LECTURER: TAI LE QUY

ALGORITHMS, DATA STRUCTURES, AND PROGRAMMING LANGUAGES

ALGORITHMS, DATA STRUCTURES , AND PROGRAMMING LANGUAGES
TOPIC OUTLINE

UNIT 7

OVERVIEW OF IMPORTANT PROGRAMMING LANGUAGES

STUDY GOALS

- Understand the challenges of programming in assembly language.
- Learn about developing compiled applications using WebAssembly.
- Understand the features that distinguish C++ from C.
- Learn about types and type promotions in Java.
- Understand the key features supporting functional programming in Haskell.

EXPLAIN SIMPLY

1. Explain WebAssembly components and their purpose.
2. Describe how C++ supports Object-Oriented-Programming.
3. Explain how lists may be implemented in different ways in Haskell.

ASSEMBLER OR ASSEMBLY LANGUAGE

- Low-level programming language.
- Instructions have close relationship with the machine language instruction in the concerned architecture.
- The assembly language code is converted to the machine code by assembler.
- Usually, every instruction in the assembly language specifies a single machine language instruction.
- Makes low level programming easier while resulting in more efficient code than what can be achieved through high level languages.
- Every assembly language must be designed for a specific architecture.

WEBASSEMBLY

COMPONENTS

WebAssembly enables execution of compiled code on the web without plug-ins.

WASM

It is the binary module (.wasm format) for executable code.

WAT

It is the human readable format for assembly code. The execution is defined in terms of a stack machine. Uses symbolic expression or S-expression format. Useful in development and debugging.

AN ALTERNATIVE

For applications which are difficult to implement in JavaScript and run in the web browser, WebAssembly offers another alternative route. Implementations can be done in a high-level language and the Wasm code generated can be embedded using JavaScript WebAssembly API.

WEBASSEMBLY AND WASMFIDDLE

- WebAssembly is a low level binary format that is compatible with common web browsers.
- WebAssembly code or the text-based Wat code can be generated from code written in high level languages like C, C++, Rust and Go.
- *WasmFiddle* (https://wasmfiddle.com) tool may be used to generate the Wat code.
- The Wasm binary is also generated by WasmFiddle.
- The resultant code can be optimized for memory usage and speed.
- The Wasm code is loaded and executed in the browser using JavaScript WebAssembly API.

- C was originally designed for the development of the UNIX operating system, in the early 1970s
- C has influenced design of many programming languages.
- C introduced the type casting operator, braces to indicate blocks. Support for data structures exist in the form of arrays, structures, unions, and pointers.
- Macros and conditional compilation are also supported.
- Embedded software is ubiquitous in electronic devices today and much software is written in C.

TEMPLATES

Allows the same function to be used with arguments of different types.

NAMESPACES

Provides a simple data-hiding mechanism. Related data, functions, and variables which are related are aggregated into separate namespaces. Facilitates information hiding. Allows same identifier names to be used for different purposes.

OBJECT-ORIENTED PROGRAMMING IN C++

C++ was created as an extension of C. C++ has various features that support object-oriented programming.

