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M2M COMMUNICATIONS SYSTEM PROPOSAL FOR MARITIME APPLICATIONS

ABSTRACT

This article describes the proposal to use the M2M communication to enhance the safety of people, ships and other marine infrastructure, in broadly defined marine systems. In addition, there are numerous examples of planned solutions to be implemented in the near future as well as new services. The proposal for M2M communication system architecture is described below. In addition, the use of the STRUGA system radio interface as the M2M communication interface is proposed.

Key words:
M2M, V2X, V2V, maritime safety.

INTRODUCTION

Nowadays, a lot of proposed solutions are designed to increase the safety of people on land, air and sea [3, 4, 6, 8]. But we also want to protect machines, goods and other movables. An example of a such communication solution, for all these applications, can be the M2M (Machine to Machine) communication.

In general, the M2M is a technology for data transmission from one terminal to another terminal, such as a machine to a machine, a sensor to a sensor, a mobile to a machine but also a man to a machine. The purpose of this M2M transmission is to allow automatic and direct transfer of data between various nodes of a network. This type of communication in maritime applications can be used e.g. in maritime transport for

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increase a safety or for ships monitoring, preventing watercraft collisions or send weather messages. The premise is that some of these types of applications will be able to collaborate without a human [1].

By the year 2024, various types of M2M radio communications, known as the Vehicle-to-Everything (V2X) are planned to be implemented [3] in terrestrial applications. Different subtypes of such communication can be expected for maritime applications, e.g.:

- Vehicle-to-Vehicle (V2V) — wireless transmission directly between vehicles (watercrafts);
- Vehicle-to-Infrastructure (V2I) — transmission of information between moving vehicles (vessels) and a coastal infrastructure;
- Vehicle-to-Home (V2H) — data transmission between vessels and port facilities;
- In Vehicle Communications (In-V) — transmission of information between different M2M sensors and control devices mounted on ships, which allows performing some maneuvers without human intervention.

The near future it will be a time with very rapid development of V2X communications, especially the V2V. It will probably allow significant safety improvement during traveling both on a land and at sea. All the time we are working on the development of new solutions, and some of them will be presented in this paper.

EXAMPLES OF M2M COMMUNICATION IN MARITIME TRANSPORT

Nowadays, it is well known that the M2M communication will be used in many applications, also in systems and maritime transport. However, it should be emphasized that currently all the M2M applications aren't known because the main development of this technology goes forward. However, it is known that the M2M in maritime transport can be used to:

- monitoring the movement of various ships (e.g. with multiple ships of the same ship-owner);
- monitoring the technical conditions of vessels by transmitting and analyzing data from multiple sensors (e.g. for monitoring various technical parameters of vessels);
- monitoring the quantities of fishing on large seas;
- monitoring the behavior of passengers on watercraft;

- transmission of data from smoke sensors, thermometers, etc. which will also improve the safety of a travel and provide the possibility of implementing emergency procedures in the event of danger;
- battery level monitoring and energy consumption measurement by various components;
- support of industrial automation;
- carrying out some operations at sea without direct human involvement;
- measuring with different sensors and quickly detect the risk of environmental pollution;
- checking the status of goods in containers on ships and at a container terminal;
- managing containers at terminals and/or in ports and/or in vessels;
- port infrastructure management;
- support for vessels entering and leaving ports;
- the V2V communication to prevent vessel collisions with poor visibility;
- development of remote passenger handling systems;
- supporting the search for castaways;
- help people with disabilities, e.g. by consolidating M2M communication with the Wireless Body Area Network for measuring and monitoring health parameters;
- others.

PROPOSED STRUCTURE OF M2M COMMUNICATION NETWORKS FOR MARINE APPLICATIONS

An exemplary structure of a the M2M communication network for marine applications is shown in figure 1. It consists of three main modules for data collecting and transmission of the data to the M2M application server, and then analyzing and making decisions [1, 5, 7].

As already mentioned, data is collected from various types of sensors that can be mounted on both vessels as well as in coastal infrastructure, in ports, container terminals or directly on or inside containers. Depending on where they will be assembled, we will deal, for example, with M2M communications between ships or between ships and various other marine infrastructure elements. The collected data will then be transmitted through the M2M gateway and various systems to the M2M server. At the server the data will be collected and continuously analyzed (e.g. using artificial intelligence algorithms) and, as a result of such analysis, there can be made some decisions. If necessary, an emergency or other type of non-security alarm will be sent [1].

