LEVERAGING MOBILE AND CLOUD COMPUTING TECHNOLOGY FOR GROWTH IN NIGERIA

A. Gokhale
Computer Systems Program,
Department of Technology,
Illinois State University, Normal,
IL 61790 USA
aagohkhale@ilstu.edu

Abstract

This paper tracks information technology breakthroughs that have impacted globalization with a focus on mobile communications and cloud computing. We begin by demonstrating the significance of mobile computing in today's culture of instant information exchange. After a brief look at the history of mobile communications and analyzing the technological improvements from one generation to the next of mobile devices and networks, we explore the trends in mobile device usage, both globally and specifically in Nigeria. A discussion of the applications of mobile communications brings us to cloud computing, which is a transforming technology. The paper discusses what is meant by cloud computing, its different usage models, and how it impacts business, government, and society as a whole, using Nigeria as an example. In closing, there is a discourse about how emerging technologies could be directed through responsible government policy for economic growth across all social strata. This leads to further investigation of this topic for entrepreneurship and sustainable development with improved quality of life for all peoples.

Keywords: cloud computing, economic growth, mobile devices, sustainable development

1. Introduction

Mobile cellular technology has been the most rapidly adopted technology in history. Today it is the most popular and wide-spread personal technology on the planet. In 2015 there were more than seven billion mobile-cellular subscriptions worldwide; and globally 3.2 billion people were using the Internet two billion of which were from developing countries (International Telecommunication Union, 2015). Pervasive computing, often synonymously called ubiquitous computing, is a field of research that explores revolutionary paradigms for computing models in the 21st century. Cloud computing has quickly emerged as a technology that is widely recognized by both industry and academia as the next-generation infrastructure; having huge implications for business, education, healthcare, government, and social development. The goal is to achieve sustainable growth as the world moves faster and faster towards a digital society.

Mobile and cloud computing technologies offer additional benefits to developing countries since they no longer have the burden of investing in costly infrastructures and can tap into data and applications that are readily available in the cloud. The aim is to reverse, slowly but surely, the marginalization of cities, neighbourhoods, or entire countries so that the human potential that is currently being wasted can be reinvested. Information and communication technologies (ICTs) are at the root of new productivity sources, new organizational forms, and the construction of a global economy. This paper addresses technology applications for

business, society, and government which include sectors like banking, agriculture, healthcare, law and order, and science.

2. Wired versus Wireless

Wired communications have been the mainstay for phones and Internet connections for decades, especially in developed countries. Weak telecommunication infrastructure in developing nations has been the main obstacle for technological development and use (Dedrick, Kraemer & Shih, 2013). The countries that have rough geographic terrains, scattered islands and isolated villages are extremely difficult to wire. However, cellular networks infrastructure has overcome these physical limitations providing connectivity to isolated people. Wired and wireless connectivity have their advantages and disadvantages.

Wired networks and devices certainly have an advantage when it comes to speed, security, and reliability (Pahlavan, 2011). Speed remains steady on hard wired connections and they also have less interference. With wireless networks, speed is highly dependent on the number of users, and one could walk in and out of the cell range, sometimes resulting in a dropped connection. Security that is built into wired networks and devices surpasses that of wireless, and the same is true of reliability.

Yet, wireless has become a first choice access method for most users primarily because of the availability of the technology, especially in rural as well as highly-populated places where wired communications are not as feasible (Goundar, 2010). In developing countries, personal computers (PCs) are not as affordable as mobile devices. As power blackouts occur very frequently in rural areas, mobile phone batteries are able to yield longer service cycles. Compared to PCs, portable phones are more convenient and better suited for roaming and rugged agriculture lifestyles. Huge proportions of the population live in rural areas where basic cellular network is prevalent. In 2012, the ratio of the sale of desktops versus mobile devices (such as tablets and smartphones) was about 1:4, which goes to show that wireless communication is the preferred mode (Tsai, Hsu & Balachandran, 2013). On an individual basis, the biggest factor that works in favour of wireless connectivity is the level of convenience, while at home or on the go.

3. History of Mobile Computing

Mobile phone technology has been continuously evolving over the last seven decades. The precursors to modern mobile telephony were first introduced in the US in the late 1940s (Agar, 2013). These early mobile phones were characterized by limited mobility, poor service, susceptibility to interference, and exorbitant cost. They required huge batteries and were unable to accommodate security codes. The First-Generation or 1G mobile networks were introduced in the 1970s based on analogue transmission systems. These systems were referred to as cellular or "cell" for short. The Second-Generation or 2G phones using Global System for Mobile (GSM) communications based on narrowband digital signals were introduced in early 1990s. Digital signals could be encoded for security, compressed, and multiplexed much more effectively than analogue voice, and the Short Message Service (SMS) or texting and email over a mobile phone became possible for the first time. An intermediary phase, 2.5G was introduced in the late 1990s which brought packet-switched data capabilities to existing networks.

