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4G NETWORKS: BENEFITS AND CHALLENGES

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ABSTRACT

The next generation of wireless communication technology known as fourth generation (4G) allows operators to use new and wider spectrum and supplements third generation 3G and 3.5G wireless technologies with higher user data rates, lower latency and a complete internet protocol(IP) base network architecture. The purpose of this paper is to provide an overview of the different aspects of 4G which includes its features, its proposed architecture, key technological enabler, it benefits over existing wireless communication system, present key challenges and point out some proposed solutions. This research paper explains the concept of multimode software for maintaining different networks, along with the mechanisms of system initiated discoveries. User account management, which is a challenge, has been discussed. The paper describes the concept of security that should be given attention. The paper vividly highlight some benefits of 4G networks to wireless mobile communication as well as 4G network standards.

Keywords: *Wireless, Communication, Mobile, 4G Networks, Multimode*

INTRODUCTION

The next generation of wireless communication technology known as fourth generation (4G) allows operators to use new and wider spectrum and supplements third generation 3G and 3.5G wireless technologies with higher user data rates, lower latency and a complete internet protocol(IP) base network architecture (Shin, Ma, Mishra, & Arbaugh, 2006). The existence of 4G Networks in today's technology driven culture is an important indicators of advancement

and change to achieve great results. Fourth generation networks (4G) are designed to facilitate improved wireless capabilities, network speeds and visual technologies to place us in a position of important fields like military, telecommunications, health-care and so on. Information technology in hands with the telecommunication and wireless communication industries have taken a giant stripe with the introduction of 4G technology in the new era of technology based scenario. Next to the much used 2G and 3G network technologies, the 4G network technology consists of the entire required standards of the previous generations of networks with advanced modifications and alteration (Savo, 2002). In a fourth generation (4G) environment, a mobile node is equipped with multiple interfaces and it will be able to handover seamlessly between heterogeneous networks to guarantee the continuity of an ongoing application session. In order to make seamless handover possible, future network devices should be capable to roam freely across various access technologies such as wireless local area networks (WLANs), WiMAX networks, cellular systems, etc (Akyildiz, Xie & Mohanty, 2004). The 4G has been developing with the aim of providing transmission rates up to 20 Mbps while simultaneously accommodating Quality of Service (QoS) features (Hui & Yeung, 2010). The goal of 4G will be to replace the entire core of cellular networks with a single worldwide cellular network completely standardized based on the IP for video, packet data utilizing Voice over IP (VoIP) and multimedia services (Hui & Yeung, 2010). The newly standardized networks would provide uniform video, voice, and data services to the cellular handset or handheld Internet appliance, based entirely on IP. 4G systems will be deployed with software defined radios, allowing the equipment to be upgraded to new protocols and services via software upgrades. It is not a system designed from scratch nor it offers completely new technical solutions. 4G is more a concept whose major goals are integration and convergence. The integration should offer seamless interoperability of different types of wireless networks with the wireline backbone. This 4G or Fourth generation is that the future technology for mobile and wireless communications. Close to 4G deployments are expected to be round the year 2010 to 2015. Nowadays, some corporations have started developing the 4G communication system, this technology can have a high transmission rate up to 200Mbps, a lot of information will transfer within the mobile .4G networks are designed to be heterogeneous networks, which permit users having integrated devices to access property anyplace and everyplace. The expectation for the 4G technology is essentially the top quality audio/video streaming over finish to finish net Protocol (Chavan & Mane, 2013).

Key features of 4G wireless networks are as follows:

• Autonomous network
• Software Independence
• Fully coated service
• Scalability
• Interoperability and simple roaming

II. EVOLUTION/BACKGROUND OF 4G NETWORKS

The development and augmentation of 4G Networks and related technologies in today's scenario is imperative indicator of advancement in the field of wireless communication and technology. This progress started back from 1970s when the expertise just learnt how to crawl on the path of development with the evolution of basic first generation networks.

Figure 1: Different Generations of Network. Source: (Rawat, 2012)

1G or the first generation wireless networks were based on analog technology, designed in 1970s (Fleck, 1999).This generation used the basic cellular structures and architectures for the purpose of mobile communications. After the first step of 1G in the path of progress, the second step was of the 2G or second generation networks which marked a transformation from the analog technology of 1G to the digital technology using digital signals. 2G networks made digital communications possible at low speeds with the introduction of GSM (Global Mobile System), TDMA (Time Division Multiple Access), PDC (Personal Digital Cellular) and CDMA (Code Division Multiple Access). Then came 2.5G and 3G in the 1990s with higher qualities of services and better communication speeds. 2.5G acted as an interim between the 2G and the 3G services. After the facility of 3G of providing higher data rates for fulfilling the data demanding needs of users, the new leap in the telecommunication industry is that of 4G

(Burucchini, 2000). The first operating 4G Network was established by Clearwire and Intel in Portland, Oregon in January 2009, marking the beginning of a new era. 4G has much promises and expectations to keep.

