

FreeBSD for High Density Servers

Intel Avoton based 5,000+ cores
NEC Micro Modular Server DX1000

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Profile

- Daichi GOTO, born in 1980
- ONGS Inc. CEO since 2002 / BSD Consulting, Inc. (Tokyo) CTO since 2012
- FreeBSD committer since 2002 daichi@ / FreeBSD Journal board member since 2013
- Skills: Design and develop of enterprise system, IT-news-writing, book-and-article-writing, etc
- <https://jp.linkedin.com/in/daichigoto>

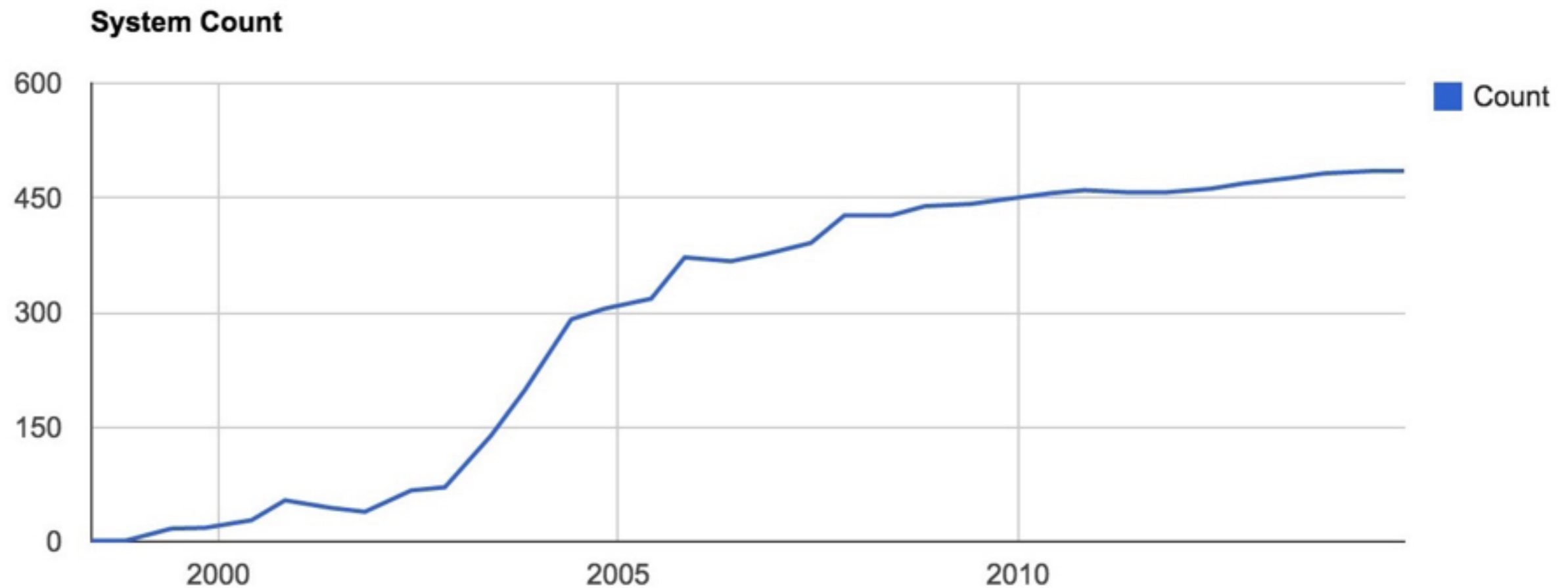
Community work - FreeBSD 勉強会



Intention

TOP500 / Linux

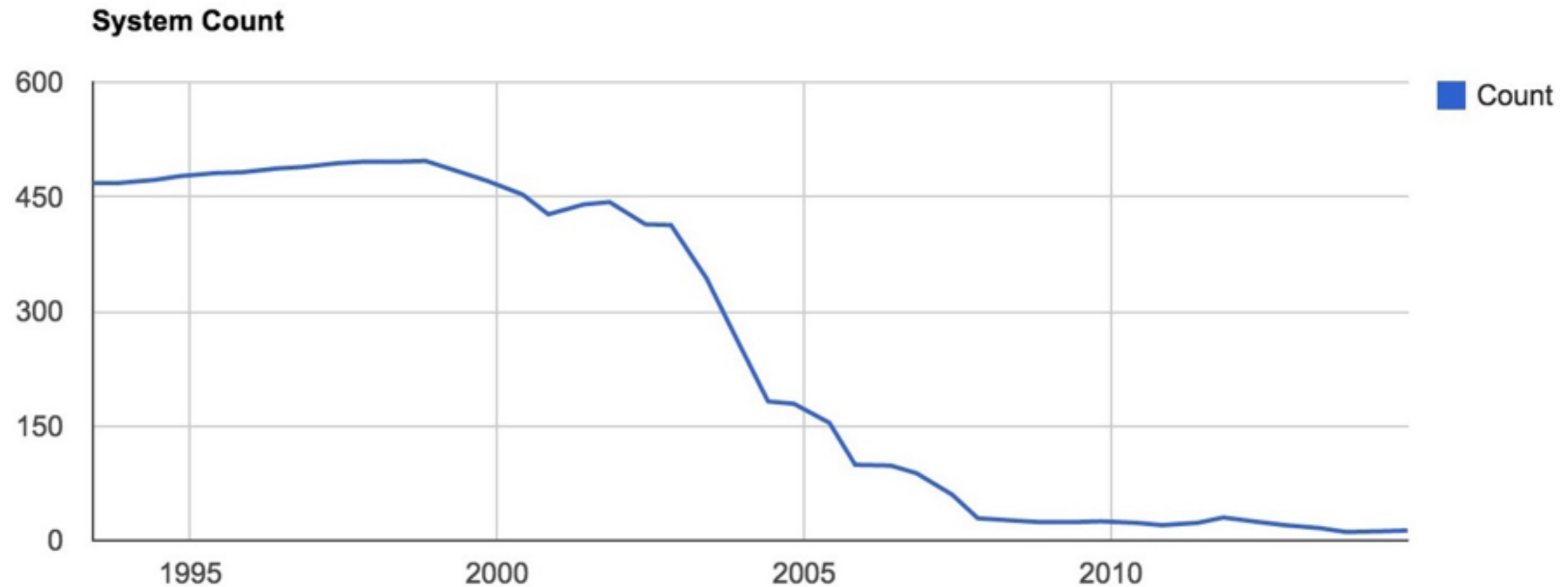
OPERATING SYSTEM FAMILY / LINUX



<http://www.top500.org/statistics/details/osfam/1>

TOP500 / Unix

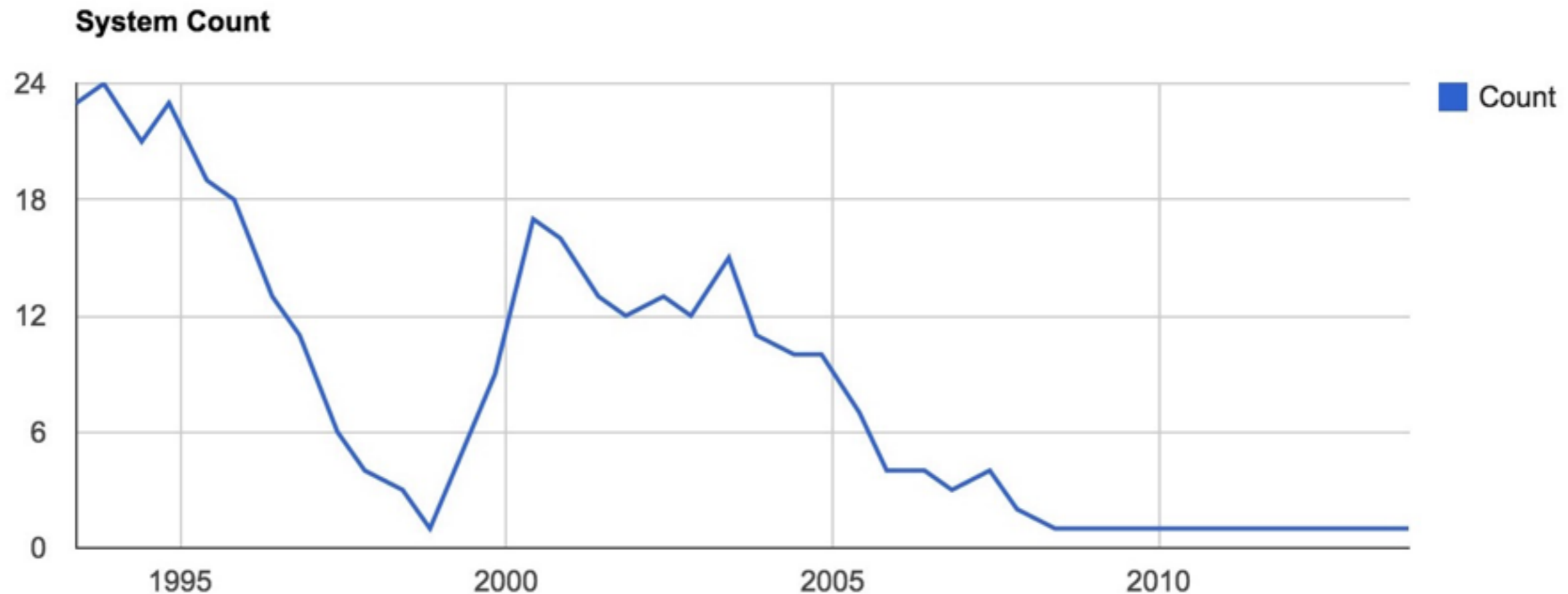
OPERATING SYSTEM FAMILY / UNIX



<http://www.top500.org/statistics/details/osfam/3>

TOP500 / BSD based

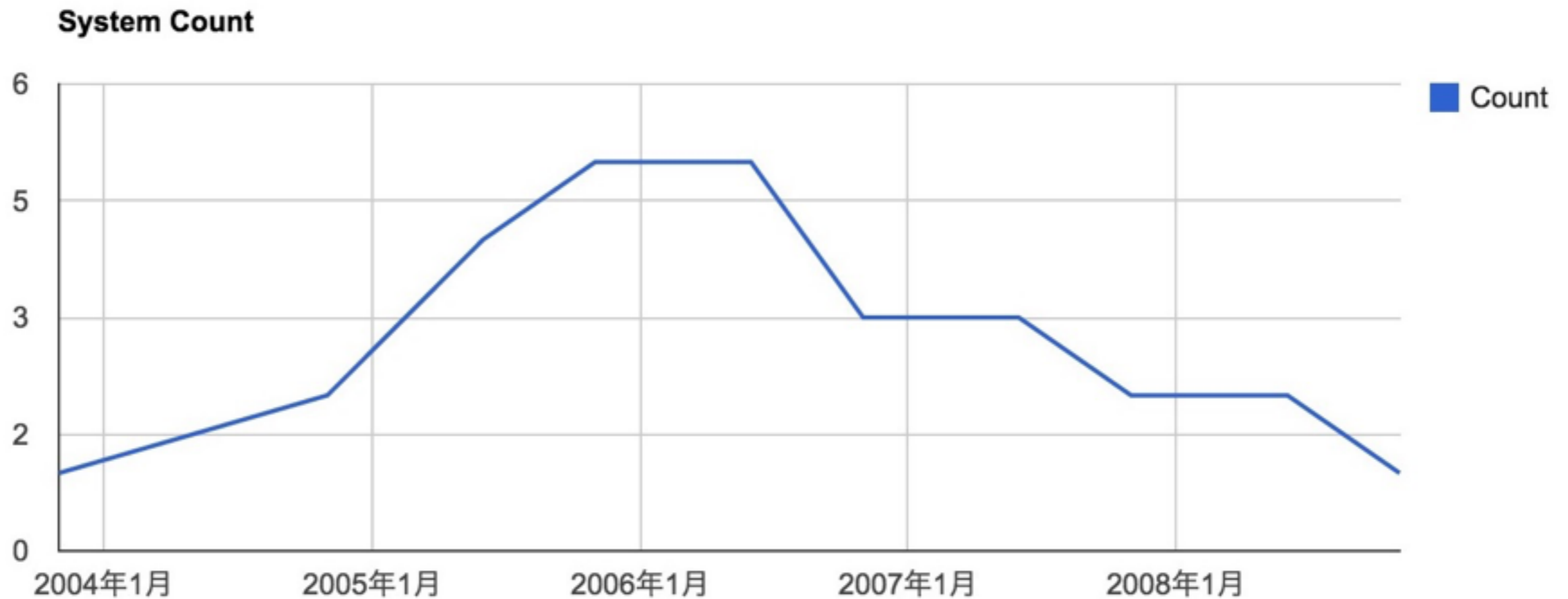
OPERATING SYSTEM FAMILY / BSD BASED



