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Comparative Study of Wireless Network Technologies

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Abstract **- In today's Internet era everything has gone wireless. The world has shifted its paradigm from long cables to no cables at all. Starting from the scratch to today's latest approach under talks, this paper summarizes the course of wireless or Wi-Fi (as we know it now) evolution along with its architecture, advantages and disadvantages. Ultimately it also provides the latest 5G Now approach that is under research and testing which will revolutionize the internet era. It is expected to provide us speed and more robust transmission techniques than ever.**

Keywords: Internet, Wireless, Wi-Fi, Telecommunication, Networks, 5G Now

I. INTRODUCTION

This paper primarily talks about the evolution pattern of the wireless technology in computer networks since the time it was first introduced. Architectural and practical details of each stage of the evolution are discussed with their merits and demerits. The paper eventually focuses on the latest technology: 5th Generation, which is currently at the stage of 'premature implementation' in the United States of America and certain European nations. The LTE and LTE-Advance is an internationally accepted standard for the 4th Generation and above; in this paper we make a significant criticism of the LTE paradigms by scrutinizing its strictness of two properties of the physical wave: Synchronization and Orthogonality.

II. 2G NETWORK

A. *Introduction:*

2G, the abbreviation of second generation wireless telephone technology, was established by Radiolinja in Finland in 1991 on the GSM standards. It revolutionized the wireless telephone technology with some of its key first time seen features. It provides digitally encrypted phone conversations, more efficient spectrum allowing higher penetration level for cellular devices and also introduces data services like text, picture and multimedia messages..

In Figure 1 there is an assumed intermediate Layer 2 POP, and there are rings in the pre-aggregation part of the network. If we consider the Cisco Resilient Ethernet Protocol topology control in the pre-aggregation layer, the MPLS/IP RAN built over Ethernet-bridged infrastructures (physical fiber rings or microwave rings) can rely solely on the Layer 2 topology protection. This means that the Layer 2 protection scheme will automatically provide protection for the Label Switched Path (LSP) and ATM/TDM pseudo wires. Because we are relying on Layer 2 convergence techniques, we can build the MPLS/IP RAN on static routes between cell site routers and the aggregation nodes. Static routes are only required between the cell site routers and the aggregation nodes to enable the MPLS LSPs and the PWE3 segments.

B. *Architecture*

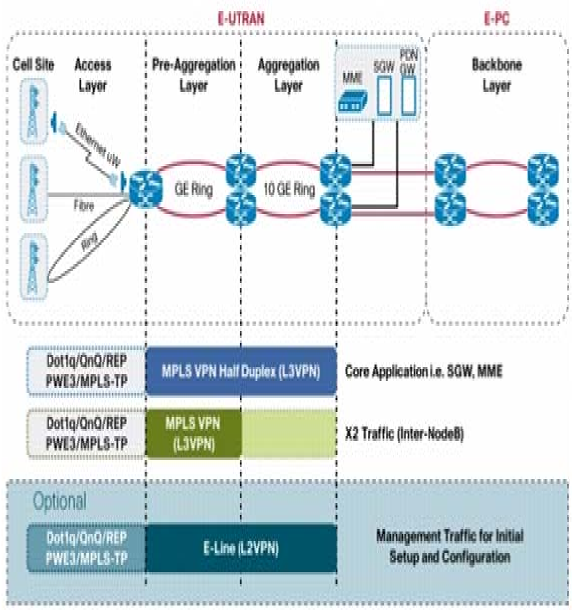

Figure 1: 2G Network Architecture

C. *Transmission rates*

When used with GPRS, it give a max. speed of 50 kbits/s.

When used with EDGE, it give a max. speed of 250 kbits/s.

D. *Advantage*

Generally the digital cells are free from static and background noise but due to the lossy compression used, it reduces the quality and hence the range of sound that it conveys is reduced. In a voice call, the person does not hear the actual tone of the caller.

