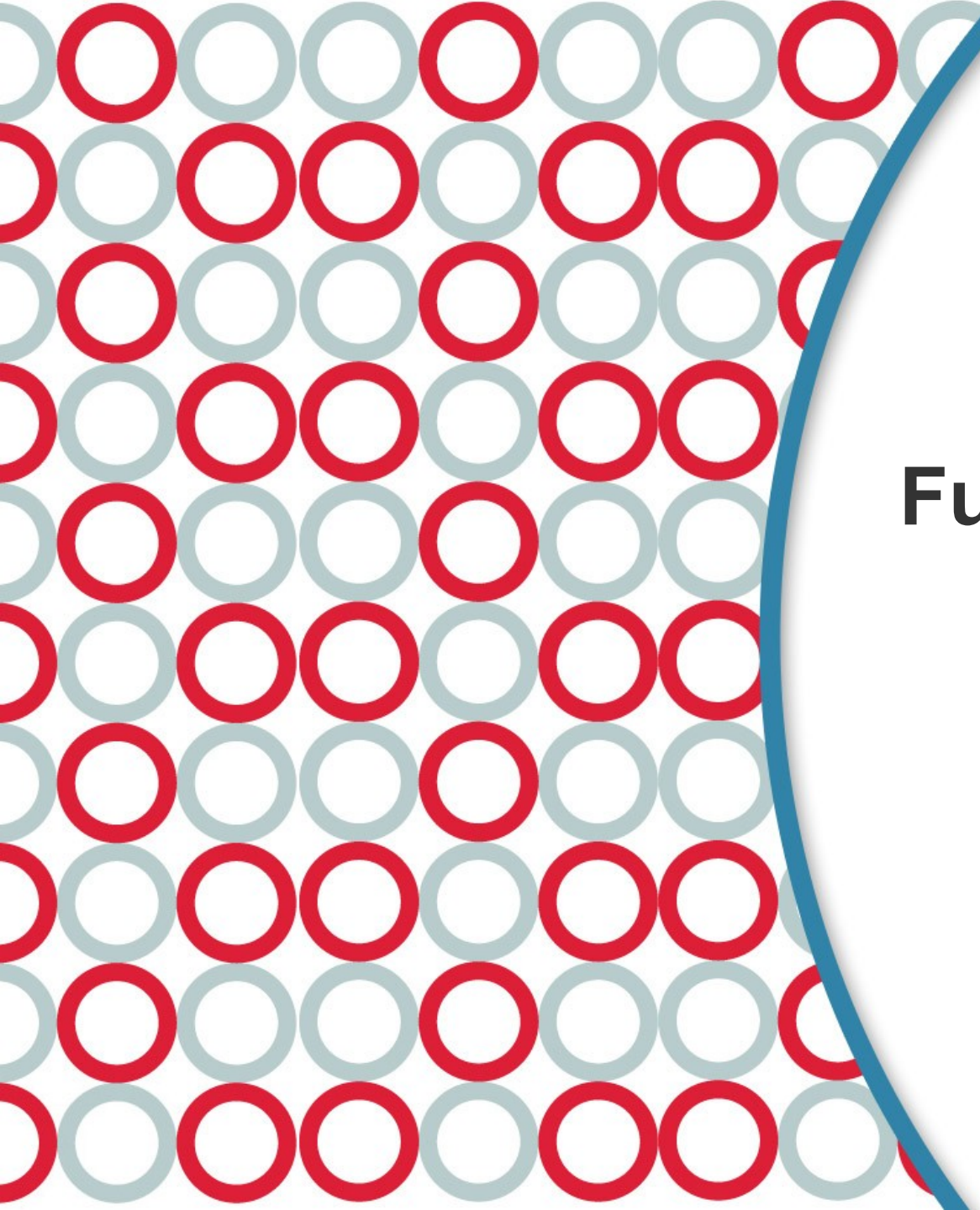

May 2019, IPT Course
Java Web Debelopment

Java Core, Functional, I/O & Concurrent Programming

Trayan Iliev

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http://iproduct.org

About me

Trayan Iliev

– CEO of IPT – Intellectual Products & Technologies

– Oracle® certified programmer 15+ Y

– end-to-end reactive fullstack apps with Java, ES6/7, TypeScript, Angular, React and Vue.js

– 12+ years IT trainer

– Voxxed Days, jPrime, jProfessionals, BGOUG, BGJUG, DEV.BG speaker

– Organizer RoboLearn hackathons and IoT enthusiast (http://robolearn.org)

IPT - Intellectual Products & Technologies

http://www.iproduct.org

Since 2003 we provide trainings and share skills in JS/ TypeScript/ Node/ Express/ Socket.IO/ NoSQL/ Angular/ React / Java SE/ EE/ Spring/ REST / SOA:

- Spring, Java EE, JSF, Portals: Liferay, GateIn
- Node.js + Express + React + Redux + GraphQL
- Angular + TypeScript + Redux (ngrx) + Progressive WA
- Reactive IoT with Reactor / RxJava / RxJS
- SOA & Distributed Hypermedia APIs (REST)
- Domain Driven Design & Reactive Microservices

What Will You Learn in the Course?

- Object Oriented Programming (OOP), SOLID principles
- Object creation and initialization
- Strings, Regular Expressions, Date and Time API, property files, ResourceBundles and Localization
- Exception handling
- Packages and access modifiers, code reuse, inheritance
- Polymorphism, abstract classes and methods, interfaces
- Inner classes and interfaces
- Functional programming with Java 8+

What Will You Learn in the Course? (cont.)

- Data structures in Java
- Generics
- Java I/O, NIO, and NIO2
- Concurrent Programming with Java

Course Schedule

- Block 1: 9.00 - 10.30
- Pause: 10.30 - 10.45
- Block 2: 10.45 - 12.15
- Lunch: 12.15 - 12.45
- Block 3: 12.45 - 14.15
- Pause: 14.15 - 14.30
- Block 4: 14.30 – 16.00
- Pause: 16.00 - 16.15
- Block 5: 16.15 - 17.15

- Training – Monday, Tuesday

Where to Find the Code?

Java Core, Functional, I/O & Concurrent Programming projects and examples are available @ GitHub:

https://github.com/iproduct/course-java-web-development

Agenda for This Session

- SOLID design principles of OOP
- Key features of Java language
- Stack and Heap (quick review)
- Literals and Operators
- Assignments and variables
- Scope
- Garbage collection
- Java Platform Module System (JPMS)

Basic Concepts in OOP and OOAD

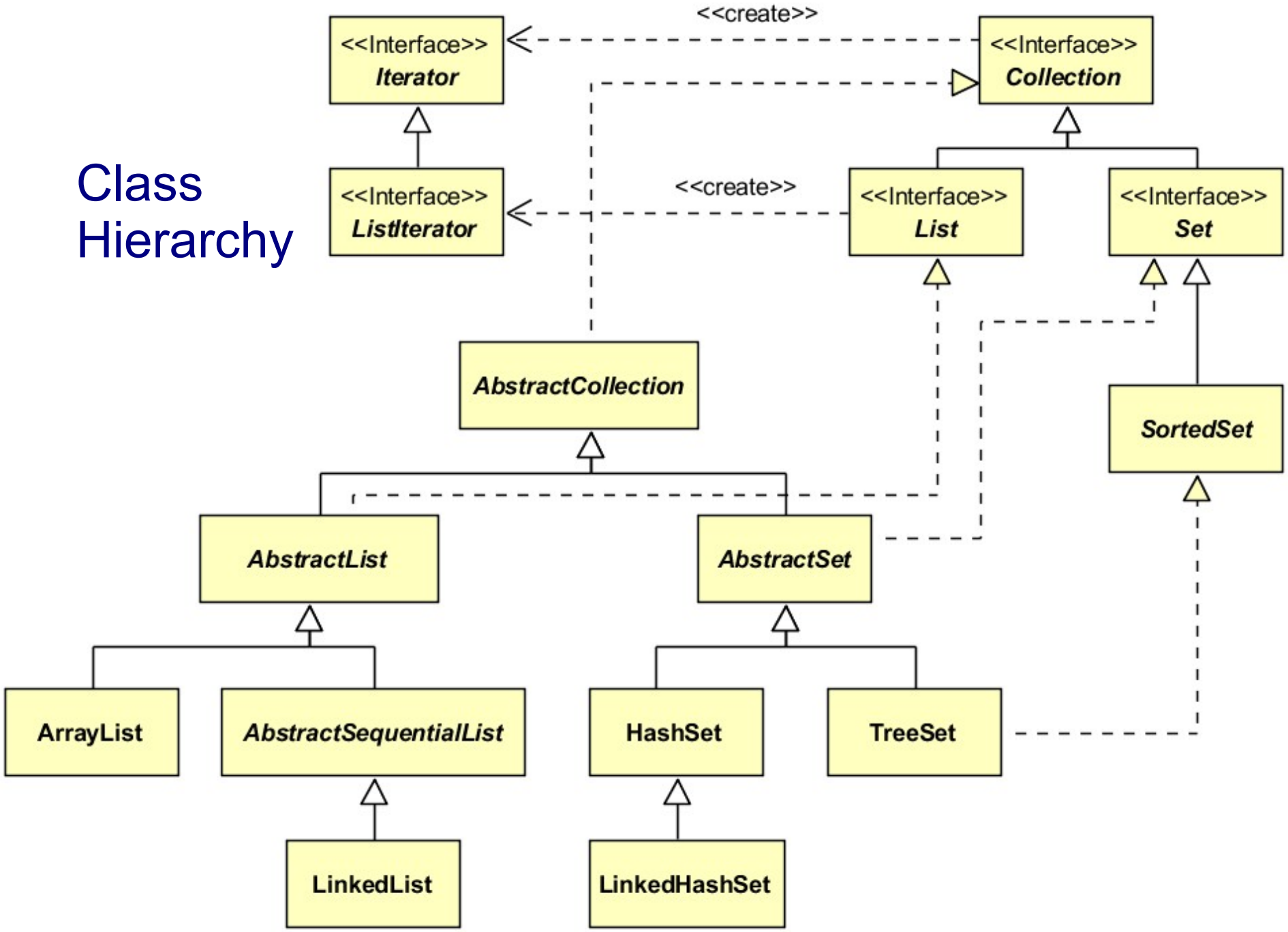
- interface and implementation – we divide what remains constant (contractual interface) from what we would like to keep our freedom to change (hidden realization of this interface)
- interface = public
- implementation = private
- This separation allows the system to evolve while maintaining backward compatibility to already implemented solutions, enables parallel development of multiple teams
- programming based on contractual interfaces

Object-Oriented Approach to Programming

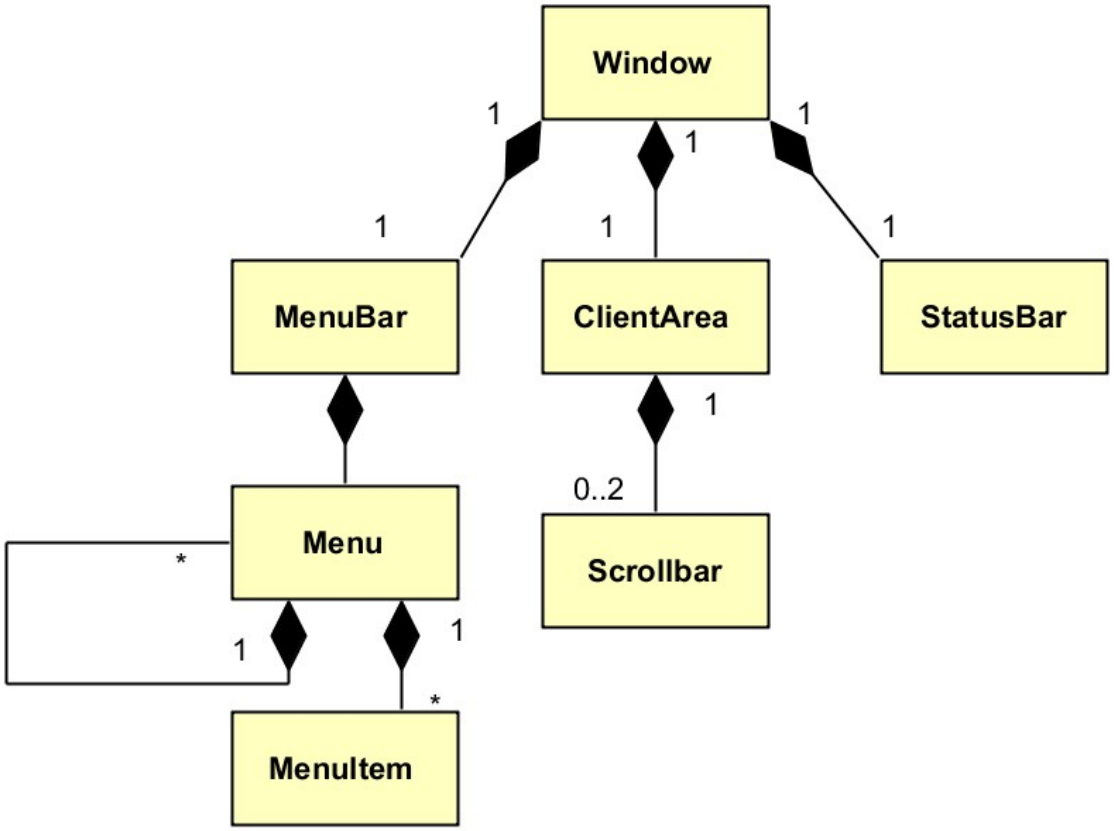
Key elements of the object model [Booch]:

- class, object, interface and implementation
- abstraction – basic distinguishing characteristics of an object
- capsulation – separating the elements of abstraction that make up its structure and behavior - interface and implementation
- modularity – decomposing the system into a plurality of components and loosely connected modules - principle: maximum coherence and the minimum connectivity
- hierarchy – class and object hierarchies

Class Hierarchy



Object Hierarchy



Object-Oriented Approach to Programming

Additional elements of the object model [Booch]:

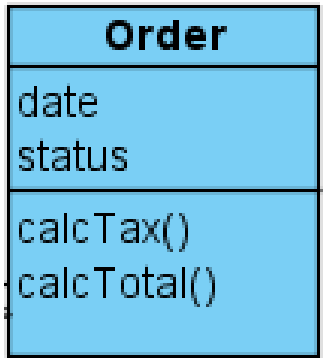
- typing – requirement for the class of an object such that objects of different types can not be replaced (or can in a strictly limited way)
  - static and dynamic binding
  - polymorphism
- concurrency – abstraction and synchronization of processes
- length of life – object-oriented databases

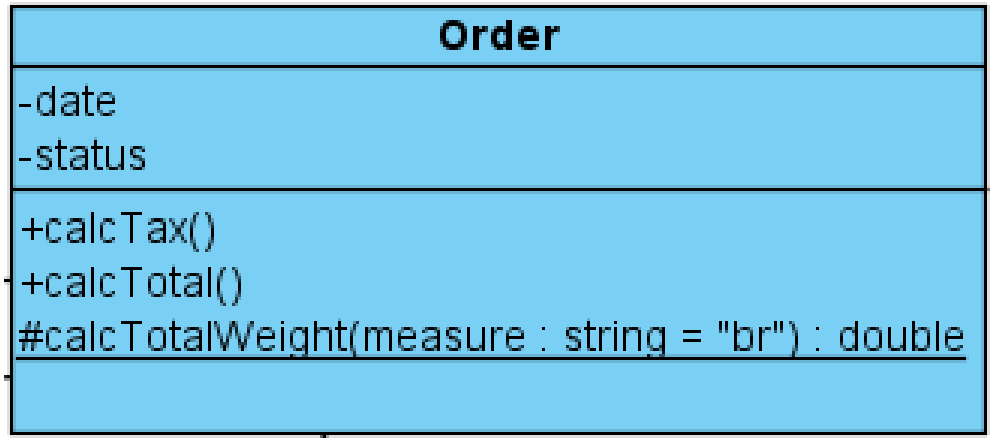
Classes

Class – describes a set of objects that share the same specifications of the characteristics (attributes and methods), constraints and semantics

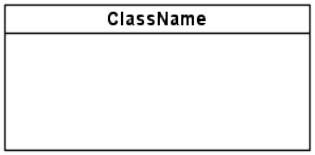
- attributes – instances of properties in UML, they can provide end of association, object *structure*
- operations - behavioral characteristics of a classifier, specifying name, type, parameters and constraints for invoking definitely associated with the operation behavior

