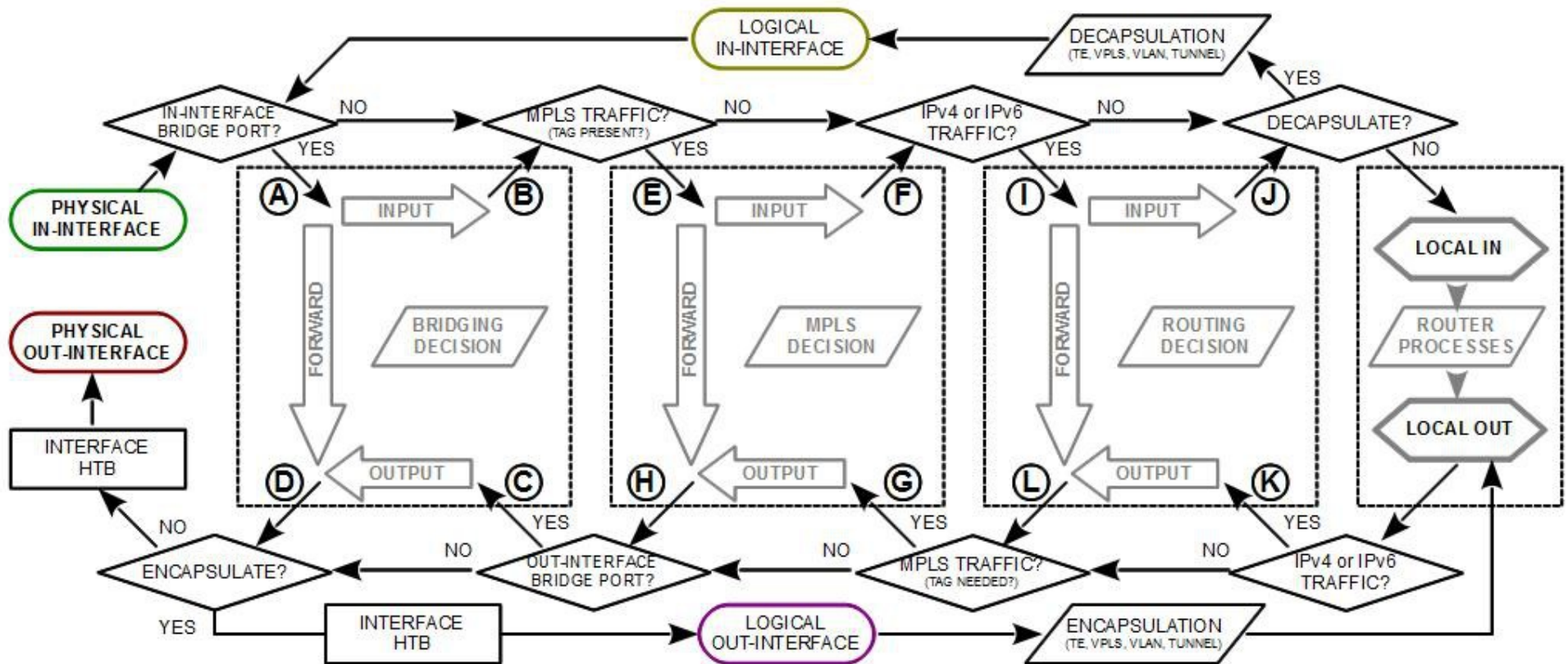
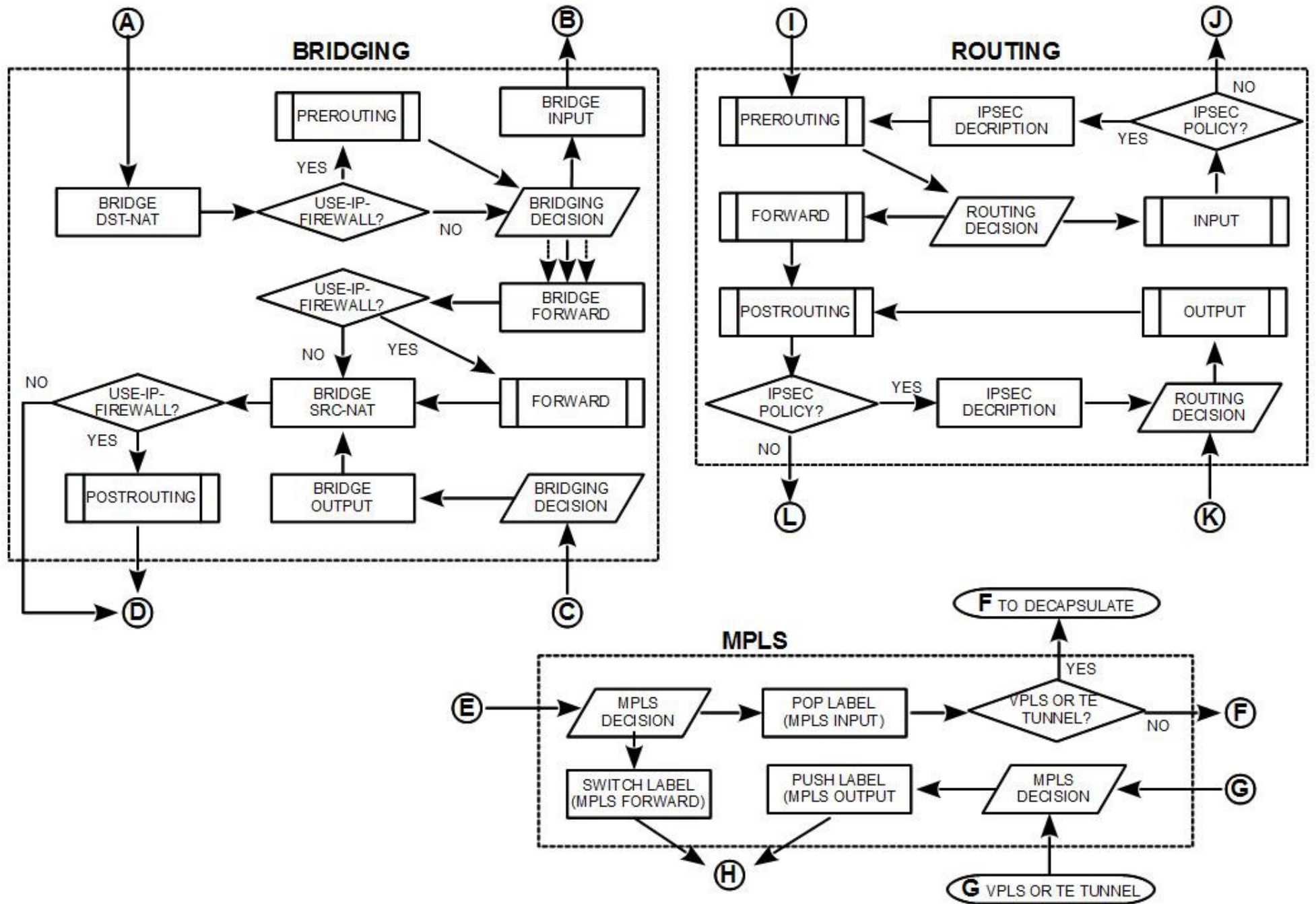


