A Survey Paper On 5G Cellular Technologies - Technical & Social Challenges

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Abstract — The cellular industry has already started working on the development of 5G, as the 4G deployments are happening worldwide. However, there are few questions that are being discussed among research institutions, standards bodies, operators, the supplier community, trade organizations and governments – What will be the 5G deployment time frame? What will be the characteristics of the cellular networks beyond 2020? What will be the likely technologies that come in to picture for 5G? This paper is a survey paper, in an attempt to address these questions in a systematic way. This paper presents the 5G requirements, use cases, spectrum requirements, considerations and the technology elements. The 5G use cases are described in Section II that includes the Internet of Things (IoT), high definition videos, public safety and context-aware services. Sections III describe the broader requirements of 5G. Section IV describes key technologies that are getting developed for 5G and the applicable technologies to the 5G systems. Section V discusses the other challenges related to computing technologies, data processing, social issues. Finally concluded with a prospective end-to-end 5G echo system, considering all the aspects discussed in the paper.

Keywords— 4G, 5G, D2D, Massive MIMO, Internet of Things(IoT), Data Mining, Cyber Security

I. INTRODUCTION

Cellular communications has evolved since its invention and in the last two decades it has evolved from 2G to 4G. Discussions are shaping up for the fifth-generation (5G) wireless access and there is a broad consensus about the introducing 5G around 2020 time frame. The innovations and defining the 5G systems are still in its early stages. Since the industry is working to define the 5G requirements, without having actual technology developed, for deployments in the 2020 timeframe, so all the requirements defined for 5G may not be implemented in the timeframe expected. The aim of this paper is to provide a survey on 5G technologies for addressing the key requirements, key technical challenges and for Wireless networks of 2020 and beyond. This paper also gives a glimpse of key new technological solutions that can be used for 5G requirements.

As the 5G requirements is not yet completely available But the broader requirements such as support of huge number of connected devices that are always on, energy efficient and support for flexible air interface are to be achieved. It may not be possible to achieve the 5G requirements by just a normal evolution from the existing systems and need a paradigms shift.

II. USE CASES FOR 5G

The main focus of the existing cellular technologies such as 3G and 4G is the mobile broadband and it has not focused on the system capacity enhancement. The future 5G era mainly focus on providing the capacity enhancement of the system along with higher data rates. However, Future 5G Networks should offer wireless access ubiquitously to anyone and anything. It means the communication will go beyond human being and involves machines. This concept is known as "the Internet of Things (IoT)," "machine-to-machine communications (M2M)," "the Networked Society,"

Future times, even machines communicate via WANs for home security, alarm monitoring, fleet monitoring and many more applications that grow continually.

A. Internet Of Things (IoT)

By 2020, it will be quite common; to have mobilility enabled IoT applications, ranging from smart gadgets to disaster detection sensors for disaster management. All of such applications are being deployed even on current day cellular networks. But, it is predicted that these IoT applications are going grow exponentially, that the existing networks cannot handle the data traffic generated optimally.

To support trillions of smart devices, any wireless network infrastructure should be not only highly scalable, but also should have the capability to handle the differing service needs. Some of the use cases with differing needs are: *Smart Grid and Critical Infrastructure Monitoring, Smart Cities, Health and Telemedicine, Automotive, Sport and Fitness*. Different uses cases include divergent requirements. These diverse requirements may call for re-architecting the existing cellular network.

B. Context Aware Services

The users of Internet-connected devices face a situation - consistently receiving information, most of which may not be relevant or interest for them. Practically service to be context aware means ability to provide the right set of information at the right time by a right means. It implicitly means the Internet comes to the user with the right information, instead user searches the information[1].

C. Exponential increase in data usage

In the coming years, the pace of the smart devices usage will be exponential and the data usage through the existing cellular networks will increase by 1000 fold. In other words, the density of smart devices (devices/area) will increase and the larger part of this increase will be contributed by D2D(Device to Device) services, which require much higher data rates compared to current available rates of few hundreds of Mbps(LTE-A targeted for 500 Mbps).

D. Public Safety

The U.S. and Canada are planning to deploy an LTE broadband network for public safety at 700 MHz to leverage pricing of standardized commercial equipment. Some of the other nations will take a lead from it, soon follow the same path. So, it is crucial that 5G should also consider the public safety use cases of monitoring the public spaces and property with High-resolution security cameras, Drone-or robot-based surveillance systems for monitoring remote areas, intrusion detection with the help of wireless sensors and tracking devices, Chemical, bio and nuclear hazard detection and emergency personnel tracking.

