Implementation of MariComm Bridge for LTE-WLAN Maritime Heterogeneous Relay Network

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***Abstract*— In this study, we shortly introduce MariComm bridge of MariComm (Maritime Broadband Communication) project to provide broadband internet/multimedia services available at a rate of 1 Mbps or more on the sea. MariComm bridge enables MariStations to form the maritime heterogeneous relay networks. Thanks to this bridge function, MariStation can act as a gateway node or a relay node according to the connection possibility of a terrestiral base station. And finally, marine performance tests of this noble maritime communication system on 4 vessels in the Korean southern sea are introduced.**

***Keywords*— Multi-hop Relay, MariComm, Maritime Bridge, MariStation**

I. INTRODUCTION

Since maritime satellite communication systems, such as Inmarsat and maritime VSAT (MVSAT) costs are high and have the constraints of the number of concurrent users, the needs of broadband marine communication have not been satisfied yet. Recently the research and development of ITU-R M.1842-1 based digital VHF radio communication systems are in progress to modernize maritime communication environments. The coverage of this emerging communication system will reach approximately 100km or more [1]. However, it is difficult to provide a broadband internet service sufficiently in the sea because the maximum data rate is only up to 300kbps [2].

MariComm (Maritime broadband communication system) project was begun to provide affordable internet services to the ships in the sea, and it has been developed to target the data rate of 1 Mbps or more. In this project, every ship could be one of the communication relay node which is connected to the terrestrial WCDMA and LTE networks.

II. RELATED WORK

Several previous works of maritime broadband communication were performed using the commercial communication technologies. One of these works is the revision of the WiMAX protocol to apply MMR (Mobile Multi-hop Relay) techniques in marine communication environments [3-6]. Another research based on IEEE 802.16 mesh mode with 802.16e for high-speed maritime communication through the mesh network configuration from the seaport to the ship [7-9]. However, these previous works based on mobile WiMAX technology have a global roaming problems, because the commercial WiMAX networks are not yet spread globally [10-11].

In this paper, we introduce the MariComm project to realize a broadband communication briefly in chapter III, and explain the design of MariComm bridge function in chapter IV. The performance test results using 4 ships in the sea are shown in chapter V, and finally conclude in chapter VI.

III. MARICOMM PROJECT

A. Components of MariComm

The goal of MariComm system is to provide broadband communication services with the data rate of 1 Mbps or more in the sea by applying multi-hop relay technique to extend the coverage of the wireless communication. It consists of MariStation, MariComm network, MariComm server, as shown in Figure 1.

B. Components of MariStation

MariStation plays a role as the multi-hop relay communication stations in marine vessels offshore. MariComm network means the maritime broadband communication network. MariComm server performs an integrated management of the communication stations, which is connected to the backbone network. MariStation consists of TAM (Terrestrial Access Module), SAM (Seaward Access Module), LAM (Landward Access Module), and MariComm bridges as shown in Figure 2.

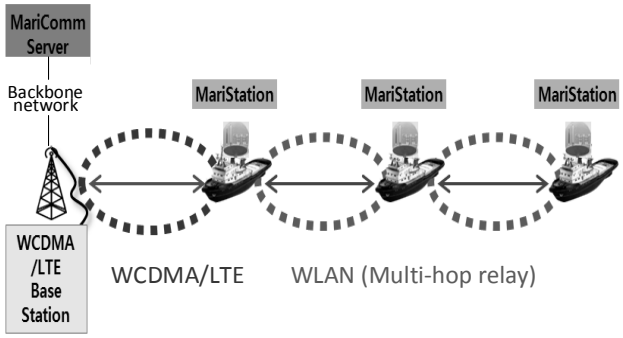

Figure 1. Conceptual diagram of MariComm system

1) ***TAM (Terrestrial Access Module):*** provides internet connection services to the MariComm bridge using the terrestrial 3G & LTE network. Consequently, it includes 3G & LTE transceiver, and control functions.

2) ***LAM (Landward Access Module):*** searches and connects to an available MariStation named SAM on other ships, and provides internet connection services to the MariComm bridge with WLAN devices.

3) ***UAM (Undefined Access Module):*** establishes a point-to-point connection to some terrestrial nodes.

4) ***SAM (Seaward Access Module):*** plays a role of repeater or AP (Access Point) for other MariStations to provide an internet connection. It shares status and configuration information with a child MariStation by setting the SSID value.

5) ***GPS (Global Positioning System):*** is used to determine the current location of MariStation itself.

