Large-scale Demonstration of RF-based Localization of Persons in Cruise Ships

C. Kassapoglou Faist, P. Dallemagne

An innovative person localization system for the safe evacuation of large numbers of people (over 500) from passenger ships has been demonstrated in real environment, with excellent results. It is designed to meet requirements for high reliability, robustness, scalability and user acceptance, while being low-cost and low maintenance. The system was handled by the crew during their drills over an extended period, confirming its operational benefits.

The cruise industry is booming. Along with the number of ships, the size of the vessels has also increased substantially, with recent cruise ships accommodating over 5000 passengers. Safety at sea has always been a major concern of the actors involved and unfortunate mishaps have shown that the ability to efficiently and rapidly localize persons in vessels during crisis situations is crucial. Nevertheless, until now, no real-time localization system has proven satisfactory, leaving a time-consuming systematic search as the only option.

The Lynceus [1] system is the culmination of two EU projects that brought together developers, safety equipment manufacturers, commissioners, cruise ship operators, as well as maritime regulators, in order to realize a system that would "see behind obstacles", as the mythological character (Lynceus) could do. During an evacuation procedure, the system is able to track, localize and depict in real-time, all of the persons on-board who are wearing their Lynceus device. Lynceus uses low-cost, low-power, battery-powered radio-frequency (RF) devices embedded in wearable items (life jackets, bracelets or key cards), which communicate with fixed elements (gateways) interconnected to the ship's wired backbone network (Ethernet), Sensors integrated on the devices can also provide an indication of the person's current health status (heart-beat detection, movement). In addition to localization, the Lynceus system can count and identify the missing persons, as well as provide updates on incident escalation, interacting with the on-board fire system. Furthermore, the safety officers can follow the evacuation status on an interactive, highly customizable, graphic interface.

The Lynceus devices are shown in Figure 1. They are developed based on the ultra-low power (ULP), CSEM icyCOM and WiseNET wireless technologies, which operate at 868MHz and 916MHz, adapting to European and American continental waters. The Medium Access Control (MAC) protocol is a high-availability variant of the ULP WiseMAC protocol, designed to exploit the asymmetry in resources between the mobile and the fixed devices. Custom antennas have been designed for optimal radio connectivity. Localization is based on received signal strength, using a simple proximity algorithm, thus coping with strict scalability requirements, while maintaining accuracy at acceptable levels for this application.

Figure 1: Lynceus mobile devices used at the large-scale tests.

Large-scale testing took place on-board the Royal Caribbean cruise ship the Rhapsody of the Seas. The deployment consisted of 724 gateways (see Figure 2) that covered a large part of the vessel, extending over 10 decks and including the engine room. Installation and test were performed while the ship was in full operation, which was quite challenging.

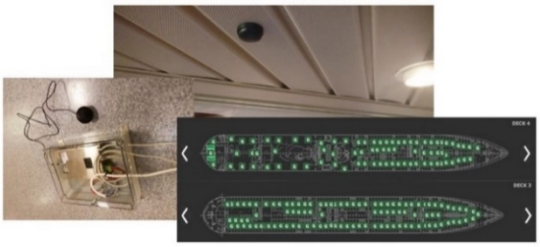

Figure 2: Lynceus gateways and their deployment shown on the GUI (partial view).

Not surprisingly, moving from the lab to a real-world, large-scale deployment revealed a number of operational issues. For example, longer transmission delays and absolute synchronicity of some events at node level affected device and network stability. Despite the complexities of deployment in an operational environment, these problems were solved and the solutions implemented thanks to the remote update function, resulting in a robust system and successful demonstration. All along, the firmware has also been greatly enhanced; in particular, the retransmission policy from the wired to the wireless medium, its wireless routing algorithms (used as a backup in case of local wired network disruptions) and remote firmware update.

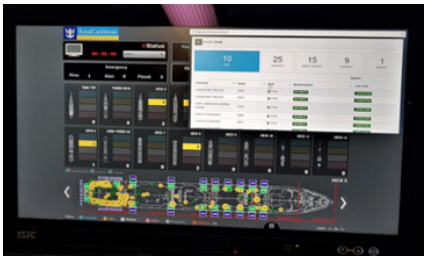

Figure 3: Graphic User Interface at large-scale demonstration.

The crew used and evaluated the system in their weekly drills over a 6-month period, providing valuable feedback. Figure 3 illustrates the security officers' GUI during the final demonstration, which was attended by several guests from the maritime sector. Over that period, 539 keycards had been distributed (number determined by the drill), among which 523 were used at the drill and successfully localized. Localization accuracy is estimated to be between 5 to 10 meters, depending on area type (indoor open space, cabins, outdoors). User acceptance, as well as overall feedback from crew, cruise officials and guests has been extremely positive if not enthusiastic. An exploitation plan has been discussed among the partners and a new project is planned that will extend the concept to oil and gas platforms.

[1] https://fr.euronews.com/2019/06/24/une-technologie-europeenne-accelere-le-sauvetage-en-croisiere