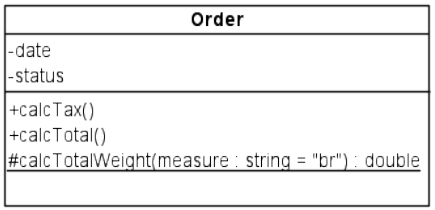
Classes - Graphical Notation in UML

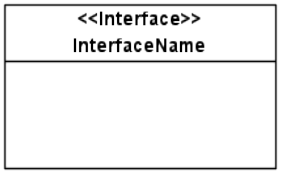


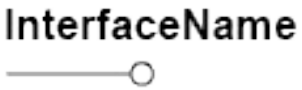


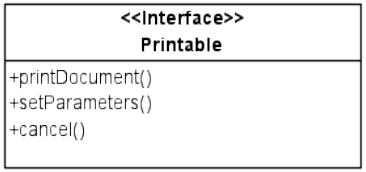
Elements of Class Diagrams





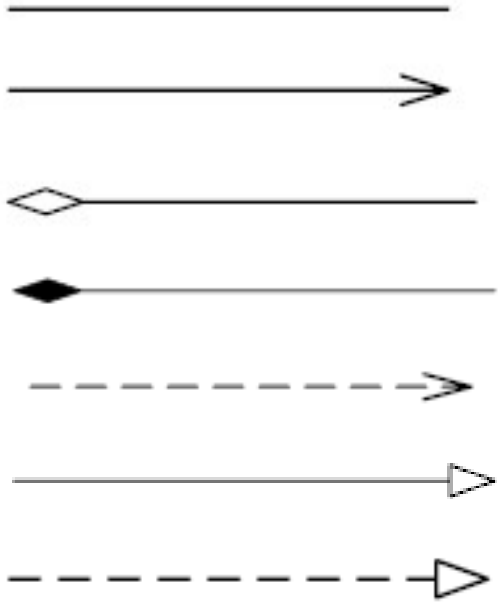




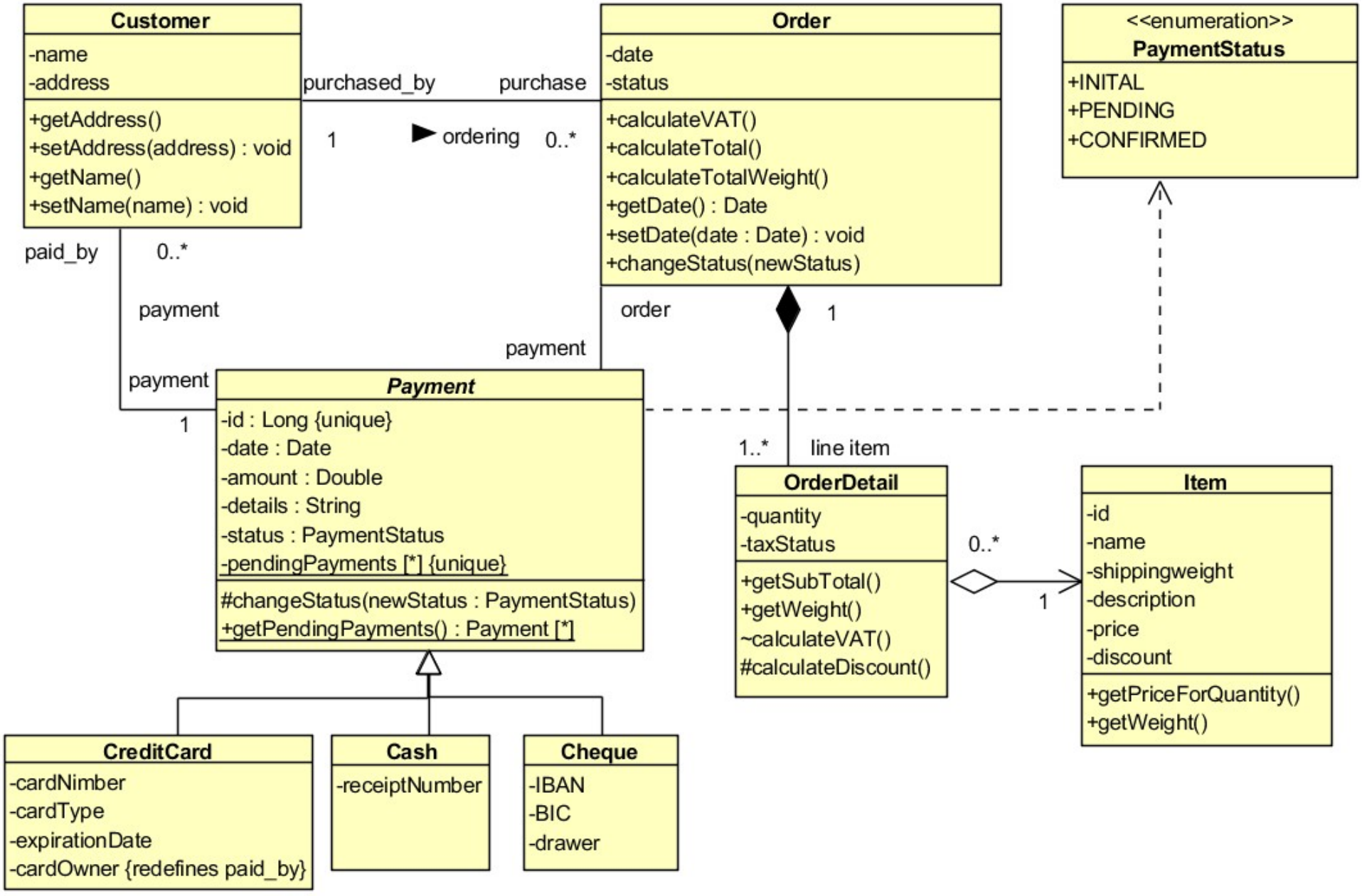


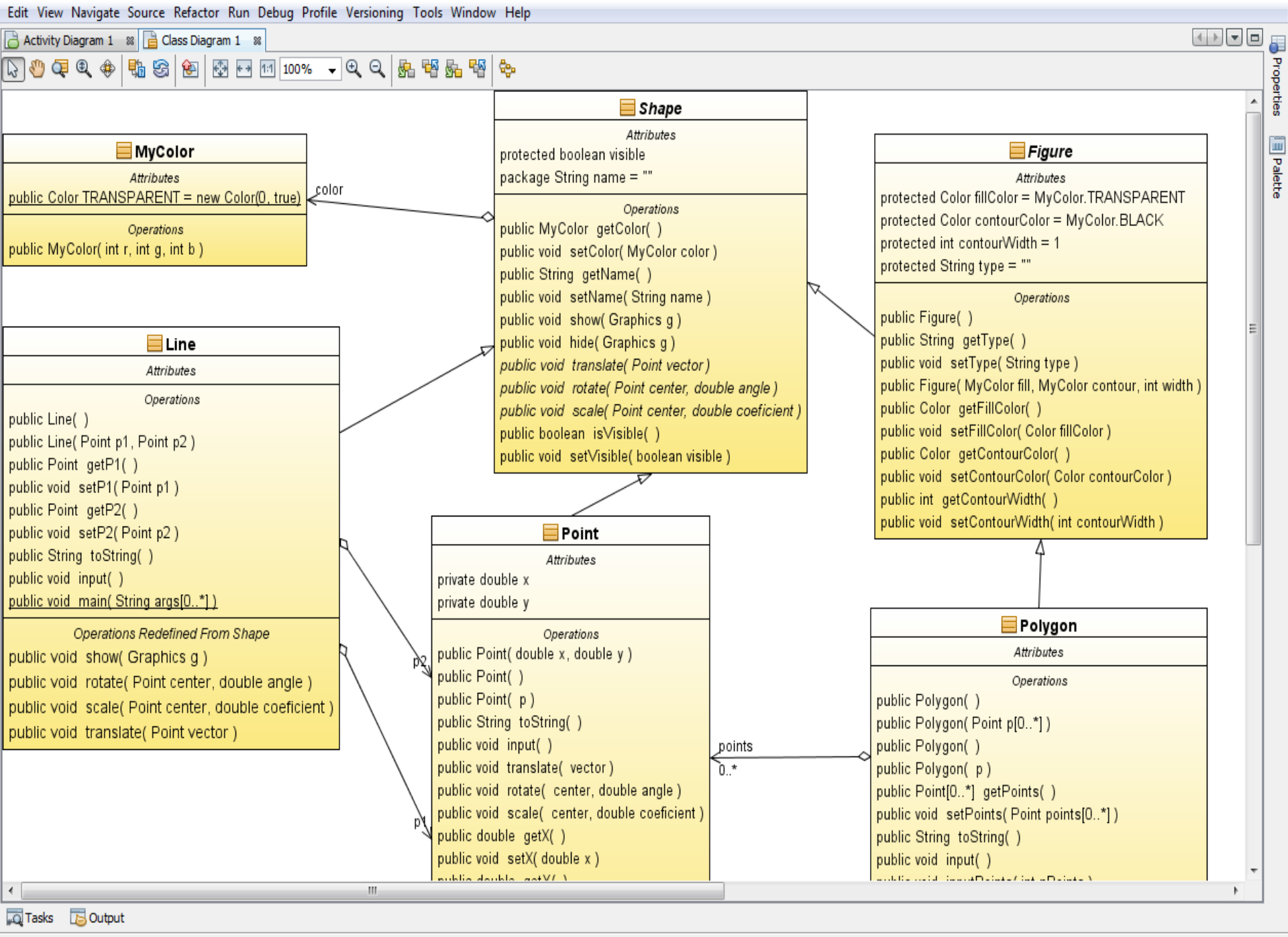
Types of connections:

- association
- aggregation
- composition
- dependence
- generalization
- realization



Class Diagram - 1

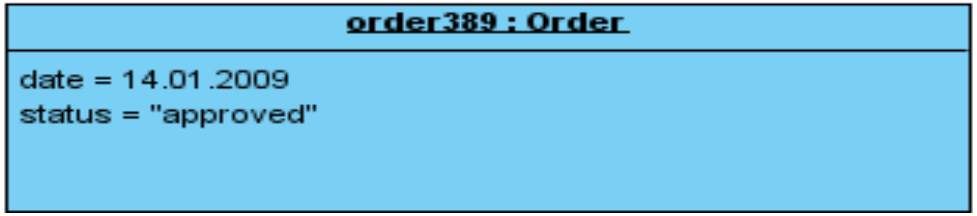



Edit View Navigate Source Refactor Run Debug Profile Versioning Tools Window Help
Activity Diagram 1
Class Diagram 1
100%
Properties
Palette
MyColor
Attributes
public Color TRANSPARENT = new Color(0, true)
Operations
public MyColor(int r, int g, int b)
color
Shape
Attributes
protected boolean visible
package String name = ""
Operations
public MyColor getColor( )
public void setColor(MyColor color)
public String getName( )
public void setName(String name)
public void show(Graphics g)
public void hide(Graphics g)
public void translate(Point vector)
public void rotate(Point center, double angle)
public void scale(Point center, double coeficient)
public boolean isVisible( )
public void setVisible(boolean visible)
Figure
Attributes
protected Color fillColor = MyColor.TRANSPARENT
protected Color contourColor = MyColor.BLACK
protected int contourWidth = 1
protected String type = ""
Operations
public Figure( )
public String getType( )
public void setType(String type)
public Figure(MyColor fill, MyColor contour, int width)
public Color getFillColor( )
public void setFillColor(Color fillColor)
public Color getContourColor( )
public void setContourColor(Color contourColor)
public int getContourWidth( )
public void setContourWidth(int contourWidth)
Line
Attributes
Operations
public Line( )
public Line(Point p1, Point p2)
public Point getP1( )
public void setP1(Point p1)
public Point getP2( )
public void setP2(Point p2)
public String toString( )
public void input( )
public void main(String args[0..*])
Operations Redefined From Shape
public void show(Graphics g)
public void rotate(Point center, double angle)
public void scale(Point center, double coeficient)
public void translate(Point vector)
p2
p1
Point
Attributes
private double x
private double y
Operations
public Point(double x, double y)
public Point( )
public Point(p)
public String toString( )
public void input( )
public void translate(vector)
public void rotate(center, double angle)
public void scale(center, double coeficient)
public double getX( )
public void setX(double x)
points
0..*
Polygon
Attributes
Operations
public Polygon( )
public Polygon(Point p[0..*])
public Polygon( )
public Polygon(p)
public Point[0..*] getPoints( )
public void setPoints(Point points[0..*])
public String toString( )
public void input( )
Tasks
Output

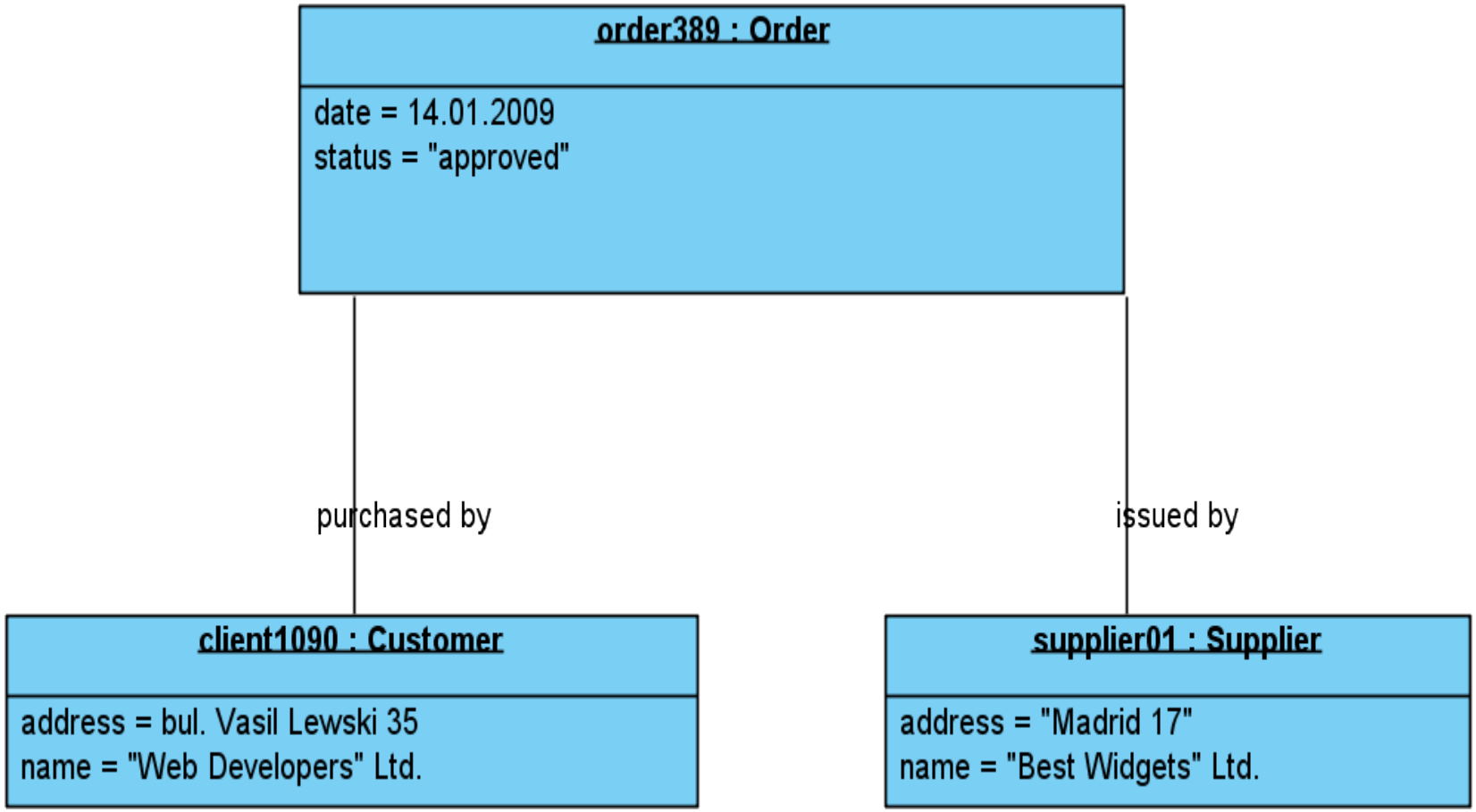
Objects

Instance specification = Object – represents an instance of the modeled system, for example class -> object association -> link, property -> attribute, etc.

- can provide illustration or example of object
- describes the object in a particular moment of time
- may be uncomplete
- Example:



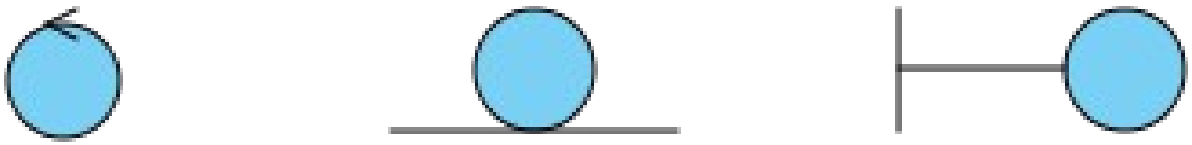
Object Diagram



Analysis Classes Stereotypes

Analysis classes are used in the mapping and analysis of system architecture - they present rather different roles and responsibilities, than specific classes to be realized, and are independent of implementation technology:

- <<controll>> - business logic
- <<entity>> - data
- <<boundary>> - user or system interface



SOLID design principles of OOP

- Single responsibility principle - a class should only have a single responsibility, that is, only changes to one part of the software's specification should be able to affect the specification of the class.
- Open–closed principle - software entities should be open for extension, but closed for modification.
- Liskov substitution principle - Objects in a program should be replaceable with instances of their subtypes without altering the correctness of that program.
- Interface segregation principle - Many client-specific interfaces are better than one general-purpose interface.
- Dependency inversion principle - depend upon abstractions, not concretions.

