Applying Maritime Wireless Communication to Support Vessel Monitoring

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***Abstract*—This paper applies wireless communication technology using 2.4 GHz frequency in marine field to support Vessel Monitoring System, where it sails on the island and marine field that are not getting signal coverage from Base Transceiver Station (BTS) on land. Applying of Long Range (LR) WiFi with 2.4 GHz frequency is used as an extension of cost-effective data service on maritime wireless communications. Updates are in Long Range WiFi which is permanently on island or buoy so that can be shared by vessels in particular fishing vessels to transmit important information relating shipping activities such as vessel positions via Global Positioning System (GPS) on a mobile phone. The result is the system that can extend data connection up to 8 km.**

Keywords—Maritime Wireless Communication; Long Range WiFi; Vessel Monitoring System; BTS; GPS.

I. INTRODUCTION

The marine and island fields are designated for various sectors of activities. As the largest archipelago in the world, with the number of islands reaching 17.508 and the coastline of 81.000 km, Indonesia needs a monitoring system in all parts. Vessel monitoring system is very useful in shipping activities to find out the ship's sailing information, due to existing conditions especially during bad weather. Length of time that fishermen spend to sailing, encouraging research in a maritime communications field.

Many telecommunication technologies can be used for vessel monitoring activities from conventional until modern technology. Satellite technology [1] and radar [2] have been performed but still, have major constraints such as high-cost and the size of devices used. The most effective solution is to use a connection from the nearest radio communications network on the land. Such as utilizing the latest BTS as a connection to connect to the network, so that can make it easier for monitoring activities on marine areas or islands that haven't covered by signal. Cause of vessel users uses mobile phones as their main communication tool so many research utilizes radio communication system in the sea such as applying WiMAX technology [3] [4]. However, WiMAX technology in Indonesia is still constrained by frequency regulation so this technology is not developed.

Application of a maricom bridge [5] with various techniques to improve performance [6] and a combination of other broadband technologies in bluecom+ project [7] is also done to support communication on the sea area which is cost effective and has high data rate access. It is also inefficient as the system applies to each vessel so it can impact on high costs and doesn't allow for small sized vessels such as fishing vessels to have them. In [8] comparing WiFi and Lora technologies at a 2.4 GHz operating frequency. From this, Lora produces a long range and low power, due to low data rate transmission. Same with [8], [9] uses LR WiFi technology on 5.8 GHz operating frequency. This system is applied in a marine field by a point-to-point link between ship and shore. The result is a range up to 7 km with data transfer rate is 1 Mbit/s.

Referring to that, this paper discusses the application of wireless communication systems using LR WiFi with 2.4 GHz operating frequency in islands and marine field which has not been covered by signal using the nearest mobile communications network on land. The 2.4GHz operating frequency is chosen because it is capable to provide the maximum range same with data rate. Implementation of this system produces distance up to 8 km, it is expected that marine and island field in Indonesia can be fully covered by multihop. This will make it easier for vessel users to send urgent information such as a location of the vessel to transceiver station on land for vessel monitoring activities.

After the introduction in section I, section II explain about system design and network architecture using wireless technology. Results and system evaluation described in section III, section IV are a conclusion and future work.

II. SYSTEM DESIGN AND ARCHITECTURE

This section illustrates a system design and network architecture for support maritime communications in the order vessel monitoring system. To get low-cost internet access in the marine field, a device used in this research is standard of wireless access technology such as LR WiFi from Ubiquiti vendor, with a frequency range of 2.4 GHz. Specifications and types of devices use are shown in Table I [10].

TABLE I. SPECIFICATIONS AND DEVICE TYPE

Device Type	Specifications
Ubiquiti NanoStation M2	Operating Frequency : 2412-2462 MHz Gain : 10.4-11.2 dBi Sensitivity : -75 up to -96 dBm Power Supply (PoE) : 24V, 0.5A Operating Temperature : -30 to 75° C (-22 to 167° F)

Device Type	Specifications
	Beamwidth : 55° (H-pol)/53° (V-pol) Polarization : Dual Linear Networking Interface : 10/100 Ethernet Ports (2).
Ubiquiti Unifi Mesh	Model: UAP-AC-M-PRO WiFi Standards : 802.11 a/b/g/n/ac Networking Interface : 10/100/1000 Ethernet Ports (2) Power Supply : 48V, 0.5A PoE Gigabit Adapter Maximum TX Power : 22 dBm Operating Temperature : -40 to 70° C (-40 to 158° F) BSSID : Up to Four per Radio Antennas : 8 dBi
Ubiquiti Rocket M2	Operating Frequency : 2412-2462 MHz Power Output : 28 dBm Operating Temperature : -30 to 75° C (-22 to 167° F) Gain : 11-16 dBi RF Connections : RP-SMA (2) Networking Interface : (1) 10/100 Mbps Power Supply : 24V, 1A PoE Adapter

