isrjournals

International Journal of Advanced Research in Computer Networking,Wireless and Mobile Communications

Volume: 5 Issue: 3 Dec,2016,ISSN_NO: 2320-7248

Challenges and Security Issues for 4G & 5G Implementation in a Distributed Environment

Deepika Verma, M.Tech. Student
Birla Institute of Technology, Mesra
Ranchi (Noida Campus), India
deepikaverma07@outlook.com

***Abstract* - Evolution of the wireless access technologies has reached its fifth generation. The 4G network technology integrates autonomous networks to provide high speed data access to the compatible wireless devices. With 4G successfully implemented across the various parts of the world, the industry has already started anticipating the technologies that the next generation(5G) will comprise of. Several pivotal challenges encountered during the global implementation of 4G and 5G systems and their respective security issues have been discussed briefly.**

Keywords* - *4G network, 5G network, LTE, 3GPP, QoS, Challenges, Security threats

I. INTRODUCTION

With the advent of 4G & 5G network technologies, Information technology as well as the Telecommunication & Wireless Communication Industry have taken a great leap towards networking advancements. 2G and 3G have been used widely all over the globe. The 4G technology took 2G & 3G several steps further by adding more advanced features and deleting the obsolete ones. With the 4G now implemented in various parts of the world, industry is slowly shifting attention towards the future technologies that will comprise the 5G wireless technology.

One of the key features of 4G is its support for high data rate. On the other hand, 5G is expected to further up the ante by increasing the downlink data rate, coverage and providing better user experience. Technocrats have already started working towards such powerful wireless technologies. And to implement the new wireless standards, the challenges and security issues must be dealt with and their solutions need to be developed.

In this paper, we identify several challenges and security issues that telecommunication industry is faced with while implementing the 4G and 5G network technologies and also propose possible solutions to some of the problems.

II. EVOLUTION OF 4G

4G is the successor of 3G and the fourth generation of network technology. The International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards called as the International Mobile Telecommunications Advanced (IMT-Advanced) specification. In the standard specifications, the speed requirements for 4G service had been set at 100 Mbps for high mobility users and maximum 1Gbps for low mobility users.

Some of the key features of 4G technology are:

- Integrated heterogeneous network
- Higher data rates
- Greater Coverage and availability
- Scalability
- Interoperability and simple roaming

According to 2015 statistics of 4G measured by OpenSignal.com, South Korea has the highest 4G penetration rate of 97%, followed by Japan (90%), Hong Kong (86%), Kuwait(86%) and Singapore(84%). These are the top 5 countries with highest 4G penetration rate. Despite not being in the top 5 list of highest 4G penetration countries, New Zealand has the fastest average 4G speed of 36Mbps. Singapore bags the second spot with an average 4G speed of 33Mbps, followed by Romania(30 Mbps), South Korea(29Mbps) and Denmark(26Mbps). These are the top 5 countries with fastest average 4G speed. Early LTE adopters like Sweden, Japan, Hong Kong, US are not in the top 5 anymore.

What about the U.S.? Although US offers 4G penetration at 78%, the average 4G download speed still lags behind at around 10Mbps. Some of the reasons for the low U.S. score is that some carriers in the U.S. built their 4G networks around 20MHz for their initial rollouts (Verizon and AT&T) and the LTE networks for Sprint and Metro PCS were built around 10MHz. Meanwhile, the European operators used 40MHz when they built their 4G LTE pipelines. The speed and penetration statistics will go on varying as technology advancements are deployed by different countries, the question of whether challenges and security concerns for successful implementation of 4G are being taken care of vigilantly remains.

In India, Airtel launched its 4G services across 296 cities recently, making it the first telecom operator to roll-out the next-generation mobile Internet technology in most parts of the country. 4G technology offers ultra-fast broadband Internet with higher data transfer speeds and improved services. Also referred to as LTE (Long Term Evolution), Airtel network is equipped to offer max speeds of up to 45Mbps. With such high download speeds, users can enjoy zero buffering while streaming high-definition videos.

III. CHALLENGES FOR IMPLEMENTING 4G

1. *Quality of Service(QoS) Support and Network Framework*

The existing network systems can be broadly classified into 2 categories: Non-IP-based and IP-based. Most of the Non-IP-based systems are highly optimized for voice services. Whereas, IP-based systems are usually optimized for data services. For implementing a 4G system, integrating these 2 systems is a big challenge in itself. For end-to-end time sensitive services, network providers need to guarantee good QoS. By integrating the networks, users will get better access to the services as QoS provided to them would be better.

