APMap: Towards mapping the Wi-Fi weather

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WE report our progress on developing a mobile application APMap - for location aware sniffing of wireless networks. The application enables mobile phone users to sniff nearby Wi-Fi access points (APs), record traces and send them to a central server. The server computes APs locations according to the traces, stores the results in the database and responds to the clients' queries for APs in range. Currently, our focus is to provide users with a map of Wi-Fi APs availability in close proximity to their locations. Nevertheless, we believe that these traces could serve as a base for research on multiple topics related to smart-phones and cellular networks utilization.

1 Problem and Motivation

The growing use of smart-phones have outlined rapid development of cellular networks. The focus, though, is more on provisioning infrastructure to meet the increasing traffic demand, while not too much is being done to audit what is currently available, pinpoint shortcomings and propose approaches to improving systems' performance and user experience.

To enable these, we need a way to collect data that would help exploring and characterizing various aspects of mobile communications including usability trends, coverage availability and networks and applications performance. The collected data must provide information for variety of locations and should enable capturing the dynamics of changing Wi-Fi and cellular networks.

We find our application extremely valuable in this sense as it will (i) enable collection of variety of traces from multiple locations (depending on where our users roam) (ii) at no additional cost while (iii) providing for timely updates of the collected traces. APMap currently supports collection of basic statistics for Wi-Fi networks but it is open and allows extension for active probing of Wi-Fi networks as well as collection of statistics for GPRS/UMTS networks.

2 Background and Related Work

To the best of our knowledge, this is the first attempt for creating a map of Wi-Fi coverage by using mobile phones to sniff and report AP locations. Similar projects with different use cases had been done before, but they were primarily using laptops or customized Wi-Fi routers to perform sniffing, which requires dedicated resources.

In our solution there is no dedication of resources. We hope to attract people in using our application by providing them with a map of AP availability. In turn, they will contribute traces collected while roaming in various locations. This concept provides the following benefits - (i) it enables gathering of traces from various locations (depending on where our users roam), (ii) traces are collected without additional cost for dedicated resources and (iii) it allows for close to real time update of Wi-Fi APs availability.

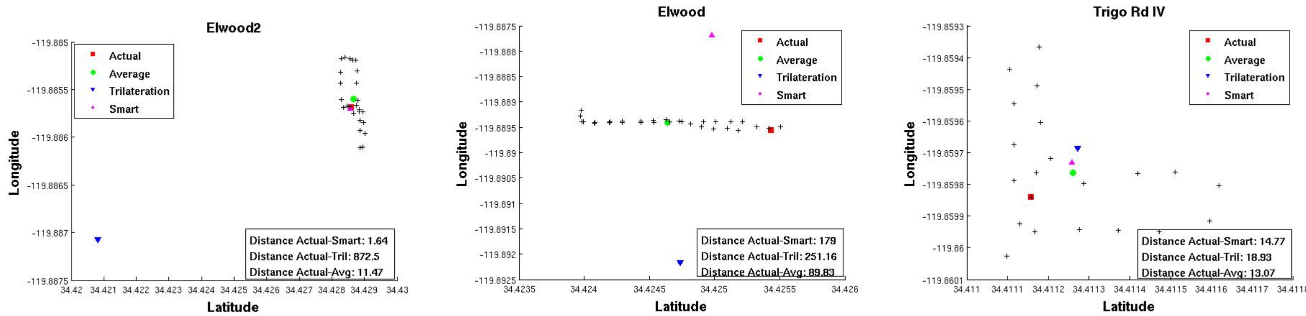
3 Approach and Uniqueness

The APMap system has two components: the mobile clients and the central server. Mobile clients scan for APs in range, record information in files and send the files to the central server. A record in the collected traces consists of user's location, APs in range and a timestamp. Upon reception of a trace file, the server estimates each APs location based on the latitude, longitude and RSSI at the mobile phone. It records the estimated location in a database and strores the trace for future reference. The clients then can query nearby APs and show a map with APs information to the users.

