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Wireless Cellular Technologies and Convergence

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Abstract: Mobile communication technologies have gone through with several innovative improvements by developing various multiple-access procedures like TDMA, FDMA, CDMA, WCDMA, EDGE etc., which are used for wireless communication. But a big challenge is to select the right technology for the applications. Common wireless technologies are using radio waves. With radio waves distances can be short, such as a few meters for television or thousands or even millions of kilometres for deep-space radio communications. Wireless communications also use other electromagnetic wireless technologies, such as light, magnetic or electric fields or sound. Mobile wireless technologies have experienced 4 or 5 generations of technology revolution and evolution in the past few decades, namely from 1G to 4G. Current research in mobile wireless technologies concentrates on high level implementation of 4G technology and 5G technology. The architecture of future 5G systems, their performance, and mobile services are requiring to be clearly define. Expectations we can set for 5G technology are, the convergence of maximum of current mobile communication networks with other complementary radio access technologies. As a result, 5G technology will not be a single radio access interface but rather a ''network of networks''.

Keywords: *1G, 2G, 3G, 4G, 5G, Convergence, Radio spectrum, Mobile Traffic, CR, SDR, SDN*

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I. INTRODAUCTION

Highly capable wireless communication system is the foremost demand of today's network environment, for this better understanding of fundamental issues in communication theory and electromagnetic spectrum is necessary. Day by day as the technology is developing devices are shrinking in size & their processing power is also growing. There is continuous demand for advanced, fast and more capable and useful applications by the consumers. If we study past different generations of mobile communication system, definitely we will found that there was tremendous growth in wireless industry in terms of subscribers and mobile technology. Just take a look on generations of mobile communication system.

II. DIFFERENT GENERATIONS

1. FIRST GENERATION (1G)

0G known as Mobile radio telephone after that came 1-G which is the first generation for wireless communication. The analog communication standards of 1-G introduced in 80's and continues up to the evolution of second generation (2G). They were called AMPS --- Advanced Mobile Phone System which was released in 1983. The main difference between the two mobile telephone systems (1G and 2G), is that the radio signals used by 1G networks are analog, while 2G networks are digital.

2. SECOND GENERATION (2G)

The 2G technology was present in 1990's. 2G technology use the concept of digital modulation.2G introduced various data services for mobile such as SMS (short message Service), MMS (Multi Media messages) and picture messages. 2G technology based on multiplexing, and is divided as TDMA and CDMA. The main 2G standards are GSM, IS-95, PDC, IDEN, IS-136. 2.5G system is transition of 2G and 3G. It introduces services like SMS, GPRS, EDGE, High speed circuit switched data and many more. If the convergence of CDMA and GSM standards will take place, they both are nothing but moving towards 3G.

3. THIRD GENERATION (3G)

3G network support services that has data rates at least 200kbps and also known as tri-band 3G. The others versions of 3G includes 3.5G and 3.75G. It can be used for wireless mobile telephony, video calls, mobile internet, fixed wireless services and mobile TV technologies. This technology was introduced in 1998 and is currently in use. Today 3G mobile systems are on the ground providing IP connectivity for real-

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time and non-real time services. IN 3G we can observe at broad level the evolution from cellular to a converged network that integrates traditional telecommunications and the technology of the Internet.

4. FOURTH GENERATION (4G)

4G first come in existence in 2008 and also known as IMT-Advance. Some of the applications of 4G are amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing,3D television, and cloud computing. 4G is described as MAGIC which means M Mobile Multimedia A Anytime Any-Where G Global Mobility I Integrated Wireless Solution C Customized personal Service. From the value-added service providers' point of view, the service and application layers in 4G networks should be open, making it possible to deploy external applications to control the network services in a convergent architecture.

III. CURRENT SCENARIO

There has been considerable research effort in recent years aimed at developing new wireless capacity through the deployment of greater intelligence in wireless networks. A key aspect of this movement has been the development of novel signal transmission techniques and advanced receiver signal processing methods that allow for significant increases in wireless capacity without attendant increases in bandwidth or power requirements [2] [3].

