CONTINUOUS PROCESS IMPROVEMENT OF MOBILE COMMUNICATION FROM 1G TO 4G

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ABSTRACT

The advent of mobile communication was like a magic to the early service subscribers as wave of joy rent the air when they could access different network services via mobile devices at anytime and anywhere they go unlike fixed network services that could be accessed in a particular location where the network is available. There has been a paradigm shift and exodus of users from fixed network to mobile network otherwise called mobile communication. Several efforts were made to achieve improved data throughput, channel bandwidth, wider network coverage using frequency reuse techniques at different locations, enhanced utilization of frequency spectrum and minimized the power consumption transmitter and this lead to the introduction of first generation (1G) mobile communication by Nordic countries. Based on the literature review, it was discovered that there is a huge gap between demand for mobile services specifically the internet services and supply of radio resources (channel bandwidth and data capacity). Lack of continuous improvement of processes for implementations, operations and maintenance of faulty network elements wittingly affected employees' efficiency. High Mean Time To Restore faulty network elements led to declined in revenue generated from cell sites. This research is performed to address this gap by conducting descriptive study to explore the features, benefits, limitations, processes for implementations, operations and maintenance of network elements using mobile telecommunication companies in Ghana as my case study. The result of the study is aiding employees of the organizations in express troubleshooting and resolving of faulty network elements. It has increased customers' satisfaction as network elements that are out of service can be repaired swiftly and put back into service and this can boost company sales.

KEYWORDS: Continuous Process, 1G, 2G, 2.5G, 2.75G, 3G, 3.5G, 3.75G, .HSPA, HSPA+, 4G

I. INTRODUCTION

Mobile communication which can also be called mobile network is a network of various transmission media allocated over diverse cell sites. It utilizes radio waves which are electromagnetic waves that are propagated by antennas.

In every mobile communication, there is a base station or cell site that communicate (transmit and receive) with mobile station at specified radio frequency spectrum. A cell site is any service area of a base station. Several base stations make use of the same spectrum.

In mobile communication, each cell site utilizes different frequencies to prevent interferences from the adjacent cell sites.

For many decades, mobile communication has experienced various types of generations from 0G to 4G (LTE). 0G (Zero generation) evolves to 1G which is the generation that was in existence before the introduction of mobile communication. Mobile telephones used in the zero generation were installed in vehicles and were also in form of brief case size.

In this study, we explore the continuous process improvement of mobile communication from 1G to 4G (LTE) particularly the features, benefits, limitations, processes for implementations, operations and maintenance of some of the network elements.

Mobile communication can be viewed in three different periods namely:
- The pioneer period: this era ends in 1920
- The pre mobile communication period: this era began in 1920 and ended in 1979
- The mobile communication period: this is the actual commencement of mobile communication which started in 1979 till date.

In 1964, Bell Lab introduced the first business mobile system in St. Louis, United States of America but the services provided by the

mobile communication were only available in few areas due to the following constraints:
- Limitation of Radio Frequency capacity
- The mobile communication employed distinct elevated transmitter that gives limited network coverage of 50 miles using analog Frequency Modulation method.

Besides Surfline that offers only data services on 4G(LTE) network, though its subscribers can take advantage of a wide range of over-the-top services like skype and viber for voice calls, other mobile telecommunication companies such as Vodafone, MTN, Tigo, Expresso, Glo Mobile Ghana Limited and Airtel offer 2G and 3G voice and data services on mobile devices.

According to Mobility Arena reported on 17th June, 2015 on the mobile communication companies have upgrade their networks to:
- Airtel Ghana: HSPA+
- Glo Ghana: HSPA+
- MTN Ghana: HSDPA
- Tigo Ghana: HSDPA
- Vodafone Ghana: HSDPA

While Expresso provides 3G services on CDMA2000 technology.

