Hardware accelerating Linux network functions

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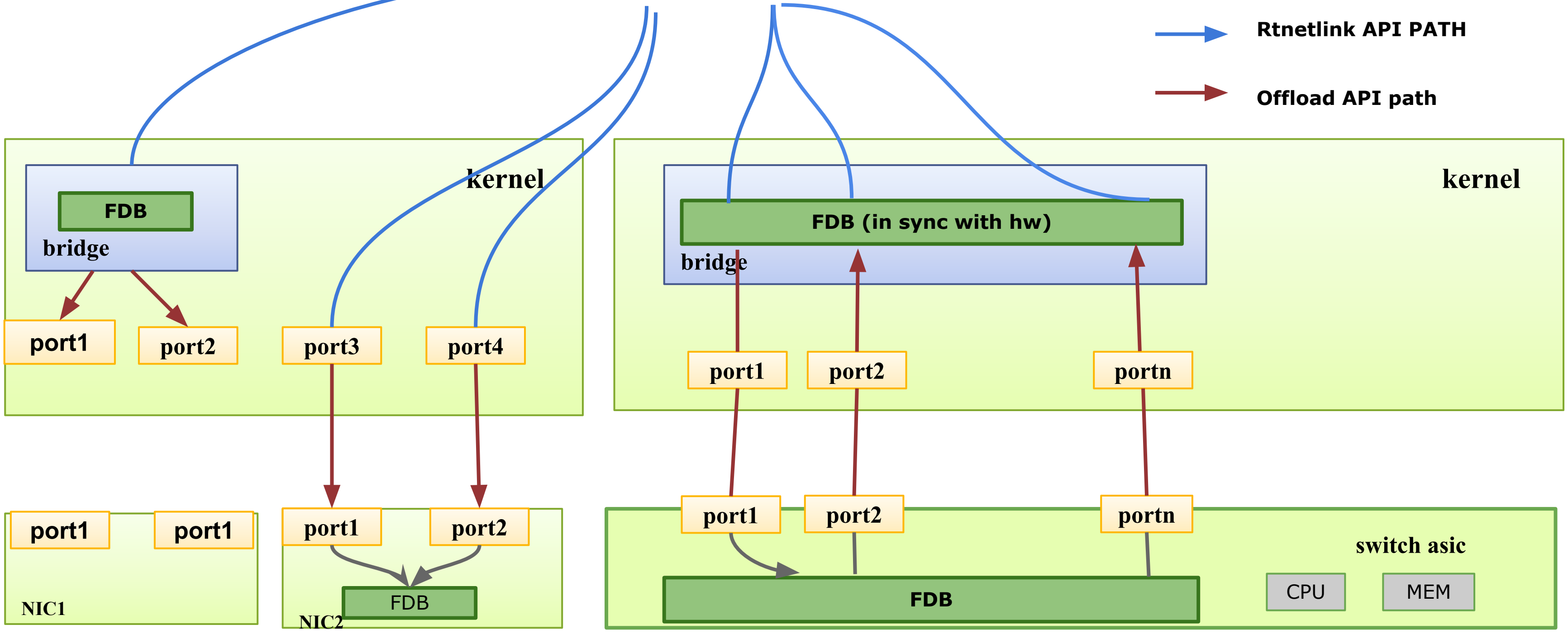
Agenda

- Recap: offload models, offload drivers
- Introduction to switch asic hardware
- L2 offload to switch ASIC
  - Mac Learning, ageing
  - stp handling
  - igmp snooping
  - vxlan
- L3 offload to switch ASIC

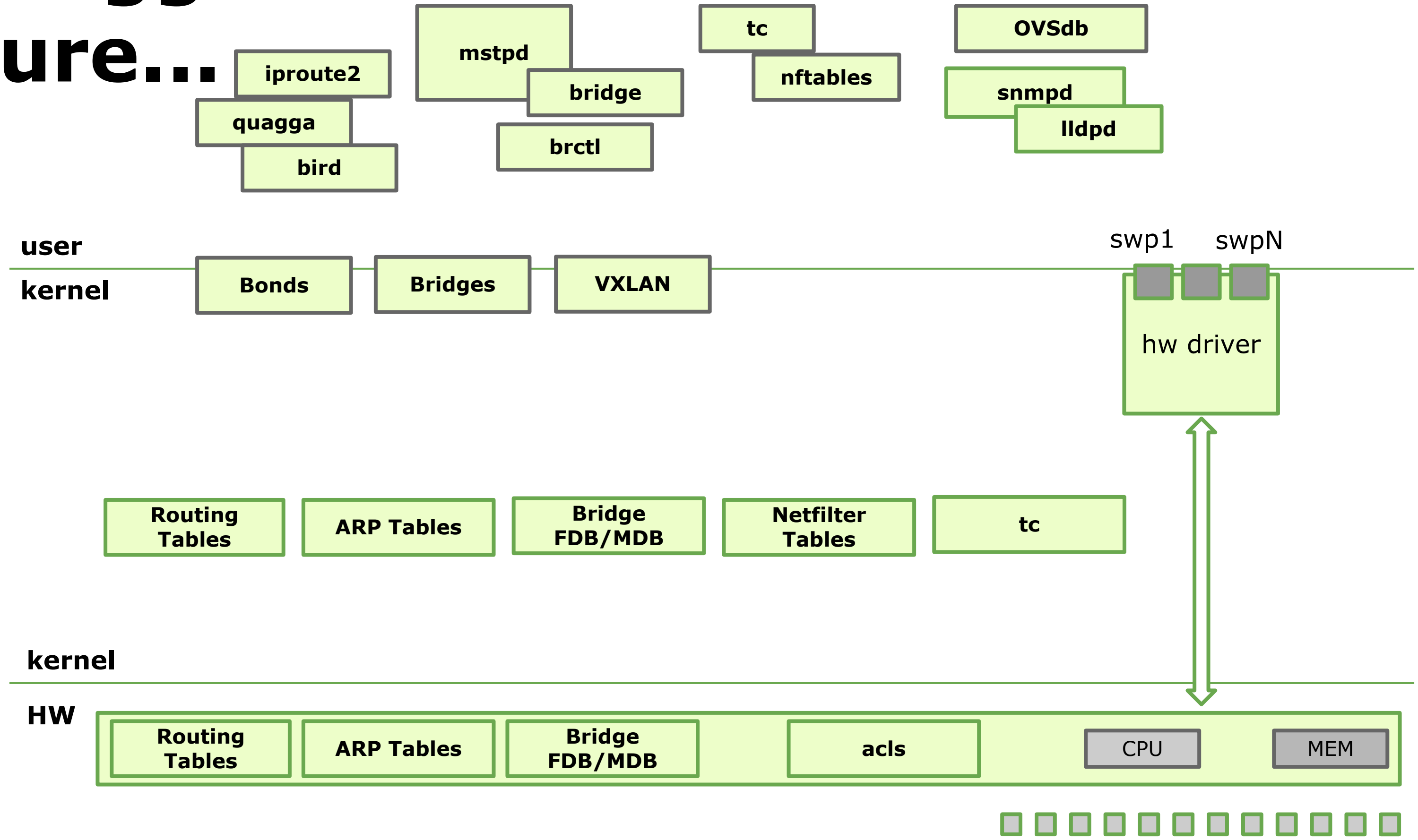
Offload models ...

