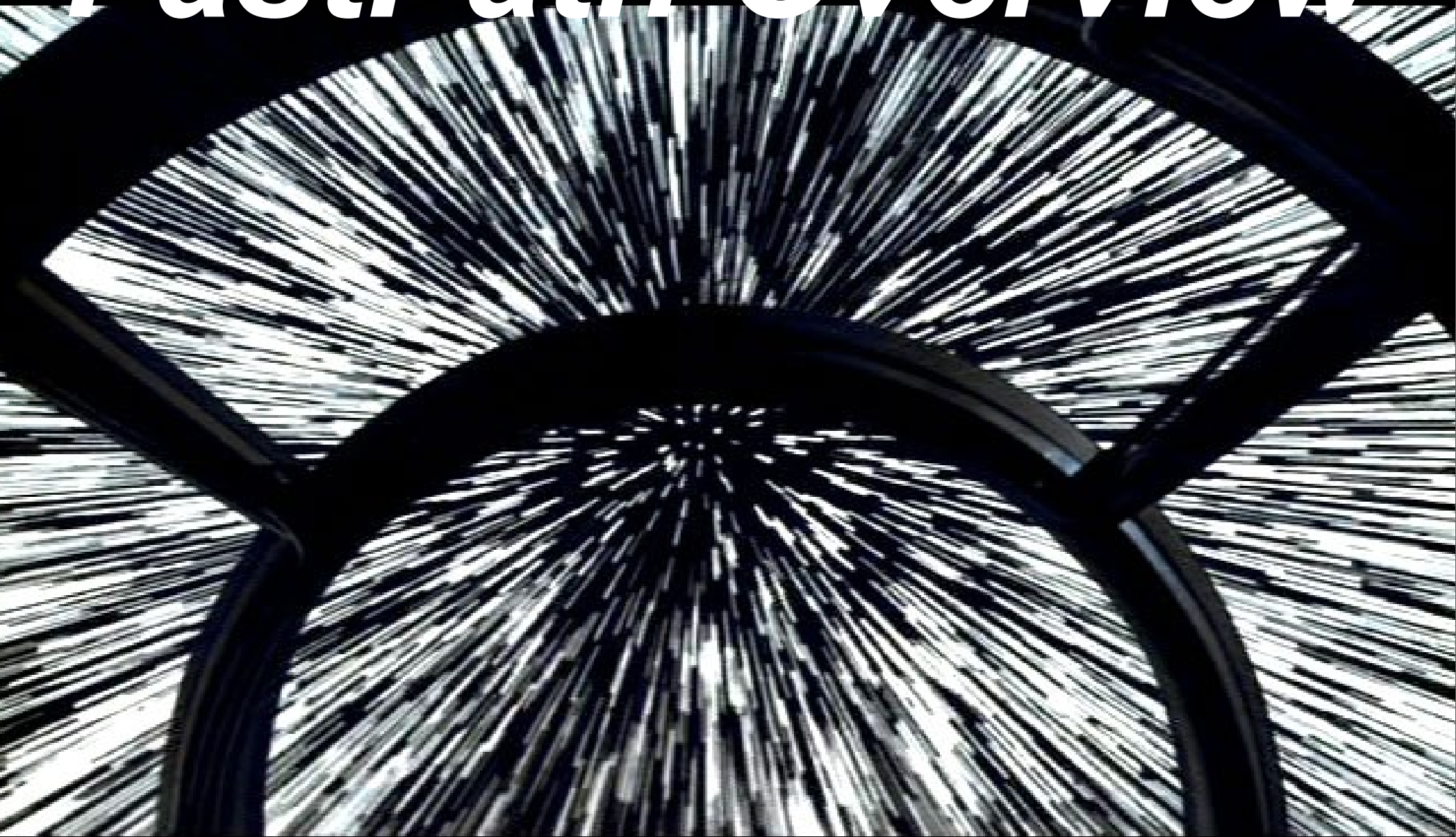
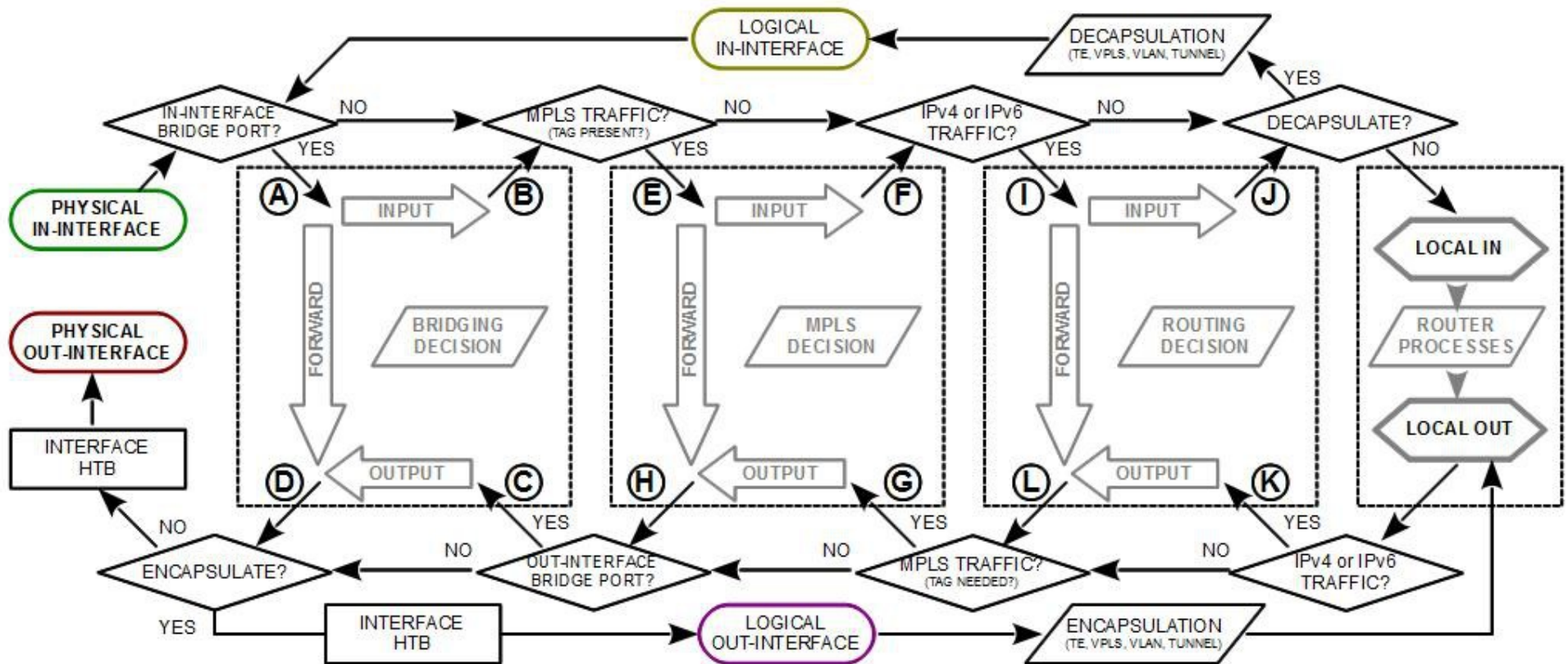