All the telecommunication companies in Ghana were selected as our case study based on these services provided by the companies

A. Study about networks

The study is undertaken to explore detailed and accurate knowledge of mobile communication from first generation to fourth generation specifically the features, benefits, limitations, processes for operations and maintenance of network elements. The study will help to:
1. provide the employees adequate knowledge of mobile communications from 1G to 4G
2. furnish the employees the processes for implementations, operations and maintenance of network elements
3. reduces the Mean Time To Restore faulty network elements
4. to increase services delivery
5. to increase customers satisfaction
6. to increase sales volumes
7. to increase employees productivity

B. Scope of the study

In this study, we explored on the continuous process improvement of mobile communication from first generation (1G) to

fourth generation (4G) specifically on the features, benefits, limitations, processes for operations and maintenance of some of network elements.

Although our main focus is on the standards set by third Generation Partnership Project (3GPP) yet we have only outline other standards set by 3GPP2 and IEE802.16.

We have specified network architecture of 2G, 3G and 4G with processes for implementation, operations and maintenance of only 2G and 3G mobile communication using mobile telecom companies in Ghana as case study.

C. Structure of the study

We adopted structured approach that is quantitative research using questionnaire and field work to collect data from the respondents and we also visited different cell sites (field) to collect primary data that enabled us to provide answers to our research questions. Secondary data were collected through comprehensive study of literature review.

Before adopting questionnaire, we considered its reliability and validity to ensure that our findings are accurate and can be authenticated by others.

- Spectrum: It is defined as an array of frequencies
- Continuous Process Improvement: Continuous Process Improvement (CPI) implies performing tasks in a better way; it is not a matter of managing calamities or disasters but to seek the root causes of any unsatisfactory result. This understanding will help us to minimize any deviations, eliminate any tasks or actions which have no value on the services or products been created and in doing this, customers satisfaction is improved.
- Questionnaire: A questionnaire is a collection of questions offered to a respondent for answers. The respondent goes through the questionnaire and answers the questions

II. LITERATURE SURVEY

This chapter covers mobile communication from 1G to 4G specifically the features, benefits, limitations, processes for implementations, operations and maintenance of some of the network elements. Comprehensive explanations with diagrams, figures and pictures of 1G, 2G, 2.5G, 2.75G,

3G, 3.5G, 3.75G, HSPA, HSPA+, LTE Release 8, LTE Release 9 and LTE Release 10 are stated.

A. First Generation (1G)

First generation (1G) was purely based on analog signal. It provided only voice traffic and it was introduced in 1970. It supported analog cell phones. Because of the analog feature of the 1G, the network elements were susceptible to noise and static as a result of close by electronic devices. It was easier to eavesdrop in a subscriber call using radio scanner device.

The first 1G mobile communication was launched in Ghana in 1992 by Mobitel using European Total Access Communication System (TACS). This system was solely based on analog. The company name was changed from Mobitel to Buzz and eventually to Tigo. Celtel Limited was renamed Kasapa Telecom Limited now called Expresso launched 1G in 1993 in Ghana and the system used was called Advance Mobile Phone System(AMPS). The system worked in 850MHz frequency band [14].

i. Benefits of First Generation (1G)

* It provided voice service on mobile phone
* Subscribers could roam within the country where the network was available

ii. Limitations of First Generation (1G)

* It required outsized gap of spectrum between users to avoid interference
* The quality of voice service was very poor
* It was purely based on analog signal
* Limited bandwidth capacity
* Lack of security features
* Handover was very unreliable
* It supported only voice traffic
* 1G mobile phone was very bulky in size and could not fit into pocket

B. Second Generation (2G)

Second generation (2G) mobile communication brought about the introduction of digital signal and this led to the improvement in the quality of voice traffic. It provided other services such as voicemail, Short Message Service, basic caller ID, Close User Group (CUG) [13]. Second generation systems include Global System for Mobile Communication (GSM), Personal Digital Communication (PDC) and Code Division Multiple Access (CDMA). In all the several incompatible 2G standards that were developed, only GSM and CDMA survived. This generation was the first to utilize digital signal when it is compared to first generation. Coverage was one of the limitations of GSM. Text messages, multimedia and caller ID features were all supported by the second generation. With the introduction of digital compression codec, several subscribers could exchange data in any cell site with less noise when compared to 1G.

