An Inch-sized Operating System for Tiny Wireless Sensor Nodes

Masayuki IWAI
The University of Tokyo
masa@iis.u-tokyo.ac.jp
http://www.mcl.iis.u-tokyo.ac.jp/~masa/

1. Project Goal

Most of sensor nodes research, like Most of Berkley mica DOT dose not focus not focused on the long life operation. Environmental monitoring system required the more than 6 month duration. The average of existing sensor nodes runs between 2 hours and 48 hours.
Second problem is the complexity of application development/configuration.
Most of sensor nodes have just simple API for developing applications. Thus, application developers should re-develop several external library components to the sensor nodes.
To assume the application such as environmental monitoring or retail item monitoring, we have to setup massive sensor node in the short preparation time.
Most of sensor nodes are not easy to configure / reconfigure using wired software update one by one. We also support application development by preparing middleware for massive sensor data mining via internet. The final and fatal problem of exiting research is the luck of security.
Most of sensor node sends a raw packet data to sink node directly. They did not concern sensor belongings. It is natural that lots of applications exist in the same area, which is developed by other company. To think about accurate monitoring, we have to protect alteration by others organization.

The project goal is to re-design and develop an operating system on tiny sensor nodes for practical situation. The second goal of this project is to provide simple APIs for configurable application development. The third goal is to provide secure grouping method for tiny sensor nodes.
The contributions of this project are that provided libraries will help developers to create practical applications easily. As the academic point of view sensor networking research will users in the real field.

2. Technical breakthrough

The challenging points of this software are shown in Fig1.

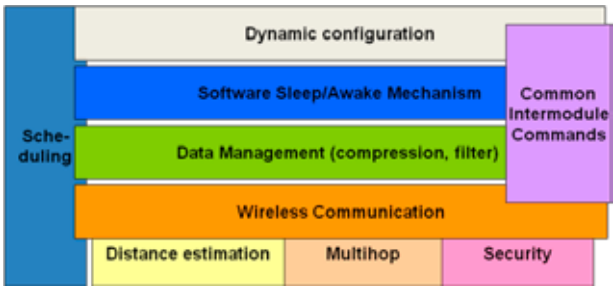

Fig 1 Grand design of Software Platform

2-1) Dynamic Wireless Configuration
Each sensor nodes dynamically setup its configuration referred to other sensor node via RF, duration of sensing packet and threat hold of sensor value to send the data

2-2) Software Sleep/Awake Mechanism
To support finer grained battery saving, we develop switch-off mechanism as a software API. Using this API, sensor device and RF dynamically turns off./turn on. Users can easily configure a sensor-values-driven switch-on/off that means when a sensor node moves, it began to send data as shown in Fig4

2-3) Smart Compressions of Sensor Data
To reduce the wireless power, Tiny sensor node supports Data compression.
If acquired data has not change to previous one, we compress them in to one packet.

2-4) Distance estimation between Sensor Nodes
We develop APIs to estimate the distance between sensor nodes to packet sender.

2-5) Multi-Hop communication support with security

Tiny sensor node can send multi-hop packet routing unlike other tiny sensor nodes.

We provide simple function to support flexible multi-hop in large scale monitoring.

2-6) Communication Protocols

We will prepare simple communication protocols between sensor nodes with security using group code sharing.

2-7)Hardware Design

This project will provide the small sensor node with the support from prof. Michael Beigl, Germany.

Fig 2 Grand design of Software Platform

3. Innovative Applications

As the application scenario, we have created ranking system [1] and middleware in the practical retail shops in electric town as figure 3. Sensors are attached on the items to detect customers' interest to buy. Using our sensor nodes we can develop this kind of marketing system easily. It is easy to develop large-scale long-span environmental monitoring like mountain, riverside sea, and farm.

We can use this sensor node to predict disasters in the urban area such car accident, train incident, earthquakes, bridge collapse, and damage from typhoon.

The other application is land monitoring in figure 4 using sensor-based picket[3]. This system enables remote monitoring of slope failure in real-time with low power consumption.

Fig 3 Sensors on Market items and Visualization of interests

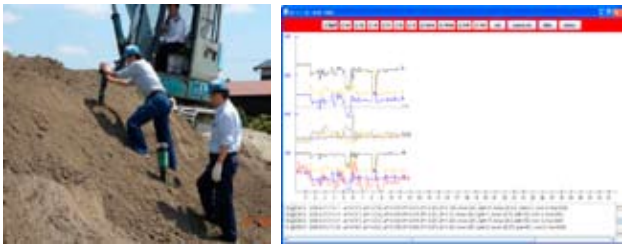

Fig 4 Land monitoring with sensor implant picket

4. Academic Achievement

Academic publications, invited talks, and new paper presses are below.

[1]Iwai,M, Mori, M., Tokuda,H. "A Marketing Analysis Using Massive Tiny Sensor Nodes"
Sixth International Conference on Networked Sensing Systems INSS2009 June 2009 Pittsburgh USA

[2]A Platform Design of Resource-limited Tiny Sensor Nodes towards Practical Applications
Masayuki Iwai, Dawud Gordon, Michael Beigl pp407-408 M-072 Fit2009

[3][excellent presentation award]
iPicket: Slope Failure Detection System Using Wireless Sensor Nodes
Masayuki IWAI, Daiki IMAI, Masanori KOBAYASHI, Yoshito TOBE, Kaoru SEZAKI
IPSJ SIG-MBL52: Mobile Computing and Ubiquitous Communications, Tokyo, 2010 Jan.

[4]Japan Nikkei News paper 2009/10/1 "Remote Monitoring with sensor implanted Picket".

[5]Invited Talk:
Masayuki Iwai (University of Tokyo),
Practical Platform enabling Wireless Human Sensing in Urban Environment,
The Second International Workshop on Wireless Sensor Networks and Embedded Systems Research,
KAIST, Korea, Deajun, 2009, June,29-30

[6]Invited Talk:
Masayuki IWAI, and Tian Hao (University of Tokyo),
"Database system for Ubiquitous Sensing Society," Northern East University, China, Agust,27-28.

[7]Invited Talk:
"Advanced Sensing Technologies and Sensing Applications for Marketing Area."
RFID utilization research forum, at Hiroshima-ken Fukuyama-city Enterprise groups,
2009/Oct/30th

5. Project Development

The project is on going with the support from the KAKEN Grant-in-Aid for Scientific Research (B)22360149 with joint researcher associate-prof. Kaoru Sezaki from this academic year(founding size is 15billion yen over 3 years).

6. Publications

Paper publication

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