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Prepaid and Postpaid VoIP Service Enhancements and Hybrid Network Performance Measurement

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Abstract: This study focuses on prepaid and postpaid VoIP technology service enhancement. The aims are to i) merge wireless technology in rural areas with wired technologies and services in urban areas. It intends to investigate the minimum requirement needs by wireless and wired technology in using of telco connectivity. It is also to define which technology will achieve a low operating cost and good performance. In addition, the most apparent benefit of implementing prepaid/postpaid VoIP network in rural areas is that to achieve a robust fault tolerance and load-balancing voice traffic between urban and rural areas. ii) Merging of WAP and VoIP network to provide Information-on-Demand (IoD) services to prepaid and postpaid VoIP users. It is to provide value added services for prepaid and postpaid VoIP users. WAP and other similar technologies will continue to play an important role in the development of Information-on-Demand (IoD) services in future. In addition, the most apparent benefit of implementing WAP technology with prepaid/postpaid VoIP network architecture is that to achieve WAP enabled mobile to access this facility during traveling, meeting, seminar and conference. Integration of WAP technology with prepaid/postpaid VoIP network architecture can achieve efficiency end-to-end information services between service providers (ISPs/ITSPs) and WAP mobile phone users. Therefore, prepaid and postpaid VoIP service enhancement can improve and obtain high efficiency network, technical, business and customer-care aspects in contributing the robust prepaid/postpaid VoIP network architecture for prepaid/postpaid VoIP users.

Key words: VoIP, hybrid network, WAP, IoD, end-to-end, mobile

INTRODUCTION

Voice over Internet Protocol (VoIP) is a set of protocols, services and applications that support the transmission of voice packets over the Internet protocol IP. VoIP is used for long distance call and it will reduce the cost more effective compared to the traditional PSTN. Some of the current enhancements done on prepaid/postpaid in next generation are[1]:

Phase I: Prepaid calling, postpaid calling, wholesales VoIP

Phase II: Broadband VoIP

Phase III: New and information, directory assistance, voice portal

The major improvements of hybrid network technique in rural areas are to i) expand the coverage in rural area, minimized telco connectivity, reducing telco failure, reducing originating and destination blocking, redundancy connectivity and load balancing Traffic. Implementation of wired technology in rural areas need a lot of cost compare with wireless technology. Prepaid/Postpaid VoIP using wireless technology in rural area can solve problems such as amount of negotiation needed with the carrier for originating and terminating circuits, VoIP call volumes, busy hour factors, distribute numbers of active users and growth rates VoIP users in urban areas. Implementing a hybrid network can achieve a robust reliability, availability and scalability to ISPs and customers

ii) Implementation of WAP technology can achieve value added services and retrieve the latest information from everywhere at anytime. The value added services are very important to prepaid/postpaid VoIP users who are using prepaid/postpaid VoIP services. End users of WAP technology will benefits from easy and secure access to relevant Internet and Intranet information through their mobile phone devices. For service providers, WAP services can increase the subscriber by improving existing services. New applications can be introduced quickly and easily without the need for additional infrastructure or modifications to the phone. This will allow service providers to differentiate themselves from their competitors with new, customized information services.

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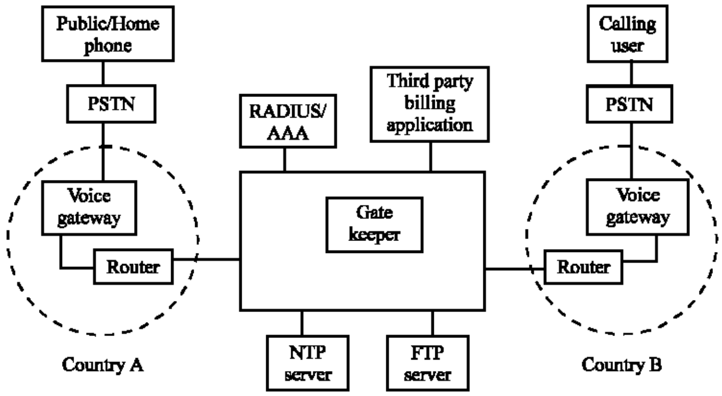

Fig. 1: Current VoIP prepaid/postpaid architecture

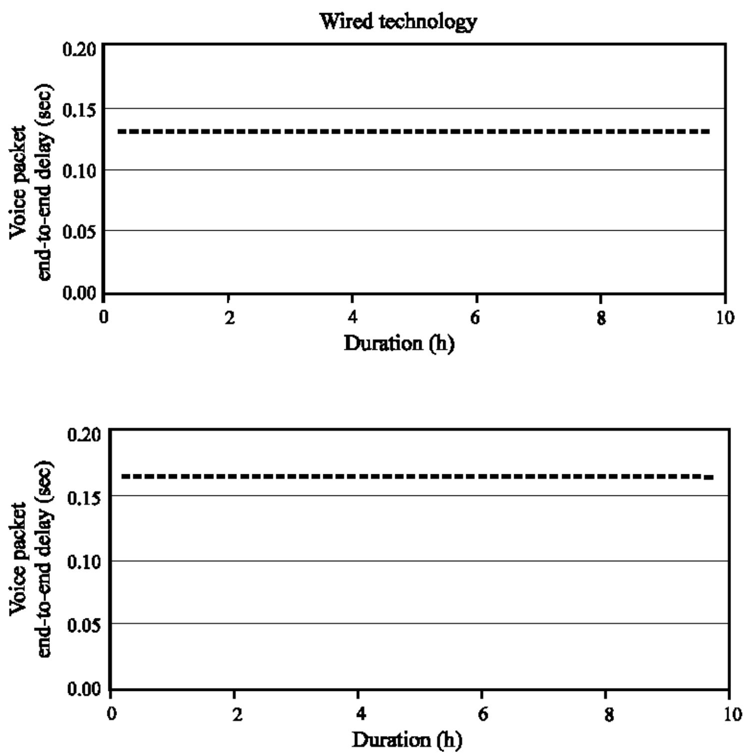

Fig. 2: Wired and wireless and-to-end delay

WAP is an interoperable framework, enabling the provision of end-to-end turnkey solutions that will create a lasting competitive advantage, build consumer loyalty and increase revenues.

VoIP current architecture and problems: Prepaid/Postpaid services enable telco and non-telco ISPs/ITSPs to offer calling card services. Prepaid/Postpaid services can be managed in two ways through an internally managed network infrastructure without using Open Settlement Protocol (OSP) and through an OSP clearinghouse[2,3]. The implementation of prepaid/postpaid services need the following network components Interactive Voice Response (IVR), RADIUS Server, third-party billing system, Trail File Transfer Protocol (TFTP) server, Voice Gateway, Network Time Protocol (NTP) Server and Voice Gatekeeper, Fig. 1. Today, prepaid and postpaid VoIP services offer the following business opportunities to new telephony service providers[4-6]:

- Gain access to new customers who do not have credit for postpaid services.

