Wireless Sensor Networks

Understanding Complex-Engineered Systems By Example

Module 4: Analog-to-Digital Conversion

muse

WSN's - The Eyes and Ears of the Internet: Sensing the Physical World

- Wirelessly networked embedded systems
- Mission: Transduce a parameter of the physical environment into a number on your desktop

- First task: choose/understand transducers
- Second task: interface a network node with transducers

Themes

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  - From measurement to knowledge
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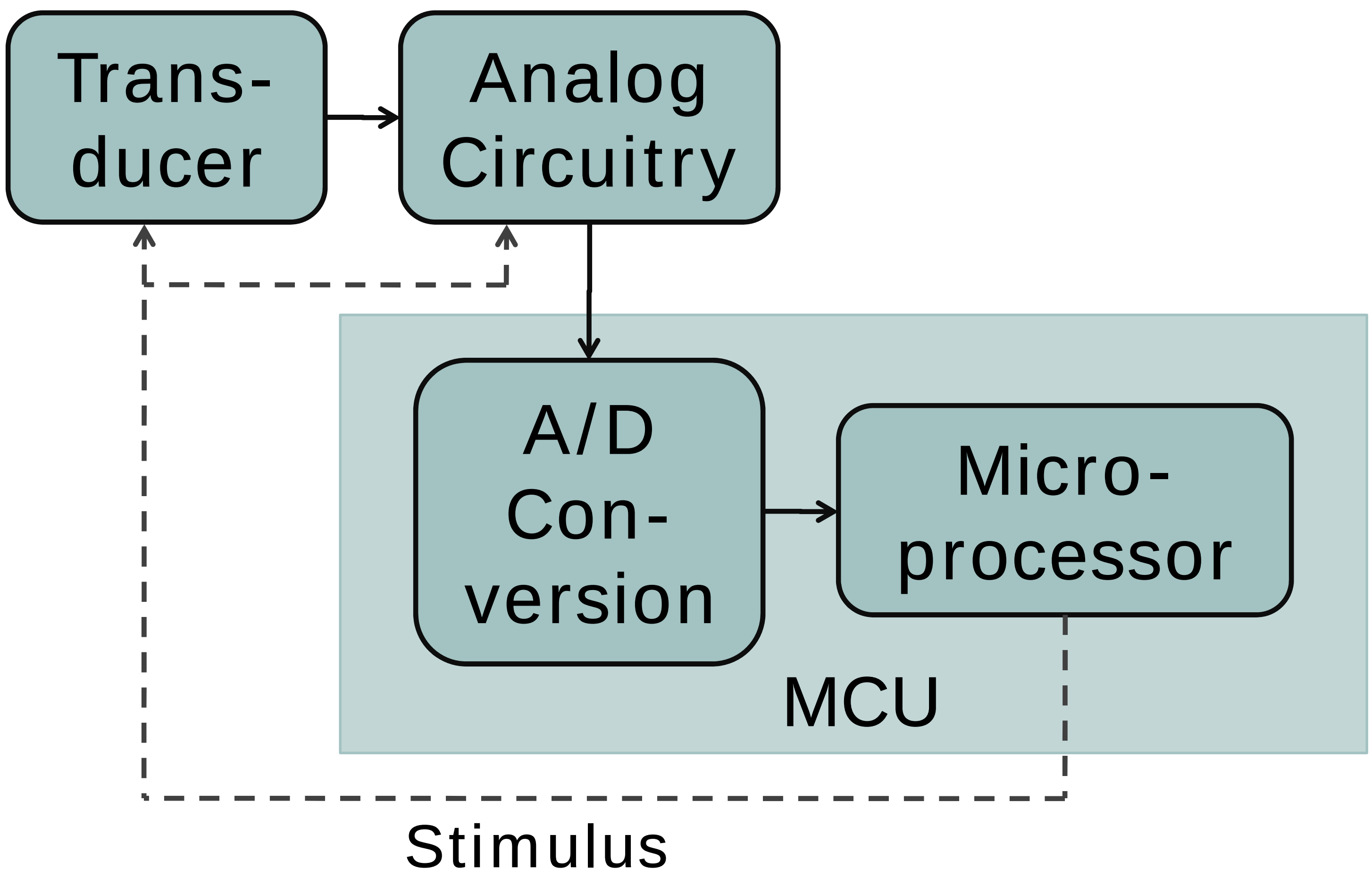
  - Digital and statistical signal processing
- Error sources
  - Transducer and electronic noise
  - Analog-to-digital conversion

