(SD2019-143) BLoc: CSI-Based Accurate Localization for BLE Tags (US Pat. No. 11,140,651)

Tech ID: 31813 / UC Case 2019-143-0

BACKGROUND

Bluetooth Low Energy (BLE) tags have become very prevalent over the last decade for tracking applications in homes as well as businesses. These tags are used to track objects, navigate people, and deliver contextual advertisements. However, in spite of the wide interest in tracking BLE tags, the primary methods of tracking them are based on signal strength (RSSI) measurements. Past work has shown that such methods are inaccurate, and prone to multipath and dynamic environments. As a result, localization using Wi-Fi has moved to Channel State Information (CSI, includes both signal strength and signal phase) based localization methods.

In indoor environments, BLE tags are the methods of choice. They provide sufficiently long range indoors, are resistant to frequency selective fading and have low power operation. BLE tags are readable by off-the-shelf smartphones and access points, because of their co-existence in the 2.4 GHz Wi-Fi band. BLE tags are, therefore, getting very popular for tracking operations in homes, factory floors, etc. Google's vision for physical web is based on extensive deployment of BLE beacons. It is in this context that localization for BLE devices becomes crucial.

Deep Neural Networks and Convolutional Neural Network techniques to overcome these limitations.

TECHNOLOGY DESCRIPTION

Researchers at UC San Diego in collaboration with a researcher from MIT have patented (US Pat. No. 11,140,651) a CSI-based localization system for BLE tags (BLoc). BLoc includes novel algorithms to compute CSI for BLE packets, to increase bandwidth of BLE signals by combining the frequency hops and to isolate the direct path from multipath reflections. By doing so, BLoc achieves sub-meter localization accuracy in a real world environment.

US Patent: https://patents.google.com/patent/US11140651B2

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OTHER INFORMATION

KEYWORDS

Bluetooth Low Energy, indoor Localization, RF-based Indoor Positioning, algorithms

CATEGORIZED AS

- **Communications**
  - Wireless

RELATED CASES

2019-143-0

(12) **United States Patent**
Ayyalasomayajula et al.

(10) **Patent No.: US 11,140,651 B2**
(45) **Date of Patent: Oct. 5, 2021**

(54) **LOCATION DETERMINATION OF WIRELESS COMMUNICATIONS DEVICES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**
H04W 24/00 (2009.01)
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(52) **U.S. Cl.**
CPC ***H04W 64/003*** (2013.01); ***H04B 7/0626*** (2013.01); ***H04L 5/023*** (2013.01);
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(58) **Field of Classification Search**
CPC . H04W 64/003; H04W 4/80; H04W 72/0453; H04W 4/029; H04B 7/0626; H04L 5/023; H04L 27/2657
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,195,556 B1 * 2/2001 Reudink G01S 5/12 342/457
6,236,849 B1 * 5/2001 Reudink G01S 5/12 342/457
(Continued)

OTHER PUBLICATIONS

V. Bahl and V. Padmanabhan. RADAR: An In-Building RF-based User Location and Tracking System. INFOCOM, 2000.
(Continued)

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(57) **ABSTRACT**

A method, a system, and a computer program product for determining a location of a communication device. Data corresponding to a detected transmission of a data packet between a tag device and one or more communication devices is received on one or more communication channels. At least one of a channel state information and a signal strength associated with the detected transmission for each frequency band in a plurality of frequency bands are determined. Based on the determined channel state information, one or more lengths of signal paths corresponding to the detected transmission of the data packet are determined. A shortest length in across one or more communication devices is selected to determine a location of the tag device.

19 Claims, 21 Drawing Sheets

APPLICATIONS

BLoc will open new avenues for localization of tens of millions of already deployed BLE tags and will serve as a tool for the research community to test out CSI-based localization algorithms for BLE devices.

The goal of BLoc is to improve localization accuracy for the BLE tags that increasingly form a part of our daily lives. In summary, each communication protocol has different applications and different deployment scenarios, therefore localization of each protocol is important. BLoc is geared to advance the Bluetooth localization towards the indoor application scenario.

ADVANTAGES

Bloc advantages:

- Achieves sub-meter localization accuracy in a real-world environment.
- Includes novel algorithms to compute CSI for BLE packets
- Increase the bandwidth of BLE signals by combining the frequency hops
- Isolates the direct path from multipath reflections.

STATE OF DEVELOPMENT

Working Prototype: tested and proved the performance of the algorithm on data collected in a real-world setup

INTELLECTUAL PROPERTY INFO

The invention is patent-pending and is available for licensing and collaborations.

RELATED MATERIALS

- Ayyalasomayajula, Roshan, Deepak Vasisht and Dinesh Bharadia. "BLoc: CSI-based accurate localization for BLE tags". CoNEXT '18 Proceedings of the 14th International Conference on emerging Networking EXperiments and Technologies; Heraklion, Greece — December 04 - 07, 2018;Pages 126-138 - 12/04/2018

PATENT STATUS

Patent Pending

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