Netflix OpenConnect & FreeBSD

BSDCan DevSummit
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Who are we?

- Scott Long <scottl@netflix.com>
  - FreeBSD 20+ year veteran
  - Former Release Engineer
  - Adaptec, Yahoo!, Netflix
- Alistair Crooks <agc@netflix.com>
  - Unix since V6, BSD since 4.1c
  - pkgsrc founder
  - NetBSD security-officer, core team
  - Wasabi, VISA Europe, Yahoo!, Netflix

What is Netflix Streaming?

- Amazon Web Services
  - Website, Business Functions, Authentication
  - Data Science
  - Encoding/Encryption
  - Command and Control
- Content Servers
  - Was Big-3 CDNs
  - Moving to "OpenConnect"

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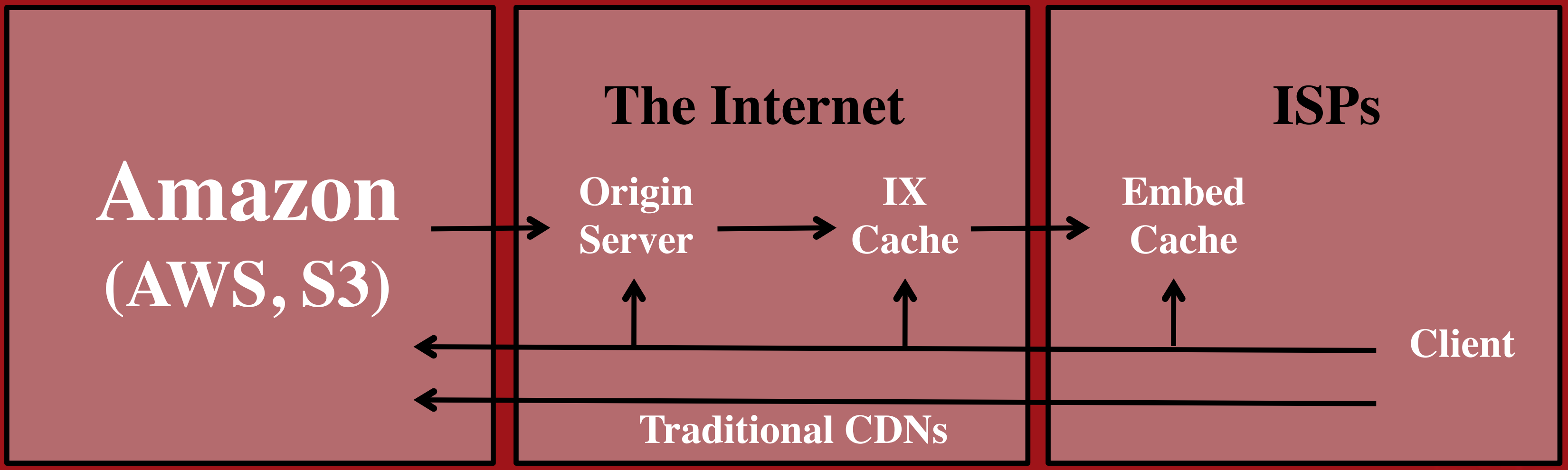
What does OpenConnect do?

- Brings content closer to the customer
- Saves ISPs and Netflix money on peering and transit costs
- Augments existing CDN capacity