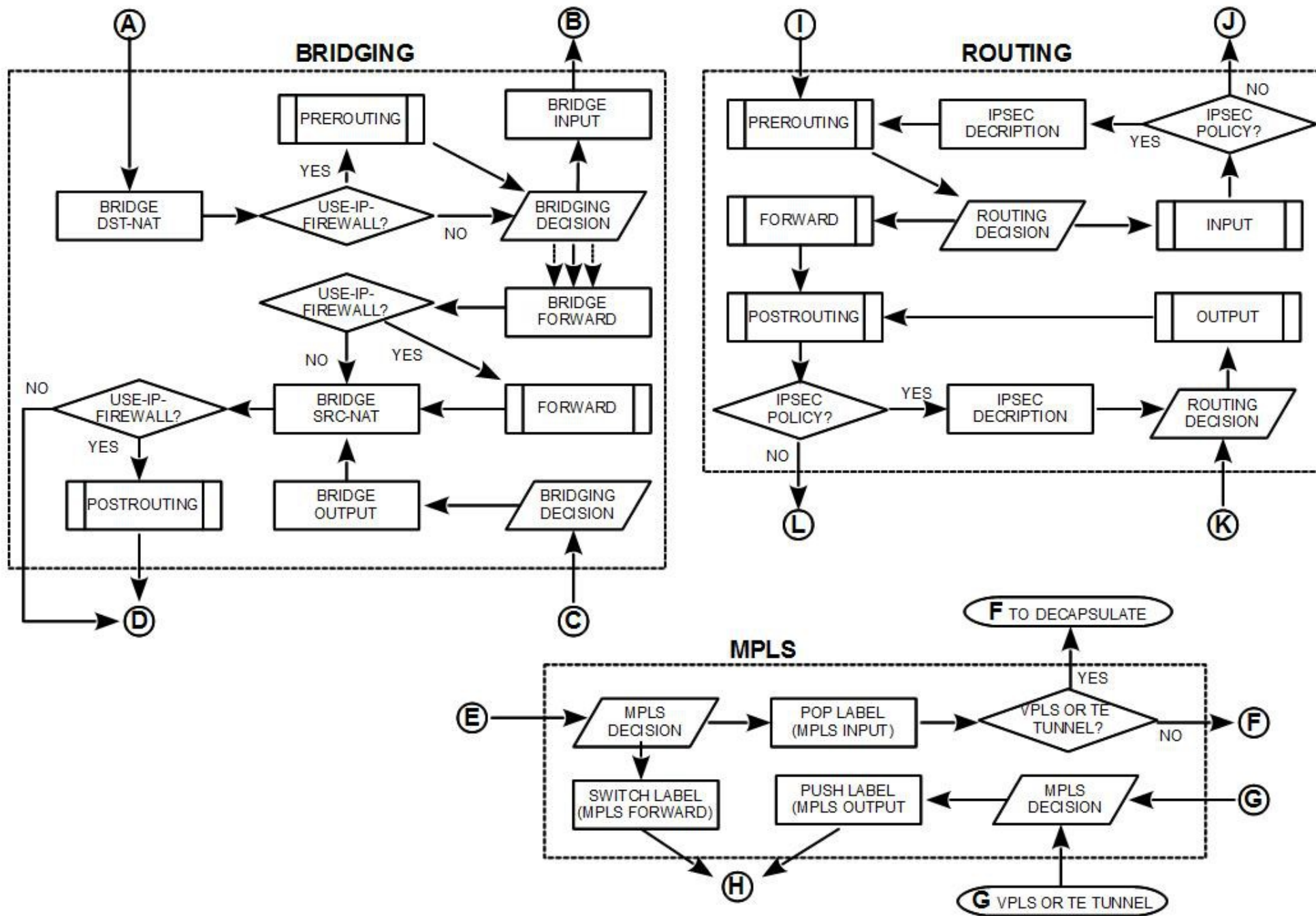
FastPath Overview



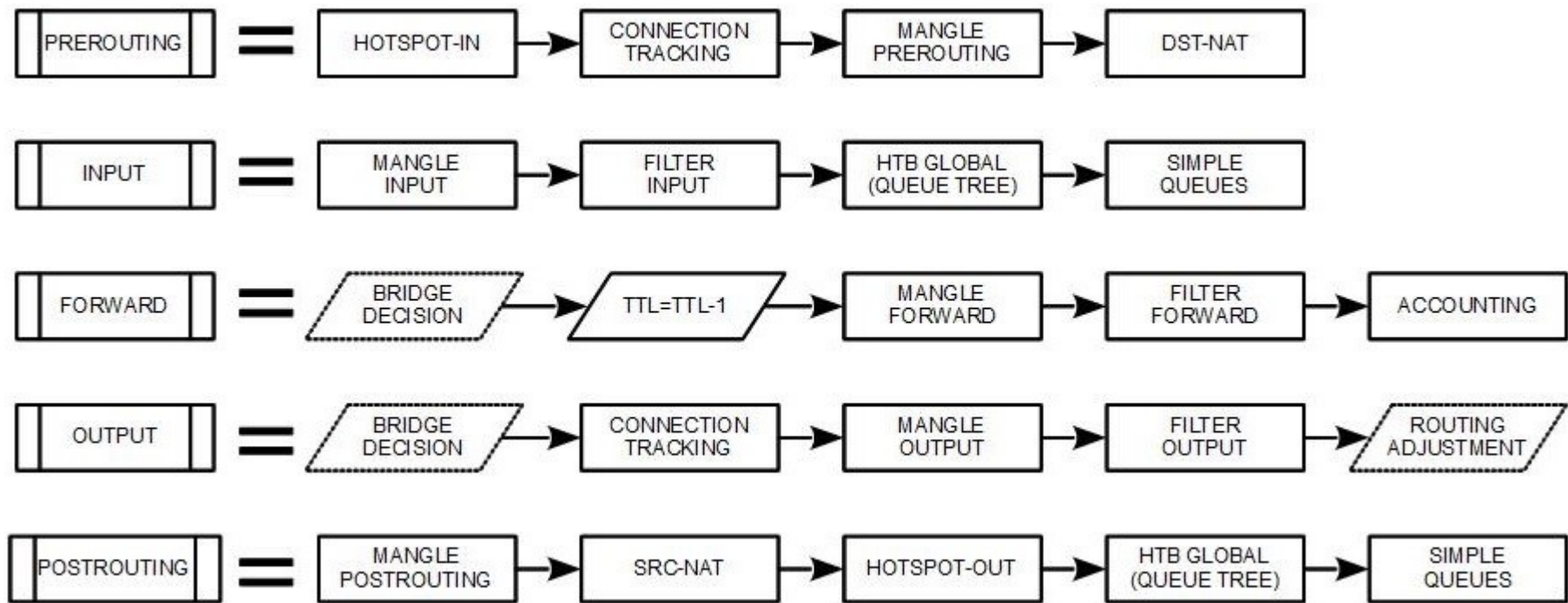
MUM Moldova, 2015

MikroTik RouterOS Packet Flow Diagram for version 6.x





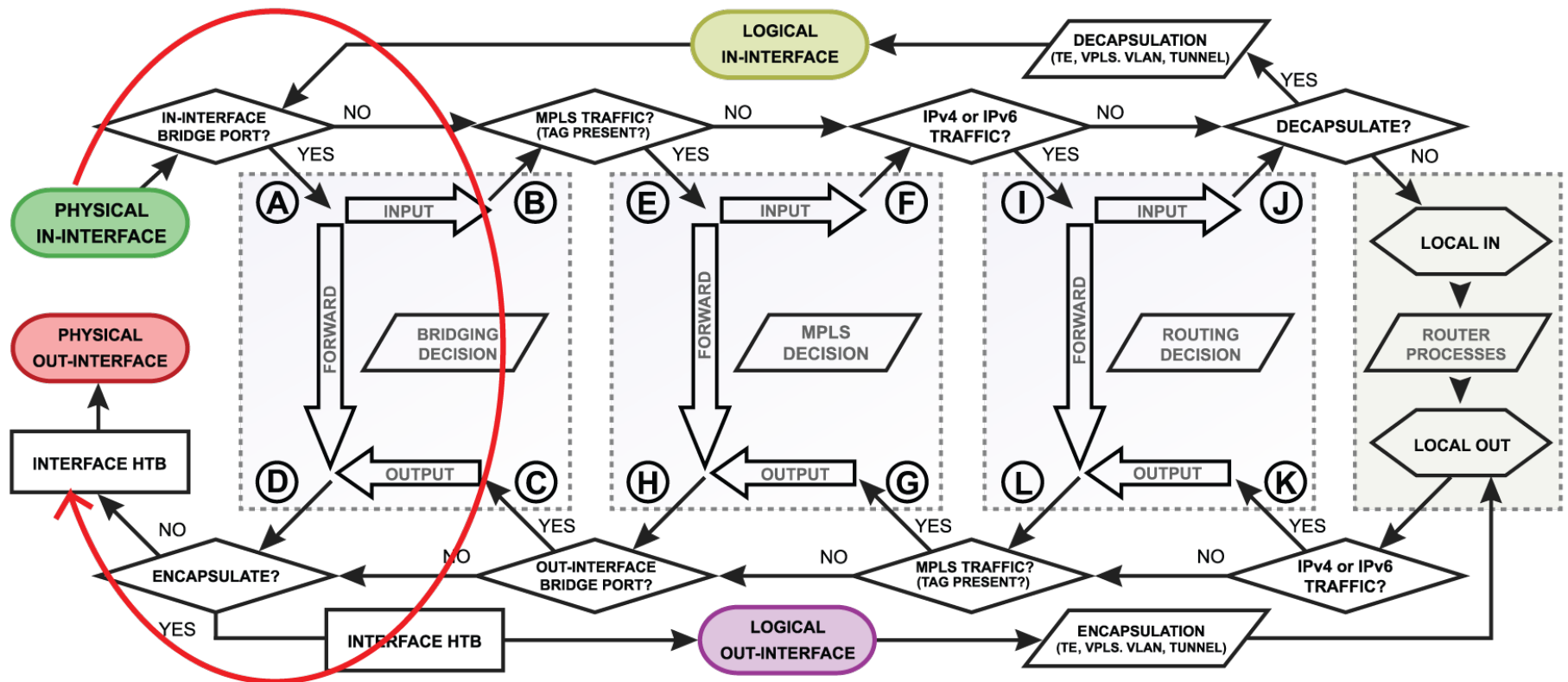
Yes, still - Packet Flow Diagram (page 3)



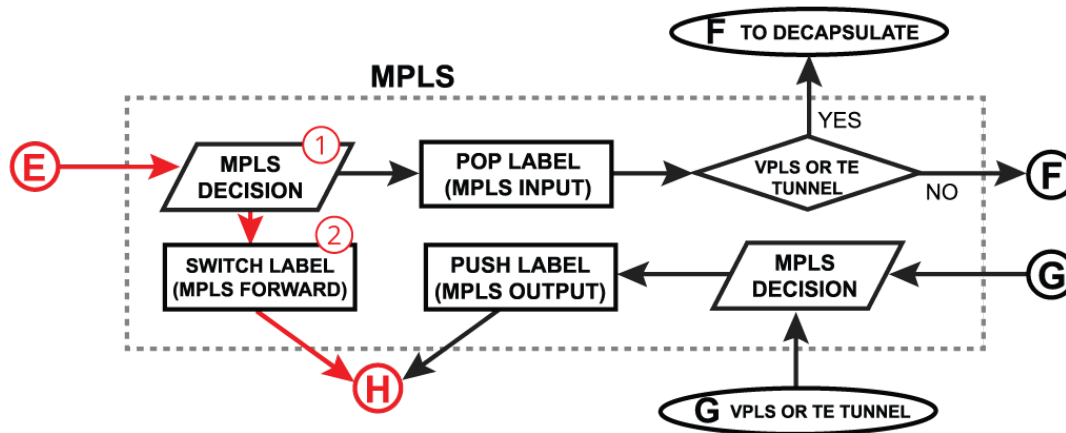
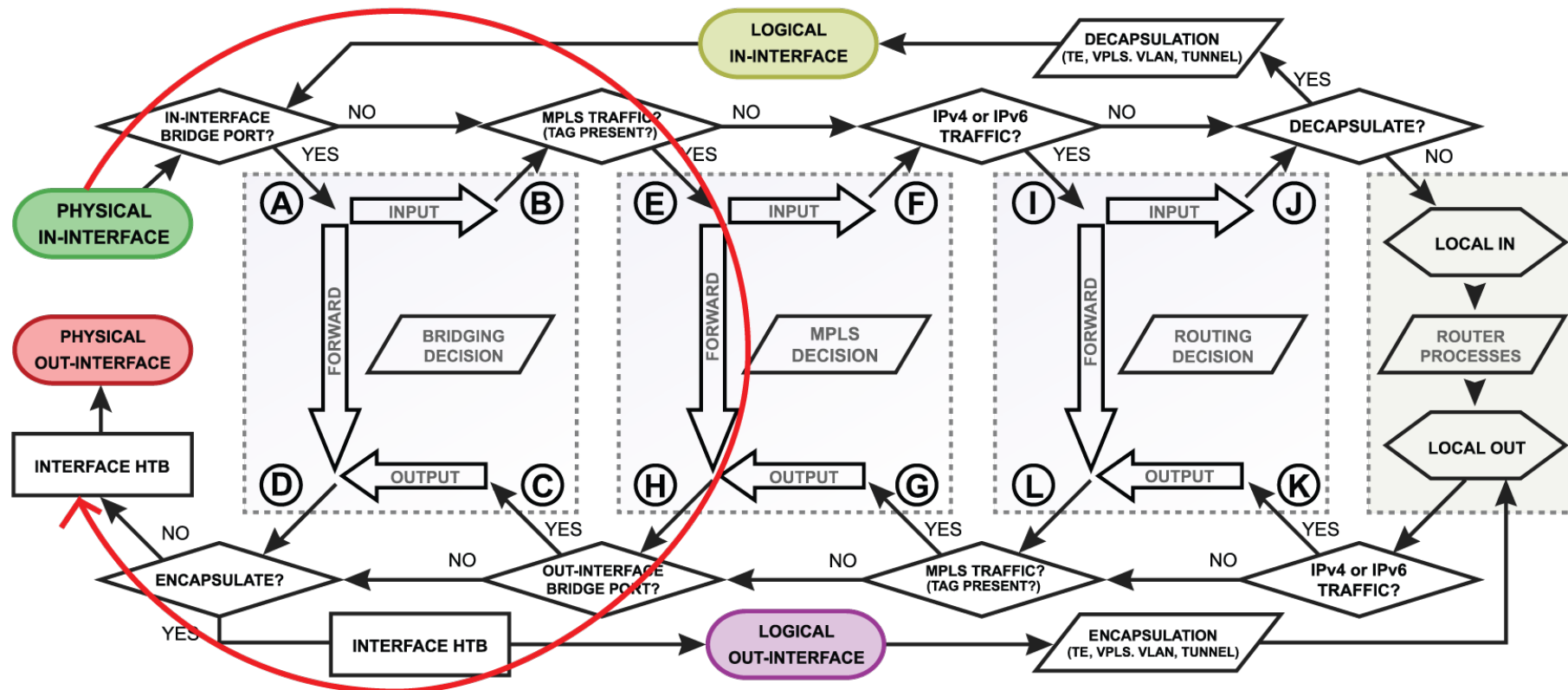
“SlowPath”

- “Slow Path” is the regular way packets are processed in RouterOS
- For each packet RouterOS has to check the whole path of the packet
- In some cases it is a considerable number of steps