CLASSES AND INHERITANCE

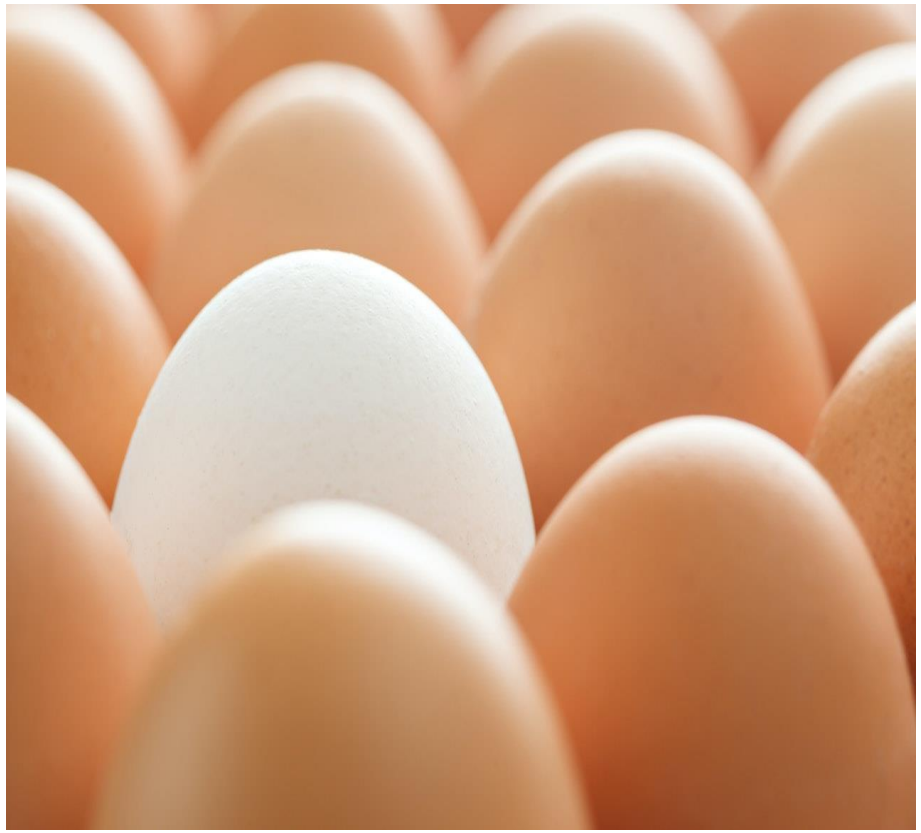
Allow us create our own customized types. For any class, we can create objects of that class and create operations manipulating such objects. Class hierarchies created through inheritance allow modular and hierarchical organization.

FUNCTION OVERLOADING

Allows two or more functions to have the same name but different types and/or different number of arguments.