Many years after the advent of wireless technology, the problem and hindrances of effective communication is still present. Many people around the world are now using the wireless communication and this has led to the congestion of network, low connectivity speed and low bandwidth. Without wireless networks, internet browsing, the usage of cellular phones which are part of everyday wireless networking that allows easy personal communications is impossible. Wireless networking is also applicable in inter-continental network systems and the use of radio satellites to communicate across the world. This technology allows for an alternative to installing physical network mediums such as, coaxial and fiber-optic cables, which are expensive. Wireless networking helps save the cost of installation of cable mediums, save time from physical installation, and also creates mobility for devices connected to a network [1].

The ongoing deployment of the fourth generation (4G) of wireless mobile systems has prompted some telecommunication companies to consider further development towards fifth generation (5G) technologies and services. Since the appearance of the first generation (1G) system in 1981, new generations have emerged approximately every 10 years. Wireless communication generations typically refer to non-backwards-compatible standards following requirements specified by the International Telecommunication Union- Radio Communication Sector (ITU-R). Examples of these specifications are International Mobile Telecommunications 2000 (IMT-2000) for 3G and IMT-Advanced for 4G.

Other standardization bodies like IEEE also develop wireless communication technologies. With these additional standards, it is common that predecessor systems occur on the market a few years before new cellular mobile generations. For instance, commercial mobile Worldwide Interoperability for Microwave Access (WiMAX) networks deployed since 2006 are considered predecessors to 4G. Later, first-release Long-Term Evolution (LTE) systems were marketed as 4G. These networks were not strictly compliant with the original IMT- Advanced technical requirements. In contrast, the latest 4G LTE-Advanced (LTE-A) systems will fully comply with the ITU-R specification and support peak downlink data rates of 100 Mbps and 1 Gbps for vehicular and pedestrian mobility, respectively.

Nevertheless, there is still some debate on the technical characteristics that 5G must possess and the services it will provide. Some EU Projects researching technology beyond 4G are METIS 2020, 5GNOW, SOLDER, iJOIN, TROPIC, MCN, COMBO, MOTO, PHYLAWS.

IV. THE FIFTH GENERATION (5G)

WLAN adapter is available in-built in 4G technology based mobile phones. Availability of Wi-MAX adapter is expected in several mobile phones in the near future. WLAN raised tremendous research on their integration with 4G technology mobile phones. 4G technology has focus towards seamless integration of cellular networks.

5G technology will be the next major phase of mobile telecommunications standards instead of the current 4G/IMT-Advanced standards. The proposed Open Wireless Architecture (OWA) in 5G is targeted to provide open baseband processing modules with open interface parameters and to support existing architectures as well as future wireless communication standards. The OWA is targeted to MAC/PHY layers of future (5G) mobile terminals [2, 4]. The 5G terminals have software defined radios and modulation scheme with new error-control schemes [4, 6]. The development is seen towards the user terminals 5G mobile networks and terminals have access to different wireless technologies at the same time. The terminal able to combine different flows from different technologies [2, 8]. The 5G communication system is envisioned as the real wireless network and capable of supporting Wireless World Wide Web (wwww).

Evolutionary and revolutionary are the two different views of 5G systems. Evolutionary view of 5G systems will be capable of supporting the www allowing a highly flexible network such as a Dynamic Ad hoc Wireless Network (DAWN). Advanced technologies including intelligent antenna and flexible modulation are keys to optimize the ad hoc wireless networks. Revolutionary view of 5G systems would be an intelligent technology capable of interconnecting the entire world without limits [2, 4]. An example application could be a robot with in-built wireless communication with artificial intelligence.

5G technology should be rolled out by 2020 to meet business and consumer demands, predicted by Next Generation Mobile Networks Alliance. In addition to simply providing faster speeds, they also predict that 5G networks will also need to meet the needs of new use-cases such as the Internet of Things as well as broadcast services and at the times of disaster lifeline communications.

