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Seamless LTE Wi-Fi Architecture for LTE with Efficient UE Authentication

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Abstract: ***Due to heavy demand of data uses and exponential increase in mobile users mobile network is suffering from heavy traffic overload in the metropolitan area network. Therefore, due to congestion as well as network overload mobile users are experiencing coverage issues such as latency, network access and very low throughput. At present network operators are actually capping data usages and throttling in speed of connection have very negative impact on satisfaction of mobile users. In such a scenario alternate solutions are expected like access point (AP) based network can be used as a complementary network. In this paper we have proposed a seamless LTE-Wi-Fi architecture by using packet gateway in LTE and Wi-Fi for maintaining the seamless connectivity for users and Wi-Fi is used as a complementary network over LTE. This proposed architecture has ANQP-DS (Access network query protocol Data Server) and AZC (Access Zone Control) are two main components to Wi-Fi network for balancing and controlling the load of User equipment's (UE) in between access points (AP). It can used as one of the mechanism in the LTE and Wi-Fi Integration Process.***

Keywords: LTE, Wi-Fi, EAP-AKA, ANQP-DS, AZC;

I. INTRODUCTION

All mobile users of metropolitan area network experiences some drawback like less throughput, very long latencies and problems in network due to heavily congested and overloaded access type of network [1]. Data uses capping and throttling in speed of connection is the main choice of operators for solving this issues [2]. There is a negative impact on user satisfaction by these oldest type of approaches. Hence some alternative mechanisms are expected like D2D-device to device and also using WLAN - wireless local area network for offloading the overloaded network Internet service providers(ISP) are using supplementary networks like Wi-Fi network for offloading some traffic is the most popular approach [3]. Some companies like Cisco, Qualcomm and AT&T had studded some new architectures for offloading 3G/4G data traffic into Wi-Fi network [4]. There are many challenges in this approach that are expected to be solved by the researchers, such as user equipment who is monitoring only open air interface connection, capacity of enodeB and access point (AP) for the network [5]. Dynamic switching is essential in between Aps when the user equipment moves to coverage area of network of Wi-Fi [6].

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At last user verification in this handover is very important while UE switches from LTE to Wi-Fi [7]. Different researchers had their related works and protocol standards for offloading the data among LTE and Wi-Fi networks. The 3GPP network access considers the data offloading and which is a probable promising answer for solving the network overload problem. They had proposed ANDSF access network discovery and selection function mechanism for triggering the handover in between different network access technology [8]. IP flow mobility is the alternative proposed offloading mechanism [9]. For the data offloading selected IP traffic offload (SIPTO) and the local input access (LIPA) [10]. Seamless internetworking flow mobility (SIFM) [11] and multipath transmission protocol (MPTCP) [12]. Out of above mentioned technologies most of the techniques are suffering badly from the latency in the authentication of user equipment (UE) during the call handover procedure [13].

We had proposed a seamless LTE and Wi-Fi architecture in this paper to overcome different drawbacks of existing available architectures for offloading the overloaded cellular networks. In LTE network we are handling the UE when it is switching from LTE to Wi-Fi by using the packet gateway (P-GW) and two main components ANQP-DS & AZC are added in Wi-Fi network. The packet gateway is working as an IP anchor for maintaining the same IP address during switching in between different networks, while ANQP-DS &AZC are responsible for managing UE mobility in the Wi-Fi network Aps are managed by AZC by load balancing of the UEs among APs and ANQP-DS are for holding the information of verification of UE and related profile of the concerned Wi-Fi network. It has been expected that during the process of call handover UE authentication time is found less than present mechanisms (e.g. EAP-AKA- Extensible Authentication Protocol Authentication and Key Agreement) and improvement in throughput of Wi-Fi network.

This paper is arranged in total VI sections. Section-I is related to Introduction, Section-II describes EPC-LTE architecture. In Section-III Wi-Fi network & its components are described. Section- IV is related to Proposed architecture of LTE and Wi-Fi integration. Section-V is related to result analysis and evaluation of performance and Section-VI describes the conclusion.

