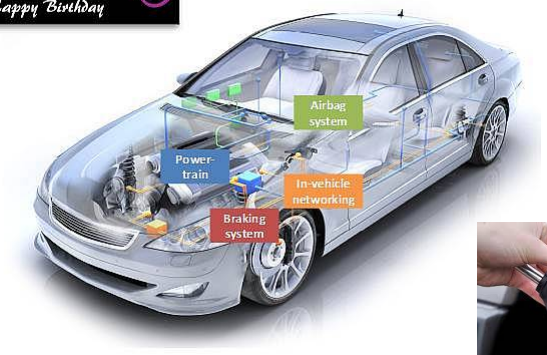
EGR 304
Embedded Microcontroller Systems
Spring, 2020

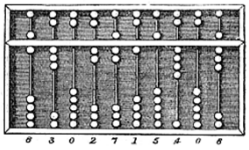


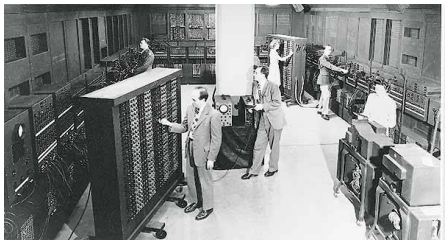


1

The *mandatory* history of computing slide(s)



Upon being completed, ENIAC contained 17,458 vacuum tubes, 7,200 crystal diodes, 1,500 relays, 70,000 resistors, 10,000 capacitors, and 5 million hand-soldered joints.

The total power consumption was a whopping 160 kilowatts. In one second, the ENIAC could perform 5,000 additions, 357 multiplications, or 38 divisions.

The total cost of ENIAC, which weighed over 25 tons and took up approximately 680 square feet, was $500,000. That's about $6 million today, adjusted for inflation.

2

The *mandatory* history of computing slide(s)

Speed → miniaturization → power reduction

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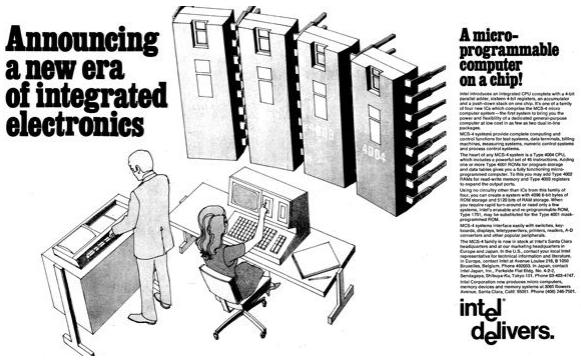
1971 The Intel 4004, designed for Busicom as the CPU for a 4-function calculator. Busicom was not interested. Intel started marketing it to anyone in order to recover their development costs. It was a success.



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1970's --Rapid evolution of 8-bit microprocessors (CPU on a chip)

Intel: Separate I/O
4004 (1971)
8008
8080
8088 (16 bits internal,
used in IBM PC--1981)

Motorola: Memory Mapped I/O
6800 (1971)
6502 (Apple][computer, 1977)
6809
6510
65C02 (WDC-- Apple //c computer)

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1980's Birth of the (practical) micro***controller***

Texas instruments, TMS1000 line dates back to the 1970's but had limited use.

Intel: 8051 and derivatives

Motorola: MC68HC05 and derivatives, especially MC68HC11, MC68HC12.

Although the above chips are obsolete, they are the foundation of many of the modern microcontroller designs. (Studying them won't hurt you, even though they are obsolete.)

Late 1990's Birth of the (practical) system-on-a-chip (SOC)

Many SoC vendors started as μC vendors.

Many vendors, so far no industry trendsetters (Possibly Cypress Semiconductor?)

A common business model is "technology incubation." In other words, buy small technology start-up companies to acquire their intellectual property. Integrate these purchases into new products. Go after a market slice—e.g. cell phones, tablets.
Some SoC vendors own no manufacturing facilities—they contract all the manufacturing.

