

# **MikroTik RouterOS Workshop**

## **QoS Best Practice**

Dallas/Fort Worth  
MUM USA 2009

# Questions and Answers

- Q: Is it possible to prioritize traffic by type for every single client while having strict per-user limitations on the same router?
- A: Yes!
  
- Q: What will I need to achieve that?
- A: You will need:
  - 1) Packet Flow Diagram
  - 2) HTB (queue tree),
  - 3) Mangle,
  - 4) PCQ,
  - 5) Address List

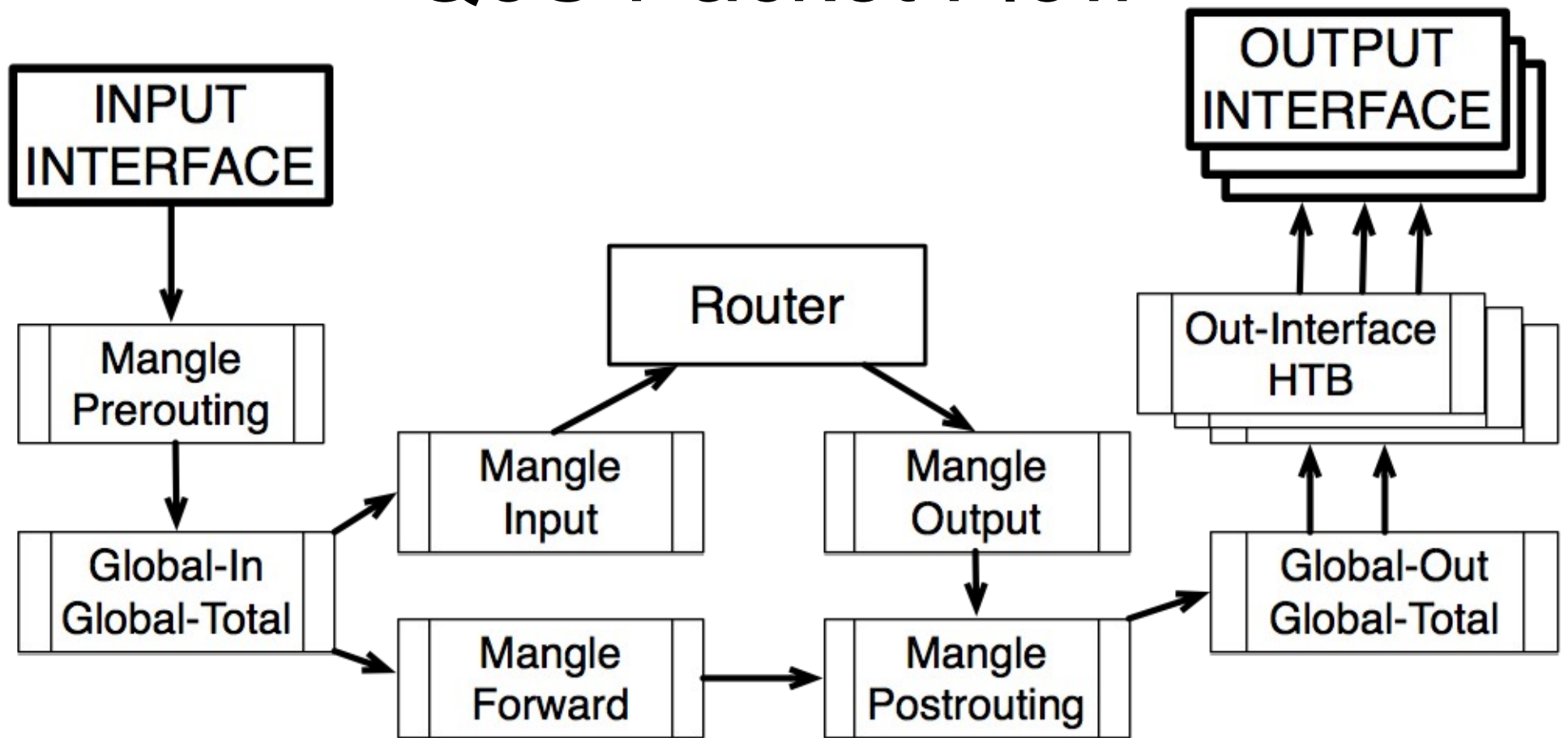
# Mangle

- The mangle facility allows you to mark IP packets with special marks.
- These marks are used by other router facilities like routing and bandwidth management to identify the packets.
- Additionally, the mangle facility is used to modify some fields in the IP header, like TOS (DSCP) and TTL fields.

# Hierarchical Token Bucket

- All bandwidth management implementation in RouterOS is based on Hierarchical Token Bucket (HTB)
- HTB allows you to create hierarchical queue structure and determine relations between queues
- RouterOS supports 3 virtual HTBs (global-in, global-total, global-out) and one more just before every output interface

# QoS Packet Flow



- This diagram is created from RouterOS Packet Flow diagram.

[http://wiki.mikrotik.com/wiki/Packet\\_Flow](http://wiki.mikrotik.com/wiki/Packet_Flow)