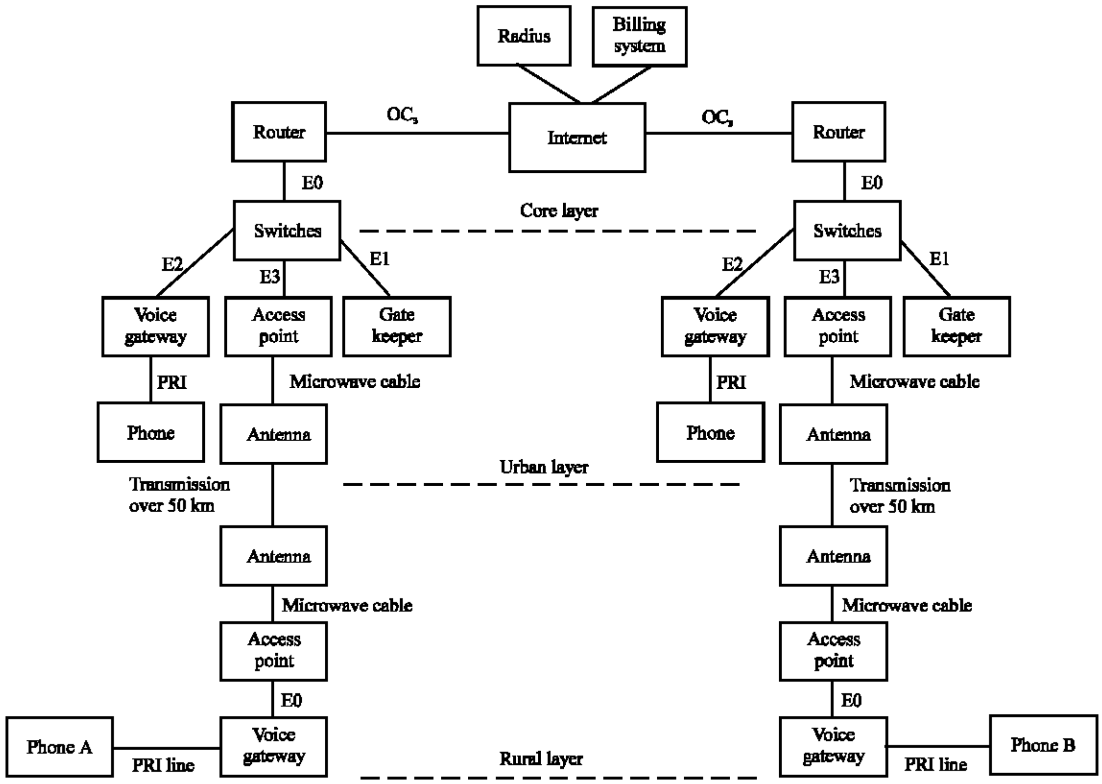

Fig. 3: Merging of wired and wireless technology in rural areas

- Prepaid/Postpaid VoIP service coverage in urban areas.
- Access markets where dedicated phone service is not readily available.
- Give customers global access to telephony services with a single account.
- Serve as an alternative to traditional telephone calling cards (concentrate on voice conversation).
- No value added services to prepaid/postpaid VoIP users.

ANALYSIS AND PERFORMANCE MEASUREMENTS

VoIP performance before merging wired and wireless technology: Performance of wired and wireless before merging this technology in rural and urban areas is related to the voice traffic volume in VoIP network model. VoIP transmission is a time-sensitive, while data is more on error-sensitive. UDP is configured as transport layer to transmit the voice packet. This wireless analysis result is depend on ideal environment without considering any fading, line of sight obstruction, attenuation, multipath interference and other constraints. For wired technology it is also, depend on ideal environment such as congestion, too much collisions on a LAN, physical media error, overloaded links, un-proper network configuration, un-managed network infrastructure. Both technologies will pump same bandwidth and transmit only for voice traffic. In ideal environment prepaid and postpaid VoIP for wired technology characteristic will occur voice packet end-to-end delay is below than 0.15 sec but wireless technology characteristic will occur above than 0.15 sec.

Therefore, wireless technology characteristic in ideal environment will occur higher voice packet end-to-end delay compared to wired technology characteristic (Fig. 2). In non-ideal environment, it will contribute the time for a voice packet to navigate the network from VoIP prepaid/postpaid source to destination party.

PROPOSED PREPAID AND POSTPAID VOIP NETWORK SERVICE ENHANCEMENTS

Hybrid network in rural areas: Figure 3 shows the prepaid/postpaid VoIP architecture merging with wireless and wired technology to achieve a robust network infrastructure and reduce the operating cost in rural area compare wired technology. For example, phone A will dial to the nearest voice gateway in rural areas then voice packet will route it through wireless technology to urban areas and internet connectivity to the destination party, phone B, in other rural areas.

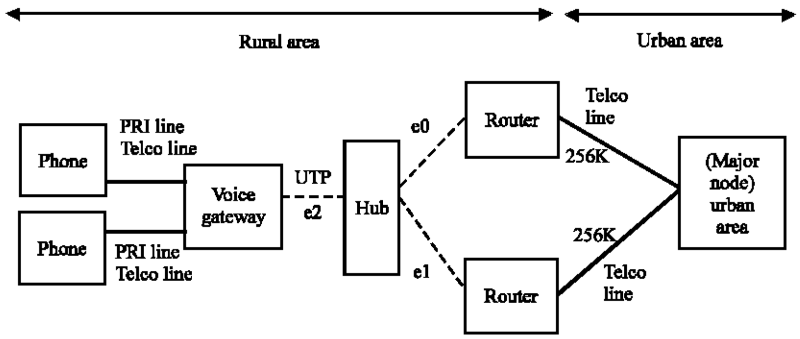

Fig. 4: Minimum requirement for wired architecture in rural area

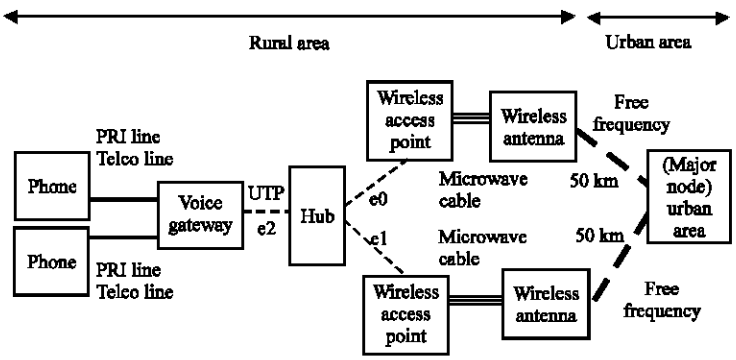

Fig. 5: Minimum requirement for wireless architecture in rural area

Table 1: Cost and technical analysis between both technologies

Minimum requirement/costing	Wired technology quantity	Wireless technology quantity
Router	2	0
Hub/switches	1	1
Voice gateway	1	1
Telco line	4 (rural and urban area)	2 rural area
Costing	Rented per -monthly basis	One time per Installation
Access point (Link activate)	Provide by Telecom, no guarantee of QoS	Own by ISP/ITSP, can control of QoS, using free frequency
Manageability	Equipment control by Telecom	Equipment control by ISP/ITSP
Installation and configuration	Need to Liaison with telecom support staff to make any changes	Easy to remove, add and change at any time. Can be shifted other areas without reconfigure

Figure 4 and 5 show the minimum requirements needed by wired and wireless technology implementation in rural areas. Implementation of wired technology in rural areas will need a minimum four telco lines. Two telco lines are linked to urban areas and other two lines will connect to voice gateway in rural areas. However, wireless technology in rural areas will need a minimum two telco lines connected to voice gateway in rural areas. The urban areas will be linked via radio frequency. The telco line is referred to all telco connectivity such as ISDN, ADSL and E1/T1 etc. In this solution, it will be used PRI line as a telco line.

