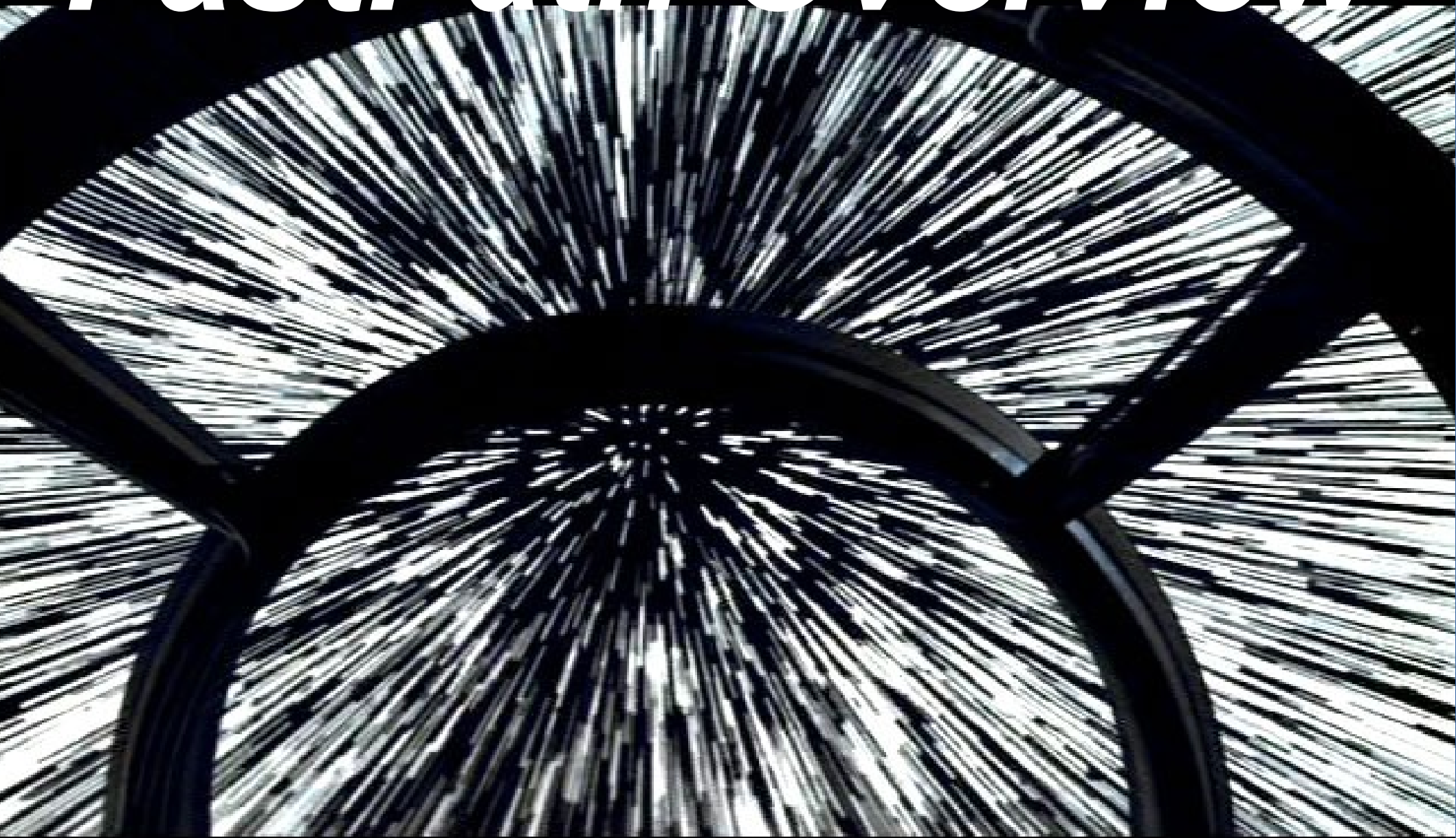
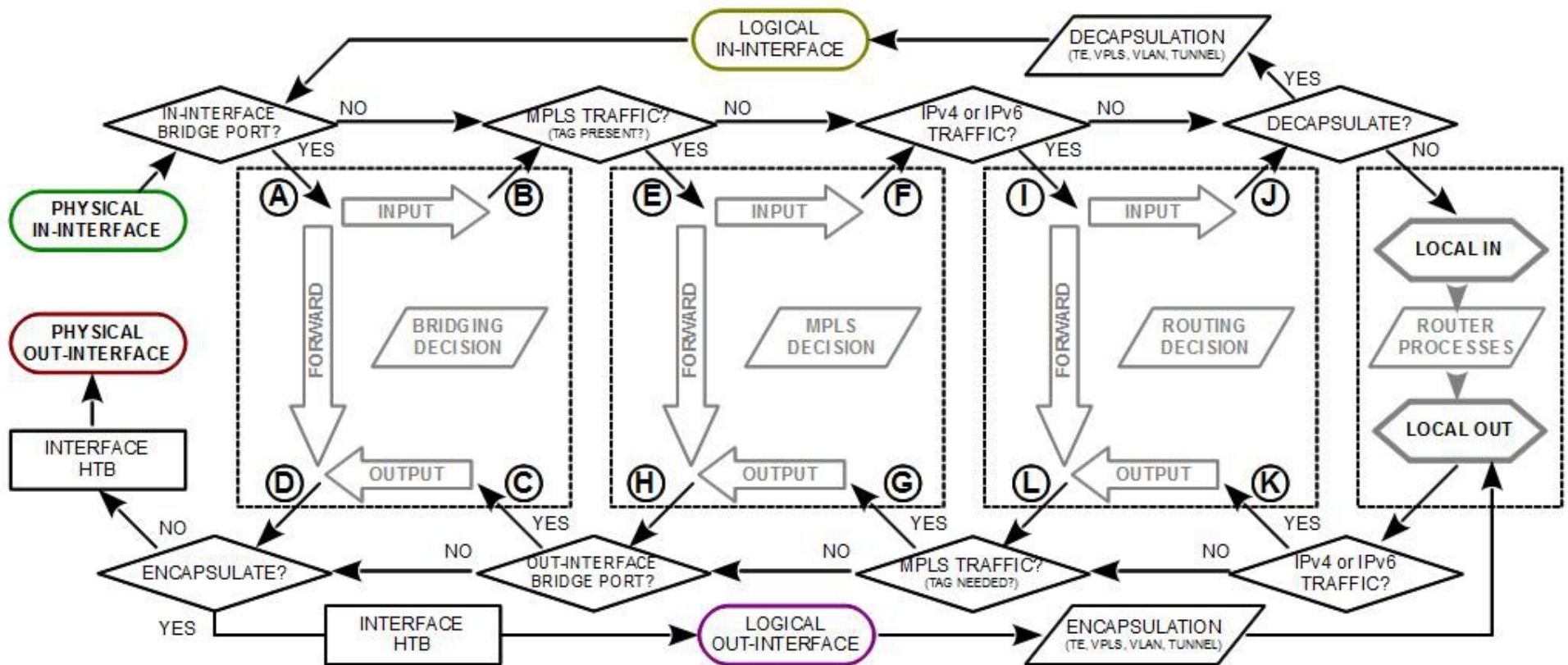


