MikroTik™

QoS, HTB, Multicore

RouterOS v6.xx

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About Me

Valens Riyadi, Citraweb (ID)

MikroTik Certified Engineer
(MTCNA, MTCWE, MTCRE, MTCTCE, MTCUME, MTCINE)

MikroTik Certified Trainer since 2004

MikroTik Certified Consultant

MikroTik Academy Coordinator

Citra.net.id WISP CEO

Manager for IDNIC (Indonesia National Internet Registry) 2009 – May 2015

IT Expert on Disaster Relief

Proud member of “Routed World” community

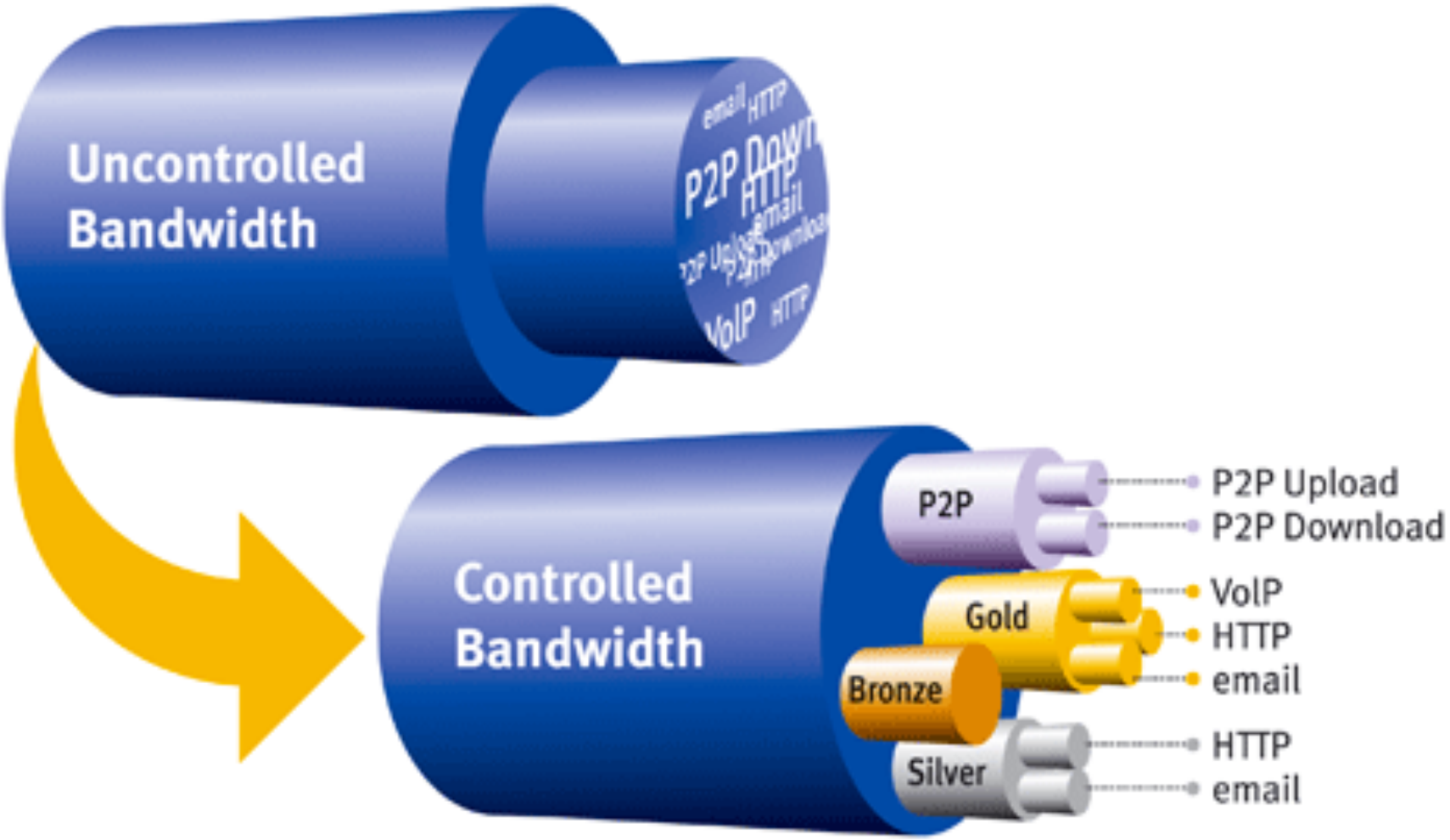
Recommended Resources

- CCR Status Update (Janis Megis – Video)
  http://tiktube.com/video/GJil3aqniCGJCIqqpGnrGznrClGoJGJo=
- Dynamic QoS on RouterOS v6 (Valens Riyadi)
  http://mum.mikrotik.com/presentations/IT14/valens.pdf
- QoS on RouterOSv6 (Valens Riyadi)
  http://mum.mikrotik.com/presentations/HR13/valens.pdf
- HTB vs PCQ (Valens Riyadi)
  http://mum.mikrotik.com/presentations/HU11/valens.pdf
- QoS and Traffic Priorities (Janis Megis)
  http://mum.mikrotik.com/presentations/CZ09/QoS_Megis.pdf
- HTB QoS (Valens Riyadi)
  http://mum.mikrotik.com/presentations/US09/Valens-MUM2009USA.pdf

QoS concept

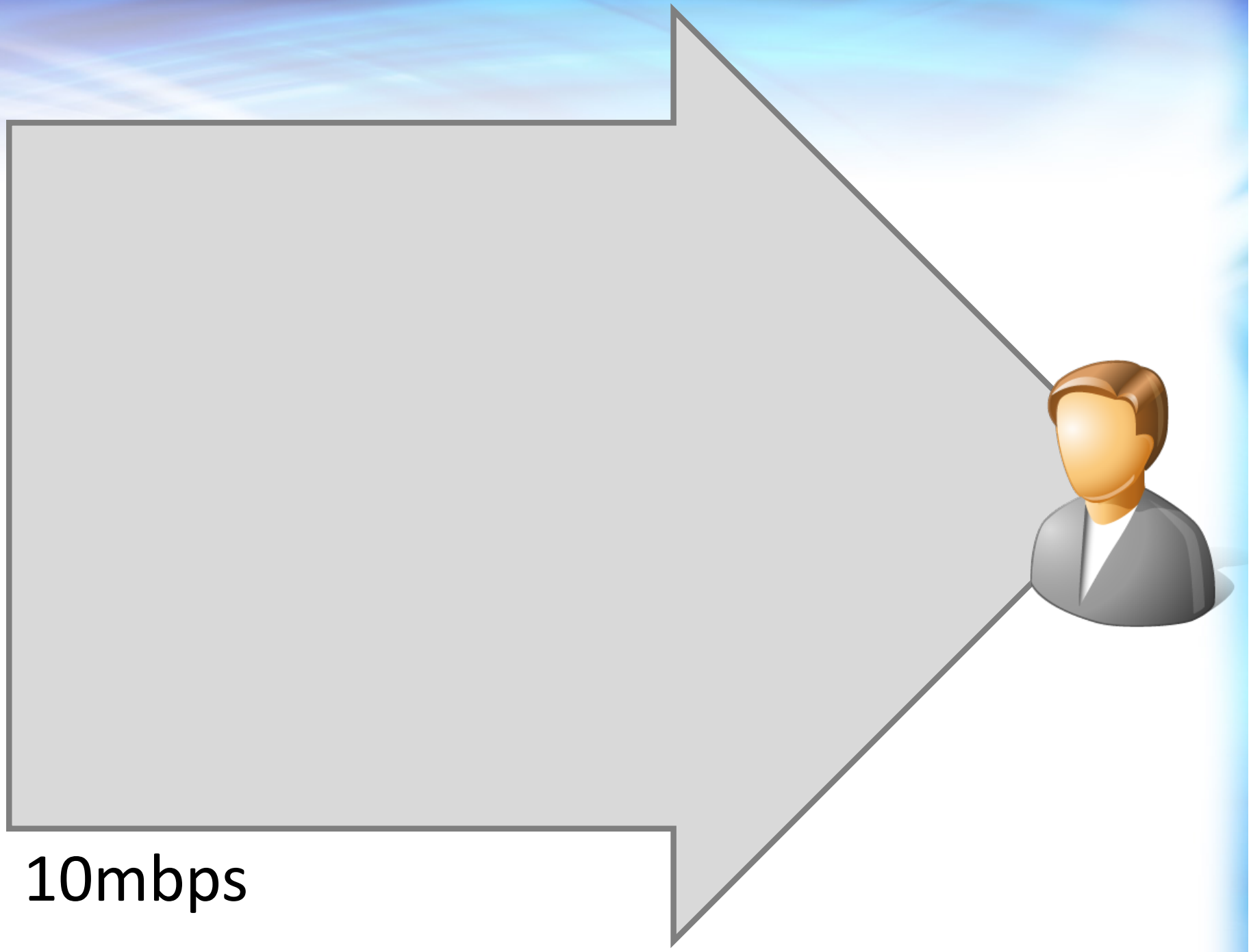
Fungsi untuk mengukur dan mengontrol komunikasi data (trafik, paket) pada jaringan, untuk menghindari overload, atau ada yang memonopoli jaringan, yang berakibat pada congestion dan performa jaringan yang buruk.

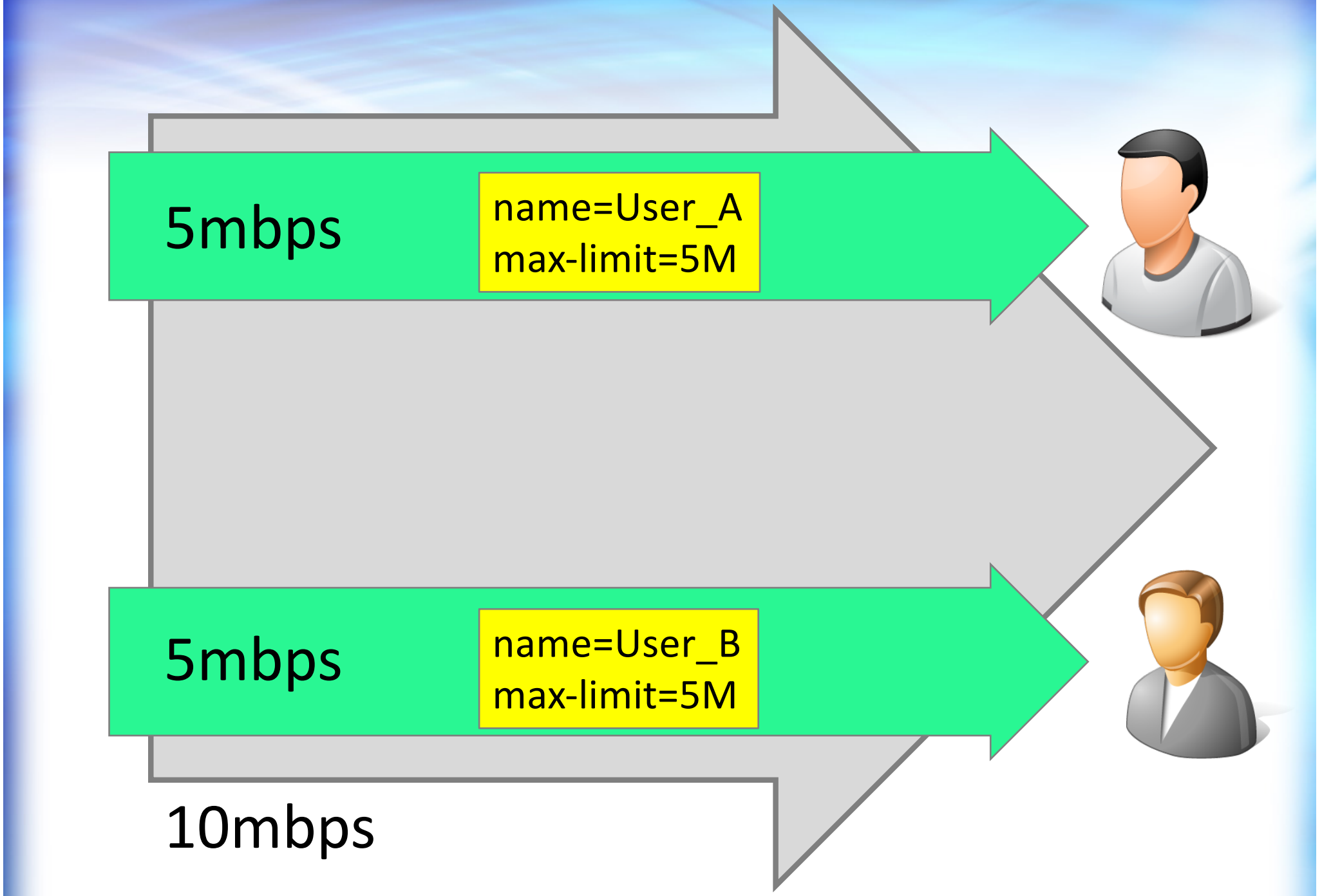
Untuk apa?

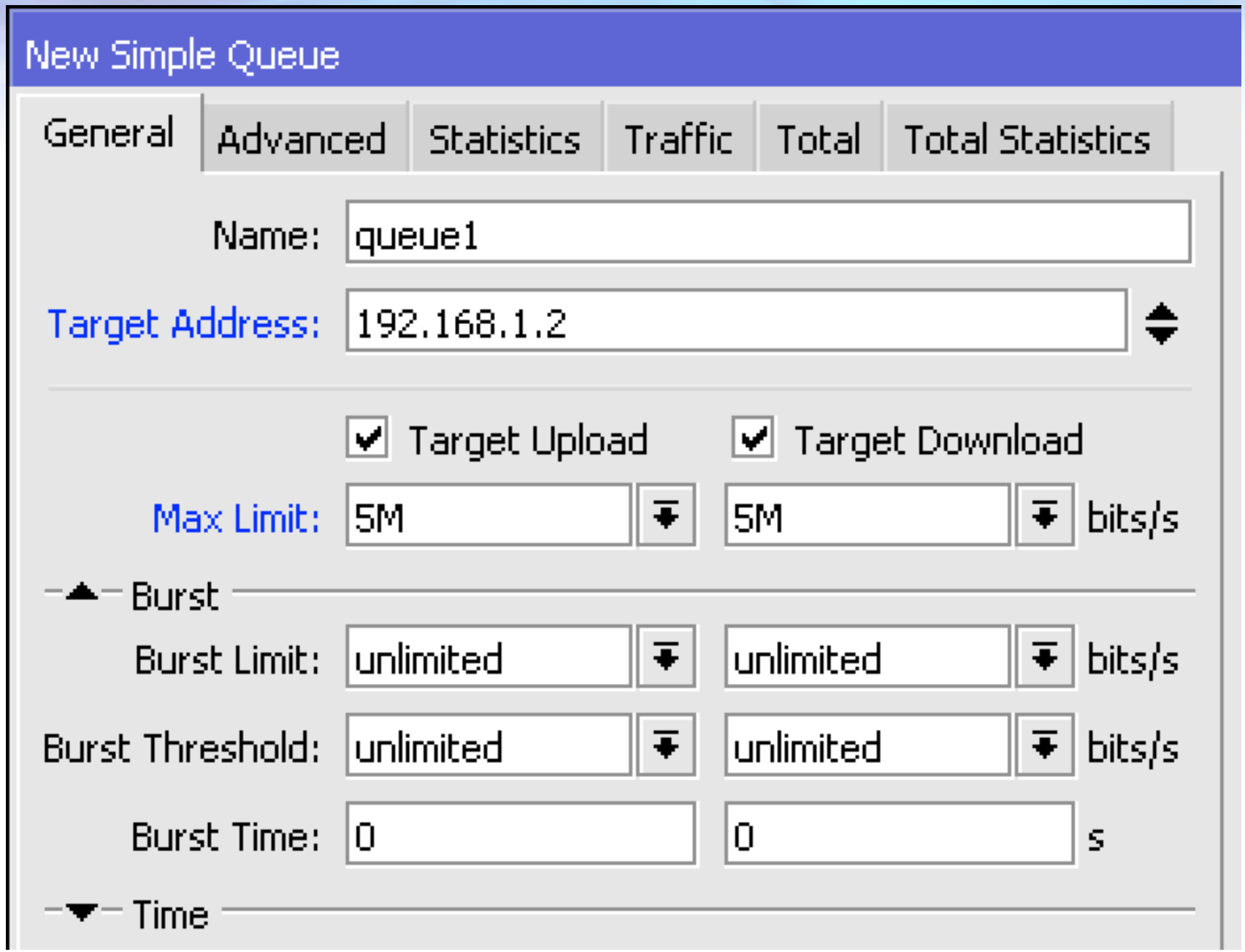

Uncontrolled Bandwidth
email HTTP
P2P
HTTP
email
VoIP HTTP
Controlled Bandwidth
P2P
P2P Upload
P2P Download
Gold
VoIP
HTTP
email
Bronze
Silver
HTTP
email

QoS on RouterOS

- MikroTik RouterOS adalah salah satu bandwidth management paling canggih, jika dibandingkan dengan merk lainnya.
- Mengapa?
  - Konfigurasi HTB yang mendalam
  - Double limitation + Burst
  - Ada banyak pilihan dan parameter → packet-mark


10mbps


5mbps
name=User_A
max-limit=5M
5mbps
name=User_B
max-limit=5M
10mbps


New Simple Queue
General
Advanced
Statistics
Traffic
Total
Total Statistics
Name:
queue1
Target Address:
192.168.1.2
Target Upload
Target Download
Max Limit:
5M
5M
bits/s
Burst
Burst Limit:
unlimited
unlimited
bits/s
Burst Threshold:
unlimited
unlimited
bits/s
Burst Time:
0
0
s
Time

Max-limit

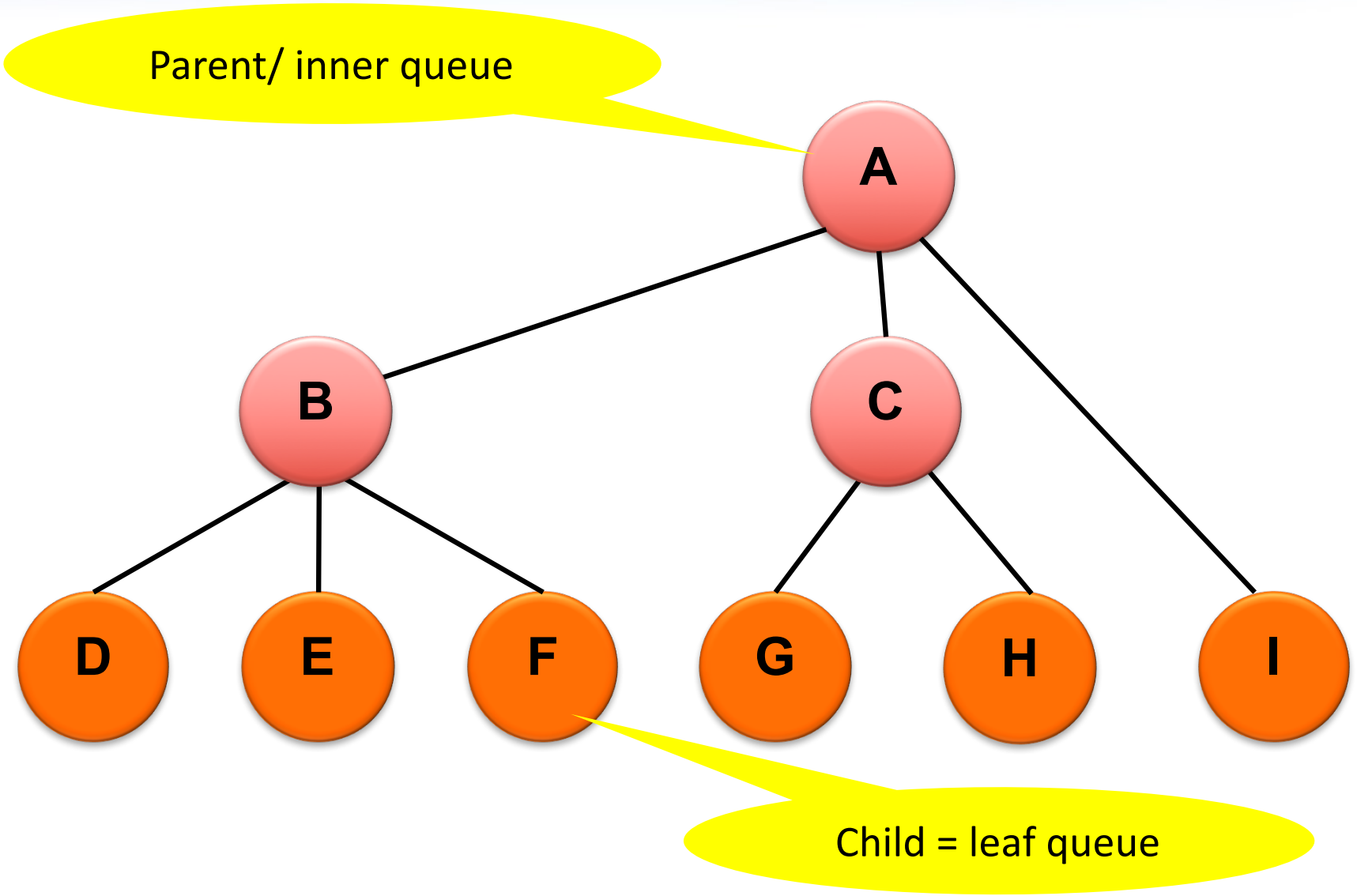
Besarnya kapasitas maksimum yang bisa dicapai oleh user tertentu

Bagaimana jika user A tidak menggunakan internet, user B dapat menggunakan semua sisa bandwidth yang tersedia?

