4th and 5th mobile network technology comparative and its impact on Internet of things IoT: Review paper

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***Abstract*--** The 4th generation of wireless technology was in service for many years, while the new 5th generation is still mostly theoretical has more challenges, but more benefits and promises. This paper review the challenges and differences between 4G and 5G and the support of the currently expanded internet of things devices.

Keywords*—*4G, 5G, IOT, technology integration

I. INTRODUCTION

It almost a decade since the 4th generation of mobile communication technology started, many advancements of the technology integration has been made, especially the integration of different communication or networking standards like Wi-Fi and WiMax [1].

All these development lead to the concept of full integration of all networking, communication, visualization and human-machine interaction technology which we call 5G [2].

Few countries have just started deploying the 5th generation of mobile technology replacing the older 4th generation which is still the highest standard in most of the world.

Larger political debate and security issue researches in the western countries about the effect of adopting this technology lead and produced by Chinese companies [3].

5G is not just about mobile technology and communication, the idea integrates many concepts of interaction between humans and machines [4].

Most of the 5G standards are still suggestion and theoretical, even some standards are under experimentation or deployed by leading companies like Huawei [5].

Integration of concepts such as augmented and virtual reality [6], which require large scale of AI software in mobile devices, which means much larger processing capability for mobile CPUs, also much higher bandwidth which mean higher bit per frequency hertz b/Hz, also the usage of light field visualization (hologram) technology for display and the 3d camera. Most of these technologies are still in their infant stages for commercial mass production [7].

The first step in 5G technology development was the advancement of communication technology and the unification of networking and mobile services and its protocols[8] [9].

Some components of the 5G technology are now in the market, and more are coming for sure. But the core idea of the 5th generation which is the unified hierarchy of Technology and protocols managed by dynamic AI systems is yet to be developed.

IoT is developing for quite sometimes but still need core unification of different services, which supposed to be provided by 5G to achieve full integration between different types of things supposed to be communicated and linked together [10].

In the next section will provide a comparative review between 4G and 5th generations from a technical perspective.

II. 4G, 5G, IOT OVERVIEW

A. 4th generation:

The 4G technology made by much-advanced developments of the previous 3G technology, some of these advancements like the multiplexing protocols like Orthogonal frequency division multiplex OFDM and Multiple-input multiple-output MIMO considered in a medium stage called 3.5G according to many references [11].

4G also integrates networking standard Ethernet and Wi-Fi with a mobile standard like WiMax and W-CDMA [1]. Later the two 4G technology LTE (Long Term Evolution) and WiMax will be integrated as a step towards 5G [8].

4G is only about communication and networking, it has some application for VoIP and multimedia [12], and some support of internet of things IOT integration [10]. But it doesn't involve any technology other than communication, while 5G core concept is the integration of many technologies from processing to management to visualization and human interaction over communications [13].

B. 5th generation:

"5G wireless networks will support 1,000-fold gains in capacity, connections for at least 100 billion devices and a 10 Gb/s individual user experience capable of extremely low latency and response times. Deployment of these networks will emerge between 2020 and 2030" this was Huawei vision of 5G at 2013 [4].

As per Huawei reference, 5G will utilize the developed version of all the previous (LTE, HSPA, GSM, Wi-Fi, and

Wi-Max.) technology into one unified integrated network. To achieve very low latency at super high speed 10 Gbps for the individual by the usage of the new Radio access technology RAT [2].

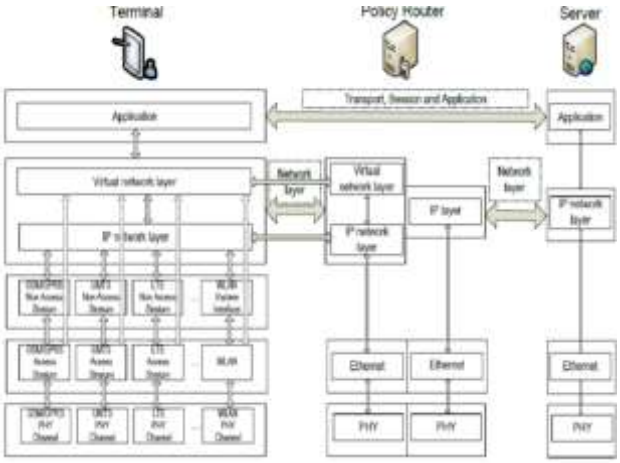

Figure 1 protocols architecture for 5G [8]

Until now most of the 5G vision is still researches and experimental projects, while some promised technologies are available most in communication like advanced LTE-A or WiMax v2.0 [14], WiMax, WWWW, RAT, virtual reality and AI was expected to be the core of 5G according to P. Sharma [15].

