Swapping: Mechanisms

Operating System (OS)

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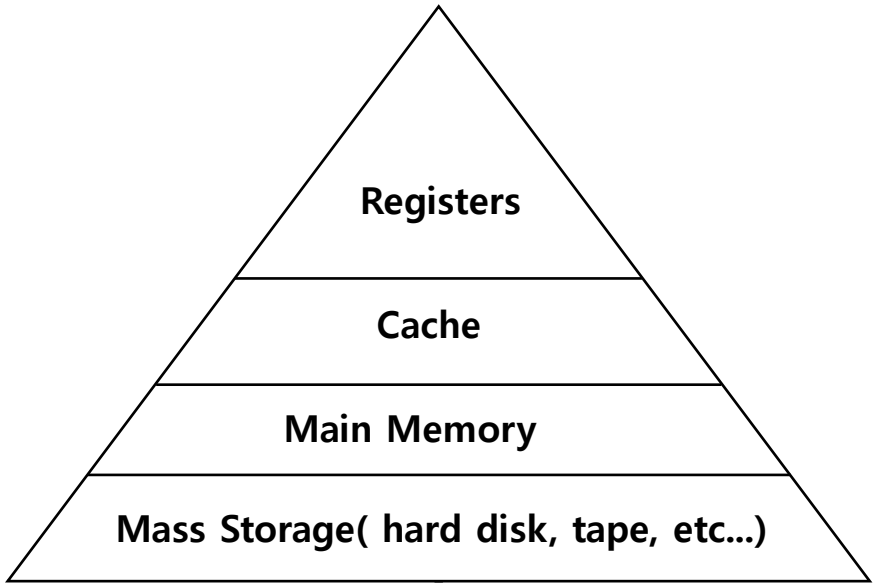
강의자료는 KAIST 원유집 교수님 OS 강의 자료를 참고했습니다.

Beyond Physical Memory: Mechanisms

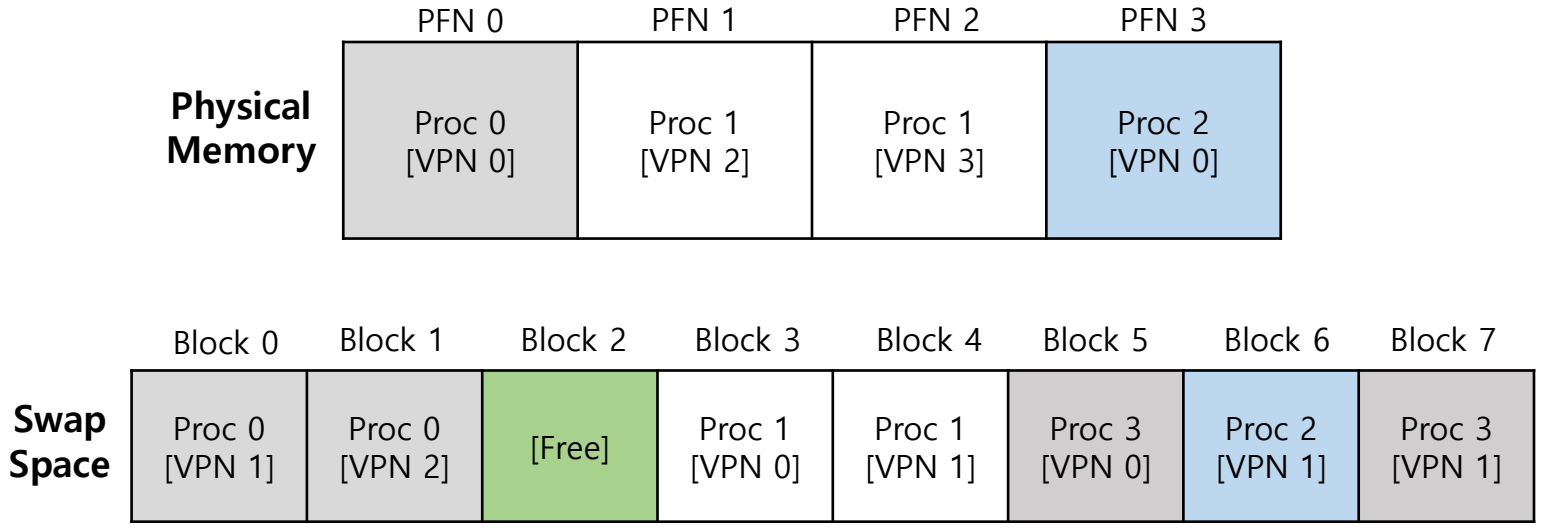
- Use part of disk as memory.
  - OS need a place to stash away portions of address space that currently aren't in great demand.
  - In modern systems, this role is usually served by a hard disk drive.



