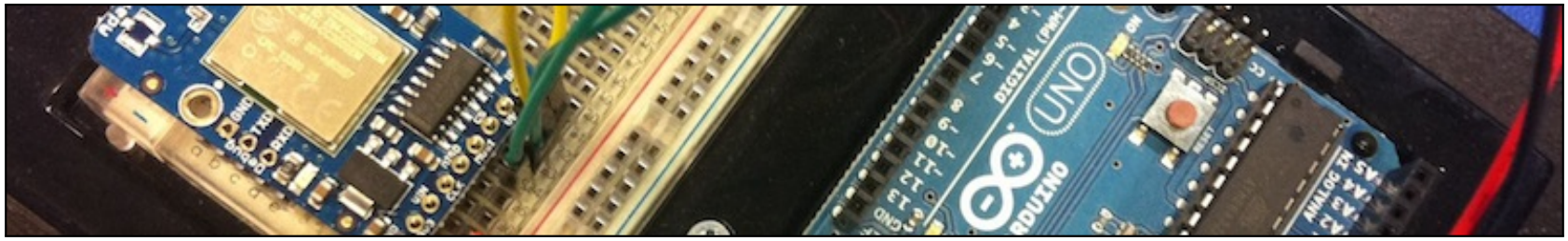
CURIE Academy 2014
Design Project: Exploring an Internet of Things

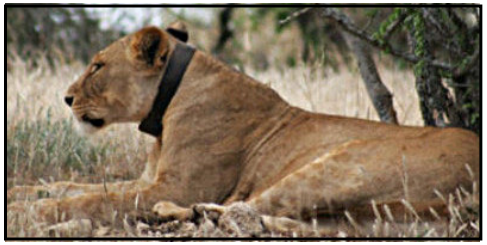


Christopher Batten
School of Electrical and Computer Engineering
Cornell University

`http://www.csl.cornell.edu/curie2014`

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:15-9:00 am Breakfast	**8:15-9:00 am** Breakfast	**8:15-9:00 am** Breakfast	**8:15-9:00 am** Breakfast	**8:15-9:00 am** Breakfast
9:30-10:30 am Field Session **Ma… & E…** MSE	**9:30-10:30 am** Field Session **App… Phy…** AEP	**9:30-10:30 am** Field Session **Civi… Env…** CEE	**9:30-10:30 am** Field Session **Che… Bio…** CBE	**9:30-10:30 am** Field Session **Me… Aer…** MAE
10:30 am – Transition	**10:30 am –** Transition	**10:30 am –** Transition	**10:30 am –** Transition	**10:30 am –** Transition
10:45-11:45 am Field Session **Co… & I…** CS	**10:45-11:45 am** Field Session **Op… Re… Information Engr** ORIE	**10:45-11:45 am** Field Session **Ear… Atm…** EAS	**10:45-11:45 am** Field Session **Bio…** BME	**10:45-11:45 am** Field Session **Engineering Admissions**
11:45 am-12:45 pm Lunch	**11:45 am-12:45 pm** Lunch	**11:45 am-12:45 pm** Lunch	**11:45 am-12:45 pm** Lunch	**11:45-12:45 pm** Lunch
1-5 pm *Des… Ses…*	**1-5 pm**	**1-5 pm**	**1-5 pm**	**1-5 pm**

ECE: Electrical and Computer Engineering



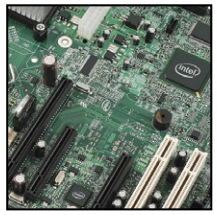
Talk Outline

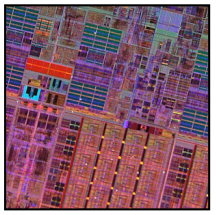
Electrical and Computer Engineering

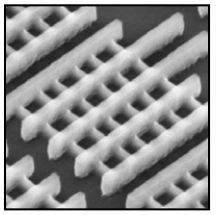
The Internet of Things

CURIE Design Project


Power Systems

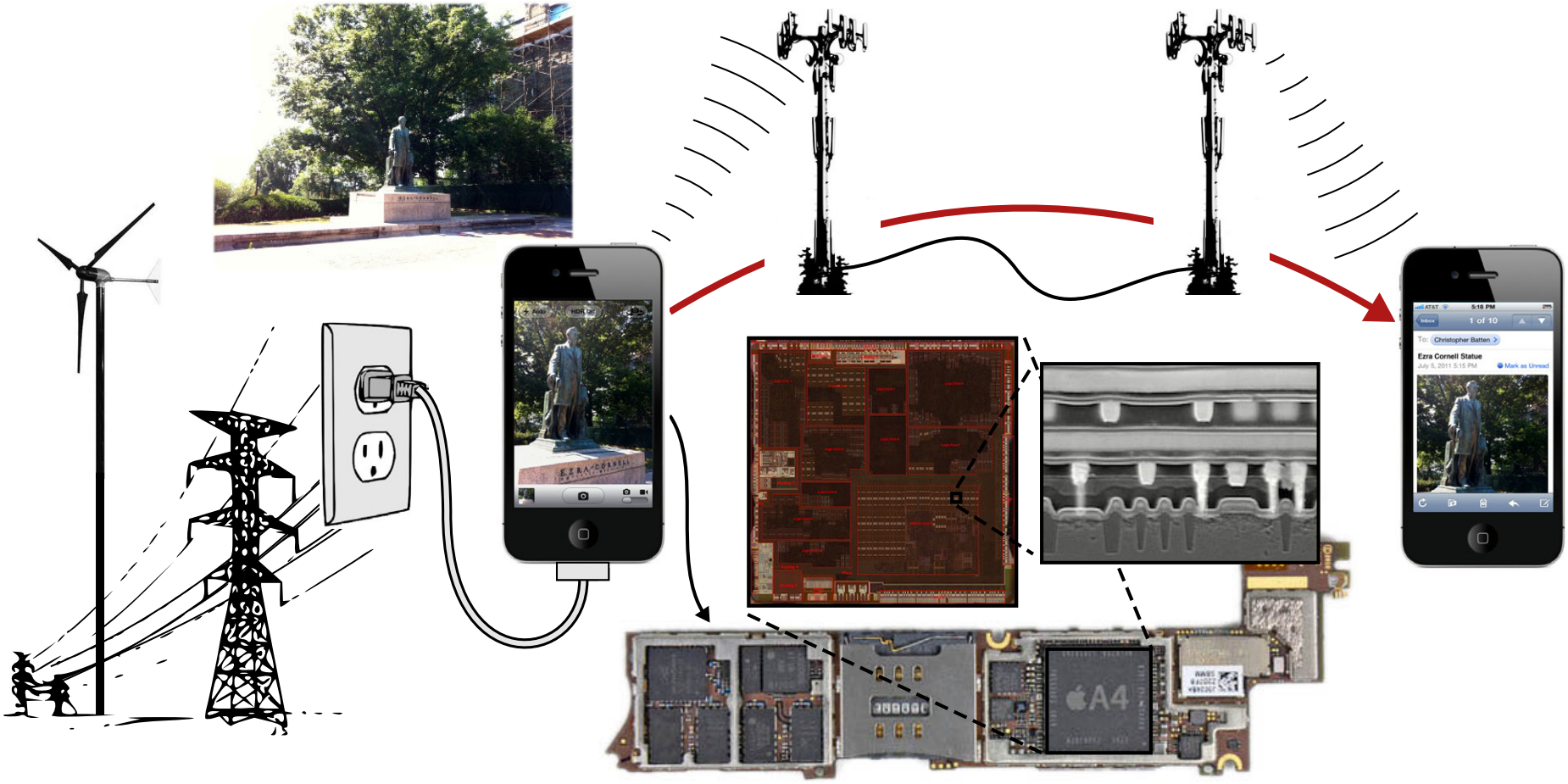

Computer Engineering


Electrical Circuits

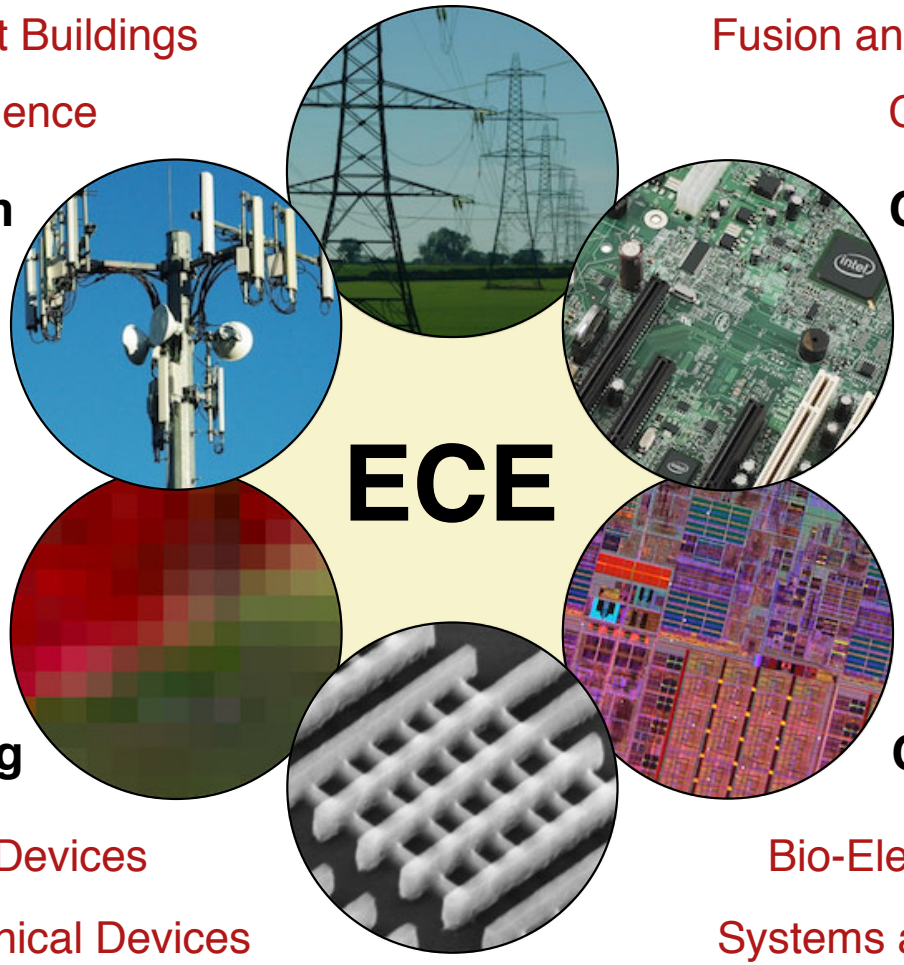

Electrical Devices


Signal Processing


Telecomm



ECE is the Study and Application of Electricity, Micro-Electronics, and Electro-Magnetism



Power Systems

Smart Grid and Smart Buildings

Atmospheric Science

Telecomm

Information Theory

Network Protocols and Optimization

Image, Audio, Video Processing

Signal Processing

Opto-Electrical Devices

Micro-Electro-Mechanical Devices

Electrical Devices

Fusion and Plasma Physics

Control Theory

Computer Engineering

Robotics

Computer-Aided Design

Analog and Digital Circuits

Electrical Circuits

Bio-Electrical Engineering

Systems and Synthetic Biology

ECE is everywhere!

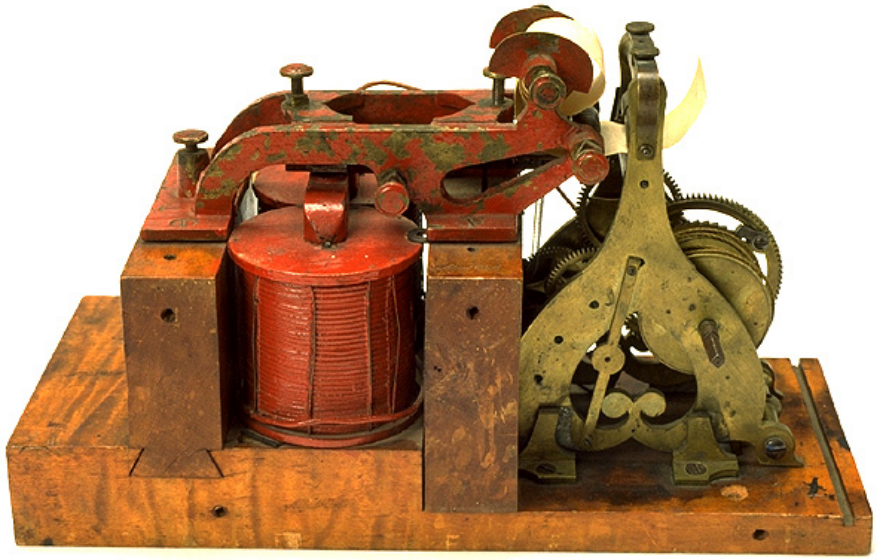
What can one do with a background in ECE?