Sancom Limited was given license in 1995 to operate 2G (GSM) in Ghana. The name was changed to spacefon in 1996 when the first commercial GMS services were launched. Spacefone was later renamed as Areeba which is now MTN. In 2000, Ghana Telecom lauched 2G services and the company name was changed to One touch which is now called Vodafone.

The cost of Subscriber Identification Module (SIM) was very expensive to purchase by the public. Only privileged ones could afford to buy SIM cards. SIM cards were sold for GHc60 by Spacefone when it launched the 2G network. Onetouch sold SIM cards for GHc120 without even air time preloaded [14]. With the continuous improvement of mobile communication from 1G to 4G, SIM card is now sold for GHc1 with preloaded air time.

Bharti Airtel which acquired Zain was given 2G license to operate GSM network. In 29th April 2012, Glo Mobile Ghana Limited launched GSM (2G) network in Ghana.

i. Benefits of 2G

* The application of advanced modulation provided
   efficiency in spectral usage.
* Several users have access to services concurrently
   as a result of lesser bit rate voice coding.
* It provides a reliable signal to interference as a
   result of good quality resource and coding channel methods used.
* Short Message Service(SMS) was introduced for
   the first time
* Subscriber Identity Module (SIM) was introduced
   in 2G.
* It provided reliable traffic handover as compared

to 1G.
- It supports global roaming
- It provides good quality voice service as compared
  to 1G
- It is compatible with Integrated Services Digital
  Network (ISDN)

ii. Limitations of 2G
- Limitation of channel Bandwidth of only 200 kHz.
- It supports only data and voice services.
- Digital signal gets faded if there is absent of network in a particular area.
- SMS only transmit in one direction and it is limited to only 160 characters

C. Introduction to 2.5 G (GPRS)
Continuous process improvement work was done on 2G and this eventually gave birth to 2.5G in 1990 with the introduction of General Packet for Radio Services (GPRS) technology which supports internet access. It enables users to get connected always without using dial up connection. It has a data rate of 115kbps. Packet switching technique was introduced in addition to circuit switching. It enables users to send graphics data in form of packets.
It was built on the existing 2G network elements with an introduction of packet switching network elements such as Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN).

i. Features of 2.5G
- Packet switching technique for data transmission
  was introduced
- Data Throughput : It provides a data transfer rate
  of up to 115kbps
- It supports browsing of web sites using Wireless
  Application Protocol (WAP)
- It supports Multi Media Services (MMS) such as
  videos and photos
- It is backward compatible with existing GSM
  (2G) network elements.

ii. Benefits of 2.5G
- It supports internet access on mobile
  devices

- It supports packet switching technique for data transmission
- Data Throughput: It provides a higher data transfer rate of 115kbps.
- It provides Multi Media Services (MMS)
- Increased in efficiency of spectra usage

iii. Limitations of 2.5 G
- Data throughput: It supports limited peak data rate of only 115kbps
- Slow internet access on mobile devices due to limited data capacity
- Limited channel bandwidth of only 200kHz

D. Introduction to 2.75G (EDGE)
Due to exponential demand for internet services on mobile devices, continuous process improvement on 2.5G led to the development of 2.75G in 2003 with an increase data transfer rate to 237kbps. Enhance Data Rate for GSM Evolution (EDGE) named as the 2.75G technology.

i. Features of 2.75G
- Data throughput : It offers data transfer rate of 236kbps
- It is built on the existing 2G network infrastructures
- It is 3GPP Release 98

ii. Benefits of 2.75G
- Increased in efficiency of spectra utilization.
- Data throughput: it provides data transfer rate of 236kbps
- It is built on the existing 2G with little upgrade of hardware and software

iii. Limitations of 2.75G
- It supports only data transfer rate of 236kbps
- Limited channel bandwidth of 200kHz

E. Third Generation (3G)
Third generation mobile communication was the first generation that provides broadband internet access connection for mobile devices. The 3G standard was released in 2001, smart phones were invented and in the mid 2000, USB dongles were developed to enable access to internet on computer systems. The main 3G system introduced by 3GPP is Universal Mobile Telecommunication System (UMTS). Third generation supports better voice, global

roaming, higher security features, video streaming, video conference, data transfer rate of 2mbps in stationary environment, 384kbps for low mobility and 144kbps for high mobility.