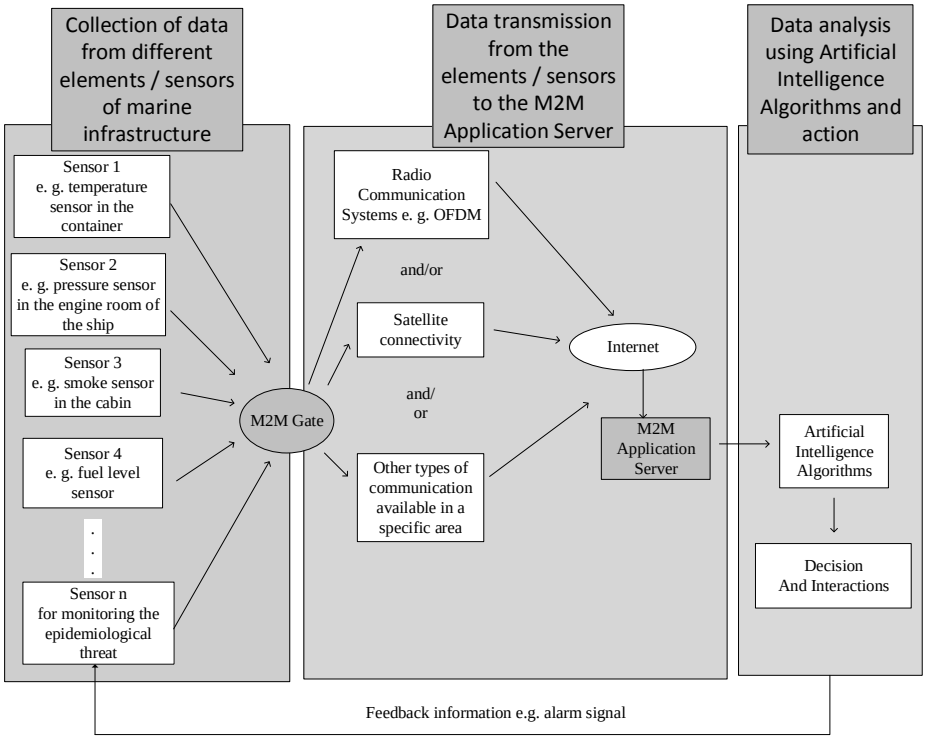

Fig. 1. Example of a proposed M2M network structure [own study]

The characteristic feature of the M2M communication is the ability to customize the network to suit individual needs (e.g. the right network structure in the port area can be designed). In addition, it will be possible to store and collect different information from various sensors, and then using the information for different purposes. Note that e.g. properly coordinated M2M port services will be able to work effectively and thus directly contribute to lowering the cost of services.

An example of M2M communication between a ship and a port infrastructure is shown in figure 2. Various sensors are installed on the ship (e.g. engine pressures, a fuel level, a temperature in the cooling tower, etc.). Data from these sensors is sent via the M2M gateway and a network to the M2M server provided with appropriate data analysis methods and/or a monitoring agent for live data streams. If irregularities are detected, the alarm signal is immediately sent to the captain of the vessel who is informed of a threat and can take appropriate action.

It is very important for data transmission and analysis to take place without undue delays and where possible in a real time. To collect information from sensors we can use e.g. the ZigBee standard. The specification of this standard covers mainly

simple network connections connecting small appliances with low power consumption. This approach also emphasizes the reliability of signal transmission, network configuration flexibility, and very simplified stack protocol handling [4].

