C# Programming

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Online Course

Class Information

- Instructor: Zheng-Liang Lu (Arthur)
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- The course website is

  https://www.csie.ntu.edu.tw/~d00922011/csharp.html.
- All lecture slides are organized in English and will be modified if necessary.

Teaching Philosophy

- I try to lower the barriers to entry.
- I provide resources as many as possible.
- I answer your questions.

Learning Tips

- Start with just one language and master it.
- Ask lots of questions; Google first.
- Practice makes permanent (and hopefully, perfect).[1]
- It may take 10000 hours, more or less; it is never too late.
- Grasp the fundamentals for long-term benefits; code from the bottom.
- Code by hand.[2]

[1] Try `https://leetcode.com/`.

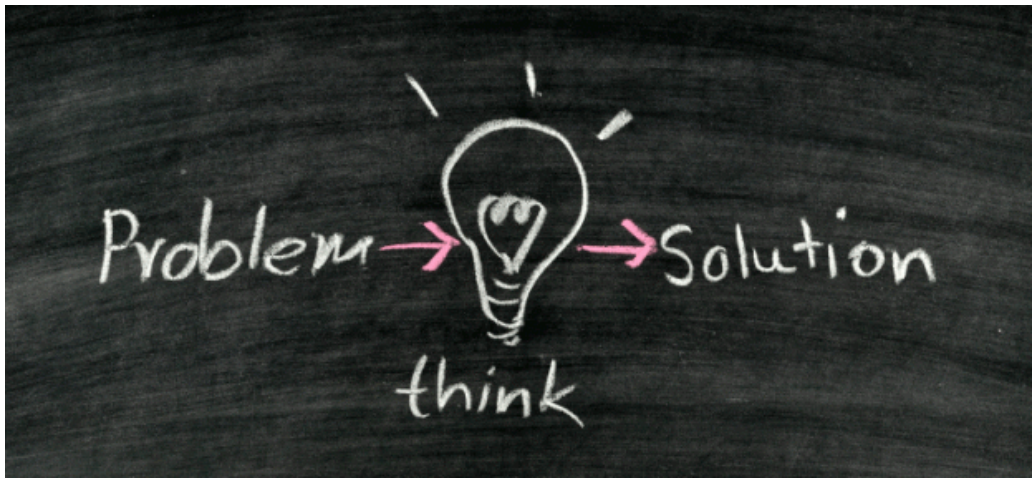
[2] It sharpens proficiency and you'll need it to get a job.

```
1 class Lecture1 {
2
3                     "Introduction"
4
5 }
6
7 // Keywords:
8 using, namespace, class, static, void, string
```


PROGRAMMER
WHAT MY MOM THINKS I DO
WHAT MY FRIENDS THINK I DO
WHAT SOCIETY THINKS I DO
[JavaScript Application]
Hello, world!
OK
WHAT ARTISTS THINK I DO
WHAT I THINK I DO
WHY WON'T YOU COMPILE?
WHAT I ACTUALLY DO

Goal

- Programming is to provide a solution to a real-world problem using computational models supported by programming languages.
- The resulting solution is a program.



Programs

- A program is a collection of instructions, written in an artificial language, to perform a specified task executed by computers.
- They are almost everywhere, for example,
  - Video games (e.g. Pokémon Go, Travel Frog, ...);
  - Operating systems (e.g. Linux, ...);
  - Transportations (e.g. traffic light, MRT, airplane, ...);
  - Search engine (e.g. Google, ...);
  - Robotics[3];
  - Computer virus[4];
  - and more.

[3] See `https://www.bostondynamics.com/` and watch `https://www.youtube.com/watch?v=7Q3YW-3KCzU`.

[4] See `http://en.wikipedia.org/wiki/Computer_virus`.

How to Run Programs[8]

- Once the program is activated, both data and instructions are loaded from the disk into the main memory.
- We now call it a process, which is the smallest unit of resource allocation.[5]
- Then the instructions in the program are scheduled to be executed by the CPU.[6]
  - A CPU contains arithmetic & logic units (ALUs), control units, and registers.[7]
- The immediate result is stored back to the main memory and further written into the disk if necessary.

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[5] See `https://en.wikipedia.org/wiki/Process_(computing)`.

[6] See `https://en.wikipedia.org/wiki/Scheduling_(computing)`.

[7] See `https://en.wikipedia.org/wiki/Central_processing_unit`.

