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A Study of 4G Network for Security System

Suk-jin Kim, Hyangran Lee, Malrey Lee*

Center for Advanced Image and Information, Technology,
School of Electronics & Information Engineering, ChonBuk National University, ChonBuk, Korea
hanuri00@jbun.ac.kr, orange1469@naver.com, *mrlee@jbnu.ac.kr

Abstract

In this paper there is an overview of some standards and security models which are implemented in such an IP-based and heterogeneous networks and we also present some security models in an open environment and finally we obtain that as a result of the nature of 4G networks there are still more security holes and open issues for expert to notice. Our survey shows that a number of new security threats to cause unexpected service interruption and disclosure of information will be possible in 4G due mainly to the fact that 4G is an IP-based, heterogeneous network. Other than that, it tells about the security issues and vulnerabilities present in the above 4G standards are discussed. Finally, we point to potential areas for future vulnerabilities and evaluate areas in 4G security which warrant attention and future work by the research and advanced technology industry.

Keywords: *4G network, security threats, challenges in4G network*

1. INTRODUCTION

We name fourth generation of cellular wireless standards to 4G in telecommunication world. This is a successor of 2G and 3G families of standards. The IMT-advanced (International Mobile Telecommunications Advanced) requirements for 4G standards specified by the ITU-R organization , in 2009.It defined speed need for 4G services , 100 Mbit/s for high mobility communication (such as from trains and cars) and 1 Gbit/s for low mobility communication (such as pedestrians and stationary users).It is expected for 4G to provide a secure and comprehensive all IP-based mobile broadband solutions to laptop computer wireless modems, smart phones and other mobile devices. It provides facilities such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia may be provided to users.[1]Till now many of societies have been preparing themselves to work on 4g ,for example IEEE 802.16m has worked to adapting IEEE 802.16 to IMT(International Mobile Telecommunication)-advanced, ITU(International Telecommunication Union) that has working on Next Generation Network(NGN) and has discussed about IMT_Advanced frequency bandwidth and also WiMAX(Worldwide Interoperability for Microwave Access) has made a broadband wireless systems based on IEEE 802.16. Also a number of

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Corresponding Author: mrlee@jbnu.ac.kr
Tel: +82-63-270-3993, Fax: +82-063-270-2394
Center for Advanced Image and Information, Technology, School of Electronics & Information Engineering, ChonBuk National University

telecommunication companies and venders such as Vodafone , Motorola and Samsung organized NGNMN(Next Generation Mobile Networks) to have cost-effective solutions for 4G.[1] [8]

Y-Comm framework which is developed by a number of institutions is a proposal of 4G architecture framework. In Y-Comm the operation and mechanisms to support heterogeneous networking has been described and detailed. Security is considered from the first steps of the design process in Y-Comm. However, in order to develop an efficient security module, it is necessary to identify the threats and risks faced by communication systems. But since analyzing security requirements of communication systems is quite complex, the ITU introduced a systematic analysis tool called X.805 as an approach to network security by discussing systems security requirements at different levels and determining potential network vulnerabilities [2].

In this paper we try to present several architectures behind 4G infrastructure and illustrate security issues of this latest generation of network which will be face in real world and situations. At last we suggest some available solutions for security vulnerabilities which will happen in 4G systems. In this paper we try to present several architectures behind 4G infrastructure for example WiMAX and 3GPP LTE architecture. Then we have present introduction to Y-COMM and analyses of AkA on Y_COMM .After that we present several models in ISM and TSM. Furthermore we do some security threat analyses and at least we prepare possible threats on 4G networks.[10]

2. 4G ARCHITECTURE

The 4G network as shown in figure 1 is a combination of multiple heterogeneous access networks such as Wimax and 3G. Although each user can use any of multiple access networks, but he will receive service from the same service unit, for example, IP Multimedia Subsystems (IMS).The core of the whole network is all IP network(IPv6 expected), in which a number of several gateways make connections to several access networks as connect to service section. And also, you can see available QOS- related protocols specially for implementing each both horizontal and vertical handover. Moreover, in such architecture as a reason of covering region by multiple RANs, one of the issues will be selecting the appropriate RAN. Because of this kind of composition of technologies we should notice to architecture of these components separately as below. [1][8]

