

MikroTik RouterOS Training

Базовый курс для
настройки оборудования
MikroTik
I-часть

Цель Курса

- Получить необходимые знания и практические навыки ПО MikroTik RouterOS по маршрутизации для небольших и средних локальных сетей.
- После окончания курса Вы сможете планировать, развертывать и обслуживать сети на MikroTik RouterOS

MikroTik's History

- 1995: Established
- 1997: RouterOS software for x86 (PC)
- 2002: RouterBOARD is born (Hardware solutions)
- 2006: First MUM (MikroTik User Meeting)
- 05.2009: First WiFi-radiolink Moldtelecom

About MikroTik

- Router software and hardware manufacturer
- Products used by ISPs, companies and individuals
- Make Internet technologies faster, powerful and affordable to wider range of users

Where is MikroTik?

- www.mikrotik.com
- www.routerboard.com
- Riga, Latvia, Northern Europe, EU

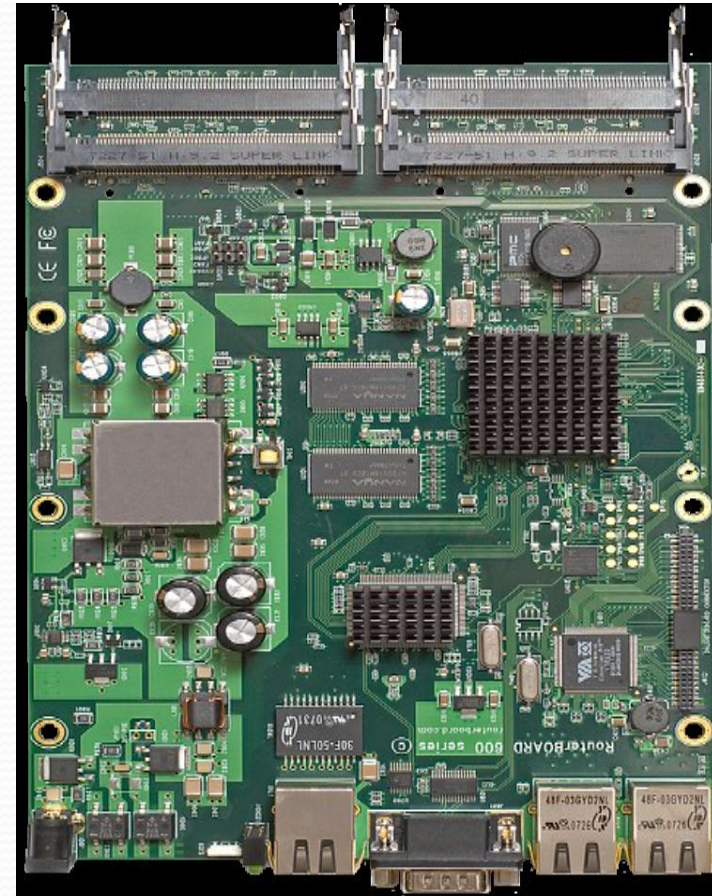
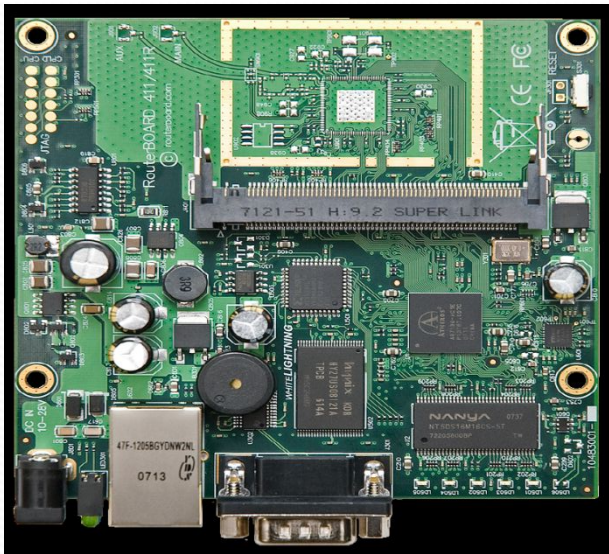


What is RouterOS ?

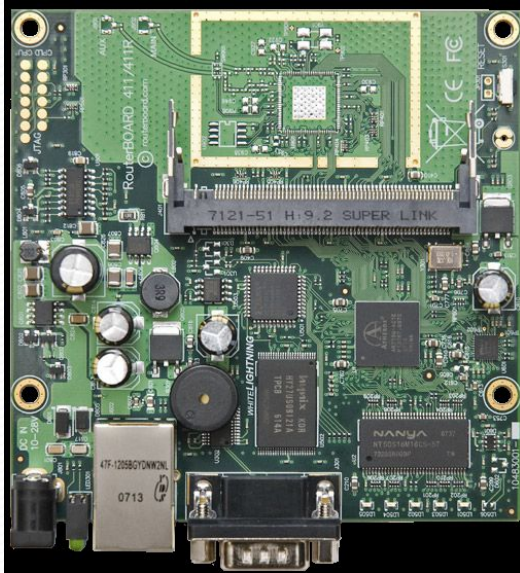
- RouterOS is an operating system that will make your device:
 - a dedicated router
 - a bandwidth shaper
 - a (transparent) packet filter
 - any 802.11 a, b/g/n wireless device
- The operating system of RouterBOARD
- Can be also installed on a PC

What is RouterBOARD ?

- Hardware created by MikroTik
- Range from small home routers to carrierclass access concentrators

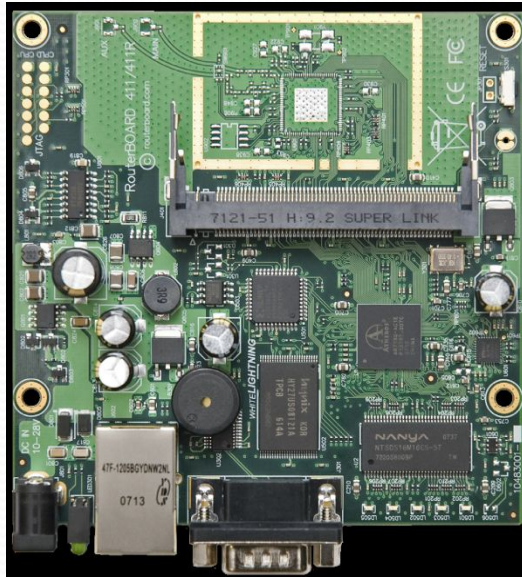


RouterBOARD 411a



CPU	Atheros AR7130 300MHz network processor
Memory	32MB DDR SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	64MB onboard NAND memory chip
Ethernet	One 10/100 Mbit/s Fast Ethernet port with Auto-MDI/X
miniPCI	One MiniPCI Type IIIA/IIIB slot
Extras	Reset switch, Beeper
Serial port	One DB9 RS232C asynchronous serial port
LEDs	Power, NAND activity, 5 user LEDs
Power options	Power over Ethernet: 10..28V DC
Dimensions	10.5 cm x 10.5 cm (4.13 in x 4.13 in) Weight: 82 g
Power consumption	~3W without extension cards, maximum – 12 W
Operating System	MikroTik RouterOS v3, Level3 license

RouterBOARD 411AH



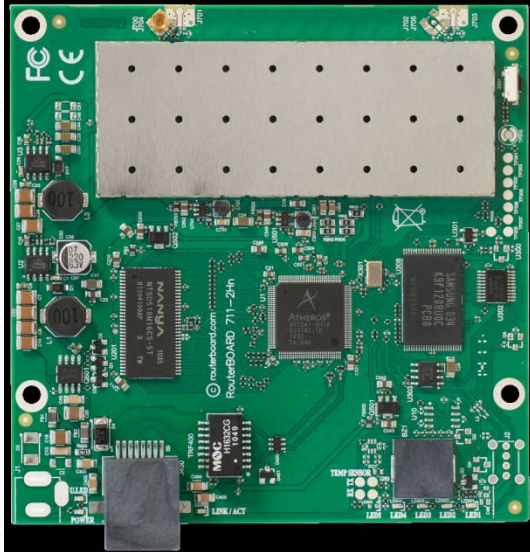
CPU	Atheros AR7161 680MHz network processor
Memory	64MB DDR SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	64MB onboard NAND memory chip
Ethernet	One 10/100 Mbit/s Fast Ethernet port with Auto-MDI/X
miniPCI	One MiniPCI Type IIIA/IIIB slot
Extras	Reset switch, Beeper
Serial port	One DB9 RS232C asynchronous serial port
LEDs	Power, NAND activity, 5 user LEDs
Power options	Power over Ethernet: 10..28V DC
Dimensions	10.5 cm x 10.5 cm (4.13 in x 4.13 in) Weight: 82 g
Power consumption	~3W without extension cards, maximum – 12 W
Operating System	MikroTik RouterOS v3, Level4 license

RouterBOARD R52n-M



- Dual band IEEE 802.11a/b/g/n standard
- Output Power of up to 23 dBm
- Support for up to 2x2 MIMO with spatial multiplexing
- Four times the throughput of 802.11a/g
- Atheros AR9220, chipset
- High Performance (up to 300Mbps physical data rates and 200Mbps of actual user throughput) with Low Power Consumption
- Two MMCX antenna connectors
- Modulations: OFDM: BPSK, QPSK, 16 QAM, 64QAM DSSS: DBPSK, DQPSK, CCK
- Operating temperatures: -50°C to 60°C
- Power consumption MAX 1.95W
- ESD protection +/- 12kV

RouterBOARD 711-2Hn



CPU	Atheros AR7241 400MHz network processor
Memory	32MB DDR SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	128MB onboard NAND memory chip
Ethernet	One 10/100 Mbit/s Fast Ethernet port with Auto-MDI/X
miniPCI	none
Wireless	Built in 2GHz AR9280 802.11b/g/n card, 1x1 MIMO, 1x MMCX
Extras	Reset switch, Beeper
Serial port	none
LEDs	Power, NAND activity, 5 user LEDs
Power options	PoE: 10..28V DC (except power over datalines). No power jack
Dimensions	10.5 cm x 10.5 cm (4.13 in x 4.13 in) Weight: 67g
Power consumption	Up to 4.5W at 18V full load (0.245A)
Operating System	MikroTik RouterOS v4, Level3 license

RouterBOARD 711-2HnD



CPU	Atheros AR7241 400MHz network processor
Memory	64MB DDR SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	64MB onboard NAND memory chip
Ethernet	One 10/100 Mbit/s Fast Ethernet port with Auto-MDI/X
Wireless	Built in 2GHz AR9283 802.11b/g/n card, 2x2 MIMO, 2x MMCX
Extras	Reset switch, Beeper
Serial port	none
LEDs	Power, NAND activity, 5 user LEDs
Power options	PoE: 8-30V DC on Ether1 (Non 802.3af).
Dimensions	10.5 cm x 10.5 cm (4.13 in x 4.13 in) Weight: 67g
Power consumption	Up to 4.5W at 18V full load (0.245A)
Operating System	MikroTik RouterOS v4, Level4 license

RouterBOARD RB751U-2HnD



Features RB751U-2HnD (USB, 2GHz, 802.11n, dual chain)

