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Garbage Collections

Object Oriented Programming

by

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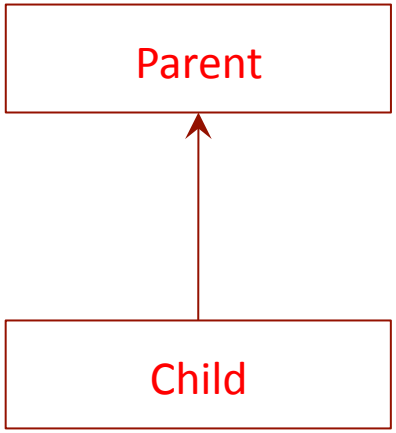
Recap: Objects in JAVA ?

- An entity that has **state** and **behaviour** is known as an object
  - **Examples:** Chair, bike, marker, pen, table, car etc
  - It can be physical or logical
- An object has three characteristics:
  - **State:** represents data (value) of an object
  - **Behaviour:** represents the behaviour (functionality) of an object such as deposit, withdraw and so on
  - **Identity (Internally used):**
    - Signature (unique) of the object
    - Object identity is typically implemented via a unique ID
    - The value of the ID is not visible to the external user
    - But, Internally by JVM to identify each object uniquely

Recap: Class Casting



✧ Let us look at the following:

Create an Object:

Parent p = new Parent();

Upcasting:

Parent p = new Child();

Downcasting:

Child c = new Parent() ➔ Compile time error

Child c = (Child) new Parent();

➔ This throws Class CastException at run time.

➔ How to solve this issue?

Polymorphism

- Polymorphism in java is a concept by which we can perform a single action by different ways
- Polymorphism is derived from: **poly** and **morphs**
- The word "**poly**" means many and "**morphs**" means forms → So polymorphism means many forms

- **Example:**
  - Person in a class room – Faculty / Student
  - Person in market – Customer
  - Person at home – Son or Daughter
  - Person at Work – Founder / Employee

    → one person present in different behaviors

Garbage Collection

What is garbage?

- A value is garbage if it will not be used in any subsequent computation by the program

- Is it easy to determine which objects are garbage?
  - No. It's undecidable.
- Example:
  - if long-and-tricky-computation then use v
  - else do not use v

Garbage Collection

- Determining which objects are garbage is tricky

- Tasks in finding a garbage:
  - It's the programmers problem:
    - Explicit allocation / deallocation
  - Reference counting
  - Tracing garbage collection

Algorithms for GC:

- There are several Garbage Collection Algorithms:
  - Copying Collectors
  - Mark and Sweep
  - Generational Collectors - Age Based Collection

Why Garbage Collection?

Why do we need GC?

- ✧ Free unreferenced objects.
- ✧ Combat heap fragmentation.
- ✧ Relieves programmer from manual freeing the memory.
- ✧ Helps in ensuring program integrity.

Disadvantages

- ✧ Extra Overhead.
- ✧ Less control over scheduling of CPU time.

Garbage Collection in JAVA

Ways for making objects eligible for collection

- ✧ Nulling a reference
- ✧ Reassigning a reference variable
- ✧ Isolating a reference

Forcing garbage collection

- ✧ Methods available to perform GC
- ✧ Only requests and no demands
- ✧ Using Runtime class
- ✧ Using static methods like

```
System.gc();
Runtime.getRuntime().gc();
```

GC – An Example

✧ Let us look at a simple example

```
for (int i = 0; i < 1000000; ++i) {
        CodeTester obj = new CodeTester(i);
        System.out.println (obj);
}
```

✧ Can we improve the above code

```
CodeTester obj = new CodeTester();
for (int i = 0; i < 1000000; ++i) {
        obj.setValue(i);
        System.out.println (obj);
}
```

GC – An Example

✧ Let us look at a simple example

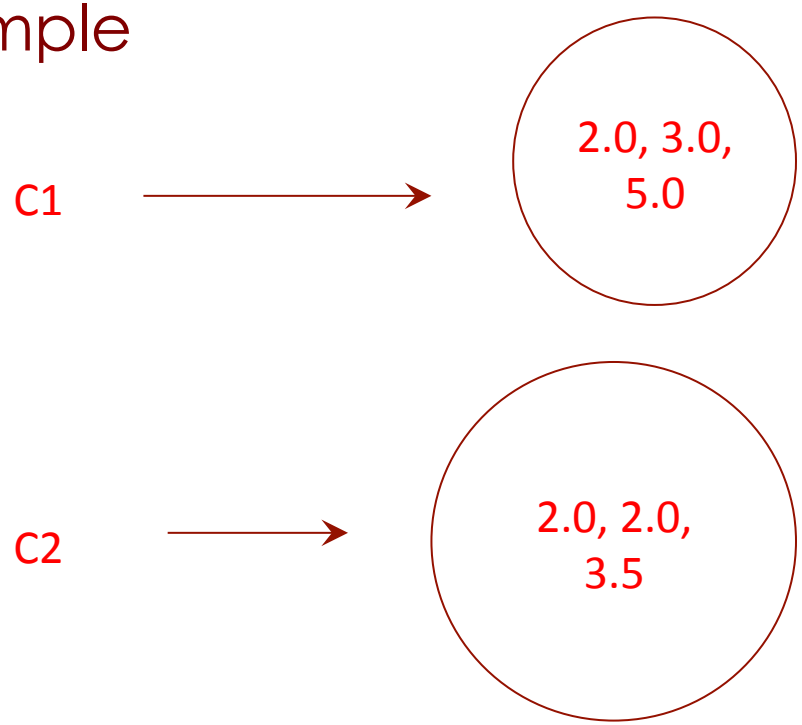
Circle c1 = new Circle();

