Software Development for Embedded Systems

Witawas Srisa-an

CSCE 496: Embedded Systems Design and Implementation

Reminder

- Homework on Gaussian Filter is due on Wednesday before 11:59 pm
  - if you are having difficulties reading the provided image file, be sure to read the help page on fopen in the Stretch IDE
- Any questions about malloc?

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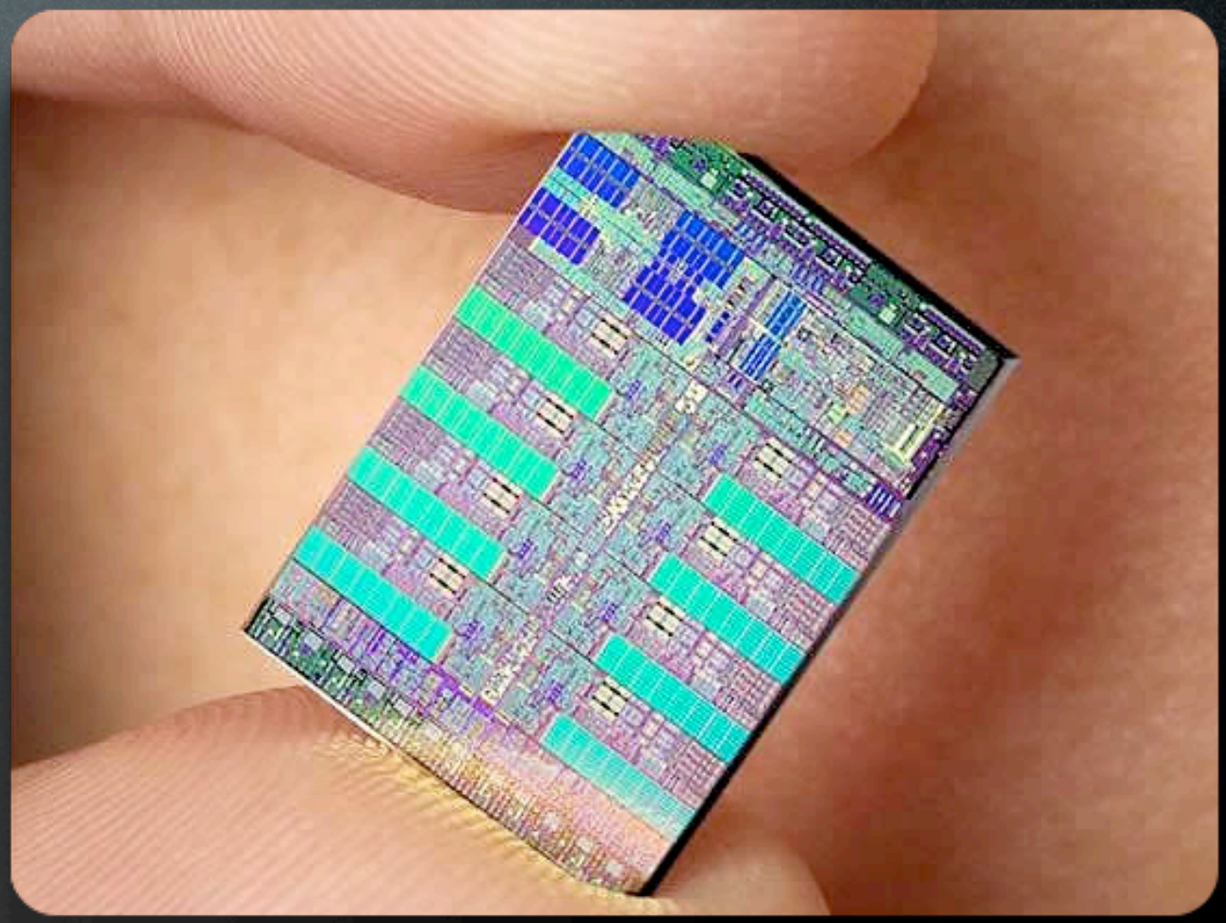
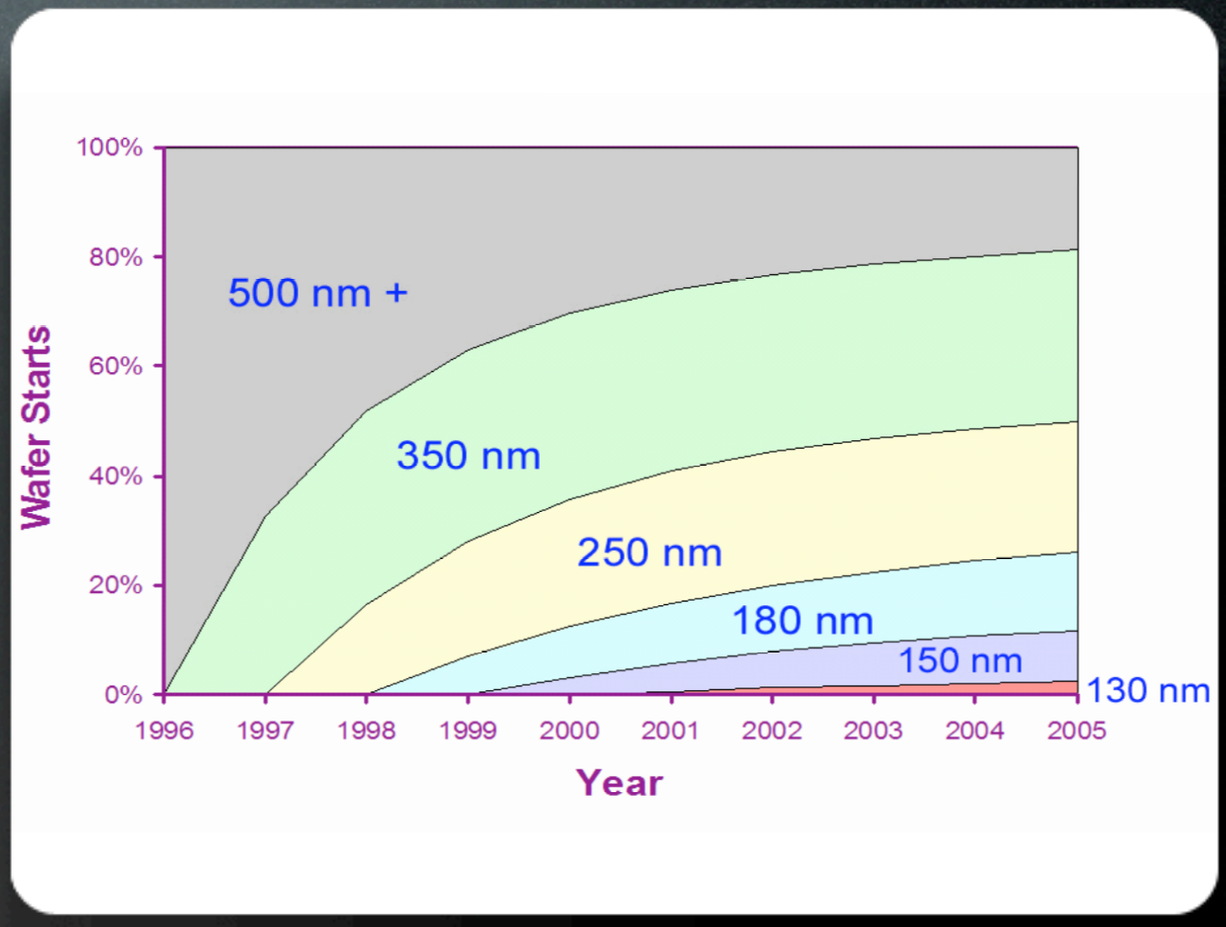
Hardware Trends

- Proliferation of complex embedded systems
  - powerful processors
    - feature-rich (e.g. Cell, Stretch, ARM)
  - advanced runtime support
    - similar features found in processors for desktop and server systems (e.g. MMU, multi-core, fast bus, etc.)