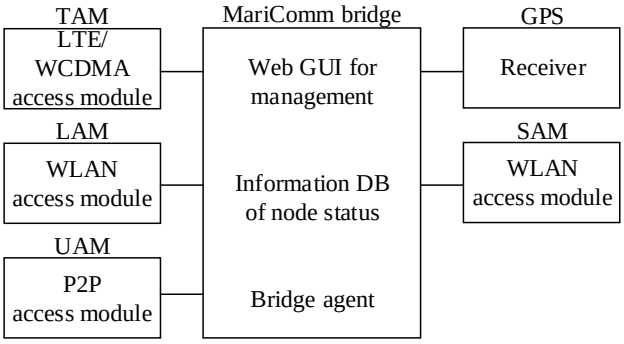

Figure 2. Structure of MariStation

C. Roles of MariStation

MariStation acts as a gateway node (gMariStation) or a relay node (rMariStation) according to the connection possibility of an on-land base station (BS). If the MariStation can connect to an on-land base station, such as LTE eNodeB, WCDMA base station, WLAN AP, it acts as a gMariStation and serves a gateway to other ships. When the MariStation cannot connect to an on-land base station directly, it acts as an rMariStation and can access to an on-land base station through other MariStatins.

The following is the roles of gMariStation.

- Gateway node of subnet
- DHCP Relay Agent
- NAT(Network Address Translation) functionalities
- WLAN Access Point & WDS(Wireless Distribution System)
- Monitoring about the connection status and failure
- Maintaining the Hop_Count (Hop_Count = 1)

The following is the roles of gMariStation.

- Relay node of subnet
- Scanning the parent node possible to connect
- Deciding the connecting node by using RSSI, Hop_Count, Child_Count etc.
- Monitoring about the connection status and failure
- Maintaining the Hop_Count (parent node Hop_Count + 1)

Figure 3 shows the role switching flow chart of MariStation in MariComm system.

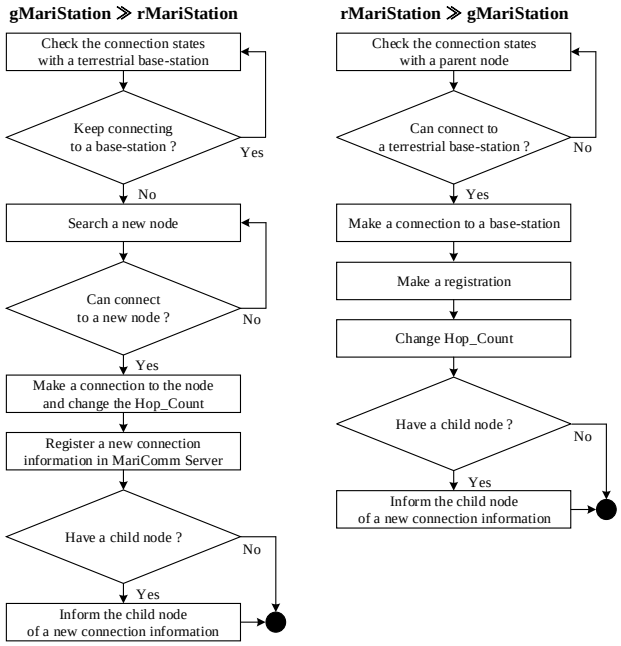

Figure 3. Role switching flow chart in MariComm System

IV. MULTI-HOP RELAY MARICOMM BRIDGE

MariComm bridge controls TAM, SAM, LAM. It monitors the signal quality of TAM, LAM (e.g., RSSI, SNR), manages communication link, bridges heterogeneous and homogeneous nodes, assigns the radio frequency channel of SAM, and exchanges the management information about the maritime network of MariComm server, as shown in Figure 4.

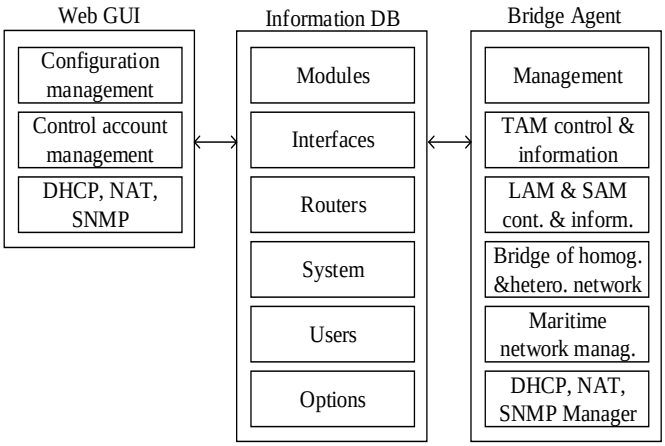

Figure 4. Functional structure of MariComm bridge

A. Web GUI for Management

Web GUI in Figure 5 let the user determine the current and past states of the MariComm bridge, and allow for manual operation. It is expressed in JavaServer Pages (JSP) and operated in Tomcat server.