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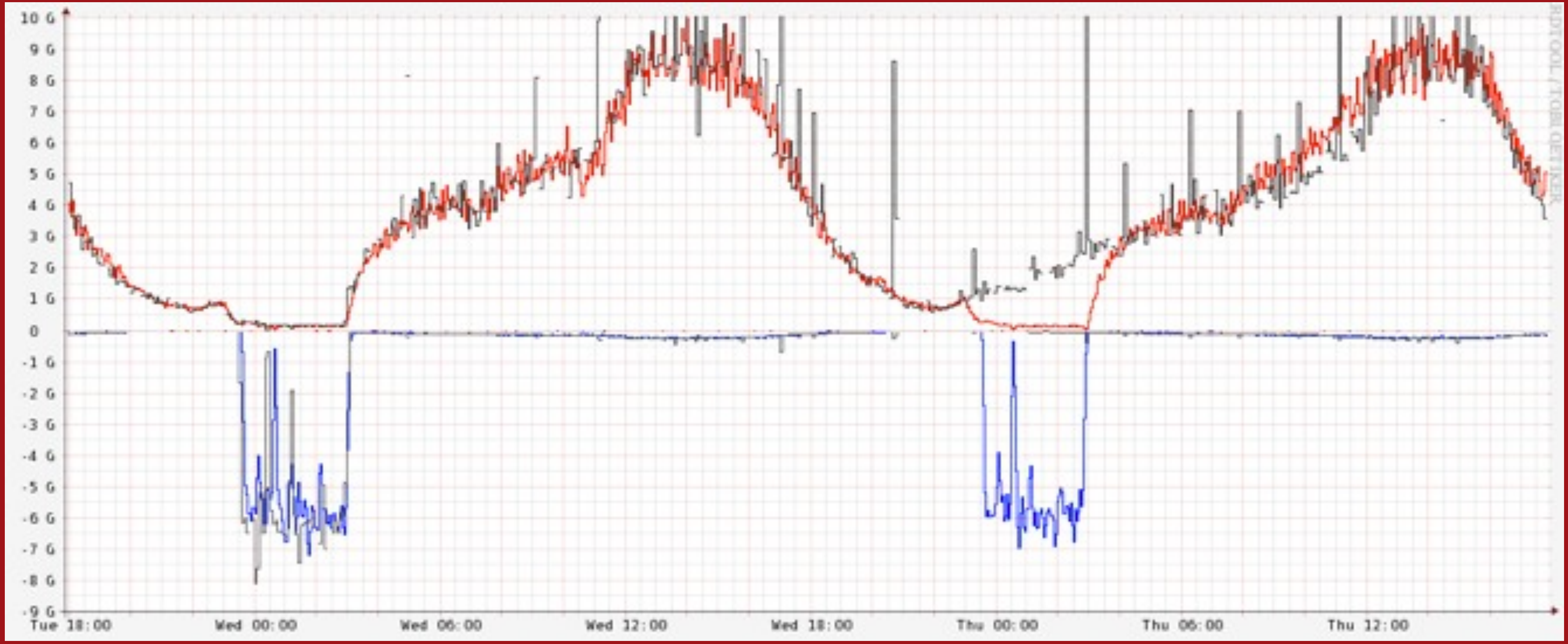
What is OpenConnect?

- Webserver for terabits of static traffic
- Content delivery network - peering and embedding
- FreeBSD 9, nginx webserver, Bird BGP
- Off-the-shelf PC components
- High-Density, ISP-friendly Chassis
- http://openconnect.netflix.com

Typical Traffic Pattern



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Building Block Architecture

- Horizontally and vertically scalable
- 1 box = 10% of the Netflix library
- 1 box = 5,000-15,000 streams
- 1 box = 60-80% bandwidth offload
- Fail-in-place design
- Fault tolerance via distributed copies, client-server feedback loop