Hardware Trends

- We are reaping the major benefit of Moore's law
  - old processors don't go away
    - powerful enough for day-to-day applications
    - very low cost



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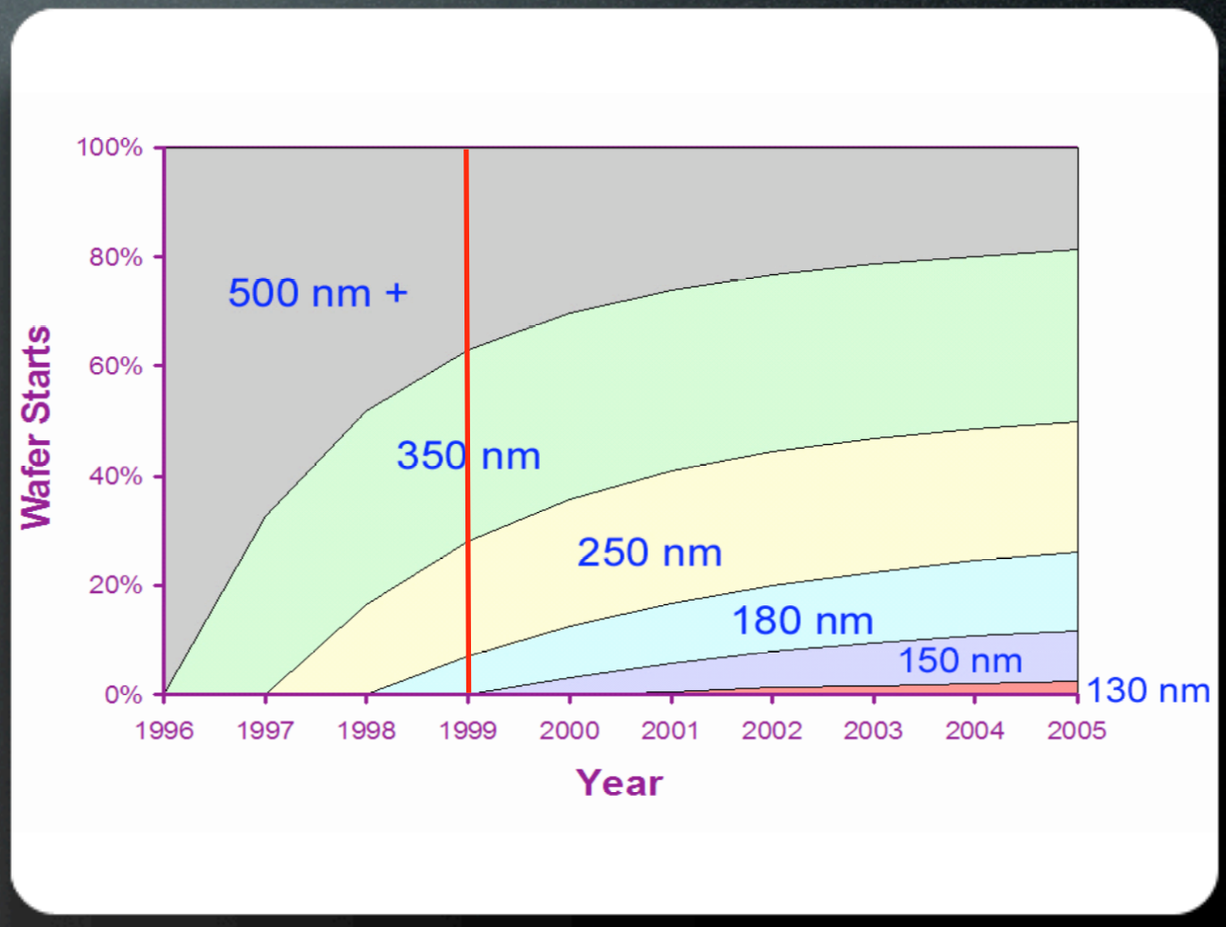

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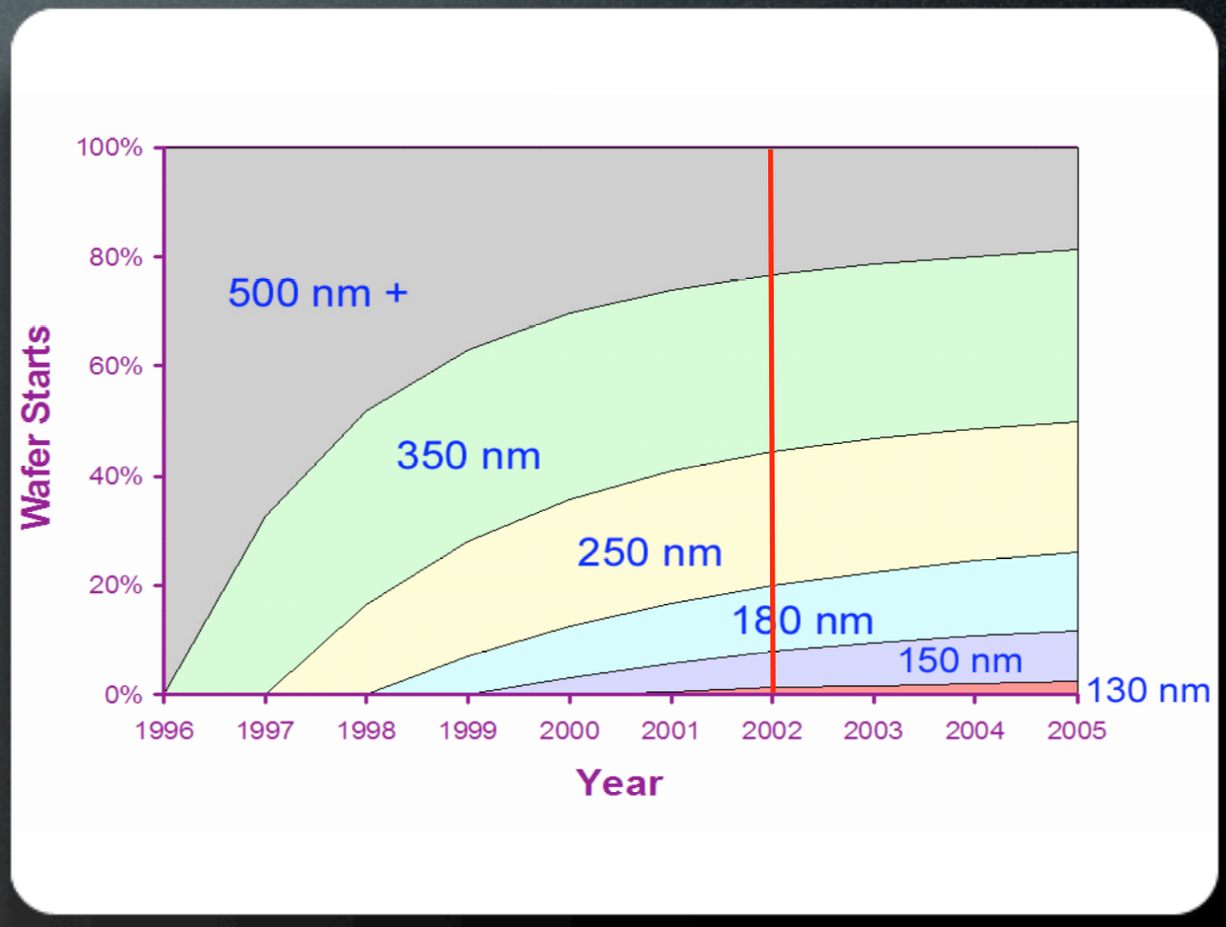

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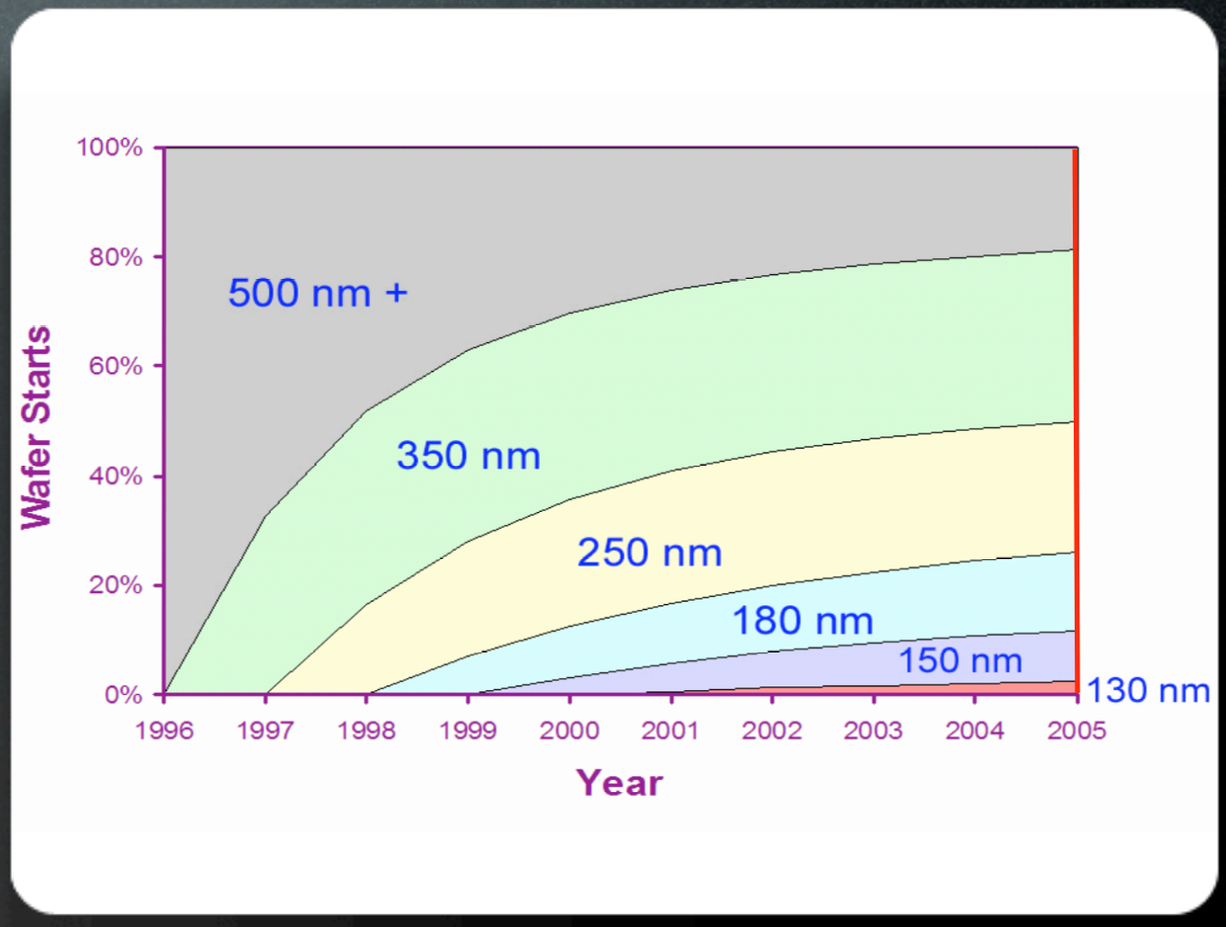