CPU Atheros AR7241 400MHz CPU

Memory 32MB DDR SDRAM onboard memory

Data storage 64MB onboard NAND storage chip

Ethernet Five independent 10/100 Ethernet ports

LEDs Power, NAND activity, 5 Ethernet LEDs, wireless activity LED

Power options PoE: 8-30V DC on Ether1 (Non 802.3af). Jack: 8-30V DC

Dimensions 113x138x29mm. Weight without packaging and cables: 230g

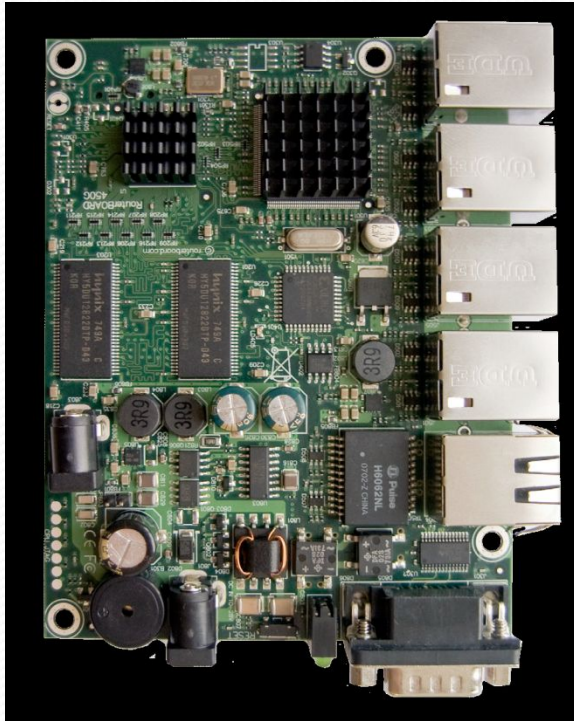
Power consumption Up to 10W

Operating Temp -20C .. +50C

Operating System MikroTik RouterOS, Level4 license

Package contains RouterBOARD in a plastic case, power adapter

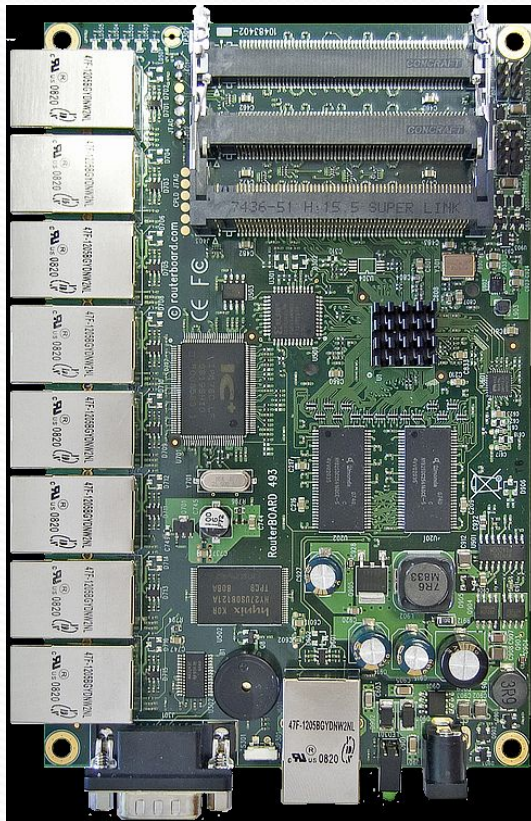
RouterBOARD 450G



CPU	Atheros AR7161 680MHz network processor
Memory	256MB DDR SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	512MB onboard NAND memory chip, microSD slot
Ethernet	Five 10/100/1000 Mbit/s Ethernet ports with Auto-MDI/X
Extras	Reset switch, Beeper
Serial port	One DB9 RS232C asynchronous serial port
LEDs	Power, NAND activity, 5 user LEDs
Power options	Power over Ethernet: 10..28V DC
Dimensions	9 cm x 11.5 cm, 105 grams
Operating System	MikroTik RouterOS v3, Level4 license

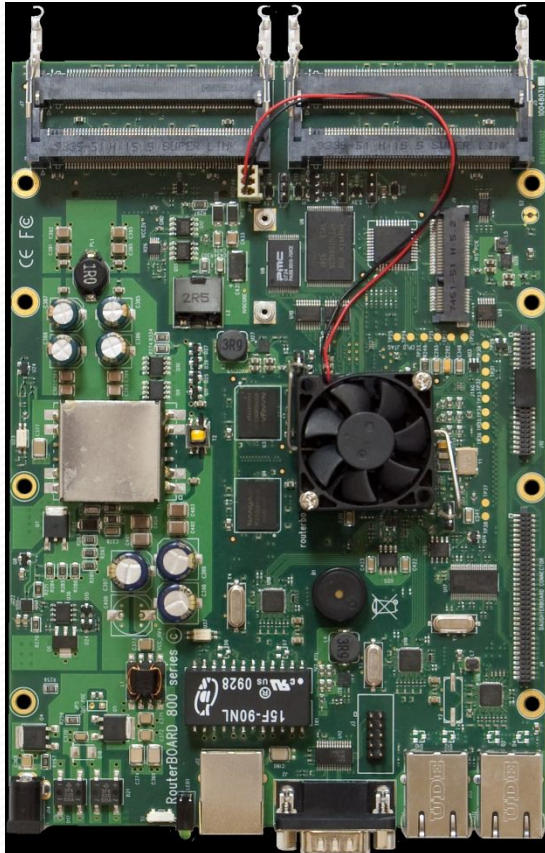


RouterBOARD 493AH



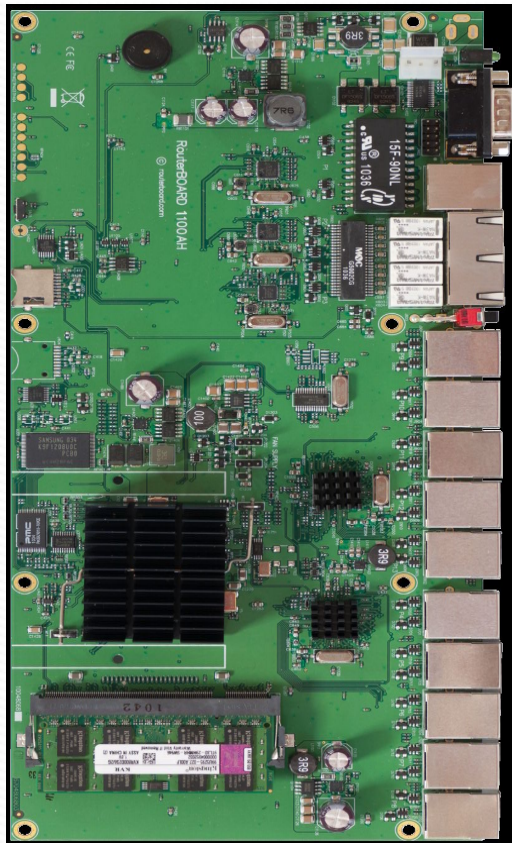
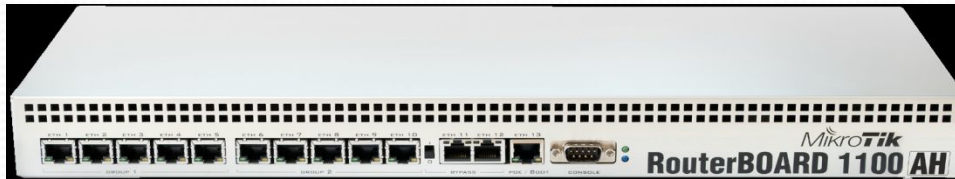
- CPU Atheros AR7161 680MHz
- Memory 128MB DDR SDRAM onboard memory
- Boot loader RouterBOOT
- Data storage 64MB onboard NAND memory chip
- Ethernet Nine 10/100 Mbit/s Fast Ethernet ports with Auto-MDI/X
- miniPCI Three miniPCI slots
- Extras Reset switch, Beeper
- Serial port One DB9 RS232C asynchronous serial port
- LEDs Power, NAND activity, 5 user LEDs
- Power options Power over Ethernet: 10..28V DC (except power over datalines). Power jack: 10..28V DC
- Dimensions 105mm x 160mm, 189 grams
- Power consumption ~3W without extension cards, maximum – 16 W
- Operating System MikroTik RouterOS v3, Level5 license

RouterBOARD 800



CPU	MPC8544 800MHz
Memory	256MB DDR2 SDRAM onboard memory
Boot loader	RouterBOOT
Data storage	NAND memory chip, CF slot on back
Ethernet	Three 10/100/1000 Mbit/s Ethernet ports with Auto-MDI/X
miniPCI	4 x miniPCI, 1 x miniPCI-e
Extras	Reset switch, Beeper, 4x Fan headers (JP1,JP3 = 3.3V, JP2,JP4 = 5.5V)
Serial port	One DB9 RS232C asynchronous serial port, One serial port
LEDs	Power, 1x User LED
Power options	PoE: 36-56V DC (including power over datalines)
Power jack:	10-56V DC
Dimensions	14 cm x 20 cm (5.51 in x 7.87 in), 285 g
Operating System	MikroTik RouterOS v4, Level6 license

RouterBOARD 1100AH



CPU	PowerPC 1066MHz network CPU
Memory	SODIMM DDR Slot, 2GB installed
Boot loader	RouterBOOT, 1Mbit Flash chip
Data storage	Onboard NAND memory chip, one microSD card slot
Ethernet	Thirteen 10/100/1000 Mbit/s Gigabit Ethernet with Auto-MDI/X
Ethernet	Includes switch to enable Ethernet bypass mode in two ports
miniPCI	none
Serial port	One DB9 RS232C asynchronous serial port
Extras	Reset switch, beeper, voltage and temperature sensors
Power options	(standard connector 110/220V), PoE (12-24V on port 13)
Fan	no fan, no fan headers
Dimensions	1U case: 44 x 176 x 442 mm, 1275g. Board only: 365g
Operating System	MikroTik RouterOS, Level 6 license

RouterBOARD 1200



- CPU PowerPC PPC460GT
- Memory SODIMM DDR Slot, 512MB RAM
- Boot loader RouterBOOT, 1Mbit Flash chip
- Ethernet Ten 10/100/1000 Mbit/s Gigabit Ethernet with Auto-MDI/X
- miniPCI none
- Storage 64MB NAND
- Serial port One DB9 RS232C asynchronous serial port
- Extras Reset switch, Beeper
- Power options IEC C14 standard connector 110/220V
- Fan no cooling fan
- Dimensions 1U case: 44 x 176 x 442 mm, 1200g. Board only: 365g
- Operating System MikroTik RouterOS, Level 6 license

RouterBOARD SXT



- Features 5HnD (5Ghz, High power wireless, 802.11n, Dual-chain)
- CPU Atheros AR7241 400MHz CPU
- Memory 32MB DDR SDRAM onboard memory
- Data storage 64MB onboard NAND storage chip
- Ethernet One 10/100 ethernet port, L2MTU frame size up to 4076
- Wireless cards Onboard dual chain 5GHz 802.11a/n Atheros AR9280 wireless module; 10kV ESD protection on each RF port
- Extras Reset switch, beeper, USB 2.0 port, voltage and temperature monitors
- LEDs Power LED, Ethernet LED, 5 wireless signal LED
- Power options Power over Ethernet: 8-30V DC
- Packaged with 24V DC 0.8A power adapter and passive PoE injector
- Dimensions 140x140x56mm. Weight without packaging, adapters and cables: 265g
- Power consumption Up to 7W
- Operating Temperature -30C .. +80C
- Operating System MikroTik RouterOS v5, Level3 license

