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MARITIME COMMUNICATION AND SEA SAFETY OF THE FUTURE — MACHINE-TYPE 5G COMMUNICATION CONCEPT

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ABSTRACT

The article presents the concept of a system based on 5G network and M2M communication increasing maritime safety. Generally, the focus was on presenting a proposal for a hierarchical, hybrid, cooperative system with M2M communication coordinated with BAN networks. The possible applications of M2M communication at sea were also presented.

Keywords:

5G, IoT, M2M, BAN.

Research article

INTRODUCTION

Currently, intensive work of scientists around the world focuses on developing standards and pre-designing the 5G network. It is already known that the proposed solutions will open a completely new era in radio data transmission. Probably in the near future in all areas of our lives we will, indirectly or directly, use radio data obtained from this new network. The pool of potential applications of the 5G network and the IoT communication (Internet of Things), directly connected with it seems to be huge, as it will be possible to hybridise various technologies, standards and methods of operation in order to achieve the ultimate success. An example of such a hybrid solution is the European Union [3] proposal regarding the implementation of C-ITS (Cooperative Intelligent Transport System) in the land area or a common radio communication system that would allow the exchange of signals between vehicles, including autonomous vehicles, and consequently, lead to a reduction in the number of traffic events resulting from human errors. The first assumptions of this system say that it will be necessary to organise hybrid communication based on the connection of the 5G network with the ETSI ITS-G5 (IEEE 802.11p) standard with the standards of local cellular networks. For transmission of data, by the decision of the European Commission (2008/671/EC), a frequency band around 5.9 GHz was reserved for security road systems [3].

The high complexity of the planned solutions means that scientists and network operators must perform a wide range of work, including building expert systems, conducting simulation tests, developing appropriate guidelines (e.g. regarding device homologation or compatibility testing) and testing networks under real conditions. The networks referred to here will be cooperative networks that combine different solutions.

It gives us an excellent opportunity to implement IoT communication in the form of M2M (machine to machine) communication, that is, automatic data transmission technology from one uniquely identified terminal to another known terminal. At the same time, this direct exchange of information between various devices and taking appropriate actions in this technology is often carried out without human intervention, and the undertaking of various activities is carried out using artificial intelligence algorithms [4].

In 5G technology, with OFDM [6], data can be transmitted with small delays; it will be possible to send signals, e.g. between sensors located at short distances, and to use for retransmission of final signals even by random people. It gives us

great opportunities to improve the safety of people and goods, e.g. when travelling or transporting goods [5].

In this article, the machine-type 5G concept for maritime communication and sea safety of the future is presented.

THE FUTURE OF MARITIME COMMUNICATION

Data transmission in the maritime area enabling the implementation of IoT services within 5G systems (with M2M communication) must be very well developed and should take into account the specificity of the marine environment [4, 8].