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Software Trends

- Complex software systems
  - why not? The hardware can handle it!
- Avionic Software for Boeing ScanEagle UAV > 300,000 line of code

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Software Trends

- Feature-rich runtime support
  - full-fledged desktop/ server operating systems in embedded devices
  - capability to run more complex software systems on these machines

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Software Trends

- Leverage mobile/ embedded devices to provide services
  - Telesensing from Lucent
    - prevent Sudden Infant Death Syndrome, detect sleep apnea, etc.
  - Full-fledged web browsers, calendars, file servers, etc.

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Software Trends

- Assume heterogeneous platforms
  - the billionth handset shipped in 2006
    - build for portability
    - build for generic input/output devices
  - about 20+ operating systems for these devices
    - build to interface with underlying runtime support features

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Software Trends

- Summary
  - large software systems now and larger in the future
    - more software reuse?
  - assume heterogeneous platforms
    - must be portable
  - providing similar runtime features to much more complex systems

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Enabling Technologies

- Modern programming languages (e.g. Java, C#, VB.NET)
  - Object-oriented paradigm
    - promote code reuse
- Virtual Machine (VM) based systems
  - achieve portability but require complex runtime support
    - now available in many embedded devices

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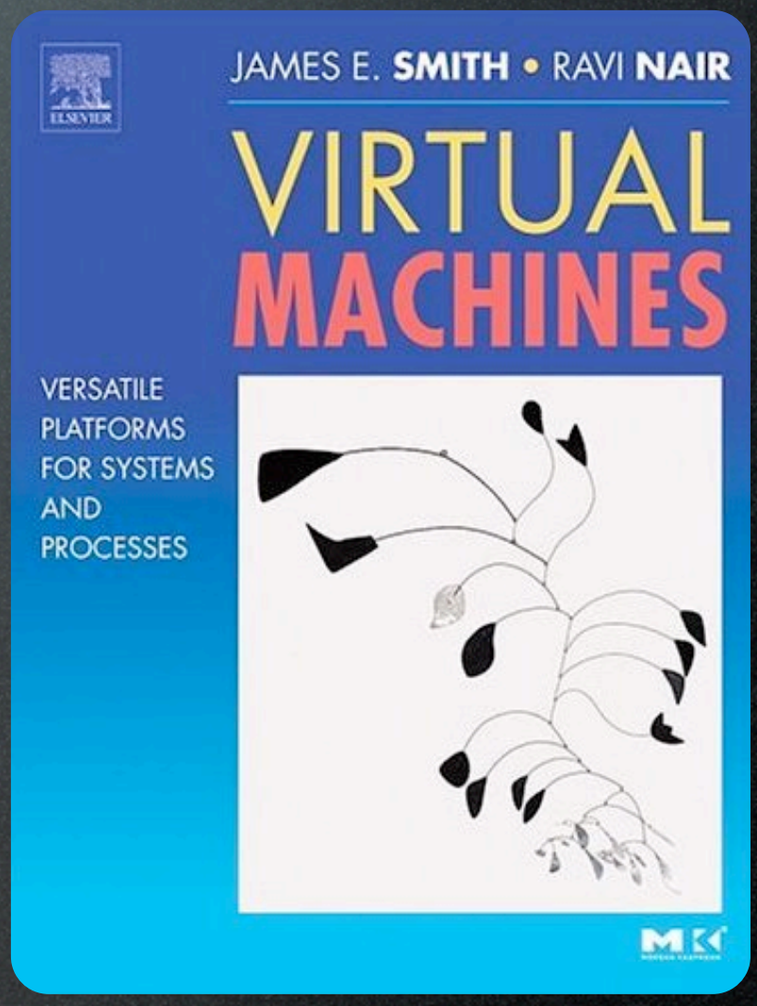
Virtual Machines

"A **virtual machine** is software that creates a virtualized environment between the computer platform and its operating system, so that the end user can operate software on an abstract machine."

Wikipedia



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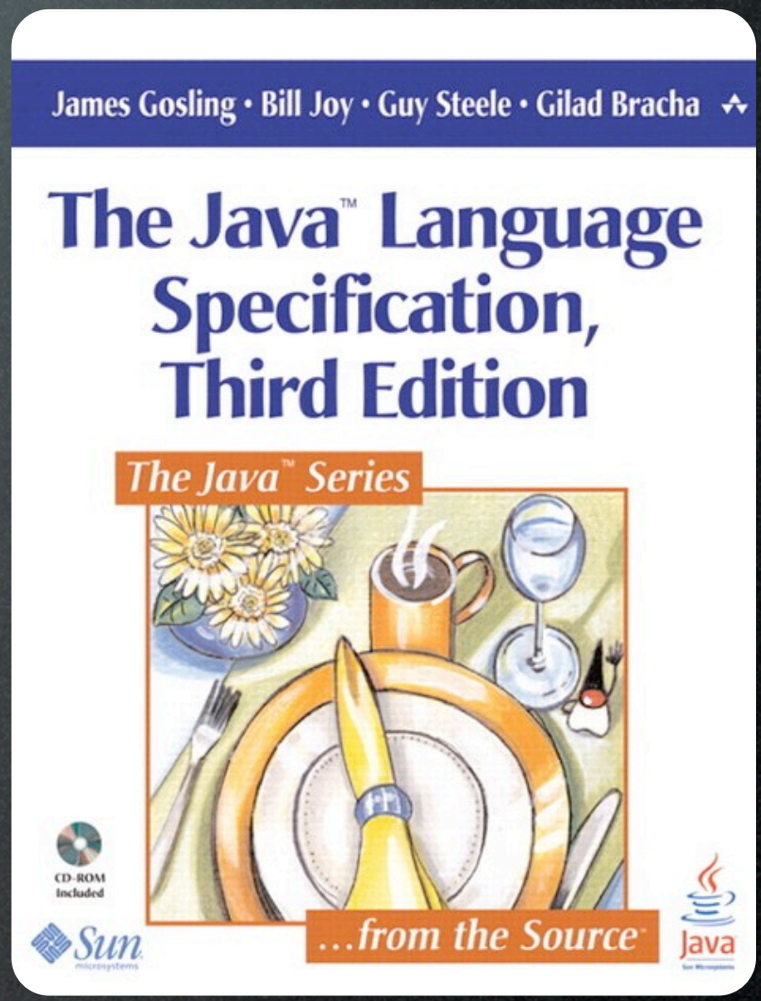
Java Virtual Machines

"A **Java Virtual Machine (JVM)** is virtual machine that interprets and executes Java bytecode. This code is most often generated by Java language compilers..."

Wikipedia



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Java Virtual Machines

- We'll look at the ones developed mainly by Sun Microsystems
  - HotSpot
  - CLDC HotSpot
  - KVM (Kilo Virtual Machine)
    - second most used VM in the world

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Java Virtual Machines

- We'll look at the ones developed mainly by Sun Microsystems

Trivia: What is the most used VM developed by Sun?

- CLDC HotSpot
- KVM (Kilo Virtual Machine)
  - second most used VM in the world

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Java Virtual Machines

- KVM vs. HotSpot
  - KVM is interpretation based
    - maximum portability
  - HotSpot combines interpretation and dynamic compilation
    - platform dependent

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Sidebar: Dynamic Compilation

- Interpreter is a big while loop with many case statements
  - each bytecode is translated to a predefine C/C+ function (e.g. new operator)
- Dynamic compiler takes each method and generates native code
  - can be optimized or non-optimized

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Sidebar: Dynamic Compilation

- Compilation strategies
  - always compile (e.g. .NET Compact Framework, Jikes RVM)
  - only compile frequently used methods
- Code size
  - a compiled method can be 6 to 8 times larger than its bytecode representation

Sidebar: Dynamic Compilation

- Storage
  - these compiled methods are stored in a dynamic memory region
    - separate code-cache or intermingled with objects in the heap
- Management strategies
  - flush when full, GC, etc.