E. *Disadvantages*

In areas where population is sparse, the weaker digital signal may not be transmitted to the cell tower by a cellular phone. This is a common problem when 2G systems are deployed on higher frequencies whereas when deployed on lower frequency it mostly does not interfere much.

Digital signals have a jagged steppy curve in comparison to analog's smooth decay curve, which can serve as a boon and curse also. When the conditions are good, the digital sound better. On the other hand when they are rough there will be occasional dropouts.

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III. 3G Network

A. *Introduction:*

3G, the abbreviation of third generation wireless telephone technology is based on the set of standards established by International Mobile Telecommunications - 2000 (IMT 2000) for mobile devices and telecommunication use services. It is more robust, secure and provides higher data transmission rates. It also finds applications in various sectors.

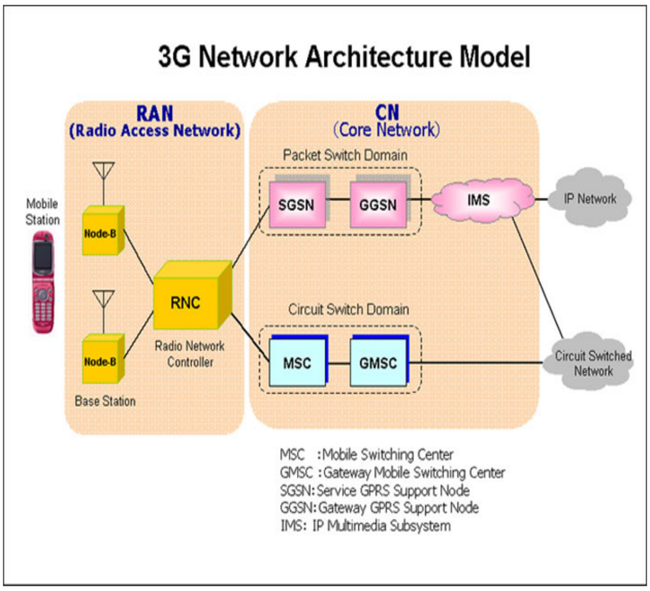

Figure 2: 3G Network Architecture

B. *Architecture*

In the transition from 2.5G to 3G, only the RAN portion of the network is required to be upgraded. The upgrade from 2.5G GERAN to 3G UTRAN, denoted by red in Figure 2, involves replacing all BTS with Node B network elements and replacing all BSC with RNC network elements. 3G UMTS reuses the previous generation circuit switched infrastructure for voice applications (MSC, HLR/VLR) and also reuses the 2.5G GPRS packet switching infrastructure (SGSN, GGSN) for packet data applications. Thus the Core Network is not required to be upgraded.

It should be noted that the sheet amount of data expected to traverse the 3G infrastructure will increase substantially. As a result, the transport capacity of the RAN backhaul, connecting the remote cell site nodes (BTS, Node B) to the central site nodes (BSC, RNC), may require an upgrade. Bonding multiple T1/E1 lines using ATM IMA (Asynchronous Transfer Mode Inverse Multiplexing) is a common approach to upgrading the RAN backhaul network for 3G networks.

C. *Transmission rates*

Stationery User Equipment (UE) provided with speeds upto 2 Mbit/s and moving UE is provided with 384 kbit/s. In India, user is expected to receive a min. of 2 Mbit/s to max. of 28 Mbit/s.

D. *Advantages*

It uses Internet Protocol (IP) connectivity which provides more reliable and secure channel for traffic transmission. There is an ease of interoperability among service providers. The overcrowding is relieved.

E. *Disadvantages*

It has a high power consumption and also does not suit the pocket with its high cost. It also requires proximity to base station. The base stations are required to be closer which are expensive and hence adds more to the cost.

F. *Applications of 3G*

Table 1

Mobile TV
Video on Demand (VoD)
Video conferencing
Telemedicine
Location-based services
Global Positioning System (GPS)

IV. 4G Network

A. *Introduction:*

4G, the abbreviation of fourth generation wireless telephone technology i.e. mobile telecommunications technology is the predecessor of 3G. It not only provides usual services of 3G system but also provides additional services of mobile ultra-broadband Internet access, like laptops with USB wireless modems, Smartphone's etc.

