Deliverable 3.3

Input to international fora on conceptual model

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Review

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Contents

"This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 636329".

1 Maritime Cloud Conceptual model submitted to IALA

A conceptual model for the Maritime Cloud was developed in the beginning of the EfficienSea2 project and submitted to INEA as deliverable D3.2. It was then the intension to submit this document to an appropriate international organisation in the pursue of pushing the Maritime Cloud concept to the international e-navigation community.

The conceptual model was submitted to IALA's e-Navigation committee's 19's session on the 19'th of August, and the content was presented and discussed in the committees working group on Harmonisation during the committee meeting taking place from the 19'th of September to the 23'rd.

In addition to the conceptual model, documents describing the Maritime Cloud service specification standard with examples, and a whitepaper on ID management and security was also submitted to IALA.

The authors of the documents was the Maritime Cloud Development forum (MCDF), which is a group of organisation that coordinates the development and use of the Maritime Cloud between the two EU projects EfficienSea2 and the STM validation project and the Korean SMART navigation project.

Feedback from IALA was captured, and IALA requested the organisations to resubmit revised versions of the documents for the next committee meeting in spring 2017, which the MCDF agreed to do.

Enclosed is the conceptual model document as it was submitted to IALA.

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Maritime Cloud – Conceptual Model

1 SUMMARY

The Conceptual Model describes the key concepts, data flows and components forming the Maritime Cloud. It is the point of reference for all subsequent more technical tasks targeted at both technical and non-technical audience.

The bulk of this document has been produced in the EfficienSea2 project (co-financed by the European union) and the document therefore has the main focus on the elements of the Maritime Cloud that will be developed in this project. This document may be further updated in the future to strengthen the descriptions of other elements of the Maritime Cloud.

For clarity it should be stressed that 'services' in the context of this document are 'technical services'. This could for instance be a service that provides the digital information about weather forecasts in a specific geographical area. It would not be the provision of pilotage in an area, which is also a service, but this would be considered an operational service.

1.1 Purpose of the document

Giving the Committee a broader understanding of the concepts of the Maritime Cloud.

1.2 Related documents

Specification guideline for Technical Services (also submitted to eNav 19)

Identity Management and Cyber Security (also submitted to eNav 19)

2 BACKGROUND

The Maritime Cloud is an initiative towards providing infrastructural functions such as supporting the concept of a digital maritime identity. Three multi-partner projects, the EfficienSea2 project, the STM validation project (co-funded by the European Commission) and the Korean SMART navigation project –

[1] Input document number, to be assigned by the Committee Secretary
[2] Leave open if uncertain

aim to establish and operate such infrastructure functions in the timeframe 2016 - 2018, to demonstrate their value and validate specific services concepts within E-navigation and Sea Traffic Management (the SeaSWIM concept). The strategic aim is to use these projects to validate the Maritime Cloud concept, while functioning as the breeding ground for establishing a sustainable operational community for the future. Although the initial aim is support within the projects, the infrastructure can be used by any maritime project that needs a similar setup.

The Conceptual Model was created to give a high-level description of the Maritime Cloud and aims to be an executive summary, facilitating a common understanding of the Maritime Cloud among the different stakeholders.

3 VISION FOR THE MARITIME CLOUD

The Maritime Cloud concept has been derived as “A communication framework enabling efficient, secure, reliable and seamless electronic information exchange among all authorized maritime stakeholders across available communication systems”, based on the IMO e-navigation strategy. The vision reaches beyond the IMO strategy, matching the goals of the EU e-maritime initiative and more.

3.1 Mission Statement

The mission of the Maritime Cloud is to enable an open and vendor-neutral platform for the maritime sector that facilitates information exchange easily and securely across various communication channels, such as the Internet, satellite or digital radio links. It will allow for interconnecting heterogeneous software systems on board various ship types, on offshore structures or on shore, including dedicated type-approved systems (e.g., ECDIS) and more ubiquitous personal devices, like smartphones, tablets and personal computers, according to standardized interfaces, protocols and access control rights.

