Coverage and Quality Radio Analysis for Single Radio Access Network Technology in GSM

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***Abstract*—Single RAN is the Radio equipment which consists of Base Band Unit (BBU) and main processor for enabling GSM, UMTS and LTE in the same platform. In the past of 5 years, operators in Malaysia using separate radio equipment for different technologies. This caused big impact on the CAPEX and OPEX to the operators to manage and maintain their network. By having single RAN, operators automatically reduce their CAPEX and OPEX for every year to manage and maintain the radio equipment. The performance of the single RAN was studied in terms of coverage and quality compared to conventional radio.**

Keywords— **BBU, RRU, GSM, UMTS, RAN**

I. Introduction

The communication technology has growing to be a research focus in the wireless communication technology. A broadband wireless communication technology, the characteristics has high communication rate, high resolution and low power consumption. It is a very competitive and development prospects wireless communication technology.

In GSM technology which commonly called 2nd Generation of mobile network or 2G, the maximum speed for data can be achieved is 236kbps with EDGE capability [11]. The architecture for GSM is more or less the same as 3G which requires RAN, BSC and Core Network.

For 3rd Generation Network or 3G network, the best speed can achieved is 21.1Mbps with HSPA+ with some configuration at the RAN which is Multiple Input Multiple Output (MIMO) at the antenna. Architecture for 3G network requires RAN and Core Network [5].

In LTE network, every elements in the network architecture are being simplified and it using the native IP. With the new network architecture, it helps to reduce latency and improve the throughput tremendously. With the earliest LTE (release 8), it can produce downlink speed up to 150Mbps and uplink speed 75Mbps whereas on LTE release 10 can produce downlink speed up to 1Gbps and 500Mbps for uplink [26].

To define performance in technologies (2G, 3G & LTE) in coverage, capacity and quality, some benchmarks test was made to compare the single RAN performance with conventional RAN. For coverage performance, drive test was made to obtain current radio coverage for conventional radio technology and the coverage for single RAN technology. Usually same routes, speed, equipment and vehicle are being used to get the benchmark in order to get good comparison.

Quality is the one of major criteria in handling mobile network for every operator in the world. There are many parameters in mobile network that brings quality in the network. Besides having good plan in Radio Frequency (RF) planning, performance of the single RAN is driven by the powerful processor of the single RAN. Study was made to obtain the comparison between conventional RAN and single RAN on the quality perspective. In order to achieve, drive test need to be done with the same route, equipment, vehicle and speed.

II. Network Architecture Overview

Every technologies has different architecture. For instance base station in GSM is called BTS (Base Station Subsystem) while in UMTS it is called nodeB and MS (Mobile Station) is used in GSM while UE (User Equipment) is for UMTS.

A. GSM (Global System for Mobile Communication)

In 1982, the main governing body of the European Post, Telegraph and Telephone Administrations (PTTs), European Conference of Postal Telecommunications Administrations (CEPT) set up a committee known as Group Special Mobile (GSM) to define a digital mobile cellular system that could be introduced across Europe by the 1990s [9]. In early 1987, the main transmission techniques are chosen based on prototype evaluation. While the service for 2G is getting more popular, the 1800 Mhz spectrum adaptation is begin to serve purposely to cater hotspot area and capacity. While 2G is moving ahead, the named of GSM has been renamed to Global System for Mobile Communication and went operational in various European countries.

GSM offers both voice call and data to the customer. Even though the data offer is not fast compare to 3G or LTE, but the main strength is on voice. With the spectrum allocated for 2G, it is good enough to provide huge coverage. Table I shows some of the list of frequencies allocated for 2G.

TABLE I

Freq Band	Uplink (Mhz)	Downlink (Mhz)
750	747.2 – 762.2	777.2 – 792.2
850	824.2 – 849.2	869.2 – 894.2
900	880.0 – 915.0	925.0 – 960.0
1800	1710.2 – 1784.8	1805.2 – 1879.8

Network architecture for GSM is consists of BTS, BSC, and MSC. Base Station Subsystem (BTS) has controls on the access layer. It is used to communicate with Mobile Station (MS). It is also a medium to provide coverage, capacity and quality to the MS. Frequency planning happen at BTS.

Base Station Controller (BSC) is the parent of BTS. It controls multiple BTS for handover purposes between BTS to BTS, radio channels allocation, receives measurements from MS.

