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Evolution of Mobile Services and Preparedness for the Deployment of Fifth Generation Technologies in Nigeria

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ABSTRACT

The paper is aim to look at the gradual evolution of mobile services and near future 5G services and its core architecture, technological hindrances and successes recorded and the readiness to deploy 5G technologies. 3G radio network planning, link budget, soft capacity and soft handover calculations are also presented with explanation on how interference margin, fading margin and equipment losses affects the link budget estimates.

Keywords: 5G core architecture; Mobile services; link budget; soft capacity; equipment losses.

1. INTRODUCTION

Growth in the adoption of mobile services by organization and individuals is making a positive impact on our daily life in Nigeria. The mobile technology is playing an increasingly central role in the country's economy and for the majority of Nigerians. Mobile phone has become more than a communication device in the modern world it has turned into an identity of an individual. Since the emergence Global System of Mobile Communication (GSM) in Nigeria, there has been exponential growth in the number of subscribers [1] [2].3G mobile broadband is the first technological advancement that brings mobile wireless internet access and thus opened the door to a whole new world. While the country is still struggling with the adoption and coverage of 4G. The 5G network model guarantees super- high speeds and robust network, it's predicted to aid the sector through the digital economy that will generate about ninety billion U.S dollars and create three million jobs [1] in the next three years when the technology is fully deployed.

2. 5G MOBILE TECHNOLOGY AND ITS OPERATION

The 5G system architecture intends to offer all-IP based model for wireless and mobile networks Interoperability. The system consists of a user terminal which has a crucial role in the new architecture and a number of independent, autonomous radio access technologies. Within each of the terminals, each of the radio access technologies is seen as the IP link to the outside Internet world [3].

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The next generation technology will use a new 5G radio interface along with other new technologies that utilizes much higher radio frequencies to transfer exponentially more data over the air for faster speeds, reduced congestion and lower latency [4], which is the delay before the transfer of data begins. This new interface-which uses mm -wave spectrum, enables multiple devices to be used within the same geographic area; it also uses a new digital technology called Massive MIMO (multiple input multiple output) that uses multiple targeted beams to spotlight and follow users around a cell site, improving coverage, speed and capacity. The technology will make use of flat IP to make it easier for different RAN to upgrade in to a single NanoCore network [4]. Nanotechnology would serve as defensive tool for security concern that may arise due to flat IP, and certainly flat IP network is the key concept to make 5G compatible for different kind of technologies. Flat IP architecture provides a way to identify devices using symbolic names, unlike the hierarchical architecture such as that used in "normal" IP addresses, this is of more interest to mobile broadband network operators [6] [4]. Therefore, with the shift to flat IP architectures, mobile operators can minimize system latency and enable applications with a lower tolerance for delay; upcoming latency enhancements on the radio link can also be fully realized.

