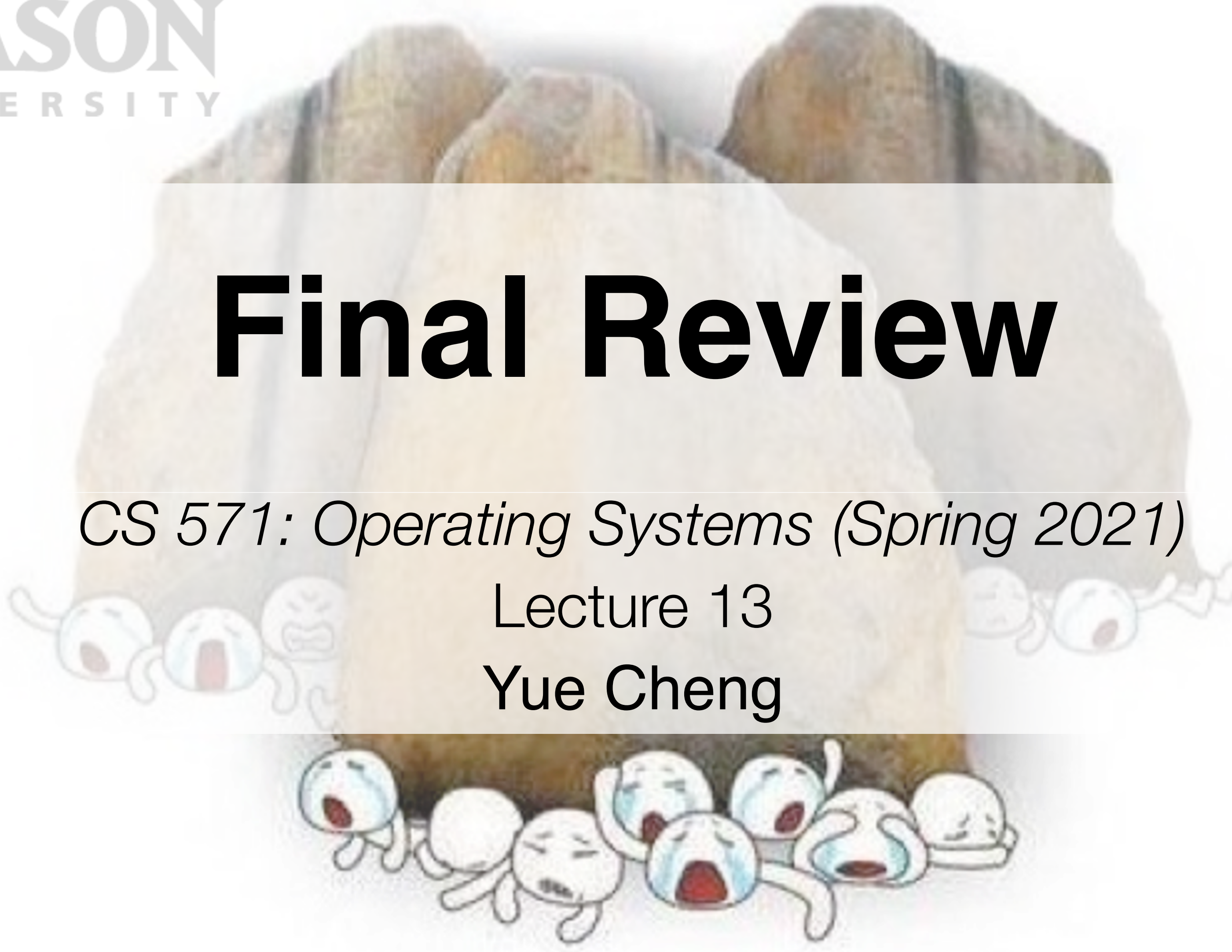


Final Review

CS 571: Operating Systems (Spring 2021)

Lecture 13

Yue Cheng

Final Exam Logistics

- Wednesday, May 5, 7:20pm – 10:00pm
  - 160 min, open book, open notes

- Covering topics from lec-1 to lec-12
  - CPU virtualization ← 30% midterm.
  - Memory virtualization
  - Concurrency
  - Persistence
  - Distributed systems

} ← 70%

Final Exam Logistics (cont.)