The evolving of smart grid network for the next generation of WiMax was the major expectation towards 5G according to [16].

More details were introduced by Toshiba Europe research team expecting smaller cells, more dense wireless, more services, protocols integrations such as 3GPP, OneM2M, a device to device D2D communication and heterogeneous networks with the integrated software development to be the main development towards 5G [17].

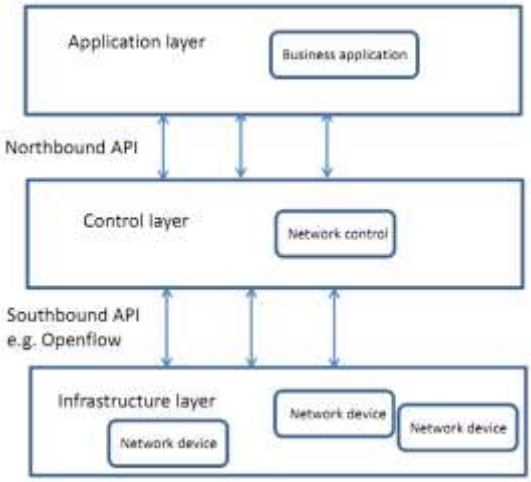

Figure 2 Toshiba suggested SDN architecture

The need for concurrent multiple network paths and communication and the integration scalability between these networks was expected to be the core development towards 5G by [8].

Moreover, Rost et el researched about RAN as service RANaaS ad multi-layer protocols within a multi-type of communication and the machine to machine M2M, all integrated into larger cloud service to be essential in the 5G network [18].

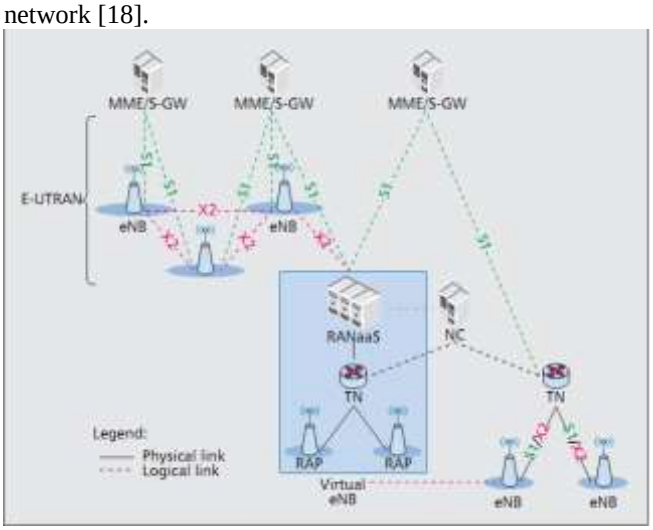

Figure 3 architecture of 5g using RANaaS [18]

Intel corporation research team studied the 5G enabled device technology and architecture, to be integrated within IoT utilizing heterogeneous networks and advanced technologies such as RAT, multi-input multi-output MIMO with all previous suggested technologies and they proposed a device architecture [9].

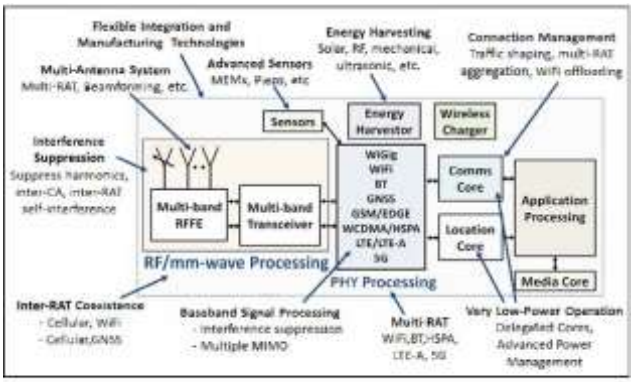

Fig.4 Example 5G Wireless Device Platform Concept.

