Poster Abstract: User-Centric Radio Power Control for Opportunistic Mountain Hiking Networks *

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ABSTRACT

Saving DTNs' battery power to prolong the system life time has been an important research topic which scientists try to optimize. Most researches fall into two categories - Time Division Multiple Access based ones, and Low Power Listening ones by turning the listener's radio on/off intermittently with long sending preambles. In this paper we propose solving the problem from a whole new angle - by using the motes' physical behavior, which is detectable by relatively energy-cheap accelerometer, as the judgment for turning the radio on/off. This scheme can be used in combination with any energy efficient DTN MAC protocols. We evaluate the protocol by running simulations with real hikers' traces and the result is shown in the evaluation section.

Categories and Subject Descriptors

C.2.4 [**Computer-Communication Networks**]: Distributed Systems

General Terms

Algorithms, Design, Experimentation.

Keywords

Wireless Sensor Networks, Opportunistic Networks, Power Control

1. INTRODUCTION

In the resource constrained DTNs, preserving energy while maintaining system performance is always a critical issue. To save battery power, cutting radio listening/transmission time is nearly always the first target given that radio transmission/listening power plays a major role on energy spending. Current researches propose either performing time synchronization between the nodes to run TDMA based protocol [1] or turning the radio on/off intermittently while listening to get better power duty cycle [4]. In this paper we propose a whole new scheme for DTNs' radio power duty cycling which is suitable for User Centric Sensor Networks.

We extended the work of Cenwits[2], which uses GPS enabled motes to record all hikers' encountering location and time to help locate the missing hiker's last seen point, and deploy it in a national park. Upon our observation, when two or more hikers meet on the hiking trail, they will slow down to yield or chat. This motion can be detected by the 3-axis accelerometers installed on the motes and be used as a reference of whether an encounter is happening or not. In our new protocol, the radio is turned on/off depending on the moving speed of the motes.

When the moving speed of the mote is lower than the preprogrammed threshold, we turn the radio on and start neighbor discovering, hand shaking and data exchanging. When the moving speed is higher than the threshold, we turn the radio off. The scheme proposed is simple yet elegant, sends no control messages over the radio and needs no complicated handshaking, topology discovering or synchronization processes. The new method can be used together with any energy efficient MAC protocol to save more power. The main idea is using the physical property seen on the motes to help us judge that something interesting has happened, and only then do we need to turn the radio on. In our case it's when hikers slow down, which indicates there might be an encounter happening. On the other hand, the same idea can be used elsewhere, e.g. a rain monitoring system only needs to turn the radio on when it rains. Using physical characters as the switch to turn on/off radio has the benefit that it's simple, easy to implement and the power used by the sensors to monitor the changes of the environment usually use a lot less power than the radio.

Figure 1: The Yushan Peak Trail.

2. THE PROPOSED APPROACH

Based on the experience of running the YushanNet system [3], we observe that ***hikers tend to slow down when they encounter someone on the trail***. There are two possible reasons for this finding. First, hikers must slow down when passing each other because most mountain trails are narrow by nature; and second, most hik-

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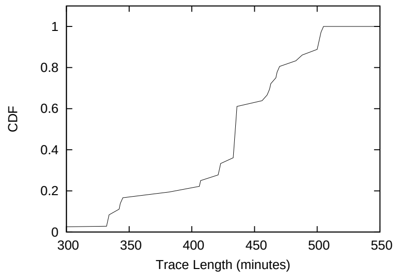

Figure 2: The CDF of trace length of the 36 hikers.

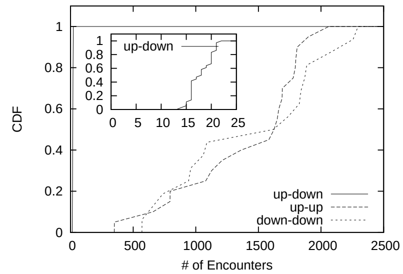

Figure 3: The CDF of the encounter numbers of the 36 hikers.

