Recent Trends and Security Analysis of Long Term Evolution (LTE)

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Abstract— Advancement and standardization of IEEE 802 project brings new fast communication technology called 4G communication or Long Term Evolution (LTE). Recently3GPP has announced the commercialized version of LTE 4G technology as a LTE-Advance (LTE-A). Previous version of the LTE i.e. Release 8 is solitary fastest broadband technologies base on orthogonal frequency division multiplexing (OFDM) to fulfill the meme lovers demands. Now everyone’s wants to virtualizes and deploy Femtocell for better coverage to be get connected. Hence to fulfill meme users demand 3GPP has developed LTE- 8 for this purpose setting up using macro/microcell paradigm, which upgrades the system capacity and offer more coverage. LTE-8 has launched with assuring minimum delay (latency), low operation cost, extensible bandwidth support, multi-antenna architecture, coherent backward compatibility with existing systems with higher peak data rates. Recently 3GPP has released the LTE version 10 which has incomparably upgraded the features of LTE-8. LTE-10 has also names as LTE-A (Advance) which can offer more coverage area and higher data rate to the subscriber. Also it reinforce heterogeneity while deploying such as nodes constituent low-power Pico-cells, Femtocell etc. which is installed in a macrocell design of cellular technology. The LTE-Advanced features facilitate fulfill or outpace the IMT-Advanced needs. This paper has addressed the recent development and advancement in LTE (4G) technology and surveyed their current problems need to be addresses especially related to the authentication in LTE network to defend against harmful attack like Denial of Service (DoS) and Replay attack. Also this article has present novel approach as a lightweight and robust authentication system for LTE into defends and secured while Handover has been initiated in the network.

Keywords- AODV, DSR, MANET, NS-3, RTT, Wormhole.

I. INTRODUCTION

With the advent of new transmission technology in wireless communication technology and its integration smart devices and freedom to roam get connected quote of the user high speed better performance with large coverage area major concerns. Secondly IP enabled mobile data connection is another requirements to use smart devices properly. Consequently [1], In Nov. 2004, 3GPP began a project to define the long-term evolution (LTE) of Universal Mobile Telecommunications System (UMTS) cellular technology to achieve the highest user satisfaction and defines following goal -

a. Higher performance
b. Backwards compatible
c. Wide application

The fundamental driven technology of LTE is OFDMA (Orthogonal Frequency Division Multiple Access) access a technique operates on downlink in while Single Carrier FDMA (SC-FDMA) has employs for uplink.

Universal Mobile Telecommunications System (UMTS) Long Term Evolution (LTE) version-8 can achieved the data rate (peak data rate) up to 300 Mb/s as a downlink speed though uplink has touched up to 75 Mb/s over a 20 MHz bandwidth channel. Subsequently it also allows the dynamic bandwidth operation onto the same frequency channel i.e. 20 MHz bandwidth. Recently various studies has been concurrently running for the augmenting LTE-8 to pace to meet or outpace with the International Mobile Telecommunications-Advanced (IMT-A) prerequisites [2].

In this paper has surveying the major areas of 4G communication (LTE) development and their security perspective.

Rest of the article is organized as follow, Section II presents the brief introduction about the LTE and its evolution, Section III discusses the recent contribution in the LTE filed with security countermeasures on it. Section IV presents proposed idea to enrich the lightweight authentication for LTE. And finally Section V concludes the papers with the future directions of this work.

