CSc 520

Principles of Programming Languages

12 : Garbage Collection — Discussion

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Unobrusive Garbage Collection

Unobrusive 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.

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.

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.

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 `:=` $x\uparrow$`.next;`

   $\Downarrow$ `(implemented as)`

   IF $x \in \mathtt{from-space}$ **THEN**

   `copy` x `to to-space;`

   `update` x`, scan, and next;`

   x `:=` x`'s new address in to-space;`

   END`;`

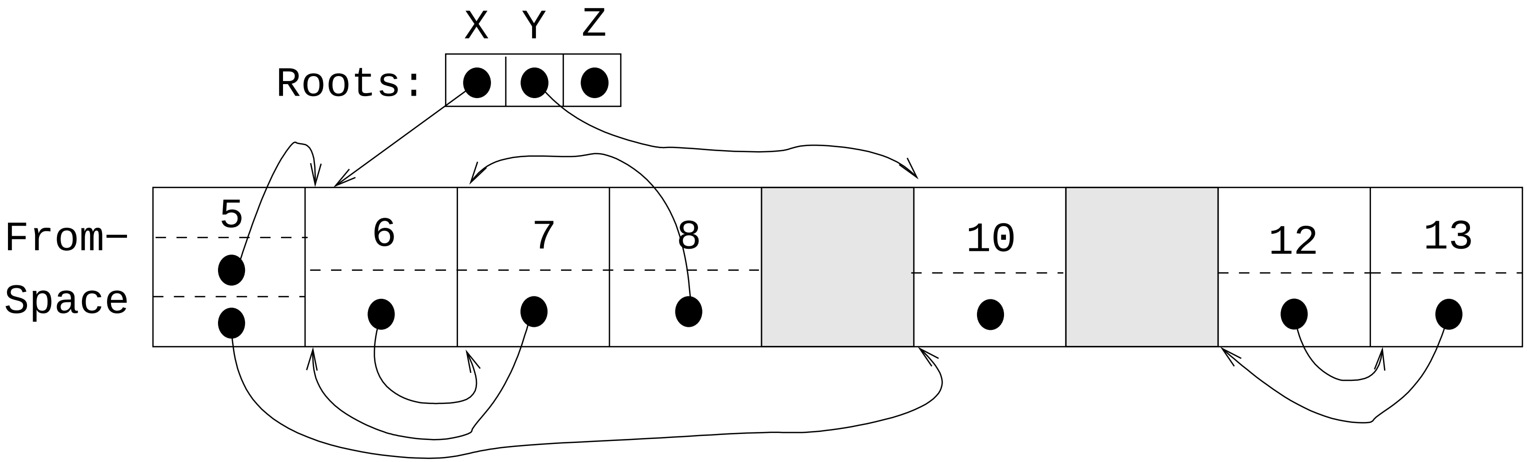
   p `:=` $x\uparrow$`.next;`

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

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.

Exam Problem I...



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?

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.

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.