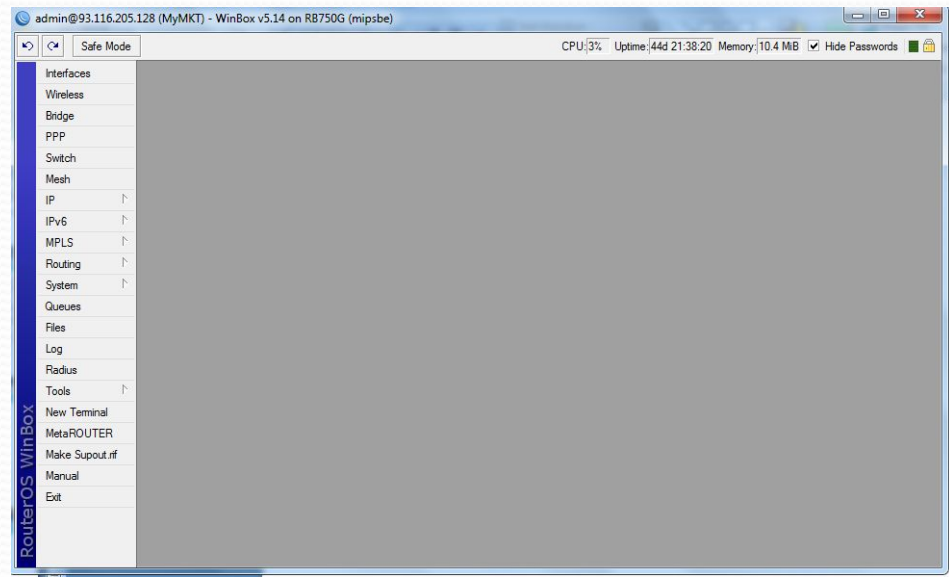
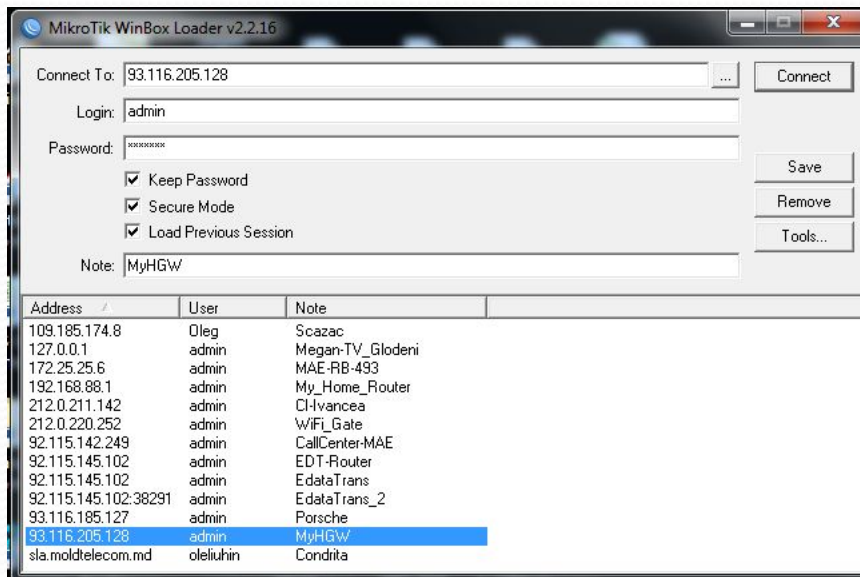


License Levels

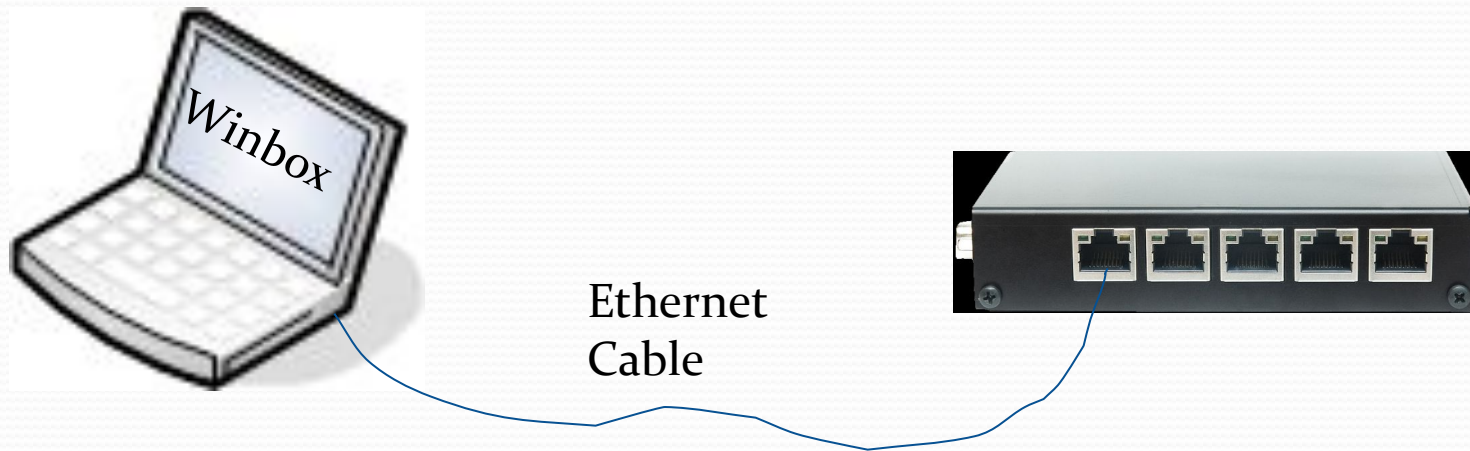
Level number	0 (FREE)	1 (DEMO)	3 (WISP CPE)	4 (WISP)	5 (WISP)	6 (Controller)
EoIP tunnels	24h limit	1	unlimited	unlimited	unlimited	unlimited
OVPN tunnels	24h limit	1	200	200	unlimited	unlimited
VLAN interfaces	24h limit	1	unlimited	unlimited	unlimited	unlimited
Queues	24h limit	1	unlimited	unlimited	unlimited	unlimited
Wireless AP	24h limit	-	-	yes	yes	yes
Wireless Client and Bridge	24h limit	-	yes	yes	yes	yes
RIP, OSPF, BGP protocols	24h limit	-	yes(*)	yes	yes	yes
RADIUS client	24h limit	-	yes	yes	yes	
Web proxy	24h limit	-	yes	yes	yes	yes
User manager active sessions	24h limit	1	10	20	50	Unlimited
PPPoE tunnels	24h limit	1	200	200	500	unlimited
PPTP tunnels	24h limit	1	200	200	500	unlimited
L2TP tunnels	24h limit	1	200	200	500	unlimited
HotSpot active users	24h limit	1	1	200	500	unlimited

Winbox

- The application for configuring RouterOS
- It can be downloaded from <http://www.mikrotik.com/download.html>



Connecting



Upgrade and Downgrade RouterOS

The screenshot shows a web browser window displaying the MikroTik website's RouterOS download page. The browser's address bar shows the URL www.mikrotik.com/download. The website header includes the MikroTik logo and navigation links for 'home', 'software', 'hardware', and 'support'. The main content area is titled 'Download MikroTik software products' and features a 'Product' dropdown menu set to 'RouterOS'. Below this, there is a section for 'Version (Stable)' with a 'VIEW MORE' button and a list of links: 'RouterOS upgrade instructions', 'Which file to download?', and 'How to use Netinstall'. A 'Downloading file' dialog box is overlaid on the page, showing the file name and type. A 'Save As' dialog box is also open, showing the file list in the 'Logical (D:)' drive. The file list includes folders for 'all_packages-mipsbe-4.17', 'all_packages-mipsbe-5.4', and 'all_packages-mipsbe-5.16', along with their corresponding ZIP files. The 'Save As' dialog box has 'File name' set to 'all_packages-mipsbe-5.19.zip' and 'Save as type' set to 'Архив ZIP - WinRAR (*.zip)'. The 'Save' button is highlighted.

Web browser address bar: www.mikrotik.com/download

Website header: **RouterOS** | home | software | hardware | support

Product: RouterOS

Version (Stable)

VIEW MORE

- RouterOS upgrade instructions
- Which file to download?
- How to use Netinstall

Downloading file dialog:

Name: [file name]
Type: [file type]
From: [source]
Open with: [application]
 Remember choice and application

Save As dialog:

File name: all_packages-mipsbe-5.19.zip
Save as type: Архив ZIP - WinRAR (*.zip)

Name	Date modified	Type
all_packages-mipsbe-4.17	29.05.2011 0:35	File folder
all_packages-mipsbe-5.4	29.05.2011 0:34	File folder
all_packages-mipsbe-5.16	13.05.2012 7:20	File folder
all_packages-mipsbe-4.17.zip	30.03.2011 0:22	Архив ZIP - WinR...
all_packages-mipsbe-5.4.zip	29.05.2011 0:34	Архив ZIP - WinR...
all_packages-mipsbe-5.16.zip	13.05.2012 7:19	Архив ZIP - WinR...

Downgrade RouterOS

Package Information

Name	Functions
advanced-tools	Email client, ping, netwatch
dhcp	DHCP Server and Client
hotspot	HotSpot Gateway
ntp	NTP server
ppp	PPP, PPTP, L2TP, PPPoE
routerboard	RouterBOARD specific functions
routing	RIP, OSPF, BGP
security	Secure Winbox, SSH, IPSec
wireless	Wireless 802.11a/b/g
user-manager	User-Manager management system
ipv6	IPv6

Upgrade RouterOS

The screenshot displays the Mikrotik WinBox interface. On the left, a Windows Explorer window shows the file structure of the RouterOS upgrade packages, including files like 'advanced-tools-5.19-mipsbe.npk', 'calea-5.19-mipsbe.npk', 'dhcp-5.19-mipsbe.npk', 'gps-5.19-mipsbe.npk', 'hotspot-5.19-mipsbe.npk', 'ip6-5.19-mipsbe.npk', 'lcd-5.19-mipsbe.npk', 'mpls-5.19-mipsbe.npk', 'multicast-5.19-mipsbe.npk', 'ntp-5.19-mipsbe.npk', 'ppp-5.19-mipsbe.npk', 'routerboard-5.19-mipsbe.npk', 'routing-5.19-mipsbe.npk', 'security-5.19-mipsbe.npk', 'system-5.19-mipsbe.npk', 'ups-5.19-mipsbe.npk', 'user-manager-5.19-mipsbe.npk', and 'wireless-5.19-mipsbe.npk'. The status bar at the bottom of this window indicates '14 items selected', 'Date modified: 18.07.2012 8:13', and 'Size: 13,5 MB'.

The main WinBox window shows the 'File List' dialog box with a table of files and an 'Uploading Files' progress window. The 'File List' table is as follows:

File Name	Type	Size	Creation Time
LIZT-P25N.key	.key file	204 B	Sep/29/2011 11:04:42
MyHGWRB750G backup	backup	175.7 KiB	Jan/02/1970 03:01:17
advanced-tools-5.19-mipsbe.npk	package	140.7 KiB	Jul/29/2012 10:15:57
auto-before-reset			970 03:01:57
dhcp-5.19-mipsbe			1012 10:15:57
hotspot-5.19-mips			1012 10:15:58
ip6-5.19-mipsbe			1012 10:15:59
mpls-5.19-mipsbe			1012 10:15:59
multicast-5.19-mip			1012 10:16:00
ntp-5.19-mipsbe.npk	package	297.0 KiB	Jul/29/2012 10:16:01
ppp-5.19-mipsbe.npk	package	418.8 KiB	Jul/29/2012 10:16:02
pub	directory		Feb/01/2012 18:29:39
routerboard-5.19-mipsbe.npk	package	216.0 KiB	Jul/29/2012 10:16:03
routing-5.19-mipsbe.npk	package	500.2 KiB	Jul/29/2012 10:16:04
security-5.19-mipsbe.npk	package	431.2 KiB	Jul/29/2012 10:16:05
skins	directory		Sep/29/2011 23:02:56
system-5.19-mipsbe.npk	package	5.7 MiB	Jul/29/2012 10:16:23

The 'Uploading Files' dialog shows the progress of uploading 'system-5.19-mipsbe.npk' (11.0 MiB of 13.5 MiB at 314.14 kb/s). The WinBox interface also shows system status: 'CPU: 100%', 'Uptime: 5d 14:52:32', 'Memory: 11.3 MiB', and 'Hide Passwords' checked. The 'RouterOS WinBox' sidebar is visible on the left, and the bottom status bar shows '17 items', '50.7 MB of 61.4 MB used', and '17% free'.

