Quality of Service in wireless Point-to-Point Links

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Quality of Service in wireless Point-to-Point Links

- **Summary**

  - Introduction
  - The problem with congested wireless links
  - How can we use prioritization in MikroTik RouterOS based wireless networks?
  - Practical exercises (Check them out at home!)
    - Practical part I – Simple QoS for a PtP Link in router mode
    - Practical part II – Simple QoS for a PtP Link in bridge mode
  - Advanced options to configure QoS in wireless
  - Sample for a complex integration with PPPoE, MPLS and VPLS

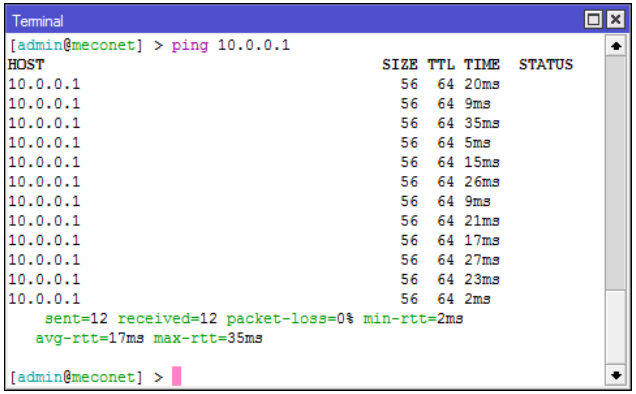
A short introduction to my person

- Lutz Kleemann (Germany), MTCNA, MTCRE, MTCWE & MTCTCE
- Working as network engineer and ISP since 1995
- First wireless connected ISP customers in 1998 with 2mbps
- First contact to RouterOS in 2003
- MikroTik Distributor and VAR (Value added Reseller) since 2004

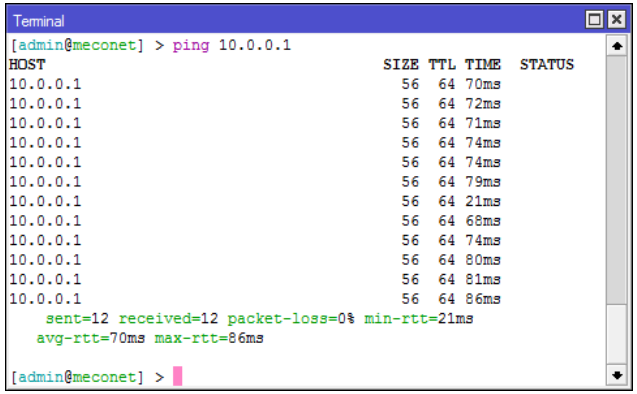
The problem with congested wireless links

- Considering the fact that 802.11 based PtP-Links today are half-duplex transmission technology and only able to use an interleaved time division duplex (in opposite to frequency duplex used in telco radios) for a bidirectional connection, users often need to use some type of Quality of Service (QoS) to prioritize certain protocols or applications over (before) others if they have congested links.

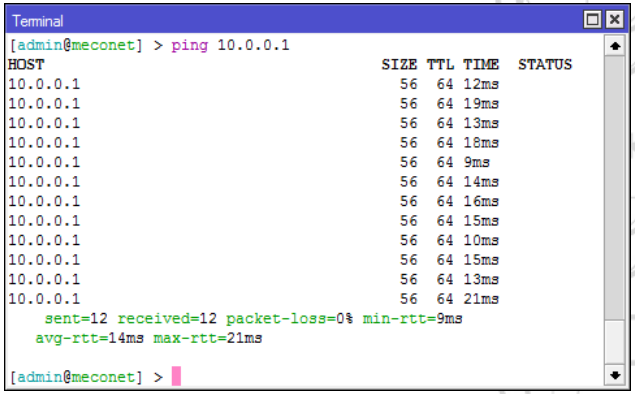
  Simple ICMP example showing the effect with and without QoS on a PtP-Link:



Empty Link without any QoS
average RTT = 17msec.



Congested Link w/o QoS
average RTT = 70msec.



Congested Link with QoS
average RTT = 14msec.

How can we use prioritization in MikroTik RouterOS based wireless networks?

- **Using NV2 wireless protocol with integrated QoS**

  MikroTik introduce the proprietary NV2 wireless protocol with RouterOS 5 early 2011. NV2 (Nstreme Version 2) is a Time Division Multiple Access (TDMA) based protocol and works only with RouterOS based systems on both sides of a link.

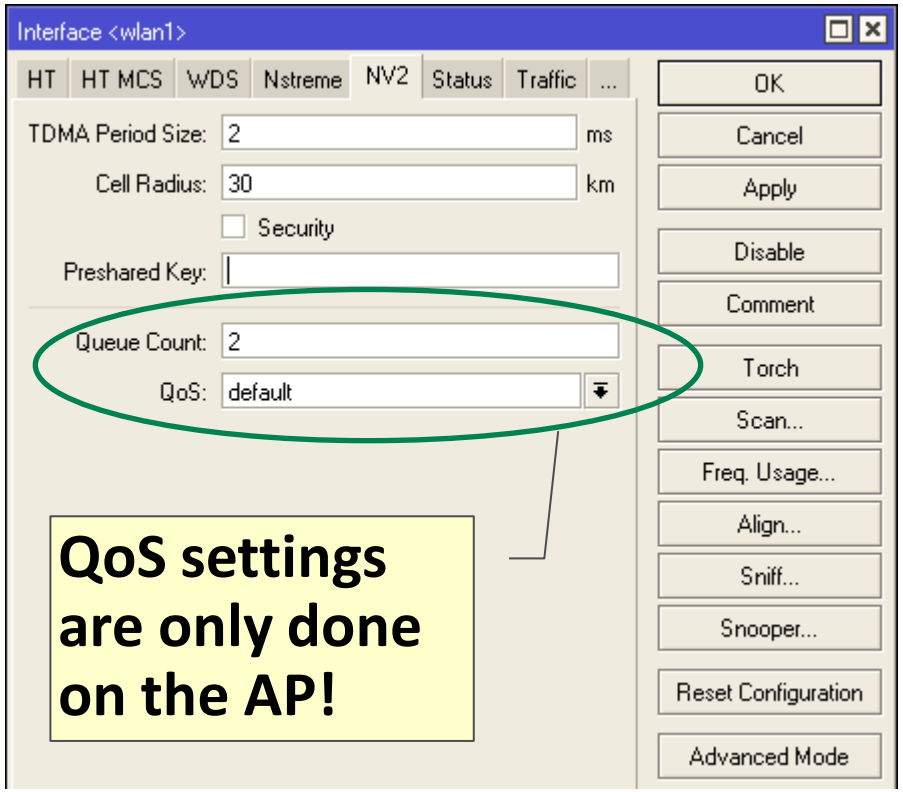
  NV2 is implemented with a variable amount of queues which can be freely configured to 2, 4 or 8 queues. The processing of the queues is based on the definition in IEEE 802.1D-2004 which means only if all higher priority queues are empty lower queues are processed. In practice, this means that initially all packets are sent from the queue with higher priority, and then the packets of the next lower queue are processed.

  In NV2 the QoS settings are controlled by the AP, wireless clients inherit the settings from the AP (this is analog to some settings in Nstreme version 1).