II. LONG TERM EVOLUTION

3GPP has launched the LTE to achieve following-

a. Need for higher data rates and greater spectral efficiency

✓ Can be achieved with HSDPA/HSUPA
✓ and/or new air interface defined by 3GPP LTE

b. Need for Packet Switched optimized system

✓ Evolve UMTS towards packet only system

c. Need for high quality of services

✓ Use of licensed frequencies to guarantee quality of services
✓ Always-on experience (reduce control plane latency significantly)
✓ Reduce round trip delay
The initial studies conducted by different Work Groups (WGs) within 3GPP on the evolution of 3G were aimed to set the minimum target requirements that LTE has to meet. The requirements and goals that are set for LTE are defined in [3], which are as follows:

**Peak Data rate**
- The target peak data rate is set to 100 Mbps on the downlink and 50 Mbps on the uplink assuming a bandwidth of 20 MHz. The target peak data rates correspond to spectral efficiency levels of 5 bits/sec/Hz on the downlink and 2.5 bits/sec/Hz on the uplink. LTE target data rates just stated are almost ten times higher than what is achieved in Release 6 of HSPA.

**Network Deployment**
- Initial deployments of LTE are 3GPP wireless technologies such as GSM and HSPA. Also, LTE is expected to be deployed in areas like GSM and HSPA. Also, LTE is expected to be deployed in areas like GSM and HSPA.

**Latency requirements**
- Simplify architecture, reduce number of network elements
- Reduced Latency requirements cover both control plane (C-plane) and user plane (U-plane) latencies.
- C-plane latency refers to the time it takes a UE to transit from either the idle or dormant states to the active state so that the UE becomes ready for an upcoming radio transmission. Dormant state refers to the wait time starting from the end of a successful transmission session till either the UE starts another transmission or goes to the idle state. LTE targets a maximum of 100 ms for the transition from the idle state to the active state, and 50 ms from the dormant state to the active state. U-plane latency refers to the time it takes a data packet to be transmitted from the UE's data buer and the serving gateway of the core network and vice versa.

**Enhanced QoS Support**
- The high LTE data rates are one of the most critical requirements for handling forecasted track loads of future services. Reduced Latency requirements cover both control plane (C-plane) and user plane (U-plane) latencies.
- The support for exible bandwidth sizes is possible in LTE due to OFDM modulation, which is explained in more detail in subsequent sections. Bandwidth exibility is an important feature of LTE due to the fragmentation of spectrum allocation, where an operator cannot guarantee a contiguous 20 MHz bandwidth in many of the frequency spectra in which it operates. Support for Heterogeneous Network Deployment a key requirement of LTE is backward compatibility with previous 3GPP technologies, like GSM and HSPA. Initial deployments of LTE are going to be in areas that are already covered by pre-LTE systems. Also, LTE is expected to be deployed in areas that are covered by non-3GPP wireless technologies such as Wi-Fi and WiMAX. The support of heterogeneous deployment with other 3GPP and non-3GPP networks provides UE mobility support across different wireless platforms, and leads to easier and more cost efficient LTE deployment. Simple Architecture refers to reducing the number of network access nodes to have as few access nodes between the UE and the network core as possible.

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Simplifying the network architecture this way reduces the COPEX and OPEX, as well as the latency just mentioned above. Also, simplifying the network architecture entails the introduction of a fully packet switched, IP-based platform. The IP-only-support provides a unified platform to support all services that are expected to run over LTE, instead of having separate packet switched and circuit switched networks like in HSPA. Hence, the choice of full IP-support further simplifies the architecture of the LTE system. Enhanced QoS Support The move to fully IP-based platform dictates supporting multiple services with a variety of QoS requirements, such as packet delay and packet loss rate. The LTE network should be able to provide enhanced QoS support in scenarios of any trace mix.

