RASID demo: A robust WLAN device-free passive motion detection system

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RASID Demo: A Robust WLAN Device-free Passive Motion Detection System

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***Abstract*—WLAN device-free passive (*DfP*) indoor localization is an emerging technology enabling the localization of entities that neither carry any devices nor participate actively in the localization process using the already installed wireless infrastructure. This technology can be promising for a variety of applications, where special hardware might not be applicable such as intrusion detection and smart homes. We present a demonstration of RASID, a system capable of detecting passive human motion using the already installed wireless networks. *RASID* uses statistical anomaly detection techniques to detect motion inside indoor environments. The system also is capable of adapting to the environment changes for enhancing its accuracy.**

I. Introduction

Motivated by the wide use of wireless LANs for indoor communication, we introduced the concept of device-free passive *DfP* localization [1], [2] which enables the localization of entities that do not carry any devices nor participate in the localization process. This concept depends on the fact that the presence and motion of entities in an RF environment affects the RF signal generated by the access points (APs) and received at the monitoring points (MPs).

In this work, we present a demonstration of the *RASID* system [3], a system that aims at providing a low-overhead, accurate and robust *DfP* motion detection system in large-scale environments. *RASID* uses statistical anomaly detection techniques to detect motion inside indoor environments. It only constructs a profile for the signal strength readings received at the MPs (such as standard laptops or WiFi-enabled devices) when there is *no human activity* during a short training phase leading to minimal deployment overhead. The system also employs techniques for adapting to the environment changes and for refining the detection decision.

RASID is a software only solution on top of the already installed wireless networks and have many applications. These include intrusion detection, sensor-less sensing, low-cost surveillance, and smart buildings. In addition, it can be used as a low-cost low-power first level security system that detects intrusions and then trigger more sophisticated security systems.

We present a demonstration of the RASID system. The demonstration enables the users to watch how the system works and how each of its modules contribute to the detection decision. It also visualizes the detection decision on the layout of the area of interest. Moreover, it provides a mechanism to compare different system configurations at the same time.

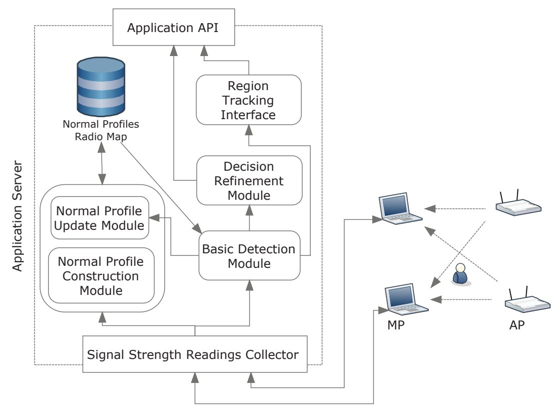

Figure 1. *RASID* system architecture [3].

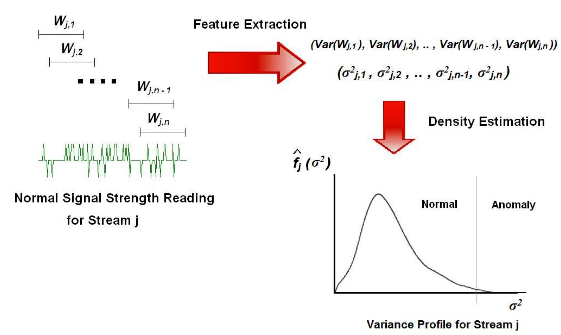

Figure 2. Illustration of the normal profile construction [3].

