

Selamat Datang

- Rekan2 boleh koneksi ke Wifi yang ada di ruangan

SSID : gpmnetwork | Password : gpmnetwork

- Buatlah account di website **mikrotik.com**

Apabila anda sudah memiliki account, mohon pastikan anda bisa masuk login ke mikrotik.com



- Copy File dari Flasdisk Trainer

Membuat Account di Mikrotik

- Untuk training dan ujian MTCNA peserta harus membuat account di web mikrotik
- Pendaftaran account di www.mikrotik.com, pada menu account isi semua form yang disediakan
- Pastikan nama anda ditulis lengkap dalam profil, karena otomatis akan tercetak dalam sertifikat.
- Informasikan email yang didaftarkan mikrotik account ke trainer

Membuat Account di Mikrotik

The screenshot shows a web browser window for the Mikrotik client at mikrotik.com/client. The address bar is highlighted with a red box and labeled '1'. The page title is 'My account'. The navigation menu includes Home, About, Buy, Jobs, Hardware, Software, Support, Training, and Account, with 'Account' highlighted by a red box and labeled '2'. A large red box highlights the 'REGISTER' button in the top right corner of the login form, labeled '3'. The login form has fields for 'Username' and 'Password' and a 'Log in' button.

mikrotik.com/client 1

ALL ABOUT UBIQU... All About Mikrotik account ScreenCast gpmnetwork.id beasiswa kaltim 2021 All About Lintasarta Mikrotik Online Oth

MikroTik

Home About Buy Jobs Hardware Software Support Training Account 2

My account

LOG IN REGISTER 3

Username

Password

Log in

Membuat Account di Mikrotik

REGISTER [LOG IN](#)

1 Registration type Natural person Legal person

Name **2**
Surname

Date of birth

E-mail **3**

Residential address

Address line **4**
City

Province/state or region

Country

Postcode **5**

Phone Number

Website URL

My location Latitude,Longitude

Allow to use my account from netinstall and winbox

Prove you are a human
 I'm not a robot

I hereby confirm that information
filled here

6

Latihan Test

- Setelah membuat account di mikrotik.com, peserta dapat login dan melakukan latihan ujian MTCNA di website mikrotik.com
- Latihan ujian MTCNA ada di menu **Account , My training session, Try example test.**
- Waktunya 30 Menit (hingga 08.30)

Enter enrollment key

Submit

Test your knowledge!

Try example test

1



Mikrotik Certified Network Associate
(MTCNA)

Let's Play Together

Membiasakan diri berdoa sebelum belajar

اللَّهُمَّ إِنِّي أَسْأَلُكَ عِلْمًا نَافِعًا
وَرِزْقًا طَيِّبًا وَعَمَلاً مُتَقَبِّلًا

**"Allahumma inni as-aluka 'ilman naafi'a wa rizqon
thoyyibaa wa 'amalan mutaqobbalaa"**

Andi Jehan Alhasan

PENDIDIKAN :

- S1 IST Akprind Jogja, Teknik Informatika
- S2 Binus Jakarta, Magister Teknik Informatika



BISNIS :

- GPMNETWORK IT Networking Training
- GPMNETWORK IT Consultant



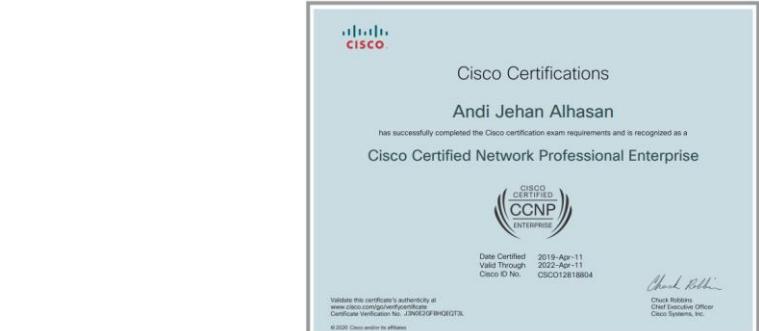
CSR :

- GPMNETWORK Academy



SERTIFIKASI :

MIKROTIK TRAINER, MTCNA, MTCRE, MTCINE,
CCNA R/S, CCNP R/S & CCNP ENTERPRISE



Social Media :

- Instagram @gpmnetwork
- Facebook Andi Jehan
- Linkedin Andi Jehan

Tentang GPMNETWORK

- **Gpm Network** adalah perusahaan IT Network Consultant dan IT Solution yang fokus pada Infrastruktur Jaringan Komputer dan Keamanan Jaringan terletak di Balikpapan, Kalimantan Timur. Layanan kami meliputi, Network, Server, Voice/Voip ,Video surveillance.
- Our Client : Telkom Divre 6, UMKT, PT GAM, Logindo, Modular Mining, Polda Kaltim, Lintasarta, IconPlus, Pemkot Balikpapan, dan lainnya
- Website : gpmnetwork.id

Perkenalkan Diri Anda

- Nama
- Pekerjaan sehari-hari
- Pengalaman menggunakan Mikrotik
- Pengalaman mengenai jaringan
- Diharapkan dari mengikuti training ini

Jadwal

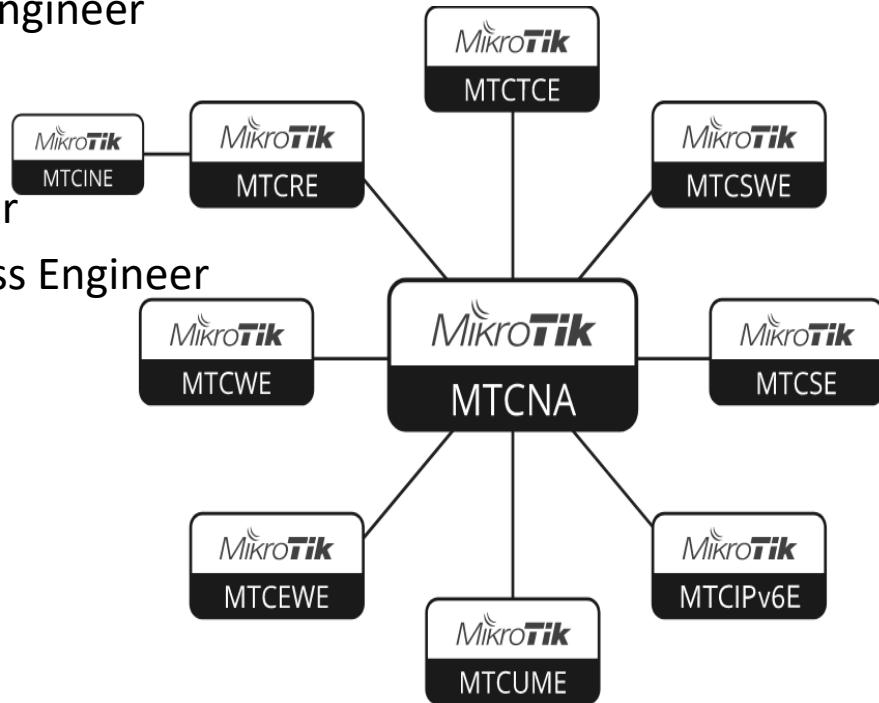
- Training Day : 08.00 – 17.00
- 20 Menit Breaks : 10.00-10.20
- 1 jam Lunch : 12.00 – 13.00
- 20 Menit Breaks : 15.00 – 15.20

Tentang Ujian Mikrotik

- Ujian dilakukan online melalui mikrotik.com
- Dilakukan pada sesi terakhir training
- Terdapat 25 soal dalam waktu 60 menit
- Nilai minimal kelulusan 60 %
- Nilai antara 50-59 % mendapatkan kesempatan kedua ujian kembali
- Mikrotik academy minimal score 75% (MTCNA dan MTCRE)
- Peserta yang lulus akan mendapatkan sertifikasi MTCNA yang diakui secara international

SERTIFIKASI MIKROTIK

- A. **MTCNA** - MikroTik Certified Network Associate
- B. **MTCRE** - MikroTik Certified Routing Engineer
- C. **MTCWE** - MikroTik Certified Wireless Engineer
- D. **MTCTCE** - MikroTik Certified Traffic Control Engineer
- E. **MTCUME** - MikroTik Certified User Management Engineer
- F. **MTCINE** - MikroTik Certified Inter-Networking Engineer
- G. **MTCIPv6E** - MikroTik Certified IPv6 Engineer
- H. **MTCSE** - MikroTik Certified Security Engineer
- I. **MTCSWE** - MikroTik Certified Switching Engineer
- J. **MTCEWE** - MikroTik Certified Enterprise Wireless Engineer



MTCNA – Materi yg dipelajari

- Introduction
- DHCP
- Bridging
- Routing
- Wireless
- Firewall
- Quality Of Service
- Tunnels
- Misc
- lebih detail di mikrotik.com

MTCRE

- Static Routing
- Point to Point Addressing
- VPN
- OSPF

MTCWE

- Wireless Installations
- Wireless Standard
- Wireless Tools
- Wireless Troubleshooting
- Wireless Advanced Settings
- 802.11n
- Wireless Security
- WDS and MESH
- Wireless Bridging
- Nstreme Protocol
- Nv2 Protocol

MTCTCE

- Packet flow diagram
- Firewall filter/nat/mangle
- Quality of Service
- DNS client/cache
- DHCP client/relay/server
- Web Proxy

MTCUME

- PPP
- PPTP, LT2P
- PPPoE
- Bridging
- IPSec

MTCINE

- BGP
- MPLS
- Traffic Engineering

MTCIPve6

- Introduction to IPv6
- IPv6 Protocol
- IPv6 Packet

Tujuan Training

- Memperkenalkan dan memberikan gambaran tentang RouterOS dan produk RouterBoard dari mikrotik
- Mempelajari dan memahami Konfigurasi, Maintenance dan dasar Troubleshooting router mikrotik
- Mendapatkan kualifikasi sebagai MTCNA (MikroTik Certified Network Associate)



Certified Network Associate (MTCNA)

Module 1

Introduction

Tentang Mikrotik

- 1996 : Established
- 1997 : RouterOS software for x86 (PC)
- 2002 : First RouterBoard Device
- 2006 : Pertama kali Mikrotik User Meeting diadakan di Prague, Republik Ceko
- 2018 : Mikrotik user meeting Indonesia 3800+

Tentang Mikrotik

- Lokasi : Riga Latvia (Eropa)
- Produsen Router Software dan Hardware
- Moto perusahaan : Routing the world
- Pengunaan produk banyak digunakan oleh ISP, Perusahaan, hingga pemakain rumahan.



Jenis Mikrotik

- **Mikrotik RouterOS**
 - Software yang dapat diinstall di pc untuk dijadikan sebagai router
 - Berbasis linux
- **Mikrotik RouterBoard**
 - Hardware Penganti pc yang menggunakan RouteOS sebagai sistem operasinya
 - Berbagai macam tipe produk dari low end sampai high end

Mikrotik RouterOS

- Sistem operasi yang diinstall sebagai pendukung perangkat RouterBoard mikrotik
- Berbasis Linux
- Bisa digunakan di komputer atau virtual mesin
- RouterOS lisensi Level 1,3,4,5,6.
- <https://wiki.mikrotik.com/wiki/Manual:License>
- Pembelian lisensi
<http://mikrotik.co.id/produk.php?kategori=10>

Lisensi Mikrotik

Level number	0 (Demo mode)	1 (Free)	3 (WISP CPE)	4 (WISP)	5 (WISP)	6 (Controller)
Price	no key	registration required	volume only	\$45	\$95	\$250
Upgradable To	-	no upgrades	ROS v7.x	ROS v7.x	ROS v8.x	ROS v8.x
Initial Config Support	-	-	-	15 days	30 days	30 days
Wireless AP	24h trial	-	-	yes	yes	yes
Wireless Client and Bridge	24h trial	-	yes	yes	yes	yes
RIP, OSPF, BGP protocols	24h trial	-	yes(*)	yes	yes	yes
EoIP tunnels	24h trial	1	unlimited	unlimited	unlimited	unlimited
PPPoE tunnels	24h trial	1	200	200	500	unlimited
PPTP tunnels	24h trial	1	200	200	500	unlimited
L2TP tunnels	24h trial	1	200	200	500	unlimited
OVpn tunnels	24h trial	1	200	200	unlimited	unlimited
VLAN interfaces	24h trial	1	unlimited	unlimited	unlimited	unlimited
HotSpot active users	24h trial	1	1	200	500	unlimited
RADIUS client	24h trial	-	yes	yes	yes	yes
Queues	24h trial	1	unlimited	unlimited	unlimited	unlimited
Web proxy	24h trial	-	yes	yes	yes	yes
User manager active sessions	24h trial	1	10	20	50	Unlimited
Number of KVM guests	none	1	Unlimited	Unlimited	Unlimited	Unlimited

Fitur RouterOS

- Firewall (Domain,Protocol,Port ...)
- Bandwidth limiter (PCQ,HTB,RED ...)
- Wireless 802.11 (a/b/g/n/ac)
- Tunnell (PPTP,L2TP,SSTP,OVPN,IPSec)
- Routing (BGP,OSPF,RIP)
- Real Time Tools (Torch,Mac-ping ...)
- Support LCD,Wireless Card, Memory Card)
- Manajemen User (DHCP,Hotspot,PPPoE ...)

MikroTik VS Cisco

source: http://wiki.MikroTik.com/wiki/Manual:RouterOS_FAQ

How does this software compare to using a Cisco router?

*You can **do almost everything** that a proprietary router does at a fraction of the **cost** of such a router and have **flexibility** in upgrading, **ease of management and maintenance**.*

Anda dapat melakukan **hampir semua** yang dilakukan proprietary router tersebut (Cisco) dengan hanya sebagian kecil dari biaya router tersebut dan memiliki **fleksibilitas dalam mengupgrade, kemudahan manajemen dan pemeliharaan.**

Mikrotik RouterBoard

- Perangkat hardware yang memakai RouterOS sebagai sistem operasinya
- Berbagai macam tipe produk dari **low end** sampai **high end**
- Bisa langsung **digunakan** atau **custom** RouterBoard dalam membangun perangkat jaringan



Tipe RouterBoard

- RouterBOARD memiliki sistem kode tertentu



433AH

- Kode lain terdapat di bagian belakang tipe
 - U - dilengkapi dengan USB
 - A - Advance, biasanya digunakan level 4 keatas
 - H - High Performance, Processor lebih tinggi
 - G - dilengkapi port Gigabit ethernet
 - n - 802.11n support
 - R – dilengkapi wireless card



Ethernet routers



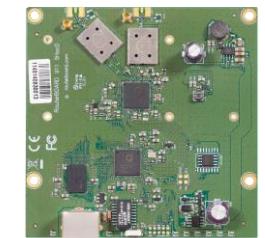
Wireless for home and office



Wireless



Switches



Tipe RouterBoard

- Hardware motherboard + Box Casing
- Hardware motherboard saja
- Hardware motherboard dengan minipci
- Interface SFP
- Accessories



Arsitektur RouterBoard

- Sampai saat ini ada 8 arsitektur dari RouterBoard yang dimiliki oleh mikrotik
- Setiap arsitektur RouterBoard memiliki karakteristik yang berbeda berdasarkan jenis prosessor pada RouterBoard.
- Digunakan untuk keperluan upgrade RouterOS pada RouterBoard agar sesuai
- Mengetahui Arsitektur Mikrotik
<https://mikrotik.com/download> Section RouterOS

Pemilihan RouterBoard

- Jenis-jenis lengkap dari Perangkat RouterBoard Mikrotik dapat di lihat pada folder katalog produk yang telah diberikan dalam **folder 2. Mikrotik Product Catalog 2023**
- Pembelian Mikrotik Routerboard
<http://www.mikrotik.co.id/>

Pemilihan Produk RouterBoard

- Fungsi Perangkat (Router, Switch, Access Point)
- Jumlah Trafik (small, medium, large)
- Fitur yang dibutuhkan (Hotspot, VPN, Wireless & lainnya)
- Alokasi Interface yang dibutuhkan (UTP/SFP)
- Dengan menggunakan PC Mikrotik atau RouterBoard, fitur dari mikrotik akan selalu sama tergantung pada lisensi yang digunakan.

Pemilihan Perangkat RouterBoard

- 300 / 400 Mhz Processor (< 5Mbps Traffic) RB450, RB450, RB750, RB433, RB941
- 680 Mhz Processor (5 ~ 20 Mbps Traffic) RB450G, RB450G, RB850Gx2, RB433AH
- 1Ghz Processor (20 ~ 100 Mbps Traffic) RB1200, RB1100AHx2
- 1Ghz Dual Core Processor (> 100 Mbps Traffic) CCR
- Multi Core x86 Processor (> 1 Gbps Traffic) Mikrobits : Aneto, Ainos, Dinara, CCR
- Xeon Processor (> 10 Gbps Traffic) Mikrobits : Dinara, CCR

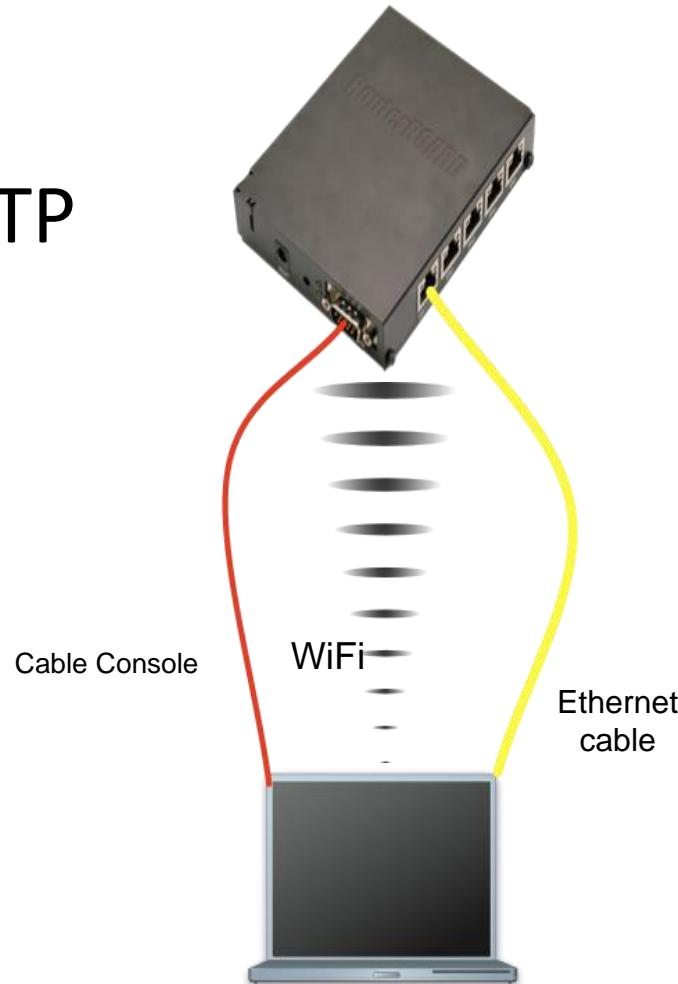
Skenario Topologi Training Mikrotik



IP address : 192.168.1.2
Subnet Mask : 255.255.255.0
Default gateway : 192.168.1.1
DNS Server : 8.8.8.8

Akses ke RouterBoard

- Cable Console
- Ethernet cable/ UTP
- Wireless



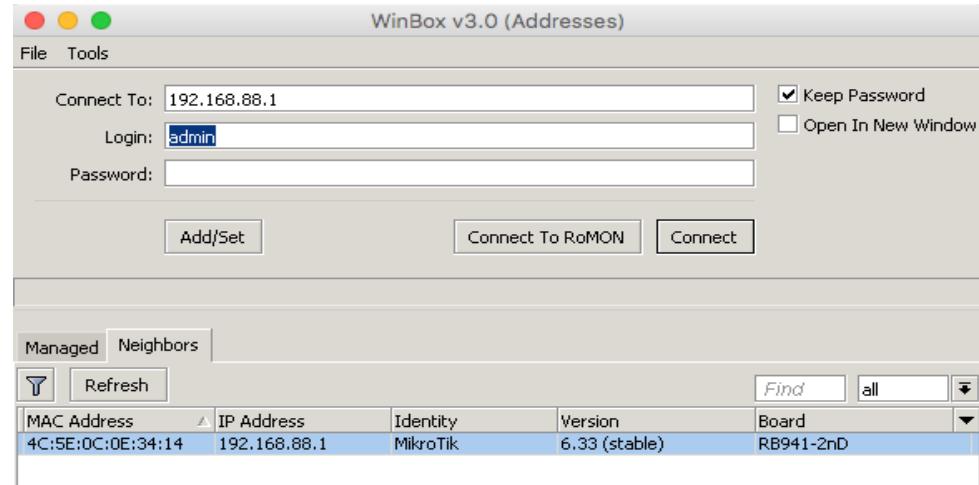
Akses ke RouterBoard

- **WinBox**
- WebFig
- SSH
- Telnet
- Terminal emulator in case of serial port connection

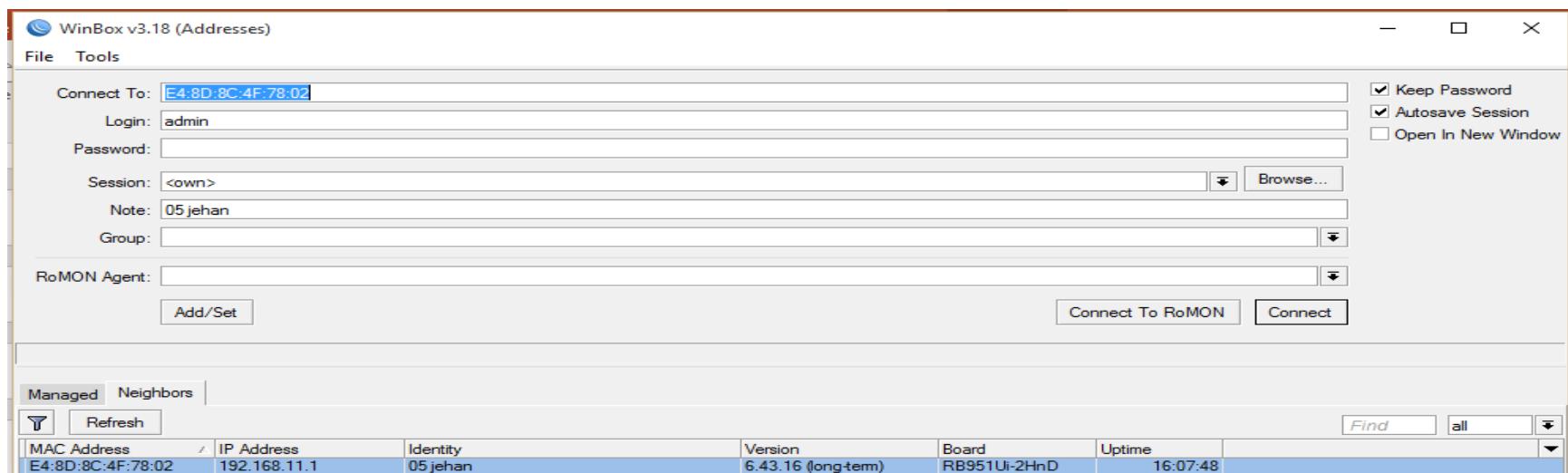
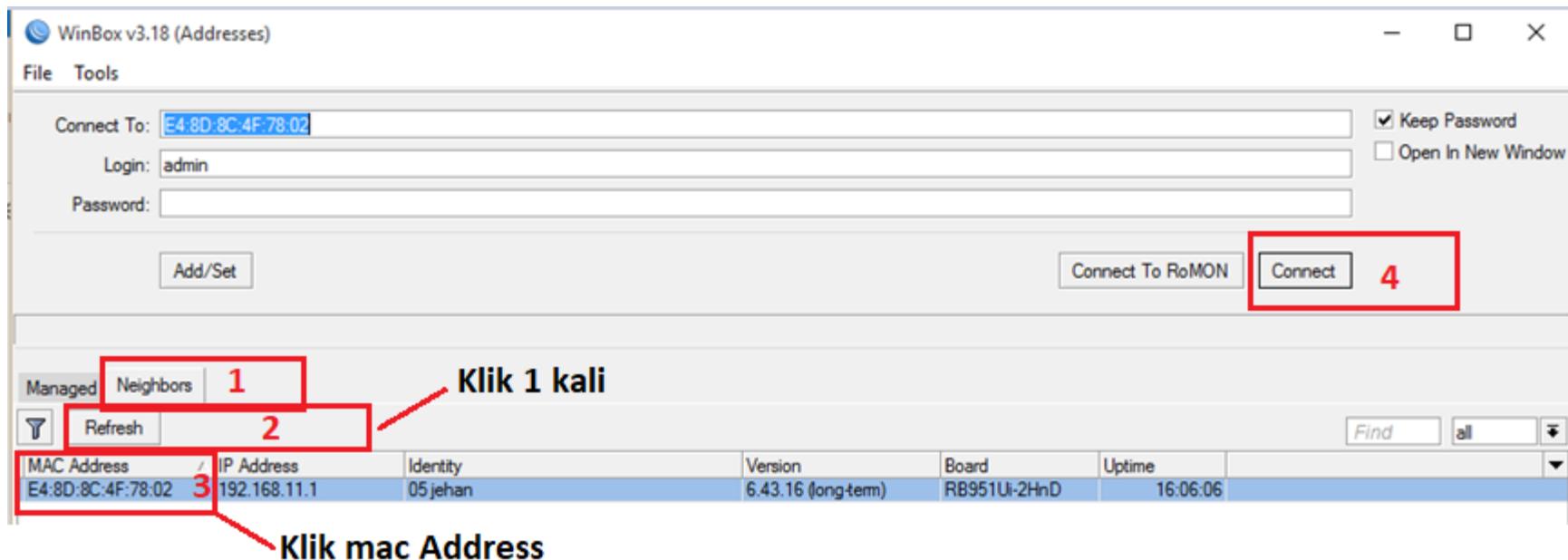
Akses Via	Koneksi	Text Base	Gui	Need IP
Keyboard				
Serial Console		YA		
Telnet & SSH		YA		YA
Winbox			YA	YA dan Tidak
FTP				
API				
WEB			YA	
Mac-Winbox			YA	Tidak
Mac-Telnet		YA		Tidak

Winbox

- Download software Winbox
<https://mikrotik.com/download>
- Aplikasi winbox berada pada **folder 5.**
Software MTCNA
- Default IP address (LAN): 192.168.88.1
- User: **admin**
- Password: **(blank)**



Tampilan Awal Winbox



Default Configuration

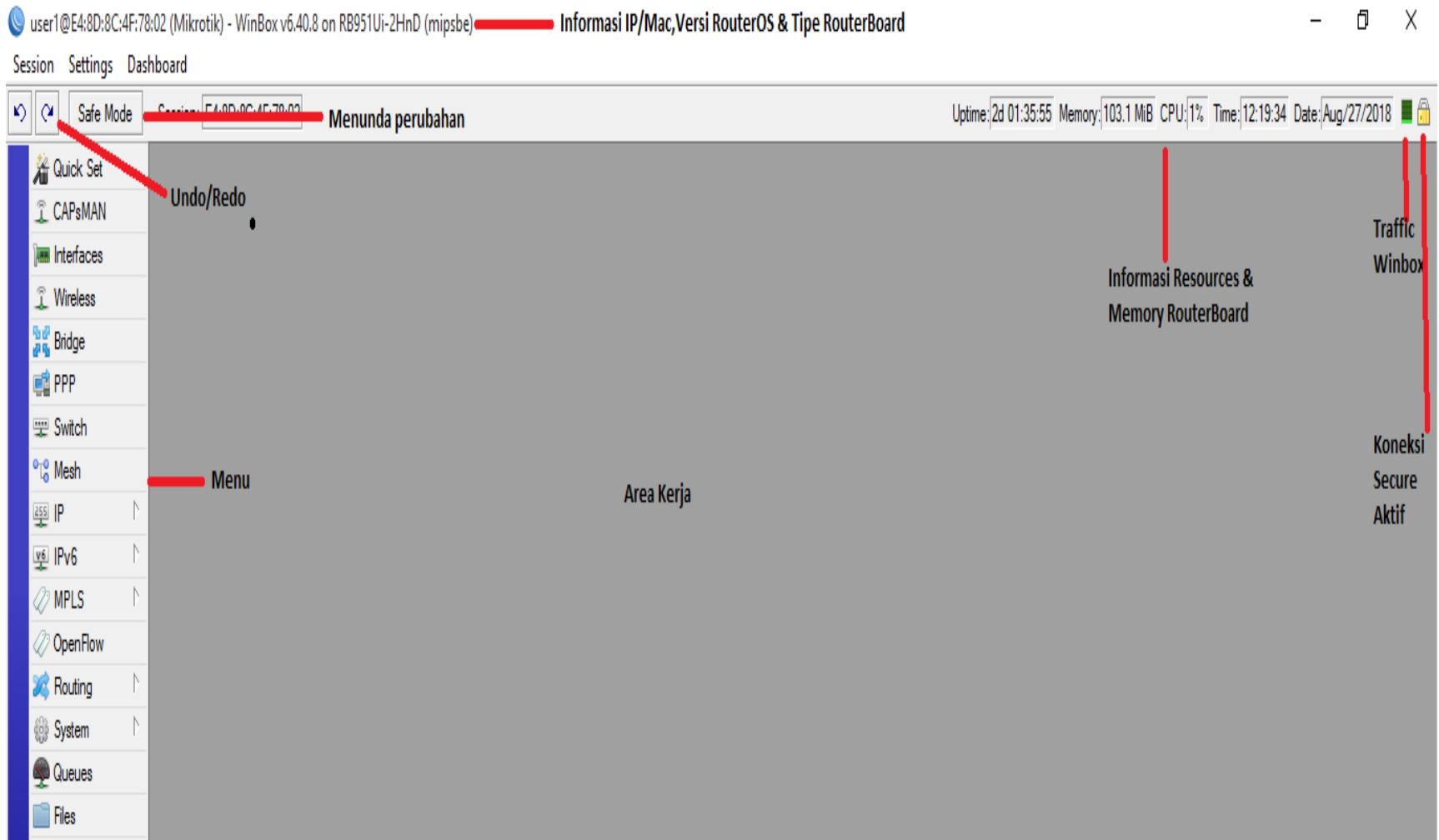
- Default Konfigurasi RouterBoard ethernet **2 sampai 5 mode switch**
- IP default RouterBoard 192.168.88.1

WebFig

- Browser - <http://192.168.88.1>



Menu Setting Mikrotik RouterBoard



Monitoring CPU Load

The screenshot shows the WinBox interface on RouterOS. A red arrow points from the 'Tools' menu in the sidebar to the 'Profile (Running)' window. Another red arrow points from the 'Profile' option in the sidebar to the table in the main window.

RouterOS WinBox

Radius

Tools

- New Terminal
- Make Supoutrif
- Manual
- New WinBox
- Exit

IP Scan

MAC Server

Netwatch

Packet Sniffer

Ping

Ping Speed

Profile

RoMON

SMS

Telnet

Torch

Traceroute

Traffic Generator

Profile (Running)

CPU: all

Name	CPU	Usage
cpu0	7.5	██████
ethemet	0	██
firewall-mgmt	0	██
management	0	██
networking	0	██
profiling	4.5	███████
unclassified	0	██
winbox	0	██
wireless	1.0	███

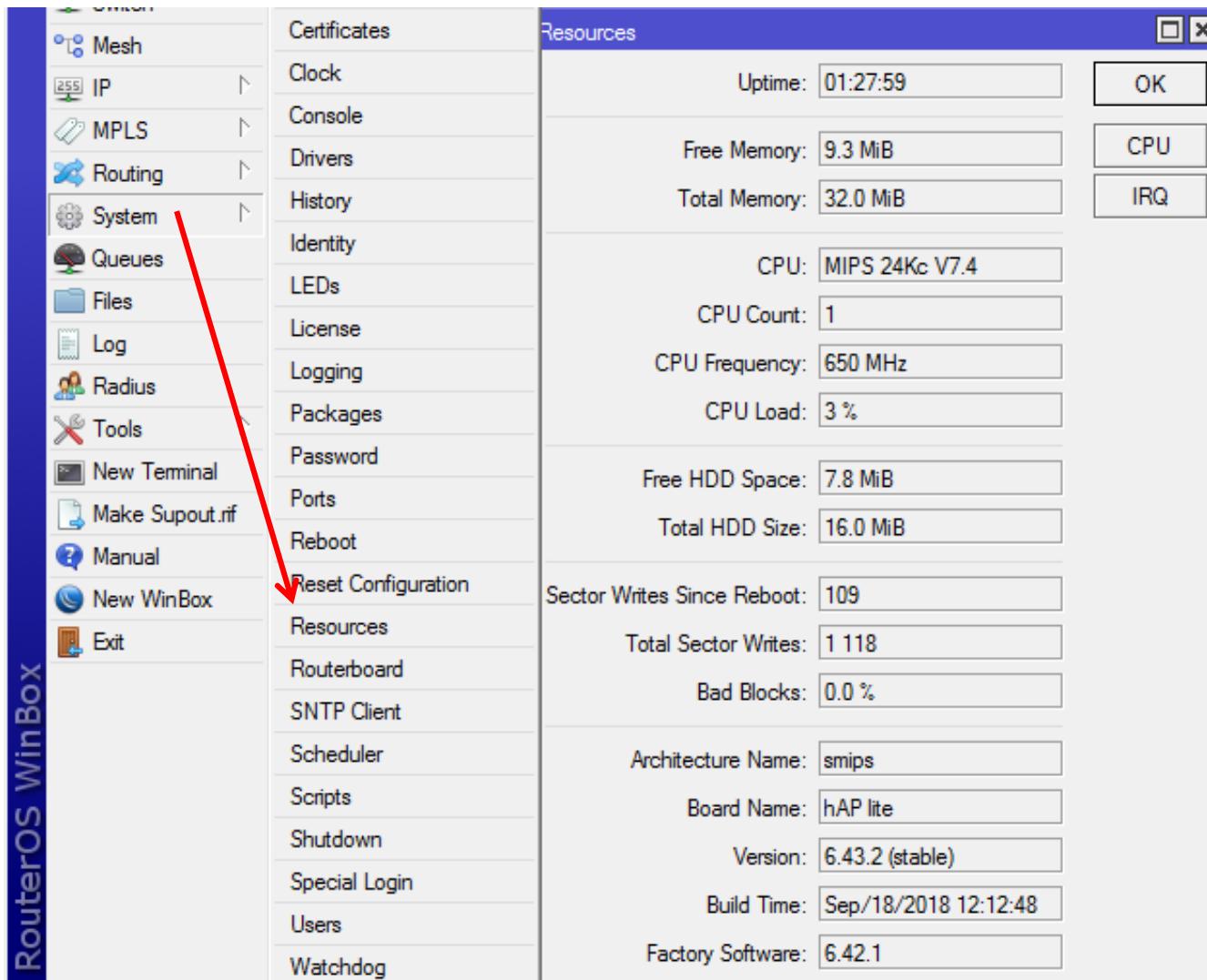
Start

Stop

Close

New Window

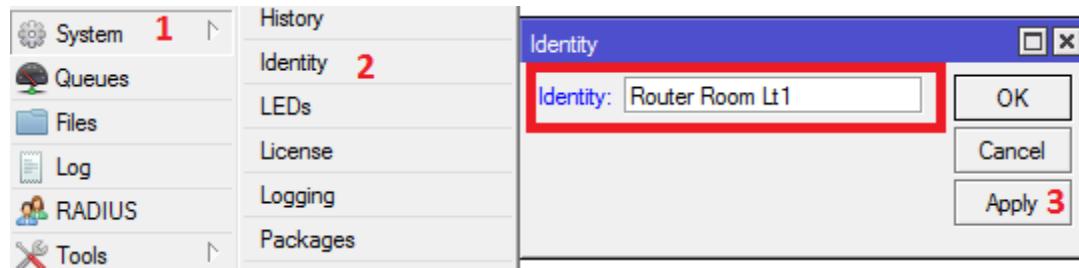
Monitoring Resource Space



Menu Interface

Interface List								
	Name	Type	Actual MTU	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)
R	::: Menuju ke Lantai 1 (Switch)	Ethernet	1500	1598	67.1 kbps	4.6 kbps	7	7
	ether1	Ethernet	1500	1598	0 bps	0 bps	0	0
	ether2	Ethernet	1500	1598	0 bps	0 bps	0	0
	ether3	Ethernet	1500	1598	0 bps	0 bps	0	0
	ether4	Ethernet	1500	1598	0 bps	0 bps	0	0
	ether5	Ethernet	1500	1598	0 bps	0 bps	0	0
	wlan1	Wireless (Atheros AR9...)	1500	1600	0 bps	0 bps	0	0

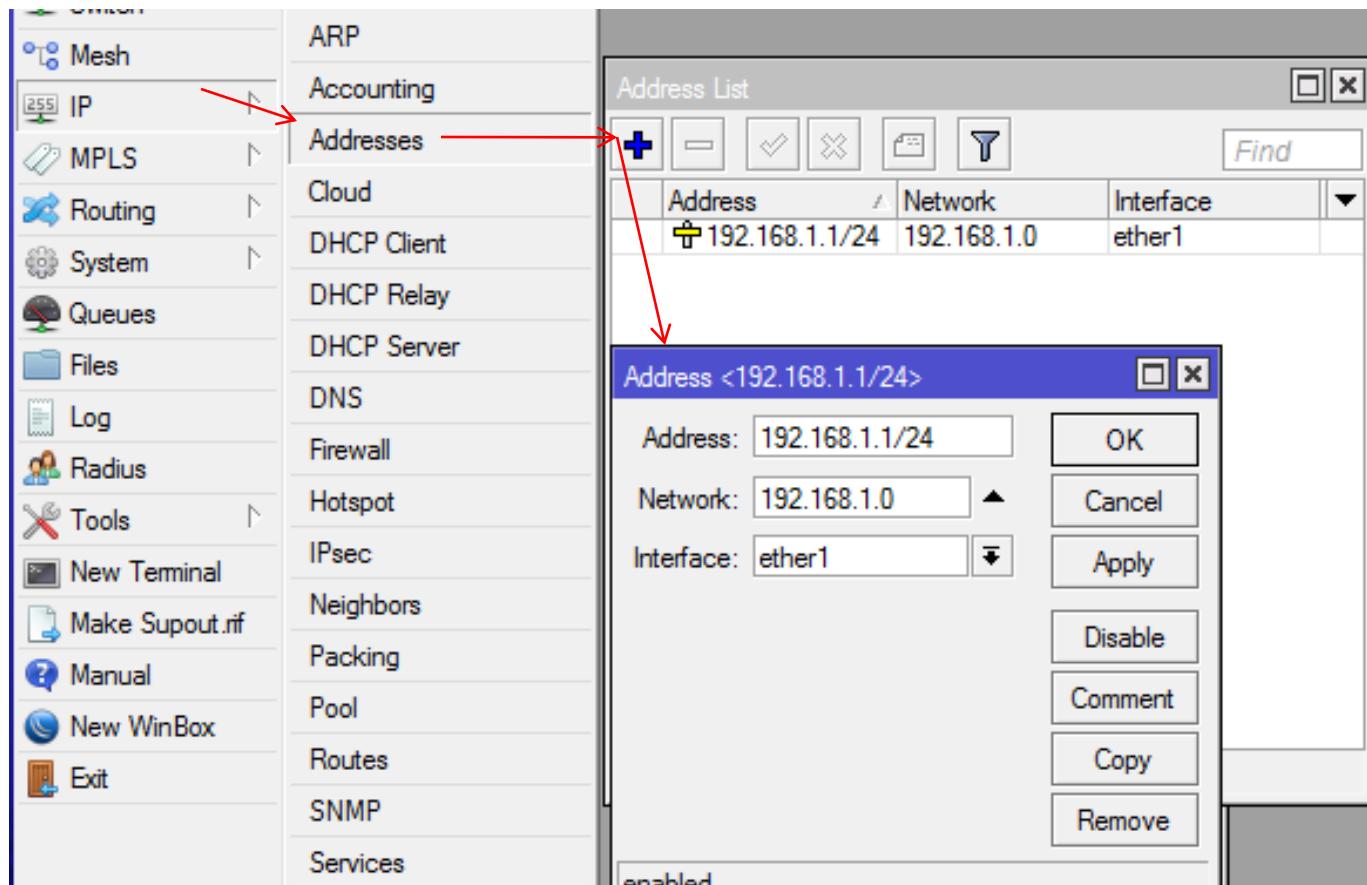
Hostname Perangkat, Log



A screenshot of a log viewer. On the left is a sidebar with icons and labels: Files, Log (1), RADIUS, Tools, New Terminal, MetaROUTER, Partition, Make Supout.nf, Manual, New WinBox, Exit. The 'Log' icon has a red number '1' above it. The main area is titled 'Log' and contains a table of log entries. A red box highlights the entire table area. The log entries are:

Jan/02/1970 00:00:17	memory	system, error	can not install system-6.45.3: it is not made for mips, but for smip
Jan/02/1970 00:00:17	memory	system, info	router rebooted
Jan/02/1970 00:00:27	memory	interface, info	ether1 link up (speed 100M, full duplex)
Jan/02/1970 00:00:44	memory	system, info, account	user admin logged in from 10:BF:48:32:AD:D6 via winbox
Jan/02/1970 00:02:02	memory	system, info, account	user admin logged out from 10:BF:48:32:AD:D6 via winbox
Jan/02/1970 00:06:36	memory	system, info, account	user admin logged in from 10:BF:48:32:AD:D6 via winbox
Jan/02/1970 00:14:10	memory	interface, info	ether1 link down
Jan/02/1970 00:14:12	memory	system, info, account	user admin logged out from 10:BF:48:32:AD:D6 via winbox
Jan/02/1970 02:50:30	memory	interface, info	ether1 link up (speed 100M, full duplex)
Jan/02/1970 03:21:20	memory	system, info, account	user admin logged in from 10:BF:48:32:AD:D6 via winbox

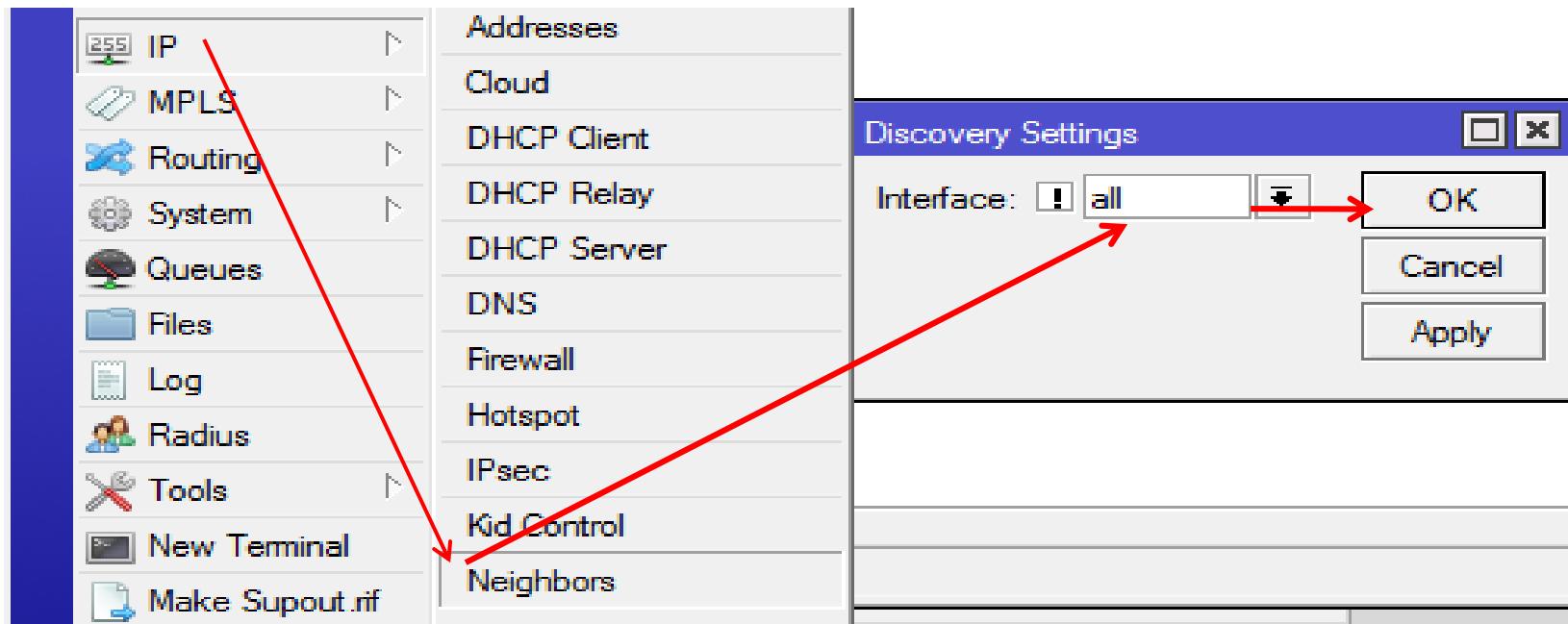
Membuat IP Adressing pada interface



MikroTik Neighbor Discovery Protocol (MNDP)

- MNDP (Mikrotik Neighbour Discovery Protocol merupakan fitur yang digunakan untuk menemukan device yang menggunakan device mikrotik, secara default MNDP aktif pada semua perangkat mikrotik.
- MNDP bekerja pada layer 2
 - bekerja pada semua non-dynamic interface
 - mendistribusikan informasi dasar (ip address, hardware, mac address)
- MNDP bisa berkomunikasi dengan CDP (Cisco Discovery Protocol).
- Disarankan untuk tidak mengaktifkan MNDP ke interface yang mengarah ke jaringan Internet atau public.

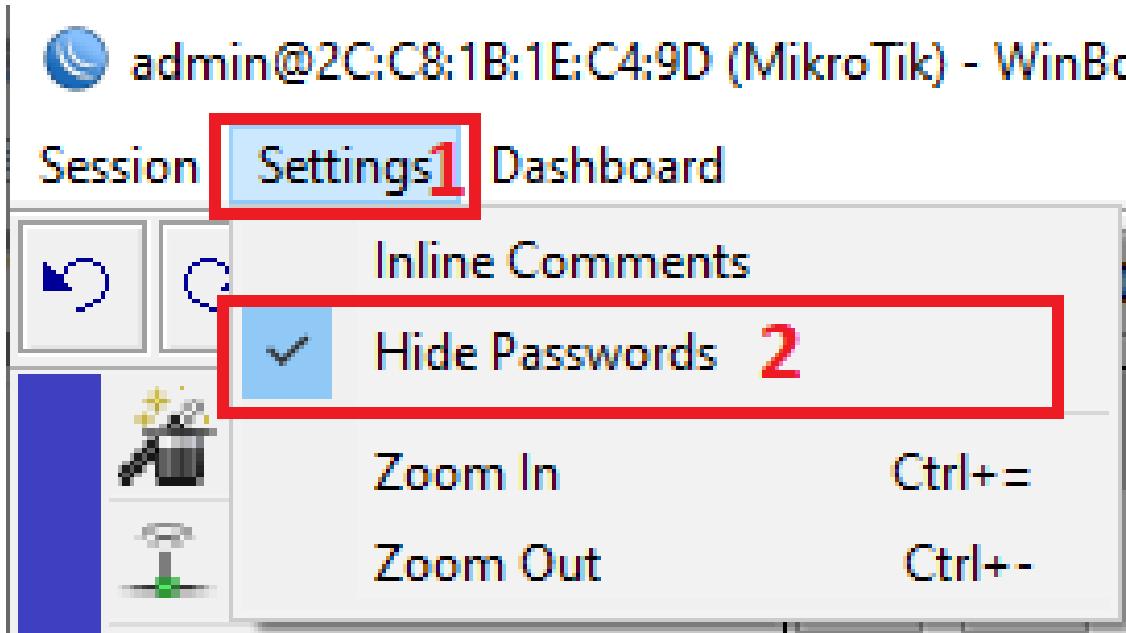
Disable MNDP



Verifikasi exit winbox dan lakukan pencarian mac address dan ip address melalui tombol neighbor

WinBox Tip

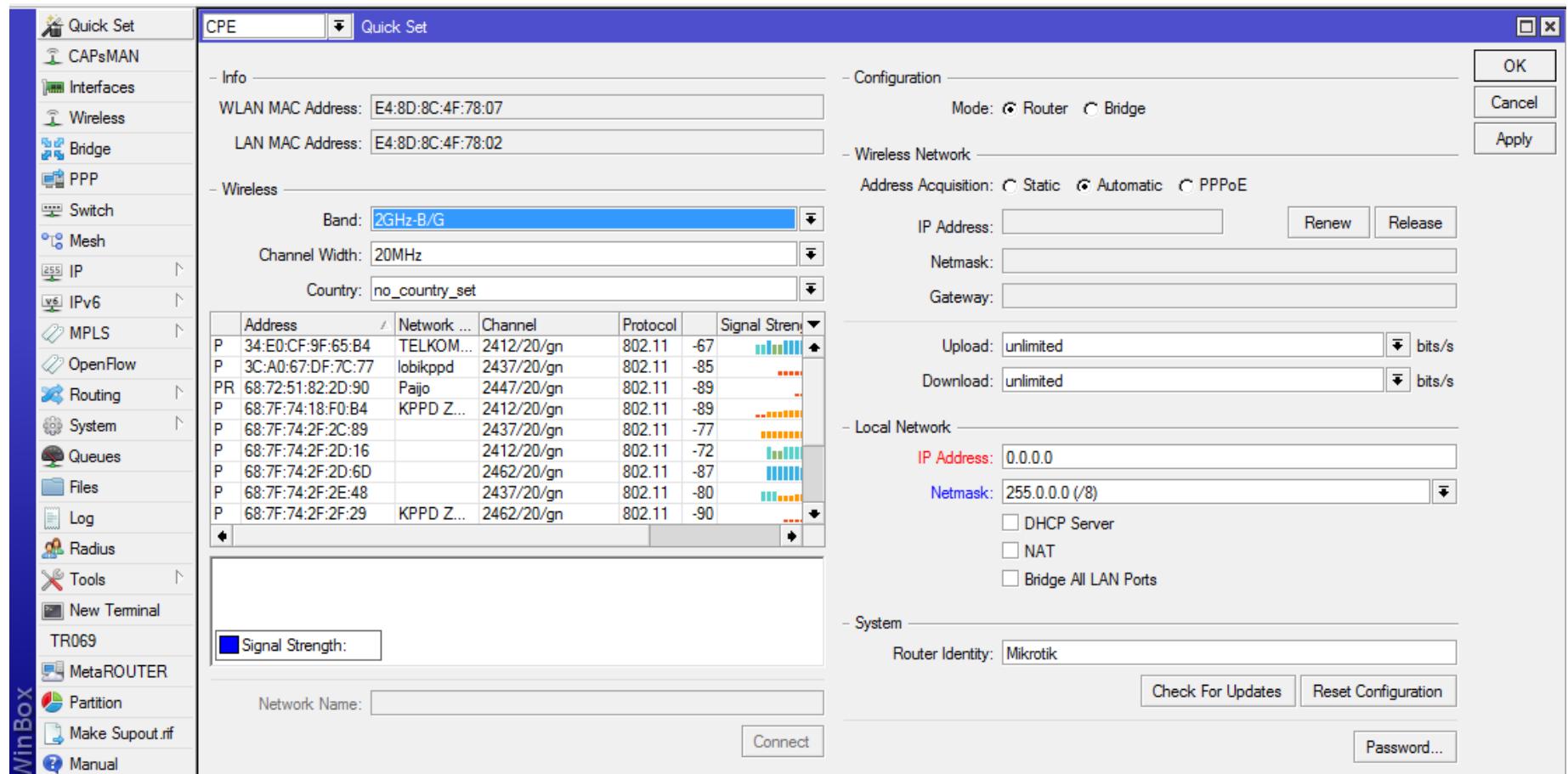
- Untuk melihat password yang disembunyikan dapat dilakukan pada menu settings → Hide Passwords



Quick Set

- Konfigurasi router secara mudah, cepat & hanya dilakukan dalam satu menu di RouterBoard
- Bisa Dilakukan pada aplikasi Winbox dan WebFig

Quick Set



Command Line Interface

- Bisa menggunakan SSH,Telnet, dan New Terminal dalam aplikasi Winbox & WebFig

```
        MMMM      MMMM      KKK          TTTTTTTTTT      KKK
        MMM MMMM MMM III  KKK  KKK  RRRRRR    000000      TTT      III  KKK  KKK
        MMM  MM  MMM III  KKKKKK    RRR  RRR  000  000      TTT      III  KKKKKK
        MMM      MMM III  KKK  KKK  RRRRRR    000  000      TTT      III  KKK  KKK
        MMM      MMM III  KKK  KKK  RRR  RRR  000000      TTT      III  KKK  KKK

MikroTik RouterOS 6.33 (c) 1999-2015      http://www.mikrotik.com/

[?]          Gives the list of available commands
command [?]  Gives help on the command and list of arguments

[Tab]         Completes the command/word. If the input is ambiguous,
              a second [Tab] gives possible options

/
..           Move up to base level
..           Move up one level
/command     Use command at the base level

[admin@mikrotik] > █
```

Command Line Interface

- **<tab>** completes command
- **double <tab>** shows available commands
- **'?'** shows help
- Navigate previous commands with **<↑>, <↓>** buttons

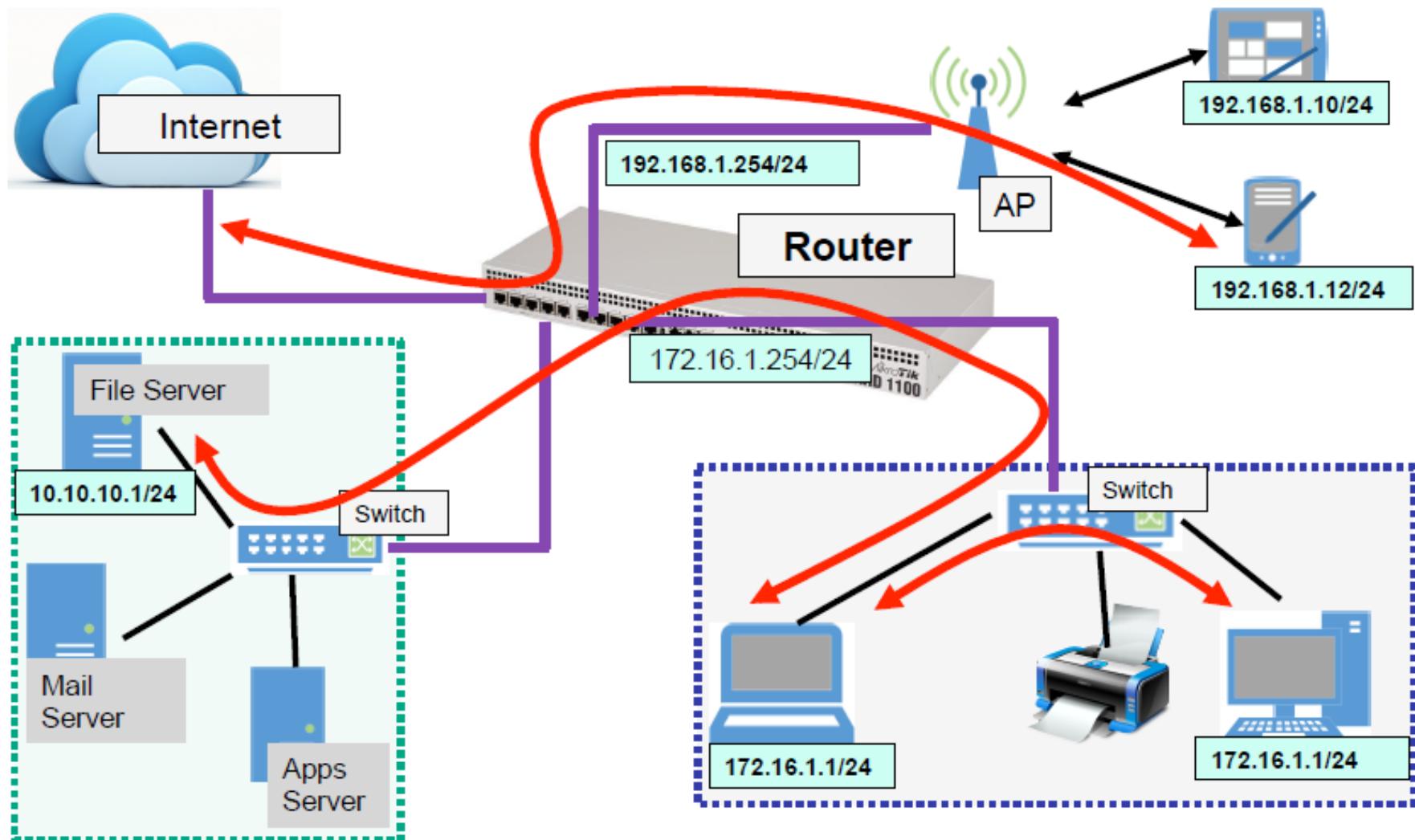
Command Line Interface

- Menggunakan Aplikasi Putty, untuk Telnet/SSH dalam mengakses RouterBoard
- Lakukanlah perintah dasar di RouterBoard, contoh tambah IP address dan seterusnya



Topologi Office

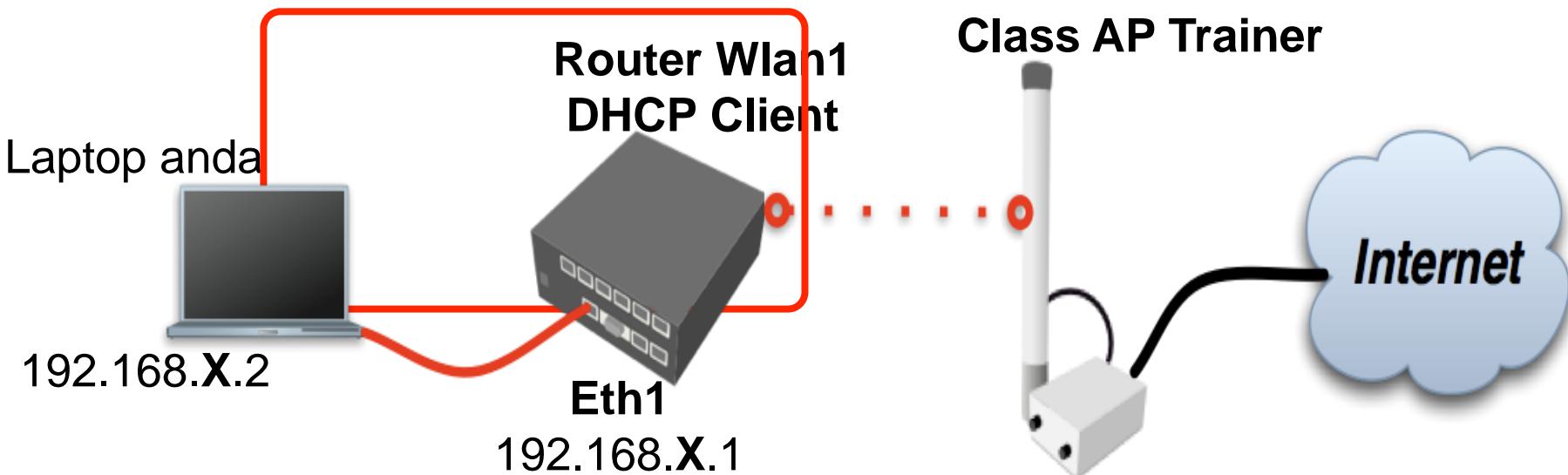
Source : mikrotik.co.id (citraweb)