At this stage, the Maritime Cloud shall not be considered as a product aimed at end users such as mariners or ship owners. Instead, it is a framework providing standardized protocol and functional support for identity and role management, authentication, encryption, authenticity validation, service discovery and bandwidth efficient messaging in a geographic context. This enables easy development of innovative solutions targeted at maritime end users in a context of global interoperability. The Maritime Cloud shall be regarded much like the Internet as the enabler of interoperable systems for email, VoIP, webpages, blogs, social networks, or online shopping sites.

3.2 Vision statement

By making the Maritime Cloud a key part of the EfficienSea2 project, we aim in the coming three years to lay the foundation for a widely used framework, that through facilitation of interoperable solutions:

Will enhance the safety and efficiency of the maritime sector, through information technology innovations that bridge gaps between information islands.

Will follow established and robust international standards wherever feasible

Will facilitate the development of, and transition towards, globally standardized information services for the maritime sector.

Will provide tools and guidelines facilitating the development of software that may safeguard the confidentiality and verify the authenticity of data exchanged between individuals and organizations.

Will minimize operating costs by efficient usage of available bandwidth in the maritime sector.

Will lower development cost and improve software quality, usability and time to market for commercial and non-commercial software products.

Will ultimately be recognized, governed and supported by a sustainable community, including important international, regional and commercial organizations in the maritime domain (such as IMO, IALA, IHO, CIRM, BIMCO and EU).

4 GENERAL CONDITIONS

The introduction of new communication frameworks has the potential to have a big effect on international seafaring. At present, vessels and shore-based facilities are equipped with a variety of heterogeneous maritime systems such as AIS or GMDSS which contribute to safe navigation. The IMO e-navigation strategy initiates a holistic approach to improve standardization of digital information and infrastructure within the maritime transportation process.

The e-navigation strategy comes with an overarching architecture, covering the (civil) maritime domain. The architecture divides the domain into ship-side and shore-side. This separation contributes to the deviant technologies and regulations on both sides. The e-navigation architecture is based on the principle of exchanging data and information between ship and shore (but also between ship and ship as well as between shore and shore). The conceptual basis for the Common Maritime Data Structure (CMDS) is the IHO-Geospatial Information Register, also called the S-100 Register. S-100 is a framework, which provides a repeatable data specification development methodology and general provision for the data specification process. The circumstance that the S-100 framework is based on the ISO 19100 series of geographic standard guarantees the compatibility within the maritime domain, but also with other spatial data created according to the relevant ISO standards.

Resulting to this, current activities such as the development of the maritime cloud concept have to take care about existing (and upcoming) maritime systems and need to be “embedded” in the maritime environment.

This results in a high need to ensure interoperability among different systems. Therefore, there is a high need to identify gaps and overlaps between heterogeneous systems and identify possible interoperability issues among them.

Besides the human parts, (maritime) systems rely upon systems architectures, which include concepts, properties and structures as well as design principles and relationships to their environment. Existing system architectures (and the associated systems) diverge in a high degree. Those systems and their application are subjected to regulations given by international or national authorities. With the upcoming e-navigation strategy, stakeholders in the maritime domain (see [5]) face the challenge to harmonize existing systems and to integrate new approaches into existing structures. The maritime cloud, with the demand of an interoperable communication framework, has to consider these aspects.

Therefore, there is a high need to align the relevant architectures to each other and coordinate the development of the maritime cloud between application, technology and related stakeholders within the maritime sector.

As a result, the EfficienSea2 project partners initiate the Maritime Architecture Framework as a solution to coordinate the development of new systems considering technology issues, governance aspects and users in-between existing architectures. This framework takes into account technical and governance issues as well as the (civil) maritime domain as specified in IMO’s e-navigation strategy.

