MikroTik RouterOS Workshop
QoS Best Practice

Prague

MUM Czech Republic 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

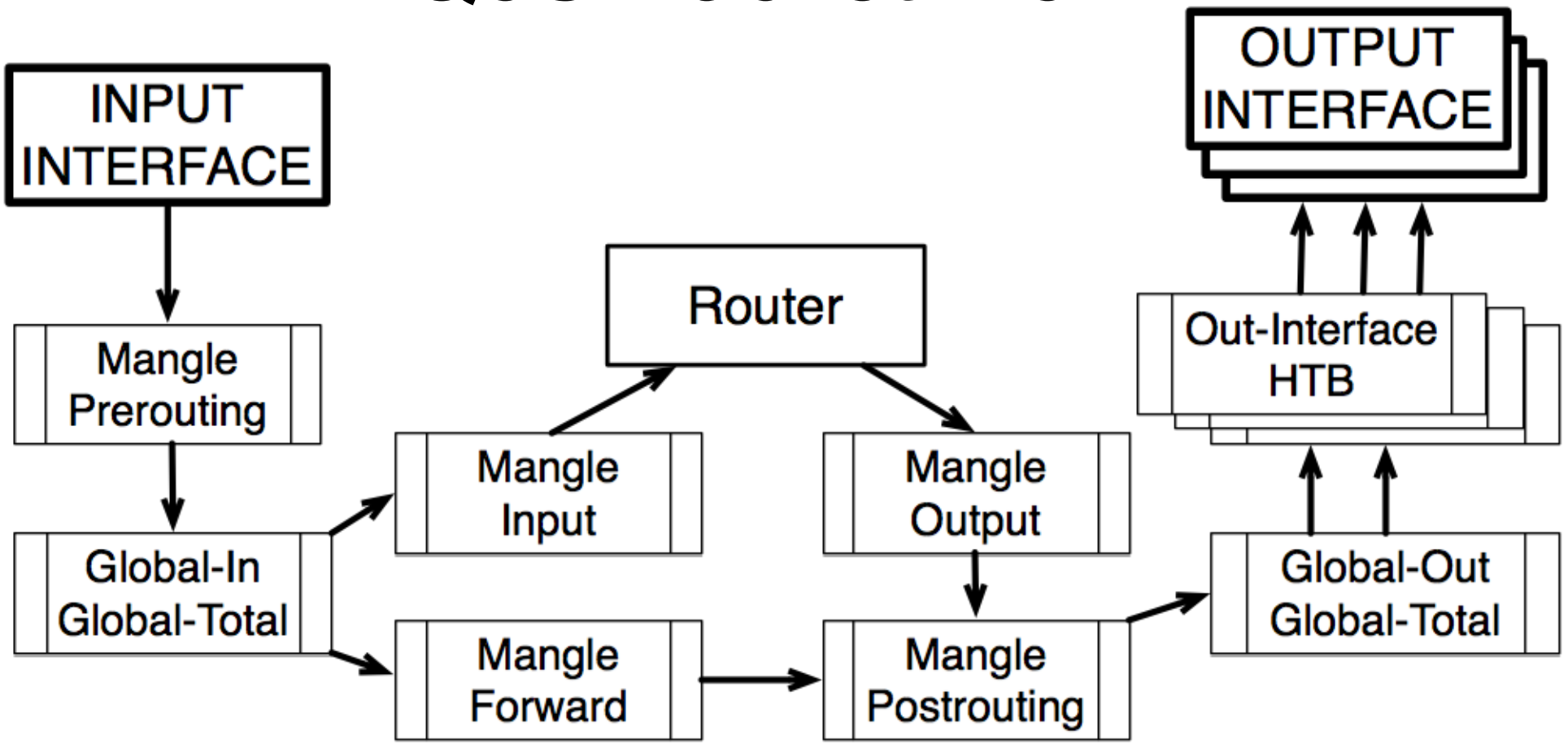
Mangle

- 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

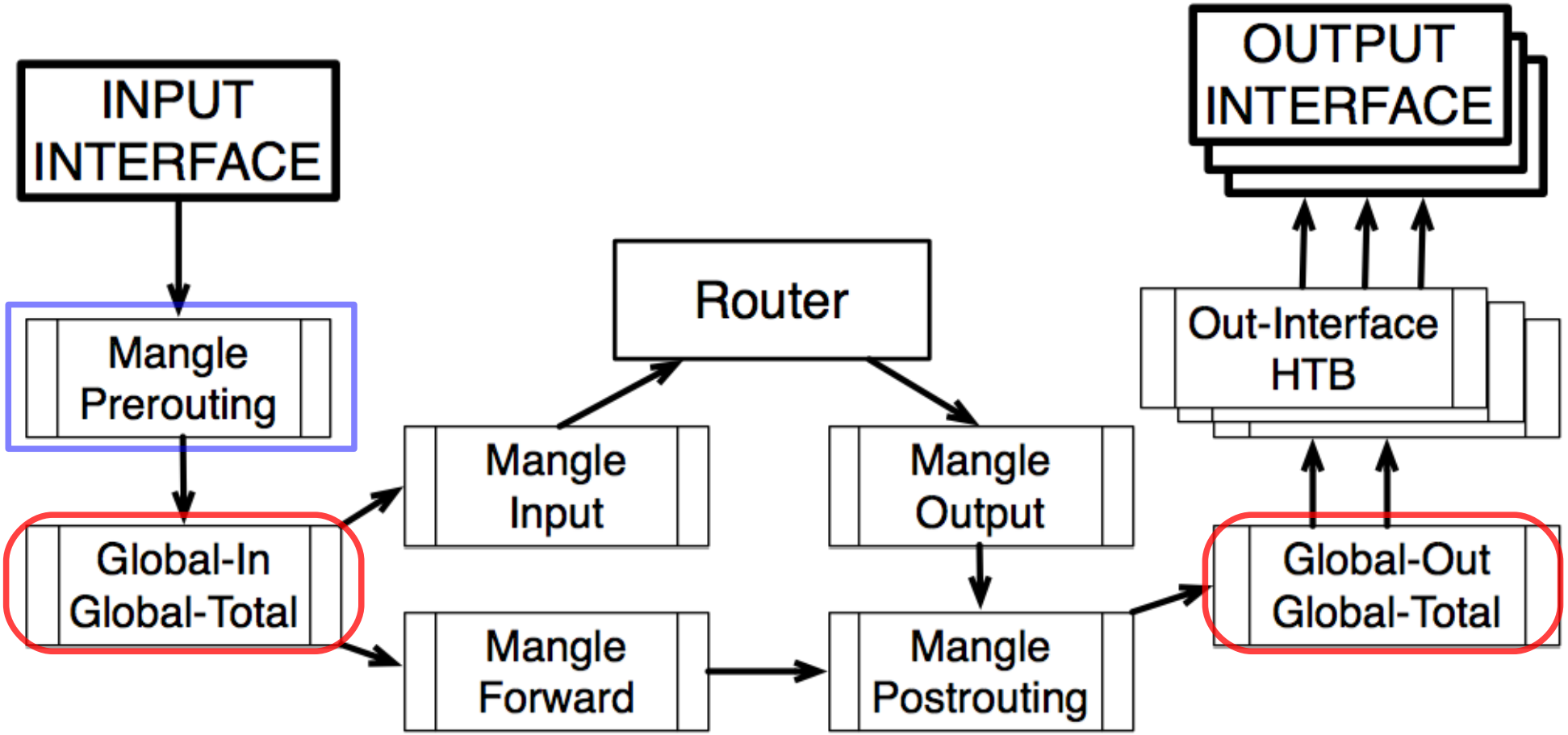
Double QoS

- 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 999th 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