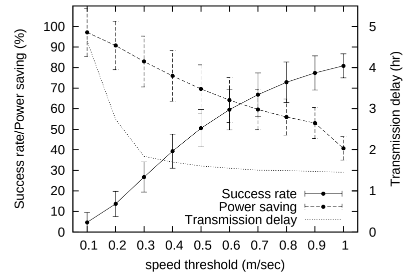

Figure 4: The distributions of the trace length and the number of encounters of the 36 hikers.

ers love to greet each other when encounter someone on the trail. As a consequence, in this paper, we propose a *User-Centric Radio Power Control* approach (UCRPC) that controls the radio duty cycle of the mobile nodes based on the speed estimate of each hiker.

In the proposed scheme, the radio is turned off by default in order to maximize the hiker node's lifespan in the network. The hiker node continuously monitors its hiking speed (e.g., by means of accelerometers), and turns on the radio for communication only when the speed estimate is below a certain threshold. Intuitively, the smaller the threshold value is, the more energy is saved; however, on the down side, the small threshold value might result in a high encounter missing rate such that the nodes cannot communicate to each other even when they encounter each other in reality. Thus, it is highly desired to conduct a thorough study on the feasibility and the effectiveness of the UCRPC scheme, and we present our preliminary evaluation results in the following sections.

3. EVALUATION

We evaluate the proposed UCRPC scheme using trace-based simulations. The trace was collected, along with the *YushanNet* experiment [3], on the *Yushan Peak Trail* on 2009/05/28. The *Yushan Peak Trail*, as shown in Figure 1, is a 10.9km long trail from the entrance to the summit of the *Yushan Mountain* (3952m, the highest mountain in North East Asia) with a 1302m altitudinal shift. We gave out 36 GPS trackers (Model: Genie GT-31[1]) to 16 hikers at the entrance and the other 20 hikers at the Paiyun Lodge, which is about 2.4km away from the summit and provides very basic overnight accommodation for hikers.

Each GPS tracker records the timestamp, latitude, and longitude information of the hiker's position every minute, and the number of records contributed by each hiker ranges from 332 to 505 depending on the hiker's speed. The trace provides the ground truth of the hikers' mobility on the trail. We define that two hikers encounter each other (i.e., yield a *communication opportunity*) when they are within the wireless transmission range[2] of each other. Note that the hiker encounters are essential for mountain hiking systems (e.g., *YushanNet* [3]) as they provide *opportunistic network contacts* for data dissemination in opportunistic mountain hiking networks.

We calculate the *hiker encounters* in the trace, and separate them into three groups, i.e., encounters of two uphill hikers (up-up), two downhill hikers (down-down), and one each uphill and downhill hikers (up-down). Figure 3 depicts the distributions of the trace length and the number of encounters of the 36 hikers.

[1] Genie GT-31/BGT-31: http://www.locosystech.com

[2] For simplicity, we use the same settings (i.e., 20 meters) of [2] as the wireless transmission range in this preliminary study.

Next, we approximate the hiker's instantaneous moving speed by calculating the average speed of every two contiguous records. We vary the threshold of the moving speed from 0.1 to 1.0 meters per second and evaluate the performance of the proposed scheme in terms of *power saving* (i.e., the percentage of the energy saved when the proposed scheme is implemented), *transmission delay* (i.e., the time between a message is initiated and transmitted to one of the base stations), and *success rate* (i.e., the percentage of the encounters where the radio of the both hikers are turned on). From the results shown in Figure 4, we observe that, when a small threshold value is used, the proposed scheme achieves a better power saving performance, because the system is operated in a higher duty cycle and the ratio is turned off most of the time; however, the drawback is that it may miss the hiker encounters, and thus result in poor transmission delay and success rate.

In contrast, when a large threshold value is used, the radio is turned on most of the time. As a result, the system can make use of most hiker encounters (which results in a higher success rate and lower transmission delay) with the expense of energy consumption. Clearly, there is a tradeoff between different performance aspects, and it is desired to adopt a proper threshold value in order to accommodate these factors. For instance, based on this trace, we find that the threshold can be set to 1m/s, since it achieves 80% success rate and 40% power saving, while the transmission delay is moderate.

4. CONCLUSIONS AND FUTURE WORK

From the result of the simulation, we suggest that using the character of the motes' behavior as an input for power duty cycling can definitely help energy saving. In User Centric Opportunistic Networks, the mote's moving speed, or other physical behavior of the motes which is detectable by the plug-in sensors, can all be used to help decide power duty cycling percentage and the proper time to turn on/off the radio. We will implement this protocol in [3] to help adaptive power duty cycling as a future work.

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