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Real Time Spectrum Sensing by using Frequency Shifted Sensor for Spectrum Sharing Cognitive Radio

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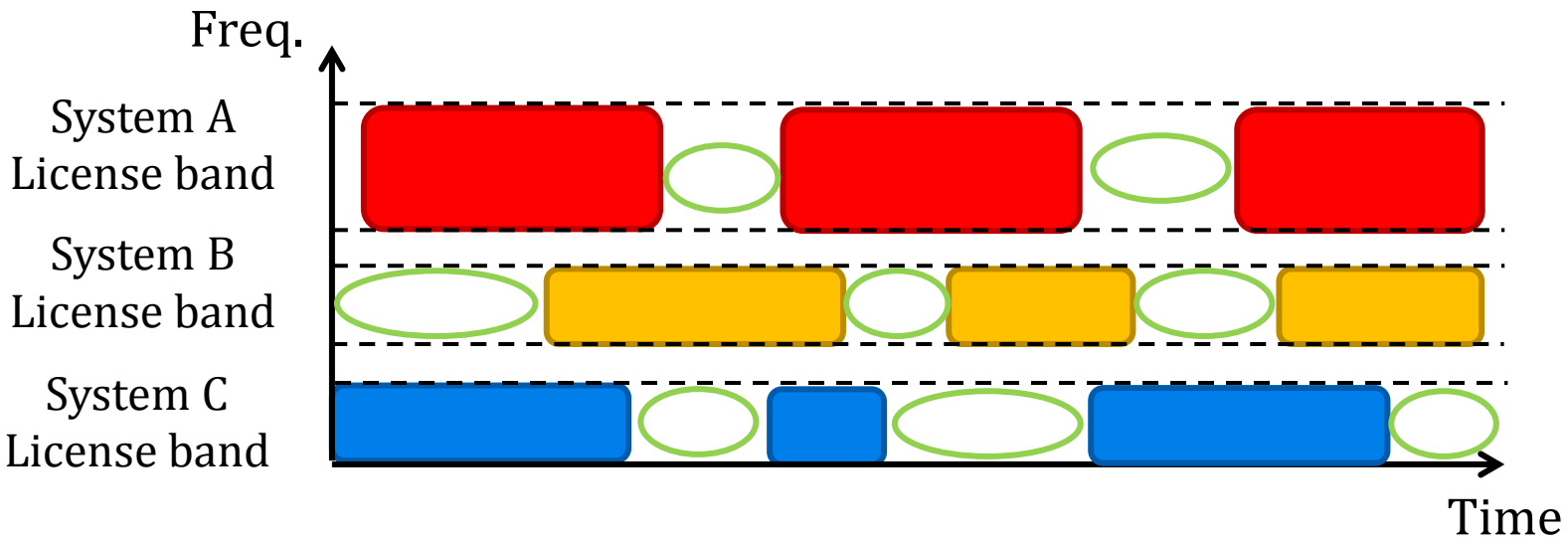
Introduction

Recent Frequency Resource

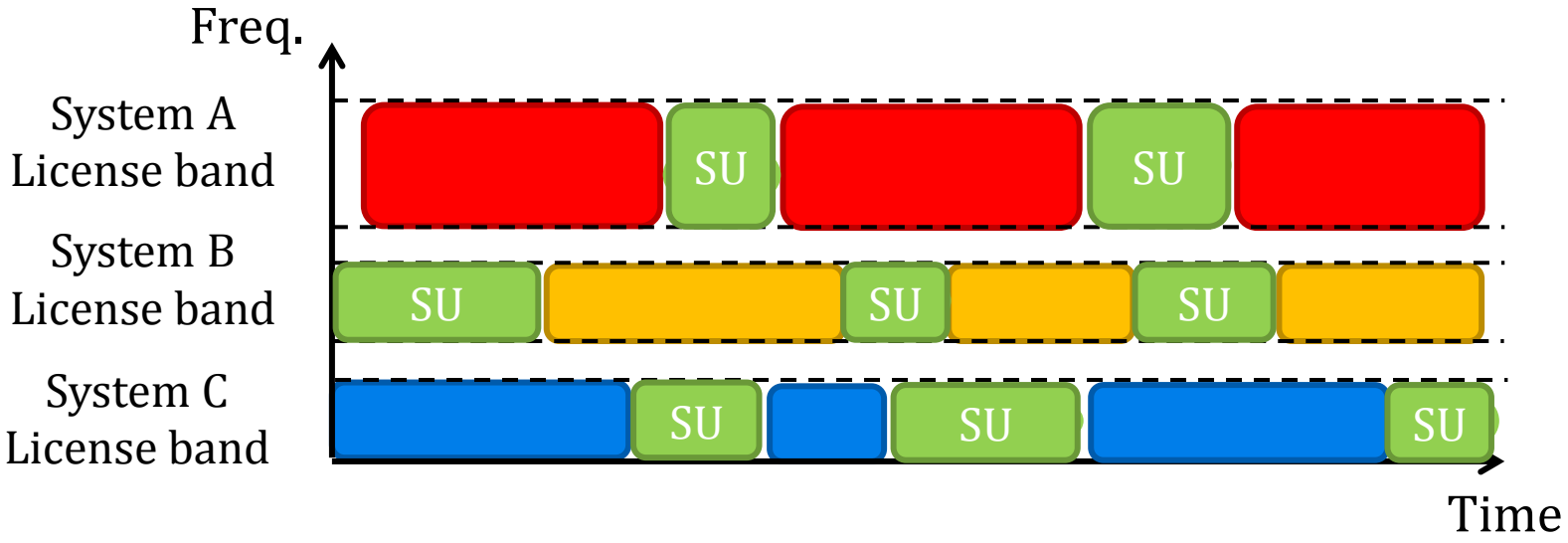
- Spectrum resource is scarce due to increasing demand for wireless communication
- Spectrum effectively used in time domain or spatial domain is 15 to 18 %