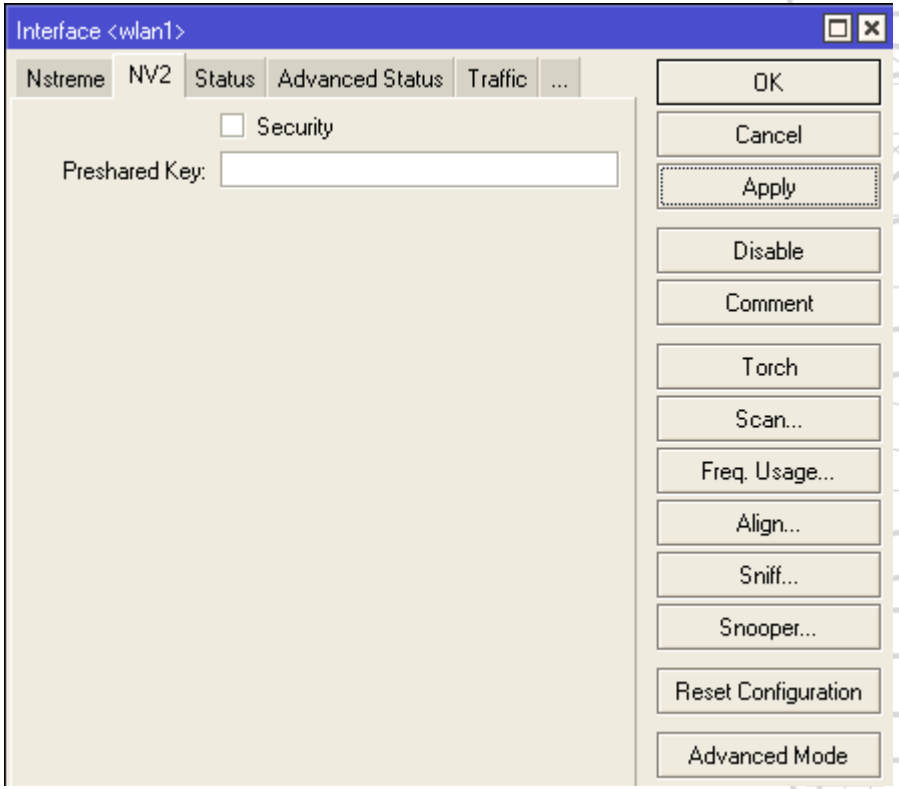
How can we use prioritization in MikroTik RouterOS based wireless networks?

- **The NV2 Configuration Tab**

AP Site (mode = bridge or ap-bridge)



Client Site (mode = station, station-wds or station-bridge)



How can we use prioritization in MikroTik RouterOS based wireless networks?

- By default (*nv2-qos=default*) NV2 use two queues (*nv2-queue=2, Queue Count in WinBox*). In this mode, all outgoing packets are handled by the integrated QoS algorithm based on type and size.

  If the built-in rules do not apply, also in this mode the queuing mechanism use the **Frame-Priority** field. So it works then the same way as with *nv2-qos=frame-priority* configured.

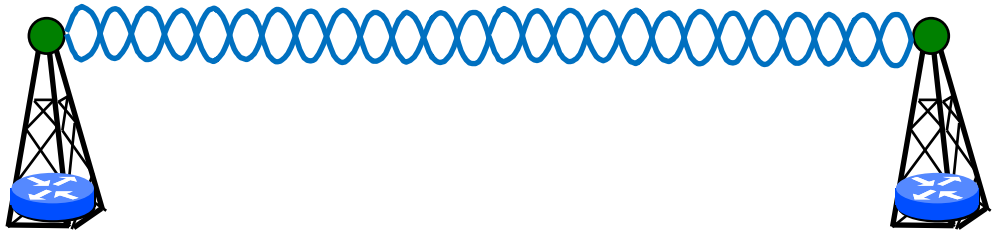
- As described, you can use 2 (RouterOS default), 4 or 8 separate queues inside a NV2 link for individual traffic classes.

  For more Info: http://wiki.mikrotik.com/wiki/Manual:Nv2

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **Let us assume a Point-to-Point NV2 Link with an AP and a Client.**

  For bandwidth testing, we reduce available air rate so the CPU of the system can generate enough traffic to fill the link! On both sides of the link we have an IP Address bound to the WLAN Interfaces.



AP with NV2 active
10.0.0.1/30 at wlan1

Client with NV2 active
10.0.0.2/30 at wlan1

- Before you start configuring NV2 with QoS, please reset your routers!

```
/system reset-configuration skip-backup=yes no-defaults=yes
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **Configure an AP and Client, using NV2 as wireless protocol**

AP WLAN configuration (with reduced TX-Power and only some air rates!)

```
/interface wireless
set 0 band=5ghz-onlyn
frequency=5200
frequency-mode=manual-txpower
ht-basic-mcs=mcs-8,mcs-9,mcs-10,mcs-11,mcs-12
ht-rxchains=0,1
ht-supported-mcs=mcs-8,mcs-9,mcs-10,mcs-11,mcs-12
ht-txchains=0,1
mode=bridge
nv2-qos=frame-priority
nv2-queue-count=8
ssid=NV2-QoS-Test
tx-power=3
tx-power-mode=all-rates-fixed
wireless-protocol=nv2
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **Configure an AP and Client, using NV2 as wireless protocol**

Client WLAN configuration (please reduce TX power and air rate also)

```
/interface wireless
set 0 band=5ghz-onlyn
frequency-mode=manual-txpower
ht-basic-mcs=mcs-8,mcs-9,mcs-10,mcs-11,mcs-12
ht-rxchains=0,1
ht-supported-mcs=mcs-8,mcs-9,mcs-10,mcs-11,mcs-12
ht-txchains=0,1
mode=station
ssid=NV2-QoS-Test
tx-power=3
tx-power-mode=all-rates-fixed
```

- Check that the Client is correctly associated with the AP

Note: Green indicates settings for indoor LAB use, Red indicates NV2 relevant settings

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **IP configuration**

  Configure IP on the AP

```
/ip address
add address=10.0.0.1/30 interface=wlan1
```

  and also on the Client

```
/ip address
add address=10.0.0.2/30 interface=wlan1
```

  So we have a running NV2 wireless link and both side are able to ping each other.

- How can we tell RouterOS now that e. g. ICMP should be prioritized before all other kind of traffic?

How can we use prioritization in MikroTik RouterOS based wireless networks?

- **The Frame-Priority Field**

  RouterOS must know, which of the available priority – each represented by one of the previously defined 2, 4 or 8 NV2 queues – should be assigned to the actual packet.

  This can easily be done using the **'action=set-priority'** functionality inside the powerful firewall subsystem of RouterOS which is available for

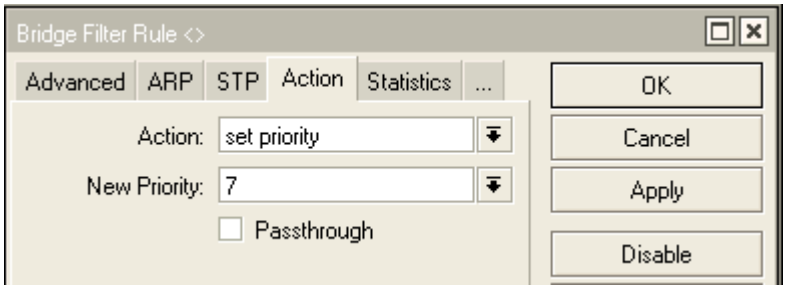
  - Layer2 (in Bridge Filter)
  - Layer3 (in IP Firewall Mangle)

- Important Note for the Frame-Priority Field

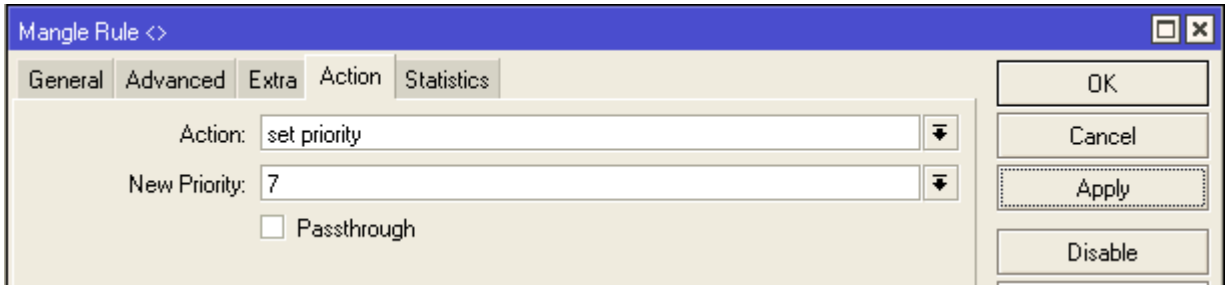
  This field is not stored anywhere in the header of the packet, it's only available inside the system where you set it and will never leave the system!

How can we use prioritization in MikroTik RouterOS based wireless networks?

- **The Frame-Priority Field**
  - **Interface Bridge Filter** settings for Layer 2 traffic classification



  - **IP Firewall Mangle** settings for Layer 3 traffic classification



How can we use prioritization in MikroTik RouterOS based wireless networks?