<http://www.top500.org/statistics/details/osfam/5>

TOP500 / Mac OS X

OPERATING SYSTEM FAMILY / MAC OS



<http://www.top500.org/statistics/details/osfam/8>

TOP500 / FreeBSD

OPERATING SYSTEM FAMILY / FREEBSD



<http://www.top500.org/statistics/details/osfam/1>

some reasons of the defeat

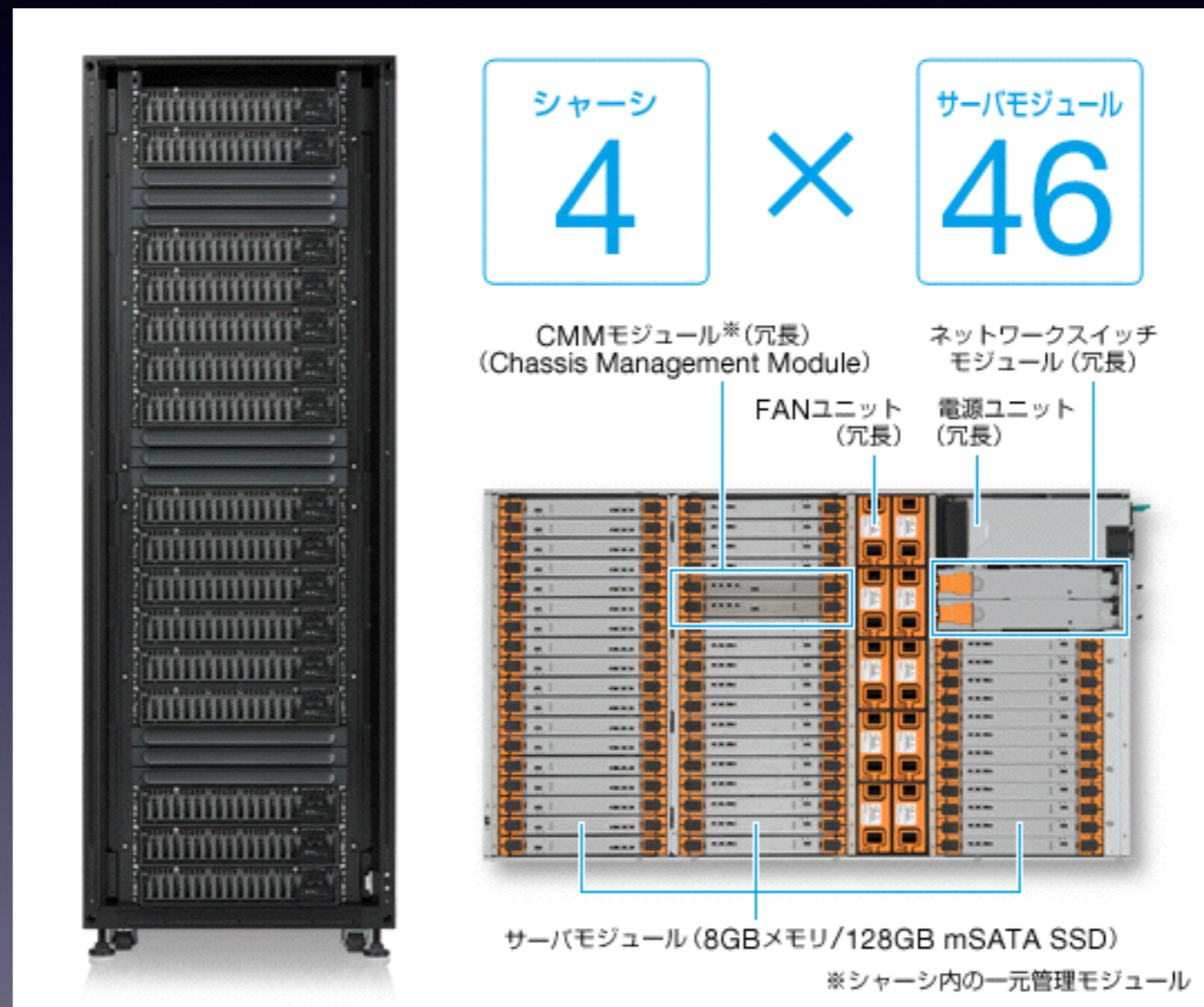
- FreeBSD has been mostly running not on HPC systems but on consumer PCs or low-price rack mount servers in the first stage
- Linux vendors (Red Hat, SUSE...) supported Linux to run on HPC systems
- Hardware vendors released Linux version device drivers rather than FreeBSD
- In fact, from the start, FreeBSD was in the wrong circumstances for HPC

Information sharing

- I have been verifying any FreeBSD behaviors with latest NEC's new rack mount servers continuously
- NEC Micro Modular Server DX1000 is one of those machines. It is extreme density, exceptional energy efficient and outstanding manageability rack mount server
- And it is too expensive for someone to buy. So information sharing about FreeBSD is worth while

Product

NEC Micro Modular Server DX1000



DX1000

- up to 46 single-processor server modules in a 2U enclosures
- Atom C2000 series 8-core processor, 4 DIMM slots, 1 SSD slot
- Operation in a 40 degree Celsius environment which minimizes cooling cost
- 80 PLUS platinum certified power supply
- All modules are hot-swappable and easy to replace

DX1000 Modules

- DX1000 is consisted by 5 types of modules (6 if including Power Unit)
- Network Switch Module
- CMM Module
- Server Module
- HDD Module
- Fan Module

DXI 000



DX1000

- Spec: 46 CPU Modules per a enclosure
- Real: 38 Server Modules per a enclosure because of its power unit limitation
- $38 \times 16 = 608$ Server Modules per a rack
- $10 \times 608 = 6,080$ bhyve hosts per a rack
- $100 \times 608 = 60,800$ jail hosts per a rack

