지그비 센서의 실내 신호 세기 분석

이종찬* · 박상준* · 박기홍*

요 약

최근의 기술 발전은 무선 통신의 발달과 새로운 센서 기술은 저비용, 저전력 다기능 센서노드의 개발을 가능케 했으며, 더불어 소형화, 근거리 무선 통신 등을 통하여, 소형의 센서 노드들을 군집화되고 있다. 본 연구에서는 모바일 센서들의 위치를 반복적으로 추적하기 위한 셀 내 위치 측정을 고려한다. 반복적인 위치 추적을 통하여 센서들의 위치를 좀 더 정확하게 추정할 수 있다. 이를 위하여 본 연구에서는 수신신호세기를 이용하여 모바일 노드의 정확성을 실험하고 분석한다.

Analysis of Indoor Signal Strength from Zigbee Sensor

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ABSTRACT

Recent technological advances allow us to envision a future where large numbers of low-power, inexpensive sensor devices are densely embedded in the physical environment, operating together in a wireless network. This paper considers localization for mobile sensors; localization must be invoked periodically to enable the sensors to track their location. Localizing more frequently allows the sensors to more accurately track their location in the presence of mobility. In this paper, we test and analyze the accuracy of a moving node localization by Received Signal Strength (RSS).

Key words : Received Signal Strength (RSS), Mobile Sensors, Location Tracking

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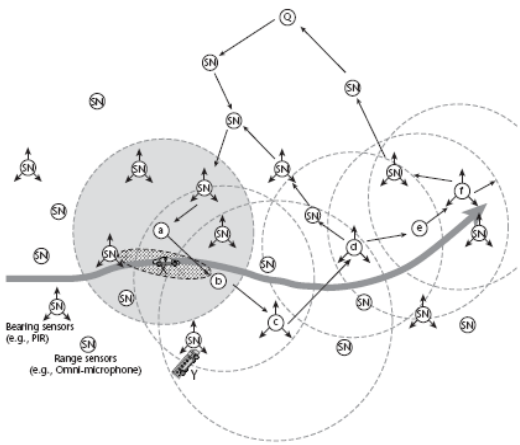
1. Introduction

Localizing and tracking moving stimuli or objects is an essential capability for a sensor network in many practical applications. Moreover, it is a familiar problem that can be used as a vehicle to study many information processing and organization problems for sensor networks. For example, target moves from left to right across the sensor field, a number of activities are initiated in the network, as shown in (Figure 1)[1~4].



(Figure 1) Tracking scenario, showing two moving targets, X and Y, in a field of sensors. Large dashed circles represent the range of radio communication for each node

The node detects and initializes tracking; a user query enters the network and is routed toward regions of interest in this case, the region around node. The node estimates the target location, possibly with help from neighboring nodes. The position estimation may be accomplished by localization arithmetic computation over a set of sensor measurements. As the target moves, node may hand off an initial estimate of the target location to node and so on. The node or may summarize track data and send it back to the querying node[5~9].

Existing research has focused on localization in static sensor networks where localization is a one-time or low frequency activity. In contrast, this paper considers localization for mobile sensors : when sensors are mobile, localization must be invoked periodically to enable the sensors to track their location. Localizing more frequently allows the sensors to more accurately track their location in the presence of mobility.

2. Radio Communication

2.1 Radio Signal Strength Measure

Commonly, mean radio signal strengths diminish with distance according to a power law. One model that showing a path-loss exponent and log-normal fading gives a very good match for short range, line-of-sight communication, particularly indoor environments[10]

$$P_{r,dB}(d) = P_{r,dB}(d_0) - \eta 10\log\left(\frac{d}{d_0}\right) + X_{\sigma,dB} \qquad (1)$$

Where Pr, dB(d) is the received power at distance dB and Pt, dB is the received power at some reference distance d0, η the path-loss exponent, and Xσ, dB a lognormal random variable with variance σ that accounts for fading effects. So, in theory, if the path-loss exponent for a given environment is known the received signal strength can be used to estimate the distance.

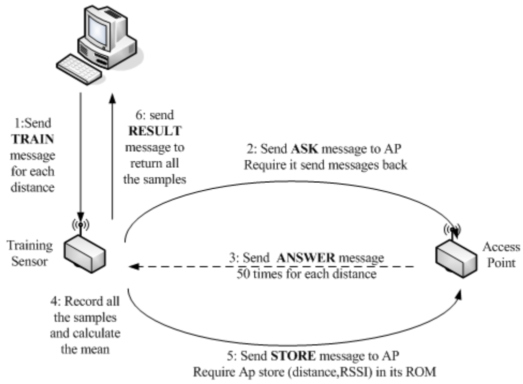
However, the fading term often has a large variance, which can significantly impact the quality of the range estimates. This is the reason RF-RSS-based ranging techniques may offer location accuracy only on the order of meters or more. RSS-based ranging may perform much better in situations where the fading effects can be combated by diversity techniques that take advantage of separate spatio-temporally correlated signal samples. The power with which a radio signal is received can be calculated by measuring the RSSI_VAL (dBm) on the RSS indicator (RSSI) pin on the Chipcon CC2420 radio.