- **The mapping 'Frame-Priority' to a 'queue'**

The mapping '**packet to queue**' depends on the selected number of available NV2 queues (2, 4 or 8 queues) you have configured and its value you set in the **priority field** as follows:

nv2-queue=2	nv2-queue=4	nv2-queue=8
priority 0,1,2,3 -> queue 0	priority 0,1 -> queue 0	priority 0 -> queue 2
priority 4,5,6,7 -> queue 1	priority 2,3 -> queue 1	priority 1 -> queue 0
	priority 4,5 -> queue 2	priority 2 -> queue 1
	priority 6,7 -> queue 3	priority 3 -> queue 3
		priority 4 -> queue 4
		priority 5 -> queue 5
		priority 6 -> queue 6
		priority 7 -> queue 7

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **Let us first prioritize ICMP packets on our NV2 link**

  To do so, we must first define which traffic we want to prioritize and then we must set the **priority field** for this packets.

  Priority configuration on AP and Client

```
/ip firewall mangle
add action=set-priority chain=output new-priority=2
protocol=icmp
```

  Log for control

```
/ip firewall filter
add action=log chain=output protocol=icmp
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- Now start a ping from the Client to the AP and you should see something similar

```
Terminal
[admin@meconet] > ping 10.0.0.1
HOST                                     SIZE TTL TIME  STATUS
10.0.0.1                                   56  64 6ms
10.0.0.1                                   56  64 27ms
10.0.0.1                                   56  64 25ms
10.0.0.1                                   56  64 11ms
10.0.0.1                                   56  64 14ms
10.0.0.1                                   56  64 18ms
10.0.0.1                                   56  64 27ms
10.0.0.1                                   56  64 25ms
10.0.0.1                                   56  64 22ms
10.0.0.1                                   56  64 8ms
10.0.0.1                                   56  64 25ms
10.0.0.1                                   56  64 2ms
10.0.0.1                                   56  64 16ms
    sent=13 received=13 packet-loss=0% min-rtt=2ms avg-rtt=17ms max-rtt=27ms

[admin@meconet] >
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- Using the /log print command you can control your configuration

Log

Freeze

all

Jan/02/1970 08:17:01	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:02	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:03	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:04	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:05	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:06	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:07	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:08	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:09	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:10	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:11	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:12	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:13	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:14	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:15	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:16	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:17	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:18	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:19	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,
Jan/02/1970 08:17:20	memory	firewall, info	output: in:(none) out:wlan1, proto ICMP (type 8, code 0), 10.0.0.2->10.0.0.	prio 0->2,

When RouterOS change the priority you will see this in the log.

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- Now start parallel to the running ping also the integrated bandwidth tester from the client to the AP.

```
Terminal
[admin@meconet] > tool bandwidth-test address=10.0.0.1 protocol=tcp direction=both
                  status: running
                duration: 31s
              tx-current: 30.8Mbps
    tx-10-second-average: 30.8Mbps
        tx-total-average: 30.1Mbps
              rx-current: 26.2Mbps
    rx-10-second-average: 26.0Mbps
        rx-total-average: 25.9Mbps
             random-data: no
               direction: both
-- [Q quit|D dump|C-z pause]
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- **What happens with the running ping now?**

```
Terminal
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                      56  64 917ms
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                                timeout
    sent=20 received=11 packet-loss=45% min-rtt=5ms avg-rtt=175ms max-rtt=917ms
HOST                                          SIZE TTL TIME  STATUS
10.0.0.1                                        56  64 208ms
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                        56  64 489ms
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                                timeout
10.0.0.1                                                timeout
```

Didn't the configured QoS work correctly?
Is RouterOS not able to handle this?

How can we use prioritization in MikroTik RouterOS based wireless networks?

- **Sure it did!** To understand this behavior, we have to take a deeper look in the IEEE Standard for 802.1D-2004 Bridge definitions!

Higher

User Priority	Acronym	Traffic Type
1	BK	Background
2	./.	Spare
0 (Default)	BE	Best Effort
3	EE	Excellent Effort
4	CL	Controlled Load
5	VI	Video
6	VO	Voice
7	NC	Network Control

As you can see, **priority 1 and 2** are **lower** then the default **priority 0!** Our TCP test traffic runs with default priority of 0 because nothing is configured for this kind of traffic. But for ICMP we use a lower priority of 2 in the actual setup!

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- Please change the **new-priority** setting in your AP and Client from old priority 2 to new, higher priority 7

```
/ip firewall mangle
set 0 new-priority=7
```

and try parallel ping and bandwidth test again.

Now you should see as result, that all pings will be answered without any additional delay or loss, even the bandwidth tester fill completely the available bandwidth of the wireless link.

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- Let us no check if traffic with a higher priority really get more bandwidth thru the link when also other traffic with different priority will be present. For a simple test with the integrated Bandwidth Tester we use an additional rule for UDP with a medium priority of 3 and one for TCP with a higher priority of 6.

  So please add on AP and Client the needed rules

```
/ip firewall mangle
add action=set-priority chain=output new-priority=3
protocol=udp
add action=set-priority chain=output new-priority=6
protocol=tcp
```

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

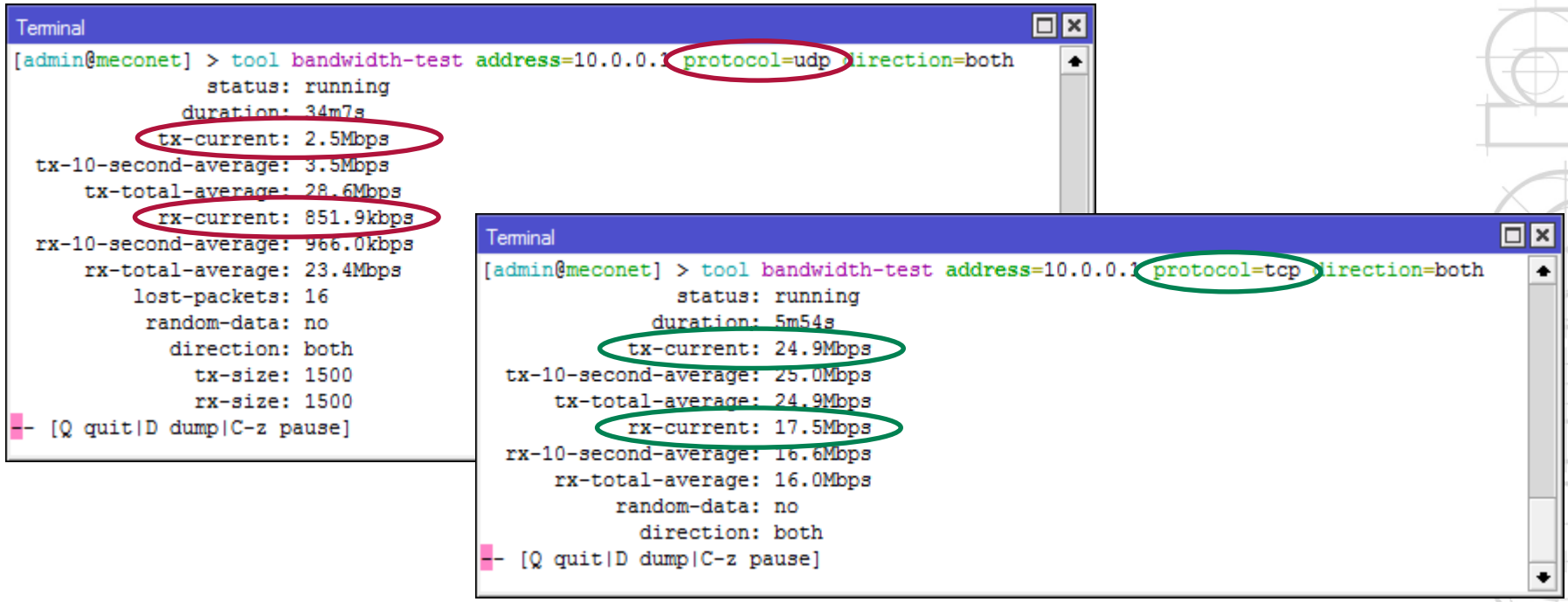
- Now first start on the Client a ping to the AP and then a bandwidth test using UDP to the AP, you should see something similar:

