Wireless Sensor Networks

Understanding Complex-Engineered Systems By Example

Module 2

muse

What this course is about

1. **Helping you understand behavioral models of a complex engineered systems at different layers**

2. **Thinking about models of interaction between layers that determine performance according to a variety of interdependent measures, such as fidelity, delay, and energy efficiency.**

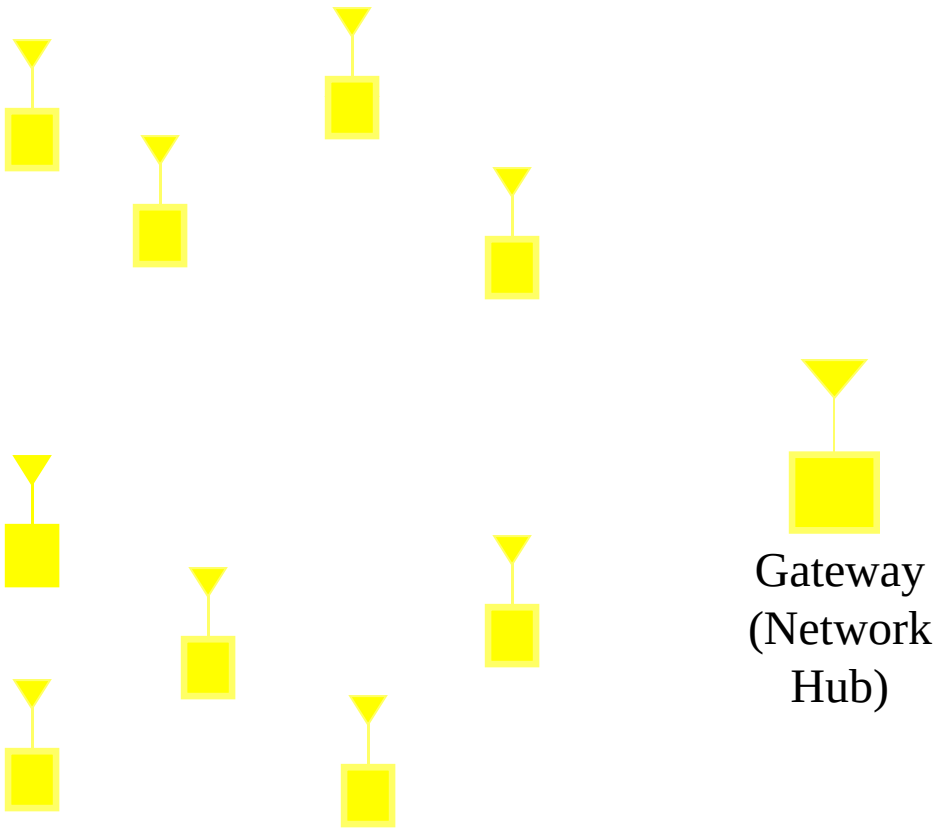
- In contrast to traditional, subdiscipline-specific courses, the course will emphasize the modeling, analysis, and simulation of complex engineered systems.

- See beyond the parts lists and toolsets of a specific discipline (e.g., TCP/IP networks or microwave circuit design) to the overall structure of the design.