Introduction

- Spectrum sharing by using Cognitive Radio
  - » Cognitive radio users(Secondary Users : SU) adaptively select the spectrum of PU without giving interference
  - » Device cognitively optimizes communication parameters

  - » Improve the frequency resource depletion problem

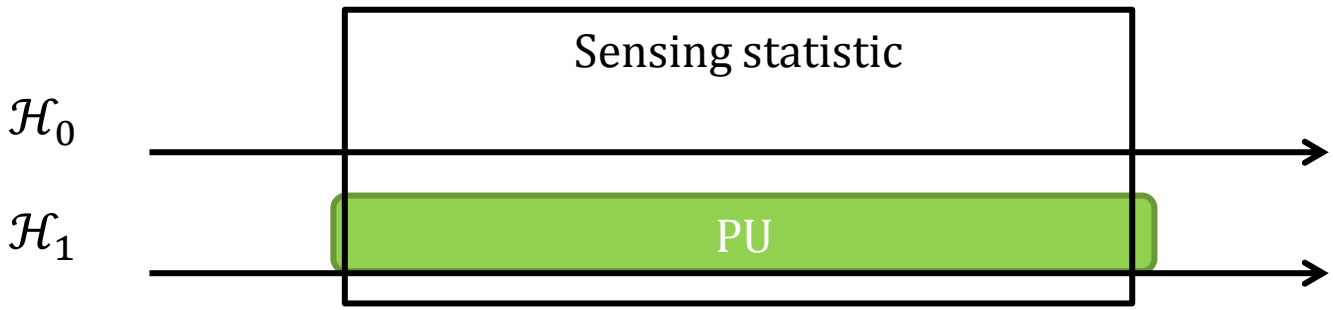


Introduction

- SUs have to avoid the interference toward PU by recognizing PU
- Spectrum Sensing by Energy Detection
  - » Detect the signal transmitted from PU at the SU device
  - » Observing the energy of the sampling signals of the received signals at SU device

$$\begin{cases} \mathcal{H}_0 : y(t) = n(t) & : \text{PU is idle} \\ \mathcal{H}_1 : y(t) = s(t) + n(t) & : \text{PU is active} \end{cases}$$

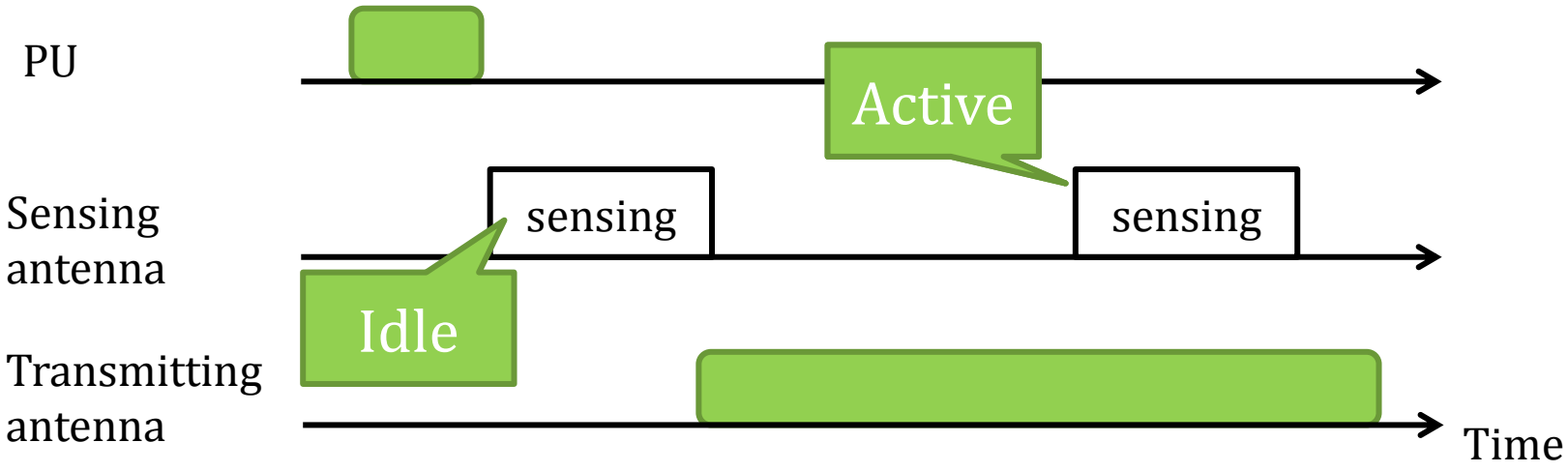
$$T_s = \frac{1}{N}\sum_{n=1}^{N} |y(n)|^2 \underset{\geq}{<} \gamma$$