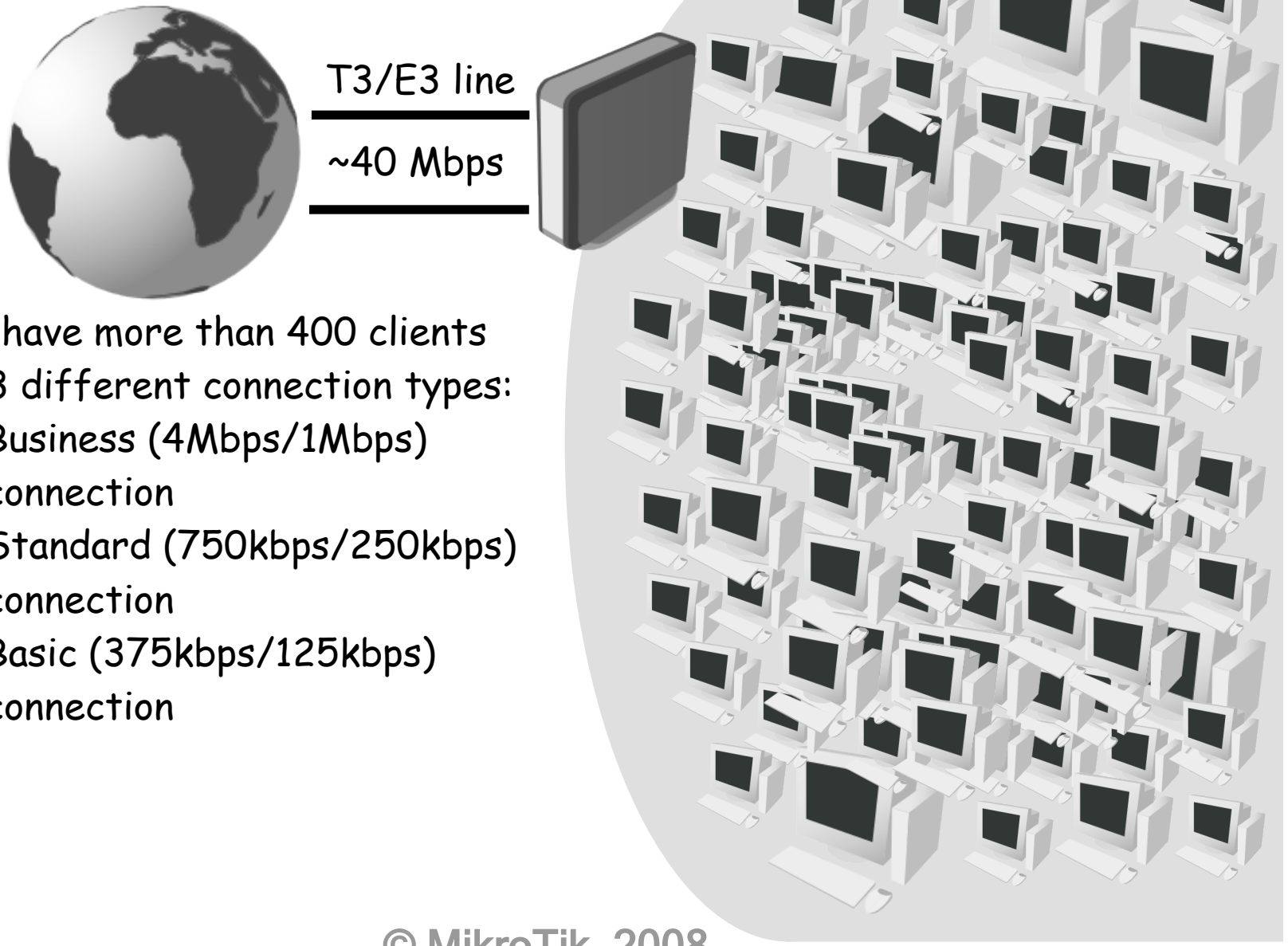
- In case of SRC-NAT (masquerade) Global-Out will be aware of private client addresses, but Interface HTB will not – Interface HTB is after SRC-NAT
- Each Interface HTB only receives traffic that will be leaving through a particular interface – there is no need for to separate upload and download in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

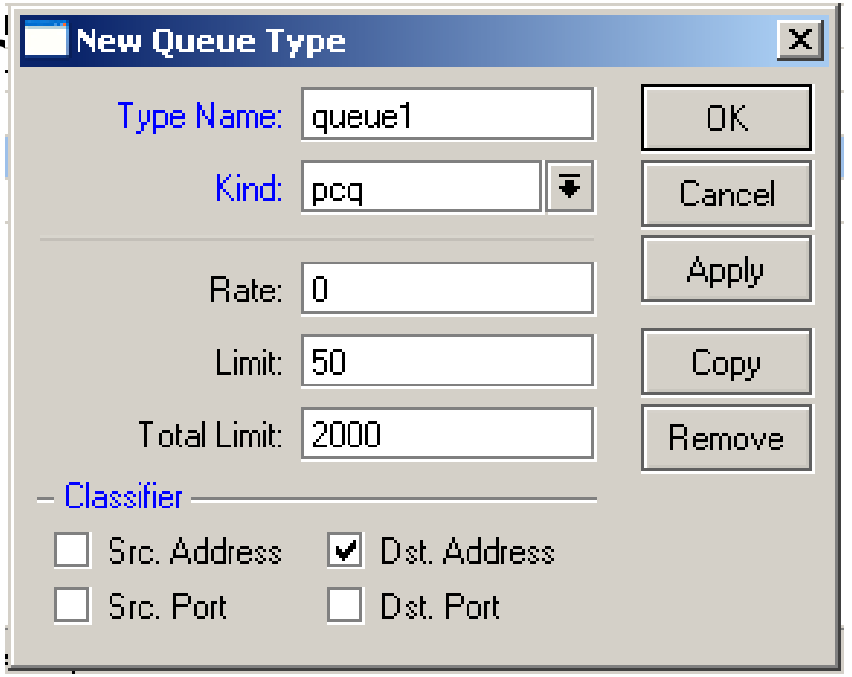


•You have more than 400 clients and 3 different connection types:

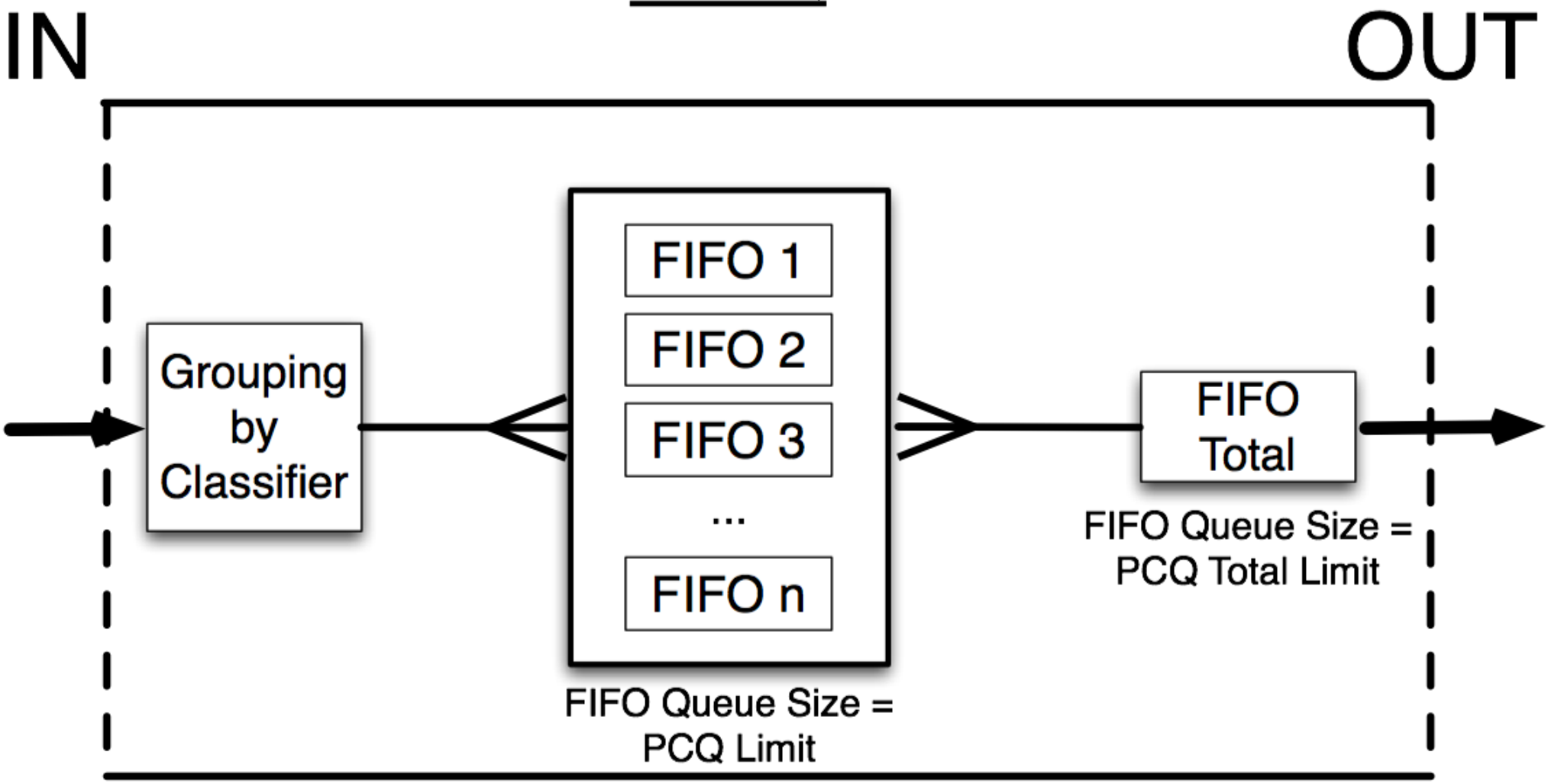
- Business (4Mbps/1Mbps) connection
- Standard (750kbps/250kbps) connection
- Basic (375kbps/125kbps) connection