5 MARITIME ARCHITECTURE FRAMEWORK

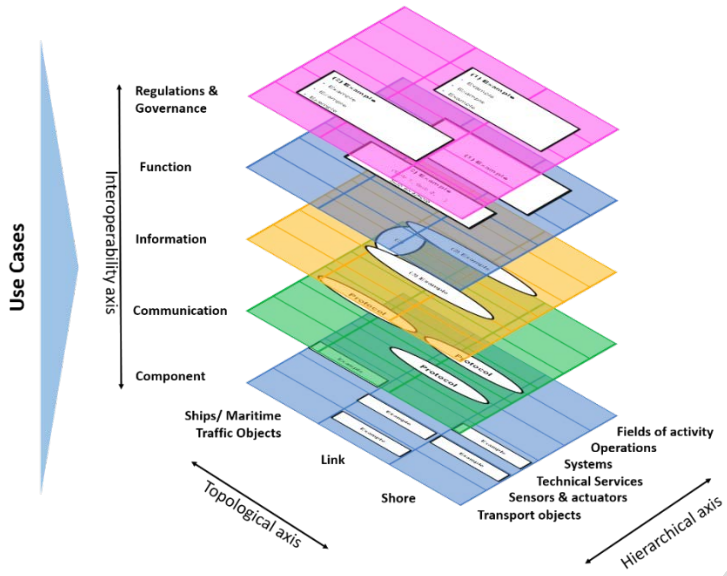
The Maritime Architecture Framework (MAF) represents the maritime domain and establish a common view and understanding concerning e-navigation architectures and their relatives. The MAF provides a consistent terminology and takes into account IMO's e-Navigation Strategy Implementation Plan [3] and e-Navigation implementation process [4] in its structure. The framework will be used as the theoretical basis to support the development of maritime service infrastructures within the Maritime Cloud (and SeaSWIM - System-wide Information Management) and its corresponding technical services.

Regarding to IMO's e-navigation context, using the MAF will support the architectural development of the Maritime Cloud within the two projects EfficienSea2 and STM The main aim of SeaSWIM is to ensure the interoperability of services (developed throughout the STM project) and to facilitate data sharing using a common information environment and structure (e.g., the Maritime Cloud). The Maritime Architecture Framework provides methods and tools to discuss, align, design and handle existing or future system architectures and architectural reference models within the maritime domain. The envisioned goal of MAF is to structure and compare different maritime IT-architectures and systems including related regulations to set them in context to each other in a consistent and harmonized manner to establish a common view and understanding concerning e-navigation architectures and their relatives. This results in the possibility to identify gaps, overlaps or interoperability issues between different maritime concepts and technologies.

The MAF adapts the approach given by Enterprise Architecture (EA) frameworks such as TOGAF and Zachman, which are used to develop strategic and architecture solutions within enterprise architecture engineering. They cover business objectives and regulations as well as required IT alignments [1]. ISO/IEC42010 describes an Architecture Framework as "*Conventions, principles and practices for the description of architectures established within a specific domain of application and/or community of stakeholders*". In 2008, an initiative in the electric utilities domain adapted the Framework-Approach and introduced the Smart Grid Architecture Model (SGAM) to present the design of related use cases regarding interoperability and standardization aspects for business and governance as well as for technical issues [2]. Therefore, MAF is also oriented towards the design principles of the SGAM.

The main objective of MAF is a stakeholder oriented analysis of existing and projected services and (reference) architectures. The stakeholders are defined by IMO's Maritime Safety Committee [3]. As released by IMO, an initial list of maritime service portfolios of the maritime domain is derived from NCSR1.28 [4], and the FAL Convention. In addition to that, the interoperability aspects are derived from existing architectural frameworks (in this case Smart Grid Architecture Model (SGAM) [2]. This top-down approach was accompanied by a bottom-up collection of structural elements of international interest groups, institutions and organizations.

MAF captures different aspects of maritime architectures mapped to a multidimensional space with different orthogonal dimensions subdivided in layers. The framework provides a mapping process starting with the definition of the related use cases and derives interoperability aspects for governance and regulation issues as well as for technical components (Figure 1).