Introduction

Energy Detection Problem

- This method compares the average energy of the received signal with the threshold
- the different signals received at the sensing device affect to the results of spectrum sensing

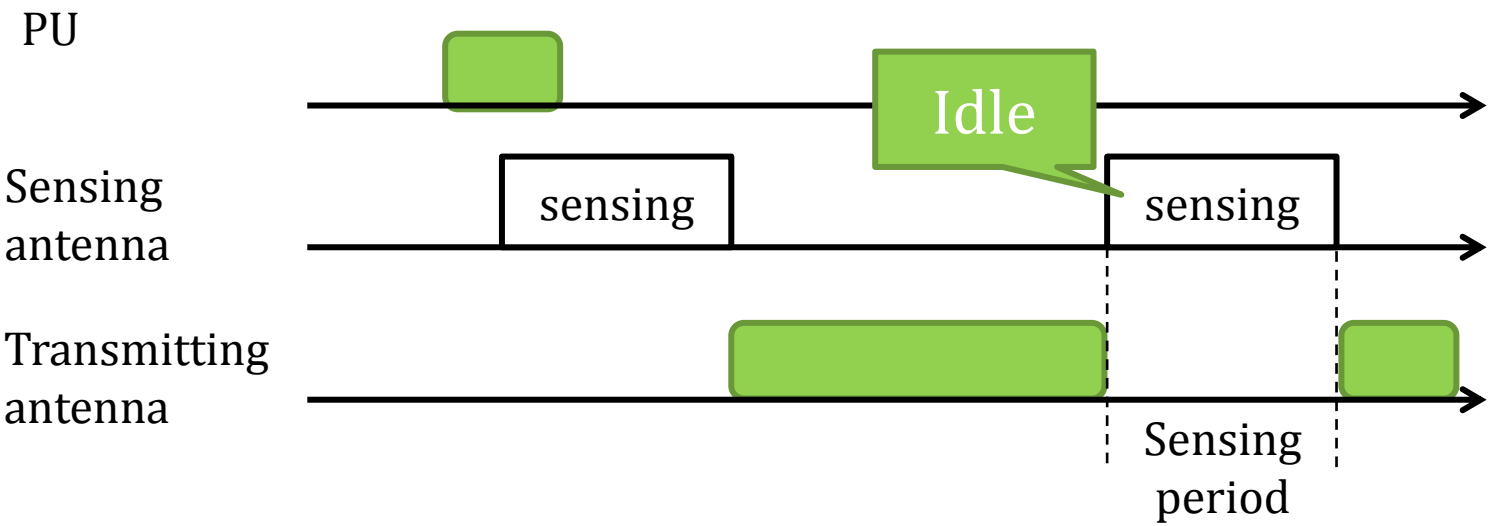


Introduction

General Solution

- SUs terminate the signal transmission during the sensing period

- Degrades the time efficiency of SUs

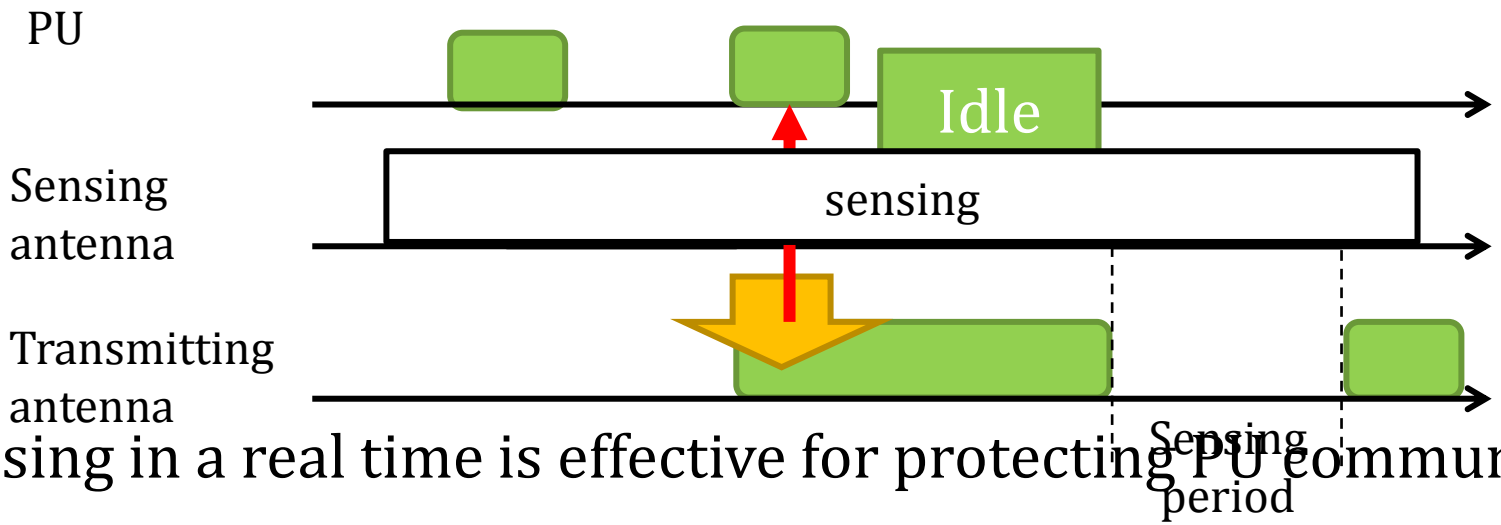


Introduction

General Solution

- SUs terminate the signal transmission during the sensing period

- Degrades the time efficiency of SUs
- SU may give the interference

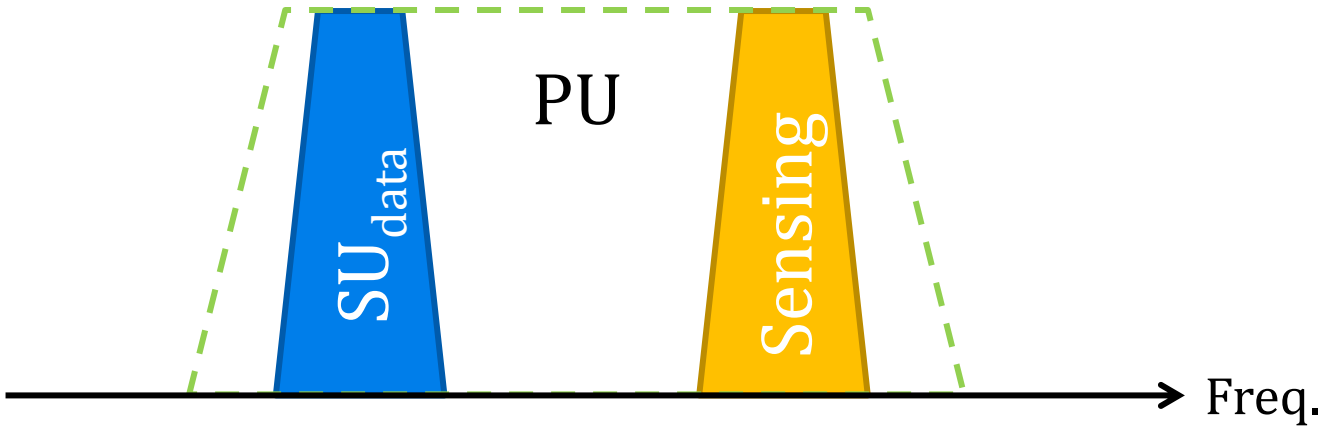


Sensing in a real time is effective for protecting PU communication

Proposed method

Frequency Shifted Sensing

- Spectrum of PU is wider than that of SU and multiple SU channels can be allocated to one PU spectrum
- If we set the channel of SU on the edge of PU spectrum, the adjacent frequency on the same PU is not occupied by SU and the frequency can be used for sensing.

