Unsupervised Proximity Detection and Pairing for Smartphones

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1. INTRODUCTION

User context, especially physical proximity, is gaining its popularity as an intelligent indicator to trigger communication between devices. Apple's iBeacon sends out notification to iPhones when customers enter their Apple stores. It detects proximity by ranging Bluetooth beacon signals emitted from anchor nodes that are preinstalled in the store.

Many short-range communication methods adopted for proximity detection demand delicate physical conditions to be met to establish a connection. Prior works in the literature require infrastructural support, special hardware on device, or training phase to obtain a signal map or model whenever to be applied on a new venue, and therefore lack scalability. Although knowing precise coordinates of users does help determining their context, existing solutions demand considerable energy consumption on device (e.g., GPS) or expensive efforts for site survey as well as infrastructural support.

In this paper, we concentrate on proximity detection through a practical and low-cost approach, compensating for room-level accuracy. We achieve wide applicability and scalability by solely leveraging Wi-Fi scan information that is easily accessible with low cost on commodity mobile devices.

2. SYSTEM ARCHITECTURE

Inspired by the prospect of high-density ubiquitous devices and prevalent Wi-Fi networks in indoor environments, we propose an unsupervised proximity detection and pairing system. The underlying intuition is that nearby devices will have high similarities in their Wi-Fi signal patterns, as they are under the coverage of same or overlapping access points. We show that this degree of similarity can be properly used in approximating relative distance between devices, and can therefore determine their proximity in an unsupervised manner.

To quantify the similarity of Wi-Fi signal patterns, we devise a similarity metric based on Morisita-Horn index [1] borrowed from the ecological literature. It incorporates relative abundance of signals from each AP rather than their incidence (i.e., presence or absence).

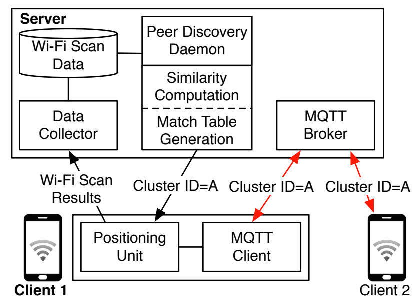

Figure 1: Architecture overview.

We verify that the index applied to Wi-Fi received signal strength (RSS) does capture the intuitive properties of distance in the real world, by satisfying the distance metric axioms.

Figure 1 shows the system architecture overview. The cloud server collects a series of Wi-Fi scan results from mobile devices and compares their RSS patterns using the similarity metric. As it is impossible to determine the number of clusters in real-time, we adopt hierarchical clustering, a method to investigate grouping in a data set simultaneously over a variety of scales by creating a cluster tree. By utilizing the cluster id as an identifier, devices can pair with others in the vicinity.

3. DEMONSTRATION DETAILS

We leverage our proximity detection technique and demonstrate a proximity-based communication service: *Flock* messaging app[1] for Android works in real deployment scenarios with no need of extensive site survey or infrastructural support. It automatically identifies nearby devices and immediately connects them with ease. Users are able to *flock* together without explicitly searching and specifying the receivers.

4. REFERENCES

[1] H. S. Horn. Measurement of overlap in comparative ecological studies. *The American Naturalist*, 100(914):pp. 419–424, 1966.

[1] play.google.com/store/apps/details?id=com.nrldev.protocol