Linux Kongress 2008-10-10

Hamburg/Germany

Open Source Routing in
High-Speed Production Use

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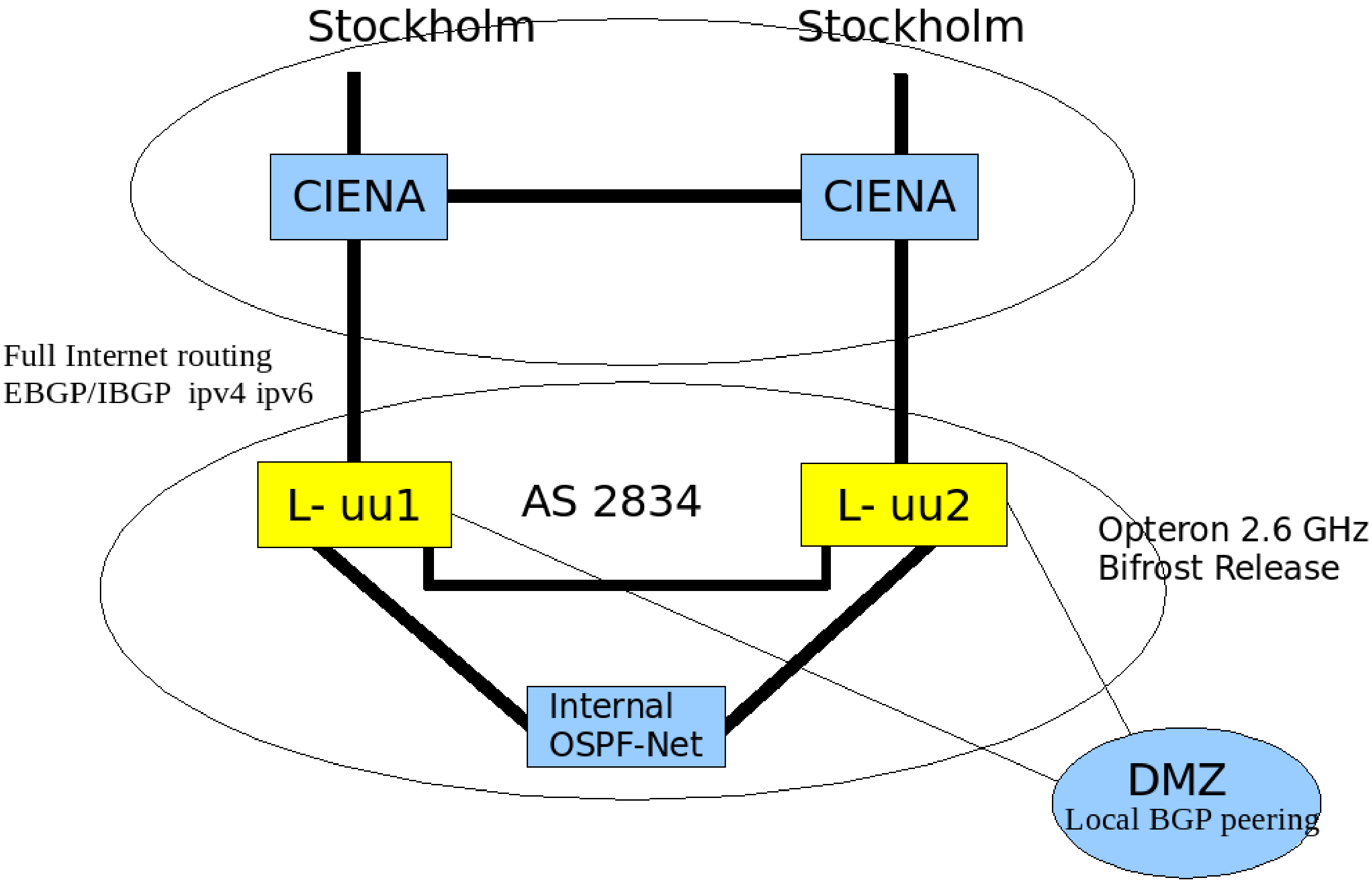
Over 10 years in production

- Three major installations

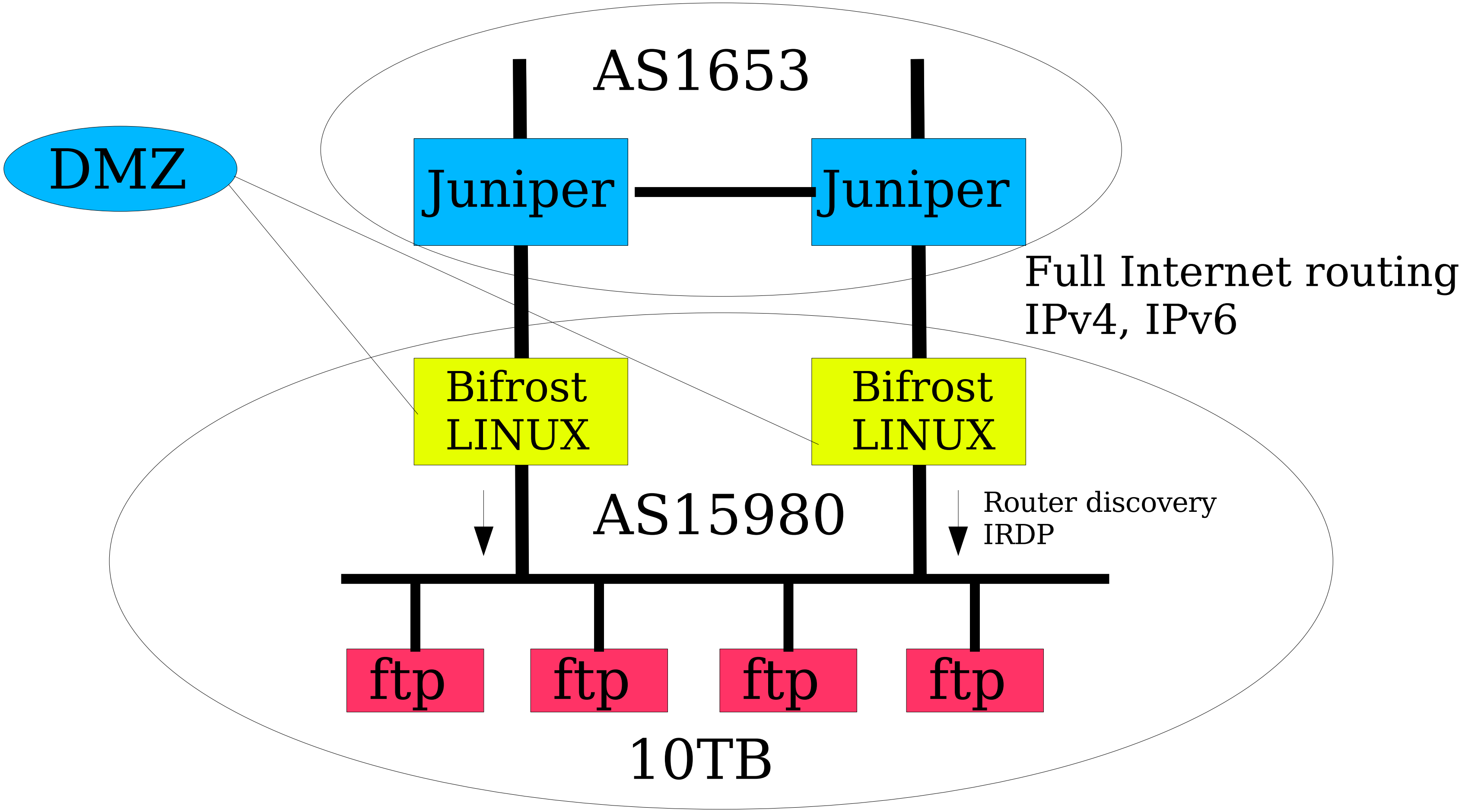
- UU core routers towards SUNET
- UU Student Network 30.000 students
- ftp.sunet.se

