6

BEYOND 2020

5th Generation wireless systems is referred as beyond 2020 mobile communications which means the 5G standards can be introduced in early 2020s. Today's current advanced technology is LTE advanced, which provides a peak download speed of 1 Gbps and upload speed of 512 Mbps.

5G has been proposed in response to the needs of the connected society 2020 and beyond which means its standards are beyond the currently existing mobile broad band technologies like 4G/LTE and HSPA. It is also that 5G might solve the problem of frequency licensing and spectral management issues [1].

The current 4G LTE system uses advanced technologies such as OFDM, MIMO, Turbo Code, Hybrid ARQ, and sophisticated radio resource management algorithms. It is worth mentioning here that WISDOM together with 4G would lead to realization of 5G systems. The fundamental concepts of 5G are being evolved and developed from the existing technologies, and 5G systems by 2020 would fulfil the requirements of interconnected society by offering very high data rates, provision of transmitting large amounts of data, and security over the data. The 5G terminals have software designed radios; also it has different modulation schemes and error control schemes [1].

5G is a concept where personalization meets connectivity and networking technological innovations by integrating under one interoperable umbrella leading technologies, such as M2M communication technologies, cognitive radio and networking technologies, data mining, decision-making technologies, security and privacy protection technologies, cloud computing technologies, and advanced sensing and actuating technologies.

5G bundles multi-radio, multi-band air interfaces to support portability and nomadicity in ultra-high data rate communications using novel concepts, and cognitive technologies. The aim of 5G is to supersede the current propagation of core mobile networks with single worldwide core network. The objective

is to offer seamless multimedia services to users accessing all IP-based infrastructure through heterogeneous access technologies [1].

6.1 Challenges for 2020 and Beyond

There are more than 5 billion wireless connected mobile devices in operation in today's world, most of which are handheld terminals and mobile broadband devices in portable laptops, tablets and computers. The result is the tremendous rise in the overall traffic on the wireless communication systems fuelled primarily by the uptake in the mobile-broadband. By 2020 and beyond the wireless devices would be approximately 7 trillion and therefore the traffic will rise manifold as compared with today. 5G system should be an intelligent technology capable of interconnecting the entire world without limits.

The cost of deploying, operation and managing 5G systems for many applications are also the major challenges as the services should be accessible to every common man living in the world [2].

Increasing bit rates led to increased energy consumption in BS. Main challenge for future mobile networks is to reduce power consumption. In cellular networks BS consumes more than 60% of the power so it is preferable to reduce power consumption in BS elements. Recent networks are designed with the consideration of high peak load, not with medium or low load consideration. In real scenario if the load on a network increased, then coverage will decrease and vice versa. To solve this power consumption issue, network topology will be designed in such a way that as load decrease BS starts to cover more regions, and some of the BSs can be shut down [3].

In the recent times, new types of devices, their respective applications and services are being developed and will appear to us in the future. We humans are connected to them through the mobile networks in our daily life. For example, medical devices, traffic lights, vehicles, etc. 5G should provide long term, efficient, high-performing solutions for all these types of services.

Development of 5G is not just replacing the current existing technologies, but it is the matter of evolving and complementing these technologies with new Radio Access technologies with respect to specific scenarios and user cases [2].

6.2 Future Mobile Technologies

Some of the future mobile technologies to be discussed are [3]:

- CR
- Beam Division Multiple Access

- Flat IP Support
- Support IPv6
- Pervasive Network
- Multi homing
- Group Cooperative Relay Technique
- Mobile Cloud Computing Support

6.2.1 Cognitive Radio

CR technology will be more efficient radio communications systems to be developed. This new radio technology share the same spectrum efficiently by finding unused spectrum and adapting the transmission scheme to the requirements of the technologies currently sharing the spectrum. CR will have knowledge of free channel and occupied channel, type of data to be transmitted, modulation scheme, position of receiving equipment and also aware of the environment. With the knowledge of above parameters radio should capture the best available spectrum to meet user requirements and quality of services [2].

When the level of occupancy increases then these systems have to move continuously from one channel to another which reduces the efficiency of the system. As use of CR increases a single frequency, signal will appear on a new frequency continuously so that effective algorithm must be developed and CR system will move only when it is necessary [3].

