) was incorporated in July 2010. The NBET will purchase electricity on behalf of the Discos until they establish a track record of paying for the power they deliver to consumers by efficiently metering electricity consumers and collecting bills.

Accurate metering systems with reliable communication facilities at the different connection points for energy producers and consumers are key requirements for settlement purposes in a competitive electricity market. The Metering Code specifies the guidelines and rules for measurement and recording of energy production and utilisation.

5. INFORMATION EXCHANGE FRAMEWORK

In order to operate or exchange information across business boundaries, business process applications must follow a standard transaction exchange protocol. The protocol must be flexible, reliable, and scalable to provide efficient transactions globally [21]. A B2B relationship involving **n** electricity MPs or enterprises without a common framework in place would involve building **(n-1)** interfaces with **n(n-1)** protocols. This will result in many to many point links. For example, exchange of information between **4** partners will involve **3** interfaces and **12** protocols. Information exchange between the MPs in electricity market requires a method that is independent of heterogeneous IT systems and that does not require applications of the MPs to be disturbed. With a common framework in place, one interface and one protocol can handle all electricity business transactions. A framework is a generic template that provides a desired functionality. To achieve interoperability and automate electricity business processes, B2B framework must provide basic features such as a standard data format, security and content management. In this section, a framework for information exchange in Nigeria deregulated electricity market is defined and discussed.

5.1 Electricity Business Process

Electricity business can be viewed as a set of processes. A process can be anything from generation of transmission schedule to calculation of energy imbalance account. Process engineering streamlines and automates processes to improve business efficiency. With the performance of electricity business processes, exchange of data takes place. This data transfer occurs between the MPs depending on their role and function in the electricity market operations. Electricity business processes can be captured in models and implemented in applications. Applications to be deployed by a MP will depend on its role and functions in deregulated markets. These applications can exchange data through a suitable interoperability mechanism as shown in Figure 3.

The Grid Code, Distribution Code and electricity Market Rules specify various actions that must be performed by each MP as part of the electricity business processes. These actions can be summarised as follows:

- Registration of market participants

- Exchange of basic data for both energy injection and withdrawal points
- Trading of energy mainly between the Gencos and Discos
- Communication of planned energy trade, production, consumption, exchanges between Discos to the market operator
- Report of planned energy schedule (transport) from and out of distribution area to the system operator for congestion management
- System operator effects the schedule and acquires auxiliary energy to keep the system balance
- Reading of meters and sending of metered data (transport, production, consumption) to the responsible MP
- Distribution of validated metered data including aggregated metered data to the relevant MP
- Settlement of imbalance account by the Market Operator and billing the Gencos
- Reconciliation and distribution of data to relevant MP
- Billing of relevant MP

