

A New Signaling System For Efficient Packet Transmission Using New Gateway System

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Abstract— The need to configure the network structure is different from the legacy network system in order to meet the needs of the core network 5G. Legacy network does not satisfy an increase in the increase in connection delay time and the traffic at the centralized model. generating requests and trigger central node which occurs in a number up connection small cell and the terminal will give much burden to the MME in charge of Mobility Management from EPC. Moreover, EPC is dependent on GTP is a protocol for supporting the terminal mobility that was used in the 2G / 3G. GTP can be that maintained to support Mobility, GTP tunnel management which requires heavy signaling and handover that occur frequently will be giving a burden to the MME complicate. In addition, the tunnel is sensitive to time and delay, will result in a packet overhead. Therefore, we attempt to propose an architecture which can meet the scheme and 5G requirements can solve the problems with GTP.

Keywords— 5G, Signalling, Convergence, NAS, GTP

I. INTRODUCTION

By the explosion of mobile traffic signals generated in the network also now increasing, changes in network structure by this is needed. When we analyze the LTE network that signaling load is very high, most of the signaling, release and configuration of connection, handover, began tracking Oh rare update[1]. Thus the communication architecture of the subsequent 4G generations must be able to resolve the signaling problem. In this paper, a more efficient network architecture that can meet the 5G requirements is needed. 3GPP EPP) architecture has been designed to provide IP connection between the User Equipment and the PDN. Current EPC architecture and experiencing a rapid increase in the dynamic traffic patterns[2]. This results in reducing the cost of the network side, and was based on the need to increase the new architecture that can drive new revenue. It also has increased periodic server connection messages generated by mobile applications and various SNS application with the increasing of smartphone. In order to transmit such a short message connects a tunnel to the mobility, it becomes increasing of the load on the control plane.

In the EPC architecture, UE is has a Connected state and Idle state. In the Connected state, UE is enable state which can set the data plane. In the IDLE state, UE do not have an active

session, to release the data plane. Thus, when the application is running in the background state, UE will be frequently changed to the Connected state and the Idle state. These changes in the periodic state, will occur the control messages between the UE and the network [3]. The article that was published in Nokia, increased sales of smartphones and tablets more than 40%, the increase in signaling traffic due to this, it announced that it had increased to 99% [4].

It was decided that a new solution for managing the dynamic characteristics of the traffic in an efficient cost on the network side to investigate needs. For example, it has been proposed to transmit the [5], instead of establishing a session for each data plane, the sporadic short messages in sporadically EPC control plane. In the proposed scheme, in order to meet the load of the data plane signaling, the structure of the network, the current and must be configured differently. It can be reduced, but it is a problem that has not been complete separation of the network structure data and control planes. Therefore, in this paper, we propose a network architecture that has solved the above problems and proposes a method which can reduce signaling overhead. The paper is organized as follows. In section II, a brief description of the EPC architecture. In section III, we propose that describes the network architecture. In section IV, we have proposed that less cost of signaling load than the existing EPC network architecture, it must be confirmed. In Section V, show the mathematical result. In section VI, it is intended to illustrate the results.

II. EPC ARCHITECTURE

A. Architectural Model

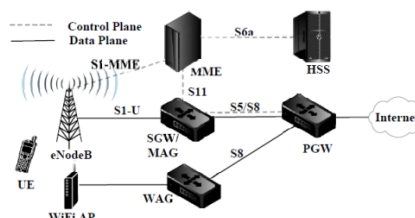


Figure 1. 3GPP-EPC Architecture.[11]

EPC architecture made of eNodeB and (Evolved Universal Terrestrial Radio Access Network) the EPC Core. The EPC Core is composed of the Serving Gateway (S-GW), PDN Gateway (P-GW), Mobility Management Entity (MME) and HSS (Home Subscriber Server) [6]. The eNodeB is respectively through the S1-MME and S1-U interface connection between MME and S-GW. MME is responsible for part for the UE connections and mobility and authentication to the network. S-GW and P-GW are forwarding data and IP mobility in the data plane. QoS level is determined from the P-GW. When the UE is Idle state, radio data bearer and S1 data bearer are released. S5 data bearer is maintained on registered the UE. The eNodeB send data to S-GW and P-GW based on the GTP.