Analysing Fig. 4 and 5, the formula can be derived as following:

Wired technology in rural area $TL = 4N$
Wireless technology in rural area $TW = 2N$

TL = Total of telco line through PSTN network
TW = Total of telco line through wireless network
N = Number of rural nodes

Table 1 shows cost and technical compatibility analysis between wired and wireless technology in rural areas. It is proved that wired would need more costing and technical requirement compare to wireless technology in rural areas.

Merging of VoIP and WAP technology: Merging of WAP technology with current VoIP network architecture can contribute many revenues to prepaid and postpaid VoIP users. Service providers are not required to restructure and redesign the current VoIP network architecture. Figure 6 shows a new design of network architecture for WAP and prepaid/postpaid VoIP technology. This

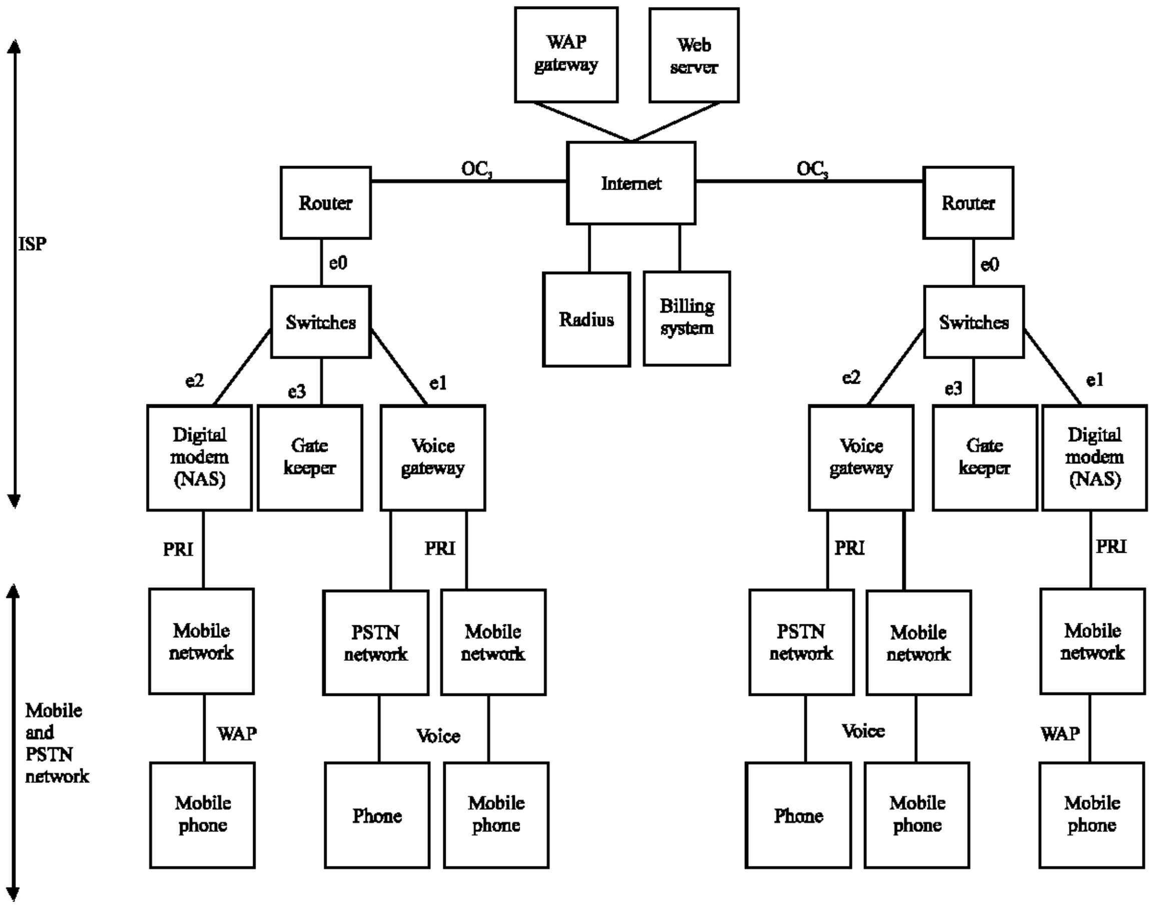

Fig. 6: Merging of wap with current VoIP architecture design

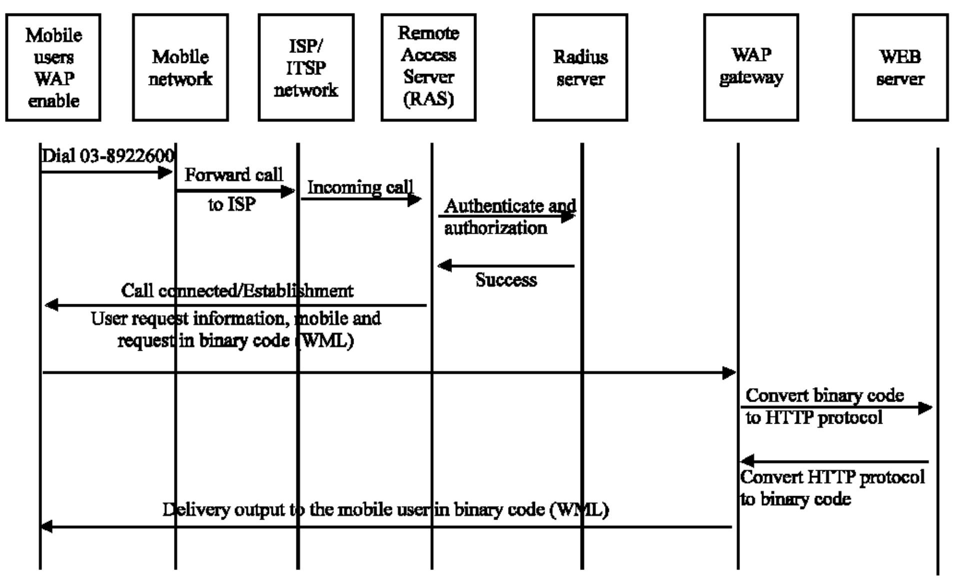

Fig. 7: WAP call flow diagram

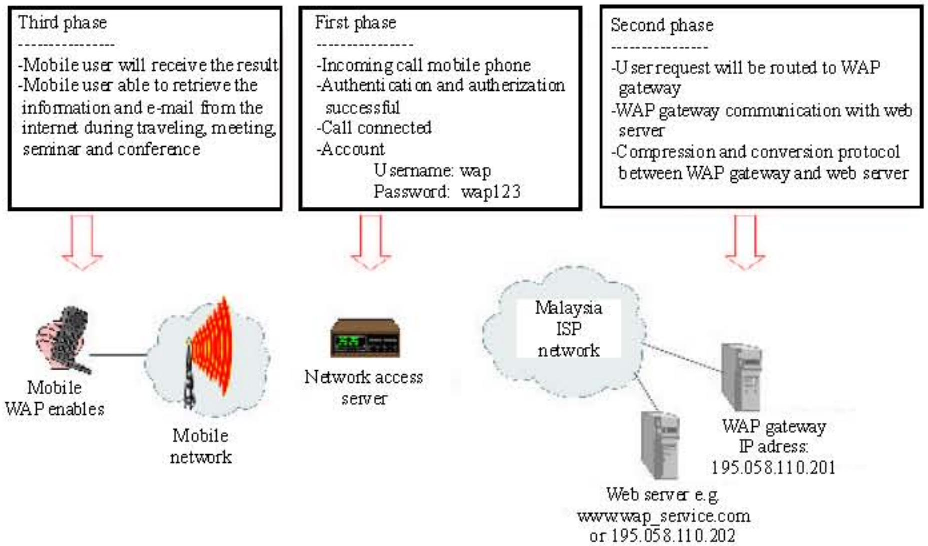

Fig. 8: WAP phases (authentication, authorization and accounting)

