On-Demand, Deploy-Anywhere Wi-Fi Diagnostics

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ABSTRACT

A Wi-Fi diagnostics system is demonstrated that uses both mobile and stationary monitors to collect and analyze low-level Wi-Fi performance characteristics, such as channel occupancy, collisions, hidden terminals, signal quality. Designed for rapid-response deployments in areas outside the administrative control of the user, the system is able to operate without network connectivity; optional battery packs enable deployments in otherwise inaccessible locations.

Demo Requirements: Internet, power, table, poster easel and board, 1 hour setup time.

Student Demo Competition Eligibility: A.B.M. Musa is a Ph.D. student at University of Illinois at Chicago.

1. INTRODUCTION

As the popularity of Wi-Fi continues to increase, performance problems arise that can be difficult to diagnose. It is not uncommon to encounter well over a hundred Wi-Fi access-points (APs) within a small area, all forced to share the 2.4 GHz ISM band without any control or coordination beyond what the IEEE 802.11 MAC provides. In open-ended Wi-Fi environments, such as high-density urban areas, hidden terminals, collisions and other interference are unavoidable facts of life.

The aggregate behavior of large numbers of uncoordinated Wi-Fi networks is not well understood; something we hope to address with this platform. Previous work has focused primarily on higher-level measurements using wardriving [3, 5], or more detailed studies in highly controlled smaller networks [4, 6] or mesh networks [1, 2]. We are primarily interested in aggregate performance measures "in the wild", necessitating a new data collection method.

Our system consists of both mobile and stationary Wi-Fi monitoring devices (monitors). Here, mobile monitors are used for "warwalking" larger areas, both to quickly gain a high-level overview of the area under study, and to be able to record traces where a stationary installation is not feasible due to theft or regulatory concerns. Our stationary nodes are deployed to create a more complete and detailed view of Wi-Fi performance in a given area. Both stationary and mobile nodes are able to either stream their measurements to a central server, or store them locally for "data mule" delivery.

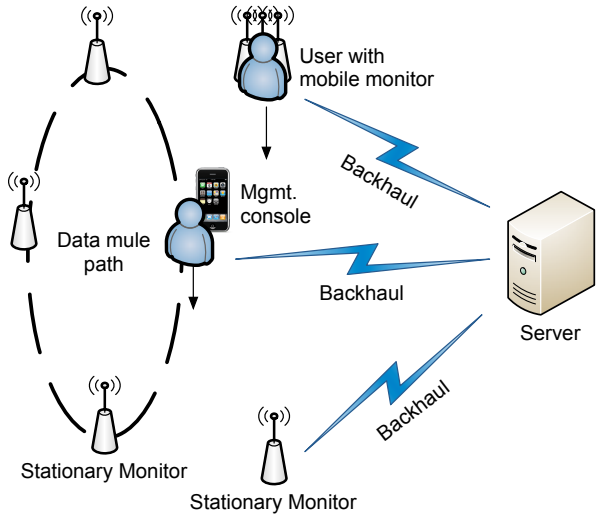


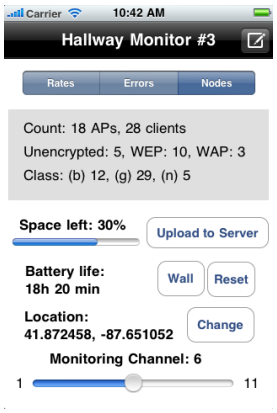
Figure 1: The system consists of mobile and stationary monitors, a mobile management console, and a central server.

Our monitoring system has several advantages. First, it can be deployed virtually anywhere, on demand. All nodes can operate either by wall power or battery pack and do not require backhaul for uploading data to the server. Second, our system is scalable. Potential applications range from diagnosing performance problems in a single location in intricate detail, to gathering wide-area statistics at city scale. Third, our system provides a user-friendly web-based interface to view and analyze collected data, making it accessible to non-expert users.

Our platform differs from others primarily in two ways: First, our interest is primarily in Wi-Fi performance at the MAC and PHY layers, which means that the type of data we aim to collect differs significantly from those before us. Second, in the ease and low cost of deployment at relatively large scale. Nodes consist of low-cost off-the-shelf access point hardware instrumented with a custom firmware, and require neither connectivity nor wall power to operate.

(a) Mobile monitor carried in a backpack. The mobile node includes 5 synchronized Wi-Fi radios, a spectrum analyzer, and a GPS receiver.

(b) Stationary monitor with a 24h battery pack. Stationary monitors upload traces to mobile management consoles, avoiding the need for a reliable backhaul connection.



(c) An iPhone-based management console allows field inspections and data retrieval.

Figure 2: Main components of the Wi-Fi monitoring system. Mobile monitor, stationary monitor, and iPhone based management console

2. SYSTEM DESCRIPTION

Fig 1 shows overall architecture of our system. It consists of a combination of mobile and stationary monitors for data collection, an iPhone-based mobile management console, and a central server for analysis and web-based viewing of the collected data.