HTB

- Sebagian besar implementasi QoS pada RouterOS berdasarkan Hierarchical Token Bucket (HTB)
- HTB memungkinkan kita membuat struktur queue berjenjang dan menentukan relasi antara parent dengan child, ataupun antar sesama child.
- RouterOS v6 mengenal 1 virtual HTBs (global), dan satu di akhir setiap interface

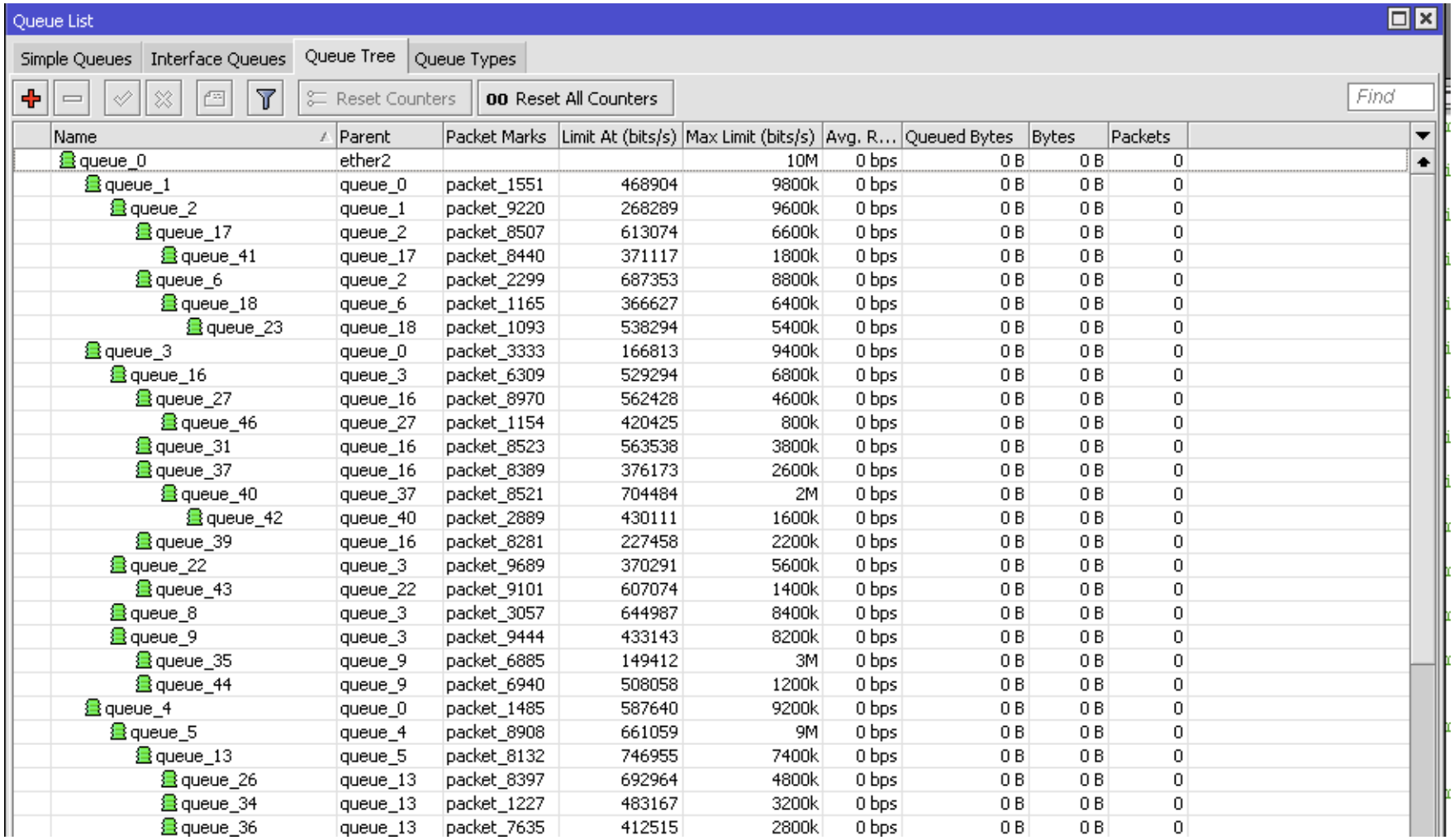
HTB Sample



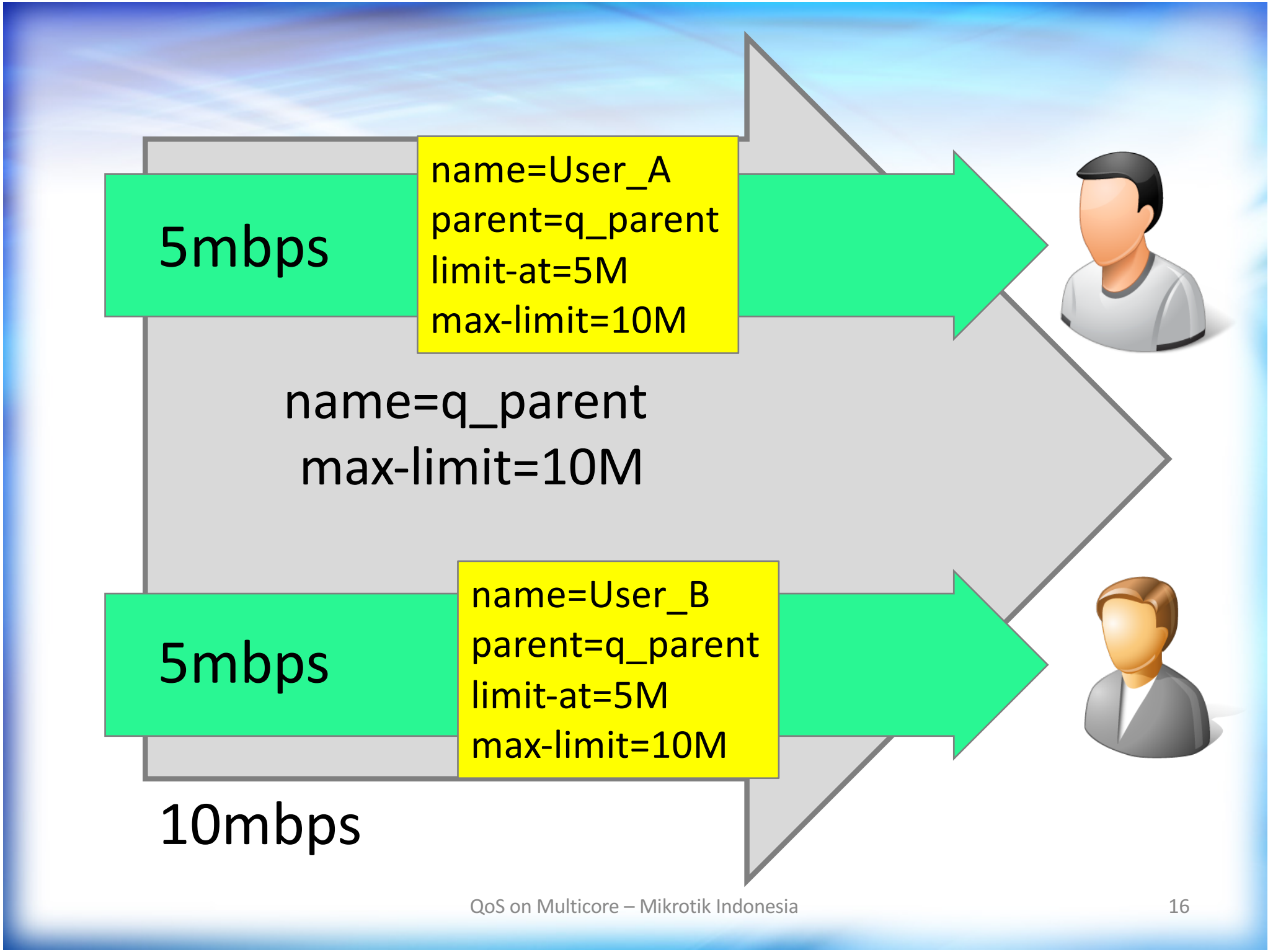
HTB Features

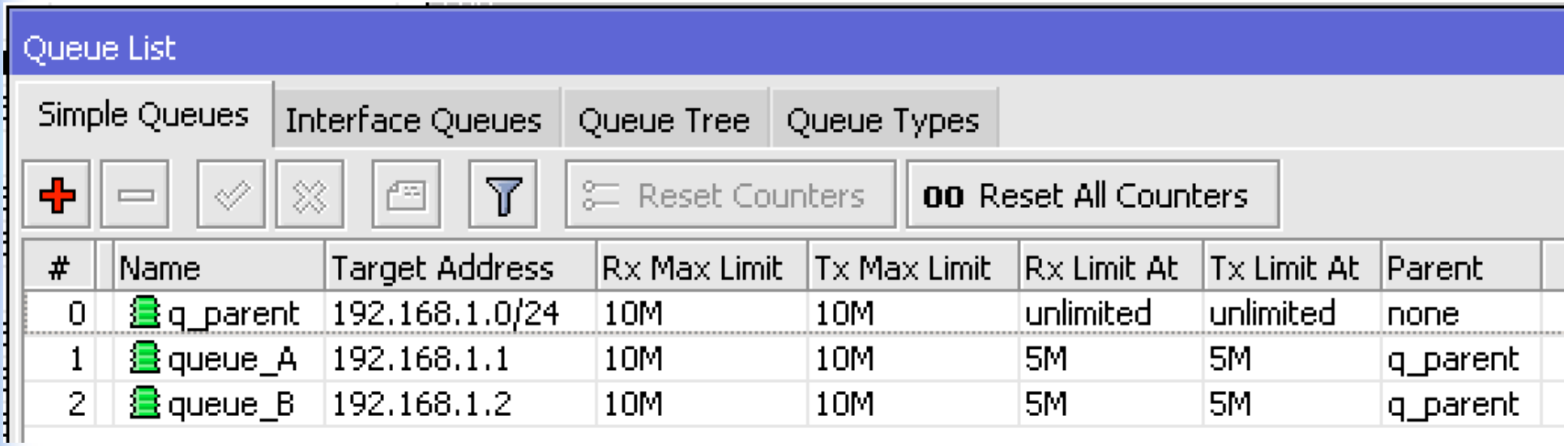
- Hirarki
  - Di routerOS, kita bisa membuat hingga 8 level hirarki
- Grouping
  - Kita bisa mengelompokkan beberapa client di dalam satu parent
  - Client yang satu bisa meminjam bandwidth dari client lainnya, jika dibutuhkan dan tersedia
- Tiap leaf queue bisa memiliki setting yang berbeda. Semua leaf akan dianggap sama, di hirarki paling bawah

HTB Implementation Example



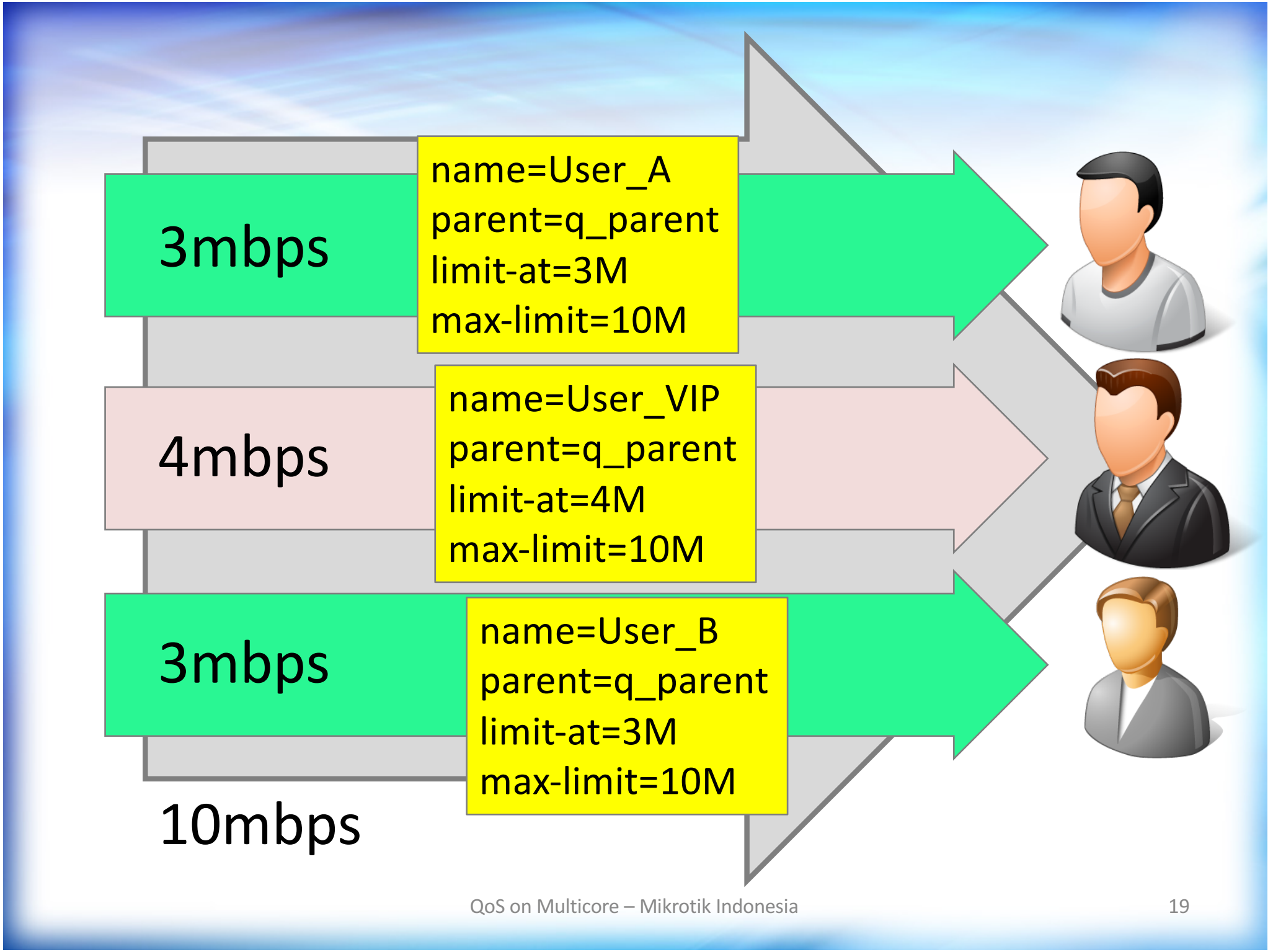
Name	Parent	Packet Marks	Limit At (bits/s)	Max Limit (bits/s)	Avg. R...	Queued Bytes	Bytes	Packets
queue_0	ether2			10M	0 bps	0 B	0 B	0
queue_1	queue_0	packet_1551	468904	9800k	0 bps	0 B	0 B	0
queue_2	queue_1	packet_9220	268289	9600k	0 bps	0 B	0 B	0
queue_17	queue_2	packet_8507	613074	6600k	0 bps	0 B	0 B	0
queue_41	queue_17	packet_8440	371117	1800k	0 bps	0 B	0 B	0
queue_6	queue_2	packet_2299	687353	8800k	0 bps	0 B	0 B	0
queue_18	queue_6	packet_1165	366627	6400k	0 bps	0 B	0 B	0
queue_23	queue_18	packet_1093	538294	5400k	0 bps	0 B	0 B	0
queue_3	queue_0	packet_3333	166813	9400k	0 bps	0 B	0 B	0
queue_16	queue_3	packet_6309	529294	6800k	0 bps	0 B	0 B	0
queue_27	queue_16	packet_8970	562428	4600k	0 bps	0 B	0 B	0
queue_46	queue_27	packet_1154	420425	800k	0 bps	0 B	0 B	0
queue_31	queue_16	packet_8523	563538	3800k	0 bps	0 B	0 B	0
queue_37	queue_16	packet_8389	376173	2600k	0 bps	0 B	0 B	0
queue_40	queue_37	packet_8521	704484	2M	0 bps	0 B	0 B	0
queue_42	queue_40	packet_2889	430111	1600k	0 bps	0 B	0 B	0
queue_39	queue_16	packet_8281	227458	2200k	0 bps	0 B	0 B	0
queue_22	queue_3	packet_9689	370291	5600k	0 bps	0 B	0 B	0
queue_43	queue_22	packet_9101	607074	1400k	0 bps	0 B	0 B	0
queue_8	queue_3	packet_3057	644987	8400k	0 bps	0 B	0 B	0
queue_9	queue_3	packet_9444	433143	8200k	0 bps	0 B	0 B	0
queue_35	queue_9	packet_6885	149412	3M	0 bps	0 B	0 B	0
queue_44	queue_9	packet_6940	508058	1200k	0 bps	0 B	0 B	0
queue_4	queue_0	packet_1485	587640	9200k	0 bps	0 B	0 B	0
queue_5	queue_4	packet_8908	661059	9M	0 bps	0 B	0 B	0
queue_13	queue_5	packet_8132	746955	7400k	0 bps	0 B	0 B	0
queue_26	queue_13	packet_8397	692964	4800k	0 bps	0 B	0 B	0
queue_34	queue_13	packet_1227	483167	3200k	0 bps	0 B	0 B	0
queue_36	queue_13	packet_7635	412515	2800k	0 bps	0 B	0 B	0