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Microprocessor (μP)
A CPU on-a-chip
Intended for high-performance
General purpose applications

Fast
Power hungry
Expensive ($100's per CPU)
Connects to the world via a bus
Needs support, RAM, I/O ports
Frequent software updates are OK
Only a few models are popular
E.g. Intel Core i7, AMD octo-core FX

Microcontroller (μC)
A CPU *with* I/O, memory, and more on-a-chip
Intended for dedicated purposes

Medium or slow speed device
Low power, may be battery operated for days
Inexpensive (<$1 per CPU)
Usually no external bus
Includes RAM, ROM, I/O ports, A/D, more
Software updates are impossible or $$$$
Thousands of specialized models available
E.g. Atmel AVR, Microchip PIC, Altera NIOS

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Microcontroller (μC)
A CPU *with* I/O, memory, and more on-a-chip
Intended for dedicated purposes

Medium or slow speed device
Low power, may be battery operated for days
Inexpensive (less than $1 per CPU)
Usually no external bus
Includes RAM, ROM, I/O ports, A/D, more
Software updates are impossible or very expensive
Thousands of specialized models available
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System-on-a-chip (SoC)

A microcontroller that reaches toward general-purpose applications
Different from an ordinary μC mainly in degree—more memory, more analog functions
Achieved by building for a particular type of product
Typical applications are computer-like devices
Cell phones, portable tablet computers
E.g. Nvida Tegra 3, Qualcomm Snapdragon S4
Broadcom BCM2835 and others—used on Raspberry Pi

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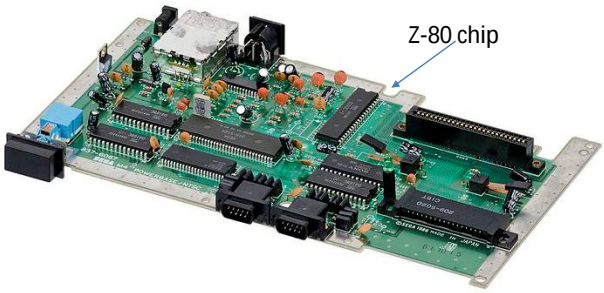
The Z-80 is a well-known ***microprocessor***



Sega Master system game console
Late 1980's

The Z-80 architecture is still used, e.g. in the TI-89 Titanium calculator and other calculators.

Still supported as on open-core
https://opencores.org/projects/t80

Used by permission: https://commons.wikimedia.org/wiki/File:Sega-Master-System-Mk1-Motherboard-FL.jpg
https://commons.wikimedia.org/wiki/File:Sega_Mark_III.jpg

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The Atmel (Brand) AVR (model line) ***microcontroller*** makes an (almost) one-chip solution that costs < $5/chip (The other chip is a temp sensor. The relay allows the μC to control 120 V AC or 204 V AC appliances. The silver oval-shaped part is a crystal timing reference. The AVR will run without it, but it makes the AVR capable of keeping real-time accurately. The read and white wire connect to power, two of the other three are used to switch the load on or off. sensor.)

AVR inside

Set-top box
Remote Control
Diabetes Monitor
Xbox hand controller
Hot Wheels radar gun
(intended as a toy, but it has a real radar).
Residential burglar alarm panel
Rumba robotic vacuum cleaner
Honeywell thermostat
Etc.

ARM inside
Nest Thermostat

Illustrations: Fair use http://embedded.dapj.com/search/label/avr-2
https://avrinside.wordpress.com/
https://nest.com/thermostat/meet-nest-thermostat/

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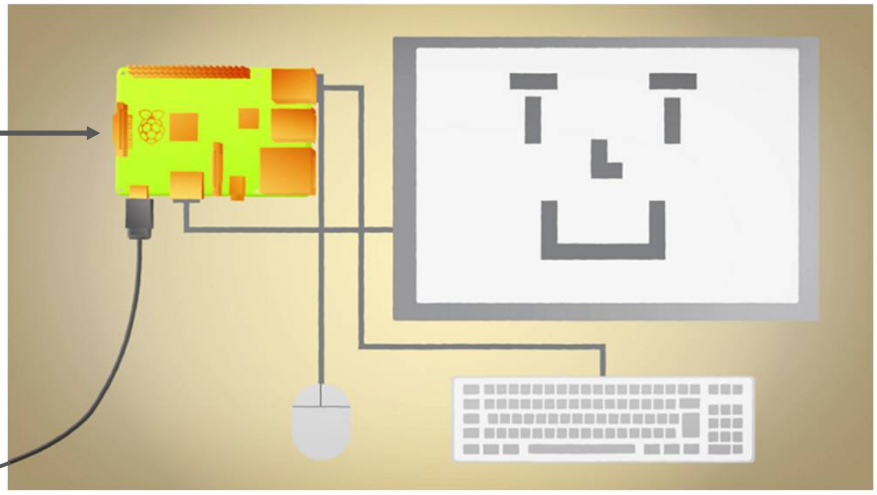
Raspberry Pi is a ***system-on-a-chip***.

In many ways it acts like a desktop computer running Linux.
It does not need to be connected to a network or the internet.
It is not primarily designed for data acquisition, although it can do some of that.

