MMS: Concepts, Design and Usages

Contents

1 Introduction

MCP (formerly known as the Maritime Cloud) is a communication framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorized maritime stakeholders across available communication systems.

MCP provides interoperability between business entities in the maritime business environments. Maritime environments include maritime, harbor and land. Business entity includes all individuals, corporations, and vessels and equipment engaged in the maritime business.

In the MCP, the elements necessary for providing interoperability between business entities are defined as entity identifier, information about services for providing contents, and data communion infrastructure for using services. These elements are provided through Identity Registry (MIR), Maritime Service Registry (MSR), and the Maritime Messaging Service (MMS).

On the other hand, it is essential that maritime wireless data communication system is used to form and maintain connectivity with shore or other vessels during their voyage to use e-Navigation. Such current maritime wireless data communication system themselves have the following problems to provide connectivity for e-Navigation.

First, the bandwidth of maritime wireless data communication system which can be represented by satellite communication, is expensive and limited compared with the land bandwidth. The e-Navigation service will continue to be provided to the vessel during the voyage, and since the vessel will periodically transmit and receive the information, it is necessary to minimize the bandwidth required for using the service.

Second, if a vessel wants to use multiple e-Navigation services, it must access each service and receive service information. This can cause a lot of unnecessary data communication traffic. In addition, each service has its own communication path, which deepens the service dependency of the vessel system.

Third, in the sea, the communication link can be changed while the ship is using the e-navigation service, because the service area where can maintain the connectivity is different according to the communication link. Therefore, it is difficult to use the service continuously. This phenomenon may occur more frequently in a sea area such as archipelago that may cause interference with non-satellite-based wireless communication.

Fourth, various communication systems are installed in the vessel. It is difficult to exchange mutual information when different communication links or communication networks are used between ships. The e-navigation service provider also has an additional burden to enable the service to be provided using various communication links.

Fifth, it is difficult to deliver selective information in consideration of specific conditions such as vessel location or type. As a result, the vessel receives the unnecessary information from sender which creates a burden to check each one. Communication link generates unnecessary traffic too. In order to prevent this, if service provider separately implements a system for selectively transmitting information, it creates additional burdens related to communication, which is not related to the contents of the service.

Last, it is difficult to confirm whether message for use and delivery of the e-Navigation service has been delivered to the recipient. Current maritime wireless data communication system focused on the transmission of information, which makes it difficult to manage and control quality over whole information delivery process. This is a factor that adversely affects the reliability of the entire e-Navigation service.

Maritime Messaging Service (MMS) is a messaging component that allows authorized maritime stakeholders to send and receive message in an efficient, reliable and seamless manner within the MCP to solve the problems of the current maritime wireless data communication system. The main functions of MMS are: (1) message queue, (2) message relay, (3) selective messaging cast, (4) service call broker (or API-Gateway?) and (5) Quality of service management.

This document is intended to deliver basic knowledge of MMS to enable (potential) key users of MMS, including e-Navigation service consumer and e-Navigation service provider, to fully utilize MMS. For this, this document contains detailed descriptions of design goal and principle of MMS, core functions of MMS, MMS in MCP, trust model for MMS, and typical usage scenario.

2 Design goals and principles of MMS

In order to solve the problems in establishing and maintaining connectivity using current maritime wireless data communication system, the proposed MMS was implemented based on eight design goals and principles: (1) distributed and federated operation of MMS instances, (2) network-agnostic information delivery, (3) securing confidentiality of user-generated data, (4) reflection of communication link usage for connectivity at sea, (5) easy provision and use of location-based service at sea, (6) system design based on up-to-date market standards, (7) incorporation of widely used & proven open source components, and (8) vigilance in quality-of-service (QoS) management. The following sections describe each of them in detail.

2.1 Distributed and federated operation of MMS instances

MMS is designed to be installed and operated as a mutually federated distributed system. Through MMS, users can request or deliver very important information in business. Also, in order to use specific functions of MMS such as group-casting, users sometimes have to share important business information with MMS operators. This situation will be a major obstacle for MMS to become a global connectivity platform in maritime sectors.

This is reflected in the MMS design so that a specific maritime entity or a stakeholder group does not operate the centralized operation by monopolizing the MMS instance. MMS is designed to be installed and operated by all users of MCP including ship owner, shipping company, maritime authority, technical service provider, and maritime service consumer.

2.2 Network-agnostic information delivery

At sea, various communication networks such as satellite, AIS, VDES, 3G/4G, etc. are being used. MMS is designed to allow the ship to maintain connectivity without being dependent on a particular communication system.

For this, MMS identifies the sender and receiver of information by using identifier in application layer which is the top-most layer of OSI 7 layers. This makes it possible to send and receive information without depending on the network locator. Therefore, if any user (or communication device used by the user) of the MMS is designated as a receiver, even if the network locator changes due to a vertical handover or horizontal handover, user can receive transmitted information successfully without being influenced by the change.

2.3 Securing confidentiality of user-generated information

Confidentiality of user-generated information is the core value that MMS, which serves as the medium for information transmission, should provide to users. MMS is designed so that the sender does not check or store the information to be transmitted to the receiver in order to ensure the confidentiality of the information transmitted through the MMS. Therefore, the user can use the MMS without any concerns that information they want to deliver through MMS is exposed to other users, including MMS itself other than recipients.

As described in section 2.1, MMS uses identifier which was generated and used in the application layer of OSI 7 layer to specify sender and receiver of the information. Therefore, MMS which exists in the same layer, can recognize the identifiers of senders and receivers that are recorded in the message header. Nevertheless, the payload of the message contains the encrypted content, so it is not exposed to anyone other than the designated recipient. Alternatively, MMS temporarily store a message passing through the MMS in a queue for message buffering for reliable transfer of information, but it does not store the message for the purpose of archive itself or in the long term for the MMS to retain the information.

2.4 Reflection of communication link usage for connectivity at sea

The MMS fully reflects the characteristics of the maritime communication system and is designed to form and maintain the most effective and efficient connectivity in a changing communication environment.

As described in section 2.1, vessels under navigation would utilize various types of communication networks in order to maintain the connectivity with land at sea and to use the e-Navigation service in the ever-changing environment. In addition, the cost of communication at sea has been (always) relatively higher than the cost of communications on land, and this will not change in the future.

Therefore, there is a need for a method that can minimize communication loss while minimizing loss of information when providing connectivity at sea. The MMS is designed to meet these needs and to be used positively in satellite communication as a key communication link for future maritime connectivity.

2.5 Easy provision and use of location-based service at sea

The e-Navigation, which is the core application area of the MMS, will provide a number of maritime services utilizing the position information of the ship. MMS is designed for a platform where maritime service providers can easily provide location-based services.

Due to the nature of the ship, which is a marine transportation system, the position of the vessel under the navigation constantly changes, and the situation at sea where the vessel is encountered is continuously changed. Changes in the situation of the ship will cause the need for e-Navigaiton service that can support safe and efficient operation, and the service will be provided by using the ship's location information. The MMS enables the maritime service to easily use the location information of the ship when transmitting information to the ship.

On the other hand, the location information of the ship is a very important information asset of the shipowners who are reluctant to share it with others. Therefore, a ship owner may want to operate MMS independently, so that federation of multiple numbers of a

MMSs was considered to provide the MMS with sufficient scalability when designing the MMS.

2.6 System design based on up-to-date market standards

The Web platform and the http(s) protocol are currently used to inform and automate business processes in almost all industries. It is producing a variety of standard solutions that are efficient and well-proven on the market. Therefore, when such standards are utilized, maritime services can be implemented and provided within a short period of time by utilizing mature technologies sufficiently and economically. The MMS is also designed based on the web platform and the http(s) protocol to maximize these benefits, as does the MCP. Figure 1 shows the HTTP(S) header format used when requesting delivery of a message to the MMS.

HTTP Header		
Field Name	Description	Example
srcMRN	MRN of a sender	srcMRN: urn:mrn:smart:service:instance:mof:S11
dstMRN	MRN of a receiver	dstMRN: urn:mrn:smart:vessel:imo-no:mof:12
HTTP Payload		
Message that a sender want to send. Ex) Hello World!		