A. Continuous spectrum sensing

In this system spectrum occupancy will monitor continuously, and CR system will use the spectrum on a non-interference basis for the user.

B. Monitor for empty alternative spectrum

When primary user returns to the spectrum, then CR system must have an alternative spectrum available, so that it can switch to secondary user on it.

C. Monitor type of transmission

The CR must have knowledge of transmission used by users so that interference can be ignored.

6.2.2 Beam Division Multiple Access

FDMA, TDMA, CDMA and OFDM are the various multiple access techniques used in the wireless communications. In these frequency and time

are divided among multiple users. But Korea has proposed a new technique called BDMA which is known as "Beam Division Multiple Access" as radio interference for 5G which does not depend on frequency/time resources.

In BDMA technique BS allocates separate beam to each mobile station and it divides the antenna beam according to the location of mobile stations. Based on the moving speed and position of mobile station, the calculations of direction and width of a downlink beam are done by the BS. When mobile stations are located at different angles with the BS then BS transmits different beams at the different angles to transmit data simultaneously. If mobile stations are at the same angle with the BS, they share same beam. This multiple access technique significantly increases the capacity of the system [4].

The BS can change the width of beams, number of beams and direction according to a communication environment. When the mobile station and BS know each other's position or when are in LOS , they will communicate with each other by a separate beam. Maximization of radiation efficiency of antenna can be done by matching the radiation pattern of mobile station and BS antennas [4].

6.2.3 Support IPv6

In the 5G system, each mobile phone will have permanent "Home" IP address and "care of address" which represents its actual location. If computer on the Internet wants to communicate with cell phone, it sends a packet to the home address and subsequently server on home address sends a packet to the actual location through the tunnel. Server also sends a packet to the computer to inform the correct address so that future packets will be sent on that address.

Because of this IPv6 has to be used for mobility. IPv6 addresses are 128 bit, which is four times more than 32 bit IPv4 address. This 128 bit address will be divided into four parts.

- The part represents the home address of a device.
- The second 32 bits may be used for care of address.
- The set of 32 bits used for tunnelling to establish a connection between wire-line and wireless network.
- The last 32 bits used for IPv6 address may be used for VPN sharing.

From this we can conclude that future 5G technology has a goal of establishing single worldwide network standard based on IPv6 for control, packet data,

video and voice. The users can experience uniform voice, video and data services based on IPv6 [3].

6.2.4 Flat IP control

In 5G world, it is beneficial to transmit all voice, video and data using packet switching instead of circuit switching. It is an important feature to make 5G acceptable for all kinds of technologies. Each mobile device has to be allocated IP based on connected network and its location; devices are identified using the symbolic name instead of conventional IP format in Flat IP. This means the data is no longer routed by traversing a hierarchy from originating user through multiple layers of aggregation to a central core and then re-routed back out in a multilayer disaggregation hierarchy to the targeted user. The flat core routers of the originating user routes data directly to the local flat core router of the targeted user. In this technology, only one access specific node type is available.

This technology uses the reduced number of components lowering the operation cost and investment. This is the reason when there occur low system failure and latency. The only issue is the security as the Internet is open for hackers and criminals along with developers. Trojan horses and phishing are the two important security challenges [3].

6.2.5 Multi Homing

It is a technique used to increase the reliability of the Internet connection for an IP network. Future generation networks will support vertical handover, and user can simultaneously be connected to several wireless access technologies and move between them. The Internet through multiple network interface or IP addresses accessible to a single device is called multi homing. The configuration of this network assigns multiple IP addresses to different wireless technologies available on the same device. If one of the links fails, then its IP address will be unreachable but other IP address will still work so we can access the Internet.

Multi homing has become popular because of IPv6 address availability, that support more network protocol for multi homing than traditional IPv4 address. This IPv6 address has availability of provider independent address space. This technique works like IPv4, supports traffic balance across multiple providers and maintains existing TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) sessions through cut-overs [3].