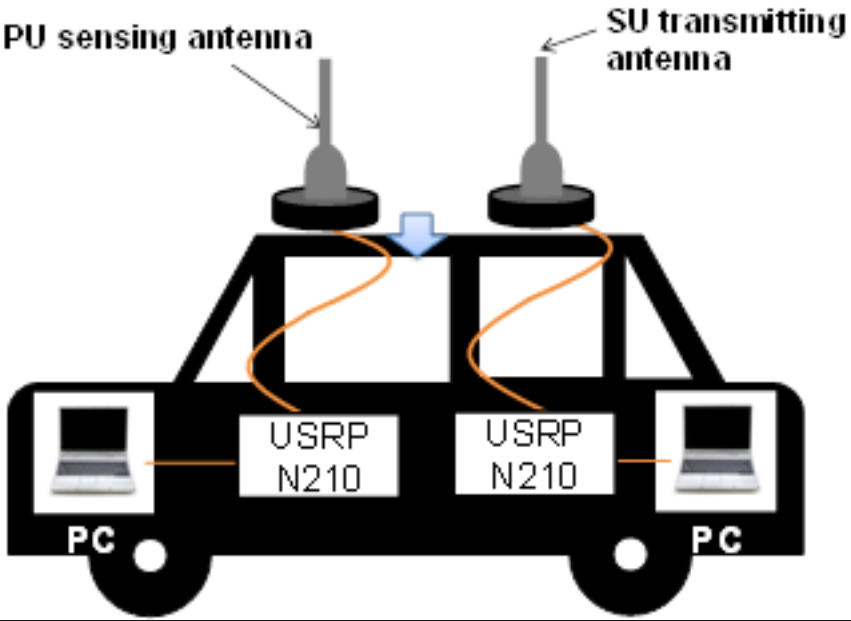


Proposed method

Frequency Shifted Sensing

- an application of wireless vehicular networks
- Separate sensing antenna from the SU transmitting antenna