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Java Virtual Machines

- KVM vs. HotSpot
  - KVM uses simple mark-sweep-compact garbage collection
    - simple but long execution pauses
  - HotSpot uses generational garbage collection
    - more complex with higher runtime overhead, but shorter pauses

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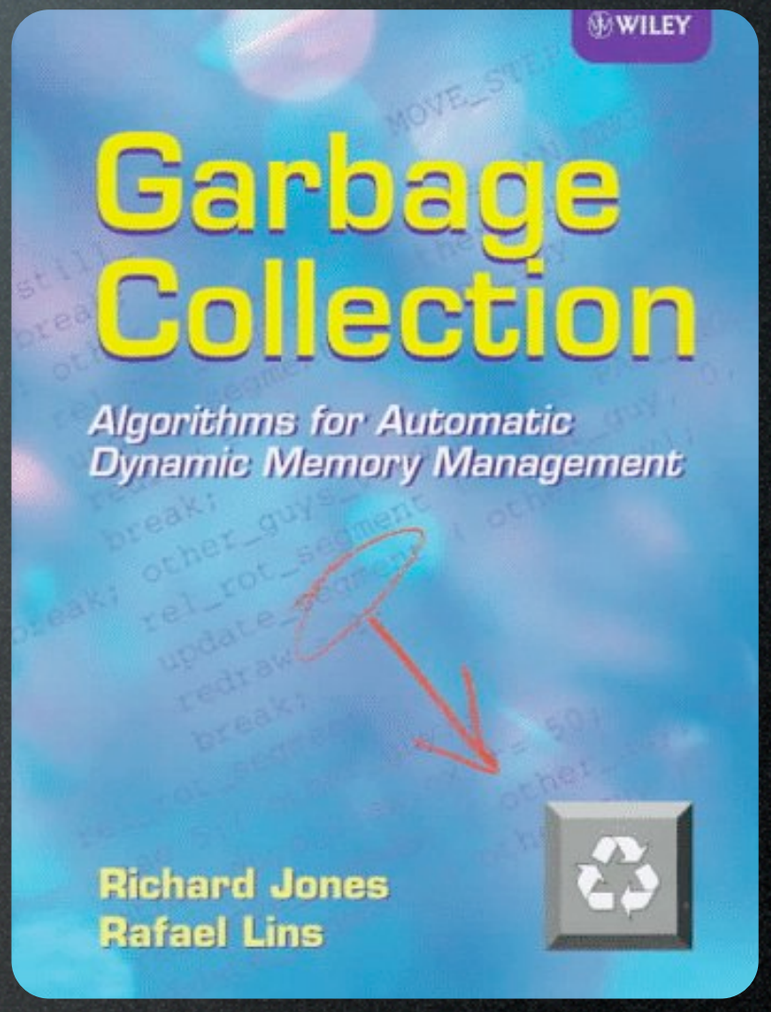
Sidebar: Garbage Collection

“Garbage Collection (**GC**) is a form of automatic memory management. The garbage collector attempts to reclaim garbage, or memory used by objects that will never again be accessed or mutated by the application.”

Wikipedia



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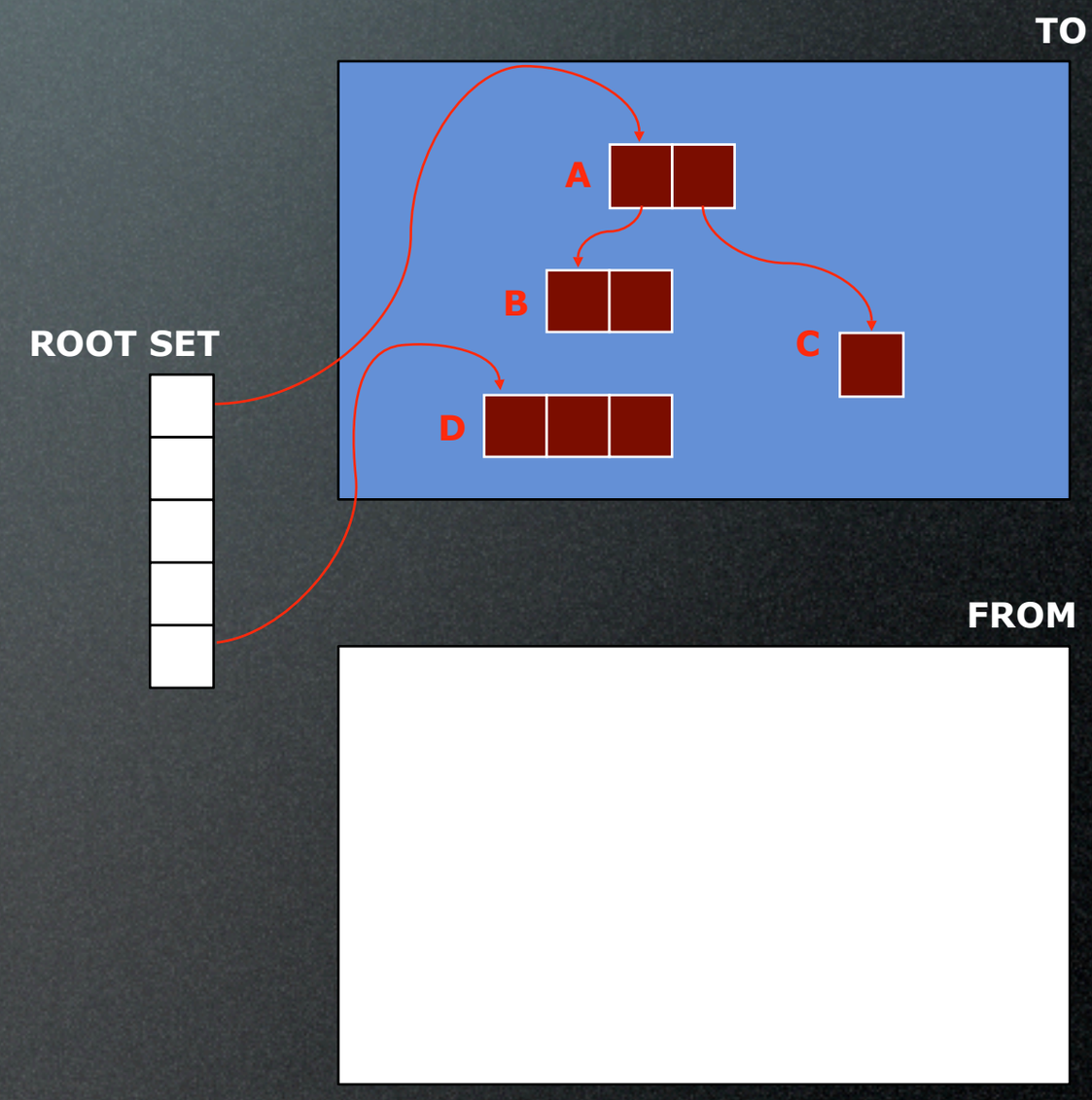
Sidebar: Garbage Collection

- Copying collector
  - split the heap in half, only one half is used each time
  - when the half is full, migrate surviving objects to the other half then allocate new objects from there