Circle c2 = new Circle();

c2 = c1;

c1 = null;

c2 = null;



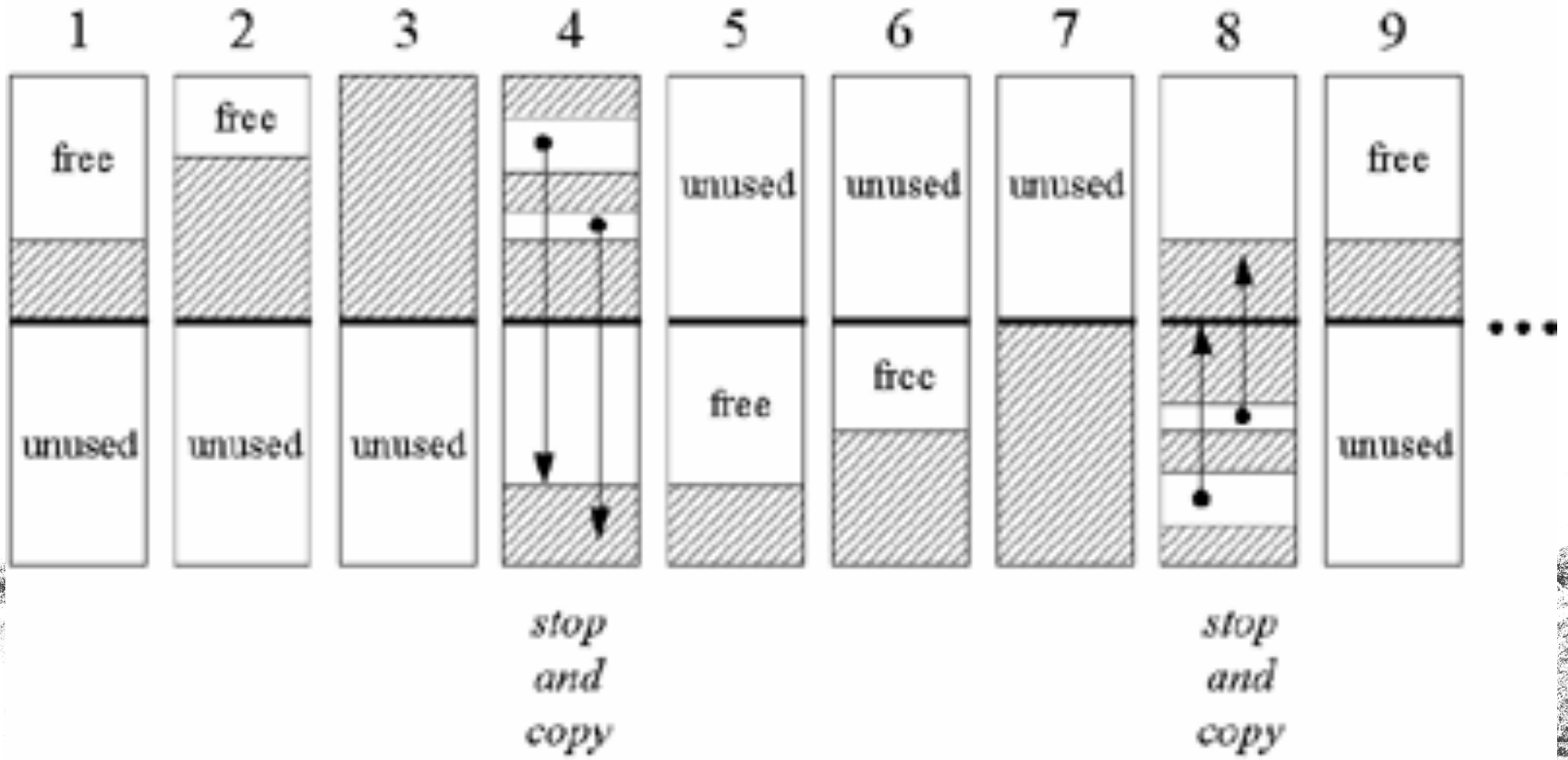
Copying Collectors

How do we apply Copying Collectors for GC?

- ✧ Heap is divided in two regions.
- ✧ All live objects copied to new area.
- ✧ Only one area is used at a time.
- ✧ Objects are copied to new area on the fly.
- ✧ Common method – Stop and Copy
- ✧ Memory requirements is disadvantage.