[8] See `http://ed.ted.com/lessons/inside-your-computer-bettina-bair`.

Memory Hierarchy[9]

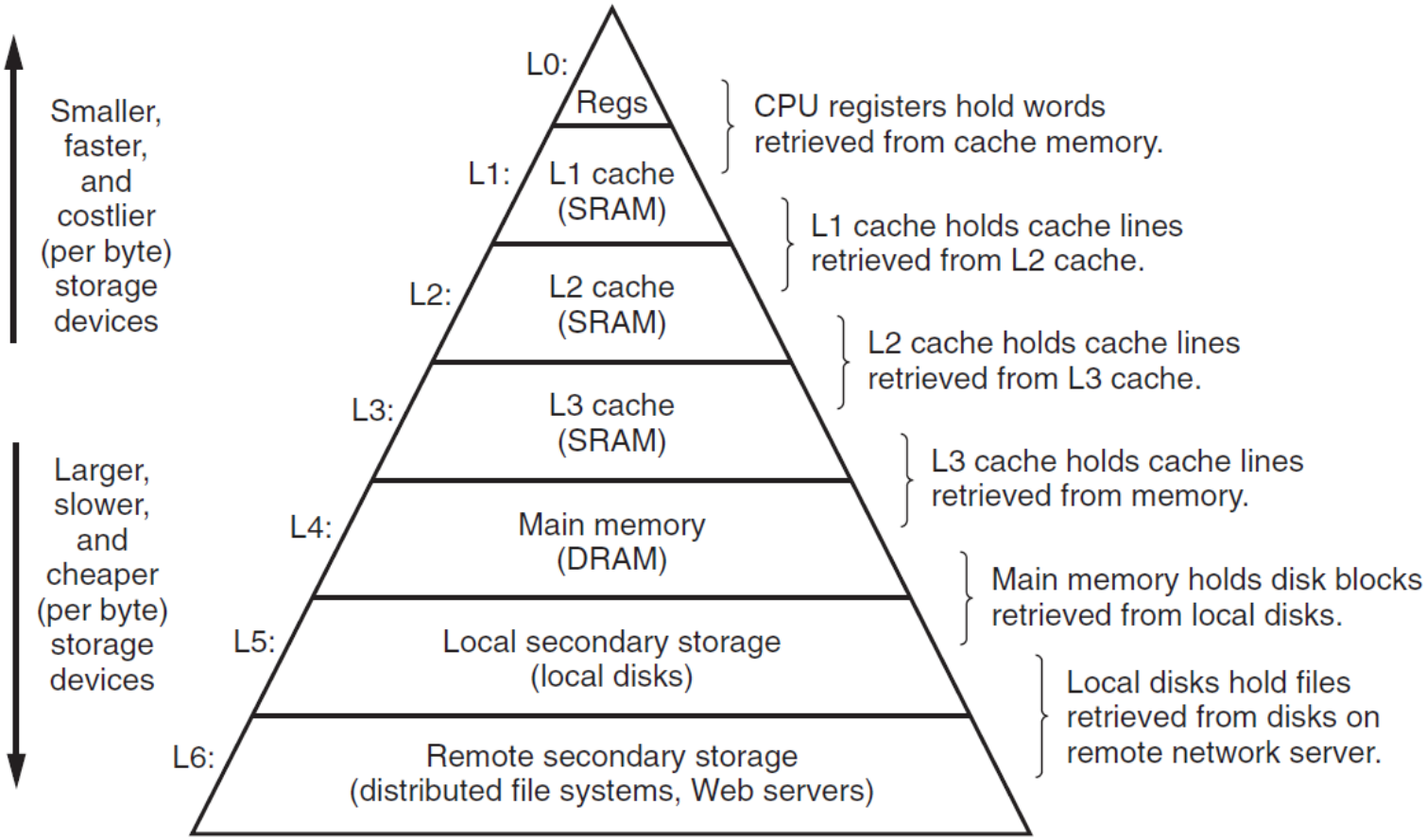

Figure 1.9 **An example of a memory hierarchy.**

[9] See Figure 1-9 in Bryant, p. 14.

Programming Languages

- A programming language is an artificial language to communicate with machines.[10]
- The elements of programming languages are syntax and semantics, used to control the behavior of machines.
- Top 20 programming languages can be found in TIOBE.
- Every language originated from some reasons.