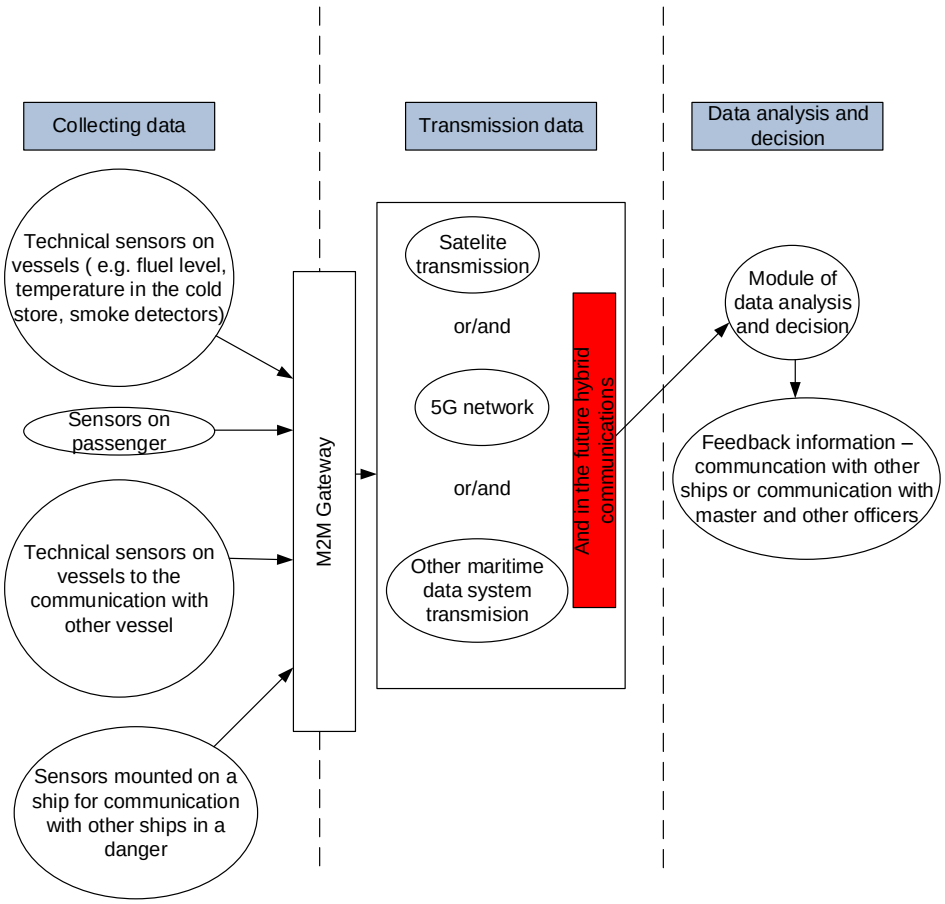

Fig. 1. M2M communication for the future maritime system

Fig. 1 shows an example structure of a typical M2M network for future marine applications. It consists of three main modules for collecting data, their transmission to the M2M application server, and then analysing and making possible decisions.

As already mentioned, data can be collected from various types of sensors that can be mounted on a ship (e.g. for monitoring the technical condition of the unit). Also, it may be data obtained from sensors in which passengers are equipped informing about, e.g., the faint person. Still, other sensors may be necessary to inform other units or, for example, port employees about a situation threatening safety (these sensors will become extremely important when autonomous vessels start shipping). Also, there can be used devices for regular communication between ships [7, 9].

Generally, sensors can be installed on ships and in ports, in terminals or directly on transported containers or inside these containers. Depending on where they will be installed, it can be dealt, e.g. with M2M communication between ships or between ships and various other maritime infrastructure elements. The collected data will then be sent via the M2M gateway and various systems to the M2M server — where it will be collected and analysed on an ongoing basis (e.g. using artificial intelligence algorithms).

In the future, M2M communication for marine systems will undoubtedly be based on 5G and/or hybrid 5G communication systems, satellite systems and other typical systems intended for maritime communications (e.g. GMDSS (Global Maritime Distress and Safety System) parts or other systems intended to monitor the security of vessels) [5]. Then the data will go to the data analysis centres where they will be analysed on an ongoing basis and based on their knowledge (thanks to artificial intelligence algorithms) will be automatically made decisions on the necessary interaction. Depending on the scale of detected irregularities, the unit's master or other officers, port support or other centres of critical management, as MRCC (Maritime Rescue Coordination Centre) or other authorities may be notified [1]. A characteristic feature of M2M communication is that it is possible to adapt the network operation to the individual needs of the user (i.e. we can plan a different network structure on the ship, e.g. in the port area) and, above all, become independent of performance problems of generally available networks. Additionally, it will be possible to remember various information (from various sensors), collect them into one whole and transmit in such a form to other users of the network in order to use for various purposes. It should be remembered that, for example, properly coordinated, thanks to M2M communication, port services will be able to work much more efficiently, which will directly translate into a reduction in service costs.

First of all, the implementation of M2M communication requires taking into account both small and significant distances between vessels and the lack of the ability to install sensors in any location (it is much easier to plan and execute on land). Also, it should be assumed that the line of sight (LOS) between the antennas will not always be ensured because either these units are too far away from each other or in the case when the small vessel is covered by a giant one. Additionally, the IoT system must be practically maintenance-free in real sea conditions and should operate mainly without human intervention, have to be reliable, easy to install, maintain and modernise. IoT systems are a brilliant solution, as they enable performing many tasks in remote ways [1, 7].

