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On the Design of Next Generation Network Architecture for a Developing Economy

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Abstract: - The design of network architecture is an essential step in the design of Next Generation Networks, leading to the prediction of the actual equipment quantities and dimensioning of the network. The network architecture is commonly drawn out as a diagram for visual representation of the overall network. This paper focuses on the design of the architectural model for a softswitch IP based backbone network for Benue State, Nigeria, as a case study of developing economies. It has been found that, in developing countries, the migration from the Public Switched Telephone Network to Next Generation Network takes the form of a major telecommunications development scheme meant for the extension of telecommunications infrastructure and services to new deserved areas and/or the modernization of the predominantly obsolete and substandard existing telecommunications infrastructure. So, the basic network planning principles have been followed to design the architecture in the most efficient and cost-effective manner possible. The key design methodology is based on intuitive demand forecasting, a snapshot of the existing network infrastructure and systematic assessment of the Public Switched Telephone Network-to-Next Generation Network migration principles. It was furthermore guided by use of the ITU-T's generic reference models enabling the proper combinations of the functional entities. The resulting Next Generation Network backbone architecture is made up of 2 Softswitches, 23 Universal Media Gateways and an MPLS/IP core. The further optimization of the architecture, which is normally achieved with dimensioning of the network, is beyond the scope of this work.

Keywords: *- Soft switch, Next Generation Networks, media gateway, architectural model, functional entities, developing economy*

I. INTRODUCTION

A Next Generation Network (NGN) is a telecommunications Networkthatuses a voice and multimedia switch based on the IP technologies. The softswitch is designed to replace the legacy local and transit switches that are based on the circuit switching technologies [1]. Softswitchis so called because it is typically a software solution implemented on general purpose computers. The general idea behind NGN is that one network transports all the information (i.e. voice, data and video) digitally by encapsulating these into packets as it is done on the Internet. The technology that is used to do this is Internet Protocol (IP). NGNs are based on IP, like the Internet, but they build in features that the Internet does not have, such as the ability to guarantee a certain quality of service and level of security.

The basic key elements of an NGN include Media Gateway; Softswitch; Signaling Gateway; and Application Server [2]. In anNGN network, the call processing function is separated from the physical switching function; the physical switching function is performed by the Media Gateway (MG), while the call processing function is performed by the softswitch [1].The softswitch is the brain of the network controlling the operations of other devices. Hence, another name for softswitch is media gateway controller. The media gateways take over the functionality of the switching hierarchy in the current Public Switched Telephone Network (PSTN) system [13].NGNs offer several fundamental benefits: significantly reduced capital and operation costs, less reliance on overlay networks, multiple bandwidth, simplified service provisioning, and new services, creating additional revenue and differentiation [1, 13]. Many operators are now transforming their PSTNs from circuit-switched into the multipurpose packet switched NGN networks [13]. The main design problem is to determine the position, number and variants of media gateways that minimize both the initial and operational costs,and also providethe reliability, scalability, and the stability of the designed network [13].

There are several network design techniques published in literature [3-6]. In such works, the main focus is usually on migration of the existing PSTN or parts thereof to NGN, in which the researchers tend to focus more on the service control (softswitch) components for replacement of local and transit exchanges, to the neglect of the underlying deficiencies in the existing telecommunications infrastructureswhich have been observed to be prevalent in developing countries. It has been observed that in most developing countries, the existing telecommunications infrastructures are in poor state, not normally suitable for retention or integration in any NGN plan. It is either the existing infrastructure is substandard, outdated and dilapidated, or in some cases, poorly developed, underdeveloped or completely nonexistent even in well-deserved areas, and oftentimes without proper records. For these deficiencies to be best catered for, it would be necessary to adopt elaborate generic network planning principles rather than apparentgraceful replacement of PSTN equipment done in developed countries. So, in this paper, the basic NGN planning principles have been followed to design a softswitch IP based backbone network architecture for Benue State, Nigeria, as a case study of developing countries,in the most efficient and cost-effective manner possible. The key design methodology is based on intuitive demand forecasting, a snapshot of the existing network infrastructure, and systematic assessment of the PSTN to NGN migration principles. It was furthermore guided by use of the ITU-T's generic reference models enabling the proper combinations of the functional entities.The resulting NGN backbone architecture is made up of 2 Softswitches, 23 Universal Media Gateways and an MPLS/IP core.

