Applying New Trust Requirements in 3GPP Mobile Systems for Improved Subscriber Identity Privacy

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Abstract- Evolution in Cellular networks has observed through various generations, starting with 1G, followed by 2G and then by 3G, cellular networks have come a long way. A recent technology that has marked the beginning of 4G is Long Term Evolution (LTE).

While transmission technologies, authentication mechanisms, confidentiality protection, etc., improved significantly through the generations, not much has improved with regards to the subscriber's identity privacy, and LTE is no exception. Much of this could be due to the trust model adopted in these networks. Introduction of sensitive services like mobile-banking, mobile commerce, etc., has increased the importance of identity privacy by many folds. Identification of threats like location tracking and comprehensive profiling where data about movement, usage, etc., of a subscriber is collective and linked to his/her identity to explore various attacks is quite shocking. In this paper, we tried to propose a new trust model for strengthening identity privacy in cellular networks; it has an additional capacity to enhance interoperability among different cellular operators. We also propose a security extension that adopts this trust model to improve identity privacy and interoperability in LTE. A formal analysis of the extension proves that it meets its security goals.

General Terms: Wireless networks, 3GPP, Authentication, Authorization, Privileges & Security

Index Terms- Cellular networks, Trust model, Long Term Evolution, Authentication and Key Agreement, Identity privacy.

I. INTRODUCTION

We In all cellular networks, a common basic architectural framework is used; in which, three parties are involved viz. and User Equipment (UE), the Home Network (HN) and a Serving Network (SN). The UE that a subscriber owns is registered with the HN. The association between the UE and the HN is created from the moment the subscriber procures a Subscriber Identity Module (SIM) from the HN and fits it into his/her UE. The HN offers services to its registered UEs through SNs that are located within or outside its own service area. Communication between the UE and the SN happens through radio link, whereas communication between the SN and the HN happens through wired medium. The radio link is considered vulnerable to various kinds of attacks as it is too open by nature for comfort of challenger, whereas the wired link is considered secure [9].

In order to uniquely identify a subscriber for authentication, authorisation and billing purposes, the HN assigns a unique permanent identity called International Mobile Subscriber Identity (IMSI) [5] to the UE. The IMSI is valuable information that should not be accessible to anyone except the HN. Its compromise will expose the subscriber to threats like location tracking and comprehensive profiling where data about movement, usage, etc., of a subscriber is amassed and linked to his/her identity to explore various attacks at a later time.

For the UE to access a particular service, it has to go through an Authentication and Key Agreement (AKA) procedure. During an AKA, the UE has to send a service request along with its identity to the SN. The SN in turn, obtains relevant authentication data from the HN by presenting the identity that it received from the UE. It then authenticates the UE using a challenge response mechanism [14].

Due to the current trust model adopted by cellular networks, there are occasions during identity presentation in the AKA procedure, when the IMSI needs to be transmitted to the SN in clear text through the vulnerable radio path [11]. Moreover, the current trust model requires the SNs to be considered trustworthy, undermining the threat that a compromised third party SN may pose. Such requirement demands unconditional trust and thus limits interoperability.

Understanding above scenario we would like to propose a new trust model that has the potential to not only enhance identity privacy, but also to boost interoperability among cellular operators. We also propose a security extension that implements this trust model in LTE. A formal analysis of the extension is performed to prove that it meets its security goals.

The rest of the article is organised as follows: in section 2, we discuss the current trust model; in section 3, we propose a new trust model; in section 4, we present the security architecture of LTE; in section 5, we discuss Evolved Packet System AKA (EPS-AKA) protocol: the AKA protocol adopted in LTE; in section 6, we discuss the identity privacy related vulnerabilities present in EPS-AKA; in section 7, we propose a new security extension for EPS-AKA; in section 8, we discuss the strong points of the proposed extension; in section 9, we perform a formal analysis of the proposed extension; With the reference of paper [1] we will implement I e proposed model in section 10,After implementation results are collected in section 11 finally, we conclude the paper in section12.

II. CURRENT TRUST MODEL

In the current trust model, the following trust requirements with reference to the permanent identity of a subscriber exist.

UE → HN: As the UE is registered and has a direct service agreement with the HN; it is bound to fully trust the HN with its IMSI.