EXCEPTION HANDLING IN C++

- C programs return a zero in case of success or non-zero in case of error.
- C++ has superior exception handling mechanism, allowing us to define an error handling function.
- Function is invoked on detection of the error.
- Exception handling is a system stack unwinding mechanism.
- This also serves as an alternative return mechanism.



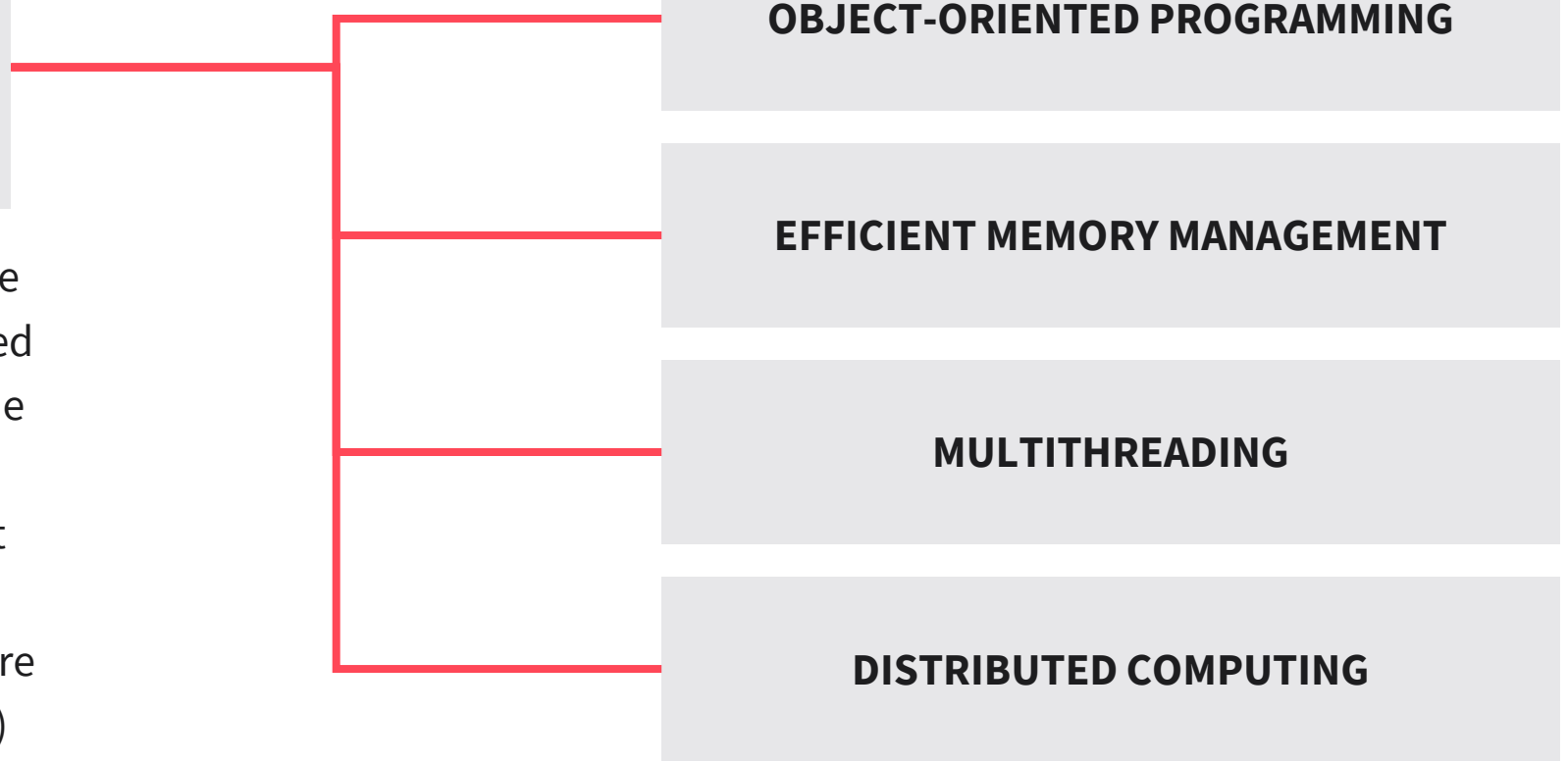
Source of the image: Filirovska, 2021.