Use case mapping process

The MAF comes with a three-dimensional structure of architectural aspects, assembled in a meaningful way in the MAF-Cube. This Cube represents subsections of the maritime domain using the three dimensions *Interoperability axis*, *Topological axis* and *Hierarchical axis*.

The layers of the Hierarchical axis reflect the hierarchy and aggregation of management and control systems in the maritime domain.

The Topological axis covers the elements and its interrelationship of maritime domain. It is an adaption of IMO's e-Navigation architecture.

The layers of the Interoperability axis of the Maritime Architecture Framework define the required definitions and agreements to ensure interoperability.

This framework is developed as an open governance concept to cover all social-technical IT-systems within the maritime domain and intermodal logistics. Therefore, the MAF is open for future extensions. Contributions from further maritime stakeholders are explicitly welcome. Upcoming extensions and changes will be discussed and defined in an open governance group.

6 OUTLINE

In the following outline, we illustrate a common use case for the Maritime Cloud, aiming to point-out potential benefits for the stakeholders, when having the Maritime Cloud in place.

6.1 Alice & Bob – A maritime cloud story

Bob is a 56 year old ship master of the Emma Cologne, a 380 meters long and 17000 TEU container vessel. He is on his 16 day voyage from Rotterdam to New York and currently the vessel is in the middle the northern Atlantic Ocean. In this region the connection to the internet is intermittent (meaning that many connection losses could occur). When the internet connection is available for a sufficient long time, Bob receives a digitally signed storm warning message for the western part of the northern Atlantic. Bob takes notice of this message and realizes that he will need external support by means of new weather routing, to arrive efficiently and safely in his next port of call. Fortunately, Bob's vessel is equipped with Maritime Cloud components, which allow him to find an adequate weather routing service. Based on his current position and intended route, he looks up available weather routing services in this region using the Service Registry of the Maritime Cloud (in the same way he would search for carpenter numbers in the yellow pages). The Maritime Cloud automatically provides him adequate services for that region where the upcoming part of his voyage route traverses. Having this list available, Bob selects for instance a service provided by Alice. Since his navigational equipment is cloud compatible, it automatically knows how to connect to Alice's service.

Bob's navigational equipment establishes the connection to the service and in parallel validates Alice' authenticity and authenticates himself. Bob now requests weather information and alternative routes by providing his current position and his planned route. As a response to this request, Bob's equipment receives weather information for the region his route is planned to go through and a suggestion for an alternative route in a standardized format. This information is automatically displayed on his navigational equipment. Bob is lucky, because the suggested alternative route allows him to arrive at his next port of call in a safe way and only with little delay. Bob thinks: "Hey, Alice's weather service is very accurate. Wouldn't it be a good idea for receiving updates of weather information automatically in future? I will try this." So, Bob subscribes to Alice's service for automatic updates.

Meanwhile Alice constantly updates the forecast data available via her service. Whenever she has an updated report available, she authenticates herself to the Maritime Cloud and is then able to provide her new forecast, digitally signing it to prove it's authentic.

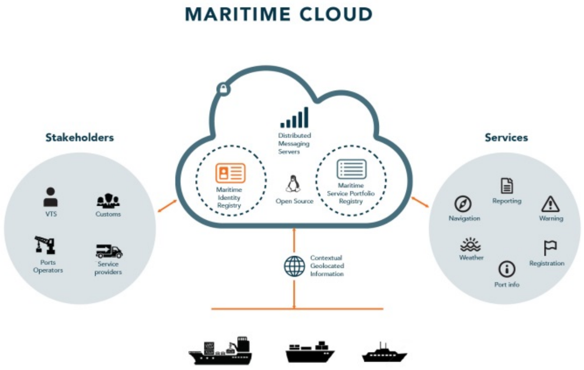
Two days later: Bob has already travelled 1.000 nautical miles to the West. By means of the Maritime Messaging Service, which is another cloud component, Bob suddenly receives an update of the weather information from Alice's service (based on Bob's current position). The storm went to the East and Bob's has already passed the critical region. Bob is lucky, since he does not have to follow Alice' alternative route anymore, but can change the course directly to the Port of New York saving 12 hours.