FastPath Overview

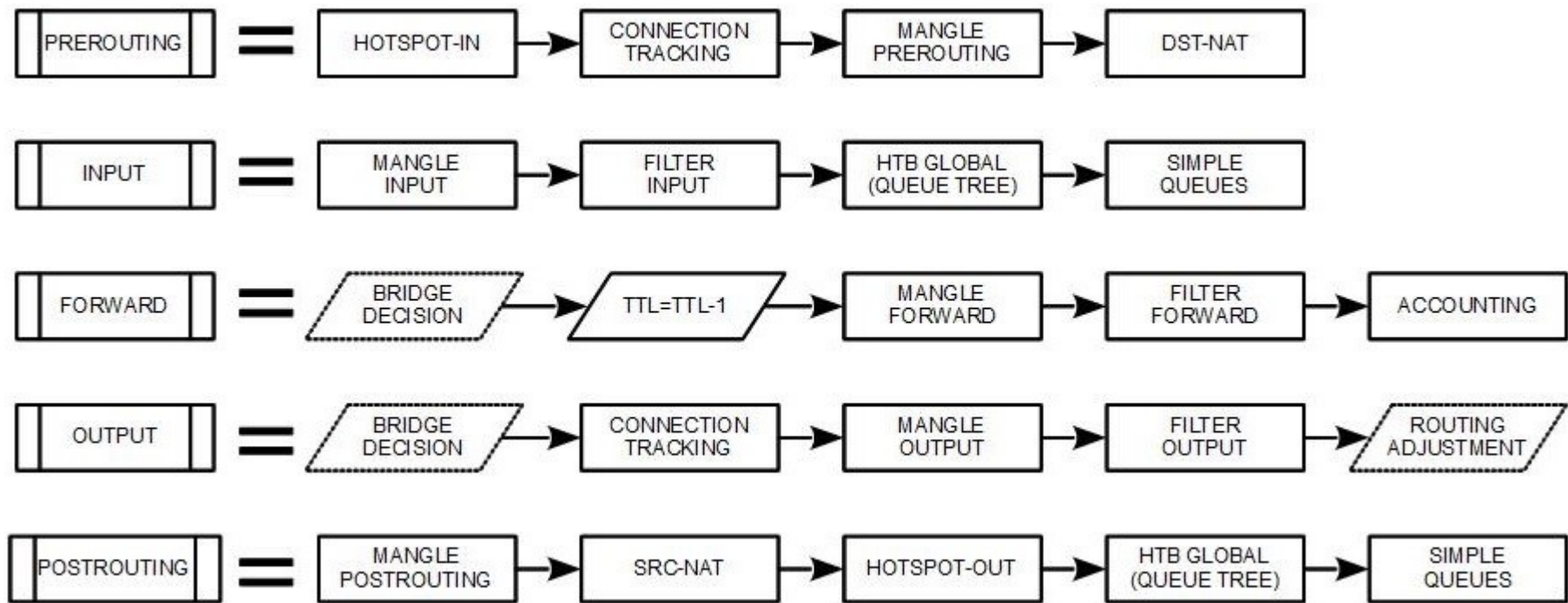
MUM Ukraine, 2015

MikroTik RouterOS Packet Flow Diagram for version 6.x





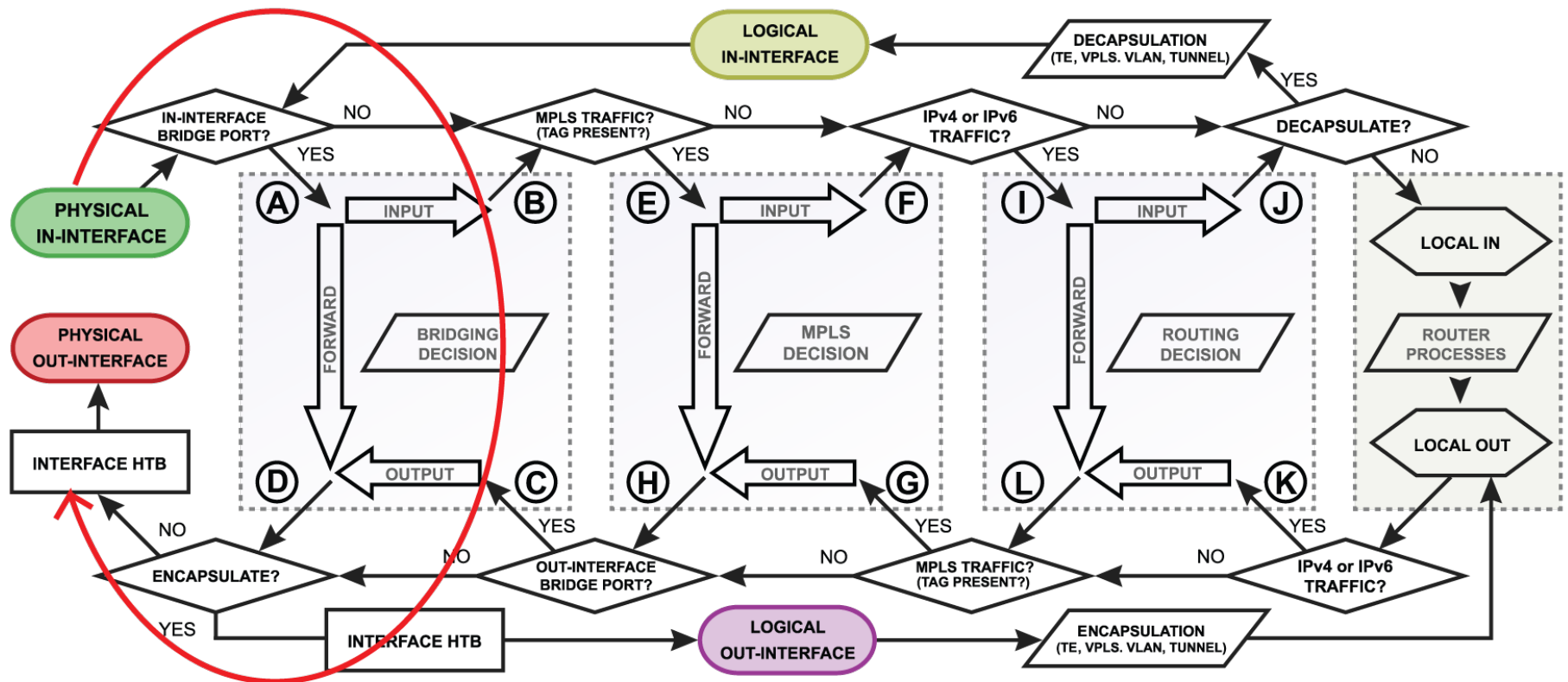
Yes, still - Packet Flow Diagram (page 3)



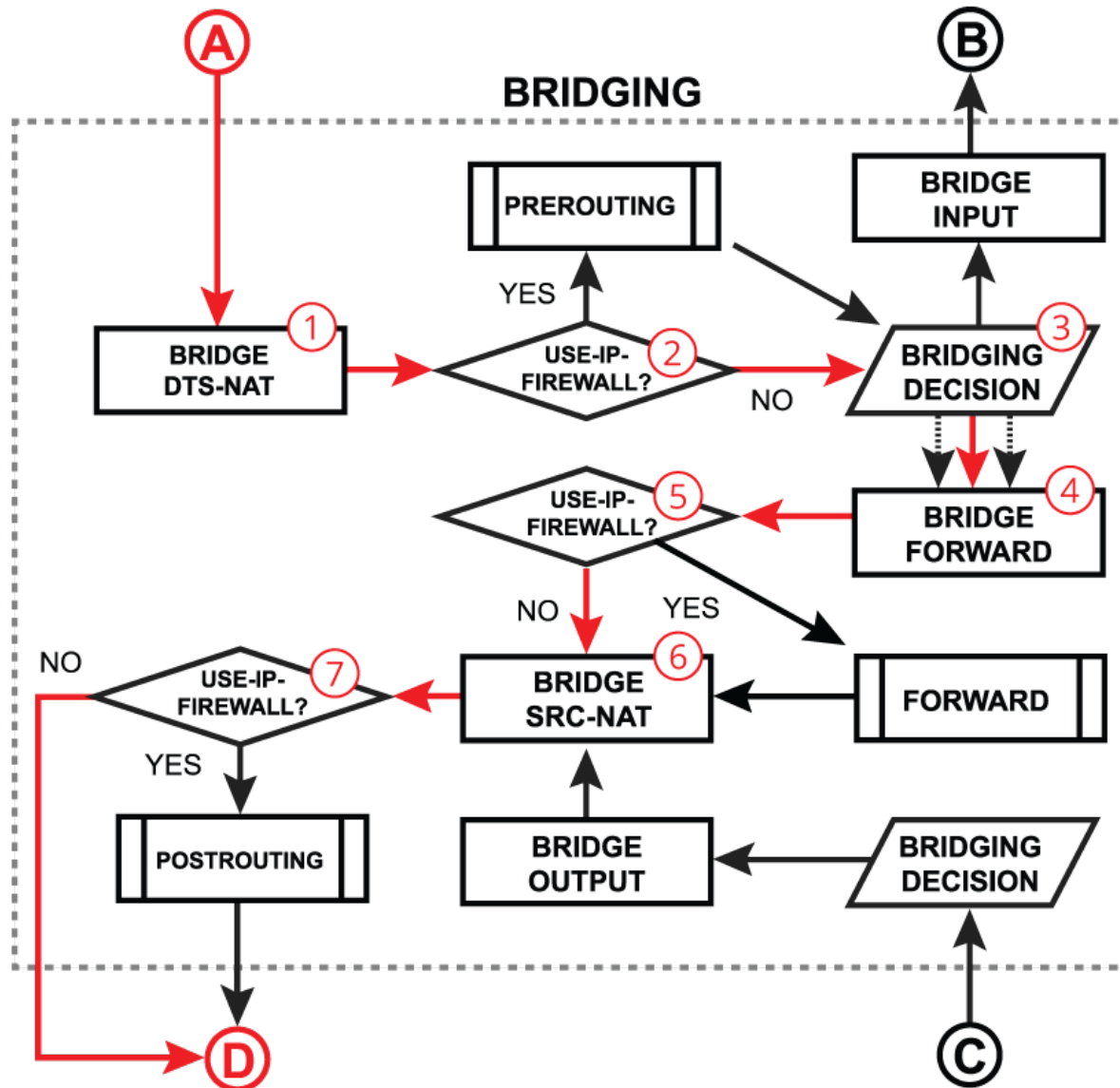
“SlowPath”