Figure 4 Intel suggested cellular device architecture

Wireless network signals and core devices architecture was studied by the team of researchers, especially high-density MIMO and antennas and cells distribution [19].

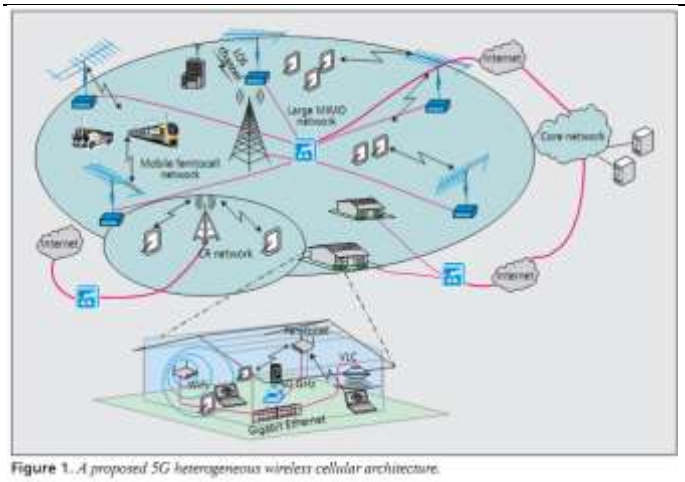

Figure 1. *A proposed 5G heterogeneous wireless cellular architecture.*

Figure 5 cells and heterogeneous distribution

YUAN Yifei and ZHU Longming studied the management strategies for the 5G network and the major application of it [13]. The expected traffic/speed/latency was the major contribution they provided as shown in table figure 6.

Table II *KPIs for different scenarios*

	Scenario	Traffic density (bps/km², DL/UL)	Density of connections (#/km²)	End-to-end delay (ms)	User experienced rate (Mbps, DL/UL)	Mobility (km/h)	Typical area	Traffic volume in typical area (bps, DL/UL)	Total # of connections in typical area
Residential	Dense apartment	3.2T /150G	10⁵	10~20	1024/512	-	1 km²	3.2T /150G	10⁵
Work	Office	15T/2T	750,000	20	1024/512	-	500~1000 m²	7~14G/ 1~2G	375
Leisure	Shopping mall	120G /150G	160,000	5~10	15/60	-	0.24 km²	29G /36G	38
	Stadium	800G /1.3T	450,000	5~10	60/60	-	0.2 km²	160G /260G	90
	Outdoor gathering	800G /1.3T	450,000	5~10	60/60	-	0.44 km²	352G /572G	198
Transportation	Subway	10T~	8(10⁴)	10~20	60~	110	410 m²	6.2G~	2⁵
	Train station	2.3T /350G	1.1(10⁵)	10~20	60/15	-	9000 m²	21G /3G	10⁵
	Highway	-	-	<5	60/15	180	-	-	
	High-speed train	1.6T /500G	700,000	50	15/15	500	1500 m²	2.4G /0.75G	10⁵

Figure 6 table show management parameter for scenarios.

LTE advance integration with 3GPP and the development of v13 then v14 which later became integrated with WiMax v2 was studied by Samsung corporation team [14].

C. Internet of things IoT:

The concept of IoT was suggested since the introduction of IP v6, as a network of low computing power devices managed by a grid of AI servers, which range from very simple sensors without any computing power for example: water level, door open, wind speed, rotation speed, light sensor and more to CCTV camera, to advanced 3D camera with recognition capabilities all linked to server via wired or wireless network [20].

Not all IoT devices are smart, some are just sensors with network connection [21].

But the smart devices are considered the building blocks of IoT while less smart devices are supported [22].

All these different devices needed to be managed interconnected, data needed to be translated between different protocols or interfaces in order for best in real-time decision making[23].

These IoT devices will generate an enormous amount of data stream, which is important to be stored, analysed and extract added value information either for day to day decision making or for better understanding and management [24].