Mobile Switching Center (MSC) was partitioned into Media Gateway (MGW) and Wireless Core Sever (WCS) for efficiency.

Glo Mobile Ghana Limited launched 3G (UMTS) concurrently with 2G (GSM) network on 29th April, 2012. Other UMTS (3G) telecom mobile operators such as Airtel, MTN, Tigo, Vodafone upgraded their networks to 3G. Expresso provides fixed wireless services and its network has also been upgraded from 2G (CDMA) to CDMA 2000 in accordance with 3GPP2. MTN was the first to launch 3G network among the six telecomm operators in Ghana that provide both voice and data services besides Surfline that provide only data services on 4G technology. [14]. 3G phone is smaller and lighter than 1G phone as

i. Benefits of 3G
- There is efficiency in spectrum usage and this has reduced the congestion on the 2G network.
- Data throughput : it provides data transfer rate of 2Mbps indoor or stationary environment, 384kbps for low mobility and 144kbps, for high mobility

- There is increase in security such as Network Access security, user domain security, Application Security and Network Domain security.
- It is backward compatible with the 2G network
- It provides reliable broadband internet access on the mobile devices at all times
- It provides reliable Multimedia Services (MMS) such as photos, movies, etc.
- It supports video calls, video conference and video streaming
- It supports high quality of voice traffic
- It unifies the Radio Access Network (RAN) and Core Network (CN)
- It supports services such as location based like weather info on mobile devices
- It supports interoperability among the network service provider

ii. Limitations 3G
- Cost: 3G operational license is very expensive

- It requires 3G handset to receive 3G services
- The battery life span of 3G handset is not durable
- The peak data transfer rate is only limited to
    2Mbps indoor or stationary environment, 384kbps for low mobility and 144kbps, for
    high mobility
- It has a limited channel bandwidth of 5MHz

F. High Speed Packet Access (3.5G)
High Speed Packet Access (HSPA) is a combination of High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA).
- The HSDPA has a data transfer rate of 14.4 Mbps
- HSDPA was first commercialized in 2002 and it
    is 3GPP Release 5
- HSUPA has a data rate of 5.8Mbps
- HSUPA was commercialized in 2004 and it is
    3GPP Release 6

i. Benefits of HSPA
- Data Throughput: faster data transfer rate up to 20Mbps
- Cost: it is pocket friendly to upgrade 3G to 3.5G
    since it is built on existing 3G networks but only required few equipment and software in
    BTS/Node B and RNC.
- Download / Upload of application is faster and
    reliable
- Improved response time between network devices
- Increased in performance of network
- It supports 14.4Mbps data transfer rate for downlink and 5.8Mbps for uplink
- Video calls and video conference
- It allows faster video streaming
- Efficient utilization of spectrum.
- It is backward compatible with the existing 3G
    network
- It supports the integration of Wireless Local
    Area Network (WLAN)

ii.   Limitations of HSPA
- Limited network coverage: Users will not receive HSPA service if they are not within the HSPA coverage area although they can receive 3G network signal if available in the area.
- Limitation of data throughput: It supports 14Mbps data transfer rate for downlink and 5.8Mbps for uplink

G. Motivations for 3.75G (HSPA+)
It became necessary to improve on 3.5G technology to achieve greater data throughput due to high usage of the services especially internet services on mobile devices. This search led to the development of 3.75G technology

i. Benefits of 3.75 (HSPA+)
- Data throughput: it allowed data transfer rate of
  up to 84 Mbps
- Superior quality of voice traffic
- Faster downloading and uploading of applications
- It is built on the existing 3G network
- Cheaper to upgrade as it required few hardware
  equipment and new software on BTS/Node B,
  RNC and radio equipment

ii.   Limitations of 3.75G (HSPA+)
- Limited channel bandwidth
- Limited data capacity

