Poster Abstract: Design of a Low-cost Sensor Node for Distributed Spectrum Sensing

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Abstract

In distributed spectrum sensing, we deploy ten thousands of sensor nodes, and a low-cost sensor node is necessary. In this work, we design the sensor node specialized in power level measurement for distributed spectrum sensing, and we discuss 3 components of the node, which are frequency range, RBW and a detector.

Categories and Subject Descriptors

C.2 [**Computer-Communication Networks**]: Distributed Systems; C.3 [**Special-Purpose and Application-Based Systems**]: Signal Processing Systems

General Terms

Design

Keywords

Distributed Spectrum Sensing, Cognitive Radio, Sensor Node

1 Introduction

Spectrum is inherently a limited resource. The need for wireless devices forces us to face spectrum shortage, and we have to effectively use spectrum resources [1]. For the effective spectrum usage, we have to deeply understand and share the current spectrum usage information. The sharing spectrum usage information is useful for researchers who study cognitive radio or spectrum policy. There have been several wide-band spectrum usage surveys [1][2], but the surveys only measure spectrum at few points.

We need higher-density spectrum data for the deep understanding of the spectrum usage information. We are developing visualization of radio spectrum with distributed spectrum sensing over wide area. Distributed spectrum sensing is high-density spectrum usage monitoring with distributed ten thousands of sensor nodes. Distributed spectrum sensing has two requirements: a low-cost sensor node and scalable spectrum information management system with a limited resource.

In this work, we discuss design of construction for a low-cost sensor node. The scalable spectrum information management system can be found elsewhere [3].

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2 Distributed Spectrum Sensing

We minimize the cost per a sensor node for high-density and wide area spectrum sensing. A general spectrum analyzer is more than ten thousand dollars on the market, and it is impractical to deploy many general spectrum analyzers. Our ultimate goal is to make a 1-chip spectrum sensor, and embeds the chip to various devices, such as a cellular phone. In order to make the 1-chip spectrum sensor, we have to identify minimum requirements for a low cost sensor node which collects the spectrum usage information. It is also important to know influences of each component on accuracy of the spectrum usage information.

We develop a $100 sensor node specialized in measuring radio power level for knowing spectrum usage. There are some devices, which enable us to measure radio power level, such as high-end spectrum analyzers, portable spectrum analyzers, and simple spectrum analyzers. Table 1 shows comparison among the spectrum analyzers and our node. The purpose of the spectrum analyzer decides the price of the spectrum analyzer. Our node only has one purpose for measuring radio power level. We discuss 3 components required for measuring radio power level: frequency range, RBW (Resolution Band Width), and a detector by comparing with the general spectrum analyzers.

We fix frequency range to VHF/UHF bands (30MHz ∼3GHz) where spectrum allocation is crowded. Out of 30MHz∼3GHz bands, there are some factors which complicate measuring mechanism as compared with its usage rate. For example, in HF, which is 9kHz∼30MHz, a sensor node has to prepare a function for spurious and internal noise. In SHF/EHF, which is 3GHz∼300GHz, the sensor node has to match impedance between different wiring materials. Moreover, the cost of a local oscillator becomes high to generate high frequency.

We fix RBW to 200kHz that lies the bandwidth of 1 channel for the FM broadcasting. 200kHz RBW is selected in consideration of fast sweep speed, and the cost of components. RBW is a function to separate two adjacent channels to each frequency, and decided by the bandwidth of an intermediate frequency (IF) filter. Sweep time is inversely proportional to square of RBW. When RBW is too narrow, sweep time becomes too long. High-end spectrum analyzers have IF filters having various bandwidth, and the band-

Table 1. Comparison of spectrum analyzers.