Copying Collector

- Garbage: Objects that are no longer required by the program



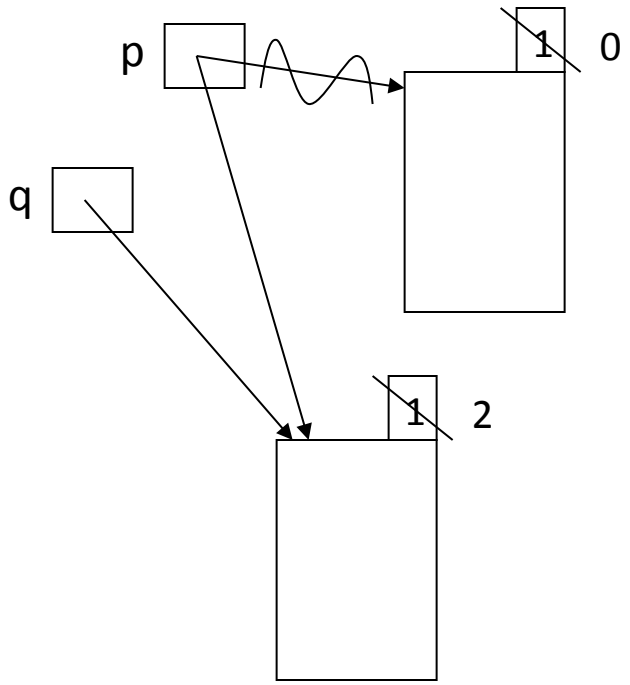
Reference Counting

- Basic idea
  - give each chunk a special field that is the number of references to chunk
  - whenever a new reference is made, increment field by 1
  - whenever a reference is removed, decrement field by 1
  - when reference count goes to zero, collect chunk
- Requires compiler support

RC – An Example

- Example
  - everything in italics is added by compiler

```
Object p = new Object;
p.count++;
Object q = new Object;
q.count++;
p.count--;
if(p.count == 0)
     collect p
p = q;
p.count++;
```

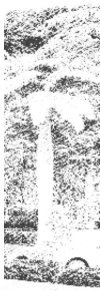


Mark and Sweep

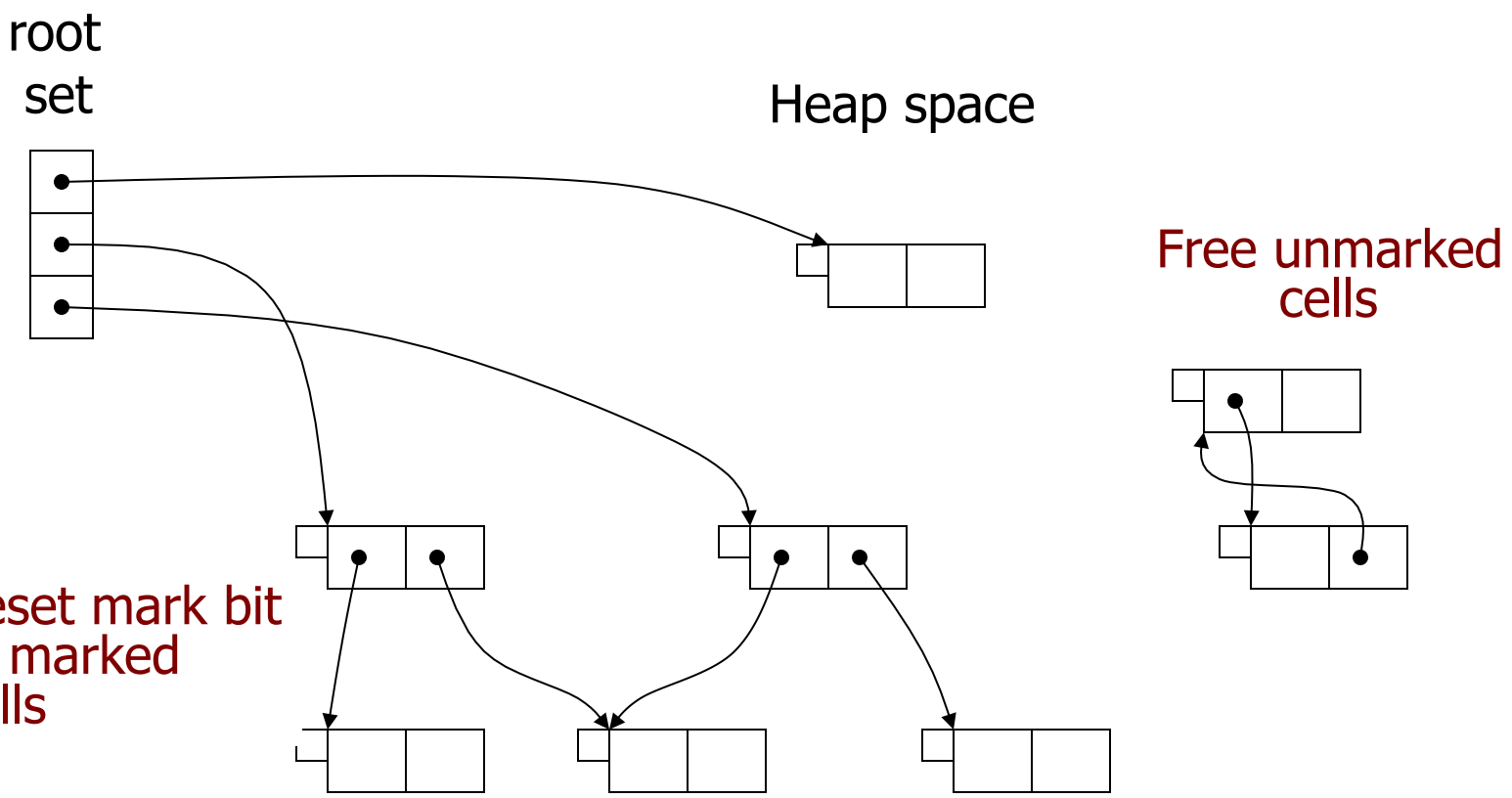
- Compute reachable nodes: Mark
  - Tracing garbage collector
- Freeing the not reachable nodes: Sweep
- Run when out of memory: Allocation