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



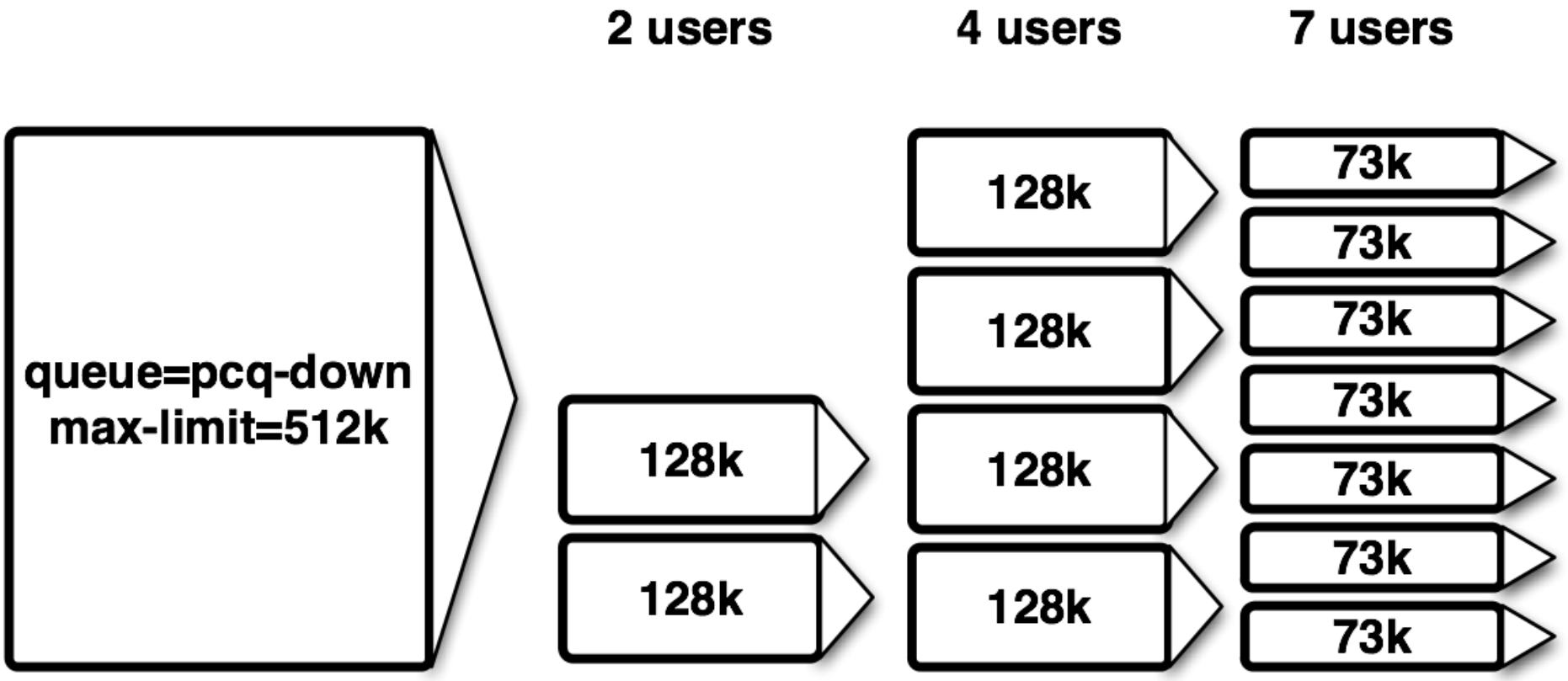
PCQ



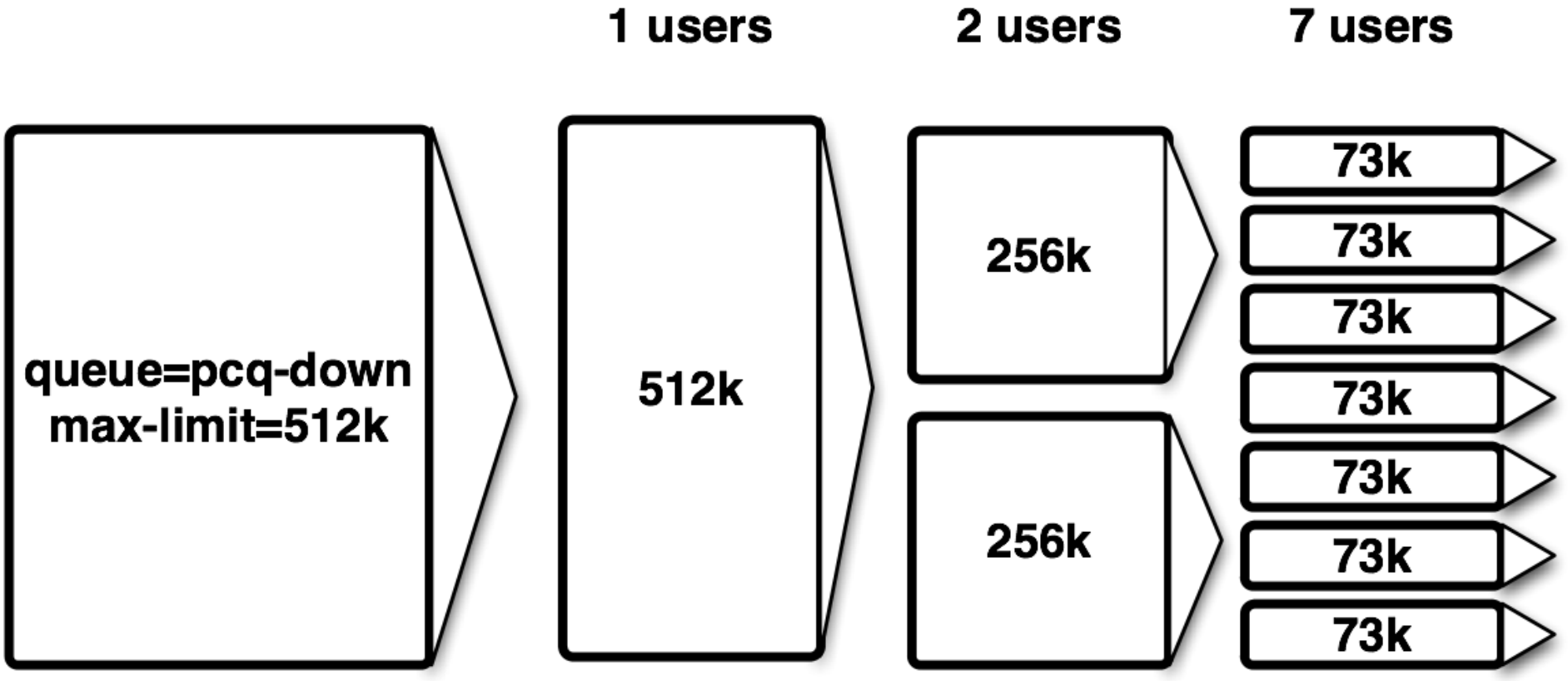
PCQ Part 2

- 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)

