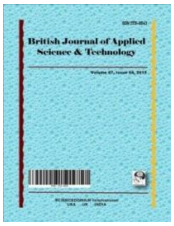

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Digitalization Maternal and Prenatal Care Reporting Systems by Using Multimodal Telecommunication Devices for Monitoring Systems in the Rural West Bandung County Indonesia

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Authors' contributions

This work was carried out in collaboration between all authors. All authors designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objectives: West Java Province contribute 19.8% mother mortality in Indonesia; is the highest than other provinces. We proposed the Digitalization Maternal and Prenatal care Systems (DigiMAPS) that tries to improve recording and reporting system in order to monitoring, improving health facility and managing prevention program.
Methods: Gunung Halu is located in West Bandung District was chosen due its contour-infrastructures obstacle. Requirement are derived by DigiMAPS and startup customer-problem-solution.
Results: We designed developed device, network, tele-consultation application and multi modality communication systems supporting various user accesses including SMS, web- and mobile

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application-based entry. It consist several access network including broadband wireline (xDSL), 2G-3G, WiFi and VSAT IP. We identified the following assumptions: (I) The communication networks are focus on public broadband IP network either using wireless/wireline approaches whenever applicable in target area. (II) The communication solutions considers various device requirements including PC, tablet and smartphone; DigiMAPS application has been developed using web- and android-based concepts. (III) The platforms are designed to support software as a service in cloud terminology, rather than client-server approach.

Conclusions: We have developed the DigiMAPS prototype in the rural area of Bandung county Indonesia. DigiMAPS will collect datas in order to monitor the quality of healthcare as well as for tele-consultation and data analysis to make early intervention by midwives, doctors and stakeholders in Bandung county, Indonesia.

Keywords: DigiMAPS; multimodal communications; maternal and prenatal care.

1. INTRODUCTION

According to 2010 Mother and Children Welfare report, West Java Province contribute 19.8% of mother mortality in Indonesia, which is the highest compared to other provinces in Indonesia [1]. In 2010, there were about 228 pregnant mother deaths per 100.000 pregnancies [2]. There are about 18 regions and 9 cities in West Java Province. Bandung Region contributed 46 mother deaths while West Bandung Region 28 deaths during 2012. Baby mortality rate in Bandung Region is about 34 among 1000 live births, which is very high compared to the target 23 per 1000 live births [3].

Indonesia has spent a lot of effort to reduce both maternal and neonatal mortality rate. The significant improvement has been achieved as can be seen from Figs. 1 and 2. However as shown from the graphs, it is still difficult to achieve 2015 Millennium Development Goals (MDG's) targets, unless hard works and revolutionary approaches can be done in the period of 2013 – 2015 [1]. On the other side, although substantial progress has been made in improving the health of persons in the United States, serious problems remain to be solved. Life expectancy is increasing, and the rates of the leading causes of death are improving in many cases; however, numerous indicators (i.e., measures of observed or calculated data on the status of a condition) of the health and safety of the U.S. population remain poor. The health status indicators described in this report were selected because of their direct relation to the leading causes of death and other substantial sources of morbidity and mortality and should be the focus of prevention efforts [4].

Hodgins et al. [5], also believe that the proportion of pregnant women receiving 4 or more antenatal care visits (ANC 4+) is used prominently as a global benchmark indicator to track maternal health program performance. This has contributed to an inappropriate focus on the number of contacts rather than on the content and process of care.

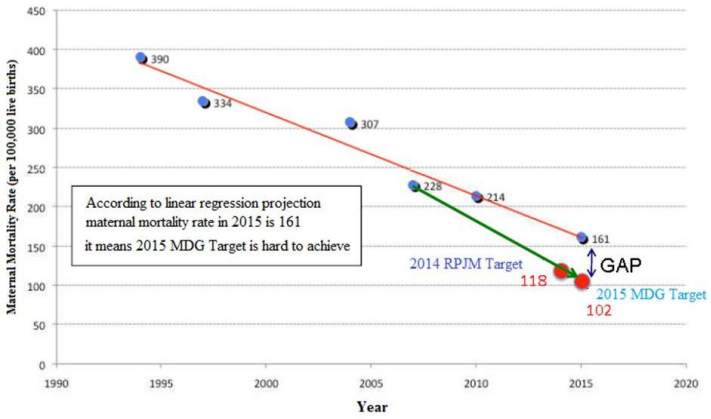


Fig. 1. The trend of maternal mortality rate in Indonesia
(Source: Indonesia Ministry of Health, 2011)

