

Assignment Project Exam Help
COMP0020 Functional Programming
Lecture 20
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Garbage Collection Techniques
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Motivation

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- Beta reduction in Miranda can cause heap cells to become detached from the program graph
- Similar effects in Java
- Fixed heap size – limited resources
- How do we reuse (recycle) memory?

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Motivation

- We need to :
 - ▶ Find which cells are no longer required by the program
 - ▶ Make those cells available to the memory allocator
- Unreferenced cells are called GARBAGE
- Key technique : “GARBAGE COLLECTION”
- Three popular variants :
 - ▶ Mark-scan
 - ▶ Two-space (or “semi-space”) copying
 - ▶ Reference counting

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1. Mark-scan

- Triggered when program has used $> 80\%$ of heap
- Evaluation suspended until collector finished
- May happen many times during program
- Mark :
 - ▶ Follow pointers from root cell of program and mark all reachable cells (set “mark bit” to 1)
- Scan :
 - ▶ All cells in the heap
 - ★ if marked, set mark bit to 0 (ready for next mark)
 - ★ else attach cell to free list

1. Mark-scan

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- Mark-scan uses a FREE LIST for allocation
 - ▶ A linked list of cells which are available for use by the program
 - ▶ Before program starts, ALL cells are on free list
 - ★ Then program is loaded
 - ★ Then program is run
 - ▶ Scanner re-creates the free list by linking all unused cells
 - ▶ Cells are unlinked from free list when allocated

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2. Two-space copying

- The two-space collector must :
 - ▶ Follow pointers from the root cell of the program in FROM space, COPY each cell into TO-space and update any pointers to that cell so they now point to the copy in TO-space.
 - ▶ Swap the names/roles of FROM-space and TO-space
 - ▶ Allow evaluation to proceed
- Garbage is “left behind” after copying
- Allocation is by simple (fast) pointer-increment

3. Reference Counting

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- Each cell is extended with a reference count field
- The reference count keeps track of how many pointers are pointing to this cell :
 - ▶ Each new pointer to this cell causes its reference count to be incremented
 - ▶ Each deletion of a pointer to this cell causes its reference count to be decremented
- Any cell with a reference count of 0 is garbage.
- All cells with reference count 0 are on FREE LIST

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Comparison

- Overheads :

- ▶ iMark-scan :

- ★ 1 bit per cell
 - ★ + a stack for traversal (or use pointer-reversal)

- ▶ Copying :

- ★ 100% space overhead

- ▶ Reference count :

- ★ typically 32 bits per cell
 - ★ + time overhead (when copy/delete pointer, must also read in and modify the cell it points to!)

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Comparison

- Compaction/fragmentation

- ▶ Mark-scan :

- ★ Must run separate compactor (during scan phase) to reduce fragmentation

- ▶ Copying :

- ★ Inherently compacting
 - ★ No fragmentation immediately after copy (BUT remember 100% overhead)

- ▶ Reference counting :

- ★ Must run separate compactor to reduce fragmentation

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Comparison

- Small program in big heap :
 - ▶ Mark-scan : visits ALL heap cells (slow)
 - ▶ Copying : only visits program cells (fast)
 - ▶ Reference count : only visits cells in use (fast)
- Large program (nearly fills heap)
 - ▶ Mark-scan : performance degrades
 - ▶ Copying : performance degrades
 - ▶ Reference count : unaffected

Comparison

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- Cyclic structures in heap : <https://powcoder.com>
 - ▶ Mark-scan : unaffected
 - ▶ Copying : unaffected
 - ▶ Reference count : needs special attention !

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Summary

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END OF LECTURE
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