The rest of the paper is organized as follows: section 2 gives a brief insight into the work ITU-Telecommunication standardization sector (ITU-T) and other international organizations have done or are doing towards standardization of the NGN. Section 3 discusses the generic NGN functional architecture according ITU-T Recommendation Y-2012. This is followed by a discussion in section 4 about the functional entities within the reference architecture according to ITU-T Recommendation Y-2017. In section 5, the PSTN to NGN migration principles are outlined. Section 6 discusses the generic network planning process; while in section 7 is the characterizationof developing countries. Section 8 discusses the case studyand the methodology for the design of the target NGN architecture for Benue state. Lastly, in section 9 is the conclusion.

II. NGN STANDARDIZATION AND DEVELOPMENT

Several international standards organizations, with the International Telecommunications Union-Telecommunication standardization sector (ITU-T) at the center, are dedicated to standardizing and developing NGNs and have achieved significant progress. The aim is to build managed IP networks that guarantee QoS and security through resource management and strict user authentication, and to replace the telephone networks, the traditional communication infrastructure [9].

The ITU and ETSI (European Telecommunications Standards Institute) are presently standardizing the overall image of the NGN, including its architecture and functions. The ITU-T has issued recommendationsthat define the basic concept and characteristics of the NGN by positioning it at the core of the communications infrastructures of the next generation. In addition, the ETSI started the TISPAN (Telecommunications and Internet converged Services & Protocols for Advanced Networking) project in 2003 to compile European standards related to the NGN, and is presently developing activities in order to turn them into international standards through the ITU-T [9, 11]. The ITU-T is a United Nations organization and its standards are regarded as representative official standards. These standards feature a high transparency of the established process and the sharing of each single standard by all of the participants.

Some of the international standards organizations engaged in NGNwith the ITU-T include3GPP (3rd Generation Partnership Project), which standardizes the IP Multimedia Subsystem (IMS); IETF (Internet Engineering Task Force), which is the organization defining Internet related protocols;ATIS NGN FG (Alliance for Telecommunication Industry Solutions, Next Generation Networks, Focus Group), a North American based body, which is committed to developing a North American set of requirements for NGNthat includes multiservice architectures and an evolution path from currently deployed architectures among other issues[11].
The ITU makes it a rule to use the existing standards whenever possible [9]. These standards include the non-official standards compiled by any of the organizations in the industry as well as theofficial standards established by the ETSI, etc.

III. GENERIC NGN FUNCTIONAL ARCHITECTURE

The collaborative efforts of the ITU-T, ETSI, TISPAN and 3GPP [23] gave rise to ITU-T recommendation Y-2012 [8] for the generalized NGN functional architecture. The functional architecture of NGN defines sets of entities where each provides a uniquefunction. Relationships and connections between functions are identified in terms of reference points. Functions are grouped to represent certain practical physical realizations.

In thegeneralized functional architecture, there is a separation between two distinct blocks or strata or layers of functionality; the transport functions reside in the transport stratum while the service functions related to applications reside in the service stratum. Each stratum comprises of one or more layers, where each layer is conceptually composed of a data (or user) plane, a control plane and a management plane.

The NGN service stratum is the part of NGN which provides the user functions that transfer service-related data and the functions that control and manage service resources to enable user services and applications. User services may be implemented by a recursion of multiple service layers within the service stratum [8]. For example, the two widely applied service layers are PSTN/ISDN Emulation Subsystem (PES) otherwise known as Softswitch and PSTN/ISDN Simulation Subsystem (PSS) otherwise known as IP Multimedia Subsystem (IMS). The NGN service stratum is concerned with the application and its services to be operated between peer entities [11].

The NGN transport stratum is the part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities. The data so carried may itself be user, control and/or management information. Dynamic or static associations may be established to control and/or manage the information transfer between such entities [8]. An NGN transport stratum is implemented by a recursion of multiple layer networks.The set of functions within the transport stratum is supported by many protocols which together compose the NGN transport network [8].

The separation of services from the network is a key cornerstone of the NGN. The vertical aspects of this separation are shown in Figure 1 [8, 10]. The separation is represented by two distinct blocks or strata of functionality. There are several points of note to be made. First, there is a set of transport functions that are solely concerned with conveyance of digital information, of any kind, between any two geographically separate points. A complex set of networks may be involved in the transport stratum, constituting layers 1 through 3 of the OSI seven-layer Reference Model. The transport functions, residing in the lower stratum, provide the connectivity between the service platforms, residing in the upper stratum, which provide the user services (telephone service, Web service, etc.). In general, any and all types of network technologies can be deployed in the transport stratum.