B. Data plane management

In this paper, we focus on initial connection and setting of access bearer for the access bearer release in the data plane.

1) Initial Attachment

When turn on the UE, UE is possible to register to the network. The UE sends a connection request message to the eNodeB to put identifying information can identify itself. The eNodeB sends a message to the MME, the authentication is successful, it is making a default bearer to send Session Create Request to S-GW, and sends the same message to the S-GW. Similarly, P-GW also sends a Create Session Response to the S-GW. This sets the S5 data bearer. MME set the Attach Accept message and the Initial Context Setup Request S1 data bearer by piggy-back the message to the eNodeB. eNodeB sends the Attach Accept message to the UE after establishing the radio data bearer, and sends the initial MME Initial Context Setup Response message. At the same time MME sends a Modify Bearer Request message to the S-GW.

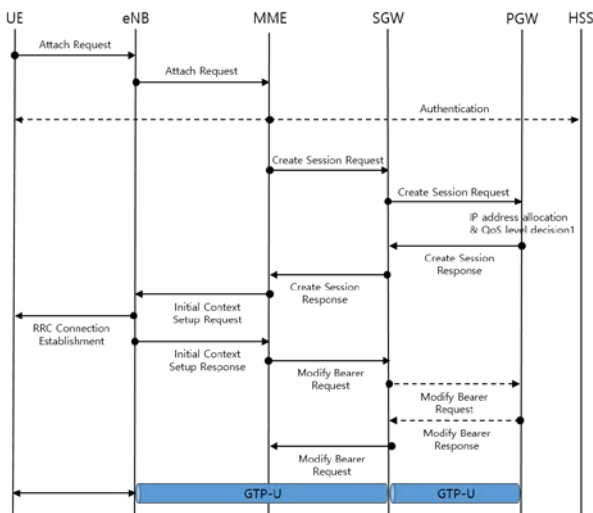


Figure 2. Initial attachment procedure..

2) Access Bearer Setup

Access Bearer Setup is executed when the UE is changed to the Idle state in the Connected state. UE is S5 data bearer even in the Idle state is maintained. At this stage we want to set the data bearer of S1. eNodeB sends the NAS Request message the UE has sent to the MME. It runs an authentication procedure of the UE when the UE context does not exist. MME sends the Initial Context Setup Request message. eNodeB, set the wireless data bearer and sends the Initial Context Setup Response message to the MME. MME and S-GW is, it will be to replace the Modify Bearer Request and Modify Bearer Response message. Finally sets the data bearer of radio data bearer and S1 UE state of this procedure is the Connected state.

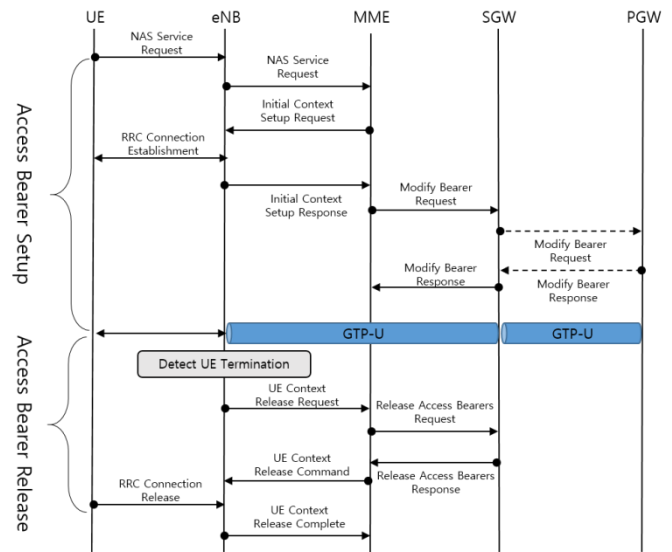


Figure 3. Access bearer setup and release procedures.