- Single consistent netlink based UAPI
- Single kernel offload API to offload to variety of hardware (nics, switch asics, ..)

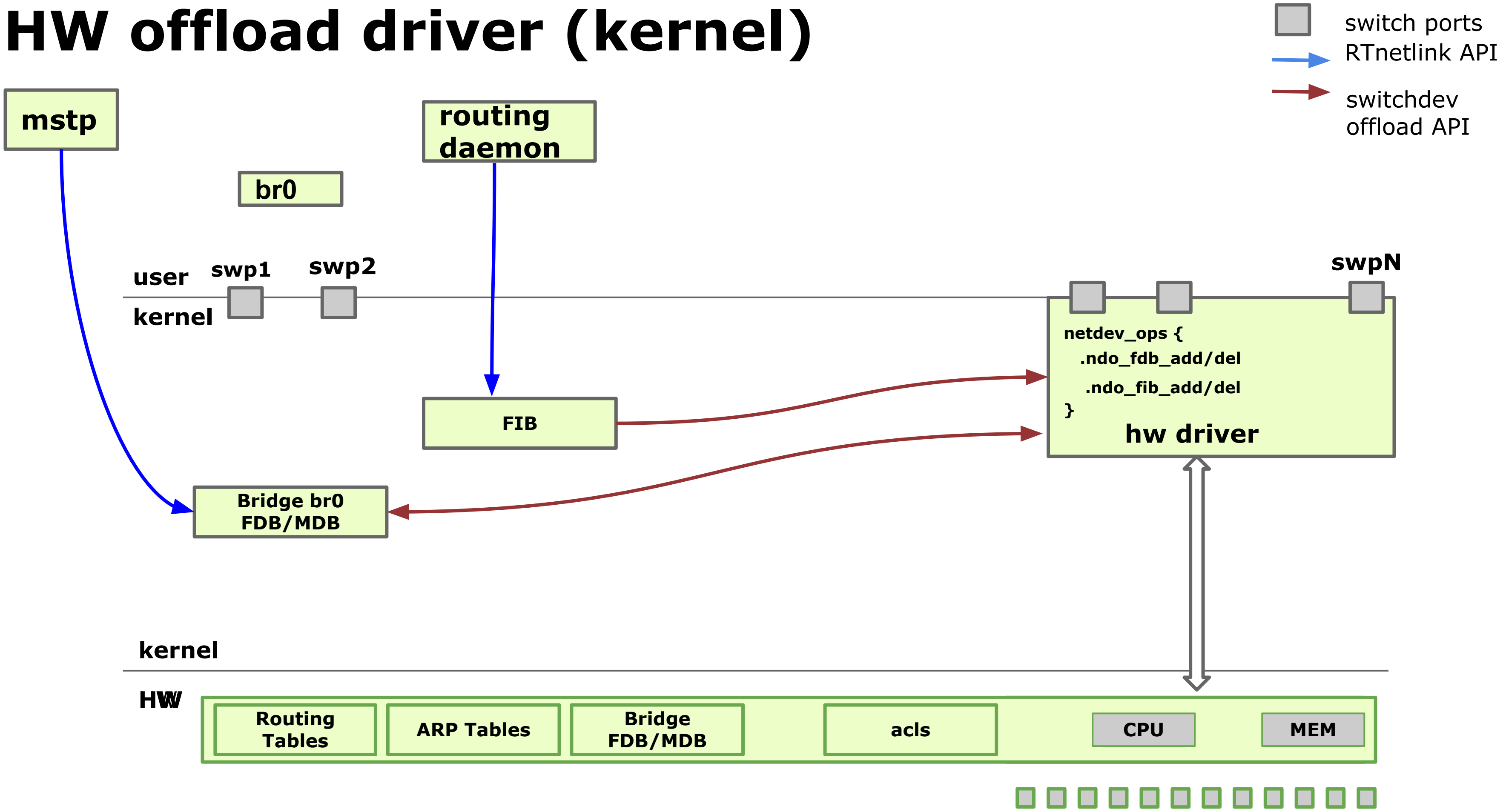
rtnetlink api:
bridge vlan add
bridge fdb add



The bigger picture…



HW offload driver (kernel)



