MOBILE PHONE: THE PAST, THE PRESENT AND THE FUTURE

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Abstract

Since the introduction of cellular analogue phone in 1985 (first generation mobile phone), there has been a continuous improvement from the first generation to digital second-generation to 2.5 generation and now the third-generation. The ground is also being prepared for the fourth-generation mobile phone. Mobile technology has transformed our lives in ways that might have seemed unimaginable some years ago and yet we are still witnessing more transformations and many more are yet to come. This paper examines the concept of cellular communication, the development of mobile phones, the features in the past, the current trends and what to the future holds in general and specifically for Nigeria. The cost implications of the various generations over the previous ones to the end users are also discussed.

1. Introduction

Generations in the development of mobile telephone networks actually means improvement on services: new service providing logic and new telecommunication network architecture. First-generation cellular system was an analogue Frequency Modulation (FM) system which was entirely for voice transfer [1] and was introduced in 1985[3] but had capacity limitations of Time Division Multiple Access (TDMA), incompatibility problem, coverage limited to a geographical entity, low speech quality, no open interfaces except the radio interface and lack of security in speech transmission[2]. The second-generation mobile cellular systems use digital radio transmission. The boundary between the first- and the second-generation systems is the analogue/digital split. The second-generation networks have much higher capacity than the first-generation systems. One frequency channel is divided simultaneously among several users either by Code Division Multiple Access (CDMA) or time (TDMA) division [1]. They are structured atop existing first-generation analogue technology and are premised on compatibility and parallel operation with analogue networks [2].

Generation 2.5 is a designation that broadly includes all advances upgrades for the second-generation networks. The third-generation systems can be used not only for person-to-person communication but also for person-to-machine communication based on Wideband Code Division Multiple Access (W-CDMA) radio technology [12]. The 3G systems are targeted to offer a wide variety of services such as telephony, teleconference, voice mail, message broadcast navigation, etc [1] and will pave the way for 4G, which is likely to be the first truly converged network [10] which will incorporate new services more advanced than what the 3G offers.

1.1 Concept of Cellular Communication

The cellular concept uses a large number of low-power transmitters designed to serve only a small area. Instead of using a large transmitter to cover a wide area, the area is divided into smaller areas called cells. By reducing the total coverage area into small cells it is possible to reuse the same frequency in different cells without disturbing interference. The essential elements of a cellular system are:

1. Low-power transmitter and small coverage areas or cells;
2. Frequency reuse;
3. Handoff and central control;
4. Cell splitting to increase call capacity [1].

2. Overview of Network Generations

2.1 First-Generation Networks

The first-generation cellular systems were analogue FM systems, which were designed only for voice transfer. There was not a dominant standard but different competing ones. Among the successful ones were Nordic Mobile Telephone (NMT), Total Access Communications System (TACS) and Advanced Mobile Phone Service (AMPS)[1,2]. Other standards were often developed and used in one country, for instance C-Nerz in West Germany and Radiocomm 200 in France. In the UK (TACS), it operates in the 90 MHz waveband providing 1000 duplex channels occupying the frequencies 890 – 915 MHz (25 MHz) and 935 – 960 (25 MHz). In the US (AMPS), it operates in the 832 MHz waveband providing 1000 duplex channels occupying the frequencies 825 – 845 MHz (20 MHz) and 870 – 890 (20 MHz). The lower frequency band is assigned for transmission from mobile to mobile [1]. The first-generation networks were dated back to 1985[3].

2.1.2 Access Method

The first-generation mobile networks used Frequency Division Multiple Access (FDMA) technology. With FDMA, each service provider divides is spectrum of radio frequencies into individual frequency channels. Each channel has a width of 10 to 30 kilohertz (KHz) and is a specific frequency that supports a one-way communication session. For a regular two-way phone conversation, every cell phone caller is assigned two frequency channel one to send and one to receive [13]. Problems of the first-generation networks are:

1. They have capacity limitations of Time Division Multiple Access (TDMA) which divides the radio spectrum into multiple 30-KHz frequency channels;
2. They are incompatible systems. For instance, the US, Japan and the European Union have different standards;
3. They have their coverage limited to national boundaries;
4. They do not have interfaces except the radio interface;
5. They have low speech quality and
6. Lack of security in speech transmission.