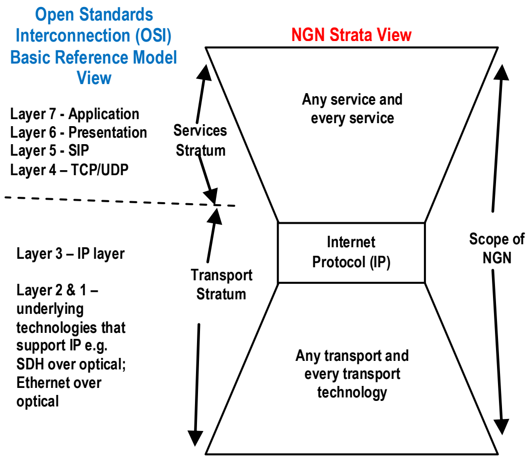


Figure 1: Generic Layered Protocol Stack Architecture

With a flexible NGN architecture which supports multiple access technologies, a core network can be set apart from another core network according to administrative needs orownership. Access networks can be set apart from core networks in that they do not provide end-user services directly other than transport. Access networks can be set apart according to technologies, administrative needs or ownership.

IV. NGN FUNCTIONAL ENTITIES

The ITU-T reference NGN architecture is a service and technology independent architecture which can be customized according to services to be offered and technologies to be used [10]. Each function is defined and specified as a set of functional entities. Groupings of functional entity are used to describe the physical NGN implementations, and determine the capabilities supported in the NGN. Therefore, network designers and operators may choose and combine the functional entities according to their business models, services and capabilities to be supported. Specific division of functional entities between the core and access networks is based on operators' business decisions rather than hard points of separation in the architecture. Functional entities may be mixed and matched in different ways. Physical equipment may have both the core and the access network function [8, 10].

Most of the NGN transport layer functions such as the Resource Admission and Control Function (RACF) and Network Attachment and Control Function (NACF) will support different types of NGN services in a common way [10]. However, NGN implementations need not implement certain layer functions such as gateway functional entities (FEs) with respect to PSTN/ISDN, if they do not require the support of such capabilities [10]. TheFEs within the Transport functions and the service functions group are specified according to ITU-T recommendation Y.2017 [8]. Within the transport functions, the Access Node FE is directly connected to end-user functions. The access link is terminated in this node. This allows different access types such as Digital Subscriber Line, optical access systems, wireless systems to be used. Commonly, the access node is a layer 2 device, but it can also support some IP functions. The Edge Node FE connects to core packet transport functions. This node terminates layer 2 access sessions. It shall also be a layer 3 device with IP capabilities in case the core network is an IP-based network.Within the services functions group, most functions are performed by the softswitch [8].

V. PSTN TO NGN MIGRATION PRINCIPLES

An NGN is essentially integrated with the PSTN. Therefore it is crucial that NGN equipment provides support for legacy networks and that interworking between the networks is reliable and flawless. Service providers must also carefully plan migration strategies that would ensure efficiency and cost-effectiveness as well as include theintroduction of new services and support for legacy interfaces. Towards this end, some basic migration principles are available, which may provide useful guide. These are briefly discussed in the following.

5.1 Topology Migration Options

There are three possible alternatives for the migration of legacy networks to NGN [14]. These are described as follows:

5.11 Migration in Overlay

In this alternative, migration is by level, that is, at transit and international levels, at local level, and at access level.

5.12 Migration in Island

Here, the migration is done by level but in each case, some legacy exchanges are retained and others replaced by NGN equipment as well as expansion of the network with NGN equipment in processes known as cap-and-replace and cap-and-grow. Cap-and-grow means keeping the existing PSTN network as it is, and growing demand with NGN equipment. Cap-and-replace means replacement of outdated Time Division multiplex (TDM) equipment present in the system [14].

5.13 Hybrid Migration

This alternative is a combination of overlay and island migration and is usually carried out by network levels, geographical regions, and obsolescence levels.

5.2 Network Migration Strategies

Two strategies generally adopted for PSTN evolution to NGN are as follows [7, 12]:

i. Softswistch devices together with Trunking Media Gateways carry out the functions of legacy tandem and toll exchanges while the local exchanges remain the same.
ii. Softswitch devices together with Access Media Gateways carry out the functions of the legacy local exchanges while the twisted pair user interface remains the same.

The use of co-deployment prior to full NGN migration most often provides the optimal balance between the maximization of revenue from new NGN services, the maximization of capital investments, and the leveraging of the existing network [7].

VI. THE GENERIC NGN NETWORK PLANNING PROCESS

Accurate network planning's goal is to provide a network that is ready to handle the current as well as future traffic, with an objective of minimizing capital (and operational) expenses while ensuring the right Quality of Service [4].