3) Access Bearer Release

When Access Bearer Release to detect activity mode from the eNodeB of the UE, will be Access Bearer Release of procedure is initiated. eNodeB sends UE Context Release Request message to the MME. MME sends the Release Access Bearers Request message to S-GW, and it requests for the release of the S1 data. The S-GW will be the eNodeB the instruction to release the radio data bearer and S1 data bearer in, MME and receives a response to the message. Thus, the end of this procedure is as to release the access bearer UE of state becomes Idle state.

C. Drawbacks

A disadvantage of the control procedures of the data plane are as follows.

Even if there is no data to send, the initial connection is set systematically

Parameters of the data plane do not know the type of session. By way of example the UE, inactivity timer parameter has a static value that has been preset in the

local eNodeB. However, this value does not apply to all sessions. In addition, UE is invalid timer, before the application reconnects, if the expiration date has expired, will be re-generate a set of data plane via an extra signaling. Applications that are not connected to the network, maintaining data plane is evoke a waste of network resources. Therefore, UE invalid timer must be applied respectively to their session profile.

In order to solve the above problems, we have proposed a new network architecture. Detailed description is, I'll explain in the next section.

III. PROPOSED NETWORK ARCHITECTURE

A. Architectural Model

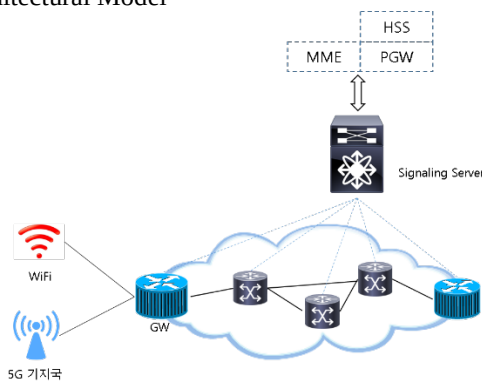


Figure 4. Proposed New Network Architecture..

We propose new network architecture. Our proposal is to propose Signaling Server(SS) architecture that can comprehensively manage and operate Convergence Gateway and networks that can support both wired and wireless networks. All signaling, in order to manage SS server, it is not using a conventional S1- MME and the S11 interface. In this architecture, it is completely separate data and control planes. SS functions are possible to each cloud can have a distributed structure.

Signaling Server(SS) : SS is main entity of the proposed architecture that we manage the GW as a major component of the architecture that provides and manages a network session and mobility. In the existing EPC architecture, it is possible to provide different protocols that were used in such S-GW, P-GW.

GW: The gateway that can handle both wired and wireless and operates by receiving a command of the SS.

B. Data plane management

The SS based structure, the management of the data plane includes a proposed Initial attachment and Access Bearer two procedures Setup. We will put only these two procedures at major concern. As a result, the procedure parameters and Access Release of Release Timer does not provide.

1) Proposed Initial Attachment

The biggest difference between the existing EPC networks, is obtained by reducing the signaling messages that occurred between the S-GW, P-GW, MME. Moreover, by introducing a centralized distribution system network architecture, signal generated unnecessarily can also be eliminated.

Initial Attachment is transferred to the SS through the GW the Attach Request from the eNodeB. GW sends an Initial Context Setup Request message, eNodeB sends the Initial Context Setup Response message to GW. GW sends Modify Bearer Request to SS, SS sends Modify Bearer Response. It is possible to remove the Create Session messages and Modify Bearer messages that occurred in the existing EPC.