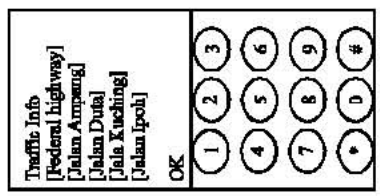

Fig. 9: Traffic information

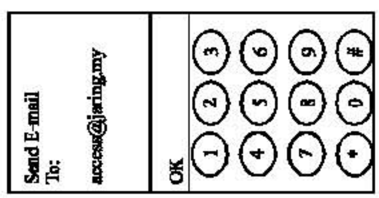

Fig. 10: Send information via e-mail

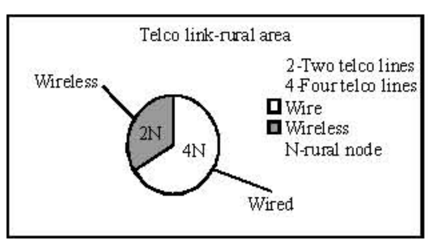

Fig. 11: Wired and wireless technology ratio in rural area

architecture will create a new era to the prepaid and postpaid VoIP services.

WAP technology is the platform for the new generation of Information-on-Demand services through mobile phones (WAP enabled). Service providers need to setup a Network Access Server, WAP gateway and WEB server (WAP content) so that WAP services are able to operate.

Figure 7 shows WAP call flow and the relationship among the WAP hardware components. WAP gateway will communicate with WEB server after receiving a request from the mobile users. WAP gateway will convert the request from binary code (WML) into HTTP request and then send it to the WEB server. The WEB server will respond and send WML page to the WAP gateway over TCP/IP, which will encode the data into binary code (WML) and send the output to the mobile phone screen (Fig. 7 and 8). WAP gateway will generate Wireless Session Protocol (WSP) and Wireless Transaction Protocol (WTP) after establishment connectivity between mobile and network access server. WSP implements both a connection-oriented and connection-less service to optimise the network for low latency and low bandwidth. Meanwhile, WTP implements a transaction-oriented protocol that can retransmit to recover from packet losses.

The binary compression makes a much faster transmission rate possible than the regular HTTP protocol. Figure 8 shows WAP phases consist of Network Access Server, WAP enabled mobile, WAP gateway and WEB server based on Authentication, Authorization and Accounting (AAA). As a result, WAP mobile phone users can access information quickly and easily whatever they are. WAP enabled mobile phone users can connect to Internet service immediately. Figure 9 and 10 shows an example of result Information-on-Demand services.

IMPLEMENTATION AND SIMULATION RESULTS

Analysis of hybrid network performance in rural areas: Wired technology in rural areas will need more telco lines and increasing of rural area nodes will increase the usage of telco lines compared to wireless technology (Table 2). Based on Fig. 4 and 5, the pie chart, Fig. 11 shows the usage of telco lines ratio between wired and wireless technology in rural areas, it clearly shows that wired technology needs higher ratio than wireless technology.

In this study, based on Fig. 3, VoIP network model was simulated using OPNET and divided into three layers, which are ISP/ITSP layer, urban area layer and rural area layer. It is called a three-tier network method in prepaid/postpaid VoIP network architecture, (Fig. 12). In addition, this architecture can distribute call volumes in

Table 2: Wired and wireless result, increasing of telco line in rural nodes

Wired technology (TL = 4N)			Wireless technology (TW = 2N)		
Minimum telco line	Rural node (N)	Total line (TL)	Minimum telco line	Rural node (N)	Total line (TW)
4	1	4	2	1	2
4	2	8	2	2	4
4	3	12	2	3	6
4	4	16	2	4	8
4	5	20	2	5	10

rural areas and introduce load-balanced traffic between urban and rural area layer.

Therefore, service providers need to implement a good network infrastructure to ensure that VoIP network able to operate in 24 h a day, 7 days a week and 365 days a year. For example, the simulation result shows that Pre-postpaid-S1 and Pre-Postpaid-S2 will route the call to the destination party either through urban or rural area layer, (Fig. 12 and 13). It can eliminate network congestion or reduce a peak hours of busy time in urban area layer. Auto load-balance of traffic between urban and rural areas can avoid prepaid /postpaid VoIP users to redial again the number to the destination party and users will not know where the voice packet will be routed as a result destination party will receive a call (Fig. 13). Therefore, it can achieve a good redundancy between urban and rural areas if any failure occurred the conversation still can be established. For example, if the link failure occurred between source party and the nearest voice gateway in urban area layer (Pre-postpaid-S1↔Voice-gateway-A) then voice traffic will route to rural area layer (Pre-postpaid-S1↔Voice-gateway-rural-A). The voice traffic will transmit the packet using wireless technology to the urban area layer then destination party (Pre-Postpaid-D1) will receive a call from source party (Fig. 12 and 14).

Figure 15 shows the simulation result that voice traffic occurs between source/destination party in urban and rural areas after merging wireless and wired technology in rural areas (hybrid network).

Figure 16 shows the simulation result in ideal environment for voice traffic that has been occurred from source to destination party through the wired technology in urban areas and wireless technology in rural areas after implemented the proposed technique using OPNET, (Fig. 3 and 12). In ideal environment, voice traffics occurred End-to-End delay between source/destination parties is 0.20 sec via the merging of wireless and wired technology in rural and urban areas. If this merging technique contributes a higher End-to-End delay result in ideal environment then it will degrade the network performance in the rural areas. Therefore, conversation between two parties will be unreliable, inconsistent and unsatisfactory.

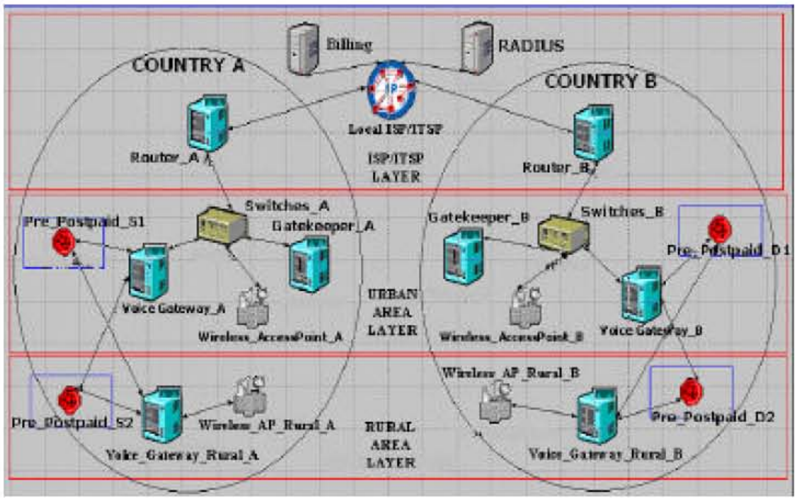

Fig. 12: Reduce network congestion and load balance traffic in urban and rural areas layer

