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The Future with 5G Name of Student Institution

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I. INTRODUCTION

With the onset of easily accessible smartphones and tablet devices, data usage has been expected to increase significantly. Over the past few years, mobile data traffic has grown so much that user demand is starting to exceed the network capacity. Cisco (2019) reported that in 2017 alone, global mobile data traffic displayed an estimated growth of 71% Year over Year. In the same document, it predicts the traffic to increase to 77 exabytes per month in 2022 - a 46% Compound Annual Growth Rate from 2017. With these consistent figures throughout the world, it is not surprising that the existing network systems are currently reaching high utilization rates.

Another factor in the increased traffic load is the expansion of the Internet of Things (IoT). Various applications, ranging from the healthcare and medicine field to the industrial and engineering sectors, have started to develop smart devices and appliances. These machines are geared towards wireless connectivity to the internet or with other gadgets, expected to be able to seamlessly connect to the network without having to expend a significant amount of power. With IoT, an exceedingly large number of devices are expected to connect to the network at the same time. Thus, not only the wireless communication system's data rate is to be improved, but also its energy consumption (Wong, 2017).

These qualities, among many others, have been standardized to become the requirements for the fifth generation (5G) of wireless networks. Peak and guaranteed data rates, mobile data volume, end-to-end latency, device count, and terminal counts are included in the list of features to be improved. In this paper, the future with 5G wireless systems will be discussed. As these enhancements are expected to affect sectors, businesses, and individuals, this paper will highlight avenues to maximize the use of 5G. This topic will also encompass new technologies and applications expected to grow and benefit from these advancements.

Development of 5G

The development from the first generations of data transmission can be described as continuous improvement. As the first generation of networks in 1979, 1G allowed mobile voice communication. However, it had unreliable handoff, low quality, and capacity, and a lack of security as voice calls were played back in radio towers (Shukla et al., 2013), making the messages vulnerable to eavesdropping. 2G brought about digital networks at the tail end of the 20th century, with messaging and roaming services. GPRS (2.5G) and EDGE (2.75G) improved the data connectivity of mobile phones. 3G, in 1998, ushered in low-cost roaming, higher quality of voice and data service, and an overall enhanced mobile internet experience. Mobile applications came in later in the generation (3.5G). With the onset of 4G in 2008 and 4G LTE in 2009, mobile users were provided a fast broadband internet experience with more than doubled data speeds (Gemalto, 2019).

There is a significant leap from the 4G standards towards 5G; to put things into perspective, the expected latency for 5G networks is 1ms, 25 times faster than the current response rate (Wong, 2017). With this development, connectivity can quickly expand beyond mobile internet and into the massively networked Internet of Things. Such a low latency allows real-time interactivity with cloud-based services, a critical component in automated devices. Mitton et al. (2012) refer to this as "Sensing and Actuation as a Service," similar to the other as-a-Service offerings on the cloud, such as platforms (PaaS), software (SaaS) and infrastructure (IaaS). Compared to 4G LTE, the fifth generation technology allows the connection at least 100 times more devices. Per square kilometer, the 5G system can provide support to over a million connections.

Most devices used in the Internet of Things are constrained by limited memory and power (Srinidhi et al., 2019) and thus need efficient data routing. With 5G, performance trade-offs can be reduced or eliminated to produce better results than the current wireless technology's output.

The Internet of Things

As touched upon in the previous section, an anticipated outcome of 5G development is an increased potential for the Internet of Things (IoT). The 5G system is expected by researchers to be a substantial boost to the deployment of IoT (Militano et al., 2015) because of its powerful connectivity features. IoT, sometimes referred to as "Industrial Internet" and "Internet of Everything," is a network of physical objects, encompassing devices of all types and sizes, which communicate with each other to achieve a set of goals (Patel et al., 2016). Often, these everyday objects work to create a better quality of life, but can also be used for industrial and business purposes. It is interesting to note that the objects involved in the IoT are not just electronic or digital devices, but even things such as food, furniture, and fashion items.

