ECE 574 – Cluster Computing
Lecture 18

Vince Weaver

http://web.eece.maine.edu/~vweaver

vincent.weaver@maine.edu

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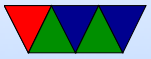
Announcements

- HW#8 will be posted
- Second Midterm will be 25th (2 weeks from today)
- Project Status Report Due Thursday (with extension to Friday)

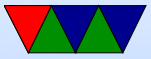


CUDA HW#8 Notes

- PAPI for GPU/CUDA counters
  Couldn't get it to work.

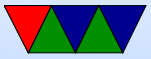
- First do combine Next, first have combine just set to 0xff (so should set whole image to white). next try setting to sobel_x and see if you can just get that output

- Understanding the grid/block/thread mess. `https://cs.calvin.edu/courses/cs/374/CUDA/CUDA-Thread-I.pdf`



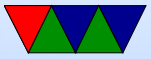
Big Data

- Until now compute or network bound systems
- What if we want to do a lot of disk/IO? Big Data?
- Where is Data Used a lot?
  - Google
  - Worldwide LHC Computing Grid (WLCG) as of 2012
    25 petabytes of data/year (petabyte=1000 terabytes)
    300 GByte/s of data incoming



- Big Data is about big data sets (Terabytes?) and trying to get useful information out of them. Data Mining.

- "Big Data: Astronomical or Genomical": PLos Biology, 7 July 2015. (as per IEEE Spectrum December 2015). Twitter: 1-17PB/year. Astronomy, 1,000PB/year, YouTube 1,000-2,000 PB/year, Genomics 2,000-40,000PB/year



Types of Storage

- Hard Disks
  - spinning rust – can be slow latency wise
  - SSD – faster, why?
  - Traditional vs Advanced features

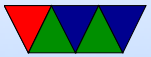
    Shingled (SMR) Disks

    Perpendicular (PMR) Disks

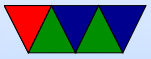
    `https://www.youtube.com/watch?v=xb_PyKuI7II`

    Helium

    Caches

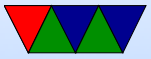


- Other flash / SD cards
- Memristors/Phase-Change/Optane/XPoint Non-volatile RAM
- Tape – robot tape libraries, etc
- Optical – CD/DVD/Blueray



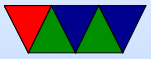
RAID

- Redundant Array of (Independent / Inexpensive) Disks
- Patterson Gibson and Katz 1987: replace expensive mainframe disks with arrays of relatively cheap desktop drives
- RAID0: striping, spreading across multiple disks, can increase performance, increases size of disk, bad things happen if one drive fails
- RAID1: mirroring – same thing written to both drives



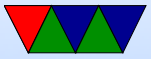
can increase performance as either drive can answer request

- RAID2: hamming code, each bit on separate drive. Not really used.
- RAID3: byte-level striping with parity. not common
- RAID4: block-level striping with dedicated parity.
- RAID5: block-level striping with distributed parity.
  can handle failure of single disk, can rebuild based on parity.



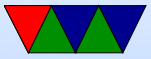
Not recommended, as you have to read entirety of all other disks to rebuild, likely to fail other disks if all of same vintage

- RAID6: block-level striping with double parity. Recommended
- Hybrid: RAID10 = RAID1 + RAIDO
- Software vs Hardware
- Some filesystems include RAID like behavior: ZFS, GPFS, brfs, xfs



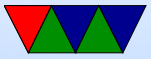
Non-RAID

- nearline storage – not offline but also not fully online
- MAID – Massive Array of Idle Drives
  Write once, read occasionally.
  Data that you want to save, but really don't access often so taking seconds to recall is OK.
  What kind of data? Backups? Old Facebook pictures? Old science data?



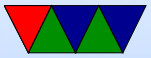
Cluster Filesystem

- Filesystem shared by multiple systems
- Parallel filesystems – spread data across multiple nodes



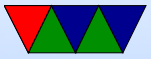
Shared-disk Filesystem

- Shared-disk filesystem – shares disk at block level
- SGI CXFS
  IBM GPFS
  Oracle Cluster Filesystem (OCFS)
  RedHat GFS
  Many Others
- RedHat GFS2
  Distributed Lock Manager



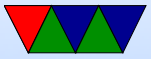
SAN – Storage Area Network

- (Don't confuse with NAS – network attached storage)
- A network that provides block-level access to data over a network and it appears to machines the same as local storage
- DAS – direct attached storage – typically how you hookup a hard-drive
- NAS – like a hard-drive you plug into the Ethernet but



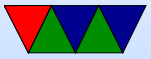
serves files (not disk blocks) usually by SMBFS (windows sharing), NFS, or similar

- NAS: appears to machine as a fileserver, SAN appears as a disk
- SAN often uses fibrechannel (fibre optics) but can also be over Ethernet



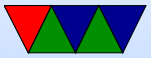
Concerns

- QoS – quality of service. Limit bandwidth or latency so one user can't overly impact the rest
- Deduplication

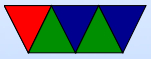


Cluster Storage

- Client-server vs Distributed
- Multiple servers?
- Distributed metadata – metadata spread out, not on one server
- Striping data across servers.
- Failover – if network splits, can you keep writing to files

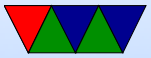


- Disconnected mode.



Network Filesystems

- NFS, SMBFS, Netware

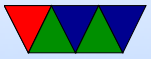


Distributed Filesystem Architectures

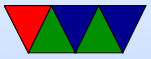
From *A Taxonomy and Survey on Distributed File Systems*

Can be any combination of the following

- Client Server – like NFS
- Cluster Based – single master with chunk servers
- Symmetric – peer to peer, all machines host some data with key-based lookup

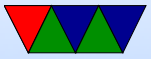


- Asymmetric – separate metadata servers
- Parallel – data striped across multiple servers



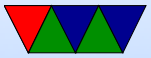
Stateless

Can you reboot server w/o client noticing? Lower overhead if server stateless because the server doesn't have to track every open file in the system



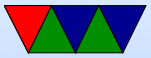
Synchronization/File Locking

- Multiple users writing to same file?
- Always synchronous?
- Same problems with consistency that you have with caches/memory

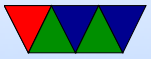


Consistency and Replication

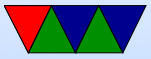
- Checksums to validate the data
- Caching – if you cache state of filesystem locally, how do you notice if other nodes have updated a file?



Failure Modes

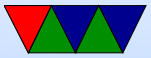


Security



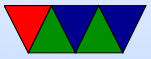
Distributed Filesystems

- Follow a network protocol, do not share block level access to disk
- Transparency is important. User doesn't need to know how it works underneath.
- Ceph, GFS, GlusterFS, Lustre, PVFS



Lustre

- "Linux Cluster"
- Complex ownership history
- Old article: `http://lwn.net/Articles/63536/`
- Used by many of the top 500 computers (6 of top 10 and 60 of top 100)
- Can handle tens of thousands of clients, tens of petabytes of data across hundreds of servers, and TB/s of I/O.

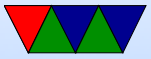


- One or more metadata servers: keep track of what files exist, metadata, etc, locking, can load balance.

- One or more object storage servers
  Boxes of bits accessed by unique tag

- File can be "striped" across multiple storage servers and stream the file data in parallel

- Failure recovery. If node crashes, another nodes remember what it missed while down and help it recover to the proper state



- Distributed Locking
- Fast networking. Use RDMA when available.