Over 10 years in production

BGP topology at Uppsala University



Over 10 years in production
The SUNET FTP ARCHIVE



Over 10 years in production

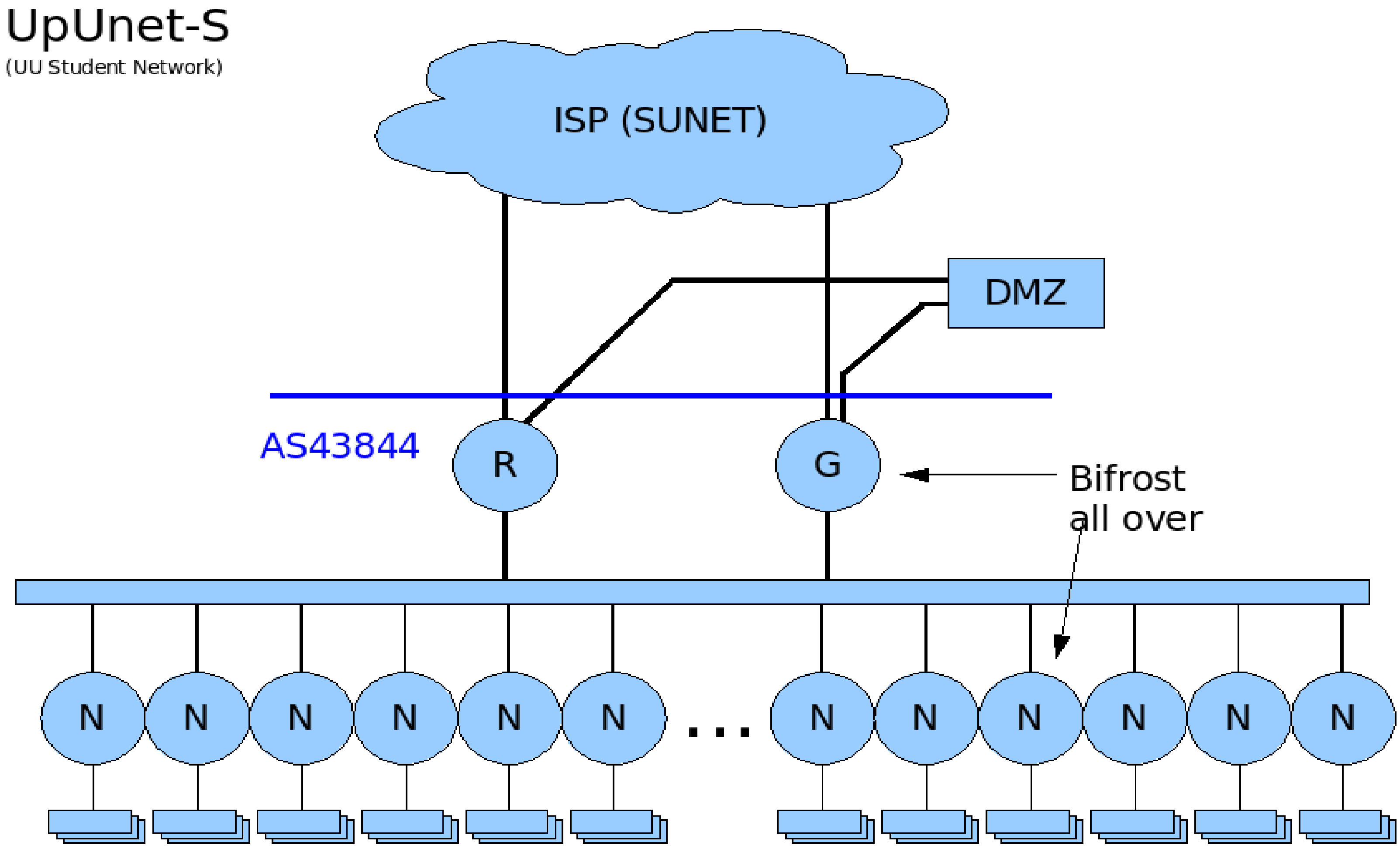
Student Network facts

Dual ISP BGP connect GIGE
Local DMZ BGP peering GIGE
Ipv4
About 30 netfilter rules
19 netlogon-service boxes for premises