HN → SN: Since HN serves its subscribers through SNs; the HN confers full trust in the SN with regards to the IMSI of a subscriber. For authentication, authorisation and billing purposes, the IMSI is exchanged unabated between the HN and the SN.

UE → SN: This trust relation is a transitive outcome of the previous two trust relations; because of which, the UE fully trusts the SN with its IMSI and it transmits its IMSI immediately upon receiving a request from the SN.

From the above trust requirements, one can easily understand that even though the SN may belong to an entrusted third party cellular operator, the UE and the HN is required to confer unconditional trust on it. As a result, there exist several vulnerabilities, which an adversary may explore to compromise identity privacy of the subscriber. Moreover, such trust requirements are impractical in today’s context when multiple cellular operators need to interoperate among each other to offer wider coverage to the subscribers. Roaming agreements with third party operators to provide service in a location where an operator has not set up its own infrastructure is a common practice. Thus, the need of the time is a paradigm shift that looks at the trust issues from a different perspective: a perspective that gives more emphasis on issues like privacy and interoperability.

III. PROPOSED TRUST MODEL

In this section, we propose a new trust model that is more flexible compared to the current trust model adopted by the cellular networks. In this, there is only one trust requirement, which is as follows:

UE → HN: The UE should trust only the HN with which it is registered and no one else. The IMSI should not be shared with any third party and in no situation should leave the UE or the HN.

The above trust model will strengthen identity privacy, as the IMSI is not shared with anyone except the HN. It will also improve interoperability among cellular operators, since the requirement to trust the SN with respect to the permanent identity is totally relaxed. In order to adopt this model to provide improved identity privacy, an alternate mechanism for identity presentation, which can be used in all situations when an IMSI is used, otherwise, has to be formulated. To adopt this model even with respect to confidentiality and integrity protection of user data, end to end application layer based ciphering and integrity protection solutions like IPSec can be used [12]. With cellular networks gradually moving towards all-IP, such solutions will not be too hard to implement.

IV. SECURITY ARCHITECTURE OF LTE

Fig.1. Simplified Architecture of LTE.

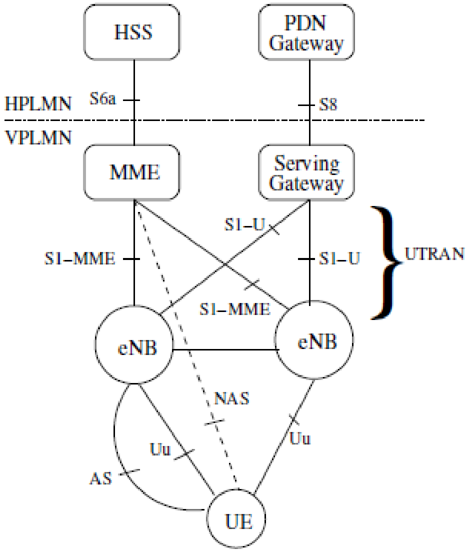


Fig. 1 depicts a simplified view of the roaming security architecture of an Evolved Universal Terrestrial Radio Access Network (E-UTRAN) [3] that serves as the core of LTE. In this, we show only the key elements associated with the AKA procedure used in LTE. Each and every user is registered with a Home public Land Mobile Network (HPLMN) (which, is the HN of the user) with their subscription and profile information stored in a Home Subscriber Server (HSS). In the Visiting Public Land Mobile Network (VPLM) (which, is the SN of the user), the User Equipment (UE) connects with an evolved NodeB (eNB) through the Uu interface, for attach, Tracking Area Update (TAU) and service requests. eNB is the new enhanced Base Transceiver Station (BTS) that provides the LTE air interface and performs radio resource management for the evolved access system. An eNB is connected with one or more Mobility Management Entities (MME) through the S1-MME interface. The MME is the key control node for the LTE access network and is responsible for authenticating the user by interacting with the HSS. For obtaining authentication data, the MME communicates with the HSS through the S6a interface. There are two layers of security between the UE and the E-UTRAN. The first layer is called the Access Stratum (AS) which protects the Radio Resource Control (RRC) plane signaling and the User Plane (UP) data between the UE and the eNB. The second layer is called the Non Access Stratum (NAS) which protects the control plane signaling between the UE and the MME. UE has access to packet data through the Packet Data Network Gateway (PDNGW) via the Serving Gate-way (SGW).

