Multi-Hop on Table-Top: A Scalable Evaluation Workbench for Wireless Ad-Hoc/Sensor Network Systems

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ABSTRACT

In this paper, we describe a scalable workbench for mobile wireless ad-hoc/sensor network systems which realize multi-hop network on table-top using regular IEEE802.11b.

Keywords

Ad-hoc/sensor network, performance evaluation

INTRODUCTION

We are developing a scalable environment for performance evaluation of wireless ad-hoc/sensor network systems. Wireless sensor nodes are promising devices for ubiquitous computing environment. They can be used as smart ID tags, context recognizers, or portable communicators. There have been many examples for such tiny devices applied for ubiquitous/sentient computing research like Cambridge‘s Active Badge, Active Bats[1], UCB/Intel’s Motes and TecO’s Smart-its[2]. Such devices are based on mobile ad-hoc network (MANET) and/or wireless ad-hoc sensor technology.

However, these tiny devices provide non-commodity and proprietary development environments; therefore programming, debugging and evaluation are very difficult tasks, without people with a lot of experience. Even if one use commodity hardware like PC, operating system like Linux and wireless communication like IEEE 802.11b, building a wireless multi-hop network requires much effort because several tough hurdles exist; it is necessary to handle multiple wireless nodes and they all have mobility, the experiment area tends to be of large scale, it is hard to control/recognize multi-hop communication activities, and so forth.

We are realizing a spatially/temporally scalable experiment workbench, where we can dynamically change the one-hop radius of the wireless communication and the re-routing latency result from node mobility. This enables us to realize a multi-hop network on a table-top using regular IEEE 802.11b wireless communication devices.

Overview of Multi-Hop on Table-Top Workbench

The application scope of our workbench includes both MANET and sensor networks; this means each node communicates in wireless multi-hop fashion and they have mobility and/or sensor devices. An imaginable situation scenario is to perform novel application services over people walking around the city who are carrying short-range wireless devices; smart advertisement, personal navigation, ad-hoc commerce etc. Our workbench naturally enables us to realize working experiments in the city, and our scaling feature also enables us to perform them on the table-top small region.

The software modules are comprised of the event producer, the query dispatcher, the sensor emulator, the cluster formation, the in-cluster processing, and the multi-hop routing. If only MANET scenario is necessary, the multi-hop routing module solely works fine. For this module, we have been extending the AODV routing protocol based on NIST’s Kernel AODV implementation[3]. Our extension includes a spatial and temporal scalable feature. The spatial scaling is done by dynamically changing the acceptable signal quality threshold, where one-hop scale should be forced to be small, even if packets are to be physically heard. For the temporal factor, we have added a control for re-routing latency in response to the degree of node mobility.

Once the sensor network factor becomes necessary in the application scenario, other modules are joined together. The event producer module generates a certain event utilizing a beacon packet randomly or in a specified pattern. The sensor emulator module is capable of sensing this kind of events, where its sensing radius is also controllable by the acceptable signal quality threshold. From an application view point, this pair of event and sensor modules might represent, for example, obtaining information of a time-limited bargain sale of a certain shopping store or just sensing my daughter safely arriving at school. The query dispatcher module would inject a query packet into the network by the normal flooding manner.

The sensor nodes which have sensed the event will form cluster which would be used for improvement in tracking the moving event generating node, power consumption control and sensing data aggregation. This is done by the cluster formation module.

The in-cluster processing module will care for replying data packet aggregation.

Each module is accompanied with a graphical user interface which dynamically visualizes each node's activity. Back-light control of each node's LCD works together with our cluster related activities, which would be convenient for illustrating cluster formation dynamics visually.

We adopt Linux-based PDA as a wireless mobile sensor host. The model we use is "Linux Zaurus / SL-C7x0" from SHARP Corporation[4]. This PDA is equipped with Intel's XScale processor, working 32MB RAM and CF/SD card

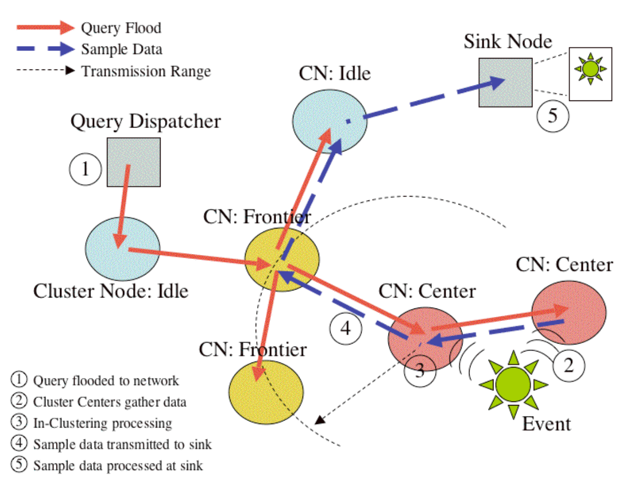

Fig. 1, Sensor network scenario on tabletop

slot. We attached it with regular IEEE 802.11b wireless LAN CF-size card. The kernel we have developed is based on the version 2.4.x with Wireless Extension 16. This commodity OS and wireless communication device accelerate our development in spite of that we have to use a cross-development environment.

Demonstration Overview

Several (from 8 to 16) Linux-based PDA hosts equipped with IEEE 802.11b wireless in ad-hoc mode are laid out on the tabletop. One of the nodes is specified as an event producer and another node will dispatch a query for the event and collect the reply data sampling about the event (this node works as a sink node). The event producer provides a sequence of a partial piece of media data such as one piece of MP3 music, a digital picture data etc. The nodes around the event producer form a cluster to sense and capture the data pieces of them, and they are sent for the sink node through wireless multi-hop network. The sink node will reconstruct the pieces of data sent and replay the music or draw the picture (Fig. 1).

At some time along the data diffusion, the event producer node is moved around, which triggers dynamic reconfiguration of the cluster and reply path routing. These events are visualized in the graphical pattern and back-light control of each node's LCD.

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