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Programming in Java

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Trayan Iliev

tiliev@iproduct.org
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

Course Schedule

- Block 1: 9:00 – 11:00
- Pause: 11:00 – 11:15
- Block 2: 11:15 – 13:15

Where to Find the Code?

Java Web Development projects and examples are available @ GitHub:

https://github.com/iproduct/java-fundamentals-2022

Agenda for This Session

- Java Class structure – package, imports, fields, methods, access modifiers;
- Creating objects – constructors, order of initialization, static members, keyword this, constructors overloading;
- Working with methods – designing methods, arguments and return values, overloading, static methods, access modifiers;
- Define the scope of variables – class(static), local, instance variables;
- Apply encapsulation principles to a class;
- Understand objects equality – the difference between "==" and equals();
- Wrapper Classes;
- Distinguish between Object reference and primitive variables, type casting; Methods reference and primitive arguments;
- Enumerations;
- Object lifecycle – destroying objects, garbage collection – finalize();

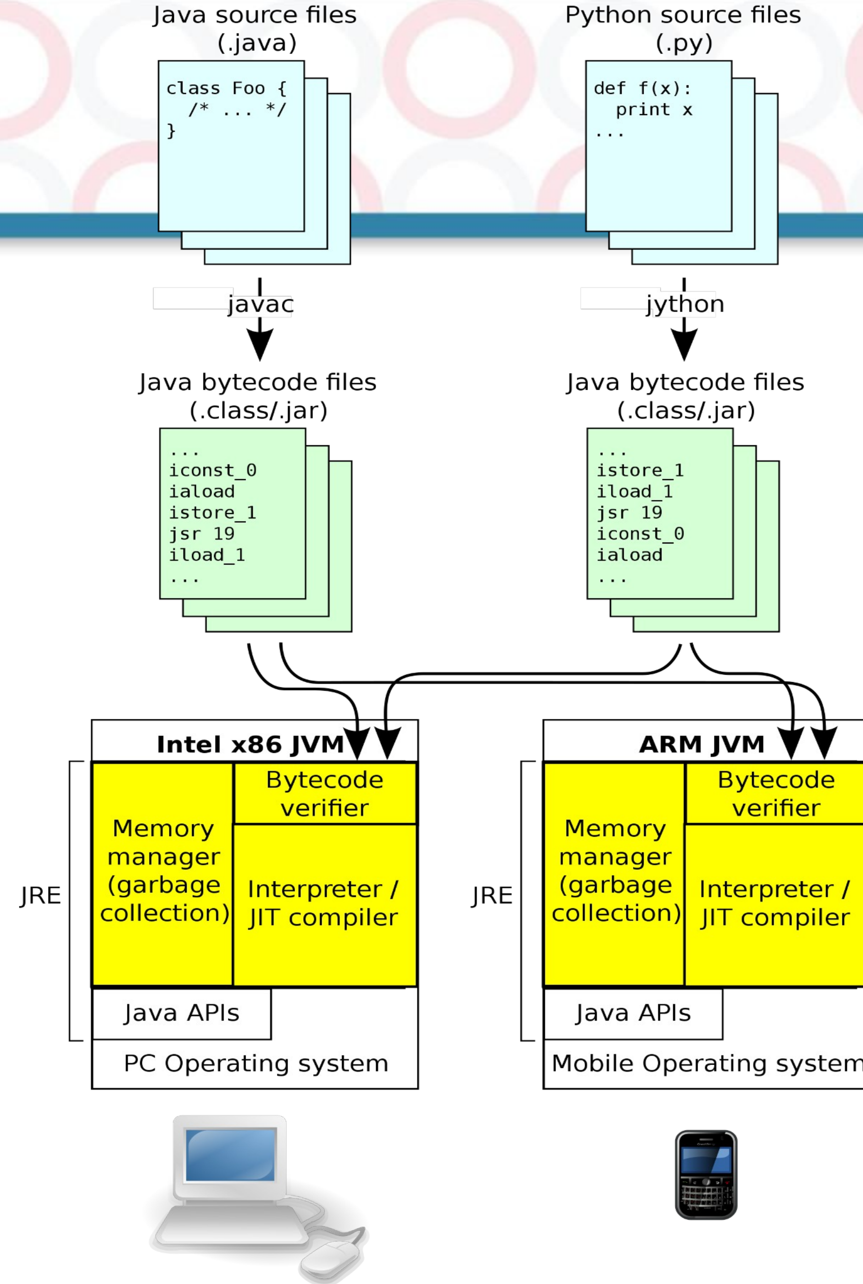
Key Features of Java Language

- 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: IntelliJ IDEA, Eclipse

Java Virtual Machine (JVM)



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

Classes, Objects and References

- Class - set of objects that share a common structure, behaviour 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 (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;
```

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”);
```

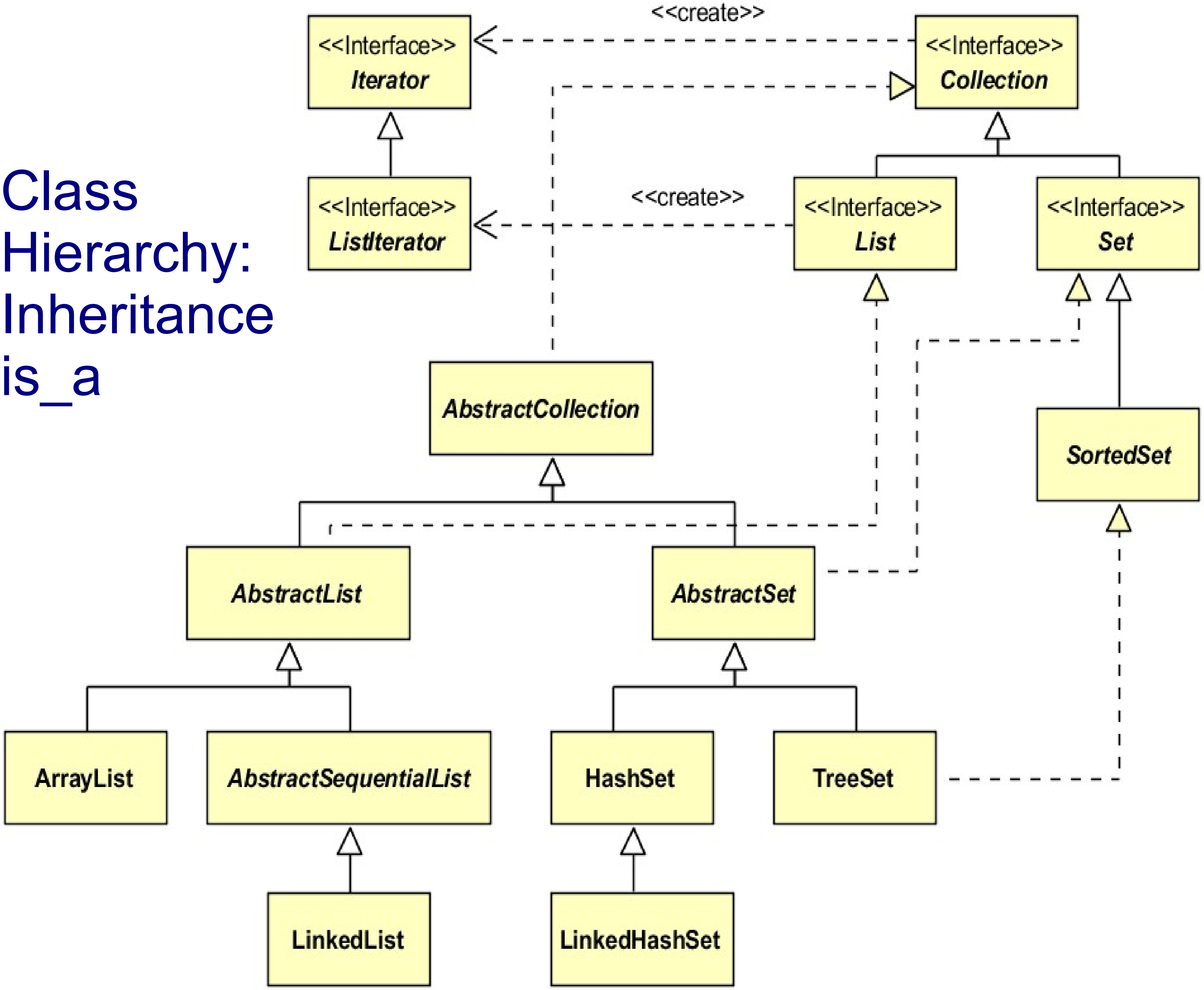
– declaration + initialization (shorter form, applies only to the class String):

```
String s = “Hello Java World”;
```

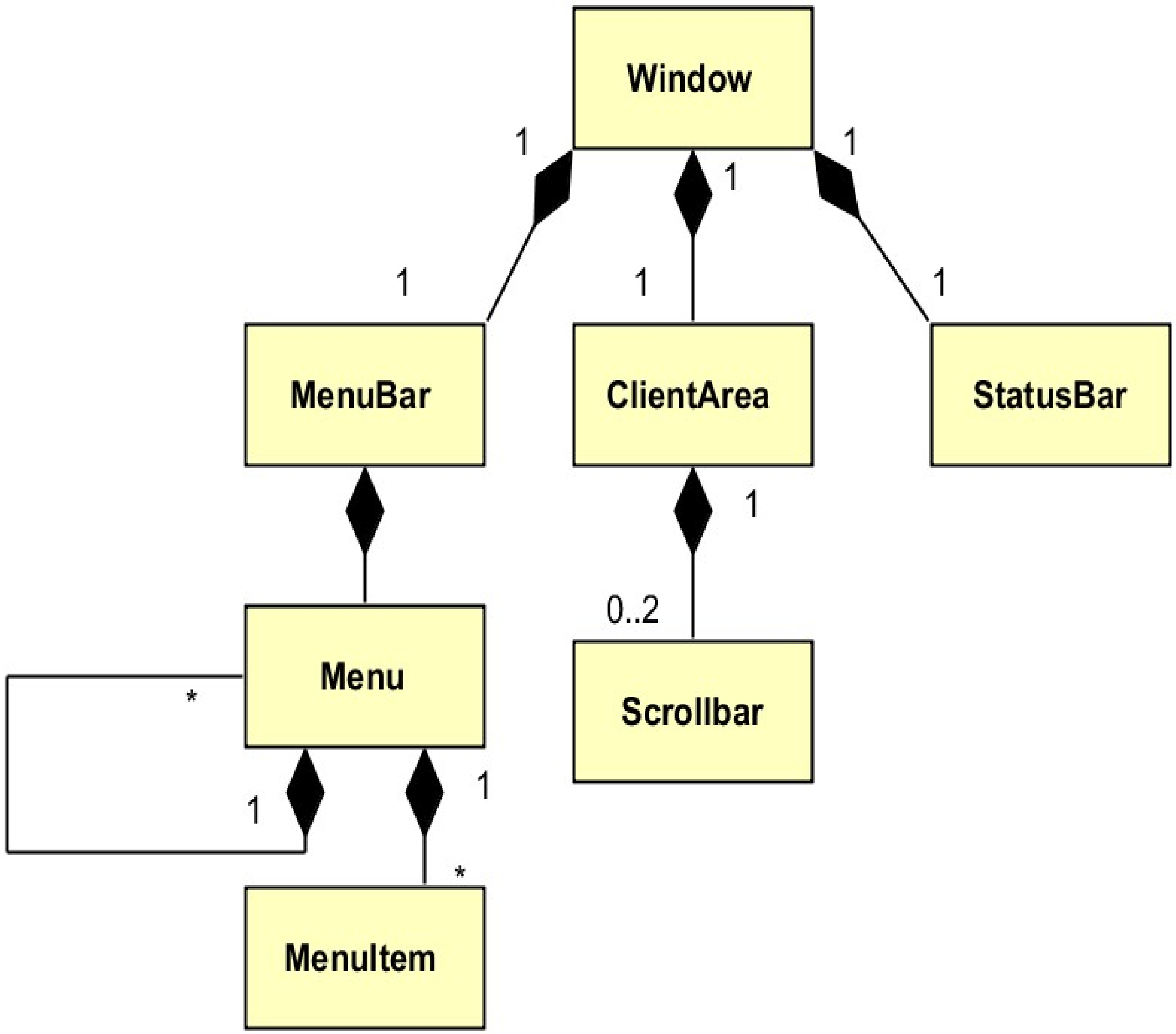
SOLID Design Principles of OOP

1. 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.
2. Open–closed principle - software entities should be open for extension, but closed for modification.
3. Liskov substitution principle - Objects in a program should be replaceable with instances of their subtypes without altering the correctness of that program.
4. Interface segregation principle - Many client-specific interfaces are better than one general-purpose interface.
5. Dependency inversion principle - depend upon abstractions, not concretions.