V. EPS-AKA

EPS-AKA [3] is the AKA procedure used in LTE; it produces keying material forming a basis for UP, RRC, and NAS ciphering keys as well as RRC and NAS integrity protection keys. EPS-AKA during the initial connection and successive connections are as follows:

5.1 The Initial Connection

For the initial connection (when the subscriber switches on the UE for the first time), the UE transmits an attach request to the MME. Since the UE does not have a temporary identity at this moment, its IMSI is included in this request. The EPS-AKA procedure during the initial connection is as follows:

(1) The MME invokes the procedure by requesting authentication data from the HSS. The request shall include the IMSI and the SN/MME identity.

(2) Upon receipt of the request, the HSS assembles a Universal Mobile Telecommunication System - Authentication Vector (UMTS-AV) [1]. An UMTS-AV contains a random part RAND, an authenticator token AUTN used for authenticating the network to the UE, an expected response XRES, a 128-bit Integrity Key IK, and a 128-bit Cipher Key CK.

$$\text{UMTS-AV} = (\text{RAND}; \text{AUTN}; \text{XRES}; \text{CK}; \text{IK}) \quad (1)$$

The AUTN contains a sequence number SQN used to indicate freshness of the AV. An EPS-AV is then derived from UMTS-AV by replacing CK and IK with a Key for

Access Security Management Entity (KASME). To derive KASME, a Key Derivation Function (KDF) [2] is used that take the following input parameters: CK, IK and SN/MME
Identity. Thus,

$$\text{KASME} = \text{KDF}(\text{CK}; \text{IK};\text{MME-identity}) \quad (2)$$

$$\text{EPS-AV} = (\text{RAND};\text{AUTN};\text{XRES};\text{KASME}) \quad (3)$$

The HSS then sends EPS-AV back to the MME.

(3) After receiving EPS-AV , the MME extracts RAND and AUTN from it and sends them to the UE as a challenge. A Key Set Identifier (KSIASME) is also send along with the Challenge. The purpose of the KSIASME is to make it possible for the UE and the MME to identify aKASME without invoking the authentication procedure. This is used to allow reuse of the KASME during subsequent connections.

(4) At receipt of this message, the UE runs UMTS algorithm [1] to verify that AUTN is correct and hereby authenticates the network. If AUTN is incorrect, the UE rejects the authentication.

If AUTN is correct, the UE computes RES, IK and CK (using UMTS algorithm). It then derives the KASME from the newly computed IK and CK. The UE then responds back to the MME with a user authentication response message that includes the computed RES.

(5) Finally, MME checks whether RES is equal to XRES. If so, the authentication is successful. If not, the MME sends an authentication reject message towards the UE.

At the end of a successful EPS-AKA, a KASME is shared between UE and MME. A hierarchy of keys are then generated from the KASME [2] to be used for protection of the NAS and the AS. The MME then allocates a fresh temporary identifier called Globally Unique Temporary Identity (GUTI) [4] to the UE by initiating a GUTI reallocation procedure through the NAS. During the GUTI reallocation procedure, the MME sends GUTI Reallocation Command to the UE and the UE returns GUTI Reallocation Complete message to the MME. A new GUTI shall be sent to the UE only after a successful activation of NAS security. A mapping between the GUTI and the IMSI of the UE is maintained at the MME. The purpose of the GUTI is to provide an unambiguous identification of the UE, so that the subscriber's permanent identity (i.e., the IMSI) is not revealed. Entire part is considered with reference [1].

5.2 Subsequent Connections

For subsequent connections (during attach requests, Tracking Area Updates (TAU) and service requests), identity presentation of the UE is accomplished by transmitting a GUTI through the radio path. The KSIASME is also sent along with the request. Before transmitting, the UE integrity protects the request using NAS security. Upon receipt of the connection request, the MME identifies the corresponding KASME with the help of the received GUTI and the KSIASME. The MME then checks the integrity protection of the message. If the integrity check succeeds, the MME, depending on the MME policy, may either decide to reuse KASME that was established during a previous AKA (without invoking a fresh authentication procedure) or may decide to go for a fresh EPS-AKA that will result in the establishment of a new KASME. In order to carry out a fresh EPS-AKA, the MME locates the IMSI of the UE in its local database through the IMSI-GUTI mapping and continues in the same manner as the initial connection (discussed above). In order to reuse a KASME a fresh set of keying material is derived form the KASME. Thus, the need to perform frequent AKA runs has been reduced in EPS through the use of a more elaborate key hierarchy. In particular, connection requests can be authenticated using a stored KASME without the need to perform a fresh AKA. Several successive connections may be secured through re-derived security contexts from the current KASME. Entire part is considered with reference [1].

