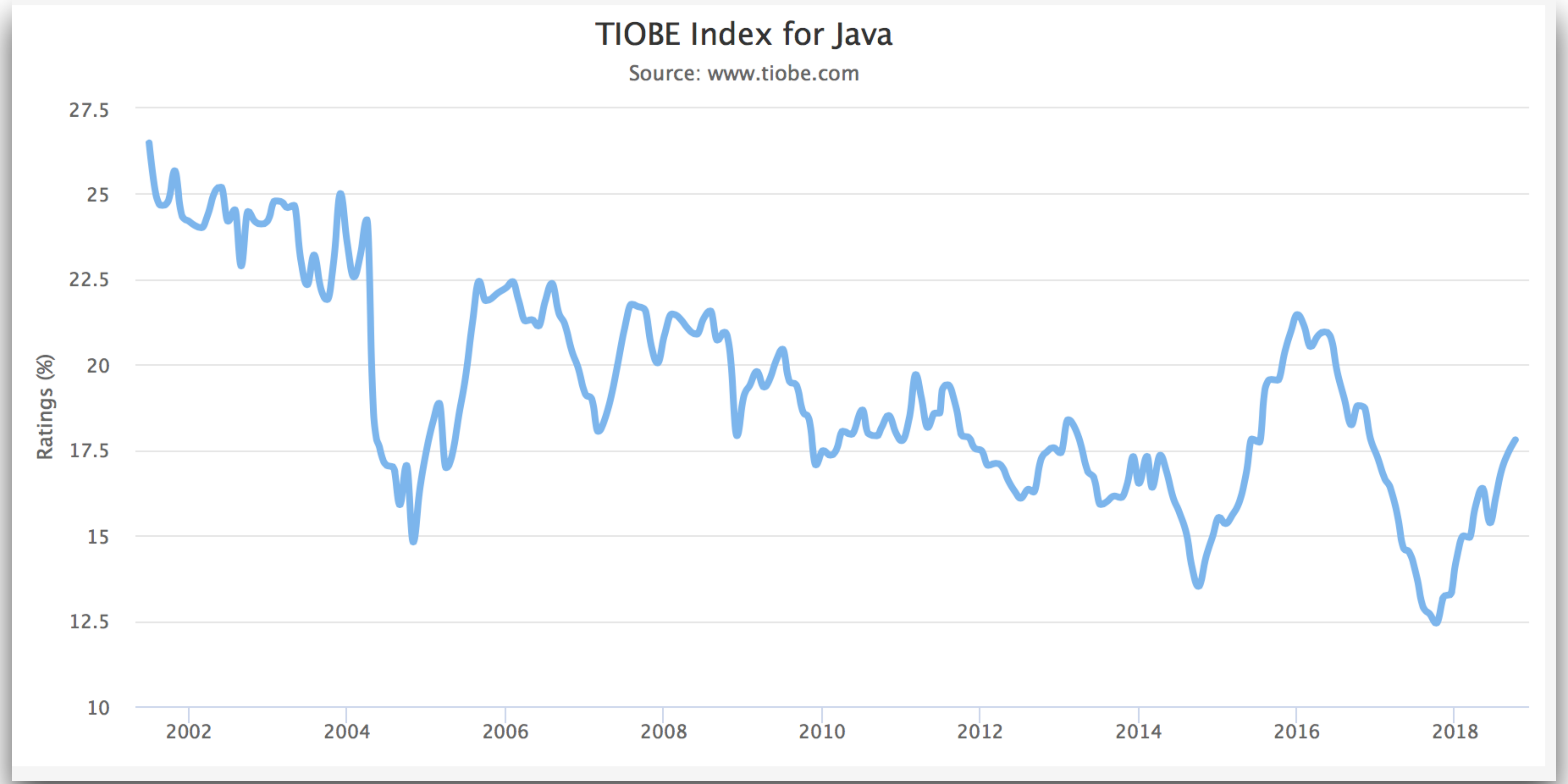
Föreläsning 16

Andreina Francisco
(based on slides by Tobias Wrigstad)

Imperativ och ***objekt-orienterad*** *programmering*

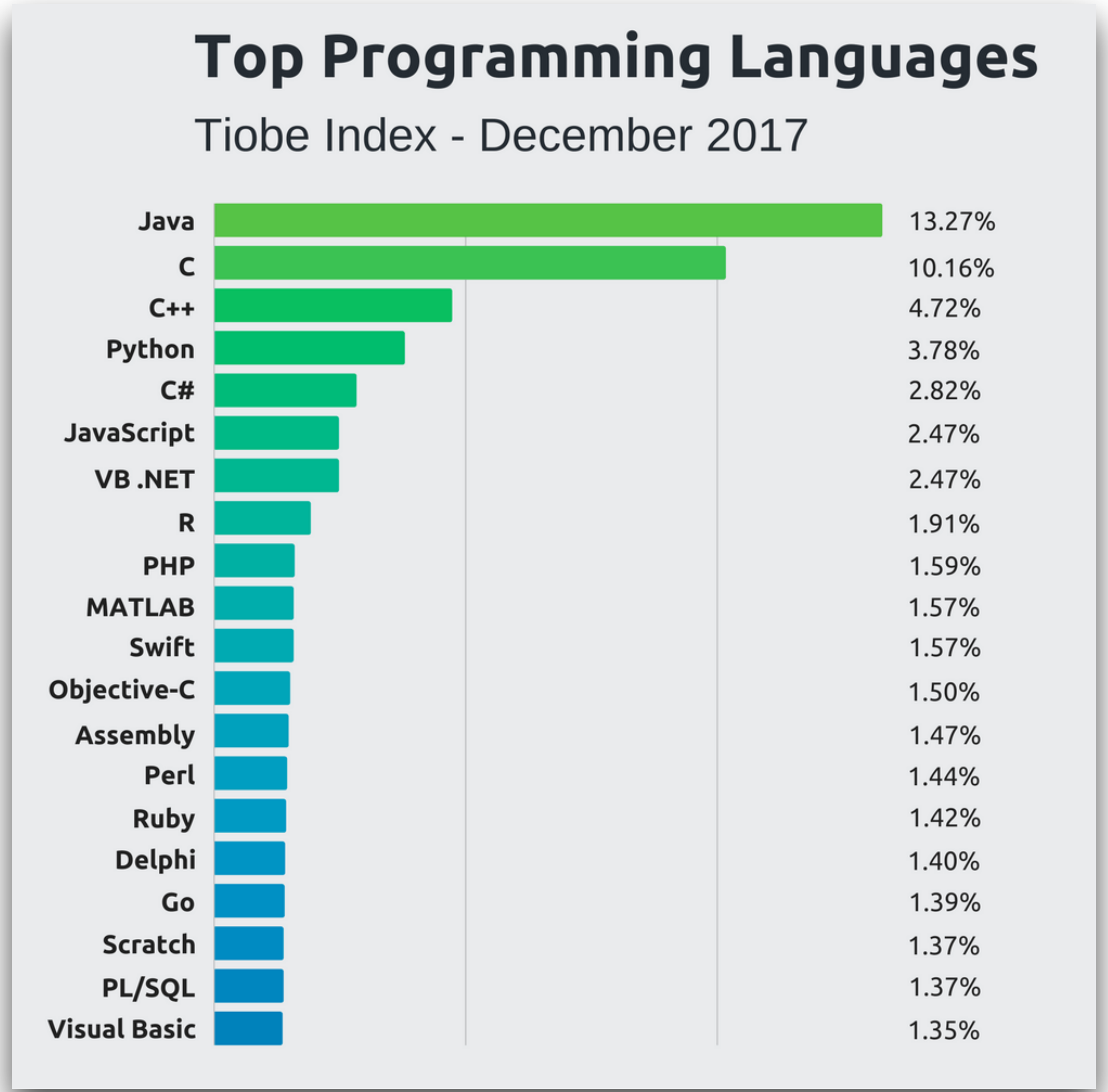
Who uses Java?



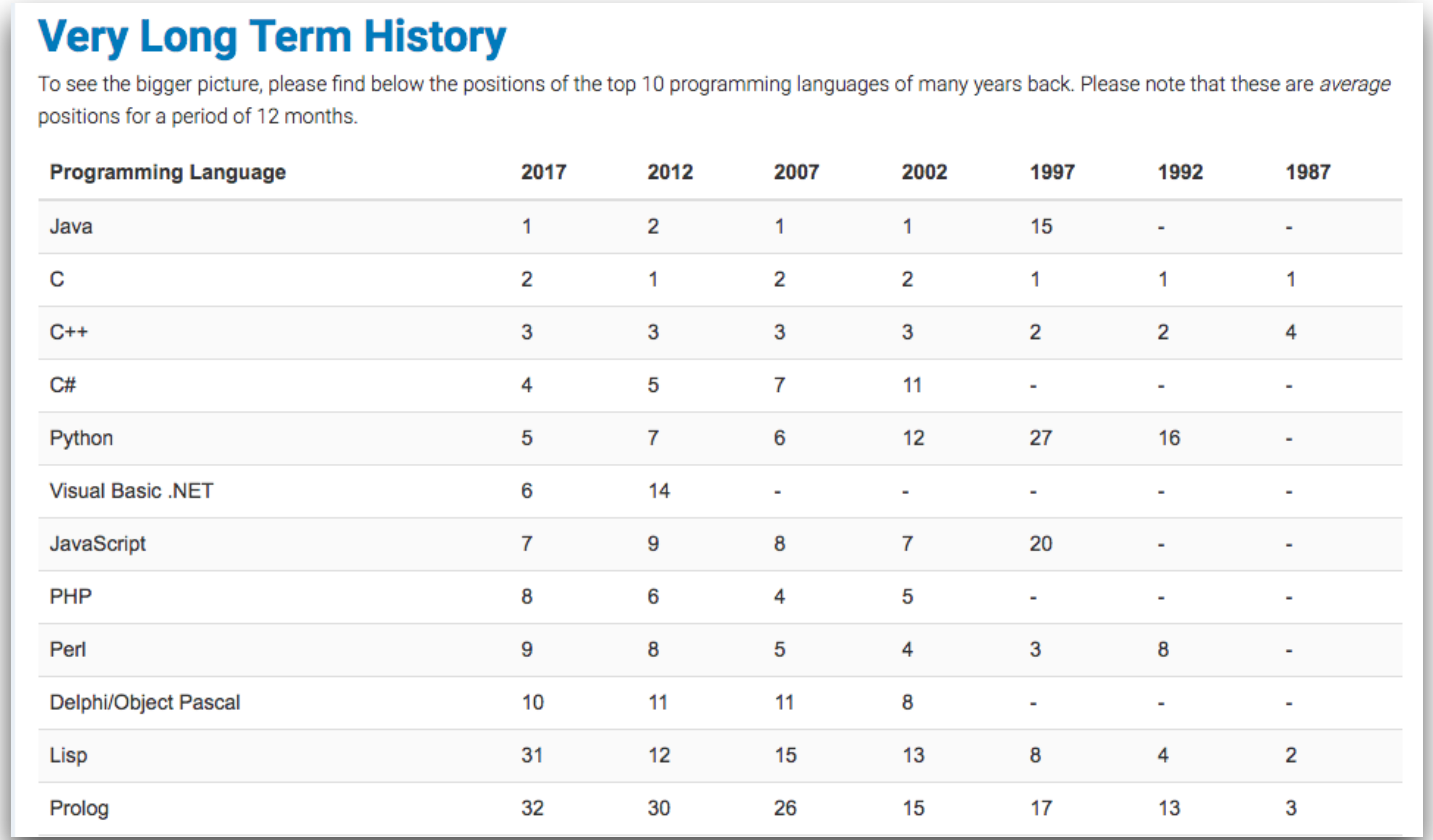
Highest Position (since 2001): #1 in Oct 2018

Lowest Position (since 2001): #2 in Mar 2015

Källa: Tiobe


Top Programming Languages
Tiobe Index - December 2017
Java 13.27%
C 10.16%
C++ 4.72%
Python 3.78%
C# 2.82%
JavaScript 2.47%
VB .NET 2.47%
R 1.91%
PHP 1.59%
MATLAB 1.57%
Swift 1.57%
Objective-C 1.50%
Assembly 1.47%
Perl 1.44%
Ruby 1.42%
Delphi 1.40%
Go 1.39%
Scratch 1.37%
PL/SQL 1.37%
Visual Basic 1.35%

Källa: Tiobe



Very Long Term History

To see the bigger picture, please find below the positions of the top 10 programming languages of many years back. Please note that these are *average* positions for a period of 12 months.