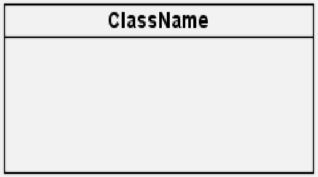
Class Hierarchy: Inheritance is_a

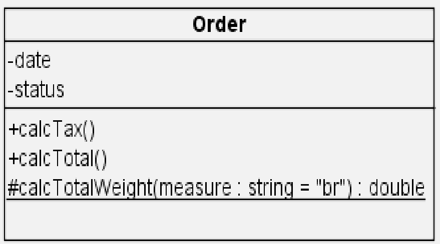


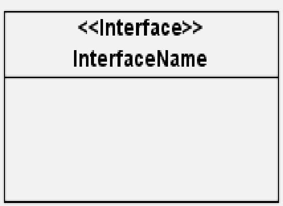
Object Hierarchy: Composition, has_a

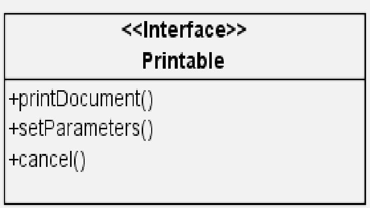


Elements of Class Diagrams



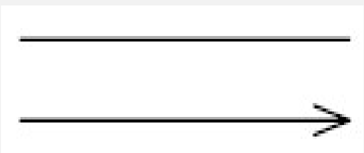






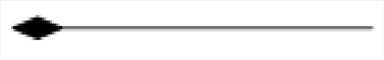
Types of connections:

- Association



- aggregation

- composition

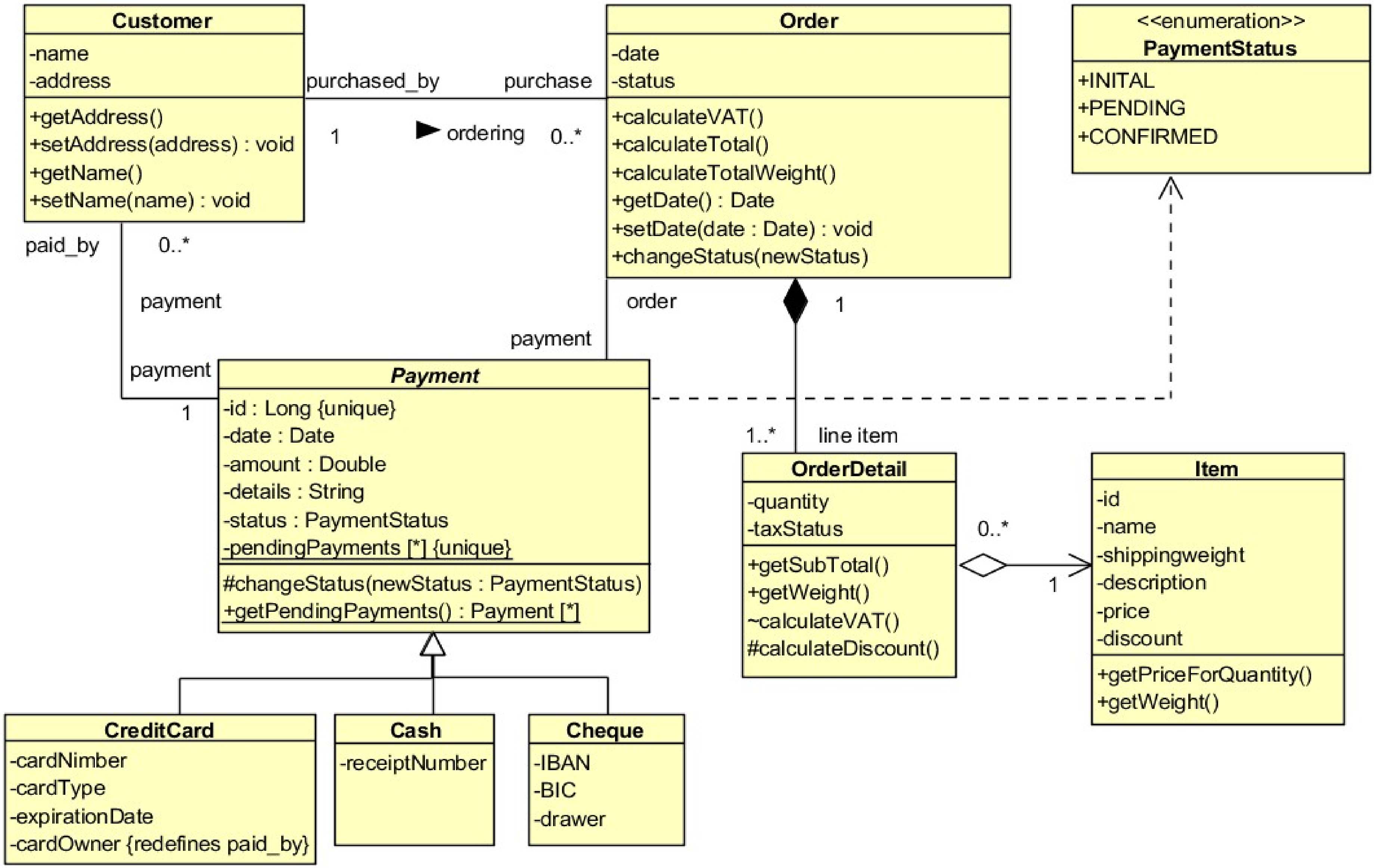


- dependence

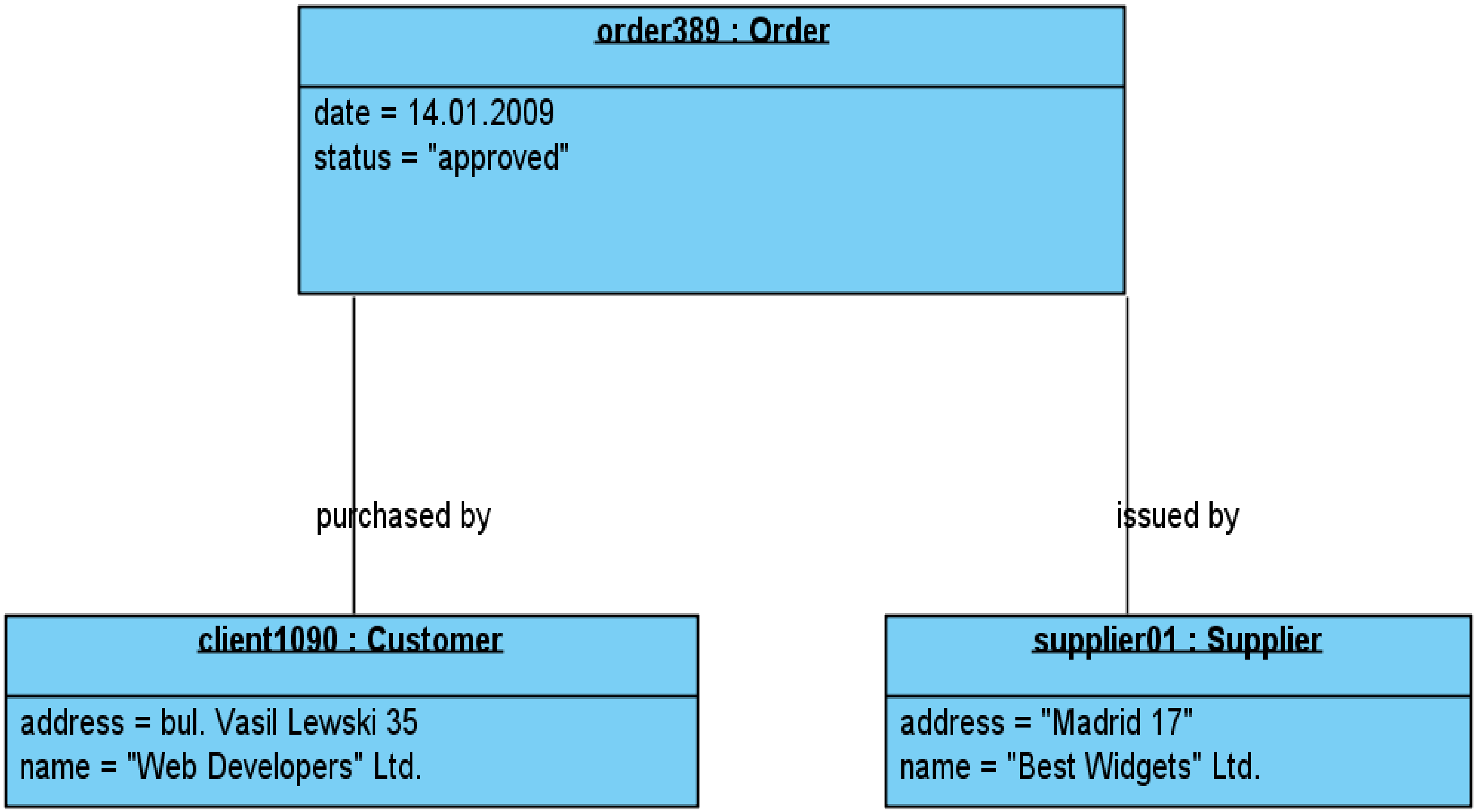
- generalization

- realization

Class Diagram



Object Diagram



Packages and Access Specifiers

- ❖Packages and directories
- ❖Importing packages – import
- ❖Access specifiers

–**public**

–**private**

–**protected**

–Friendly access – by default within the package

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

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

Object (Reference) Data Types

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

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

Method Name

Arguments

Return Type

Method Body

Returning Value

Object Constructors in Java

- Initialization of objects with constructors
- Overloading of constructors and other methods
- Default constructors
- Reference to the current object – **this**

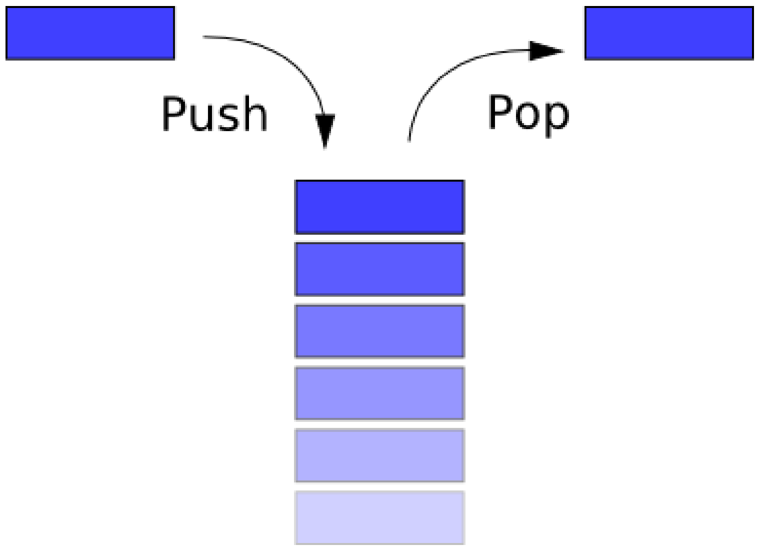
Objects Initialization. Array initialization

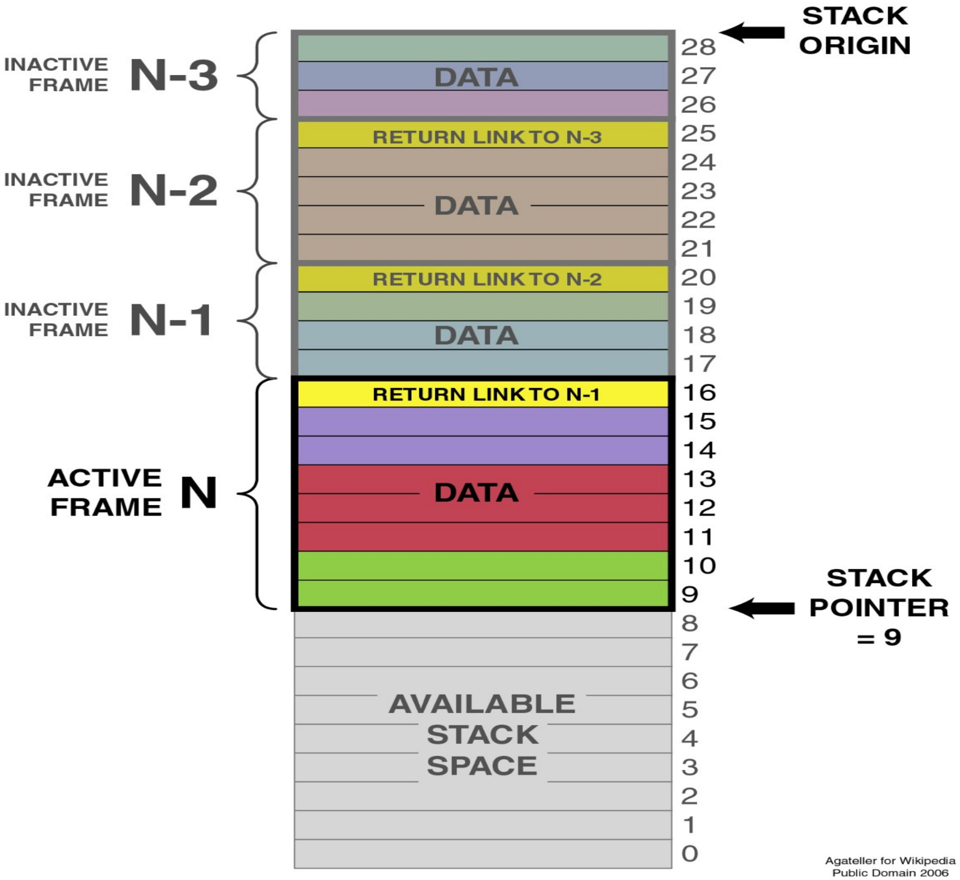
- Initialization in declaration
- Initialization in constructor
- „Lazy“ initialization
- Initialization of static class members
- One-dimensional and multi-dimensional arrays
- Array initialization

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

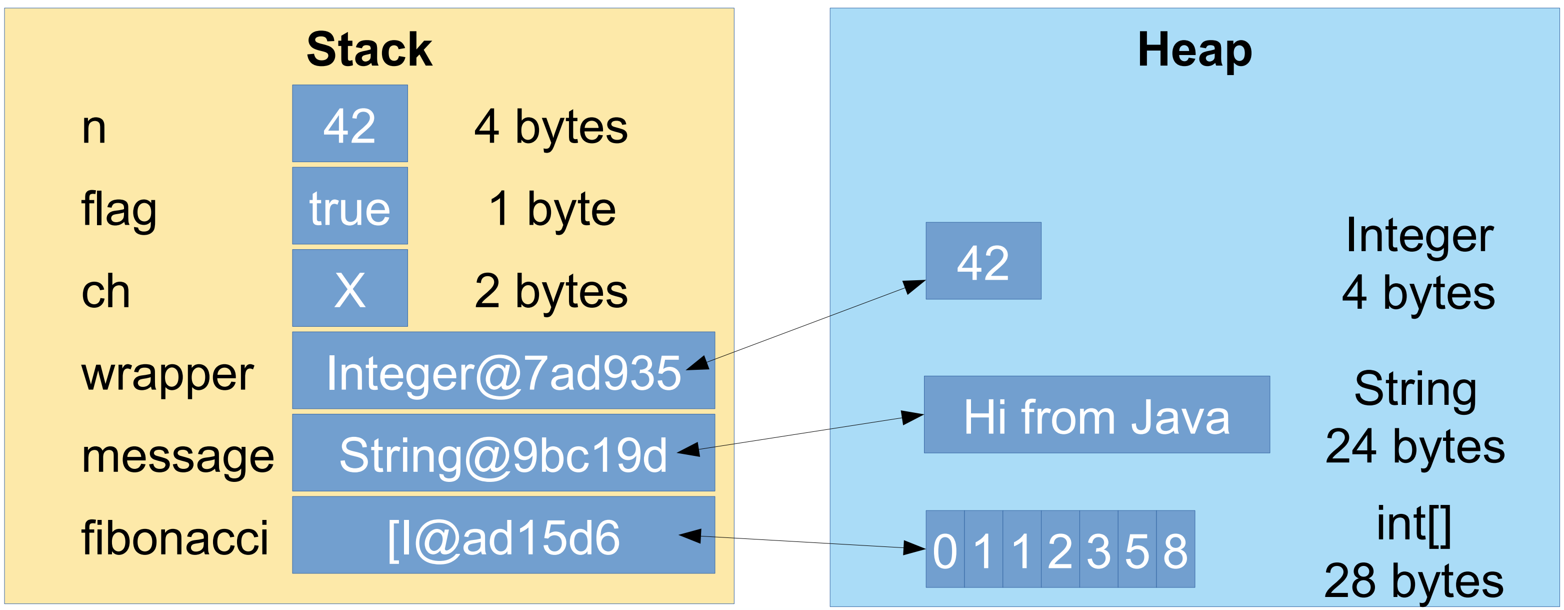
C:\Windows\system32\cmd.exe

```
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)
```

