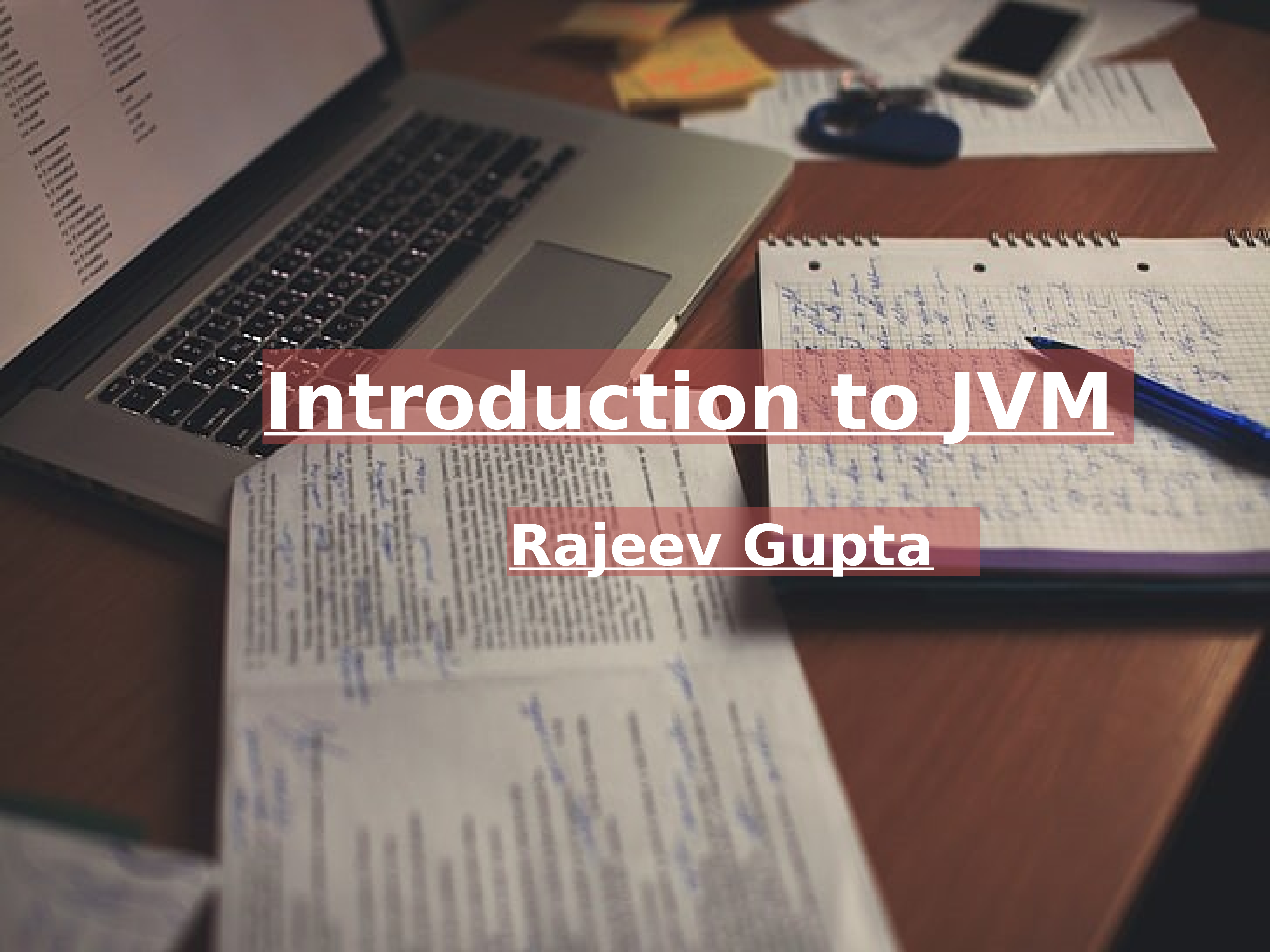
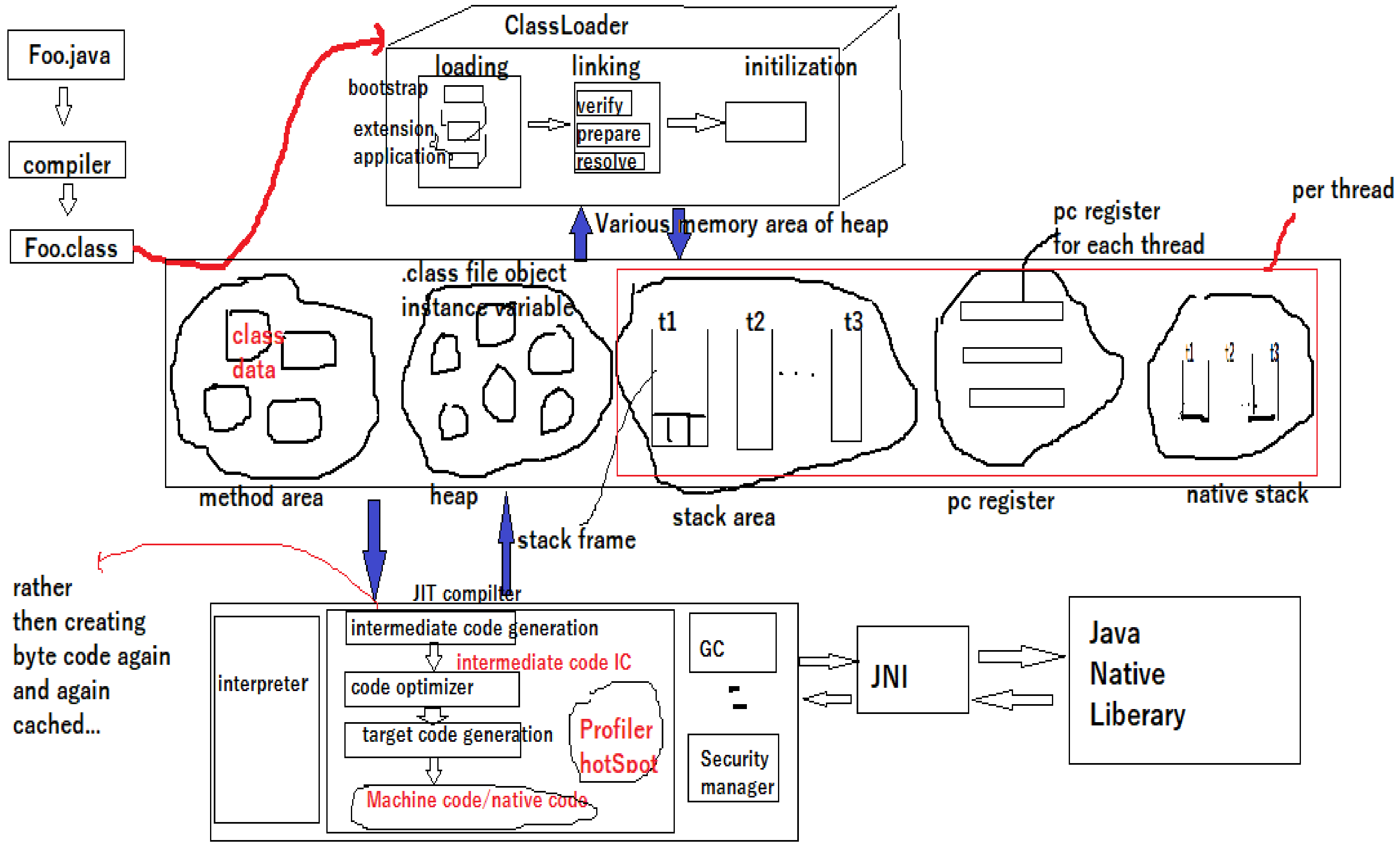


Introduction to JVM

Rajeev Gupta

JVM architecturere



Topics

- JVM, JRE, JDK
- basic arch of JVM
- Class loader sub system
  - loading ,linking,
- initialization Types of class loader
  - boot strap class Loader
  - extension class Loader
  - application class Loader
- ❖ How class loader works?
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- ❖ Pseudo code to define customized class Loader
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  - ❖ Running Java visual VM
  - ❖ Mark and sweep algorithm
  - ❖ Generational collection
  - ❖ Analysis heap dump
- ❖ Execution engine

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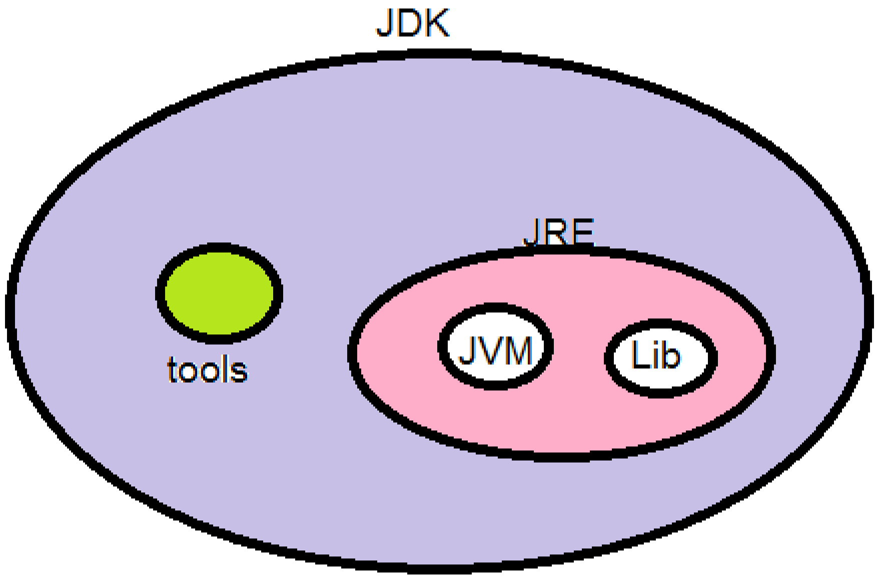
Differentiate JVM JRE JDK

- **Java Virtual Machine (JVM)**
  - Is an abstract computing machine.
- **Java Runtime Environment (JRE)**
  - Is an implementation of the JVM.
  - JVM becomes an instance of JRE at runtime of a java program.
  - It is widely known as a runtime interpreter.
- **Java Development Kit (JDK)**
  - Contains JRE along with various development tools like Java libraries, Java source compilers, Java debuggers, bundling and deployment tools.



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Various memory area of JVM

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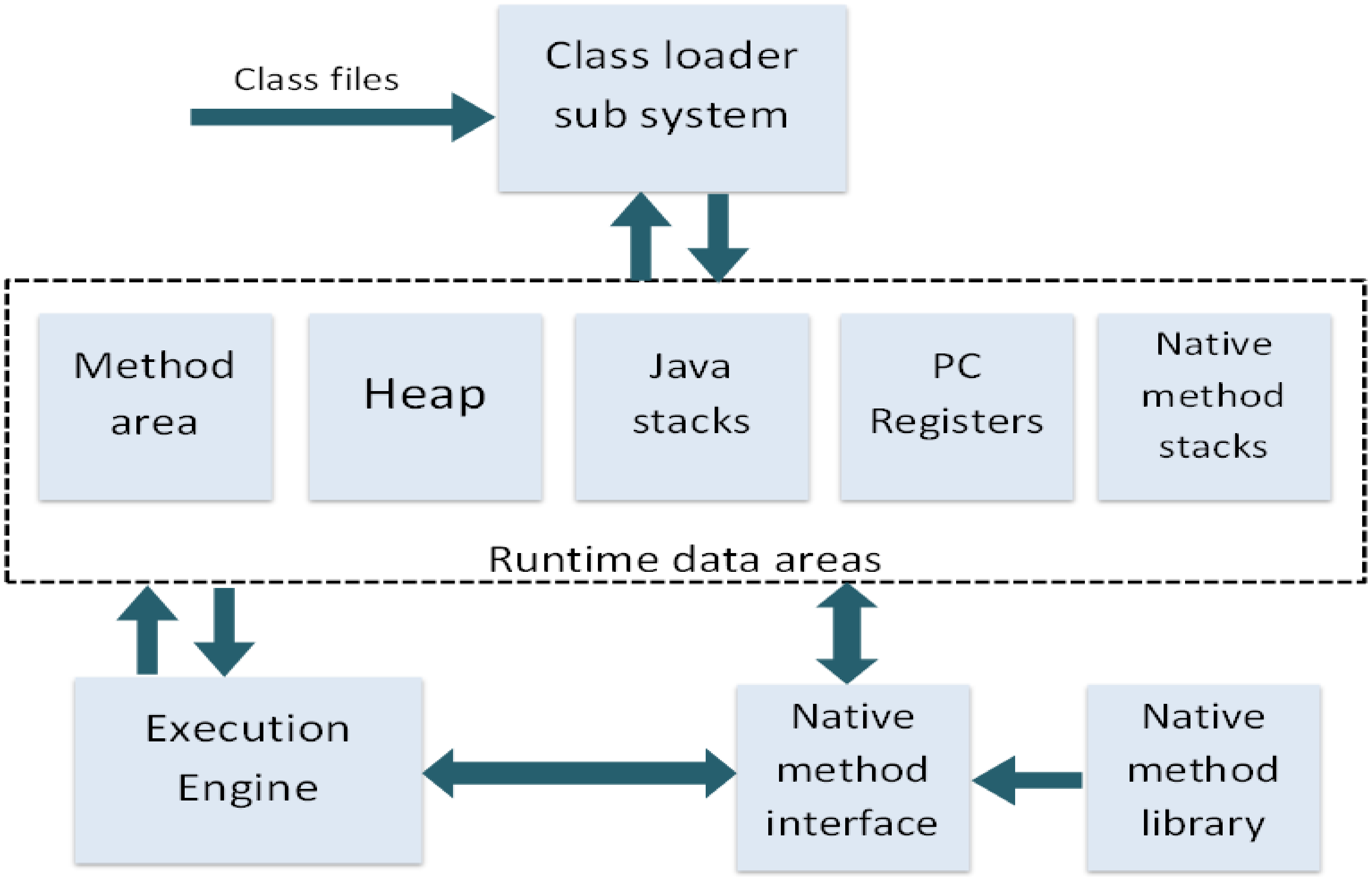
basic arch of JVM



3 Main component of JVM?

- class loader
- memory area
- execution engine

JVM primary responsibility to load and run .class files

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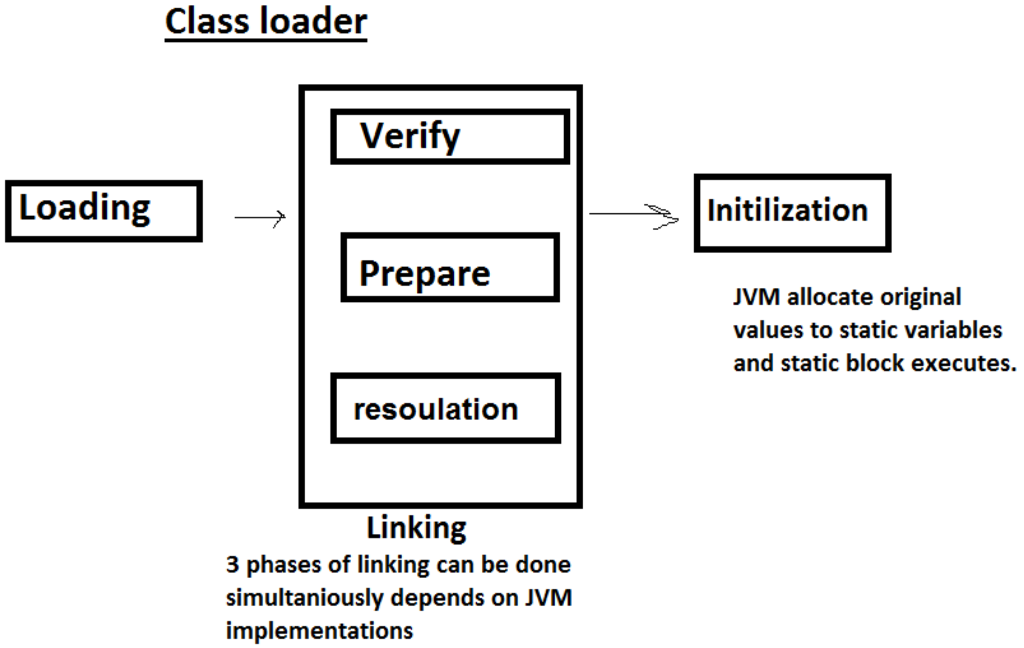
- Program ot display heap memory statistics
- How to set max and min heap size
- Execution engine

Class loader subsystem

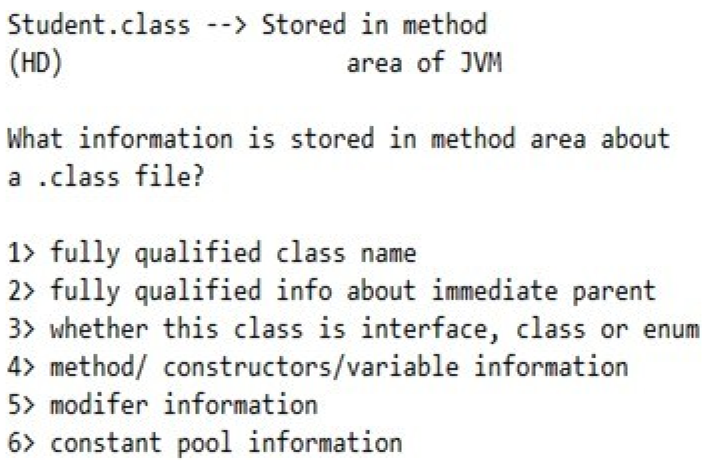
- Class loader is mainly responsibly for 3 activity:
- loading
- linking
  - verificatior
  - perpetratic
  - resolution
- Initialization


Class loader
Loading
Verify
Prepare
resoulation
Linking
3 phases of linking can be done simultaniously depends on JVM implementations
Initilization
JVM allocate original values to static variables and static block executes.