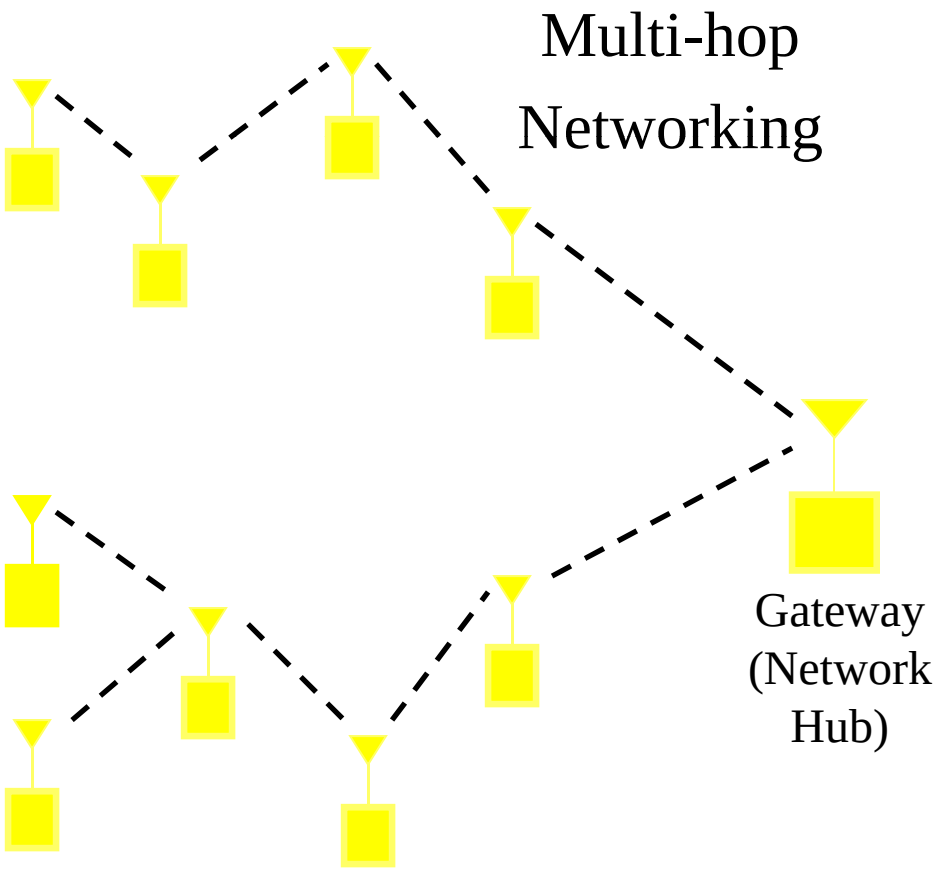
Module 2: Outline

- WSN's
  - The networking aspect
  - What to do with the data?
- Differences from infrastructured wireless (mobile telephony, WiFi)
- Define embedded computing systems, and how they differ from other types of computing systems
- How WSN's enable new applications
- Mesh-connected society of people and things: pros and cons