Figure 1 HTTP Message Format for MMS

2.7 Incorporation of widely used & proven open source components

The MCP has open source software (OSS) license policy. OSS has advantages such as low entry cost, fast and flexible development by using open format and protocols, and independence on specific SW/HW etc.

The MMS, one of core components of the MCP, will also comply with the OSS license policy. At the same time, it is designed to us OSS when developing the MMS. Ultimately, it is expected that a sufficiently validated and widely used sub-component will reduce development time and costs while make it possible to develop high-quality systems.

2.8 Vigilance in quality-of-service (QoS) management

The MMS is expected to be the most heavily loaded of core components of the MCP, a platform for providing connectivity to maritime systems and stakeholders. A large amount of information for using the maritime service will be delivered through the MMS, and many real-time users will rely on information from the MMS to perform maritime business, especially navigation. Therefore, reliability and resiliency in service provision are more important than other core components. Considering this, the MMS is designed to evaluate and manage quality of service.

3 Core functions of MMS

The MMS consists of six core functions, as shown in the picture below (Figure 2). By using one or more of these core functions, the users of the MMS could deliver their e-navigation services to customers efficiently and effectively.

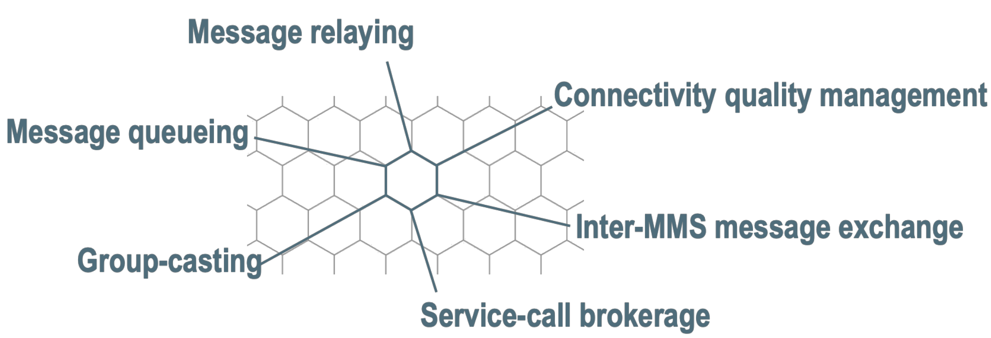


Figure 2 Six core functions

3.1 Message queueing (MQ)

Message queueing is a function that enables ships to use the e-Navigation service efficiently and stably by converting information received from an e-Navigation service provider or other ship, which is an information sender, into a message and storing it temporarily. And then the MMS allows the information receiver, normally ship, to fetch the corresponding message (Figure 3).

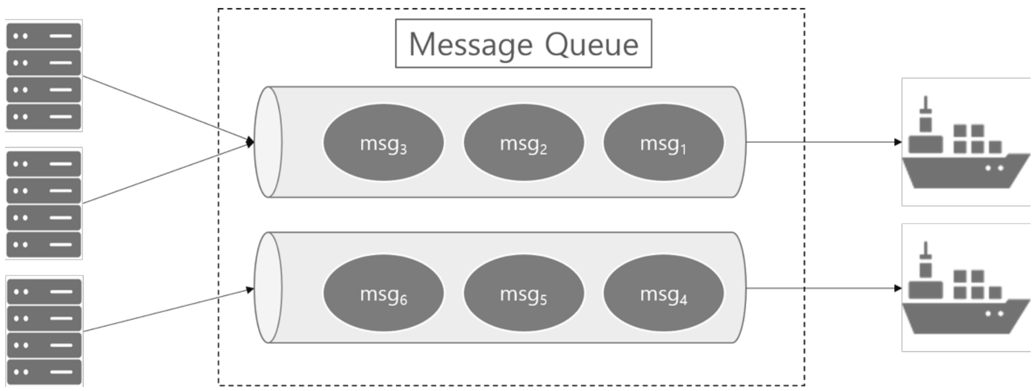


Figure 3 Message Queueing

When using the MMS, we can expect to separate of request and response into two sessions. Therefore, if a service user in the situation that does not receive the information about the requested service caused by the sudden deterioration of the communication situation, which is the characteristic of the maritime wireless communication environment, the MMS allows receiving the response information stored in the message queue after the communication network is restored without duplicated service request. However, since it is assumed that the MMS and maritime service provider maintain a stable connection with the wire, the request message transmitted from the service user side is not stored in the queue separately but relayed to the maritime service provider as soon as it is received in the MMS.

MMS's Message Queue also supports flexible queuing policy settings. By message queueing policy, Message queue designs the message priority, the time that the message is stored in the queue and message structure to be stored in the queue. Currently, the MMS message is provided through a polling method that provides the message when requested by the ship rather than pushing it directly to the ship. With this method, it is possible to provide a message that is not transmitted to the ship through the retransmission request even after the communication of the ship is disconnected and restored.

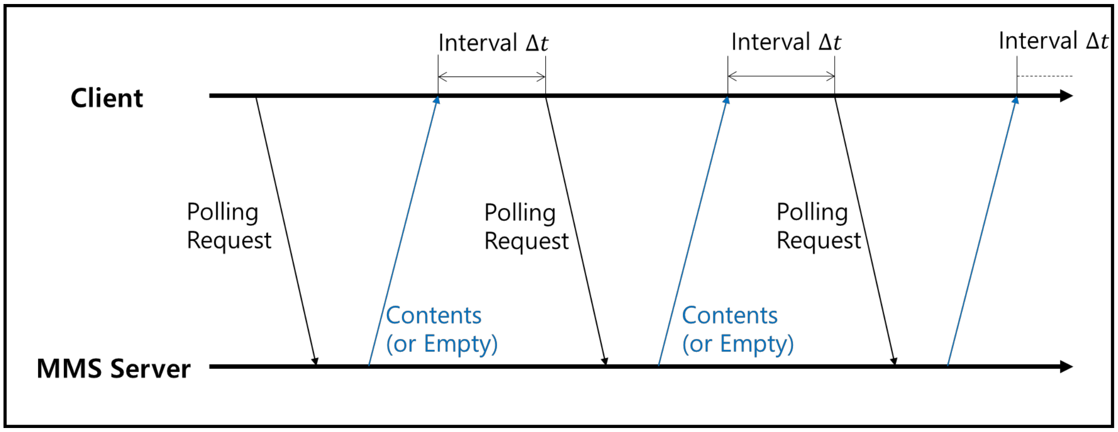


Figure 4 Pure Polling

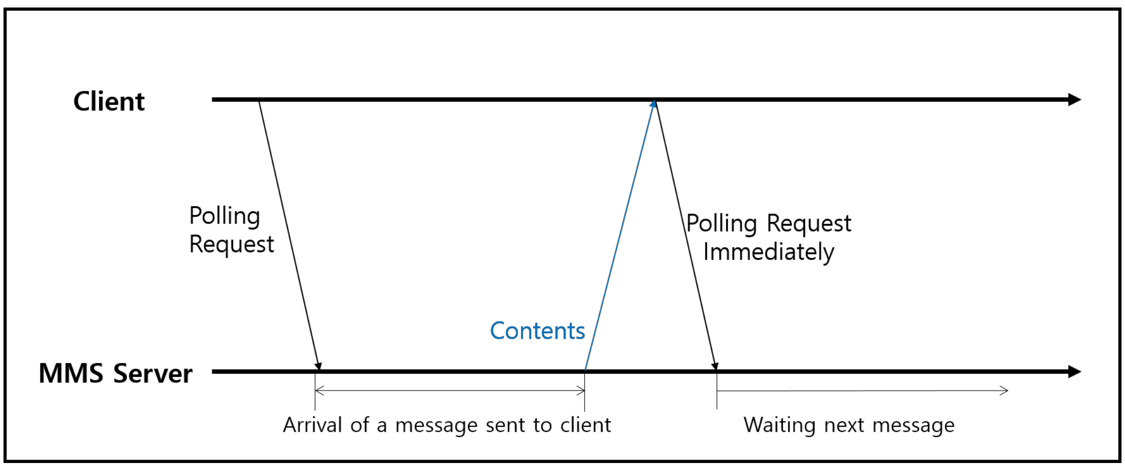


Figure 5 Long Polling

Currently, the MMS supports two polling methods: pure polling and long polling. Figure 4 describes pure polling. Pure polling is a method by which the client checks to see if a message arrives at the MMS for a certain period (Δt). The MMS sends a message in response to a polling request if there is a message directed to the client, and it returns an empty message if there is no message to forward. Pure polling does not require management of client session, but there is network load due to periodic message transmission, server load on client's polling request, and message delay by a certain period even if there is no data to be delivered by client.