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Building Block Architecture

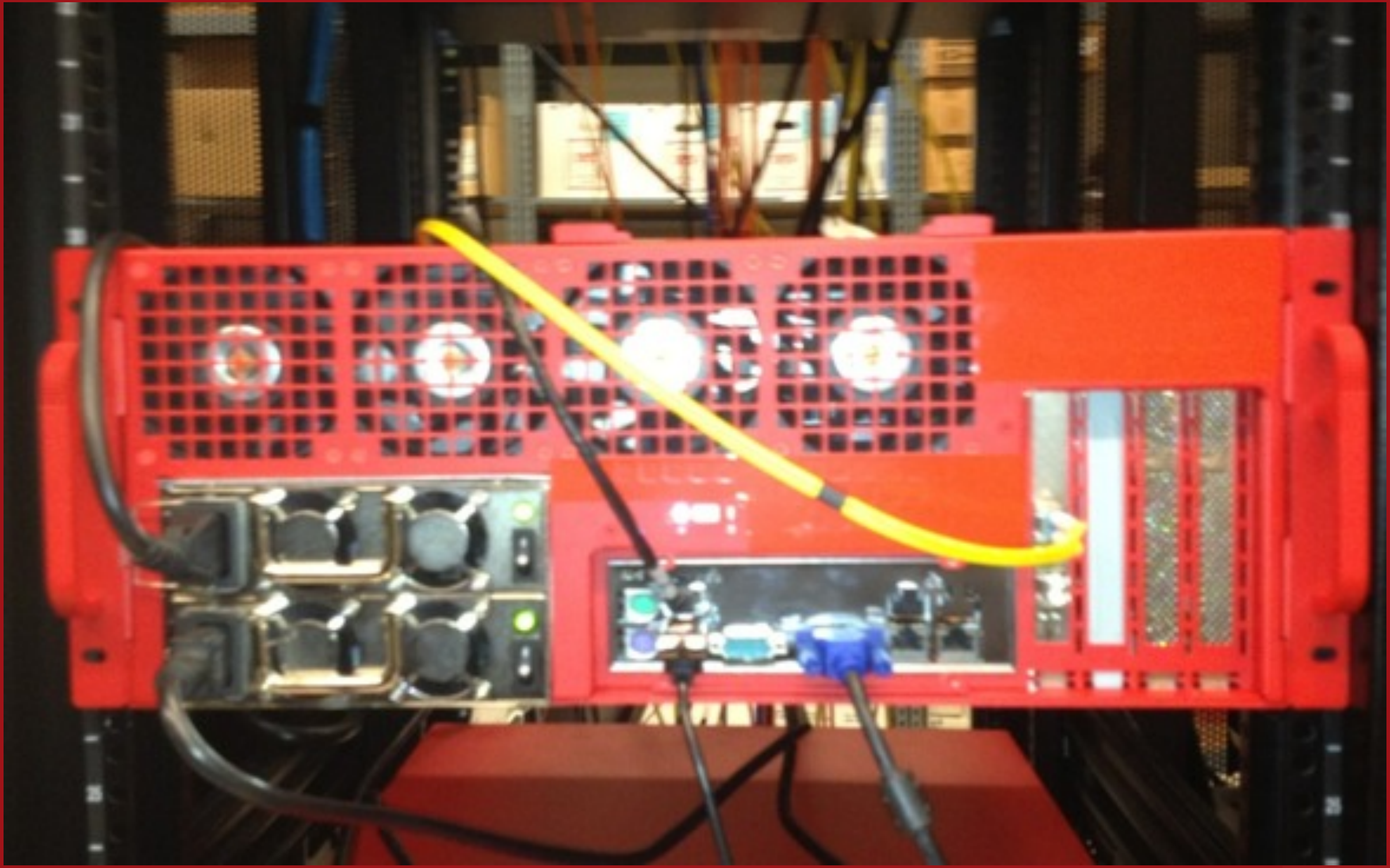
Initial design goals

- Modest compute resources
- ~10Gbps of traffic
- Maximized capacity: No RAID!
- No hot swap drives, few user-serviceable parts
- No SAS expander or other single-points-of-failure
- 600W power footprint, reasonable airflow, data-center friendly

Revision A Hardware

- Supermicro X9SCM-F, Intel E3-1260L
- Custom chassis, 4U x 25” deep
- 36 3TB Seagate Barracuda HDDs
- 2 Crucial M4 512GB SSDs
- 2 16-port LSI SAS/SATA
- 32 GB RAM
- Dual port Intel 10 GbE Fibre
- 8,000 - 10,000 clients, 8.5Gbps

Revision A Hardware



Revision C Hardware

- Custom chassis, 4U x 20” deep
- Supermicro X9SRL-F Motherboard
- Intel E5-2650 8-Core Xeon, 64GB RAM
- 36 Hitachi Enterprise 4TB HDD’s
- 6 Crucial M4 512GB SSD’s
- 4 8 port LSI SAS
- 2 Dual-port Chelsio 10GbE Fibre
- 15,000 clients, 15-18Gbps

Revision C Hardware

Revision D Hardware

- 1U Chassis
- Supermicro X9SRH-7F Motherboard
- Intel E5-2650 8-Core Xeon, 64GB RAM
- 14 Crucial M5 960GB SSDs
- Onboard 8-port LSI SAS
- Quad-port Chelsio 10GbE Fibre
- >20,000 connections, >20Gbps