Mobile Switching Center (MSC) consists of multiple BSC. It handles inter-working function (IWF), connection to Public Switched Telephone Network (PSTN) and Integrated Services Digital Network (ISDN). Function of MSC is to route the voice call & SMS, mobility management and charging.
Overall network architecture for GSM shown in Fig. 1.

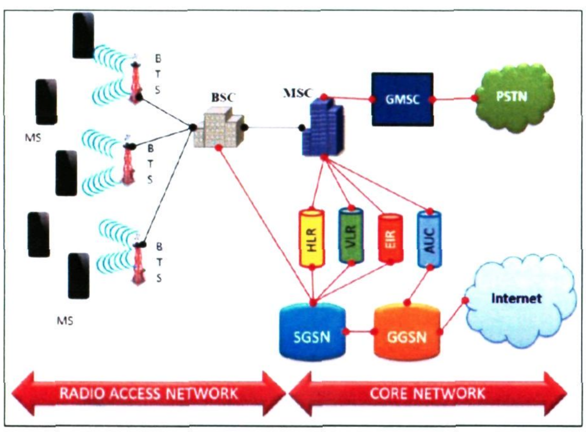

Fig. 1 GSM Network Architecture

B. *UMTS (Universal Mobile Telecommunication System)*

Universal Mobile Telecommunication System (UMTS) or known as 3G or 3rd Generation mobile network offers enhancement in term of speed compare to GSM. With 3G network, user can achieve up to 42Mbps downlink with HSPA+ configuration of 2x2 MIMO (Multiple Input Multiple Output) antenna. Spectrum allocation for UMTS is difference throughout region. The most spectrum used for UMTS is 2100Mhz. Besides, Malaysia is using 2100Mhz and 900Mhz as for UMTS while other countries may apply 850Mhz, 1700Mhz and 1900Mhz.

UMTS network architecture is almost similar to GSM but the capabilities, interfaces and protocol are different from GSM. From the Radio Access, the base station is called NodeB. The group of NodeB are connected to Radio Network Controller (RNC). RNC then connected to MSC for voice and SGSN for data. The overall network diagram for 3G as shown in Fig. 2.

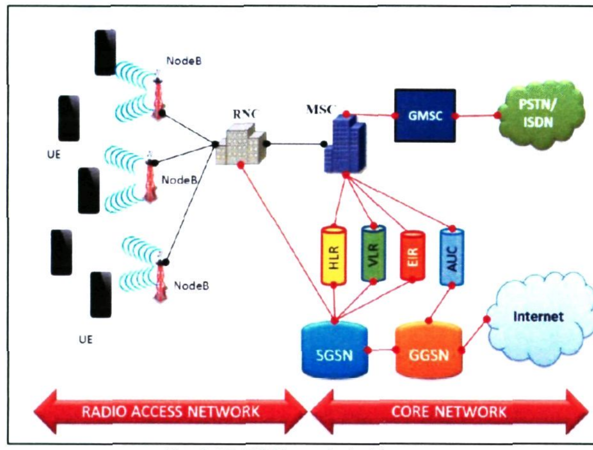

Fig. 2 UMTS Network Architecture

C. *LTE (Long Term Evolution)*

LTE is the short name of Long Term Evolution which is currently has the best mobile technology that can cater needs from customer especially when having a HD video conference, online gaming and much more. LTE has two variants which is TDD and FDD. Despite of the variants, LTE is IMT-Advance which requires all-IP packet switched network and peak data rates approximately 75Mbps and up to 1Gbps for low mobility.

As of to date, LTE is still new technology in Asia Pacific. In Malaysia, the spectrum allocated for LTE is 850Mhz, 1800Mhz & 2600Mhz. Each of the spectrum are given with different size of bandwidth. Most of the components inside LTE network are simplified. For instance, BSC and RNC in GSM and UMTS has been removed and replaced by intelligent radio which is called eNodeB. EnodeB is directly connected to MME and S-GW (Serving Gateway) for mobility and signalling. From S-GW it will connect to P-GW (Packet Gateway). It is illustrated in Fig 3. In LTE, there is no circuit switch and it is all running in IP.