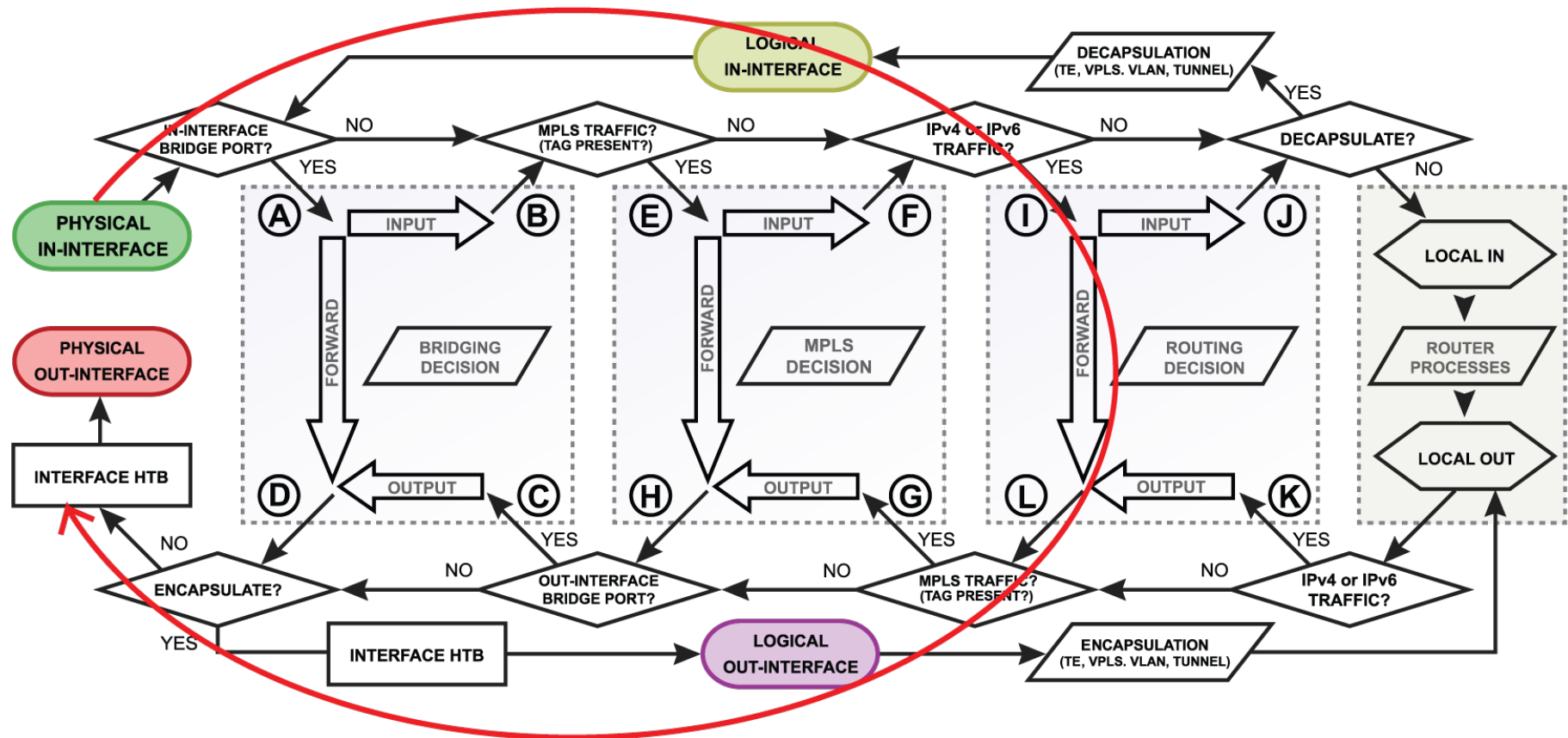
Bridge Forwarding



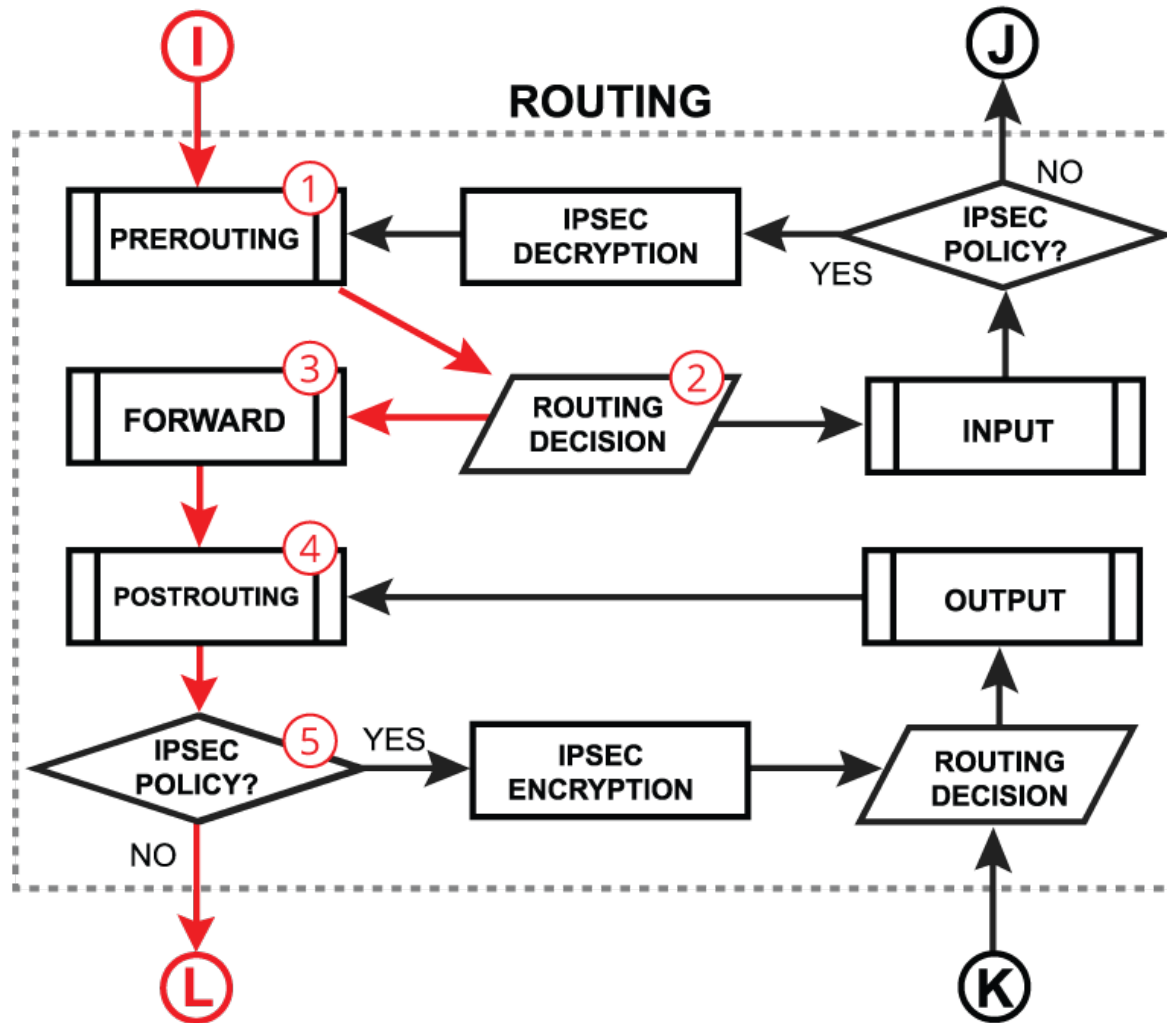
MPLS Forwarding



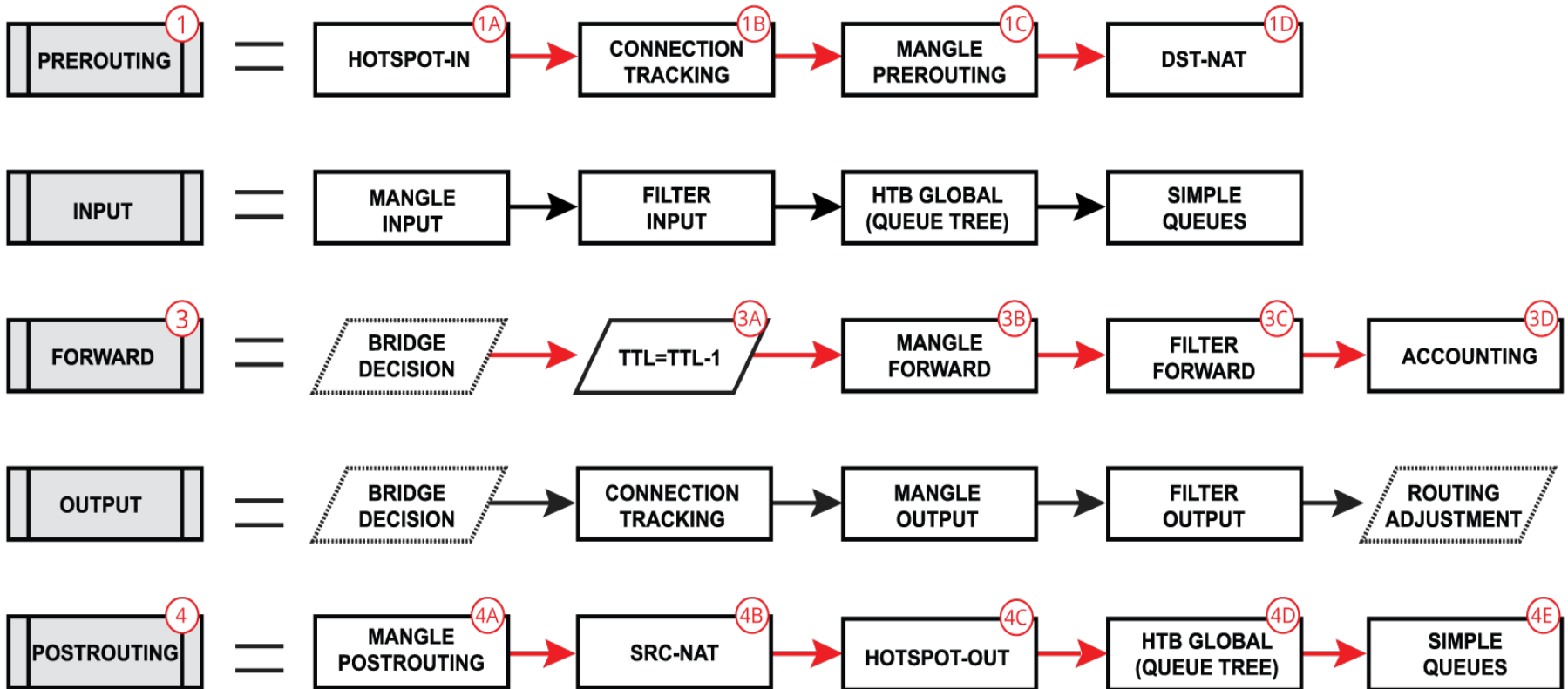
Routing Forwarding



Routing Forwarding



Routing Forwarding



Initial FastPath Implementation

- FastPath is interface driver extension, that allows to receive/process/send traffic without unnecessary processing
- Interface driver now can talk directly to specific RouterOS processes skipping all other
- FastPath requirements
 - Interface driver support
 - FastPath should be allowed in configuration
 - No configuration in specific facilities.

