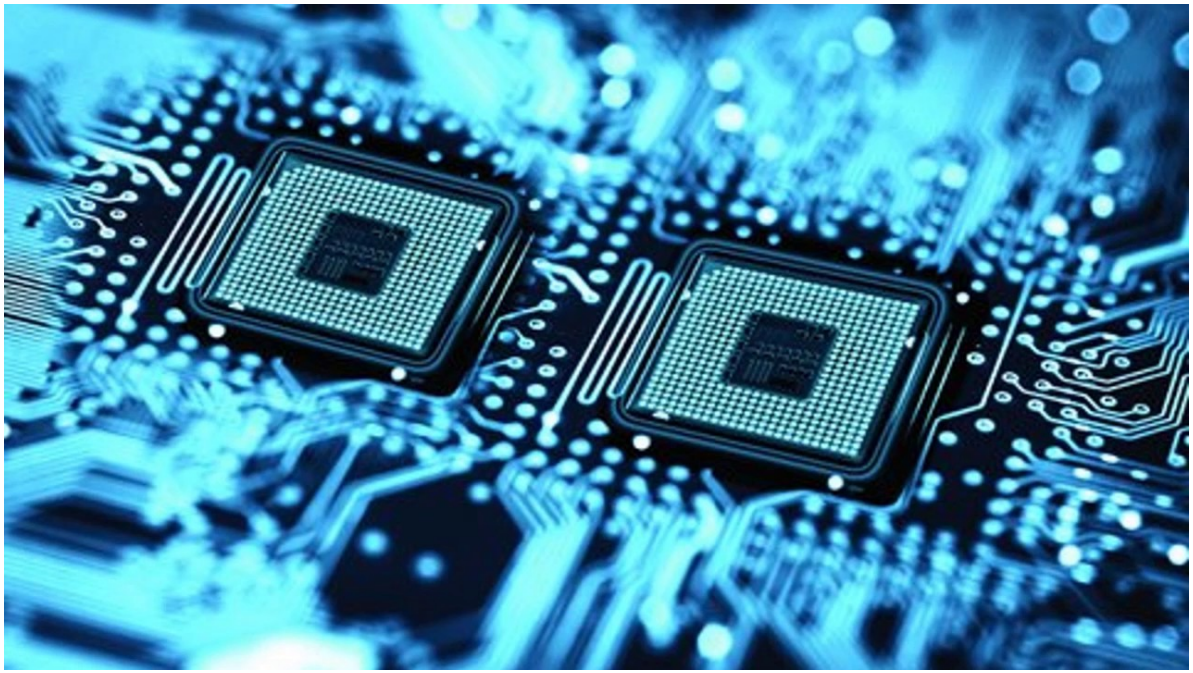
NWEN 242 COMPUTER ORGANIZATION



Lecturing team

- Course lecturer: Matt Stevens (week 1 to week 6)
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- Course lecturer: Ali Ahmed (week 7 to week 12)
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- Course coordinator: Aaron Chen
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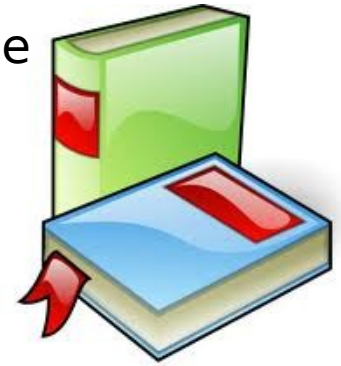
Learning objectives

- Develop an understanding of the structure of computers and how they execute programs.
  - Key components/subsystems of a computer
  - The functionalities of each component
  - The interconnection among components
  - Mechanisms that enable reliable/efficient execution of programs
  - Instruction set architecture (ISA)
  - Performance of a computer system

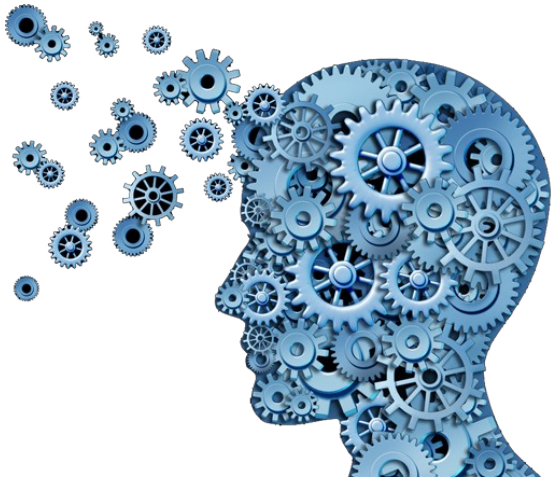
Major topics

- Computer abstractions and technology
  - Basic computer organization and performance
- Instruction set architecture
  - MIPS instructions
  - MIPS addressing mode
  - Mechanisms to support procedure calls
  - Mechanisms to handle basic data structures