Based on data in table I, link budget calculation will be doing use Okumura-Hata model approach. Receiving power (P_{Rx}) is sum between transmit power (P_{Tx}) with antenna gain (G_{Tx} and G_{Rx}) minus all losses occurring in a link. It can be seen in (1).

$$P_{Rx} = P_{Tx} + G_{Tx} - L_{cable} - L_{FSL} + G_{Rx} \quad (1)$$

Where free space path loss is a sum of transmitting and receive distance (d) with operating frequency (f) as in (2).

$$L_{FSL} = 32{,}4 + 20 \log d + 20 \log f \quad (2)$$

A. System Design

System design on marine field and island as a whole is shown in Fig.1. WiFi connection from the unifi access point (AP) is used by mobile phone or GPS vessel, derived from LR WiFi on the island or buoy as Customer Premises Equipment (CPE).

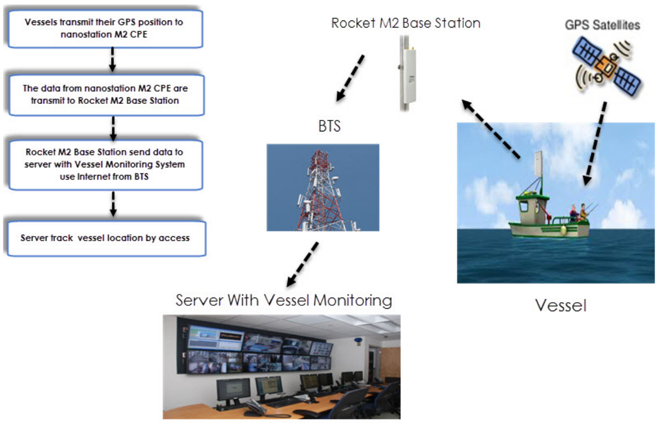

Fig. 1. System Design.

Internet connection from nearest BTS using rocket M2 as a Base Station (BS) on land and still coverage by BTS signal, which produces point-to-point or point to multipoint connectivity.

Installation of a device on the island is shown in Fig.2. An installation of the device is very important to do physical parameter settings so BS and CPE can communicate as well.

Fig. 2. Installation of Ubiquiti Device.

The measurement of distance generated between BS and CPE depends on environmental conditions and physical parameters of an antenna during the experiment, which will be used as a reference extension of internet connection to the sea.

B. Network Architecture

The base station on land provides a point to multipoint connection to CPE, which forwards WiFi connection to the mobile phone using a mesh topology. This will maximize the use of networks to support vessel monitoring services in marine and island field. Fig.3 shows the network architecture in use.

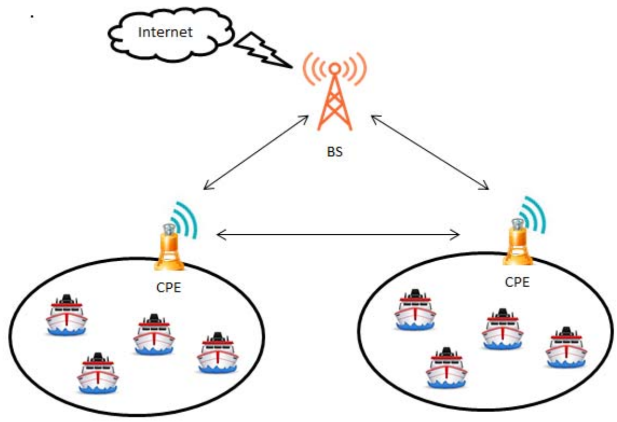

Fig. 3. Network Architecture.

The vessel was already registered in the system and under CPE coverage can be easily monitored. Vessel position information that was obtained by CPE forwarded to another CPE or directly sent to the BS on land.

III. RESULT AND DISCUSSION

Field trials were conducted in the coastal areas of Makassar, Indonesia. Tests were conducted with BS placed on coastal and CPE on ships. Maximum distance measurements are taken by the CPE is moving away from the BS until signal BS becomes unacceptable. Each point is a stop to take vessel position and strength signal data by enabling monitoring application and supporting applications on the mobile phone. Overall, a point of data retrieval conducted to produce a range of maximum internet connectivity distance up to 8 km. The distance is measured using the aerial distance between starting point to the end point as Fig.4.

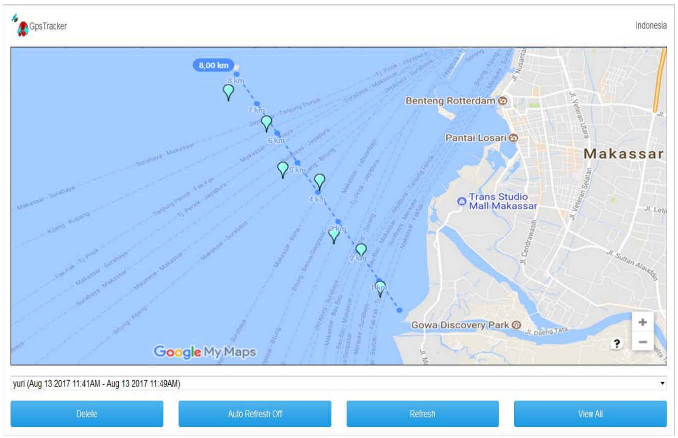

Fig. 4. Vessel Monitoring Results.

