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Introduction

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Radio technologies started their first step to connect the whole world together by introducing the analogue cellular systems in 1980s. Afterwards radio technologies have experienced a rapid evolution in their paths with the launch of the digital wireless communication systems in different steps from Global System for Mobile Communications (GSM) to the Fifth Generation Mobile Technology (5G). 5G technology promises to evolve the mobile communication system with its features especially within very high bandwidth. It is predicted, users experience a huge difference between 5G technology and previous mobile generations, which makes 5G technology more powerful in near future.

5G promises its users enjoying high speed up to 1Tera bps (1Tbits/s = 10^{12} bits/s) wireless link rates, wider range of applications, connectivity everywhere, watching high quality videos on their cell phones, lower battery consumption and much more around the year 2020, where it is promised to implement 5G in the reality. For now still huge amount of works and researches are needed to configure 5G standards, network design, signal processing and many other issues to be addressed.

1.1 The Journey to 5G Wireless Communication

The Journey began in 1819, when the Danish physicist Chritian Oersted founded the fundamental relationship between electricity and magnetism. Nowadays we know it as electromagnetic field. In 1832, Michael Faraday used the concept of electromagnetic and discovered a way to provide electricity.

Later on James Clerck Maxwell introduced his magic equations in 1865 and 1873. The fundamental of critical inventions in next decades are defined by Maxwells' equations.

The road towards radio communication started in fact in 1895, when Guglielmo Marconi sent radio telegraph transmission across the English Channel. Similar works by other contemporary scientist, Jagdish Chandra Bose from India pioneered several dimensions towards the field of radio communications. The journey continued with first voice over radio transmission in 1914 and first long-distance TV transmission in the United States, conducted by AT&T Bell Labs in 1927. Frequency modulation (FM) was introduced by Armstrong in 1935, which was a huge step forward at that time.

In the 1980s, the First Generation Mobile Networks (1G) were introduced. The 1G signaling systems were designed based on analog system transmissions. Some of the most popular standards set up for 1G system were Advanced Mobile Phone System (AMPS), Total Access Communication Systems (TACS) and Nordic Mobile Telephone (NMT).

In the early 1990s, the Second Generation Mobile Networks (2G) based on Global System for Mobile Communications (GSM) was launched. 2G is the starting point towards wireless digital communication. The main concern of new system was covering the problems with security weakness of analog communication systems. Another novelty in designing GSM was using digital modulation to improve voice quality but the network offers limited data service. The 2G carriers also began to offer additional services, such as paging, faxes, text messages and voicemail.

An intermediary phase, 2.5G was introduced in the late 1990s. It uses the General Packet Radio Services (GPRS) standard, which delivers packet-switched data capabilities to existing GSM networks. It allows users to send graphics-rich data as packets. The importance for packet-switching increased with the rise of the Internet and the Internet Protocol (IP).

The Third Generation Mobile Systems (3G) is proposed in 2000s to provide high speed Internet access to allow mobile phone customers using video and audio applications. One of the main objectives of designing 3G system was to standardize on a single global network protocol instead of the different standards adopted previously in Europe, the U.S. and other regions. 3G phone speeds deliver up to 2 Mpbs, but only under the best conditions and in stationary mode. Moving at a high speed can drop 3G bandwidth to a mere 145 Kbps [1].

The Fourth Generation Mobile System (4G) offered in 2010s promised for providing transmission rates up to 20 Mbps. The concept of Quality of Service (QoS) got more attention in 4G system. It is promised accommodating QoS features in 4G system. QoS will allow telephone carrier to prioritize traffic according to the type of application using bandwidth and adjust between different telephones needs at a moment's notice. High quality video and audio streaming over end to end Internet Protocol is the most attraction of 4G. There are two important standards in 4G technologies; Worldwide Interoperability for Microwave Access (WiMax) and Long Term Evolution (LTE). 4G is currently using in many countries all over the world [2]. Figure 1.1 shows a trend in cell phones and their development to the future.