MACHINE-TYPE 5G COMMUNICATION CONCEPT

M2M communication has vast applications, also in the field of marine transport systems. It should be emphasised that at the moment all marine M2M applications are unknown, and the key development of this technology is still ahead of us. However, it is already known that M2M can be used to:

- monitoring of moving various vessels (e.g. in the case of many vessels of the same shipowner) which will improve the safety of both ship and cargo crews, and, on the other hand, will increase the shipowner's comfort and to some extent protect him against the actions of dishonest employees;
- monitoring the technical conditions of vessels by transmitting and analysing data from many sensors (monitoring various technical parameters of vessels);
- monitoring, e.g. the amount of fish caught by fishermen on seagoing vessels;
- monitoring the behaviour of passengers on, e.g. a ferry;
- sending information from smoke detectors, thermometers, carbon sensors, etc., which will also improve travel safety and ensure the possibility of implementing rescue procedures in case of danger;
- monitoring the battery level and measuring energy consumption by various devices and machines;
- support for industrial automation;
- carrying out certain operations at sea without direct human involvement;
- making measurements performed by various sensors, thanks to which it will be possible to quickly detect hazardous situations that may lead to, e.g. environmental contamination;

- monitoring the condition of goods in containers on ships and on the terminal and alarming, e.g. in the case of detection of excessive temperature in food containers;
- container management on terminals and/or ports and/or on vessels;
- port infrastructure management;
- support for vessels when entering or leaving ports;
- monitoring, even more accurately than ever, weather hazards in the immediate zone around the vessel based on information from multiple sensors;
- remote warning of captains of approaching other vessels, which in many situations may prevent tragedy (especially in places with limited visibility due to bad weather conditions) — so-called V2V communication technology;
- creating remote passenger service systems;
- supporting the search for survivors;
- help for people with disabilities, e.g. in the form of sending M2M signals, for service ships or ferries sending the information on disability and the assistance expected;
- active support of rescue operations;
- medical assistance at sea;
- others.

Previously mentioned possibilities of using M2M communication in marine conditions are solutions that potentially can be used, but on condition that wireless data transmission is available at a given area of the sea (not necessarily with the help of satellite systems that are known to be very expensive to use). Due to the development and first implementation of 5G systems with IoT, it will be possible to implement all these services with much higher reliability, minimal delay and rationalised costs. Please note that it is essential to ensure efficient data transmission within a given vessel.

The model of cooperative operation of maritime safety systems with BAN (Body Area Network) networks is presented in the next section. It allows monitoring the health of passengers and the ship's crew.

HIERARCHICAL HYBRID COOPERATION 5G SYSTEM TO INCREASE SEA SAFETY

Generally, BANs are networks which, using sensors mounted on the human body, in the human body or its immediate vicinity, allow monitoring selected life parameters of such a person (blood pressure monitoring sensor, a pulse monitoring sensor, ECG sensor, the sensor for measuring the brain waves, the sensor for

monitoring patient's breath, the sensor for measuring the concentration of glucose, and others). Data from sensors are always saved on the disk or transmitted to the server where they are analysed. After analysing the collected data, there is possible to modify the number of medicines administered or decide the need to take immediate medical intervention. From marine systems based on the 5G network, in the future, they may prove very important [2].

Together with IoT and 5G networks, it will be possible to apply the BAN to increase on a global scale the safety of passengers and workers of ships, cutters and other vessels and crew members. It is necessary to equip passengers with special vests, containing not only various sensors but also applicators of different medications. On the other hand, the entire maritime area will be covered by the reach of a hybrid communication system (including 5G), so it will be possible to monitor the health status of these people on an ongoing basis. Thanks to the 5G network, it will be possible to create a hierarchical system using hybrid cooperation communication structure, which is presented in fig. 2. In other words, it will be possible to monitor passengers in the area of a given vessel by data centres located on that vessel, but also to be aggregate data centres that will collect and analyse data from many vessels [5].

In fig. 2, one can see that the network is created based on a hierarchical structure. First of all, local M2M communication networks are created on vessels. These networks can work closely with BAN network sensors. Each passenger and crew member can be equipped with adequate sensors. Data from sensors are sent in two ways. Once through local cooperative networks to data centres located on a vessel. On the other hand, it can be sent by hybrid data transmission systems to the land M2M network and, eventually, to neighbouring vessels. If after the data analysis, it turns out that there are any irregularities, the ship's master or other person designated by him gets alarmed information and can take appropriate action. Thus, he can check what is happening with the passenger and at the same time, send information to the M2M land the network about the need to provide help.