H. Fourth Generation (4G)
LTE Release 10 (LTE – Advance or IMT-
  Advance)
Enormous continuous improvement was performed on LTE release 9 and this was called LTE release 10. This release meets the 4G requirements set up by the third generation partnership project. The release is called 4G mobile communication. It provides data transfer rate of 1Gbps for low mobility (downlink) and 100mbps for high mobility (uplink).
Presently, only Surfline Communication Limited provides LTE services to the public and it was launched in 20th August 2014. Surfline does not provide 2G and 3G services. 4G mobile phone is lighter and smaller than 1G mobile phone and can fit into pocket like 2G and 3G phones.

i. Benefits of 4G
- Superior spectral efficiency
- Data Throughput: higher data transfer rate of
  1Gbps downlink and 100Mbps uplinks
- Wider channel bandwidth of 100MHz
- Cost per bit is minimized
- Greater quality of service
- Enhanced scheduling and call admission management method.
- It provides seamless network without interrupting
  services for travelers
- It is purely IP based services for mobile devices
- It provides faster video streaming, better video
  calls and video conference

ii. Limitations of 4G
- Cost: it is very expensive to implement
- The 4G mobile phone battery is not durable
- Data throughput: it is limited to only data transfer
  rate of 1Gbps for low mobility (downlink) and
  100mbps for high mobility (uplink)
- Channel bandwidth: it is limited to only bandwidth of 100MHz
- License cost of acquiring the 4G is very expensive

III.   METHODOLOGY

Methodology helps us to find answers to research questions. It is the umbrella of research design, population, sample design and data collection instrument as well as data analysis.

A. Proposed Variables
[3] The proposed variables include:
- BSS/TX Engineers: he performs operations and maintenance of network elements as well as transmissions related issues in a specific region. He reports to the Regional Technical Head/Regional Managers
- Regional Technical Head/Regional Managers: he oversees the network operations and maintenance of network elements such as core network, access network and transmission

network elements. He also undertake other tasks such as power management, security management, issues related to computer systems maintenance, resolving Environmental Protection Agency , Landlord and District issues. He reports to the National Head of Operations.

- National Head of Operations: he oversees operations and maintenance of network elements in the ten (10) regions of Ghana.
- Chief Technical Officer: he is the overall boss in charge of technical department. He oversees network operations and maintenance, planning, Project (rollout). In Tigo, the duty of CTO and Chief Information Officer (officer in charge of Information Technology) is handled by Chief Technical Information Officer(CTIO) . The CTO/CTIO reports to the Chief Operating Officer or Chief Executive Officer as in the case of Tigo.
- Employees: they are the staff of mobile communication companies and it is compulsory that all the staff use the company SIM card.
- Subscribers of the network: they are the users of the company services and products such as voice and data services
- Corporate internet service users: they are heavy internet users of the mobile communication companies such as banks, universities, polytechnics.

A suitable methodology was adopted to organize a down-to-earth questionnaire and practicable size of the sample size of the subscribers so as to carry out successful survey based on the availability of time and other resources.

B. Population
Population can be viewed as individuals, organizations or communities who provides information to the researcher or who the research collects data from. Six mobile communication companies in Ghana provides both voice and data services while Surfline communication limited which is the seventh and the newest operator provides only data service. The six operators provide 2G and 3G services while Surfline provides only 4G services.
According to Dr. Yaw Akoto, the Chief Executive Officer for Surfline limited said," Ghanaians are disillusioned with the internet

services that are currently on offer, because they have not experienced what was promised. "Surfline's 4G LTE service has been created with a single-minded focus on data, which means our network quality will not be compromised. With our service, customers are always guaranteed a 4G LTE service and nothing less". Surfline was launched in 20th August, 2014.