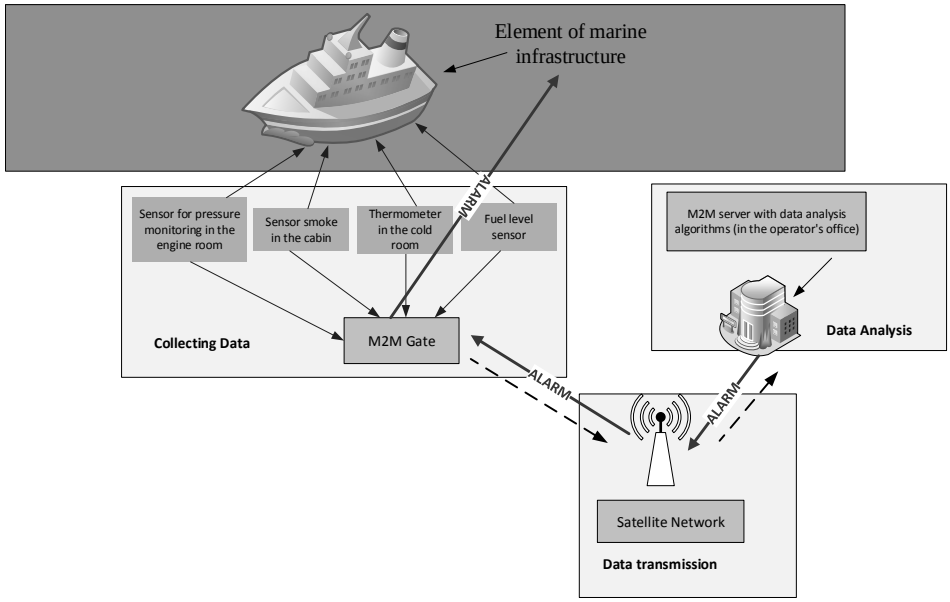

Fig. 2. Proposal for the M2M communication in maritime applications [own study]

As future M2M communication methods will arrive, it is necessary to develop universal radio interfaces for their implementation. It seems necessary to develop and search for new, differentiated interfaces for communication between floating, stationary and mobile devices. In the case of a combination of several sensors, or when we communicate mobile devices to a device, but also to a machine, we will need a differential solutions. In addition, it seems reasonable to create separate interfaces for data collecting from multiple users (e.g. during ship fleet monitoring), and, otherwise, when for single object data monitoring (e.g. a single passenger).

THE V2V COMMUNICATION IN MARITIME APPLICATIONS

Nowadays, the most developed V2V [3] applications allow for wireless data transmission between vessels. Thanks to such communication, it is possible to efficiently exchange data between ships, such as weather conditions or fish stocks in

specific areas. On the other hand, the V2V communication, automatically implemented, is designed to protect objects against the risk of collisions, which is particularly important during storms or other dangerous weather events [6]. Nowadays, the ships have connectivity but it is not automated and multi-level communication. The communication can be full automated if the V2V solutions will be deployed. Keep in mind that V2V communications will also automatically respond to terriers or epidemiological threats.

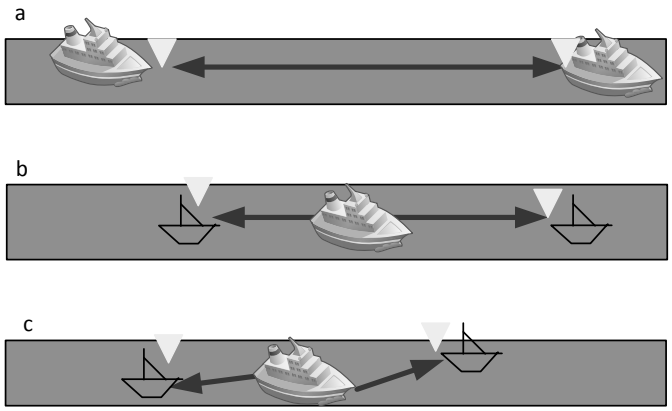

Fig. 3. Examples of collision scenarios and V2V applications in shipping [own study]

The most common cases of potentially colliding vessels for floating and the use of V2V applications is shown in figure 3. As we can see, in figure 3a there is a situation in which two ships moving in the same direction and exchange information with V2V. If the ship approaches too fast, the warning signals will appear and, in the absence of a captain's reaction, the emergency procedure will be triggered. It should be noted that much more conditions should be taken into account for very large passenger or cargo ships but such situations and the use of V2V technology can also affect small motorboats and protect people from sinking. Figure 3b is a small boat in front of a passenger ferry and behind the ferry that is not visible to each other. Using the V2V signals they know about their existence. The ferry in this case communicates with one and the other boats. In figure 3c, one of the boats decides to change the travel path and is warned that another ship is already operating after this track, and caution should be exercised.