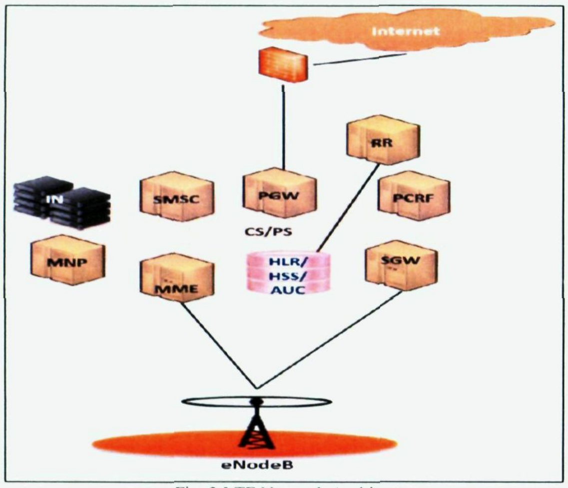

Fig. 3 LTE Network Architecture

III. Single Radio Access Network

Network sharing using the Single Radio Access Network (RAN) gives a lot of benefits to operator. With combination of technologies such as UMTS and GSM in one single radio is the key advantage to the operator without having different set of radio [2]. The sharing mechanism is at BBU which process multiple technologies at one time. Possibility of sharing antenna and RRU for different technology also is a part of the sharing mechanism. From the business perspective, single RAN is reducing CAPEX and OPEX. Besides, single RAN added value to environmental friendly with low power usage green technology and less equipment footprint such as number of antenna and baseband unit (BBU) [1]. Fig. 4 shows the RAN elements.

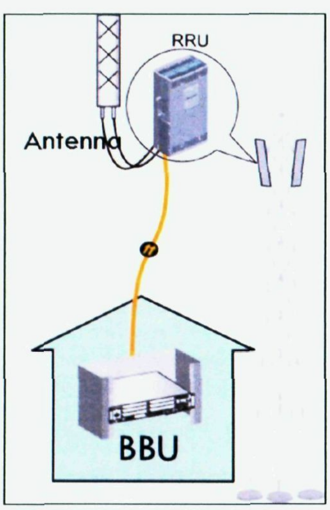

Fig. 4 Radio Access Network Element

Every elements has their own functionality. Table II shows the functionality of element resides in single RAN.

TABLE II

No	Element	Function
1	BBU	• Central processing unit • Support multiple frequencies such as 900Mhz & 2100Mhz in single box • Process UL and DL • Perform resource management • Perform signalling • Provides reference clock for network • Provides operation and maintenance port
2	RRU	• Converts analog to digital signal and vice versa • Provides power amplifier to the antenna to boost the coverage • Support multiple bandwidth of multiple frequencies
3	Antenna	• Medium to user equipment (UE)/mobile station (MS) • Provides coverage • Support multiple frequencies

IV. Methods

In order to define improvement in the single RAN network is to do comparison before and after implementation. For instance coverage for existing 2G is captured using specific tools which is called Nemo Outdoor. It is used to measure coverage before and after implement Single RAN.

A. Drive Test

Drive test is to verify the strength and quality of the coverage by measure and collect signal data which consists of signal strength, quality, cell id and many more. In order to do drive test, route must be determined first, followed by what parameter need to capture and when is the best time to start taking measurement. Sites location is the key access to define above requirements. In this research, criteria to do site selections is dependent to Celcom Axiata Sdn Bhd migration plan. Once site has been identified, Google Earth software in Fig. 5 is used to plan desired drive test route. Based on outcome from Google Earth, drive test can be scheduled.

In order to capture and measure coverage and quality for both before and after single RAN implementation, important parameter such as signal strength (RxLev), signal quality (RxQual), Call Success Rate (CSSR), uplink and downlink throughput need to be in place.

