Current status of NetBSD MP-safe network stack project

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Summary

- Background and goal
- What we've done
- What we're working on
  - Nexthop cache separation
  - TX multi-queue support
  - MP-safe gif(4)
  - Performance measurements
- Roadmap
- Future plan

Background

- NetBSD's network stack and network device drivers don't run in parallel between CPUs
  - Device drivers need to run with KERNEL_LOCK
  - The network stack need softnet_lock

Goal

- Make (part of) the network stack and (some) device drivers MP-safe
  - Make them runnable without the big locks
- Targets
  - Layer 2/3 forwarding
    - and some other components: gif, ipsec, ppp{oe}, etc.
  - Intel NICs and some drivers for VMs
    - wm(4), vioif(4), vmx(4) and some others
  - amd64/i386 (and ARM?)

What we did

- Interrupt distribution / IRQ affinity
  - intrctl(8) changes interrupt destination CPUs
- MSI/MSI-X support
  - i386 and amd64
- Hardware multi-queue support of wm(4)
  - Only RX queues for now
- MP-safe device drivers
  - wm(4), vioif(4) and vmx(4)
- MP-safe bridge(4)
  - Utilizing pserialize(9)
- Lots of ATF tests for the network stack

What we've done

- Lots of ATF tests
  - rump-ifying rtadvd(8), gif(4)
- New L2 nexthop cache implementation
  - Derived from FreeBSD
  - For L2 nexthop cache separation from the routing table
- No hardware interrupt context in the network stack
  - Make remaining parts run in softint
  - Except for ieee80211 and bpf(4)
- Restructuring and refactoring
  - No routing lookups in Layer 2
  - Use time_uptime instead of time_second
  - Kill open codes of manipulating rtentry#rt_refcnt
  - Many other small tweaks…

Added ATF tests (1/2)

- net/arp/t_arp
  - cache_expiration_10s, cache_expiration_5s, cache_overwriting, command, grap, link_activation, proxy_arp
- net/arp/t_dad
  - dad_basic, dad_duplicated
- net/icmp/t_icmp_redirect
  - icmp_redirect, icmp_redirect_timeout
- net/icmp/t_icmp6_redirect
  - basic
- net/if/t_ifconf
  - basic
- net/if/t_ifconfig
  - create_destroy, options, parameters
- net/if_bridge/t_bridge
  - basic, basic6, member_ip, member_ip6, rtable
- net/if_gif/t_gif
  - basicipv{4,6}overipv{4,6}, ioctlipv{4,6}overipv{4,6}, recursiveipv{4,6}overipv{4,6}
- net/if_tap/t_tap
  - create_destroy, stand_alone, bridged

Added ATF tests (2/2)

- net/ndp/t_dad
  - dad_basic, dad_duplicated
- net/ndp/t_ndp
  - cache_expiration, cache_overwriting, command, link_activation, neighborgcthresh
- net/ndp/t_ra
  - basic
- net/net/t_forwarding
  - basic, basic6, fastforward, fastforward6, misc
- net/net/t_ipaddress
  - ipaddr_same_address, ipaddr_same_address6
- net/net/t_ipv6address
  - linklocal, linklocal_ops
- net/net/t_ipv6_lifetime
  - basic
- net/route/t_flags
  - route_flags_{announce,blackhole,cloned,connected,default_gateway,icmp_redirect,lo, reject,static,xresolve}
- net/route/t_route
  - non_subnet_gateway

What we're now working on

- L2 nexthop cache separation from the routing table
- TX multi-queue
  - wm(4) at first
- MP-safe IP forwarding
  - Make data structures MP-safe
    - The routing table, ipaddr, ifnet, etc.
- MP-safe gif(4)
- pwe(4) (L2TPv3) support
- Polling mode of network device drivers
  - Like NAPI of Linux
- Performance measurements
  - ipgen

Nexthop cache separation

- Summary
  - Stop treating nexthop caches like ARP/NDP entries as part of the routing table
  - Store nexthop caches in each interface
  - Drop concept of cloning/cloned routes
- Motivation (for MP-safe work)
  - Remove recursive operations to handle cloned routes
  - Reduce contentions on the routing table
- ToDo
  - Get it done with keeping backward compatibility AMAP
    - It’s hard!

