SEQUITUR: An Ultra-wideband Flexible 3D Locating Platform

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I. Extended Abstract

SEQUITUR[1] is a short-range and low-cost radio localization platform based on the ultrawide-bandwidth (UWB) technology providing high-definition 3D positioning in indoor and outdoor environments. This platform offers a high-level of flexibility to fit a huge variety of potential applications ranging from logistic, sport training, security to robots and drones navigation.

SEQUITUR is composed of a set of wireless devices, namely *Anchor nodes*, deployed in fixed positions and forming the positioning infrastructure, and one of more small and battery-powered mobile devices, the *Tags*, which are attached to objects or persons to be localized. Nodes are based on the low-cost the Raspberry Pi© hardware equipped with an additional ad-hoc designed board containing a IEEE802.15.4a UWB radio interface [1], [2] as well as 3D inertial, magnetometer and barometer sensors (see Fig. 1).

Both wireless time-difference-of-arrival (TDOA) and two-way ranging (TWR) measurement techniques have been implemented providing the user a high-level of flexibility in trading performance, energy consumption, refresh rate and number of tags. In fact, while in general TWR provides a higher positioning accuracy thanks to the possibility to better counteract oscillators clock drifts, TDOA permits a drastic reduction in packet exchanges between tags and anchors thus allowing a significant improvement in terms of refresh rate and number of tags. Thanks to the wireless TDOA feature implemented, only-transmitting tags following the ISO/IEC 24730-62:2013 [3] 12 bytes blink packet standard can be managed by the system. In addition, no antenna delay calibration procedures are needed as offsets are intrinsically eliminated by the differential measurement.

The SEQUITUR architecture is configurable depending on applications needs. Specifically, two different and complementary architectures can be set up via software. In the first architecture (*centralized architecture* in Fig. 2), the network of anchors is controlled by a central server that can be installed on a general-purpose computer or one anchor node. Anchors and server can be connected via Wi-Fi or cable connections. The server can be interrogated by one or more remote clients allowing the 3D visualization and interaction with all tags as well as an easy set up and configuration of the network. This architecture is mainly intended to support low-cost and energy efficient tags. The second architecture (*distributed architecture* in Fig. 3) works in a similar way as GPS where anchors emit synchronized signals that are received by each tag that calculates its own position autonomously via TDOA measurements. This configuration allows an unlimited number of tags moving in the same environment.

Position calculation is performed through state-of-the-art Bayesian filters, using the particle filter implementation [4], by employing innovative measurements fusion and clock drift compensation techniques to enable TDOA.

The deployment of the demo consists of the installation of a sufficient number of battery-powered anchor nodes positioned in the perimeter of the area of interest on tripods or suitable arrangement, approximately at the same or higher height as that of the mobile node. The number of anchor nodes will depend on the area to be covered. Both manual anchor position measurement and self-localization capability can be adopted, the former providing the best performance but requiring a longer set up time. In the first architecture the location of tags is reported by a smartphone or tablet app (user terminal) which interrogates the network via Wi-Fi, collects and shows all tags position (example in Fig. 4). In the distributed architecture, the user terminal is directly connected to the mobile tag and reports its own position like in GPS terminals.

The system has been tested in different indoor and outdoor environments providing an average localization accuracy below 50cm including persons and 3D tracking of drones. Thanks to its high-versatility and low-cost infrastructure, SEQUITUR has been adopted by a Spin-off company of the University of Bologna to pursue the technology industrialization and commercialization.

[1]SEQUITUR is a latin word meaning "follow him".

Acknowledgment

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References

[1] "ScenSorDW1000, DecaWave," *http://www.decawave.com/products/dw1000*.

[2] *IEEE Std 802.15.4a-2007 (Amendment to IEEE Std 802.15.4-2006)*, pp. 1–203, 2007.

[3] "ISO/IEC 24730-62:2013 standard," 2013.

[4] D. Dardari, P. Closas, and P. M. Djuric, "Indoor tracking: Theory, methods, and technologies," *IEEE Trans. Veh. Technol.*, vol. 64, no. 4, pp. 1263–1278, April 2015.

Fig. 1. Example of battery-powered SEQUITURE node.

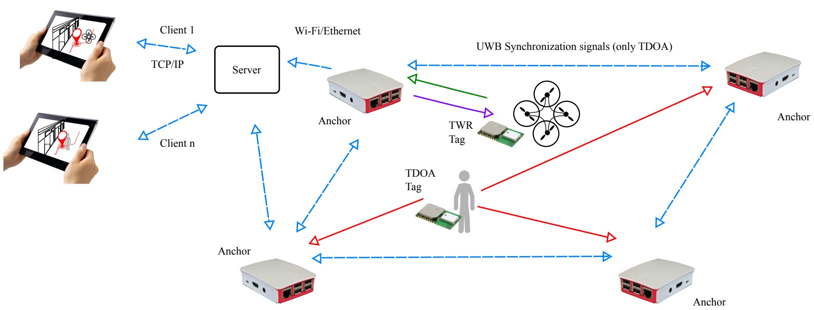

Fig. 2. Centralized architecture configuration.

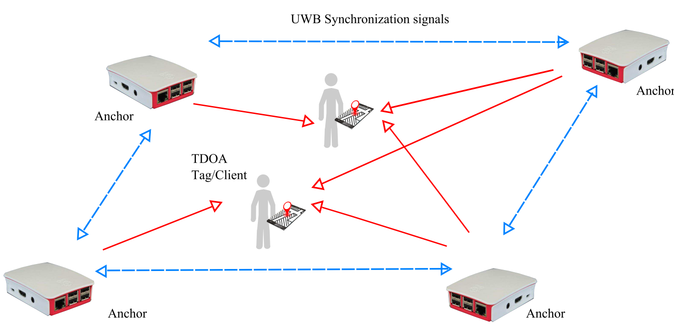

Fig. 3. Distributed architecture configuration.

Fig. 4. Example of user interface.