VI. IDENTITY PRIVACY RELATED VULNERABILITIES IN EPS-AKA

In EPS-AKA, a GUTI that is obtained in the previous connection (as explained in section 5.1) is transmitted instead of the IMSI for identity presentation. The purpose of the GUTI is to provide an unambiguous identification of the UE that does not reveal the subscriber's permanent identity (i.e., the IMSI). In spite of this security arrangement, there are occasions when the IMSI may be transmitted in clear text. Some of the identity privacy related vulnerabilities in EPS-AKA are as follows:

—During the very first attach procedure the IMSI has to be transmitted in clear text(TS 33.401 [2] section 5.1.1), since no GUTI is available for identity presentation at this stage.

—The IMSI has to be transmitted in clear text through the radio link as and when the MME requests for it. The MME has provision to make such a request when it cannot map the received GUTI with the corresponding IMSI. For instance, whenever the UE visits a new MME and the new MME can-not acquire the IMSI of the UE from the old MME. Such a recovery mechanism provides an opening for a fake MME to compromise subscribers IMSI [9].

—The SN, whose trustworthiness we question, has full knowledge about the IMSIs of all subscribers to whom it provides services.

—The responsibility of creation and allocation of temporary identities (i.e., GUTI) are assigned to the MME, whose trust-worthiness can itself be questioned.

Moreover, it is clearly evident that the trust model adopted in LTE is the current trust model discussed in section 2. Therefore, all the identity privacy related vulnerabilities and interoperability related drawbacks discussed in section 2 exist in LTE as well. Entire part is considered with reference [1].

VII. SECURITY EXTENSION FOR EPS-AKA

In this section, we propose a security extension for EPS-AKA to achieve improved identity privacy and enhanced interoperability in LTE. The extension protects the permanent identity of a sub-scriber in the radio path as well as in the wired path. Knowledge of the IMSI of a subscriber is restricted only to the UE and the HE. In the extension, a Dynamic Mobile Subscriber Identity (DMSI) is transmitted by the UE instead of the IMSI. The role of the DMSI is to randomize and mask the IMSI so that an adversary having access to a particular DMSI cannot link it with any subscriber or any previous communication. This extension is based on our work that was presented in [7]. For successful functioning of the security extension the following operator specific random number and functions are used:

RIC: Random number for Identity Confidentiality (RIC) is a random number that uniquely identifies a UE within a particular HE for an epoch of time. RIC is used to compute a DMSI as
DMSI = MCC||MNC||RIC||ERIC (4)

Where, MNC, MCC and ERIC stands for Mobile Network Code, Mobile Country Code and Encrypted RIC (explained later in equation 16) respectively. Size of RIC (b) in bit should be lesser than 128 bits and shall be determined by the operator depending on the subscriber base of the HE. A RIC of size b provides a pool of n = 2b unique RIC values. A fresh not-in-use RIC called RICFresh is chosen every time a new EPS-AV is generated at HSS. RICFresh is then cryptographically embedded into the RAND of EPS-AV . The resultant random number after embedding RIC into RAND is called Embedded RAND (ERAND). Only UE having the knowledge of the long term shared keyKi is capable of extracting RIC from the ERAND.Multiple (m) RICs comprising of the fresh and few previously generated RICs RICNew;RICPrev;RICOld, etc.) are maintained at the HSS against a particular IMSI in order to ensure robustness of the protocol even when an AV gets lost in transit (or due to some reason does not get utilised). Such an arrangement ensures that a mapping between the RIC that is currently stored at the UE and the corresponding IMSI is always maintained at the HSS. An additional RIC called RICInUse is maintained at the HSS. RICInUse enables the MME to uniquely identify the UE as long as the later continue to stay within the former's service area.

fi: This function returns a RIC that can be used to uniquely identify an UE. This is done by randomly selecting a not-inuse RIC from the RIC-Index, the later being an index for the HSS's local database consisting of n = 2b unique RIC entries arranged in ascending order (Fig. 2), b being the number of bits in RIC. Each RIC entry in the RIC-Index has a pointer called IMSI-Pointer against it. A RIC that is already allotted to some UE, will have its IMSI-pointer pointing to that particular row in the HSS's database, which contains the IMSI of the concerned UE. A null pointer against a particular RIC in the RIC-Index denotes that the particular RIC is (not-in-use) not allotted to any specific UE and is free to be used.