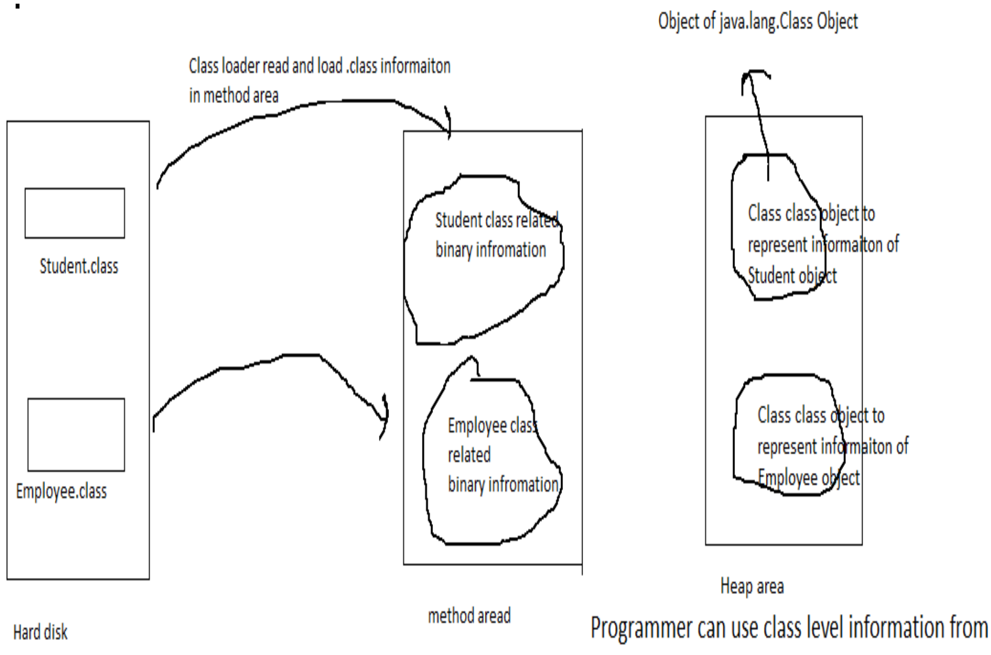
Note : while Loading , Linking , Initializing if any problem occur so JVM will give Runtimeexception re: java.lang.LinkageError

Class Loading process

During loading phase class loader read .class file from HD and dumped d method area



```
Student.class --> Stored in method
(HD)                   area of JVM

What information is stored in method area about
a .class file?

1> fully qualified class name
2> fully qualified info about immediate parent
3> whether this class is interface, class or enum
4> method/ constructors/variable information
5> modifer information
6> constant pool information
```

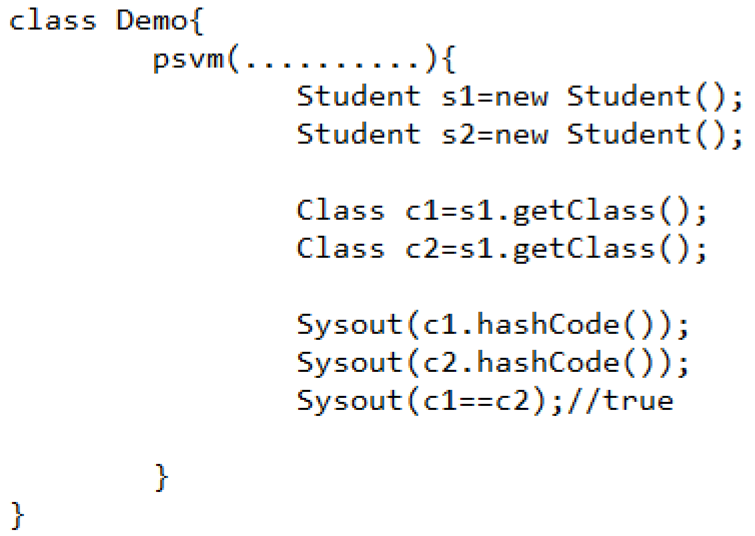

Object of java.lang.Class Object
Class loader read and load .class informaiton in method area
Student.class
Employee.class
Hard disk
Student class related binary infromation
Employee class related binary infromation
method aread
Class class object to represent informaiton of Student object
Class class object to represent informaiton of Employee object
Heap area

Programmer can use class level information from this class object using Java reflection!

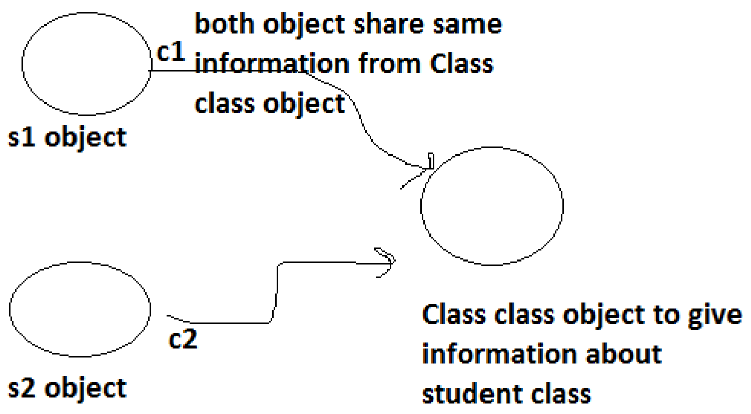
After loading class information in method area , JVM create an Class class information binary information and stored in Heap area

Class Loading process

- For every loaded .class file only one class object will be created, even though we are using class multiple times in our applications

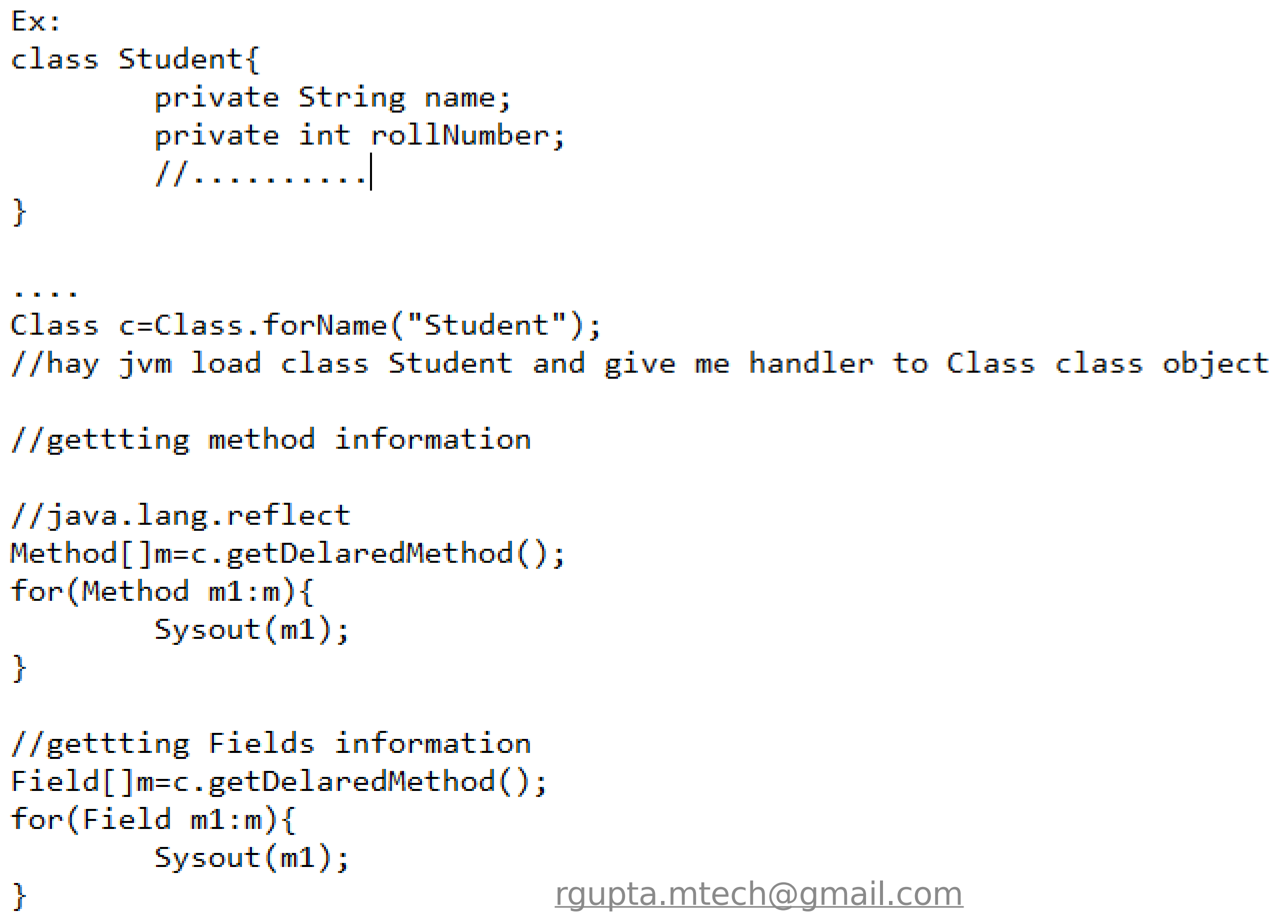


```
class Demo{
        psvm(..........){
                Student s1=new Student();
                Student s2=new Student();

                Class c1=s1.getClass();
                Class c2=s1.getClass();

                Sysout(c1.hashCode());
                Sysout(c2.hashCode());
                Sysout(c1==c2);//true

        }
}
```


both object share same information from Class class object
c1
s1 object
c2
s2 object
Class class object to give information about student class

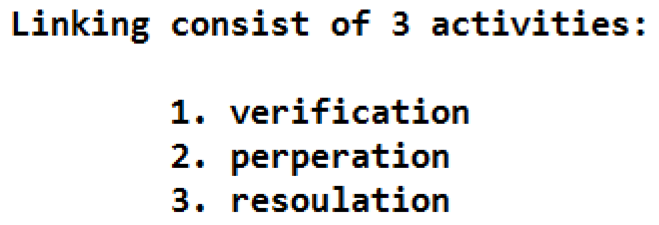
Getting class information using java reflection

- Programmer can use Class class information using java reflection



```
Ex:
class Student{
        private String name;
        private int rollNumber;
        //..........
}

....
Class c=Class.forName("Student");
//hay jvm load class Student and give me handler to Class class object

//gettting method information

//java.lang.reflect
Method[]m=c.getDelaredMethod();
for(Method m1:m){
        Sysout(m1);
}

//gettting Fields information
Field[]m=c.getDelaredMethod();
for(Field m1:m){
        Sysout(m1);
}
```

Linking phase



```
Linking consist of 3 activities:

        1. verification
        2. perperation
        3. resoulation
```

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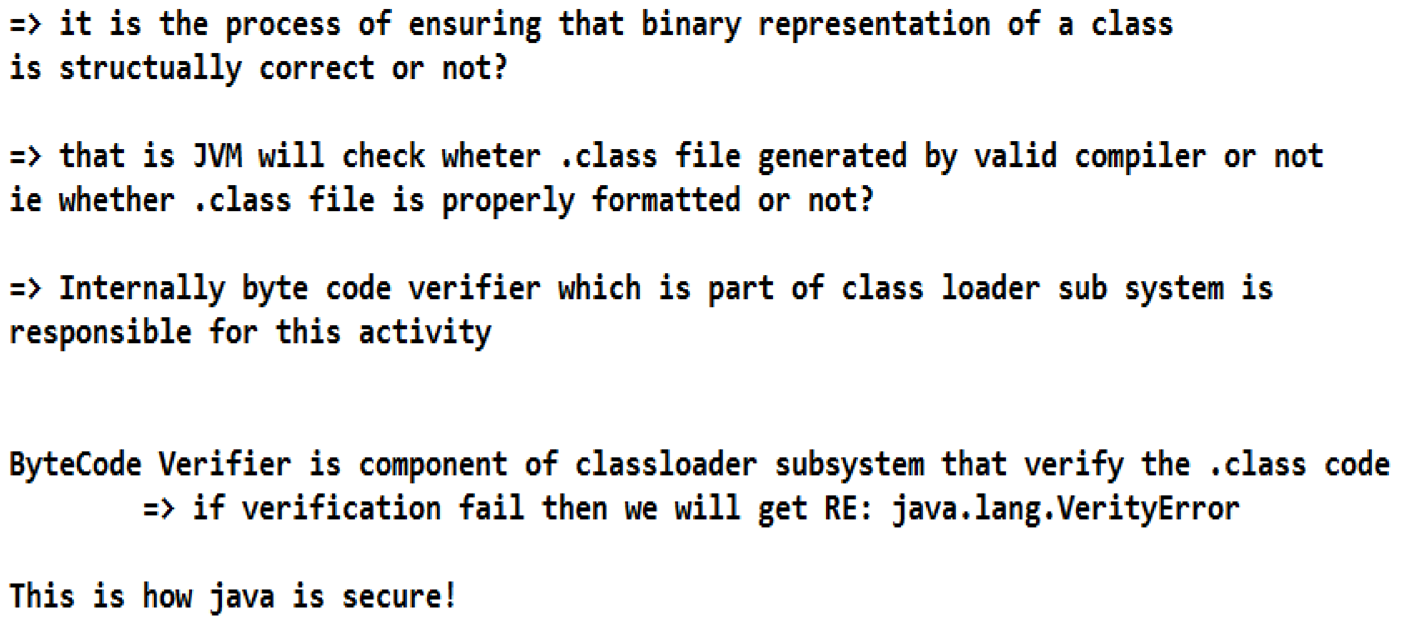
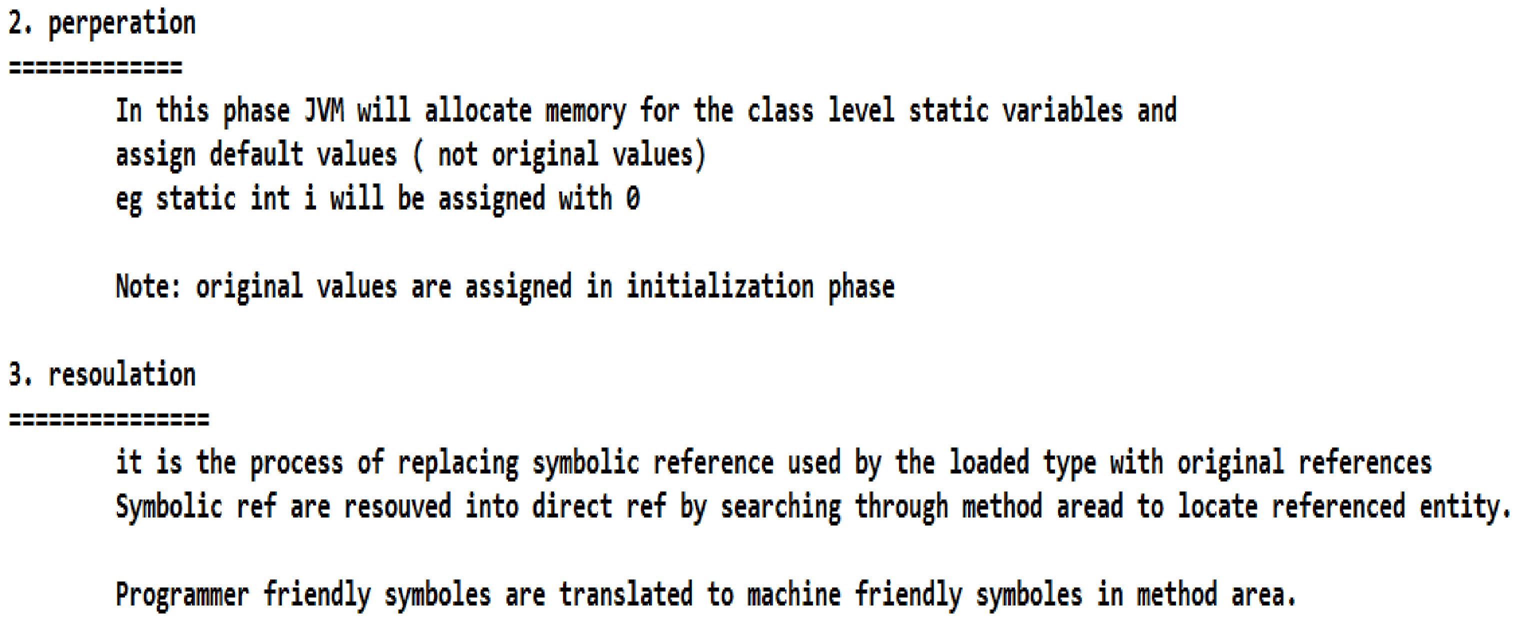
Verification phase



```
=> it is the process of ensuring that binary representation of a class
is structually correct or not?

=> that is JVM will check wheter .class file generated by valid compiler or not
ie whether .class file is properly formatted or not?

=> Internally byte code verifier which is part of class loader sub system is
responsible for this activity


ByteCode Verifier is component of classloader subsystem that verify the .class code
        => if verification fail then we will get RE: java.lang.VerityError

This is how java is secure!
```

Perpetration and resolution phase



```
2. perperation
==============
	In this phase JVM will allocate memory for the class level static variables and
	assign default values ( not original values)
	eg static int i will be assigned with 0

	Note: original values are assigned in initialization phase

3. resoulation
================
	it is the process of replacing symbolic reference used by the loaded type with original references
	Symbolic ref are resouved into direct ref by searching through method aread to locate referenced entity.

	Programmer friendly symboles are translated to machine friendly symboles in method area.
```