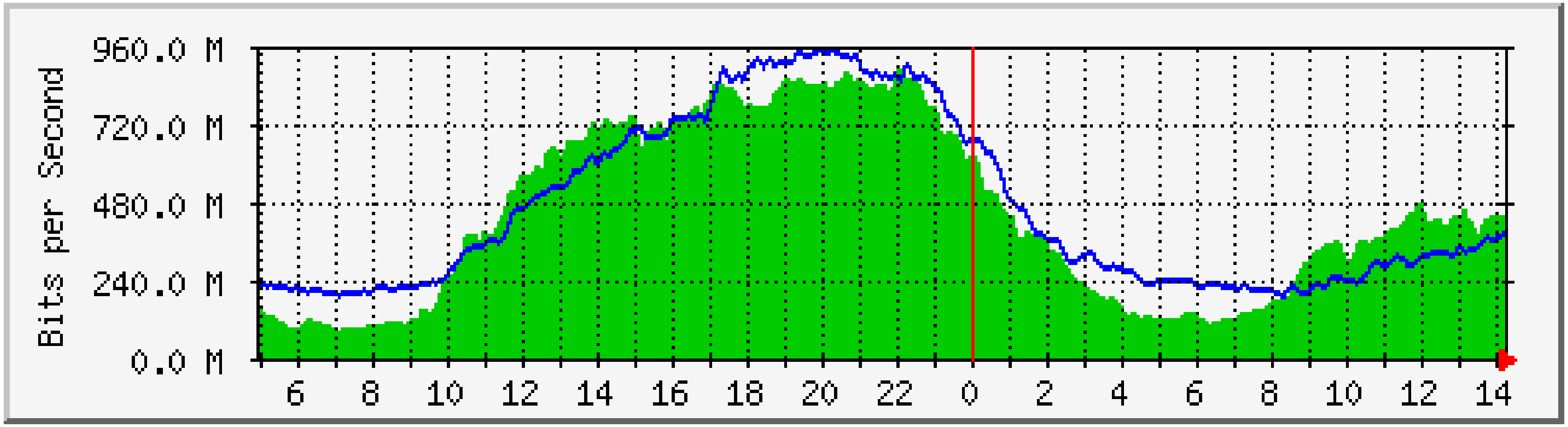
Very “innovative” users
Well connected

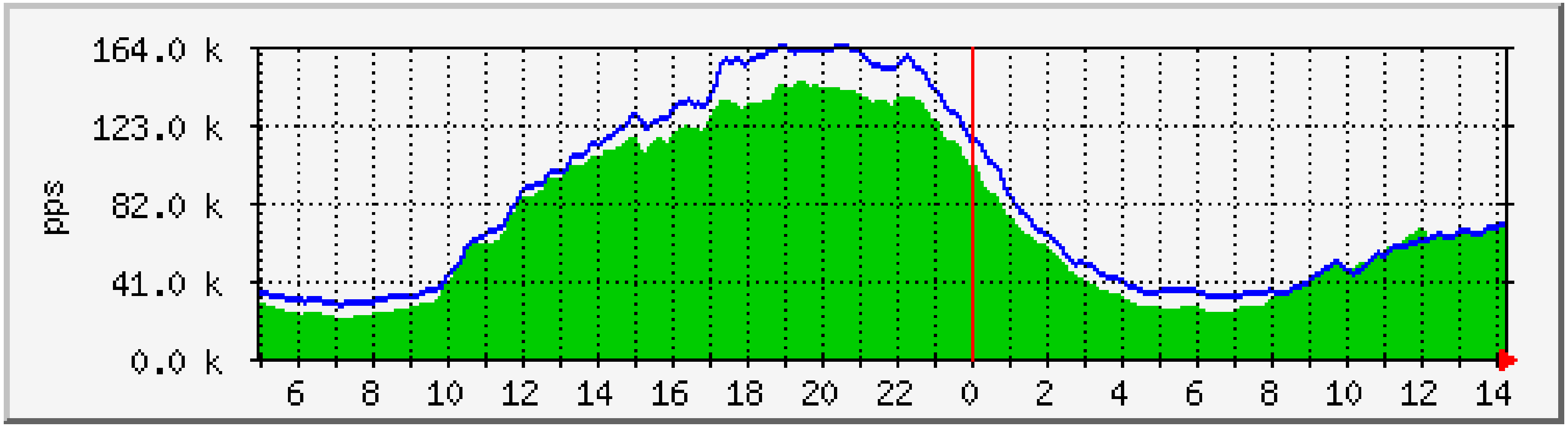
10g planned

Over 10 years in production



Over 10 years in production
Student Network Core Router

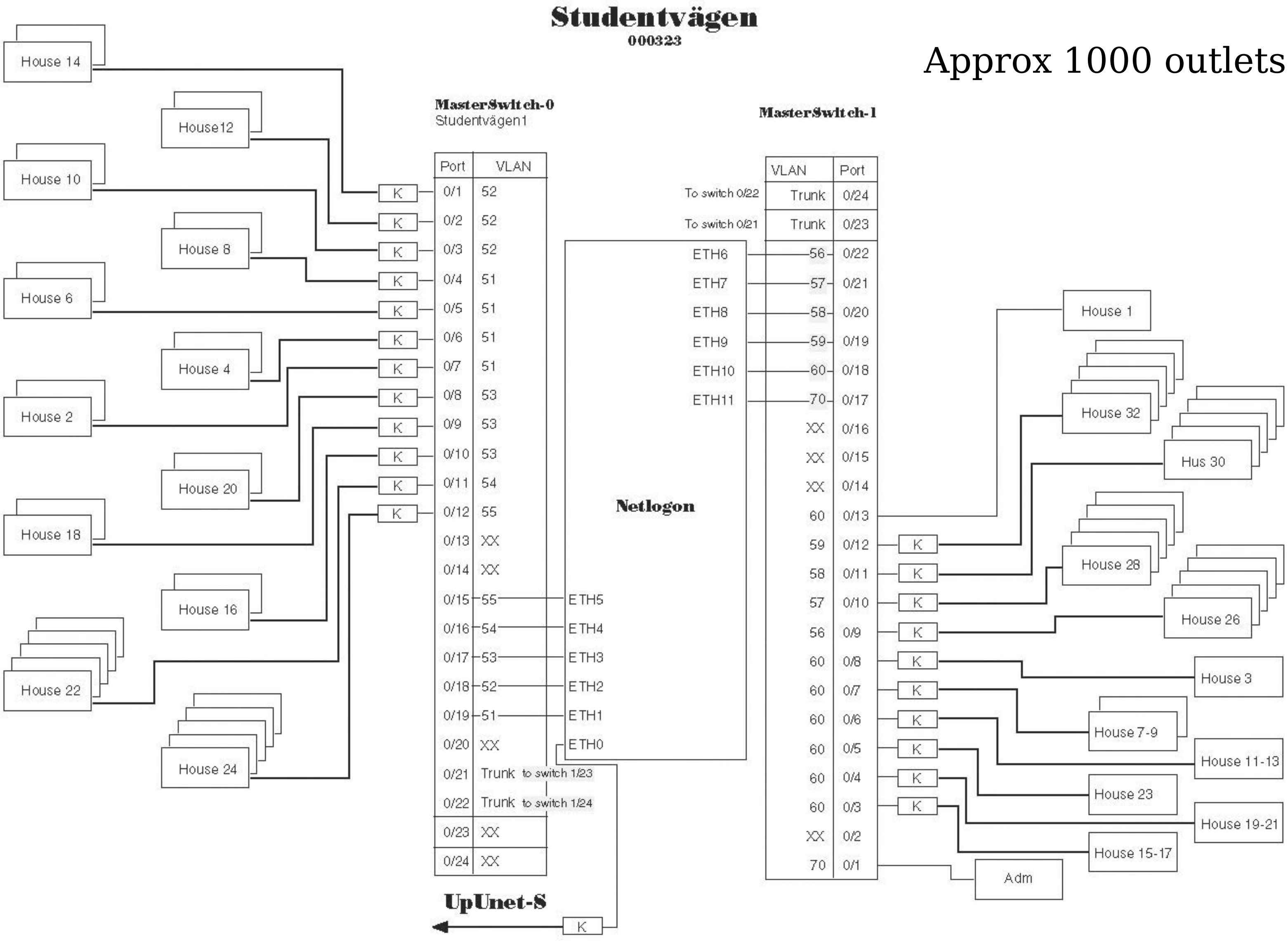




IP-login installation

at Uppsala University

Approx 1000 outlets



Studentvägen
000323

MasterSwitch-0
Studentvägen1

Port	VLAN
0/1	52
0/2	52
0/3	52
0/4	51
0/5	51
0/6	51
0/7	51
0/8	53
0/9	53
0/10	53
0/11	54
0/12	55
0/13	XX
0/14	XX
0/15	55
0/16	54
0/17	53
0/18	52
0/19	51
0/20	XX
0/21	Trunk to switch 1/23
0/22	Trunk to switch 1/24
0/23	XX
0/24	XX

MasterSwitch-1

	VLAN	Port
To switch 0/22	Trunk	0/24
To switch 0/21	Trunk	0/23
	56	0/22
	57	0/21
	58	0/20
	59	0/19
	60	0/18
	70	0/17
	XX	0/16
	XX	0/15
	XX	0/14
	60	0/13
	59	0/12
	58	0/11
	57	0/10
	56	0/9
	60	0/8
	60	0/7
	60	0/6
	60	0/5
	60	0/4
	60	0/3
	XX	0/2
	70	0/1

Testing, Verification Development & Research

- Started out as simple testing.
- Curiosity, Open Source, Collaboration
- Relatively freedom, the idea to use in own infrastructure. No need for external funding.
- OS was intended for desktops.

Building Blocks

- Hardware:
  - PC
    - Motherbord/CPU/Memory
    - Network Interfaces
      - GIGE/10g WiFi etc
- Software
  - Operating System
    - Linux/BSD/Microsoft
    - Applications
      - Routing Daemons
        - Quagga/XORP
      - IP-login/netlogon
- Network
  - Cable, Fiber, Copper
  - Equipment, Switches

Testing, Verification Development & Research

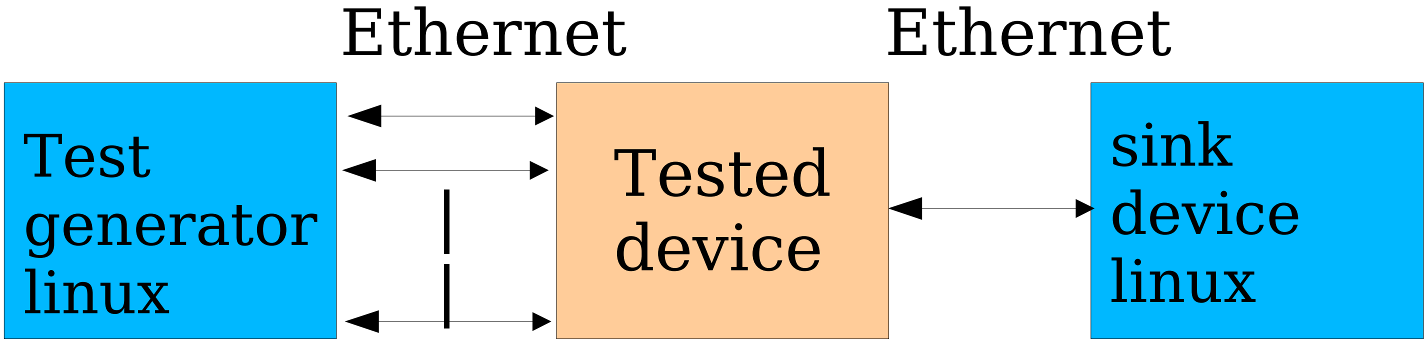
No need for test network. We could test in own infrastructure.

We could work on complicated issues

- NAPI 3 years
- Route cache stats, rtstat 1 month
- Pktgen 2 years
- fib_trie 1year
- TRASH 1 year
- Hardware Testing Many years

Flexible netlab at Uppsala University

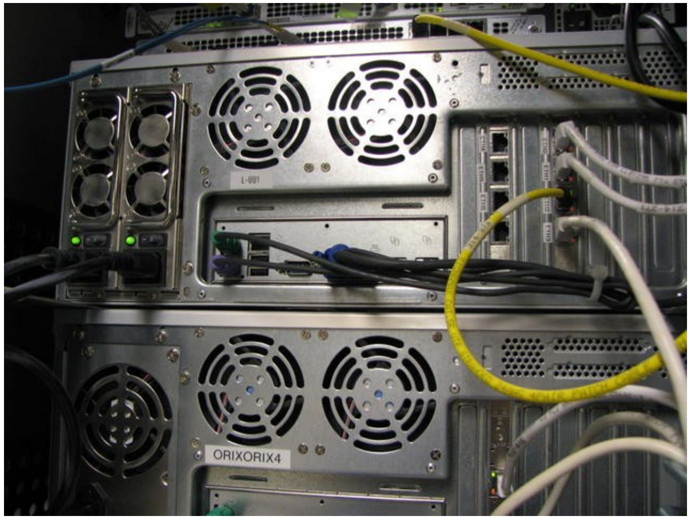
El cheapo-- High customable -- We write code :-)



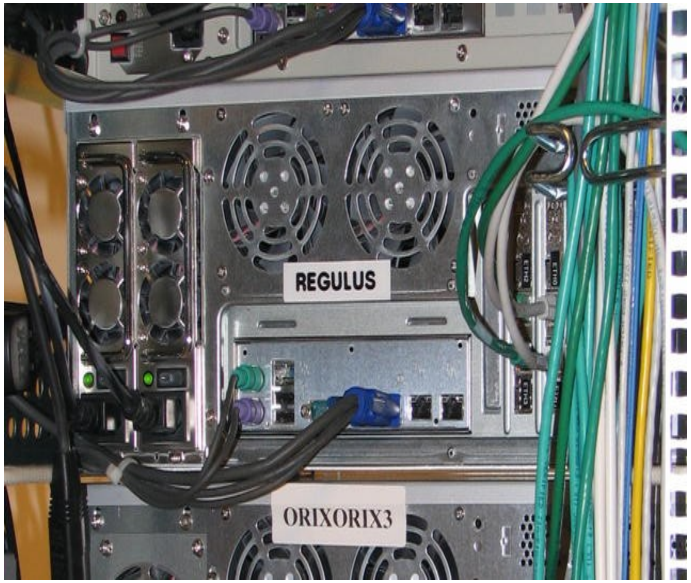
* Raw packet performance
* TCP
* Timing
* Variants

