

# An Introduction to Embedded Systems Technologies

Varun Sampath

# Overview

- Basics of Embedded Systems
- Microcontrollers
  - Arduino Platform
  - ArduPilot
- Networking
  - ZigBee

# What is an Embedded System?

- “Do at most a few things, and do them well.”
- “Embedded” because part of a larger hardware system
  - e.g. washing machine controller
- Contrast with a typical PC, a type of general-purpose computer

# Purposes of Embedded Systems

- Cheaper, lower power solutions to a computable task
  - Unnecessary for system to adapt to different tasks
- Examples
  - Cars
    - fuel injection, cruise control, entertainment systems...
    - 14% of car cost is in software
  - Personal electronics
    - Game Boy, iPod Shuffle

# Microcontrollers

- Tiny and cheap integrated circuits consisting of:
  - CPU
  - Memory (not just RAM, but EEPROM, FLASH too)
  - I/O Peripherals
    - Serial buses (SPI, I2C, UART), ADC, GPIO, PWM

# Comparison

## Atmel ATmega328p

- AVR Instruction Set
- 20 MIPS @ 20MHz
- 2KB SRAM
- 0.0011W
- \$4.25
- $\approx 100\text{mm}^2$



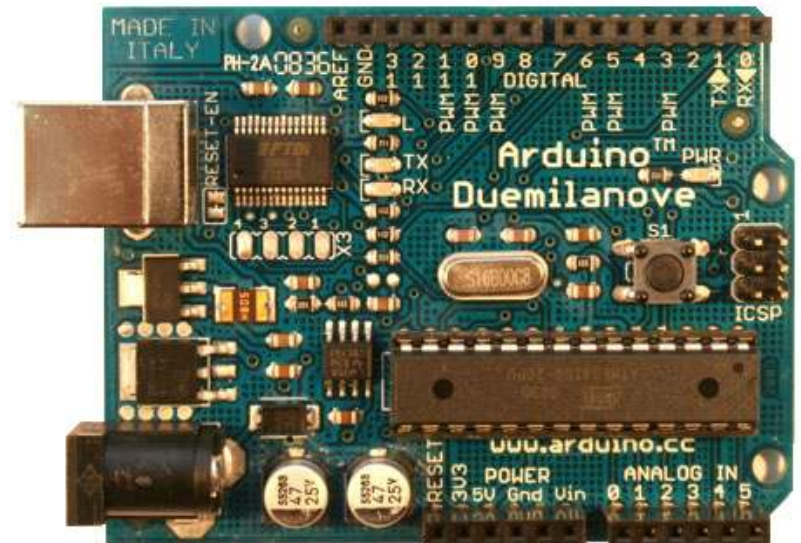
## Intel Core 2 Extreme X6800

- x86-64 Instruction Set
- 27,079 MIPS @ 2.9 GHz
- 4MB L2 Cache, x GB of DRAM
- 65W
- \$240
- $143\text{mm}^2$



# Arduino

- Open source hardware and software microcontroller platform
  - Popular hobbyist platform
  - \$30 for Arduino Duemilanove
- Hardware
  - ATmega328 microcontroller
  - USB interface (via FTDI chip)
- Software
  - Arduino IDE (Java)
  - Wiring Programming Language
    - Based on C++



# “Hello, World!”

```
// HelloWorld: Outputs a string via the UART bus
```

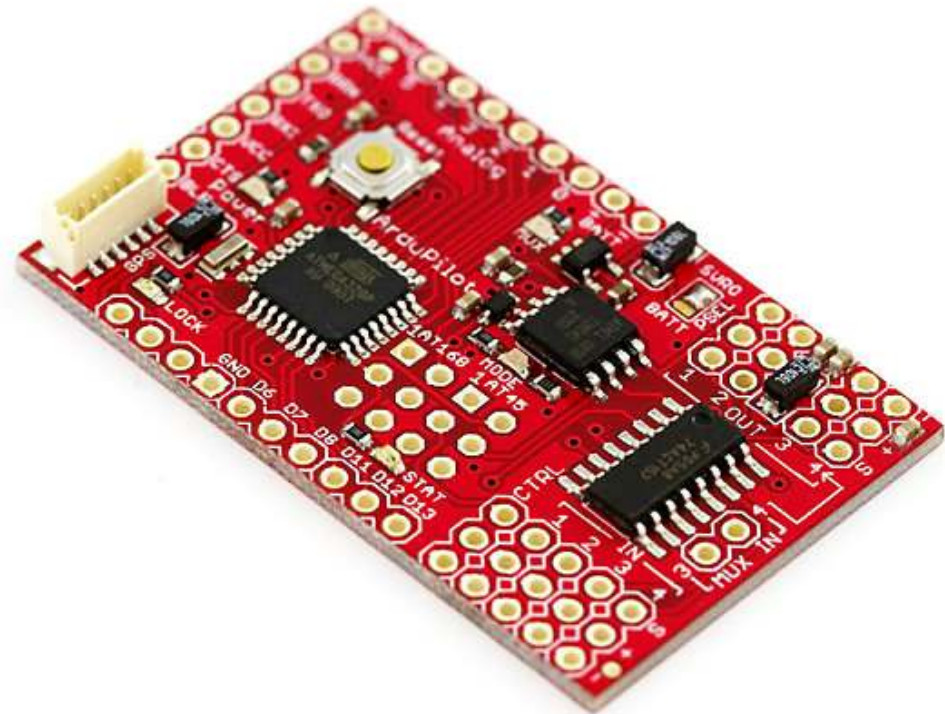
```
void setup() {  
    Serial.begin(9600);  
}
```

```
void loop() {  
    Serial.println("Hello, world!");  
    delay(1000);  
}
```



# ArduPilot

- ATmega328 with a ATTiny 45 for failsafe
- Shield with airspeed sensor and connections for thermopile sensors
- GPS connected through Serial bus
- Output for servo motors



# IEEE 802.15.4

- Physical and MAC layer standard for WPANs
- Physical
  - 900MHz or 2.4GHz bands used in North America
  - 250kbit/s max transfer rate
- MAC
  - Peer-to-peer and star topologies
  - CSMA/CA



# XBee Pro ZB Modules

- 63mW output
- 2mi line-of-sight range
- Programmed using AT or API commands
- 4 ADC channels, 10 GPIO