Properties:

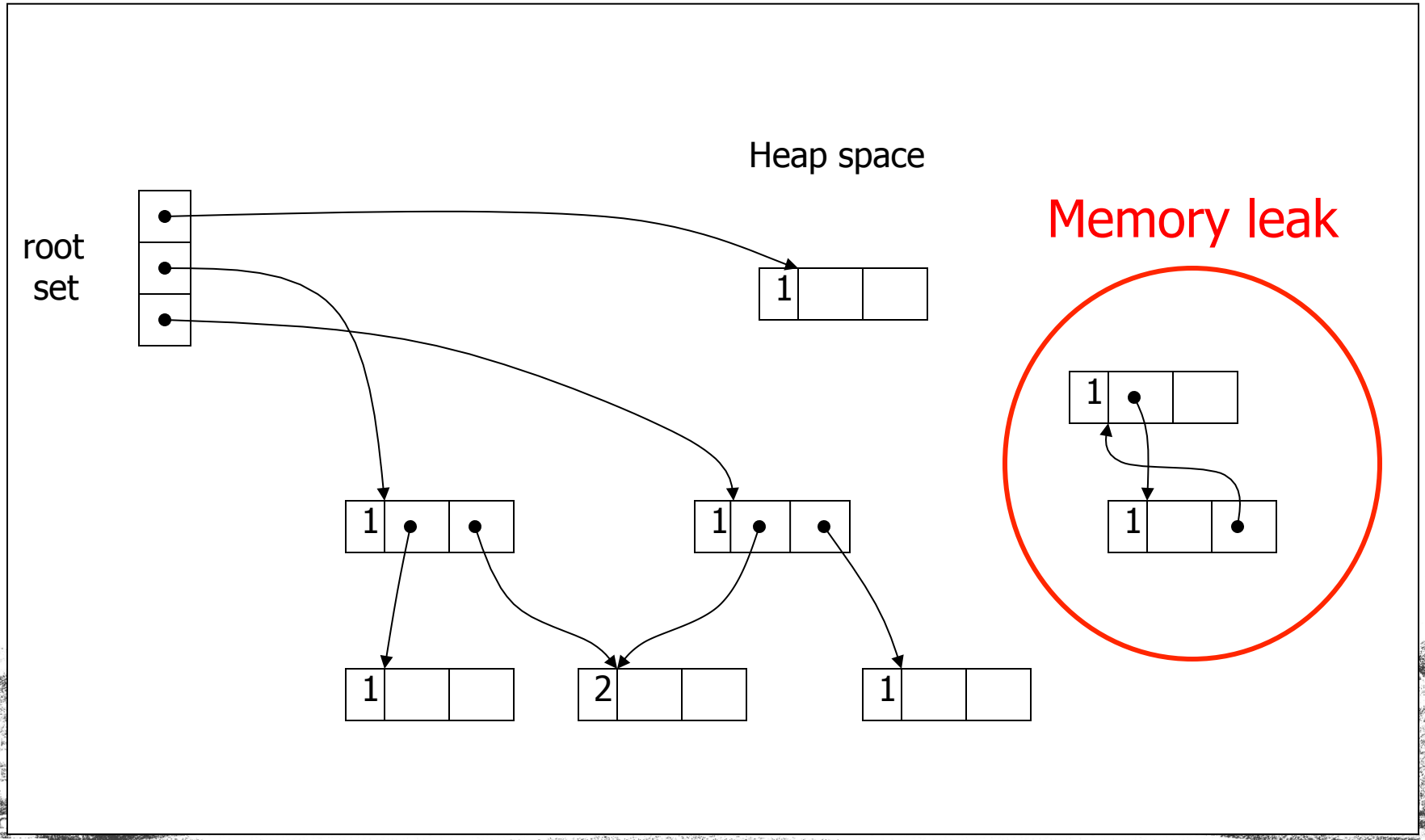
- Covers cycles and sharing
- Time depends on
  - live nodes (mark)
  - live and garbage nodes (sweep)
- Computation must be stopped
  - non-interruptible stop/start collector
  - long pause
- Nodes remain unchanged (as not moved)
- Heap remains fragmented