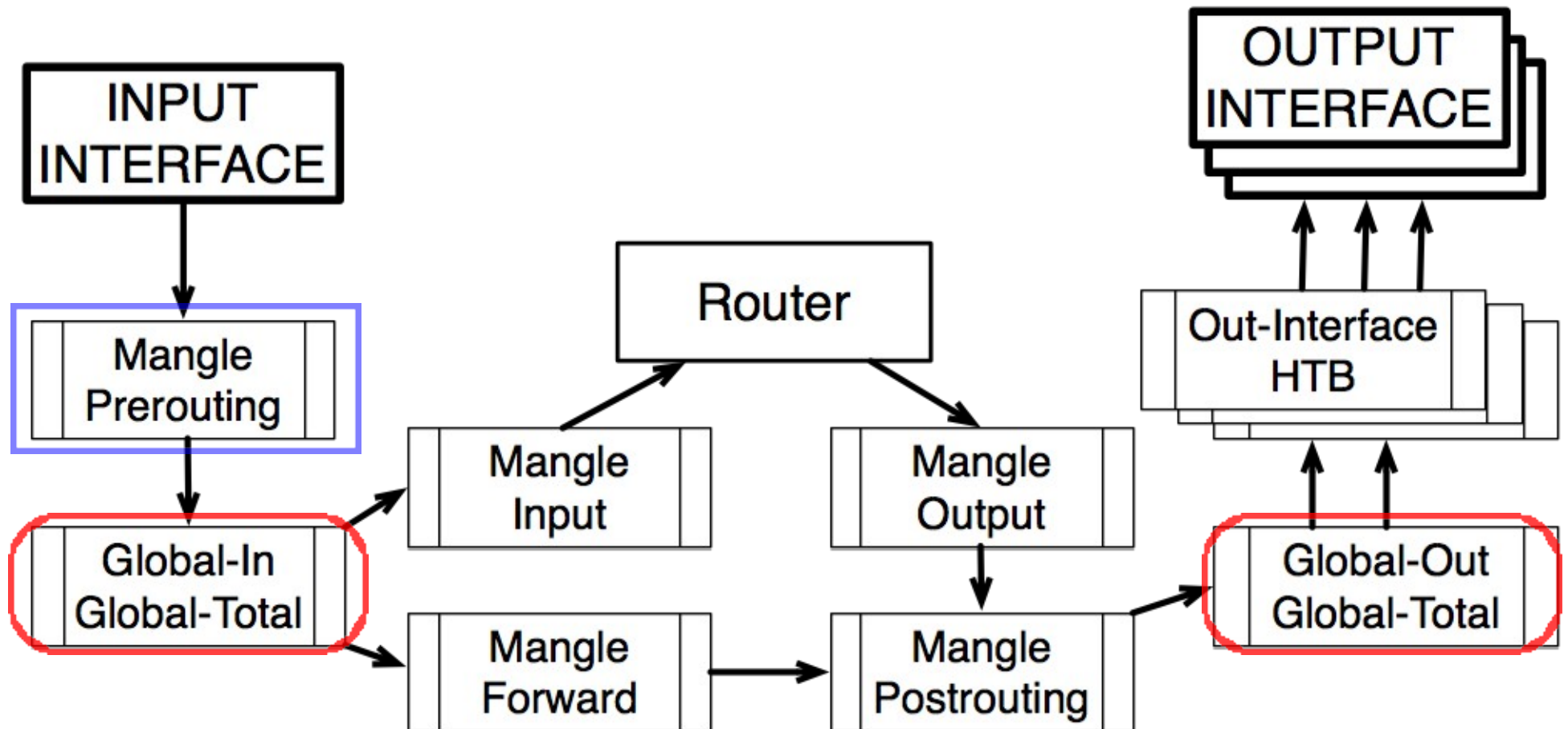
# Double QoS

- It is possible to mark and shape traffic twice in the same router:
  - ◆ Mangle chain Prerouting – for first marking
  - ◆ Global-in HTB – for first shaping
  - ◆ Mangle chain Forward or Postrouting for second marking
  - ◆ Global-out or Out-interface HTB for second marking
- Double QoS is only possible with Queue Tree

# Why not Simple Queues?

- Simple queues are ordered - similar to firewall rules
  - ◆ In order to get to 999<sup>th</sup> queue packet will have to be checked for match to all 998 previous queues
- Each simple queue **might** stand for 3 separate queues:
  - ◆ One in Global-in (“direct” part)
  - ◆ One in Global-out (“reverse” part)
  - ◆ One in Global-total (“total” part)

# Simple Queues and Mangle





# Queue Tree

- Tree queue is one directional only and can be placed in any of the available HTBs
- Queue Tree queues don't have any order – all traffic is processed simultaneously
- All child queues must have packet marks from “/ip firewall mangle” facility assigned to them
- If placed in the same HTB, Simple queue will take all the traffic away from the Queue Tree queue

# Global-Out or Interface HTB?

There are two fundamental differences

- In case of SRC-NAT (masquerade) Global-Out will be aware of private client addresses, but Interface HTB will not – Interface HTB is after SRC-NAT
- Each Interface HTB only receives traffic that will be leaving through a particular interface – there is no need for to separate upload and download in mangle

# Conclusions

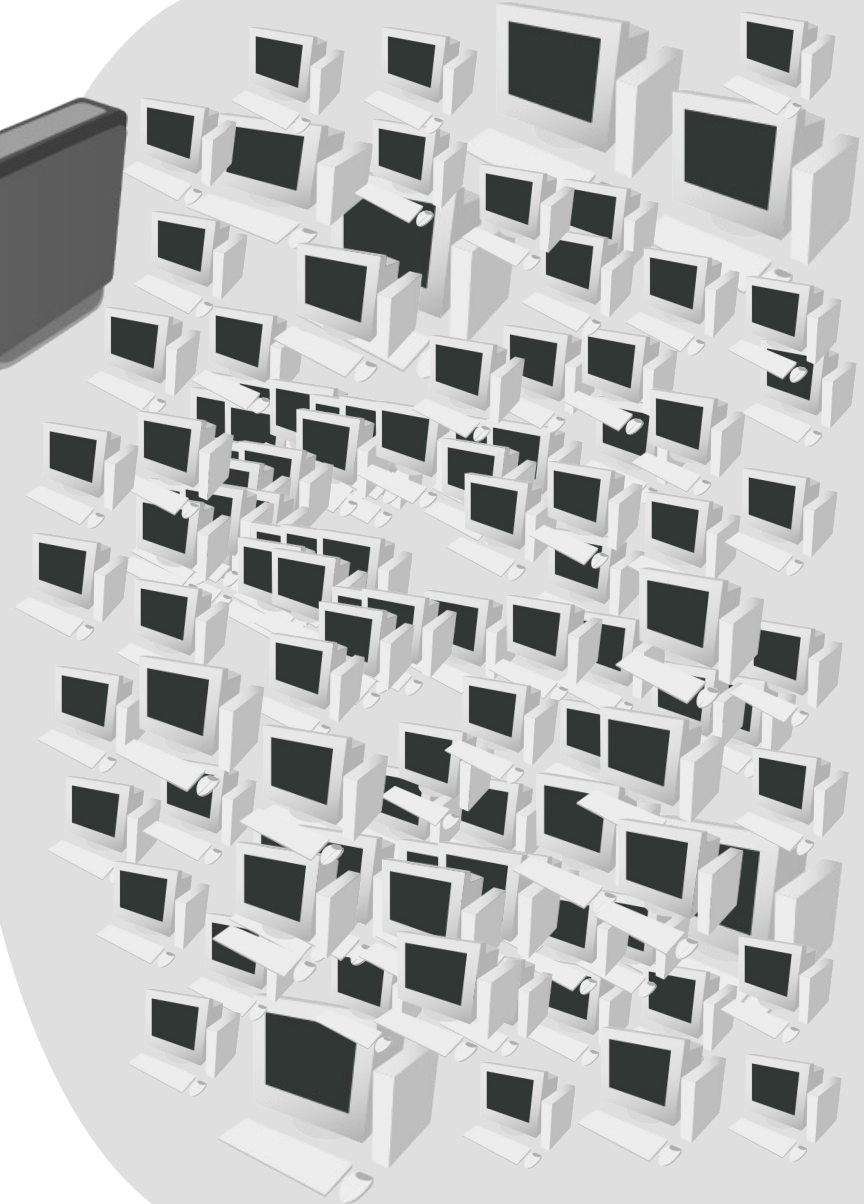
- We will use mangle and queue tree:
  - ◆ Mark traffic by traffic type in mangle chain Prerouting
  - ◆ Prioritize and limit traffic by type in Global-in HTB
  - ◆ Re-Mark traffic by clients in mangle chain Forward
  - ◆ Limit traffic per client in Interface HTB
- It is necessary to keep the amount of mangle rules and queues to a minimum to increase the performance of this configuration.

# Client Limitation



T3/E3 line

~40 Mbps



- You have more than 400 clients and 3 different connection types:
  - Business (4Mbps/1Mbps) connection
  - Standard (750kbps/250kbps) connection
  - Basic (375kbps/125kbps) connection

