ECE 574 – Cluster Computing
Lecture 20

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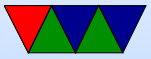
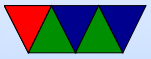
Announcements

- Projects
- Thanksgiving question
- Supercomputing



Announcements

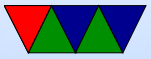
- HW `#SBATCH --tasks-per-node=4`
- -N = number of nodes
- -n = number of tasks, default is one task per node?
- N=4 tasks-per-node=4, 16
  N=4 tasks-per-node=4, sbatch -n 8, 16 (N=nodes, n=tasks)
  N=4 tasks-per-node=4, sbatch -N 8, 32



nothing, sbatch -N 8, 32

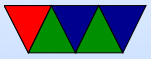
nothing, sbatch -n 8, (8, 2 nodes * 4 each)

nothing, sbatch -N 8 -n 8 (8, 8 nodes * 1 each)



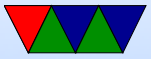
Architectural Vulnerability factor

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



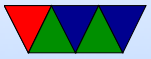
Failure and Error Rates

- 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

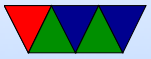


Testing

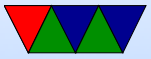
- Single event upset characterization of the Pentium MMX and Pentium II microprocessors using proton irradiation, IEEE Transactions on Nuclear Science, 1999.

- Pentium II, took off-shelf chip and irradiated it with proton. Only CPU, rest shielded with lead. Irradiate from bottom to avoid heatsink

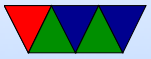
- Various errors, freeze to blue screen. no power glitches or "latchup 85% hangs, 14% cache errors no ALU or



FPU errors detected.

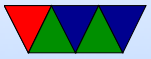


Things you can do Software



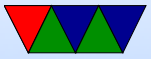
Byzantine Failure

- 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.



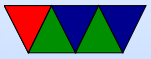
N-version software

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



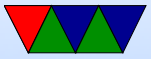
Algorithm Based

- 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



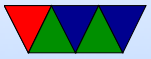
Control Flow Checking

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



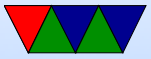
Checking Data Structures

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



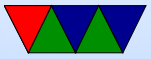
Application Level Checkpointing

- 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.



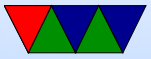
Difficulty? All program state, network connections, RAM contents, disk state, open files, etc. Hard (I've written one). Some support in Linux kernel, need lots of patches as some syscalls are write-only.

- 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