- Combinational and sequential logic, arithmetic and logic unit (ALU)
- Processor design
  - Building a datapath, pipeline design, data hazard, control hazard, instruction level parallelism
- Memory hierarchy
  - Cache, virtual memory, a common framework for memory hierarchies
- I/O subsystem

Knowledge assumed



- Basic mathematics skills
  - Binary calculation
  - Boolean algebra
- Knowledge desired
  - Basic electronics knowledge might help but is not compulsory
    - Logic circuit
- C programming knowledge
  - NWEN241
  - Online c tutorial:
    - http://www.cprogramming.com/tutorial/c-tutorial.html

Assessments

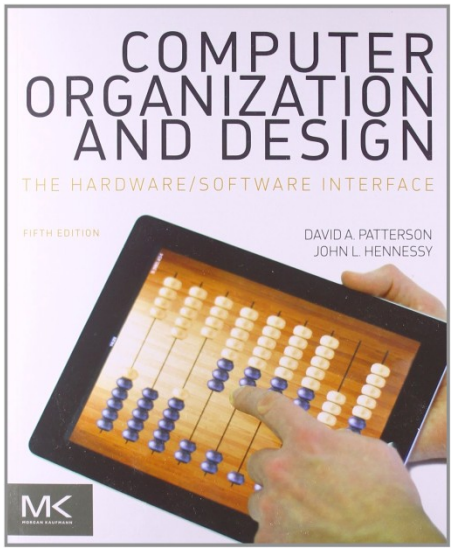
Item	Weight	Due	Learning objectives
Homework Assignment 1	2.5%	Fri., Week 4 (Midnight 11 August)	1, 2, 3, 6
Homework Assignment 2	2.5%	Fri., Week 6 (Midnight 25 August)	3, 4, 5, 6
Homework Assignment 3	2.5%	Fri., Week 9 (Midnight 29 September)	5, 6
Homework Assignment 4	2.5%	Fri., Week 11 (Midnight 13 October)	5, 6
Lab Project 1	10%	Fri., Week 5 (Midnight 18 August)	2, 3
Lab Project 2	10%	Fri., Week 10 (Midnight 6 October)	5, 6
Lab Project 3	10%	Fri., Week 12 (Midnight 20 October)	5, 6
Final Examination	60%		1, 2, 3, 4, 5, 6

You are expected to do all the assignments/labs.

- All topics covered in lectures, tutorials, assignments, and projects are examinable
- Actual due dates for assignments could vary, please check the submission system.

Reference book

- David A. Patterson and John L. Hennessy, Computer Organization and Design, Fifth Edition, Morgan Kaufmann Publishers.



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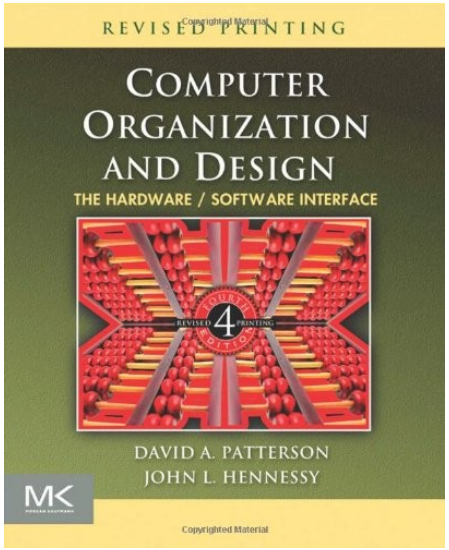


2011

- One copy of the 4th edition of the book is available in the reservation room of our library.

Lecture & tutorial arrangement

Lectures for NWEN 242 are:

Day	Time	Room
Monday	15:10 - 16:00	LT002, Hugh Mackenzie, Kelburn
Wednesday	15:10 - 16:00	LT002, Hugh Mackenzie, Kelburn

Ad-hoc tutorials (only when scheduled) are:

Day	Time	Room
Friday	15:10 - 16:00	LT002, Hugh Mackenzie, Kelburn

Help desk arrangement

- Help desk sessions are provided to help you work on your lab projects and complete homework assignments.