At the moment, the same data is automatically sent to the land M2M network and further to the MRCC or other authorities [1]. There, these land centres are also equipped with data analysis servers that analyse the received data. Such a hierarchical structure is critical because, in the case of, e.g. a catastrophe of an individual, it is necessary to carry out a rescue operation. Then local networks located on vessels will not be sufficient.

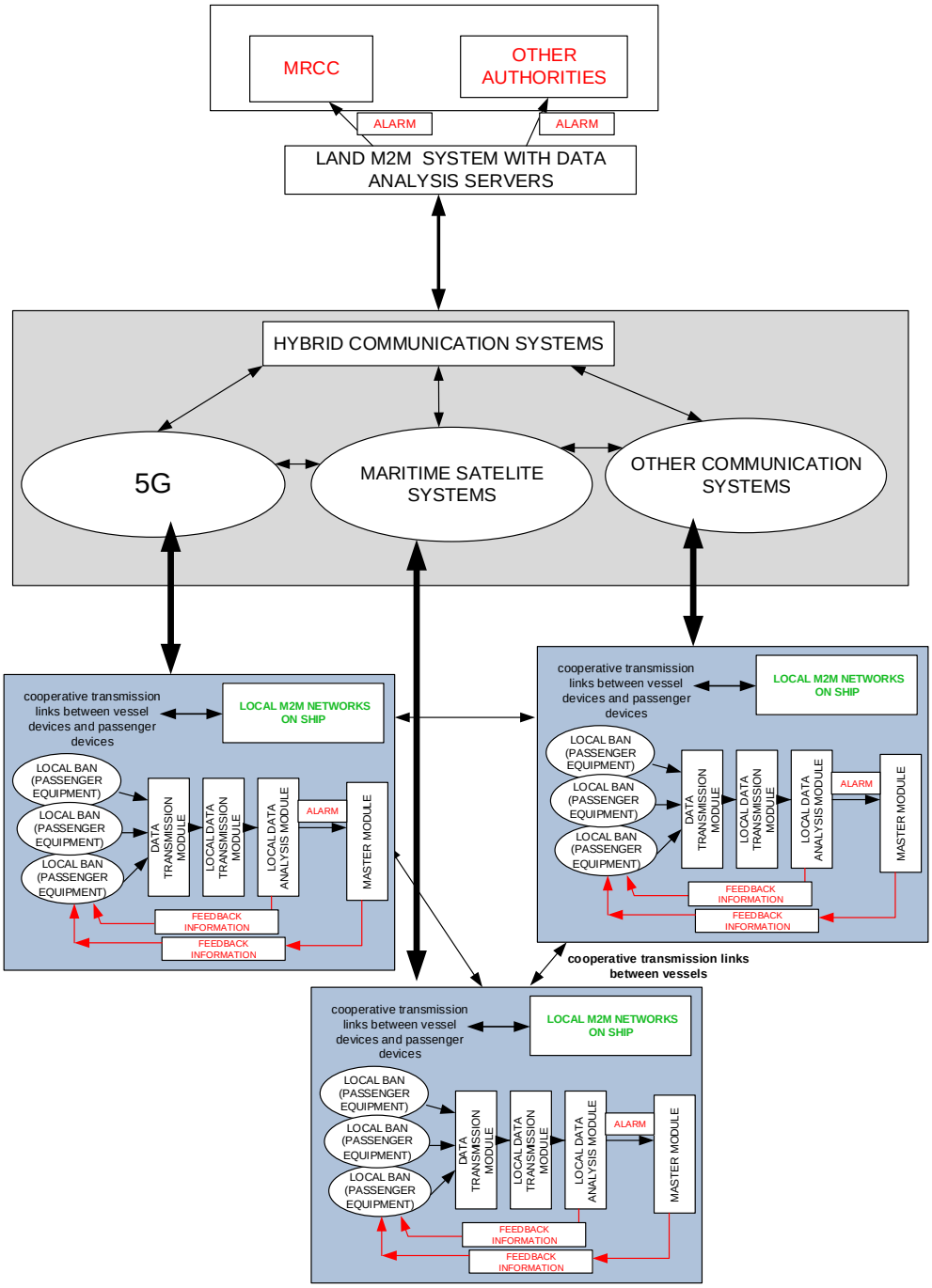

Fig. 2. The hierarchical cooperative hybrid maritime system based on 5G and BAN

The cooperative transmission means that there is possible to sent information not only directly to 5G terrestrial or satellite network but indirectly using some relay nodes located on the deck of a vessel or in other vessels. It is necessary when the signal from satellite or terrestrial 5G network is not available (e.g. too large direct distance or the signal is not available in cabins due to the use of steel material for the vessel construction). On the other hand, the relaying is possible between devices located in a life raft, a life jacket, wear, rescue beacons and others [5].