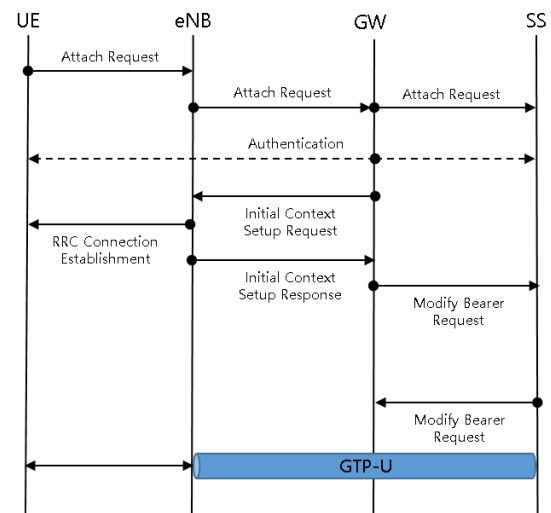


Figure 5. Proposed Initial Attachment procedure.

2) Proposed Initial Access Bearer Setup

As with the above procedure, it is possible to eliminate unnecessary signaling and tunneling.

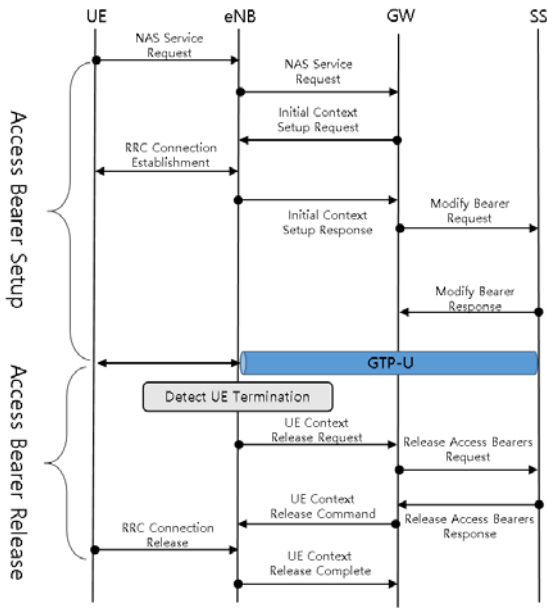


Figure 6. Proposed Access bearer setup and release procedures.

IV. SIGNALING COS

V. T ANALYSIS

In the Section, it compares to the load of the signal generated by the management procedures of the data plane and the 3GPP EPC architecture that we have proposed. Each UE may service corresponding to the smart phone that support the n pieces of session, it is assumed that the voice call, Web browsing and e-mail. The average arrival rate per UE session λ_n , session the time that remains in the average from the network μ_n^{-1} . And the distance between the eNodeB and MME is $D_{e,c}$, the distance between the eNodeB and MME is $D_{c,s}$, the distance S-GW and P-GW is $D_{s,p}$. Formula used in this paper, see [7]. In addition, authentication attach request/response and NAS service request message in steps are not considered when calculating, because of the same in both architectures. And, it is not taken into account the signaling load of the UE and the eNodeB. Table I is the message size of the 3GPP LTE / EPC that is defined in 3GPP specifications [6], [8], [9].

The proposed network architecture, using the parameters of Table II, defines the distance of each entity with Fig7.

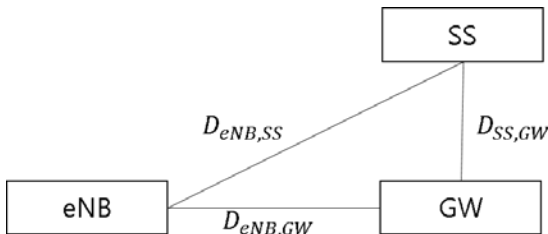


Figure 7. Proposed System Model

TABLE 1. SYSTEM MODEL MESSAGE SIZES (BYTES) IN 3GPP-EPC.