Mark-Sweep Example

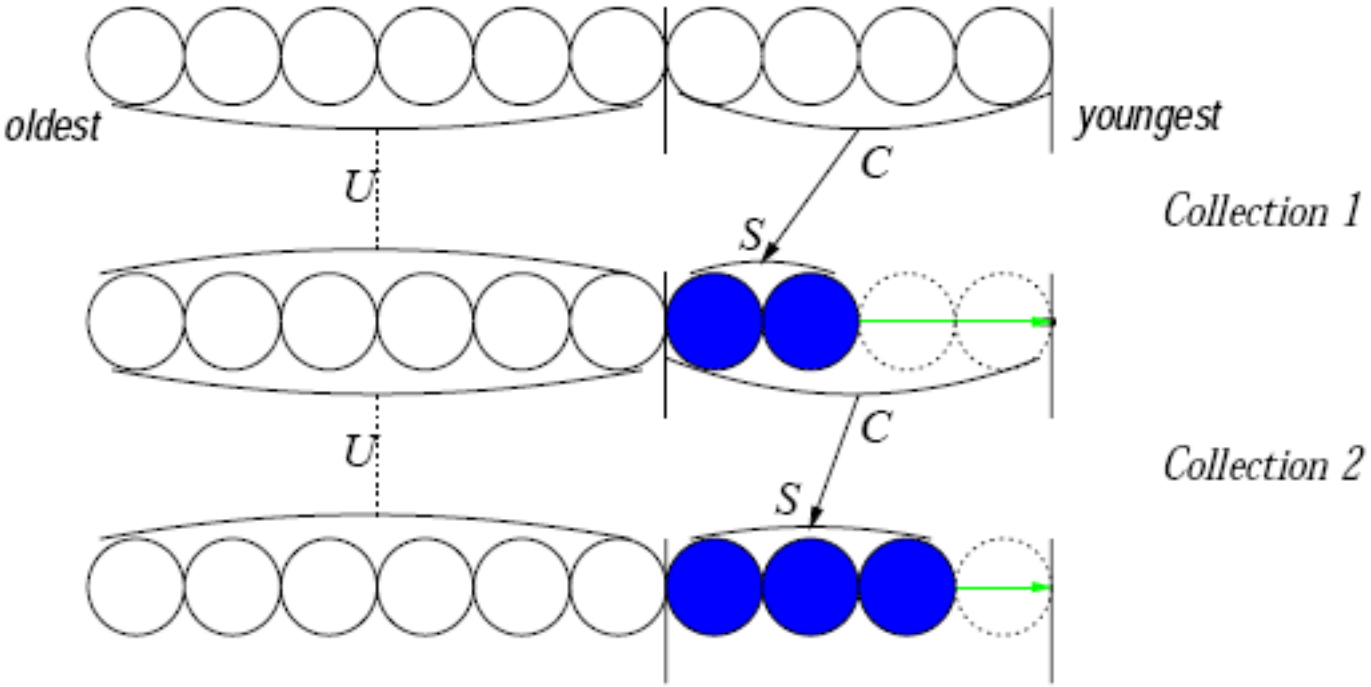


Mark and Sweep



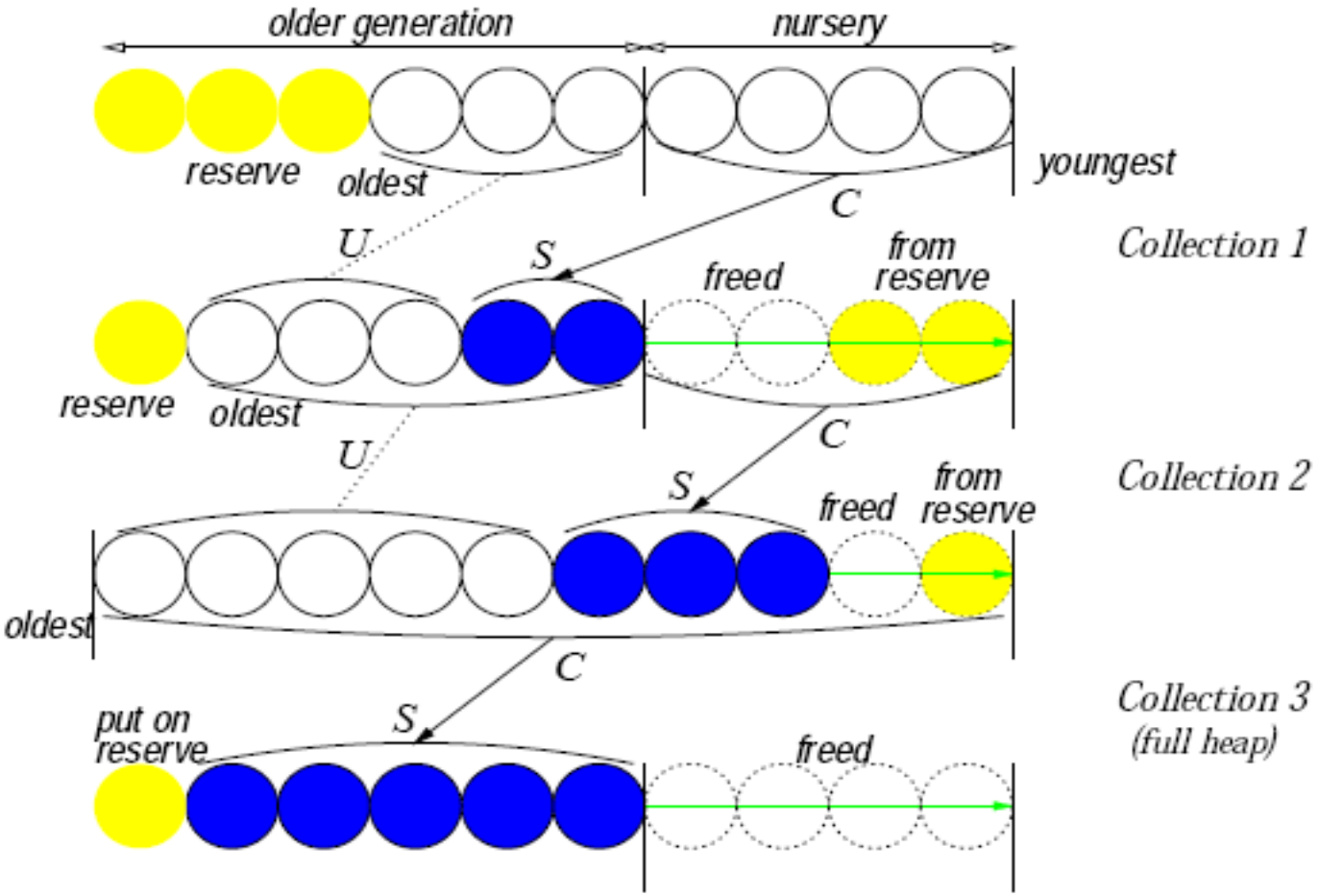
Age Based Collectors

- Use Age ordered list
- Youngest-only (YO) collection



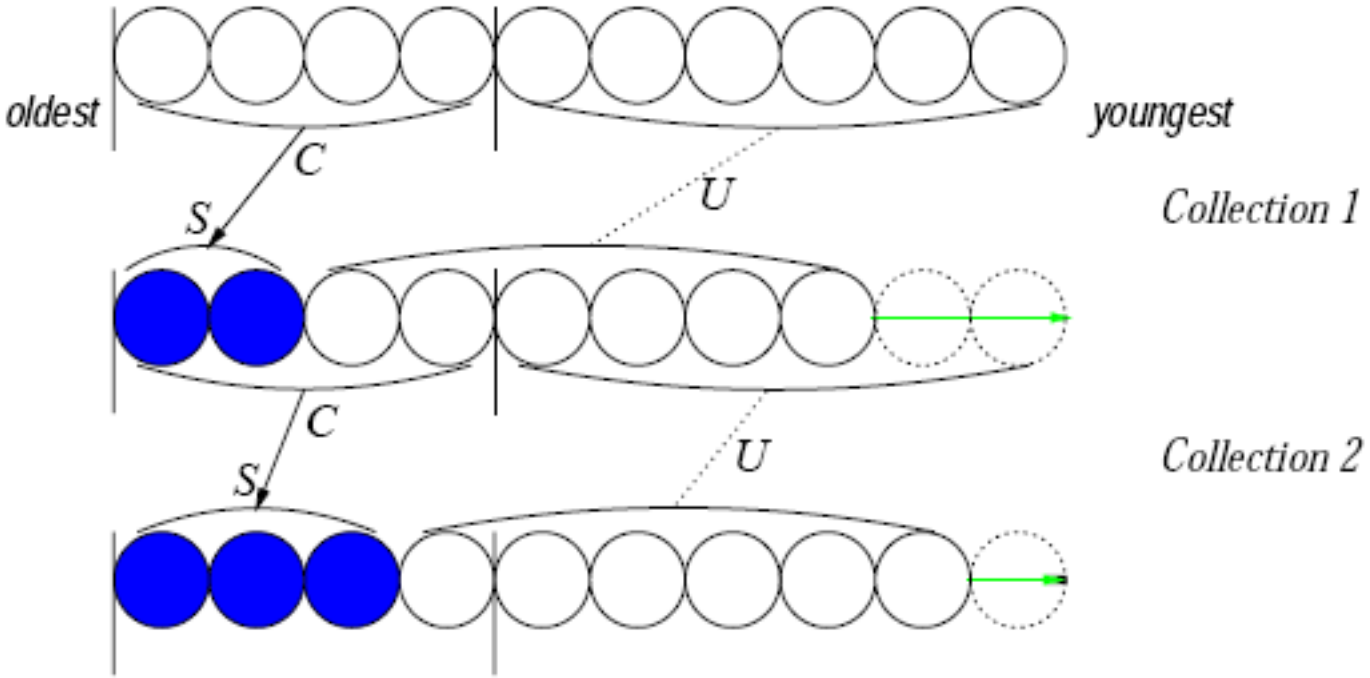
Generational Younger-Only

- Generational Younger-only collection



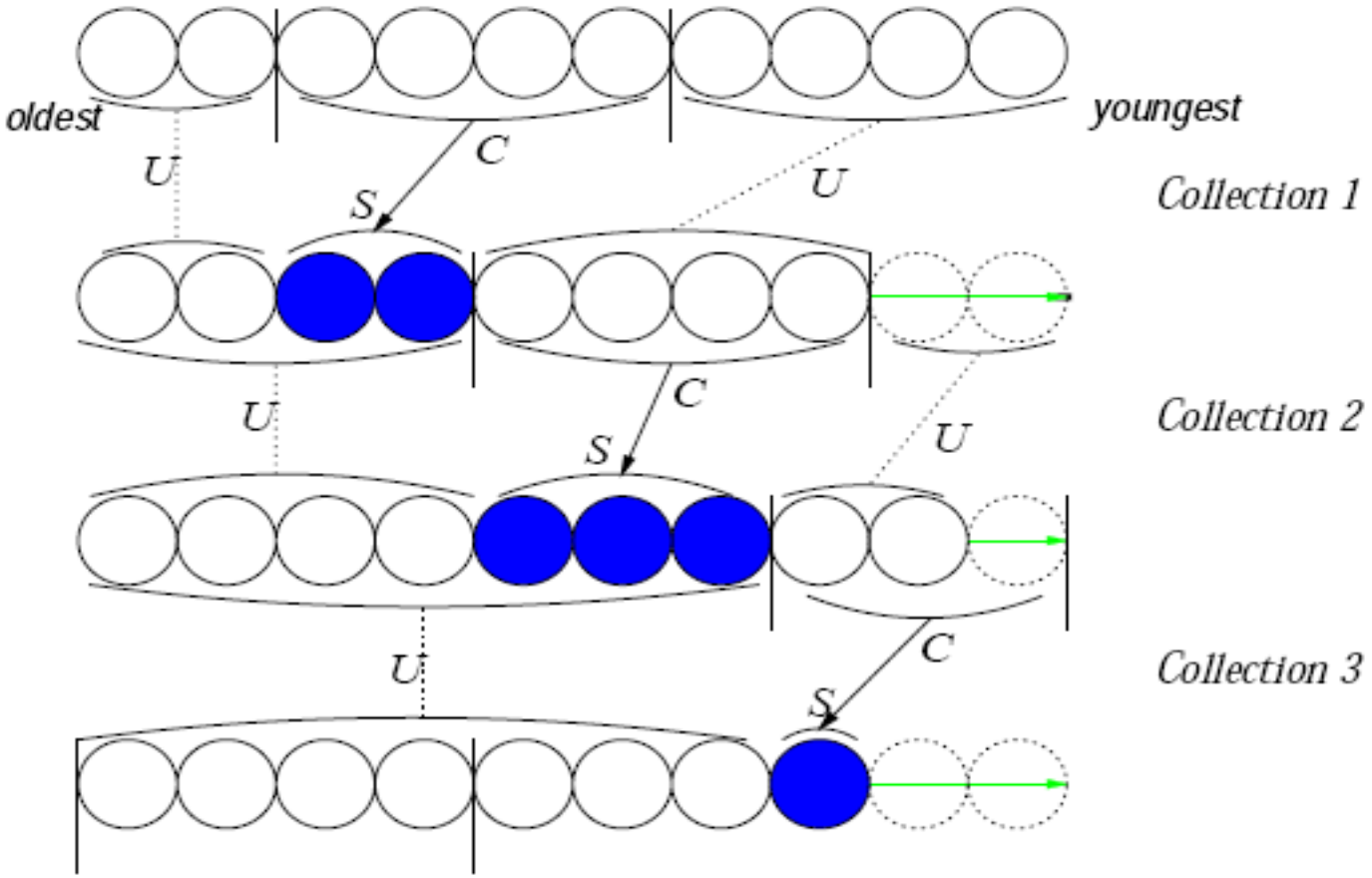
Older Only

