

Energy Efficient Echo-Hiding Extraction Method Based on Fine Grain Intermittent Power Control

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■ Introduction

- Background, motivation, and our goal
- Basics of audio steganography ~echo-hiding~

■ Proposed extraction method of echo-hiding

- Early termination of extraction
- Skipping extraction based on reliability
- Judgement of data embedding

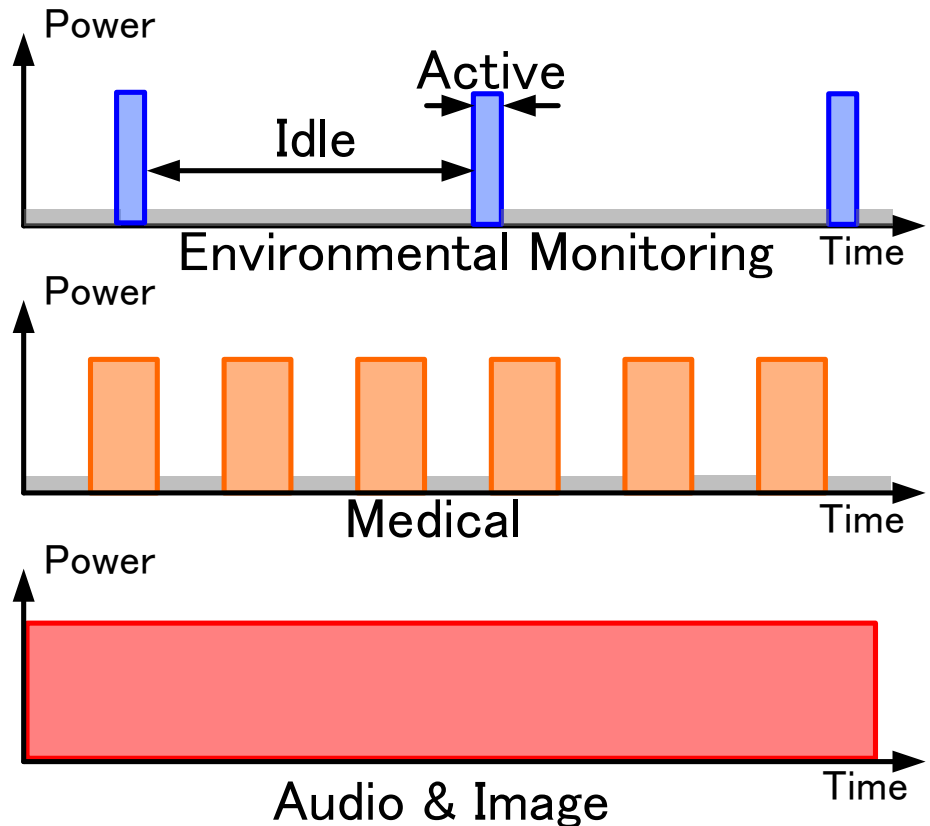
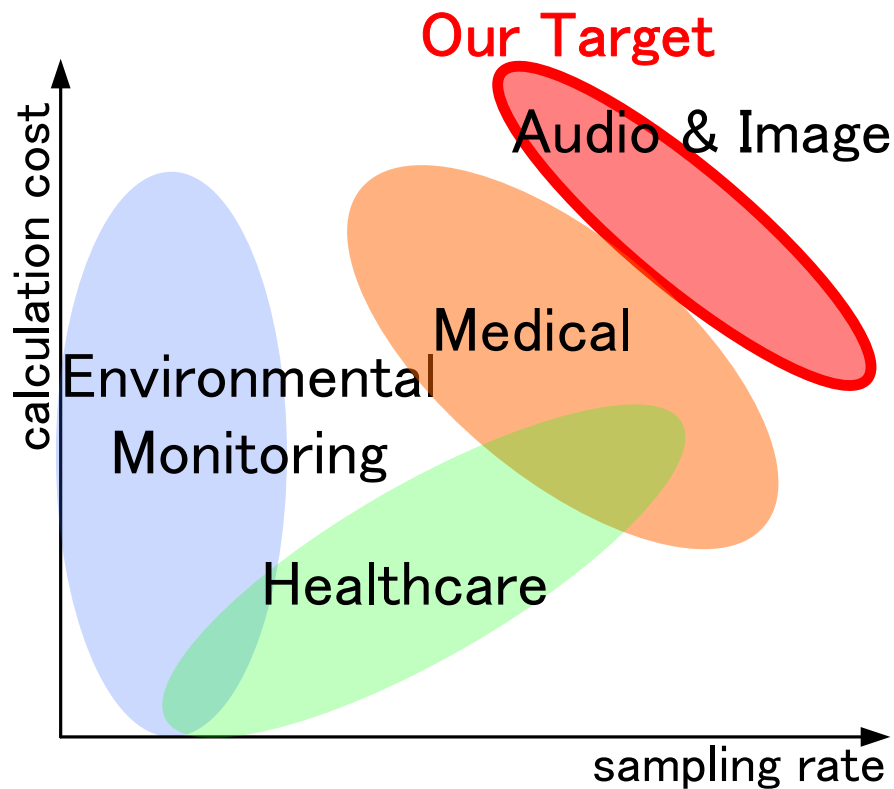
■ Experiments