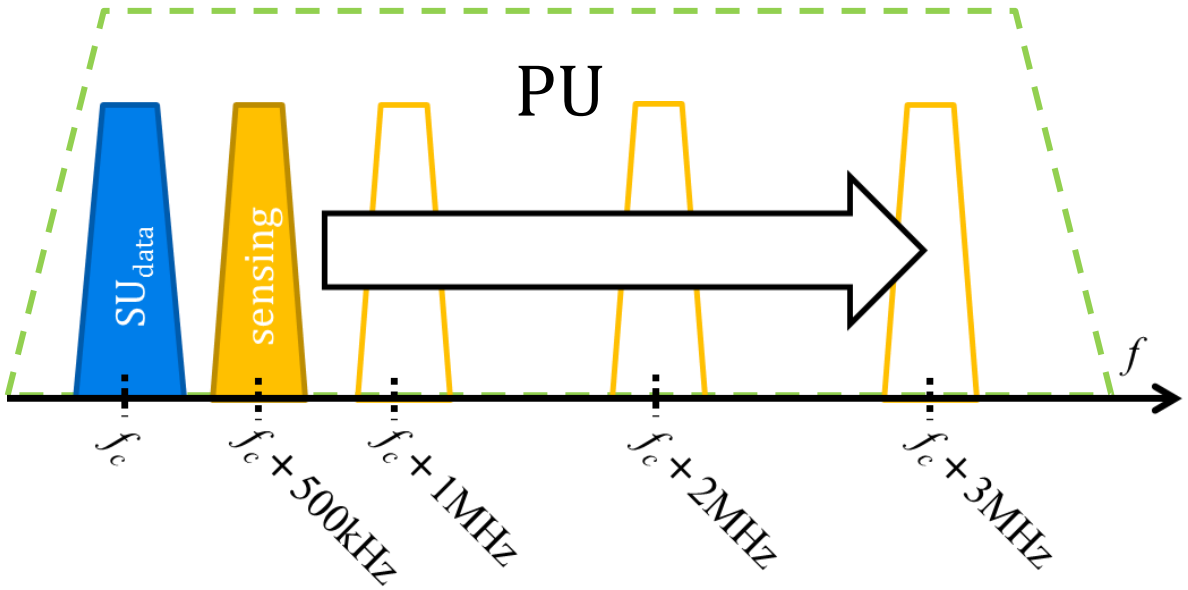
- Influence of SU signal decreases



Experimental Configuration

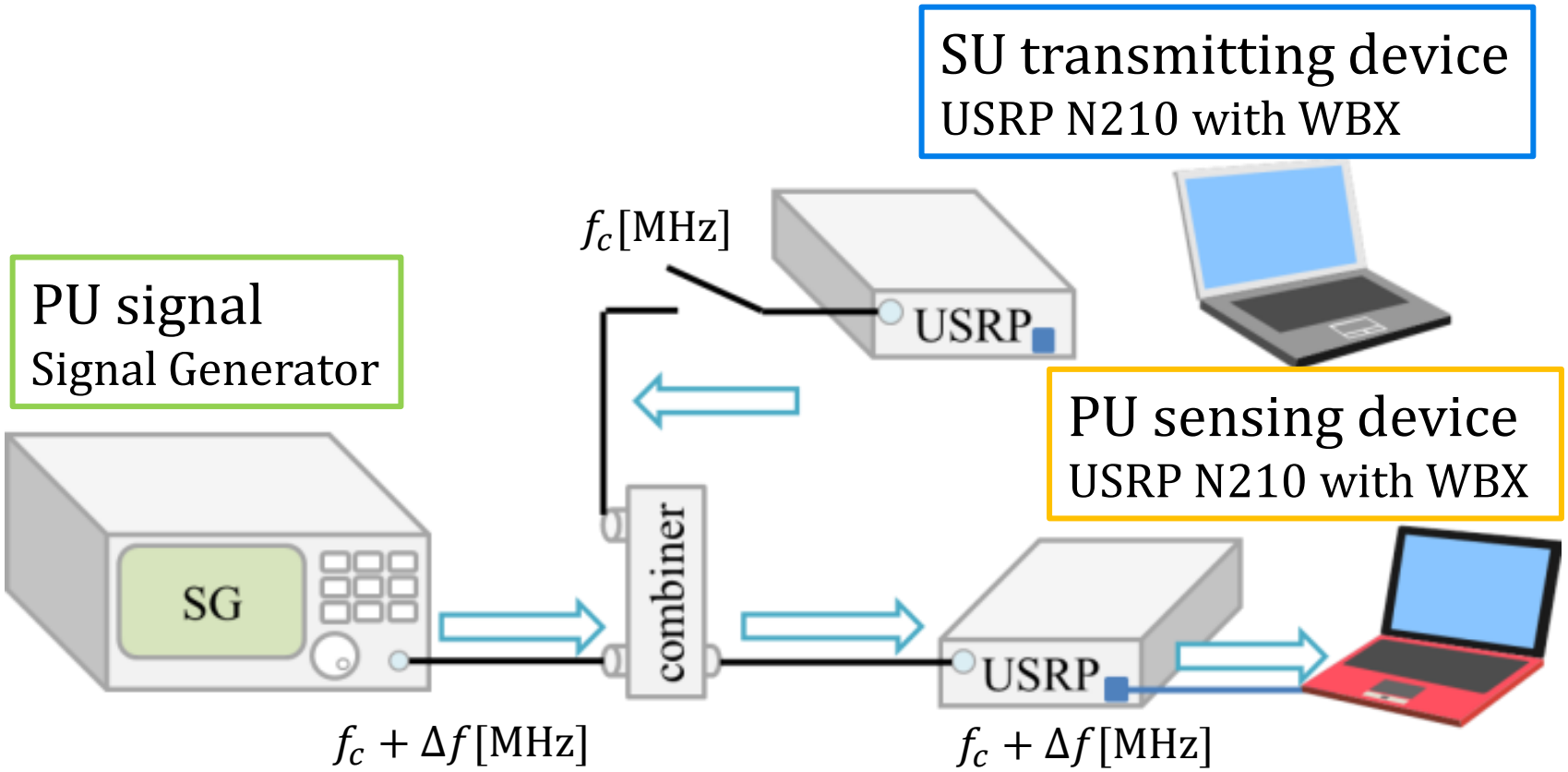
Spectrum Allocation

- SU transmits the signal on the data channel
- We set 412.5 MHz for the center frequency of SU Tx.
- Sensing frequency is shifted by 500 kHz, 1 MHz, 2 MHz, and 3 MHz.