Driver Support

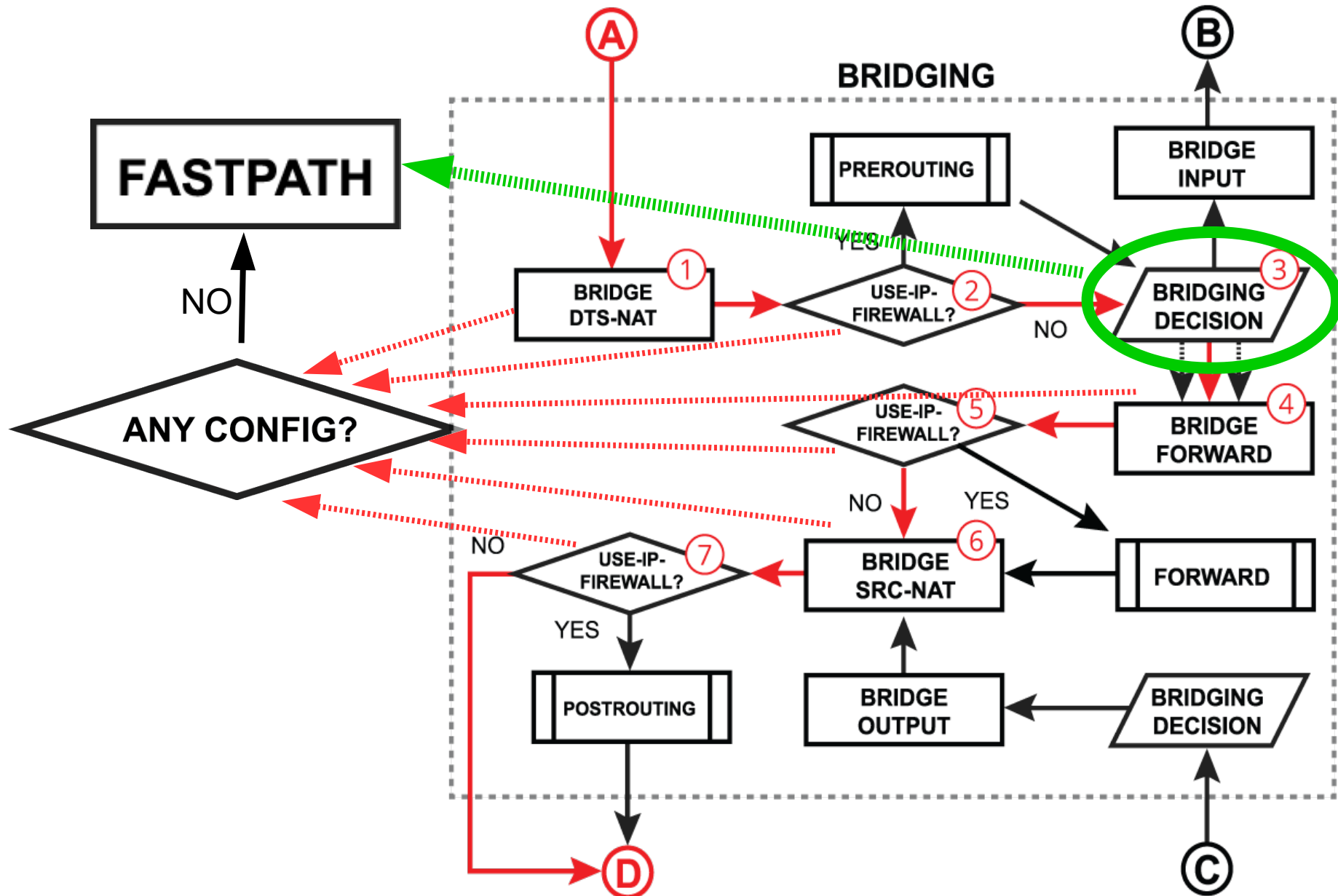
- CCR, CRS, RB7xx, RB9xx, hEX, hAP, wAP, cAP, mAP, SXT, Metal, Groove, DynaDish, OmniTIK series - all ports
- RB1100 series - ether1-11
- RB6xx series and RB800 - ether1,2
- RB1000, RB3011, RB2011 - all ports
- All Wireless interfaces, if **wireless-fp** or **wireless-cm2** package used

Allow FastPath

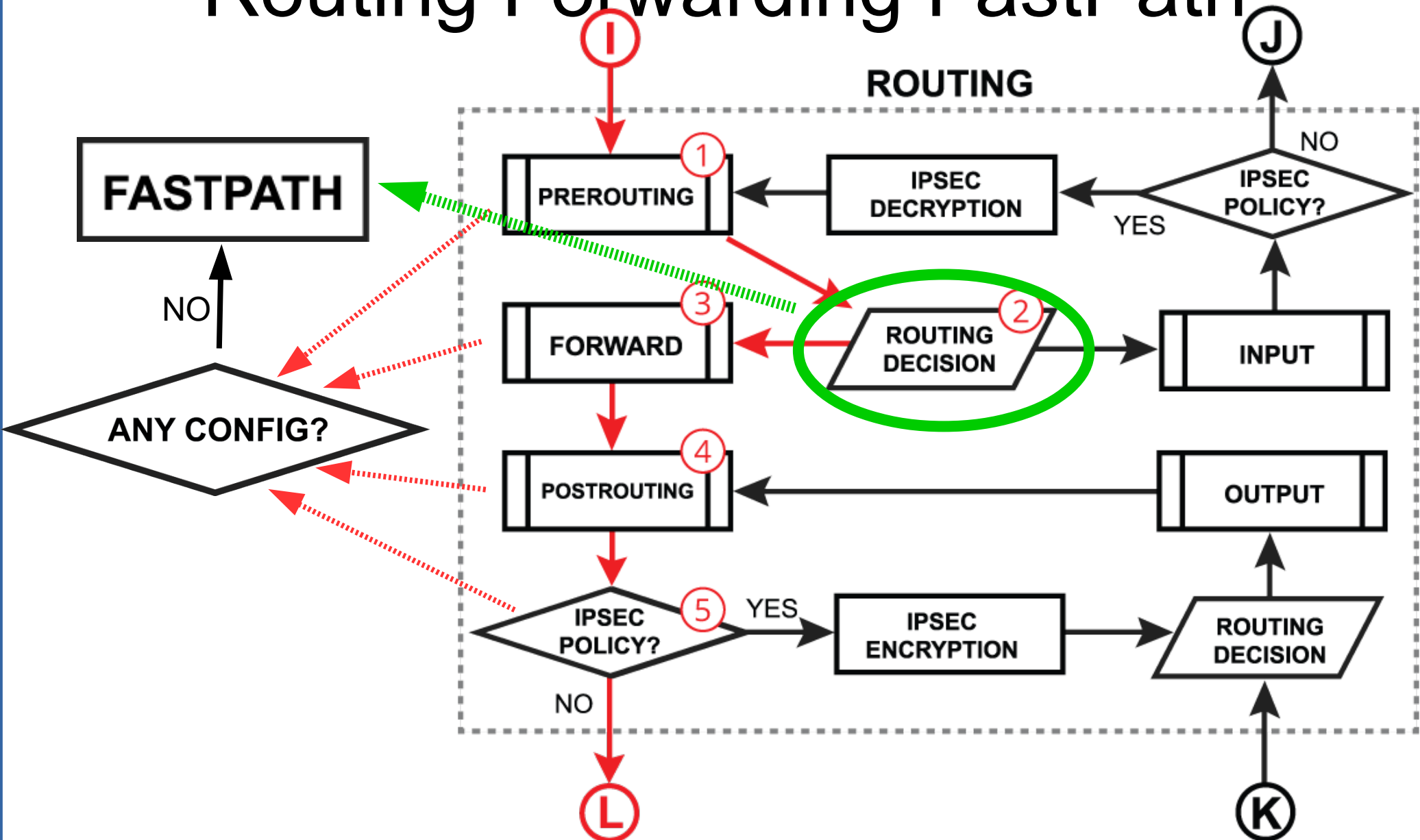
The image displays three network configuration windows with several settings highlighted by red circles:

- IP Settings:**
 - IP Forward
 - Send Redirects
 - Accept Redirects
 - Secure Redirects
 - Accept Source Route
 - Allow Fast Path
 - Route Cache
 - RP Filter: no
 - TCP SynCookies
 - Max ARP Entries: 8192
 - ARP Timeout: 00:00:30
 - ICMP Rate Limit: 10
 - IPv4 Fast Path Active
 - IPv4 Fast Path Packets: 1 182
 - IPv4 Fast Path Bytes: 160.0 KiB
 - IPv4 Fasttrack Active
 - IPv4 Fasttrack Packets: 0
 - IPv4 Fasttrack Bytes: 0 B
- Connection Tracking:**
 - Enabled: auto
 - TCP Syn Sent Timeout: 00:00:05
 - TCP Syn Received Timeout: 00:00:05
 - TCP Established Timeout: 1d 00:00:00
 - TCP Fin Wait Timeout: 00:00:10
 - TCP Close Wait Timeout: 00:00:10
 - TCP Last Ack Timeout: 00:00:10
 - TCP Time Wait: 00:00:10
 - TCP Close: 00:00:10
 - TCP Max Retransmit Timeout: 00:05:00
 - TCP Max Retransmit Timeout: 00:05:00
- Bridge Settings:**
 - Use IP Firewall
 - Use IP Firewall For VLAN
 - Use IP Firewall For PPPoE
 - Allow Fast Path
 - Bridge Fast Path Active
 - Bridge Fast Path Packets: 11 964 594
 - Bridge Fast Path Bytes: 7.1 GiB