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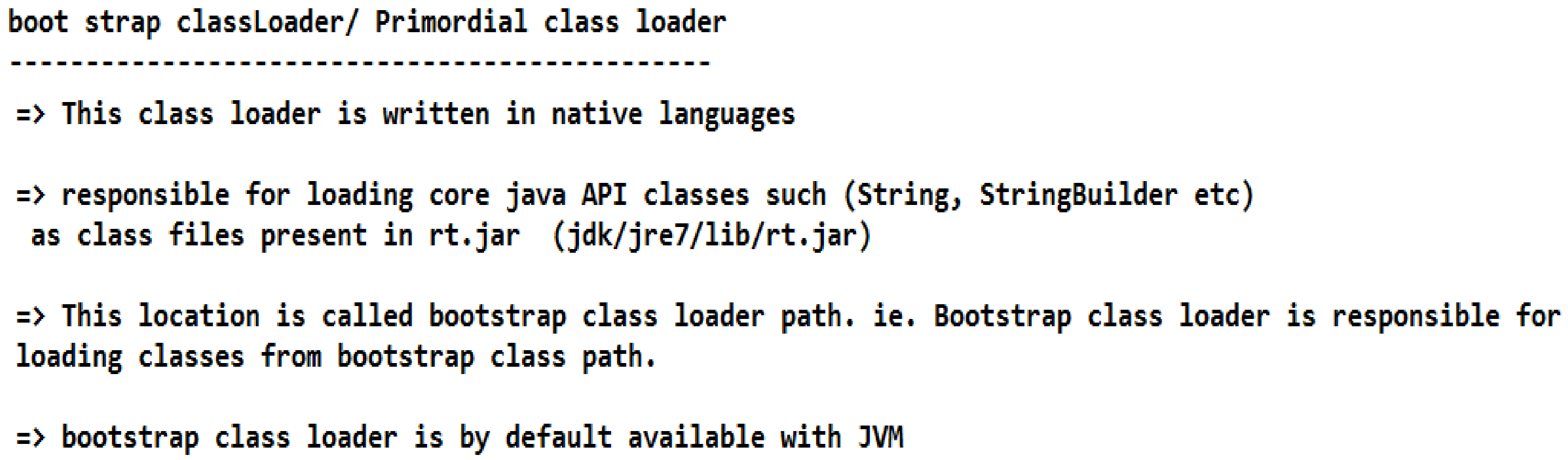
Type of class loaders

```
Every class loader subsystem contain 3 class loaders:


boot strap classLoader
        |
 extension classLoader
        |
 applicatin classLoader


=> boot strap classLoader/ Primordial class loader
=> extension classLoader
=> applicatin classLoader/ System class loader
```

Boot strap class loader



boot strap classLoader/ Primordial class loader

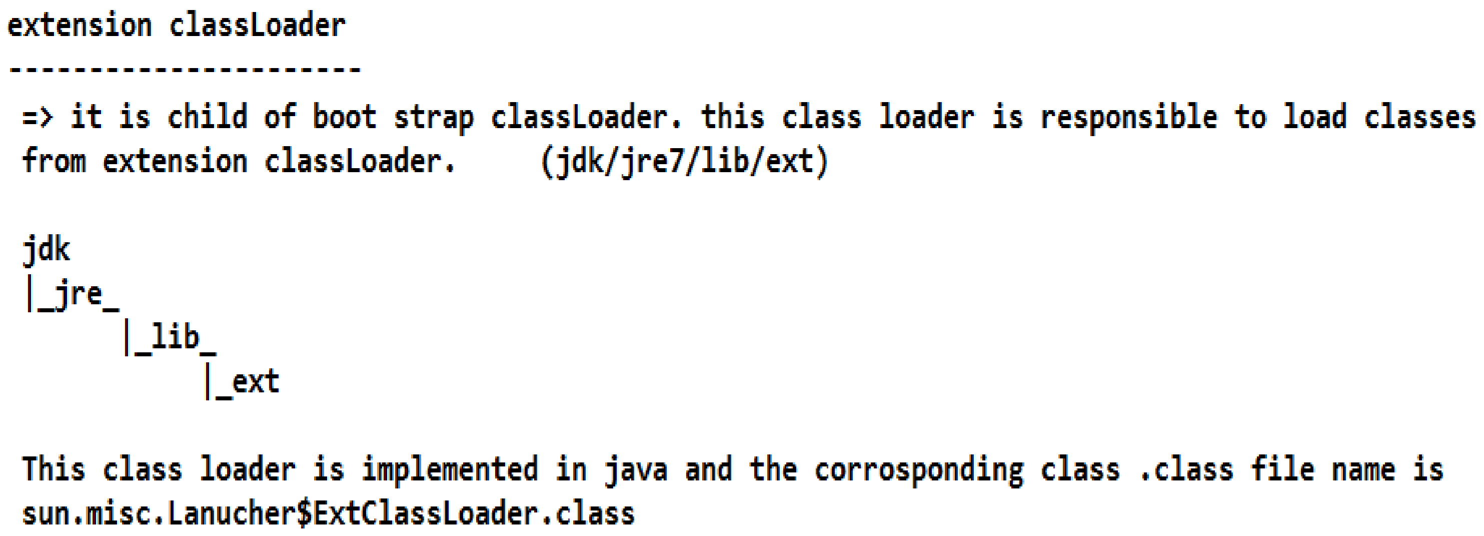
=> This class loader is written in native languages

=> responsible for loading core java API classes such (String, StringBuilder etc)
as class files present in rt.jar (jdk/jre7/lib/rt.jar)

=> This location is called bootstrap class loader path. ie. Bootstrap class loader is responsible for loading classes from bootstrap class path.

=> bootstrap class loader is by default available with JVM

Extension class loader

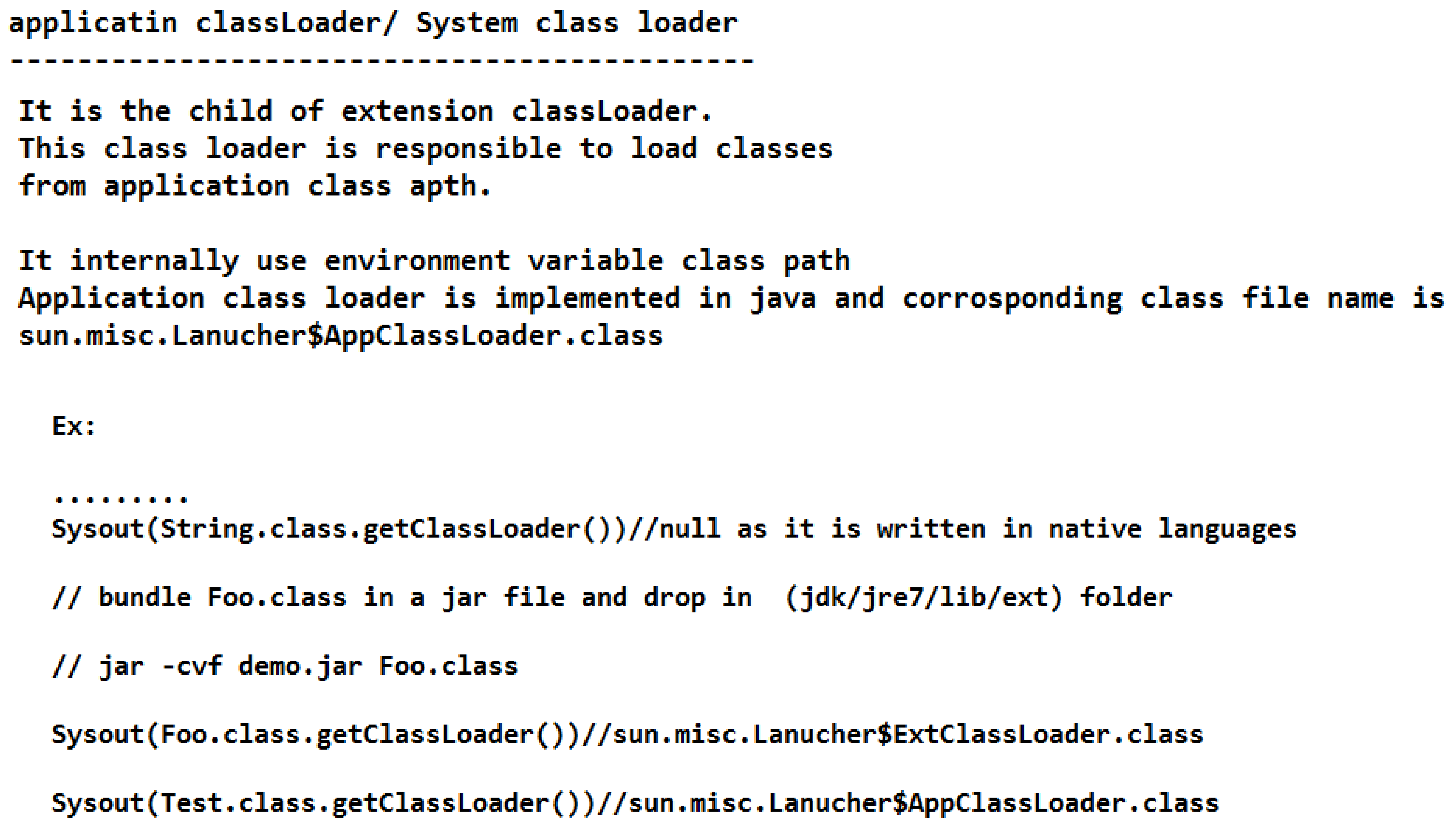


```
extension classLoader
----------------------
 => it is child of boot strap classLoader. this class loader is responsible to load classes
 from extension classLoader.     (jdk/jre7/lib/ext)

 jdk
 |_jre_
       |_lib_
             |_ext

 This class loader is implemented in java and the corrosponding class .class file name is
 sun.misc.Lanucher$ExtClassLoader.class
```

Application class loader



```
applicatin classLoader/ System class loader
---------------------------------------------

 It is the child of extension classLoader.
 This class loader is responsible to load classes
 from application class apth.

 It internally use environment variable class path
 Application class loader is implemented in java and corrosponding class file name is
 sun.misc.Lanucher$AppClassLoader.class


   Ex:

   .........
   Sysout(String.class.getClassLoader())//null as it is written in native languages

   // bundle Foo.class in a jar file and drop in  (jdk/jre7/lib/ext) folder

   // jar -cvf demo.jar Foo.class

   Sysout(Foo.class.getClassLoader())//sun.misc.Lanucher$ExtClassLoader.class

   Sysout(Test.class.getClassLoader())//sun.misc.Lanucher$AppClassLoader.class
```

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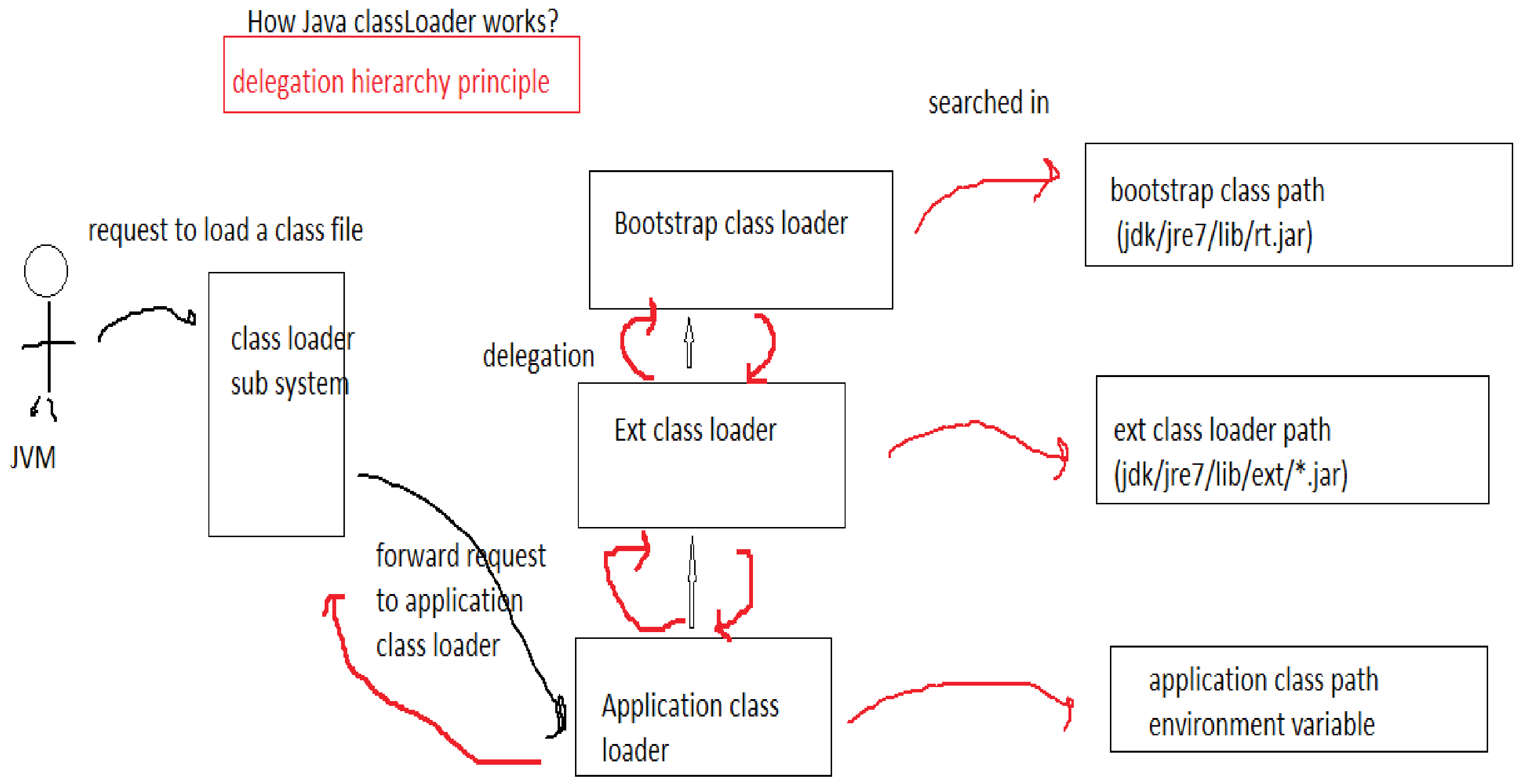
Delegation hierarchy, How Class loader works?


How Java classLoader works?
delegation hierarchy principle
searched in
request to load a class file
JVM
class loader sub system
Bootstrap class loader
bootstrap class path (jdk/jre7/lib/rt.jar)
delegation
Ext class loader
ext class loader path (jdk/jre7/lib/ext/*.jar)
forward request to application class loader
Application class loader
application class path environment variable

```
HOw class loader works?
=======================
 1> class loader follows delegation hierarchy principle

 2> wheneverJVm comes across a particular class, first it will check
 wheterh the corrospondng class is already loaded or not?

 3> If it is already loaded in memory area then JVM will use that loaded class

 4> If it is not already loaded then JVM requests class loader sub system to load
 that particular class, then class loader sub system handover
 that request to applicatin class loader

 5> Application class loader delegates request to extension class loader and
 ext class loader in turn delegates to boot strap class loader

 6> boot strap class loader searches in boot strap class path ( JDK/JRE/lib).
 If the specified class is available then it will be loaded.
 Otherwise bootstrap class loader delegates the request to extension class loader

 7> Extension class loader will searches in extension class path(JDK/JRE/Lib/ext).
 If the specified class is available then it will be loaded.
 otherwise it delegates the request to application class

 8> Application class loader will search in application class path.
 If the specified class is already available then it will be loaded otherwise
  we will get RE: ClassNotFoundExecption
```

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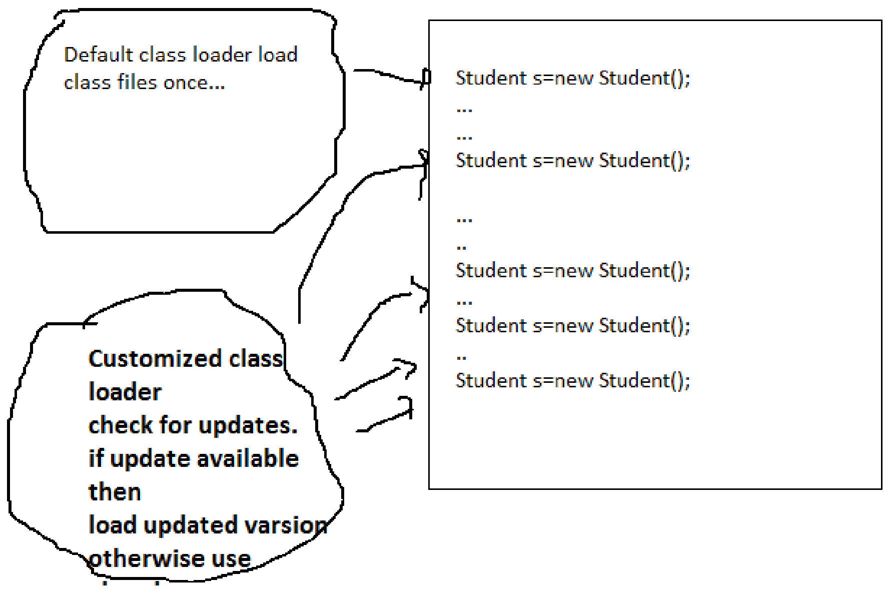
Need of custom class loader?



Default class loader load class files once...

