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ARTICLES

4G LTE Evolved Packet Core Planning with Call Switch Fallback Technology

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***Abstract*—Long Term Evolution (LTE) is a 4 Generation (4G) technology that supports high-speed data services. Currently, 4G LTE have yet covers all regions in Indonesia. Since 4G LTE is the latest technology in Indonesia, therefore it needs LTE Network Planning, which is consists of E-UTRAN (Evolved-Universal Terrestrial Radio Access Networks) and Evolved Packet Core (EPC). EPC is the major part in 4G LTE. In order to support LTE Network Planning in Indonesia, this paper develops 4G LTE which is focused on EPC Planning in City X. The implementation of 4G LTE network uses Call Switch Fallback (CSFB) technology. Based on the planning, it needs minimum 6 pieces of MSC (Mobile Switching Center) Server (MSS) that are 1 pieces HSS, 2 pieces MME and minimum 2 pieces SGW-PGW. In this planning, the interfaces can be divided by two parts, control plane interface and user plane interface. The control plane interface such as S6A, S11, S10, S1-MME requires minimum bandwidth of 0.355 Gbps. For user interface plane S5 / S8, S1-U and SGI requires a minimum bandwidth of 17.75 Gbps up to 127.80 Gbps.**

***Index Terms*—4G LTE; 4G Interface ; Call Switch FallBack (CSFB); Evolved Packet Core (EPC).**

I. INTRODUCTION

4G (4th Generation) implementation in Indonesia has been started in the middle of 2015 but the most of area in Indonesia has been served by a 3G and 2G technologies. In order to support the services and high-speed data, LTE technology is superior to the previous technologies [1].

Cities X is a city which has many users using data services. Because of this reason, the researcher propose the design for 4G-LTE Core Network Planning (EPC) in Cities X. This planning includes the EPC which consist of Home Subscription Service (HSS), Mobility Management Entity (MME), Serving Gateway (SGW), Packet Data Network Gateway (PGW), and MSS for CSFB's voice [2],[3].

The planning is conducted by researchers refer to a scientific journal entitled "4G LTE Core Network Planning in Bandung" made by Bayu Saptiyanto, Telkom University student, in 2015 [4].

A. *Evolved UMTS Terrestrial Radio Access Network (E-UTRAN)*

4G LTE access network (E-UTRAN) consists of many eNodeBs networks which interconnected via X2 interfaces and the EPC interconnected via S1 interfaces. Figure 1 shows E-UTRAN Architecture [5].

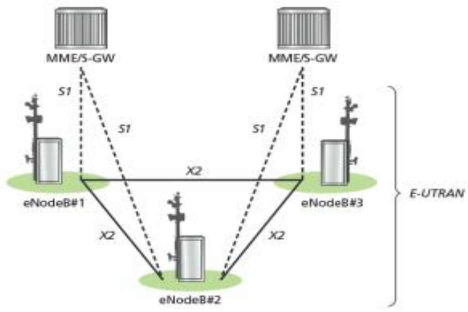

Figure 1: E-UTRAN Architecture [5]

B. *Evolved Packet Core (EPC) and The Interfaces*

Evolved Packet Core (EPC) is standardized by 3GPP (3rd Generation Partnership Project) Release 8 . EPC can support the data and converged voice on a network based on 4G LTE. EPC have function to combine the voice and data on IP service architecture. EPC can help operators to run and deploy one packet network for 2G-GSM, 3G-WCDMA, 4G-LTE, WLAN or fixed access. Figure 2 shows EPC Architecture and the interfaces of EPC[6]

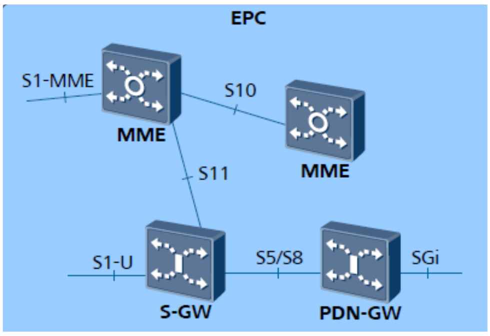

Figure 2: EPC Architecture and The Interfaces [6]

a. *S11 Interface*

S11 is an interface between MME and S-GW [6].

$$S11CP = \frac{SubsNum \times Sig\ msg}{3600} \quad (1)$$

where : S11CP = S11 Control Plane
SubsNum = Subcriber Number
Sig msg = Signaling message/subcriber Number at busy hour

b. S5/S8 Interface

S5/S8 is an interface between SGW and PGW [6].

