Basics of programming 3

Java language basics

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Basics of programming courses

- BoP 1: *Structural programming*
  - Variables, control, functions, data structures, etc
  - Language: *C*
- BoP 2: *OO concepts*
  - Classes, encapsulation, inheritance, polymorphism, etc
  - Language: *C++*
- BoP 3: *OO development using APIs*
  - I/O, collections, multithreading, graphics, unit tests, etc
  - Language: *Java*

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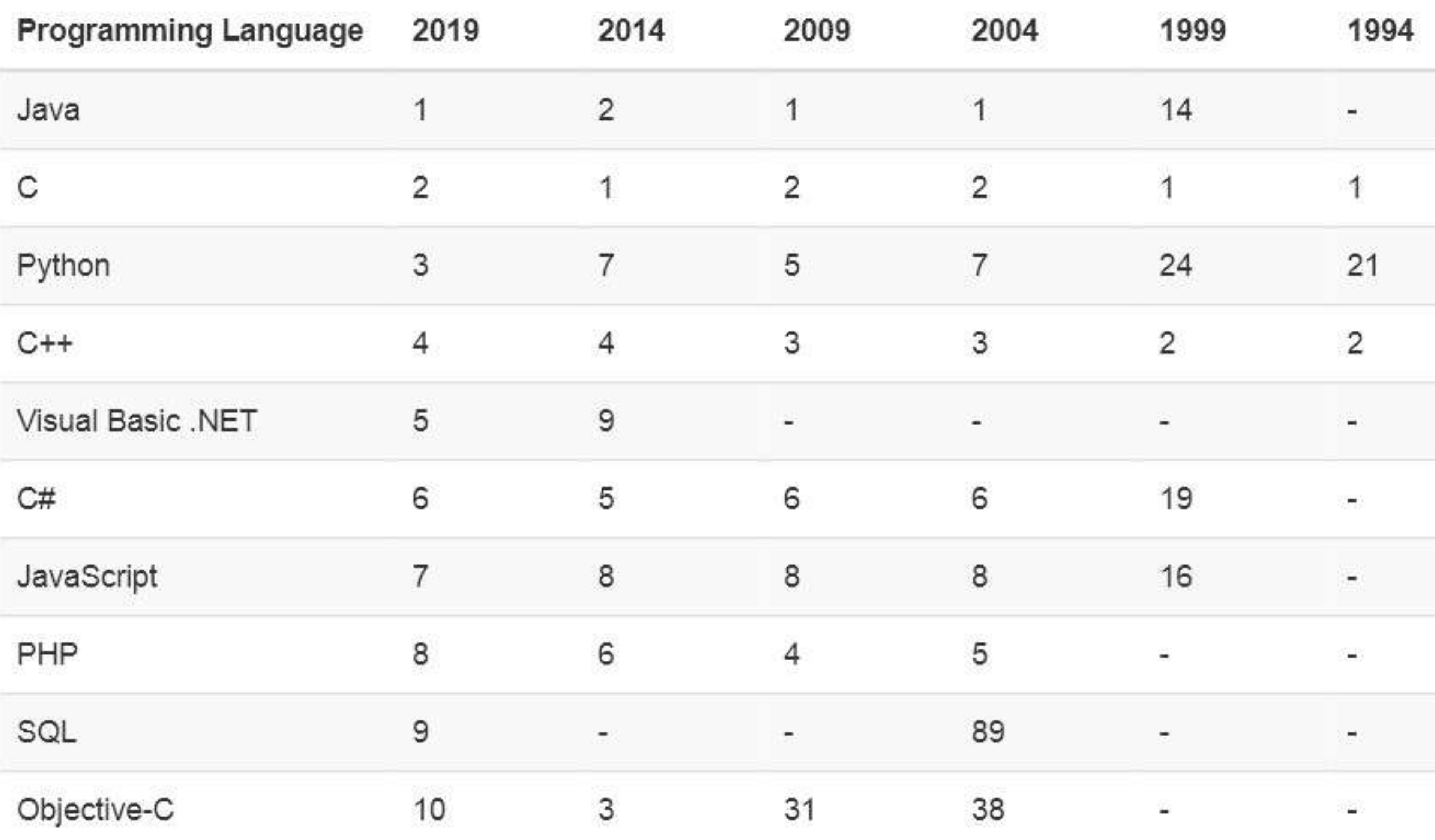
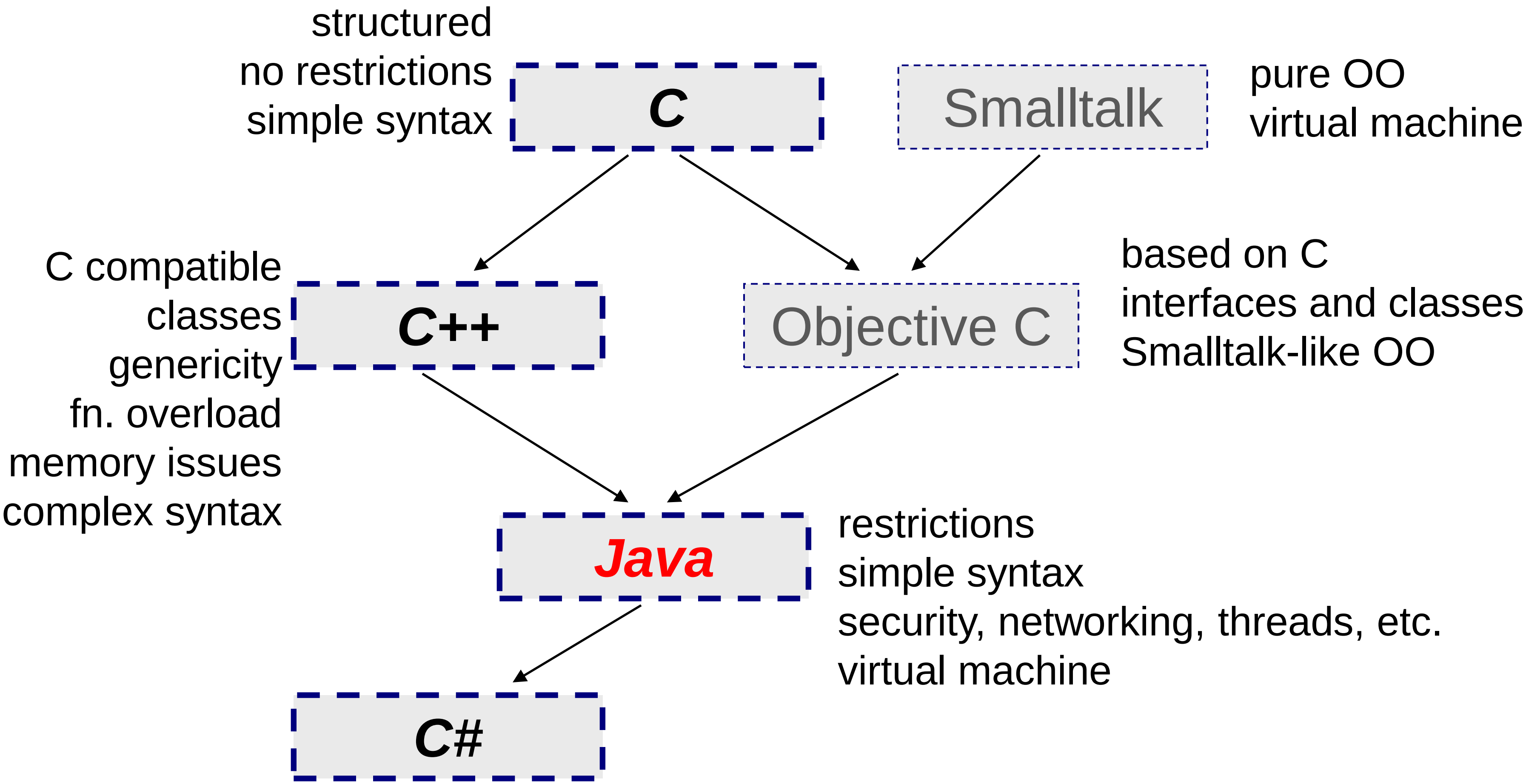


Programming Language	2019	2014	2009	2004	1999	1994
Java	1	2	1	1	14	-
C	2	1	2	2	1	1
Python	3	7	5	7	24	21
C++	4	4	3	3	2	2
Visual Basic .NET	5	9	-	-	-	-
C#	6	5	6	6	19	-
JavaScript	7	8	8	8	16	-
PHP	8	6	4	5	-	-
SQL	9	-	-	89	-	-
Objective-C	10	3	31	38	-	-