While making the journey over the Atlantic Ocean Bob's internet connection breaks down temporarily. Suddenly a radio based message about an iceberg warning arrives from an unknown source. Normally, the authenticity of the message could be validated by contacting the identity registry and see if the sender of the message is a valid maritime actor. However, with no internet connection the navigation equipment instead automatically turns to the Almanac which contains an easily updatable offline version of the identity and service registry. Having successfully verified the authenticity of the message Bob diverts the course and avoids a collision with the iceberg.

After 17 days, Bob finally reached the port of New York in an efficient and safe way. As he has seen in the Almanac that Alice service Station is located in this port of call, he decides to visit the service centre and potentially meet Alice.

7 MANAGEMENT SUMMARY

The Maritime Cloud is a collection of infrastructure services, standards and governance facilitating secure information exchange in the maritime domain.



Services can be easily registered, discovered and used.

Identities can be verified and used to digitally sign communication.

Messages can be exchanged between components connected to the cloud, these can be either clients operated by humans or services.

Geographic and organizational contexts (e.g., a vessel's location) are used as key parameters for service discovery, identity verification and message exchange.

The maritime cloud offers a so-called Service Registry. You can imagine this component as an automated switchboard.

Components connected to the cloud call the "operator"/service registry asking for a route to a service.

Depending on the request (Name, Type, Location …) the end user is provided with possible dialogue partners and can then choose to whom to speak.

Nowadays, daily processes include a lot of paper work. Documents need to be signed to prove authenticity. The Maritime Cloud offers means to digitally assure the identity of the communicating partners.

Every message can be certified using state-of-the art technologies.

The maritime cloud does not include data storage or application hosting. This remains the responsibility of service providers and organizations.

Focusing on improving communication and digital interactions based on open standards, while reusing existing components and infrastructure within the current organizations enables a smooth transition.

To the extent possible, there is no organizational change necessary.

8 CORE COMPONENTS OF THE MARITIME CLOUD

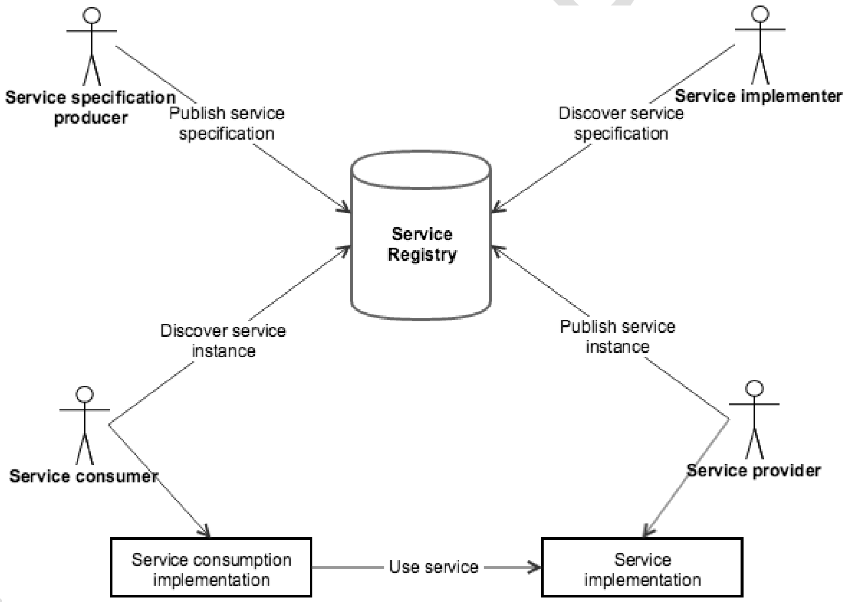
8.1 Service Registry / Service Management

Enabling services providers to deliver their services to customers with increased security and productivity while decreasing the cost and effort.