EN

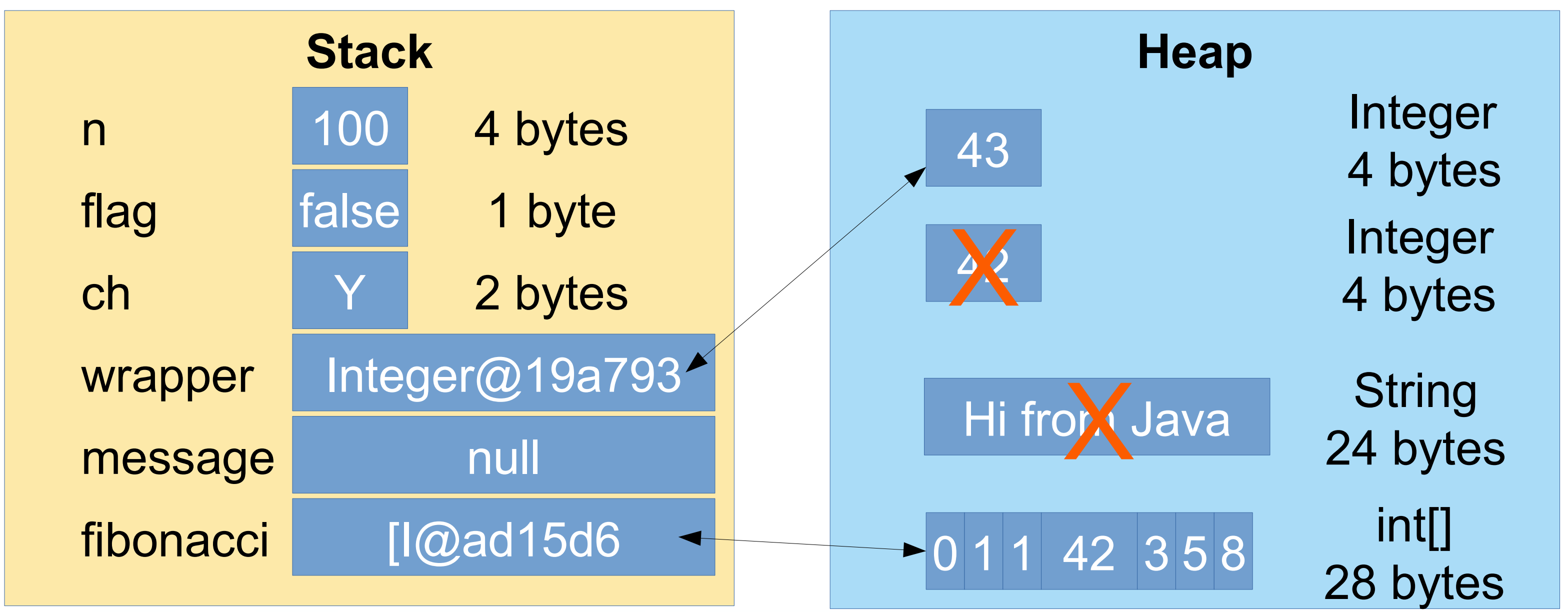
Stack and Heap (Quick Review)

```java
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
    }
}
```

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 or by 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>;
}
```

Enumeration Types

```java
public class MyEnumeration {
  public enum InvoiceType { SIMPLE, VAT }
  public static void main(String[] args) {
    for(InvoiceType it : InvoiceType.values())
        System.out.println(it);
    }
}
```

Резултат: SIMPLE
VAT

Низове

- Класът **String** предоставя **immutable** обекти – т.е. всяка операция върху низа създава нов обект в хипа
- **StringBulider** – предоставя ефикасен откъм ресурси начин да модифициране на низове, като реализира Reusable Design Pattern: **Builder** – за постъпково изграждане на низа (основно с метод **append** и **insert**)
- Основни операции в класа **String**. Форматиран изход – метод **format()** и клас **Formatter**. Спецификатори:

%[argument_index$][flags][width][.precision]conversion

Конверсия на типа при форматиране

- d – decimal, интегрални типове
- c – character (unicode)
- b - boolean
- s - String
- f – float, double (с десетична точка)
- e - float, double (scientific notation)
- x – шестнайсетична стойност на интегрални типове
- h – шестнайсетичен хеш код

Регулярни изрази (1)

- Символни класове
  - **.** Any character (may or may not match line terminators)
  - **\d** A digit: [0-9]
  - **\D** A non-digit: [^0-9]
  - **\s** A whitespace character: [\t\n\x0B\f\r]
  - **\S** A non-whitespace character: [^\s]
  - **\w** A word character: [a-zA-Z_0-9]
  - **\W** A non-word character: [^\w]

Регулярни изрази (2)

- Квалификатори:
  - **X?** X, once or not at all
  - **X*** X, zero or more times
  - **X+** X, one or more times
  - **X{n}** X, exactly n times
  - **X{n,}** X, at least n times
  - **X{n,m}** X, at least n but not more than m times
- **Greedy, Reluctant (?) & Possessive (+)** квалификатори
- **Capturing Group - (X)**

Регулярни изрази (3)

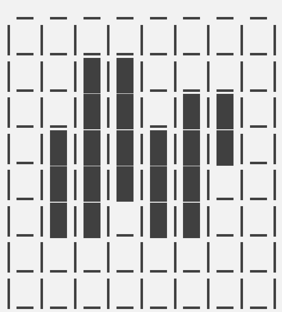
- Клас **Pattern** – основни методи:
  - **public static Pattern compile(String regex)**
  - **public Matcher matcher(CharSequence input)**
  - **public static boolean matches(String regex, CharSequence input)**
  - **public String[] split(CharSequence input, int limit)**
- Клас **Matcher** – основни методи:
  - **public boolean matches()**
  - **public boolean lookingAt()**
  - **public boolean find(int start)**
  - **public int groupCount()** и **public String group(int group)**

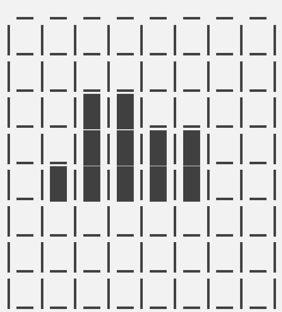
Problem: Word Counting

Реализирайте конзолно приложение което по подадено като аргумент от команден ред име на файл извлича top 20 ключови думи за файла на база на честотата на тяхното срещане.

Problem: Melting Iceberg

Айсберг има форма, която може да се изобрази в таблица с N реда и N стълба, 7 < N < 200, например айсбергът от фиг. 1 след един час в резултат на топенето се превръща в айсберга от фиг. 2:


фиг. 1


фиг. 2

Клетките от първия и последния ред и стълб са винаги празни. Външните клетки, които са изложени на съприкосновение с топлия въздух и вода се топят, а вътрешните не. Айсбергът се топи по следното правило: всяка клетка която има поне 2 от съседните 4 клетки (с обща страна) празни се стопява изцяло за 1 час, а останалите клетки не се топят изобщо. Напишете програма, която прочита от текстов файл размера и съдържанието на таблицата:

```
8
00000000
00**0000
00**0**0
0******0
0*****00
0**0**00
00000000
00000000
```

В резултат програмата следва да извежда на екрана броя часове, за които айсбергът ще се разтопи изцяло. В горния пример изходът на програмата следва да бъде: 4.

Problem: Melting Iceberg II

Реализирайте конзолно приложение за интерактивно въвеждане и редактиране на таблицата от задача 3. Приложението следва да поддържа текстово меню с възможности за:

1) редактиране на таблицата;

2) създаване на нова празна таблица с възможност за редактиране;

3) прочитане на таблицата от текстов файл;

4) запис на таблицата в текстов файл;

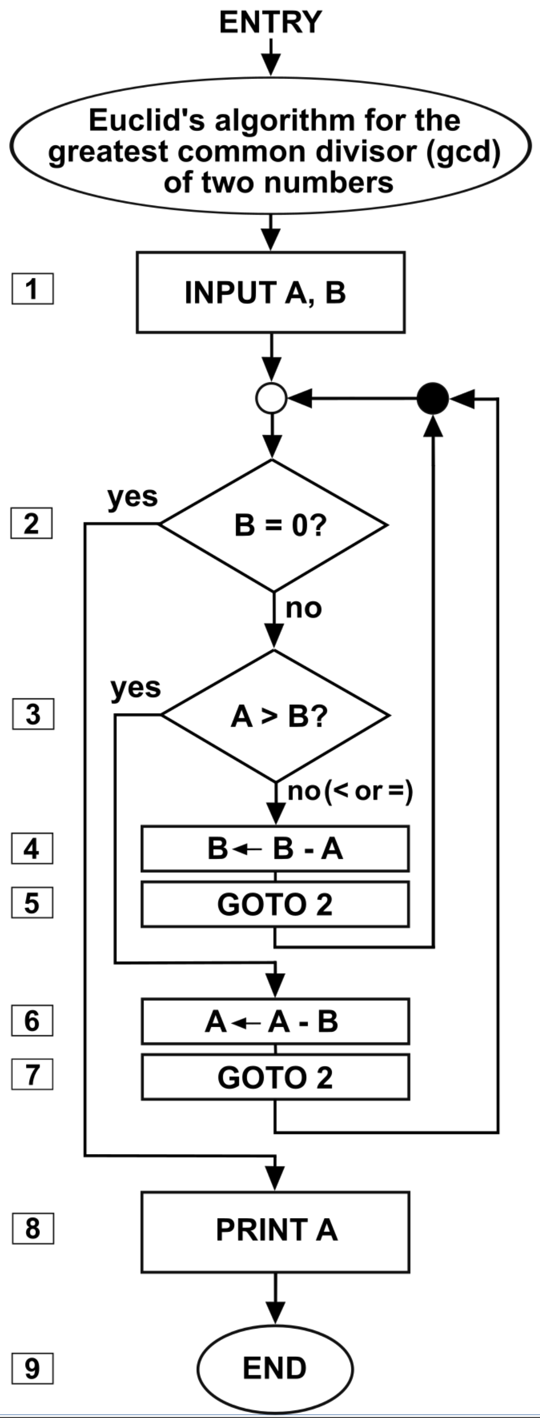
5) изход от програмата.

Редактирането на таблицата трябва да стане в текстов вид, интерактивно от клавиатурата с поддържане на активен курсор (символ '#') и с натискане на '+' за запълване на клетката където е курсора и '-' за изчистване на клетката, където е курсора. Преместването на курсора става със стрелките от клавиатурата.

След натискане на всеки клавиш се извежда цялата таблица и един празен ред за разделител. Редактирането приключва с натискане на клавиша <Enter>, след което се връщаме в главното меню на програмата, като редактираната таблица се запомня.

Basic Algorithms

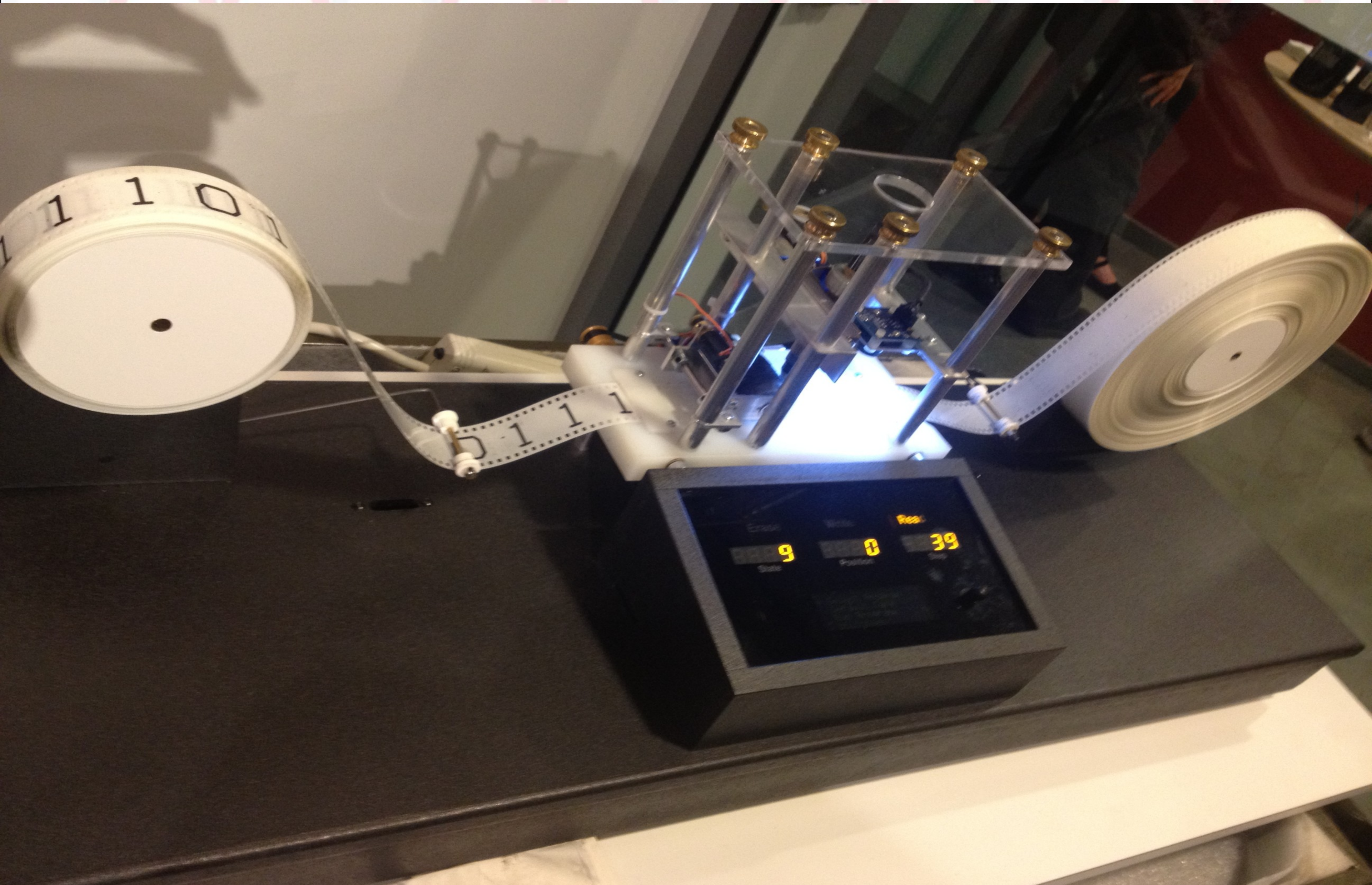
- Algorithm is a finite sequence of well-defined instructions, typically used to solve a class of specific problems or to perform a computation.
- Algorithms are used as specifications for performing calculations and data processing. By making use of artificial intelligence, algorithms can perform automated deductions (referred to as automated reasoning) and use mathematical and logical tests to divert the code through various routes (referred to as automated decision-making).



Algorithms and Datastructures

- Minsky: "But we will also maintain, with Turing ... that any procedure which could "naturally" be called effective, can, in fact, be realized by a (simple) machine. Although this may seem extreme, the arguments ... in its favor are hard to refute".
- Gurevich: "… Turing's informal argument in favor of his thesis justifies a stronger thesis: every algorithm can be simulated by a Turing machine … according to Savage, an algorithm is a computational process defined by a Turing machine".
- Typically, when an algorithm is associated with processing information, **data** can be read from an input source, written to an output device and stored for further processing. Stored data are regarded as part of the internal state of the entity performing the algorithm. In practice, the state is stored in one or more **data structures**.

Turing Machine



Turing Machine

A finite table of instructions that, given the state(qi) the machine is currently in and the symbol(aj) it is reading on the tape (symbol currently under the head), tells the machine to do the following in sequence:

- Either erase or write a symbol (replacing aj with aj1).
- Move the head (which is described by dk and can have values: 'L' for one step left or 'R' for one step right or 'N' for staying in the same place).
- Assume the same or a new state as prescribed (go to state qi1).

Turing Machine

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- Assume the same or a new state as prescribed (go to state qi1).

Algorithmic Schemes: Exhaustive Serach

Used when the generation of values to search is cheap:

```
for(i = 0; i < n; i++)  {
    process_value(i);
}
```

- Permutations
- Combinations

Merging – Merge Sort

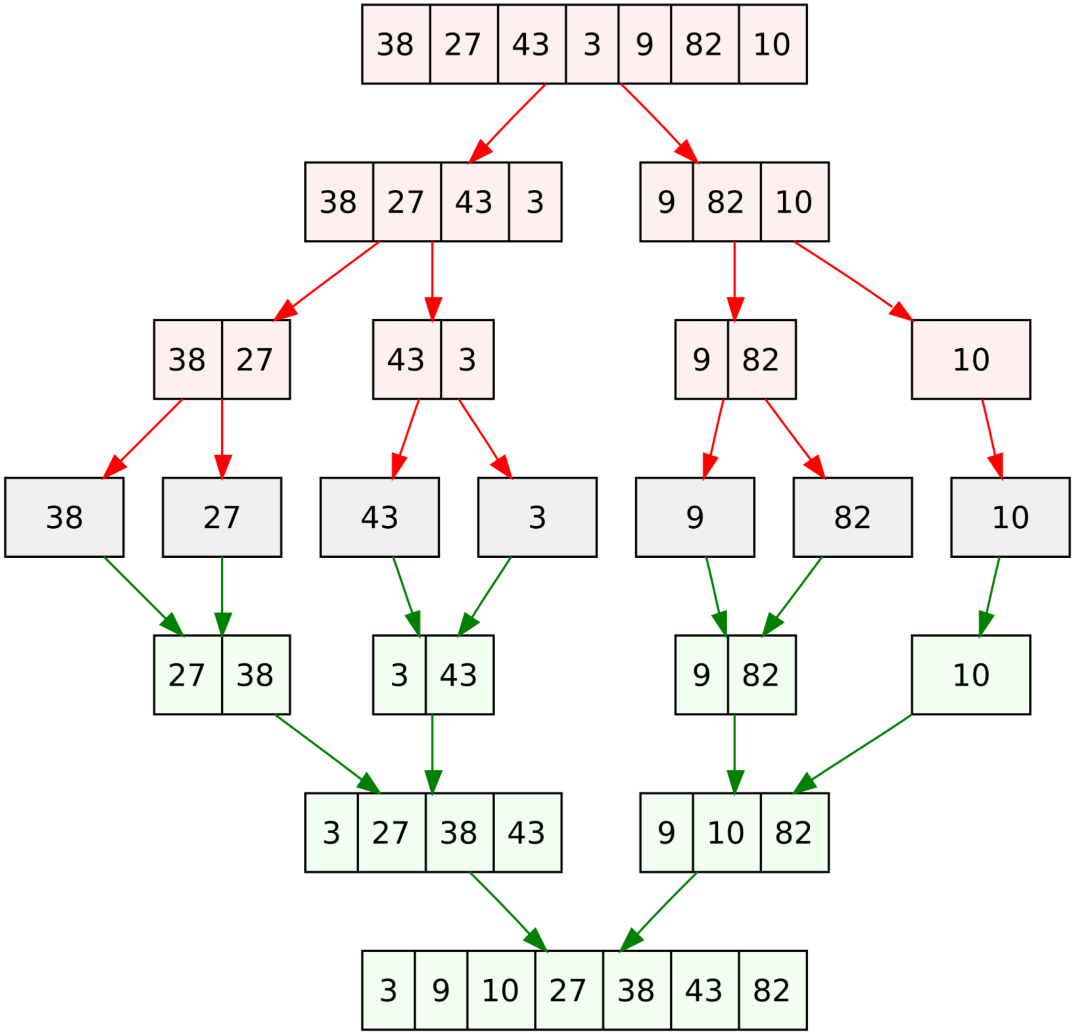
```
function merge_sort(list m) is
    // Base case. A list of zero or one elements is sorted, by definition.
    if length of m ≤ 1 then
        return m
    // Recursive case. First, divide the list into equal-sized sublists
    // consisting of the first half and second half of the list.
    // This assumes lists start at index 0.
    var left := empty list
    var right := empty list
    for each x with index i in m do
        if i < (length of m)/2 then
            add x to left
        else
            add x to right
    // Recursively sort both sublists.
    left := merge_sort(left)
    right := merge_sort(right)
    // Then merge the now-sorted sublists.
    return merge(left, right)
```

```
function merge(left, right) is
    var result := empty list

    while left is not empty and right is not empty do
        if first(left) ≤ first(right) then
            append first(left) to result
            left := rest(left)
        else
            append first(right) to result
            right := rest(right)

    // Either left or right may have elements left; consume them.
    // (Only one of the following loops will actually be entered.)
    while left is not empty do
        append first(left) to result
        left := rest(left)
    while right is not empty do
        append first(right) to result
        right := rest(right)
    return result
```

Divide and Conquer - QuickSort



Dynamic Programming

- Dynamic Programming is a technique in computer programming that helps to efficiently solve a class of problems that have overlapping subproblems and optimal substructure property.
- If the problem can be divided into subproblems recursively, and if there are overlapping subproblems, then the solutions to these subproblems can be saved for future reference (momising - such problems involve repeatedly calculating the value of the same subproblems to find the solution).
- optimal substructure property - if an optimal solution can be constructed from optimal solutions of its subproblems, used to determine the usefulness of dynamic programming and greedy algorithms for a problem.
- Example : Fibonacci sequence

Graph Algorithms

- Depth First Search (DFS)
- Breadth First Search (BFS)
- Backtracking - a general algorithm for finding solutions to some computational problems, notably constraint satisfaction problems, that incrementally builds candidates to the solutions, and abandons a candidate ("backtracks") as soon as it determines that the candidate cannot possibly be completed to a valid solution.
- The classic textbook example of the use of backtracking is the eight queens puzzle, that asks for all arrangements of eight chess queens on a standard chessboard so that no queen attacks any other. In the common backtracking approach, the partial candidates are arrangements of k queens in the first k rows of the board, all in different rows and columns. Any partial solution that contains two mutually attacking queens can be abandoned.

Greedy Algorithms

- A greedy algorithm is an approach for solving a problem by selecting the best option available at the moment. Does not always find optimal result.
- The algorithm does not return to previous candidate solutions already processed, even if the choice is wrong. It works in a top-down approach.
- It always goes for the locally optimal best choice to produce the global best result.
- GA to be applicable the problem should posses the following properties:

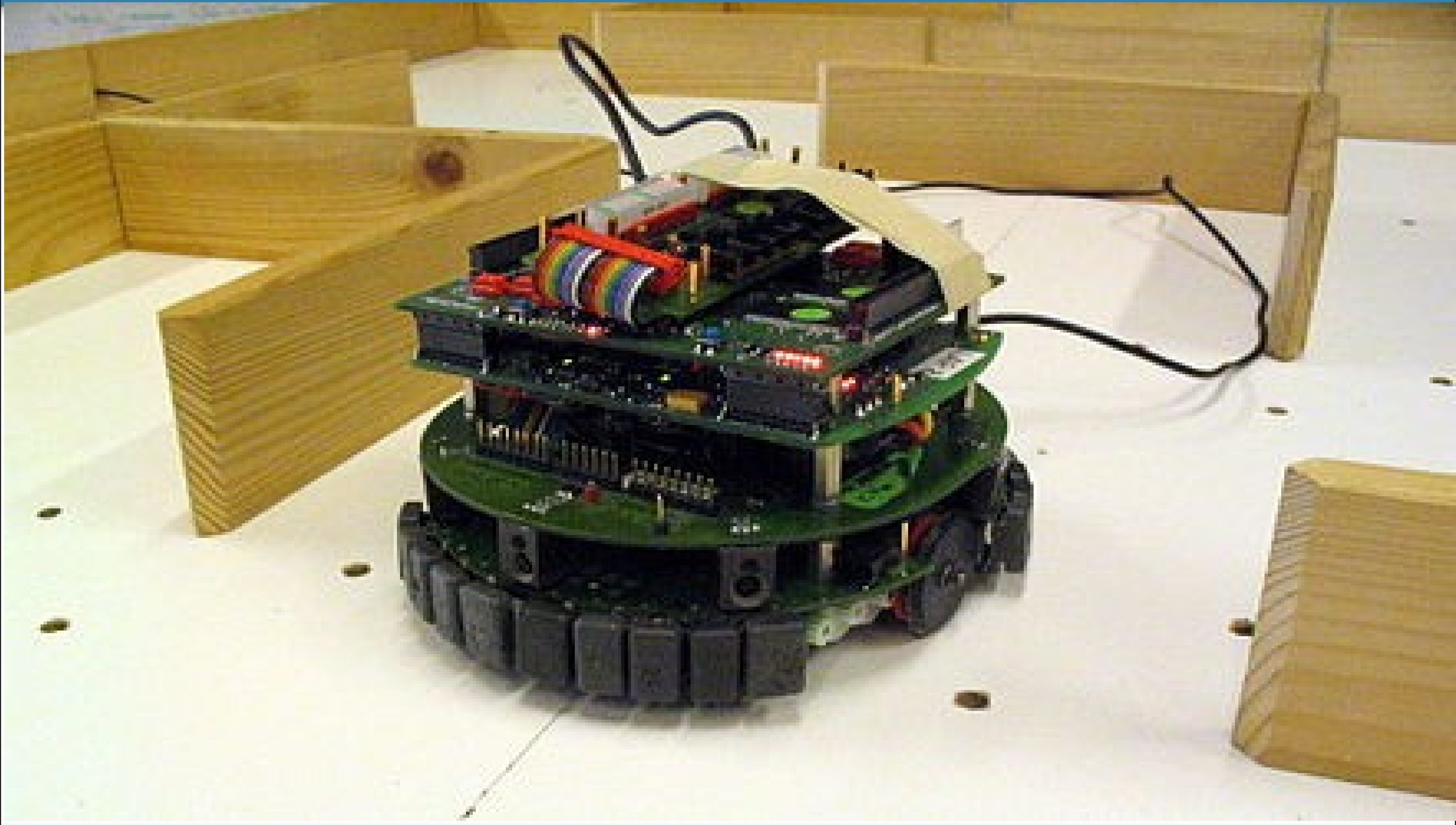
1. Greedy choice - the optimal solution to the problem can be found by choosing the best choice at each step without returning to the previous steps.
2. Optimal substructure - If the optimal overall solution to the problem corresponds to the optimal solution to its subproblems.

- Example: Dijkstra's minimal spanning tree algorithm

Backtracking Algorithm

