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COLLABORATIVE POSITIONING AND TRACKING IN SPARSE DISRUPTION TOLERANT NETWORKS

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ABSTRACT: The main theme is the usage of Decentralized cooperative method called pulse counting for DTN localization and tracking method called probtracking.Pulse counting evaluates the user walking steps and movement orientations using accelerometer and electronic compass equipped in cell phones.It estimates the user location by accumulating the walking segments and improves the estimation accuracy by exploiting the encounters of mobile nodes.To track user movement,the proposed prob tracking method uses Markov chain to describe movement patterns and determines the most possible user walking trajectories without full record of user locations.To implement the positioning and tracking system in Android phones and deployed a real time environment of any location in university campus. The effectiveness and accuracy of the proposed method,show an average deviation of 9m in our system compared to GPS.

KEYWORDS: Disruption tolerant network, positioning, tracking, cooperation

I. INTRODUCTION

DISRUPTION tolerant networks (DTNs) are sparse mobile ad hoc networks where nodes connect with each other
intermittently. Since DTNs allow people to communicate without network infrastructure, they are widely used in battlefields,wildlife tracking, and vehicular communications .Location information is extremely important to enable context-aware and location-based applications . However, due to the lack of fixed infrastructure and continuous networkconnection in DTNs, identifying the location of mobile users and tracking their movement trajectories are challenging.

Assume a DTN is formed by a set of wireless nodes (e.g., cellphones) moving within a field. Each node has a communication range of distance r ($r > 0$).Two nodes can communicate when they move into each other's communication range, which is called an encounter of nodes. Since DTNs are sparse and highly dynamic, a constant communication path does not exist between any pair of nodes. Consider there are four different components in the system. The landmarks represent fix-deployed infrastructures like WiFi access points(APs), which can provide network service. An infostationis a server connecting to the APs to collect information from mobile nodes. The GPS-nodes are high-end mobile devices equipped with Global Positioning System (GPS).There are only a few of them in the network and they can be used as mobile reference points. The common-nodes are ordinary mobile phones without GPS support, which have the majority number in the system. They are only equipped with simple sensors (such as accelerometer and electronic compass), and can communicate with other nodes via WiFi or Bluetooth occasionally.The positioning and tracking problem in DTNs is twofold:the common-nodes (without GPS module) need to determinetheir locations based on the limited number of referencepoints (APs or GPS nodes) they encountered; and the infostation needs to track the trajectories of the common nodes with the partial information collected by the APs opportunistically.Early positioning systems rely on triangulation using physical signals from the fixed deployed infrastructures such as GPS satellites and GSM celltowers.WiFi-based localization strategies collect the radio fingerprints quantified from the WiFi signal strengths at many physical positions and multiple APs, and identify user location by retrieving and matching the fingerprints.Such methods either require densely-deployed infrastructures or they need to collect a large amount of signal samples,which cannot be applied to sparse networks.

Several recent research focuses on GPS-free localization in wireless networks by incorporating fixed landmarks and surrounding characteristics.Surroundsense identifies logical location using the surrounding information like sounds, lights and colors. CompAcc adopts a distance estimation method using accelerometer and compass and determines location by matching to possible path signatures generated from an electronic map. Escort provides a logical navigation system to help a person navigate to another person in a public place with the aid of context features.However, these methods need continuous communication with a centralized server to process a large amount of surrounding data, which are not suitable for the decentralized structure and the opportunistic communication nature of DTNs. decentralized cooperative method called PulseCounting for DTN localization and a probabilistic method called ProbTracking to track the movement of mobile nodes. PulseCounting evaluates the number of user walking steps using the accelerometer data, and decides the orientation of each step using the electronic compass measurements. By accumulating the segments of walking steps, it is able to form an estimation of current location.PulseCounting further takes advantage of the opportunity of encounters in DTNs to refine the location estimation: on the one hand, the encountering APs and. phones equipped with GPS could be regarded as reference points; on the other hand, the encounters of two mobile nodes enable the possibility of mutual adjustment to reduce estimation error. Prob-Tracking detects the movement trajectory based on the partial location information reported by the other mobile nodes. It constructs a Markov chain using the movement history data and uses it to determine the most probable user walking route without the need for global location information in DTNs.We implemented the positioning and tracking system in Android phones, and deployed a testbed in the campus of University for performance evaluation.Experiments show that the system has an average deviation of 9m compared to GPS.