The first 4G system was deployed in Korea in 2006 under Mobile WiMAX standard and the first-release, Long Term Evolution (LTE) standard was deployed in Norway and Stockholm, Sweden since 2009. In March 2008, the International Telecommunications Union – Radio communication Sector (ITU-R) established a set of requirements for 4G standards, naming it International Mobile telecommunications Advanced (IMT-A). 4G supports Internet Protocol (IP) unlike others which support traditional circuit switched telephony service. Spread Spectrum radio technology which is used in 3G is given up in 4G and replaced by OFDMA multi carrier transmission and other frequency domain equalization (FDE) schemes to achieve high bit transfer rates.

B. *Architecture*

In the RAN, the 3G Node B network elements are replaced with 4G Node B. Notice that 4G RAN (aka LTW) has a simpler architecture and consists of a single hierarchy containing only Node B elements. Some of the features normally implemented by the 3G RNC have been pushed down into the Node B, and some of the RNC features have been brought into the 4G Serving Gateway or into the Mobility Management Entity (MME).

In the Core Network, the entire infrastructure needs to be replaced. The older 3G network is an overlay network, with separate and distinct equipment handling only voice circuir switching and distinct equipment handling only packet data. In addition, by historical development, the 3G GPRS Core Network is largely based on ATM technology. The architecture for the 4G Core Network (aka EPC) is specified to be a simplified and flatter "all-IP" network, with all applications - voice, video and data - running over this common IP network. Thus the migration from 3G to 4G requires completely new infrastructure equipment in the Core Network

Figure 3:Wireless Network transition from 3G to 4G

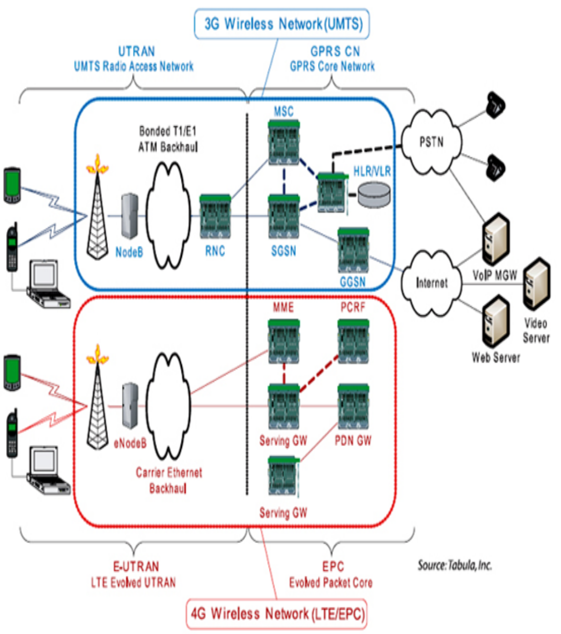

Figure 3: 4G Network Architecture

C. *Transmission rates*

Table 2

	Data speeds of LTE Advanced
LTE Advanced	
1 Gbit/s	Peak download
500 Mbit/s	Peak upload

Table 3

	Data speeds of LTE
LTE	
100 Mbit/s	Peak download
50 Mbit/s	Peak upload

D. *Advantages*

It is based on Internet Protocol based mobile system. It provides high speed, high capacity and low cost per bit. It also has global access, seamless switching and a variety of QoS driven services. It also provides with better spectral efficiency.

E. *Disadvantages*

It will be difficult to add new frequencies. Hardly any of the existing devices would support this new technology. It also has an expensive and complex hardware and hence making it altogether more costly.

V. 5G NETWORK

A. *Introduction:*

5G, the abbreviation of fifth generation of wireless telephony technology or mobile networks is a major revolution that when implemented will obfuscate all the existing 4G/IMT-Advanced/LTE technologies. It is also referred as a technology beyond 2020 mobile communication technologies. As of yet no official paper or document has been made public by telecommunication standardization body for 5G Networks. Although Vodafone has a paper on the same but it is accessible only to its employees and they are currently under testing basis in United Kingdom (UK).

