Demo: Blink - Room-Level Localization Using SmartMesh IP

Yasuyuki Tanaka, Hai Le, Victor Kobayashi, Camilo Lopez, Thomas Watteyne, Mina Rady

Demo: Blink – Room-Level Localization Using SmartMesh IP

Yasuyuki Tanaka, Ba Hai Le, Victor Kobayashi, Camilo Lopez, Thomas Watteyne
Inria, Paris, France
first.last@inria.fr

Mina Rady
Orange Labs, Meylan, France
mina1.rady@orange.com

Abstract

This demo presents a room-level localization solution built on top of the market leading SmartMesh IP industrial low-power wireless mesh network. Without any changes to the hardware or protocol stack of that product, we re-purpose Blink – a feature designed to allow for mobile nodes – for localization. We demonstrate how we can deploy the resulting localization solution throughout a building by installing an anchor node in each room, and locate the room a mobile tag is in. Initial results indicate that this solution offers over 90% room-level localization accuracy, and at worst adjacent room localization. The unique aspect of it is that the entire network of anchor nodes in battery powered and operates for years on a pair of AA batteries. There are countless applications looking for easily to install and fully battery powered room-level localization, for which our solution, which is production-ready, is ideal.

Keywords

Localization, low-power, TSCH, SmartMesh IP.

1 Introduction

Low-power wireless mesh solution have been a commercial reality, with tens of thousands of networks deployed in applications ranging from industrial monitoring, to smart building, smart parking and environmental sensing. All of these networks use a variant of Time Synchronized Channel Hopping (TSCH). And while these networks are used to carry sensor data and actuator commands, there are many use cases where being able to localize at least a certain number of motes opens up many new applications. A representative example is the mobile echograph machine in a hospital, a piece of medical equipment on wheels which is shared by the medical personnel, and which travels from room to room. We are trying to design a solution that fits that need: know in which room the echograph is (e.g. centimeter-level accuracy is absolutely not needed), and make sure that solution is fast to deploy and cheap (e.g. does not require wires).

There are many localization technologies, based on Ultra-Wide Band [1], ultra-sound or BLE beacons [2]. While they generally work, they either require anchor nodes to be mains powered, or tags to be recharged every day or so. And while some offer a much better localization accuracy, the lack of low-power makes them unsuitable.

In this demo, we demonstrate a full indoor room-level localization solution, which consists of only wireless devices which can be deployed in a couple of hours throughout a building, and operate for years without requiring any battery change. We do so by re-purposing the existing Blink feature of SmartMesh IP, without requiring any changes to the hardware. This makes our solution production-ready, as it benefits from the industrial performances and overall quality of this product. All elements which are not part of SmartMesh IP are available open-source.

2 Blink Localization System

SmartMesh IP is a commercial low-power wireless mesh networking solution designed by the Dust Networks team, and commercialized by Analog Devices[1]. It is the market leading low-power wireless mesh solution for demanding applications. Over 76,000 SmartMesh networks are deployed today; a SmartMesh IP network offers >99.999% end-to-end reliability, <50 μA average current draw even for routing nodes (i.e. over a decade of battery lifetime), and NIST-certified security [3].

Blink is part of the production SmartMesh IP firmware, any mote implements it. In Blink mode, when a mote has information to send, it goes through what looks like a regular secure join process, but, rather than sending a join request to the manager, it sends application data. After sending that data, the mote turns back off consuming virtually nothing. The Blink traffic benefits from the same security and reliability as any traffic in a SmartMesh IP network. Blink was built to allow for very large networks (up to 500,000 Blink motes in a network), and for Blink motes to move. We re-purpose Blink and have the mote report the identifiers and RSSI of neighbor motes it discovered. We then use that information to get an idea of where the Blink mote is.

[1] https://www.analog.com/en/applications/technology/smartmesh-pavilion-home.html

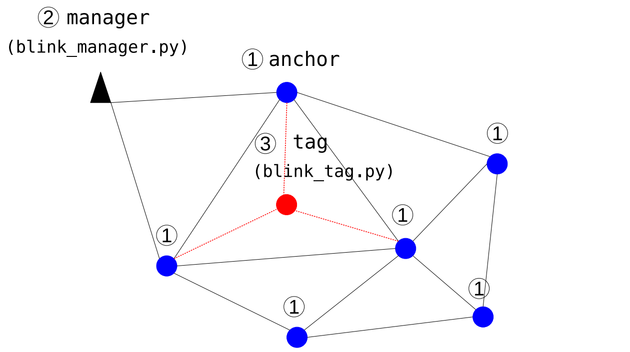

Figure 1. Architecture of the Blink localization system.