Help desk sessions (start from week 2) have been arranged as below:

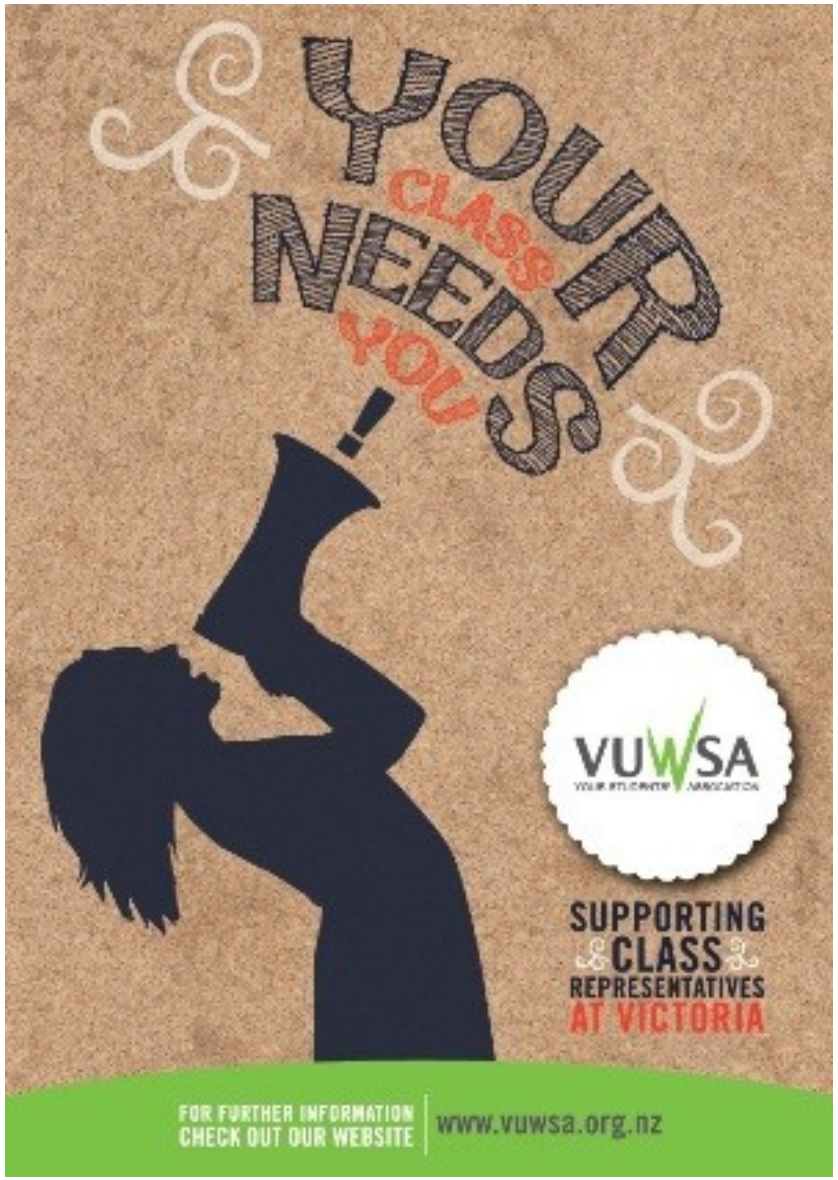
Session	Day	Time	Room
1	Monday	16:00 - 17:00	CO246
2	Tuesday	15:00 - 16:00	CO246
3	Wednesday	11:00 - 12:00	CO246
4	Friday	12:00 - 13:00	CO246

No signup for Helpdesk sessions. Lab project starts from Week 2.

What to do after this lecture

- Look at the course website
  - https://ecs.victoria.ac.nz/Courses/NWEN242_2017T2/
- Refresh your c programming
  - If necessary, follow some online c programming tutorials
  - www.learn-c.org
- Go and buy the course textbook
- Be prepared for your lab project.