B. *Transmission Rates*

5G is expected to provide a speed of 25 Mbps using bi-directional bandwidth shaping. Although, recently the telecommunications gear maker conducted a test and were able to achieve a whopping speed of 5 Gigabits per second as specified in their statement.

C. *Features*

5G is expected to provide high resolution using its bi-directional bandwidth shaping. Using its error avoidance policy it is expected to support almost 65,000 connection simultaneously. It will also offer transport class gateway along unparalleled consistency and the traffic consistency will be more accurate..

D. *Advantages*

5G is expected to provide a data bandwidth of minimum 1 Gbps or higher. This technology will be globally accessible. It will be provided with dynamic information access.

VI. 5GNOW APPROACH

A. *Introduction*

5GNOW (5th Generation Non-Orthogonal Waveforms for Asynchronous Signaling) is a European collaborative research project supported by the European Commission within FP7 ICT Call 8 (09/2012-02/2015). The scope of the project is described next.

B. *Technical understanding*

The project challenges the common basic underlying design principles of LTE and LTE - Advanced i.e synchronism and orthogonality - of the PHY layer of today's network technologies. Hence 5GNOW Approach devises the PHY layer from the scratch with no stringent requirements of these two parameters. On removal of these two parameters there will be adherence to crosstalk's and interference but to control this implementation of more complex transceiver structure with a boost to Moore's law will be done. Hence 5GNOW Approach changes the basic design PHY and MAC layer of the existing 4G/LTE architecture.

1) *PHY Layer*

5GNOW addresses the design of a PHY layer for asynchronous signaling and increased robustness in point to multipoint (or conversely) Multiple Input Multiple Output (MIMO) transmission using non orthogonal waveforms. The research will be explored along the key scenarios of Machine Type Communication (MTC), Coordinated Multipoint (CoMP) and Heterogeneous Network (HetNet). At the base station, using the state-of-the-art sparse MIMO signal processing methodology the non orthogonal PHY layer RACH channel enables the transmission of MTC traffic. MTC traffic in todays devices is forced for to be constantly awake to synchronize with the orthogonal waveforms. In 5GNOW, it is liberated to be coarsely synchronized and be awake only occasionally and transmit the message right. To meet the requirement of CoMP and HetNet concepts based on non orthogonal MIMO PHY layer, a transceiver and transmission technique needs to be designed in presence of relaxed time/frequency synchronization requirements. The waveforms to be used for the same are Generalized Frequency Division Multiplexing (GFDM) and/or Filter Bank Multicarrier (FBMC). By doing so we reach the objective of reduced signaling effort and reduced backhaul traffic and at the same time keeping up with its benchmark performance. In turn it leads to the reduction of overhead per payload.

2) *MAC Layer*

5GNOW also addresses the adaption of the respective system aspects to enable efficient and scalable multi-cell operation within heterogeneous environment. To achieve this, it requires a re-design of selected MAC layer functionalities for the underlying new PHY layer. The development of non orthogonal waveform for the PHY layer and their specific structure need to be incorporated into the control signaling for MAC layer for different waveforms leading to different designs for each waveform. This provision of non orthogonal scheduling framework is measurable in terms of performance gains in sum throughput and standard fairness metrics. The objective of reduced control signaling will hopefully be gained.

VII. CONCLUSIONS

The expected outcome of 5GNOW is a much more robust transmission technique which efficiently exploits the huge number of (design) degrees of freedom available in a heterogeneous network and inherently supports a future differentiated service architecture ranging from MTC traffic to e.g. super-high rate video streaming etc. The S/T results of 5GNOW will also provide a fundamental understanding in all its aspects of the potential benefit of a non-orthogonal, asynchronous air interface. Altogether, the results will be condensed to a single proposal for a new non-orthogonal, asynchronous architecture for 5G mobile communication system.

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