CS 241 Discussion Section (2/9/2012)

MP2 continued

- Implement malloc, free, calloc and realloc

- Reuse free memory
  - Sequential fit
  - Segregated fit

Basic Allocator Mechanisms

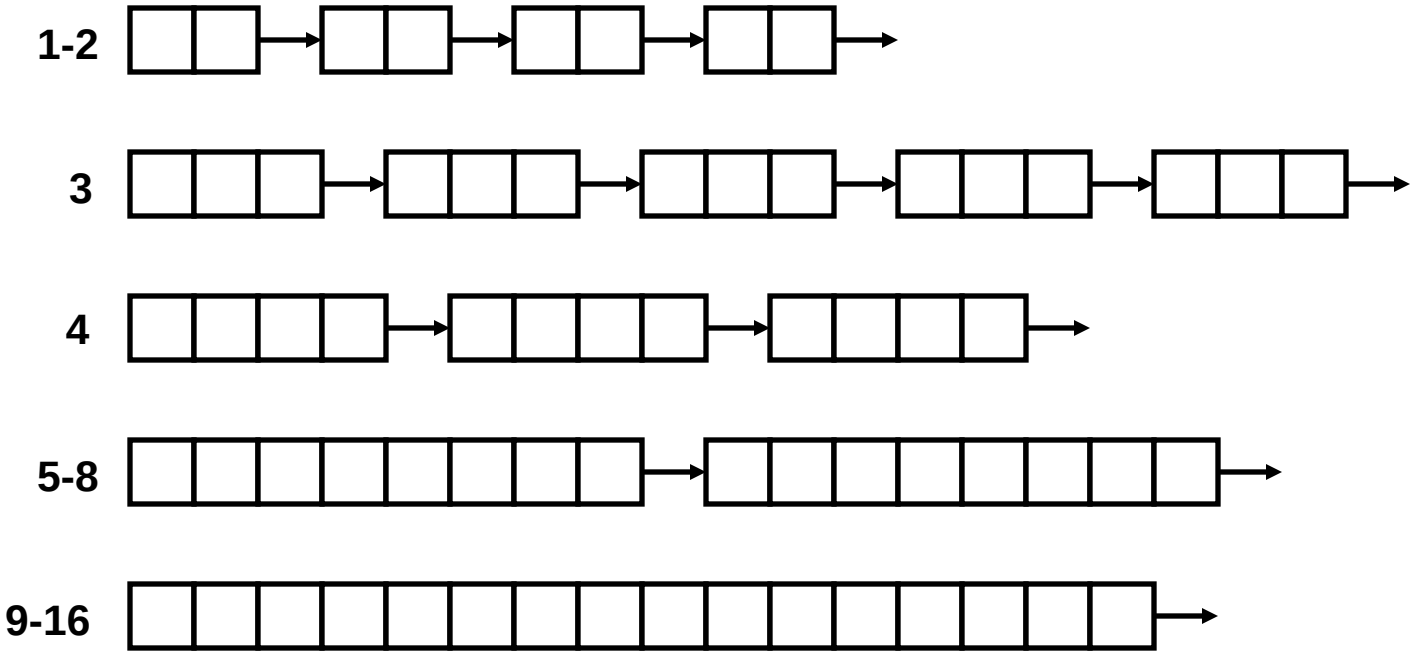
- Sequential fits (implicit or explicit single free list)
  - best fit, first fit, or next fit placement
- Tradeoffs
  - Expand: No fit
  - Split: Threshold
  - Coalesce: Immediate or Deferred

Basic allocator mechanisms

- Segregated free lists
  - –simple segregated storage -- separate heap for each size class
  - –segregated fits -- separate linked list for each size class
- Tradeoffs
  - –Expand: No big blocks
  - –Split: No “right” sized blocks
  - –Coalesce: Immediate or Deferred

Segregate Storage

- Each size “class” has its own collection of blocks



- Often have separate collection for every small size (2,3,4,…) FAST
- For larger sizes typically have a collection for each power of 2 EFFICIENT