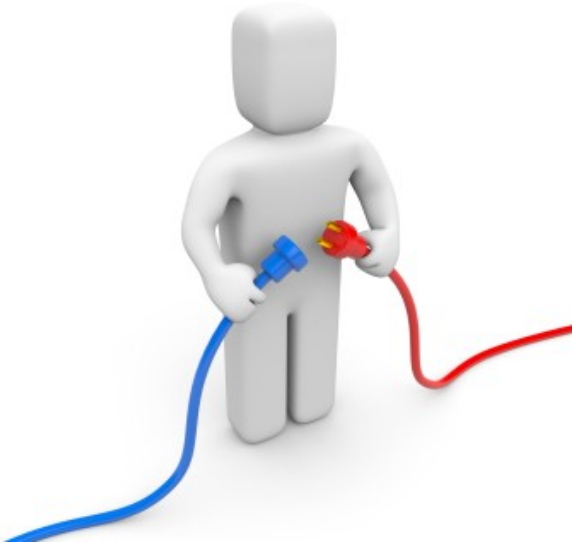
Now it's time to elect your class representative!!!



Let’s start our learning journey together …

NWEN 242

1. Introduction

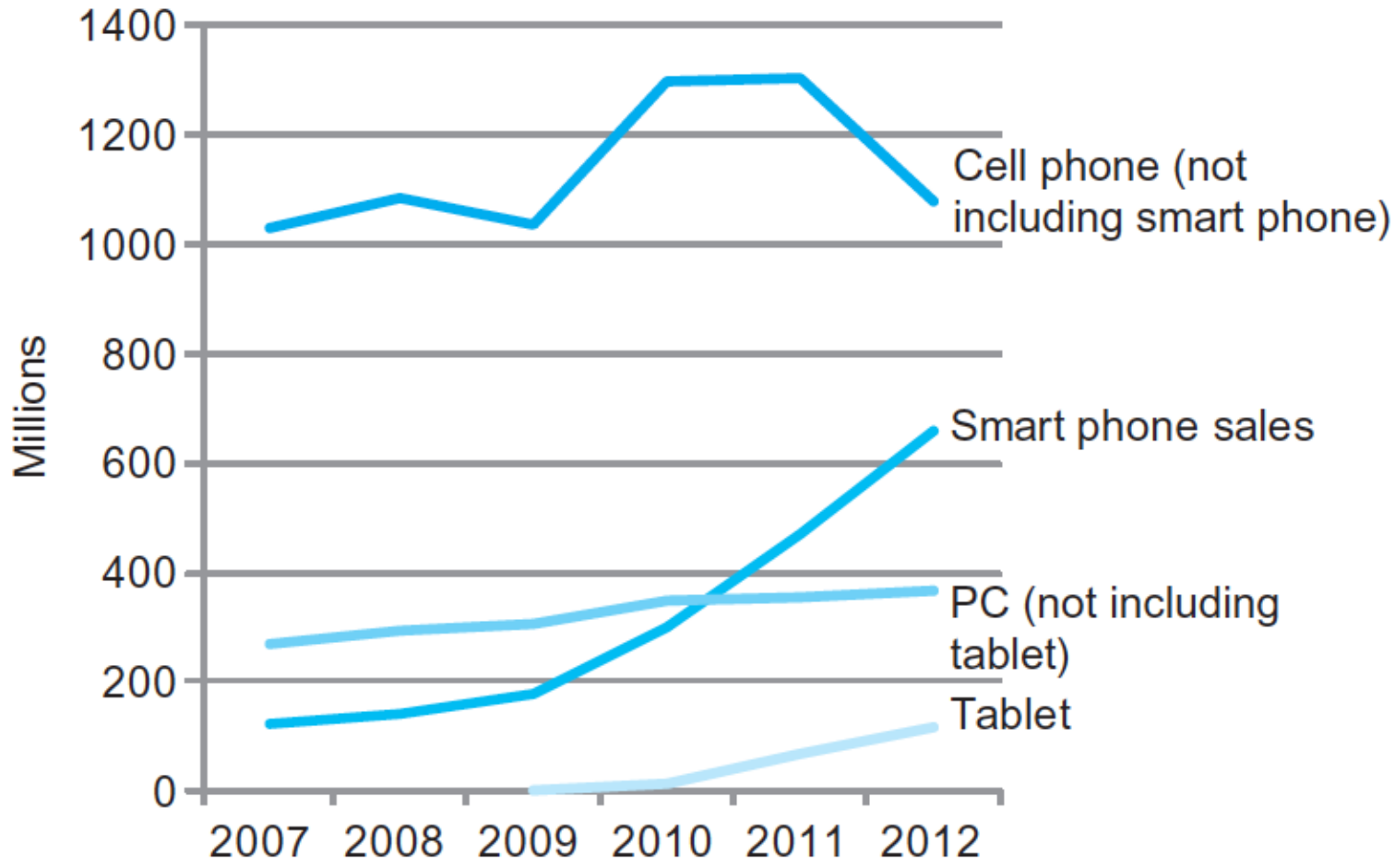


Classes of computing applications/systems

- Desktop computers
  - Designed for use by an individual, usually incorporating a graphics display, a keyboard, and a mouse.
- Server
  - Designed for running large programs for multiple users, often simultaneously, and typically accessed only through a network.
  - small-scale server, supercomputers, Internet datacenters
- Embedded computers
  - A computer inside another device used for running one predetermined application or collection of software.

Which class of computing application is the most widely used?