Continuous monitoring of large scale environments would require hundreds or thousands of monitoring nodes, which is often impractical. Instead, we use a combination of mobile and stationary monitors. Here, mobile monitors are able to cover a large area quickly but are impractical for monitoring a particular area for an extended period, or for collecting data from multiple vantage points simultaneously. For more detailed, long-term monitoring, we use stationary devices, which are able to use existing wireless or wired connectivity as a backhaul, or rely on opportunistic uploads to nearby mobile nodes where no backhaul is available.

2.1 Mobile Monitor

The mobile monitor (Fig. 2(a)) is battery powered, and consists of several time-synchronized Wi-Fi radios for parallel multi-channel recording, a GPS receiver and a spectrum analyzer. Using multiple radios is particularly important for the mobile monitor, where the radio environment is constantly changing, and the amount of time spent in a given location is limited.

All data is logged with a corresponding location trace – this is used for spatial analysis of the log files, and to plan stationary deployments. Our mobile monitor is typically carried in a backpack, together with a netbook acting as a controller. Compared to traditional wardriving, this is better suited to monitoring and diagnosing areas where vehicles cannot go (i.e. where Wi-Fi devices are used the most), and provides more comprehensive logging capabilities through the use of multiple radios.

2.2 Stationary Monitor

For cost and practicality reasons, our stationary monitoring devices (Fig. 2(b)) are designed to operate without a backhaul connection, though they are able to make use of a backhaul when this is available. This allows us to create stationary monitors with minimal labor and cost. The stationary monitors use a single radio (multiple monitors can be deployed together to provide simultaneous channel coverage), and retain a compact representation of observed packets. This data is periodically uploaded to our central server, when a backhaul connection (wired or wireless) is available. When no backhaul is available, stationary nodes listen for "data probe" packets from a nearby management console, to which they upload their data opportunistically.

2.3 Data Retrieval and Inspection

An iPhone based inspection, configuration, and data retrieval console (Fig. 2(c)) is developed for stationary monitors without backhaul. One can simply walk around the stationary monitors and inspect their various status such as disk-space usage, battery usage etc using the iPhone. Stationary monitors can be configured from iPhone without accessing the devices physically, which is useful for deploying monitors in the places that are difficult to access regularly. Saved log files from the stationary monitors can be also collected and later transmitted to the server for analysis. The iPhone-based interface makes the interaction with the stationary monitors simple and effective.

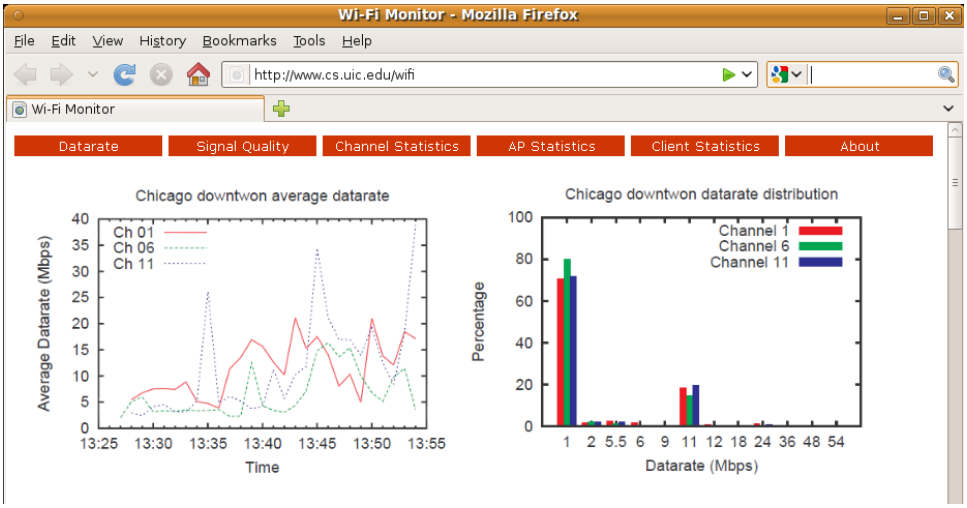


Figure 3: Web interface for viewing and analyzing Wi-Fi statistics and characteristics

2.4 User Interface

Our system provides an easy-to-use and integrated web interface for monitoring and analyzing Wi-Fi characteristics. Fig 3 shows an example screenshot of Wi-Fi statistics provided by our system.

3. THE DEMONSTRATION

We will perform a live demonstration of stationary and mobile Wi-Fi monitoring and analysis, using stationary monitors deployed around the conference venue, at the University of Illinois at Chicago, and in one or more locations downtown. The demo will also feature a mobile node moving around Chicago, with live updates. Example hardware will be on display, as will a poster describing the system in some detail.

More specifically, the following features of our system will be demonstrated:

- Mobile data collection - demonstrated in real-time with the mobile monitor touring downtown
- Multi-observer statistics - showing the utility of observing a phenomenon from multiple viewpoints
- iPhone management console - for stationary monitor management and data retrieval
- Hardware show-and-tell - we will have example hardware for display on the demo floor
- Low-level Wi-Fi statistics - such as bit error rates, transmission rates observed, channel occupancy, collisions etc.

4. REFERENCES

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