COMP2611: Computer Organization

Programs and Numbers

Overview

- You will learn the following in this tutorial:
  - the compilation process of computer programs into machine instructions.
  - the conversion between binary, decimal and hexadecimal numbers.
  - the computer numerical unit prefix.

Programs and Numbers

Computer programs

- the compilation process

Number bases

- the introduction of different bases

Conversion between binary and decimal

- conversion methods and exercises

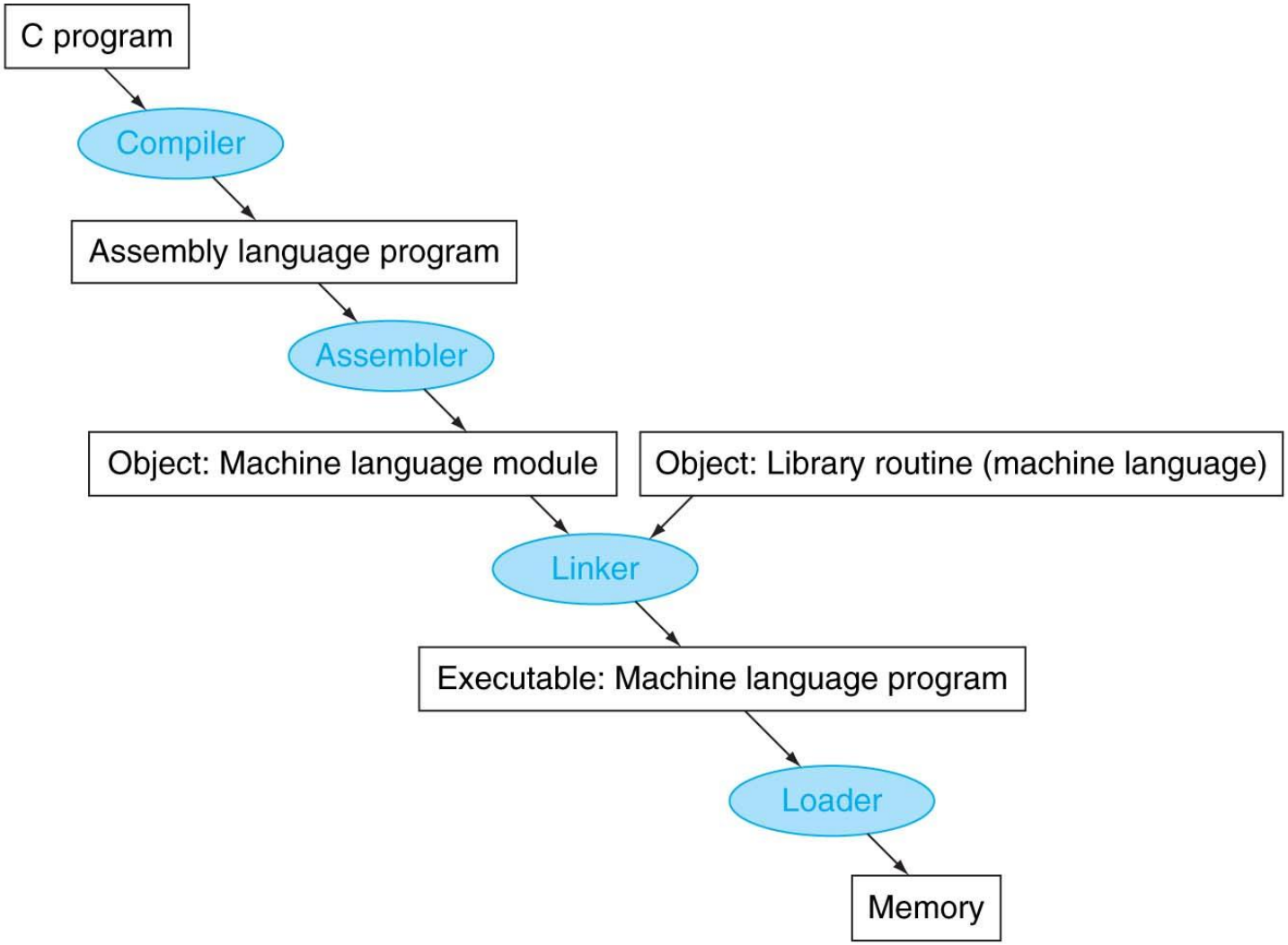
Conversion between binary and hexadecimal