```
procedure backtrack(c) is
    if reject(P, c) then return
    if accept(P, c) then output(P, c)
    s ← first(P, c)
    while s ≠ NULL do
        backtrack(s)
        s ← next(P, s)
```

Backtracking Algorithm – N Queens, Maze



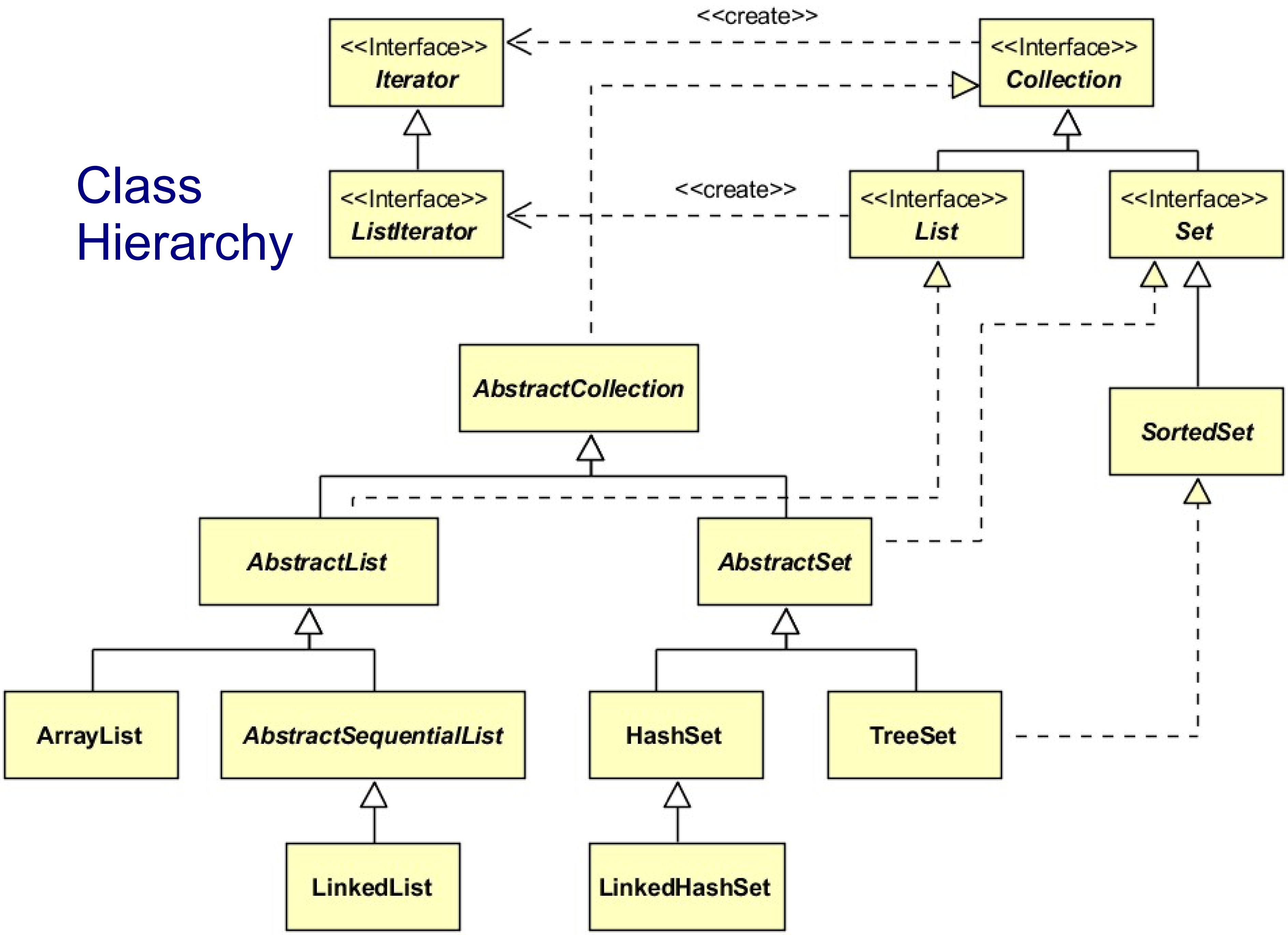
Arrays. Comapring and Sorting

- Arrays and working with them
- Utility methods of the class **Arrays**:
  - equals()
  - fill()
  - copyOf() и copyOfRange()
  - binarySearch()
  - sort()
- Comparing objects – interfaces **Comparable** and **Comparator**

Container Classes and Interfaces. Iterators.

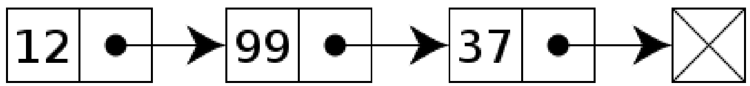
- Колекции – интерфейс **Collection**
- Списъци – интерфейс **List**, реализации – **ArrayList**, **LinkedList**, ...
- Множества – интерфейс **Set**, реализации – **HashSet**, **TreeSet**, …
- Асоциативни списъци – интерфейс **Map**, реализации – **HashMap**, **TreeMap**, **LinkedHashMap**, **WeakHashMap**, …
- Обхождане на колекция с итератор.
- Реализиране на структури от данни стек, опашка, дек – интерфейси **Queue** и **Dequeue**. Реализации: **ArrayDeque**

Class Hierarchy

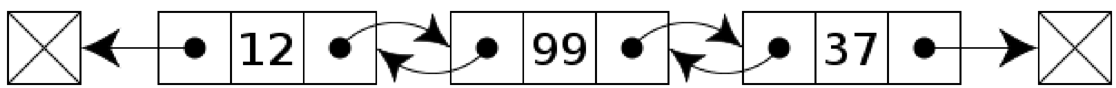


Data Structures

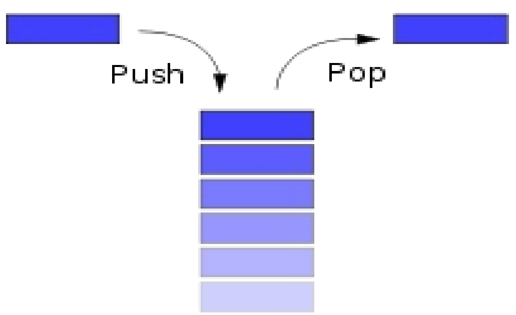
- Linked list:



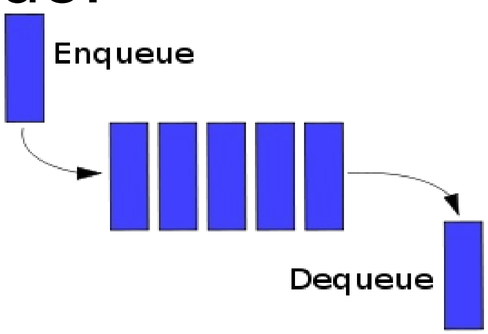
- Doubly-linked list:



- Stack:

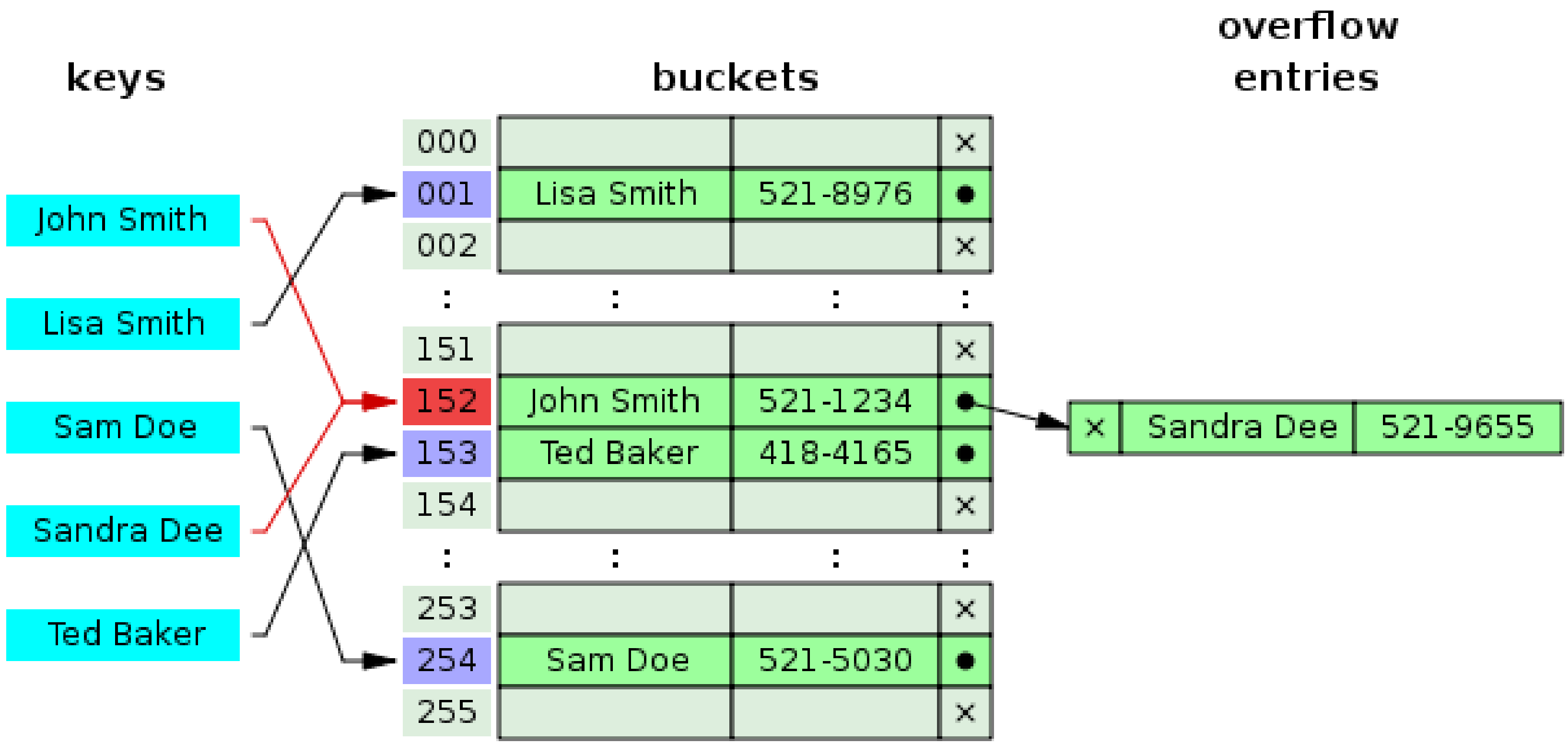


- Queue:

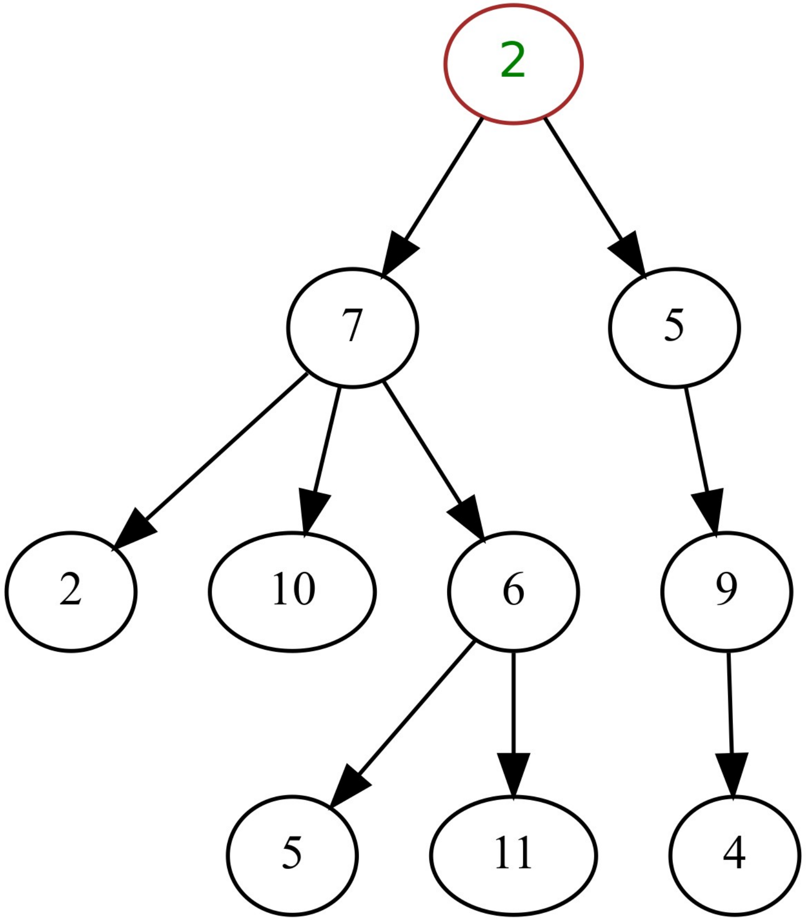


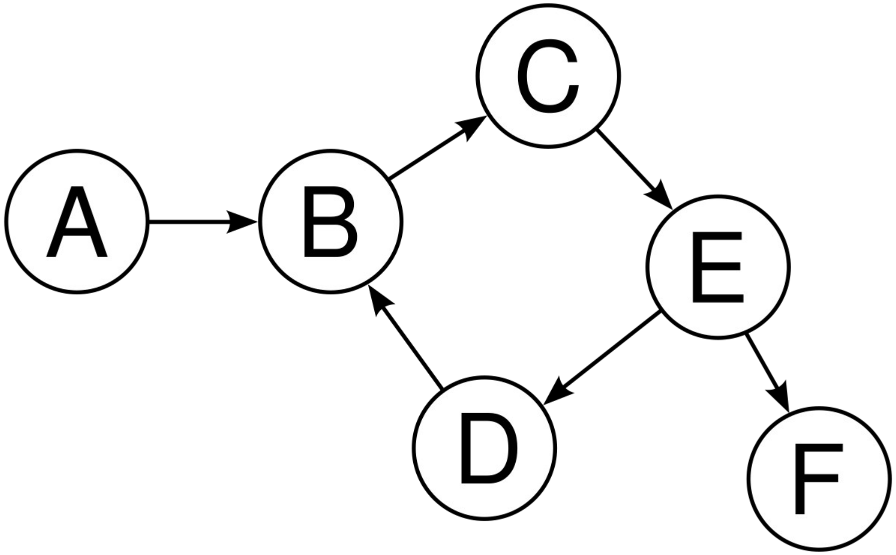
Source: Wikipedia, http://en.wikipedia.org/