```
Terminal
[admin@meconet] > tool bandwidth-test address=10.0.0.1 protocol=udp direction=both
                  status: running
                duration: 2m7s
              tx-current: 32.5Mbps
    tx-10-second-average: 32.7Mbps
        tx-total-average: 32.3Mbps
              rx-current: 27.1Mbps
    rx-10-second-average: 27.2Mbps
        rx-total-average: 26.7Mbps
            lost-packets: 465
             random-data: no
               direction: both
                 tx-size: 1500
                 rx-size: 1500
-- [Q quit|D dump|C-z pause]
```

And the ping should also work proper during the test, because the **priority 7** for ICMP is higher then the **priority 3** used for UDP now.

Practical exercise I – Simple QoS on a NV2 wireless link in router mode

- The next step is to start an additional bandwidth test but now using TCP.



The UDP stream now reduce throughput significantly and ping works still proper. If you stop the TCP test, the UDP stream will directly get back the full available bandwidth of the wireless link.

Quality of Service in wireless Point-to-Point Links

- **Where can this configuration be useful?**

  This is a typical environment for business customer where two different locations are connected together with a wireless link and the MikroTik wireless systems are acting as router between both locations.

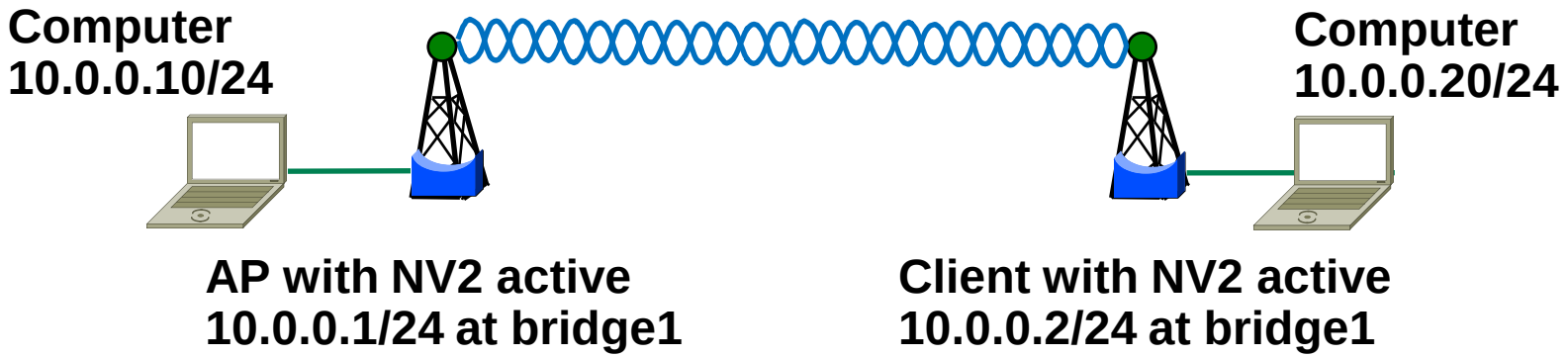
  In this environment the prioritization is mostly used for

  - VoIP
  - ERP, CRM, SQL, …
  - other important applications from the customer

- We use this configuration in a more complex way also in our routed (W)ISP installations.

Practical exercise II – Simple QoS on a NV2 wireless link in bridge mode

- Let us reconfigure the existing NV2 Link between AP and Client so the WLAN Interface is bridged with an Ethernet Interface and connect computers to that Ethernet Interfaces. For bandwidth testing still reduce available air rate so the CPU of the system can generate enough traffic to fill the link!



Take care for the correct WLAN Interface configuration on the wireless Client! The used 'station' mode can't bridge traffic from the LAN to the WLAN. If you don't know why, please ask after the presentation or read

http://wiki.mikrotik.com/wiki/Manual:Wireless_Station_Modes#802.11_limitations_for_L2_bridging

Practical exercise II – Simple QoS on a NV2 wireless link in bridge mode

- AP WLAN configuration

```
No changes needed
```

Client WLAN configuration

```
/interface wireless
set 0 mode=station-bridge
```

Add Bridge Interface on both systems

```
/interface bridge
add name=bridge1
```

and add the needed Ports to the new Bridge Interface on both systems

```
/interface bridge port
add bridge=bridge1 interface=ether1
add bridge=bridge1 interface=wlan1
```

Practical exercise II – Simple QoS on a NV2 wireless link in bridge mode

- AP IP configuration

```
/ip address
set 0 interface=bridge1 address=10.0.0.1/24
```

Client IP configuration

```
/ip address
set 0 interface=bridge1 address=10.0.0.2/24
```

Remove all existing Mangle Rules on both systems

```
/ip firewall mangle
remove [find]
```

Remove all existing Log Rules on both systems

```
/ip firewall filter
remove [find]
```

Practical exercise II – Simple QoS on a NV2 wireless link in bridge mode

- Now we have a bridged Layer 2 Network, so you have two possibilities to find and mark your packets.

- You can activate **'use-ip-firewall=yes'** in the Bridge settings and still work with your Mangle Rules in IP Firewall settings.

- But you can do this task also directly in the Bridge Firewall, without any use of Layer3 firewalling.

```
/interface bridge filter
add action=set-priority chain=forward ip-protocol=icmp
mac-protocol=ip new-priority=7
```

And if you like also logging

```
/interface bridge filter
add action=log chain=forward ip-protocol=icmp mac-protocol=ip
```

Practical exercise II – Simple QoS on a NV2 wireless link in bridge mode

- Now you can ping from one Computer to the other thru the bridged wireless link and start an additional bandwidth test from one wireless system to the other to verify that your QoS rule for ICMP works as expected.

- During running ICMP and bandwidth test, just deactivate/activate the Bridge Filter on one or both systems and see the difference in the RTT of the ping.

Quality of Service in wireless Point-to-Point Links

- Where can this configuration be useful?

  This is a typical environment for business customer where two different locations are connected together with a bridged wireless link.

  In this environment the prioritization is mostly used for

  - VoIP
  - ERP, CRM, SQL, …
  - other important applications from the customer

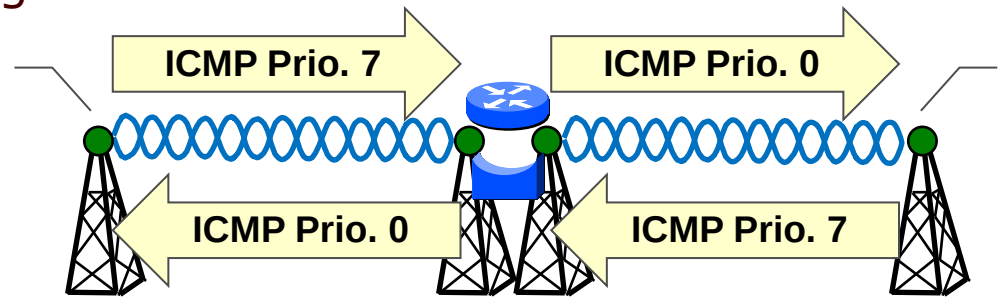
- (W)ISPs with completely bridged backbone topologies can use this to improve customer satisfaction by more stable and latency reduced connections for e. g. VoIP traffic, ICMP for the gamer and so on.

Quality of Service in wireless Point-to-Point Links

- **Important note for NV2 QoS and internal priority field!**

If you want to use priority settings and your traffic goes thru an additional bridge or router like

```
/ip firewall mangle
add action=set-priority
chain=output new-priority=7
protocol=ICMP
```