2.2 Second-Generation Networks

The second-generation systems dated back to 1991 are digital and are capable of providing voice/data/fax transfer as well as a range of other value-added services. They have much higher capacity than the first-generation systems. One frequency channel is simultaneously divided among several users either by code (CDMA) or time (TDMA). There are four main standards for second-generation systems: Global System for Mobile (GSM) Communication and its derivative, Digital Advanced Mobile Phone Service (D-AMPS), Code Division Multiple Access (CDMA [IS-95]) and Personal Digital Cellular (PDC). GSM is by far the most successful and widely used 2G system [1]. The basic GSM uses the 900 MHz band, but there are also two derivatives: Digital Cellular System 1800 MHz and

PCS 1900. The reason for the new frequency band was the lack of capacity at 900 MHz band. The 1800 MHz band can accommodate far greater user population and thus has become quite popular especially in densely populated areas. The coverage area of the 1800 MHz is smaller than 900 MHz networks, and thus dual-band mobiles are used, where the phone uses a 1800 MHz network when such is available and otherwise roams to a 900 MHz network. D-AMPS is backward compatible with AMPS. It uses a digital control channel whereas AMPS has an analogue control channel [1]. Digital cordless systems are also mentioned as part of the second-generation systems. Two examples of these are: Digital Enhanced Cordless Telecommunications (DECT) and Personal Handyphone System (PHS). They do not have a network component. A typical system configuration includes a base station and a group of handsets. The base station is attached to some other network, which can be either a fixed or mobile network. The coverage area is often quite limited, consisting of town centres or office buildings. PHS is an advancement system and can do many things usually associated with mobile cellular systems [1].

2.2.1 Access Method

The second generation networks make use of CDMA or TDMA. Code Division Multiple Access (CDMA) instead of dividing a spectrum of radio frequencies into narrow frequency bands or time slots, uses a very large portion of that radio spectrum called frequency channel. Frequency channel has a wide width of 1.25 mega hertz (MHz) and is segmented into 64 multiple channels using a code to identify users. For duplex communications, each cell phone uses two of these wide CDMA frequency channels: one to send and the other to receive. CDMA is more immune to interference than TDMA and supports more users. Its capacity is not fixed but depends on coverage and total voice bandwidth [3].

Time Division Multiple Access (TDMA) divides the radio spectrum into multiple 30-KHz frequency channels. Every two-way communication requires two of these frequency channels: one to receive and the other to send. TDMA further subdivides each frequency channel into three to six time slots called voice/data channels, so that up to six digital voice or data sessions can take place using the same frequency [13]. The capacity is dependent on the number of available timeslots and cell phones for TDMA networks will not work with CDMA networks and vice versa[3]. Problems of the second-generation network are:

1. The biggest problem with the plain GSM is its low interface data rates;
2. The 2G network uses either CDMA or TDMA but cell phones for TDMA networks will not work with CDMA and vice versa;
3. For CDMA, cell size reduces due to spectrum use during peak periods;
4. For TDMA, capacity is dependent on the number of available timeslots.

2.3 2.5 Generation Network

This improves on the second-generation and there are three types of improvements:

a) **HSCSD (High Speed Circuit Switched Data):** It is the easiest way to speed up things. With HSCSD a mobile station can use several time slots for data connection. Currently, commercial implementations have a maximum of four time slots. The total rate is the product of the time slots and the rate of one slot. Its merits and demerits are those of circuit switching technique because it is circuit switched [1].

b) **GPRS (General Packet Radio Services):** This enables data rates to be pushed up to 115kbs and it is packet switched and as a result does not allocate the radio resources continuously but only when there is something to be sent. GPRS is suitable for non-real-time applications like e-mail and the Web surfing. It is not suited for real-time applications because the resource allocation in GPRS is connection based and thus it cannot guarantee an absolute maximum delay [1]

c) **EDGE (Enhanced Data Rate for Global Evolution):** It uses a modulation scheme called eight-phase shift keying (8PSK). This increases data rates of standard GSM networks by up to threefold. It requires a software upgrade to base station if the Radio Frequency (RF) amplifiers can handle high non-constant envelope modulation with EDGE's relatively high peak-to-average power ratio.