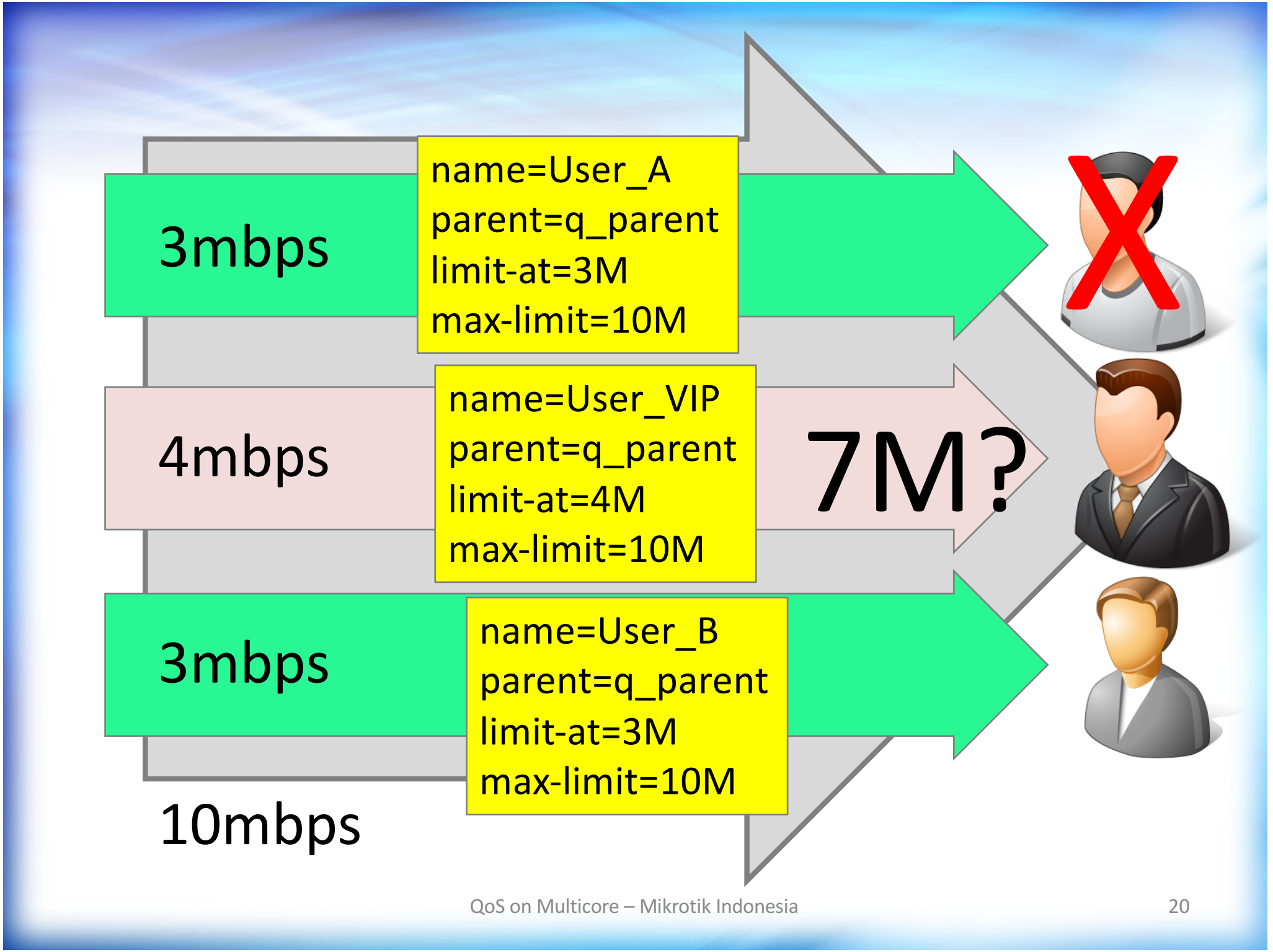

5mbps
name=User_A
parent=q_parent
limit-at=5M
max-limit=10M
name=q_parent
max-limit=10M
5mbps
name=User_B
parent=q_parent
limit-at=5M
max-limit=10M
10mbps

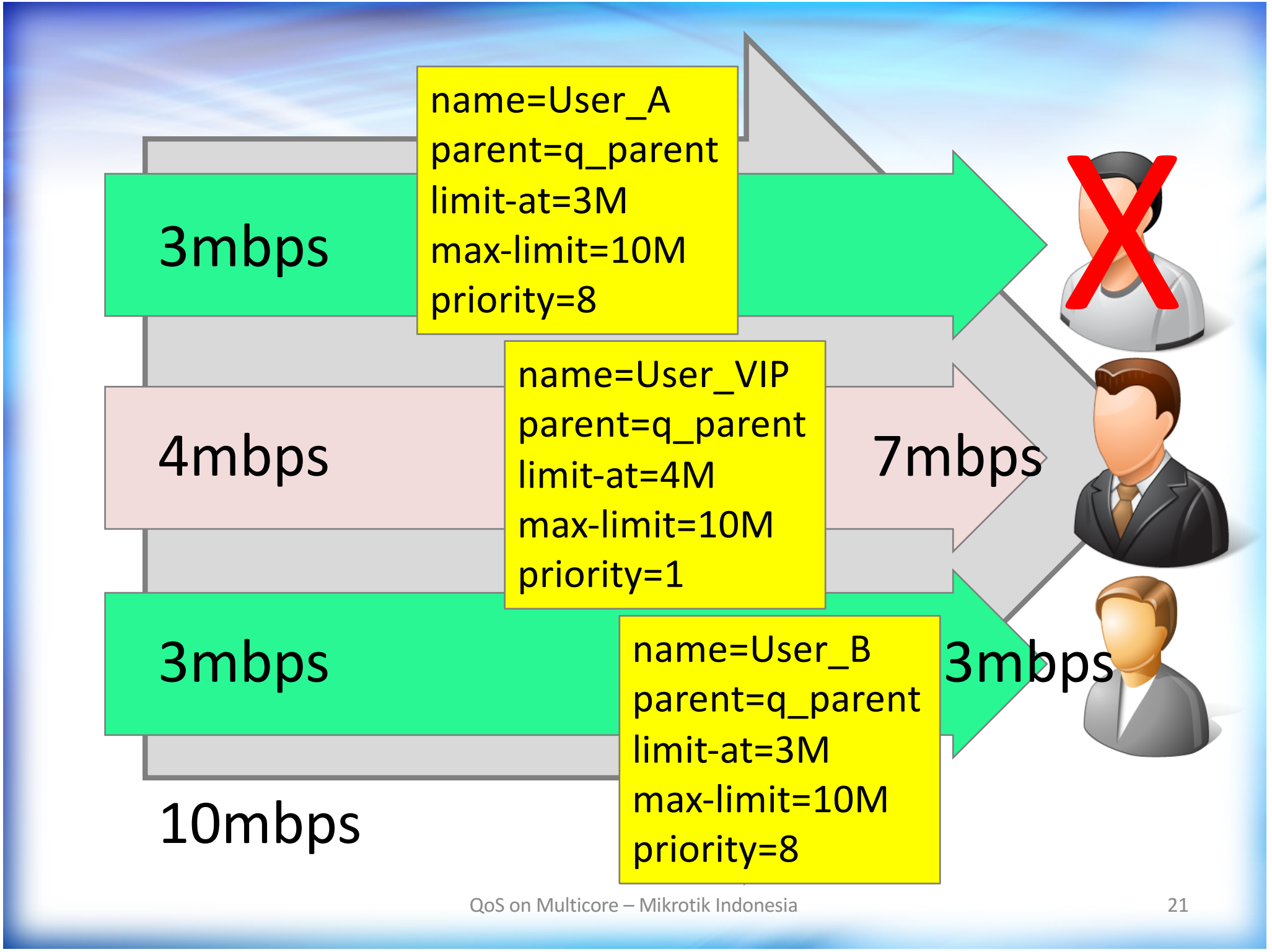

Queue List
Simple Queues
Interface Queues
Queue Tree
Queue Types
Reset Counters
Reset All Counters
Name Target Address Rx Max Limit Tx Max Limit Rx Limit At Tx Limit At Parent
0 q_parent 192.168.1.0/24 10M 10M unlimited unlimited none
1 queue_A 192.168.1.1 10M 10M 5M 5M q_parent
2 queue_B 192.168.1.2 10M 10M 5M 5M q_parent

Limit-at

Besarnya kapasitas yang dijamin dapat diterima oleh user tertentu, selama bandwidth masih tersedia


3mbps
name=User_A
parent=q_parent
limit-at=3M
max-limit=10M
4mbps
name=User_VIP
parent=q_parent
limit-at=4M
max-limit=10M
3mbps
name=User_B
parent=q_parent
limit-at=3M
max-limit=10M
10mbps


3mbps
name=User_A
parent=q_parent
limit-at=3M
max-limit=10M
4mbps
name=User_VIP
parent=q_parent
limit-at=4M
max-limit=10M
7M?
3mbps
name=User_B
parent=q_parent
limit-at=3M
max-limit=10M
10mbps

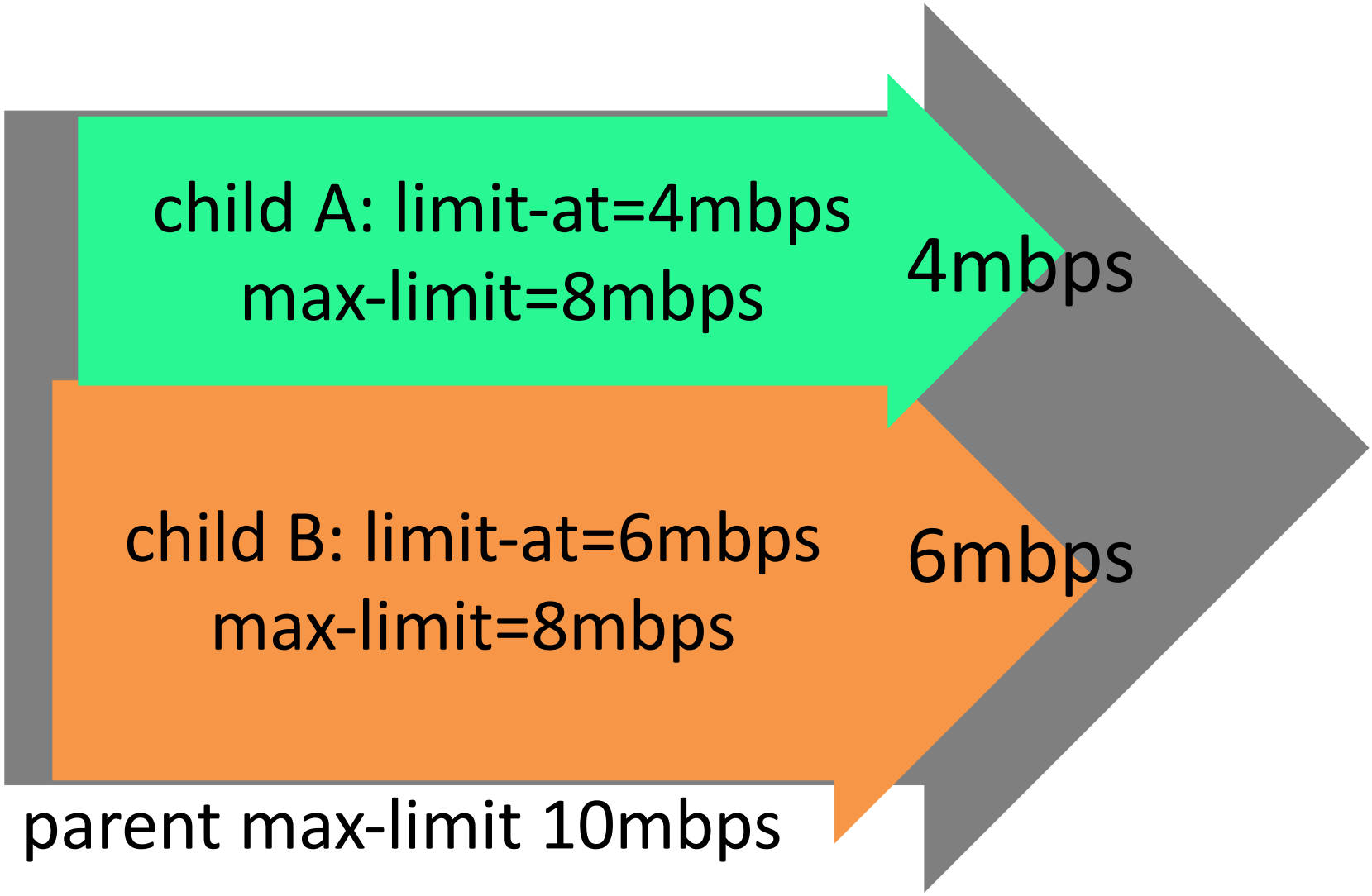

name=User_A
parent=q_parent
limit-at=3M
max-limit=10M
priority=8
3mbps
name=User_VIP
parent=q_parent
limit-at=4M
max-limit=10M
priority=1
4mbps
7mbps
3mbps
name=User_B
parent=q_parent
limit-at=3M
max-limit=10M
priority=8
3mbps
10mbps

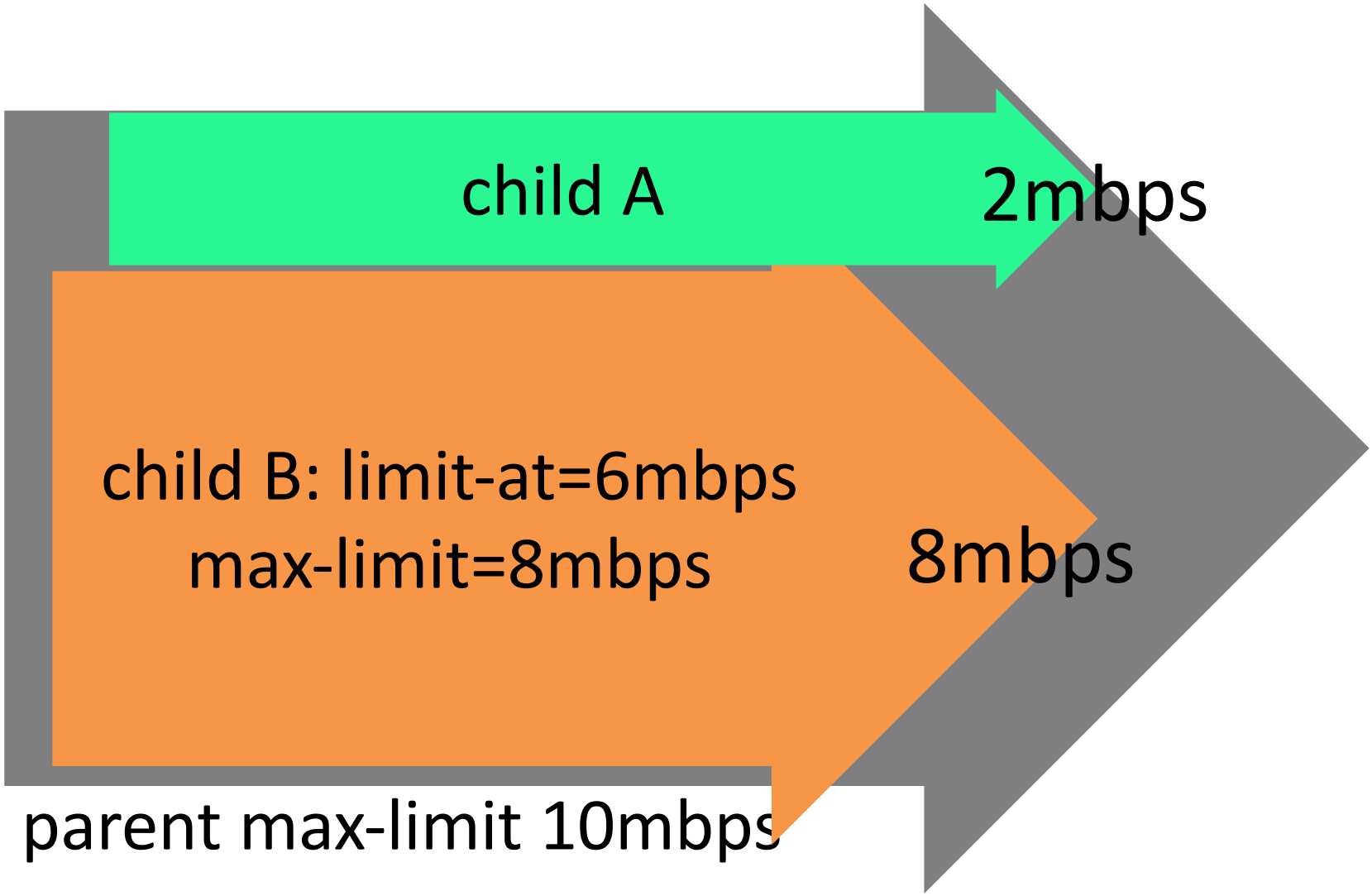
Priority

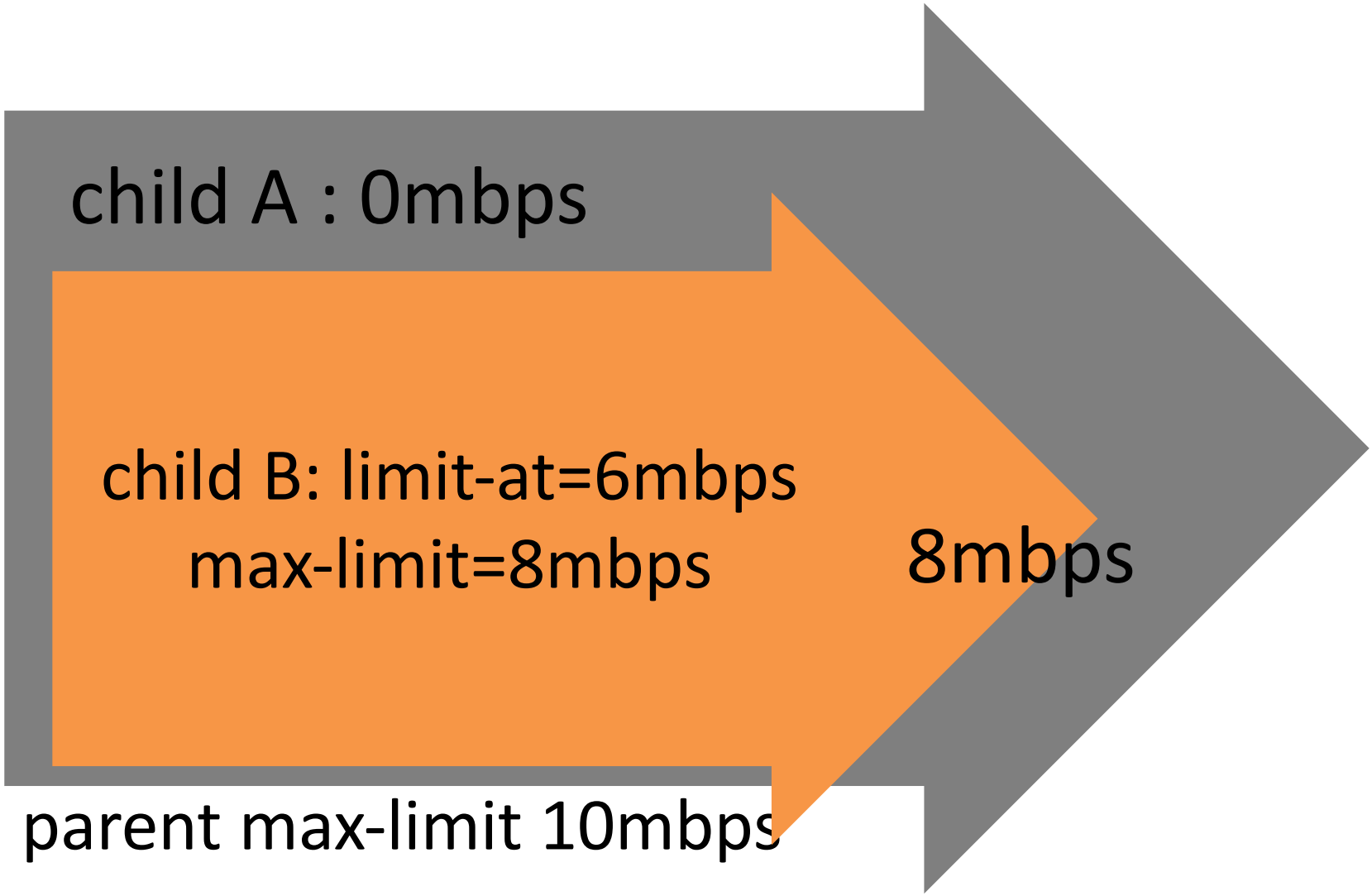
Memberikan prioritas untuk user tertentu dibanding user lainnya, jika semua limit-at sudah terpenuhi.