- Evaluation board for power-conscious applications
- Experimental results

■ Conclusion

Background

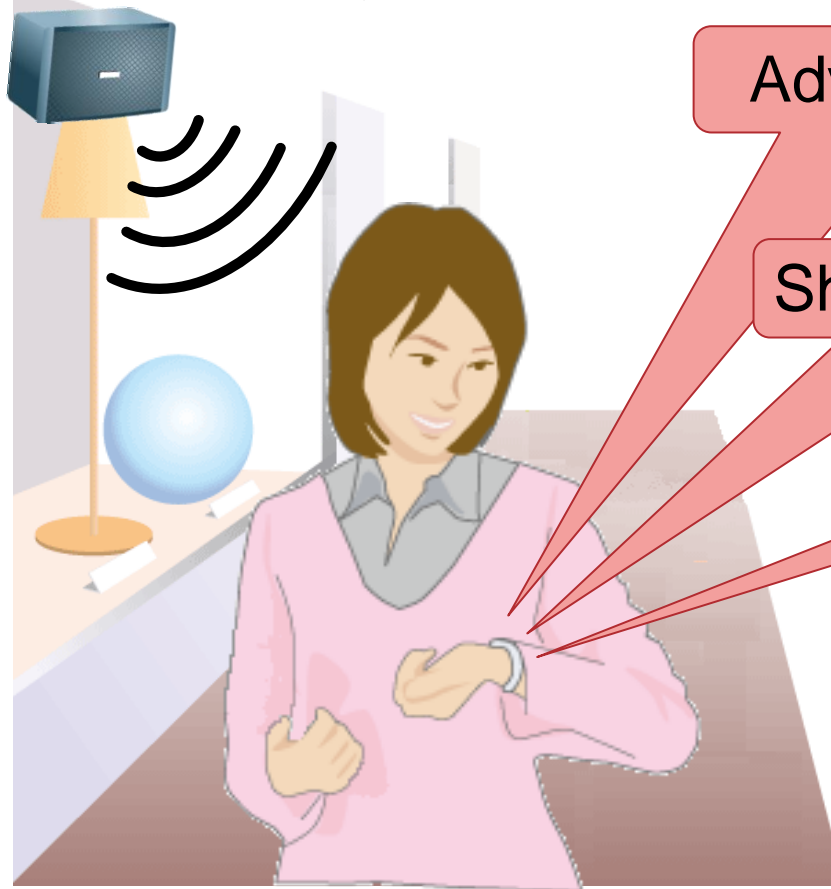
- Long term sensing is main interest in sensor nodes
- Reduction of active rate greatly reduces power consumption
 - Can be clocked-off or be powered-off while they are in idle
 - Suitable for sparse sensing because of shorter active time



- Audio steganography can be used to low cost data distribution
 - Distributor play music with embedded data
 - Devices with microphone automatically extract data from music
 - User can get various information just like E-mail



e.g. Smart Watch with Mic.



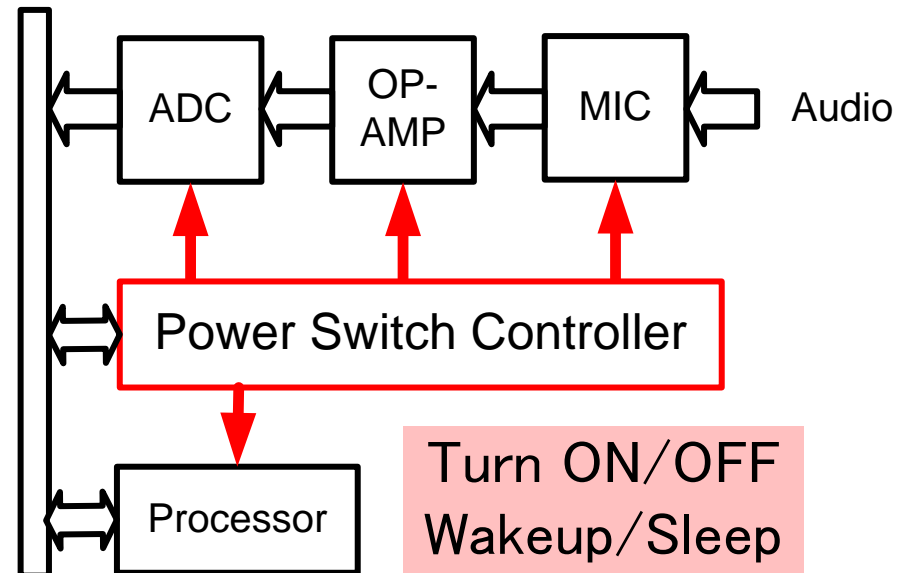
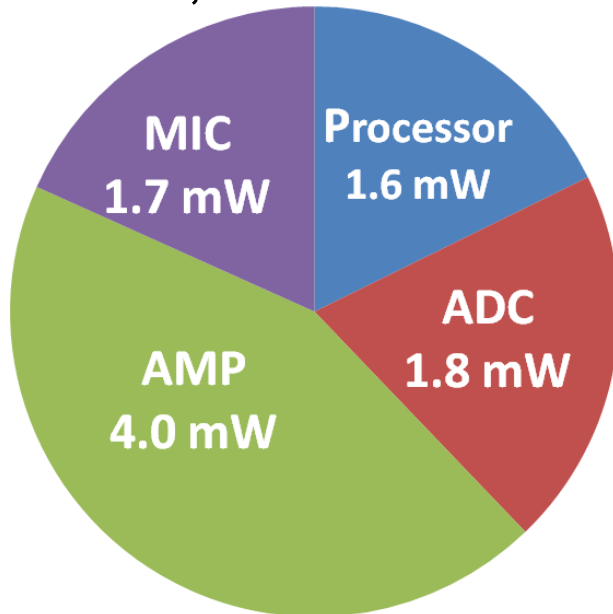
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Goal of This Work