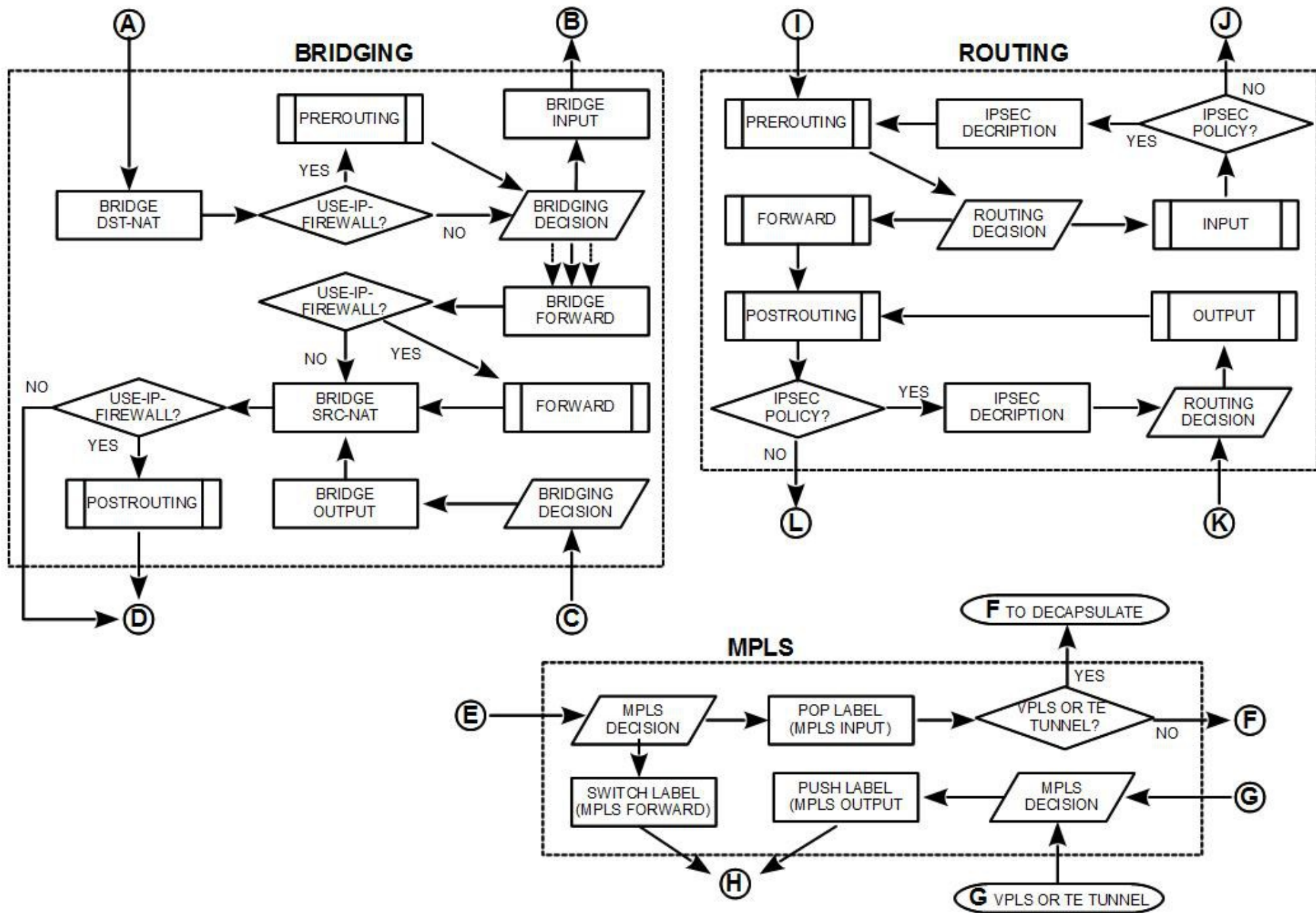
FastPath Overview



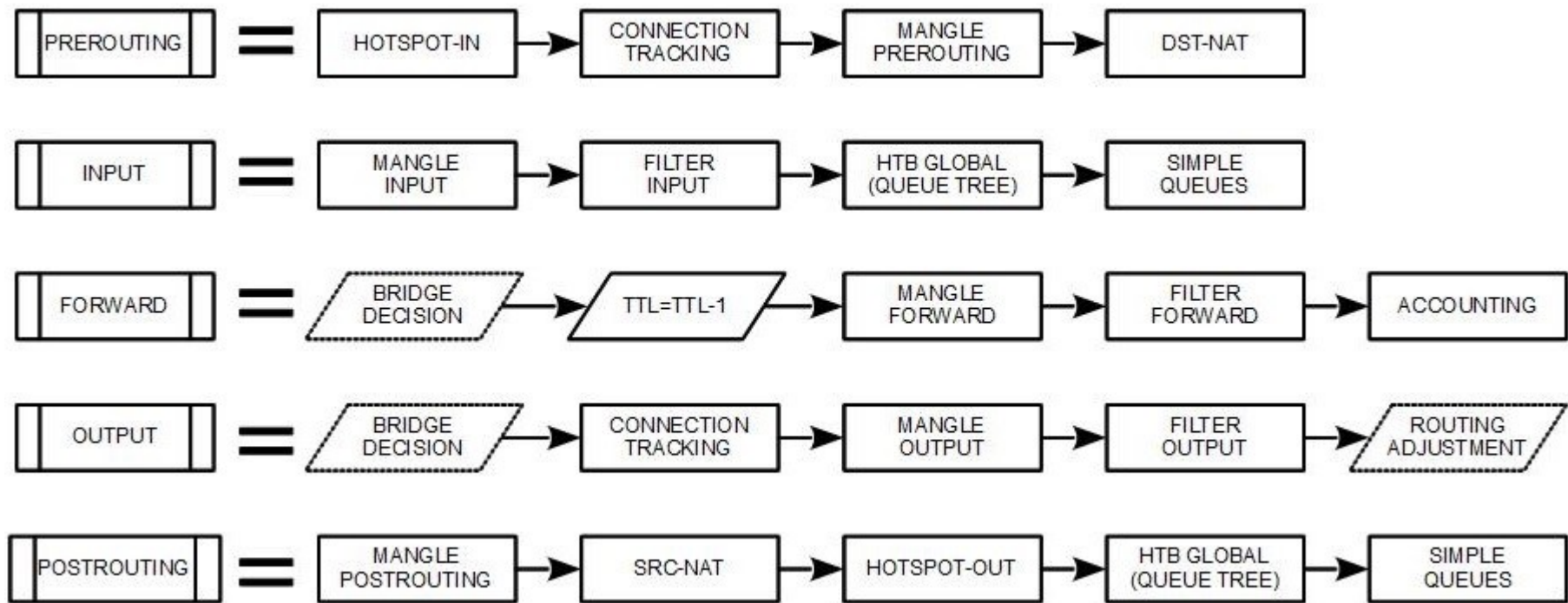
MUM Germany, 2016

MikroTik RouterOS Packet Flow Diagram for version 6.x





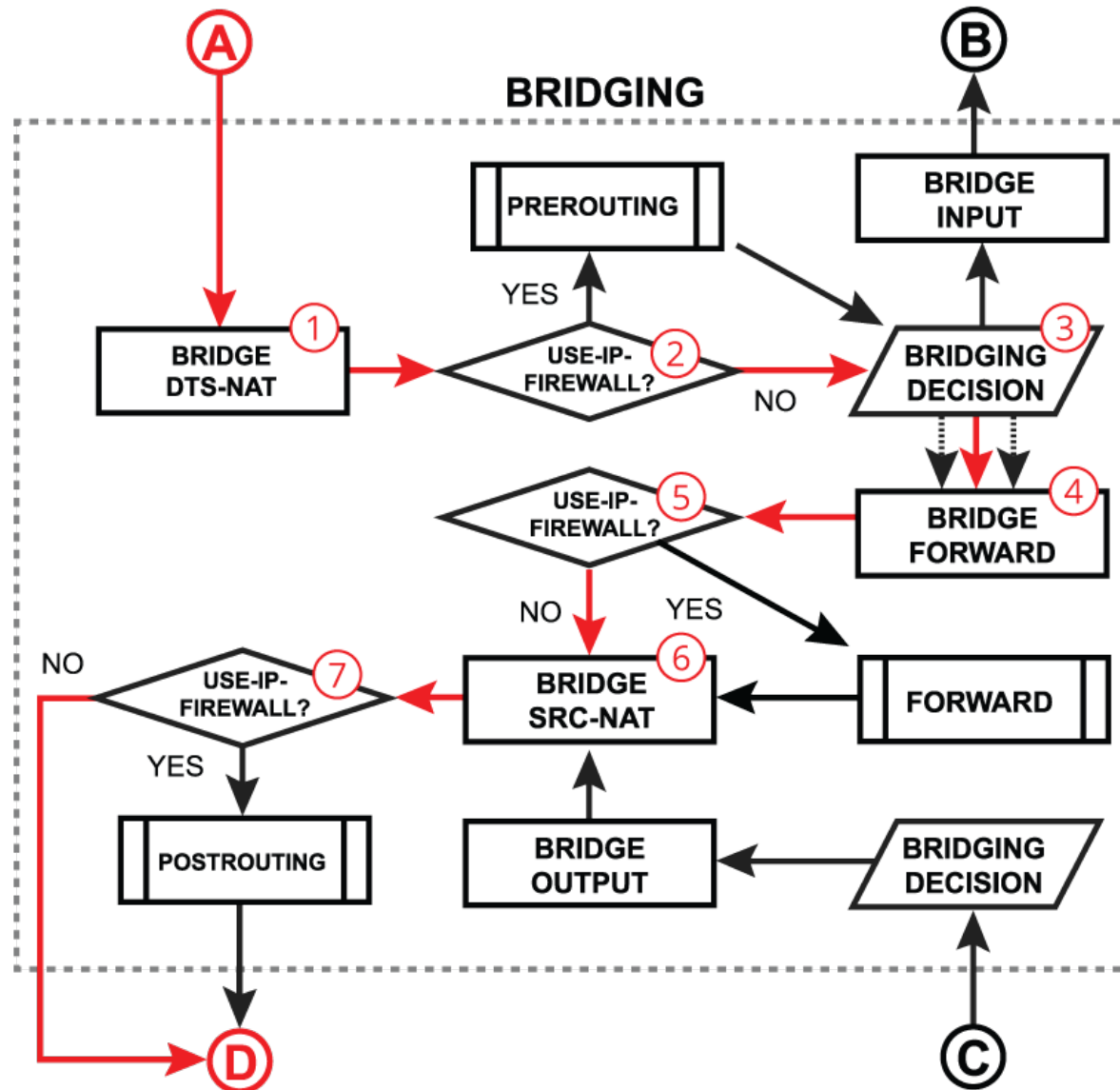
Yes, still - Packet Flow Diagram (page 3)



