What we’ll do today?

- Why learn about IT infrastructure?
- What is a computer?
- Introduction to number systems
- The Little Man Computer
- About the course TDDC31
Typical Computer Ad

FASTCAT™ Desktop
Top Performance, Great Value!
- Intel® 2.7 GHz Pentium® 4 Processor
- 1 GB up to 2 GB DDRAM
- 120 GB Ultra ATA 7200 RPM HD 16 MB cache
- 10/100 PCI Ethernet card
- 64 MB GeForce 4x AGP Video
- DVD-ROM/RW + CD-R/RW
- 2 USB-2, 1 IEEE 1394 Firewire®
- 17" Non-Interlaced Full Flat Screen Monitor
- 26gp (1024 x 768) Add $300 for
- 17" TFT LCD (1280 x 1024)

- Is the computer fast enough to run necessary programs?
- Is the computer cost-effective?
- Will it be obsolete in 6 months?

Why Study Computer Architecture?

- User
  - Understand system capabilities and limitations
  - Make informed decisions
  - Improve communications with information technology professionals
- Systems Analyst
  - Conduct surveys, determine feasibility and define and document user requirements
  - Specify computer systems to meet application requirements
- Programmer
  - Create efficient application software for specific processing needs
Why Study Computer Architecture?

- **System Administrator / Manager**
  - Install, configure, maintain, and upgrade computer systems
  - Maximize system availability
  - Optimize system performance
  - Ensure system security
- **Web Designer**
  - Optimize customer accessibility to Web services
  - System administration of Web servers
  - Select appropriate data formats
  - Design efficient Web pages

What is a computer?

- A computer is a data processing machine which is operated automatically under the control of a list of instructions (called a program) stored in its main memory.

- The power of the computer lies in ability to perform simple operations at an extremely high rate of speed.
Input-Process-Output Model (IPO)

- Input: keyboard, mouse, scanner, punch cards
- Processing: CPU executes the computer program
- Output: monitor, printer, fax machine
- Storage: hard drive, optical media, diskettes, magnetic tape

Architecture Components

- **Hardware**
  - Processes data by executing instructions
  - Provides input and output
- **Software**
  - Instructions executed by the system
- **Data**
  - Fundamental representation of facts and observations
- **Communications**
  - Sharing data and processing among different systems
Hardware Component

- Input/Output devices
- Storage Devices
- CPU
  - ALU: arithmetic/logic unit
  - CU: control unit
  - Interface unit
- Memory
  - Short-term storage for CPU calculations

CPU: Central Processing Unit

- ALU: arithmetic/logic unit
  - Performs arithmetic and Boolean logical calculations
- CU: control unit
  - Controls processing of instructions
  - Controls movement of data within the CPU
- Interface unit
  - Moves instructions and data between the CPU and other hardware components
  - Bus: bundle of wires that carry signals and power between different components
Memory

- Also known as primary storage, working storage, and RAM (random access memory)
- Consists of bits, each of which hold a value of either 0 or 1 (8 bits = 1 byte)
- Holds both instructions and data of a computer program (stored program concept)
Software Component

- Applications
- **Operating System**
  - API: application program interface
  - File management
  - I/O
  - Kernel
    - Memory management
    - Resource scheduling
    - Program communication
    - Security
  - Network Module

Communications Component

- Hardware
  - Communication **channels**
    - Physical connections between computer systems
    - Examples: wire cable, phone lines, fiber optic cable, infrared light, radio waves
  - Interface hardware
    - Handles communication between the computer and the communication channel
    - **Modem** or **network interface card (NIC)**
- Software
  - Network protocols: HTTP, TCP/IP, ATAPI
Computer Systems

All computer systems, no matter how complex, consists of the following:
- At least one CPU
- Memory to hold programs and data
- I/O devices
- Long-term storage

Classification of computers:
- Supercomputers (superdatorer)
- Mainframe computers (stordatorer)
- Office computers (kontorsdatorer)
- Embedded computers (inbyggda datorer)

Protocols

- Common ground rules of communication between computers, I/O devices, and many software programs
- Examples
  - HTTP: between Web servers and Web browsers
  - TCP/IP: between computers on the Internet and local area networks
  - ATAPI: between a CPU and CD-ROMs
Standards

- Created to ensure universal compatibility of data formats and protocols
- May be created by committee or may become a de facto standard through popular use
- Examples:
  - Computer languages: Java, SQL, C, JavaScript
  - Display standards: Postscript, MPEG-2, JPEG, GIF
  - Character set standards: ASCII, Unicode, EBCDIC
  - Video standards: VGA, XGA, RGB