LAB

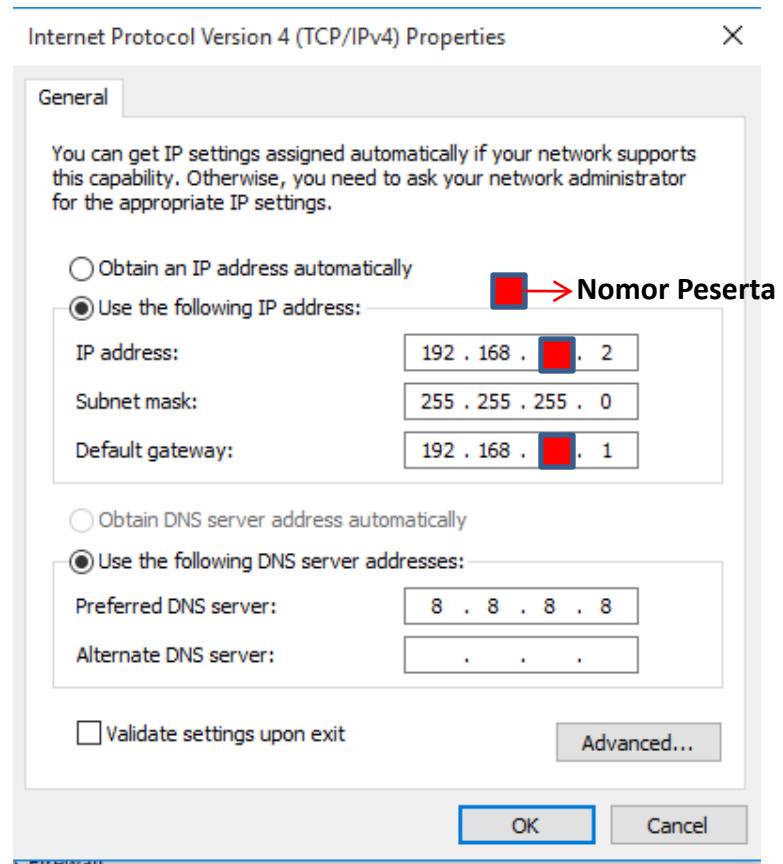
Setting Router dalam Kelas Training

X = Nomor peserta



Setting IP Address Laptop

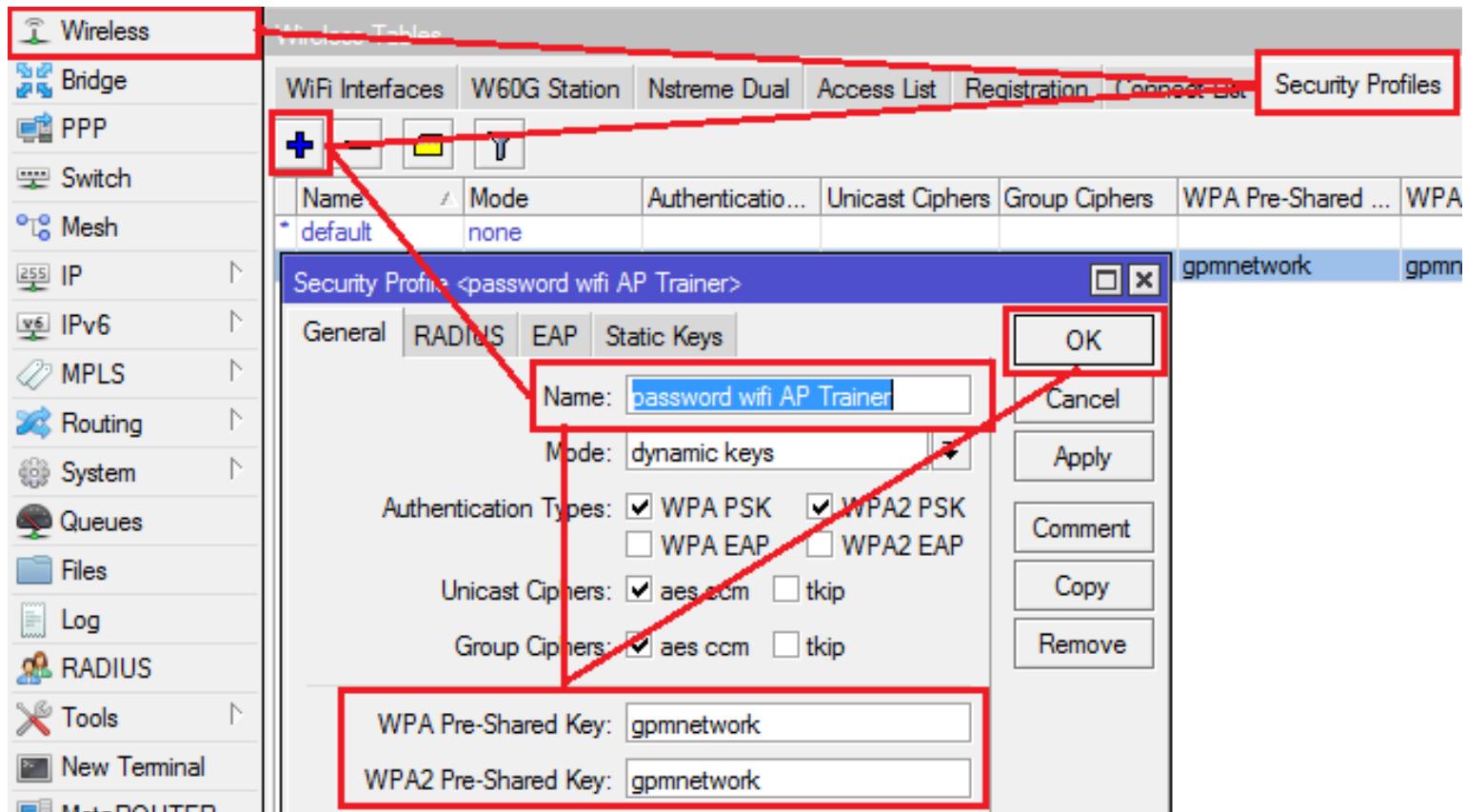
- **IP address :** 192.168.X.2
- **Subnet Mask :** 255.255.255.0 (/24)
- **Gateway :** 192.168.X.1
- **DNS :** 8.8.8.8



LAB

Router – memasukkan Pasword

Set Name and
Pre-Shared Keys



Wireless → Security Profiles

Enable Wireless Interface

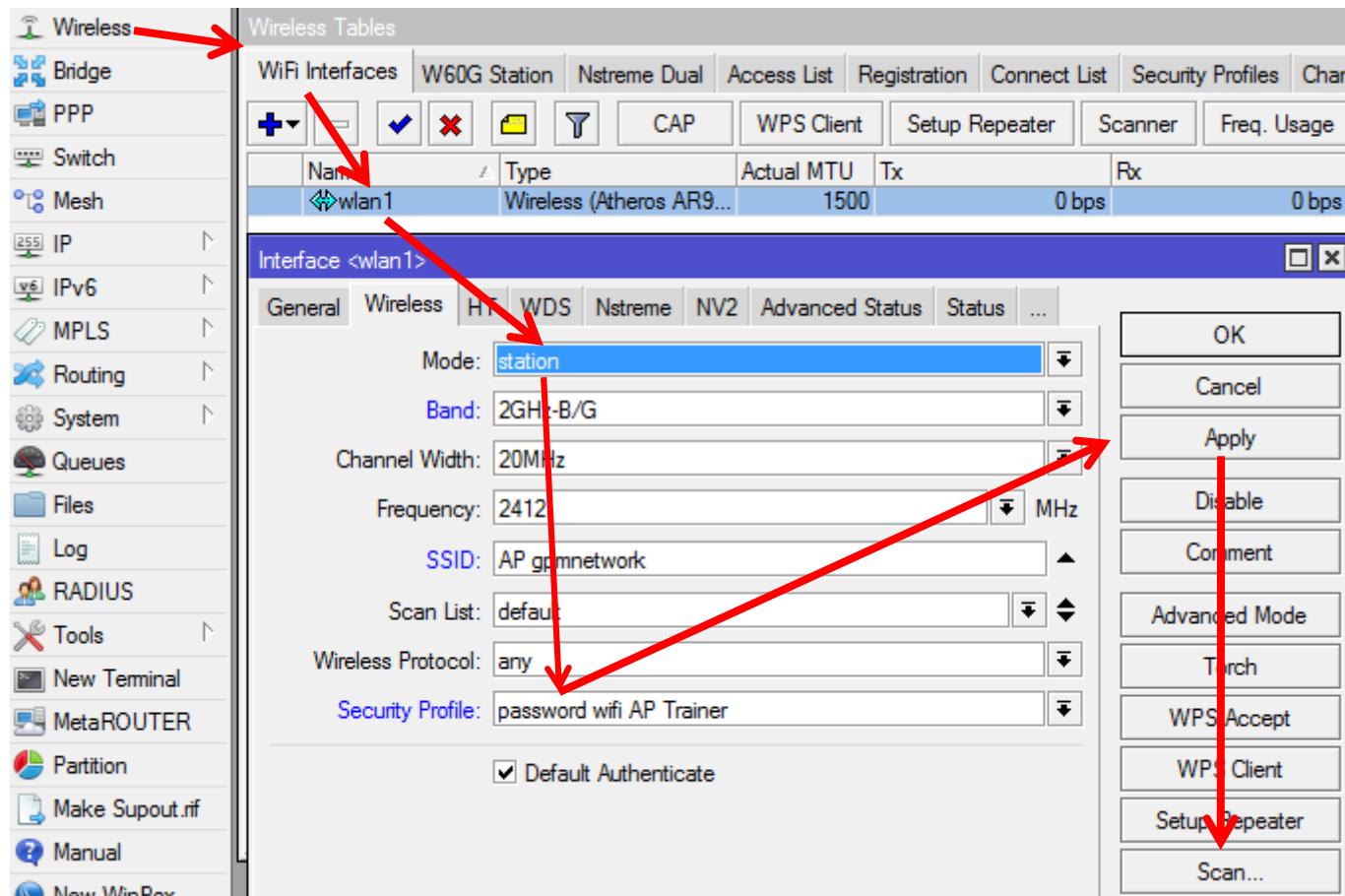
The screenshot shows the Winbox interface for managing network interfaces. The left sidebar has a 'Wireless' icon with a red number '1'. The main window title is 'Wireless Tables'. A red box labeled '2' highlights the 'WiFi Interfaces' tab. Below it, a red box labeled '3' highlights the 'wlan1' interface row in the table. A red box labeled '4' highlights the 'Name' column header in the table header.

	Name	Type	Actual MTU	Tx	Rx	Tx F
X	wlan1	Wireless (Atheros AR9...)	1500	0 bps	0 bps	

Setting RB sebagai wirelles Client

LAB

**Set Mode to
'station', SSID
to 'ClassAP'
and Security
Profile to
'class'**

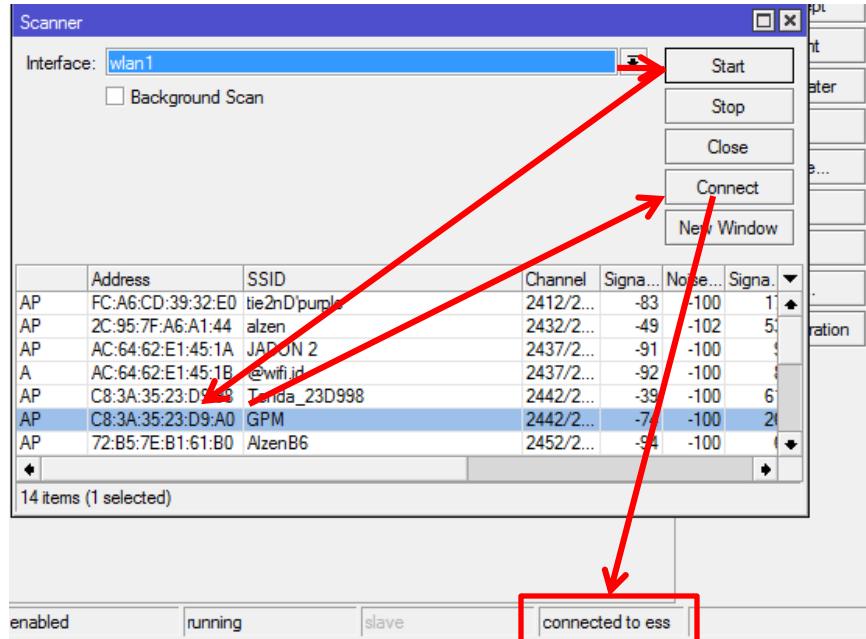


Wireless → Interfaces

Menu Scan adalah tool yang digunakan untuk melihat SSID di sekitar ruangan yang dipakai

LAB

Mengkoneksikan ke AP Trainer



The screenshot shows the Aircrack-NG Wireless Tables interface. On the left, there is a sidebar with icons for "Wireless" (highlighted with a red box), "Bridge", "PPP", "Switch", and "Mesh". The main area has tabs for "WiFi Interfaces", "W60G Station", "Nstreme Dual", "Access List", "Registration" (highlighted with a red box), "Connect List", "Security Profiles", and "Channels". Below the tabs is a search bar with a magnifying glass icon and a "Reset" button. The main table has columns for Radio Name, MAC Address, Interface, Uptime, AP, W..., Last Activit..., Tx/Rx Signal..., Tx Rate, and Rx Rate. A single row is selected, showing "Radio Name: C8:3A:35:23:D9:98", "MAC Address: C8:3A:35:23:D9:98", "Interface: wlan1", "Uptime: 00:06:30", "AP: yes", "W...: no", "Last Activit...: 7.680 -40", "Tx/Rx Signal...: 1Mbps", "Tx Rate: 1Mbps", and "Rx Rate: 1Mbps".

Wireless → Registration

Registration adalah yang digunakan untuk melihat koneksi dan stabilitas point to point wireless

LAB

Meminta IP Address pada AP Trainer

Set DHCP
client to the
WiFi interface

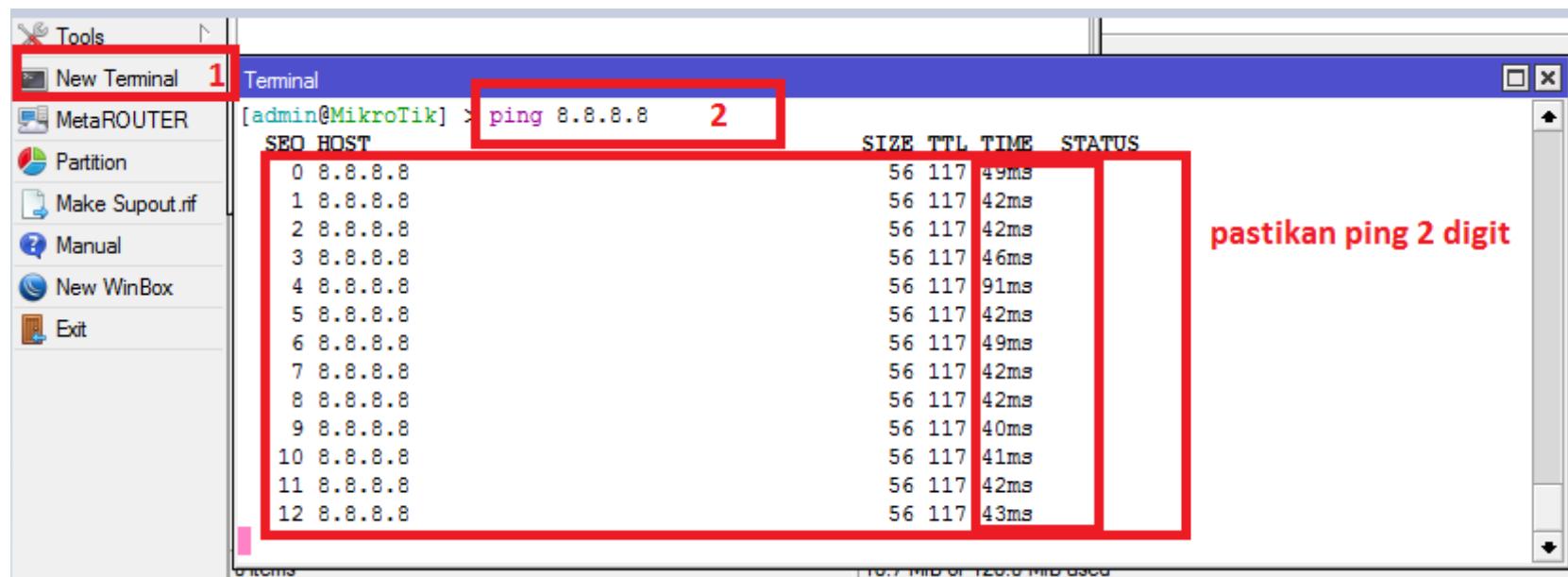
The screenshot shows the AP Trainer configuration interface. On the left, a sidebar lists various network settings: Cloud, DHCP Client, DHCP Relay, DHCP Server, DNS, Firewall, Hotspot, IPsec, Kid Control, Neighbors, Packing, Pool, Routes, and Partition. A red arrow points from the 'IP' icon in the sidebar to the 'DHCP Client' tab in the main window. The main window title is 'DHCP Client'. It has two tabs: 'DHCP Client' (selected) and 'DHCP Client Options'. Below the tabs are several buttons: a blue '+' button, a minus button, a checkmark button, a delete button, a file icon, a filter icon, a 'Release' button, and a 'Renew' button. A search bar with a magnifying glass icon and a 'F' button are also present. A table titled 'DHCP Client <wlan1>' shows the configuration for the wlan1 interface. The table has columns: Interface, Use P..., Add D..., IP Address, Expires After, and Status. A single row is shown: wlan1, yes, yes, 192.168.7.2/24, 3d 00:07:57 bound. A red box highlights this row. Below the table is a dialog box titled 'DHCP Client <wlan1>'. It has three tabs: 'DHCP' (selected), 'Advanced', and 'Status'. The 'DHCP' tab contains fields: 'Interface' set to 'wlan1', and checkboxes for 'Use Peer DNS' and 'Use Peer NTP', both of which are checked. There is also a dropdown menu for 'Add Default Route' with 'yes' selected. To the right of the dialog are buttons: 'OK', 'Cancel', 'Apply', 'Disable', and 'Comment'. A red box highlights the 'DHCP' tab of the dialog.

IP → DHCP Client & IP → Address

The screenshot shows the AP Trainer configuration interface. On the left, a sidebar lists: Switch, Mesh, IP (selected), IPv6, and MPLS. A red arrow points from the 'IP' icon in the sidebar to the 'Address List' tab in the main window. The main window title is 'Address List'. It has a toolbar with a blue '+' button, a minus button, a checkmark button, a delete button, a file icon, a filter icon, and a 'Find' button. A table titled 'Address List' shows the assigned address. The table has columns: Address, Network, and Interface. One row is highlighted with a red box: D, 192.168.7.2/24, 192.168.7.0, wlan1.

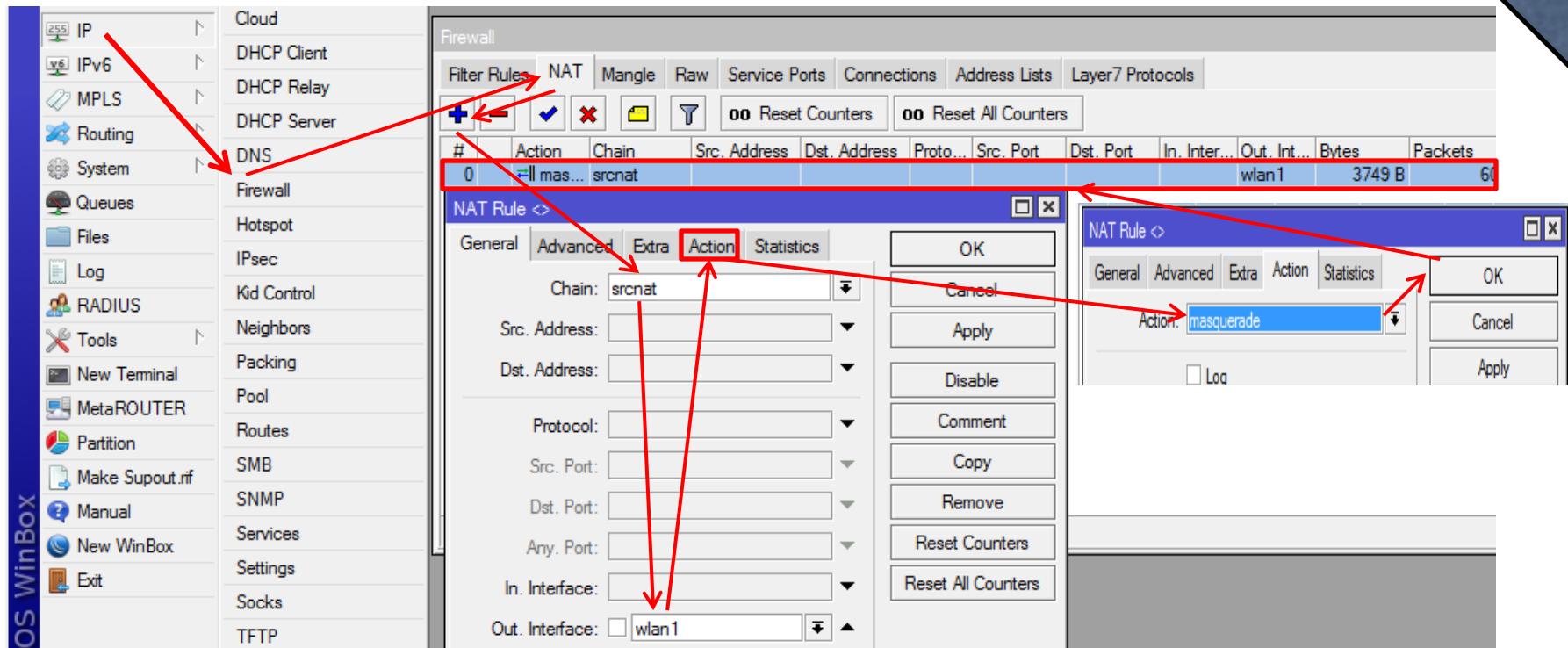
LAB

Memastikan konektifitas internet dari RB ke internet



LAB

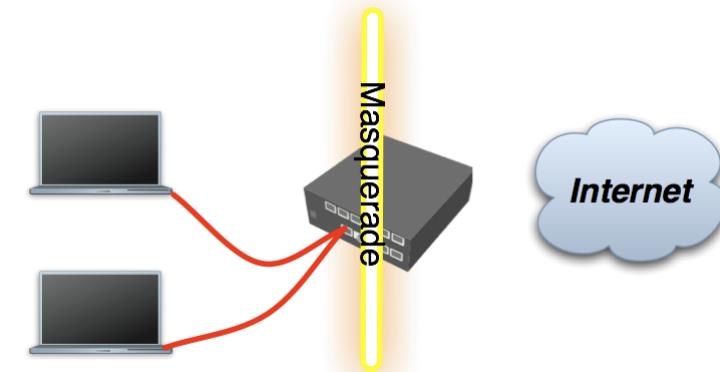
Setting NAT



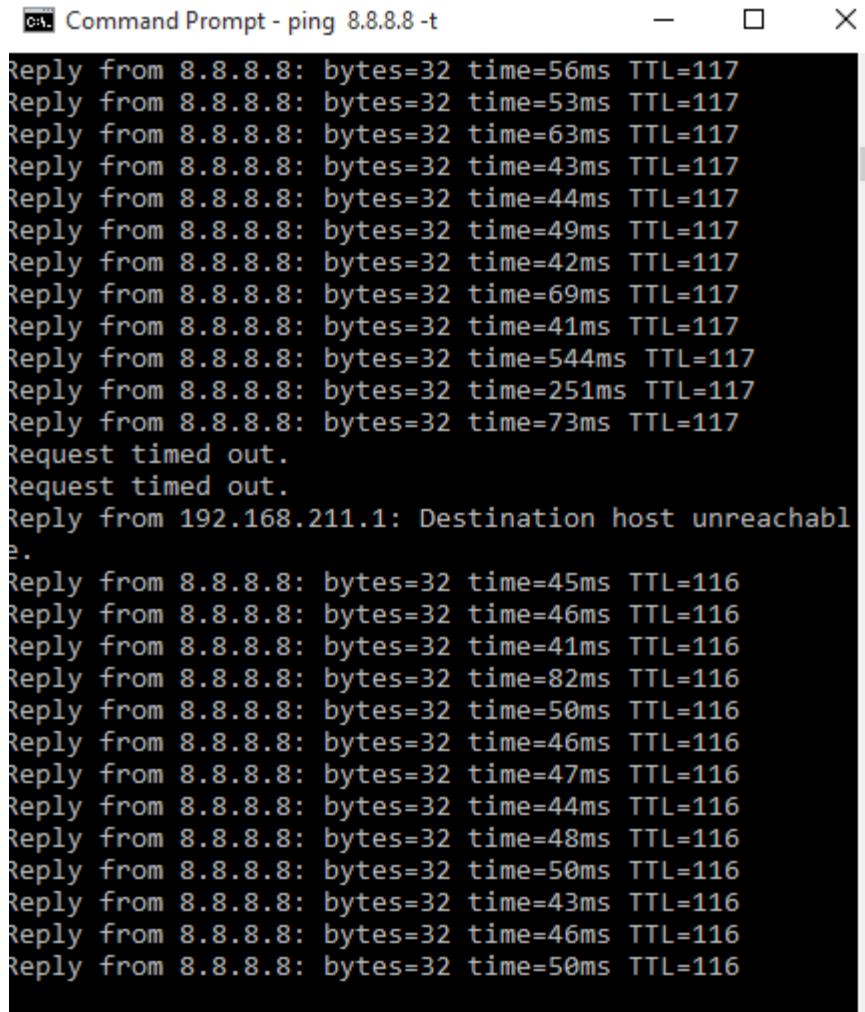
IP → Firewall → NAT
Konfigurasi masquerade pada Wlan Interface

Private & Public Space

- Dilakukan Masquerade agar jaringan private dapat diketahui oleh jaringan public atau internet
- Termasuk IP Private adalah
- 10.0.0.0 – 10.255.255.255
- 172.16.0.0 – 172.31.255.255
- 192.168.0.0 – 192.168.255.255



Disable koneksi wireless di Laptop, pastikan akses internet via LAN Ethernet

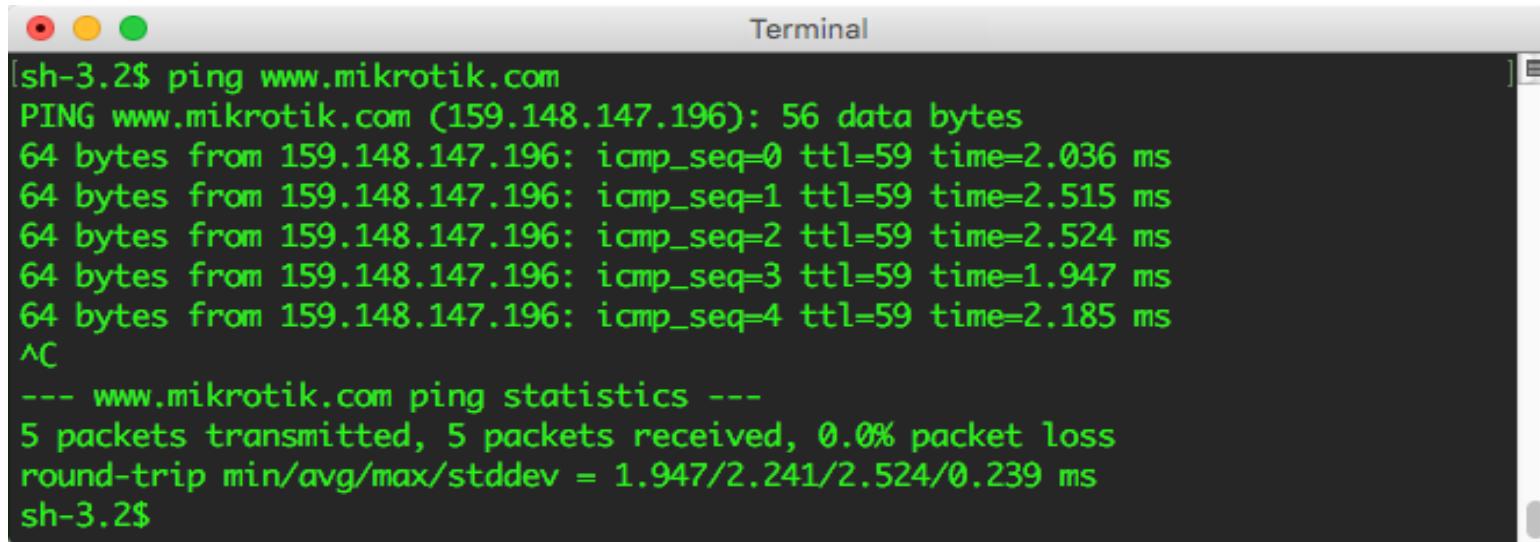


A screenshot of a Windows Command Prompt window titled "Command Prompt - ping 8.8.8.8 -t". The window displays the results of a ping command to the IP address 8.8.8.8. The output shows multiple replies from the target host, with varying round-trip times (RTTs) and TTL values. The window has standard minimize, maximize, and close buttons at the top right. A vertical scroll bar is visible on the right side of the window.

```
Reply from 8.8.8.8: bytes=32 time=56ms TTL=117
Reply from 8.8.8.8: bytes=32 time=53ms TTL=117
Reply from 8.8.8.8: bytes=32 time=63ms TTL=117
Reply from 8.8.8.8: bytes=32 time=43ms TTL=117
Reply from 8.8.8.8: bytes=32 time=44ms TTL=117
Reply from 8.8.8.8: bytes=32 time=49ms TTL=117
Reply from 8.8.8.8: bytes=32 time=42ms TTL=117
Reply from 8.8.8.8: bytes=32 time=69ms TTL=117
Reply from 8.8.8.8: bytes=32 time=41ms TTL=117
Reply from 8.8.8.8: bytes=32 time=544ms TTL=117
Reply from 8.8.8.8: bytes=32 time=251ms TTL=117
Reply from 8.8.8.8: bytes=32 time=73ms TTL=117
Request timed out.
Request timed out.
Reply from 192.168.211.1: Destination host unreachable.
Reply from 8.8.8.8: bytes=32 time=45ms TTL=116
Reply from 8.8.8.8: bytes=32 time=46ms TTL=116
Reply from 8.8.8.8: bytes=32 time=41ms TTL=116
Reply from 8.8.8.8: bytes=32 time=82ms TTL=116
Reply from 8.8.8.8: bytes=32 time=50ms TTL=116
Reply from 8.8.8.8: bytes=32 time=46ms TTL=116
Reply from 8.8.8.8: bytes=32 time=47ms TTL=116
Reply from 8.8.8.8: bytes=32 time=44ms TTL=116
Reply from 8.8.8.8: bytes=32 time=48ms TTL=116
Reply from 8.8.8.8: bytes=32 time=50ms TTL=116
Reply from 8.8.8.8: bytes=32 time=43ms TTL=116
Reply from 8.8.8.8: bytes=32 time=46ms TTL=116
Reply from 8.8.8.8: bytes=32 time=50ms TTL=116
```

Cek Koneksi

- Lakukan ping atau traceroute untuk windows pc ke webpage mikrotik.com pada menu **new terminal**



```
[sh-3.2$ ping www.mikrotik.com
PING www.mikrotik.com (159.148.147.196): 56 data bytes
64 bytes from 159.148.147.196: icmp_seq=0 ttl=59 time=2.036 ms
64 bytes from 159.148.147.196: icmp_seq=1 ttl=59 time=2.515 ms
64 bytes from 159.148.147.196: icmp_seq=2 ttl=59 time=2.524 ms
64 bytes from 159.148.147.196: icmp_seq=3 ttl=59 time=1.947 ms
64 bytes from 159.148.147.196: icmp_seq=4 ttl=59 time=2.185 ms
^C
--- www.mikrotik.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 1.947/2.241/2.524/0.239 ms
sh-3.2$
```

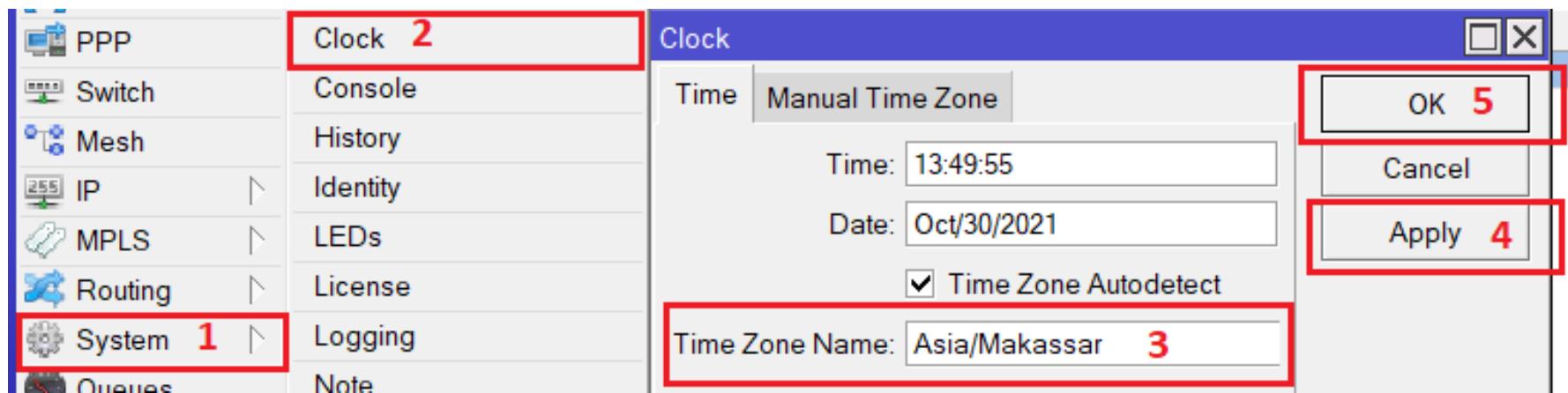
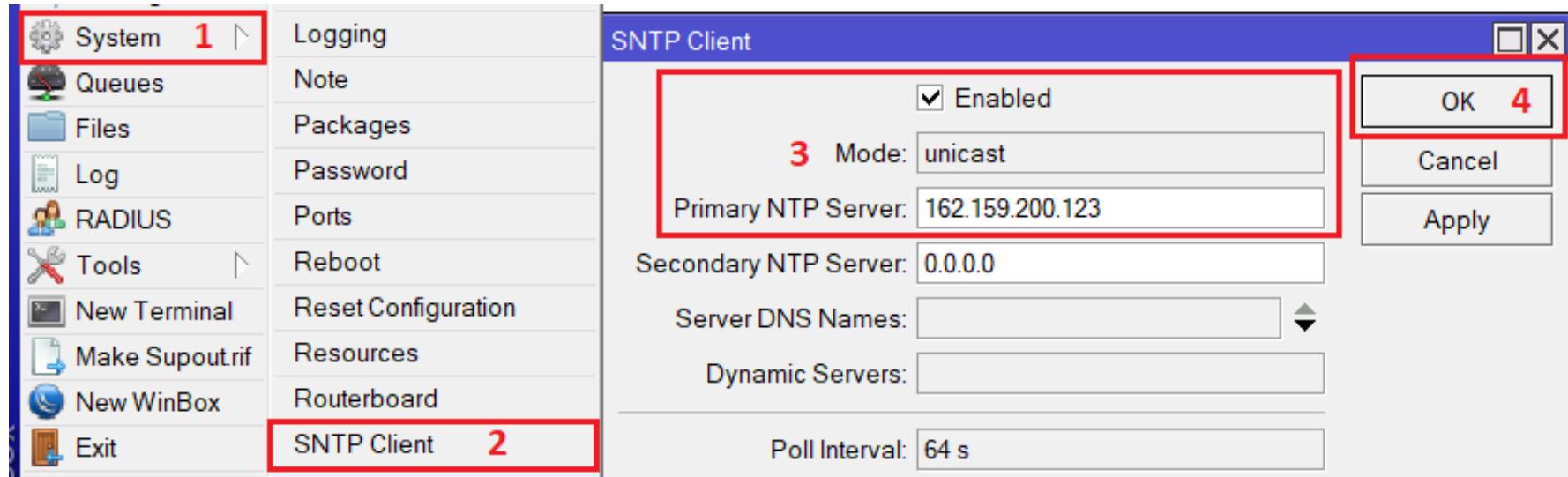
Troubleshooting

- Router tidak bisa ping AP ?
- Laptop tidak bisa ping Router ?
- Masquerade tidak berhasil ?

Network Time Protocol

- NTP berfungsi untuk menyeragamkan waktu dalam sebuah perangkat jaringan
- Router memerlukan NTP untuk mendapatkan waktu yang benar, karena tidak semua routerboard mempunyai hardware BIOS untuk menyimpan waktu
- Digunakan oleh semua RouterBOARD
- TIDAK memerlukan paket NTP untuk menggunakan sebagai ntp client .
- NTP menggunakan protocol **UDP no 123**

Setting NTP Client & Clock



Konfigurasi Backup

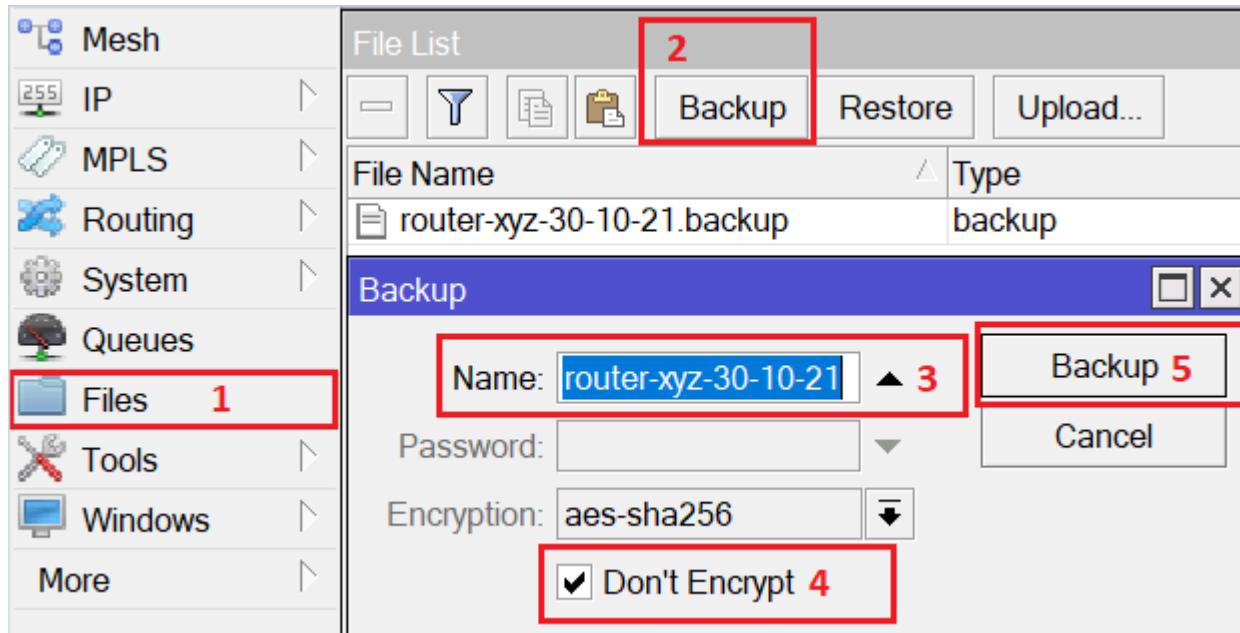
- Ada 2 type backup di mikrotik RouterOS
- **Backup (.backup)** file – digunakan untuk restore konfigurasi di router yang sama
- **Export (.rsc)** file – memindahkan file konfigurasi ke router yan berbeda

Konfigurasi Backup (.backup)

- File extensi .backup bisa created & restore di menu file winbox
- File .backup terbinary, secara default terenkripsi dengan user password
- .backup file mengembalikan semua konfigurasi

Konfigurasi Backup (.backup)

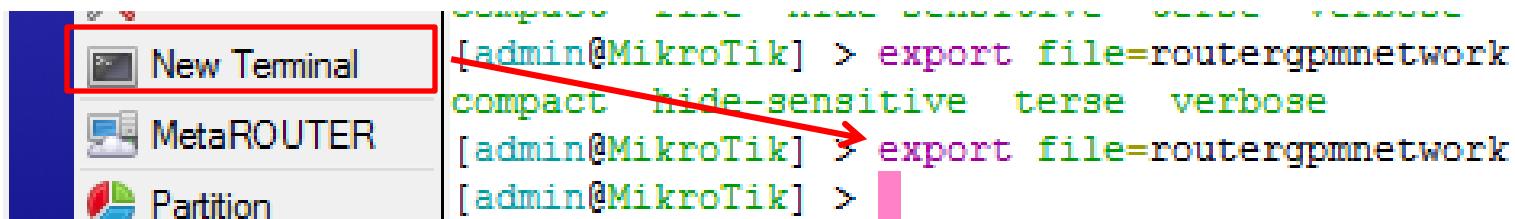
- Bisa menginputkan username & password
- Identitas router & tanggal pada saat backup akan secara otomatis menjadi nama file backup, jika tidak di ganti



Konfigurasi Backup (.rsc)

- Export (.rsc) file berupa script, konfigurasi dapat di backup & direstore
- Plain Text file (editable, bisa di edit di notepad)
- Export/backup file hanya bisa dilakukan pada menu new terminal di winbox dengan command CLI
- Restore konfigurasi menggunakan import
- RouterOS users & password tidak dapat dibackup

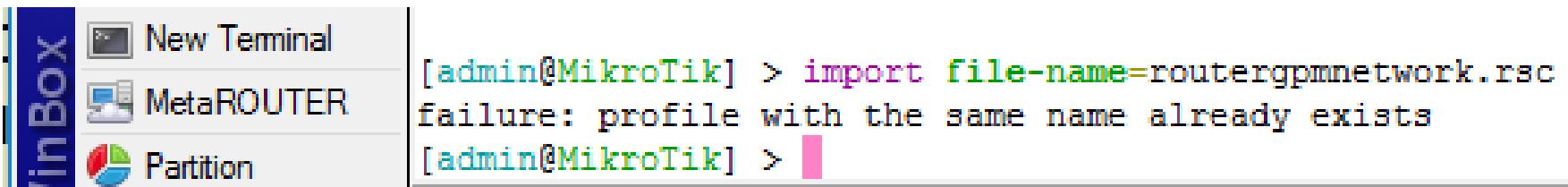
Konfigurasi Backup & restore (.rsc)



A screenshot of a terminal window titled 'New Terminal'. The window shows a command-line interface with the following text:

```
[admin@MikroTik] > export file=routergpmnetwork  
compact hide-sensitive terse verbose
```

The 'New Terminal' option in the sidebar is highlighted with a red box.



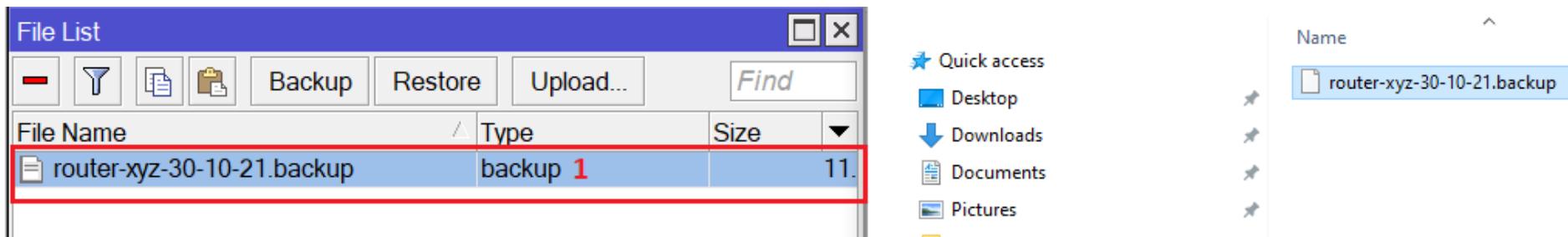
A screenshot of a terminal window titled 'inBox'. The window shows a command-line interface with the following text:

```
[admin@MikroTik] > import file-name=routergpmnetwork.rsc  
failure: profile with the same name already exists
```

Configuration Backup & Restore

- Lakukan Backup pada RouterBoard anda .Backup & .rsc
- .backup pada menu files, download ke laptop menggunakan drag & drop ke laptop dari menu files di winbox
- Backup file .rsc menggunakan CLI di new terminal winbox

Backup Konfigurasi ke laptop

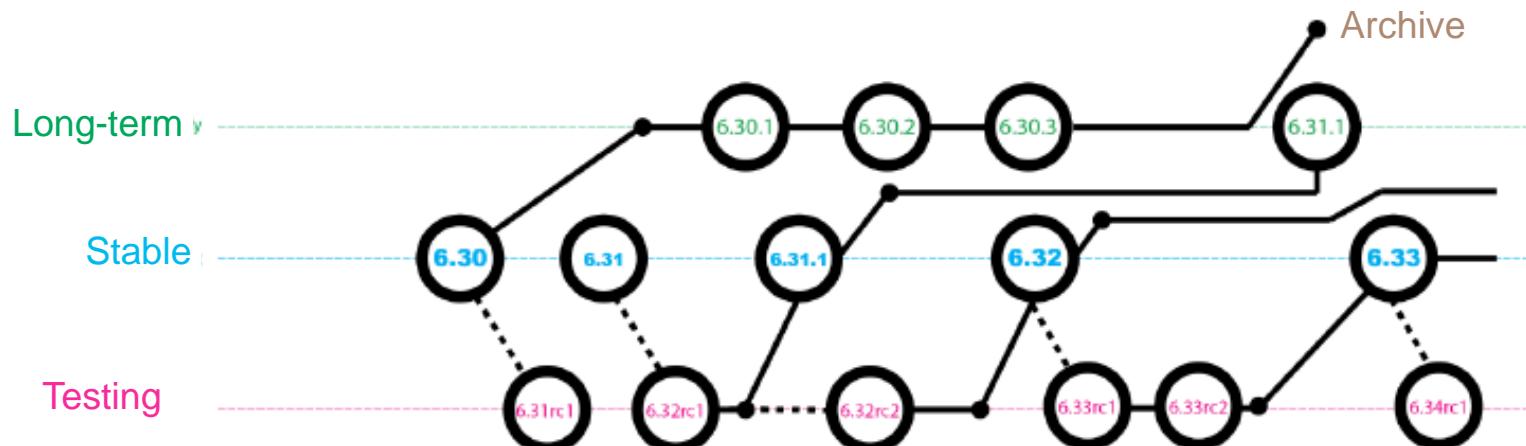


Upgrade & Downgrade RouterOS

- Usahakan selalu upgrade versi terbaru, untuk fix bugs, new feature dll.
- Downgrade dilakukan apabila hardware kurang mendukung terhadap versi baru atau terdapat bug pada versi aktifnya.
- Upgrade paket harus memperhatikan aturan level dan lisensi yang berlaku.
- Upgrade dan downgrade juga harus memperhatikan kompatibilitas terhadap jenis arsitektur hardware

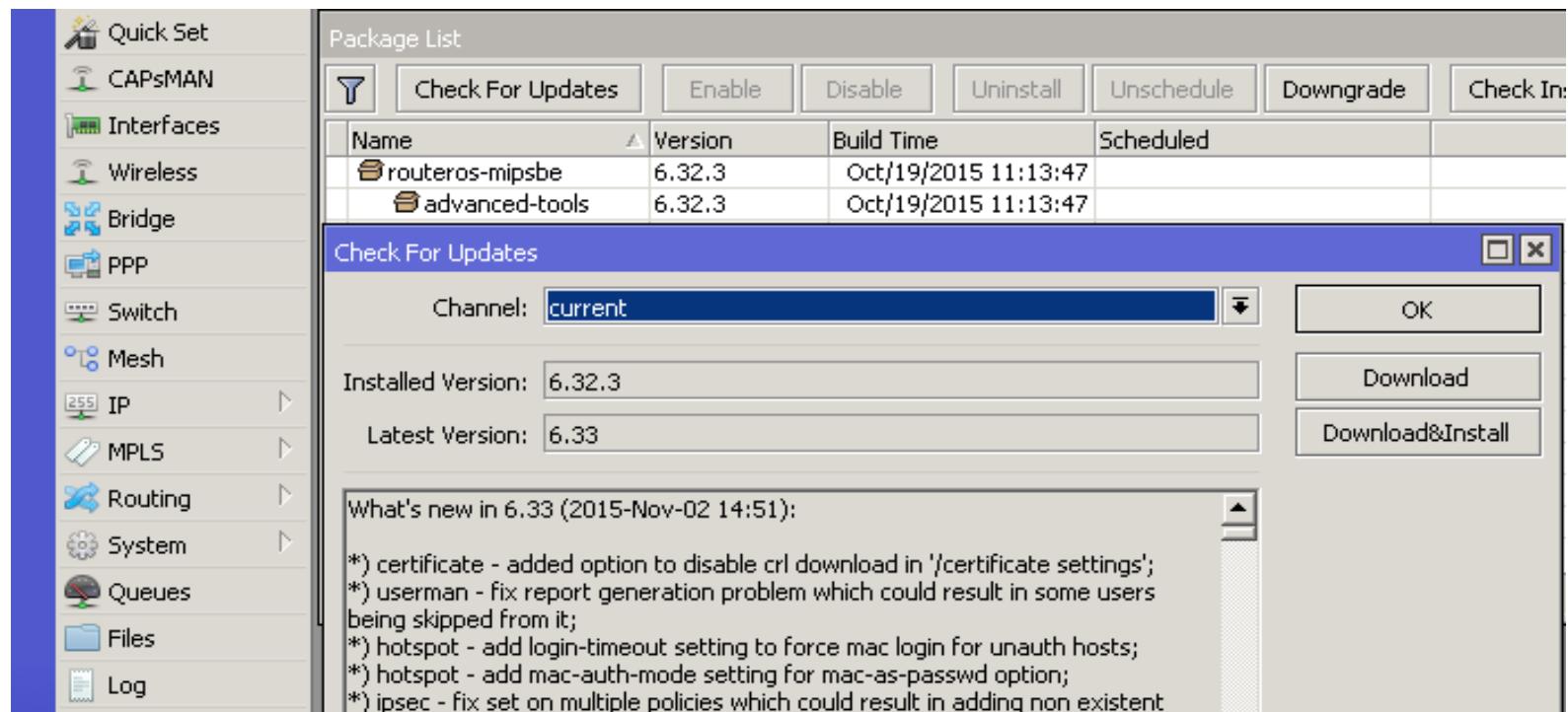
RouterOS Releases

- **Long-term** - fixes, no new features
- **Stable** - same fixes + new features
- **Testing** - consider as a ‘beta version’
- Development -



Upgrade RouterOS

- Cara termudah Upgrade



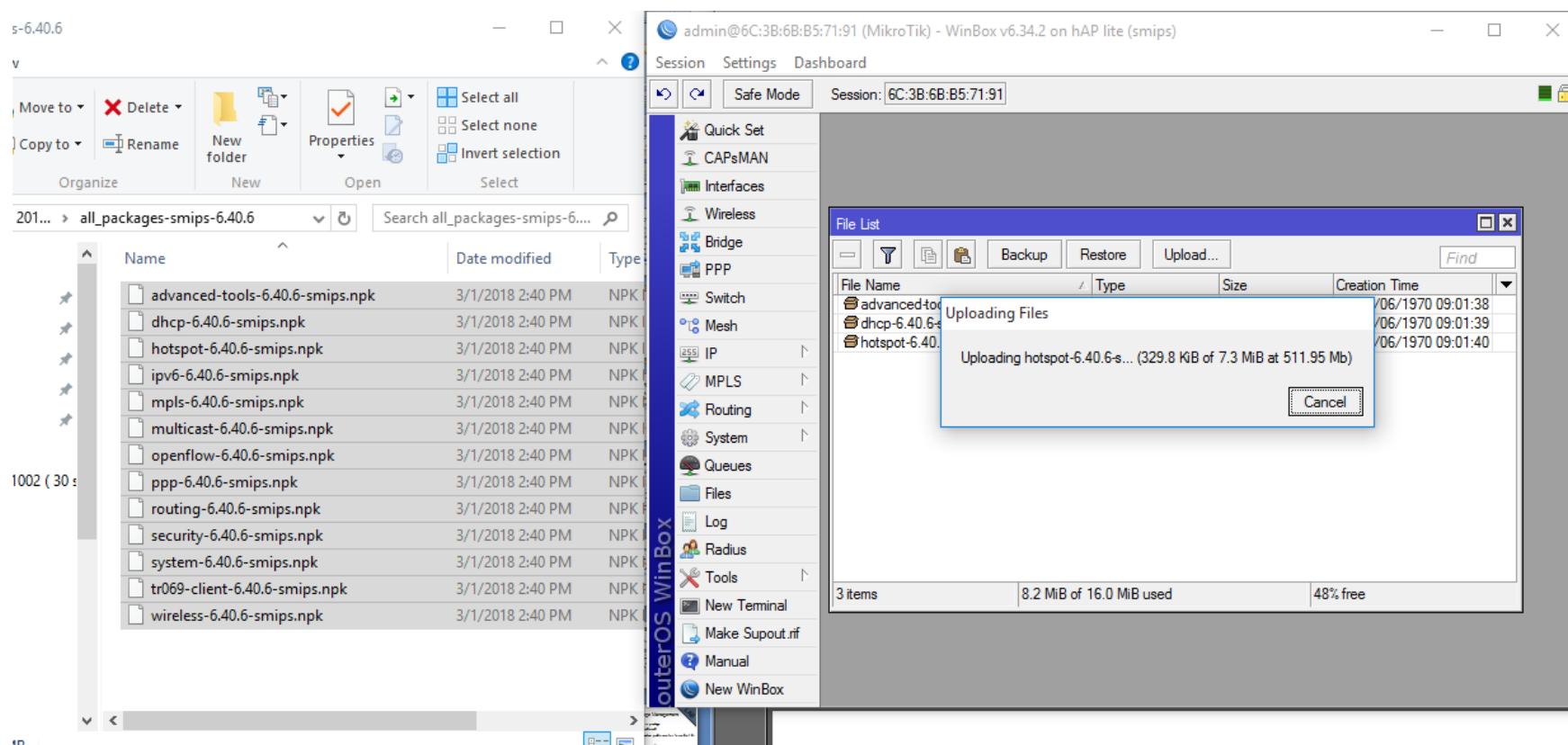
System → Packages → Check For Updates

Upgrade RouterOS

- Upgrade bisa dilakukan dengan drag & drop file .npk yang telah di download ke dalam winbox. Drag ke menu /Files
- Bisa juga dilakukan upload file .npk melalui WEbFig files menu,FTP,sFTP
- Download RouterOS terbaru di
<https://mikrotik.com/download>
- Setelah RouterOS di upload, lakukan Reboot

LAB

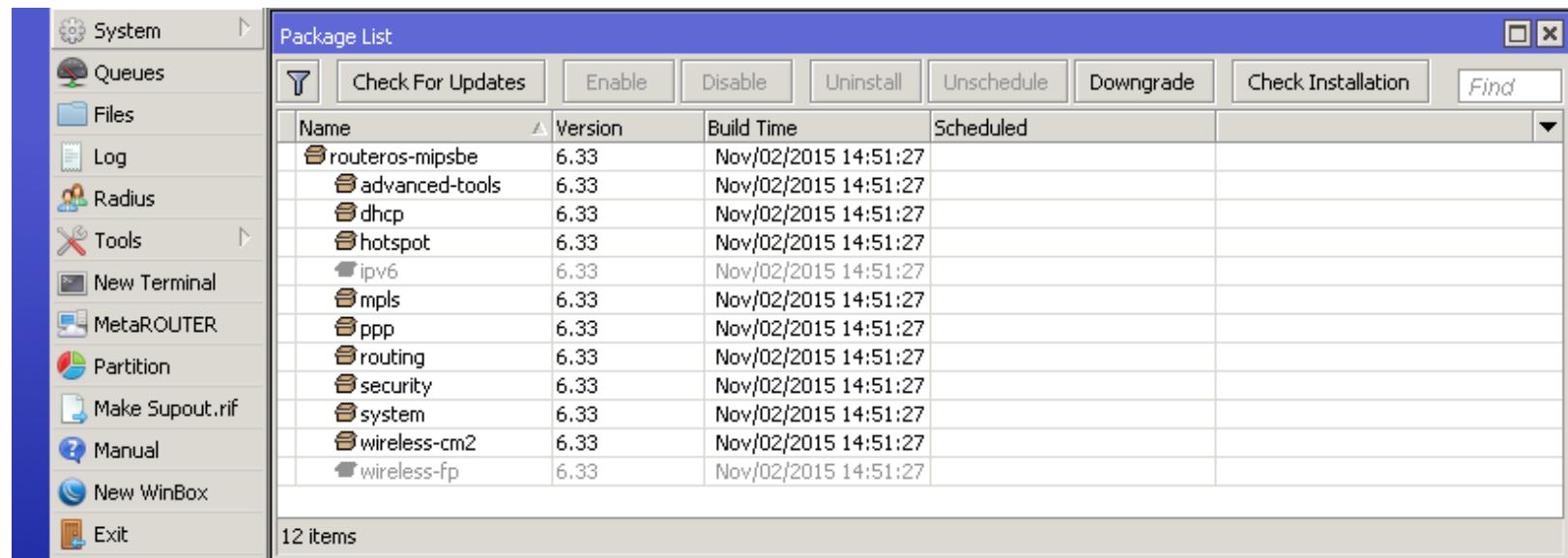
Mengupload paket



System → Files → Reboot

RouterOS Package Management

- Fitur RouterOS package dapat diaktifkan atau dinonaktifkan dengan cara enable/disable



System → Packages

RouterOS Packages

Package	Functionality
advanced-tools	Netwatch, wake-on-LAN
dhcp	DHCP client and server
hotspot	HotSpot captive portal server
ipv6	IPv6 support
ppp	PPP, PPTP, L2TP, PPPoE clients and servers
routing	Dynamic routing: RIP, BGP, OSPF
security	Secure WinBox, SSH, IPsec
system	Basic features: static routing, firewall, bridging, etc.
wireless	802.11 a/b/g/n/ac support, CAPsMAN v2

- For more info see [packages wiki page](#)

Paket dan Fungsi Paket

Package	Features
<code>advanced-tools (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	Advanced ping tools (flood-ping, ping-speed), Netwatch, ip-scan, SMS tool, Wake-on-LAN
<code>calea (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	Data gathering tool for specific use due to "Communications Assistance for Law Enforcement Act" in USA
<code>dhcp (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	Dynamic Host Control Protocol client and server
<code>gps (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	Global Positioning System devices support
<code>hotspot (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	<code>HotSpot</code> captive portal server for user management
<code>ipv6 (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	IPv6 addressing support
<code>lte (mipsbe)</code>	Required package only for SXT LTE (RBSXTLTE3-7), which contains drivers for the built-in LTE interface.
<code>mpls (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	Multi Protocol Labels Switching support
<code>multicast (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	Protocol Independent Multicast - Sparse Mode; Internet Group Managing Protocol - Proxy
<code>ntp (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	Network protocol server, also includes simplistic client. NTP client is also built into the system package and functions well without this package installed.
<code>openflow (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	Enables OpenFlow support
<code>ppp (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	MIPPP client, PPP, PPTP, L2TP, PPPoE, ISDN PPP clients and servers
<code>routerboard (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	accessing and managing RouterBOARD. RouterBOARD specific imformation.
<code>routing (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	dynamic routing protocols like RIP, BGP, OSPF and routing utilities like BFD, filters for routes.
<code>security (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	IPSEC, SSH, Secure WinBox (necessary for Winbox versions up to v3.14)
<code>system (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	basic router features like static routing, ip addresses, sNTP, telnet, API, queues, firewall, web proxy, DNS cache, TFTP, IP pool, SNMP, packet sniffer, e-mail send tool, graphing, bandwidth-test, torch, EoIP, IPiP, bridging, VLAN, VRRP etc.). Also, for RouterBOARD platform - MetaROUTER Virtualization
<code>tr069 (mipsbe, ppc, x86, mmips, arm)</code>	<code>TR069 Client</code> package
<code>ups (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	APC ups management interface
<code>user-manager (mipsle, mipsbe, ppc, x86, mmips, arm)</code>	MikroTik User Manager server for controlling Hotspot and other service users.
<code>wireless (mipsle, mipsbe, ppc, x86, mmips, arm, smips)</code>	wireless interface support. Sometimes sub-types are released, for example <code>wireless-fp</code> introduced FastPath support, <code>wireless-cm2</code> introduced CAPsMAN v2 and <code>wireless-rep</code> introduced Repeater mode. These packages are occasionally released separately, before the new features get merged into the main wireless package.
<code>arlan (x86)</code>	legacy Aironet Arlan support
<code>isdn (x86)</code>	ISDN modem support
<code>lcd (x86)</code>	LCD panel support for serial/parallel port devices. Not needed for RouterBOARD LCD panels.
<code>radiolan (x86)</code>	RadioLan cards support
<code>synchronous (x86)</code>	FarSync support
<code>xen (discontinued x86)</code>	XEN Virtualization
<code>kvm (x86)</code>	KVM Virtualization

<https://wiki.mikrotik.com/wiki/Manual:System/Packages>

Package Management

- Disable wireless package
- Reboot RouterBoard
- Lakukan Pengamatan pada router tersebut di interface list
- Enable wireless packages
- Reboot kembali RouterBoard anda

Package Management

- Lakukan download extra package file di mikrotik.com yang sesuai dengan arsitektur CPU RouterBoard anda
- Pastikan versi RouterOS package pada RouterBoard anda sama dengan versi package yang akan ditambahkan pada router
- Drag & install file package baru tersebut ke RouterBoard anda. Dengan cara upload ke RouterBoard anda.