- “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

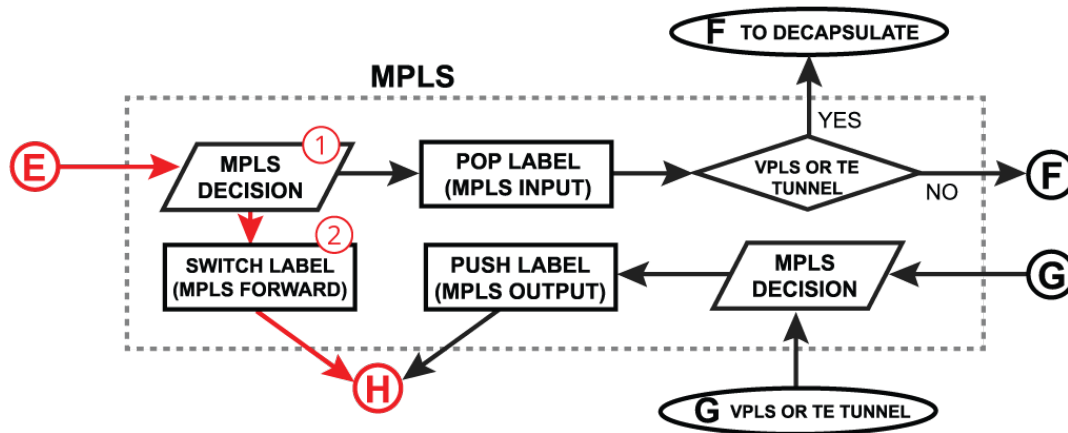
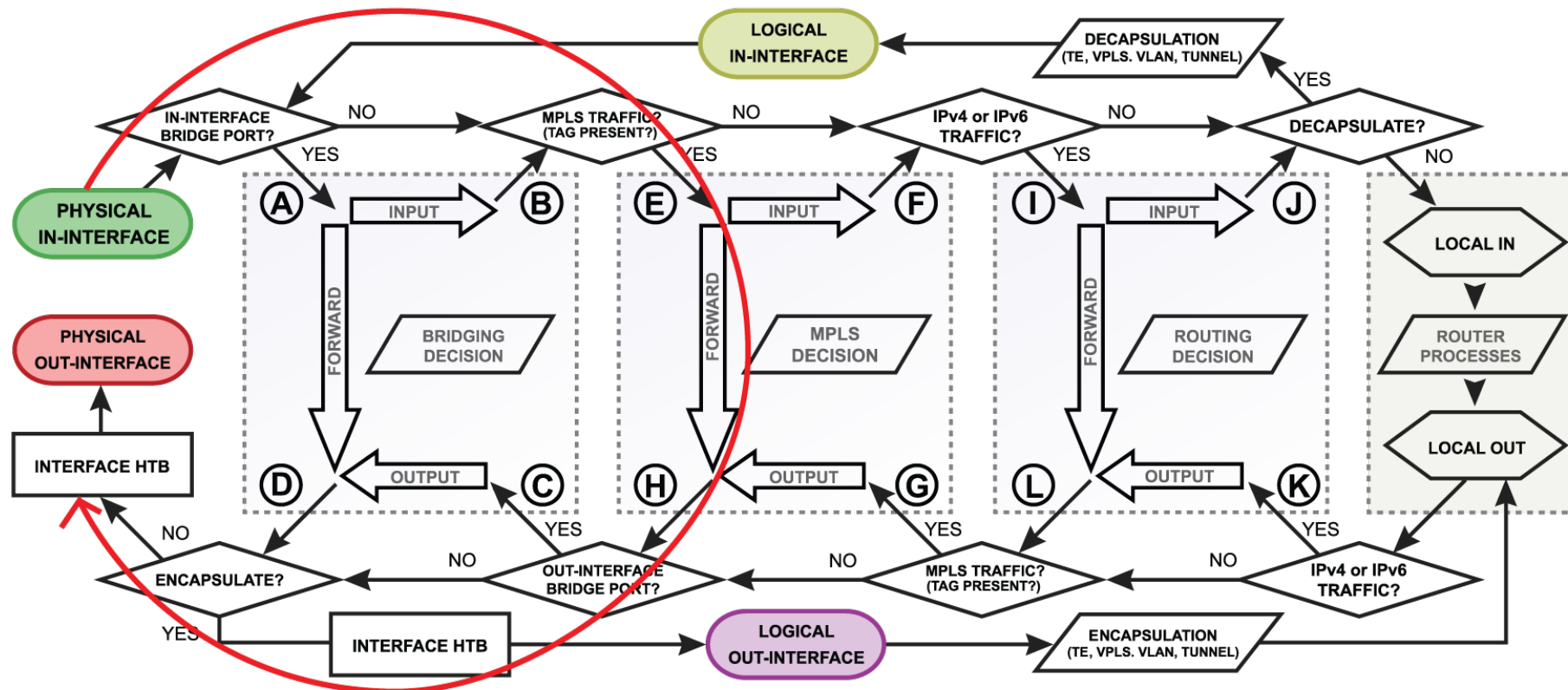
Bridge Forwarding



