

Fifth Generation (5G) Wireless Communication

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Abstract—Fifth Generation technology is the next big thing in our future for the next decade and a half. 5G is going to create new technology that hasn't been invented yet. Speeds will be almost instant with latency. It will have a big effect on the global economy and how we communicate with each other. 5G will change how data travels through cell towers and how its transmitted. There are a few new important security features, but also some flaws that will carry over from third generation and fourth generation networks.

Fifth generation technology will come at a cost. In this paper I will explain the cost and cost benefits of 5G. Its customers and business will see a sharp increase in bills and data plans. Overall 5G will benefit the world. We will be more connected than ever before, and it'll make some aspects of our everyday lives easier.

I. INTRODUCTION

Fifth Generation wireless communication is the next big thing in wireless technology. It is the latest and greatest cellular technology. Its main upgrade will upgrade speeds and responsiveness of wireless communication networks [8]. Speeds can reach upwards to twenty gigabits with some estimations [8]. The latency could be one millisecond or less. With more available bandwidth and better antenna technology more data will be able to be transmitted [8]. This is a huge plus considering how much data is transferred over wireless networks nowadays. With people streaming, playing games, and video chatting just to name a few, there will be less lag and drop time.

With Internet of Things, a problem that I've found was security issues over Wi-Fi. It was easy for attackers to hack into these smart devices or their smart hubs. With additional improvements on fifth generation wireless communication Internet of Things devices will use secure, data only connections. Figure one below shows how wireless networks have transformed since the 1990s.



Figure 1: Growth in wireless networks

II. 5G OVERVIEW

1) Status

Fifth generation wireless networks are currently operating in major cities in four different countries. The United States, Japan, South Korea and China are currently diving into 5G [8]. Through 2030 network operators will spend billions on fifth generation expenses. Business models will be written up for investment and benefits of this new wireless technology [8].

2) How does 5G work?

Fifth generation wireless signals will be transmitted through antennas on top of buildings and through light poles [8]. This will allow a stronger and better signal for fifth generation enables wireless devices. The use of multiple small cell stations will allow large amounts of traffic to pass through them [8]. Fifth generation will rely on 30 gigahertz and 300 gigahertz band of spectrum to produce these high speeds. This spectrum is allowed through the millimeter wave spectrum [8]. This spectrum is vital for fifth generation networks because frequencies for this new wireless technology run on this spectrum. It is a huge step from fourth generation networks.

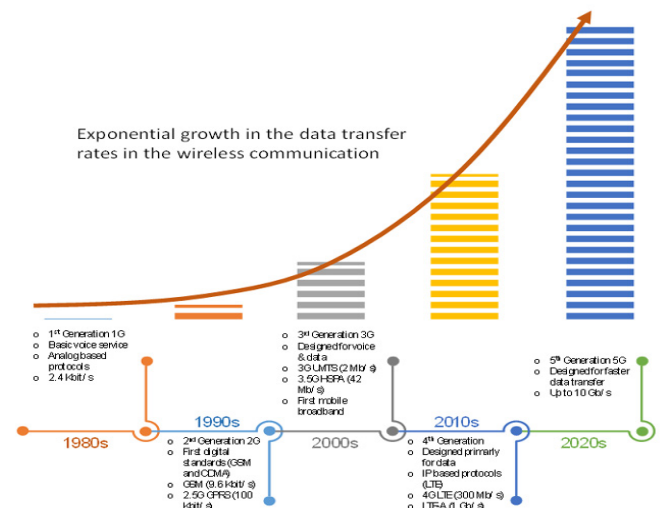


Figure 2: Exponential growth chart

3) 5G VS. 4G

To give you a breakdown of how much faster 5G really is, fourth Generation Networks are five hundred times faster than third generation networks [8]. Fifth generation technology will be one hundred times faster than fourth

generation networks [8]. Latency will be the biggest difference in fourth generation verses fifth generation. Fifth generation networks will have a much lower latency than fourth generation networks [8]. The encoding methods between the two networks are also different. 5G will be using Orthogonal Frequency Division Multiplexing (OFDM) encoding. Figure two explains the growth from each wireless network up to 5G. It provides big advancements in data links. It uses the most updated bandwidth which will contribute to the large amounts of traffic that fifth generation networks can handle.