EMERGENCE OF JAVA

- 1990s saw requirement of an architecture-independent language for applications running on consumer electronic devices.
- These devices were using many different CPUs as controllers.
- It was expensive to create compilers for languages which were designed to be compiled for specific targets.
- The need of the hour was a portable and platform independent language that could generate codes that ran on a variety of CPUs.
- This led to the creation of Java.
- The large-scale success of Java came from the emergence of the World Wide Web, with its associated portability issues.

JAVA: KEY TO SUCCESS

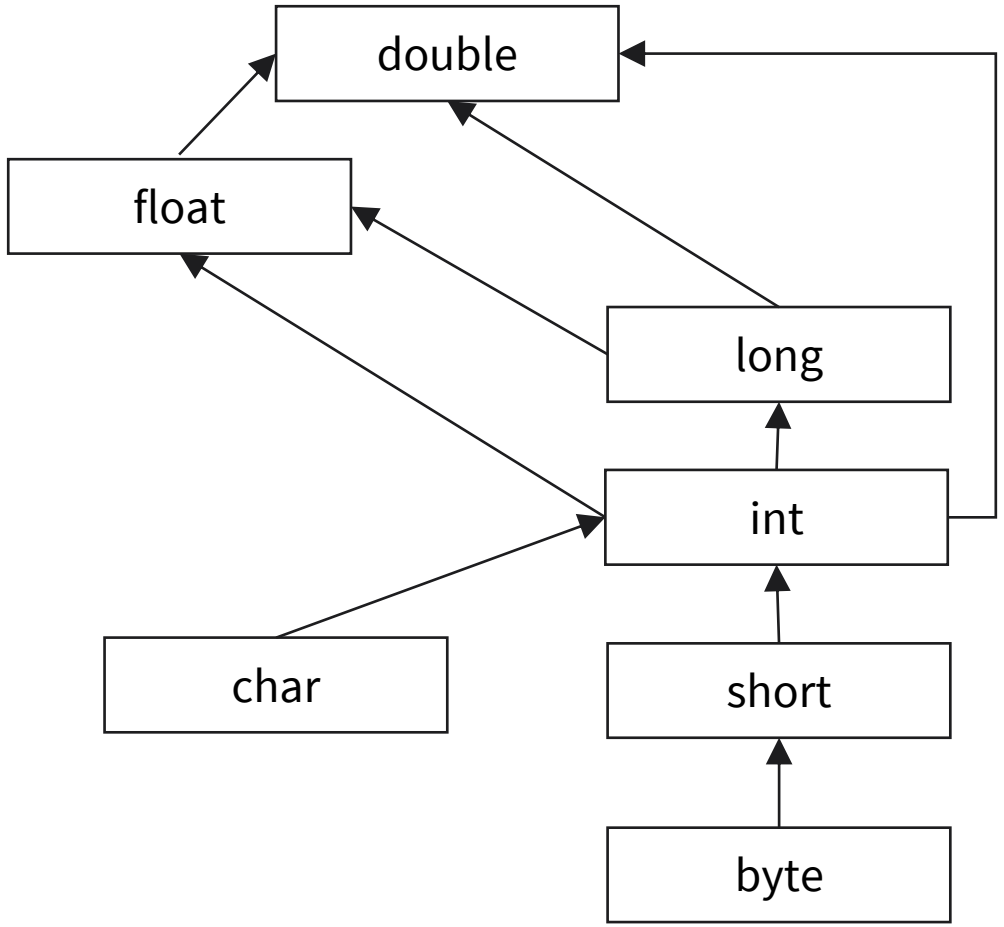
JAVA
Supports several features which make it useful for a wide variety of applications.