netlab at UU

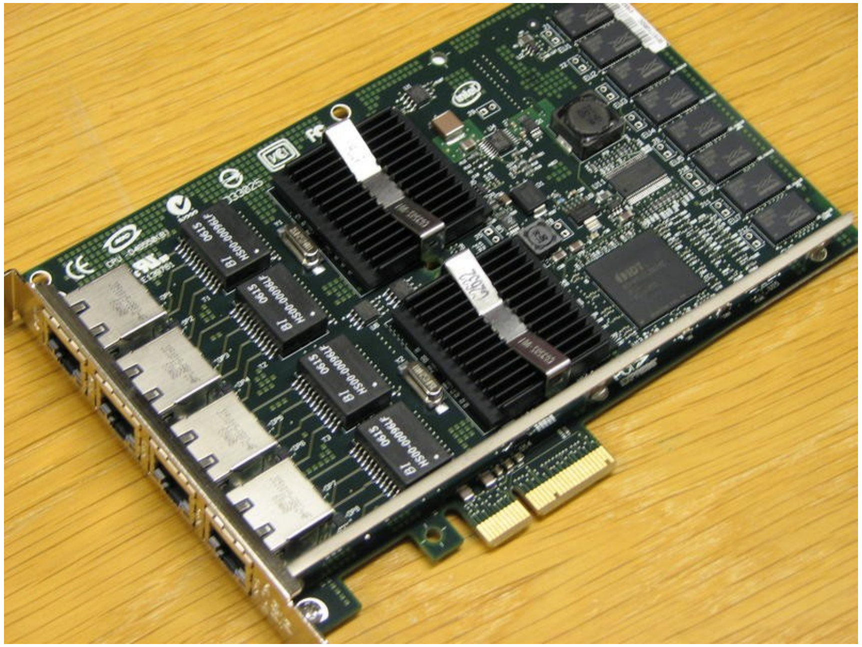
Dual-Power supply



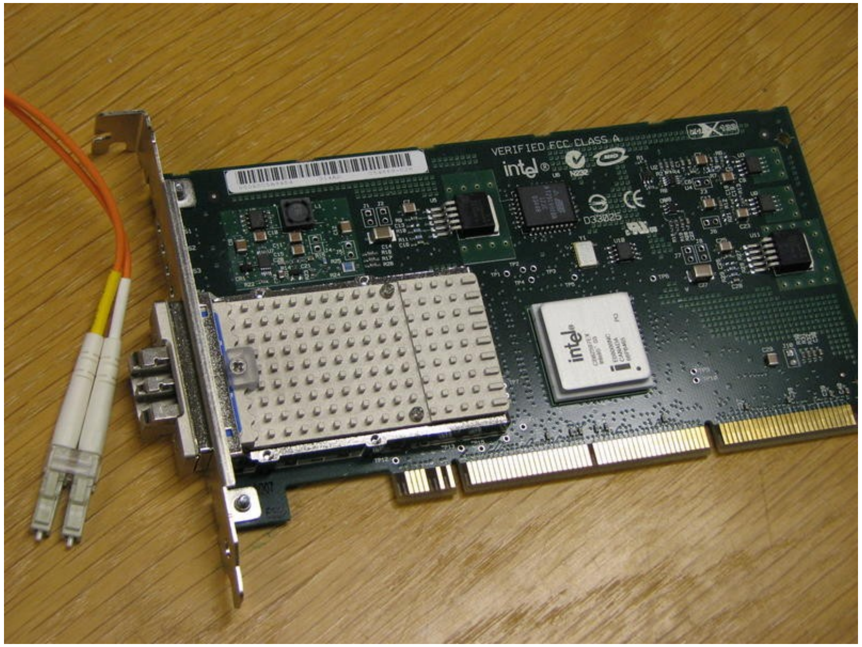
PIII for many years
ftp.sunet.se

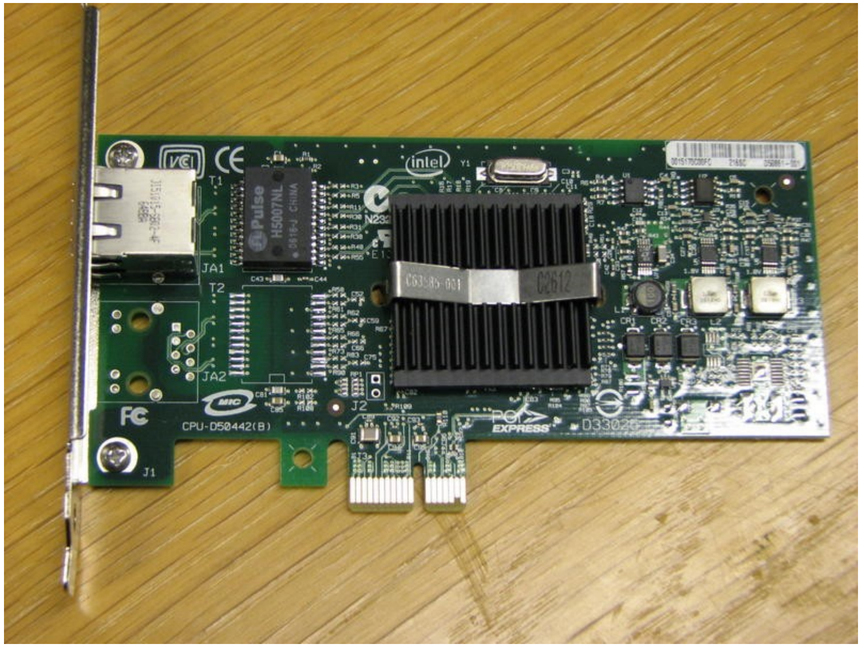


Intel NIC's

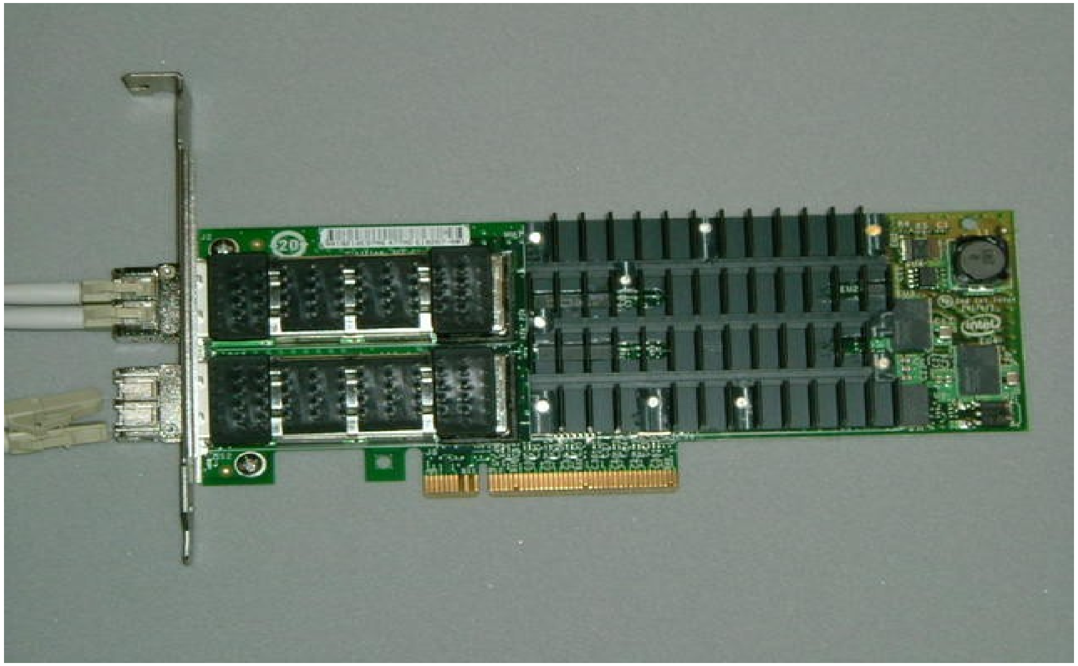


Not seen yet
82576 board??





Latest & Greatest Hardware



Intel 10g board Chipset 82598

Open chip specs. Thanks Intel!
But why fixed XFP's??
Better classifier needed.