The Third-Generation, or 3G phones, introduced at the start of the 21st century started delivering up to 2 Mbps and users could simultaneously use voice and data services over the Internet. One of the main objectives behind the Universal Mobile Telecommunications System (UMTS) or 3G was to standardize on a single global network protocol instead of the different standards adopted previously in the US, Europe, and other regions (Gokhale, 2004). The current generation of mobile telephony, dubbed Fourth-Generation, or 4G by the International Mobile Telecommunications (IMT)-Advanced has been developed with the aim of providing transmission rates up to 20 Mbps while simultaneously accommodating Quality of Service (QoS) features. True 4G utilizes an all-IP packet switching transmission, supported by mobile and fixed networks, as opposed to 3G which supports both packet and circuit switched data transmission. An all-IP transmission eliminates complexity of multiple protocols and facilitates integration of heterogeneous wired and wireless networks (cellular, 3G, WiFi, Bluetooth, and others). 4G applications include high-performance streaming of multimedia content like television and video.

The 4G has evolved via two standards: LTE-Advanced (Long Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access), an IEEE 802.16m standard (Raychaudhuri & Mandayam, 2012). There are significant similarities between these two standards: (1) both use Orthogonal Frequency Division Multiple-Access (OFDMA); (2) both offer full backward compatibility and interoperability; and (3) the Media Access Control (MAC) layer of both systems supports multicarrier operation and heterogeneous networks. The differences lie in how they have evolved. LTE is developed by telecom carriers and is an extension of cellular networks, which started as pure voice systems. On the other hand, WiMAX is an extension of WiFi, which was designed as a data service only, voice not being a consideration.

4. Penetration of Mobile Computing

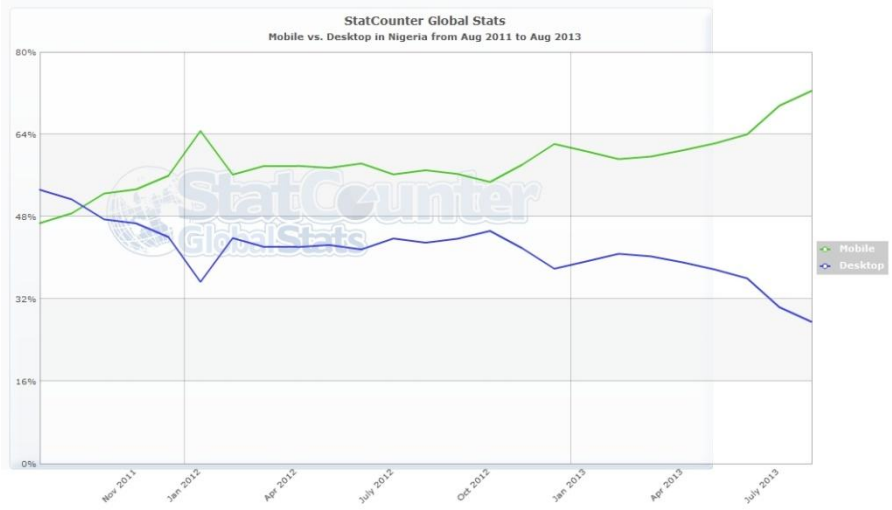
In a 2015 study, Pew Research found that 88 percent of all American adults have a cell phone — and two-thirds of those are smartphones (Smith, 2015). Similarly, cell phones and other mobile devices have penetrated and saturated developing countries. The short-term vision of the 21st century is accessing Internet services from lightweight portable devices, instead of accessing them from a traditional desktop.

4.1 Mobile Usage Statistics in Developing Countries: Nigeria as a Case Study

Nigeria is Africa's largest telecom market; a little over a decade ago there were about 100,000 phone lines in Nigeria, mostly landlines run by the state-owned telecom Nigeria Telecommunications Limited (Nigerian Communications Commission, 2012). In 2012, the ratio of mobile subscribers to fixed lines was 219:1, and total mobile subscriptions surpassed 100 million, which was 65.8 percent of the country's population (Hassan, 2012). The number of internet users on Nigeria’s telecoms networks has risen from 45 million in 2012 to 97.21 million in August 2015 according to figures released by the NCC (Premium Times, 2015). PC penetration is very low, and the mobile device has become the de facto communications device for calls, messaging, and Web access. Figure 1 (using Stat Counter) shows that in Nigeria, mobile device usage overtook desktop usage in 2011 and the gap has since increased with desktop use dropping significantly in 2013.