Customized class loader
check for updates.
if update available then
load updated varsion
otherwise use

```
Student s=new Student();
...
...
Student s=new Student();

...
..
Student s=new Student();
...
Student s=new Student();
..
Student s=new Student();
```

```
Need of customized classLoader?
=================================
If our programming req is not satisified with predefine class loader,
 we can define custom class loader

Ex: Default Class loader will load class files only once, what if
class def is modified afterward,
class loader dont do that update....

Our programm may miss updated information.. we need customized class loader....
```

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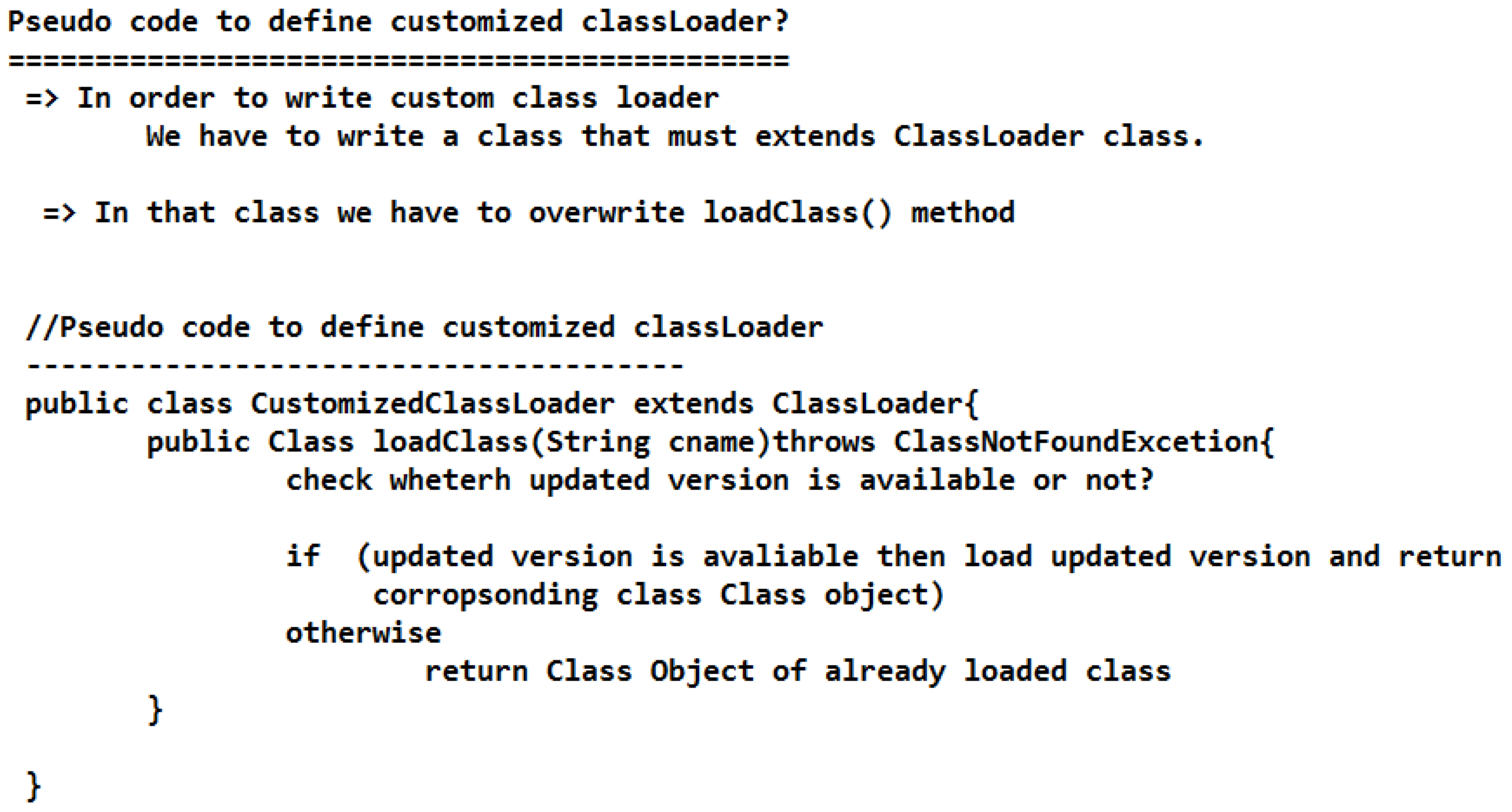
Pseudo code for custom class loader?



```
Pseudo code to define customized classLoader?
=============================================
 => In order to write custom class loader
        We have to write a class that must extends ClassLoader class.

  => In that class we have to overwrite loadClass() method


 //Pseudo code to define customized classLoader
 --------------------------------------
 public class CustomizedClassLoader extends ClassLoader{
        public Class loadClass(String cname)throws ClassNotFoundExcetion{
                check wheterh updated version is available or not?

                if  (updated version is avaliable then load updated version and return
                     corropsonding class Class object)
                otherwise
                        return Class Object of already loaded class
        }

 }
```

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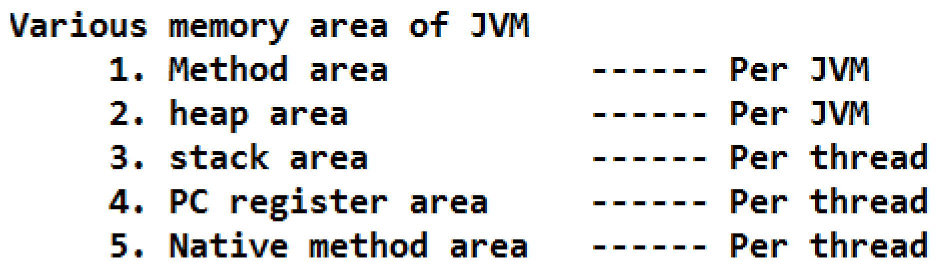
Various memory area of JVM

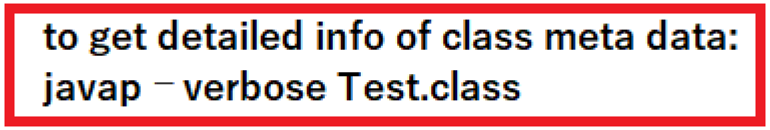


Various memory area of JVM

1. Method area	------ Per JVM
2. heap area	------ Per JVM
3. stack area	------ Per thread
4. PC register area	------ Per thread
5. Native method area	------ Per thread

Method area

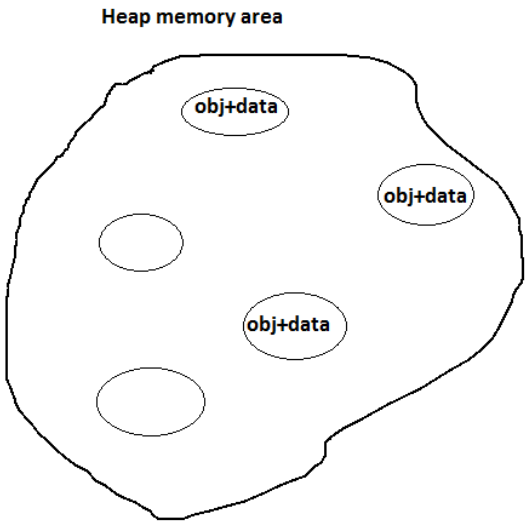
- JVM dumped class meta data into method area. Static variable are also stored in method area


to get detailed info of class meta data:

```
javap – verbose Test.class
```

Heap area

```
 heap area:
 =========
=> All objects with instance varaible stored in heap, all thread access same heap
so heap in not thread safe
=> Heap area is per JVM
=> Heap area is created at JVM startup
=> Every array is object in java, hence stored in heap area
=> can be accessed by multiple threads, hence data stored in heap memory is not thread safe
=> need not to be continous

Heap memory statatics?
======================
Program to display heap memory stats...display heap memroy, fre memory, used memory

Java    RunTime class (Singleton class java.lang.*)
App       ------->      JVM

Using Runtime class (Singleton class)   we can get infromation
RunTime  r=new Runtime ();
double mb=1024*1024;
r.maxMemory()/mb;
r.freeMemory()/mb;
r.initalMemory()/mb;

consumed memory=inital memory-consumed memory
```

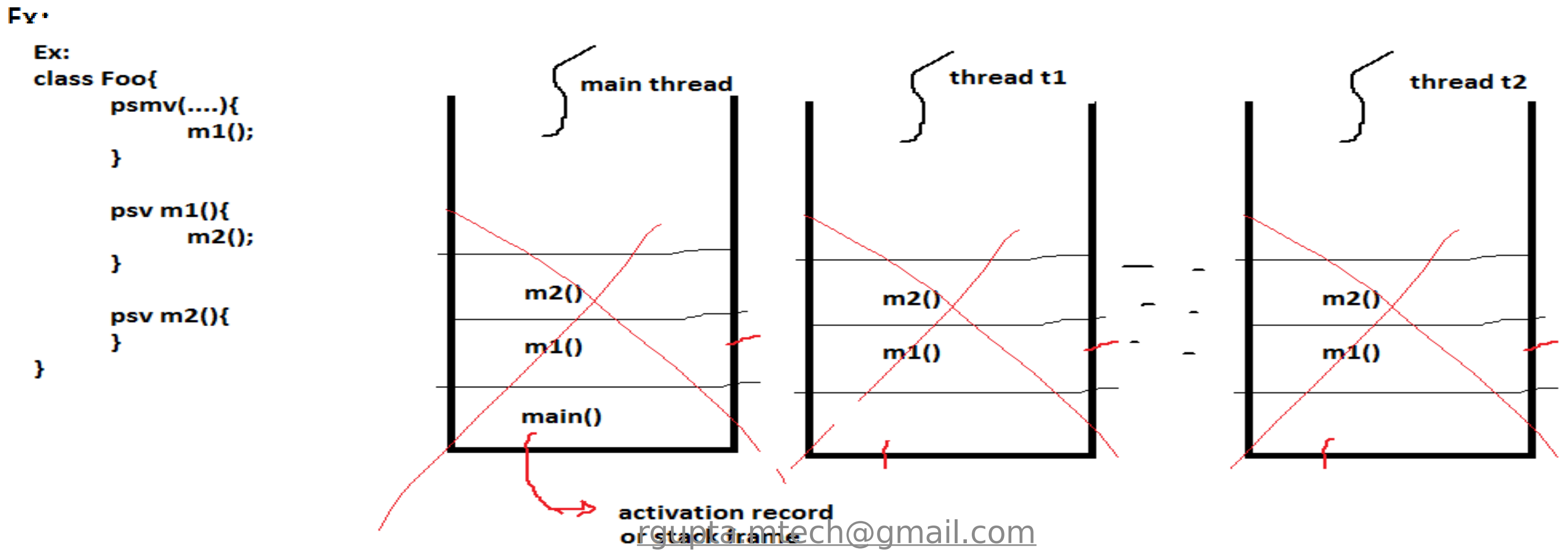


```
How to set max/min heap size?
-----------------------------
heap memory is finite memroy, we can adjust as per our requirments

java -Xmx512M Demo  //will set max heap memory to 512M (default 256Mb)
java -Xms64M Demo  //will set min heap memory to 64M (default 16Mb)

in one go:
java -Xmx512M -Xms64M Demo
```

Stack area

```
stack area
==========
 => for every thread jvm create one stack area
 => thread safe
 => each method call and local variable stored in stack area
 After completing all methods of Foo class RuntimeStack is destroyed.
```

for every thead jvm create an sepeate stack, at the time of thread creation, each and every method call performed by that thread will be stored in the stack including local variable also. After completing an method corrosponding entry (stack frame) form the stack will be removed.After completing all methods call stack will be empty and that empty stack will be destroyed by the JVM, just before termaniting the thread



```
Ex:
class Foo{
        psmv(....){
                m1();
        }

        psv m1(){
                m2();
        }

        psv m2(){
        }
}
```

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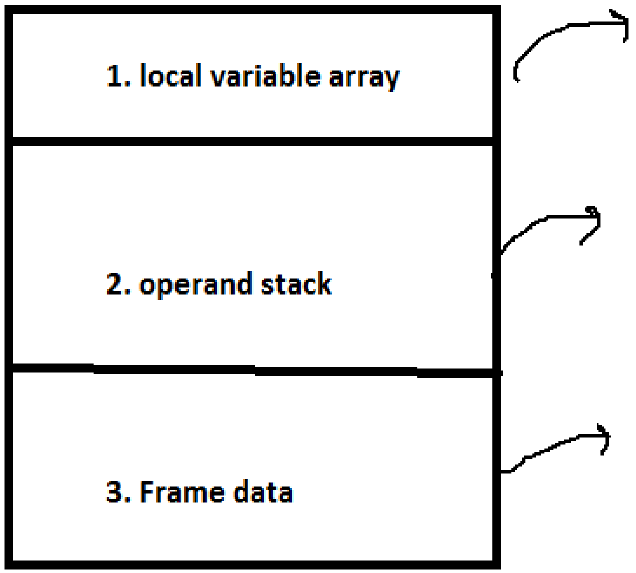
```
Internal of stack frame?
------------------------
 Each stack frame contain 3 parts:
 1. local variable array
         contain array of all local varaible passed in method
 2. operand stack
 3. Frame data


 public void foo(int a, float b, boolean f, Bar bar){
 }
```

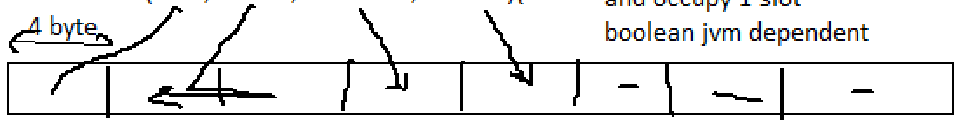
Internal of stack frame?



Stack frame

local variable array: store method arguments

```
public void foo(int a, float b, boolean f, Bar bar){
}
```

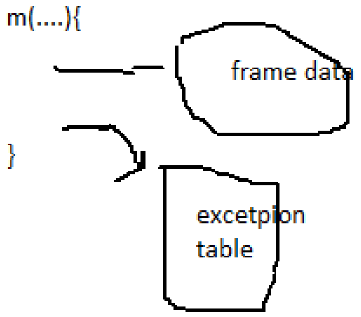


byte etc promoted to int
and occupy 1 slot
boolean jvm dependent

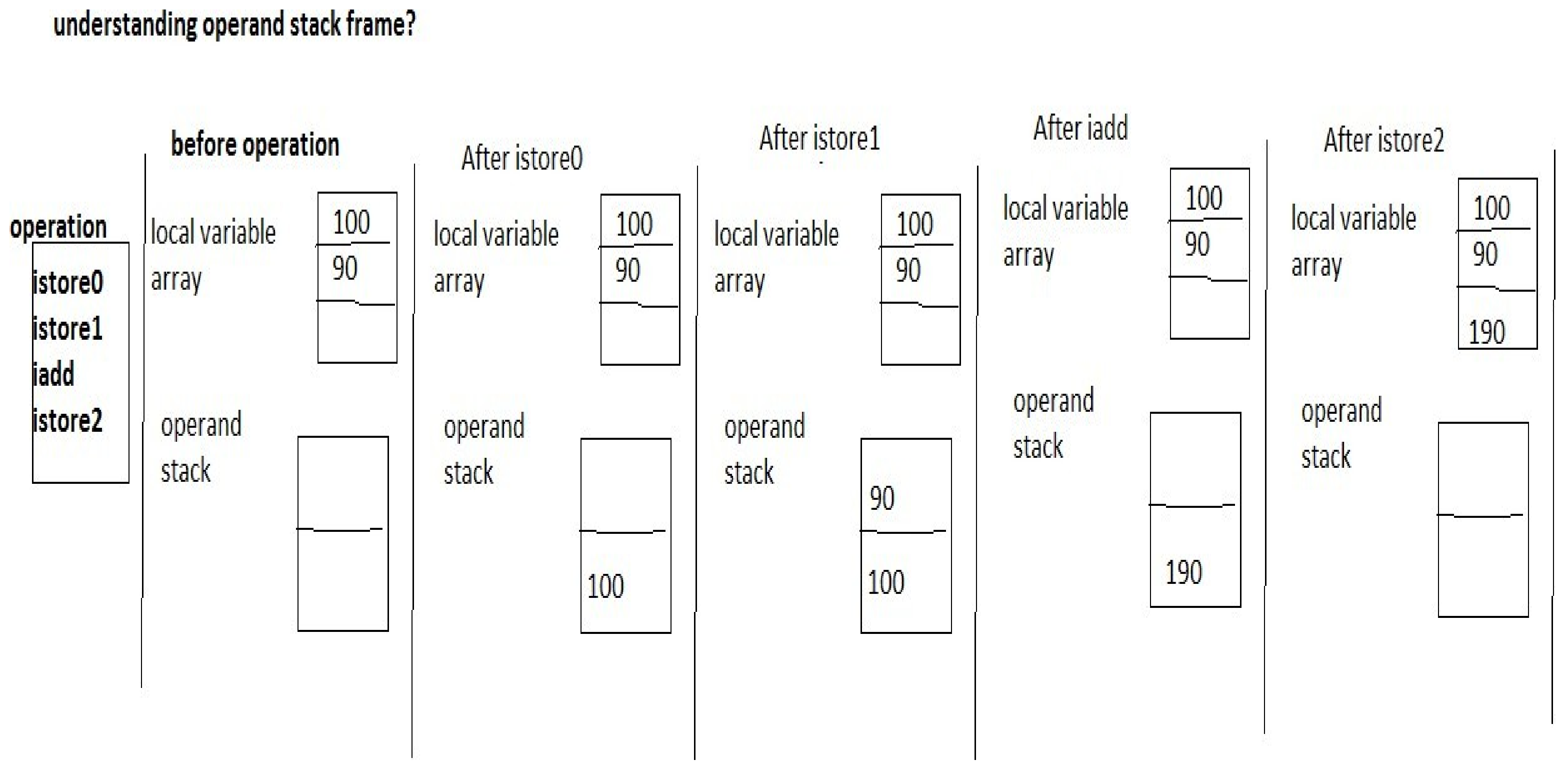
aka of erable roughf work..
.operand stack is workspack to performing and store intermediate result of processing used by JVM
some instruction push/pop/operation values from operand stack

There are many symbols used in method,stored in frame data.

