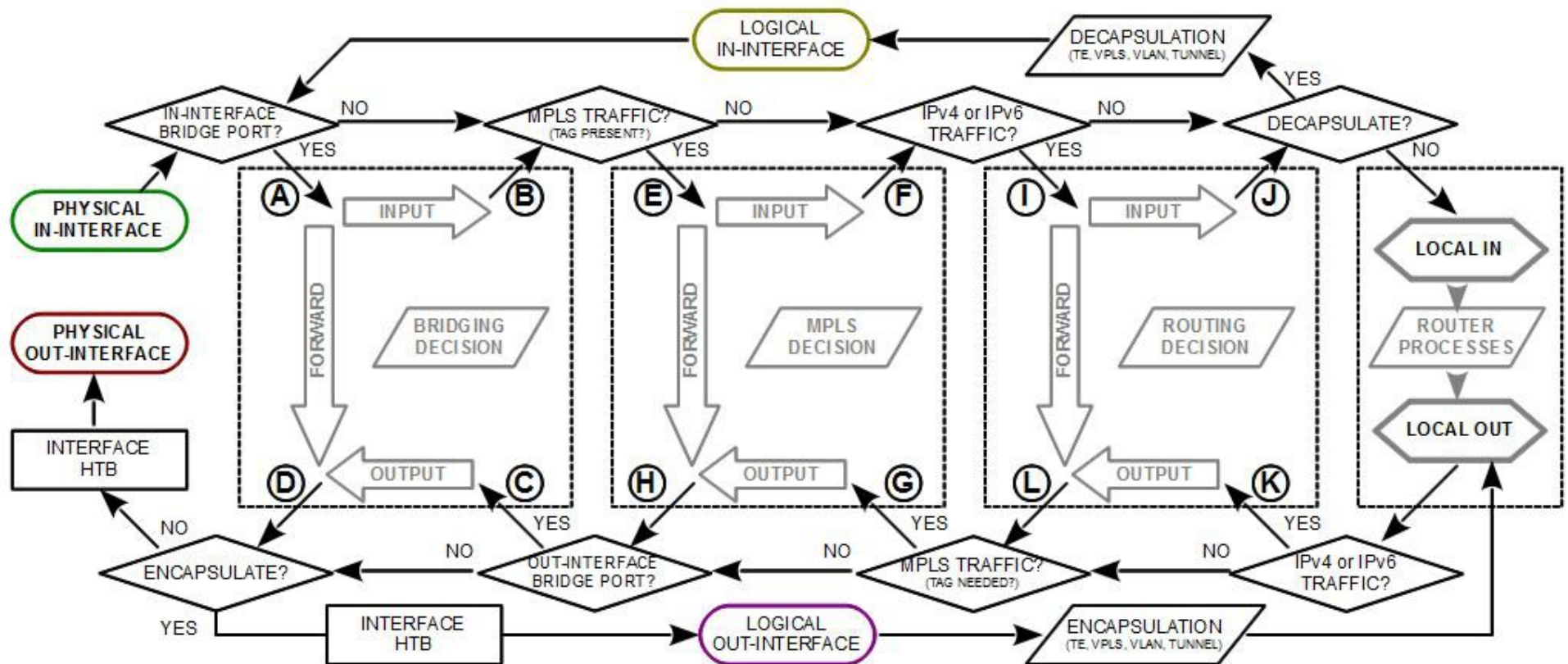


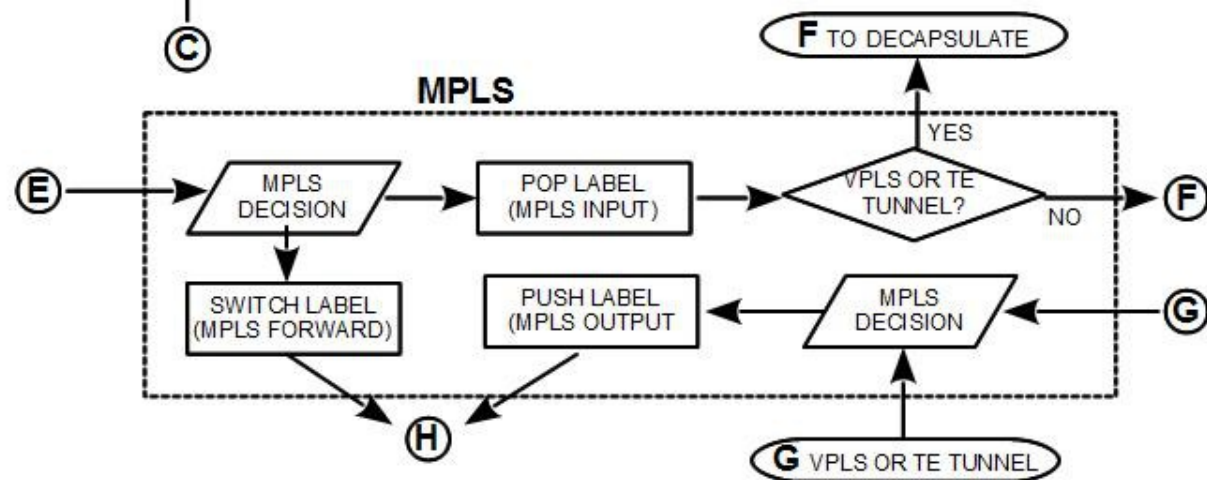
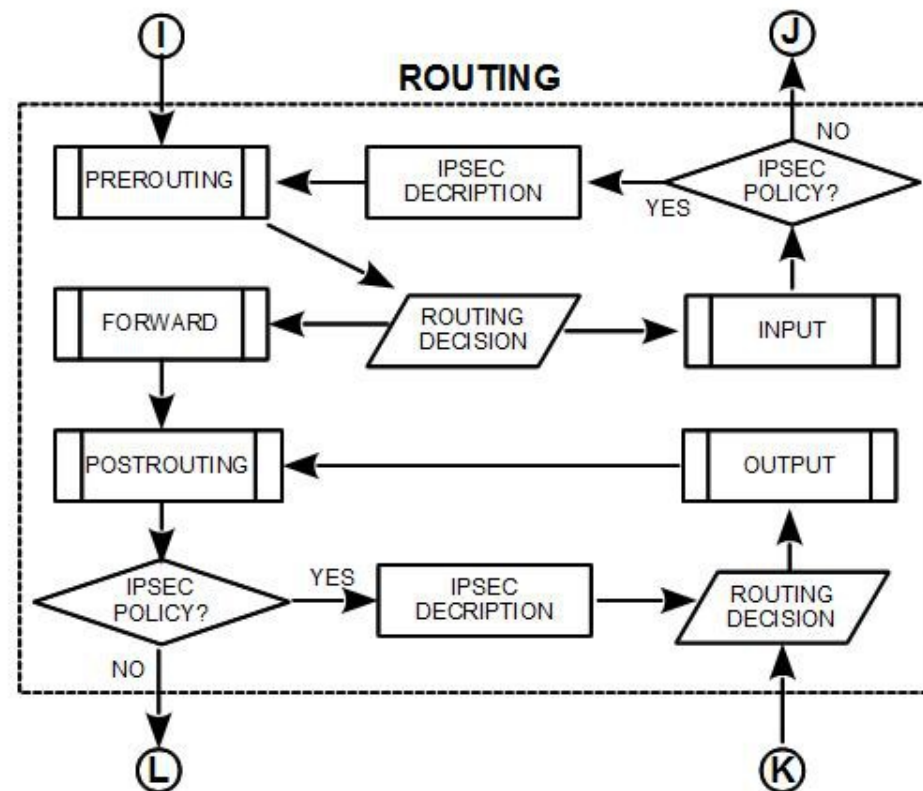
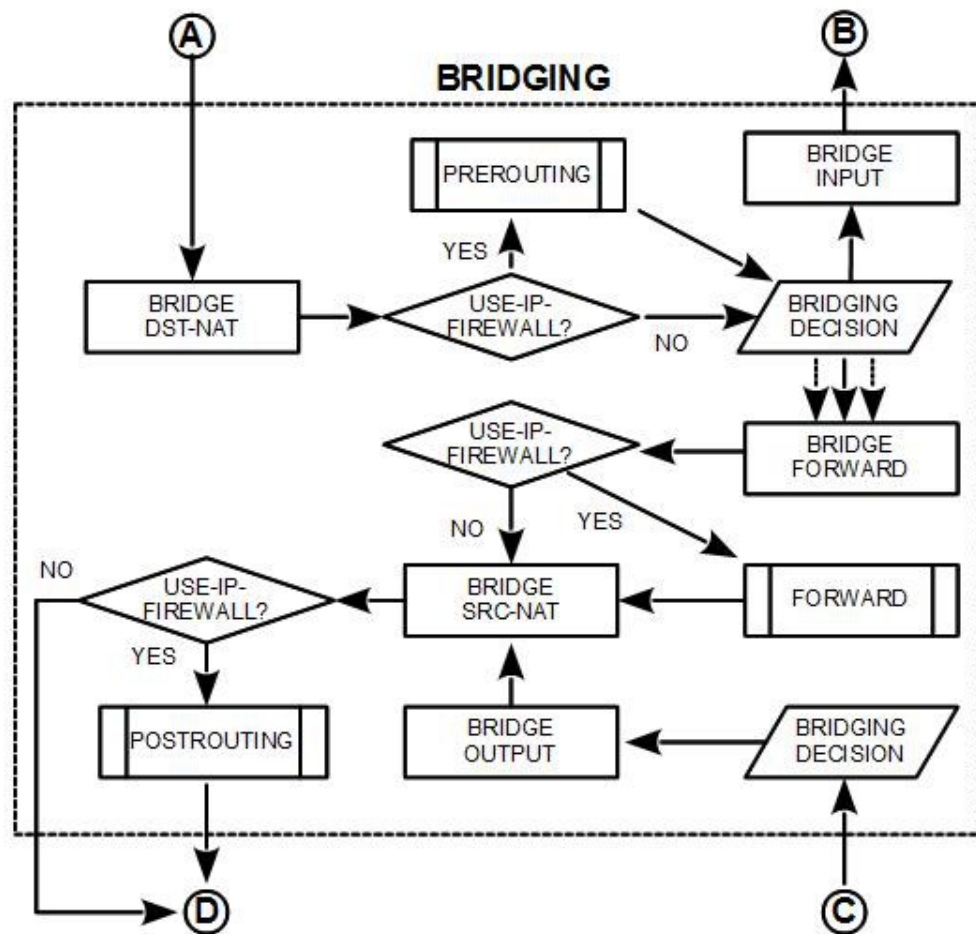