```
/ip firewall mangle
add action=set-priority
chain=output new-priority=7
protocol=ICMP
```

It's not enough to set the priority on the systems at the edges of the wireless network. As mentioned before, the used priority information is only valid inside the system where you set it, the system in the middle of this link don't know anything about priorities defined at the edge systems, so the packet will leave this system with default value of 0.

In this case you have to repeat the priority configuration also on all systems where the traffic goes thru.

Quality of Service in wireless Point-to-Point Links

- **Which further options offers RouterOS to set priorities?**

  Until now we only set the needed priorities by hand in the Bridge Filter or IP Firewall Mangle settings. But RouterOS provides much more and powerful possibilities for this task. If one of the following methods is used in the existing network

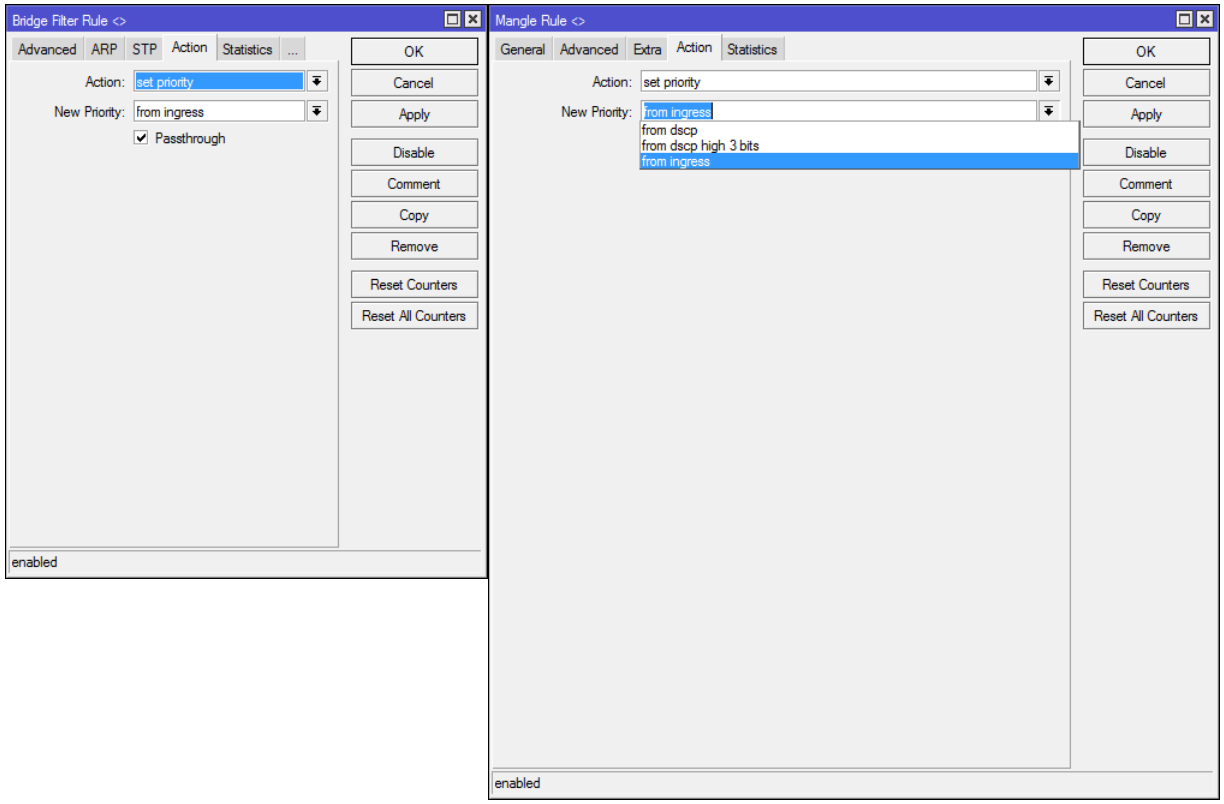
  - **TOS/DCSP** - Type of Service/DiffServ, 6 Bit for Differentiated Services Codepoint (DSCP) between 0 and 63
  - **VLAN with active TCI** - Tag Control Identifier, 3 Bit for priority, 0 = lowest, 7 = highest
  - **MPLS with active EXP-Bit** - Experimental Bit, 3 Bit for priority, 0 = lowest, 7 = highest

  You can use the existing QoS parameters directly for the NV2 priority queuing, regardless if you use Bridge Filter or IP Firewall Mangle.

Quality of Service in wireless Point-to-Point Links

- **Which further options offers RouterOS to set priorities?**

  To use this feature, we can let RouterOS copy the existing priority at the ingress.



RouterOS will now copy the given priority information from the packet header to the only system internally used priority field.

Keep in mind, that the values 0, 1 and 2 for the priority have different meanings in the IEEE 802.1D bridge used for NV2 priority queuing on one side and on the other side as CoS identifier in the packet header! Take care of this if you plan the CoS value in the entire network, or remap them for use in NV2.

Quality of Service in wireless Point-to-Point Links

- **Which further options offers RouterOS to set priorities?**

  Of course you can also use all existing parameters like

  - Interfaces
  - previously defined Marks
  - Protocol, IP, Address List Information