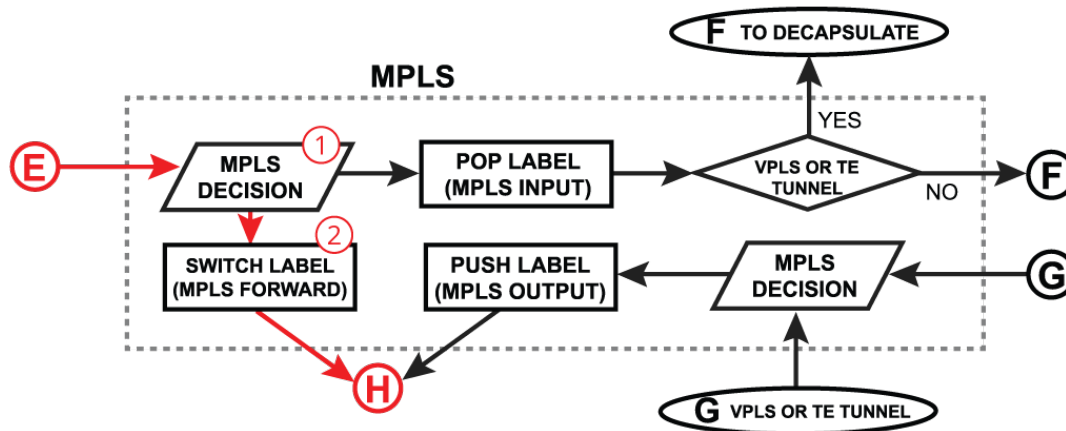
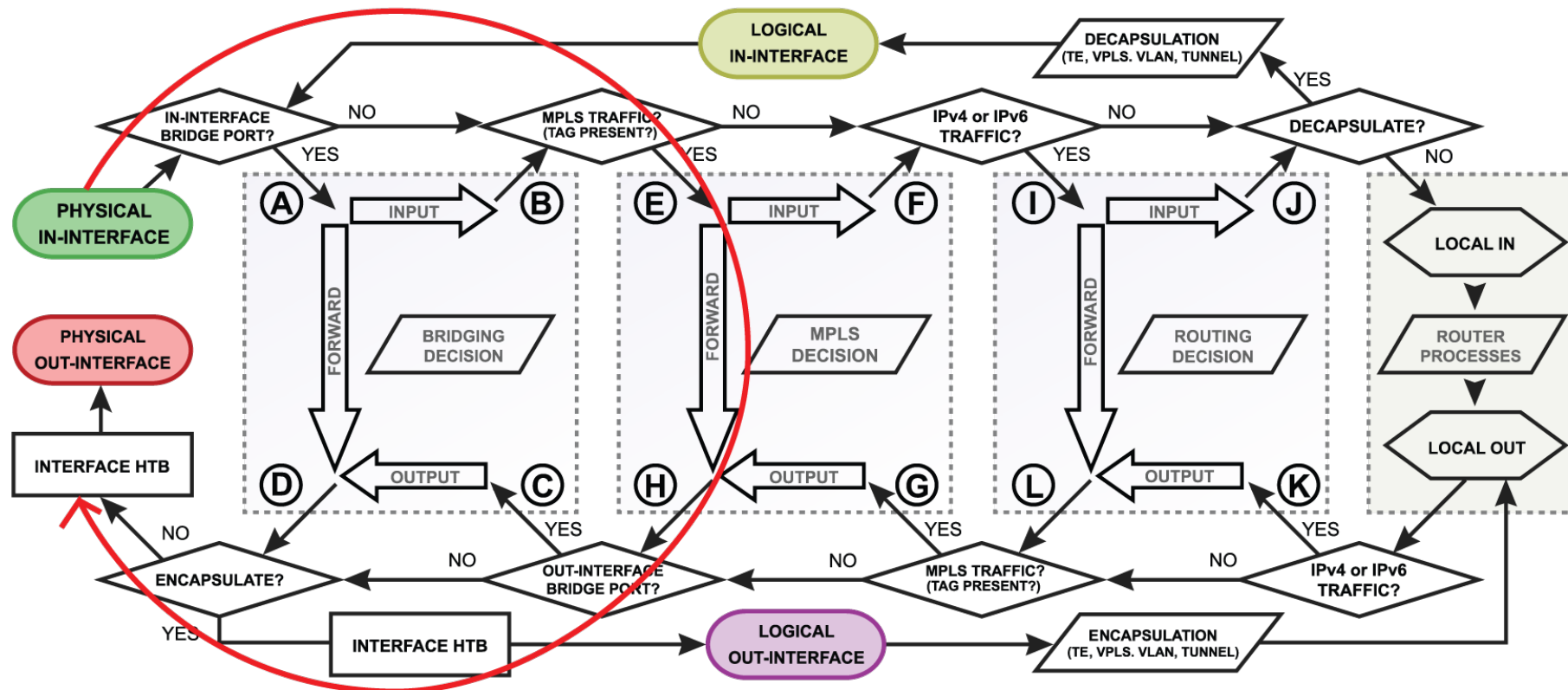
“SlowPath”