### III. RECENT TRENDS IN LTE & COUNTERMEASURES

Since the advancement and development of 3GPP LTE project of 4G has growing in as a mobile communication technology domain and popularized in meme users. Hence there is increasing requirements for tools and instruments capable of evaluating QoS performance of LTE to make it more scalable, robust, energy efficient and higher efficient systems in order to tune and optimize with the recent growth and requirements. For more accurate analysis a variety of levels has been required to be evaluated to be add-on more significant enhancement on to the of upcoming releases of the system or technology to preserve and pace the standardization of the product, as well as for the good design and ultimate realization 4G network enabled devices for the rising of LTE network technologies and its infrastructures. Comparatively LTE is complex technology thus conventional tools for evaluating the LTE system performance based on analytical approach conceived very small sections of LTE complex module. Hence analyst and communication developer particularity entrust on simulators as a test bed for analyzing the QoS of LTE systems. Specifically, open source network simulation tools are profoundly admired by researchers due to their consistent extensiveness approval from open research interest group as well as the problem (bugs) has been resolve quicker. Various comprehensive analyses have been performed recently to address the effectiveness of the tools available for various purpose related to the LTE. For instance the to evaluate the Physical layer performance [5] and [6] has done the deep inspection and found that found that simulation tools such as [5] and [6] are reasonably confined to evaluate the performance at the physical layer only with respect to the all metrics the related to the QoS of the PL. Listed simulator in [5] [6] only normally centered on a single transmitter-receiver pair. Whereas System level simulators mentioned in [7] and [8], extends their functionality up to MAC layer. These tools have been customarily approved by the research group for the effective estimation of the Radio Resource Management (RRM) layer of LTE and its algorithms. However they are confined about the accuracy measurement of the higher layer by the cause of
abstraction for the higher layers in these tools. Hence such tools are unable to measure the end-to-end performance precisely moreover unable to predict the exclusive view of the network. Network simulators are produces more accurate and optimize solutions to overcome the problems mentioned in [5-8]. Network simulators results are more accurate and present the crystal image of the network due to integrating all the layers onto the simulators. However only all layers integration alone is not sufficient to assure the accuracy of the outcome of the test bed. However the consistent and continuation of the research and development on individual layers related to the network simulators by the big research community has done great job that promises more accurate and realistic results from MAC to application layer. Author of [9] has initiated in this direction, author has talked about an open source network simulators related to the LTE which reinforce the single and multi-cell architectural functionality in it. Including the Quality of Service (QoS) management, providing multiuser settings, allows the user mobility, enabling and disabling handover mechanism for the cellular communication, advance features like all types of scheduling (uplink and downlink) with the glue of and frequency reuse procedures. Unfortunately, this simulator endeavor to underneath LTE network architecture exclusively, inadequate manifold countenance of multi-purpose network simulator like network simulator-3 (NS-3), e.g. the availability of a full-fledged TCP/IP protocol stack, the backing for alternative wireless network technologies like Wi-Fi and WiMAX, the possibility of integration with test beds and real application binaries, etc. The simulation LTE module mentioned in this article was absolutely devised concerning to fill this gap. NS-3 offers test bed simulation functionality for the LTE network technology. With the advent features of designing capability of the Evolved Universal Terrestrial Radio Access (E-UTRA) module which is also termed as radio interface of LTE [10].

Author of [11] has surveyed about various techniques used to enhanced the LTE communication, finally author conclude that the contiguous RB allocation constraint is a fundamental prerequisite for the Up Link (UL) scheduling methods in algorithms LTE, still untouched area of the research concerned to SC-FDMA. Afterward the article [12] [13] has imported the concept of Proportional Fair (PF) mechanism (algorithm) globally popular and deliberated in research community for instance delay mentioned in [14] and [15], whereas instability issues addressed in [16] [17]. Hence it has been considered as a benchmark standard in context of standard scheduling method (algorithm) associated with the modern single-carrier wireless systems like CDMA 2000 1xEV-DO [18] [19]. The area of FDPS scheduling is new, and most of studies directly adapt the time-domain PF algorithm into frequency domain context. Their results show the potential gains of up to 40-60% average system capacity improvement over time domain only scheduling [19], and moreover [20] shows that the frequency selectivity of FDPS indeed helps significantly improve the short-term fairness. Andrews et al. [21] have proposed the FDPS-version of MaxWeight algorithm1, and addressed the resource wastage problem induced by small queue condition in DL FDPS context. The objective of the MaxWeight algorithm is the system stability, and the authors have presented the performance from the queue perspective.