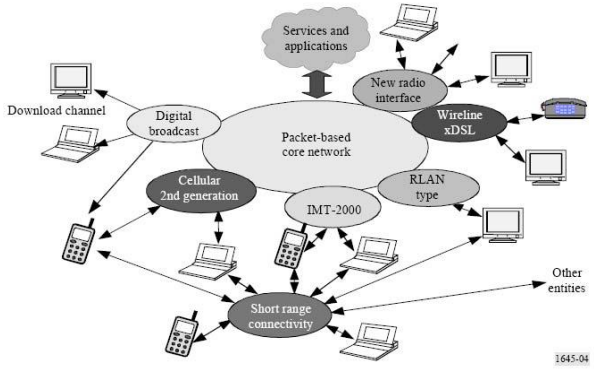

Figure 1. IMT-advanced 4G network system specified in ITU

A. WiMAX Architecture

As shown in Fig. 2 the Network Reference Model (NRM) for WiMAX architecture, For having connection between mobile stations or service stations to Network Service Provider there is an access

serving network . In WiMAX there are three access network profiles which are considered by WiMAX. We can see Base Transceiver Station (BTS) and Base Station Controller (BSC) as separated one in profile A. By the reason that functions like AAA, paging and routing exist in the BSC so ciphering happen in BSC but In profile B you can see most functions including AAA and paging reside in BS. And at the end in profile c, functions like AAA, paging and routing are in ASN-GW (Access Network- Gateway).[1]

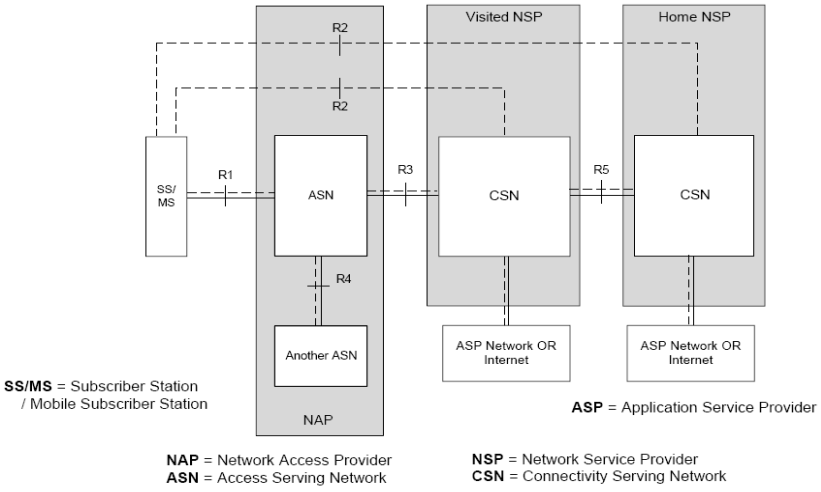

Figure 2. Network Reference Model (NRM) ofWiMAX

B. 3GPP LTE Architecture

As shown in below diagram, you can see two core networks in 3GPP LTE architecture [13]:1- GPRS core network to offer network connections for existing RANs (for example, GERAN and UTRAN) and 2-Evolved Packet Core network to give network connections to Evolved RAN and non-3GPP IP access. IP service for example IMS is provided via Evolved Packet Core to any RANs; it is connected to SAE (System Architecture Evolution) Anchor point, which has a connection to GERAN/UTRAN via SGSN. In 3GPP access network radio resource control function is in ENB (e-Node B) while AAA function and ciphering functions are in AGW (access-Gateway).[1]

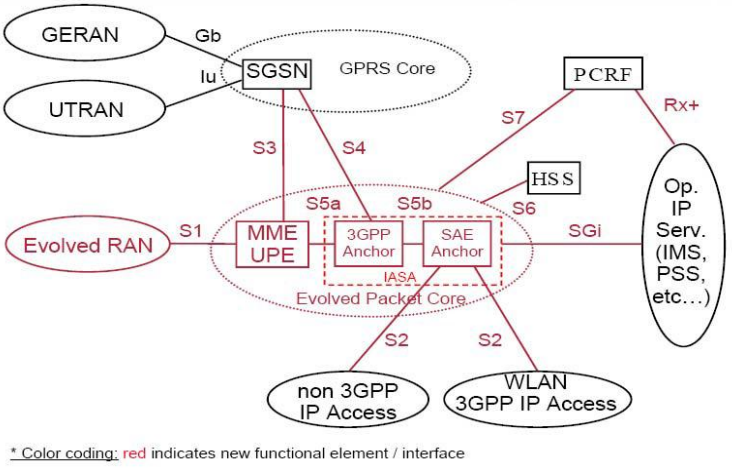

Figure 3. Network Architecture of 3GPP LTE

3. INTRODUCTION TO THE X.805 STANDARD

The X.805 standard mentions security layers, planes and dimensions and the relation between these three parameters. Three security layers include: applications, services and infrastructure also security planes which include :end user, control and management and eight security dimensions that address general system vulnerabilities such as access control, data integrity, authentication, non-reputation, data confidentiality, communication security availability, and privacy. Figure 1 shows the complete architecture of the X.805 standard including parameters mentioned. The security layers of X.805 standard have already been applied to different communication systems such as WiFi , ATM and IP-based networks respectively.[5] [11] [9]