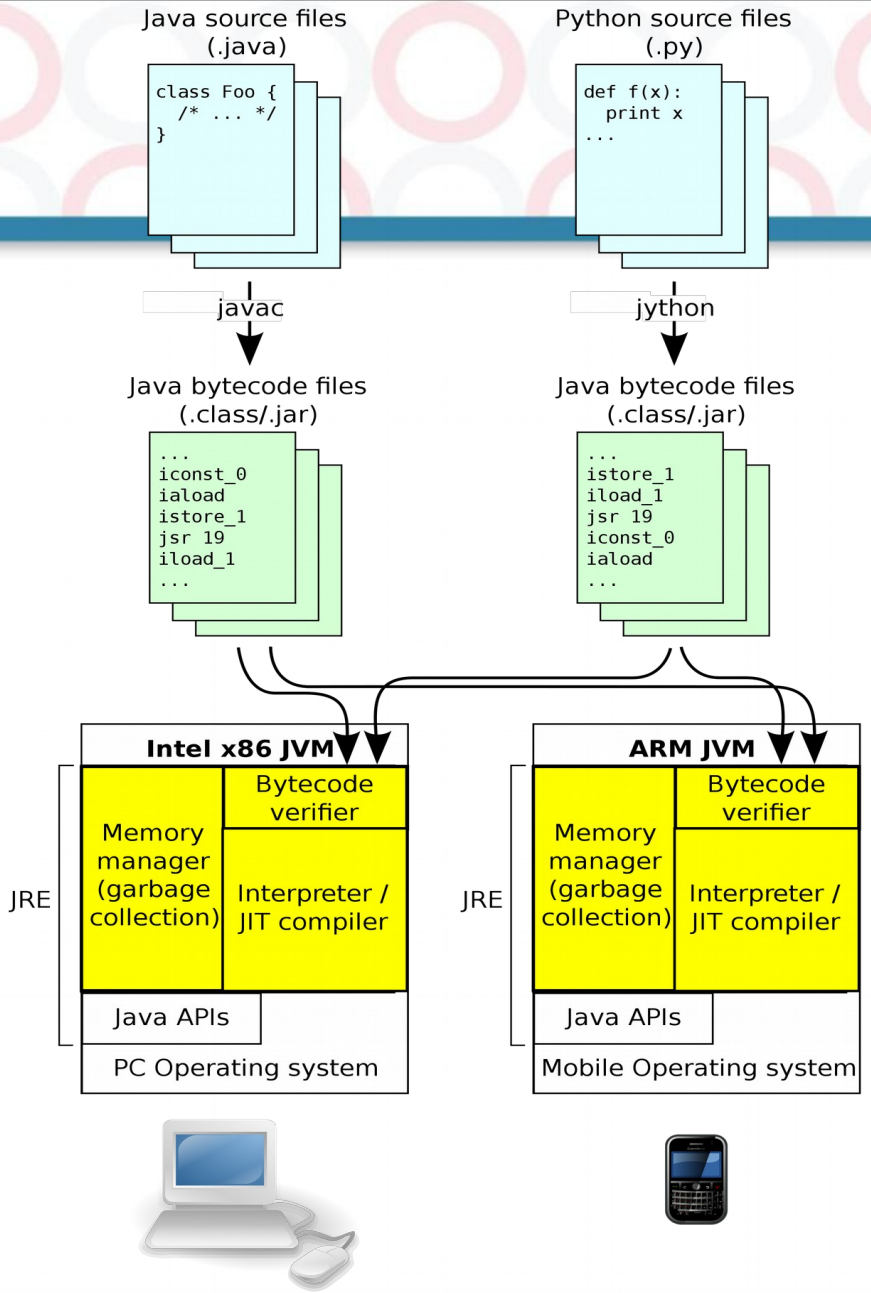
Key Features of Java Language

- Single base hierarchy - inheritance from only one parent class, with the possibility of implementation of multiple interfaces
- Garbage Collector – portability and platform independence, fewer errors
- Secure Code – separation of business logic from the error handling and exceptions
- Multithreading - easy realization of parallel processing
- Persistence – Java Database Connectivity (JDBC) and Java Persistence API (JPA)

Integrated Development Environments for Java Applications

- Java™ development environment types:
  JavaSE, JavaEE, JavaME, JavaFX
- JavaSE: Java Development Kit (JDK) and Java Runtime Environment (JRE)
- Java™ compiler - javac
- Java Virtual Machine (JVM) - java
- Sourse code → Byte code
- Installing JDK 8
- Compile and run programs from the command line
- IDEs: Eclipse, IntelliJ IDEA, NetBeans

Java Virtual Machine (JVM)



Source: http://en.wikipedia.org/wiki/File:Java_virtual_machine_architecture.svg

Java Application Stack

Level of Optimization

Java™ Custom Application – Level & patterns of garbage production, Concurrency, IO/Net, Algorithms & Data structures, API & Frameworks

Application Server – Web Container, EJB Container, Distributed Transactions Dependency Injection, Persistence - Connection Poolling, Non-blocking IO

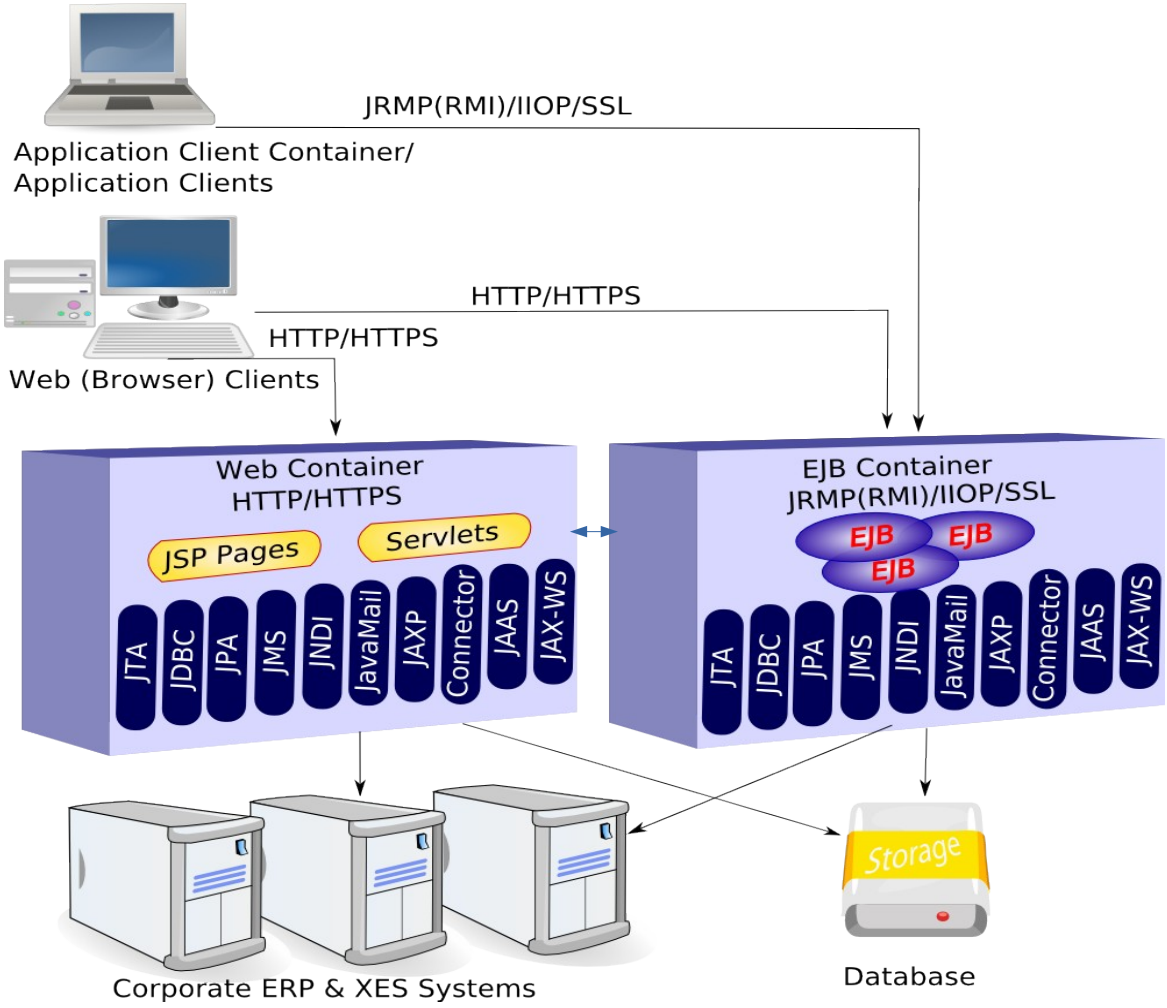
Java™ Virtual Machine (JVM) – Gartbage Collection, Threads & Concurrency, NIO

Operating System – Virtual Memory, Paging, OS Processes and IO/Net libraries

Hardware Platform – CPU, Memory, IO, Network

Processing Node 1 | Processing Node2 | ... | Processing Node N

Java EE Architecture



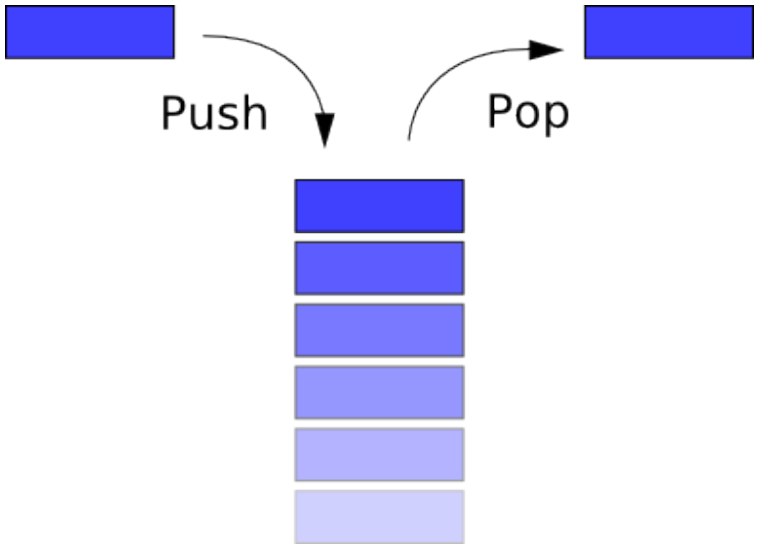
Key Elements of Java™ Language - Data Types, Variables and Constants

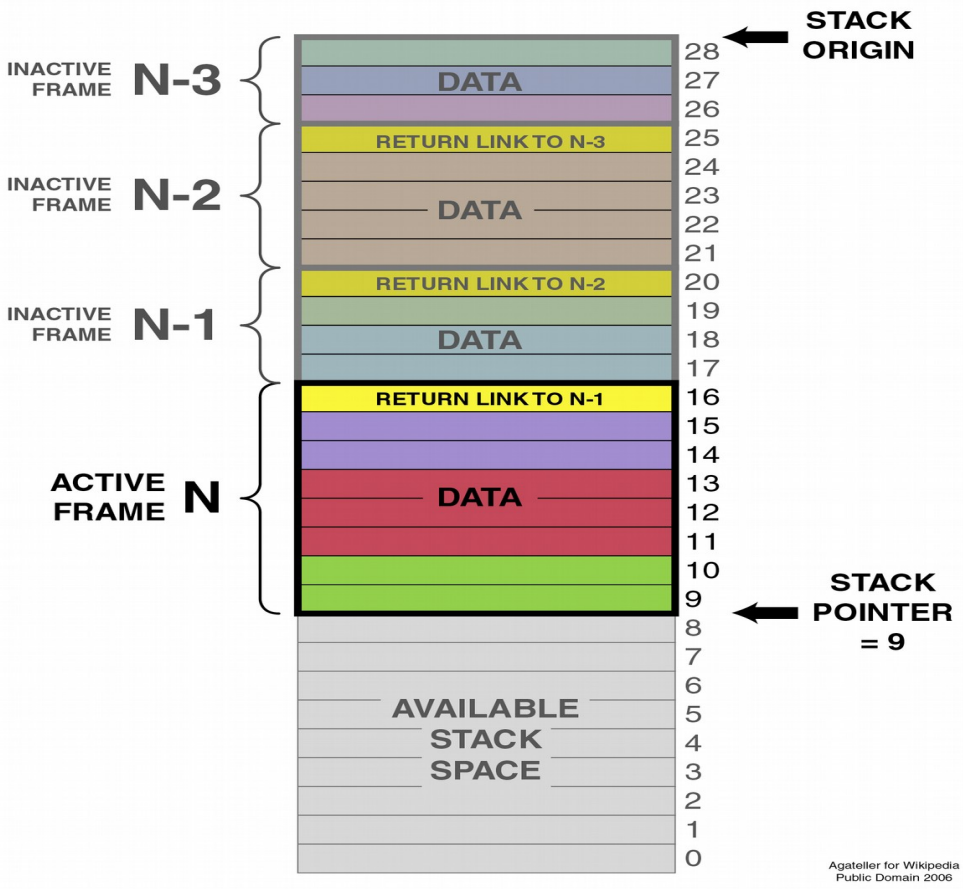
- Objects and references
- Creating objects
- Primitive and object data types
- Data Structures - arrays
- Fields and methods of an object
- Using ready libraries
- Static attributes and methods - static
- Variables and constants - final

Memory Types

- Register memory - CPU registers, fast, small numbers stored operand instructions just before treatment
- Program Stack = Last In, First Out (LIFO) – Keep primitive data types and references to objects during program execution
- Dynamically allocated memory – Heap – can store different sized objects for different periods of time, can create new objects dynamically and to be released – Garbage Collector
  - Young generation – objects that exist for short period
  - Old generation – objects that exist longer
  - ~~Permanent Generation = class definitions.~~ Java 8 Metaspace
- Constant storage, non-RAM storage (external memory)

Program Stack





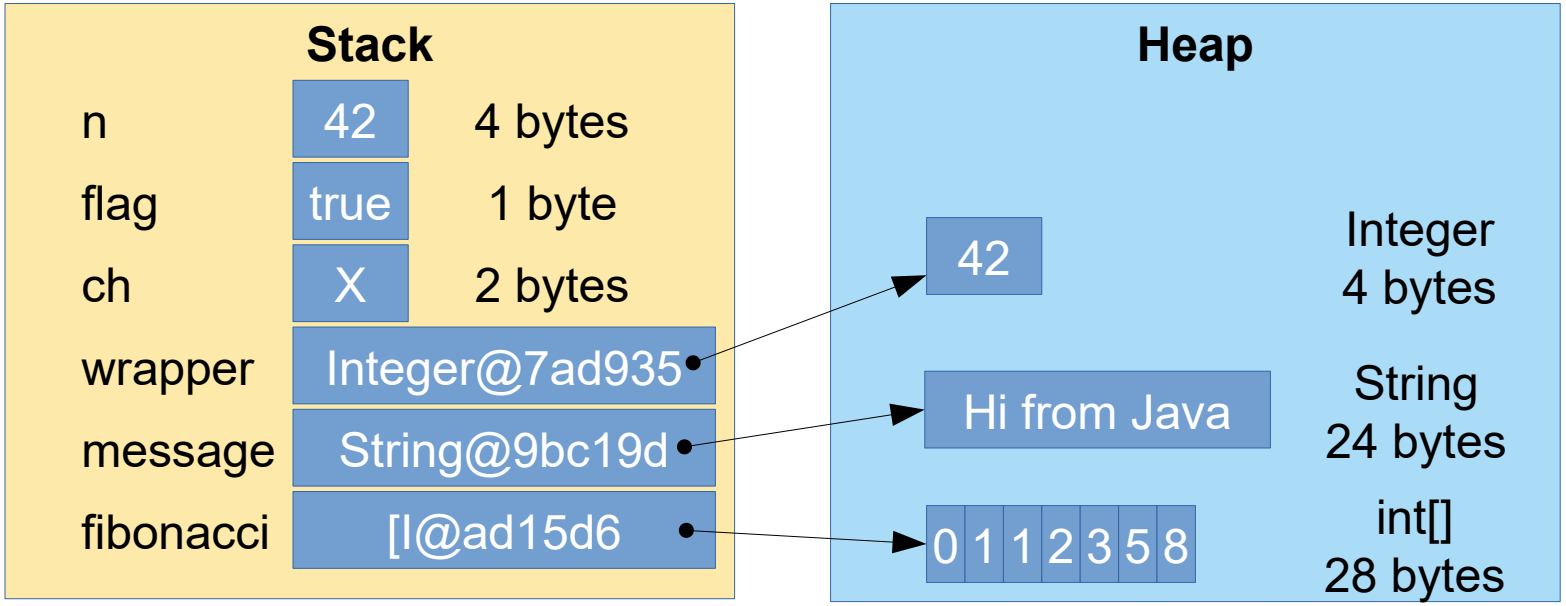
Source: http://en.wikipedia.org/wiki/File:ProgramCallStack2.png

C:\Windows\system32\cmd.exe

```
c:\CourseAdvancedJavaVerint\Temp>jstack 1612
2015-07-16 15:52:18
Full thread dump Java HotSpot(TM) 64-Bit Server VM (25.45-b02 mixed mode):

"DestroyJavaVM" #21 prio=5 os_prio=0 tid=0x00000000024b8000 nid=0x1f04 waiting on condition [0x0000000000000000]
   java.lang.Thread.State: RUNNABLE

"Thread-9" #20 prio=5 os_prio=0 tid=0x000000000bea7000 nid=0x2348 waiting for monitor entry [0x000000000d14f000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-8" #19 prio=5 os_prio=0 tid=0x000000000bea5800 nid=0x6ac waiting for monitor entry [0x000000000ca2e000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-7" #18 prio=5 os_prio=0 tid=0x000000000bea5000 nid=0x1ffc waiting for monitor entry [0x000000000cfcf000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-6" #17 prio=5 os_prio=0 tid=0x000000000bea2000 nid=0x40c waiting for monitor entry [0x000000000cd5f000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-5" #16 prio=5 os_prio=0 tid=0x000000000bea0800 nid=0x1708 waiting for monitor entry [0x000000000ceae000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-4" #15 prio=5 os_prio=0 tid=0x000000000be9d000 nid=0xc0c waiting for monitor entry [0x000000000c7df000]
   java.lang.Thread.State: BLOCKED (on object monitor)
        at simpletest.TwoThreadsSynchronizedCounter.lambda$0(TwoThreadsSynchronizedCounter.java:14)
        - waiting to lock <0x00000000d5e660a0> (a java.lang.Object)
        at simpletest.TwoThreadsSynchronizedCounter$$Lambda$1/424058530.run(Unknown Source)
        at java.lang.Thread.run(Thread.java:745)

"Thread-3" #14 prio=5 os_prio=0 tid=0x000000000be9c800 nid=0x2394 waiting for monitor entry [0x000000000cc2f000]
   java.lang.Thread.State: BLOCKED (on object monitor)
```

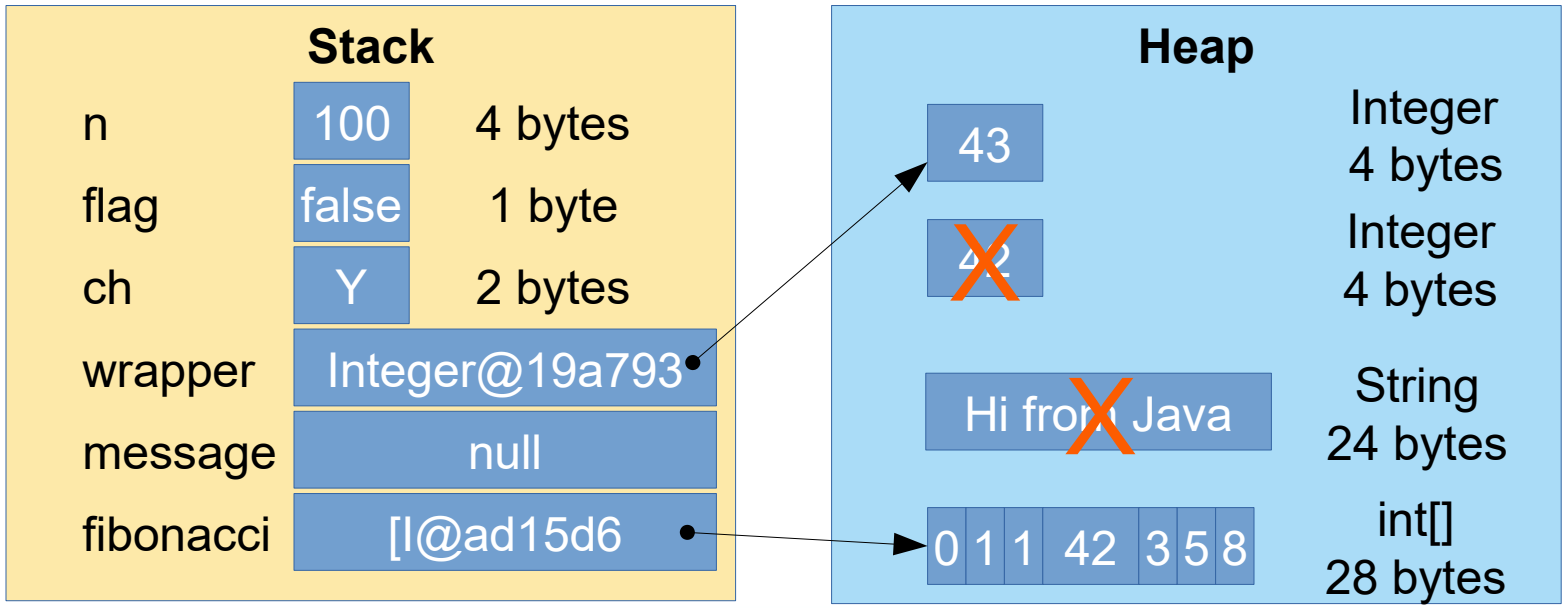
Stack and Heap (Quick Review)

```
int n = 42;
boolean flag = true;
char ch = 'X';
Integer wrapper = n;
String message = "Hi from Java!";
int[] fibonacci = { 0, 1, 1, 2, 3, 5, 8 };
```



