CSE 120 - Discussion session 7

May 20, 2019

Logistics

1. Homework 3 - Tonight 11:59 pm
2. Project 3 - June 7 11:59 pm (NO EXTENSIONS!!)

Project 2

- How did we allocate memory to a process?
  - Assigned necessary #pages upfront
- Page Table mapping?
  - Fixed on initialization
- Disadvantages?
  - Not enough memory for all processes
  - Processes may not use all the pages assigned to them
  - Thus, inefficient memory utilization

Project 3

Functionality to implement

1. Demand Paging
2. Lazy Loading
3. Page Pinning

To modify

- VMKernel.java - extends UserKernel.java
- VMProcess.java - extends UserProcess.java

Demand Paging

- Pages loaded into memory on a need only basis
- Initially, no pages in memory
- Keep loading necessary pages into memory
- If memory full, evict pages

- Which page to evict?
  - Use page replacement strategies

Lazy Loading

- Each user process - not statically assigned pages
- Use demand paging to load necessary pages for each process
  - i.e. lazily load pages
- No pages loaded initially. Even first instruction must be brought in using demand paging

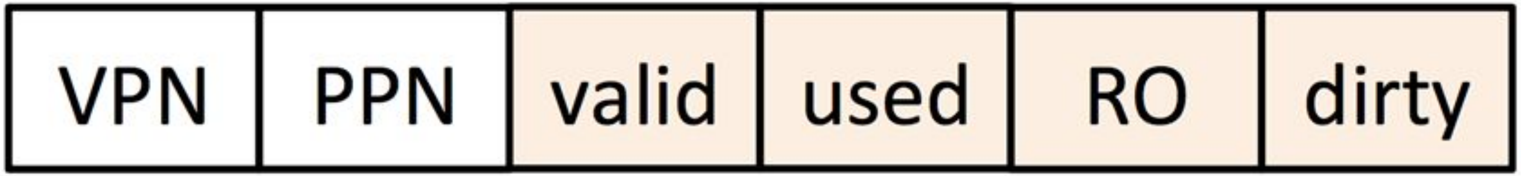
Page pinning

- What if a page must not be evicted for a certain duration of time?
- Pin the page
- Make it temporarily impossible to evict

When might page pinning be necessary?

- Say Process A is reading a page and writing to user memory
- We context switch to B. B then evicts the page A was using and replaces it with its own page.
- Now what if we context switch back to A?

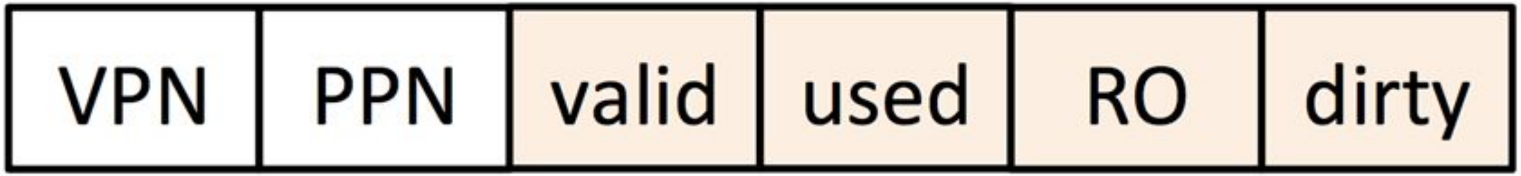
Translation Entry bits



VPN	PPN	valid	used	RO	dirty

- Valid
    - Is this page in memory?
    - If false, invoke TLB miss/page fault
- Used(Reference)
    - Has this page been accessed?
    - Important for page replacement

