Poster Abstract: RF Technologies for Indoor Localization and Positioning

Xuanjiao Zhu
University of Duisburg-Essen
Embedded Systems Engineering
Duisburg, Germany
xuanjiao.zhu@stud.uni-due.de

Marcus Handte
University of Duisburg-Essen
Networked Embedded Systems
Essen, Germany
marcus.handte@uni-due.de

Rasit Eskicioglu*
University of Duisburg-Essen
Networked Embedded Systems
Essen, Germany
rasit.eskicioglu@umanitoba.ca

ABSTRACT

Location-based services have become an important market. At their core, location-based services generally rely on identifying the location of individuals or objects. In outdoor environments, determining the location is typically accomplished by means of GPS. In indoor environments, Bluetooth Low Energy (BLE) based localization has received a lot of attention. Most recently, an increasing number of mobile devices are capable of supporting ANT as an alternative low-power communication protocol. Unlike BLE, however, the suitability of ANT for localization has not been analyzed extensively. We report the initial results of an experimental study to compare ANT and BLE when used for localization. The results suggest that ANT-based localization can clearly outperform BLE, when using fingerprinting as the underlying localization principle.

ACM Reference Format:

Xuanjiao Zhu, Marcus Handte, and Rasit Eskicioglu. 2018. Poster Abstract: RF Technologies for Indoor Localization and Positioning. In *SenSys '18: Conference on Embedded Networked Sensor Systems, November 4–7, 2018, Shenzhen, China.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3274783.3275217

1 INTRODUCTION

Location-based services have become an important market that is growing rapidly. At their core, location-based services generally rely on identifying the physical location of individuals or objects. In outdoor environments, determining the physical location is typically accomplished by means of GPS. In indoor environments, however, the availability and precision of GPS is often not sufficient. Due to the wide availability and support through large companies, Bluetooth Low Energy (BLE [1]) based indoor localization technologies (e.g. iBeacon, EddyStone) have received a lot of attention and systems relying on them are already deployed in the field [2]. In addition to BLE, an increasing number of mobile devices are capable of supporting ANT [3] as an alternative low-power communication protocol in the 2.4 GHz range. Unlike BLE, however, the suitability of ANT for indoor localization has not been analyzed extensively. In the following, we report the initial results of an experimental study to compare ANT and BLE when used for indoor localization. The results suggest that ANT-based localization can outperform BLE, especially, when using fingerprinting [4] as the underlying localization principle. Given that several BLE chipsets are also capable of supporting ANT, we think that this result could exhibit a high practical relevance in the near future.

*Rasit Eskicioglu is currently on research leave from the University of Manitoba.

SenSys '18, November 4–7, 2018, Shenzhen, China

ACM ISBN 978-1-4503-5952-8/18/11…$15.00
https://doi.org/10.1145/3274783.3275217

2 CASE STUDY

To enable a fair comparison of BLE and ANT in localization applications, we use the same hardware to perform all the experiments. In particular, we use Dynastream D52QM6 modules (Figure 1) that are built around Nordic Semiconductor's multiprotocol nRF52832 System-on-Chip (SoC)s [5]. This SoC has a 32-bit ARM® Cortex™-M4F CPU with 512kB + 64kB RAM. The SoCs embedded 2.4GHz transceiver supports BLE, ANT and proprietary 2.4 GHz protocol stacks.

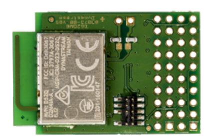

Figure 1: Dynastream D52QM6 Module

On the Dynastream D52QM6 SoC modules, ANT and BLE are implemented as *soft devices (SD)* that are loaded onto the chip together with applications. There are three SD types: BLE-only, ANT-only, and BLE-ANT. We use the BLE-ANT SD throughout our experiments. Although both BLE and ANT protocols support multiple topologies, we use peer-to-peer connection with the BLE-ANT SD.

3 METHODOLOGY AND RESULTS

To study and compare the localization performance of BLE and ANT, we measured and analyzed *received signal strength indicator (RSSI)* [6] values that are captured at different distances, ranging from 20cm to 5m. For each protocol and for each distance, we collected 1000 RSSI values over a period of approximately 5 minutes. Thereby, we only consider a single room, i.e. a large empty lab space, without obstacles and we use two modules to generate and capture the data. One module, connected to a laptop via USB, acts as a base station and collects RSSI values, and the other acted as a beacon that periodically sends messages. To ensure that we are only measuring the differences between the protocols, we used the