Stack and Heap (Quick Review)

```
n = 100;
flag = !flag;
h = ++ch;
wrapper = ++wrapper;
message = null;
fibonacci[3] = 42;
```



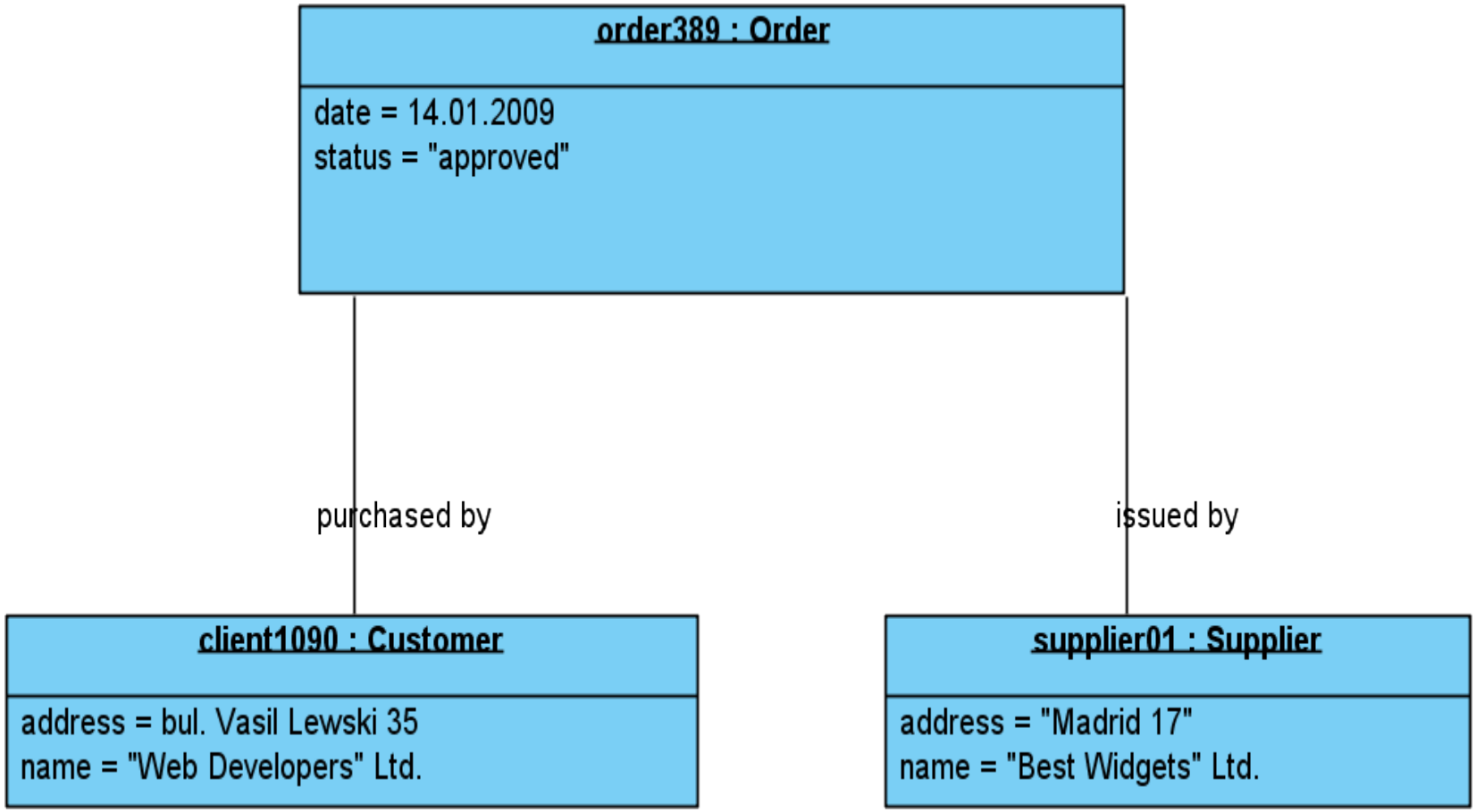
Variable Scopes

```
public class VarScopes {
    static int s1 = 25;
    int i1 = 350;
    public static void main(String[] args) {
      if(s1 > 10){
          int a = 42;
          // Only a available
          {
              int b = 108;// Both a & b are
available
          }
          // Only a available, b is out of scope
      }
      // a & b are out of scope
   }
}
```

Classes, Objects and References

- Class - set of objects that share a common structure, behavior and possible links to objects of other classes = objects type
  - structure = attributes, properties, member variables
  - behaviour = methods, operations, member functions, messages
  - relations between classes: association, inheritance, aggregation, composition – modeled as attributes (references to objects from the connected class)
- Objects are instances of the class, which is their addition:
  - own state
  - unique identifier = reference pointing towards object

Object Diagram



Creating Objects

- Class String – modeling string of characters:
  - declaration:

    String s;
  - initialization (on separate line):

    s = new String(“Hello Java World”);
  - declaration + initialization:

    String s = new String(“Hello Java World”);
  - declaration + initialization (shorter form, applies only to the class String):

    String s = “Hello Java World”;

Primitive and Object Data Types

- Primitive data types, object wrapper types and default values for attributes of primitive type
  - boolean --> Boolean — false
  - char --> Character — '\u0000'
  - byte --> Byte — (byte) 0
  - short --> Short — (short) 0
  - int --> Integer — 0
  - long --> Long — 0L
  - float --> Float — 0.0F
  - double --> Double — 0.0D
  - void --> Void
- BigInteger and BigDecimal - higher-precision numbers

Object (Reference) Data Types

- Creating a class (a new data type)

  class MyClass { /* attributes and methods of the class */ }

- Create an object (instance) from the class MyClass :

  MyClass myObject = new MyClass();

- Declaration and initialization of attributes:

```
class Person {
        String name = “Anonimous”;
        int age;
}
```

- Access to attribute: Person p1 = new Person();

  p1.name = “Ivan Petrov”; p1.age = 28;

Object (Reference) Data Types

- Initialization with default values
- Value of uninitialized reference = null
- Declaring class methods

```
class Person {
    String name;
    int age;
    String setNameAndAge (String aName, int anAge)
    {
        name = aName;
        age = anAge;
        return "Name: " + name + " Age: " + age;
    }
}
```

Method Name

Arguments

Return Type

Method Body

Returning Value

Primitive Type Literals

- in decimal notation:
  int: 145, 2147483647, -2147483648
  long: 145L, -1l, 9223372036854775807L
  float: 145F, -1f, 42E-12F, 42e12f
  double: 145D, -1d, 42E-12D, 42e12d
- in hexadecimal notation:
  0x7ff, 0x7FF, 0X7ff, 0X7FF
- in octal notation: 0177
- in binary notation: 0b11100101, 0B11100101

Operators in Java - I

- Assignment operator
- Mathematical operators
- Relational operators
- Logical operators
- Bitwise operators
- String operators
- Operators for type conversion
- Priorities of operators

Operators in Java - II

- Each operator has priority and associativity - for example, + and – have a lower priority from * and /
- The priority can be set clearly using brackets (and) - for example (y – 1) / (2 + x)
- According associativity operators are left-associative, right-associative and non-associative: For example:
  x + y + z => (x + y) + z, because the operator + is left-associative
- if it was right associative, the result would be
  x + (y + z)

Operators in Java - III

- Assignment operator: **=**
  - is not symmetrical – i.e. **x = 42** is OK, **42 = x** is NOT
  - to the left always stands a variable of a certain type, and to the right an expression from the same type or type, which can be automatically converted to present
- Mathematical operators:
  - with one argument (unary): **-, ++, --**
  - with two arguments (binary): **+, -, *, /, %** (remainder)
- Combined: **+=, -=, *=, /=, %=**

  For example: **a += 2** <=> **a = a + 2**

Send Arguments by Reference and Value

- Formal and actual arguments - Example:

Static method - no **this**

Formal Argument
- copies the actual value

```
public static void incrementAgeBy10(Person p){
    p.age = p.age + 10;
}

Person p2 = new Person(23434345435L, "Petar
Georgiev", "Plovdiv", 39);
incrementAgeBy10(p2);
System.out.println(p2);
```

Actual Argument

Send Arguments by Reference and Value

- Case A: When the argument is a primitive type, the formal argument copies the actual value
- Case B: When the argument is a object type, the formal argument copies reference to the actual value
- Cases A & B: Changes in the copy (formal argument) does not reflect the actual argument
- However, if formal and actual argument point to the same object (Case B) – then **changes in properties (attribute values) of this object are available from the calling method** – i.e. we can return value from this argument

Operators in Java - IV

- Relational operators (comparison): **==, !=, <=, >=**
- Logical operators: **&&** (AND), **||** (OR) and **!** (NOT)
  - the expression is calculated from left to right only when it's necessary for determining the final outcome
- Bitwise operators: **&** (AND), **|** (OR) and **~** (NOT), **^** (XOR), **&=**, **|=**, **^=**
  - bitwise shift: **<<**, **>>** (preserves character), **>>>** (always inserts ziros left – does not preserve character), **<<=**, **>>=**, **>>>=**

Operators in Java - V

- Triple **if-then-else** operator:

  <boolean-expr> ? <then-value> : <else-value>

- String concatenation operator: **+**

- Operators for type conversion (type casting):

  (byte), **(short)**, **(char)**, **(int)**, **(long)**, **(float)** ...

- Priorities of operators:

  unary > binary arithmetical > relational > logical > three-argumentative operator **if-then-else** > operators to assign a value

Controlling Program Flow - I

- Conditional operator - **if-else**
- Returning Value – **return**
- Operators organizing cycle - **while, do while, for, break, continue**
- Operator to select one from many options - **switch**

Controlling Program Flow - II

- Conditional operator **if-else**:

```
if(<boolean-expr>)
   <then-statement>
```

or

```
if(<boolean-expr>)
   <then-statement>
else
    <else-statement>
```

Controlling Program Flow - III

- Returning value to exit the method: **return;** or **return <value>;**
- Operator to organize cycle **while**:

```
while(<boolean-expr>)
    <body-statement>
```

- Operator to organize cycle **do-while**:

```
do <body-statement>
while(<boolean-expr>);
```

Controlling Program Flow - IV

- Operator to organize cycle **for**:

```
for(<initialization>; <boolean-expr>; <step>)
   <body-statement>
```

- Operator to organize cycle **foreach**:

```
for(<value-type> x : <collection-of-values>)
   <body-statement-using-x>
```

Ex.:
```
for(Point p : pointsArray)
    System.out.println("(" +p.x + ", " + p.y + ")");
```

Controlling Program Flow - V

- Operators to exit block (cycle) **break** and to exit iteration cycle **continue**:

```
<loop-iteration> {
    //do some work
    continue;  // goes directly to next loop iteration
    //do more work
    break;  // leaves the loop
    //do more work
}
```

Controlling Program Flow - VI

- Use of labels with **break** and **continue**:

```
outer_label:
<outer-loop> {
    <inner-loop> {
        //do some work
        continue; // continues inner-loop
        //do more work
        break outer_label; // breaks outer-loop
        //do more work
        continue outer_label;  // continues outer-loop
    }
}
```

Controlling Program Flow - VII

- Selecting one of several options **switch**:

```
switch(<selector-expr>) {
  case <value1> : <statement1>; break;
  case <value2> : <statement2>; break;
  case <value3> : <statement3>; break;
  case <value4> : <statement4>; break;
  // more cases here ...
  default: <default-statement>;
}
```

Garbage Collection – Main Concepts

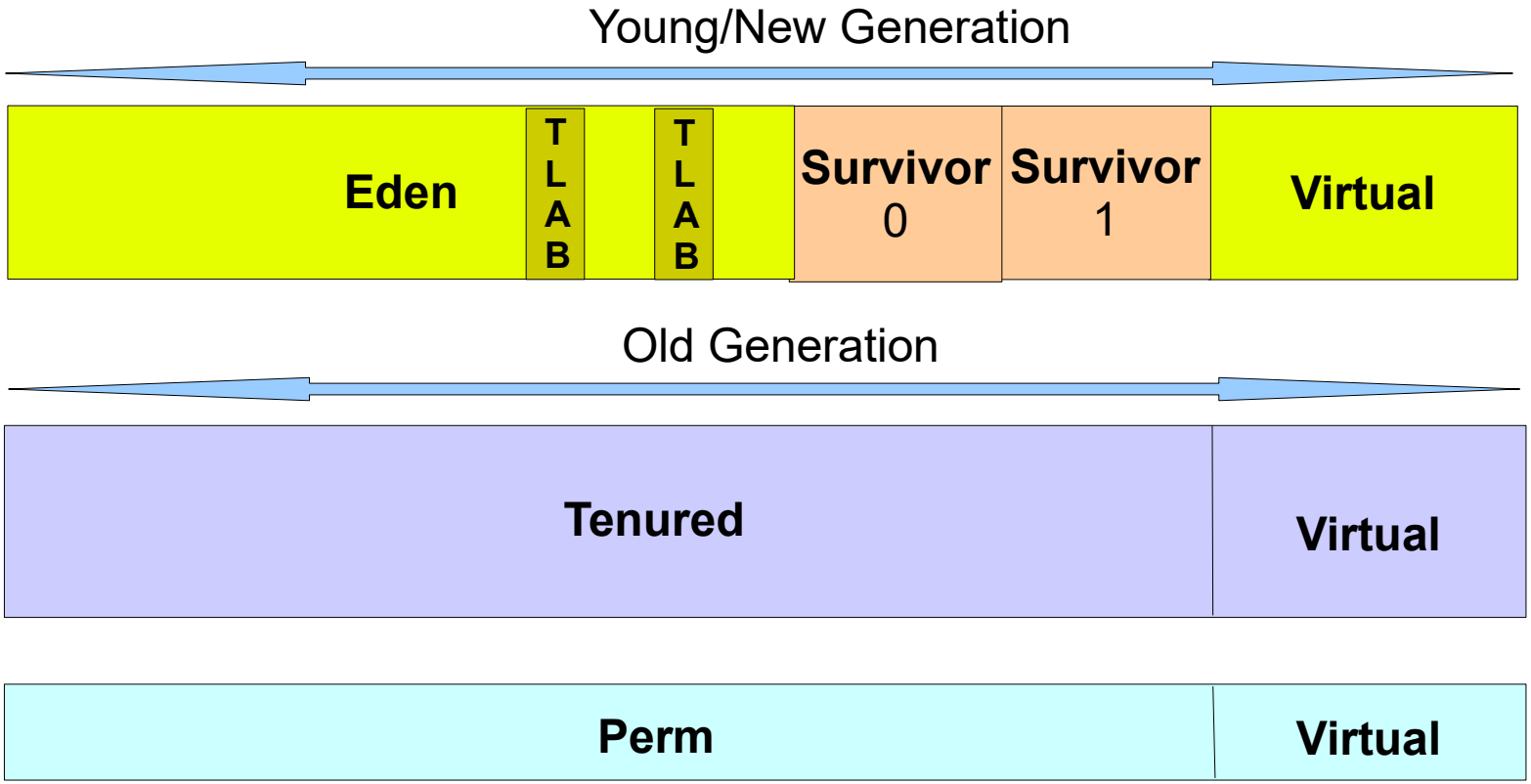
- Client and Server VMs (≠ JIT Compiliers & Defaults), x86, x64
- Generational Garbage Collection – Young, Old & ~~Permanent~~ (in Java 8 → Metaspace) – Weak generational hypothesis:
  - Most of the objects become unreachable soon;
  - Small number of references exist from old to young objects.
- Tuning for Higher Throughput:

java -d64 -server -XX:+AggressiveOpts -XX:+UseLargePages -Xmn10g -Xms26g -Xmx26g

- Tuning for Lower Latency

java -d64 -XX:+UseG1GC -Xms26g Xmx26g -XX:MaxGCPauseMillis=500 -XX:+PrintGCTimeStamp

Garbage Collection – Main Concepts



Garbage Collection – Basic Settings

- **-Xms** – Heap area size when starting JVM
- **-Xmx** – Maximum heap area size
- **-Xmn, -XX:NewSize** – размер на young generation (nursery)
- **-XX:MinHeapFreeRatio=<N>** **-XX:MaxHeapFreeRatio=<N>**
- **-XX:NewRatio** – Ratio of New area and Old area
- **-XX:NewSize** **-XX:MaxNewSize** – New area size <= Max
- **-XX:SurvivorRatio** – Ratio of Eden area and Survivor area
- **-XX:+PrintTenuringDistribution** – treshold and ages of New gen
- **-XX:PermSize -XX:MaxPermSize** – Initial/Max Permanent generation heap size (not supported in Java 8)

GC Strategies and Settings

- Serial GC **-XX:+UseSerialGC**
- Parallel GC **-XX:+UseParallelGC**

  -XX:ParallelGCThreads=<N>
- Parallel Compacting GC **-XX:+UseParallelOldGC**
- Conc. Mark Sweep CMS GC **-XX:+UseConcMarkSweepGC**