A. Interconnecting autonomous networks

Interconnecting the heterogeneous wireless network systems such that they can work together in harmony to form the 4G network is a huge challenging as each of these autonomous systems may be working on different architectures and protocols for providing wireless network services.

B. Varying conditions of network

Network bandwidth, jitter, round trip delay etc may vary across networks, resulting in varying quality of service that users are provided. Maintaining the provided service quality across heterogeneous networks under varying network conditions is crucial..

2. *Analyzing and Selecting Appropriate Network*

Since 4G will be a heterogeneous network, compatible wireless devices will have to detect the surrounding signals of various service providers, analyze the services available, and then affix to desired service provider either manually or automatically. As various service providers use different sets of protocols for their networks, they might be incoherent with the other networks as well as with the wireless devices. Due to this issue, it becomes even more perplexing to choose the most apt service provider.

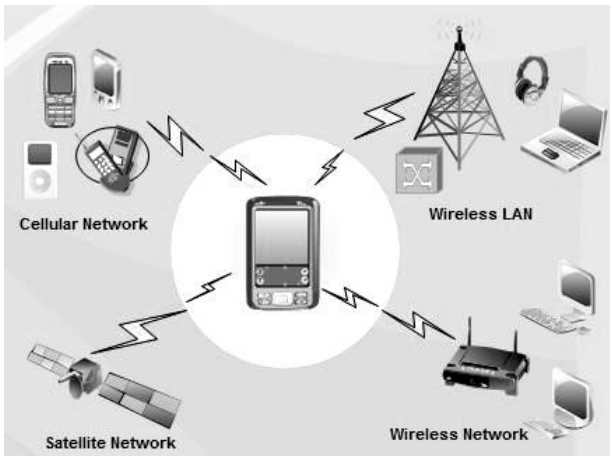

Fig.1. A depiction of Overlay Network providing automatic system discovery on the user device.

A feasible solution for this problem is "System-initiated discoveries". In this mechanism, the compatible software is automatically downloaded in the user device depending on the network he/she is connected to[1]. Another mechanism for solving this issue could be to use "Overlay networks". In this approach, each device could be connected to a number of networks through an overlay network, which is somewhat like a virtual network layer. This Overlay network layer will carry out all the decisive protocol conversions, QoS arbitration etc as depicted in Fig.1.

3. *Incompatible roaming frequencies*

Roaming frequency incompatibility is another major challenge when implementing a heterogeneous network. Even if you get a 4G compatible device, there is no guarantee that you will be able to use 4G when you travel outside of country. As many countries are use frequency spectrums different than others for their network services, it is highly possible that their 4G service spectrum is going to be different from the one your device is capable of receiving and processing. So you might need to switch to services other than 4G such 3G or 2G, rollouts of which were more universal. Most probably in the near future, the wireless devices will include chipsets which can process a wide range of frequency spectrums to solve this problem.

4. *Cost Planning and Keeping track of User Records*

With high speed 4G networks, tracking user data statistics and hence maintaining user accounts has become much more complicated for the service providers. As mobile users are constantly interacting with different service providers when switching from 1 cell(service area) to another, it will be difficult to collect, manage and store customer's account information. Thereafter, providing the customer with a simple but detailed bill becomes a huge challenge.

In terms of cost planning for 4G networks, the most important issue that needs to be considered is that the service costs should be kept realistic and affordable for customers. Service providers must plan service costs carefully in order to keep the expenses realistic.

5. *Meeting Consumer Expectation*

4G networks provide users with high degree of possible customization power, i.e., users can select the desired radio environment, QoS level etc. Customers need to have a strong sense of liking towards the services they are paying for. Hence, meeting customer's expectations is a major challenge as ultimately, it's the users who matter.

IV. SECURITY ISSUES OF 4G

Security policies and the implemented protocols of the service providers must address the security issues that come inherent due to the very nature of 4G technology. Some of the important security issues that must be addressed are:

1. Access Protection: The network resources need to be protected against unauthorized access by malicious users.

2. User Authentication: Users accessing the network must be authenticated before they are given access to the network.
3. Non-repudiation of data: It is used to prove the origin of the data.
4. Data confidentiality: The data must not be exposed to unauthorised users on the network.
5. Security of end-to-end Communication: Flow of information between authorized end points must be secured and it should be ensured that data is exchanged only among these end points.
6. Integrity of Data: To ensure that no unauthorised user can access and modify/delete/replicate the data in order to maintain the integrity of data.
7. Availability of data: It must be ensured that no authorised user is denied access to the data available on the network.
8. Network Privacy: The network must be secured and protected so that no information can be derived by observing the network activities.
9. Secure online Services: E-commerce services and other advanced applications must be secured over the network access.