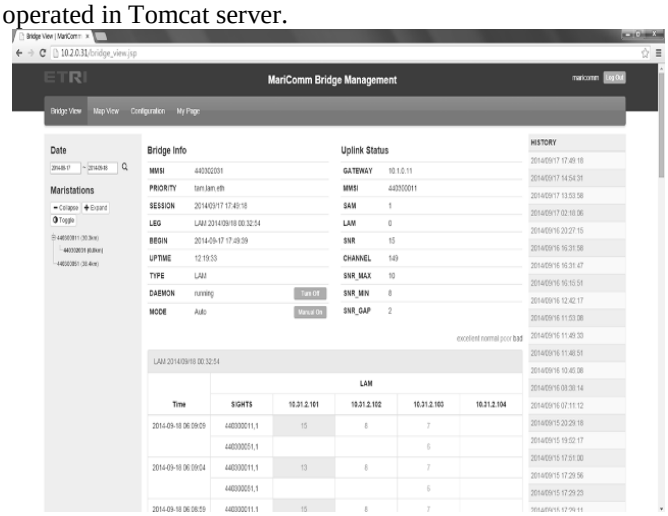

Figure 5. Implemented results of Web GUI of MariComm bridge

B. Information DB of Node Status

Information DB includes state information about the nodes connected to MariComm bridge, and configuration information of MariComm bridge itself.

C. Bridge Agent

Bridge agent performs the following functions.

- Checks the state of the associated node, and chooses the link connection in accordance with its state.
- Writes the state information in the information DB to make it available in the Web GUI.
- Checks the fault of the associated node, and processes the fault information.
- Performs the command delivered by the Web GUI.

D. Network Interface

Network interface of MariComm bridge is shown in Figure 6. Because Ethernet port no. 0 to 2 in Figure 6 are not powered, they are used for TAM and other client node. Ethernet port no. 3 is connected to the uplink network, and no. 4 to 5 are for LAM, SAM, UAM since they have PoE (Power of Ethernet) function.

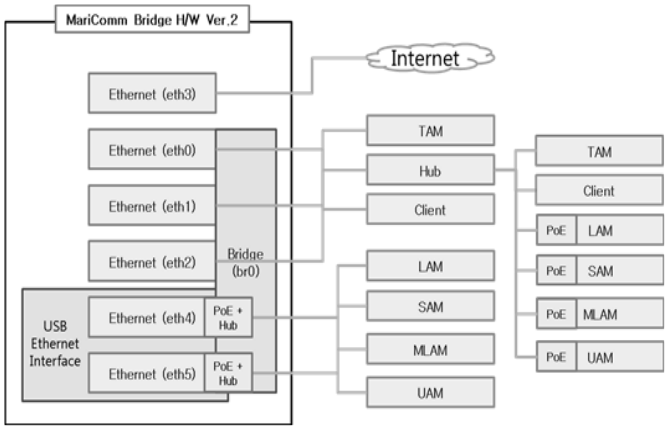

Figure 6. Network interface of MariComm bridge

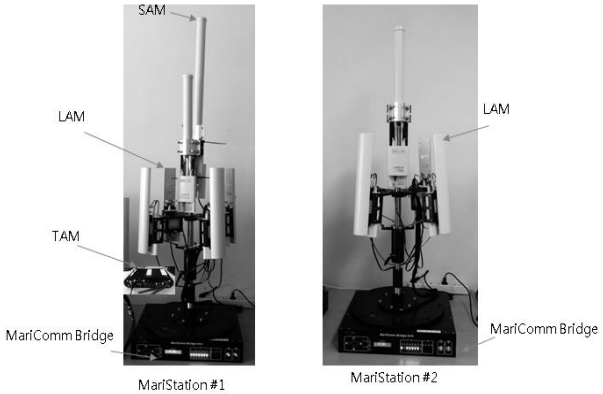

Figure 7. Implemented results of MariComm bridge and Antenna

Figure 7 shows MariStation which consists of MariComm bridge, TAM, SAM, LAM, and several antennas. As mentioned previously, TAM makes a MariComm bridge to be connected to the terrestrial LTE eNodeB, LAM and SAM construct marine communication networks. Antennas of SAM are omnidirectional to play a role of repeater or AP (Access Point) toward another MariStation, and LAM has 4 directional antennas to extend the communication coverage. Therefore, MariComm bridge should explore and choose one of 4 LAM antennas which has the best receive signal strength and SNR (Signal to Noise Ratio).