Figure 5 describes long polling. Long polling is a method in which a client sends a polling request and MMS server waits until it receives a message directed to the client and responds when the message arrives. The client sends a polling request as soon as the message is returned. Long polling responds to a polling request only when there is a message directed to the client, and sends the message to the client when the message arrives on the MMS. Therefore, the network load is less and the delay time of the message is less than the pure polling method. However, since the management of the client session is required in MMS, the server load and server complexity are increased. Long polling is a proposed method assuming that the service user is unlikely to accept the push method. Also, MMS implementation supporting push method is being considered.

3.2 Message Relaying (MR)

Message Relaying in the MMS is a function that allows a message to be delivered to a recipient without depending on a network locator based on a unique identifier defined by Maritime Resource Name (MRN). In a maritime situation where the ship's Network Locator may change, sending a message that is dependent on the Network Locator may cause problems in reliability of information transmission. This is solved through message relaying.

Every MCP user has a unique identifier. Maritime Resource Name (MRN) is used as a unique identifier to uniquely identify maritime resources. MRN is defined by IALA and follows the Uniform Resource Name format defined by the IETF standardization body. The MMS performs message delivery based on the MRN of the MMS user. If the message sender specifies the MRN as the destination and sends the message to the MMS, the MMS delivers the message to the current Network Locator of the MMS user using the Casting Manager which has the Network Locator information for MRN.

Changing the maritime communication means changes the Network Locator of the ship. If the Network Locator of the destination ship to which the message is delivered is changed in a situation where the sender is unexpected, the message delivered to the ship's previous Network Locator cannot be delivered to the ship. Here, the Network Locator indicates the address on the network where the communication system can receive the message at it. In the IP Network, IP address is the Network Locator of the network. Therefore, to receive a reliable message, a message must be transmitted based on a unique identifier rather than a network locator.

The current version of MMS is implemented to support pure polling and long polling, but the design for message relaying supports push as well. A ship can utilize various communication systems at sea and the network locator to be coupled with the ship is changed accordingly. Therefore, real time tracking of the network locator and mapping with MRN are essential if push mode is supported.

In order to deliver the MRN-based message to the MMS user, it is necessary to define the Source MRN and the Destination MRN in the header of the HTTP message via the MMS. In the IP network, the destination is the destination IP address. As shown in Figure 6, the destination IP address of the client using MMS is MMS, and the specified destination MRN is the end point to which the actual message is transmitted. For example, even if the ship's IP address changes, the ID is a fixed value, so messages destined for the ship's ID may be directed to the changed IP address. Therefore, in order to support the push mode, the MRN should be transmitted as a unique identifier to the user designated by the MRN by inquiring and utilizing the latest network locator mapped to the corresponding identifier.

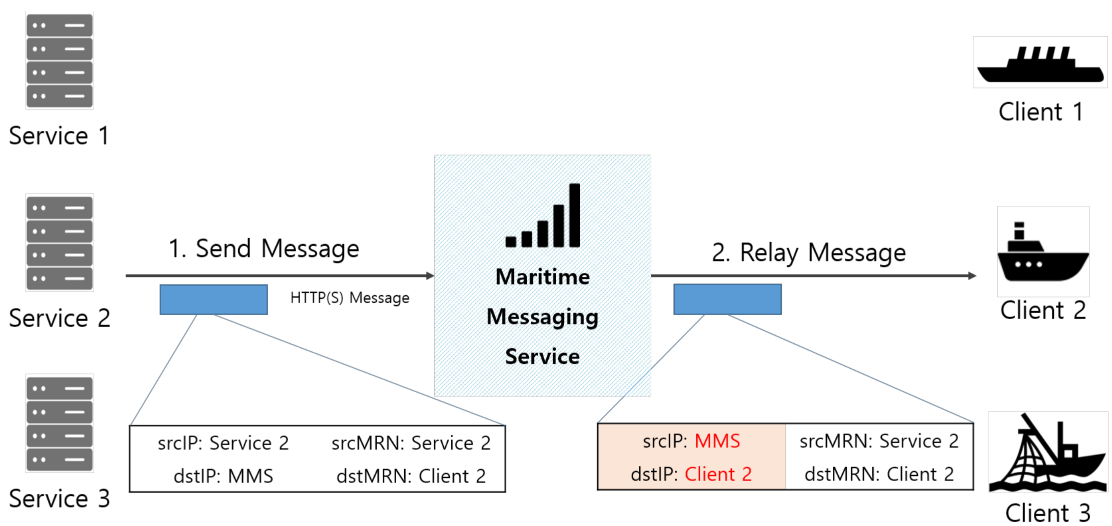


Figure 6 Message Relaying in push mode

3.3 Group-Casting (GC)

Some maritime services can provide information to a group of users (or vessels) that meet certain conditions. If each maritime service provider is required to carry out screening of vessels to be served, the respective provider must have the necessary information. This will put a heavy burden on maritime service providers. Group-casting is a method of selecting a single or multiple selected recipient(s) that satisfy a given condition by using the corresponding information.

In order to provide Group-Casting (GC), service utilization and supply contract must be made between maritime service consumer and maritime service provider. In addition to this, both the service provider and the service consumer must agree that information or message generated by service should be delivered through MMS. In this way, mutual contracts and agreements are made between a service consumer, a service provider, and an MMS. Then service consumers provide MMS with the information to be used for selection of recipients list in. The service provider sends the information to the MMS, and the GC is carried out by means of multiple uni-casts by MMS.

Typically, digital information has been broadcasted at sea. Although this is advantageous in terms of communication network traffic, information recipients will need to select the information they need, as it will bring unnecessary information along with it. If GC is used, the problem could be solved by sending the information only to users who need it.

A typical example of GC is geo-casting. Geo-casting means casting a message to maritime entities in a particular geographical area. Geochrono-casting can be considered as a more advanced form of geo-casting. This means casting a message to maritime entities that will be located at a specific geographical area after a certain time. Geocasting is a simple example of geochrono-casting.

By the way, when a message is transmitted using the GC, the sender can not specify the recipient of the message. Therefore, there is a problem that the sender cannot encrypt the message at the time of sending the message to the MMS. Also, the location information of the receiver, which will be mainly used as a ship in GC, is likely to be used as key information in grouping. However, the location information of the ship is a core information asset of the shipping company and there are properties that do not share well. Therefore, GC is much more useful when sending messages that do not require encryption to multiple users or when shipping company directly operates the MMS.

3.4 Service Call Brokerage: API-Gateway

As described above, the current MMS mediates the HTTP message between the sender and the receiver by using the MRNs of the sender and the receiver. In order to subscribe the maritime service through MMS, the service consumer should find the MRN of the service provider. Then, the service consumer creates the HTTP message containing the header MRN as the source MRN and designating the MRN of the service provider as the destination MRN.

The maritime service subscription based on MRN is advantageous in that service request and service related information transmitted and received between the service consumer and the service provider are not exposed to the MMS. Nevertheless, at present maritime services cannot make service requests using MRN directly. This is because the maritime services developed so far have not been implemented considering the use of MMS.