- conversion methods and exercises

Computer numerical unit prefix

Exercises

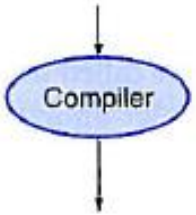
Computer programs



Programs for MIPS processor

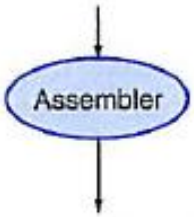
High-level language program (in C)

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



Assembly language program (for MIPS)

```
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 (for MIPS)

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

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Number bases

- Numbers can be represented using various bases.
  - i.e. base 2, base 10, base 16, etc.
- Decimal numbers are of base 10.
  - For example, $174_{(10)} = (1 \times 10^2) + (7 \times 10^1) + (4 \times 10^0)$
- Binary representation (base 2) is the basis of digital data.
  - For example, $18_{(10)} = 10010_{(2)}$
- If a number is represented using the base x, each digit of the number can only be one of the values 0, 1, 2, …, x – 1.
- For example, a digit of a binary number (called a *bit*) is either 0 or 1.

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Exercises

Converting positive decimal integer to binary

- We keep on dividing the decimal integer by 2 until the quotient is 0. The remainder at each step corresponds to a digit of the integer in base 2, from the Least Significant Digit (LSD) to the Most Significant Digit (MSD).

Exercises

Question 1: Convert $37_{(10)}$ to the binary format.

Converting positive binary integer to decimal

- The value represented by the i-th bit d of a positive binary integer is in fact d x 2^i. Note that the Least Significant bit is the 0-th bit.
- Take the integer $ABCD_{(2)}$ as an example, it effectively corresponds to:

  $ABCD_{(2)} = (Ax2^3) + (Bx2^2) + (Cx2^1) + (Dx2^0)$

2's power	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}
value	2	4	8	16	32	64	128	256	512	1024

Exercises

Question 1: Convert the positive integer 10 $1001_{(2)}$ to the decimal format.

Converting positive binary integer to decimal

- A positive integer of the base t can be represented by a polynomial of t: the i-th digit d of the integer is in fact d x t^i.
- Take the integer $ABCD_{(t)}$ as an example, it effectively corresponds to:

  $ABCD_{(t)} = (A \times t^3) + (B \times t^2) + (C \times t^1) + (D \times t^0)$

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Exercises

Hexadecimal format

- The binary number system is verbose in that even small numerical values could require long strings of bits to represent.
- Hexadecimal number system is a number system that has a base of 16 (instead of 2).
- Under the hexadecimal system, there are 16 possible values for each digit, as shown in the table.

Decimal value	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hexa-decimal digit	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Converting binary number to hexadecimal

- We just group the binary number into groups of 4 bits, and then each group represents one digit of the corresponding hexadecimal number.
- The conversion can be made immediately by eye inspection.

Exercises

Question 1: Convert $0011\ 0010_{(2)}$ to the hexadecimal format.

Converting hexadecimal number to binary

- We just expand each digit of the hexadecimal number into 4 bits, and then the resulting bits from all the digits represent the corresponding binary number.
- Again, the conversion can be made immediately by eye inspection.

Question 1: Convert $A7_{(16)}$ to the binary format.

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Computer numerical unit prefix

- For representing a number of bits or bytes in computers, the unit prefix Kilo is often used to represent 2^{10} (equal to 1024) not 1000.
- For examples, 1 kilobytes = 1024 bytes and 1 kilobits = 1024 bits.
- Similarly, we have the following table for the common prefixes used for bytes and bits:

Unit prefix	Value
Kilo	2^{10} (or 1024)
Mega	2^{20} (or 2^{10} Kilo)
Giga	2^{30} (or 2^{10} Mega)
Tera	2^{40} (or 2^{10} Giga)

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Question 1: Convert $176_{(10)}$ to the binary format.

Exercises

Question 2: Convert the positive integer $11\ 0100\ 1001_{(2)}$ to the decimal format.

Exercises

Question 3: Convert $1010\ 0011\ 1001\ 0111\ 0100_{(2)}$ to the hexadecimal format.

Exercises

Question 4: Convert $B12A3F01_{(16)}$ to the binary format.

Conclusion

- You have learnt:
  - the compilation process of computer programs into machine instructions.
  - the conversion between binary, decimal and hexadecimal numbers.
  - the computer numerical unit prefix.