Cohen et al. [22] recently studied the DL OFDMA scheduling problem somewhat related to this contiguous allocation requirement in WiMAX. They present several heuristic algorithms for constructing the OFDMA frame matrix as a collection of rectangles which fit into a single matrix. The algorithms, however, assume that 1) at each time slot the base station somehow knows the scheduled data size for each user in advance; 2) the same channel rate is across all RBs as well as all users. In the WLAN context, Yuan et al. [23] have considered a contiguous channel assignment problem to dynamically allocate the variable-width channel to each access point (AP). The key difference from our problem is that no channel diversity (i.e. they assume the achievable data rate is linear to the available bandwidth) is considered in their WLAN context. That is, an AP with the fixed bandwidth will attain the same throughput regardless of its central frequency assigned, which makes their problem as a special case of ours.

The benefits of cooperative relaying cannot be fully leveraged with the conventional mobile association scheme. Mobile association and load balancing in a cooperative relay network emerged as a new research subject recently. In [3], a path-loss-based scheme is proposed for mobile admission control to expand the RN coverage. Therefore the MS will be biased toward the RNs for node connection. In [4], a heuristic algorithm is provided for suboptimal resource allocation in a multihop cellular network with fixed RN deployment. However, in these studies, the loading conditions on various network nodes are not carefully considered in order to improve the global system resource utilization. Furthermore, the radio link quality and resource consumption on the wireless backhaul is overlooked. In this article, we address these challenges in the cooperative relay networks by proposing a new mobile association and load balancing scheme that can achieve system wide load balancing and global spectrum efficiency.

Author of [33] has surveyed that HSTCP introduce a new mechanism based on enhancement the time of loss recovery of classic TCP by variation the standard algorithm of TCP’s Additive Increase Multiplicative Decrease (AIMD). The developed mechanism of HSTCP works effectively with large congestion windows. That mean, when the congestion window less than the threshold, HSTCP uses AIMD algorithm to control congestion in network connections, but if congestion
window high its use the algorithm of high speed AIMD. Actually, designing of HSTCP is depending on the response variation in environments of the low congestion occurring in bottleneck and to the response activation of standard TCP in environments of packet loss rates. FullTCP can only apply with the congestion control of TCP Reno. However, FullTCP must be provided with fully algorithms of congestion control such as Tahoe, Vegas, and Sack. In TCP-Linux, it’s introduced three main characteristics to developing the performance of TCP-Linux. These three elements are:
- Standard interface for congestion control algorithms.
- Redesigned loss detection module.
- New event queue scheduler that increases the test speed.

As we mentioned before, this study and the experimental test depended on analysis the behavior of three TCP’s over LTE network topology. LTE is the 3GPP specification for the fourth generation of mobile networks and referred to as Evolved UMTS Terrestrial Radio Access (E-UTRA). LTE systems aim to provide a step forward in wireless and mobile systems by providing high speed data transmission to users by providing low latency links an improved spectral efficiency.

Comparing with Wideband Code Division Multiple Access (WCDMA) and HSPA, LTE provides higher rate of data with downlink reaches more than 100Mbps uplink of 50 Mbps. In fact, LTE systems released wide achievements in telecommunication networks by providing lower user costs than other systems, better spectrum efficiency, and a very small latency.

### Authentication in LTE

Author of [24] has addresses the necessity of robust and lightweight authentication scheme for LTE (Long Term Evolution) 4G network.

According to article [24], to support Evolved Packet System (EPS) in the Long Term Evolution (LTE) networks, the 3rd Generation Partnership Project (3GPP) has proposed an authentication and key agreement (AKA) protocol, named EPS-AKA, which has become an emerging standard for fourth-generation (4G) wireless communications.

However, due to the requirement of backward compatibility, EPS-AKA inevitably inherits some defects of its predecessor UMTS-AKA protocol that cannot resist several frequent attacks like –

1. redirection attack
2. man-in-the-middle attack
3. DoS attack.