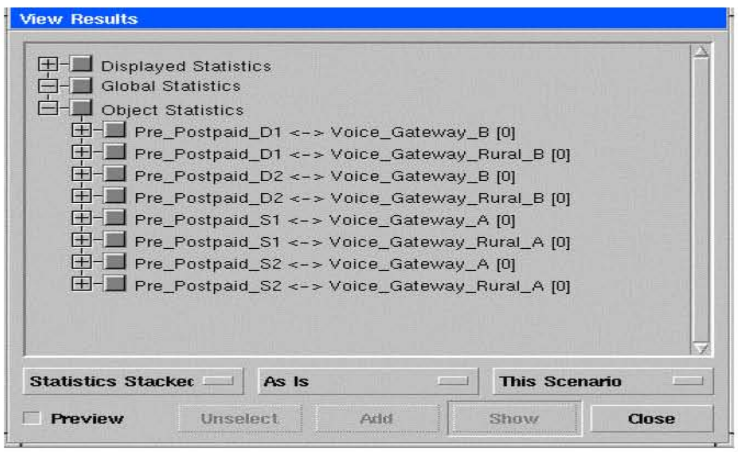

Fig. 13: Result VoIP traffic distribution in urban and rural area layer

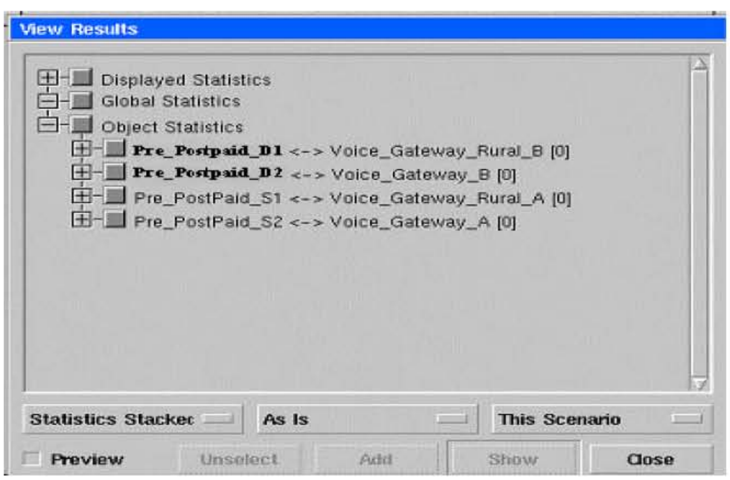

Fig. 14: Voice traffic occur after link failure in urban and rural area layer

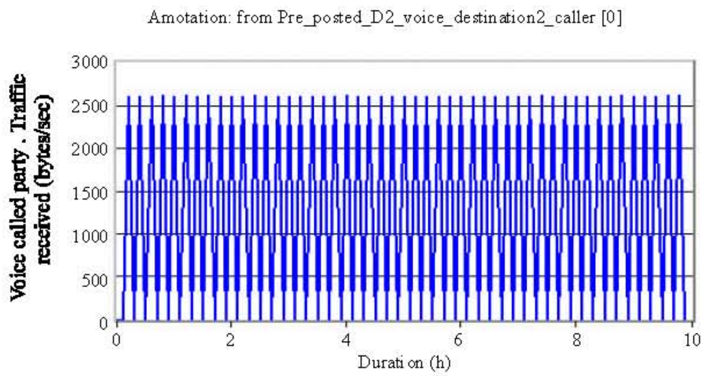

Fig. 15: Source/destination result voice traffic in rural areas

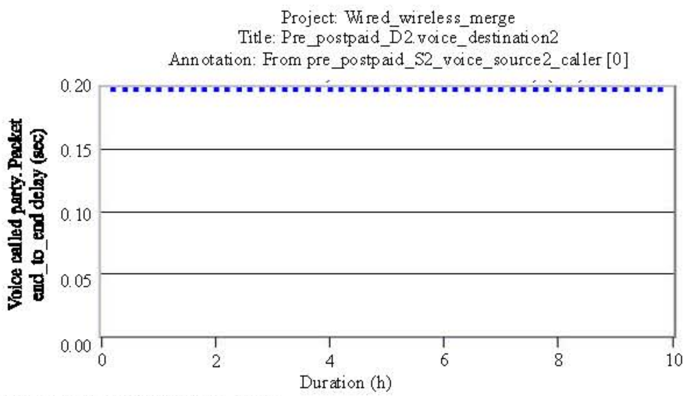

Fig. 16: End-to-end delay source/destination party

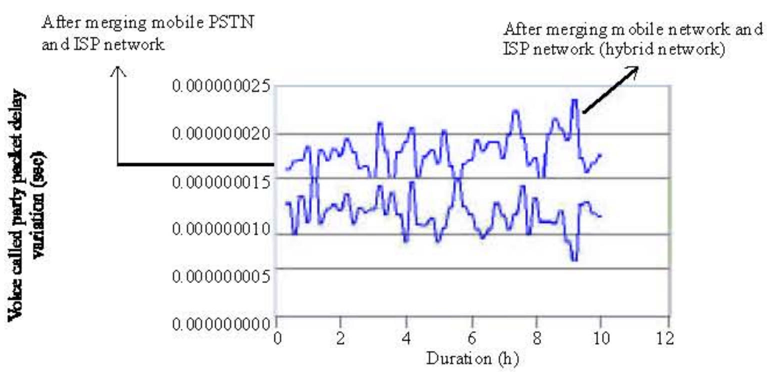

Fig. 17: Comparison of delay variation after implementing hybrid network

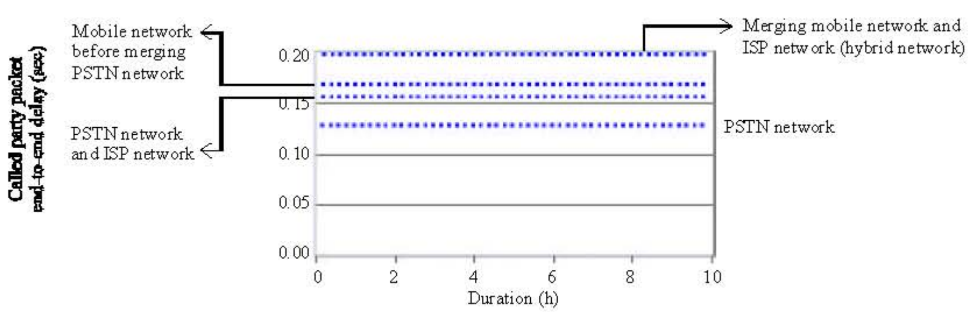

Fig. 18: Comparison before and after implementing hybrid network performance

There are several delay factors in prepaid and postpaid VoIP network architecture after implementing hybrid network in rural areas based on ideal environment (Fig. 16) that can affect the voice quality during voice conversation as follows: i) Access network layer delay (urban and rural areas), ii) IP network delay, iii) IP-to-PSTN gateway delay, iv) Algorithmic delay, v) Processing delay, vi) Hardware delay, vii) Propagation delay, viii) Serialization delay and ix) Variable delay.

Delay occurring on IP networks primarily results from bandwidth sharing and processing at router and end-point within the networks (Fig. 12). Figure 17 shows delay variations (jitter), resulted from packets arriving to destination party at irregular intervals. Figure 17 shows the delay variation results occur after implementing hybrid network in rural areas are higher than wired technology in urban areas. Bursts of Internet traffic create jitter problems and severe jitter in IP voice transmission causes jittery or unstable voice quality. If the implementation of merging wired and wireless technology (hybrid network) in rural areas is considered as non-ideal environment then it must implement techniques to improve QoS. Therefore, efficient and effective QoS provisioning techniques are important to achieve a robust network. There are several techniques that can be used to reduce delay (end-to-end and variation) and improve QoS for VoIP network in rural areas as follows: i) Dejitter buffer, ii) Type of Service (ToS), iii) Weighted Fair Queuing (WFQ) and iv) Random Early Detection (RED).