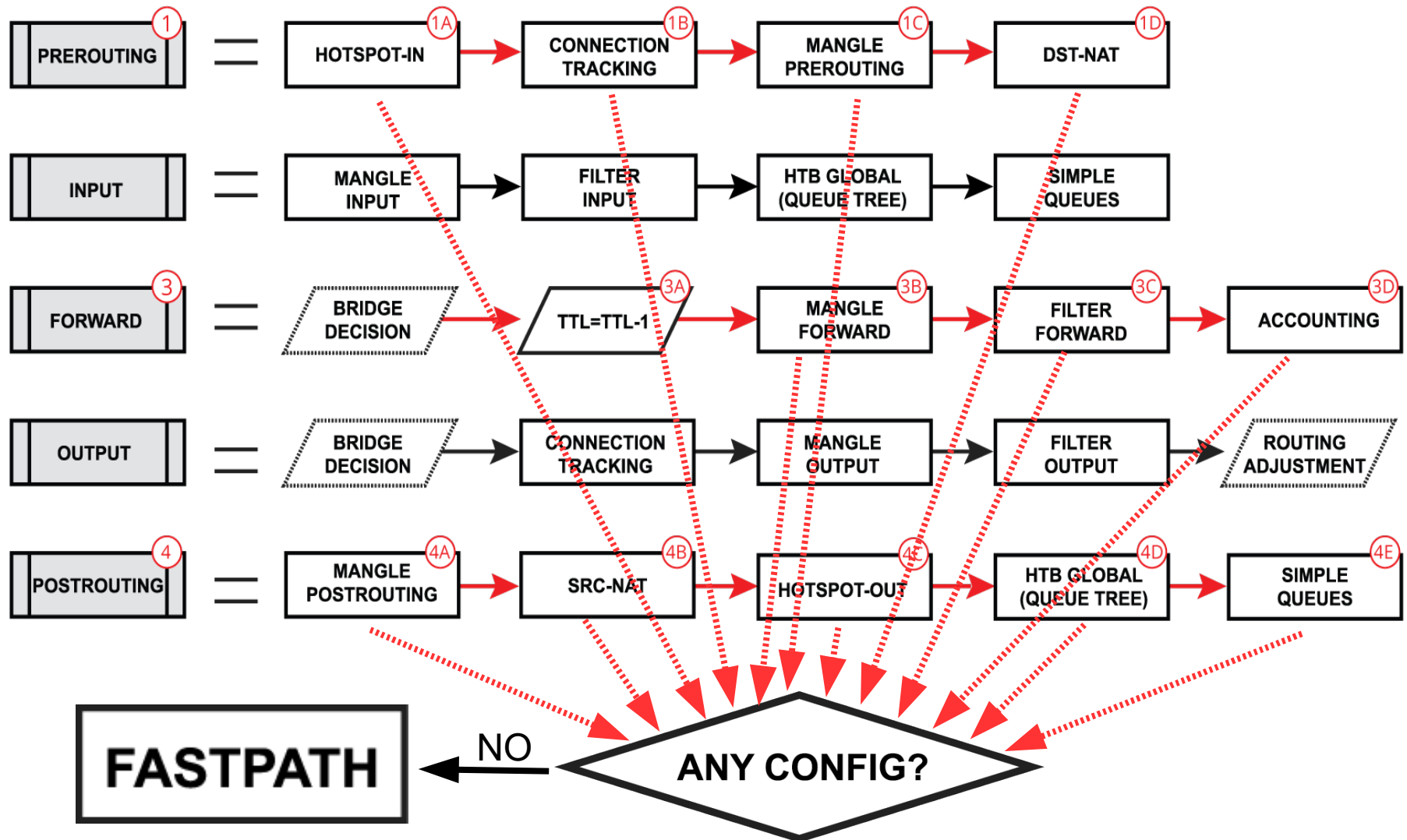
Bridge Forwarding FastPath



Routing Forwarding FastPath



Routing Forwarding FastPath



SlowPath vs FastPath

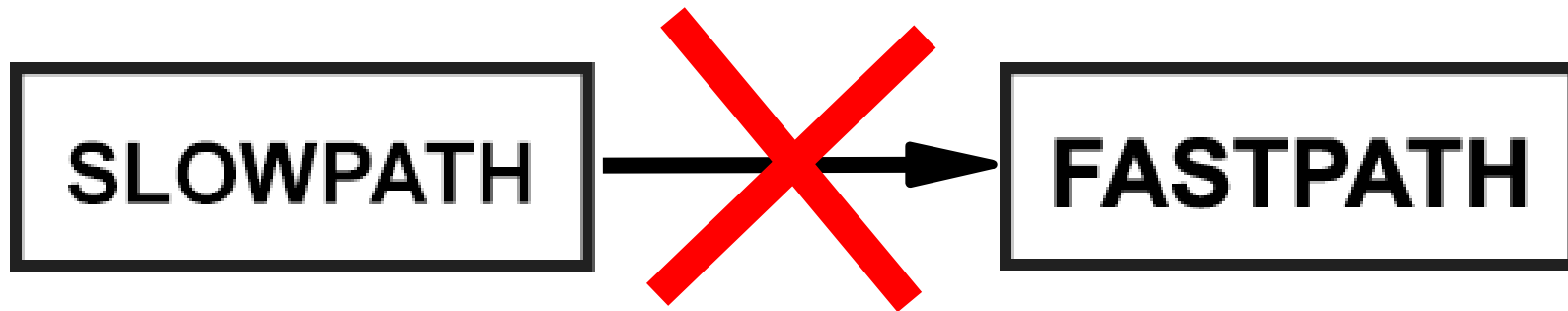
- What are the performance benefits of regular FastPath?

| RB750Gr2 720Mhz | | All port test | | RouterOS v6.31rc2 | | | |
|-----------------|------------------------|---------------|-------|-------------------|-------|-------------|-------|
| Mode | Configuration | 64 byte | | 512 byte | | 1518 byte | |
| | | kpps | Mbps | kpps | Mbps | kpps | Mbps |
| Bridging | none (fast path) | 773.7 | 396.1 | <u>234.9</u> | 962.2 | <u>81.2</u> | 986.1 |
| Bridging | 25 bridge filter rules | 114.6 | 58.7 | 112.3 | 460.0 | <u>81.2</u> | 986.1 |
| Routing | none (fast path) | 729.2 | 373.4 | <u>234.9</u> | 962.2 | <u>81.2</u> | 986.1 |
| Routing | 25 simple queues | 184.8 | 94.6 | 178.4 | 730.7 | <u>81.2</u> | 986.1 |
| Routing | 25 ip filter rules | 78.9 | 40.4 | 81.2 | 332.6 | <u>81.2</u> | 986.1 |

| CCR1072 (1200Mhz, DDR1600) | | RouterOS v6.31rc2 | | | | | |
|----------------------------|------------------------|-------------------|----------|-----------------|----------|----------------|----------|
| Mode | Configuration | 64 byte | | 512 byte | | 1518 byte | |
| | | kpps | Mbps | kpps | Mbps | kpps | Mbps |
| Bridging | none (fast path) | <u>119,047.6</u> | 60,952.4 | <u>18,790.0</u> | 76,963.8 | <u>6,502.0</u> | 78,960.3 |
| Bridging | 25 bridge filter rules | 10,432.3 | 5,341.3 | 9,099.2 | 37,270.3 | <u>6,502.0</u> | 78,960.3 |
| Routing | none (fast path) | 94,668.4 | 48,470.2 | <u>18,790.0</u> | 76,963.8 | <u>6,502.0</u> | 78,960.3 |
| Routing | 25 simple queues | 13,683.5 | 7,006.0 | 13,500.0 | 55,296.0 | <u>6,502.0</u> | 78,960.3 |
| Routing | 25 ip filter rules | 6,104.0 | 3,125.2 | 6,125.5 | 25,090.0 | 5,247.6 | 63,726.9 |

Half-FastPath

- What if an interface driver doesn't have FastPath support?

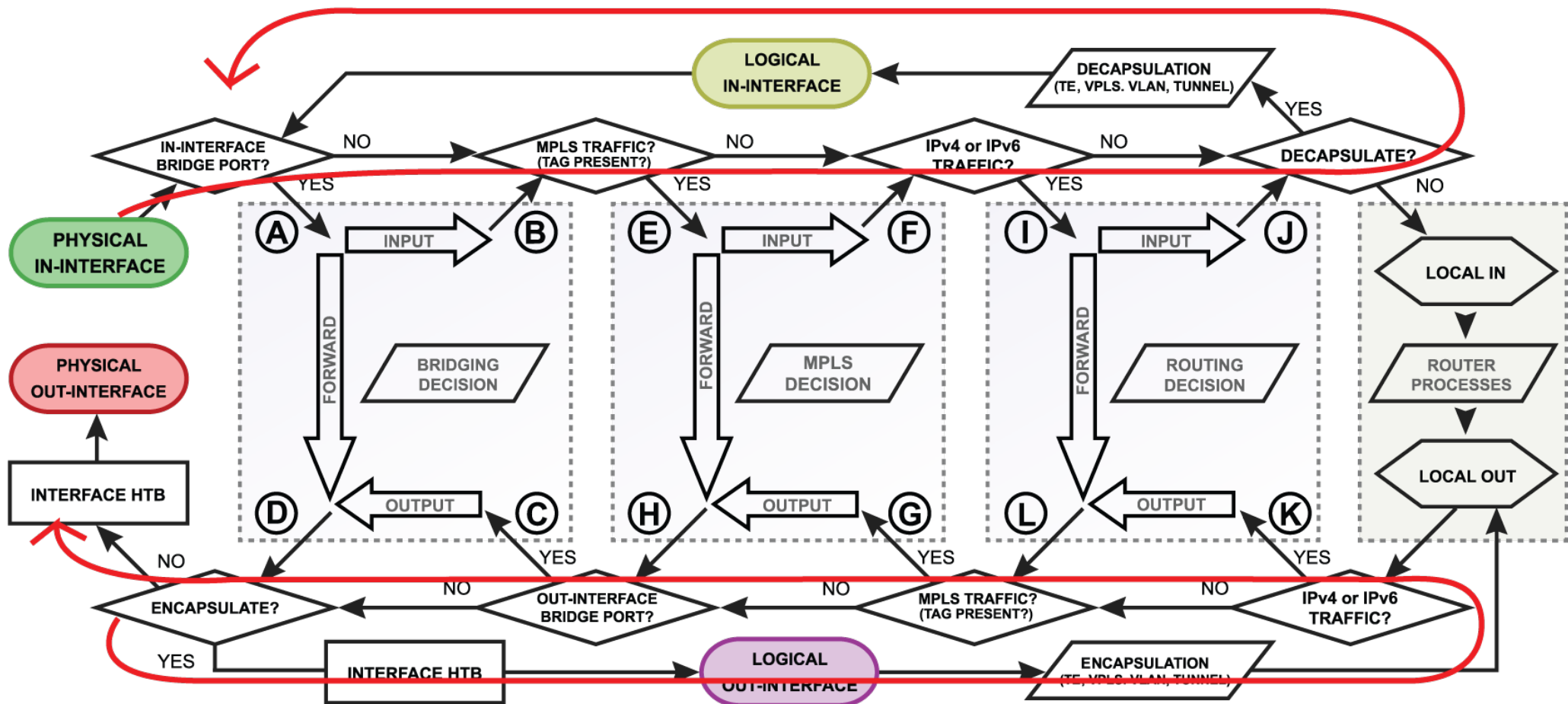


FastPath for Logical Interfaces

FastPath is supported for these logical interfaces

- Bridge interfaces (since v6.29)
- VLAN interfaces (since v6.30)
- VRRP interfaces (since v6.30)
- Bonding interfaces - RX only (since v6.30)
- EOIP, GRE, IPIP interfaces – without IPSec encryption and without fragmentation (since v6.33)
- PPPoE client interface – without encryption and fragmentation (**coming soon**)

Logical Interfaces in RouterOS



EOIP, GRE, IPIP and FastPath

- Per interface "allow-fast-path" setting
- Packet fragments and encrypted traffic **can't** be received in FastPath
- Traffic traveling in FastPath will be invisible to other router facilities (firewall, queues, etc)
- It is important to prepare your configuration (firewall, queues) for SlowPath part of tunnel traffic.

FastPath for Features

- Traffic Generator (since v6.0) - the only way to simulate FastPath speeds.
- MAC-Winbox (since v6.33) – doesn't disable FastPath anymore
- MAC-Telnet (since v6.33) – doesn't disable FastPath anymore
- Traffic Flow (since v6.33) – can see FastPath traffic also
- Connection Tracking (since v6.29)*

FastPath + Conntrack

- Conntrack entries now have “Fasttracked” flag
- Implemented as “fasttrack-connection” action for firewall filter/mangle
- Packets from “Fasttracked” connections are allowed to travel in FastPath
- Works only with IPv4/TCP and IPv4/UDP
- Traffic traveling in FastPath will be invisible to other router facilities (firewall, queues, etc)
- Some packets still will go the regular path to maintain conntrack entries