II. EVOLVED PACKET CORE IN LTE NETWORK (EPC)

LTE has many components that can make up the network. There are five main elements in LTE network listed as main part of LTE network. a)

User equipment b)E-UTRA (Evolved Universal Terrestrial Radio access) the LTE air interface c) E-UTRAN (Evolved Universal Terrestrial Radio access network) eNodeB d) EPC (Evolved Packet core) the LTE Core e) Non LTE - applications servers, internet, legacy network. Here we are interested in Evolved Packet core in the LTE network as shown in figure.1

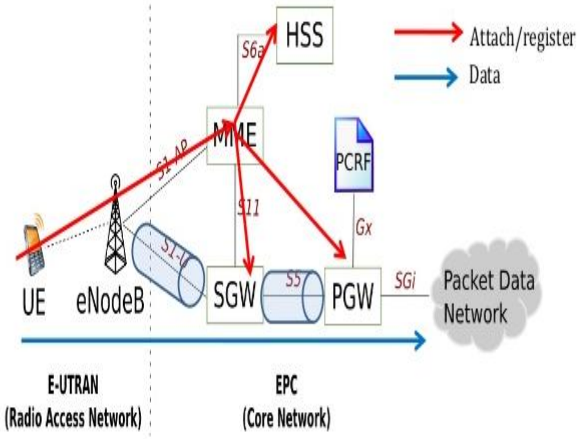

Fig. 1. LTE Network

A) Mobility Management Entity (MME):

This element is the brain of EPC operation that processes and controls the signaling in between UE and EPC. There are many MMEs in the larger LTE network. The main role of MME is to manage and track the location of UE when UE moves in different coverage area of eNodeB within LTE network. MME also interacts with S-GW and P-GW and HSS [14]. The MME is responsible to authenticate and authorize the UE before connecting the call. The UE can be in one of the three states i.e. connected, idle and dormant that the MME can keeps track of these status. The MME also determines which SGW and PGW the UE will utilize based on information it obtains about the UE from the HSS. The MME also monitors the traffic and has the ability to avoid or resolve an overload situation through traffic shedding. The MME also handles charging and billing functions as well as handling both the bearer management and authentication process [19].

B) Serving Gateway (S-GW)

It is the main gateway for connecting interface in between EPC and EUTRAN. All IP packets sent to or from the UE are routed through the serving gateway (S-GW), serves as the main mobility anchor in this data bearers when UE moves in between the eNodeBs. Typically, the UE remain connected to the same SGW when it moves from eNodeB to eNodeB in the network.

The SGW is therefore the local mobility anchor point for the inter eNodeB operation of handover, packet buffering in downlink and network triggered service requests initiation. The SGW is also directly involved in the lawful intercept for regulatory compliance of wireless mobile network.

The SGW also manages QCI granularity as part of the service delivery including UL/DL charging per UE.

The SGW also retains the information about the bearers when the state of UE is idle and temporarily buffers downlinking of data when the MME is initiating the paging of UE for reestablishing the bearers. In addition, the SGW mainly performs administrative functions for charging like sending and receiving data volume from user.

C) Packet Data Network Gateway (PGW)

The PGW is mainly responsible for IP address allocation (IPV4, IPV6) for connecting the UE with IP network as well as enforcement of QoS and mainly flow based and charging according to the rules it obtains from policy control and charging rule functions (PCRF).

It mainly works as an IP anchor for maintaining the same IP address when 3GPP and non 3GPP mobility services are in process. When a mobile device is requesting to bearer or when a bearer is expecting to setup for a video or IMS call, the PGW and PCRF are interacting together for getting sure of right policy enforcement to that bearer.

D) Home Subscriber Server (HSS)

The HSS is the similar in function to Home Location Register (HLR) except that it is IP based. The HSS is a data base which contains all user subscription data for the wireless network.