III. FIFTH GENERATION BENEFITS

A. Speed

One of the best improvements is speed in the next generation. Fifth generation speeds will reach five hundred to 1500 megabits per second [8]. In terms, you'll be able to download movies in seconds. This will make getting content and streaming online much easier as we move into the world of streaming. According to Forbes there will be thirty billion connected devices by 2020 [6]. Internet of Things will keep growing [6].

B. 5G Utilization

Fifth generation enabled phones will be able to switch between 4G and 5G to find the most stable signal. 5G will be beneficiary for many industries. Entertainment, automotive, manufacturing and logistics will benefit from this new wireless technology [6]. Figure three below shows the interconnectivity between devices and 5G networks. Different devices will benefit and connect from 5G. 5G will speed up technology advancements in cars and other autonomous systems. Robotics will begin to emerge as everything will begin to become connected like infrastructure, healthcare, and Internet of Things [6].



Figure 3: Connectivity for 5G

C. Business Benefits

Fifth generation technology will increase production and overall make life easier for businesses [6]. Production in factories will help businesses produce more product as well as it will reduce cost. Businesses will have to make a big investment into 5G as it will be more expensive [6]. Users will be connected and it's important for businesses to keep

up [5]. Businesses will have new advancement in artificial intelligence since fifth generation lowers latency to 1 millisecond or less. Businesses also have the opportunity to educate their employees on 5G and security related concerns. It is important for businesses to prepare properly for this new wireless technology. It is also expected to bring millions of new jobs by 2015 according to IBM [5].

D. Internet of Things & 5G

With 5G being able to carry heavier amounts of data quicker and more efficiently, the Internet of Things (IoT) technology will explode [4]. With the adoption of 5G we will see more smart everything. 5G will increase innovation rates of buildings, agriculture, drones, routers, switches and access points [4].

E. Economy

With the advancements of 5G all industries will be affected. Like the example of a smart car and 5G connection, your car could know your estimated time of arrival to work and create the best route for you. The healthcare industry will have its benefits too. Doctors and patients will have new smart devices to monitor health and see live data that will lead to better care [4]. According to MIT there will be over twenty billion devices installed that will generate big data [4]. This will bring new goods and services as well as capabilities throughout the world. This will change the economy in many ways. It will create a new type of revenue. Up to 12.3 trillion dollars in revenue can be produced across multiple industries according to IHS Markit [3]. China, United States, Germany, South Korea, France and the United Kingdom will contribute to the most growth of 5G [3]. 5G is going to make it possible to develop new technology that hasn't been invented yet.



Figure 4: Smart City

It will inspire new industries that could also affect existing businesses. 5G will create a giant ecosystem. Qualcomm says

the 5G Real Global Gross Domestic Product growth will be equivalent to the size of a country like Italy [3]. Qualcomm says 91 percent of new products have not even been invented yet. There will be an 89 percent increase in productivity and small businesses will thrive in this new industry. Since the first standard of 5G has already been completed the economic output has been increased to one trillion dollars [3]. For future economic growth 5G is expected to invest over 235 billion dollars per year [3]. Figure four shows how a sample of a smart city map. 5G will bring new features that will benefit us everyday moving through a smart city. Figure five below shows some of the benefits 5G will bring in the next decade.