According to National Communication Authority (NCA) reports, the mobile data figure for the month of August 2015 is 17,089,304 and the mobile voice figure for the month of August 2015 is 32,826,405. The analyses of the figures are as followings:

Mobile Data figures
- MTN=8,205,700
- Vodafone=3,093,210
- Tigo=2,594,945
- Airtel=2,628,112
- Glo=522,014
- Expresso=45,323

Mobile Voice Figures
- MTN=15,211,803
- Vodafone=7,353,155
- Tigo=4,452,988
- Airtel=4,279,835
- Glo=1,396,958
- Expresso=131,666

C. Sample and Sampling Procedure
60 people as samples were selected from the above population using quota sampling method. The quota sample method used represented the subset of the population size [4]. Field assistants and the researcher administered the questionnaires in the ten (10) regions where all the mobile communication companies operate. The regions in Ghana include:
- Ashanti
- Brong-Ahafo
- Central
- Eastern
- Greater Accra
- Northern
- Upper East
- Upper West
- Western
- Volta

Sampling involves the following questions:
1. Who will be surveyed? In this research study, the mobile communication employees, mobile communication subscribers and mobile communication corporate internet service users were all surveyed.
2. Number of people who will be surveyed? Total number of 60 people were investigated :
- 20 employees
- 20 subscribers
- 20 corporate internet service users which include banks like Guarantee Trust Bank, FBN bank Ghana Limited and institution like Koforidua Polytechnic
3. How should the sample be selected? In my survey, a quota sample was used to collect sample data.

D. Instrument for Data Collection
In my research study, we used questionnaire and field work as instruments of primary data collection. The field work enabled me to prepare adequate processes for implementations, operations and maintenance of network elements.

The respondent goes through the questionnaire and answers the questions. We used this instrument because of its flexibility [1]. Questionnaires were used for data gathering because of its benefits which include:
- It requires less time and efforts to administer
- Respondents feel lighten up completing the form because questionnaire provides a high degree of anonymity
- Questionnaire is a flexible instrument of collecting data
- Respondents answers to questions on the questionnaire instrument cannot be manipulated because the questions are printed on a paper unlike the use of interview to collect data where the researcher can easily influence the respondents answers for his selfish interest

In this study, we prepared 60 closed-ended questionnaires for mobile communication employees, subscribers and corporate internet users. The questions were written in English Language since it is the first and general language spoken by all Ghanaians. During the data collection, we gave the company employees express guarantees that the answers they provided would not be disclosed to the company and that it would be used solely for the purpose of my research work.

The questionnaire is self-explanatory as the respondents only need to tick the most appropriate answers from the questions provided.

E. Data Collection
Collecting data from the sampled respondents enabled us to draw inferences and conclusions on our research study. During our data collection using questionnaires and participating in the field work, we ensured the ethical issues were considered and these include:
- Not building nervousness or put stress on the respondents
- requested permission from the respondent
- not to provide incentives to the respondents before or after providing answers to the questions on the questionnaires
- safeguarding data confidentiality by not disclosing data collected to anyone
- respondents were not exposed to any harm

Primary data were collected using closed-ended questionnaires with boxes for the respondents to tick**.** We hired the services of field assistants who distributed questionnaires in the ten regions where all the communication companies operate even though we also administered the questionnaires in Accra and Koforidua, the capital cities of Greater Accra and Eastern Regions. The respondent goes through the questionnaires and answers the questions accordingly.

All the respondents were enlightened about the goal of the research work and were informed that the data provided by them would not pose any potential risk or incur them of any cost.
Responses from some of the employees include:
One of the respondents who works in Surfline affirmed, "my company provides the fastest data services in Ghana even though we don't provide voice services but you can talk to your people on skype or imo"
Another respondent who works in Glo affirmed, "we provide the fastest mobile internet services in Ghana on HSPA+ network

platform even though we have not gotten licensed for 4G".

We met three respondents in Accra who could not read the questionnaires written in English language, the language barrier was resolved with the assistance of some Ghanaians who translated the English language to Ga which is the local language spoken by Ghanaians in Accra. After the translation, the subscribers were able to provide answers to the questions on questionnaires.

F. Data Analysis

We used quantitative data analysis in the research study due to its benefits which include:

- Time is saved in data analysis when quantitative
  research method is used because of the use of
  statistical software such as Statistical Package
  for Social Science (SPSS).
- Relationship between different variables can be
  studied with the help of quantitative research
  method
- It provides the best method to reach people who
  are often in the field.
- It allows respondents to provide sincere answers to questions since they do not specify their names.
- Respondent's answers are not prejudiced since it does not involve interviewer.

After data gathering using questionnaire, the data were examined in order to detect and correct any errors.

