Analysis of Operator XL Axiata’s Readiness on IP Based Voice Interconnection to Support Voice over LTE Implementation

Gunawan Wibisono, M. Suryanegara, Ajib S, Ihsan Ibrahim and Farianto

Department of Electrical Engineering, Faculty of Engineering Kampus Baru UI Depok, Universitas Indonesia, Depok, 16424, Indonesia

Abstract. Indonesian cellular operators have deployed Long Term Evolution (LTE) technology to improve data services to users. To provide voice service, LTE operators introduce Voice over LTE (VoLTE) with better quality than Voice over IP (VoIP) service because it has low latency and larger capacity. VoLTE technology with an IP Multimedia Subsystem (IMS) platform is an IP based technology that will work best when interconnecting between IP telecommunication operators using IP protocols such as SIP or SIP-I session protocol. Currently, interconnection of telecommunication operators in Indonesia is still time-based division multiplexing (TDM) interconnection. This research will discuss mobile operator infrastructure readiness to migrate interconnection from TDM-based network to IP and will calculate bandwidth requirement for IP interconnection network. With data from XL Axiata operator it was found that IP interconnection caused a decrease in bandwidth requirements of XL Axiata operator compared when using TDM-based interconnects. The value of bandwidth requirement reduction is strongly influenced by the type of codec used. It appears that the G.723 codec provides significant bandwidth reduction but has a low mean opinion score (MOS).

1. Introduction

The increasing number of smartphone users worldwide and the increasing average volume of data usage, especially video content services, has triggered an increase in global mobile data traffic, which grew by around 50% within 2015 - 2016.1,2 Long Term Evolution technology is predicted to become a radio network access technology for dominant mobile broadband services and by the end of 2022 its users are estimated to reach 4.6 billion subscribers worldwide1,2. The continuation of the data service on the 4G LTE network, to accommodate voice services on the LTE network operators to deploy voice over LTE (VoLTE) with one of the advantages is the ability of high definition (HD) voice service. With VoLTE, LTE operators can compete with Over-The-Top (OTT) players as well as other voice over IP (VoIP) voice call service providers. VoLTE generally has lower delayed characteristic and greater capacity than OTT or VoIP services which are only best effort. In addition, VoLTE has better voice quality compared to VoIP which is expressed by high mean opinion score (MOS) and low speech path delay3,7.

VoLTE implementation by an operator can go through different stages depending on the capabilities of each operator such as the factors of voice service development strategy, technology
architecture, business objectives, market conditions and so on. VoLTE voice service at the beginning of LTE network development is implemented with circuit switched fall back (CSFB), then implement single radio voice call continuity (SRVCC) when IMS platform has been developed followed by developing LTE network coverage [4].

To support the VoLTE implementation plan, operator readiness is required in interconnection with other operators. Current interconnection between operators is still dominated by the form of legacy time division multiplexing (TDM) using ISUP signaling and G.711 codecs because it has a good redundancy mechanism. For the development of LTE network, VoLTE, and HD voice interconnection based on TDM less optimal result due to limitations of ISUP protocol, so IP interconnection is needed. With IP interconnection between operators it is expected that all services can occur at IP level end-to-end. The use of VoLTE will bring some implications for regulatory changes and pricing models. The combination of VoLTE and the change of TDM-based interconnection to IP is a huge change in interconnection for mobile networks in more than two decades [6]. Both regulators and operators need to extensively review both technical, commercial, financial implications (CAPEX and OPEX) as well as roaming and regulatory issues in transition to VoLTE implementation.