The client is developed on Android Motorola A855 smart-phone running Android 2.2 operating system. *androild.net.wifi* and *android.location* APIs[3] are used to collect AP and location information. *com.google.android.maps.ItemizedOverlay* API is used to display a map with AP availability to the user.

The server functionality is implemented in Java and includes *location calculator*,a *TCP server-client interface* and a *MySQL database interface*. We store all the AP information along with the corresponding estimated locations in a MySQL database.

We evaluated three approaches to localization, the first one of which is based on averaging the latitudes and longitudes of the clients who have reported an AP. We call this algorithm *Average*. As our results show, *Average* is very sensitive to the spatial configuration of the reporting clients (e.g. it is highly inaccurate when the mobile clients are aligned). In order to improve localization accuracy, we designed another approach to localization called *Simple Trilateration*.



(a) Elwood 2 (b) Elwood (c) Trigo RD Isla Vista

Fig. 1: **Localization in different neighborhoods in Goleta, CA**

Our results showed that *Simple Trilateration*, similarly to *Average*, is highly sensitive to the spatial configuration of the reporting clients. That is why we needed to further improve our localization method by embedding some intelligence in the trilateration algorithm. We changed our trilateration method so that it picks the three furthest with respect to each other clients and trilaterates against them. We called this improved algorithm *Smart trilateration*.

To perform trilateration, we needed a function that approximates the client-AP distance based on RSSI. We obtained our function by performing curve fitting [2] over a set of points with known distance-to-RSSI relation. Similar approach to distance approximation is applied in [6]. We compared our function with the one from [6] and it turns out that the level of accuracy is comparable within few meters. Furthermore, previous work [1] had shown that RSSI remains stable over time. Thus, we are convinced that such model to distance approximation is feasible.

4 Results and Contributions

We evaluate APMap in terms of localization accuracy and power consumption. In order to measure the localization accuracy of APMap, we collected a set of traces with known location of one AP. This is what we refer to as the "ground truth" set. Against these traces we evaluated the localization accuracy of APMap.

Fig. 1 presents part of our results for APMap's localization accuracy (the + marker represents various locations of mobile clients that reported the AP). We can see on Fig 1(a) that *Smart Trilateration* achieves very high level of accuracy - 1.64m, if the configuration of mobile clients is scattered in all directions around the AP. At the same time, *Simple Trilateration* returned extremely inaccurate result, most likely due to picking bad configuration of points against which to trilaterate. On Fig 1(b) we see a configuration of mobile clients that are all aligned in one direction with respect to the AP. Such configuration forces all the localization methods to perform quite poorly. In the general case, though (Fig 1(c)) our *Smart Trilateration* algorithm achieves accuracy in the range of 30m, which is comparable to *Average* and clearly outperforms *Simple Trilateration*. Thus *Smart Trilateration* is good enough to assure that our clients will be sent in range of the AP regardless of the spatial configuration of reporting clients.

We "decompose" APMap with respect to its most power consuming modules - LCD display, Wi-Fi and GPS - and measure the power consumption per module. Due to the lack of API that could report battery level at fine granularity, we used PowerTutor [4] to measure the power consumption of the application. PowerTutor uses a model to estimate the amount of power consumed by the phone based on the CPU utilization. Our results indicate that there is not much to be done on optimizing GPS and LCD power consumption. However, we can save power by performing less frequent Wi-Fi communication and reducing the number of Wi-Fi scans. In addition, we can leverage cellular networks instead of GPS to detect user location, since the former method is more power saving.

5 Conclusions

We believe that providing a map of AP availability is only one of multiple applications of APMap's back-end. The collected traces can also be used for Wi-Fi coverage prediction, which would be extremely helpful in making decisions for offloading data traffic from GPRS and UMTS networks through Wi-Fi. The traces that APMap collects are capable of providing fine time granularity information about occurrence of APs, thus they could also be used for research on Wi-Fi networks evolution. Lastly, APMap's back-end can be further extended to perform active measurements in Wi-Fi networks and/or to collect basic information for GPRS and UMTS networks. That is why we believe that APMap's back-end could serve as a base for research on multiple topics related to smartphones and cellular networks utilization.

References

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