The journey is continuing to the Fifth Generation Mobile System (5G) to achieve the huge promises made by 5G in terms of high data rate, low latency, low power consumption and much more. It is a big step forwards during this road and no one knows if this step makes the human to achieve the peak of the wireless communications or still there is a long way ahead.

Figure 1.1 Cell phone development to the future.

1.2 Background and Future of 5G Technology

The concept of realizing 5G communication network based on Wireless Innovative System for Dynamic Operation Mega Communication (WISDOM) followed by other leading initiatives at research facilities in industry and academia is as shown in Table 1.1 [3].

The future of 5G technology is under discussion and research. It is expected that 5G technology increases the bandwidth, QoS, improves usability and security, decreases delays and cost of services, reduces battery consumption, improves reliability of the communications and much more. It is mentioned that, the architecture of 5G is highly advanced and service providers can implement the new technology easily [6].

The challenges of 5G such as, Inter-cell interference, traffic management, multiple services, security and privacy, standardization and so on should be addressed before implementation of 5G technology, which is expected for 2020. It needs lots of efforts from universities and industries to exchange their findings and ideas to reach the final and promised point in 5G system.

Table 1.1 Significant 5G initiatives till date

Year	5G Initiative	Entity	Country
2008 February	WISDOM [3]	Center of TeleInFrastruktur, Aalborg University	Denmark
2008 November	5G through WISDOM [4]	Center of TeleInFrastruktur, Aalborg University	Denmark
2008 November	5G systems based on Beam Division Multiple Access [4]	South Korea IT R&D department	South Korea
2012 May	First 5G System [4]	Samsung Electronics	South Korea
2012 October	5G Research Center [4]	University of Surrey	United Kingdom
2013 November	Research on 5G systems [4]	Huawei Technologies Co. Ltd	China
2014	5G: 2020 and Beyond [5]	Center of TeleInFrastruktur, Aalborg University	Denmark

1.3 Applications of 5G

Researchers expected 5G technology supports the speed up to 1 Tbit/s, less than 1ms latency, almost 10% network coverage, 1000 times reduction in power consumption, deep indoor coverage, 10 to 100 connected devices, 100x average data rate and so on. The question is what users can do if all promises will be met by 5G technology? Actually the applications of 5G is very much equivalent to achievement of dream. Users could expect unified global standard, network availability anywhere any time, Wireless Fidelity (Wi Fi) global zone and much more. With this great offer from 5G wireless technology people are able to play online games against friends across the world with lots of new experiences, cars can drive automatically, which is a big help to transportation system, health care could be done remotely, a great help to elderly people and video conferencing becomes much more real like you are at the same room with a person who you talk to.

One of the most inspiring application of 5G is Human Bond Communication, proposed in 2015 [7]. Human bond communication is a novel concept that incorporates olfactory, gustatory, and tactile that will allow more expressive and holistic sensory information exchange through communication techniques for more human sentiment centric communication. 5G is the tool to achieve this idea as long as it supports very high data rates. Figure 1.2 shows how the concept of Human bond communication could work in the reality.

Visible Light Communications (VLC) is another useful application of 5G for ambient assisted living discussed in 2014 [8]. VLC is an alternative to communication technology using RF wireless spectrum and proposes a concept for integrating VLC to enable intelligent communication infrastructure. The VLC systems can be deployed along with a repeater system for targeted discrete deployment as shown in Figure 1.3.

5G technology can evolve wireless health monitoring system due to its speed, reliability, security and so on. Elderly monitoring system could develop to remote surgery. It is a huge help to people from not very developed countries to receive the same care and medical services as other people. 5G technology will promises us better future in the world more equality and more welfare.