XL Axiata as one of the cellular operators in Indonesia has tested LTE technology in 2014 and launched this service commercially in 2015. XL has also tested phone calls through its internal network using VoLTE in 2016 in Surabaya and Denpasar, a commercial VoLTE service in 2017. This VoLTE service will run on top of the IMS platform that is also being developed. Up to the fourth quarter of 2016, XL has a total of 84,484 Base Station 2G, 3G and 4G, consisting of 37,549 BTS (2G), 38,731 NodeB (3G) and 8,204 eNodeB (4G). Currently, XL divides its operational areas into 6 regions namely Central (Java), North (Kalimantan), Jabotabek (Jakarta, Bogor, Tangerang, Bekasi), East (Sulawesi, Bali, Lombok, Papua) and West (Sumatra). Interconnect with other operators and use TDM as the main media. XL has 96 PoI with 2,921 E1. The huge amount of E1 circuits become a problem faced by XL operators in developing LTE network expansions and future VoLTE service implementation plans. VoLTE services and NGN networks are generally All-IP based technologies and will work optimally if supported by IP networks as well. IP interconnection will result in more efficient bandwidth usage, improved speech quality, reduced costs and is an appropriate step for full multimedia services. Therefore, this research will evaluate the readiness of XL Axiata as one of mobile operator in Indonesia towards IP based voice interconnection. In addition, it will review the bandwidth requirements calculation on IP interconnection networks and compare them with TDM-based interconnects.

2. Operator’s Readiness Towards Interconnection

IP interconnection is principally an expansion of TDM-based interconnection, in which TDM is known for point of interconnection (PoI) and point of charge (PoC). PoI is the physical location of the interconnection and is the limit of authority and responsibility for provision, management and maintenance of telecommunication networks of each party [18]. In TDM interconnections, the PoI setting is static, while on IP networks that allow technically to connect at any location. The determination of the PoI should be open to operators who will conduct interconnection to be able to propose interconnection at different points along with the development of its network. In Indonesia itself there are currently several conditions related to the arrangement of the number and location of the PoI, among which are [20]: the number of interconnection points stipulated as mutual agreement among operators of network providers; the number of PoIs varies for each operator; and Mobile operators are granted the freedom to self-determine the number of PoIs in accordance with the technical design of each provider’s network, taking into account the number of subscribers, traffic volume and routing.

IP interconnection has considerable effect on network structure, investment cost, interconnection service, tariff, technical implementation and so on. IP technology enables bundling of services and infrastructure to make transmission-related costs less dependent on distance. Consequently, the amount of PoI required for IP interconnection is less in number compared to TDM-based interconnections [21].
Each mobile operator has different characteristics regarding the availability of transmission network infrastructure, backbone network configuration, the protocol used, the point of network access point (NAP) for connectivity to the IP network and so on. In Indonesia there are 4 mobile operators and one public telecommunication switch operator network (PSTN). Mobile technologies owned by operators include 2G, 3G, 4G LTE, and VoLTE technologies. To see operator-based interconnection readiness in Indonesia, it is necessary to evaluate the availability of IP technology. The operator has to have some equipments criteria on a network of both mobile telecommunications operators and PSTN (IMS based) that are considered to be ideal and ready to implement IP interconnects, then these equipments that being owned by operator are checked. Table I shows the availability of XL, Indosat (Isat), Telkomsel (Tsel) and Tree operators in conducting IP interconnection services.

| No. | Equipments       | XL  | Isat | Tsel  | Three |
|-----|------------------|-----|------|-------|-------|
| 1   | 2G Technology    |     |      |       |       |
|     | Access IP        | x   | x    | x     | -     |
|     | Core network NGN | √   | √    | √     | √     |
|     | Protocol H.323   | √   | √    | √     | √     |
|     | Transmission IP  | √   | √    | √     | √     |
| 2   | 3G Technology    |     |      |       |       |
|     | Access IP        | √   | √    | √     | √     |
|     | Core network IMS | √   | √    | √     | √     |
|     | Protocol SIP     | √   | √    | √     | √     |
|     | Transmission     | √   | √    | √     | √     |
| 3   | 4G LTE Technology|     |      |       |       |
|     | Access IP        | √   | √    | √     | √     |
|     | Core network IMS | √   | √    | √     | √     |
|     | Protocol SIP/SIP-I| √ | √ | √ | √ |
|     | Transmission     | √   | √    | √     | √     |

From Table I it can be seen that technically all cellular operators are ready to migrate towards IP as well as interconnection.