Across the rest of the continent the trends are similar: between 2000 and 2010, Kenyan mobile phone subscriber base increased more than 500-fold (Aker & Fafchamps, 2013). In 2010 alone the number of mobile phone users in Rwanda grew by 50%, based on figures

from the country's regulatory agency. People are using mobile devices not just to make calls, but to send and receive text messages, check email, surf the web, take pictures, and more.



The power of mobile devices is enhanced by apps, which continue to rise in number and popularity. At the same time, mobile devices are facing many challenges with respect to battery life, storage, bandwidth, and security. Enter cloud computing. This technology allows users to use infrastructure (e.g., servers, networks, and storage), platforms (e.g., operating systems), and software (e.g., application programs) that do not reside on the user's device but rather outside, minimizing mobile device computing power and storage requirements.

5. What is Cloud Computing?

According to the National Institute of Standards and Technology (Mell & Grance, 2011), cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Gartner defines cloud computing as a style of computing where scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies (Plummer, Bittman, Austin, Cearley & Smith, 2008). The cloud concept draws on the existing technologies such as virtual computing, cluster computing, and distributed computing, which are integrated and shifted from a localized processing unit to a globalized network.

Many industry pundits are predicting that the cloud will surpass the Internet as a universal communications infrastructure (Ayanso, Cho & Lertwachara, 2013). One of the limitations of the Internet is its dependence on web browsers and computers for connectivity and service. The evolution of mobile computing from 2G to 3G and now 4G has enabled the providers to build simple interfaces into mobile devices; once connected, the cloud service provider's processing power, storage capacity and computing resources become available to the user. The technology will enable companies or organizations to host their services without worrying about IT infrastructure at the user-end. The apps enable interaction with

users via mobile phones, tablets, laptops, and other mobile devices. The term "app" has become popular, and in 2010 was listed as "Word of the Year" by the American Dialect Society. There are many statistics regarding cloud computing ─ Gartner estimated the cloud market at USD$150 billion in 2013 and it is predicted that the public cloud infrastructure, platforms, and applications market is growing much more quickly than any other type of IT market (Hill, Hirsch, Lake & Moshiri, 2013).

5.1 Cloud Computing Usage Models

There are three basic usage-based cloud computing models:

1. Software as a Service ─ SaaS makes software and web applications available, without the burden of purchasing and installing in specific machines. Users pay only for whatever they use for a specific duration, against the traditional way of buying and paying for the full application.
2. Platform as a Service ─ PaaS provides clients computing platforms for developing applications, and associated storage for hosting those applications.
3. Infrastructure as a Service ─ IaaS includes all components of a computer network.

Every time there is a major advancement in IT, there is usually a corresponding change in the competitive edge. With cloud computing, there is potential for a significant narrowing of the IT competitive edge gap between developed countries and developing countries since all aspects of computing, including infrastructure has become available globally. The rise of mobile phone technology in African and Asian countries combined with strategic approaches to leverage cloud computing could narrow the digital divide.

6. Mobile and Cloud Computing Technology

With the explosive growth in mobile applications, platforms and end user demands, limitations at the mobile device end significantly impede further improvements in application QoS. Limitations include metrics like computation ability, storage capacity, energy, and shared wireless medium. Typical measures of QoS include user experienced delay, service reliability/availability and information privacy. Mobile Cloud Computing (MCC) aims to overcome these limitations by integrating cloud computing into the mobile environment to enable mobile users and mobile application providers to elastically utilize resources in an on-demand fashion.

Specifically for Nigeria, there is currently a high degree of enthusiasm for cloud computing among businesses and government and non-government agencies. MCC is regarded as the next big revolution to happen in Nigeria, after the telecommunication industry stormed the country in the early 2000 (Dogo, Salami & Salman, 2013). However, there still remain major challenges to its full adoption in Nigeria; these include ownership and security of data and information on the cloud, internet availability, unstable power supply, policy implications arising from implementing cloud services, litigations and legislation on data ownership in the cloud and infringement rights, interoperability, and international legislation (Muhammed, Isma'il Zaharaddeen & Turaki, 2016).

