

CSc 520 — Principles of Programming Languages

12 : Garbage Collection — Discussion

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Unobtrusive Garbage Collection

1 Unobtrusive Garbage Collection

GC Requirements:

batch programs: We want short total GC time.

interactive programs: We want unnoticable GCs.

Unobtrusive GC:

Incremental Collection

- Do a little GC-work every time an object is allocated, or a pointer is changed.

Concurrent Collection

- Run the collector and the program in different processes, or on different processors.

2 Incremental GC

- Use **copying collection**, but rather than stop when you run out of memory and then do all the GC work in one shot, do a little bit whenever a pointer variable is referenced or when a new object is allocated.
- We start out by forwarding (copying) the objects pointed to by global variables.
- Then, instead of continuing forwarding recursively, we resume the program.
- Every time a pointer is referenced we check to see whether it is pointing into **from-space**. If it is, we forward that object too.

3 Incremental GC...

- Even objects which are not explicitly referenced have to be checked, to see if they have become garbage. Therefore, every time we allocate a new object we forward k pointers. A good value for k has to be determined by experimentation.
- Eventually **scan** will catch up with **next** and we switch **from-space** and **to-space** and start an new cycle.
- Baker's algorithm (on the next slide) is a variant of **copying collection**.

4 Incremental GC...

1. Copy and update objects pointed to by global pointers to **to-space**.
2. Resume program.
3. When an object in **from-space** is referenced, first copy it to **to-space**.

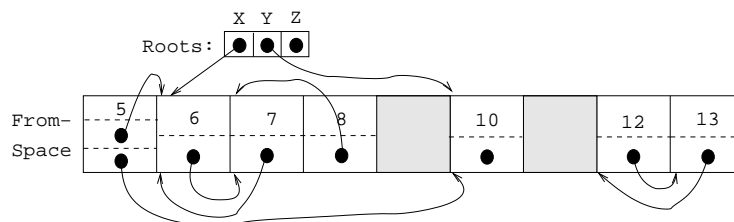
```
p := x ↑.next;  
    ↓ (implemented as)  
IF x ∈ from-space THEN  
    copy x to to-space;  
    update x, scan, and next;  
    x := x's new address in to-space;  
END;  
p := x ↑.next;
```

4. Every time **NEW** is called, k pointers are forwarded.

5 Exam Problem

1. Why is generational collection more appropriate for functional and logic languages (such as LISP and Prolog), than for object-oriented languages (such as Eiffel and Modula-3)?
2. The heap in the figure on the next slide holds 7 objects. All objects have one integer field and one or two pointer fields (black dots). The only roots are the three global variables X, Y, and Z. Free space is shaded. Show the state of **To-Space** after a copying garbage collection has been performed on **From-Space**. Note that several answers are possible, depending on the visit strategy (Depth-First or Breadth-First Search) you chose.

6 Exam Problem I...



7 Exam Problem...

1. Name five garbage collection algorithms!

2. Describe the **Deutsch-Schorr-Waite algorithm**! When is it used? Why is it used? How does it work?
3. What are the differences between **stop-and-copy**, **incremental** and **concurrent** garbage collection? When would we prefer one over the other?

8 Readings and References

- Read Scott, pp. 395–401.
- Apple’s Tiger book, pp. 257–282
- Topics in advanced language implementation, Chapter 4, Andrew Appel, Garbage Collection. Chapter 5, David L. Detlefs, Concurrent Garbage Collection for C++. ISBN 0-262-12151-4.
- Aho, Hopcroft, Ullman. Data Structures and Algorithms, Chapter 12, Memory Management.

9 Readings and References...

- Nandakumar Sankaran, A Bibliography on Garbage Collection and Related Topics, ACM SIGPLAN Notices, Volume 29, No. 9, Sep 1994.
- J. Cohen. Garbage Collection of Linked Data Structures, Computing Surveys, Vol. 13, No. 3, pp. 677–678.