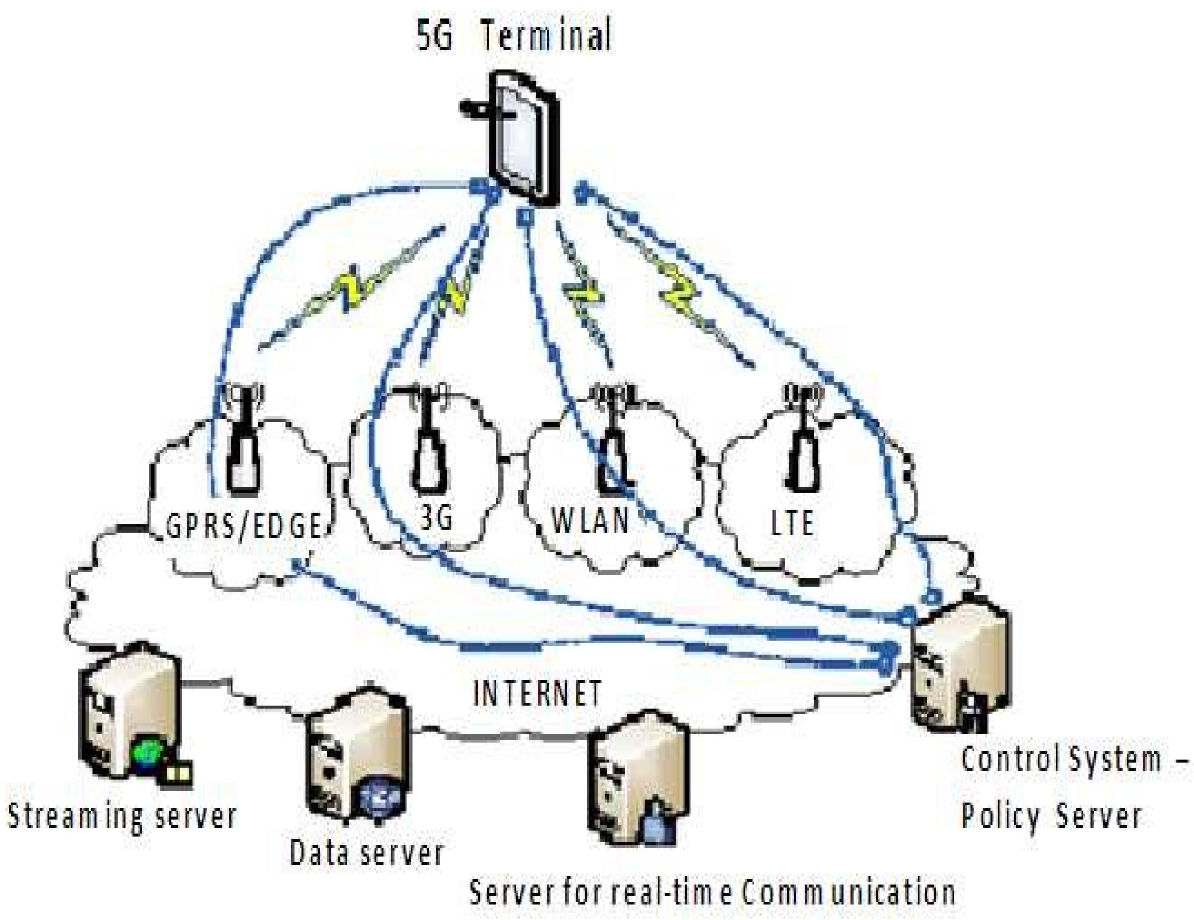

Figure 1: The future- 5G Mobile Network System [1]

3. THE 5G CORE ARCHITECTURE

The 5G core architecture is a convergence of nanotechnology, all IP platform and cloud computing, which is referred as NanoCore [4] [6] as shown in figure 1. Nanotechnology is the application of nanoscience to control process on nanometer scale, ranges from 0.1-100nm.Mobile devices are referred as Nano Equipment as they are geared up with nanotechnology. These devices together with the intelligence that will be embedded in human environments – our homes, offices, public places – will create a new platform that enables ubiquitous sensing, computing, and communication specification of NanoEquipment would include: **self-cleaning** – the phone cleans by itself, **self-powered** – the phone derives its energy/power from the sun, water, or air, **sense the environment** – the phone will tell you the weather, the amount of air pollution present, **flexible** – bend but not break, **transparent** – see through phones [5] [4]

3.1 Cloud computing

Cloud computing is a technology that uses the internet and central remote server to maintain data and applications. In 5G network this central remote server will be the content provider. Cloud computing allows consumers and business to use applications without installation and access to their personal files at any device with the internet access. The same concept is going to be used in Nanocore where the user tries to access his private account from a global content provider through Nanocore in form of cloud [4] [7].

3.2 All IP Network

The convergence of different technologies to form a single 5G NanoCore, will require a common platform to interact. Flat IP architecture act as an essential part of 5G network.