Meanwhile, there are additional security issues associated with the EPS-AKA protocol, i.e., the lack of privacy-preservation and key forward/backward secrecy (KFS/KBS). In addition, there are new challenges with the emergence of group based communication scenarios in authentication. In this paper [24], Chengzhe Lai and et. Al proposed a secure and efficient AKA protocol, called SE-AKA, which can fit in with all of the group authentication scenarios in the LTE networks.

Specifically, SE-AKA uses Elliptic Curve Diffie-Hellman (ECDH) to realize KFS/KBS, and it also adopts an asymmetric key cryptosystem to protect users’ privacy. For group authentication, it simplifies the whole authentication procedure by computing a group temporary key (GTK). Compared with other authentication protocols, SE-AKA cannot only provide strong security including privacy-preservation and KFS/KBS, but also provide a group authentication mechanism which can effectively authenticate group devices. Extensive security analysis and formal verification by using proverif have shown that the proposed SE-AKA is secure against various malicious attacks. In addition, elaborate performance evaluations in terms of communication, computational and storage overhead also demonstrates that SE-AKA is more efficient than those existing protocols as author described.

To validate the proposed authentication scheme author has used ProVerif Tool.

While author of [25], has talking about the authentication scheme during Handover operation in LTE network.

According to author: There are two types of base stations in the long term evolution (LTE) wireless networks, home eNodeB (HeNB) and eNodeB (eNB). It is critical to achieve seamless handovers between the HeNB and the eNB in order to support mobility in the LTE networks. A handover from an eNB/HeNB to a new eNB/HeNB, suggested by the third generation partnership project (3GPP), requires distinct procedures for different mobility scenarios, which will increase the system complexity. Besides, the existing handover schemes for other wireless networks are not suitable for the mobility scenarios in the LTE networks due to their inherent vulnerabilities. In this paper, we propose a fast and secure handover authentication scheme, which is to fit in with most of the mobility scenarios in the LTE networks. Compared with other handover schemes, author’s scheme cannot only achieve a simple authentication process with desirable efficiency, but also provide several security features including perfect forward/backward secrecy (PFS/PBS), which have never been achieved by the previous works.

The experiment results and formal verification by using the automated validation of internet security protocols and applications (AVISPA) tool show that the proposed scheme is efficient and secure against various malicious attacks.

### IV. PROBLEM FORMULATION & PROPOSED IDEA

#### Problem Identification

- As the interest in LTE as a mobile communication technology increases, there is a growing need for instruments able to characterize the performance of LTE systems in order to tune and optimize them. This need is present at various stages: for the standardization of future version of the technology, as well as for the design and implementation of devices and...
network equipments and the roll-out of LTE network infrastructures. LTE is a rather complex technology, and for this reason traditional performance evaluation methods based on analytical models can be applied only to very small portions of it. As consequences, researchers and engineers most often rely on simulators to assess the performance of LTE systems.

- In particular, open source network simulation tools are highly valued by researchers, because of their usually wider acceptance within the research community. In the literature, several LTE simulators have been proposed for different purposes. Physical layer simulation tools such as [5] and [6] are quite limited in that they consider the performance at the physical layer only, normally focusing on a single transmitter-receiver pair. System level simulators, such as for instance [7] and [8], go beyond the physical layer by normally introducing the MAC layer together with an abstract model of the higher layers.

- They are usually adopted in the research community for the evaluation of Radio Resource Management (RRM) algorithms, but due to their abstraction of the higher layers they cannot provide an accurate evaluation of the end-to-end performance and of the behavior of the network as a whole.

- The most promising solution to this problem is represented by network simulators, which feature an accurate implementation of all the protocol layers from the MAC up to the application. A first step in this direction is done with [9], which is an open source LTE network simulator that supports single and multi-cell environments, QoS management, multiuser environment, user mobility, handover procedures, scheduling, and frequency reuse techniques. Unfortunately, since this simulator aims at supporting LTE only, it lacks the many features of general purpose network simulator like ns-3, for example the availability of a full-fledged TCP/IP protocol stack, the support for other wireless technologies such as WiFi and WiMAX, the possibility of integration with test beds and real application binaries, etc.