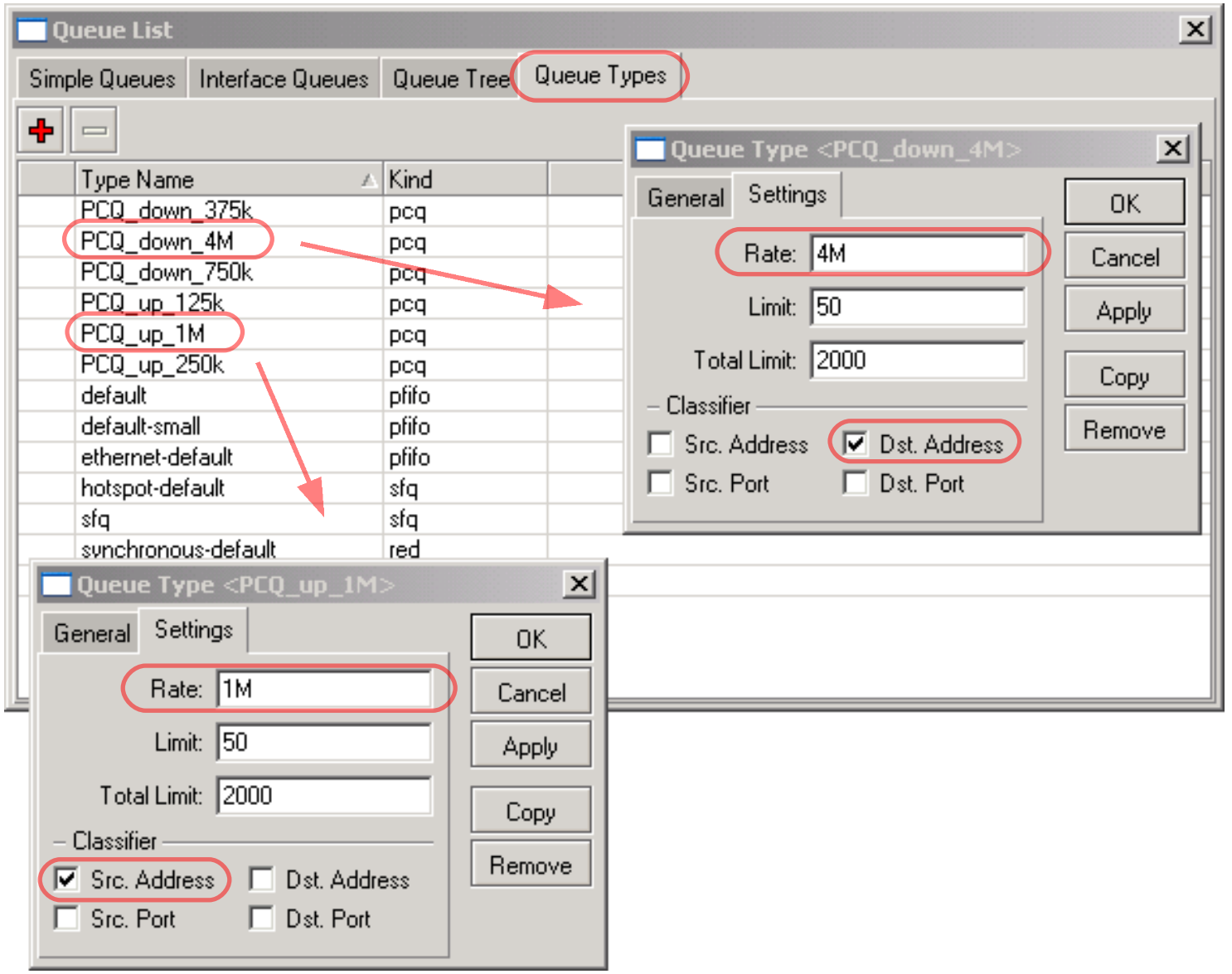
pcq-rate=128000



pcq-rate=0


1 users
2 users
7 users
queue=pcq-down
max-limit=512k
512k
256k
256k
73k
73k
73k
73k
73k
73k
73k