Connections

- Analog circuit design
  - Signal conditioning, amplification, filtering
- Mixed signal circuit design
  - analog-to-digital conversion. Conversion speed, quantization noise, dynamic range, and linearity
- Signals and systems, DSP
  - Filtering, sampling rate, linearity
- Statistical signal processing
  - Transducer noise and bias, quantization noise, interference

From physical parameter to number



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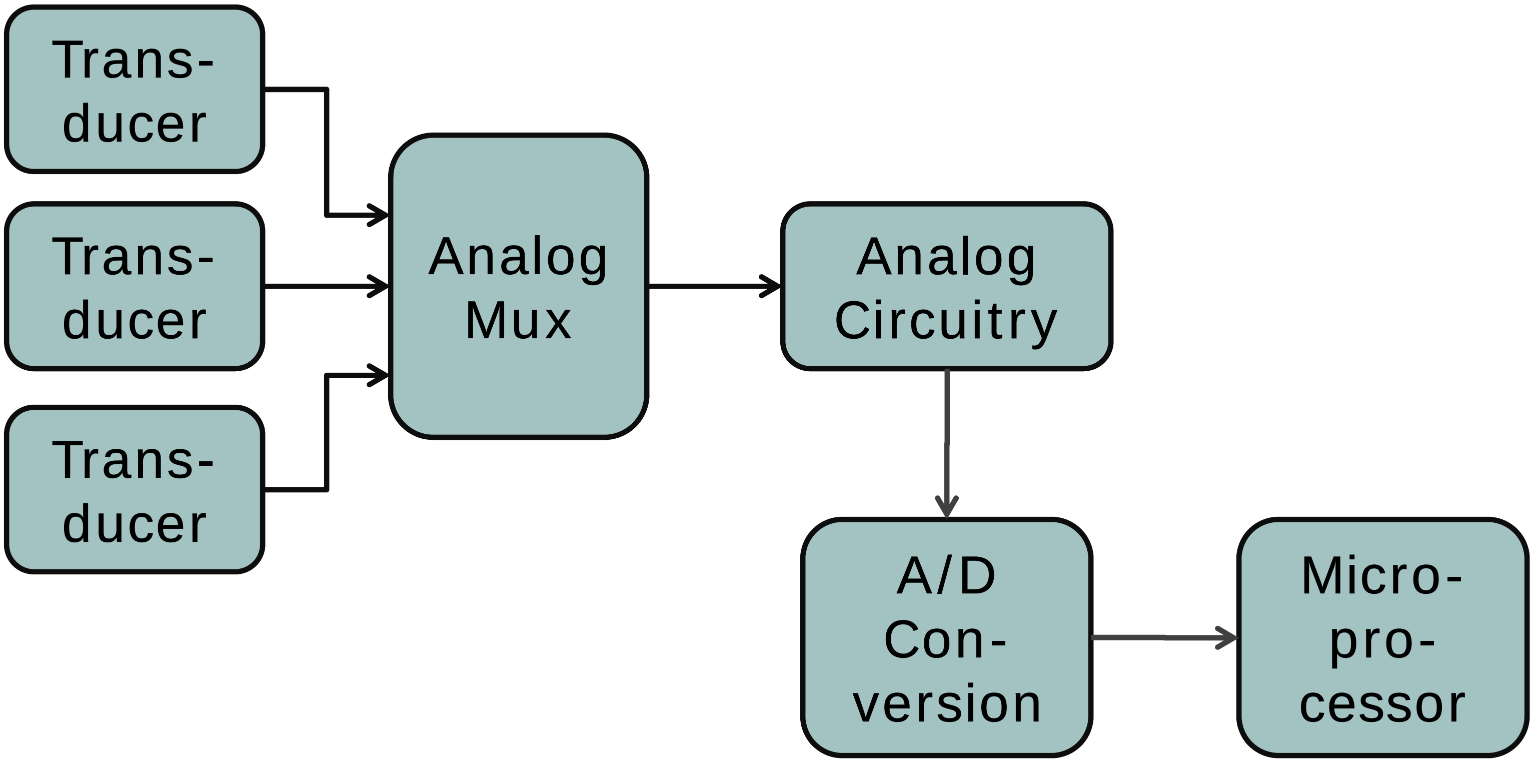