FastPath Overview

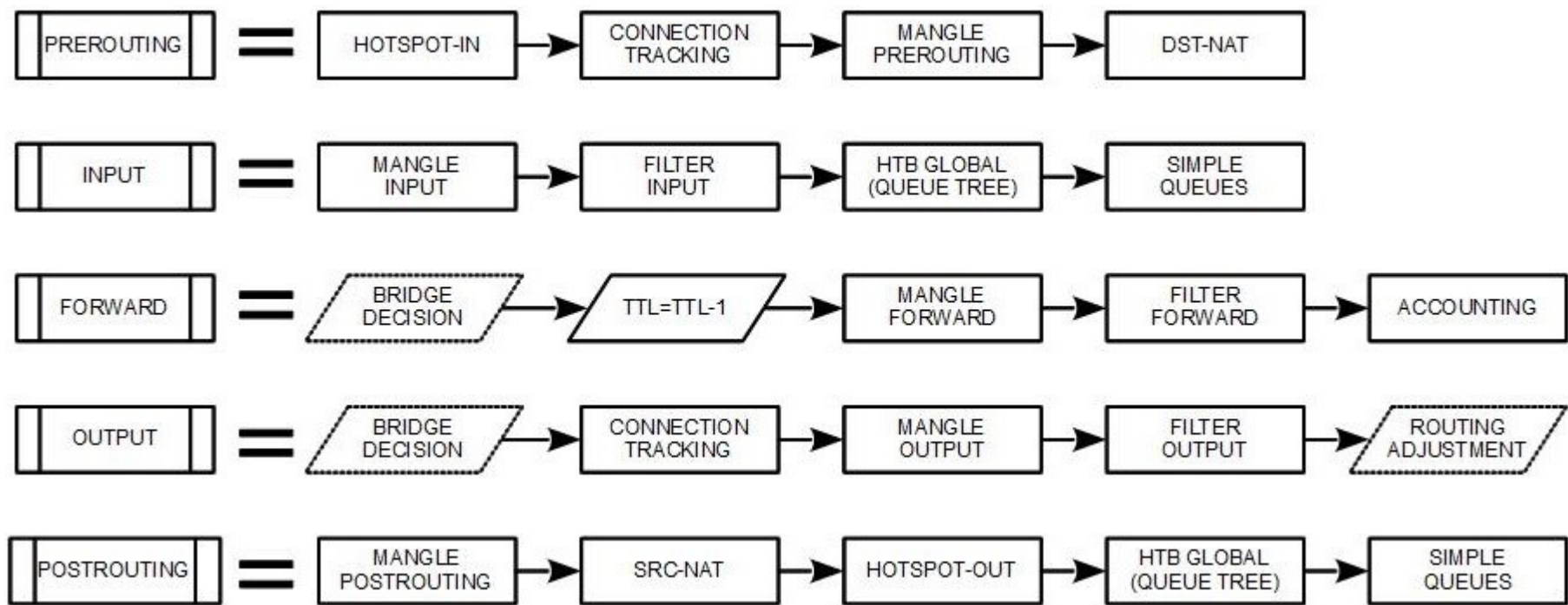
MUM Copenhagen, Denmark, 2016

MikroTik RouterOS Packet Flow Diagram for version 6.x





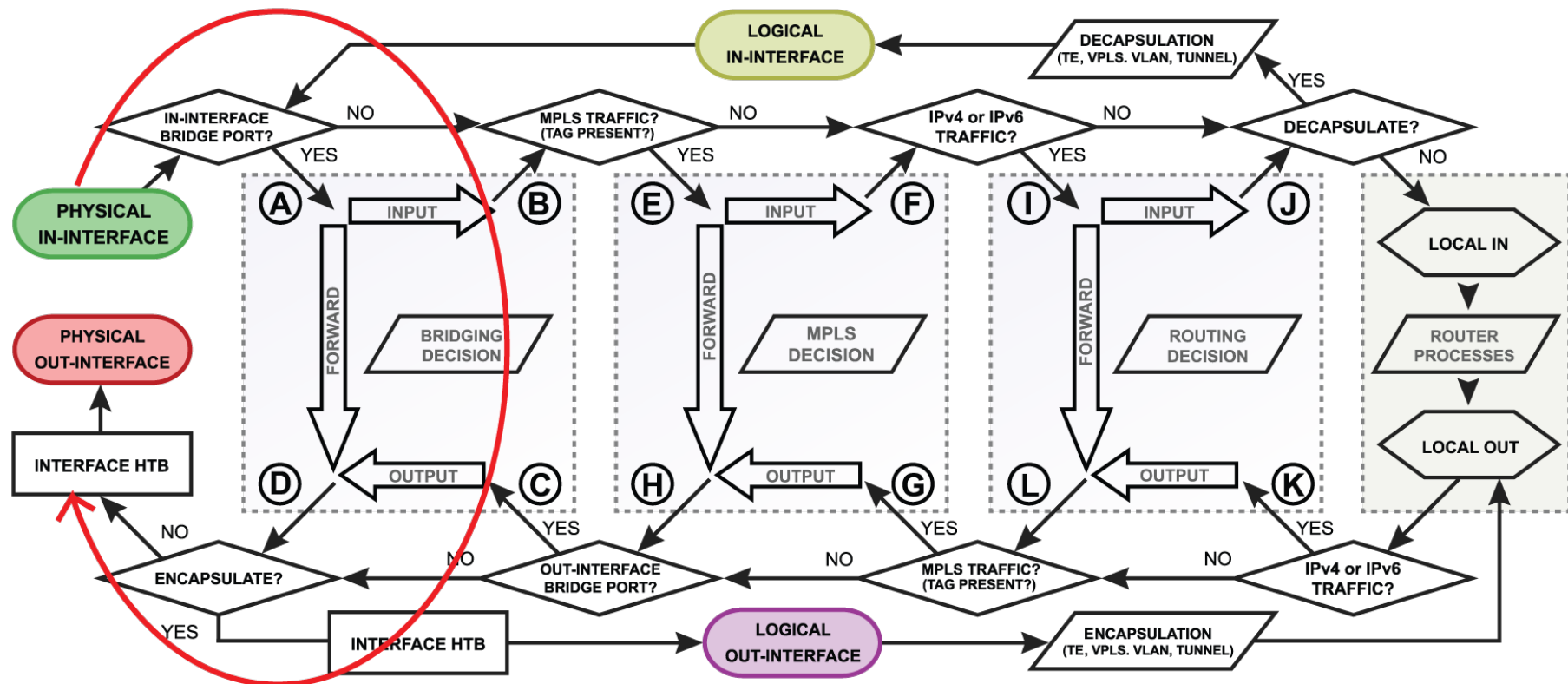
Yes, still - Packet Flow Diagram (page 3)



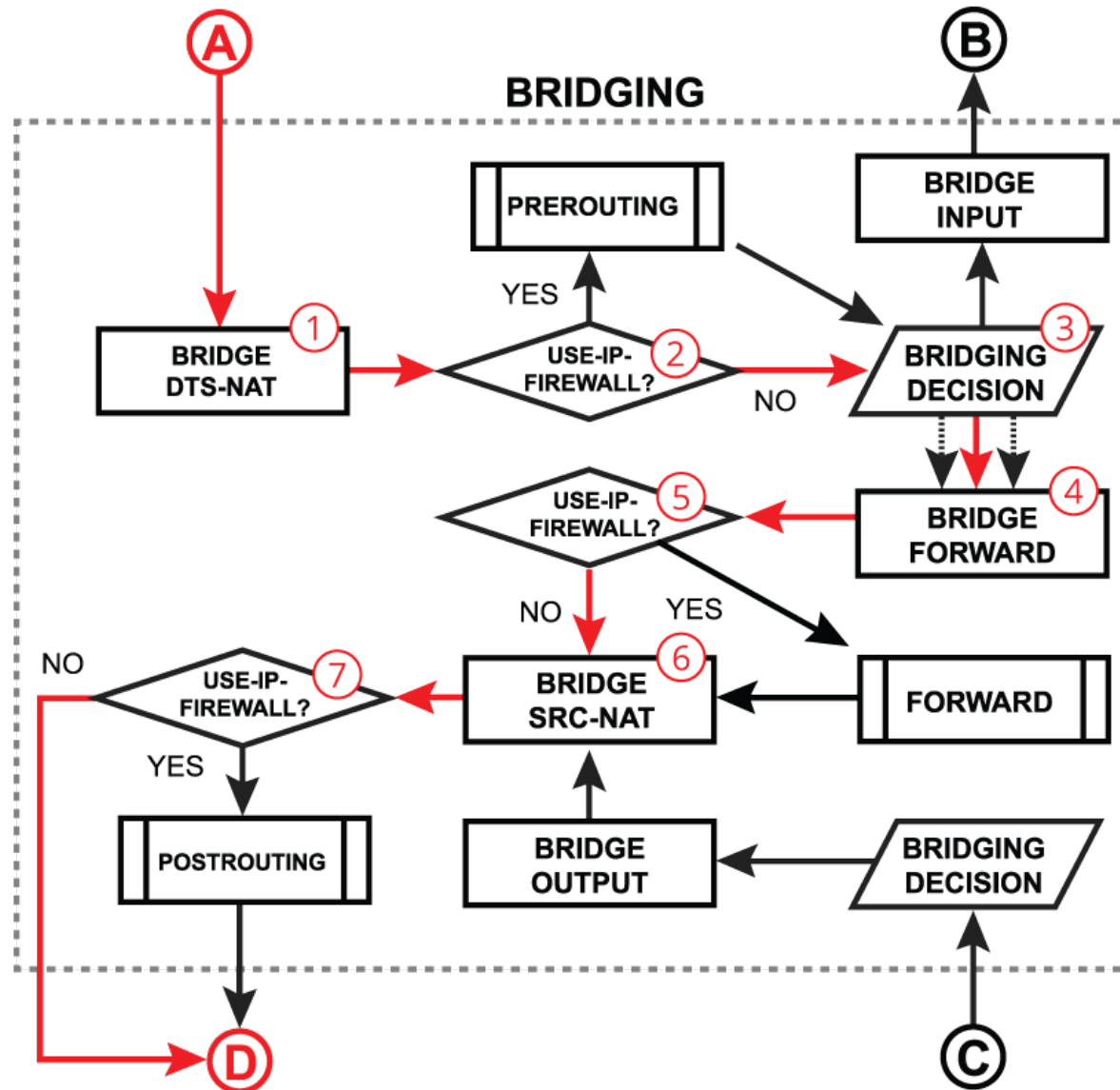
“SlowPath”

- “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

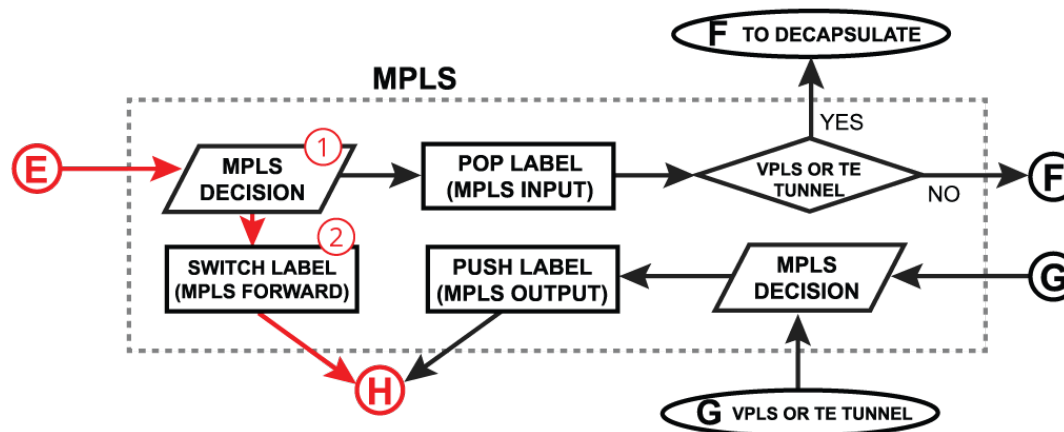
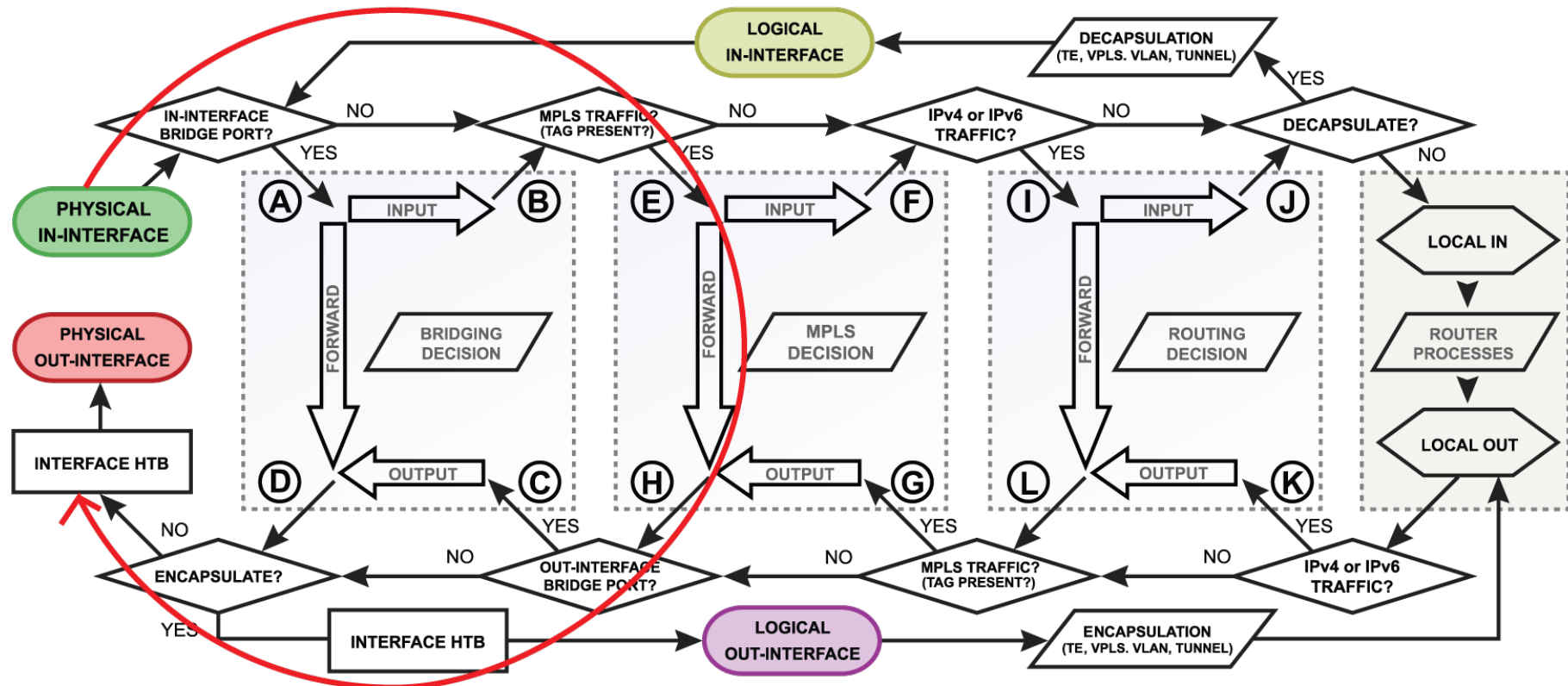
Bridge Forwarding