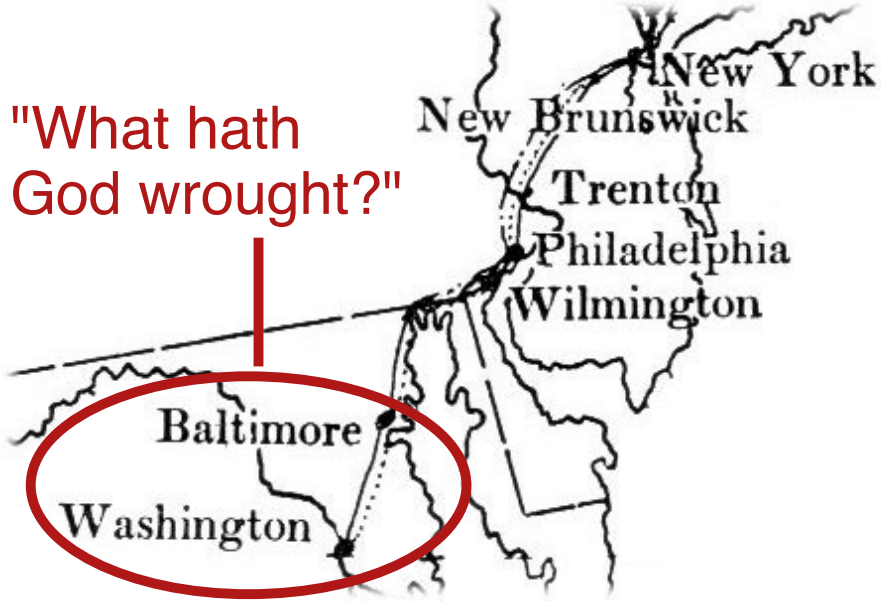
- **ECE Industry**: Intel, AMD, Analog Devices, NVIDIA, HP, Apple
- **General Engineering Industry**: GE, Lockheed Martin, Raytheon
- **Software Industry**: Microsoft, Amazon, Mathworks
- **Join a Startup**: Achronix, Hillcrest Labs
- **Research Lab**: Sandia National Labs, Draper Labs, NASA
- **Consulting**: McKinsey, Accenture, Deloitte, Booz Allen Hamilton
- **Finance**: Deutsche Bank, Capital One, UBS, Bloomberg
- **Graduate School**: Law School, Business School, Med School
- **Found a university!**

Cornell was founded because of ECE!

Samuel Morse invented the telegraph (a digital communication device), but needed help building the network

Ezra Cornell built the first telegraph line (the beginning of telecommunications), and invested in the Western Union Telegraph Co



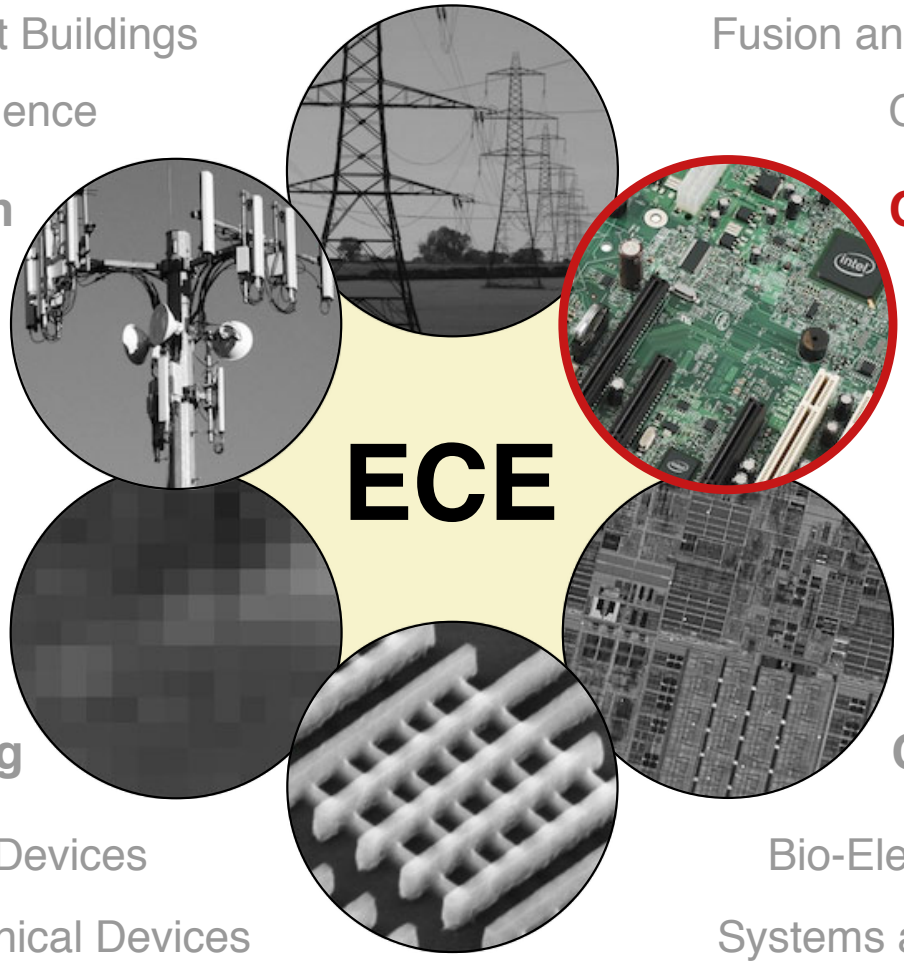


Ezra Cornell's investments created the fortune that eventually enabled the founding of Cornell University

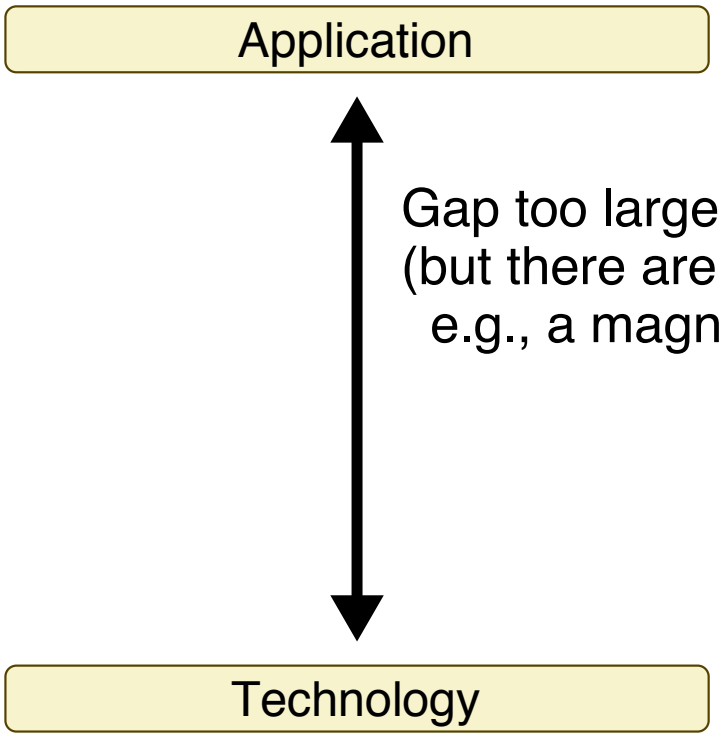
"Optional Homework"

- Visit the statue of Ezra Cornell on the Arts Quad
- Does something on the back of the statue relate to ECE?
- Take a picture with your cellphone and send it to your friend!
  - Power systems
  - Computer engineering
  - Electrical circuits
  - Electrical devices
  - Signal processing
  - Telecommunications

Computer Engineering



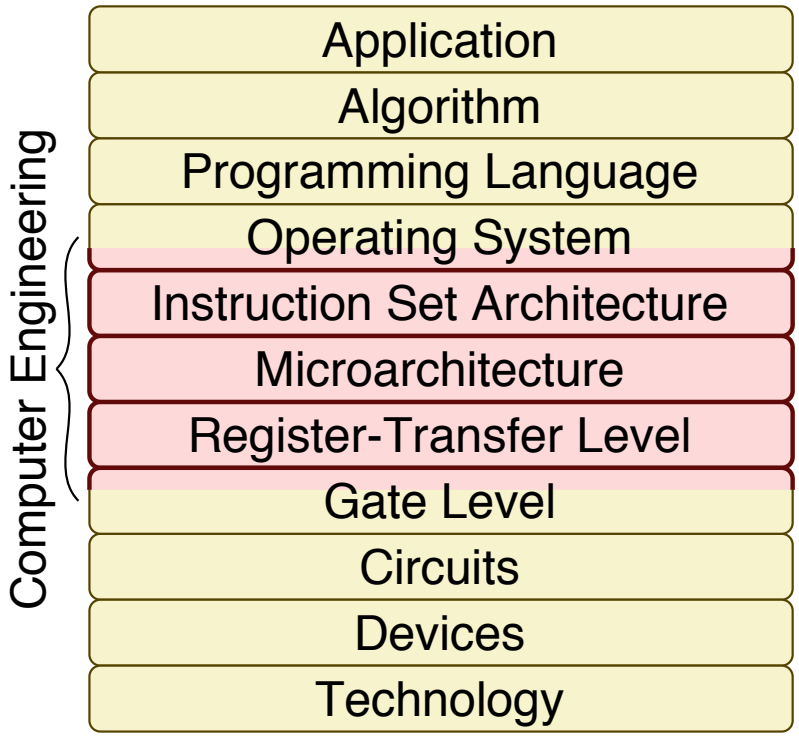
The Computer Systems Stack



Gap too large to bridge in one step
(but there are exceptions,
e.g., a magnetic compass)

In its broadest definition, computer engineering is the development of the abstraction/implementation layers that allow us to execute information processing applications efficiently using available manufacturing technologies

The Computer Systems Stack



Sort an array of numbers

2,6,3,8,4,5 -> 2,3,4,5,6,8

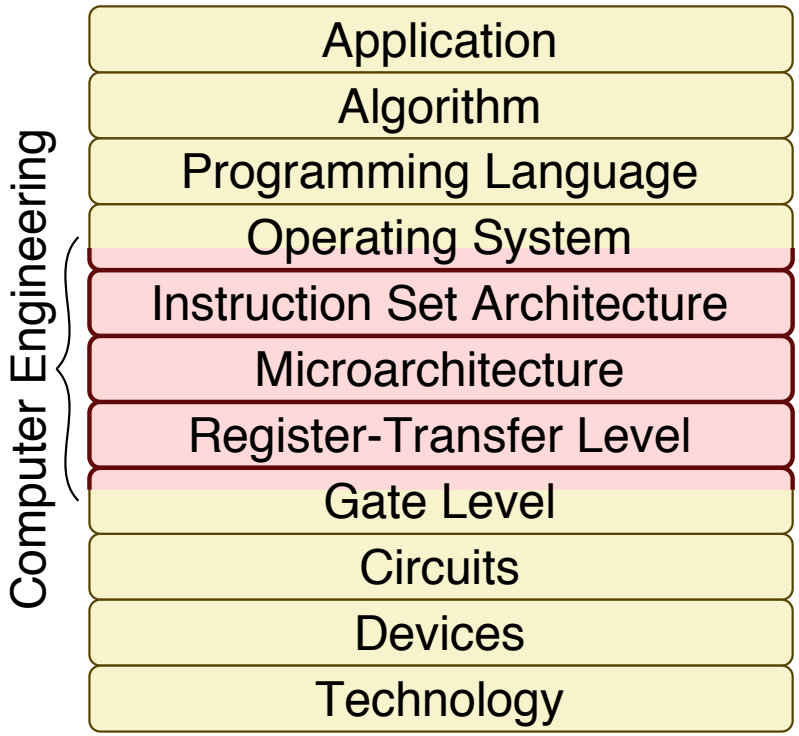
Insertion sort algorithm

1. Find minimum number in input array
2. Move minimum number into output array
3. Repeat steps 1 and 2 until finished

C implementation of insertion sort

```
void isort( int b[], int a[], int n ) {
  for ( int idx, k = 0; k < n; k++ ) {
    int min = 100;
    for ( int i = 0; i < n; i++ ) {
      if ( a[i] < min ) {
        min = a[i];
        idx = i;
      }
    }
    b[k]   = min;
    a[idx] = 100;
  }
}
```