- “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

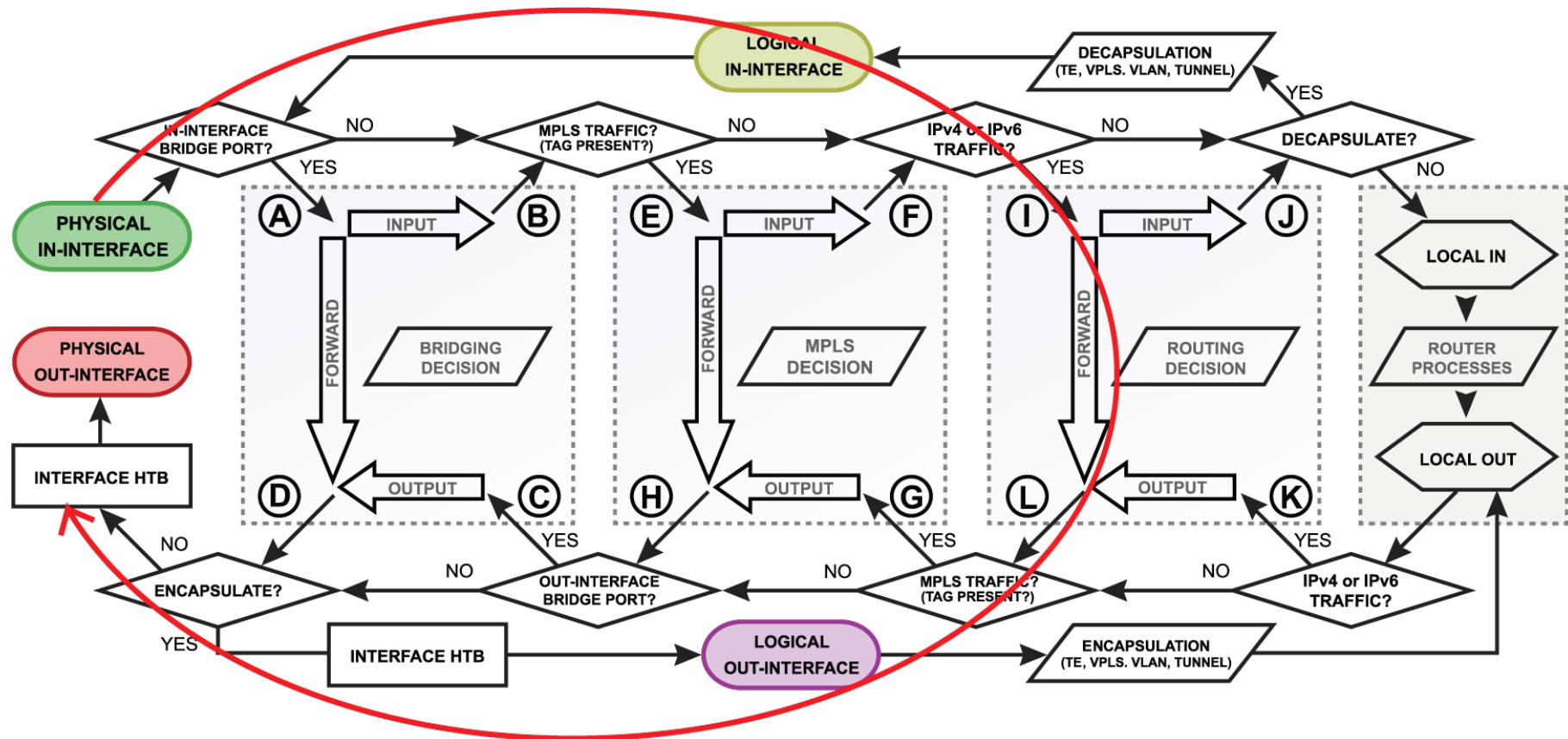
Bridge Forwarding



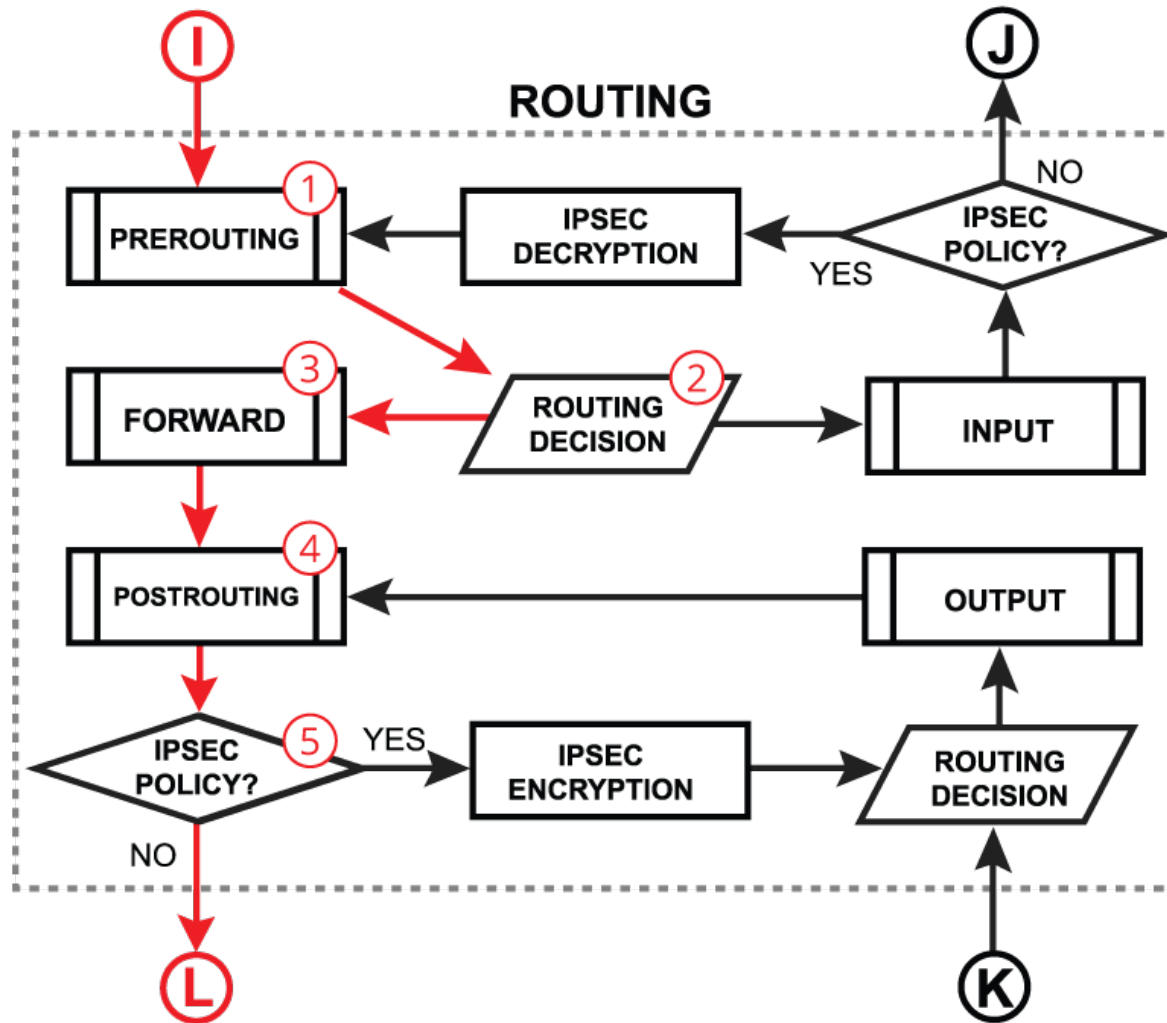
MPLS Forwarding



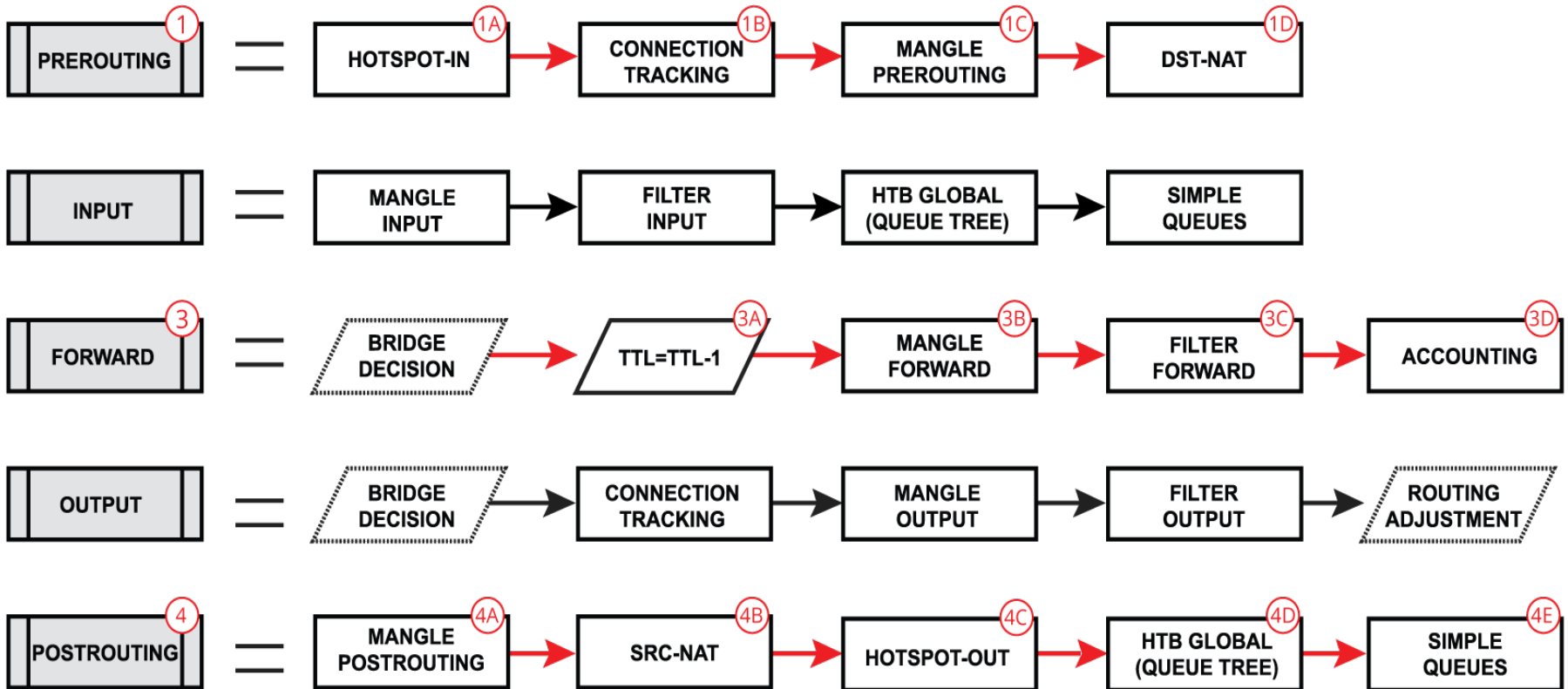
Routing Forwarding



Routing Forwarding



Routing Forwarding



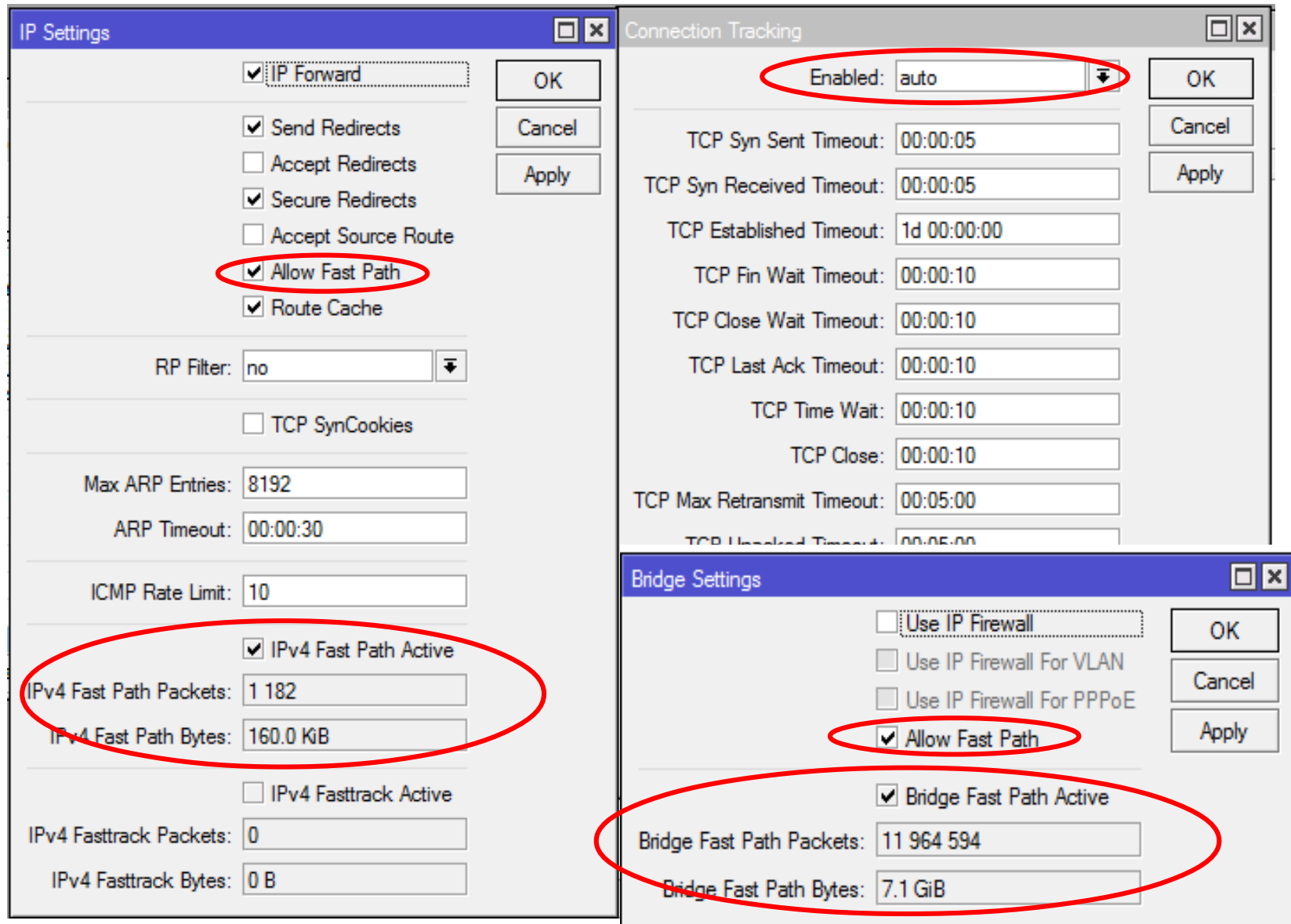
Initial FastPath Implementation

- 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.