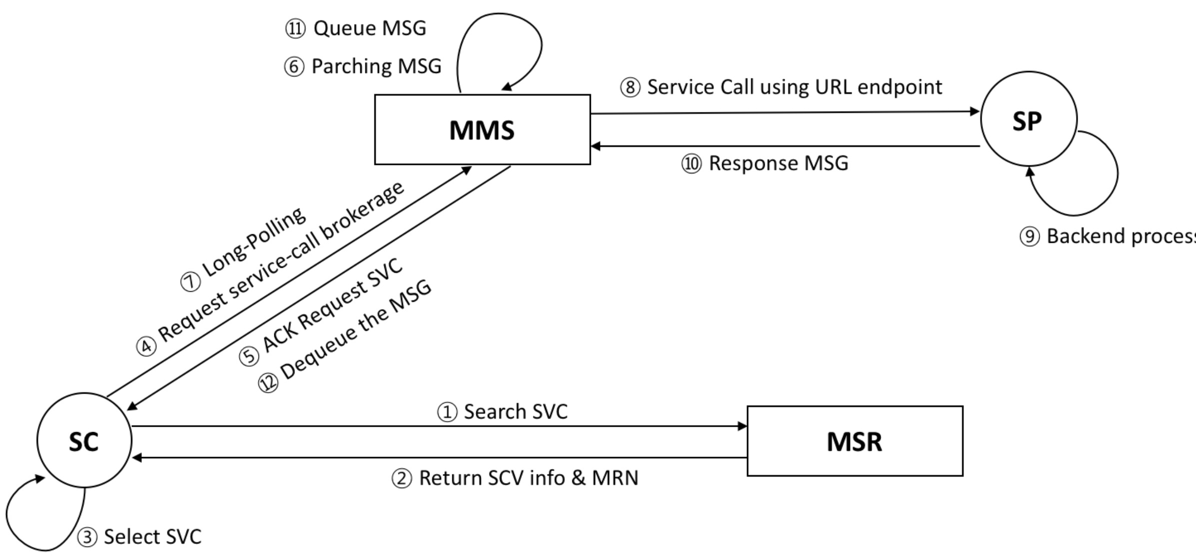


Figure 7 Interactions in service-call brokerage

To solve this problem, the MMS provides a service call brokerage (SCB) function which acts as a gateway to call the url based API of the maritime services developed so far (Figure 7). SCB works as follows. First, the MMS receives an HTTP message for the service call brokerage request containing the service request string based on the url in the payload from the service consumer. Then, the MMS acts as a service consumer and requests the url based maritime service using the service request string contained in the payload of the message. In response, the maritime service sends the response string to the MMS. The MMS creates an HTTP message by putting the corresponding string in the payload, setting the source MRN to its own service call brokerage MRN and the service consumer calling the service call brokerage to destination MRN respectively. Finally, the message is delivered to the service consumer by polling of the service consumer or pushing by the MMS.

SCB has several advantages. The service provider maintains its own service delivery method, and the terminal manufacturer for service use interacts with the MMS to implement the system in a standardized service usage manner. In addition, Maritime service providers can provide services in an existing way without converting them into a method based on HTTP messages of MMS. However, if SCB is used as described above, there is a disadvantage that information for service request is directly exposed to MMS. Therefore, it can be said that such shortcoming does not occur when the ship owner operates the MMS directly or highly trusted maritime entity does it.

3.5 Message Exchange with Other MMSs

The MMS is designed to work in conjunction with distributed systems. Although there is only one logical MMS on the globe, it can be said that there are many MMSs physically all over the world. That is, the MMS used by each user may be different, and therefore, a mechanism for sending and receiving messages between the MMSs to be physically installed and operated is needed. To this end, the MMS uses the concepts of "Home-MMS" and "Visited-MMS."

Users of MMS, i.e. SP and SC, register their Home-MMS respectively that is used when an MMS, which they do not use, forwards messages bound for them. Home MMS is the default MMS for each SC and SP. Home MMS is a frontend MMS where each user sends and receives a message. If the designated recipient does not exist in the MMS that received a message directly from a user, it forwards the message to the Home-MMS of the recipient (

Figure 8)

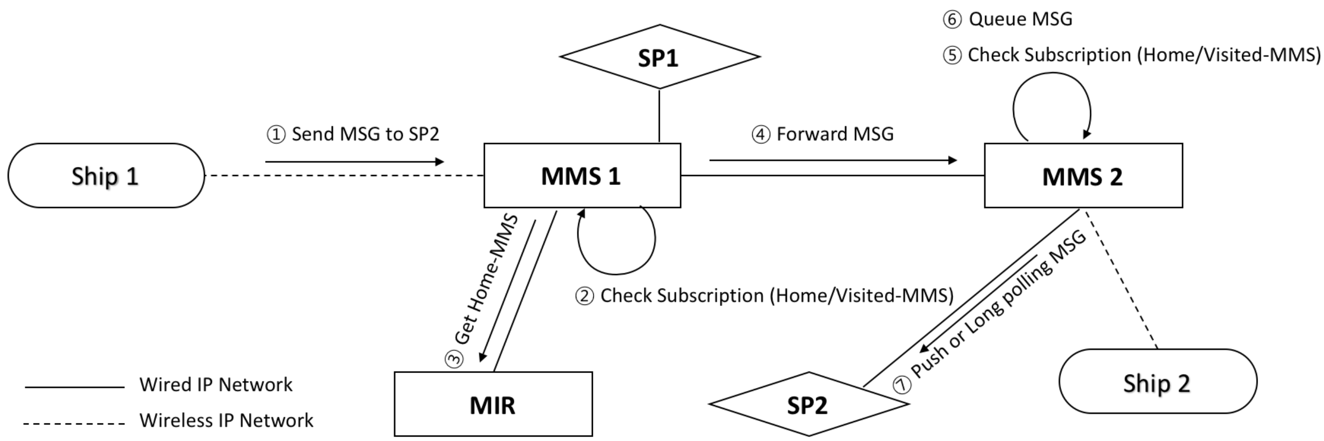


Figure 8. Federation between MMSs

When SP or SC is using an MMS which is other than their Home-MMS under certain situation such as non-ip network access, the concept of Visited-MMS is used to designate the MMS SP or SC is currently accessing to exchange messages with other SPs or SCs. In this case, when the SP or SC accesses the MMS that it wants to use, it sends a message to the MMS that it will be used as Visited-MMS, the MMS registers the user in its own visitor list and sends the same message to the Home-MMS. The concept of Visited-MMS is useful when the SC cannot access its Home-MMS due to network accessibility, or to specify an MMS for temporary use for a specific purpose, such as seamless roaming. Information on each MRN's Visited-MMS should be registered on its Home-MMS and its current Visited-MMS simultaneously.

3.6 Connectivity Quality Management (CQM)

MMS is a gateway through which HTTP messages using MRN as an identifier for sending and receiving in Maritime environment pass. The MMS is where the URL-based maritime service Request & Response is switched to that based on MRN. It is also where information is exchanged between maritime service providers and consumers, where messages are stored in queue or relayed, and GC is performed according to various criteria. Therefore, it is necessary to analyze the logs in the MMS and monitor the messaging status or the connection status of the ship in order to grasp the message operation status of the MMS (Figure 9).

MMS provides log analysis and monitoring functions to administrators as part of connectivity quality management (CQM). Logging allows the MMS manager to check the status and events of the MMS. Maritime service provider and service client system developers can use to improve service and client quality.

Logs used in MMS support existing standard internet protocols or compatibility with external components by applying widely used methods. The log used in MMS needs to determine a log level and log format because it has to deliver accurate event contents. Since the ship has mobility, when recording the event of the ship to be logged, MRN is used as session information, not the source IP or destination IP.

For MMS monitoring, log events can be filtered and viewed according to their importance. For this purpose, we defined the log level which shows the importance of log. MMS log should have high log level or high priority if high severity, low log level or low priority if low severity.

In addition, the MMS Monitoring Service provides a web interface to enhance accessibility and ease of use for users. The main page of the Web service provided by the MMS Monitoring Service is configured as shown in Figure 9. We will also provide various QoS tools by setting various indexes and indicators related to QoS in the future.