Upgrade RouterOS

The screenshot shows the Mikrotik WinBox interface. The top bar displays the user 'admin@192.168.88.1 (MyMKT)' and the device 'WinBox v5.17 on RB750G (mipsbe)'. The status bar shows CPU usage at 6%, uptime of 5d 14:55:28, and memory usage at 11.2 MB. The left sidebar contains a menu with categories like Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.nf, Manual, and Exit. The 'System' category is expanded, showing options like Auto Upgrade, Certificates, Clock, Console, Drivers, Health, History, Identity, LEDs, License, Logging, NTP Client, NTP Server, Packages, Password, Ports, Reboot, Reset Configuration, Resources, Routerboard, Scheduler, Scripts, Shutdown, Special Login, Stores, Users, and Watchdog. The 'File List' window is open, displaying a table of files and folders. The table has columns for File Name, Type, Size, and Creation Time. The status bar at the bottom of the File List window shows 19 items, 53.6 MB of 61.4 MB used, and 12% free space.

File Name	Type	Size	Creation Time
LIZT-P25N.key	key file	204 B	Sep/29/2011 11:04:42
MyHGW-RB750G.backup	backup	175.7 KiB	Jan/02/1970 03:01:17
advanced-tools-5.19-mipsbe.npk	package	140.7 KiB	Jul/29/2012 10:15:57
auto-before-reset.backup	backup	11.9 KiB	Jan/02/1970 03:01:57
dhcp-5.19-mipsbe.npk	package	210.3 KiB	Jul/29/2012 10:15:57
hotspot-5.19-mipsbe.npk	package	244.5 KiB	Jul/29/2012 10:15:58
ipv6-5.19-mipsbe.npk	package	356.5 KiB	Jul/29/2012 10:15:59
mpls-5.19-mipsbe.npk	package	259.8 KiB	Jul/29/2012 10:15:59
multicast-5.19-mipsbe.npk	package	240.3 KiB	Jul/29/2012 10:16:00
ntp-5.19-mipsbe.npk	package	297.0 KiB	Jul/29/2012 10:16:01
ppp-5.19-mipsbe.npk	package	418.8 KiB	Jul/29/2012 10:16:02
pub	directory		Feb/01/2012 18:29:39
routerboard-5.19-mipsbe.npk	package	216.0 KiB	Jul/29/2012 10:16:03
routing-5.19-mipsbe.npk	package	500.2 KiB	Jul/29/2012 10:16:04
security-5.19-mipsbe.npk	package	431.2 KiB	Jul/29/2012 10:16:05
skins	directory		Sep/29/2011 23:02:56
system-5.19-mipsbe.npk	package	7.9 MiB	Jul/29/2012 10:16:33
user-manager-5.19-mipsbe.npk	package	1301.3 KiB	Jul/29/2012 10:16:39
wireless-5.19-mipsbe.npk	package	1157.5 KiB	Jul/29/2012 10:16:45

Upgrade RouterOS

The screenshot shows the RouterOS WinBox interface. The top status bar indicates the user is 'admin@192.168.88.1 (MyMKT) - WinBox v5.17 on RB750G (mipsbe)'. System metrics show CPU at 4%, Uptime at 5d 14:57:48, and Memory at 11.2 MiB. A 'Safe Mode' button is visible on the left. The main interface is divided into a left sidebar with navigation options (Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.rf, Manual, Exit) and a main content area. The main content area displays a 'File List' window with a table of files and a 'Reboot' dialog box overlaid on top.

File Name	Type	Size	Creation Time
LIZT-P25N.key	.key file	204 B	Sep/29/2011 11:04:42
MyHGW-RB750G.backup	backup	175.7 KiB	Jan/02/1970 03:01:17
advanced-tools-5.19-mipsbe.npk	package	140.7 KiB	Jul/29/2012 10:15:57
auto-before-reset.backup	backup	11.9 KiB	Jan/02/1970 03:01:57
dhcp-5.19-mipsbe.npk	package	210.3 KiB	Jul/29/2012 10:15:57
hotspot-5.19-mipsbe.npk	package	244.5 KiB	Jul/29/2012 10:15:58
ipv6-5.19-mipsbe.npk	package	356.5 KiB	Jul/29/2012 10:15:59
mpls-5.19-mipsbe.npk	package	259.8 KiB	Jul/29/2012 10:15:59
multicast-5.19-mipsbe.npk	package	240.3 KiB	Jul/29/2012 10:16:00
ntp-5.19-mipsbe.npk	package	297.0 KiB	Jul/29/2012 10:16:01
ppp-5.19-mipsbe.npk	package	418.8 KiB	Jul/29/2012 10:16:02
pub	directory		Feb/01/2012 18:29:39
routerboard-5.19-mipsbe.npk	package	216.0 KiB	Jul/29/2012 10:16:03
5.19-mipsbe.npk	package	500.2 KiB	Jul/29/2012 10:16:04
-5.19-mipsbe.npk	package	431.2 KiB	Jul/29/2012 10:16:05
5.19-mipsbe.npk	directory		Sep/29/2011 23:02:56
5.19-mipsbe.npk	package	7.9 MiB	Jul/29/2012 10:16:33
nager-5.19-mipsbe.npk	package	1301.3 KiB	Jul/29/2012 10:16:39
-5.19-mipsbe.npk	package	1157.5 KiB	Jul/29/2012 10:16:45

Reboot

Do you want to reboot the router?

19 items | 53.6 MB of 61.4 MB used | 12% free

Upgrade RouterOS

The screenshot shows the WinBox interface for RouterOS. The main window title is "admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)". The status bar at the top right shows "CPU: 4%", "Uptime: 00:26:09", and "Memory: 11.7 MiB". A "Safe Mode" button is visible in the top left. The left sidebar contains a menu with items: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.rf, Manual, and Exit. The "Package List" window is open, displaying a table of installed packages. The table has columns for Name, Version, Build Time, and Scheduled. The packages listed are: advancedtools, dhcp, hotspot, ipv6, mpls, multicast, ntp, ppp, routerboard, routing, security, system, user-manager, and wireless. All packages are at version 5.19 and were built on Jul/16/2012. The window also includes buttons for "Enable", "Disable", "Uninstall", "Unschedule", and "Downgrade", along with a "Find" search box. The bottom of the window indicates "14 items".

Name	Version	Build Time	Scheduled
advancedtools	5.19	Jul/16/2012 08:20:29	
dhcp	5.19	Jul/16/2012 08:21:51	
hotspot	5.19	Jul/16/2012 08:25:51	
ipv6	5.19	Jul/16/2012 08:25:17	
mpls	5.19	Jul/16/2012 08:24:52	
multicast	5.19	Jul/16/2012 08:37:14	
ntp	5.19	Jul/16/2012 08:32:23	
ppp	5.19	Jul/16/2012 08:22:47	
routerboard	5.19	Jul/16/2012 08:32:51	
routing	5.19	Jul/16/2012 08:23:58	
security	5.19	Jul/16/2012 08:21:24	
system	5.19	Jul/16/2012 08:20:02	
user-manager	5.19	Jul/16/2012 08:36:19	
wireless	5.19	Jul/16/2012 08:28:24	

Downgrade RouterOS

The screenshot shows the WinBox interface for RouterOS. The left sidebar contains a menu with 'System' highlighted. A 'Package List' window is open, displaying a table of installed packages. The 'Downgrade' button is highlighted in red. The terminal window shows the current system configuration.

Terminal Output:

```
[admin@MyMKT] >
# NAME
0 syst
1 hota
2 ntp
3 dhcp
4 mpla
5 ipv6
6 ppp
7 secu
8 mult
9 routing 5.19
10 routerboard 5.19
11 advanced-tools 5.19
12 user-manager 5.19
13 wireless 5.19
[admin@MyMKT] >
```

Name	Version	Build Time	Scheduled
advanced-tools	5.19	Jul/16/2012 08:20:29	
dhcp	5.19	Jul/16/2012 08:21:51	
hotspot	5.19	Jul/16/2012 08:25:51	
ipv6	5.19	Jul/16/2012 08:25:17	
mpls	5.19	Jul/16/2012 08:24:52	
multicast	5.19	Jul/16/2012 08:37:14	
ntp	5.19	Jul/16/2012 08:32:23	
ppp	5.19	Jul/16/2012 08:22:47	
routerboard	5.19	Jul/16/2012 08:32:51	
routing	5.19	Jul/16/2012 08:23:58	
security	5.19	Jul/16/2012 08:21:24	
system	5.19	Jul/16/2012 08:20:02	
user-manager	5.19	Jul/16/2012 08:36:19	
wireless	5.19	Jul/16/2012 08:28:24	

14 items

SCHEDULED

Interface WAN

The screenshot displays the Mikrotik WinBox interface. The top status bar shows the user is logged in as 'admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)'. The system status includes CPU: 12%, Uptime: 01:51:49, and Memory: 11.8 MiB. The left sidebar shows the 'Interfaces' menu item selected. The main window is divided into two panes. The left pane, titled 'Interface List', contains a table of network interfaces. The right pane, titled 'Interface <WAN_Eth1>', shows the configuration for the selected interface.

Interface List

Interface	Ethernet	EoIP Tunnel	IP Tunnel	GRE Tunnel	VLAN	VRP	Bonding
R	↕ Bridge_IPTV	Bridge					
R	↕ Bridge_LAN	Bridge					
R	↕ WAN_Eth1	Ethernet					
R	↕ vlan35_IPTV	VLAN					
X	↕ bridge_EoIP	Bridge					
X	↕ eoip-tunnel1	EoIP Tunnel					
R	↕ ether2	Ethernet					
R	↕ ether3	Ethernet					
R	↕ ether4	Ethernet					
R	↕ ether5	Ethernet					
X	↕ ipip_WiFi-MTC	IP Tunnel					
:::	Humcane Electric IPv6 Tunnel Broker						
R	↕ sit1	6to4 Tunnel					

12 items (1 selected)

Interface <WAN_Eth1>

General | Ethernet | Status | Overall Stats | Rx Stats | ...

Name: WAN_Eth1

Type: Ethernet

MTU: 1500

L2 MTU: 1520

Max L2 MTU: 1520

MAC Address: 00:0C:42:AD:05:9F

ARP: enabled

Master Port: none

Bandwidth (Rx/Tx): unlimited / unlimited

Switch: 0

enabled | running | slave | link ok

Set static Ip address on WAN interface

The screenshot displays the Mikrotik WinBox interface. The left sidebar shows the navigation menu with 'IP' selected. The main window is divided into several panels:

- Add Address:** A dialog box for adding a new IP address. The 'Address' field is set to 172.17.17.2/24, the 'Network' is 255.255.255.0, and the 'Interface' is WAN_Eth1.
- Route List:** A dialog box for adding a new route. The 'Dst. Address' is 0.0.0.0/0 and the 'Gateway' is 172.17.17.1.
- Background Table:** A table showing existing IP addresses and routes.

Address	Network	Interface
D 93.116.205.128/24	93.116.205.0	WAN_Eth1
X 172.17.1.1/30	172.17.1.0	ipip_WiFi-MTC
93.116.205.1/24	192.168.88.0	Bridge_LAN

Dst. Address	Gateway
DAS 0.0.0.0/0	93.116.205.1 reachable
S 10.10.0.0/16	172.17.1.2 unreachable
XS 10.10.10.0/24	10.77.77.3
DAC 93.116.205.0/...	WAN_Eth1 reachable
DAC 192.168.88.0/...	Bridge_LAN reachable

Set dynamic Ip address on WAN interface

The screenshot shows the Mikrotik WinBox interface. On the left sidebar, the 'IP' menu item is highlighted with a red box. A red line connects this box to the 'DHCP Client' configuration window. In this window, the 'Interface' dropdown menu is also highlighted with a red box and contains the text 'WAN_Eth1'. The main window displays a table of DHCP clients with the following data:

Interface	Use P...	Add D...	IP Address	Expires After	Status
WAN_Eth1	yes	yes	93.116.205.1...	00:41:07	bound

Below the table, the 'DHCP Client <WAN_Eth1>' configuration dialog is open, showing the 'Interface' dropdown set to 'WAN_Eth1' and other options like 'Use Peer DNS', 'Use Peer NTP', and 'Add Default Route' checked. The status at the bottom of the dialog is 'enabled' and 'Status: bound'.

