A Wireless Sensor Network for Safe Ship Evacuation

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Real-time localization aboard large vessels is achieved using ultra-low power wireless sensor network technologies, enhancing safety through efficient decision support and emergency management. The system has been designed to meet requirements for high reliability, robustness, scalability and user acceptance, while being low-cost and low-maintenance. Small scale, real environment demonstrations have been performed.

The growing capacity of modern cruise ships raises serious challenges for efficient mustering and evacuation procedures in case of emergency. In the aftermath of recent mishaps, maritime security agents have identified the need to locate all persons on-board in all phases of a ship evacuation. The EU projects Lynceus (FP7, Support for SME and SME Associations) [1] [2] and Lynceus2Market (Horizon 2020) propose the use of ultra-low power (ULP) wireless sensor network technologies for unobtrusive, real-time localization and tracking of people on-board and overboard.

The Lynceus concepts and technologies have been already described [3]. The present article focuses instead on the localization tests that were recently performed in a real environment, on-board a cruise ship. Lynceus embeds low-cost, low-power, battery-powered radio-frequency (RF) devices in wearable items (life jackets, bracelets) and in fixed elements (gateways) that are interconnected to the ship wired infrastructure network (e.g. Ethernet). The current gateway demonstrators are designed to be integrated in smoke detectors and to use their communication network. The Lynceus devices are shown in Figure 1. They are based on ULP CSEM icyCOM technology and ULP communication protocols (WiseMAC). Sensors integrated on the devices provide additional information on person condition.

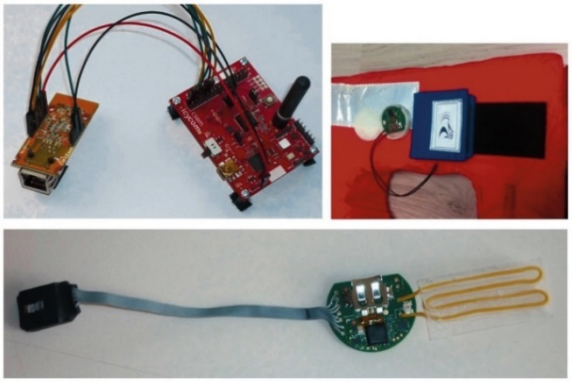

Figure 1: Lynceus devices.

On board, localization is based on received signal strength indicator (RSSI) of low-power RF signals. The mobile devices emit short-range, small periodic signals (beacons). The gateways know whether a mobile device is near them based on reception and power strength of its beacons. They send reports on the mobile devices in their vicinity to a central processing unit over the infrastructure backbone network of the vessel. In case of backbone failure, which is quite probable during emergencies, the gateways organize themselves into a multi-hop RF network and continue operating at a reduced data rate.

The localization algorithm is centralized, range-free and based on proximity detection. Its accuracy in such a harsh environment is not expected to be high but is still in accordance with the project requirements. The mobile locations are displayed in real-time on the Lynceus Graphic User Interface (GUI).

Small scale, real environment tests were performed on board Celestyal/Louis cruise ship Thomson Spirit, demonstrating the Lynceus concept and providing an opportunity to evaluate the system. Nine gateways were deployed at distances from 7 to 15 meters from each other, covering an area spanning over two contiguous decks, with corridors, cabins, open indoor and outdoor spaces. An Ethernet local area network was installed in the test area. The gateways also formed a multi-hop RF network to the central unit using three additional relay nodes. Crew members wearing mobile devices (11 life jackets and 4 bracelets) simulated an evacuation procedure that lasted 50 minutes. The locations of the nodes were displayed on the GUI and projected in the nearby ship cinema, where the central processing unit was placed. Three trajectories were pre-defined and their timing recorded, for result evaluation.

Figure 2: GUI snapshot onboard Thomson Spirit.

All devices were traced successfully throughout the tests. The accuracy achieved was on the order of 5 meters, with low latency (about 20 seconds over the backbone network, 40-60 seconds in multi-hop), yielding very satisfactory results.

The scalability of the system was shown through simulations conducted using the OMNeT++™ tool, assessing channel occupancy and delays in beacon reception. In the case of 200 nodes "competing" around two gateways, the medium was shown not to be overloaded with only 2% beacon losses, meaning that everybody could be located in a short time.

Lynceus2Market will deploy a large-scale demonstration of the system in 2017, involving 7000 devices.

[1] www.lynceus-project.eu

[2] www.euronews.com/2014/05/05/don-t-panic

[3] C. Kassapoglou-Faist, Y. Brunet , P. Dallemagne, "Localization and Person Condition Monitoring on Board Cruise Ships for Safe Evacuation", CSEM Scientific and Technical Report (2014) ,137