The key input to a network planning system is a snapshot of the current network infrastructure and already planned resources, including detailed information on various equipments, links, physical and logical connections and services [4]. The aggregated traffic demand input includes existing and forecasted traffic demands (by service, by geographical region). This could include new technologies and equipment which may be needed for additional capacity built-out of the network, taking advantage of innovation in technology and cost advantages, or providing fundamentally different, but required support for new, innovative services. It also should include decommissioning of old equipment and network which may not be able to meet new service need and/or operationally may not be cost effective. These steps involve, in large measure, the prediction of traffic parameters which are a key factor in the calculation of equipment quantities. A planning system takes all these inputs and generates a detailed plan for built-out of a right sized network for a particular time period.

VII. CHARACTERIZATION OF DEVELOPING COUNTRIES

As stated earlier, there are three generally accepted alternatives for the migration of existing PSTN infrastructures to NGN. They are: migration in overlay; migration in island; and hybrid migration [14]. In each case, the general approach is phased migration mostly aimed at protection of investment; simplification of the existing PSTN and other legacy installations; cost savings; and new services and revenues. Evidently, this approach seems more suited to developed countries where the existing telecommunications infrastructures are usually state-of-the-art, well designed and built. However, in developing countries, these infrastructures are in poor state, not normally suitable for retention or integration in any NGN plan thereby making the faithful application of the above stated principles a difficult thing to follow.

For instance, it is either the existing infrastructure is substandard, outdated and dilapidated, or in some cases poorly developed, underdeveloped or completely nonexistent even in well-deserved areas,and oftentimes, without proper records. One striking example is the absence of a functional PSTN in Nigeria since 2006. It is clearly evident that in these circumstances, a different approach fromthe normalone for developed countries will be required for developing countries. It becomes a question of provision of an entirely new telecommunications development scheme in the case of developing countries, which requires detailed subscriber surveying and planning than usual. Some of the identified special characteristics of a developing economy as exemplified in Benue State are as follows:

- Poor existing telecommunications infrastructure:
  - Predominantly voice copper-based and aged dilapidated access network;
  - Predominantly analogue and obsolete transmission and switching equipment;
  - Non-existence of PSTN infrastructure in many deserved areas;
  - Existence of PSTN infrastructure in some undeserved areas;
  - Lack of fixed and mobile broadband and data networks;
  - Lack of functional PSTN;
- Newly created states and local government areas,over the years, requiring provision of new telecom infrastructure;
- High level GSM penetration and subscription (there are four 2.5G and 3G companies operating in the state);
- Rapidly increasing computer literacy level and ICT awareness creating potential demand for NGN services and players;
- High social, academic, political and commercial activities creating potential demand for triple play services;
- High satellite TV and video film viewing public creating potential demand for new services;
- Globalization (in NGN, services can be offered in form of applications programs, so third parties even from abroad can be active participants);

The transformation from legacy telecommunications networks to NGNs comes as a great opportunity for developing countries to plan and develop an adequate network targeted to cover all of the above stated issues and trends and to bridge the digital divide. Firstly, the choice of the transport system both at the core and access levels must be state-of the-art and of the highest capacity, scalability and reliability. Also adequate measures should be taken, independent of financial and economic considerations, when designing NGNs for developing economies so that there is no undue tampering with and rearrangement of installed systems through frequent expansion programmes.

The provision/migration from the PSTN to NGN should be viewed as a major telecommunications development scheme for the extension of telecommunications infrastructure and services to new deserved areas and replacement of obsolete and inappropriate infrastructure. Also, it is important that new designs and installations should be done taking due cognizance of the latest technological advancements in the developed world to avoid the high operational cost usually associated with scarcity of spare parts resulting from adoption of outdated technologies. Modeling of NGNs in a developing economy should therefore be majorly characterized by extensive provision of latest telecommunications infrastructure and replacement of existing ones in a revolutionary manner. This is in sharp contrast to developed countries, where expansion, optimization and modernization are carried out on a continuous basis efficiently so that the existing telecommunications infrastructure are already at advanced stage ready for transformation to the NGN and the transformation done gracefully as a cost saving and revenue boosting measure.

VIII. CASE STUDY: BENUE STATE, NIGERIA

Benue is a state in Central Nigeria. Nigeria is a developing country and the most populatedin Africa. Benue State is made up of 23 local government areas and a population of about five million people and covers a land area of about 3409 square kilometers. The population is evenly spread throughout the state.