Network Switch Module



CMM Module



Server Module



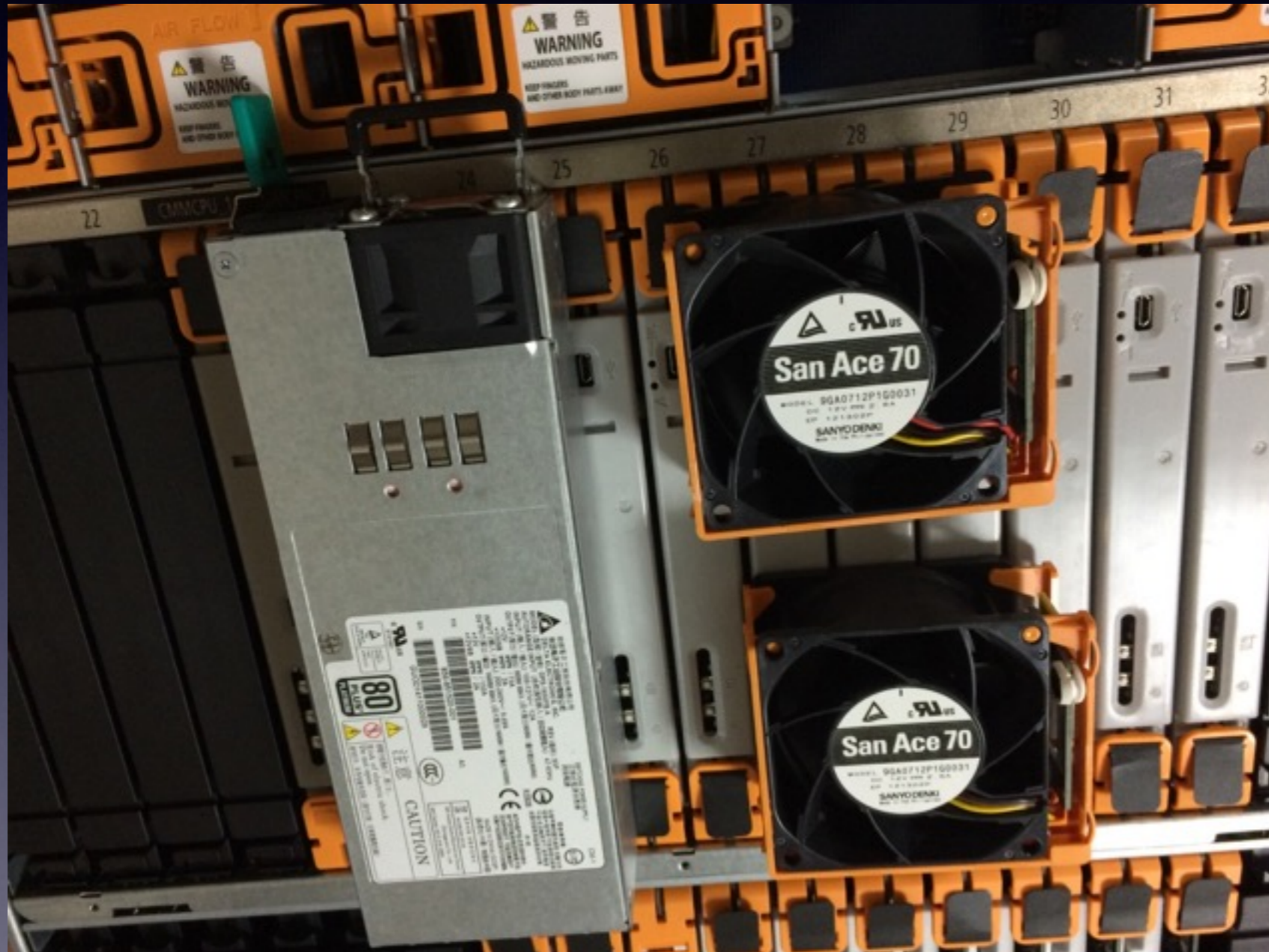
HDD Module



Fan Module



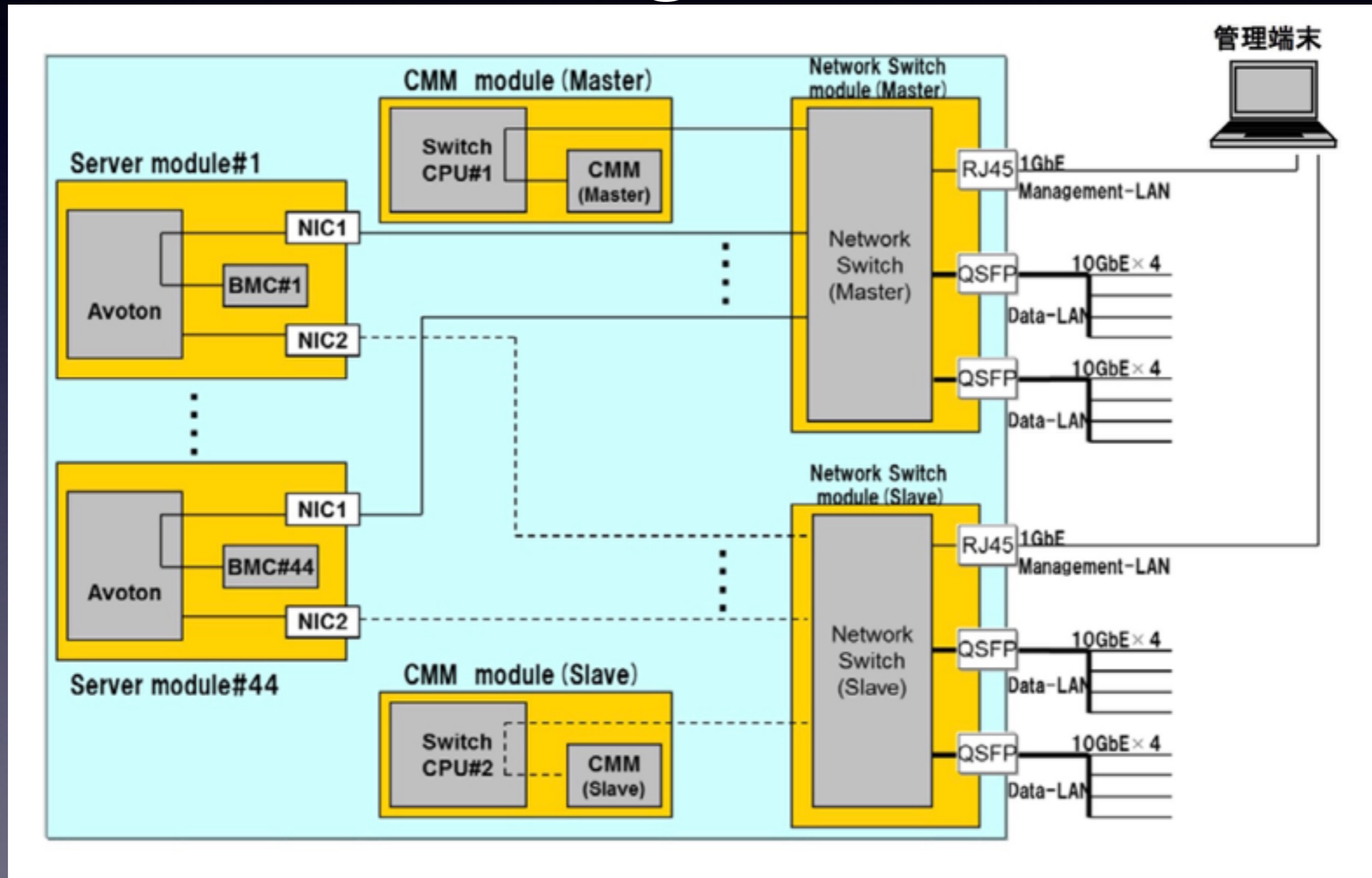
Power Unit



Front panel



Module relationship diagram



Server Module*1

Form factor	Server module that plugs into the Module Enclosure
Number of Processors	1
Processors	Intel® Atom™ Processor C2750 (2.40 GHz/8-core/4 MB) Intel® Atom™ Processor C2730 (1.70 GHz/8-core/4 MB)
Memory Type	DDR3-1600 ECC LV SO-DIMM
Memory Slots	4
Maximum memory	32 GB
Storage type	Non-hot plug mSATA SSD
Maximum internal storage	128 GB
Expansion slots	1 PCIe x8 Gen 2 slot (Using a server module slot, available for up to 12 server modules)
Network	2 2.5 GbE links to switch modules
Systems management	Embedded BMC with IPMI 2.0
Operating systems and virtualization software	Red Hat® Enterprise Linux® 6 Ubuntu 12.04

HDD Module*1

Form factor	HDD module that plugs into the Module Enclosure *HDD module can be connected to a server module with Intel® Atom™ Processor C2750 only
Number of HDDs	1
Storage type	2.5-inch SATA 500 GB or 1 TB

Module Enclosure*1

Form factor / height	Rack mount 2U
Server module slots	46 (16 slots can be used for HDD modules and 12 slots can be used for PCIe cards)
Network interconnects	Up to 2 switch modules and each has the following: 2 40GbE QSFP+ uplinks, 1 1000BASE-T for management, and 46 2.5GbE down links to server modules
Redundant cooling fan	Standard, hot plug
Power supplies	2 1,600 Watt 80 PLUS® Platinum certified hot plug power supply units 200-240 VAC ± 10% 50 / 60 Hz ± 3 Hz
Redundant power supply	Standard, hot plug
Temperature and humidity conditions (non-condensing)	Operating: 10 to 40* °C/ 50 to 104* °F, 20 to 80% Non-operating: -10 to 55 °C/14 to 131 °F, 20 to 80% * In specific configurations, the operable ambient temperature is up to 35°C/95°F
Dimensions (W x D x H) and maximum weight	448.0 x 777.9 x 86.5 mm / 17.6 x 30.6 x 3.4 in 34 kg / 74.96 lbs.

Mount to a rack

- Operate follow a user guide document
- However the DX1000 is lighter than any other similar products, it's heavy. Please do careful.

Installation

Network Switch Module configuration

- Login into 1st Network Switch Module through the serial console port on left side on front panel
- baud rate: 115,200 bps
- ID: admin
- PASSWORD: admin

Left side port




```
# cu -l /dev/cuaU0 -s 115200
```

```
Connected
```

```
Wind River Linux 5.0.1.10  
console
```