V. Vision for 5G Systems

Shifting in the channel access method was the main characteristics of evolution from 1G technology to 4G technology. Shift occurs from FDMA - TDMA - CDMA – OFDMA and in improved modulation and coding schemes. However, it is likely that 5G will not be a single air interface based on a single radio access technology (RAT) on the model of the previous generations [16]. As modern communication systems approach the Shannon limit [9] and a wider range of devices demand wireless connectivity, some industry representatives envisage 5G as a "network of networks," i.e., a heterogeneous system comprising a variety of air interfaces, protocols, frequency bands, access node classes, and network types [10]. The proliferation of mobile broadband services is expected to increase tremendously in the coming years. According to some forecasts [13,15], telecommunication networks in 2020 will have to support more than one thousand times today's mobile traffic volume. Currently, more than six billion wireless mobile terminals operate worldwide. Beyond 2020, the number of devices demanding wireless connectivity may reach fifty billion, comprising wireless sensors and machine communications [15].
5G spectrum which is nothing but Radio Spectrum shall be used on a RAT-neutral basis, ideally by applying Cognitive Radio (CR) principles to small and large cells [7]. 5G technology may require additional spectrum which may include 100 MHz of bandwidth below 1 GHz to improve rural wireless broadband access and 500 MHz of the band between 1 and 5 GHz for enhanced high data rate capacity [13].
Ultra-Dense Radio Access Networks (UDRANETs) are the new concepts foreseen in the context of 5G [15]. UDRANETs are envisaged as low-power access nodes a few meters apart for indoor areas. The main goal of UDRANETs will be to provide an extremely high traffic capacity over highly-reliable short-range links.
5G technology feature which differentiate it from previous mobile communication generations is the anticipated extensive use of Cognitive Radio (CR), Software-Defined Radio(SDR), and Software Defined Networking (SDN) technologies.

VI. 5G and Mobile Traffic

Smartphones, tablets, and other mobile broadband devices generate unprecedentedly large amounts of traffic. Mobile operators are facing great challenges to serve such a tremendous traffic growth with the current cellular infrastructure. It is evident that mobile networks beyond 4G will need to implement sophisticated traffic offloading strategies [6] beside the traditional network scaling of deploying more base stations per area. WiMAX can be considered as an offloading alternative, but it is more suitable as the backhaul for large-scale Wi-Fi networks.
Traffic offloading solutions will allow the virtual expansion of the spectrum allocated to cellular networks, thereby increasing their capacity. However, important issues, like user authentication, network security, and service pricing [9] must be addressed first. The emerging software-defined networking technology has the potential to solve some of these problems, since this approach provides a radio network controller (RNC) with a real-time updated view of the state of each link and device in the network.

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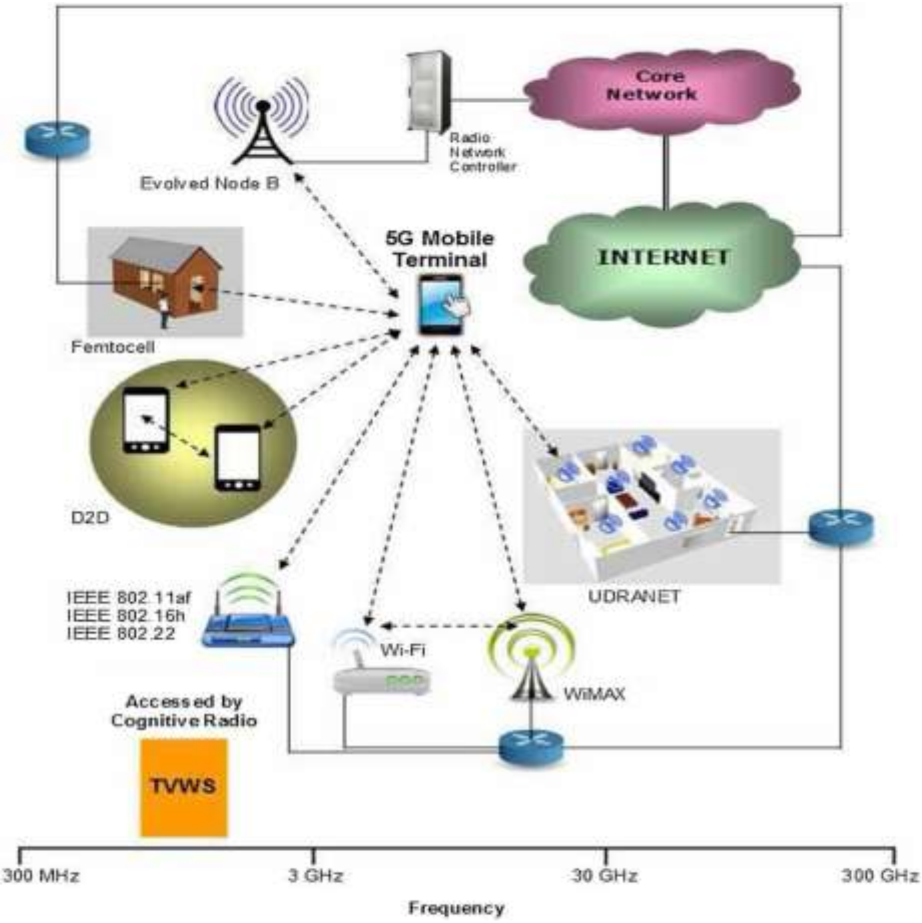