□ switch ports

RTnetlink API

switchdev offload API

mstp

routing daemon

br0

user

kernel

swp1

swp2

swpN

```
netdev_ops {
  .ndo_fdb_add/del
   .ndo_fib_add/del
}
```

hw driver

FIB

Bridge br0 FDB/MDB

kernel

HW

Routing Tables

ARP Tables

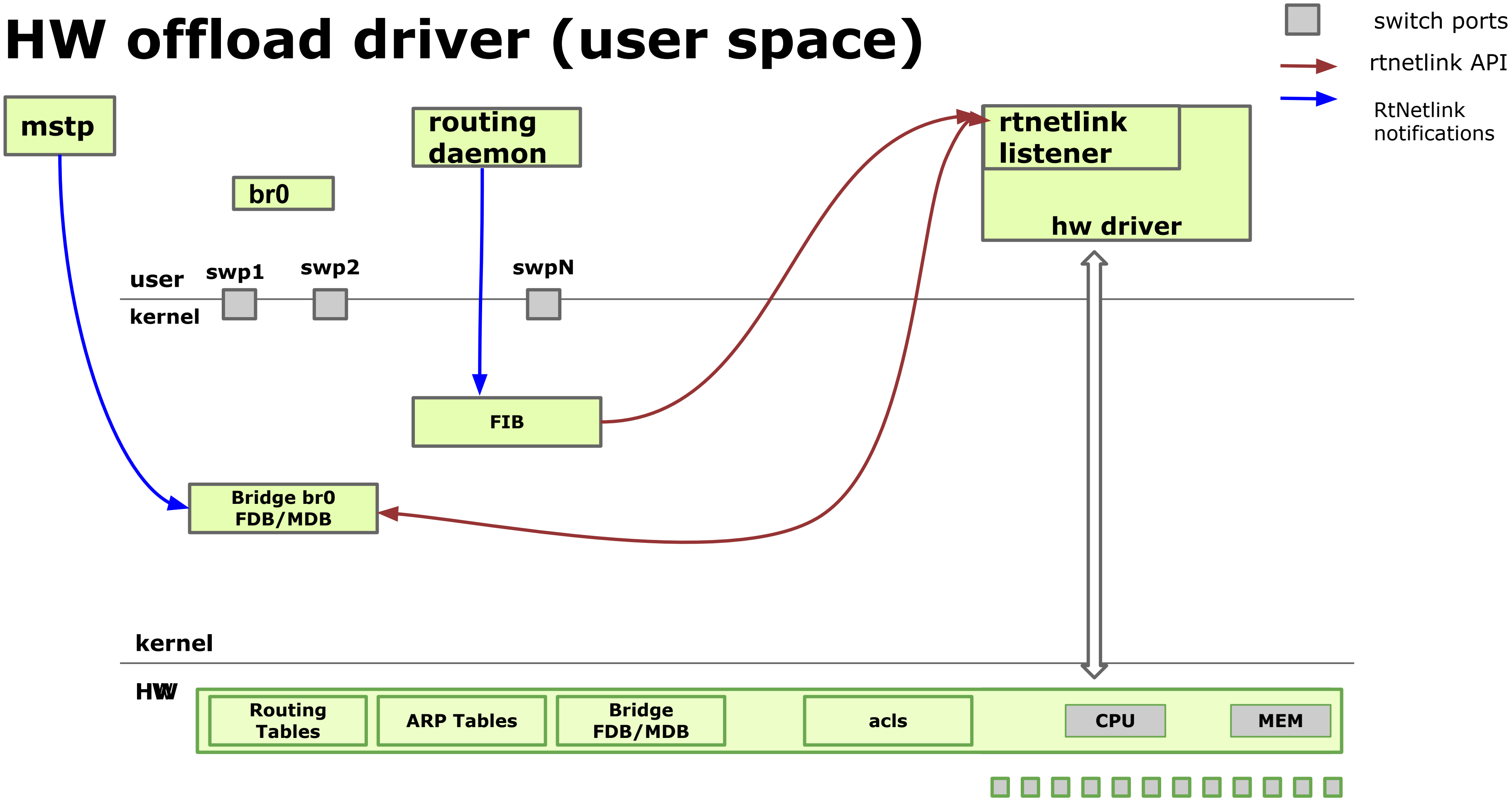
Bridge FDB/MDB

acls

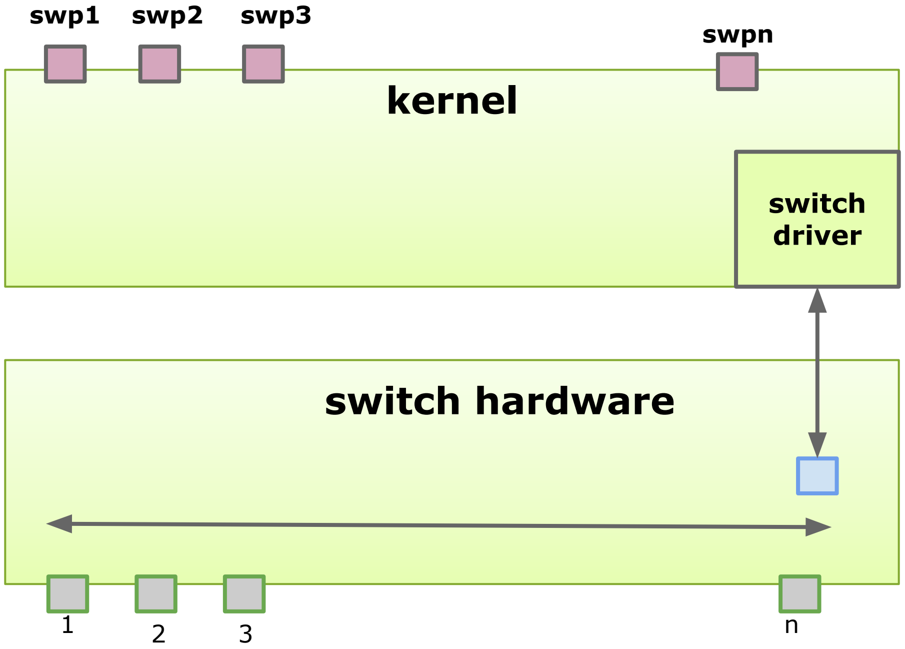
CPU

MEM

HW offload driver (user space)



switch hardware



switch driver:

- **Creates netdevs for front panel ports**
- **Port netdevs only see traffic forwarded to the CPU port**
- **Sets hardware offload flag NETIF_F_HW_SWITCH_OFFLOAD on netdevs**

🟪 netdevs for each front panel ports

🟦 cpu port

🟩 front panel ports

ip link show switch ports

```
# ip link show
1: lo: <LOOPBACK> mtu 16436 qdisc noqueue state DOWN mode DEFAULT
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP mode DEFAULT qlen 1000
    link/ether 00:e0:ec:27:4e:b6 brd ff:ff:ff:ff:ff:ff
3: swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode DEFAULT qlen 500
    link/ether 44:38:39:00:27:ac brd ff:ff:ff:ff:ff:ff
4: swp2: <BROADCAST,MULTICAST> mtu 9000 qdisc pfifo_fast state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:b8 brd ff:ff:ff:ff:ff:ff
```

[snip]

```
55: swp53: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:f7 brd ff:ff:ff:ff:ff:ff
56: swp54s0: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:fb brd ff:ff:ff:ff:ff:ff
57: swp54s1: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:fc brd ff:ff:ff:ff:ff:ff
58: swp54s2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:fd brd ff:ff:ff:ff:ff:ff
59: swp54s3: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT qlen 500
    link/ether 00:e0:ec:27:4e:fe brd ff:ff:ff:ff:ff:ff
```