Revision D Hardware

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Structured Cabling

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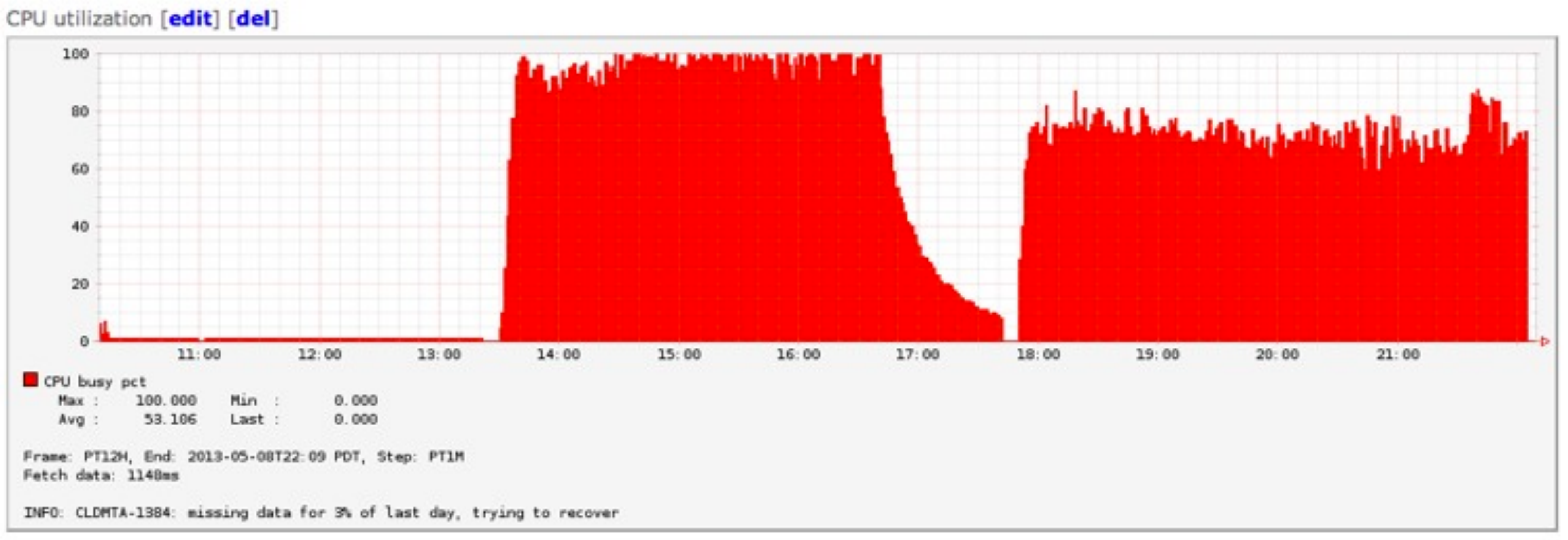
Why FreeBSD?

- Availability of expertise, outstanding community
- Works well, good vendor support
- No GPL
- Features used:
  - SUJ
  - gmirror – boot drive only
  - AIO
  - Dtrace, HWPMC
  - TCP Stack, modular CC

Netflix Contributions

- Camcontrol mods to download SATA firmware
- IPv6 ref counting fixes
- ixgbe interrupt mitigation, RX optimizations
- Fixes for isci driver for firmware download
- Collaboration with FF, Isilon on Unmapped I/O
- VM/VFS Tuning: vfs.read_min

