CSE190 Fall 2023

Lecture 2
Intro to Project and MCUs

Wireless Embedded Systems
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Wireless Embedded Systems

– Computing systems embedded within things/gadgets connected to the Internet

– Hard to call out any one thing/gadget, nearly everything now has a microcontroller and a wireless chipset in it

– 100s of millions of units produced yearly, versus millions of desktop/laptop units
Examples of wireless embedded systems
Amazon Echo (Alexa) – Voice Assistant

WiFi/Bluetooth

Microcontroller/DSP

8x microphone array
Examples of wireless embedded systems
Sharing Economy Scooters
YouLostIt Project Overview

Privacy-enabled Lost item tracker

Attaches to an item (e.g., backpack) and tells any nearby smartphone when it thinks it is “lost”. Provides visual identifier of user when lost, and radio notifications when it is lost for a long time.
YouLostIt:
Your privacy preserving battery-powered
lost-device tracker

• Hardware
  – Accelerometer to detect when device is lost
  – LEDs to indicate who the lost owner is
    • (captured with smartphone video)
  – MCU that manages sensors, radios, and power
  – Bluetooth Low-Energy to tell a smartphone about lost device
    • Who owns it? How long has it been lost?
  – Flash memory to persistently store program binary
  – Clocks/Timers to keep track of time
  – Power from battery for several days to months.

• Software in a smartphone
  – Listen for nearby devices
  – Alert if the lost device goes out of range
What will you take away from this project?

- General knowledge of how an embedded system works
  - GPIO, Clocks, Interrupts, DMA, ADC, SPI, I2C, UART

- Low-level firmware development in C
  - Device drivers
  - Digital signal processing

- Hardware testing (and building)
  - Reading circuit layout and schematics
  - Analog circuit measurement (Oscilloscope, Multimeter)
  - Digital logic observation (Digital Logic Analyzer)
YouLostIt Hardware Platform

ST Micro Discovery board
What do you need to succeed with this project?

• C knowledge

• Desire to learn more about what happens inside of your computer.

• Tenacity: Hardware is hard (but fun!).
  – Need to find out how it works
  – Net to write code in C
  – Need to debug an entire computer w/no OS

• You would be surprised what you are capable of, you can make a physical thing!
Introduction to Microcontrollers

A microcontroller (MCU) is a small computer on a single integrated circuit consisting of a relatively simple central processing unit (CPU) combined with peripheral devices such as memories, I/O devices, and timers.

– By some accounts, more than half of all CPUs sold worldwide are microcontrollers
Billions of microcontrollers in use today

General MCU market overview: annual shipments in Munit
(Source: Microcontroller Quarterly Market Monitor, Q4 2021, Yole Développement)
Microcontroller VS Microprocessor

• A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

• A microprocessor incorporates the functions of a computer’s central processing unit (CPU) on a single integrated circuit.
Reading for next week

• Posted on Website – Please skim.
  — “ARM Cortex-M for Beginners”
Microcontrollers are full computers integrated into a single chip.
Die shot of a microcontroller
Types of Processors

• In general-purpose computing, the variety of instruction set architectures today is limited, with the Intel x86 and ARM “Thumb” ISAs overwhelmingly dominating all.

• There is no such dominance in embedded computing. On the contrary, the variety of processors can be daunting to a system designer.

• Things that matter
  – Peripherals, Concurrency & Timing, Clock Rates, Memory sizes (SRAM & flash), Package sizes
Types of Microcontrollers

- Bits
  - 4
  - 8
  - 16
  - 32
- Memory/devices
  - Embedded
  - External
- Instruction set
  - CISC
  - RISC
- Memory architecture
  - Princeton
  - Harvard

Family

- 8051
- Motorola
- PIC
- Texas
- National
- ARM
- others

- Intel
- Atmel
- Dallas
- Phillips
- Siemens