Fast growth of cell phone market



Fast growth of car automation

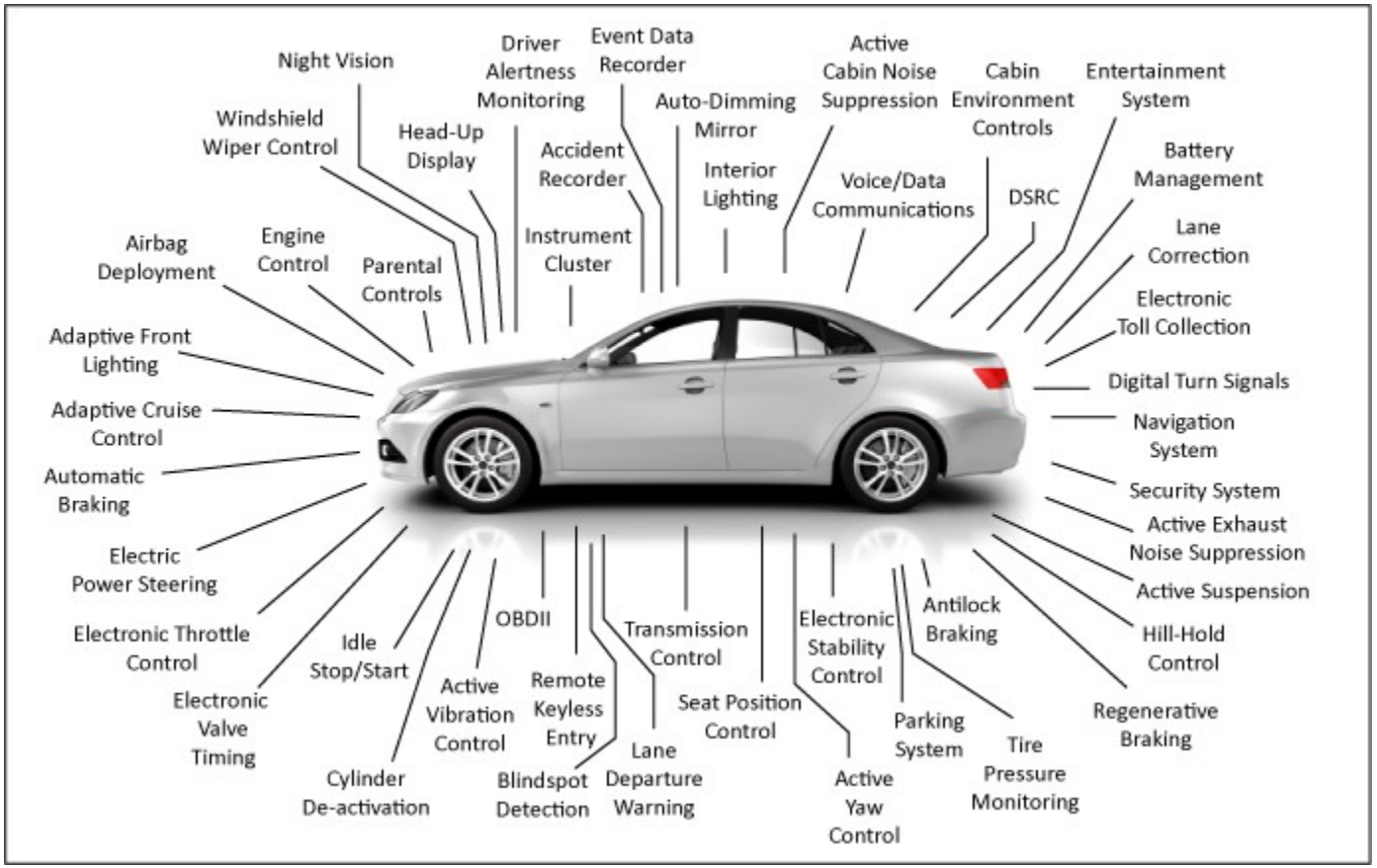


Image source: http://www.chipsetc.com/computer-chips-inside-the-car.html

Fast growth of car automation

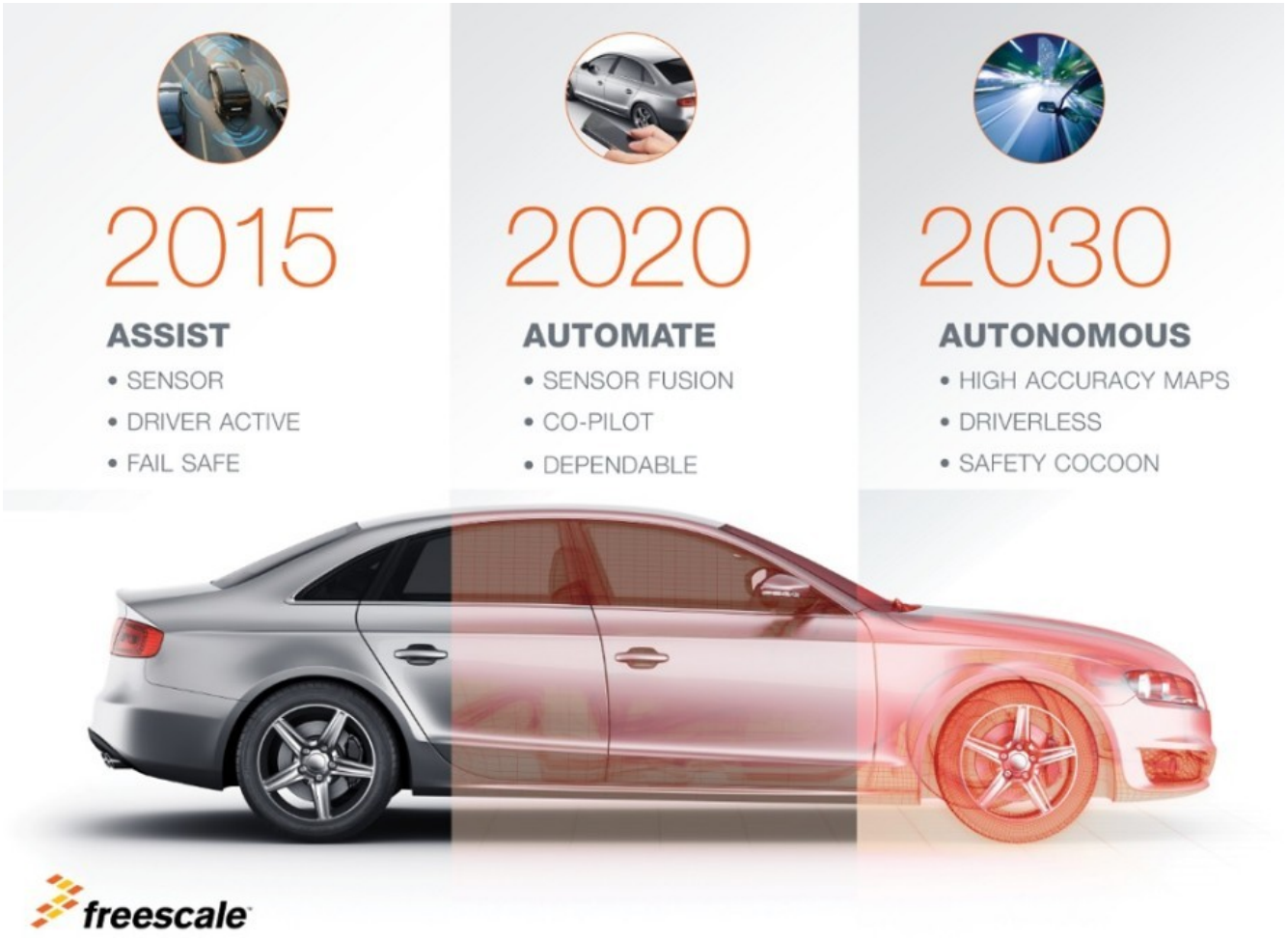


Image source: http://venturebeat.com/2015/03/01/freescale-launches-quad-core-processor-for-self-driving-cars/

Questions we seek to answer in this course

- How are programs written in a high-level language, such as C or Java, translated into language of the hardware, and how does the hardware execute the resulting program?
- What is the interface between the software and hardware
  - How does software instruct the hardware to do *stuff* ?
- What determines the performance of a program, and how can a programmer improve the performance?
- What techniques can be used by hardware designers to improve performance?