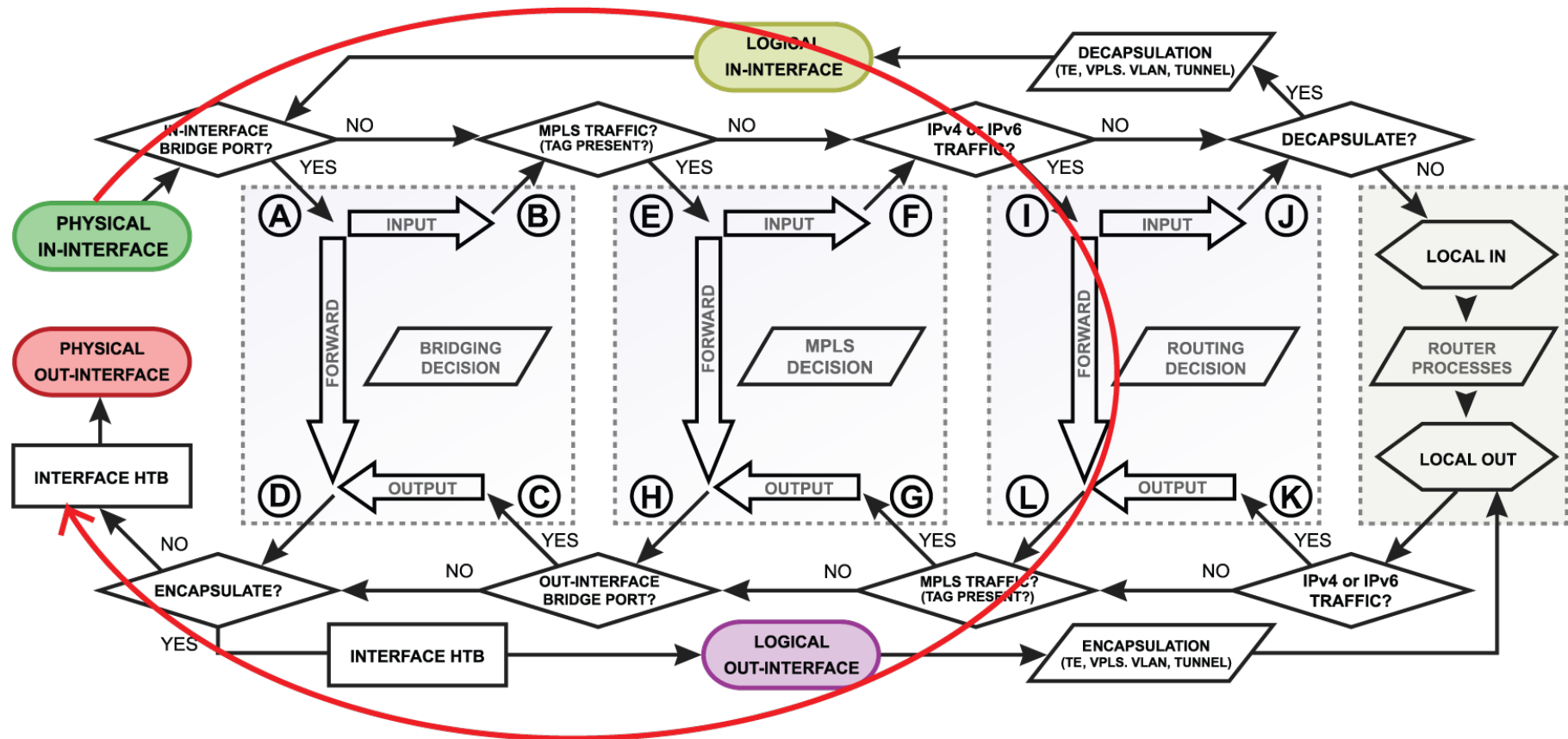
Bridge Forwarding



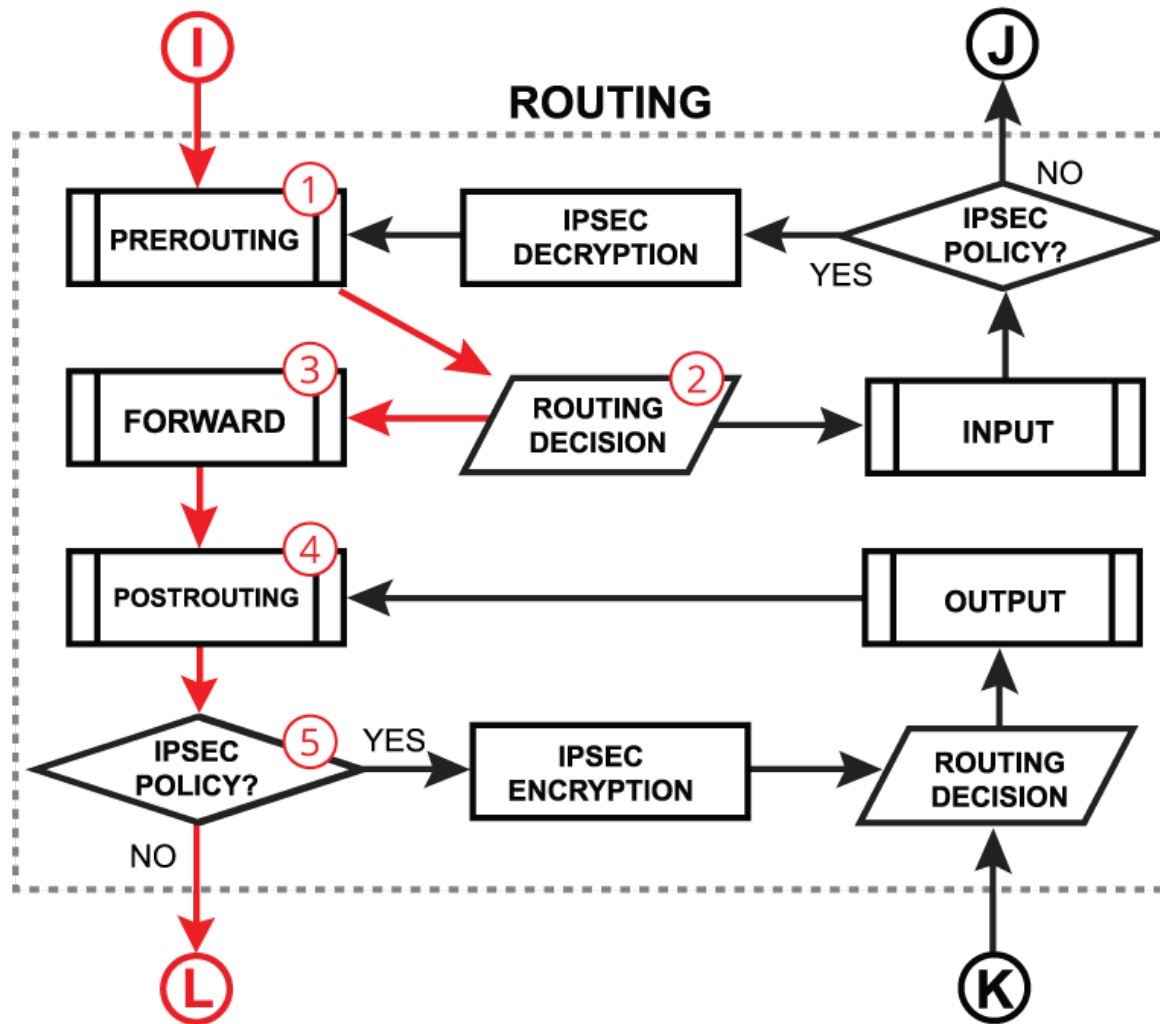
MPLS Forwarding



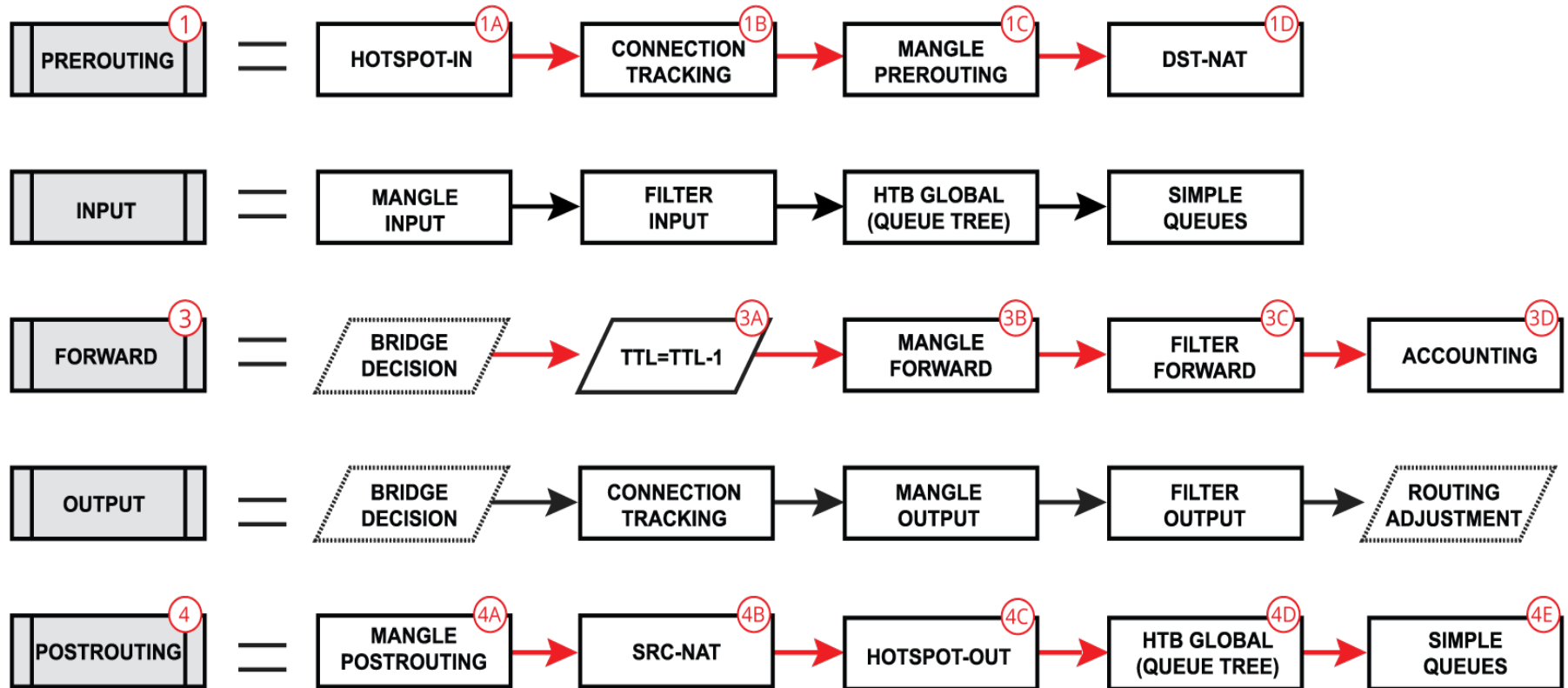
Routing Forwarding



Routing Forwarding



Routing Forwarding



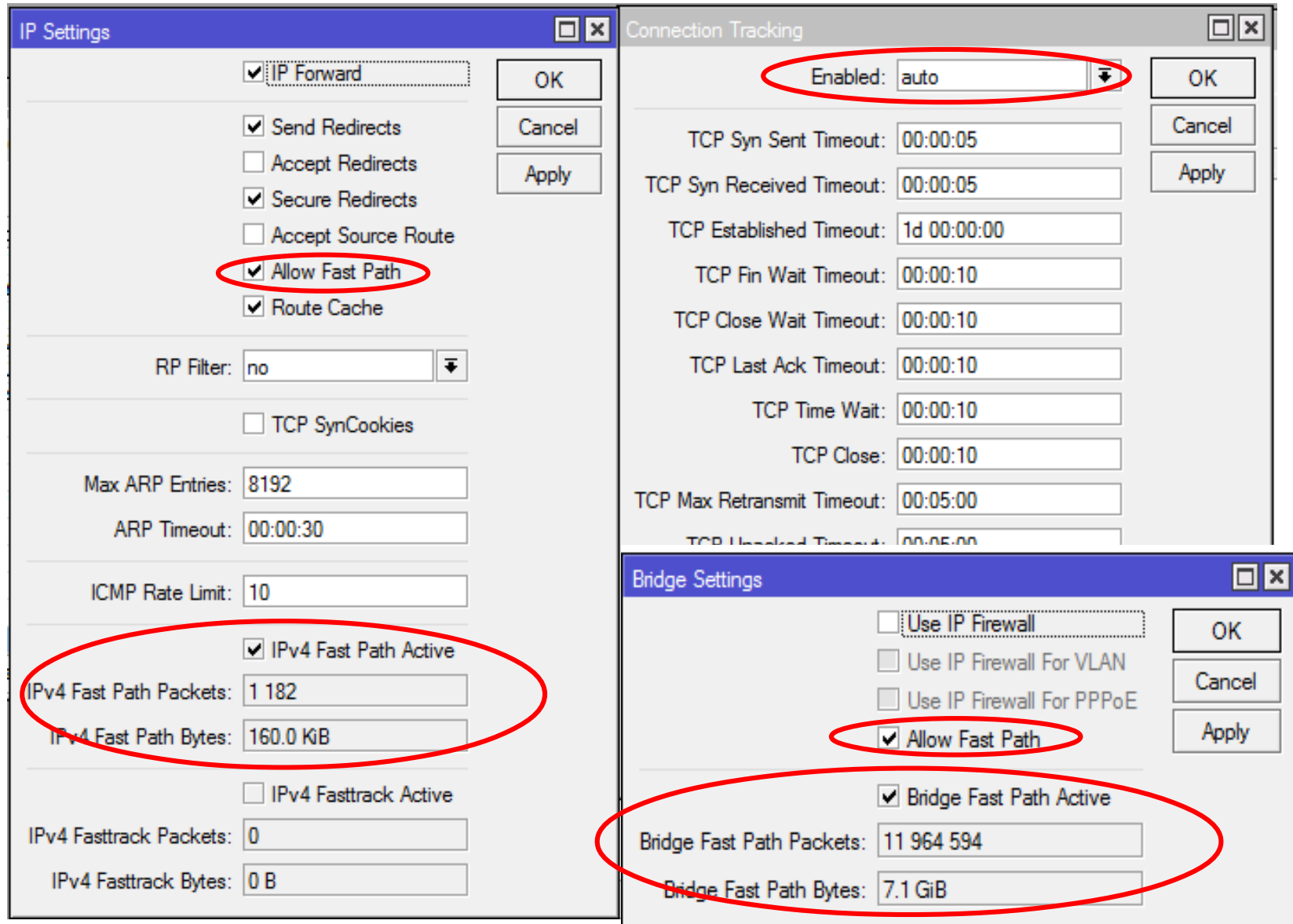
Initial FastPath Implementation

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

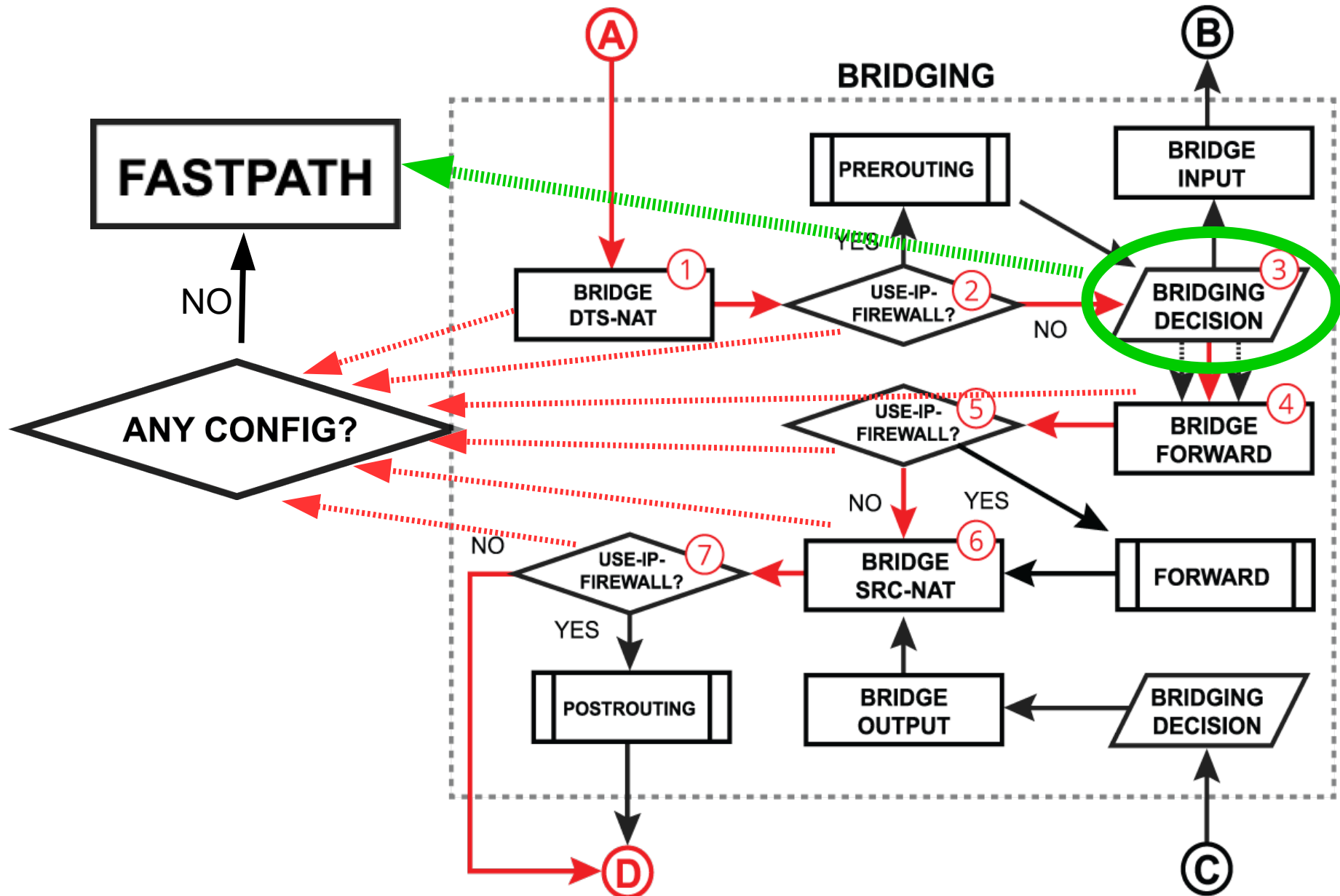
Driver Support

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