  -XX:+UseParNewGC

  -XX:+CMSParallelRemarkEnabled

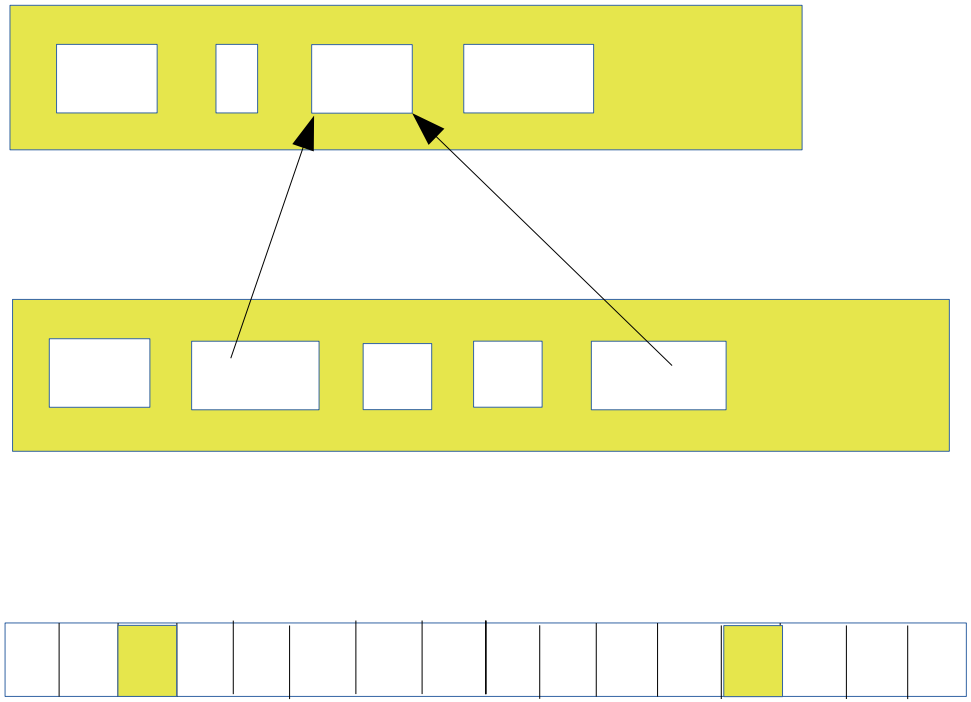
  -XX:CMSInitiatingOccupancyFraction=<N>

  -XX:+UseCMSInitiatingOccupancyOnly
- G1 **-XX:+UseG1GC**

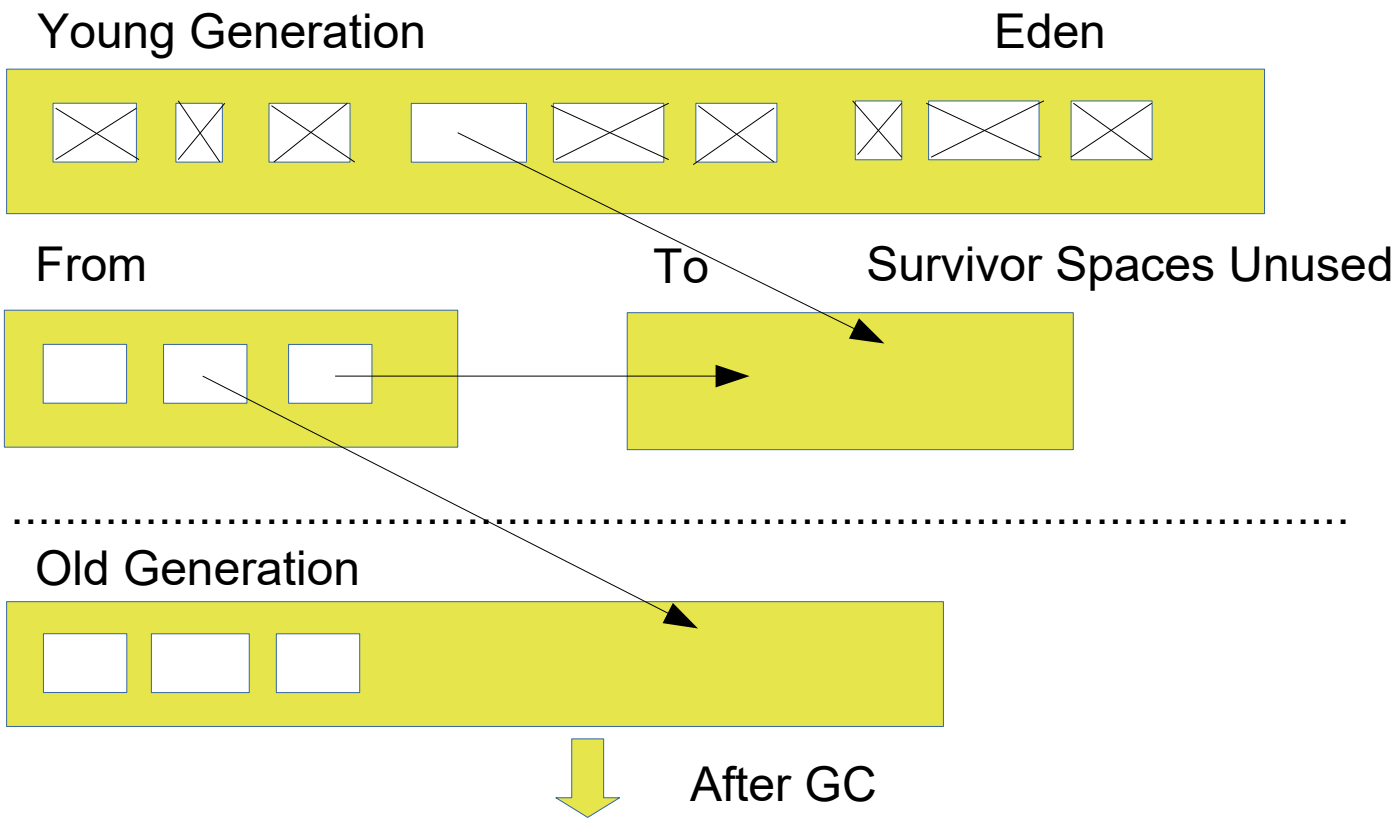
GC Strategies and Settings

-XX:+PrintTenuringDistribution -XX:+PrintGCDetails -XX:+PrintGCTimeStamps

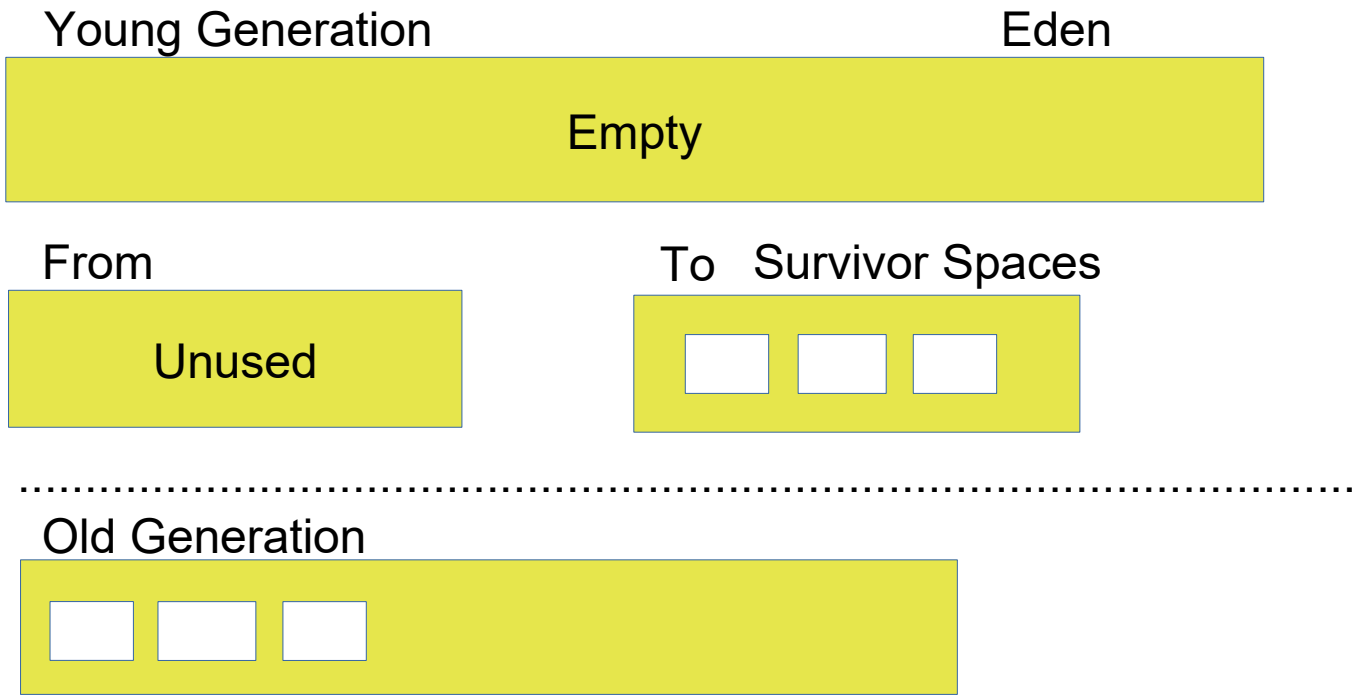
Card Table Structure



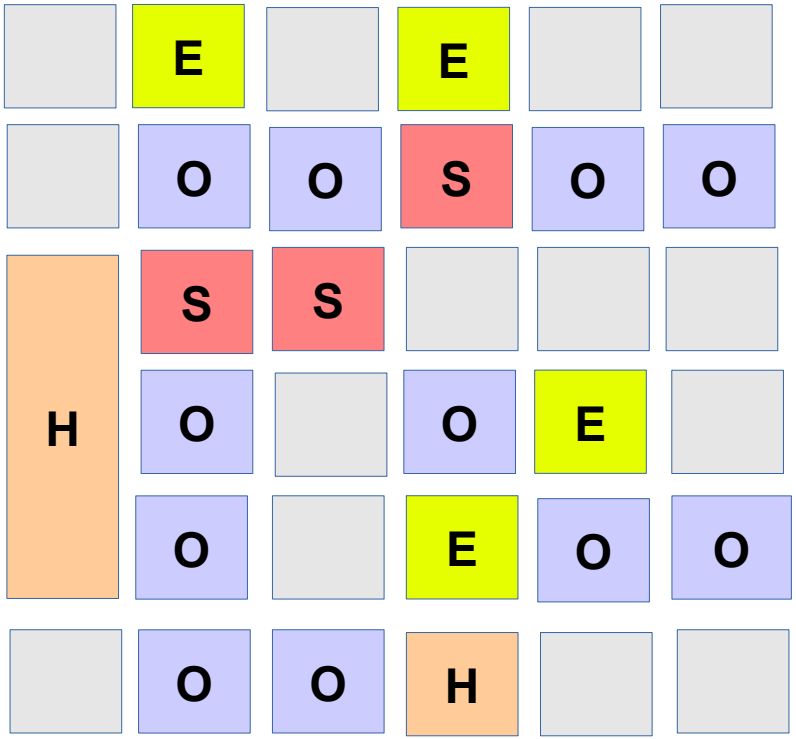
Before GC

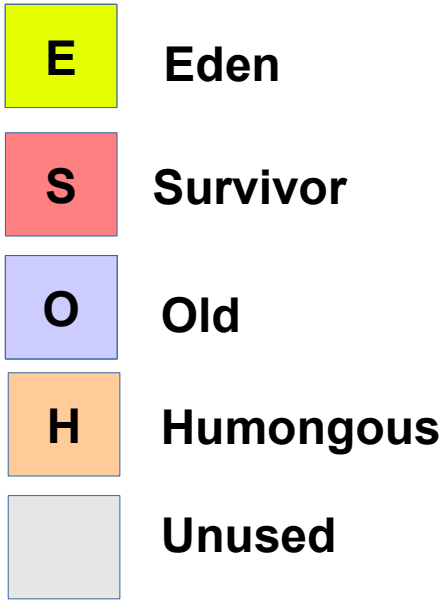


After GC



Garbage First G1 Partially Concurrent Collector

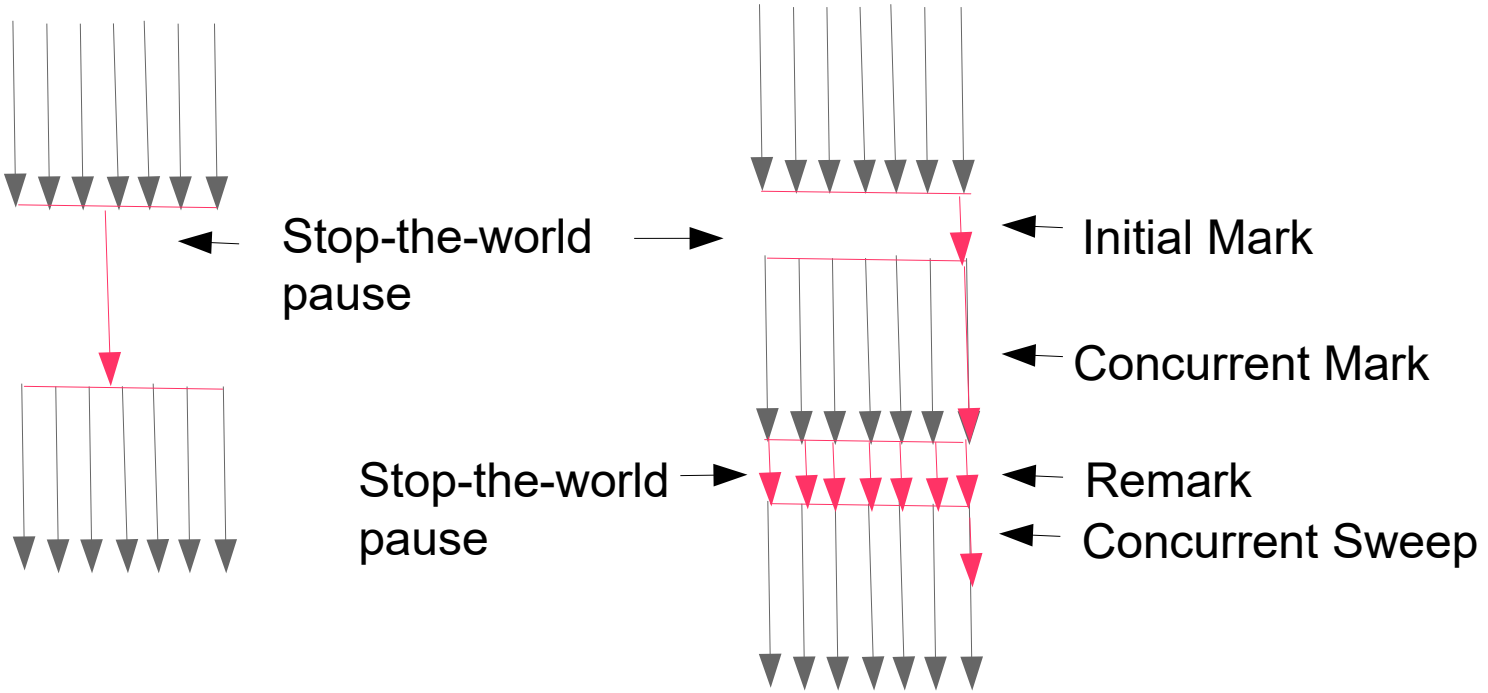




CMS GC (-XX:+UseConcMarkSweepGC)

Serial Mark-Sweep-Compact Collector

Concurrent Mark-Sweep Collector



Profiling Recommendations: GC

- **Garbage Collection** – be sure to minimize the GC interference by calling **System.gc()** several times before benchmark start. Call **System.runFinalization()** also. GC activity can be monitored using **-verbose:gc** JVM command. Another way to minimize GC interference is to use serial garbage collector using **-XX:+UseSerialGC** and same value for **-Xmx** and **-Xms**, as well as explicitly setting **-Xnm** flags.
- Use more precise **System.nanoTime()**, but be aware that the time can be reported with varying degree of accuracy in different JVM implementations.

Java Command Line Monitoring/Tuning Tools - I

- **jps** – reports the local VM identifier (**lvmid** - typically the process identifier - **PID** for the JVM process), for each instrumented JVM found on the target system.
- **jcmd** – reports class, thread and VM information for a java process: **jcmd <PID> <command> <optional arguments>**
- **jinfo** – provides information about current system properties of the JVM and for some properties allows to be set dynamically:

  jinfo -sysprops <PID>

  jinfo -flags <PID>

  jinfo -flag PrintGCDetails <PID>

  jinfo -flag -PrintGCDetails <PID> - sets -XX:-PrintGCDetails

Java Command Line Monitoring/Tuning Tools -II

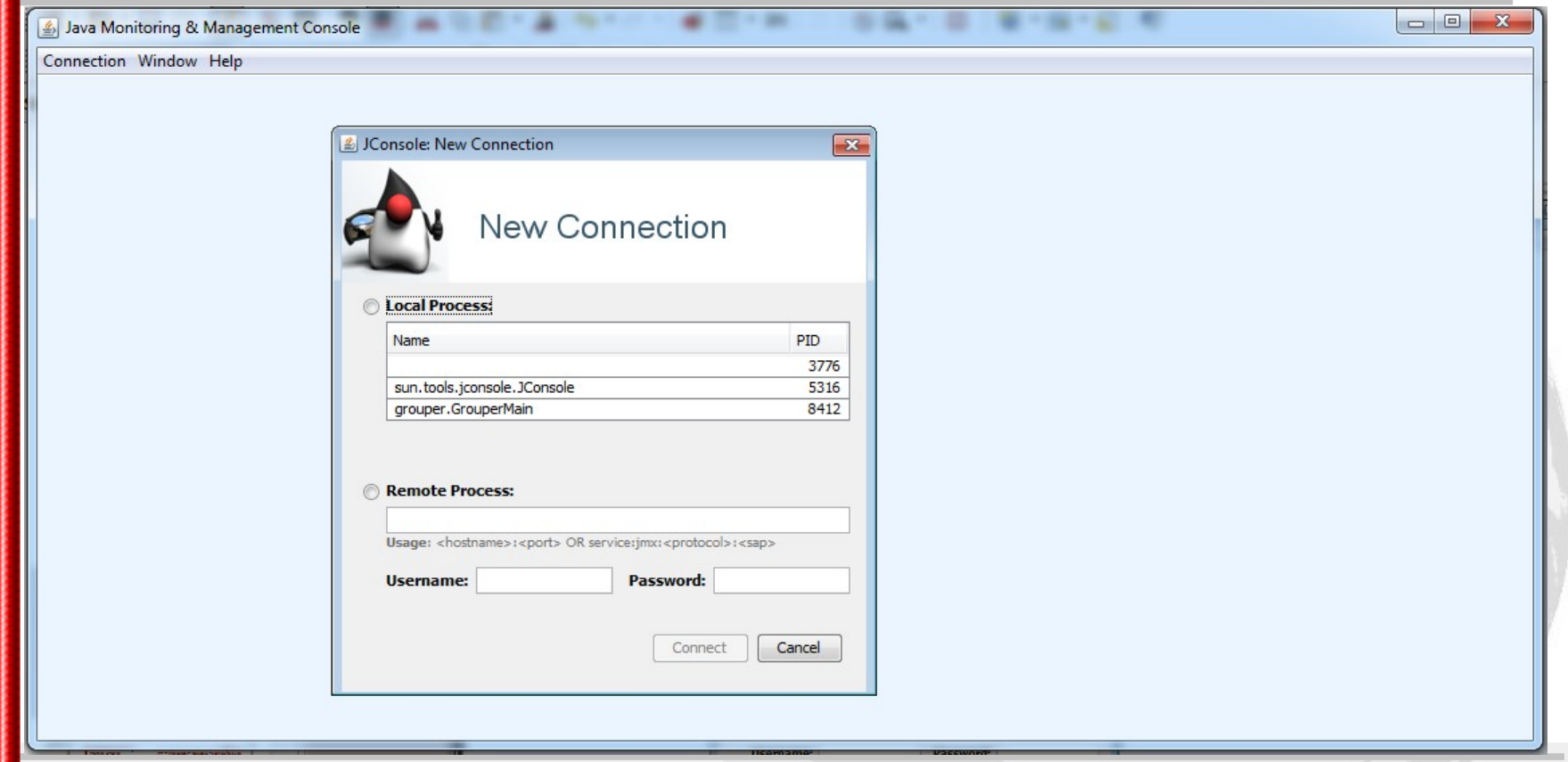
- **jstat & jstatd** – provide information about GC and class loading activities, useful for automated scripting (jstatd = RMI deamon):

  jstat [generalOption | outputOptions vmid [interval[s|ms] [count]]] Ex: **jstat -gc -t -h20 4572 2s**