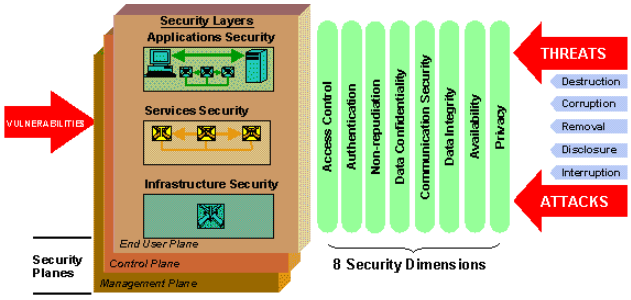

Figure 4. The X.805 standard architecture

4. ANALYSIS OF AKA ON Y-COMM USING THE X.805 STANDARD

	Infrastructure layer
Management Plane	Module One
Control Plane	Module Two
User Plane	Module Three

In the table below, Table 1. relation between vulnerability and Module 1, 2 and 3has been shown.[5]

Table 1. relation between vulnerability and Module 1, 2 and 3

Vulnerabilities	**Modules Involved**
Access Control	Modules 1&2 ; no access control methods such as Access Lists (ACLs) or Firewalls are advised to limit the access to network resources.
Data Integrity	Modules 1, 2 & 3: AKA by implementing Integrity Key (IK)and Hashing algorithm (F7) for the MS- MSc/SGSN connection , prepare Data Integrity .
Authentication	Modules 1, 2 & 3: AKA protocol prepare two ways authentication between the mobile device (but not the user) and the network.
Availability	Module 1, 2 & 3: to make sure that network resources are immune against denial of service attacks , no specific methods such as intrusion detections/protections are implemented .
Data Confidentiality	Modules 1, 2 & 3: By using Cipher Key (CK) and F6 function as an encryption algorithm, data confidentiality for the connection between the mobile device and the MSc/SGSN is obtained .However, no encryption is done beyond MSc/ SGSN.
Communication Security	Modules 1 & 2: for protecting the data transmitted in the core network no specific security mechanisms are proposed so it will be mentioned physically secure. Module 3: from a user's point of view, the security of the wireless part of the connection is guaranteed, when authentication and key agreement processes are done.
Non-Repudiation	Modules 1,2 & 3: since AKA protocol uses keybased symmetric methods, no repudiation is not prepared.
Privacy	Module 1, 2 & 3: although confidentiality is obtained by using encryption, there is no guarantee that subscribers' credentials are appeared to only authorized users.

Since one of the 4G's attributes is IP-Based environment of it, most of the IP-specific security vulnerabilities may be happen as in the Internet. The experience of the Internet world as the best example of a successful open architecture has shown us that it is not enough to only protect data but it needs also to protect entities from each other (DoS, Spam) and also it is needed to protect network infrastructure. So 4G systems should also concern these issues too.[2][5]

5. SECURITY THREATS ANALYSIS

If we want to manage the security threats in each environment such as an open and heterogeneous one as 4G infrastructure , it is needed to identify the critical risks which may be the network expose to in a clear way ; and for obtain to this aim we can use each of methodologies that described in previous section. Because of the nature of 4G networks that is included with several kinds of networks in this section we present a security analyze for famous standards like: WiMAX, Wi-Fi, 3GPP.

A. Wifi Security

We can see the use of Wi-Fi technology implemented on wireless LANs for more than a decade. However, the history of using this standard notices that it has been used more in homes and public places such as airports, hotels, cafés and shopping centers in which the security is not more critical, but the valuable benefits of Wi-Fi which increases mobility and flexibility attract the enterprise environments therefore security expert have tried to focus on security threats of Wi-Fi networks to make it viable in enterprise environments. As a complete security assessment based on the ITU-T X.805 standard that has been done by Bell Labs, we notice that original Security mechanism of Wi-Fi, named Wired Equivalent Privacy (WEP) had some kinds of defects which are obtained because of mis-application of cryptography for example, using of CRC-32 authentication and also RC4 stream cipher.