Number systems

- Computers use **binary**, or base 2, number system
- Each digit in a binary number is known as **bit**
- **Byte** = 8 bits
- We count in **decimal**, or base 10, number system
- Different number systems are really just a different way of **representing** the same number
Numbers: Physical Representation

- Different numerals, same number of oranges
  - Cave dweller: I III I
  - Roman: V
  - Arabic: 5
- Different bases, same number of oranges
  - $5_{10}$
  - $101_2$
  - $12_3$

Number System

- Roman: position independent
- Modern: based on positional notation (place value)
  - Decimal system: system of positional notation based on powers of 10.
  - Binary system: system of positional notation based powers of 2
  - Octal system: system of positional notation based on powers of 8
  - Hexadecimal system: system of positional notation based powers of 16
Positional Notation: Base 10

\[ 527 = 5 \times 10^2 + 2 \times 10^1 + 7 \times 10^0 \]

<table>
<thead>
<tr>
<th>Place</th>
<th>$10^2$</th>
<th>$10^1$</th>
<th>$10^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>100</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Evaluate</td>
<td>$5 \times 100$</td>
<td>$2 \times 10$</td>
<td>$7 \times 1$</td>
</tr>
<tr>
<td>Sum</td>
<td>500</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

Positional Notation: Binary

\[ 1101 \ 0110_2 = 214_{10} \]

<table>
<thead>
<tr>
<th>Place</th>
<th>$2^7$</th>
<th>$2^6$</th>
<th>$2^5$</th>
<th>$2^4$</th>
<th>$2^3$</th>
<th>$2^2$</th>
<th>$2^1$</th>
<th>$2^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Evaluate</td>
<td>$1 \times 128$</td>
<td>$1 \times 64$</td>
<td>$0 \times 32$</td>
<td>$1 \times 16$</td>
<td>$0 \times 8$</td>
<td>$1 \times 4$</td>
<td>$1 \times 2$</td>
<td>$0 \times 1$</td>
</tr>
<tr>
<td>Sum for Base 10</td>
<td>128</td>
<td>64</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
Range of Possible Numbers

- $R = B^K$ where
  - $R =$ range
  - $B =$ base
  - $K =$ number of digits
- Example #1: Base 10, 2 digits
  - $R = 10^2 = 100$ different numbers (0…99)
- Example #2: Base 2, 16 digits
  - $R = 2^{16} = 65,536$ or $64K$
  - 16-bit PC can store 65,536 different number values

Decimal Range for Bit Widths

<table>
<thead>
<tr>
<th>Bits</th>
<th>Digits</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0+</td>
<td>2 (0 and 1)</td>
</tr>
<tr>
<td>4</td>
<td>1+</td>
<td>16 (0 to 15)</td>
</tr>
<tr>
<td>8</td>
<td>2+</td>
<td>256</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1,024 (1K)</td>
</tr>
<tr>
<td>16</td>
<td>4+</td>
<td>65,536 (64K)</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
<td>1,048,576 (1M)</td>
</tr>
<tr>
<td>32</td>
<td>9+</td>
<td>4,294,967,296 (4G)</td>
</tr>
<tr>
<td>64</td>
<td>19+</td>
<td>Approx. $1.6 \times 10^{19}$</td>
</tr>
<tr>
<td>128</td>
<td>38+</td>
<td>Approx. $2.6 \times 10^{38}$</td>
</tr>
</tbody>
</table>
Base or Radix

- **Base:**
  - The number of different symbols required to represent any given number
- **The larger the base, the more numerals are required**
  - Base 10: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
  - Base 2: 0, 1
  - Base 8: 0, 1, 2, 3, 4, 5, 6, 7
  - Base 16: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Number of Symbols vs. Number of Digits

- For a given number, the **larger** the base
  - the **more** symbols required
  - but the **fewer** digits needed
- **Example #1:**
  - 65₁₆ 101₁₀ 145₈ 110 010₁₂
- **Example #2:**
  - 11C₁₆ 28₄₁₀ 43₄₈ 1 0001 110₀₂
### Counting in Base 2