- Suppose to use 450mAh and 3.0V rechargeable battery
 - Continue to extract embedded data for 1 week \Rightarrow under 6mW
 - Continue to search embedded data for 1 month \Rightarrow under 1mW
- Power switch controller can reduce active rate of not only a processor, but other main devices



Low power sensing by reduction of active rate in the extraction of audio steganography

Basics of Audio Steganography ~Echo-Hiding~

Embed data as artificial echo

Use autocepstrum coefficients for extraction

Specified numbers of samples

=> We call "frame"

Original signals

Artificial echo

Delay d0

Express symbol '0'

Original signals

Delay d1

Express symbol '1'

Autocepstrum

Delay d0

Extract symbol '0'

msec

Autocepstrum

Delay d1

Extract symbol '1'

msec

Audio samples

FFT()

abs()

log()

IFFT()

acf()

Autocepstrum coef.

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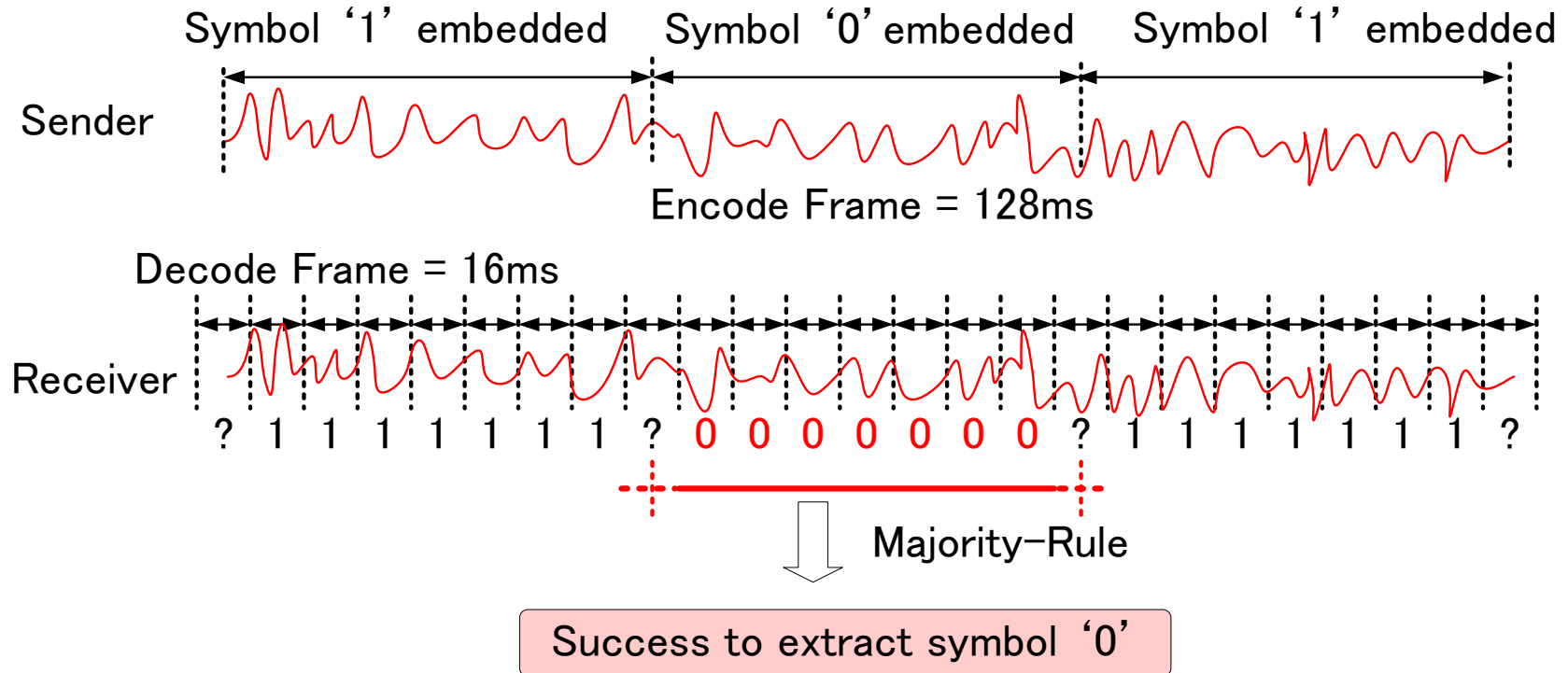
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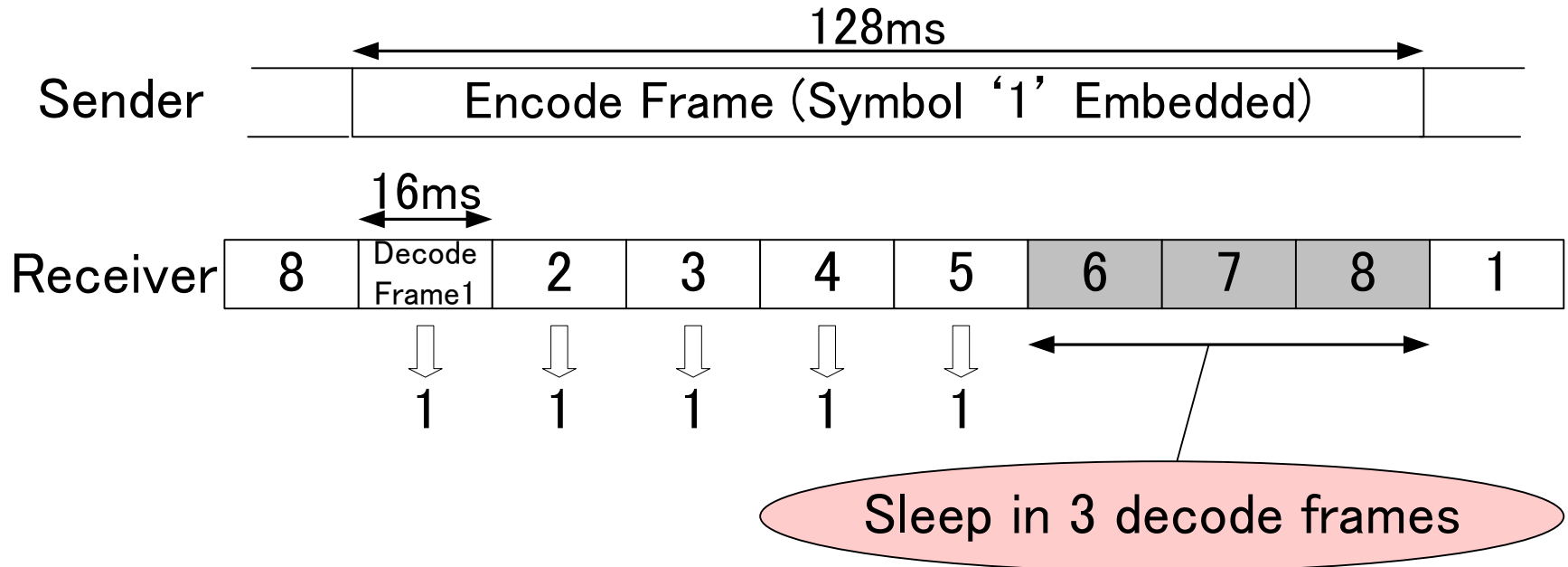
Our Basic Approach ~Majority-Rule Extraction~

- Decode frame width can become shorter than the encode frame width



- Majority-rule extraction is suitable for reduction of active rate
1. Early termination of extraction
 2. Skipping extraction based on reliability
 3. Judgement of data embedding