[10] See `https://en.wikipedia.org/wiki/Programming_language`.

Short History[14]

- 1st generation: machine code.
- 2nd generation: assembly code.
- 3rd generation: high-level programming languages.
  - For example, C[11], C++[12], [13], and C#.
- 4th generations.
  - For example, SQL.

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[11] Dennis Ritchie (1973).

[12] Bjarne Stroustrup (1983).

[13] James Gosling (1995).

[14] See https://en.wikibooks.org/wiki/A-level_Computing_2009/AQA/Computer_Components,_The_Stored_Program_Concept_and_the_Internet/Fundamentals_of_Computer_Systems/Generations_of_programming_language and https://www.computerhope.com/history/programming.htm.

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;
}
```

Compiler

Assembly language program (for MIPS)

```
swap:
      multi $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
```

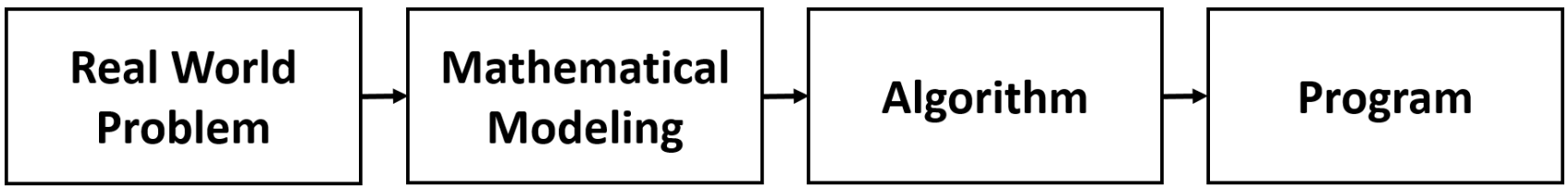
Assembler

Binary machine language program (for MIPS)

```
00000000101000100000000100011000
00000000100000100001000000100001
10001101111000100000000000000000
10001110000100100000000000000100
10101110000100100000000000000000
10101101111000100000000000000100
00000011111000000000000000001000
```

What Can A Program Do?

- A program is an implementation of an algorithm expressed in a specific programming language.

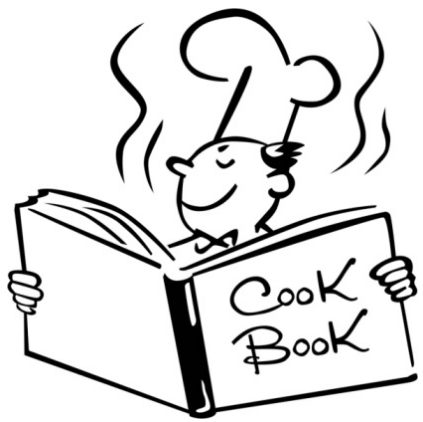


- It is similar to the roles in one software project: SA, SD, RD, and PG.[15]

[15] SA: System Analyst (do the right thing), SD: System Designer (do the thing right), RD: ~~Ready to Die~~ Research and Development Engineer, PG: Programmer.

Algorithms In A Nutshell[16]

- An algorithm is a well-defined computational procedure that takes necessary information as input and produces an correct answer as output.
- Simply put, an algorithm is a procedure that solves a specific class of problems, like a recipe or a cookbook.



[16] Also see `http://ed.ted.com/lessons/your-brain-can-solve-algorithms-david-j-malan`.

- An algorithm has properties as follows:
  - Definiteness: all steps are precisely defined.
  - Finiteness: for any input, the algorithm must terminate after a finite number of steps (time).
  - Effectiveness: operations are basic enough (e.g. $+ - \times \div$) to be able to done exactly and in a finite number of steps.
- Note that an algorithm could be expressed not only in programming languages, but also in human languages, flow charts, and pseudo codes.

Example: Greatest Number

- Let A be a list of numbers.
- For example, consider $A = \{1, 7, 9, -2, 4\}$.
- Then it is clear that the answer is 9.
- Now propose an algorithm which finds the greatest element in for any list of numbers.

Input: A.
Output: the greatest element in A.

- Try a top-down approach in your native language?

Optimal Solution

- Let $A(1)$ be the first element of A and so on.
- The symbol $\leftarrow$ is a copy operator from right to left.