# PCQ

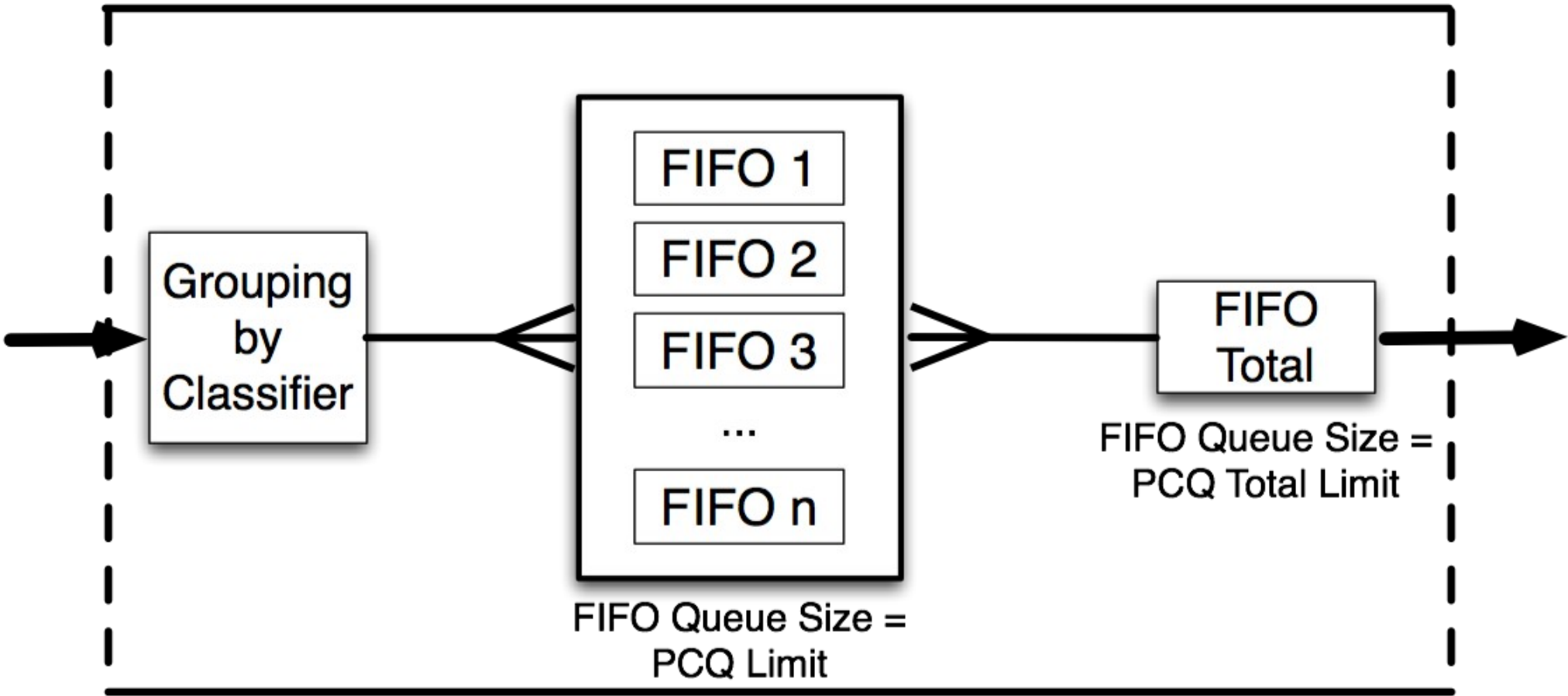
- Per Connection Queue is a queue type capable of dividing traffic into sub-streams based on selected classifiers
- Each sub-stream will then go through FIFO queue with queue size specified by “pcq-limit” option and maximal rate specified by “pcq-rate” option

The screenshot shows the 'New Queue Type' configuration dialog box. The 'Type Name' field is set to 'queue1'. The 'Kind' dropdown menu is set to 'pcq'. The 'Rate' field is set to '0', the 'Limit' field is set to '50', and the 'Total Limit' field is set to '2000'. Under the 'Classifier' section, the 'Dst. Address' checkbox is checked, while 'Src. Address', 'Src. Port', and 'Dst. Port' are unchecked. The dialog includes standard buttons for 'OK', 'Cancel', 'Apply', 'Copy', and 'Remove'.

# PCQ

IN

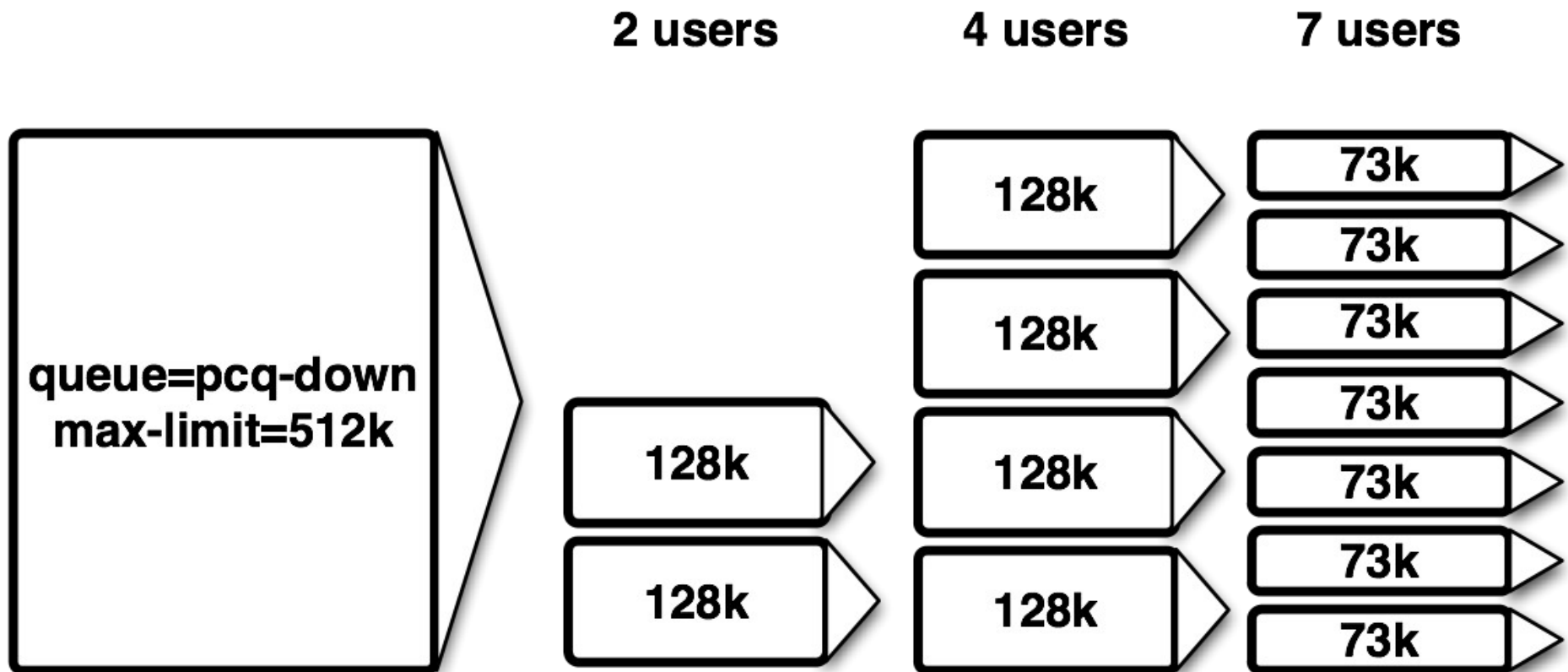
OUT



# PCQ Part 2

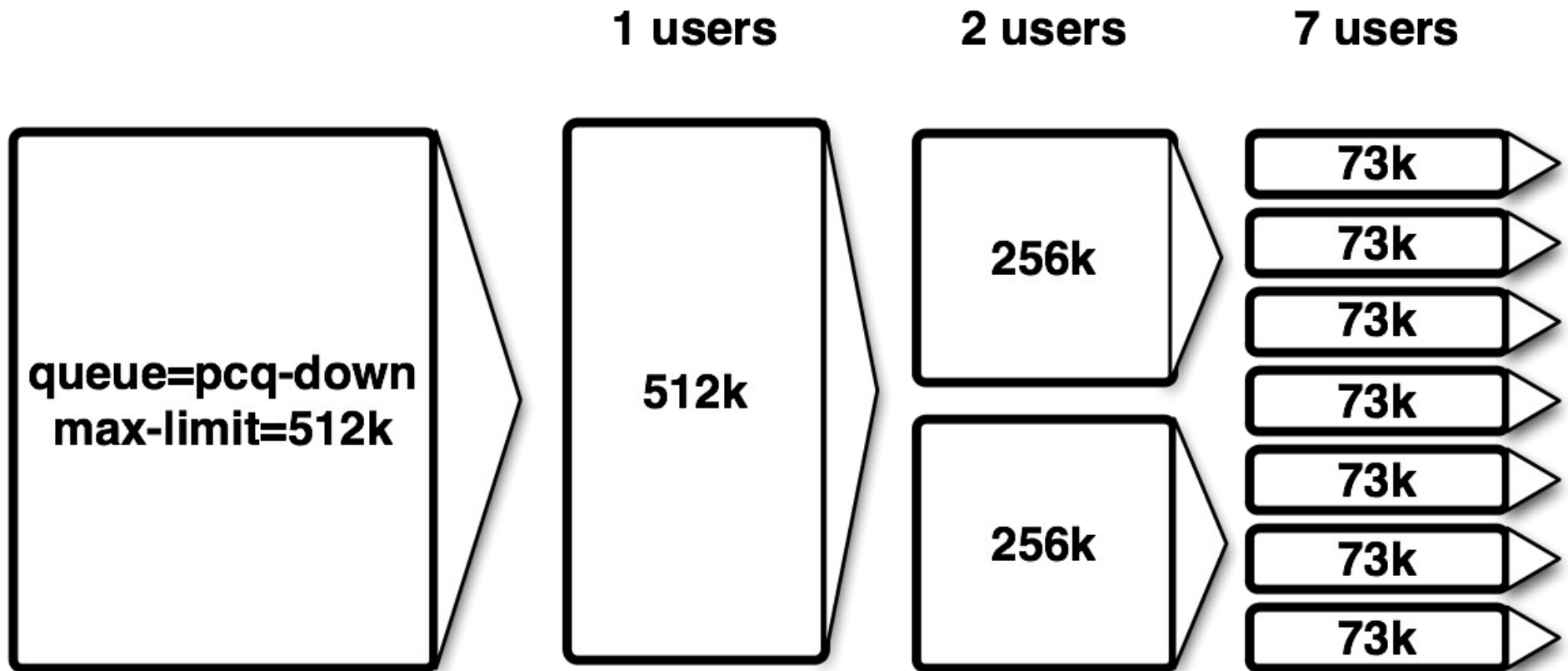
- In order to ensure that each PCQ sub-stream represents one particular client we need to create 2 different PCQ types:
  - ◆ PCQ\_upload – source address as classifier
  - ◆ PCQ\_download - destination address as classifier
- PCQ will distribute available traffic equally between sub-queues until the pcq-rate is reached (if it is specified)

