Remote command and control capabilities for data acquisition systems provided by delay-tolerant network mechanisms

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The paper presents an assessment of a remote device reconfiguration service employing a Delay Tolerant Network (DTN) mechanisms. This service has been implemented as a part of a communication appliance dedicated to marine data transfer in off-shore and open sea areas. The service has been successfully deployed and validation test have been completed. The practical use-case has been defined as remote access to the equipment operating onboard RV "Oceania" during cruise on Southern Baltic Area. A summary of service characteristics is included, as well as simulation results of large scale deployment of the system in the south and central areas of Baltic Sea.

Continuous observations conducted at sea have a wide range of applications: enhancement of environment understanding, observations of climate changes, preparation or validation of numerical models [1]. Advances in sea telemetry, observations and data acquisition offer unprecedented opportunities introduced by an increasing number of floaters or buoys equipped with new digital sensors and communication devices. On the other hand, surface waving, seawater properties and evaporation effects cause harsh conditions for radio waves propagation and make wireless communication and data collection difficult [2]. Many solutions to these problems in off-shore data acquisition have been presented, however there is one important element of the process, which is frequently overlooked – the ability to deploy, verify and modify configuration of off-shore environment monitoring systems from the distance. As opposed to data collection procedures that can be performed off-line, the opportunity to command, control and reconfigure devices remotely and on-demand is highly desirable.

Selected data acquisition processes conducted on-board RV Oceania have been used as the test case for this infrastructure's capability measurements. The ongoing measurements ongoing during cruises cover Temp, Sal, Oxy, pH and pCO2 parameters. Sensors used for data acquisition should be controlled and underway data should be delivered and published in NRT mode.

Delay-Tolerant Networking (DTN) is a class of computer-network solutions, which do not require an uninterrupted network communication between the source and destination, but mobile nodes of such network can store significant amounts of data to be delivered when opportunity arises. Data packages are carried by intermediary nodes and transferred to newly encountered neighbors, eventually reaching the destination.

The proposed remote device reconfiguration mechanism was implemented as a part of an information sharing system (developed during netBaltic project [3] and enhanced during ePionier initiative [4]). It is dedicated to off-shore marine research, adopts DTN mechanisms to disseminate configuration updates for a wide range of devices (for example dedicated to environment monitoring). Each request is encrypted by means of authenticated encryption assuring confidentiality and authenticity of data. Thus, any attempt of a manipulation performed by intermediary nodes can be detected by the destination. DTN mechanisms operate over a uniquely adaptable self-organizing heterogeneous network – capable of transparently utilizing effectively any communication technology supporting IPv6 communication, which makes it easy to deploy in a variety of different use-cases [5].

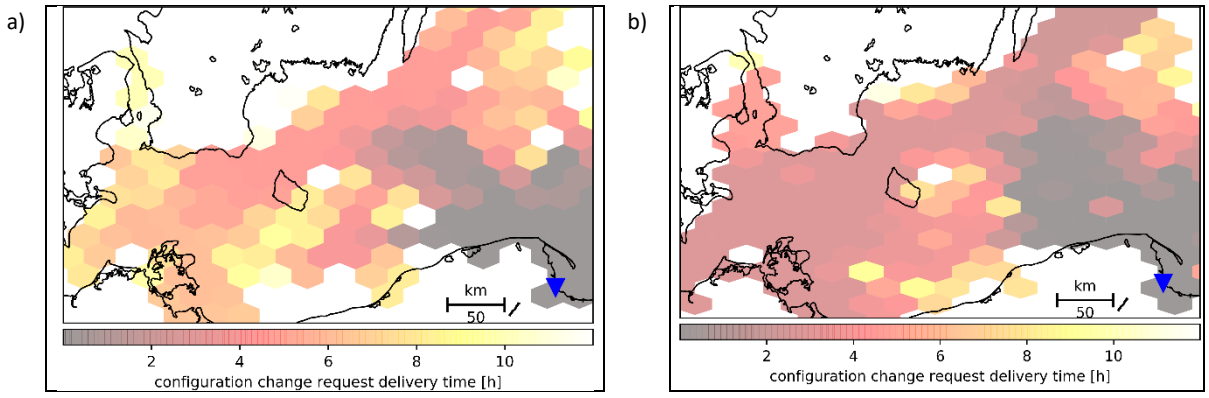

Figure 1: Visualizations of the minimum time required to deliver a re-configuration request to remote location for radio communication range: a) R_c=10km; b) R_c=15km.

Event-driven simulations of the proposed system have been conducted using vessel mobility traces obtained from a real-world AIS dataset aggregated by VTS. Based on results of the research conducted as a part of netBaltic project, it was assumed that an AIS-equipped vessel can also be equipped with a radio link offering communication in a ranges of R_c=10 km and R_c=15 km. Such communication ranges have been archived using the mentioned data sharing system in combination with off-the-shelf, industrial Wi-Fi equipment installed about 4 m over the sea-level. The presented results refer to the best-case scenario in that 100% of AIS-equipped vessels in the area participate in the system.

A reconfiguration request (marked as blue triangle at Fig. 1) is generated on-shore, in Sopot (Poland) – at the location of the Institute of Oceanology Polish Academy of Sciences. The request has been sent at the beginning of the simulation to be disseminated using DTN principles. Figure 1 illustrates the amount of time necessary to deliver the request to recipients in the particular area. Recipients in white areas did not receive the message before requested time (12 hours) for delivery void.

It can be seen that even for the shorter range of R_c=10km the coverage of the system includes most of the area in question, but the delivery time exceeds 8 h in less frequented zones. If the communication range is extended to R_c=15km, the coverage becomes almost complete and the time required to deliver a reconfiguration request tends to be lower than 6 hours.

While it is obvious that a participation of a significant number of vessels assumed in the presented scenario extend transfer capacity, we should also consider the possibility employing a number of vessels, which will modify or even plan their route to automatically deliver such a re-configuration request to devices in a specified area. Additionally, the data sharing system allows different communication technologies to be used instead of an industrial Wi-Fi – including a number of relatively low-throughput, but long ranged and energy efficient solutions well suited for autonomous measurement devices. Combined with the fact, that the system also allows data acquisition using DTN communication, we are confident, that it presents a useful solution for off-shore research.

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