Memory Hierarchy in modern system

Swap Space

- Reserve some space on the disk for moving pages back and forth.
- OS needs to remember the swap space, in page-sized unit



Physical Memory and Swap Space

Present Bit

- Add some machinery higher up in the system in order to support swapping the pages to and from the disk.
  - When the hardware looks in the PTE, it may find that the page is not present in physical memory.

Value	Meaning
1	page is present in physical memory
0	The page is not in memory but rather on disk.

Concept

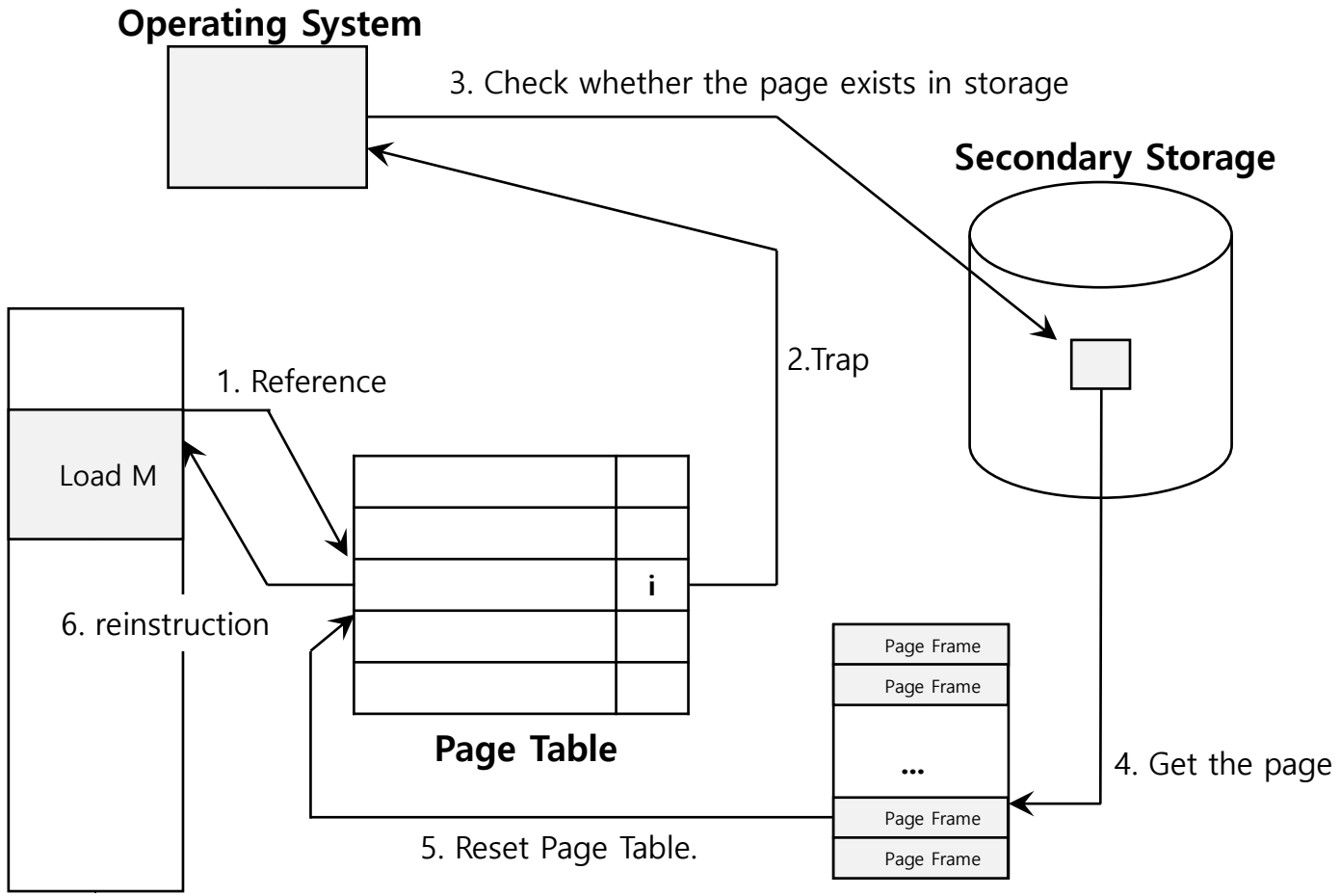
- Page fault
  - Accessing page that is not in physical memory
  - If a page is not present and has been swapped disk, the OS needs to swap the page back into memory in order to service the page fault
- Page replacement
  - The OS likes to page out pages to make room for the new pages the OS is about to bring in
  - The process of picking a page to kick out, or replace is known as page-replacement policy