Messages	Notation	Src-Dst	Size`
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Initial Attachment procedure

Initial Context Setup Request	M_{icsq}	MME-eNB	145
Initial Context Setup Response	M_{icsr}	eNB-MME	86
Create Session Request	M_{csq}	MME-SGW	335
Create Session Response	M_{csr}	SGW-MME	241
Create Session Request	M_{csq}	SGW-PGW	335
Create Session Response	M_{csr}	PGW-SGW	224
Modify Bearer Request	M_{mbq}	MME-SGW	101
Modify Bearer Response	M_{mbr}	SGW-MME	81
Modify Bearer Request	M_{mbq}	SGW-PGW	67
Modify Bearer Response	M_{mbr}	PGW-SGW	81

Access Bearer Setup (Idle to Connected State)

Initial Context Set Up Request	MT_{icsq}	MME-eNB	145
Initial Context Set Up Response	MT_{idsr}	eNB-MME	86
Modify Bearer Request	MT_{mbq}	MME-SGW	104
Modify Bearer Response	MT_{mbr}	SGW-MME	106
Modify Bearer Request	MT_{mbq}	SGW-PGW	65
Modify Bearer Response	MT_{mbr}	PGW-SGW	81

Access Bearer Setup (Idle to Connected State)

UE Context Release Request	M_{csq}	eNB-MME	67
UE Context Release Command	M_{crd}	MME-eNB	67
UE Context Release Complete	M_{crte}	eNB-MME	65
Release Access Bearers Request	M_{rabq}	MME-SGW	65
Release Access Bearers Response	M_{rabr}	SGW-MME	66

TABLE 2. MESSAGE SIZES (BYTES) IN PROPOSED ARCHITECTURE.

Messages	Notation	Src-Dst	Size`
Proposed Initial Attachment procedure			
Initial Context Setup Request	MP_{icsq}	eNB-SS	145
Initial Context Setup Response	MP_{icsr}	eNB-SS	86
Create Session Request	MP_{csq}	SS-GW	335
Create Session Response	MP_{csr}	GW-SS	241
Modify Bearer Request	MP_{mbq}	SS-GW	101
Modify Bearer Response	MP_{mbr}	SS-GW	81
Proposed Initial Access Bearer Setup			
Initial Context Set Up Request	MPT_{icsq}	SS-eNB	145
Initial Context Set Up Response	MPT_{idsr}	eNB-SS	86
Modify Bearer Request	MPT_{mbq}	SS-GW	104
Modify Bearer Response	MPT_{mbr}	GW-SS	106

A. EPC architecture

- 1) *Unit signaling cost:* We are interest in the signaling load on the access bearer release procedure by initial attachment and access bearer setup. The load of Unit signaling evaluated by the four scenarios. The size of sent message and distance of between each message by are calculated at a distance of hops [10].

Scenario 1: State that is not registered in the UE still network, signaling cost is as follows.

$$SC_1^{3GPP} = (M_{icsq} + M_{icsr})D_{e,c} + (M_{csq} + M_{csr} + M_{mbq} + M_{mbr})D_{c,s} + ((M_{csq'} + M_{csr'} + (M_{mbq'} + M_{mbr'} +)P_{ho})D_{s,p} \quad (1)$$

P_{ho} will be displayed in the probability that the handover occurs in 3GPP in the non-3GPP.

Scenario 2: Although UE has been successfully registered, still Idle state. S5 data bearer already set state, signaling cost is as follows.

$$SC_2^{3GPP} = (M_{icsq} + M_{icsr})D_{e,c} + (M_{mbq} + M_{mbr})D_{c,s} + ((M_{mbq'} + M_{mbr'} +)P_{ho})D_{s,p} \quad (2)$$

Scenario 3: UE is fully registered in the network, the Connected state. In this scenario, do not make the signaling load.

$$SC_3^{3GPP} = 0 \quad (3)$$

Scenario 4: access bearer release procedure is performed, the UE of the state to move Connected state to Idle, signaling cost is as follows.