In this test, BS antenna placed as high as 5 m and CPE antenna in 2 m with an antenna tilt of 0^o. Field testing was conducted to determine the maximum signal distance from BS that can still be received by CPE. The result will be compared with the link budget calculation obtained from equation (1). If the result of strength signal level at receiver is better than sensitivity antenna receiver value from a datasheet, the link is feasible. The results aimed to prove the feasibility of a given wireless communication solutions.

The signal level measured at the receiver is shown in Table II.

TABLE II. RESULT OF STRENGTH SIGNAL MEASUREMENT BASED ON DISTANCE BETWEEN BS TO CPE

Distance (km)	High Antenna Transmitter BS (m)	High Antenna Receiver CPE (m)	Strength Signal (dBm)
1	5	2	-58
2	5	2	-64
4	5	2	-70
5	5	2	-72
6	5	2	-73
8	5	2	-76

This measurement is taken using the android app on a mobile phone. From (1) calculated link budget according to input data in table I, the result as in Fig.5.

Fig. 5. Link budget calculation using Okumura-Hata model.

At 8 km, link budget calculation results -75 dBm while the results of field measurements -76. If the antenna sensitivity receives in -96 dBm to -75 dBm, then the result of field data acquisition and a received signal is still entered at the minimum level of receipt sensitivity of the device. This means a link is still feasible.

Fresnel zone that can still be achieved in the state of LOS with assumption earth's surface is curved. Fresnel zone with a distance between BS and CPE is 8 km and height of CPE antenna in 2 m and BS in 5 m is shown in Fig.6. In the wireless network, it is taken 60% of the first Fresnel zone as a clearance zone.

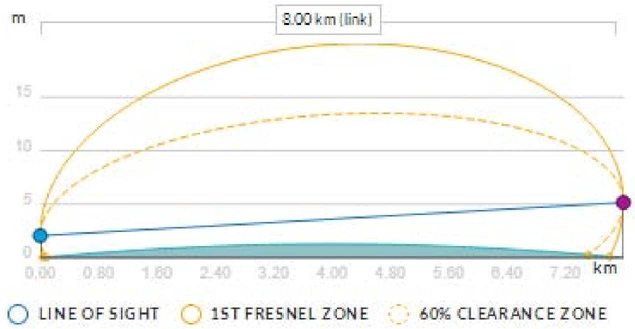

Fig. 6. Fresnel Zone

The most optimal channel usage produced by the system is in channel 6 shown in Fig.7.

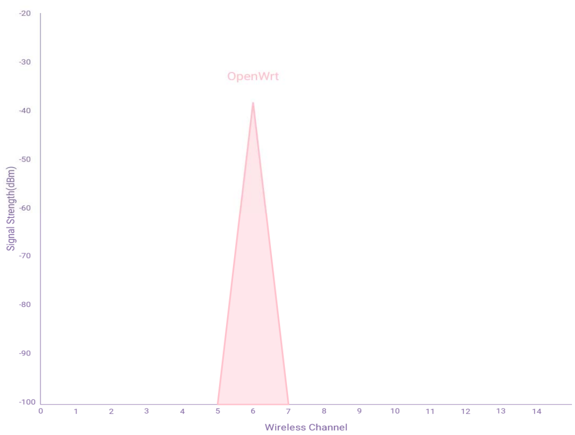

Fig. 7. Channel In Use.

On the side of user mobile phone, is also testing the data speed. The results obtained data download speed up to 2.43 Mbps and upload speed up to 1.92 Mbps derived from the emission signal WiFi access point as shown in Fig.8.

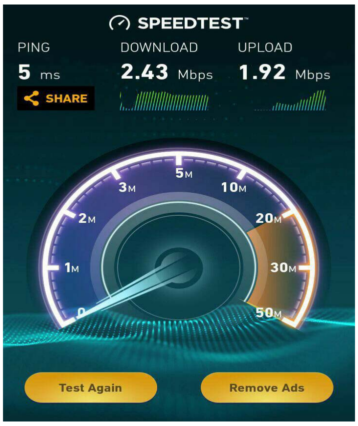

Fig. 8. Speedtest Results.

IV. CONCLUSION AND FUTURE WORK

This paper applies usage of LR WiFi as a solution extension of a low-cost data service connection from land to the marine and islands field are not reachable signal. This system able to extend connection up to 8 km with signal level measurement at CPE is -76 dBm. This value is still in the range of sensitivity signal receive in -96 dBm to -75 dBm so CPE can still receive signals from BS as well. Utilization of the system for vessel monitoring has also done so in the future need to develop an application for public service system, especially for island communities.

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