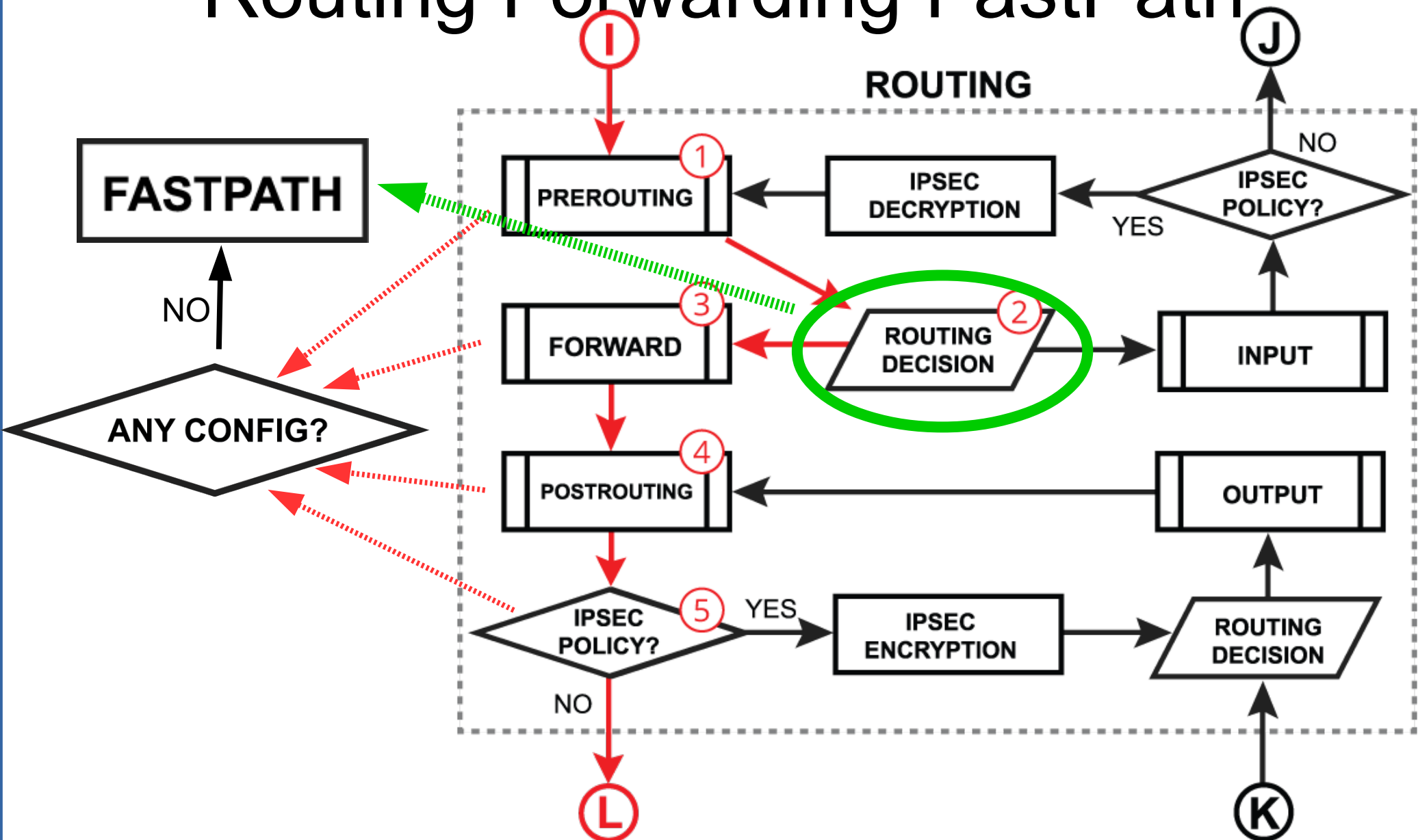
Allow FastPath



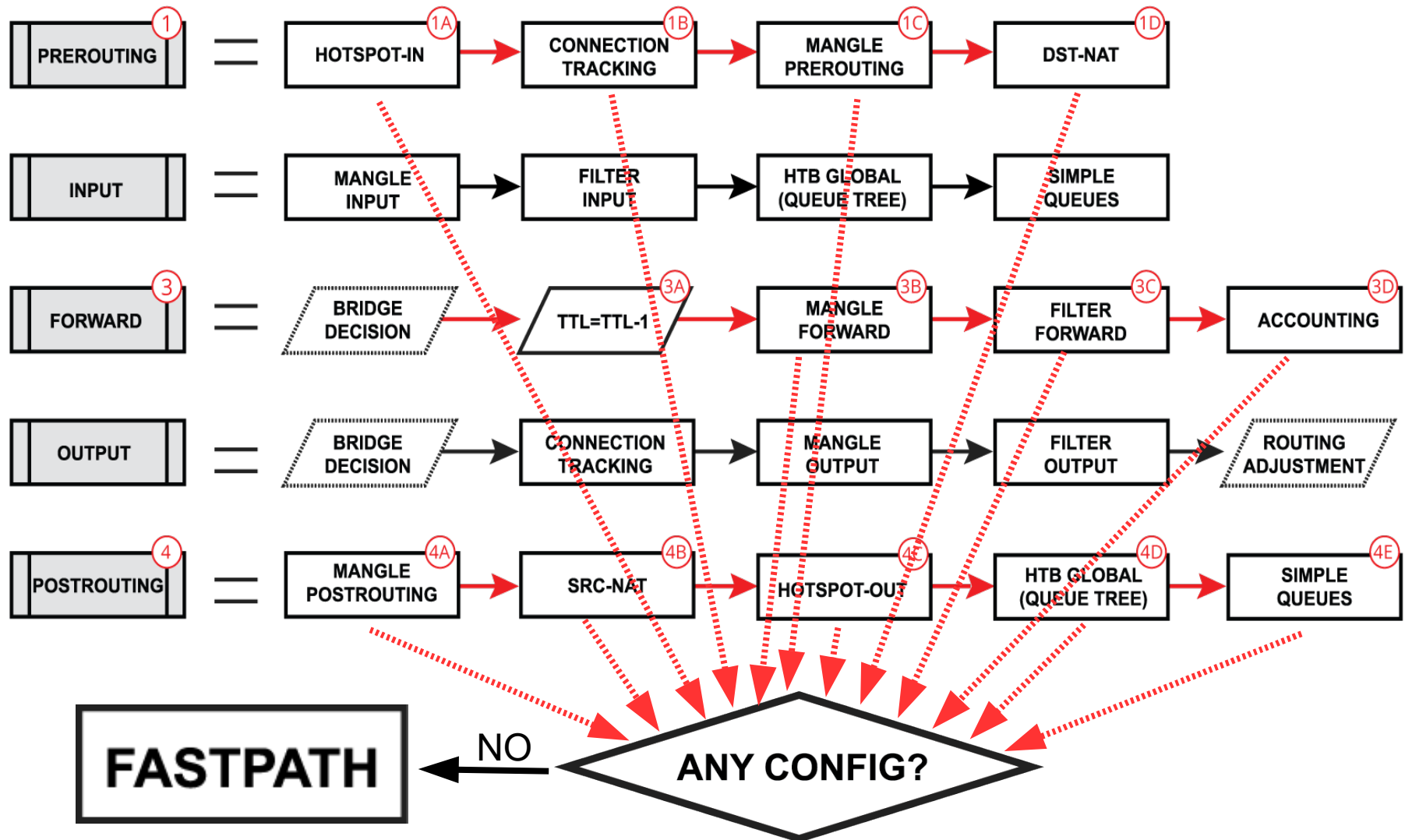
Bridge Forwarding FastPath



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

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)*

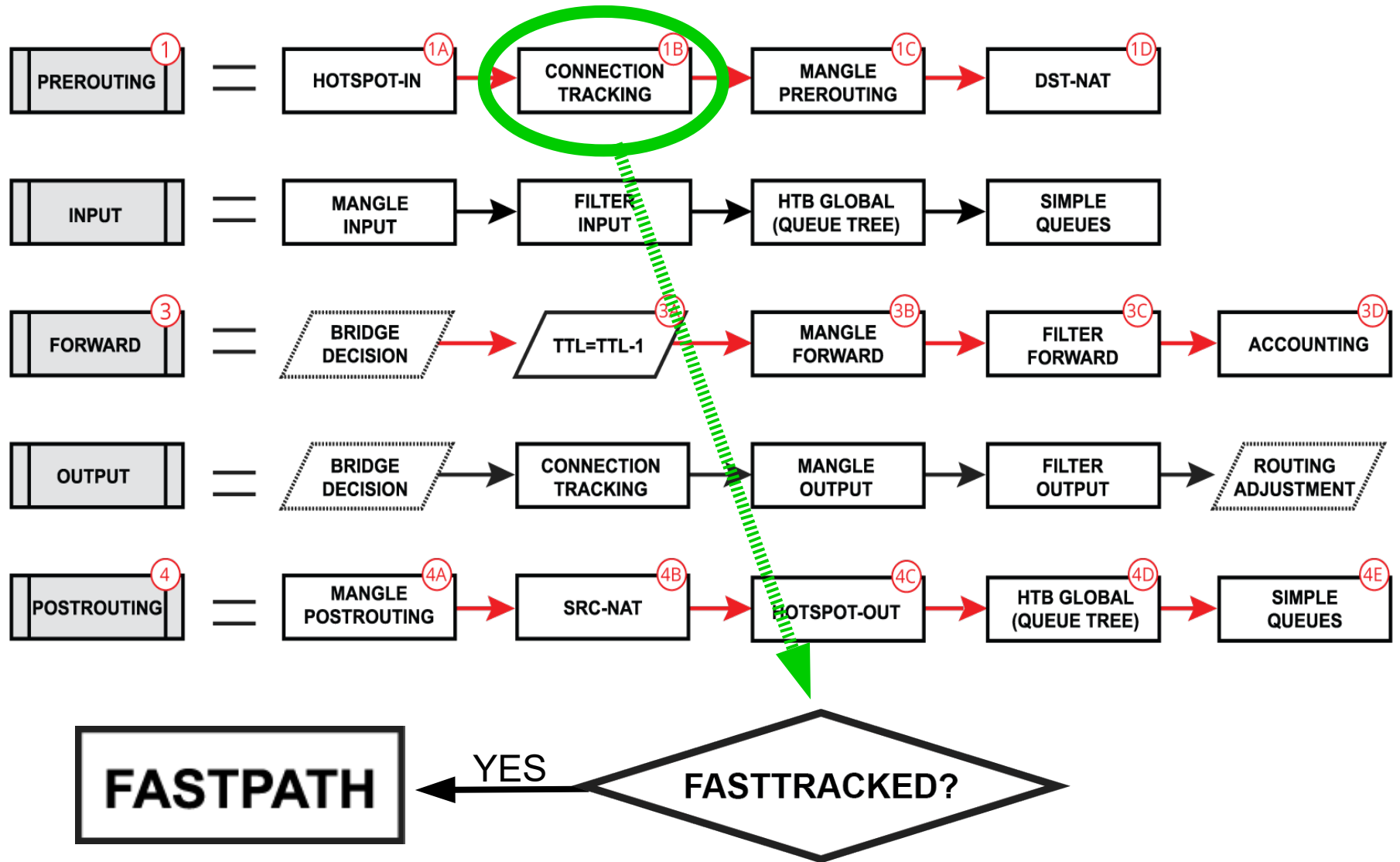
FastPath + Conntrack

- 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 will still follow the regular path to maintain conntrack entries

FastPath + Conntrack = FastTrack