Unmapped I/O



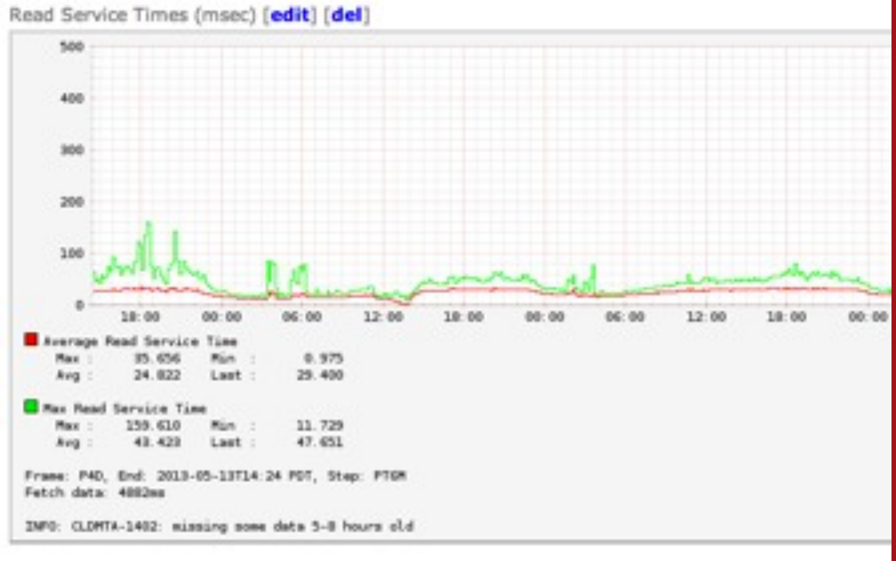
CPU utilization [edit] [del]

```
🟥 CPU busy pct
     Max :    100.000    Min  :      0.000
     Avg :     53.106    Last :      0.000

Frame: PT12H, End: 2013-05-08T22:09 PDT, Step: PT1M
Fetch data: 1148ms

INFO: CLDMTA-1384: missing data for 3% of last day, trying to recover
```

vfs.read_min



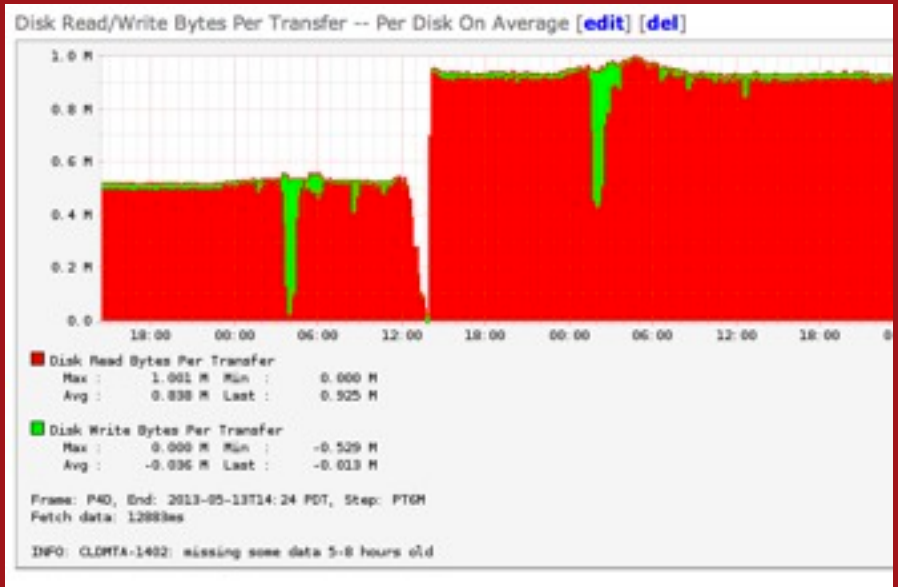
Read Service Times (msec) [edit] [del]

```
■ Average Read Service Time
    Max :      35.656    Min  :       0.975
    Avg :      24.822    Last :      29.400

■ Max Read Service Time
    Max :     159.610    Min  :      11.729
    Avg :      43.423    Last :      47.651

Frame: P4D, End: 2013-05-13T14:24 PDT, Step: PT6M
Fetch data: 4882ms

INFO: CLDMTA-1402: missing some data 5-8 hours old
```