Queue Parameter

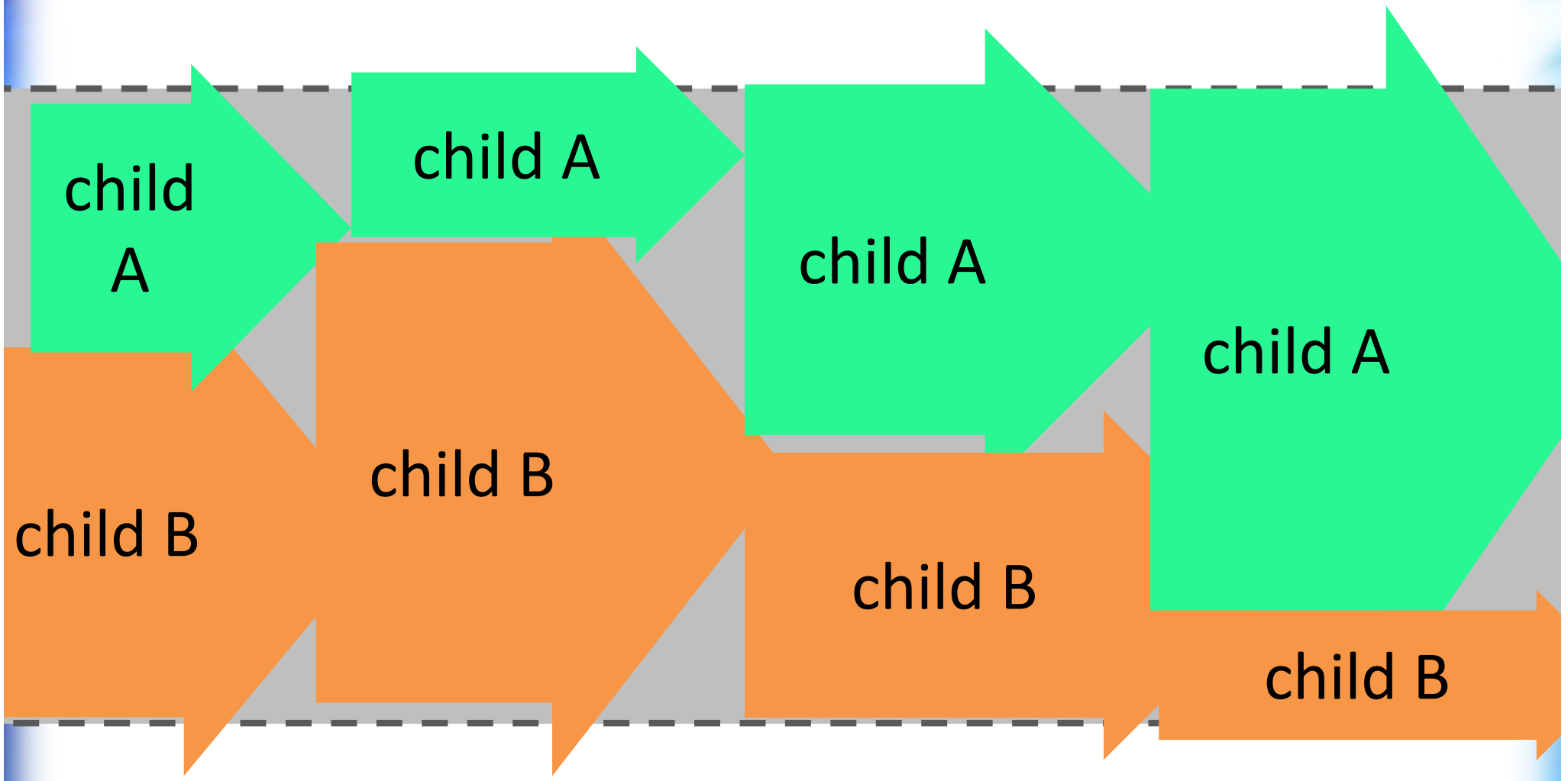
- limit-at (CIR)
- max-limit (MIR)
- burst (threshold, limit, time)
- queue type (FIFO, RED, SFQ, PCQ)
- parent


child A: limit-at=4mbps
max-limit=8mbps
4mbps
child B: limit-at=6mbps
max-limit=8mbps
6mbps
parent max-limit 10mbps


child A
2mbps
child B: limit-at=6mbps
max-limit=8mbps
8mbps
parent max-limit 10mbps

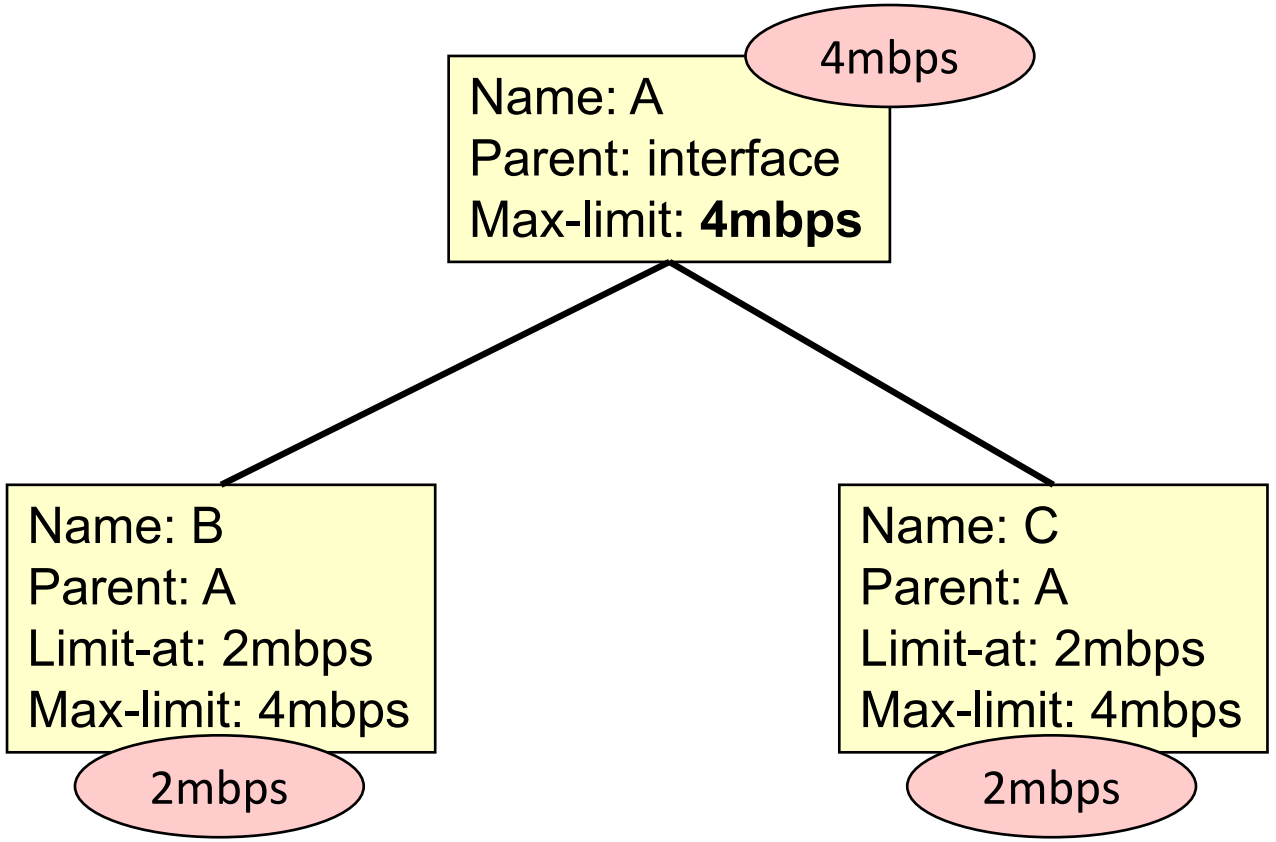

child A : 0mbps
child B: limit-at=6mbps
max-limit=8mbps
8mbps
parent max-limit 10mbps

without parent, with 10mbps link



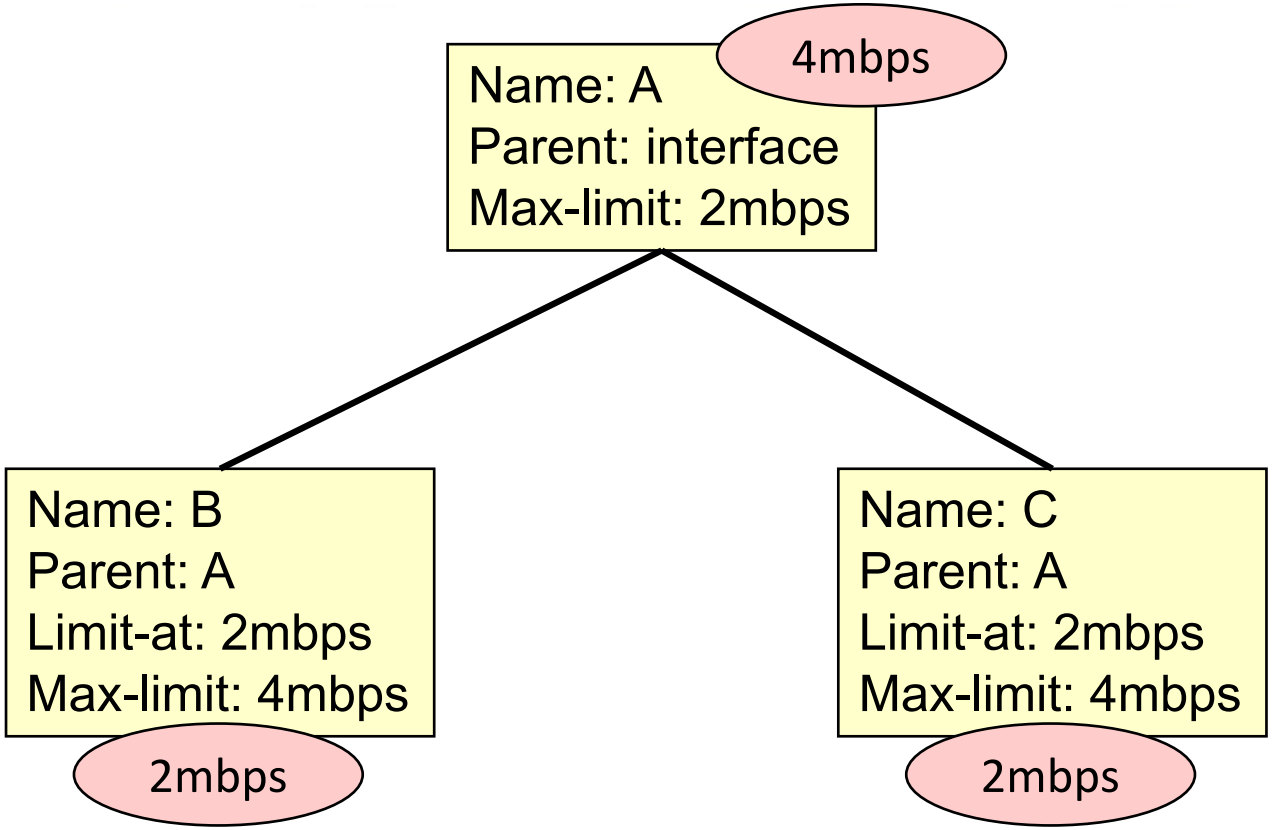
Tanpa parent,
parameter limit-at dan
priority akan diabaikan.

HTB Distribution (1)



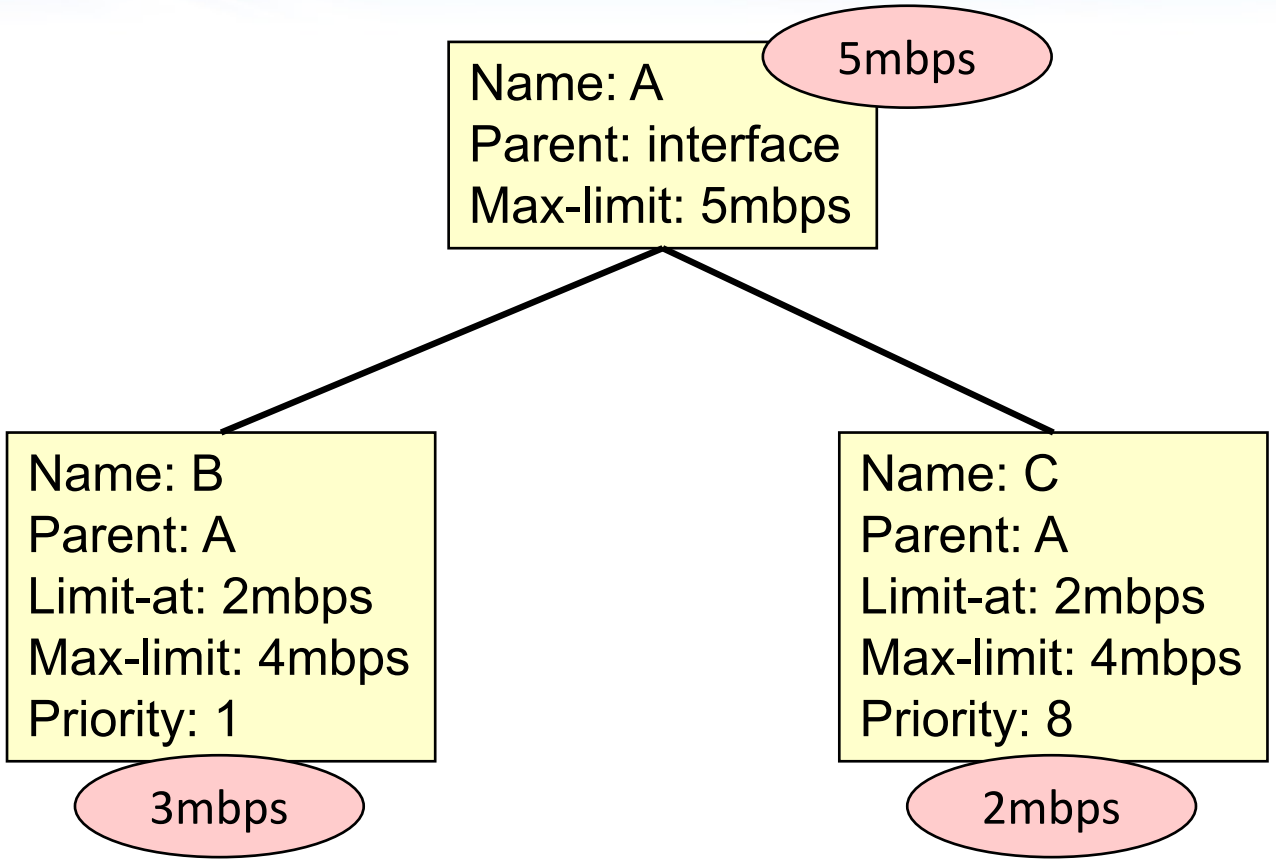
If Child B and C use the link, they will have 2mbps each, but if child C is not using it, child B will get 4 mbps.

HTB Distribution (2)



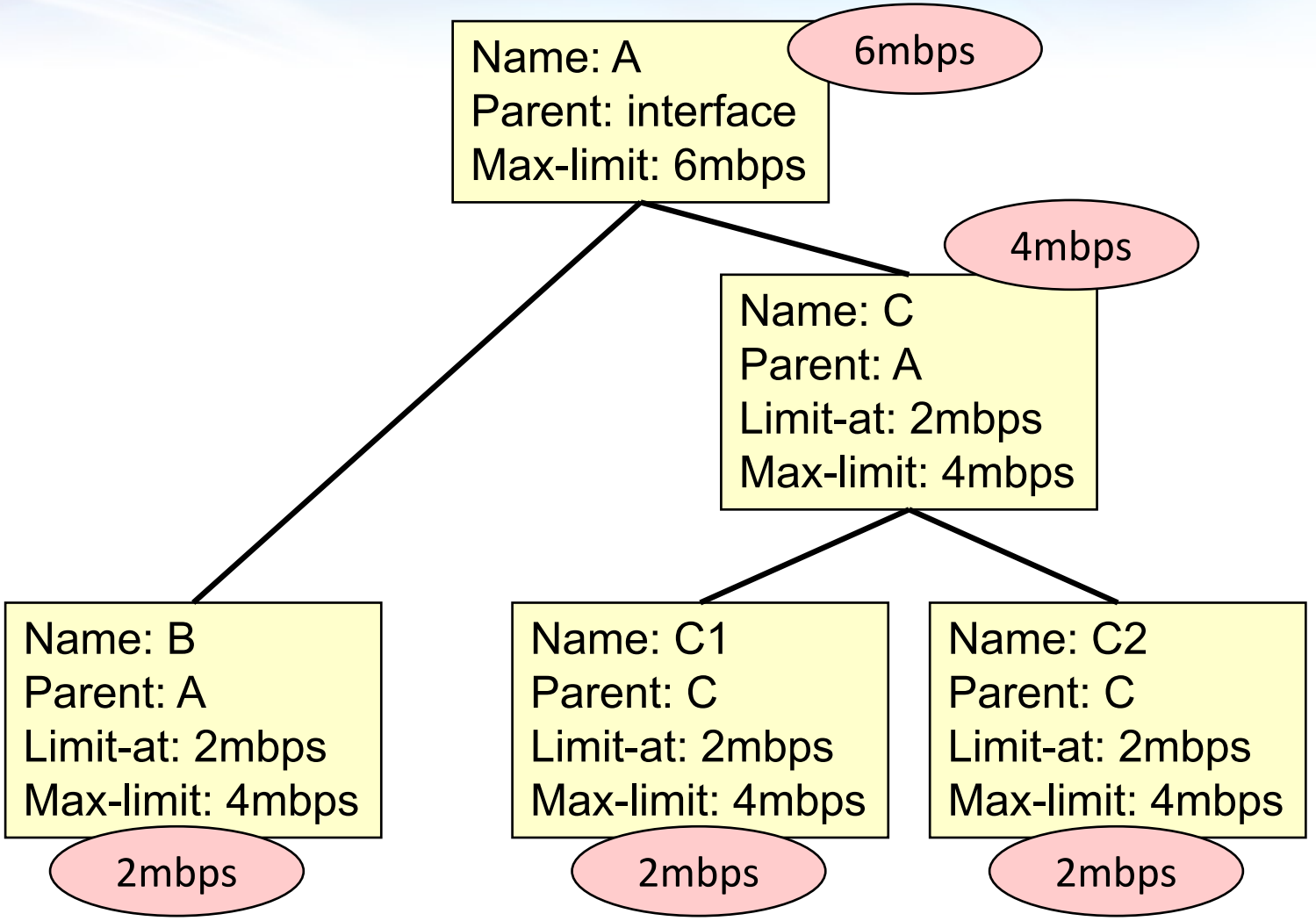
Even the max-limit of the parent is 2mbps, but child B and child C will still get 2 mbps each (total of 4 mbps). If C is not use the link, B will still get 2 mbps, can not extend to 4 mbps, because limited by max-limit of its max-limit parent. Max-limit of parent A should be at least 4 mbps.

HTB Distribution (3)



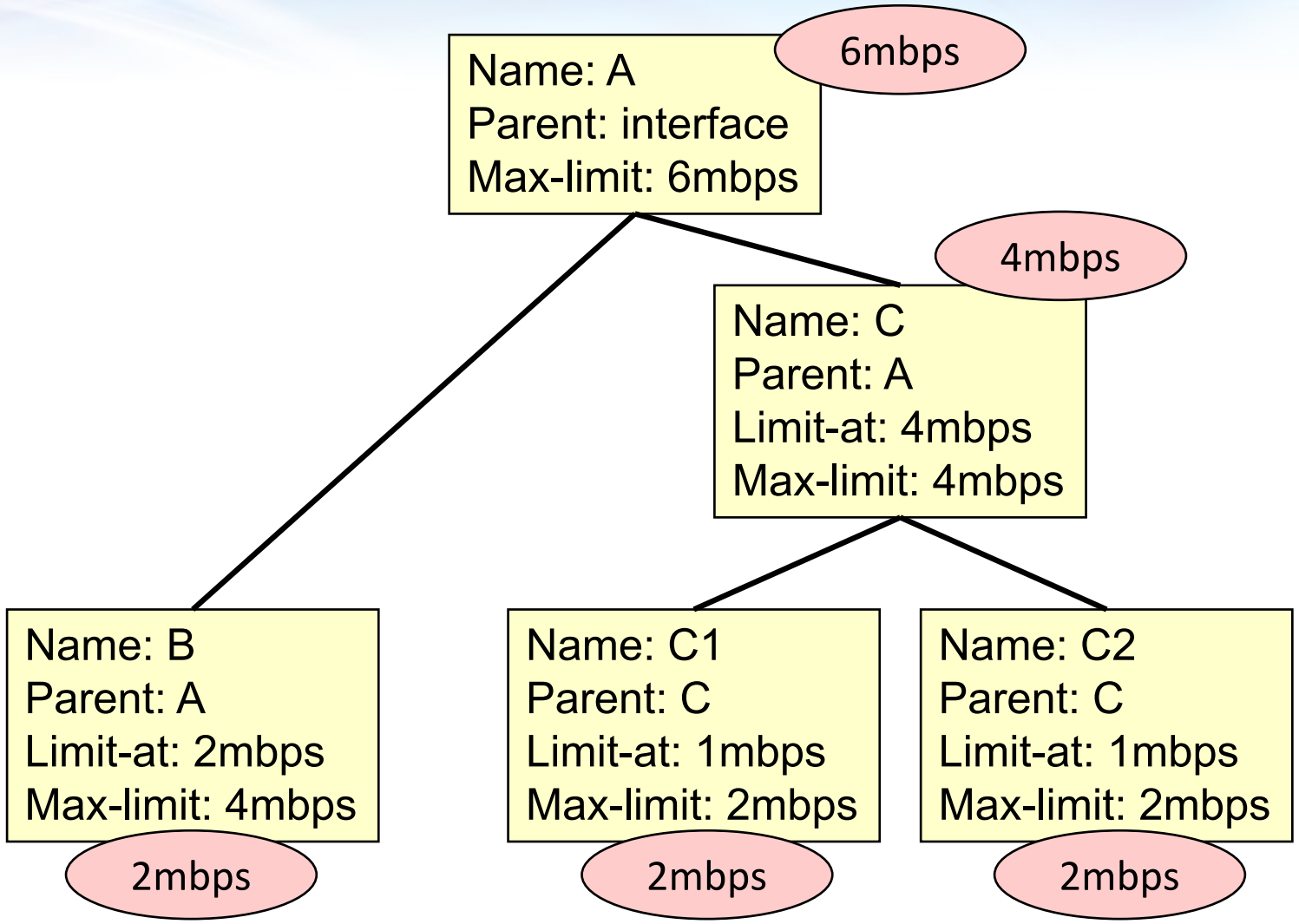
B can extend from 2 mbps to 3 mbps, because parent A still have remaining bandwidth, and B have higher priority than C.

