High-Resolution Indoor RF Ranging

Thomas Schmid
Greina Technologies, Inc.
thomas@rfranging.com

Daniel Lee
Greina Technologies, Inc.
daniel@rfranging.com

***Abstract*—Our recently developed indoor RF Ranging technology allows new levels of accurate indoor localization based on carrier-phase measurements. Measuring the phase difference over multiple frequencies, and combining it with a novel multipath angle-of-arrival differentiation technique, we achieving accuracies of a few centimeters in direct line of sight, and a few tens of centimeters in non-direct line of sight. Similar to GPS satellites, our system requires self-localizing multi-antenna base stations as a infrastructure and anchor points.**

Keywords—RF Ranging, Localization

I. Introduction

The ability to tag objects and record their location in real-time is critical for devices that make up the Internet-of-Things, where wireless nodes in the cyber space have to be assigned to physical locations. The incremental overhead of just finding a node with a specific node ID can be daunting, and quickly remove any potential monetary benefits such a system could provide. Consequently, Real-Time Location Systems (RTLS) using radio frequencies in the public 2.4 GHz ISM band have gained popularity in the market- place, but are often just tacked on as an after-thought with less then ideal technologies as the system operators realize that without location information, maintenance becomes too expensive.

The focus of our company is on phase-based techniques, as it is the only solution that provides the potential for sub-centimeter accurate tracking and integration of an Angle-of-Arrival system using multiple antennas, while providing significant benefits over chirp-spread-spectrum technologies. For example, a phase-based system can frequency-hop over the same spectrum band as a chirp, but can do so in discontinuous steps in frequency and/or time. This allows a phase-based system to avoid interfering devices, or redo certain measurements at a later time when the interfering device is not present anymore.

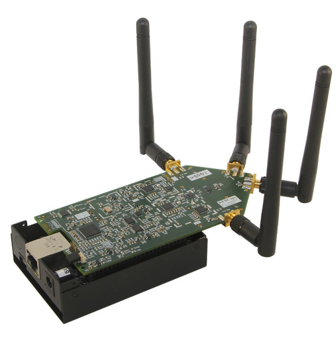

Figure 1: RF Ranging Basestation with Carrier-Phase and Angle-of-Arrival capabilities.

II. Approach

Our system measures distance from the change in phase of a radio signal rather than a direct time measurement. Distances greater than one wavelength are measured by combining frequencies and measuring their “Delta Phase”. When two different frequencies $f1$ and $f2$ are broadcasted alternately or together, they share a fixed relationship that, when the phase on transmission and phase on reception are known, can be used to determine the distance within the wavelength of the resulting beat frequency $\Delta f = f2 - f1$, which is significantly lower than any one of the two frequencies.

In order to achieve higher resolution ranging, a high beat frequency has to be chosen. This, however, limits the maximum range of the ranging system itself, as after one wavelength of the beat frequency, the phase repeats. Additionally, the clocks at the transmitter and receiver must be synchronized in order to perform the phase measurement. We solve the latter problem by introducing a high-precision RF reflector node (the tag) that synchronizes its clock to the carrier frequency utilizing a custom developed high-precision tunable oscillator. This reflector node reproduces the carrier frequency with high accuracy. An initiating node thus sends out a carrier tone, which the RF reflector sends back as if the carrier bounced from it. The initiating node now calculates the path length the carrier wave took from the transmission, until reception of the reflected wave, and thus measures the distance between itself and the reflector.

III. Deployment Requirements

We will deploy up to 10 self-localizing RF Ranging Basestations (see Figure 1). The basestations search and localize tags within their radio range, and provide a map with the tag’s location. The tag will be put on a tablet or phone that can visualize the generated map and user’s location.

References

1. Greina Technologies, Inc. Website: http://www.rfranging.com