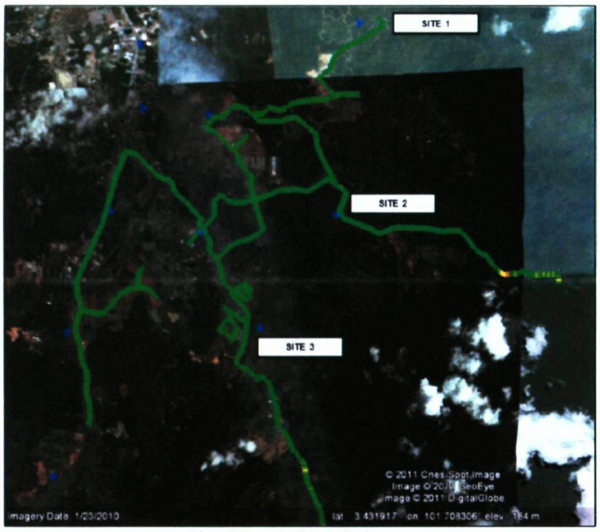

Fig. 5 Google Earth Software

After having above step, next important step is to prepare compulsory equipment for drive test which is laptop equipped with:

- Nemo Outdoor Software (illustrate in Fig. 6)
- GPS
- Test phones with Celcom simcard
- Dongle for Nemo Outdoor

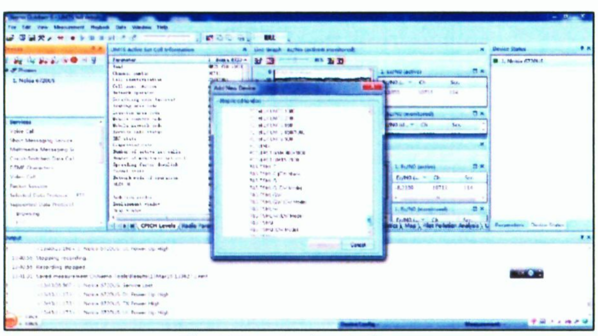

Fig. 6 Nemo Outdoor Software

B. Analysis of Data

During the drive test, important parameter and data captured are being process using Nemo Analyze and MapInfo Professional. These software are used to calculate the percentage of drive test coverage with specific threshold, create statistic and for analysis. Fig. 7 and 8 show snapshot of Nemo Analyze and MapInfo Professional.

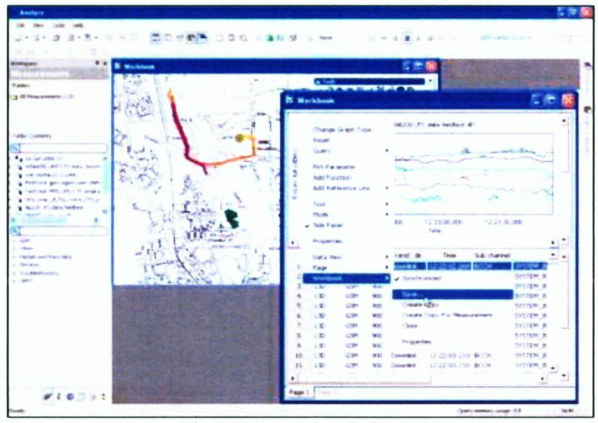

Fig. 7 Nemo Analyze Software

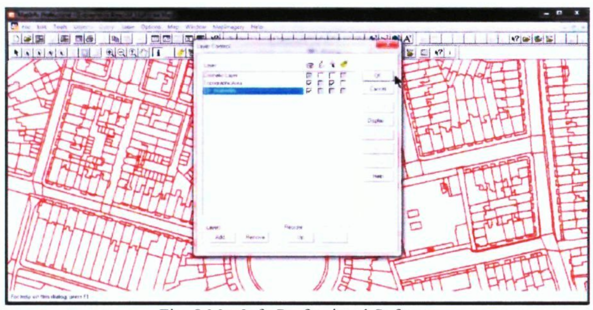

Fig. 8 MapInfo Professional Software

V. Analysis and Result

Outcome from drive test is translate to Nemo Analyze. Key function of Nemo Analyze is to analyze drive test data which contains set of parameters such as RxLev and RxQual. Below are the analysis for respective parameter before and after single RAN implementation.