The HSS that is accessed for obtaining the subscriber information can also be for a different wireless operator depending on the home network that the UE identifies itself with.

The HSS therefore provides all the relevant information necessary for the system to determine what services and functions the subscriber is allowed to use and receive. Included in the information from the HSS about the subscriber is their QoS profile amid possible roaming profile if they are visiting the network, and their current location /presence information that would include dynamic tracking of MME to which the UE is currently attached or registered so that services can be properly delivered to the subscriber. The HSS may also integrate the Authentication Center (AUC), which generates the vectors for authentication and security keys [19].

III. WI-FI NETWORK

The UEs having Wi-Fi network coverage area were identified in LTE network. In LTE to Wi-Fi networks when switching of UE takes place from LTE to Wi-Fi network then enquiry for all data subscriptions will be needed as part of maintaining the continuity without interrupting the present connected network.

As shown in figure 2 in this paper for controlling and management we have added two main components in Wi-Fi network. The very first component is Access Zone Control (AZC), to handle the UE and APs, where UE can move into different APs without needing enquiry at each and every time from LTE to Wi-Fi Network. The second component is Access Network Query Protocol Data Server (ANQP-DS) which is responsible for collecting and storing data of UE from LTE network for staying always connected to the Wi-Fi network without interruption of services. The functionality of AZC and ANQP-DS has been described in detail as follows.

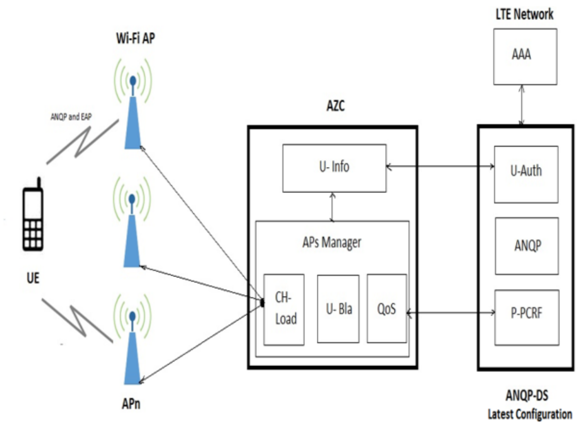

Figure 2: Wi-Fi control components

A) Access Zone Control (AZC)

This access zone control is responsible for managing all APs and UEs in the Wi-Fi zone coverage area. It consists of two main components for collaboration with each other and also to handle the seamless mobility, load balance of UEs and coverage area of APs and to maintain QoS in Wi-Fi zone for individual user. The details of the components of AZC are given below:

a) U-Info*:* This is the most important element just like a cash memory for saving the UE identity and information. When UE first switches from LTE to Wi-Fi network then it is added initially to U-info. Normally the process is like that when UE is switching from first AP to next AP then at that time it needs to be authenticated at each and every time from LTE network and due to that delay increases in the handover process. Here the UE is added in to the U-info after switching successfully to Wi-Fi AP and completion of the process of authentication. After this process for next switching of UE in next AP of Wi-Fi network the re-authentication process is not required as the UE is moving in the same access zone (AZC) control coverage area.

b) APs Manager*:* Its function is to manage APs within the Wi-Fi zone by doing load balancing of channel and also load balancing of user in this related coverage specific area of AP and to maintain QoS for user with specific application.

B). Access network Query Protocol Data Server (ANQP-DS)

We are introducing the ANQP-DS as a data server. User related data collected from LTE network like user profile, authentication information, subscriber identifier etc. are stored in this server for doing the management of user seamlessly during the switching process to Wi-Fi network. The ANQP- DS consists of three elements shown in the figure 2.

a)User Authentication (U-AUT)*:* The function of this element is to store the related information of user after the successful authentication in the LTE network from the HSS. When first time UE request for joining the Wi-Fi network then information collection of the user is done by U-AUT from HSS. In the decision of authentication of UE, if it is HSS verified means UE is accepted else UE is denied. To join the LTE network this authentication is necessary.