8.1 The Existing PSTN Infrastructure in Benue State

The Benue share of Nigeria's telecommunications infrastructure includes 3 digital exchanges at Makurdi, Otukpo and Gboko, and 1 analogue exchange at Katsina-Ala (see Figure 2). The digital exchange at Makurdi, the state capital acts as both primary (transit) and local exchange. The transmission systems are predominantly analogue microwave radio. These include Makurdi – Gboko analogue radio link; Gboko – Katsina-Ala analogue radio link; and Makurdi – Aliade – Otukpo analogue radio link. There is no data network infrastructure and no broadband access. However, 4 GSM operators, namely MTN, Globacom, Airtel, Etisalat are present in the State having presence in all the 23 local government areas. The PSTN infrastructure, which is owned by the premier national carrier, Nigerian Telecommunications Limited (NITEL), exists only in the four towns having exchanges. It should be noted that there is no functional PSTN in Nigeria at present including Benue State, as NITEL has stopped operations since 2006.

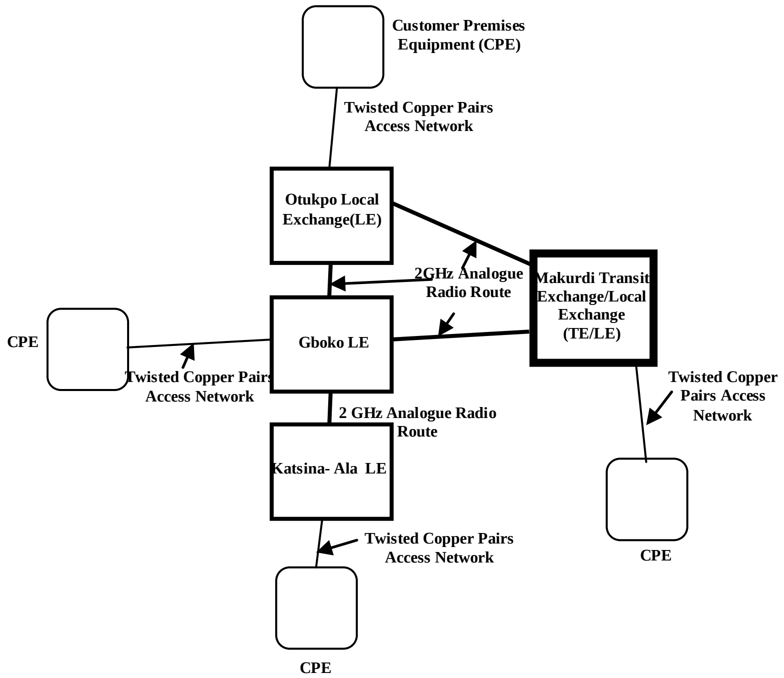


Figure 2: The Existing Benue State PSTN Network

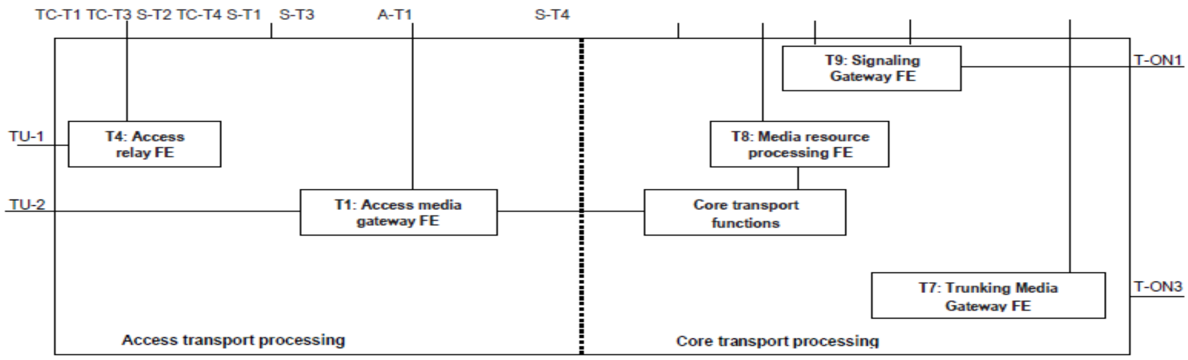
8.2 Design Methodology and Analysis

The key design methodology is based on intuitive demand forecasting [15] based on various statistics, which include the existing PSTN network as detailed in section 8.1 and as shown in Figure 2; population and demographic statistics; and geographical locations of the Local Government areas in the State. Since it is a backbone network design, the top-down method of forecasting is used in which the 23 Local Government headquarters are considered as top level residential and business centres for the provision of media gateways. Here, the exact location of subscribers is not required [15]. The design was furthermore guided by systematic assessment of the PSTN to NGN migration scenarios and use of the ITU-T's generic reference models, enabling the proper combinations of the functional entities.