Create Bridge-LAN interface

The screenshot shows the Mikrotik WinBox interface. On the left sidebar, the 'Bridge' menu item is highlighted with a red box. A red arrow points from this menu item to the 'Interface <Bridge_LAN>' configuration window. In this window, the 'Name' field is set to 'Bridge_LAN' and is also highlighted with a red box. The main window displays a table of existing bridge interfaces.

	Name	Type	L2 MTU	Tx	Rx	Tx P
R	↕↔ Bridge_IPTV	Bridge	1516	0 bps	23.8 kbps	
R	↕↔ Bridge_LAN	Bridge	1520	71.9 kbps	22.5 kbps	
X	↕↔ bridge_EoIP	Bridge		0 bps	0 bps	

3 items out of 12 (1 selected)

Interface <Bridge_LAN> configuration details:

- General tab selected
- Name: Bridge_LAN
- Type: Bridge
- MTU: 1500
- L2 MTU: 1520
- MAC Address: 00:0C:42:AD:05:A0
- ARP: enabled
- Admin. MAC Address: (dropdown menu)
- Status: enabled, running, slave

Add ether-LAN to Bridge-LAN interface

The screenshot shows the Mikrotik WinBox interface for configuring a Bridge. The left sidebar lists various configuration categories, with 'Bridge' selected. The main window displays the 'Bridge' configuration page, which includes a table of bridge ports and three detailed configuration panels for 'ether2_LAN', 'ether3_LAN', and 'ether4_LAN'. Red boxes and arrows highlight the configuration details for each port.

Bridge Configuration Table:

Interface	Bridge
ether2_LAN	Bridge_LAN
ether3_LAN	Bridge_LAN
ether4_LAN	Bridge_LAN
ether5_IPTV	Bridge_IPTV
vlan35_IPTV	Bridge_IPTV

Bridge Port <ether2_LAN> Configuration:

- Interface: ether2_LAN
- Bridge: Bridge_LAN
- Priority: 80
- Path Cost: 10
- Horizon: (empty)
- Edge: auto
- Point To Point: auto
- External FDB: auto

Bridge Port <ether3_LAN> Configuration:

- Interface: ether3_LAN
- Bridge: Bridge_LAN
- Priority: 80
- Path Cost: 10
- Horizon: (empty)
- Edge: auto
- Point To Point: auto
- External FDB: auto

Bridge Port <ether4_LAN> Configuration:

- Interface: ether4_LAN
- Bridge: Bridge_LAN
- Priority: 80
- Path Cost: 10
- Horizon: (empty)
- Edge: auto
- Point To Point: auto
- External FDB: auto

Set static Ip address on Bridge-LAN interface

The screenshot shows the Mikrotik WinBox interface. On the left sidebar, the 'IP' menu item is highlighted with a red box. A red arrow points from this menu to the 'Addresses List' window. In the 'Addresses List' window, a table displays the following data:

	Address	Network	Interface
D	93.116.205.128/24	93.116.205.0	WAN_Eth1
X	172.17.1.1/30	172.17.1.0	ipip_WiFi-MTC
	192.168.88.1/24	192.168.88.0	Bridge_LAN

The entry for 192.168.88.1/24 on the Bridge_LAN interface is selected. A second red arrow points from this entry to the 'Address <192.168.88.1/24>' configuration dialog. In this dialog, the 'Address' field is set to 192.168.88.1/24, the 'Network' is 192.168.88.0, and the 'Interface' is Bridge_LAN. The 'enabled' checkbox is checked.

Set DHCP-Server on Bridge-LAN interface

The screenshot shows the Mikrotik WinBox interface. The left sidebar has 'IP' highlighted. The main window is titled 'DHCP Server' and contains a table with the following data:

Name	Interface	Relay	Lease Time	Address Pool	Add AR...
dhcp1	Bridge_LAN		1d 00:00:00	dhcp_pool1	no

Below the table is a 'DHCP Setup' dialog box with the following fields and buttons:

- Text: Select interface to run DHCP server on
- Dropdown menu: DHCP Server Interface: Bridge_LAN
- Buttons: Back, Next, Cancel

Red boxes highlight the 'IP' menu item, the 'DHCP Server' window title, the 'DHCP Setup' button, the 'DHCP Server Interface' dropdown, and the 'Next' button.

Set wireless interface

The screenshot shows the MikroTik WinBox v5.14 interface. The top bar indicates the user is 'admin@92.115.145.102' on a MikroTik RB433 (mipsbe) device. The left sidebar contains a menu with 'Wireless' highlighted in red. The main window shows the 'Wireless Tables' section with 'wlan1' selected. A red box highlights the 'wlan1' entry in the table. The 'Interface <wlan1>' configuration window is open, with the 'Wireless' tab selected. A large red box highlights the configuration fields for the wireless interface, including Mode (ap bridge), Band (2GHz-B/G/N), Channel Width (20MHz), Frequency (2462 MHz), SSID (bdwgh1801), Radio Name (000C42611C14), Wireless Protocol (unspecified), Security Profile (SecProfile), Frequency Mode (manual txpower), Country (no_country_set), and Antenna Gain (0 dBi). The right sidebar contains buttons for OK, Cancel, Apply, Disable, Comment, Torch, Scan..., Freq. Usage..., Align..., Sniff..., Snooper..., Reset Configuration, and Simple Mode.

Set wireless interface

The screenshot shows the MikroTik WinBox interface. The top bar displays the user 'admin@92.115.145.102' and the device 'MikroTik - WinBox v5.14 on RB433 (mipsbe)'. A 'Safe Mode' button is visible. The left sidebar contains a menu with options: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.rtf, Manual, and Exit. The main window is titled 'Wireless Tables' and has tabs for 'Interfaces', 'Nstreme Dual', 'Access List', 'Registration', 'Connect List', and 'Security Profiles'. A table lists two security profiles: 'SecProfile' (dynamic keys, WPA PSK W..., tkip aes ccm, tkip) and 'default' (none). A red box highlights the '+' icon for adding a new profile. A dialog box titled 'Security Profile <SecProfile>' is open, showing the 'General' tab. The 'Name' is 'SecProfile' and the 'Mode' is 'dynamic keys'. Under 'Authentication Types', 'WPA PSK' and 'WPA2 PSK' are checked. Under 'Unicast Ciphers', 'tkip' and 'aes ccm' are checked. Under 'Group Ciphers', 'tkip' is checked. The 'WPA Pre-Shared Key' and 'WPA2 Pre-Shared Key' fields are masked with asterisks. The 'Group Key Update' is set to '00:05:00' and 'Management Protection' is set to 'allowed'. The dialog has 'OK', 'Cancel', 'Apply', 'Copy', and 'Remove' buttons.

Name	Mode	Authenticatio...	Unicast Ciphers	Group Ciphers	WPA Pre-Shared ...
SecProfile	dynamic keys	WPA PSK W...	tkip aes ccm	tkip	*****
default	none				*****

Security Profile <SecProfile>

General RADIUS EAP Static Keys

Name: SecProfile

Mode: dynamic keys

Authentication Types

- WPA PSK
- WPA2 PSK
- WPA EAP
- WPA2 EAP

Unicast Ciphers

- tkip
- aes ccm

Group Ciphers

- tkip
- aes ccm

WPA Pre-Shared Key: *****

WPA2 Pre-Shared Key: *****

Supplicant Identity:

Group Key Update: 00:05:00

Management Protection: allowed

Management Protection Key:

OK Cancel Apply Copy Remove

Add wireless interface to Bridge-LAN

admin@92.115.145.102 (MikroTik) - WinBox v5.14 on RB433 (mipsbe)

Safe Mode

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.rif
Manual
Exit

Wireless Tables

Name	Type	L2 MTU	Tx	Rx	Tx Pac...	Rx Pac...	Tx Drops	Rx Drops	Tx Errors	Rx Errors	MAC Address
wlan1	Wireless (Atheros 11N)	2290	0 bps	0 bps	0	0	0	0	0	0	00:0C:42:61:1C:14

Bridge

Ports

Interface	Bridge	Priority
eoip-tunnel1	Bridge_LAN	
ether2	Bridge_LAN	
ether3	Bridge_LAN	
wlan1	Bridge_LAN	

1 item out of 6 (1 selected)

Bridge Port <wlan1>

General

Interface: wlan1
Bridge: Bridge_LAN

Priority: 80 hex
Path Cost: 10
Horizon:
Edge: auto
Point To Point: auto
External FDB: auto

enabled inactive

OK
Cancel
Apply
Disable
Comment
Copy
Remove

Set for DHCP-Server address space

The screenshot shows the Mikrotik WinBox interface for configuring a DHCP server. The main window is titled "DHCP Server" and has tabs for "DHCP", "Networks", "Leases", "Options", and "Alerts". A table lists the DHCP configuration:

Name	Interface	Relay	Lease Time	Address Pool	Add AR...
dhcp1	Bridge_LAN		1d 00:00:00	dhcp_pool1	no

A "DHCP Setup" dialog box is open, titled "Select network for DHCP addresses". It contains a text field for "DHCP Address Space" with the value "192.168.88.0/24". Below the field are three buttons: "Back", "Next", and "Cancel". The "Next" button is highlighted with a red circle. The dialog also shows "1 item (1 selected)" at the bottom.

Set for DHCP network default gateway

The screenshot shows the Mikrotik WinBox interface for configuring a DHCP server. The main window is titled "DHCP Server" and has tabs for "DHCP", "Networks", "Leases", "Options", and "Alerts". The "DHCP" tab is active, showing a table with one entry:

Name	Interface	Relay	Lease Time	Address Pool	Add AR...
dhcp1	Bridge_LAN		1d 00:00:00	dhcp_pool1	no

A "DHCP Setup" dialog box is open, titled "Select gateway for given network". It contains a text field labeled "Gateway for DHCP Network:" with the value "192.168.88.1" entered. Below the text field are three buttons: "Back", "Next", and "Cancel". The "Next" button is highlighted with a red box. The dialog box also has a "Find" search field and a "1 item (1 selected)" indicator at the bottom.

RouterOS WinBox

Set for DHCP network IP addresses range

The screenshot shows the Mikrotik WinBox interface for configuring a DHCP server. The main window is titled "DHCP Server" and has tabs for "DHCP", "Networks", "Leases", "Options", and "Alerts". The "DHCP" tab is active, showing a table with one entry:

Name	Interface	Relay	Lease Time	Address Pool	Add AR...
dhcp1	Bridge_LAN		1d 00:00:00	dhcp_pool1	no

Below the table, a "DHCP Setup" dialog box is open. It contains a dropdown menu with the text "Select pool of ip addresses given out by DHCP server". Below this, the "Addresses to Give Out" field is set to "192.168.88.20-192.168.88.254". At the bottom of the dialog, there are three buttons: "Back", "Next", and "Cancel". The "Next" button is highlighted with a red box. The status bar at the bottom of the dialog indicates "1 item (1 selected)".

Set for DHCP network DNS servers

The screenshot shows the Mikrotik WinBox interface for configuring a DHCP server. The main window is titled "DHCP Server" and has tabs for "DHCP", "Networks", "Leases", "Options", and "Alerts". Below the tabs is a table with columns: Name, Interface, Relay, Lease Time, Address Pool, and Add AR... The table contains one entry: "dhcp1" on "Bridge_LAN" interface with a lease time of "1d 00:00:00" and address pool "dhcp_pool1".