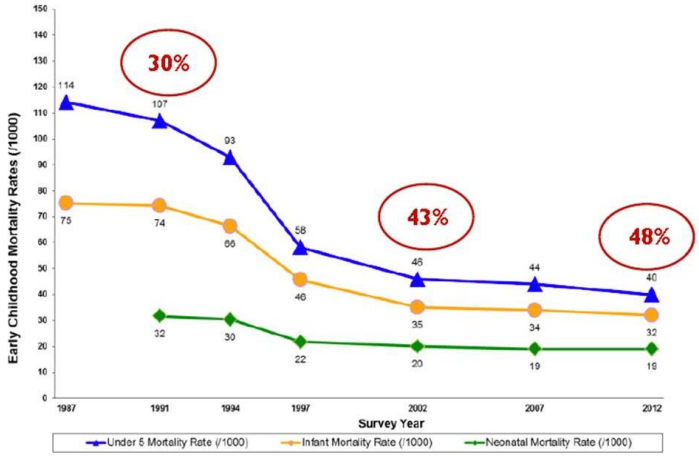


Fig. 2. The trend of neonatal mortality rate in Indonesia
(Source: Dr. Masee Bateman, USAID, 2013)

Information Communication Technology (ICT) in some extends help government to achieve the first two recommendations, therefore in this study we proposed the prototyping of Digitalization Maternal and Prenatal care Systems (DigiMAPS) that tries to improve recording and reporting system in order to help government for monitoring, improving health facility and managing the program to prevent complication, in compare to the conventional report systems that takes one month from the public health center to the health office in the capital city.

2. METHODS

2.1 Background Location

Gunung Halu is located in West Bandung District. The road infrastructures are still very poor. It tooks 2-3 hours from local public health in Gunung Halu to the nearest referral hospital in Cililin District. Therefore Gunung Halu public health service becomes the center of medical services in this District which support 9 villages. Fig. 3 shows the Gunung Halu District Map and some photos.

Every month, Gunung Halu local health service has to report about maternal and children health to the Health of West Bandung County. In order to report it, Gunung Halu local health service has to gather the statistical data report from midwives in 9 villages in Gunung Halu. Currently, the sources of data reports are from Mother and Child Book, Cohort Report and Helping Book, etc that are still in paper based.

2.2 Systems Development

The development of communication solution for DigiMAPS project will be explained based on the framework shown in Fig. 4. The requirement of communication solutions are derived from DigiMAPS and lean startup customer-problem-solution fit. The objective of DigiMAPS was to design and develop Device, Network, and Application (DNA) for consultation purpose and multimodality communication systems that supporting various user accesses including web-based, SMS and mobile application-based entry. Multimodal communication system consist of several access network including Broadband wireline (xDSL), 2G Cellular, 3G Sellular, WiFi and VSAT IP as can be shown in the Fig. 5.

Tele-Obgyn will be used in order to make Obgyn specialist available during a consultations. Telepresence video conference system will be used as part of DigiMAPS solution. In this case, the emergency patient who needs to be helped, the midwife can be assisted by Obgyn specialist from other hospital. Fig. 6 shows Telepresence system configuration. The Telepresence-Obgyn supports the following features:

- Co-browsing: to allow sharing a internet browser session with other participants
- Application and video sharing: to allow sharing any application installed on a PC/device with other participants
- Remote Control: to allow a participant to take control of other PC
- File Transfer: to allow a participant to send/cross transfer medical image or any kind of files rapidly and securely

- Electronic whiteboard: share and edit a joint workspace
- Polling: take real time polls on specific topics
- Session recording: record a session for playback later
- Extended desktop: supports extended desktop view for multi-monitor setups
- Live text chat: communicate using instant messages direct from the Spontania UI
- One-click invites: invite other participants to the Spontania session with a single click.