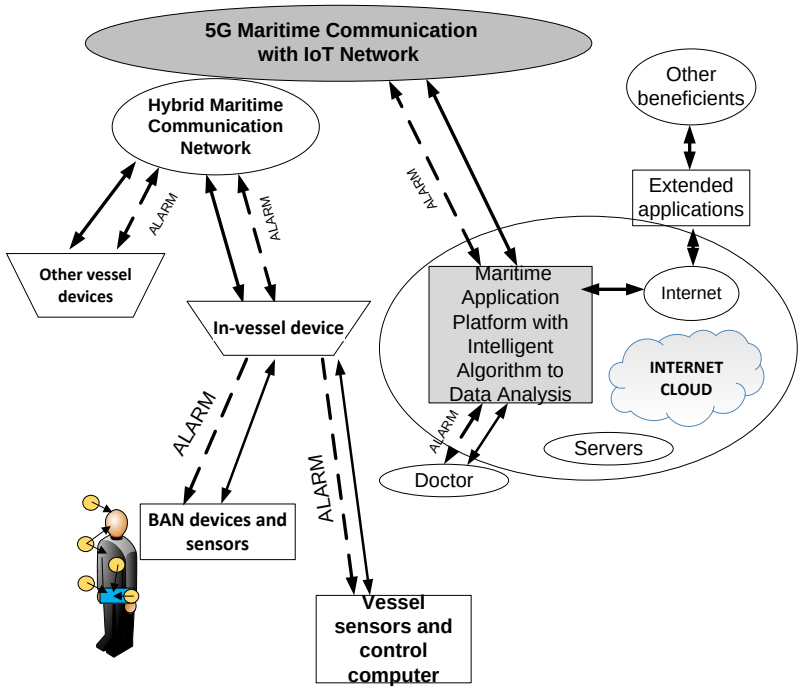

Fig. 3. Proposal of BAN network in hierarchical hybrid cooperative sea network

Fig. 3 shows the network in a slightly different view. As one can see, the 5G network and hybrid data transmission is essential here. Thanks to the fact that in these systems it will be possible to transmit data almost in quasi-real time there will be completely new possibilities.

First of all, it will be possible to create sensors for the BAN network intended for maritime rescue operations. There may be vests packed with sensors that will be able to inject appropriate medications (e.g. enhancers) in the case of feedback from the MRCC about this necessity. It will be possible to create specialised vests, e.g. for patients with diabetes or cardiological diseases, who in an extreme situation will

give the right dose of medicine. Also, it will be another element facilitating the location of survivors. Everything will be more accessible, thanks to the 5G network that works reliably.

CONCLUSIONS

The article presents the model of communication for improving sea safety based on the 5G network and BAN. The essence of this model is hierarchical transmission by which the information of lower importance can be transmitted only on the vessel. While in critical situations the information is sent to other vessels and a land M2M network connected to MRCC and other authorities. There is possibly the beginning of the global rescue operation or access some telemedical service for crews or passengers. The model uses cooperative transmission using relay nodes if the signal is not available (e.g. inside cabins). The health parameters monitoring is possible, thanks to the use of BAN sensors. Thus, the monitoring of the current situation on a vessel can be realised, including technical conditions of a vessel, status of goods as well as health monitoring of passengers and crew members. However, the most important is that it allows real-time reactions to any critical threats.

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KOMUNIKACJA NA MORZU I BEZPIECZEŃSTWO MORSKIE PRZYSZŁOŚCI — KONCEPCJA KOMUNIKACJI M2M POPRZEZ SIEĆ 5G

STRESZCZENIE

W artykule przedstawiono koncepcję systemu opartego na sieci 5G i komunikacji M2M do poprawy bezpieczeństwa na morzu. W ogólności skupiono się na przedstawieniu propozycji hierarchicznego, hybrydowego, kooperacyjnego systemu z komunikacją M2M, skoordynowanego z sieciami BAN. Przedstawiono również możliwe zastosowania komunikacji M2M na morzu.

Słowa kluczowe:
5G, IoT, M2M, BAN.

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