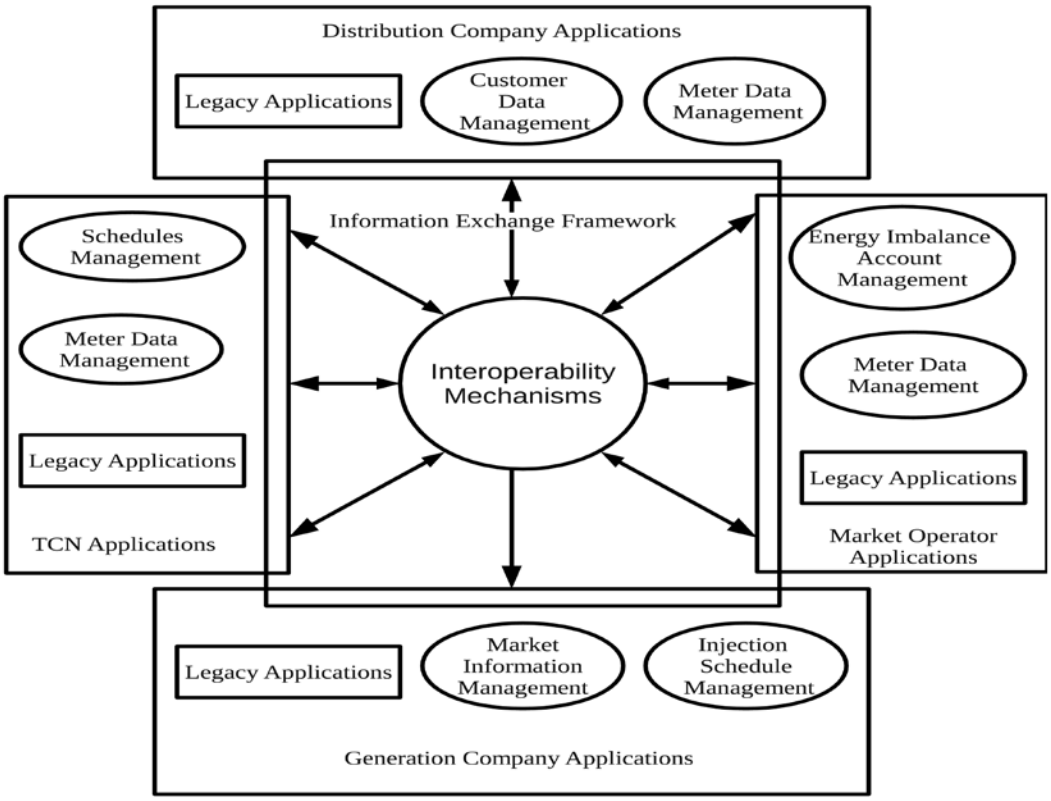

Figure 3: Illustration of framework in B2B interactions in a deregulated electricity market.

In order to define an interoperability mechanism, the business process interaction patterns or business collaborations between the MPs must be identified. We identified the required collaborations between the MPs in a deregulated electricity market in Nigeria from the above actions. For example, generation, sending and receiving of the transmission schedule, interchange schedule, injection schedule, metering data, energy imbalance account, etc. are some of the business process interaction patterns in deregulated electricity market in Nigeria. The process interaction patterns can be modelled using a suitable data modelling language, such as UML as earlier described. The model can then be converted into XML schema and kept in a repository as illustrated in Figure 4. As earlier explained, the vocabularies and syntax defined in the XML schema now forms the basis of interoperability mechanism for the deregulated electricity market in Nigeria. Any new electricity business process can be identified, modelled, converted and added to XML schema.

Information exchange between MPs can now take place using message passing technology and by leveraging the appropriate communication protocol and security algorithms. Any number of MPs can get involved in the exchange of information any time and anywhere using this framework mechanisms.

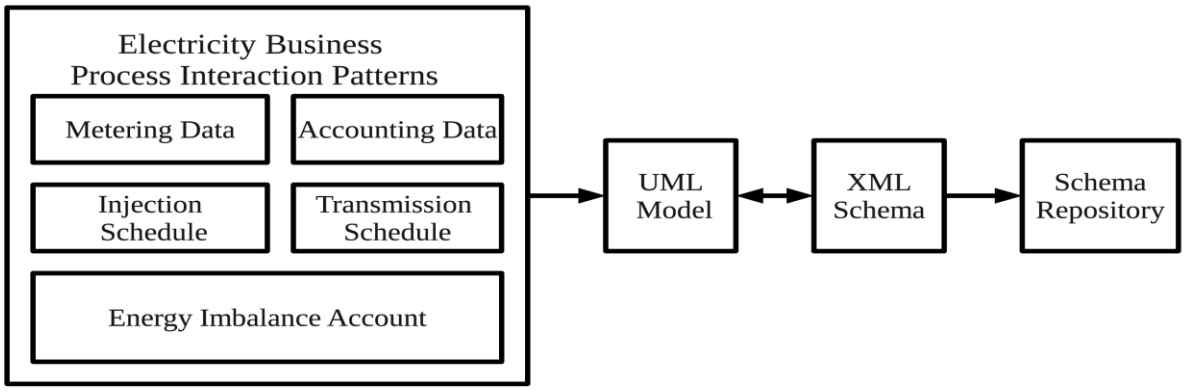

Figure 4: Generation of XML schema from data model of business process interaction patterns.

