# Demo Abstract: Radio Information Management for Distributed Spectrum Sensing

Junichi Naganawa, Hojun Kim, Kosuke Nishimura, Shunsuke Saruwatari, Makoto Suzuki, Masateru Minami, Hiroyuki Morikawa
RCAST, The University of Tokyo
{naga, kimhojun, kosuke, saru, makoto, minami, mori}@mlab.t.u-tokyo.ac.jp

## Abstract

Radio spectrum has turned into a precious natural resource from free goods due to the rapid development of wireless communication technology. In order to efficiently utilize radio spectrum, a spectrum policy should be enough appropriate to create new industries and new technologies. From this point of view, we have developed a distributed spectrum sensing system which collects dense information of spectrum usage over large area. In this work, we discuss the requirements and the design of the distributed spectrum sensing system.

## Categories and Subject Descriptors

C.2.4 [**Distributed Systems**]: Distributed Systems—*Distributed applications*

## General Terms

Design, Performance

## Keywords

Distributed Spectrum Sensing, Cognitive Radio, Sensor Network, Radio Information

## 1 Distributed Spectrum Sensing

The distributed spectrum sensing system provides the visualization service to access the spectrum information collected at each distributed sensor node. Each sensor node can be chosen among wide range of devices from a low-end 100-dollar spectrum analyzer to high-end spectrum analyzers which cost tens of thousands of dollars.

Figure 1 shows a screen shot of the system. When a user accesses to the visualization service provided by the system, the spectrum usage information is shown on the map. In Figure 1, the spectrum usage at Komaba campus of the University of Tokyo is shown with the graph in which the horizontal axis corresponds to the frequency and the vertical axis corresponds to the time. The user is also able to access raw data by clicking a sensor node on the map. This visualization service allows many applications such as finding white space and detecting radio disturbance. Even analyzing the disturbance cause is possible by examining raw data, determining shadowing or illegal radio transmission. The spectrum sensing will also contribute to the emerging cognitive radio technology [1].


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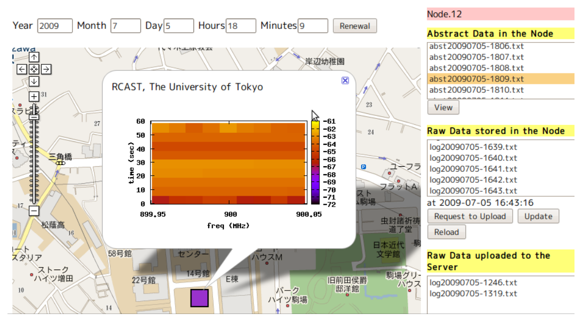


**Figure 1. Screen shot.**

This distributed spectrum sensing, however, can not be achieved by merely distributing many high-end spectrum analyzers and connecting them to the Internet. There are two technological issues: the first one is how to efficiently collect spectrum usage information over large area, and the second one is how to manage enormous raw data.

For the first issue, to achieve efficient collection of spectrum usage information over large area, the distributed data acquisition system should satisfy network constraints such as network bandwidth. The distributed spectrum sensing system collects data from thousands of sensor nodes. Hence, appropriate data format of spectrum usage information and traffic management are essential for distributed spectrum sensing system to accommodate such a large number of sensor nodes under the limited network resource.

For the second issue, to manage enormous amount of raw data on a sensor node, the storage capacity management that satisfies storage resource constraints is necessary. For example, in the case of 100MHz bandwidth signals to be stored in a local storage, the storage resource is consumed at 800Mbyte per a second because a single symbol has 8byte of data amount. Obviously, no high-end spectrum analyzer can store such a huge amount of data for ever.

## 2 System Design

### 2.1 System Architecture

Figure 2 shows the overall system architecture of the distributed spectrum sensing system. The system is composed of a management server and sensor nodes. The management server provides the visualization service and bridges between sensor nodes and users. A sensor node is composed of a front-end, an acquisition function, a storage function,

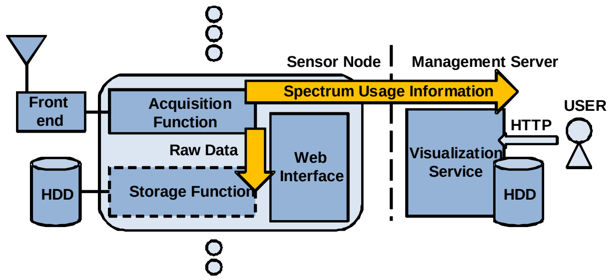


**Figure 2. Distributed spectrum sensing system.**

and web-interface. The front-end is a device to receive radio information. The received radio information is passed to the acquisition function to generate the spectrum usage information. Then, web-interface sends the spectrum usage information to the server. If the sensor node is equipped with a storage function, the collected radio information is written in the storage as raw data.