Implementing (QoS) mechanisms in non-ideal environment is a method to improve VoIP over hybrid network performance in rural areas. The challenges in deploying VoIP over hybrid network in rural areas are mainly from issues related to access point congestion (wireless technology, WLAN or WWAN) and this will affect the voice link quality. Results in Fig. 17 and 18 show that wireless technology for rural areas in ideal environment will contribute higher delay with more network jitter (delay variation), end-to-end delay and packets congestion that can easily occur compared to wired technology (Fig. 2 and 16-18).

There are two main approaches or techniques available to reduce the delay and jitter in wireless technology: it is to make the VoIP devices less sensitive to the wireless technology characteristics and the other is to make the wireless technology itself can manage better voice traffic.

In addition, the efficiency of the prepaid and postpaid VoIP network architecture in rural areas can quickly deteriorates when the number of users increases in non-ideal environment. Therefore, it should define how many concurrent prepaid and postpaid VoIP users can access the access point at one time. Over subscription of voice network via hybrid network in rural areas can affect the VoIP network performance. When designing prepaid and postpaid VoIP services via hybrid network in rural areas, it is important to consider the characteristics of wireless technology in minimizing overall delay and delay variation (jitter). It can also affect the amount of packet loss in wireless technology compare to wired technology. As advised by ITU, jitter should not exceed 40 ms to provide sufficient voice quality. Therefore, in non-ideal environment of hybrid network in rural areas, for example, limited radio coverage and interference from other devices can further degrade VoIP link quality and consequently reduce available bandwidth occurs.

Poor link quality in prepaid and postpaid VoIP hybrid network in rural areas can also lead to increase number of retransmission voice packet that directly affects the delay (latency) and delay variations (jitter) in non-ideal environment. It is important that the delay be minimized in every component of the VoIP implementation. Convergence of VoIP traffic into hybrid network in rural areas will be occurred of performance issues because the characteristics of wired and wireless technology differed (Fig. 17 and 18). Therefore, it is important to understand how latency and jitter affects speech quality and how a voice gateway can be configured to reduce latency and jitter. The rural areas are suitable to implement hybrid network because of low VoIP subscriber compared to urban areas. Therefore, proper design can mitigate most of the negative effects that are related to VoIP characteristics.

Analysis of VoIP and WAP technology performance: This section analyzes, measures and compares mobile phone VoIP (WAP enabled) and fix/public phone VoIP performance in ISP/ITSP via mobile and PSTN networks. Figure 19 shows a network simulation model with merging WAP technology and prepaid/postpaid VoIP network architecture. This network model is based on public, home and WAP mobile phone users. This scenario shows WAP phone users are able to use VoIP and WAP services.

Figure 20 shows WAP mobile phone users can use the VoIP and WAP facility offer by ISPs/ITSPs in delivering the information. WAP mobile phone users can dial to Network Access Server (NAS) or voice gateway for delivering voice or data packet. One of the next generations of prepaid and postpaid VoIP is News and Information. Implementation of WAP architecture will resolve the current problems. Users will be able to receive and request information in a controlled, fast and low-cost environment, a fact that renders WAP services more attractive to prepaid/postpaid VoIP users who demand more value and functions from their mobile terminals.

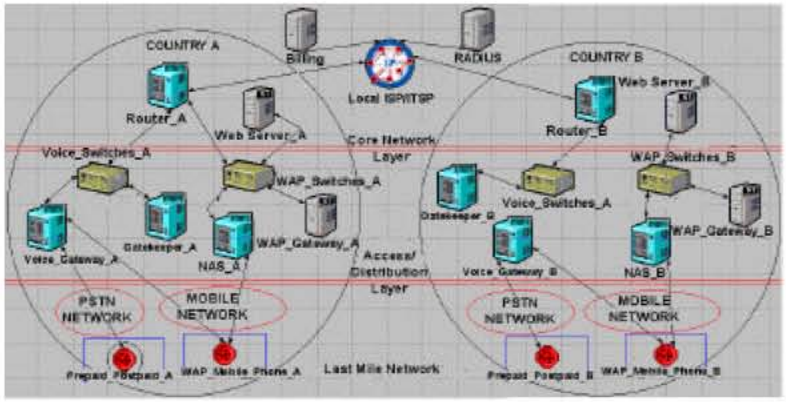

Fig. 19: Merging WAP technology and VoIP architecture

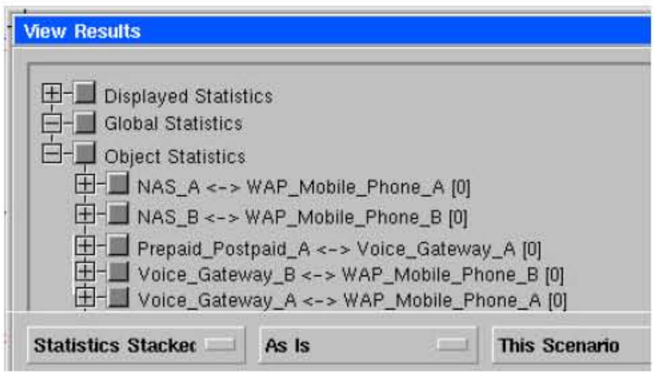

Fig. 20: WAP mobile phone users establish WAP and VoIP services

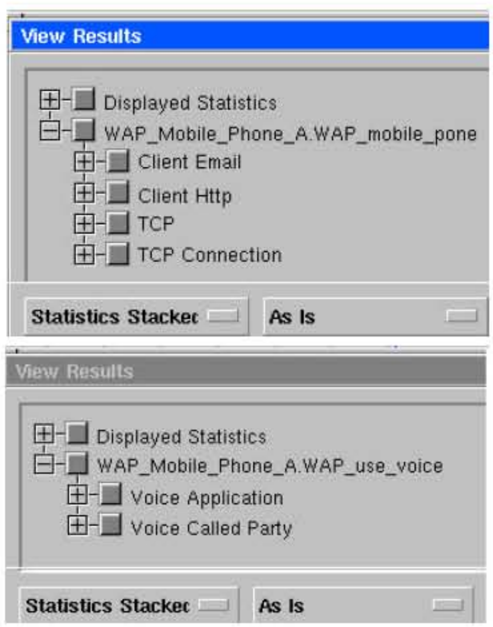

Fig. 21: WAP technology connectivity

Table 3: WAP and VoIP technology characteristics

Characteristic	VoIP technology	WAP technology
Hardware requirement for ISPs/ITSPs	Voice gateway, gatekeeper, billing system, Radius server, TFTP and NTP server	Network access server, WAP gateway and Web server
Transport protocol	UDP/RTP	TCP
Types of packet	Voice packet.	Data packet.
Protocol enable	H.323 enables	HTTP and WML
User-end parameters	Use traditional phone without any setup and the instruction of IVR system.	Need to configure on mobile phone to enable the WAP services.
Data rates	5 Kbps-64 Kbps Low bandwidth depends on CODEC selection.	9.6 Kbps - 14.4 Kbps Low bandwidth.
Middleware communication	Need PSTN network.	Need mobile network (GSM).
Compression method	CODEC	Conversion HTTP to binary code (WML)
Delay	Sensitive to delay	Can tolerate delay
Packet	Drop sensitive	Drop insensitive
Application	Real time	Non real time
Last mile users	Home, public and mobile phone users.	Mobile phone users that enable WAP features
Function of technology	For long distance call and reduce cost.	Information-on-demand services at anywhere, anyplace and anytime.