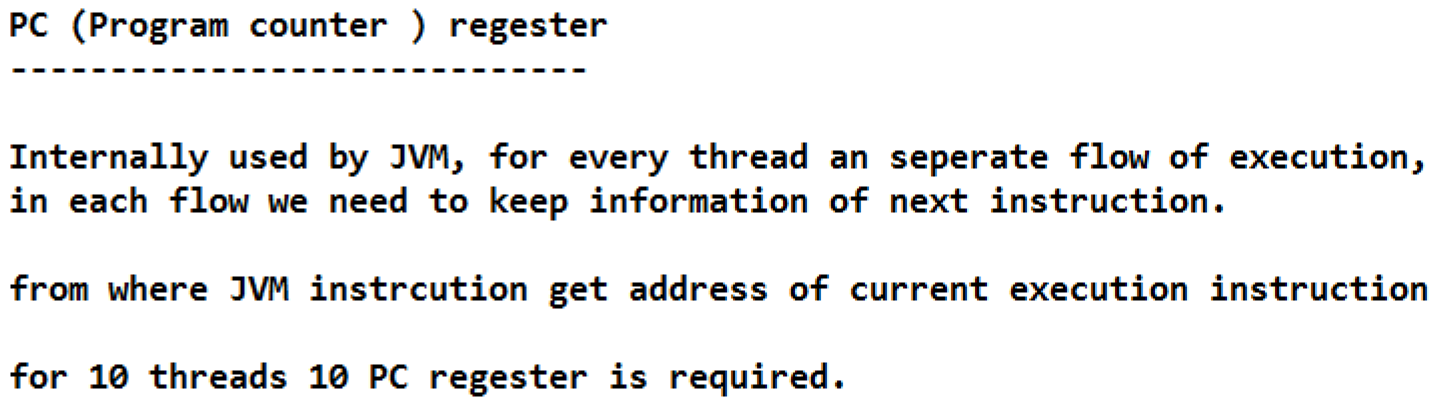
frame data contain pool of all constant symbol used in method.
it also cotain reference to all exception table which provide corrosponding catch block information in case of exception.



Operand stack



Program counter register



```
PC (Program counter ) regester
-----------------------------

Internally used by JVM, for every thread an seperate flow of execution,
in each flow we need to keep information of next instruction.

from where JVM instrcution get address of current execution instruction

for 10 threads 10 PC regester is required.
```

Topics

- JVM, JRE, JDK
- basic arch of JVM
- Class loader sub system
  - loading ,linking,
- initialization Types of class loader
  - boot strap class Loader
  - extension class Loader
  - application class Loader
- ❖ How class loader works?
- ❖ Need of customized classLoader
- ❖ Pseudo code to define customized classLoader
- ❖ Java Memory management
- ❖ Various memory area of JVM
  - ❖ Method area heap area stack area
  - ❖ PC register area Native method area

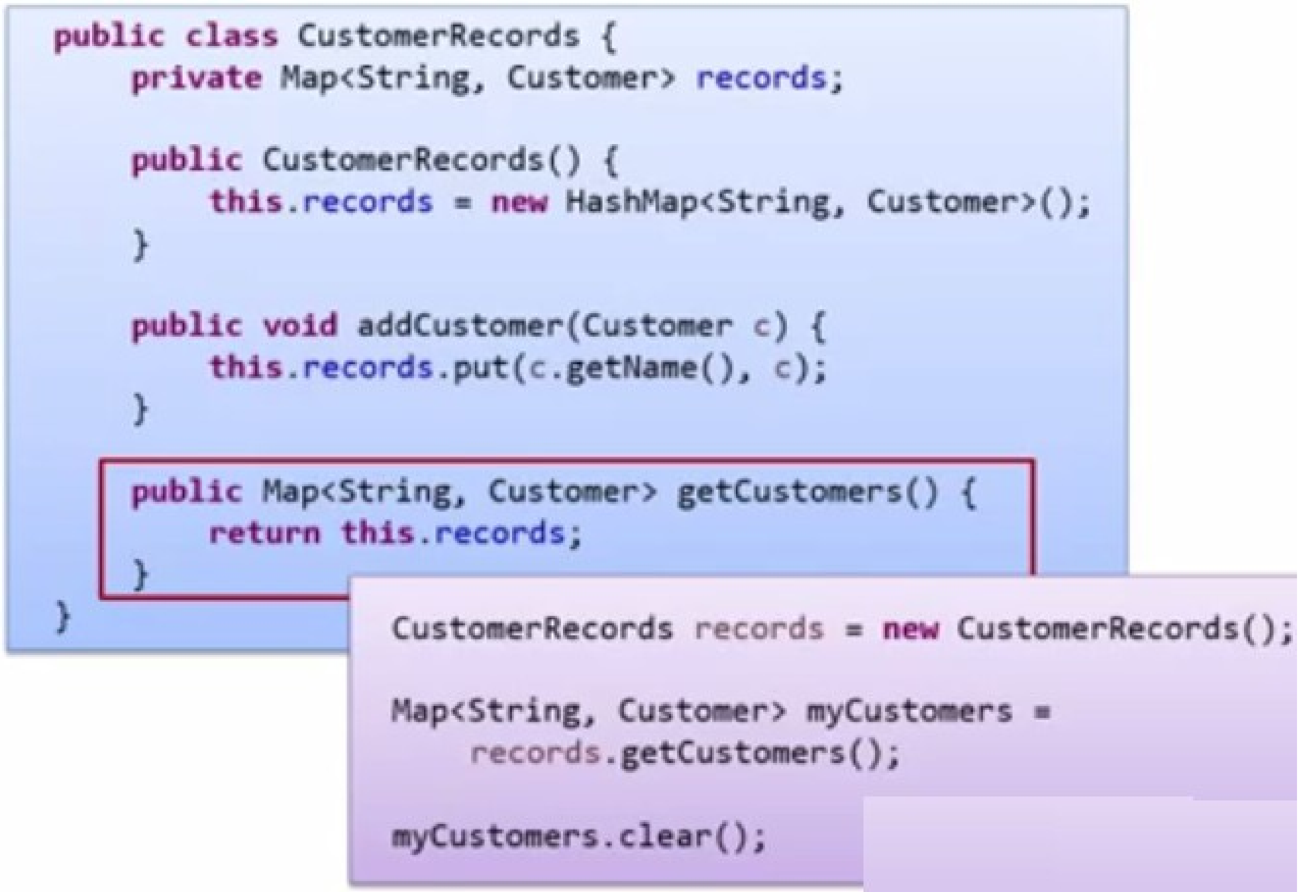
- ❖ **Garbage collector**
  - ❖ **Issue of memory leak, soft link**
  - ❖ **Running Java visual VM**
  - ❖ **Mark and sweep algorithm**
  - ❖ **Generational collection**
  - ❖ **PemGen space problem**
  - ❖ **Analysis heap dump**
- ❖ Execution engine

Garbage collector

- GC is used to remove objects that goes out of scope.
- We can create object by "new" but no keyword as "delete“ in Java
- what GC gets started?
  - GC is application program that runs inside jvm, when we invoke “ java” command it get started as demon process

Escaping reference

- Consider CustomerRecord code, it have issue of escaping reference



```
public class CustomerRecords {
    private Map<String, Customer> records;

    public CustomerRecords() {
        this.records = new HashMap<String, Customer>();
    }

    public void addCustomer(Customer c) {
        this.records.put(c.getName(), c);
    }

    public Map<String, Customer> getCustomers() {
        return this.records;
    }
}
```

```
CustomerRecords records = new CustomerRecords();

Map<String, Customer> myCustomers =
    records.getCustomers();

myCustomers.clear();
```

How GC works?

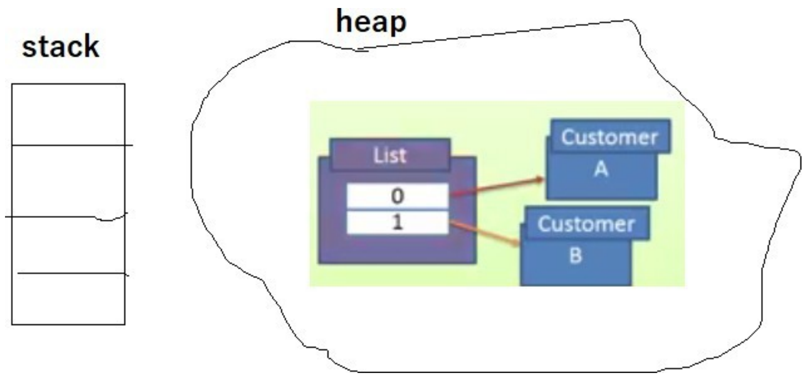
For C/C++ programmer must write code to indicate freeing memory.
If memory leak only solution is to restart system, what if it is web server?
Eventually system crash
Finding memory leak is very difficult
Java avoid memory leak by :

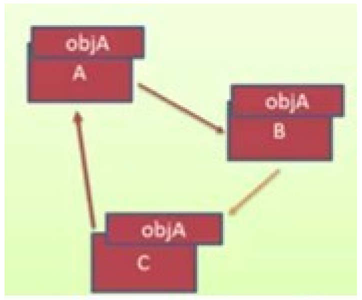
1. Memory is not acquire from OS directly as happens in C/C++,
   Memory provided by JVM and OS level memroy leak is not a possibility in java

2. Java provide GC

How GC come to know an object is candidate of GC?

Any object on the heap which can not be reached through a reference from the stack is "eligible for GC"





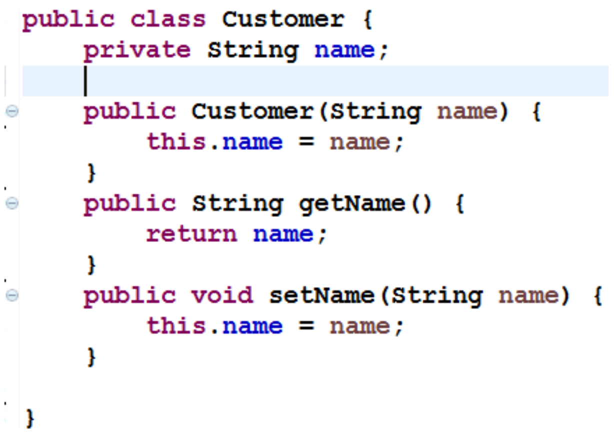
circular ref

what about System.gc()

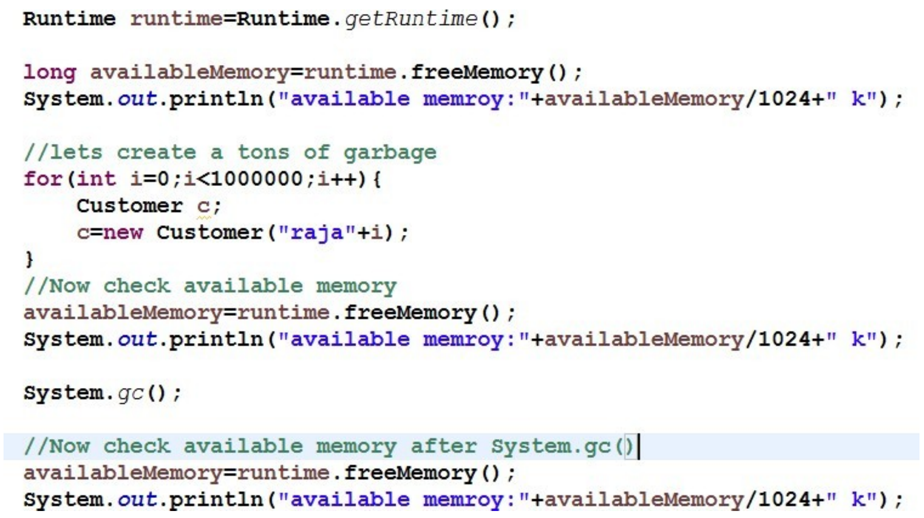
About System.gc() ?

System.gc()?

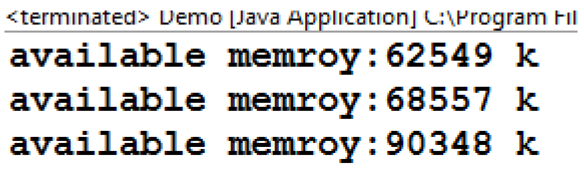
Can not say when when GC will run,even GC may not run at all after calling System.gc()
When GC run application is suspended, till GC process is not complete, therefor calling GC is not good idea
When GC remove an object, finilize() method is called.
finilize is not reliable



```
public class Customer {
    private String name;
    
    public Customer(String name) {
        this.name = name;
    }
    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }

}
```



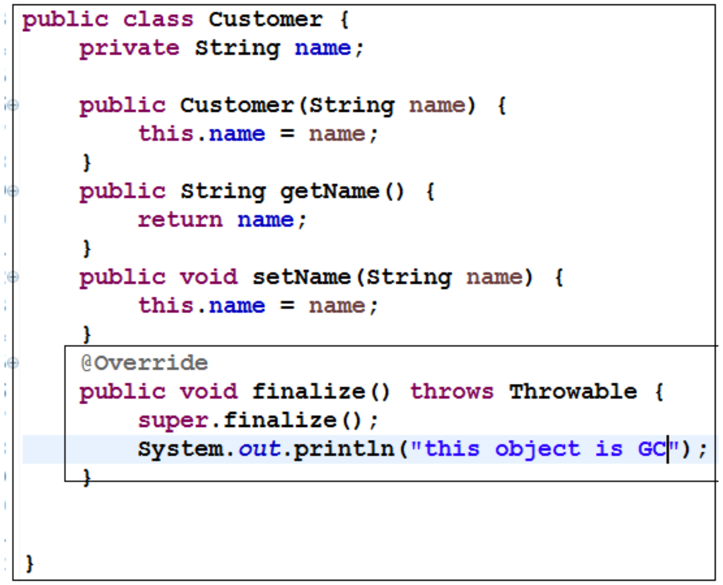
```
Runtime runtime=Runtime.getRuntime();

long availableMemory=runtime.freeMemory();
System.out.println("available memroy:"+availableMemory/1024+" k");

//lets create a tons of garbage
for(int i=0;i<1000000;i++){
    Customer c;
    c=new Customer("raja"+i);
}
//Now check available memory
availableMemory=runtime.freeMemory();
System.out.println("available memroy:"+availableMemory/1024+" k");

System.gc();

//Now check available memory after System.gc()
availableMemory=runtime.freeMemory();
System.out.println("available memroy:"+availableMemory/1024+" k");
```



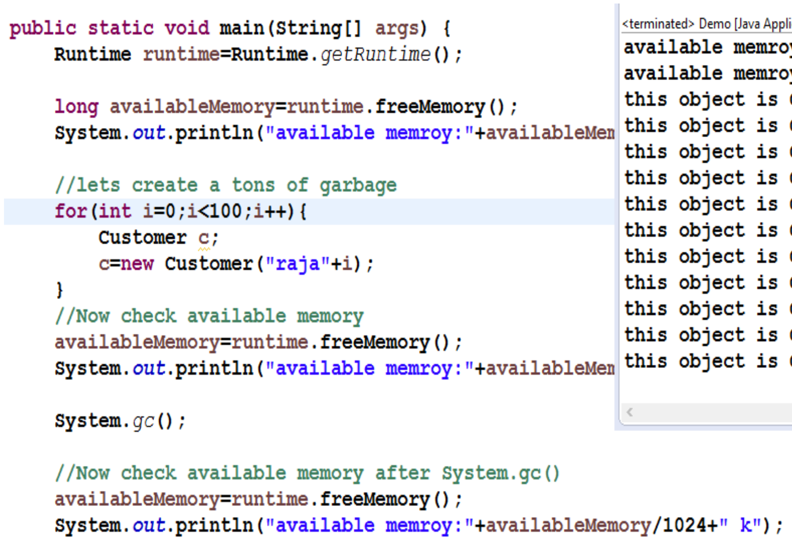
```
<terminated> Demo [Java Application] C:\Program Fil
available memroy:62549 k
available memroy:68557 k
available memroy:90348 k
```

Effect of finalize() method

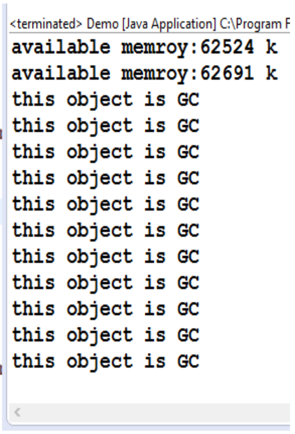
- Java run finalized when GC remove an object from heap, but it is not guaranteed. Don't trust on this method
- When below code is run, finalized() is called 10 time not 100 time.\
- GC don't run just because we call it, the purpose of GC is to keep Heap nice and clear himself.



```
public class Customer {
    private String name;

    public Customer(String name) {
        this.name = name;
    }
    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
    @Override
    public void finalize() throws Throwable {
        super.finalize();
        System.out.println("this object is GC");
    }

}
```



```
public static void main(String[] args) {
    Runtime runtime=Runtime.getRuntime();

    long availableMemory=runtime.freeMemory();
    System.out.println("available memroy:"+availableMem

    //lets create a tons of garbage
    for(int i=0;i<100;i++){
        Customer c;
        c=new Customer("raja"+i);
    }
    //Now check available memory
    availableMemory=runtime.freeMemory();
    System.out.println("available memroy:"+availableMem

    System.gc();

    //Now check available memory after System.gc()
    availableMemory=runtime.freeMemory();
    System.out.println("available memroy:"+availableMemory/1024+" k");
```



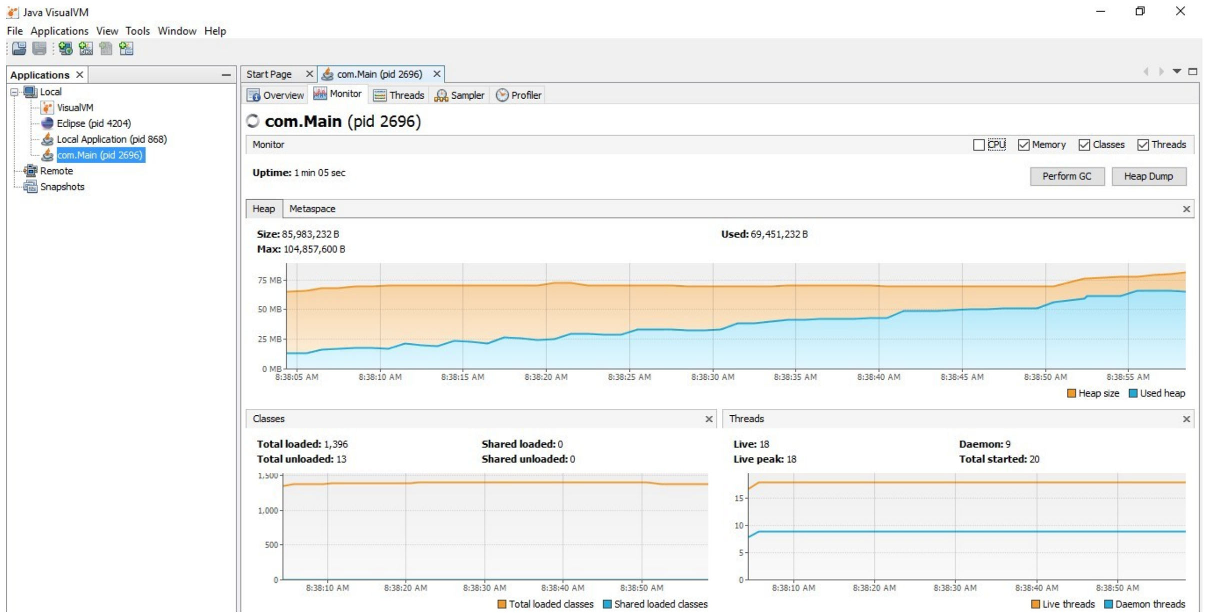
```
<terminated> Demo [Java Application] C:\Program F
available memroy:62524 k
available memroy:62691 k
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
this object is GC
```

Garbage Eligibility

- Java avoid memory leak by
  - Runtime on a VM (avoid so level memory leak)
  - Adopts a garbage collector strategy
- – Soft link an object is reference on the stack even though it is not going to be used again.