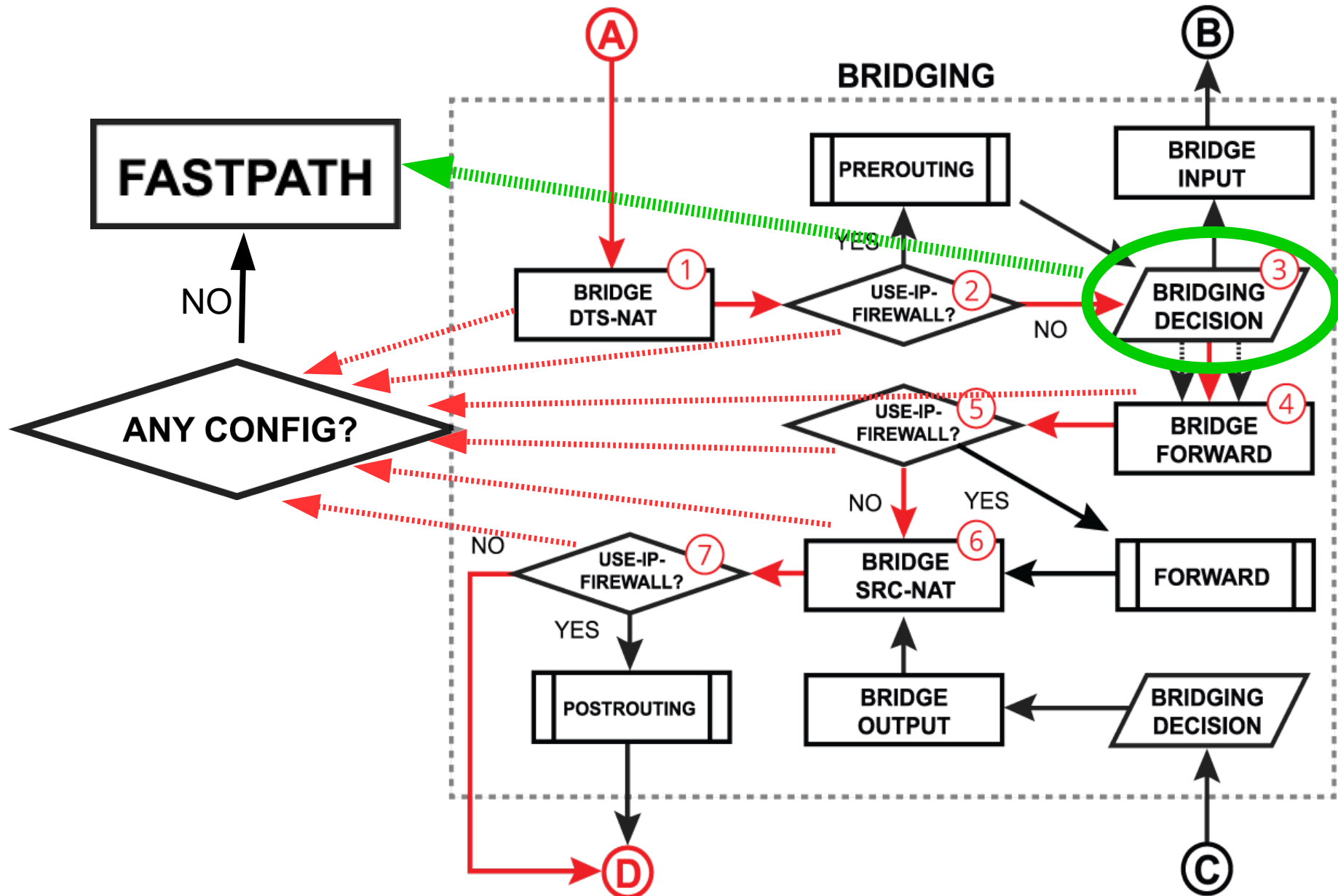
Driver Support

- 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

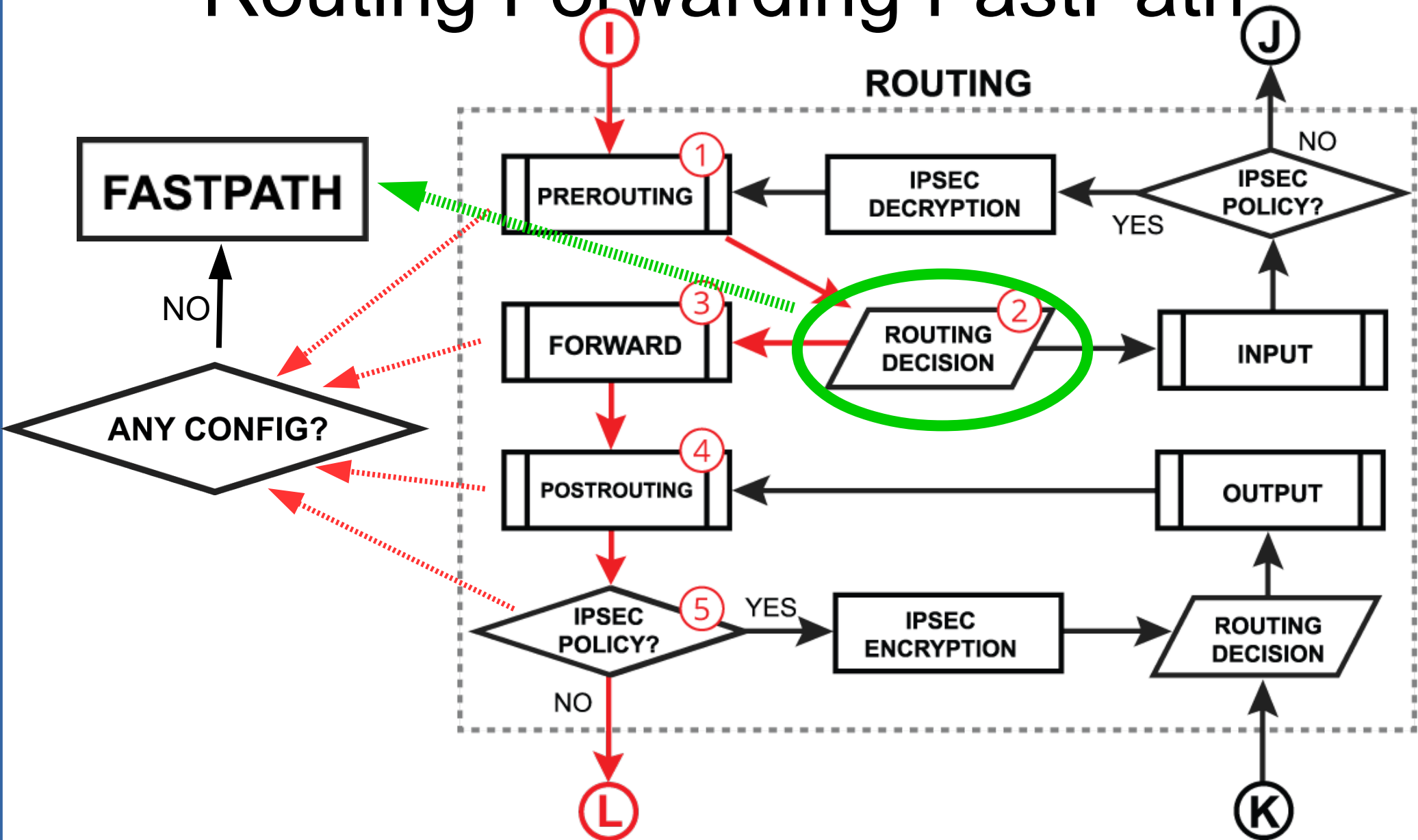
Allow FastPath



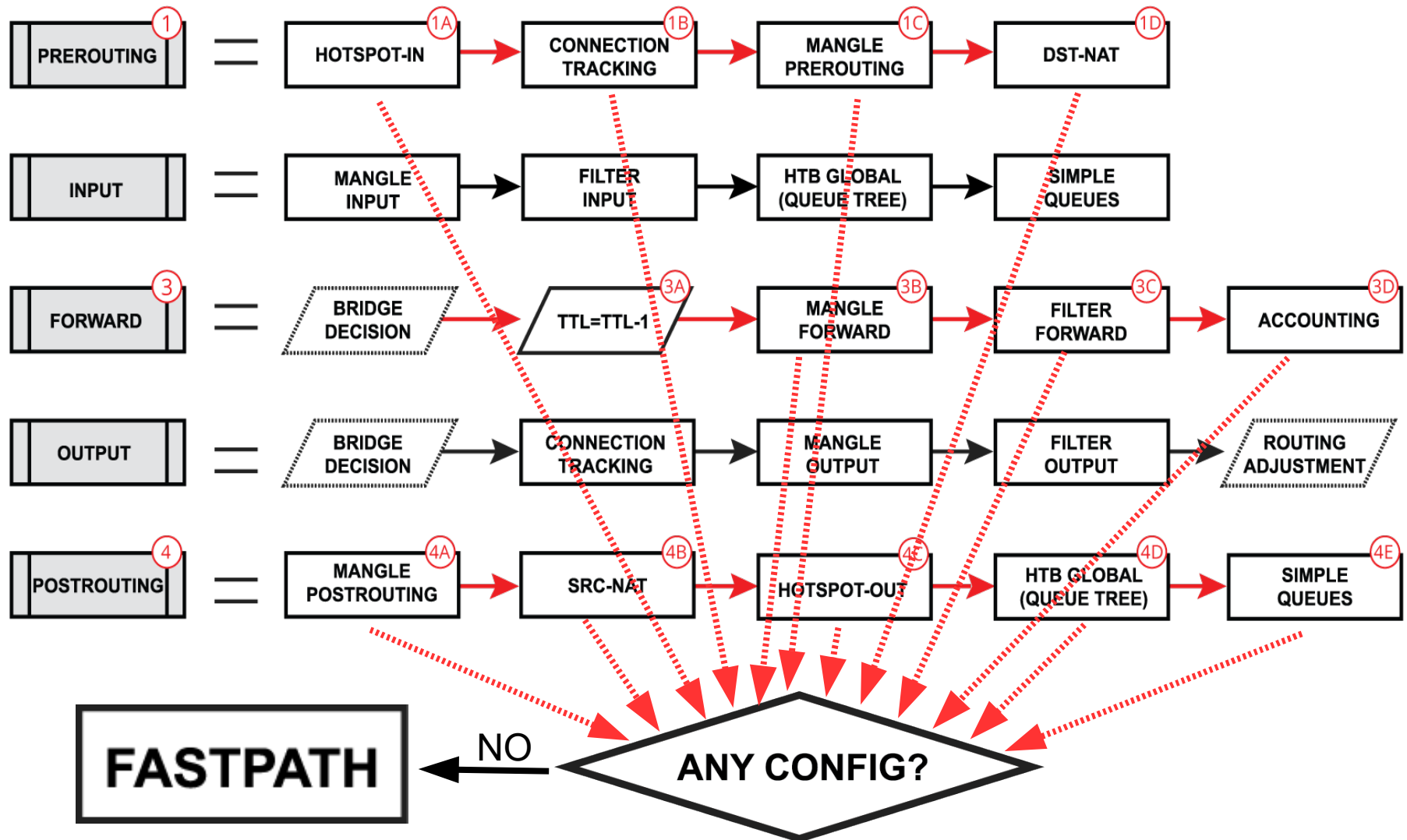
Bridge Forwarding FastPath



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

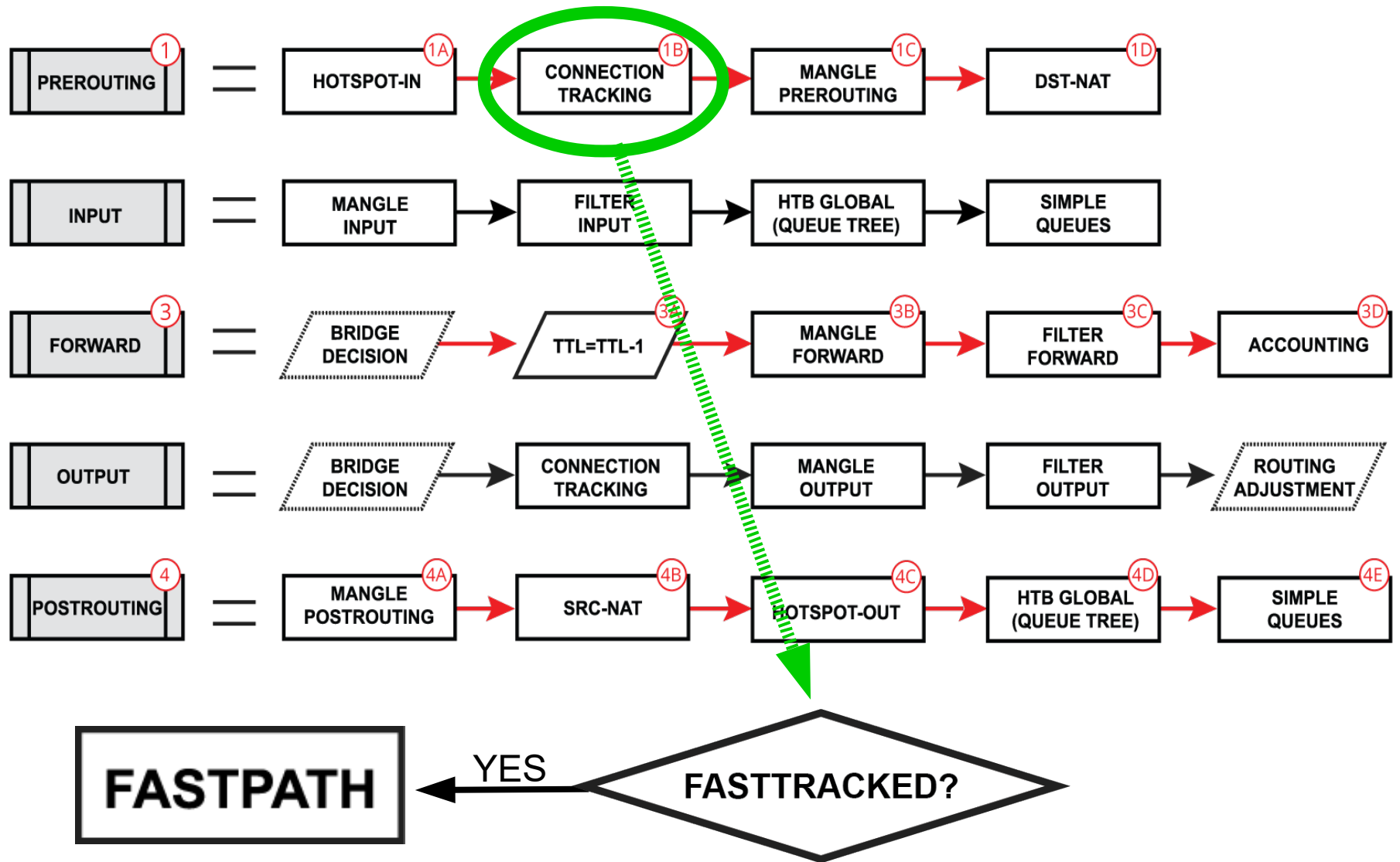
Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

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

Firewall

#	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:

- Firewall 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 include 'Send Redirects', 'Accept Redirects', 'Secure Redirects', 'Accept Source Route', and 'Allow Fast Path' (checked). 'RP Filter' is set to 'no'.