The Computer Systems Stack

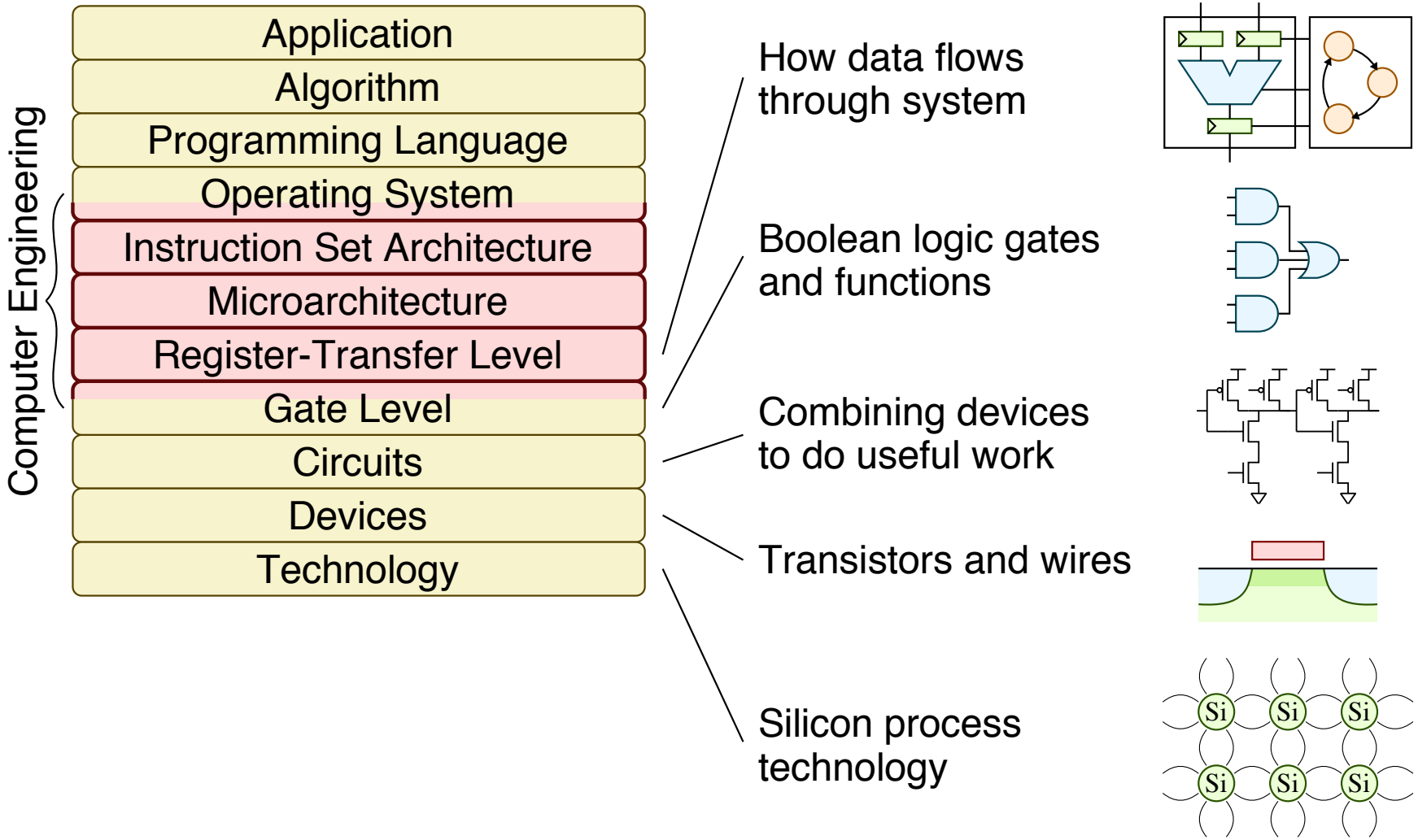


Mac OS X, Windows, Linux
Handles low-level hardware management

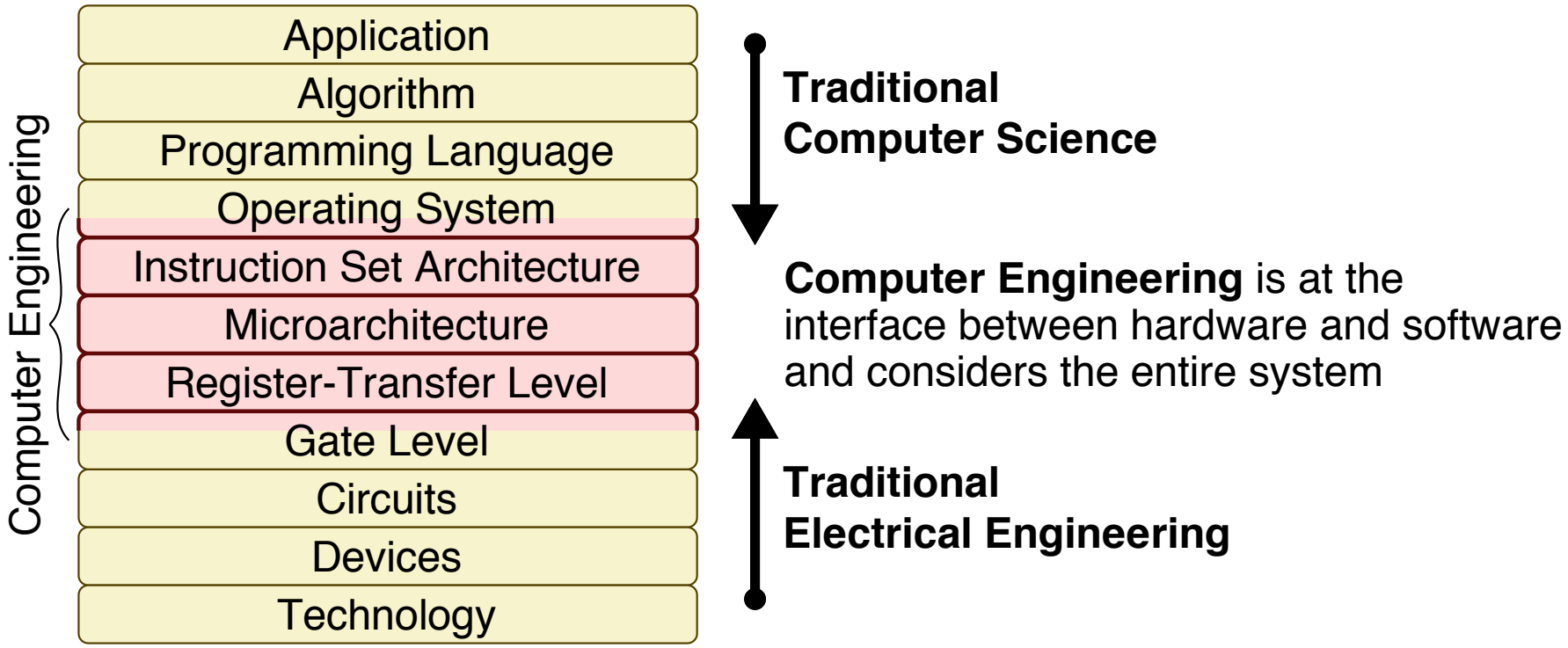
MIPS32 Instruction Set
Instructions that machine executes

```
blez  $a2, done
move  $a7, $zero
li    $t4, 99
move  $a4, $a1
move  $v1, $zero
li    $a3, 99
lw    $a5, 0($a4)
addiu $a4, $a4, 4
slt   $a6, $a5, $a3
movn  $v0, $v1, $a6
addiu $v1, $v1, 1
movn  $a3, $a5, $a6
```

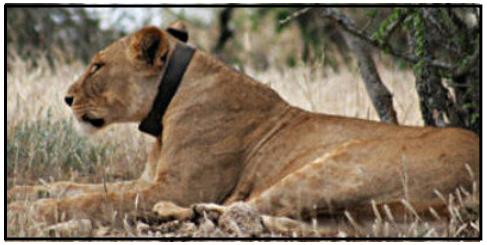
The Computer Systems Stack



Computer Systems: CS vs. EE vs. CE



In its broadest definition, computer engineering is the development of the abstraction/implementation layers that allow us to execute information processing applications efficiently using available manufacturing technologies



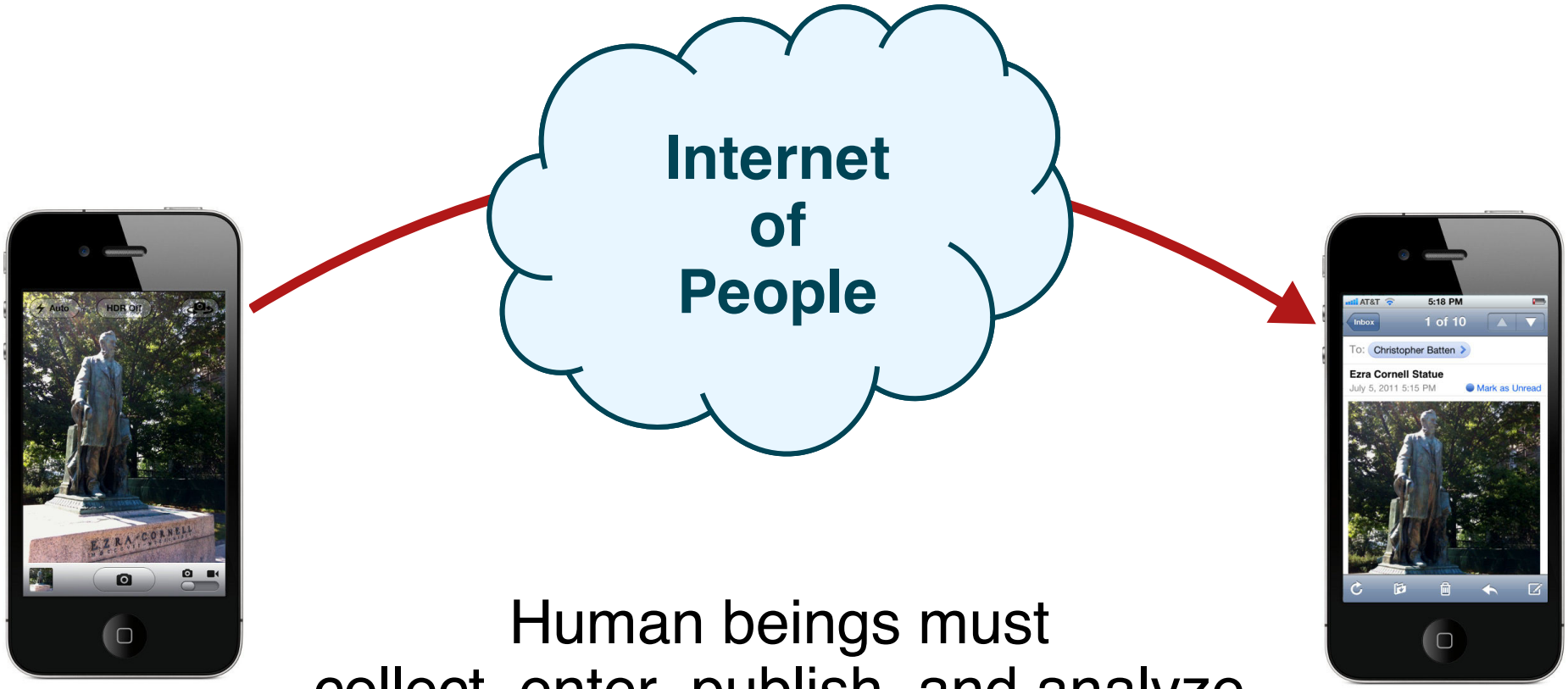
Talk Outline

Electrical and Computer Engineering

The Internet of Things

CURIE Design Project

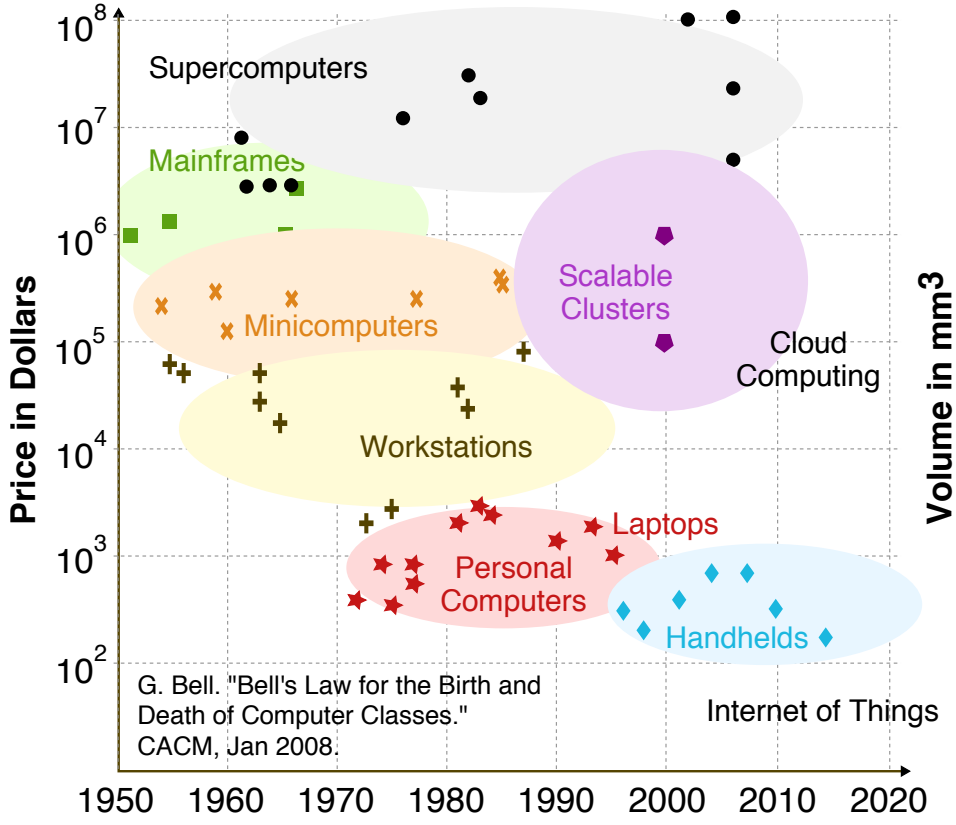
The "Traditional" Internet

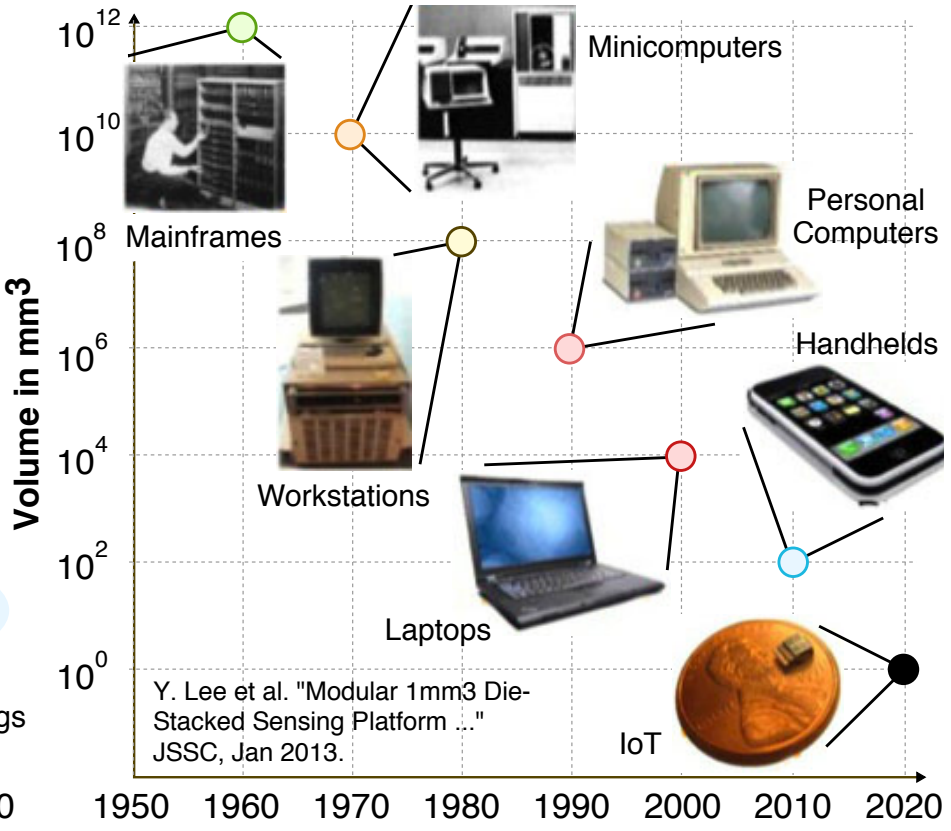


Human beings must
collect, enter, publish, and analyze
almost all of the information
that is transmitted over the Internet