$$S5/S8\ \text{User Plane} = \frac{SubsNum \times \text{Packet per}}{3600}$$
$$S5/S8\ Control\ \text{Plane} = \frac{SubsNum \times Signs\ \text{per}}{3600} \quad (2)$$

where : SubsNum = Subcriber Number
Packetper = Packet per subcriber Number at busy hour
Signs per = Signaling message Number at busy hour

c. S10 Interface

S10 is an interface between MME and MME [6].

$$Bandwidth\ \text{int}\ \ S10 = \frac{SubsNum \times Sig\ \text{msg}}{3600} \quad (3)$$

where : SubsNum = Subcriber Number
Sig msg = Signaling message Number at busy hour

d. SGi Interface

Interface between PGW and DN [6].

$$Bandwidth\ S\text{Gi} = \frac{SubsNum \times Sig\ \text{msg}}{3600} \quad (4)$$

where : SubsNum = Subcriber Number
Sig msg = Signaling message/subcriber Number at busy hour

C. Mobility Management Entity (MME)

MME is the main control element found on the EPC and only works on the control plane and does not include user plane data. The main function of MME on 4G-LTE network architecture are authentication and security, mobility management, managing subscription profile and service connectivity. [7]

D. Serving Gateway (SGW)

The highest functional level of SGW is the bridge between management and user plane switching. SGW is part of the network infrastructure as the operating and maintenance center. SGW has responsible for the source itself and allocate it based on the request of MME, PGW, or PCRF, which requires set-up, modification or explanation to the EU. [8].

E. Packet Data Network Gateway (PDN-GW)

PDN-GW is an important component of 4G-LTE for termination with Packet Data Network (PDN). The function of the PDN-GW is to support policy enforcement features, packet filtering, charging support on LTE [9]

F. Circuit Switch Fallback (CSFB) in EPC [11]

CSFB is a technology whereby voice and SMS services are delivered to 4G-LTE UE through the use of 2G or 3G.

CSFB is needed because 4G-LTE is a packet-based all-IP network that cannot support circuit-switched calls. When an 4G-LTE device is used to make or receive a voice call or SMS, the device "falls back" to the 2G or 3G network to complete the call or to deliver the SMS, Figure 3 show CS Fallback Registration location Procedure [10].

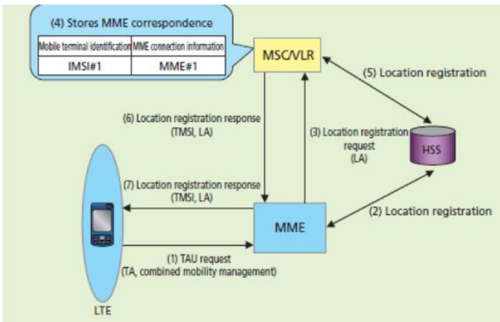

Figure 3: CS Fallback Registration location Procedure [11]

II. Research Methodology

A. Flowchart

This flowchart is used to plan on 4G LTE EPC network in City X. this research uses CSFB technology. Figure 4 shows the flowchart of planning 4G LTE EPC.

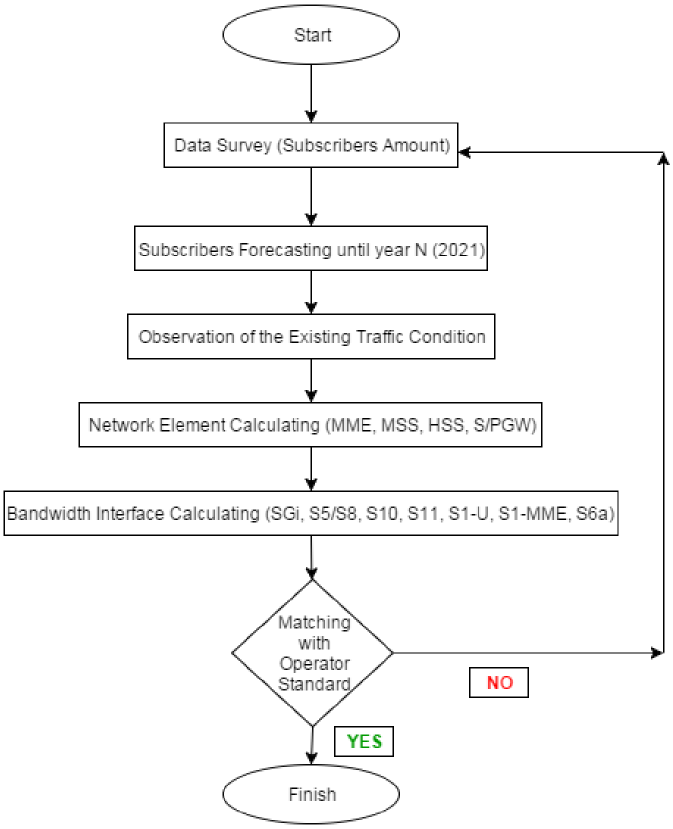

Figure 4: Planning of 4G LTE EPC

B. Network Dimensioning

Dimensioning is the network planning stage aimed to calculate the network needs to obtain an effective network, which in terms of cost, technical, and performance. Output of dimensioning stage are:

1. Estimated traffic will be generated by all subscribers.
2. The number of required network elements.
3. Interfaces Capacity required to handle all the traffic.

III. RESULTS AND DISCUSSION

A. Subscribers Number Forecasting for Operator X

The number of existing subscribers (2G and 3G) is one of the variables to perform dimensioning for EPC planning. Researcher used the subscribers data from 2014 until 2016. Tabel 1 shows the Existing subscribers number.

Table 1
Existing Subscribers Number 2G and 3G for Operator X

No	Years	Subscribers Number
1	2014	5.500.000
2	2015	6.000.000
3	2016	7.000.000

Table 2 shows the subscribers prediction number for Operator X.

Table 2
Prediction Number of Subscribers until 2021

Years	Subscribers
2014	5.500.000
2015	6.000.000
2016	7.000.000
2017	7.893.871
2018	8.904.286
2019	10.044.035
2020	11.329.671
2021	12.779.869

B. MSC Server Dimensioning

MSS Number are:

$$\text{MSS Number} = \text{Max}\left[\frac{\text{Number}_{\text{Subs}}}{\text{Subs}_{\text{Cap}}};\frac{\text{BHCA}}{\text{BHCA}_{\text{Cap}}};\frac{\text{Simult}_{\text{Call}}}{\text{SimultCall}_{\text{Cap}}}\right]; \quad (5)$$

$$\text{MSS Number} = \text{Max}\left[\frac{12.779.869}{4.000.000};\frac{14.478.881}{2.500.000};\frac{5.500}{10.000}\right]$$

MSS Numbers = 6

C. Home Subscriber Server (HSS) Dimensioning

$$\text{HSS Number} = \frac{\text{Number}_{\text{Subs}}}{\text{Subs}_{\text{Cap}}} \quad (6)$$

$$\text{HSS Number} = \frac{12.779.869}{24.300.090};$$

HSS Numbers = 1

D. Mobility Management Entity (MME) Dimensioning

MME capacity are determined by the number of subscribers which can be attached by simultaneously, simultaneous PDP context, and data throughput. MME have the following specifications, the maximum active subscribers for 1 MME is 13.000.050 million subscribers, simultaneous maximum PDP context is 13.000.050 million , maximum throughput / bearer is 14,400 Mbps.

The maximum active subscribers during rush hour is 4.2 million subscribers, simultaneous maximum PDP context is 4,200,000, and the maximum throughput is 560 Mbps.

$$\text{Number MME} = \text{Max}\left[\frac{\text{Number}_{\text{Subs}}}{\text{Subs}_{\text{Cap}}};\frac{\text{Bearer}}{\text{Bearer}_{\text{Cap}}};\frac{\text{Trafik}}{\text{Throughput}_{\text{Cap}}}\right] \quad (7)$$

$$\text{Number MME} = \text{Max}\left[\frac{4.200.000}{13.000.050};\frac{4.200.000}{13.000.050};\frac{560\text{ Mbps}}{14.400\text{ Mbps}}\right];$$

Numbers MME = 1

Number MME needed for EPC planning are 2 pieces (one for operations and one standby).

E. Serving-Packet Gateway (S-PGW) Dimensioning

SGW-PGW device have a maximum bearer specification are 13.000.050 million, the maximum throughput are 14.400 Mbps, Number maximum bearer context are 4,200,000, throughput of 560 Mbps, to determine SGW-PGW Number Minimum are:

$$\text{Number S}-\text{PGW} = \text{Max}\left[\frac{\text{Bearer}}{\text{Bearer}_{\text{Cap}}};\frac{\text{Trafik}}{\text{Throughput}_{\text{cap}}}\right] \quad (8)$$

$$\text{Number S}-\text{PGW} = \text{Max}\left[\frac{4.191.426}{13.000.050};\frac{560\text{ Mbps}}{14.400\text{ Mbps}}\right];$$

Number S – PGW = 1

Number S-PGW needed for Evolved Packet Core (epc) planning are 2 pieces (one for operations and one standby).