$$SC_4^{3GPP} = (M_{csq} + M_{csd} + M_{crte})D_{e,c} + (M_{rabq} + M_{rabr})D_{c,s} \quad (4)$$

2) *Total signaling cost:* UE has to support the N-type applications, and represents an average arrival rate of λ_n , it indicates the average duration of μ_n session. Total signaling costs are calculated as follows.

$$SC_{total}^{3GPP} = \lambda_n \{ (SC_1^{3GPP} + SC_4^{3GPP})P_1^{3GPP} + (SC_2^{3GPP} + SC_3^{3GPP})P_2^{3GPP} + SC_3^{3GPP}P_3^{3GPP} \} \quad (5)$$

$P_1^{3GPP}, P_2^{3GPP}, P_3^{3GPP}, P_4^{3GPP}$ is the probability that each scenario occurs, UE of P_2^{3GPP} and P_3^{3GPP} indicate the Idle state and Connected state. In other expression can be represented by (X_n, Y_n) . Expressed in expectation, it can be represented $E[X_n] = \mu^{-1}, E[Y_n] = \lambda^{-1}$. P_2^{3GPP} is $P_{idle} = \prod_{n=1}^N \frac{\mu_n}{\lambda_n + \mu_n}$. UE in Connected state can be represented by $P_3^{3GPP} = 1 - P_2^{3GPP}$.

We can determine N_{ue} , it is the total signaling overhead by considering the total of N number of UE.

$$SC_{Total}^{3GPP} = N_{ue} SC_{Total-ue}^{3GPP} \quad (6)$$

B. Proposed architecture

1) *Unit signaling cost:* It will be calculated in the same way as EPC architecture

Scenario 1: State that is not registered in the UE still network, signaling cost is as follows.

$$SC_1^{Proposed} = (MP_{icsq} + MP_{icsr})D_{eNodeB,SS} + (M_{csq} + M_{csr} + M_{mbq} + M_{mbr})D_{SS,GW} \quad (7)$$

Scenario2: Situation the UE registration has been, the state data bearer has not yet been created. The application is first started, S1 data bearer and S5 data bearer is maintained

$$SC_2^{Proposed} = (M_{icsq} + M_{icsr})D_{eNodeB,SS} + ((M_{mbq'} + M_{mbr'} +)P_{ho})D_{GW,SS} \quad (8)$$

Scenario3: State of the UE has been registered in the network, but is the Idle state. S1 data bearer and S5 data bearer of which are still maintained. In this scenario, because of the situation where the application is using the network, the signaling load is not generated.

$$SC_3^{Proposed} = 0 \quad (9)$$

2) *Total signaling cost:* Total signaling costs are calculated as follows.

$$P_2^{Proposed} = P_{idle} P_{no\ S1\&\ S6\ bearers} \quad (10)$$

$$P_3^{Proposed} = 1 - (P_1^{Proposed} + P_{idle} P_{no\ S1\&\ S6\ bearers}) \quad (11)$$

$$SC_{total-ue}^{Proposed} = \lambda_n (SC_1^{Proposed} P_1^{Proposed} + SC_2^{Proposed} P_2^{Proposed} + SC_3^{Proposed} P_3^{Proposed}) \quad (12)$$

Therefore, it is calculated in consideration of the above of N,

$$SC_{Total}^{Proposed} = N_{ue} SC_{Total-ue}^{Proposed} \quad (13)$$

VI. NUMERICAL RESULTS

This section will be explained through a numerical computed value results in the architecture we proposed. Each of the parameters, it is defined as follows.

$$D_{eNodeB,C\&M} = D_{e,c} = 3, D_{CGW,C\&M} = D_{c,s} = 1 \\ D_{s,p} = 1, P_1^{3GPP} = P_1^{Proposed} = 0.2, \\ P_{idle} P_{no\ S1\&\ S6\ bearers} = 0.1, P_{ho} = 0$$

Handover it assumes a situation that does not occur.