II. RASID System Overview

Figure 1 gives an overview of the system architecture. The modules of the proposed system are implemented in the application server that collects samples from the monitoring points and processes them. The system works in two phases:

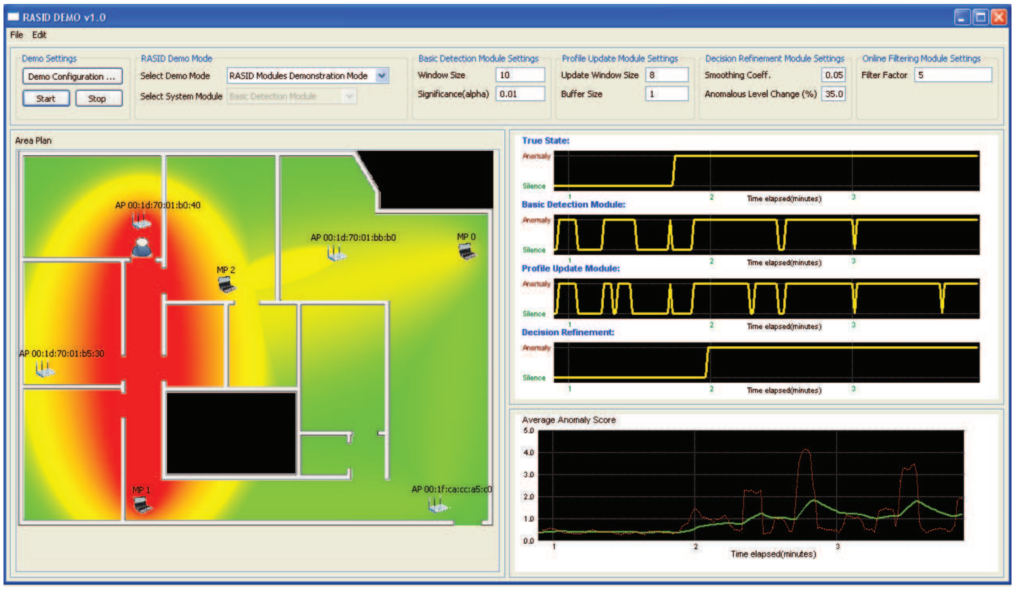

Figure 3. The full-functionality mode interface.

1) An *offline* phase, during which the system studies the signal strength values when no human is present inside the area of interest to construct what we call a normal or silence profile. 2) A *monitoring* phase, in which the system collects readings from the monitoring points and decides whether there is human activity (anomalous behavior) or not based on the information gathered in the offline phase. It also updates the stored normal profile so that it can adapt to environment changes. Finally, a decision refinement procedure is applied to further enhance the accuracy.

The system consists of the following modules:

- The *Normal Profile Construction Module* constructs the initial silence profile based on a short training phase. This module extracts the variance values from a moving sliding window over the collected training data and estimates its distribution (Figure 2). The density function of the variance is estimated using kernel density estimation. This is done for each stream independently.
- The *Basic Detection Module* examines each stream in the monitoring phase and calculates the variance of a moving sliding window over its readings, and then decides whether there is an anomalous behavior or not, based on the variance profile constructed in the offline phase. It also calculates an anomaly score for each stream, to express the significance of any generated alarms.
- The *Normal Profile Update Module* runs in the online phase. This module updates the normal profiles constructed in the offline phase in order to adapt to changes in the environment. This is done by updating the profiles using the readings that have low anomaly probability.
- The *Decision Refinement Module* applies heuristic methods to refine the decision generated by the basic detection module to reduce the false alarms.
- The *Region Tracking Interface* provides an interface that visualizes the output of the above modules. This interface enables the user to identify detection events and provides the regions of the moving entities.

III. Demo Goals and Description

The demonstration applies and visualizes the system procedure to real data sets collected in large-scale environments. The demonstration enables the user to observe how each module in the RASID system contributes to the detection process. This includes monitoring the changes in the stored profiles over time and the output of the region tracking module. Moreover, the demonstration enables the user to investigate the effect of different system parameters simultaneously. The demo works in two modes:

A. Full Functionality Mode

In this mode, the demo runs all the procedures of the system based on the input parameters from the user. It displays the region tracking output while providing the detection decision after adding each module based on the input parameters. This is to illustrate how each module contributes to the result. The interface of this mode is shown in Figure 3. As shown in the figure, there are three main components: the output of the region tracking interface, the decision of each module and the decision refinement curves.