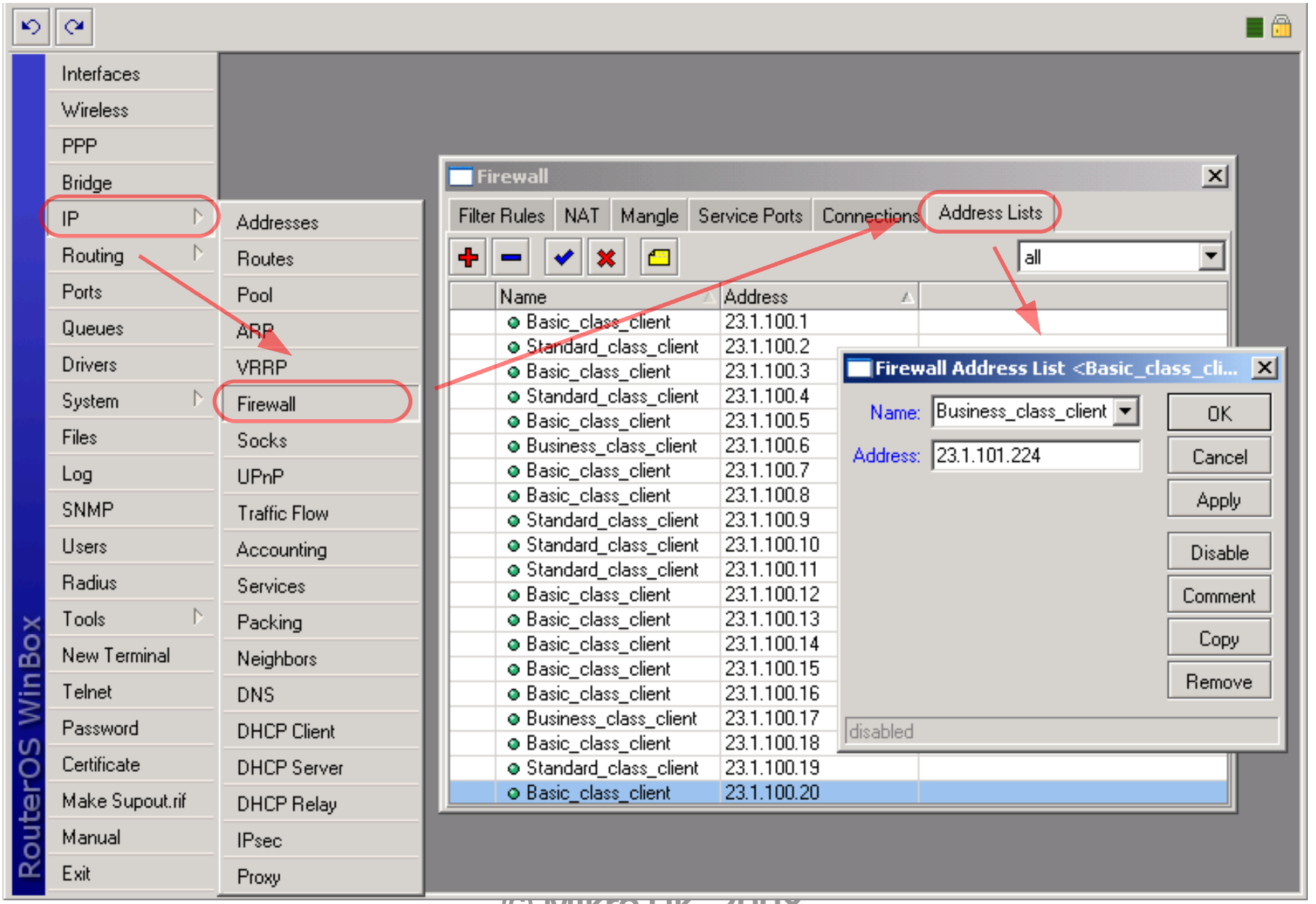
PCQ Types – Winbox View



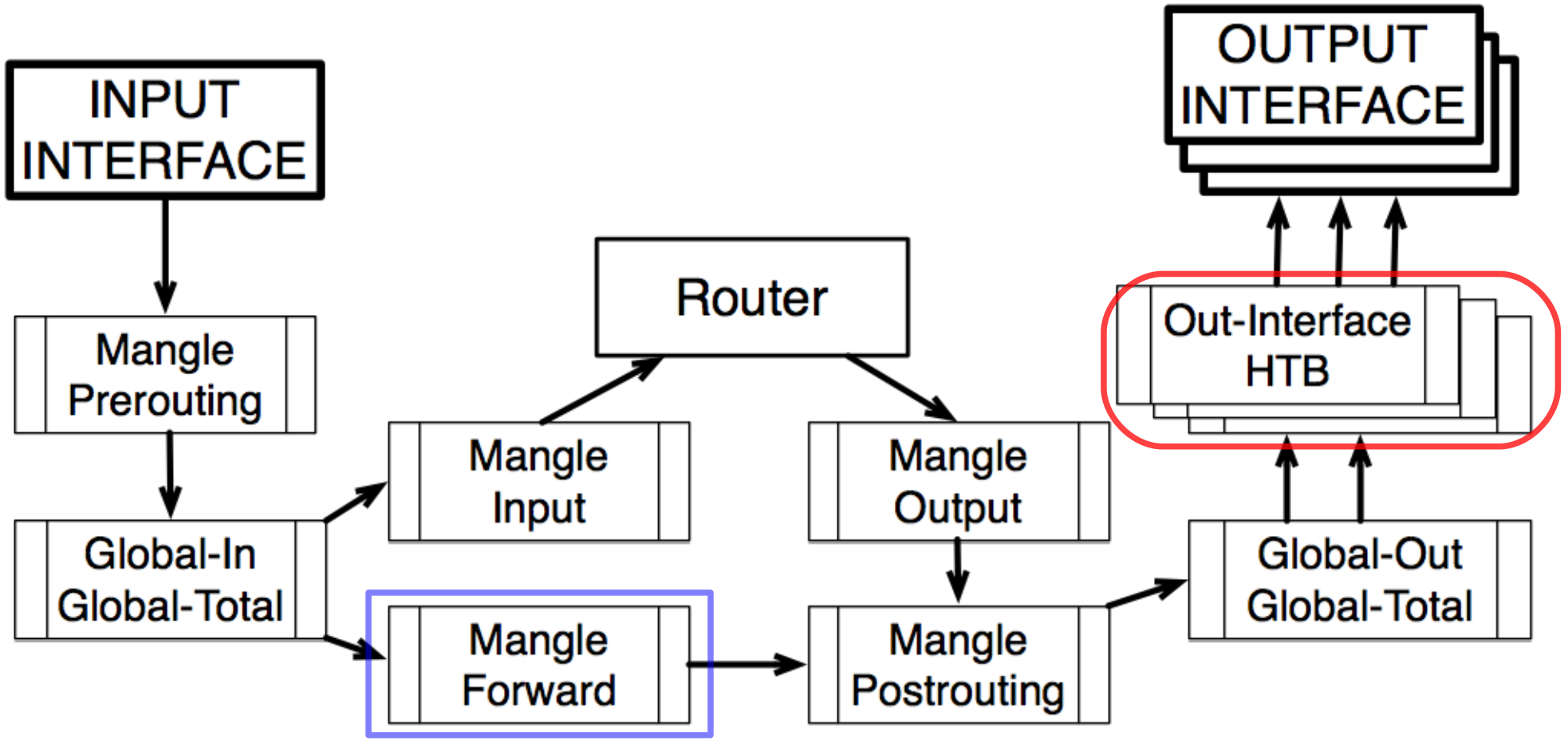
Address Lists

- 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



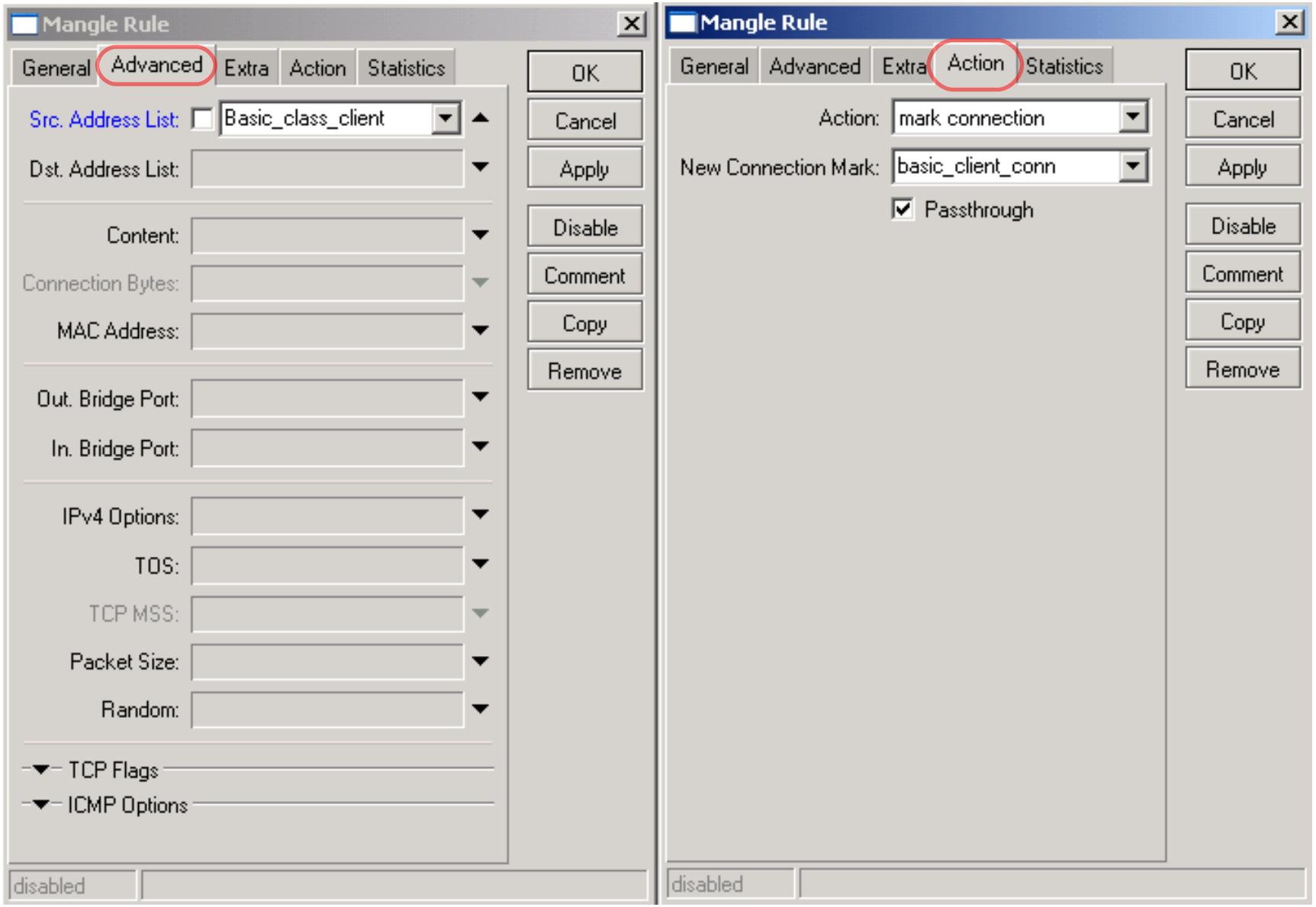
Where?


INPUT INTERFACE
Mangle Prerouting
Global-In Global-Total
Router
Mangle Input
Mangle Forward
Mangle Output
Mangle Postrouting
OUTPUT INTERFACE
Out-Interface HTB
Global-Out Global-Total