```
localhost login: admin
```

```
Password:
```

```
Last login: Tue Jan 20 20:28:53 UTC 2015 from 192.168.36.10 on pts/0
```

```
Connecting ...
```

```
Checking ONS status... It may take few minutes...
```

```
Checking application states ...
```

```
Checking table states ...
```

```
Checking platform information ...
```

```
Getting user information ...
```

```
Authenticating ...
```

```
Switch >
```

```
Switch >enable
Switch #show system
```

```
System Name ..... ONS
System Description ..... Open Network Software
Ethernet Switch Type ..... Fulcrum Switch
Name ..... ONS CoreSwitch
Model ..... ONS
Platform ..... Mercury
Chip Version ..... Board:01
Chip Subtype ..... fm6000
API Version ..... FocalPoint 3.3.5_00268148 +
mercury-20131213
Software Version ..... 1.2.0.1425-2
CPU ..... x86_64
CPU Architecture ..... x86_64
OS ..... Linux
OS Version ..... 3.4.43-WR5.0.1.10_standard
Serial Number ..... N/A
IP Address ..... 10.1.1.1
Mask ..... 255.255.255.0
Gateway ..... N/A
MAC Address ..... 74:D4:35:E9:E2:62
Default VLAN ..... 1
Current Partition ..... /dev/sda3
```

```
Switch #
```

calc MAC address

- 74:D4:35:E9:E2:62 obtained by command
- 74:D4:35:E9:E2:61 MAC of ONS
- 74:D4:35:E9:E2:60 MAC of CMM Module

\$ arp -a

```
dullmdaler.ongs.co.jp (202.216.246.94) at 00:0d:b9:2c:6c:62 on vr2 permanent [ethernet]
zenosblead.ongs.co.jp (202.216.246.89) at 00:0b:a2:8c:84:de on vr2 expires in 1180 seconds [ethernet]
natial.ongs.co.jp (202.216.246.90) at 00:0d:b9:2b:d2:38 on vr2 expires in 1072 seconds [ethernet]
hepitas.ongs.net (202.216.246.91) at 00:0d:b9:32:9c:7c on vr2 expires in 1085 seconds [ethernet]
? (192.168.1.40) at 78:31:c1:d5:6e:fc on vr0 expires in 1178 seconds [ethernet]
? (192.168.1.106) at 64:4b:f0:00:13:4c on vr0 expires in 963 seconds [ethernet]
? (192.168.1.10) at 00:0d:0b:80:3e:18 on vr0 expires in 1182 seconds [ethernet]
? (192.168.1.1) at 00:0d:b9:2c:6c:60 on vr0 permanent [ethernet]
? (192.168.1.29) at 74:D4:35:E9:E2:60 on vr0 expires in 1198 seconds [ethernet]
? (192.168.1.34) at 04:db:56:0d:cb:7c on vr0 expires in 1170 seconds [ethernet]
? (192.168.1.101) at e0:69:95:f5:42:84 on vr0 expires in 748 seconds [ethernet]
```

\$ ping 192.168.1.29

```
PING 192.168.1.29 (192.168.1.29): 56 data bytes
64 bytes from 192.168.1.29: icmp_seq=0 ttl=64 time=0.698 ms
64 bytes from 192.168.1.29: icmp_seq=1 ttl=64 time=0.648 ms
64 bytes from 192.168.1.29: icmp_seq=2 ttl=64 time=0.548 ms
```

