Opportunistic Data Dissemination in Mobile Phone Sensor Networks

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Abstract
Situated communication technologies in emergencies are subject to decay or fail because of their inadequate services. With the advances in tiny-sensor technologies and ubiquity of smart phones, public awareness on urgent situations can be raised in more efficient and distributed ways. We center on opportunistic data dissemination schemes where the objective is to provide an operability among sensing, communication, and data spread. Such mobile networks do not require end-to-end routes or servers; however connectivity and scalability issues may last forever without determinism. We have started implementing context-aware services to understand the mobile phone carriers' characteristics and routines in order to increase the quality of service in our collaboration and dissemination objectives. We are currently working on real implementation of mobile ad hoc networks and routing algorithms. Besides, we simulate an urban city network with different scenarios and objectives to analyze the open research challenges.

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ACM Classification Keywords
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General Terms
Algorithms, Design, Human Factor, Performance

Introduction
Public awareness during emergencies is tried to be raised by disseminating current knowledge through situated communication services. Experts who want to inform people through conventional networks generally face with reachability issues due to inoperable or ruined infrastructures or servers. People utilizing the same communication domains are eventually confronted with low quality of service (QoS). Consequently, when the information of current importance needed to be issued to the public, conventional network services running on fixed infrastructures generally cannot reach to large regions, or can decay due to high community demand, or can totally fail because of unavoidable disasters.

Current researches in wireless sensor networks try to solve scalability and QoS problems with participatory sensing approaches and opportunistic routing schemes [1]. Exploiting mobility of network nodes, they focus on enriching information quality and covering regions with spotty communication services with the help of the local communities in urban areas. Emergencies can be monitored or informed at any point and in a distributed manner by mobile-phone carriers, which provides an efficient and a cheap way of network service. Concordantly, ubiquity of sensor-fitted mobile phones has led up to a brand-newness for information sharing in a such manner that qualified mobile phones are recently able to form different connection types such as peer-to-peer, ad hoc, and mesh networks [2]. In addition, processing on-the-fly data becomes gradually viable with ever-developing storage, memory, and computational capabilities. Mobile phones which satisfy aforementioned conditions can sense any kind of phenomena, make several deductions, and keep operand information until it is relayed to another nodes. As a consequence, opportunistic routing schemes have emerged in which mobile nodes are enabled to communicate with each other even if a route between them never exists [3]. Nodes are not supposed to possess any knowledge about the network topology, however they need to know others' and their own characteristics and behaviors to decrease forecast uncertainty of end-to-end communication routes. Context-awareness is required to increase packet delivery ratios and provide timeserving actions [4].

We aim to develop efficient context-aware services for opportunistic data routing and dissemination in highly dynamic mobile phone sensor networks. Mobile phones with different sensors, capabilities, and possessors create heterogeneous and dynamic context. To overcome this ever-changing complexity, we embody our research plans with a group of data types, network models, and their inter-relationships. In this paper, we elaborate on research objectives, network architecture, experimental setups, performance analysis, and overall research plan.

Our Objectives

The following 3 inter-connected topics constitute the objectives in my research:

- **Sensing:** For any kind of autonomous event detection, a group of mobile phones with different sensors will be utilized. Since interpretation of sensor data needs efficient processing, an expedient set of mobile phones will perform distributed sensing and data processing. In the end, coherence of mobile phones which serve for the same purpose will considerably increase the application performance. To achieve this, an effective and reliable communication is required.
- **Communication:** For event detection, mobile phones in a specific locality must form a circumstantial ad hoc or mesh network with their WiFi chipsets. Most stable entities will be determined and be selected for communication. By sensing, mobile phones will be aware of available resources in their environment to draw an overview of the network that they will participate. This transient participation can be organized either with a distributed way or with an infrastructure assistance.
- **Dissemination:** Mobility is an advantage for spreading information to although it is a critical problem for communication. When a mobile phone finds a group of suitable candidates to forward its current information, it will relay the message to the ones which are more likely to carry information to other regions.