II. RELATED WORK

Disruption tolerant networks have been widely studied in the last decade. Most existing works focus on the fundamental problem of data routing in DTNs. To achieve data transmission without the need of end-to-end communication paths, several mobility-assisted routing strategies have been proposed to reduce the number of hops, the delivery delay and energy consumption. A few works addressed the issues of selfish behavior of nodes to enhance the cooperation for data relays in DTNs .Different from the existing works, this paper focuses on the issues of positioning and tracking mobile nodes in DTNs,which have not been well addressed in the past.Previous

research on wireless localization rely on deploying wireless infrastructures (e.g., telecommunication satellites or cell towers) and installing dedicated hardware(e.g., GPS modules or RFIDs) in the environment . In these systems, mobile devices measure the wireless signals to several infrastructures in known locations and estimate the actual locations based on their geometric relationships.Cell tower triangulation is a popular technique for determiningthe location of a mobile device . Locating the position of mobile phones by measuring signals to GSM cell towers was studied in , which showes that GSM devices can achieve a positioning accuracy with a median error of 94-196 meters. WiFi-based strategies rely on deploying fixed Access Points and require calibrating WiFi signal strengths at many physical positions to enable localization. RADAR constructs detailed radio fingerprints of the available APs
and combines empirical measurements with signal propagation modeling to determine user location. Place Lab allows commodity hardware clients like PDAs and cell phones to locate themselves by listening for radio beacons
of WiFi and GSM cell towers. It generates a radio map by war-driving and estimates the location of mobile devices by looking up the overhead WiFi/GSM beacons in the radio map. In the recent years, a couple of works address the issues of localization using fixed landmarks and surroundings.SurroundSense identifies a user's location using the surrounding information collected by sensors and camera on mobile phones. The main idea is to fingerprint the location based on its ambient sound, light, color, RF, as well as the layout-induced user movement, but fails to provide the geographical coordinates. AAMPL introduces a location estimation method using accelerometer and compass. It can estimate rough physical coordinates of mobile phones augmenting with context-aware logical localization. To improve location accuracy,ComAcc uses the similar estimation method like AAMPL, and refines the location estimation by matching it against possible path signatures generated from a local map. It achieves a location accuracy of less than 11 meters. However, it needs to construct path signatures from electronic maps beforehand,which is complex and time-consuming. Escort provides a logical navigation system for social localization. Its goal is not to identify the physical location, but to help a person navigate to another person in a public place such as a hotel.By periodically learning the walking trails of different individuals,as well as how they encounter each other in spacetime,a route is computed between any pair of persons.However, it needs global information of users' movements and their encounters to construct the navigation graph,which does not apply for DTNs.

III. PROPOSED METHOD

In DTNs, most of time the common-nodes have no GPS nodes and landmarks within their communication range,which makes them hard to decide their locations. We propose the PulseCounting method for Cooperative Positioning in DTNs,which consists the following six steps.

1.Bootstrapping:

As the first step, each node needs to know its position initially.Without the initial position, there is no reference point for location estimation. In DTNs, we assume a small number of fixed landmarks (e.g., wireless APs) are deployed in the environment with known locations. We also assume that there are a few GPS-nodes willing to report their locations to other nodes. Thus the common-nodes can obtain a rough initial location when they firstly encounter the landmarks or GPS-nodes. It is unlikely for all common-nodes to obtain their initial locations at the same time, so the initialization process is asynchronous.With the initial location information, a map in this area will be downloaded to the user's cellphone. We use the Google Map in our implementation since it provides open access to its data and APIs. The map is downloaded opportunistically when the device has a chance to access
the Internet (i.e., entering the communication range of an AP). Unlike the existing positioning systems such as AAMPL and CompAcc, the proposed PulseCounting method does not rely on the Map data to aid localization..It purposes just to help visualizing the movement trajectory on the cellphone screen.