Quantitative data analysis was performed using Statistical Package for Social Science (SPSS) software. We used the SPSS software in my data analysis due to the followings advantages:

- It is friendly software based on graphical user
  interface rather than command line interface to
  generate data variance, regression and
  correlation analysis
- It can be used to calculate frequency of data
- It can carry out larger amount of data analysis

- It can be used to perform data entry and analysis
- It can be used to create tables and graphs

IV. DATA ANALYSIS AND PRESENTATION

The data collected with questionnaires were processed using Statistical Package for Social Science software and the results were presented in tables as shown in the tables below. The ages of respondents ranges between 21years and 55years. The respondents' educational qualification ranges from Senior High School and Doctorate Degree certificates except three respondents who were illiterate. They were traders who are Glo subscribers. Respondents' occupations includes; Lecturing, Banking, Engineering, Technical, Trading, Student.

Table 1: Responses from corporate internet service users

Question	N			Frequency	%
Do you receive quality of service from your network provider	20		Yes	16	80
			No	4	20
			Don't know	0	0
Do you access internet service on your mobile devices	20		Yes	20	100
			No	0	0
			Don't know	0	0
Is the internet service available for use every time	20		Yes	17	85
			No	3	15
			Don't know	0	0
Do you receive 3G services from your service provider?	20		Yes	20	100
			No	0	0
			Don't know	0	0
Do you receive quick support from your service provider	20		Yes	17	85
			No	2	10
			Don't know	1	5

i. **Percentage distribution of quality of services provided by mobile telecommunication companies**
According to the survey as presented in Table 1, most of the respondents (16 out of 20 representing 80%) received quality of services from mobile telecommunication companies in Ghana, 4 out of the 20 respondents representing 20% did not receive quality of service from mobile telecom companies. The result implies that mobile telecommunication companies in Ghana are providing quality of services which are geared towards retaining their data service corporate customers.

ii. **Percentage distribution of subscribers' access to internet service on their phones**

When respondents were asked if they have easy access to internet services on their mobile devices, all of the 20 respondents representing 100% as per Table 1 confirmed they have easy access to internet services on their mobile devices. The result indicates that mobile telecommunication companies provide excellent mobile internet connectivity.
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iii. Percentage distribution of availability of internet services

As shown in Table 1, most of the respondents 17 (85%) out of 20 do have fast access to the internet for use at all times as opposed to the 3 (15%) out of 20 respondents who had no access to the internet at all times. The result implies that mobile telecommunication companies in Ghana have internet connectivity for their customers and this should be sustained in order to remain indispensable and retain customers on the networks.

iv. Percentage distribution of 3G services provided by mobile telecommunication companies

When respondents were asked if they received 3G services from their service provider, all of the respondents (20 out of 20, representing 100%) as presented in Table 4.1 confirmed they received 3G services. The result proved that mobile telecommunication companies in Ghana have stable and reliable 3G services hence the telecom companies must work to maintain this standard in order to attract more subscribers.

v. Percentage distribution of quick service from service providers

As shown in Table 1, most of the respondents 17 (85%) out of 20 respondents received rapid support from mobile telecommunication companies as opposed to 2 (10%) out of 20 respondents who do not enjoy quick support from their service provider, while 1(5%) out of 20 respondents remained undecided. The results indicate that most subscribers of mobile telecommunication companies are satisfied with the services they receive from their providers and this should be sustained by all the mobile telecom companies in Ghana.