Fig. 3. Gunung Halu situation

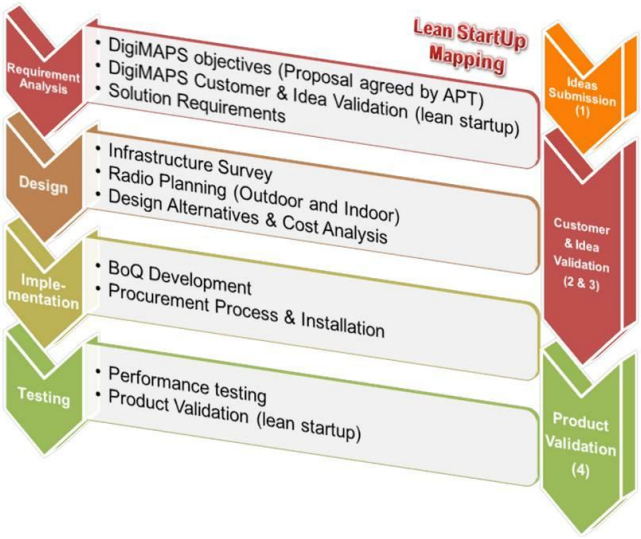


Fig. 4. Lean startup mapping

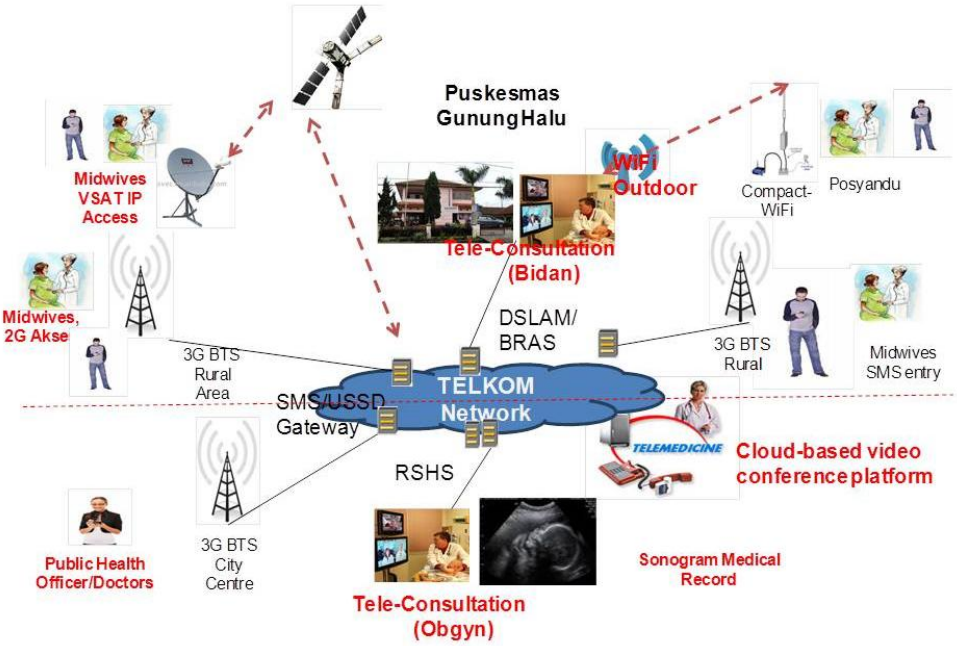


Fig. 5. DigiMAPS multimodal communication system

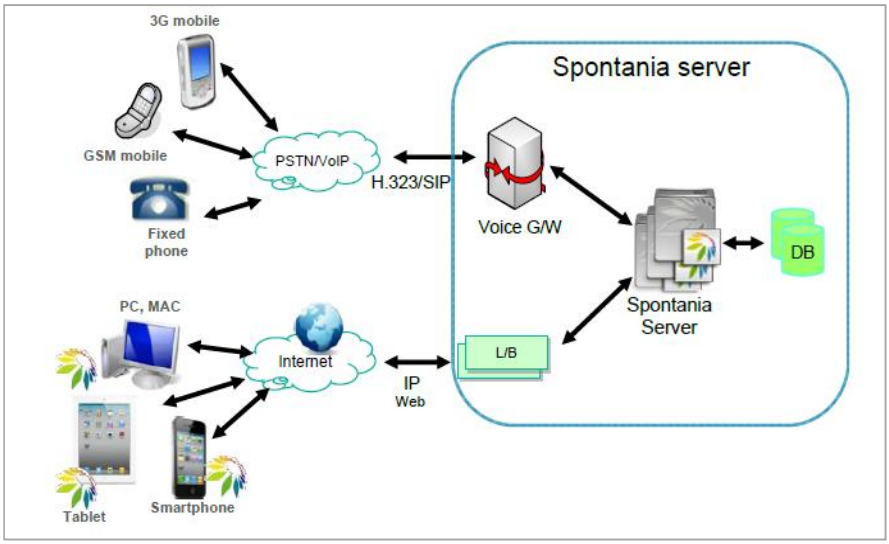


Fig. 6. Spontania system configuration
(NEC Indonesia, 2013)

3. RESULTS AND DISCUSSION

3.1 Analysis Communication Resource

The communication accessed were designed by considering survey result, radio planning result and implementation cost. It is important to know the public communication infrastructure available in Gunung Halu, therefore several survey activities were performed in order to get the information of telecommunication infrastructure in Gunung Halu especially in Gunung Halu Districts, Celak and Cilangari, where the DigiMAPS system will be tried. To get the coordinates of main target places and the performance of existing infrastructure we assessed telecommunication infrastructure available in Gunung Halu District as shown on

the Table 1. In this table representing that all area has internet connection and there was one area without accessible internet because the access link was in 2G edge/GPRS. Therefore we need alternative communication network in this area.