- Statistics options (part of outputOptions):

  -class - statistics on the behavior of the class loader;
  -compiler - behavior of the HotSpot Just-in-Time compiler;
  -gc - statistics of the behavior of the garbage collected heap;
  -gccapacity - capacities of the generations and their spaces;
  -gccause, -gcutil - summary of garbage collection statistics/causes;
  -gcnew, -gcnewcapacity, -gcold, -gcoldcapacity, -gcpermcapacity
  – Young/Old/Permanent genration stats
  -printcompilation - HotSpot compilation method statistics

Java GUI tools – JConsole



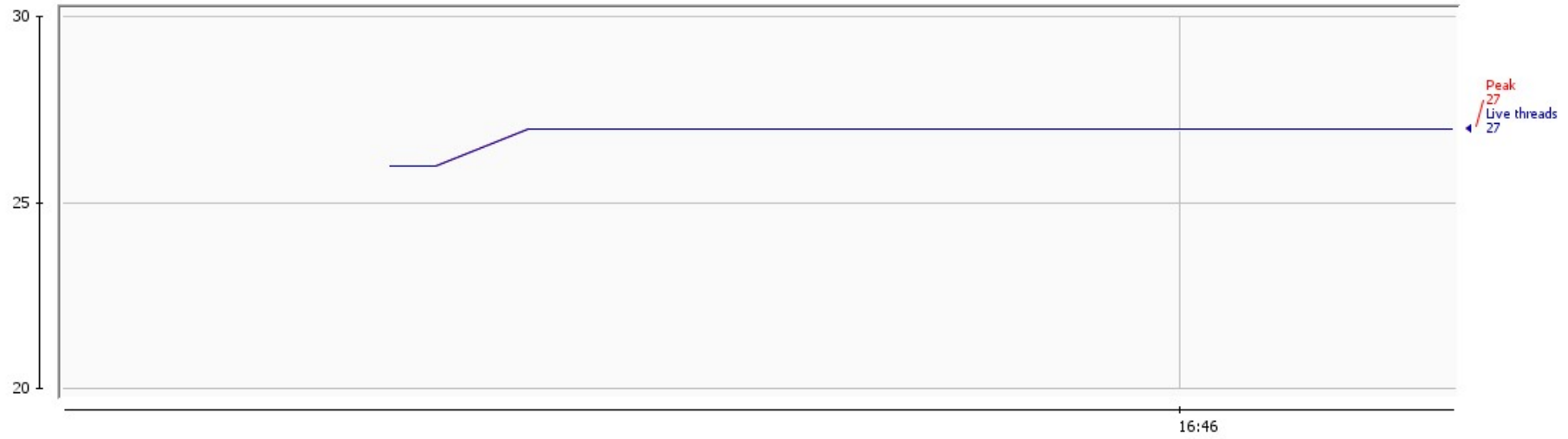
Java Monitoring & Management Console - pid: 8412 grouper.GrouperMain

Connection Window Help

Overview | Memory | Threads | Classes | VM Summary | MBeans

Time Range: All

Number of Threads



Threads

- Signal Dispatcher
- Attach Listener
- pool-1-thread-1
- pool-1-thread-2
- pool-1-thread-3
- pool-1-thread-4
- pool-1-thread-5
- pool-1-thread-6
- pool-1-thread-7
- pool-1-thread-8
- ForkJoinPool.commonPool-worker-1
- ForkJoinPool.commonPool-worker-4
- ForkJoinPool.commonPool-worker-5
- ForkJoinPool.commonPool-worker-6
- ForkJoinPool.commonPool-worker-3
- ForkJoinPool.commonPool-worker-2
- ForkJoinPool.commonPool-worker-7
- RMI TCP Accept-0
- RMI TCP Connection(1)-192.168.56.1

```
Name: pool-1-thread-1
State: RUNNABLE
Total blocked: 143,586  Total waited: 143,672

Stack trace:
java.lang.Object.wait(Native Method)
java.util.concurrent.ForkJoinTask.externalAwaitDone(ForkJoinTask.java:334)
java.util.concurrent.ForkJoinTask.doInvoke(ForkJoinTask.java:405)
java.util.concurrent.ForkJoinTask.invoke(ForkJoinTask.java:734)
java.util.Arrays.parallelSort(Arrays.java:1119)
java.util.stream.SortedOps$OfRef.opEvaluateParallel(SortedOps.java:158)
java.util.stream.AbstractPipeline.opEvaluateParallelLazy(AbstractPipeline.java:735)
java.util.stream.AbstractPipeline.sourceSpliterator(AbstractPipeline.java:471)
java.util.stream.AbstractPipeline.evaluate(AbstractPipeline.java:233)
java.util.stream.ReferencePipeline.collect(ReferencePipeline.java:499)
grouper.controller.impl.inmemory.VehicleControllerConcurentHashMapImpl.get(VehicleControllerConcurentHashMapImpl.java:93)
grouper.task.VehicleTask.call(VehicleTask.java:76)
grouper.task.VehicleTask.call(VehicleTask.java:1)
java.util.concurrent.FutureTask.run(FutureTask.java:266)
java.util.concurrent.Executors$RunnableAdapter.call(Executors.java:511)
java.util.concurrent.FutureTask.run(FutureTask.java:266)
java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1142)
java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:617)
java.lang.Thread.run(Thread.java:745)
```

Filter

Detect Deadlock

No deadlock detected

Connection Window Help

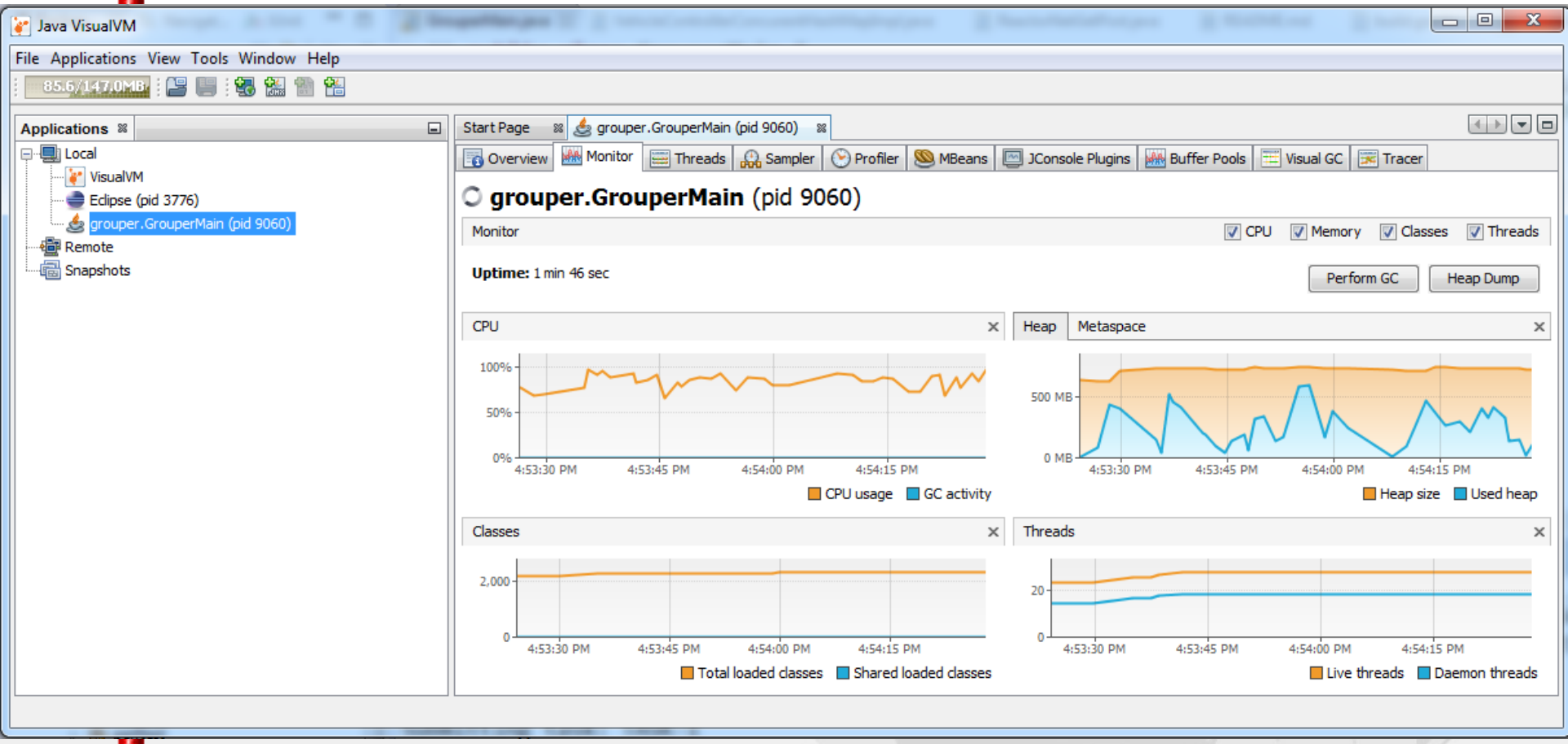
Overview | Memory | Threads | Classes | VM Summary | MBeans

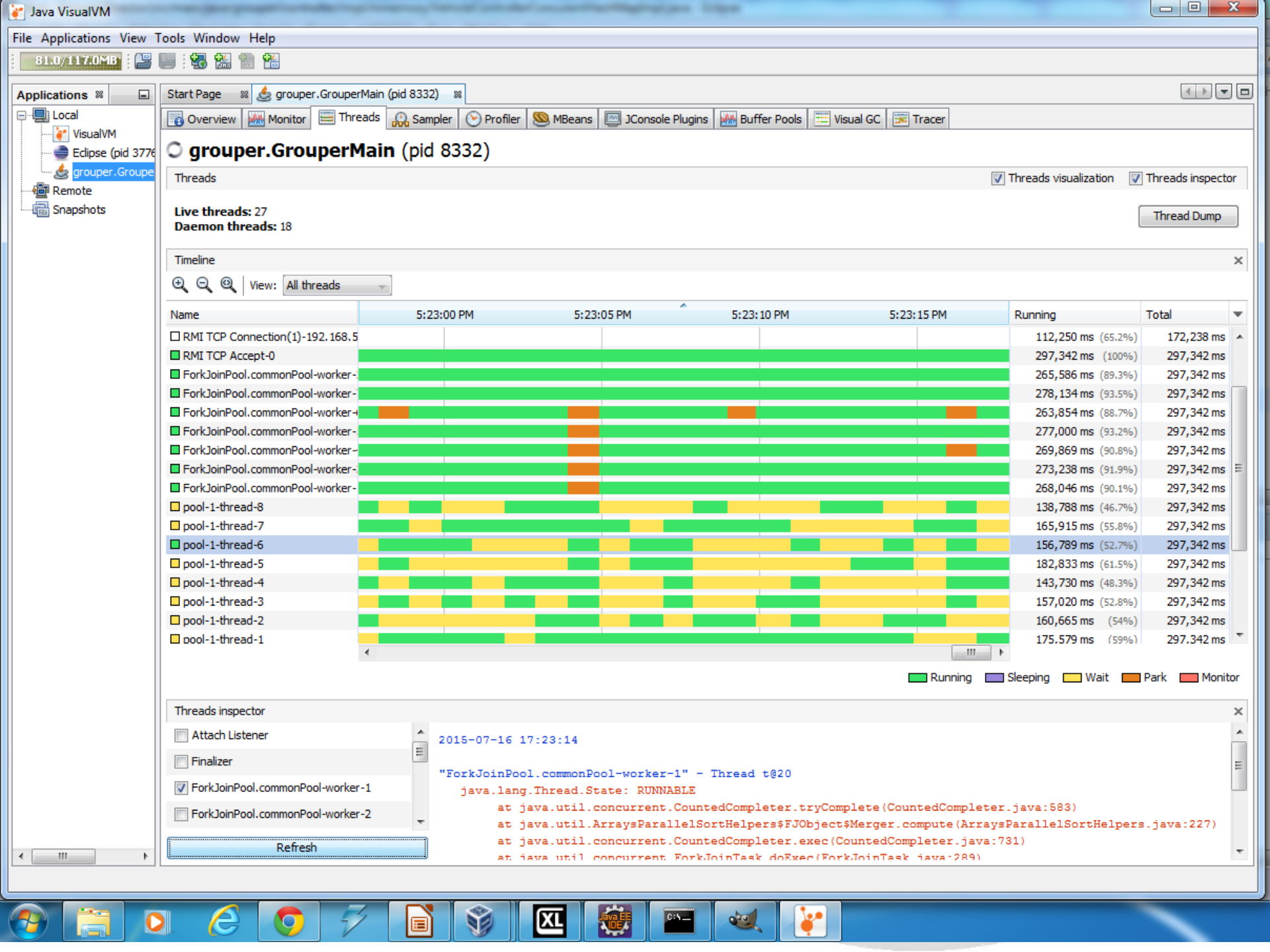
Chart: Heap Memory Usage Time Range: All Perform GC

Details

Time: 2015-07-16 16:49:30
Used: 295,252 kbytes
Committed: 474,624 kbytes
Max: 1,840,640 kbytes
GC time: 0.000 seconds on PS MarkSweep (0 collections)
1.143 seconds on PS Scavenge (455 collections)

Java GUI tools – jvisualvm




Java VisualVM
File Applications View Tools Window Help
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Applications
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VisualVM
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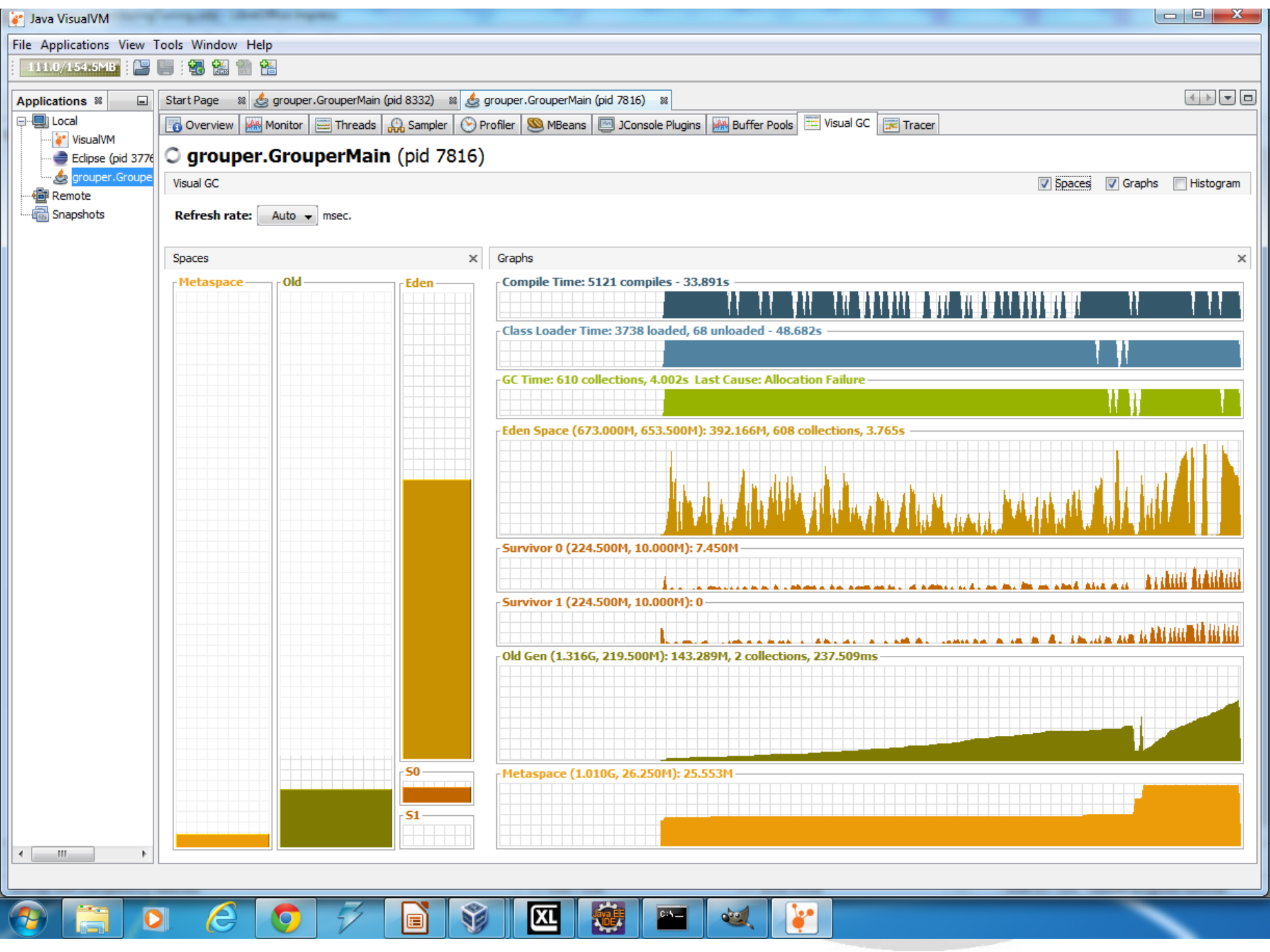
Snapshots
Start Page
grouper.GrouperMain (pid 8332)
Overview
Monitor
Threads
Sampler
Profiler
MBeans
JConsole Plugins
Buffer Pools
Visual GC
Tracer
grouper.GrouperMain (pid 8332)
Threads
Threads visualization
Threads inspector
Live threads: 27
Daemon threads: 18
Thread Dump
Timeline
View: All threads
Name
5:23:00 PM
5:23:05 PM
5:23:10 PM
5:23:15 PM
Running
Total
RMI TCP Connection(1)-192.168.5
RMI TCP Accept-0
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
ForkJoinPool.commonPool-worker-
pool-1-thread-8
pool-1-thread-7
pool-1-thread-6
pool-1-thread-5
pool-1-thread-4
pool-1-thread-3
pool-1-thread-2
pool-1-thread-1
112,250 ms (65.2%) 172,238 ms
297,342 ms (100%) 297,342 ms
265,586 ms (89.3%) 297,342 ms
278,134 ms (93.5%) 297,342 ms
263,854 ms (88.7%) 297,342 ms
277,000 ms (93.2%) 297,342 ms
269,869 ms (90.8%) 297,342 ms
273,238 ms (91.9%) 297,342 ms
268,046 ms (90.1%) 297,342 ms
138,788 ms (46.7%) 297,342 ms
165,915 ms (55.8%) 297,342 ms
156,789 ms (52.7%) 297,342 ms
182,833 ms (61.5%) 297,342 ms
143,730 ms (48.3%) 297,342 ms
157,020 ms (52.8%) 297,342 ms
160,665 ms (54%) 297,342 ms
175.579 ms (59%) 297.342 ms
Running
Sleeping
Wait
Park
Monitor
Threads inspector
Attach Listener
Finalizer
ForkJoinPool.commonPool-worker-1
ForkJoinPool.commonPool-worker-2
Refresh
2015-07-16 17:23:14
"ForkJoinPool.commonPool-worker-1" - Thread t@20
java.lang.Thread.State: RUNNABLE
at java.util.concurrent.CountedCompleter.tryComplete(CountedCompleter.java:583)
at java.util.ArraysParallelSortHelpers$FJObject$Merger.compute(ArraysParallelSortHelpers.java:227)
at java.util.concurrent.CountedCompleter.exec(CountedCompleter.java:731)