Programming Language	2017	2012	2007	2002	1997	1992	1987
Java	1	2	1	1	15	-	-
C	2	1	2	2	1	1	1
C++	3	3	3	3	2	2	4
C#	4	5	7	11	-	-	-
Python	5	7	6	12	27	16	-
Visual Basic .NET	6	14	-	-	-	-	-
JavaScript	7	9	8	7	20	-	-
PHP	8	6	4	5	-	-	-
Perl	9	8	5	4	3	8	-
Delphi/Object Pascal	10	11	11	8	-	-	-
Lisp	31	12	15	13	8	4	2
Prolog	32	30	26	15	17	13	3

Källa: Tiobe

Java is Platform Independent

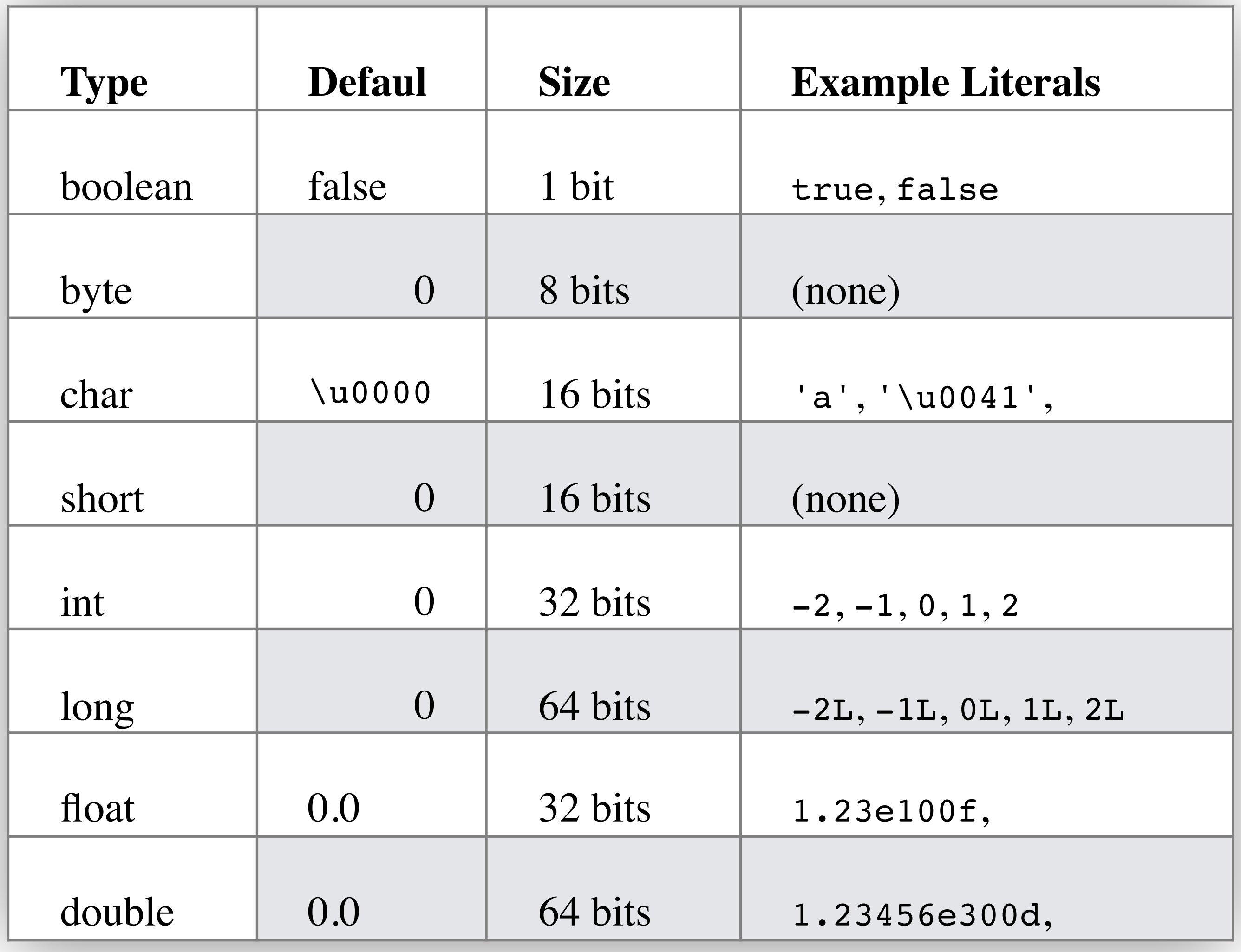
- Data types have a standard size
- All classes in the standard library are available on all machines
- Java's memory model is the same on all machines
- Your program will behave similarly on your friends computer

  You don't even have to recompile the program! — you can move it at once

  Caveat: Interface programs and OS-specific services

  `C:\foo\bar.txt` vs. `/foo/bar.txt`

Java is Platform Independent



Type	Defaul	Size	Example Literals
boolean	false	1 bit	`true, false`
byte	0	8 bits	(none)
char	`\u0000`	16 bits	`'a', '\u0041',`
short	0	16 bits	(none)
int	0	32 bits	`-2, -1, 0, 1, 2`
long	0	64 bits	`-2L, -1L, 0L, 1L, 2L`
float	0.0	32 bits	`1.23e100f,`
double	0.0	64 bits	`1.23456e300d,`

Datatyperna är samma oavsett plattform

Automatic Memory Management

Objects know their size
(but we may not!)

```
new LinkedList();
```

Unreachable objects
are reclaimed

```
/// This program does not leak
LinkedList list = new LinkedList();
for (int i = 0; i < 1000000; ++i) {
    list.add(new Object());
}
list = null;
```

Unused objects
are not…

```
/// This program might "leak"
LinkedList list = new LinkedList();
for (int i = 0; i < 1000000; ++i) {
    list.add(new Object());
}
```

Metadata

- An object knows its origin

```
Object o = new Person();

o instanceof Person // true

Class c = o.getClass();

c.newInstance(); // create a new person
```

- Reflection and introspection

```
Method m = o.getClass().getMethod("setName", String.class);

m.invoke(o, "Barbara")

for (Method m : c.getMethods()) { if (m.startsWith("test")) m.invoke(); }
```

- …and more, e.g., `array.length`

Encapsulation

- Name-based encapsulation controls who can use/name a particular name
- `Node` is just a valid type inside `LinkedList`
- Requires active stance from you!
- The default (no access modifier) is “package” — i.e. accessible everywhere from the module

```
public class Pair {
    private Object fst;
    private Object snd;
    Object getFst() { return this.fst; }
    void setFst(Object o) { this.fst = o; }
}
```

```
public class LinkedList {
    private Node first = new Node();
    private class Node {
        Node next;
        Object element;
        public Node(Object o, Node n) {
            this.element = o;
            this.next = n;
        }
    public void prepend(Object o) {
        this.first =
            new Node(o, this.first);
    }
…
```

The World's Richest Standard Library (?)

- Search for “java 10 api Class Name”
- Generated with JavaDoc based on comments in the source code — (inspiration for D9)
- Included in packages. Most important packages for you:

  `java.lang`

    Basic objects, and system objects

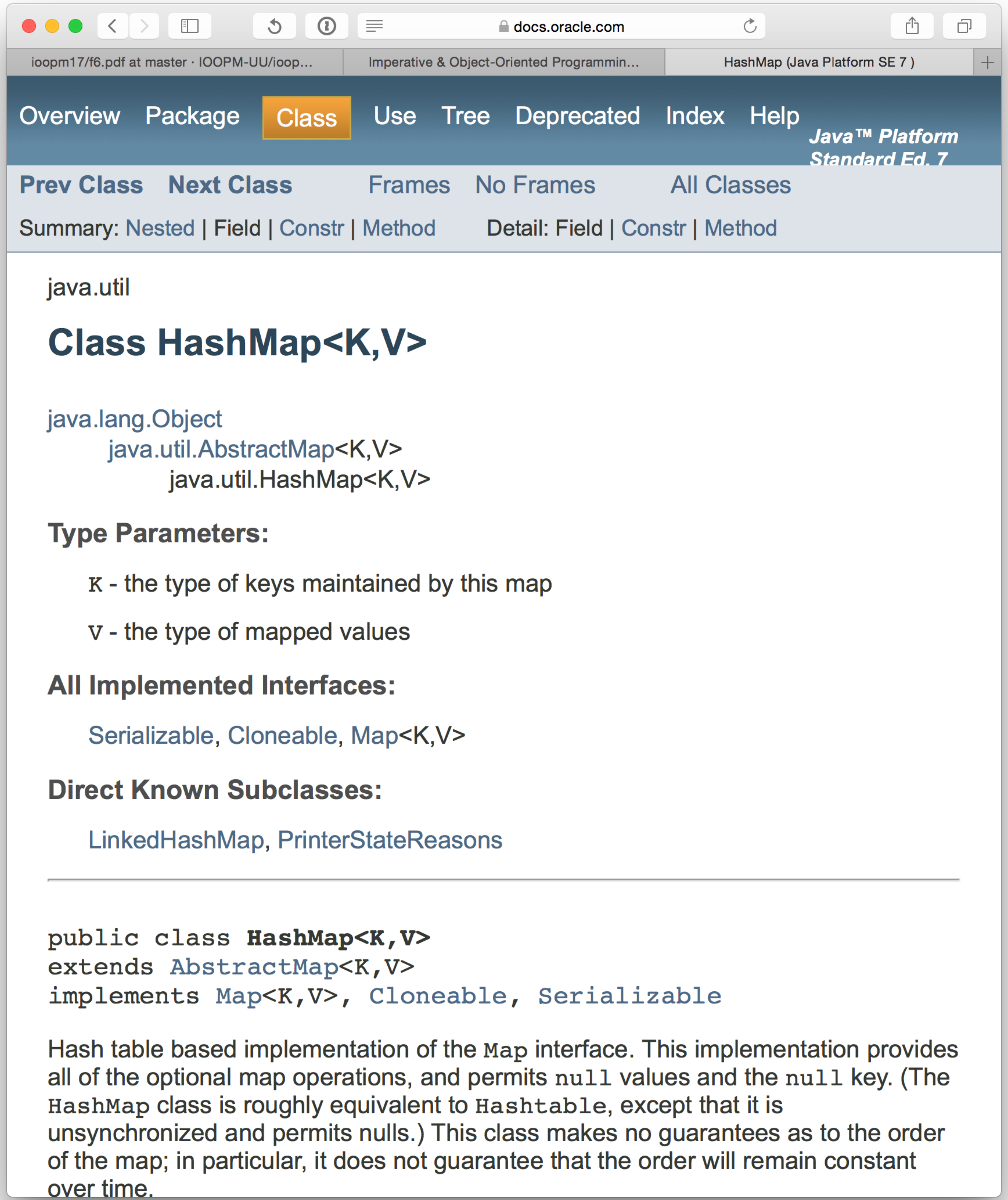
  `java.util`

    Common data structures, StringTokenizer

  `java.io`

    I/O

http://docs.oracle.com/javase/*X*/docs/api/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HashMap (Java Platform SE 7)
Overview Package Class Use Tree Deprecated Index Help
Java™ Platform Standard Ed. 7
Prev Class Next Class Frames No Frames All Classes
Summary: Nested | Field | Constr | Method Detail: Field | Constr | Method

java.util

Class HashMap<K,V>

java.lang.Object
    java.util.AbstractMap<K,V>
        java.util.HashMap<K,V>

Type Parameters:

`K` - the type of keys maintained by this map

`V` - the type of mapped values

All Implemented Interfaces:

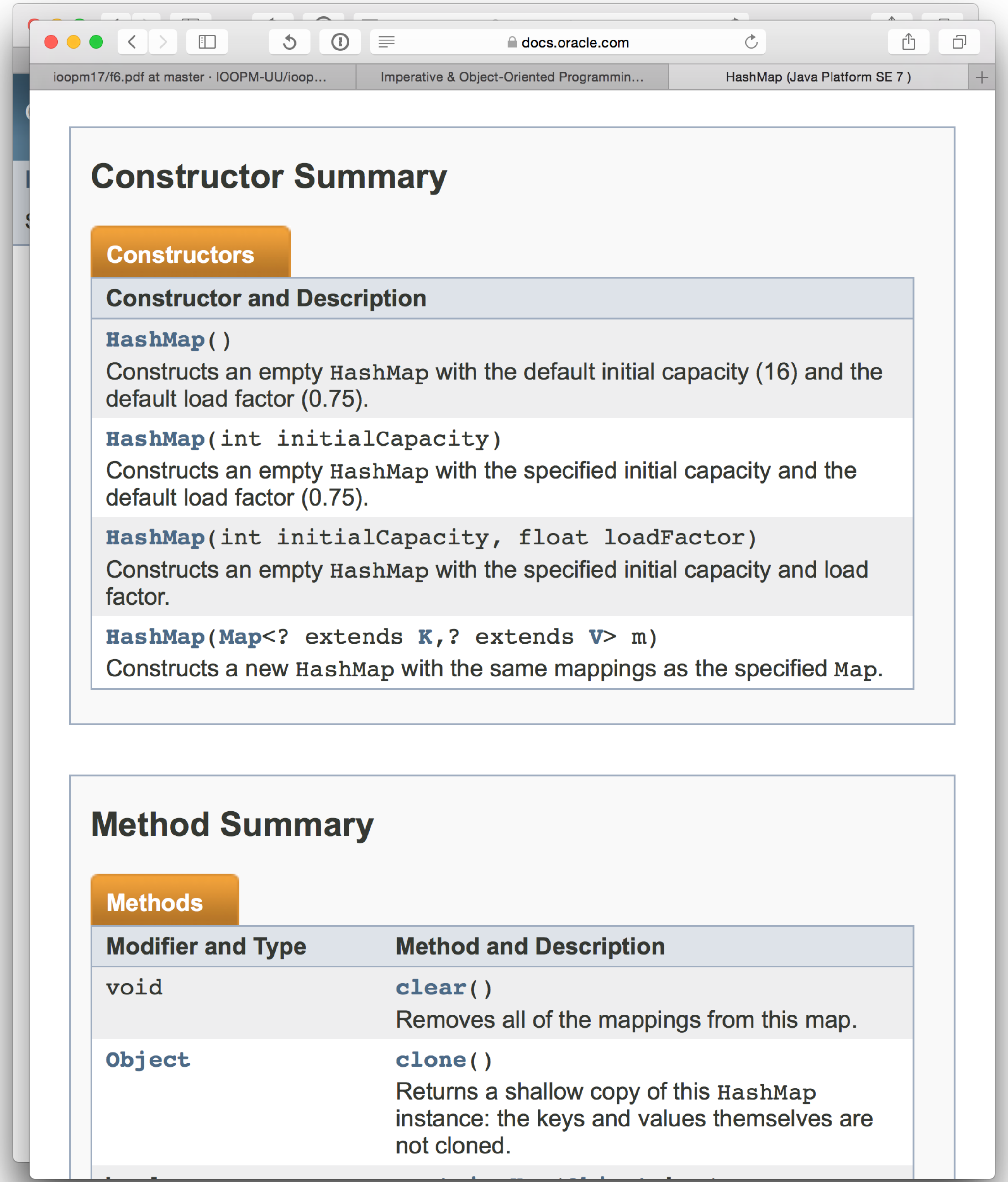
Serializable, Cloneable, Map<K,V>

Direct Known Subclasses:

LinkedHashMap, PrinterStateReasons

```
public class HashMap<K,V>
extends AbstractMap<K,V>
implements Map<K,V>, Cloneable, Serializable
```

Hash table based implementation of the `Map` interface. This implementation provides all of the optional map operations, and permits `null` values and the `null` key. (The `HashMap` class is roughly equivalent to `Hashtable`, except that it is unsynchronized and permits nulls.) This class makes no guarantees as to the order of the map; in particular, it does not guarantee that the order will remain constant over time.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HashMap (Java Platform SE 7)

Constructor Summary

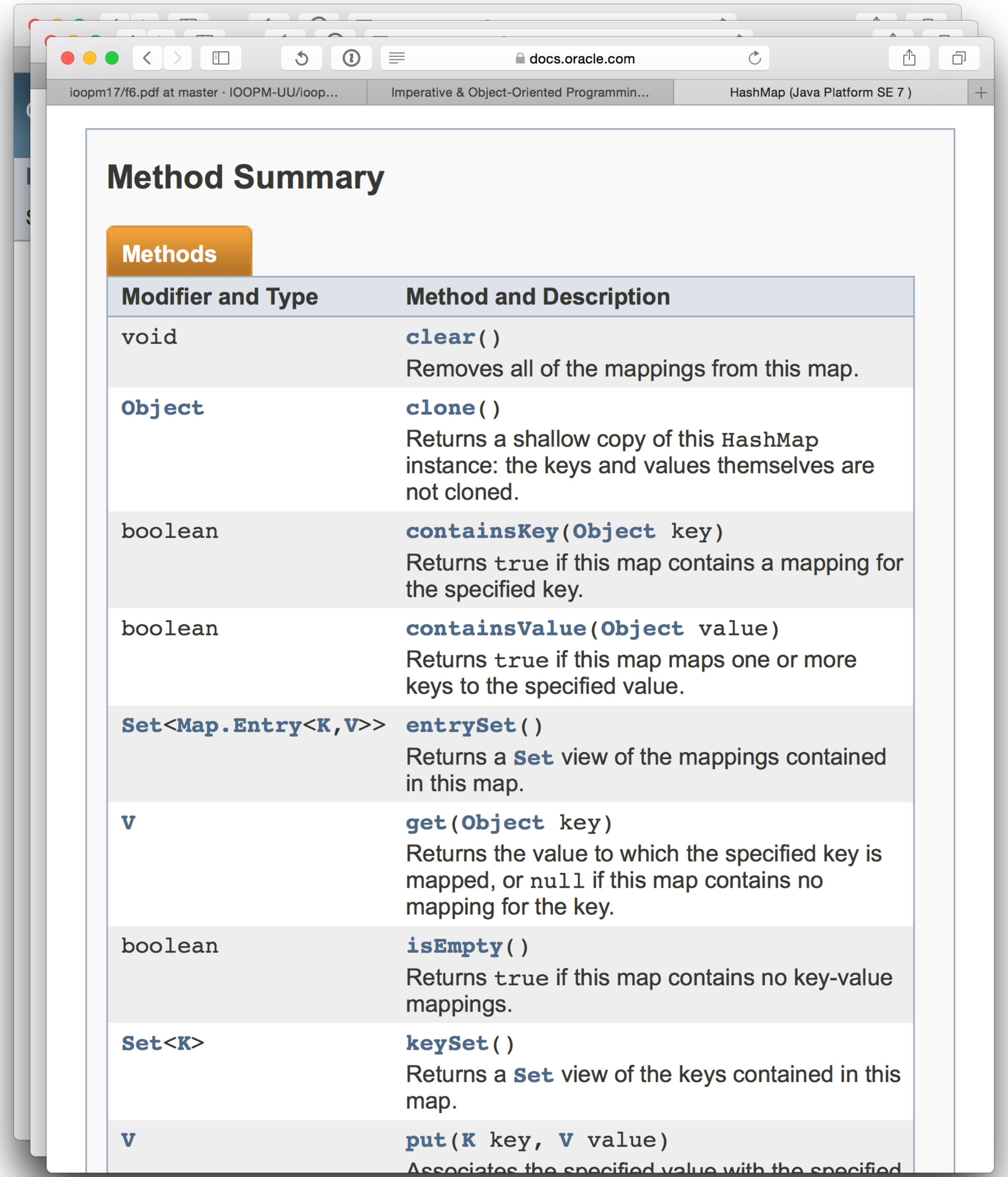
Constructors

Constructor and Description
`HashMap()` Constructs an empty `HashMap` with the default initial capacity (16) and the default load factor (0.75).
`HashMap(int initialCapacity)` Constructs an empty `HashMap` with the specified initial capacity and the default load factor (0.75).
`HashMap(int initialCapacity, float loadFactor)` Constructs an empty `HashMap` with the specified initial capacity and load factor.
`HashMap(Map<? extends K,? extends V> m)` Constructs a new `HashMap` with the same mappings as the specified `Map`.

Method Summary

Methods

Modifier and Type	Method and Description
`void`	`clear()` Removes all of the mappings from this map.
`Object`	`clone()` Returns a shallow copy of this `HashMap` instance: the keys and values themselves are not cloned.



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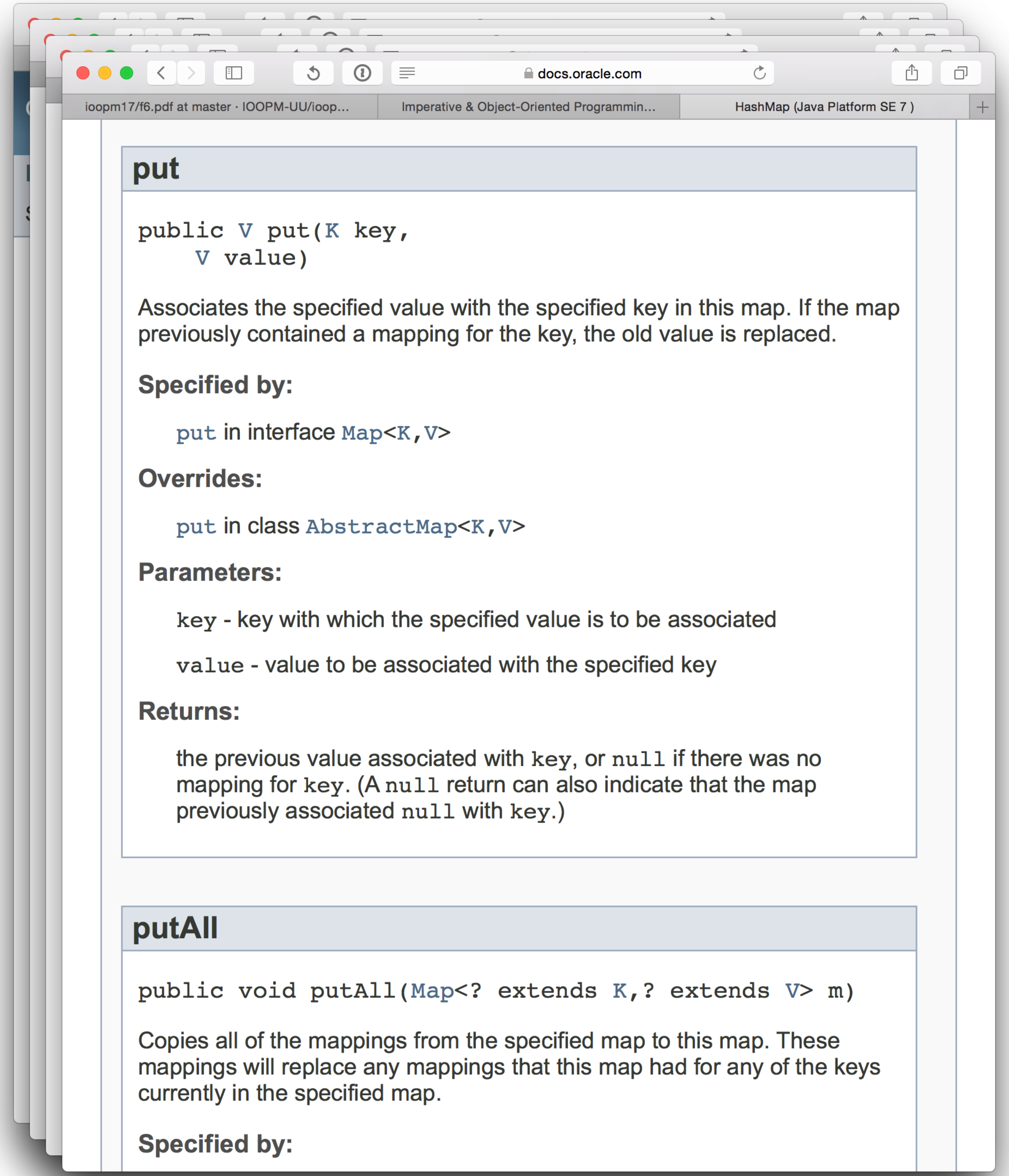
ioopm17/f6.pdf at master · IOOPM-UU/ioop… | Imperative & Object-Oriented Programmin… | HashMap (Java Platform SE 7)