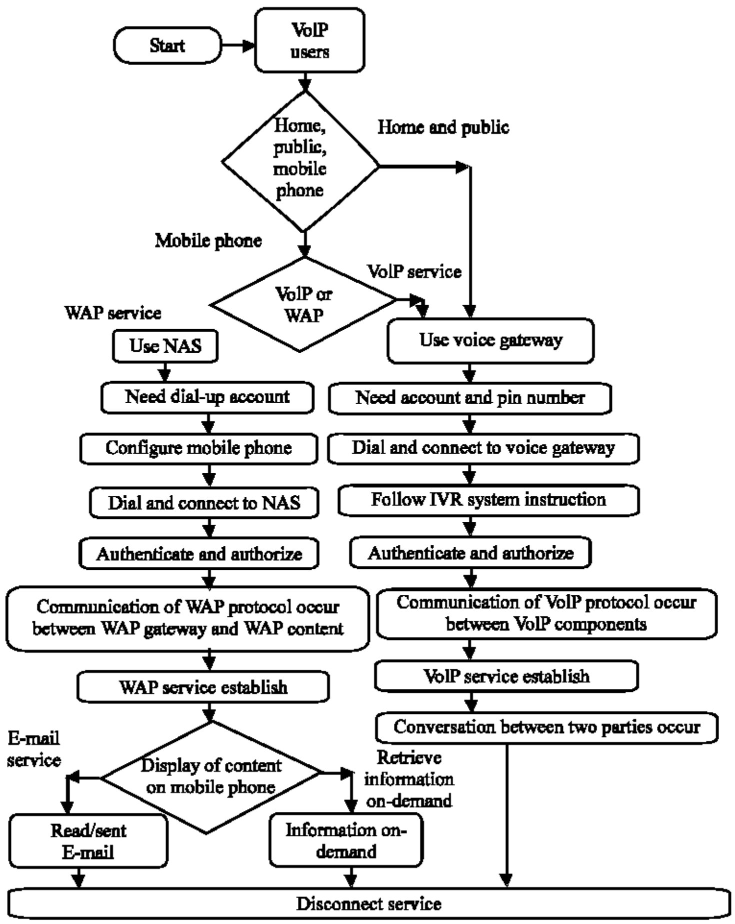

Fig. 22: WAP and VoIP technology process

Figure 21 shows WAP and VoIP connectivity of delivering the information to the last mile users. These applications are characterized by their low traffic but are not sensitive to delay or delay variations. Data transmission such as e-mail and content information can accept delivery time for several hours. Table 3 shows the comparisons between WAP and VoIP technology characteristics.

For deployment of data oriented applications for wireless terminals, WAP has provided a technological solution for VoIP mobile information services. WAP specifies end-to-end communication platform between the mobile terminals and WAP gateway. Figure 22 shows the processes of VoIP between WAP mobile phone, fix and public phone users.

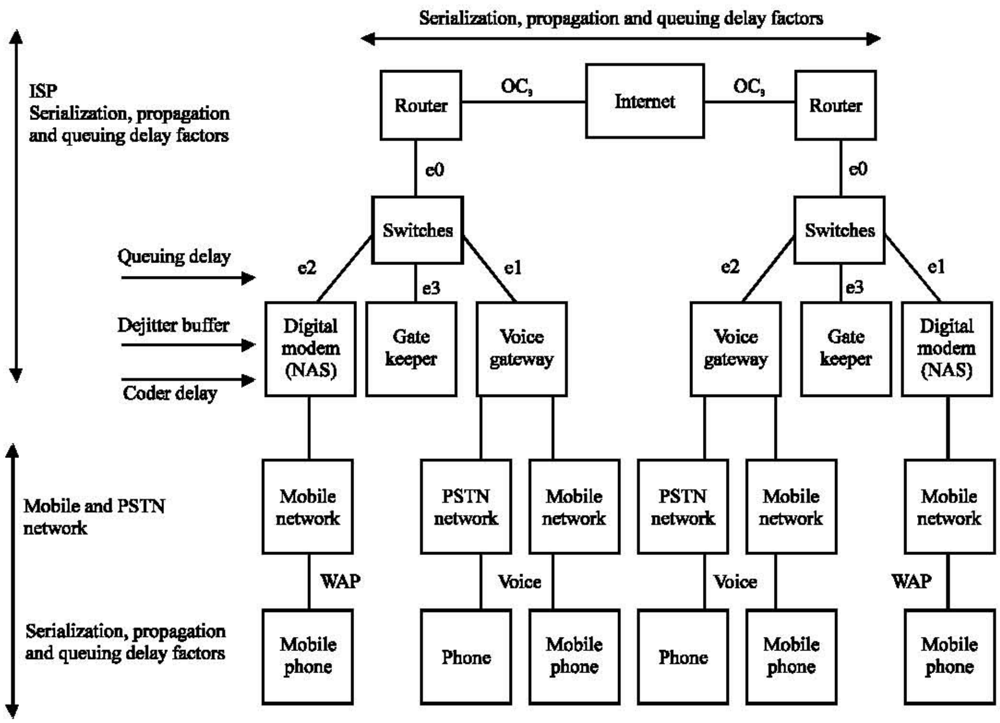

Fig. 23: Delay factors and its affects on network performance of mobile and fixed phones

Fixed (Home) and public phone users VoIP will be connected through PSTN network while mobile phones VoIP (WAP enabled) are connected through mobile (cellular) network. PSTN and mobile (cellular) network act as middleware communication between prepaid/postpaid VoIP users and ISP/ITSP to establish voice conversation. Hybrid voice services method shows that PSTN and ISP network use fully wired technology as a medium to transfer and receive VoIP traffic. On the other hand, mobile (Cellular) network uses wireless transmission medium for transferring or receiving VoIP traffic over the ISP/ITSP network. When prepaid and postpaid VoIP users (fixed or mobile phone) use this service, voice traffic has to be routed to different media communications.

This section discusses the merging of IP to PSTN network (hybrid, IP _ PSTN or IP-to-PSTN) and IP to Mobile network (hybrid, IP _ Mobile or IP-to-mobile). The voice traffic flows from PSTN and Mobile carriers to ISP network. Carriers network (PSTN and Mobile) and ISP network operate on different network architecture. Both carriers network contribute different network performances. Mobile phone VoIP networks exhibit different characteristics than non-mobile phone VoIP networks. Figure 23 shows network performance that affects mobile phone (WAP and prepaid/postpaid VoIP) and fixed phone.

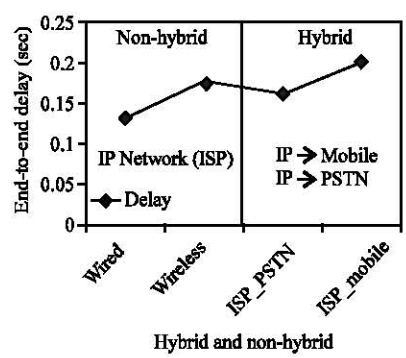

Fig. 24: Hybrid and non-hybrid voice service measurement performance

Mobile phone VoIP and fixed phone VoIP are implemented based on hybrid voice communication that incorporates both IP- to-PSTN and IP-to-mobile networks. This interworking will be referred to as hybrid voice services. This hybrid voice services can also be defined as communication between packet switch (ISP) and circuit switch (PSTN and Mobile). Figure 24 shows that non-hybrid voice services are represented by IP network (ISP) while hybrid voice services is comprised of PSTN, mobile and IP networks.