Simple segregated storage

- Separate heap and free list for each size class
- No splitting
- To allocate a block of size n:
  - if free list for size n is not empty,
    - allocate first block on list (note, list can be implicit or explicit)
  - if free list is empty,
    - get a new page
    - create new free list from all blocks in page
    - allocate first block on list
  - constant time
- To free a block:
  - Add to free list
  - If page is empty, return the page for use by another size (optional)
- Tradeoffs:
  - fast, but can fragment badly

Segregated fits

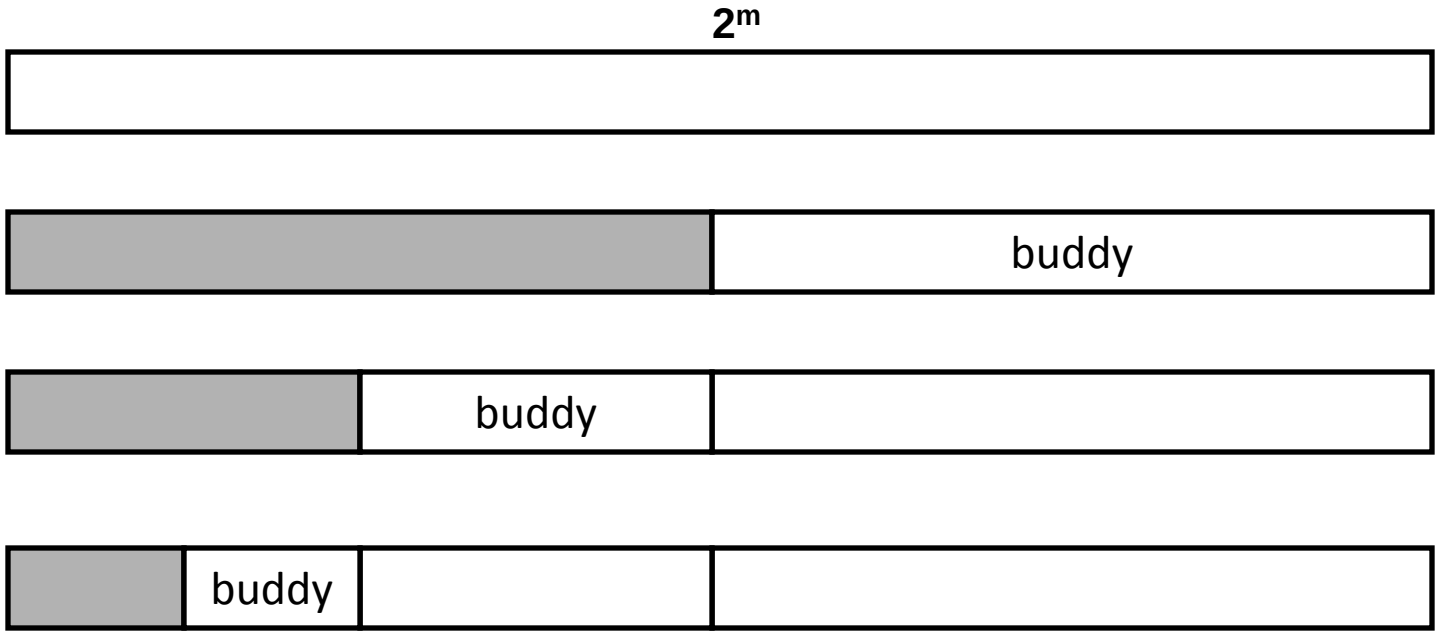
- Array of free lists, each one for some size class
- To allocate a block of size n:
  - search appropriate free list for block of size m > n
  - if an appropriate block is found:
    - split block and place fragment on appropriate list (optional)
  - if no block is found, try next larger class
  - repeat until block is found
- To free a block:
  - coalesce and place on appropriate list (optional)
- Tradeoffs
  - faster search than sequential fits (i.e., log time for power of two size classes)
  - controls fragmentation of simple segregated storage
  - coalescing can increase search times
    - deferred coalescing can help

Buddy systems

- Special case of segregated fits.
  - all blocks are power of two sizes
- Basic idea:
  - Heap is 2^m words
  - Maintain separate free lists of each size 2^k, $0 <= k <= m$.
  - Requested block sizes are rounded up to nearest power of 2.
  - Originally, one free block of size 2^m.