# pcq-rate=128000





# pcq-rate=0



# PCQ Types – Winbox View

The screenshot displays the Mikrotik Winbox interface for configuring PCQ (Per-Connection Queue) types. The main window, titled "Queue List", shows a table of existing queue types. The "Queue Types" tab is selected and highlighted with a red circle. Two queue types, "PCQ\_down\_4M" and "PCQ\_up\_1M", are circled in red. Red arrows point from these entries to their respective configuration dialog boxes. The "Queue Type <PCQ\_down\_4M>" dialog shows a "Rate" of 4M, a "Limit" of 50, and a "Total Limit" of 2000. The classifier is set to "Dst. Address". The "Queue Type <PCQ\_up\_1M>" dialog shows a "Rate" of 1M, a "Limit" of 50, and a "Total Limit" of 2000. The classifier is set to "Src. Address".

Type Name	Kind
PCQ_down_375k	pcq
PCQ_down_4M	pcq
PCQ_down_750k	pcq
PCQ_up_125k	pcq
PCQ_up_1M	pcq
PCQ_up_250k	pcq
default	pfifo
default-small	pfifo
ethernet-default	pfifo
hotspot-default	sfq
sfq	sfq
synchronous-default	red

**Queue Type <PCQ\_down\_4M> Settings:**

- Rate: 4M
- Limit: 50
- Total Limit: 2000
- Classifier:  Dst. Address

**Queue Type <PCQ\_up\_1M> Settings:**

- Rate: 1M
- Limit: 50
- Total Limit: 2000
- Classifier:  Src. Address

# Address Lists

- Address lists was introduced to assign multiple IP addresses/ranges to the same firewall rule, in this way reducing the total number of firewall rules and increasing router performance
- Address lists can be created:
  - ◆ Manually
  - ◆ Automatically from PPP profile – just specify address-list option and as soon as the client connects it will be added to the proper address list
  - ◆ Automatically from RADIUS – attribute “Mikrotik:19”

# Address Lists

The screenshot displays the Mikrotik RouterOS WinBox interface. The left sidebar shows the 'RouterOS WinBox' menu with 'IP' expanded to 'Firewall'. The main window shows the 'Firewall' configuration page with the 'Address Lists' tab selected. A table lists the following address lists:

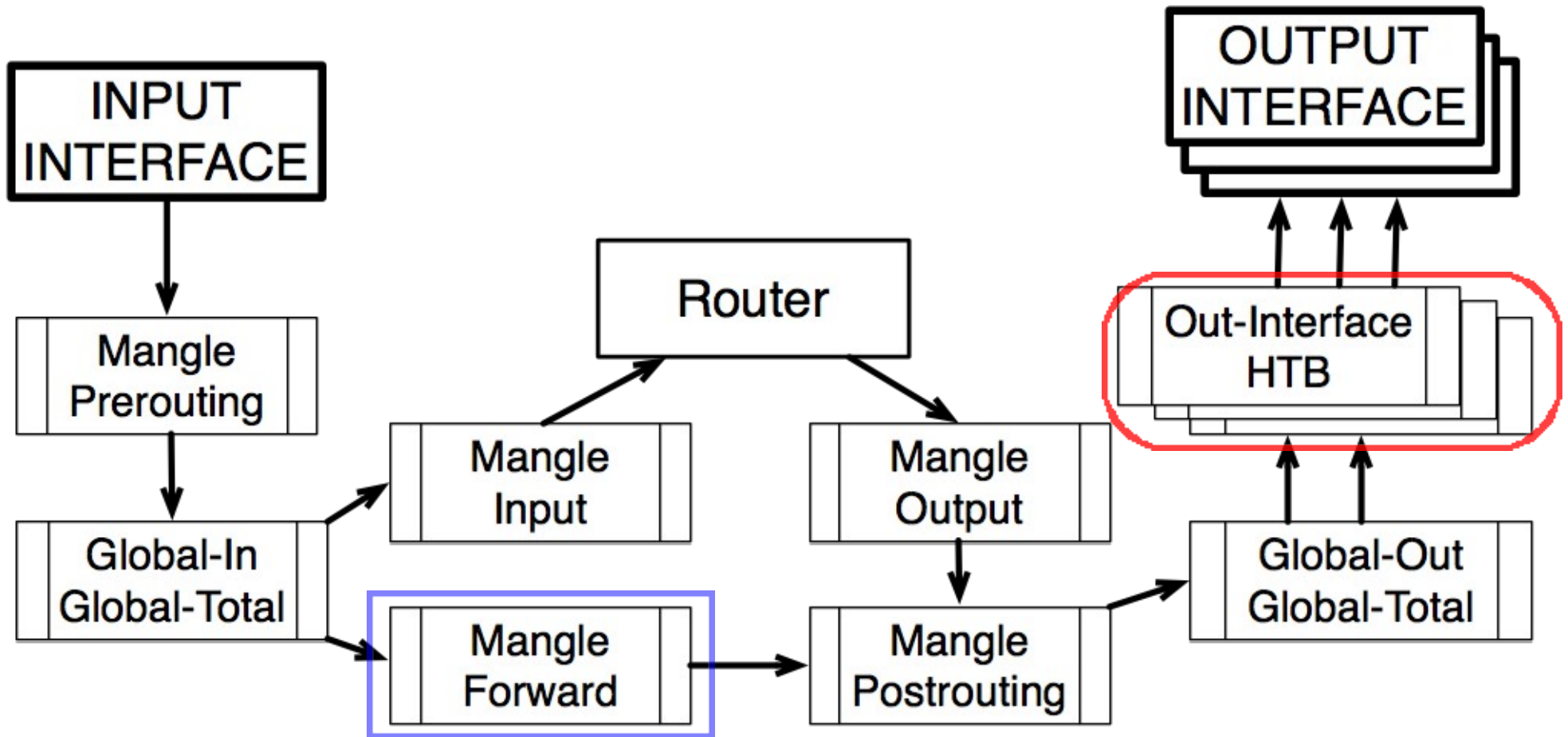
Name	Address
Basic_class_client	23.1.100.1
Standard_class_client	23.1.100.2
Basic_class_client	23.1.100.3
Standard_class_client	23.1.100.4
Basic_class_client	23.1.100.5
Business_class_client	23.1.100.6
Basic_class_client	23.1.100.7
Basic_class_client	23.1.100.8
Standard_class_client	23.1.100.9
Standard_class_client	23.1.100.10
Standard_class_client	23.1.100.11
Basic_class_client	23.1.100.12
Basic_class_client	23.1.100.13
Basic_class_client	23.1.100.14
Basic_class_client	23.1.100.15
Basic_class_client	23.1.100.16
Business_class_client	23.1.100.17
Basic_class_client	23.1.100.18
Standard_class_client	23.1.100.19
Basic_class_client	23.1.100.20

A dialog box titled 'Firewall Address List <Basic\_class\_cli...' is open, showing the following configuration:

- Name: Business\_class\_client
- Address: 23.1.101.224

The dialog box also includes buttons for OK, Cancel, Apply, Disable, Comment, Copy, and Remove, and a 'disabled' status indicator.