3. IP Based Voice Interconnection Of XL Axiata Sumatra Region

Although the infrastructure of Indonesian telecommunication operators is ready to migrate to IP network, but in fact because of the lack of IP interconnection regulation, the interconnection is still TDM based. In general, the calculation of bandwidth requirements for VoIP services depends on the amount of traffic distributed and the type of codec used. The calculation and conversion phases from TDM to IP are generally shown in Figure 1.

Figure 1. Calculation process of conversion bandwidth requirement from TDM to IP
The conversion from TDM to IP is determined by the codec used, the header on layer 2 and IP, the packet frequency, and the payload size used. The selection of codecs will determine the quality of the conversation that results in the Mean Opinion Score (MOS) value. Some commonly used codecs are G.711, G.722, G.723, G.729. Header Layer 2 of the OSI protocol (Data Link Layer). For Ethernet Layer 2, Frame Header 802.3, Frame Control Sequence (FCS), preamble, Cyclic Redundancy Check (CRC) and InterFrameGap (IFG) are 18 bytes. For IPv4, the header for the IP protocol is 20 bytes, UDP 8 bytes and RTP 12 bytes, totaling 40 bytes (octet). The packet frequency is measured by packet units per second (pps). This parameter shows the number of packets that must be sent every second to reach the bit rate codec. The packet frequency value is represented by

$$F_{packet} = \frac{bit}{rate/payload}$$  

(1)

The process of encapsulating digital voice into IP format is shown in Figure 2.

![Figure 2. Encapsulation of digital voice into IP](image)

Based on Figure 2., the total packet size is given by

$$T_{packet} = Ethernet \text{ header} + IP \text{ header} + UDP \text{ header} + RTP \text{ header} + payload$$  

(2)

Then the required ethernet bandwidth is given by

$$BW_{ethernet} = F_{packet} \times T_{packet}$$  

(3)

A. PoI and PoC

West Region covers the region of Sumatra which is divided into North and South regions. This region is divided into 38 PoC and 8 PoI. The busy hour amount of traffic from each PoI of XL on February 2017 can be seen in Table 2.

| No. | PoI     | Interconnection Partner | Traffic (Erl) |
|-----|---------|-------------------------|---------------|
| 1   | Aceh    | -                       | 5,533         |
| 2   | Batam   | 810                     | 1,523         |
| 3   | Jambi   | 1,148                   | -             |
| 4   | Lampung | 3,045                   | 2,517         |
| 5   | Medan   | 8,709                   | 3,018         |
| 6   | Padang  | 921                     | -             |
| 7   | Palembang | 8,387               | 5,572         |
| 8   | Pekanbaru | 267                  | 1,118         |

| Total Traffic (Erlang) | 23,286 | 11,192 | 8,089 | 42,567 |

It is shown from Table III that that for the West area (Pulau Sumatera) XL has 7 (seven) PoI with Indosat, 5 (five) PoI to Telkomsel and 2 (two) PoI to the operator Three. Of the total PoI, the highest number of traffic is found in PoI Palembang which ranks first and consists of interconnection traffic with Indosat and Three. PoI Medan ranks second highest traffic consisting of interconnection traffic
towards Indosat and Telkomsel. Based on the traffic measurement results in Table 4.2, where Palembang and Medan have the highest traffic, the two cities are proposed as candidates for the new PoI point for Sumatra region for IP interconnection. PoI Medan can be an interconnection point for the northern part of Sumatra and Palembang for the south. Figure 3. shows the proposed XL interconnection scheme in Sumatra region.

From Figure 3. it appears that the two cities' elections are also based on the need for redundancy for the regional region of Sumatra, where if there is one interconnection link broken into one city, then links in other cities will become backup. The division of Sumatra into northern and southern regions has also been applied to existing network core networks so that it becomes synchronized with the proposed two PoI points for IP interconnection.