🟩 switch ports

🟦 management port

ethtool on switch port

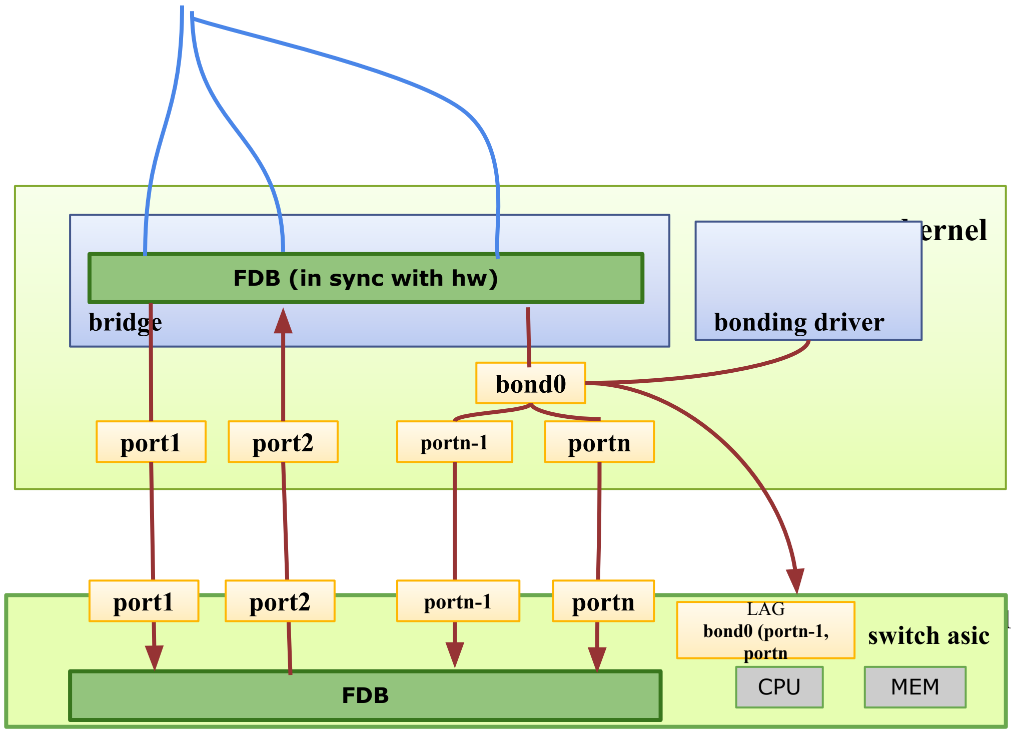
```
$ethtool swp1
Settings for swp1:
        Supported ports: [ FIBRE ]
        Supported link modes:   1000baseT/Full
                                10000baseT/Full
        Supported pause frame use: Symmetric Receive-only
        Supports auto-negotiation: Yes
        Advertised link modes:  1000baseT/Full
        Advertised pause frame use: No
        Advertised auto-negotiation: No
        Speed: 10000Mb/s
        Duplex: Full
        Port: FIBRE
        PHYAD: 0
        Transceiver: external
        Auto-negotiation: off
        Current message level: 0x00000000 (0)

        Link detected: yes
```

Creating a hardware accelerated Linux bridge device

```
# ip link add br0 type bridge

# ip link set dev swp1 master br0

# ip link set dev swp2 master br0

# bridge vlan add vid 10-20 dev swp1

# bridge vlan add vid 20-30 dev swp2
```

Bonds as bridge ports

rtnetlink api:
bridge vlan add
bridge fdb add

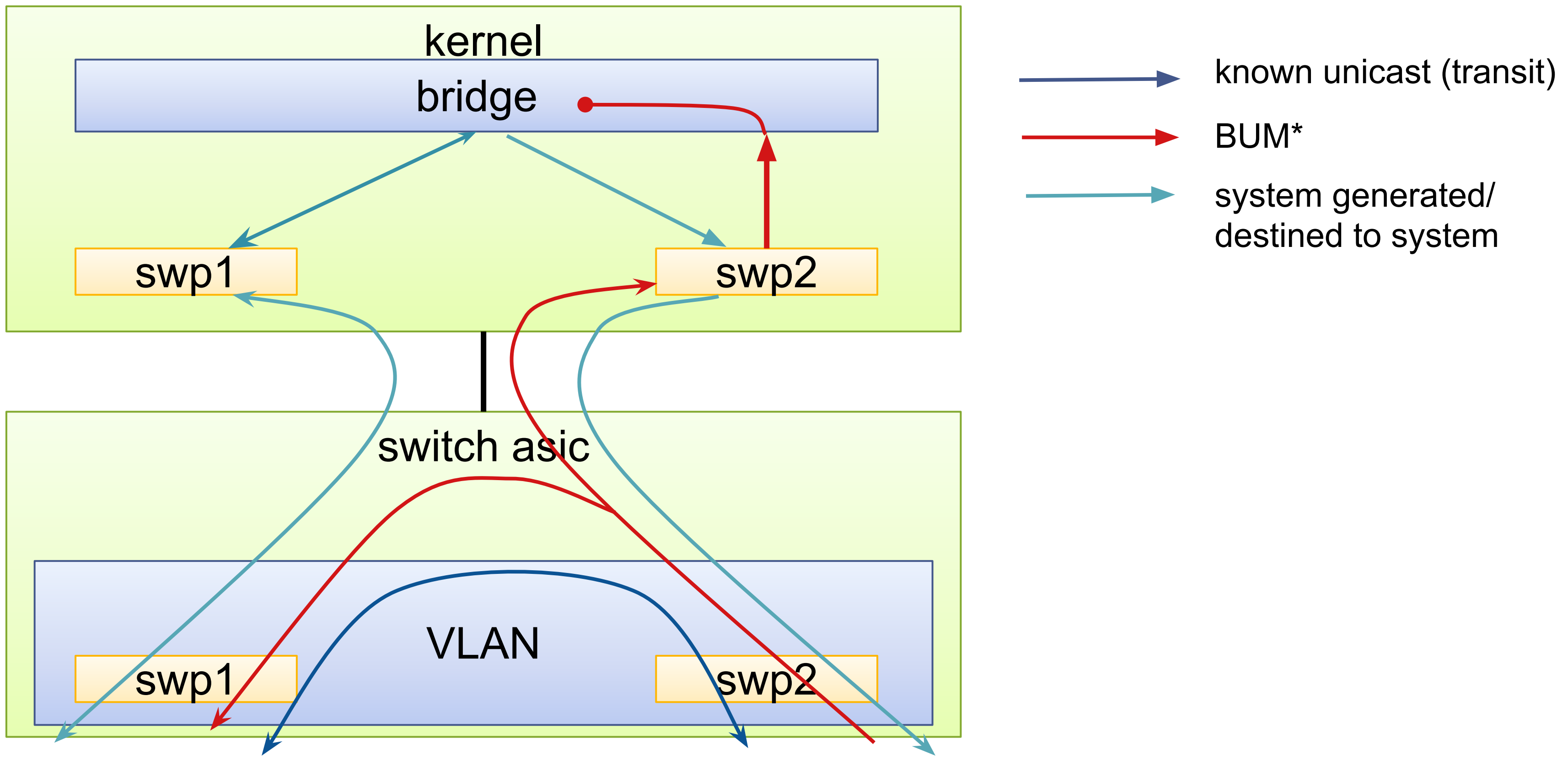


- switch ASICS support Link aggregation
- bonding driver LAG config is offloaded to the switch ASIC
- fdb and vlan offloads go through the bonding driver