FastPath + Conntrack = FastTrack

Firewall

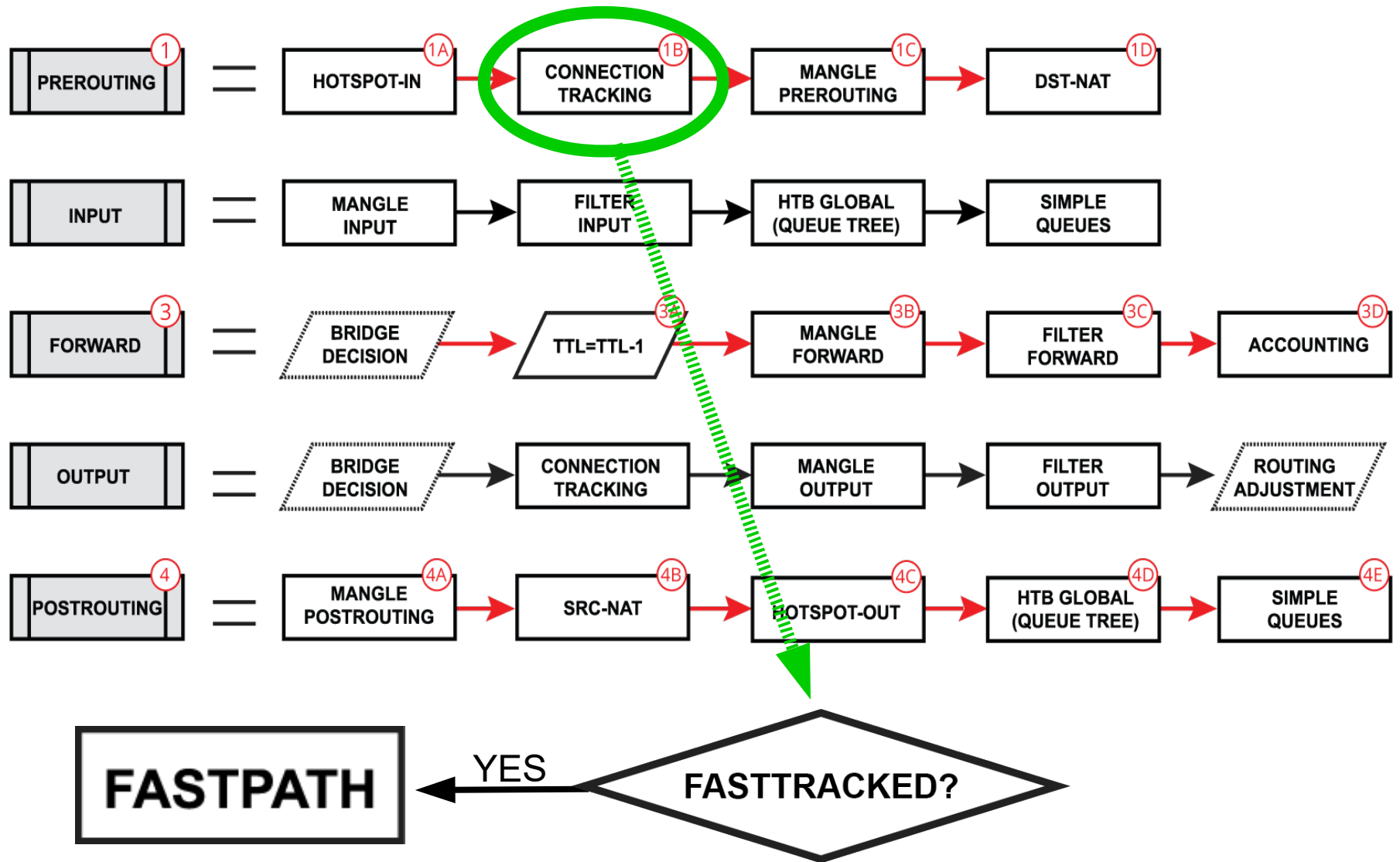
Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

Tracking Find

| | Protocol | Timeout | TCP State | Orig./Repl. Rate | Orig./Repl. Bytes | Orig./Repl. Packets | Orig./Repl. Fasttrack Bytes | Orig./Repl. Fasttrack Packets |
|-------|---|-------------|-------------|-----------------------|-----------------------|---------------------|-----------------------------|-------------------------------|
| SACFs | 6 (tcp) | 1d 00:04:02 | established | 54.4 kbps/1546.4 kbps | 141.0 MiB/3662.3 MiB | 2 737 217/2 717 ... | 141.0 MiB/3662.1 MiB | 2 737 213/2 716 883 |
| SACFd | 17 (udp) | 00:05:01 | | 1984 bps/34.6 kbps | 3107.7 KiB/6.5 MiB | 9 070/10 870 | 3107.1 KiB/6.5 MiB | 9 068/10 869 |
| SACFd | 17 (udp) | 00:04:33 | | 0 bps/0 bps | 2653.7 KiB/3491.0 KiB | 6 630/5 828 | 2653.3 KiB/3490.9 KiB | 6 628/5 826 |
| SACFs | 17 (udp) | 00:04:51 | | 0 bps/0 bps | 445.5 KiB/50.6 KiB | 4 842/477 | 445.0 KiB/50.2 KiB | 4 836/474 |
| SACFd | 17 (udp) | 00:04:55 | | 0 bps/0 bps | 858.6 KiB/3085.5 KiB | 4 711/4 608 | 858.3 KiB/3085.4 KiB | 4 709/4 607 |
| SACFs | 17 (udp) | 00:05:03 | | 39.7 kbps/3.6 kbps | 2856.8 KiB/507.5 KiB | 4 566/3 922 | 2856.3 KiB/507.4 KiB | 4 564/3 921 |
| SACFd | 17 (udp) | 00:01:52 | | 0 bps/0 bps | 1997.0 KiB/2866.6 KiB | 4 536/4 754 | 1996.3 KiB/2866.6 KiB | 4 534/4 753 |
| SACFs | 6 (tcp) | 1d 00:03:32 | established | 0 bps/0 bps | 922.7 KiB/367.4 KiB | 4 406/4 659 | 920.3 KiB/366.9 KiB | 4 399/4 649 |
| SACFd | 17 (udp) | 00:01:43 | | 0 bps/0 bps | 262.7 KiB/1607.1 KiB | 4 260/2 618 | 262.3 KiB/1607.1 KiB | 4 258/2 617 |
| SACFs | 17 (udp) | 00:05:02 | | 0 bps/0 bps | 518.4 KiB/188.6 KiB | 4 254/1 632 | 517.8 KiB/187.8 KiB | 4 248/1 622 |
| SACFd | 17 (udp) | 00:05:03 | | 3.1 kbps/39.5 kbps | 1066.7 KiB/3245.1 KiB | 3 977/5 265 | 1066.3 KiB/3245.0 KiB | 3 975/5 264 |
| SACFd | 6 (tcp) | 00:00:00 | time wait | 0 bps/0 bps | 232.7 KiB/2113.2 KiB | 3 546/3 540 | 232.5 KiB/2113.1 KiB | 3 541/3 537 |
| SACFd | 17 (udp) | 00:02:15 | | 0 bps/0 bps | 212.9 KiB/1922.1 KiB | 3 154/3 048 | 212.7 KiB/1921.8 KiB | 3 152/3 047 |
| SACFd | 6 (tcp) | 1d 23:59:02 | established | 6.6 kbps/38.0 kbps | 217.6 KiB/1869.3 KiB | 3 103/4 144 | 217.5 KiB/1869.3 KiB | 3 101/4 143 |
| SACFs | 6 (tcp) | 1d 23:59:03 | established | 37.0 kbps/3.4 kbps | 1093.6 KiB/75.3 KiB | 2 614/1 111 | 1093.5 KiB/75.2 KiB | 2 611/1 110 |
| SACFd | S - seen reply, A - assured, C - confirmed, F - fasttrack, d - dstnat | | | | 155.3 KiB/1588.4 KiB | 2 504/1 973 | 154.9 KiB/1588.4 KiB | 2 502/1 972 |
| SACFd | 17 (udp) | 00:04:48 | | 0 bps/0 bps | 162.5 KiB/1670.8 KiB | 2 483/2 732 | 162.0 KiB/1670.7 KiB | 2 480/2 730 |
| SACFd | 17 (udp) | 00:05:00 | | 2.3 kbps/45.6 kbps | 153.6 KiB/1617.9 KiB | 2 436/2 701 | 153.3 KiB/1617.8 KiB | 2 434/2 700 |
| SACFd | 17 (udp) | 00:05:02 | | 992 bps/32.9 kbps | 222.0 KiB/1548.0 KiB | 2 133/2 608 | 221.7 KiB/1547.9 KiB | 2 131/2 607 |
| SACFd | 17 (udp) | 00:03:13 | | 0 bps/0 bps | 136.6 KiB/1350.7 KiB | 2 063/2 243 | 136.3 KiB/1350.7 KiB | 2 061/2 242 |
| SACFd | 17 (udp) | 00:00:31 | | 0 bps/0 bps | 134.3 KiB/1451.4 KiB | 2 029/2 316 | 134.0 KiB/1451.3 KiB | 2 027/2 315 |
| SACFd | 17 (udp) | 00:05:01 | | 3.2 kbps/39.5 kbps | 121.1 KiB/1547.2 KiB | 1 878/2 379 | 120.6 KiB/1547.2 KiB | 1 876/2 378 |
| SACFd | 17 (udp) | 00:05:01 | | 1984 bps/34.3 kbps | 119.3 KiB/1259.9 KiB | 1 832/2 100 | 118.7 KiB/1259.8 KiB | 1 829/2 098 |
| SACFs | 6 (tcp) | 1d 23:59:02 | established | 34.0 kbps/4.2 kbps | 1156.8 KiB/108.4 KiB | 1 824/1 777 | 1156.8 KiB/108.4 KiB | 1 822/1 776 |
| SACFd | 6 (tcp) | 00:00:00 | time wait | 0 bps/0 bps | 113.1 KiB/1859.6 KiB | 1 814/2 089 | 112.9 KiB/1859.5 KiB | 1 810/2 086 |

991 items out of 978 (1 selected) Max Entries: 218032

Routing Forwarding FastPath



Fasttrack-Connection

IF Settings

IP Forward OK

Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

+ - ✓ ✗ 📁 🔍 UU Reset Counters UU Reset All Counters Find forward

| # | Action | Chain | Src... | Dst.... | Prot... | Src. Port | Dst. Port | In. I... | Out.... | Bytes | Packets |
|---|-------------------------|---------|--------|---------|---------|-----------|-----------|----------|---------|-----------|---------|
| ::: Drop new connections from internet that is not dst-natted | | | | | | | | | | | |
| 52 | ✗ drop | forward | | | | | | eth... | | 0 B | 0 |
| ::: fasttrack connections that have related and established packets | | | | | | | | | | | |
| 53 | ▶▶ fasttrack connection | forward | | | | | | | | 240.2 MiB | 319 850 |
| ::: accept related and established packets | | | | | | | | | | | |
| 54 | ✓ accept | forward | | | | | | | | 240.2 MiB | 319 850 |
| ::: drop invalid packets | | | | | | | | | | | |
| 55 | ✗ drop | forward | | | | | | | | 40.9 KiB | 765 |
| ::: drop data to bogon IP's | | | | | | | | | | | |
| 56 | ✗ drop | forward | | | | | | brid... | | 43.0 KiB | 2 398 |
| ::: Drop all other local subnets | | | | | | | | | | | |
| 57 | ✗ drop | forward | !19... | | | | | brid... | | 0 B | 0 |
| ::: drop data from bogon IP's | | | | | | | | | | | |
| 58 | ✗ drop | forward | | | | | | eth... | | 0 B | 0 |
| ::: jump to viruses chain | | | | | | | | | | | |

9 items out of 335 (1 selected)

IPv4 Fasttrack Active

IPv4 Fasttrack Packets: 19 773 551

IPv4 Fasttrack Bytes: 15.1 GiB

Without Fasttrack

The screenshot shows the Mikrotik WinBox interface with several windows open:

- Filter Rules:** A table showing three rules. Rule 0 is 'accept', rule 1 is 'drop', and rule 2 is 'drop'. All are in the 'forward' chain.
- IP Settings:** A dialog box with 'IP Forward' checked. Other options like 'Send Redirects', 'Secure Redirects', and 'Allow Fast Path' are also checked.
- Profile (Running):** A window showing CPU usage for various services. 'firewall' is at 44.0%, 'networking' at 24.5%, and 'ethernet' at 12.5%.
- CPU:** A window showing 'cpu0' with 100% load, 96% IRQ, and 0% disk usage.
- Network Traffic:** A table showing high throughput on the 'cpu0' interface.

| # | Action | Chain | Src... | Dst... | Protocol | Src... | Dst... | In. Int... | Out. I... | Bytes | Packets |
|---|--------|---------|--------|--------|----------|--------|--------|------------|-----------|-------|---------|
| 0 | accept | forward | | | | | | | | | |
| 1 | drop | forward | | | | | | | | | |
| 2 | drop | forward | | | | | | | | | |

| Name | Usage |
|--------------|-------|
| firewall | 44.0 |
| networking | 24.5 |
| ethernet | 12.5 |
| wireless | 10.5 |
| bridging | 6.5 |
| management | 1.0 |
| unclassified | 1.0 |
| logging | 0.0 |
| profiling | 0.0 |
| winbox | 0.0 |

| CPU | Load (%) | IRQ (%) | Disk (%) |
|------|----------|---------|----------|
| cpu0 | 100 | 96 | 0 |

