ECE 574 – Cluster Computing
Lecture 15

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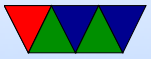
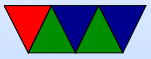
Announcements

- HW#7 will be posted.
- HW#6 almost graded



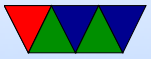
Hand Back Midterms

- Average was a 94

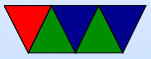


Further HW#6 review

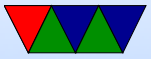
- Fix warnings!
- More code comments too
- Remember, we want from 1 to y-1, not 0 to y
  That is tricky when subtracting off
- If you create a temp buffer, that's fine, but might want to zero-it-out before reusing it or else the edges might have old data in them.
- sizeof operator... what is `sizeof(image.pixels)`
- Calculating the tail-ends of things and copying it in place



- If you get a staggered/shifted effect. Should probably gather in multiples of xsize, otherwise it will be shifted. Gather in the same size as your ysize limits.
- I'll attach my changes when I send out grades

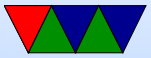


Things you can do Software



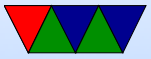
Algorithm Based

- Parity checks, CRC
- Spread out work so that if one gives wrong result it can be checked. Overlap work.
- Add some extra values to calculation that can be checked, can tell if something went wrong



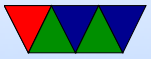
Control Flow Checking

- Knows where code should be allowed to jump to
- If you jump somewhere impossible, checker stops things



Checking Data Structures

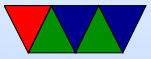
Extra state in data structure or checksum so can tell if it gets corrupted.



Memory Failures

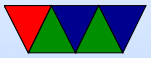
- Memory Errors in Modern Systems
  ASPLOS 2015

- Battling Borked Bits
  IEEE Spectrum December 2015



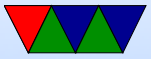
Architectural Vulnerability factor

- Some bit flips matter less
- (branch predictor) others more (caches) some even more (PC)
- Parts of memory that have dead code, unused values



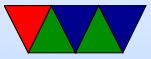
Failure and Error Rates

- Cassini, flight recorders, each with 2.5GB RAM
  Single bit error rate of 280 errors/day
- Google SIGMETRICS 2009 paper
  25-70k errors per billion hours per megabit
  5 single bit errors in 8GB per hour
- ASCI White when came out, MTBF 5hrs, got it to 55hrs
- Sequoia MTBF around 1 day, Blue Waters: 2 per day,



Titan MTGF: less than a day

- 20% of computation is recovering from failures (big energy waste)
- Most of failures do not take down more than one node Jaguar/Titan 92% crashes single-node crashes



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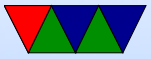
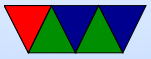


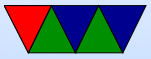
Byzantine Failure

- Byzantine General Problem, Lamport et al
  Generals surround a city. Want to all attack or all retreat; doing it part way will fail.
  Might be traitorous generals with complex things (split their vote, if 5R 4A, tell the 5A and 4R).
  Unreliable messengers.



N-version software

- Implement same code many different ways, vote on result. Need a tight spec to make sure results will all match.



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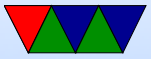

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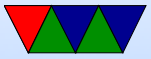

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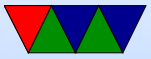
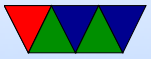


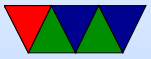
Application Level Checkpointing

- Checkpoint your program state periodically.
- If a failure takes down a program or hardware node, you can restore to last checkpoint rather than starting from scratch.
- Two kinds – manual (you save out your state manually and have to write code to restart from arbitrary point)
- Automatic – kernel stores everything possible about your state and can restart a program from a snapshot.



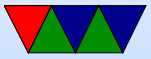
Difficulty? All program state, network connections, RAM contents, disk state, open files, etc. Hard (I've written one). Some support in Linux kernel, need lots of patches as some syscalls are write-only.

- Checkpoints have high overhead. Have to stop while taking them? Write GB to disk?
- Multilevel checkpoint – big checkpoint occasionally and smaller subcheckpoints



Crash Only Software

- Crash-only software – crashing and restarting can take less time than clean reboot.
- So why write code to cleanly shutdown? Instead write your code so it can handle crashes cleanly. That way your cleanup code is tested every exit, rather than rarely on a crash.



Approximate Computing

- Approximate Computing – some algorithms don't necessarily need the "right" value
- Video rendering, voice recognition, web search, robotics, GPS, image processing