V. RESULTS OF MARINE TEST

Performance tests of this noble maritime communication system are performed in the Korean southern sea on 4 vessels, as shown in Figure 8.

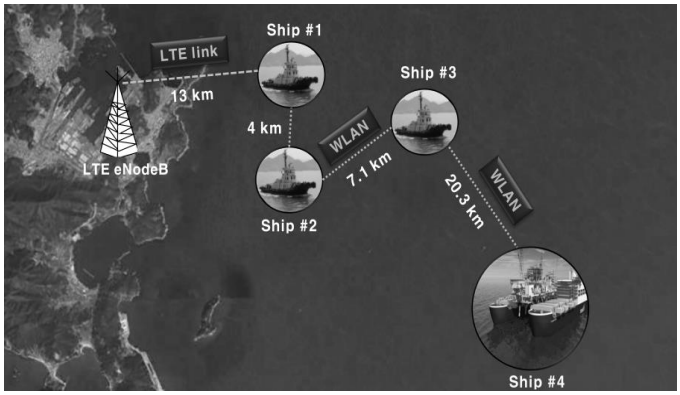

Figure 8. Marine performance test environments

MariStation on ship no. 1 is connected to the terrestrial LTE network, and another MariStation on ship no. 2 via a wireless LAN link. This LTE-WLAN interworking function can be enabled by MariComm bridge functions. Other marine communication link between ship no. 2, 3, and 4 in Figure 8 uses WLAN communication link. Thus, their ships are provided to WLAN based broadband data communication services.

Important communication related parameters of this marine test environment are shown in Table 1.

TABLE I. COMMUNICATION PARAMETERS OF MARINE TEST

Parameter	MariStation			
	Ship #1	Ship #2	Ship #3	Ship #4
Radio access technology	LTE	WLAN		
Freq. band [MHz]	824 - 894	5,825	5,785	5,765
Channel no.	N/A	CH165	CH157	CH153
Bandwidth	20 MHz			
Max. data rate [Mbps]	7.6	4.7	2.2	2.0
Max. distance to parent node	10 km	20 km	20km	20km

Figure 9 shows the result of maximum communication range between ship and shore.

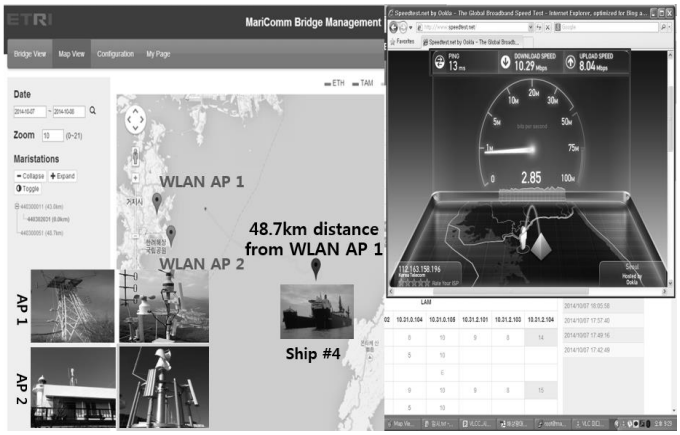

Figure 9. The Result of Maximum Communication Range

As shown in Fig. 9, the maximum ship (ship #4) to shore (WLAN AP 1) communication range is more than 48km, and download data throughput is more than 10Mbps, and upload data throughput is more than 8Mbps, and ping delay is 13ms.

Figure 10 shows the result of multi-hop relay communication.

Figure 10. The Result of Maximum Communication Range

The multi-hop (ship to shore is 1 hop, ship to ship is 3 hop) relay configuration is same to Fig. 8. As shown in Fig. 10, download data throughput is more than 2Mbps, and upload data throughput is more than 1Mbps, and ping delay is 31ms.

The test results show that the MariComm system is able to provide a transfer rate of over 1 Mbps within 100 km from the shore and MariComm bridge successfully supports the multi-hop relay functionalities.

VI. CONCLUSIONS

It is necessary to extend the terrestrial internet services to the sea using multi-hop relay communication techniques. MariStation on the ships of MariComm project could provide global roaming and maritime broadband internet service, which is based on a variety of wireless communication systems of the earth such as WCDMA, LTE, and WLAN etc.

In this paper, we introduced a MariComm Project, and especially showed the MariComm bridge HW specifications and SW architecture for multi-hop relay functions in MariComm System. The test results showed MariComm system is able to provide broadband internet/multimedia services available at a rate of 1 Mbps or more on the sea, and

MariComm bridge successfully performs the multi-hop relay functionalities to extend the communication range within 100km from the shore.

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