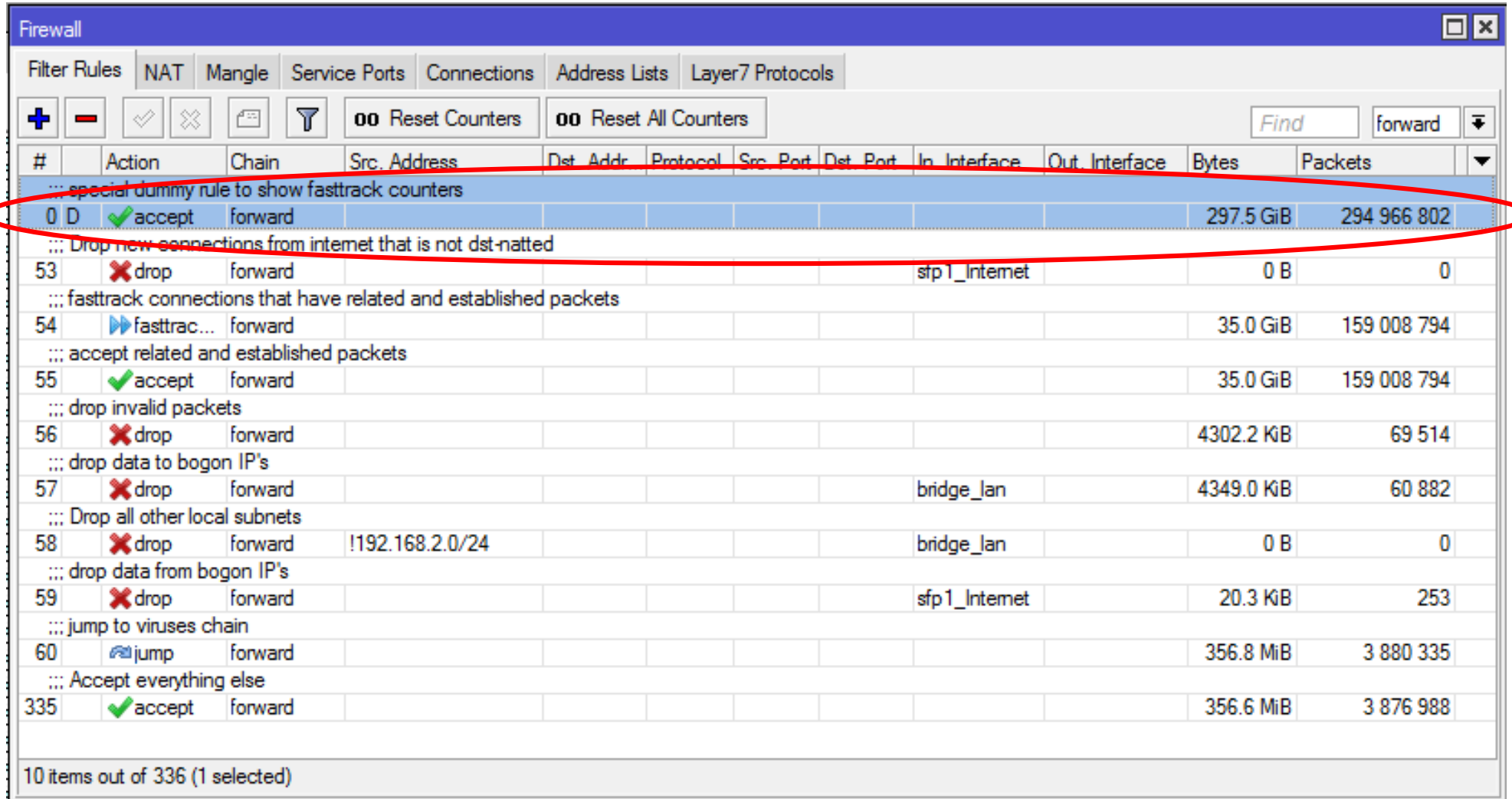
| | Rx | Tx Packet (p/s) | Rx Packet (p/s) |
|------------|------------|-----------------|-----------------|
| 6.7 Mbps | 368 bps | 15 293 | 1 |
| 6.7 Mbps | 358.8 Mbps | 15 294 | 29 924 |
| 358.8 Mbps | 7.3 Mbps | 29 910 | 15 278 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |
| 0 bps | 0 bps | 0 | 0 |

- Board: RB2011UiAS-2HnD
- Configuration: default Home AP
- Throughput: 358Mbps
- CPU load: 100%
- Firewall CPU load: 44%

Fasttrack-connection

- “fasttrack-connection” action works similar to “mark-connection” action
- “fasttrack-connection” rule is usually followed by identical “accept” rule
- Most common Fasttrack implementations :
 - Fasttrack if connection reach connection-state=established and related
 - Fasttrack to exclude some specific connections from the queues
 - Fasttrack all local connections

Special Dummy Rules



Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

+ - [check] [x] [filter] [funnel] 00 Reset Counters 00 Reset All Counters Find forward

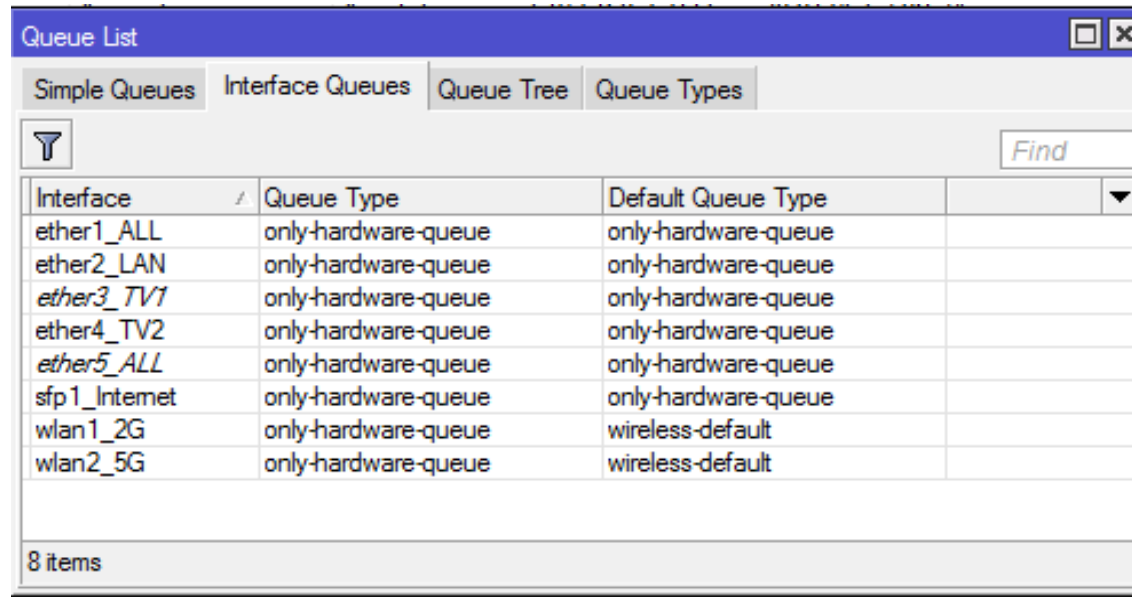
| # | Action | Chain | Src. Address | Dst. Addr. | Protocol | Src. Port | Dst. Port | In. Interface | Out. Interface | Bytes | Packets |
|---|--------|-------------|--------------|-----------------|----------|-----------|-----------|---------------|----------------|------------|-------------|
| ::: special dummy rule to show fasttrack counters | | | | | | | | | | | |
| 0 | D | accept | forward | | | | | | | 297.5 GiB | 294 966 802 |
| ::: Drop new connections from internet that is not dst-natted | | | | | | | | | | | |
| 53 | X | drop | forward | | | | | sfp1_Intemet | | 0 B | 0 |
| ::: fasttrack connections that have related and established packets | | | | | | | | | | | |
| 54 | ▶▶ | fasttrac... | forward | | | | | | | 35.0 GiB | 159 008 794 |
| ::: accept related and established packets | | | | | | | | | | | |
| 55 | ✓ | accept | forward | | | | | | | 35.0 GiB | 159 008 794 |
| ::: drop invalid packets | | | | | | | | | | | |
| 56 | X | drop | forward | | | | | | | 4302.2 KiB | 69 514 |
| ::: drop data to bogon IP's | | | | | | | | | | | |
| 57 | X | drop | forward | | | | | bridge_lan | | 4349.0 KiB | 60 882 |
| ::: Drop all other local subnets | | | | | | | | | | | |
| 58 | X | drop | forward | !192.168.2.0/24 | | | | bridge_lan | | 0 B | 0 |
| ::: drop data from bogon IP's | | | | | | | | | | | |
| 59 | X | drop | forward | | | | | sfp1_Intemet | | 20.3 KiB | 253 |
| ::: jump to viruses chain | | | | | | | | | | | |
| 60 | ▶ | jump | forward | | | | | | | 356.8 MiB | 3 880 335 |
| ::: Accept everything else | | | | | | | | | | | |
| 335 | ✓ | accept | forward | | | | | | | 356.6 MiB | 3 876 988 |

10 items out of 336 (1 selected)

Special Dummy Rule

- This is not an actual rule, it is for visual information only
- Dummy rule shows user that some traffic traveling in FastPath and will not reach their firewall rules
- Rule will show up as soon as there are at least one “Fasttracked” connection tracking entry.
- Rule will disappear only after last “Fasttracked” connection tracking table are fully timed out
- Dummy simple queue possible in future.

Interface Queue and FastPath



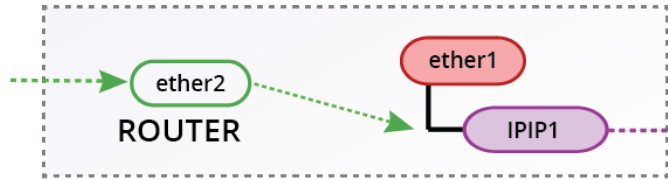
The screenshot shows a window titled "Queue List" with four tabs: "Simple Queues", "Interface Queues", "Queue Tree", and "Queue Types". The "Interface Queues" tab is selected. Below the tabs is a search bar with a filter icon and a "Find" button. The main area contains a table with the following data:

| Interface | Queue Type | Default Queue Type |
|---------------|---------------------|---------------------|
| ether1_ALL | only-hardware-queue | only-hardware-queue |
| ether2_LAN | only-hardware-queue | only-hardware-queue |
| ether3_TV1 | only-hardware-queue | only-hardware-queue |
| ether4_TV2 | only-hardware-queue | only-hardware-queue |
| ether5_ALL | only-hardware-queue | only-hardware-queue |
| sfp1_Internet | only-hardware-queue | only-hardware-queue |
| wlan1_2G | only-hardware-queue | wireless-default |
| wlan2_5G | only-hardware-queue | wireless-default |