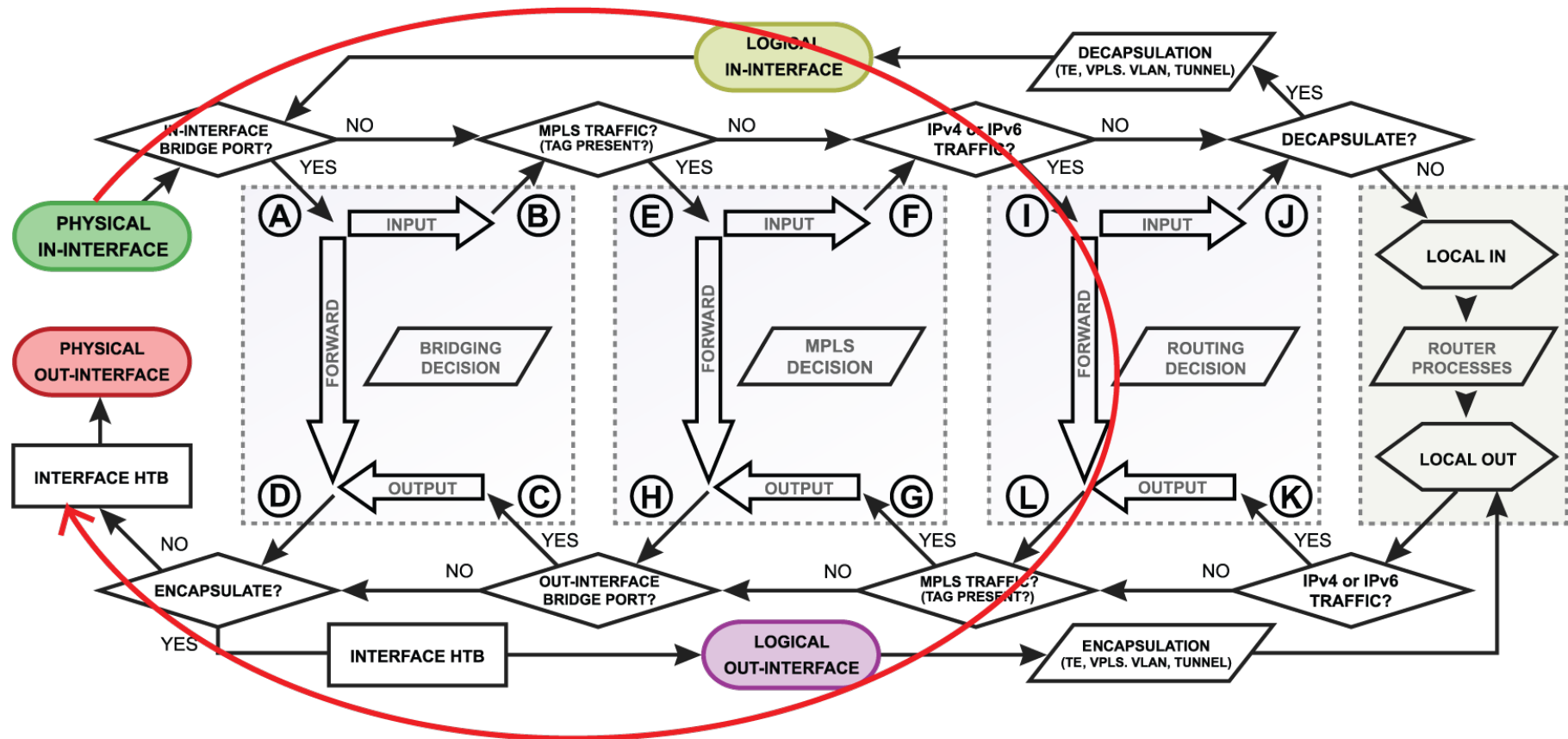
Bridge Forwarding



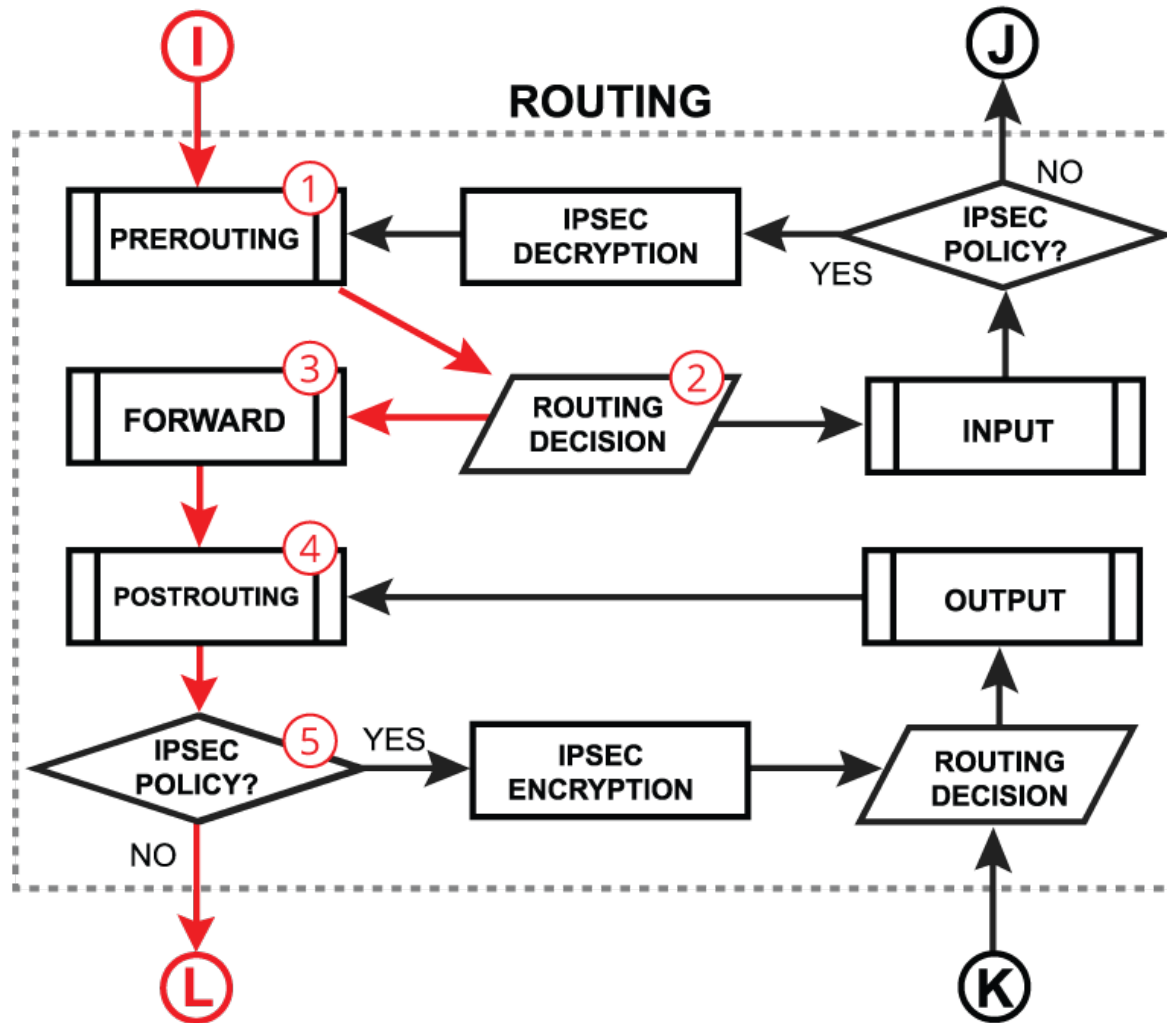
MPLS Forwarding



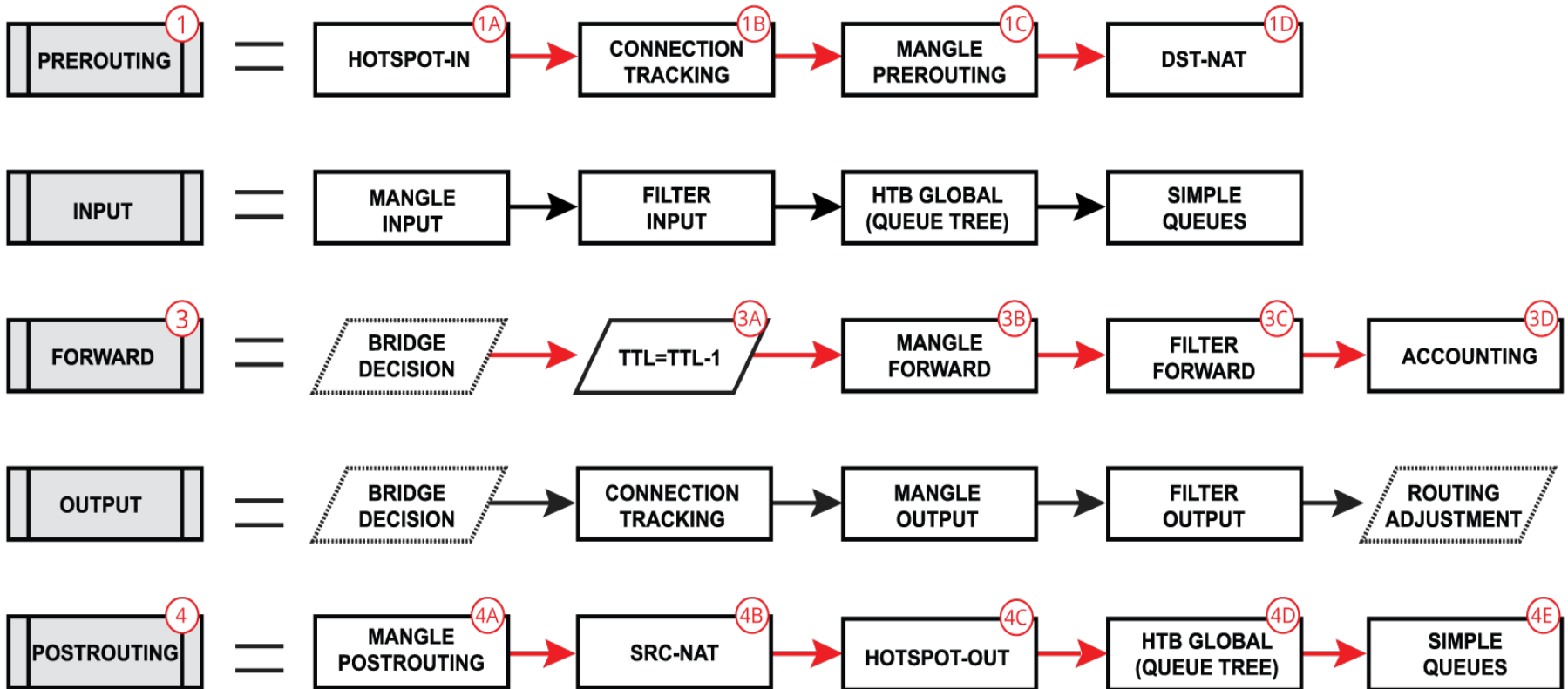
Routing Forwarding



Routing Forwarding



Routing Forwarding



Initial FastPath Implementation

- What if I have nothing else except default forwarding enabled? Do I need to go full process path?
- Solution: FastPath. It allows to forward packets without unnecessary processing
- 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 overlapping network configuration windows. The 'IP Settings' window (top left) has 'Allow Fast Path' checked and circled in red. Below it, 'IPv4 Fast Path Active' is checked, and the statistics 'IPv4 Fast Path Packets: 1 182' and 'IPv4 Fast Path Bytes: 160.0 KiB' are circled in red. The 'Connection Tracking' window (top right) has 'Enabled: auto' circled in red. The 'Bridge Settings' window (bottom right) has 'Allow Fast Path' checked and circled in red, and 'Bridge Fast Path Active' checked. Below it, the statistics 'Bridge Fast Path Packets: 11 964 594' and 'Bridge Fast Path Bytes: 7.1 GiB' are circled in red.