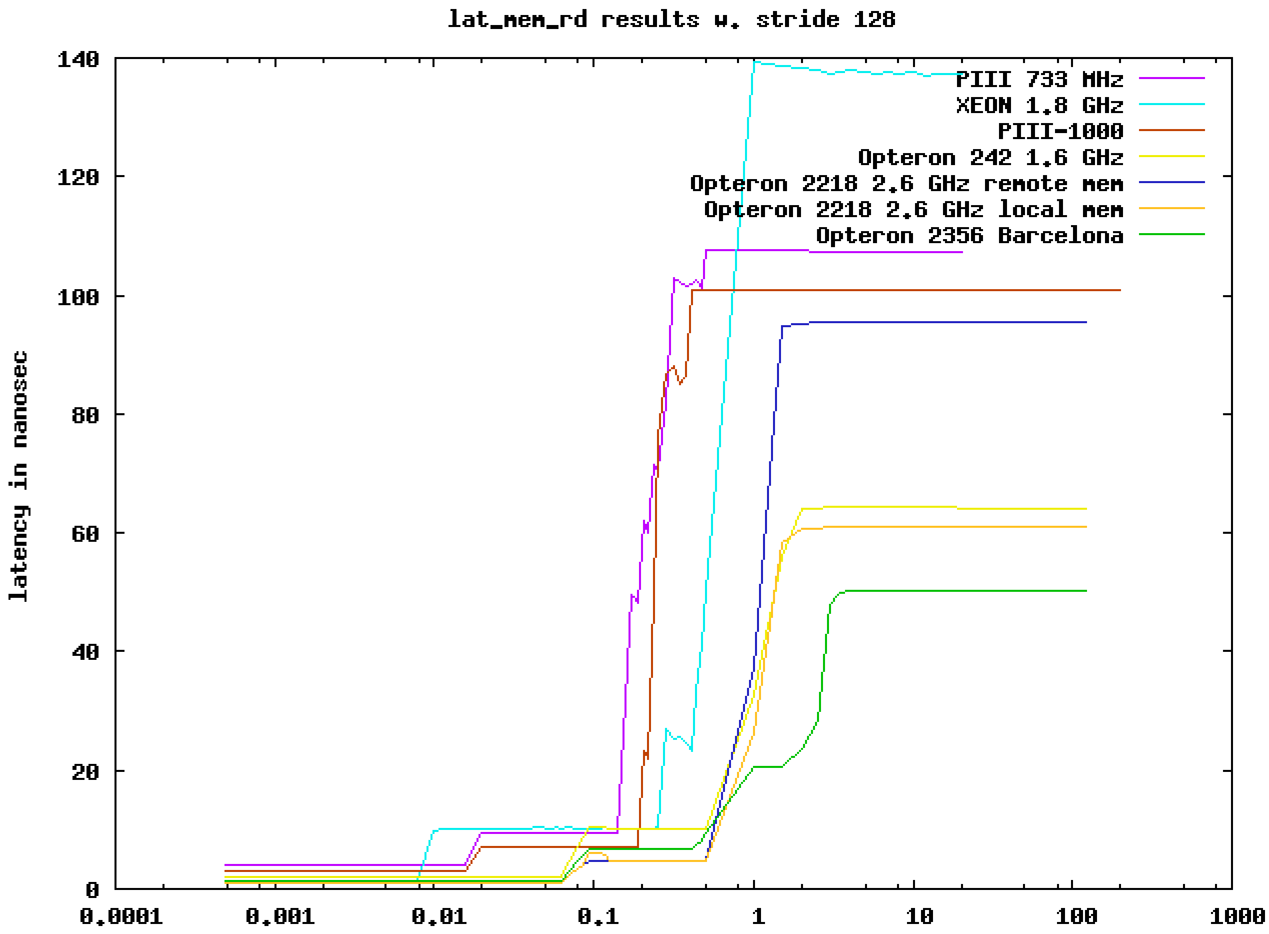
Latest & Greatest Hardware

2U Hi-End Opteron box
TYAN S2927/Barcelona

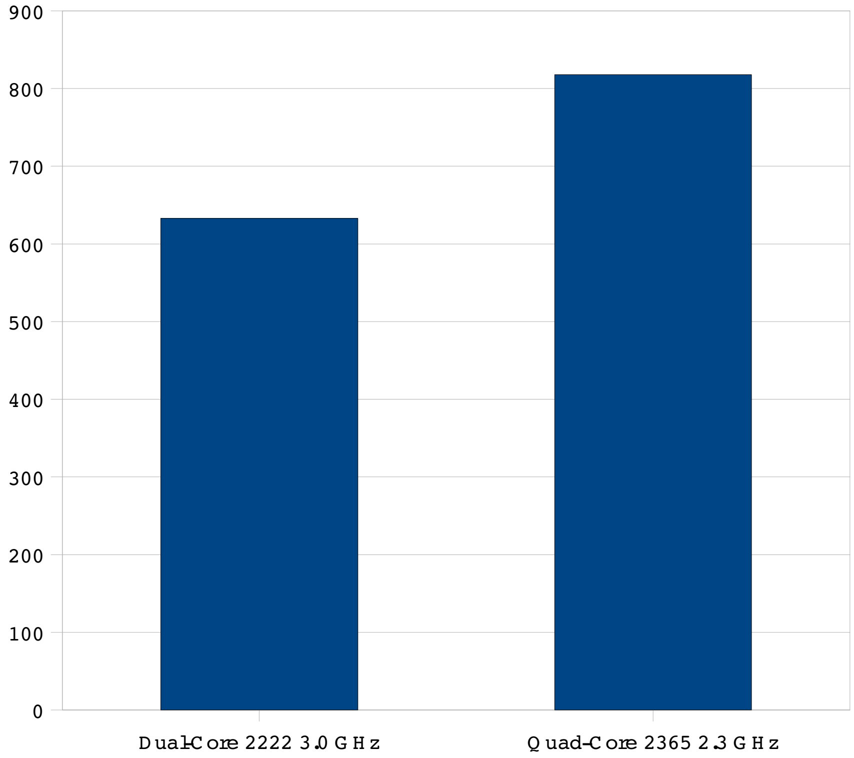
Not all were blessed...

Memory Latency

lat_mem_rd from LMbench



Quad vs Dual Core Opteron



Surprising!

One CPU core on 2.3 GHz is faster then is the 3.0 GHz

- Dual-Core.

L3 cache, Microcode?

2U Hi-End Opteron box
TYAN S2927/Barcelona

Bifrost concept

- Collaboration, Linux kernel
- Performance testing, development of tools and testing techniques
- Hardware validation, support from big vendors
- Detect and cure problems in lab not in the network infrastructure.
- Test deploy (Often in own network)

Bifrost the Linux anti-distribution

- Only support some HW
- No frequent releases
- No GUI, nothing flashy
- Documentation is lagom
- Intended for USB or flash disk
- Been around for 10 years
- Targeted for forwarding/routing, 32-bit
- Proven in lab and infra-structure
- We use it ourself...

The Linux Ashram

The guru is ANK

Kernel footprints

HW_FLOWCONTROL
    Tulip

FASTROUTE path

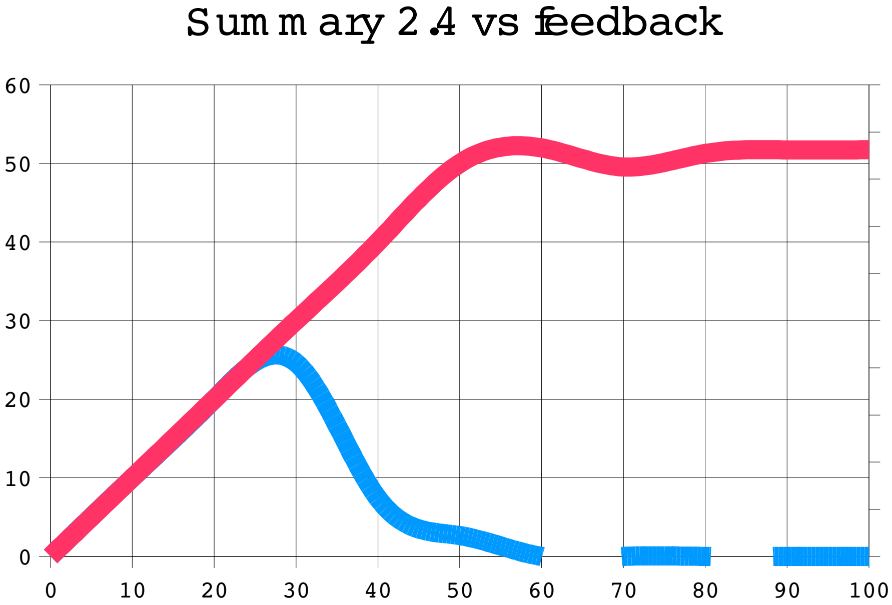
Whitehole device. In the middle of dev.c
Hardwired IP addresses. (Russian?)

A guy with a penguin joined

Jamal Hadi Salim

Overall Effect

- Inelegant handling of heavy net loads
  - System collapse
- Scalability affected
  - System and number of NICS
    - A single hogger netdev can bring the system to its knees and deny service to others



March 15 report on lkml

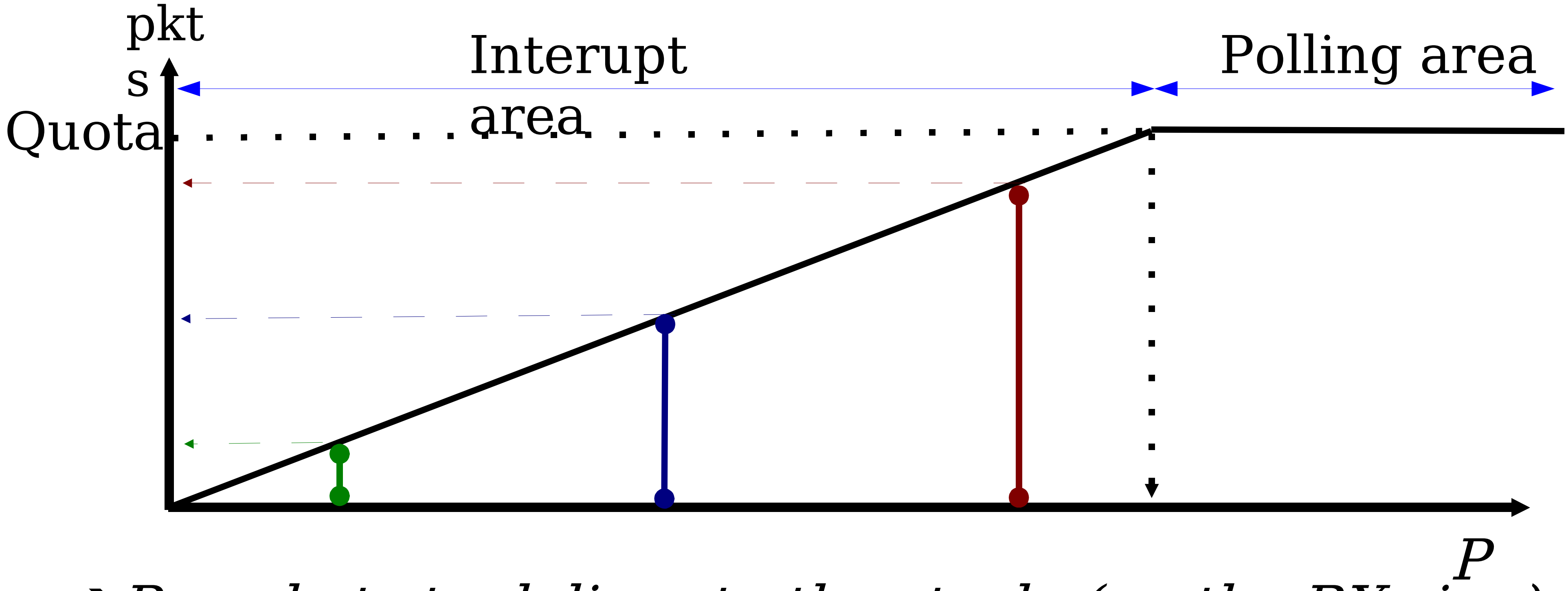
Thread: "How to optimize routing perfomance"