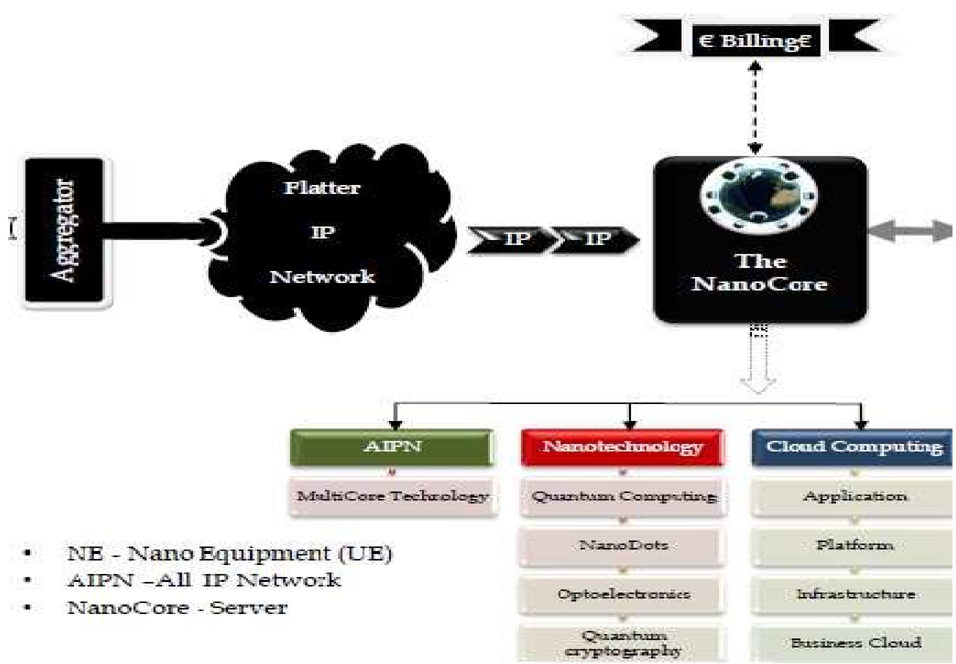

Figure 2: 5G Core Architecture [4] [6]

The All-IP Network (AIPN) is an evolution of the 3GPP system to meet the Increasing demands of the mobile telecommunications subscribers [5]. It primarily focused upon enhancements of packet switched technology, AIPN provides a continued evolution and optimization of the system concept in order to provide a competitive edge in terms of both performance and cost. The key benefits of flat IP architectures include lower costs, universal seamless access, improved user experience and reduced system latency. The drive to all IP-based services is placing stringent performance demands on IP-based equipment and devices, which in turn is growing demand for multicore technology.so the 5G NanoCore architecture will efficiently utilizes all the above three segments to satisfy his customer demands [6] [4]

A. **Network Planning Parameters**

1) Analyzing the expected user traffic:
    - This involves analyzing; the geographic spread of users across the average area.
    - Using market projection to identify subscriber distribution.
    - Calculation on the offered traffic per subscriber.

The results derived from traffic analysis can then be used to generate a traffic map which shows the possible amount of traffic throughput [3] [8]. The traffic map serves as a tool which will be used in network dimensioning.

2) **Cell Coverage Estimation:** Calculation should be done on the impact of load factor in the link budget; effect of load factor is that it reduces the cell range as the interference margin increases. To reduce this effect, multi-user detection technique can be employed; it enables interference cancellation, thereby reducing the effect of multiple access interference.
3) **Blocking Rate:** A blocking probability of 2% can be assumed during network dimensioning. Blocking refers to as the probability of a blocked cell on the first attempt. When a cell runs out of capacity and intending users cannot gain access to the network, this is referred to as soft blocking while hard blocking is the total lack of network resources.

B. **Detailed Network Planning**

It starts with the determination of the numbers of cells for complete coverage, followed by planning the propagation of the RF for each of the cells, putting into consideration, factors such as base station power output, height location, antenna positioning and obstruction element [8].

1) **Control Channel Power Planning:** The propagated power levels of the control channel usually have side effect on network capacity. without adequate control channel power, U.E would be unable to access the network. For W-CDMA air interface, the total transmitted power available will depend on the power allocated to the pilot, paging, synchronization, broadcast and traffic channels. The control channel coverage smust be greater than the traffic channel coverage if a U.E is to detect a neighboring base station in order to perform soft or softer handover.
2) **Code Planning:** The number of available codes will usually have a consequent effect on the type of service the user wants. There are two classes of codes; short codes which are always very limited and must be managed effectively, and long codes which are usually more than enough to supply the users in any one cell. Different services use different types of codes; high data rate traffic such as video to video would require the use of short codes, which also requires a low spreading factor. A code three is needed to ensure that orthogonality between the users is maintained.

3) **Dimensioning:** This refers to process involved in creating an implement able estimate in order to get the network up and running. The estimates derived from dimensioning would be the values to be implemented proceeding to network take off. Importance should be attached to making sure the network and backhaul capacity will be able to handle the predicted volume of traffic.
4) **Capacity Improvements:** A planner can increase network capacity by taking into consideration sectorization and transmit diversity. If the financial implication in terms of increase in overhead cost is not to be considered, sectorization will be the ideal method of increasing capacity. It involves splitting of the cells into either 3-sectors or 6-sectors cells with new antennas being installed, re-planning and re-optimization of the radio network must be carried out. Depending on the type of sectorization, efficiency is around 90 percent.
5) **Optimization:** It is that part of the network that is responsible for ensuring that maximum level of design expectation is achieved. Optimization makes use of all the initial design parameters, re-adjusting them to meet both the network and operators specification.
6) **Testing:** Once the network has been developed up to the required specification, several tests must be carried out in order to monitor performance and Q.O.S of the system. Drive testing includes coverage problem identification; signal strength measurement, co-channel and ACI testing, cell site parameter adjustment, software change testing, post cell turn on. Re-optimization of the network parameters should be carried out in order to ascertain which parameter needs re-adjustment.