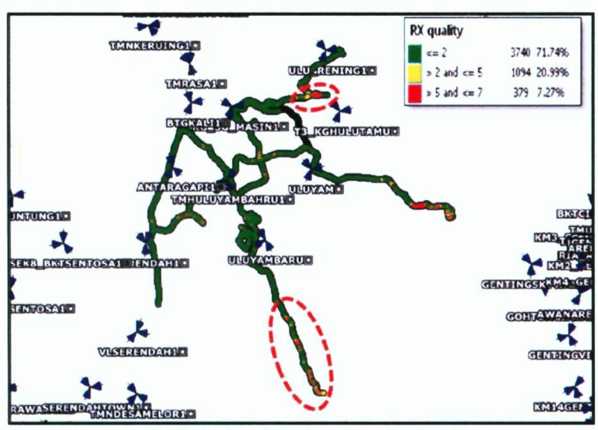

Fig. 9 RxQual Before Single RAN

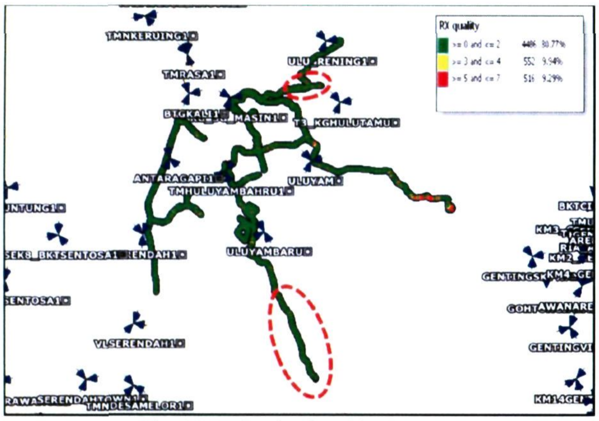

Fig. 10 RxQual After Single RAN

Red dotted in Fig. 9 and Fig. 10 show difference of signal quality before and after. It is proven that signal quality is improved after implementing single RAN. Signal quality (RxQual<= 2) measured in Fig. 9 is 71.74% while in Fig. 10 is 80.77%.

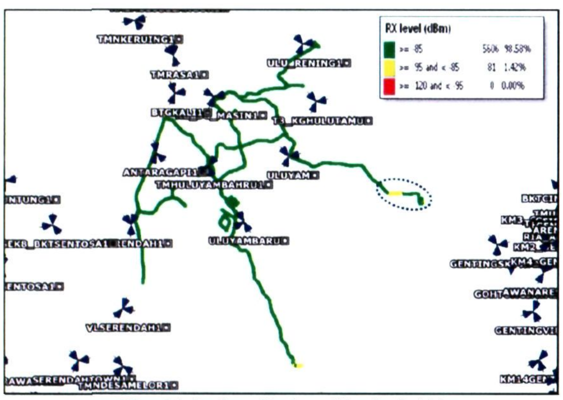

Fig. 11 RxLev Before Single RAN

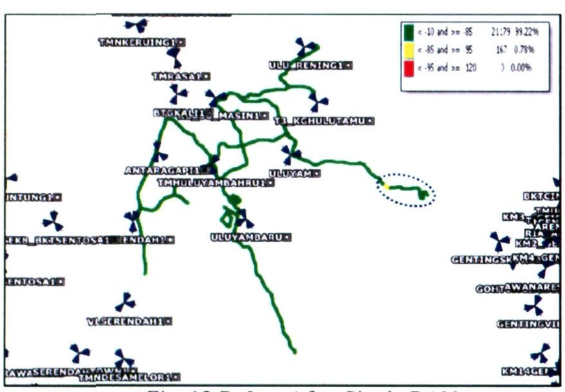

Fig. 12 RxLev After Single RAN

Signal strength before and after single RAN implementation captured in Fig. 11 and Fig. 12. From the Fig. 11, Rx Level <= -85dBm before implement single RAN is 98.58%. After single RAN implemented, coverage is having slight improvement to 99.22% as shows in Fig. 12 with blue dotted.

Throughput test was done for downlink before and after Single RAN implemented. Theoretically, by having good signal strength and good quality of coverage, it will contribute to high throughput. Hence, Fig. 13 and Fig. 14 show throughput before and after single RAN implemented. Throughput data after single RAN is improved by 49.2% compare to before single RAN.