5.2 Message Passing Systems

Information exchange between different processes belonging to the organisations can be handled by means of message passing paradigm using XML as described above. A message is a structured piece of information sent from one subsystem to another over a communication channel. A subsystem is a high-level system component, defined around a particular function, or utility, or role in the overall system. The whole Nigeria electricity market information exchange network can be broken down into many subsystems. MPs (Market Operator, Discos, Gencos and System Operator) will have their own information system classified as a subsystem of the overall information exchange network. The overall system can be thought of as a co-ordinated group of subsystems working to accomplish some goal. The XML provides facilities to create self-describing messages. This capability is independent of the transport mechanisms, calling conventions (the order in which parameters are passed as well as how data is returned), and data formats. Using XML-formatted electricity business data offers standard and extensible information formats with which the different subsystems for the electricity MPs can exchange information with one another. XML is used in this work to integrate MPs' information network subsystems together. Because XML data is self-describing, an application can share its data without any predefined knowledge of the applications receiving the data.

However, one still needs a reliable mechanism in order to send and receive XML messages. One could use Common Object Request Broker Architecture (CORBA), Java Remote Method Invocation (RMI) or Distributed Component Object Model (DCOM) to integrate these subsystems, but these technologies require a common security domain context, function calling convention, binary data types, and way of locating and activating remote applications. Furthermore, Java RMI, CORBA and DCOM require that server applications must be ready to service a request when the client wishes. Two enterprises that only need to exchange data don't need to tightly-couple their system environments together to allow for direct Remote Procedure Call (RPC) or remote-method interactions. Thus these technologies are better suited to assembly of tightly coupled components, and less suitable to loosely coupled subsystems, which only need to exchange data [7].

To link these subsystems together, a message broker technology is proposed for the development of a messaging server. The messaging server, which can be a simple mail server or implemented as a web application will send and receive messages on behalf of the subsystems. Message broker is an intelligent intermediary that directs the flow of messages between applications, which become sources and consumers of information. With a message broker technology, an electricity business application, for example, meter data management system can send messages to a broker message queue of a messaging server for delivery. The messages are then picked up by the message broker of the messaging server and dispatched to other external messaging server or external application. Figure 5 illustrates the information exchange framework based on the messaging server and XML technology.

5.3 Communication Protocol

The messaging server of the MPs requires reliable communication protocols for transmitting XML messages. Many XML protocols have been proposed, among which the most popular is Simple Object Access Protocol (SOAP) [22]. SOAP is a lightweight protocol for the exchange of information in a decentralised, distributed environment. SOAP over Hypertext Transfer Protocol (HTTP) is proposed as communication protocol for the Messaging Server. The SOAP-based Messaging Server will serve as a Gateway for Nigeria electricity information network subsystems. It will send and receive messages for each of the MPs. The packaging and routing of XML-based messages will be over the Internet using communications infrastructure based on HTTP. As interim, the XML-based messages can be exchange using SMTP protocol (Email) before the necessary infrastructures for the electricity information network are put in place.