HTB Distribution (4)



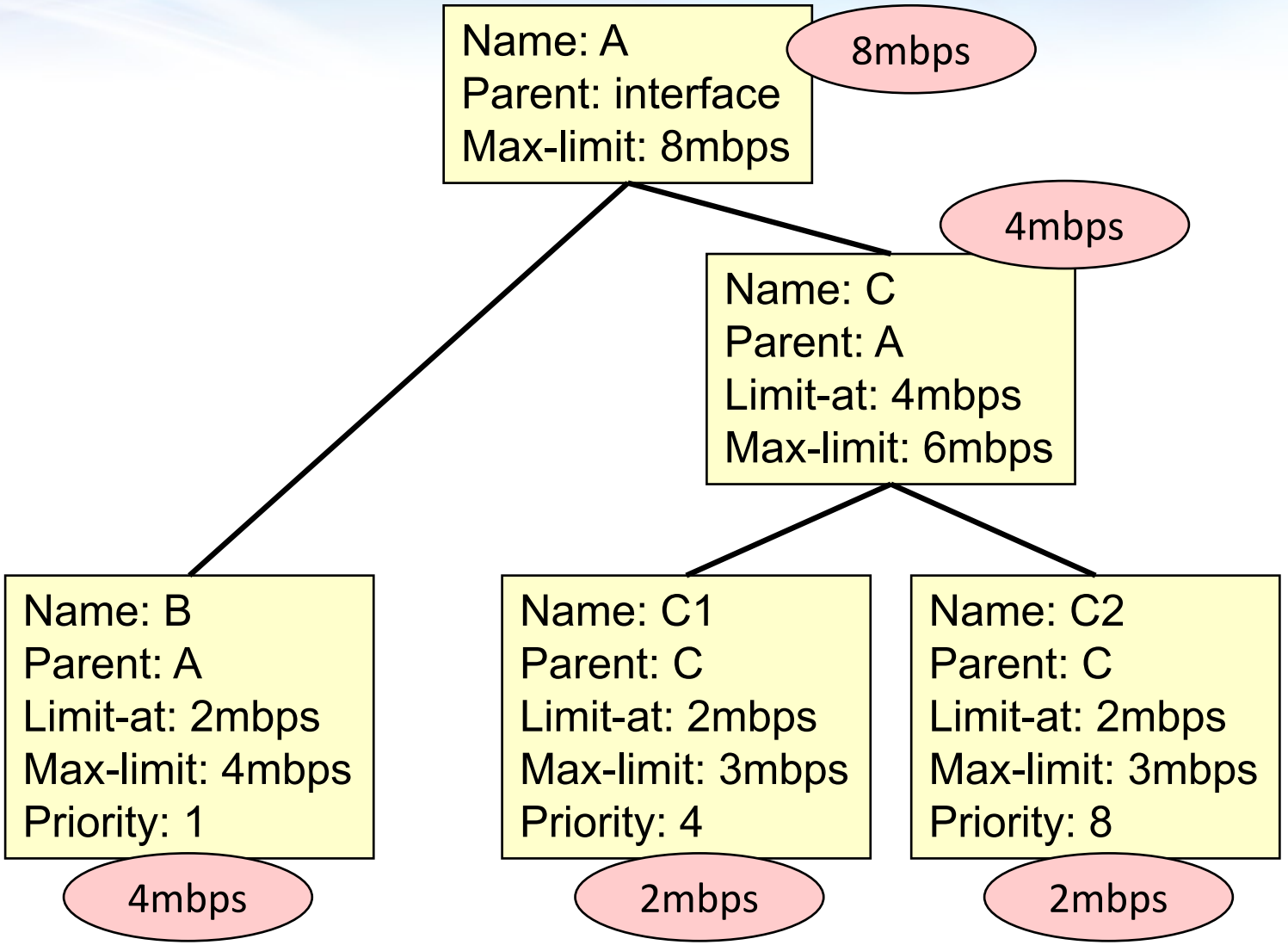
B, C1, and C2, will get 2 mbps each, as set at limit-at.

HTB Distribution (5)



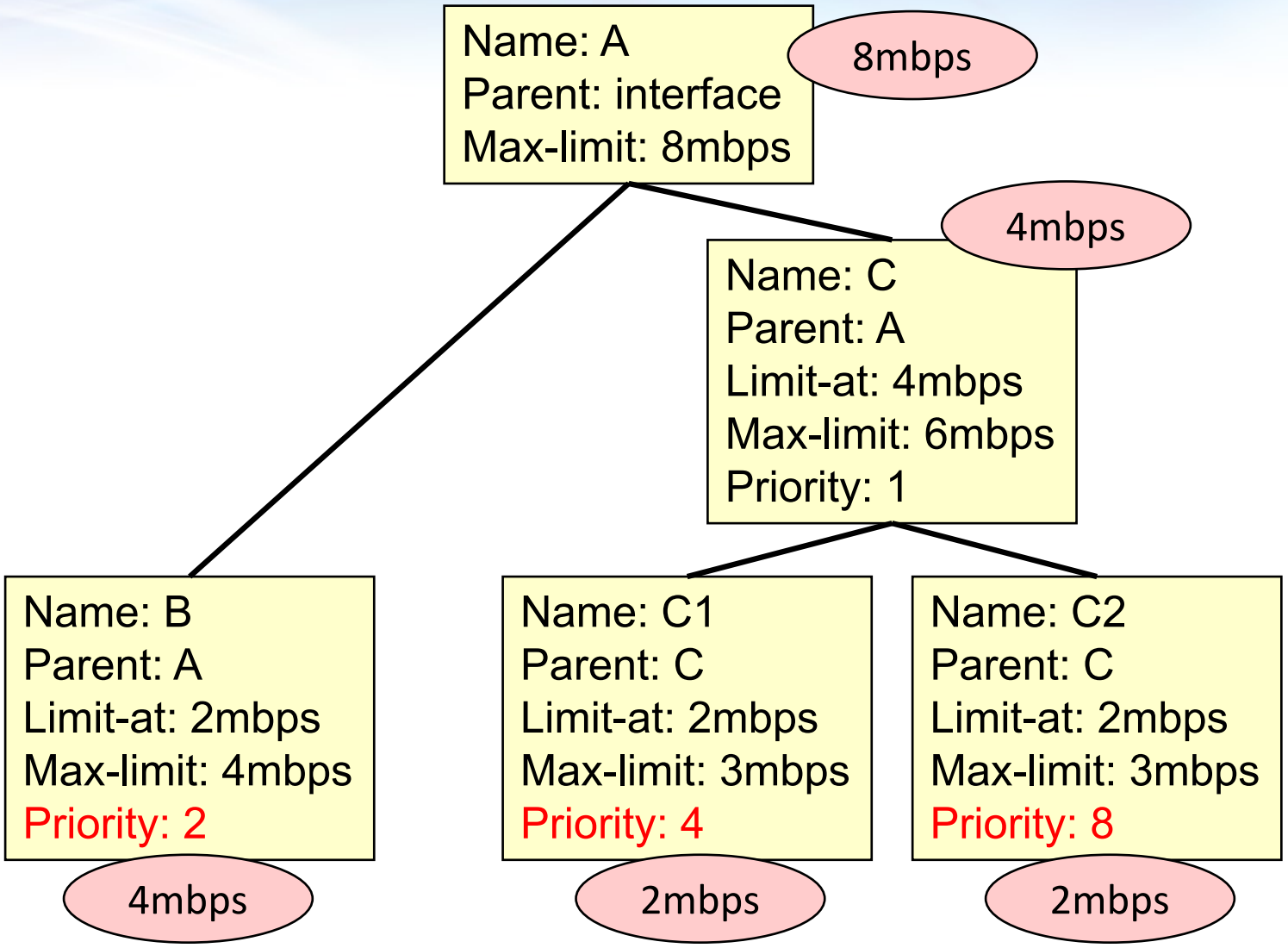
C1 and C2 can get 2 mbps (max-limit), because their parent (C) has limit-at 4 mbps.

HTB Distribution (6)



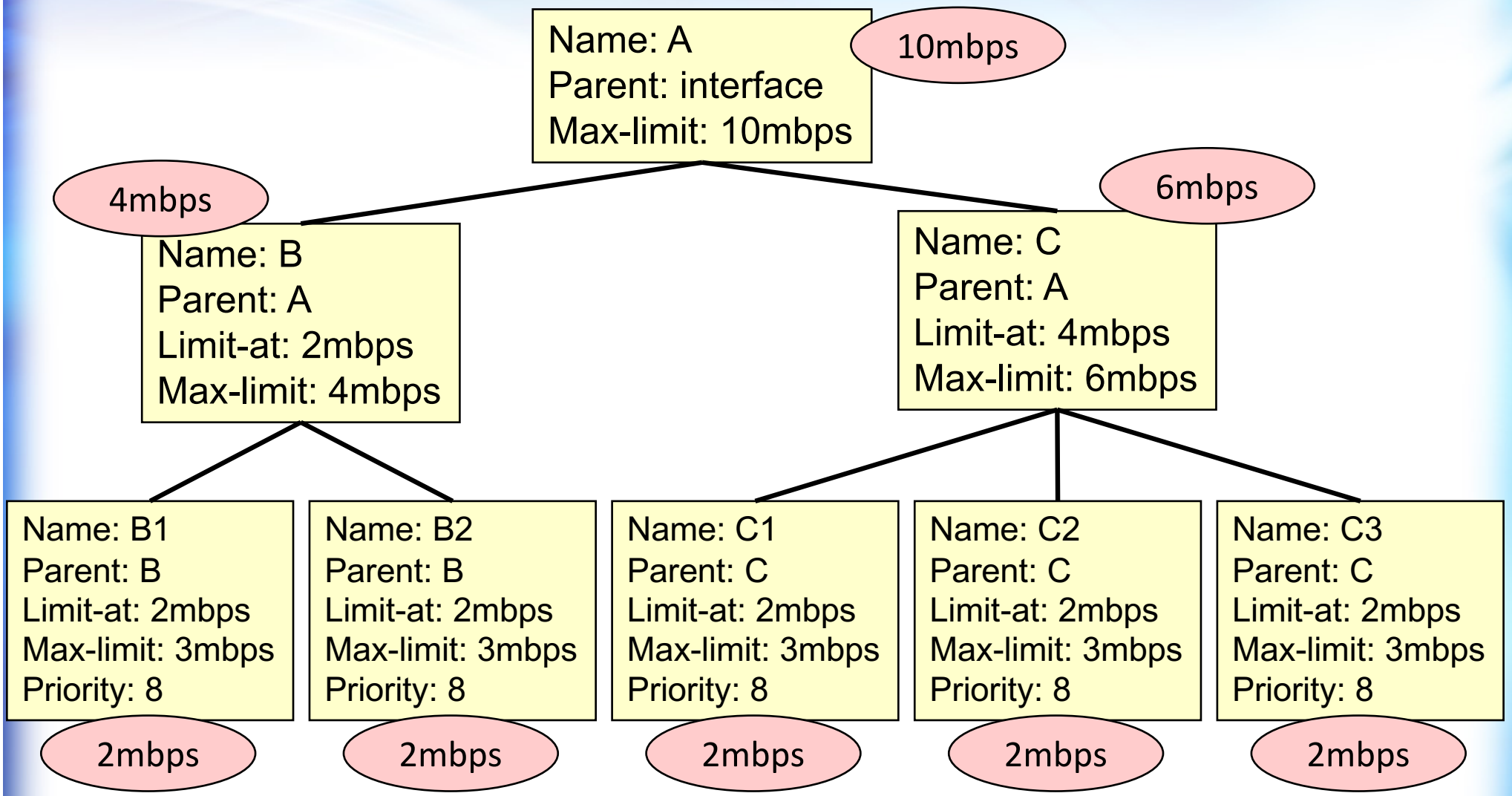
After all limit-at fulfill, remaining bandwidth will distributed base on priority

HTB Distribution (7)



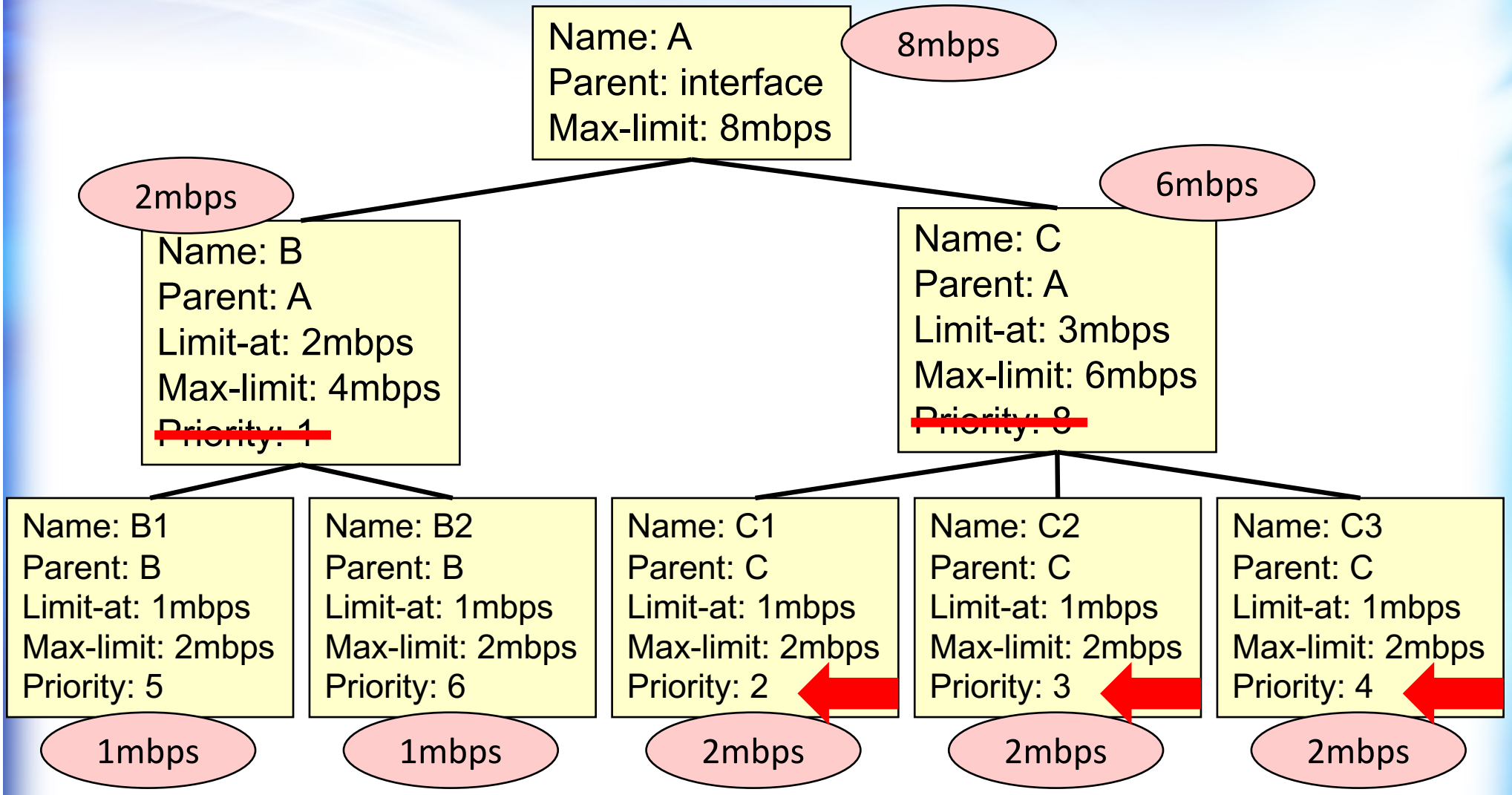
Only priority on client (leaf) will count.

HTB Distribution (8)



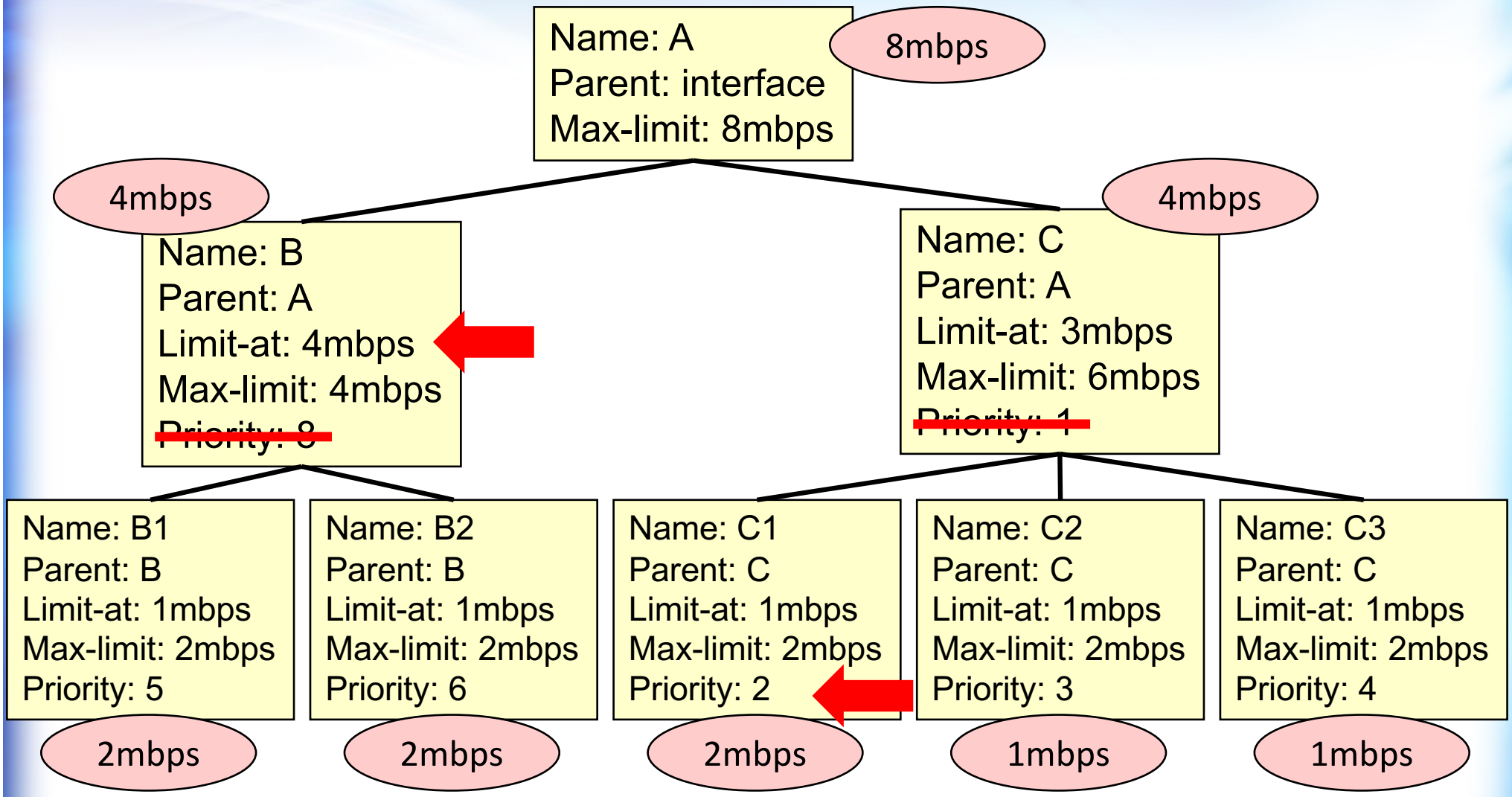
All leaf queue will get 2 mbps.