Table 2: Responses from telecom Employees

Question	N		Frequency	%
Does continuous improvement of processes for implementations, operations and maintenance of network elements leads to employees' higher productivity and customers' service delivery?	20	Yes	20	100
		No	0	
		Don't know	0	
Does continuous improvement of bandwidth reflects increase in data capacity in your operations?	20	Yes	19	95
		No	0	0
		Don't know	1	5
Does revenue generated from cell site decline due to high Mean Time To Restore faulty network elements?	20	Yes	19	95
		No	0	0
		Don't know	1	5
Is delay in restoring faulty network element leads to subscribers' dissatisfaction?	20	Yes	20	100
		No	0	0
		Don't know	0	0
Does your company provide 1G services to the public?	20	Yes	0	0
		No	20	100
		Don't know	0	
Does your company provide 2G services to the public?	20	Yes	18	90
		No	2	10
		Don't know	0	0
Does your company provide 3G services to the public?	20	Yes	18	90
		No	1	10
		Don't know	0	0
Does your company provide 4G services to the public?	20	Yes	2	10
		No	18	90
		Don't know	0	0
Does the introduction of 4G mobile communication resulted in decrease in operational and capital expenditure of your company?	20	Yes	17	85
		No	3	15
		Don't know	0	0
Does continuous process improvement of mobile communication from 1G to 4G leads to higher data transfer rate?	20	Yes	17	85
		No	3	15
		Don't know	0	0

As shown in Table 2, all 20 respondents representing 100% were in agreement to the statement that continuous improvement of processes for implementations, operations and maintenance of network elements lead to employees' higher productivity and customers' service delivery. The result implies that mobile telecommunication companies need to improve on their processes for implementation, operations and maintenance of network to retain its customers and win undecided customers to its fold.

Table 3: Responses from Mobile Subscribers

Questions	N		Frequency	Percentage (%)
Does the continuous process improvement of mobile communication from 1G to 4G leads to reduction of tariff paid by you?	20	Yes	15	75
		No	2	10
		Don't know	3	15
Can you access 3G services in your mobile phone?	20	Yes	20	100
		No	0	0
		Don't know	0	0
Does the continuous process improvement lead to faster application downloading and uploading on your mobile phone?	20	Yes	15	75
		No	4	20
		Don't know	1	5
Does continuous improvement of mobile communication from 1G to 4G lead to the reduction of cost of SIM card?	20	Yes	20	100
		No	0	0
		Don't know	0	0
Do you access internet services on your phone regularly?	20	Yes	13	65
		No	6	30
		Don't know	1	5

As presented in Table 3, 15 out of 20 respondents representing 75% all of the respondents responded in the affirmative that the continuous process improvement of mobile communication from 1G to 4G leads to reduction of tariff paid by them as opposed to the 2 respondents who disagreed. However, 3 out of the 20 respondents representing 15% remained undecided. The result implies that subscribers pay less tariff due to continuous process improvement of mobile communication from 1G to 4G.

V. SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

The researcher has been able to explore continuous process improvement of mobile communication from 1G to 4G specifically the features, benefits, limitations, processes for implementations, operations and maintenance of some of the network elements. Detailed surveyed of 1G, 2G, 2.5G, 2.75G, 3G, 3.5G, 3.75G, HSPA, HSPA+, LTE Release 8, LTE Release 9 and LTE Release 10 which is considered as the best candidate for 4G according to 3GPP were carried out successfully.

The good news about the generations of mobile communication from 1G to 4G is that it has evolved mobile communication from analog to digital communication, from purely voice service only to several services ranging from quality of voice traffic, broadband internet access, high speed download and upload of applications, location based services, self organizing network, etc.

With the continuous process improvement of mobile communication the subscriber Identification Module (SIM) that was sold for GHc120 by Onetouch without even air time preloaded during second generation is now currently sold for GHc1 in this third and fourth generation of mobile communication. All these would not have been possible without continuous process improvement of generations of mobile communication.

Continuous processes for implementations, operations and maintenance of network elements should be adopted in order to improve employee's productivity, enhance revenues generation from each cell site, increase sales, saves time in resolving faulty network elements.

The researcher suggested that continuous process improvement should be applied in fifth generation of mobile communication so as to bridge the gap between demand (services such as internet usage) and supply (such as data throughput and bandwidths).

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Dr. Egho-Promise Ehigiator Iyobor (PhD) is an IT, Telecom, Management Consultant, Innovator, Trainer, Research Scientist and a writer with over 20 qualifications. 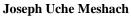He possesses over 15 years working experience in teaching, telecom, banking, information technology, oil and gas industry. His qualifications are indeed broad and cover the disciplines of Business Management, Project Management, Accounting, Data Processing, Computer Science, Electrical and Electronics

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