2.4 Overview of the Third Generation Systems

The year 2003 saw the full fledged appearance of what have been called third-generation mobile phones [4]. Third-generation systems are targeted to offer wide variety of services such as telephony, teleconference, voice mail, message broadcast navigation, location information, etc. Most of the services are wireless extension of Integrated Services Digital Network (ISDN) whereas services such as navigation and location information are mobile specific. Wireless network users will expect a quality of services similar to that provided by the wireline networks such as ISDN. Third-generation network will concentrate on the service quality, system capacity and personal and terminal mobility issues. The systems will be improved by using smaller cells and the reuse of frequency channels in a geographically ordered fashion [1]. Applying high-speed data transfer and state-of-the-art radio terminal technology, third-generation systems enable multimedia. It will be a catalyst for a whole new set of mobile service, enabling us to access advanced services anytime. It will free us from the confines of cables, fixed access points and low connection speeds. 3G brings together high-speed radio access and Internet Protocol (IP)-based services into one, powerful environment. IP is packet based, which means that users can be "online" at all times, but without having to pay until data is actually received or sent [2].

2.5 Data Transfer Rates of the Different Generations of Mobile Phone

The following are the data transmission rates of the different generations of mobile phone:
First-Generation: NMT- 380 bits per second (bps), 600 – 1,200 bps [19], TACS – 8 kilobits per second (kbps), AMPS – 10kbps [17].
Second-Generation: CDMA – 307kbps [20], TDMA – 10kbps [22].
2.5-Generation: GPRS – 115 kbps, EDGE – 384kbps [23], HSCSD – 43.2kbps [24].
Third-Generation: For high mobility – 144 kbps, for restricted mobility – 384 kbps and for indoor office environment – 2 mbps [26].

2.6 Cost Implications of the Different Generations of Mobile Phone to the End Users

The second-generation phones provided better quality and higher capacity at lower cost to end users [18]. GPRS which belongs to the 2.5 generation brings cost savings to both the mobile operator and consumers because GPRS radio resources are only needed while transferring the message. For the end user, it means you only pay for the time it takes to download [20].

High investments running into hundreds of billions are required in the third-generation mobile communication in the face of highly uncertain demand for 3G services and products [27]. The five UK licenses for the third-generation frequencies have fetched over twenty billion pound (£20,000,000,000) [6] and what this means is that the huge price paid for the licenses suggests that the facilities will not come cheap to the users at take-off. But, allowing more operators to come in will eventually force the price down as witnessed in Nigeria when Globacom rolled out its services. Generally, improvements from one generation to another enable reduced cost for the end users.

3. What the Future Looks Like

In 2003, full-fledged appearance of third-generation mobile phones was made. Data transfer rate is more than 100 times faster than that of second-generation mobile phones. This makes it possible to send and receive TV-quality images. There are now even some mobile phones that can receive actual TV broadcasts. And because a high-speed internet connection is possible, the fusion of mobile phones with personal computers is moving ahead [4]. The future of mobile phone is hard to predict, and trying is asking to be proved wrong. Nonetheless, the following are to be watched out for in the future and in the areas of mobile phone application:

i. Fourth-Generation System: Research into 4G system will be intensified and the focus will be in the areas of improving data transfer, capacity, introduction of diverse services and network transport protocols. The 4G system is likely to be the first truly converged network [10].

ii. Advertisement: Technological trajectories will likely continue for many years, making the phone a portable entertainment player, a new marketing tool for retailers and manufacturing, a multi-channel shopping device, a navigation tool, a new type of ticket and money and a new mobile Intranet device [11].