When to perform replacement

- Lazy approach
  - OS waits until memory is entirely full, and only then replaces a page to make room for some other page
  - This is unrealistic
- Swap Daemon, Page Daemon
  - There are fewer than LW (low watermark) pages available, a background thread that is responsible for freeing memory runs.
  - The thread evicts pages until there are HW(high watermark) pages available.

Page Fault Control Flow

- PTE used for data such as the PFN of the page for a disk address.



When the OS receives a page fault, it looks in the PTE and issues the request to disk.

Page Fault Control Flow – Hardware

```
1:      VPN = (VirtualAddress & VPN_MASK) >> SHIFT
2:      (Success, TlbEntry) = TLB_Lookup(VPN)
3:      if (Success == True) // TLB Hit
4:          if (CanAccess(TlbEntry.ProtectBits) == True)
5:              Offset = VirtualAddress & OFFSET_MASK
6:              PhysAddr = (TlbEntry.PFN << SHIFT) | Offset
7:              Register = AccessMemory(PhysAddr)
8:          else RaiseException(PROTECTION_FAULT)
9:      else // TLB Miss
10:         PTEAddr = PTBR + (VPN * sizeof(PTE))
11:         PTE = AccessMemory(PTEAddr)
12:         if (PTE.Valid == False)
13:             RaiseException(SEGMENTATION_FAULT)
14:         else
15:             if (CanAccess(PTE.ProtectBits) == False)
16:                 RaiseException(PROTECTION_FAULT)
17:             else if (PTE.Present == True)
18:                 // assuming hardware-managed TLB
19:                 TLB_Insert(VPN, PTE.PFN, PTE.ProtectBits)
20:                 RetryInstruction()
21:             else if (PTE.Present == False)
22:                 RaiseException(PAGE_FAULT)
```

Page Fault Control Flow – Software

```
1:        PFN = FindFreePhysicalPage()
2:        if (PFN == -1) // no free page found
3:                PFN = EvictPage() // run replacement algorithm
4:        DiskRead(PTE.DiskAddr, PFN) // sleep (waiting for I/O)
5:        PTE.present = True // update page table with present
6:        PTE.PFN = PFN // bit and translation (PFN)
7:        RetryInstruction() // retry instruction
```

- The OS must find a physical frame for the soon-be-faulted-in page to reside within.
- If there is no such page, waiting for the replacement algorithm to run and kick some pages out of memory.

Summary

- Swapping: making the part of disk as memory
- Present bit required