Java VisualVM
File Applications View Tools Window Help
111.0/154.5MB
Applications
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Eclipse (pid 3776
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JConsole Plugins
Buffer Pools
Visual GC
Tracer
grouper.GrouperMain (pid 7816)
Visual GC
Spaces
Graphs
Histogram
Refresh rate:
Auto
msec.
Spaces
Metaspace
Old
Eden
S0
S1
Graphs
Compile Time: 5121 compiles - 33.891s
Class Loader Time: 3738 loaded, 68 unloaded - 48.682s
GC Time: 610 collections, 4.002s Last Cause: Allocation Failure
Eden Space (673.000M, 653.500M): 392.166M, 608 collections, 3.765s
Survivor 0 (224.500M, 10.000M): 7.450M
Survivor 1 (224.500M, 10.000M): 0
Old Gen (1.316G, 219.500M): 143.289M, 2 collections, 237.509ms
Metaspace (1.010G, 26.250M): 25.553M

Objects Initialization. Array initialization

- Initialization in declaration
- Initialization in constructor
- „Lazy“ initialization
- Initialization of static class members
- One-dimensional and multi-dimensional arrays
- Array initialization

What Modularity Means?

- Modularization is the decomposition of a system to set of **highly coherent** and **loosely coupled** modules.
- All the communication between modules is done through **well defined interfaces**.
- Modules are artifacts containing **code and metadata** describing thee module.
- Each module is **uniquely identifiable** and ideally recognizable from compile-time to run-time.

Why Modularity is Important?

- **Strong encapsulation** – separation between public and private module APIs (e.g. sun.misc.Base64Encoder)
- **Well-defined interfaces** and interaction protocols
- **Explicit module dependencies** and library version management => module graph
- **Reliable configuration** – no more *NoClassDefFoundError* in runtime
- **Mitigates the 'JAR / Classspath hell'** problem

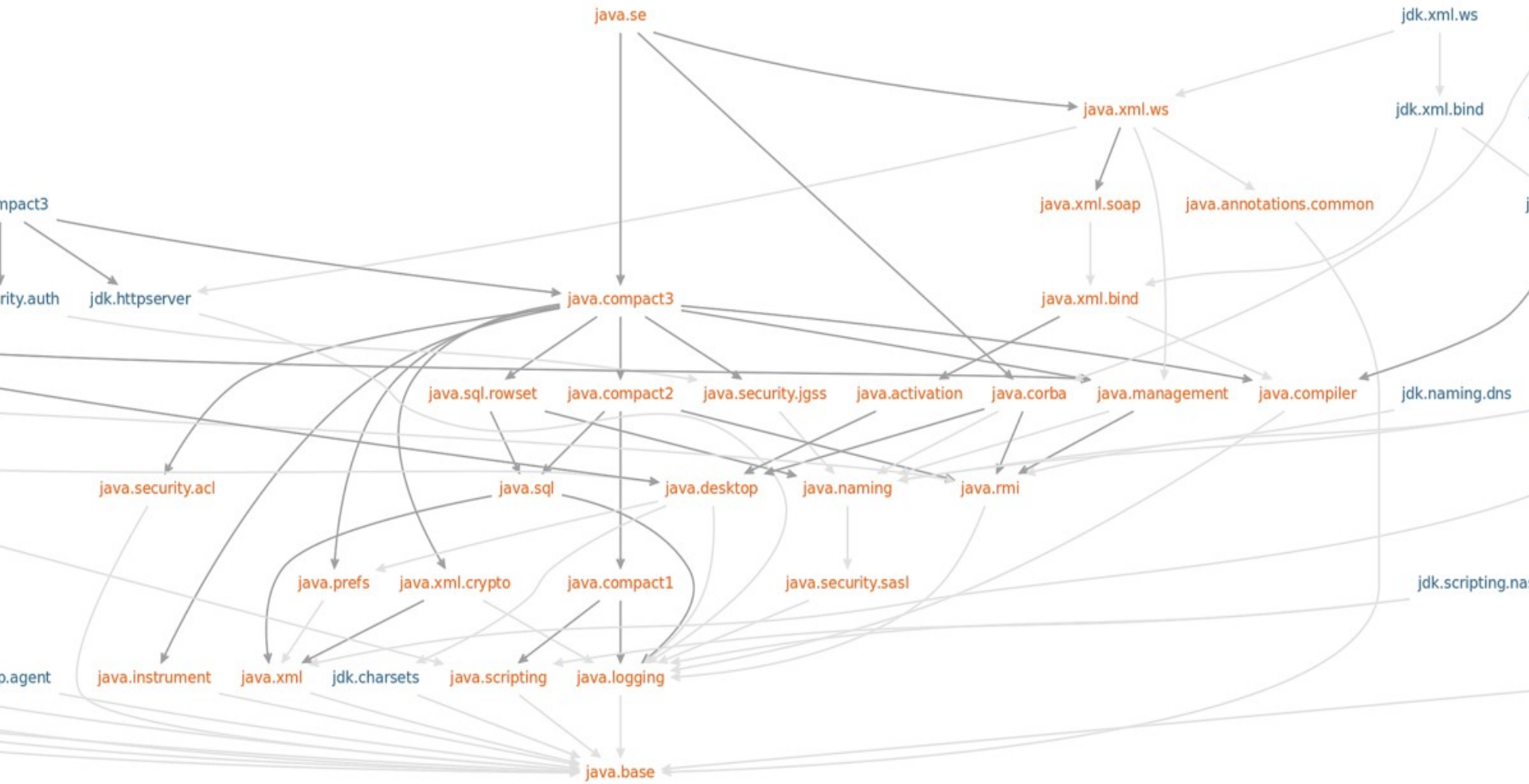
Java 9 Modularity – Project Jigsaw

- **Reliable configuration** – makes easier for developers to construct and maintain libraries and large apps
- Improved the **security and maintainability** of Java SE Platform Implementations, JDK and app libraries
- Enable improved **application performance**
- Make Java SE Platform / JDK to **scale down** for use with small devices and dense cloud deployments
- To achieve these goals, **a standard module system for the Java SE 9 Platform** was implemented.

Project Jigsaw – JEPs and JSR

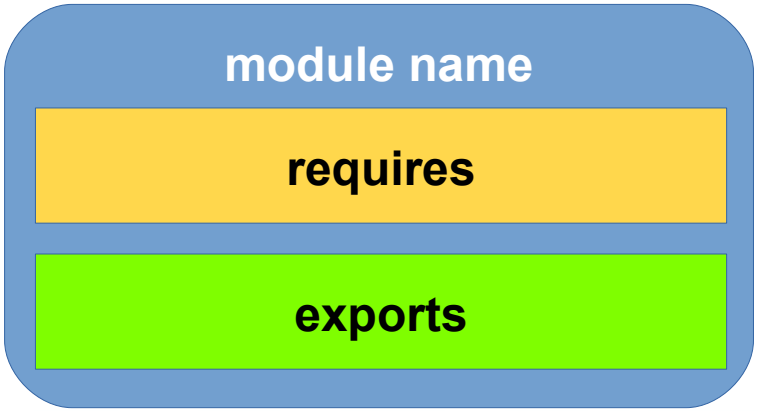
- **JEPs:**
  - 200: Modular JDK
  - 201: Modular Source Code
  - 220: Modular Run-time Images
  - 260: Encapsulate Most Internal APIs
  - 261: Module System
  - 282: jlink: Java Linker
- **JSR 376 Java Platform Module System**

JDK Modularization



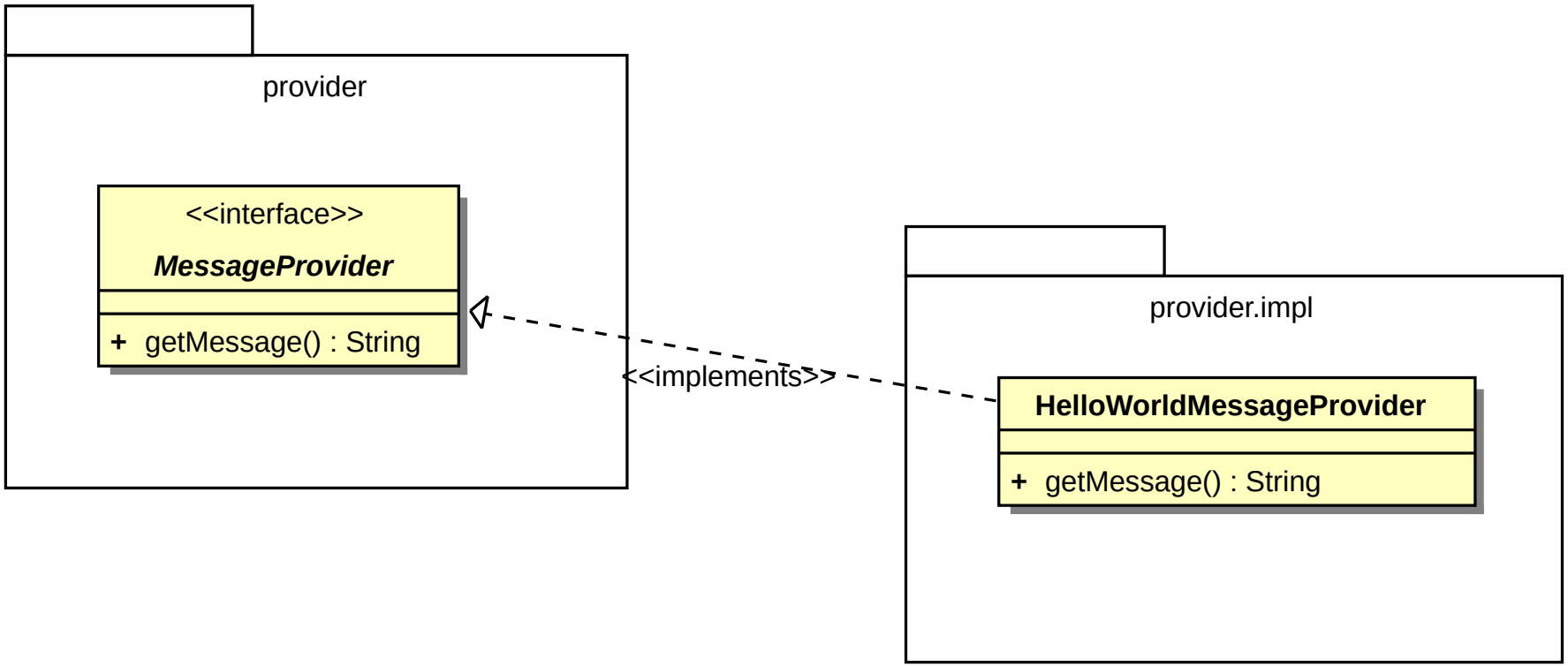
Java 9 Modules

- Each JAR becomes a module, containing **explicit references** to other modules specified in a module metadata descriptor file called `module-info.java` available at the root of the classpath for that JAR.
- Dependencies are **available at runtime** and are eagerly **resolved before the application is started**




```
module renderer {
    requires provider;
    exports renderer;
}
```

Separation of Public & Private APIs



- *Problem:* How to publish the **MessageProvider** service interface but to hide the service implementation?

Java 9 Accessibility Options

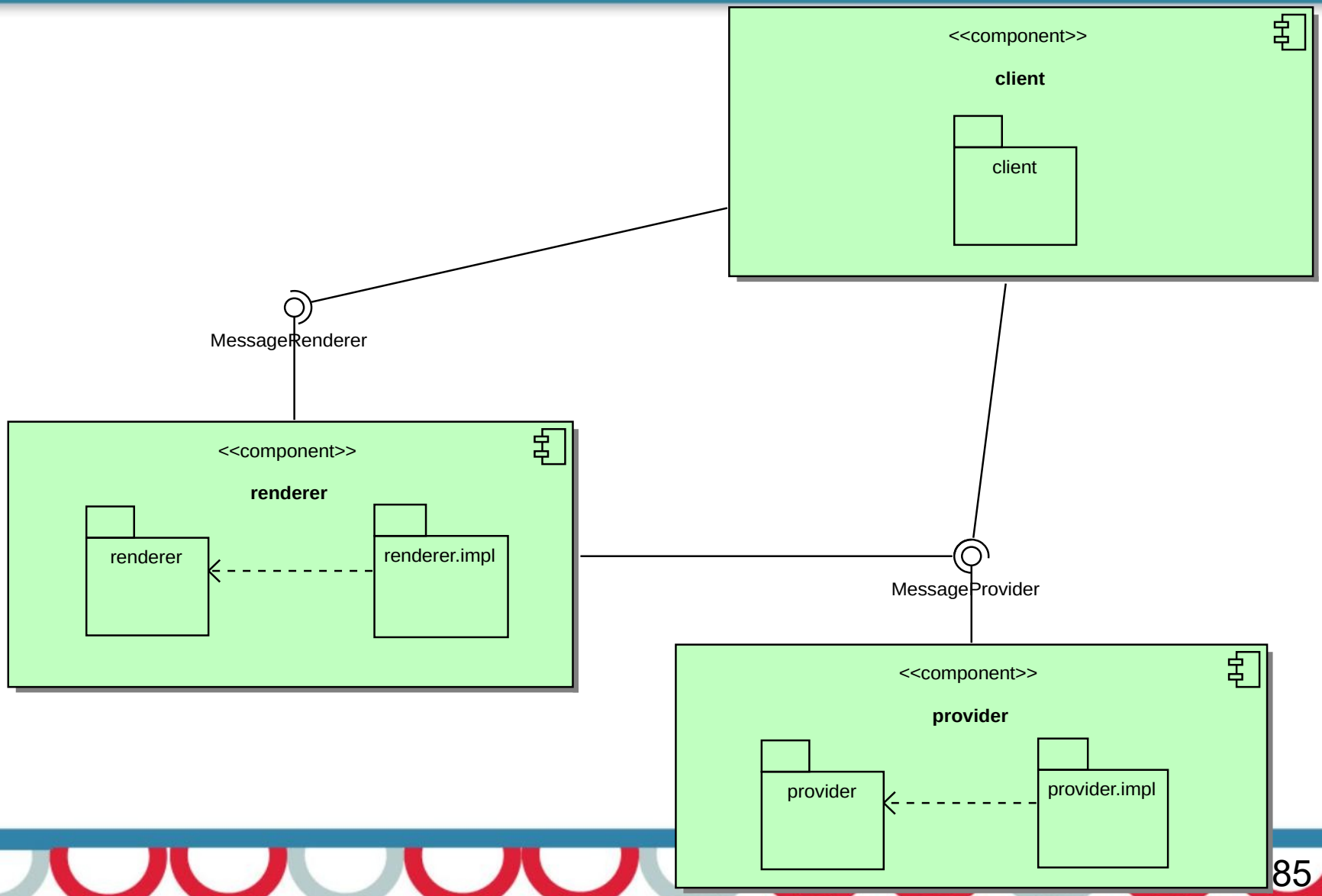
Java 1.1 – 1.8	Java 9
private	private
default (package private)	default (package private)
protected	protected
public	public within a module
	public to specific modules
	public for all modules

Module Definition: module-info.java

[https://www.baeldung.com/java-9-modularity]

```
<open> module <module-name> {
        [export <java package> [to <module name>]
        [requires [transitive] <module-name>]
        [opens <module name> [to <module name]]
        [provides <interface> with <implementation>]
        [uses <interface>]
}
```

Demo App: Module Dependencies



Demo App: Provider Module

```
|-- provider
|   |-- bin
|   |   |-- module-info.class
|   |   `-- provider
|   |       |-- MessageProvider.class
|   |       `-- impl
|   |           `-- HelloWorldMessageProvider.class
|   `-- src
|       |-- module-info.java
|       `-- provider
|           |-- MessageProvider.java
|           `-- impl
|               `-- HelloWorldMessageProvider.java
```