```
1 max <- A(1) // Initial guess, without loss of generality!
2 for i <- 2 ~ n
3     if A(i) > max
4         max <- A(i)
5     end
6 end
7 return max
```

- In Line 1, why not $\boxed{\text{max} \leftarrow 0}$ but $\boxed{\text{max} \leftarrow A(1)}$?
- You may extend this solution to more questions:
  - Smallest element?
  - Location of the greatest element?

"Computers are good at following instructions, but not at reading your mind."

– Donald Knuth (1938-)

"There are two ways of constructing a software design: One way is to make it so simple that there are obviously no deficiencies, and the other way is to make it so complicated that there are no obvious deficiencies. The first method is far more difficult."

– Tony Hoare (1934-)

Alan Turing

- Provided a formalization of the concepts of algorithm and computation with the Turing machine[17], which can be considered a model of a general-purpose computer.
- Proposed the famous question: "*Can machines think?*"[18]
  - Well-known as the Turing test.
- Turing Award is recognized as the highest distinction in computer science and the"Nobel Prize of computing".[19]

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[17] Turing (1936). Try `http://www.google.com/doodles/alan-turings-100th-birthday`.

[18] Turing (1950). You could find the paper here: `https://phil415.pbworks.com/f/TuringComputing.pdf`. Also see `https://en.wikipedia.org/wiki/Turing_test`.

[19] See `https://en.wikipedia.org/wiki/Turing_Award#Recipients`.

- You may watch The Imitation Game (2014).
- Britain's £50 note will honor computing pioneer Alan Turing.[20]

[20] See `https://www.nytimes.com/2019/07/15/business/alan-turing-50-pound-note.html`.

About C#

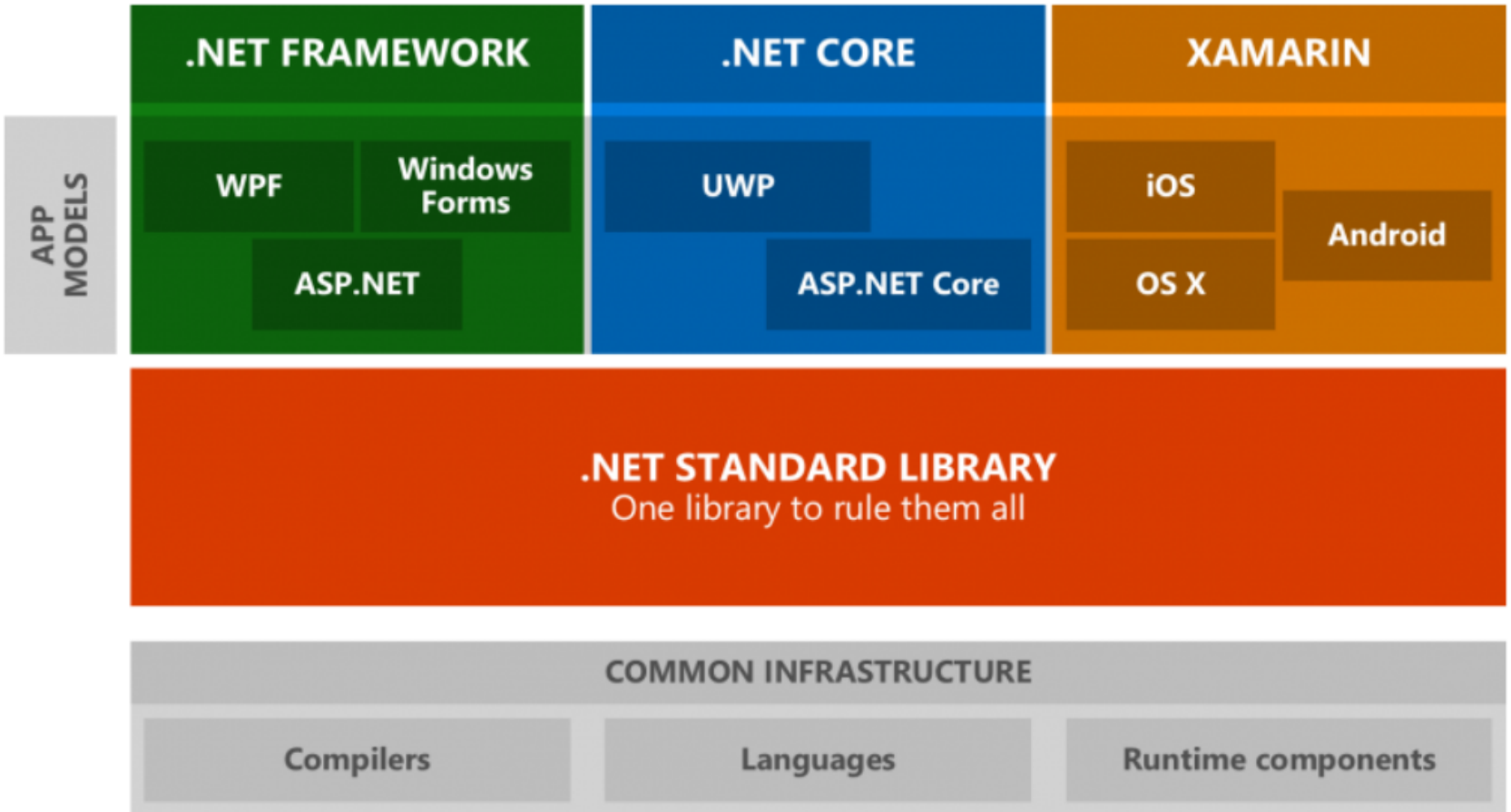
- C# was first appeared in 2000 by Microsoft as part of its .NET initiative.[21]
- C# is based on C++ and Java with additional extensions.[22]
- The mainstream version of C# is 7.x while the latest version released in 2019 is 8.0.[23]

[21] See https://docs.microsoft.com/en-us/dotnet/csharp/whats-new/csharp-version-history.

[22] See https://en.wikipedia.org/wiki/Comparison_of_C_Sharp_and_Java and https://www.guru99.com/java-vs-c-sharp-key-difference.html.

[23] See https://www.jetbrains.com/lp/devecosystem-2019/csharp/.

Microsoft Tech Stack[24]



[24] See https://dotnetprofessionals.com.au/5-reasons-why-microsoft-stack-is-still-a-viable-choice/.

Common Language Runtime (CLR)[26]

- The .NET Framework provides a run-time environment called the common language runtime, which runs the code and provides services that make the development process easier.
- Clearly, CLR is a virtual machine which executes C# programs.
- It is similar to the relationship between Java Virtual Machine (JVM) and Java programs.[25]

[25] https://blog.overops.com/clr-vs-jvm-how-the-battle-between-net-and-java-extends-to-the-vm-level

[26] See https://docs.microsoft.com/en-us/dotnet/standard/clr.

Software Installation

- Install Visual Studio Community 2019 and select .Net Desktop Development for Windows users.
- Install Visual Studio for Mac and select .Net Core for MacOS users.
- You may try other IDEs, for example, Visual Studio Code with proper packages.

First Program: Hello, World[27]