2.2 Ranging Experimental Setup

We designed an experiment to identify the extent to which RSS ranging is affected by various environmental factors. We collected data from 5 slightly different environments and then characterized the data in terms of these factors. This allows us to quantify the effects of several important environmental influences. However, note that while the influences identified are very significant, most are minor compared to differences due to multipath effects or large attenuating obstacles.

The experiment platforms we used are Crossbow MICAz-kit, which have an Atmel Atmega 128 4MHz processor and a Chipcon CC2420 radio. Our micaz mote sed Direct sequence spread spectrum radio which is resistant to RF interference. The transmission power we used is 0dBm.

We collected the RSSI data in this study using our collection program that we present in (Figure 2). There are five types of commands : TRAIN, ASK, ANSWER, STORE, RESULT. Using these commands we exchange data among pc and two sensors.



(Figure 2) Flowchart of training RSSI

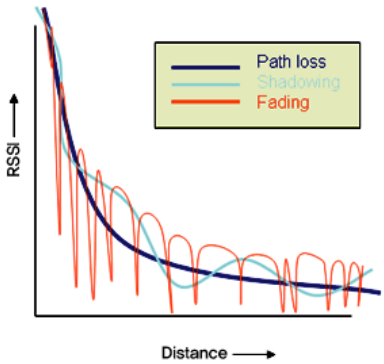
We give a certain distance, then pack the value into TRAIN message and send the message to Training sensor. So the Training sensor receive coordinate message from PC mote (Figure 3).

```
event TOS_MsgPtr ReceiveBMsg.receive(TOS_MsgPtr pmsg)
  {
    BeaconMsg *message = (BeaconMsg *)pmsg->data;
      //if(message->action == REPLY)
      //{
            atomic{
                id[currentBea] = message->sourceID;
                x[currentBea] = message->xpoint;
                y[currentBea] = message->ypoint;
                dis[currentBea] = message->distance;
                rssi[currentBea] = message->action;
                currentBea++;
            }
        if(currentBea >= REFNUM)
        {
            if(!send_pending)
            {
                call Leds.redToggle();
                post report();
            }
}
      //}
      return pmsg;
```

(Figure 3) Training sensor send ASK message to AP

2.3 Some Factors on the Resulting RSS Measure Error

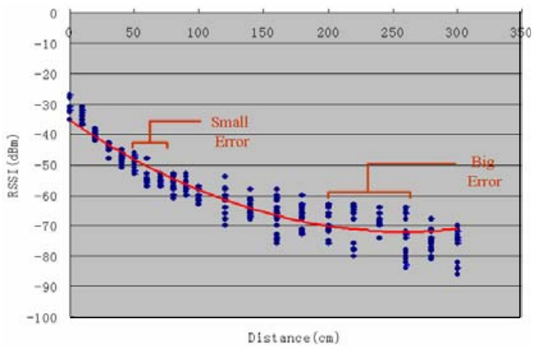
Changes in radio signal strength due to propagation indoors are difficult to predict because of dense environment and propagation effects such as reflection, diffraction and scattering. The multipath fading effect, which is the result of either constructive or destructive combination of multiple signal copies at the receiver, and the Doppler Effect, which is the change in frequency and wavelength of a wave as perceived by an observer moving relative to the source of the waves. For waves that propagate in a wave medium, such as vadio waves, the velocity of the observer and of the source are reckoned relative to the medium in which the waves are transmitted, causes the received signal to fluctuate around a mean value at a particular location. As shown in (Figure 4), the received signal is usually modeled by the combined effects of large-scale fading and small- scale fading.



(Figure 4) Radio Signal Propagation

The attenuation rate is the rate n at which signal strength decreases over distance : RSS∼1/dn. As a rule of thumb, if n=2 then signal strength drops by 3dB every time distance doubles.

This sub-linear attenuation rate means that the difference in signal strength between 1m and 2m is similar to the difference between 10m and 20m : exactly 3dB. Taking this into account, a constant level of noise can result in ever increasing error when signal strength is used to estimate distance; if RSS noise is sufficient that we cannot tell the difference between 1 and 1.5m, we also cannot tell the difference between 10m and 15m. As shown in (Figure 5), changes in signal strength due to distance become small relative to noise, even if the level of noise remains the same over distance.