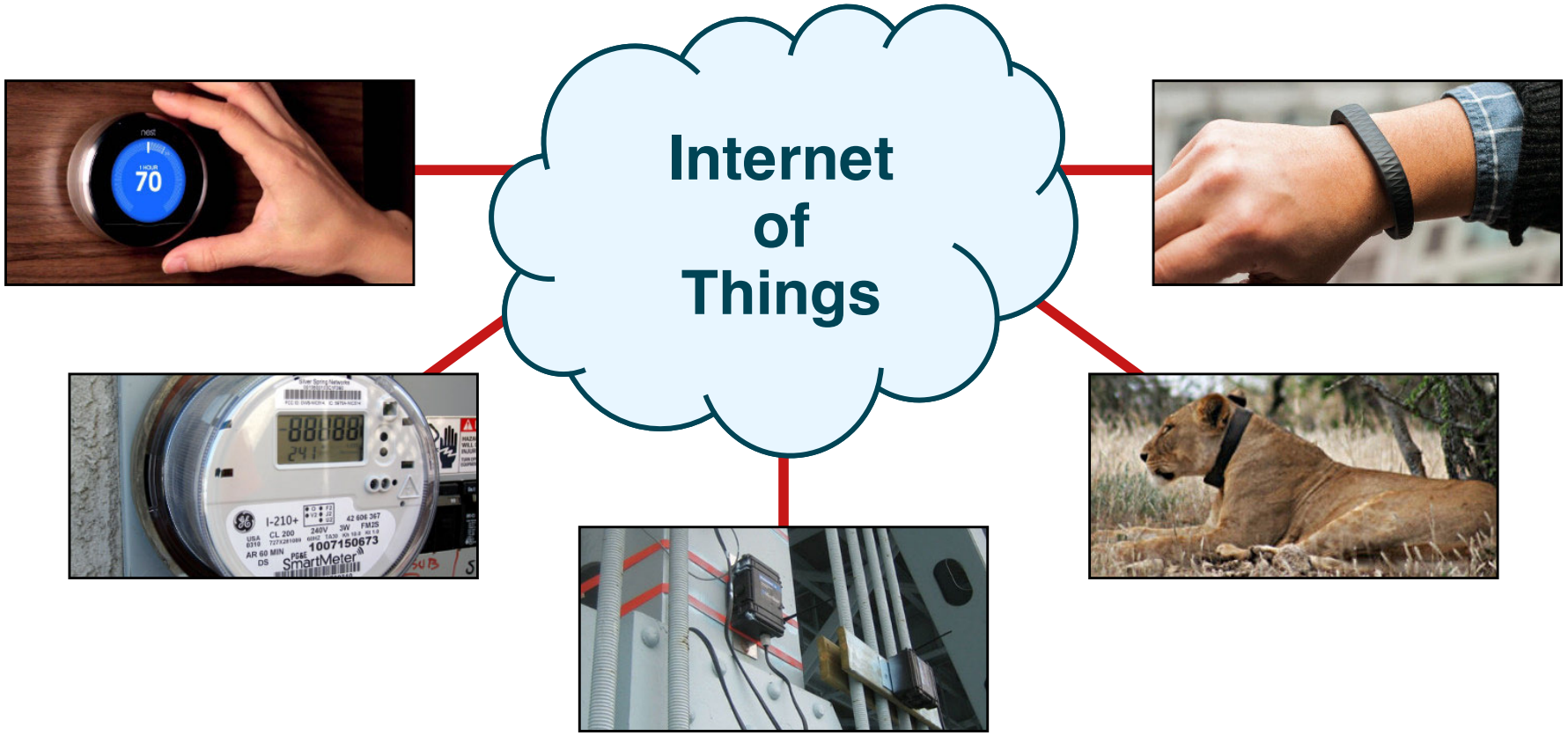
Bell's Law

Roughly every decade a new, smaller, lower priced computer class forms based on a new programming platform resulting in entire new industries



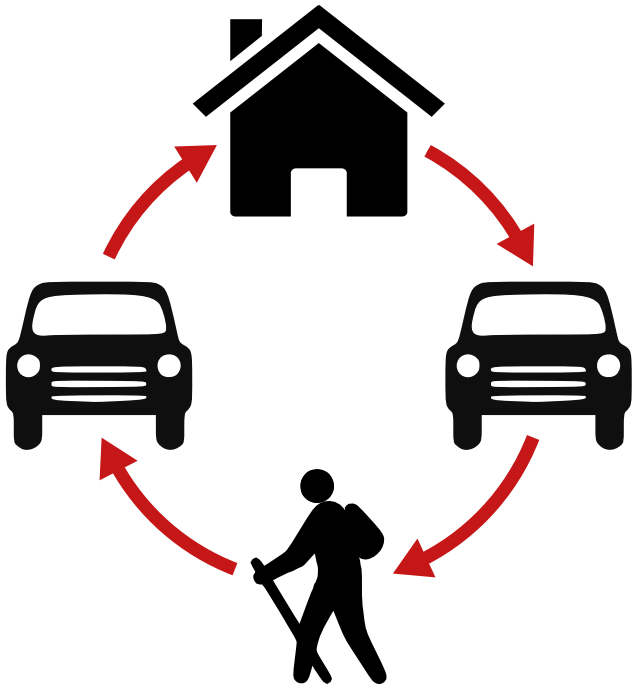


Emerging Trend Towards an Internet of Things

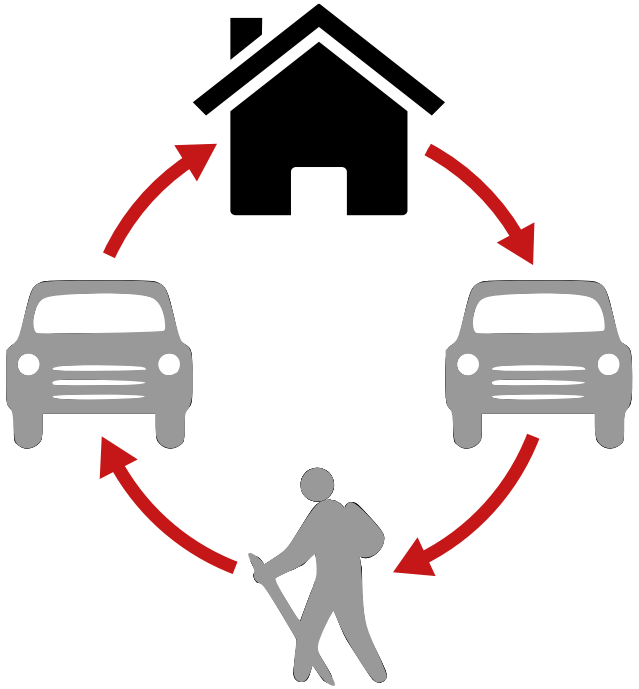


Interconnected "things" augmented with inexpensive embedded controllers, sensors, actuators to collect information and interact with the world