Security goals help focus on the potential problem areas before the problems arise. This way, service providers can mitigate a lot of issues by simply preventing them from occurring at the first place.

Specifically, The 4G core addresses quality, security, and QoS through reuse of existing mechanisms while still attempting to work on some quality and relinquishing issues[2]. For network systems with speeds as fast as 1Gbps, establishing security measures is an absolute necessity. Data transmission over the network should be secured from malicious attacks as malevolent entities will have ample opportunities to breach the user data. Hence, multi layered security protocols needs to be implemented in order to protect the data disseminated over the network[3].

2 different approaches can be followed to address these security issues:

1. Either the service providers can modify the existing security policies so that they can adapt to the new systems.
2. Or they can devise new mechanisms which are more dynamic in nature. Reconfigurable mechanisms which can easily adapt with changing system needs will be much more efficient[4].

V. EVOLUTION OF 5G

5G is the proposed successor of 4G and the fifth generation of wireless network technology. 5G shall offer speeds beyond the bounds of 4G.

The standard requirements for technologies that will define the future 5G networks are:

- 1-10 Gbps maximum data rate
- 100Mbps minimum data rate
- 1 ms latency
- Increased bandwidth
- Increased connection density
- Greater availability
- Increased coverage
- Decrease in network energy consumption
- Reduced battery/power consumption
- Increased spectral efficiency

South Korea and China has already started working towards implementing 5G technology. Trial services are expected to begin in 2017 and total rollout can be expected by 2020. 5G is expected to be so much blazingly fast that an 800MB movie can be downloaded in just one second. It is also being predicted that with the advent of such a high speed network, there will be no further need of a 6G network.

VI. CHALLENGES FOR IMPLEMENTING 5G

While a shift to 5G would be hugely impactful, the industry will need to overcome a series of challenges if these benefits are to be realized.

1. *Spectrum and Coverage implications*

A number of frequency bands are being considered to be used in the implementation of 5G network, but main focus is on the higher frequency spectrum, as high as 6GHz with frequency bands of 300GHz. However, high frequency bands come with a limitation- higher the frequency band, smaller the cell radius. Hence, achieving widespread coverage would pose a huge challenge for the service providers.

One of the possible solutions for this problem can be the Beam forming method. In this method, the radio interface is focused into a beam which will be usable over greater distances. However, using this method means that the beam itself will have to track each device independently. This could make 5G an expensive technology to deploy on a large scale.

Another method for increasing the bandwidth is by using High-order MIMO (Multi-Input, Multi-Output). In this, an array of antennae is installed in a device and multiple radio connections are established between a device and a cell. However, high-order MIMO can have issues with radio interference, so some solution is required to help mitigate this problem.

2. *Latency Reduction*

In order to achieve network speeds of upto 10Gbps, the end-to-end round trip delay or latency needs to be reduced to less than 1ms. Attaining such low latency requires changes in the current technology framework.

No matter how high the processor speeds and low the network latency be by 2020, the speed of signals travelling through optic fiber cables will be restricted due to the very nature of law of physics. This implies that for wireless services that require round trip delay time less than 1ms, all the content must be served from antennas placed very close to the user device. This implies that the cellular antenna towers must be placed in close proximity to each other.

If any service requiring 1 ms delay also has a need for interconnection between one operator and another, this

interconnectivity must also occur within 1km of the customers. This could well be the case in a service such as social networking content pushed into augmented reality. Today, inter-operator interconnect points are relatively sparse, but to support a 5G service with 1 ms delay, there would likely need to be interconnection at every base station, thus impacting the topological structure of the core network. Roaming customers would need to have visited network contextual roaming capabilities, and have content relevant to their applications available directly from the visited network, posing challenges for the existing roaming model.

Best case scenario would be to implement a single network framework which can be used by all the service providers. This would make it easier to achieve latency of less than 1ms as all the customers could be served from a single point at the base station of the network operators that would maintain all the interactions between the user devices. This also implies that only one wireless network can be structured which can be shared by all the operators. See Fig. 2.