2.Step Counting:
We introduce the method of using the accelerometer to measure walking steps. The accelerometer records user movement in three dimensions: X (the direction of front and back), Y (the direction of left and right), and Z (the direction of up and down).

3.Direction Mapping:
The other important aspect of movement is direction,which can be measured by electronic compass. The cell phone compass records the useras orientation in the form of an angle with respect to magnetic north. Similar to the accelerometer data, the compass data is densely sampled (about 22 data per seconds) and appears fluctuating and noisy, thus it cannot be used directly. We proposed the direction mapping method to make the compass data discrete. For a rough estimation, we project the compass data to eight discrete directions:North, Northeast, East, Southeast, South, Southwest,West, and Northwest, which are numbered by 0_7 accordingly.

4.Trajectory Generation:
With the results from step counting and direction mapping, we are able to describe user movement trajectories. A movement trajectory is defined as a series of segments with distance and direction.

5.Location Estimation:
Given a trajectory TðP0 ! P1Þ, if the location of departure point P0 is known, we can roughly estimate the location of P1 by accumulating the trajectory segments.

6.Refinement:
When a common-node meets a GPS-node (or a landmark), it can obtain the location from the encountering node and use it as a reference point to adjust the estimation. When a common-node encounters another common-node, although both of them have no accurate location information,it is still possible for them to use each other as reference point to refine location estimation.

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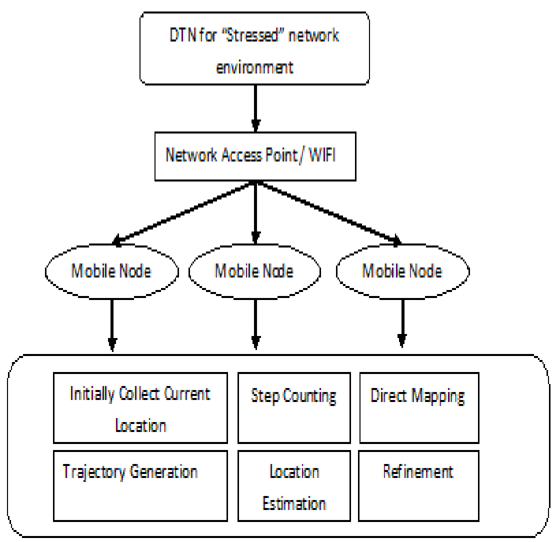
IV.IMPLEMENTATION

Implemented the PulseCounting localization method in the lenevo phone. The lenevo Android smart phone has built-in GPS, WiFi and Bluetooth communication modules, as well as sensors such as accelerometer and compass. To track the movement of users, we implemented the ProbTracking method in a PC server, where MySQL and PHP are adopted to store user historical data and calculate the movement trajectories. The tracking service was deployed in an Apache server, and it can be accessed from a web browser with JavaScript. Note that the positioning accuracy depends on the communication range of the mobile devices. Theoretically the proposed approach is applicable to different wireless communication techniques including WiFi, BlueTooth, ZigBee, etc, and different communication technique will yield different accuracy accordingly. In our system, we choose WiFi for implementation since it is widely available and equipped in most smart phones. communication range of WiFi is about 10 meters, and the average accuracy of 9 meters (compared to GPS) is achieved using the proposed positioning and refinement approaches.



V. CONCLUSION

Localization in DTNs faces two major difficulties: the mobile node can only use sparse reference points to estimate its location,and the tracking server need to determine and predict movement trajectories with partial location information. To overcome these difficulties, we propose PulseCounting and ProbTracking for positioning and tracking in DTNs.We implement the system in Android phones and evaluate its performance in a testbed in the University campus. Extensive experiments show that the proposed system achieves an average deviation less than 9mcompared to GPS.

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