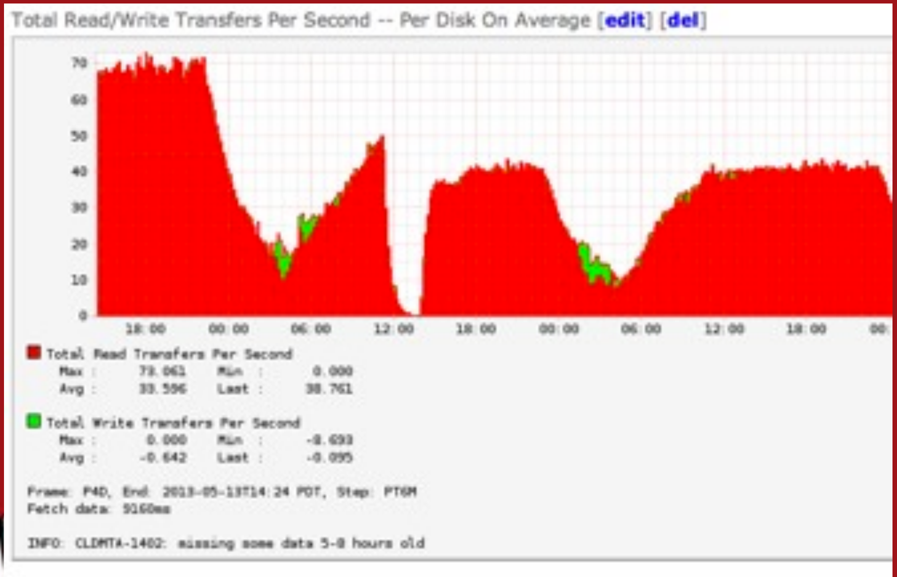
Disk Read/Write Bytes Per Transfer -- Per Disk On Average [edit] [del]

```
■ Disk Read Bytes Per Transfer
    Max :      1.001 M  Min  :       0.000 M
    Avg :      0.838 M  Last :       0.925 M

■ Disk Write Bytes Per Transfer
    Max :      0.000 M  Min  :      -0.529 M
    Avg :     -0.036 M  Last :      -0.013 M

Frame: P4D, End: 2013-05-13T14:24 PDT, Step: PT6M
Fetch data: 12883ms

INFO: CLDMTA-1402: missing some data 5-8 hours old
```



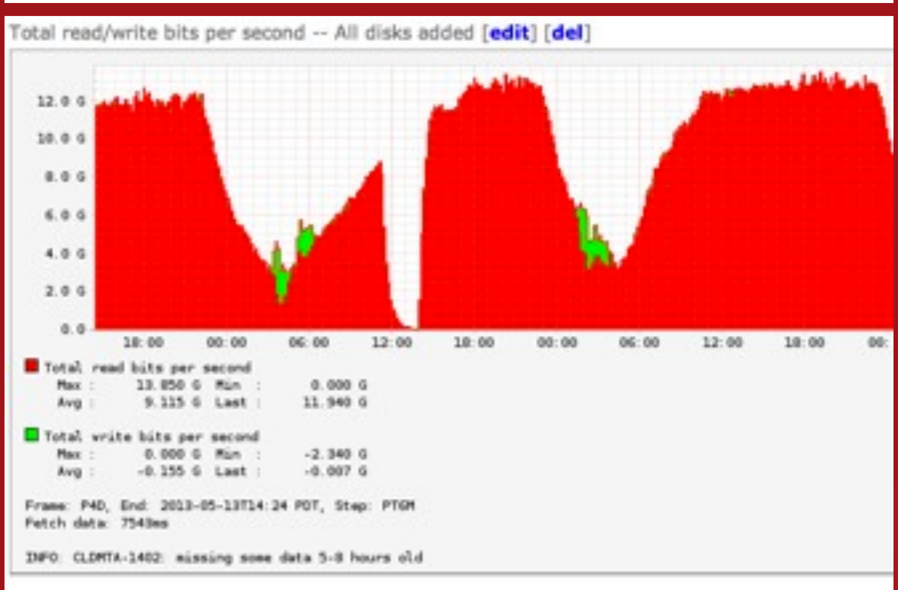
Total Read/Write Transfers Per Second -- Per Disk On Average [edit] [del]

```
■ Total Read Transfers Per Second
    Max :      73.061    Min  :       0.000
    Avg :      33.596    Last :      38.761

■ Total Write Transfers Per Second
    Max :       0.000    Min  :      -8.693
    Avg :      -0.642    Last :      -0.095

Frame: P4D, End: 2013-05-13T14:24 PDT, Step: PT6M
Fetch data: 5160ms

INFO: CLDMTA-1402: missing some data 5-8 hours old
```