B. Interconnection Bandwidth Requirement
The bandwidth requirement for IP interconnection of XL Axiata operator in Sumatra region can be calculated using equation (3). Required data is the amount of current traffic to each destination (other operators). Table 3. shows the results of bandwidth requirements for interconnection between XL and Indosat using 2 (two) different codec types.

| No | PoI    | No. of E1 | No. of DS0 | Traffic (Erl) | IP Bandwidth (Mbps) |
|----|--------|-----------|-----------|---------------|---------------------|
|    |        |           |           | G.711 | G.729 | G.723 |
| 1  | Batam  | 6         | 186       | 33.36 | 3.02 | 1.15 | .87  |
| 2  | Pekanbaru | 4    | 124       | 12.5  | 1.13 | .43  | .33  |
| 3  | Medan  | 56        | 1736      | 631.17| 57.06| 21.71| 16.48|
| 4  | Jambi  | 8         | 248       | 45.46 | 4.11 | 1.56 | 1.19 |
| 5  | Lampung| 9         | 279       | 107.43| 9.71 | 3.70 | 2.80 |
| 6  | Padang | 4         | 124       | 43.02 | 3.89 | 1.48 | 1.12 |
| 7  | Palembang | 26   | 806       | 255.93| 23.14| 8.80 | 6.68 |

| Total | 3,503 | 1,129 | 102.05 | 38.83 | 29.47 |

From Table 4.3 it can be seen that for the total traffic of 1,129 Erlang in all interconnection points of Sumatra region between XL Axiata and Indosat required 103 Mbps bandwidth using G.711, 39 Mbps codec using G.729 and 30 Mbps codec using G.723 codec.

By using Table 4.3 it can also be compared the need of IP bandwidth with the number of E1 that exist today. Using the results from the table, it can be concluded for the total number of TDM interconnections totaling 113 E1 equivalent to 226 Mbps of bandwidth can be selected three codec usage options that will determine the required IP bandwidth and the resulting sound quality consequences (using MOS values). With the G.711 codec, the bandwidth efficiency obtained is the smallest of 54% with the best voice quality (MOS = 4.1). With the G.726 codec, the bandwidth
efficiency gained is that of 83% with good voice quality (MOS = 3.92). With G.723 codec, the highest bandwidth efficiency is 87% with good voice quality (MOS = 3.9). It is shown from the table that the bandwidth requirement is depend on the codec type. The operator able to select the type of codec that will be used to determine the amount of IP bandwidth required and the voice quality to be generated based on the MOS value. This bandwidth requirement is only based on current traffic and does not take into account the prediction of future needs and backup capacity if there is an outage or link failure.

C. Inter Access Technology

Since 4G network are still being developed in phases by most of operators in Indonesia, some part of the regions currently still operates in legacy 2G or 3G network or combination of it. For voices services, in core network part mostly still being served by Mobile Switching System (MSS) entity instead of IMS since it is also under deployment stage. These situations bring difference types of voice call handling from network point of view.

Operators equipped either with MSS or IMS platform in the core network are basically ready for IP based voice interconnection. IMS is using Border Gateway Function (BGF) and Media Gateway component to interconnect with TDM (E1) interface and using Interconnection Border Control Function (IBCF) subsystem to interconnect with IP protocols. MSS and PSTN Switch needs additional component called Session Border Controller (SBC) to be able to interconnect with another operator using IP interface and protocols.

4. Conclusions

The readiness evaluation of XL Axiata operator shows that the operator is ready to migrate to IP-based interconnects. It can be seen from the results that with IP-based interconnection for voice services has reduced the need for bandwidth significantly. By using G.711 codec obtained bandwidth requirement of 103 Mbps with MOS 4.1, whereas when used G.723 codec requires bandwidth of 30 Mbps but with MOS 3.9. For the case of XL Axiata operator, migration to IP-based interconnection is one of the strategies to support VoLTE deployment.

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