Quick exercise

- Which of the following can affect program performance
  - A. Your code
  - B. The compiler
  - C. The CPU
  - D. The I/O subsystem

From a high-level language to the language of the hardware

Program in C

High-level language program (in C)

```
swap(int v[], int k)
{int temp;
   temp = v[k];
   v[k] = v[k+1];
   v[k+1] = temp;
}
```

MIPS assembly program

```
swap:
      muli $2, $5,4
      add  $2, $4,$2
      lw   $15, 0($2)
      lw   $16, 4($2)
      sw   $16, 0($2)
      sw   $15, 4($2)
      jr   $31
```

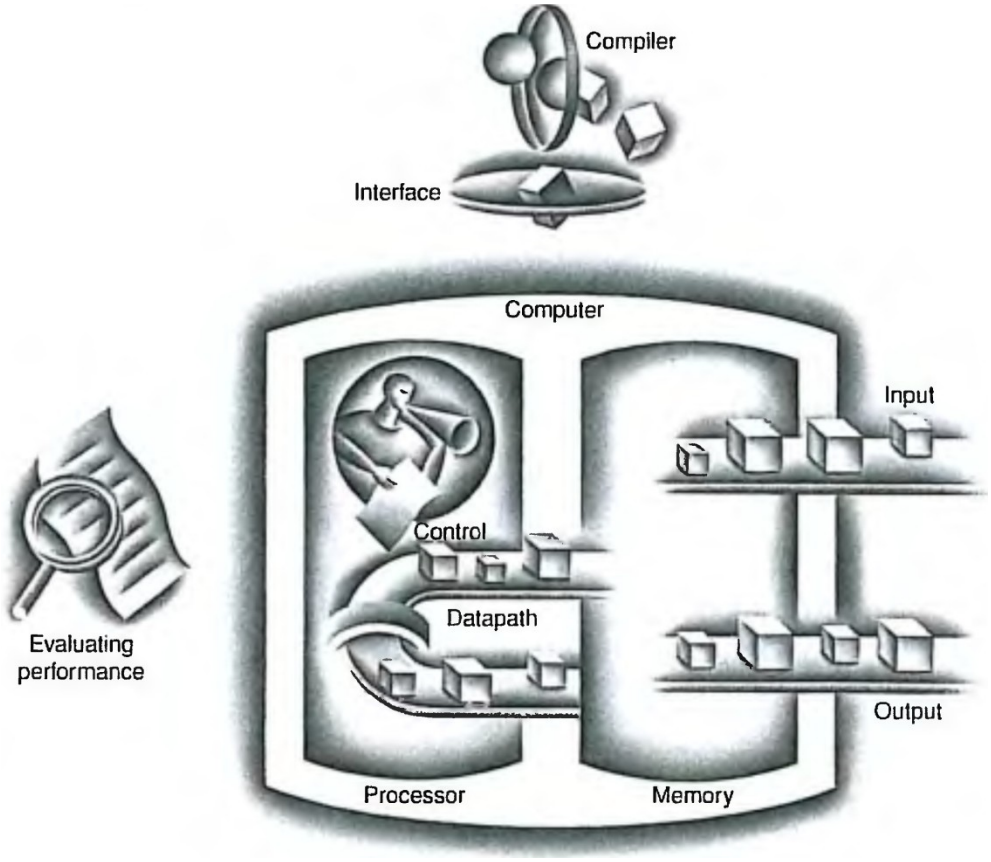
Binary machine language program

```
00000000101000010000000000011000
00000000000011000000110000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

Stored program computer

Organization of a computer

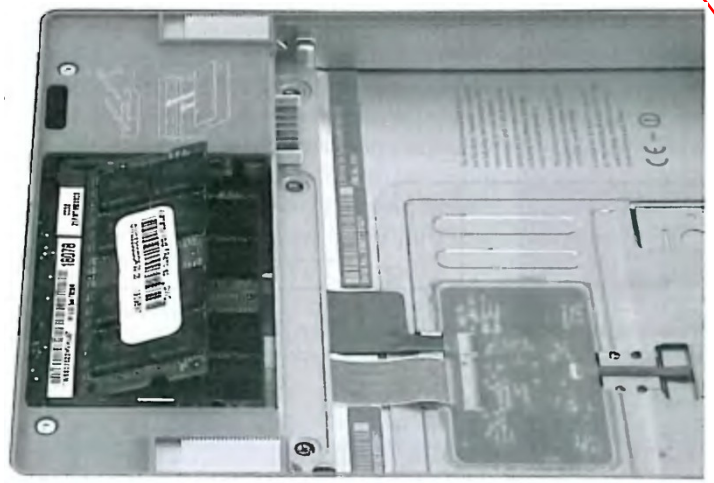
- What are the major components of a computer?



conceptual view

outside view

Memory technology

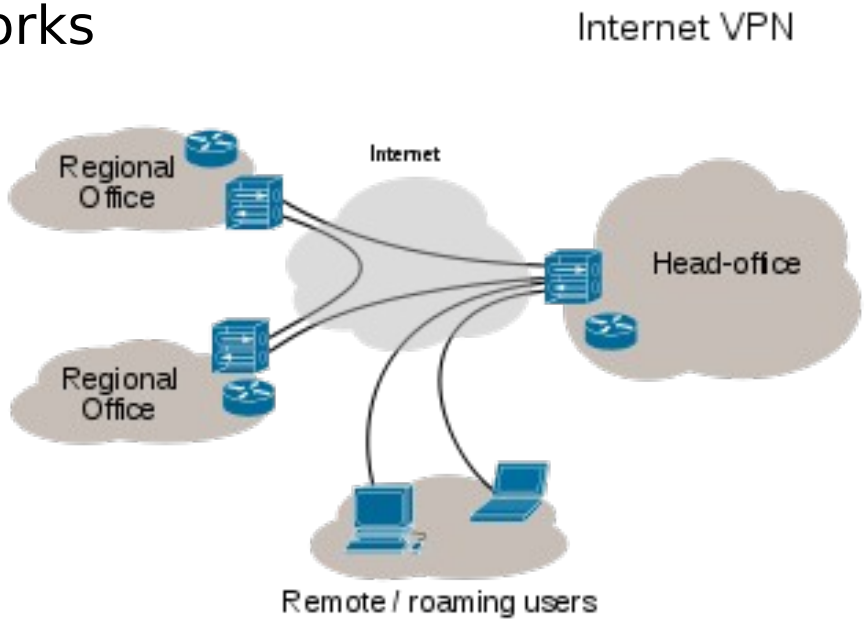


- Main memory (volatile):
  - Dynamic random access memory (DRAM)
  - Synchronous dynamic random access memory (SDRAM)
  - Dual inline memory module (DIMM)

- Cache (volatile)
  - Static random access memory (SRAM)
- Secondary storage (non-volatile)
  - Hard disk, dvd disk & dvd drive, flash drive
  - Use mechanical components
  - DRAM is over 100,000 faster to access than magnetic disks