  - Ingress Priority, Priority, TOS/DSCP
  - all the other things included in the firewall subsystem of RouterOS

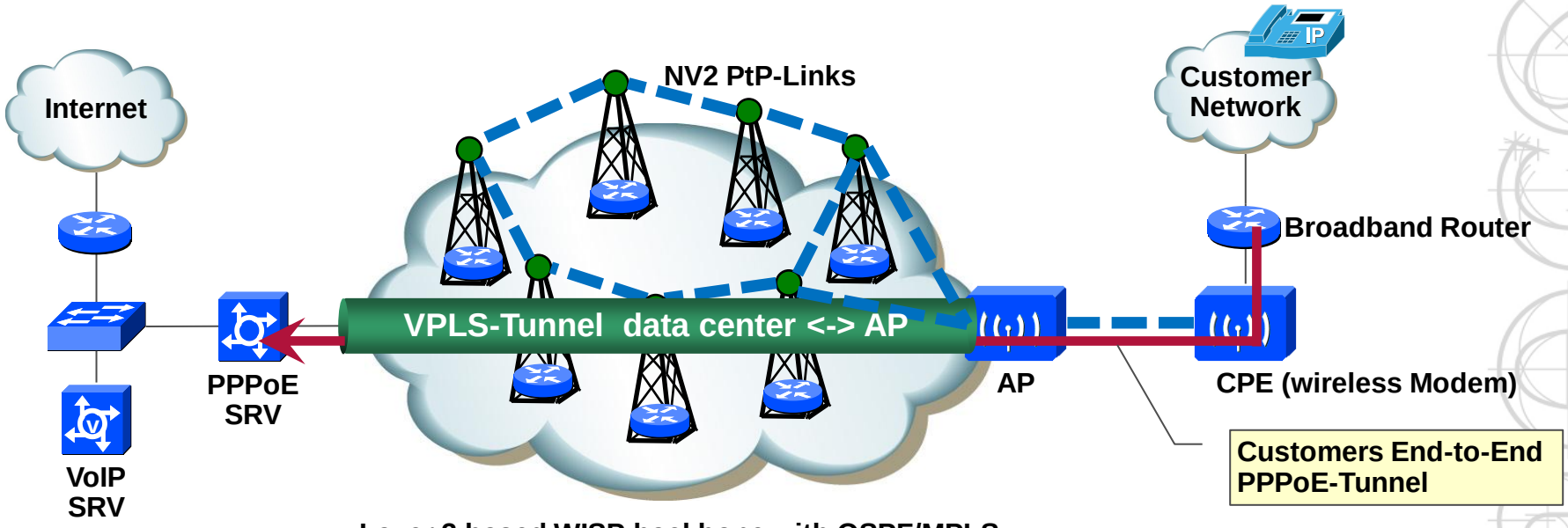
  In the Bridge Filter or IP Firewall Mangle to identify your traffic and set new priority value as needed for further queuing in NV2.

  So RouterOS offer you a very powerful and extremely flexible QoS environment also for use in wireless networks.

Quality of Service in wireless Point-to-Point Links

- **Sample for a complex integration with PPPoE and MPLS/VPLS**

  Let's see how QoS can be integrated in a WISP backbone using PPPoE thru VPLS Tunnel over a routed backbone, to provide End-to-End QoS for VoIP services.



Layer 3 based WISP backbone with OSPF/MPLS as transport network for VPLS Tunnel to provide needed Layer2 connection for PPPoE

Quality of Service in wireless Point-to-Point Links

- **Sample for a complex integration with PPPoE and MPLS/VPLS**

  As you can see in the network drawing, all packets coming from the customer or going to the customer are PPPoE encapsulated and this PPPoE Tunnel is carried inside a VPLS Tunnel from the AP to the data center of the ISP or vice versa.

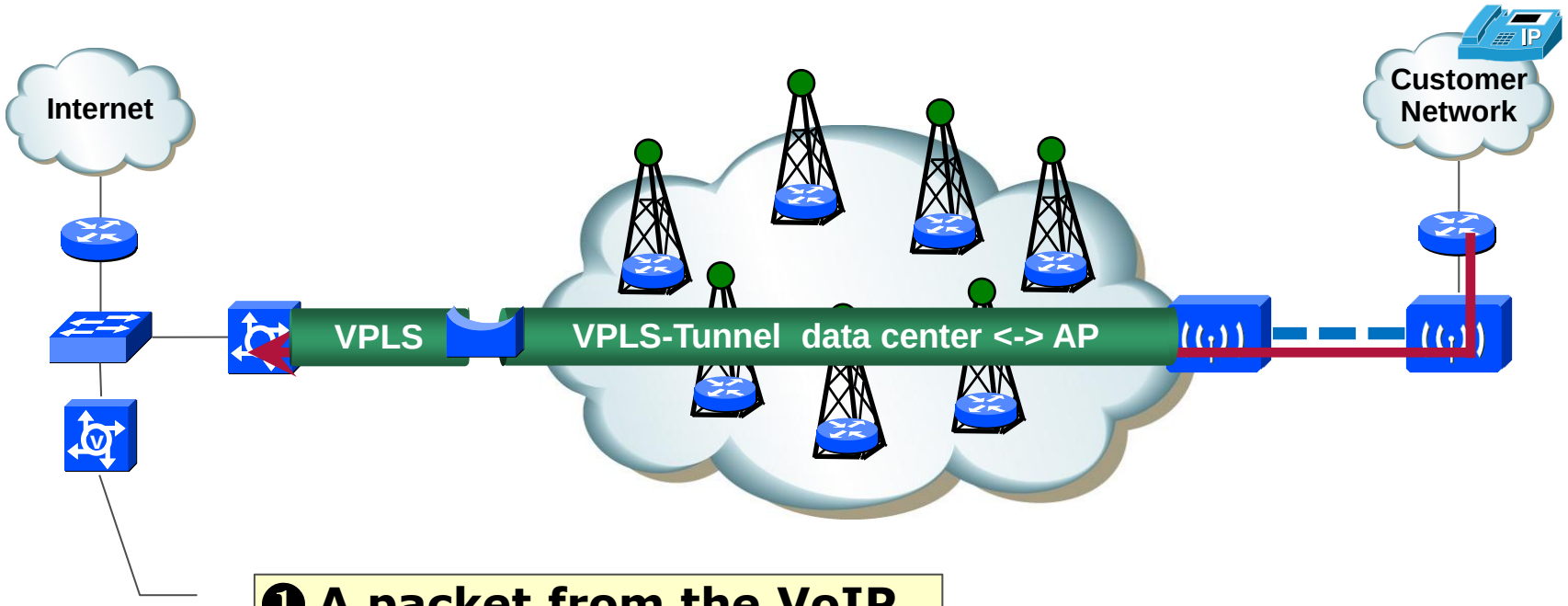
  So each System in the backbone only 'see' a MPLS Label – which is enough to switch the packet to the correct next hop – but have no idea what type of data is inside. If you strip of the MPLS Label, you get a PPPoE packet. So also at this point, you have no chance to know what is inside the PPPoE Tunnel. And last but not least PPPoE itself did not offer any way to carry a priority information.

  So how can we now integrate a real End-to-End QoS for e. g. VoIP packets and take care, that every router in the backbone who is participating in the transmission of the packet will know about this?

Quality of Service in wireless Point-to-Point Links

- **Sample for a complex integration with PPPoE and MPLS/VPLS**

  With RouterOS it's much easier as you think!



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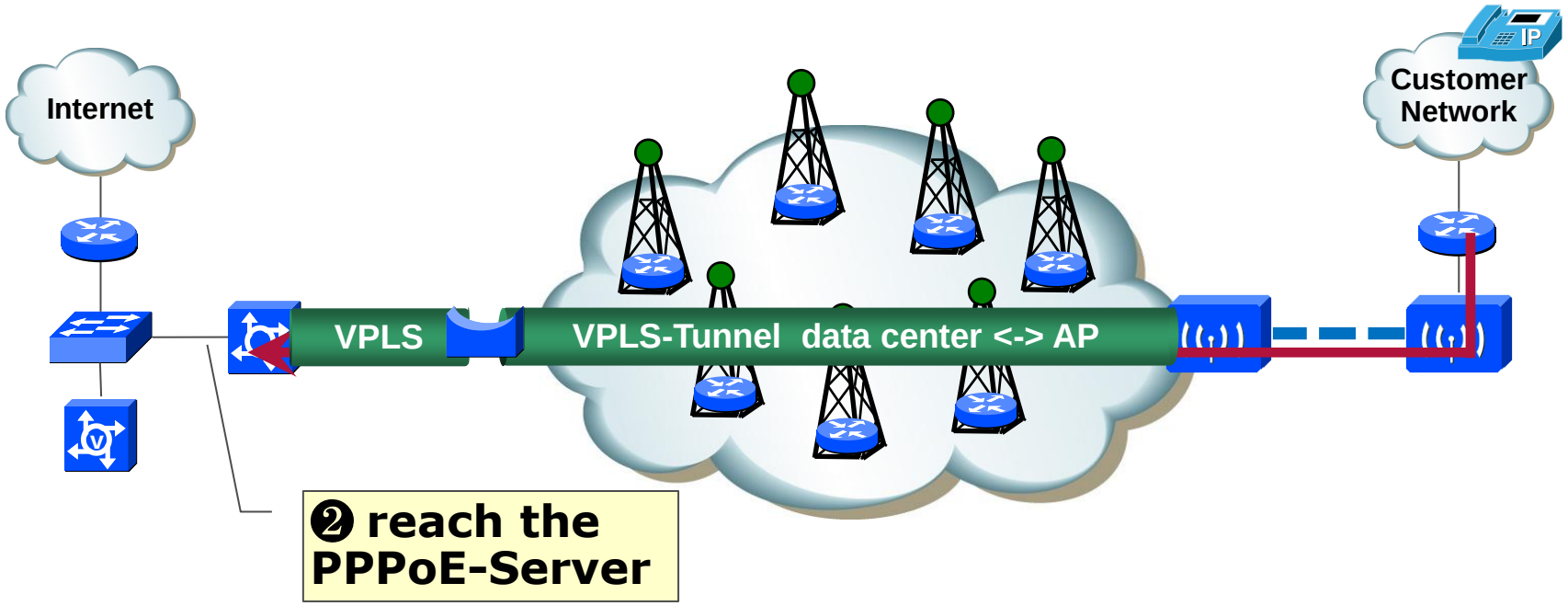


Quality of Service in wireless Point-to-Point Links

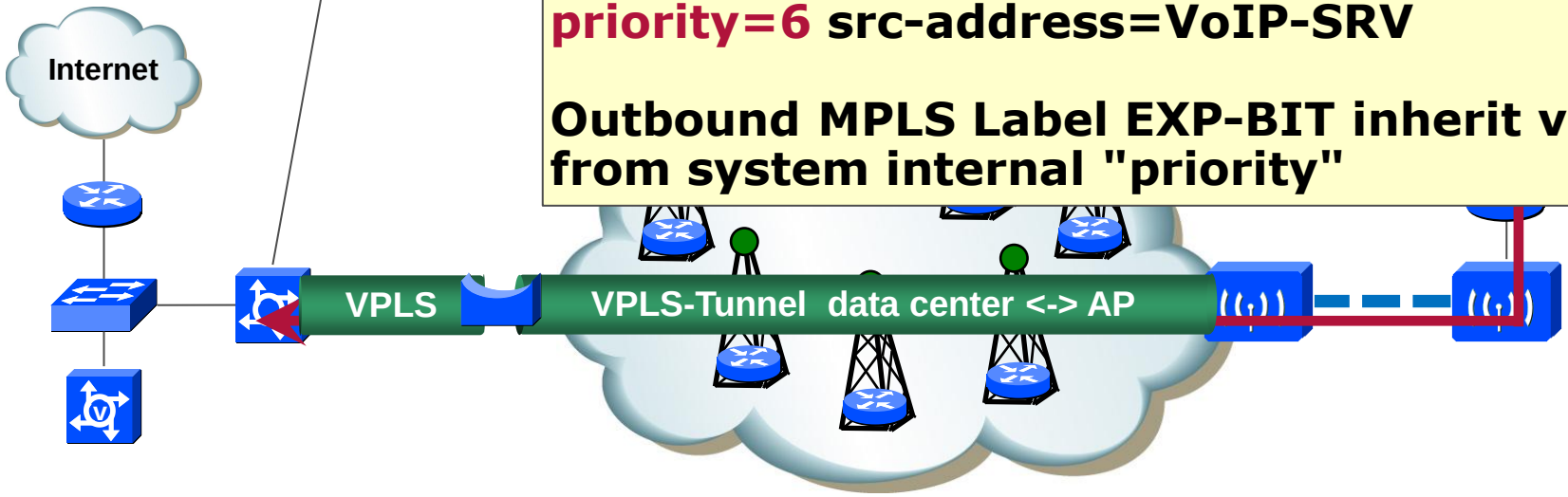
- **Sample for a complex integration with PPPoE and MPLS/VPLS**

With RouterOS it's

❸ PPPoE-Server apply Mangle Rule:

```
/ip firewall mangle
chain=prerouting action=set-priority new-priority=6 src-address=VoIP-SRV
```

Outbound MPLS Label EXP-BIT inherit value 6 from system internal "priority"



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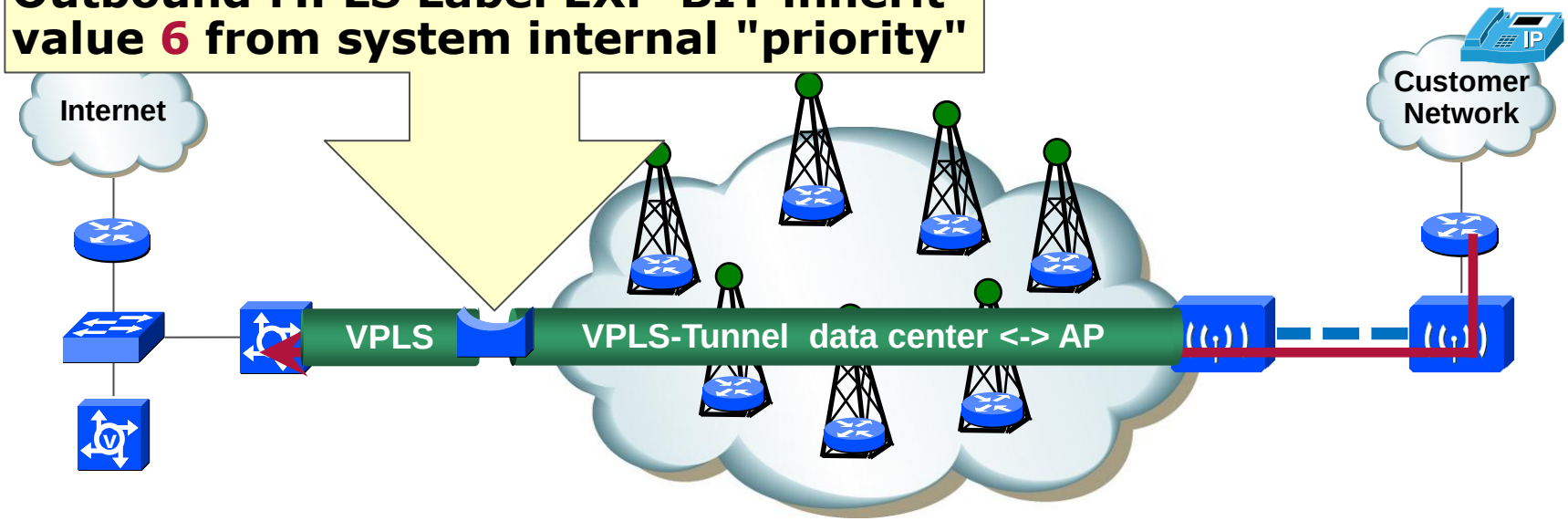
ith PPPoE and MPLS/VPLS

!

❹ **Inbound MPLS Label EXP-BIT=6**

System apply Bridge Filter:
/interface bridge filter
chain=forward action=set-priority new-priority=from-ingress

Outbound MPLS Label EXP-BIT inherit value 6 from system internal "priority"



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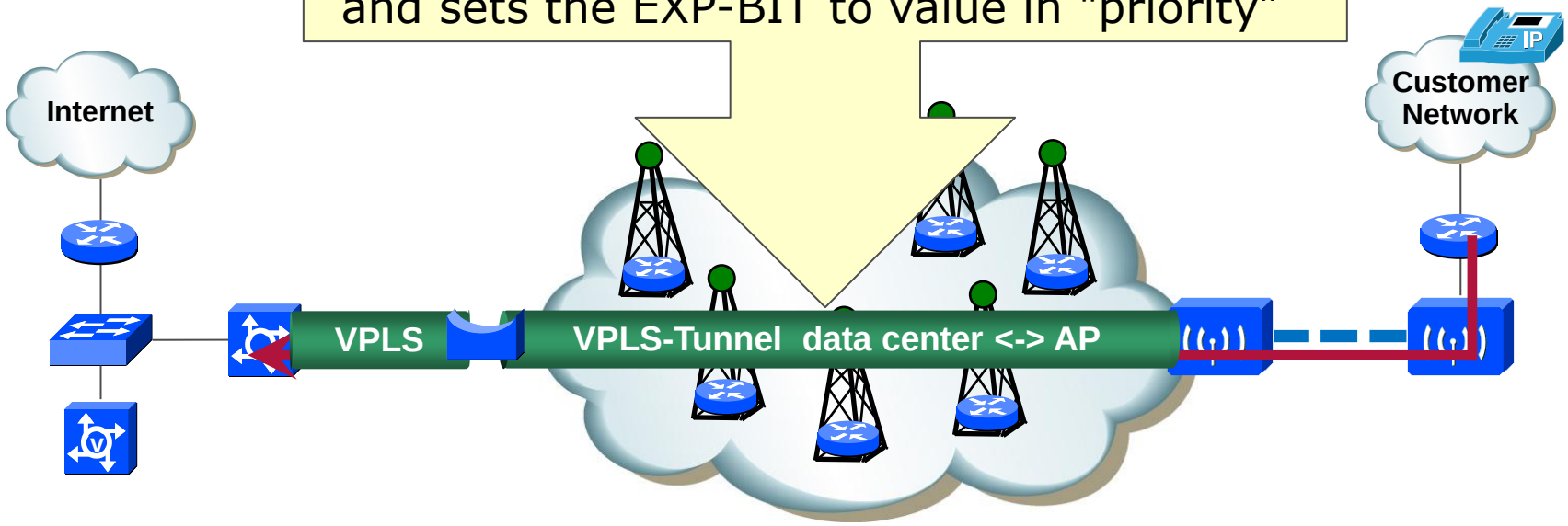
- Sample fo

With Rout

❺ As long as packet is MPLS switched, EXP-BIT field in new label will be the same as in received label, because:

- RouterOS sets "ingress priority" to EXP-BIT in received label
- Switching automatically sets "priority" to "ingress priority"
- RouterOS label packet with new label and sets the EXP-BIT to value in "priority"