- Like midterm, the final exam sheet will be available on Blackboard (under "**Assignment**") for downloading at 7:20 pm

- You may work directly on the Word document
  - Or, you may print it out and write on printed papers – make sure to scan to pdf **with visible resolution**
  - ***Convert it to pdf for submission***

- Submission closes at 10 pm, so please make sure to submit before the deadline

CPU Job Scheduling

- FIFO
  - How it works?
  - Its inherent issues (why we need SJF)?
- SJF
  - How it works?
  - Any limitations (why we need STCF)?
- STCF (preemptive SJF)
  - How it works? How it solves SJF's limitations?
- RR
  - How it works (time quantum or slice)?
  - Why it is needed (compared to SJF & STCF)?
    - The turnaround time vs. response time tradeoff

optimal.

* Jobs arrived same time

* Jobs arrived diff time

CPU Scheduling Metrics

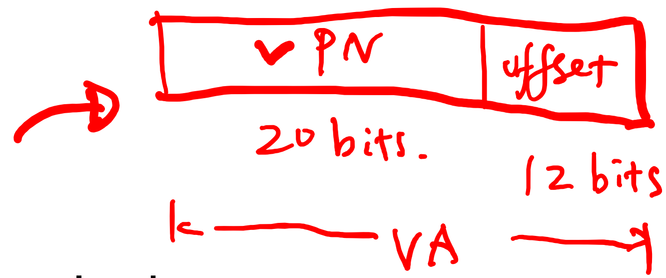
- Average waiting time
- Average turnaround time

- How to calculate the metric under a specific schedule (Gantt chart)

Memory Management: Addresses & PT

32-bit.
4KB.

- Virtual addresses and physical addresses
  - VPN, PFN, page offset
  - Virtual address = VPN | offset



- Virtual to physical address translation
  - (Basic) linear page table: using VPN as index of array

array: Sz(PTE) = 4B.

VPN.

4KB.

$2^{20} \times 4B = 1MB \times 4 = 4MB.$

$\frac{4MB}{4KB} = 1K.$

Advanced Page Tables

- Approach 1: Linear inverted page table
  - Whole system maintains only one PT
  - Performs a whole-table linear search using `pid+VPN` to get the index
- Approach 2: Hash inverted page table
  - Leverages hashing to reduce the time complexity from `O(N)` to `O(1)`
- Approach 3: Multi-level page table
  - Uses hierarchy to reduce the overall memory usage

Condition Variables

- CV: an explicit queue that threads can put themselves when some condition is not as desired (by waiting on that condition)

- **`cond_wait(cond_t *cv, mutex_t *lock)`**
  - assume the lock is held when **`cond_wait()`** is called
  - puts caller to sleep + **release** the lock (atomically)
  - when awaken, **reacquires** lock before returning

- **`cond_signal(cond_t *cv)`**
  - wake a single waiting thread (if >= 1 thread is waiting)
  - if there is no waiting thread, just return, **doing nothing**

Condition Variables (cont.)

- Traps when using CV
  - A `cond_signal()` may only wake one thread, though multiple are waiting
  - Signal on a CV with no thread waiting results in a lost signal

- Rules of using CV
  - Always do wait and signal while holding the lock
  - Lock is used to provide mutual exclusive access to the shared variable
  - `while()` is used to always guarantee to re-check if the condition is being updated by other thread

Classic Problems of Synchronization

- Producer-consumer problem (CV-based version)
- Readers-writers problem
- Dining philosophers problem

I/O and Storage

block dev.

- Hardware storage mediums
  - HDDs:
    - Internal mechanical pieces
    - Performance model: seek, rotate, data transfer

    sectors.

  - Flash SSDs: SLC. MLC.
    - Asymmetric read-write performance
    - Due to inherently different architecture

Flash pages.
Flash blocks.
planes / banks.

program. → fine grained. W. μs.
/page.

erase. → coarce-grained W. ms.
/block.

RAID

- Tradeoffs of different RAID configurations

Stripe.

- RAID-0: No redundancy, perf-capacity upper bound
- RAID-1: Mirroring

XOR. parity. cal.

- RAID-4: A disk is solely used for storing parity
- RAID-5: Rotating parity across disks

MapReduce

- Why MapReduce:
  - Google workload characteristics
- How MapReduce works:
  - The MapReduce paper
- How data flows within a MapReduce job:
  - Use of local file system and use of GFS
- Limitations of MapReduce

Workflow → Multiple MR jobs.
Job1 → WC. → output. (spilled to GFS).
Job2 → indexing.
(memory). save I/Os. improve perf!
Spark.
workflow. map. shuffle. reduce.
input. — GFS.
intermediate — local FS. ~~GFS~~
output. → GFS.

Question Types

- Multi-choice questions

- Problem solving

Good Luck!