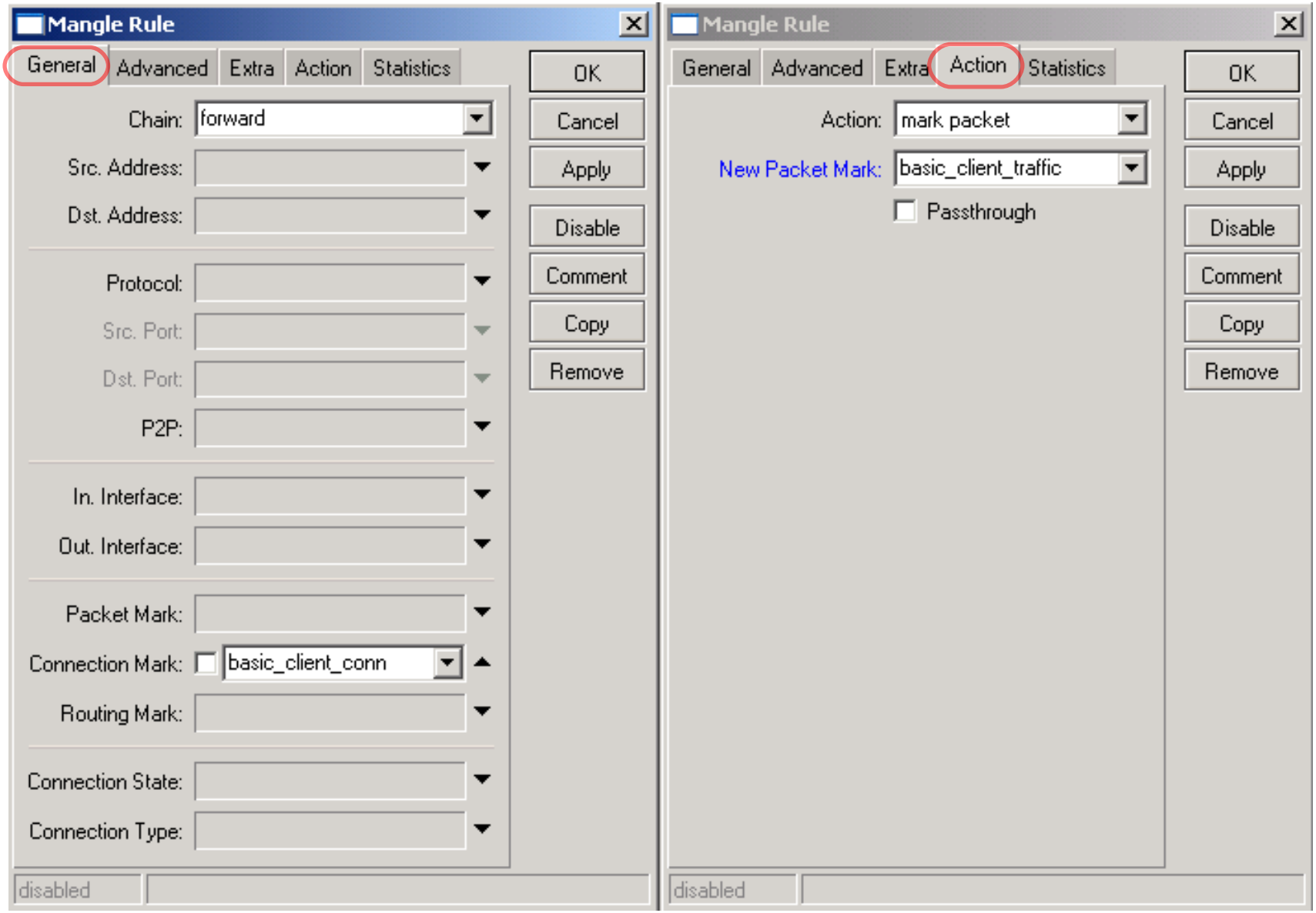
Packet Marking

- 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?