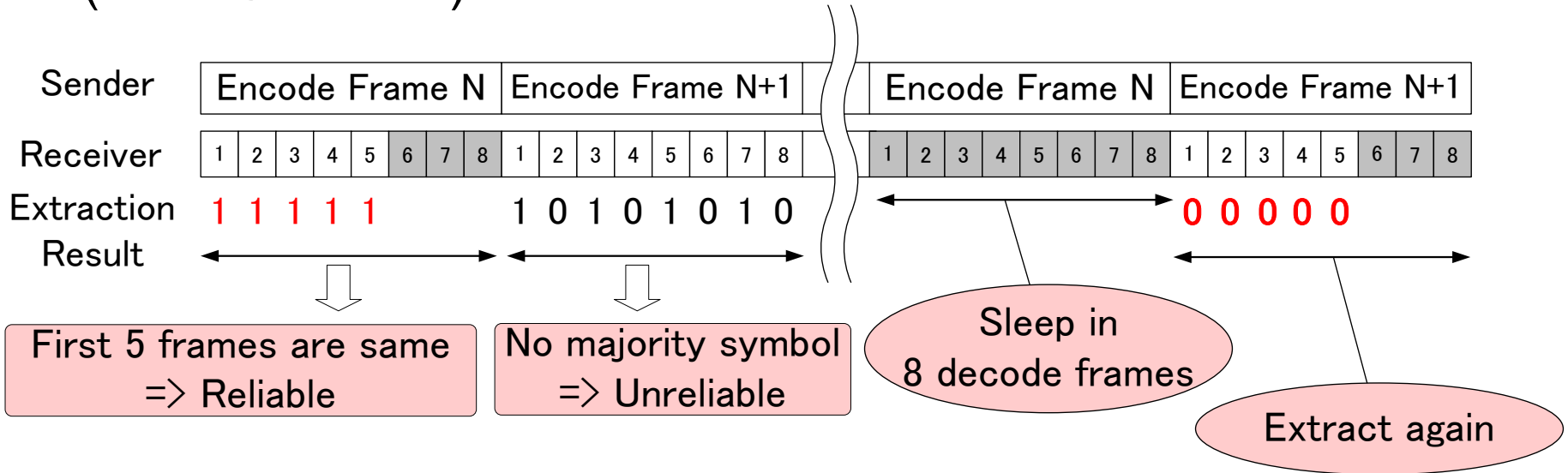
1. Early Termination of Extraction



The result of majority-rule can be decided before final decode frame
=> Sensor node can sleep until next extraction process

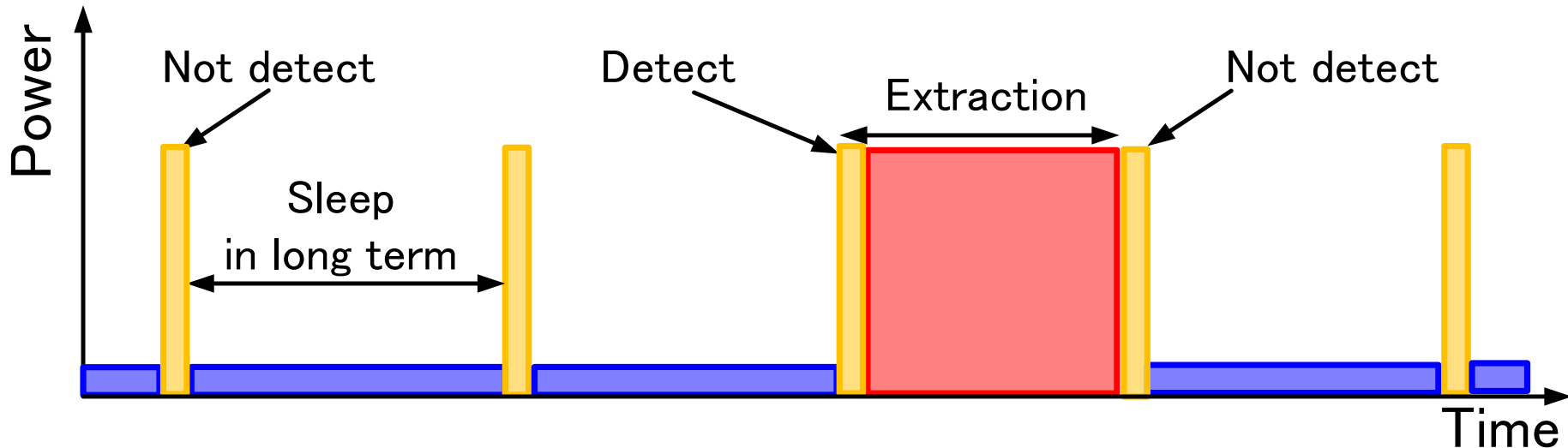
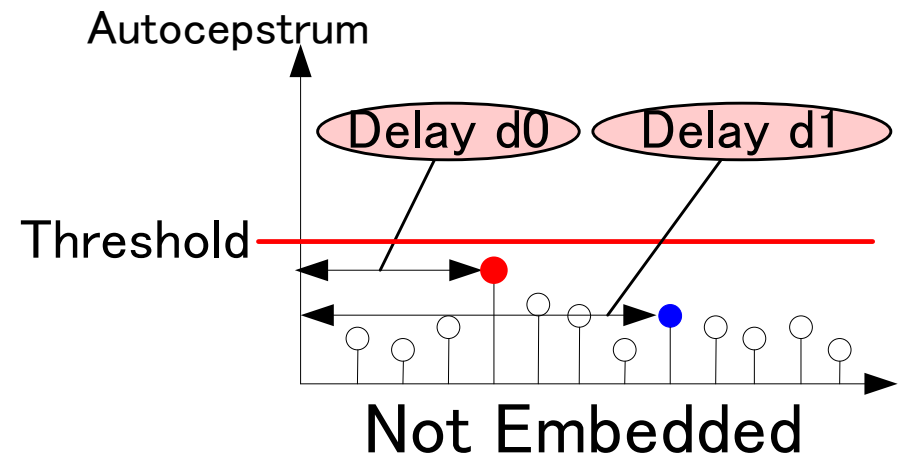
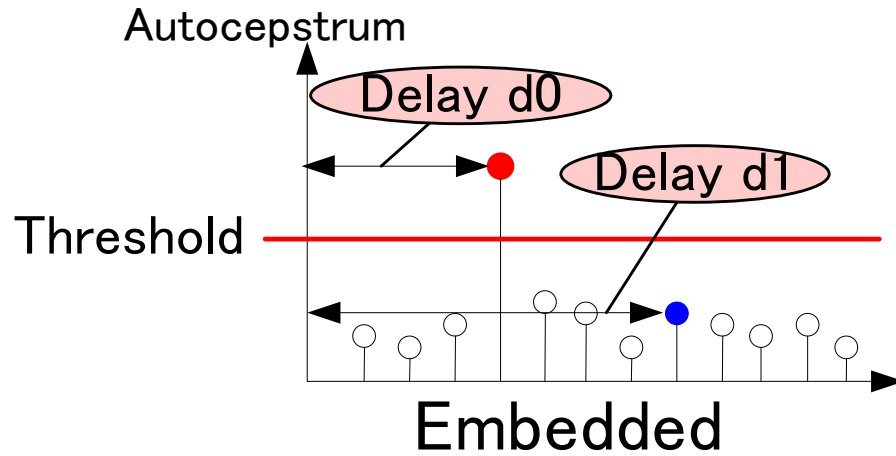
2. Skipping Extraction Based on Reliability