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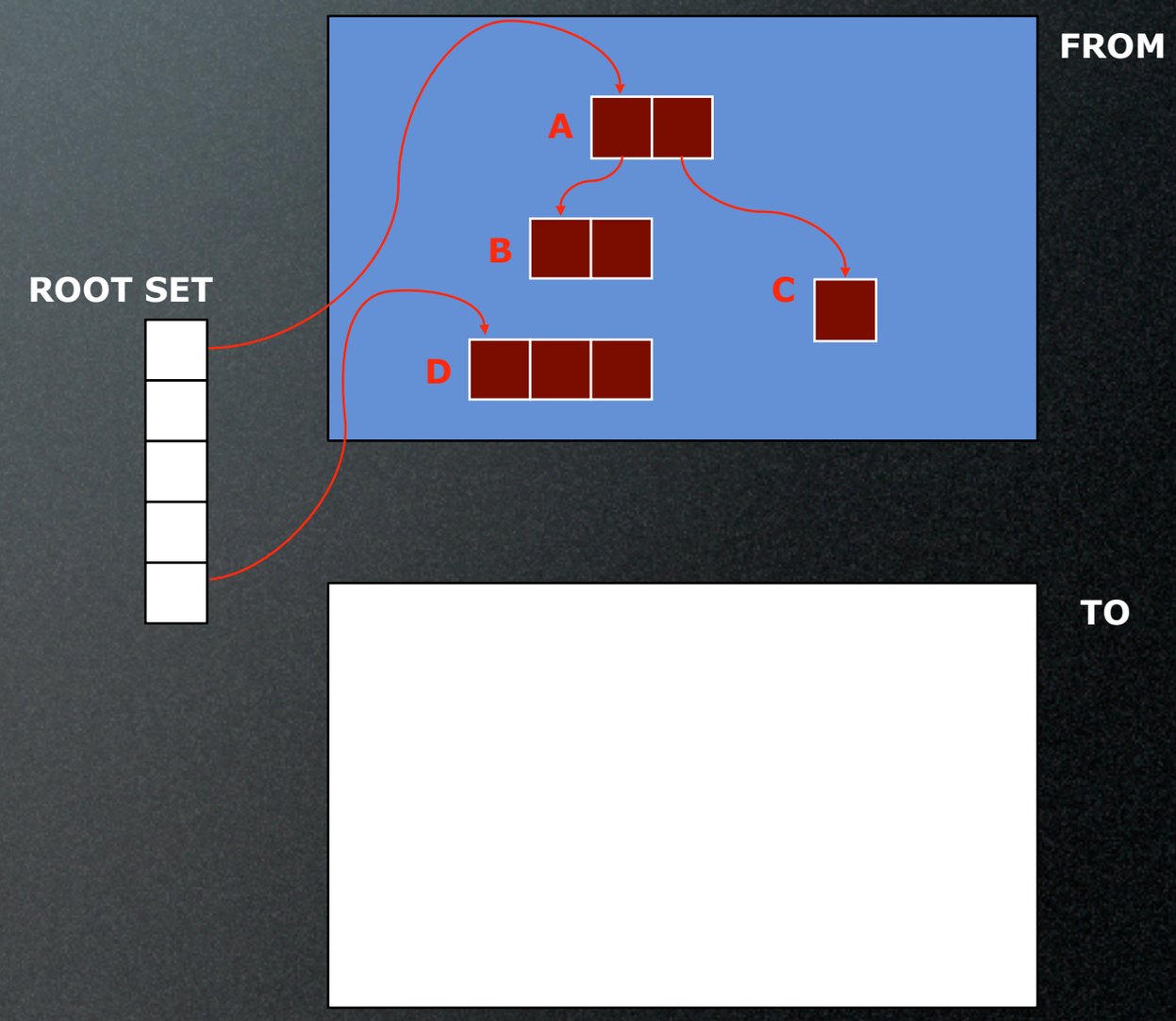

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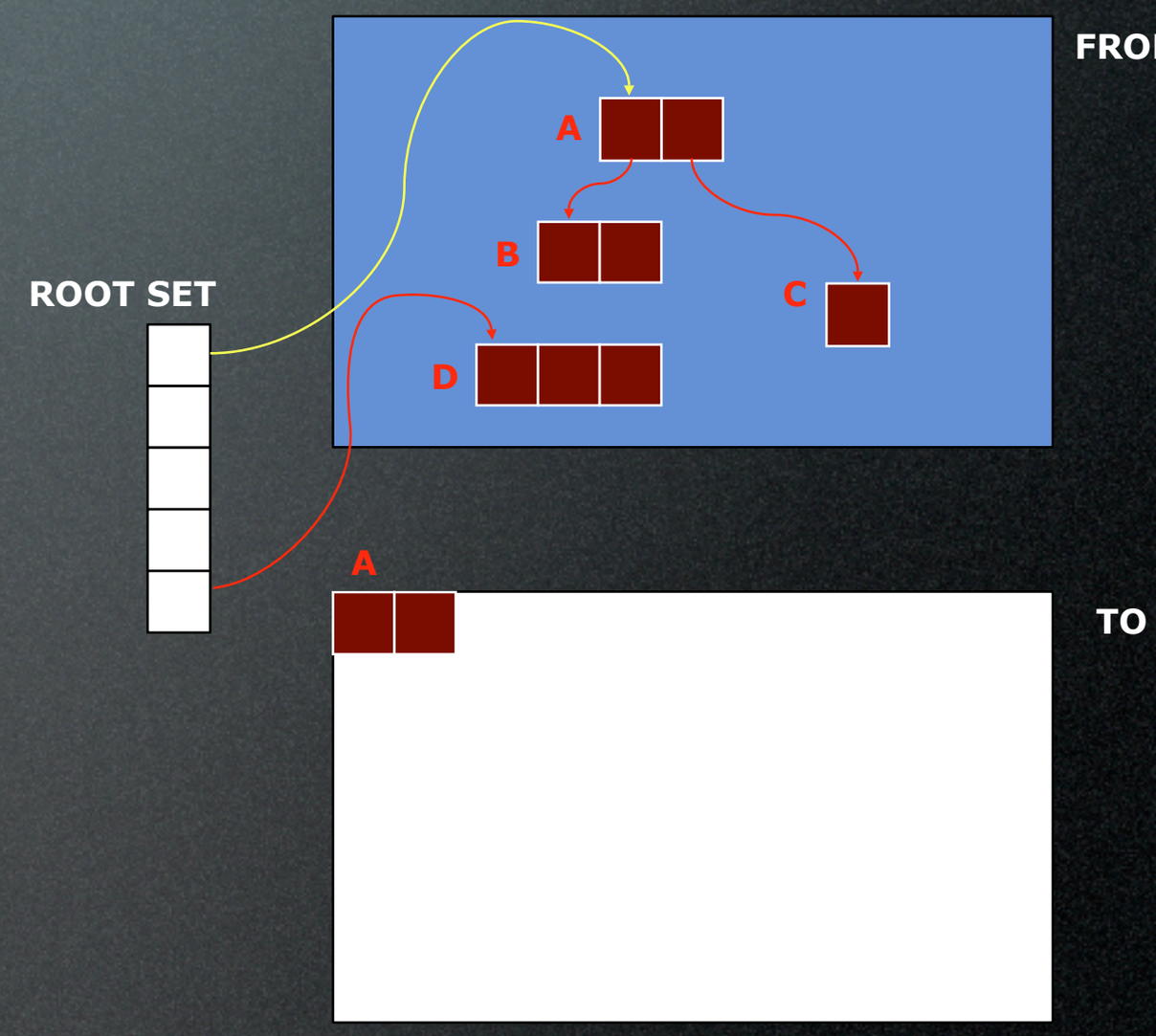

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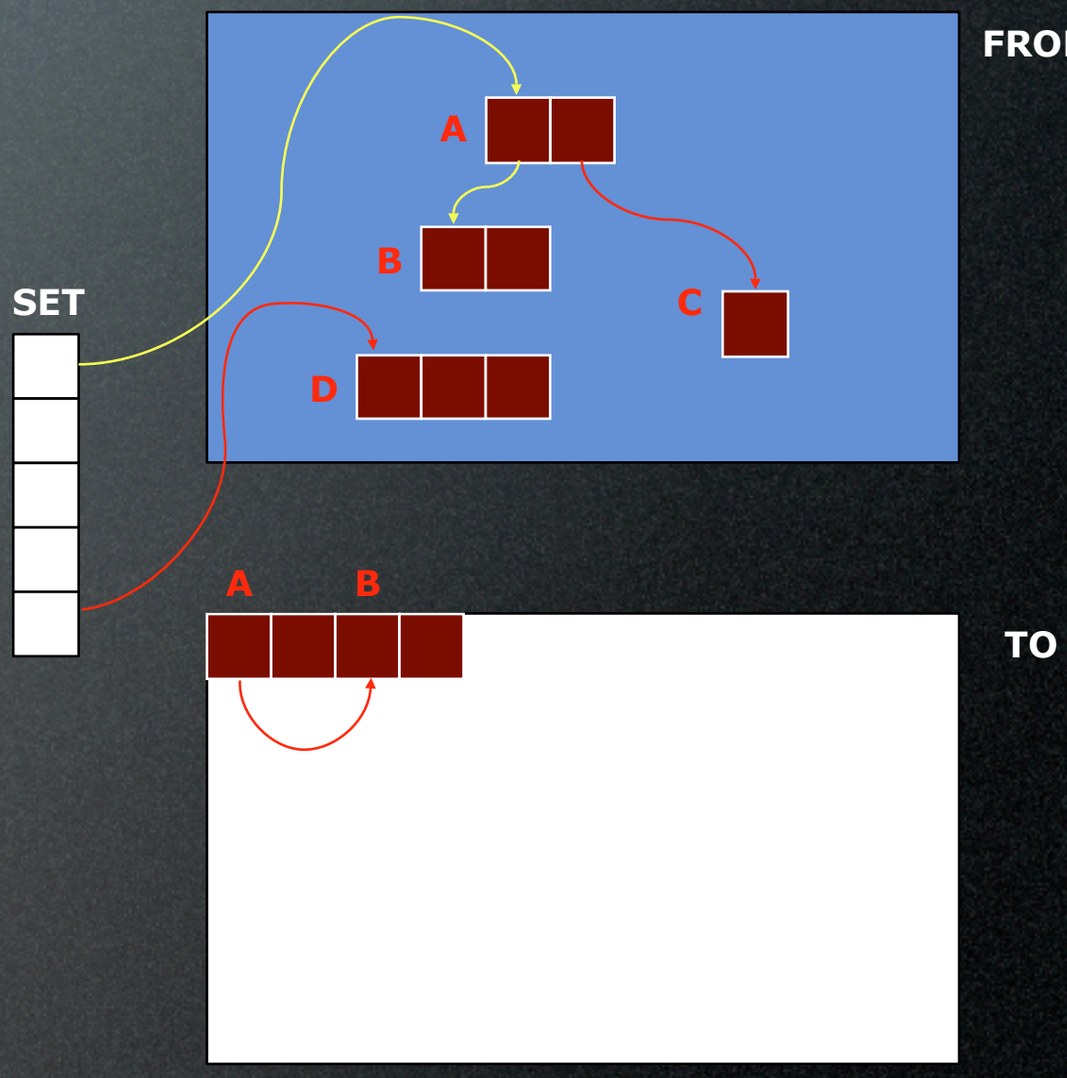