The 4G Network process requires a unique approach to developing effective models for strategic purposes. The necessity for 4G networks is associated with the increased utilization of data websites such as You Tube and Facebook, which require tremendous bandwidth in order to be use successfully (Jackson, 2009). Because these websites are becoming increasingly popular amongst the general public, it is more important than ever for telecommunication providers to develop opportunities to accommodate the needs of their consumer's population. Consumers have come to depend on different sources of data as a source of entertainment and for convenience. Therefore, it is important that organizations such as Verizon and AT&T continue to identify areas where technological improvements are required. In January 2009, the first operating 4G Network was established by a joint venture between Clearwire and Intel, which reflected an opportunity for residents and businesses in Portland, Oregon to "connect wirelessly anywhere in Portland at true broadband speeds" (Al-Muhtadi, Mikanus & Campbell, 2002). However, with the technology quickly approaching a widespread rollout, many cities, states, and countries will soon possess similar capabilities, as consumers and businesses alike will be provided with different opportunities to expand their networks and interfaces with advanced capabilities. Furthermore, it is evident that the Clearwire strategy is not without its disadvantages, and additional efforts must be made to overcome any technology-related problems that might persist before a widespread rollout is even considered.

BENEFITS/OPPORTUNITIES OF 4G NETWORKS

In general, it is believed that the existence of the 4G network is designed to facilitate the development of a superior alternative to the existing 3G strategy in terms of quality and data transmission speed. For developers of 4G Networks, there is a great dependence upon advanced technologies and increased speed in order for the network to be a success. It is known that in terms of the 4G Network, "it requires substantial improvements to multimedia messaging services, including video services, in order to approve a new generation. It wants a data speed transfer rate of at least 100 megabits per second while a user is physically moving at high speeds and a one gigabit per second data rate in a fixed position" (Eguchi, Nakajima & Wu, 2002). From this perspective, it is important for the new data network to meet the expected

demand of the consumer and of different industries, which have come to depend upon high-speed data networks with minimal interruptions for a variety of needs.

4G Network Standards

The International Telecommunication Union (ITU) named the International mobile Telecommnication-2000 (IMT-2000) as a global standard for 3G wireless communications in previous time but later went further to improve the initiative by introducing IMT-Advance which is considered as the specification for 4G wireless (Leo, Kai & Liu, 2011). The objective of IMT Advance stated that 4G wireless technology must support the following:

1) High data rate (1Gbps peak rate for low mobility and 100Mbps peak rate for high mobility).
2) High capacity.
3) Low cost per bit.
4) Low latency.
5) Good quality of service (QOS).
6) Wider coverage.
7) Mobility support at high speeds.

Benefits/Opportunities of 4G networks

A. Cost and Affordability

In terms of 4G Network cost and affordability, there are a number of issues to consider that reflect some degree of risk, as well as opportunity, so that these networks are successful once rolled out to the general public, and in general, 4G Networks are designed in order to create an environment that supports high-speed data transmission and increased profit margins for organizations that utilize these capabilities (Accenture, 2009). Developing a successful 4G Network platform is a positive step towards the creation of a wireless and broadband environment that possesses rapid transmission speeds, data integrity modules, and other related events that encourage users to take additional risks in promoting successful utilization of these 4G tools.

B. Capabilities and Features

Although the 4G Network platform is not brand new, many telecommunications providers have not yet developed their own alternatives that will support this network in full. Therefore, 4G -related products are still in the development phase, with additional products to be

developed and rolled out on a periodic basis. With the creation of these alternatives, it is likely that 4G Networks will continue to expand their scope and promote their own brand of personalization for consumers that seek these types of alternatives (Stefano & Santoro, 2000). In general, the possibilities associated with 4G Networks are endless, as high-speed data transmission and associated capabilities are more feasible than ever. This supports the notion that the demand for more complex networks and related capabilities are stronger than ever, as a greater number of consumers continue to buy into the potential that exists with advanced networks, such as 4G.