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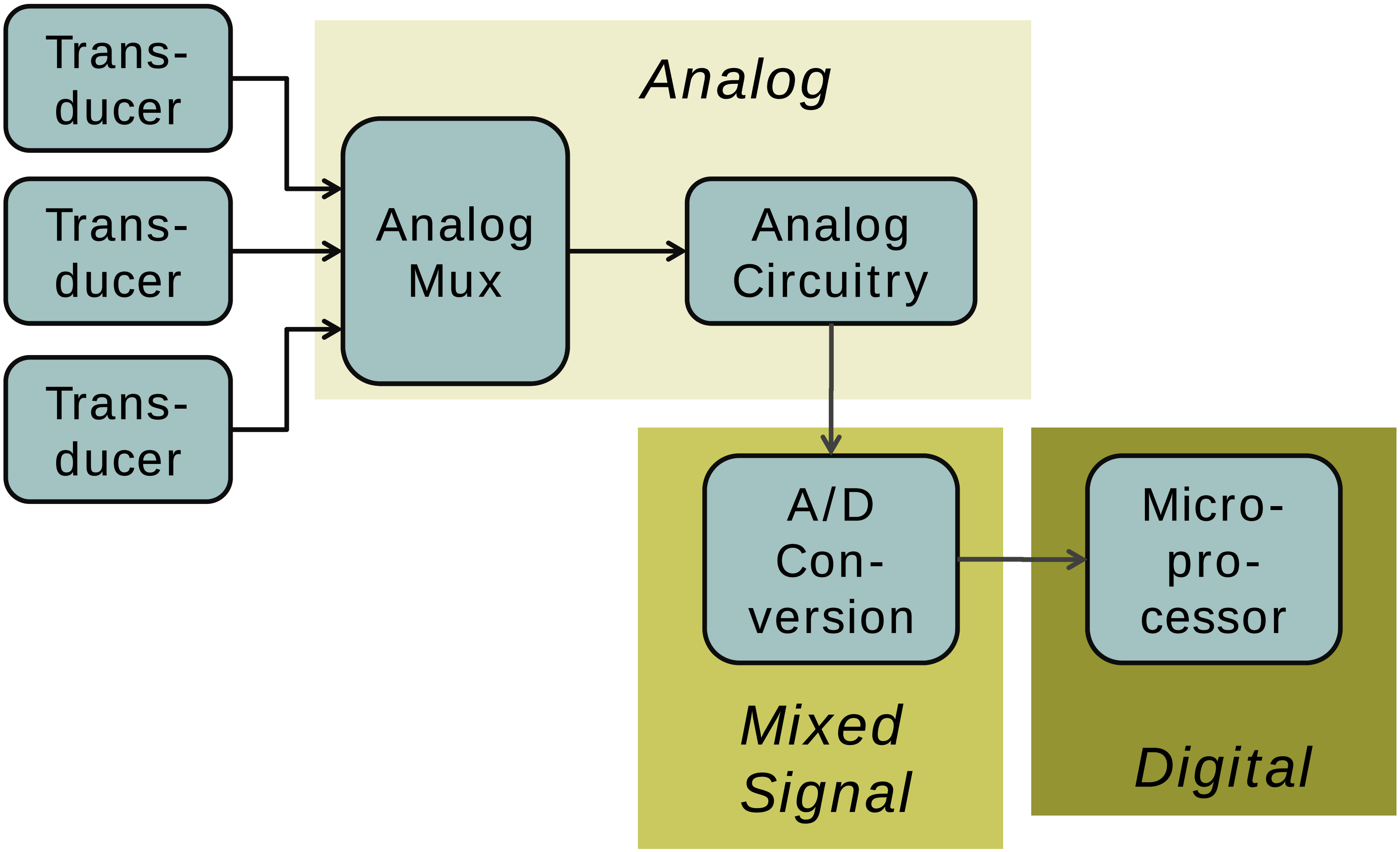