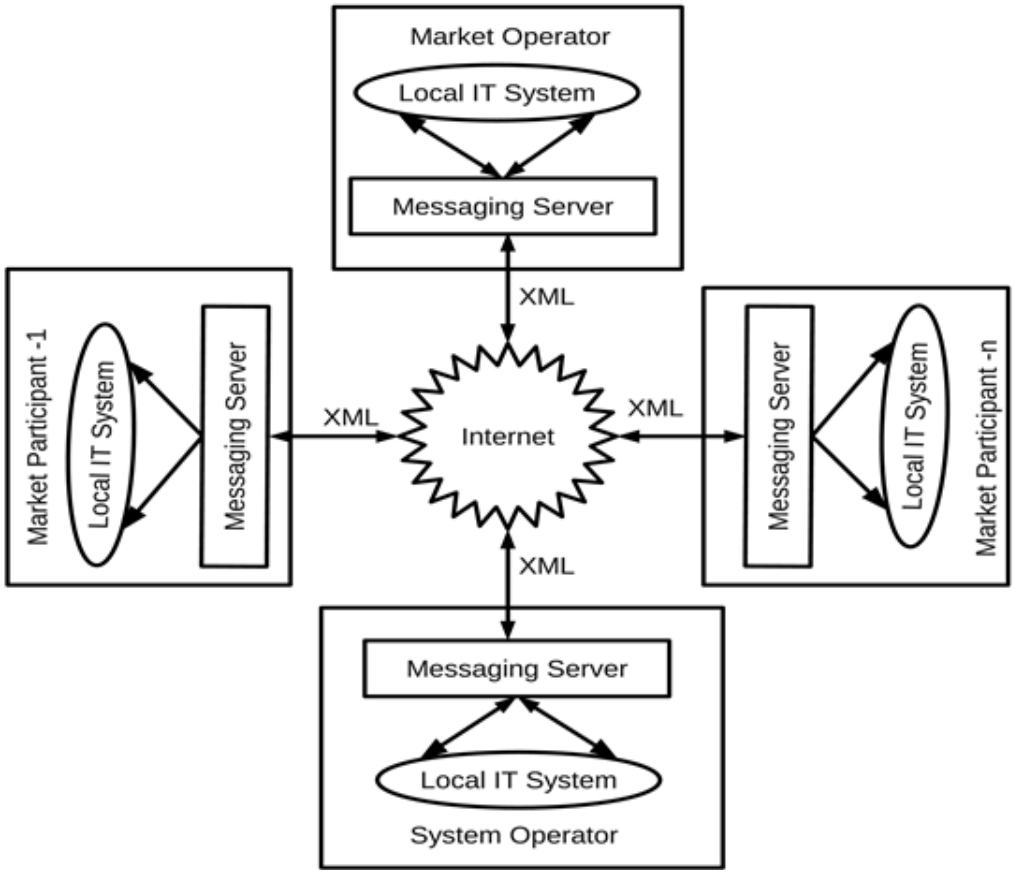

Figure 5: Information exchange framework using XML technology. Local IT Systems represent the various applications of MPs as defined in Figure 4 above. All applications of a MP will send and receive data through the Messaging Server.

6. CONCLUSIONS

Nigeria is on the move to deregulated electricity market operation. This will require massive exchange of information and data between several MPs. Exchange of information and data in heterogeneous IT's environment of the open electricity MPs will be very difficult due to different information, data, files, databases and application or calculation model. To overcome the difficulty, we proposed information exchange framework based on XML to enable the MPs to exchange information and data with minimum human interactions. The framework provides a useful generic mechanism for exchanging information and data in deregulated electricity market in Nigeria.

All communication using the framework is by means of messages. By using XML as the data representation medium for content exchange between the MPs the data exchange systems can support any content source or data format and automate data extraction, delivery, and management. HTTP communication protocol for the message transport allows the existing security mechanisms to be used for the protection of data transmission between the communicating partners. HTTP permits the information exchange network to work within

the firewall of the actor's Local Area Network (LAN) without any alteration.

New actor can easily be added by implementing the necessary interface. The proposed information exchange framework is easily extensible and can be adjusted to different electricity market models. The extensibility of the XML schema allows for inclusion of additional data and provides a mechanism for easy integration of new MPs into the electricity market operation as the deregulated electricity market in Nigeria mature.