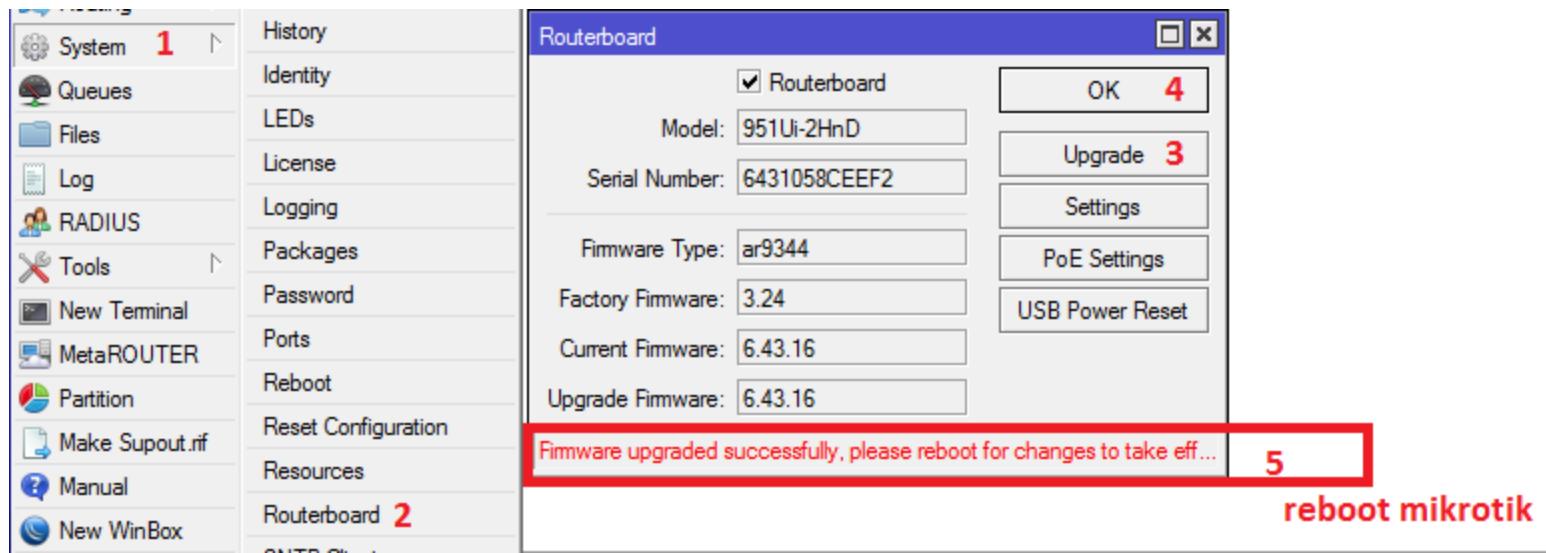
Downgrade RouterOS

- Downgrade RouterOS jika RouterOS yang teristall saat ini terdapat bugs pada RouterBoard
- **System > Packages menu > Downgrade**

RouterBOOT

- Firmware responsible for starting RouterOS on RouterBOARD devices
- Two boot loaders on RouterBOARD - **main** and **backup**
- Main can be updated
- Backup loader can be loaded if needed

RouterBOOT



Router Identity

- Opsi Optional untuk memberikan informasi identitas nama RouterBoard agar mudah dikenali

The screenshot shows the WinBox interface with the following components:

- Identity Dialog:** A window titled "Identity" with a text input field containing "XY_YourName". It has buttons for "OK", "Cancel", and "Apply".
- Terminal:** A terminal window showing the command line:
 - / Move up to base level
 - .. Move up one level
 - /command Use command at the base level
 - [admin@XY_YourName] > [highlighted]
- Status Bar:** Shows "admin@192.168.88.1 (XY_YourName) - WinBox v6.33 on hAP (mipsbe)"
- System → Identity Page:** A table with the following data:

MAC Address	IP Address	Identity	Version	Board
D4:CA:6D:E2:65:90	192.168.88.1	XY_YourName	6.33 (stable)	RB951Ui-2nD

System → Identity

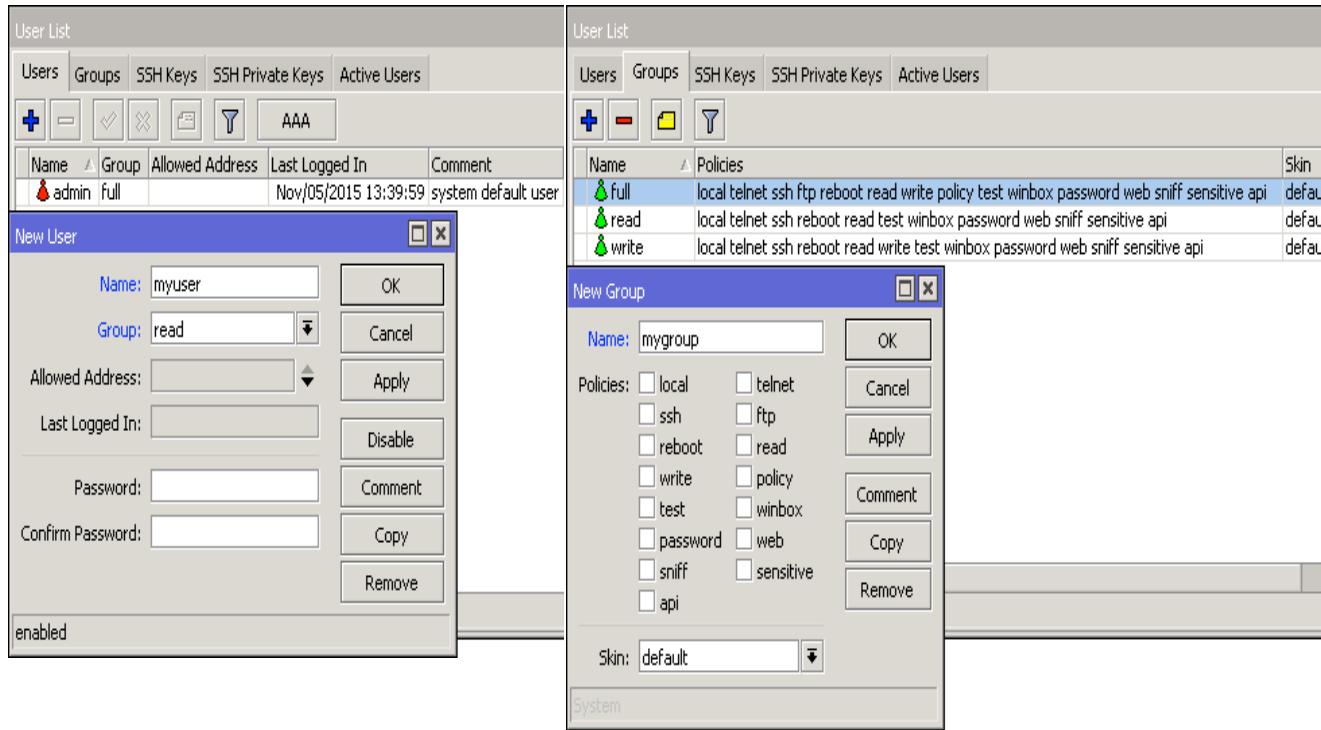
Router Identity

- Ubahlah nama identitas RouterBoard anda
- Contoh : Rb_(nama anda)

Manajemen Login

- Default user admin, group **full**
- Additional groups - **read and write**
- Group bisa di custom sesuai dengan kebutuhan

RouterOS Users



The image shows two screenshots of the RouterOS User List interface. The left screenshot displays the 'User List' window with tabs for 'Users', 'Groups', 'SSH Keys', 'SSH Private Keys', and 'Active Users'. It includes a toolbar with icons for adding (+), deleting (-), and filtering (magnifying glass). Below the toolbar is a table with columns: Name, Group, Allowed Address, Last Logged In, and Comment. A row for 'admin' is shown with 'full' in the Group column and 'Nov/05/2015 13:39:59 system default user' in the Comment column. A 'New User' dialog box is overlaid on the bottom-left, containing fields for 'Name' (myuser), 'Group' (read), 'Allowed Address' (dropdown), 'Last Logged In' (dropdown), 'Password' (text input), 'Confirm Password' (text input), and 'Comment' (button). Buttons for 'OK', 'Cancel', 'Apply', 'Disable', 'Comment', 'Copy', and 'Remove' are also present. The right screenshot shows the same 'User List' window with a table of users and policies. The table has columns: Name, Policies, and Skin. Three rows are listed: 'full' (local, telnet, ssh, ftp, reboot, read, write, policy, test, winbox, password, web, sniff, sensitive, api, skin: default), 'read' (local, telnet, ssh, reboot, read, test, winbox, password, web, sniff, sensitive, api, skin: default), and 'write' (local, telnet, ssh, reboot, read, write, test, winbox, password, web, sniff, sensitive, api, skin: default).

System → Users

RouterOS Users

- Tambahkan user baru pada RouterBoard dengan group **full access**
- Ubahlah group user admin menjadi group **read access**
- Login ke RouterBoard dengan user admin
- Lakukan perubahan atau Penambahan konfigurasi pada router. Apakah berhasil ?

Manajemen Services

- Tambahan untuk Firewall/Security bagi RouterBoard
- Untuk mengakses RouterOS, terdapat beberapa service yang disediakan

The screenshot shows the RouterOS IP Services configuration interface. On the left, there is a navigation menu with items like IP, MPLS, Routing, System, Queues, Files, Tools, Windows, and More. The 'IP' item is highlighted with a red box and the number '1'. Below the menu, there is a list of services: Packing, Pool, Routes, SNMP, Services, Settings, Socks, TFTP, and Traffic Flow. The 'Services' item is highlighted with a red box and the number '2'. To the right, there is a detailed 'IP Service List' window. It has a header row with columns for Name and Port. The list contains the following entries:

Name	Port
api	8728
api-ssl	8729
ftp	21
ssh	22
telnet	23
winbox	8291
www	80
www-ssl	443

Manajemen Services

The screenshot shows a network management interface with a sidebar and a main content area.

Left Sidebar:

- IP **1** (highlighted with a red box)
- MPLS
- Routing
- System
- Queues
- Files
- Tools
- Windows
- More

Main Content Area:

Packing

Pool

Routes

SNMP

Services **2** (highlighted with a red box)

Settings

Socks

TFTP

Traffic Flow

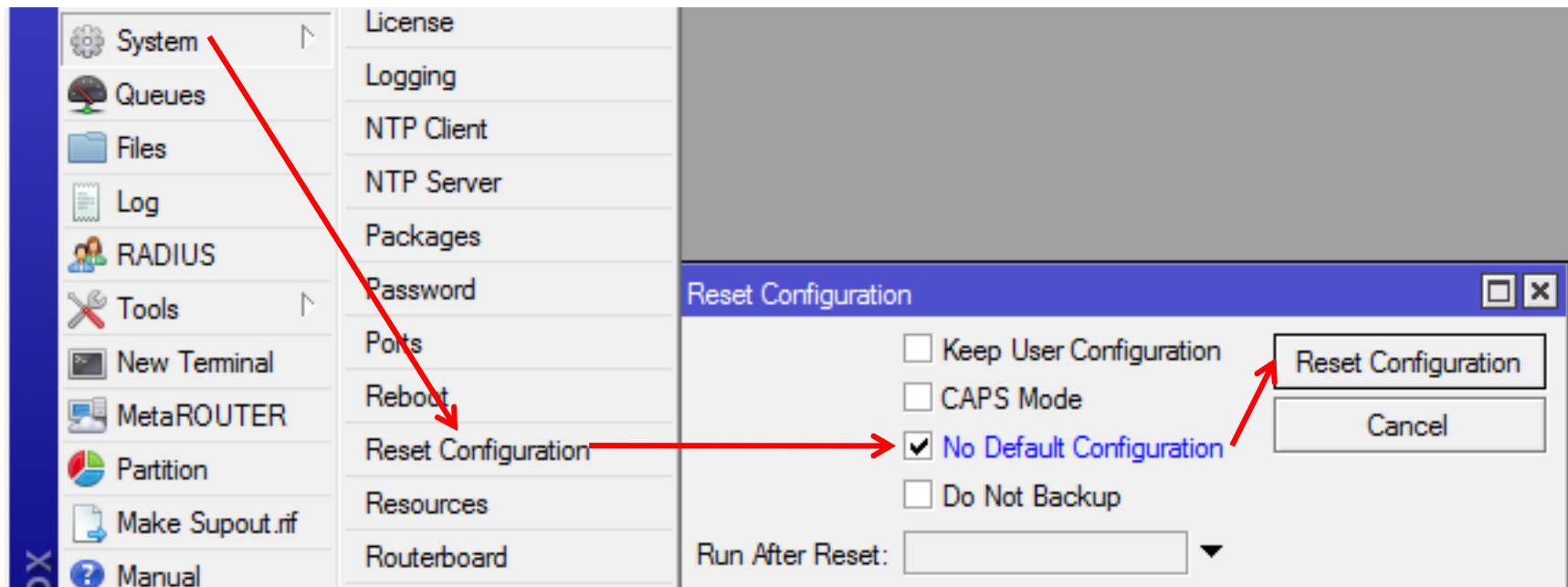
IP Service List

Name	Port
api	8728
api-ssl	8729
ftp	21
ssh	22
telnet	23
winbox	8291
www	80
www-ssl	443

RouterOS Services

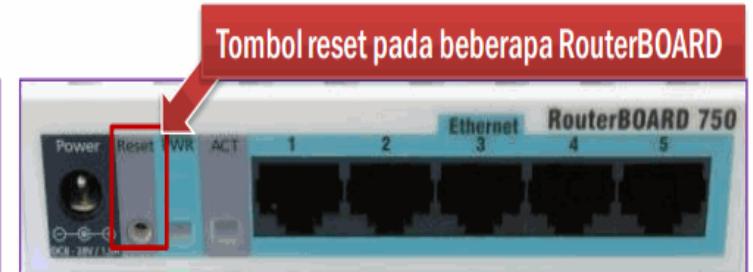
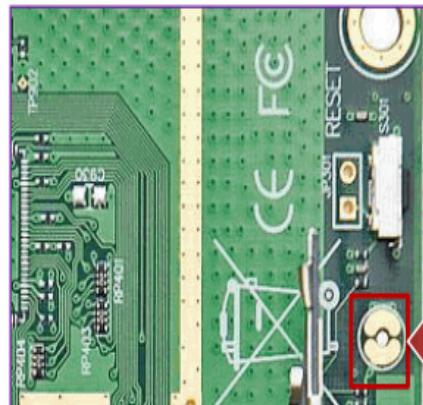
- Lakukan disable pada service SSH
- Lakukan akses router menggunakan aplikasi Putty
- Apakah kita dapat mengakses router kita?

Reset Konfigurasi di Winbox



Hard Reset

- Menekan Tombol Hard reset di bagian RouteBoard, maka router akan
 - Load Backup RouterBoot load
 - Reset router ke default konfigurasi
 - Enable CAPs mode (Controlled AP)
 - Start in Netinstall mode

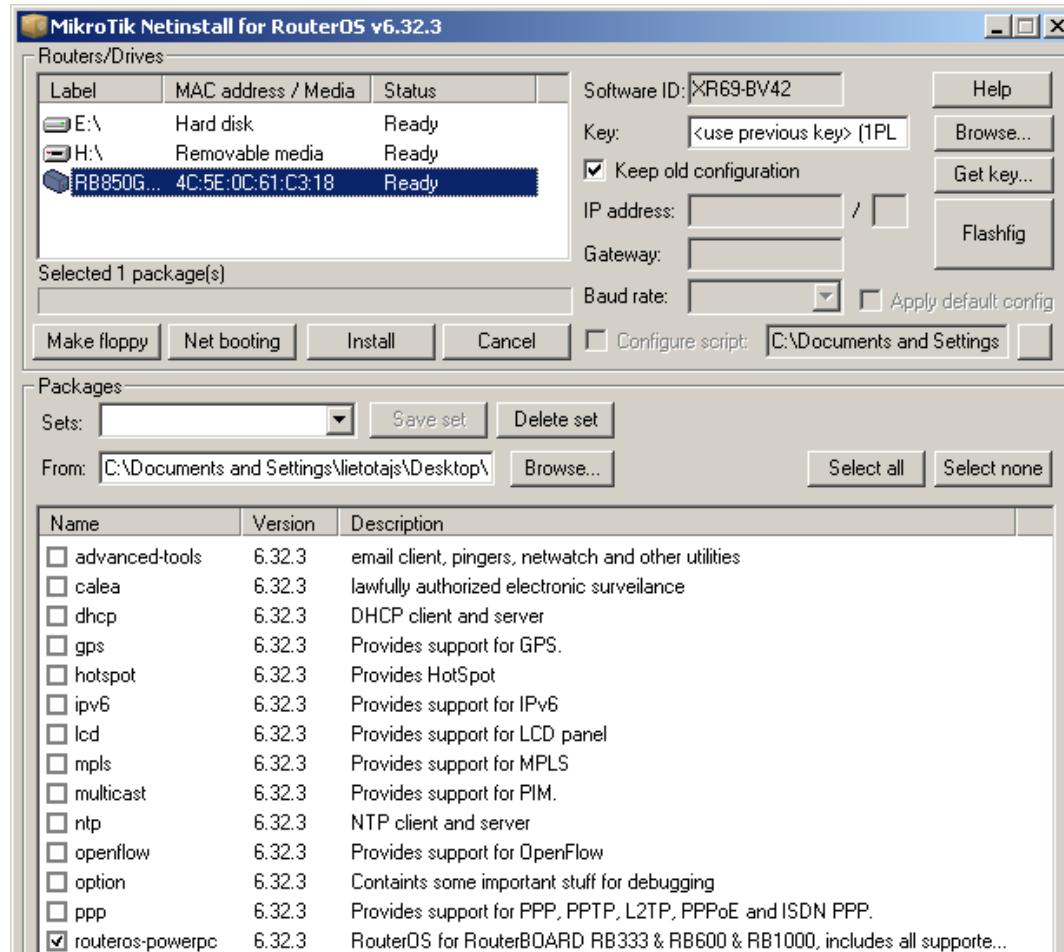


Hard reset dilakukan dengan menjumper saat router reboot

Install RouterOS via Netinstall

- Aplikasi ini digunakan untuk install dan reinstall RouterOS ke RouterBoard
- Kabel UTP diharuskan terhubung langsung antara router dengan laptop
- Kabel harus dikoneksikan ke ether1 (kecuali RouterBoard tipe CCR & RB1xxx – port/ethernet terakhir)
- Software hanya running di OS windows
- Aplikasi netinstall dapat didownload di mikrotik.com

Netinstall



Netinstall dapat di download di mikrotik.com/download

Netinstall

- Download netinstall di mikrotik.com
- Boot RouterBoard menggunakan netinstall mode
- Net boot harus satu segment dengan ip laptop
- Tekan reset button di RouterBoard
- Install RouterOS
- Mengembalikan konfigurasi yang sudah kita backup sebelumnya

Mikrotik RouterOS Lisensi

- Perangkat Hardware Routerboard sudah ada lisensinya yang melekat pada perangkat
- Fitur-fitur dalam mikrotik ditentukan dengan level lisensi
- Lisensi di Routerboard tersimpan pada media Nand,Hardisk,USB,compact flash)
- RouterOS license tidak akan hangus
- CHR atau X86 lisensi dapat dibeli di mikrotik.com atau distributor yang ada di indonesia

RouterOS Licensing

Level	Type	Typical Use
0	Trial Mode	24h trial
1	Free Demo	
3	CPE	Wireless client (station)
4	AP	Wireless AP: WISP, HOME, Office
5	ISP	Supports more tunnels than L4
6	Controller	Unlimited RouterOS features

Lisensi RouterOS

Level number	0 (Trial mode)	1 (Free Demo)	3 (WISP CPE)	4 (WISP)	5 (WISP)	6 (Controller)
Price	no key	registration required	do not sell	\$45	\$95	\$250
Initial Config Support	-	-	-	15 days	30 days	30 days
Wireless AP	24h trial	-	-	yes	yes	yes
Wireless Client and Bridge	24h trial	-	yes	yes	yes	yes
RIP, OSPF, BGP protocols	24h trial	-	yes(*)	yes	yes	yes
EoIP tunnels	24h trial	1	unlimited	unlimited	unlimited	unlimited
PPPoE tunnels	24h trial	1	200	200	500	unlimited
PPTP tunnels	24h trial	1	200	200	500	unlimited
L2TP tunnels	24h trial	1	200	200	500	unlimited
OVPN tunnels	24h trial	1	200	200	unlimited	unlimited
VLAN interfaces	24h trial	1	unlimited	unlimited	unlimited	unlimited
HotSpot active users	24h trial	1	1	200	500	unlimited
RADIUS client	24h trial	-	yes	yes	yes	yes
Queues	24h trial	1	unlimited	unlimited	unlimited	unlimited
Web proxy	24h trial	-	yes	yes	yes	yes
User manager active sessions	24h trial	1	10	20	50	Unlimited
Number of KVM guests	none	1	Unlimited	Unlimited	Unlimited	Unlimited

System → License

Cloud Hosted Router

- RouterOS version tailored for running in virtual environments
- Runs on most popular virtualisation platforms like - VMware, Microsoft HyperV, VirtualBox, XEN, KVM, etc.
- Cloud services - Amazon, Azure and others

CHR Use Cases

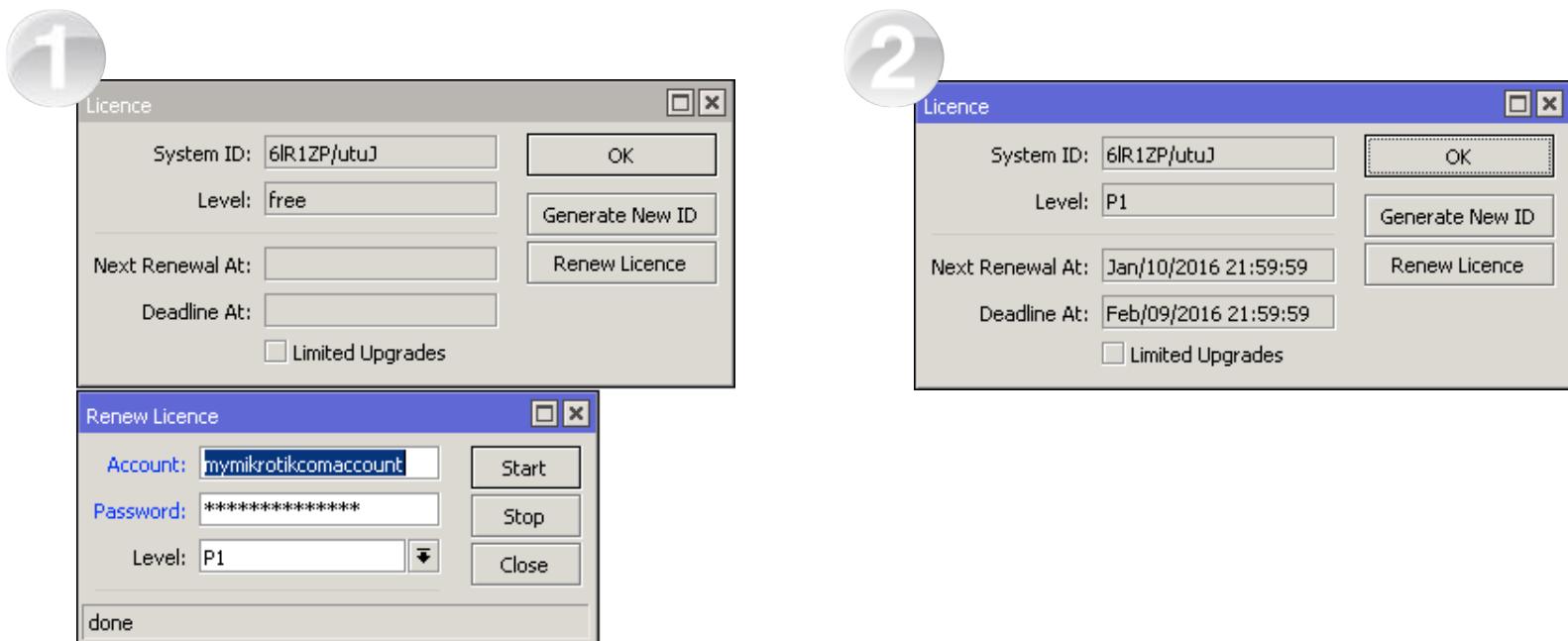
- Firewall for the cloud services
- VPN server in the cloud
- The Dude monitoring server
- Simulate networks for learning or training
- And many more

CHR Licensing

Free	1Mbit	FREE
P1	1Gbit	
P10	10Gbit	
P-Unlimited	Unlimited	

- 60 day trial available
- Purchased license can be transferred to another CHR

CHR Licensing



WinBox → System → License

Informasi Tambahan

- **wiki.mikrotik.com** - RouterOS documentation and examples
- **forum.mikrotik.com** - communicate with other RouterOS users
- **mum.mikrotik.com** - MikroTik User Meeting page
- Distributor and consultant support
support@mikrotik.com



Mikrotk Certified Network Associate (MTCNA)

Module 2
DHCP

Skenario Topologi Training Mikrotik



IP address	: 192.168.1.2
Subnet Mask	: 255.255.255.0
Default gateway	: 192.168.1.1
DNS Server	: 8.8.8.8

DHCP

- Dynamic Host Configuration Protocol
- Biasanya digunakan di jaringan yang memberikan IP addressnya secara otomatis dari router kepada client
- IP address DHCP server harus di install pada interface yang digunakan
- Konfigurasi DHCP server dilakukan pada menu **ip dhcp > DHCP Setup**
- RouterOS dapat support **DHCP server** dan **DHCP client** secara bersama

DHCP Client

- Untuk mendapatkan IP address, subnet mask, gateway, DNS server & lainnya
- RouterBoard by default ether 1 WAN, sudah terkonfigurasi DHCP client pada interfacenya

LAB

DHCP Client

Set DHCP client to the WiFi interface

The screenshot shows the Winbox interface for a MikroTik device. On the left, a sidebar lists various network protocols: IP (selected), IPv6, MPLS, Routing, System, Queues, Files, Log, RADIUS, Tools, New Terminal, MetaROUTER, and Partition. A red arrow points from the 'IP' entry in the sidebar to the 'DHCP Client' tab in the main window. The main window has two tabs: 'DHCP Client' (selected) and 'DHCP Client Options'. Below the tabs is a toolbar with icons for adding (+), deleting (-), checking (✓), unchecking (✗), saving (disk), filtering (magnifying glass), releasing (Release), renewing (Renew), and a search field (F). A table titled 'DHCP Client' lists one entry: wlan1, Use P... (yes), Add D... (yes), IP Address (192.168.7.2/24), Expires After (3d 00:07:57), and Status (bound). A red box highlights this table. Below it, a dialog box titled 'DHCP Client <wlan1>' is shown, also with wlan1 selected in the 'Interface' dropdown. This dialog has three tabs: 'DHCP' (selected), 'Advanced', and 'Status'. Under 'DHCP', there are checkboxes for 'Use Peer DNS' and 'Use Peer NTP', both of which are checked. There is also a dropdown for 'Add Default Route' with 'yes' selected. Red arrows point from the 'OK' button in the dialog to the 'OK' button in the toolbar, and from the 'OK' button in the dialog to the 'OK' button in the table header.

IP → DHCP Client & IP → Address

The screenshot shows the Winbox interface for a MikroTik device. On the left, a sidebar lists: Switch (selected), Mesh, IP (selected), IPv6, and MPLS. A red arrow points from the 'IP' entry in the sidebar to the 'Address List' tab in the main window. The main window has three tabs: 'Addresses' (selected), 'Cloud', and 'DHCP Client'. Below the tabs is a toolbar with icons for adding (+), deleting (-), checking (✓), unchecking (✗), saving (disk), filtering (magnifying glass), and a search field (Find). A table titled 'Address List' shows one entry: D, Address (192.168.7.2/24), Network (192.168.7.0), and Interface (wlan1). A red box highlights this table.

LAB

DHCP Server

The image shows a network configuration interface with a sidebar and several configuration windows.

Sidebar:

- IP
- IPv6
- MPLS
- OpenFlow
- Routing

Main Window (DHCP Server tab):

- Buttons: +, -, checkmark, X, search icon.
- Tabs: DHCP, Networks, Leases, Options, Option Sets, Alerts.
- Buttons: DHCP Config, DHCP Setup.
- Table headers: Name, Interface, Relay, Lease Time, Address Pool, Add AR...

Detailed Configuration Steps:

- DHCP Setup Step 1:** Select interface to run DHCP server on. **Interface: ether1**
- DHCP Setup Step 2:** Select pool of ip addresses given out by DHCP server. **Addresses to Give Out: 168.1.2-192.168.1.254**
- DHCP Setup Step 3:** Select lease time. **Lease Time: 3d00:10:00**
- DHCP Setup Step 4:** Select network for DHCP addresses. **DHCP Address Space: 192.168.1.0/24**
- DHCP Setup Step 5:** Select DNS servers. **DNS Servers: 8.8.8.8**

Final Configuration Table (Bottom Right):

Name	Interface	Relay	Lease Time	Address Pool	Add AR...
dhcp1	ether1		3d 00:10:00	dhcp_pool1	no

Path Summary: IP > DHCP Server > DHCP Setup

Verifikasi DHCP Client di laptop

- setting IP Address dan DNS pada laptop menjadi otomatis
- Verifikasi pada laptop apakah sudah mendapatkan IP Address dari DHCP Server
- C:\ ipconfig [enter]
- C:\ ipconfig /release
- C:\ ipconfig /renew
- Verifikasi ping atau browsing ke internet **ping 8.8.8.8 -t**

DHCP Static Leases

- Memberikan IP address yang akan pasti selalu sama pada perangkat laptop,HP,dan lainnya. Mengidentifikasi menggunakan Mac address
- DHCP server bisa dikonfigurasi tanpa dinamic IP Pool & memberikan alamat ip address ke client sesuai yang telah dikonfigurasi pada DHCP server

DHCP Static Leases

The screenshot shows a network management interface with a sidebar on the left containing icons for IP, IPv6, MPLS, OpenFlow, Routing, and System. A red arrow points from the 'IP' icon to the 'DHCP Server' entry in a list of components. Another red arrow points from the 'Leases' tab in the main window to the 'Leases' table below. A third red arrow points from the 'Make Static' option in the context menu of the bottom-left table to the 'Convert dynamic lease to static' text.

DHCP Server

DHCP Networks Leases Options Option Sets Alerts

+ - ✓ ✘ Find

Address	MAC Address	Client ID	Server	Active Address	Active MAC
192.168.1.254	10:BF:48:32:AD:D6	1:10:bf:48:32:ad:d6	dhcp1	192.168.1.254	10:BF:48:32:AD

Show Categories
Detail Mode
Inline Comments
Show Columns >
Find Ctrl+F
Find Next Ctrl+G
Select All Ctrl+A
Add INS
Remove DEL
Enable Ctrl+E
Disable Ctrl+D
Comment Ctrl+M
Make Static

Convert dynamic lease to static

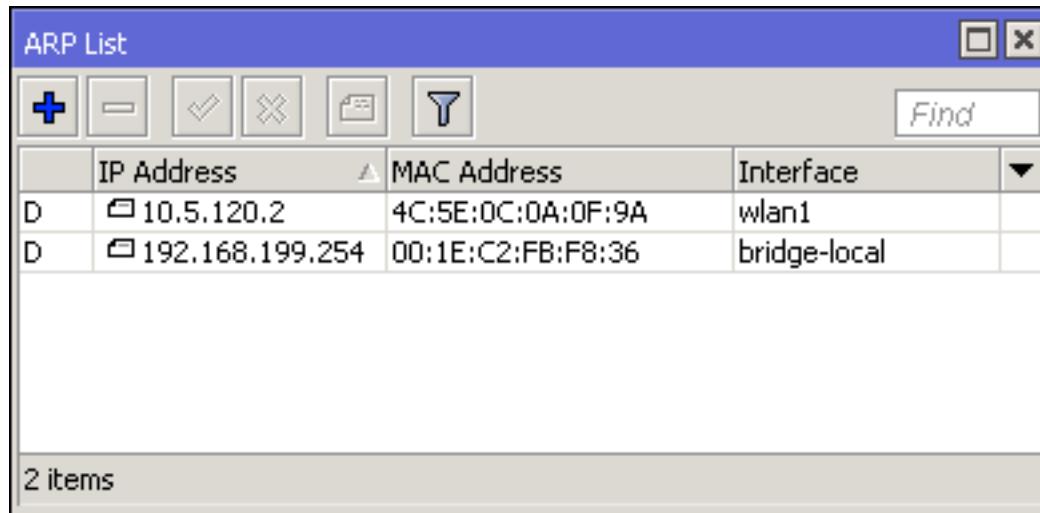
IP → DHCP Server → Leases

ARP

- Address Resolution Protocol
- Menggabungkan IP address (layer3) dan Mac address (layer2)
- Cara kerja ARP secara dinamic
- Tabel Entri ARP dapat dikonfigurasi secara static/manual untuk meningkatkan keamanan jaringan. Dengan menambahkan pada tabel entri ARP

Table ARP

- Table ARP menyediakan informasi terkait IP address & Mac address yang terkoneksi ke mikrotik



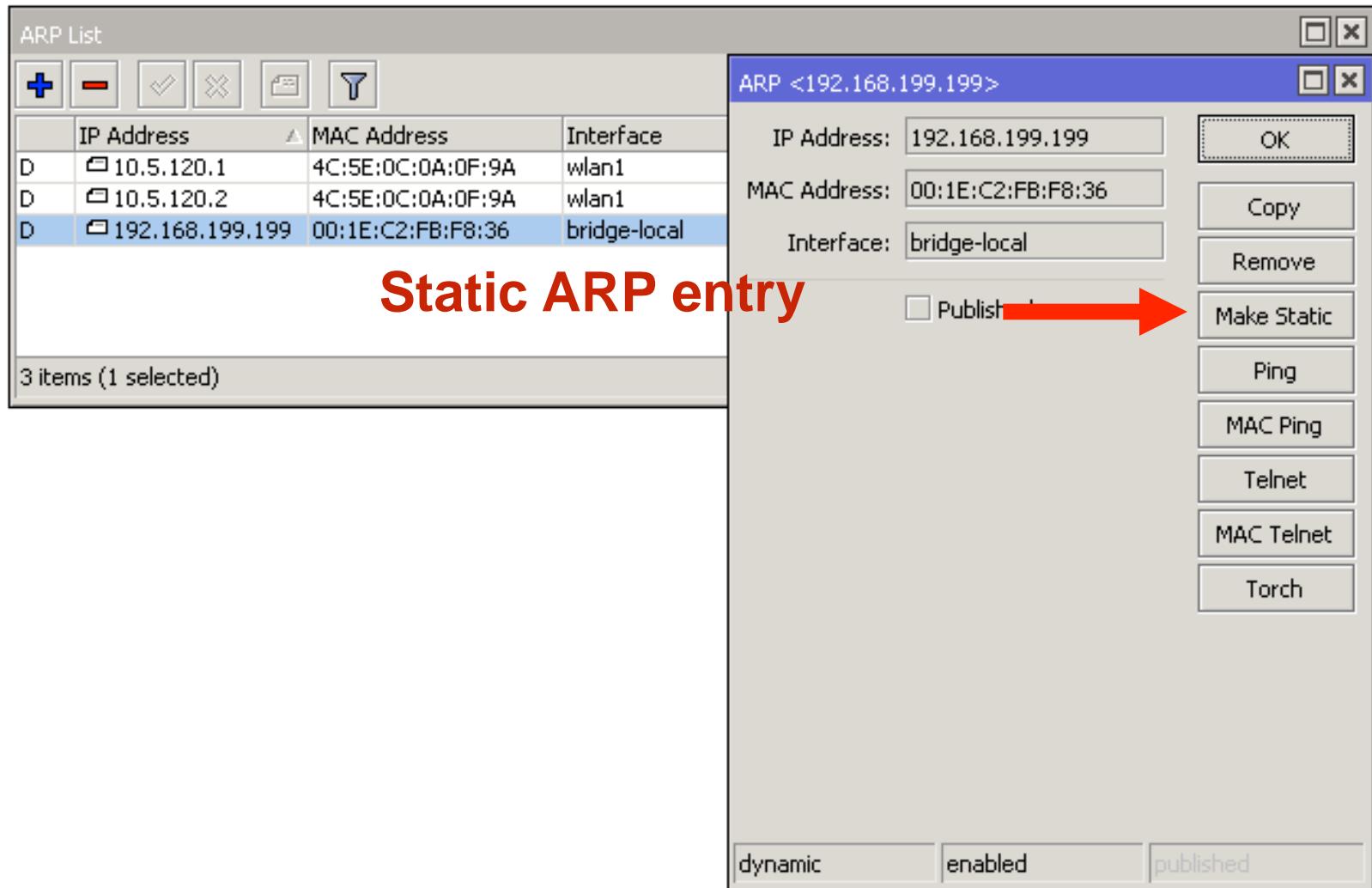
The screenshot shows the 'ARP List' window from the Winbox interface. The window has a blue header bar with the title 'ARP List' and standard window controls. Below the header is a toolbar with icons for adding (+), deleting (-), selecting (checkmark), clearing (X), saving (disk), and filtering (magnifying glass). To the right of the toolbar is a 'Find' input field. The main area is a table with three columns: 'IP Address', 'MAC Address', and 'Interface'. There are two entries in the table:

	IP Address	MAC Address	Interface
D	10.5.120.2	4C:5E:0C:0A:0F:9A	wlan1
D	192.168.199.254	00:1E:C2:FB:F8:36	bridge-local

At the bottom left of the table area, it says '2 items'.

IP → ARP

Static ARP



IP → ARP

Static ARP

The screenshot shows the RouterOS WinBox interface configuration window. On the left, the sidebar lists various management sections: Quick Set, CAPsMAN, Interfaces (selected), Wireless, Bridge, PPP, Switch, Mesh, IP, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, Make Supout.rrf, Manual, and New WinBox. A red arrow points from the 'Interfaces' entry in the sidebar to the 'Interface List' table.

The 'Interface List' table has tabs for Interface, Ethernet, EoIP Tunnel, IP Tunnel, GRE Tunnel, VLAN, VRRP, Bonding, and LTE. It displays two interfaces: ether1 (selected) and ether2. The table columns include Name, Type, L2 MTU, Tx, and Rx.

A detailed configuration dialog is open for 'Interface <ether1>'. The 'General' tab is selected. The configuration fields are:

- Name: ether1
- Type: Ethernet
- MTU: 1500
- L2 MTU: 1598
- Max L2 MTU: 2028
- MAC Address: 6C:3B:6B:B5:71:91
- ARP: reply-only (highlighted in blue)
- Master Port: proxy-arp
- Bandwidth (Rx/Tx): reply-only (highlighted in blue)
- Switch: switch1

On the right side of the dialog, there is a vertical toolbar with buttons: OK, Cancel, Apply, Disable, Comment, Torch, Cable Test, Blink, Reset MAC Address, and Reset Counters.

Interface will reply only to known ARP entries

Interfaces → ether1

Mode ARP

- **Mode Enable** ini default enable pada semua interface di MikroTik. Semua ARP akan ditemukan dan secara dinamik ditambahkan dalam ARP tabel.
- **Mode Disable** permintaan ARP dari klien tidak dijawab oleh router. Oleh karena itu, statis arp entri harus ditambahkan disamping disisi router juga disisi client. misal pada Windows menggunakan perintah arp: C: \> arp-s 192.168.2.1 00-aa-00-62-c6-09
- **Mode Reply Only** ARP reply-only memungkinkan router hanya kan mereply ARP statis ditemukan di tabel ARP, akses ke router dan ke jaringan di belakang router hanya dapat diakses oleh kombinasi Ip dan mac address yang ditemukan di tabel ARP.

DHCP & ARP

- Interface yang dikonfigurasi DHCP Server dapat menambahkan ARP entri secara otomatis
- static lease dan replay-only ARP dapat digabungkan untuk meningkatkan keamanan pada router

Static ARP

- Setting menjadi **reply-only** di **interface ether1**
- Lakukan ping dari laptop ke router **192.168.x.1** pastikan ping berhasil pada router
- Pada IP-ARP List copy dan simpan ip address dan mac address di notepad
- hapus ip address dan mac address dalam tabel ARP list, perhatikan ping dari laptop ke router, pastikan RTO
- Add ip address dan mac address untuk dapat kembali teknoneksi ke jaringan

Module 2

Summary



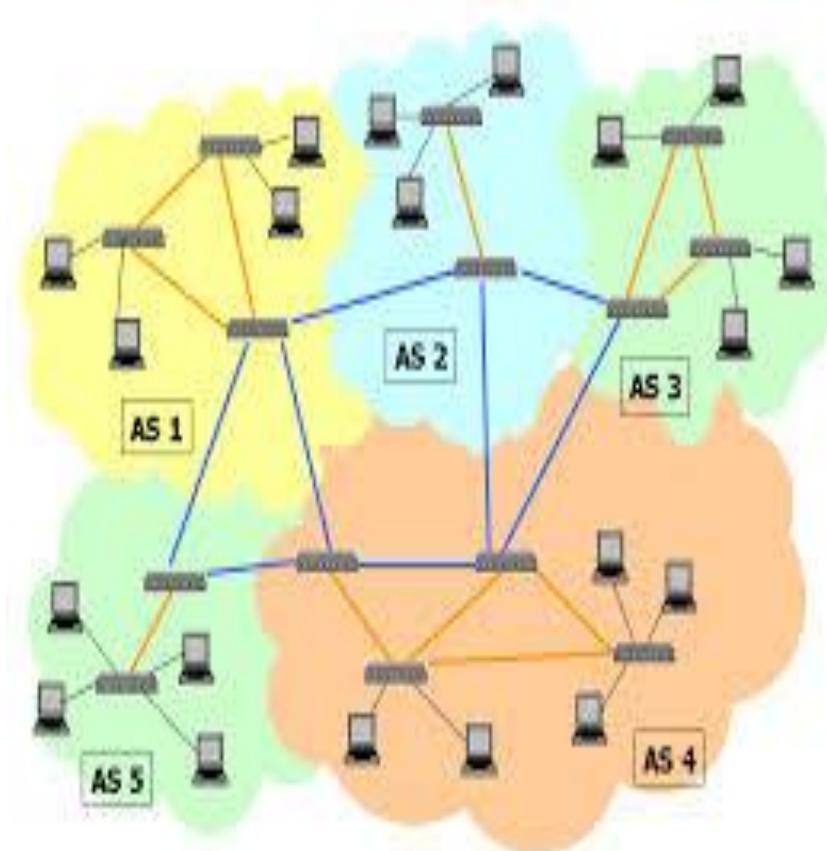
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(MTCNA)

Module 3

Routing

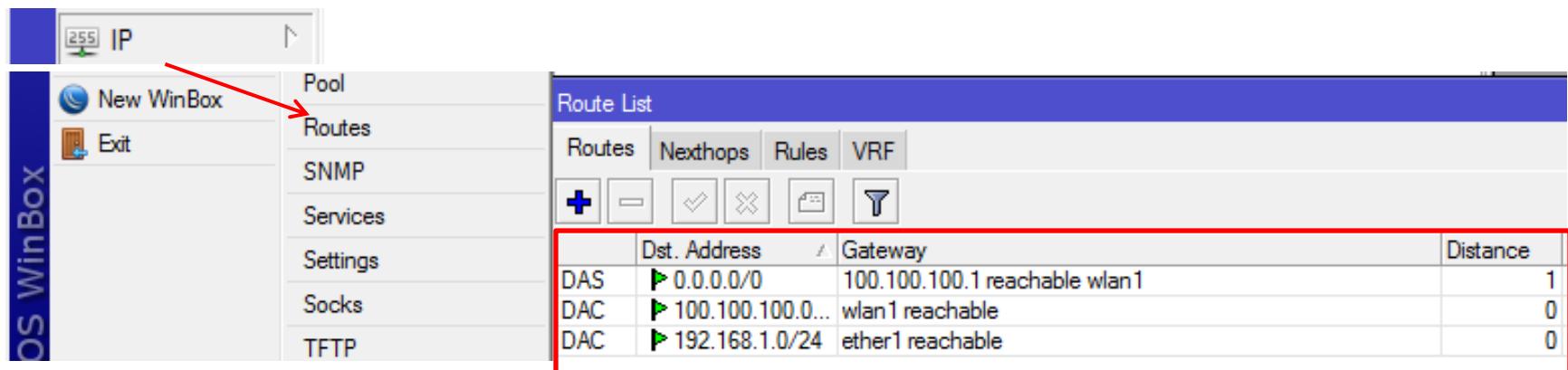
Routing

- Banyak router di dunia saling terhubung, dengan routing protocol dan membentuk dinamakan internetworking (Internet)



Routing

- OSI Layer berkerja pada layer 3
- Fitur routing rules di mikrotik mendefinisikan tujuan packet akan dikirimkan

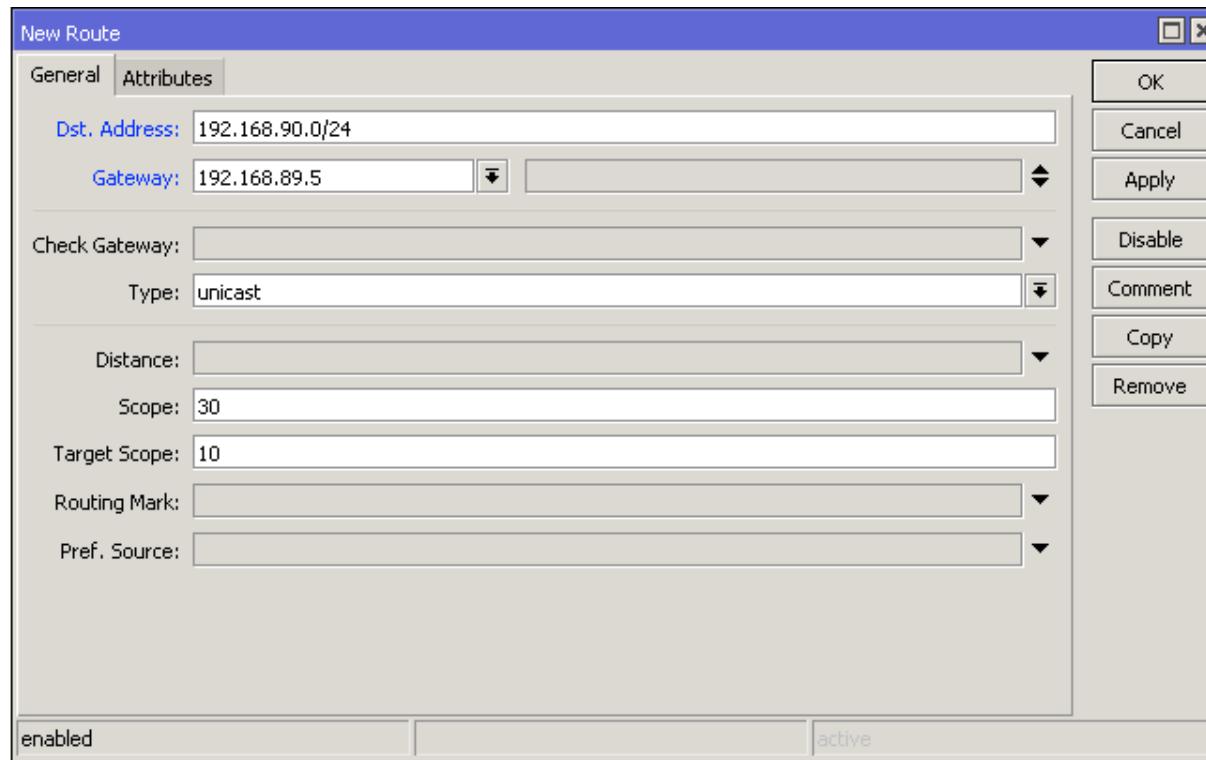


IP → Routes

Jenis Routing Protocol

- Static Route (network skala kecil)
- Dynamic Route (network Skala Besar)
- Default Route (route terhubung ke Internet)

New Static Route



IP → Routes

Skenario Topologi Training Mikrotik

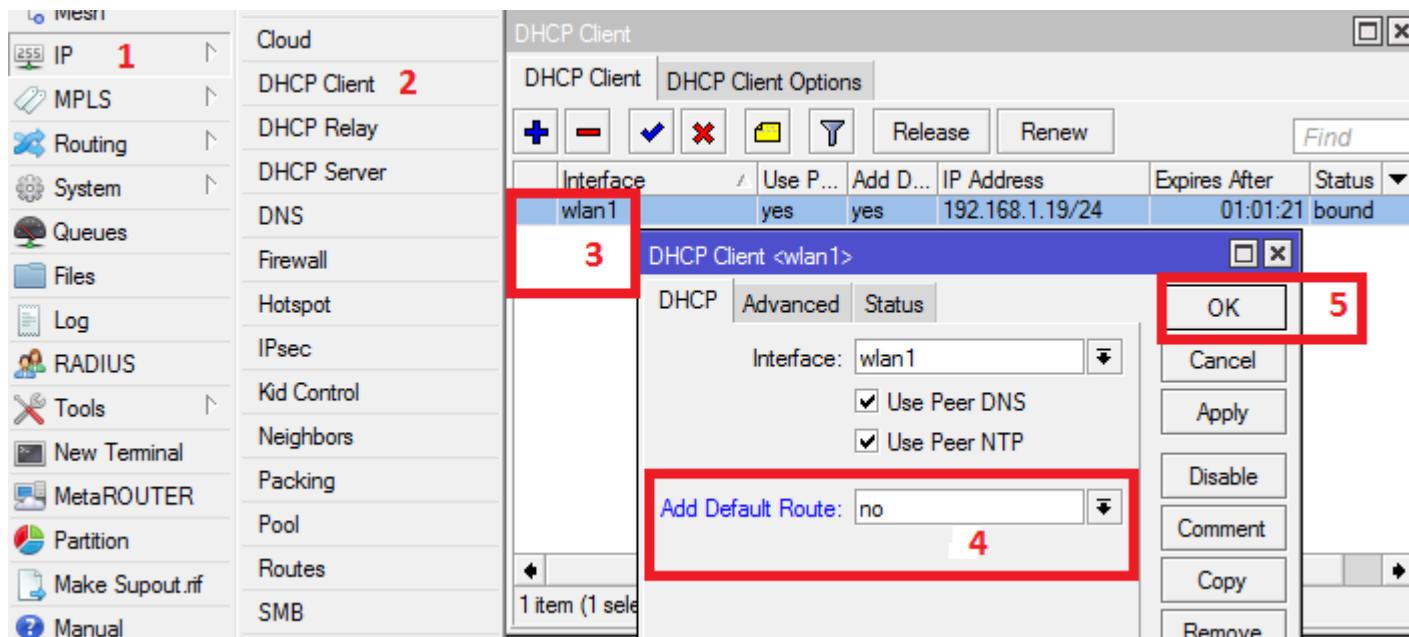
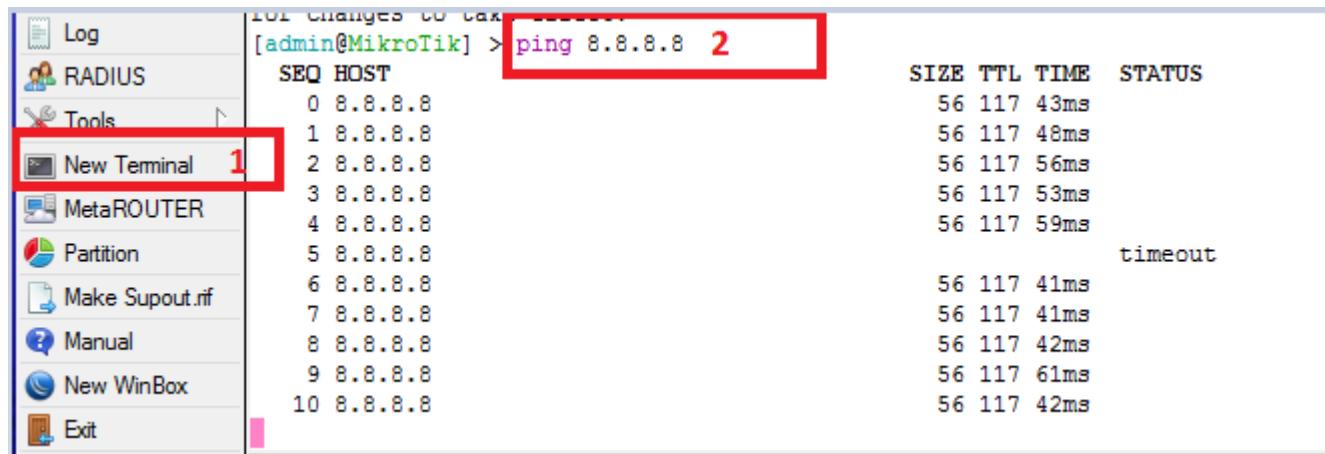


IP address	: 192.168.1.2
Subnet Mask	: 255.255.255.0
Default gateway	: 192.168.1.1
DNS Server	: 8.8.8.8

Default Gateway

- IP default gateway pada RouterBoard anda, saat ini mendapatkan IP address dari DHCP-Client
- Lakukanlah disable **add default route** pada menu DHCP-Client setting
- Verifikasi koneksi internet RouterBoard anda

IP Default Route



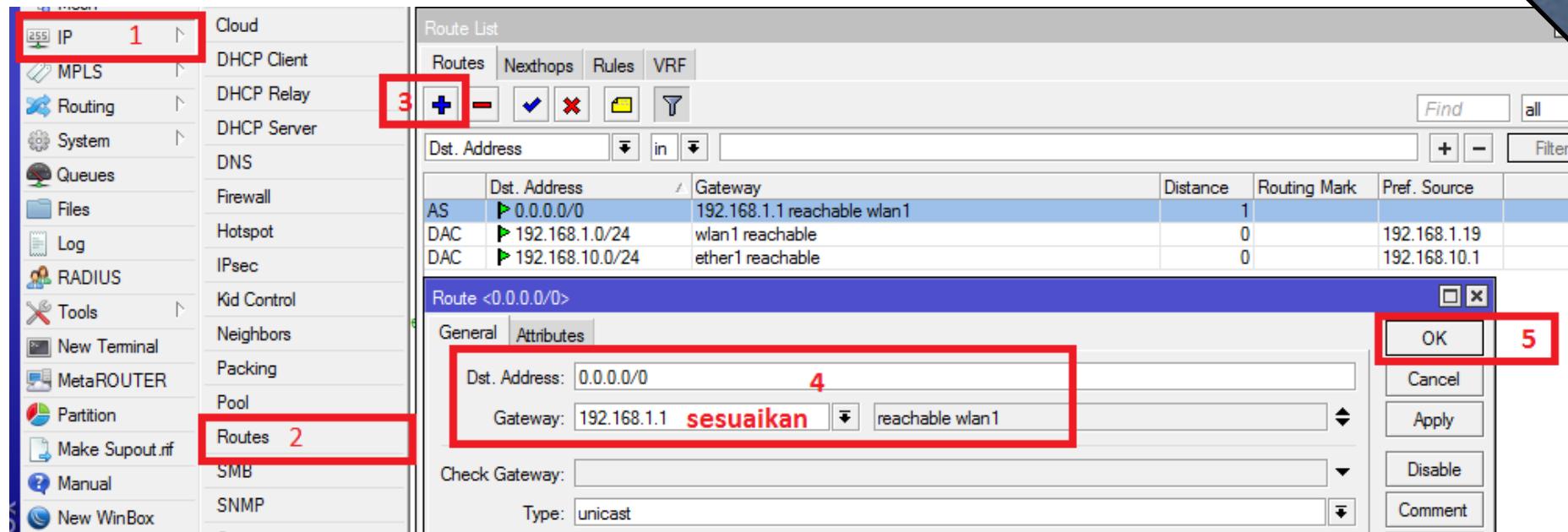
Setelah di disable add default route pada dhcp Client – koneksi terputus dari RB to internet

The screenshot shows a terminal window with two main sections. The top section displays network statistics for a connection to 8.8.8.8, showing 291 to 299 packets sent/received with various RTT values. The bottom section shows a table of connections from port 300 to 311, all of which have a status of "no route to host".

