Data Dissemination in Mobile Phone Sensor Networks

[Extended Abstract]

Viet-Duc Le*
Pervasive Systems
University of Twente
Enschede, the Netherlands
levietduc@utwente.nl

ABSTRACT

Deploying sensors over large areas is costly in terms of configuration, hardware, and maintenance. Using onboard sensors of today mobile phones can significantly reduce the expenses in monitoring areas and disseminating events or data. Via the available short-range Bluetooth and/or WiFi interfaces, measured data are not only gradually delivered, but also possibly more reliable. In our simulation, existing Delay-Tolerant Network routing algorithms show poor performance on a complex network comprising diverse kinds of sensor nodes, such as, mobile phones, cars, and road side units. New approaches that can perform well on such heterogeneous networks are needed. They also need to support exchanging measurements among sensors for more accurate inference. In the early phase, we set up a heterogeneous architecture composed of different sorts of sensors, and propose an algorithm, Unified routing, for routing and disseminating. A further variant of the scheme is being developed. Early simulation results are consistent with theoretical prediction. After finishing the first step, Unified routing, the focus of our research will be on distributed data processing. Finally, routing and distributed data processing will be investigated in a testbed in a realistic context.

*Viet-Duc Le joined Pervasive Systems in June 2011 for a 4-year Ph.D. program. He is doing his research in the SenSafety project, where the main focus is on opportunistic sensing and networking, and on distributed sensor data processing. He received a Bachelor degree in Electrical-Electronics Engineering from Ho Chi Minh City University of Technology, Vietnam, in 2002, and a Master degree in Computer Engineering from KyungHee University, South Korea, in 2009. He is interested in Machine Learning and Pattern Recognition. More specifically, the focus of his research is to design and analyze inference algorithms for data in Wireless Sensor Networks and Opportunistic Network that can be applied to Health-care applications, Location Tracking, Public Safety, and Smart Transportation Systems. Besides his academic research, he has worked more than six years as a researcher or a team leader of many industrial projects related to sensor applications and web database.

Keywords

mobile phone sensors, dissemination, unified routing.

1. INTRODUCTION

Recently, with powerful onboard sensors, mobile phones can be sensor nodes in opportunistic networks to measure and transfer data to reduce the costs of sensor hardware, sensor deployment and maintenance. Data gathering by traditional sensor networks, augmented by data gathered by mobile phones, greatly enhances reliability and accuracy. Hence, focusing on mobile phone sensor networking, our research is divided in three main areas: sensing, disseminating, and distributed data inferencing. A flock of phones measures data, such as location, CO2 concentration, and sound. Then, measured data are disseminated mainly via available short-range interfaces, Bluetooth and WiFi. Finally, gathered data are distributively processed to retrieve occurring events and then further broadcasted to other nodes.

In the first phase of my Ph.D research, we have been concerned with the data dissemination in mobile phone sensor networks. Due to mobility, short-range communication, and sparse density of mobile phones, the network topology is unstable, and conventional routing protocols fail to find end-to-end connectivity, simply because such a route does not exist. In the literatures [3], [5], [4], [2], several new opportunistic routing protocols are proposed, but these are not appropriate for heterogeneous architectures as shown in [1]. Heterogeneity means that there is more than one kind of sensor node, such as pedestrians, cars, busses, or road side units (RSUs).

To suit such an architecture, consisting of opportunistic sensor nodes with different mobility patterns, we propose a new routing scheme, Unified Routing Algorithm. It partly modifies and merges well-known opportunistic routing algorithms such as Direct Delivery (DD) [3], Epidemic [5], Spray and Wait(SnW) [4], and oracle-based algorithm ProPHET [2] into one simple routing scheme. The proposal uses two main parameters, the number of limited copies and delivery capability, to optimize its performance in terms of delivery ratio, delivery speed, latency, and transmission cost. Depending on the physical characteristic of each type of node, as analyzed in [1], these parameters are optimally set to match with each performance requirement. For instance, the number of message copies is set large for RSUs and small for pedestrians, cars, and busses. RSUs are supposed to possess the highest delivery capability since messages can be transferred very fast via the RSUs' network.

Our observations from the early simulation results point out that our proposed routing schemes give better performances on message delivery ratio, latency, delivery speed. Proposed algorithm can obtain better delivery ratio compared to related work. The tradeoff for better delivery ratio is the increase in transmission costs. More messages are disseminated in the network, but for our application domain of public safety, this is acceptable.