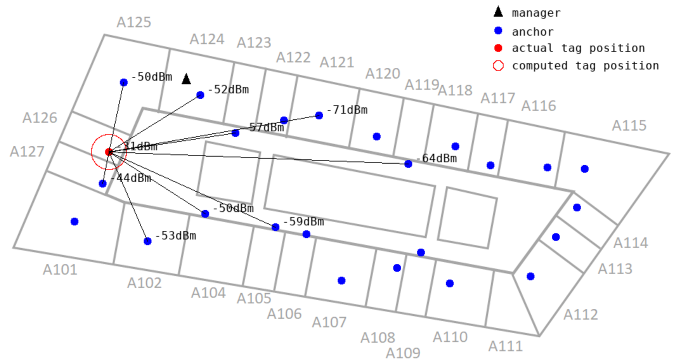

Figure 2. The system positions the tag in the right office.

There is very comprehensive body of work which focuses on RSSI-based localization. It is a very appealing technique, as any radio can measure and report the RSSI for any received frame; RSSI measurements are free. The problem is that it does not work, as receive signal strength is not a good indicator of distance in any sort of practical setting.

We are not looking to use RSSI for ranging or trilateration. Instead, the idea is simple: deploy an anchor in each room and if the tag is located in the same room as an anchor, because of the walls separating the rooms, it will hear the anchor in that room which an RSSI much higher than anchors in other rooms.

Fig. 1 shows the resulting architecture. ① A number of anchor motes are deployed in the building to be equipped, one per room, and form a canopy low-power wireless network. These are unmodified SmartMesh IP motes, configured to join the SmartMesh IP network. ② A SmartMesh IP manager is deployed in the vicinity of the anchor motes, and is in charge of managing the SmartMesh IP network. This is an unmodified SmartMesh IP manager connected to a Raspberry Pi running the `blink_manager.py` script. ③ One or more SmartMesh IP motes roam around the building, and are the mobile tags. These are unmodified SmartMesh IP motes, configured *not* to join the SmartMesh IP network. Instead, they run an application which sends Blink packets. All SmartMesh IP hardware is built around the LTC5800 chip.

3 Demonstration

Initial testing of our demonstration is carried out across a floor of our office building at Inria-Paris. We believe our building to be representative of most modern office buildings. We deploy 25 anchor nodes, one per office. The ceiling of this building is metallic, so we use a magnet with a 50 cm long wire on which the mote dangles. This allows us to deploy the entire network of anchors in less than 15 min, without needing to climb a ladder. We place the manager, connected to a Raspberry Pi, in office A124. On the Raspberry Pi, we run the `blink_manager.py` script that collects the Blink packets. We use a cart to walk about the area. On the cart, we put the tag mote and a laptop computer.

During the demonstration, we make sure all anchors are switched on, and form a stable SmartMesh IP mesh network around the manager. We start the `blink_manager.py` script on the Raspberry Pi. We then walk around with the tag. At each location, which have the tag to send Blink packets; these are received and logged by the `blink_manager.py` script on the Raspberry Pi.

Fig. 2 shows the resulting localization. Initial testing suggests that the solution positions the tag in the correct room 90% of the time, and in the room right next to it 10% of the time. The solution runs with only battery-powered devices, and hence benefits from the ultra low-power nature of SmartMesh IP, and anchors having a battery lifetime of a decade.

4 Discussion

This solution offers over 90% room-level localization accuracy, and adjacent room localization in all other cases. What you concede in term of localization accuracy against for example UWB solution, you get back in total cost of ownership. The entire solution is wireless, including the canopy network of anchor nodes, which can be set up in a matter of minutes. The position of every tag can be monitored centrally. This localization solution is built on the market-leading low-power wireless product, so offers an industrial level of reliability and security, making this localization solution production-ready.

A ideal example use case for this localization is tracking rolling equipment in a hospital. The building is already in use and installing a heavy localization infrastructure, possibly involving wiring up many components, is a non-starter. The proposed localization solution can be retrofit to an existing building with the full installation throughout a building taking a couple of hours. Once installed, every anchor is battery-powered and runs for over a decade on batteries. The systems supports a very large number of tags to roam around the building, simply stuck to the equipment to track.

5 References

[1] F. Despaux, A. van den Bossche, K. Jaffrès-Runser, and T. Val. N-TWR: An accurate time-of-flight-based N-ary ranging protocol for Ultra-Wide band. *Elsevier Ad Hoc Networks*, 79:1–19, 2018.

[2] K. E. Jeon, J. She, P. Soonsawad, and P. C. Ng. BLE Beacons for Internet of Things Applications: Survey, Challenges, and Opportunities. *IEEE Internet of Things Journal*, 5(2):811–828, 2018.

[3] T. Watteyne, J. Weiss, L. Doherty, and J. Simon. Industrial IEEE802.15.4 e networks: Performance and trade-offs. In *IEEE International Conference on Communications (ICC)*, pages 604–609. IEEE, 2015.