Method Summary

Methods

Modifier and Type	Method and Description
void	`clear()` Removes all of the mappings from this map.
`Object`	`clone()` Returns a shallow copy of this `HashMap` instance: the keys and values themselves are not cloned.
boolean	`containsKey(Object key)` Returns `true` if this map contains a mapping for the specified key.
boolean	`containsValue(Object value)` Returns `true` if this map maps one or more keys to the specified value.
`Set<Map.Entry<K,V>>`	`entrySet()` Returns a `Set` view of the mappings contained in this map.
`V`	`get(Object key)` Returns the value to which the specified key is mapped, or `null` if this map contains no mapping for the key.
boolean	`isEmpty()` Returns `true` if this map contains no key-value mappings.
`Set<K>`	`keySet()` Returns a `Set` view of the keys contained in this map.
`V`	`put(K key, V value)`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put

```
public V put(K key,
     V value)
```

Associates the specified value with the specified key in this map. If the map previously contained a mapping for the key, the old value is replaced.

Specified by:

`put` in interface `Map<K,V>`

Overrides:

`put` in class `AbstractMap<K,V>`

Parameters:

`key` - key with which the specified value is to be associated

`value` - value to be associated with the specified key

Returns:

the previous value associated with `key`, or `null` if there was no mapping for `key`. (A `null` return can also indicate that the map previously associated `null` with `key`.)

putAll

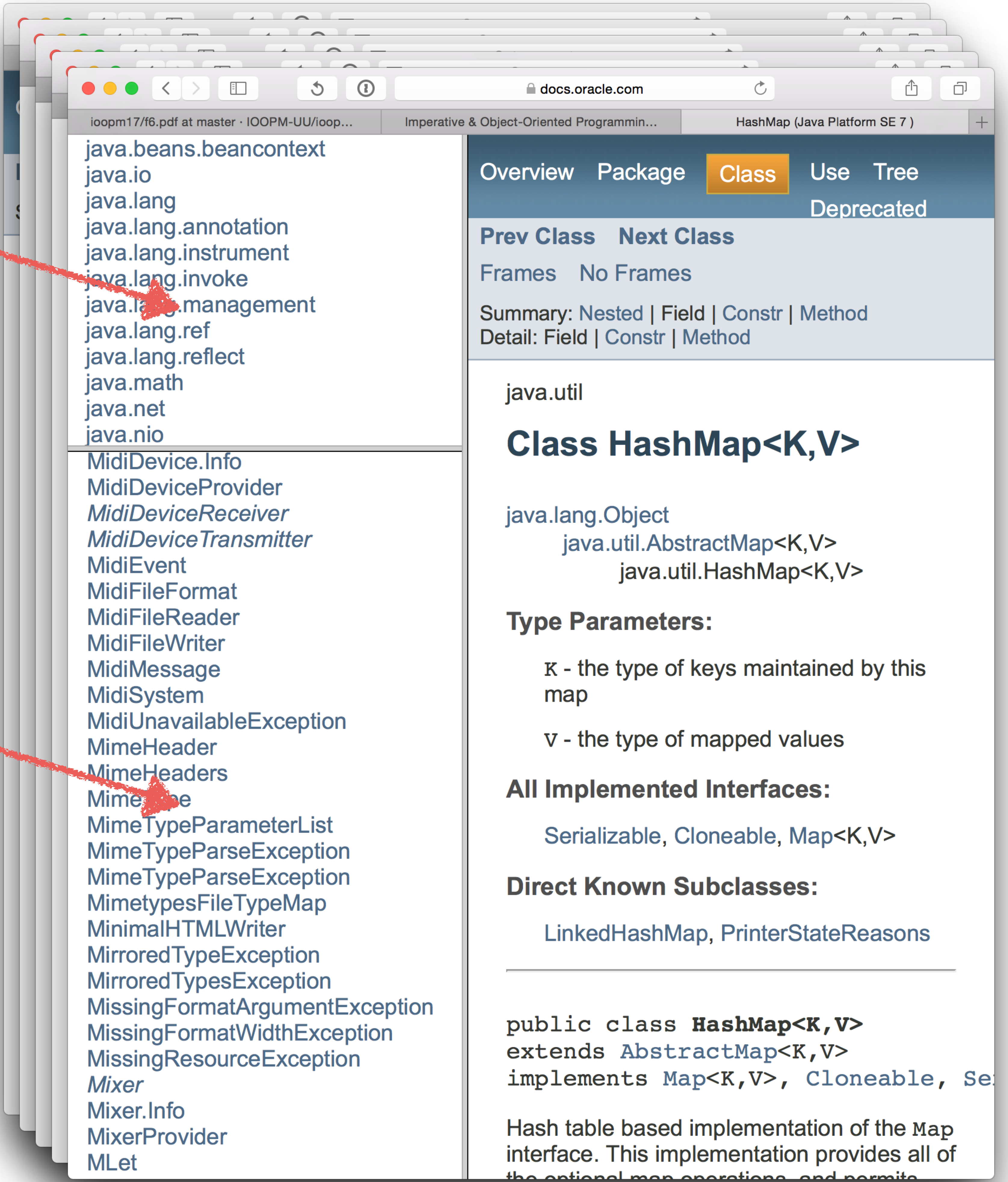
```
public void putAll(Map<? extends K,? extends V> m)
```

Copies all of the mappings from the specified map to this map. These mappings will replace any mappings that this map had for any of the keys currently in the specified map.

Specified by:

Hundratals paket

Tusentals klasser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java.beans.beancontext
java.io
java.lang
java.lang.annotation
java.lang.instrument
java.lang.invoke
java.lang.management
java.lang.ref
java.lang.reflect
java.math
java.net
java.nio

MidiDevice.Info
MidiDeviceProvider
MidiDeviceReceiver
MidiDeviceTransmitter
MidiEvent
MidiFileFormat
MidiFileReader
MidiFileWriter
MidiMessage
MidiSystem
MidiUnavailableException
MimeHeader
MimeHeaders
MimeType
MimeTypeParameterList
MimeTypeParseException
MimeTypeParseException
MimetypesFileTypeMap
MinimalHTMLWriter
MirroredTypeException
MirroredTypesException
MissingFormatArgumentException
MissingFormatWidthException
MissingResourceException
Mixer
Mixer.Info
MixerProvider
MLet

Summary: Nested | Field | Constr | Method
Detail: Field | Constr | Method

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extends AbstractMap<K,V>
implements Map<K,V>, Cloneable, Se
```

Hash table based implementation of the `Map` interface. This implementation provides all of

Strong Typing

- Java is strongly typed (C weakly!)

  We cannot treat one type as another

  Trying to do so will generate a clear runtime error

```c
/// Type punning in C
elem_t e; /// unknown content
e.int_value = 42;
float f = e.float_value; ///???
```

```c
/// Type casting in C is abusive
void *ptr = (void *)42;
int i = (int) ptr;
```

```java
/// Bad type cast generates runtime error
Object o = new Object();
Person p = (Person) o; /// Compiles
```

↓

ClassCastException

Parametric Polymorphism

```
/// Revisiting previous examples – and improving them!
Person p1 = new Person();
Class<Person> cp = p1.getClass();
Person p2 = cp.newInstance();
```

```
/// Revisiting previous examples – and improving them!
LinkedList<Person> list = new LinkedList<>(); /// !!
list.add(new Object()); /// Will not compile
Person p = list.first();
```

```
/// Revisiting previous examples – and improving them!
public class Person implements Comparable<Person> {
    ...
}
```

No Segmentation Fault

Null Pointers in Java:

```
Exception in thread "main" java.lang.NullPointerException
        at com.example.myproject.Book.getTitle(Book.java:16)
        at com.example.myproject.Author.getBookTitles(Author.java:25)
        at com.example.myproject.Bootstrap.main(Bootstrap.java:14)
```

Lookup in arras with `index < 0` or `index >= array.length`