```
1  using System;
2
3  namespace ConsoleApp1
4  {
5      class Program
6      {
7          static void Main(string[] args)
8          {
9              // This is my first program.
10             Console.WriteLine("Hello World!");
11         }
12     }
13 }
```

[27] See https://en.wikipedia.org/wiki/%22Hello,_World!%22_program.

Table of Special Characters

Symbol	Name	Description
{ }	Opening/closing braces	Denote a block to enclose statements.
( )	Opening/closing parentheses	Mostly used with methods.
[ ]	Opening/closing brackets	Denote an array.
//	Double slashes	Precede a comment line.
" "	Opening/closing quotation marks	Enclose a string.
;	Semicolon	Mark the end of a statement.

Bugs

- A bug is an error, flaw, failure, or fault in a computer program or system, producing an incorrect or unexpected result, or misbehaving in unintended ways.
  - Compile-time error: most of them are syntax errors.
  - Runtime error: occurs when the C# program runs, e.g. 1/0.
  - Logic error: introduced by implementing the functional requirement incorrectly.
- Note that logic (semantic) errors are the obscurest because they are hard to be found.

"If debugging is the process of removing software bugs, then programming must be the process of putting them in."

– Edsger W. Dijkstra (1930–2002)

"Why do we fall sir? So that we can learn to pick ourselves up."

– Alfred Pennyworth, *Batman Begins* (2005)

Programming Style

- Good programming style makes a program easy to read and helps programmers prevent from errors.
  - For example, C# Coding Conventions by Microsoft.
- In particular, we use indentation to enhance the structural relationships by visual.
- Be consistent through the whole program!