RIC = fi(RIC-Index) (5)

fe: This function embeds RIC into RAND to produce ERAND, using the long term shared secret key Ki as parameter.

ERAND = feKi(RIC;RAND) (6)

fx: This function extracts RIC from ERAND, using the long term shared secret key Ki as parameter.

RIC = fxKi(ERAND) (7)

Example algorithms for fe and fx are proposed in [6].

fn: This function takes in a 128 bit ERAND and the secret key Ki as parameter and encrypts a 32 bit RIC to produce a 128 bit output called Encrypted RIC (ERIC).

ERIC = fnKi(RIC;ERAND) (8)

fd: This function decrypts ERIC by using Ki as parameter to produce RIC.

RIC = fdKi(ERIC) (9)

fs: This function stores a freshly generated RIC (RICFresh) against a given IMSI in the HSS's database. In order to make space for RICFresh, the oldest RIC stored against the corresponding IMSI is freed up. For example, for m = 3 with RICNew;RICPrev and RICOld as the RICs stored against the corresponding IMSI, the oldest RIC (i.e., RICOld) is returned to the pool of not-in-use RICs by setting a null pointer against it in the RIC-Index. RICOld is then replaced by RICPrev, and RICPrev is replaced RICNew. Finally RICNew is replaced by RICFresh. An entry in the RIC-Index
against the IMSI-Pointer of RICFresh is also made accordingly.
RICOld:IMSI-Pointer = null (10)
RICOld = RICPrev (11)
RICPrev = RICNew (12)
RICNew = RICFresh (13)

fm: This function moves a given RIC (say RICp) from its current location to RICInUse in the HSS's database. When RICp is passed as parameter, fm searches for it in the RIC-Index.The IMSI-Pointer against RICp in the RIC-Index leads to the IMSI to which RICp is allotted. The particular RIC field (ie.RICInUse, RICNew, RICPrev, RICOld, etc.) in the HSS's database against which RICp is stored is then located. If RICp is found in the RICInUse field, no updation is required and the function quits. Otherwise, if RICp is found in a RIC field (say RICc) other than RICInUse, than all the RIC fields older than RICc are set to null. The RIC values in these older fields are then returned to the pool of not-in-use RIC by setting their IMSI-Pointers to null in the RIC-Index. The value in RICc is then copied intoRICInUse. And finally,RICc is also set to null.

For example, for n = 3 with RICNew;RICPrev and RICOld as the RICs stored against the corresponding IMSI, if RICp is found in RICNew then:
RICPrev = RICold = null (14)
RICPrev:IMSI-Pointer = null (15)
RICOld:IMSI-Pointer = null (16)
RICInUse = RICNew (17)
RICNew = null (18)

A summary of all the cryptographic functions used in the extension is presented in table 1.

Table 1. Cryptographic Functions

fi	Returns a not in use RIC from the RIC index.
fe	Embeds RIC into RAND to Produce ERAND
fx	Extracts RIC from ERAND.
fn	Encrypts RIC to produce ERIC.
fd	Decrypts ERIC to find RIC.
fs	Stores a fresh RIC in the HSS’s database.
fm	Moves a specified RIC from its current location to the RICInUse field in the HSS’s database.

An ERAND (Say ERANDFirst) that has a unique RIC called RICFirst embedded into it, is stored in the USIM’s flash memory in a field called ERANDUE before a subscriber procures it from the service provider. RICFirst is also stored at the HSS and an entry in the RIC-Index is made accordingly.

RICFirst is meant for one time usage during the initial connection.