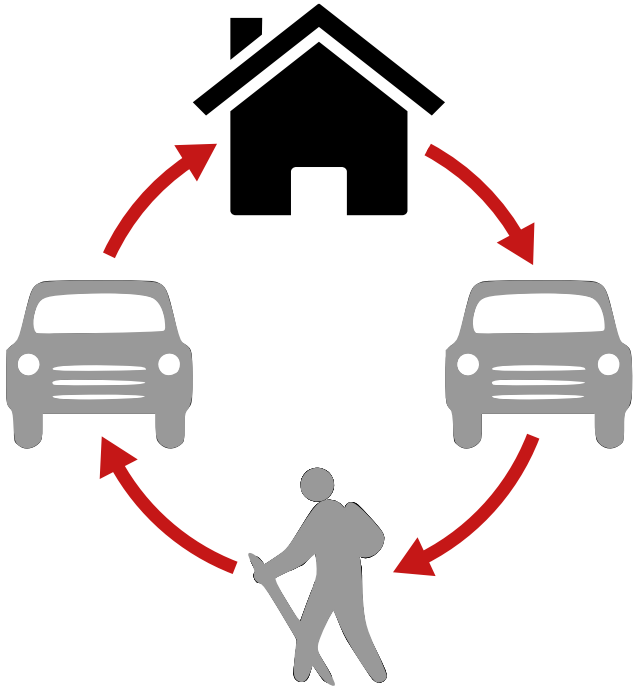
IoT Example: Spending the Day Hiking

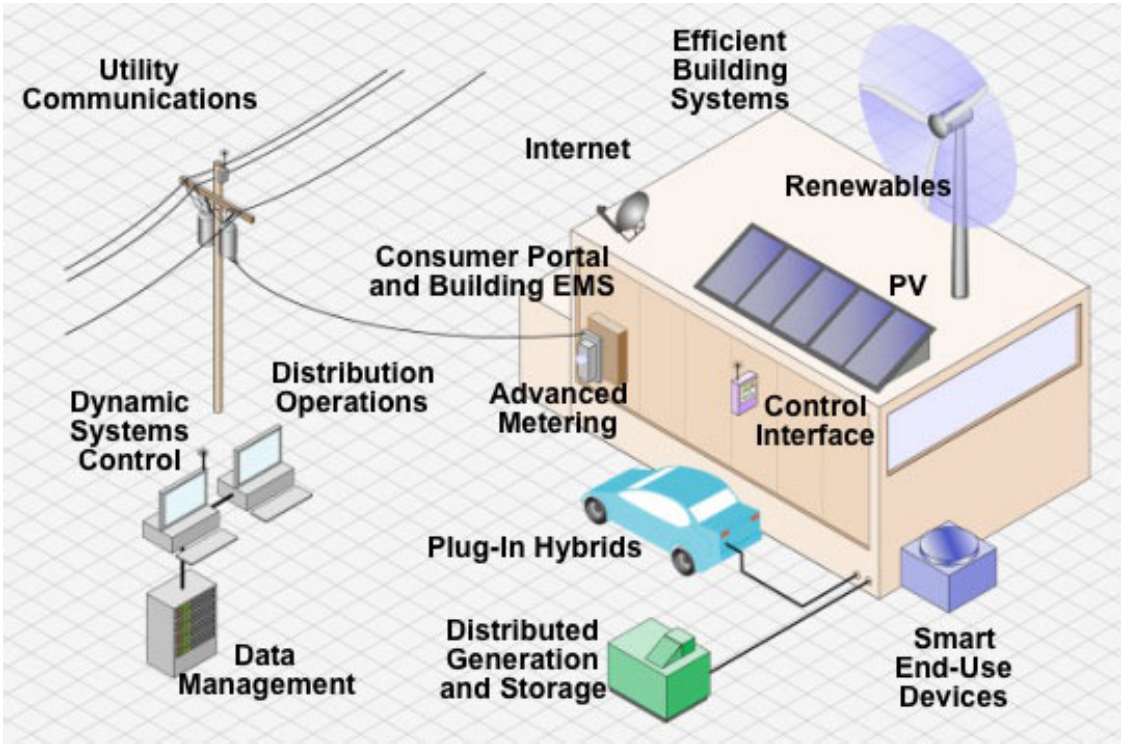


IoT Smart Home

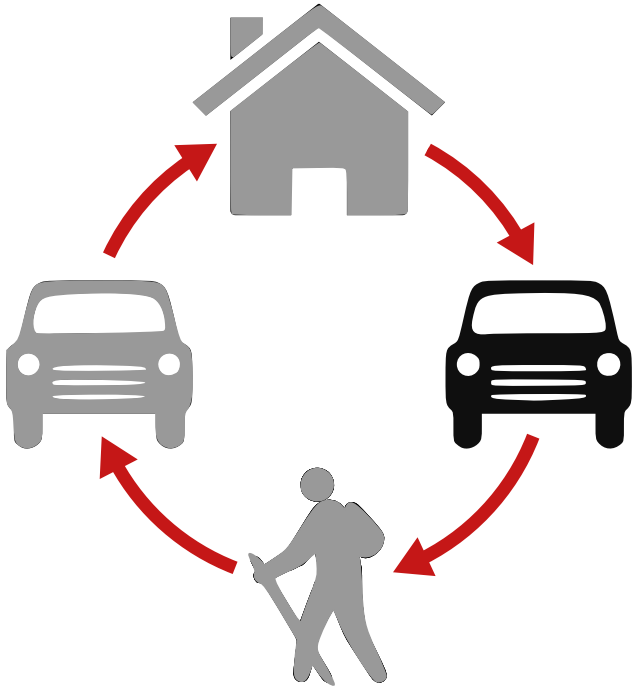


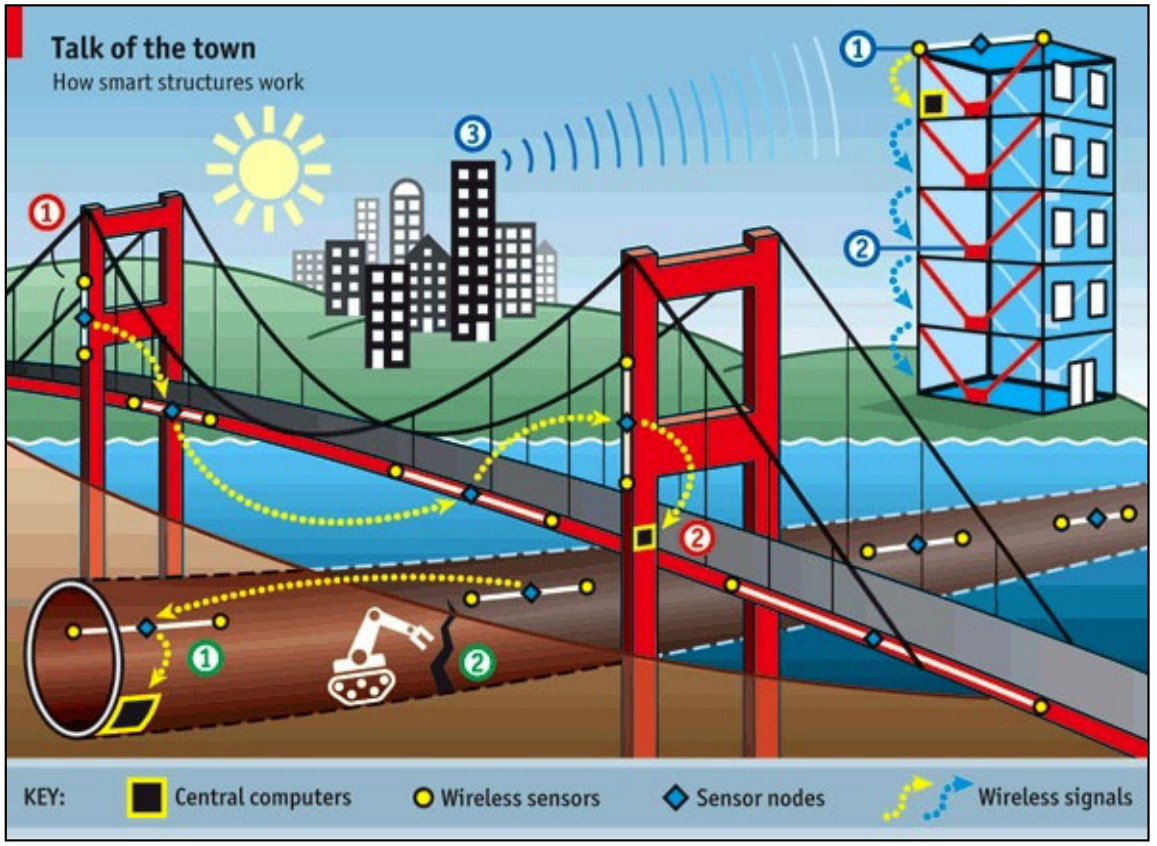
IoT Smart Power Distribution Grid



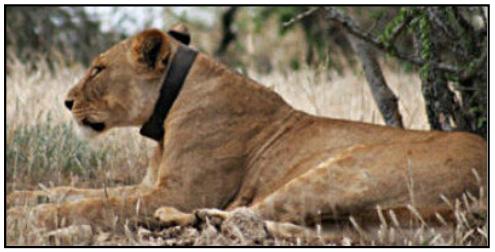


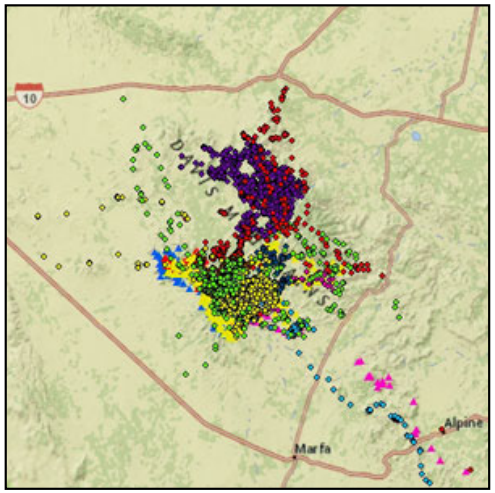
IoT Early Disaster Warning System

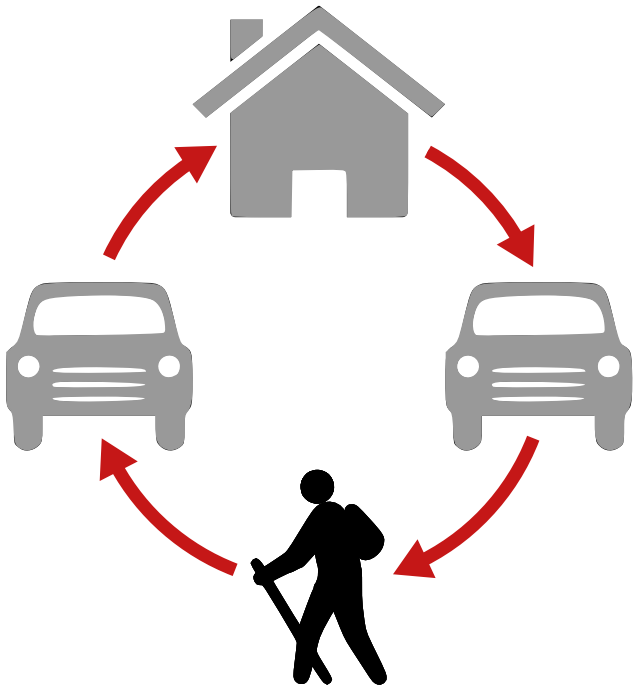




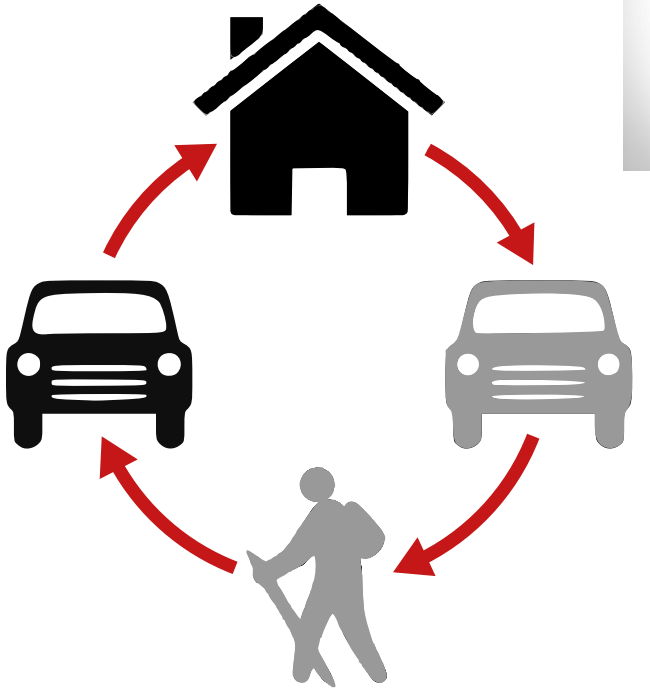
IoT Wildlife Tracking System



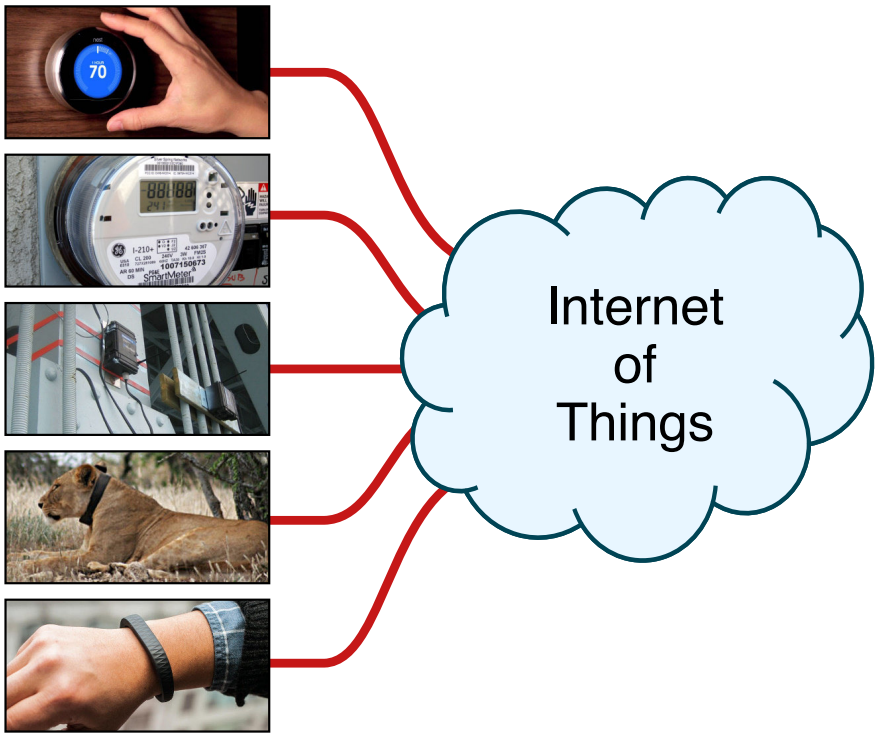


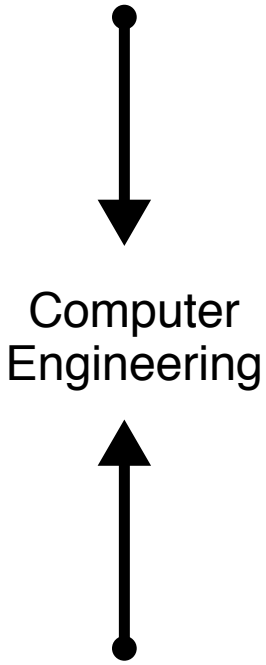


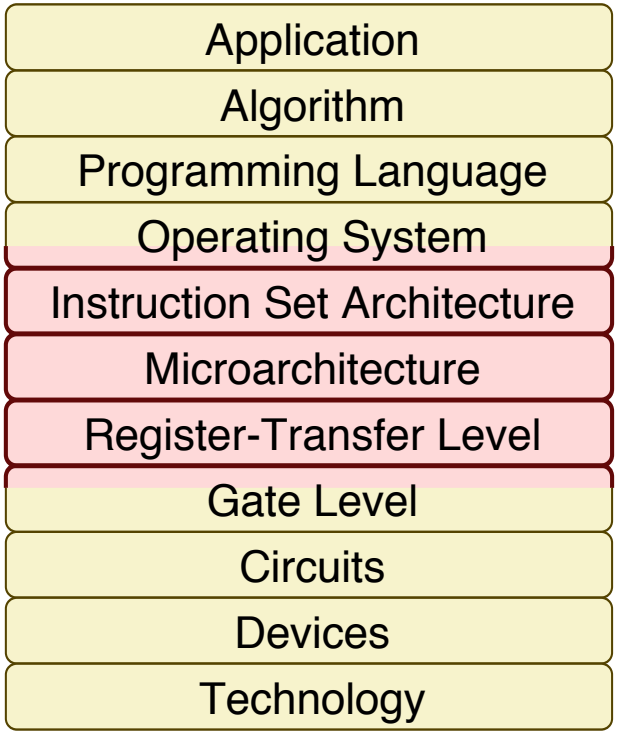
IoT Wearable Health Monitor



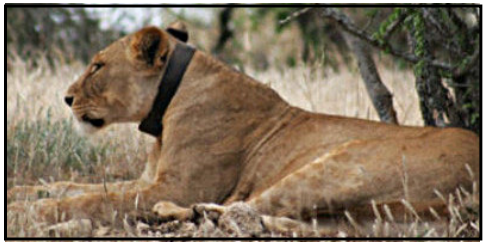
Internet of Things + Computer Engineering







Field of computer engineering is well-situated to serve as a foundation for students interested in this emerging area