Laboratory Experiment

■Experimental instrument



Laboratory Experimental Configuration

Sensing device

Parameters	value
Sampling rate	200 kHz
FFT size	2048
Center frequency	413,413.5,414.5,415.5 MHz

Transmitting device

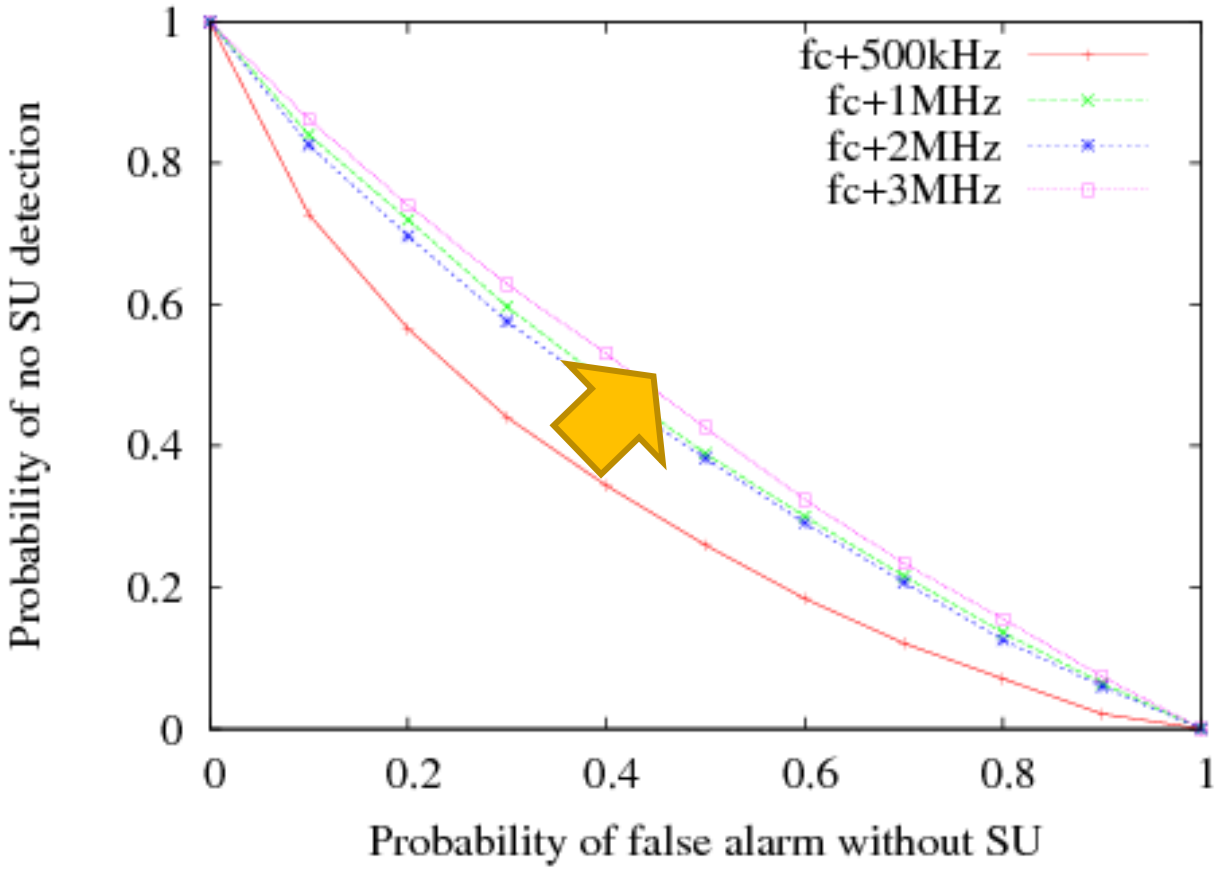
Parameters	value
Modulation	GMSK
Bandwidth	200 kHz
Receive power at sensor	-40 dBm