Micro SD serves as solid-state hard drive



Power from USB wart

Broadcom SoC used in many smartphones

e.g. Samsung Galaxy Grand,
Galaxy S4
Galexy Trend II

Other SoC companies
Qualcomm
Samsung
Texas Instruments
Nvidia

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A Cyber-Physical System

The present trend is to merge more and more physical systems and computing systems into one overall system.
Example: The "Nest" thermostat. Not just an electronic emulation of a thermostat.
Integrate it with fire protection, home entertainment system, alarm clock, doorbell camera, etc.

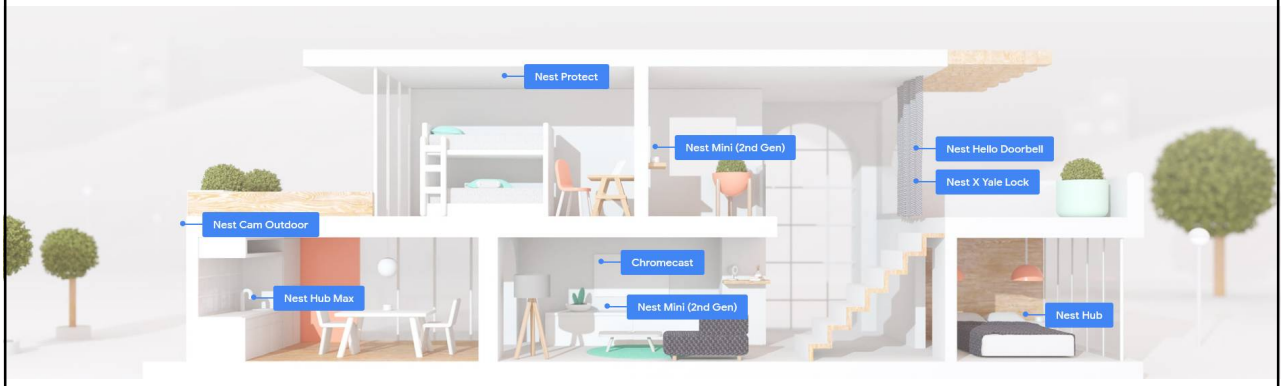

Illustration: Fair use, https://store.google.com/us/category/connected_home

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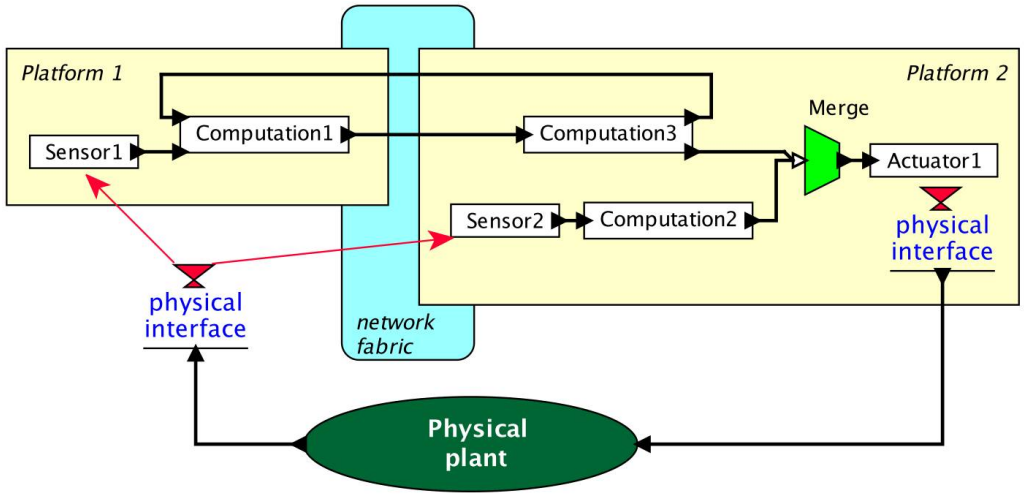
A Cyber-Physical System
The present trend is to merge more and more physical systems and computing systems into one overall system. The system may typically have more than one computer platform.