Talk Outline

Electrical and Computer Engineering

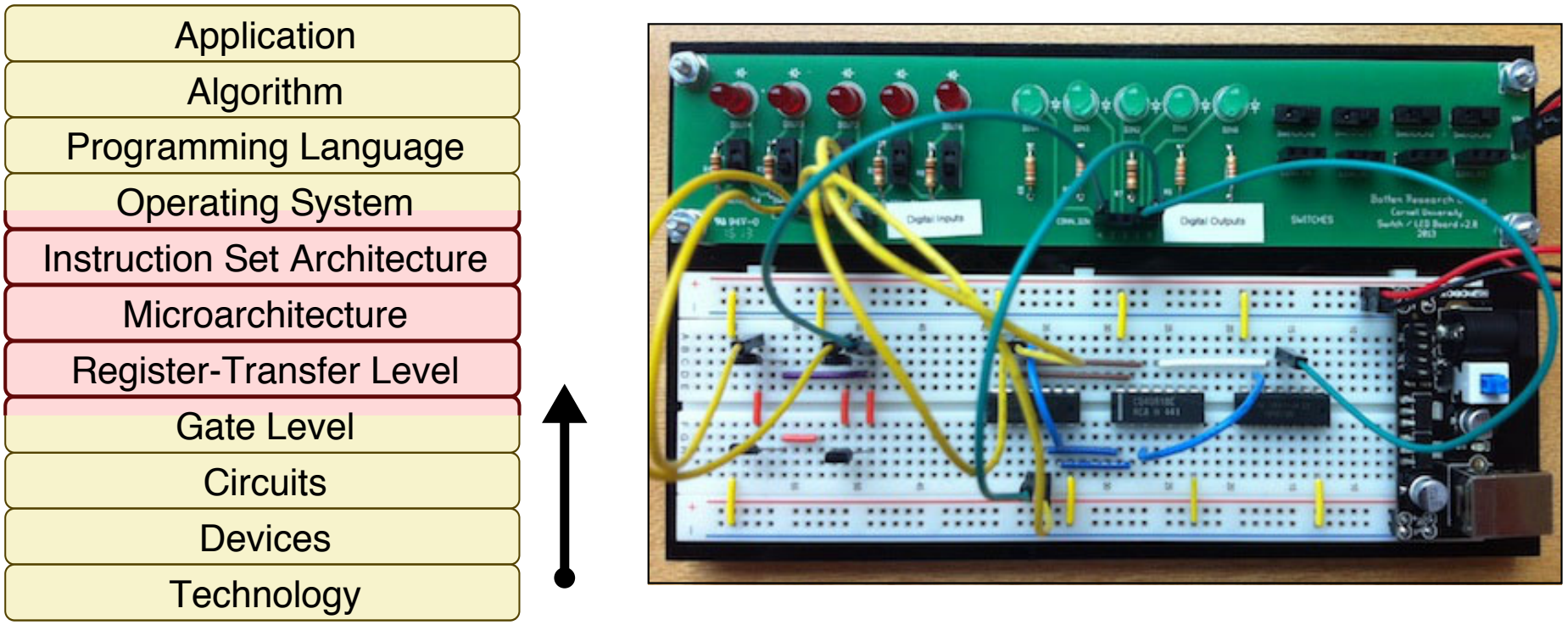
The Internet of Things

CURIE Design Project

CURIE Design Project Schedule

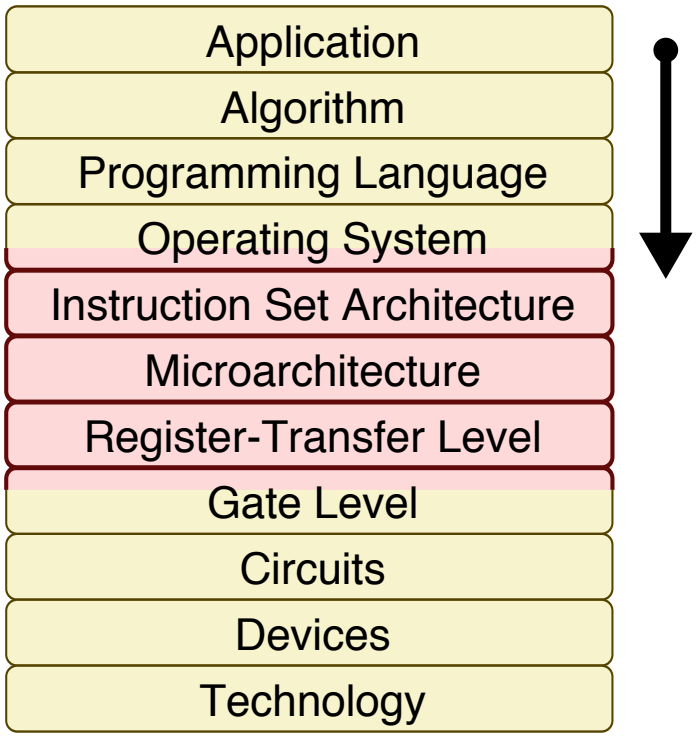
Monday	Lab 1: Computer Engineering – Hardware Perspective Simple calculator out of basic logic gates
Tuesday	Lab 2: Computer Engineering – Software Perspective Mobile robot control application
Wednesday	Lab 3: “Smart Door” IoT System Begin Designing IoT System for Project
Thursday	Design, Implement, and Test IoT System
Friday	Test IoT System Prepare Project Demonstration and Presentation

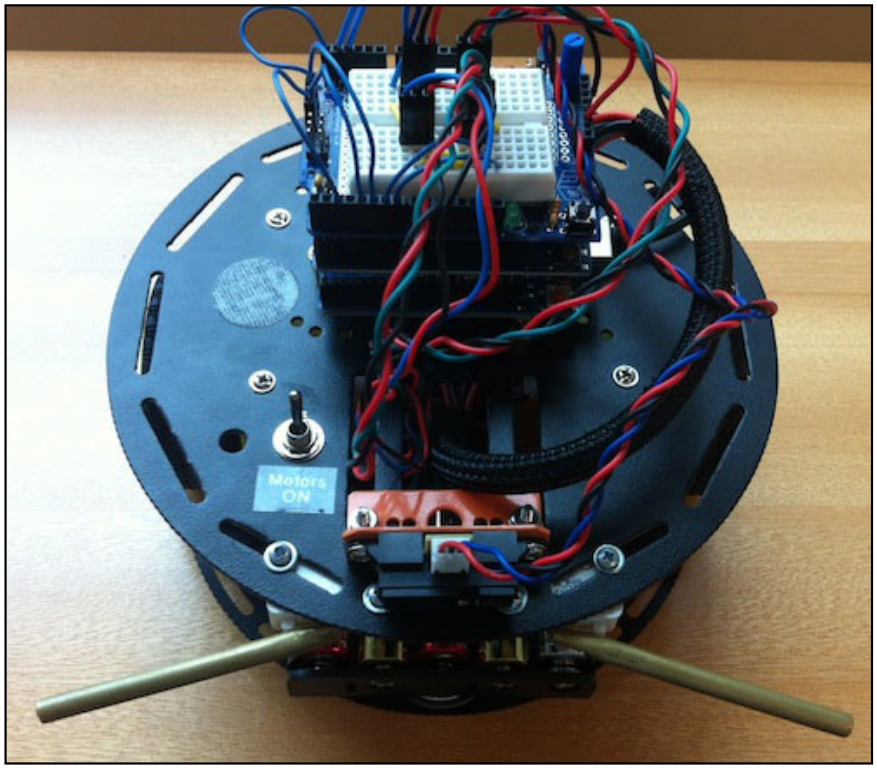
Lab 1: Computer Engineering – Hardware Perspective



Scholars will incrementally build a simple "calculator" capable of adding small binary numbers using basic logic gates

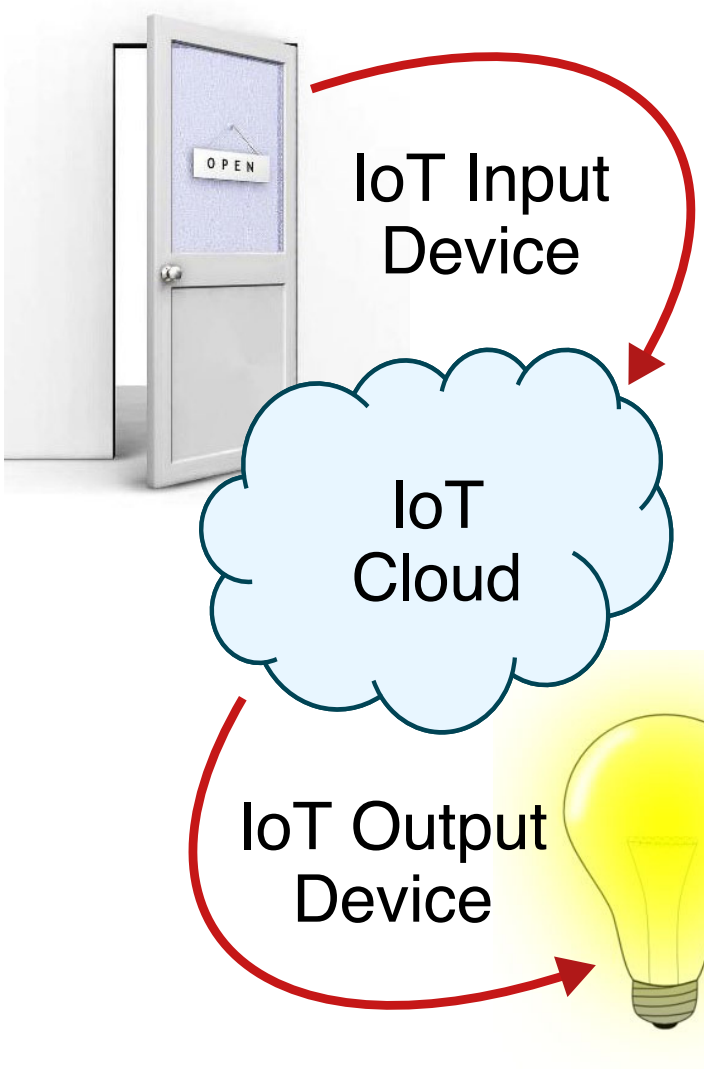
Lab 2: Computer Engineering – Software Perspective

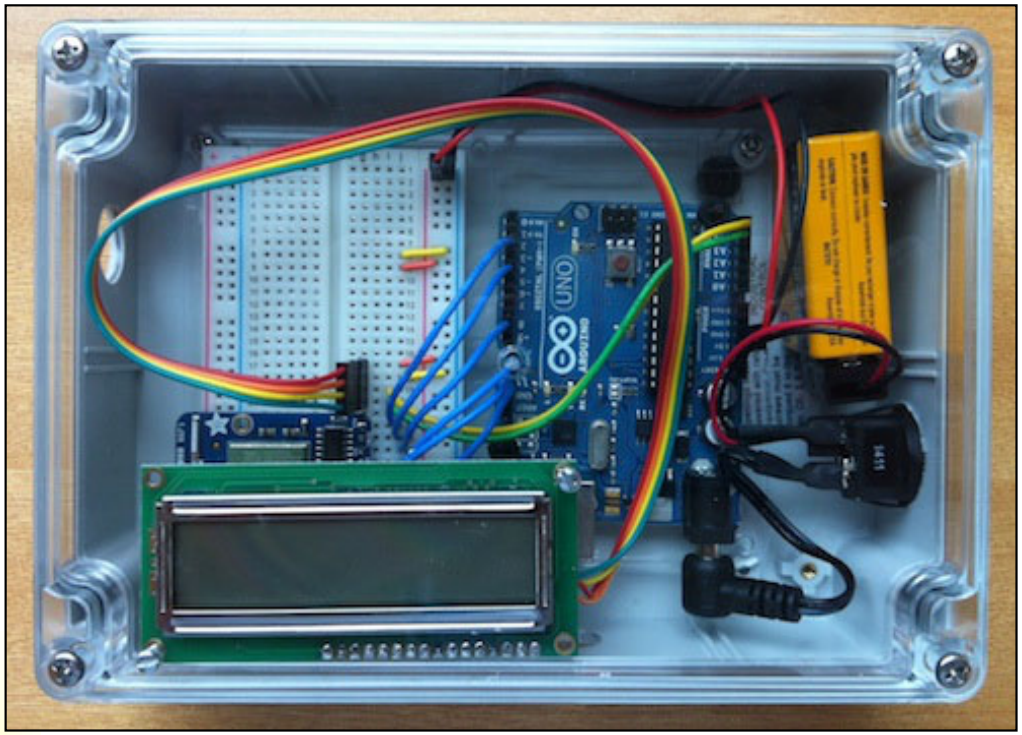




Scholars will incrementally build a mobile robot control application capable of wandering an environment to find a target using the popular Arduino micro-controller