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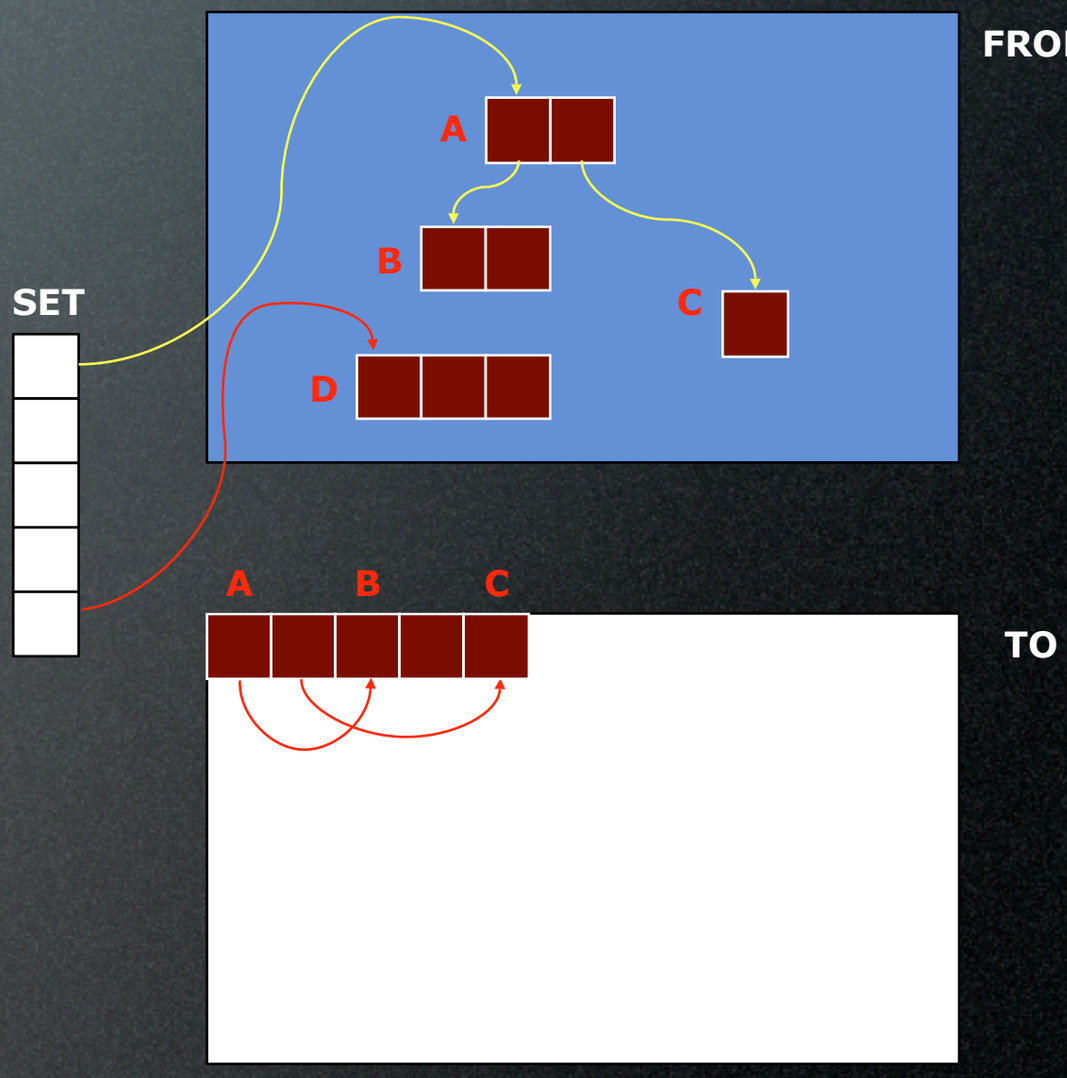

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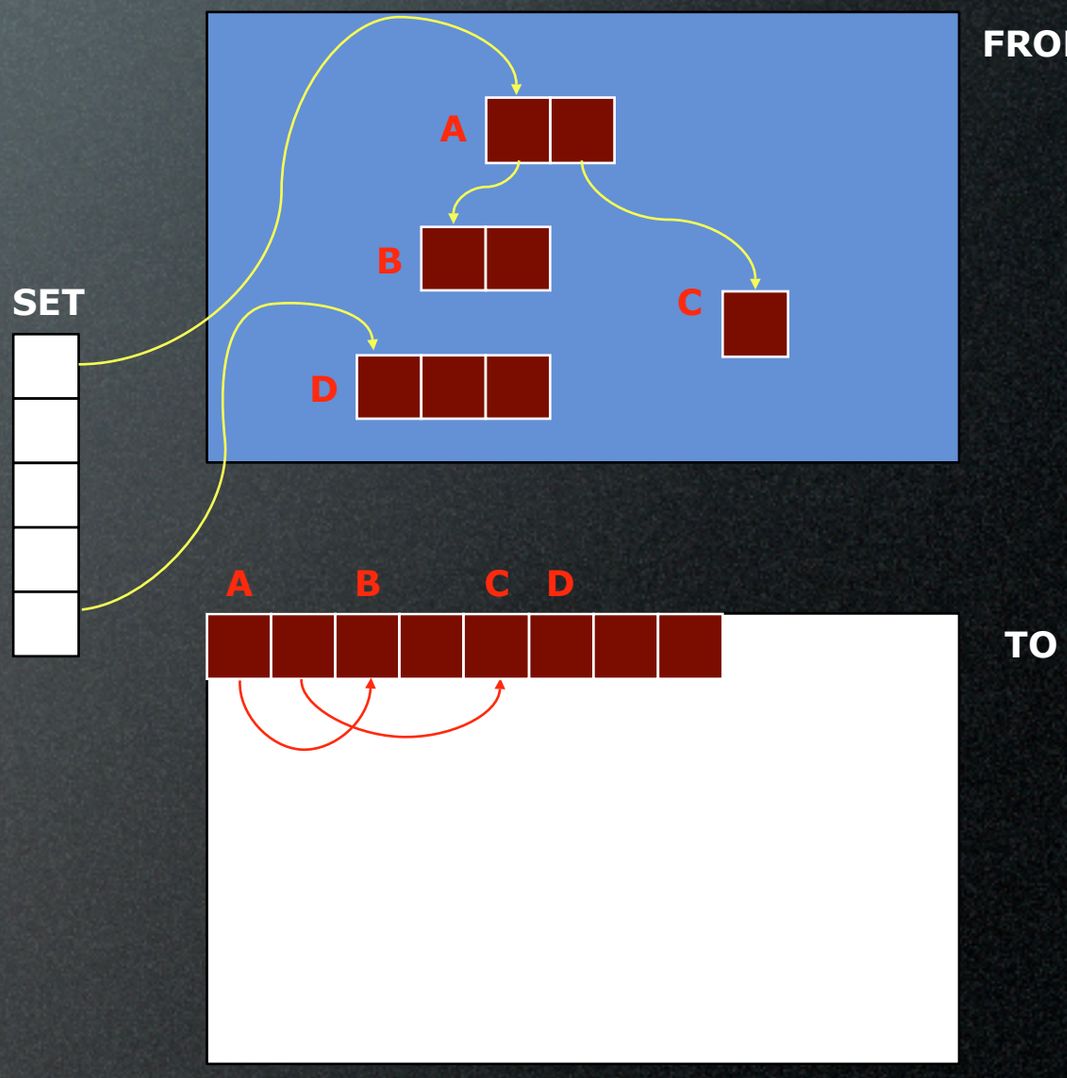