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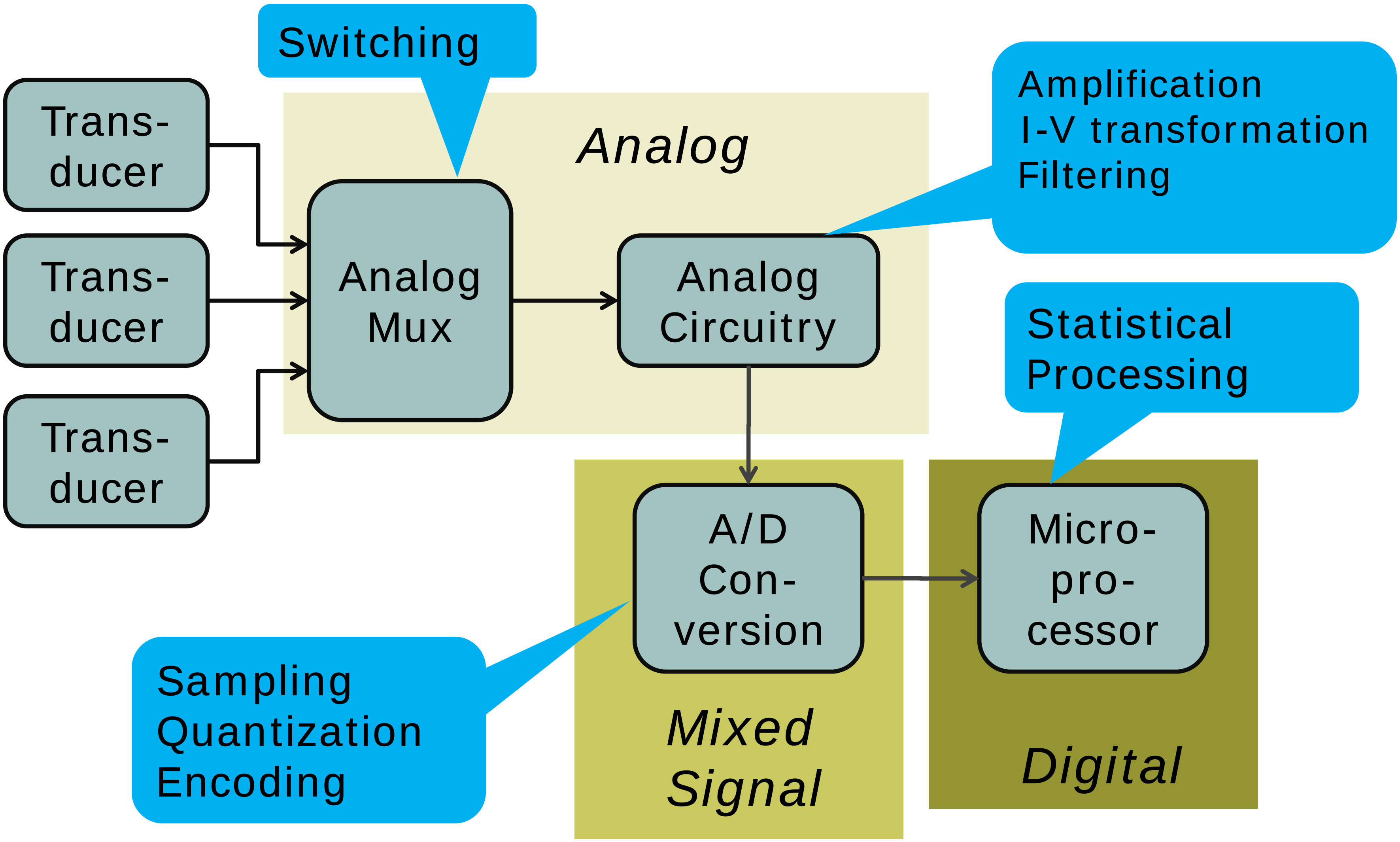