F. Interface Dimensioning

Bandwidth interface for signaling s6a, s11, s10, s5/s8 control plane, s1-MME.

$$\text{Signalling Interface} = \frac{\text{Number Subscribers} \times \text{Msg signal}_{\text{persubs}}}{3600\text{s}} \quad (9)$$

$$\text{Signalling Interface} = \frac{12.779.869 \times 100\text{Kbit}}{3600\text{s}};$$

The interface bandwidth required for EPC planning are 0.355 Gbps.

Bandwidth interface for trafik, S5/S8 user plane, S1-U, Sgi:

$$\text{Traffic Interface} = \frac{\text{Number Subscribers} \times \text{Packet}_{\text{perSubs}}}{3600\text{s}} \quad (10)$$

$$\text{Traffic Interface} = \frac{12.779.869 \times 5000\text{Kbit}}{3600\text{s}};$$

The interface bandwidth required for EPC are 17.75 Gbps

G. Network Element Result Dimensioning

Table 3 show the network element dimensioning result.

Table 3
Network Element Dimensioning Result

No	Network Element	Numbers
1	MSS	6
2	HSS	1
3	MME	2
4	S/PGW	2

Table 4
EPC Interface Result Dimensioning

No	Interface	Bandwidth
1	S6a	0.355 Gbps
2	S11	0.355 Gbps
3	S10	0.355 Gbps
4	S5/S8 UP	17.75 Gbps 127.80 Gbps
5	S5/S8 CP	0.355 Gbps
6	S1-U	17.75 Gbps 127.80 Gbps
7	S1-MME	0.355 Gbps
8	SGi	17.75 Gbps

The results of research for Evolved Packet Core (EPC) planning should have six pieces of MSS, 1 piece HSS, MME 2, 2 S/PGW. Interface or control plane signaling of 0.355 Gbps, and user plane 17.75 Gbps interface.

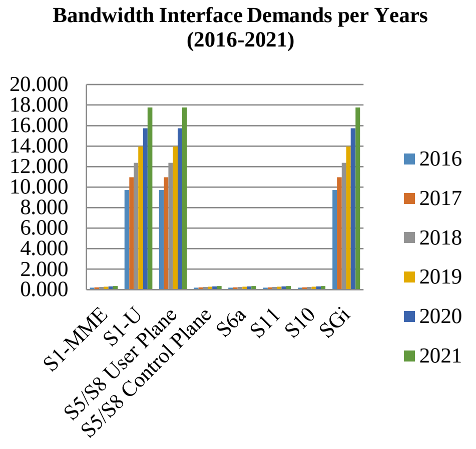

Figure 5: Bandwidth Interface requirement per Years (2016-2021) (Gbps)

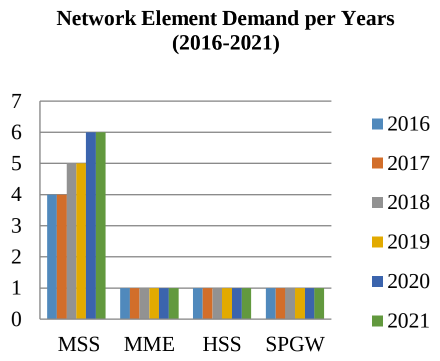

Figure 6: Network Element requirement per Years (2016-2021)

Figure 7 shows the EPC modeling based on the interface bandwidth and network element dimensioning result.

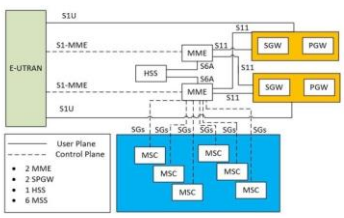

Figure 7: EPC Planning Result

IV. CONCLUSION

Based on the planning, the network element dimensioning of EPC had 6 pieces MSS, 1 piece HSS, MME 2 pieces (one active and one standby), and 2 S / PGW (one active and one standby). The bandwidth required for such signaling interface S6A, S11, S10, S1-MME, S5 / S8 control plane were 0.355 Gbps. The bandwidth for user plane interface such as the S5/S8 user plane, S1-U, SGI was 17.75 Gbps. Suggested transmission medium is fiber optic, because fiber optic have large capacity and have a smaller delay compared to radio and copper. Transport links for signaling interface use two fiber optic cables with a capacity of 1 Gbps. One piece of cable for active and One piece of cable for for standby. Transport links user plane interface can use three pieces of optical fiber cable with a capacity of 10 Gbps. Two piece of cable for active, and one piece of cable for standby

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