Geneology of Java



structured
no restrictions
simple syntax

C

Smalltalk

pure OO
virtual machine

C compatible
classes
genericity
fn. overload
memory issues
complex syntax

C++

Objective C

based on C
interfaces and classes
Smalltalk-like OO

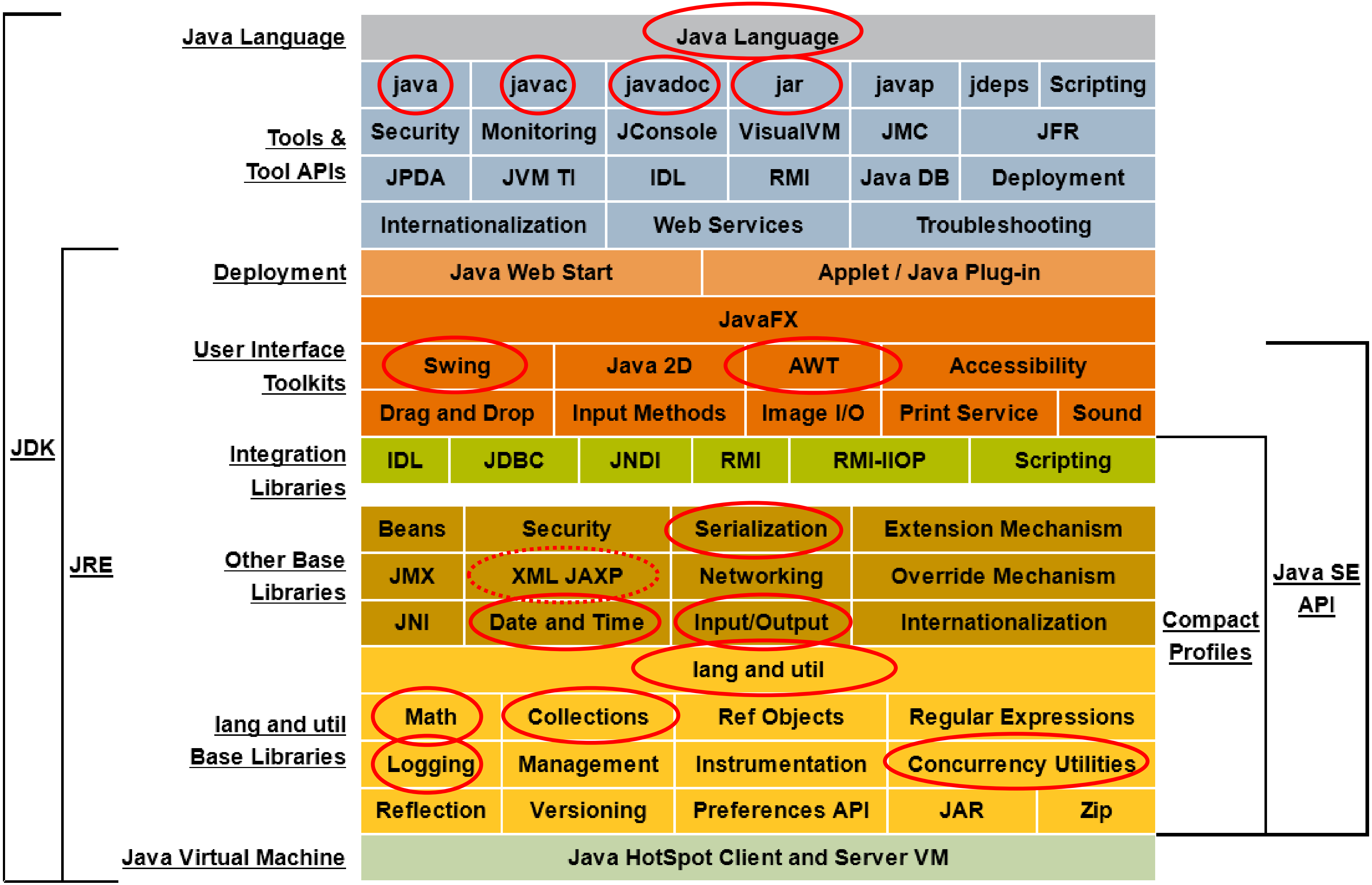
Java

restrictions
simple syntax
security, networking, threads, etc.
virtual machine

C#

J2SE framework

- Java is like C
  - simple syntax
  - huge API
- Java programming is like playing lego
  - putting together already existing building blocks
  - everything is implemented
    - usually better than we could do it
  - real knowledge is that of the API
  - versions differ in API and syntax
    - latest major version: 12 (2019-03-19)