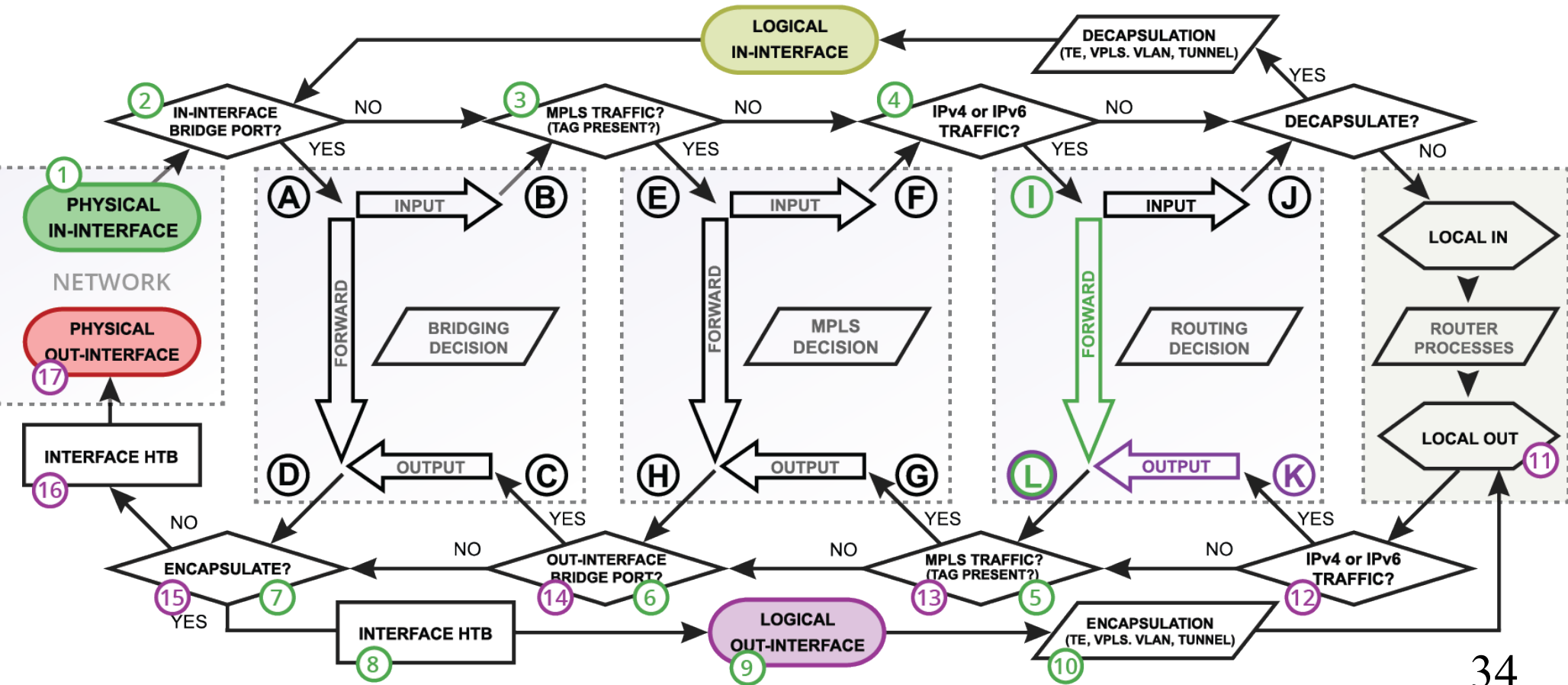
At the bottom of the window, it says "8 items".

- Only interface queue that guarantees FastPath is “only-hardware-queue”
- Minimal impact on physical interfaces, as “Interface HTB” is the last step in the packet flow diagram

- Ether1 and ether2 have FastPath support
- IPIP1 "allow-fast-path" setting enabled
- IP forwarding FastPath allowed

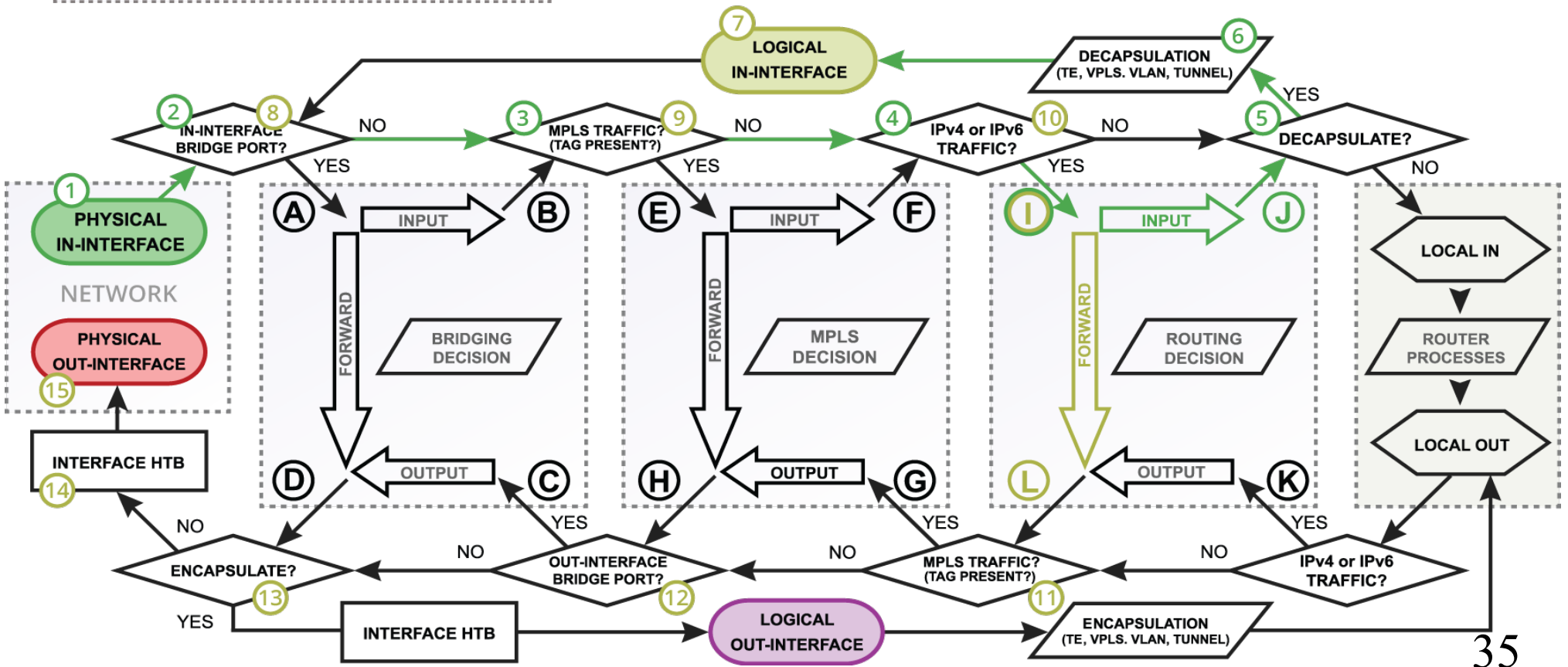
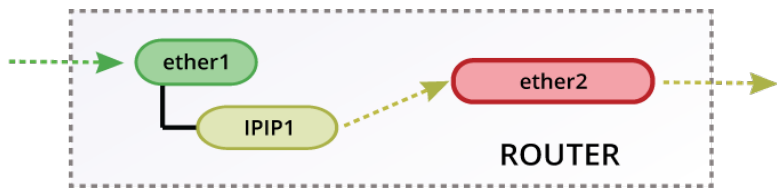


- TCP "FastTraked" connection
- Simple queues

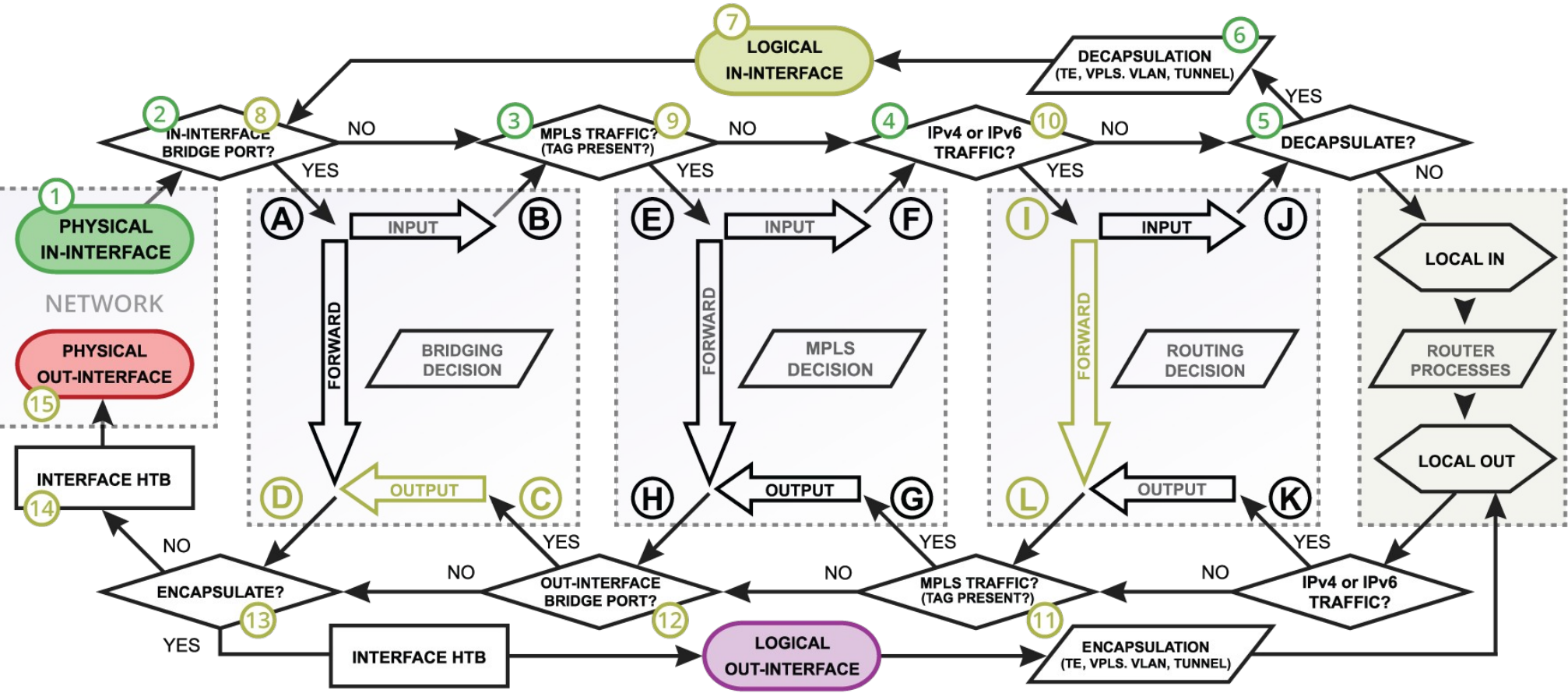
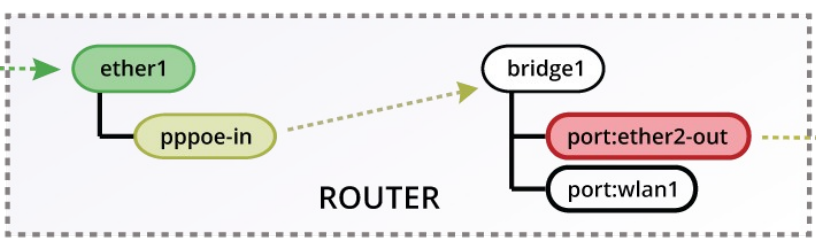


- ether1 and ether2 have FastPath support
- IPIP1 "allow-fast-path" setting enabled
- IP forwarding FastPath allowed

- ICMP traffic
- NAT



- ether1 and ether2-out have FastPath support
- IP forwarding FastPath allowed
- “FastTracked” TCP connection



Bottom Line

- FastPath is a feature that allows you to reduce CPU load in specific configurations
- You trade some RouterOS functionality for performance
- Packet fragments can't use FastPath, so plan your network's MTU/MSS carefully
- Core thing needed for FastPath is interface driver support, without it there is no FastPath, no FastTracked connections ect.

Questions!!!