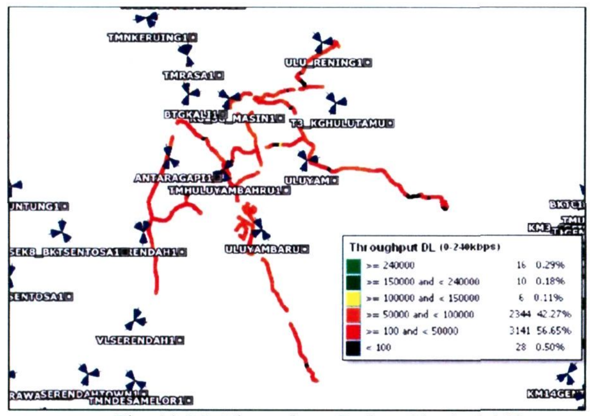

Fig. 13 DL Throughput Before Single RAN

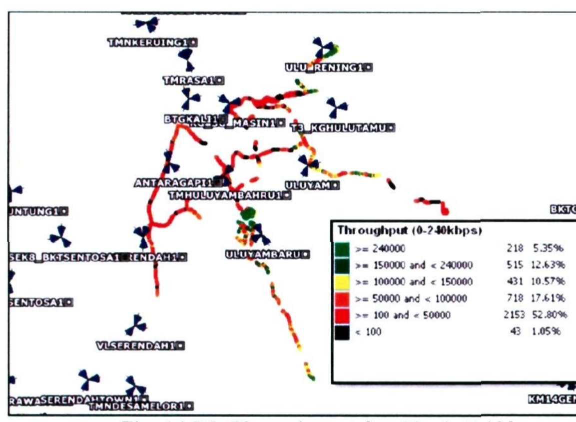

Fig. 14 DL Throughput After Single RAN

Uplink data is measured before and after single RAN. This is to ensure quality of the network whether maintain or improve while implementing single RAN. Comparison was made between before (Fig. 15) and after, and as result, significant improvement made as shown in Fig. 16. 141% improvement obtained after single RAN implemented.

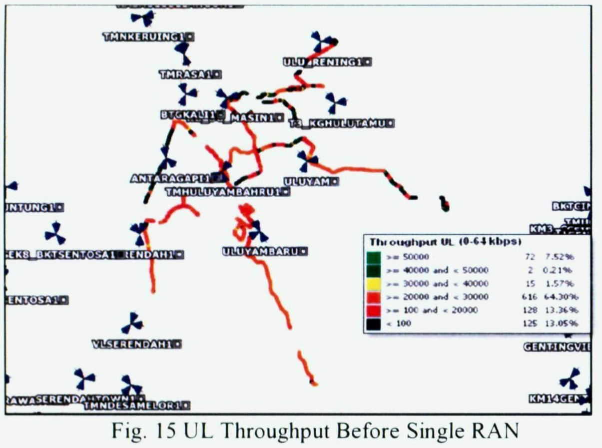

Fig. 15 UL Throughput Before Single RAN

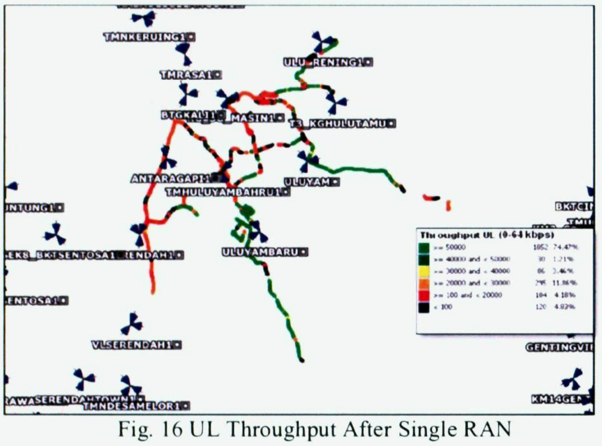

Fig. 16 UL Throughput After Single RAN

Summary of the analysis illustrated in Table III for voice and Table IV for data.

TABLE III

Voice KPI	Before	After	Comment
Rx_Qual (0-2)	71.74%	80.77%	Improved
Rx_Lev <=85dBm) (Avg)	98.58%	99.22%	Improved

TABLE IV

PS KPI	Before	After	Comment
Avg DL Throughput (Kbps)	44.81 Kbps	66.90 Kbps	Improved
Avg UL Throughput (Kbps)	20.083 Kbps	48.53 Kbps	Improved

VI. Conclusion

Telecommunication industry is moving so fast as to cater needs from user. Trends of lifestyle and mobile devices availability contribute to fast growth of telecommunication industry. Hence operator needs to comply the needs with less investment CAPEX and OPEX as well as giving the best services in term of coverage and quality. Based on analysis and result, it is proven that single RAN not only helps reducing investment but it is also improve network for coverage and quality compare with conventional radio.

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