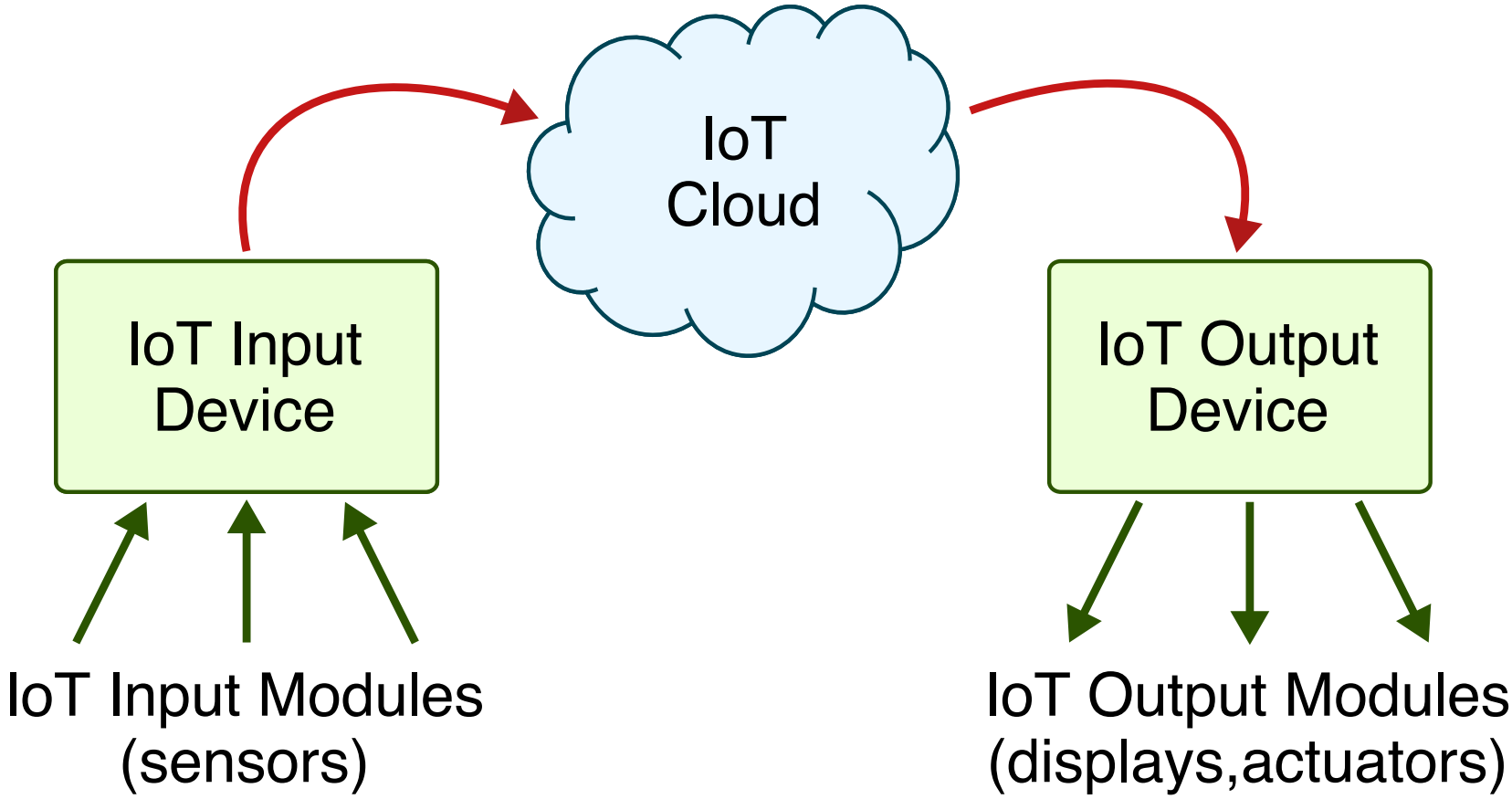
Lab 3: "Smart Door" IoT System





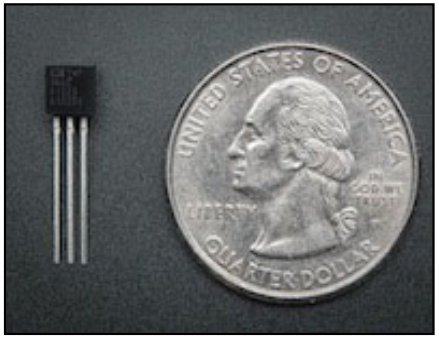
Scholars will build a basic IoT system including an IoT device to send the door status to the cloud and an IoT device to display the door status