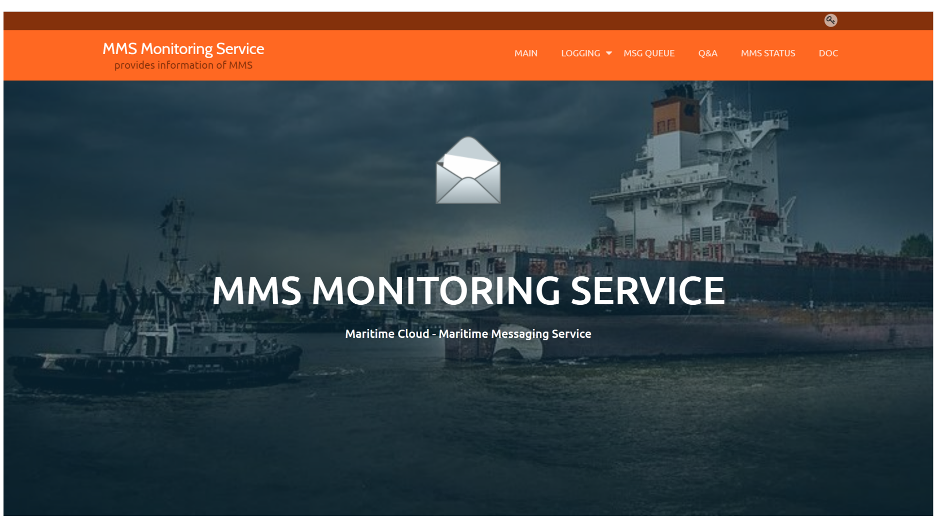


Figure 9 MMS Monitoring Service

4 MMS in MCP

As is known, MCP has MIR, MSR and MMS as core components. Basically, MMS is responsible for information exchange between SP and SC. MIR provides the necessary functions for user authentication and information protection while using MMS. The MRN allocated to each user including machine in MIR is used as the value of source MRN and destination MRN indicating the sender and receiver of service request and response HTTP message transmitted to MMS (Figure 10).

In addition, when a service consumer requests a service using MMS and fetches the information transmitted from the service, the MMS authenticates the corresponding service consumer using MIR.

MSR is a registry that provides information about the maritime service. The SC retrieves the service from the MSR and obtains the MRN of the service to be used. The obtained MRN is used as an identifier of the target service when requesting a service. In particular, MRN can be a more appropriate choice as a service identifier when considering the versatility and uniqueness aspects of url, which is an identifier specific to an ip-based network.

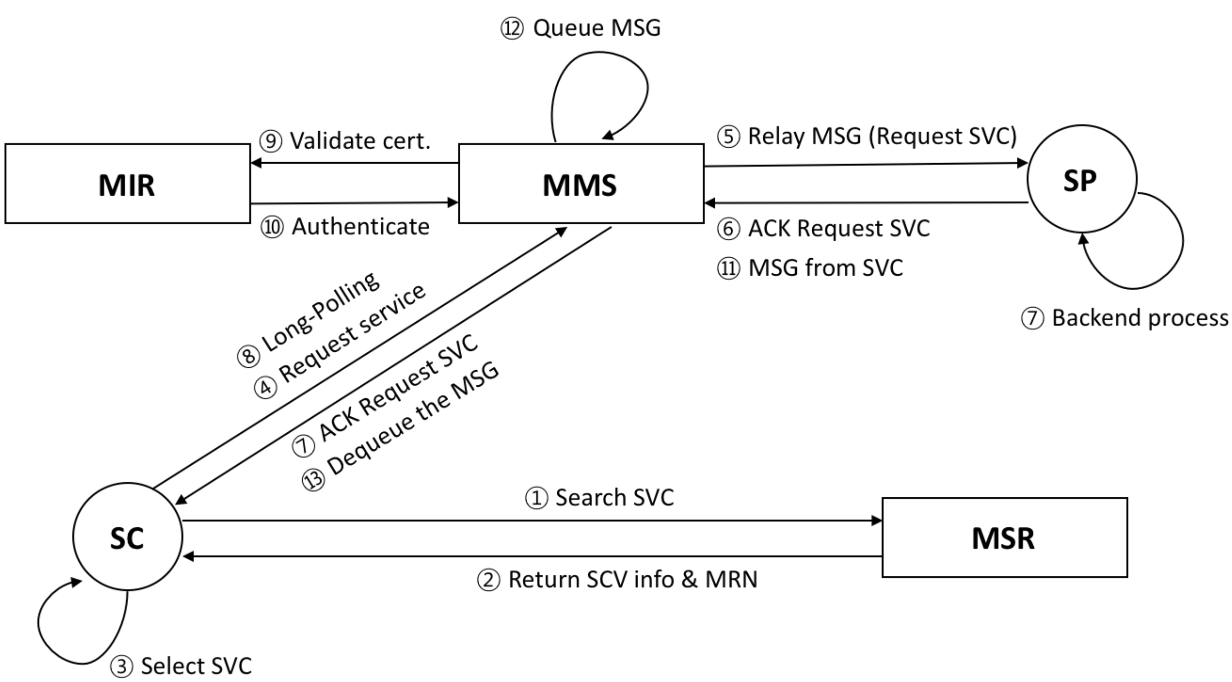


Figure 10 Interaction among MIR, MSR and MMS

On the other hand, if shipping companies want to operate MMS for their own vessels as it has been expected during the design and implementation of the MMS, ultimately a large number of MMS instances will be operated and federation between MMS instances is important. To do this, it is necessary to register each MMS instance as a service instance in MSR and its URL-based endpoint should be shared with other MMS instances and SCs.

Also, in order to seamlessly link MMS messages, Home-MMS information should be managed for each MRN. It is necessary to store the information in the MIR. For this, we can consider to allow the certificate and token to contain the information, or to allow the MMS to directly transmit a query for the Home-MMS informatin to MIR.

5 Trust model & security in MMS

5.1 Trust among SC, SP and MMS

When MMS is used for provision and consumption of maritime service, the trust models to consider are: (1) trust between SC and SP; (2) trust between SC and MMS; and (3) trust between SP and MMS. The trust link between MMSs will make trust link among between subsidiaries of the MMSs as well (Figure 11).

First, the trust between SC and SP is obviously related to authorization and payload encryption / description as the basis of all maritime service usage. The point of time when the trust information between SC and SP is applied to the use of MMS is what requires technical troubles. If an SC that could not obtain an authorization to use the service from the SP repeatedly requests the SP to use the service through the MMS, the federated MMS network will repeatedly receive the unnecessary traffic load correspondingly. To solve this problem, a continuous or deliberate service request of an unauthorized SC is notified to the corresponding home MMS at an appropriate time so that unnecessary message forwarding between MMSs can be prevented.

The trust between the SC and the MMS is formed when the SC registers the MMS with its home MMS and submits its own information necessary for using the MMS, and the MMS performs the related authorization operation to the corresponding SC. The SC then posts an HTTP message to its home MMS for a maritime service request and polls its home

MMS to receive information from the maritime service. If the SC is in a push-enabled network, the MMS pushes the message from the maritime service to the SC. When the SC and the Home MMS are owned by the same stakeholder, a maximum trust can be formed between them. For this reason, shipping companies are expected to make efforts to operate their own MMS.

The trust between SP and MMS is formed similar to the trust between SC and MMS. The SP needs to register the specific MMS with its home MMS and submit the information to the MMS for the SP to forward the HTTP message from the MMS. Then, the information requesting the maritime service of the corresponding SP is transmitted to the SP only through the corresponding home MMS. Unlike the SC, the SP does not need to submit business-sensitive information for message reception. Therefore, maximum trust can be formed even if SP and Home MMS are different. Therefore, it is expected that SP will not try to operate MMS that dedicate itself.