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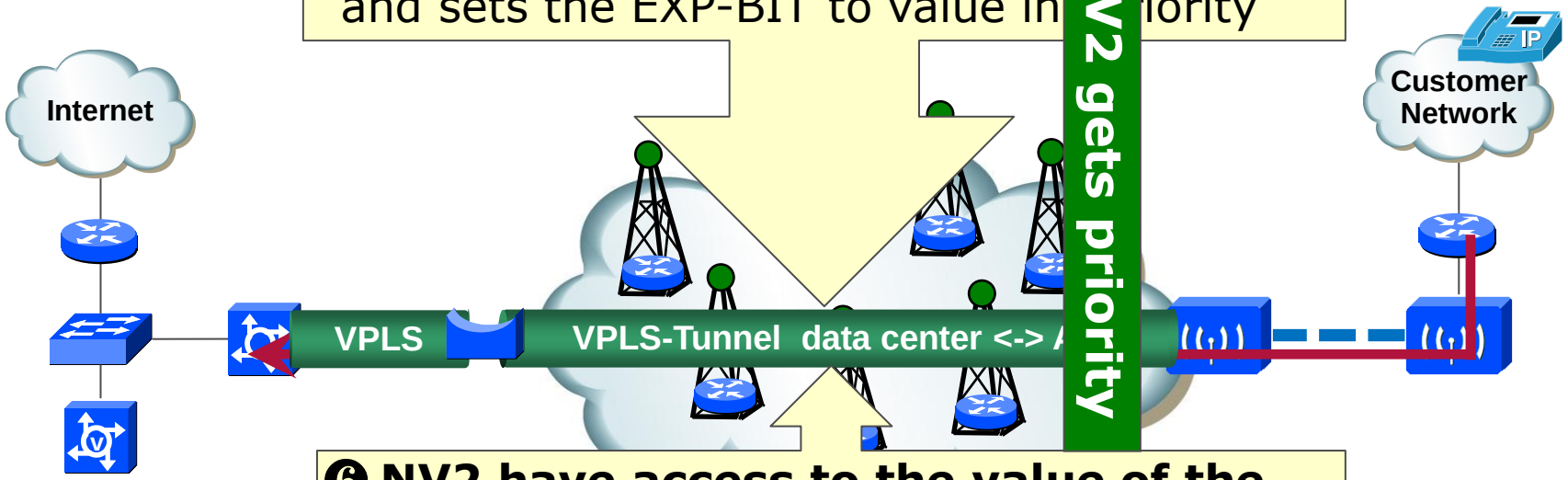

❻ NV2 have access to the value of the internal used "priority" and can apply correct queue to the packet

Quality of Service in wireless Point-to-Point Links

- **Sample for a complex integration with PPPoE and MPLS/VPLS**

  With RouterOS it's much easie

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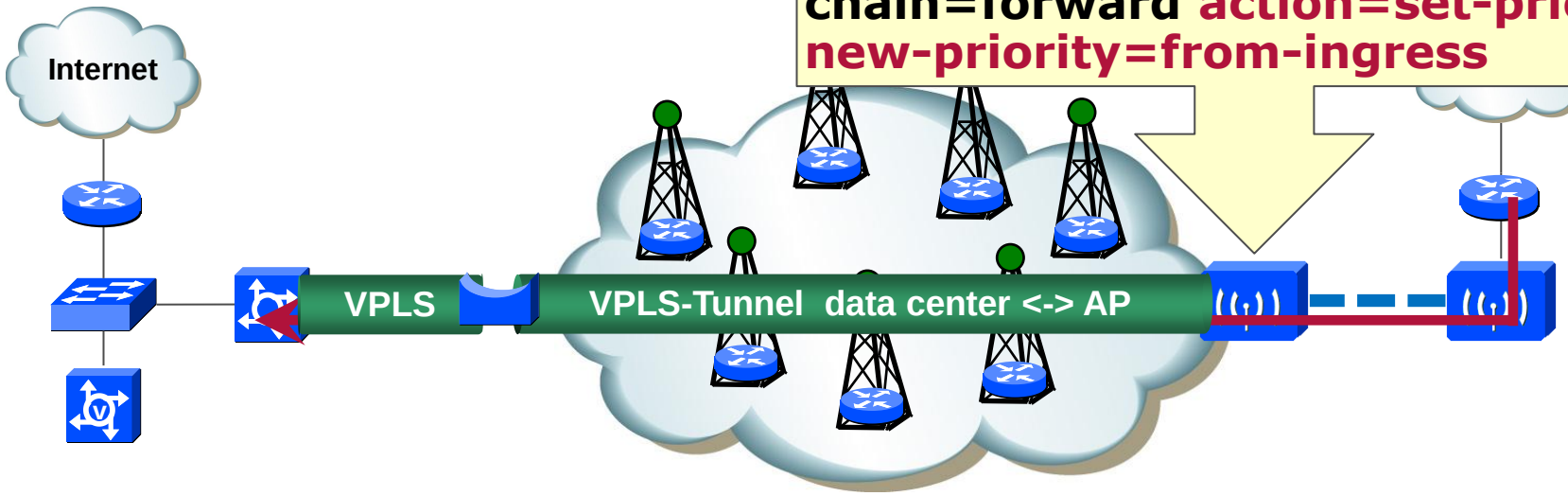
new-priority=from-ingress



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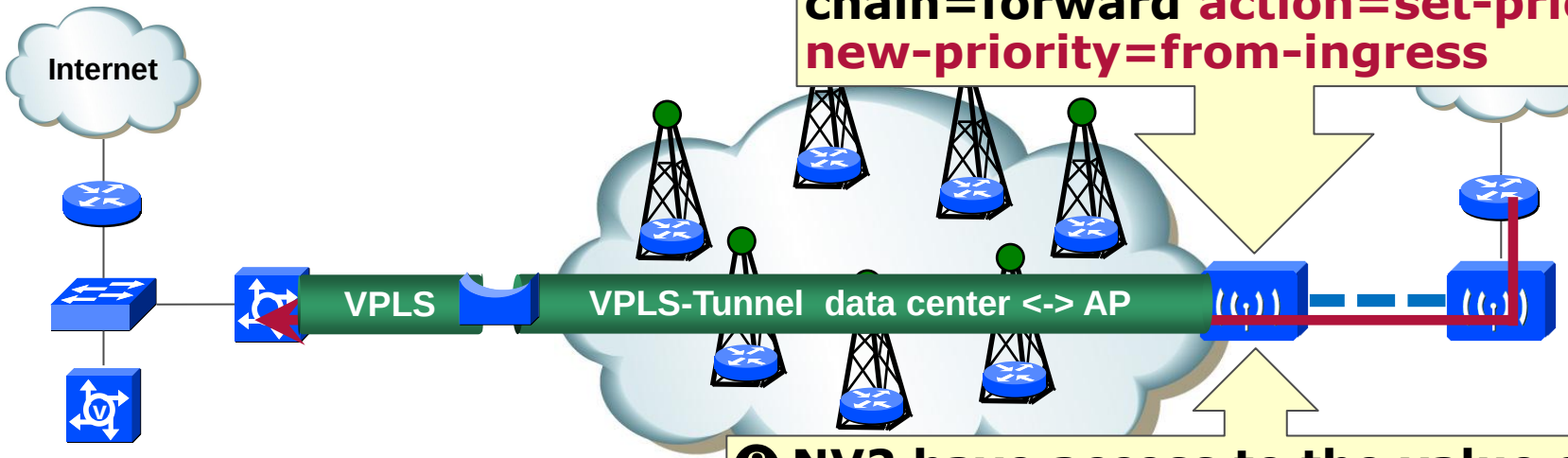

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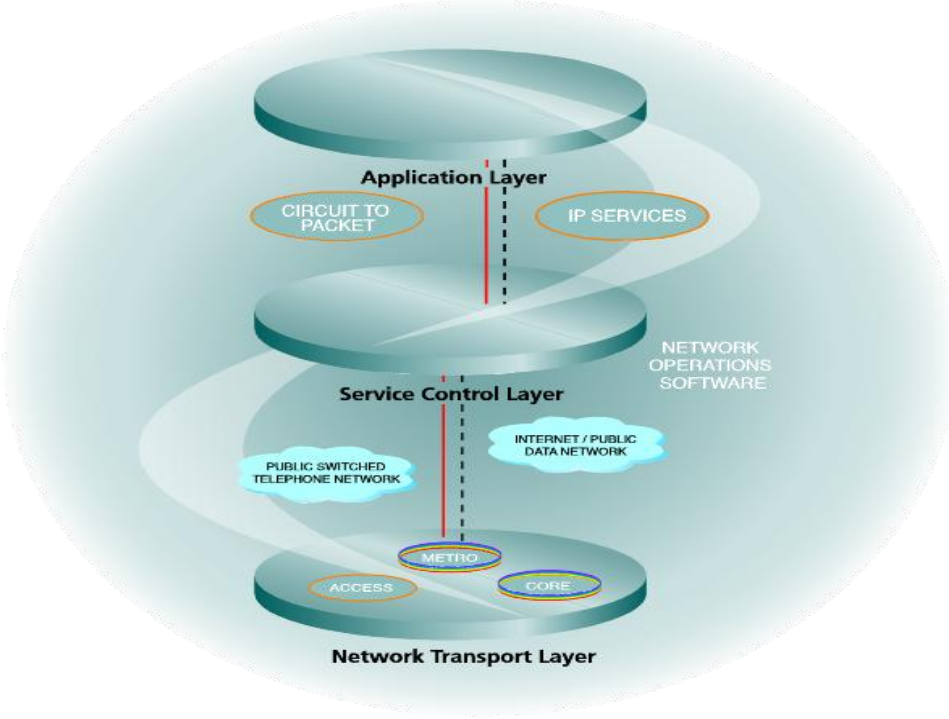
Quality of Service in wireless Point-to-Point Links

Thank you for your attention!

Just try the examples at home, QoS can be so easy and powerful - even wireless!



If you have any questions, please don't hesitate to ask now or send an email to lutz.kleemann@meconet.de

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