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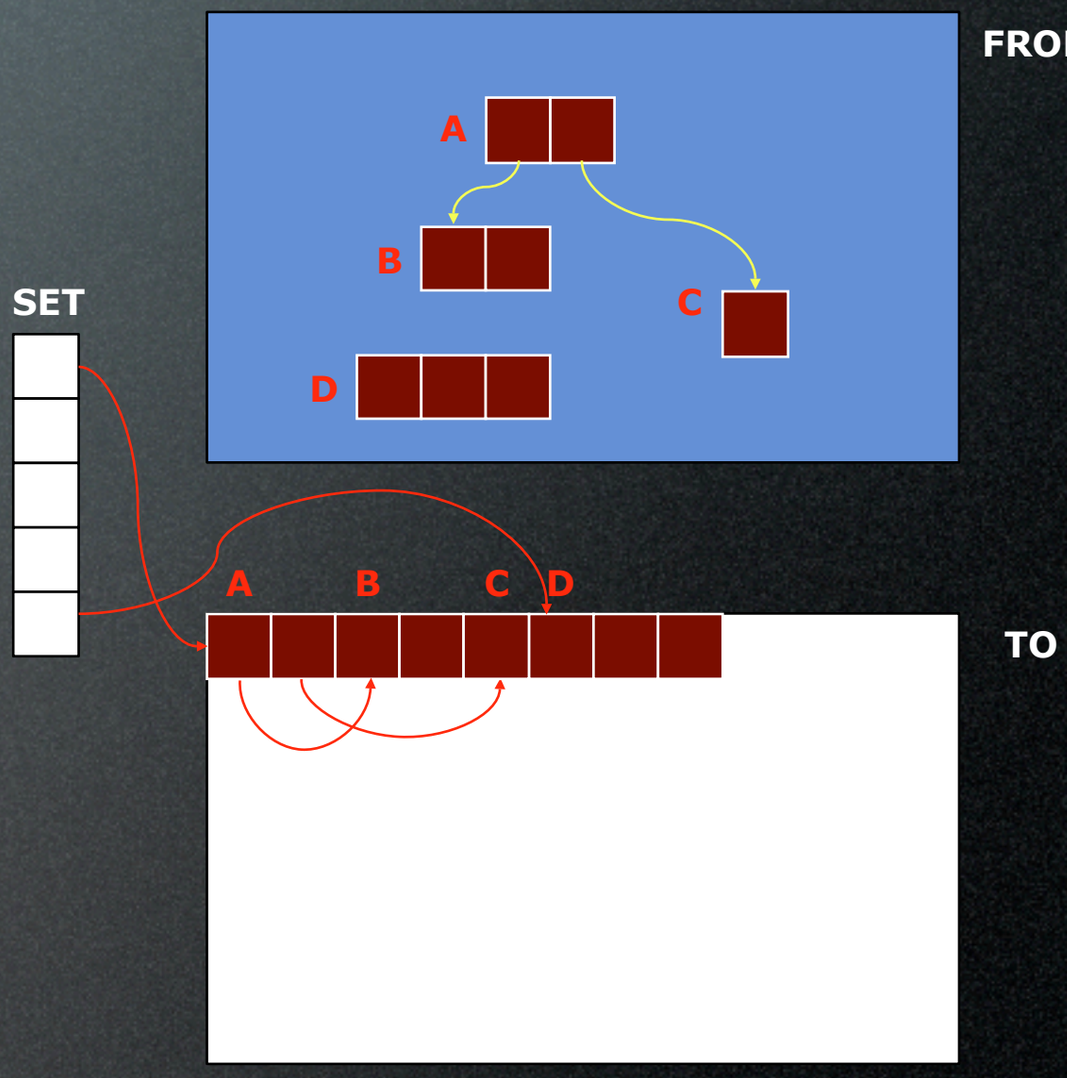

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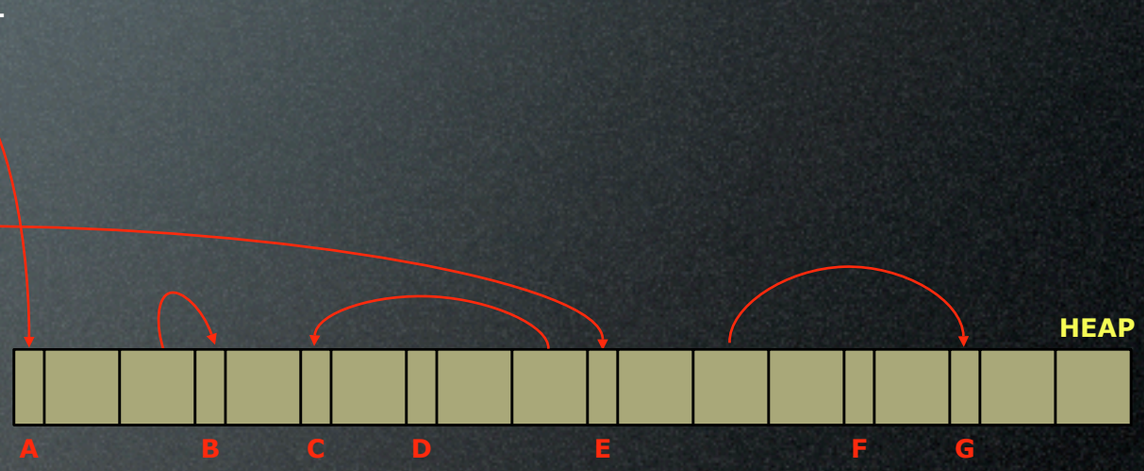
- Mark-sweep collector
  - collect the entire heap each time
  - when the heap is full, identify live objects (marking), then free dead objects (sweeping)



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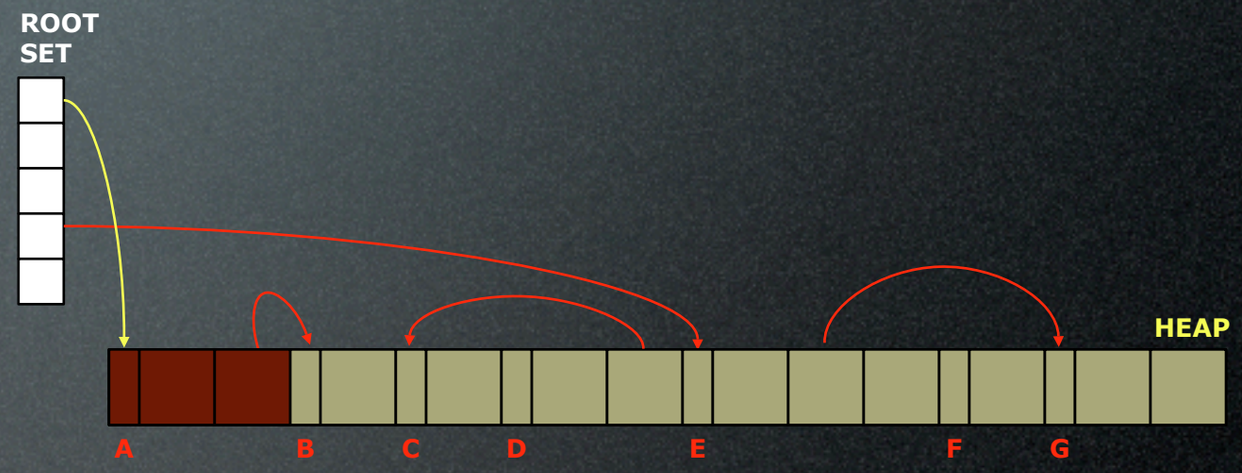

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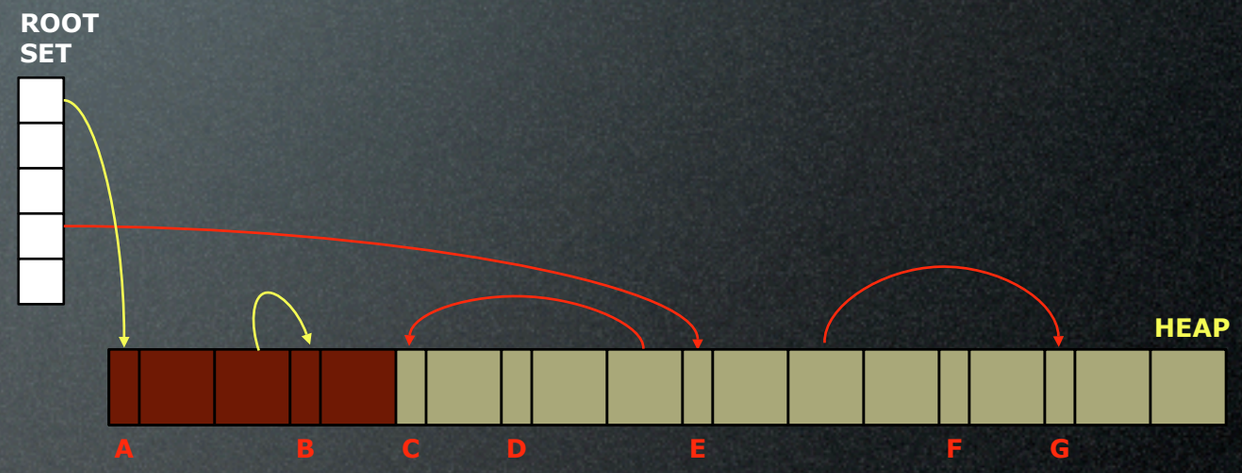