PORT	SIZE	TIME	STATUS
300			no route to host
301			no route to host
302			no route to host
303			no route to host
304			no route to host
305			no route to host
306			no route to host
307			no route to host
308			no route to host
309			no route to host
310			no route to host
311			no route to host

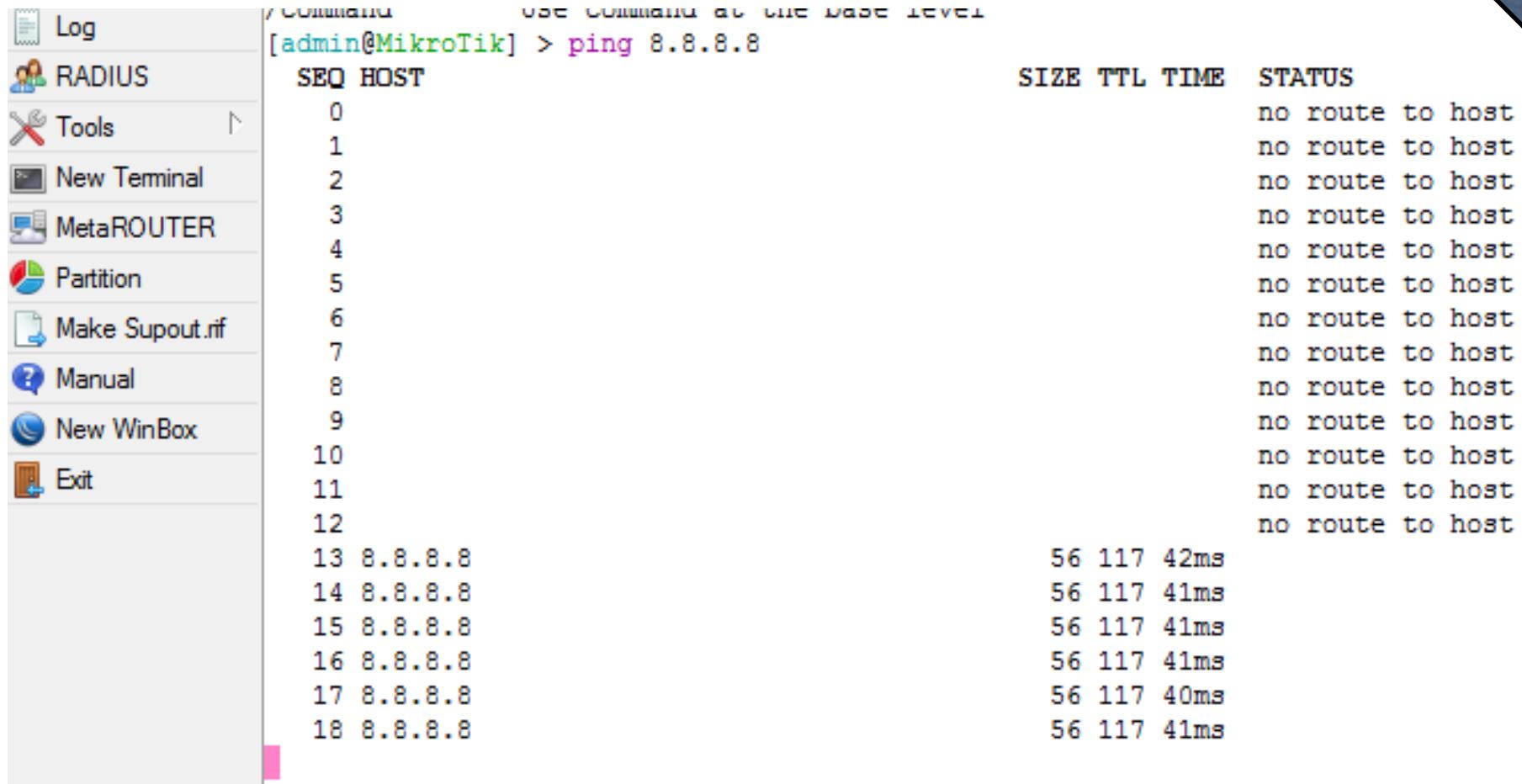
Menambahkan IP Default Route pada Router Mikrotik

LAB



Setelah di tambahkan default route, internet kembali normal

LAB



The screenshot shows the WinBox interface with a terminal window open. The terminal window title is '/ commands' and the subtitle is 'use commands at the next level'. The command entered is '[admin@MikroTik] > ping 8.8.8.8'. The output of the ping command is displayed in a table format:

SEQ	HOST	SIZE	TTL	TIME	STATUS
0					no route to host
1					no route to host
2					no route to host
3					no route to host
4					no route to host
5					no route to host
6					no route to host
7					no route to host
8					no route to host
9					no route to host
10					no route to host
11					no route to host
12					no route to host
13	8.8.8.8	56	117	42ms	
14	8.8.8.8	56	117	41ms	
15	8.8.8.8	56	117	41ms	
16	8.8.8.8	56	117	41ms	
17	8.8.8.8	56	117	40ms	
18	8.8.8.8	56	117	41ms	

Routing

- Default gateway : router (next hop) di mana semua lalu lintas traffic yang tidak memiliki tujuan jelas yang akan dikirimkan atau kirimkan ke semua
- Dalam hal ini dibedakan menjadi tujuan network yaitu **0.0.0.0/0**

Routing

- Check gateway – **ICMP dan ARP**, setiap 10 detik mengirim balik permintaan echo ping
- Apabila ada beberapa route menggunakan gateway yang sama dan salah satu yang route enable **check gateway**, maka semua route akan mengikuti perilaku check-gateway

Routing

Apabila ada beberapa route yang ditujukan ke tujuan alamat ip address yang sama, maka route yang lebih spesifik akan digunakan.

- Contoh Jika paket ingin dikirim ke **10.10.10.2**, gateway manakah yang akan digunakan yang akan digunakan 10.10.10.x
- Dst: 10.10.10.0/24 gateway 10.10.10.254
- Dst: 10.10.10.0/25 gateway 10.10.10.126

Route Flags

- DAC : route yang secara dynamic akan selalu ada apabila ada jaringan terhubung langsung dengan RouterBoard yaitu

IP → Addresses

The screenshot shows two windows from the Winbox interface of a MikroTik RouterBoard.

Address List window:

Address	Network	Interface	Comment
D 10.5.120.243/24	10.5.120.0	wlan1	
D 192.168.88.1/24	192.168.88.0	bridge-local	default configuration

2 items

Route List window:

Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS 0.0.0.0/0	10.5.120.1 reachable wlan1	1		
DAC 10.5.120.0/24	wlan1 reachable	0		10.5.120.243
DAC 192.168.88.0/24	bridge-local reachable	0		192.168.88.1

3 items

IP → Routes

Route Flags

- A : active
- C : connected
- D: dynamic
- S : static

Route List						
		Routes	Nexthops	Rules	VRF	
		Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS		▶ 0.0.0.0/0	10.5.120.1 reachable wlan1	1		
DAC		▶ 10.5.120.0/24	wlan1 reachable	0		10.5.120.243
DAC		▶ 192.168.88.0/24	bridge-local reachable	0		192.168.88.1

3 items

IP → Routes

Static Routing

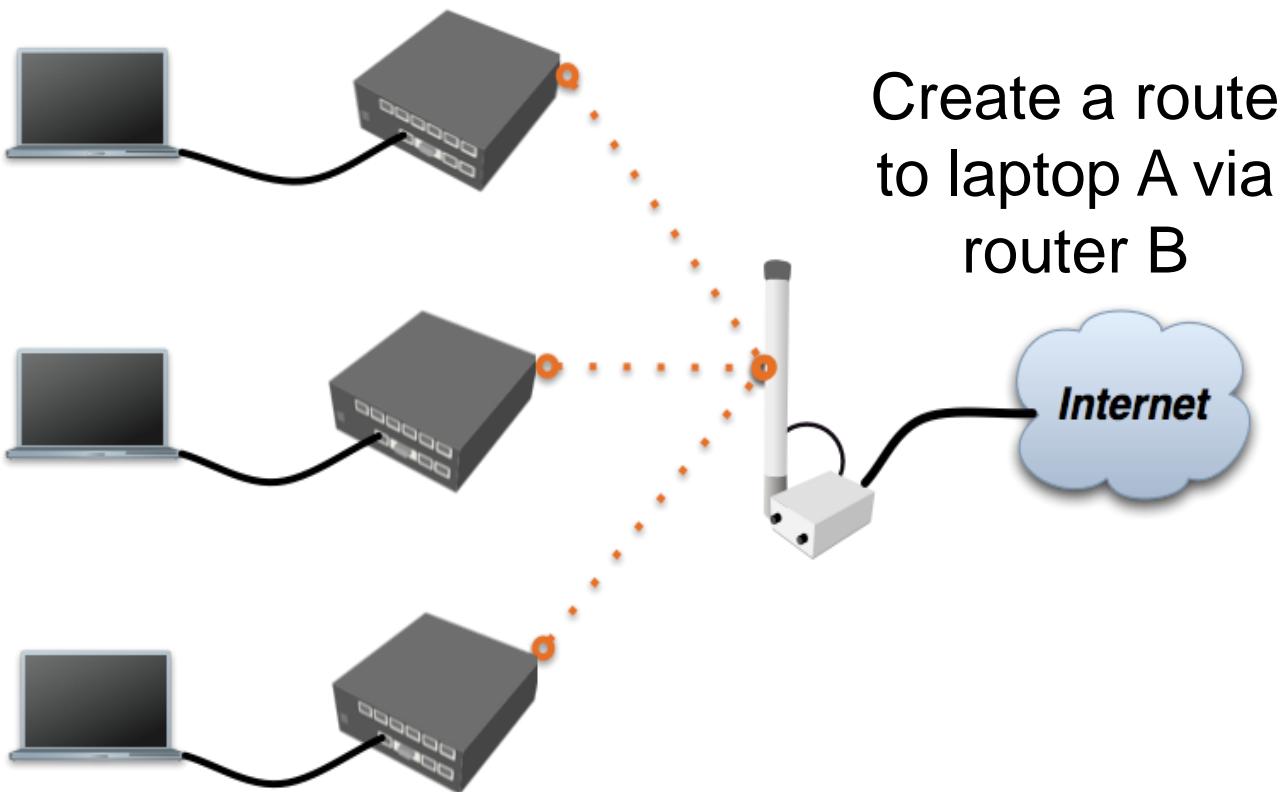
- Static route bagaimana mendefinisikan untuk mencapai ke network tujuan (destination network)
- **Default gateway** merupakan static route, membuat semua jalur traffic langsung menuju ke gateway

Static Routing

- Menggunakan resource pada router sangat kecil
- Mudah untuk di konfigurasi di network skala kecil
- Tidak baik jika digunakan jika network yang sangat besar

LAB

Static Routing



LAB

Static Routing

Screenshot of a network configuration interface showing static routing tables and a route editor.

Left Sidebar:

- CAPsMAN
- Interfaces
- Wireless
- Bridge
- PPP
- Switch
- Mesh
- IP
- MPLS
- Routing
- System
- Queues
- Files
- Log
- Radius
- Tools

Top Bar:

Routes Nexthops Rules VRF

Tool Buttons:

+ - ✓ ✗ 🗑️ 🔍 Find all ↴

Table View (Routes Tab):

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
S	► 0.0.0.0/0	192.168.12.2 unreachable	1		
DAS	► 0.0.0.0/0	192.168.43.1 reachable wlan1	0		
DC	► 192.168.1.0/24	ether1 unreachable	255		192.168.1.1

Route Editor (Route <192.168.2.0/24>):

General Tab:

- Dst. Address: 192.168.2.0/24
- Gateway: 192.168.9.1 unreachable
- Check Gateway: [empty]
- Type: unicast
- Distance: 1
- Scope: 30

Buttons (Right Side):

OK Cancel Apply Disable Comment Copy Remove

Module 4 Summary



Certified Network Associate
(MTCNA)

Module 4

Firewall

What is firewall

Firewall adalah komponen kunci dari network security, tugasnya adalah menjaga jaringan kita dari malicious traffic, data loss, and unauthorized access. firewall bisa berupa hardware, software atau kombinasi dari hardware dan software.

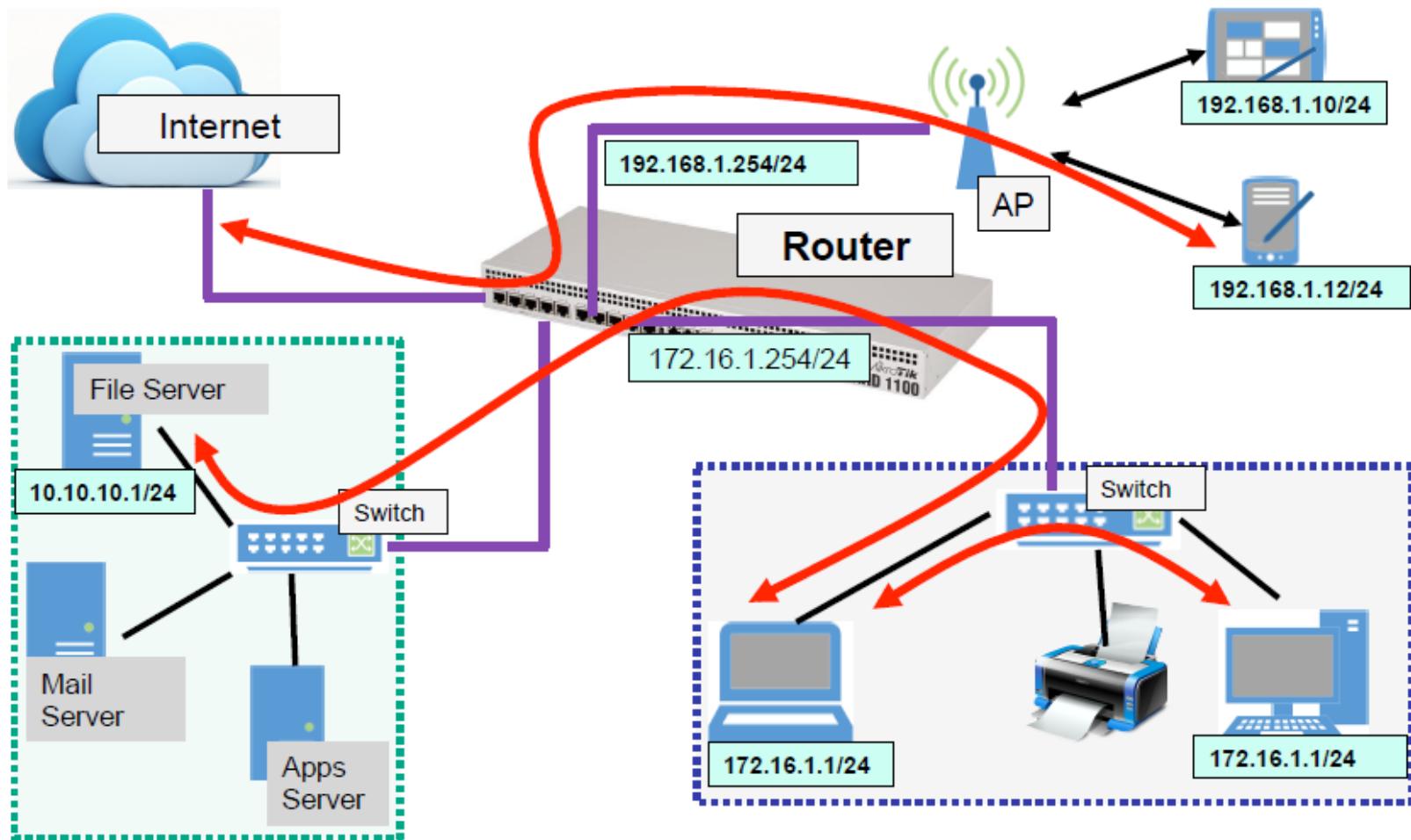


Firewall

- Network Security system untuk memproteksi router dari Internet/WAN dan maupun dari client (local area network).
- Aturan firewall di RouterOS secara berurutan dari rule paling atas ke bawah hingga rule ditemukan atau lewat saja
- Rule firewall RouterOS berada pada menu firewall filter dan firewall NAT

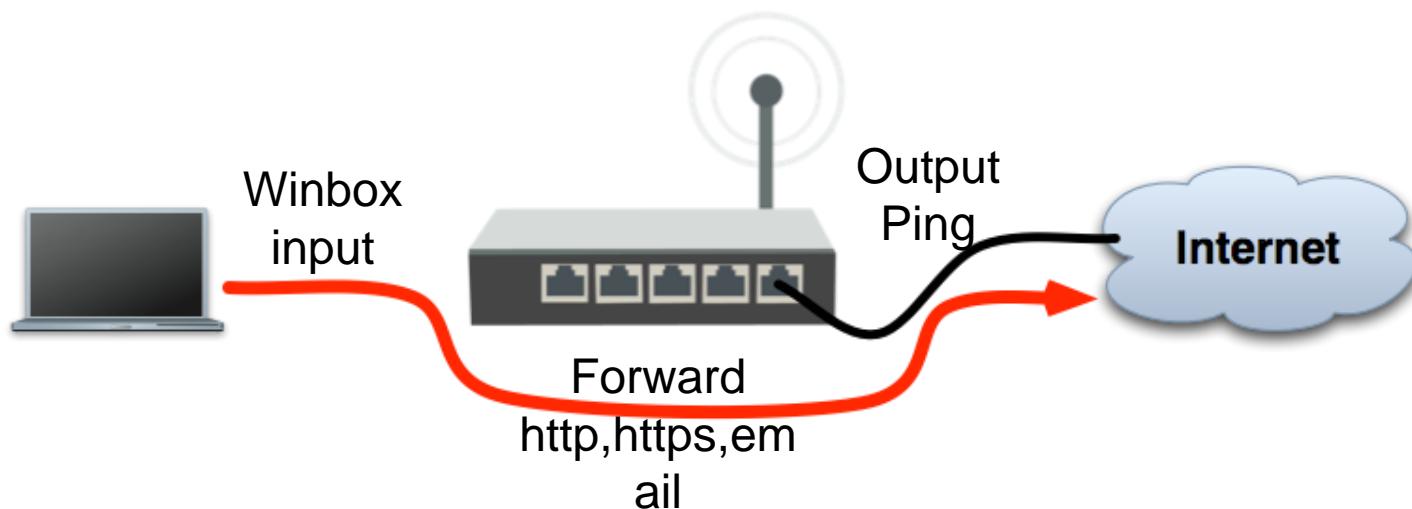
Topologi Umum jaringan Komputer

● ● ● | Topologi Office



Firewall Filter Rule

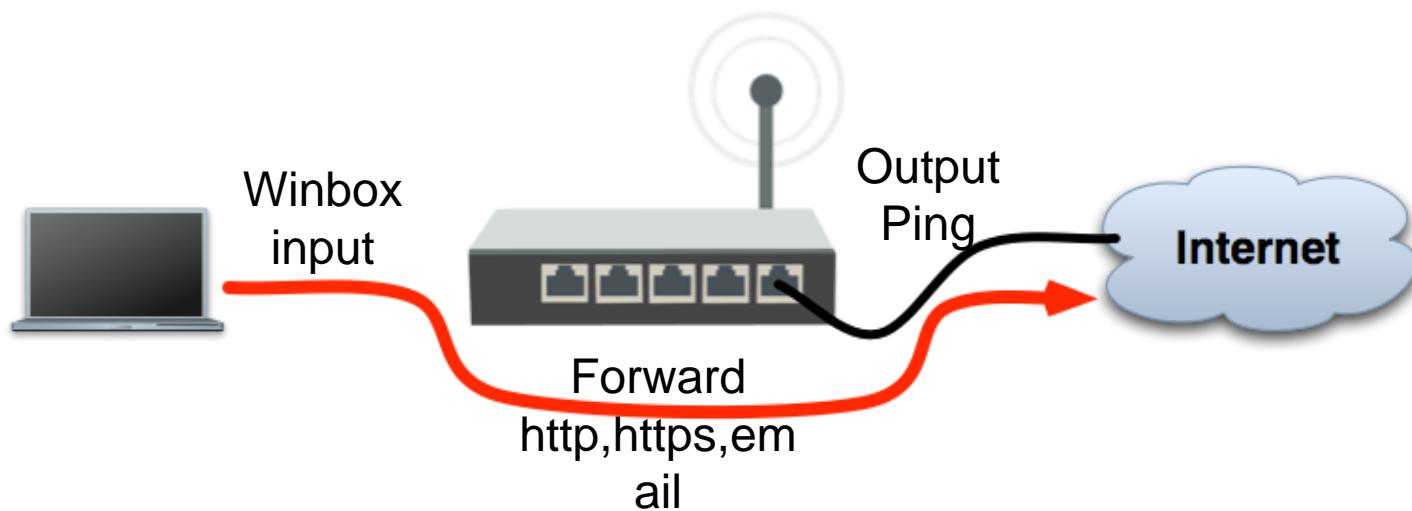
- Default chain firewall filter rule (input,forward,output)
- Aturan rule yang dibuat akan dibaca oleh router dari atas ke bawah



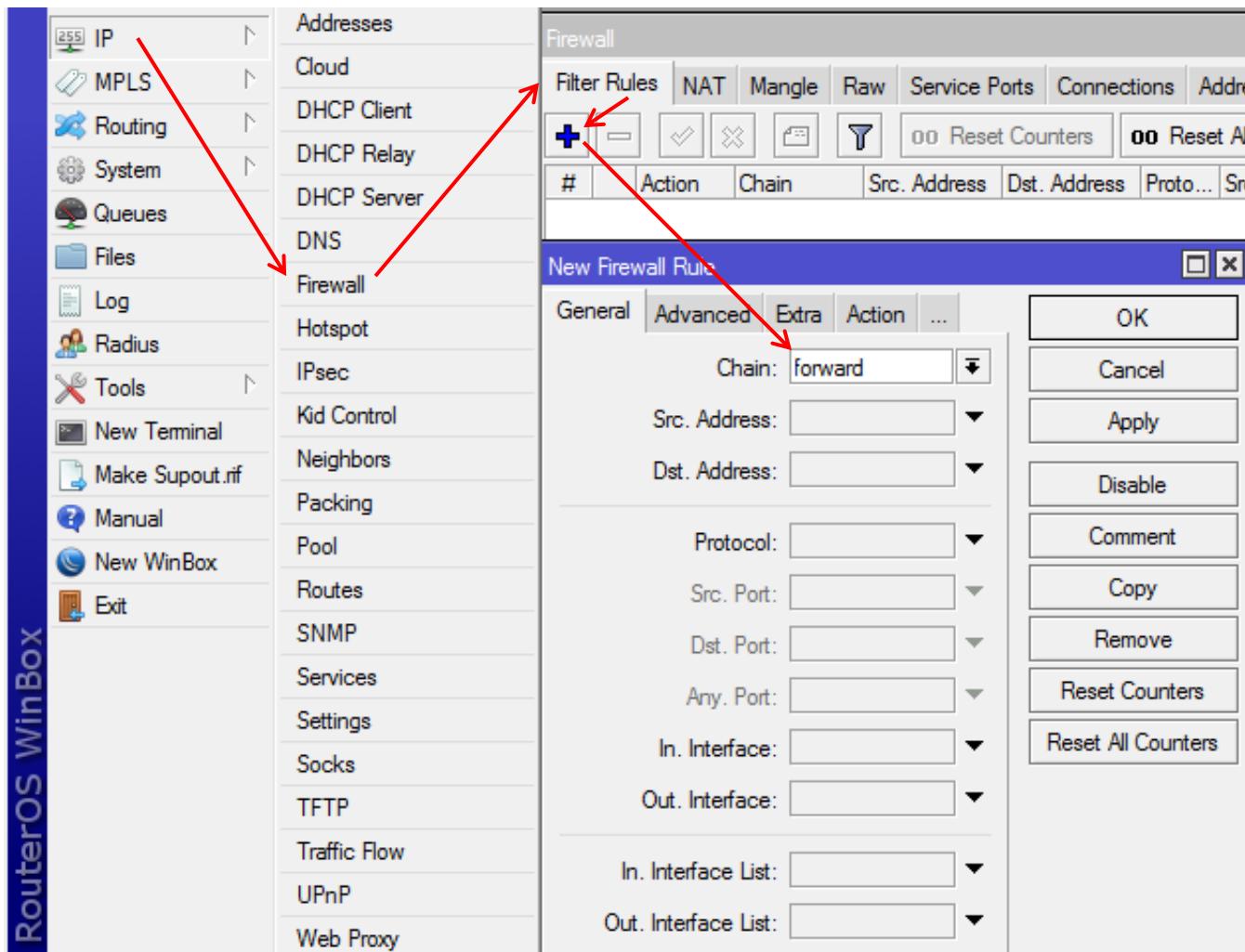
Packet Flow

By default chain yang telah ada

- Input (Lan menuju router)
- Output (Dari Router menuju wan/Lan)
- Forward (Lan melalui/melewati router)



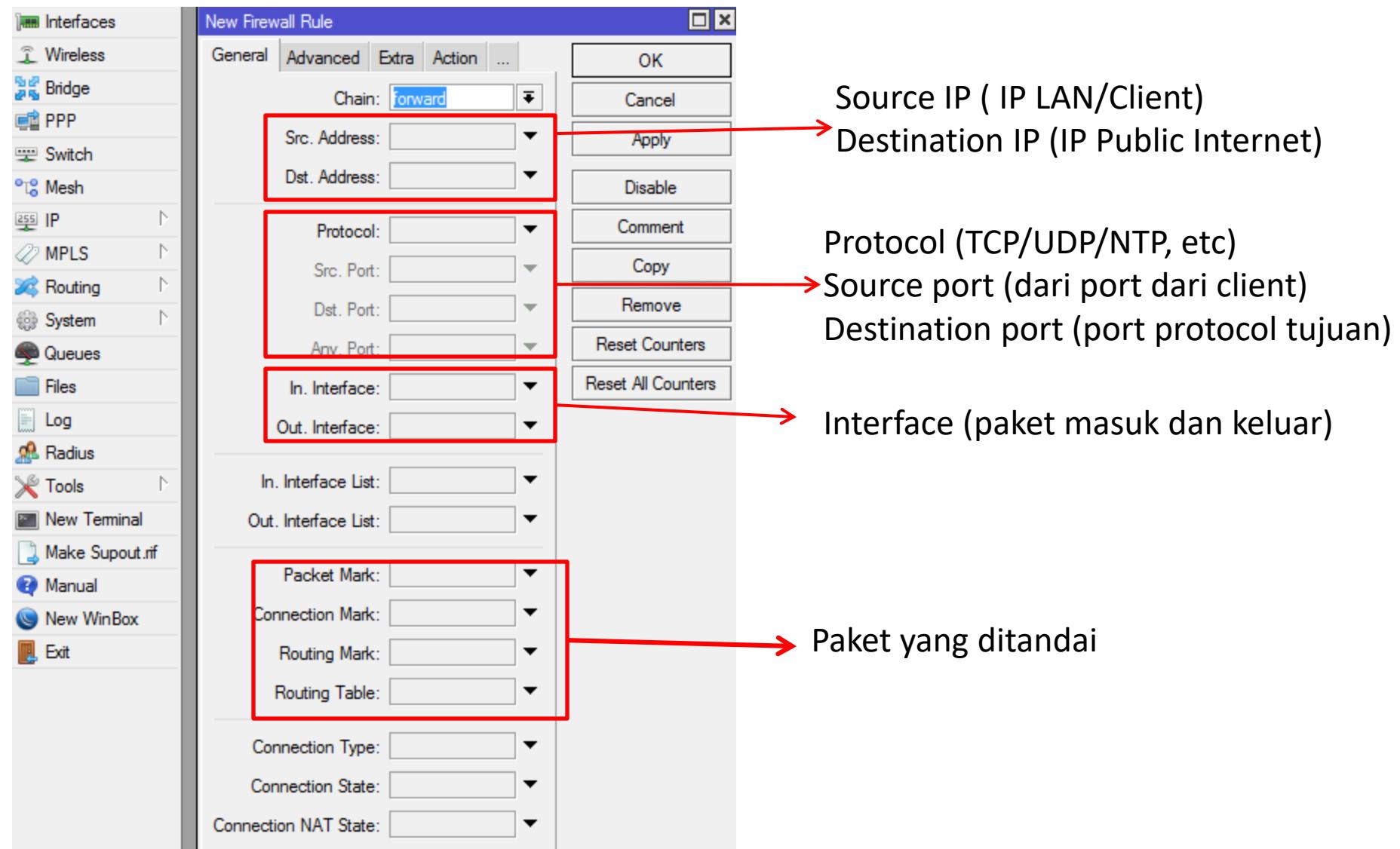
Firewall Filter Rule



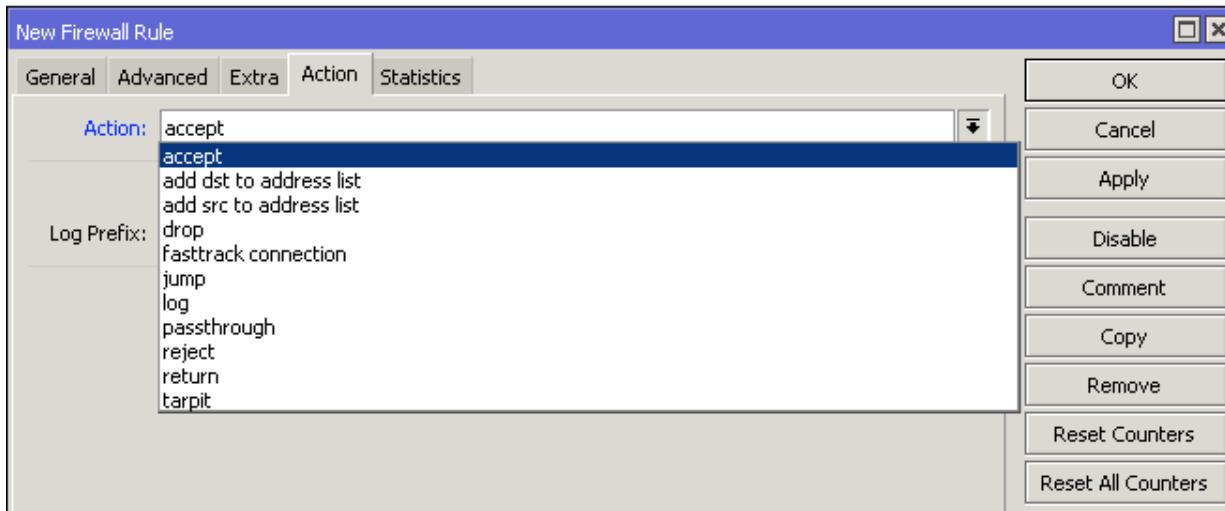
Firewall Rule

- Bekerja dengan algoritma **IF -Then** (Jika-Maka)
- **IF (jika)** packet memenuhi syarat kriteria yang kita buat.
- **THEN (maka) action** apa yang akan dilakukan pada packet tersebut
- Chain dibaca oleh RouterOS Berurutan
- By default terdapat chain yang sudah ada
- Bisa menambahkan chain baru atau custom chain

Firewall – IF (Condition)



Firewall – THEN (Action)



IP → Firewall → New Firewall Rule (+) → Action

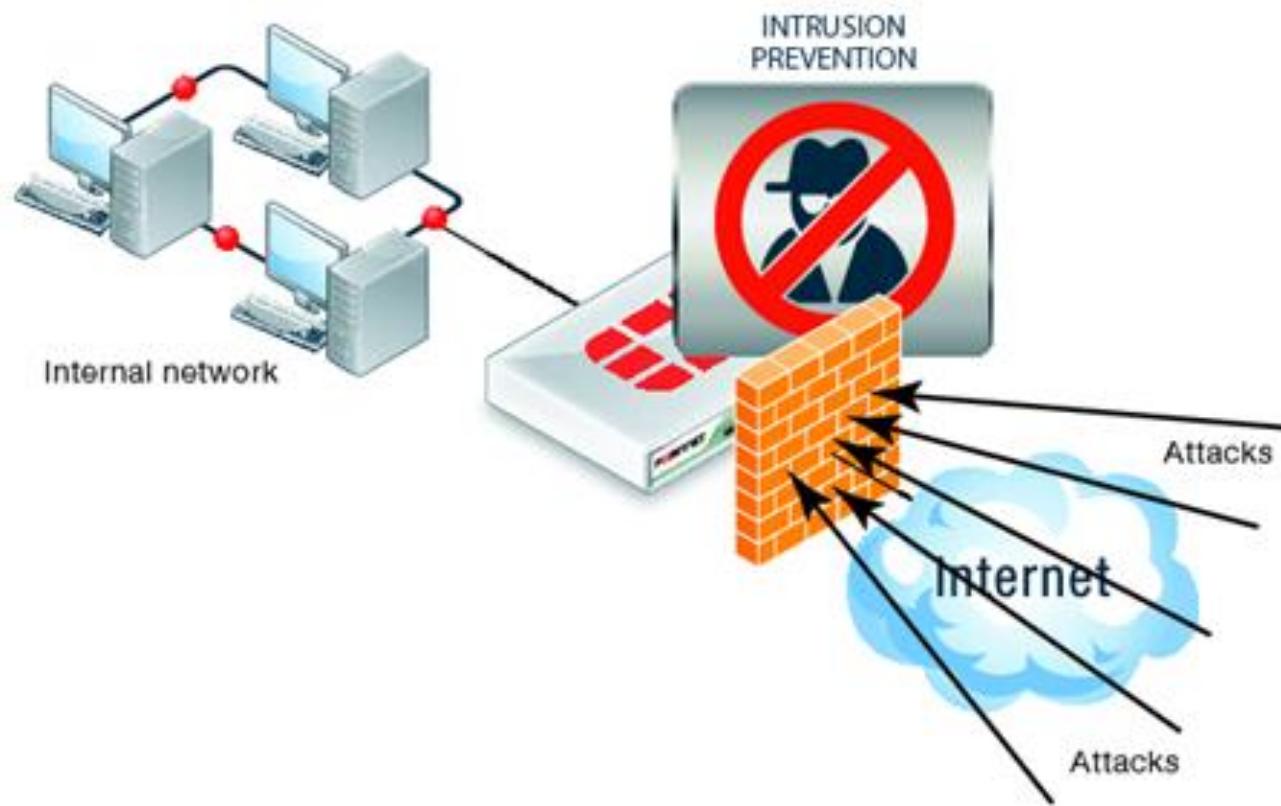
Filter Actions

- Setiap aturan chain memiliki action, apakah yang akan dilakukan ketika paket ada yg cocok dengan chain :
- **Accept**
- **Drop** (diam-diam) atau **reject** (drop dan send ICMP information)
- **Jump/return** menuju atau dari chain yang telah ditentukan
- Dan lainnya lihat firewall wikipage mikrotik

Best Practice Setting Firewall

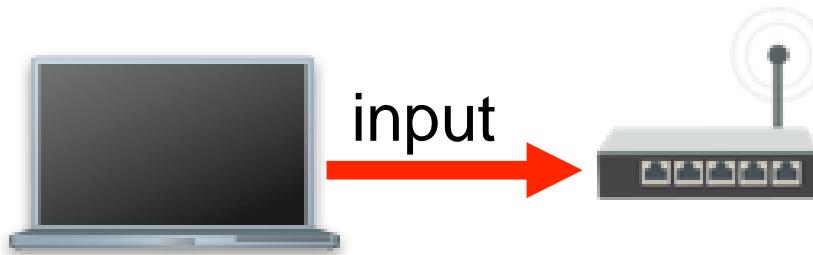
- Banyak traffik yang harus difilter dan dipilah mana yang harus di perbolehkan (accept) dan mana yang harus di buang (drop)
- Ada 2 metode untuk menyederhanakan rule firewall yang kita buat:
 - Drop beberapa, lainnya diterima (*drop few, accept any*)
 - Terima beberapa, lainnya dibuang (*accept few, drop any*)
- By default bila tidak ada rule apapun di firewall, semua traffik akan di diterima oleh router

IPS (Intrusion Prevention System)

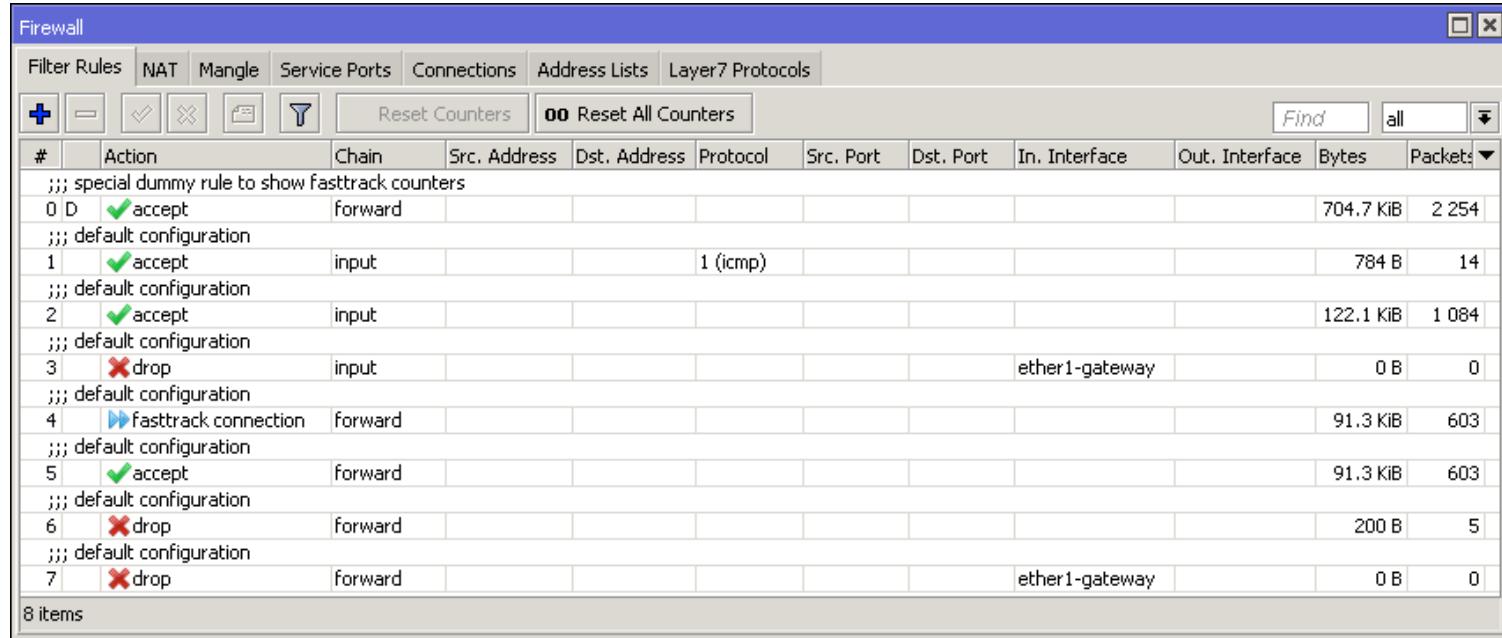


Mengamankan RouterBoard dari serangan internet to LAN

- Buka File konfigurasi di Notepad dan kemudian copy paste konfigurasi ke routerboard



Filter Chains



The screenshot shows a Windows-style application window titled "Firewall". The menu bar includes "File", "Edit", "Filter Rules", "NAT", "Mangle", "Service Ports", "Connections", "Address Lists", and "Layer7 Protocols". The "Filter Rules" tab is selected. Below the menu is a toolbar with icons for adding (+), deleting (-), accepting (checkmark), dropping (cross), and saving (disk). A "Reset Counters" button is also present. The main area is a table with the following columns: #, Action, Chain, Src. Address, Dst. Address, Protocol, Src. Port, Dst. Port, In. Interface, Out. Interface, Bytes, and Packets. The table contains 8 items, each with a comment starting with ";;".

#	Action	Chain	Src. Address	Dst. Address	Protocol	Src. Port	Dst. Port	In. Interface	Out. Interface	Bytes	Packets
;; special dummy rule to show fasttrack counters											
0	D ✓accept	forward								704.7 KiB	2 254
;; default configuration											
1	D ✓accept	input			1 (icmp)					784 B	14
;; default configuration											
2	D ✓accept	input								122.1 KiB	1 084
;; default configuration											
3	D ✗drop	input						ether1-gateway		0 B	0
;; default configuration											
4	D ➤ fasttrack connection	forward								91.3 KiB	603
;; default configuration											
5	D ✓accept	forward								91.3 KiB	603
;; default configuration											
6	D ✗drop	forward								200 B	5
;; default configuration											
7	D ✗drop	forward						ether1-gateway		0 B	0

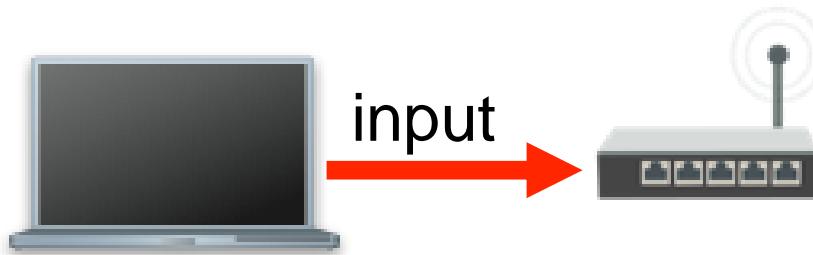
IP → Firewall

- TIP: untuk memudahkan troubleshooting nantinya, lebih baik jika firewall rule yang kita buat diberi comments agar mudah dikenali

Mengamankan akses ke RouterBoard dari LAN

LAB

- Membuat rule hanya IP address laptop pribadi yang bisa mengakses ke routerboard

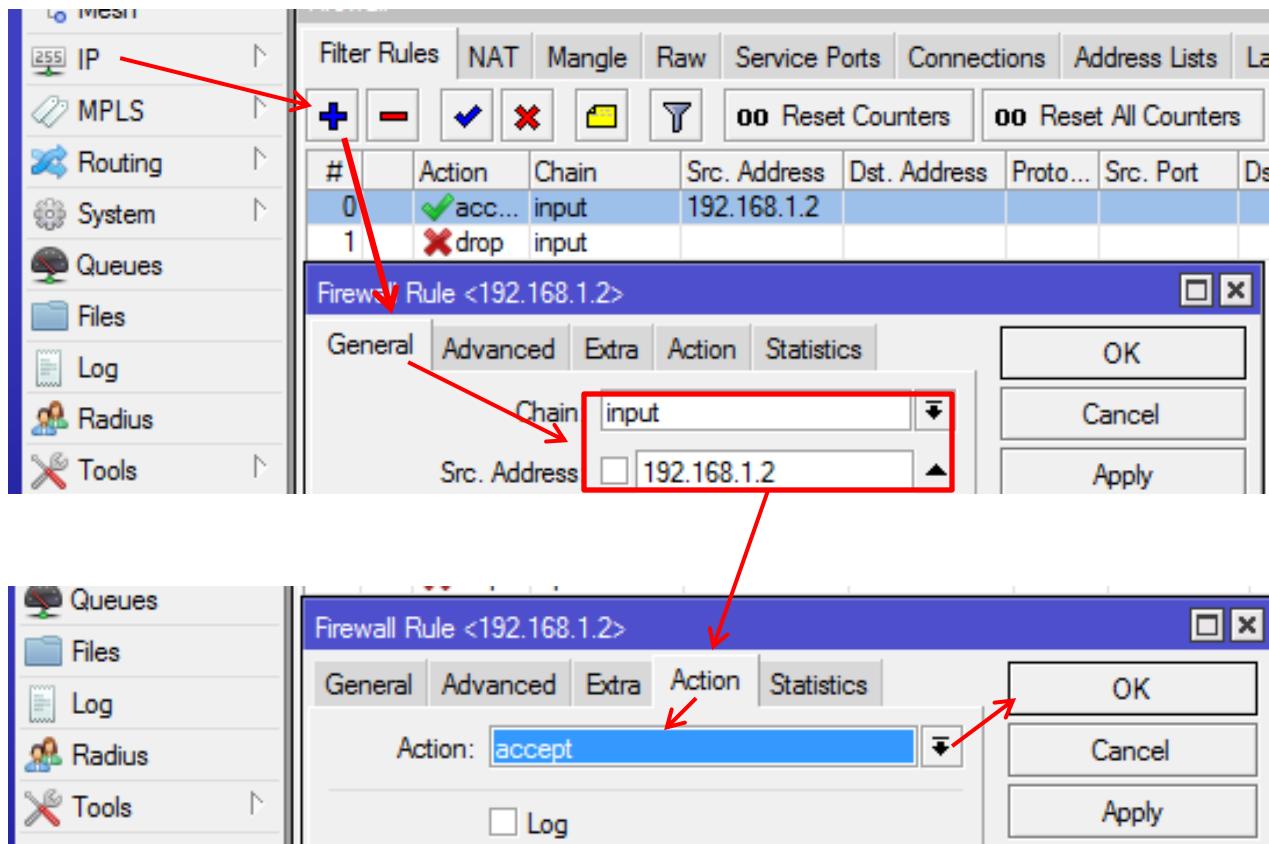


Chains: input

- Buatlah rule **accept input** di firewall filter pada interface yang menuju laptop anda contoh (src.address = 192.168.x.2)
- Buatlah rule **drop input** aturan filter pada interface yang menuju ke laptop anda tanpa src.address

LAB

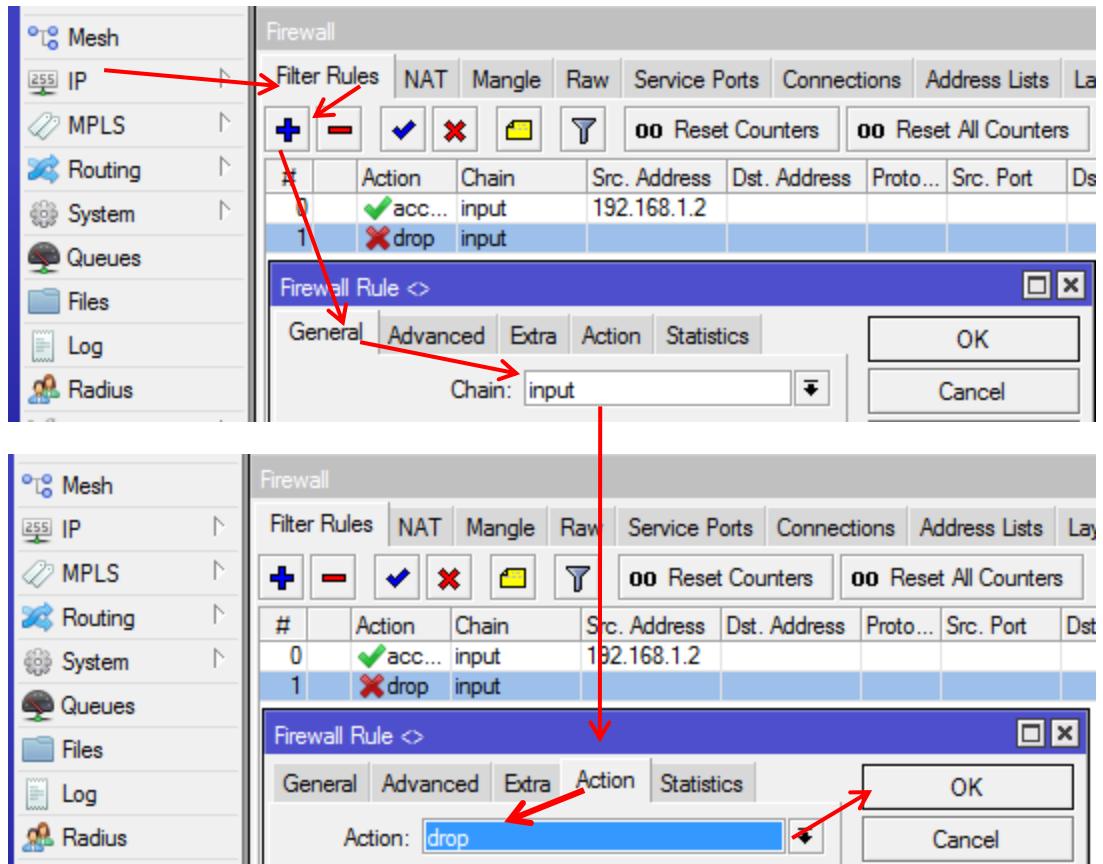
Mengamankan akses ke RouterBoard



IP → Firewall → New Firewall Rule (+)

LAB

Mengamankan akses ke RouterBoard



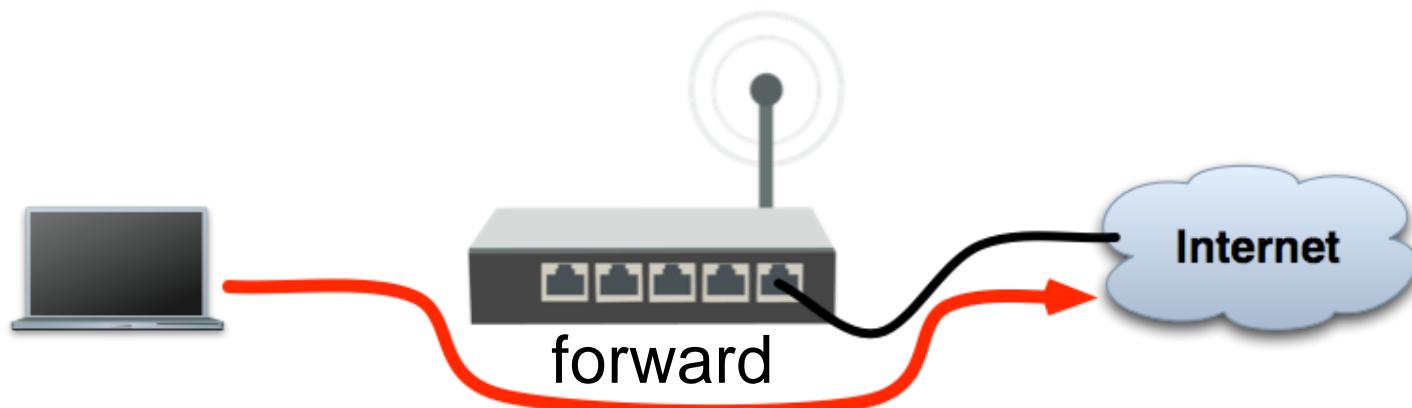
IP → Firewall → New Firewall Rule (+)

Mengamankan akses ke RouterBoard

- Ubahlah IP address laptop anda,dengan menganti IP address yang berbeda dari yang telah dibuat pada firewall input src.address sebelumnya.
- Lakukan verifikasi dengan coba login melalui winbox dengan ip address
- **Apakah bisa Login ke perangkat Mikrotik ?**

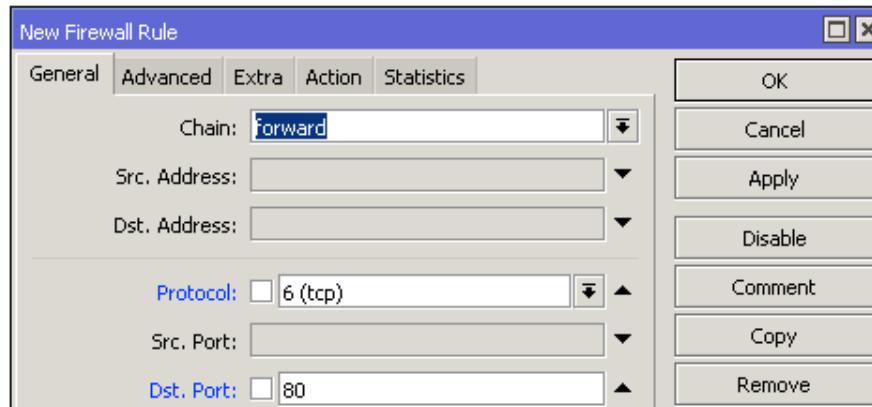
Chain: forward

- Aturan yang mana paket yang melewati/melalui router akan dikontrol
- Chain Forward mengontrol lalu lintas traffic antara client dan internet, walaupun antara client itu sendiri



Chain: forward

- Buatlah rule drop forward untuk aturan memfilter/memblok youtube.com
- Menggunakan metode layer 7



IP → Firewall → New Firewall Rule (+)

Drop Akses domain dari client to internet

- Web Proxy (hanya HTTP, HTTPS tidak bisa)
- Content
- Addreslist
- Layer 7
- TLS

Drop menggunakan layer 7

The image shows two screenshots of the MikroTik Winbox interface. The top screenshot displays the main menu on the left and the Firewall tab selected in the top navigation bar. The bottom screenshot shows a detailed configuration dialog for a Firewall L7 Protocol rule.

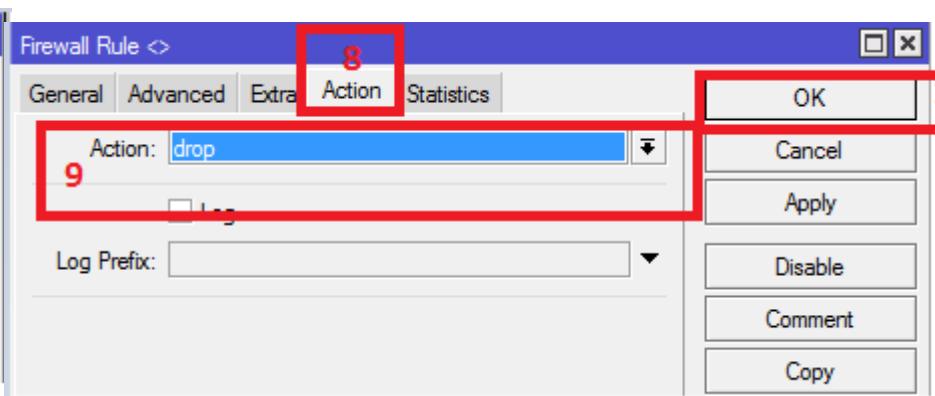
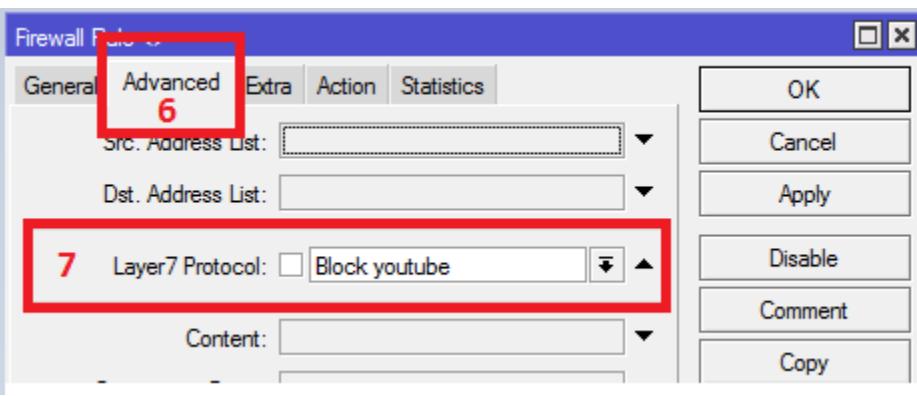
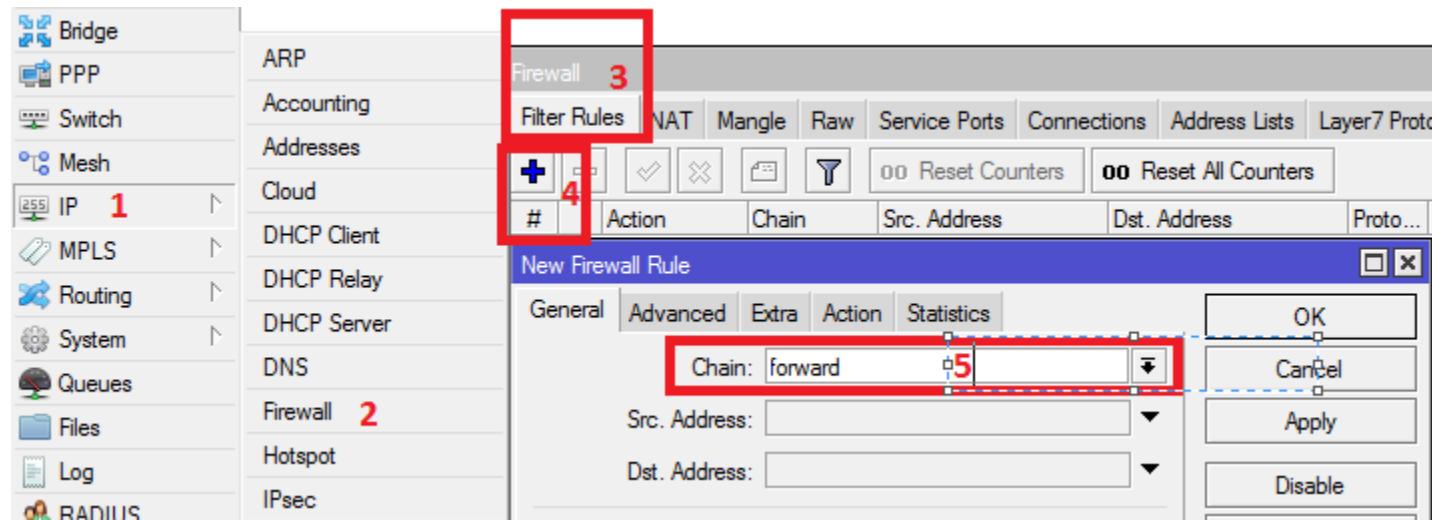
Top Screenshot (Main Menu):

- Left sidebar:
 - PPP
 - Switch
 - Mesh
 - IP 1**
 - MPLS
 - Routing
 - System
 - Queues
 - Firewall **2**
 - Files
- Top navigation bar: ARP, Firewall, Accounting, Addresses, Cloud, DHCP Client, DHCP Relay, DHCP Server, DNS, Firewall **2**.
- Right panel: Firewall tab selected, showing Filter Rules, NAT, Mangle, Raw, Service Ports, Connections, Address Lists, and Layer7 Protocols tab (highlighted with a red box).

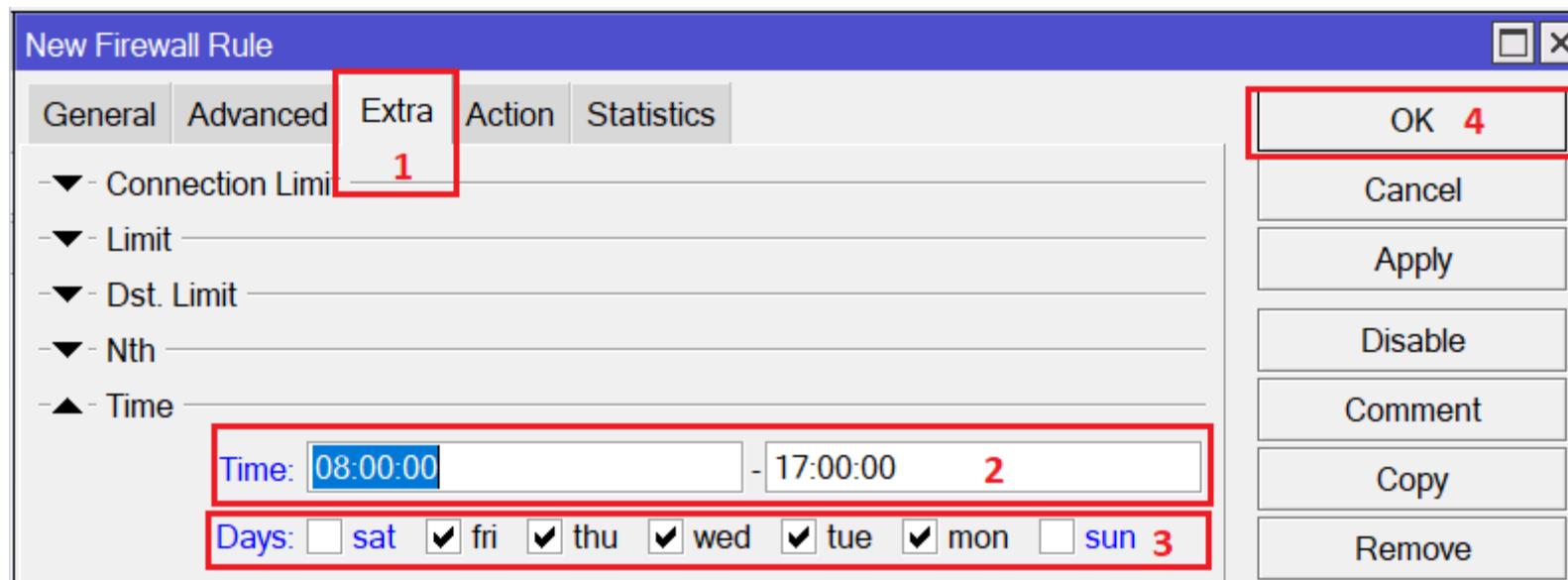
Bottom Screenshot (Detailed Configuration):

- Left sidebar: Firewall tab selected.
- Top navigation bar: Filter Rules, NAT, Mangle, Raw, Service Ports, Connections, and Layer7 Protocols tab (highlighted with a red box).
- Buttons: New (highlighted with a red box), Delete, Copy, Paste, and Filter.
- Table header: Name **4**, Regexp.
- Table row: Block youtube, .youtube.*.
- Modal dialog: Firewall L7 Protocol <Block youtube>
 - Name: **Block youtube 2** (highlighted with a red box).
 - Regexp: **.youtube.* 3** (highlighted with a red box).
 - Buttons: OK **4** (highlighted with a red box), Cancel, Apply, Comment, Copy, and Remove.