```
Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException
        at com.example.myproject.BookStore.getBook(BookStore.java:52)
        at com.example.myproject.BookStore.getLatest(BookStore.java:33)
        at com.example.myproject.Bootstrap.main(Bootstrap.java:17)
```

Note that the program prints which line it crashed on!!!!

Exception Handling

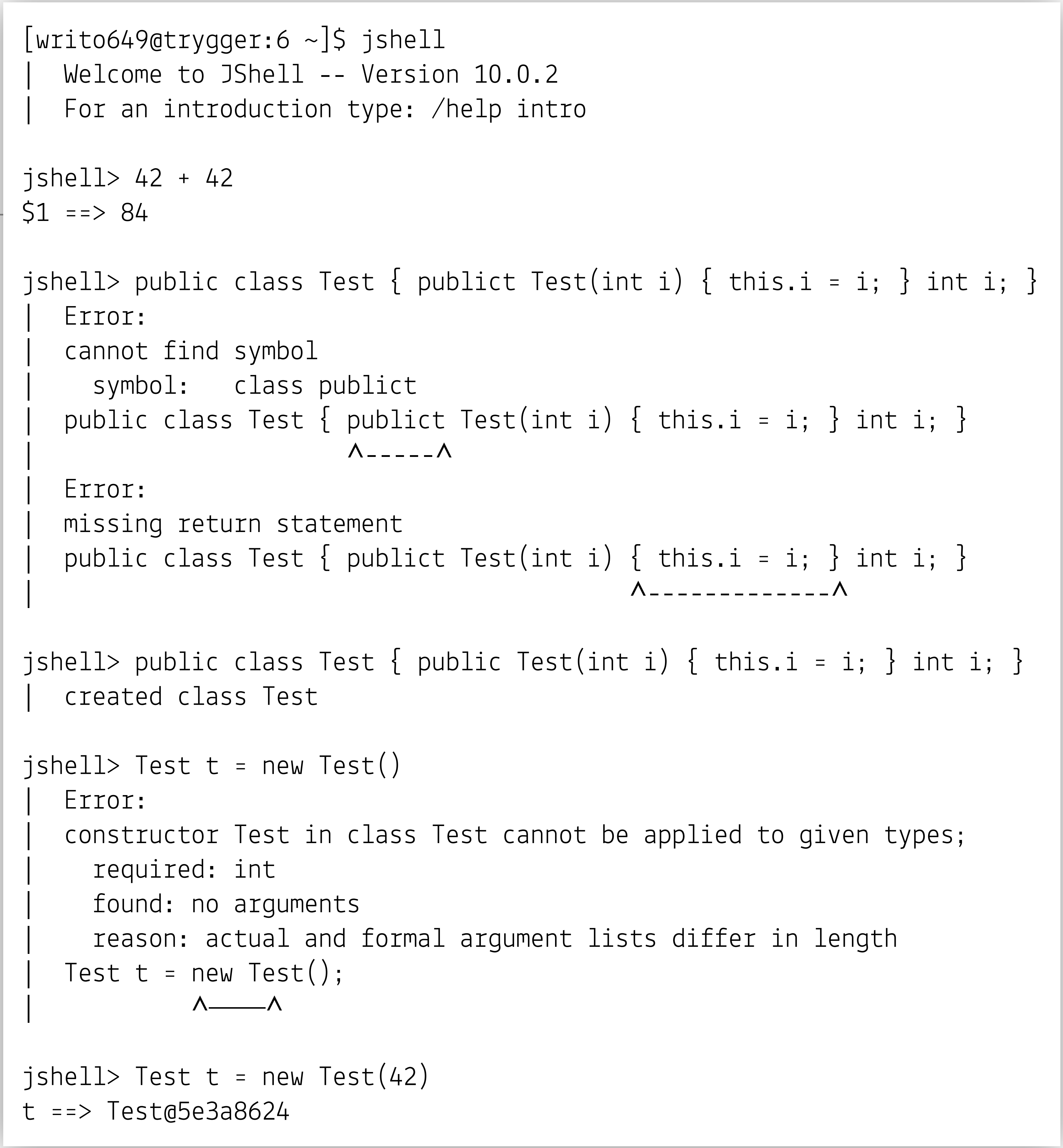
```
/// Bad type cast generates runtime error
BufferedReader in = null;
try {
    in = new BufferedReader(new FileReader("foo.in"));
    while (true) {
        node = node.next;
    }
    ...
} catch (NullPointerException e) {
    /// Went too far in the list!
    e.printStackTrace(System.err);
} finally {
    if (in != null) {
        in.close();
    }
}
```

References

- No pointer arithmetic
- A reference cannot be created out of nothing
- No dangling pointers
- A **pointer is an address** — an integer — an offset from 0
- A **reference is and handle**, a token through which one can access an object
- Sometimes we say pointers, nevertheless, it is obvious they are references by context
- A `null`-pekare is NOT a reference, it is the **absence of a reference!**

Jshell

- From JDK 9, Java has finally gotten a REPL (Read-Eval-Print Loop)
- Play with Java in an interactive, live environment

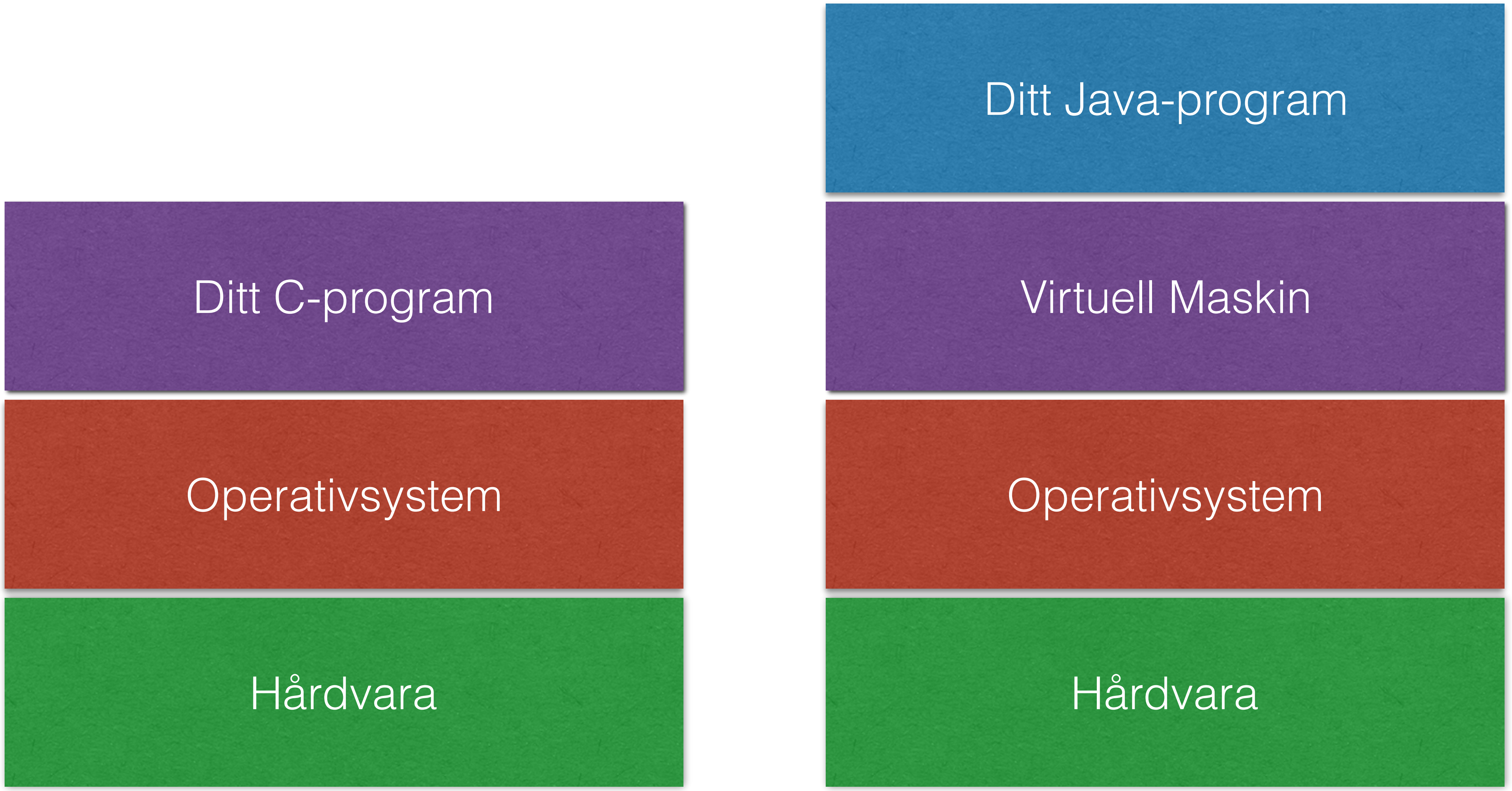


```
[writo649@trygger:6 ~]$ jshell
|  Welcome to JShell -- Version 10.0.2
|  For an introduction type: /help intro

jshell> 42 + 42
$1 ==> 84

jshell> public class Test { publict Test(int i) { this.i = i; } int i; }
|  Error:
|  cannot find symbol
|    symbol:   class publict
|  public class Test { publict Test(int i) { this.i = i; } int i; }
|                      ^-----^
|  Error:
|  missing return statement
|  public class Test { publict Test(int i) { this.i = i; } int i; }
|                                          ^-------------^

jshell> public class Test { public Test(int i) { this.i = i; } int i; }
|  created class Test

jshell> Test t = new Test()
|  Error:
|  constructor Test in class Test cannot be applied to given types;
|    required: int
|    found: no arguments
|    reason: actual and formal argument lists differ in length
|  Test t = new Test();
|           ^----^

jshell> Test t = new Test(42)
t ==> Test@5e3a8624
```

Object Oriented?

- Hopefully you will also appreciate object orientation…

The Stack in Java vs. The Stack in C



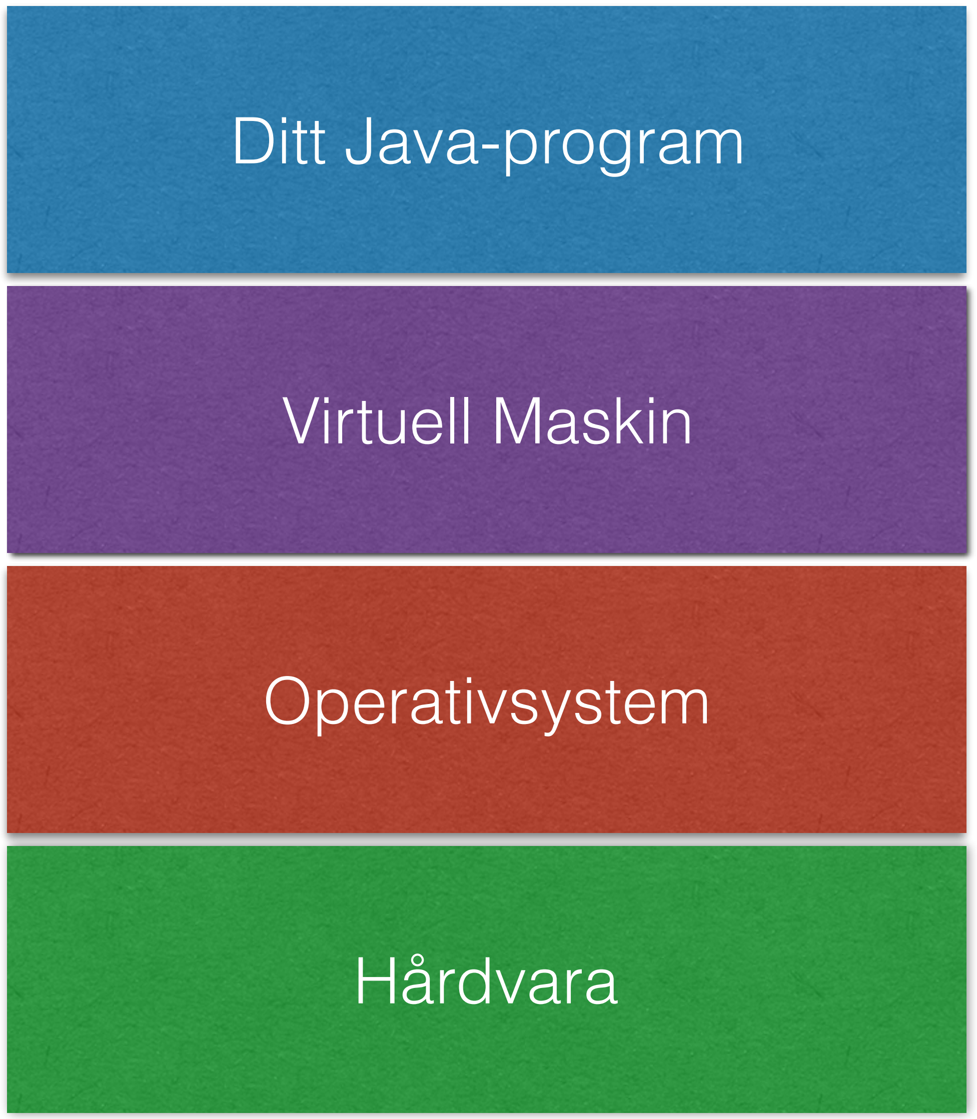
Kompilera och köra ett Java-program