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

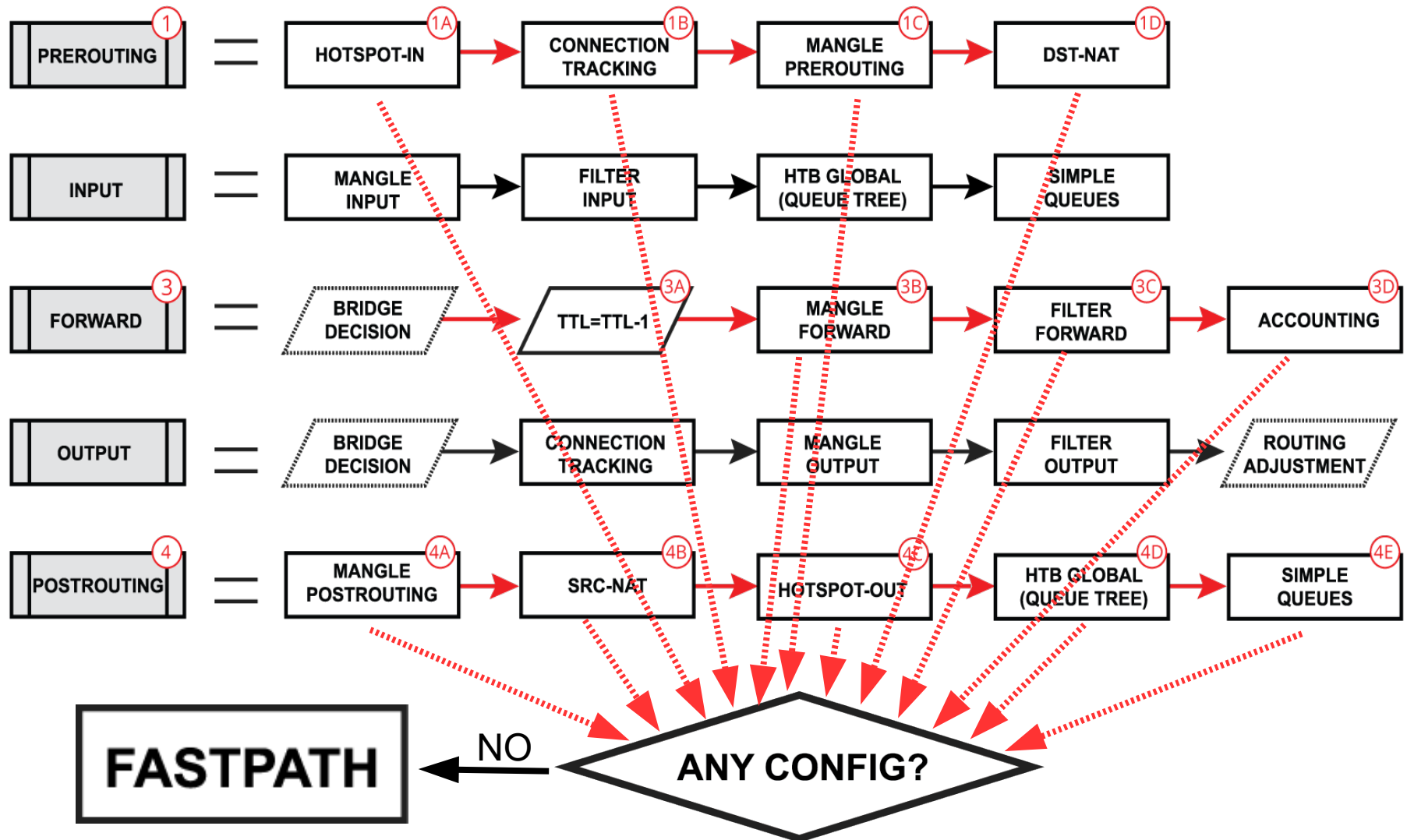
Connection Tracking

- 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

Routing Forwarding FastPath



SlowPath vs FastPath

- What are the performance benefits of 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

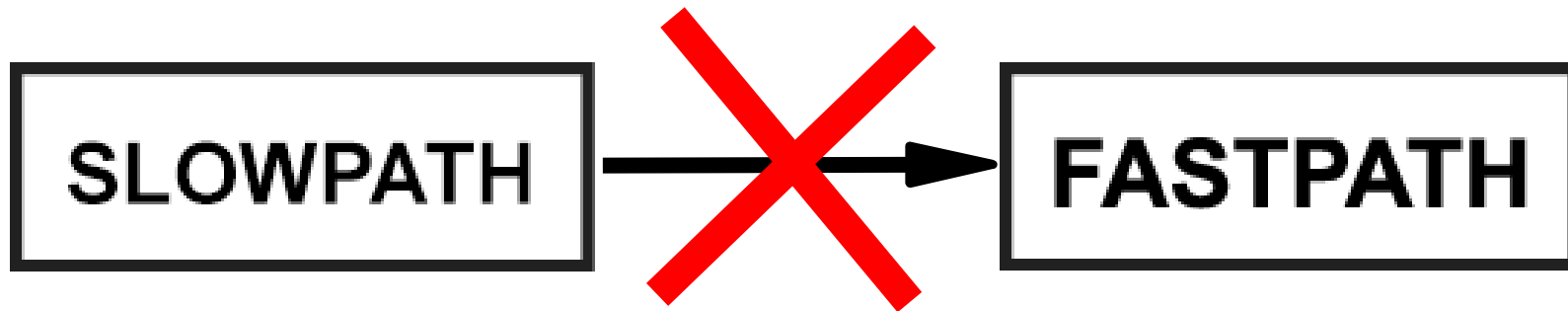
CCR1072 (1200Mhz, DDR1600)

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 doesn't have FastPath support?

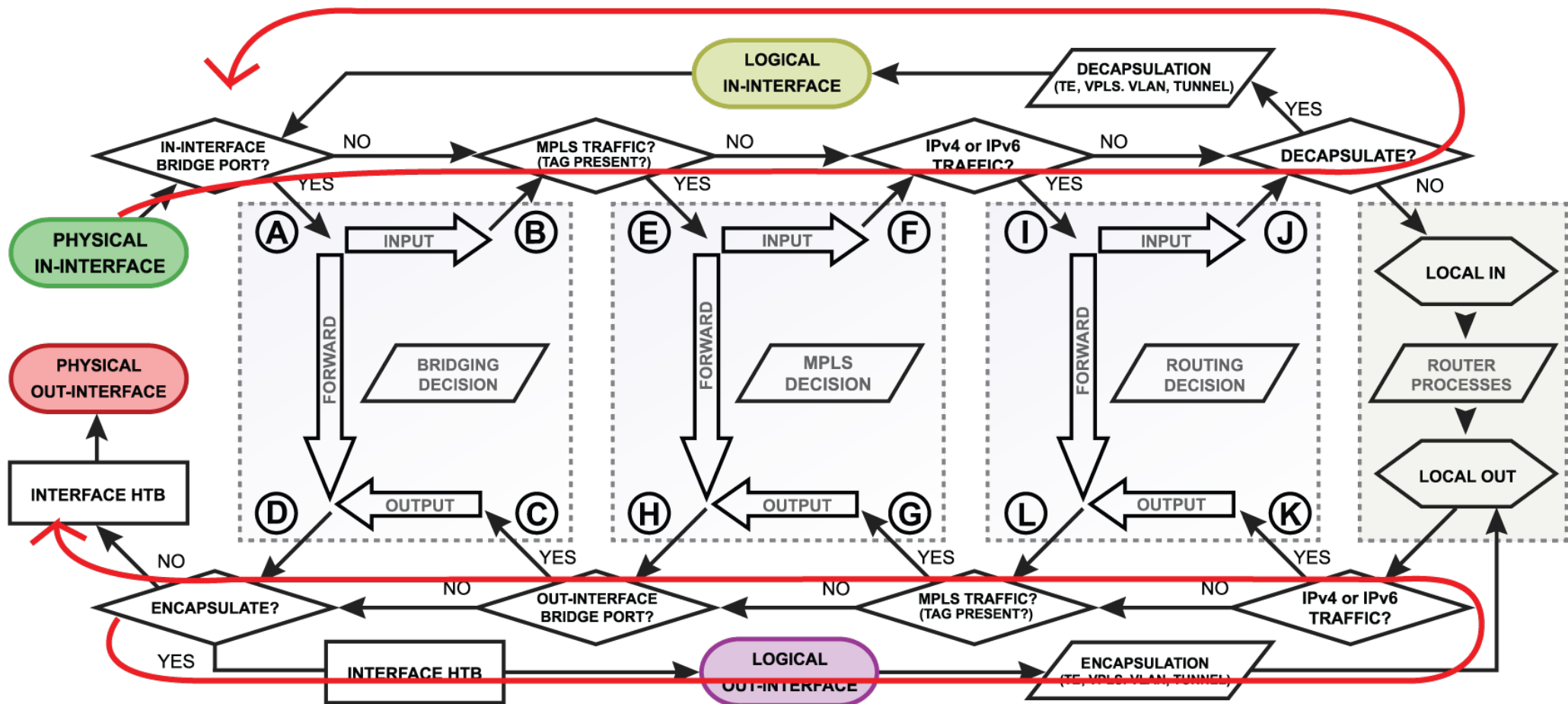


FastPath for Logical Interfaces

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 (TBA)

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) – only for IPv4/TCP and IPv4/UDP connections.