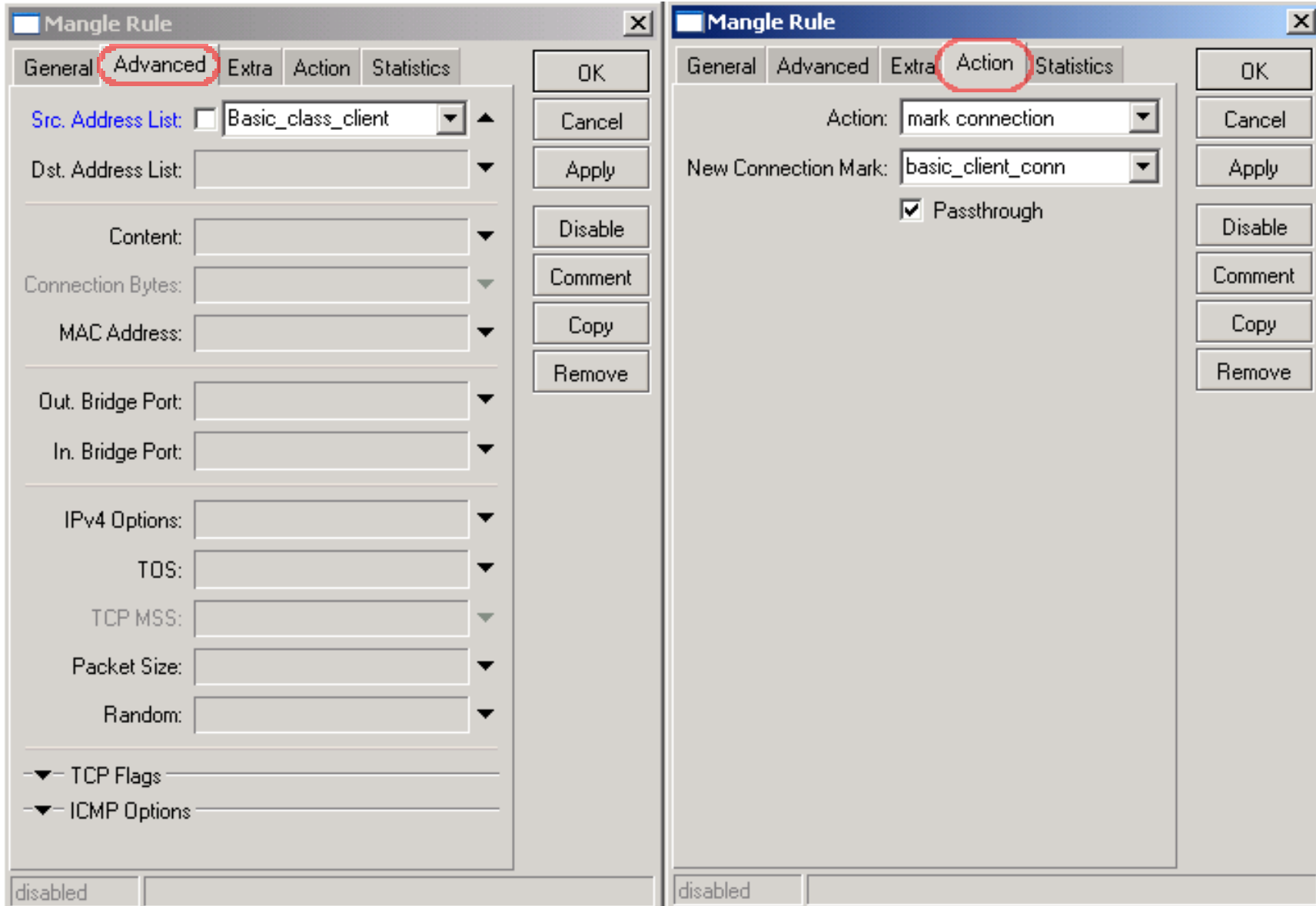
# Where?



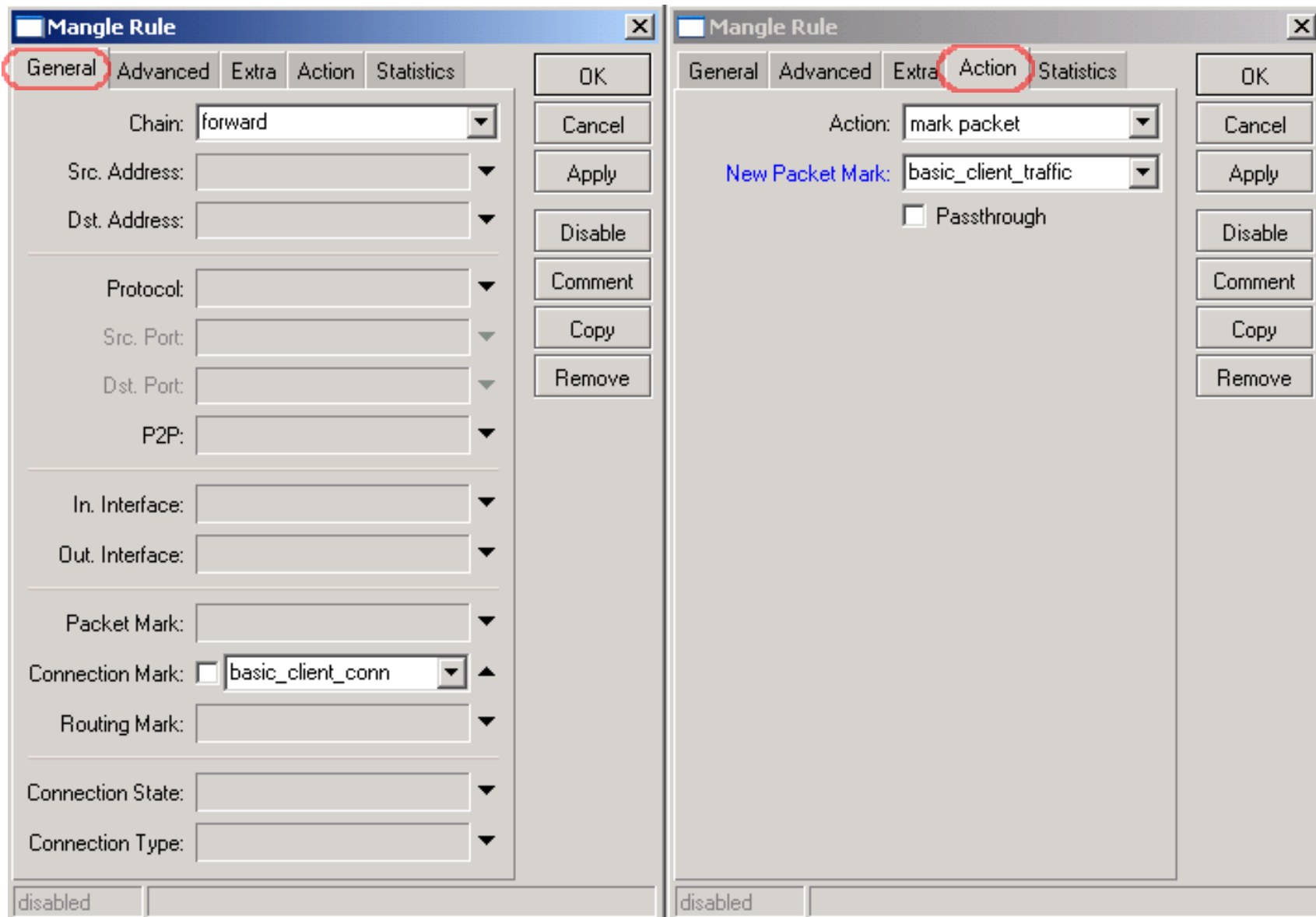
# Packet Marking

- Use “connection-mark” action to classify all connections based on client address list
- Use “packet-mark” action to classify all traffic based on connection marks
- Questions to think about:
  - ◆ What speed should be available for Business client if downloading from basic client?
  - ◆ Do you still have unmarked traffic?