Translation entry bits



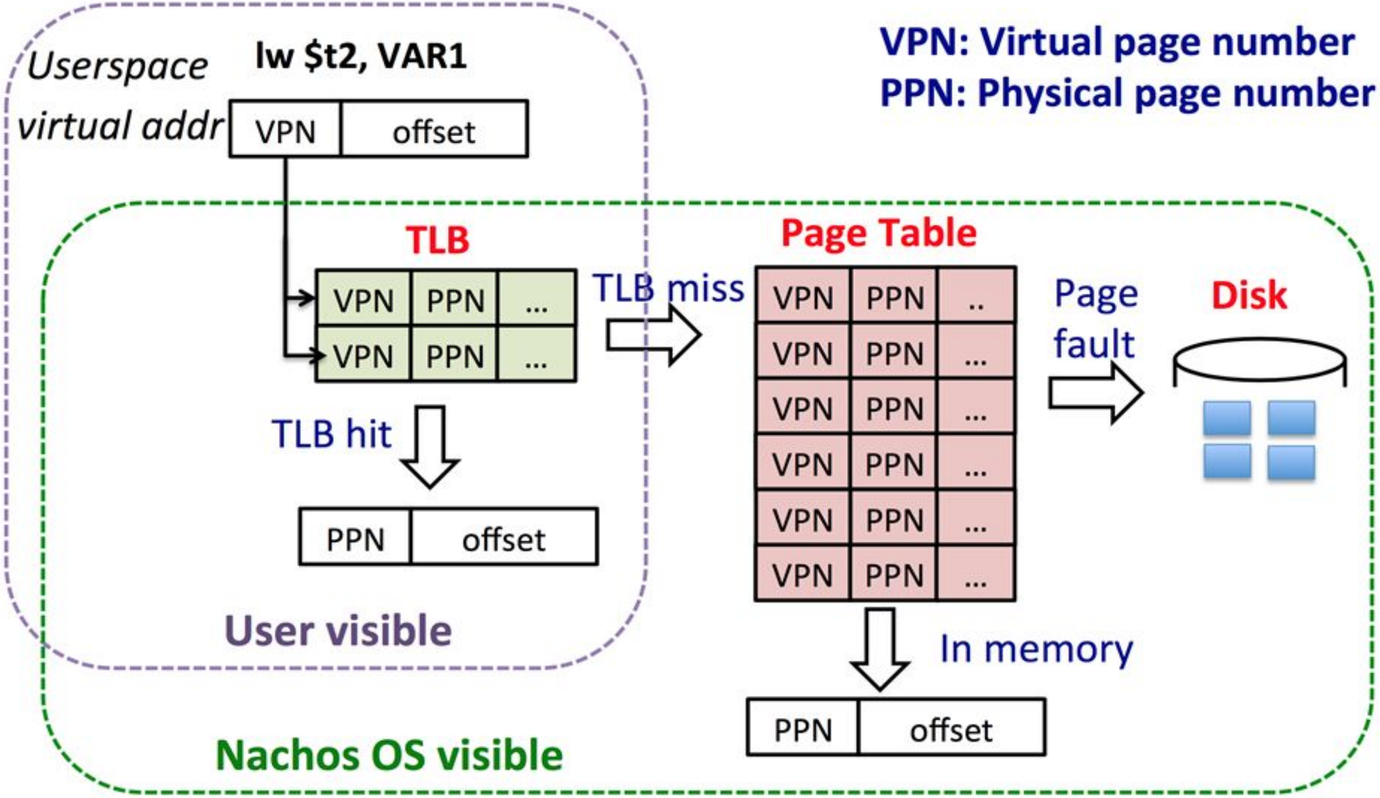
VPN	PPN	valid	used	RO	dirty

- RO
  - Is this page read only?
  - Important in swapping
- Dirty
  - Has this page been written?
  - Important in swapping

Let’s first answer the following questions!

1. What is a TLB?
2. What happens on a TLB hit?
3. What happens on a TLB miss?
4. What happens on a Page Table hit?
5. What happens on a Page Table miss?

Demand Paging : The Big Picture



VPN: Virtual page number
PPN: Physical page number

Userspace **lw $t2, VAR1**

virtual addr

VPN	offset

TLB

VPN	PPN	...
VPN	PPN	...

TLB miss

TLB hit

PPN	offset

User visible

Page Table

VPN	PPN	..
VPN	PPN	...
VPN	PPN	...
VPN	PPN	...
VPN	PPN	...
VPN	PPN	...

Page fault

Disk

In memory

PPN	offset

Nachos OS visible

Page Replacement

```
if (freePageList is not empty)
{
    Allocate one from list; // same with proj2
}
else {
    //No free memory, need to evict a page
    Select a victim for replacement; //Clock algorithm
    if (victim is dirty) {
        swap out;
    }
    Invalidate PTE and TLB entry of the victim page
}
```

Clock Algorithm

- a.k.a Second Chance Algorithm
- Selects a page for eviction based on the value of the used bit
- Works like FIFO but skips over pages whose used bit is set

What if all the pages are pinned?

Swapping

- When do we swap out a page?
  - If the page to be evicted is dirty
- When do we swap in a page?
  - If page being accessed was swapped out
- Which pages should not be swapped?
  - Read only
  - Pinned