Figure 5: Benefits of 5G

IV. 5G SECURITY OVERVIEW

As with a lot of new technology, there comes new security vulnerabilities that can be exploited [7]. There are a lot of intrusion points with fifth generation technology. According to wired fifth generation wireless technology still has vulnerabilities as it rolls out this year [7]. One of the biggest worries is that attackers can possibly know the location of users. There have been 11 design issues concerning 5G protocols [7]. These vulnerabilities include location, throttling your service, tracking your phone calls, texts or browser history. These threats were identified with a security tool called 5GReasoner [7]. Previous flaws from third and fourth generation wireless could possibly be inherited to fifth generation as well. Other attacks include sending your devices IMSI number unencrypted [7]. Devices use a Temporary Mobile Subscriber Identity that refreshes constantly to hinder tracking. Researchers according to Wired have found alarming security issues that would let attackers override Temporary Mobile Subscriber Identity [7]. Attackers could use software-based radios to exploit these attacks [7].

Replay attacks are also possible with the new technology. So, an attacker could replay the same message that could drive up a customer's bill [2]. User data can be exploited through its continued roll out. The good news is 5G is still being tested and worked on [2]. Security will be improved as it continues to roll out into the next decade. Figure six shows how packets and data is authenticated when it moves to the cloud and other networks. Attacks are pointed to be low impact but it's still facing lots of scrutiny in the security community. Palo Alto, a

firewall company has rolled out a fifth-generation firewall to protect mobile devices. The firewall is designed to prevent mobile attacks targeting network services and Internet of Things devices. This is a big help because Internet of Things devices have known security vulnerabilities that can be easily exploited.

Ways to prevent vulnerabilities on your 5G enabled device is not to share your location with unauthorized or suspicious applications. Fifth generation will come equipped with a new type of network security encryption called International Mobile Subscriber Identity. IMSI authenticates your device as it transmits data on the network [2]. Attackers won't be able to read the code as it's transmitted throughout the network [2].

Cyber security is one of the biggest problems in today's technology field world. It will be interesting to see how fifth generation wireless networks play its role in it. It will be vital for these networks to be secure as millions of people and multiple businesses will adapt to it.

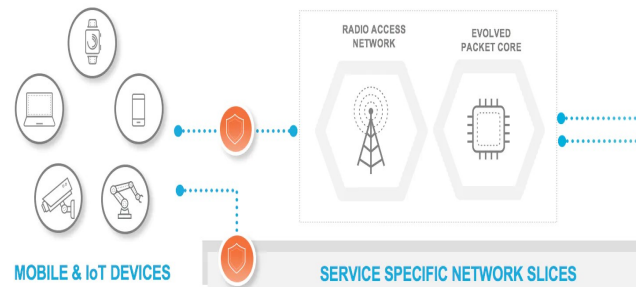


Figure 6:

V. 5G SECURITY CONTINUED

A. More about IMSI Encryption

International Mobile Subscriber Identity encrypts your information like who you are and where you are as it travels through the air. Since attackers won't have the decryption key, they won't be able to break it. IMSI helps protect your identity and makes the network safer [2]. IMSI authenticates your device as its data travels through the network [2]. Figure seven below shows how adding IMSI encryption to 5G is more secure when switching cell towers.

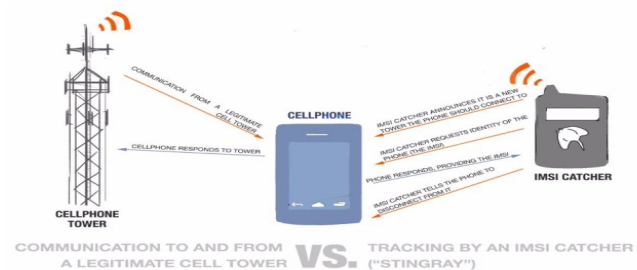


Figure 7: IMSI Authentication

B. 5G Home Network Control

Home network control will allow users to authenticate their devices from one cell tower to another [2]. This broadens your security protections since the average user connects their devices to multiple networks like Wi-Fi, Bluetooth and networks overseas [2]. Home network control will help protect your data just like IMSI encryption [2]. Home network control upgrades the whole security system for mobile devices.