- Embedded data is transferred by multiple times (Data Carousel)



Majority-rule gives reliability to extracted data.
=> Retry extraction only in “unreliable” frames

3. Judgement of Data Embedding



Avoid unnecessary extractions
=> Reduce active time in the environment without embedded data

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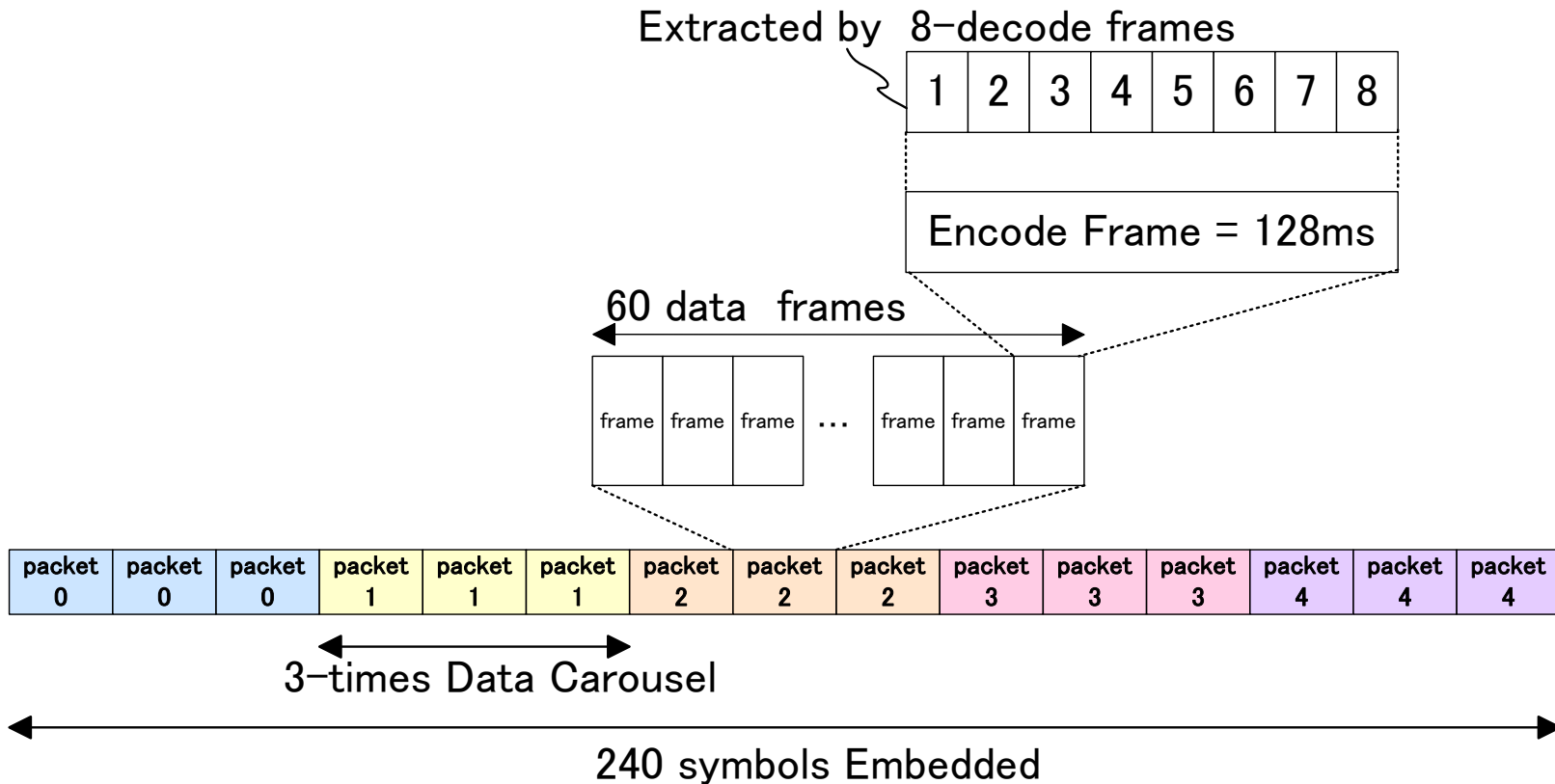
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■ Format of Embedded Data