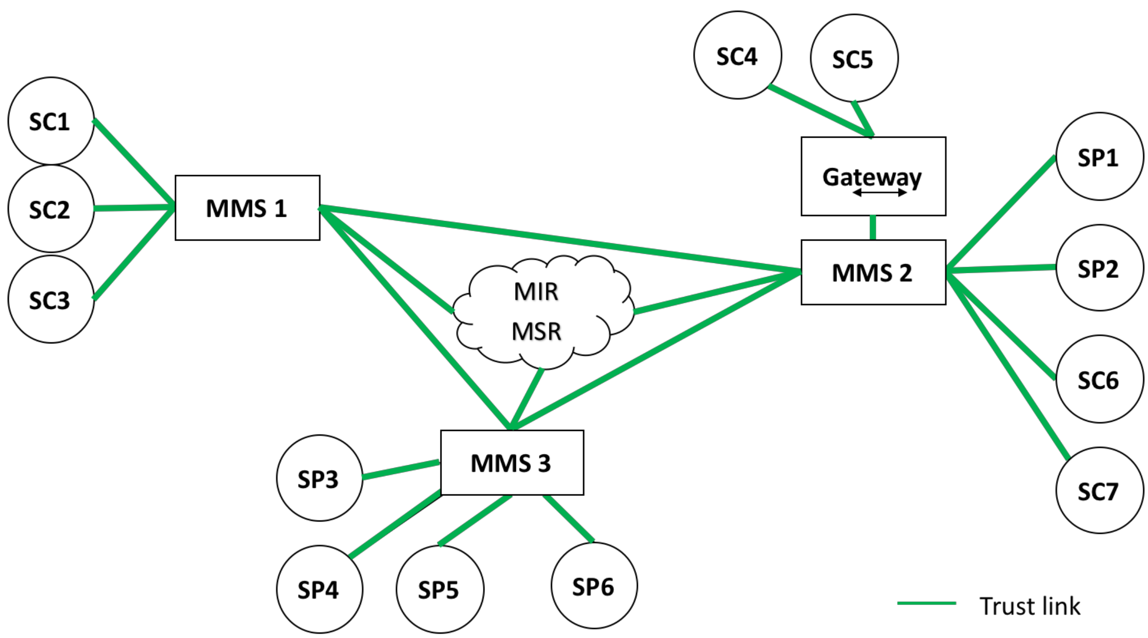


Figure 11 Trust construction with MMSs

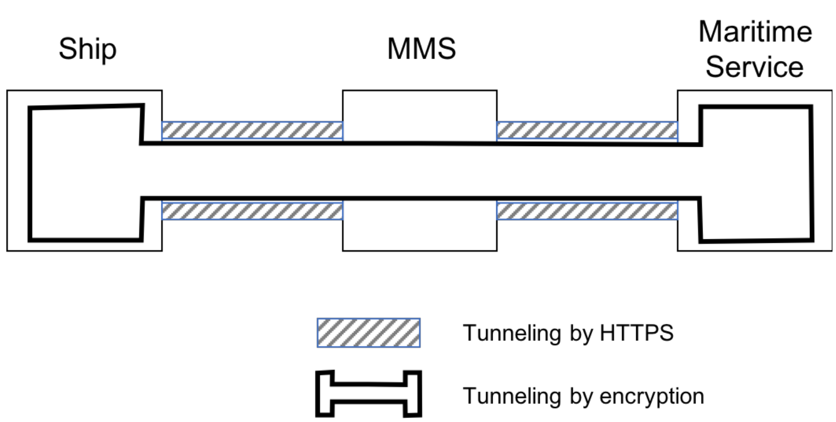
5.2 Security Policy of MMS

MMS acts as a message hub for maritime service provision and consumption. To ensure the best service quality in terms of security, MMS has four security policies.

First, only users registered in MIR can use MMS. If the source MRN and the destination MRN recorded in the HTTP message header are not registered in the MIR, the MMS may deny message transmission and reception for the secured and reliable operation of the federated MMS.

Second, the right to send a message and the right to receive can be given separately based on a certain condition. The MRN specified in the Source MRN shall be the MRN of the user holding the message transmission right, and the MRN specified in the destination MRN shall be the MRN of the user capable of receiving the information. This policy will be more useful if future MMS is used as a connectivity platform of maritime IoT.

Third, SC-MMS and SP-MMS communication guarantee end-to-end security and is not exposed to message MMS exchanged between SC-SPs via MMS (Figure 12).



Finally, if a message that may adversely affect the stability and health of the MMS intentionally or continuously invades the MMS, it detects and protects the invasions.

Figure 12 Tunneling scheme in MMS

6 Usage scenarios

This chapter describes how the SP and SC can use the MMS functions described above in maritime service provision and consumption. In Section 6.1, the relationship model among MMS, SP and SC is described first, and the detailed usage scenarios are described by combining the functions of MMS from section 6.2 to section 6.6.

6.1 Topology map of MMS, Service Provider and Service Consumer

As described above, MMS is designed to be installed and operated as a distributed federated system. Therefore, SPs and SCs can utilize MMS for their provision or subscription of maritime services in a form that best achieves their business objectives, such as minimizing communication costs or maintaining business information confidentiality while guaranteeing sufficient connectivities among all SPs and SCs on the globe. MMS has three types of operation model: (1) MMS operated by service SPs, (2) MMS operated by SCs, (3) MMS operated by neutral organizations to SPs and SCs (Figure 13). The present method of delivering services directly to the SC without using the MMS is not included in the contents of this document because it cannot be regarded as a form of using the MMS.

An MMS operated by the SP is used to collectively respond to the SC through one gateway without directly responding to the SC when the maritime service is provided. In this model, SC regards MMS in the same trust chain of SP. SC will periodically receive information from the maritime service while navigating. Using the long polling function provided by the MMS, the SC can obtain the best information update period with minimum cost. In addition, the SP can provide a plurality of maritime services to the service user. If the MMS is utilized in providing the service, the URL-based endpoint of each service is not exposed. SMART-Navigation, which is being implemented in Korea, will provide services to SC by using MMS.

An MMS operated by a SC can be used when a SP does not provide maritime service via MMS, or when the SC tries to subscribe maritime service under optimal conditions in its own efforts. A typical example would be an MMS operated by a shipping company. Group-casting of information based on the ship's position or voyage plan is a very important function for the best use of maritime service. In this case, MMS must be able to use the information. However, shipping companies believe that sharing such information with outside organizations is a major threat to their business. Therefore, a shipping company may operate its own MMS to provide maritime service through the MMS to its fleet so that its fleet can use its maritime service in the optimal way without releasing important business information to the outside.

The MMS based on the final operation model is an MMS operated by an organization or company that is widely accepted by sufficiently neutral in the market. This is useful when the SP or SC does not have the ability or need to operate the MMS on its own initiative. In addition, it is an MMS operational model that can be established when a company specialized in communication services such as satellite communication service providers plans to provide a communication service combined with maritime service contents.

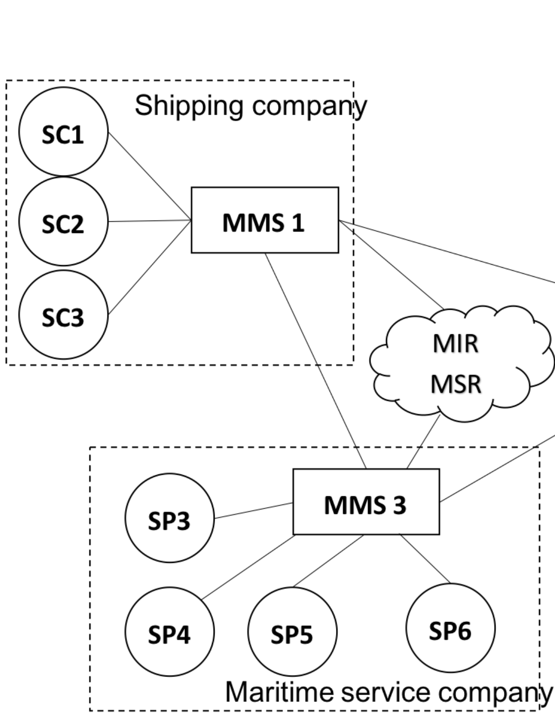


Figure 13 Topology map of MCP and MMSs

6.2 E-Navigation service subscription

The most basic usage scenario of MMS with the operational model described in 6.1 is e-Navigation service subscription. If we use message queue and relay function of the MMS, it allows ships to receive navigation-related information at the best timing with a sufficiently low communication cost.