<table>
<thead>
<tr>
<th>Binary Number</th>
<th>Equivalent</th>
<th>Decimal Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 x 2^0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1 x 2^0</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1 x 2^1</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>1 x 2^1</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>1 x 2^1</td>
<td>4</td>
</tr>
<tr>
<td>101</td>
<td>1 x 2^2</td>
<td>5</td>
</tr>
<tr>
<td>110</td>
<td>1 x 2^2</td>
<td>6</td>
</tr>
<tr>
<td>111</td>
<td>1 x 2^2</td>
<td>7</td>
</tr>
<tr>
<td>1000</td>
<td>1 x 2^3</td>
<td>8</td>
</tr>
<tr>
<td>1001</td>
<td>1 x 2^3</td>
<td>9</td>
</tr>
<tr>
<td>1010</td>
<td>1 x 2^3</td>
<td>10</td>
</tr>
</tbody>
</table>

### Hexadecimal numbers

- Commonly used as a shorthand notation for binary numbers
- Each hexadecimal number exactly represents 4 binary bits

2A4F<sub>16</sub> is equivalent to
2 x 16<sup>3</sup> + 10 x 16<sup>2</sup> + 4 x 16 + 15, or
10831<sub>10</sub>
Little Man Computer

Instructions of LMC

- All numbers in LMC have only 3 digits
- First digit will be used for instruction code or operation code (op code)
- Second two will be used for mailbox address, if operation requires use of a mailbox.

- LOAD (op code 5)
- STORE (op code 3)
- ADD (op code 1)
- SUBTRACT (op code 2)
- INPUT (op code 9, “address” 01)
- OUTPUT (op code 9, “address” 02)
- COFFEE BREAK (op code 0)
A simple program in LMC

- \( A = B + C \)

<table>
<thead>
<tr>
<th>mbox</th>
<th>code</th>
<th>instruction description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>901</td>
<td>INPUT B</td>
</tr>
<tr>
<td>01</td>
<td>399</td>
<td>STORE DATA</td>
</tr>
<tr>
<td>02</td>
<td>901</td>
<td>INPUT C</td>
</tr>
<tr>
<td>03</td>
<td>199</td>
<td>ADD B TO C</td>
</tr>
<tr>
<td>04</td>
<td>902</td>
<td>OUTPUT RESULT (A)</td>
</tr>
<tr>
<td>05</td>
<td>000</td>
<td>HALT</td>
</tr>
<tr>
<td>99</td>
<td></td>
<td>DATA</td>
</tr>
</tbody>
</table>
Internal computer data format

- In computer, all data is stored as binary numbers of various sizes.
- Programming languages provide data types to interpret and use the binary data:
  - Boolean
  - char
  - integer
  - real
  - enumerated data types

The instruction cycle. FETCH portion.

1. The little man reads the address from the location counter
2. ... walks over to the mailbox that corresponds to the location counter
**FETCH portion (continued)**

1. ... and read the number on the slip of paper. (If the user asks for the slip of paper back, in case he should need to read it again later.)

**EXECUTE portion of the instruction cycle**

1. The Little Man goes to the mailbox address specified in the instruction he previously fetched.

2. ... he reads the number from the mailbox (he remembers to replace it in case it's needed again.)
EXECUTE portion (continued)

The components of the CPU
The Little Man Computer revisited

Course objectives

- After the completed course you will have the basic knowledge about software and hardware aspects of IT-infrastructure.
- The aim is to get insights about the infrastructure of IT:
  - Computer architecture,
  - Operating systems and
  - Computer networks.
Course contents and organization

- The course consists of a series of lectures that covers basic terminology and concepts, covering three main areas: Computer architecture, Operating systems and Computer networks.
- As a project work (in groups of 4), you will also perform a study in which you will investigate an IT-subject and present the results in a written report. More on the project later in the course.

Literature


See reading guidelines on the course webpage
Alternative sources of information

- **Computer Science** – an overview, 7th ed, J. Glenn Brookshear, Addison Wesley, 2003
- **Grundläggande datorteknik**, Olof Roos, Studentlitteratur, 1995
- **Datorsystem – Program- och maskinvara**, Mats Brorsson, Studentlitteratur, 1999
- **Webopedia** - online dictionary and search engine for computer and Internet technology. http://www.webopaedia.com/

Teachers

**Course leader, examiner**
- Krisjanis Steins, e-mail: krist@ida.liu.se

**Teachers**
- Petru Eles (Computer Architecture)
- Alexandru Andrei (Operating Systems)
- Juha Takkinen (Computer Networks)