That stream of data from IoT will be a big challenge for network design, either wireless or wired, as data needed in many locations for real-time monitor or decision, or for long term analytics or for future reference or usage [21].

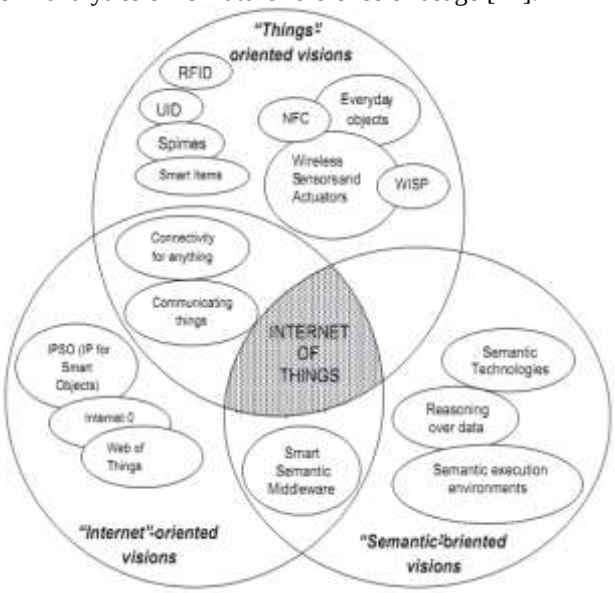

Figure 7 . ''Internet of Things" paradigm as a result of the convergence of different visions [25]

III. A COMPARATIVE REVIEW OF 4G AND 5G

The first point to compare 4G and 5G technology is the networking and wireless characteristics:

TABLE 1: 4G & 5G Network Characteristics

	4G	5G
bandwidth	2Mbps to 1Gbps	1Gbps to 10Gbps
frequency	2 to 8 GHz	3 to 300 GHz
multiplexing	OFDMA, W-CDMA LMPS	W-CDMA BDMA
latency	300 m.s	3 m.s
switching	Full packet switching	Full packet switching
technology	Unified IP, seamless integration of broadband LAN/WAN/PAN and WLAN	Unified IP, seamless integration of broadband LAN/WAN/PAN/WLAN and advanced technologies based on OFDM modulation used in 5G

A. IoT support:

Even IoT device does not require large bandwidth than what 4G LTE or WiMax provide, but the huge number of IoT devices is more than what could 4G network handle in real time, when a large number of IoT devices exist in an area 4G network architecture will probably fail, while there is no deployment of high concentration of IoT devices over 5G network yet, but in theory 5G should handle normal concentration of devices [26].

The integration of copper and optical wired network with multi high-speed wireless technology in 5G and better management of resources at 3GPP v14 allow a 5G network to better handle the need of high concentration of IoT devices [14].

B. Integration of AI and human experience

Many functions of 4G utilize AI solution for management and better in time solution, but this was not a full integration of AI technology in network management, while 5G is trying for full integration of AI technology in management and human experience [27].

On the other hand, no integration with human experience solutions such as a hologram or other visualization technology or the augmented and virtual reality AR & VR, while the integration of these technologies is intended in 5G network design even no report on successful deployment of such integrating until now [28, 29].

Vertical Handover Decision (VHD) algorithms are indispensable components of Forthcoming 4G heterogeneous wireless networks architecture. [30, 31].

In addition, high speed bandwidth of 5G wireless network is support Integration system application such as E-learning system [32], E-shopping and biometric integration devices in smart campus, in data transmission is important to use method of compression with high compression ratio to reduce time of data transmission via internet [33, 34, 35] simulations based powerline channel [36, 37] has presented and investigated in adaptive shuffled frog leaping for optimal power rate allocation in high speed network data systems [38].

IV. 5. Conclusion

While the 4G network has about a decade of deployment the new 5G technology is still mostly theoretical, which make real comparative also theoretical.

On the other hand, some of the promised 5G technology is real deployed in some places, others are being tested in a controlled environment which make the promises of 5G more realistic.

But 5G is still very expensive and require a larger investment in infrastructure than previous 3G and 4G technology, as it's not only communication but integration with many other technologies.

5G wider bandwidth, better resources management, and utilization is much more capable for deployment of high concentration of IoT devices.

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