# Connection-mark rule



# Packet-mark rule





# Working Mangle- Winbox view

Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists

forward ▾

#	Action	Chain	Priority	New Packet Mark	New Connection Mark	Bytes	Packets
::: mark basic client traffic							
	mark connection	forward			basic_client_conn	9893.1 MiB	18 599 504
	mark packet	forward		basic_client_traffic		22575.4 MiB	35 292 323
::: mark standard client traffic							
	mark connection	forward			standard_client_conn	825.4 MiB	2 747 515
	mark packet	forward		standard_client_traffic		6396.7 MiB	7 248 925
::: mark bussiness client traffic							
	mark connection	forward			business_client_conn	190.2 MiB	912 903
	mark packet	forward		business_client_traffic		1324.9 MiB	1 929 206
::: Check for unmarked traffic							
	log	forward				2062.0 KiB	9 014

# Working Mangle- Export view

```
/ ip firewall mangle
add chain=forward src-address-list=Basic_class_client action=mark-connection \
    new-connection-mark=basic_client_conn passthrough=yes comment="mark basic \
    client traffic" disabled=no
add chain=forward connection-mark=basic_client_conn action=mark-packet \
    new-packet-mark=basic_client_traffic passthrough=no comment="" disabled=no
add chain=forward src-address-list=Standard_class_client \
    action=mark-connection new-connection-mark=standard_client_conn \
    passthrough=yes comment="mark standard client traffic" disabled=no
add chain=forward connection-mark=standard_client_conn action=mark-packet \
    new-packet-mark=standard_client_traffic passthrough=no comment="" \
    disabled=no
add chain=forward src-address-list=Business_class_client \
    action=mark-connection new-connection-mark=business_client_conn \
    passthrough=yes comment="mark bussiness client traffic" disabled=no
add chain=forward connection-mark=business_client_conn action=mark-packet \
    new-packet-mark=business_client_traffic passthrough=no comment="" \
    disabled=no
add chain=forward action=log log-prefix="" comment="Check for unmarked \
    traffic" disabled=no
```

# Queue Tree – Winbox View

The screenshot shows the Winbox 'Queue List' window. It has a title bar 'Queue List' and four tabs: 'Simple Queues', 'Interface Queues', 'Queue Tree' (selected), and 'Queue Types'. Below the tabs are several control buttons: a red plus sign, a minus sign, a checkmark, an 'X' mark, a '00 Reset Counters' button, and a '00 Reset All Counters' button. The main area contains a table with the following columns: Name, Parent, Packet Mark, Limit At, and Max Limit. The table lists a hierarchy of queues for two interfaces: local\_ether1 and public\_ether3. Each interface has a 'Total' queue, which is the parent of three sub-queues: 'basic\_client', 'business\_client', and 'standard\_client'. All queues have a 'Limit At' and 'Max Limit' of 0. At the bottom of the window, there are two status boxes: '0 B queued' and '0 packets queued'.

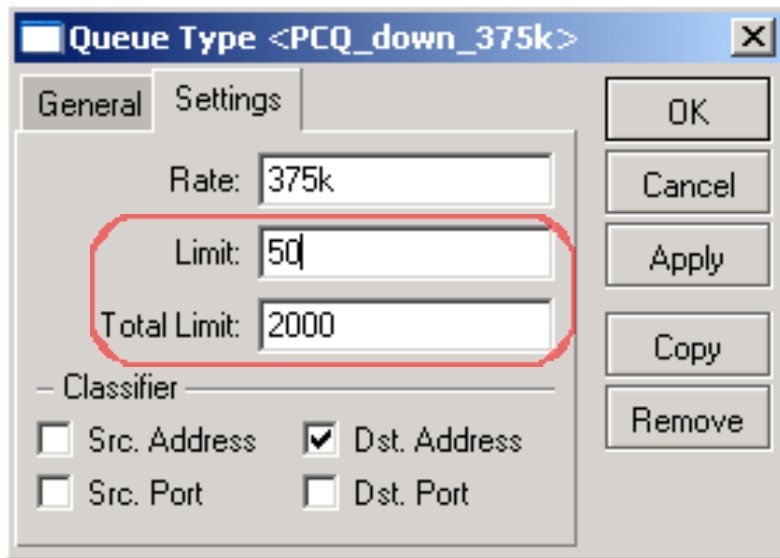
Name	Parent	Packet Mark	Limit At	Max Limit
Total_download	local_ether1		0	0
basic_client_download	Total_download	basic_client_traffic	0	0
business_client_download	Total_download	business_client_traffic	0	0
standard_client_download	Total_download	standard_client_traffic	0	0
Total_upload	public_ether3		0	0
basic_client_upload	Total_upload	basic_client_traffic	0	0
business_client_upload	Total_upload	business_client_traffic	0	0
standard_client_upload	Total_upload	standard_client_traffic	0	0

0 B queued      0 packets queued

# Queue Tree – Export View

```
/ queue tree
add name="Total_download" parent=local_ether1 packet-mark="" limit-at=0 \
    queue=default priority=1 max-limit=0 burst-limit=0 burst-threshold=0 \
    burst-time=0s disabled=no
add name="basic_client_download" parent=Total_download \
    packet-mark=basic_client_traffic limit-at=0 queue=PCQ_down_375k priority=8 \
    max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s disabled=no
add name="standard_client_download" parent=Total_download \
    packet-mark=standard_client_traffic limit-at=0 queue=PCQ_down_750k \
    priority=4 max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s \
    disabled=no
add name="business_client_download" parent=Total_download \
    packet-mark=business_client_traffic limit-at=0 queue=default priority=1 \
    max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s disabled=no
add name="Total_upload" parent=public_ether3 packet-mark="" limit-at=0 \
    queue=default priority=8 max-limit=0 burst-limit=0 burst-threshold=0 \
    burst-time=0s disabled=no
add name="basic_client_upload" parent=Total_upload \
    packet-mark=basic_client_traffic limit-at=0 queue=PCQ_up_125k priority=8 \
    max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s disabled=no
add name="standard_client_upload" parent=Total_upload \
    packet-mark=standard_client_traffic limit-at=0 queue=PCQ_up_250k \
    priority=4 max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s \
    disabled=no |
add name="business_client_upload" parent=Total_upload \
    packet-mark=business_client_traffic limit-at=0 queue=PCQ_up_1M priority=1 \
    max-limit=0 burst-limit=0 burst-threshold=0 burst-time=0s disabled=no
```