Total read/write bits per second -- All disks added [edit] [del]

```
■ Total read bits per second
    Max :     13.850 G  Min  :       0.000 G
    Avg :      9.115 G  Last :      11.940 G

■ Total write bits per second
    Max :      0.000 G  Min  :      -2.340 G
    Avg :     -0.155 G  Last :      -0.007 G

Frame: P4D, End: 2013-05-13T14:24 PDT, Step: PT6M
Fetch data: 7543ms

INFO: CLDMTA-1402: missing some data 5-8 hours old
```

More than just code

- Community sponsorship
  - FreeBSD Foundation
  - MeetBSD, EuroBSDCon
- Working with Intel
  - Improve community relationships
  - Monthly meeting to discuss issues
- Advocate for FreeBSD with Supermicro, Seagate, HGST, LSI, Adaptec, etc

Challenges and Future Work

- Disk I/O
  - I/O scheduling
  - Command queue management
  - GEOM
- Network
  - Pipelining RX path
  - TCP Congestion Control
  - Traffic Classification/Prioritization

Challenges and Future Work

- Filesystem
  - Layout optimized for streaming
  - Journaling/SU bugs
- VM/Buffer/Cache
  - aio_sendfile()
  - LRU cache policy = worst case scenario
- FreeBSD 10

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Review - what does an OCA do?

- Serves HTTP range requests to clients
- Communicates with control plane in AWS
- Allows ISPs to specify AS and CIDRs
- Hardware fail-in-place
- Serve and fill simultaneously
- In ISP or IX locations
- Currently serves 20%+ of US internet

OpenConnect Software

- FreeBSD 9.1 Stable
  - Sync every week with freebsd.org by **svn merge**
  - **nanobsd** is used to make 2 embedded images
- Nginx 1.2/1.4
  - Formerly sync'ed every week by **svn merge**
  - Now by **hg up**
- And....

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Other parts of the system

- 2 images
  - 1 custom production-ready image
  - 1 GENERIC image; prod embedded in thrash
- Scripts and programs
  - For nginx, bird/bird6, normal system configuration
  - For communications with control plane
  - Reporting and monitoring
- Netflix-specific ports tree

Packaging

- 51 ports/packages
  - some bespoke ones
    - fast digest functions
    - control plane communications and reporting
- Ports tree is location independent
- Sandbox builds in a chroot are used
  - avoid build system leaks
  - Binary packages on systems

What’s different?

- saved-options file as part of meta-data
- metadata versions are saved as part of pkg
- a single package defines OCA firmware level
- no indirection through system **.mk** files
- single script to make all packages in a chroot
- no version number necessary on command line
- no chroot building for src yet

Repository

- Subversion - easy to sync with freebsd/nginx
- Git mirror (but we know where the git user lives)
- Formerly sync’ed with Perforce
- Websvn for web-based access
  - primary source of truth for most users
- JIRA integration - ticketing and code review

Installer

- One size fits all
- Hardware-based profiles used
  - easy to add new hardware
  - try out new boards, memory or motherboards
- Disk sizes automatically calculated

OCA Firmware Images

```
-rw-r--r--  1 agc  domainus   102M May 13 15:19
prod-20130513-r2072-red1-image.bz2

-rw-r--r--  1 agc  domainus   394M May 13 15:19
prod-20130513-r2072-thrash-image.bz2

-rw-r--r--  1 agc  domainus   406M May 13 15:19
prod-20130513-r2072-thrash.iso
```

Lessons learned

- Package-based approach
  - allows us to upgrade individual machines
  - is never used
- Cross-building of packages would be good
  - aio_mlock experiments with nginx
  - need a kernel with that system call in it

More lessons learned

- nanobsd’s /cfg is useful, but can be dangerous
  - need to umount before rebooting
- tracking stable has been good for us
- control plane-controlled firmware-refresh nice
- from previous lives - no local patches

Any questions?

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