Getting a handle on data fidelity

- Accuracy
- Precision
- Resolution

How good is the sensed data?
Part I: transducer signal

Analog measurement y of data x^* from the transducer is uncertain.

Error $\beta + \text{ò}$ is the sum of a bias (offset) β and noise ò:

$$y = x^* + \beta + \text{ò}$$

$$\text{ò} \sim (0, \sigma^2)$$

large $|\beta|$ => low accuracy
large σ^2 => low precision

How do we deal with noise?

Tasks

1. Evaluate and Calibrate
   a) Determine accuracy – find the bias
   b) Determine precision – find the noise variance (power)

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   b) Determine precision – find the noise variance (power)
2. Design algorithms to get desired performance

   --- manage the noise

1a. Estimate the bias

1a. Estimate the bias (ii)

1b. Estimate the measurement noise

2. Manage the noise

2. Manage the noise (ii)

Bias and Noise: Putting it all together

Lab: Calibration	Field: Data Acquisition

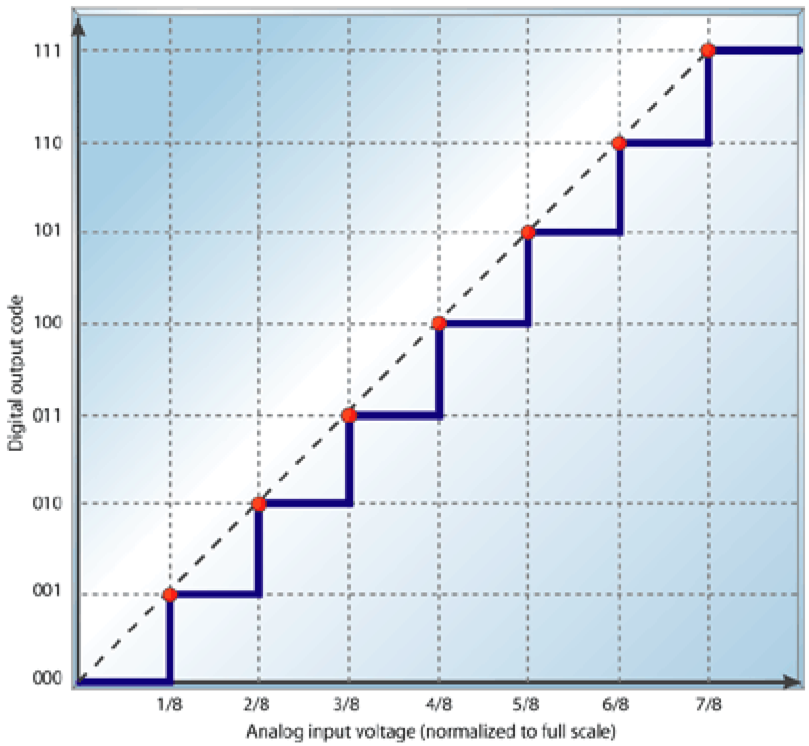
How good is the sensed data?
Part II: A/D conversion

A/D conversion can distort the value.

Error types:

- Resolution
- Noise
- Nonlinearities

High resolution does **not** imply high precision or accuracy!



L. Staller. Understanding analog to digital converter specifications. Embedded Systems Design (02/24/05, 05:24:00 PM EST)

A/D converter: SP model

How many A/D bits do I need?