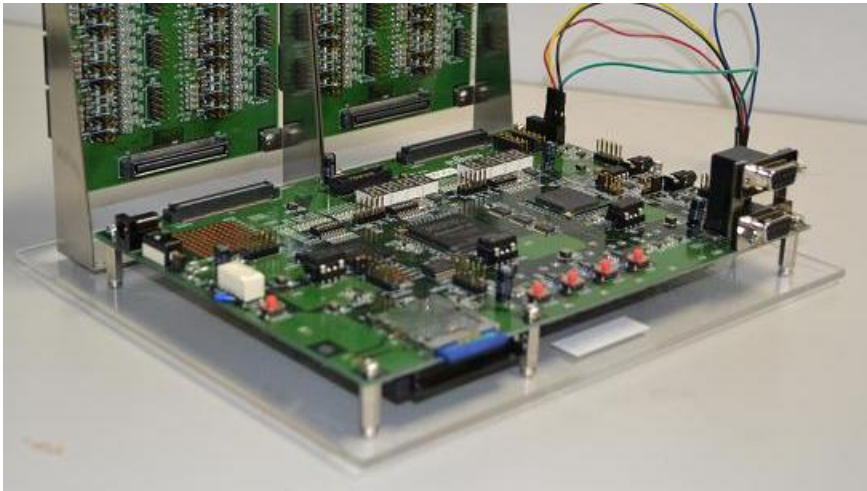


- Measured active rate of sensor node in the extraction of 240 symbols
- Encode frame width is 128ms and decode frame width is 16ms
- Suppose 3-times data carousel

Evaluation Board for Power-Conscious Application

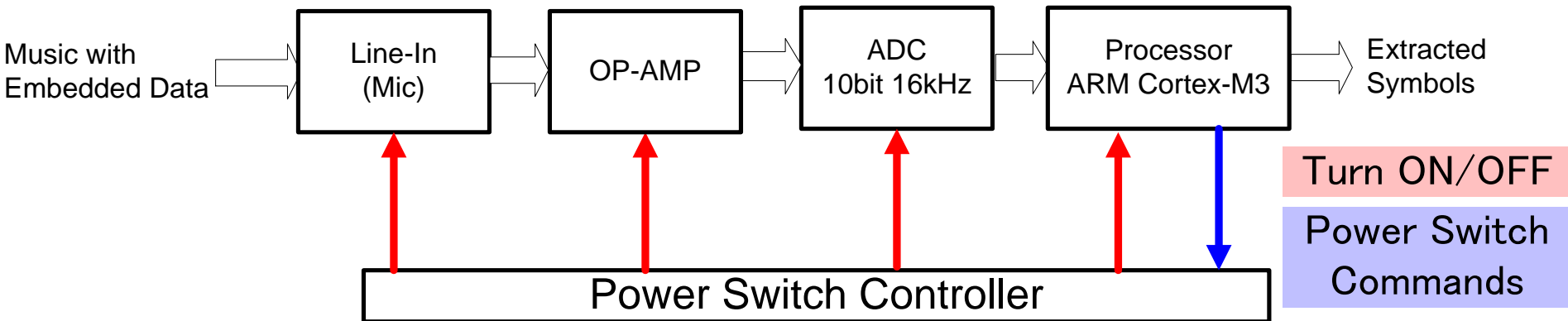
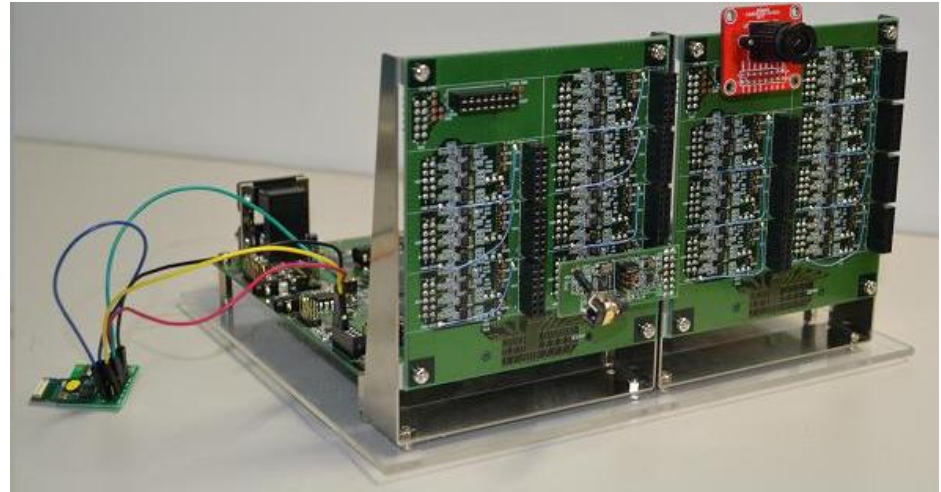
Main Board