The survey results were very useful in order to plan the communication solution based on the real condition in Gunung Halu and Hasan Sadikin referral Hospital. In general, Gunung Halu Puskemas and Hasan Sadikin Hospital have internet access using broadband wireline. The broadband speed is enough to support DigiMAPS applications. However we have decided to upgrade the connection in Gunung Halu Puskesmas to match with the broadband connection in Hasan Sadikin Hospital. In order to support Tele-Obgyn accessible from PC/wide screen TV, we have decided to upgrade into Speedy 3 Mbps to support multimedia application.

In most locations, midwives near Puskesmas Gunung Halu, and midwives in 8 other villages can access internet using 3G services from either TELKOMSEL or XL telcom provider. However, senior/experience midwives in Gunung Halu, should be supported by other broadband accesses, because the existing 2G data service will not be able to access DigiMAPS applications. We have studied the possibility to implement point-to-point WiFi between Puskesmas and Bindan (midwife) which are geographically separated about 5.36 kilometers. In this case, we use Atoll planning tool to map both location in digital map and observe how line of sight (LOS) can be achieved. There are 2 possibilities to achieve LOS:

- Setup two towers with @ 110 meter high in Gunung Halu Puskesmas and Bidan Enden House/Pustu
- Setup three towers with @ 20 meter high in Gunung Halu Puskesmas, repeater location and Bidan Enden House/Pustu. Fig. 7 shows the LOS Analysis, the WiFi P2P solution with 2 towers and 3 towers.

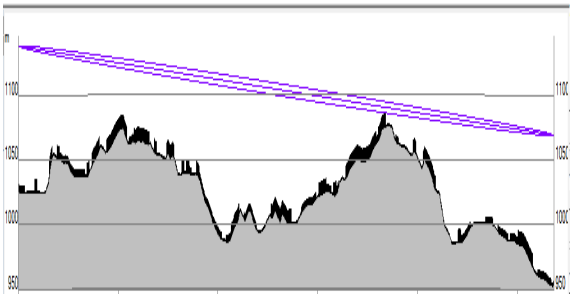
3.2 Designed the Indoor Communication Solution of Community Health Center (Puskesmas) in Gunung Halu

Along with speedy 3 Mbps installation, we design the indoor coverage for Puskesmas, therefore KIA Online can be accessed within Puskesmas Building. From initial measurement it was found that a single AP (Access point) will not able to cover all Puskesmas building as can be seen from Fig. 8. The coverage of one AP placed in the maternal-neonatal office initially was measured. The result was used to calibrate the coverage prediction of Aero-hive WiFi indoor planning tool. Based on the simulation, one AP and three repeaters are required to cover Puskesmas including maternal-neonatal house and USG room in the main building. The repeaters are placed at a location where the signal strength of the AP or the repeater is around -63 dBm.

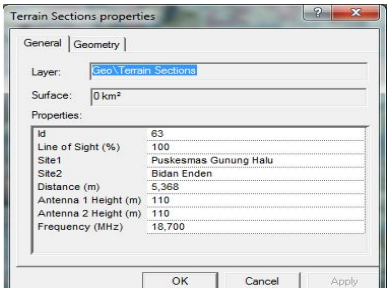
Table 1. Survey result of telecommunication infrastructure in Gunung Halu

Location	Coordinates	Existing infrastructure	Notes
Local health service, Gunung Halu	7° 1' 28.77" S 107° 18' 48.42" E	xDSL 384 kbps 3G	xDSL 384 kbps → upgradable to 2-3 Mbps
Doctor Ponet, Gunung Halu	7° 1' 31.72" S 107° 18' 44.39" E	3G	3G DL : 1.8 Mbps, UL 1.1 Mbps, ping 57 ms
Midwife Lilis, Gunung Halu	7° 1'24.30"S 107°18'46.93"E	3G	3G DL:1.9 Mbps, UL: 1.3 Mbps, ping 77ms
Midwife Cilangari	7° 2' 45.6" S 107° 13' 19.81" E	3G	3G DL : 2.1 Mbps, UL 345 kbps, ping 92 ms
Integrated health service, Montaya	7° 1'34.80"S 107°18'41.83"E	3G	3G DL : 1.8 Mbps, UL 1.1 Mbps, ping 57 ms
Midwife Enden, Celak	7° 0' 26.30" S 107° 21' 31.77" E	2G – Edge/GPRS	DL : 21 kbps, UL : 0 kbps → requires alternatives, not possible to access web
Hasan Sadikin Hospital	6° 53' 54'' S 107° 35' 52'' E	3G & Internet/Intranet	Internet DL : 0.47 – 1.92 Mbps, UL : 0.29-039, ping 53-161 ms