Services themselves and the service based economy are a central part of the vision of the Maritime Cloud. In the context of service-oriented architecture, a service usually refers to a set of related software functionalities that can be reused for different purposes, together with policies that governs and controls its usage. The Maritime Cloud comprises a much broader scope that also includes services that do not solely rely on machine to machine communication such as services delivered over telephone calls (voice or fax), email, websites, Navtex and other "primitive" solutions.

The service registry is a central part of that vision. A registry contains service specifications according to an envisioned Service Specification Standard and provisioned service instances implemented according to these service specifications. The service registry aims at improving the visibility and accessibility of available maritime information and services. This enables service providers, consumers, and regulatory authorities to share a common view on service standards and provisioned services. The service registry does not provide actual maritime information but a specification of various services, the information they carry, and the technical means to obtain it. The service registry also provides the mechanisms to manage the life cycle of service specifications and service instances.

As depicted below, the service registry enables the "provider" to "publish" information related to its service instances so that the "consumer" is able to "discover" them and obtain everything (e.g. interface information) required to ultimately use these services.



Service Management Concept

The service registry is intended to facilitate or implement the Maritime Service Portfolio (MSP) concept by providing a repository for the specification of operational and technical services and provisioned service instances. The service registry is intended to comprise all maritime services, not only digital services, thereby making it a single reference point for provisioning and discovery.

The users of the service registry are primarily thought to fall within one of the following categories.

Role	Description
Service Consumers	Consumer uses service instances provided by service providers. All users within the maritime domain can be service customers, e.g., ships and their crew, authorities, VTS stations, organizations (e.g., meteorological), commercial service providers, etc.
Service Providers	Provides instances of services according to a service specification. All users within the maritime domain can be service providers, e.g., authorities, VTS stations, organizations (e.g., meteorological), commercial service providers, etc.
Service Provisioning administrators	Administrators handling the life-cycle of service instances. The provider of a service instance will be the owner and administrator of each instance of service.
Service Specification Administrators	Administrators handling the life-cycle of service specifications e.g. adoption, retirement, etc. The issuer of a service specification will be the owner and administrator of each specification.
Service Specification Implementers	Implementers of services from the service provider side and/or the service consumer side. Everybody can be a service implementer but mainly this will be commercial companies implementing solutions for shore and ship.
Service Specification Producers	Producers of service specifications in accordance with the Service Specification Standard.

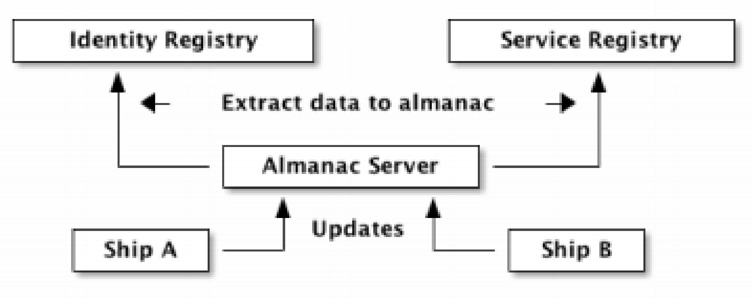
8.2 Identity Management and Security

Please refer to informational paper on Identity Management and Cyber Security (also submitted to eNav 19).

8.3 Almanac

The Almanac is an offline version of parts of the Identity and Service Registry, acting as a 'white/yellow pages phone book'.

The data stored in the Almanac can be updated, whenever a (suitably low cost or flat rate) data connection is available. By using the Almanac, it is possible to automatically look-up e.g., the MMSI number for a DSC call, VHF working channel or e-mail address, phone numbers or other contact information of a VTS center, Port, the nearest MRCC or another ship you may wish to contact. An on-board system or person might also look-up which providers of a specific information service are available along a planned voyage.



