Scribe Notes for Tuesday 11/5/13

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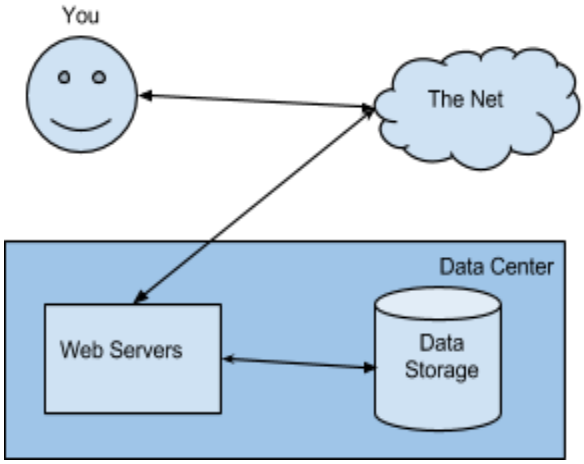
- OS01
    - Attack to erase welcome's code using memset (sets it all to 0's)
        - The 0's erased the permissions and made it inaccessible, so we get pagefaults
        - How do we fix it?
            - We can't protect one process against another process without making it inaccessible to every other process except the kernel
            - Since otherwise we might prevent it from reaching its own code as well, we should fix it by setting a second level pagetable
            - Allocate space for hello's new pagetable
            - Memset first level pagetable to 0's (we'll only ever need the first entry, and we set it to point to the top of the new second level table)
            - Take away user permissions then add them back for the first entry (which is the program's own code)
    - Give each process its own physical page to make it seem like each process has control of the entire kernel
        - You can map x in process 1 and x in process 2 and not have a conflict
        - We do this with **virtual addresses (VA's)**
        - <u>Mapping from one virtual address to a physical address</u>
            - %cr3 → control register
                - Holds the address of the current process's L1 page table
            - The **offset** is the location in the physical page that the process wants to access
                - It's the least significant 12 bits of the VA
                - You can't change the offset when you translate
            - **Identity mapping** — mapping the virtual address to the same physical address
            - The **Pagetable Level 1 Index (PTL1)** is the most significant (top) 10 bits of the VA
            - The **Pagetable Level 2 Index (PTL2)** is the next most significant 10 bits of the VA
            - <u>Example 1</u>
                - ·Given:
                    - Virtual Address: 0x00408050
                    - Physical Address (PA): 0x11111050
                    - %cr3: 0x10000000
                    - [0, 0x03000000 | P | U | W | 0]
                - We get:

                - PTL1 = first 10 bits of 0x004 = 4
                    - 0x004 = 0000 0000 0100 in decimal
                - Pagetable Level 2 Index (PTL2) = last 10 bits of 0x408 = 8
                    - 0x408 = 0100 0000 1000 in decimal
                - Offset = 0x050
            - 0x80
                - 32 00000|P|W|U
            - If you wanted to map VA: 0x00408050 to PA: 0x00408052, you CAN'T
                - page table never messes with the offset → 050 has to go to 052
        - Kernel keeps a process descriptor → holds all the info of a given process
        - Takes all the state of process 1 and saves them all
        - When it goes back to P1, reloads all the registers and restarts the process
- OS02: Three Processes
    - Allocator
    - Recursive process
    - Simple fork
    - Systems calls vs. function calls
        - System call: put your arguments in registers, put return in eax, and then **call interrupt** which notifies kernel
    - Allocator
        - Allocates a page
    - First Attack
        - Can't call sys_page_alloc because it's not properly aligned
        - How should the kernel fix this?
            - Return an error when argument is not multiple of PAGESIZE
            - Check that the address that was passed into the system call is aligned, otherwise return -1
    - Another attack: Pass addresses in the Kernel itself
        - sys_page_alloc(char*) [addr]
        - Now we're messing with Kernel memory
        - Will be worse than a panic → OS continuously duplicates
        - Double fault handler → computer gets reset. This is a triple fault since the kernel trap causes a single fault, the handler check causes a double fault, and the double fault handler also fails, which makes it a triple fault
        - git checkout origin/v05
            - Not only check that it's aligned, but check that address is in user space and not kernel memory
    - Recursive Program
        - Calculate recursively from 0 to 999 n*(n+1)/2

        - Helper function prevents compiler from inlining everything
        - Problem: sys_page_alloc returned -1
            - going to run out of memory
            - The recursive functions creates a huge chain of stack frames that can overflow
            - We pagefault because we try to step past the allocated memory
            - We can fix this by allocating a new page every time we pagefault
                - Trapping and handling allows OS to fix problems as they happen
                - The general pattern is having the process fail, fixing the problem, and restarting the process
                - This solution could fail because many different things can trigger a pagefault
- Adventures in Systems Research
    - 

    - A project that Eddie and his grad students have been working on — Web servers/data storage at a data center
    - If too many people are trying to access a data center through a web server, it can cause a malfunction in the data storage (even a fire, apparently)
    - Need to get data from somewhere else → data storage is a bottleneck
    - How do we fix this?
        - We could just increase the number of data centres, and be able to handle all the requests, but they'd still be slow
        - We can implement caching, buffered I/O
        - This reduces the load on the datastore (and prevents fires)
        - It also improves the read performance
            - There's higher throughput and lower latency
                - Important because people are impatient (if Amazon took 10 seconds to load a page, customers would go elsewhere)
                - Latency = response time for a user to access a web page
        - When/What to cache?
            - When reads are repeated

            - Whole pages (Wikipedia) or fragments (Reddit)
        - When reads are predictable
            - Computed results or aggregates & summaries
- Twitter
    - How can we use caching to help construct twitter timelines faster?
    - You take the posts from the people you follow, sort them, and return them
    - There's more than 100 timeline checks per every new tweet (so reading dominates)
    - 2M users, fixed workload
    - Caching Idea
        - Cache as many recent posts and follows as possible
        - The client collects the posts and assembles the timeline
        - This comes with problems
            - It's too slow to do on every timeline check, and it'd be useless if there are no updates to read
            - There is a linear relationship between runtime and percent of active users
    - Rethinking the Cache
        - Is anything repeated? No. You don't get the same tweet twice
        - Is anything predictable? Yes! Tweets are always getting refreshed
            - You're going to want to look at most recent tweets
        - Is anything computed? Yes again!
        - Is it expensive to compute? Yup.
    - A Good Idea
        - Optimize for reads by doing more work on writes
        - Keep an updates, cached timeline per user
            - On a write, append the tweet to the followers' timelines
        - For a timeline check, just read from the cache
            - In case of a cache miss, just construct the timeline as before
        - Twitter already does this, and the linear relation is less sloped
            - It performs better for ~10% or greater active users, but worse for less
- Research Idea
    - Allow the cache to generate new data from the existing data
        - Want to be able to keep it up to date after it's been generated
        - On the first access, generate it anew
        - Maintain the derived data incrementally
    - Optimize for predictable reads
        - Social media streams and aggregates of high-rate data
- **Pequod**
    - A key-value cache with additional features
        - Range scan primitive

        - Cache joins
            - Relate input data (sources) with generated data (sinks)
    - Contact Eddie, Margo Seltzer, Stratos Idreos, or Steve Chong if you're interested!