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Global Impact of 5G Network Topology

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ABSTRACT

Network densification is foreseen as a potential solution to fulfill the 5G spectral efficiency requirements. The spectral efficiency is improved by shrinking base stations' (BSs) footprints, thus improving the spatial frequency reuse and reducing the number of users sharing the resources of each BS. This premise has leaded various countries like Germany, United Kingdom, South Korea and China leading in the most advance technology today. The solution to this issue is to make the best use of all spectrum types through matured technology.

Keywords: Global Impact, 5G, Network, Spectrum.

INTRODUCTION

Fifth generation (5G) communication has been proposed as next generation wireless telecommunication standard [1]. Rather than faster peak internet connection speeds, 5G design aims to accomplish higher capacity than current fourth generation (4G) communication. Hence, will allow a higher number of mobile broadband users with consumption of higher or limitless data quantities in gigabytes. This unprecedented escalation in capacity demand has imposed significant challenges due to the limited licensed spectrum for cellular networks. Any effort to achieve capacity growth through network densification faces the challenge of severe inter-cell interference [2]. The solution to this issue is to make the best use of all spectrum types through matured technology. Therefore, the significant amount of underutilized spectrum below 6 GHz band is motivating operators to combine LTE with Wi-Fi technologies in 5G. LTE in unlicensed bands, popularly known as LAA, is considered as one of the latest groundbreaking innovations by 3rd Generation Partnership Project (3GPP) to provide high performance and a seamless user experience under a unified radio technology [3]. This innovative LAA has the physical layer topology to access Wireless Local Area Network (WLAN) band, specifically the 5GHz U-NII (Unlicensed National Information Infrastructure) bands. Due to the rapid proliferation of mobile phones, tablets, and other handheld devices, an increasing traffic demand is observed worldwide. Such proliferation has driven the evolution of small base stations (BSs), such as micro, pico, femto BSs, to complement the traditional macro BSs coping with the rapid capacity growth. For instance, the 5G evolution for cellular networks dictates 1000 fold capacity improvement, which is expected to be fulfilled by an evolutionary heterogeneous network densification phase [4]. Deploying more BSs within the same geographical region shrinks the footprint of each BS, which increases the spatial spectral efficiency and offers more capacity. However, the foreseen capacity gains offered by network densification are achieved at the expense of increased handover (HO) rates. Such important negative impact of BS densification (i.e., HO rate) is usually overlooked [5]. In addition to the HO signaling overhead, the HO procedure interrupts the data flow to the user due to link termination with the serving BS and link establishment with the target BS. Increasing the HO rate increases the frequency of such undesirable

interruptions as well as the associated signaling overhead, which may diminish or can even nullify the foreseen network densification gains. Consequently, studies about network densification are never complete without incorporating the corresponding HO cost [6].

The Top Countries with 5G Deployments and Trials

The top countries with 5G include South Korea, the United Kingdom, Germany, and the United States. Since the first commercial launches of the fifth generation of mobile networks in late 2018, these four countries have emerged as leaders because multiple companies in these countries have deployed networks and are selling compatible devices [7]. Countries including Switzerland and Finland are up and comers in 5G development, as they have limited deployment.

1. China: Three Companies Lead the Charge

The world's largest 5G network was launched by the three largest Chinese network operators Oct 31, 2019, according to the state-run news agency Xinhua. China Mobile, China Unicom, and China Telecom all activated their networks in less than five months after they were issued 5G licenses. Each of the network operators offered their 5G services at $18 per month in 50 Chinese cities at the time of reporting [8]. "What we are seeing is a concerted effort by the Chinese, the operators, vendors, and government regulators to deploy 5G as quickly as possible," Chris Nicoll, principal analyst at ACG Research, said in a Nov 1, 2019 SDxCentral article. With all of these players working together, the three network operators had collectively deployed nearly 86,000 5G base stations with plans to have over 130,000 by the end of 2019. The latter number breaks down into China Unicom and China telecom, with each planning to install 40,000 base stations, and the market leader China Mobile to install 50,000. The GSMA expects 36% of China's mobile users to be using 5G by 2025. That's about 600 million subscribers, who would also make up 40% of the entire global 5G market by that year. This is all despite efforts made by the United States government to hamper the progress of Chinese vendors, though those efforts may affect how Chinese companies may expand into the global market.