Fig. 1 Traffic offloading approaches for 5G systems

UDRANETs will perform the role of traffic offloading alternatives for extremely high data rate applications, but the main challenge here is to produce low-cost mobile terminals that can operate in super-high frequency (SHF) and extremely-high frequency (EHF) bands. Cognitive radio (CR) has long been considered an enabling technology for the next generation of mobile communications [8]. The CR paradigm proposes an opportunistic utilization of the underused parts of licensed frequency bands, i.e., spectrum holes [15], by unlicensed (secondary) users and/or the efficient sharing of the licensed-exempt spectrum.

Reconfigurable platforms based on software-defined radio (SDR) will facilitate the dynamic air interface reconfiguration of the network nodes by software modifications, reflecting current traffic demands.

Both CR and SDR technologies do not involve the control of the cellular core network. Until now, no coordination of traffic flow is possible at the core network. The revolutionary concept of software- defined networking (SDN) aims at providing a coordinator that has a global view of the network infrastructure, thereby facilitating a number of networking functionalities. In essence, the SDN concept consists in decoupling the forwarding plane and the control plane [14].

5G systems will leverage the availability and variety of the deployed infrastructure to better address the need for capacity, coverage, and high quality of service instead of relying on a single technology, topology, or regulatory approach [12].

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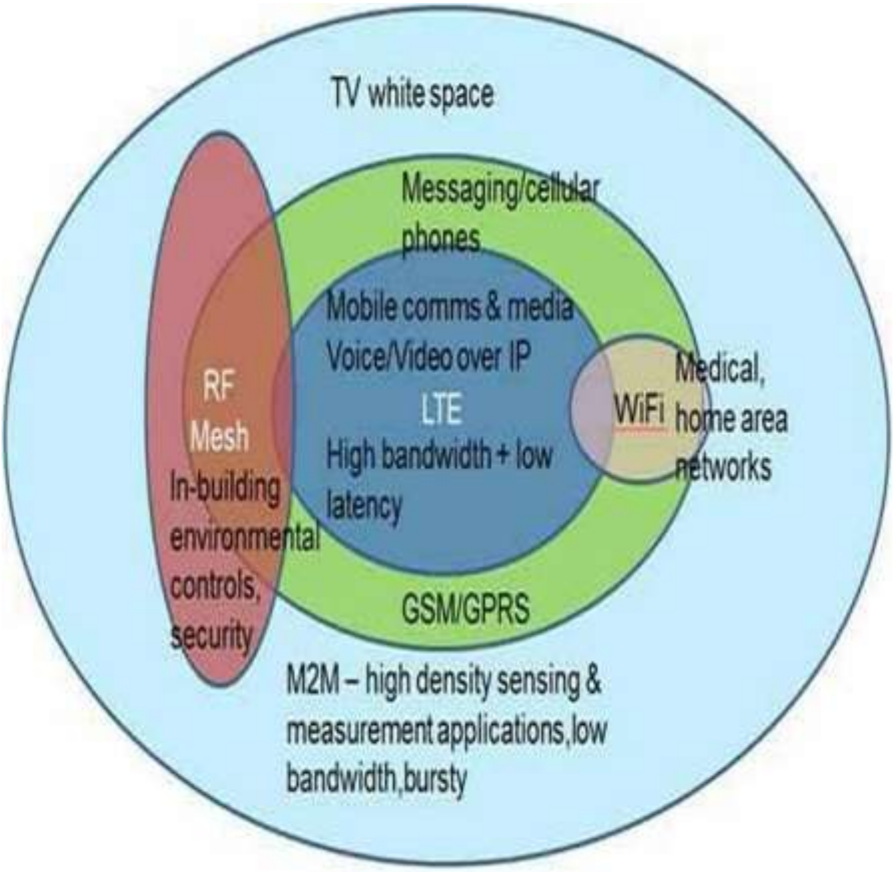