^C

--- 192.168.1.29 ping statistics ---

```
3 packets transmitted, 3 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.548/0.631/0.698/0.062 ms
```

\$

```
$ ./mng_niclist -I 192.168.1.29 -C all
```

CPU Board	Management LAN MAC	IP	Data LAN-1 MAC	Data LAN-2 MAC
CPU Board23	74:D4:35:83:78:16	0.0.0.0	74:D4:35:83:78:14	74:D4:35:83:78:15
CPU Board24	74:D4:35:83:75:60	0.0.0.0	74:D4:35:83:75:5E	74:D4:35:83:75:5F
CPU Board25	74:D4:35:83:79:1E	0.0.0.0	74:D4:35:83:79:1C	74:D4:35:83:79:1D
CPU Board26	74:D4:35:83:73:D3	0.0.0.0	74:D4:35:83:73:D1	74:D4:35:83:73:D2
CPU Board27	74:D4:35:83:75:75	0.0.0.0	74:D4:35:83:75:73	74:D4:35:83:75:74
CPU Board28	74:D4:35:83:75:54	0.0.0.0	74:D4:35:83:75:52	74:D4:35:83:75:53
CPU Board29	74:D4:35:83:75:3C	0.0.0.0	74:D4:35:83:75:3A	74:D4:35:83:75:3B
CPU Board30	74:D4:35:83:79:45	0.0.0.0	74:D4:35:83:79:43	74:D4:35:83:79:44
CPU Board31	74:D4:35:83:78:52	0.0.0.0	74:D4:35:83:78:50	74:D4:35:83:78:51
CPU Board32	74:D4:35:83:78:55	0.0.0.0	74:D4:35:83:78:53	74:D4:35:83:78:54

```
$
```

calc MAC address

- 74:D4:35:83:78:16 obtained by command
- 74:D4:35:83:78:5F MAC of NIC2
- 74:D4:35:83:78:5E MAC of NIC1


```
$ cat /usr/local/etc/dhcpd.conf
```

```
option domain-name "bsdconsulting.co.jp";  
option domain-name-servers 192.168.1.1;  
default-lease-time 600;  
max-lease-time 7200;
```

```
# DHCP settings
```

```
subnet 192.168.1.0 netmask 255.255.255.0 {  
    range 192.168.1.20 192.168.1.60;  
    option routers 192.168.1.1;  
    option broadcast-address 192.168.1.255;  
    option subnet-mask 255.255.255.0 ;
```

```
# PXE boot settings
```

```
# kernel looking path (look at /etc/inetd.conf too)
```

```
next-server 192.168.1.1;
```

```
filename "pxeboot";
```

```
# nfs server path
```

```
option root-path "192.168.1.10:/home/pxefreebsd";
```

```
}
```

```
host dx1000mmc1 { hardware ethernet 74:D4:35:E9:E2:60; fixed-address 192.168.1.80; }  
host dx1000s23bmc { hardware ethernet 74:D4:35:83:78:16; fixed-address 192.168.1.81; }  
host dx1000s24bmc { hardware ethernet 74:D4:35:83:75:60; fixed-address 192.168.1.82; }  
host dx1000s25bmc { hardware ethernet 74:D4:35:83:79:1E; fixed-address 192.168.1.83; }  
host dx1000s26bmc { hardware ethernet 74:D4:35:83:73:D3; fixed-address 192.168.1.84; }  
host dx1000s27bmc { hardware ethernet 74:D4:35:83:75:75; fixed-address 192.168.1.85; }  
host dx1000s28bmc { hardware ethernet 74:D4:35:83:75:54; fixed-address 192.168.1.86; }  
host dx1000s29bmc { hardware ethernet 74:D4:35:83:75:3C; fixed-address 192.168.1.87; }  
host dx1000s30bmc { hardware ethernet 74:D4:35:83:79:45; fixed-address 192.168.1.88; }  
host dx1000s31bmc { hardware ethernet 74:D4:35:83:78:52; fixed-address 192.168.1.89; }  
host dx1000s32bmc { hardware ethernet 74:D4:35:83:78:55; fixed-address 192.168.1.90; }  
host dx1000s23nic { hardware ethernet 74:D4:35:83:78:14; fixed-address 192.168.1.91; }  
host dx1000s24nic { hardware ethernet 74:D4:35:83:75:5E; fixed-address 192.168.1.92; }  
host dx1000s25nic { hardware ethernet 74:D4:35:83:79:1C; fixed-address 192.168.1.93; }  
host dx1000s26nic { hardware ethernet 74:D4:35:83:73:D1; fixed-address 192.168.1.94; }  
host dx1000s27nic { hardware ethernet 74:D4:35:83:75:73; fixed-address 192.168.1.95; }  
host dx1000s28nic { hardware ethernet 74:D4:35:83:75:52; fixed-address 192.168.1.96; }  
host dx1000s29nic { hardware ethernet 74:D4:35:83:75:3A; fixed-address 192.168.1.97; }  
host dx1000s30nic { hardware ethernet 74:D4:35:83:79:43; fixed-address 192.168.1.98; }  
host dx1000s31nic { hardware ethernet 74:D4:35:83:78:50; fixed-address 192.168.1.99; }  
host dx1000s32nic { hardware ethernet 74:D4:35:83:78:53; fixed-address 192.168.1.100; }
```

```
$
```

PXE Boot

- 1) Host obtains an IP address and tftp information from DHCP server
- 2) loading pxeboot kernel from tftp server
- 3) loading installer from NFS server
- write `/etc/rc.conf`, `/etc/inetd.conf`, `/etc/exports`, `/usr/local/etc/dhcpd.conf` for DHCPd, tftp and NFS

DHCP configuration

```
$ pkg install isc-dhcp43-server
```

```
/etc/rc.conf  
    dhcpd_enable="YES"
```

```
/usr/local/etc/dhcpd.conf  
look at 2 pages back
```


tftp configuration

```
/etc/rc.conf
```

```
inetd_enable="YES"
```

```
/etc/inetd.conf
```

```
tftp dgram udp wait root /usr/libexec/tftpd \  
tftpd -l -s /tftpboot/amd64/10.1
```

```
$ cp /boot/pxeboot /tftpboot/amd64/10.1/
```

```
$ ls -l /tftpboot/amd64/10.1/
```

```
total 260
```

```
-r--r--r--  1 daichi  daichi 264192 Mar  9 14:49 pxeboot
```

```
$
```