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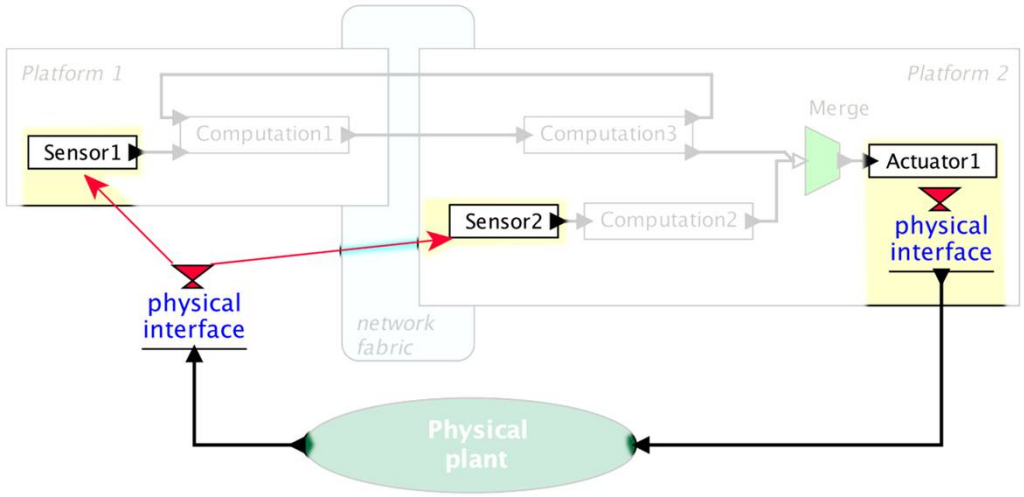
This portion of the system might be called *Interfacing*. This is maybe 1/3 of this course.



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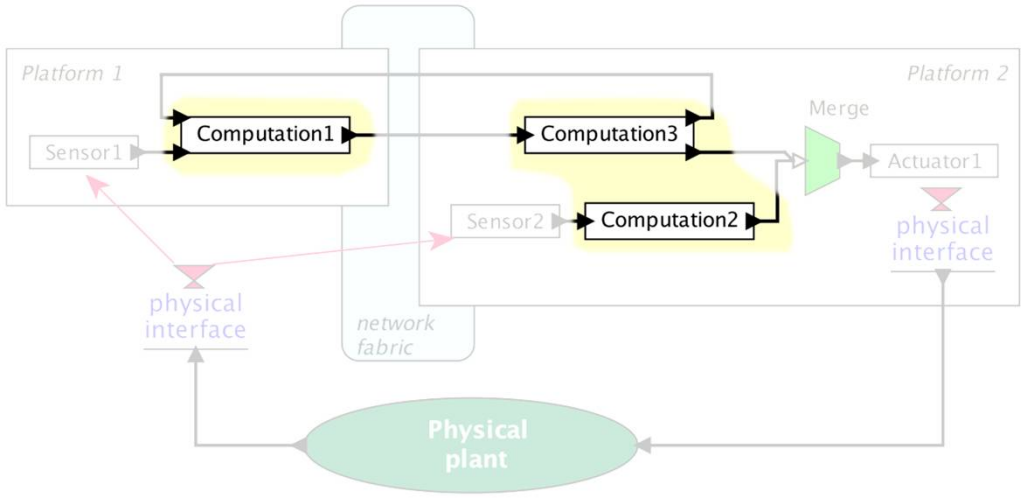
These systems require computations coordinated in time. Dealing with *real-time issues* is maybe 1/3 of this course.



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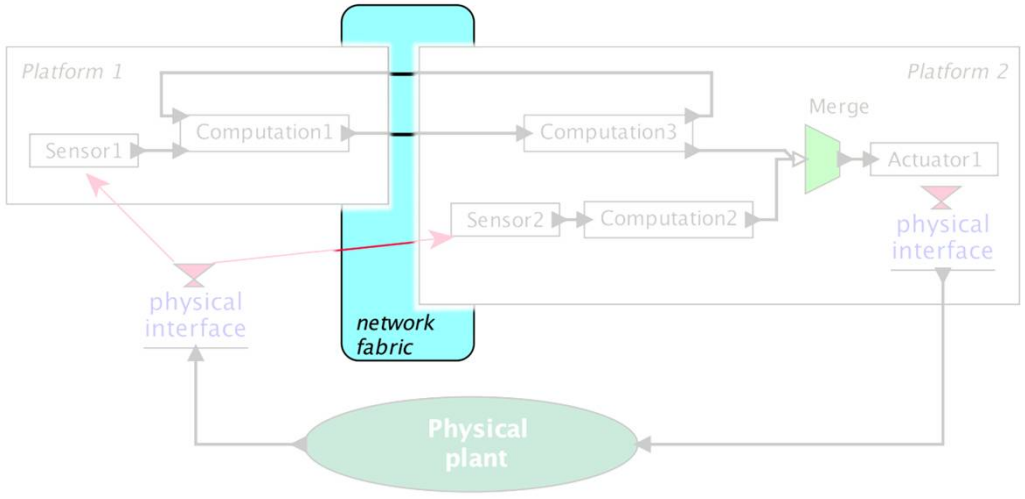
The computing systems need to talk to each other via various networks. Perhaps this is another 1/3 of the course.



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