B. Parameter Analysis Mode

The demo enables the user to observe the effect of the different system parameters by running the system proce-

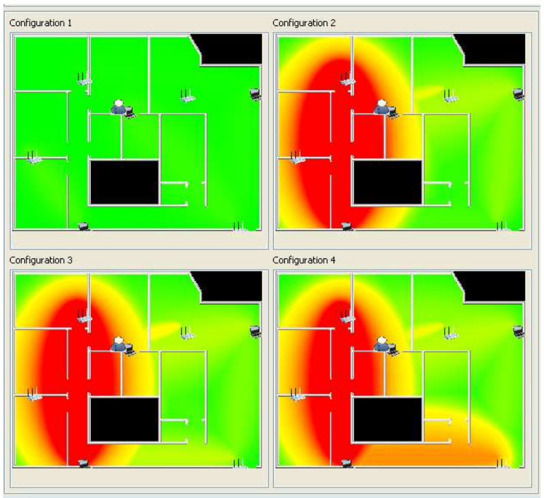

Figure 4. Illustrating the effect of the basic detection module parameters in the parameter analysis mode.

dures concurrently for different configurations. This mode displays two aspects: the parameters effect on the module's procedure in addition to the detection decisions in all of the configurations concurrently. Using this mode, the user will be able to analyze the effect of different system parameters for the main three modules of the system:

- Basic Detection Module: By changing the parameters of this module (e.g. the sliding window size shown in Figure 2), this will result in changing the sensitivity of the system. This can be illustrated by observing how the colors change on the region tracking interfaces concurrently (Figure 4).
- Normal Profile Update Module: Assigning different parameters to this module will lead to different ways for updating the stored normal profiles (Figure 5).
- Decision Refinement Module: Changing the parameters of this module leads to changing the overall sensitivity of the system, as this module's parameters affect the smoothing of this module's data series and the detection thresholds. (Figure 6).

IV. Setup

The demo uses data sets that were previously collected in large-scale environments. These data sets include signal strength data collected in both silence and motion states to show the system response in both cases. The demo only requires a single laptop to run the program, in addition to a standard power supply.

V. Conclusion

In this work, we present a demonstration of the RASID system that complements our paper at the conference. The demo introduces the RASID device-free passive motion detection capabilities to the attendees and illustrates how

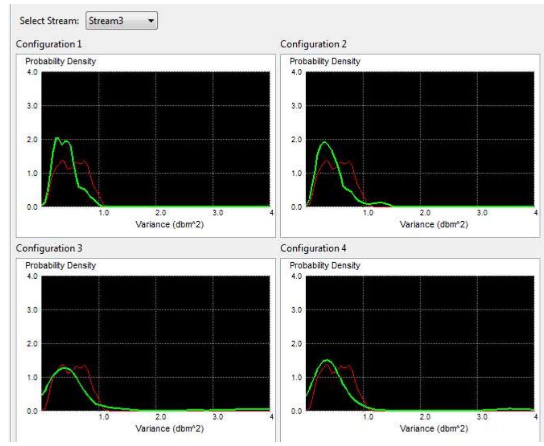

Figure 5. Illustrating the effect of the normal profile update module parameters in the parameter analysis mode.

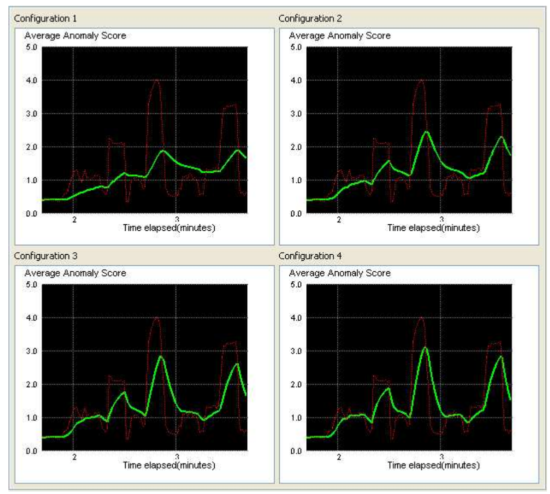

Figure 6. Illustrating the effect of the decision refinement module parameters in the parameter analysis mode.

it works. The attendees will be able to change the different system parameters and see their effect. We will also discuss with the attendees our current work on the RASID system, providing details about the current progress and challenges.

Acknowledgment

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