2. South Korea: SK Telecom and Korea Telecom Compete

SK Telecom and Korea Telecom (KT) are the main competitors for the South Korean 5G market. SK Telecom acquired spectrum in the 3.5 GHz and 28 GHz frequencies to prepare for deploying 5G [9]. In April of 2019, the enterprise claimed to be the first mobile carrier in the world to launch 5G services to work on 5G smartphones. SK Telecom asserted an edge over rival Verizon, as the former launched 5G services available at the same time as Samsung Galaxy S10 5G smartphone launched in South Korea. Verizon launched mobile 5G services in the U.S. before a 5G enabled smartphone was available to U.S. consumers. SK Telecom has also conducted tests with a 5G Standalone (SA) Core (a core not reliant on the 4G network) for their 5G network in cooperation with Samsung Electronics. In early 2017, KT rolled out a trial 5G network ahead of the 2018 Winter Olympics in Pyeongchang, South Korea. However, the network was used primarily for demonstrations as was not accessible by attendees' smartphones. At the time, reception was lukewarm. Since then, KT's network has expanded to cover the country's most populated areas and the operator claims to have "the world's first nationwide commercial 5G wireless network." [10] Consumers have played a crucial role in turning South Korea into a 5G country. According to research from IHS Markit, South Korean consumers have been purchasing 5G devices so quickly that stores can't stay in stock. It only took 69 days for South Korea to reach one million subscribers to 5G services after the initial network launch.

3. United Kingdom: Four Providers Launch Deployment Throughout 2019

Countries with 5G also fall within the U.K. Over the course of 2019, EE, Vodafone UK, Three UK, and O2 UK launched

commercial deployments in the U.K [11]. These operators are using equipment namely from Ericsson, Nokia, and Huawei. O2 UK is an exception in that it's not using Huawei equipment, despite running 5G radio access network (RAN) tests with it. Three UK has announced an unlimited data service that is speed-cap free at no extra cost. To speed up rollouts of active 5G equipment, Vodafone UK reached a deal with O2 UK to share equipment, which can be seen with radio antennas on joint network sites [12]. Cornerstone Telecommunications Infrastructure will be managing shared facilities. Vodafone has reached similar agreements in Italy and Spain.

4. Germany: Vodafone and Deutsche Lead 5G market

In 2019, Vodafone Germany and Deutsche Telekom Germany launched 5G services in several cities. Vodafone Germany started with 20 cities and municipalities (including Cologne and Dusseldorf), while Deutsche Telekom Germany launched in only six (including Berlin and Munich) [13]. Vodafone plans to offer 5G services for $5.61 less per month than Deutsche Telekom. When the German government auctioned off spectrum bands, a new player, 1&1 Drillisch, came into the picture by bidding $1.2 billion for 70 megahertz of spectrum. However, the company will have to wait until 2021 to use the new spectrum.

5. The United States Endeavors to Lead the 5G Race

In Sept. 2018 the FCC announced its 5G FAST Plan in an effort to advance the country's position among the countries that have deployed 5G networks [14]. Part of this plan includes spectrum auctions. In March 2016, prior to the official start of the 5G FAST plan, the FCC hosted an "incentive auction" that began repurposing spectrum and opening up low-band spectrum for wireless broadband that can be used for 5G networks. A second auction of the upper 37 GHz, 39 GHz, and 47 GHz bands was set for 2019. Money raised from these auctions will be used to bring high-speed broadband to the rural U.S. AT&T and Verizon are considered the 5G leaders in the U.S., although it's debated which of those two was truly first to market. In December 2018, AT&T was the first U.S. carrier to launch a standards-based mobile 5G network servicing a dozen cities, albeit without any 5G-enabled devices. In October 2018, Verizon was the first to have a non-standards-based deployment that was actually a fixed broadband network in four cities. In March 2019, Verizon turned on its standards-based 5G network in Minneapolis and Chicago, also before mobile 5G devices were available. Verizon began selling Samsung Galaxy S10 5G on May 16, 2019 and claims it will have 5G in 30 cities by the end of 2019. As of August 2019, AT&T had deployed 5G in 21 cities and claimed the 5G network would be deployed in 30 states by the end of 2019.