Firewall									
<div> <div>Filter Rules</div> <div>NAT</div> <div>Mangle</div> <div>Service Ports</div> <div>Connections</div> <div>Address Lists</div> <div>Layer7 Protocols</div> </div> <div> <div>Tracking</div> <div>Find</div> </div>									
	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

+ - ✓ ✗ 📁 T 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											

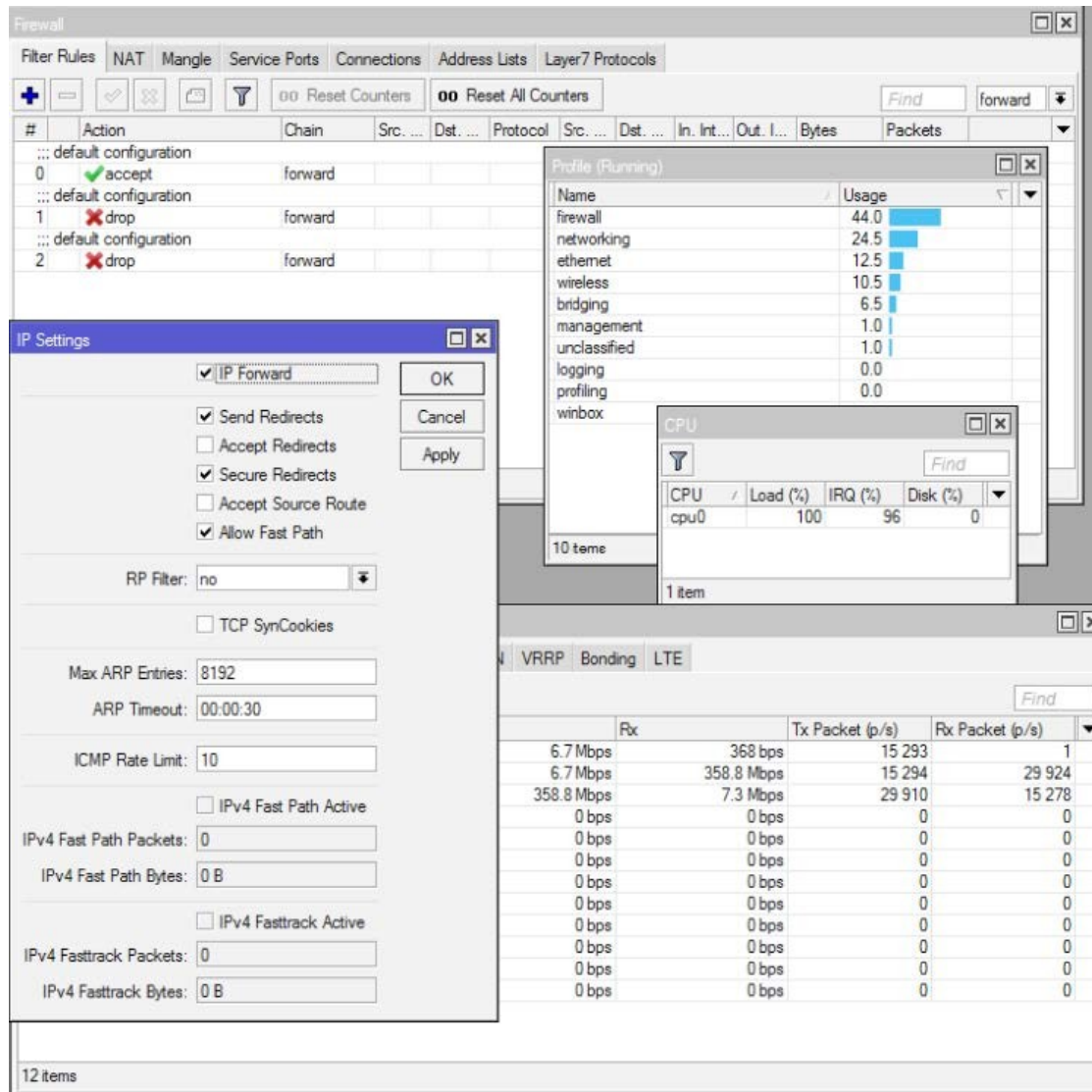
9 items out of 335 (1 selected)