HTB Distribution (9)



C1, C2, C3 will get 2 mbps, because they have higher priority than B1 and B2

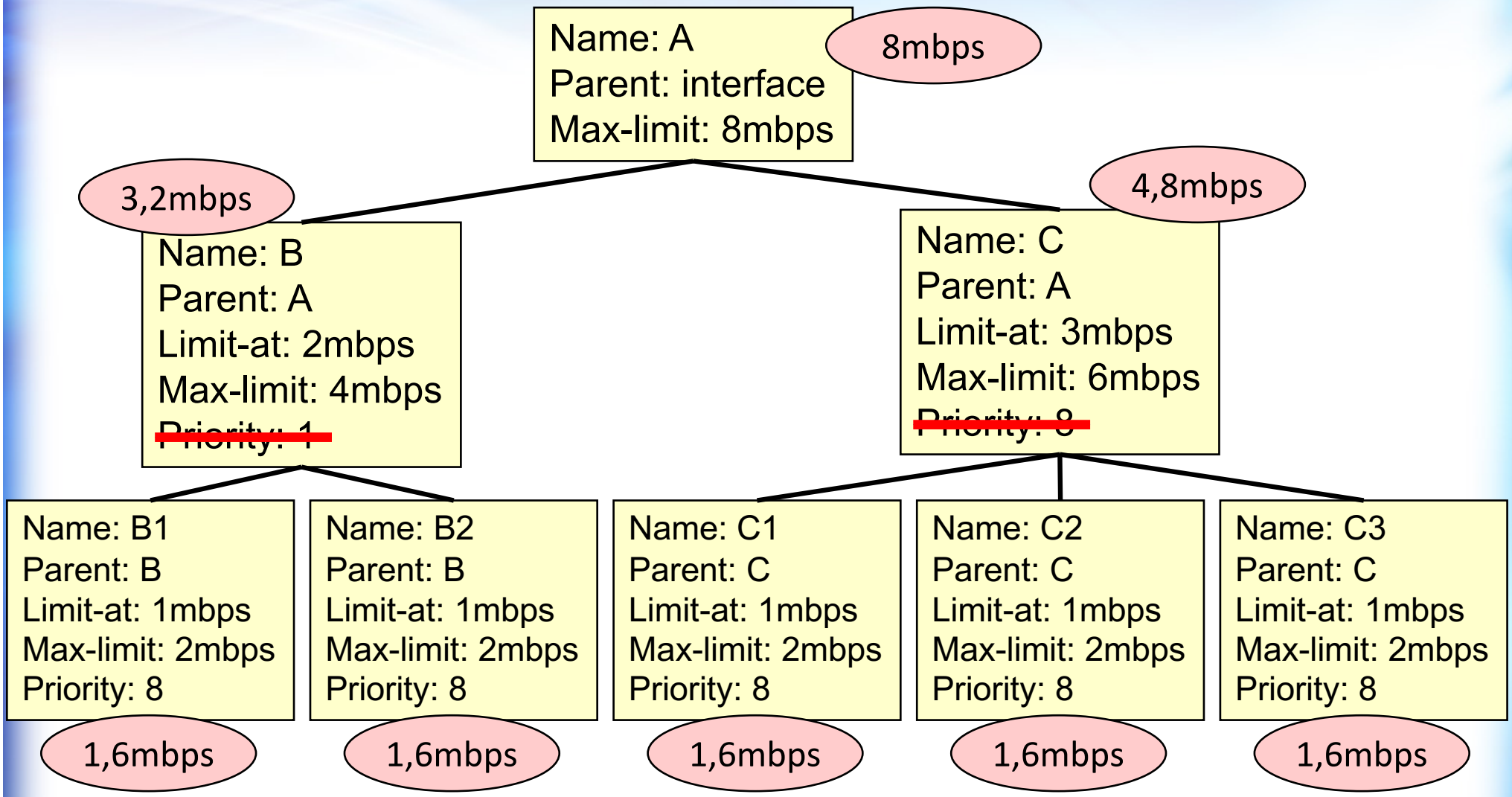
HTB Distribution (10)



B get 4 mbps because its limit-at, and then divided to B1 and B2 (2mbps each).

C1 > C2 and C3 because have higher priority.

HTB Distribution (11)



Bandwidth devided equaly to B1, B2, C1, C2, C3 becase they have same priority.

Tipe Queue

- Simple Queue
- Queue Tree

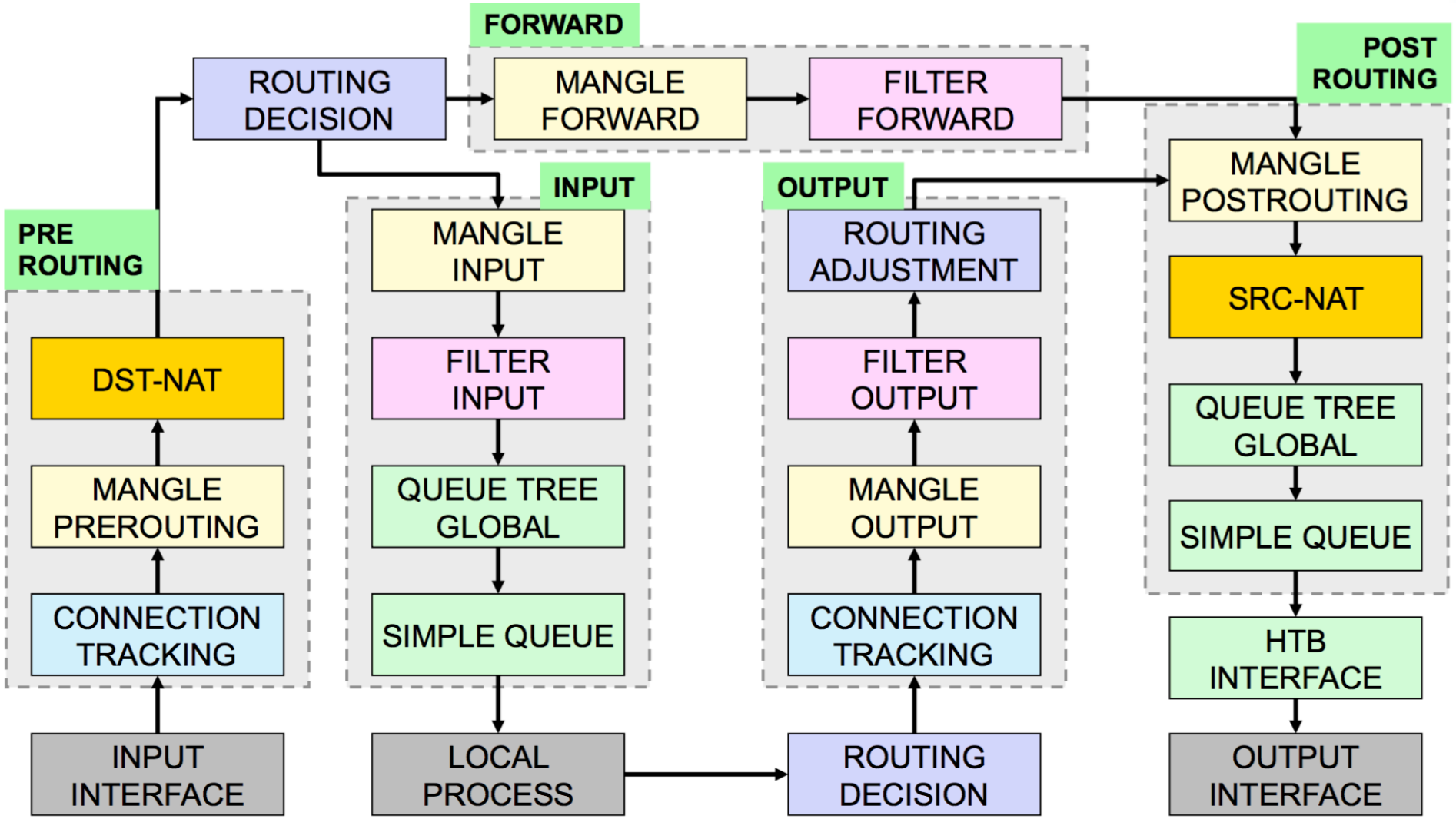
Simple Queue

- Mudah digunakan
- Untuk limitasi src-address dan dst-address, dapat digunakan tanpa fitur bantu lainnya (mangle)
- 1 rule dapat digunakan sekaligus untuk traffic uplink dan downlink
- Dapat digunakan untuk melimit total traffic (downlink + uplink)
- Jika dibutuhkan, dapat memanfaatkan packet-mark dan juga parent
- Proses hanya dapat dilakukan pada interface virtual (global)

Queue Tree

- Membutuhkan packet-mark untuk menandai traffic
- Dapat digunakan dengan priority dan parent
- 1 rule hanya untuk downlink atau uplink
- Proses dapat dilakukan di interface fisik, ataupun di interface virtual (global)

Packet Flow


FORWARD
ROUTING DECISION
MANGLE FORWARD
FILTER FORWARD
POST ROUTING
INPUT
OUTPUT
PRE ROUTING
MANGLE INPUT
ROUTING ADJUSTMENT
MANGLE POSTROUTING
DST-NAT
FILTER INPUT
FILTER OUTPUT
SRC-NAT
MANGLE PREROUTING
QUEUE TREE GLOBAL
MANGLE OUTPUT
QUEUE TREE GLOBAL
CONNECTION TRACKING
SIMPLE QUEUE
CONNECTION TRACKING
SIMPLE QUEUE
HTB INTERFACE
INPUT INTERFACE
LOCAL PROCESS
ROUTING DECISION
OUTPUT INTERFACE

MULTICORE?

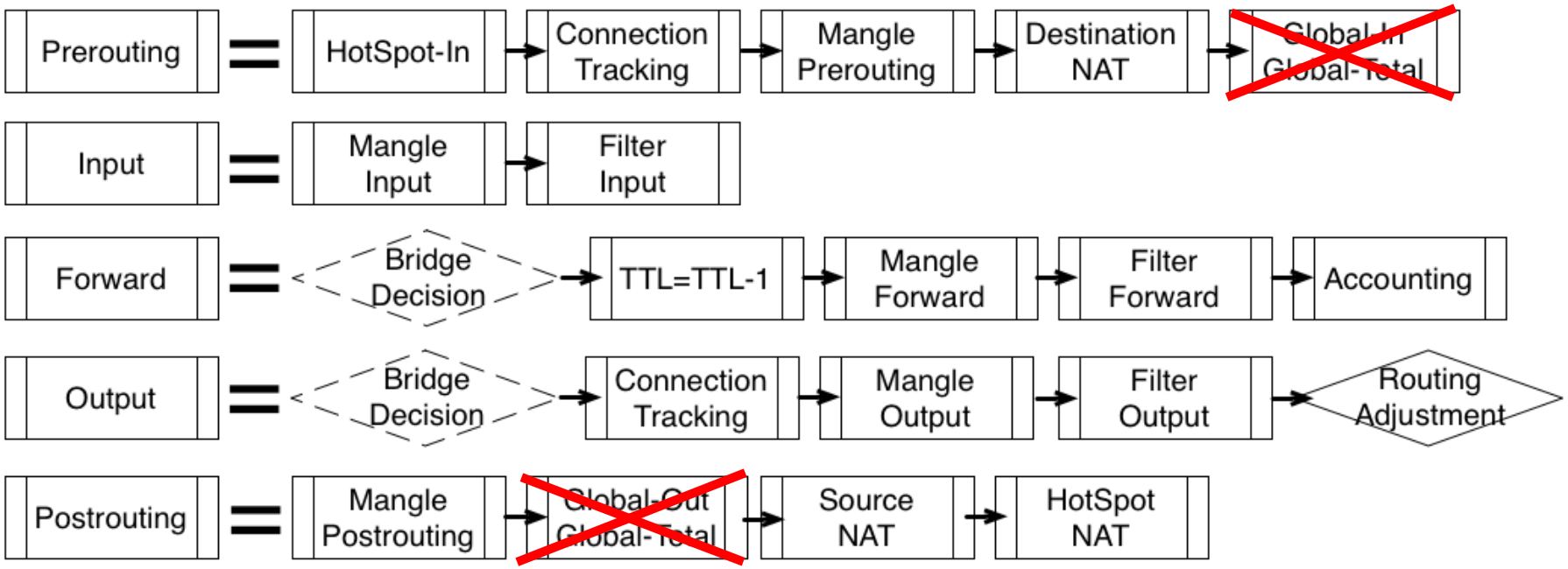
Queue & Multicore Processing

- Sebagian besar waktu yang dihabiskan sebuah paket adalah menunggu dalam queue.
- Supaya tidak memboroskan siklus CPU core saat menunggu, core tersebut akan meninggalkan paket di queue.
- Paket akan diambil secara random dari antrian untuk diproses pada core tertentu.
- Secara sederhana: queue akan membagikan paket untuk CPU Core tertentu.

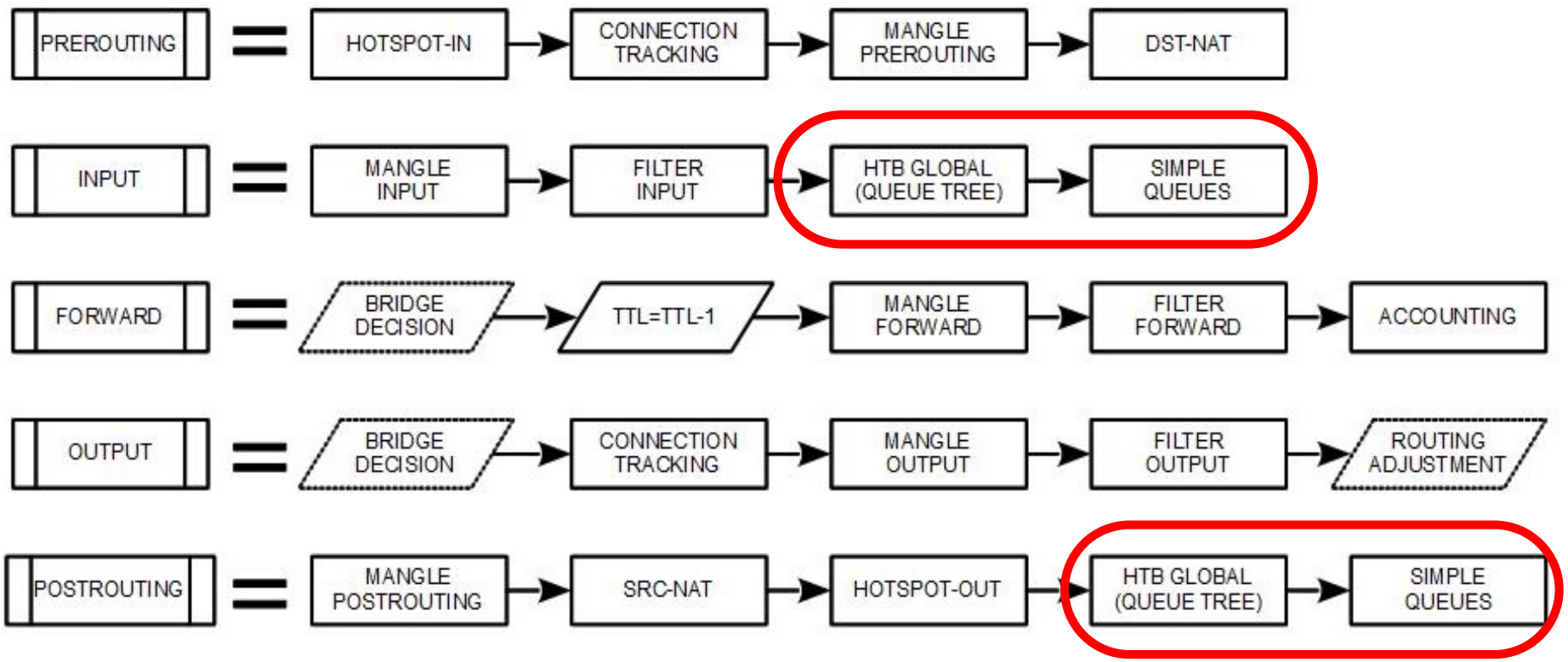
Perubahan Packet Flow

- Pada RouterOS v5.x, paket melalui proses queue beberapa kali, sehingga proses pemilihan core juga terjadi beberapa kali.
- Untuk RouterOS v6, proses QoS dirombak sehingga proses queue hanya terjadi di suatu kelompok proses, pada akhir flow.

HTB in RoS v5


Prerouting
HotSpot-In
Connection Tracking
Mangle Prerouting
Destination NAT
Input
Mangle Input
Filter Input
Forward
Bridge Decision
TTL=TTL-1
Mangle Forward
Filter Forward
Accounting
Output
Bridge Decision
Connection Tracking
Mangle Output
Filter Output
Routing Adjustment
Postrouting
Mangle Postrouting
Source NAT
HotSpot NAT

HTB in RoS v6


PREROUTING
HOTSPOT-IN
CONNECTION TRACKING
MANGLE PREROUTING
DST-NAT
INPUT
MANGLE INPUT
FILTER INPUT
HTB GLOBAL (QUEUE TREE)
SIMPLE QUEUES
FORWARD
BRIDGE DECISION
TTL=TTL-1
MANGLE FORWARD
FILTER FORWARD
ACCOUNTING
OUTPUT
BRIDGE DECISION
CONNECTION TRACKING
MANGLE OUTPUT
FILTER OUTPUT
ROUTING ADJUSTMENT
POSTROUTING
MANGLE POSTROUTING
SRC-NAT
HOTSPOT-OUT
HTB GLOBAL (QUEUE TREE)
SIMPLE QUEUES

Queue Tree on Multicore

- Jika ditinjau dari perspektif Kernel, keseluruhan HTB tree adalah satu queue, sehingga diproses hanya oleh satu core
- Optimasi seperti yang dilakukan pada simple queue akan juga dilakukan pada queue tree.
- Saran:
  - Gunakan HTB dengan interface, dan hindari menggunakan HTB global.
  - Gunakan simple queue.