rtnetlink API

switchdev
offload API

Bridging hardware offload: packet path



kernel

bridge

swp1

swp2

switch asic

VLAN

swp1

swp2

known unicast (transit)

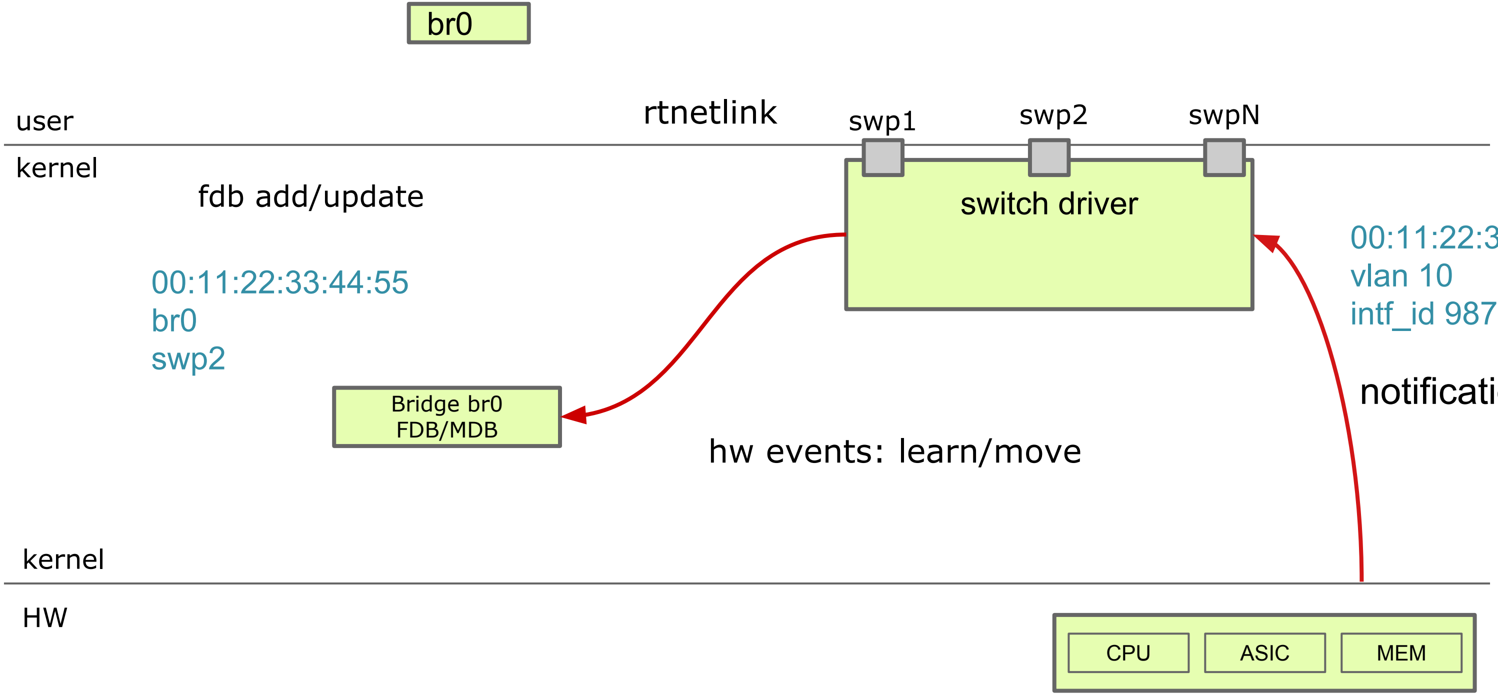
BUM*

system generated/
destined to system

Bridging hardware offload: packet path

- Known unicast traffic not destined to system is forwarded only in hardware
- BUM traffic is forwarded in hardware plus a copy MAY be sent to kernel
- BUM traffic in kernel should not be forwarded again (duplicate copies from hardware and software)