reported by

Marten.Wikstron@framsfab.se

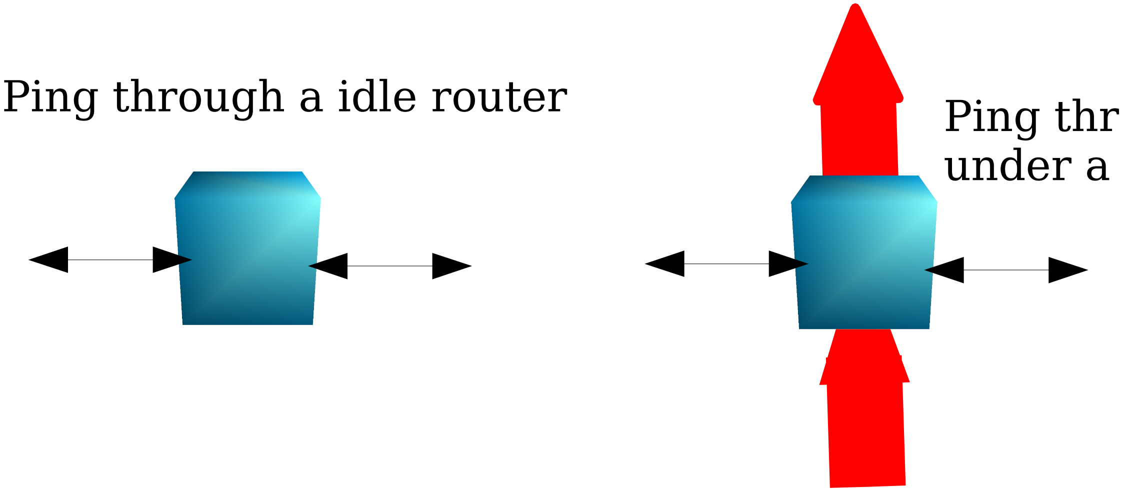
- Linux 2.4 peaks at 27Kpps
- Pentium Pro 200, 64MB RAM

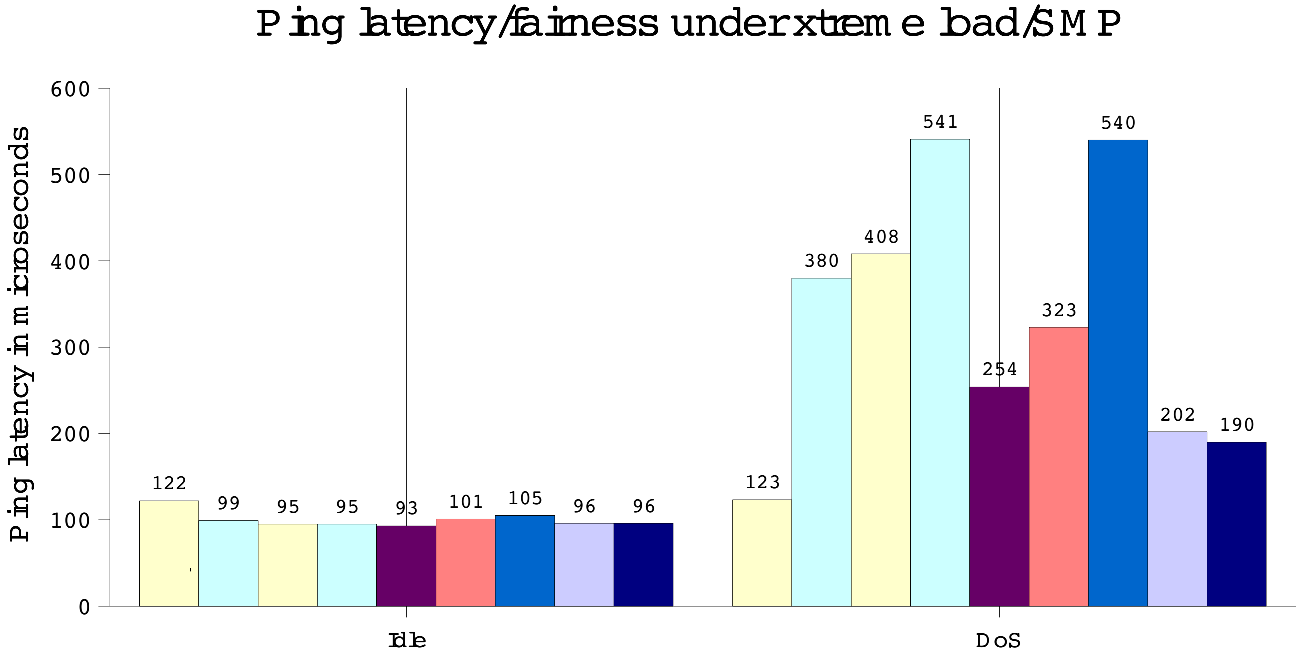
A high level view of new system



- ➔*P packets to deliver to the stack (on the RX ring)*
- ➔Horizontal line shows different netdevs with different i
- ➔Area under curve shows how many packets before next
- ➔*Quota* enforces fair share

NAPI observations & issue: fairness





Very well behaved just an increase a couple of 100 microsec !!

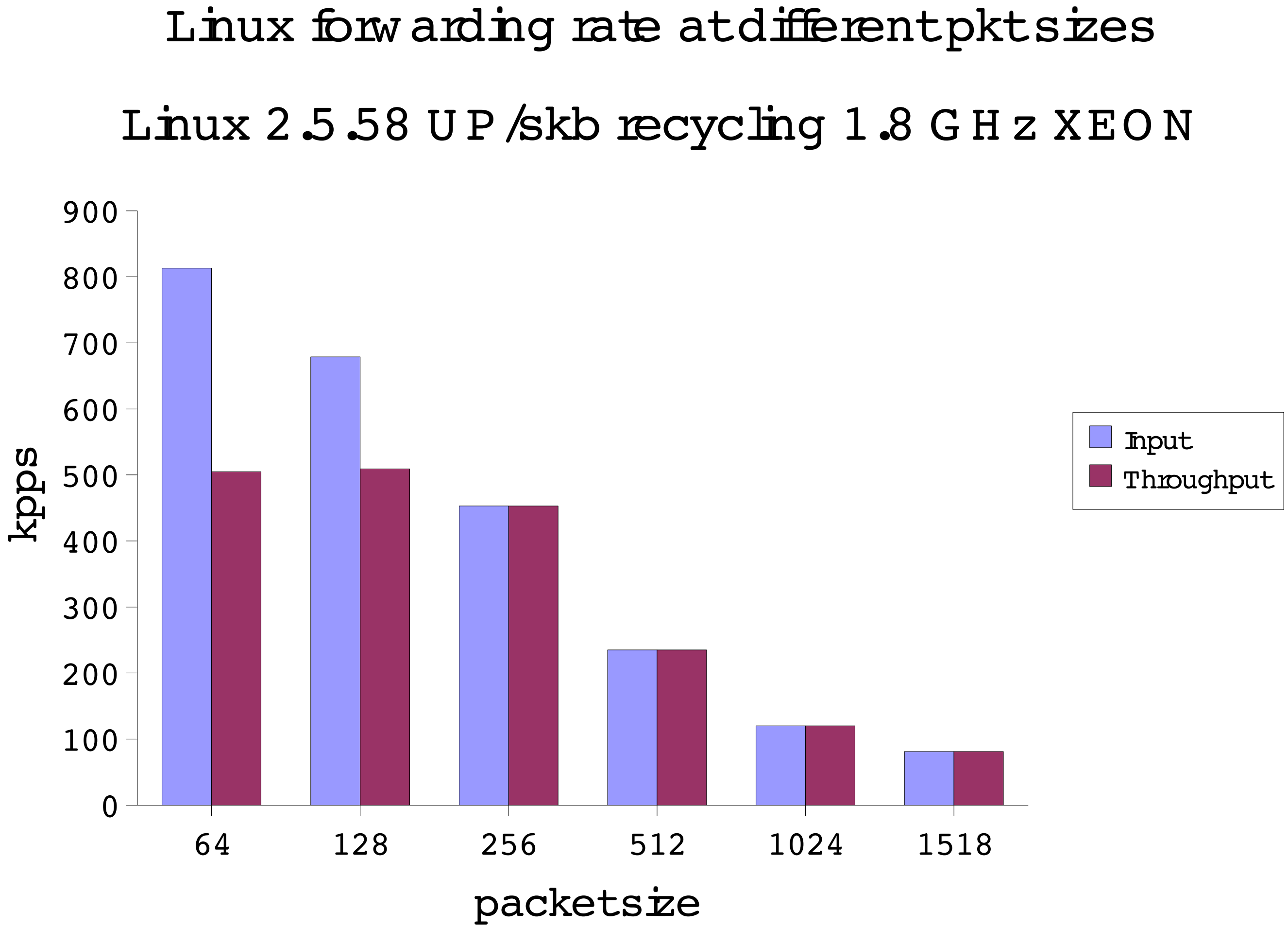
NAPI Kernel support

NAPI kernel part was included in:
2.5.7 and back ported to 2.4.20

Current driver support:

e1000 Intel GIGE NIC's – (UFO driver)
First driver where (RX & TX done in softirq)
tg3 BroadCom GIGE NIC's
dl2k D-Link GIGE NIC's
tulip (pending) 100 Mbs

