Demo Abstract: SurePoint: Exploiting Ultra Wideband Flooding and Diversity to Provide Robust, Scalable, High-Fidelity Indoor Localization

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ABSTRACT

We present SurePoint, a system for drop-in, high-fidelity indoor localization. SurePoint builds on recently available commercial ultra-wideband radio hardware. While ultra-wideband radios provide a pairwise range estimate natively, we show that with the addition of frequency and spatial diversity, we can achieve a 53% decrease in median range error. Because this extra diversity requires many additional packets for each range estimate, we leverage an efficient broadcast ranging protocol for localization that ameliorates this overhead. In stationary and fast-moving environments SurePoint achieves up to 0.08 m median error and 0.53 m 99th percentile error. As ranging requires the tag to have exclusive access to the channel, we employ a protocol to coordinate the localization of multiple tags in space. This protocol builds on recent work exploiting the constructive interference phenomenon, however SurePoint is the first to demonstrate constructive interface using the 802.15.4a ultra-wideband PHY. Finally, as the ranging protocol requires careful management of the ultra-wideband radio and tight timing, we utilize TriPoint, a dedicated "drop-in" ranging module that provides a simple I^2C interface. We show that this additional microcontroller demands only marginal energy overhead while facilitating interoperability by freeing the primary microcontroller to handle other tasks.

This demo complements the paper "SurePoint: Exploiting Ultra Wideband Flooding and Diversity to Provide Robust, Scalable, High-Fidelity Indoor Localization" to be presented at SenSys'16.

Categories and Subject Descriptors

B.0 [**Hardware**]: General; C.3 [**Special-Purpose and Application-Based Systems**]: Real-time and embedded systems

Keywords

Indoor Localization, Ultra-Wideband Communications, Constructive Interference

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1. INTRODUCTION

The research community has made great strides by designing indoor localization systems using multiple modalities that achieve decimeter-accurate localization quality (e.g. ALPS [7], Harmonium [5], Chronos [8], and Luxapose [6]). Given the growing abundance of systems that offer very high accuracy, perhaps continuing to evaluate systems on accuracy alone is no longer useful, and indeed decimeter level error is good enough. As localization technology begins to mature, we argue that it is time to focus on the other aspects necessary for a viable and reliable localization system.

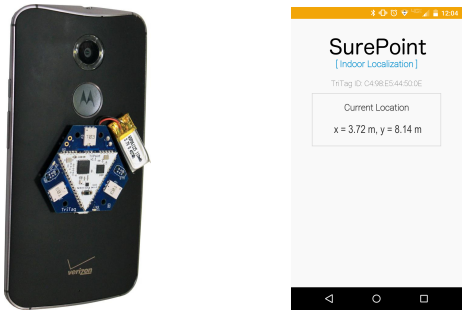
To that end, we present SurePoint, a decimeter-accurate, robust, reliable, scalable, and easily integrable localization system. SurePoint is able to achieve a 0.29 m median position error and 99 percent of ranging error is *within 53 cm*. SurePoint builds on our previous system, PolyPoint [4], but adds robustness, higher accuracy, an improved location solver, and support for localizing multiple tags. This entire system is then packaged into a drop-in localization module that can be added to other hardware designs.

SurePoint achieves its high accuracy by leveraging the high-fidelity time-of-flight primitive provided by ultra-wideband radios. SurePoint further improves on this raw primitive with the addition of frequency and polarization diversity by exploiting multiple communication channels and multiple antennas.

Supporting multiple tags in RF-based systems is often overlooked. While unidirectional broadcast systems, such as ALPS [7] or Luxapose [6] naturally support an unbounded number of devices, recent RF-based systems such as WiTrack [1] or Harmonium [5] do not address the challenge of supporting multiple tags. SurePoint takes inspiration from the recent Low Power Wireless Bus [2] to build a ranging protocol that dynamically adapts to the number of tags currently in the environment.

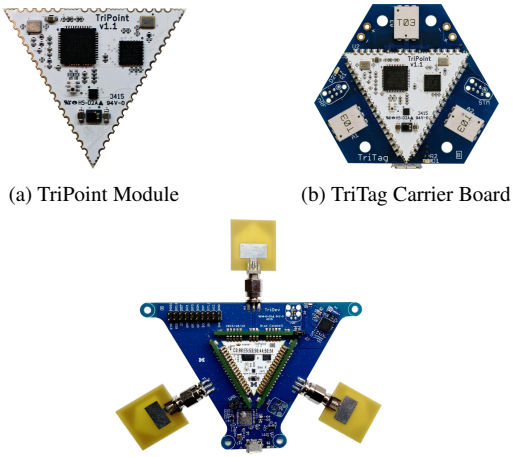
Using ultra-wideband, while advantageous for ranging, presents an interesting challenge when coupled with a design similar to the Low Power Wireless Bus. That bus protocol relies on Glossy floods [3] to synchronize nodes, and Glossy floods rely on the constructive interference phenomenon. Loosely, constructive interference occurs when two radios send the exact same packet at sufficiently the exact same time such that the collision of the two packet is actually additive, resulting in a more robust transmission. Previous work in constructive interference has focused on narrowband 802.15.4, which uses a different modulation scheme than the UWB 802.15.4 PHY. We explore the constructive interference phenomenon in the UWB channel, demonstrating that it continues to improve transmission performance with UWB as well.

Finally, we observe that implementing a reliable and accurate localization system is challenging. Obtaining consistent location



(a) TriTag with smartphone (b) Base SurePoint smartphone UI

Figure 1: **TriTag interfaces with smartphones.** TriTag is designed to be an accessory for smartphones that provides localization for users, and the user's current position is displayed on the phone in a UI similar to the one shown in Figure 1b.



(a) TriPoint Module (b) TriTag Carrier Board

(c) TriDev Calibration Board

Figure 2: **SurePoint hardware.** (a) shows the TriPoint module, a solder-on device that implements the SurePoint system and exposes location information over an I^2C interface. In (b), TriPoint is soldered onto a carrier board that includes a BLE interface. (c) shows the TriDev calibration board, allowing temporary TriTag connection to SMA antennas (pictured) or direct coaxial connection for multipath-free calibration measurements.

updates often requires meeting tight timing constraints, performing expensive processing, adapting to local conditions by selecting appropriate algorithmic parameters, and integrating this complexity with the system or device to be localized. For these reasons, we introduce TriPoint, a drop-in hardware module that provides localization as a simple I^2C peripheral. We show how prefabricated modules help to address the calibration problem, ease system integration, and ultimately make locating any Bluetooth-enabled device, such as a smartphone or tablet, as simple as sticking a tag to it.

2. DEMO

For this demo, we will localize multiple SurePoint-enabled smartphones, such as the one shown in Figure 1. During the demo, users will be able move the phones around the space and watch their location estimates update in real time. Multiple tags may be active in the same space, and users will be able to seamlessly join new phones to be localized to the network simply by turning the localization service on (or leaving and re-entering the space).

3. ACKNOWLEDGMENTS

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