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

FastPath + Conntrack = FastTrack

- Implemented as “fasttrack-connection” action for firewall filter/mangle, flags connection tracking entries as “Fasttracked”
- Works only with IPv4/TCP and IPv4/UDP
- Traffic traveling in FastTrack will be invisible to other router facilities (firewall, queues, etc)
- Some packets still will go the regular path to maintain connection tracking table timeouts
- Packet fragments **can't** be received in 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:

IPv4 Fasttrack Bytes:

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 'ether1' 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
0 bps	0 bps	0	0

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

With Fasttrack

The screenshot shows the Mikrotik WinBox Firewall configuration interface. The main window displays a list of firewall rules, with rule 0 (fasttrack connection) selected. An 'IP Settings' dialog box is open, showing the 'IP Forward' checkbox checked and 'Allow Fast Path' checked. A 'Profile (Running)' window shows the CPU usage for various services, with 'ethernet' at 36.0%. A 'CPU' window shows the CPU load for 'cpu0' at 86%. A 'VRRP Bonding LTE' window shows network statistics for 'Rx' and 'Tx Packet (p/s)'. The 'Tx Packet (p/s)' column shows 37 214, 37 215, and 73 848. The 'Rx Packet (p/s)' column shows 1, 73 857, and 37 203.

Name	Usage
ethernet	36.0
idle	16.5
bridging	13.0
networking	12.5
wireless	8.0
unclassified	6.5
firewall	6.0
management	1.0
profiling	0.5
winbox	0.5

CPU	Load (%)	IRQ (%)	Disk (%)
cpu0	86	82	0

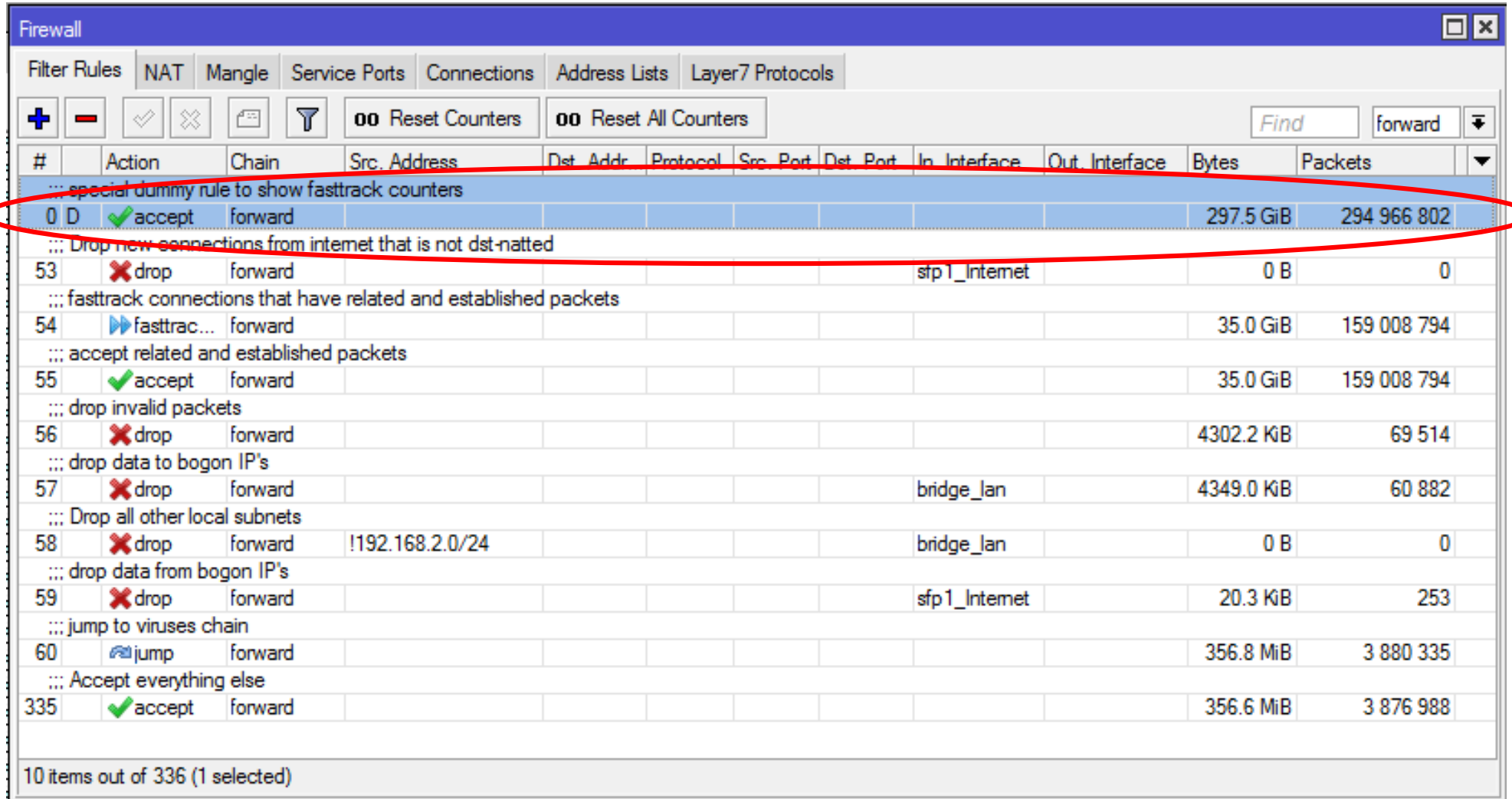
Rx	Tx Packet (p/s)	Rx Packet (p/s)
18.0 Mbps	368 bps	37 214
18.0 Mbps	890.6 Mbps	37 215
890.6 Mbps	17.9 Mbps	73 848
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0
0 bps	0 bps	0

- Board: RB2011UiAS-2HnD
- Configuration: default Home AP
- Throughput: 890Mbps
- CPU load: 86%
- Firewall CPU load: 6%

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

+ - ✓ ✗ [Filter Icon] 00 Reset Counters 00 Reset All Counters Find forward

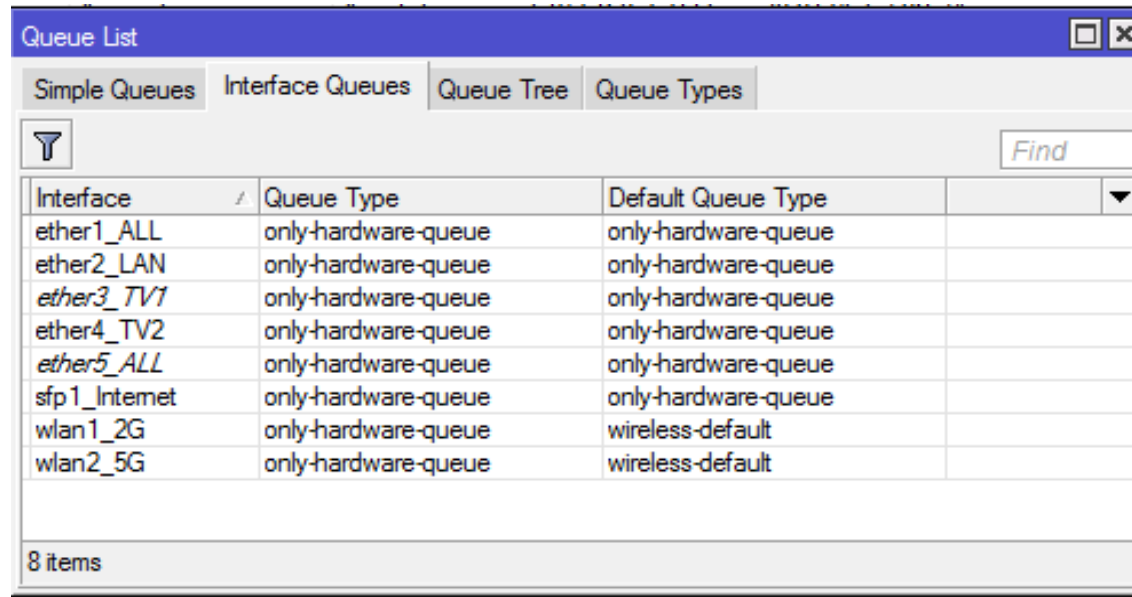
#	Action	Chain	Src. Address	Dst. Addr.	Protocol	Src. Port	Dst. Port	In. Interface	Out. Interface	Bytes	Packets
::: special dummy rule to show fasttrack counters											
0	D ✓ accept	forward								297.5 GiB	294 966 802
::: Drop new connections from internet that is not dst-natted											
53	✗ drop	forward						sfp1_Intemet		0 B	0
::: fasttrack connections that have related and established packets											
54	▶▶ fastrac...	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	✗ drop	forward								4302.2 KiB	69 514
::: drop data to bogon IP's											
57	✗ drop	forward						bridge_lan		4349.0 KiB	60 882
::: Drop all other local subnets											
58	✗ drop	forward	!192.168.2.0/24					bridge_lan		0 B	0
::: drop data from bogon IP's											
59	✗ 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 is FastTracked
- 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