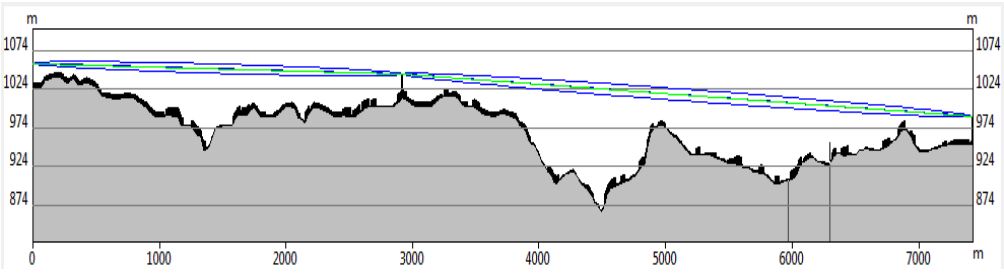
Note: DL = Downlink, UL = Uplink



(a) LOS of two towers with 110 m high



(b) Terrain section properties to see the tower high for LOS analysis



(c) LOS of three towers with 20 m high

Fig. 7. LOS analysis using atoll planning tool

3.3 Outdoor Communication Solution to Cover Gunung Halu District Center

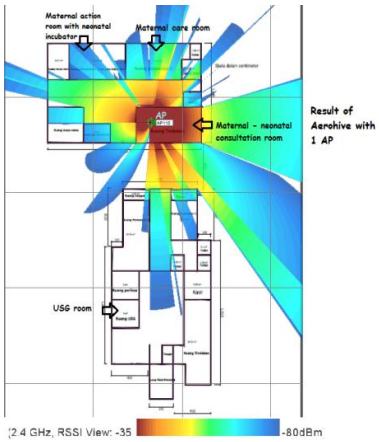
Posyandus (integrated medical service post for mother and children) are located in every Rukun Warga (Neighborhood association), assisting Puskesmas (Pustu) and Village Office. There are 100 posyandus in Gunung Halu Districts which are distributed within 9 villages. We only limit the design in Gunung Halu centre of District. The purpose of this design is to provide a model of communication solution to cover Posyandus location. In addition, it is to make use of the new speedy 3 Mbps installation in Puskesmas. So the midwives and cadres can access KIA Online from Posyandu, Midwives house location near Puskesmas, with free of charge. In order to achieve this purpose, the speedy connection in Puskesmas is extended to the centre of District office. In the District office, there is a communication tower which allowed to be used by DigiMAPS team with low rental cost. By using this tower, Posyandus can have internet access using P2P and P2MP WiFi Outdoor (Fig. 9).

xDSL Modem which located at Puskesmas Gunung Halu is used as the backhaul network. By using P2P (point to point) WiFi, we can have internet link from Puskesmas Office to the District Office. In order to make P2P, we connect the Modem+Wifi ADSL with the Access Point (AP) that will be put at the Puskesmas building on the second floor. The P2P network uses the AP as the main point and Tower Wifi at District office as the second point. From that point in District office, we use P2P WiFi outdoor to spread the WiFi signal to the wireless clients in Posyandu, Doctor and midwife houses (Fig. 10).

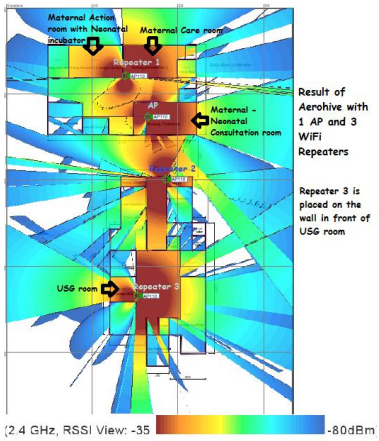
3.4 Implementation of Multimodal Communication System

DigiMAPS applications are enabled by multimodal communication framework. The framework identified by the following basic assumptions:

- The communication networks are focus on public broadband IP network either using wireless or wireline approaches whenever applicable in the target area.
- The communication solutions considers various device requirements including PC, tablet, and smartphone, thanks to the web-based and android-based application concepts, DigiMAPS application has been developed by considering these two concepts.
- The communication platforms are designed to support Software as a Service (SaaS) in cloud computing terminology, rather than client-server approach.



