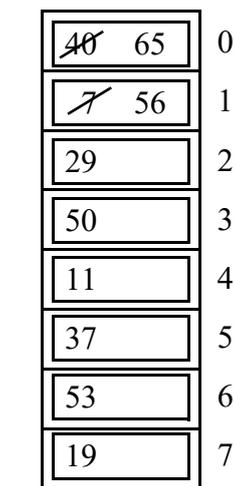Technology
Arts Sciences
TH Köln

Memory Management – Solutions

Exercise 1: Cache Management

- Given:

  - Three caches, each initially empty:

    - A fully associative cache with a total size of 8 blocks

    - A direct mapped cache with a total size of 8 blocks
      where a main memory block *n* is stored at cache position *n mod 8*

    - A set associative cache with a total size of 8 blocks in 2 sets
      where a main memory block *n* is stored at some position in set *n mod 2*

  - A sequence of memory blocks to be brought into the cache
    with block numbers 40, 7, 29, 50, 11, 37, 53, 19, 65, 56

- For each of the three caches:

  - Bring the blocks (one after the other) into the cache, possibly evicting other blocks.
    State at which cache positions these blocks are stored.
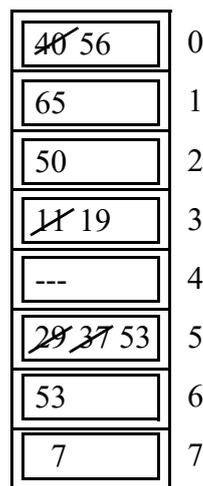
  - How many evictions will occur at least?
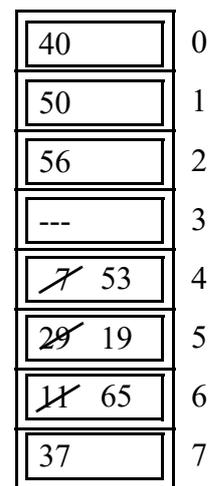
Solution:

| Fully Associative:		Direct Mapped:		Set Associative:	
~~40~~ 65	0	~~40~~ 56	0	40	0
~~7~~ 56	1	65	1	50	1
29	2	50	2	56	2
50	3	~~11~~ 19	3	---	3
11	4	---	4	~~7~~ 53	4
37	5	~~29~~ ~~37~~ 53	5	~~29~~ 19	5
53	6	53	6	~~11~~ 65	6
19	7	7	7	37	7
$\rightarrow$ 2 evictions		$\rightarrow$ 4 evictions		$\rightarrow$ 3 evictions	

Exercise 2: Main Memory Management

- Given:

  - A main memory with a size of 2 GB, initially empty

  - A sequence of requests for memory space and releases of memory space:
    1.) Request R1: 600 MB
    2.) Request R2: 200 MB
    3.) Request R3: 100 MB
    4.) Request R4: 600 MB
    5.) Release of the memory space allocated for R1
    6.) Release of the memory space allocated for R3
    7.) Request R5: 100 MB
    8.) Request R6: 600 MB

- For First Fit and for Best Fit memory allocation:
  Sketch the state of main memory (i.e. its allocated and free segments) after steps 4, 6, 7, 8
  and the free memory list after steps 4 and 6.

  - If a request can be satisfied only by relocating an allocated data segment, find and carry
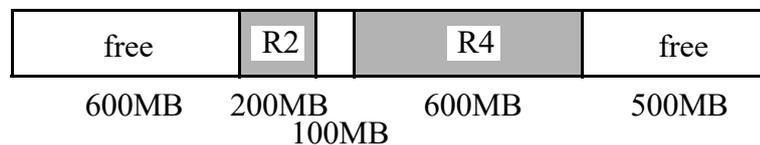   out the relocation that moves as few data as possible.
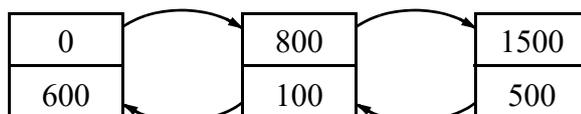
Solution:

After step 4 - Best Fit & First Fit:

R1	R2	R3	R4	free

600MB   200MB   600MB   500MB
              100MB
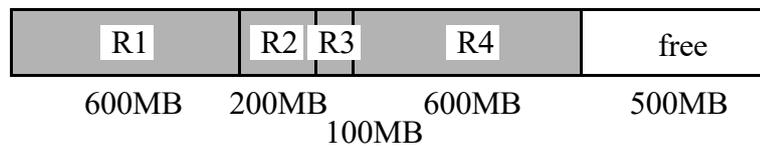
Free Memory List after step 4 (addresses and lengths in MB):

1500	start address
500	length

After step 6 - Best Fit & First Fit:

free	R2		R4	free

600MB   200MB   600MB   500MB
              100MB

Free Memory List after step 6:

0		800		1500
600		100		500

After step 7 - Best Fit:

free	R2	R5	R4	free
600MB	200MB		600MB	500MB

100MB

After step 8 - Best Fit:

R6	R2	R5	R4	free
600MB	200MB		600MB	500MB

100MB

After step 7 - First Fit:

R5	free	R2		R4	free
100MB	500MB	200MB		600MB	500MB

100MB

After step 8 - First Fit:

R6	R2	R5	R4	free
600MB	200MB		600MB	500MB

100MB
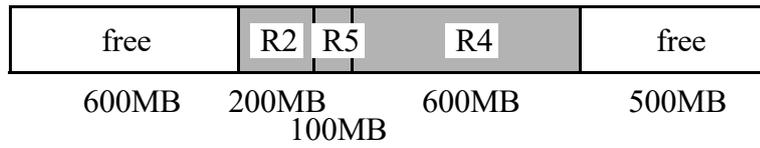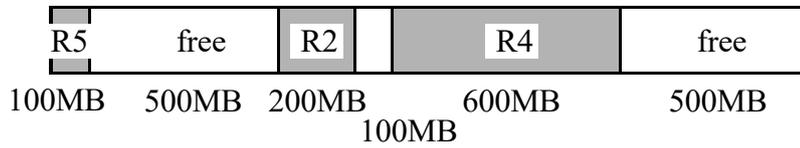
1.) Relocate R5

2.) Store R6

Exercise 3: Disk Scheduling

- **Part A:**

  - Given: Three hard disks with identical sequences of access requests (all requests present at the beginning). To handle the requests, the disks access their tracks in the following orders:

    - Disk 1: 50, 48, 47, 53, 55, 40, 30, 80, 90

    - Disk 2: 50, 48, 47, 40, 30, 53, 55, 80, 90

    - Disk 3: 50, 90, 30, 48, 80, 47, 55, 53, 40

  - What scheduling strategies are used for the three disks? Write down the names of three different strategies.

Solution:

- Disk 3 → FCFS (can neither be SSTF nor SCAN)

- Disk 1 → SSTF (cannot be SCAN)

- Disk 2 → SCAN

- **Part B:**

  - Given: A sequence of requests to access a hard disk

    - Tracks 70, 30, 10, 90, 100, 20, 60 shall be accessed.

    - The requests have arrived in this order.

    - The initial position of the read/write head is on track 50.

  - State the order by which the tracks are accessed according to the

    - First-Come First-Served (FCFS) strategy.

    - Shortest Seek Time First (SSTF) strategy.

    - SCAN / elevator strategy
      (where the head first moves in the direction of lower track numbers).

Solution:

- FCFS: 50, 70, 30, 10, 90, 100, 20, 60

- SSTF: 50, 60, 70, 90, 100, 30, 20, 10

- SCAN: 50, 30, 20, 10, 60, 70, 90, 100