iii. Larger Display: Japanese firms have increased the size of phone display from a maximum of 2.0 inches (on the diagonal) in 1999 to 2.4 inches in 2003. New technologies will likely continue in this trend [11].

iv. Processing and Network Speeds: More immediate effects are expected from increases in processing power, memory and network speeds since they can improve the user interface without increases in the size of the display. Increased processing and memory capabilities reflect Moor's law. Decreasing semiconductor line widths have caused computing speed and memory size to roughly double every 18 months for the last 42 years. Similar trends are also seen in the mobile Internet, where the need for lower power consumption requires different circuit designs. Phones released in 2003 had speeds in the 100MHz to 200 MHz range and speeds greater than 500 MHz is expected in the future. Phones with more than 5 megabytes of internal memory were also released; some could save 2,000 photos (taken with a 300,000 pixel camera), 2,000 ring tones (with 40 polyphonic tones) or 100 Java programs. Phones with higher capacities than these are expected. Networks speeds will increase through the diffusion of third-generation services and other forms of networks are also expected to play an important role in the mobile internet [11].

v. Growth, New Services and Technologies: Since 2001 when the first GSM operator in Nigeria was licensed [5], the number of subscribers to the different GSM networks in Nigeria has continued to skyrocket. There were 113.55 million African mobile subscribers by the end of 2005 and it is forecast that it will rise to 378 million by 2011 [8]. As price competition among the various GSM network operators forces margins down, the mobile networks will move to offer additional services to increase revenue and customer commitment [6].Mobile phones are evolving very fast. Today's latest handset model is new for just a few weeks, and obsolete in a few months. The network technologies used are moving on fast. It is expected that new technologies mobile phones will be the order of the days ahead. Many people expect that phones will continue to become smaller and predict the arrival of models that can be worn as a wristwatch or pendant [6].

vi. CD-Quality Music Will Be The Killer Cell Phone Application: Within four years compact disk (CD)-quality music is going to be on more than half the entry-level cell phones used around the world. Music will be the killer application on cell

phones measured by consumer use and revenue-generated by handset makers and wireless service providers [7].

vii. Mobile TV Use on Cell Phones Will Grow, but Not as Fast as CD-Quality Music:
Mobile TV will continue to be developed in the next few years, but will be challenged to win market acceptance because of the small size of cell phone screens. Music conversely, will be a non-stop, slam dunk appealing feature of a cell phone that won't require staring into a small screen [7].

viii. Digital Cameras on Cell Phones Will Have Less Customer Adoption Compared with Music: A cell phone camera generally produces average-to-poor quality photos compared with stand-alone cameras, which is no wonder when looking at the price. Average cell phone cameras cost virtually nothing whereas stand-alone cameras have a price tag similar to a feature phone. Further still, only a small percentage of cell phone users, similar to the overall population at large, are avid users of cameras. This percentage is much lower than the number of people who like to listen to music. Cameras will not disappear from cell phones, but usage of average cell phone cameras will be low compared to music players [7].

ix. Simultaneous Cell Phone Applications Will Be Crucial:
Cell phones that can do most simultaneous applications like listening to music when receiving and answering a text message and playing music while a call comes in, downloading a video clip while listening to music etc at the most affordable costs will win over customers[11].

x. More Feature-Rich Cell Phones Will Be Key in Enabling Wireless Service Providers to Boost Their Average Revenues Per User: Wireless service providers will continue to grapple with a problem that has been vexing them for years. The problem is that even though the growth rate for cell phone sales and cell phone subscribers continues to increase, the average revenue the service providers and handset manufacture gain from each subscriber continues to fall. To increase that revenue, a growing number of service providers will continue to pitch and offer cell phones and subscribers on more feature-rich, revenue-generating services such as high quality audio streaming, download portals for music and video, and mobile TV [7].