7.1 The Initial Connection

For the initial connection, the UE transmits an attach request that contains a DMSI (instead of the IMSI, section 5.1) calculated according to the following steps.
RICr = fxKi (ERANDUE) (19)
ERICr = fnKi (RICr, ERANDUE) (20)
DMSIr = MCC||MNC||RICr||ERICr (21)

(1.1) The MME initiates the authentication procedure by sending a request for a fresh EPS-AV along with DMSIr to the HSS.

(1.2) On receiving the request, the HSS separates RICr from DMSIr and with the help of RIC-Index locates the corresponding IMSI and the secret key Ki of the UE in its database. It then calculates:

RICd = fdKi (ERICr) (22)

and checks if RICd = RICr. If they do not match the request is rejected. If they match, it confirms that the request has been send by the concerned UE and not by a third party with malicious intentions; RICr is thus moved from its current position to RICInUse using fm, and a fresh EPS-AV (EPS-AVf) is generated as explained in section 5.1.
HSS then computes
RICFresh = fi(RIC-Index) (23)
RICFresh is then cryptographically embedded into the RAND (RANDf) of EPS-AVf using fe.
ERANDf = fe(RICFresh;RANDf) (24)

A copy of RICFresh is also stored using fs at the HSS’s database. After embedding RICFresh into RANDf EPS-AVf looks like the following:
EPS-AVf = (ERANDf ;XRESf ;CKf ;IKf ;AUTNf) (25)

From now on, ERANDf is used (instead of RANDf) as the effective 128 bit random number for EPS-AKA related computations. Finally, HSS sends EPS-AVf along with DMSIr back to the MME.(1.3) On receipt, MME continues the AKA procedure by extracting ERANDf and AUTNf from EPS-AVf . ERANDf and AUTNf are then transmitted as a challenge towards the UE.(1.4) The UE and the MME completes the remaining part of the AKA procedure following the same steps as explained in section 5.1. If the mutual authentication process is successful:

—UE saves the recent ERANDf that it has received from the MME as ERANDUE.

—The MME stores DMSIr into the field meant for storing IMSI in its local database. Let us call this field as MSIMME.

MME continues to uniquely identify the UE with DMSIMME till it receives a new DMSI (during a successful AKA) from the UE.(1.5) At the end of the AKA procedure, a shared KASME is established between the UE and the MME . The MME then allocates a new GUTI to the UE by initiating a GUTI reallocation procedure through the NAS (as explained in section 5.1). MME stores this GUTI against DMSIMME in its local database. The GUTI is also stored in the UE’s memory (say in a field called GUTIUE) for identity presentation during the next authentication.

7.2 Subsequent Connections

For all subsequent connections and the corresponding AKA procedure, the UE may present its identity in two different ways:

(i) By transmitting a GUTI received in the previous AKA: In this case, UE transmits the GUTI stored in GUTIUE. Out of the two options, this one is the preferred option since it reduces authentication latency (as the authentication procedure happens locally between the UE and the MME without involving the HE).

(ii) By transmitting a fresh DMSI: This option is less preferred and the UE may be forced to opt for this option when the UE roams into the area of a new MME or when the MME cannot identify the UE with its current GUTI.

The protocol flow for subsequent authentications through the transmission of a fresh DMSI is same as that of the initial connection (i.e., step 1.1 through 1.5). The protocol flow for subsequent connections through the transmission of GUTI is as follows:

(2.1) UE extracts GUTIUE from its memory and transmits it to the MME.

(2.2) through this GUTI, MME identifies the corresponding DMSI (ie. DMSIMME stored in its database). MME then sends a request for a fresh AV to the HSS along with DMSIMME.

(2.3) After receiving the request, HSS extracts the embedded RIC (say RICr) from DMSIMME. The IMSI-Pointer against RICr leads to the record (in the HSS's database) that contain details related with the corresponding IMSI of the UE. The remaining portion of this step proceeds in the same manner as in step 1.2.(2.4) The remaining part of the protocol flow is same as steps 1.3through 1.5. Entire part is considered with reference [1].

VIII. ACHIEVEMENTS OF THE EXTENSION

The key achievements of the proposed extension may be summarised as follows:

—End to end identity privacy: Knowledge of IMSI is confined only to the UE and the HSS; it is never transmitted at any stage of the network.

—Enhanced interoperability: MME to MME as well as HSS/UE to MME trust relationship requirement with respect to the permanent identity (i.e. IMSI) is relaxed; thereby, enhancing interoperability among cellular operators.