The analysis and measurement of prepaid/postpaid VoIP are based on end-to-end delay performance. The

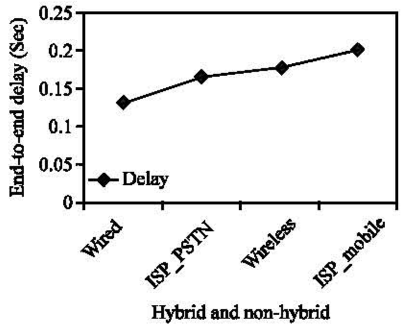

Fig. 25: Comparison of end-to-end delay measurement performance between ISP-to-PSTN and ISP-to-mobile networks

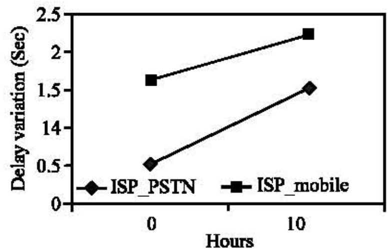

Fig. 26: Packet delay variation performance via hybrid voice services

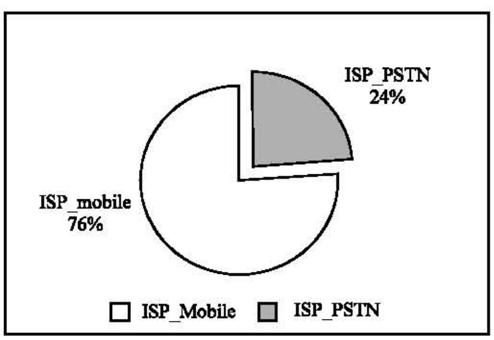

Fig. 27: Packet delay variation ratio

hybrid voice services through IP-to-PSTN are lower than wireless technology characteristics. The reasons is that PSTN uses circuit switching that guarantees the best sounding call because all packets will go in order and contribute minimum delay compare to wireless technology. Traditional voice communication over PSTN is characterized as a toll quality that is low delay, high availability and adequate voice quality. Delay on VoIP services over hybrid PSTN and IP network usually come from ISP network that uses packet switching technology. Therefore, end-to-end delay results between wired technology (non-hybrid) and IP-to-PSTN (hybrid) is will not be as high wireless and IP-to-mobile. The reason is because processing delay in wireless networks is higher than PSTN due to the fact that IP-to-PSTN is a fully operating wired technology. Figure 24 and 25 show the result of end-to-end delay for prepaid/postpaid hybrid and non-hybrid voice services compared to the existing wired and wireless technology performance (Fig. 2). The result shows that end-to-end delay increased via prepaid/postpaid hybrid voices services, which are IP-to-PSTN and IP-to-mobile. Wireless technology has proven to perform higher end-to-end delay than IP-to-PSTN (hybrid) and wired technology (non-hybrid).

The results end-to-end delay increase higher the moment voice traffic pass through ISP and Mobile network (IP-to-mobile). Prepaid/Postpaid VoIP calls that are made from mobile phones and from wire-line (PSTN) phones will encounter more delay for mobile calls than wire-line calls. Wireless technology produces lower speed and higher packet loss rates than wired networks. ISP and mobile network are hybrid networks that merge with wired and wireless technology. The end-to-end delay results will increase higher delay if network model is measured based on non-ideal environment. Prepaid/Postpaid VoIP calls involve signaling hand-offs between IP networks and IP-to-PSTN or IP-to-mobile networks during call-setup delays are taking place. Network Time Protocol (NTP) is deployed to synchronize router clocks. Accuracy of clocks and clock drift affect the accuracy of one-way delay measurements. High rates of drift can be much more problematic and may be symptom of hardware problems. These can cause by high temperatures in end system such as voice gateways.

Figure 26 shows delay variation occurs on IP-to-PSTN and IP-to-mobile networks. The result makes a comparison between prepaid/postpaid VoIP services over hybrid IP-to-PSTN and IP-to-mobile networks and its shows that IP-to-mobile has achieved higher delay variation. Figure 27 has proven that IP-to-mobile network achieved higher delay variation percentage than IP-to-PSTN. The ratio packet delay variation between IP-to-PSTN and IP-to-mobile is 1:3. Wireless technology can introduce several types of problem to prepaid/postpaid VoIP. Problems may be due to handoffs between access points that introduce gaps in the speech path and areas of low signal strength that result in high rates of jitter or packet loss due to congestion. In addition, packet losses caused by wireless connectivity such as media access and bit errors. Under conditions of low signal strength this results in increased retransmission and hence an increase in jitter (Fig. 25-27).

Wireless link layers may contribute to packet delays due to the forward and reverse Media Access Control (MAC) traffic flow. The wireless connectivity delay consists of two sections: queuing delay occurred by the local queue in the mobile phone and access queue in the AP and the other is the MAC access delay. Therefore, packet delay variation ratio increases will affect the performance and system to become unstable (Fig. 25 and 26). In wireless LAN 802.11 technology, it is supporting multiple frequencies so it can deploy LAN interference. The Radio Frequency (RF) signal loses power with distance then signal strength will diminish as it moves through the air. Other factors will impact throughput such as the type of antenna used at access point and power output from the AP and wireless devices. The 802.11 protocols attempt to mitigate interference concerns by allowing different access point to operate on different channels. The large numbers of channels make it easier to assign channels to access point that can minimize interference. If the channel detects an error, it will decrease the capacity and increase delay because more retransmission is required on the medium. In wireless technology, if the traffic increases, time to access the channel will also increase. This behavior will contribute end-to-end delay and packet delay variation. Radio Frequency (RF) is an inherently unreliable transmission medium when compared to wired link (Fig. 24-26). In non-ideal and ideal environment, higher end-to-end delay and packet delay variation can achieve a packet loss for IP-to-PSTN and IP-to-mobile as following reasons (Fig. 27): i) Packet arrives too late, ii) Packet misrouted and iii) Error-packet.

In addition, delay in the VoIP network could be caused by security and authentication server (AAA Server). The wireless technology measurement of performance can be affected due to (Fig. 25 and 26): i) high error rate, ii) poor end-to-end performance due to packet loss, iii) link error will reduce the throughput of the link, iv) hand-off between AP, v) if the system load is high, collision overhead will make the throughput low and vi) higher jitter and higher packet delay variation can cause the channel overhead. To ensure the successful implementation of prepaid and postpaid VoIP services, it needs to understand current traffic characteristics of the new network architecture. By measuring and analyzing jitter, end-to-end delay and packet loss before deployment of new prepaid/postpaid VoIP services, can aid in the correct redesign and configuration of traffic prioritization in voice network equipment.

CONCLUSIONS

This study discussed which technology between wired and wireless could produce low operating cost and good performance. The results proved that the hybrid network model is able to contribute and achieve reliability, scalability, extend the network coverage, redundancy network and load-sharing traffic approach between urban and rural areas. In addition, merging WAP technology with prepaid and postpaid VoIP network architecture has built to support non-real time applications for VoIP users. The purpose of WAP technology is to enable easy and fast delivery of relevant information on-demand services to VoIP users. This technique can achieve a robust fault tolerance.

Therefore, implementing of QoS management should be measured and analyzed globally because prepaid/postpaid VoIP services include the ability for users (fixed phone or mobile phone) to call PSTN or mobile networks. As a result, users' perception should include the global QoS of both network (IP-to-PSTN or IP-to-mobile) and the interconnection.

Future improvements needed to implement and introduce a robust security using VPN-MPLS technique for End-To-End solution and how VSAT, broadband VoIP, will influence enhancements of prepaid/postpaid VoIP architecture in next generation.

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