b)ANQP: The ANQP protocol is enquiring the information useful for the related network and the UE for selecting AP to connect to UE to network. The role of this element here is to store all related information of the network operator and network capability like throughput capacity of network, number of user with the individual AP and also vendor information. Here the UE will enquire about the information of network that are stored before choosing AP and joining to the new network.

c)P-PCRF*:* In the LTE network, the main function of P-PCRF is to copy the rules of QoS and save for implementation in the Wi-Fi network coverage area. For each UE who wish to switch to the Wi-Fi network needs an IP address for availing the service (The IP address may be same or may be different). Hence here when PGW is assigning an IP address to UE in Wi-Fi network then it is also expected here to identify rules and policies of QoS for availing the service. These rules are copies from PCRF of LTE to P-PCRF.

IV. PROPOSED LTE & WI-FI NETWORK INTEGRATION

The proposed architecture of LTE and Wi-Fi network Integration is shown in figure 3. The half part on upper side shows the LTE EPC components and another half part on lower side shows the Wi-Fi network. When UE is moving from LTE to Wi-Fi Network the PGW (packet data network gateway) maintains the required IP flow for user equipment UE. There are two different scenarios when UEs (User Equipment) are moving from LTE network to Wi-Fi network. First scenario is related to the situation when network operator is expecting to offload some data traffic of LTE network, for that offloading of some active UEs will be done with UEs of non-delay and related applications such as FTP file as well as Web pages etc.[16]. Second scenario is related to situation when UE is expecting to move from LTE network to Wi-Fi network hence handover is necessary for switching to Wi-Fi network. Firstly, IPS are sending a control message for UE enquiry regarding the availability of APs to join within the controlling of AZC. Second case UE is sending a request message for switching to another AP having enough capacity as well as best RSS [18].

Our main focus in this paper is on the Wi-Fi network. Here we are assuming clearly that previously UE are in LTE network coverage area.

The work flow chart 4A and 4B clearly shows the detail processing in between LTE and Wi-Fi components. Initially UE scans for all available APs shown in figure 4A. After scanning for the detected AP, UE is sending a request message for connecting to it, this message is asking the AP for responding along with ANQP information. Along with AP profile each AP has its ANQP which is used by UE for matching with ANQP-UE along with ANQP-AP. If there is mismatch, then UE is searching for another AP else UE is sending the acknowledge message along with the related information needed for AP authorization. Now the AP is forwarding the message to ANQP/DS server for doing the UE authentication.

ANQP/DS server is used for authenticating a UE by using one of the required EAP models that UE is using, in our existing scenario we are using the same authentication method of LTE network. Here in the LTE network UE is joining first time to Wi-Fi network, hence ANQP-DS will enquire for AAA (authentication, authorization and accounting) server for the authorization of present UE.

