Non-copying Generational collection, Scheduling GC

Not every generational GC is a copying generational GC. Knowing when to schedule GC can also impact performance

Trapping & recording inter-gen ptrs

- Entry tables
- Remembered sets
- Sequential store buffer
- Page marking with hardware support
- Page marking with virtual memory support
- Card marking

Card marking

- Divide heap into # regions called cards
  - Smaller than pages (~ 128 Bytes)
  - Requires card table
  - Bit is set in card table for a card whenever a word in the card modified
  - Scans dirty cards for inter-generational ptrs at collection time
  - Advantages
    - Portable
    - Independent of virtual memory system
    - Flexible → card size can be picked to optimize locality

Card marking

- Cost of scanning
  - Proportional to number of cards marked
  - Proportional to size of card
- GC can use dirtiness info to
  - Segregate objects on written-to-cards from clean cards
  - Gather dirty cards on same virtual memory page
  - # pages holding cards to be scanned is reduced

Non-copying generational GC

- Mark-sweep based generational GC
  - Yields no worse performance than copying base collectors
- Zorn's system
  - Four generations, each containing a mark bitmap
  - A fixed-sized-object region
  - A variable-sized-object region

Zorn's fixed-sized-object region

- Divided into # areas
- Each area stores objects of a fixed size
- Use mark-and-deferred-sweep GC
- Promote objects en masse by copying, after 3 collections

Zorn's variable-sized object region

- Holds object that cannot fit in any of the fixed-sized object areas
- Collected with two semi-space copying collector
- Zorn's finding
  - Mark-sweep collector suffered from greater CPU overhead
  - Mark-sweep collector required 30% to 40% less real memory than the copying collector
  - Promotion thresholds, pause times, cache miss ratio were important

When do we schedule GC

- Two options:
  - Hide collections at times when user least likely to notice pauses
  - Trigger efficient collections when there is likely to be most garbage collected

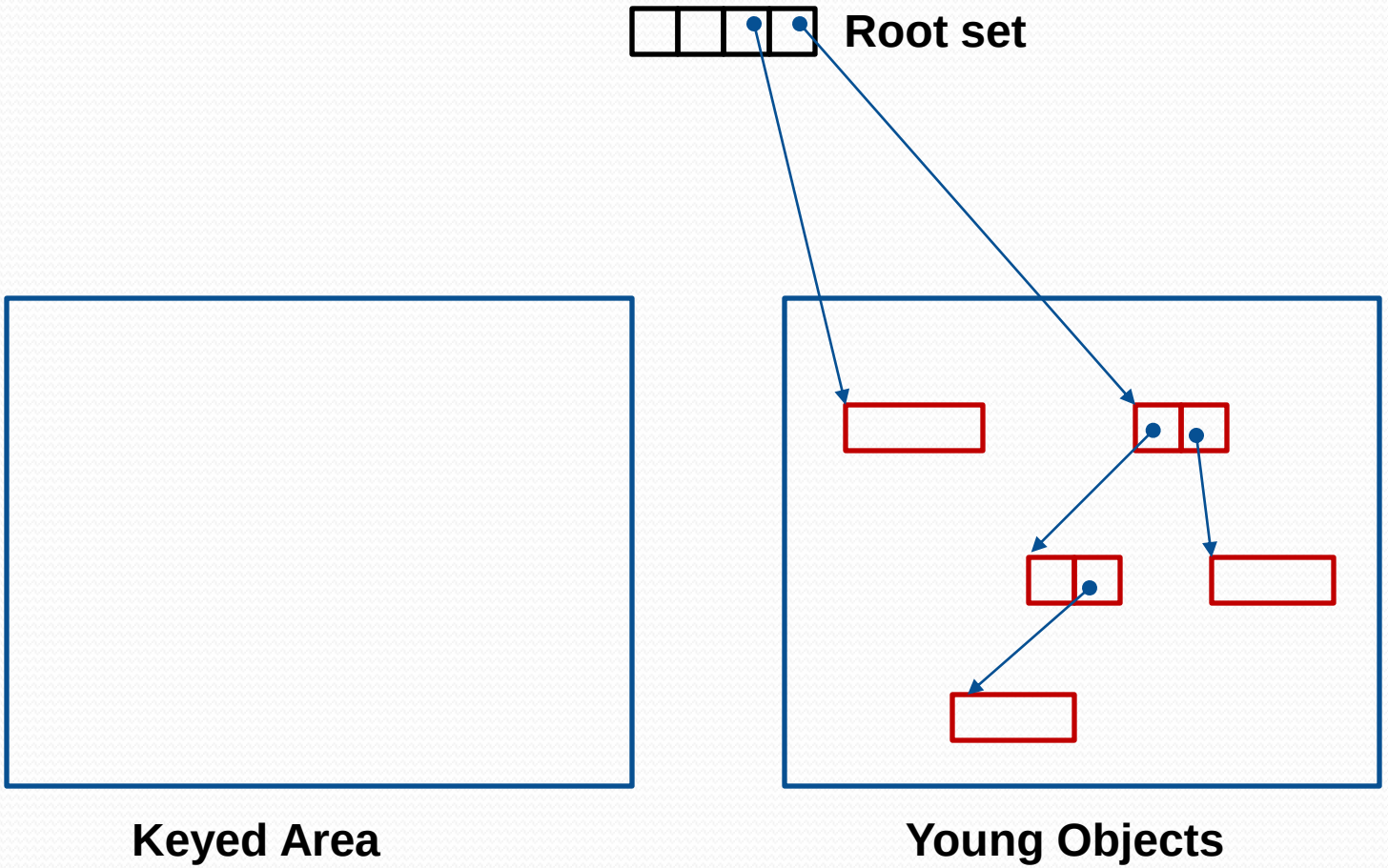
Hiding garbage collection

- In long lived systems
  - Perform GC overnight
  - Perform GC when machine is idle
- Perform GC at points in program when pause is less likely to be disruptive
  - End of compute-bound periods
    - Volume of live data is low
  - User given opportunity to interact with program and does not do so
    - Can attach code to monitor user interaction (good heuristic)
    - Emacs uses this strategy