The goal of 4G is to allow everyone to access the Internet anytime and anywhere. The provided connection to Internet will allow users to access all type of services including text, databases, and multimedia. 4G, unlike 3G, is IP based, that is every user connected to the Internet will have an IP address. This feature makes it easier to integrate the infrastructure of all current networks and consequently will be much easier for users to access services and applications regardless of the environment. 4G network will also provide higher bandwidth, data rate, lower authentication overhead, and will ensure the service is constantly provided to the user without any disruption. Another key feature of 4G networks is high level of user-level customization. That is, each user can choose the preferred level of quality of service, radio environment, etc. Accessing 4G networks will be possible virtually by using any wireless device such as PDAs, cell phones, and laptops. Figure 2 illustrates elements and techniques to support the adaptability of the 4G domain.

Figure 2: 4G will allow everyone to access the Internet from everywhere using almost any wireless device.

Benefits of 4G networks to Wireless Mobile Communication

Some key benefits of 4G network to mobile communications are as follows (Akintoye, 2013):

a). User friendliness: 4G aims at providing myriad of services to the end users at high speed. The applications developed to avail these services should be highly user friendly minimizing the interaction between the application and the user.

b). User personalization: High data transfer rates and ubiquitous coverage of 4G networks would provide users access to large repository of data and services. Users should have flexibility to filter these data and services as per his preferences by configuring the operational mode of their devices, so that he can preselect the service features he wants to use.

c). High Performance: Low transfer rates of 3G restrict the user's ability to take advantage of the rich multimedia contents across the wireless networks. 4G is expected to provide wireless download speeds of about 1Gbps in local area network (LAN) and 100 Mbps in wide area network (WAN), about 260 times greater than the 3G wireless networks.

d). Interoperability: Multiple standards of 3G restrict the user's mobility and interoperation across different networks. 4G targets at providing a unified global standard which will facilitate global mobility and service portability. In other words, end user can subscribe to different services from different service providers using the same mobile device.

e). Scalability: Scalability in mobile networks is the ability to handle the increasing numbers of users and services. 4G will use IPv6 addressing scheme which will support large number of wireless devices eliminating the need for Network address translation (NAT). NAT is technique of sharing limited number of addresses among large number of devices. The huge expanse of current internet world signifies the scalability support of IP. Thus, the use of IP as core network layer will make 4G easily scalable.

f). Lower power consumption: Battery technology has not been able to keep pace with the growing telecom industry. 2G devices required one battery while 3G required two batteries. Battery drain is a persistent problem of wireless devices. 4G aims at breaking this directly proportional rule. Shorter communication links is one of the few solutions proposed to cater to this requirement.

g). Intelligent Networking: 3G is based primarily on cell or base station WAN design. 4G aims at building hybrid networks utilizing both the Wireless LAN concept and WAN design. Thus, the world would have base stations everywhere providing ubiquitous network coverage to

users at high speed. For example, a user walking on road is browsing internet using GPRS (General Packet Radio Service–WAN design). The moment he enters a mall with Wi-Fi (LAN design), seamless hand-over from GPRS to Wi -Fi would take place without the user's knowledge.

CHALLENGES/POSSIBLE SOLUTIONS

A. Security and Privacy

In the development of 4G Networks, security measures must be established that enable data transmission to be as safe as possible. Specifically, "The 4G core addresses mobility, security, and QoS through reuse of existing mechanisms while still trying to work on some mobility and handover issues" (Buracchini, 2000). Therefore, it is necessary for the organization to develop an effective series of tools that support maximum 4G security measures as a means of protecting data that is transmitted across the network from hackers and other security violations. Because of the nature of the 4G network, there is an increased likelihood of security attacks, and therefore, multiple levels of security, including increased requirements for authentication, will be necessary to protect data and information that is transmitted across the network (Buracchini, 2000). One of the main goals of 4G networks is to cover a very wide geographic area with seamless service. Obviously, smaller local area networks will run different operating systems. The heterogeneity of these wireless networks exchanging different types of data complicates the security and privacy issues. Furthermore, the encryption and decryption methods being used for 3G networks are not appropriate for 4G networks as new devices and services are introduced for the first time in 4G networks. To overcome these security and privacy issues, two approaches can be followed. The first is to modify the existing security and privacy methods so that they will be applicable to heterogeneous 4G networks. Another approach is to develop new dynamic reconfigurable, adaptive, and lightweight mechanisms whenever the currently utilized methods cannot be adapted to 4G networks (Montavont & Noel, 2002).