Figure 14 shows the problem that occurs when a ship, which can be regarded as the minimum unit of SC, scribes e-Navigation services without using the MMS. If the MMS is not used, the ship shall individually regularly with some interval access all e-Navigation services under subscription to ensure that there is information to be transmitted to it. There is no doubt that the higher the rate of no information to be transmitted, the greater the amount of wasted communication resources caused by unnecessary communications. You can consider using long polling to solve this problem, but it is not a factor that SCs decide, but a factor that SPs decide, so it is difficult for SCs to consider long polling as a solution for the ineffective communication problem. Also, since SPs must support long polling for all the SCs of each service it provides to solve this problem, SPs could think that the additional resource requirements on the server side may become excessive.

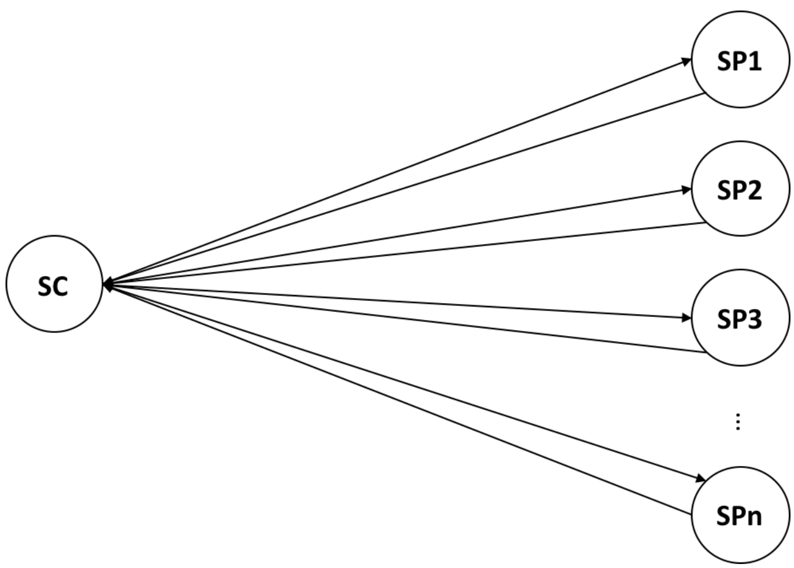


Figure 14 Maritime service subscription without MMS

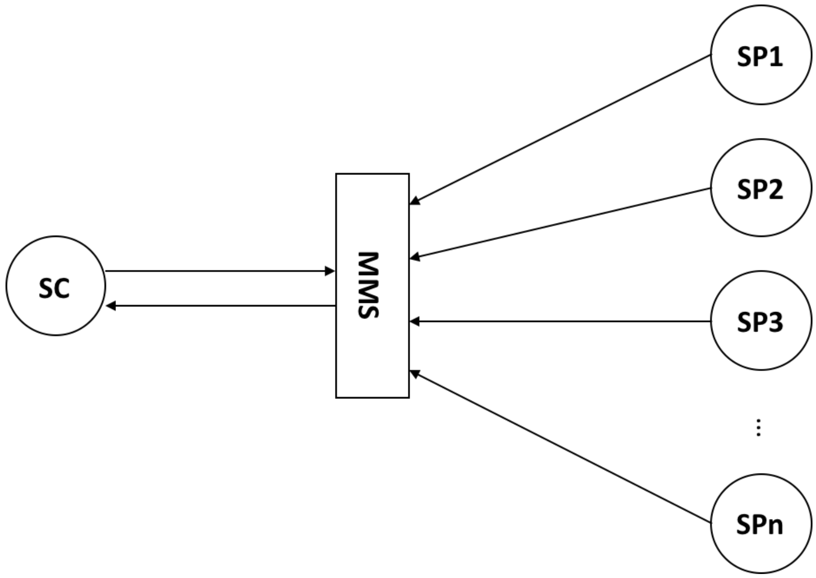


Figure 15 Maritime service subscription with MMS

On the other hand, if either the SP or the SC uses MMS, the e-Navigation service can be provided or subscribed much more efficiently. As shown in Figure 15, when the SP provides information, MMS can be used to push it to the MMS as soon as it has information to be delivered to the ship. Since the MMS basically supports long polling, ships will be able to take it immediately right after a message arrives at the MMS.

6.3 Geochrono-casting

A typical example of group-casting described in Section 3.3 is geochrono-casting. Geochrono-casting allows only those ships that existed, existed, or existed in a particular geographical location for a specific time to poll a message by inserting the message in the message queue of each ship. Geocasting, which was presented at the beginning of MCP development, is a case in which ships are grouped according to certain geographical condition without considering time condition (Figure 16). Figure 17 shows the http message format for geocasting.

On the other hand, as mentioned above, securing the position information and the voyage information of ships to be used for geochrono-casting is very important for the shipping business. Therefore, geochrono-casting will be easy if an MMS instance is installed and operated by shipping companies. In this case, it will be also possible to groupcasting with various conditions by using all information about the ship which is acquired and maintained by ship owners in addition to geochronical conditions.

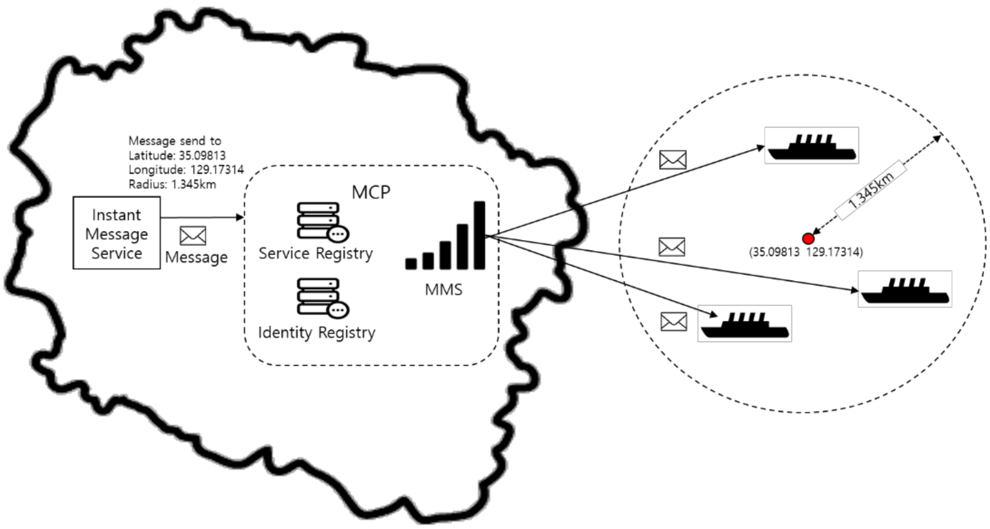


Figure 16 Geocasting function of MMS

HTTP Header		
Field Name	Description	Example
srcMRN	MRN of a sender	srcMRN: urn:mrn:smart:service:instance:mof:S11
dstMRN	MRN of MMS	dstMRN: geocastingMRN
geocasting	Marking of geocasting message. If it is geocasting message, the value “true” is put.	geocasting: true
lat	Latitude in hddd.ddddd°	lat: N35.09813
long	Longitude in hddd.ddddd°	long: E129.17314
rad	Radius in ddd.ddd KM	rad: 1.345
HTTP Payload		
Message that a sender want to send. Ex) Hello Geocasting!		

Figure 17 Message format of Geocasting

6.4 Network-Agnostic Message Exchange

The most primitive usage scenario of MMS is that one ship delivers the message to the other ship using the id of the other party that it knows. Until now, the most common method for exchanging information between ships at sea was voice communication using the same wireless communication channel. However, there is a growing need to exchange information between vessels using data communication in situations where various navigation equipment capable of processing digital information is installed and operated on the ship.