A "DHCP Setup" dialog box is open, titled "Select DNS servers". It has a text input field labeled "DNS Servers:" containing the IP address "192.168.88.1". Below the input field are three buttons: "Back", "Next", and "Cancel". The "Next" button is highlighted with a red box. At the bottom of the dialog, it says "1 item (1 selected)".

The left sidebar of WinBox shows a menu with the following items: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.rf, Manual, and Exit.

The top status bar shows: admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe), CPU: 5%, Uptime: 03:54:59, Memory: 11.2 MiB, and a "Hide Passwords" checkbox.

Verification of settings for DHCP-server

The screenshot displays the Mikrotik WinBox interface for configuring a DHCP server. The left sidebar shows the navigation menu with 'Bridge' and 'IP' highlighted. The main window is divided into several panes:

- DHCP Server:** Shows a table of DHCP servers. The 'dhcp1' server is selected, with interface 'Bridge_LAN', lease time '1d 00:00:00', and address pool 'dhcp_pool1'.
- DHCP Network <192.168.88.0/24>:** Shows configuration for the DHCP network, including Address (192.168.88.0/24), Gateway (192.168.88.1), Netmask, DNS Servers (192.168.88.1), and other options.
- DHCP Server <dhcp1>:** A detailed configuration window for the selected server, showing Name (dhcp1), Interface (Bridge_LAN), Relay, Lease Time (1d 00:00:00), Bootp Lease Time (forever), Address Pool (dhcp_pool1), and other settings.
- IP Pool:** Shows a table of IP pools. The 'dhcp_pool1' pool is selected, with addresses 192.168.88.100-192.168.88.252 and next pool 'none'.
- IP Pool <dhcp_pool1>:** A detailed configuration window for the selected IP pool, showing Name (dhcp_pool1), Addresses (192.168.88.100-192.168.88.252), and Next Pool (none).

Verification of settings for DHCP-server

The screenshot displays the Mikrotik WinBox interface for configuring a DHCP server. The left sidebar shows the navigation menu with 'Bridge' and 'IP' highlighted. The main window is divided into several panes:

- DHCP Server:** Shows a table of DHCP servers. The 'dhcp1' server is selected, with interface 'Bridge LAN', lease time '1d 00:00:00', and address pool 'dhcp_pool1'.
- IP Pool:** Shows a table of IP pools. The 'dhcp_pool1' pool is selected, with addresses '192.168.88.100-192.168.88.252' and next pool 'none'.
- DHCP Server <dhcp1>:** A configuration dialog for the selected server. It shows:
 - Name: dhcp1
 - Interface: Bridge_LAN
 - Relay: (empty)
 - Lease Time: 1d 00:00:00
 - Bootp Lease Time: forever
 - Address Pool: dhcp_pool1
 - Src. Address: (empty)
 - Delay Threshold: (empty)
 - Authoritative: after 2s delay
 - Bootp Support: static
 - Options: Add ARP For Leases, Always Broadcast, Use RADIUS
 - Status: enabled
- DHCP Network <192.168.88.0/24>:** A configuration dialog for the DHCP network. It shows:
 - Address: 192.168.88.0/24
 - Gateway: 192.168.88.1
 - Netmask: (empty)
 - DNS Servers: 192.168.88.1
 - Domain: (empty)
 - WINS Servers: (empty)
 - NTP Servers: (empty)
 - Next Server: (empty)
 - Boot File Name: (empty)
 - DHCP Options: (empty)

Setup for cache DNS-server

The screenshot displays the Mikrotik WinBox interface. The main window title is "admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)". The top status bar shows "CPU: 4%", "Uptime: 04:58:22", and "Memory: 11.4 MiB". A "Safe Mode" button is visible in the top left. The left sidebar contains a menu with categories: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP (highlighted with a red box), IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.rtf, Manual, and Exit. The main area shows the "DNS Settings" dialog box, which is also highlighted with a red box. The dialog contains the following fields and options:

- Servers:** 172.27.137.20, 172.27.137.10
- Dynamic Servers:** 172.27.137.20, 172.27.137.10
- Allow Remote Requests
- Max UDP Packet Size:** 512
- Cache Size:** 2048 KB
- Cache Used:** 162

Buttons on the right side of the dialog include OK, Cancel, Apply, Static, and Cache. Red lines connect the "IP" menu item to the "DNS Settings" dialog and the "Allow Remote Requests" checkbox.

NAT Network address translation

- Router is able to change **Source** or **Destination** address of packets flowing through it
- This process is called **src-nat** or **dst-nat**

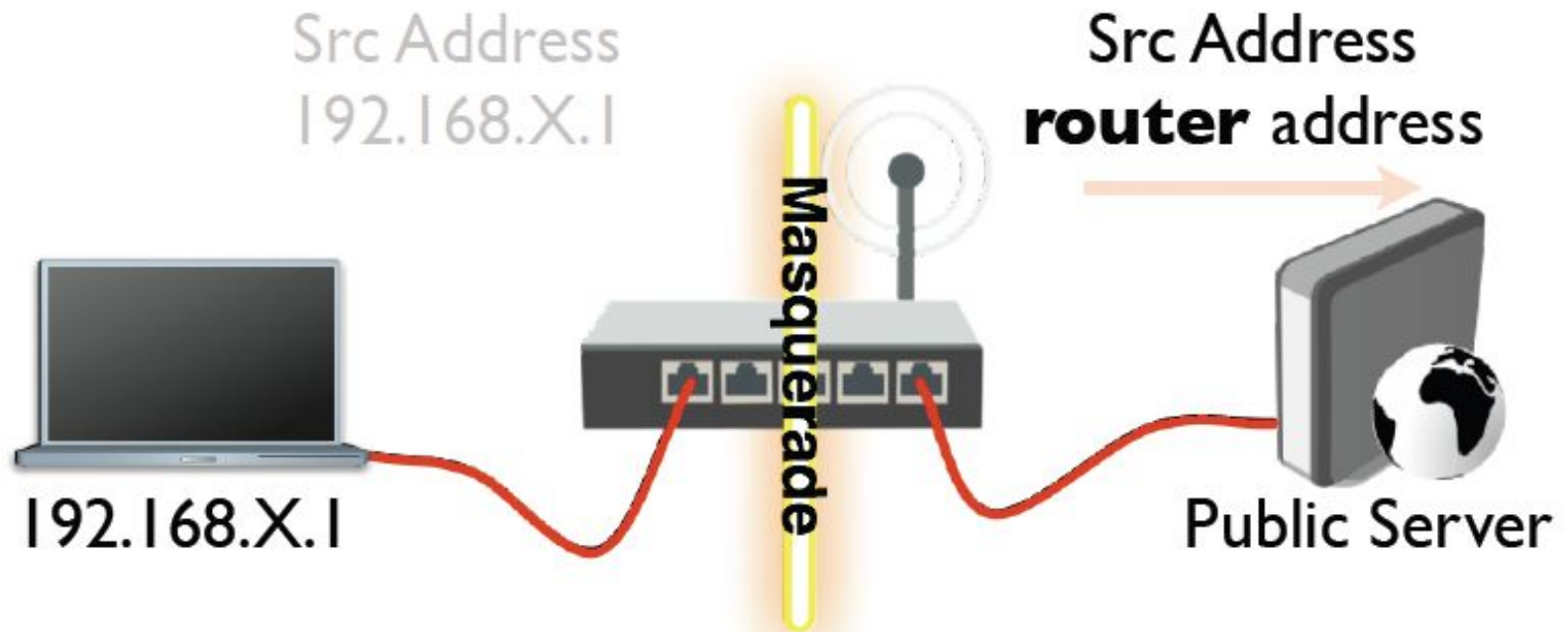
NAT Network address translation

SRC-NAT

- SRC-NAT changes packet's source address
- You can use it to connect private network to the Internet through public IP address
- **Masquerade** is one type of SRC-NAT

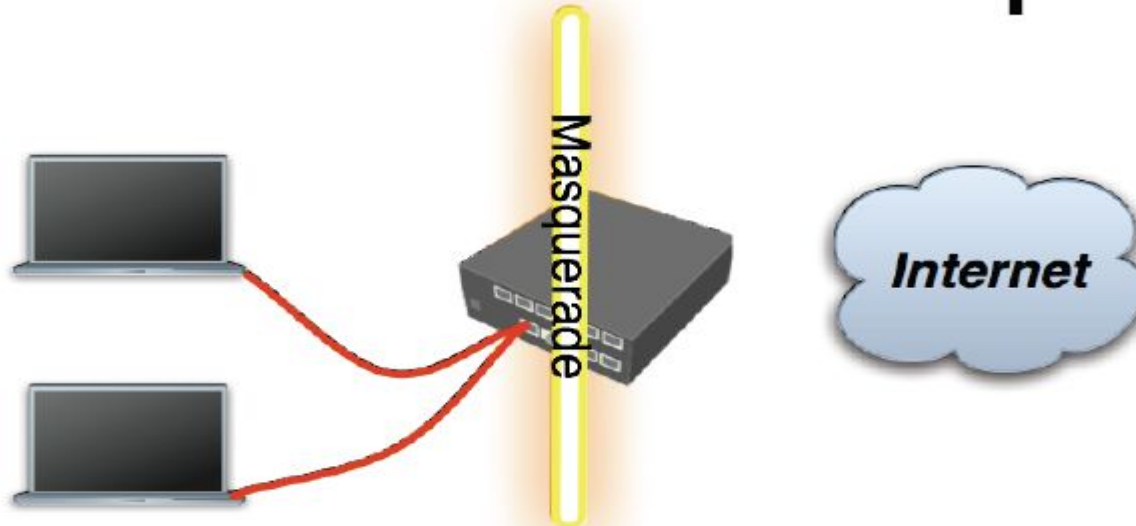
NAT Network address translation

Masquerade



NAT Network address translation

Private and Public space



- **Masquerade** is used for Public network access, where private addresses are present
- Private networks include 10.0.0.0-10.255.255.255, 172.16.0.0-172.31.255.255, 192.168.0.0-192.168.255.255

SRC-NAT over Masquerade

The screenshot shows the Mikrotik WinBox interface. The left sidebar has 'IP' highlighted in red. The 'Firewall' tab is active, and a '+' icon is highlighted in red. A red arrow points from this icon to the 'NAT Rule <192.168.88.0/24>' configuration window. In this window, the 'Chain' is set to 'srcnat' and the 'Out. Interface' is 'WAN_Eth1'. The 'Routing Mark' field is highlighted with a dotted border. The status at the bottom is 'enabled'.

#	Action	Chain
0	X - ^ dst...	dstnat
1	= mas...	srcnat
2	= mas...	srcnat
3	- ^ dst...	dstnat

SRC-NAT over Masquerade

The screenshot shows the Mikrotik WinBox interface. The top bar displays the user 'admin@192.168.88.1 (MyMKT)' and system information: 'WinBox v5.19 on RB750G (mipsbe)', 'CPU: 3%', 'Uptime: 05:26:23', and 'Memory: 10.8 MiB'. The left sidebar contains a menu with categories like Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.nf, Manual, and Exit. The main window is titled 'NAT Rule <192.168.88.0/24>' and has tabs for General, Advanced, Extra, Action, and Statistics. The 'Action' tab is active, showing a dropdown menu with 'masquerade' selected. A red rectangle highlights this dropdown. Below the dropdown is a table of NAT rules:

#	Action	Chain
::: redirect to squid proxy		
0	X - * dst...	dstnat
1	= mas...	srcnat
2	= mas...	srcnat
3	- * dst...	dstnat

At the bottom of the window, the status 'enabled' is visible. On the right side, there are buttons for OK, Cancel, Apply, Disable, Comment, Copy, Remove, Reset Counters, and Reset All Counters.