# PCQ Queue Size



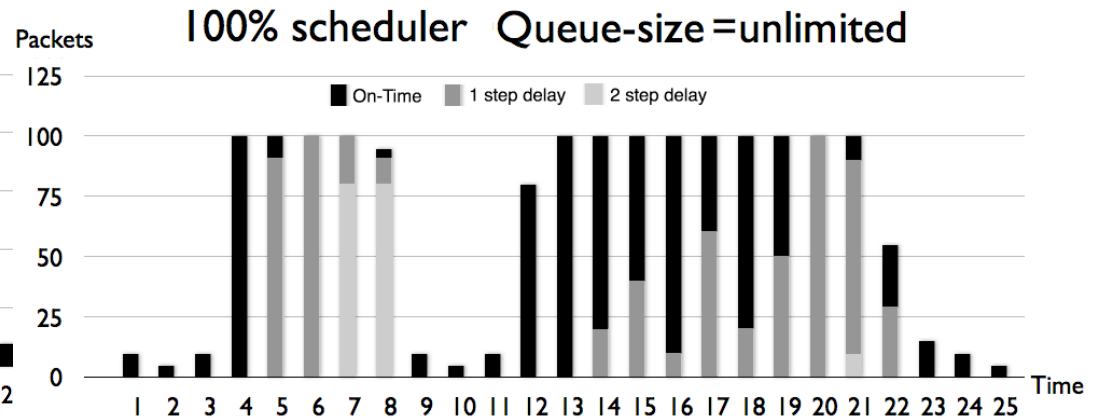
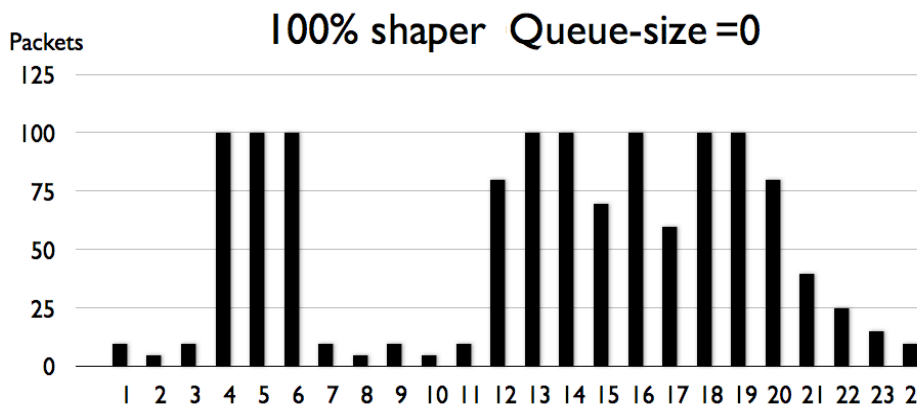
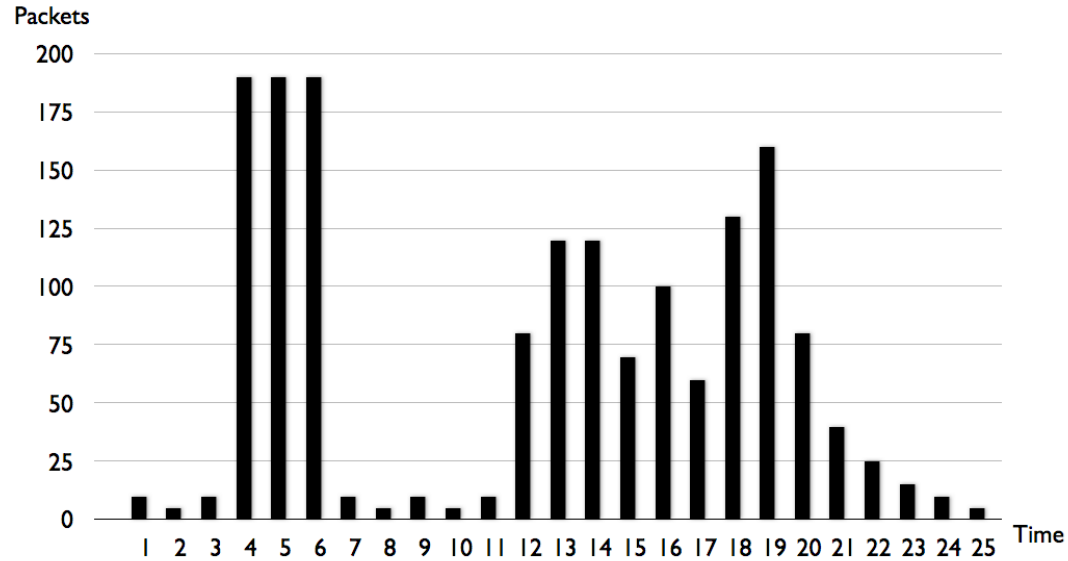
Total\_limit = X can take up to  
 $X \times (2000 \text{ bytes} + 200 \text{ bytes})$  of RAM

2000 bytes – buffer for 1 packet  
200 bytes – service data for 1 packet

total\_limit = 2000 =< 4,2MB RAM  
total\_limit = 5000 =< 10,5MB RAM

- It can take only 40 users to fill the queue  
(because  $\text{total\_limit}/\text{limit} = 2000/50 = 40$ )
- It is necessary to increase “total\_limit” and/or decrease the “limit” value
- There should be at least 10-20 packet places in queue available per user

# Queue Size



# PCQ Adjustments

- There are ~340 Basic class clients so:
  - ➔  $pcq\_limit = 40$
  - ➔  $pcq\_total\_limit = 7000$  (  $\sim 20 * 340$ ) ( $\sim 15MB$ )
- There are ~40 Standard class clients so:
  - ➔  $pcq\_limit = 30$
  - ➔  $pcq\_total\_limit = 1000$  (  $\sim 20 * 40$ ) ( $\sim 2MB$ )
- There are ~20 Business class clients so:
  - ➔  $pcq\_limit = 20$  (!!!)
  - ➔  $pcq\_total\_limit = 500$  (  $\sim 20 * 20$ ) ( $\sim 1MB$ )

# Traffic Prioritization



T3/E3 line  
~40 Mbps  
~5Mbps abroad



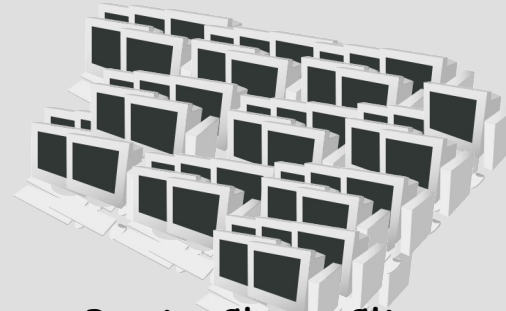
You have problems with on-line communications (video, audio, VOIP, games)

