

COMP0020 Functional Programming

Lecture 18

Automatic Memory Management

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What is Dynamic Memory Management (DMM) ?

- Problem to be solved : (i) don't know until run time what memory will be needed ; and (ii) desire to re-use memory locations (memory is a scarce resource)
- Problem to be solved : required blocks of memory may be of differing sizes
- A solution : write a Storage Manager (SM) library, with functions “malloc” and “free”
- Give malloc the size of memory required, it returns a pointer
- Give free a pointer to a block that is not longer required, it makes it available for re-use
- The library functions will manage the differently-sized blocks of “live” and “free” memory in an optimal way

What is AMM ?

- Biggest source of bugs : POINTERS
- A solution :
 - ▶ Don't let programmers have direct access to memory locations (NO POINTERS)
 - ▶ Let system manage memory allocation/deallocation
 - ▶ Functional languages, Java
- An onerous responsibility for the system
 - ▶ must never go wrong

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How does AMM work ?

- Just like DMM, a storage manager (SM) subroutine services requests from the rest of the program
 - ▶ Program (runtime system) requests “N bytes of memory” from the SM
 - ▶ SM :
 - ★ searches for appropriate chunk of “free” memory
 - ★ Allocates the chunk (tags it “in use” or “live”)
 - ★ returns a pointer to that chunk
 - ▶ Programmer never sees the pointer – only used by runtime system
- SM detects when “in use” chunk becomes garbage and tags it “free”

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How does AMM work ? (2)

- Memory allocation techniques
 - ▶ Which chunk (block) of memory should the SM return in response to a request ? Does it matter ?
- Garbage collection techniques
 - ▶ How to identify garbage
 - ▶ How to collect garbage
- Compaction/defragmentation techniques
 - ▶ How does fragmentation occur
 - ▶ How can it be reduced or removed

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Issues : Garbage collection

- How is garbage created?
▶ Beta reduction, delta reduction ...
- How is garbage identified?
▶ Number of references? ... or connectivity
- How is garbage collected?
▶ Use a free list? ... or not
- How is garbage reused?
▶ Cooperation with memory allocation

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Issues : how much does it cost ?

- Time Assignment Project Exam Help
 - ▶ Performance degradation
 - ▶ Embarrassing pause ? <https://powcoder.com>
 - ★ Real-time systems ?
- Space Add WeChat powcoder
 - ▶ Some memory set aside for administration ?
 - ▶ Some extra memory required per cell ?
 - ▶ Size of code ?

Issues : fragmentation

- What is it ?
- Why is it a problem ?
 - ▶ Embedded systems
 - ▶ Virtual memory - paging overhead
- How can it be solved ?
 - ▶ Coalescing
 - ▶ Compaction :
 - ★ Copying
 - ★ Sliding

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Summary

- What is AMM ?
 - ▶ Programmer control vs system control
 - ▶ Reuse/recycling of memory
- How does AMM work ?
 - ▶ Memory allocation
 - ▶ Garbage collection
- Issues
 - ▶ How is garbage created, detected, reused ?
 - ▶ What overheads do we incur ? (space/time)
 - ▶ Fragmentation

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