Interactions with the Maritime Cloud Almanac Component

The basic architecture would be a single logical Almanac server that gathers updates from the service and identity registry. Each ship can then query the Almanac server for updates whenever a suitable connection is available. The Almanac server will typically be accessed through the Maritime Cloud Client Component that is part of the reference implementation of the Maritime Cloud. This client also takes care of storing updates and provides an interface for querying the data stored in the Almanac. Equipment manufactures would not need to implement any details of the protocol as all access to the actual data would flow through high level interfaces exposed by the almanac client.

8.4 Maritime Messaging Service

The Maritime Messaging Service (MMS) is a proposed Messaging Service intended to offer transparent seamless information transfer across different communication links in a carrier agnostic and geolocation context sensitive manner.

The MMS primarily addresses ship-shore connectivity and will be based on internet connectivity, yet any number of alternative communication services may be connected to and utilized by the Maritime Messaging Service via dedicated gateways. This way, a message sent by one specific ship using INMARSAT access to the MMS, may be received via a VSAT terminal on another ship, an HF data connection on yet another ship, or a VTS operator on a DSL landline internet connection.

Each communication service will impose technology and situation specific limitations in terms of restrictions to capabilities, bandwidth availability, size of transferrable data packages, latencies, etc. – but basic transfer of text or structured data (e.g., XML) will be possible.

Thus, when a maritime actor wishes to transfer information to another maritime actor or in need of multicasting information to a group of actors, the MMS can ensure delivery across whichever communication link is currently active at each relevant actor. Actors in a multicast group thus do not need to be within range of a single communication link, and actors inside a geographic multicast may be addressable by an information provider, although the identity and exact position of the actors are unknown to the provider of information. In case a ship temporarily has no active communication link, the MMS will function as a prioritized store-and-forward queue of messages where the validity period can be defined for the messages sent.

Through mechanisms of protocol level acknowledgements, the delivery of information via the MMS can be quality assured.

The MMS mechanism requires each actor to maintain a persistent connection or regularly establish a connection to the MMS, maintaining knowledge of which data links are open towards each mobile actor. At each connect, or regularly, mobile actors provide a position update at protocol level to the MMS, enabling a geographical awareness of the position of each actor at the MMS. The geographical awareness may be strengthened through the supplement of (satellite) AIS, providing high resolution but requiring no additional communication. The geographic awareness enables 'Geocasting' – i.e. actors may logically 'broadcast to' or 'listen to' an area around their own position, regardless of which communication link is used for broadcasting or listening in to the broadcast. Shore entities (or military or law enforcement units) may 'listen' to geocasts of an area of interest without specifying their position, and ships may listen to its current geographic context, without exposing its own position to anyone else than the MMS, ensuring the privacy of own position information.

Priority information such as safety-related information may be priority queued for delivery according to priority, ensuring that messages with higher priority are handled before routine traffic.

8.5 Maritime Cloud Client Component

The services of the Maritime Cloud will be provided to ship- and shore-side applications by a Maritime Cloud client component.

This component allows for keeping the Maritime Cloud services abstracted from the physical components and encapsulates the complexities of communication roaming. The Maritime Cloud client will function as a local information hub, connected to relevant sensors, navigation displays and communication equipment through relevant firewall arrangements.

The component's API will provide services for

Secure authentication, signing and encryption support through online use of the Maritime Identity Registry or offline use provided by the Almanac.

Service discovery through online use of the Maritime Service Registry or offline use provided by the Almanac.

Service provision of dynamic services, e.g. a vessel providing its own position and navigational data to a trusted party.

Communication via the MMS through generic communication functions, providing seamless roaming via available communication systems based on a user defined rule set.

8.6 Data Flows

Data can be exchanged directly or using the Maritime Messaging Service.

Note: Data to be exchanged via the Maritime Cloud shall comply with defined and agreed data modelling frameworks (e.g., IHO S-100 for e-navigation MSP’s).

Components connected to the Maritime Cloud can use two possible ways to communicate with each other.