2. MY APPROACHES

Initially, each type of node, a component, is assigned an initial number copies L, the maximum number of message copies allowed in the network, and delivery capability D. Within a group, the current number of copies l is updated by the Binary Spray and Wait mechanism proposed in [4]. Each time a node i hands out a copy of a message to another node j in the same group, both nodes update $l = l/2$. However, if the receiving node j belongs to another group, l of the copy is updated depending on from which group the message is created. If the unique message originates from the group of the sender i, l of the copy on node j is set to L_j. Otherwise, l is set as 1.

The delivery capability is fixed for every group. If a node i has more than one connection with other nodes, messages are transmitted to nodes with higher delivery capability first. Then, for each connection, two nodes exchange summary vectors to determine which messages the other node does not own similarly to epidemic [5]. These requested messages are sorted by a message sorting scheme, such as, random or First In First Out (FIFO), before being pushed into the outgoing buffer. From now, node i can start sending out selected messages connection by connection. In such way, the algorithm possibly enhances delivery ratio. The values of L and D depend on the physical characteristic of each group, and affect network performance. The optimal setting of these parameters needs further investigation.

3. SIMULATION RESULTS

We reuse the simulation set up from previous work [1], except for a few changes in parameter configuration, such as the net bit rate, message and buffer sizes. For a realistic setting, the map of the city of Enschede, 4000 by 4000 meters, is imported into the simulation. There are 336 RSUs deployed in linear formation at main roads. 600 pedestrians and 50 cars scatter over the city in a uniform distribution. Moreover, four distinct bus lines in the city are mapped into the simulation. For each bus line, two busses shuttle their route.

The number of copies L of mobile nodes is varied from 1..50. Meanwhile, L of RSUs is set infinite for all cases. Figure 1 shows that Unified Algorithm obtains best performance with an optimal setting of L for the mobile phone sensor group. This observation is consistent with the theoretical optimum $L = 19$ estimated from [4].

A comparison with FC, SnW, Epidemic, and ProPHET is also made. For the same reason as mentioned in [1], the Message Ferries protocol is not used for busses in our simulation. By looking at Table 1, we can see that our Unified algorithm scores the best, especially when messages are sorted according to priority for each connection (PU). Since important messages with shorter time-to-live are sent out first, buffers have more space for other incoming messages and the delivery ratio increases.

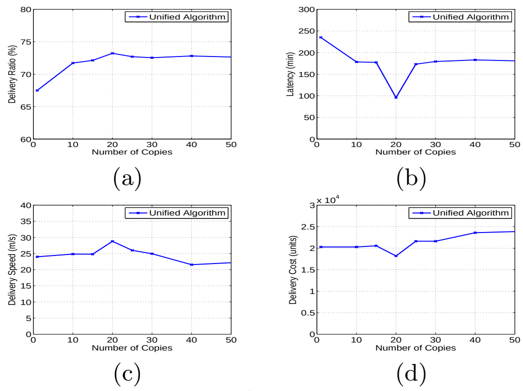

Figure 1: Unified Algorithm performance

DD	SnW	Epi	ProPHET	Unified	PU
19.54%	64.21%	68.17%	69.81%	73.22%	85.50%

Table 1: Delivery Ratio Comparison

4. CONCLUSIONS

We have been studying the new approach, which has a high potential to improve mobile phone sensor networks. More simulations are ongoing to validate and improve the Unified algorithm. When our research on the Unified routing algorithm is finished, the next step will be the distributed sensor data processing to improve reliability and accuracy.

5. ACKNOWLEDGMENTS

This work is supported by the SenSafety project in the Dutch Commit program. I would like to thank Hans Scholten and Paul Havinga of the Pervasive Systems Group of the University of Twente for their supervision in this work.

6. REFERENCES

[1] V.-D. Le, H. Scholten, and P. Havinga. Towards opportunistic data dissemination in mobile phone sensor networks. In *Proc. The Eleventh International Conference on Networks (ICN 2012)*, 2012.

[2] A. Lindgren and A. Droia. Probabilistic routing protocol for intermittently connected networks. *Internet Draft draft-lindgren-dtnrg-prophet-02, Work in Progress*, 2006.

[3] T. Spyropoulos, K. Psounis, and C. Raghavendra. Single-copy routing in intermittently connected mobile networks. In *Proc. Sensor and Ad Hoc Communications and Networks (SECON)*, pages 235–244, 2004.

[4] T. Spyropoulos, K. Psounis, and C. Raghavendra. Spray and wait: An efficient routing scheme for intermittently connected mobile networks. In *Proc. of ACM SIGCOMM Workshop on Delay-Tolerant Networking (WDTN)*, 2005.

[5] A. Vahdat and D. Becker. Epidemic routing for partially connected ad hoc networks. Technical report, Department of Computer Science, Duke Univeristy, Durham, NC, 2000.