6.1 Leveraging MCC for Business

We cannot ignore the huge potential of technology to leverage business operations or how these operations can foster the development of home-grown technology to meet the needs of both business and customer. Let us demonstrate this with a simple example. Business

registration is increasingly recognized as an important gateway for entrepreneurs into the formal economy. Through formal business registration, they can benefit from increased rights, such as access to government services, fair treatment under the law, and limited personal liability (in many cases). Registered enterprises also have opportunities to grow through improved access to finance and through potential clients in the formal economy and government. Formalization also involves increased obligations, including compliance with tax laws as well as regulatory and information disclosure requirements. Empirical evidence has shown that significant reductions in the time and costs required to register a business can have a material effect on new registrations (Yahr, 2014). Deploying mobile apps to increase efficiency and transparency by reducing the time and effort required for business registration and associated procedures would reduce corruption and promote lawfulness among entrepreneurs and government employees.

The next question is for businesses themselves: how to leverage information across the organization to make the right business decisions and create differentiation for the organization? Effective technology would provide a platform to manage business operations and reduce costs.

6.2 Leveraging MCC for Society

Technological growth, if not carefully managed could challenge the fabric of societies and erode social cohesion from rising socio-economic disparities within and between countries (Castells, Caraça & Cardoso, 2012). If businesses and countries compete on the basis of worsening the conditions of work and concentrating as much of the wealth as possible in a few hands, they will kill incentives for most workers to invest their own mental capital in a collective undertaking, slow down the learning curve, and restrict both purchasing power and the drive towards innovation. Such a rise in informational capitalism could result in the growth of social exclusion and human despair that would be socially unsustainable.

6.2.1 Focus on Education

Education is one of the primary enablers for development across all socio-economic groups. Easy access to learning resources with opportunities for collaboration, both locally and globally are changing the education paradigm. Today's students born between 1978 and 2000, referred to as the “Net Generation,” or “Millennials,” are the largest generation (Greenberg & Weber, 2008). The first generation to be raised on cell phones and Internet, Millennials or digital natives are always connected and have little tolerance for delays (Elliott, 2013). Here are some general traits: digital technology is a given; multi-tasking is common; and attention span of students is declining. Assumptions about the Millennials’ tech-savvy nature are driving curriculum decisions, teaching approach, learning theories, and even workplace expectations.

Educational institutions have been quick to realize the needs and desires of the Millennials and have been implementing technology in various ways:

- Wireless-access throughout campuses enables students to access data anywhere, anytime;
- Publishing information online and streamlining procedures like application, admission, registration, and class enrolment in an e-environment provides global access to institutional resources; and

- Online classes or Massive Open Online Courses (MOOCs) provide students flexibility and fit well with the digital culture.

Yet, all students do not conform to this tech-savvy model.

Let us pause and ask the question: are all Millennials ready for self-motivated technology-driven learning? For example, Stanford University's MOOC Introduction to Artificial Intelligence was subscribed by 160,000 students from 190 countries. Of these, only 23,000 reportedly completed the course, which is 14.3%. Is this an acceptable passing percentage for a traditional class (Cobb, 2013) ? MOOC may be more appropriate for knowledge-seeking students demonstrated by MITx Open Course Ware, which averages one million visits a month. When asked about the purpose for using the site, "enhance personal knowledge" ranked at the top of the list.

Recent studies of the Net Generation highlight their desire for hands-on and participatory learning. MCC enables a learner-centred environment that appeals to the Millennials who often seek information and knowledge online and like idea of constructing knowledge within a social community.

Nigeria as a nation has recognized the potential of ICT in her educational system (Agbetuyi, & Oluwatayo, 2012). The 2004 Nigerian National Policy on Education emphasized three major objectives: (1) empower youths with ICT skills to prepare them for competitiveness in a global environment; (2) integrate ICT into the mainstream of education and training; and (3) establishment of multifaceted ICT institutions as centres of excellence in ICT. This policy promoted a shift to a learner-centred environment, which has resulted in improving the quality of education and training by increasing learners' motivation and engagement, and facilitating the acquisition of basic skills.

6.2.2 Focus on Healthcare

In addition to education, healthcare is primary to society. Driven by technology, the healthcare model is changing, from doctor-centric to patient-centric and from acute reactive to continuous preventive (Doukas, Pliakas & Maglogiannis, 2010). Developing countries have higher poverty rates, a larger percentage of population in poorer health, and have fewer doctors, hospitals, and other health resources. Many medical errors occur due to a lack of correct and complete information at the location and time that it is needed, resulting in wrong diagnosis and drug interaction problems. The required medical information can be made available at any place, at any time using distributed networked and mobile healthcare systems.