III. REQUIREMENTS FOR 5G CELLULAR

As a result of many of the industry and standards body initiatives that have progressed with work on 5G and the requirements that are broadly accepted [2],[3],[4] is depicted in the Figure 1:

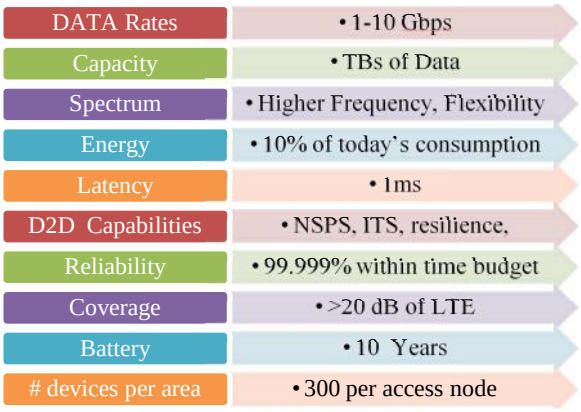

Figure 1 - 5G Requirements

IV. POTENTIAL TECHNOLOGIES FOR 5G

This section describes potential key technologies for 5G to address the use cases described in Section II, and the requirements of 5G identified in Section III. The following are identified as the key technologies and challenges [5]:

- Massive MIMO
- RAN Transmission at Centimetre and Millimetre Waves
- New Waveforms
- Shared Spectrum Access
- Advanced Inter-node Coordination
- Simultaneous Transmission Reception
- Multi-RAT Integration and Management
- Device-to-Device Communications
- Efficient Small Data Transmission
- Wireless Backhaul/Access Integration
- Flexible Networks
- Flexible Mobility
- Context Aware Networking
- Information Centric Networking (ICN)
- Moving Networks

V. OTHER CHALLENGES FOR 5G

Riding on a 5G network, user could feel more like compute power and information always at his helm. Smart phones, tablets and other gadgets with sensors that are location and context aware will work together with apps and services you use. In this section, we are going to discuss other areas where the challenges lie for 5G networks realization.

A. Processing Power

As we are talking about 5G Speeds are in the order of Giga Bits per second/user and the networks should be able to handle Peta Bytes (10005 Bytes) of data per second, which need to be addressed. All the current generation of processors – including general purpose, DSP, Embedded Processors need to be upgraded. For example if we consider the DSP processing power required to implement high order modulation schemes across many antennas and many sectors, as with massive MIMO, is immense and will be in Tera Multiply Accumulate (MAC) units per second.

B. Information processing

With 5G, we will see the computing capabilities fused with communications everywhere, so trillions of wearable and other devices along with networks that can do any processing needed. To realize this industry should gear up with new Information processing tools such as newer software models, data encryption and compression techniques to cope with the demands of 5G.

C. Smarter Devices

As, 5G Devices have more complex challenge of combining communications and computing together so intelligence is at your fingertips, advancements in terms of embedded processors as well as multiple protocol software that are to be embedded in to the smarter devices. And also it provides a lot of scope for the applications to support context awareness, smart data processing.

D. Data Storage and Mining

As 5G networks provide higher speeds and capacity, different users will freely floating lot of the data which have high resolution videos, pictures on the cloud servers. Newer challenges will be arising in terms of storage capacity and mining of the data for context aware services, where user is expecting relevant information from the servers. Newer smarter data mining algorithms are needed for data retrieving from the servers.

E. Cyber Security

As 5G networks provide the data rates of Gbits/sec, the security of the data at that speeds is a real issue and that is the challenge that has to be addressed by cyber security Industry. Newer Anti-Virus software may be needed as the data speeds are high means faster spreading of the malicious software and damage of the systems are much faster.

F. Social challenges

There will be few social challenges may arise of the proposed 5G Networks. There are always pros and cons for any technology. In the following section, we have discussed few social challenges anticipated due to this technology evolution and can be considered while designing itself.

a) Privacy Issues:

Some of the 5G requirements such as ubiquitous coverage of the network and support for D2D communication will have privacy issues. In 5G networks, anywhere user can be tracked and identified, without his knowledge. This can be treated as intruding in to the privacy of the individual and may lead to lawsuits in some countries. So the smarter devices and applications of 5G need to be designed considering this aspect in mind.

b) Law Enforcement:

5G network provides an unimaginable power for the user with smarter devices, unlawful elements can use the technology for cyber crimes, rumors spreading with malicious intent, This is a very a big challenge for law enforcement of authorities, where they need to have be "always one step ahead of You" tools, both in terms of software tools as well as technical resources for understanding and present them to the executive and judiciary systems.

VI. CONCLUSIONS

The development of 5G network should provide a single framework for all the wireless technologies and allow time for the feasibility studies, standardization, true advances of technology, and product development. Since 5G is not defined by any official document or standards body till date, it is suggested that the industry and standards body should come under single umbrella at the earliest for the faster development of 5G networks. 5G planning should consider all major technological advances on the road to 5G and should have envisioned initial deployments around 2020. In conclusion, it is suggested that development of the end-to-end 5G system should take in to consideration of all the use cases, requirements, regulatory issues, the technology challenges and other challenges described in Sections II, III, IV, and V.

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