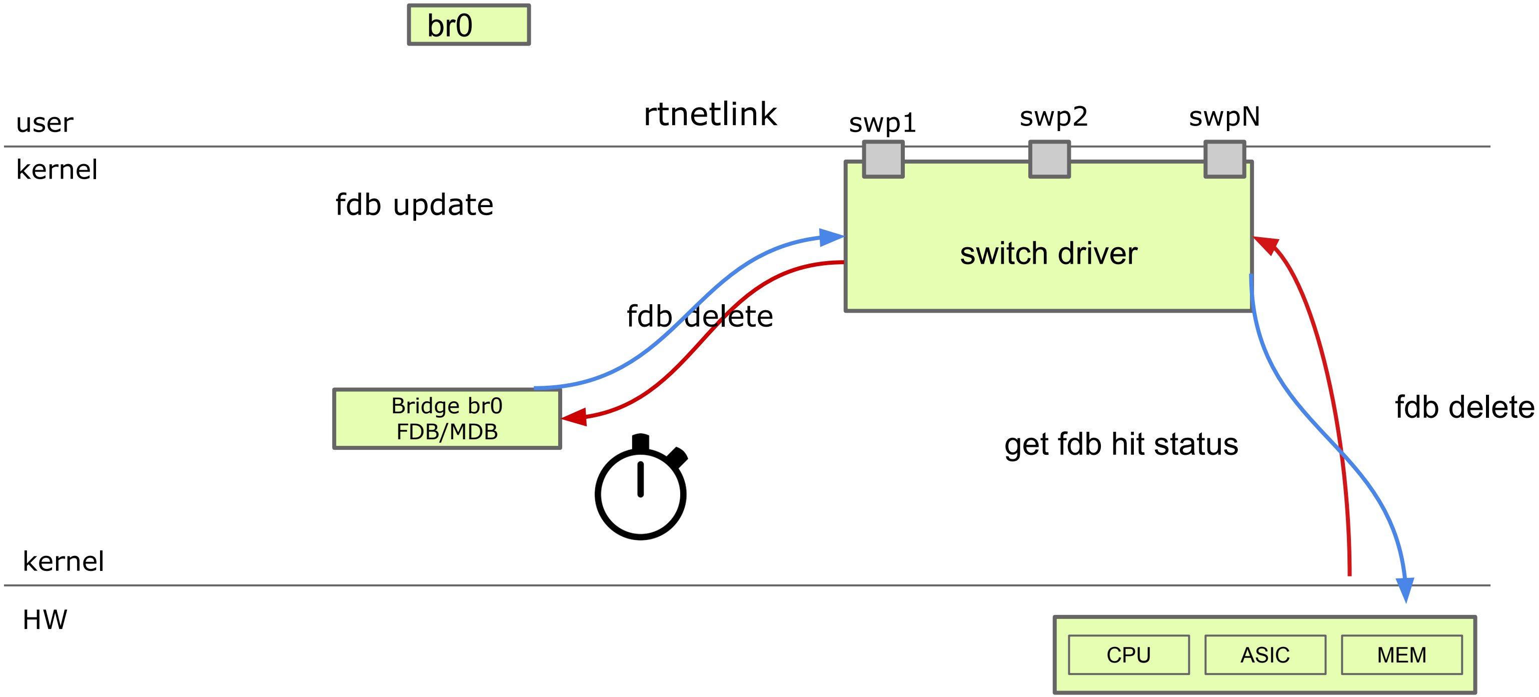
Bridging hardware offload: fdb learn



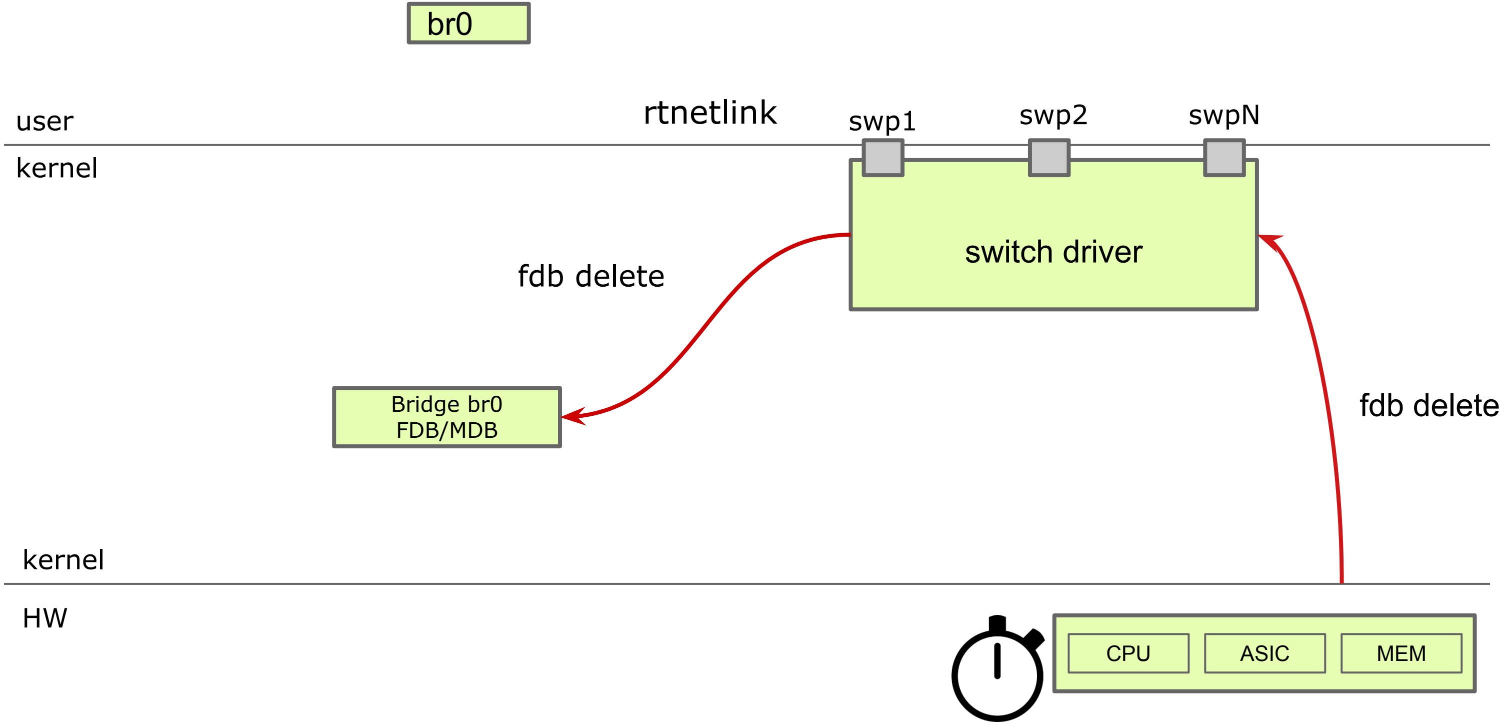
Bridging hardware offload: learning in HW

- Turn off learning in bridge driver
- switch driver listens to learn notifications from hardware
- converts hardware interface id and vlan to kernel ifindex of bridge port (and vlan) and bridge
- sends netlink fdb update to kernel (userspace driver) or calls bridge driver learn sync switchdev API (kernel driver)

Bridging hardware offload: kernel ageing



Bridging hardware offload: hardware ageing



Bridging hardware offload: ageing

Bridge driver very seldom sees packets with hardware offload. FDB age is not up to date.