JDK

JRE

Java SE API

Compact Profiles

Java Language

- Java Language

Tools & Tool APIs

- java, javac, javadoc, jar, javap, jdeps, Scripting
- Security, Monitoring, JConsole, VisualVM, JMC, JFR
- JPDA, JVM TI, IDL, RMI, Java DB, Deployment
- Internationalization, Web Services, Troubleshooting

Deployment

- Java Web Start, Applet / Java Plug-in

User Interface Toolkits

- JavaFX
- Swing, Java 2D, AWT, Accessibility
- Drag and Drop, Input Methods, Image I/O, Print Service, Sound

Integration Libraries

- IDL, JDBC, JNDI, RMI, RMI-IIOP, Scripting

Other Base Libraries

- Beans, Security, Serialization, Extension Mechanism
- JMX, XML JAXP, Networking, Override Mechanism
- JNI, Date and Time, Input/Output, Internationalization

lang and util Base Libraries

- lang and util
- Math, Collections, Ref Objects, Regular Expressions
- Logging, Management, Instrumentation, Concurrency Utilities
- Reflection, Versioning, Preferences API, JAR, Zip

Java Virtual Machine

- Java HotSpot Client and Server VM

Java basics

- Everything is a class or object
  - no global functions
  - application structure:
    - packages > classes > methods and variables > statements
- Two kinds of types
  - primitive (int, double, boolean, …)
    - variable stores value
  - object (String, Vector, …)
    - variable stores reference

Java basics 2

- Syntax very similar to C/C++
  - operators (+,-, >>, …)
  - control structures (for, while, switch)
  - method call
- But
  - *no pointers*
  - *no goto*
  - *no operator overloading*
  - *separate* byte, char, *and* boolean *types*

Java basics 3

- Arrays are objects
  - length → run-time check

```
int a[] = new int[10];
//int[] a = new int[10]; // also OK
for (int i = 0; i < a.length; i++) {
      a[i] = i*2;
}
```

- Only pass by value
  - no pointer arithmetics
- Garbage collection
  - no delete

Hello world

```
// C/C++

int main(int argc, char** argv) {
    printf(“Hello world\n”);
}
```

```
// Java (Hello.java)

public class Hello {
    static public void main(String[] args) {
        System.out.println(”Hello world”);
    }
}
```

Compiling and running

- Rule of thumb:
  - for each class separate source file
    - `class Hello` → 🗎 *Hello.java*
  - for each class separate bytecode (class) file is generated
  - `> javac Hello.java` → 🗎 *Hello.class*
- JVM starts the *main* method of the selected class
  - `> java Hello`

Write Once, Run Anywhere

- C, C++, etc:
  - *write once, compile everywhere*
- Java:
  - source compiled into *bytecode*
  - bytecode run by virtual machine
  - no need for recompilation when migrating
- write once, debug everywhere
  - good design is important
  - it is still easy to create platform-specific application

Starting Java applications

- Simple run
  - needs command prompt or batch file
- Jar file
  - special zip file with manifest
  - *“starts when clicked”*
- Applet
  - embedded into a webpage
  - restricted functionality and permissions
  - *flash* predecessor
- Java Web Start
  - pl. NAV website

Basic types, operators, statements

Primitive types and variables

- Primitive types
  - boolean
  - char (16bit unicode)
  - byte, short, int, long (8, 16, 32, 64 bit signed integer)
  - float, double (32 and 64 bit real)
- Variable declaration and definition
  - similar to C and C++

```
int a = 13;
double d = f = 3.14;
```

Complex types

- Arrays and objects are complex
  - String, Vector, etc.
- Variable stores reference
  - resembles C++ pointer
  - no pointer arithmetic
- Assigning to variable
  - discards former reference

```
String s = "12345";
s = "hello"; // former value discarded
```