Communicating with other computers

- Benefits of computer networks
  - Communication
  - Resource sharing
  - Non local access



- Computer network types
  - Local area network
  - Wide area network

- Computer networks are discussed in more detail in NWEN 243

Technologies for building processors and memory

- Transistor: an on/off switch controlled by electricity.
- Integrated circuit: dozens to hundreds of transistors combined into a single chip.
- Very large-scale integrated circuit (VLSI)

Year	Technology used in computers	Relative performance/unit cost
1951	Vacuum tube	1
1965	Transistor	35
1975	Integrated circuit	900
1995	Very large-scale integrated circuit	2,400,000
2005	Ultra large-scale integrated circuit	6,200,000,000

Quick exercise

- What is Moore's law
  - A. the number of transistors in a dense integrated circuit doubles approximately every two years.
  - B. The law is named after Gordon E. Moore, co-founder of Intel Corporation
  - C. Moore's law is considered a natural law in computer science.
  - D. The growth as predicted by Moore's law is likely to increase.

Interesting reading

- Wikipedia (just to get an overview)
  - DRAM
  - SDRAM
  - DIMM
  - SRAM
- Google
  - How many embedded processors in a modern car?
  - Toyota's killer firmware: Bad design and its consequences
  - Killer apps: Embedded software's greatest hits