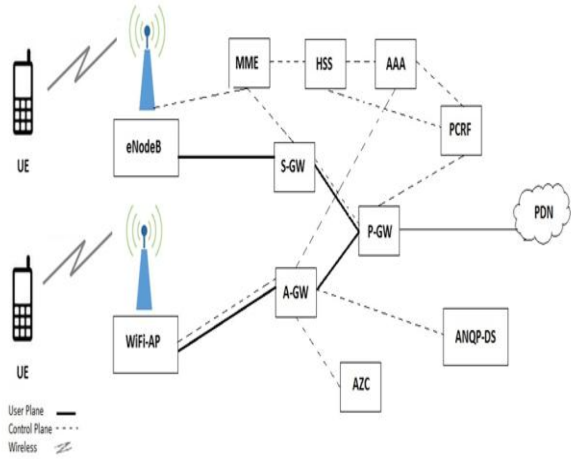

Figure 3: Proposed LTE and Wi-Fi Network Integration

Here if AAA server is unable to recognize the UE, then it will send a response with a message to ANQP-DS that this UE is not recognised to join to Wi-Fi network and after that ANQP-DS server sends a rejection message to AP for forwarding to UE. On the another hand, if AAA server recognizes the UE, it needs to aggregate the additional information of UE such as when it was with the LTE network and after that it will send to ANQP-DS to Wi-Fi network with previous PCRF policy service. As shown in the Proposed work flow chart between LTE and Wi-Fi components i.e. figure 4B, when AAA server sends an acceptance to ANQP-DS, then ANQP-DS is playing its role for adding the UE towards the U-Info in AZC and to mark the UE as authenticated UE for the future purpose so that this UE will need not to be re-authenticated when it is moving in between Wi-Fi APs during the entire handover process, because here the AZC is just checking UE-info for the related enquiry regarding the status of UE authentication. It results in decrease of delay time of UE re-authentication in the entire handover process in between the APs.

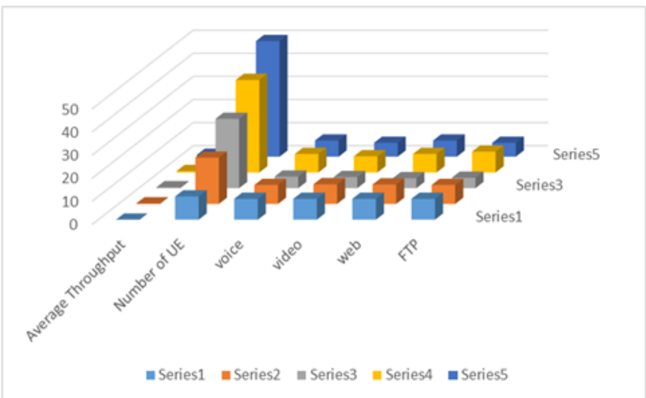

Figure 5. Average Throughput response for different applications like Voice, Video, Web and FTP etc.