Forwarding performance (old)

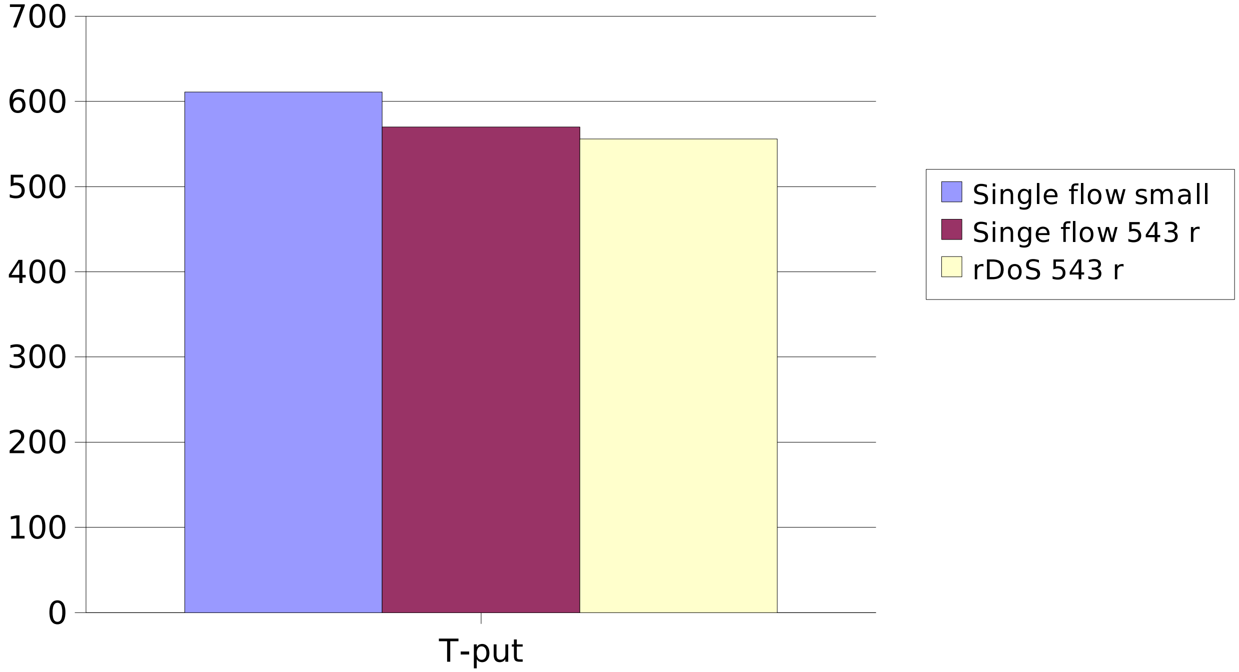


Fills a GIGE pipe -- starting from256byte pkts

ipv6 performance(old)

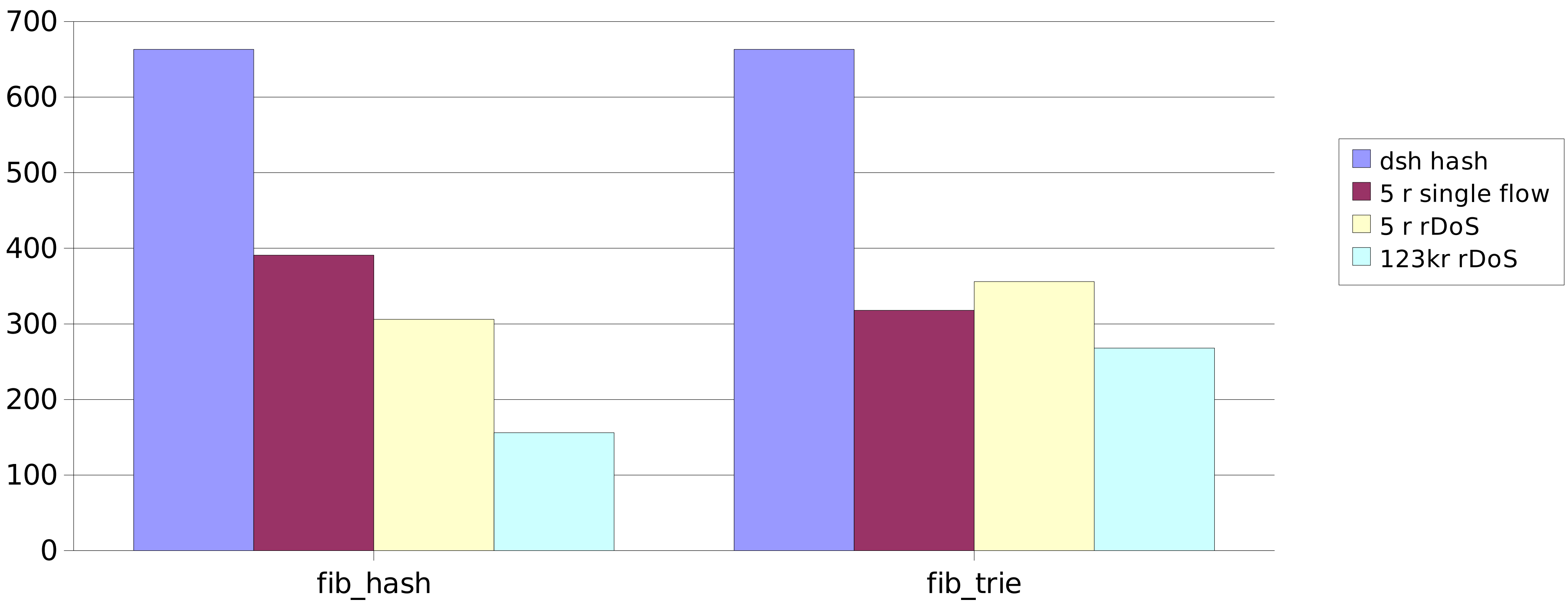
Forwarding kpps 76 byte pkt.

Linux 2.5.12 1 CPU(SMP) Opteron 1.6 GHz e1000



How rDoS work on sparse routing table?

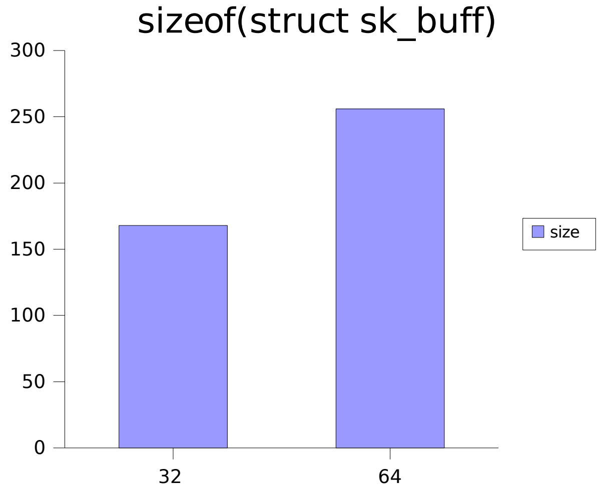
fib_trie performance comparison

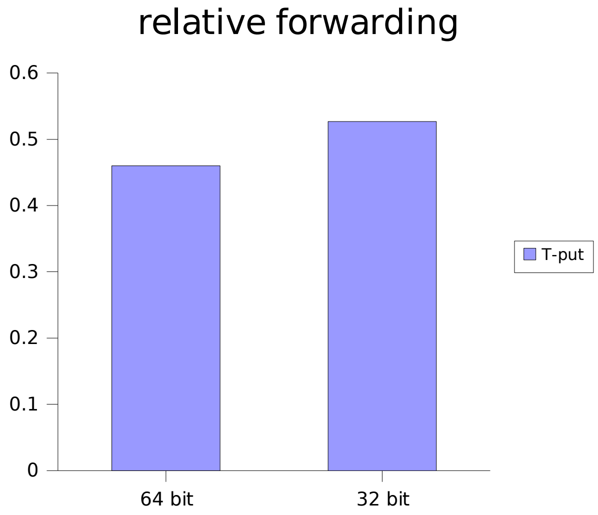

forwarding kpps

Linux 2.6.16 1 CPU used(SMP) Opteron 1.6 GHz e1000

Preroute patches to disable route hash

32/64 bit || sizeof(sk_buff)


sizeof(struct sk_buff)


relative forwarding

Gcc 3.4 x86_64 vs i686 on same HW

Trash data-structure

Interesting novel approach. Trie-Hash --> Trash

When extending the LC-trie

Paper with Stefan Nilsson/KTH

Exploits that key-length does not affect tree depth

We lengthen the so key it can be better compressed.