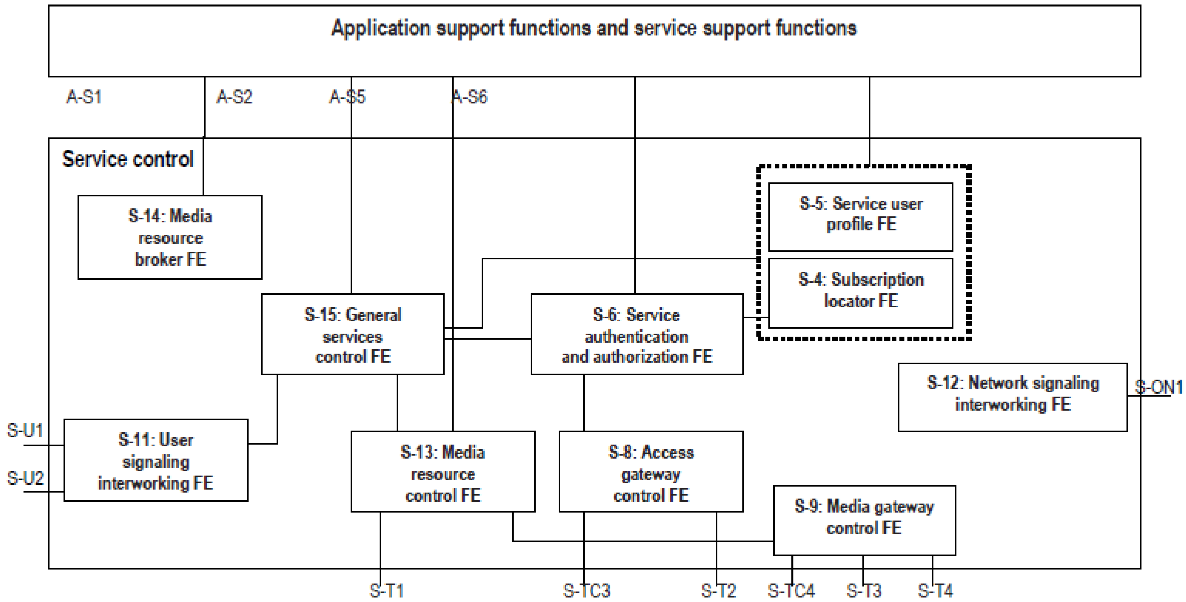
An analysis of the Functional Entities (FEs) within the Transport Functional Group from ITU-T Recommendation Y.2017 [8, 9] shows that five FEs, namely Access Node, Access Transport Functions, Edge Node, Border Gateway and Interconnection Border Gateway are not used for the Benue NGN design and implementation. This is because this design particularly focuses on the backbone network. From this standard, the access node (TU-3) is a layer 2 device placed too deeply into the access network even before the access transport functions that constitute the access transport technologies. What is required in this particular design is a multilayer switch (layer 2 and 3) such as a media gateway having both access and trunk conversion capabilities. Furthermore, the combination of functional entities between user-transport interface 3 (TU-3) and core network, including the edge node and access border gateway, is more suited to areas and regions with a high population density of business and residential users. The combination of FEs between user-transport interface 2 (TU-2) is a preferred option for the Benue State NGN design in view of the suburban nature of most of the towns (local government headquarters) in the state, where there would be no need for aggregation transport functions. In the same vein, another core network is not envisaged in the state, so the Interconnection Border Gateway is excluded from the design.

Similarly, in the FEs in the Service Control Group, five FEs are eliminated from the general ITU-T model, for the Benue State NGN design. The affected FEs are Proxy Call Session Control, Serving Call Session Control, Interrogating Call Session Control, Breakout Gateway Control and Interconnection Border Gateway Control. The first four FEs are components of the IP Multimedia Subsystem (IMS) [3, 11], which is an alternative technology to the Softswitch system. Since, the Benue state NGN is based on the softswitch, the IMS components are not required. Interconnection Border Gateway Control FE is not required because of the exclusion of Interconnection Border Gateway from the transport functions group.This gives the likely combination of FEs for the Benue State NGN design as shown in Figures 3 and 4representing the Transport Functions Group and the Services Control Group respectively. As a backbone network, the final architecture will comprise mainly of the control, core and access layers.