- Older only collection



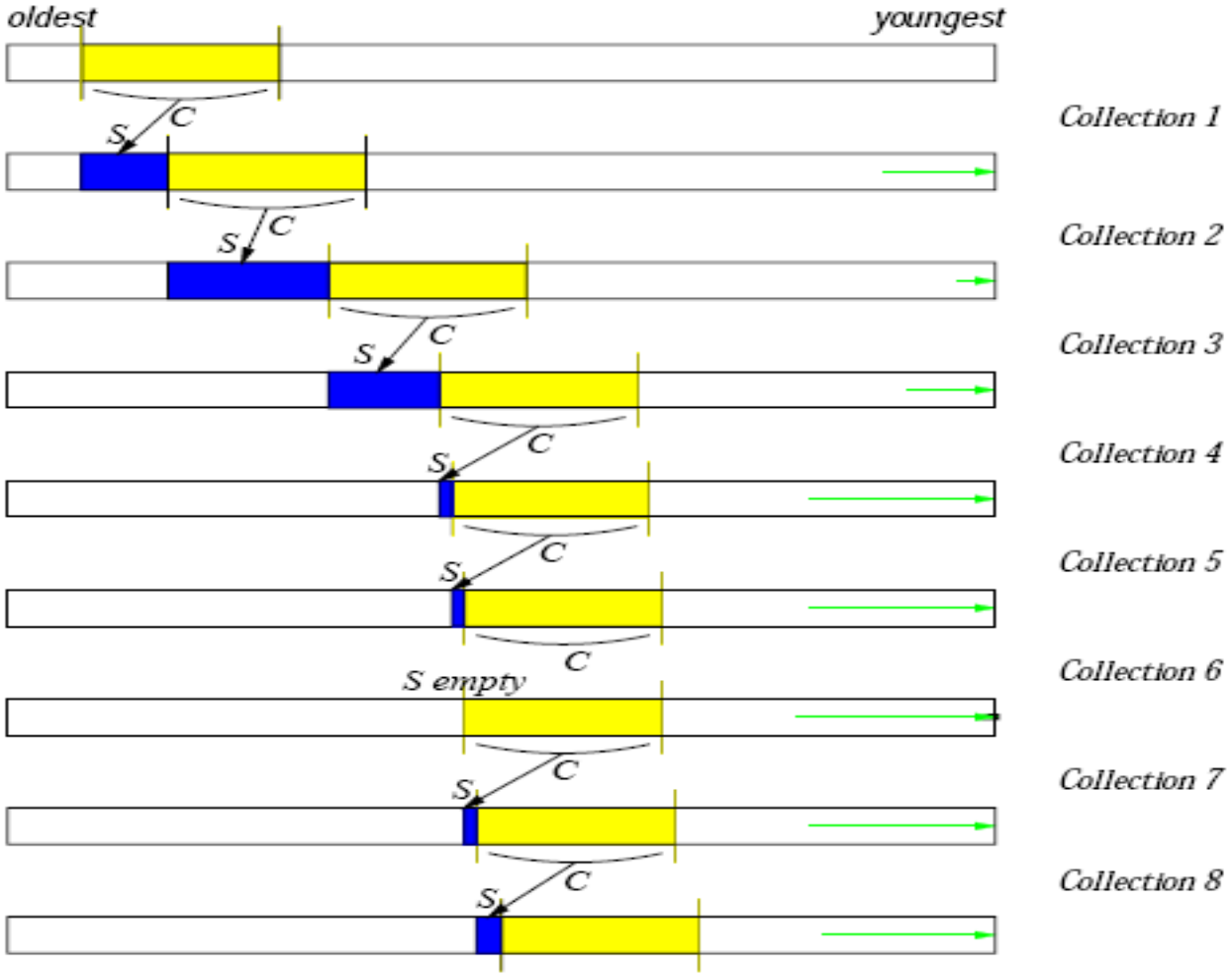
Older First Only

✧ Let us look at the following:



Older First Window Motion

✧ Let us look at the following:



Exercise - 9

- **Perform Various Garbage Collection Algorithms**
  - Mark and Sweep
  - Collector Based GC
  - Age Based GC

Assignments / Penalties

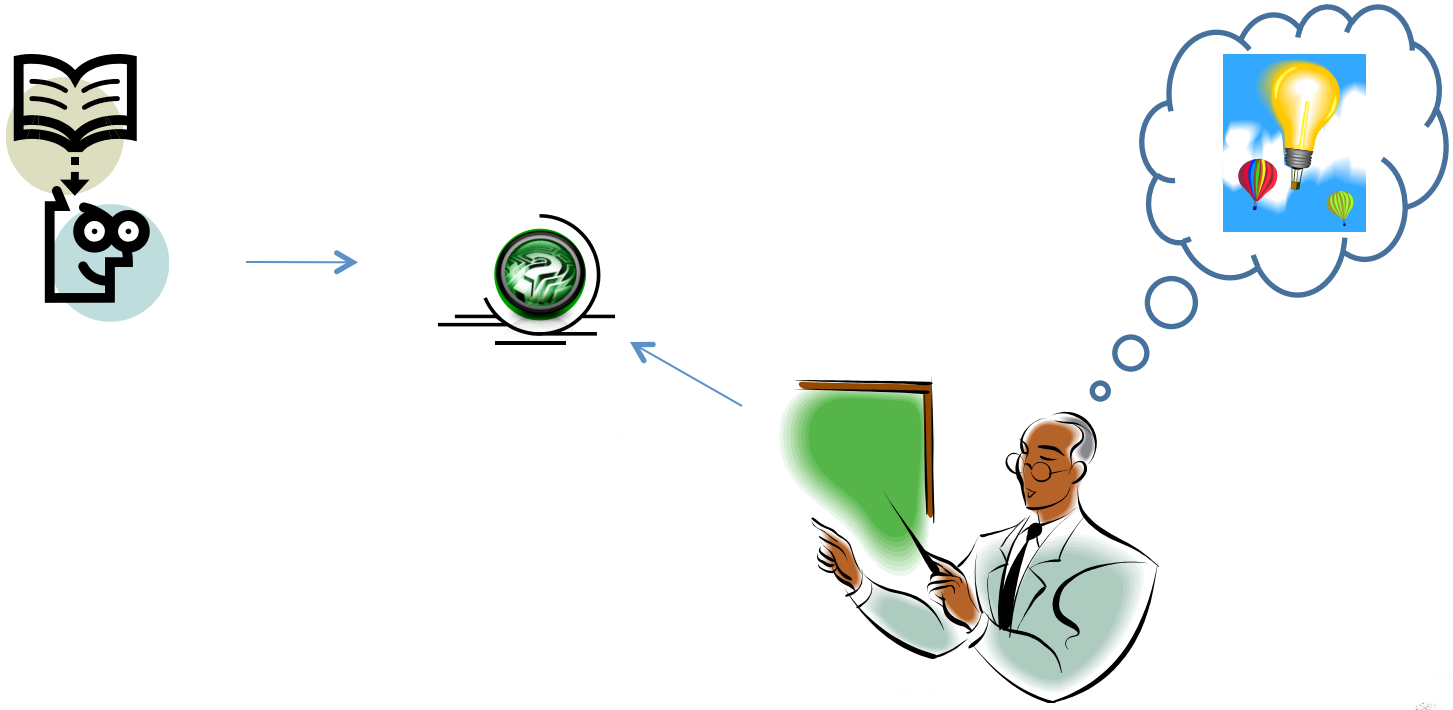
- Every Student is expected to complete the assignments and strictly follow a fair Academic Code of Conduct to avoid severe penalties

- Penalties would be heavy for those who involve in:
  - **Copy and Pasting** the code
  - **Plagiarism** (copied from your neighbor or friend – in this case, both will get "0" marks for that specific take home assignments)
  - If the candidate is **unable to explain his own solution**, it would be considered as a "copied case" !!
  - **Any other unfair means** of completing the assignments

Assistance

- You may post your questions to me at any time
- You may meet me in person on available time or with an appointment
- You may leave me an email any time
  (email is the best way to reach me faster)

Thanks …



… Questions ???