**Project supervisors**
- Erik Bergström
- Krisjanis Steins
- Vivian Vimarlund
# Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Information</th>
<th>Room</th>
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<tbody>
<tr>
<td><strong>Week 35</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon 28 Aug</td>
<td>Lect 1</td>
<td>Introduction, basic concepts and definitions</td>
<td>S6</td>
</tr>
<tr>
<td>H 8-10</td>
<td></td>
<td>Individual project work</td>
<td></td>
</tr>
<tr>
<td>Tue 29 Aug</td>
<td>Lect 2</td>
<td>Computer Architecture, part 1</td>
<td>S41</td>
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<tr>
<td>H 13-15</td>
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<tr>
<td>Fri 1 Sept</td>
<td>Lect 3</td>
<td>Computer Architecture, part 2</td>
<td>R41</td>
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<tr>
<td>H 10-12</td>
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<tr>
<td><strong>Week 36</strong></td>
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<tr>
<td>Tue 5 Sept</td>
<td>Lect 4, 5</td>
<td>Operating systems, part 1 and 2</td>
<td>S41</td>
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<tr>
<td>H 13-17</td>
<td></td>
<td>Alexander Andrei / IDA</td>
<td></td>
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<tr>
<td>Fri 8 Sept</td>
<td>Lect 6</td>
<td>Operating systems, part 3</td>
<td>S32</td>
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<tr>
<td>H 10-12</td>
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<td>Alexander Andrei / IDA</td>
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<tr>
<td><strong>Week 37</strong></td>
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<tr>
<td>Mon 11 Sept</td>
<td>Lect 7</td>
<td>Introduction to project work</td>
<td>S22</td>
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<td>H 10-12</td>
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<td>Karina Stens / IDA</td>
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<tr>
<td>Fri 15 Sept</td>
<td>Lect 8</td>
<td>Networks, part 1</td>
<td>S32</td>
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<tr>
<td>H 10-11</td>
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<td>John Talvrem / IDA</td>
<td></td>
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**Economic Information Systems**  
Department of Computer and Information Science, Linköping University  
Linköping, HT2006

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**Schedule, continued**

<table>
<thead>
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<th>Time</th>
<th>Activity</th>
<th>Information</th>
<th>Room</th>
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<tr>
<td><strong>Week 38</strong></td>
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<tr>
<td>Tue 19 Sept</td>
<td>Lect 9</td>
<td>Networks, part 2</td>
<td>R41</td>
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<tr>
<td>H 13-15</td>
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<td>Karina Stens / IDA</td>
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<td><strong>Week 39</strong></td>
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<tr>
<td>Tue 26 Sept</td>
<td>Lect 10</td>
<td>Networks, part 3</td>
<td>R41</td>
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<tr>
<td>H 13-15</td>
<td></td>
<td>John Talvrem / IDA</td>
<td></td>
</tr>
<tr>
<td>Thu 28 Sept</td>
<td>Groupwork</td>
<td>Project work</td>
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<td>H 17-21</td>
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<td><strong>Week 40</strong></td>
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<td>Tue 3 Oct</td>
<td>Groupwork</td>
<td>Project work</td>
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<td>H 17-21</td>
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<tr>
<td><strong>Week 41</strong></td>
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<tr>
<td>Tue 10 Oct</td>
<td>Quiz</td>
<td>Written test</td>
<td>VAL</td>
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<tr>
<td>H 13-17</td>
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<td>Karina Stens / IDA</td>
<td></td>
</tr>
<tr>
<td>Tue 10 Oct</td>
<td>Groupwork</td>
<td>Project work</td>
<td></td>
</tr>
<tr>
<td>H 17-23</td>
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<td></td>
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</table>

**Computer Hardware & Systems Software**

Economic Information Systems  
Department of Computer and Information Science, Linköping University  
Linköping, HT2006
The course has the following examination items:

- **Project work.** Group work (group size - 4 students), resulting in a written report about a selected and approved topic related to course objectives. (Grade = Pass/Fail)
- **Written test.** Individual written test (a shorter exam), on topics covered in lectures and in the textbook. (Grade = U,3,4,5)

Example project topics

- Stock trading over internet
- E-mail security
- Bluetooth technology
- Firewalls
- Smartcards
- Comparison of CPUs for PCs (Intel, AMD)
- Mobile internet solutions
- …
Important dates

- Week 35/36 (latest at September 8)
  Form project groups and propose a topic, send information to Kriss (krist@ida.liu.se)
- Week 41, Written test, 10/10, 13-17.
- Week 42, 16/10, Deadline for submitting the project report.
- More information on course homepage
  http://www.ida.liu.se/~TDDC31

Questions?