Hashinng. Hash-Functions. Hash Tables



Trees and Graphs





Garbage Collection – Main Concepts

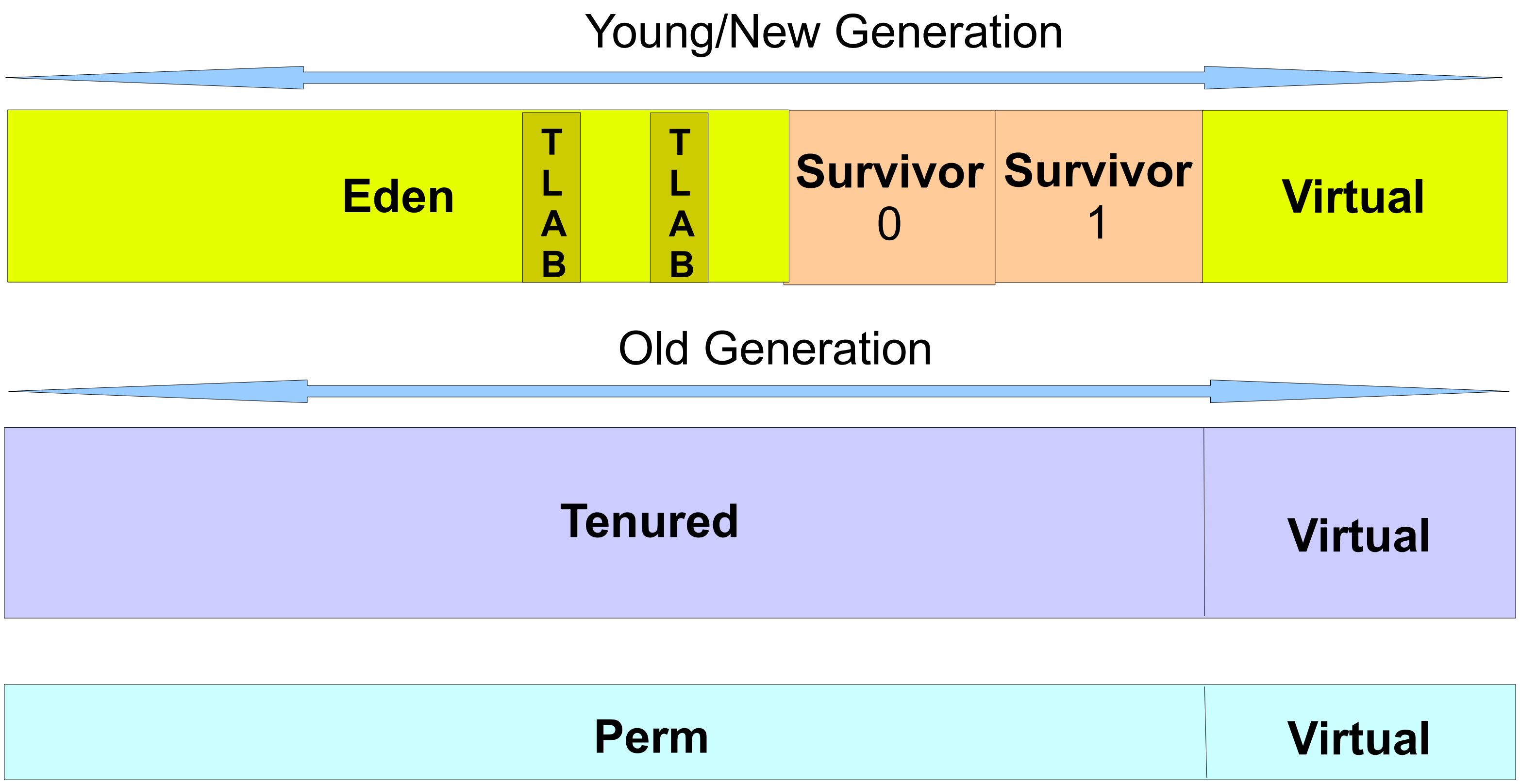
- Garbage collaction and finalization – method finalize()
- Client and Server VMs (≠ JIT Compiliers & Defaults), x86, x64
- Generational Garbage Collection – Young, Old & ~~Permanent~~ (in Java 8 → Metaspace) – Weak generational hypothesis:
  - Most of the objects become unreachable soon;
  - Small number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

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

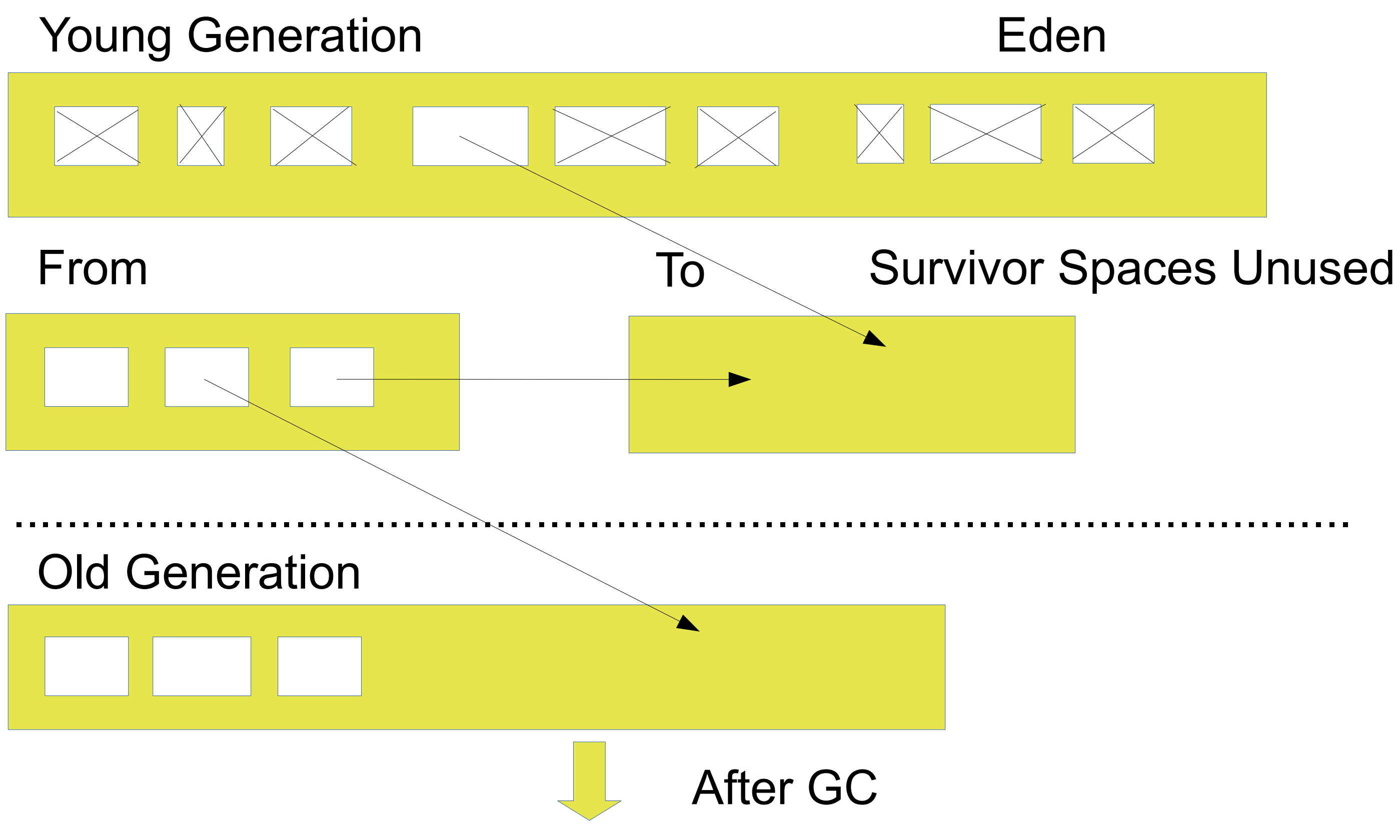
- Tuning for Lower Latency

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

Garbage Collection – Main Concepts

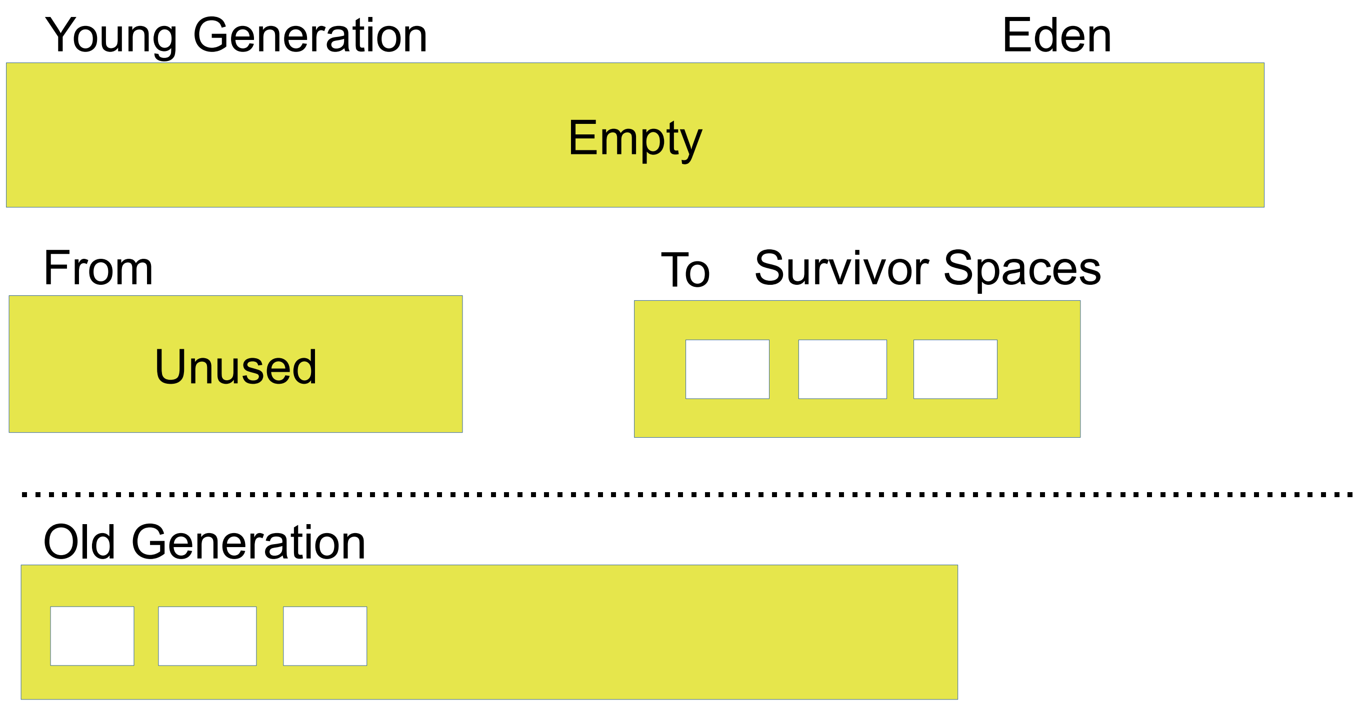


Before GC



Young Generation
Eden
From
To
Survivor Spaces Unused
Old Generation
After GC

After GC


Young Generation
Eden
Empty
From
Unused
To
Survivor Spaces
Old Generation

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 generation

-XX:+PrintGCDetails

-XX:+PrintGCTimeStamps

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

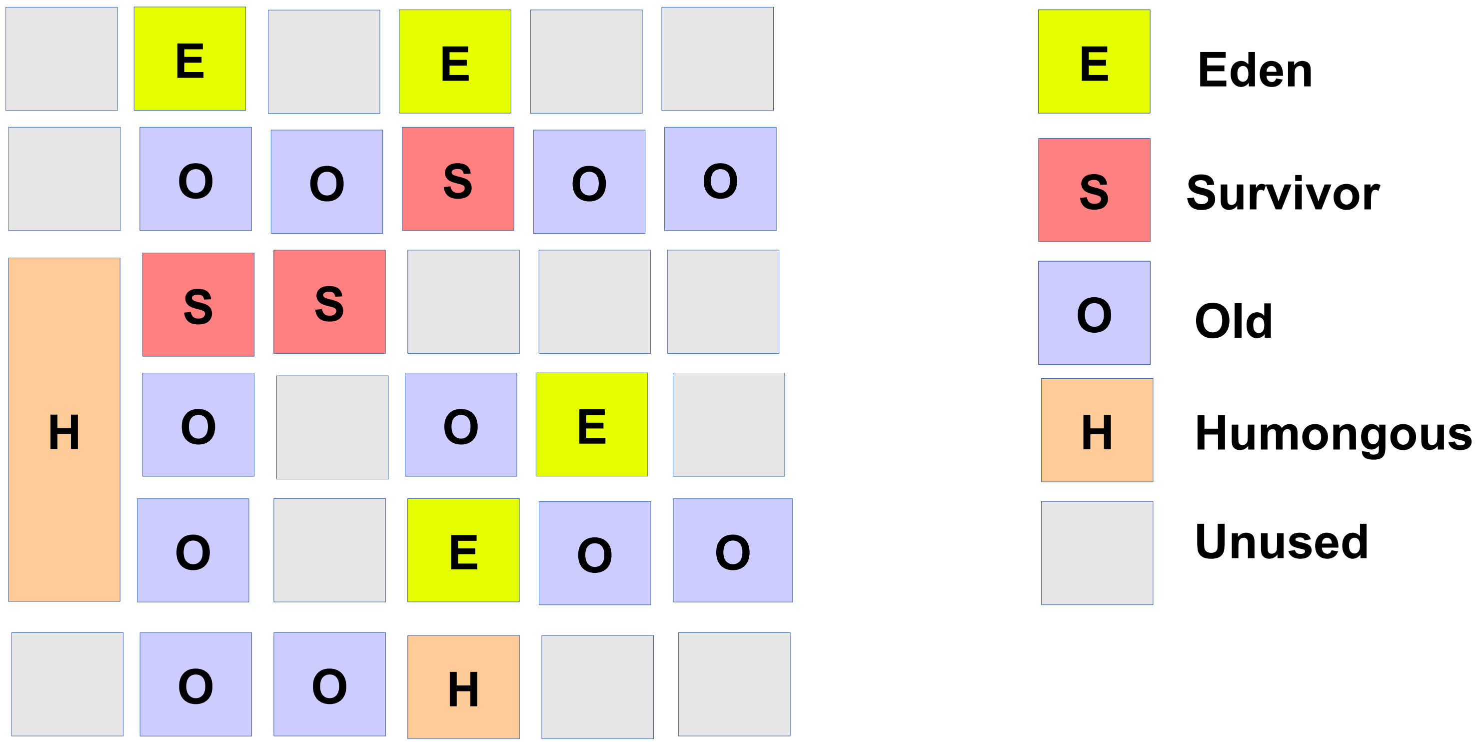
-XX:+CMSParallelRemarkEnabled

-XX:CMSInitiatingOccupancyFraction=<N>

-XX:+UseCMSInitiatingOccupancyOnly

G1 **-XX:+UseG1GC**

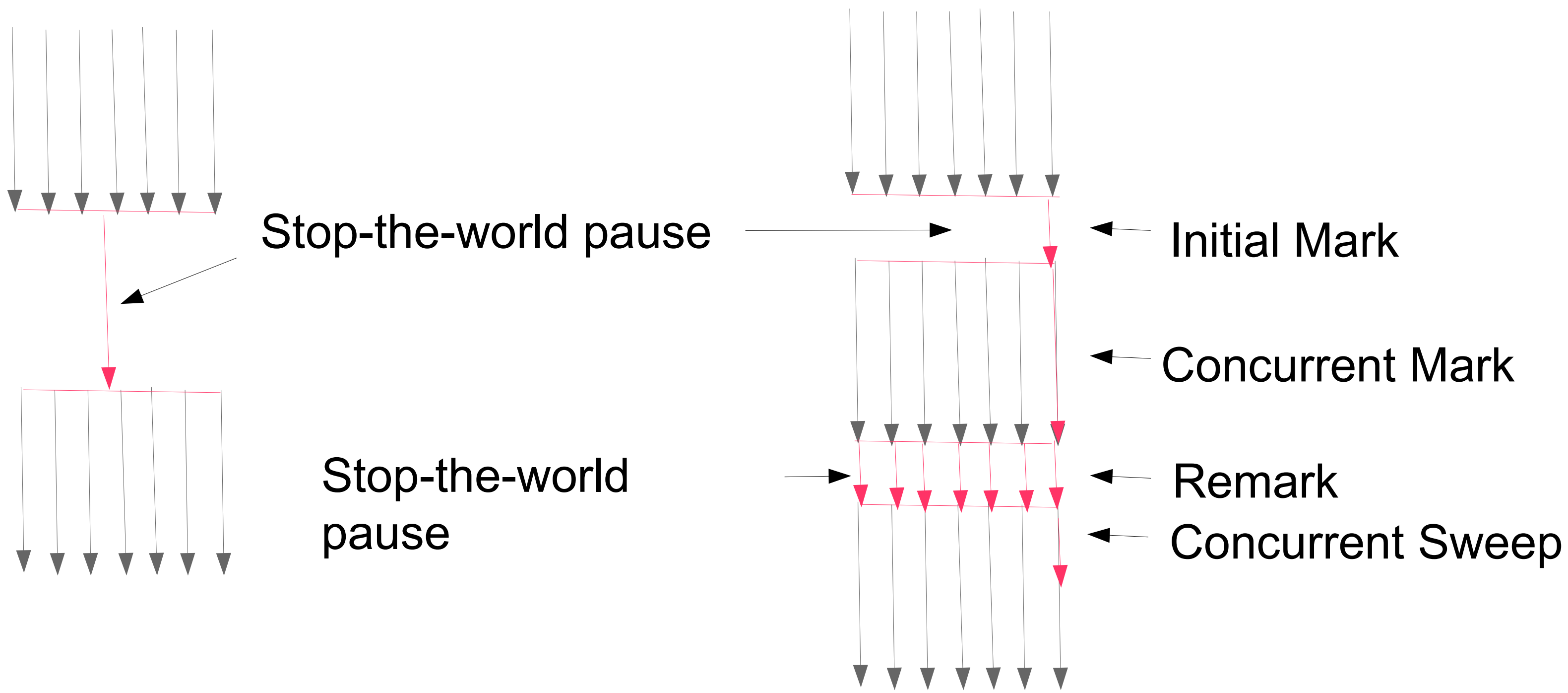
Garbage First G1 Partially Concurrent Collector



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

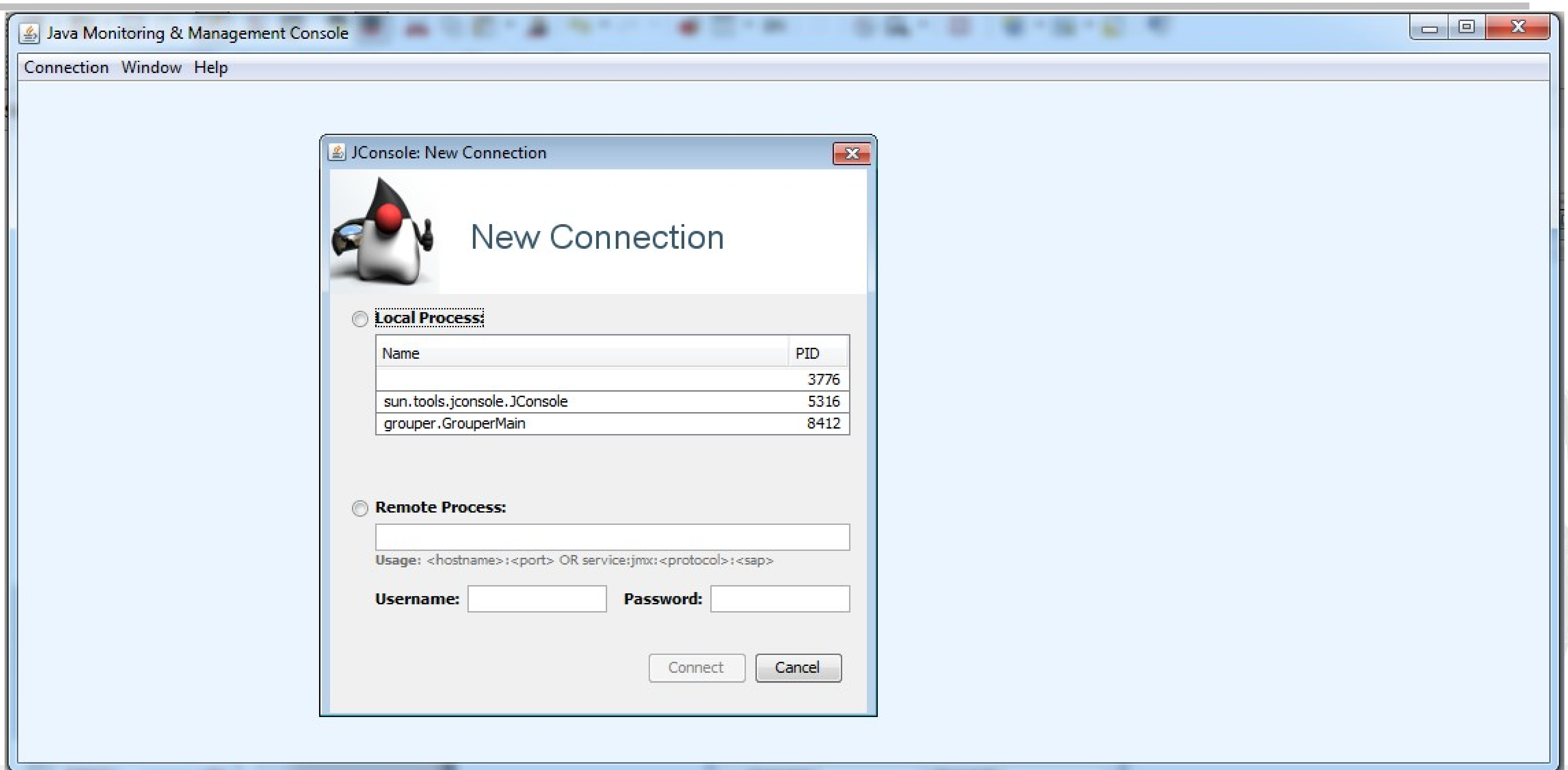