NFS configuration

/etc/rc.conf

```
rpcbind_enable="YES"  
rpc_statd_enable="YES"  
rpc_lockd_enable="YES"  
nfs_server_enable="YES"  
nfs_server_flags="-u -t -n 4"  
nfsd_enable="YES"  
mountd_enable="YES"
```

/etc/exports

```
V4: / -sec=sys -network 192.168.1.0 -mask 255.255.255.0  
/home/pxefreebsd -ro -alldirs -maproot=root
```

```
$ mdconfig -a -t vnode \  
  FreeBSD-10.1-RELEASE-amd64-disc1.iso  
md0  
$ mount_cd9660 /dev/md0 /mnt  
$ tar zvxf /mnt/usr/freebsd-dist/base.txz \  
  -C /home/pxefreebsd/  
...  
$ ls /home/pxefreebsd/  
COPYRIGHT      README.TXT      docbook.css     proc            usr  
ERRATA.HTM     RELNOTES.HTM   etc             rescue         var  
ERRATA.TXT     RELNOTES.TXT   lib            root  
HARDWARE.HTM  bin           libexec        sbin  
HARDWARE.TXT  boot         media          sys  
README.HTM    dev          mnt            tmp  
$ vi /home/pxefreebsd/boot/loader.conf /etc/ttys  
$ cat /home/pxefreebsd/boot/loader.conf  
boot_serial="YES"  
console="comconsole"  
comconsole_port="1000"  
comconsole_speed="115200"  
$ grep ^ttyu2 /home/pxefreebsd/etc/ttys  
ttyu2  "/usr/libexec/getty std.115200" xterm  on  secure  
$
```


Installation

Power on the Server Module

```
$ ipmitool -I lanplus \  
-U Administrator -P Administrator \  
-H 192.168.1.81 power on  
$ ipmitool -I lanplus \  
-U Administrator -P Administrator \  
-H 192.168.1.81 sol activate
```

Version 2.16.1242n Copyright (C) 2013 American Megatrends, Inc.
BIOS Date: 08/20/2014 09:32:52 Ver: 5.6.0007

IPMI Base Board Management Controller was detected.

Device ID	: 20	Device Revision	: 01
IPMI Version	: 2.0	Firmware Revision	: 01.21
Self Test Result	: 5500		

Press <F2> SETUP

BIOS Information

BIOS Version 5.6.0007
Build Date 08/20/2014

Choose the system
default language

Memory Information

Total Memory 32768 MB (DDR3)

System Language [English]

System Date [Tue 03/10/2015]

System Time [14:02:00]

Access Level Administrator

-
- ><: Select Screen
- ^v: Select Item
- Enter: Select
- +/-: Change Opt.
- F1: General Help
- F2: Previous Values
- F3: Optimized Defaults
- F4: Save & Exit
- ESC: Exit

Boot Configuration

Sets the system boot
order

Boot Option #1 [P0: TOSHIBA THNSNH1...]

Boot Option #2 [IBA GE Slot 00A0 v1543]

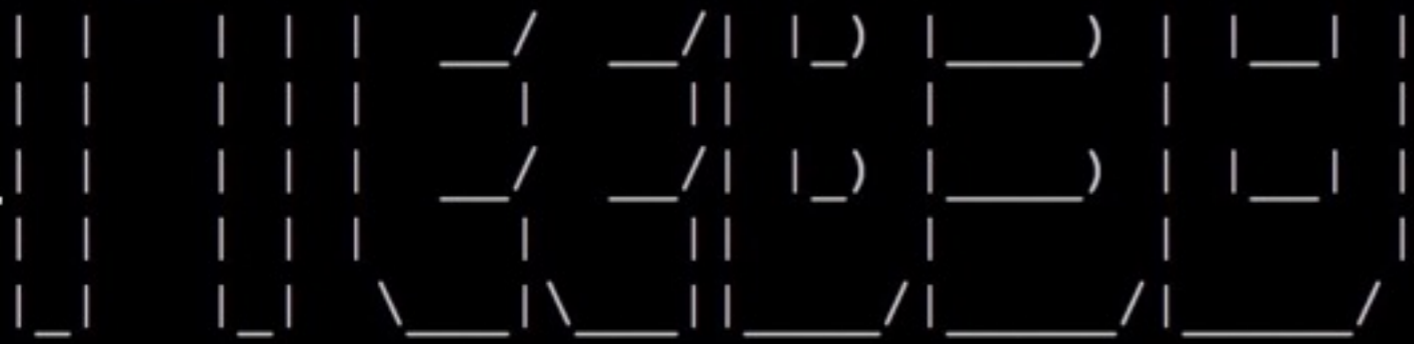
Network Device BBS Priorities

Hard Drive BBS Priorities

><: Select Screen
^v: Select Item
Enter: Select
+/-: Change Opt.
F1: General Help
F2: Previous Values
F3: Optimized Defaults
F4: Save & Exit
ESC: Exit

Intel(R) Boot Agent GE v1.5.43
Copyright (C) 1997-2013, Intel Corporation

CLIENT MAC ADDR: 74 D4 35 83 78 14 GUID: 14788335 D474 8001 E311 CD7D00741F87
CLIENT IP: 192.168.1.91 MASK: 255.255.255.0 DHCP IP: 192.168.1.1
GATEWAY IP: 192.168.1.1
TFTP.._



*****Welcome to FreeBSD*****

- * 1. Boot Multi User [Enter]
- * 2. Boot Single User
- * 3. Escape to loader prompt
- * 4. Reboot

- * Options:
- * 5. Kernel: default/kernel (1 of 2)
- * 6. Configure Boot Options...



/boot/kernel/kernel text=0xf8f898 data=0x124a30+0x2055c0 syms=[0x8+0x1405e0+0x8+0x15b077-

```
add net ::ffff:0.0.0.0: gateway ::1
add net ::0.0.0.0: gateway ::1
Generating host.conf.
eval: cannot create /etc/host.conf: Read-only file system
eval: cannot create /etc/host.conf: Read-only file system
eval: cannot create /etc/host.conf: Read-only file system
/libexec/resolvconf/libc: cannot create /etc/resolv.conf: No such file or directory
Creating and/or trimming log files.
Starting syslogd.
ELF ldconfig path: /lib /usr/lib /usr/lib/compat
32-bit compatibility ldconfig path: /usr/lib32
Clearing /tmp (X related).
Starting local daemons:
Welcome to FreeBSD!
```

Please choose the appropriate terminal type for your system.

Common console types are:

ansi	Standard ANSI terminal
vt100	VT100 or compatible terminal
xterm	xterm terminal emulator (or compatible)
cons25w	cons25w terminal

Console type [vt100]: _

\

FreeBSD Installer

Welcome

Welcome to FreeBSD! Would you like to begin an installation or use the live CD?