C. **Link Budget**

It gives the planner knowledge of the loss in the signal strength on the path between the mobile station [8] and the station antenna. Analysis for the link budget is usually calculated separately for the up-link and down-link. Due to the difference between the power transmitted by the mobile station antenna and the power transmitted by the base station antenna, the up-link power budget is more crucial than the down link power budget.

For a typical network configured to have cell load capacity of 20-50%, since cell loading and interference margin are directly proportional to each other, typical value for interference margin in a coverage limited scenario will be around 1-3db. The standard signal to noise ratio Eb/No within a WCDMA system is given as 7.5db.

Processing gain, Gp= Bt/Bi

Bt = Transmitted Bandwidth.

Bi = Information Bandwidth.

Transmission capacity X = Gp/Eb/No

Table 1: UE Assumptions

Assumption	Data Terminal	Voice Terminal
Antenna gain	**2dBi**	**0dBm**
Body loss	**0**	**3**
Maximum Tx power (dBm)	**24**	**21**

Table 2: Base Station Assumption

Assumption	Parameter
Antenna gain	18dBi(three sector base sation)
Noise figure	5.0dB
Eb/No requirement	Voice:5.0dB 144kbps RT data:1.5dB 384kbps NRT data 1.0
Cable loss induced	2.0dB

Table 3: UMTS UL Budget

TX	
Mobile Max Power=0.125(dBm)	21
Body loss-Antenna gain(dB)	2
EIRP(dBm)	19
RX	
BTS noise density(dBm/Hz)=Thermal noise density + BTS noise figure	**168**
Rx noise power(dBm) -168+10* + Log(3840000)	**102.2**
Interface Margin (dB	**3**
Rx Interference power (dBm)=10* log(10n((-102.2+3)/10)-10n(-102.2/10)	**102.2**
Noise and interference(dBm) =10* log(10n((-102.2)/10)+10n(-102.2/10)	**99.2**
Process gain (dB) =12.2k voice =10* log(10n(3840/.12.2)	**25**
Required Eb/No for speech (dB)	**5**
Antenna gain(dBi)	17
Cable and connector losses	3
Fast fading margin(dB)=slow moving mobile	4
Rx sensitivity (dBm)	129.2
Total available path loss(dB)	148.2
Dimensioning	
Log normal fading margin(dB)	7
Indoor/in-vehicle loss (dB)	0
Soft handover gain(dB)	3
Call edge target propagation loss (dB)	144.2
cell range(km) L= 137.4#6.2LOG(R)	1.56

Estimation of the number of cell sites.
The number of cell sites required for a particular region can be determined if the size of the area to be covered is known. Assuming a network is to be designed to cover an area of 1,000km2 .Assuming the base station to be used are 6-sectored, with a cell coverage range of 1.5km.

Area covered by each cell site = K [R^2]

K = 1.95(standard value).

Area covered = 1.95 [1.5^2]

= 4.39km^2

Total number of sites = 1000/4.39

= 227 sites.

2. Soft capacity, soft handover calculation.

Soft capacity = (Es/Eh) - 1

Where
Es =Erlang capacity with soft blocking
Eh =Erlang capacity with hard blocking
J+I= (Ai/Ci) -i 1

Where
Ai = Adjacent cell interference
Ci = Current cell interference

J+I = (Ai + Ci) / Ci

Therefore
J + 1 = (Isolated cell capacity) / (Multi cell capacity)

Table 4: Soft Capacity Calculation

Data Rate (Kbps)	Channels Per cell	Hard blocked capacity	Trunking Efficiency (%)	Soft blocked Capacity	Soft Capacity (%)
12.2	60.5	50.8	84	53.5	5
16	39	30.1	77	32.3	7
32	19.7	12.9	65	14.4	12
64	12.5	7	56	8.2	17
144	6.4	2.5	39	3.2	28

4. CONCLUSION

Fifth generation mobile telecommunication technology is expected to revolutionize the mobile industry, improve and change the ways we live by creating truly connected smart cities and the supporting network for autonomous vehicles. Likewise, the technology will be the catalyst for connecting humans and machine together on an unprecedented scale for the new businesses and economic opportunities. It also promises super-high speed, eliminate congestion and allows data sharing in real-time. Coverage and capacity are important issues in the network planning processes, it assist in knowing the service traffic demands and have a clue of maximum number of users sending or receiving adequate signal strength in a cell.

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