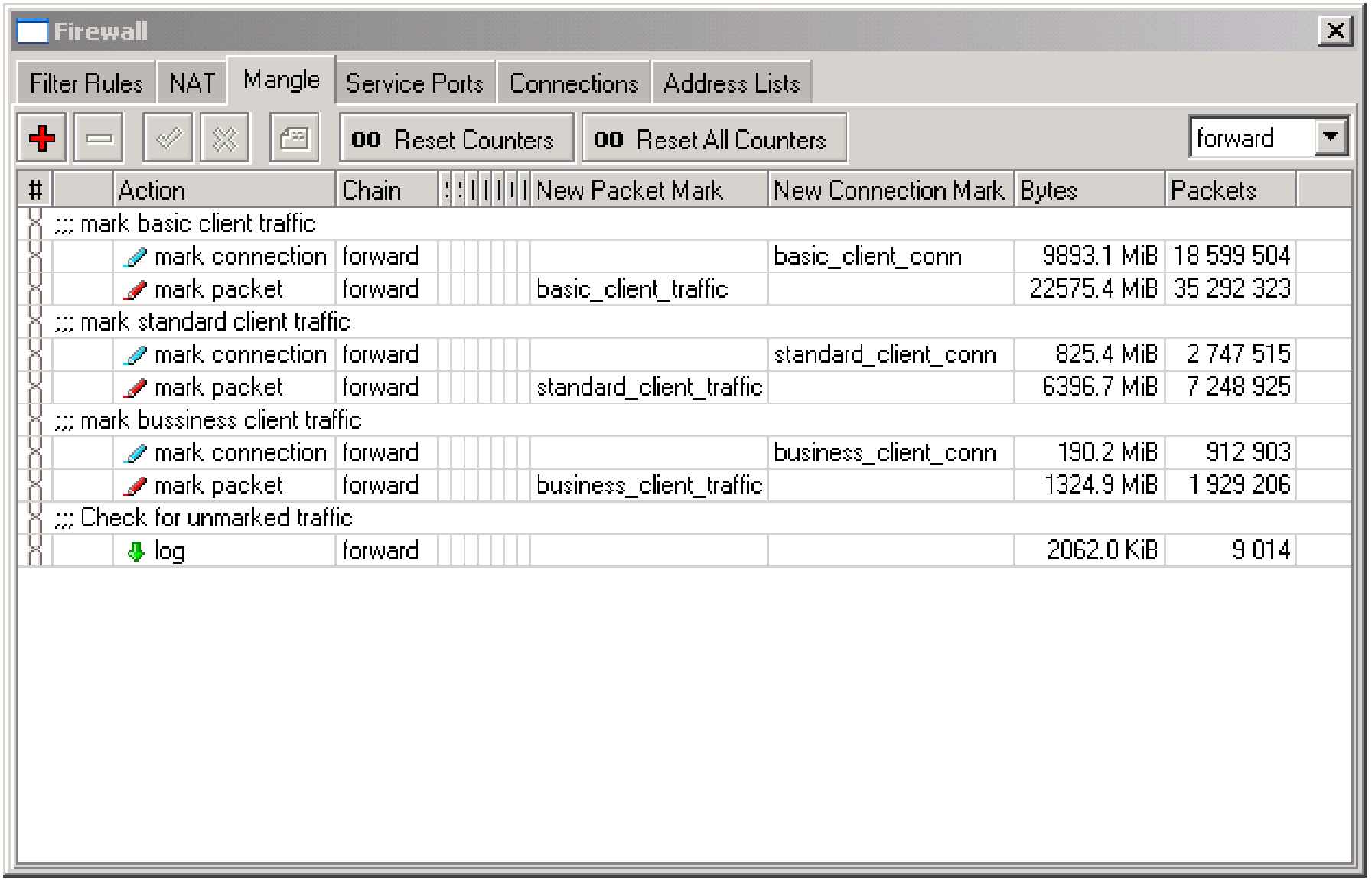
Connection-mark rule



Packet-mark rule



Working Mangle- Winbox view

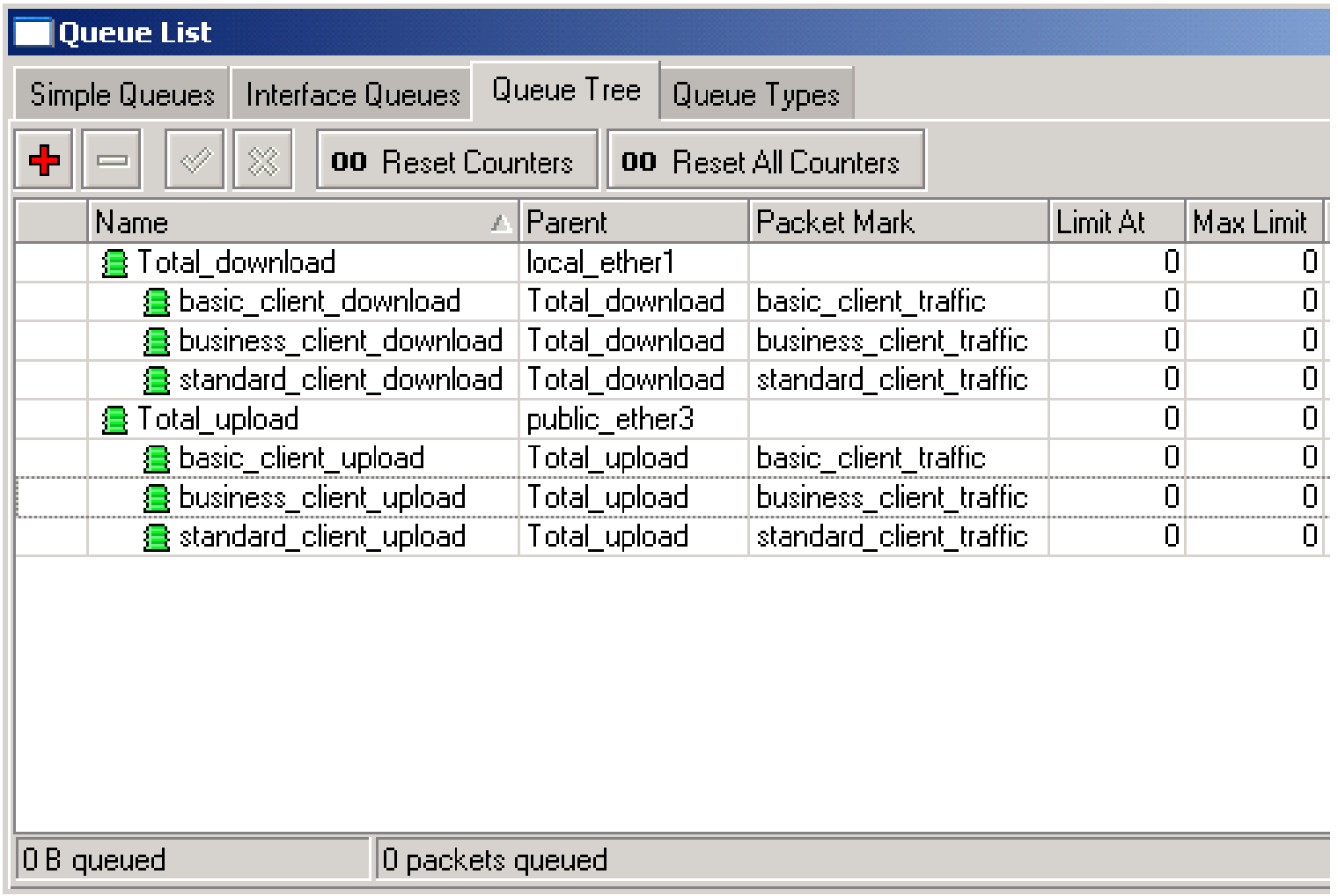


#	Action	Chain	New Packet Mark	New Connection Mark	Bytes	Packets
;;; mark basic client traffic						
	mark connection	forward		basic_client_conn	9893.1 MiB	18 599 504
	mark packet	forward	basic_client_traffic		22575.4 MiB	35 292 323
;;; mark standard client traffic						
	mark connection	forward		standard_client_conn	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
```

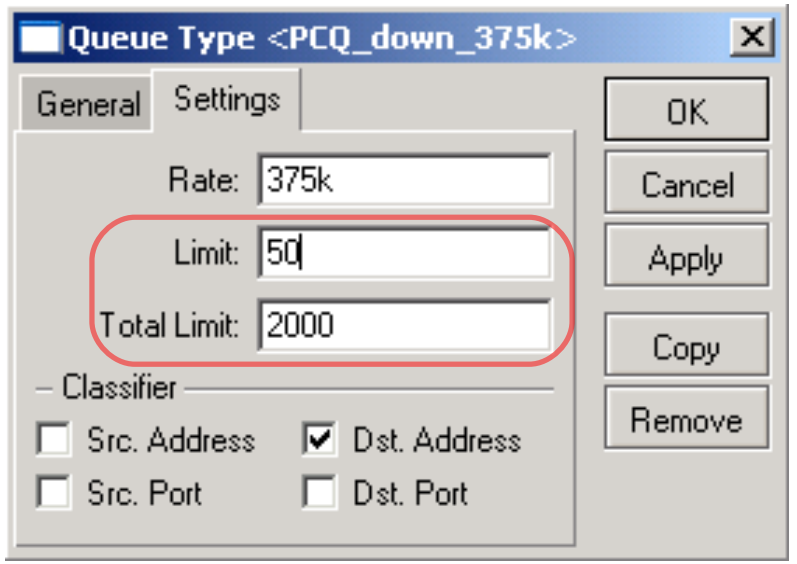
Queue Tree – Winbox View



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*(2000 bytes + 200 bytes) of RAM

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

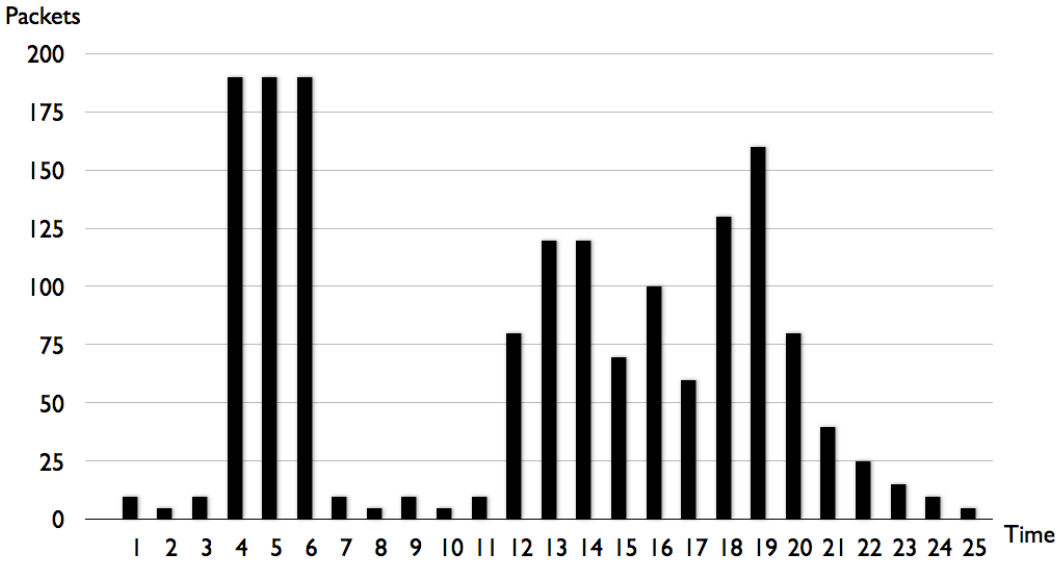
total_limit = 2000 =< 4,2MB RAM
total_limit = 5000 =< 10,5MB RAM

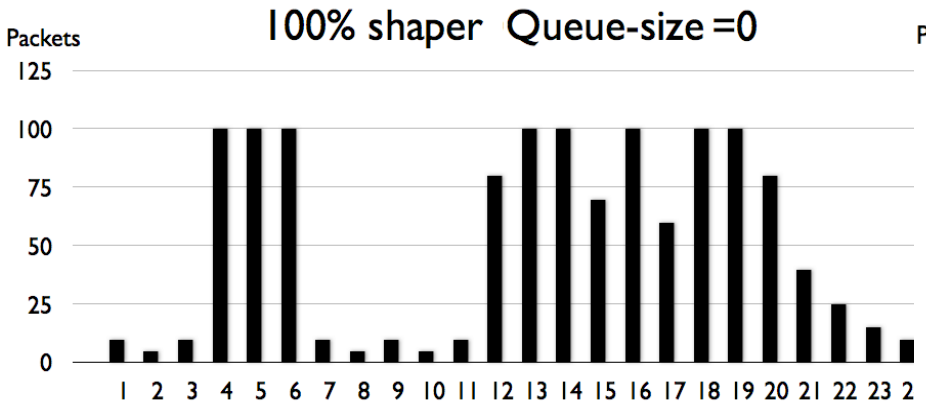
- It can take only 40 users to fill the queue

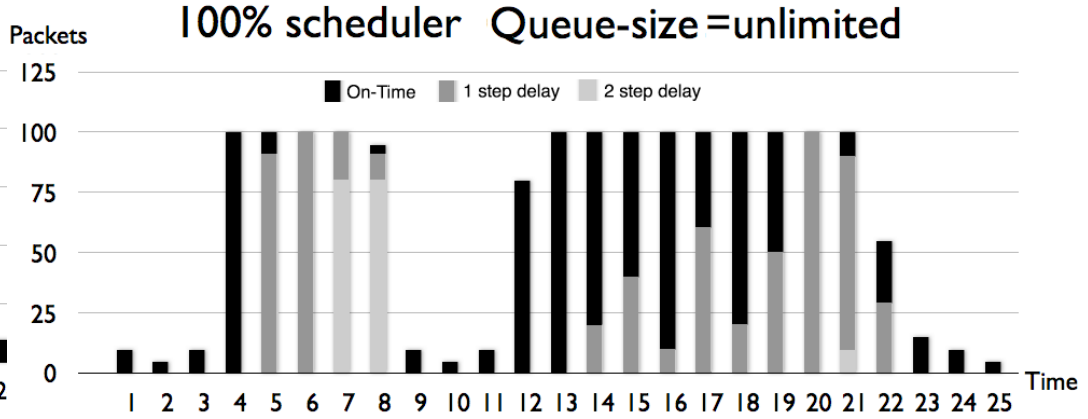
(because total_limit/limit = 2000/50 = 40)

- 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 (~20*340) (~15MB)
- There are ~40 Standard class clients so:
  - pcq_limit = 30
  - pcq_total_limit = 1000 (~20*40) (~2MB)
- There are ~20 Business class clients so:
  - pcq_limit = 20 (!!!)
  - pcq_total_limit = 500 (~20*20) (~1MB)

Traffic Prioritization

T3/E3 line

~40 Mbps
~5Mbps abroad

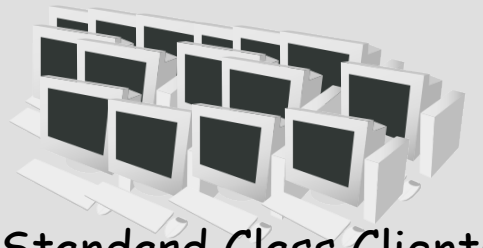
Business Class Clients

Basic Class Clients

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

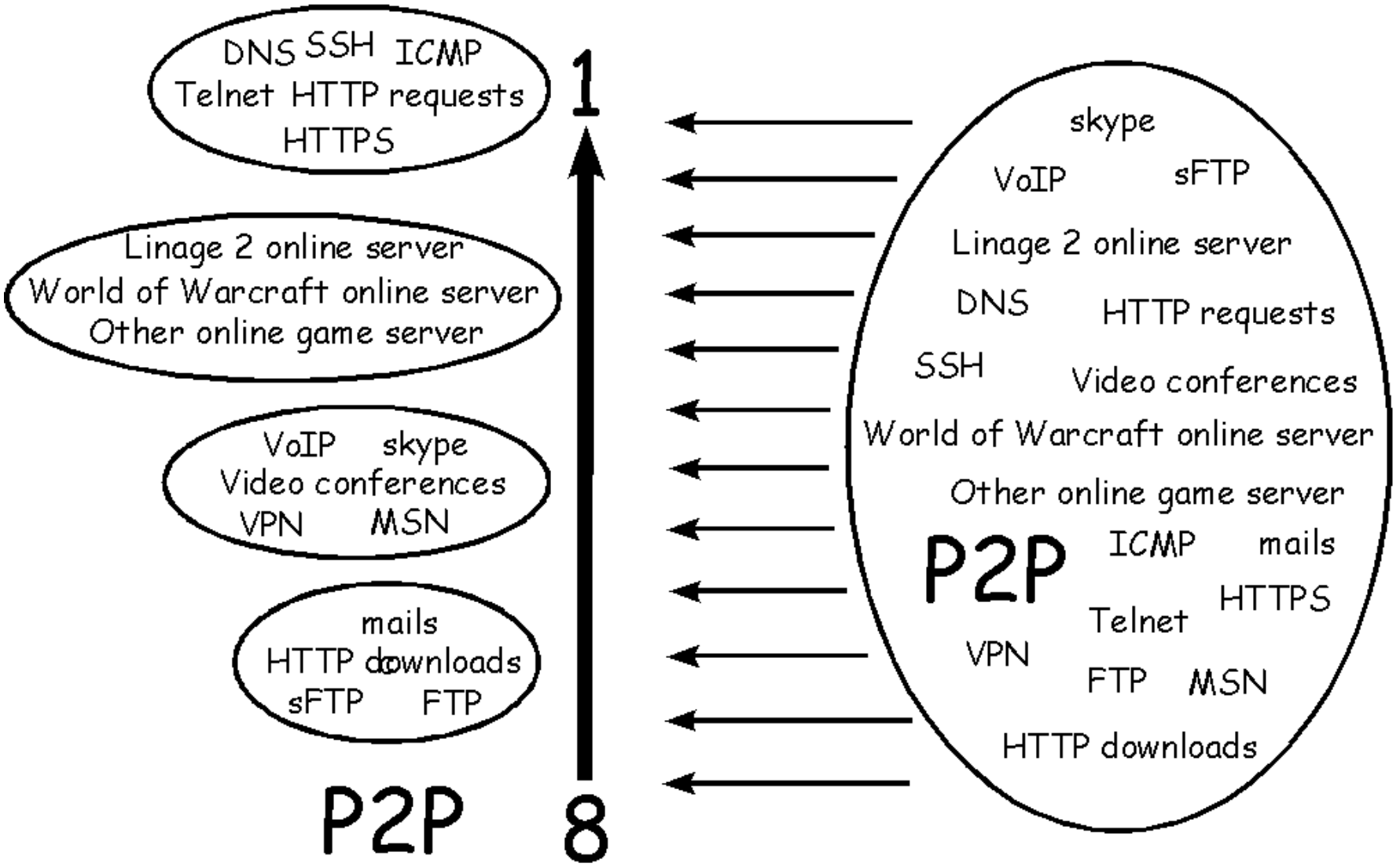
Task:

Prioritize the traffic



Standard Class Clients

Prioritization Plan



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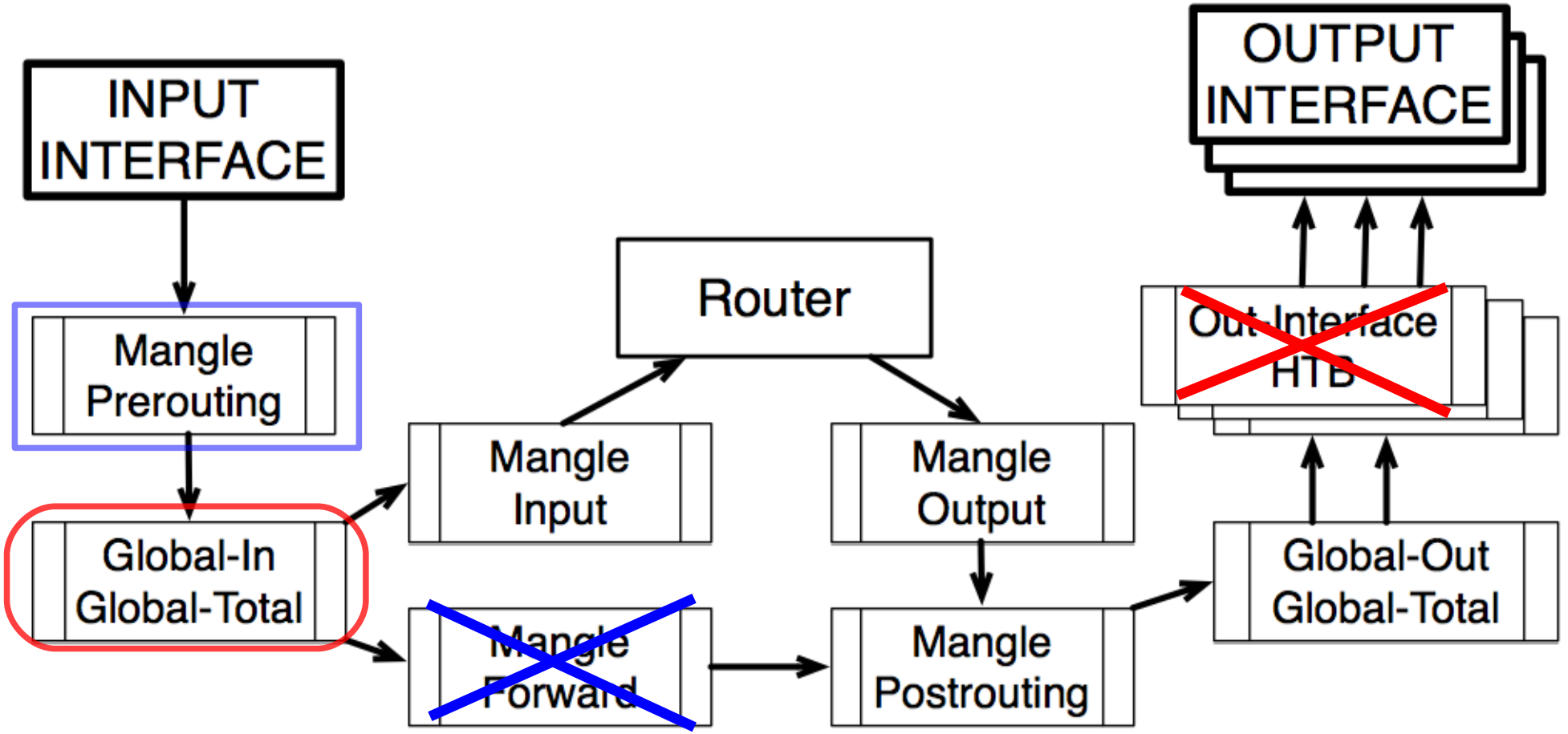
INPUT INTERFACE
Mangle Prerouting
Global-In Global-Total
Router
Mangle Input
Mangle Forward
Mangle Output
Mangle Postrouting
OUTPUT INTERFACE
Out-Interface HTB
Global-Out Global-Total

How?

Group	Service	Protocol	Dst-Port	Other conditions
P2P_services	P2P			p2p=all-p2p
Download_services	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
Ensign_services	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
User_requests	Online game servers			Dst-address-list=user_requests
Communication_services	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)