(Figure 5) Noises and errors in the curve

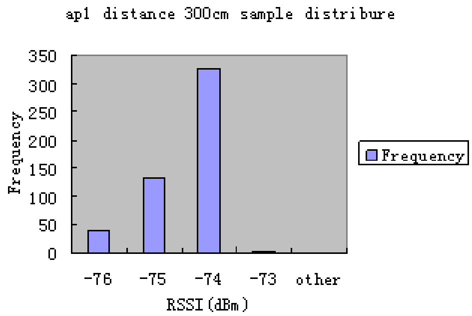
The value n=2 is a theoretical attenuation rate derived from the point-source antenna model which distributes propagated energy over a sphere with surface area 4πd2. In the real world, however, propagation patterns are non-spherical and environmental sources of attenuation often cause the value n to be greater than 2. Higher values cause the curve 1/dn to level-off much more quickly. Following the logic from above, therefore, higher values (distance) correspond to lower resolution in distance in the face of equivalent noise.

3. Ranging Result

We analyzed the data sets collected in the experiments describe above in terms of the factors defined above. A comparison of the different data sets allowed us to identify the effect on RSS of each factor.

3.1 Noise

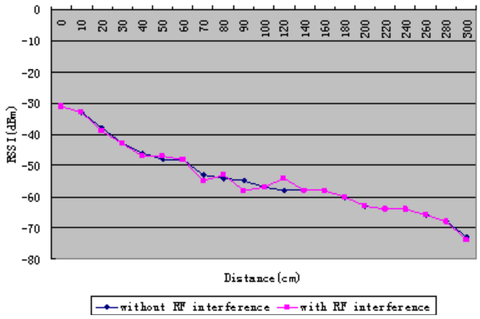
To analyze the distribution of the noise, we measure the RSSI values 500 times (off-line sample) each distance 300cm in position AP1. From (Figure 6), we can observe that the sample distributions of RSSI values follow Gaussians distribution law. That means we can sample RSSI many times and then get Arithmetic mean to reduce the noise. The smaller noise is, the smaller error is.



(Figure 6) AP1 distance 300cm sample distribute

3.2 RF Interference

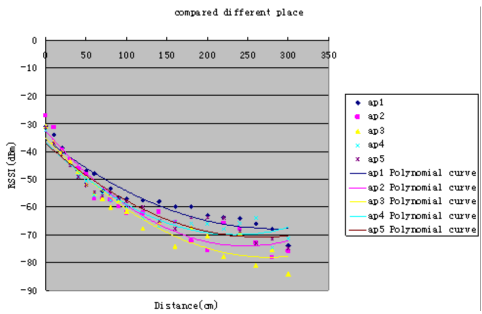
We compared the data collected in the same positions at the same transmission power using different numbers of APs (single or Multi) to identify the effects of RF interference on RSS. (Figure 7) shows that the mote can resistant to RF interference and the curve doesn't change obviously.



(Figure 7) RF interference as a comparison in the control experiment AP

3.3 Position

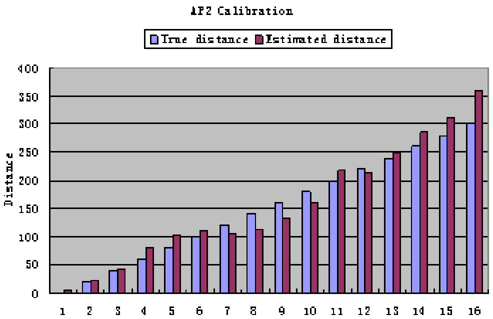
Though the differences of 5 AP's position are slightly, the varieties of relation curves between RSSI and distance identified are still significant. As shown in (Figure 8), if we use the same curve in any positions, we will introduce unnecessary errors. So we do trainings to each Reference Node and store the results in their roms. Every reference Node has its own relation curve. It's more accurate to use distribute "map" than to use central "map".



(Figure 8) APs RSSI-Distance Curves

3.4 Effective RSS and Range

At AP2 we do the range measure test to find out the differences between standard distance and estimate distance. From (Figure 9) we can see, along with the growth of distance, the error is gradually increased. When the distance reaches 3 m, estimation error is about 0.5 m. In other words, 3 m is Effective range in our test. Correspondingly we can get to the value of ERSS : -70 dBm.



(Figure 9) Calibration test in AP2

5. Conclusion

In this paper we characterized various environmental factors affected RSS measurement. And then we introduce a conception : ERSS. Using this restriction we achieve less than 1m error in a 6 reference nodes network deployed in a 3x5m2 sized areas. In our plan, this algorithm is going to be used as auxiliary car parking system. Two points need attention :

Firstly, 1m error maybe can't provide a sufficient resolution of fine-grained, ranging-based localization application. The shorter the distance is; the more accurate estimation is. So the sensor can alter in time when car meet an obstacle. Above The experimental results demonstrate that RSS-based localization can be a feasible for the application.

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