The design of an architectural model is also affected by the type of migration scenario decided upon based on the existing telecommunications infrastructure and other business and administrative considerations. The three possible scenarios, as earlier mentioned, include migration in overlay, migration in Island, and hybrid migration. Obviously, the application of any of these scenarios, all of which recommend gradual replacement of mainly transit and local exchanges and/or expansion with NGN equipment will not work in the case of the Benue State NGN design just as in most developing countries, since no section of the network is worth keeping, including the trunks. By analyzing the generalized models described above, to design the Benue NGN, by applying the Cap-and-Grow option will result in a worst-case scenario, because the Media Gateway replacement for the transit exchange in Makurdi do not have interfaces for Frequency Division Multiplex (FDM) analogue trunks. Taking a critical look at the traditional approaches, it was discovered that a “Replace-and-Grow” solution would be more suitable to the conditions of a developing society like the ones reported for Benue State, which means replacing of the entire network and growing with NGN equipment. Moreover, based on intuitivedemand forecasting, each of the 23 local government areas will require at least one media gateway as part of a major telecommunications development scheme. By applying this additional requirement, and with due regard to the design of a backbone network, results into the NGN architecture shown in Figure 5, showing three main sections, that is, softswitch, IP/MPLS core network, and the access node representing the softswitch IP based backbone network architecture required for Benue State. The initial estimates for the number and capacities of equipment are based on the forecasted demand; the actual quantities could be calculated during optimization of the architecture. The media gateways, being considered, are the universal type, which can be configured into Access, Trunk, Video, Wireless, and Signaling Gateways and have interfaces for E1, T1, and STM1 digital trunks and supports a wide variety of protocols [16]. This is to ensure maximum interoperability and easy provision of existing and new services. The universal media gateway also comes in a series product of mini, medium, and large capacities. The two softswiches are considered based on the population of Benue state, which is in the region of 5 million inhabitants. Each softswitch has a maximum capacity of 2 million subscribers [16].



FE = Functional Entity
Figure 3: Functional Entities within the Transport Functions Group for Benue State NGN Architecture



FE = Functional Entity
Figure 4: Functional Entities within the Service Control Group for Benue State NGN Architecture

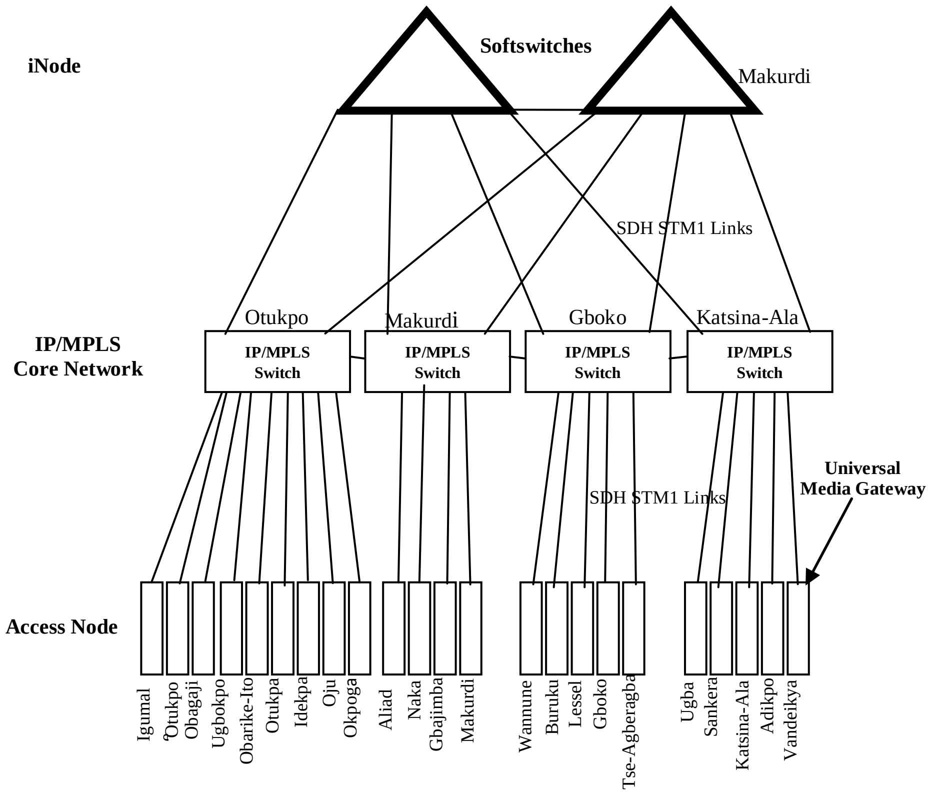


Figure 5: The Softswitch IP based Backbone Network Architecture for Benue State showing the iNode, IP/MPLS Core and Access Node (AN)

