

# Linux Networking State

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# TCP

Per-flow Pacing

Fast Open

Dynamic TSO Sizing

Datacenter TCP

TCP Small Queues

Advanced TCP statistics (web10g)

# Queueing Minimization

Socket queues

- TCP Small Queues

QDISC queues

- Fair Queue Packet Scheduler (per-flow pacing)

- Effect on TCP Timestamps

Device queues

- Byte Queue Limits

# Checksumming

Partial checksum propagation through encaps

Power of CHECKSUM\_COMPLETE

Remote Checksum Offload

Encapsulation meta-data which allows  
deducing

the checksum of the encapsulated protocol

# Switch Offloading

Bridge forwarding

IPV4/IPV6 route forwarding

nftables

# Offload Policy Part 1

Example: `ip route add xxx`

If we are offloading ipv4 forwarding to hardware, and the device indicates that this new route cannot fit in its hardware tables, what do we do?

# Policy Part 2

## Option 1:

Do not install the route and return an error.

## Option 2:

Uninstall all hardware routes and do all forwarding in software.

## Option 3:

Use hw as much as possible w/sw fallback

# Policy Guiding Constraints

It must by default be %100 transparent to the user.  
This means no errors when exceeding hw capacity.  
By this definition options #2 and #3 are permissible

But... we can provide facilities for people who want to do something sophisticated in this situation.

# Multiple Offload API Tracks

Direct bridge FDB and ipv4-route device operations (Scott Feldman and Jiri Pirko)

Flow API (John Fastabend).

And if a third set of interfaces is proposed, that's OK too.

Eventually with enough experience things will converge.

# What Really Matters

A clear plan, with well defined constraints.

Unambiguous reasons for each and every constraint.

Someone will be unhappy with the design we come up with, this is inevitable. So we must be able to explain our design decisions precisely.

# rhashtables

Resizable hash tables using RCU locking

Current users: netlink sockets and nftables

Use for TCP sockets in the future

# TX Overhead Mitigation

`skb->xmit_more`

Decreases number of doorbell rings per packet  
Especially important for virtualization devices  
Enhanced with bulk dequeue support in packet scheduler

# Busy Polling

Alternative to blocking at `recvmsg()` time

If `recvmsg()` finds socket receive queue empty

Call into device driver and poll for RX packets

If any found, feed into networking stack

`recvmsg()` pulls any received data into userspace

# Memory Allocation Batching

Networking stresses SLAB/SLUB

Unbalanced RX/TX allocation/free patterns

Allocation overhead can exceed the time budget we have for processing small packets at 10GB wire rate

qmempool developed as an experiment to see what allocation batching can do

SLAB/SLUB extended to have batching interfaces

# Thanks

Linus Torvalds

Jamal Hadi Salim

And in advance, I'd like to thank the first hardware vendor to merge a hw switching driver upstream. You will be a true trail-blazer.