Queue Change in 6.19

Di RouterOS v6.19, ada pengubahan software untuk meningkatkan kinerja queue:

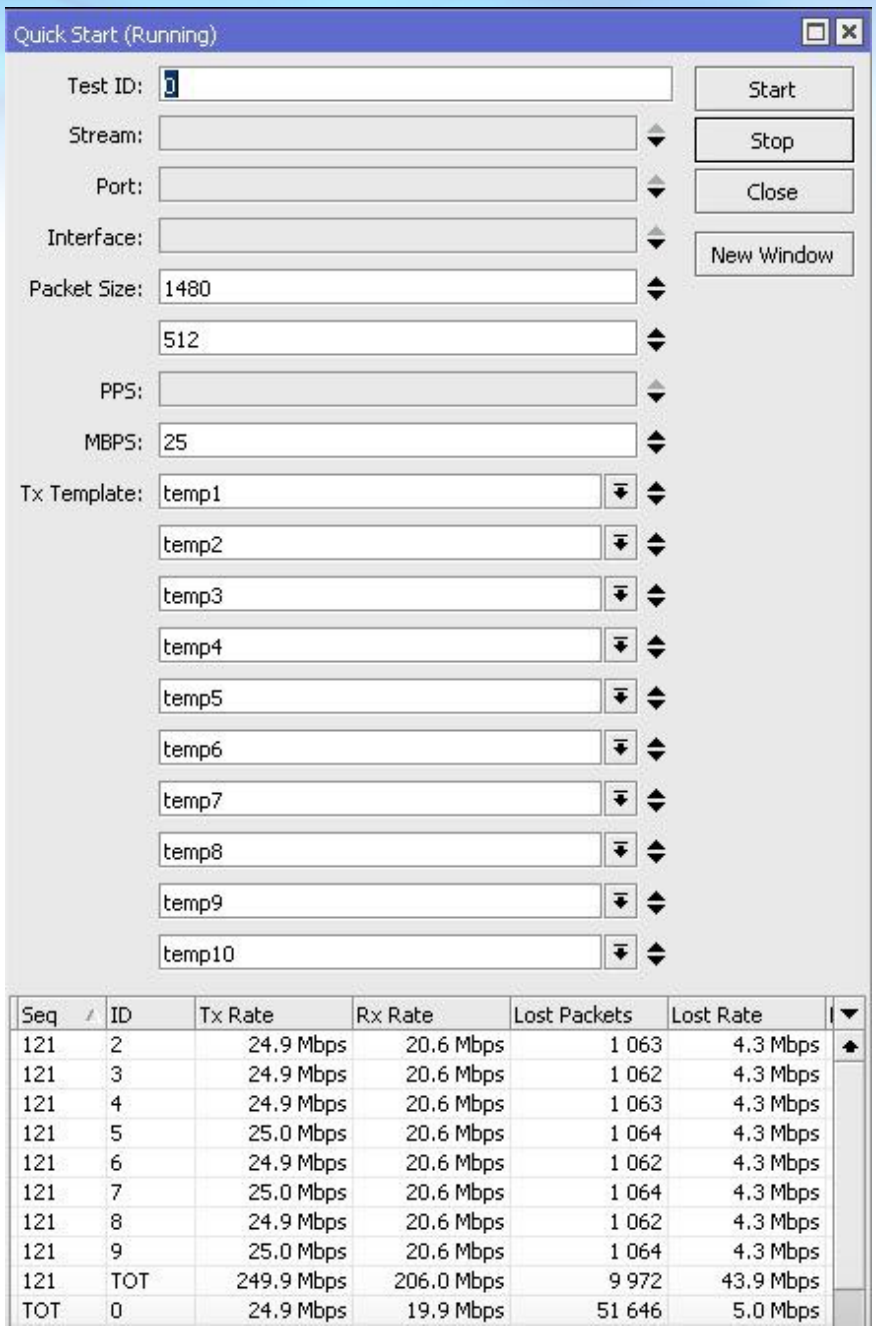
- Sebelumnya: core akan meninggalkan paket di queue, dan core lainnya akan dipilih secara random untuk mengatur paket tersebut
- Sekarang: core tersebut tidak hanya meninggalkan paket, tapi juga harus mengambil paket lainnya yang sudah ada di queue.
- Jika limit di queue belum tercapai, paket yang sama akan ditinggalkan dan langsung diambil lagi oleh core yang sama, membuat proses ini jauh lebih cepat.

Lab Test

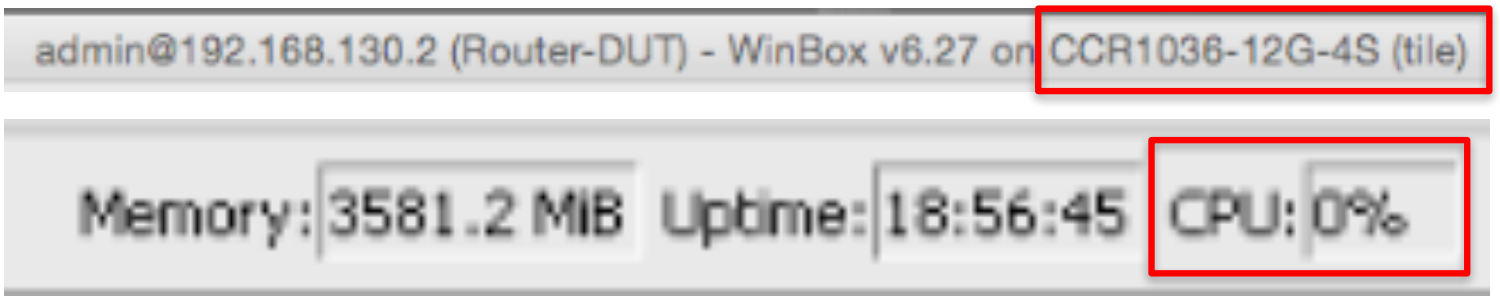
2 CCR 1036 melakukan traffic generator, melalui 1 CCR 1036, routing mode.

Traffic Generator

Setiap mesin mengirimkan 10 streams (masing-masing 25mbps), dari 10 ip address yang berbeda, menuju 10 ip address yang berbeda.



Without any configuration



Interface List

Interface | Ethernet | EoIP Tunnel | IP Tunnel | GRE Tunnel | VLAN | VRRP | Bonding | LTE

Find

	Name	Type	L2 MTU	Tx	Rx	Tx Pac
R	ether6	Ethernet	1590	250.2 Mbps	250.2 Mbps	
R	ether1	Ethernet	1590	250.2 Mbps	250.2 Mbps	
RS	ether12	Ethernet	1590	2.2 Mbps	100.8 kbps	
R	bridge-remote	Bridge	1590	2.1 Mbps	79.4 kbps	
RS	ether10	Ethernet	1590	41.8 kbps	26.8 kbps	
RS	ether11	Ethernet	1590	41.8 kbps	26.8 kbps	
	ether2	Ethernet	1590	0 bps	0 bps	

Mangle

- Kita perlu membuat firewall mangle untuk packet marking jika akan menggunakan queue tree

```
/ip firewall mangle

add action=mark-packet chain=prerouting \
new-packet-mark=packet-src-0.255 \
passthrough=no src-address=172.16.0.255

add action=mark-packet chain=prerouting \
new-packet-mark=packet-dst-0.255 \
passthrough=no dst-address=172.16.0.255
```

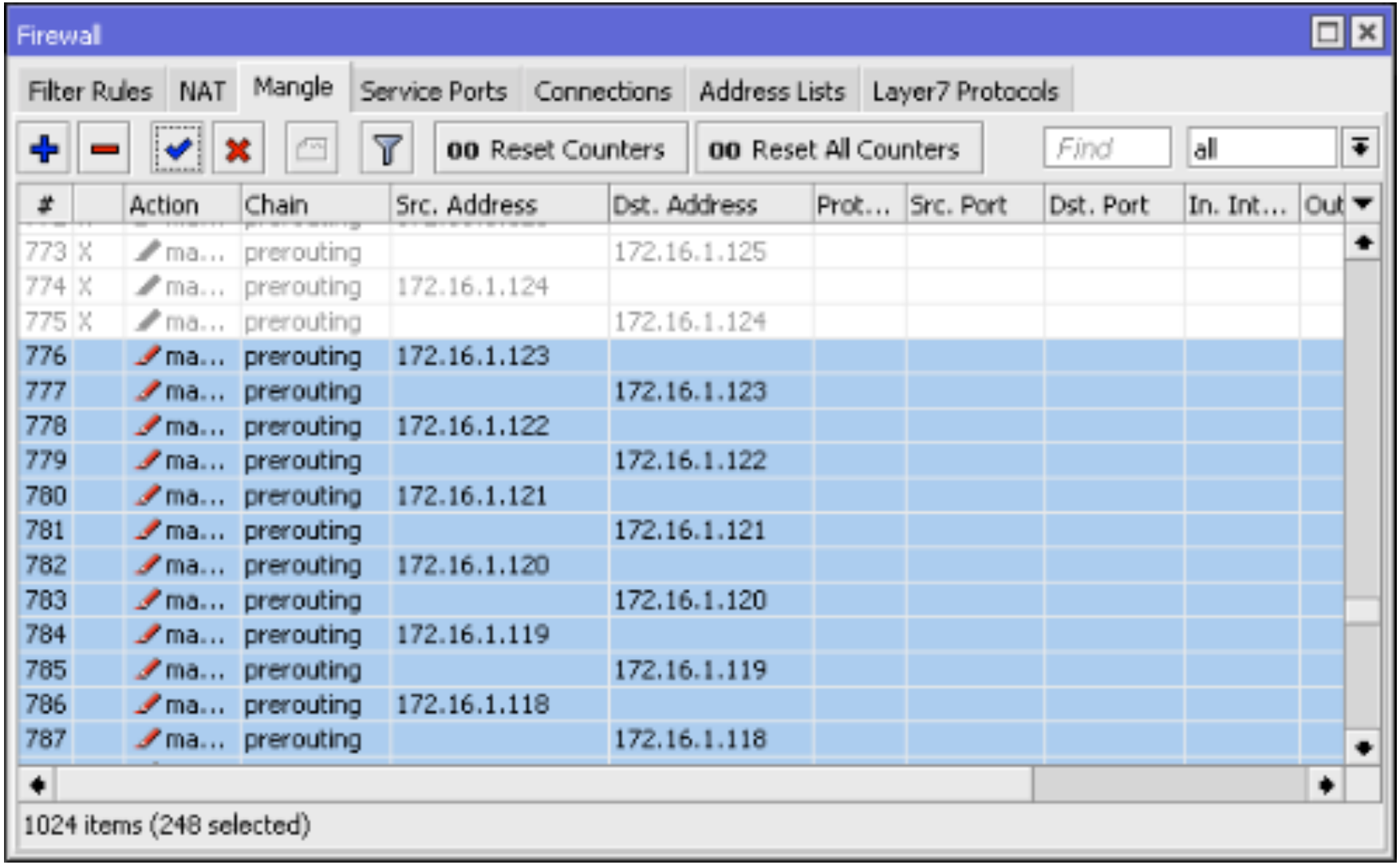
- Korelasi antara packet-mark dan cpu-load?

Conn-Mark?

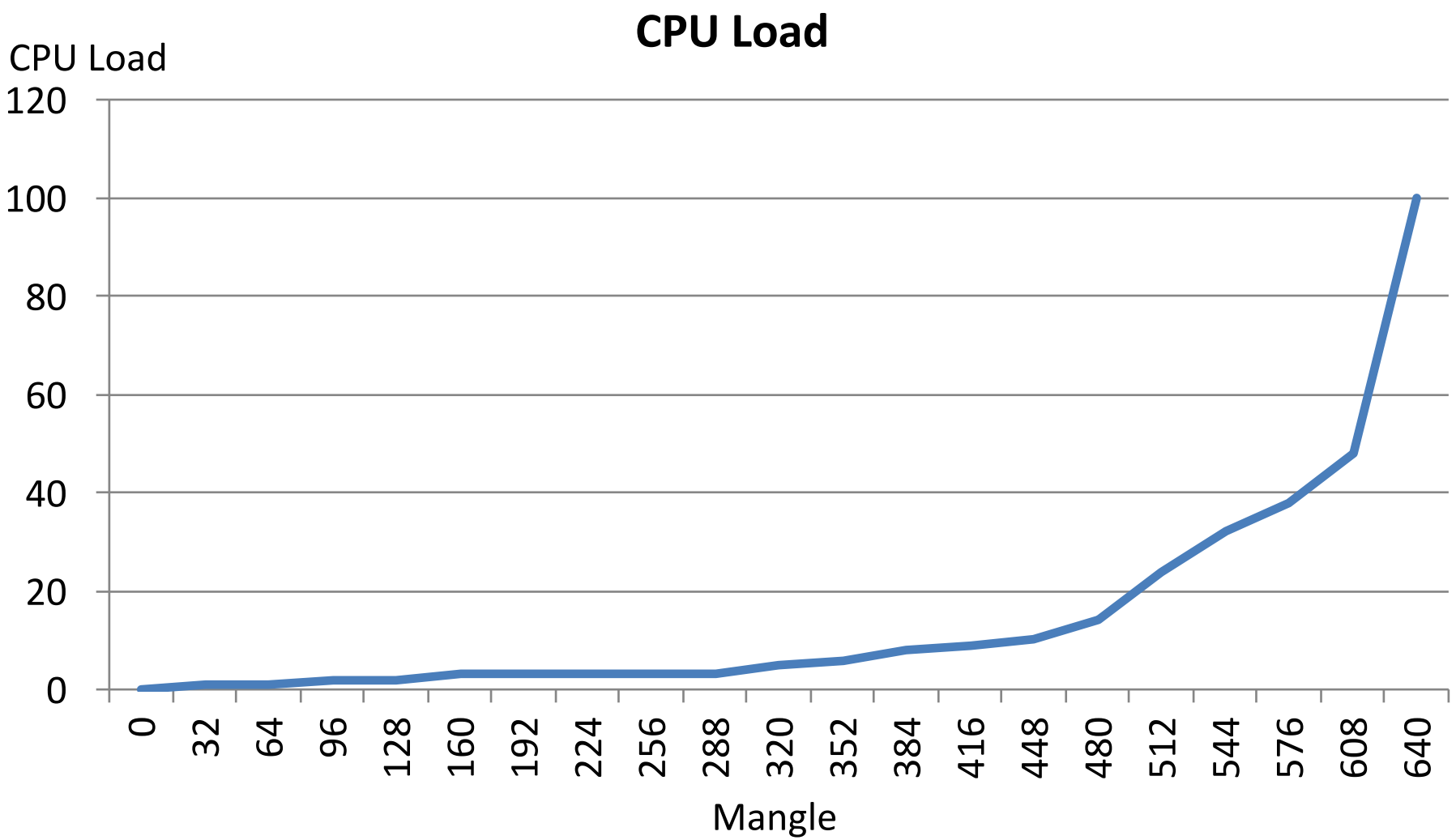
- Tidakkah seharusnya kita menggunakan connection-mark sebelum packet-mark di firewall mangle?

- Ya.
  Tapi di lab-test ini kita ingin melihat seberapa banyak CCR dapat bertahan sehubungan dengan jumlah packet-mark
  Later, I test with conn-mark, almost same result.

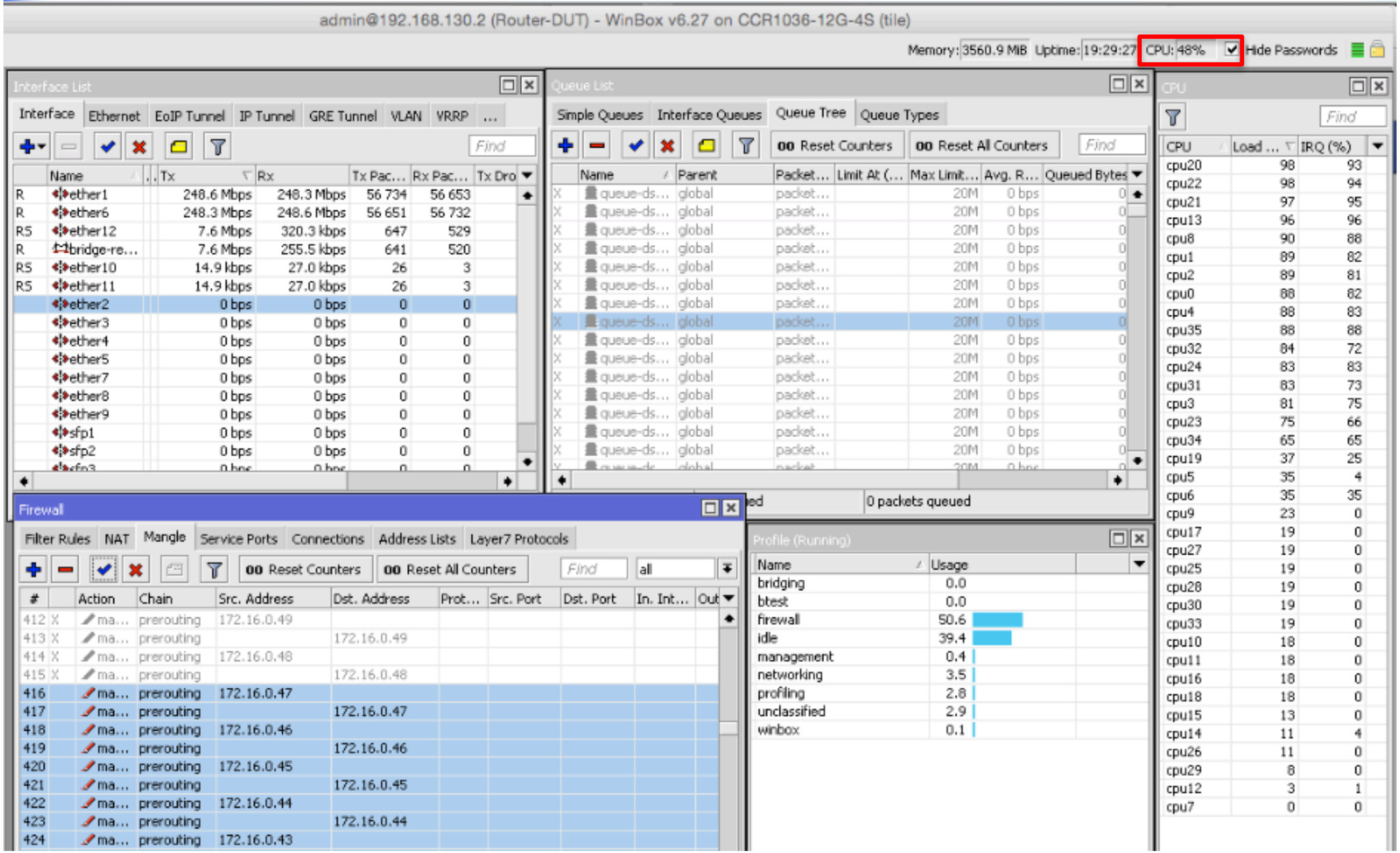
Firewall - Mangle



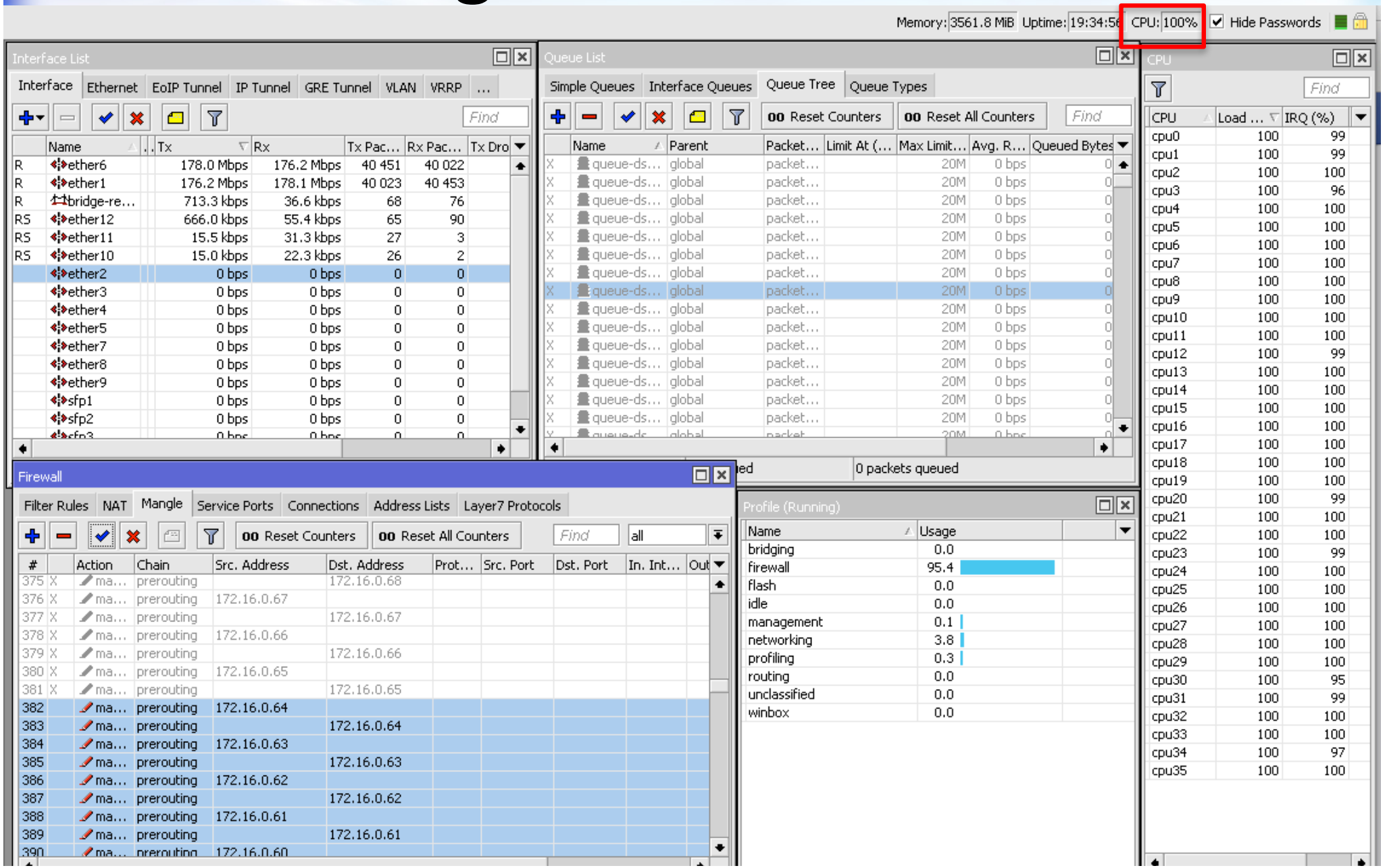
Graphs


CPU Load
CPU Load
120
100
80
60
40
20
0
0
32
64
96
128
160
192
224
256
288
320
352
384
416
448
480
512
544
576
608
640
Mangle

