MOBIX: System for managing MOBility using Information eXchange

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I. Introduction and Motivation

In the future mobile world, users will be carrying devices with multiple radio interfaces. Despite rapid progress in battery technology, small, mobile devices of the future will still be energy constrained. Thus, turning on all wireless interfaces all the time to detect available network points of attachments will significantly shorten the battery life of most portable devices.

Current methods rely on the radio interfaces itself for detecting network availability. This limits decisions on what is the "best" point of attachment to radio layer parameters and necessitates turning on the interface to make measurements. Another approach, such as that used in [1], predicts future network conditions from past experiences. Prediction-based schemes require a period of learning however, and will fail when users deviate from their patterns or visit new locations. Yet another approach in [2] involve generating network maps of the area. These maps are non-trivial to produce however and need a central server for the aggregation of map data.

We explore a novel approach to the problem of network availability which leverages on the fact that nodes on the move will meet other nodes who will be able to share conditions of networks they have recently encountered. We propose MOBIX, a system where mobile users exchange reports of network conditions with other nodes they encounter using a short-range, low-power communication channel, ie Bluetooth.

Although it may seem counter-intuitive, we argue that there are benefits to such a system. Firstly, to turn on all of the multiple radio interfaces to monitor for current conditions will be an extreme drain on battery power. For instance, the WiFi interface can consume more than 60% of total system power, even when idle [3]. The Bluetooth interface on the other hand consumes very little power even when active. Secondly, only RSSI can be measured by relying on the radio layer. With MOBIX, we can share information such as actual throughput and delay experienced by other users on their networks. Finally, we can presumably make better decisions as our information hinges not just on a single measurement at a specific point in time but on multiple measurements gathered by other devices nearby.

II. System Overview

Nodes generate reports on network conditions at certain points in time and keep these reports in a fixed-size data store. When a node encounters another node, they exchange information by sending some of the stored reports. The node then calculates the relevance of each report and keeps the top N reports in the data store. When a packet has to be sent to the Internet, the node retrieves reports generated within a maximum radius from its current location and determines the integrity of each report by calculating its trustworthiness value. It then combines these reports to make a decision on which network point of attachment to use for data transfer.

We used a time-based approach in producing and transmitting reports. Reports are arranged in the data store according to relevance factor, $Relevance_R = W_{age} * age + W_{dist} * dist$, where W_{age} and W_{dist} are the weighting factors of the report's age and distance, respectively. When a node encounters another node, it sorts the data store from highest to lowest relevance factor and transmits the top N reports. Upon reception, the node checks for duplicate reports, computes the relevance factors, and inserts the new reports.

Due to the highly mobile and ephemeral nature of node encounters, the integrity of reports cannot be determined using traditional notions of security (eg by verifying the integrity of the source). Instead we propose a *data-centric* approach to estimating the trustworthiness of reports, similar to [4].

The trustworthiness of a report is evaluated as a function of its static and dynamic properties. The *static trustworthiness* depends on the attributes of the node which generated the report. *Privately* owned nodes have relatively low default values while *publicly* owned *fixed* nodes, such as those set up by government agencies, have higher trust settings. The *dynamic trustworthiness* is a function of the distance and age of the report. Reports generated much closer and more recently are deemed more reliable than those generated earlier and farther away. Cryptographic means can be used so that these geo-timestamps cannot be tampered by other nodes.

We adopted weighted averaging for combining reports in our preliminary evaluation of the system, with the trustworthiness values treated as weights. We are currently investigating the use of Bayesian Inference (BI) and Dempster-Shafer Theory (DST) to combine reports, with the report's trustworthiness values interpreted as probabilities.

III. Initial Results

We simulated MOBIX in NS2 using random waypoint and Manhattan grid models. Our simulations show that even at low number of mobile nodes, we can gather relevant data from other nodes more than 50% of the time. Additionally, we estimate that the required population density needed to have 100% data store hit is is not unrealistic for densely populated metropolitan areas. The average age of reports used in decision-making is less than 10 minutes and it is possible to lower this value to less than a minute by adding more nodes.

References

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