Upcoming 5G Countries

Switzerland

The European carrier Swisscom's goal is to make Switzerland a 5G country with a nationwide 5G New Radio (NR) Non-Standalone (NSA) network established by the end of 2019 [15]. The service will be in the 2.1 and 3.5 GHz bands, which could be a first in Europe. The carrier is preceding its network launch with the sale of 5G-capable smartphones and subscriptions. Swisscom has competitors in Switzerland; Sunrise and Salt Mobile have also purchased spectrum bands at auction. Salt Mobile has plans for a 5G launch in the third quarter of 2019. Sunrise claims 5G network availability in 150 locations and is offering a fixed wireless access service, and is offering its service on the Samsung Galaxy Note 10 Plus 5G.

Nordic Countries

In 2018 Denmark, Finland, Iceland, Norway, and Sweden began a unique path toward being countries with 5G by signing a letter of intent. The goal is to create a unified approach to 5G deployment in each country to allow for an interconnected 5G network throughout the region [16]. The approaches listed in the letter included encouraging new testing facilities, coordinating 5G frequency bands across countries, removing obstacles to deployment of 5G

infrastructure, and keeping track of the development of 5G in areas like transport and advanced automation.

Security concerns and threat.

On October 18, 2018, a team of researchers from ETH Zurich, the University of Lorraine and the University of Dundee released a paper entitled, “A Formal Analysis of 5G Authentication” [17]. It alerted that 5G technology could open ground for a new era of security threats. The paper described the technology as “immature and insufficiently tested,” the one that “enables the movement and access of vastly higher quantities of data, and thus broadens attack surfaces”. Simultaneously, network security companies such as Fortinet, Arbor Networks, A10 Networks, and Voxility advised on personalized and mixed security deployments against massive DDoS attacks foreseen after 5G deployment. IoT Analytics estimated an increase in the number of IoT devices, enabled by 5G technology, from 7 billion in 2018 to 21.5 billion by 2025. This can raise the attack surface for these devices to a substantial scale, and the capacity for DDoS attacks, cryptojacking, and other cyberattacks could boost proportionally. In December 2018, Arne Schönbohm, head of Germany's Federal Office for Information Security (BSI), stated that the country had not yet seen evidence that Huawei had used its equipment to conduct espionage on behalf of China. That month, it was also reported that the Japanese government had ceased future procurement of Huawei and ZTE products. The Czech Republic's cybersecurity agency issued a warning against Huawei and ZTE products, arguing that Chinese law required companies to "cooperate with intelligence services, therefore introducing them into the key state systems might present a threat" [18]. Huawei refuted the arguments, stating that it is not required to include backdoors in its products, nor has the company ever received any requests to do so. Shortly afterward, prime minister Andrej Babiš ordered that government offices cease using Huawei and ZTE products. However, the ban was reversed after the agency's claims were found to be without basis. Huawei commissioned attorneys of the London-based law firm Clifford Chance and Beijing-based law firm Zhong Lun to review two Chinese bills commonly cited in these allegations (the 2017 National Intelligence Law, and the 2014 Counter-Espionage Law) [19]. They concluded that there was no such requirement in Chinese law for backdoors to be included in telecom equipment, and that the laws were directed more towards the actual operators of telecom services, and not extraterritorial. These findings were published in a wired (magazine) opinion piece by Zhou Hanhua. Follow up reporting from Wired cast doubt on these findings, particularly because the Chinese "government doesn’t limit itself to what the law explicitly allows” when it comes to national security [16].

CONCLUSION

Due to fears of potential espionage of users of Chinese equipment vendors, several countries (including the United States, Australia and the United Kingdom as of early 2019) have taken actions to restrict or eliminate the use of Chinese equipment in their respective 5G networks. Chinese vendors and the Chinese government have denied these claims. A report published by the European Commission and European Agency for Cyber security details the security issues surrounding 5G while notoriously trying to avoid mentioning Huawei. The report warns against using a single supplier for a carrier's 5G infrastructure, especially those based outside the European Union. (Nokia and Ericsson are the only European manufacturers of 5G equipment.) It has been alleged that the United States via the FBI, the UK via GCHQ and other intelligence agencies have sought to adjust 5G standards through 3GPP in order to allow as much metadata as possible to be collected for mass surveillance purposes.

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