To help the security flaws of Wi-Fi, several solutions have been presented in [1][4][5][6]. As mentioned we can use from Robust Security Network (RSN) for the IEEE 802.1x standard's which is port based access control and is known as a layer 2 authentication mechanism and illustrates how EAP can be encapsulated in the Ethernet frames. And also for overcoming with man-in-the-middles attacks, it uses LEAP to support two way authentications between application and a mobile terminal. Another solution for solving the existing problem to relieve the weakness of RC4 is developing TKIP via frequent renewal of encryption key and also authors suggested automated mechanisms to produce the new encryption key.

As a result we can say that by several systematic methods which recognize the security weaknesses and develop suitable deliberations, important improvements have been happened in the last few years about security threats of Wi-Fi network. Therefore by using these new mechanisms we can deploy a reasonable tolerance to risks in most enterprise environments.[6]

B. WiMAX Security

WiMAX (Worldwide Interoperability for Microwave Access) addresses to a communication technology For preparing high-speed internet service in a large areas. With the 2011 update revision of WiMAX it provided up to 1 Gbit/s for fixed stations. It is a part of a fourth generation of network technology. It notices the compatibility of broadband wireless access products which uses IEEE 82.16 standard which include IEEE 802.16-2004 for fixed and 802.16e-2005 for mobile architectures. Two different sets of security mechanism apply by those two standards.

IEEE 802.16-2004 uses private key management (PKM) protocol in which Mobile Station (MS) authenticates itself, then gets Authorization Key (AK) from the Base Station (BS), and derives other keys like TEK and KEK. It also supports two encryption algorithms, i.e. DES in CBC mode and AES in CCM mode. But some kinds of weakness has been shown in this standard for example as a reason of lack of mutual authentication between BS and MS there will be a threat from BS.

Second problem is that the encryption key is generated by BS instead of two parties. And also as third vulnerability this standard does not support integrity protection of management which provides denial of service attack. At last it does not define the management of certificates such as store, revoke and renew. In IEEE 802.16e-2005, a developed version of PKM is improved to solve the known vulnerabilities with several options. The new change of PKM prepares two way authentications between BS and MS with RSA. In addition integrity protection is ensured because of frames management. And also to provide flow protection AES algorithm in CBC, CTR and CCM modes is used.

C. 3GPP LTE Security

As the generation changes the security in cellular system developed. If you notice to the history you consider that, because of the lack of suitable encryption in place there was not enough attention to security in 1G cellular system; and eavesdropping of conversation could easily happen by intercepting the serial number in mobile phones.

By evolved generation in 2G, we saw GSM (Global System for Mobile) which uses AKA (Authentication and Key Agreement) for authentication and encryption and named to GSM AKA. In this mechanism user firms its identity by responding to a variant of time in the network. Never the less the security is still weak because the authentication is in one way and user can not authenticate the providing network. And also the authentication data and cipher keys can be used again in the network. But after improving happened in 3GPP AKA, the issues mentioned were solved because the mutual authentication between serving network and mobile terminal has been done and new agreed cipher key and integrity key was generated in encryption methods with using sequence number.

Despite enhancements potential security issues need to be addressed within LTE – categorized below into 4 key types.

1) Location Tracking

Location tracking refers to tracking the UE presence in a particular cell or across multiple cells. Location tracking as such does not pose a direct security threat, but it is a security breach in the network and can be a potential threat. Location tracking is made possible by tracking a combination of the Cell Radio Network Temporary Identifier (C-RNTI) with handover signals or with packet sequence numbers as described below.

The C-RNTI is a unique and temporary UE identifier (UEID) at the cell level. As the C-RNTI is transmitted in clear text, a passive attacker can determine whether the UE using the C-RNTI is still in the same cell or not. During handover, a new CRNTI is assigned to the UE via the Handover Command message. A passive attacker can link the new C-RNTI from the Handover Command message and the old C-RNTI unless the allocation of C-RNTI itself is confidentiality protected. This allows tracking of the UE over multiple cells [29].

If continuous packet sequence numbers are used for the user plane (RLC, PDCP) or control plane (RRC, NAS) packets before and after a handover, then mapping between the old and new C-RNTI's is possible based on the continuity of packet sequence numbers.

2) Bandwidth Stealing

Bandwidth stealing could emerge as a security issue in LTE. In one example, this can be achieved by inserting messages during the DRX period [29]. During a DRX period in the E-UTRAN, a UE is allowed to stay in active mode, but turn off its radio transceiver to save power. During such a DRX period, the UE's context (e.g. C-RNTI) remains active in the eNB. During a long DRX period, the UE is still allowed to transmit packets because the UE may have urgent traffic to send after entering the DRX period. This may create a potential security hole. It is possible for an attacker to inject a C-PDU by using the C-RNTI of a UE during a long DRX period.