Fig. 2 5 G encompassing the range of cellular, local and personal area network

This approach is likely to increase in dominance over the coming years due to two main reasons: (1) it is unlikely that a single technology/ standard will be able to provide a sufficient capacity and coverage to accommodate all market sectors; (2) networks seeking to maximize the utility of existing infrastructure in a bid to increase the return on capital investments will continue to pursue new avenues for offloading, data aggregation, active sharing, and licensed shared access options [18].

5G networks have the potential to improve the mobile broadband access in rural areas. The capital expenditure for deploying a large number of base stations and the low average revenue per user (ARPU) [11] has delayed the complete coverage of rural environments. By using TVWS and traffic offloading solutions, the deployment of 5G networks in rural areas will be possible at a lower cost thanks to more favorable propagation conditions in the VHF/UHF spectrum that directly translate into fewer base stations [16].

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VII. COMPARISON OF 1G TO 5G TECHNOLOGIES

Technology/Features	1G	2G/2.5G	3G	4G	5G
Start/ Development	1970/ 1984	1980/ 1999	1990/ 2002	2000/ 2010	2010/ 2015
Data Bandwidth	2 kbps	14.4-64kpbs	2 Mbps	2000 Mbps to1 Gbps for low mobility	1 Gbps and higher
Standards	AMPS	2G:TDMA, CDMS, GSM 2.5:GPRS, EDGE, 1xRTT	WCDMA, CDMA-2000	Single unified standard	Single Unified standard
Technology	Analog Cellular technology	Digital cellular technology	Broad bandwidth CDMA, IP technology	Unified IP and seamless combination of broadband, LAN/WAN/PAN and WLAN	Unified IP and Seamless combination of broadband, LAN/WAN/PAN /WLAN and wwww
Service	Mobile Telephony (voice)	2G: Digital voice, Short Messaging 2.5G: Higher capacity Packetized data	Integrated Higher Quality audio, video and data	Dynamic Information Access, Wearable devices	Dynamic Information Access, wearable device with IA capabilities
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Switching	Circuit	2G: Circuit 2.5G: Circuit for access network & air interface; packet for core network and data	Packet except circuit for air interface	All packet	All packet
Core Network	PSTN	PSTN	Packet network	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal and vertical	Horizontal and vertical

Table1: General comparison of technologies [4][5].

Internet of Things (IoT), the hyper-dense network and 5G will not be economic or practical without the convergence and coexistence of licensed and unlicensed technologies [17].

VIII. CONCLUSION

In this paper we review the various generations of mobile wireless technology, their portals, performance, advantages and disadvantages of one generation over other. This field is still full of research opportunities. The benefits to service providers and end users drive the adoption of services that, in turn, lead to the demand for even more advanced services. For higher data rates and lower latencies beyond 4G network capabilities, the next generation of wireless mobile communications has to adopt revolutionary ways of using the radio spectrum. Different offloading techniques will contribute to an ‘‘unlimited’’ access to large amounts of multimedia data anywhere and anytime. The incoming technology 5G, unlike 4G, involves exclusively-licensed LTE in a predominantly cellular-based topology. 5G technology will focus on knitting together cellular, local and personal area networks, short range device technologies and topologies. 5G systems are expected to provide significant gains over 4G like higher data rates, much better levels of connectivity, and improved coverage. As a result, 5G technology will not be a single radio access interface but rather a ‘‘network of networks’’.

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