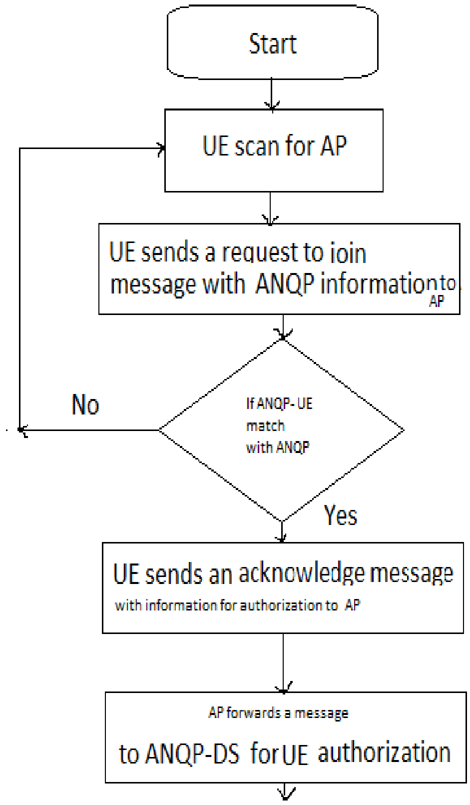

Figure 4A: The Proposed work flow chart between LTE and Wi-Fi components

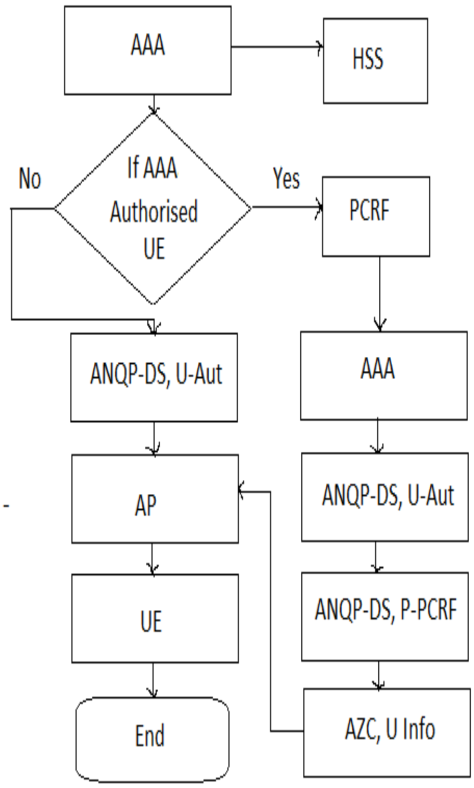

Figure 4B: The Proposed work flow chart between LTE and Wi-Fi components

V. RESULT ANALYSIS AND EVALUATION OF PERFORMANCE

This section shows the comparative result analysis and evaluation of performance of our proposal with the available EAP-AKA standard and other proposal. This comparison is totally based on authentication delay and the throughput of UE observed during the entire handover process. Here the simulation parameters are shown in table-1 which represents the network topology of our simulator.

Table 1: Comparison of different Simulation Parameters

Sr.No.	Parameters	Internet Speed / Capacity
1	Internet Connection	1Gbps
2	LTE Capacity (UL/DL)	100Mbps
3	Wi-Fi Network Capacity	54Mbps
4	Data Traffic at each UE	1Mbps for each Application

In LTE network the uplink and downlink capacity is 100mbps and it is 54Mbps in Wi-Fi network. All available UEs are connect to either LTE or Wi-Fi networks accordingly. In LTE Network maximum 25UEs are connected without congestion with the assumption of data traffic of 1Mbps towards each UE. All the recommended offloading IP /flows are not sensitive to latency for different applications like Web and FTP etc. and are called non delay type of sensitive applications [16]. In our present work, voice and video traffic are highly recommended with LTE network because it is more latency sensitive else the offloading will be for IP- flows and with non-delay type sensitive applications. Here figure 5 shows Average Throughput response for different applications like Voice, Video, Web and FTP etc. by UE for various offloading values of our existing proposal. It is observed that the throughput is almost equal from 10 UEs to 20 UEs and having data traffic of 1Mbps for each application. In no offload scenario, when there is increase in number of UEs then there is sharp decrease in throughput. As shown at 30 UEs, LTE network is having congestion as UE exceeds beyond the threshold value of UEs. When there is congestion in LTE network then rise is observed in effectiveness of offloading and the average of throughput at 40 UEs. As the count in offloading IP flow from LTE to Wi-Fi network increases then it causes congestion in the Wi-Fi network. The percentage of offload IP flows reached to 48% at 50 UEs. In EAP-AKA standard the round trip messaging time is 150ms in between the Wi-Fi and LTE network. [17], in Proposal it is approximately 72ms. As in EAP-AKA, every time UE needs to get connected to AAA server in LTE for verification when it gets switches towards AP. Moreover, in our proposal for this authentication it is expected that UE needs to get attached to the latest configuration of ANQP-DS Server. In the fastest handover, if we use EAP-AKA mechanism for UE authentication process then the exact time required is 605ms [13], In A. Alfoudi, G. M. Lee, M. Dighiri's Proposal shows that they had reduced this UE authentication process time and is 330ms [18]. In our proposed proposal it is observed that the UE re- authentication time is just 303ms. Hence the re-authentication time is decreases by 70% as compared to existing authentication mechanisms and is shown in Table 2.

Table 2: Comparison of different authentication Mechanisms and Authentication latency

Sr. No.	Authentication Mechanisms	Authentication Latency (ms)
1	EAP-AKA standard	605ms
2	A. Alfoudi, G.M.Lee, M.Dighiri's Proposal	330ms
3	Our Proposed Proposal	303ms

VI. CONCLUSION

We have proposed a seamless network architecture for LTE and Wi-Fi integration for offloading the overloaded LTE network using the PGW as a main anchor in IP flow for maintaining a seamless connectivity in between LTE and Wi-Fi network. ANQP-DS (Latest configuration server) and AZC are the two main components added in Wi-Fi core network in order to control and manage the authentication of UE and balancing of load of UEs in between APs. It is observed in our proposal that UE authentication latency in between LTE and Wi-Fi networks are decreased as compare to the other available authentication mechanisms.