Running Java visual VM to analysis application with leak

- Application with soft leak almost consume all the heap and (40 out of 50Mb). Why some of the memory 10mb can not be used.
- Increasing heap size is not the solution.



com.Main (pid 2696)

Uptime: 1 min 05 sec

Heap

Size: 85,983,232 B
Max: 104,857,600 B
Used: 69,451,232 B

Classes

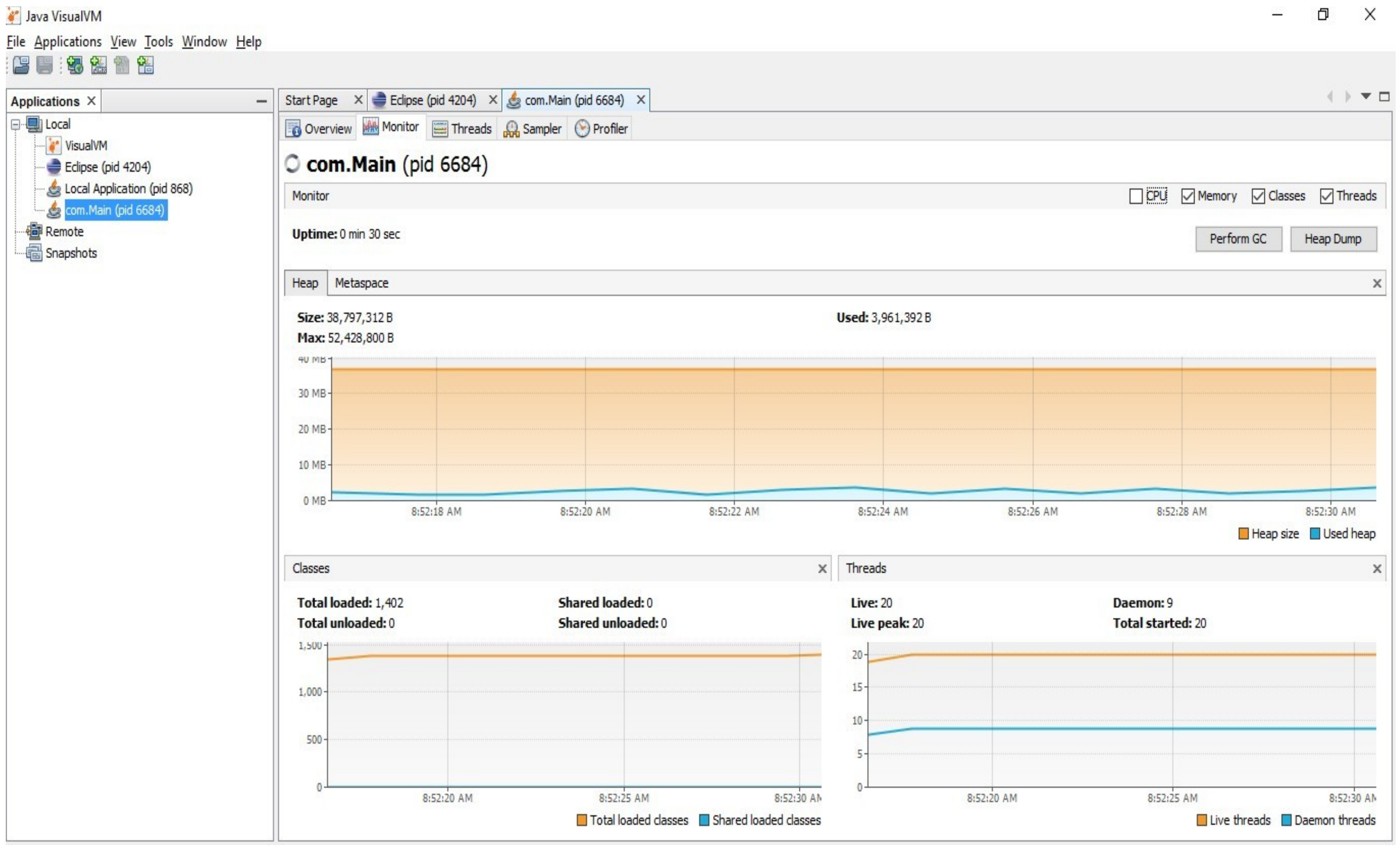
Total loaded: 1,396
Total unloaded: 13
Shared loaded: 0
Shared unloaded: 0

Threads

Live: 18
Live peak: 18
Daemon: 9
Total started: 20

Running Java visual VM to analysis application with leak

- After solving leak issue



com.Main (pid 6684)

Monitor

Uptime: 0 min 30 sec

Heap

Size: 38,797,312 B
Max: 52,428,800 B
Used: 3,961,392 B

Classes

Total loaded: 1,402
Total unloaded: 0
Shared loaded: 0
Shared unloaded: 0

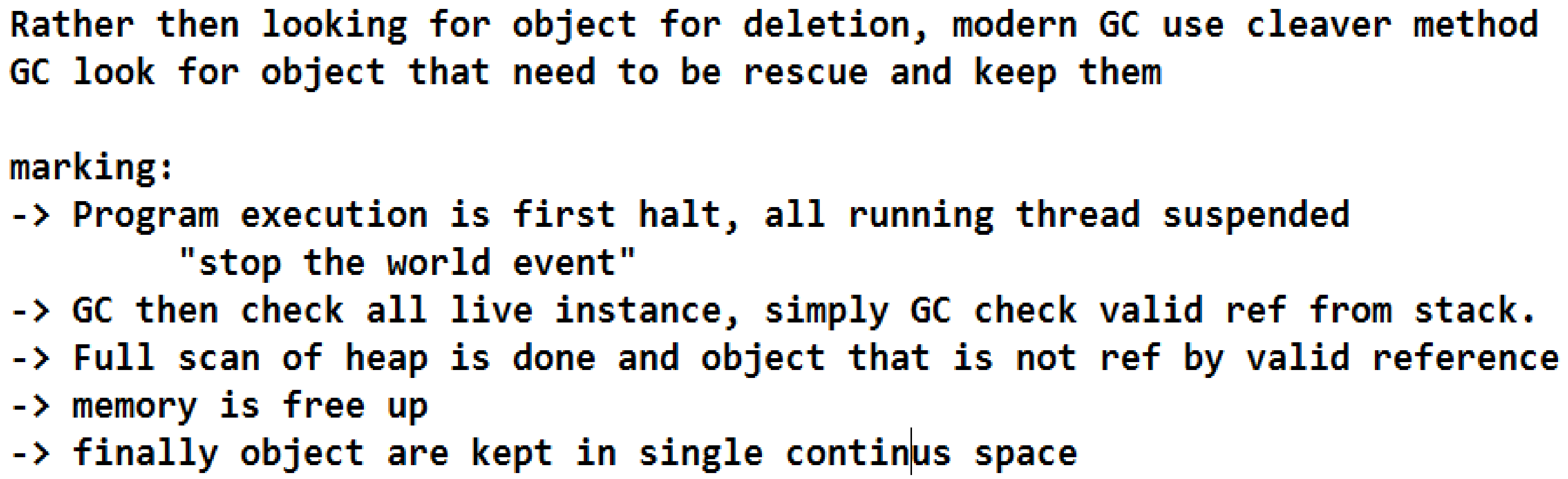
Threads

Live: 20
Live peak: 20
Daemon: 9
Total started: 20

rgupta.mtech@gmail.com

Algorithm GC used?

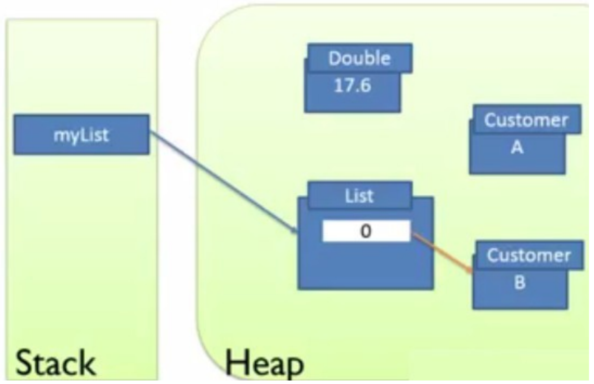
- **Mark and swap methodology**



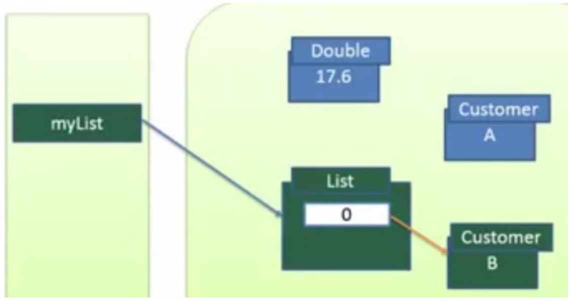
```
Rather then looking for object for deletion, modern GC use cleaver method
GC look for object that need to be rescue and keep them

marking:
-> Program execution is first halt, all running thread suspended
        "stop the world event"
-> GC then check all live instance, simply GC check valid ref from stack.
-> Full scan of heap is done and object that is not ref by valid reference
-> memory is free up
-> finally object are kept in single continus space
```

Mark and swap methodology

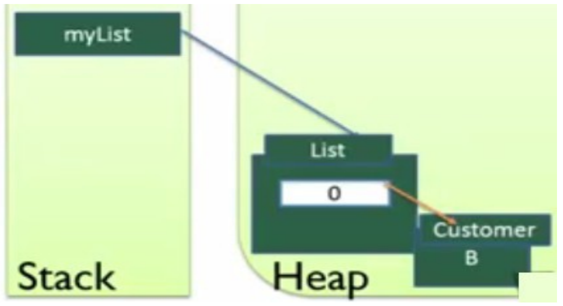
- Step 1: full scan of heap is done



- Step 2: all the valid reference object are marked, and unused objects are swept

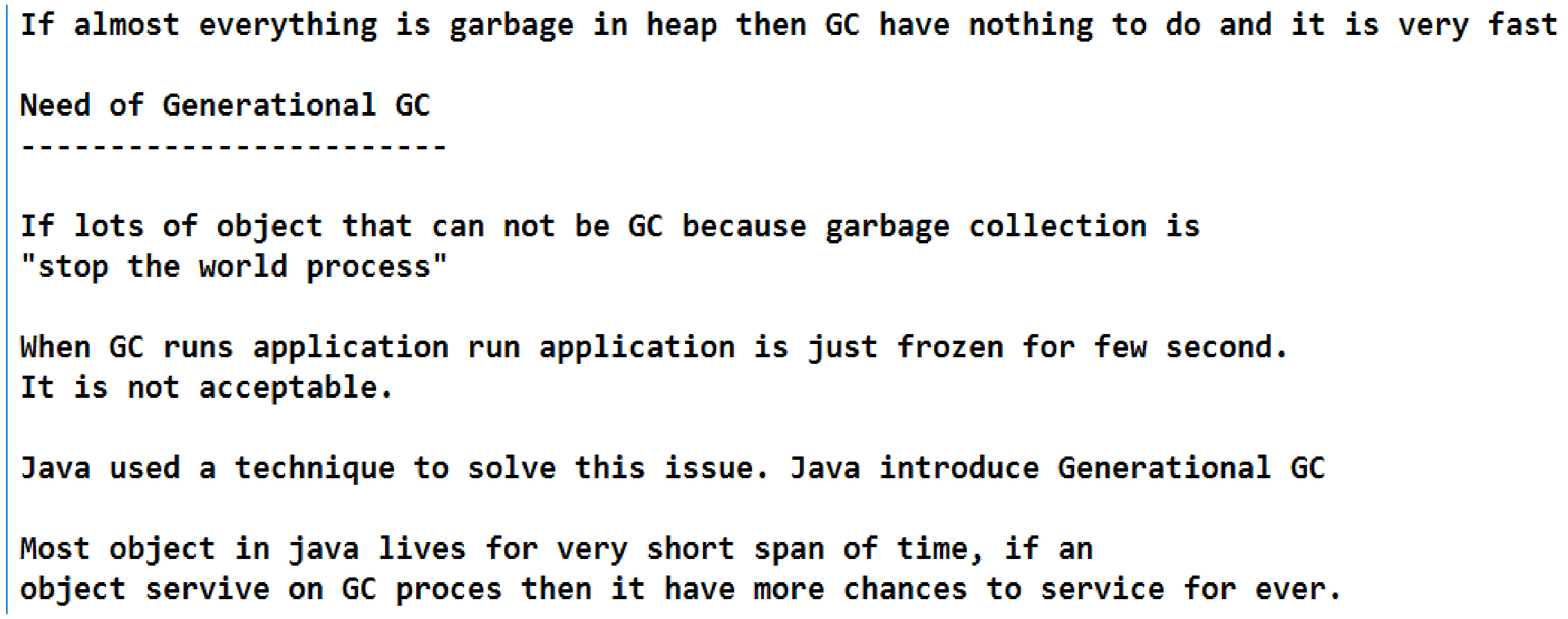


- Step 3: reshuffling of objects in continuous memory



Generational GC

- Generation is way to organized heap



If almost everything is garbage in heap then GC have nothing to do and it is very fast

Need of Generational GC

If lots of object that can not be GC because garbage collection is
"stop the world process"

When GC runs application run application is just frozen for few second.
It is not acceptable.

Java used a technique to solve this issue. Java introduce Generational GC

Most object in java lives for very short span of time, if an
object servive on GC proces then it have more chances to service for ever.

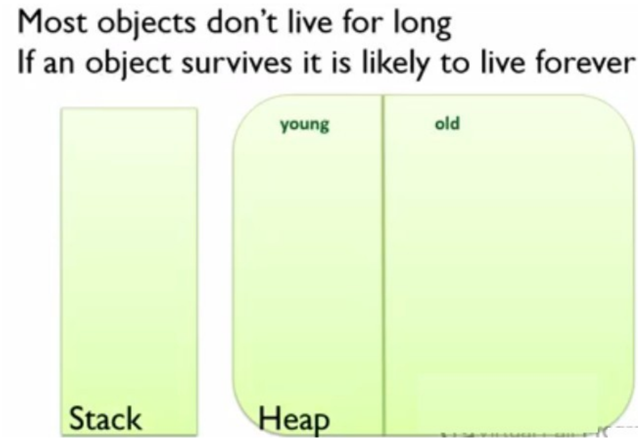
Generational GC

new object created in young generation space, fill fast,
GC collection work on young generation and it is very quick process, fraction of second
application don't freeze.
=> GC that run on new generation is called "minor GC"

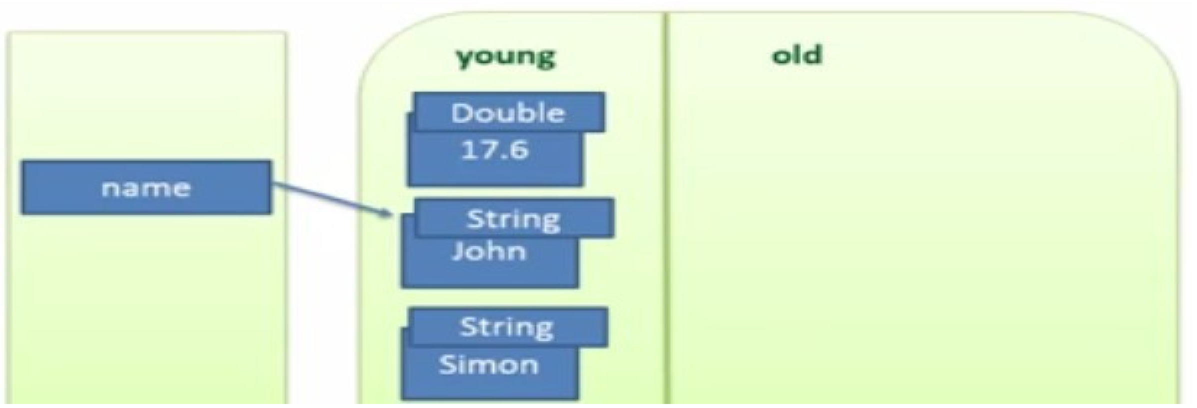
All surviving object moved to old generation

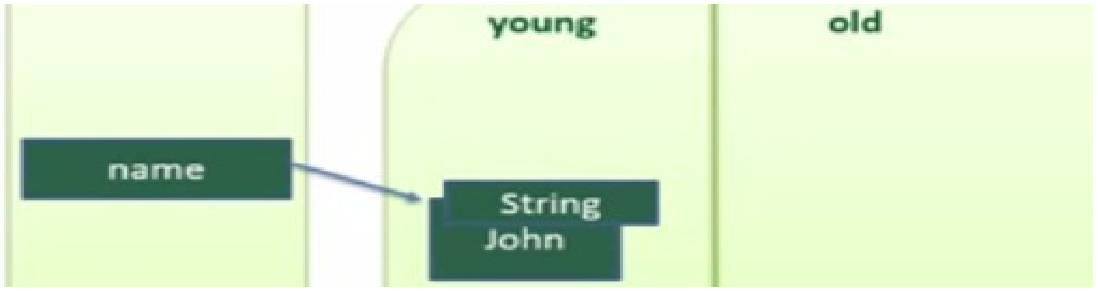
=> GC also run on old generation only if it needed, if old generation heap is filled
=> GC for old generation is called "major collection " and it is slower as compared to minor GC
  as it have bigger memory area to sweep and most of the object in this memory are required to be
  alive