- Profile (Running):** A window showing CPU usage for various services: 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%), and winbox (0.0%).
- CPU:** A window showing CPU load for 'cpu0' at 100%, with an IRQ of 96% and Disk usage of 0%.
- Network Traffic:** A window showing a table of network statistics for '12 items'.

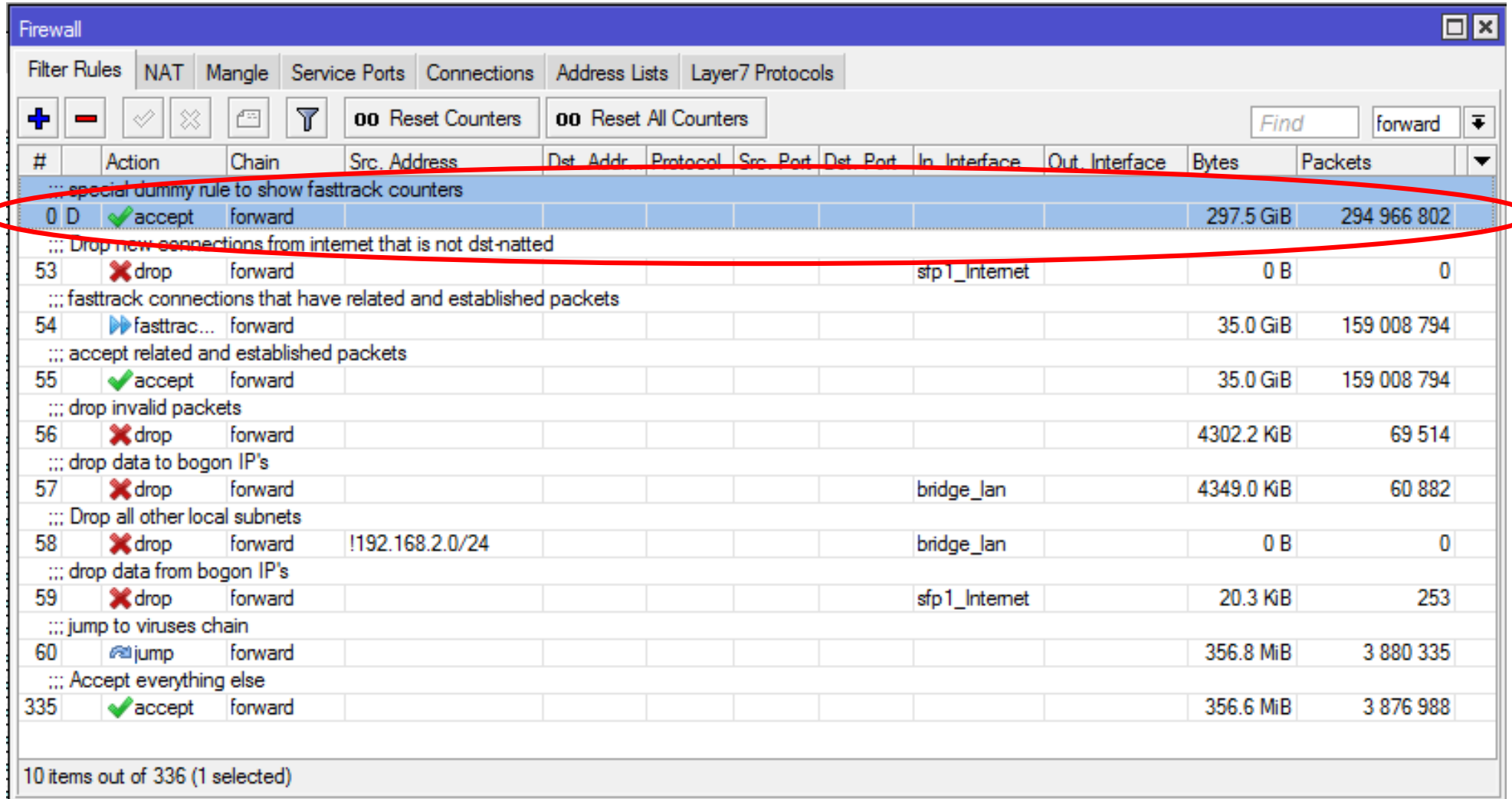
	Rx	Tx Packet (p/s)	Rx Packet (p/s)
6.7 Mbps	368 bps	15 293	1
6.7 Mbps	358.8 Mbps	15 294	29 924
358.8 Mbps	7.3 Mbps	29 910	15 278
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps	0	0
0 bps	0 bps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