IX. CONCLUSION

In the design of the NGN architecture for a developing economy, there are issues more complex and diverse to deal with than for developed countries. In developed countries, this is done by simply migrating the PSTN to NGN on a cap-and-grow and/or cap-and-replace basis, in accordance with global norms. In this case, the general approach is phased migration mostly aimed at protection of investment and simplification of the existing PSTN and other legacy installations which are usually state-of-the-art, well designed and built. However, it has been observed that in most developing countries, the existing telecommunications infrastructures are largely inappropriate, not normally worthy of retention or integration in any NGN plan. In these circumstances, a different approach than the normal one for developed countries will be required. For instance, these deficiencies could be best catered for, if more elaborate generic network planning principles are adopted rather than apparent graceful replacement of PSTN equipment done in developed countries. So, in this paper, the basic NGN planning principles have been followed to design a softswitch IP based backbone network architecture for Benue State in the most efficient and cost-effective manner possible. The key design methodology is based on intuitive demand forecasting, a snapshot of the existing network infrastructure and systematic assessment of the PSTN to NGN migration principles. It was furthermore guided by use of the ITU-T's generic reference models enabling the proper combinations of the functional entities.The resulting NGN backbone architecture is made up of 2 Softswitches, 23 Universal Media Gateways and an MPLS/IP core. The result is a good estimate of the target NGN architecture, which would be optimized with the calculation of the actual quantities of equipment and resources in future work.The initial study has revealed that for developing countries, the provision/migration from the PSTN to NGN should take the form of a major telecommunications development scheme meant for the extension of telecommunications infrastructure and services to new deserved areas and/or the modernization of the predominantly obsolete and substandard telecommunications infrastructure. By and large, the study has led to the initial conclusion that the replace-and-grow solution producing the all-IP model (without PSTN/legacy networks integration) is the best for a developing country.

REFERENCES

[1] The International Engineering Consortium, www.iec.org, "Local-Exchange Softswitch System: Sosftswitch and Packet voice" Web Proforum Tutorials, 2002.

[2] Andrew Hendrey, "Call Control in the New Public Network: An Overview", News Letter, September 2001.

[3] Ahmad A. Almughaless and Ali M. Alsaih, "Next Generation Network Design, Dimensioning & Services Innovation" IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.6, June 2010.

[4] CherifGhazel and Leila Saidane, "Dimensioning of NGN Main Components with Improved and Guaranteed Quality of service", Journal of Networks, Vol. 5, July 2010.

[5] A. Krendzel, V. Derjavina, S. Lopatin, "Method of Estimating Parameters of NGN Traffic", WSEAS Transactions on Communications, Volume 6, 2010

[6] ArianitMaraj, IlirImeri, "WiMAX Integration in NGN Network, Architecture, Protocols and services", WSEAS Transactions on Communications, Issue 7, Volume 8 July, 2009.

[7] Paul Drew, Chris Gallon, "Next-Generation VoIP Network Architecture", Multiservice Switching Forum Technical Report (MSF-TR-ARCH-001-FINAL), March, 2003.

[8] Terje Jensen, "Next Generation Network Architecture", ISSN 0085-7130 Telenor ASA, 2009

[9] ITU-T Y.2001, Next Generation Networks – Frameworks and functional Architecture Models: "General overview of NGN", December, 2004.

[10] IDA Singapore, "Reference Specifications for Next Generation Networks (NGN) Technical Frame Work", IDA RS NGN Tech Framework, Issue 1, February, 2007

[11] Miguel. An. Garcia, "Next Generation Networks (NGN)", NOKIA NGN - HUT.PPT /13-04-2005/Miguel. An. Garcia, Espoo, Finland Nokia Research Center, 13 April 2005.

[12] Oscar González Soto, "NGN Business Modeling and Planning" ITU-D Workshop on NGN and Regulation for the Philippines Manila, (Philippines), June 2010.

[13] Halldor Matthias Sigurdsson, Saemundur E. Thorsteinsson, Thomas K. Stidsen, "Cost Optimization Methods in theDesign of Next Generation Networks",IEEE Communications Magazine, September 2004.

[14] Oscar González Soto,ITU Consultant Expert, "Local NGN Network evolution, VPN and Metro-Ethernet", Workshop on "New Technologies and Applications", Tehran, Iran (Islamic Rep. of)14 –18 June, 2009

[15] Angelfire, "Access Network Planning and Technologies: Subscriber Demand and Traffic Forecasting" http://www.angelfire.com/nt/acccess1/forecast1.html

[16] Huawei Technologies. "Product Catalogue for Fixed Network Solutions", 2003