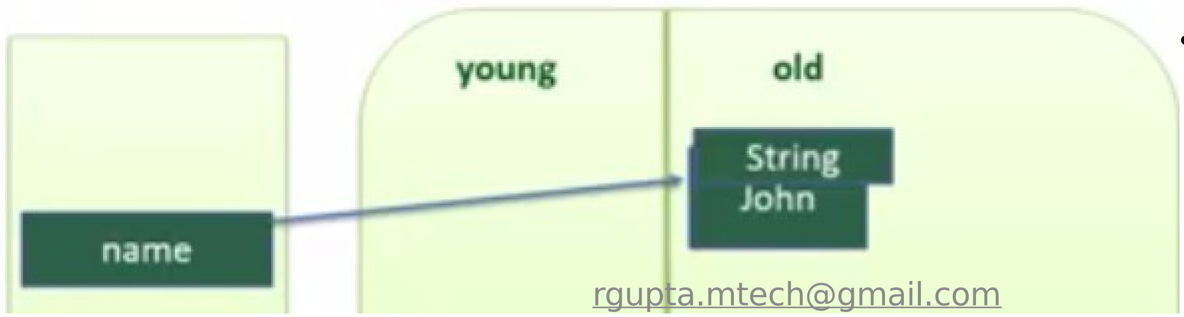
=> compacting process also takes some time
=> major generation takes some seconds as compared to fraction of seconds in case of young generation


Most objects don't live for long
If an object survives it is likely to live forever

Generational GC



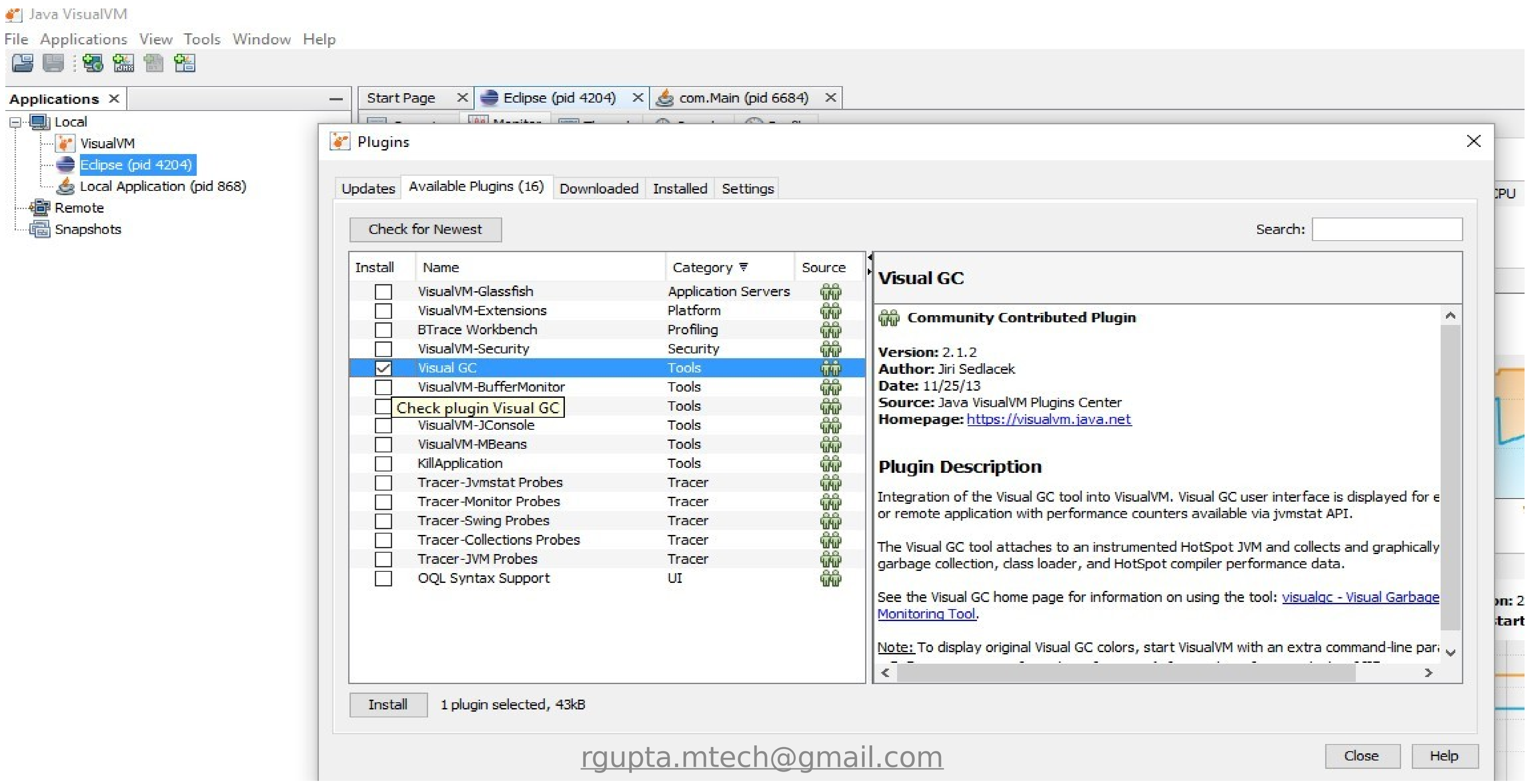




- Object that survive first go process moved to old generation

Study generation of GC

- To study generation of GC we need to install a plug-in in java VisualVM tool that is called Visual GC



Java VisualVM

File Applications View Tools Window Help

Applications | Start Page | Eclipse (pid 4204) | com.Main (pid 6684)

- Local
  - VisualVM
  - Eclipse (pid 4204)
  - Local Application (pid 868)
- Remote
- Snapshots

Plugins

Updates | Available Plugins (16) | Downloaded | Installed | Settings

Check for Newest   Search:

Install	Name	Category	Source
☐	VisualVM-Glassfish	Application Servers	
☐	VisualVM-Extensions	Platform	
☐	BTrace Workbench	Profiling	
☐	VisualVM-Security	Security	
☑	Visual GC	Tools	
☐	VisualVM-BufferMonitor	Tools	
☐	Check plugin Visual GC	Tools	
☐	VisualVM-JConsole	Tools	
☐	VisualVM-MBeans	Tools	
☐	KillApplication	Tools	
☐	Tracer-Jvmstat Probes	Tracer	
☐	Tracer-Monitor Probes	Tracer	
☐	Tracer-Swing Probes	Tracer	
☐	Tracer-Collections Probes	Tracer	
☐	Tracer-JVM Probes	Tracer	
☐	OQL Syntax Support	UI	

Visual GC

Community Contributed Plugin

Version: 2.1.2
Author: Jiri Sedlacek
Date: 11/25/13
Source: Java VisualVM Plugins Center
Homepage: https://visualvm.java.net

Plugin Description

Integration of the Visual GC tool into VisualVM. Visual GC user interface is displayed for e
or remote application with performance counters available via jvmstat API.

The Visual GC tool attaches to an instrumented HotSpot JVM and collects and graphically
garbage collection, class loader, and HotSpot compiler performance data.

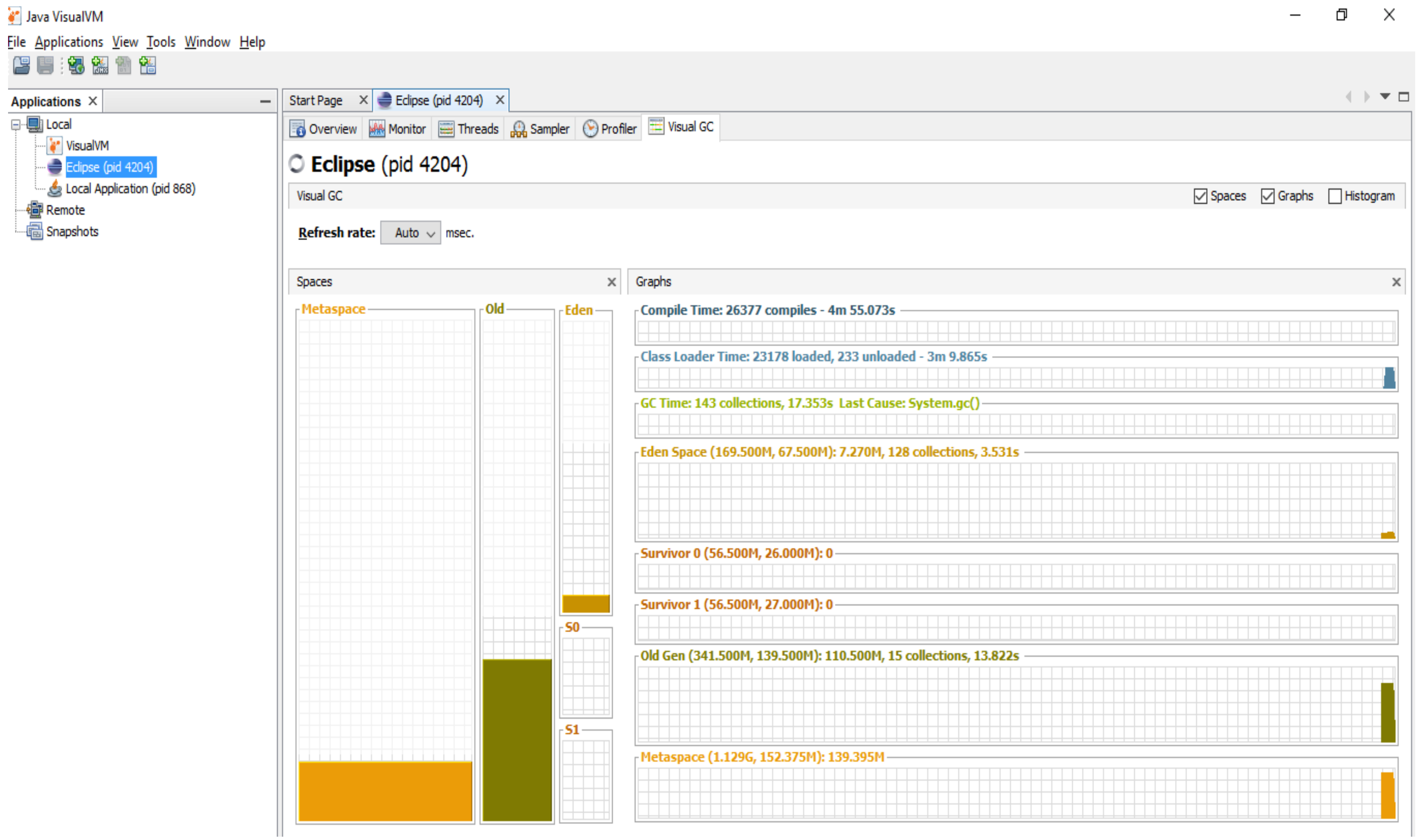
See the Visual GC home page for information on using the tool: visualgc - Visual Garbage Monitoring Tool.

Note: To display original Visual GC colors, start VisualVM with an extra command-line par

Install   1 plugin selected, 43kB

Close   Help

Study generation of GC



Java VisualVM

File Applications View Tools Window Help

Applications

- Local
  - VisualVM
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  - Local Application (pid 868)
- Remote
- Snapshots

Start Page | Eclipse (pid 4204)

Overview | Monitor | Threads | Sampler | Profiler | Visual GC

Eclipse (pid 4204)

Visual GC [✓ Spaces] [✓ Graphs] [ ] Histogram

Refresh rate: Auto msec.

Spaces

Graphs

Compile Time: 26377 compiles - 4m 55.073s

Class Loader Time: 23178 loaded, 233 unloaded - 3m 9.865s

GC Time: 143 collections, 17.353s Last Cause: System.gc()

Eden Space (169.500M, 67.500M): 7.270M, 128 collections, 3.531s

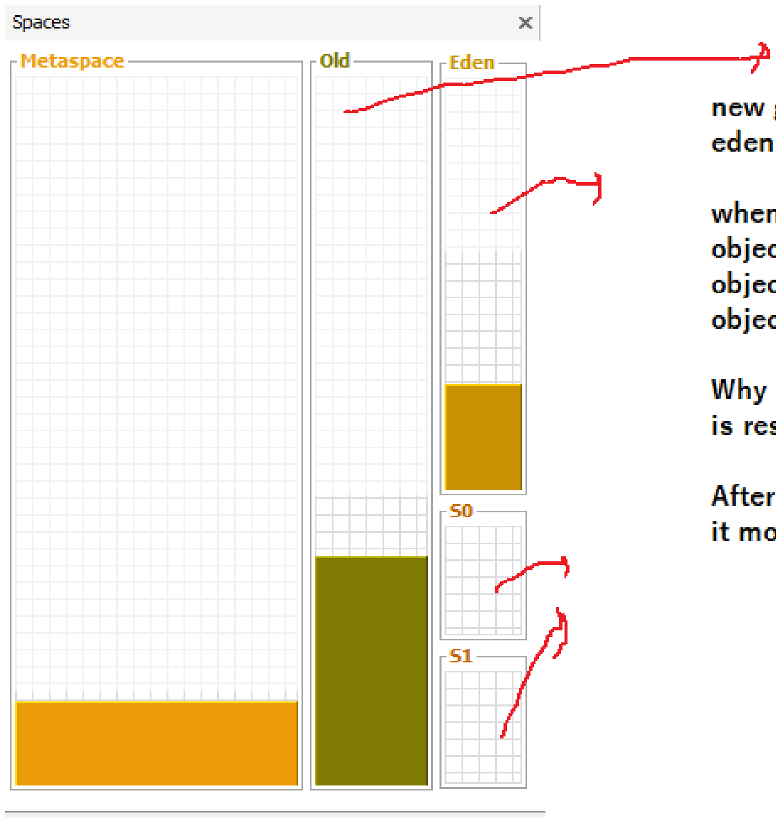
Survivor 0 (56.500M, 26.000M): 0

Survivor 1 (56.500M, 27.000M): 0

Old Gen (341.500M, 139.500M): 110.500M, 15 collections, 13.822s

Metaspace (1.129G, 152.375M): 139.395M

Study generation of GC



new generation is divided into 3 area:
eden, s0 and s1 (serviver space)

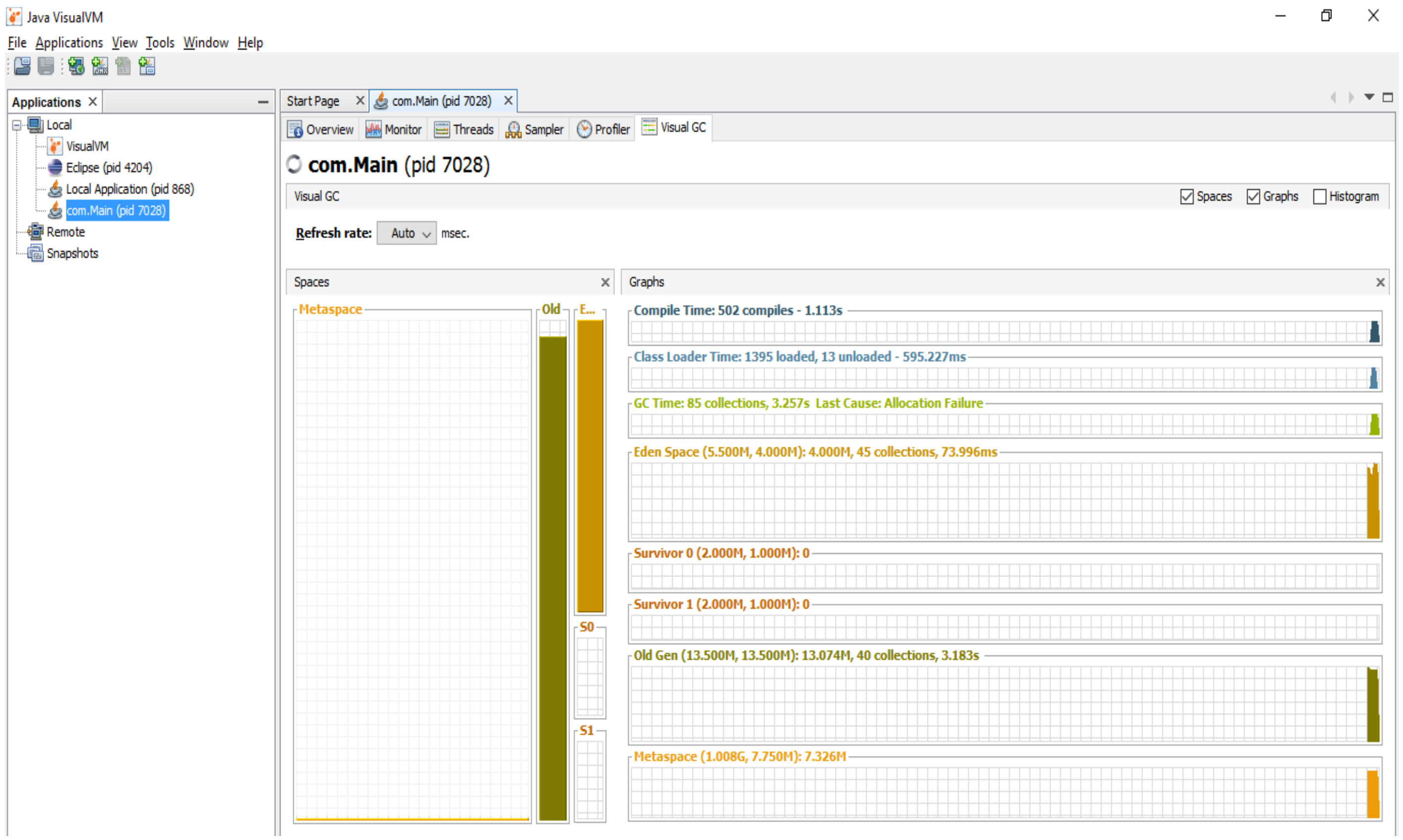
when eden is full, GC process happens
object that service moved to s0, next time GC happen any object are moved to s1. Compacking process can put all object in s1 and s0 become empty.