TX multi-queue support

- ToDo
  - New TX API
    - if_transmit instead of if_start
      - Pass packets (mbuf) directly to a network device driver
      - Not via if_snd queue (IFQ_ENQUEUE)
    - Multiple (soft) queues on each driver
      - Used if hardware is busy
  - Consideration
    - Which TX (hardware) queue we should use?
      - if # of CPUs > # of hw queues
      - if # of CPUs < # of hw queues

MP-safe gif(4)

- Done
  - Mutual exclusion between ioctl and packet processing
- ToDo
  - Lockless packet processing
    - with pserialize(9), not rwlock(9)
    - with passive reference?
  - ip_encap
    - Utility functions used by gif(4), stf(4), and ipsec
    - Fix scaling problem with lots of tunnels
      - Remove linear search in packet processing path (encap[46]_lookup)

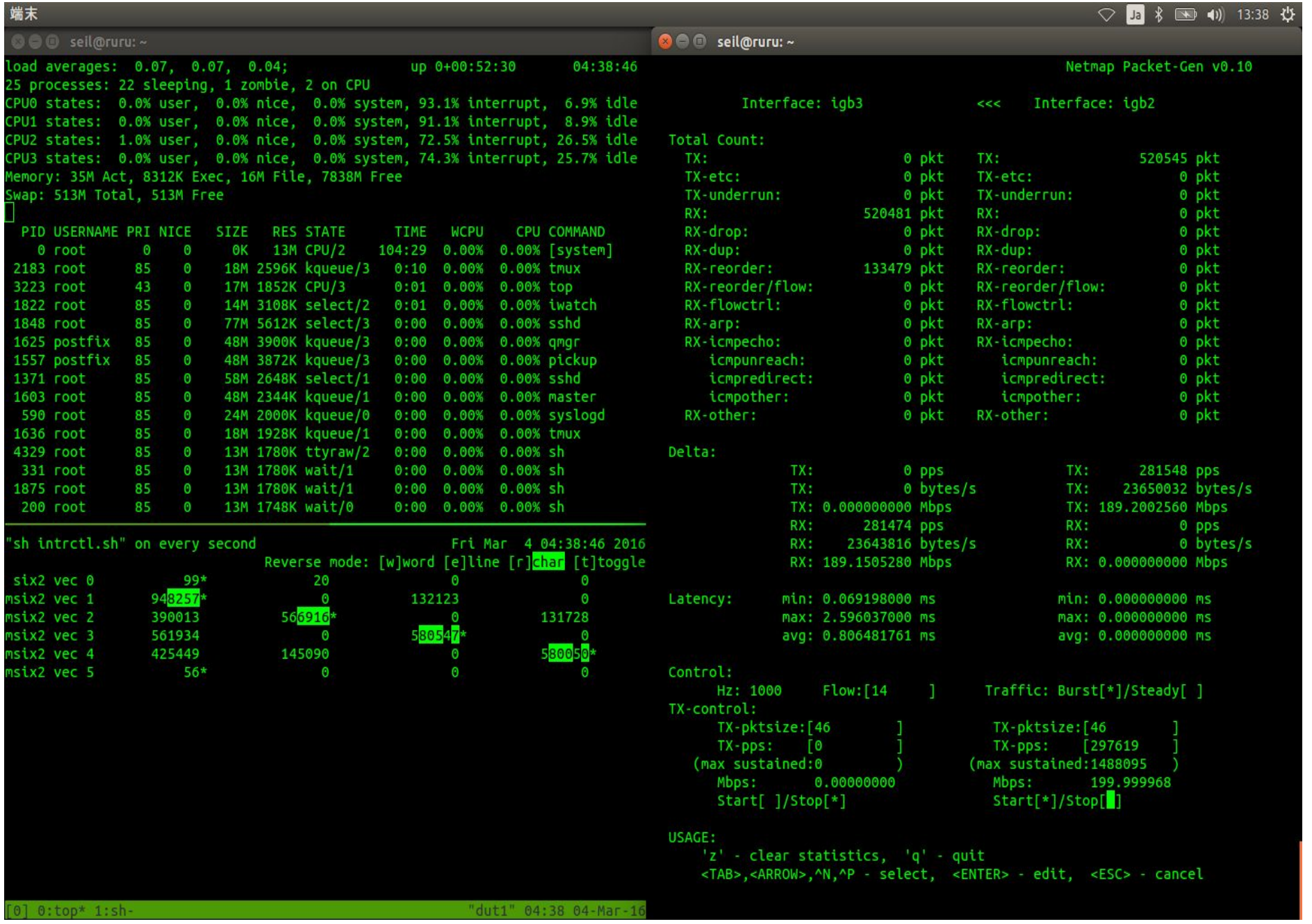
Performance measurements

- We have to know if MP-safe changes improve performance
- Throughput and latency of IP and bridge forwarding
  - Variable sized frames
  - Multiple flows
- ipgen is used by the measurements

What is ipgen?

- ipgen: interactive packet generator
  - A packet generator utilizing netmap(4) of FreeBSD
  - Developed by ryo@
- Features
  - Wire rate traffic with short packets on 1 GbE
    - Not known for 10 GbE
  - Experiments for packet forwarder (DUT)
    - RFC 2544 test
    - Multiple flows
  - Interactive UI (curses and web)
  - Drop/dup/reorder counters
  - Packet pacing by controlling inter packet gap