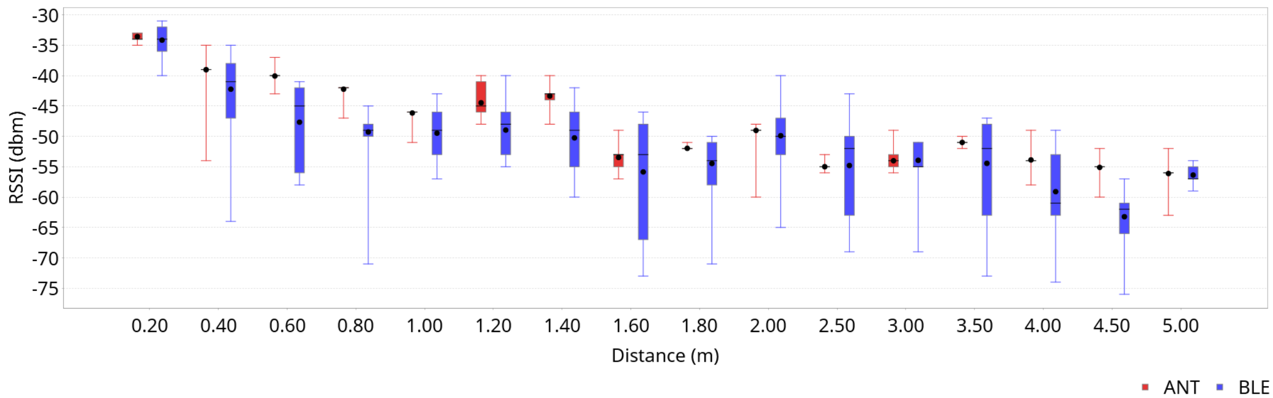

Figure 2: RSSI Distribution of BLE and ANT Measurements at Different Distances

same two devices for all measurements and we did not modify the physical environment during the measurements. Furthermore, we ensured that nobody is inside the room while the measurements were ongoing.

Figure 2 shows the distribution of the RSSI measurements of the two protocols at different distances in a box-and-whiskers plot with error bars. The boxes show the 25th and 75th percentile of the values. The error bars indicate the minimum and maximum values. The black dot and the bar show the average and median values, respectively.

When looking at the tendency of the averages over increasing distance, it becomes apparent that both protocols are generally exhibiting a logarithmic drop in RSSI which is expected for free-space line-of-sight measurements. However, this trend is clearly not perfect. For example, when comparing the measurements at 1.6m with 2.0m, Figure 2 shows an increased RSSI for an increasing distance. This can only be explained by the effects of multi-path propagation of RF signals in the lab environment.

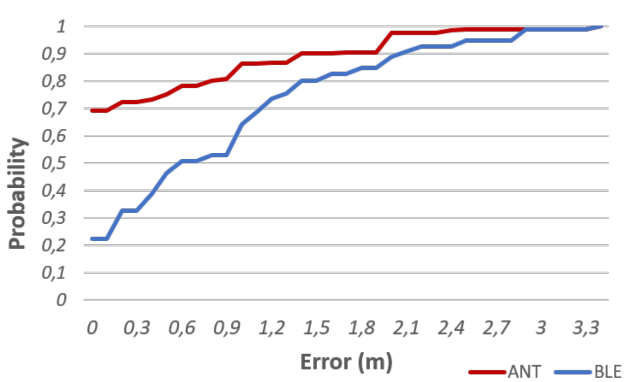

Figure 3: Fingerprinting Accuracy (CDF)

While these effects can be problematic when using lateration [4] as the underlying localization principle, it is also possible to exploit them when using fingerprint-based localization, instead. To successfully apply fingerprinting, however, it is important that the measurements at the same position exhibit the same RSSI values. Apparently, when comparing the ANT and BLE measurements in Figure 2, the RSSI values of ANT are significantly more stable than those of BLE. With a few exceptions at 1.2m, 1.6m and 3.0m, the boxes of the ANT plot are completely collapsed onto the average and median values, indicating no variance.

To demonstrate this, we implemented a simple fingerprint-based localization algorithm based on RADAR [7]. We used the first 500 values at each point as training set and the remaining 500 values to perform 500 localization attempts. The resulting error distribution is depicted in Figure 3. As mentioned previously, the fingerprinting accuracy of ANT is significantly higher than BLE. For example, the number of correct matches of ANT lies at 69%, whereas BLE only exhibits 23% accuracy. Similarly, the 90th percentile error of ANT lies at 1.4m, whereas BLE lies at 2.1m. Given these results, we can conclude that ANT clearly outperforms BLE with respect to localization performance in our laboratory setting.

4 FUTURE WORK

Since we are using the same physical environment and identical hardware for all experiments, we can attribute the differences in performance to the differences of the communication protocols. However, given the limited scope of our experiments, a more thorough study is needed to harden these conclusions. Currently, we are extending the experiments to a larger number of devices and to different environments, such as hallways and multiple rooms.

REFERENCES

[1] Bluetooth Consortium. Bluetooth Low Energy (BLE). https://www.bluetooth.com. Accessed: 2018-08-10.

[2] S. Wagner, N. Fet, M. Handte, and P. J. Marrón. An Approach for Hybrid Indoor/Outdoor Navigation. In *2017 International Conference on Intelligent Environments (IE)*, pages 36–43, Aug 2017.

[3] Thisisant, Inc. ANT Network. https://www.thisisant.com/. Accessed: 2018-08-10.

[4] Y. Gu, A. Lo, and I. Niemegeers. A survey of indoor positioning systems for wireless personal networks. *IEEE Communications Surveys Tutorials*, 11(1):13–32, First 2009.

[5] Nordic Semiconductor, Inc. nRF52832 SoC. https://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF52832. Accessed: 2018-07-15.

[6] K. Srinivasan and P. Levis. RSSI Under-Appreciated. In *Proc. of the 3rd Workshop on Embedded Networked Systems (EmNets)*, 2006.

[7] P. Bahl and V.N. V.N. Padmanabhan. RADAR: an in-building RF-based user location and tracking system. In *Proc. of the 19th Conf. on IEEE Computer Communications*, volume 2, pages 775–784, 2000.