As already mentioned, V2V applications communicate by means of radio communication signals, which are transmitted using omnidirectional antennas. Communicating with these signals gives the possibility of obtaining information

about the presence of other vessels or boats, or e.g. information on their position and speed, even in the absence of direct visibility. In addition, it should be emphasized that the V2V system is intended to operate irrespective of weather conditions and regardless of various other environmental factors.

The use of V2V for vessels communications does not exclude and restrict the use of radars, and GPS positioning and other systems for watercraft radiolocation. The V2X communication is the future of a maritime transport which aims to enhance the safety of all maritime transport participants by exchanging information between the different elements of a maritime infrastructure. Thanks to the various sensors connected by the V2V we can protect not only ships from collisions but also prevent environmental catastrophes. Properly programmed sensors and properly configured communication between ships, between ships and the port or terminal can save the lives of many people. The condition is that the signal transmission can take place in real time and at the right quality, and the servers to receive and analyze this information can operate reliably using fashionable data processing algorithms such as artificial intelligence algorithms or highly sophisticated expert systems. In addition to the above sensor types we can imagine that with V2X communications in the sea we will also use audiovisual sensors to detect unauthorized persons in forbidden areas or locate people by face and voice analysis and comparison.

THE STRUGA SYSTEM AS A PERSPECTIVE SOLUTION FOR M2M COMMUNICATION

In Department of Radio Communication Systems and Networks there is built the STRUGA system for special applications of border guard. Signal transmission in this system is implemented in Time Division Duplex (TDD) mode in a single 10 MHz (or 8 MHz) frequency channel. The frequency of the system is about 1.457 GHz. The system's design range is up to 50 km. In the radio interface, Orthogonal Frequency Division Multiplexing (OFDM) technique is used where the transmission of signals in a full allocated frequency band is carried out on many orthogonal subcarriers transmitted simultaneously. This way of transmitting signals increases the immunity of the transmitted signals to frequency selective decay which is the biggest problem in the radio communication broadband systems [2].

In TDD mode, the signal transmission takes place in a single frequency channel which is alternately designed to transmit signals in both directions of transmission,

i.e. in downlink (DL) and uplink (UL). The downlink is compiled from the terrestrial base station located in the coastal zone to the mobile object, while the uplink is set up from the mobile object to the base station [2].

In general, it is possible, among other things, to transmit real-time data from camera images. But this is just the basic application of the system. In case of developing systems with M2M communication it will be possible to use it as a component of a such architecture. Most importantly, the data will be sent adequately protected from unauthorized interference [2].

CONCLUSIONS

The article presents a wide range of examples of M2M communication in maritime transport applications and own proposal for the architecture of such system. It has been shown that introduction of this communication method gives hope for a major improvement in maritime safety. Particularly high hopes can be placed in the V2X communication systems between the vessels, boats and various elements of coastal infrastructure. The V2X development will certainly allow us to increase our ability to improve our security in areas that today are simply abstract. Certainly using this communication method will greatly improve maritime safety. One can see that it will be another communication revolution as it will be possible to develop system characteristics to ensure the reliability of warning and control messages related to maritime distress. An interesting idea is to use STRUGA components as an radio interface for M2M communication between vessels.

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KOMUNIKACJA TYPU M2M W ZASTOSOWANIACH MORSKICH

STRESZCZENIE

W artykule opisano propozycję zastosowania komunikacji typu M2M do zwiększenia bezpieczeństwa ludzi, statków i innych elementów infrastruktury morskiej w szeroko pojętych systemach morskich. Podano liczne przykłady planowanych do wdrożenia w najbliższej przyszłości tego typu rozwiązań, jak również zaproponowano nowe usługi. W dalszej części opisano strukturę komunikacyjną dla M2M. Przedstawiono propozycję architektury systemu komunikacyjnego M2M. Ponadto zaproponowano wykorzystanie interfejsu radiowego systemu STRUGA jako interfejsu komunikacyjnego M2M.

Słowa kluczowe:
M2M, V2X, V2V, bezpieczeństwo na morzu.