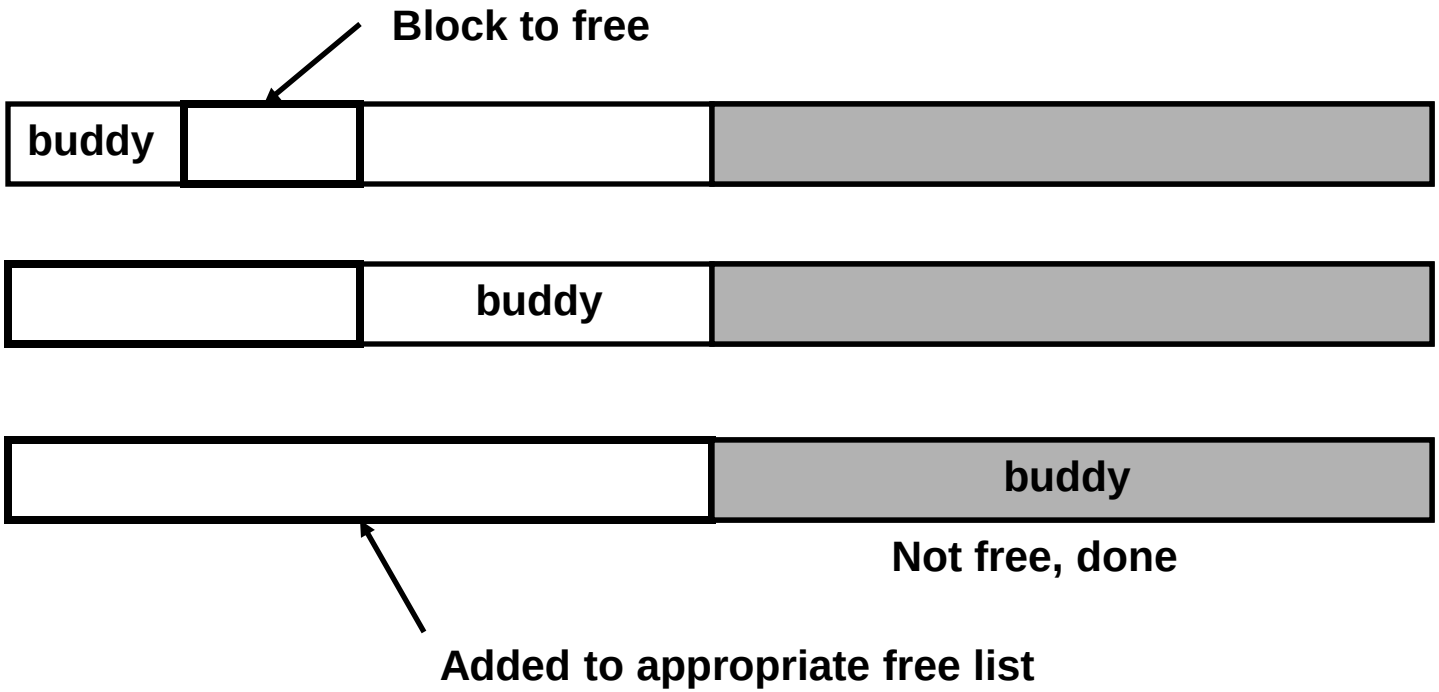
Buddy systems (cont)

- To allocate a block of size 2^k:
  - Find first available block of size 2^j s.t. k <= j <= m.
  - if j == k then done.
  - otherwise recursively split block until j == k.
  - Each remaining half is called a “buddy” and is placed on the appropriate free list



Buddy systems (cont)

- To free a block of size 2^k
  - continue coalescing with buddies while the buddies are free



Buddy systems (cont)

- Key fact about buddy systems:
  - given the address and size of a block, it is easy to compute the address of its buddy
  - e.g., block of size 32 with address `xxx...x00000` has buddy `xxx...x10000`
- Tradeoffs:
  - fast search and coalesce
  - subject to internal fragmentation

Other Sources of Wisdom

- Many implementations and algorithms online…
- All work should be your own!
- Good Luck

Let’s Start Coding

- ds3/alloc.c
  - Integrate the bookkeeping, or *metadata*, with the memory segments themselves