6.2.6 Pervasive Networks

The growth in the mobile broadband technology increases air interference technology and provides local area connectivity to the wide area. Future network will be "network of networks" which will provide uninterrupted service when roaming across many radio access schemes. The user can simultaneously be connected to several wireless access technologies and move between them which can be 2.5G, 3G, 4G or 5G mobile networks, Wi-Fi, WPAN, or any other future access technology. In 5G user can provide multiple concurrent data transfer and also user can move globally. Beyond 4G, network gives media independent handover, vertical handover and IEEE 802.21 support.

This IEEE standard 802.21 supports handover between same type of networks as well as distinct type of networks. Mobile IP provides vertical handover mechanisms for different types of networks, but can be slow in the process. To support this mechanism, mobile station must have dual mode cards so that it can work on WLAN and UMTS band and modulation scheme. To support vertical handover mobile station must have dual mode cards so that it can work on WLAN and UMTS band and modulation scheme [3].

6.2.7 Group Cooperative Relay Techniques

With the development of the MIMO systems, there is also higher throughput and reliability in a wireless network. This technology seems beneficial for BS side, but not on the user side due to size and power consumption. The alternate solution for this is group cooperative diversity techniques. In cooperative communication, source transmits data to the destination and at that time neighbour user (relay user) can also hear a transmission. The relay user also processes and forwards this message to the destination where received signals are combined. Both signals are transmitted with the different path as this gives diversity in the relaying the information. [3].

6.2.8 Mobile Cloud Computing Support

Cloud computing is a new and unique technique to access data like documents, application, video files, music file, etc., from any place without carrying any data-storage devices. A cloud user can access all data from anywhere in the world any time, and the best example of cloud computing is Gmail.

Mobile world is depended upon two factors:

- Network availability (3G, 4G, WIFI, etc.,)
- Handset availability (Feature phones, Smart phones).

The cloud computing is best option for low processing capability, low data storage. Some of the mobile applications that run on one mobile phone cannot operate on other phone. This problem can be solved by mobile computing. In this, the application runs on the specific device called cloud, and user can access the data and application. Requirement is user must have the Internet, without need for more computing capacity [3].

6.3 High Altitude Stratospheric Platform Station Systems

The transfer of the large data requires large band width. To use high-bandwidth solution is to use lower wavelength waves, which require LOS propagation, that are challenged to compare with lower frequency propagation. Wireless communication services are facilitated by terrestrial and satellite systems. The terrestrial systems are used to render services in complex propagation areas. Satellite links are used during the lack of availability of terrestrial links. Nowadays research is going on aerial platforms at high altitudes to provide LOS propagation.

A High Altitude Platform (HAP) is powered by battery, engine or solar cell. HAPs work similar to a BS and can be compared with a tall antenna that delivers a wireless communication. HAP is powered by battery, engine or solar cell. HAP can be easily deployed in hours which make it favourable in emergencies and disasters.

HAP does not require expensive launching like satellites which gives cost-effective way. HAPs will vary in position vertically and laterally depending upon the wind. This movement changes the look angle from the ground terminal. If this variation is greater than beam width of an antenna, then it requires the gain to operate the link.

HAPs provide a coverage radius of 30 Km, giving us the benefit of establishing single HAP instead of several terrestrial BSs in suburban and rural areas [4].

6.4 Human Bond Communications

WISDOM based 5G communication would usher the society into a digital age whereby humans can communicate in a real sense. The conventional communication network carries information between users in a ‘digitized’

form, which is significantly different from the real communication that is anticipated between two users if they are physically present next to each other. Human beings interact with the environment through five senses, i.e., skin, eyes, ears, nose and tongue. Overall understanding of a physical subject by human beings depends on the degree to which the observations are made by the five senses. However, the conventional information communication mechanisms have been centred on either visual (eyes) or audio (ears) based communication. Therefore, for a particular subject the overall judgement that can be drawn by human beings would be based on just these two senses, ignoring the possible utility of other three sensory systems completely. Accordingly, the judgement by the brain based on just the two sensory inputs is indeed only a partial representation of the actual physical subject. Human bond communication (HBC) stresses on utilizing all the five senses for modelling a physical subject with appropriate representation in digital form based on appropriate actuation and transmission across the communication network to support all sensory information [5]. WISDOM based 5G network that can support very high data rate would be capable of supporting the communication bandwidth requirements, if the overall sensor data is to be transmitted. Forming an almost true (complete) understanding of a physical subject through HBC supported on WISDOM 5G would create an information rich society that is unimaginable in today's communication world.