### 2.2 Traffic Management

Generating spectrum usage information is a essential function of the sensor node. It is achieved by following steps. First, the sensor node estimates spectrum every minutes. Then, the sensor node adds a time stamp, a center frequency, bandwidth, and existence of corresponding raw data to the estimated spectrum in order to form spectrum usage information. If the size of the generated spectrum usage information exceeds a maximum data size, the sensor node repeats to decimate odd line data until the data size becomes below the maximum data size. The maximum data size is decided depending on the load of the management server and a number of sensor nodes, then the server notifies the maximum data size to all sensor nodes. For example, we assume that we have 10,000 sensor nodes and each node generates 5Kbyte data every minutes. In this case, the network bandwidth should be at least 6.7Mbps, and the management server should handle 500 sessions at a time under the assumption that a single session needs 3 seconds.

### 2.3 Storage Capacity Management

Storing raw data is a optional function of the distributed spectrum sensing system, which only high-end sensor nodes is equipped with. Because raw data consume huge storage capacity, we introduce RSSI (Received Signal Strength Indicator) as a criterion for storing so that only important raw data is stored. Storing raw data is achieved by following steps. First, a user set the threshold value of RSSI, which is determined from an intended application type. Then, the sensor node stores raw data in a separated file every minutes. Receiving and writing raw data, the sensor node calculates RSSI at the same time. If the calculated RSSI in the minutes does not exceed the threshold, the corresponding raw data file is deleted. Thus, unnecessary data is avoided to be stored. In addition, when the sensor node begins to run out of the available storage capacity, the storage function deletes the old data and notifies the deletion to the server.

## 3 Implementation

We implemented the management server and the sensor nodes. The server is implemented as a web service with Apache and PHP. As a sensor node, we use spectrum analyzers such as PXI-5660 of National Instruments[3], USRP[4] with GNU Radio[5], and 100-dollar spectrum analyzers[2]. For the initial evaluation, we selected USRP2 with GNU Radio and measured the CPU utilization of tasks for the distributed spectrum sensing system. In the implementation, we used laptops with 1GB memory, Core 2 Duo P8400 as a CPU, 1TB HDD connected via USB as a storage. The measurement result shows that receiving 200kHz bandwidth signals, writing to the storage, calculating RSSI, and generating abstract data consumed 6.6%, 0.1%, 3.7%, and 0.4% of the CPU power respectively and 10.8% in total. In this case, raw data is stably stored at 96Mbyte per a minute.

## 4 Demonstration

Figure 3 shows the demonstration setup. In the demonstration, we show measurement and visualization of the spectrum usage on the demonstration site. During the measurement, visitors can see the uploaded abstract data as a screen shot in Figure 1 by using the visualization service. The visualization service mashes up Google Maps and the spectrum usage information. Each sensor node is represented by an icon on the map. The visitors can also view the radio information from the sensor nodes located in several points in Japan.

## 5 Conclusions

In this paper, we discussed the requirements and the method to manage spectrum information. Now we are preparing to measure radio information over wide region using sensor node described in this paper.

## 6 Acknowledgments

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## 7 References

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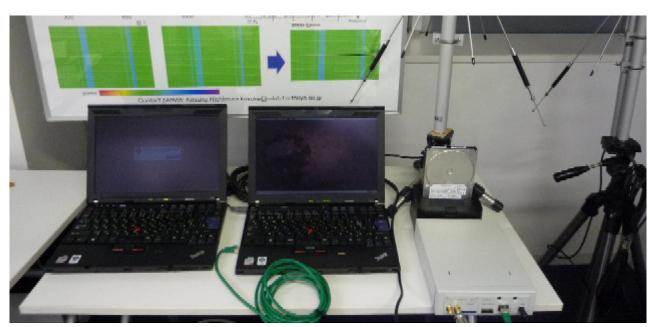

**Figure 3. Demonstration setup.**