(a) Coverage of one AP



(b) Of one AP, 3 WiFi repeaters

Rooms	Condition based on Aerohive planning tool
Maternal Neonatal consultation room (main AP)	Good received signal . The RSSI is about -35 dBm until -40 dBm. The room is covered by excelent signal strength.
Maternal care room (Repeater 1)	Good received signal . The RSSI is about -35 dBm until -40 dBm. The room is covered by excelent signal strength. Without repeater the signal from main AP was -74 dbm
Behind the back door of main building (repeater 2)	Good received signal . The RSSI is about -35 dBm until -50 dBm, the RSSI of a little part of thye room is -60 dBm. The room is covered by excelent signal strength. Without repeater the signal strength from main AP around -60 dBm
On the wall in front of the USG room (Repeater 3)	Good received signal . The RSSI is various and the best is -35 dBm, but a little space of this room is not covered. This is not a problem as long as most of the space of the room is covered by WiFi signal.

Fig. 8. The coverage of indoor AP and repeters in Puskesmas Gunung Halu

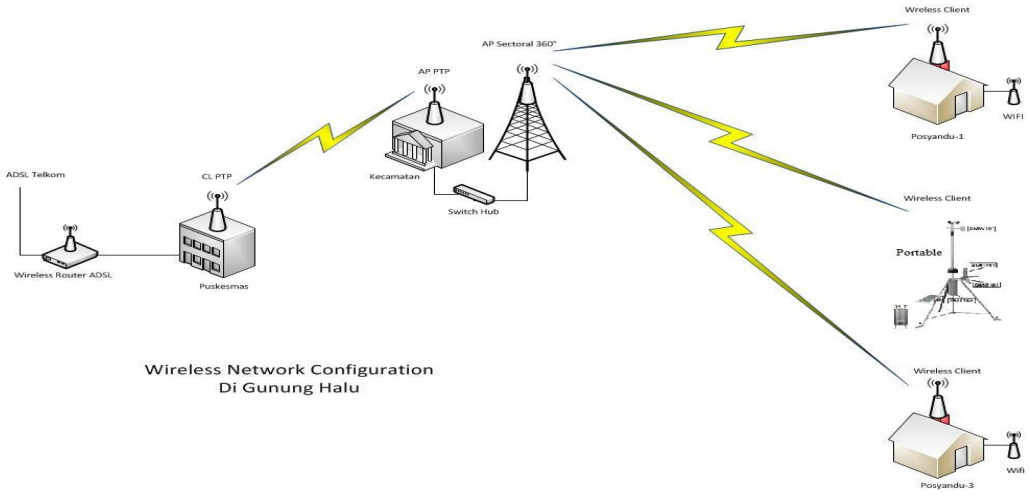


Fig. 9. Outdoor Mesh Wifi network configuration to cover Posyandu

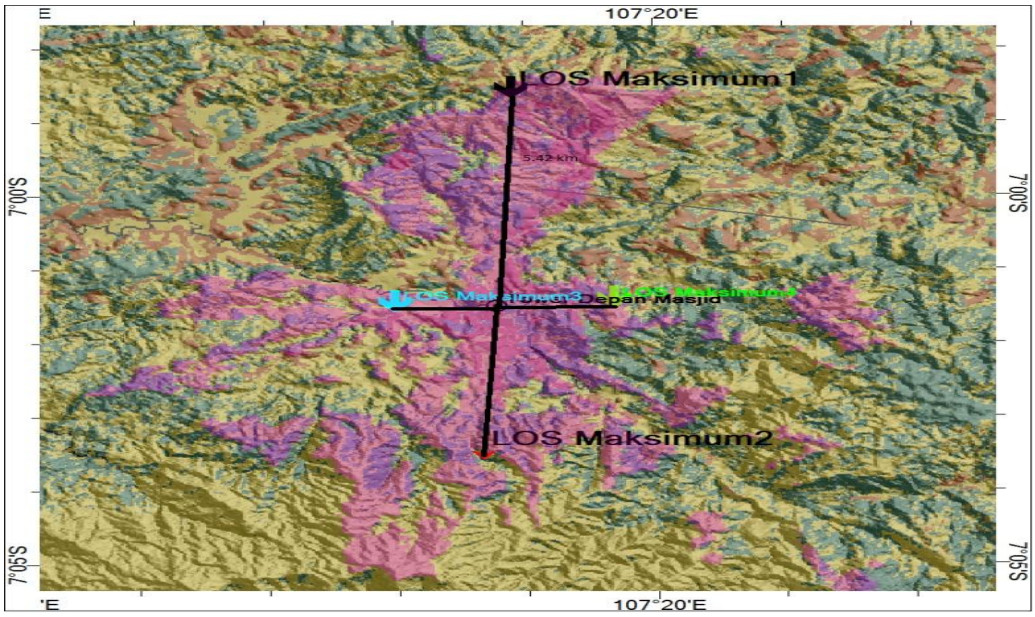


Fig. 10. Coverage estimation of P2P WiFi in Gunung Halu District

These approaches have several advantages including capex-opex efficiency for targeted users (government, health staffs, midwives and doctors), minimum maintenance efforts by the users and can be leveraged easily to cover both rural, suburban, urban areas in the wider scales. However we also understand if the target users (ie. Public health department, clinics, hospitals) may want to keep KIA Online database in their intranet for security reasons, then the DigiMAPS system can adopted easily.