In a second example, fake buffer status reports can be utilized. The buffer status report is used as input information for packet scheduling, load balancing, and admission control. Sending false buffer status reports on behalf of another normal UE can change the behaviour of these algorithms. By changing the packet-scheduling behaviour at the eNB, it is possible to carry out a bandwidth stealing attack making the eNB believe that the UE does not have anything to transmit.

3) Security Issues Due to Open Architecture

The 4G LTE network will be an IP network with a large number of devices which are highly mobile and dynamic with activity periods ranging from a few seconds to hours. The types of end-devices will be very diverse and will include a heterogeneous range of end-users. Additionally, a broad range of automated devices are emerging which operate without human interaction. Such devices take advantage of the ubiquity of wireless network coverage and include for example sensors, alarms, presence indicators and remote cameras.

Diversity in device types and security levels coupled with the open architecture of an IP-based LTE network will result in greater numbers of security threats than seen in 3G networks. At present, hand-held mobile devices (mainly cellular phones) are the most wide spread users of wireless networks. Such devices have typically been proprietary in their design and makeup. While there is initial evidence of malicious activity in cellular networks, large scale infection of cellular smart phones has not yet occurred. As one example, in [25], the authors carried out a study from a 3G network in Europe. They studied data traffic from laptops running Microsoft windows in an Austrian service provider. The study revealed that a large fraction (50%) of uplink packets on laptops with UMTS cards were TCP SYN packets directed to the ports TCP:135 and TCP:445 from infected user devices.

4) Denial-of-Service (DoS) Attacks

In LTE networks, there may be two possible ways to carry out a DoS. The first type of DoS attack would be against a specific UE. A malicious radio listener can use the resource scheduling information along with the C-RNTI to send an uplink control signal at the scheduled time, thus causing a conflict at the eNodeB and service problems for the real UE.

Newly arriving UEs are susceptible to a second type of DoS attack. In LTE, the UE is allowed to stay in active mode, but turn off its radio transceiver to save power consumption. This is achieved via the DRX (Discontinuous reception) period. During a long DRX period, the UE is still allowed to transmit packets because the UE may have urgent traffic to send. However, this can create a potential security hole. For example, attackers can inject C-PDU packets during the DRX period to cause DOS attacks against newly arriving UEs.

A third type of DoS attack can be based on the buffer status reports used by an eNB for packet scheduling, load balancing, and admission control. Attackers can send reports impersonating a real UE. If the

impersonator sends buffer status reports which report more data to send than are actually buffered by the real UE, this will cause a change in the behaviour of admission control algorithms [29]. If the eNB sees many such fake buffer status reports from various UEs, it may believe that there is a heavy load in this cell. Consequently, the eNB may not accept newly arrived UEs.

Although 3GPP AKA is known as reliable method and used, there still remain weaknesses.
For example it may redirect user traffic by using false BS and mobile terminal or by giving a high value of counter value by adversary, life time of mobile terminal may be shortened.

Finally because of a home network, a fault in counter database may affect all mobile terminals and also when MT request resynchronization; this may result in resynchronization message attack to the home network.

By having a look at all improvements or implementation of telecommunication technologies and considering to statistical reports of different security vulnerabilities we understand that integrity, reliability and availability problems have not being solved in the past decades and this means that nowadays in 4G the security issues is still open and needs to more research in this domain by researchers.

6. CONGLUSION

This study of security issues in 4G networks has revealed that both WiMAX and LTE security architectures are at advanced stage of specification. This study focused primarily on MAC layer vulnerabilities for WiMAX and LTE. To interference and scrambling techniques, both standards also have some physical layer vulnerabilities. Susceptible to DoS attacks, eavesdropping, replay attack, service degradation, and vulnerabilities due to faulty key management at the MAC layer, WiMAX. LTE also has a set of potential vulnerabilities at the MAC layer. Examples of specific vulnerabilities include: illegal use of user and mobile equipment, location tracking, DoS attacks and data integrity attacks.

The robustness and effectiveness of end-to-end security approaches in WiMAX and LTE will become clear only after deployment. For continued study on 4G security issues and development of appropriate counter measures, we believe there is a strong need. To augment this initial research with emulation and test bed related studies which will likely reveal further issues and challenges to be addressed, we suggest that there is a critical need.

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