☒ IPv4 Fasttrack Active

IPv4 Fasttrack Packets: 19 773 551

IPv4 Fasttrack Bytes: 15.1 GiB

Without Fasttrack



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

With Fasttrack

The screenshot displays the Mikrotik WinBox Firewall configuration interface. The main window shows the 'Filter Rules' tab with a list of rules. Rule 0 is 'fasttrack connection' with action 'forward'. Rule 1 is 'accept' with action 'forward'. Rule 2 is 'drop' with action 'forward'. Rule 3 is 'drop' with action 'forward'. The 'IP Settings' dialog is open, showing 'IP Forward' checked, 'Send Redirects' checked, 'Accept Redirects' unchecked, 'Secure Redirects' checked, 'Accept Source Route' unchecked, and 'Allow Fast Path' checked. The 'RP Filter' is set to 'no'. The 'Max ARP Entries' is 8192, 'ARP Timeout' is 00:00:30, and 'ICMP Rate Limit' is 10. The 'IPv4 Fast Path Active' checkbox is unchecked, while 'IPv4 Fasttrack Active' is checked. The 'IPv4 Fasttrack Packets' counter shows 91 731 558 and 'IPv4 Fasttrack Bytes' shows 84.5 GiB. The 'Profile (Running)' window shows the following 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, and winbox 0.5. The 'CPU' window shows 'cpu0' with a load of 86%, IRQ of 82, and disk of 0%. The 'VRRP' window shows the following statistics:

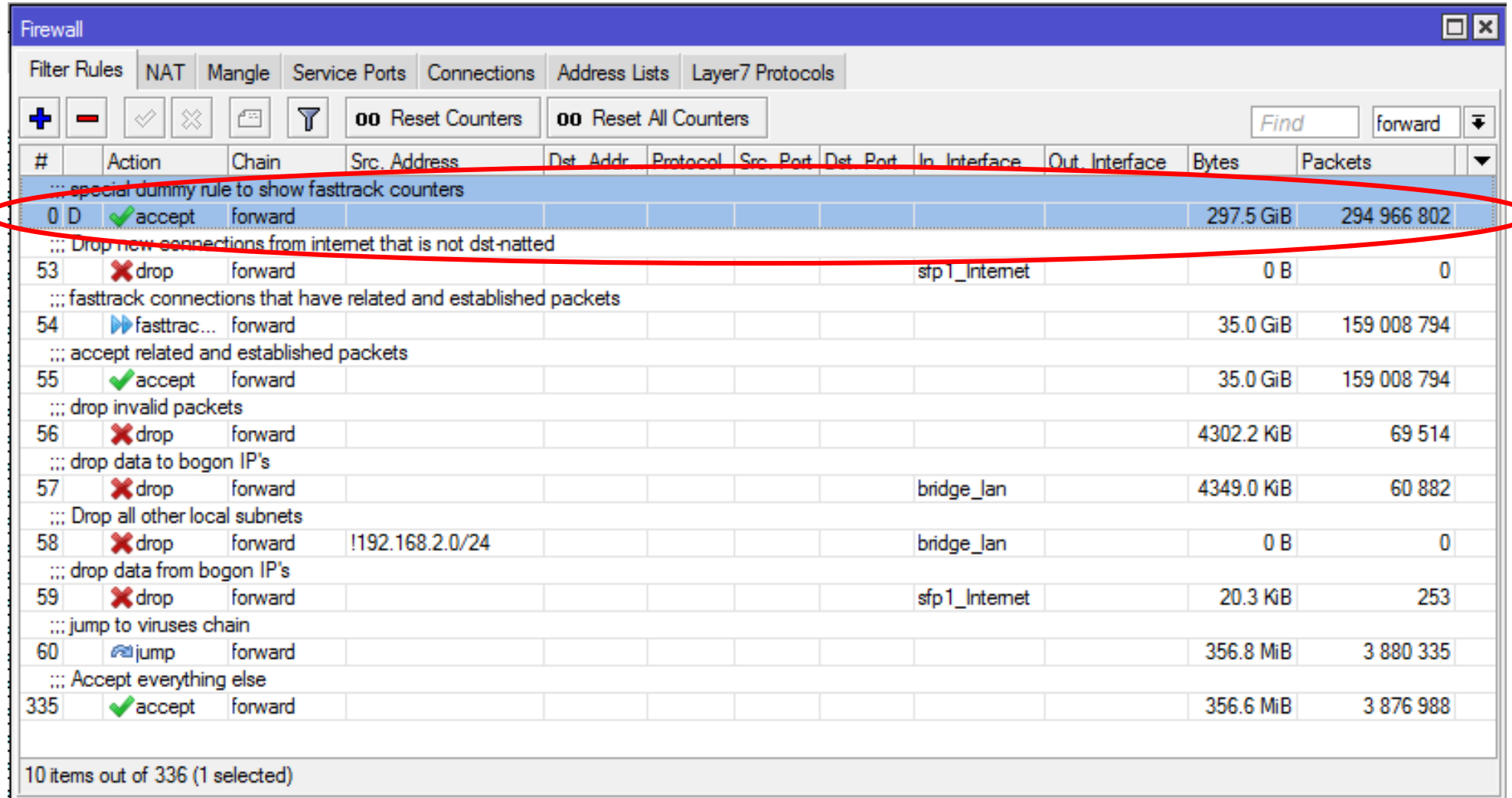
	Rx	Tx Packet (p/s)	Rx Packet (p/s)
18.0 Mbps	368 bps	37 214	1
18.0 Mbps	890.6 Mbps	37 215	73 857
890.6 Mbps	17.9 Mbps	73 848	37 203
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0

- Board:
RB2011UiAS-2HnD
- Configuration:
default Home AP
- Throughput:
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

+ - [check] [x] [filter] [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 [check] accept	forward								297.5 GiB	294 966 802
::: Drop new connections from internet that is not dst-natted											
53	[x] drop	forward						stp1_Intemet		0 B	0
::: fasttrack connections that have related and established packets											
54	[fasttrack] fasttrac...	forward								35.0 GiB	159 008 794
::: accept related and established packets											
55	[check] 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] jump	forward								356.8 MiB	3 880 335
::: Accept everything else											
335	[check] accept	forward								356.6 MiB	3 876 988

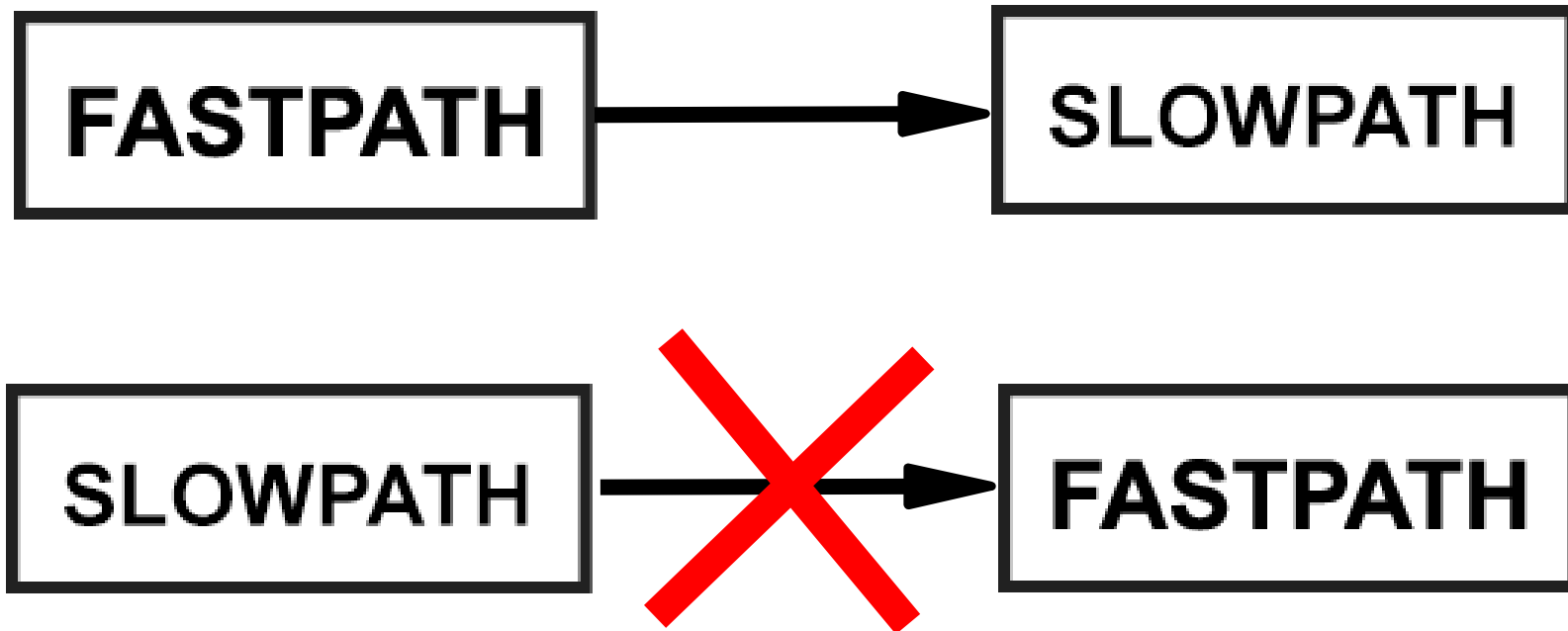
10 items out of 336 (1 selected)