Implemented in Linux forwarding patch as a replacement to the route hash.

Trash data-structure

Can do full key lookup. src/dst/sport/dport/proto/if etc and later socket.

For even ip6 with little performance degradation

Could be a candidate for the grand unified lookup

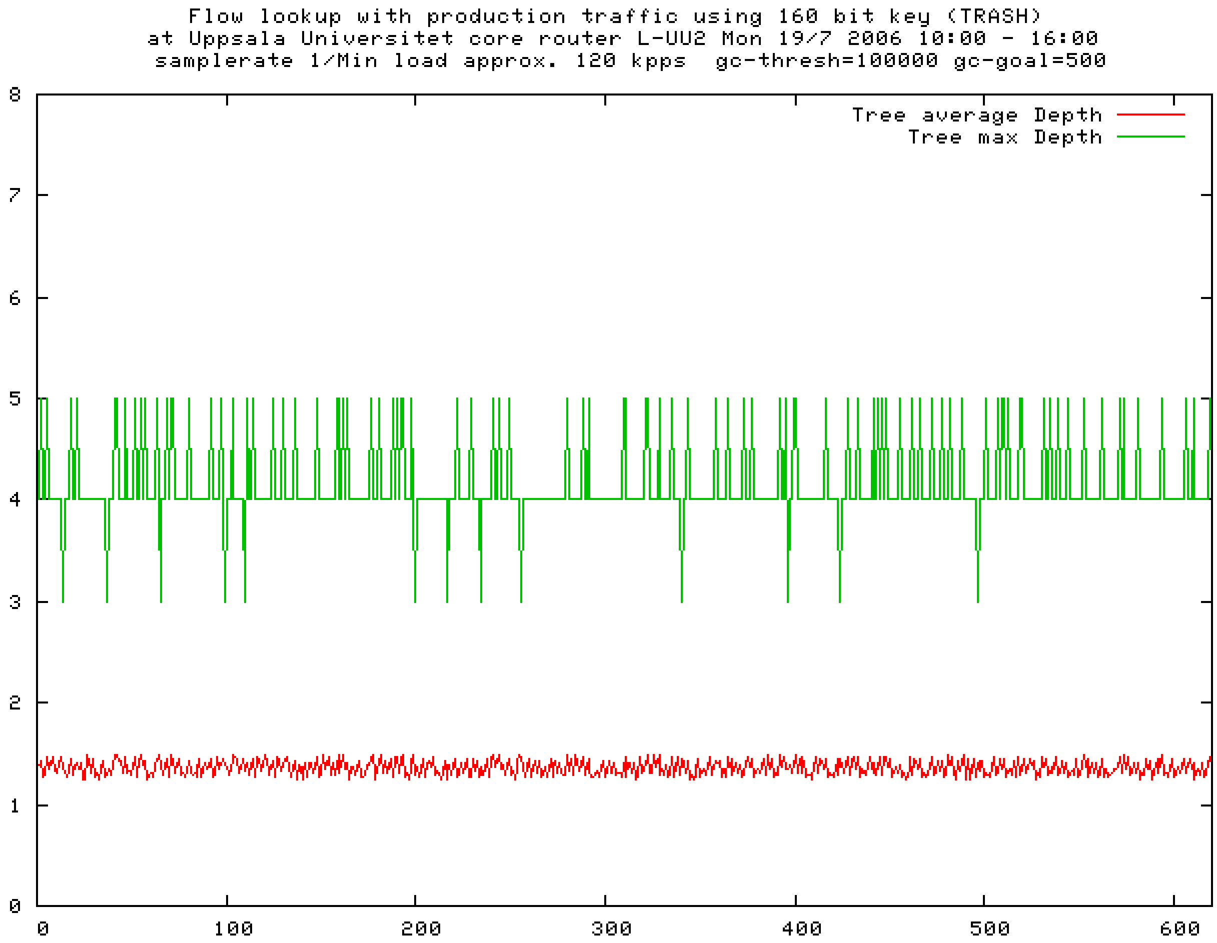
Full flow lookup can understand connections.

Free flow logging etc

New garbage collection (GC) possible. Active GC stated
AGC in the paper. Listen to TCP SYN, FIN and RST
Show to be performance winner.

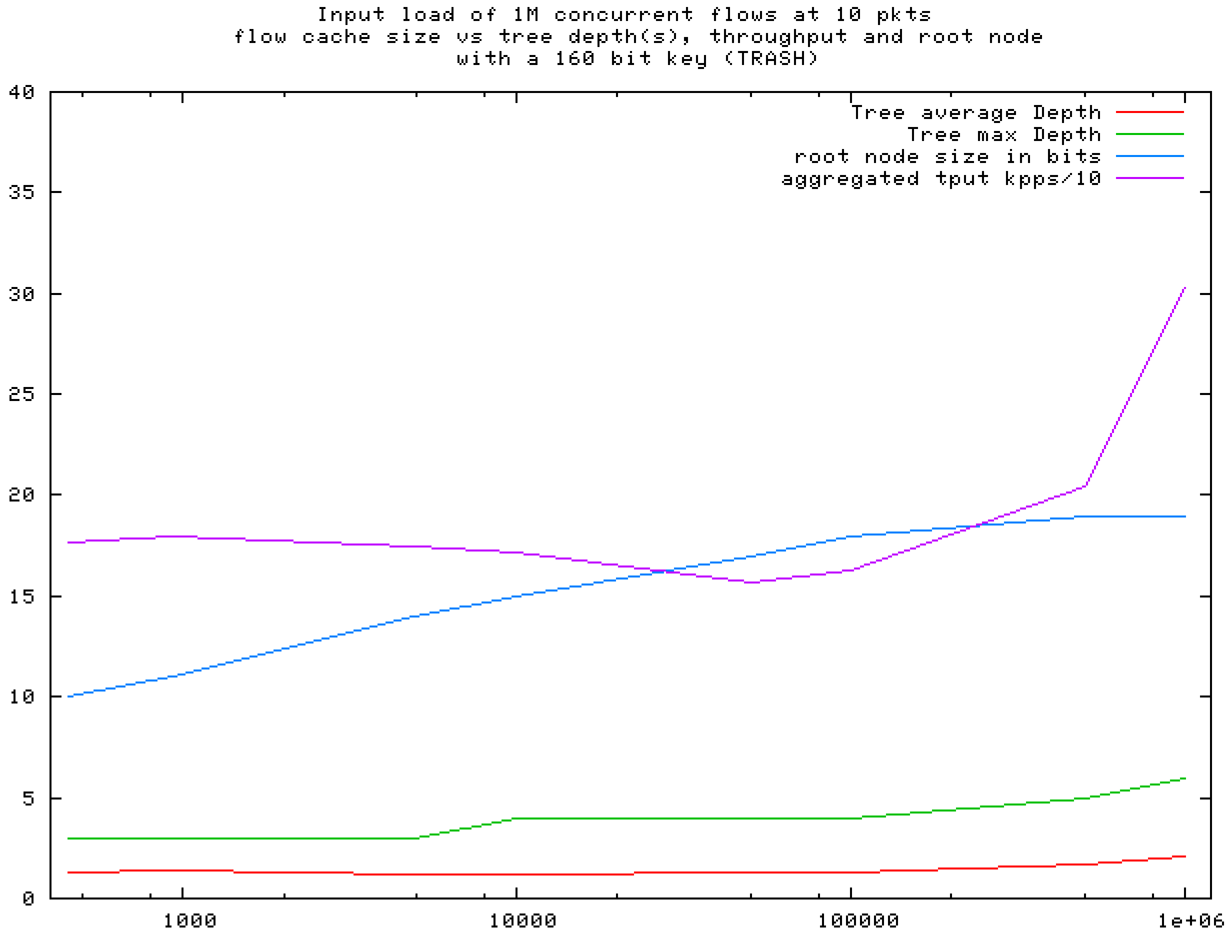
Trash data-structure

Uppsala Universitet core router



Trash data-structure

Very flat(fast) trees



Fully parallel router

multi-queue breakthrough

Load from one incoming 10g interface can be split among several CPU-cores

Using RSS (Receiver Scale Option). New NIC HW classifier

MSI-X interrupts affinity for RX, TX so a packet a skb is handled by one CPU core.

Breakthrough forwarding and for networking in general.

Fully parallel router concept

multi-queue breakthrough

In experiment we used Intel 82598 adapters.
Intel follows MS NDIS 6.0 for virtualization

SUN's 10g board has a more potent HW classifier aka TCAM.

Potent classifiers can give a breakthrough for both functions and performance.

Control plane separation, (routing daemons)
QoS, filters etc.

Fully parallel router

multi-queue breakthrough

Flow load. 31.000 fib_lookups/sec
BGP table w. 271.064 routes
Different 3 packet sizes

64 bytes	45%
576 bytes	25%
1500 bytes	30%

RSS and Multi-Queue (RX and TX) in use
Linux 2.6.27-rc2 ixgbe-1.3.31.5 + patches
Using 2/4 CPU cores from AMD Barcelona 2.3 GHz

Forwarding:: 6.2 Gbit/s (960 kpps)

10g boards

multi-queue breakthrough

SUN's seems to use XFP's. Anyone using it....

Other boards with SFP/SFP+/XFP ??

A new network symbol has been seen…

The Penguin Has Landed