Arrays

- Simple arrays

```
int a[] = new int[13];
double[] d = new double[20];
```

- Multidimensional arrays
  - arrays of arrays

```
int[][] a = new int[10][20];

int[][] b = new int[4][];
for (int i = 0; i < b.length; i++) {
    b[i] = new int[i*2];
}
```

Operators

- Same operators as in C/C++
  - same precedence and association rules
  - logical operators only for logical expressions
    - no logical-integer mix-up
- Removed operators (not in Java)
  - **`delete`**, **`->`**
- New or modified operators
  - **`>>`** (sign is shifted)
  - **`>>>`** (0 is inserted from left)
  - non-lazy logical operators: **`&`**, **`|`**, **`^`**

Statements

- Similar to C/C++
  - if-else, while, do-while, for, switch-case
    - **`if`**, **`while`**, **`for`** (2nd expr) need logical expression
    - (Java 7: **`case`** for *strings* also)
  - continue, break, return
    - labels can be used for break and continue

```
int i = 1;
loop: while (i < 100) {
    for (int k = i; k < 300; k++) {
        if (k == i*2) break loop;
    }
}
```

  - no ***`goto`***

Objects, Classes and Interfaces

Classes

- Resembles C++
  - minor and major differences
- Differences from C++
  - visibility also on class level (packages)
  - visibility separately for each attribute and method
  - attributes get default value (0, null, etc)
  - only “inline” methods
  - all methods virtual
    - private methods are hidden
  - no operator overloading

Classes 2

- Differences from C++ cont.
  - only object’s reference is passed
    - no copy constructor
  - no initialization list
  - no default parameters
  - no multiple or virtual inheritance
  - *this* also for constructor call
  - destructor is *finalize()*
  - reference resembles C++ pointer, not C++ reference

Classes example

```
public class Something {
  int a; // package visibility
  private double d;
  protected long l;
  public String s;

  public Something(int a) {
      this.a = a;
  }

  public Something() {
      this(10);
      l = 141;
  }
  // ...
```

Classes example cont.

```
  // ...
  public void finalize() {
      ...
  }

  private void increment(int i) {
      a += i;
  }
  public long add(int i) {
      increment(i);
      l += i;
      return l;
  }
}
```

Classes example cont.

```
// somewhere in a class....

public static void main(String[] args) {

  // parenthesis is mandatory for ctr-s
  // s holds reference to object
  // NO '*' operator!
  Something s = new Something(5);

  // field access by .
  // NO '->' operator!
  long f = s.add(34);

}
```

Field modifiers

- private
  - same as C++: access from same class only
- *package* (no modifier, “default-access”)
  - not in C++: *access from same package only*
- protected
  - similar to C++: access inside subclasses and same package
- public:
  - same as C++: access from anywhere

Field modifiers cont.

- static
  - same as C++: *class-level attribute or method*
- final
  - not in C++:
    - for methods: subclasses *must not* override
    - for variables: like C++ *const*
- abstract
  - for methods and classes only
  - same as C++ pure virtual: no implementation, non abstract subclasses must implement
  - if method is abstract, class must be abstract too

Static members

- Static members similar to C++
  - □ static members can only access static members directly
  - □ static members can be accessed by non-static methods
- Variable initialization

```
class A {
   static long l = 13; // inline
   static long k;
   static { // initialization block
       k = 15; // run when class is loaded
   }
}
```

String: a special class

- Provides usual string operations
  - `length()`, `equals()`, `startsWith()`
  - `substring()`, `trim()`, `split()`, `concat()`
  - `toUpperCase()`, `toLowerCase()`, `replace()`
  - `charAt()`, `indexOf()`, `lastIndexOf()`
  - `valueOf()`
  - ...
- Only class with + and += overloaded
  - concatenation, not efficient
- Immutable
  - object’s state doesn’t change

Inheritance

- Syntax different from C++
  - □ *extends*

```
class A {...}
class B extends A {...}
```

  - □ use *super()* for calling superclass’ constructor
- Semantics different from C++
  - □ all methods virtual
  - □ no multiple inheritance for classes
  - □ topmost superclass: *Object*
  - □ constructors initialized differently

Inheritance example

```
class A {
   int k;
   public A() { k = 13; }
   public A(int i) { k = i; }
   public void foo() { System.out.println("A"); }
   public void bar() { foo(); }
}

class B extends A {
   public B() {}
   public B(int j) { super(j); }
   public void foo() { System.out.println("B"); }
}
```