Hardware ageing

- bridge driver should not do ageing if hardware is doing it
- fdb show will need to get age from hardware during ‘show’, or need periodic age update from switch driver

Kernel ageing

- definitely need periodic age update from switch driver

STP offload

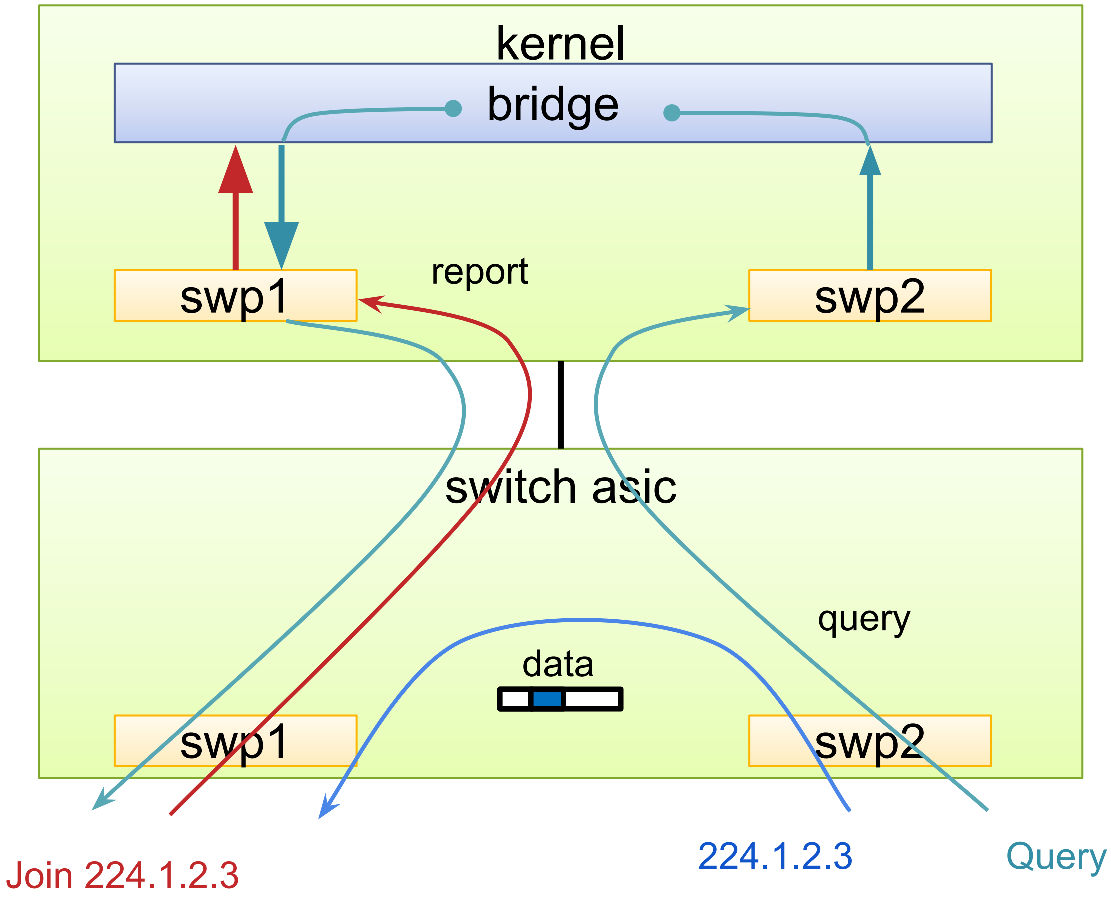
STP

- bridge driver maintains STP states (either kernel STP or userspace STP)
- bridge driver communicates STP states to switch driver using switchdev offload API
- OR a switch driver in userspace can listen to STP state notifications to update HW state

IGMP snooping offload

dev bridge port swp1 grp 224.1.2.3 temp

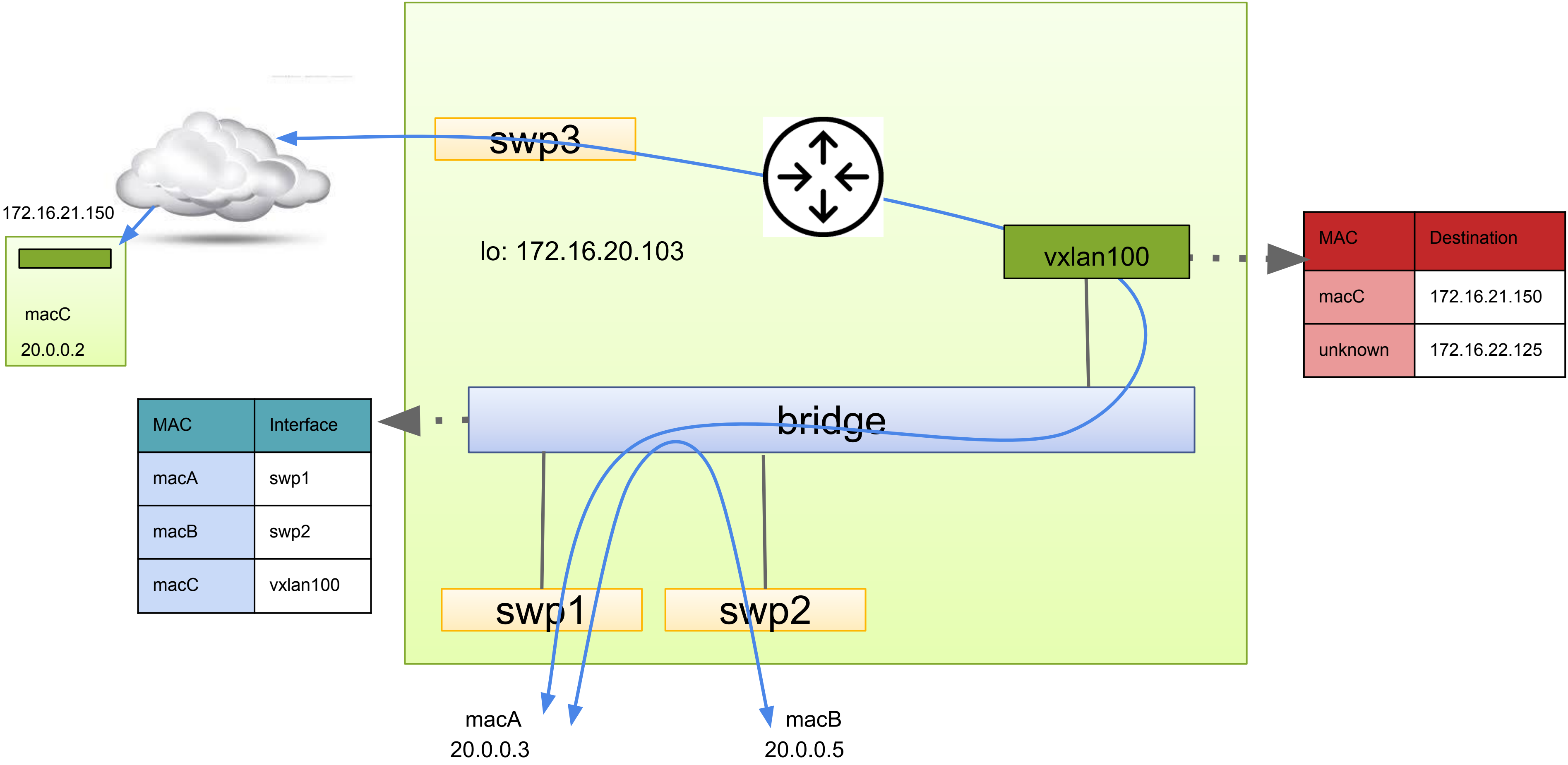
router ports on bridge: swp2



IGMP snooping offload

- switch driver configures hardware to send IGMP reports and queries to software
- bridge driver maintains IGMP group membership
- in some cases the reports or queries need to be re-forwarded in the kernel