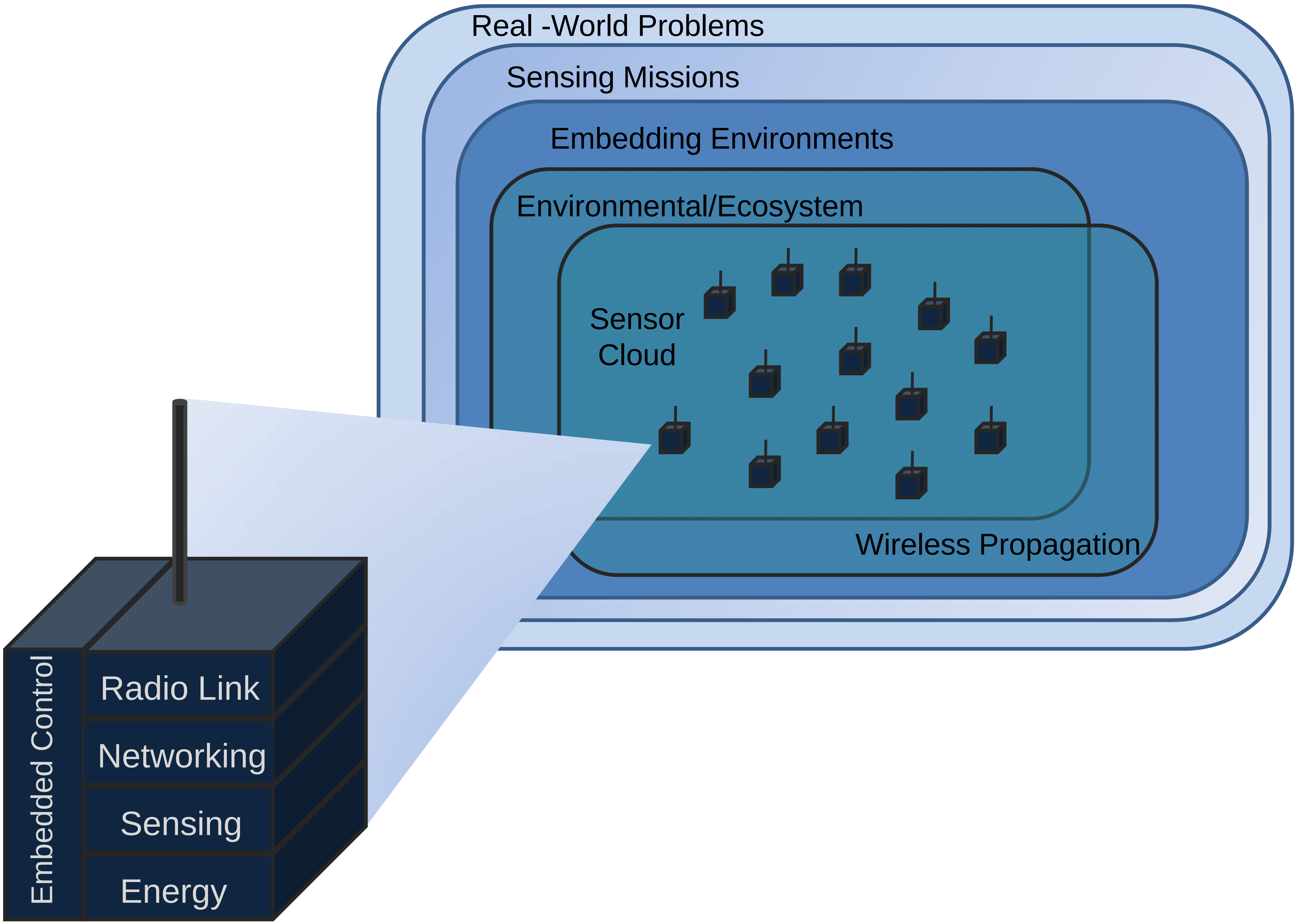
How much does another bit buy?

Modeling the quantization error

Calculating the Improvement

Remaining Questions

- How often to sample
- Where to sample
- How to encode the information for transmission
- How to use the information for the construction of predictive models


Real -World Problems
Sensing Missions
Embedding Environments
Environmental/Ecosystem
Sensor
Cloud
Wireless Propagation
Embedded Control
Radio Link
Networking
Sensing
Energy