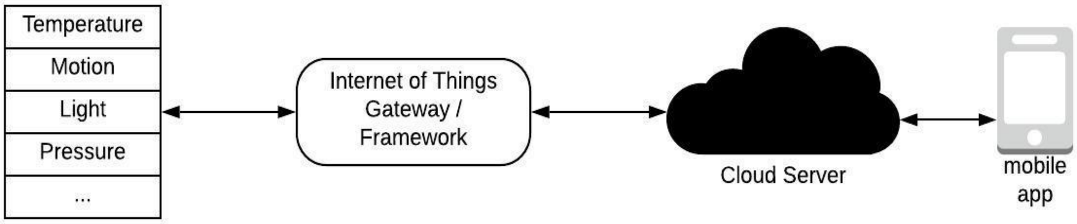

Fig. 1 Simplified diagram of IoT (Alluwar, 2016)

Gopal & Kuppusamy (2015) state that the ideal Internet of Things would allow mobile devices to gather and process data and transmit the information to networked objects without human input. These data may include location, weather conditions, and even device usage. IoT can already be applied to various sectors. However, armed with the power and potential of 5G technology, the results are expected to be impressive. With a mobile data volume of 10Tb/s/km2, 1000 times higher than its 4G counterpart, 5G systems could recognize drivers along highways and directly deliver media on their phone instead of traditional billboard advertisements. This method could also work for mobile phones detected to periodically visit specific locations, such as a gym, a particular clothing shop, or a favorite restaurant. Because of 5G's higher reliability rate of 99.999%, coupled with its end-to-end latency of less than 1ms, self-steered motor vehicles are expected to achieve subhuman reflexes and lower rates of failure. Not only will this apply to cars, but more massive transportation modes such as trains and aircraft as well.

Another improvement from 4G is the 1 trillion IoT terminal capacity of 5G networks. In any medical facility with a plethora of devices, such as pacemakers, heart monitors, or even weight-sensitive beds and reactive room conditions, 5G's ability to provide a high number of connections allows for a better quality of service. Communication among these devices, along with a centralized repository for further human analysis, can elevate healthcare to higher standards. Similarly, energy utilization can be monitored and minimized in homes and buildings through 5G capabilities and IoT. With 90% less energy consumption than 4G networks, 5G can connect objects for as long as ten years without human intervention (Gemalto, 2019). Even on a scaled-back estimate of several months, the power conserved within these systems is still significant. Life at home can also be improved with water and air quality monitoring, alongside other environmental concerns (Gopal & Kuppusamy, 2015). Large-scale infrastructure may also benefit from the 5G and IoT cooperation. Bridges, railways, and roads can be monitored and given a prompt response with the use of smart sensors and cameras. Urban planning, including waste management and traffic administration, offers scenarios that could be solved with the help of 5G.

Applications of 5G

Augmented Reality and Virtual Reality

One of the primary concerns raised about the newest generation's technology is its lack of value for consumers. In an article on the network's potential, Dignan (2019) states that while users would be able to access new devices and higher bandwidths, 5G remains a "business event first." In a report by Ericsson Consumer & IndustryLab (2019), the world-class research entity dispels common misconceptions on the consumer's perspective on 5G. The report reveals that consumers see the potential of 5G, and the majority are likely to engage with it within the next few years. In the same statement, over 66% of the respondents stated that they were willing to pay a premium to avail 5G services, with rates ranging from 20% up to 32%, the latter for early adopters. However, this concurrence hinges on the precondition that new 5G functionalities are included in the plan.

Video consumption is expected to rise sharply with the introduction of 5G. This development opens the door for the fascinating world of Augmented Reality (AR) and Virtual Reality (VR). Applications with AR/VR technology are expected to account for at least an hour of use, requiring large amounts of data for a fully immersive experience. Ericsson's report (2019) also forecasts that 200GBs per month will be consumed by one in five smartphone users. In an interview by Tibken (2019), Sethi, head of Ericsson's ConsumerLab, shares that 10 minutes of daily AR use can reach up to 50GBs in a month. Consumers may be unable to predict their increase in data use because these metrics are not readily available to the public. AR and VR games and applications demand higher bandwidth and lower latency to produce acceptable results. These streaming requirements currently cannot be provided by mobile networks. Nikolov, CEO of a VR solutions company, states that with 5G, real-time AR/VR experiences can be integrated seamlessly (Bozorgzadeh, 2019).

According to ABI Research (2019), AR/VR ventures rely on three key components: high capacity, low latency, and network uniformity. While some implementations may require one element more than the others, all three features are critical in the user experience of AR/VR applications. Thus, 5G is a necessity to expand and mass-market AR/VR offerings.