B. Quality of Service

With respect to network quality, many telecommunications providers are promising that there will be enhanced connectivity, and the quality of data that is transmitted across the network will be of the highest possible quality, as in the case of Ericsson's 4G Network for TeliaSonera (Fleck, 1999). The company promises that "The new 4G network will do for broadband what mobile telephony did for voice. With real-time performance, and about 10 times higher data

rates compared to today's mobile broadband networks, consumers can always be connected, even on the move " (Fleck, 1999). As a result, it is important for providers to develop an effective approach to the 4G Network that will enhance quality, provide effective security measures, and will ensure that all users are provided with extensive alternatives for downloading video, music, and picture files without delays. The main challenge that 4G networks are facing is integrating non-IP-based and IP-based devices. It is known that devices that are not IP address based are generally used for services such as VoIP. On the other hand, devices that are IP address based are used for data delivery. 4G networks will serve both types of devices. Consequently, integrating the mechanisms of providing services to both non-IP-based as well as IP-based devices is one of key challenges 4G networks have to address (Taylor, 2009), (Tipper, Dahlberg, Shin & Charnsripinyo, 2002).

C. Complex Architecture

a). Multimode End-User Terminals:

To reduce operating costs, devices that operate on 4G networks should have the capability to operate in different networks. This will not only reduce the operating cost but will also simplify design problems and will reduce power consumption. However, accessing different mobile and wireless networks simultaneously is one of the major issues 4G networks have been addressing. One mechanism that has been proposed to handle this problem is termed "multi-mode devices". This mechanism can be achieved through a software radio that allows the end-user device to adapt itself to various wireless interfaces of the networks. Figure 3 shows an example of such solution.

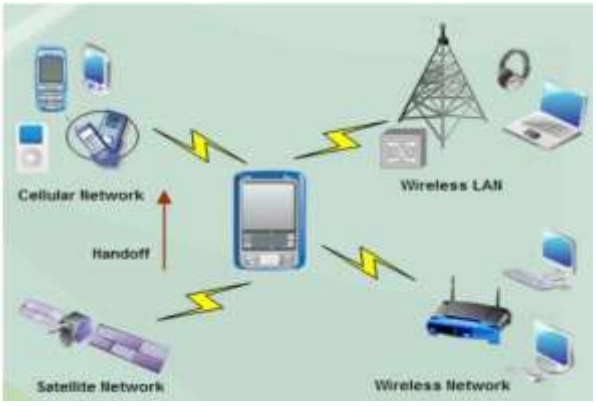

Figure 3: Accessing multiple networks and services through multi-mode software

b). System Discovery and Selection:

Due to the heterogeneity of 4G networks, wireless devices have to process signals sent from different systems, discover available services, and connect to appropriate service providers. Various service providers have their own protocols which can be incompatible with each other as well as with the user's device. This issue may complicate the process of selecting the most appropriate technology based on the time, place and service provided, and thus, may affect the Quality of service provided to the end user.

One solution to resolve this issue is called "System-initiated discoveries". This mechanism allows automatic download of software modules based on the wireless system the user is connected to (Lyle, 2009). Another approach to handle this problem is based overlay networks. In such case, the end-user device is connected to different networks through an overlay network. The overlay network performs all necessary tasks such as protocol translation and Quality of service negotiation as depicted in Figure 4.

Figure 4: Automatic system discovery is one of the features provided by 4G networks.

c). Service and Billing:

Managing user accounts and billing them has become much more complicated with 4G networks. This is mainly due to heterogeneity of 4G networks and the frequent interaction of service providers. The research community addressed this concern and proposed several frameworks to handle the customers' billing and user account information (Ghys & Vaaraniemi, 2003), (Higgenbotham, 2008)

CONCLUSION

This paper present 4G networks benefits and challenges with some possible solutions. 4G wireless networks not only enable more efficient, scalable, and reliable wireless services but also provides wider variety of services. These opportunities come with a need for rethinking our security, privacy; architecture and billing technologies have been used for previous generations. Its believe however, that future research will overcome these challenges and integrate newly developed services to 4G networks making them available to everyone, anytime and everywhere. 4G technology offers high data rates that will generate new trends for the market and prospects for established as well as for new telecommunication businesses.4G networks, when tied together with mobile phones with in-built higher resolution digital cameras and also High Definition capabilities will facilitate video blogs. After successful implementation, 4G technology is likely to enable ubiquitous computing, that will simultaneously connect to numerous high date speed networks offers faultless handoffs all over the geographical regions. Many network operators possibly utilize technologies for example; wireless mesh networks and cognitive radio network to guarantee secure connection and competently allocates equally network traffic and bandwidth. Today's wired society is going wireless and it has a problem. 4G is the answer.

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