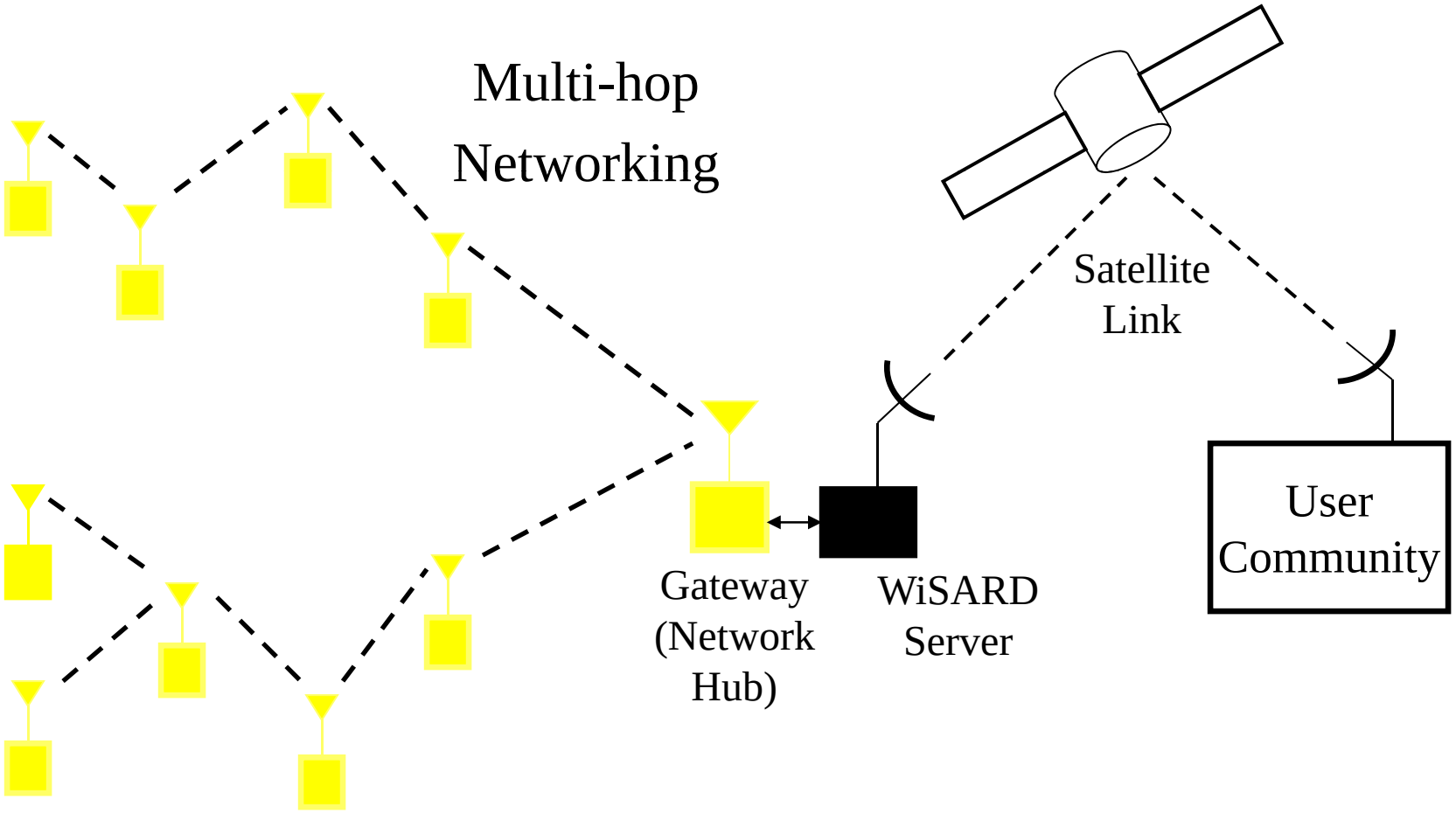
Concept



Concept



Concept


Multi-hop
Networking
Satellite
Link
User
Community
Gateway
(Network
Hub)
WiSARD
Server

WSN Engineering

- Analog/mixed-signal design
- Software-programmable digital hardware (microprocessors) and peripherals
- Digital and statistical signal processing
- Control theory
- Embedded systems design
- RF/microwave design
- Communication and coding theory
- Network engineering
- Self-organizing systems
- Mechanical/packaging engineering

From point-to-point to networked communication

Time matters

Computation has a role, too

- Embedded computing systems
- Intelligent signal processing
- Autonomic networks

What to do with the data? (I)

What to do with the data? (II)

Quantifying Design: Financial

Quantifying Design: Technical - Power

Quantifying Design: Technical - Energy

Energy is critical

Sensors sample, communicate, and hibernate

$$E = v(i_S q_S + i_C q_C + i_H q_H)(t - t_0)$$

Typically

i_S = 500 i_H

i_C = 1000 i_H = *2.5* i_S

=>Hardware technology

=>Software-level design strategies

How can we improve energy efficiency?
1. Embedded Systems

1. **Goal: ensure that every electronic component uses the minimum amount of energy to do its job**
   - **Optimize process technologies**
     - **Digital, analog, RF**
   - **Improve power regulation and management**
2. **Goal: no electronic component uses energy unless it is doing something useful**
   - **Clock domains (and gating)**
   - **Power domains (and gating)**
   - **Dynamic voltage scaling**

How can we improve energy efficiency?
2. Communication and Networking

1. Minimize useless radio operation

- transmitting when there is no relevant node to receive
- listening when no relevant node is transmitting

Use communication energy only when transmitting or receiving data

2. Transmit only what is necessary to solve the problem of model/data inference

- exploit spatio-temporal redundancy of the data
- use coding to protect data

Make sure the transmitted data is informative

Can we generalize from the environmental monitoring app?