Drop menggunakan layer 7

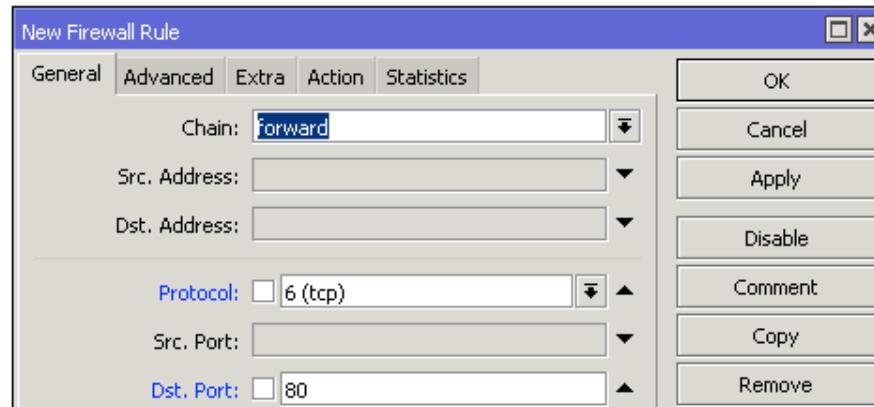


Drop Akses domain dari client to internet (berdasarkan waktu)



Drop Akses Aplikasi dari client to internet (berdasarkan Protocol dan Port)

- Buatlah rule drop forward untuk aturan memfilter/memblok aplikasi game
- Ketika kita menginginkan port lebih spesifik, IP protocol harus di pilih



IP → Firewall → New Firewall Rule (+)

Drop Akses Aplikasi dari client to internet (berdasarkan Protocol dan Port)

Google port game terbaru 2021 1

Sekitar 716.000.000 hasil (0,64 detik)

<https://bilhanet.com/daftar-port-game-online-untuk-mikrotik-firewall> 2

Daftar Port Game Online untuk MikroTik Firewall - BILHANET 2

UPDATE 11 Juli 2021 ... yang 2021 sudah ada atau masih sama dengan yang lama gan, ...
semoga sehat selalu dan sering update port game terbaru.

4 Des 2020 · Diupload oleh BILHANET

Daftar Port Game Online untuk... · Mobile Legend (ML)

Anda telah mengunjungi halaman ini berkali-kali. Kunjungan terakhir: 27/10/21

bilhanet.com/daftar-port-game-online-untuk-mikrotik-firewall/

Learn Cisco Website Lowongan... ALL ABOUT UBIQU... All About Mikrotik gpmnetwork.id beasis

Mobile Legend (ML)

- tcp: 5000-5221,5224-5227,5229-5241,5243-5508,5551-5559,5601-5700,9001,9443
- tcp: 5520-5529,10003,30000-30300
- udp: 4001-4009,5000-5221,5224-5241,5243-5508,5551-5559,5601-5700
- udp: 2702,3702,5517,5520-5529,8001,9000-9010,9992,10003,30000-30300

PUBG Mobile

- tcp: 7889,10012,13004,14000,17000,17500,18081,20000-20002,20371
- udp: 8011,9030,10491,10612,12235,13004,13748,17000,17500,20000-20002
- udp: 7086-7995,10039,10096,11455,12070-12460,13894,13972,41182-41192

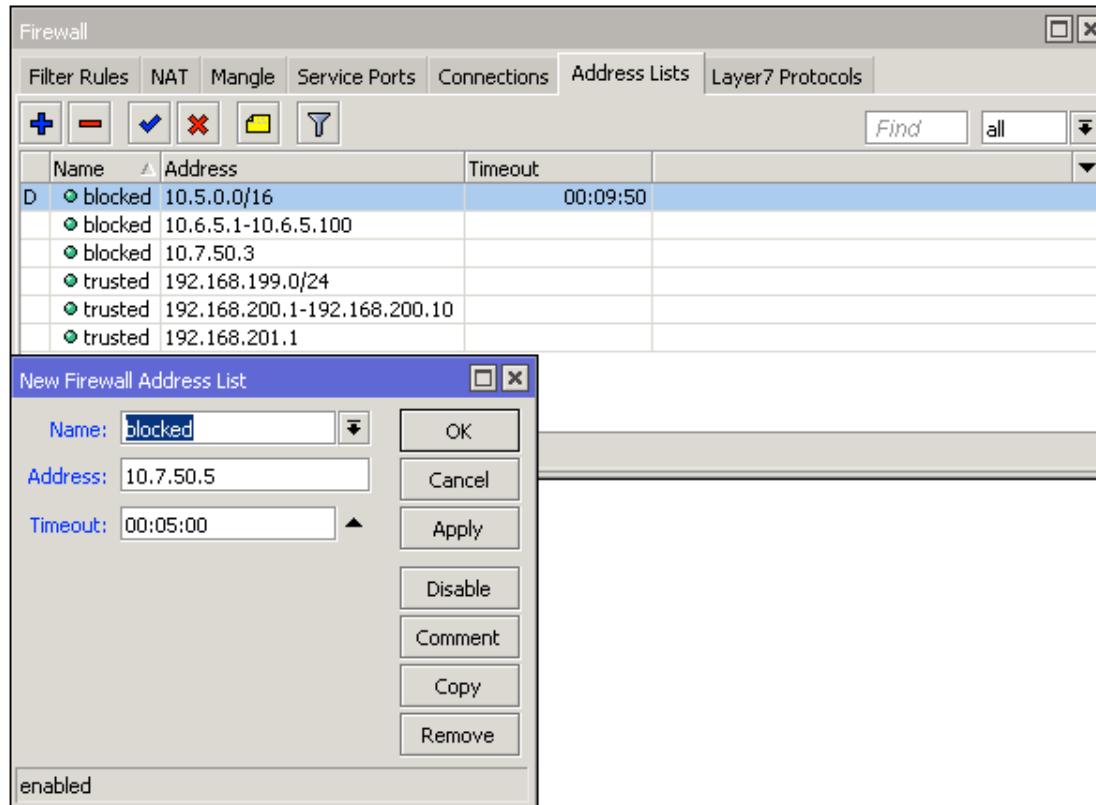
Frequently Used Ports

Port	Service
80/tcp	HTTP
443/tcp	HTTPS
22/tcp	SSH
23/tcp	Telnet
20,21/tcp	FTP
8291/tcp	WinBox
5678/udp	MikroTik Neighbor Discovery
20561/udp	MAC WinBox

Address List

- Address-list digunakan untuk memfilter group IP address dengan 1 rule firewall.
- Dimungkinkan untuk dapat secara otomatis menambahkan IP address ke address list
- IP address dapat di tambahkan ke list address list secara permanen atau hanya sementara berdasarkan waktu
- Address list bisa berupa single IP address atau hanya satu subnet network saja

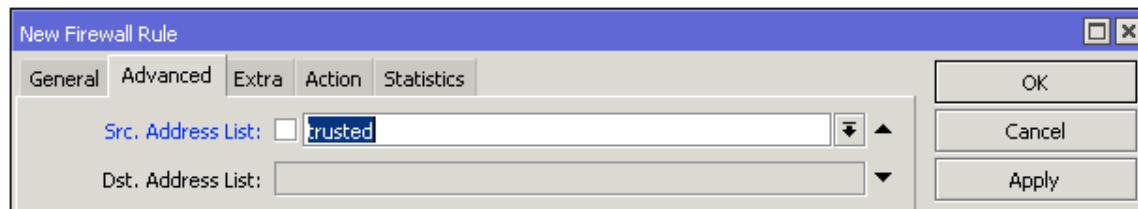
Address List



IP → Firewall → Address Lists → New Firewall Address List (+)

Address List

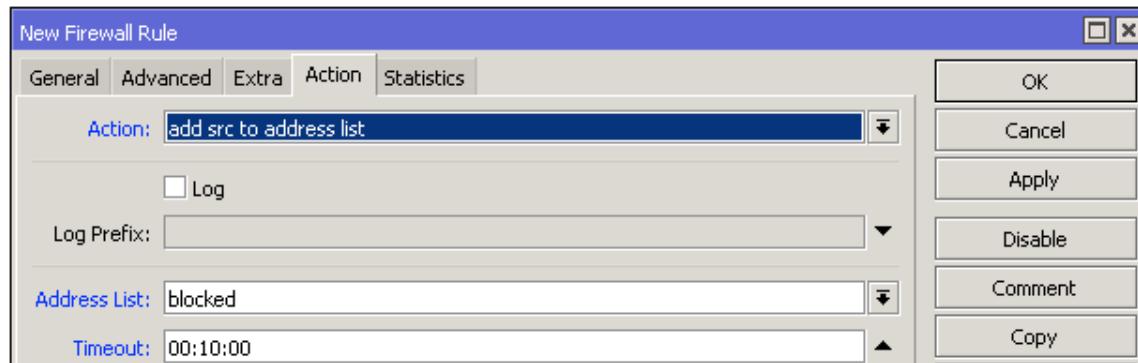
- Address list yang sudah kita buat dimasukkan ke dalam src.address list atau dst.address list pada menu advanced bukan menu general



IP → Firewall → New Firewall Rule (+) → Advanced

Address List

- Firewall action bisa secara otomatis membuat address kedalam address list
- Address list dapat permanen atau hanya sementara



IP → Firewall → New Firewall Rule (+) → Action

Address List

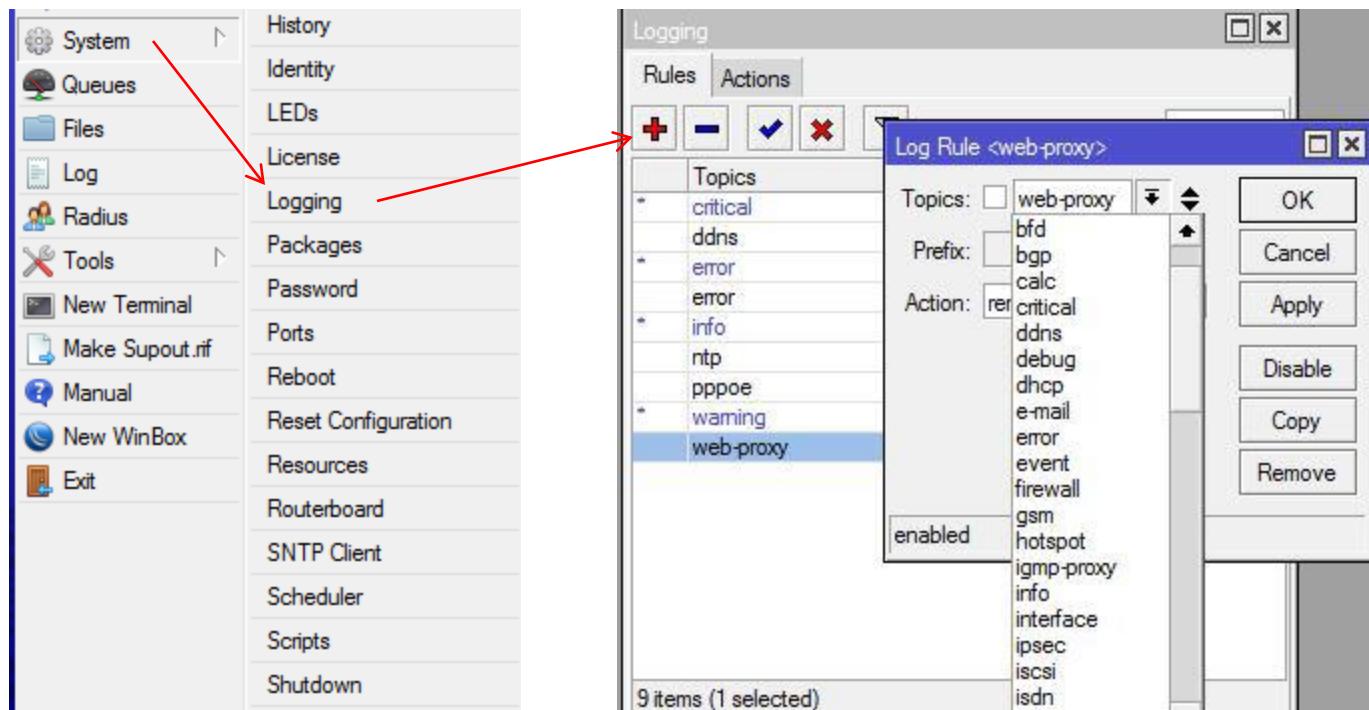
- Buatlah address list dengan domain address yang akan kita blok, contoh detik.com/okezone.com
- Buatlah filter firewall **drop forward** untuk tujuan in-interface lokal atau yang menuju laptop RouterBoard anda , untuk semua traffic dengan tujuan address list yan kita buat dapat di blok oleh RouterBoard

Firewall Log

- Setiap rule firewall bisa di masukkan di Log
- Bisa ditentukan prefix spesifik (nama) untuk memudahkan menemukan logs dikemudian hari, untuk keperluan analisa

LAB

Firewall Log



Connection Tracking

Firewall									
	Filter Rules	NAT	Mangle	Raw	Service Ports	Connections	Address Lists	Layer7 Protocols	
	Tracking								
SACs	192.168.114.253:51322	108.177.97.188:5228	6 (tcp)		Connectio...	21:07:44	established	0 bps/0 bps	1909 B/13.5 KiB
SACs	192.168.115.9:39381	165.243.59.241:48920	17 (ud...			00:02:58		512 bps/1024 bps	1546.1 KiB/1540.9 ...
SACs	192.168.115.9:52291	47.74.249.5:8802	17 (ud...			00:02:46		0 bps/0 bps	561.0 KiB/597.3 KiB
SACs	192.168.115.9:53264	47.241.231.194:15301	6 (tcp)			23:59:59	established	2.6 kbps/1768 bps	385.9 KiB/260.5 KiB
SACs	192.168.115.11:52144	64.233.189.188:5228	6 (tcp)			00:02:10	established	0 bps/0 bps	1161 B/18.2 KiB
SACs	192.168.115.11:63618	52.137.103.130:443	6 (tcp)	T-Int		03:03:22	established	0 bps/0 bps	1915 B/4525 B
SACs	192.168.115.12:53949	165.243.17.15:53	6 (tcp)	T-Int		05:45:01	established	0 bps/0 bps	168 B/88 B
SACs	192.168.115.13:50685	172.217.31.174:443	17 (ud...	T-Int		00:01:26		0 bps/0 bps	5.4 KiB/4834 B
SACs	192.168.115.13:53975	8.8.4.4:443	17 (ud...	T-Int		00:02:00		0 bps/0 bps	4071 B/4947 B
SACs	192.168.115.13:54266	20.198.162.78:443	6 (tcp)	T-Int		23:46:19	established	0 bps/0 bps	3655 B/5.9 KiB
SACs	192.168.115.13:54302	8.215.3.116:800	6 (tcp)			23:59:53	established	0 bps/0 bps	22.3 KiB/19.4 KiB
SACs	192.168.115.13:54476	52.88.108.8:443	6 (tcp)	T-Int		23:56:15	established	0 bps/0 bps	3677 B/6.4 KiB
SACs	192.168.115.13:54859	31.13.70.49:443	6 (tcp)	T-Int		00:04:59	established	2.3 kbps/0 bps	183.2 KiB/3029.9 KiB
SACs	192.168.115.13:54862	119.161.16.12:443	6 (tcp)	T-Int		23:59:49	established	0 bps/0 bps	317.2 KiB/4265.8 KiB
SACs	192.168.115.13:55700	35.244.247.133:443	6 (tcp)	T-Int		23:59:36	established	0 bps/0 bps	2246 B/4827 B
SACs	192.168.115.13:55707	172.217.31.174:443	6 (tcp)	T-Int		23:59:34	established	0 bps/0 bps	1547 B/7.7 KiB
SACs	192.168.115.13:55708	204.79.197.219:443	6 (tcp)	T-Int		23:59:48	established	0 bps/0 bps	1920 B/6.8 KiB
SACs	192.168.115.13:55709	204.79.197.219:443	6 (tcp)	T-Int		23:59:48	established	0 bps/0 bps	884 B/487 B
SACs	192.168.115.13:56904	31.13.70.49:443	17 (ud...	T-Int		00:01:16		0 bps/0 bps	2003 B/6.4 KiB
SACs	192.168.115.13:62332	172.217.31.142:443	17 (ud...	T-Int		00:00:04		0 bps/0 bps	3675 B/4714 B
SACs	192.168.115.22:35318	172.217.175.227:443	6 (tcp)	T-Int		05:41:05	established	0 bps/0 bps	1077 B/5.1 KiB
SACs	192.168.115.22:44078	31.13.70.1:443	6 (tcp)	T-Int		05:41:02	established	0 bps/0 bps	4942 B/4846 B
SACs	192.168.115.22:45878	47.89.93.129:80	6 (tcp)	T-Int		05:43:48	established	0 bps/0 bps	950 B/798 B
SACs	192.168.115.22:50252	172.217.175.42:443	6 (tcp)	T-Int		05:41:08	established	0 bps/0 bps	1048 B/1696 B
SACs	192.168.115.22:50284	172.217.175.42:443	6 (tcp)	T-Int		05:40:55	established	0 bps/0 bps	1057 B/5.5 KiB
SACs	192.168.115.22:50298	172.217.175.42:443	6 (tcp)	T-Int		05:41:13	established	0 bps/0 bps	1057 B/5.5 KiB
SACs	192.168.115.22:50302	47.89.74.73:80	6 (tcp)	T-Int		05:42:10	established	0 bps/0 bps	1258 B/918 B
SACs	192.168.115.22:54650	64.233.189.188:5228	6 (tcp)			01:27:09	established	0 bps/0 bps	2282 B/7.8 KiB
SACs	192.168.115.22:55906	31.13.70.50:443	6 (tcp)	T-Int		05:43:31	established	0 bps/0 bps	1284 B/1680 B

Connection Tracking

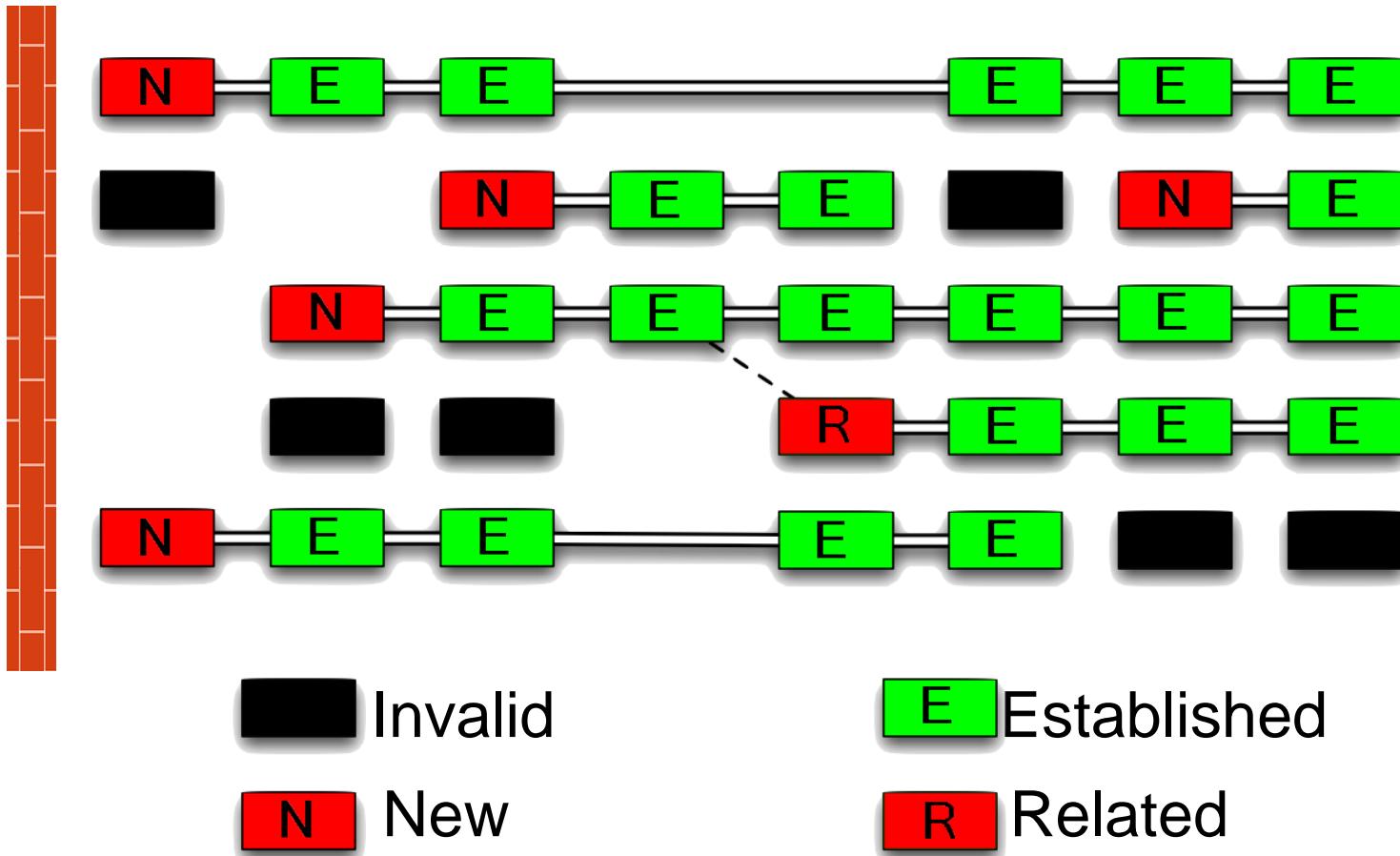
Jika Anda tidak ingin ada paket - paket invalid lalu lalang di jaringan Anda, Anda juga bisa melakukan filtering dengan mendefinisikan parameter connection state.

Paket invalid merupakan paket yang tidak memiliki koneksi dan tidak berguna sehingga hanya akan membebani resource jaringan. Kita bisa melakukan drop terhadap paket - paket ini dengan mendefinisikan parameter connection state.

Connection Tracking

- Connection Tracking dapat dilihat pada menu **IP > firewall > connection**.
 - Connection tracking mempunyai kemampuan untuk dapat melihat informasi koneksi seperti source dan destination IP dan port yang sedang digunakan,
 - status koneksi, tipe protocol, dll.
- **established** = *the packet is part of already known connection*
- **new** = the packet starts a new connection or belongs to a connection that has not seen packets in both directions yet
- **related** = the packet starts a new connection, but is associated with an existing connection, such as FTP data transfer or ICMP error message.
- **invalid** = the packet does not belong to any known connection and, at the same time, does not open a valid new connection.

Connections



Connection Tracking

Firewall						
	Filter Rules	NAT	Mangle	Service Ports	Connections	Address Lists
C	Src. Address	Dst. Address	Protocol	Connection Mark	Timeout	TCP State
C	192.168.199.200:17500	255.255.255.255:17500	17 (udp)		00:00:09	
SACFs	192.168.199.200:11785	213.199.179.172:40035	17 (udp)		00:00:30	
SACFs	192.168.199.200:11785	213.199.179.157:40023	17 (udp)		00:02:35	
SACFs	192.168.199.200:11785	213.199.179.153:40025	17 (udp)		00:00:30	
C	192.168.199.200:17500	192.168.199.255:17500	17 (udp)		00:00:09	
SAC	192.168.199.200:59898	192.168.199.254:8291	6 (tcp)	23:59:59 established		
SACFs	192.168.199.200:62355	191.235.128.131:443	6 (tcp)		00:00:09	close
SACFs	192.168.199.200:11785	157.56.52.44:40026	17 (udp)		00:00:30	
SACFs	192.168.199.200:11785	157.56.52.29:40021	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	157.55.235.172:40018	17 (udp)		00:02:30	
SACFs	192.168.199.200:11785	157.55.235.172:40002	17 (udp)		00:02:35	
SACFs	192.168.199.200:11785	157.55.235.157:40021	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	157.55.235.146:40005	17 (udp)		00:00:27	
SACFs	192.168.199.200:11785	157.55.130.176:40035	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	157.55.56.148:40032	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	152.236.66.231:48760	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	111.221.77.174:40003	17 (udp)		00:02:32	
SACFs	192.168.199.200:11785	111.221.77.170:40013	17 (udp)		00:00:31	
SACFs	192.168.199.200:11785	111.221.77.170:40004	17 (tcp)		00:00:31	

41 items (1 selected) Max Entries: 88080

Connection Tracking

Enabled: auto

TCP Syn Sent Timeout: 00:00:05

TCP Syn Received Timeout: 00:00:05

TCP Established Timeout: 1d 00:00:00

TCP Fin Wait Timeout: 00:00:10

TCP Close Wait Timeout: 00:00:10

TCP Last Ack Timeout: 00:00:10

TCP Time Wait: 00:00:10

TCP Close: 00:00:10

TCP Max Retransmit Timeout: 00:05:00

TCP Unacked Timeout: 00:05:00

UDP Timeout: 00:00:10

UDP Stream Timeout: 00:03:00

ICMP Timeout: 00:00:10

Generic Timeout: 00:10:00

IP → Firewall → Connections

Connection Tracking

- Pada saat membuat firewall, pada baris paling atas umumnya akan dibuat rule sebagai berikut:
 - Pada IP>Firewall>Filter Rule buat chain
 - Chain Foward – Connection state invalid > action Drop
 - Connection state established > action Accept
 - Connection state related > action Accept
 - Connection state new > action pass-through
 - System rule ini akan sangat menghemat resource router, karena proses filtering selanjutnya akan dilakukan ketika koneksi dimulai (connection state = new)

NAT

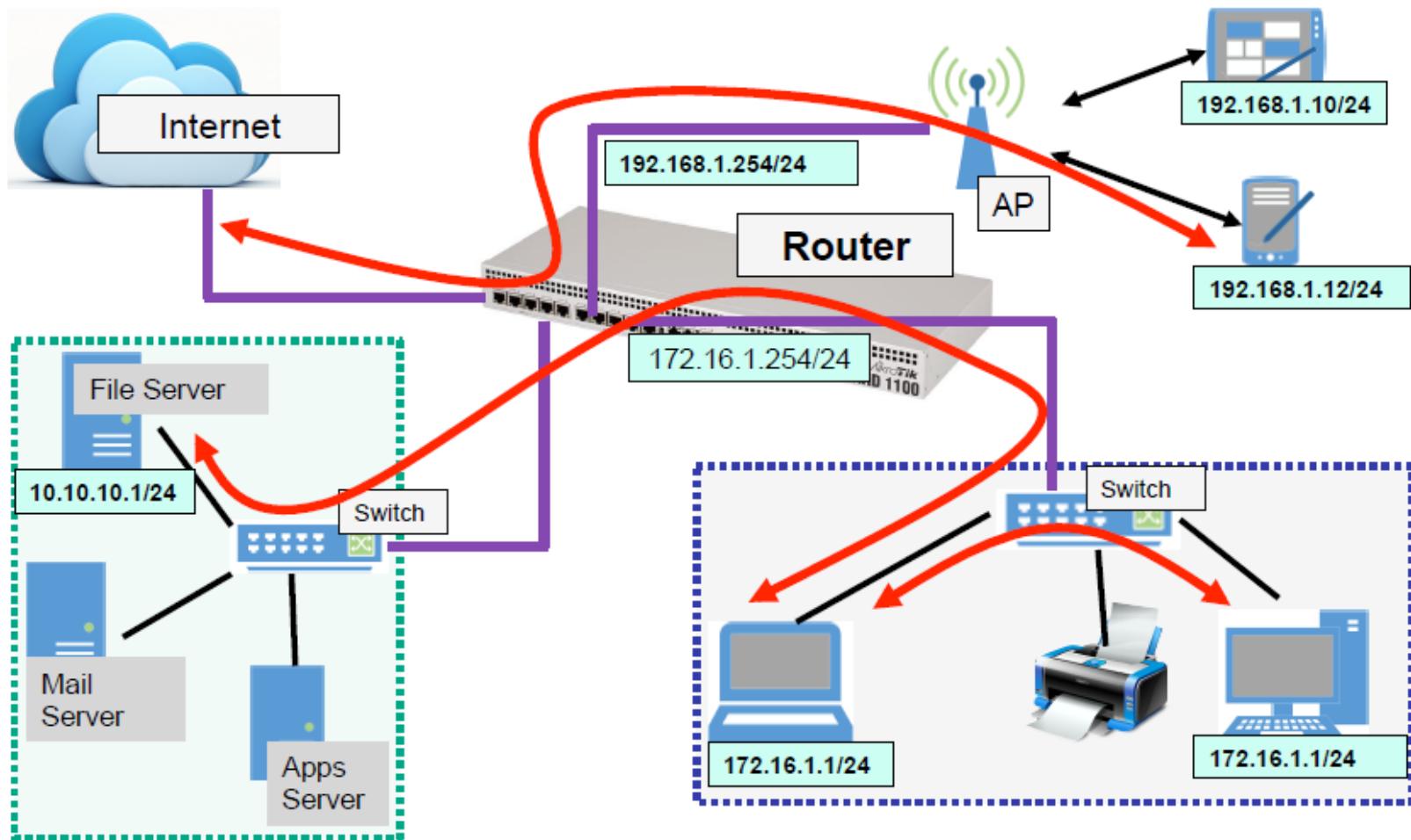
- Network address Translation (NAT) merupakan sebuah metode untuk menentukan atau digunakan memodifikasi source/destination IP address
- Ada 2 type NAT : **src-nat** (source) dan **dst-nat** (destination)

NAT

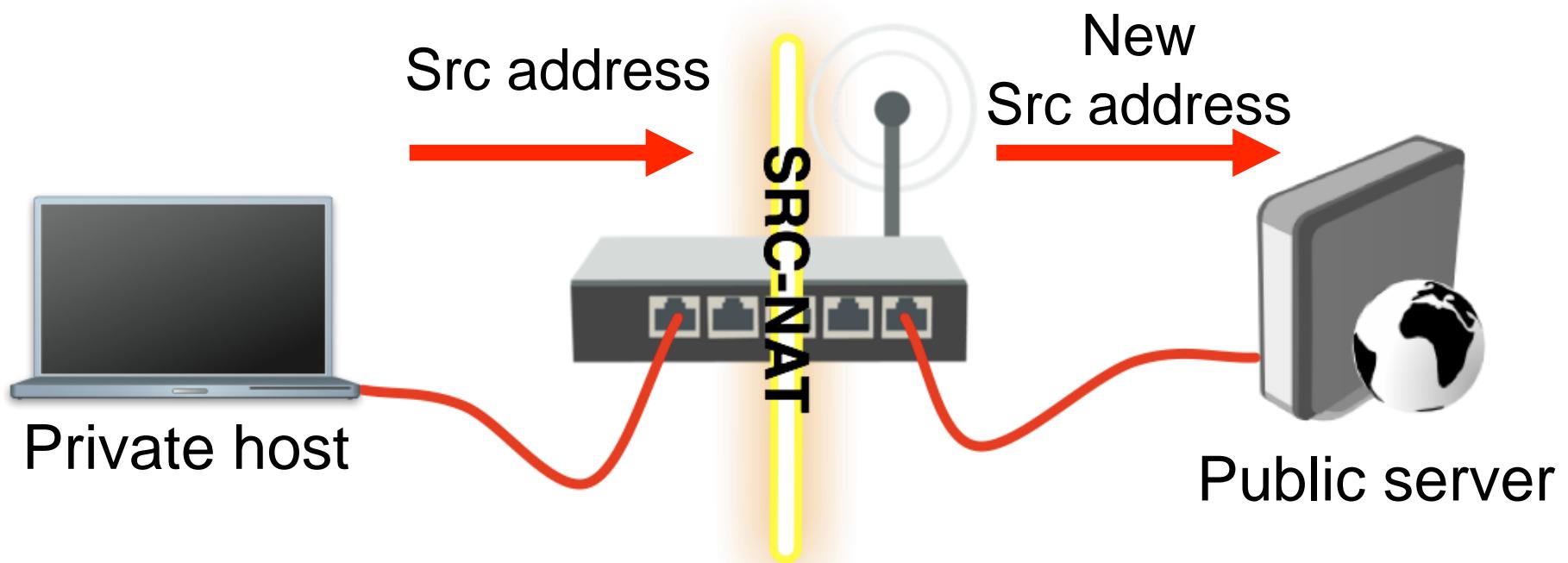
- Nat **src-nat** digunakan untuk menyediakan akses eksternal network untuk dapat diketahui/dikenali IP Private (**src-nat**)
- Nat **dst-nat** dapat digunakan untuk akses jaringan dengan tujuan IP address tertentu dengan port dan protocol yang lebih spesifik pada network interna (**dst-nat**)

Topologi Umum jaringan Komputer

● ● ● | Topologi Office



NAT



NAT – Masquerade

- NAT yaitu suatu teknologi yang dapat mengkoneksikan banyak komputer (LAN) ke Internet (WAN) dengan menggunakan satu atau beberapa IP public
- Tujuan NAT digunakan, karena keterbatasan alamat IP Public
- Tujuan penggunaan NAT terkait keamanan Security dan kemudahan dalam mengelola jaringan

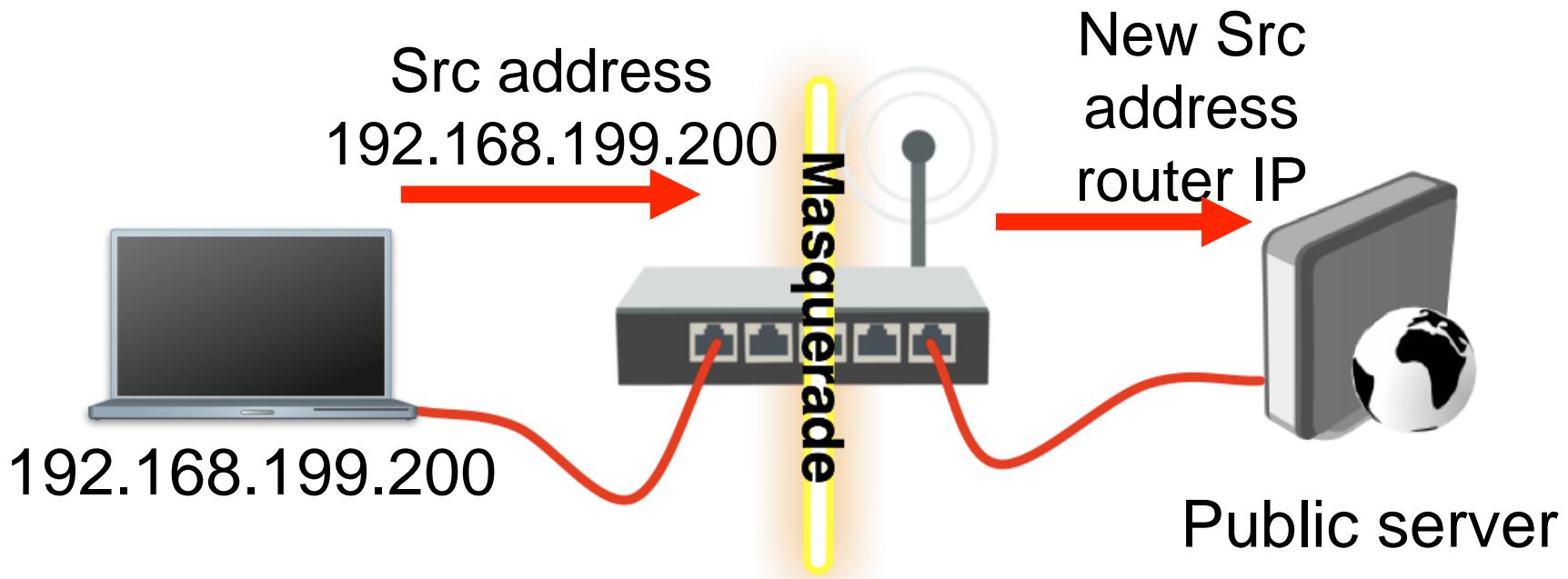
NAT Chain

Chain pada IP Firewall NAT

1. srcnat, dengan action yang diperbolehkan:
Masquerade – subnet LAN to 1 dinamic IP WAN
Src-nat – subnet LAN to 1 static IP WAN

2. dsnat (port fowarding), dengan action yang diperbolehkan:
Dst-nat – membelokkan traffik ke luar router
Redirect – membelokkan traffik ke router sendiri

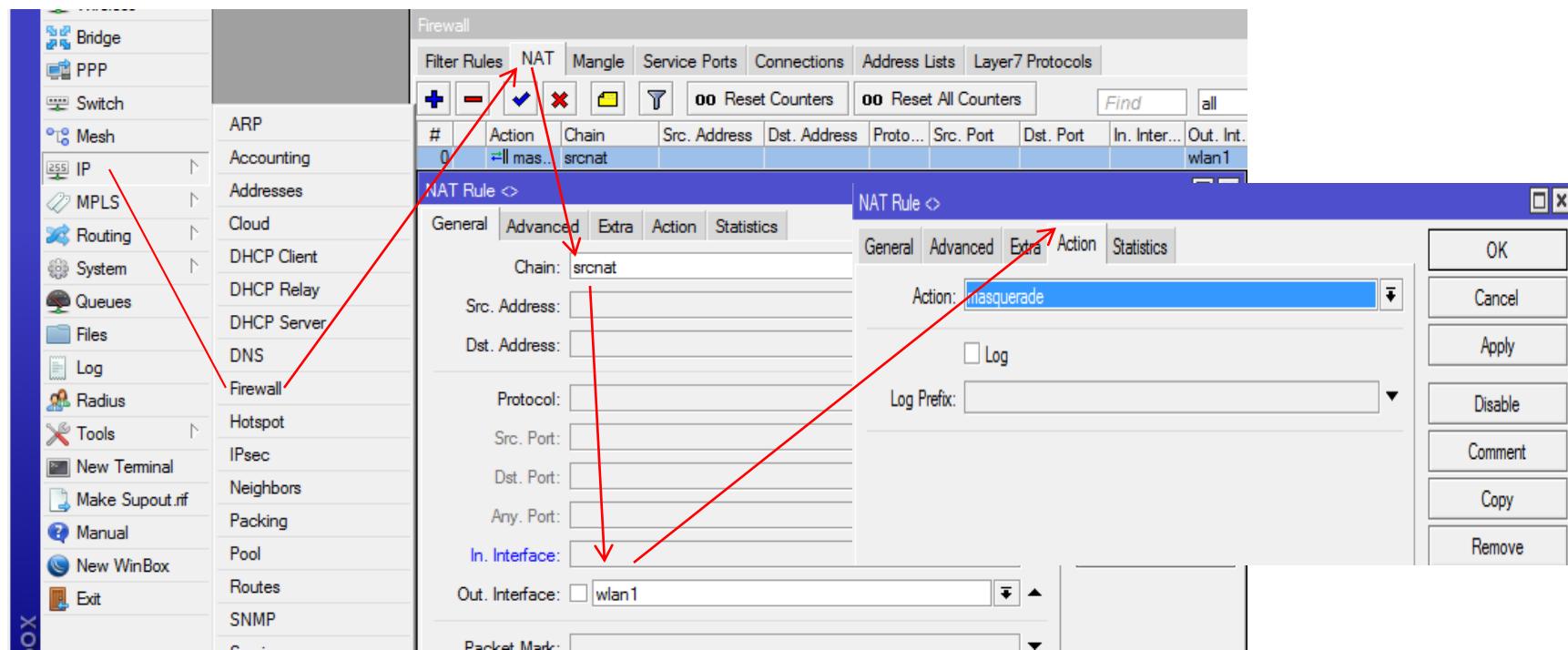
Src NAT



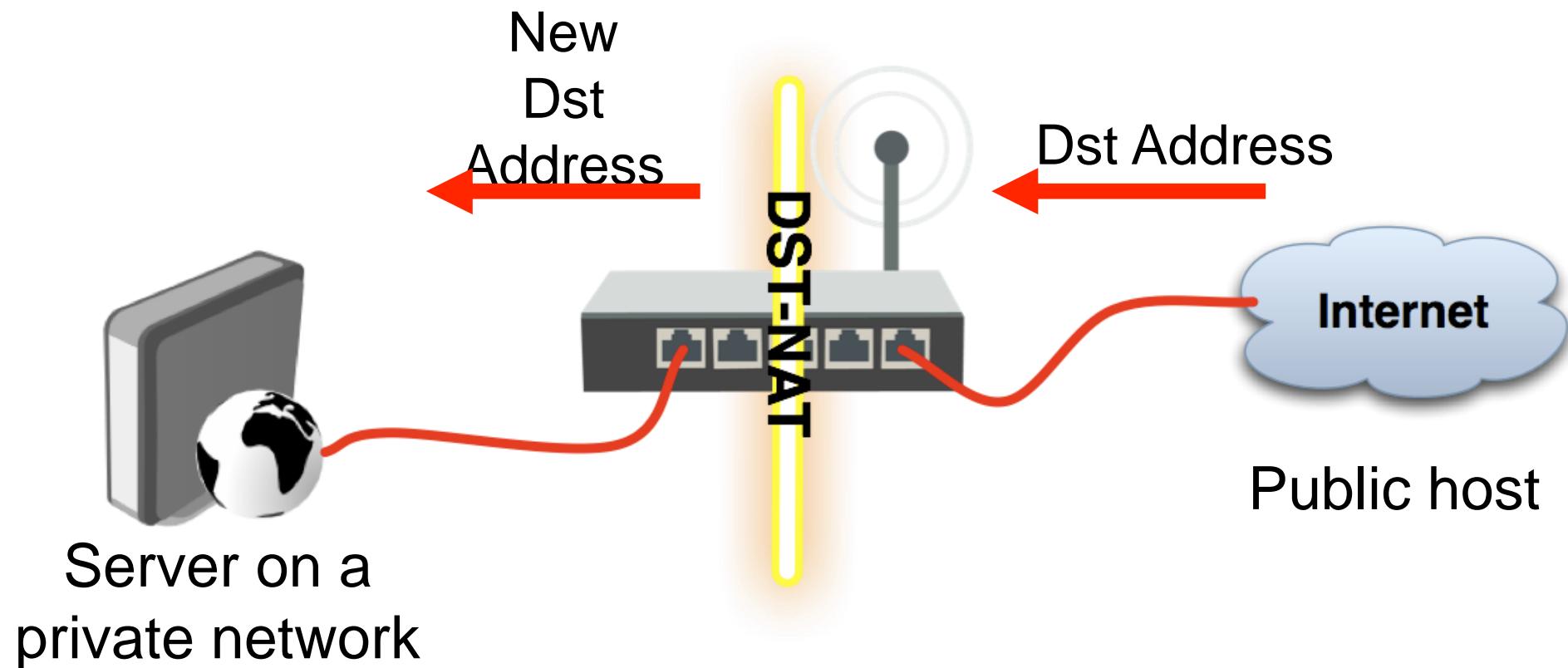
- Masquerade merupakan special type dari **srcnat**

LAB

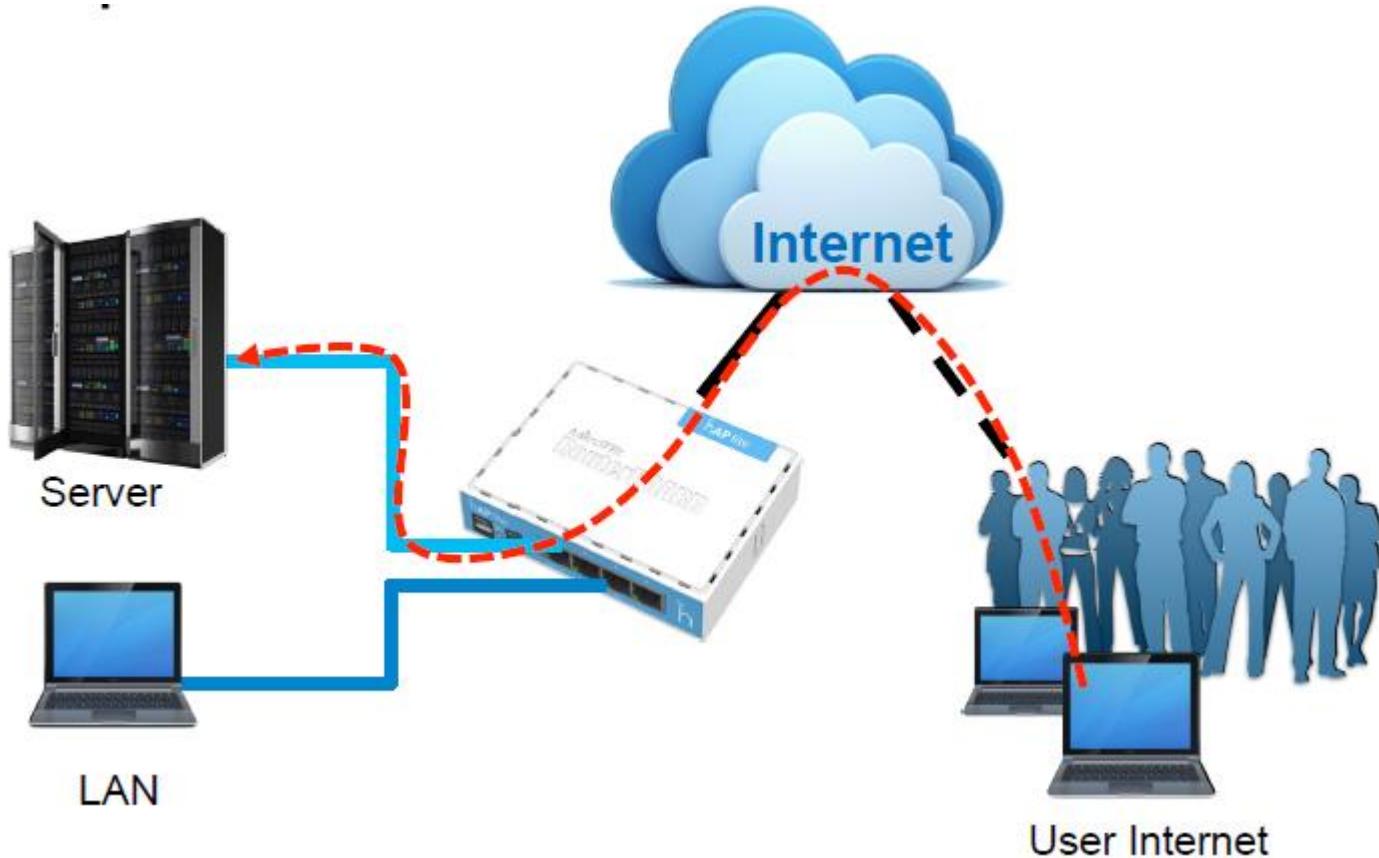
NAT-Masquerade



NAT

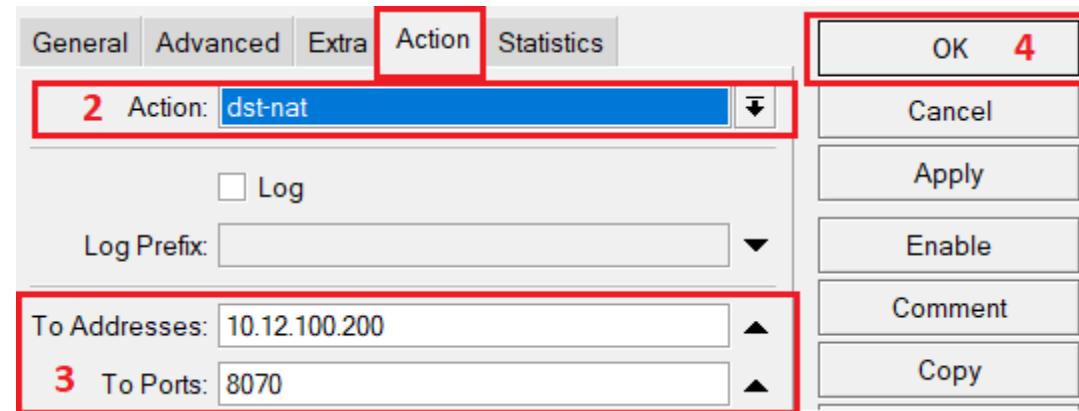
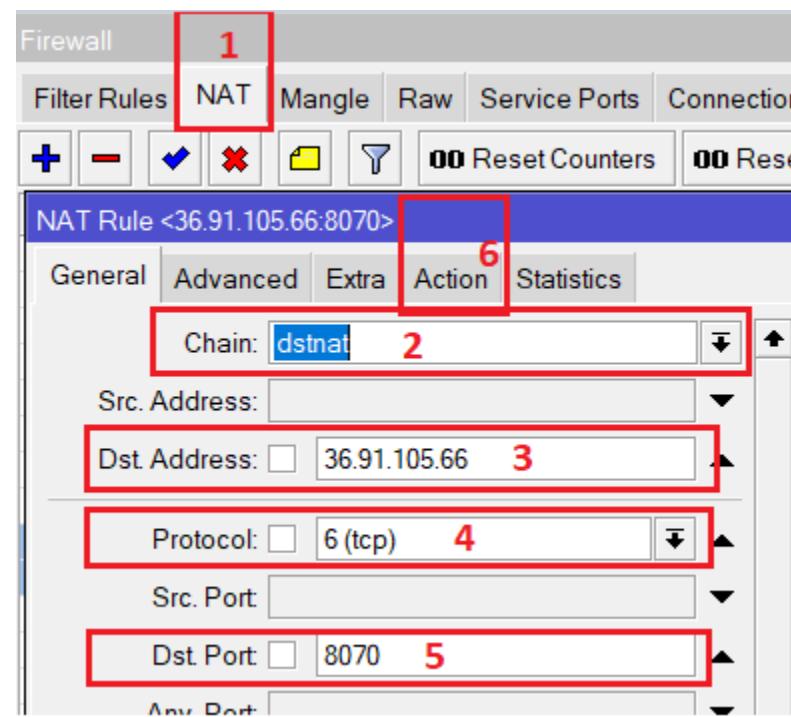


Dst NAT



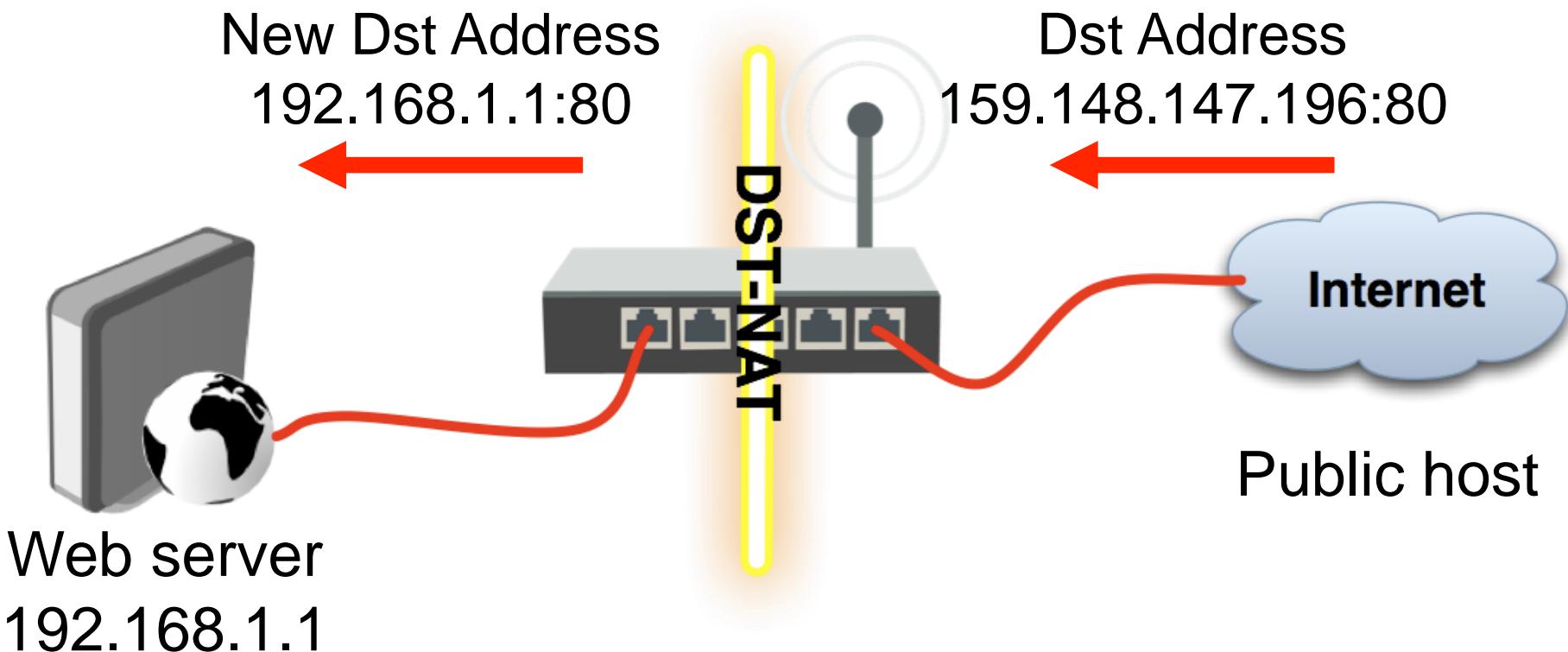
Contoh ada di artikel : [http://www.mikrotik.co.id/
artikel_lihat.php?id=75](http://www.mikrotik.co.id/artikel_lihat.php?id=75)

LAB - Dst NAT Web Server



IP → Firewall → NAT → New NAT Rule (+)

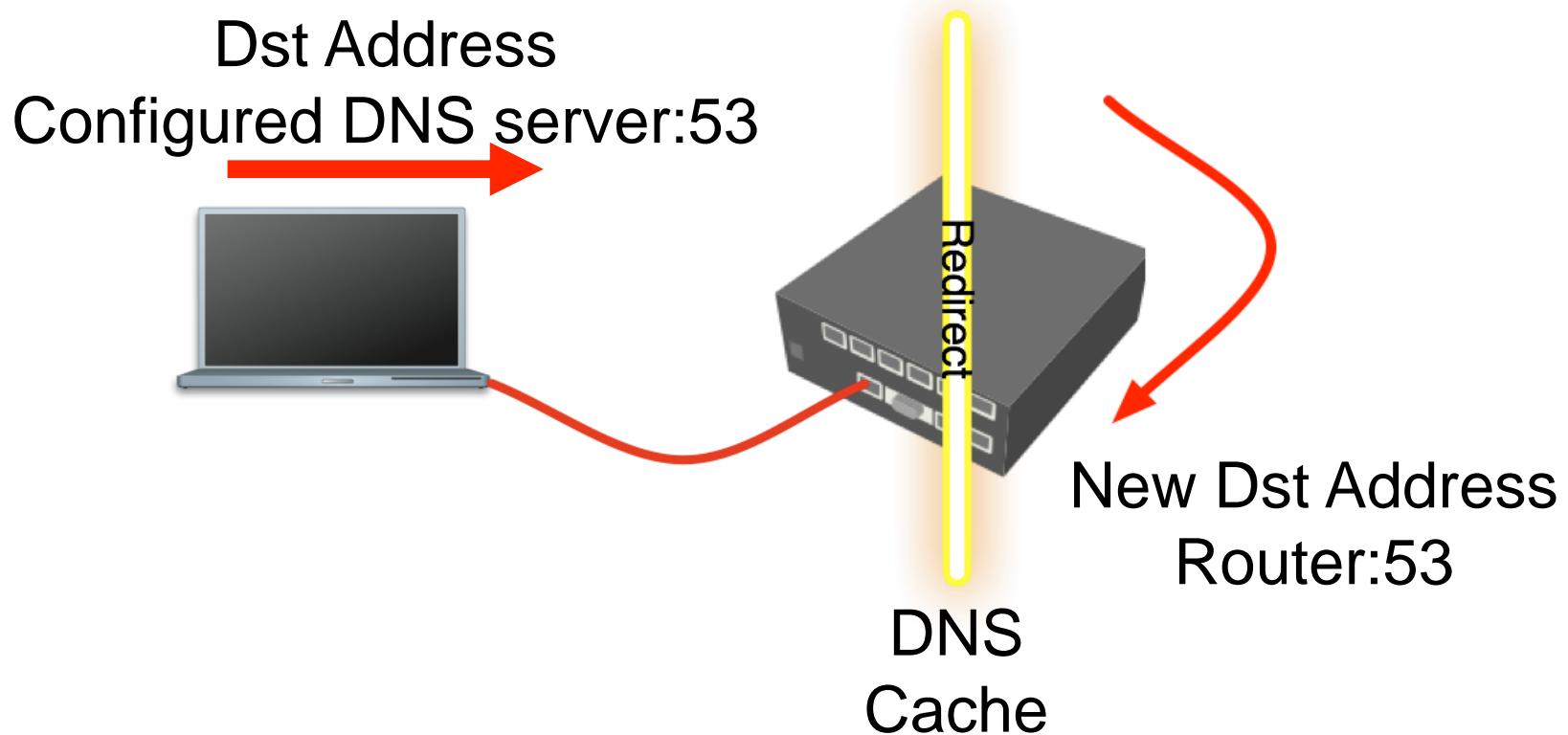
LAB - Dst NAT Web Server



Redirect

- NAT tipe spesial dari pada **dst-nat**
- Paket dari LAN akan men redirect sendiri kedalam router
- Banyak digunakan pada transparent proxy service

Redirect



DNS

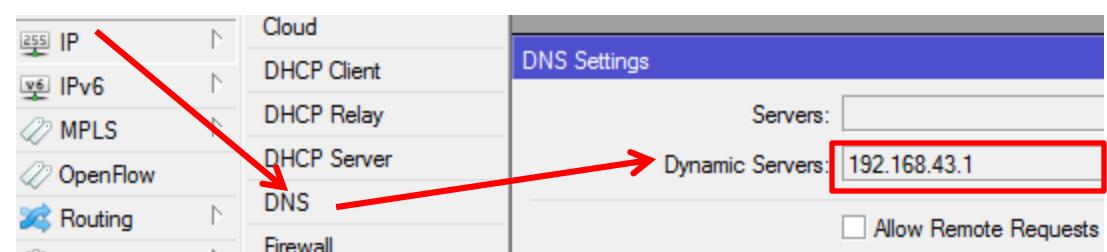
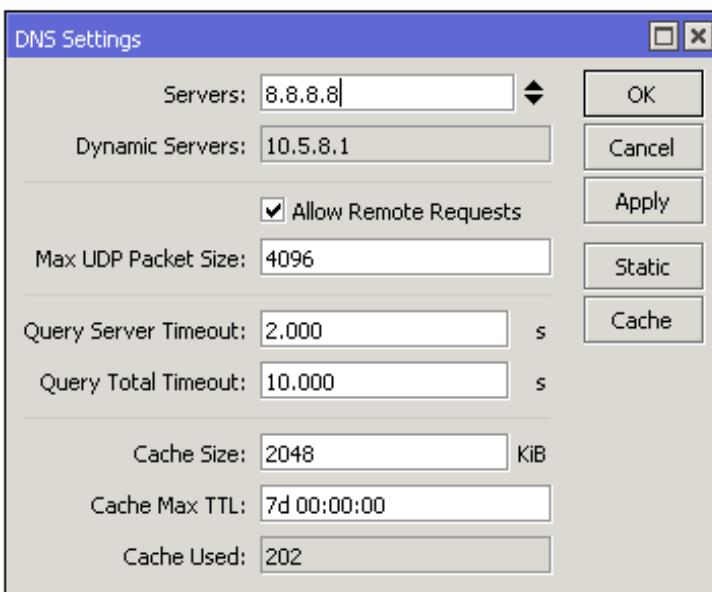
- DNS (Domain Name System) diperlukan untuk translate dari nama domain ke IP address
- DNS port 53
- dikarenakan alamat yang kita hubungi di internet itu adalah IP address
- Kita lebih mudah mengingat domain google.com daripada mengingat IP Publicnya nya google.com
- DNS ini seperti buku telephone, dimana kita lebih mudah mengingat **nama orangnya** daripada nomer telponnya

Contoh:

- www.google.com 142.251.12.102

DNS

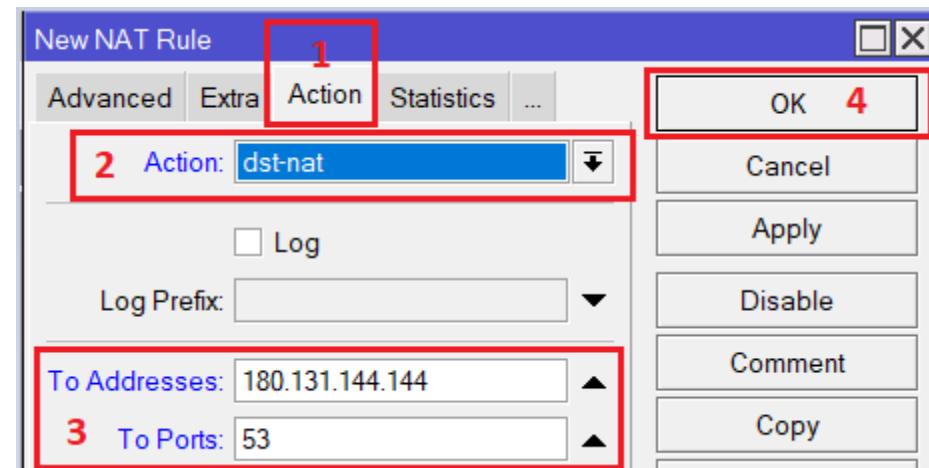
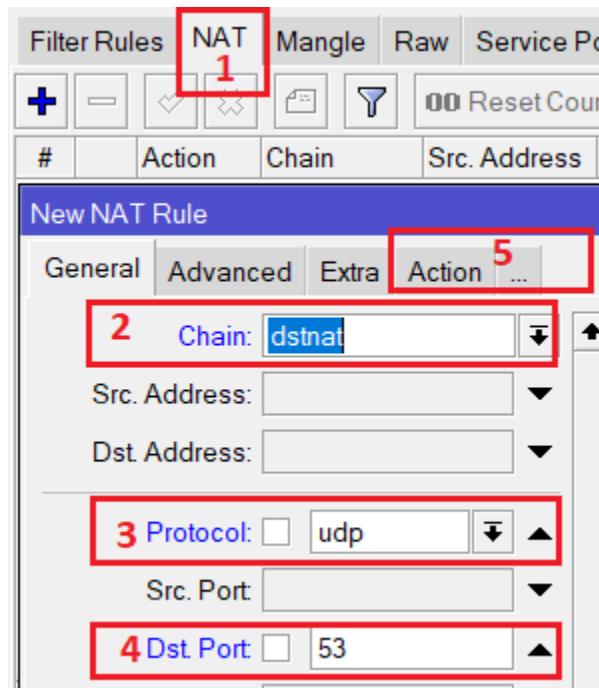
- By default DHCP client akan menambahkan secara otomatis DNS jika dibutuhkan atau ada tambahan konfigurasi di sisi DHCP server
- Dapat dikonfigurasi secara manual



IP → DNS

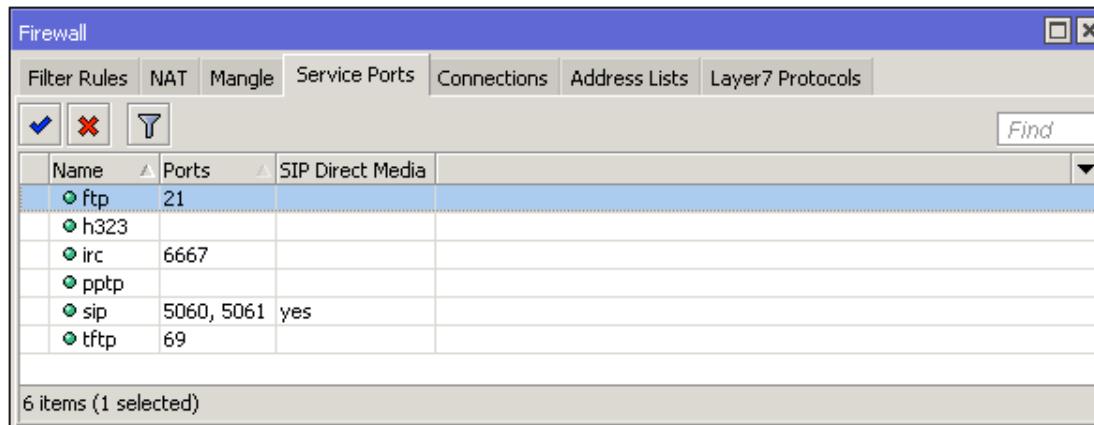
LAB – Transparent DNS Nawala

- Transparent DNS memaksa user untuk akses DNS server tertentu
- Buatlah rule baru pada menu IP>Firewall>NAT , redirect protocol TCP dan UDP port 53 ke IP port DNS Nawala 180.131.144.144



NAT Helpers

- Beberapa protocol sangat dibutuhkan NAT helper bekerja untuk membantu menentukan secara langsung



IP → Firewall → Service Ports

FastTrack

- A method to accelerate packet flow through the router
- An established or related connection can be marked for **fasttrack connection**
- Bypasses firewall, connection tracking, simple queue and other features
- Currently supports only TCP and UDP protocols

FastTrack

Without	With
360Mbps	890Mbps
Total CPU usage 100%	Total CPU usage 86%
44% CPU usage on firewall	6% CPU usage on firewall

- Tested on RB2011 with a single TCP stream
- For more info see [FastTrack wiki page](#)

Module 5 Summary



Certified Network Associate
(MTCNA)

Quality Of Service

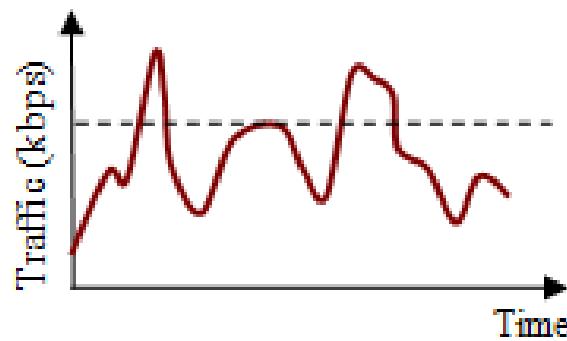
Quality of Service

- QOS secara umum merupakan keseluruhan kinerja daripada network, biasanya kinerja yang terlihat pada user client di network
- QoS (Quality of Service) adalah sebuah cara yang digunakan untuk mengatur penggunaan bandwidth secara rasional. untuk menghindari terjadinya trafik yang memonopoli seluruh bandwidth yang tersedia.
- Banyak fitur di RouterOS untuk mengimplementasikan Qos untuk digunakan membatasi speed (shaping) bandwidth,Traffic prioritas bandwidth dan lain2nya

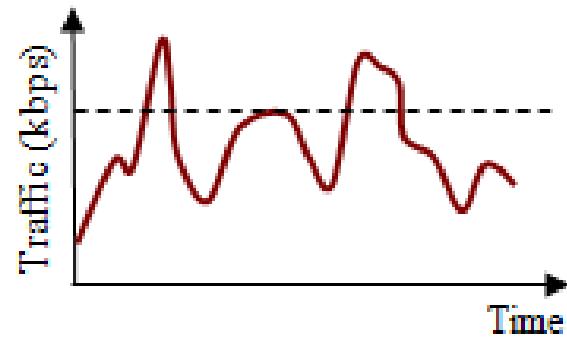
Quality of Service

- Pada Mikrotik, limitasi bandwidth diatur dalam Quality-of-Service
- QOS tidak hanya mengatur penggunaan bandwidth melainkan juga mengatur prioritas bandwidth, burstable, dual-limitation dan lainnya
- Sistem yang digunakan yaitu antrian (Queue), jadi traffic tidak di drop, melainkan diatur dalam antrian

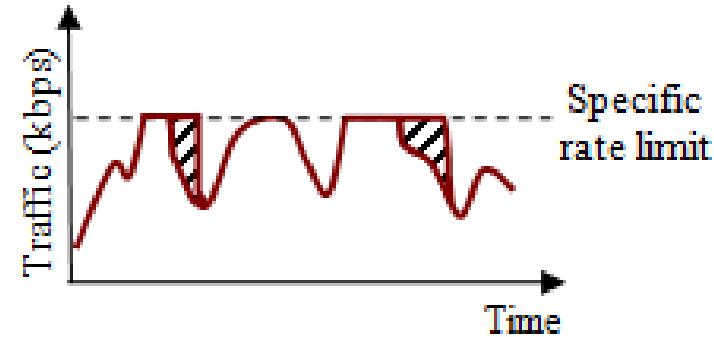
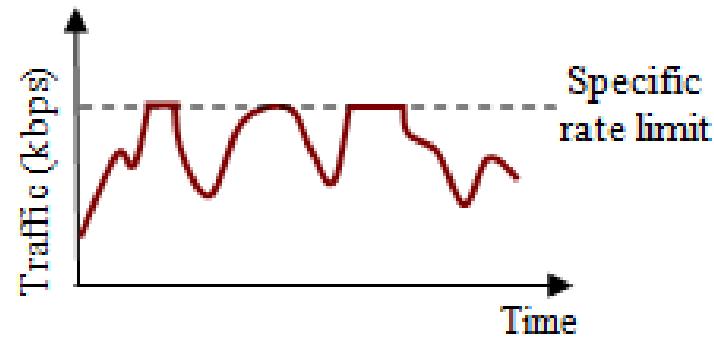
QOS-Bandwidth Limiter



Rate limiting
(shaper)



Rate equalizing
(Scheduler)



Simple Queue

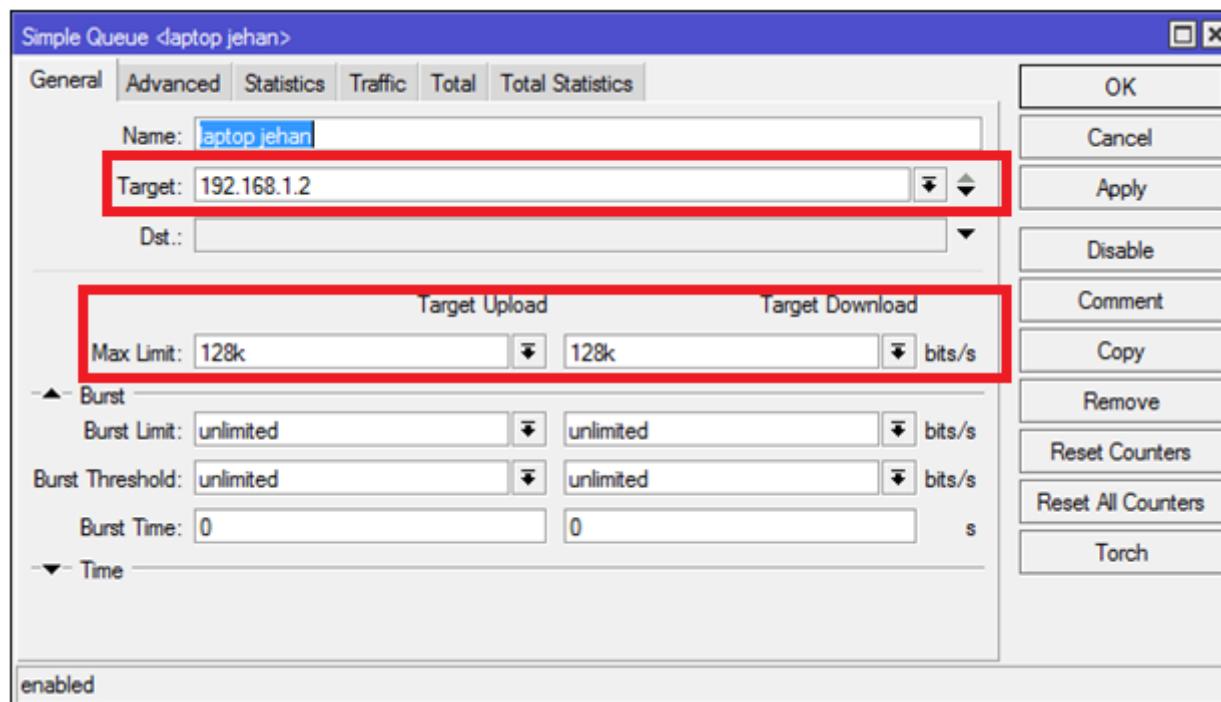
- Pengaturan QOS diatur pada menu **Queue**
- Cara paling simple manajemen bandwidth adalah **simple queue**
- **Simple Queue dapat melimit**
Upload Client (\uparrow) speed
Download Client (\downarrow) speed
Total (upload/Donwload) dari client ($\downarrow + \uparrow$)

Simple Queue

- Untuk menggunakan Simple Queue, yang wajib diisikan yaitu **target address (IP)**
- **Urutan dalam rule-rule Simple Queue sangat penting**

Simple Queue - Limit laptop

- Download : 128 kbps
- Upload : 128 kbps



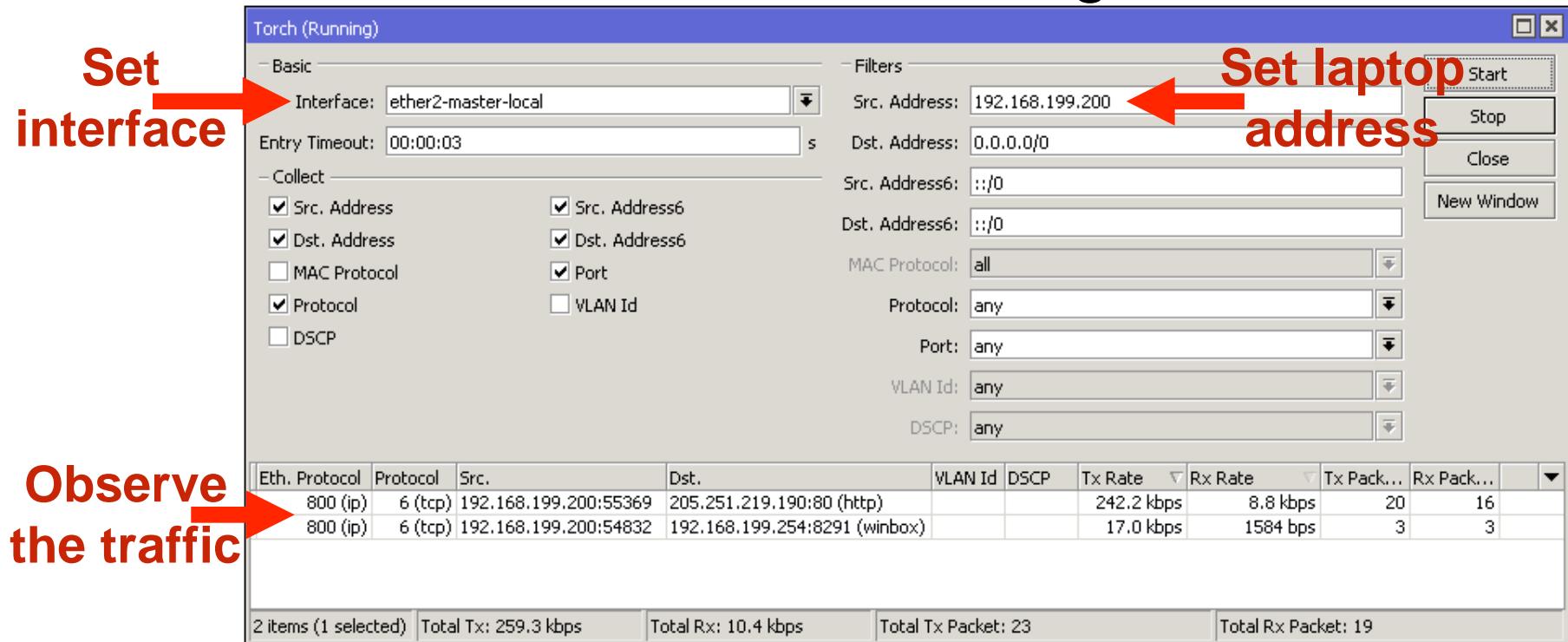
Queues + Add

Perubahan Warna Queue rule

- Hijau : 0 – 50% bandwidth digunakan.
- Kuning : 51 – 75% bandwidth digunakan
- Merah : 76 – 100% bandwidth digunakan

Torch

- Real-time traffic monitoring tool



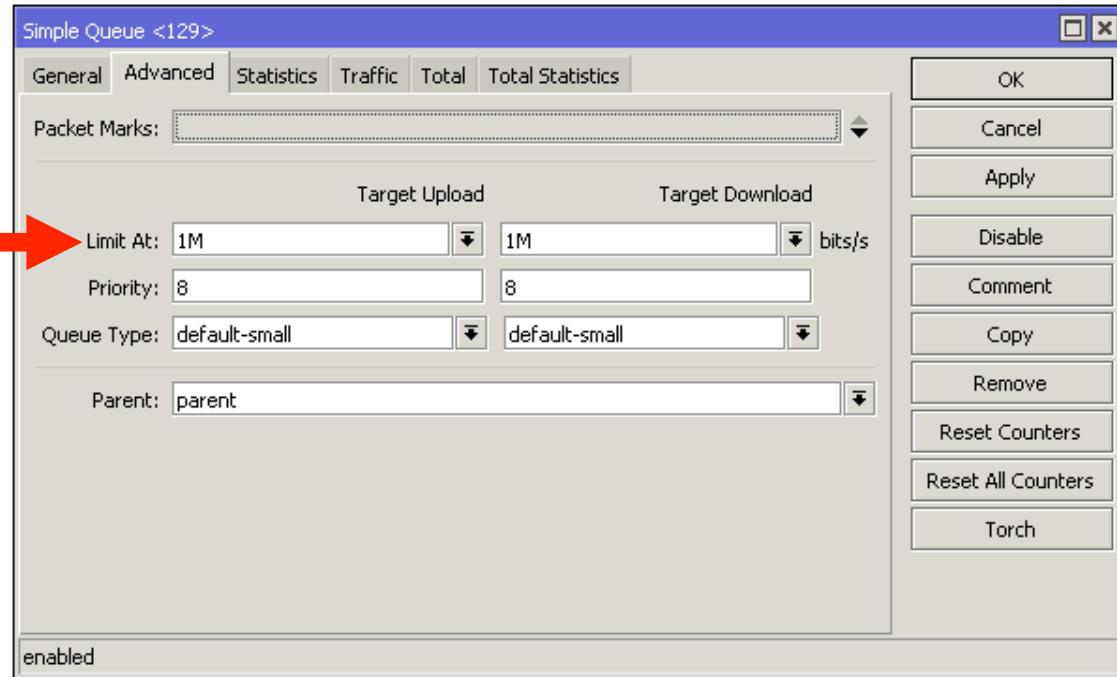
Tools → Torch

Garansi Bandwidth

- Untuk memastikan client bisa mendapatkan batas minimum bandwidth
- Trafic yang akan di sharing berdasarkan yg diterima pertama, maka selanjutnya akan mendapatkan lebih dahulu
- Konfigurasi guaranteed bandwidth pada mikrotik terdapat pada **limit-at** parameter

Guaranteed Bandwidth

Set limit at



Queues → Simple Queue → Edit → Advanced

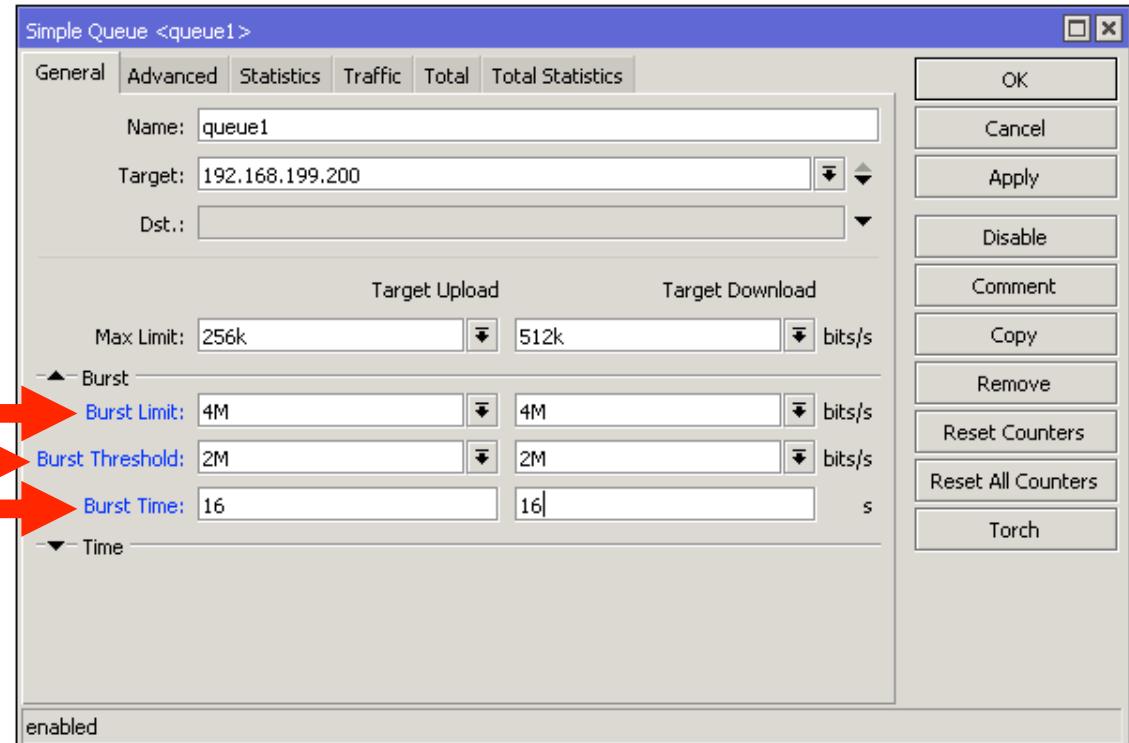
- Client akan mendapatkan download dan upload 1 megabits

Burst

- Used to allow higher data rates for a short period of time
- Useful for HTTP traffic - web pages load faster
- For file downloads Max Limit restrictions still apply

Burst

Set burst limit,
threshold and
time



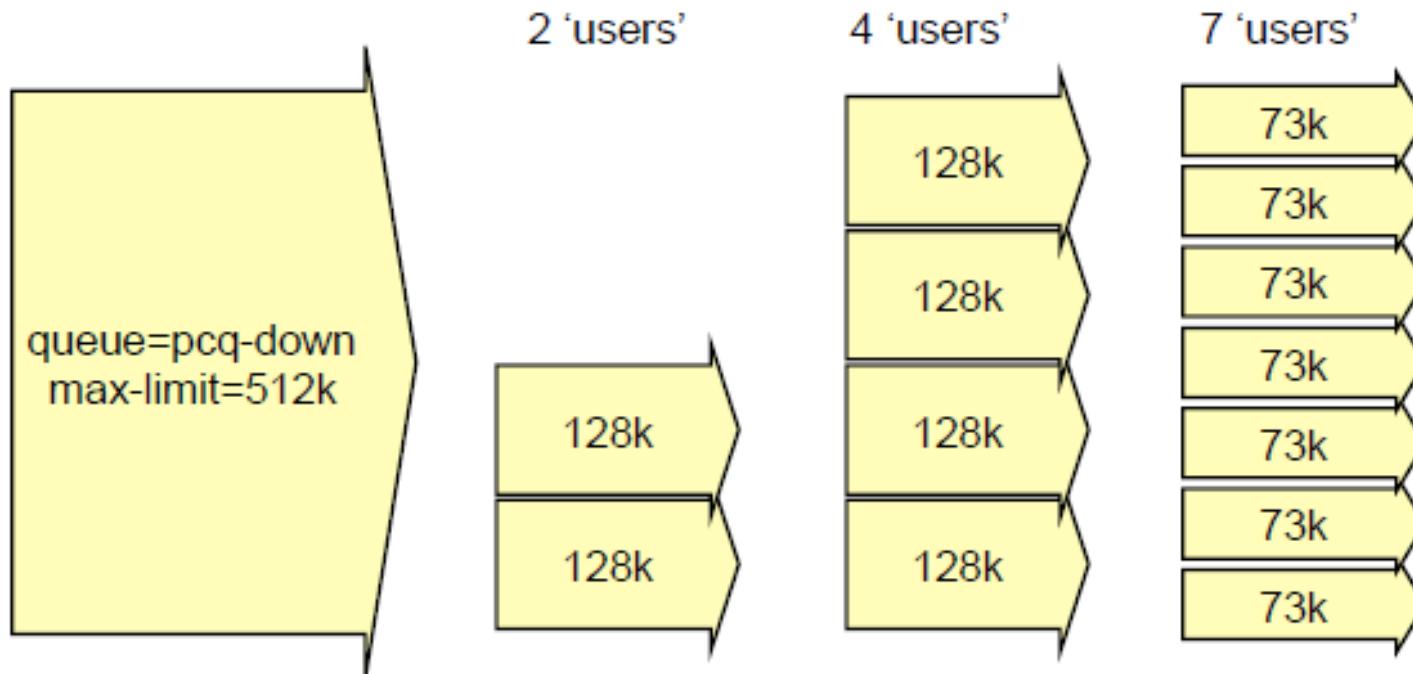
Queues → Simple Queue → Edit

Per Connection Queueing (PCQ)

- Salah satu type Queue adalah PCQ
- PCQ mengoptimalkan bandwidth berdasarkan pengunaan user
- PCQ menggunakan beberapa klasifikasi seperti
 - Source/Destiation IP Address
 - Source/destination Port

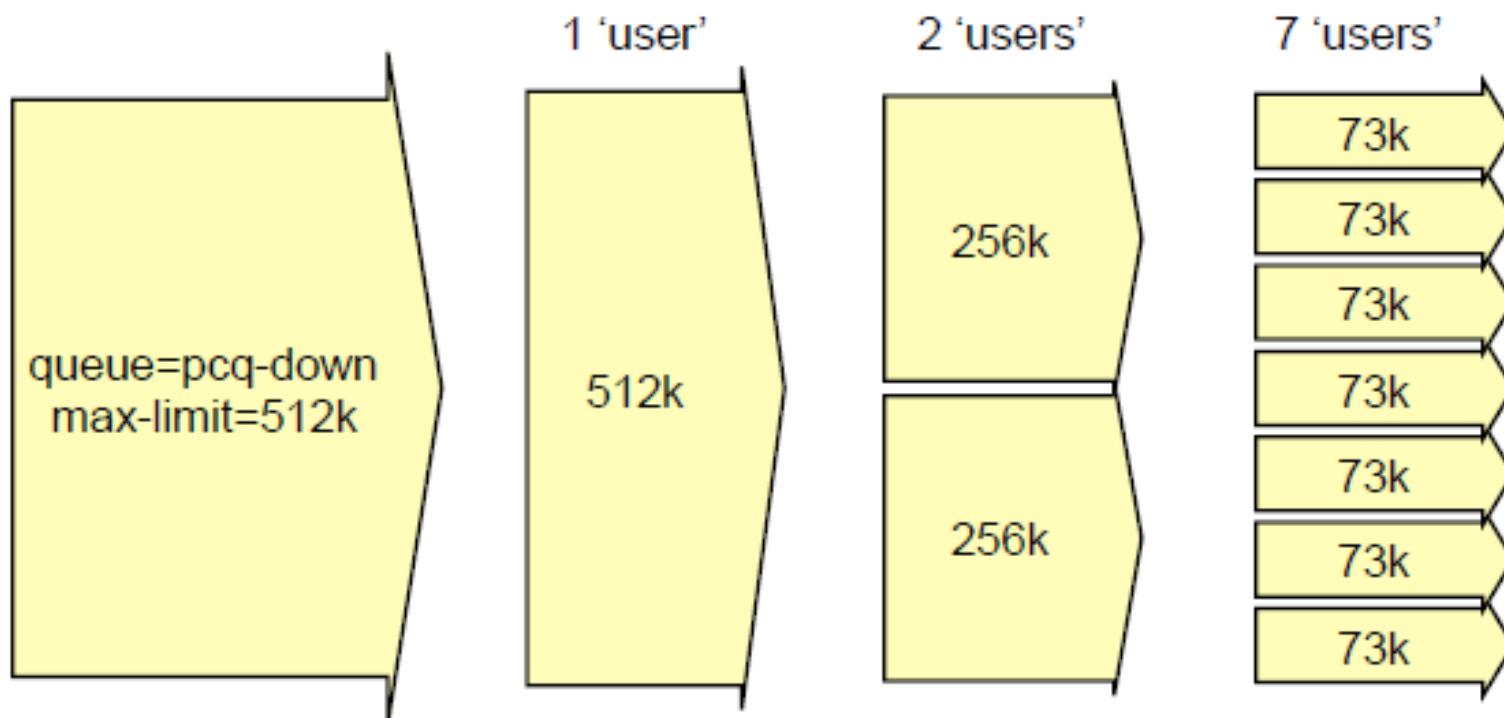
Contoh Penggunaan PCQ

Pcq-rate=128000



Contoh Penggunaan PCQ

Pcq-rate=0



Queue List

Simple Queues Interface Queues Queue Tree Queue Types



Type Name	Kind
* default	pfifo
* default-small	pfifo
* ethernet-default	pfifo
* hotspot-default	sfq
* multi-queue-ethernet-default	mq pfifo
* only-hardware-queue	none
* pcq-download-default	pcq
pcq-upload-default	pcq

Queue Type <pcq-upload-default>

Type Name:	pcq-upload-default	OK
Kind:	pcq	Cancel
Rate:	0 bits/s	Apply
Limit:	50 KiB	Copy
Total Limit:	2000 KiB	Remove
Burst Rate:		bits/s
Burst Threshold:		
Burst Time:	00:00:10	
Classifier:	<input checked="" type="checkbox"/> Src. Address <input type="checkbox"/> Dst. Address <input type="checkbox"/> Src. Port <input type="checkbox"/> Dst. Port	
Src. Address Mask:	32	
Dst. Address Mask:	32	
Src. Address6 Mask:	128	
Dst. Address6 Mask:	128	
default		

PCQ Queue Kind

Queue Type <pcq-download-default>

Type Name:	pcq-download-default	OK
Kind:	pcq	Cancel
Rate:	0 bits/s	Apply
Limit:	50 KiB	Copy
Total Limit:	2000 KiB	Remove
Burst Rate:		bits/s
Burst Threshold:		
Burst Time:	00:00:10	
Classifier:	<input type="checkbox"/> Src. Address <input checked="" type="checkbox"/> Dst. Address <input type="checkbox"/> Src. Port <input type="checkbox"/> Dst. Port	
Src. Address Mask:	32	
Dst. Address Mask:	32	
Src. Address6 Mask:	128	
Dst. Address6 Mask:	128	

LAB

PCQ Queue

LAB

Simple Queue <Limit Network LAN>

General Advanced Statistics Traffic Total Total Statistics

Name: Limit Network LAN
Target: 192.168.2.0/24
Dst.: [redacted]

Target Upload Target Download

Max Limit: 1M bits/s
Burst

Burst Limit: unlimited bits/s
Burst Threshold: unlimited bits/s
Burst Time: 0 s

New Simple Queue

General Advanced 1 Statistics Traffic Total Total Statistics

Packet Marks: [redacted]

Target Upload Target Download

Limit At: unlimited bits/s
Priority: 1 2
Bucket Size: 0.100 ratio
Queue Type: pcq-upload-default 3 pcq-download-default

OK 4 Cancel Apply Disable Comment Copy Remove

Module 7 Summary



Certified Network Associate
(MTCNA)

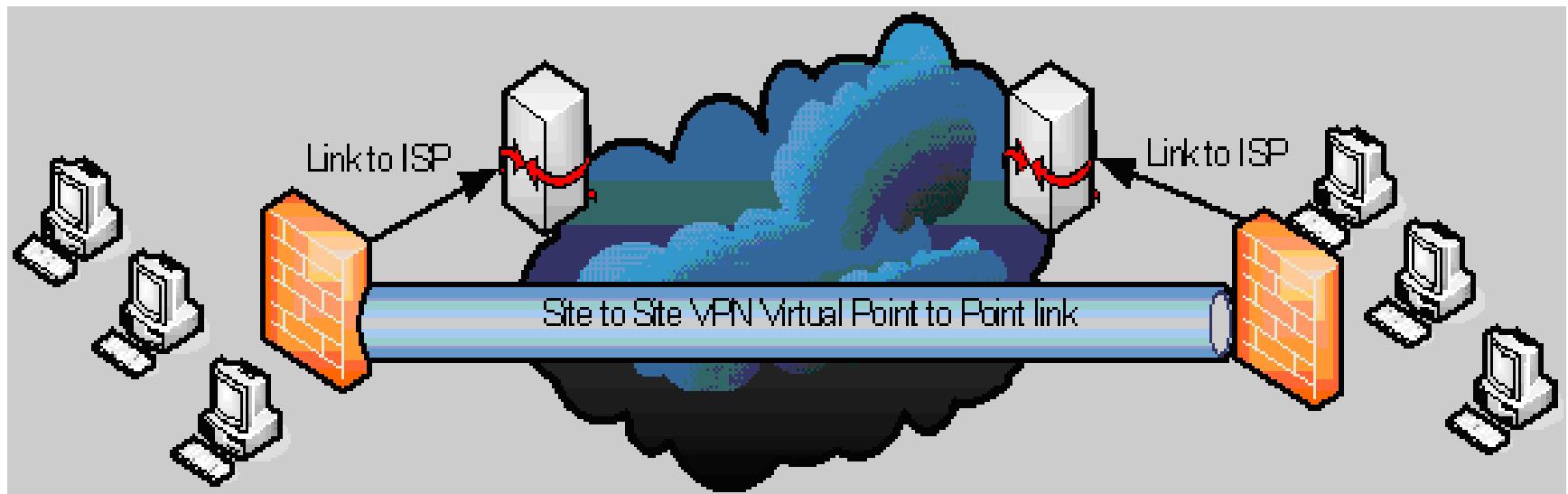
Module 8

Tunnels

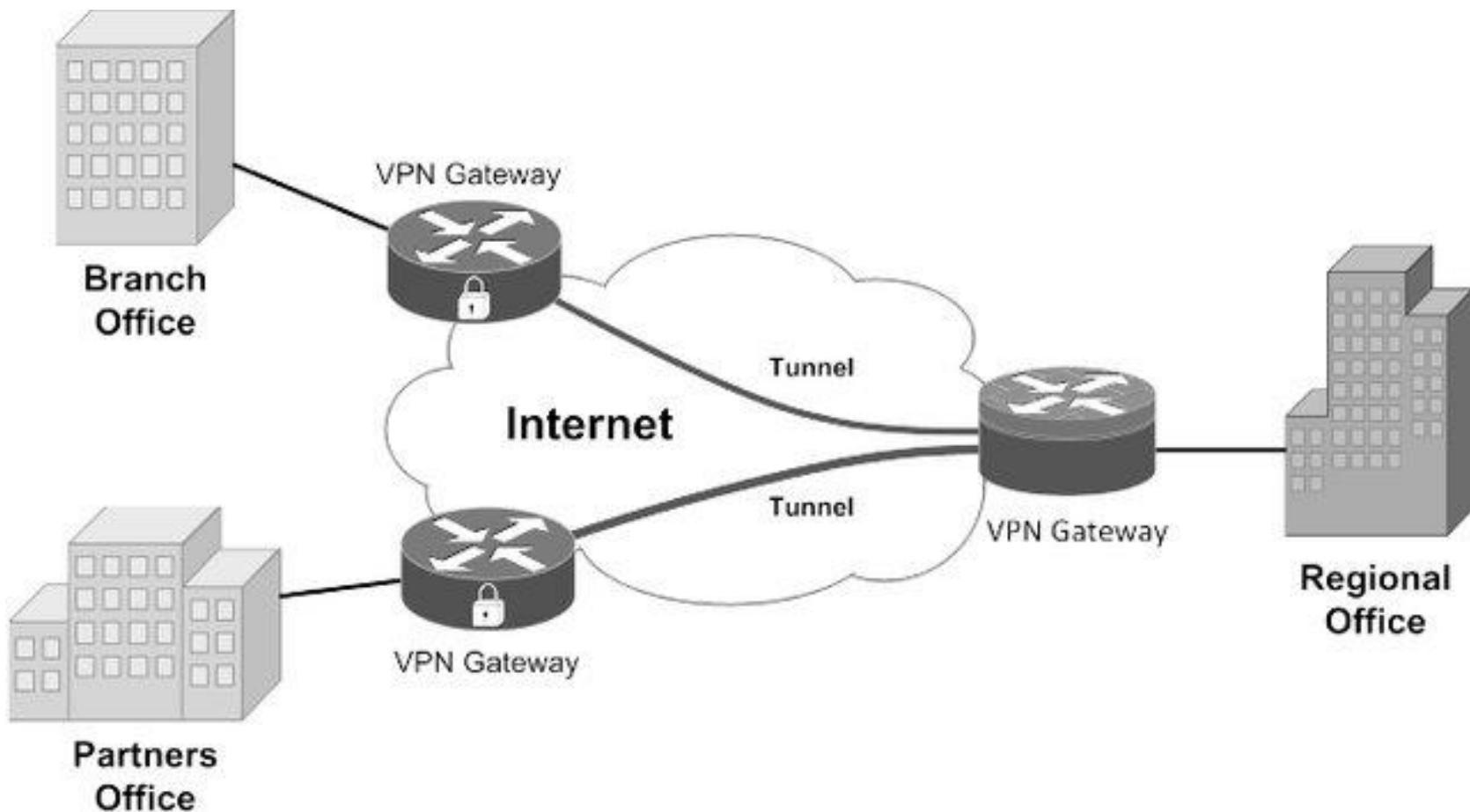
Tunnel

- Tunnel adalah sebuah metode penyelubungan (encapsulation) paket data di jaringan
- Sebelum dikirim, paket data mengalami sedikit pengubahan atau modifikasi, yaitu penambahan header dari tunnel
- Ketika data sudah melewati tunnel dan sampai di tujuan (ujung) tunnel, maka header dari paket data akan dikembalikan seperti semula (header tunnel dilepas).

Tunnel



Site-to-Site VPN/Tunnel

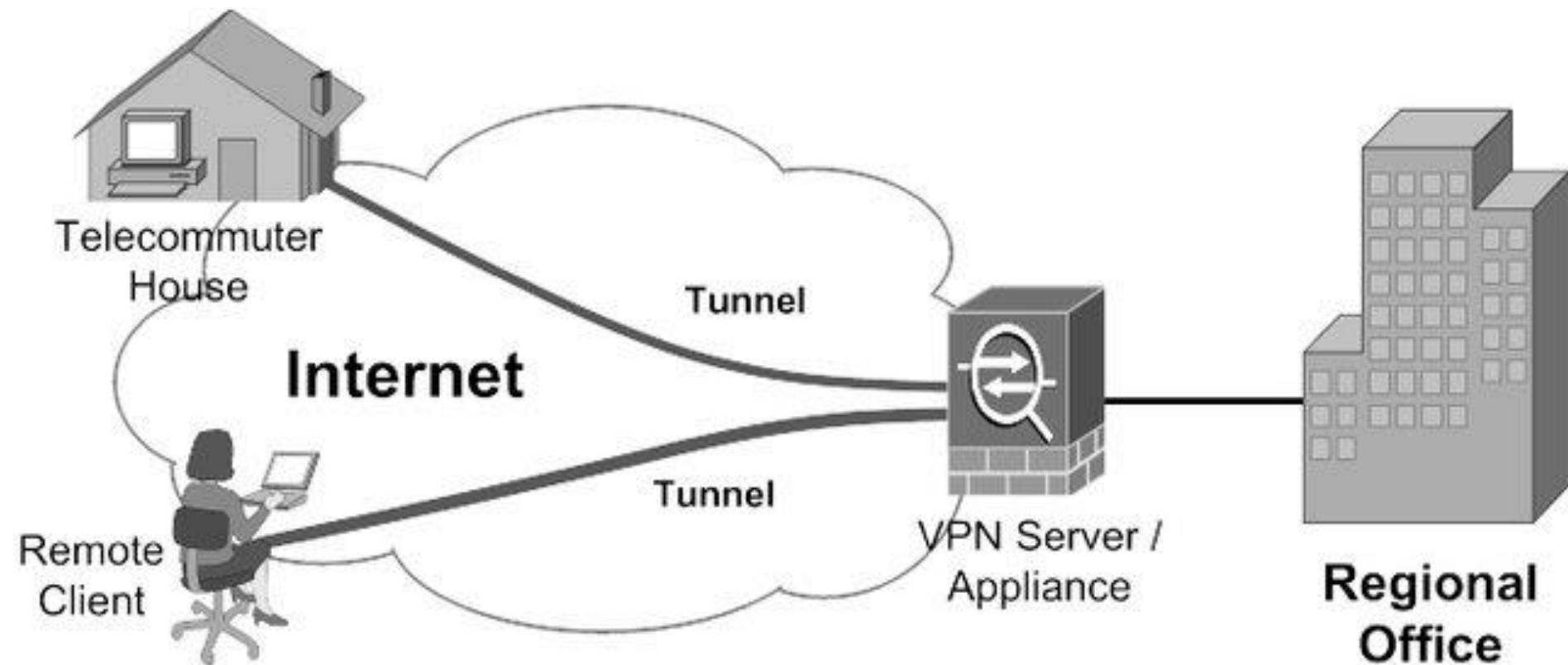


Source Zornitsa Yakova

What is VPN

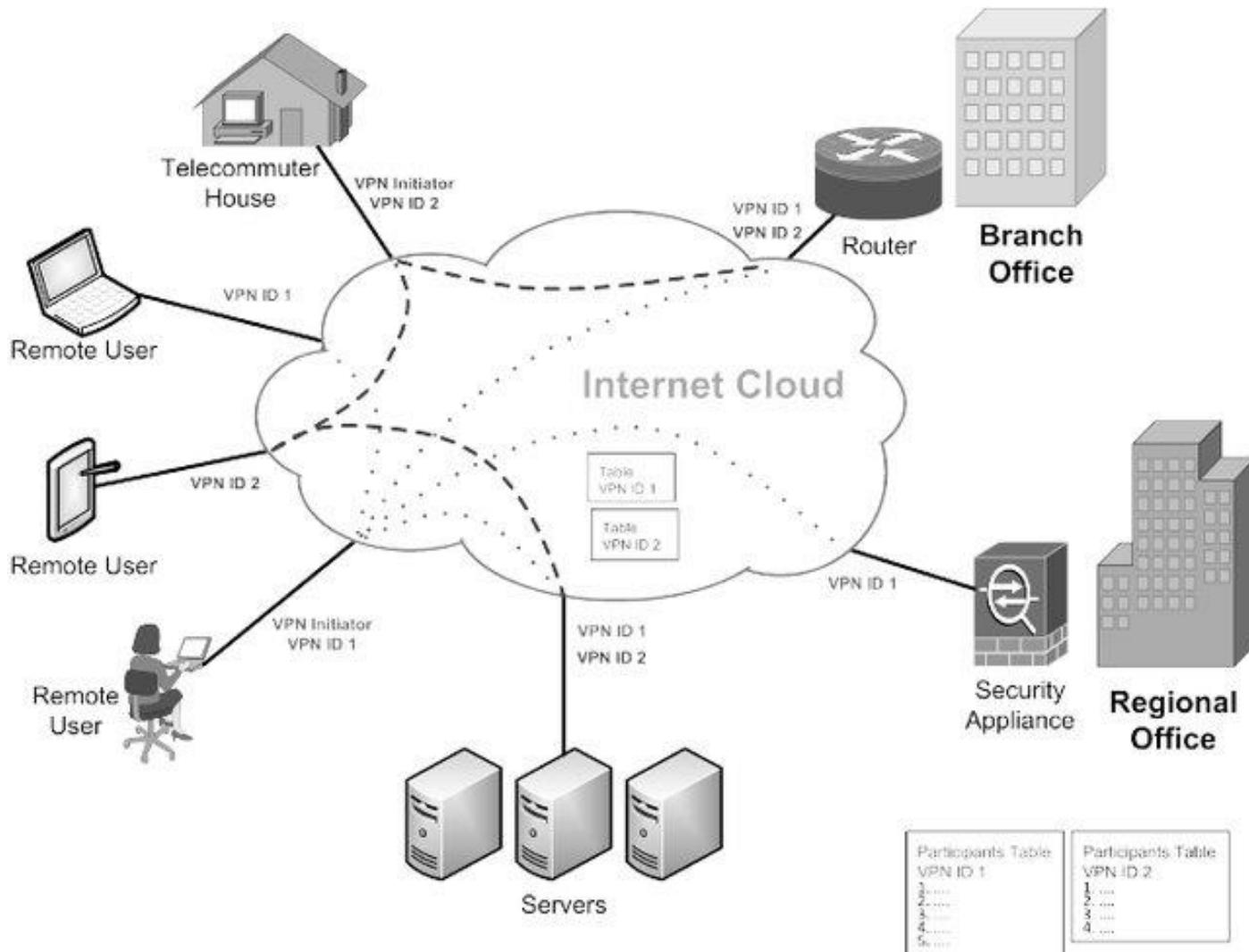
- VPN merupakan sebuah metode untuk membangun jaringan yang menghubungkan antar node jaringan secara aman / terenkripsi dengan memanfaatkan jaringan publik (Internet / WAN).
- Mikrotik support beberapa metode VPN seperti **PPTP**, **L2TP**, **SSTP**, dan **OpenVPN**

Remote-access VPN



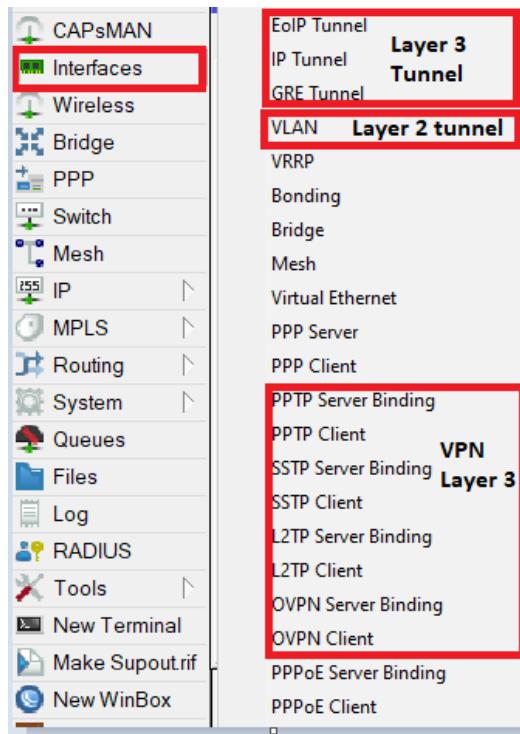
Source Zornitsa Yakova

A new VPN access model



Source Zornitsa Yakova

Tunnel dan VPN di Mikrotik



Compare VPN types (RouterOS)



	L2TP	L2TP/IPSEC + psk	OpenVPN	PPTP	SSTP	IPSec IKE2
Protocol	UDP	UDP over UDP/ESP	TCP	GRE	TCP	UDP, ESP
Performance	Fast	Medium	Slow	Fast	Slow	Very fast
Connection establishment	Medium	Slow	Slow	Medium	Medium	Very fast
Requires strong CPU for encryption	No	Yes	Yes	No	Yes	Yes
Multicore CPU load balance	Yes	Yes	No	Yes	Yes	Yes
Security	Low	Strong	Strong	Low	Strong	Very strong
Push routes	No	No	Yes	No	No	Yes
Bypass NAT	Yes	Yes	Yes	Yes	Yes	Yes
Has interface	Yes	Yes	Yes	Yes	Yes	No
OS popularity	High	Very high	High	Very high	Low	High

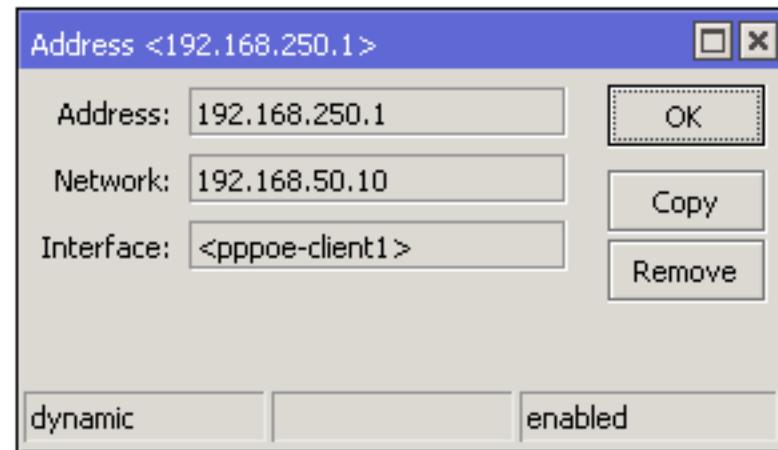
Nikita Tarikin / nikita@tarikin.com

Point-to-Point Protocol

- Point to Point Protocol atau PPP biasanya digunakan untuk tunelling (direct connection)
- PPP dapat menggunakan authentication,enkripsi dan kompresi
- Mikrotik RouterOS support PPP tunell contohnya PPPoE, SSTP, PPTP, L2TP dan lainnya

Point-to-Point Addressing

- Apabila koneksi di create diantara PPP client dan server, /32 address yang akan di masukan
- Untuk client network address (gateway) adalah ujung tunnel (router)



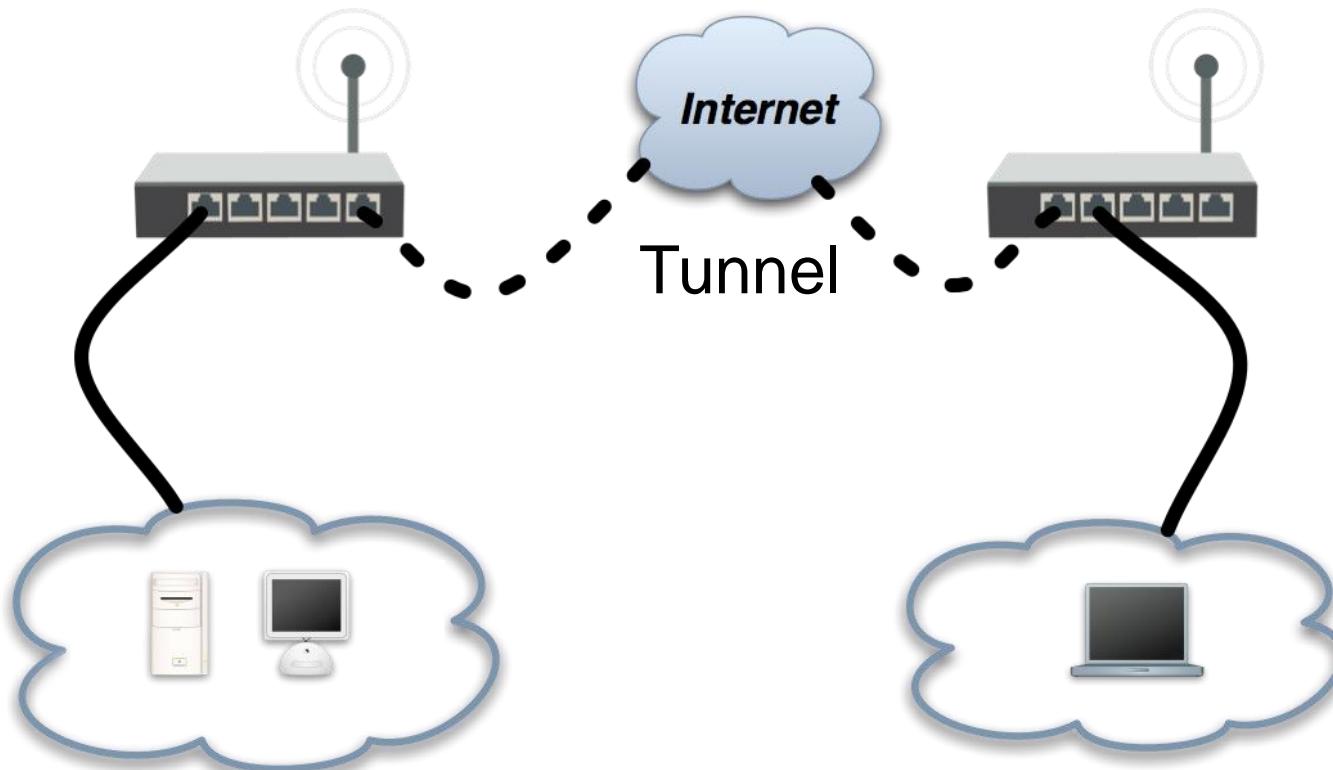
Point-to-Point Addressing

- Subnet tidak akan ada hubungannya ketika menggunakan PPP addressing
- PPP addressing menggunakan 2 IP address
- jika PPP addressing tidak support menggunakan device lain, /30 network addressing harus digunakan

PPTP

- Point-to-Point Tunneling Protocol (PPTP) melayani enkripsi tunnel melalui IP layer 3
- Biasanya digunakan sebagai koneksi yang aman antara lokal network melalui Internet
- RouterOS support menjalankan PPTP client dan server secara bersamaan
- NAT helper digunakan untuk mendukung PPTP didalam NAT
- Port **TCP 1723** dan IP protocol nomor **47 – GRE Tunnels**

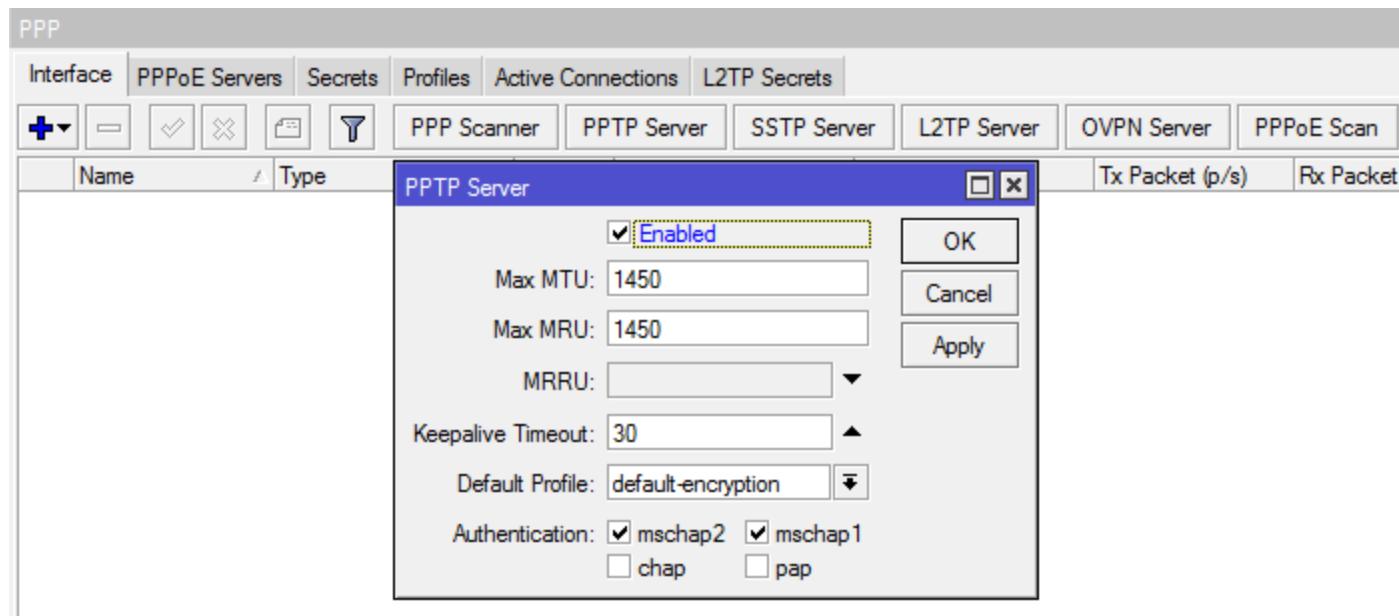
PPP Tunnel



LAB

PPTP Server

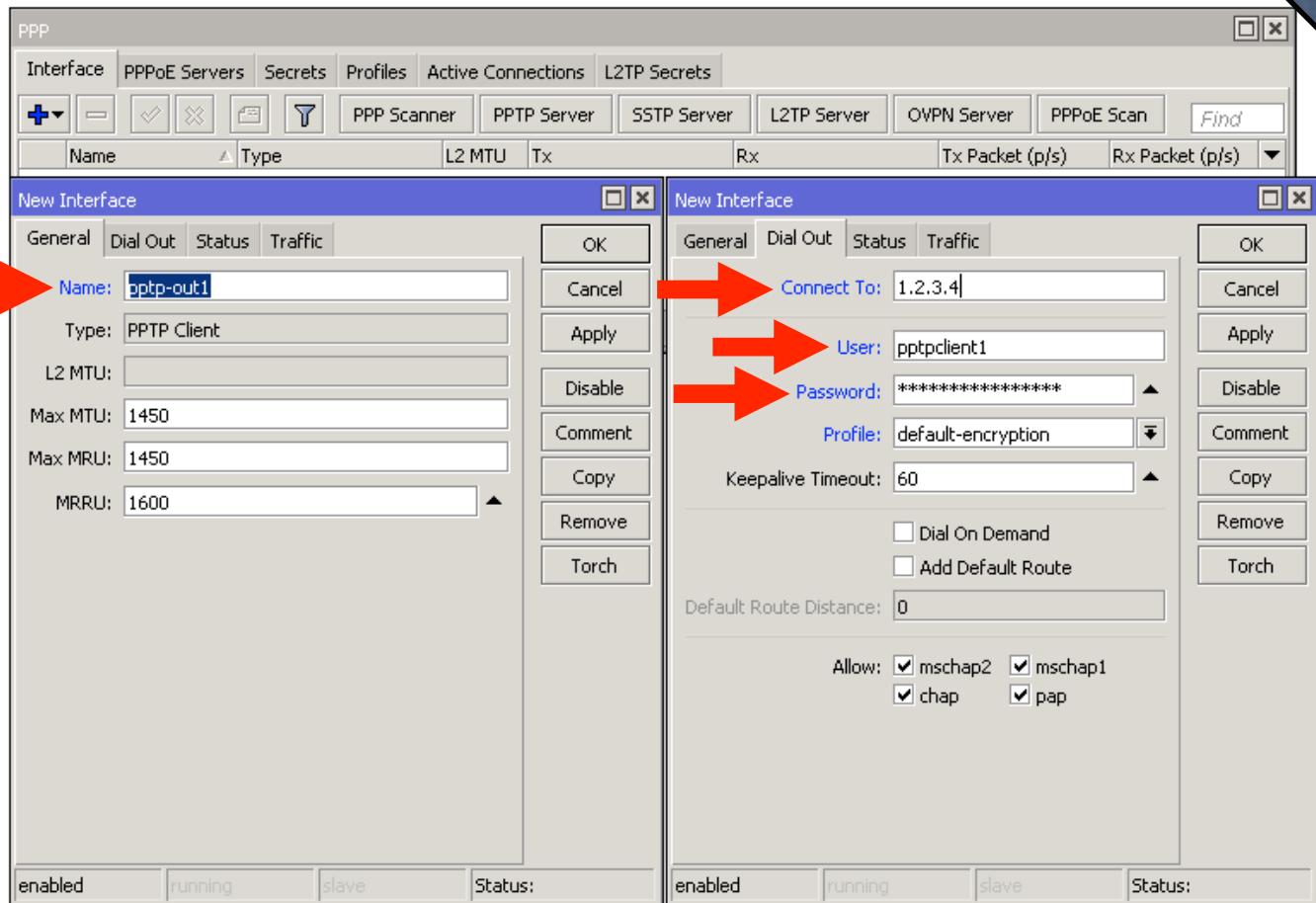
- RouterOS melayani simple **PPTP Server** untuk mempermudah konfigurasi PPTP



LAB

PPTP Client

Set name,
PPTP server
IP address,
username,
password



PPP → New PPTP Client(+)