- **jstat & jstatd** – provide information about GC and class loading activities, useful for automated scripting (jstatd = RMI deamon):

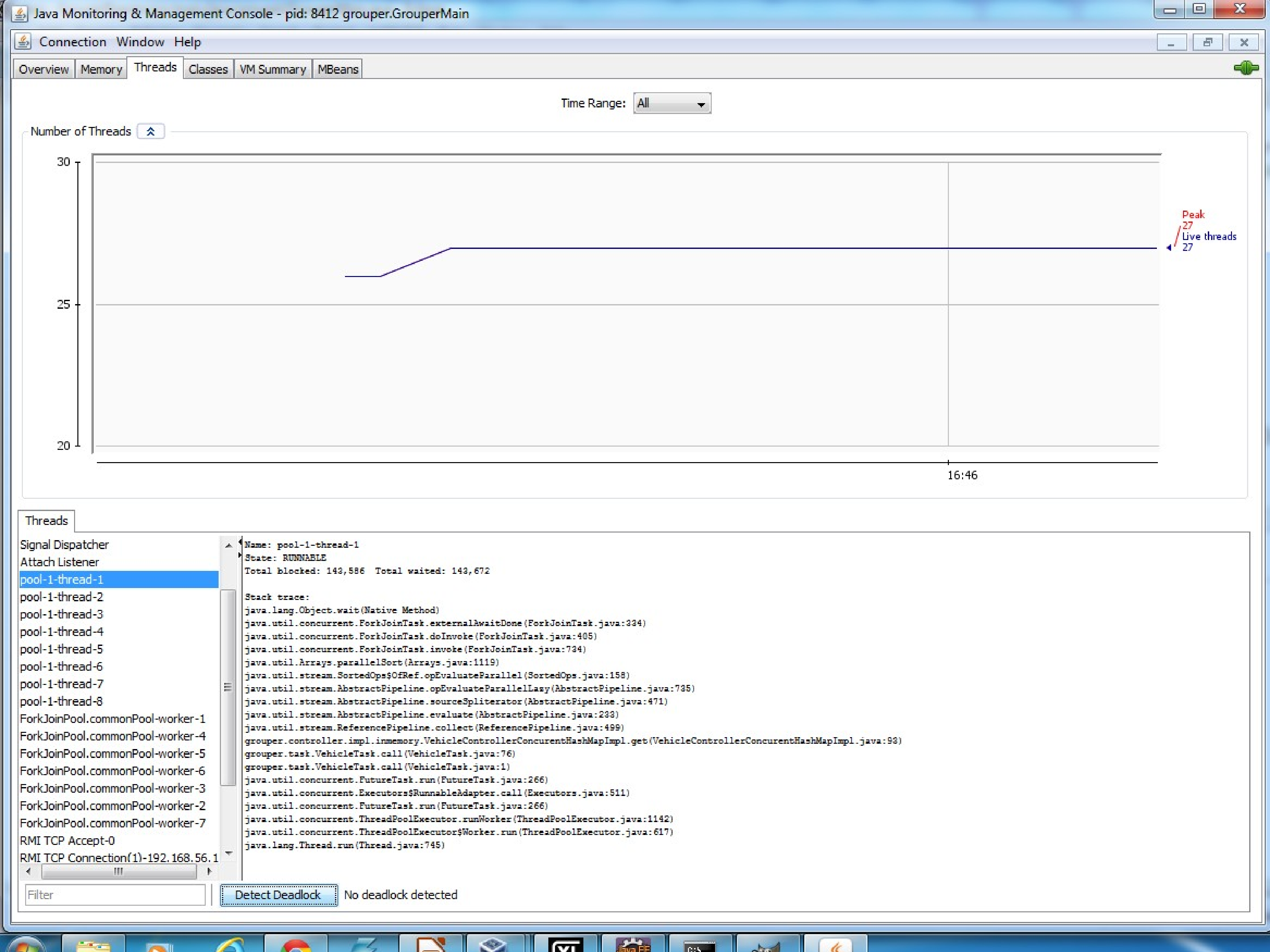
jstat [generalOption | outputOptions vmid [interval[s|ms] [count]]] Ex: **jstat -gc -t -h20 4572 2s**

- Statistics options (part of outputOptions):

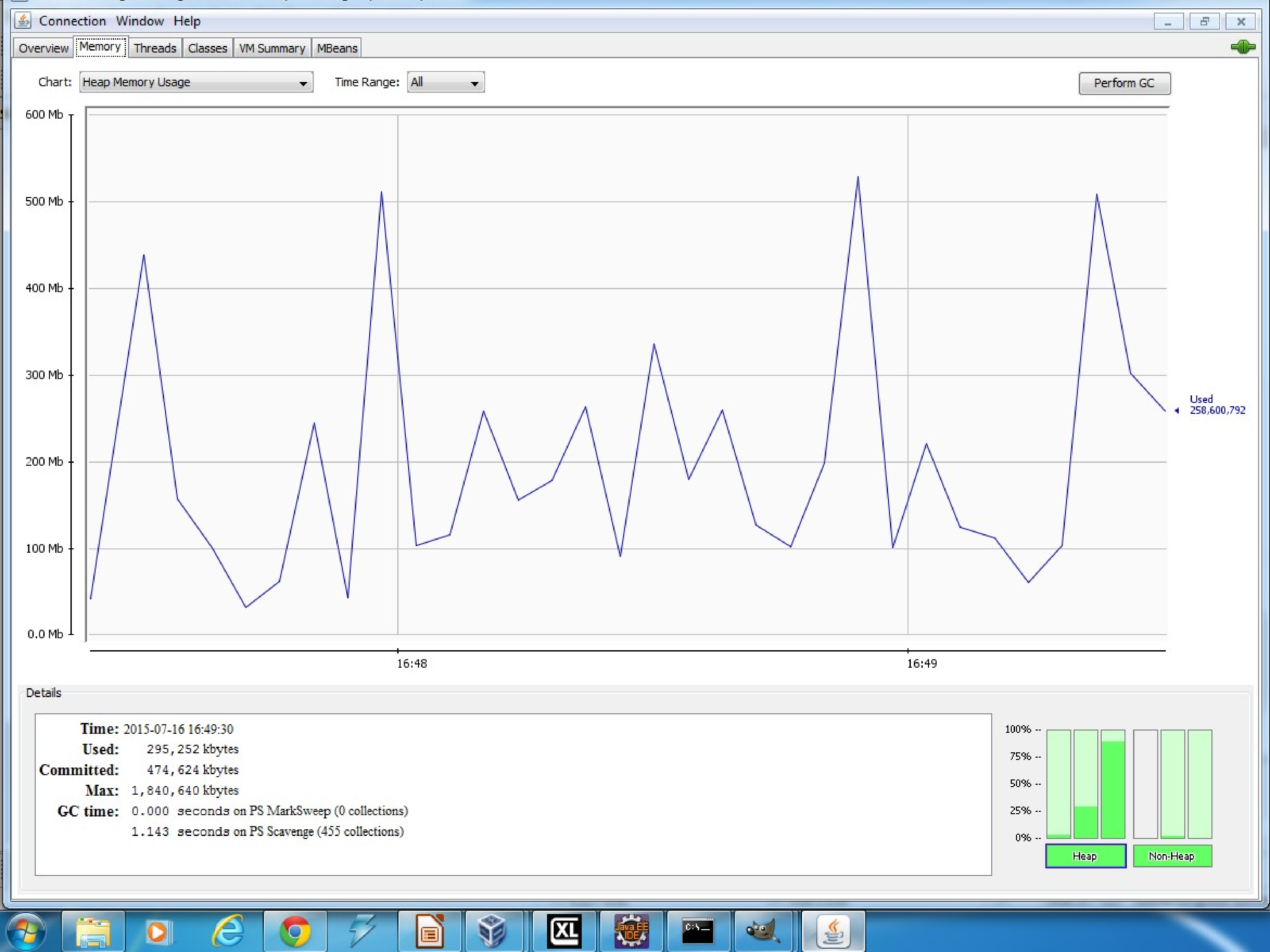
-class - statistics on the behavior of the class loader;
-compiler - behavior of the HotSpot Just-in-Time compiler;
-gc - statistics of the behavior of the garbage collected heap;
-gccapacity - capacities of the generations and their spaces;
-gccause, -gcutil - summary of garbage collection statistics/causes;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

Java GUI tools – JConsole

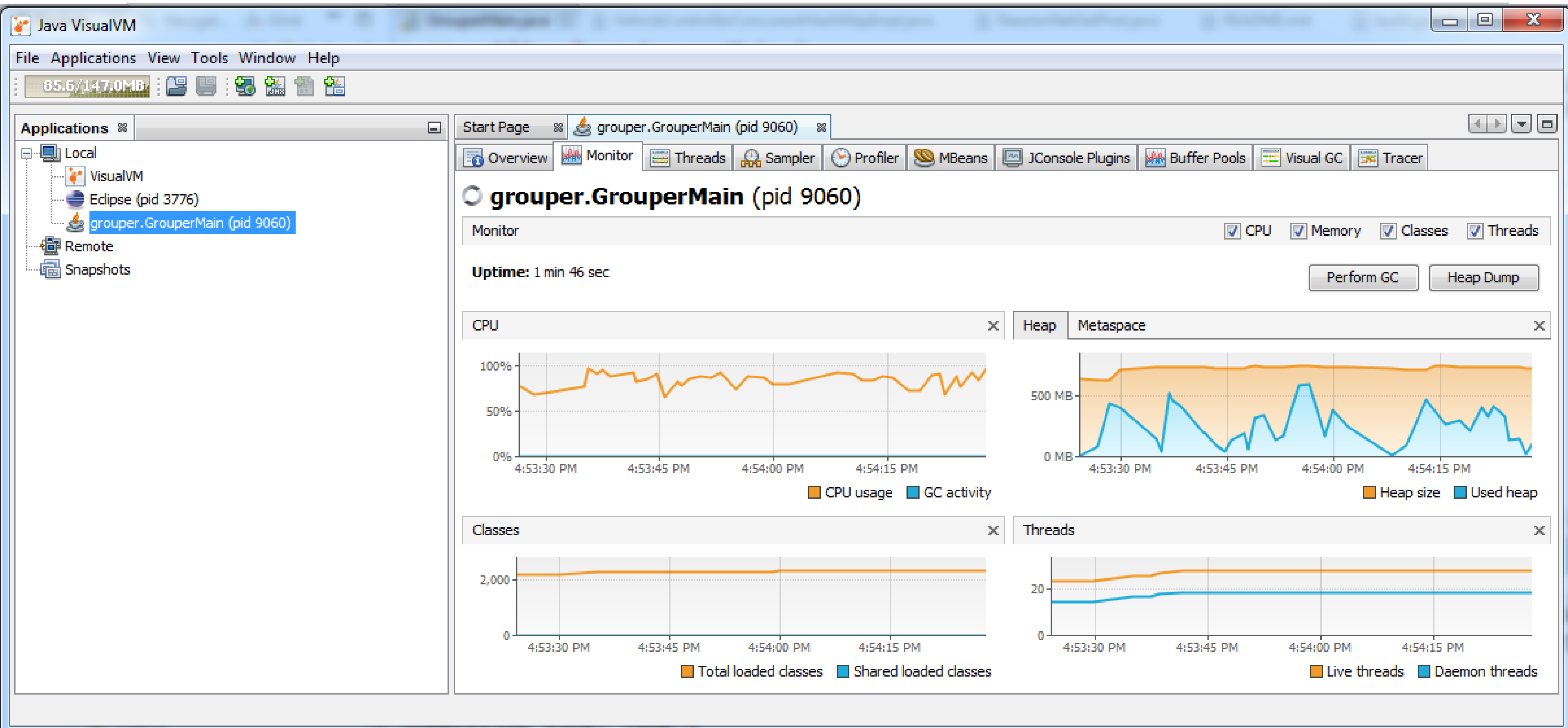


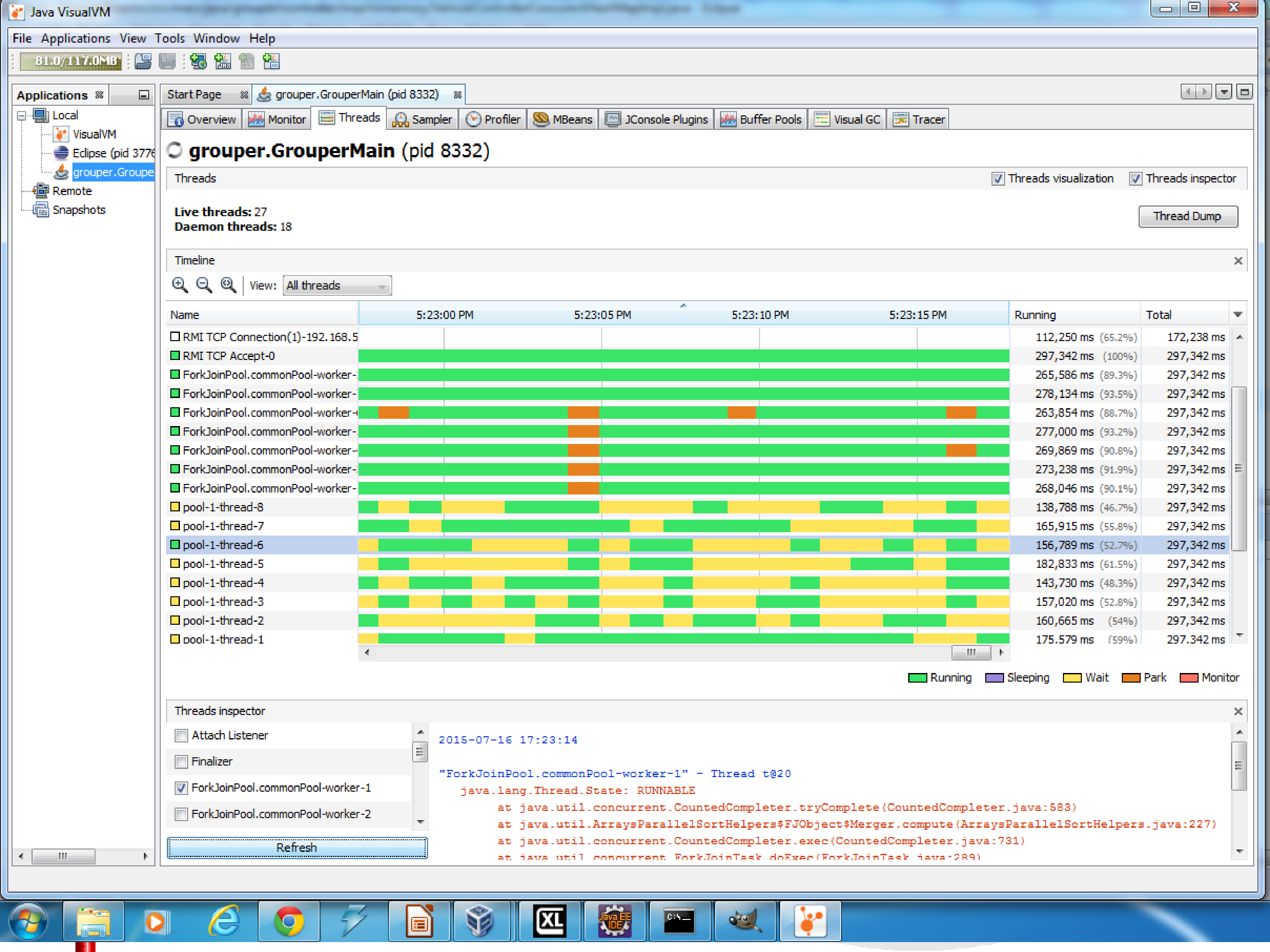


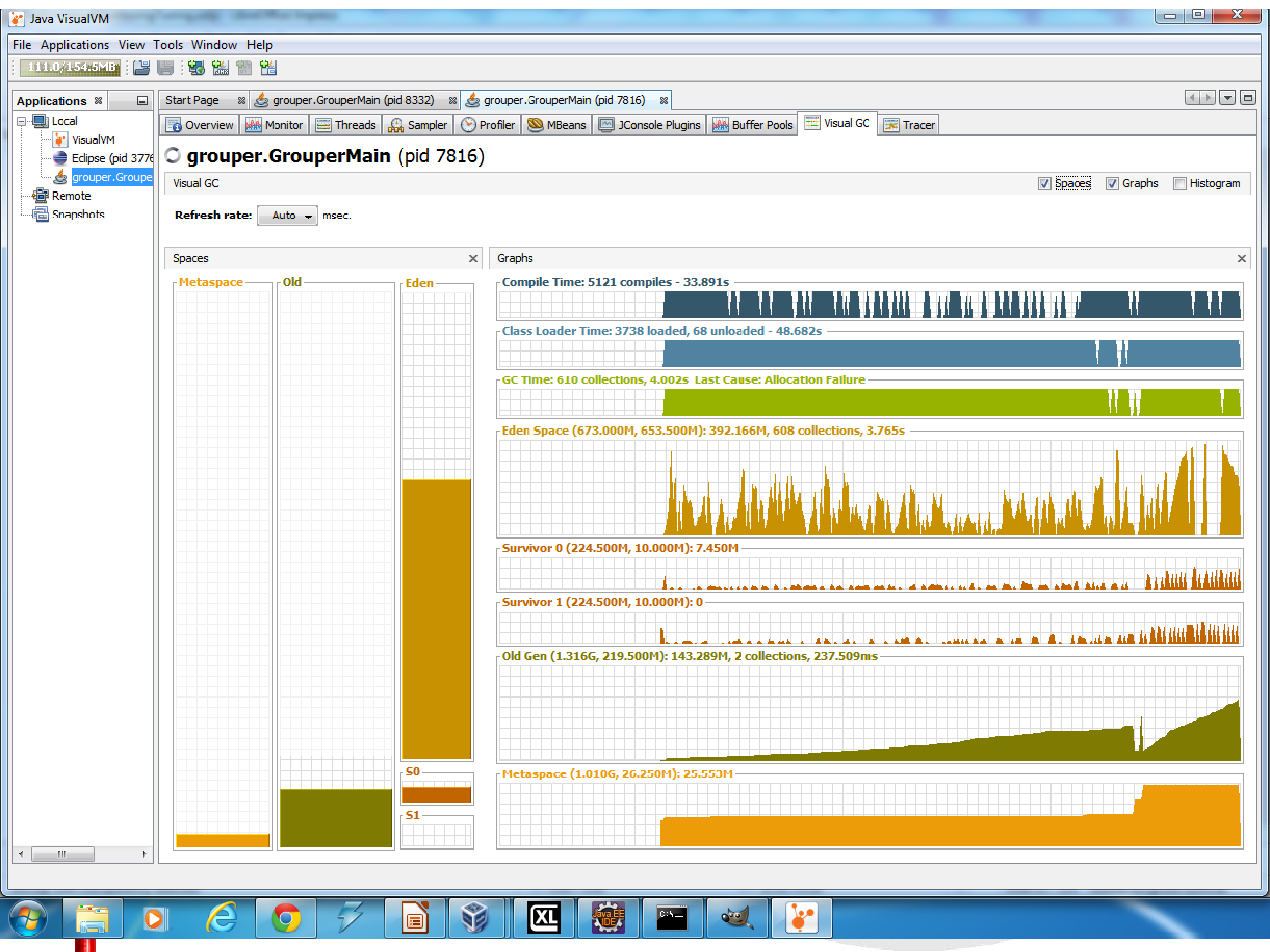
Java Monitoring & Management Console - pid: 8412 grouper.GrouperMain
Connection Window Help
Overview
Memory
Threads
Classes
VM Summary
MBeans
Time Range: All
Number of Threads
30
25
20
16:46
Peak
27
Live threads
27
Threads
Signal Dispatcher
Attach Listener
pool-1-thread-1
pool-1-thread-2
pool-1-thread-3
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
600 Mb
500 Mb
400 Mb
300 Mb
200 Mb
100 Mb
0.0 Mb
16:48
16:49
Used
258,600,792
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)
100%
75%
50%
25%
0%
Heap
Non-Heap

Java GUI tools – jvisualvm




Java VisualVM
File Applications View Tools Window Help
81.0/117.0MB
Applications