6.5 CONASENSE – Communication, Navigation, Sensing and Services

The WISDOM based 5G amply covers the communication aspect of the network, which as discussed earlier would involve one large core network. It has also been stated the significance of sensing the environment is through the capacity of individuals to gain rich information from machines (IoT). However, one of the objectives is to allow seamless connectivity to users even if they are mobile at high speeds. In the case of a user who is mobile at high speeds, it is just not the high speed connectivity that is necessitated, providing the user with effective navigational information is also an expected service requirement.

CONASENSE stresses on collective addressing of communication, sensing and navigation aspects dependent on the context, as the three aspects bidirectionally relate with each other to deliver services to the end user [6], [7]. The services that these three aspects provide have been referred as Quality

of Life services. This justifies that QoL (Quality of Life) for common people would be ensured in future only if these aspects are collectively handled. This is validated considering the enormous utility of intelligent transportation systems (ITS) and V2V. Both the broad areas rely heavily on navigation information and both in turn influence the information and communication that is available to the end user.

HBC and CONASENSE are complementary aspects in terms of enormous utility of sensing obtained from the myriad types of physical sensors that could be deployed in the biosphere for garnering information. HBC stresses on specific sensing capabilities that human beings utilize to interact with their environment. Therefore HBC and CONASENSE would collectively ensure that information requirements of the future society in 2020 and beyond are appropriately met. The relation between WISDOM, HBC and CONASENSE, and their collective result as assured through the advent of 5G is shown in Figure 6.1.

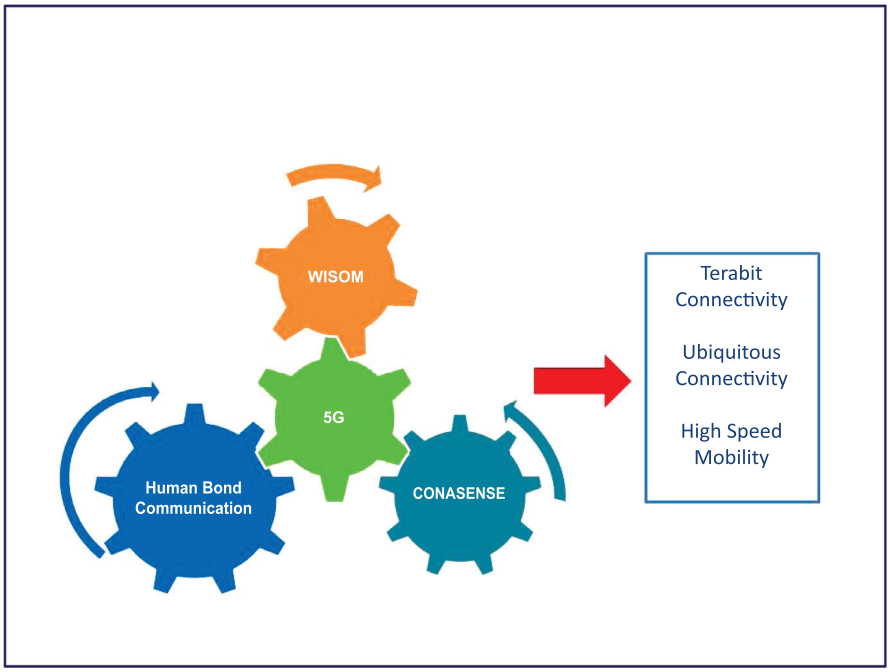

Figure 6.1 WISDOM, HBC and CONASENSE Collectively.

6.6 Summary

5G technologies will play a vital role in our lives by enabling unlimited access to information and data sharing to anyone, anywhere at any time. To fulfil the requirements of the users to experience Terabit communications, a 5G system must be a combination of different technologies like integrated Radio Access Technology (RAT), including evolved versions of LTE and HSPA and other special advanced technologies.

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