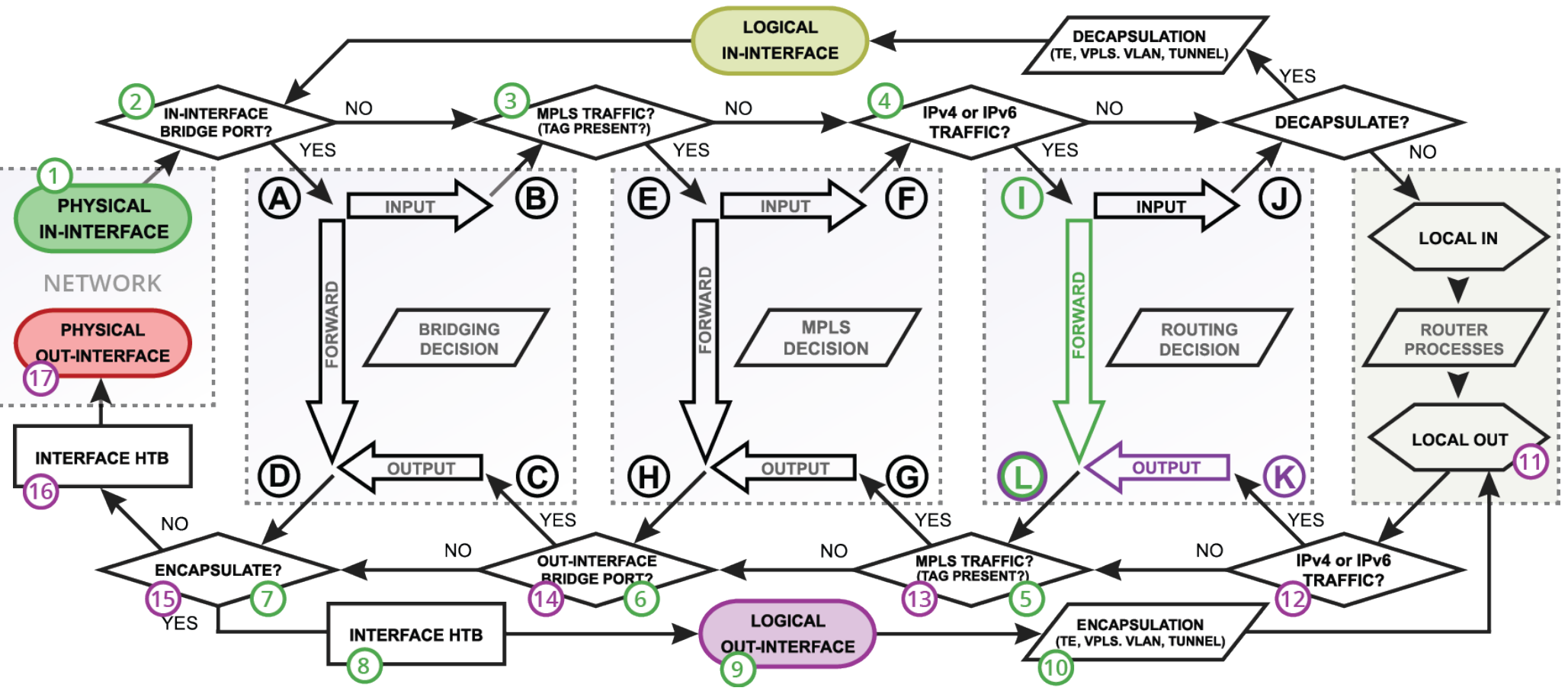
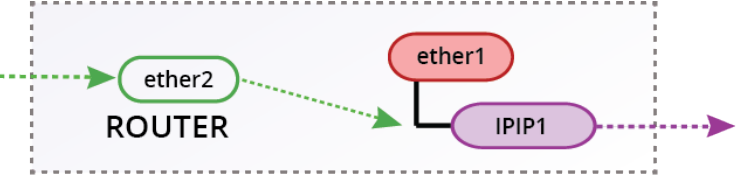
The screenshot shows a window titled "Queue List" with four tabs: "Simple Queues", "Interface Queues", "Queue Tree", and "Queue Types". The "Interface Queues" tab is selected. Below the tabs is a search bar with a filter icon and a "Find" button. The main area contains a table with the following data:

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

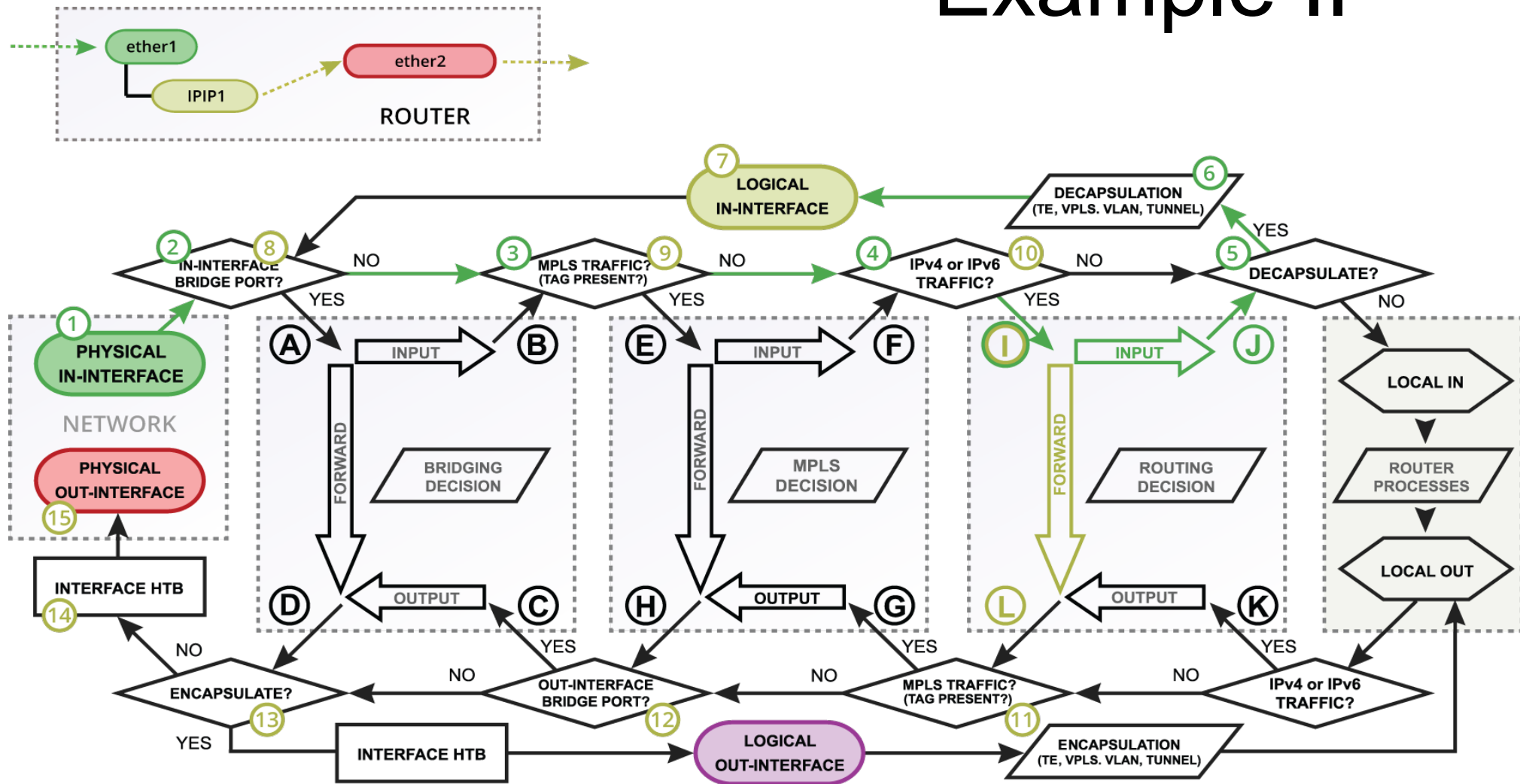
At the bottom of the window, it says "8 items".