- 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

+ - ✓ ✗ [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	▶▶ 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	✗ 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

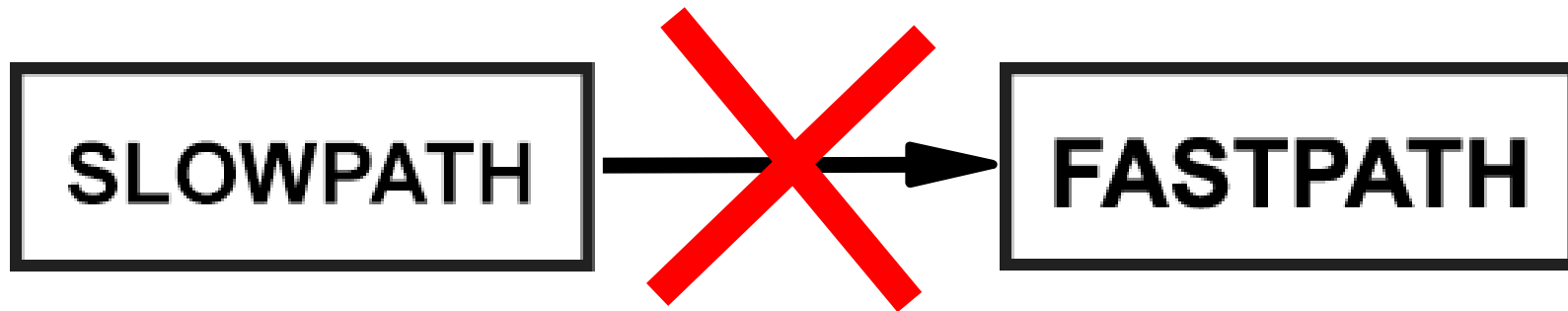
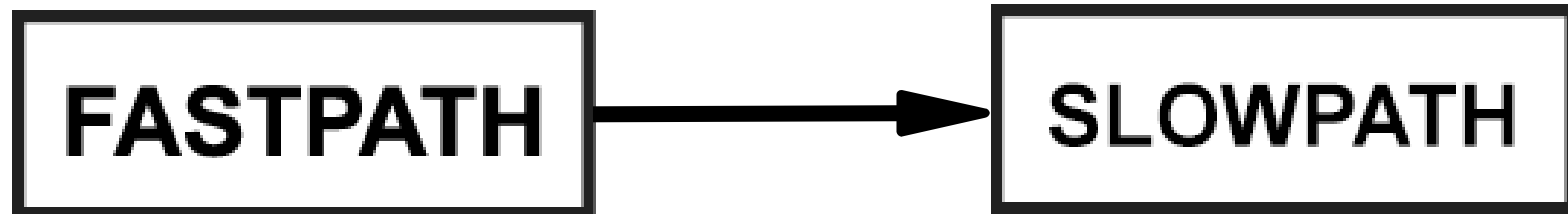
10 items out of 336 (1 selected)

Special Dummy Rule

- This is not an actual rule, it is for visual information only
- Dummy rule shows user that some traffic 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?

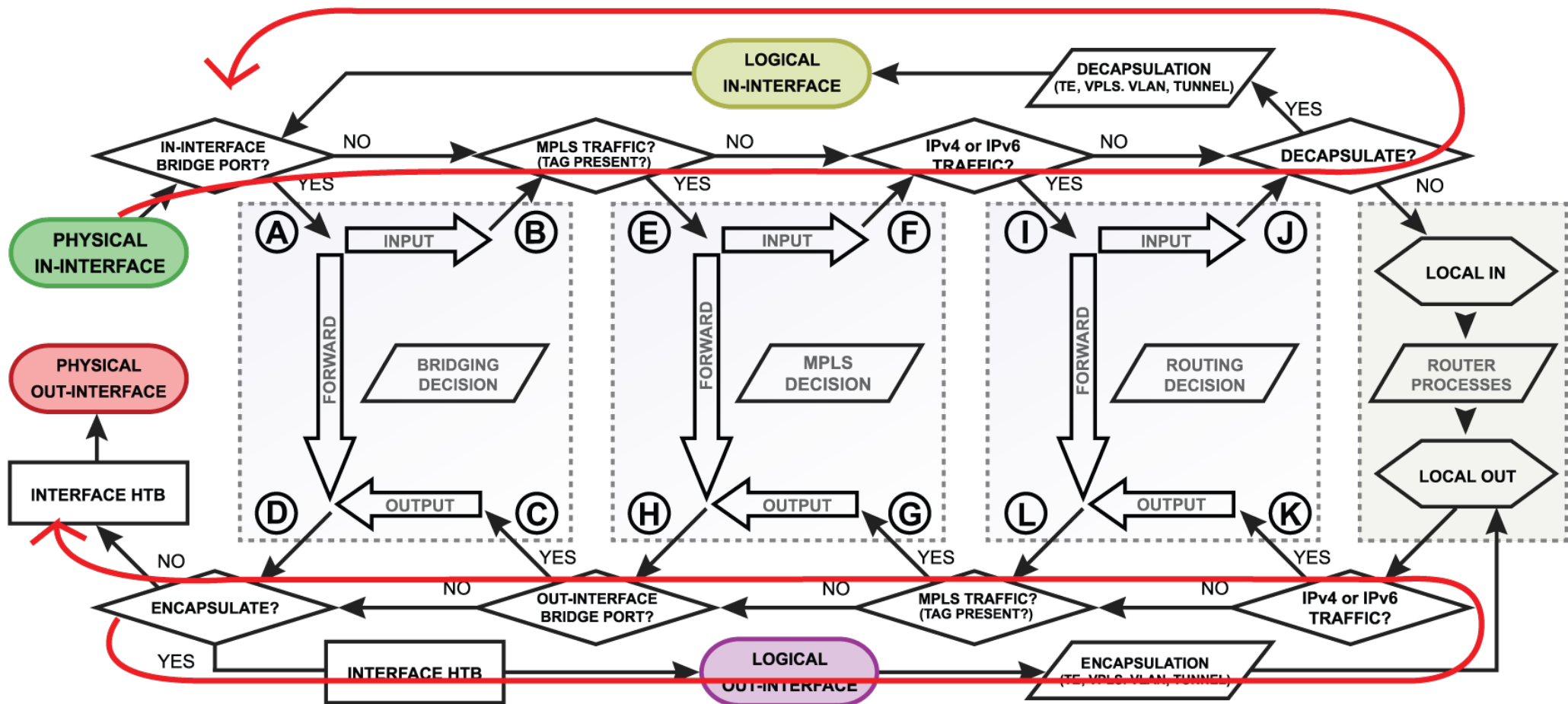


FastPath for Logical Interfaces

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, IPIP, 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, showing the Firewall configuration window and the Interface List window. The Firewall window shows a list of 8 items, including a special dummy rule for fasttrack counters and several default configuration rules. The Interface List window shows a list of 14 interfaces, with the PPPoE client interface selected. A CPU usage window is also visible, showing high CPU load (99%) and IRQ (93%) for the selected interface.

Firewall Configuration Table:

#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inte...	Out. In...	By
0	D	acc...	forward							19
1		fast...	forward							23
2		acc...	forward							23
3		acc...	input		1 (ic...					
4		acc...	input							
5		drop	input					ether1		
6		drop	forward							

Profile (Running) Usage Table:

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

Interface List Table:

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

CPU Usage Table:

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

With pppoe-client Fastpath Support

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

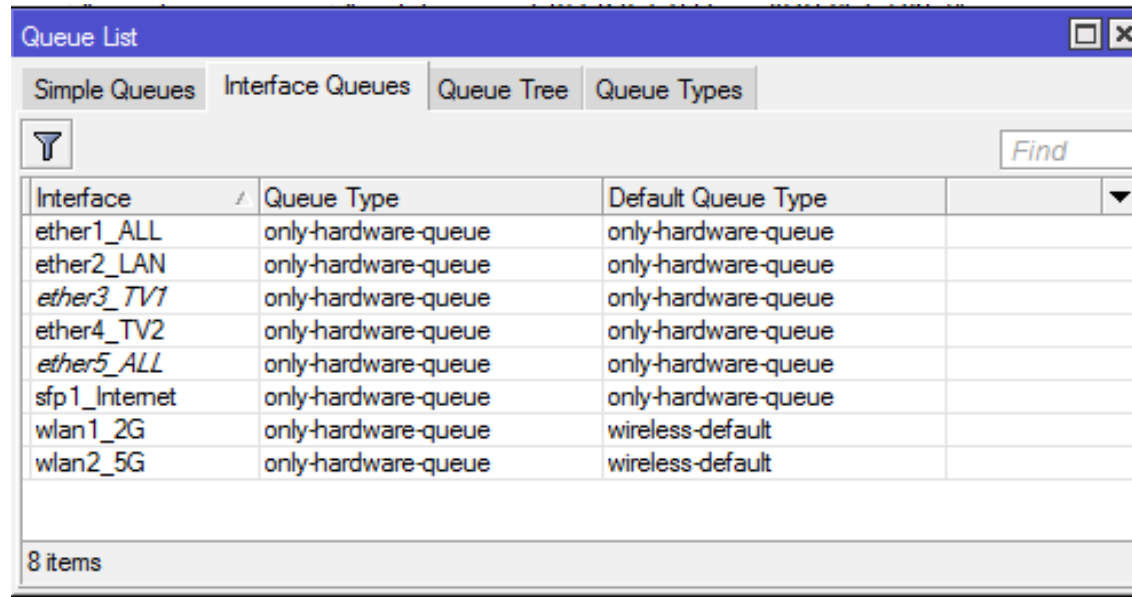
- Firewall:** Shows a list of 8 items. Rule 1 is highlighted, showing a fasttrack action.
- Profile (Running):** A table showing usage for various profiles.
- Interface List:** Shows a list of interfaces, with 'pppoe-out1' selected as a PPPoE Client.
- CPU:** A small window showing CPU usage for 'cpu0'.