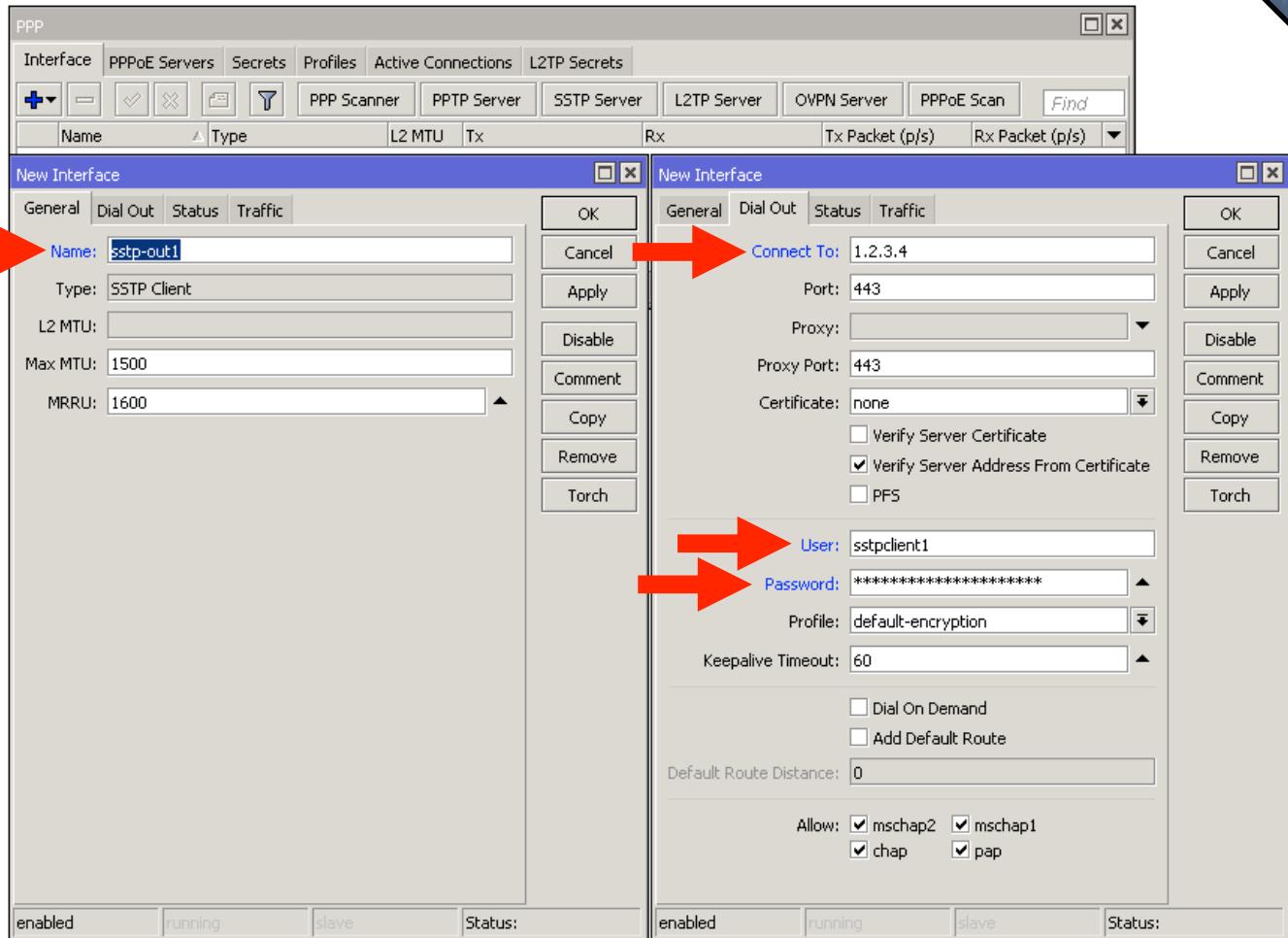
SSTP

- Secure Socket Tunneling Protocol (SSTP) menggunakan enkripsi tunnel over IP
- port tcp/443
- SSTP client pada OS windows berada di vista SP1 keatas
- RouterOS dapat menjalankan secara bersama antara SSTP client dan server. Since RouterOS 5.0

LAB

SSTP Client

Set name,
SSTP server
IP address,
username,
password



SSTP Client

- Untuk terhubung ke windows, harus memiliki sertifikat yang valid
- Sejak RouterOS 5.0 pada perangkat RouterOS ke RouterOS atau mikrotik ke mikrotik tidak memerlukan sertifikat (SSL)
- Sertifikat dapat dibuat pada system – certificate (certificate authority - CA)



Certified Network Associate
(MTCNA)

Module 9

Wireless

Wirelless

- Mikrotik RouterOS banyak mendukung fitur IEEE 802.11 (a,n,ac) 5Ghz & 802.11 b/g/n (2.4Ghz) wireless networking standards

PERHATIAN

Yang harus dilakukan

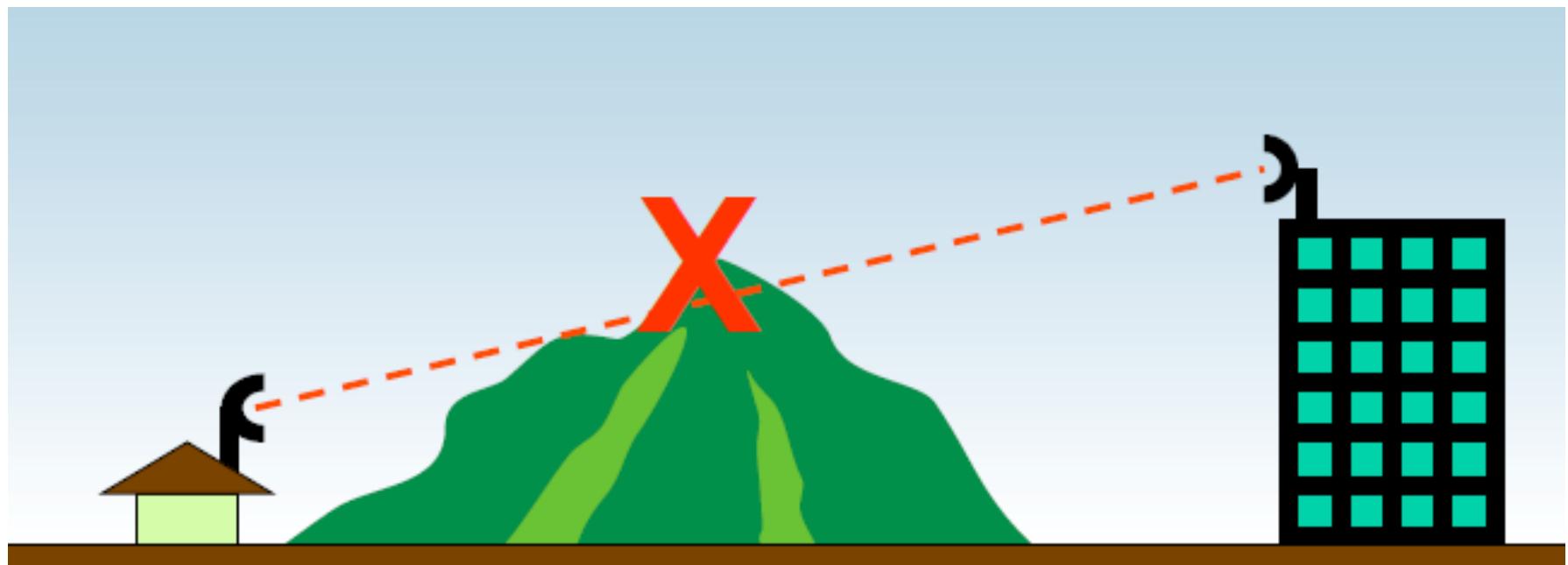
- Apabila ingin di backup konfigurasinya dipersilahkan
- Hapus seluruh konfigurasi di router board, **system-reset configuration-no default configurationnya** di ceklis - dan **reset configuration – reboot**
- Join kembali menggunakan zoom meeting melalui koneksi wireless wifi rumah atau ttring HP

Wireless Standards

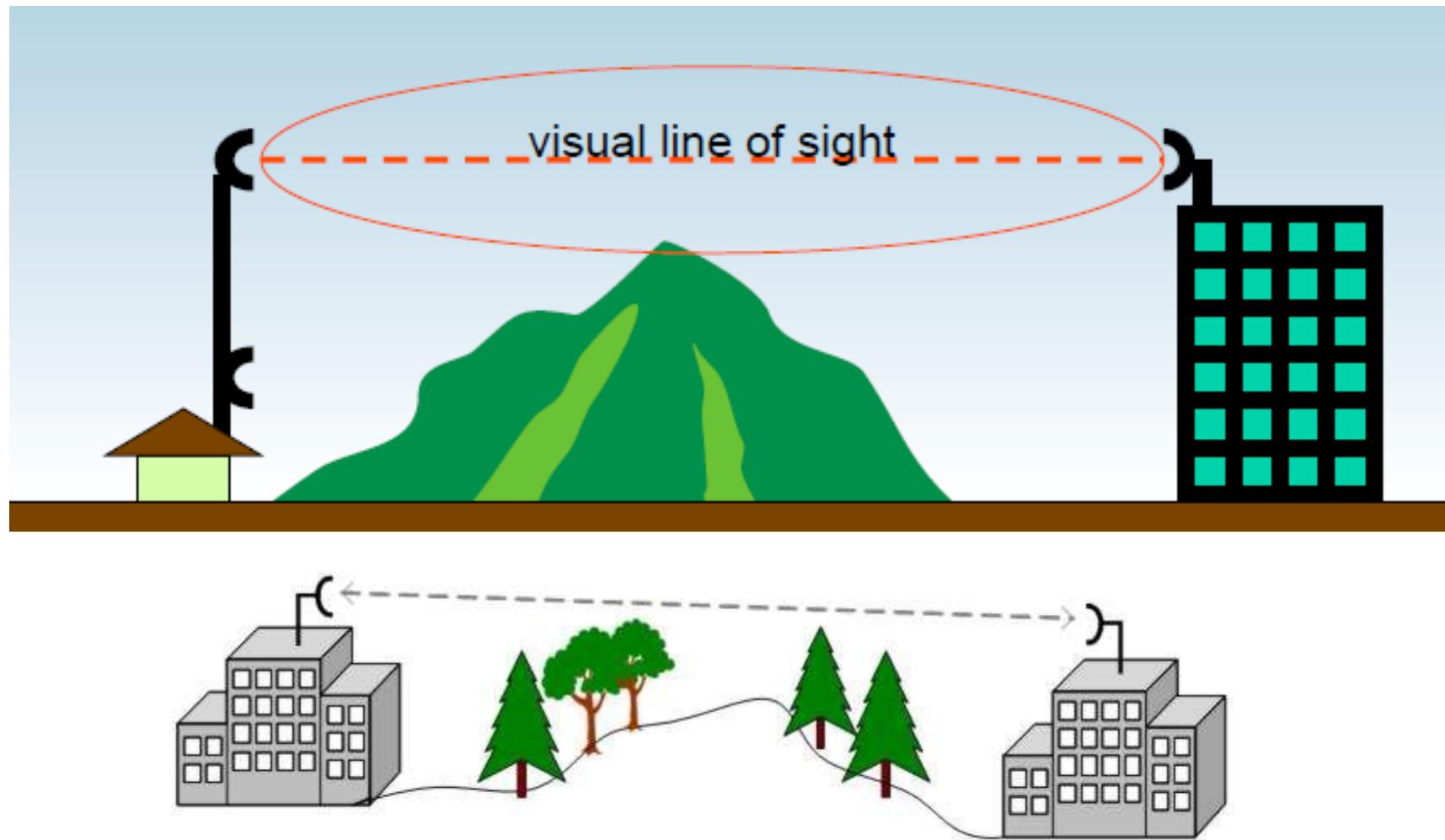
IEEE Standard	Frequency	Speed
802.11a	5GHz	54Mbps
802.11b	2.4GHz	11Mbps
802.11g	2.4GHz	54Mbps
802.11n	2.4 and 5GHz	Up to 450 Mbps*
802.11ac	5GHz	Up to 1300 Mbps*

*Depending on RouterBOARD model

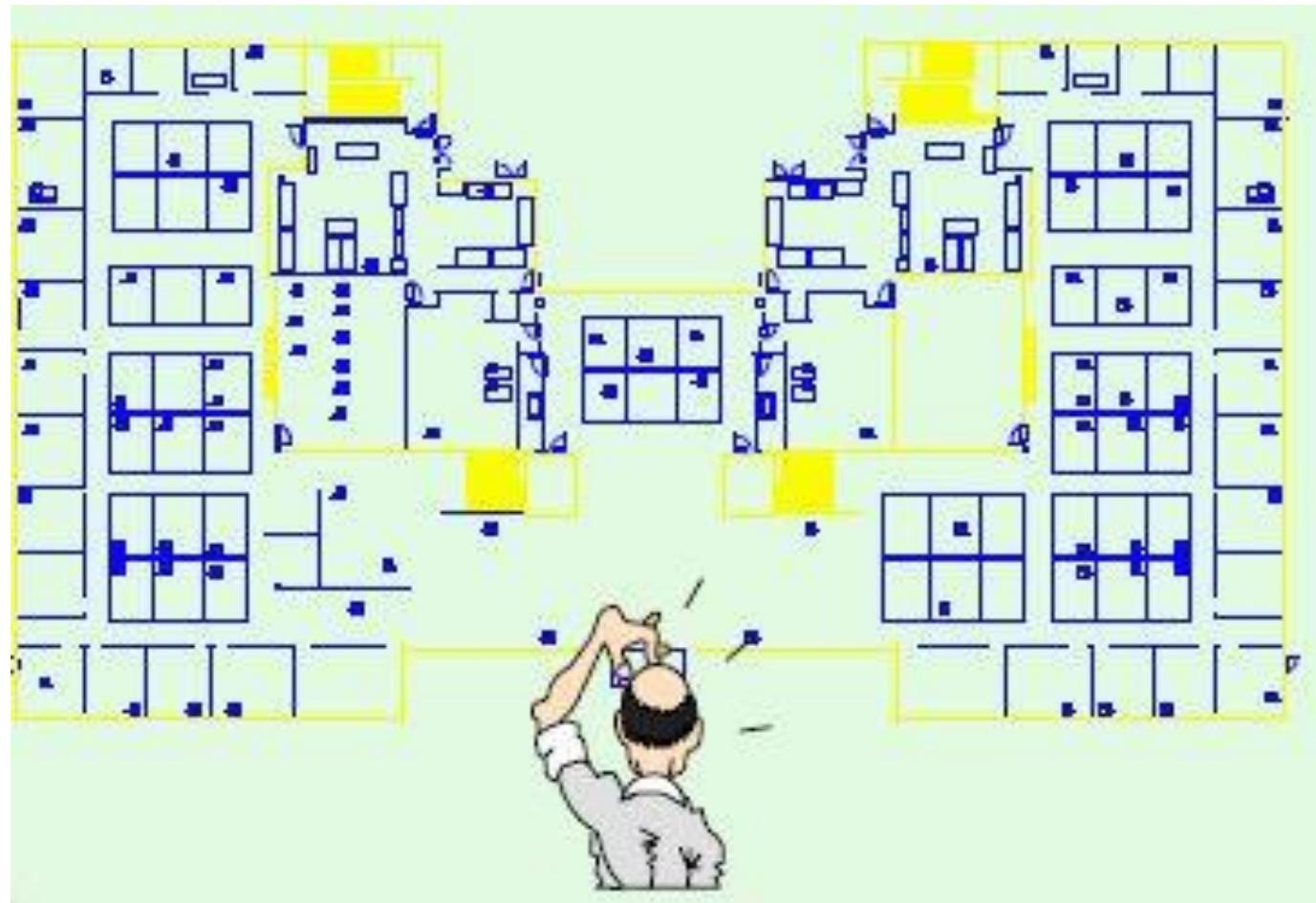
Line of Sight (LOS)



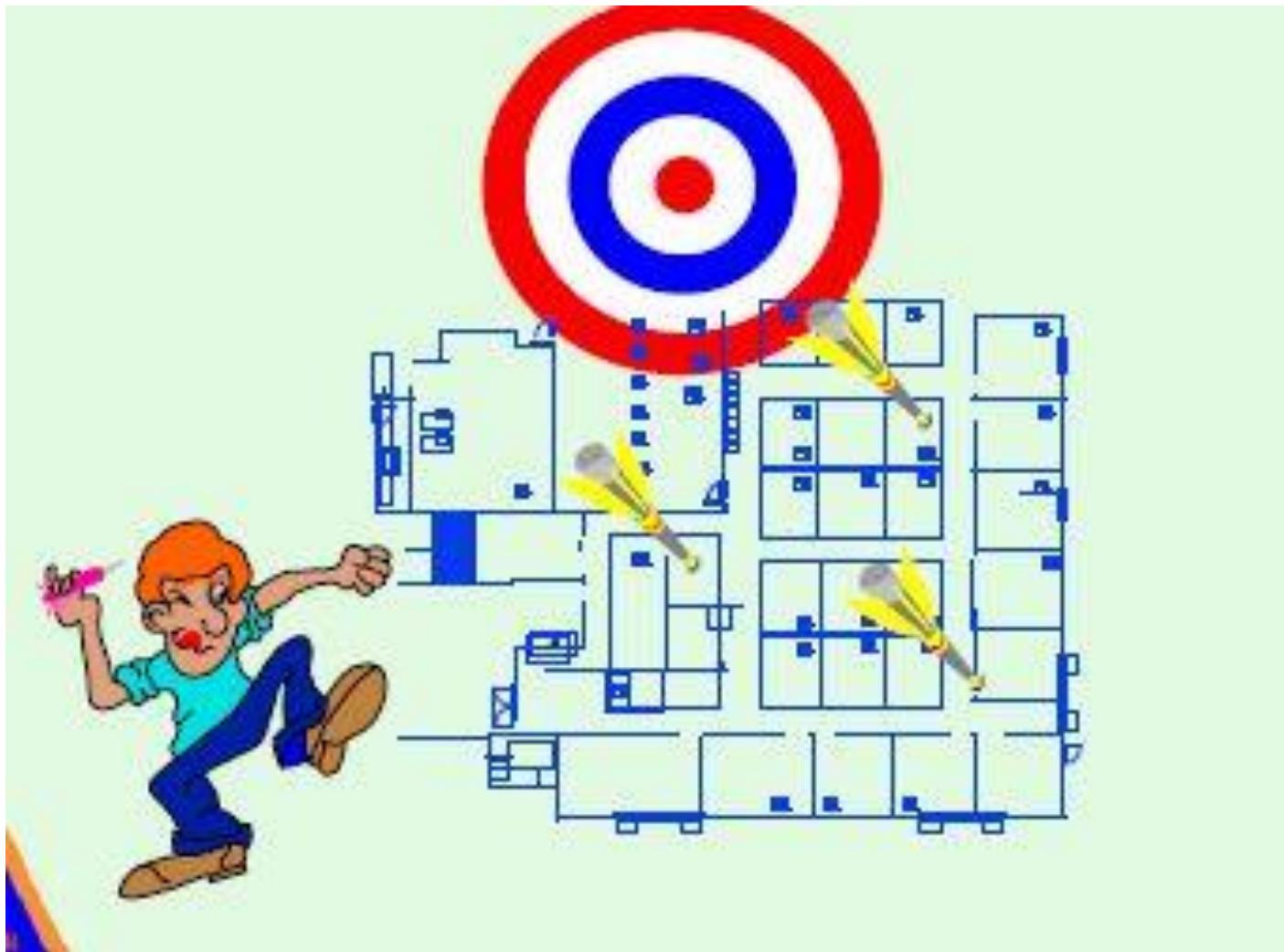
Topologi Wirelles Line of Sight (LOS)



Site Survey



Site Survey



Wireless Link Calculator Online

https://mikrotik.com/calculator

Frequency
Desired data rate: 812 Mbps

Point A device Point B device

SXTsq Lite5 SXTsq Lite5

Antenna Gain (dBi) Antenna Gain (dBi)
16 16

RX Sensitivity (dBm) RX Sensitivity (dBm)
-75 -75

Output Power (dBm) Output Power (dBm)
19 19

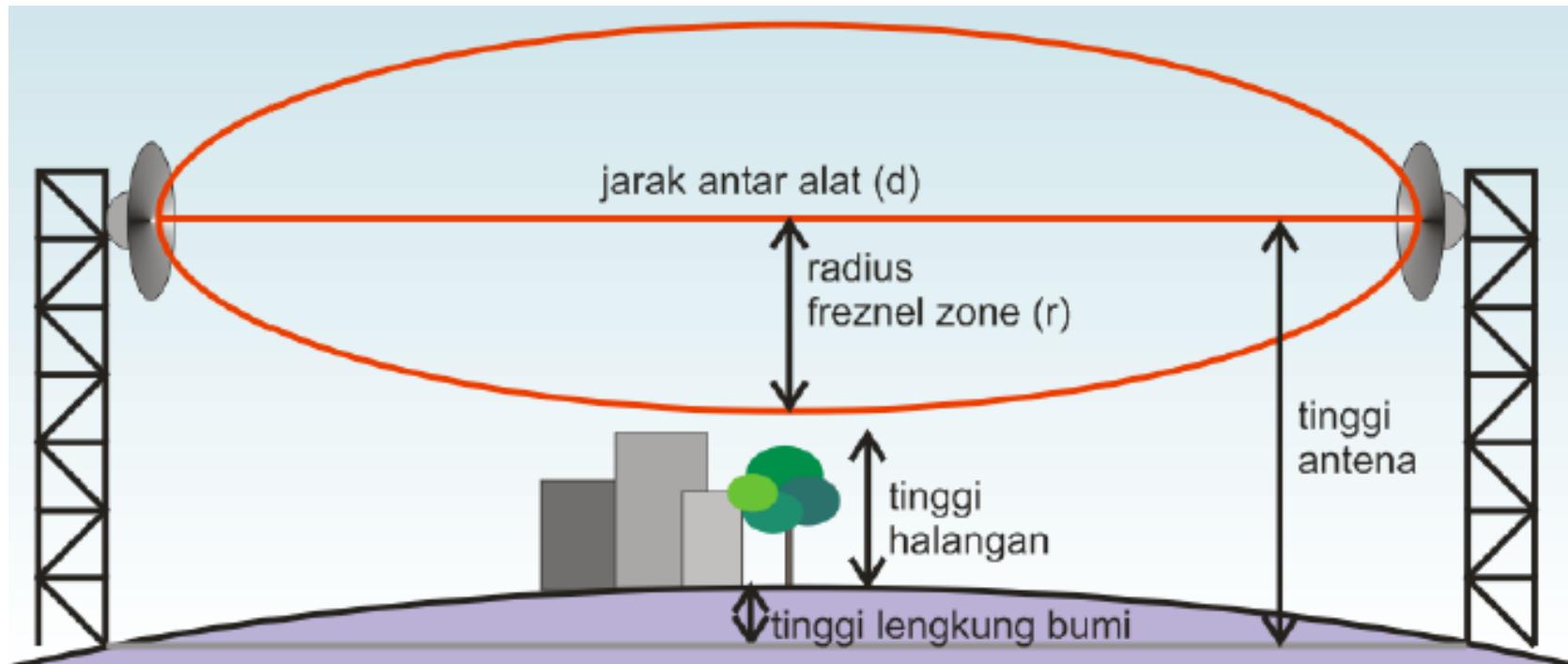
Point A, Point B
Distance: 5.5 Km (3.42 miles)
Free Space Path Loss:
Theoretical signal level at Point A:
Theoretical signal level at Point B:
Link status:

Reset Calculate link

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

<https://mikrotik.com/calculator>

Wireless Calculation



Konsep Antena

- Omnidirectional (ke segala arah)& Directional
- Antenna Gain
- Polarisasi pancaran antenna

Jenis Antena



www.kost-net.com

Omni



Mikrotik Dish



Grid

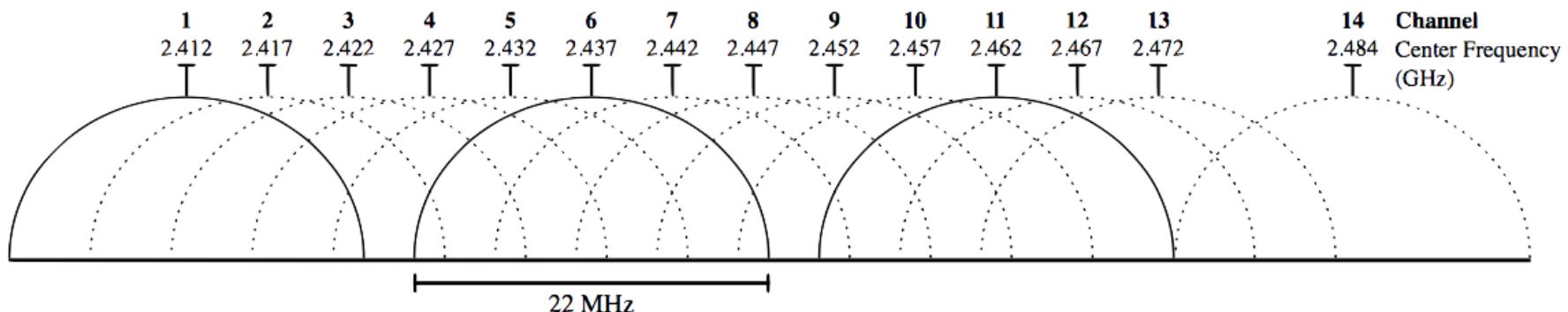


Mikrotik Mant Sectoral

Perangkat Wirelles RouterBoard



2.4GHz Channels



- 13x 22MHz channels (standarisasi sebagian besar negara di dunia)
- 3 channel tidak saling tabrakkan(1, 6, 11)
- 3 AP bisa ditaruh di tempat area yang sama, tanpa mengganggu ap lainnya

5Ghz Channels

- RouterOS mendukung full frekuensi 5Ghz
- 4920-6100Mhz (tergantung pada perangkat wireless card RouterBoard)
- Setiap negara memiliki regulasi frekuensi yang berbeda-beda yang telah ditetapkan masing2

5Ghz Channels

Channel	Frequency	Usage
36	5.180 MHz	Indoor
40	5.200 MHz	Indoor
44	5.220 MHz	Indoor
48	5.240 MHz	Indoor
52	5.260 MHz	Indoor & Outside
56	5.280 MHz	Indoor & Outside
60	5.300 MHz	Indoor & Outside
64	5.320 MHz	Indoor & Outside
100	5.500 MHz	Indoor & Outside
104	5.520 MHz	Indoor & Outside
108	5.540 MHz	Indoor & Outside
112	5.560 MHz	Indoor & Outside
116	5.580 MHz	Indoor & Outside
120	5.600 MHz	No Operation Permitted
124	5.620 MHz	No Operation Permitted
128	5.640 MHz	No Operation Permitted
132	5.660 MHz	Indoor & Outside
136	5.680 MHz	Indoor & Outside
140	5.700 MHz	Indoor & Outside
144	5.720 MHz	Indoor & Outside
149	5.745 MHz	Indoor & Outside
153	5.765 MHz	Indoor & Outside
157	5.785 MHz	Indoor & Outside
161	5.805 MHz	Indoor & Outside
165	5.825 MHz	Indoor & Outside

5GHz Channels

IEEE Standard	Channel Width
802.11a	20MHz
802.11n	20MHz
	40MHz
802.11ac	20MHz
	40MHz
	80MHz
	160MHz

Mode Interface Wireless

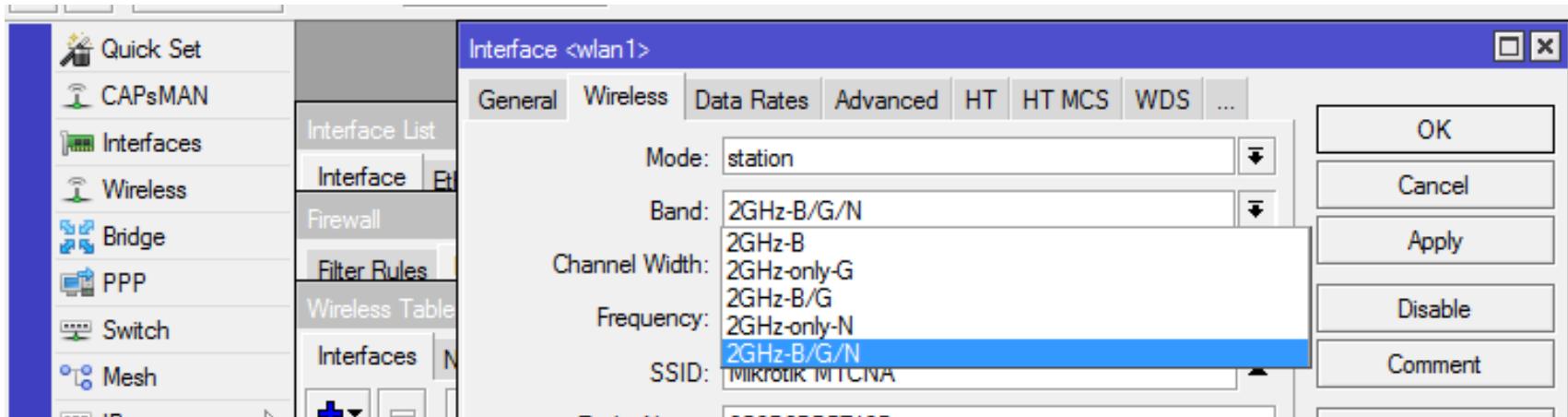
AP Mode

- **AP-bridge** – wireless difungsikan sebagai Akses Poin.
- **Bridge** - hampir sama dengan AP-bridge, namun hanya bisa dikoneksi oleh 1 station/client, mode ini biasanya digunakan untuk point-to-point.

Station Mode

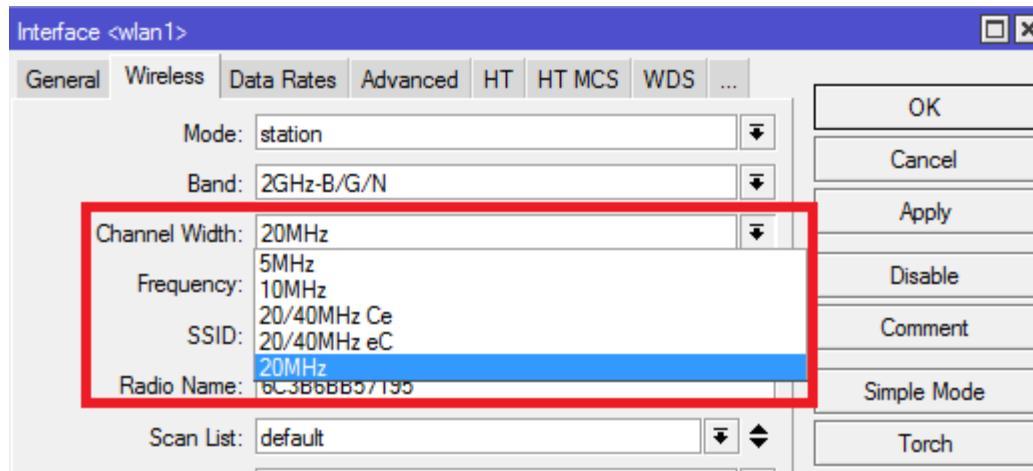
- **Station** – scan dan connect AP dengan frekuensi & SSID yang sama, mode ini TIDAK DAPAT di BRIDGE
- **Station-bridge** – sama seperti station, mode ini adalah MikroTik proprietary. Mode untuk L2 bridging, selain wds.
- **Station-wds** – sama seperti station, namun membentuk koneksi WDS dengan AP yang menjalankan WDS.
- **station-pseudobridge** – sama seperti *station*, dengan tambahan MAC address translation untuk bridge.
- ***station-pseudobridge-clone*** – Sama seperti *station-pseudobridge*, menggunakan station-bridge-clone-mac address untuk koneksi ke AP.

Wireless Band



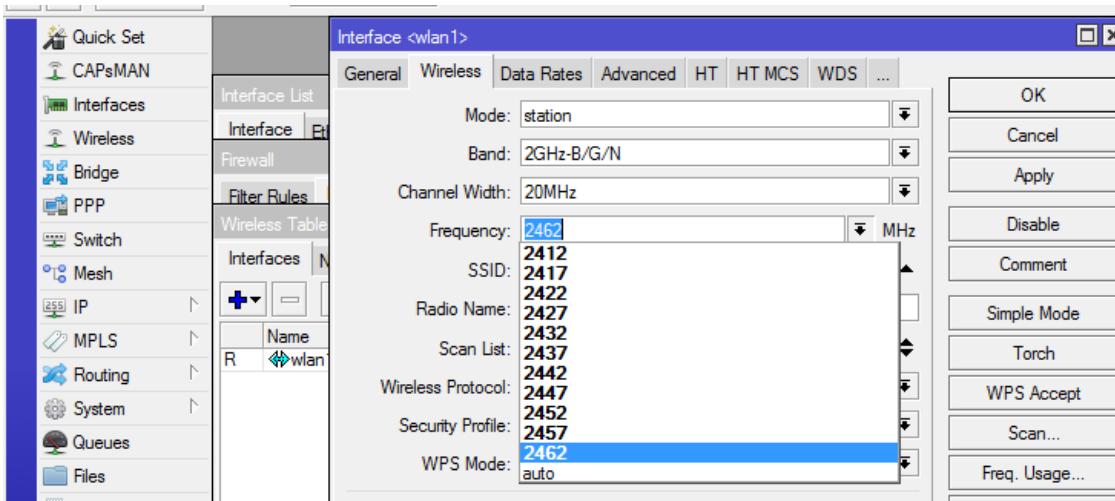
- band merupakan cara untuk menentukan standart protokol yang akan digunakan oleh wireless interface.
- Selain menentukan standart protokol, band juga menentukan data rates yang bisa dilewatkan, channel frequencies dan lebar channel
- Untuk mengkoneksikan 2 perangkat wireless, kedua sisi perangkat bekerja pada band frekuensi yang sama

Wirelles Channel Width



- Parameter channel width berbanding lurus dengan throughput data, artinya semakin lebar channel width maka semakin besar pula throughput yang bisa dilewatkan.
- Tetapi ukuran channel width juga memiliki konsekuensi. Semakin besar channel width kemungkinan terjadinya interferensi juga semakin besar.

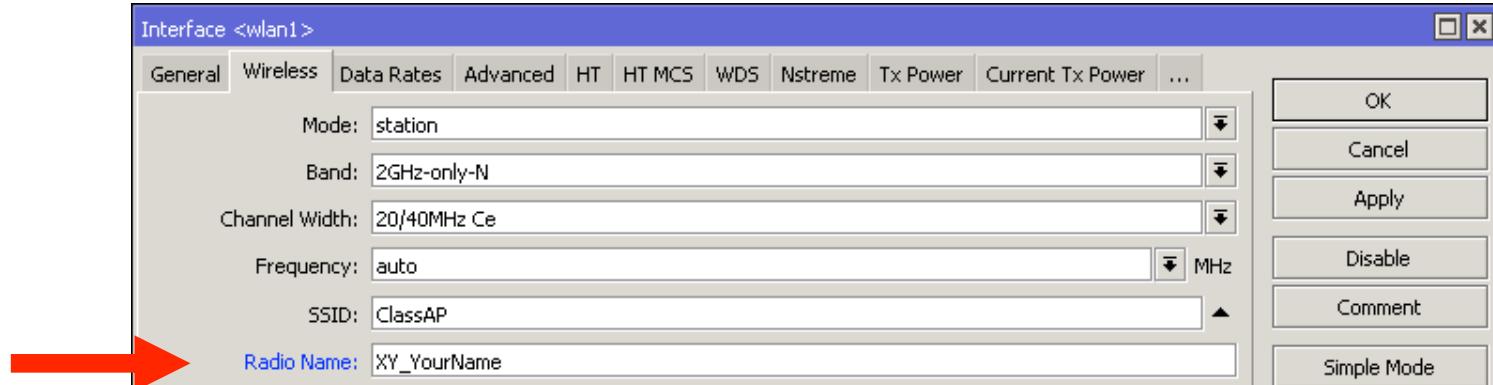
Wireless Frequency Channel



- Frequency channel yaitu Menentukan frekuensi perangkat wireless Access Point dalam suatu band yang digunakan
- Pemilihan band yang dipilih, tergantung kemampuan wireless card atau aturan regulasi di suatu negara.

Radio Name

- Wireless interface : radio name
- Mikrotik – Mikrotik
- Bisa di lihat di wireless table



Radio Name

- Wireless interface “name”
- RouterOS-RouterOS only
- Can be seen in Wireless tables



Radio Name	MAC Address	Interface	Uptime	AP	WDS	Last Activi...	Tx/Rx ...	Tx Rate	Rx Rate
XY_YourName	D4:CA:6D:E2:65:94	wlan1	00:16:52	no	yes	0.000	-28/-28	144.4Mbps-20MHz/25/5GI	130Mbps-20MHz/25/5GI

1 item

Wireless → Registration

Radio Name

- Gantilah nama indentitas pada RouterBoard wireless anda. Contoh : Wireless_(nama)

Regulasi Frekuensi Wireless

- Setiap negara memiliki aturan regulasi wireless tertentu dalam hal frekuensi wireless untuk penyebaran wireless
- Di Indonesia untuk menggunakan frekuensi 2.4GHz berdasarkan KEPMENHUB No. 2/2005 berkat perjuangan para penggerak internet sejak tahun 2001
- Regulasi tersebut dalam mikrotik terdapat pada bagian Wireless “country-regulation”.

Regulasi Frekuensi Wireless

admin@B8:69:F4:A8:4B:53 (MikroTik) - WinBox v6.43.2 on hAP lite (smips)

Session Settings Dashboard

Session: B8:69:F4:A8:4B:53

Quick Set CAPsMAN Interfaces Wireless Bridge PPP Switch Mesh IP MPLS Routing System Queues Files Log Radius Tools New Terminal

Interface <wlan1>

General Wireless Data Rates Advanced HT HT MCS WDS ...

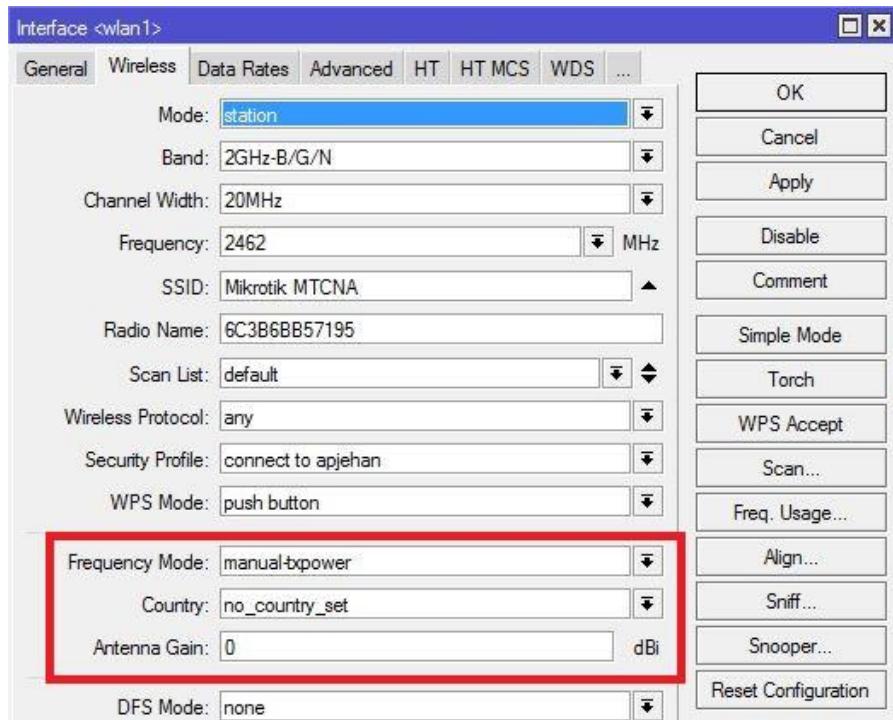
Mode: ap bridge
Band: 2GHz-B/G/N
Channel Width: 20MHz
Frequency: 2437 MHz
SSID: gpmnetwork
Radio Name: B869F4A84B58
Scan List: default
Wireless Protocol: any
Security Profile: profile1
WPS Mode: push button

Frequency Mode: manual-txpower
Country: regulatory-domain
Antenna Gain: 0 dBi

OK Cancel Apply Disable Comment Simple Mode Torch WPS Accept WPS Client Setup Repeater Scan... Freq. Usage... Align...

The screenshot shows the WinBox interface for managing a wireless interface (wlan1). The left sidebar lists various network-related sections like Quick Set, CAPsMAN, and Wireless. A red arrow points from the 'Wireless' link in the sidebar to the 'Wireless' tab in the main configuration window. The main window displays settings for wlan1, including Mode (ap bridge), Band (2GHz-B/G/N), Channel Width (20MHz), Frequency (2437 MHz), SSID (gpmnetwork), Radio Name (B869F4A84B58), Scan List (default), Wireless Protocol (any), Security Profile (profile1), and WPS Mode (push button). A red box highlights the 'Frequency Mode' dropdown menu, which lists four options: manual-txpower, manual-txpower (selected), regulatory-domain, and superchannel. The right side of the window contains buttons for OK, Cancel, Apply, Disable, Comment, Simple Mode, Torch, WPS Accept, WPS Client, Setup Repeater, Scan..., Freq. Usage..., and Align... .

Regulasi Frekuensi Wireless



Frequency Mode

1. manual-tx-power

Transmit power diatur manual (tidak menyesuaikan dengan negara tertentu).

2. regulation-domain

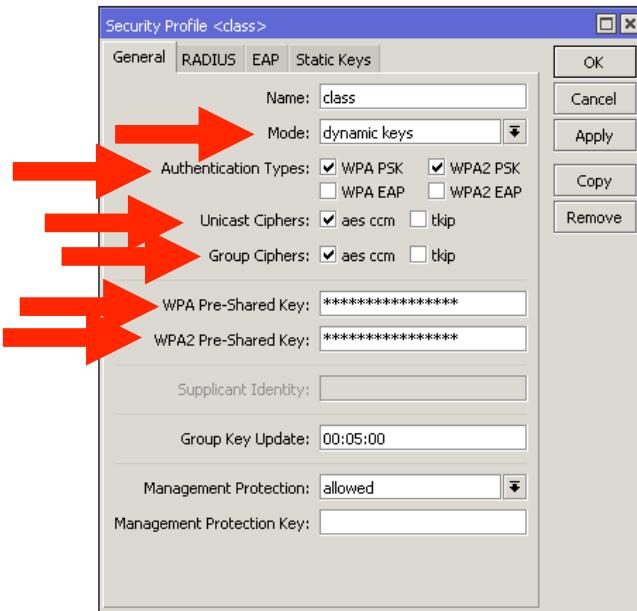
Frekuensi channel disesuaikan dengan frekuensi-frekuensi yang diijinkan di suatu negara.

3. Superchannel

Membuka semua frekuensi yang bisa disupport oleh wireless card

Security

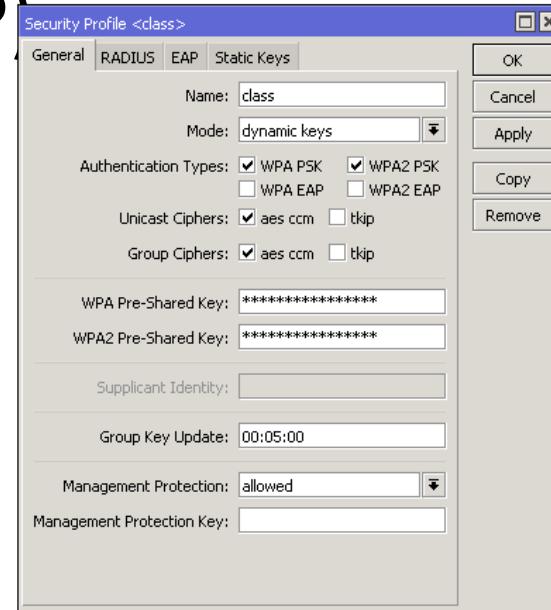
- WPA & WPA2 key dapat secara bersama dilakukan untuk mengizinkan spesifik koneksi dari laptop/hp yang tidak mendukung WPA2 & begitu pun sebaliknya
- Selalu gunakan password yg aman/strong key



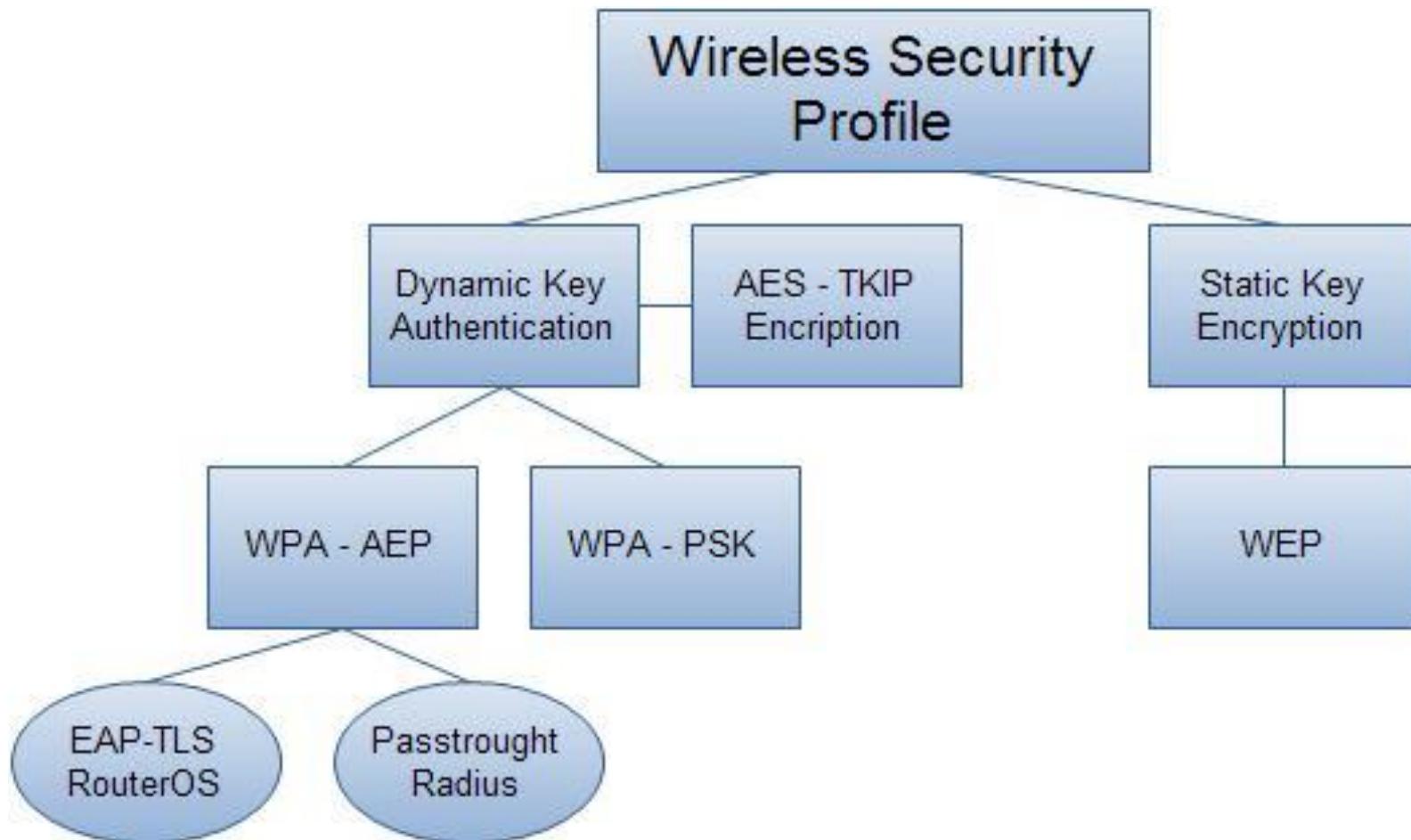
Wireless → Security Profiles

Wireless Security

- Karakteristik keamanan wireless yaitu:
- – Authentication (WPA-PSK, WPA-AEP)
- – Enkripsi (AES, TKIP, WEP)



Wireless Security



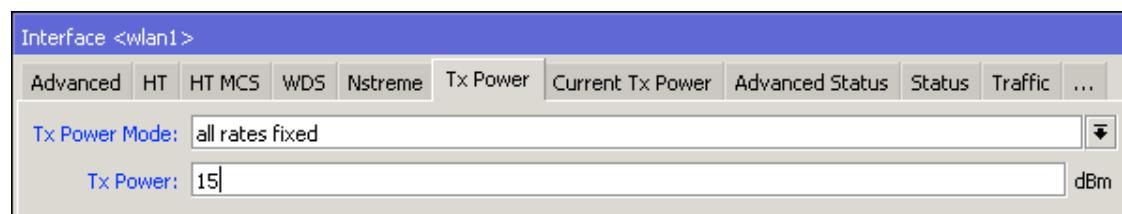
Wireless Chains



- 802.11n pada mikrotik RouterBoard support konsep MIMO (Multiple in and Multiple Out)
- Mengirimkan dan Menerima packet data menggunakan multiple radio antenna secara bersamaan/parallel
- 802.11 menggunakan satu chain (SISO) dan hanya dapat mencapai 72.2Mbps pada card wireless versi lama mencapai 65Mbps

Tx Power

- Untuk dapat mengatur/menyesuaikan power transmit pada wireless card
- Dapat merubah ke **all rate fixed** dan dapat menyesuaikan power

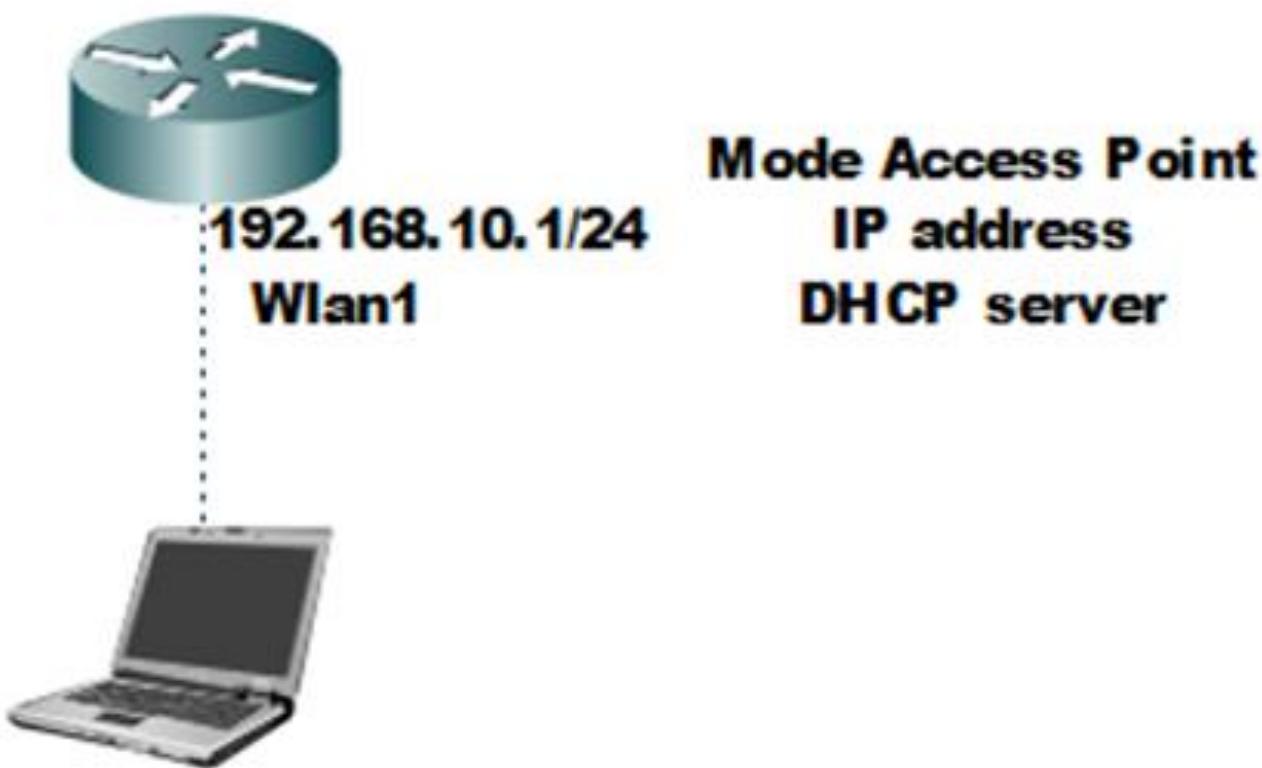


Wireless → Tx Power

Tx Power

Wireless card	Enabled Chains	Power per Chain	Total Power
802.11n	1	Equal to the selected Tx Power	Equal to the selected Tx Power
	2		+3dBm
	+5dBm		+5dBm
802.11ac	1	Equal to the selected Tx Power	Equal to the selected Tx Power
	-3dBm		+3dBm
	-5dBm		+5dBm

Topologi training Akses Point



Membuat Access Point

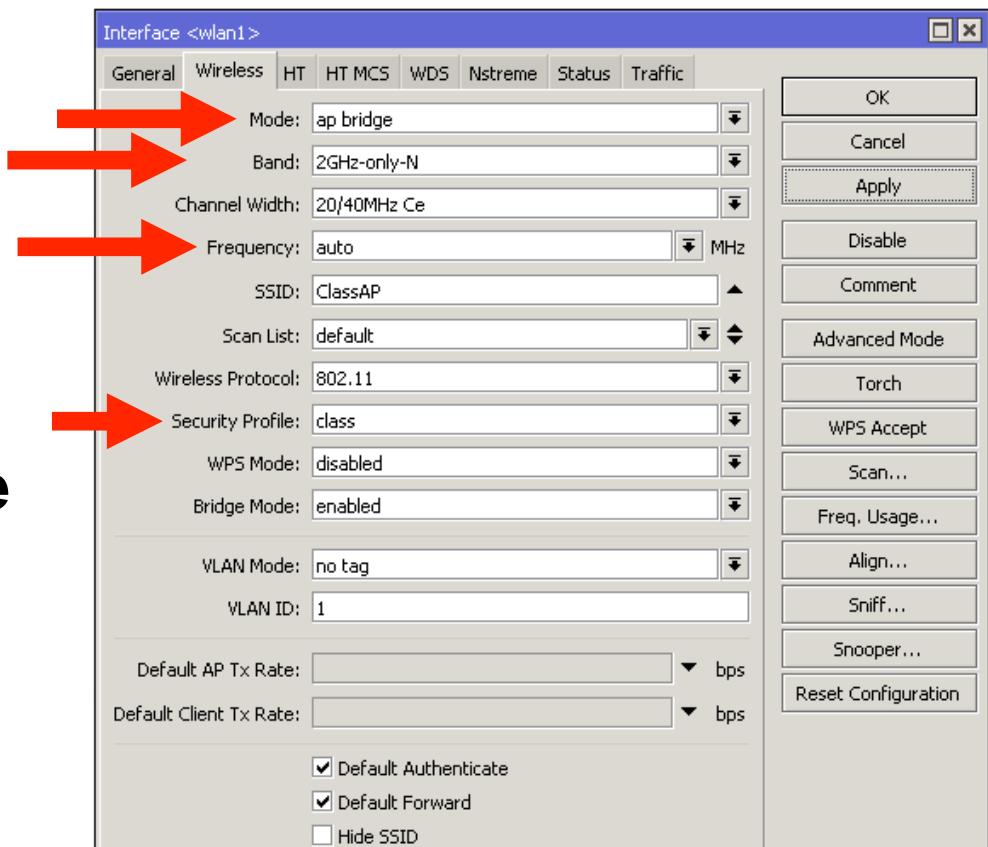
- Koneksikan HP/laptop lainnya ke accespoint yg telah dibuat, dengan SSID nama anda tadi
- Apabila ada hp/laptop berlebih koneksi 2 device ke access point

Membuat Access Point

- Gantilah nama indentitas pada RouterBoard wireless anda. Contoh : Wireless_(nama)
- Sesuaikan Mode Wirelles
- Sesuaikan Band
- Sesuaikan SSID
- Sesuaikan enkripsi dan authentifikasi
- Frekuansi channel tidak perlu sama terserah

Access Point

- Set interface ke **mode=ap bridge**
- Select **band**
- Set **frequency**
- Set **SSID** (wireless network ID)
- Set **Security Profile**



Access Point

- Buat security profile baru pada profile wireless RouterBoard anda
- RouterBoard anda sebagai Access Point dan pilih security profile yang telah dibuat sebelumnya
- Disconect kabel UTP laptop dari router
- Koneksikan laptop anda ke Access point yang telah dibuat sebelumnya

Registration Table

- Untuk digunakan melihat seluruh perangkat yang terkoneksi ke acces point RouterBoard kita.