PU signal

Parameters	value
Modulation	GMSK
Bandwidth	200 kHz
Transmit power at indoor	variable

Laboratory Experimental Result

■Probability of no SU detection

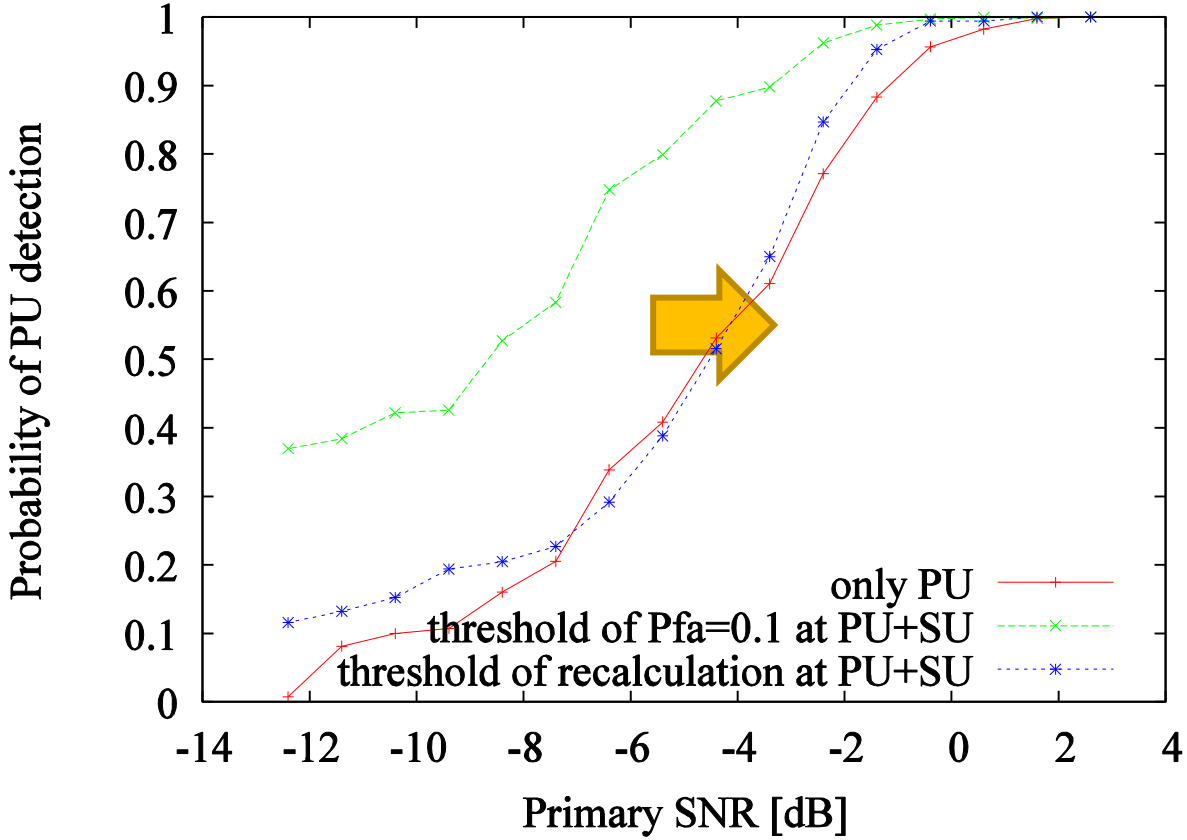


2-MHz or more center frequency is detached

sensing antenna can reduce the influence from SU

Laboratory Experimental Result

■Probability of PU detection



Threshold is again set up in SU transmitting

⇒ Same performance as only PU

Field Experiment

Field Experiment Environment

- At Kyushu Institute of Technology
- Antenna distance : 1.5m

Field Experimental Configuration

Sensing device

Parameters	value
Sampling rate	200 kHz
FFT size	2048
Center frequency	413,413.5,414.5,415.5 MHz

Transmitting device