—No impact at the MME/SN: As no extra computation is introduced at the MME, the adoption of the extension in EPS-AKA will be easy. The extension can be adopted with minor modifications at the UE and the HSS (without requiring any modification at the intermediary network that may even belong to a third party).

—Reduced communication overhead: The extension reduces two protocol messages. Unlike EPS-AKA, during handover, the extension does not need the current MME to communicate with the previous MME to acquire the permanent identity of the UE. Instead, a DMSI is directly sent to the new MME. Entire part is considered with reference [1].

IX. FORMAL ANALYSIS

In this section, we perform a formal analysis of the proposed security extension through an enhanced BAN logic [6] called AUT-LOG [12]. Through this analysis, the security goals described in the following subsection are proven to be achieved by the extension. Entire part is considered with reference [1].

9.1 Security Goals

IMSI should be a shared secret between the UE and the HN/HSS; it should not be disclosed to any third party including the SN/MME:

—G1: UE believes UE IMSI $\underset{\longleftrightarrow}{\text{HSS}}$

G2: UE believes ¬ (MME sees IMSI)

GUTIs and DMSIs are transmitted in lieu of the IMSI of a UE. During every successful run of the protocol, if the UE receives a fresh GUTI and a fresh DMSI, it can easily protect its IMSI (section 7).

—G3: UE believes UE has GUTI
—G4: UE believes fresh(GUTI)
—G5: UE believes UE has DMSI
—G6: UE believes fresh(DMSI)

It should not be possible to link a GUTI with the corresponding DMSI and a DMSI with the corresponding IMSI.

—G7: UE believes ¬ (GUTI =DMSI)
—G8: UE believes¬ (DMSI =IMSI)

9.2 Prerequisites & Proving the security goals

UE recognizes Ki and believes that it is a good key for communication
with HSS:
UE has Ki (26)
UE recognises K i (27)
U E believes f resh(SEQ) (29)
UE regards the following messages as atomic messages
(X) U E = X X {ERAN D, GUT I} (30)

Similar to all above equations by reference paper [1] we can derive formulas no As proven in equation 33, 34, and 35, the UE receives a pair of fresh DMSI and GUTI during every successful run of the AKA protocol.

These new dynamic identities (as explained in section 7) may be used by the UE to identify itself (instead of the IMSI). Thus the following may be assumed about the UE:
UE believes UE controls ¬ (MME sees IMSI)
Entire part is considered with reference [1].

X. IMPLEMENTATION

For implementation purpose I have used
Simulation tool : NS-2.3x
Languages us : C++
Script Languages: AWK, TCL
Graph evaluation: Xgraph
In following module wise :

Module 1:
Apply LTE patch in ns2 and create a base LTE network with enodeB and users and transfer the data from sender node to receiver node.
Implementation: TCL, LTE Patch

Module 2:
Implement Existing Security architecture model (eNB is connected with one or more Mobility Management Entities (MME) through the S1-MME interface) and transfer data between users and eNodeB.
Implementation: TCL, C++

Module 3:
Measure Successful data delivery ratio and delay of Existing Security architecture model implemented LTE network and outputs are shown using graphs.
Implementation: TCL, AWK, Xgraph

Module 4:
Implement Proposed TRUST MODEL (The UE should trust only the HN with which it is registered And no one else) and transfer data between users and eNodeB.

Implementation: TCL, C++

Module 5:

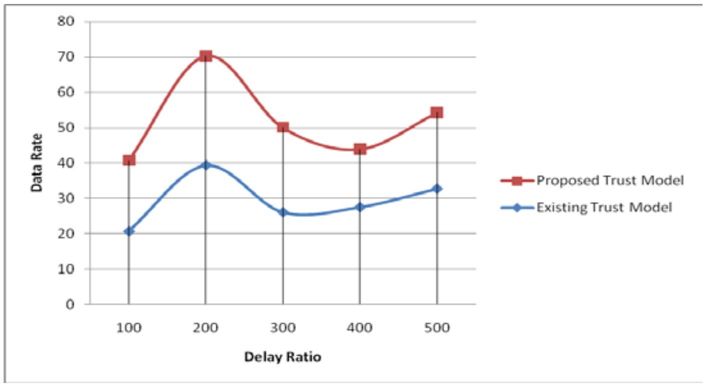
Measure Successful data delivery ratio and delay of Proposed Secure TRUST MODEL implemented LTE network and outputs are shown using graphs.
Implementation: TCL, AWK, Xgraph