Provider Module Code

```
package provider;
public interface MessageProvider {
    String getMessage();
}

package provider.impl;
import provider.MessageProvider;
public class HelloWorldMessageProvider
                            implements MessageProvider {
    @Override
    public String getMessage() {
        return "Hello Java 9 Modularity!!!";
    }
}
```

Provider Module module-info.java

```
module provider {
    exports provider;
    exports provider.impl;
}
```

Demo App: Renderer Module

```
`-- renderer
    |-- bin
    |   |-- module-info.class
    |   `-- renderer
    |       |-- MessageRenderer.class
    |       `-- impl
    |           `-- StandardOutMessageRenderer.class
    `-- src
        |-- module-info.java
        `-- renderer
            |-- MessageRenderer.java
            `-- impl
                `-- StandardOutMessageRenderer.java
```

Renderer Module Interface

```
package renderer;

import provider.MessageProvider;

public interface MessageRenderer {
    void render();
    void setMessageProvider(MessageProvider provider);
    MessageProvider getMessageProvider();
}
```

Renderer Module Implementation

```
public class StandardOutMessageRenderer
                    implements MessageRenderer {
    private MessageProvider provider;

    @Override
    public void render() {
        if (provider == null)
            throw new RuntimeException("No Provider”);
        System.out.println(provider.getMessage());
    }

    @Override
    public void setMessageProvider(MessageProvider
        provider) {   this.provider = provider;   }
...
```

Renderer Module module-info.java

```
module renderer {
    requires provider;
    exports renderer;
    exports renderer.impl;
}
```

Demo App: Client Module

```
.
|-- client
|   |-- bin
|   |   |-- client
|   |   |   `-- HelloModularityClient.class
|   |   `-- module-info.class
|   `-- src
|       |-- client
|       |   `-- HelloModularityClient.java
|       `-- module-info.java
```

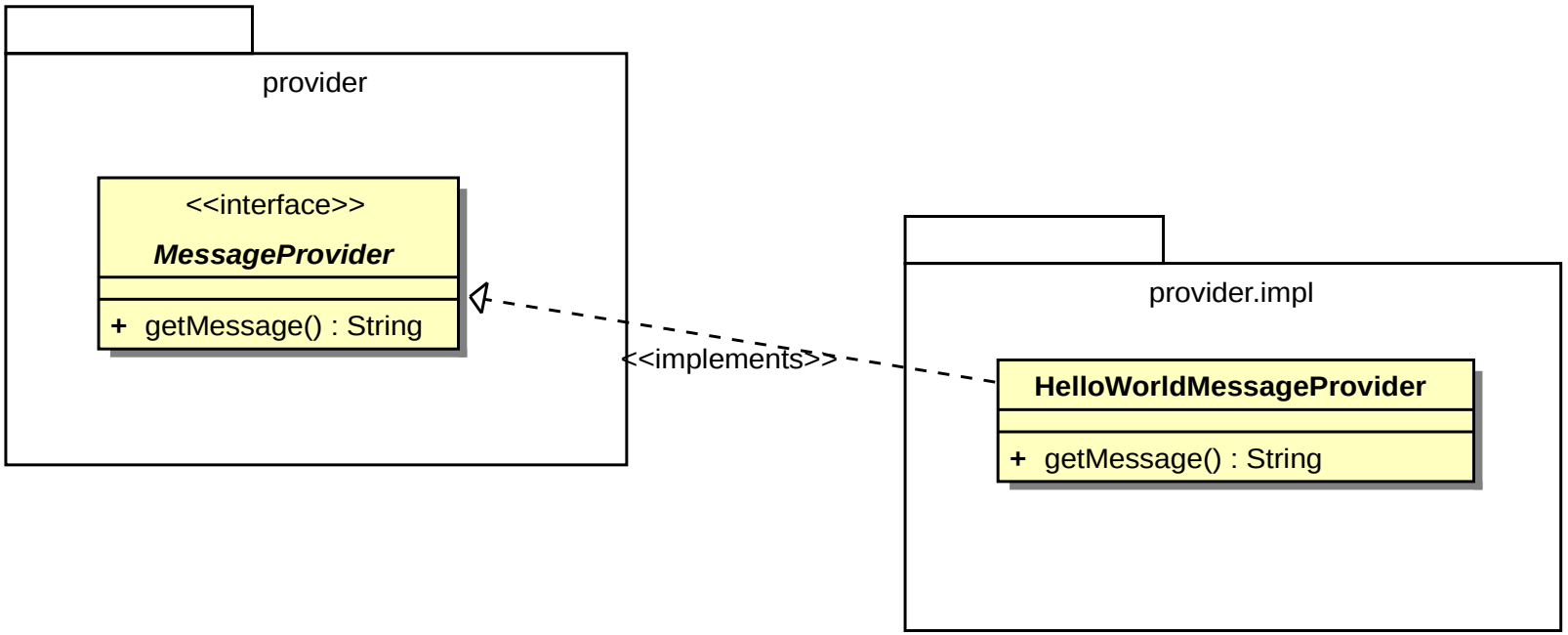
Client Module Code

```
package client;
import provider.MessageProvider;
import renderer.MessageRenderer;
import provider.impl.HelloWorldMessageProvider;
import renderer.impl.StandardOutMessageRenderer;

public class HelloModularityClient {
    public static void main(String[] args) {
    MessageProvider provider = new MessageProvider();
    MessageRenderer renderer =
          new StandardOutMessageRenderer();
    renderer.setMessageProvider(provider);
    renderer.render();
    }
}
```

Client Module module-info.java

```
import provider.MessageProvider;
import renderer.MessageRenderer;

module client {
    requires provider;
    requires renderer;
    exports client;
}
```

Separation of Public & Private APIs



- *Problem:* How to publish the **MessageProvider** service interface but to hide the service implementation?
- *Solution:* **class ServiceLoader<S>**

Provider Module module-info.java

```
module provider {
    exports provider;
    // exports renderer.impl;

    provides provider.MessageProvider
        with provider.impl.HelloWorldMessageProvider;
}
```

Renderer Module module-info.java

```
module renderer {
    requires provider;
    exports renderer;
    // exports renderer.impl;

    provides renderer.MessageRenderer with
        renderer.impl.StandardOutMessageRenderer;
}
```

Client Module module-info.java

```
import provider.MessageProvider;
import renderer.MessageRenderer;

module client {
    requires provider;
    requires renderer;
    uses MessageProvider;
    uses MessageRenderer;
    exports client;
}
```

Client Module with ServiceLoader I

```
package client;
import java.util.Iterator;
import java.util.ServiceLoader;
import provider.MessageProvider;
import renderer.MessageRenderer;

public class HelloModularityClient {
    public static void main(String[] args) {
//  MessageProvider provider = new MessageProvider();
    ServiceLoader<MessageProvider> loaderProvider =
        ServiceLoader.load(MessageProvider.class);
    Iterator<MessageProvider> iterProvider =
        loaderProvider.iterator();
    (-continue on next slide -)
```

Client Module with ServiceLoader II

```
    (- continued -)
    if (!iterProvider.hasNext()) throw new
        RuntimeException("No MessageProvider!");
    MessageProvider provider = iterProvider.next();

    ServiceLoader<MessageRenderer> loaderRenderer =
        ServiceLoader.load(MessageRenderer.class);
    Iterator<MessageRenderer> iterRenderer =
        loaderRenderer.iterator();
        ...
    MessageRenderer renderer = iterRenderer.next();

    renderer.setMessageProvider(provider);
    renderer.render();
}}
```

Module Artifacts

- **Modular JAR files** – regular JAR files with **module-info.class** on top of the classpath:

```
|-- META-INF
|   `-- MANIFEST.MF
|-- module-info.class
`-- provider
    |-- MessageProvider.class
    `-- impl
        `-- HelloWorldMessageProvider.class
```

- **Exploded module directory**
- **JMOD module format** – can include native code

Platform Modules

```
module java.base {
    exports java.io;
    exports java.lang;
    exports java.lang.annotation;
    exports java.lang.invoke;
    exports java.lang.module;
    exports java.lang.ref;
    exports java.lang.reflect;
    exports java.math;
    exports java.net;
    ...
}
```

Module Resolution

- **Module path (--module-path)** – different from classpath, includes platform modules + app modules, resolved upfront → acyclic module dependency graph
- **Reliable configuration** – module system ensures that each dependence is fulfilled exactly by one module
- Each **package belongs to exactly one module**
- **Faster class search** – no need to search the entire *classpath*
- **Implied readability**

Example: **requires transitive java.logging**

Module Types

- **System Modules** – ***java --list-modules***
- **Named modules** – explicitly define **module-info**
- **Unnamed module** – if a request is made to load a type which does not belong to any observable module, module system will attempt to load it from *classpath*. It is assumed that such type belongs to *unnamed module.* **Unnamed module reads every named module, exports all its packages, but is not readable by default by named modules, use: ALL-UNNAMED**
- **Automatic modules** – the name of the module is derived from the name of jar file implicitly, r**eads all modules including unnamed** → top-down migration.

Advanced Modules: Reflection

- Each class has **Class::getModule()** method
- **Module::getDescriptor()** returns a **ModuleDescriptor**
- Can be built programmatically using **ModuleDescriptor.Builder** – e.g.:

```
ModuleDescriptor descr =
ModuleDescriptor.newModule("org.iproductstats.core")
    .requires("java.base")
    .exports("org.iproduct.core.clustering")
    .exports("org.iproduct.core.stats")
    .packages(Set.of("org.iproduct.core.internal"))
    .build();
```

And More ...

- **ClassLoaders** – each module is loaded by exactly one *class loader*, but one *class loader* can load several modules, and there may be different *class loaders* for different modules.
- **Layers** – can be thought of as resolving modules in parallel module universes which can have hierarchical dependencies (parent-child) between them. There is always initial **ModuleLayer** called **boot layer**. Sophisticated app containers like application servers may load different versions of library modules / service providers for each contained app.

Essential Module Tooling

- **jdeps** – allows to obtain crucial information about module inter-dependencies – e.g:

```
jdeps  -jdkinternals --module-path modules
modules/client.jar
```

- **jlink** – produces run-able image containing only used JDK and application modules (~70 MB) – e.g:

```
jlink -p "%JAVA_HOME%\jmods";modules --add-
modules client --output small-image --bind-
services --launcher start-app=client --
strip-debug -compress=2
```

- **jmod** – produces mixed java native code modules

Java 9 Process API Updates

- Retrieve PID of Current Process:

```
long pid = ProcessHandle.current().pid();
```

- Checking if process is running:

```
Optional<ProcessHandle> handle = ProcessHandle.of(pid);
boolean isAlive = processHandle.isPresent() &&
                  processHandle.get().isAlive();
```

- Retrieving process information

```
ProcessHandle.Info info = handle.get().info();
System.out.println("CPU time: " +
                   info.totalCpuDuration().orElse(null));
```

- Running post-termination code, getting children, etc.

Immutable Collections

- **List**, **Set** and **Map** have been added new factory methods for immutable collections:
- **of(...)** factory methods for **Set** and **List,** one with varargs parameters.
- **of(...)** factory methods for **Map** with key and value arguments, one with varargs of Entry type **ofEntries(Entry<? extends K, ? extends V>... entries)**
- Returned collections are instances of nested types defined under **java.util.ImmutableCollections**

Stack-Walking API (JEP 259)

- Replaces now deprecated **sun.reflect.Reflection** with **StackWalker** class:
- public <T> T **walk(**Function<Stream<StackFrame>,T> function**)** – traverses the satckframes of the current thread as stream and applying the given function
- public Class<?> **getCallerClass()** – returns the invoking class

Reactive Streams Spec.

- Reactive Streams – provides standard for asynchronous stream processing with non-blocking back pressure.
- Minimal set of interfaces, methods and protocols for asynchronous data streams
- April 30, 2015: has been released version 1.0.0 of Reactive Streams for the JVM (Java API, Specification, TCK and implementation examples)
- Java 9: java.util.concurrent.Flow

Reactive Streams Spec.

- **Publisher** – provider of potentially unbounded number of sequenced elements, according to Subscriber(s) demand.

Publisher.subscribe(Subscriber) => **onSubscribe onNext* (onError | onComplete)?**

- **Subscriber** – calls **Subscription.request(long)** to receive notifications
- **Subscription** – one-to-one **Subscriber** ↔ **Publisher**, request data and cancel demand (allow cleanup).
- **Processor** = **Subscriber** + **Publisher**

Futures in Java 8 - I

- Future (implemented by FutureTask) – represents the result of an cancelable asynchronous computation. Methods are provided to check if the computation is complete, to wait for its completion, and to retrieve the result of the computation (blocking till its ready).
- RunnableFuture – a Future that is Runnable. Successful execution of the run method causes Future completion, and allows access to its results.
- ScheduledFuture – delayed cancelable action that returns result. Usually a scheduled future is the result of scheduling a task with a ScheduledExecutorService

Future Use Example

```
Future<String> future = executor.submit(
    new Callable<String>() {
        public String call() {
            return searchService.findByTags(tags);
        }
    }
);

DoSomethingOther();

try {
    showResult(future.get()); // use future result
} catch (ExecutionException ex) { cleanup(); }
```

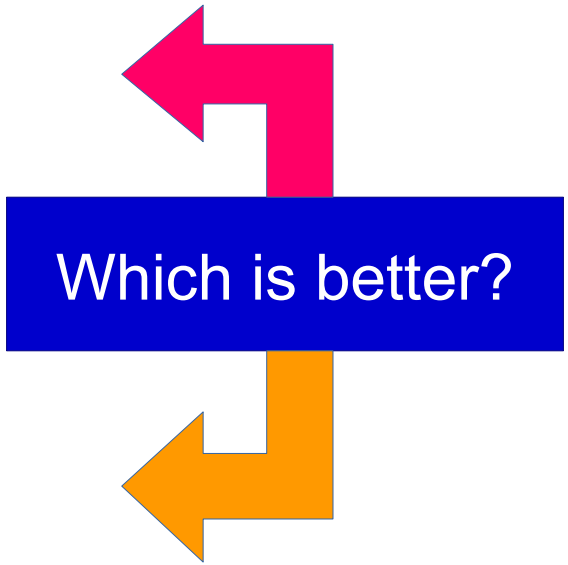
Futures in Java 8 - II

- CompletableFuture – a Future that may be explicitly completed (by setting its value and status), and may be used as a CompletionStage, supporting dependent functions and actions that trigger upon its completion.

- CompletionStage – a stage of possibly asynchronous computation, that is triggered by completion of previous stage or stages. A stage performs an action or computes value and completes, triggering next dependent stages. Computation may be Function (apply), Consumer (accept), or Runnable (run).

CompletableFuture Example - III

```
 try {
   System.out.println(results.get(10, TimeUnit.SECONDS));
 } catch (ExecutionException | TimeoutException
          | InterruptedException e) {
   e.printStackTrace();
 }
 executor.shutdown();
}


// OR just:
System.out.println(results.join());
executor.shutdown();
```



CompletionStage

- Computation may be Function (apply), Consumer (accept), or Runnable (run) – e.g.:

```
completionStage.thenApply( x -> x * x )
        .thenAccept(System.out::print )
        .thenRun( System.out::println )
```

- Stage computation can be triggered by completion of 1 (then), 2 (combine), or either 1 of 2 (either)
- Functional composition can be applied to stages themselves instead to their results using compose
- handle & whenComplete – support unconditional computation – both normal or exceptional triggering

CompletionStages Composition

```
public void testlCompletableFutureComposition() throws
InterruptedException, ExecutionException {
    Double priceInEuro = CompletableFuture.supplyAsync(
            () -> getStockPrice("GOOGL") )
      .thenCombine(CompletableFuture.supplyAsync(
            () -> getExchangeRate(USD, EUR)), this::convertPrice)
      .exceptionally(throwable -> {
          System.out.println("Error: " + throwable.getMessage());
          return -1d;
      }).get();

  System.out.println("GOOGL stock price in Euro: " +
     priceInEuro );
}
```

New in Java 9: CompletableFuture

- Executor **defaultExecutor()**
- CompletableFuture<U> **newIncompleteFuture()**
- CompletableFuture<T> **copy()**
- CompletionStage<T> **minimalCompletionStage()**
- CompletableFuture<T> **completeAsync(**
  Supplier<? extends T> supplier[, Executor executor]**)**
- CompletableFuture<T> **orTimeout(**
  long timeout, TimeUnit unit**)**
- CompletableFuture<T> **completeOnTimeout(**
  T value, long timeout, TimeUnit unit**)**

Async HTTP/2 & WebSocket clients

- Why HTTP/2?
  - Header compression and binary encoding
  - bidirectional communication using push requests
  - multiplexing within a single TCP connection
  - long running connections

- *module-info.java* :

```
module org.iproduct.demo.profiler.client {
  requires java.se;
  requires jdk.incubator.httpclient;
  requires gson;
  exports org.iproduct.demo.profiler.client;
  exports org.iproduct.demo.profiler.client.model;
  opens org.iproduct.demo.profiler.client.model to gson;
}
```

Async HTTP/2 Client Example I

```
HttpClient client = HttpClient.newHttpClient();

HttpRequest processesReq = HttpRequest.newBuilder()
    .uri(new URI(PROFILER_API_URL + "processes"))
    .GET()
    .build();

TypeToken<ArrayList<ProcessInfo>> token =
    new TypeToken<ArrayList<ProcessInfo>>() {};

Gson gson = new GsonBuilder().create();
```

Async HTTP/2 Client Example II

```
client.sendAsync(processesReq, HttpResponse.BodyHandler.asString())
    .thenApply( (HttpResponse<String> processesStr) -> {
        List<ProcessInfo> something =
            gson.fromJson(processesStr.body(), token.getType());
        return something;
    }).thenApply(proc -> {
        proc.stream().forEach(System.out::println);
        return null;
    }).exceptionally((Throwable ex) -> {
        System.out.println("Error: " + ex);
        return null;
    }).thenRun(() -> {System.exit(0);});

Thread.sleep(5000);
```

More Demos ...

Java 9 modules, CompletableFuture,... @ GitHub:
https://github.com/iproduct/reactive-demos-java-9

- modularity-demo – Java 9 modules in action :)
- http2-client – Java 9 modules + HTTP/2 client + GSON
- completable-future-demo – composition, delayed, ...
- flow-demo – custom Flow implementations using CFs
- completable-future-jaxrs-cdi-cxf – async observers, ...
- completable-future-jaxrs-cdi-jersey

Thank's for Your Attention!

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