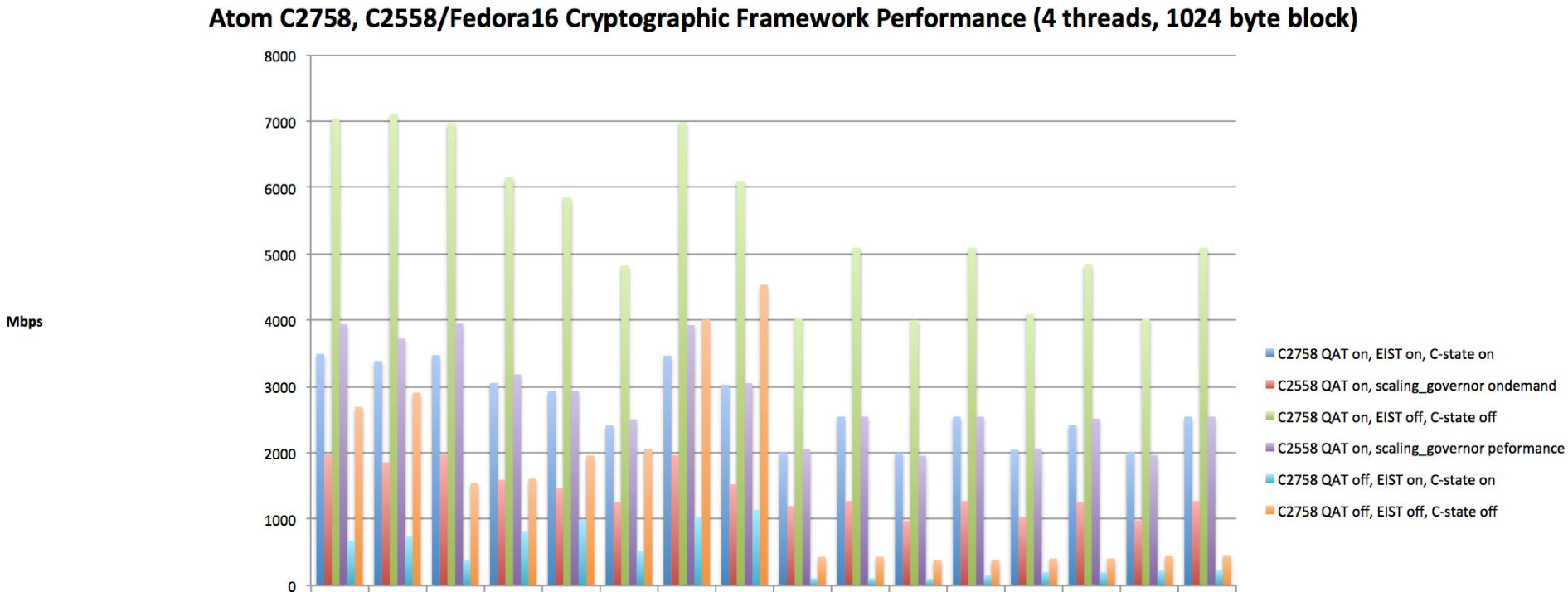
PR: demo at IIJ booth



SEIL/BPV4

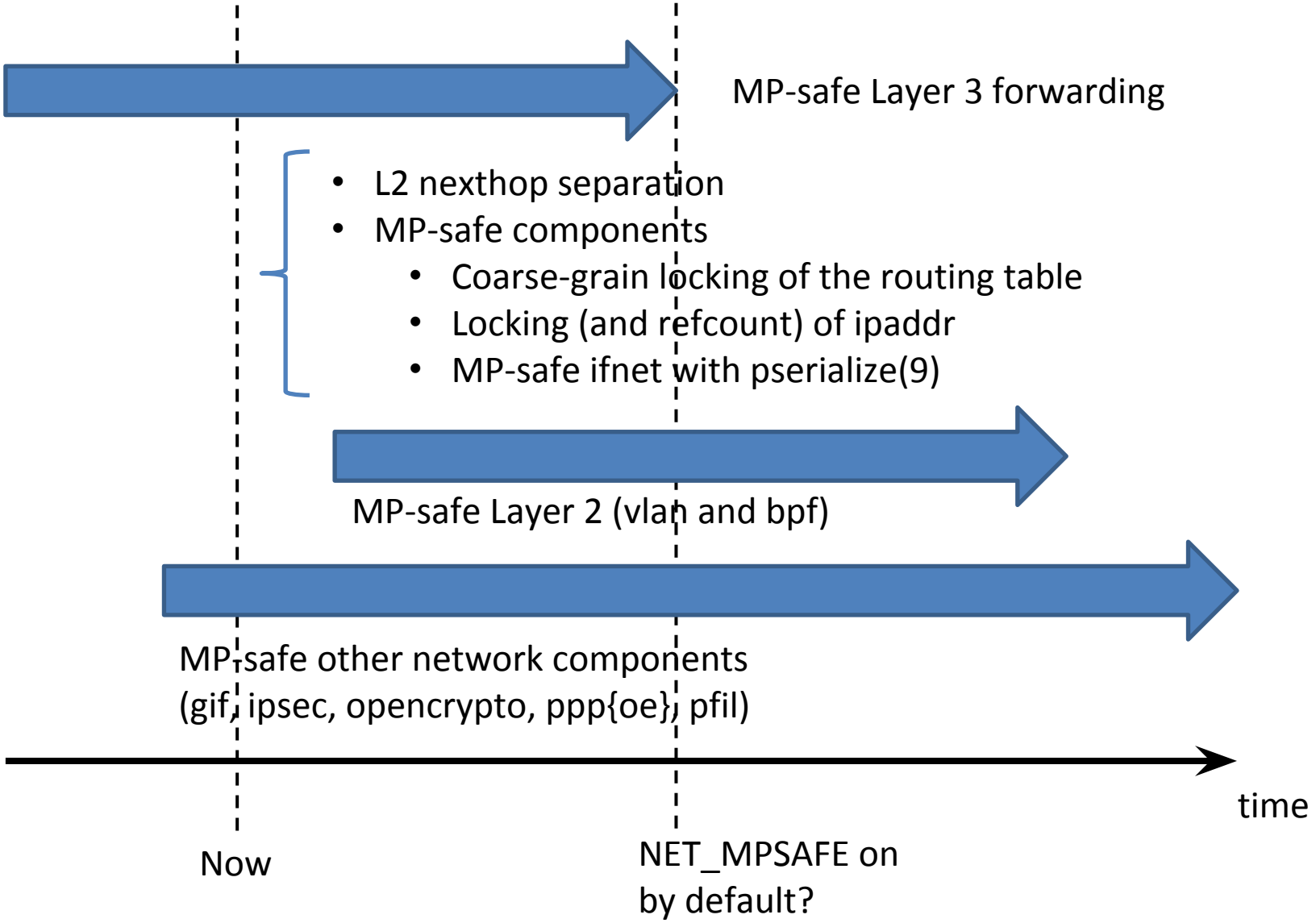
- Press release (in Japanese)
  - http://www.iij.ad.jp/news/pressrelease/2015/0930.html
- Intel C2558 (Rangeley)
  - qat(4): Intel Quick Assist Technology Driver
    - Developed by hikaru@
    - Uses MSI-X
    - Used by opencrypto
    - Written from scratch
    - Not merged into –current yet