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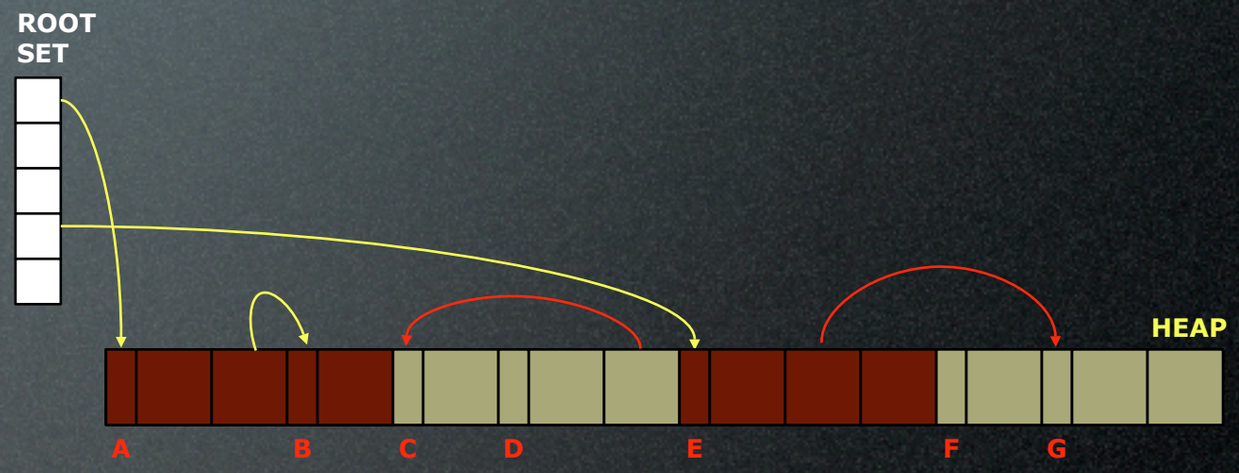

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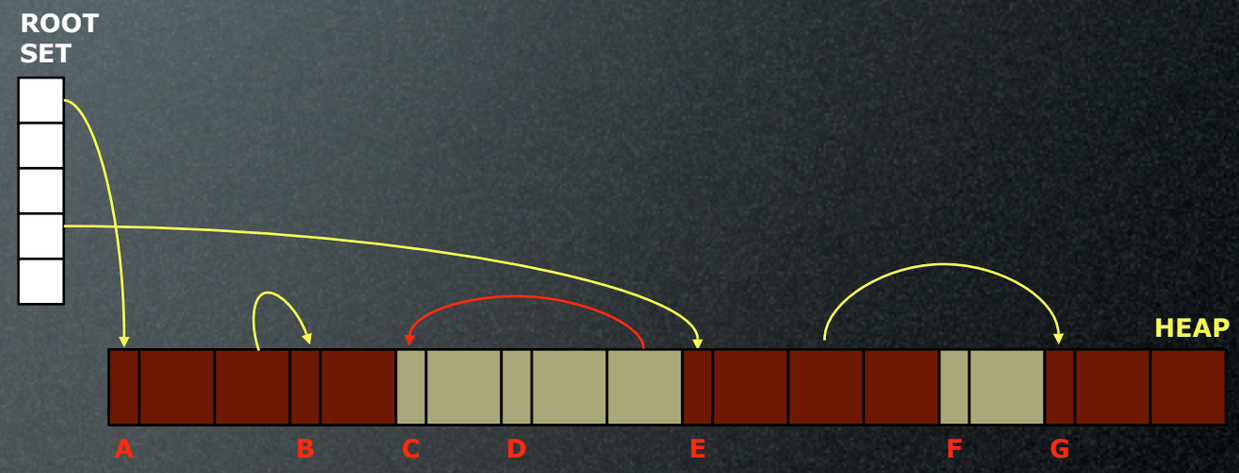

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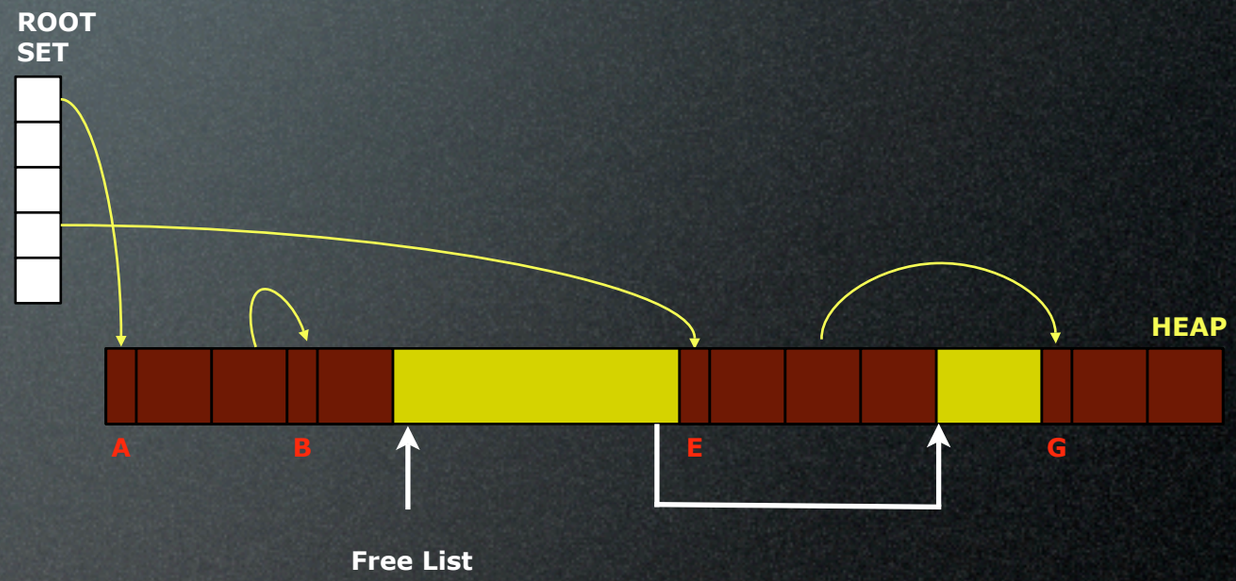

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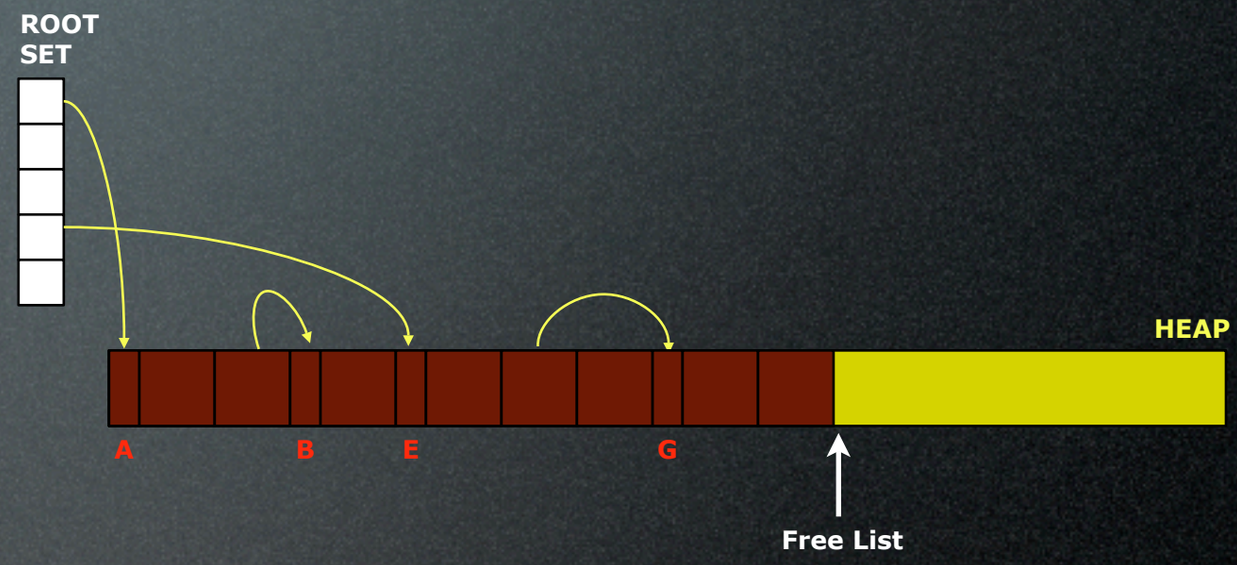
Sidebar: Garbage Collection

- Mark-sweep-compact collector
  - collect the entire heap each time
  - similar to mark-sweep collector except that heap is compacted after sweeping



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Java Virtual Machines

- But typical JVMs are not ready for deployment in realtime embedded systems
  - lacking real-time support
  - unpredictable execution of operations
  - no support for real-time threads
  - no priority inversion avoidance
  - unbounded garbage collection

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Java Virtual Machines

- But typical JVMs are not ready for deployment in realtime embedded systems

These topics will be the focus of the next few lectures

- unpredictable execution of operations
- no support for real-time threads
- no priority inversion avoidance
- unbounded garbage collection

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