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

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

Interface Queue and FastPath



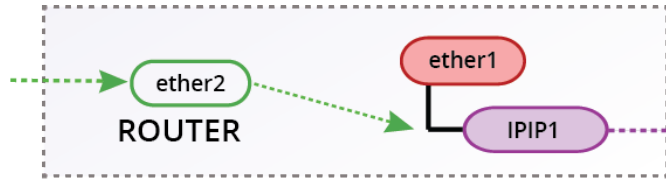
The screenshot shows a window titled "Queue List" with four tabs: "Simple Queues", "Interface Queues", "Queue Tree", and "Queue Types". The "Interface Queues" tab is selected. Below the tabs is a search bar with a filter icon and a "Find" button. The main area contains a table with the following data:

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

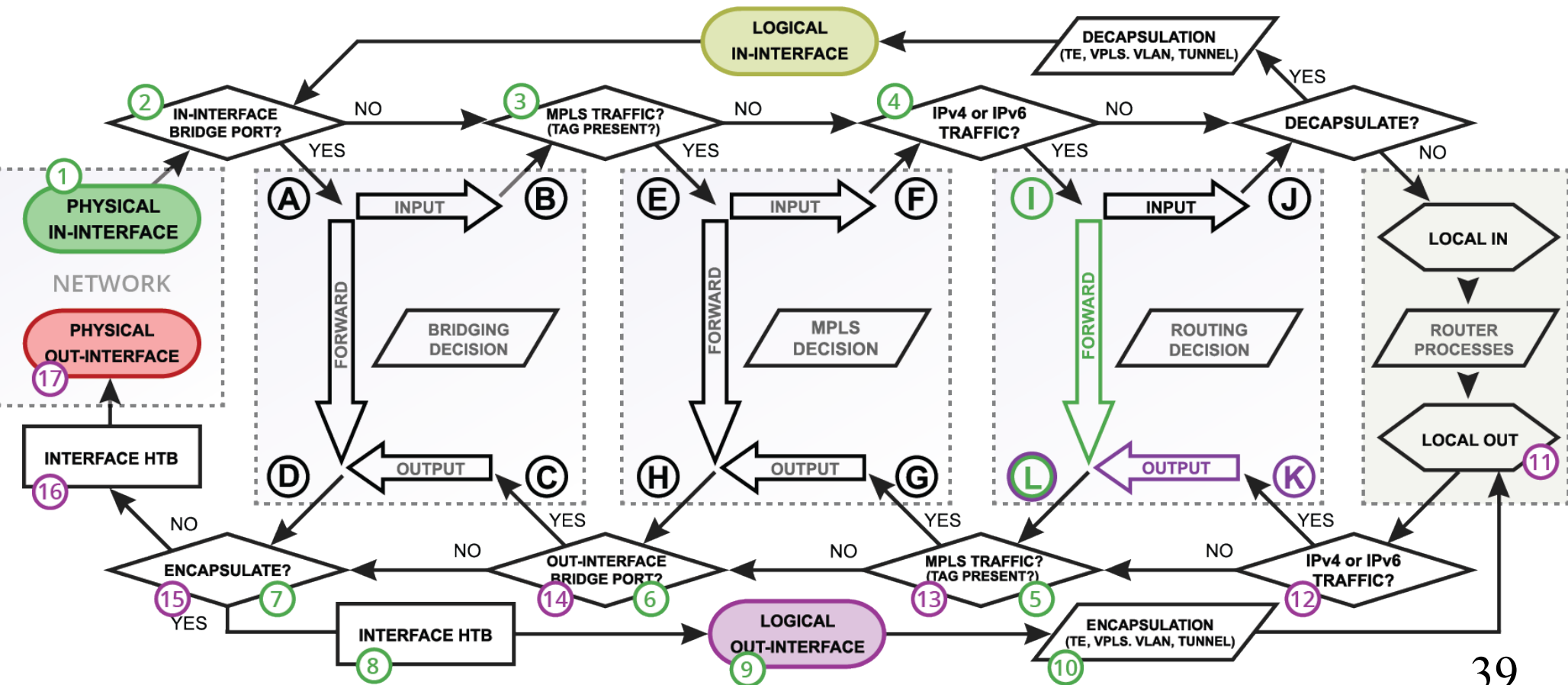
At the bottom of the window, it indicates "8 items".

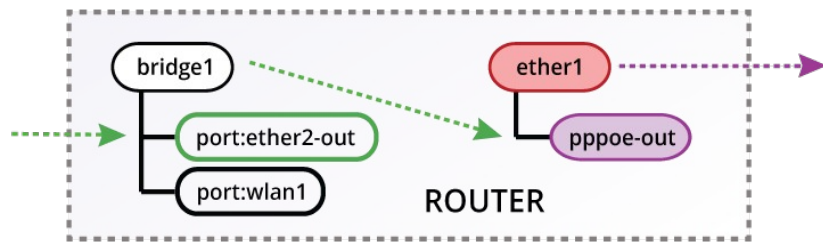
- Only interface queue that guarantees FastPath is “only-hardware-queue”
- Minimal impact on performance, as “Interface HTB” is the last step in the packet flow diagram

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

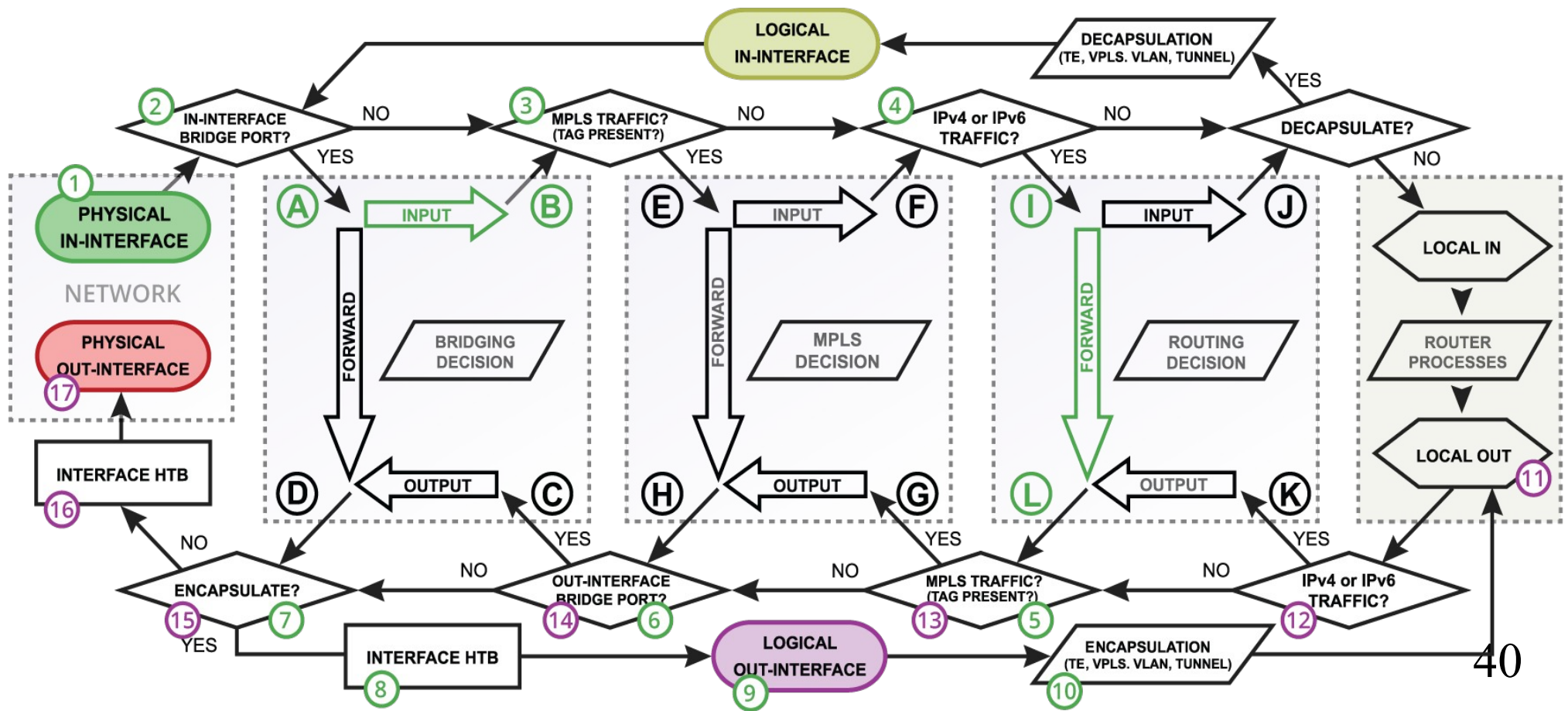


- TCP "FastTraked" connection
- Simple queues





- 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!!!