Proximity Detection with Single-Antenna IoT Devices

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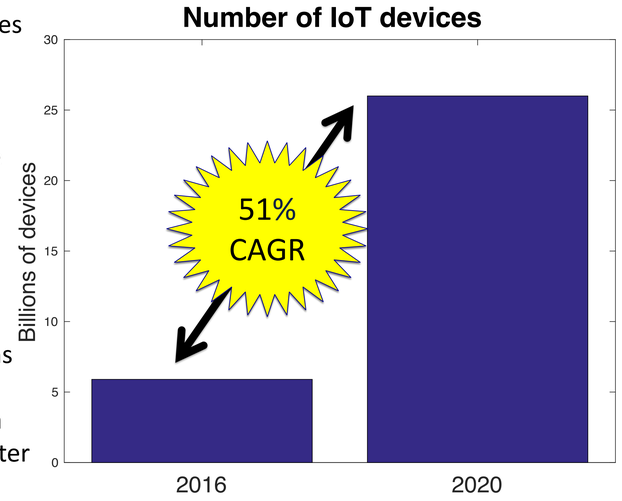
Internet of Things (IoT) devices may frequently encounter new devices

- Analysts predict billions of IoT devices will be deployed in the near future[1]
- IoT devices are envisioned to share data among themselves
- Some shared data may be privacy sensitive or have security implications
- With billions of devices deployed, a device may encounter dozens of new devices every day



Proximity can be a basis for trust when devices are first encountered

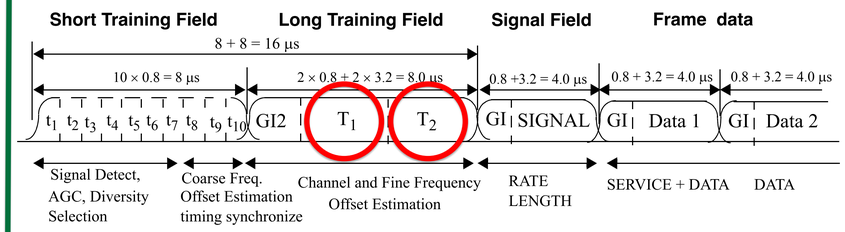
- Assume an adversary is not able to gain close physical proximity to devices (e.g., adversary does not break into a home to gain physical proximity)
- Proximity can then serve as a basis for trust
- Techniques exist for multi-antenna devices to detect proximity
- No proximity techniques exist for single-antenna devices

Distant adversary

Nearby legitimate devices

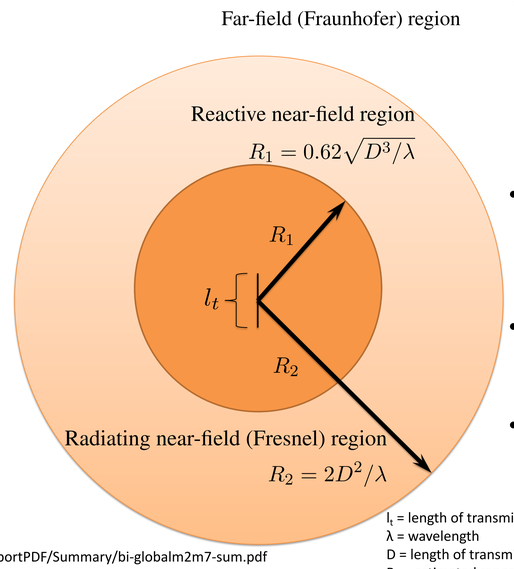
Use repeating portions of Wi-Fi Long Training Field (LTF) for proximity

Wi-Fi Preamble



- T_1 and T_2 are identical 64-sample portions of the Long Training Field in the Wi-Fi preamble[2]
- Repeated LTF portions T_1 and T_2 are used for channel estimation
- T_1 and T_2 are expected to match at the receiver (plus noise)
- All Wi-Fi receivers must evaluate T_1 and T_2
- Even single-antenna devices can measure T_1 and T_2

Near-field effects can cause mismatches in the repeating LTF

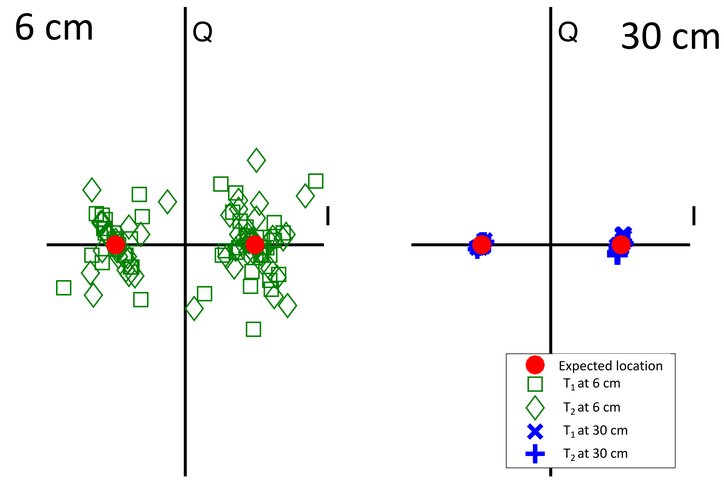


- In the reactive and radiating near-field regions around a transmitter, the electric and magnetic fields are not yet aligned
- Fields form a vector that rapidly rotates in time in a plane parallel to the direction of propagation[3]
- Rotation causes mismatches between T_1 and T_2
- With Wi-Fi, near-field effects extend to roughly 14 cm from transmitter

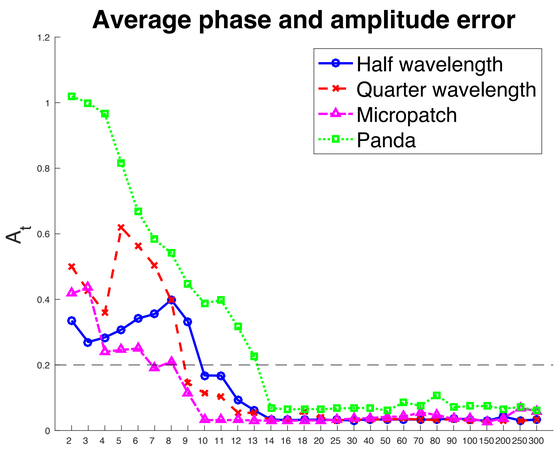
l_t = length of transmitting antenna
λ = wavelength
D = length of transmitting antenna + length of receiving antenna
R_1 = estimated range of reactive near-field region
R_2 = estimated range of radiating near-field region

Repeating portions mismatch at close range, but not at long range

T_1 and T_2 on all Wi-Fi subcarriers



Proximity is detected if the mismatch is over a fixed threshold



Average A_t of 1,000 frames transmitted from each antenna type shown

- A_t is the sum of the Euclidean distance between T_1 and T_2 over all 64 subcarriers
- A_t is high at close range, low at long range
- Declare proximity if A_t is above a fixed threshold

National Science Foundation
Award CNS-1329686

CAGR = Compound Annual Growth Rate

[1] Berg Insight. *Wireless IoT connectivity technologies and markets.* Online at http://www.berginsight.com/ReportPDF/Summary/bi-globalm2m7-sum.pdf
[2] Institute of Electrical and Electronics Engineers. 802.11n standard. Online at http://standards.ieee.org
[3] Constantine A. Balanis. Antenna Theory: Analysis and Design. Wiley, third edition, 2005