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

Half-FastPath

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

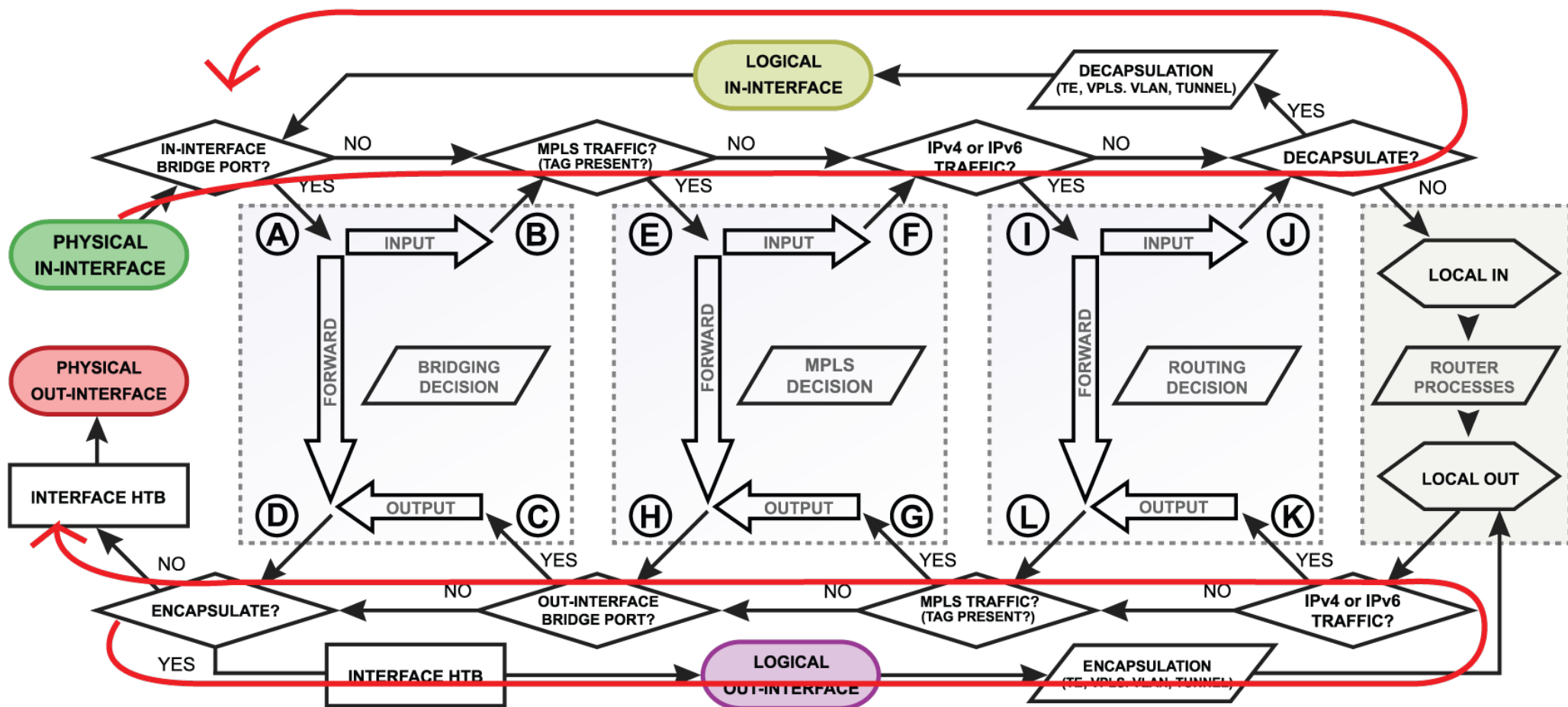


FastPath for Logical Interfaces

FastPath is supported for these logical interfaces
(without encryption and no fragmentation)

- Bridge (since v6.29)
- VLAN (since v6.30)
- VRRP (since v6.30)
- Bonding - RX only (since v6.30)
- EOIP, GRE, IPIP (since v6.33)
- PPPoE client (**since v6.35**)
- L2TP (**since v6.35**) (PPPoE client + L2TP = LNS)

Logical Interfaces in RouterOS



PPPoE FastPath Performance

- Without fragmentation and encryption

Setup: CCR1036<--10G-->CCR1036

In kpps

Conntrack	FastPath	Version	Packet size			
			64B	512B	1024B	1280B
No	N/A	6.7	294.8	305.4	302.3	305.3
No	N/A	6.8rc1	5,519.3	<u>4,634.2</u>	<u>2,378.9</u>	<u>1,913.1</u>
No	FastPath	6.35rc34	26,065.1	<u>4,634.2</u>	<u>2,378.9</u>	<u>1,913.1</u>
Yes	N/A	6.7	277.2	260.4	192.3	183.9
Yes	N/A	6.8rc1	2,730.6	2,462.7	2,103.6	1,910.6
Yes	No	6.35rc34	3,065.6	3,001.7	<u>2,378.9</u>	<u>1,913.1</u>
Yes	Fasttrack	6.35rc34	12,379.1	<u>4,634.2</u>	<u>2,378.9</u>	<u>1,913.1</u>

EOIP, GRE, IP/IP, L2TP 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.

L2TP FastPath Performance

- Without fragmentation and encryption

Setup: CCR1036<--10G-->CCR1036

In kpps

Conntrack	FastPath	Version	Packet size			
			64B	512B	1024B	1280B
No	N/A	6.7	120.9	123.4	197.5	197.8
No	N/A	6.8rc1	3,708.6	3,522.1	<u>2,312.6</u>	<u>1,869.8</u>
No	FastPath	6.35rc34	19,645.0	<u>4,385.4</u>	<u>2,312.6</u>	<u>1,869.8</u>
Yes	N/A	6.7	98.1	105.4	103.2	101.5
Yes	N/A	6.8rc1	1,687.1	1,580.9	1,382.3	1,302.8
Yes	No	6.35rc34	2,379.5	2,320.3	2,156.8	<u>1,869.8</u>
Yes	Fasttrack	6.35rc34	8,109.3	<u>4,385.4</u>	<u>2,312.6</u>	<u>1,869.8</u>

Without pppoe-client Fastpath Support

The screenshot displays the Mikrotik WinBox interface with three main windows open:

- Firewall:** Shows a list of 8 items. The rules are as follows:

#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inte...	Out. In...	By
;;; special dummy rule to show fasttrack counters										
0	D	acc...	forward							19
;;; defconf: fasttrack										
1	fast...	forward								23
;;; defconf: accept established,related										
2	acc...	forward								23
;;; defconf: accept ICMP										
3	acc...	input			1 (ic...					
;;; defconf: accept established,related										
4	acc...	input								
;;; defconf: drop all from WAN										
5	drop	input						ether1		
;;; defconf: drop invalid										
6	drop	forward								

8 items

- Profile (Running):** Shows usage for various profiles.

Name	Usage
firewall	53.0
ethernet	17.5
networking	15.5
bridging	6.5
wireless	3.5
unclassified	1.0
management	1.5
idle	0.5
profiling	0.5
winbox	0.5

10 items

- Interface List:** Shows a list of interfaces. The first item is highlighted:

Name	Type	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP T...
R	pppoe-out1	PPPoE Client		4.1 Mbps	388.4 Mbps	9 943	32 825	0 bps	0 bps

1 item out of 14

CPU: Shows system statistics.

CPU	Load (%)	IRQ (%)	Disk (%)
cpu0	99	93	0

1 item

With pppoe-client Fastpath Support

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

- Firewall**: Shows a list of 8 firewall rules. Rule 0 is a dummy rule for fasttrack counters. Rule 1 is a fasttrack rule. Rule 2 is a default rule for established/related connections. Rule 3 is a rule for ICMP. Rule 4 is a rule for established/related connections. Rule 5 is a rule to drop all traffic from the WAN interface (ether1). Rule 6 is a rule to drop invalid connections.
- Profile (Running)**: Shows the usage of various profiles. The 'ethernet' profile is the most used at 53.5%.
- Interface List**: Shows a list of interfaces. The 'pppoe-out1' interface is highlighted, showing it is a PPPoE Client with a speed of 7.2 Mbps.
- CPU**: Shows the CPU status for 'cpu0', with a load of 95% and an IRQ of 90.

Firewall Rules Table:

#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inte...	Out. In...	B
0	acc...	forward								
1	fast...	forward								
2	acc...	forward								
3	acc...	input			1 (ic...					
4	acc...	input								
5	drop	input						ether1		
6	drop	forward								

Profile (Running) Usage Table:

Name	Usage
ethernet	53.5
networking	16.5
bridging	9.5
unclassified	7.0
idle	6.0
management	3.0
firewall	2.0
wireless	2.0
winbox	0.5
firewall-mgmt	0.0

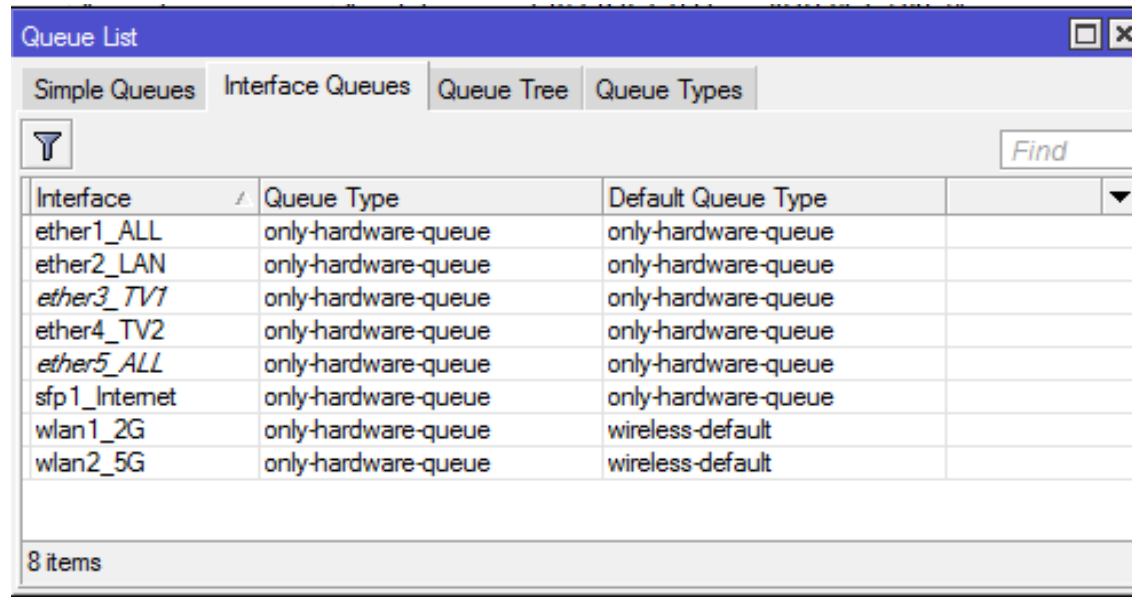
Interface List Table:

Name	Type	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP 1
pppoe-out1	PPPoE Client		7.2 Mbps	887.3 Mbps	13 629	74 259	7.2 Mbps	887.3 Mbps	

CPU Status Table:

CPU	Load (%)	IRQ (%)	Disk (%)
cpu0	95	90	0

Interface Queue and FastPath



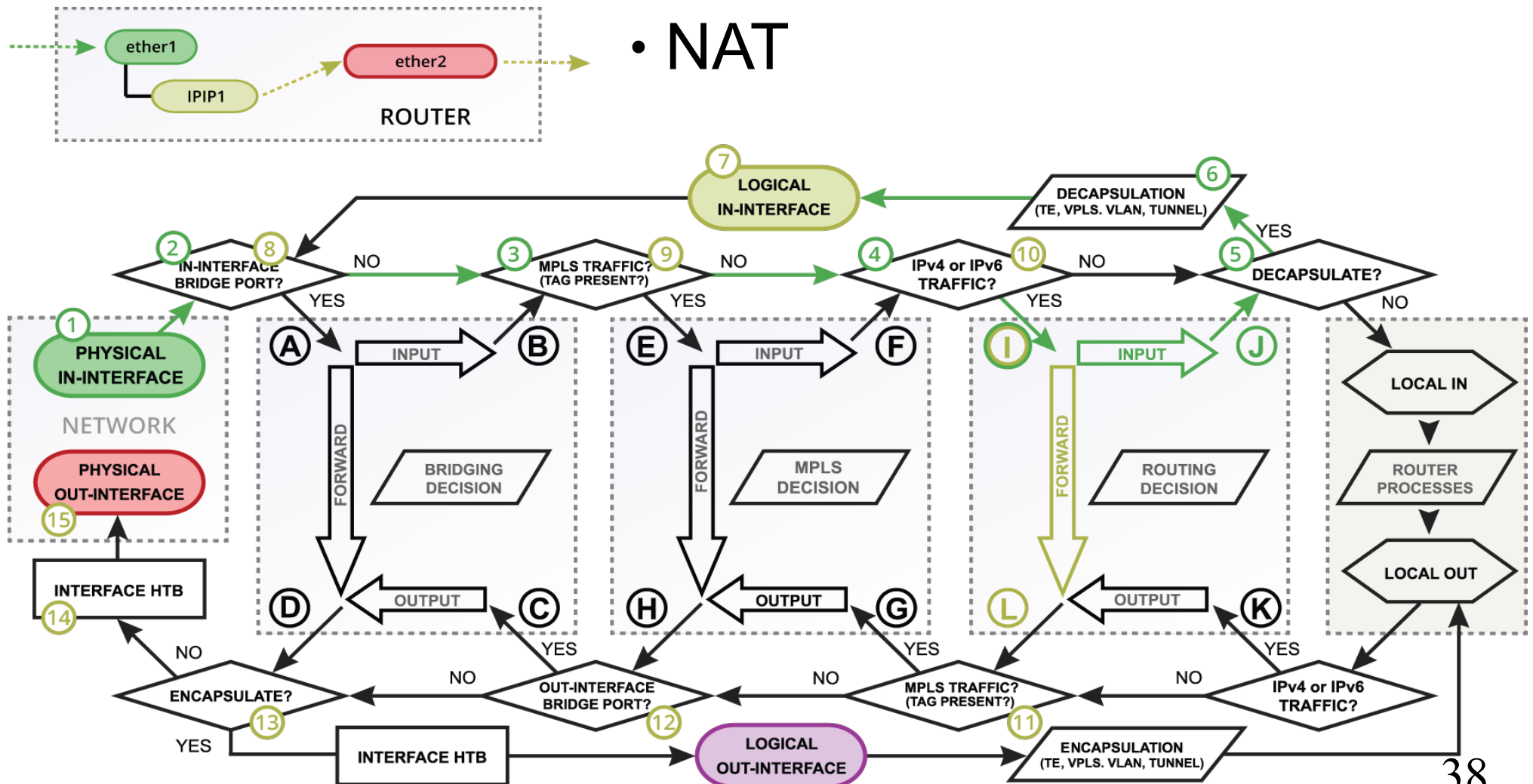
Interface	Queue Type	Default Queue Type
ether1_ALL	only-hardware-queue	only-hardware-queue
ether2_LAN	only-hardware-queue	only-hardware-queue
ether3_TV1	only-hardware-queue	only-hardware-queue
ether4_TV2	only-hardware-queue	only-hardware-queue
ether5_ALL	only-hardware-queue	only-hardware-queue
sfp1_Internet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