## Task:

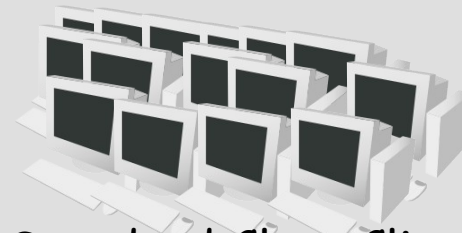
Prioritize the traffic



Business Class Clients



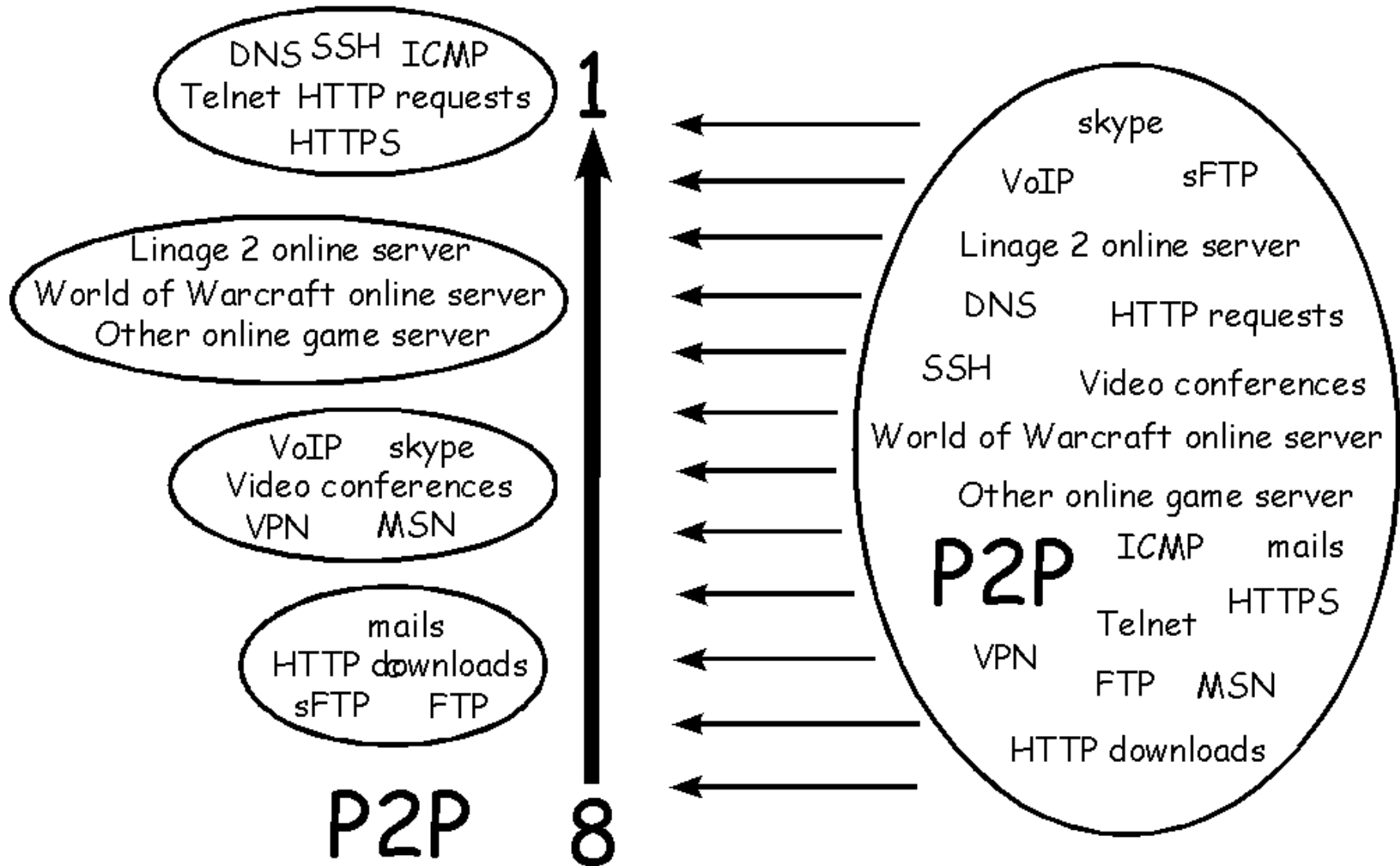
Basic Class Clients



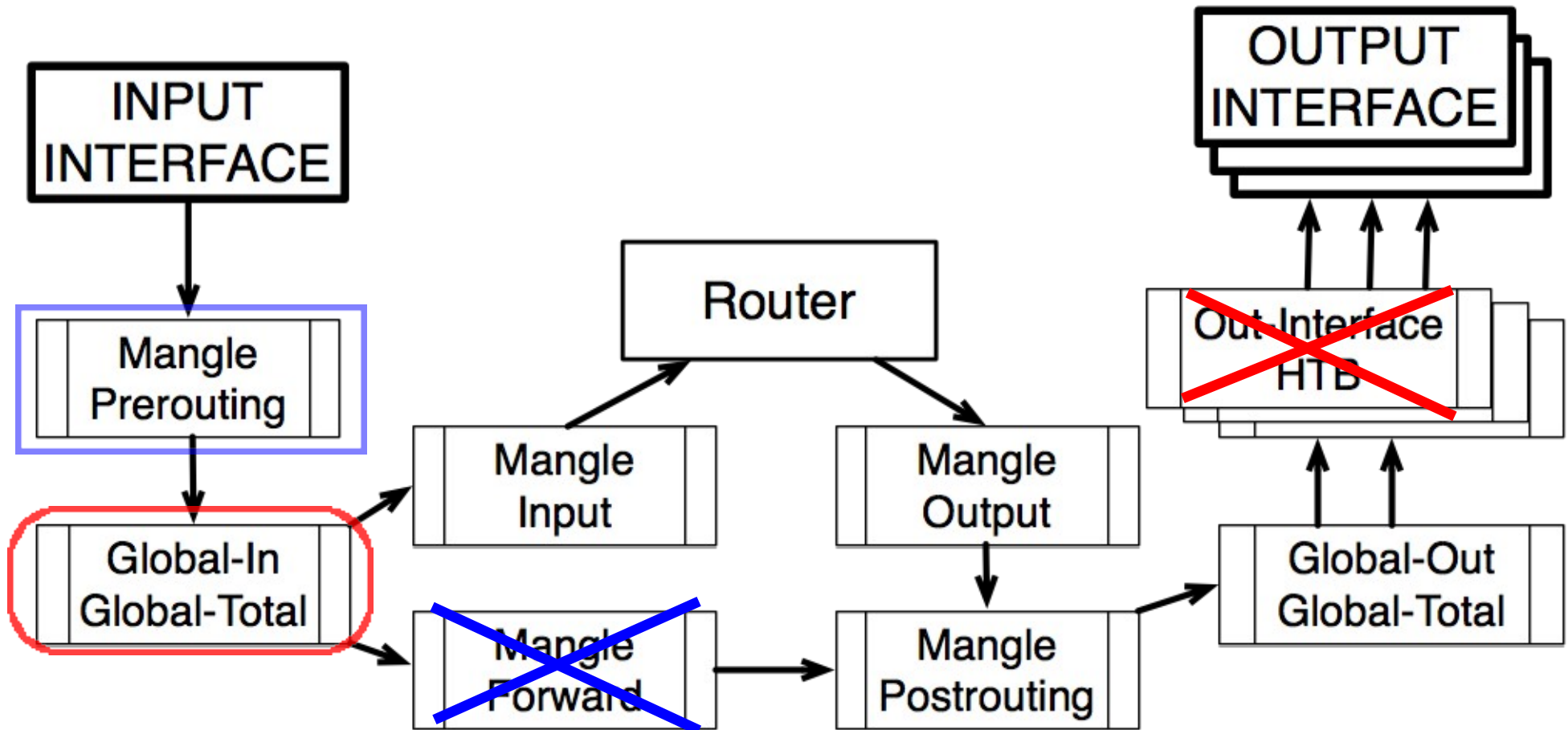
Standard Class Clients



# Prioritization Plan



# Where?



# How?

Group	Service	Protocol	Dst-Port	Other conditions
<b>P2P_services</b>	P2P			p2p=all-p2p
<b>Download_services</b>	Mails	TCP	110	
		TCP	995	
		TCP	143	
		TCP	993	
		TCP	25	
	HTTP downloads	TCP	80	Connection-bytes=500000-0
	FTP	TCP	20	
		TCP	21	
	SFTP	TCP	22	Packet-size=1400-1500
<b>Ensign_services</b>	DNS	TCP	53	
		UDP	53	
	ICMP	ICMP	-	
	HTTPS	TCP	443	
	Telnet	TCP	23	
	SSH	TCP	22	Packet-size=0-1400
	HTTP requests	TCP	80	Connection-bytes=0-500000
<b>User_requests</b>	Online game servers			Dst-address-list=user_requests
<b>Communication_services</b>	VoIP			
	Skype			
	Video conferences			
	VPN			
	MSN			

# Priorities

- Create packet marks in the mangle chain “Prerouting” for traffic prioritization in the global-in queue
  - ◆ Ensign\_services (Priority=1)
  - ◆ User\_requests (Priority=3)
  - ◆ Communication\_services (Priority=5)
  - ◆ Download\_services (Priority=7)
  - ◆ P2P\_services (Priority=8)