REFERENCES

[1] Hunt S, Shuttleworth G. Competition and Choice in Electricity. John Wiley & Sons Ltd, England, 1996

[2] Klom AM. Electricity deregulation in the European union. Technical report, European Commission Directorate-General XVII (Energy), 1996

[3] Dada JO. Information Exchange Network for the Liberalised Electricity Market with Object-Oriented and Internet-Based Technologies. Fortschritt-Berichte VDI-Verl., Germany, 2002

[4] Joskow PL. Restructuring, competition and regulatory reform in the U.S. electricity market. Journal of Economic Perspective 1997; 11(3): 119-138.

[5] Chao Hp, Huntington HG. Designing Competitive Electricity Markets. Kluwer Academic Publishers, Boston/Dordrecht/London, 1998

[6] Nigeria Electric Power Reform Act 2005. (http://www.nercng.org/) Accessed January 20 2011

[7] Dada JO, Kochs HD. XML-based open electricity market information exchange network using object-oriented methods, International Journal of Computers and Applications 2005; 27: 153-160. doi:10.2316/Journal.202.2005.3.202-1577

[8] Biron PV, Malhotra A. XML schema part 2: Datatypes second edition, W3C Recommendation, 2004 (http://www.w3.org/TR/xmlschema-2/) Accessed March 2 2011

[9] Bray T, Paoli J, Sperberg-McQueen CM, Maler E, Yergeau F. Extensible markup language (xml) 1.0 (fth edition), W3C Recommendation, 2008 (http://www.w3.org/TR/REC-xml/) Accessed March 2 2011

[10] Monti M. Document exchange between market participants, the etso solution for the internal electricity market in Europe. In: Proc. Int CIGRE/IEEE PES Symp. 2005; 239-253. doi:10. 1109/CIGRE.2005.1532748.

[11] Becker D, Saxton TL. CIM standard for model exchange between planning and operations. In: Proc. IEEE Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century 2008; 1-5. doi:10.1109/PES.2008.4596090.

[12] de Vos A, Widergren SE, Zhu J. XML for CIM model exchange. In: Proc. Innovative Computing for Power - Electric Energy Meets the Market. 22nd IEEE Power Engineering Society, Int. Conf. Power Industry Computer Applications PICA 2001; 31-37. doi:10.1109/PICA.2001.932315.

[13] Hucka M, Finney A, Sauro HM, Bolouri H, Doyle JC, et al., The systems biology markup language (sbml): a medium for representation and exchange of biochemical network models. Bioinformatics 2003; 19: 524-531.

[14] Dada JO, Spasic I, Paton NW, Mendes P. SBRML: a markup language for associating systems biology data with models. Bioinformatics 2010; 26: 932-938.

[15] Shim SSY, Zeng Z, Gao J. Automatic generation and integration of rosettanet based on generic templates and components. In: Proc. Fourth IEEE Int. Workshop Advanced Issues of E-Commerce and Web-Based Information Systems WECWIS 2002; 33-40. doi:10.1109/WECWIS.2002.1021239.

[16] Unified modelling language infrastructure, Object Management Group, 2011 (http://www.omg.org/spec/ UML/2.4.1/Infrastructure/PDF) Accessed June 12 2011

[17] The Distribution Code for Nigeria electricity distribution system, Nigeria Electricity Regulatory Commission (http://www.nercng.org/) Accessed June 20 2011

[18] The Market Rules, Nigeria Electricity Regulatory Commission (http://www.nercng.org/) Accessed June 20 2011

[19] Metering Code, Nigeria Electricity Regulation Commission (http://www.nercng.org/) Accessed July 2 2011

[20] The Grid Code for Nigeria Transmission Systems, Nigeria Electricity Regulatory Commission (http://www.nercng.org/) Accessed July 2 2011

[21] Shim SS, Pendyala VS, Sundaram M, Gao JZ. Business-to-business e-commerce frameworks. Computer 2000; 33(10): 40-47.

[22] Mitra N, Lafon Y. Soap version 1.2 part 0: Primer (second edition), W3C Recommendation, 2007, (http://www.w3.org/TR/2007/REC-soap12-part0-20070427/) Accessed August 20 2011