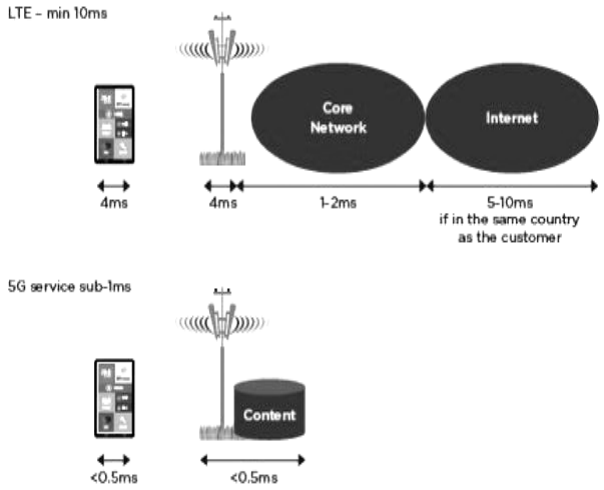

Fig.2. Latency performance for LTE compared to latency requirement for 5G

VII. SECURITY ISSUES OF 5G

Several likely security issues[8] are:

1. *Threats posed due to increased connection density.*

5G is expected to drive Internet of Things(IoT). As more and more people get connected to the internet, new security threats will be introduced. For example, users could be locked out of their Smartphone or Personal Computer or even their Smart-Homes which are well equipped with internet services. The very nature of 5G may give ample opportunities to the malicious users to hack into the Internet enabled devices of other users or servers and misuse their data and/or prevent them from accessing other data on the network. DDoS[9] attacks could exponentially increase with increased connection density.

2. *Increased Data infiltration rate*

High data transfer rate proposed for 5G technology implies increased rate of data infiltration. The time required to access and transfer data will be so less that it would be very easy for malicious users to infiltrate the user data. Data infiltration or large malicious file transfers would be as fast as the blink of an eye, which makes addressing the security issues even more crucial.

3.*Security Breaches*

Security breaches comes inherent with increased network speed. As more and more services become reliant on internet services, privacy and security breaches become increasingly severe. Driverless cars and remote medical consultations & surgeries are 2 examples of technologies that are expected to be enabled by 5G. The aftermath of security breaches in these technologies could be highly drastic.

Hence, it is imperative that security standards are modified to suit the evolving nature of 5G networks in order to keep users safe from severe consequences of security breaches.

TABLE I. SUMMARIZATION TABLE

4G	5G
▪ Network speed: upto 1 Gbps	▪ Network speed: upto 10 Gbps
▪ Implemented successfully across many countries	▪ Implementation expected to begin by 2020
▪ Main Implementation Challenges: 1. QoS Support 2. Network Framework 3. Apt Network selection 4. Incompatible Roaming frequencies 5. Cost planning & Record tracking	▪ Main Implementation Challenges: 1. Spectrum & Coverage implications 2. Latency reduction
▪ Security Issues: 1. Access Protection 2. User Authentication 3. Data confidentiality 4. Non-repudiation of data 5. Integrity of Data 6. Secure Channel 7. Availability of data 8. Network Privacy 9. Secure online Services	▪ Security Issues: 1. Increased data infiltration rate 2. Threats posed due to increased connection density 3. Security breaches due to high speed network

VIII. CONCLUSION

In this paper, I have tried to put together the challenges faced by the industry and researchers in implementing 4G and 5G networks as well as the possible security threats imposed for their implementation in a distributed environment.

Even though 4G has been implemented in various parts of the world and design & implementation of 5G is already underway in South Korea and China, telecom operators are still struggling with the challenges faced due to complex architectural shifts for implementing 4G efficiently and effectively and at the same time delivering secure service to customers by counteracting the security threats imposed by the network speed.

Since the framework of 4G is an integration of different network systems, we can expect the same for 5G or probably an advancement of it. But a majority of opinions among the technocrats is still unclear on what will define the 5G technology. Hopefully, in the coming years, 4G and 5G will be driving parallel to their full potential, improving cost and energy efficiency. It will be enabling new wider services with a much more capable platform.

References

[1] Lyle, Clear, first 4G network launched, 2009

[2] 3GPP TS 23.107 v.5.9.0, "Quality of Service (QoS) Concept and Architecture," June 2003.

[3] N. Montavont and T. Noel, "Handover Management for Mobile Nodes in IPv6 Networks," IEEE Commun. Mag.,vol. 40, no. 8, Aug. 2002, pp. 38–43.

[4] Al-Muhtadi, D. Mickunas, and R. Campbell, "A Lightweight Reconfigurable Security Mechanism for 3G/4G Mobile Devices," IEEE Wireless Commun., vol. 9,no. 2, Apr. 2002, pp. 60–65

[5] https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf

[6] N. McKeown et al., OpenFlow: enabling innovation in campus networks, ACM CCR, April 2008.

[7] https://www.opennetworking.org/sdn-resources/sdn-definition.

[8] http://dwaterson.com/2015/03/09/security-implications-of-5g/

[9] http://dwaterson.com/2013/04/08/ddos-attacks-how-they-work/

[10] https://en.wikipedia.org/wiki/List_of_countries_by_4G_LTE_penetration