Local
VisualVM
Eclipse (pid 3776
grouper.Groupe
Remote
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)-192.168.5 112,250 ms (65.2%) 172,238 ms
RMI TCP Accept-0 297,342 ms (100%) 297,342 ms
ForkJoinPool.commonPool-worker- 265,586 ms (89.3%) 297,342 ms
ForkJoinPool.commonPool-worker- 278,134 ms (93.5%) 297,342 ms
ForkJoinPool.commonPool-worker- 263,854 ms (88.7%) 297,342 ms
ForkJoinPool.commonPool-worker- 277,000 ms (93.2%) 297,342 ms
ForkJoinPool.commonPool-worker- 269,869 ms (90.8%) 297,342 ms
ForkJoinPool.commonPool-worker- 273,238 ms (91.9%) 297,342 ms
ForkJoinPool.commonPool-worker- 268,046 ms (90.1%) 297,342 ms
pool-1-thread-8 138,788 ms (46.7%) 297,342 ms
pool-1-thread-7 165,915 ms (55.8%) 297,342 ms
pool-1-thread-6 156,789 ms (52.7%) 297,342 ms
pool-1-thread-5 182,833 ms (61.5%) 297,342 ms
pool-1-thread-4 143,730 ms (48.3%) 297,342 ms
pool-1-thread-3 157,020 ms (52.8%) 297,342 ms
pool-1-thread-2 160,665 ms (54%) 297,342 ms
pool-1-thread-1 175,579 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
Local
VisualVM
Eclipse (pid 377
grouper.Groupe
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Start Page
grouper.GrouperMain (pid 8332)
grouper.GrouperMain (pid 7816)
Overview
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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

Thank’s for Your Attention!

Trayan Iliev

CEO of IPT – Intellectual Products & Technologies

http://iproduct.org/

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