Constructor tasks

- Creating object structure
  - attribute initialization to 0
  - initialization of virtual function tables
- Initializing superclasses
  - ...
- Initializing class
  - explicit attribute initialization
  - initialization block *(i.e. a stand-alone block)*
  - constructor as invoked

Constructor tasks

```
class A {
   int k,l;
   { k = 20; } // init. block
   public A() { l = 13; }
   public void foo() { System.out.println("A"); }
}

class B extends A {
   public B() {}
   public void foo() { System.out.println("B"); }
}
```

`Object` superclass

- Topmost superclass
- Methods
  - □ `boolean equals(Object o)`
    - for content based equality *(default impl. reference based)*

      `a == b` vs. `a.equals(b)`
  - □ `int hashCode()`
    - hash code generation for efficient access in collections
  - □ `void finalize()`
    - like C++ destructor, called by garbage collector

`Object` superclass 2

- Methods cont.
  - □ **`String toString()`**
    - returns string representation
    - mostly for debugging
    - called where String is needed

```
″my car: ″ + myCar + ″;″
```

  - □ **`Object clone()`**
    - returns a copy of the object *(always of the bottommost class)*
    - *Cloneable* interface for public access

Interfaces

- Like classes, but no implementation
  - each interface into a separate file
- Methods only declared, always implicit public
  - no implementation is specified
- May have attributes
  - automatically *public static final* (global constant)

```
interface A {
   void foo();
   int bar(String s);
   public static final int maxLength = 100;
}
```

Interfaces 2

- Multiple inheritance of interfaces is supported
  - only if no ambiguous attributes
- Class can implement multiple interfaces
  - *implements* keyword

    ```
    class A extends B implements C, D {}
    ```
- Class doesn't have to implement all methods
  - must be abstract class

Interface example

```
interface A {
   void foo();
   int bar(String s);
}

abstract class B implements A {
   ...
   public void foo() { System.out.println("B"); }
   abstract public int bar(String s);
}
class C implements A {
   ...
   public void foo() { System.out.println("B"); }
   public int bar(String s) { return s.length();}
}
```

Packages

Packages

- Provide hierarchical namespace
  - like *namespaces* in C++
- Package hierarchy with corresponding directories (folders)
  - same name, same hierarchy
- Classes and interfaces
  - source code must specify the packages
    - **`package foo.bar.baz;`**
  - source file must be put into the folder of the package

Packages and class names

- Full name
  - **`foo.bar.baz.MyClass`**
- Importing names
  - only classes and interfaces
  - similar to *using namespace X*
  - specifies packages to be searched for identifiers
  - if colliding, full names must be used
    - e.g. *List* is part of *java.util* and *java.awt*
  - static import for fields

```
import foo.bar.baz.*;
import mypack.MyClass;
```

Memory handling

Memory handling

- **C**: memory problems
  - pointers + arithemtics
  - void*
  - malloc/calloc/realloc/free

```
a[3] ≡ *(a+3) ≡ *(3+a) ≡ 3[a]
```

- **C++** tries to overcome problems, but fails
  - copy constructor
  - vitrual destructor
  - assignment
  - new/delete

```
class C : A, virtual B {
  int l; Complex c;
public:
  C(Complex k, int i)
    : A(i), c(k), l(i)
      { l++; }
};
```

Memory handling 2

- Java has a built in Garbage Collector (GC)
  - **`new`** : allocates on heap
  - **`delete`**: not explicitly, GC frees
- GC deletes objects with no reference
  - **`void finalize()`** is called
- Starting GC explicitly:
  - **`System.gc()`** or **`Runtime.gc()`**

Coding and style

Identifier style

- Variables, attributes and methods
  - **`camelCase`**, initial lower case
    - **`getSecondBiggestNumber()`**
    - **`int importantVariable;`**
- Class names
  - **`CamelCase`**, initial upper case
    - **`StringBuffer`**
- Package names
  - lower case
    - **`java.util`**

Parenthesis style

- Parenthesis
  - □ opening at end of line

    ```
    while (true) {
    ```

  - □ continuation after closing

    ```
    if (a<b) {
      ...
    } else {
      ...
    }
    ```