In addition, the number of UE 0 to 1000, looking at the figure below, it can be confirmed that the cost of the signal at the proposed architecture was reduced.

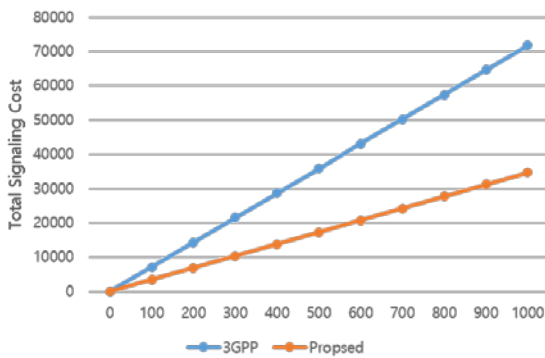


Figure 8. Total Signaling Cost.

Also, depending on the applications running on the smartphone, there may be a change in signaling costs. Session has to be noted that the signaling cost can vary depending on time is maintained in the network.

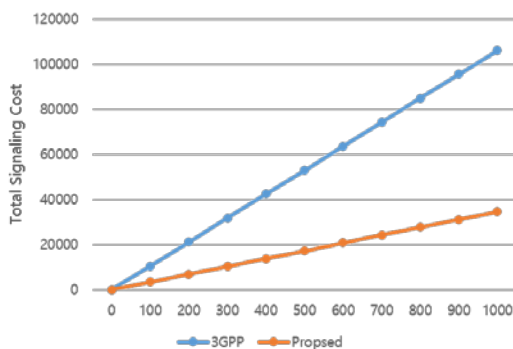


Figure 9. Total Signaling Cost t. ($\mu_n = 0.03$)

VII. CONCLUSIONS AND FUTURE STUDY

In the existing EPC architecture, and it has a problem of control signals and various support and overhead reaches the limit. In this paper, we propose a new network architecture, it is proposed for a method which can reduce signaling overhead in the proposed network architecture, the results proposed contents were analyzed in the group, unnecessary signaling and tunneling costs to indicate that it has decreased. Future study is scheduled to be the study of the function structure and operation mechanism of Gateway

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REFERENCES

- [1] D. Nowoswiat and G. Milliken, "Alcatel-Lucent: Managing the Signaling

- Traffic in Packet Core," <http://www2.alcatel-lucent.com/techzine/>
- [2] U. Paul, A. Subramanian, M. Buddhikot, and S. Das, "Understanding traffic dynamics in cellular data networks," in Proceedings IEEE INFO-COM, april 2011.
- [3] D. Nowoswiat and G. Milliken, "Managing LTE core network signaling traffic," July 30, 2013.
- [4] "Nokia siemens networks smart labs understanding smartphone behavior in the network," 2011.
- [5] I. Sato, A. Bouabdallah, and X. Lagrange, "Improving lte/epc signaling for sporadic data with a control-plane based transmission procedure," in 14th International Symposium on Wireless Personal Multimedia Communications (WPMC), oct. 2011.
- [6] 3GPP Specification TS 23.401 General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access ver13.4.0 2015-09-22
- [7] Malla Reddy Sama, Enabling Network Programmability in LTE/EPC rchitecture Using OpenFlow, 2014
- [8] 3GPP Specification TS 29.274 Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3, 2015-09-23
- [9] 3GPP Specification TS 29.281 General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U), 2015-09-23
- [10] J.-H. Lee, T. Ernst, and T.-M. Chung, "Cost analysis of ip mobility management protocols for consumer mobile devices," IEEE Transactions on Consumer Electronics, may 2010
- [11] Sakshi Chourasia SDN Based Evolved Packet Core Architecture For Efficient User Mobility Support, 2015



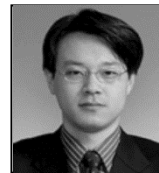
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