3.5 Verification and Testing

The prototype verification test has been performed, which mainly for knowledge sharing and demo of Tele-Obgyn and KIA Online application, Verifying KIA and PWS-KIA Online application (prototype version), testing of Tele-Obgyn performance over xDSL and 3G service, verifying communication design for VSAT IP, WiFi tower for P2MP, and Repeaters placement. Knowledge sharing and demo for KIA Online and Tele-Obgyn had been performed successfully. While the application verification has been done and reported separately by DigiMAPS application team. Table 2 is the summary of performance measurement of xDSL link and 3G Flash in Gunung Halu Puskesmas.

Tele-Obgyn solution has been provided as Software as a Service (SaaS) in TELKOM Sigma cloud computing facilities. The system was running well on mobile terminal and PC/laptop when the trial was done. The video conference enabled a midwife in Gunung Halu communicate with a doctor in Hasan Sadikin Hospital. During the conversation, the video communication using xDSL was not really smooth because of delay in the network. Fortunately the communication using mobile device with 3G Flash could be done with better quality compared to the one using xDSL link.

We managed to investigate the network quality by using the online measurement tool from www.ringcentral.com and provide the test result summary as in Table 2. We further investigate the problem in xDSL by sending ping packet to Spontania server 118.97.213.131. The result confirms the one from ringcentra.com that the xDSL performance is not optimum. The upstream delay was unstable, and loss connection was often occurred, resulting 6-8% packtet loss (Fig. 11). This is to explain why the MOS score for xDSL was very low compared the one using 3G Flash. By using this finding, we escalated the issue to TELKOM Speedy contact, and now the link has been improved. Regardless the problem in xDSL link, we still managed to achieve the objective by using 3G Flash. Thanks to Spontania system, this could be accessed from mobile devices. In addition we managed to get valuable feedback for DigiMAPS KIA and PWS Online.

Table 2. Summary of performance measurement of xDSL link and 3G Flash

Performance indicator	Speedy 3Mbps	3G flash ultima 3GB
Throughput upstream	0.30 Mbps	1.32 Mbps
Throughput downstream	2.04 Mbps	4.35 Mbps
Average delay	139 ms	162 ms
Average jitter	41.2 ms	17.8 ms
Packet loss	15.9%	0%
Estimated MOS audio	1.0	3.7