Why 10Mb is not used in last example. As some memory is reserved for s0 and s1.

After an object servive 8 GC porcess as explain above then it moved to old generation.

Study generation of GC for broken code

- Application is just going to crash Memory leak



com.Main (pid 7028)

Refresh rate: Auto msec.

Compile Time: 502 compiles - 1.113s

Class Loader Time: 1395 loaded, 13 unloaded - 595.227ms

GC Time: 85 collections, 3.257s Last Cause: Allocation Failure

Eden Space (5.500M, 4.000M): 4.000M, 45 collections, 73.996ms

Survivor 0 (2.000M, 1.000M): 0

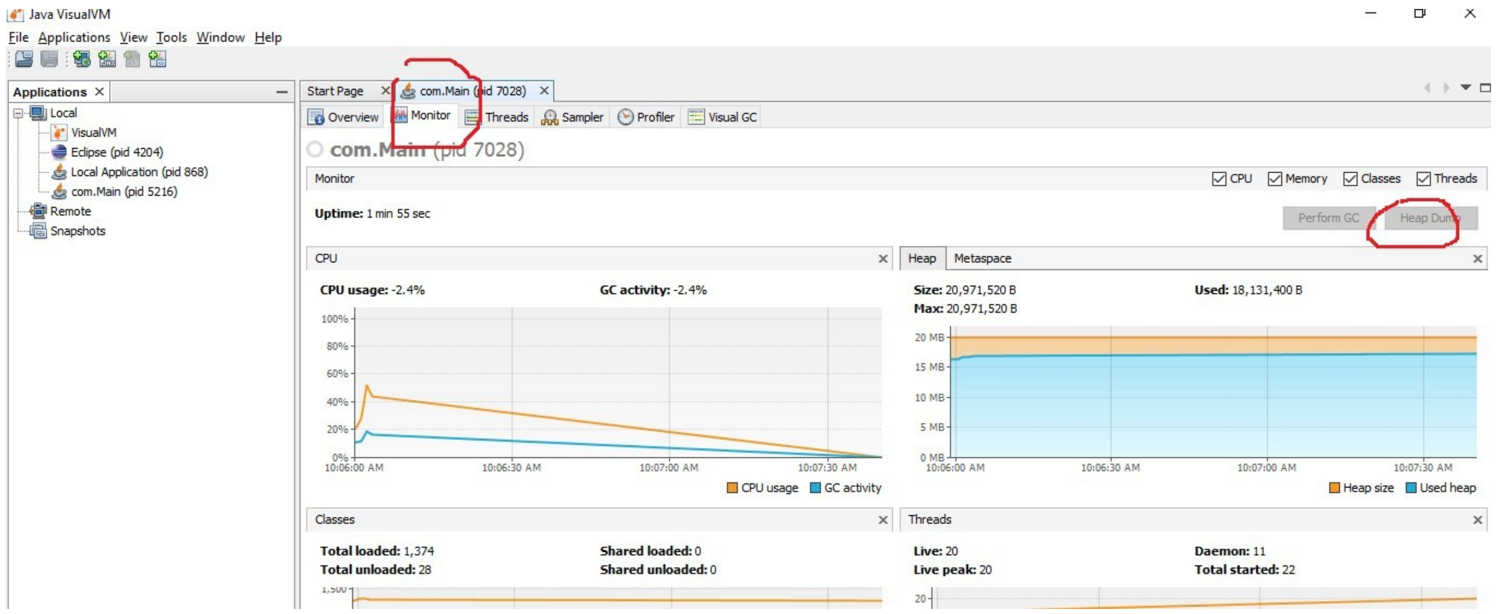
Survivor 1 (2.000M, 1.000M): 0

Old Gen (13.500M, 13.500M): 13.074M, 40 collections, 3.183s

Metaspace (1.008G, 7.750M): 7.326M

Heap dump analysis

- Heap dump analysis is the technique to understand what cause memory leak in our application.
- Click on monitor tab and Heap dump



Uptime: 1 min 55 sec

CPU usage: -2.4%   GC activity: -2.4%

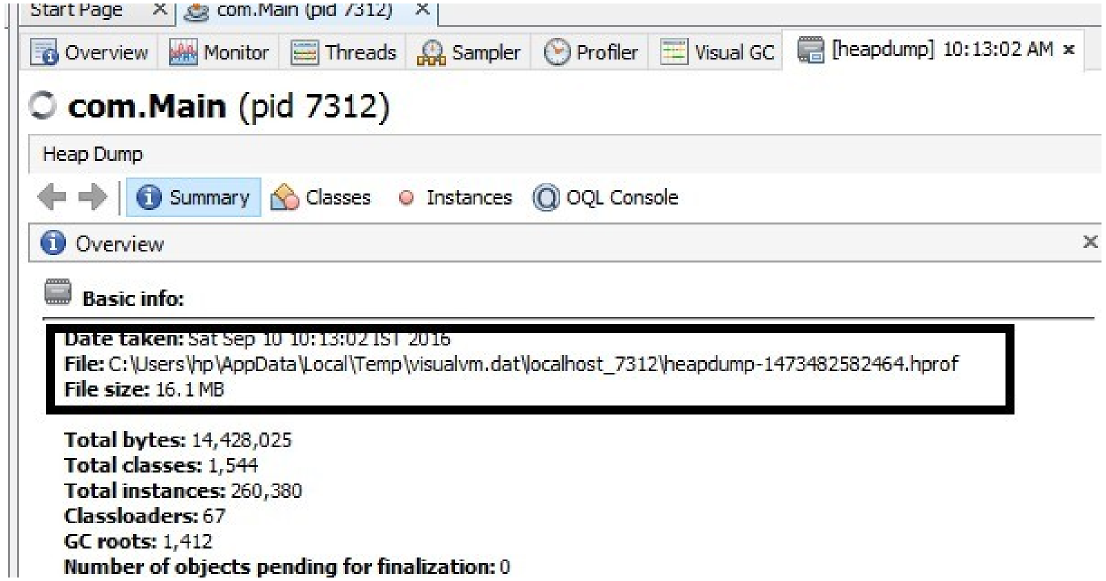
Size: 20,971,520 B   Used: 18,131,400 B
Max: 20,971,520 B

Total loaded: 1,374   Shared loaded: 0
Total unloaded: 28   Shared unloaded: 0

Live: 20   Daemon: 11
Live peak: 20   Total started: 22

Heap dump analysis

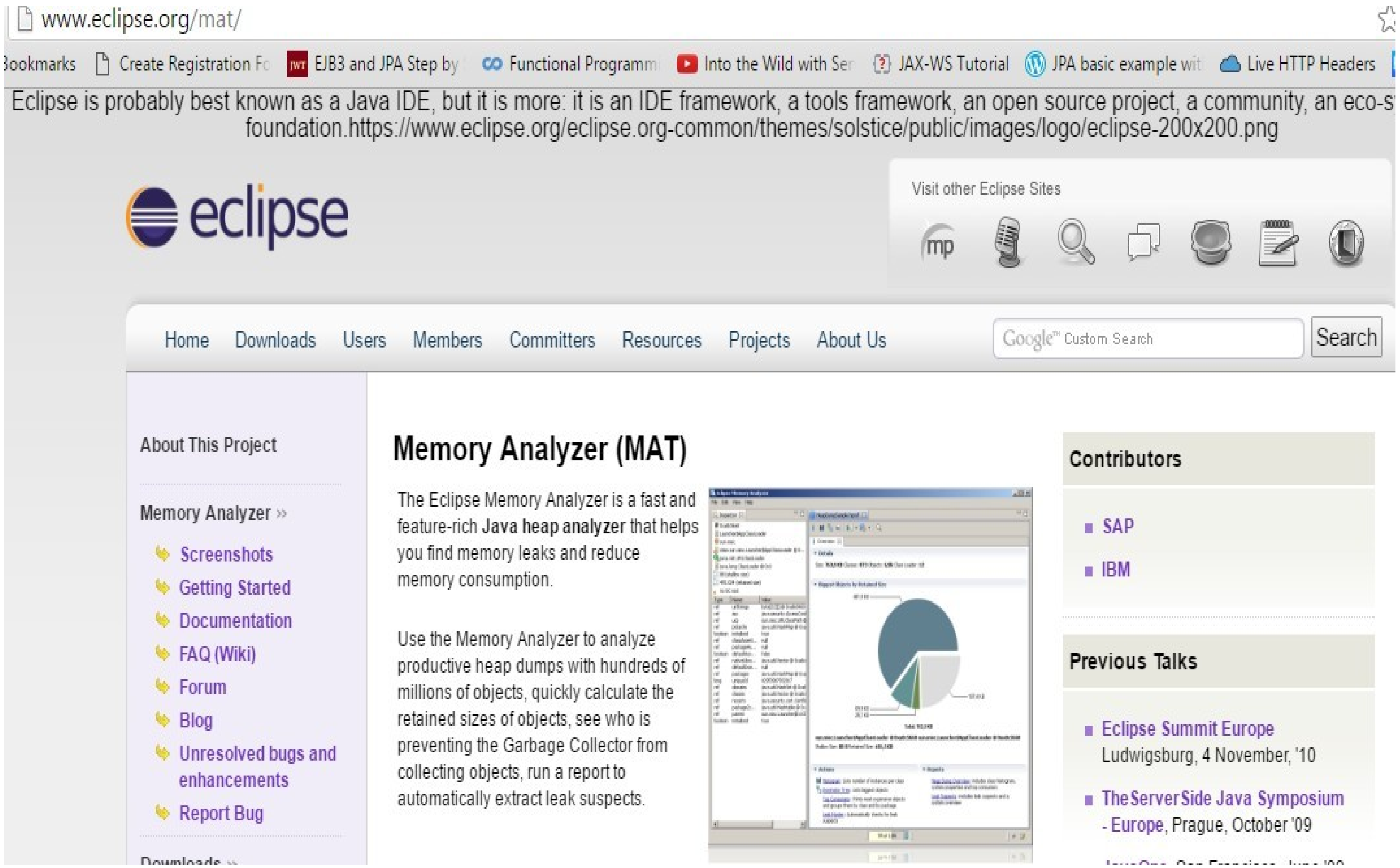
- Copy the location of file and save it.
- Tool to analysis heap dump is called Memory analyzer (MAT), download and install it.



Date taken: Sat Sep 10 10:13:02 IST 2016
File: C:\Users\hp\AppData\Local\Temp\visualvm.dat\localhost_7312\heapdump-1473482582464.hprof
File size: 16.1 MB

Total bytes: 14,428,025
Total classes: 1,544
Total instances: 260,380
Classloaders: 67
GC roots: 1,412
Number of objects pending for finalization: 0

Memory analyzer tool



www.eclipse.org/mat/

Bookmarks | Create Registration Fo | EJB3 and JPA Step by | Functional Programm | Into the Wild with Ser | JAX-WS Tutorial | JPA basic example wit | Live HTTP Headers

Eclipse is probably best known as a Java IDE, but it is more: it is an IDE framework, a tools framework, an open source project, a community, an eco-s
foundation.https://www.eclipse.org/eclipse.org-common/themes/solstice/public/images/logo/eclipse-200x200.png

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About This Project

Memory Analyzer »

- Screenshots
- Getting Started
- Documentation
- FAQ (Wiki)
- Forum
- Blog
- Unresolved bugs and enhancements
- Report Bug

Downloads »

Memory Analyzer (MAT)

The Eclipse Memory Analyzer is a fast and feature-rich **Java heap analyzer** that helps you find memory leaks and reduce memory consumption.

Use the Memory Analyzer to analyze productive heap dumps with hundreds of millions of objects, quickly calculate the retained sizes of objects, see who is preventing the Garbage Collector from collecting objects, run a report to automatically extract leak suspects.

Contributors

- SAP
- IBM

Previous Talks

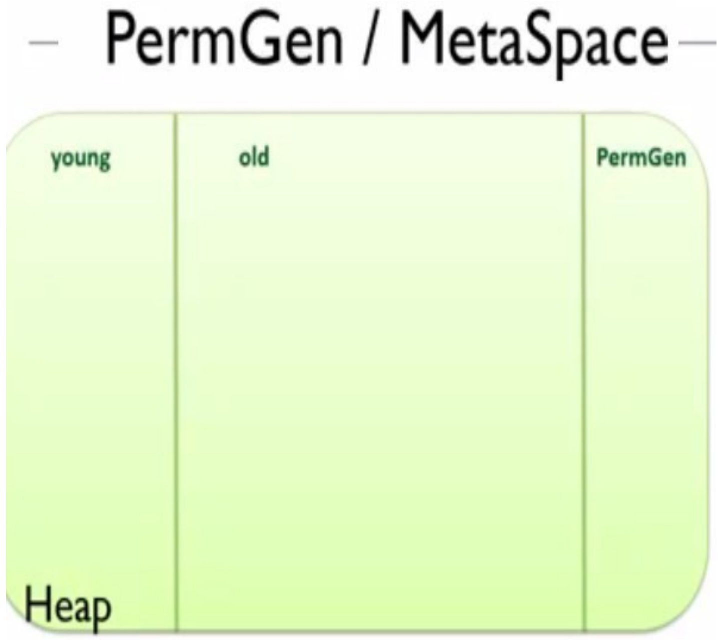
- Eclipse Summit Europe
  Ludwigsburg, 4 November, '10
- TheServerSide Java Symposium - Europe, Prague, October '09

Perm gen space

- Object in permgen never garbage collection
- Two type of object stored in perm gen
  1. Internalized string
- 2. class meta data

- Problem:
- Application crashed due to perm gen error
- Solution:
  - 1. increase perm gen space
  - 2. restart application

- If we reply an application on tomcat, old meta data of application is still there on tomcat!
- On a live a server only solution is to stop and restart the server



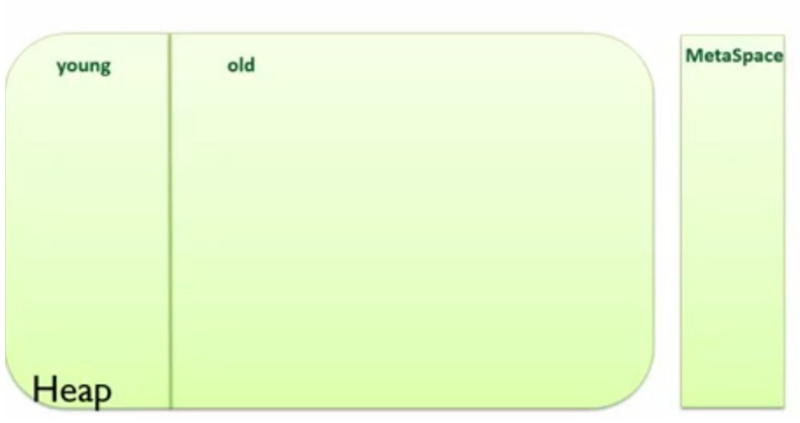
Perm gen space is now removed

In Java 7:

- ❖ Internalised string now stored in old part of heap
- ❖ now it is not contribute to perm gen problem

Java 8:

- ❖ Java remove perm gen totally form architecture
- ❖ replaced meta space with perm gen
- ❖ if we redeploy an application all older meta data is deleted :)
- ❖ Size of meta data can grown to whole memory



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❖ **Execution engine**

Execution engine

- Is the component that is actually involve in converting the byte code to the execution code.
- Lets see how Execution engine is evolved over the time

- **Java 1.0/1.1**

➔ Execution engine started as interpreter, executed one line of code one by one.

➔ Java was so slow10-13 time slower then C/C++.

➔ If we have while loop 100 time same instruction are going to execute 100 times.

- **Java 1.2**
  - Execution engine improved to use JIT
  - what happen with JIT?

  Sun provided cache with execution engine. so what ever code is going to be compiled is going to be put in cache. some improvement over Java 1.1

  - Problem?
  - limited cache

Execution engine over the year

- Java 1.3
  - JIT is replaced by hotspot JVM
  - Here with the hotspot jvm , with the help of some algorithm execution engine can determine critical path of the code ,that much code is going to be place in the cache.

- Now more and more improved hotspot JVM JRockit

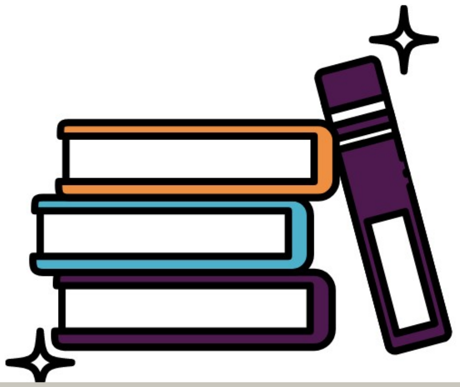
- **Just-in-time Compiler (JIT)**

  – JIT is the part of the Java Virtual Machine (JVM) that is used to speed up the execution time.

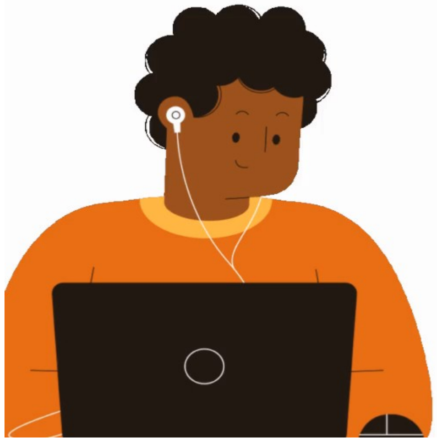
  JIT compiles parts of the byte code that have similar functionality at the same time, and hence reduces the amount of time needed for compilation.

  Here the term “compiler” refers to a translator from the instruction set of a Java virtual machine (JVM) to the instruction set of a specific CPU

Any questions?



thank you



you're doing great!