	High-end spectrum analyzer	Portable spectrum analyzer		Simple spectrum analyzer	Ours
	FSL6 [4]	SRM-3000 [5]	SpeCat2 [6]	GigaSt [7]	Ours
Cost	about $10,000˜	about $15,500	about $3,990	about $385	< $100
Freq. range	9kHz˜6GHz	100kHz˜3GHz	100kHz˜3GHz	3MHz˜12GHz	30MHz˜3GHz
RBW	300Hz˜10MHz	1kHz˜5MHz	1kHz˜250kHz	15kHz˜180kHz	200kHz
Detector	MAX, MIN, SAMPLE, AVERAGE, RMS, QUASI PEAK	MAX, RMS	MAX, MIN, RMS	MAX, RMS	RMS
Purpose	General purpose	Safety analysis of RF	Interference, power level	Power level, freq response	Power level

width is from hundreds of Hz to tens of MHz. The high-end spectrum analyzers switch the IF filters to analyze various signals. When we measure EMI (Electro Magnetic Interference), C/N (Carrier vs. Noise), and a spurious emission at low frequency, the spectrum analyzers require narrow RBW, which is hundreds of Hz. When we analyze the wideband signal such as wireless LAN, the spectrum analyzers require wide RBW, which is tens of MHz. On the other hand, since the purpose of our node is only to measure radio power level, the node does not need functions except for the purpose. For example, our node does not need to separate adjacent signals.

Our node uses only RMS as a detector. General spectrum analyzers have some detectors offering positive/negative peak, RMS, sample, average values, and so on. The general spectrum analyzers switch detectors corresponding to various measurement standards. However, our node uses only one detector for RMS value, which is generally used to judge the radio spectrum usability.

3 Design

From discussion in section 2, we design a spectrum sensor node. Figure 1 shows the block diagram of the designed sensor node. The sensor node, which is superheterodyne receiver, is composed of an attenuator (ATT), high-pass filters (HPF), low-pass filters (LPF), mixers, local oscillators (LO), band-pass filters (BPF), a detector (DET), and a micro controller (MCU). The attenuator attenuates input power level to under the maximum signal level where the mixers work. The mixers up/down-convert the received signal to intermediate frequency (IF) with multistep combination of high-pass filters, low-pass filters, and local oscillators. After the band-pass filter passes IF band, the detector measures signal power level. The micro controller converts analog IF signals to digital signals. In addition, the micro controller controls not only switches which decide the number of step for mixer input, but also the local oscillator which generates required oscillation frequency. The following detaily shows components of the sensor node.

(1) Up/down converter: Mini-Circuits AT-20 is used as an attenuator, and TUF is used as a mixer. A PLL circuit is used for high stability of local oscillators. The PLL circuit consists of a loop filter, a voltage-controlled oscillator (VCO), and a frequency synthesizer. Mini-Circuits POS series are used as the VCO, and Fujitsu MB15E05 is used as the frequency synthesizer. Inverting level shift with a lag-lead filter

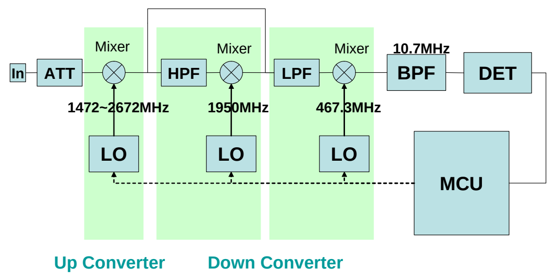

Figure 1. Block diagram.

is used as the loop filter.

(2) BPF: Murata Manufacturing SFELF10M7 is used. SFELF10M7 has 10.7MHz center frequency and 200kHz bandwidth.

(3) Detector: Analog Devices AD8307 is used. AD8307 provides a logarithmic amplifier as well as RMS detection.

(4) Micro controller: Microchip PIC18F2321 is used.

4 Conclusions

We have discussed design of a low-cost spectrum sensing node for distributed spectrum sensing. The sensor node is specialized in measuring radio power level. We are currently preparing for deployment of the sensor nodes in wide area.

5 Acknowledgments

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6 References

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