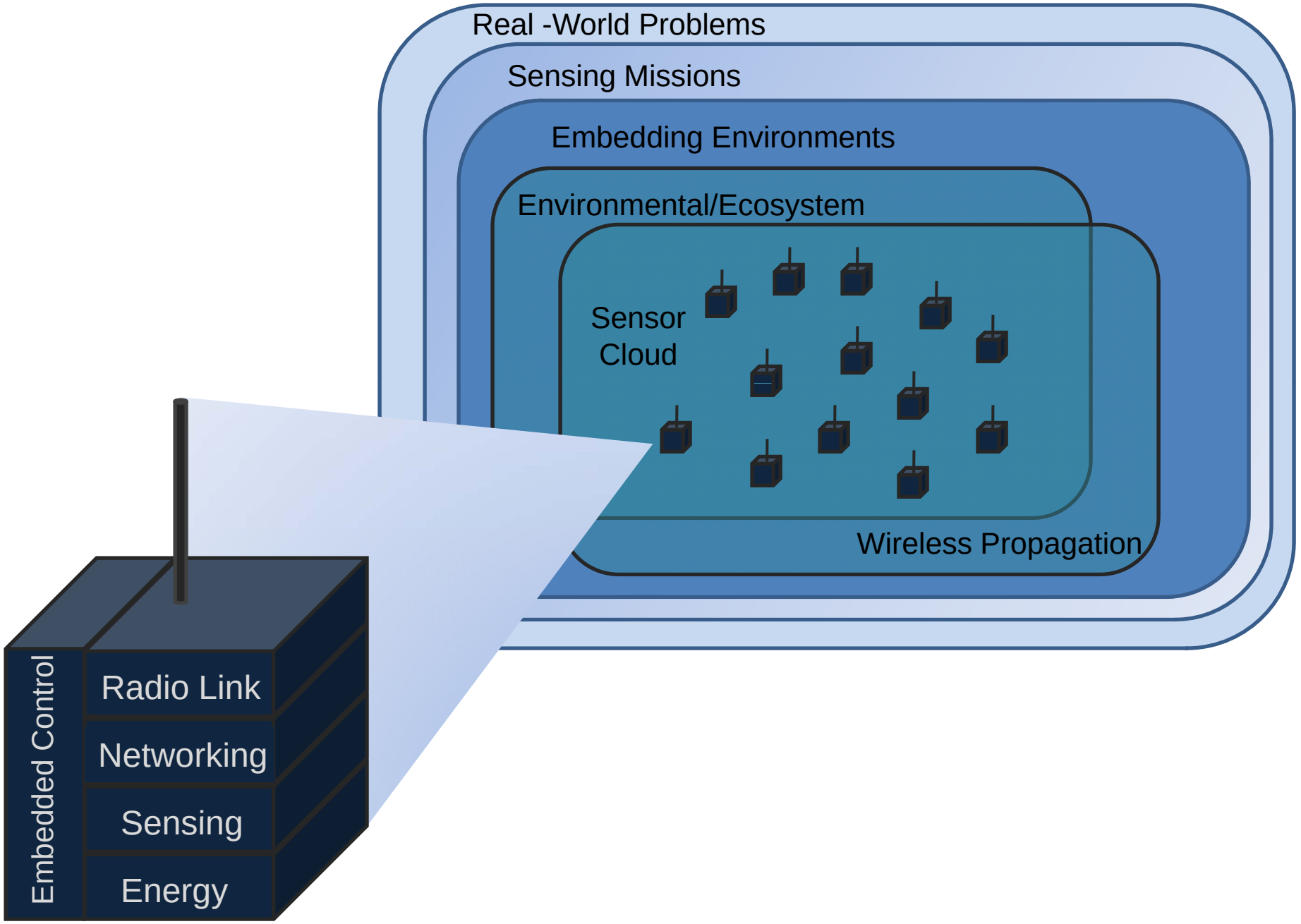
Applications

- Monitoring of built environments
- Manufacturing
- Structural monitoring
- Public safety
- Health care

The Challenge

Report meaningful change to whomever or whatever needs it, when it is needed---at minimum cost

Mesh-connected society of people and things: pros and cons


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