xi. 3G Cell Phones Will Not Be All About Merely Enabling the Connected Lifestyle, but Rather Perfecting the Connected Lifestyle: The cell phone will be central for perfecting the connected lifestyle. This means that in the future, reliable, consistent, always-on connectivity will become essential anywhere, anytime. It will become less acceptable during the next few years to just make a cell phone connection. The connection will need to be perfected, meaning not flawed and unreliable, but rather as good as it can be. Lousy service, interrupted calls, the inability to connect and stay connected will become less tolerated than ever. An industry-changing mindset will take over, in which it won't be about being wirelessly connected. It will be about being wirelessly connected quickly, easily, inexpensively and reliability-in other words, perfectly [7].

xii. More Collaborations Will Be Necessary to Survive and Thrive in the Cell Phone Market:
Wireless service providers are teaming with the holders of music and video rights to offer downloads, and they will be building relationships with broadcasters to deliver mobile TV without burdening the mobile network. On the handset side, a rapidly growing number of collaborations will be formed between hardware and software companies to build more complete, more reliable, and more feature-rich cell phone platforms. Fewer companies will be able to do everything required to build a platform on their own. Cellular baseband experts, for example, will collaborate with providers of global positioning system solutions,

for installation in these basebands, to provide value-added functionality. These collaborations will help accelerate time to market while minimizing research and development expenses.

xiii. More Use Will Be Made of Mobile Phones in the Education Sector: In the education sector, mobile phones are going to be used more extensively for learning purpose. Some education authorities are already sending truant 'text alerts' to parents. They are also being used for notification of lesson and classroom changes and cancellation of lectures and to inform students that library books are overdue. When camera phones are more commonplace, students could make notes and take photographs on field trips and file their reports using those pictures and notes. The notes could be on mobile device which is synchronized with a PC or server for immediate processing and results [13].

xiv. Convergence: In the short-to mid-term, the mobile industry will most likely follow a paradise lost scenario, in which existing players will find their market share and their profits threatened by new entrants. Cooperation among industry players is likely. Alliances to save costs and to pool parts of the value chain are already occurring, for example between Sharp and Sony Ericcson for 3G Research and Development activities. Personal Digital Assistants (PDAs) and mobile phones will no longer be distinct devices and increasing number of handsets will continue to incorporate digital cameras as a standard feature [10].

4. Nigeria and the Future of Mobile Phone

The growth of mobile phone is greater in Nigeria than in any other country in the continent [15] and as such, the future looks promising much more therein than in any other place. As at April, 2002, Mobile Telephone Network (MTN) and Econet provided six hundred thousand (600,000) lines [15] and as at December, 2005, nineteen million (19,000,000) were provided by all the Global System for Mobile Communications (GSM) service providers. This number is expected to at least double in the next five years. The expected increase in the number of mobile phones users in Nigeria will culminate in more foreign investment especially in the area of handset manufacturing thereby creating more employment opportunities and boosting the economy. Few banks in Nigeria like Guarantee Trust bank (GTB) already offer mobile banking services. With the expected rise in the number of mobile phones, the expectation is that more banks will join the league of those already offering the service. This of course, will boost the income generation capacity of the different mobile networks on whose platforms the service is enabled. More corporate organizations will make use of mobile phone for advertisement as currently being done by Spring bank in connection with Globacom. There will also be a proliferation of mobile banking applications as more and more organizations register their presence in the mobile world. Tariffs competition among the various GSM networks will eventually force the price down as currently being witnessed between Globacom and MTN. Universities like Covenant University and University of Ibadan, have already introduced mobile programming curricula. More schools are expected to follow suit.

5. Conclusion

The introduction of the first-generation analogue mobile phones brought transformation into our lives though not without their limitations. The second-generation systems brought in much more transformation and high capacity services. The concentration of the third-generation network will be value-added services, service quality, system capacity and personal and terminal mobility issues. As the third-generation mobiles prepare ground for the fourth-generation, a range of new services, technologies and applications will be introduced. Convergence in terms of alliances on the part of existing players in the industry

will not be inevitable to save cost, as each one will find its market share and profit being threatened by the new entrants. Nigeria as a nation with the highest potential growth for mobile phone in Africa will not be left out of reaping the benefits of the future especially economic wise.

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