The Java bytecode is the output of the Java compiler and is a highly optimized set of instructions. It is executed on the Java Virtual Machine (JVM). The latter needs to be implemented for different platforms but not the Java bytecode. However, now many Java programs are also compiled using Just-in-Time (JIT) compilers. They compile Java bytecodes to machine code at run time.

TYPES IN JAVA

- Java has both classes and primitive types.
- There are no pointers in Java, only a reference type instead.
- All subprograms need to be wrapped in classes as methods.
- Java supports an elaborate system of type conversions and automatic type promotions which facilitates programming.



An arrow from type A to type B means that a variable of type A may be promoted to type B.

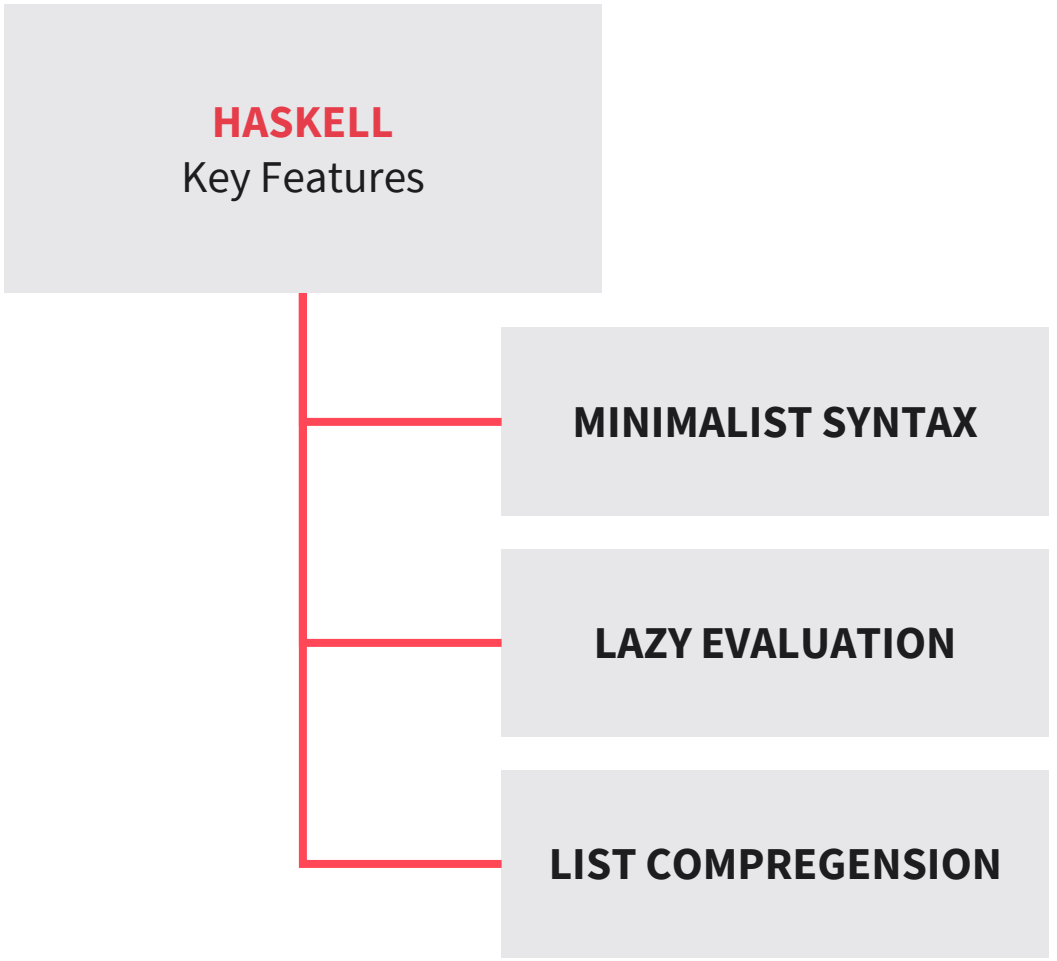
C#

- Created by Microsoft for its .NET framework in 2000
- Components of a C# “assembly”:
  - its program code in the Common Intermediate Language (CIL)
  - metadata describing every class defined in the assembly and external classes used
  - collection of all other assemblies referenced by that assembly and the version number
- “Get” and “set” methods give public access to private variables in a class.
- C# also supports generics or template types. A method can be defined with arguments or return objects of generic type T.
- C# also supports generic collection classes, which allow for the definition of arrays, lists, stacks, queues, and dictionaries of generic type
- Wildcard is not supported in C#

LISP (LIST PROCESSOR)

- The first functional programming language, designed by John McCarthy in 1960
- Lisp has been used for solving various problems in artificial intelligence, game playing, electronic circuit design, and other areas.
- The two basic data objects in Lisp are atoms and lists
- Atoms are indivisible objects and may be either numeric or symbolic
- The syntax of Lisp is characterized by uniformity and simplicity: Both data and programs take the same form, that of lists

- Haskell is a purely functional language.
- Haskell has *nonstrict semantics.*
- This is a property of a language that makes it possible to evaluate a function even if all arguments of the function are not evaluated.
- This is more efficient since some computations are avoided by taking advantage of *lazy evaluation*.
- An actual parameter of a function is evaluated only if its value is needed for the evaluation of the function.



REPRESENTING LISTS IN HASKELL

LISTS COMPREHENSION
(For finite lists)
e.g., [2*x+3 | x ← [1..10]]

ENUMERATION
Finite lists may be represented by explicit enumeration as in [0,1,2,3]

LISTS IN HASKELL
The List is the fundamental data structure in Haskell and may be represented in many ways.

RANGES
Finite lists may also be represented by ranges as in [1..10]

LIST COMPREHENSION
(For infinite lists) e.g.
[2*x+3 | x ← [1,2..]].

JAVASCRIPT AND ITS RELATIVES

- A central language in web applications, uses the browser as a platform and first appeared in the Netscape Navigator browser in 1995.
- Helps to track all user actions including mouseovers, selecting, scrolling, clicking, and zooming.
- Has access to the elements in the web document, local file systems, and system resources.
- The basic syntax of JavaScript has similarities with C, with support for variables, expressions, operators, conditionals, and loops. The code can be embedded in HTML code.
- Hierarchy of objects is defined using the Document Object Model

REVIEW STUDY GOALS

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SESSION 6

TRANSFER TASK

TRANSFER TASKS

1. Please try to suggest how to implement a stack in Java with elements of generic types.
2. Discuss how wildcard types may be used for this implementation.

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

1. Which of the following programs offers inheritance as a feature?
   a) C only
   b) C++ only
   c) Both C++ and C
   d) Neither C++ nor C

2. What is the naming encapsulation construct in Java called?
   a) Package
   b) Namespace
   c) Generics
   d) Assemblies

3. What is the object hierarchy used in Javascript called?
   a) Document hierarchy
   b) Object hierarchy
   c) Object organization
   d) Document Object Model

How did you like the course?

LIST OF SOURCES

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