8 items

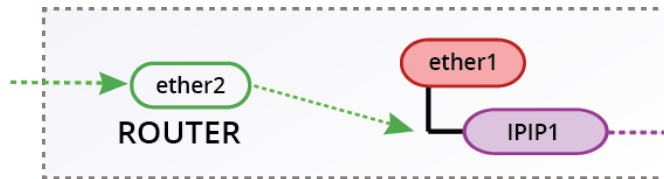
- Only interface queue that guarantees FastPath is “only-hardware-queue”
- Minimal impact on performance, as “Interface HTB” is the last step in the packet flow diagram

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

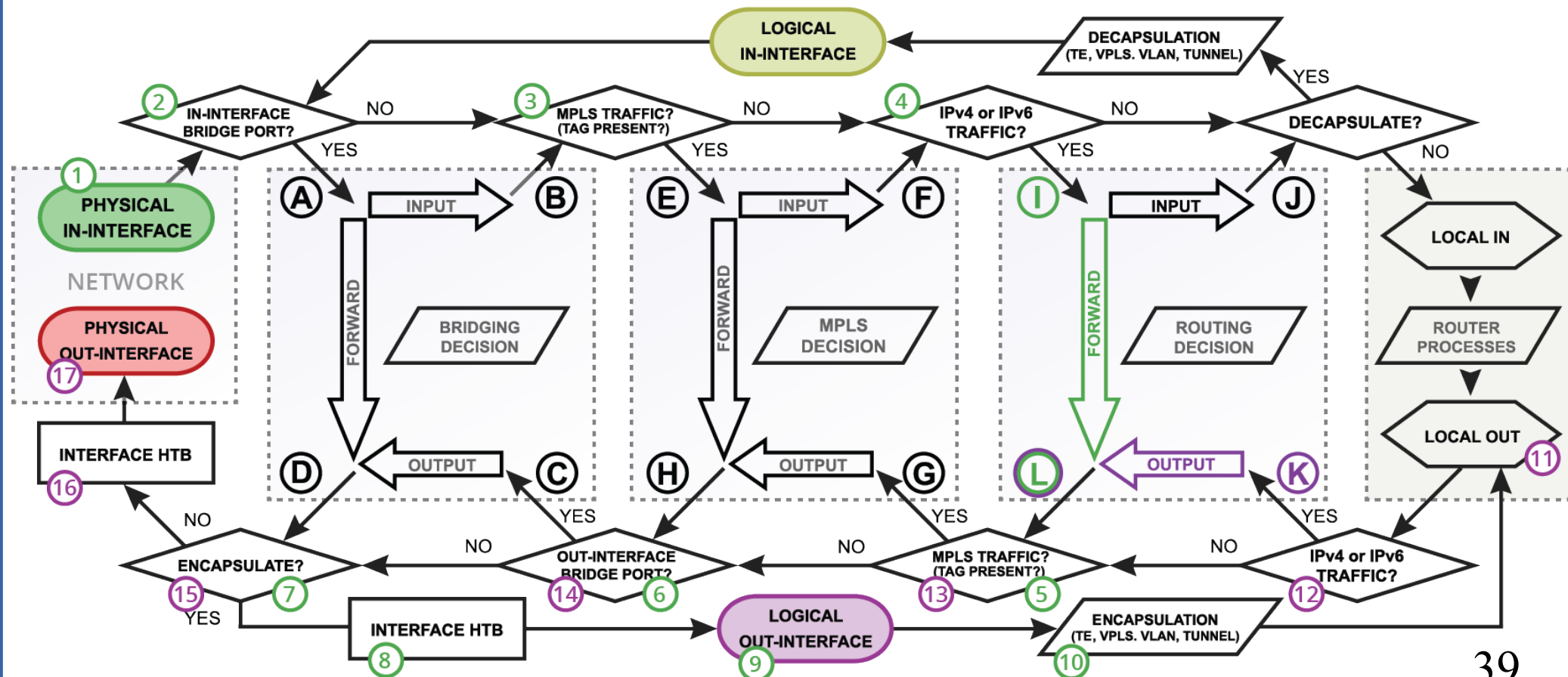
- ICMP traffic
- NAT

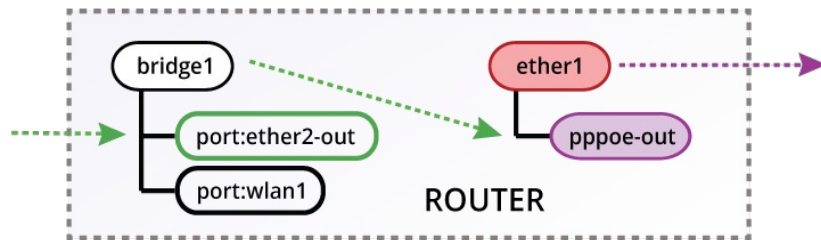


- ether1 and ether2 have FastPath support
- IPIP1 "allow-fast-path" setting disabled
- IP forwarding FastPath allowed

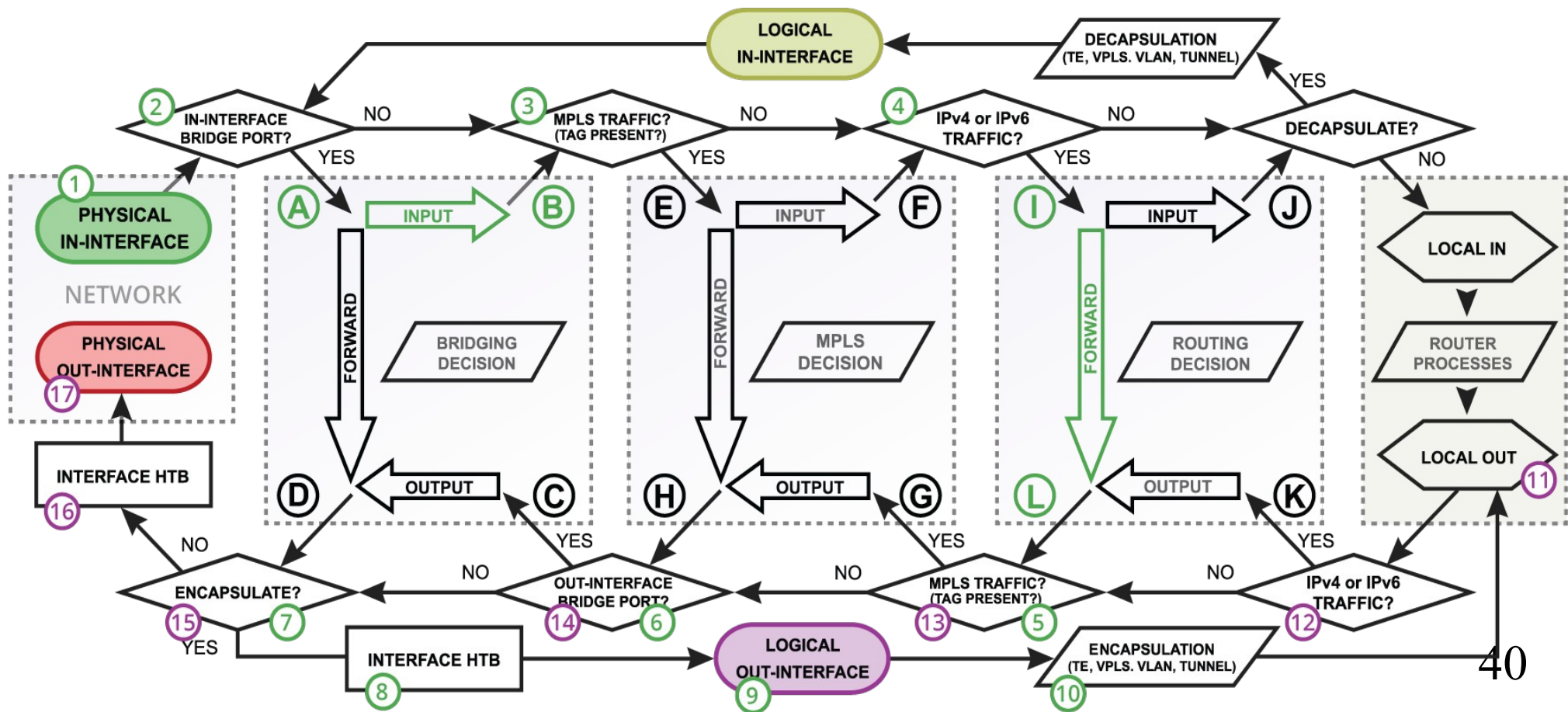


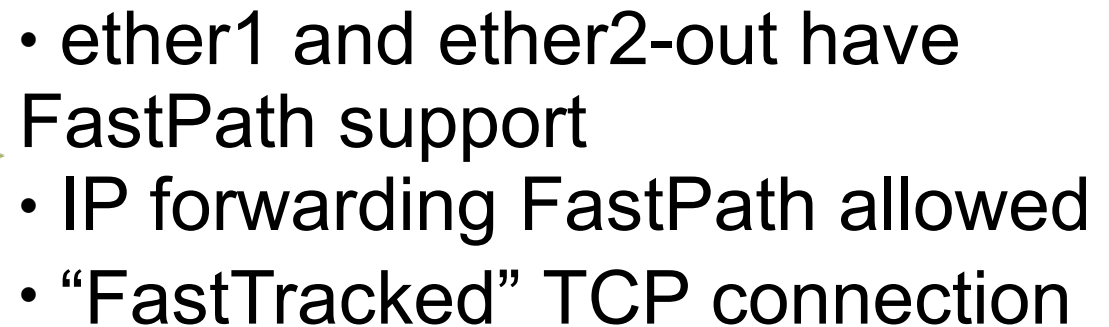
- TCP "FastTraked" connection
- Simple queues





- ether1 and ether2-out have FastPath support
- IP forwarding FastPath allowed
- IPv6/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 and no FastTracked connections.

Questions!!!