ITP30002 Operating System

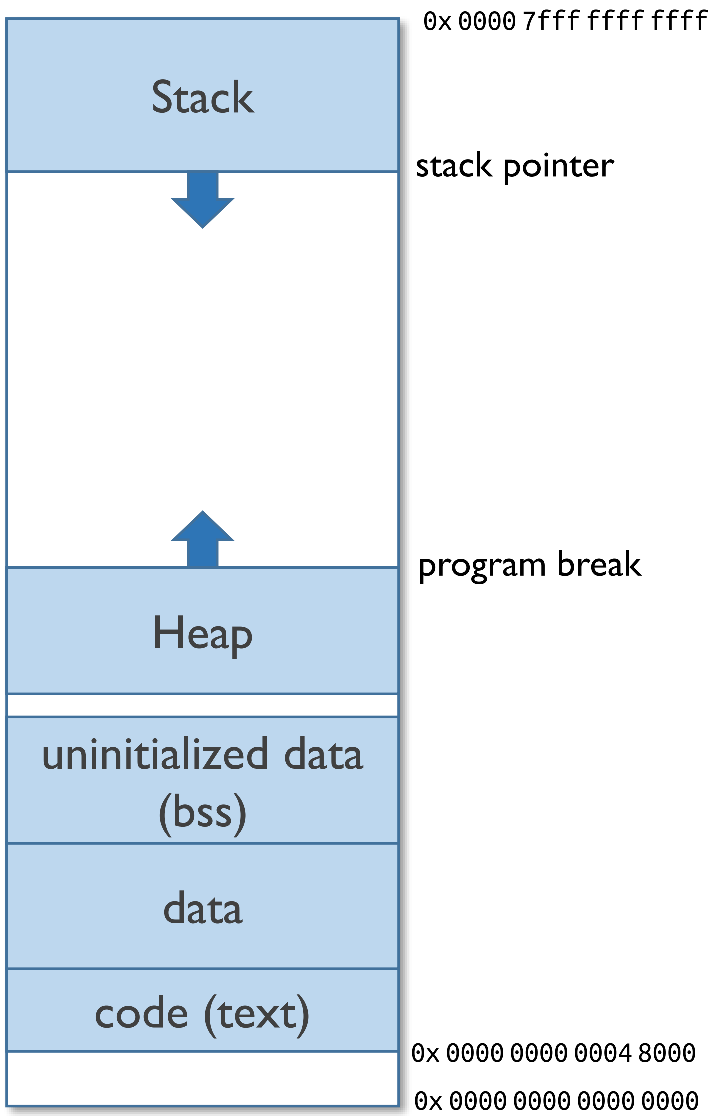
Homework 5

Smalloc: Simple Heap Memory Allocation Library

Overview

- Upgrade a given heap memory allocation library *smalloc* 1.0 to smalloc 2.0
  - Ver 1.0 https://github.com/hongshin/OperatingSystem/tree/sysprog/Homework5
    - basic APIs
    - first-fit algorithm for allocating memory slot
  - Ver 2.0
    - implement best-fit algorithm for allocating memory slot
    - merge unused continuous containers at free
    - implement `print_mem_uses()`
    - implement `srealloc()`
    - implement `sshrink()`
- Sumbission
  - Deadline: 11:59 PM, June 24 (Wed)
  - Deliverables
    - Source code files: source code file of smalloc 2.0
    - Write-up: 1 page (PDF) in the homework report template
  - Submit deliverables to Hisnet

Background: Segmentation Layout (Linux, x86-64)



- `&etext` points to the first address past the end of the text segment
- `&edata` points to the first address past the end of initialized data segment
- `&end` points to the first address past the end of the uninitialized data segment

- `sbrk(0)` returns the first address past the end of the currently given heap segment
- `sbrk(s)` retains additional `s` bytes in heap and returns the starting address.
  - returns null when OS denies the request
- `getpagesize()` returns the number of bytes in a page

- c.f. https://en.wikipedia.org/wiki/X86-64#Virtual_address_space_details

Smalloc Version 1.0 - APIs

- `void * smalloc(size_t s)`

  `smallaoc` allocates continuous `s` bytes in unused heap segment, and returns its starting address. Depending on memory use, `smallaoc` may retain more heap memory to allocate `s` bytes. This function returns `null` if it fails at allocating `s` bytes.