Using MMS, digital information can be transmitted and received between a sender and a receiver even if they use different data communication systems without subscribing any SP. For example, if a ship sends a route plan in the RTZ format to another ship to MMS by using satellite communication, the recipient ship could display the route plan of the sender ship on the navigation support equipment that was transmitted by the MMS through LTE communication. This makes navigator know the intended route of the target ship more easily and accurately. Thus, using MMS, it is possible to exchange information between vessels irrespective of whether or not they use the same communication channel (Figure 18).

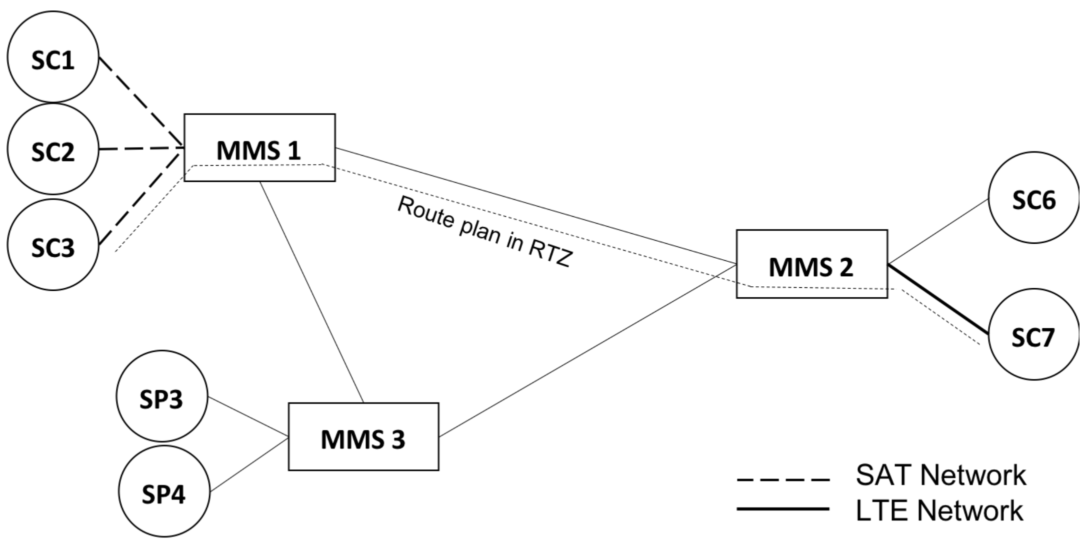


Figure 18 Network-agnostic message exchange via MMS

6.5 Multi-modal Seamless roaming (MMSR): vertical handover & buffering

As it was described in the beginning of this document, at the sea, the communication link can be changed while the ship is using the e-navigation service. Therefore, it is difficult to use the service continuously. And various communication systems are installed in the vessel.

The e-navigation service provider also has an additional burden to enable the service to be provided using various communication links.

By combining the message queue and message relay function of the MMS in addition to the message exchange function between MMSs using Home-MMS and Visited-MMS, the MMS is able make SP to provide SC with services without any interruption even if the SC changes the network it uses while the service is in use.

Typically, seamless roaming is a marketing term that collectively refers to vertical handover and horizontal handover (Figure 19). Vertical handover in which a user's communication terminal is automatically registered in a heterogeneous network without any additional work on the user's side to receive communication services. Horizontal handover in which a user can be connected to a network without interruption when the user communication terminal moves from a base station to another one in the homogeneous network.

The seamless roaming provided by the MMS is different from the normal seamless roaming in which the user of the service is emphasized. It enables an SP to provide an SC with uninterrupted maritime service even if the SC carries out vertical handover during its service access (Figure 20).

In other words, if the MMS is used, an SP can provide services in the same way without any technical considerations or measures, whether the ship is requesting service through an IP-based network or a non-IP-based network. Also, even if information transmission to the ship is inevitably delayed according to the user's communication environment, the MMS enables the information provided by the SP to be transmitted to the ship through the buffering function without loss.

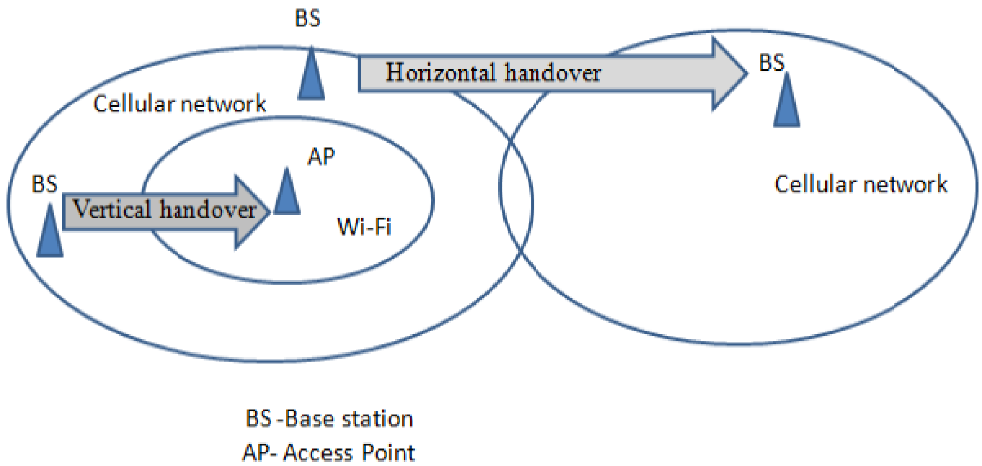


Figure 19. Horizontal and vertical handover[1]

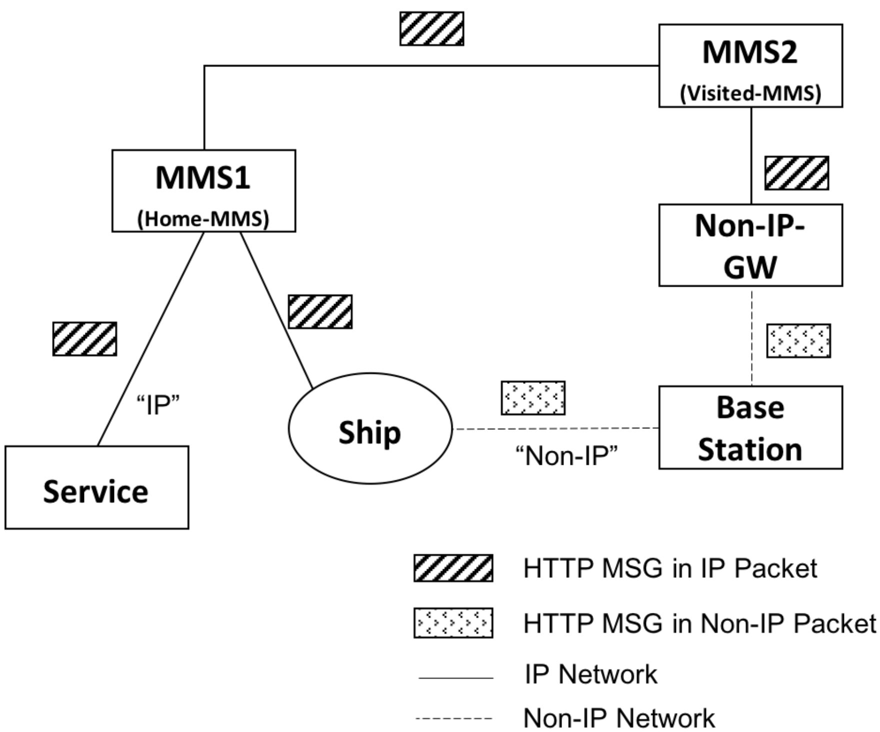


Figure 20 Seamless roaming via MMS

[1] *International Journal of Computer Applications (0975 – 8887) Volume 105 – No. 11, November 2014*