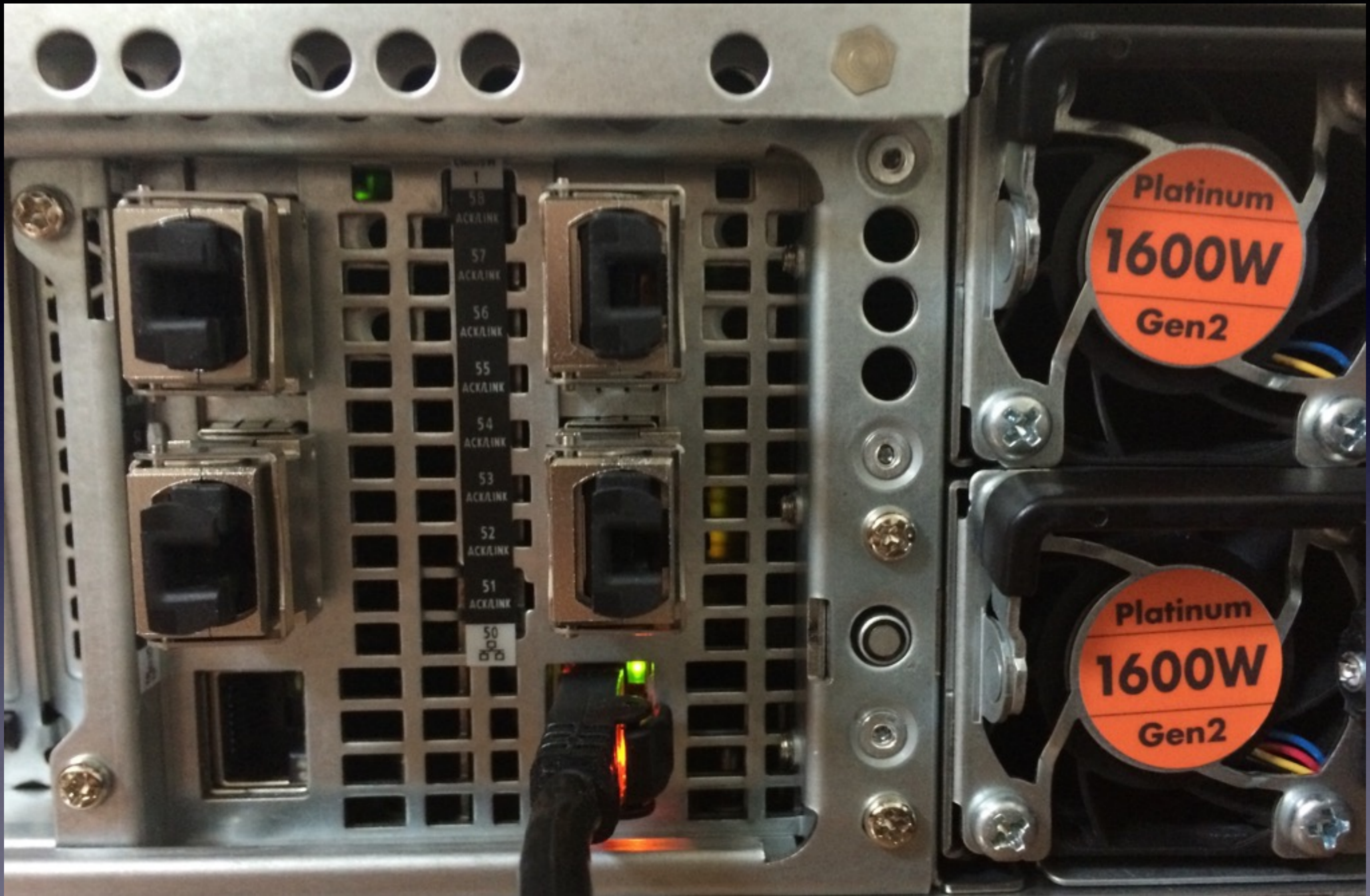
<Install> < Shell > <Live CD>

Conclusion

Conclusion

- NEC Micro Modular Server DX1000 is affordable as Hadoop clusters or to bundle many physical servers into a rack
- Installation into DX1000 Server Modules is a little bit confusion, but no problem
- FreeBSD can run on DX1000 Server Modules

Appendix a.
change QSFP to RJ45



58
ACKLINK
57
ACKLINK
56
ACKLINK
55
ACKLINK
54
ACKLINK
53
ACKLINK
52
ACKLINK
51
ACKLINK
50
ACKLINK

Platinum
1600W
Gen2

Platinum
1600W
Gen2


```
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x17 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x18 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x19 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1a 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1b 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1c 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1d 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1e 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x1f 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
$ ipmitool -I lanplus -U Administrator -P Administrator -H 192.168.1.80 raw \
  0x30 0x06 0x40 0x20 0x00 0x20 0x30 0xb0 0x26 0x00 0x01 0x01 0x14 0x00 0x00 0xc4
```

```
$ cu -s 115200 -l /dev/cuaU0
```

```
Connected
```

```
Wind River Linux 5.0.1.10  
console
```

```
localhost login: admin
```

```
Password:
```

```
Last login: Mon Mar 9 18:14:21 UTC 2015 on console
```

```
Connecting ...
```

```
Checking ONS status... It may take few minutes...
```

```
Checking application states ...
```

```
Checking table states ...
```

```
Checking platform information ...
```

```
Getting user information ...
```

```
Authenticating ...
```

```
Switch >
```



```
Switch >enable
Switch #configure
Switch (config)#interface range xe47,xe50
Switch (config-if-range)#switchport pvid 1
Switch (config-if-range)#no switchport vlan add 4092
Switch (config-if-range)#switchport vlan add 1 untagged
Switch (config-if-range)#exit
Switch (config)#interface range xe1-xe46
Switch (config-if-range)#shutdown
Switch (config-if-range)#no switchport vlan add 4092
Switch (config-if-range)#no shutdown
Switch (config-if-range)#exit
Switch (config)#no spanning-tree
Switch (config)#exit
Switch #save config
```

Configuration saving is in progress. It may take few minutes.

```
Switch #exit
```

Appendix b. contact list

interested in purchasing

- North America: NEC Corporation of America

<http://www.necam.com/servers>

- Europe: NEC Enterprise Solutions

<http://www.nec-enterprise.com/>

- APAC: NEC Corporation

<http://www.nec.com/express>