Our Network Architecture

Objectives at issue are investigated under 3 different network models: Collaboration Networks (C-Nets), Social Networks (S-Nets), and Intermediary Networks (I-Nets). As shown in Figure 1, mobile nodes moving in a large region can temporarily form different kinds of clusters and thereby serve for different objectives for a specific time period. This figure does not depict any fixed or mobile infrastructure, however we will also test the contribution of several road-side-units (RSUs), access points (APs), and vehicular networks on several routing approaches in our experimental setups.

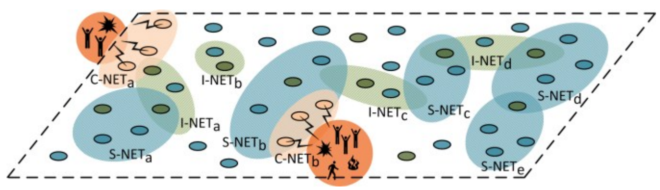

Figure 1: For event detection at any locality, a C-Net can be formed up with a set of mobile phones which typically generate a mobile ad hoc network (MANET). For S-Nets, another type of MANET can be established in order to provide awareness in social communities. An I-Net is a circumstantially formed delay-tolerant network (DTN) for data dissemination.

Work in Progress

As the initial research phase, we investigated the location and time data as the first context types. We analyzed the effect of spatiotemporal observations with a novel periodicity awareness model [5]. In this model, mobile entities keep track of their own spatiotemporal trajectories for a couple of weeks and project their future trajectories by considering their past periodicities when they encounter other nodes. By this means, they predict their future movements and jointly compromise on involving one of the presented objectives by comparing estimated routines with their encounters. For example, when two nodes run across, they can set off a collaboration network if their predicted future displacements are alike, or one can relay its message to its encounter for the sake of dissemination if they have different future paths. We aimed to use this model in 3 separate setups as a follow-up set of experiments:

Experimental Setups & Performance Analysis

Firstly, we investigate the contribution of the periodicity awareness model in a hybrid dissemination scheme. A realistic large city network is simulated which consists of pedestrians with several work day periodicities and realistic map-based movement models, scheduled public transportation units, RSUs, and APs. The tests are taken in order to see the performance of I-Nets. Secondly, the analogical tests are taken to investigate S-Nets as well. With these tests, we want to compare the delivery and response probabilities as well as the latencies and hop counts of our model with of the long-familiar DTN methods. Currently, performance evaluation parts are in preparation. Thirdly, we purposed to implement the periodicity awareness model on a real MANET (C-Net) routing in order to investigate the real behaviors. We utilize 5 Google Nexus 7 tablets running a firmware of Google Android OS that enables WiFi ad hoc mode. Running on the ad hoc network established, we developed an Android application that provides peer-to-peer communication where we looked into overall packet delivery ratios. We are currently working on an appropriate ad hoc routing algorithm as well as we are implementing the periodicity awareness model for this application. After that, implementation costs will be calculated in terms of CPU cycles, data memory, and storage usage. The scalability tests will be held by increasing the number of devices.

Overall Research Plan

As the subsequent step, we plan to contemplate feasibility issues in mobile opportunistic networking after instantiating the presented work in progress. We intend to utilize other data types for context-awareness such as user profiles, schedules, social relationship records, current network and environment situation (by either sensing or obtaining from others) to improve connectedness and resource management during data dissemination. This short-list of data types will be further formalized and tested during the coming months. Then, their correlations over several routing schemes will be investigated and the best optimization parameters will be searched for within a cost function. At a later stage, since people's dynamism in urban areas are quite high, corresponding factors affecting the network or device context can be investigated as well. A mathematical model can be developed in order to define our context-awareness elements and factors.

Biographical Sketch

Okan Turkes is currently a doctoral candidate at the Pervasive Systems Group, University of Twente. As of February 2012, he has started his four-year-long PhD studies within SenSafety project[1], where the main objective is to provide efficient and effective urban monitoring infrastructures by means of opportunistic sensing and networking. He has been working under the supervision of Mr. Hans Scholten[2] and Prof. Paul Havinga[3]. His current research interests are in the design and analysis of opportunistic routing protocols and schemes for mobile wireless networks, particularly for mobile ad hoc and delay tolerant networks.

1 Please click here to see the website of SenSafety project.
2 Please click here for the biography of Hans Scholten.
3 Please click here for the biography of Paul Havinga.

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