```
$ javac MyProg.java
```

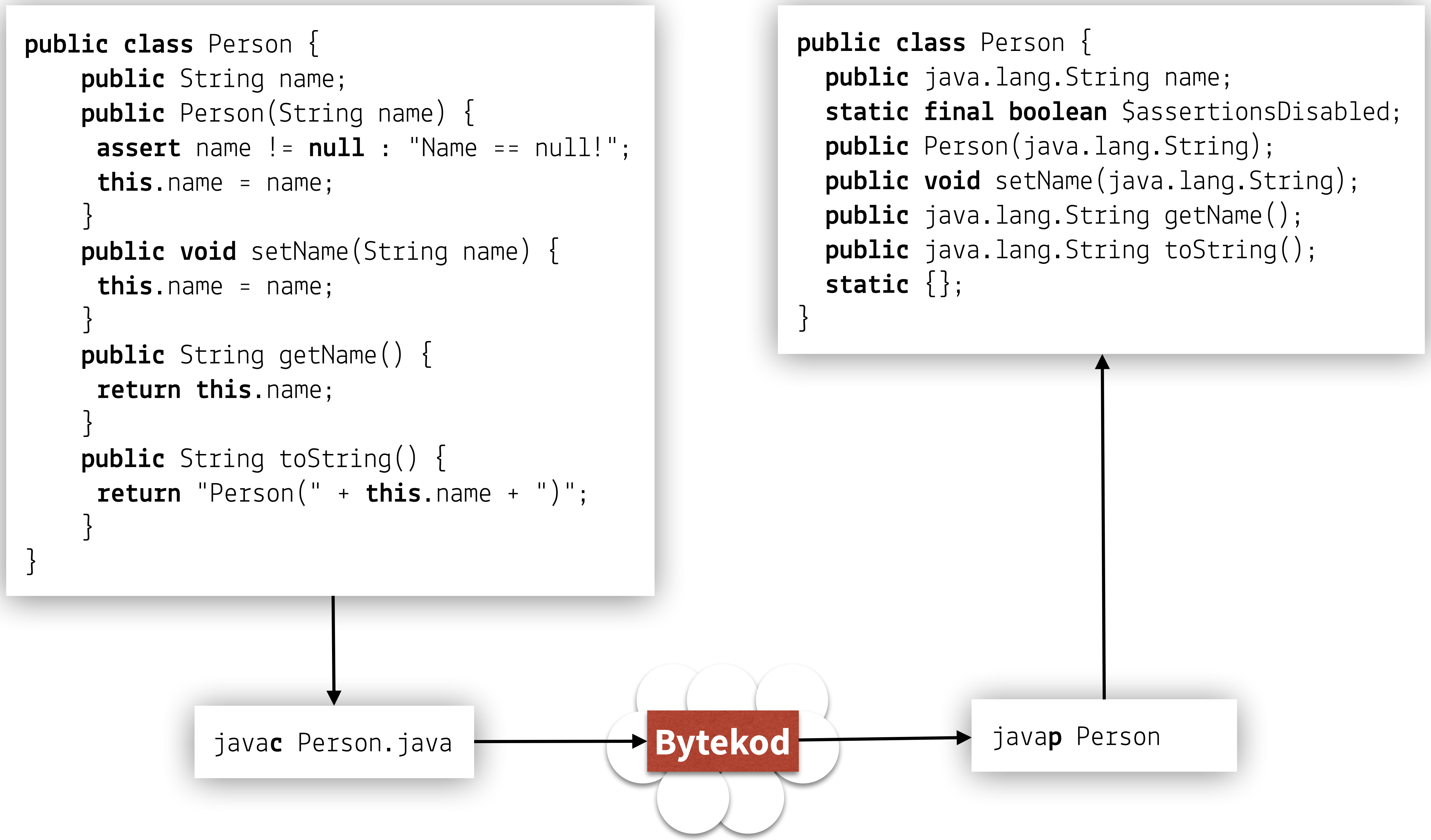
Creates one or more .class files, one of which is called MyProg.class

```
$ java MyProg
```

Startar den virtuella maskinen och laddar in MyProg och kör



Compiling your Java-program



```java
public class Person {
    public String name;
    public Person(String name) {
     assert name != null : "Name == null!";
     this.name = name;
    }
    public void setName(String name) {
     this.name = name;
    }
    public String getName() {
     return this.name;
    }
    public String toString() {
     return "Person(" + this.name + ")";
    }
}
```

```
javac Person.java
```

```
javap Person
```

```java
public class Person {
  public java.lang.String name;
  static final boolean $assertionsDisabled;
  public Person(java.lang.String);
  public void setName(java.lang.String);
  public java.lang.String getName();
  public java.lang.String toString();
  static {};
}
```

Use the source, Luke!

```
javap -c Person
```

```
Compiled from "Person.java"
public class Person {
  public java.lang.String name;

  static final boolean $assertionsDisabled;

  public Person(java.lang.String);
    Code:
       0: aload_0
       1: invokespecial #1                  // Method java/lang/Object."<init>":()V
       4: getstatic     #2                  // Field $assertionsDisabled:Z
       7: ifne          24
      10: aload_1
      11: ifnonnull     24
      14: new           #3                  // class java/lang/AssertionError
      17: dup
      18: ldc           #4                  // String Name must not be null!
      20: invokespecial #5                  // Method java/lang/AssertionError."<init>":(Ljava/lang/Object
      23: athrow
      24: aload_0
      25: aload_1
      26: putfield      #6                  // Field name:Ljava/lang/String;
      29: return

  public void setName(java.lang.String);
    Code:
     25: aload_1
     26: putfield      #6                  //
     29: return

public void setName(java.lang.String);
  Code:
      0: aload_0
      1: aload_1
      2: putfield      #6                  //
      5: return

public java.lang.String getName();
  Code:
      0: aload_0
      1: getfield      #6                  //
      4: areturn

public java.lang.String toString();
  Code:
      0: new           #7                  // class java/lang/StringBuilder
      3: dup
      4: invokespecial #8                  // Method java/lang/StringBuilder."<init>":()V
      7: ldc           #9                  // String Person(
      9: invokevirtual #10                 // Method java/lang/StringBuilder.append:(Ljava/lang/
                                           //                        String;)Ljava/lang/StringBuilder;
     12: aload_0
     13: getfield      #6                  // Field name:Ljava/lang/String;
     16: invokevirtual #10                 // Method java/lang/StringBuilder.append:(Ljava/lang/
                                           //                        String;)Ljava/lang/StringBuilder;
     19: ldc           #11                 // String )
     21: invokevirtual #10                 // Method java/lang/StringBuilder.append:(Ljava/lang/
                                           //                        String;)Ljava/lang/StringBuilder;
     24: invokevirtual #12                 // Method java/lang/StringBuilder.toString:()Ljava/lang/String
     27: areturn
```