Healthcare system in Nigeria is moving towards digitalization, especially in the management of patients' health information, with a view to harmonizing medical care practice for improved healthcare quality (Adeleke, Salami, Achinbee, Anamah, Zakari & Wasagi, 2015). The authors recommend that going forward, to evolve better electronic healthcare environments, which tend to evolve an improved healthcare quality, it is important that hospitals and other healthcare facilities organize specific and intensive ICT training for their employees and make necessary infrastructures available for the implementations. MCC can be utilised for such training, and host medical information and similar resources that healthcare providers can draw on in the course of their work.

6.3 Leveraging MCC for Government

Technology, and in particular mobile and cloud computing which provide global connectivity and infrastructure, can be used to improve governance and enable efficient and effective public services for large numbers of people around the world. Access to services has become a key international development issue and improved proficiency in the use of ICT has been recommended as one way to improve access. Governments typically oversee special sectors like agriculture and energy, and many have adopted e-government policies. Let us first discuss the role of government in empowering agriculture and next address the status of e-governance in Nigeria.

Modernization of agriculture include three aspects: (1) wide use of modern agricultural machinery; (2) extensive use of latest agricultural planting and breeding technologies, including weather observation and forecasting; and (3) implementing effective organization and management methods (Cho, Cho, Shin, Park & Lee, 2012). The U.S. or other developed countries use significantly sophisticated technologies in agriculture but developing countries are far behind in the technological race. Although agricultural mechanization has been achieved in many developing nations, there are outstanding issues in technology and management. Governments of developing countries should deploy MCC technologies for integration of resources, information sharing, and decentralized management.

According to Abdulkareem (2015), in 2000, Nigeria adopted a policy of e-government to improve governance and promote efficiency as well as effectiveness in the delivery of public services. The author found that despite the government making huge investments in the ICT to realize the objectives stated in the policy document, minimal progress has been achieved. The lack of massive success can be attributed to infrastructural gap, power failure, digital divide, low ICT literacy level, theft and vandalism of ICT equipment, privacy and security.

A synergistic model that integrates government, social development, and economic growth through technological innovation will protect, empower, and ensure equality for all socio-economic groups. A more inclusive society enjoys good health, decent housing, psychological stability, and cultural fulfilment; in other words, a multidimensional improvement in the quality of life. Human development should be viewed as a creative process that is shaped by society itself, rather than as the product of a combination of external factors.

7. Conclusion

Anytime anywhere access to information characterizes information systems in the 21st century enabled by rapidly improving wireless communications. Until recently, IT infrastructure was a significant barrier for integrating technology into business, education, government, and social services. This could be due to lack of, or unaffordable electricity and broadband connections in the remote regions of developing countries. With the ubiquity of mobile devices and advent of cloud computing, technology adoption and usage has become a reality for users on both sides of the digital divide.

Going forward, trust is a key challenge for cloud services in business, government, and societal affairs. Companies can capture a great volume of structured and unstructured data from multiple sources such as customer searches, preferences, order history, social networking sites, and online records. Equipped with sophisticated sensors and advanced

computing hardware, phones can be used to infer user's location, activity, social setting, and more. As devices become increasingly intelligent, their capabilities evolve beyond inferring context to anticipating it. The huge worldwide mobile-phone penetration is increasingly turning the mobile network into a gigantic ubiquitous sensing platform, enabling large-scale analysis and applications (Hoteit, Secci, Sobolevsky, Pujolle & Ratti, 2013).

The technology services must not only meet end-user expectations about availability, but more importantly about privacy and intellectual property rights. The government will play an increasing role in legislation associated with MCC technologies. Legal aspects of technology services, negotiation of contracts, and compliance of MCC services with national and international law are all new areas of research with a lot of unknowns.

8. Future work

Finally, here is some food for thought, something we could ponder on: Humans continuously seek to innovate and control technology development and use, but upon profound reflection we will find instances when technology has controlled human development. This paper has addressed information technology breakthroughs that have impacted our way of life and created generational differences. How has technology affected our holistic quality of life? How have cultures adapted technology differently and thus produced different outcomes? Can we direct our innovative and creative tools to promote entrepreneurship and carve technologies to produce the desired changes in society? These stimulating questions set the stage for intellectual discussions by researchers and topics for future research.

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