608 Mangle → 48% CPU Load



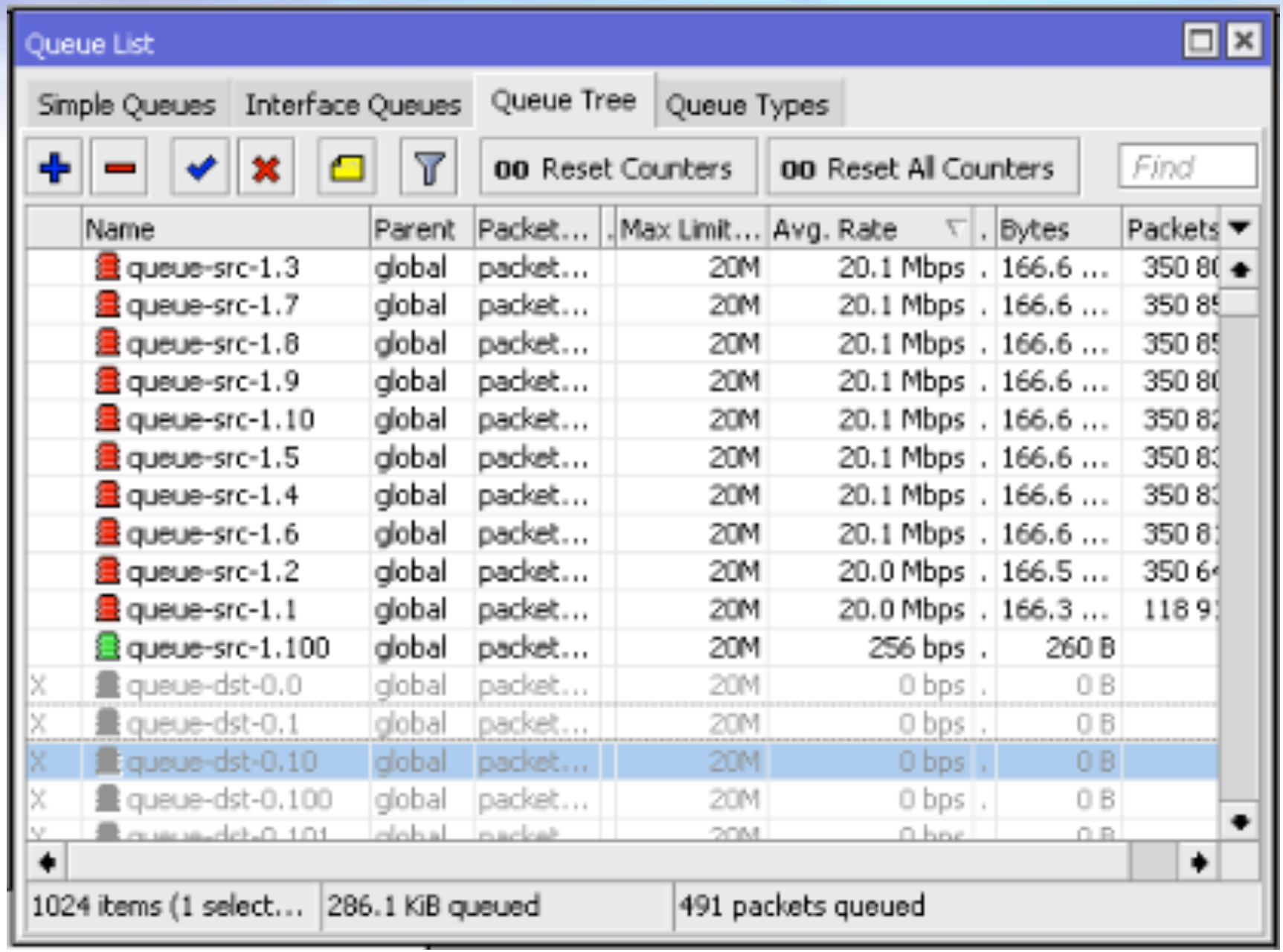
640 mangles → 100% CPU load



What next?

- Test sebelumnya hanya menggunakan packet –mark. Kita lanjutkan dengan queue tree (512 rules).
- Kita gunakan 512 mangles, 24% CPU load.

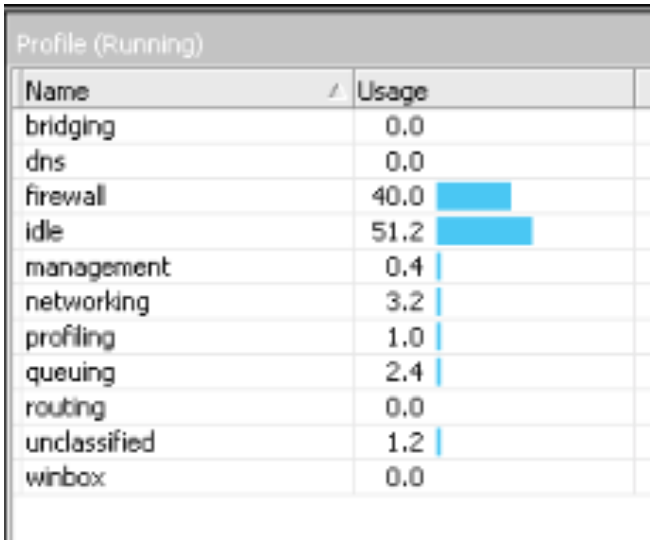
```
/queue tree

add max-limit=20M name=queue-src-1.1
packet-mark=packet-src-1.1 parent=global
queue=default

add max-limit=20M name=queue-dst-1.1
packet-mark=packet-dst-1.1 parent=global
queue=default
```


Queue List
Simple Queues
Interface Queues
Queue Tree
Queue Types
Reset Counters
Reset All Counters
Find
Name
Parent
Packet...
Max Limit...
Avg. Rate
Bytes
Packets
queue-src-1.3 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.7 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.8 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.9 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.10 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.5 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.4 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.6 global packet... 20M 20.1 Mbps 166.6 ... 350 8
queue-src-1.2 global packet... 20M 20.0 Mbps 166.5 ... 350 6
queue-src-1.1 global packet... 20M 20.0 Mbps 166.3 ... 118 9
queue-src-1.100 global packet... 20M 256 bps 260 B
X queue-dst-0.0 global packet... 20M 0 bps 0 B
X queue-dst-0.1 global packet... 20M 0 bps 0 B
X queue-dst-0.10 global packet... 20M 0 bps 0 B
X queue-dst-0.100 global packet... 20M 0 bps 0 B
1024 items (1 select...
286.1 KiB queued
491 packets queued

CPU Load

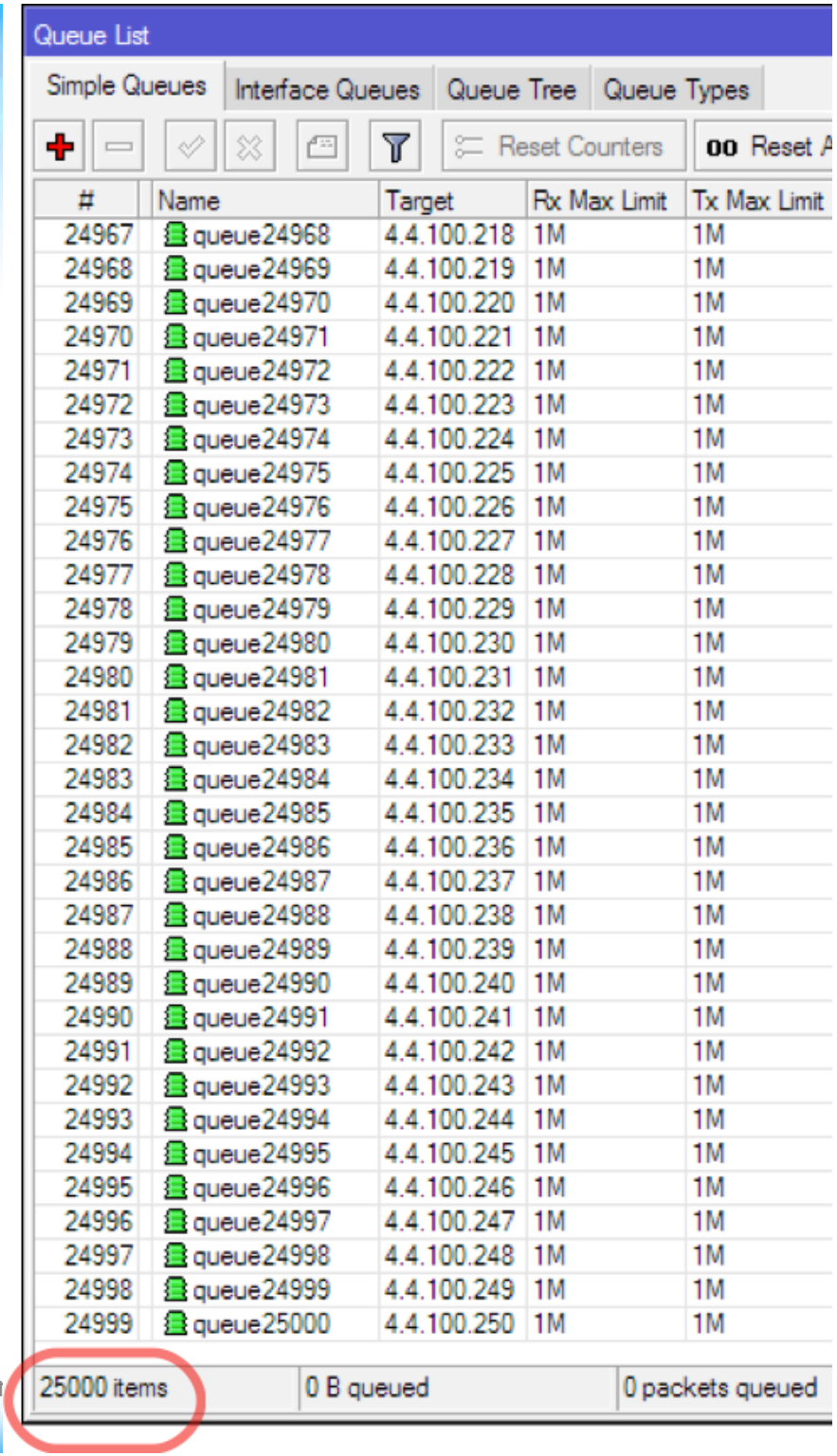
- Dengan 512 mangles tanpa queue tree, 24% CPU load.
- Dengan 512 mangles + 512 queue tree, 43% CPU Load (hampir 2 kali lipat).

- Tapi, on Tools – Profile, load untuk queue masih rendah.



Simple Queue

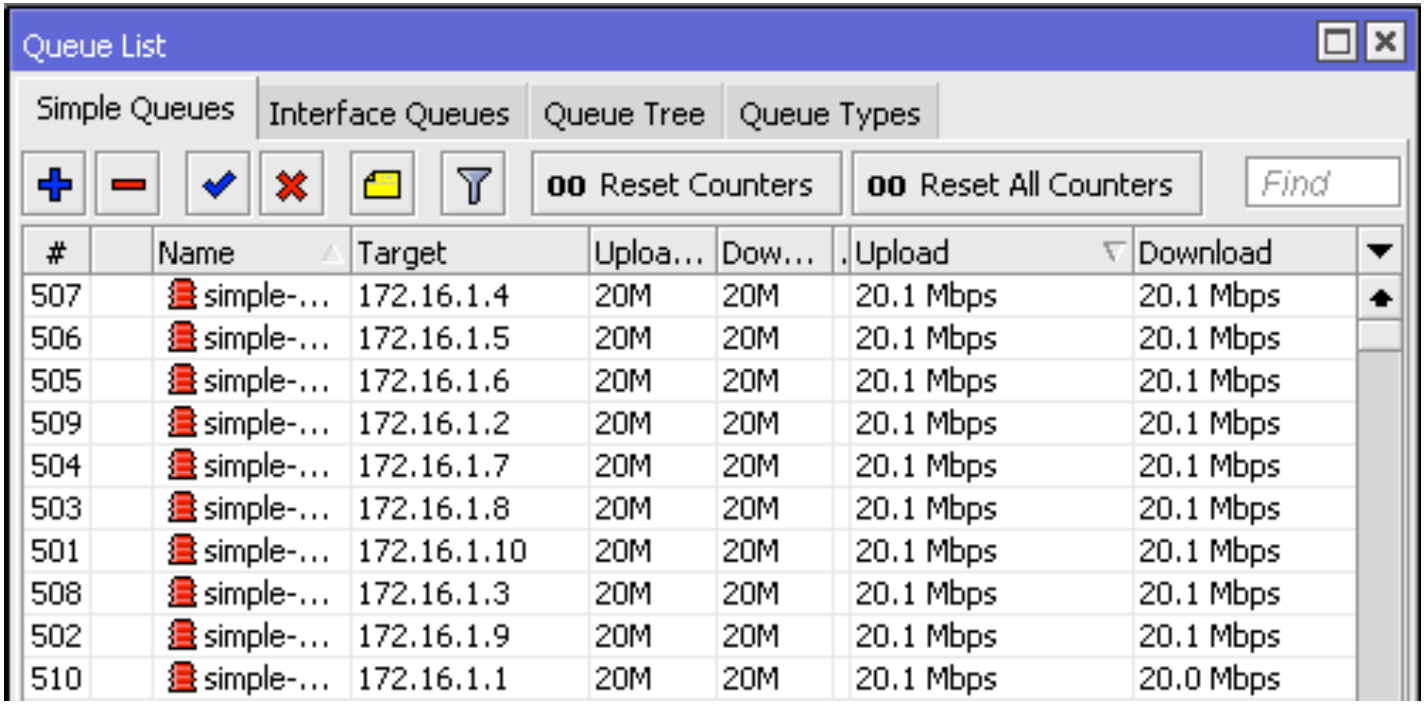
- Algoritma pencocokan (matching) telah diubah:
  - berdasarkan hash
  - proses pencocokan lebih cepat
- QoS akan optimal pada perangkat dengan multi core jika simple queue teratas (parent) berjumlah minimal 32, sehingga proses tersebut dapat disebar lebih merata.



Let’s try Simple Queue

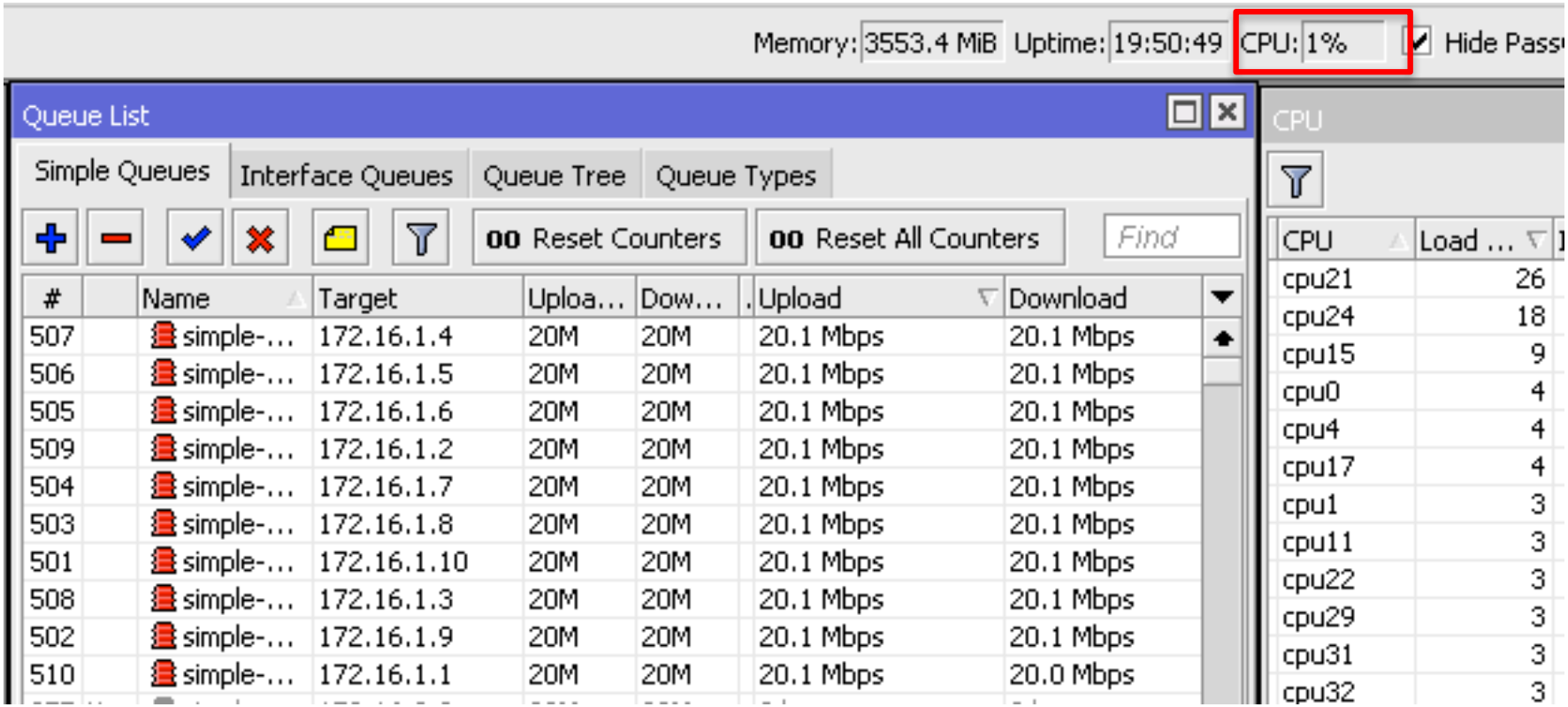
- Kita membuat 512 simple queue :

```
/queue simple add max-limit=20M/20M
name=simple-queue-1.1  target=172.16.1.1/32
```



#	Name	Target	Uploa...	Dow...	Upload	Download
507	simple-...	172.16.1.4	20M	20M	20.1 Mbps	20.1 Mbps
506	simple-...	172.16.1.5	20M	20M	20.1 Mbps	20.1 Mbps
505	simple-...	172.16.1.6	20M	20M	20.1 Mbps	20.1 Mbps
509	simple-...	172.16.1.2	20M	20M	20.1 Mbps	20.1 Mbps
504	simple-...	172.16.1.7	20M	20M	20.1 Mbps	20.1 Mbps
503	simple-...	172.16.1.8	20M	20M	20.1 Mbps	20.1 Mbps
501	simple-...	172.16.1.10	20M	20M	20.1 Mbps	20.1 Mbps
508	simple-...	172.16.1.3	20M	20M	20.1 Mbps	20.1 Mbps
502	simple-...	172.16.1.9	20M	20M	20.1 Mbps	20.1 Mbps
510	simple-...	172.16.1.1	20M	20M	20.1 Mbps	20.0 Mbps

Dengan Simple Queue



Hanya 1% of CPU Load dengan Simple Queue

Why Simple Queue?

- Jika kita gunakan simple queue, tidak harus menggunakan mangle (mangle membutuhkan CPU resources yang besar).
- Simple Queue di v6 memiliki proses hashing yang efisien.
- Untuk layanan non dedicated, bisa menggunakan fitur burst.
- Jika kita gunakan Queue tree, queue dalam satu interface parent akan diproses hanya oleh satu CPU core.

Kesimpulan

- Untuk jaringan dengan bandwidth yang tidak besar, overloaded network:
  - kombinasi packet-mark, dengan
  - queue tree, HTB, dan burst
- Untuk high throughput backbone:
  - gunakan multicore router:
    - CCR 36 – 72 core
    - Intel base quad core Xeon (8 thread)
  - simple queue (no parent)

Thank you

Comments and suggestions:

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