Both data flows are described using the same Actors, Maritime Cloud Core Services and initial steps. On the actor side there are:

A Weather Forecaster Alice – the Service Provider

A Bridge Officer Bob – the Service Consumer

Participating system components are:

Server– providing a Weather Forecast

Client – providing the capability to display the Weather Forecast data

Identity Registry – Maritime Cloud Core Service

Service Registry – Maritime Cloud Core Service

The initial steps are always the same, and described in more detail in other sections of this document.

1 Bridge Officer Bob requests a weather forecast via his client

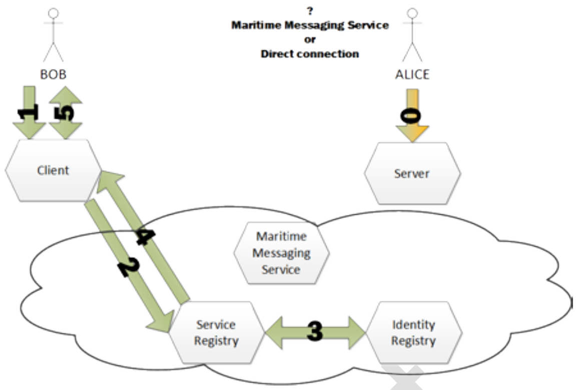
2 Client automatically connects to the Service Registry and asks for a suitable weather forecast service

3 Service Registry may, as any other service, utilize Identity Registry to authenticate the Client’s request, where needs for access control apply

4 Service Registry provides a list of available Services (and instructions how to connect to them) to the Client

5 Bridge Officer Bob decides to work with the Weather Forecast Service operated by Alice

Then, the “switchboard” steps required before being able to use the Maritime Cloud, are completed.



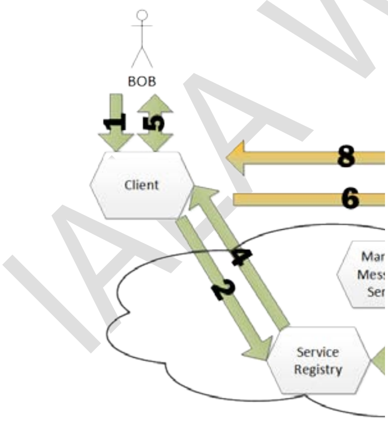
Now, there are two options possible for further data exchange, dependent on a service design choice made by Alice’s organization earlier.

(For the sake of simplicity the interactions with the Maritime Cloud Core Services are not described in full detail.)

Point To Point Communication

Alice decided to make her service available directly, and thus the Maritime Cloud is not involved anymore in the communication between the server and the client.

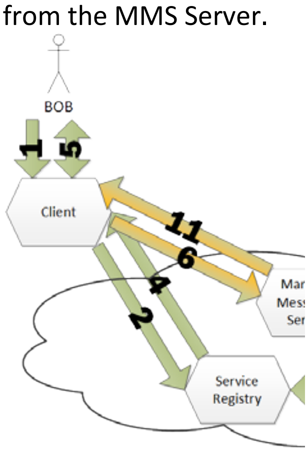
6. Bob’s client connects directly to Alice’s server, e.g., using standard web technologies,
7. Alice’s server verifies Bob’s identity using the Identity Registry,
8. Bob can work with Alice’s weather forecast.



Maritime Messaging Service

Alice decided to utilize the data transport capabilities of the Maritime Cloud, the Maritime Messaging Service (MMS).

6. Bob’s client connects to a MMS Server, and sends a request for a weather forecast provided by Alice’s server,
7. The MMS Server verifies Bob’s identity using the Identity Registry,
8. The MMS Server forwards the request Bob’s request to Alice’s server
9. Alice’s Server provides a response (the weather forecast) to the MMS Server,
10. The MMS Server verifies Alice’s identity using the Identity Registry,
11. Bob’s client picks up the weather forecast from the MMS Server.



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EfficienSea2 Project (No 636329) Deliverable D3.1 “Analysis Report on Maritime communication and infrastructure”

10 ACTION REQUESTED OF THE COMMITTEE

The Committee is requested to note the information and take appropriate action.