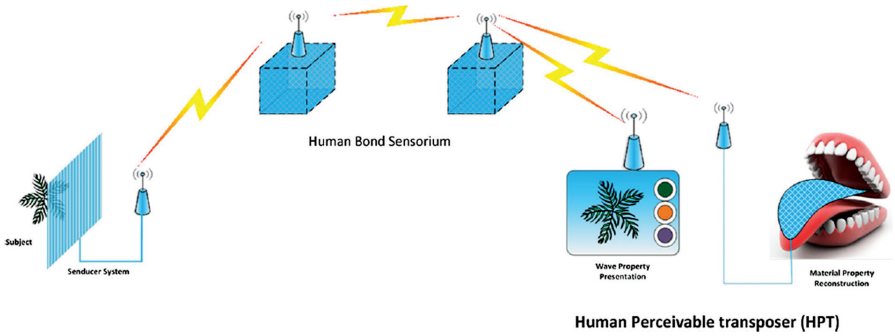

Figure 1.2 Human bond communication in real world.

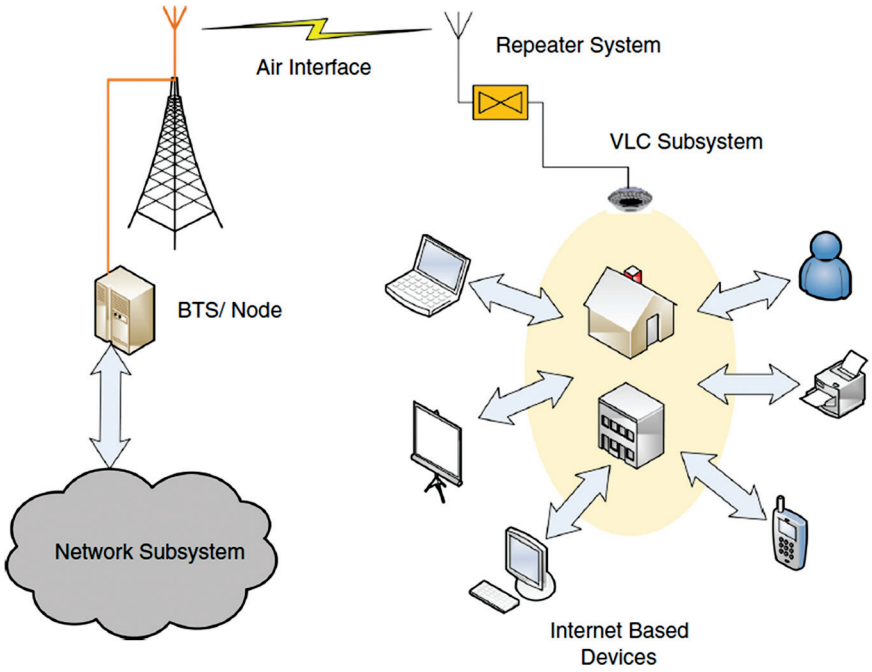

Figure 1.3 VLC system architecture.

1.4 Summary

Mobile wireless communications do not stop growing; the evolution from 1G to 4G has developed the quality of human life dramatically. Lots of dreams came to reality by wireless communication technologies and applications.

5G as the next generation of mobile communication promises to evolve the wireless technology with its speed, reliability and other features. It is expected that, implementation of 5G happens in 2020. Till that time researchers and industry leaders need to carry on different works and exchange data and ideas to achieve the 5G promises. This book presents the latest research results and innovative ideas from both university and industry.

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About the Author

Maryam Rahimi is currently a Research Assistant at CTIF, Aalborg University. She has studied her Ph.D. at Aalborg University in Wireless Communications and her Master at University Putra Malaysia in Microelectronics. Her focus during Her Ph.D. was at MIMO, signal processing and channel propagation. Maryam has some industrial work experience as an Electronics Engineer. She was involved in different projects and research namely, Design and Development of Radio Frequency (RF) Front-end for a Wireless Receiver or Transceiver, project of ministry science, 2008–2009 and Analysis of Measured Channels, Channel Propagation, Cooperative MIMO Capacity, 2010–2014. She is author and co-author of more than 15 Journal and Conference papers.