The screenshot shows the 'Wireless Tables' window in Winbox. The 'Registration' tab is selected. The table displays two entries:

Radio Name	MAC Address	Interface	Uptime	AP	WDS	Last Activi...	Tx/Rx ...	Tx Rate	Rx Rate
40:B0:FA:81:21:4A	wlan1	00:47:14	no	no	11.130	-79	48Mbps	1Mbps	
XY_YourName	D4:CA:6D:E2:65:94	wlan1	00:42:39	no	no	0.000	-28/-32	144.4Mbps-20MHz/25/SGI	130Mbps-20MHz/25/SGI

2 items

Wireless → Registration

Access List

- Untuk digunakan AP mengontrol client yang terkoneksi
- Memberikan informasi MAC address dengan fitur comment
- Setting client/station apakah oleh terhubung atau tidak (authentication) ke AP
- AP Bisa menentukan limit waktu client pada saat terhubung

Access List

Wireless Tables

Interfaces Nstreme Dual Access List Registration Connect List Security Profiles Channels

#	MAC Address	Interface	Signal St...	Authentication	Forwarding	
0	AA:6C:B4:8A:C0:C9	wlan1	-120..120	yes	yes	

AP Access Rule <AA:6C:B4:8A:C0:C9>

MAC Address: AA:6C:B4:8A:C0:C9
Interface: wlan1
Signal Strength Range: -120..120

AP Tx Limit:
Client Tx Limit:

Authentication
 Forwarding

Disable Comment Copy Remove

VLAN Mode: no tag
VLAN ID: 1

Private Key: none 0x
Private Pre Shared Key:
Management Protection Key:

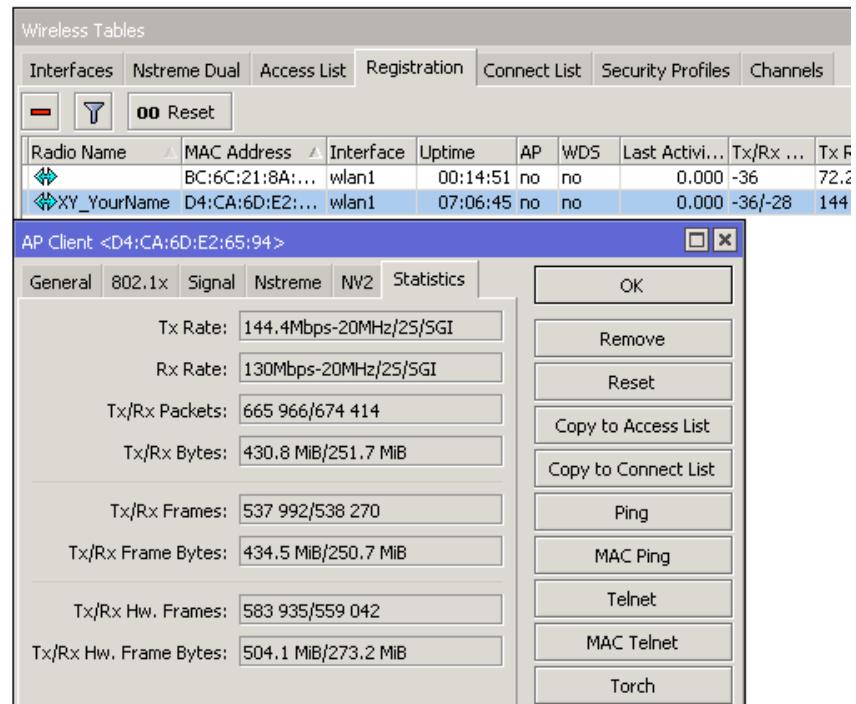
Time: 00:00:00 - 1d 00:00:00
Days: sun mon tue wed thu fri sat

enabled

Wireless → Access List

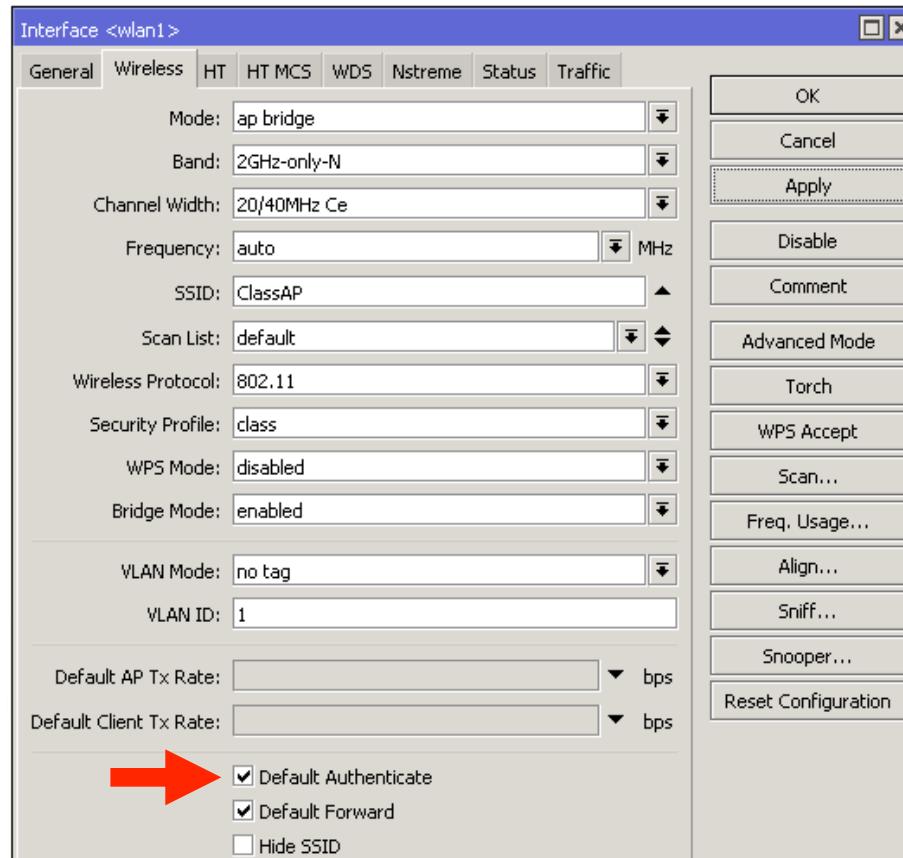
Registration Table

- RouterBoard bisa menggunakan fitur **copy to access list** atau **copy to connect list** yang terdapat pada menu registration table, apabila perangkat telah terhubung, jika kita ingin limit



Wireless → Registration

Default Authenticate

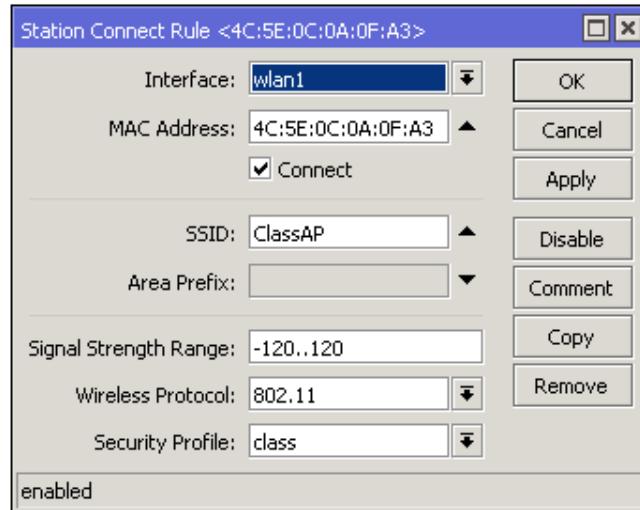


Default Authenticate

Default Authentication	Access/Connect List Entry	Behavior
✓	+	Based on access/connect list settings
	-	Authenticate
✗	+	Based on access/connect list settings
	-	Don't authenticate

Connect List

- Rule pengunaan station untuk **memilih** atau **tidak memilih** AP

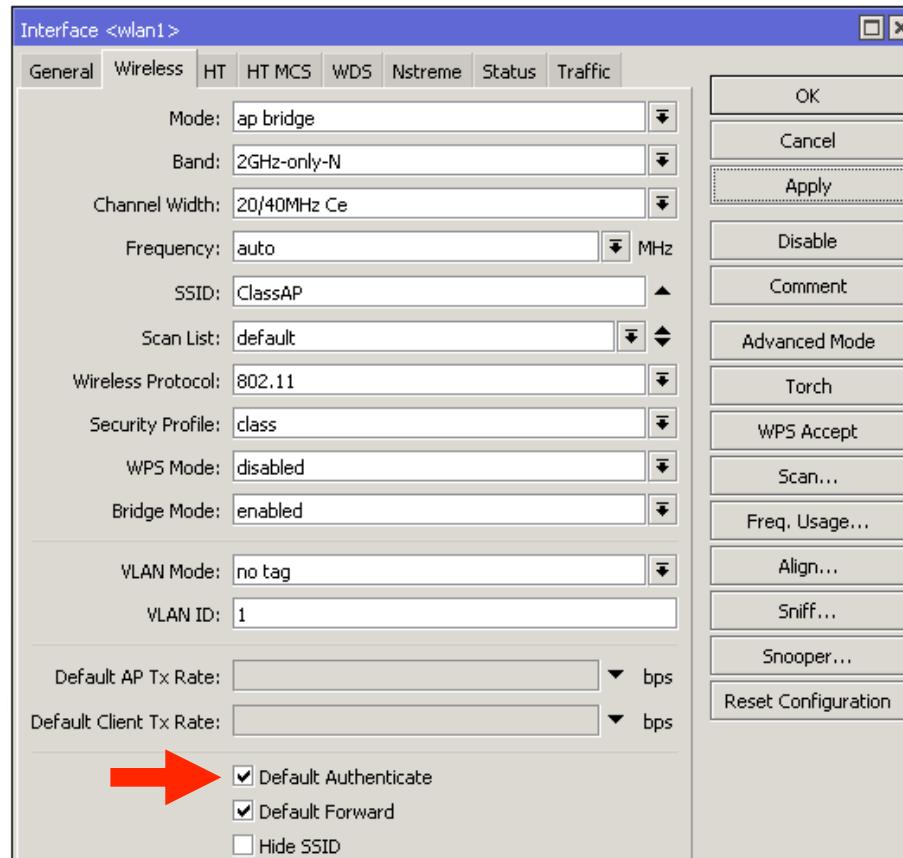


Wireless → Connect List

Connect List

- Pastikan RouterBoard anda sudah terkoneksi dengan wireless access point
- Buatlah rule untuk tidak memperbolehkan client terhubung ke Access Point

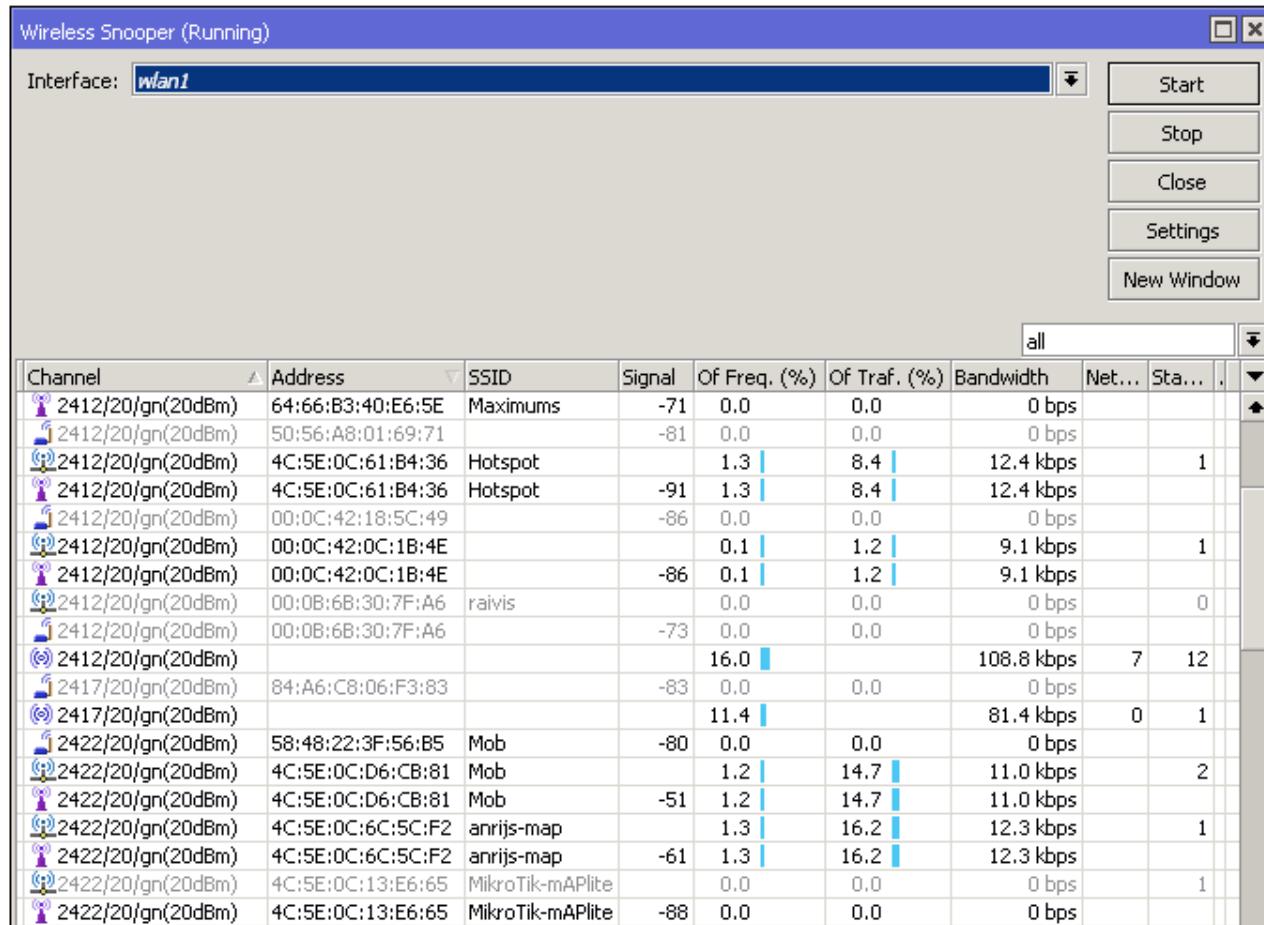
Default Authenticate



Snooper

- Seluruh gambaran dari wireless network band yang kita pilih/gunakan
- Interface wireless akan disconnect/mati selama proses scanning
- Digunakan untuk menentukan pemilihan channel untuk digunakan/dipilih,biar tidak interference dengan AP lainnya

Snooper



Wireless → Snooper

Tools Wireless

- **Scan** Mengetahui informasi Acess Point yang aktif, dengan melihat SSID yang aktif
- **Align** untuk digunakan pointing antenna.
- **Sniff** untuk mengetahui lalu lintas paket data di jaringan wireless.
- **Snooper** seperti tool scan, memberikan informasi detail terkait AP yang aktif di sekitar
- **Tool Bandhwidth Test** digunakan untuk test bandwidth antar koneksi wirelles

LAB

Wireless Network



Wireless stations

Mode Wireless Bridge

- Station-bridge : Mikrotik To Mikrotik
- Station: Mikrotik To Merk lainnya
- Station-pseudobridge : Mikrotik To merk lainnya
- Station-wds (Wirelless Distribution System) : Mikrotik - Mikrotik



Certified Network Associate (MTCNA)

Module 7

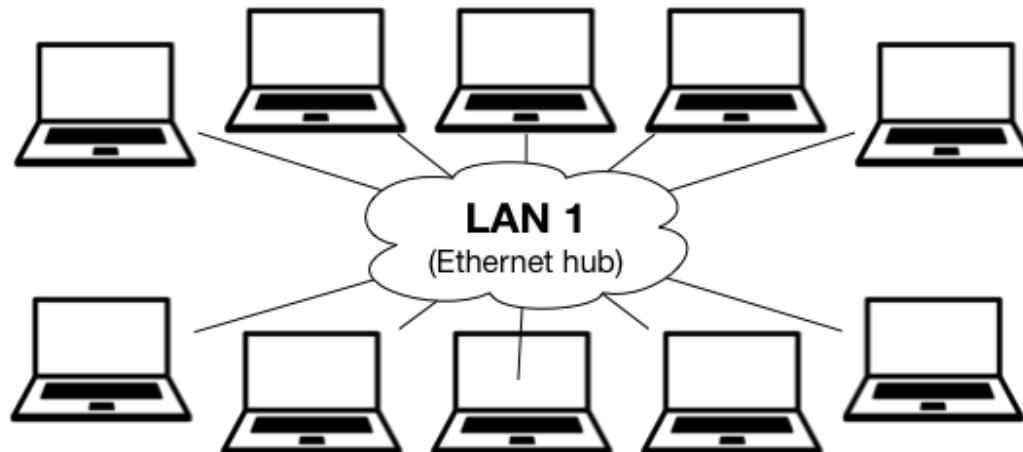
Bridge

Bridge

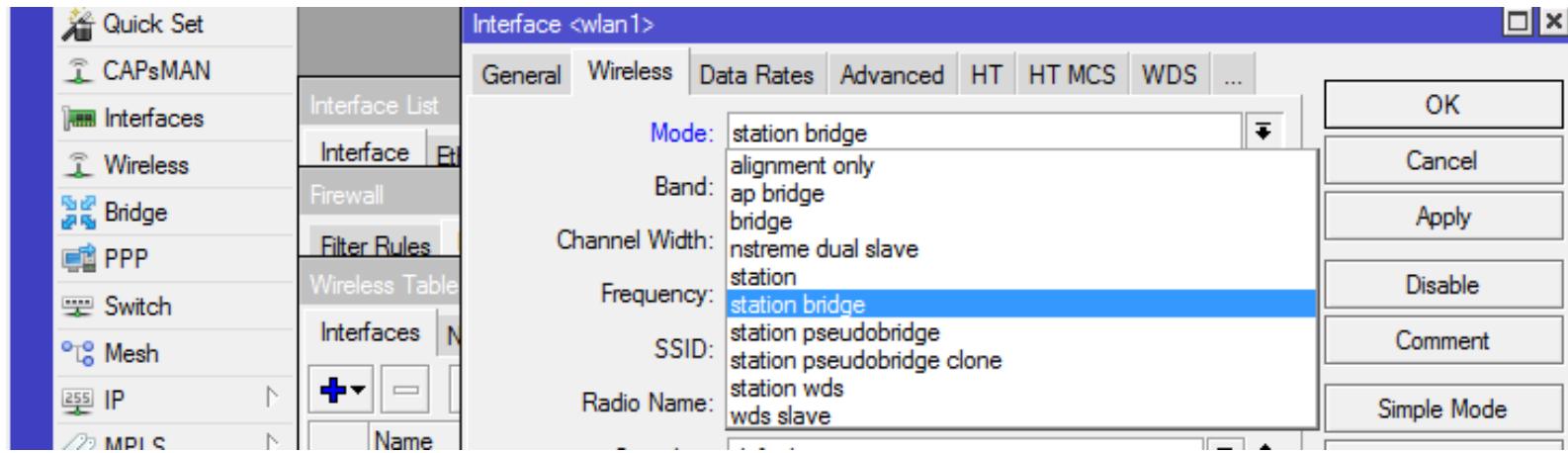
- Bridge OSI layer 2 device
- Bridge merupakan transparent device
- Konsep bridge adalah menggabungkan 2 atau lebih interface ethernet atau sejenisnya sehingga seolah-oleh berada dalam segmen network yang sama.
- Interface bridge adalah interface virtual, dimana kita dapat membuat sebanyak yang kita inginkan.
- Step membuat bridge yaitu membuat bridge baru dan selanjutnya menambahkan interface port ke dalam bridge baru
- Jika kita membuat interface bride tanpa menambahkan interface fisik pada portnya, maka bridge tersebut dianggap sebagai interface loopback.

Kekurangan Bridge

- Apabila terjadi masalah pada satu port/segmen akan membuat masalah di port/segmen pada bridge yang sama.



Wirelles Bridge



Semua mode wireless bisa dibridging, kecuali mode station.

Bridge

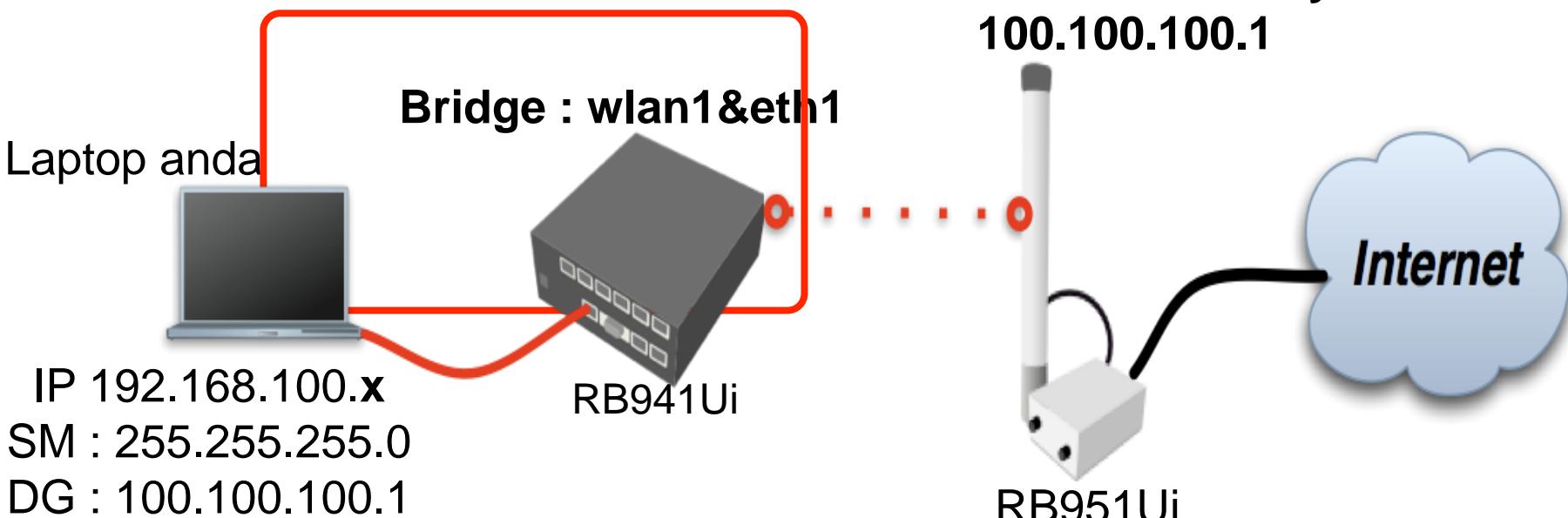
- Menu mode Bridge bisa menggunakan IP Firewall
- Lan ethernet RouterBoard dalam mode switch, tidak bisa dimasukkan ke dalam mode port Bridge dan sebaliknya
- Mode wireless **station** tidak bisa di bridge
- Semua mode wireless bisa dibridging, kecuali mode station.

Mode Wireless Bridge

- Station-bridge : Mikrotik To Mikrotik
- Station: Mikrotik To Merk lainnya
- Station-pseudobridge : Mikrotik To merk lainnya
- Station-wds (Wirelless Distribution System) : Mikrotik - Mikrotik

LAB

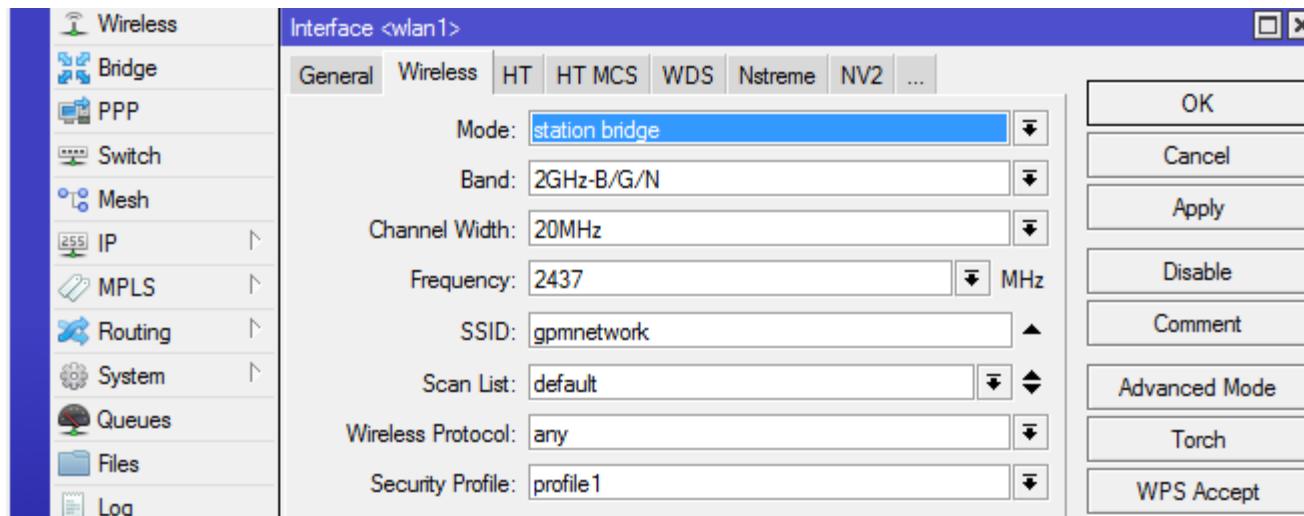
Topologi Bridge



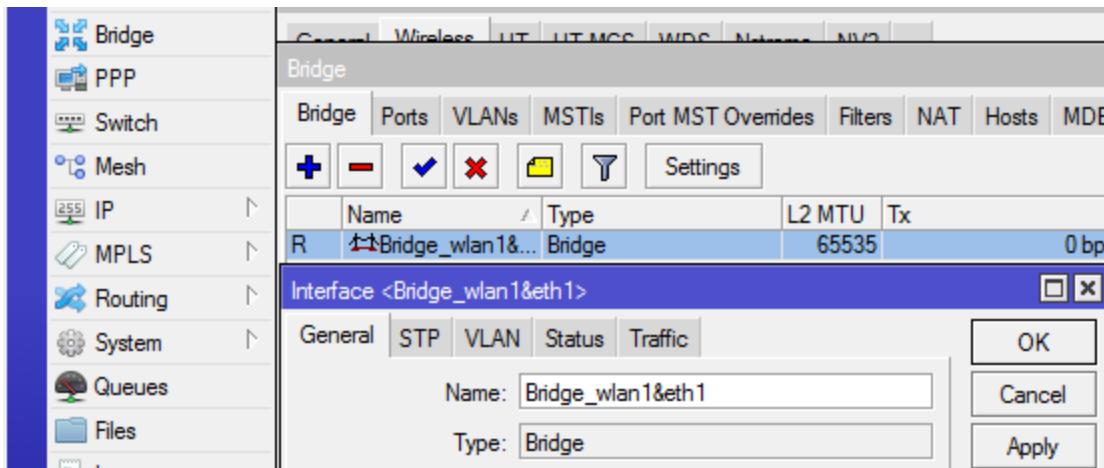
Pemberian IP address Laptop akan diberikan oleh AP Trainer

Bridge

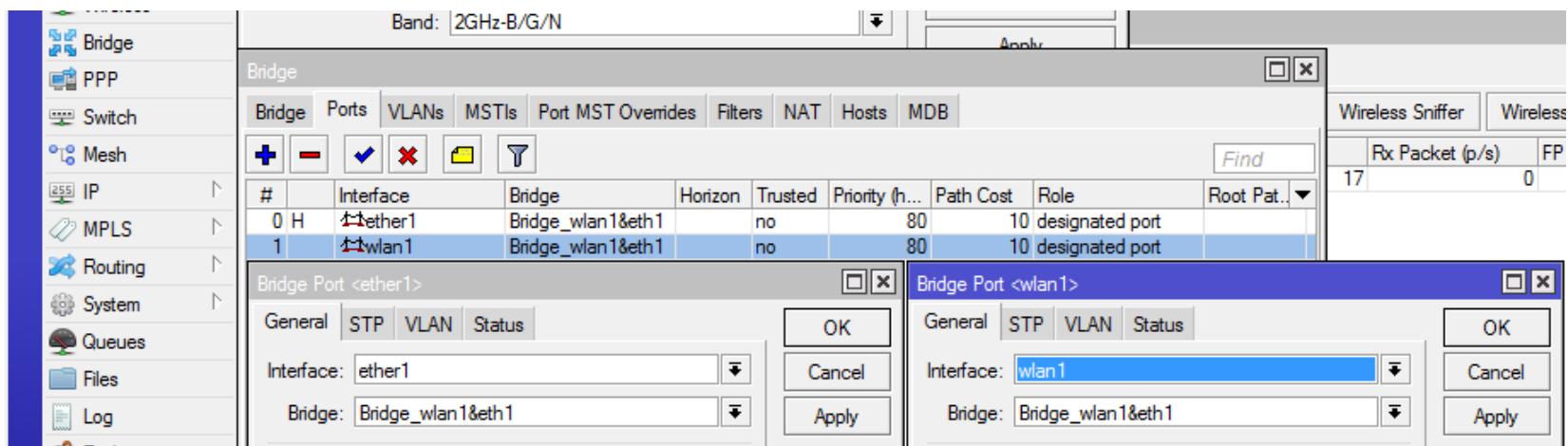
- Dalam lab ini akan mempraktekan membuat network antara local ethernet (**Eth1**) dan wireless interface (**Wlan1**)
- Mengubah Mode wireless menjadi **station bridge**



Bridge



Membuat Interface Virtual Bridge

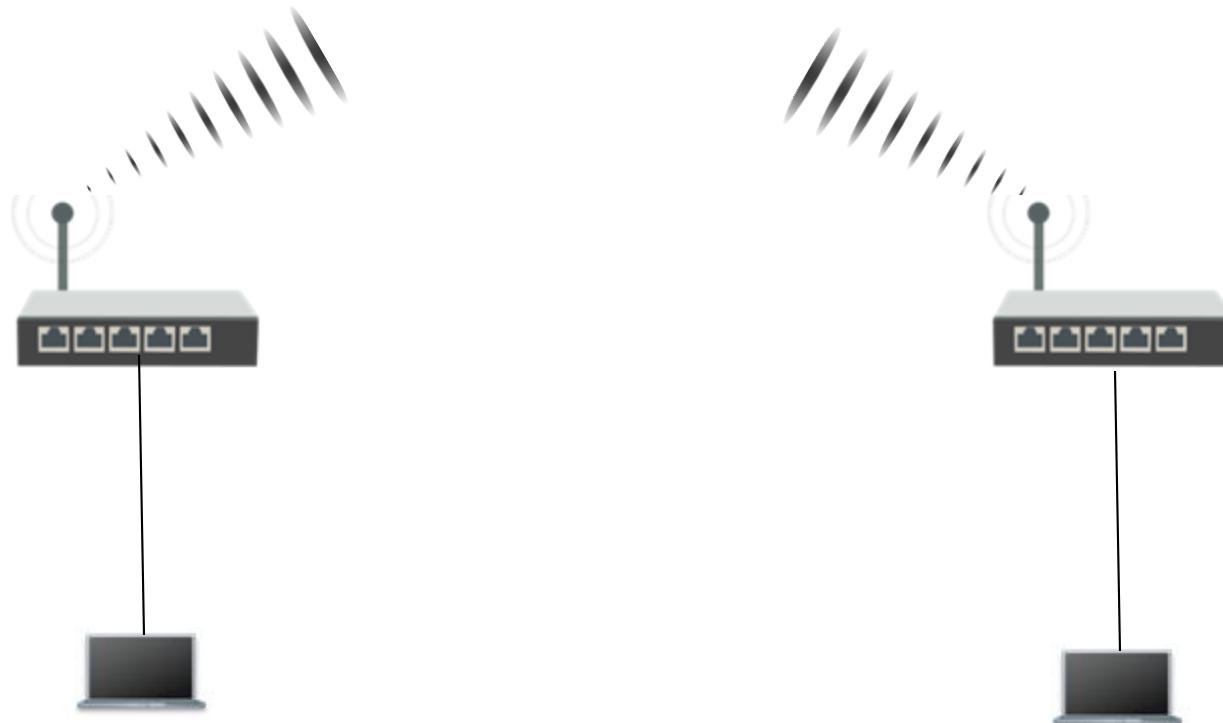


Tambahkan wireless interface & ethernet 1
kedalam inteface virtual **Bridge_wlan1ð1**

Bridge → Ports

LAB

Wireless Network



Wireless stations

Verifikasi Bridge

- Perbarui IP address pada PC/Laptop anda
Command prompt : **ipconfig /release** then
ipconfig /renew
- Laptop anda akan mendapatkan semua perangkat mikrotik yang terhubung di neighbor discovery router mikrotik anda
- RouterBoard mikrotik sekarang bekerja sebagai **transparent bridge**
- PC/Laptop akan mendapatkan IP address dari AP Trainer yaitu 100.100.100.X

Bridge Firewall

- Fitur Bridge support **firewall**
- Trafic yang melewati bridge dapat diproses dengan firewall aktif
- Untuk dapat mengaktifkan bridge firewall dengan cara : **Bridge > Setting > ceklis Use Ip Firewall**

Restore ke konfigurasi awal, terhubung ke internet dengan Dhcp Router Peserta

- Hapus Port **wlan1ð1** di interface virtual **Bridge_wlan1ð1** pada menu Bridge
- Hapus interface virtual **Bridge_wlan1ð1** pada menu Bridge
- Cmd : **ipconfig /release** kemudian **ipconfig /renew**. Pastikan kembali mendapatkan ip address

Module Summary



Certified Network Associate
(MTCNA)

Module 9

Misc

Mikrotik Login page



Powered by MikroTik RouterOS

RouterOS Tools

Mikrotik RouterOS memiliki variasi utilities yang dapat membantu network administrator memonitor router lebih spesifik



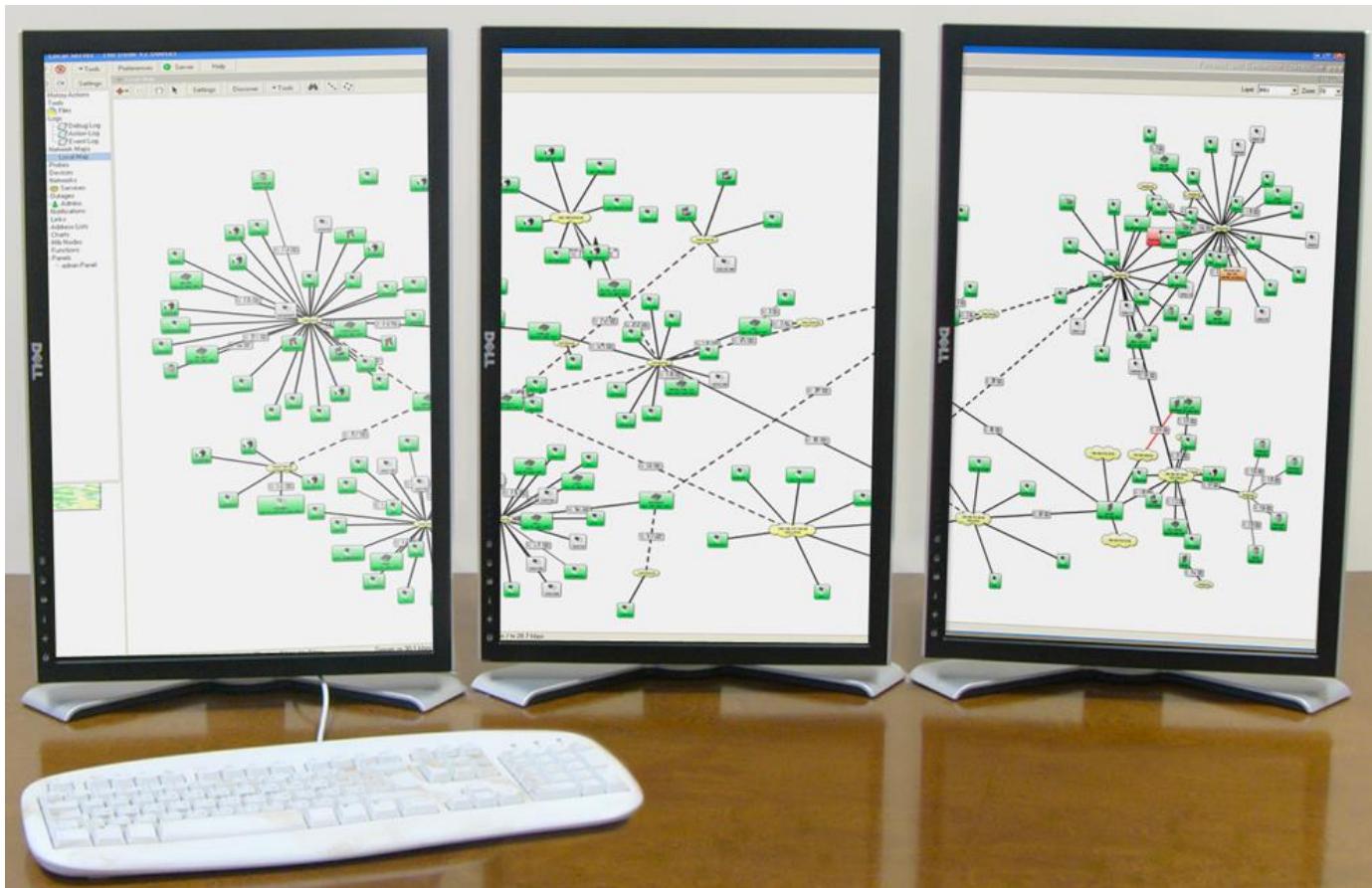
The Dude

- Aplikasi Network Monitoring sistem dari mikrotik
- Otomatis discovery dan layout map
- Monitoring service dan alarm
- Gratis

The Dude

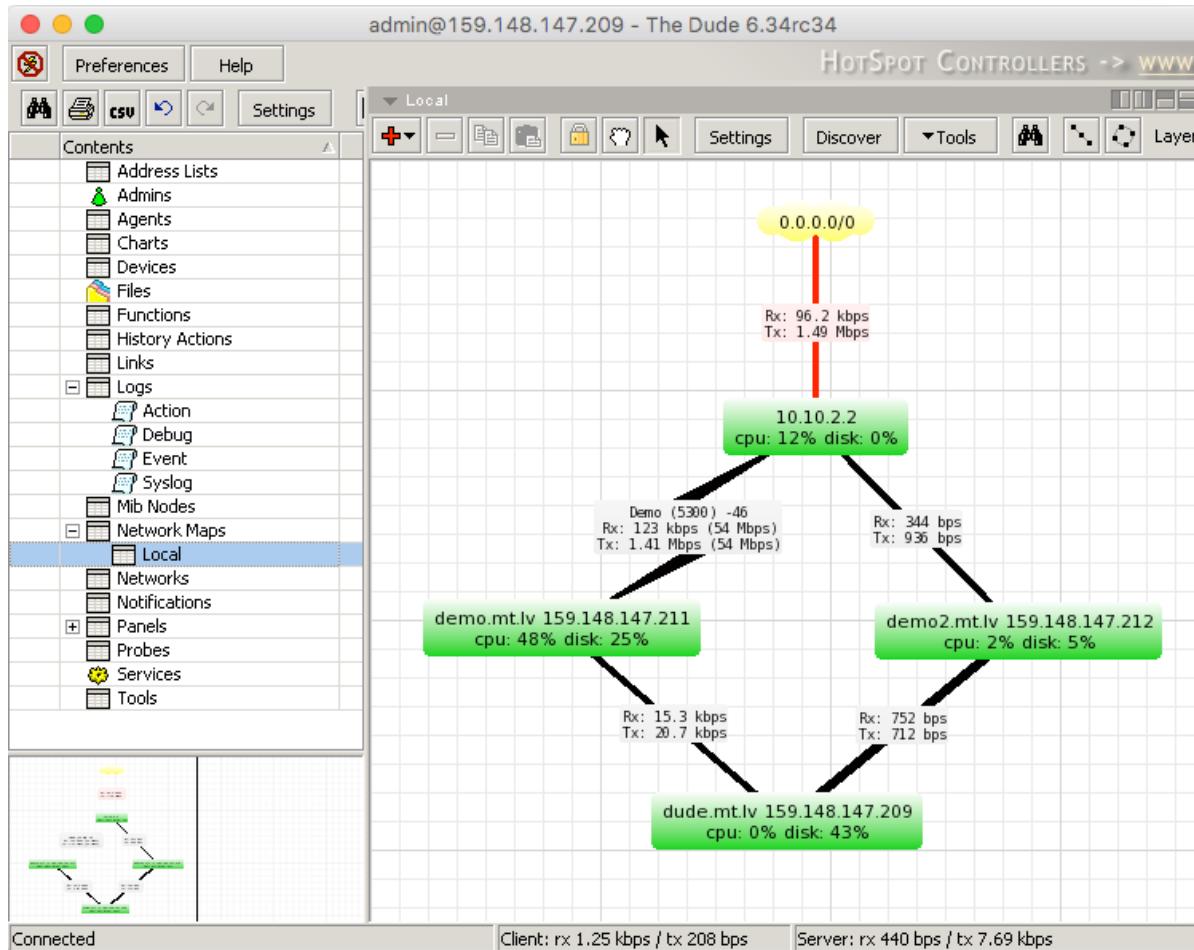
- Support SNMP, ICMP, DNS, dan TCP monitoring
- Server running pada RouterOS (CCR, CHR or X86)
- Client pada Windows (Linux dan OS X menggunakan wine emulator)
- For more info see The Dude wiki page

The Dude



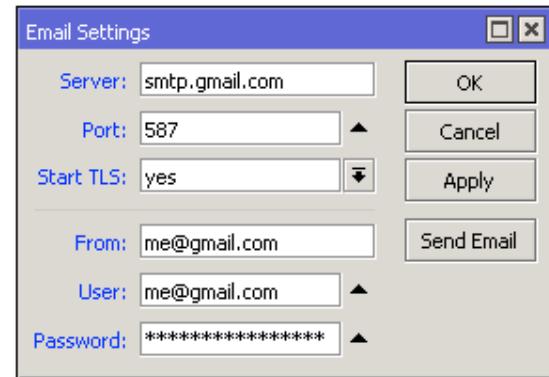
LAB

The Dude



E-mail

- Allows to send e-mails from the router
- For example to send router backup



Tools → Email

```
/export file=export
/tool e-mail send to=you@gmail.com\
    subject="$[/system identity get name] export" \
    body="$[/system clock get date] \
    configuration file" file=export.rsc
```

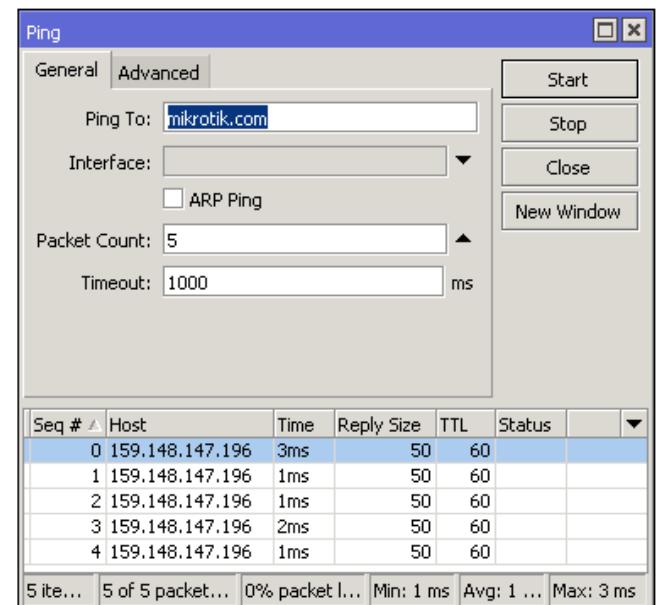
A script to make an export file and send it via e-mail

E-mail

- Configure your SMTP server settings on the router
- Export the configuration of your router
- Send it to your e-mail from the RouterOS

Ping

- Used to test the reachability of a host on an IP network
- To measure the round trip time for messages between source and destination hosts
- Sends ICMP echo request packets



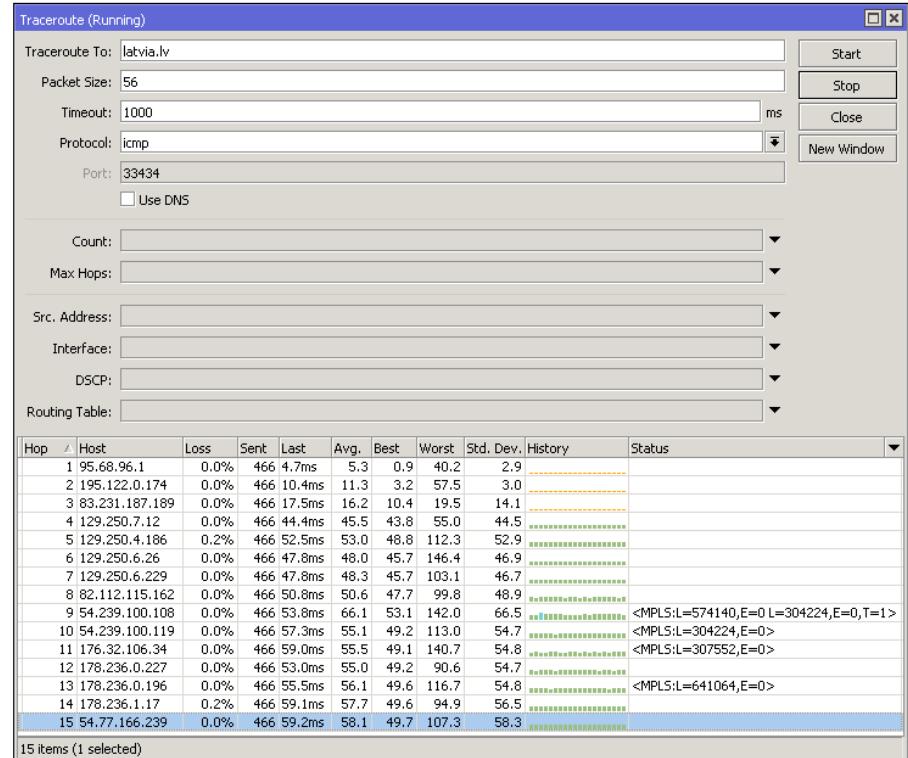
Tools → Ping

Ping

- Ping your laptop's IP address from the router
- Click 'New Window' and ping www.mikrotik.com from the router
- Observe the round trip time difference

Traceroute

- Network diagnostic tool for displaying route (path) of packets across an IP network
- Can use **icmp** or **udp** protocol



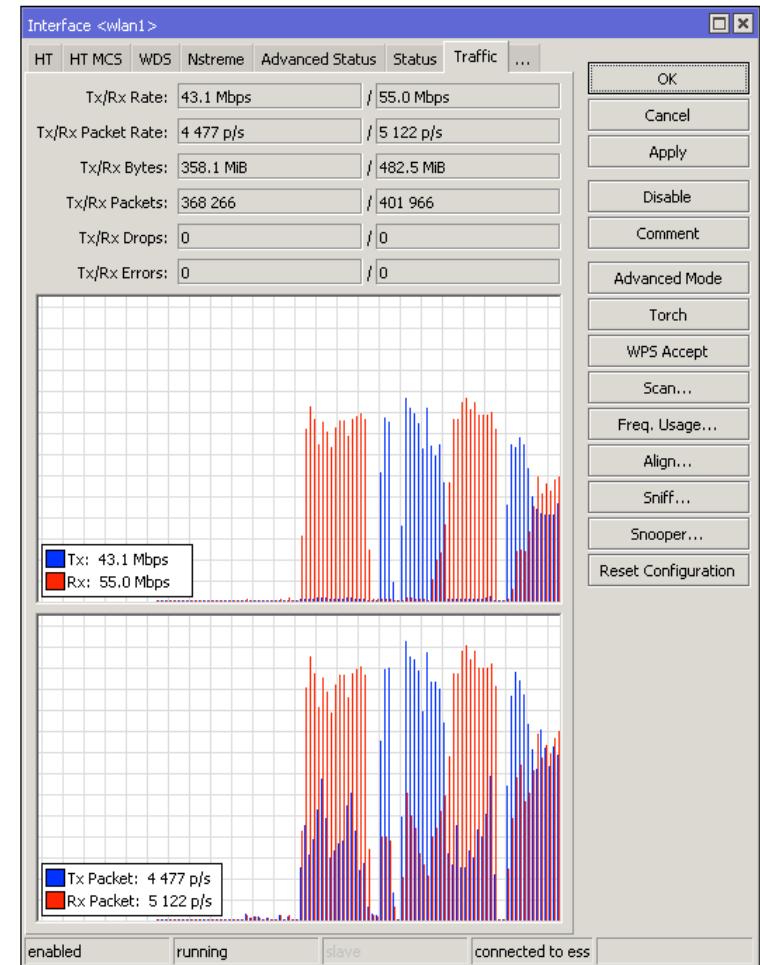
Tools → Traceroute

Traceroute

- Choose a web site in your country and do a traceroute to it
- Click ‘New Window’ and do a traceroute to www.mikrotik.com
- Observe the difference between the routes

Interface Traffic Monitor

- Real time traffic status
- Available for each interface in traffic tab
- Can also be accessed from both WebFig and command line interface

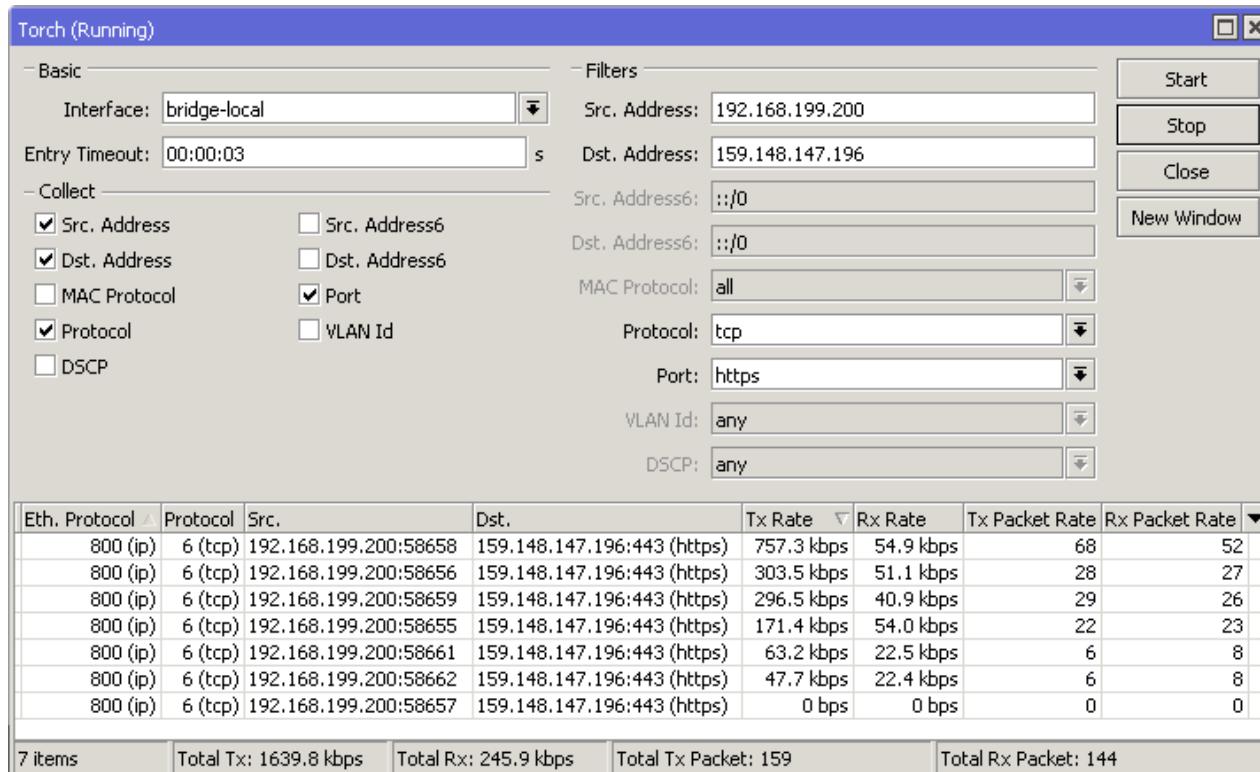


Interfaces → wlan1 → Traffic

Torch

- Real-time monitoring tool
- Can be used to monitor the traffic flow through the interface
- Can monitor traffic classified by IP protocol name, source/destination address (IPv4/IPv6), port number

Torch



Tools → Torch

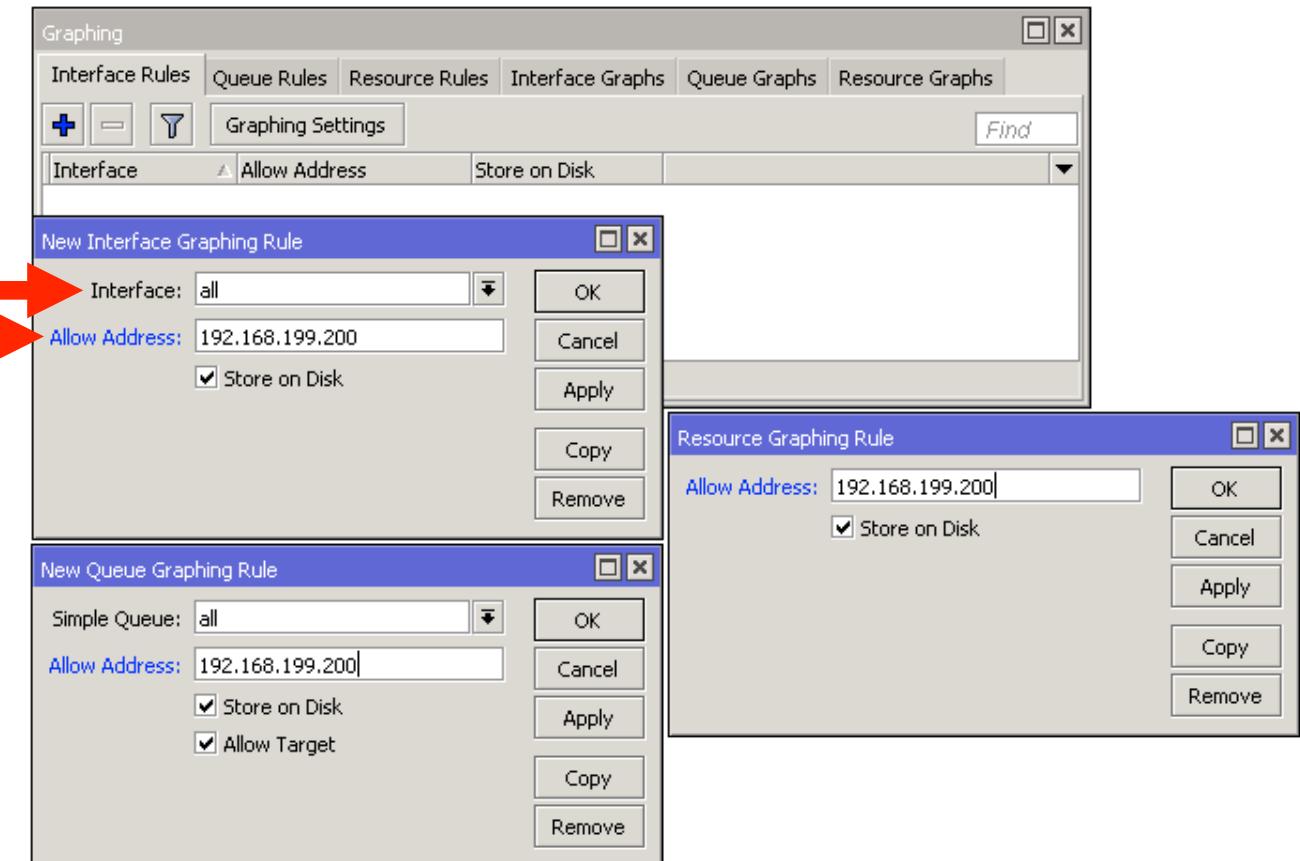
- Traffic flow from the laptop to the mikrotik.com web server HTTPS port

Graphs

- RouterOS can generate graphs showing how much traffic has passed through an interface or a queue
- Can show CPU, memory and disk usage
- For each metric there are 4 graphs - daily, weekly, monthly and yearly

Graphs

Set specific interface to monitor or leave all, set IP address/subnet which will be able to access the graphs



Tools → Graphing

Graphs

Traffic and system resource graphing

[CPU usage](#)

[Memory usage](#)

[Disk usage](#)

You have access to 4 queues:

[129](#)

[130](#)

[131](#)

[parent](#)

You have access to 7 interfaces:

[ether1-gateway](#)

[ether2-master-local](#)

[ether3-slave-local](#)

[ether4-slave-local](#)

[ether5](#)

[wlan1](#)

[bridge-local](#)

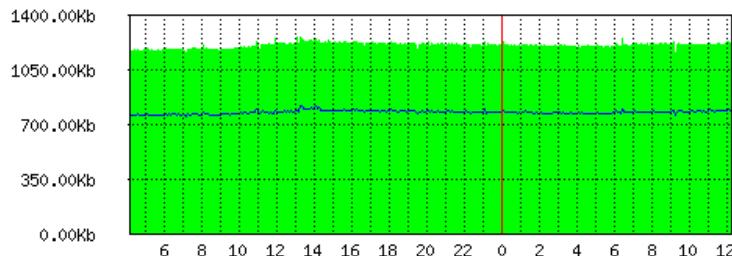
- Available on the router:
http://router_ip/graphs

Graphs

Interface <ether1-gateway> Statistics

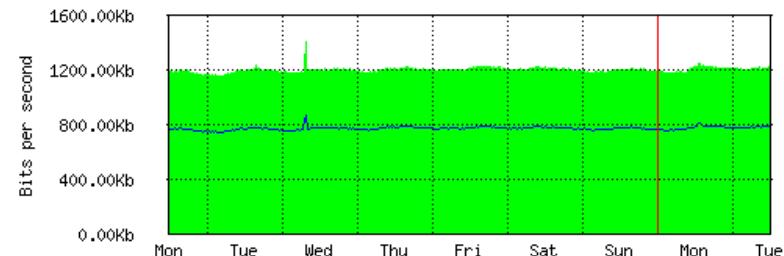
- Last update: Wed Dec 31 23:59:59 2015

"Daily" Graph (5 Minute Average)



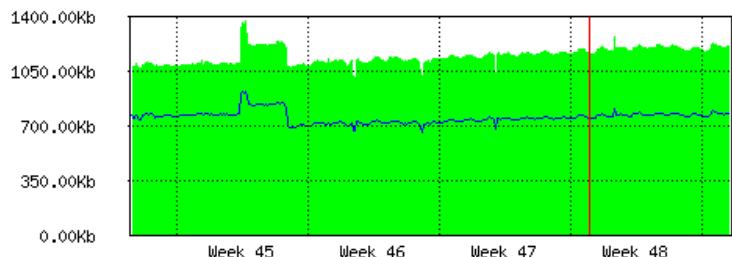
Max In: 1.26Mb; Average In: 1.21Mb; Current In: 1.22Mb;
Max Out: 821.58Kb; Average Out: 780.56Kb; Current Out: 793.75Kb;

"Weekly" Graph (30 Minute Average)



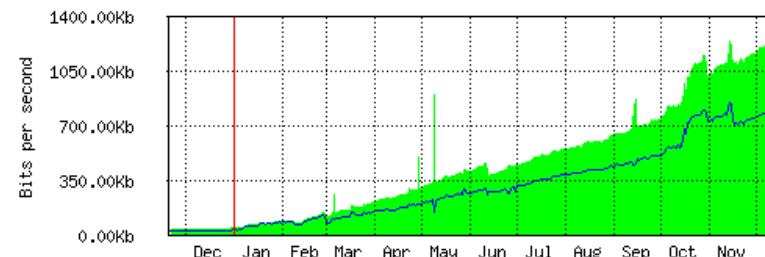
Max In: 1.41Mb; Average In: 1.20Mb; Current In: 1.22Mb;
Max Out: 872.20Kb; Average Out: 772.71Kb; Current Out: 792.54Kb;

"Monthly" Graph (2 Hour Average)



Max In: 1.37Mb; Average In: 1.15Mb; Current In: 1.21Mb;
Max Out: 922.93Kb; Average Out: 757.19Kb; Current Out: 786.12Kb;

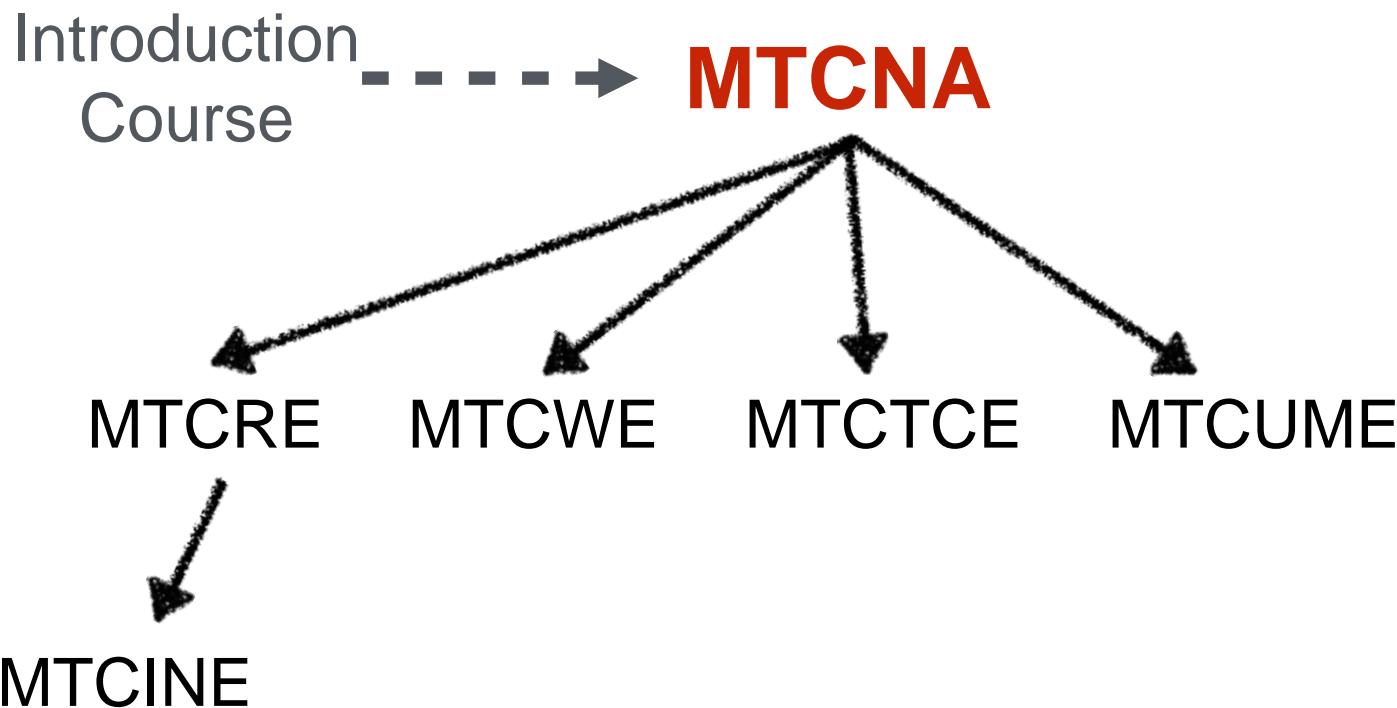
"Yearly" Graph (1 Day Average)



Max In: 1.24Mb; Average In: 445.51Kb; Current In: 1.20Mb;
Max Out: 850.52Kb; Average Out: 303.36Kb; Current Out: 772.42Kb;

MTCNA Summary

MikroTik Certified Courses



For more info see: <http://training.mikrotik.com>

Certification Test

- If needed reset router configuration and restore from a backup
- Make sure that you have an access to the www.mikrotik.com training portal
- Login with your account
- Choose my training sessions
- Good luck!

Resource

- <http://demo.mt.lv/webfig/>
- wiki.mikrotik
- Material PDF
- Internet