Module 6:

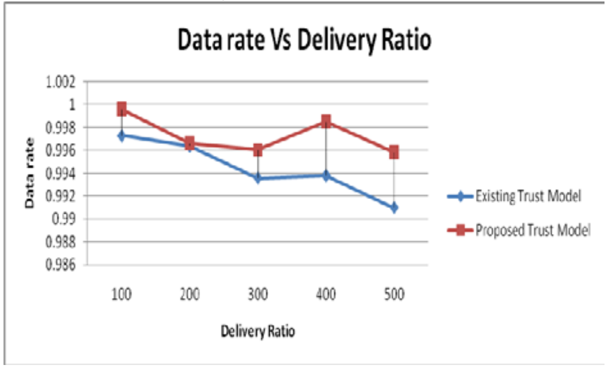
Compare Existing Security architecture model with proposed Secure TRUST MODEL using the measured Parameters (Successful data delivery ratio and delay) and outputs are shown using graphs.
Implementation: Xgraph

XI. RESULTS

11.1 Data Rate vs. Delay Ratio



11.2 Data rate vs Delivery Ratio



XII. CONCLUSION

In conclusion, Compare Existing Security architecture model with proposed Secure TRUST MODEL using the measured Parameters (Successful data delivery ratio and delay) and outputs are shown using graphs. As part of conclusion the implementation contributed to understanding the importance and the current status of subscriber's identity privacy in cellular network. With more and more operators taking a plunge into the competitive cellular market, interoperability is a key issue. A major factor that influence the ease at which interoperation may happen between cellular operators, depends on the flexibility of the trust model adopted by a cellular network. In this article, we implemented a trust model that may help in improving the status of identity privacy and as an additional benefit may make interoperability between cellular operators easier. Entire part is considered with reference [1].

REFERENCES

[1] New Trust Model for Improved Identity Privacy in Cellular Networks at International Journal of Computer Applications (0975 - 8887) Volume 56 - No. 14, October 2012.

[2] 3GPP. 3G Security; Security architecture. TS 33.102, 3rd Generation Partnership Project (3GPP), 2011.

[3] 3GPP. 3GPP System Architecture Evolution (SAE); Security architecture. TS 33.401, 3rd Generation Partnership Project (3GPP).

[4] 3GPP. General Packet Radio Service (GPRS) enhance-ments for Evolved Universal Terrestrial Radio Access Network. TR 23.401, 3rd Generation Partnership Project (3GPP), 2011.

[5] 3GPP. Numbering, addressing and identification. TS 23.003, 3rd Generation Partnership Project (3GPP), 2011Thesis.

[6] M. Burrows, M. Abadi, and R.M. Needham. A logic of authentication. Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences, 426(1871):233–271, 1989.

[7] H. Choudhury, B. Roychoudhury, and D.K. Saikia. Enhancing user identity privacy in lte. In Trust, Security and Privacy in Computing and Communications (TrustCom),2012 IEEE 11th International Conference on, pages 949–957. IEEE, 2012

[8] G.M. Koien. An introduction to access security in umts. Wireless Communications, IEEE, 11(1):8–18, 2004.

[9] U. Meyer and S. Wetzel. A man-in-the-middle attack on umts. In Proceedings of the 3rd ACM workshop on Wireless security, pages 90–97. ACM, 2004.

[10] CB Sankaran. Network access security in next-generation 3gpp systems: A tutorial. Communications Magazine, IEEE, 47(2):84–91, 2009.

[11] G. Wedel and V. Kessler. Formal semantics for authentication logics. In Computer Security ESORICS 96, pages 219–241. Springer, 1996.

[12] C. Xenakis and L. Merakos. Ipsec-based end-to-end vpn deployment over umts. Computer Communications,27(17):1693–1708, 2004.

[13] M. Zhang and Y. Fang. Security analysis and enhancements of 3gpp authentication and key agreement protocol. Wireless Communications, IEEE Transactions on, 4(2):734–742, 2005.

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