- 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

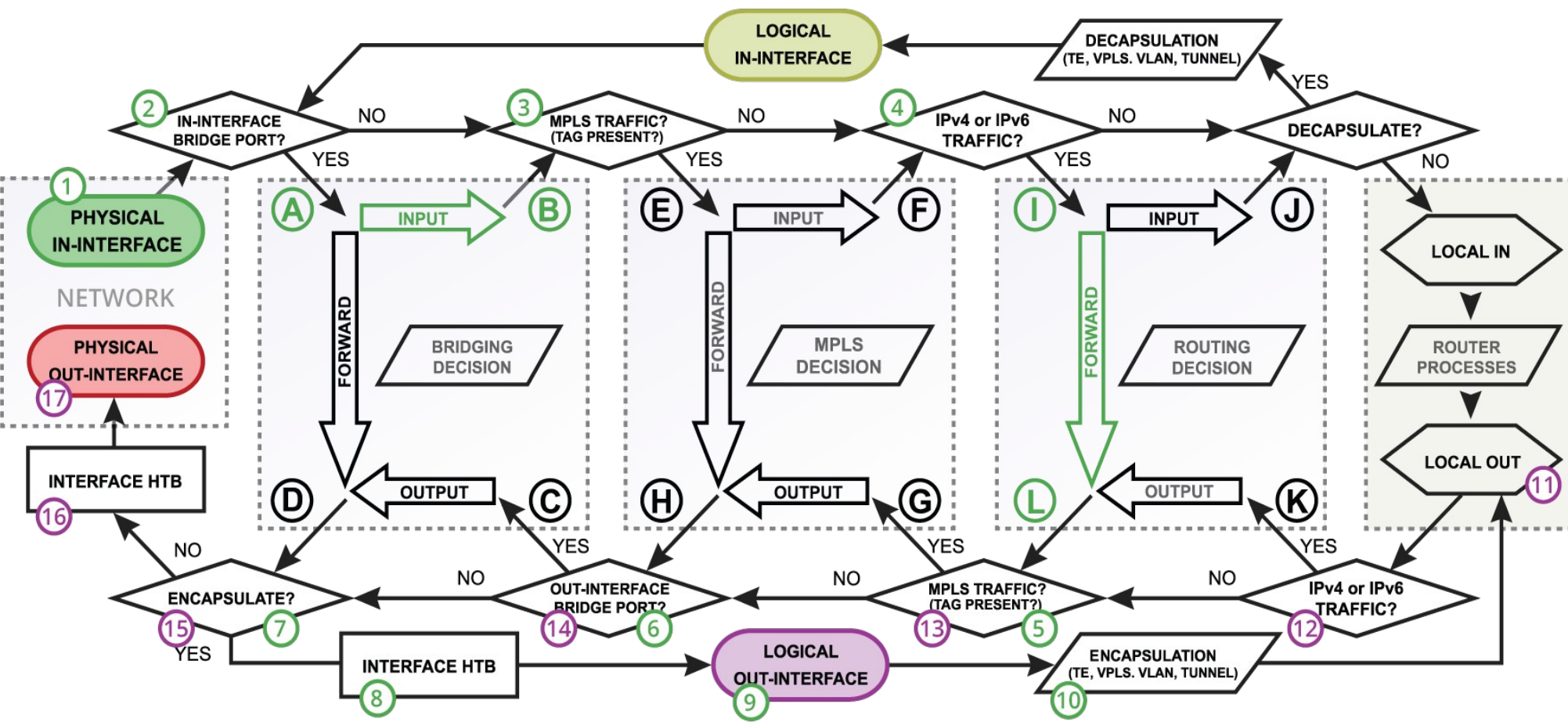
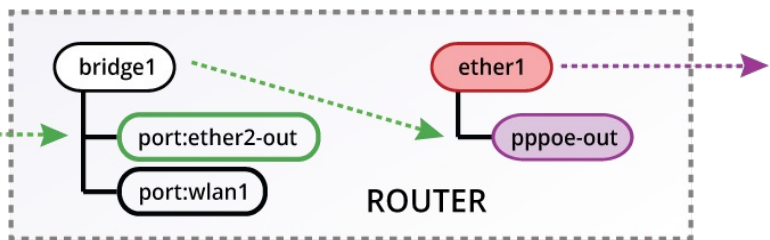
Example I



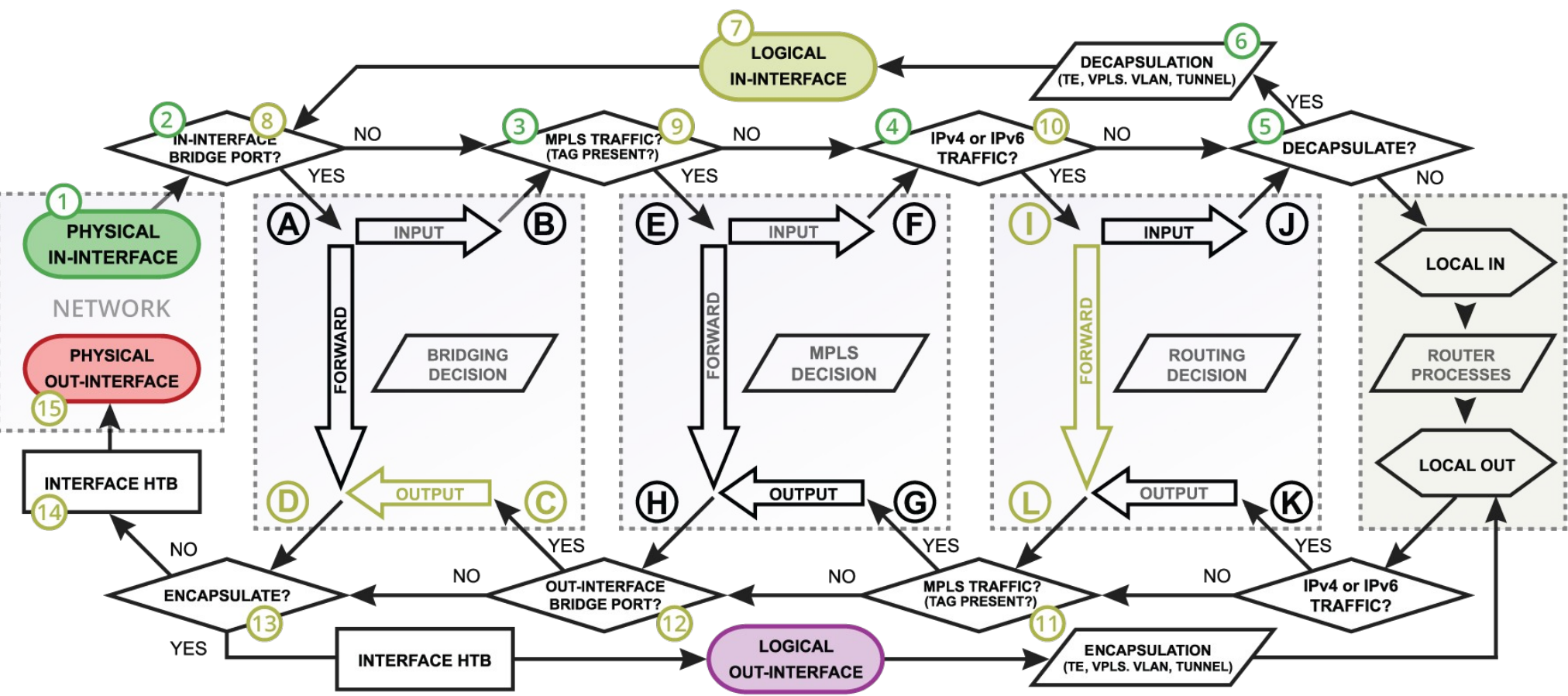
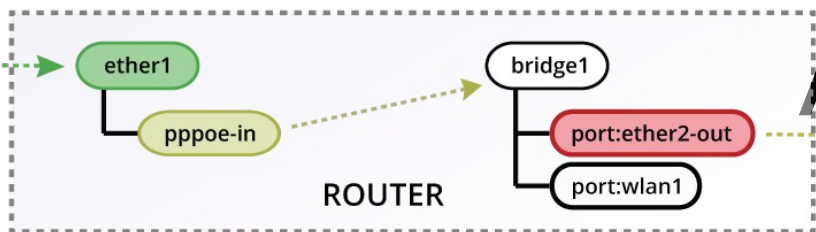
Example II



Advanced Example I



Advanced Example II



Bottom Line

- FastPath is a feature that allows you to improve CPU performance in specific configurations
- You trade some RouterOS functionality for performance
- Packet fragments can't use FastPath, so plan your network's MTU/MSS carefully
- Fasttrack is a part of FastPath, it has the same requirements

Questions!!!