C. 5G Network Virtualization

With the amount of data fifth generation wireless technology will have it will have to provide cloud security [2]. A lot of things for example authentication and network data virtually will allow a network to be more flexible and more trustworthy [2]. It will also add to the security rather than having it stored physically [2]. On a virtual network speed and storage will be increased. With 5G responsiveness will be almost instant. Heavy data can be moved to the cloud automatically. Another benefit of network virtualization is that there will be less outages [2]. Updated security abilities and security software updates can be pushed out faster to customers on a virtual network.

D. Personal Device Updates

With 5G wireless network providers will be able to send out security patches and updates to devices on their network [2]. There will be a new system that will identify different types of devices on a network rather it's a refrigerator, smartphone or an IoT device. This is done through authentication systems that will be equipped with 5G networks [2]. When the authentication system figures out which device is which on the network, a custom security update will be sent to this particular device. This is also called plug-in security [2]. With latency being one millisecond and possibly even lower, these security updates will be pushed out extremely fast to almost instant. The security updates will allow your device to provide defense from cyber threats [2]. Another benefit of these updates is that there will be almost no disruption to your smart device.

VI. CLOSING REMARKS

Fifth generation is the future for technology and the world needs to prepare for it. It's going to make life much easier and change how we are connected with each other. By 2020 most of cellular devices will be 5G enabled. One of the big topics that is still being assessed and tested today is the security threat it may pose. Although there are several new security features 5G will bring the existing threats remain. One thing there is to know is that security vulnerabilities will always exist when it comes to technology. Almost all the average tech user's data is on their phone, how will this data be protected from cyber criminals?

Some of the downsides to 5G is how much data will be transmitted through the new cell towers. 5G will allow big amounts of data to be transmitted which can cause congestion over a network. How will networks handle this? Another

potential problem with 5G is cost. 5G infrastructure alone will be expensive. Also, because its new and lightning fast this will come at a huge price. The cost for engineers to install and maintain its towers over time will have a huge effect will 5G becomes widely available. The cost for you to be on a 5G plan may hurt your pockets on your bill.

Although there will be more available bandwidth with 5G that means there will be less coverage. Sense there will be more bandwidth that means more cell towers need to be installed which again plays a factor into the cost. Radio frequency is another thing that will need attention with 5G. Since 5G will be running in gigahertz it will be running on the six gigahertz network. This frequency is already congested with other signals operating on it currently like satellites. Sending and receiving data may be difficult over this frequency.



Figure 8: 5G Communication

Besides all the negative possibilities with fifth generation networks, this new technology is going to be big. It's going to change the way we communicate. I think one of the best new inventions coming with 5G is the smart light pole. Figure nine shows an example of a smart pole with cameras and a data display attached. It will have 5G antennas attached to it for stronger signal and easy for data. These poles will be the start to future smart cities. The smart light pole will accommodate Internet of Things devices and energy efficient lighting as well [1]. These smart poles will provide a variety of smart services for a city. Sensors, cameras, microphones and even display screens for messages [1]. The sensors will have the ability to do supervise the environment like the air quality [1]. Cameras can monitor roads and improve the flow of traffic [1]. This can send alerts to navigation applications like Google Maps and Waze apps. This will help alert people to go a new route, road closures or to leave at a certain time.

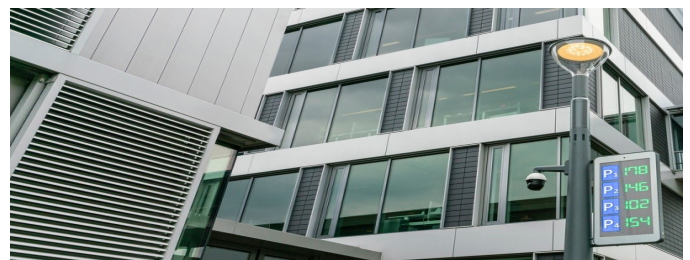


Figure 9: Smart Pole

Fifth Generation wireless technology will benefit us like never before. It'll interesting to see how wireless networking companies roll out their new technologies for it. Speeds and latency will be nonexistent with almost 0 lag. It creates new technology that will connect a whole city to its people. Next decade 5G will have a huge effect on our everyday lives.

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