VXLAN offload - hardware vtep



MAC	Interface
macA	swp1
macB	swp2
macC	vxlan100

MAC	Destination
macC	172.16.21.150
unknown	172.16.22.125

VXLAN offload - hardware vtep

Model

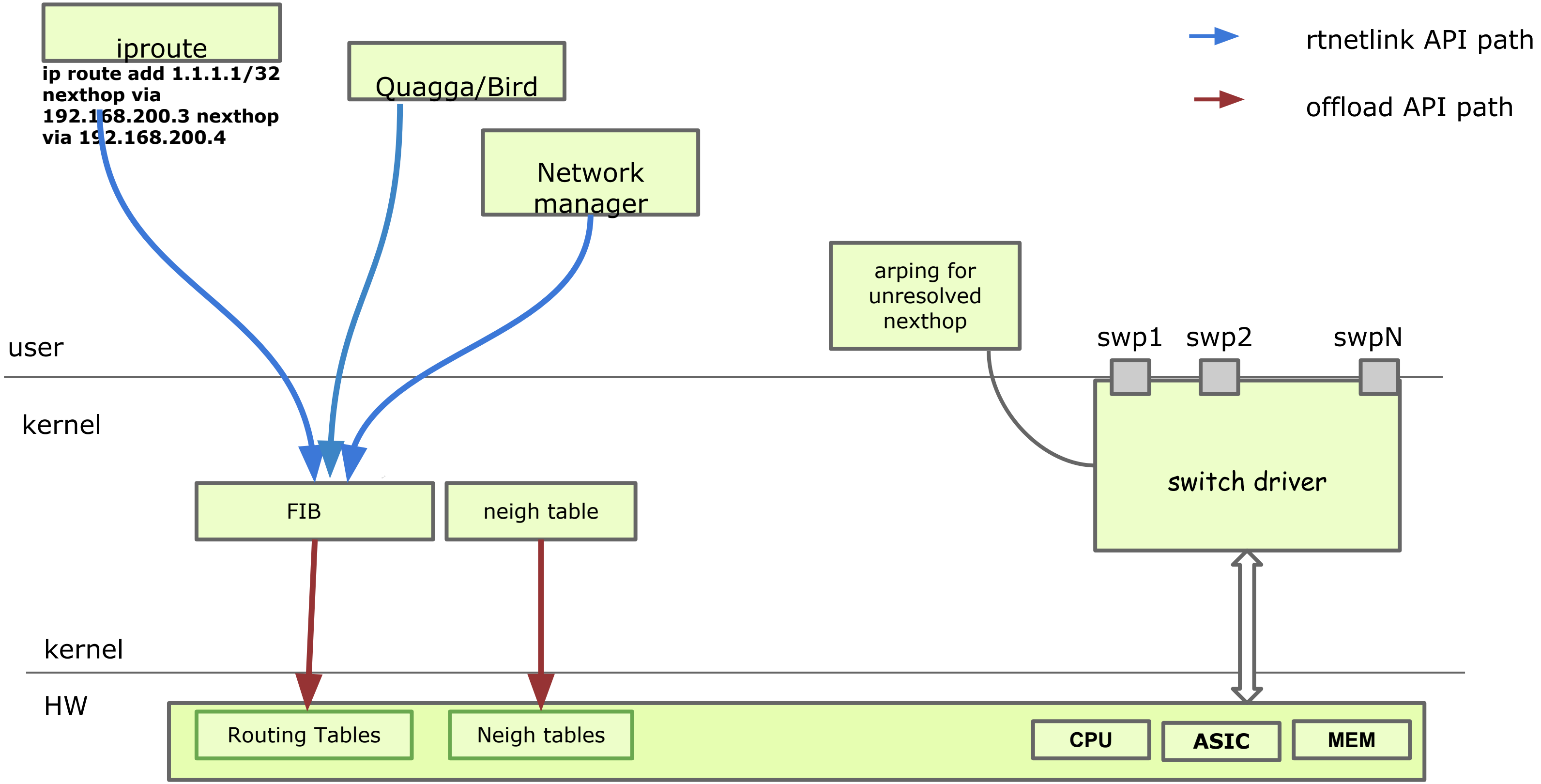
- VXLAN link as bridge port
    - bridging between local ports
    - VXLAN tunneling for remote MACs
- BUM traffic handling
    - multicast
    - using off-system replicator
        - could have a list of redundant replicators, need to choose ONE out of the list of remote dests (per flow or per vni etc.)
    - self replication
        - vtep sends to a list of remote vteps, need to choose ALL of the list of remote dests

VXLAN offload - ovsdb integration

Agent to translate ovsdb schema objects to kernel constructs.

OVSDB	Linux kernel
logical switch	vxlan link + bridge
physical switch tunnel_ip	vxlan link local ip
logical port binding	bridge member port, vlan
unicast remote mac + physical locator	bridge fdb (mac, vlan, dst <remote ip>)
mcast remote mac “unknown” + physical locator list	vxlan link default dest
unicast local mac + physical locator	bridge fdb (mac, vlan, local dev)

l3 offloads


iproute
ip route add 1.1.1.1/32 nexthop via 192.168.200.3 nexthop via 192.168.200.4
Quagga/Bird
Network manager
rtnetlink API path
offload API path
arping for unresolved nexthop
swp1
swp2
swpN
user
kernel
switch driver
FIB
neigh table
kernel
HW
Routing Tables
Neigh tables
CPU
ASIC
MEM

l3 hardware offload

- Routes via routing daemons go to the kernel
- Unresolved next hops, point to CPU in HW
- switch driver tries to resolve them by probes (arping)
- Refresh neigh entries for pkts routed through hardware (hit bit provided by hardware)