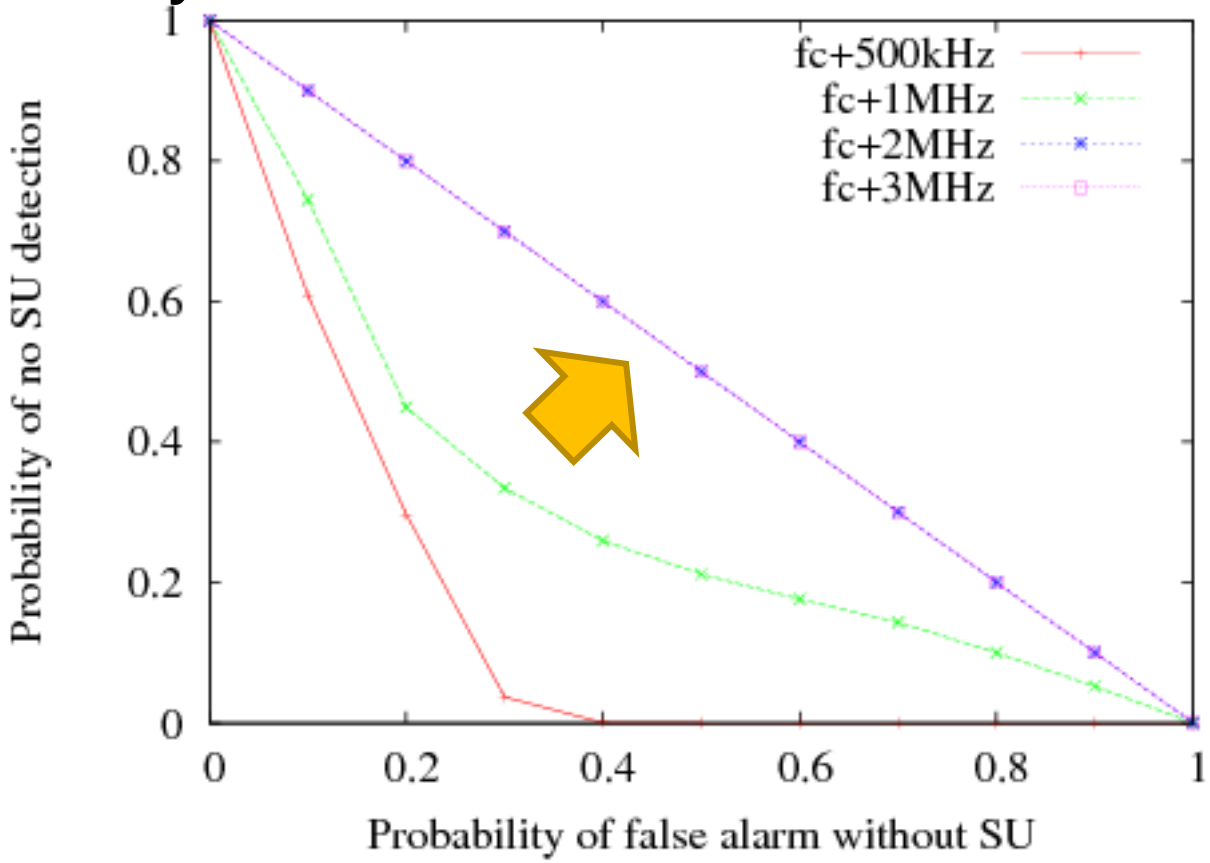
Parameters	value
Modulation	GMSK
Bandwidth	200 kHz
Receive power at sensor	10 dBm

PU signal

Parameters	value
Modulation	GMSK
Bandwidth	200 kHz

Field Experimental Result

■Probability of no SU detection



Sensing frequency shift 2MHz or more

→ Sensing performance can be satisfied

Conclusion

- Problem of Energy Detection
  - » Miss detection by SU transmitting
  - » Loss of real-time
- Proposed method
  - » Frequency shifted spectrum sensor
  - » SU can detect the PU signal at real-time even when SU is active
- Result
  - » We derive the detection performance when sensing is performed in the frequency shifted channel under active SU

Thank you for your attention