REFERENCES

1. P.Taylor "Data overlaod threatens mobile networks". BENTON FOUNDATION [online] available. Https:// www.benton.org/node/122825.
2. S.CURTIS, "Can you servive on 4G alone?" the telegraph [Online]available. http://www.telegraph.co.uk/technology/internet%20/10272292/Can-You-Survive-On-4G- alone.html.
3. CISCO, "Architecture for mobile data over Wi-Fi access networks," Vol.8,no.2008, pp.1-23,2012.
4. Qualcomm, "A 3G LTE Wi-Fi offload framework:connectivity engine (CnE) to manage Inter System Radio Connection and Applications". No.June,2011.
5. J. ling, S.Kanugovi, S.Vasudevan, and A.K.Pramod, "Enhanced capacity and coverage by Wi-Fi LTE integration," IEEE commun.Mag.,vol.53,no.3,pp.165-171, 2015.
6. Z. Zhong, P. Kulkarni, F.Cao,Z.Fan,and S.armour, "Issues and challenges in dense Wi-Fi networks," IWCMC 2015/11th
7. Int.Wirel.Commun. Mob.Comput.Conf.,pp.947/951,2015.
8. J.Kao,M.Ma. and H.Li, "An uniform handover authentiction between E-UTRAN and Non-3GPPSS networks,"IEEE trans.Wireless Communication vol.11no.10,pp3644-3650 -2012 .
9. T. Specification, "Etsi ts 124 615," vol.0.no.Im, pp.0-28,2012.
10. T. Specification and G. Services, "3Gpp Tr 23.829," vol.1.no.Release 10,pp.1-43,2011.
11. Sheets. R, "Local area network," pat.no.US5127067,vol.0,pp.0-23,1985.
12. D.R.Purohit, A.Hegde, and K.M. Sivalingam, "Network architecture supporting seamless flow mobility between LTE and Wireless Network". Proc.WowMoM 2015 A worldwireless. Mob.Multimedia.Networks,2015.
13. M.A.Patino Gonzalez, T. Higashino,and M.Okada, "Readio access considerations for data offloading with multipath TCP in Cellular-Wi-Fi networks". Int.Conf.Inf.Netw.,pp.680/685,2013.
14. Y.EI Hajjaji EI Idrissi, N.Zahid, and M.Jedra, "A new fast re-authentication method for 3G-WLAN interworking based on EAP-AKA,"2013 20th Int.Conf.Telecommunicaton, ICT 2013,2013.
15. A.Basta,W.Kellerer,M.Hoffmann,H.J. Morper, and K. Hoffman, "Applying NFV and SDN to LTE mobile core gateways, the function placement problem,". Proc.4th work. All things Cell. Oper.appl.challenges-All Things Cell, 14,pp.33-38-2014.

16. Y.Zaki, L.Zhao,C.Goerg, and A.Timm-Giel, "LTE mobile network virtualization exploiting multiplexing and multi-user diversity gain," Mob.Network appl.,vol.16,4,pp.424-432 2011.
17. "Mobile data offload – Wi-Fi ," Telecommunication Engg.Cent.,vol.19,no.3,2015.
18. H.Kwon,K Cheon,K.Rho, and A Park, "USIM based Authentication Test bed for UMTS-WLAN Handover," Infocomm,pp.8-10,2006.
19. A.Saeed,Gyu M.Lee, M.Dighriri "Seamless LTE-WiFi architecture for offloading the overloaded LTE with efficient UE Authentication" International conference on Developments in eSystems Engineering (DeSE), pp.118-122, 2016.
20. Clint Smith and Daniel Collins "Wireless Networks Design and Integration for LTE, EVDO, HSPA, and WIMAX".

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