Performance of qat



	AES-CBC/SHA1 Encrypt	AES-CBC/SHA1 Decrypt	AES-CBC/SHA256 Encrypt	AES-CBC/SHA256 Decrypt	AES-CBC/SHA512 Encrypt	AES-CBC/SHA512 Decrypt	AES-CBC/MD5 Encrypt	AES-CBC/MD5 Decrypt	3DES-CBC/SHA1 Encrypt	3DES-CBC/SHA1 Decrypt	3DES-CBC/SHA256 Encrypt	3DES-CBC/SHA256 Decrypt	3DES-CBC/SHA512 Encrypt	3DES-CBC/SHA512 Decrypt	3DES-CBC/MD5 Encrypt	3DES-CBC/MD5 Decrypt
C2758 QAT on, EIST on, C-state on	3492	3385	3473	3054	2927	2412	3465	3025	2009	2546	1999	2546	2048	2417	2010	2546
C2558 QAT on, scaling_governor ondemand	1970	1853	1972	1591	1465	1254	1963	1528	1196	1273	977	1273	1032	1258	982	1273
C2758 QAT on, EIST off, C-state off	7034	7103	6974	6155	5854	4823	6984	6099	4026	5092	4002	5092	4093	4838	4019	5092
C2558 QAT on, scaling_governor peformance	3938	3722	3947	3182	2932	2505	3927	3050	2051	2546	1956	2546	2065	2516	1965	2546
C2758 QAT off, EIST on, C-state on	676	735	386	807	989	519	1025	1137	108	107	99	148	202	203	226	228
C2758 QAT off, EIST off, C-state off	2690	2907	1539	1610	1958	2061	4013	4534	428	432	382	385	405	407	452	456

Roadmap


MP-safe Layer 3 forwarding
• L2 nexthop separation
• MP-safe components
• Coarse-grain locking of the routing table
• Locking (and refcount) of ipaddr
• MP-safe ifnet with pserialize(9)
MP-safe Layer 2 (vlan and bpf)
MP-safe other network components
(gif, ipsec, opencrypto, ppp{oe}, pfil)
time
Now
NET_MPSAFE on
by default?

Future plan

- MP-safe bpf(4)
  - Need to make ieee80211_input and some drivers run in softint (not must but desired to make MP-safe work easy)
- Alternative to the radix tree
  - rttree(3) ?
- Drop rtcache?
  - If the routing table is enough fast, we don’t need caches?
  - Or introduce a fast cache structure like Poptrie or SAIL?
- A common infrastructure of interfaces
  - for polling mode