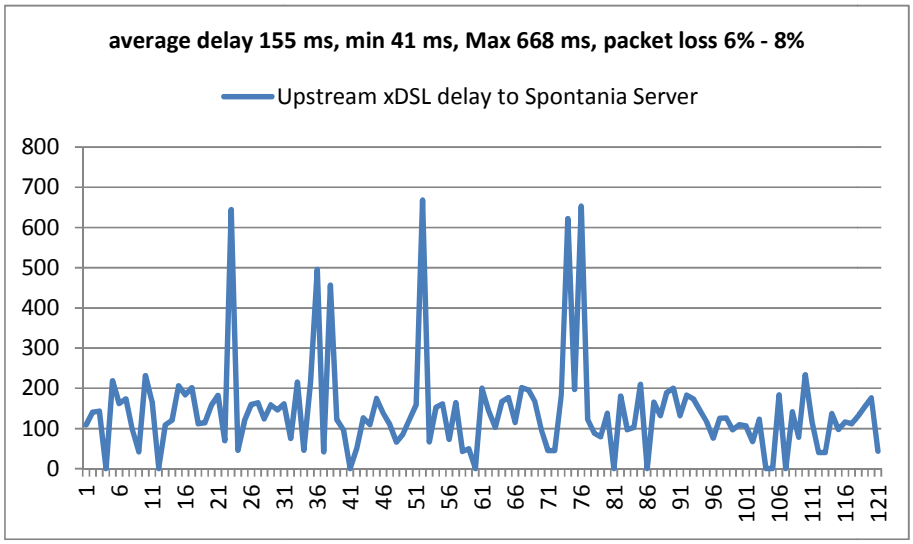


Fig. 11. Upstream delay performance of xDSL link

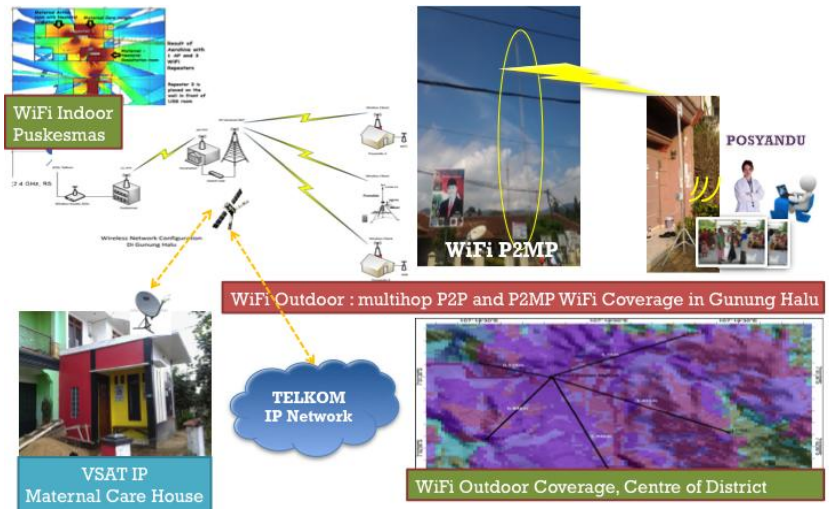


Fig. 12. Multimodal communication facilities in Gunung Halu District

Indonesia initiated a programme in 1989, aiming to place a midwife in every village, in response to high maternal mortality rates and low rates of births attended by trained birth assistants. Ngana R et al reported that remote rural villages in eastern Indonesia have difficulty recruiting and retaining village midwives. These midwives play a crucial role in health reporting. During 2010 a new system of recording and reporting by clinics was implemented. There was incomplete coverage by village midwives in the two subDistricts studied; 28% of villages had a resident midwife, 48% had a visiting midwife and 24% had only monthly visits by a mobile clinic.

Village midwives performed duties additional to their official duties and training. Village midwives had problems associated with the reporting system including inconsistency in reporting, poor access to individual patient histories and poor access to clinics. These problems resulted in incompleteness and poor timeliness of data transfer [6,7].

The usefulness of database in DigiMAPS is very important for statistical analysis to knowing the risk of morbidity in pregnant woman, because it collect all data related to risk prediction. It has been used and reported by Bekkevold et al, that, the data mining to identify possible correlates between preterm delivery and medicines used by 92,235 pregnant Danish women who took part in the Danish National Birth Cohort (DNBC). We then evaluated the association between one of the identified exposures (vaccination) and the risk for preterm birth by using logistic regression. The women were classified into groups according to their exposure to vaccination. The regression analyses were adjusted for the following covariates: parity, infant's gender, maternal Body-Mass Index (BMI), age, smoking, drinking, job, number of inhabitants in the place of residence, infections, diabetes, high blood pressure and preeclampsia [8].

4. CONCLUSION

Based on the results of this study we have implemented until this report is made, some tentative conclusions can be drawn from our progress report, as follows: We have developed the prototype of DigiMAPS for monitoring maternal and prenatal care (Fig. 12) in the rural area in Bandung county Indonesia. The system will collect data of maternal and prenatal care in order to monitor the quality of healthcare as well as for teleconsultation and data analysis to make early intervention by doctors, midwives and authorities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Widjojo P, Loetan S, Simatupang DS. Progress report on indonesian millennium development goals (MDGs). Jakarta; 2004.
2. Indonesia Health Sector Review. Accelerating improvement in maternal health: Why reform is needed. Policy and Discussion Notes. Jakarta: World Bank, August; 2010.
3. Ministry of Planning and National Development. Indonesian MDGs Repots; 2012.
4. Johnson NB, Hayes LD, Brown K, Hoo EC, Ethier KA. Centers for disease control and prevention (CDC). CDC National Health Report: Leading causes of morbidity and mortality and associated behavioral risk and protective factors--United States, 2005-2013. MMWR Surveill Summ. 2014;63(Suppl 4):3-27.
5. Hodgins S, D'Agostino A. The quality-coverage gap in antenatal care: Toward better measurement of effective coverage. Glob Health Sci Pract. 2014;2(2):173-81.
6. Ngana RF, Myers BA, Belton S. Health reporting system in two subDistricts in Eastern Indonesia: Highlighting the role of village midwives. Midwifery 2012;28(6):809-15.
7. Morgan M, De Jong-van den Berg LT, Jordan S. Drug safety in pregnancy-monitoring congenital anomalies. J Nurs Manag. 2011;19(3):305-10.
8. Bekkevold OI, Jensen H, Stensballe L, Olsen J. Maternal vaccination and preterm birth: Using data mining as a screening tool. Pharm World Sci. 2007;29(3):205-12.

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