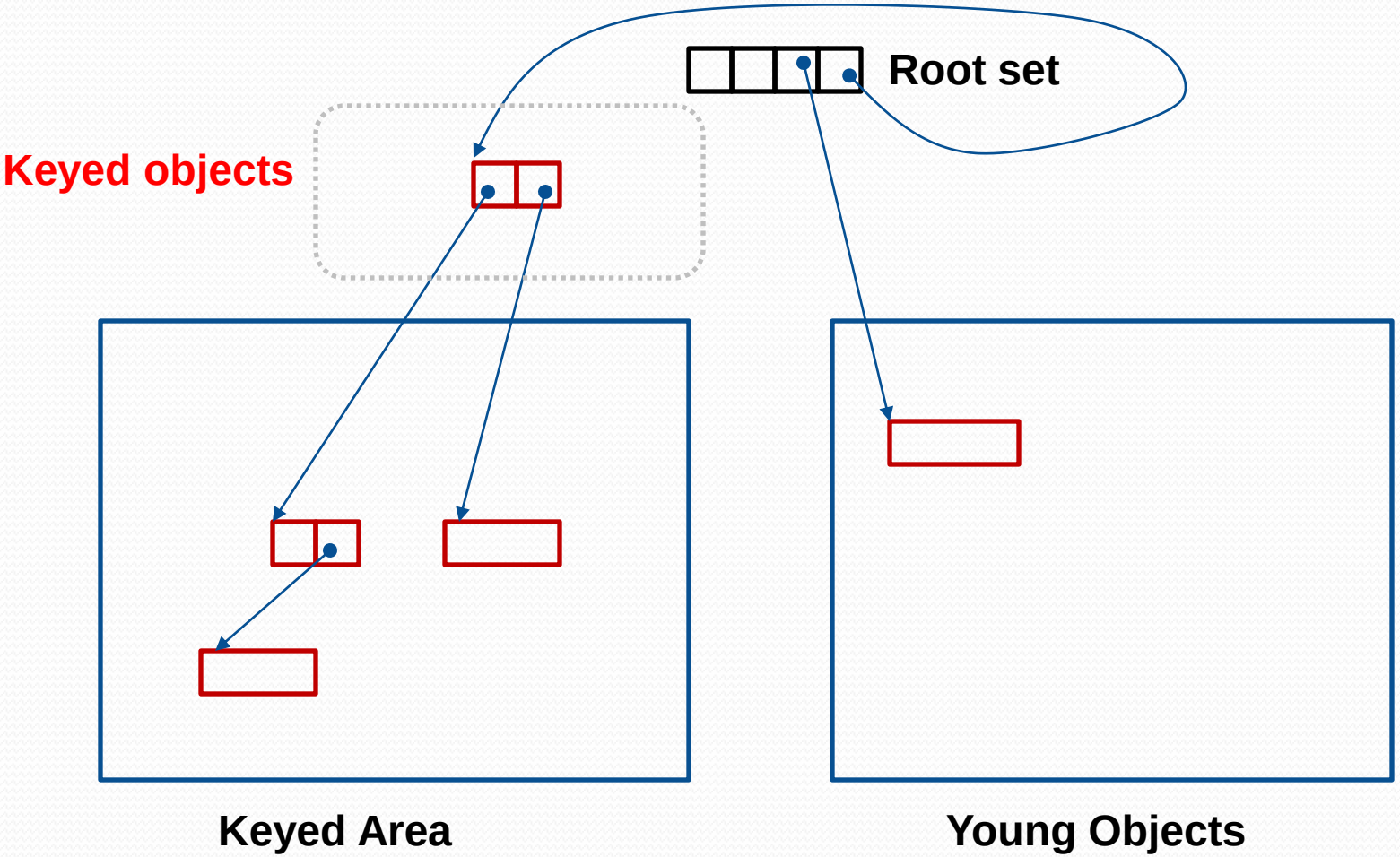
Key objects as indicators

- Hayes observed that death of objects allocated at roughly the same time closely correlate
  - Object demographics arise from typical programming style
    - Few static pointers to large data structures
      - Root of a tree
      - When program finish with tree it is only accessible from root
      - When ptr to root is deleted, entire tree is garbage
    - Use these key objects as indicators for GC
    - When death of a cluster no longer predictable by their age, should be promoted out of time-based generation
      - One key object (root of tree) retained in generational scheme

Key objects before promotion



Key objects after promotion



Using a mature object space

- Promote very old objects out of time-based generation scheme into mature object space, all at once
  - Avoid disruptive collections
- Mature object space divided into areas, each with remembered set
  - Each collected one at a time in round-robin fashion
  - Area is collected when its remembered set is empty
- What if objects too big to fit in one area?
  - Use carriages and train analogy