Some of the potential uses outlined by ABI Research include automotive video streaming. An AR/VR experience while inside a moving vehicle requires a handoff between multiple supporting cell sites within the network, something that could be challenging with current 4G limitations. Another use case presented is the mitigation of data congestion in densely populated areas. Specifically, in places where events require concurrent data processing, capacity and latency must be at their most effective rates. Supporting videos with 6 Degrees of Freedom, which allows for the changing of both position and orientation along the three axes, need a significantly high bitrate to adjust with the movement. As with most immersive experiences, it would require higher bandwidth and a faster response rate.

Tactile internet, which is hailed as the next step after the Internet of Things, enables spatial-based interaction among humans, machines, and their environment in real-time (Kavanagh, 2018). A low latency system is expected to simulate human interaction and natural reaction times. Network reliability is crucial as tasks are scheduled to be done remotely. Near-perfect performance with a round trip latency of less than 5ms is ideal for complete usability.

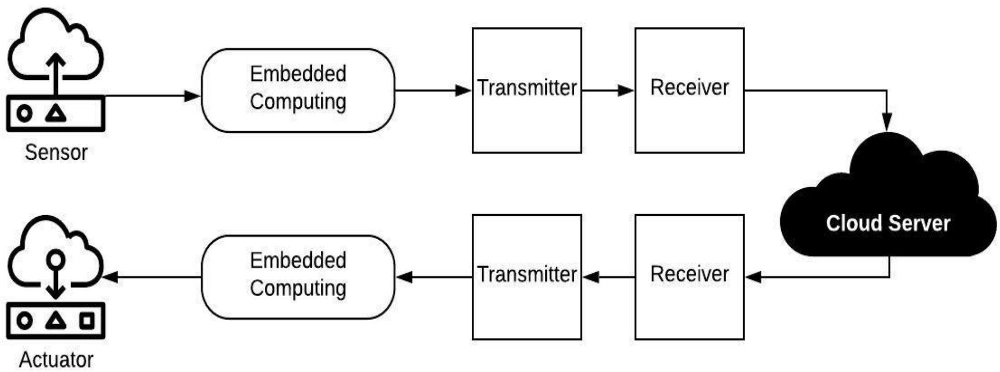

Fig. 2 Tactile Internet Diagram (ZeitgeistLab, 2019)

Simultaneous Translations

Another engaging opportunity that 5G presents is the possibility of near real-time translations. While standards on remote interpreting are far from developed (Capelli, 2019), much can be explored with the onset of new technology. Without the limitation of having to be physically present, off-location interpreters can queue engagements more efficiently and can provide services without imposing their presence. Improved network systems that allow the fast and reliable transfer of data-intensive and time-sensitive information would revolutionize the remote translation industry.

With the evolution of 5G to provide higher audio and video resolutions, augmented reality would mitigate the possible estrangement in remote interpreting. Similar to an online business video conference, the translator's virtual presence could be projected onto a single view for everyone, such as next to the speaker or host. As technologies develop, it could even be possible to replicate the virtual reality such that each attending participant gets their translator right next to their seats. Capelli (2019) predicts these advancements to come into fruition within ten years.

In the future, interpreting services would likely pull from and feed into Artificial Intelligence. Given a sufficiently large amount of data that passed through the translator, quantum computers can compute and process speech patterns. These data sets may be analyzed with short processing time, allowing predictive suggestions to be made to the translator service. This behavior is similar to the concept of human translators working without any prior information about the topic; stock knowledge and previous experiences guide them into interpreting given a generic context. Since 5G will compel higher data consumption - and consequently produce more massive amounts of data - it gives quantum computers a chance to learn and develop a simultaneous translator service continuously.

II. CONCLUSION

5G is introduced as a way to alleviate the increase in mobile data traffic over the last decade. As data consumption is only expected to grow, it is reasonable to establish systems capable of higher bandwidth, lower latency, and overall better efficiency. The development of 5G opens the door for various opportunities, such as the Internet of Things (IoT), Augmented and Virtual Reality (AR/VR), and simultaneous interpretation. What seemed to be the product of science fiction is slowly materializing in the next few years, thanks to the 5G network. Indeed, 5G plays a significant role in revolutionizing the future.

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