- `void sfree(void * p)`

  `sfree` reclaims the memory region allocated by `smallaoc`, which starts from memory address `p`.

- `void print_sm_containers()`

  `print_sm_containers` displays the internal status of memory management by the `smalloc` library. It prints out to standard error the details of the `sm_container` linked list. Note that `print_sm_containers` must not be changed over version-ups.

Smalloc Version 1.0 – Data Structure

- The smalloc library manages the retained memory locations with a doubly linked list of `sm_container_t` objects
  - A `sm_container_t` object holds an allocable continuous memory region and its metadata
  - A list of `sm_container_t` objects fill out the memory retained by the smalloc library

- struct `sm_container_t`

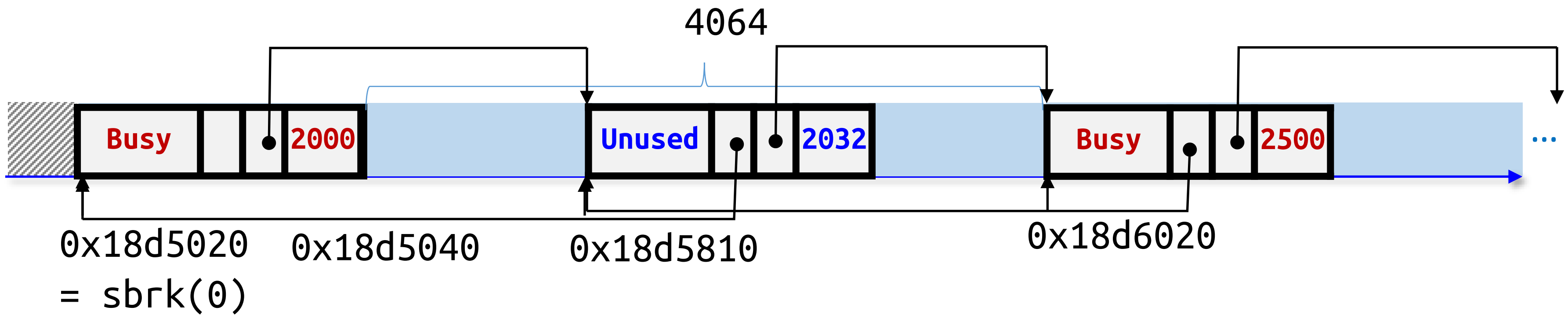
```
- sm_container_status status ;   /* Busy or Unused */
- sm_container_ptr next ;        /* sm_head at last element */
- sm_container_ptr prev ;        /* sm_head at first element */
- size_t dsize ;                 /* the size of data in byte */
```

- A `sm_containter_t` object takes 32 bytes
  - i.e., `sizeof(sm_container_t)` is 32

Example: test1.c

- smalloc(2000) ;
  - retain_more_memory(2000) ;
    - sbrk(4096) ;
  - sm_container_split(hole, 2000) ;

- smalloc(2500) ;



Tasks for Version 2.0 (1/2)

- **Task 1**

  Revise `smalloc()` to select a best-fit unused container to allocate requested memory. In addition, construct a new test case test4.c on which the best-fit algorithm performs better than the first-fit algorithm (i.e., smalloc-1.0)

- **Task 2**

  Revise `sfree()` to merge adjacent unused containers if possible. Merge such adjacent unused containers as much as possible.

Tasks for Version 2.0 (2/2)

- **Task 3**

  Add a new API `print_mem_uses()`, according to the following description:

  ```
  void print_mem_uses ()
  ```

  > `print_mem_uses` prints out the following information to standard error: (1) the amount of memory retained by `smalloc` so far, (2) the amount of memory allocated by `smalloc` at this moment, (3) the amount of memory retained by `smalloc` but not currently allocated.

- **Task 4**

  Add a new API `realloc(p,nsize)`, which resizes the memory allocated at pointer p as a new size `nsize`. Resize should be done without changing p if possible. Otherwise, it should give a new address after migrating the data to the new address.

- **Task 5**

  Add a new API `sshrink()` which reduces the program break point (i.e., reduce allocated heap size) as much as possible at its execution time

Evaluation

- Evaluation points

Technical soundness	70%
Presentation	15%
Discussion	15%

  - discuss possible improvements over smalloc 2.0

- Note
  - Your programs will be executed with test cases for evaluation
  - TAs will test the submitted files on the peace server