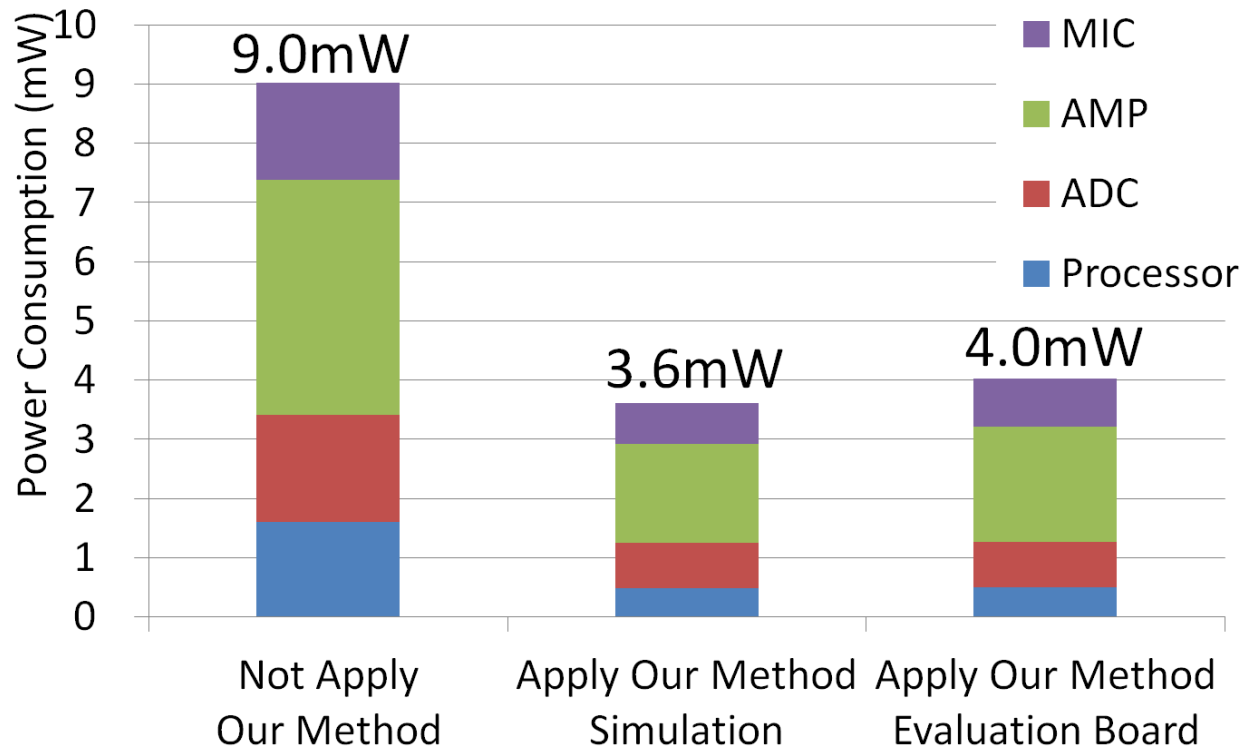
- Micro-controller
- Power switch controller



Daughter Board

- Sensor socket array



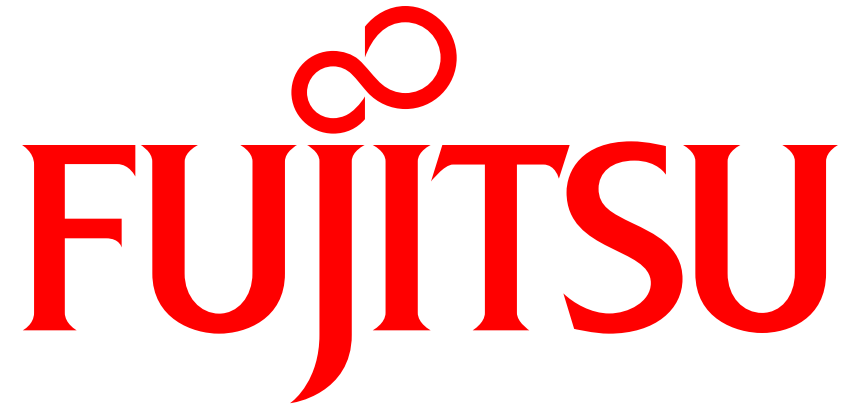


- The board was affected by noise and frequency response
 - Decreased the chance of early termination, and skipping extraction
- Active rate in the environment without embedded data was almost 1% => only 100uW

- 60% reduction in extraction process
- 99% reduction in the environment without embedded data

- Energy efficient echo-hiding extraction method based on majority-rule extraction
 - Early termination of extraction
 - Skipping extraction based on reliability
 - Judgement of data embedding

- Experimental results shows
 - Reduced 60% power consumption in extraction process
 - Reduced 99% power consumption in the environment without embedded data



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