```java
public class Person {
    public String name;
    public Person(String name) {
     assert name != null : "Name == null!";
     this.name = name;
    }
    public void setName(String name) {
     this.name = name;
    }
    public String getName() {
     return this.name;
    }
    public String toString() {
     return "Person(" + this.name + ")";
    }
}
```

Automatic Garbage Collection

- Objective: to give the programmer the illusion that memory is infinite
- Method: identify the junk data and release it **automatically**
- Definition of garbage: data that cannot be accessed by the program (no references)
- More formally, the object O is garbage if there is no path in the memory graph from any root (the variable on the stack, global variables, etc.) to O
- Two basic ways to do automatic garbage collection:

  Reference counting

  Tracing

Reference Counting

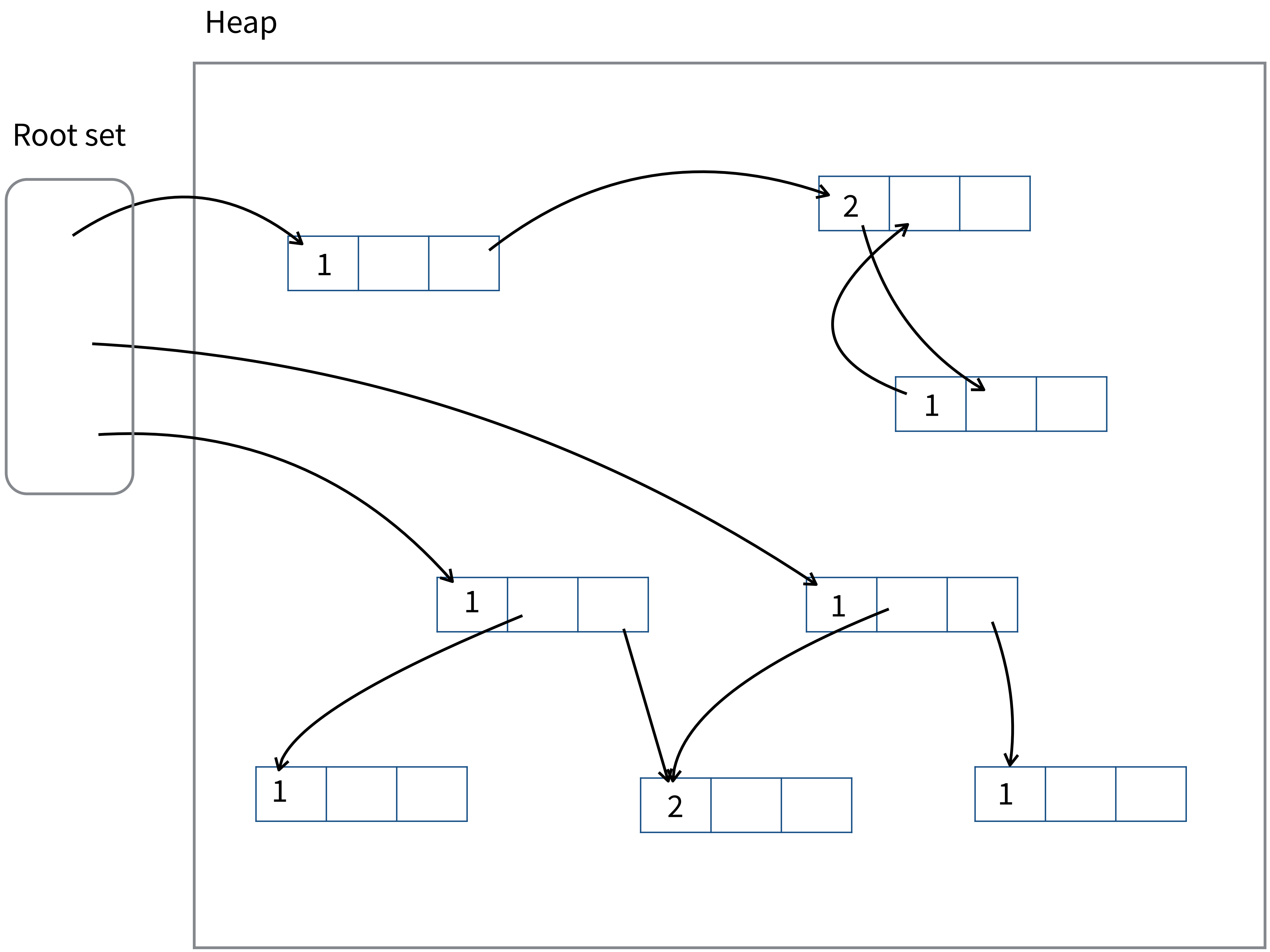
- Basic idea: each item saves information on how many people point to it
- When this counter reaches 0 - remove the object
- Each time a reference is created / deleted, update the reference counter:

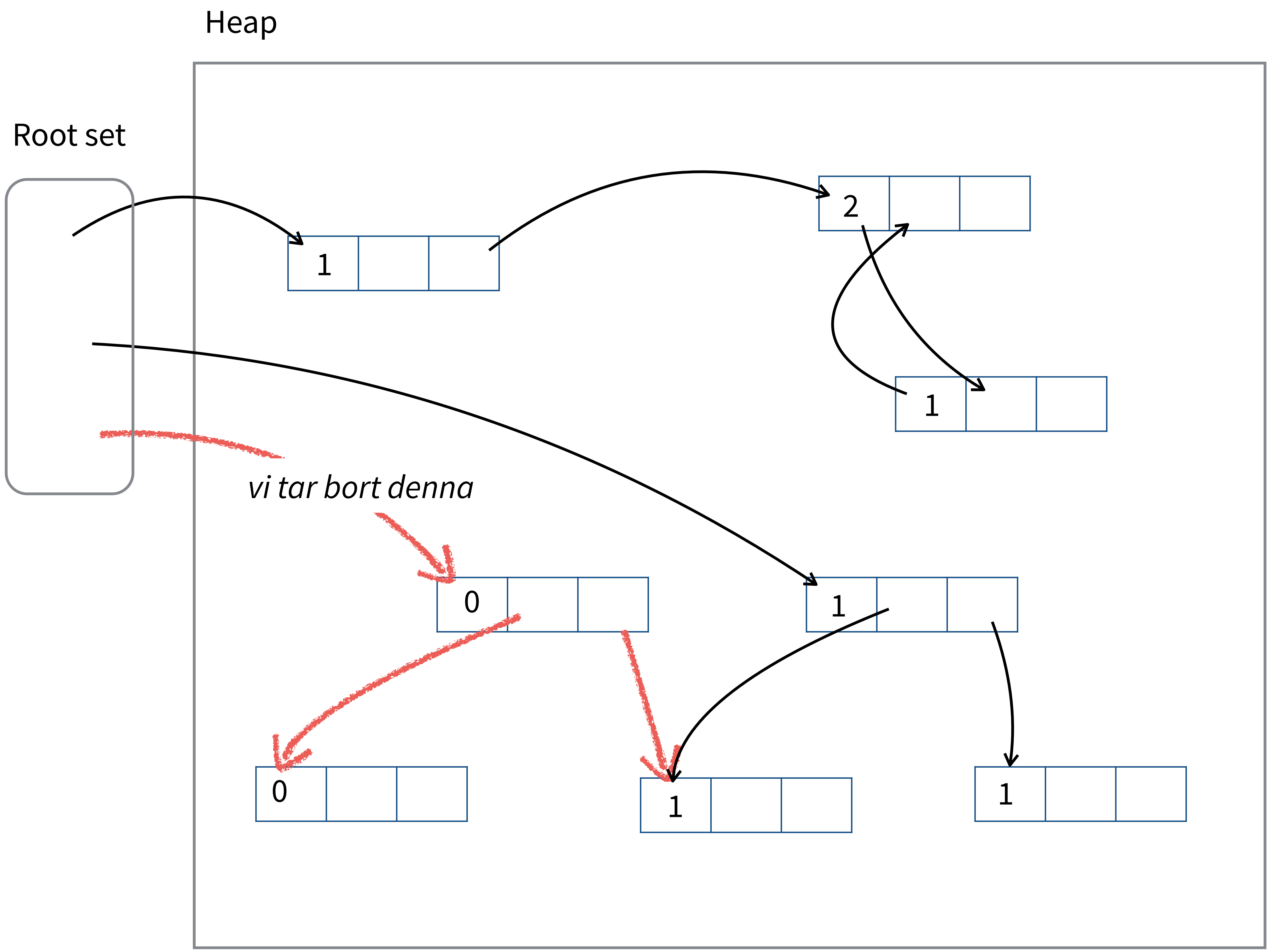
```
void *p = malloc(2048); // refcount 1
void *x = p; // refcount 2
p = NULL; // refcount 1
x = NULL; // refcount 0, free(x)
```

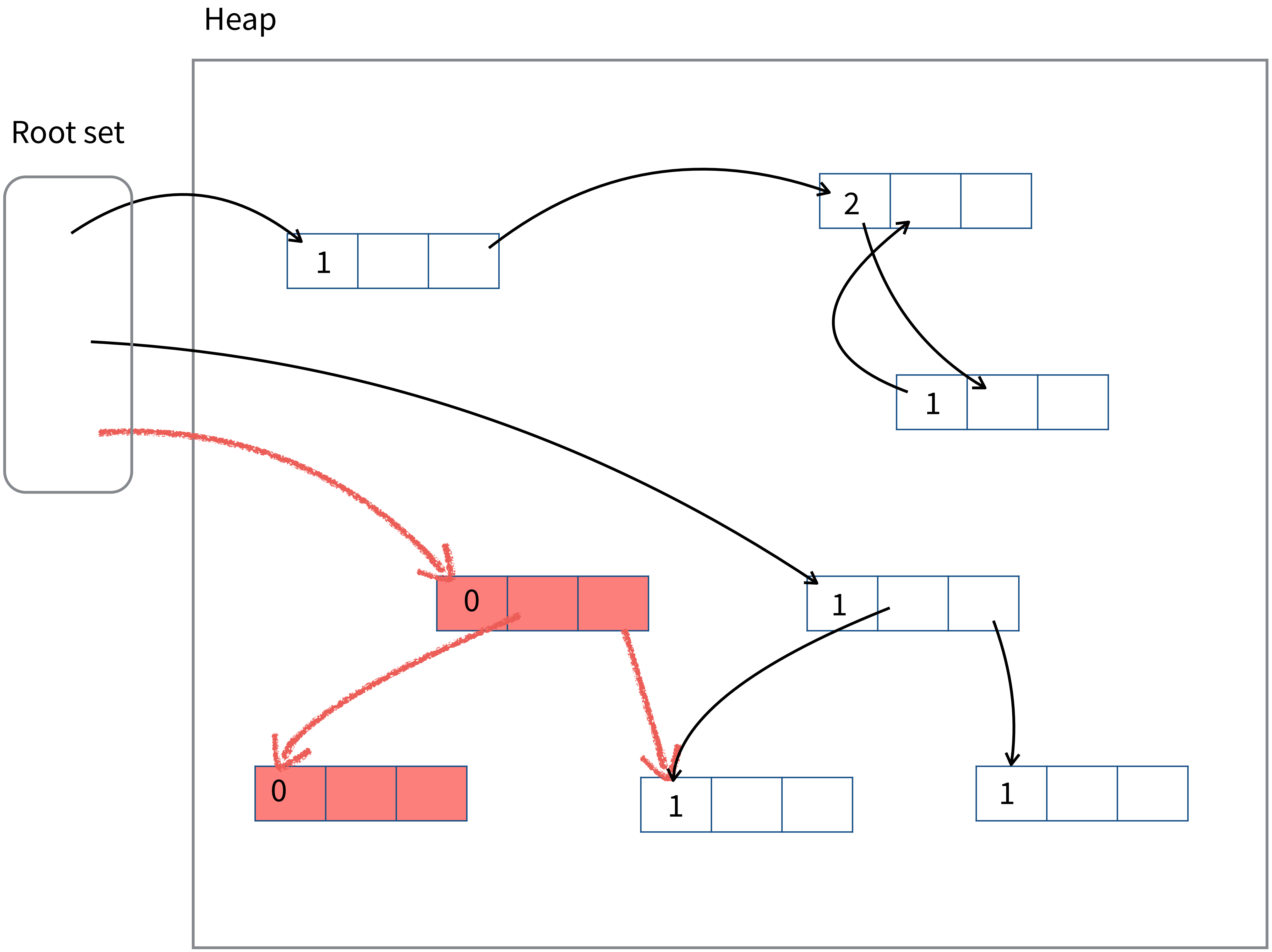
- Problem:

  Cyclic structures (see next pages)

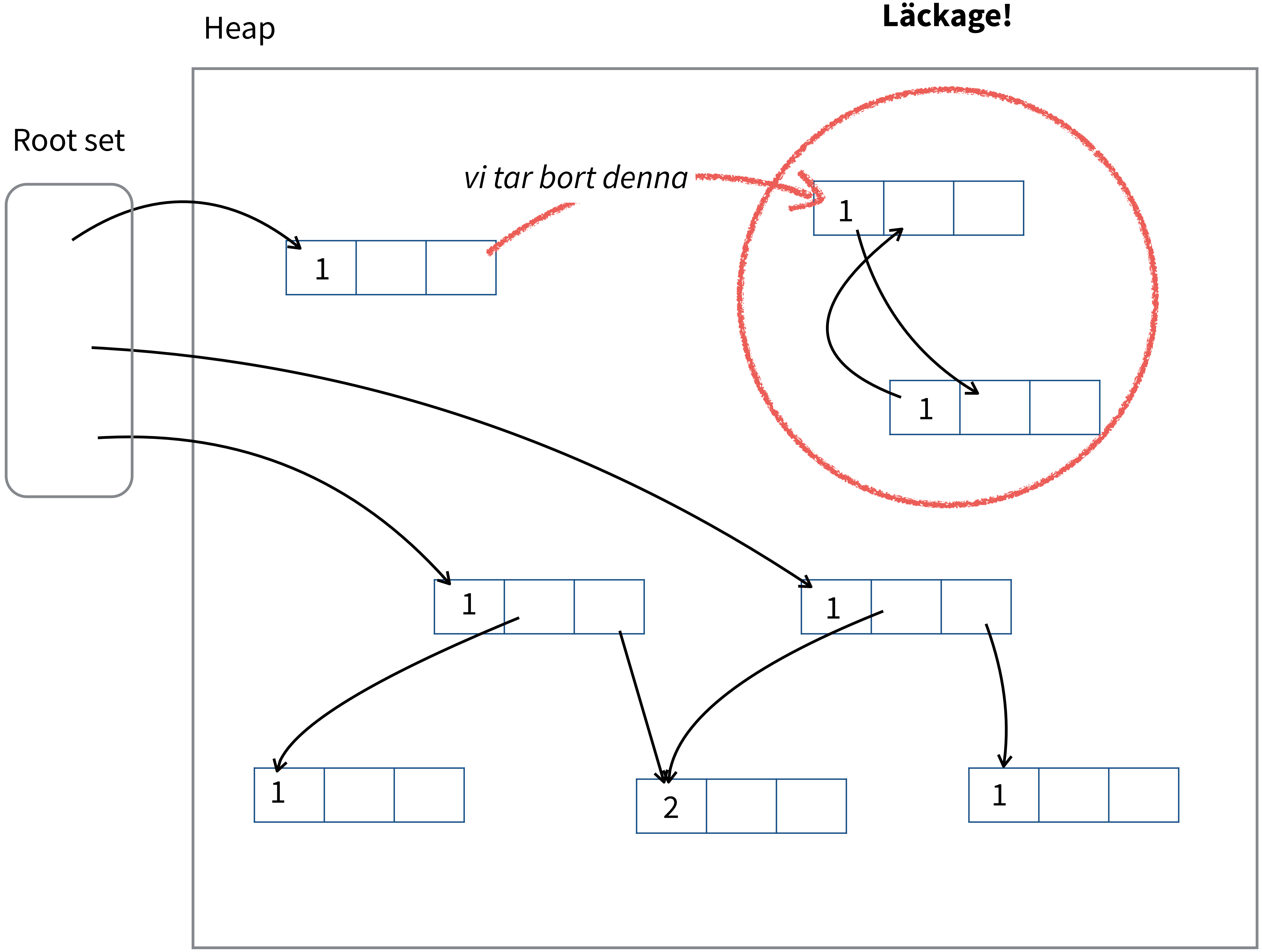
  Långlivat minne som manipuleras ofta kostar, fast vi aldrig tar bort det


Heap
Root set
1
2
1
1
1
1
2
1


Heap
Root set
1
2
1
vi tar bort denna
0
1
0
1
1


Heap
Root set
1
2
1
0
1
0
1
1

Läckage!



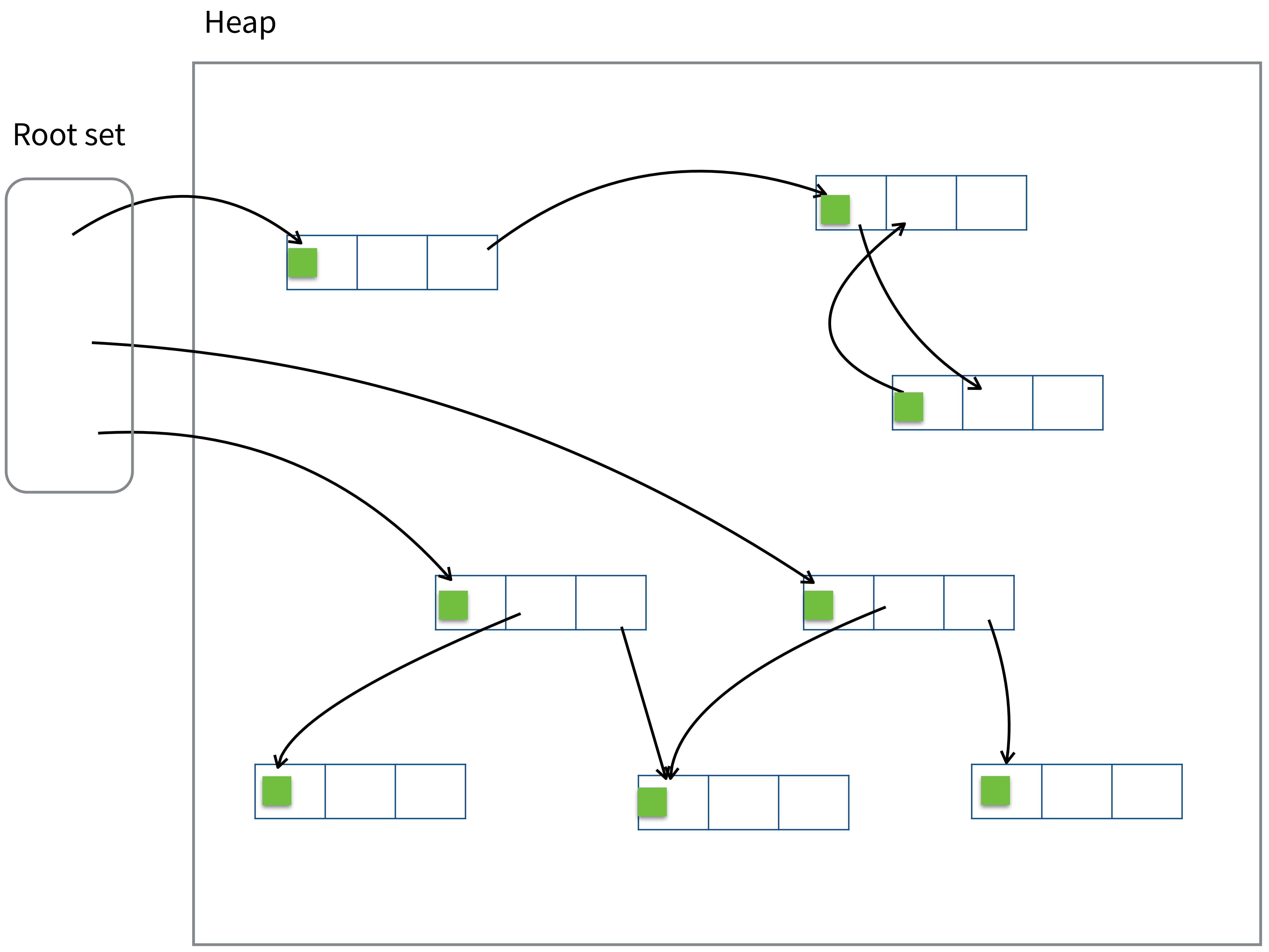
Tracing GC: Mark-Sweep

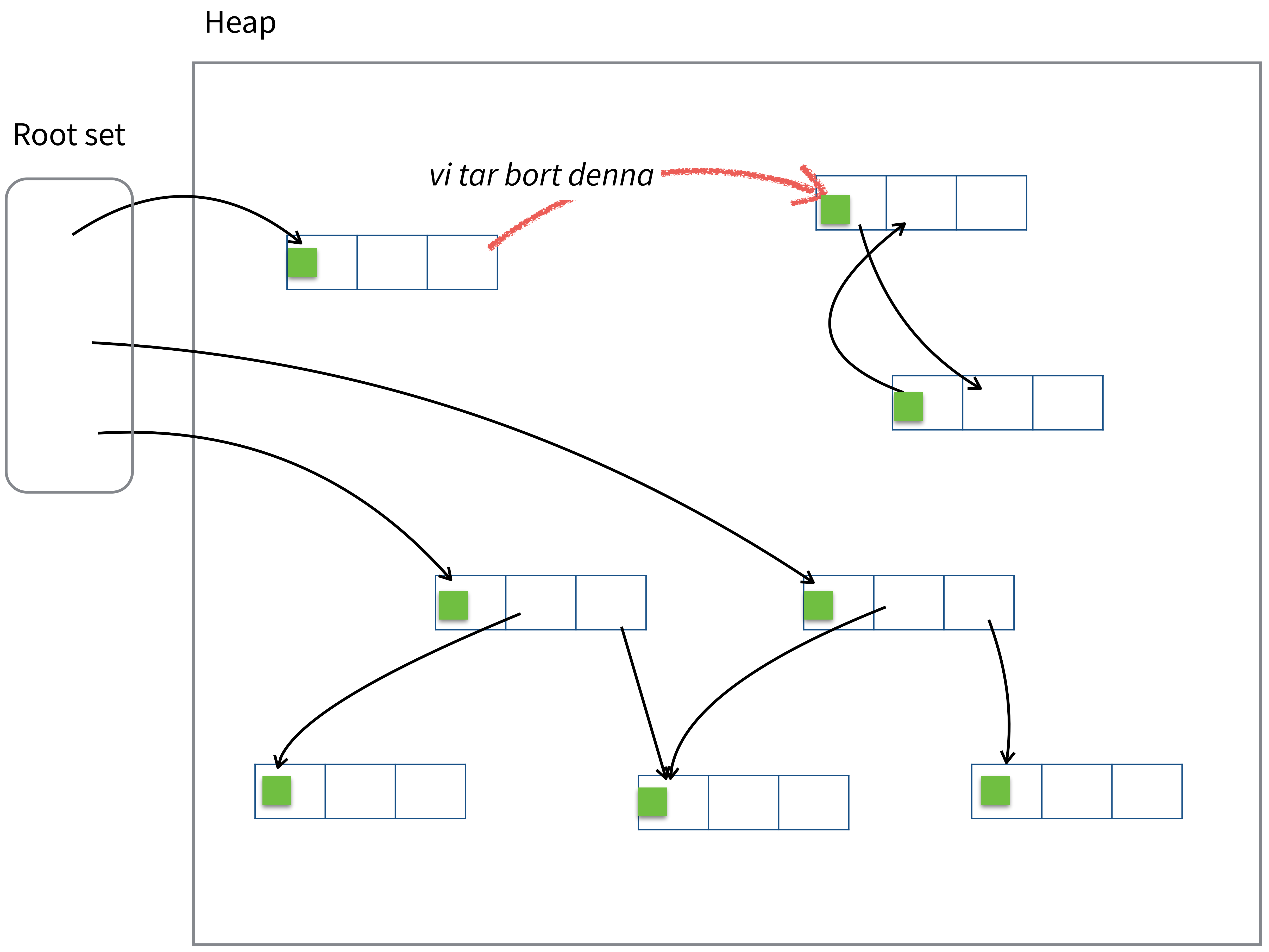
- When memory runs out:

  1. Follow the roots and select all items that can be reached

  2. Iterate all items and release all that are not marked in 1.

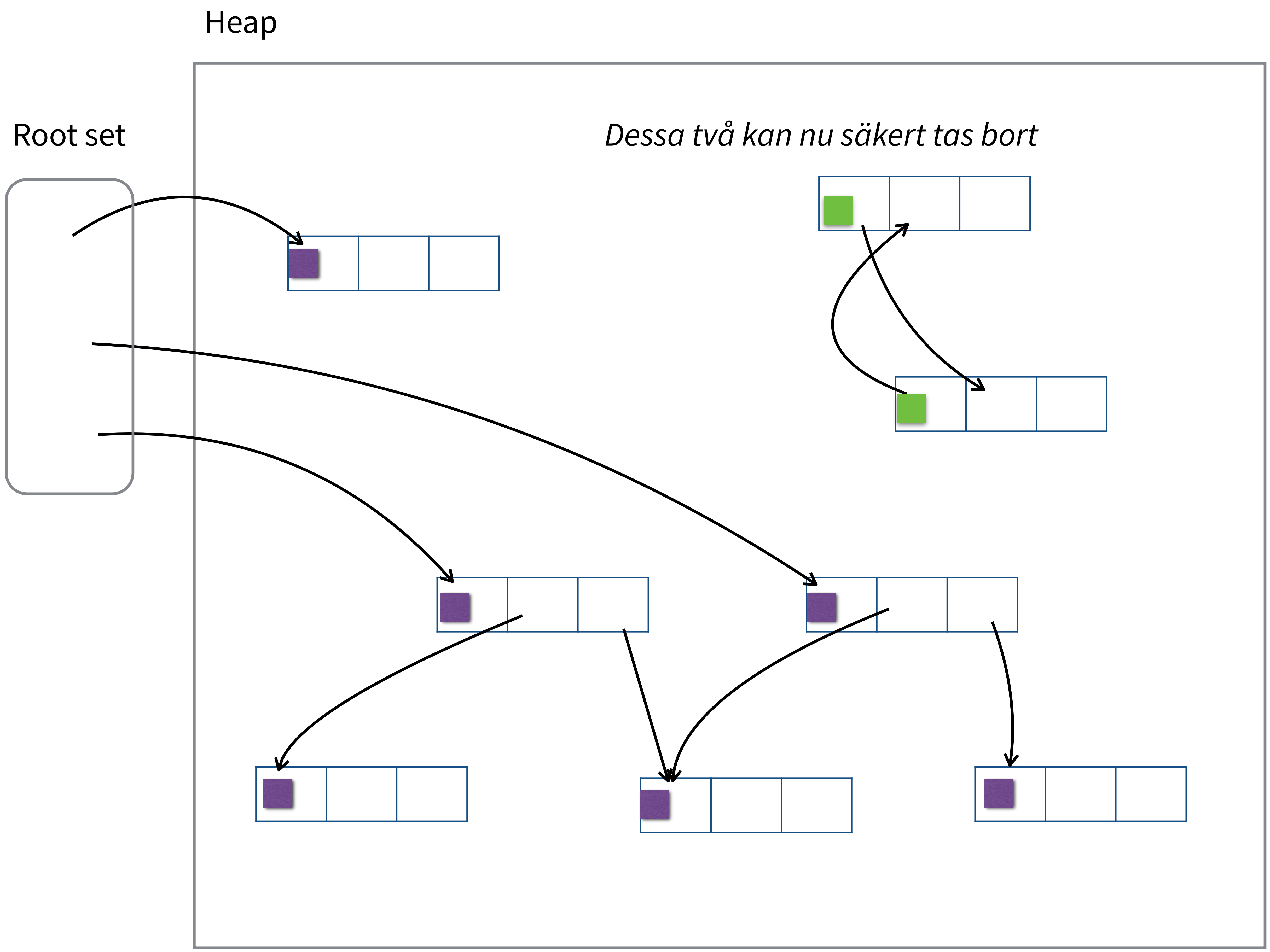
- The next slide shows the mark in the ground phase (1.)


Heap
Root set


Heap
Root set
vi tar bort denna

I nästa mark-fas markerar vi med annan färg 🟪

- Om något är grönt fortfarande efter denna fas är det skräp och skall tas bort


Heap
Root set
Dessa två kan nu säkert tas bort

KEEP
CALM
AND
LOVE
PROGRAMMING