- The simulation module that we describe in this paper was explicitly designed in order to fill this gap. It introduces support for the simulation of the LTE technology in the ns-3 simulator, with a particular attention on modeling the most relevant aspects of the Evolved Universal Terrestrial Radio Access (E-UTRA), which is the radio interface of LTE [19].

- Author of [24] has addresses the necessity of robust and lightweight authentication scheme for LTE (Long Term Evolution) 4G network.

- According to article [24], to support Evolved Packet System (EPS) in the Long Term Evolution (LTE) networks, the 3rd Generation Partnership Project (3GPP) has proposed an authentication and key agreement (AKA) protocol, named EPS-AKA, which has become an emerging standard for fourth-generation (4G) wireless communications.

- However, due to the requirement of backward compatibility, EPS-AKA inevitably inherits some defects of its predecessor UMTS-AKA protocol that cannot resist several frequent attacks like –
  1. Redirection attack
  2. man-in-the-middle attack
  3. DoS attack.

- Meanwhile, there are additional security issues associated with the EPS-AKA protocol, i.e., the lack of privacy-preservation and key forward/backward secrecy (KFS/KBS). In addition, there are new challenges with the emergence of group based communication scenarios in authentication. In this paper [24], Chengzhe Lai and et. Al proposed a secure and efficient AKA protocol, called SE-AKA, which can fit in with all of the group authentication scenarios in the LTE networks. Specifically, SE-AKA uses Elliptic Curve Diffie-Hellman (ECDH) to realize KFS/KBS, and it also adopts an asymmetric key cryptosystem to protect users’ privacy. For group authentication, it simplifies the whole authentication procedure by computing a group temporary key (GTK). Compared with other authentication protocols, SE-AKA cannot only provide strong security including privacy-preservation and KFS/KBS, but also provide a group authentication mechanism which can effectively authenticate group devices. Extensive security analysis and formal verification by using proverif have shown that the proposed SE-AKA is secure against various malicious attacks. In addition, elaborate performance evaluations in terms of communication, computational and storage overhead also demonstrates that SE-AKA is more efficient than those existing protocols as author described.

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- The experiment results and formal verification by using the automated validation of internet security protocols and applications (AVISPA) tool show that the proposed scheme is efficient and secure against various malicious attacks.

Proposed Idea:

- There is urgent need to secure the current communication network from various harmful attacks. LTE is the latest fast and IP based 4G network which provides higher data rate with seamless handover to the user. Since its release in 2010 (latest version) by 3GPP there is need of more robust authentication scheme that can provide defends against various types of attack in wireless network i.e. LTE network. Many schemes has been proposed but they have their own limitation.

- Our proposed work is closely related to the article [24] and [25] scheme. Following problem has been identified as research agenda –
  a. Light weight and robust authentication scheme for the LTE network while maintaining seamless handover.
  b. Defense against Denial of Service attack in LTE network.
  c. Our proposed work is based on the idea of [24] and [25] the main extension which will achieve during thesis and research development is to test the above mentioned point by applying various test bed to validate the proposed scheme with applying various simulation parameter like Mobility ratio, Handover and without Handover and etc.
  d. In concrete following test bed will be used –
     - NS-3.22 Simulator
     - AVISPA Tool
     - Proverif

V. CONCLUSION

As the interest in LTE as a mobile communication technology increases, there is a growing need for instruments able to characterize the performance of LTE systems in order to tune and optimize them. This need is present at various stages: for the standardization of future version of the technology, as well as for the design and implementation of devices and network equipments and the roll-out of LTE network infrastructures. LTE is a rather complex technology, and for this reason traditional performance evaluation methods based on analytical models can be applied only to very small portions of it. As consequences, researchers and engineers most often rely on simulators to assess the performance of LTE systems.

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REFERENCES