CURIE IoT Design Projects

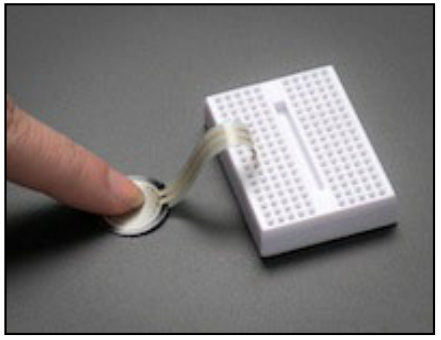


CURIE IoT Input Modules

Light

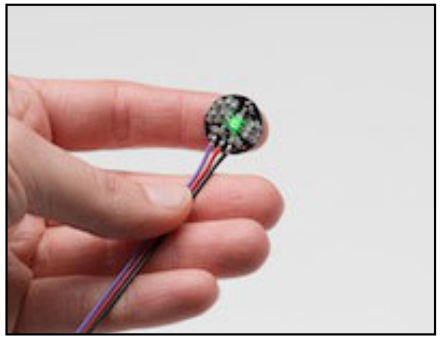


Temperature

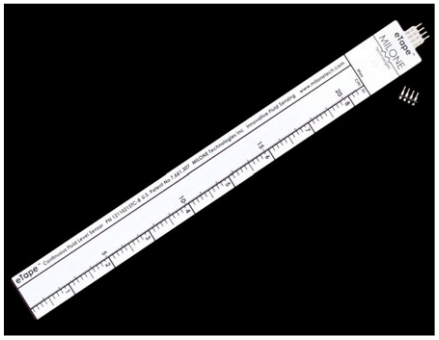


Force

Range

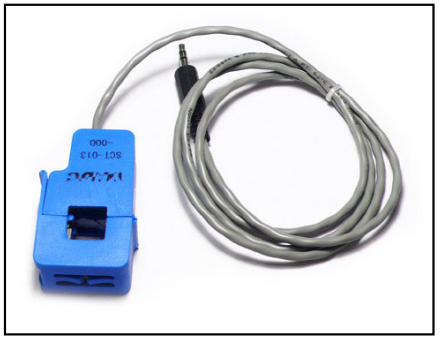


Pulse



Water

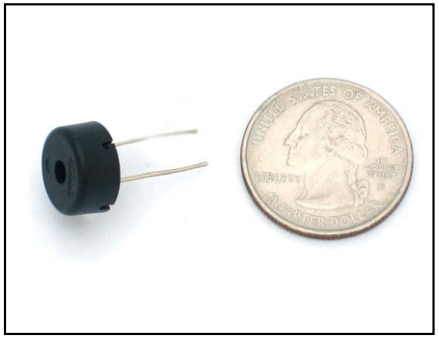
Acceleration



Current

CURIE IoT Output Modules

RGB LED

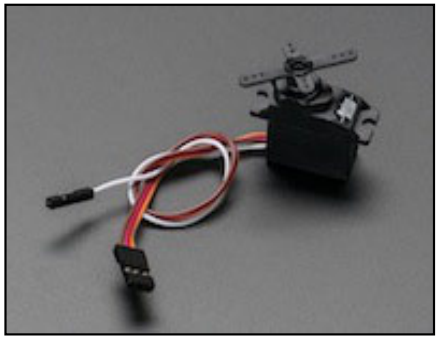


Piezo Buzzer

LED Matrix

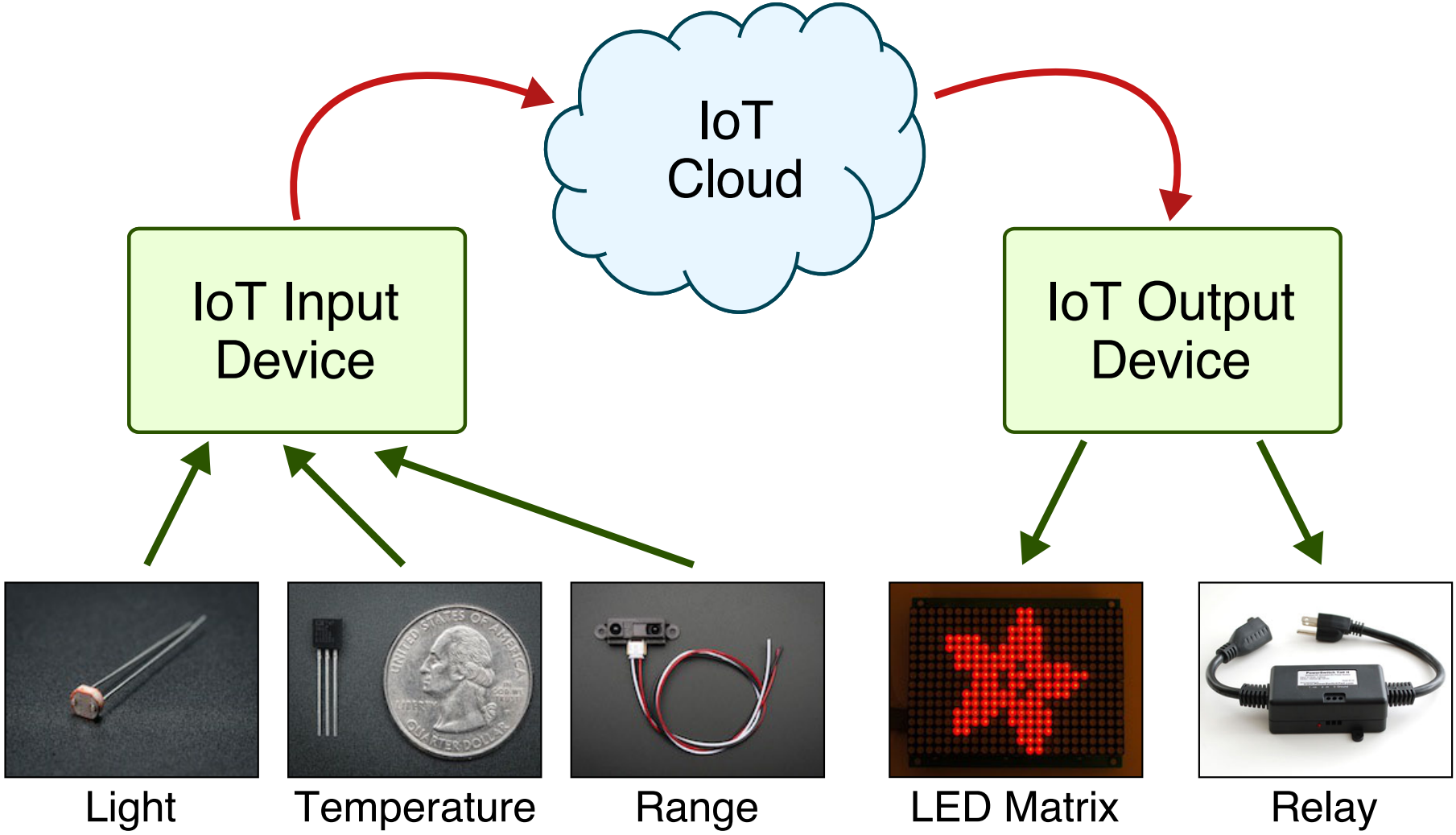
Relay

Miniprinter

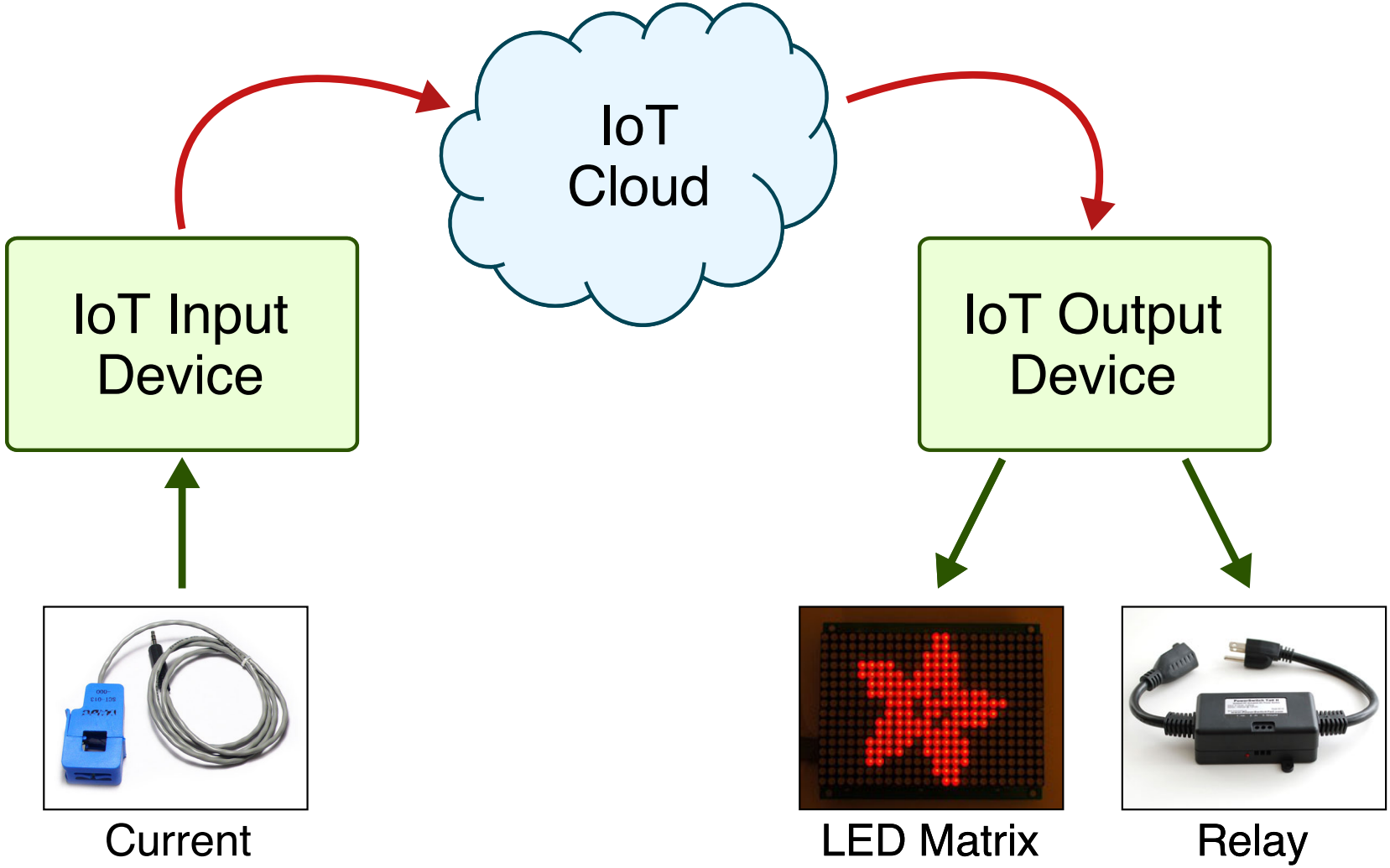


Servo

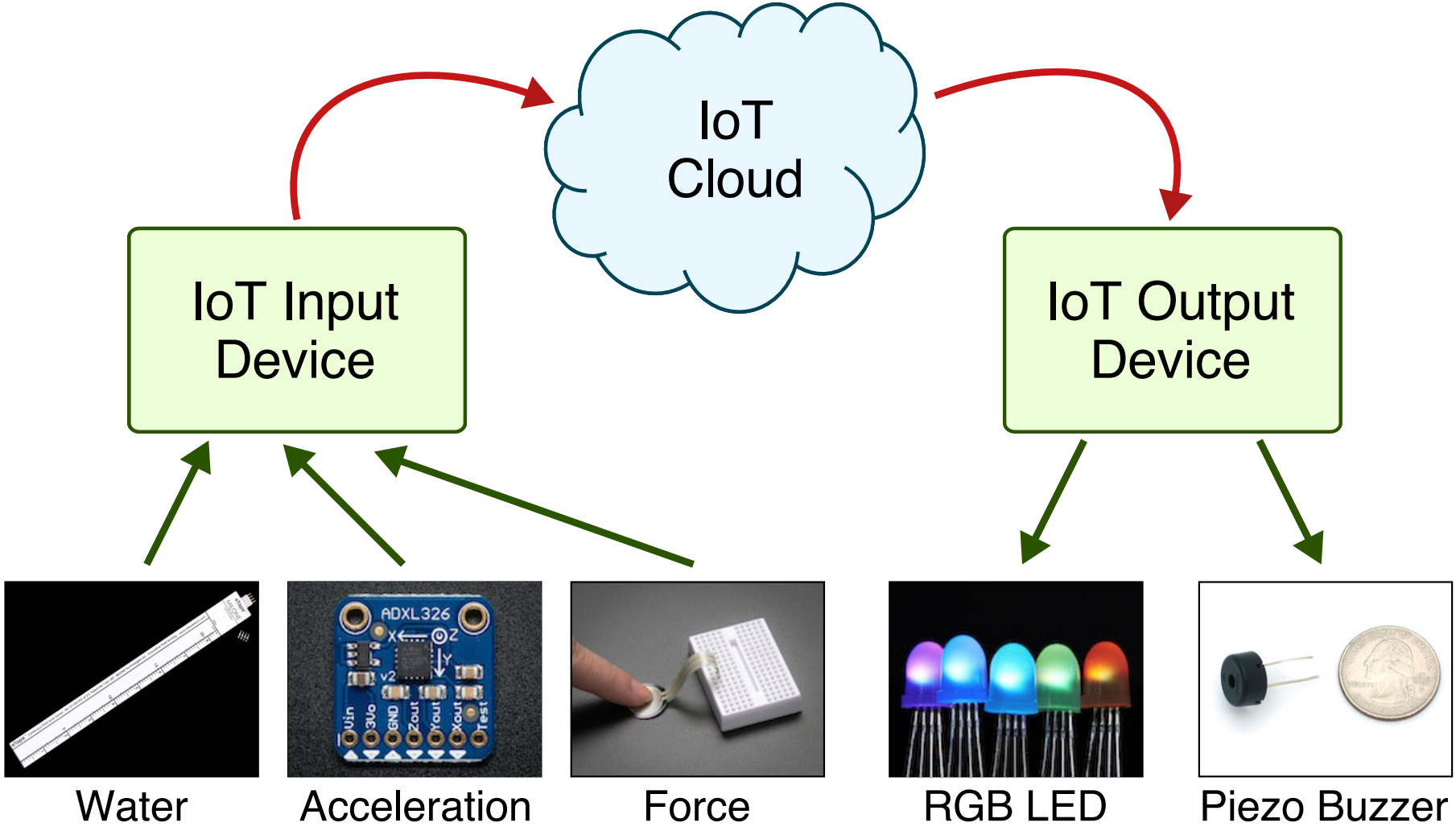
CURIE IoT Smart Home



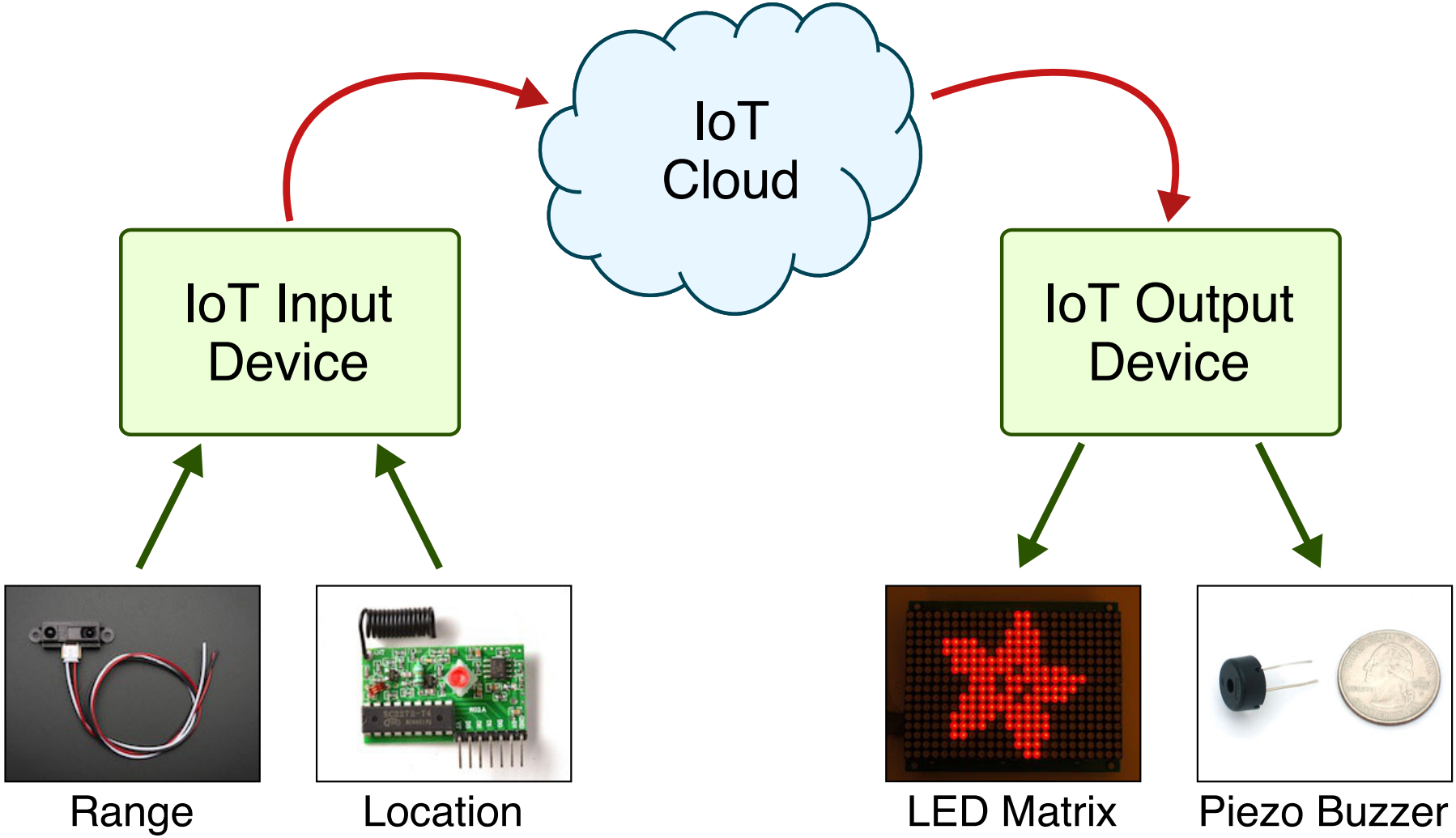
CURIE IoT Smart Power Distribution Grid



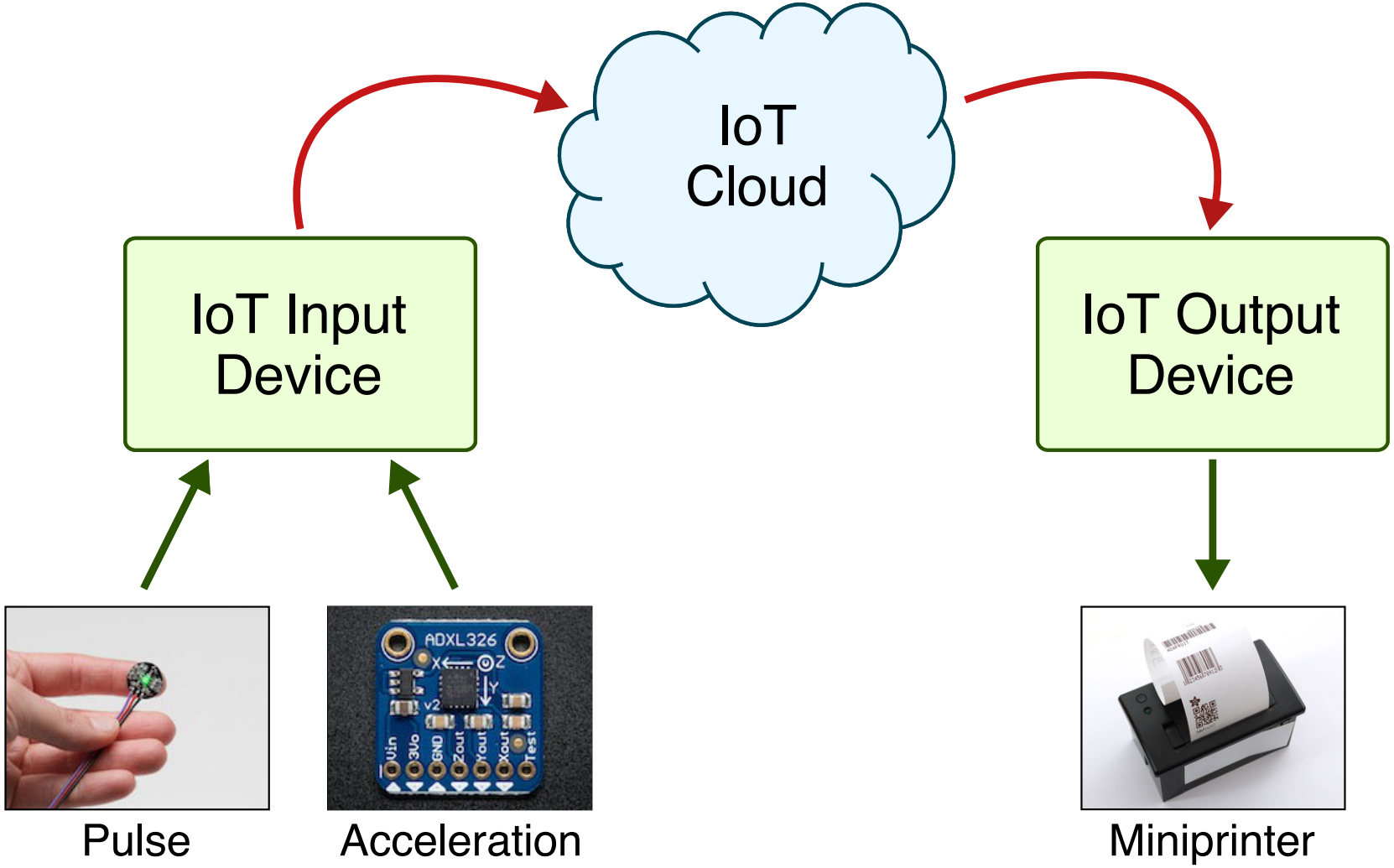
CURIE IoT Early Disaster Warning System

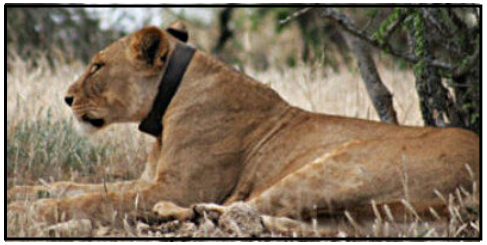


CURIE IoT Wildlife Tracking System



CURIE IoT Wearable Health Monitor





Design Project Summary

- Lab 1: Computer Engineering from the Hardware Perspective
- Lab 2: Computer Engineering from the Software Perspective
- Lab 3: “Smart Door” IoT System
- Projects will involve designing, implementing, and testing a simple IoT device inspired by real-world applications of IoT

Goal: Introduce CURIE scholars broadly to the practice of engineering and more specifically to computer engineering