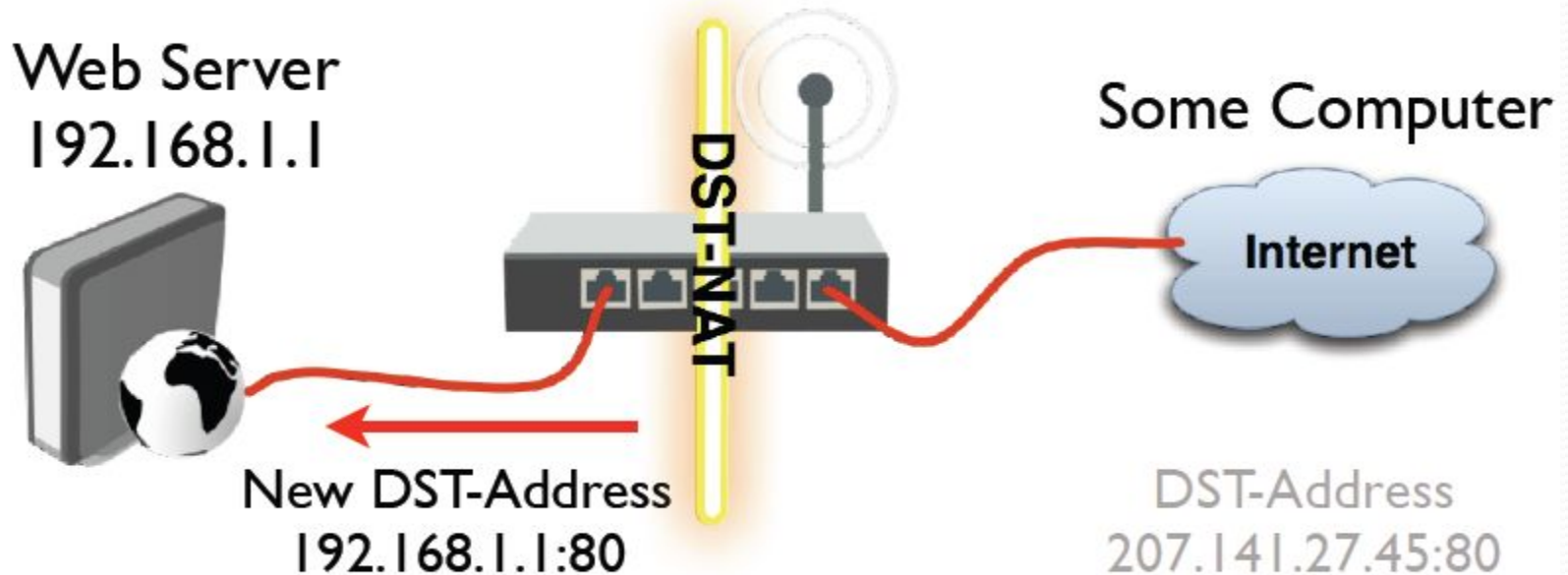
NAT Network address translation

DST-NAT

- DST-NAT changes packet's destination address and port
- It can be used to direct internet users to a server in your private network

NAT Network address translation

DST-NAT Example



DST-NAT for clients services

The screenshot shows the Mikrotik WinBox interface. The left sidebar has 'IP' selected. The main window displays the 'Filter Rules' tab with a table of rules. A 'New NAT Rule' dialog is open, showing the 'General' tab. Red boxes highlight the 'Firewall' menu, the 'NAT' tab, the '+' button, the 'IP' menu item, and the 'General' tab of the dialog.

#	Action	Chain	Src. Address
0	X redirect to squid proxy		
1	= mas...	srcnat	192.168.88...
2	= mas...	srcnat	192.168.90...
3	= dst...	dstnat	212.0.218...

New NAT Rule - General Tab

- Chain: dstnat
- Src. Address: [empty]
- Dst. Address: 207.141.27.45
- Protocol: 6 (tcp)
- Src. Port: [empty]
- Dst. Port: 80
- Any. Port: [empty]
- In. Interface: [empty]
- Out. Interface: [empty]
- Packet Mark: [empty]
- Connection Mark: [empty]
- Routing Mark: [empty]
- Routing Table: [empty]
- Connection Type: [empty]

Buttons: OK, Cancel, Apply, Disable, Comment, Copy, Remove, Reset Counters, Reset All Counters

DST-NAT for clients services

The screenshot shows the Mikrotik WinBox interface. The main window is titled "admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)". The "Firewall" tab is active, and the "NAT" sub-tab is selected. A "New NAT Rule" dialog box is open, showing the configuration for a new rule. The "Action" tab is highlighted, and the "Action" field is set to "dst-nat". The "To Addresses" field is set to "192.168.1.1" and the "To Ports" field is set to "80". A red box highlights the "Action" field and its value "dst-nat".

Interfaces

Wireless

Bridge

PPP

Switch

Mesh

IP

IPv6

MPLS

Routing

System

Queues

Files

Log

Radius

Tools

New Terminal

MetaROUTER

Make Supout.rif

Manual

Exit

RouterOS WinBox

Firewall

Filter Rules NAT Mangle Service Ports Conn

#	Action	Chain	Src. Address
0	X	redirect to squid proxy	
1	X	mas...	srcnat 192.168.88...
2	X	mas...	srcnat 192.168.90...
3	X	dst...	dstnat 212.0.218...

New NAT Rule

General Advanced Extra Action Statistics

Action: dst-nat

To Addresses: 192.168.1.1

To Ports: 80

OK

Cancel

Apply

Disable

Comment

Copy

Remove

Reset Counters

Reset All Counters

Table of NAT connections

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe) CPU:5% Uptime:08:44:13 Memory:10.4 MiB Hide Passwords

Safe Mode

RouterOS WinBox

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.tif
Manual
Exit

Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

Tracking Find

	Src. Address	Dst. Address	Protocol	Connecti...	Connecti...	P2P	Timeout	TCP State
U	46.55.13.11:24431	93.116.205.128:64852	17 (udp)				00:00:02	
U	67.185.82.228:8080	93.116.205.128:64852	17 (udp)				00:00:01	
U	71.170.237.244:63602	93.116.205.128:55994	17 (udp)				00:00:07	
U	77.124.156.233:50677	93.116.205.128:55994	17 (udp)				00:00:01	
U	90.188.101.164:1034	93.116.205.128:55994	17 (udp)				00:00:01	
U	91.215.122.12:55266	93.116.205.128:64852	17 (udp)				00:00:00	
U	91.235.147.113:61548	93.116.205.128:64852	17 (udp)				00:00:04	
U	92.114.234.56:58241	93.116.205.128:55994	17 (udp)				00:00:03	
U	92.115.113.67:59655	93.116.205.128:55994	17 (udp)				00:00:03	
U	92.115.143.97:51751	93.116.205.128:55994	17 (udp)				00:00:03	
U	92.240.216.222:59462	93.116.205.128:64852	17 (udp)				00:00:02	
U	93.116.51.23:15438	93.116.205.128:64852	17 (udp)				00:00:07	
U	93.116.205.56:137	93.116.205.255:137	17 (udp)				00:00:04	
	93.116.205.128	216.66.84.46	41				00:09:52	
U	93.116.205.128	239.192.1.1	2 (igmp)				00:09:22	
U	93.116.205.128:1234	212.0.218.241:1234	17 (udp)				00:00:04	
U	93.116.205.132:137	93.116.205.255:137	17 (udp)				00:00:03	
U	93.116.205.132:138	93.116.205.255:138	17 (udp)				00:00:00	
U	93.116.205.170:138	93.116.205.255:138	17 (udp)				00:00:01	
U	93.116.205.219:137	93.116.205.255:137	17 (udp)				00:00:03	
U	93.116.205.244:137	93.116.205.255:137	17 (udp)				00:00:01	
U	93.116.245.158:10016	93.116.205.128:1029	17 (udp)				00:00:05	
U	93.157.47.2:59113	93.116.205.128:64852	17 (udp)				00:00:07	
U	94.31.163.224:56077	93.116.205.128:55994	17 (udp)				00:00:04	
U	94.232.75.42:22401	93.116.205.128:64852	17 (udp)				00:00:01	
U	95.65.66.5:26954	93.116.205.128:55994	17 (udp)				00:00:04	
U	95.79.15.134:35751	93.116.205.128:64852	17 (udp)				00:00:04	
U	95.191.40.87:59959	93.116.205.128:55994	17 (udp)				00:00:02	

268 items out of 304 Max Entries: 26624

Firewall

- Protects your router and clients from unauthorized access
- This can be done by creating rules in Firewall Filter and NAT facilities

Firewall rules

Filter Chains

- Rules can be placed in three default chains
 - input (**to** router)
 - output (**from** router)
 - forward (**through** the router)

Firewall rules

Firewall Chains



Firewall rules

Firewall Chains



Firewall rules

Firewall Chains



Firewall. Input chain

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode

Interfaces

- Wireless
- Bridge
- PPP
- Switch
- Mesh
- IP**
- IPv6
- MPLS
- Routing
- System
- Queues
- Files
- Log
- Radius
- Tools
- New Terminal
- MetaROUTER
- Make Supout.nif
- Manual
- Exit

Firewall

Filter Rules NAT Mangle Serv

#	Action	Chain
0	X ✓ acc...	input
1	✓ acc...	input
2	✓ acc...	input
3	✓ acc...	input
4	✓ acc...	input
5	✗ drop	input
6	✗ drop	input
7	✗ drop	input
::: Established		
8	✓ acc...	forward
::: Related		
9	✓ acc...	forward
::: New		
10	✓ acc...	forward
::: Invalid		
11	✗ drop	forward

12 items (1 selected)

Firewall Rule <>

General Advanced Extra Action Statistics

Chain: **input**

Src. Address:

Dst. Address:

Protocol: 1 (icmp)

Src. Port:

Dst. Port:

Any. Port:

P2P:

In. Interface:

Out. Interface:

Packet Mark:

Connection Mark:

Routing Mark:

Routing Table:

Connection Type:

Connection State:

OK

Cancel

Apply

Disable

Comment

Copy

Remove

Reset Counters

Reset All Counters

Firewall. Input chain

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.nf
Manual
Exit

Firewall

Filter Rules NAT Mangle Serv

#	Action	Chain
0 X	✓ acc...	input
1	✓ acc...	input
2	✓ acc...	input
3	✓ acc...	input
4	✓ acc...	input
5	✗ drop	input
6	✗ drop	input
7	✗ drop	input
::: Established		
8	✓ acc...	forward
::: Related		
9	✓ acc...	forward
::: New		
10	✓ acc...	forward
::: Invalid		
11	✗ drop	forward

12 items (1 selected)

Firewall Rule <>

General Advanced Extra Action Statistics

Action: accept

OK
Cancel
Apply
Disable
Comment
Copy
Remove
Reset Counters
Reset All Counters

Firewall. Input chain

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode CPU: 6%

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.rtf
Manual
Exit

Firewall

#	Action	Chain	Src. Address
0	✓ accept	input	172.17.1.2
1	✓ accept	input	
2	✓ accept	input	
3	✓ accept	input	212.0.218.0/
4	✓ accept	input	212.0.220.25
5	✗ drop	input	!212.0.218.2
6	✗ drop	input	!212.0.218.2
7	✗ drop	input	
... Established			
8	✓ accept	forward	
... Related			
9	✓ accept	forward	
... New			
10	✓ accept	forward	
... Invalid			
11	✗ drop	forward	

12 items (1 selected)

Firewall Rule <!212.0.218.241->22>

General Advanced Extra Action Statistics

Chain: input

Src. Address: 212.0.218.241

Dst. Address:

Protocol: 6 (tcp)

Src. Port:

Dst. Port: 22

Any. Port:

P2P:

In. Interface: WAN_Eth1

Out. Interface:

Packet Mark:

Connection Mark:

Routing Mark:

Routing Table:

Connection Type:

Connection State:

OK
Cancel
Apply
Disable
Comment
Copy
Remove
Reset Counters
Reset All Counters

Firewall. Forward chain

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe) CPU:4% Uptime:14:19:01 Memc

Safe Mode

Interfaces

- Wireless
- Bridge
- PPP
- Switch
- Mesh
- IP
- IPv6
- MPLS
- Routing
- System
- Queues
- Files
- Log
- Radius
- Tools
- New Terminal
- MetaROUTER
- Make Supout.rf
- Manual
- Exit

Firewall

#	Action	Chain	Src. Address	Dst. Address	Prot
0 X	✓ accept	input	172.17.1.2		
1	✓ accept	input			1 (c
2	✓ accept	input			
3	✓ accept	input	212.0.218.0/24		
4	✓ accept	input	212.0.220.254		
5	✗ drop	input	!212.0.218.241		6 (t
6	✗ drop	input	!212.0.218.241		6 (t
7	✗ drop	input			6 (t
::: Established					
8	✓ accept	forward			
::: Related					
9	✓ accept	forward			
::: New					
10	✓ accept	forward			
::: Invalid					
11	✗ drop	forward			
12	✗ drop	forward	192.168.88.0/24	192.168.90.0/24	

13 items (1 selected)

Firewall Rule <192.168.88.0/24->192.168.90.0/24>

General Advanced Extra Action Statistics

Chain: forward

Src. Address: 192.168.88.0/24

Dst. Address: 192.168.90.0/24

Protocol:

Src. Port:

Dst. Port:

Any. Port:

P2P:

In. Interface:

Out. Interface:

Packet Mark:

Connection Mark:

Routing Mark:

Routing Table:

Connection Type:

Connection State:

OK

Cancel

Apply

Disable

Comment

Copy

Remove

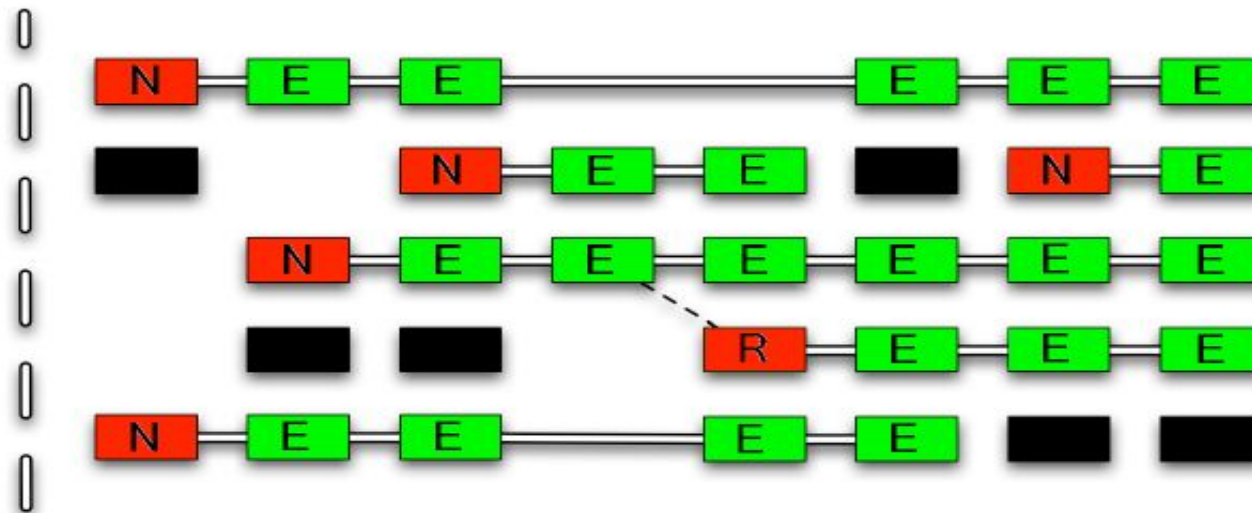
Reset Counters

Reset All Counters

Firewall. Connections state

Connections

Firewall



invalid



established



new



related

Firewall. Connections state

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.tif
Manual
Exit

Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

+ - ✓ ✗ 📁 📏 00 Reset Counters 00 Reset All Counters Find all

#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inter...	Out. Int...	Bytes	Packets
0 X	✓ accept	input	172.17.1.2					ipip_Wi...		0 B	0
1	✓ accept	input			1 (ic...					2087.9 KiB	37 817
2	✓ accept	input						Bridge_...		13.3 MiB	200 885
3	✓ accept	input	212.0.218.0/24					WAN_...		361.6 KiB	4 956
4	✓ accept	input	212.0.220.254					WAN_...		0 B	0
5	✗ drop	input	!212.0.218.241		6 (tcp)		80	WAN_...		316 B	6
6	✗ drop	input	!212.0.218.241		6 (tcp)		22	WAN_...		168 B	3
7	✗ drop	input			6 (tcp)		3128	WAN_...		174.9 KiB	3 409
... New											
8	✓ accept	forward						WAN_...		0 B	0
... Established											
9	✓ accept	forward						WAN_...		482.9 MiB	1 739 601
... Related											
10	✓ accept	forward						WAN_...		5.5 MiB	68 700
... Invalid											
11	✗ drop	forward						WAN_...		0 B	0
12	✗ drop	forward	192.168.88.0/24	192.168.90.0...						300 B	5

13 items (1 selected)

Bandwidth limit

Simple Queue

- The easiest way to limit bandwidth:
 - client download
 - client upload
 - client aggregate, download+upload
- You must use **Target-Address** for Simple Queue
- Rule order is important for queue rules

Bandwidth limit

The screenshot shows the Mikrotik WinBox interface. On the left sidebar, the 'Queues' menu item is highlighted with a red box. A red arrow points from this menu item to the 'Queue List' window. The 'Queue List' window displays a table of queues:

#	Name	Target Address	Rx Max Limit	Tx Max Limit	Pa
0	queue2_IPTV		unlimited	unlimited	
1	queue1	192.168.88.0/24	unlimited	unlimited	
2	queue3_192.168.88.7	192.168.88.7	256k	512k	

Below the table, it shows '3 items', '0 B queued', and '0 packets queued'. A red arrow also points from the '+' icon in the Queue List toolbar to the 'Simple Queue <queue3_192.168.88.7>' configuration window. This window has tabs for 'General', 'Advanced', 'Statistics', 'Traffic', 'Total', and 'Total Statistics'. The 'General' tab is active, showing the following configuration:

- Name: queue3_192.168.88.7
- Target Address: 192.168.88.7
- Target Upload
- Target Download
- Max Limit: 256k (Rx) / 512k (Tx) bits/s
- Burst: Burst Limit: unlimited (Rx) / unlimited (Tx) bits/s
- Burst Threshold: unlimited (Rx) / unlimited (Tx) bits/s
- Burst Time: 0 s

At the bottom of the configuration window, the status is 'enabled'. On the right side of the configuration window, there are buttons for 'OK', 'Cancel', 'Apply', 'Disable', 'Comment', 'Copy', 'Remove', 'Reset Counters', 'Reset All Counters', and 'Torch'.

Check bandwidth rate

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode

Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
MetaROUTER
Make Supout.tif
Manual
Exit

Queue List

Simple Queues

#	Name
0	queu
1	queu
2	queu

3 items

Torch (Running)

Basic

Interface: WAN_Eth1

Entry Timeout: 00:00:03 s

Filters

Src. Address: 0.0.0.0/0

Dst. Address: 0.0.0.0/0

Src. Address6: ::/0

Dst. Address6: ::/0

MAC Protocol: all

Protocol: any

Port: any

VLAN Id: any

Collect

Src. Address Src. Address6

Dst. Address Dst. Address6

MAC Protocol Port

Protocol VLAN Id

Start

Stop

Close

New Window

Eth. Proto...	Prot...	Src.	Dst.	VLAN Id	Tx Rate /	Rx Rate	Tx Pack...	Rx Pack...
800 (ip)		10.20.22.51	239.100.10.102		0 bps	3.1 Mbps	0	285
800 (ip)		10.21.103.9	229.100.100.3		0 bps	24.6 kbps	0	7
800 (ip)		216.66.84.46	93.116.205.128		4.5 kbps	5.5 kbps	3	2
800 (ip)		94.245.121.251	93.116.205.128		522 bps	1306 bps	0	1
800 (ip)		86.106.214.107	93.116.205.128		826 bps	901 bps	1	1
800 (ip)		46.10.245.25	93.116.205.128		32.4 kbps	877 bps	3	1
800 (ip)		84.127.184.100	93.116.205.128		698 bps	709 bps	1	1
800 (ip)		2.39.151.193	93.116.205.128		288 bps	400 bps	0	0
800 (ip)		178.140.246.15	93.116.205.128		488 bps	376 bps	0	0
800 (ip)		212.0.218.241	93.116.205.128		3.1 kbps	373 bps	0	0
800 (ip)		93.116.205.224	93.116.205.255		0 bps	368 bps	0	0
800 (ip)		109.185.117.69	93.116.205.128		576 bps	250 bps	0	0
800 (ip)		91.189.245.212	93.116.205.128		576 bps	250 bps	0	0
800 (ip)		93.114.15.87	93.116.205.236		0 bps	200 bps	0	0
800 (ip)		78.24.54.236	93.116.205.246		0 bps	192 bps	0	0
800 (ip)		92.115.35.26	93.116.205.184		0 bps	192 bps	0	0
800 (ip)		88.205.168.125	93.116.205.128		266 bps	192 bps	0	0

45 items Total Tx: 51.4 kbps Total Rx: 3.1 Mbps Total Tx Packet: 10 Total Rx Packet: 298

Add VLANs for IPTV and VoIP services

The screenshot shows the MikroTik WinBox interface. The top bar indicates the user is 'admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)'. The left sidebar contains a menu with 'Interfaces' highlighted. The main window displays the 'Interface List' with tabs for 'Interface', 'Ethernet', 'EoIP Tunnel', 'IP Tunnel', 'GRE Tunnel', 'VLAN', 'VRRP', 'Bonding', and 'LTE'. The 'VLAN' tab is active, and a red box highlights the '+' icon used to add a new interface. Below the list, a table shows the details for 'vlan35_IPTV':

Interface	Ethernet	EoIP Tunnel	IP Tunnel	GRE Tunnel	VLAN	VRRP	Bonding	LTE			
Name	Type	MTU	L2 MTU	Tx	Rx	Tx Pac...	Rx Pac...	Tx Drops	Rx Drops	Tx Errors	Rx Er
R	vlan35_IPTV	VLAN	1500	1516	0 bps	3.1 Mbps	0	293	0	0	0

An 'Interface <vlan35_IPTV>' configuration dialog is open, showing the following settings:

- Name: vlan35_IPTV
- Type: VLAN
- MTU: 1500
- L2 MTU: 1516
- MAC Address: 00:0C:42:AD:05:9F
- ARP: enabled
- VLAN ID: 35
- Interface: WAN_Eth1
- Use Service Tag

Buttons on the right include OK, Cancel, Apply, Disable, Comment, Copy, Remove, and Torch. At the bottom, the status is shown as 'enabled', 'running', and 'slave'.

Add VLANs for IPTV and VoIP services

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe)

Safe Mode

Interfaces

Wireless

Bridge

PPP

Switch

Mesh

IP

IPv6

MPLS

Routing

System

Queues

Files

Log

Radius

Tools

New Terminal

MetaROUTER

Make Supout.rif

Manual

Exit

Interface List

Interface	Ethernet	EoIP Tunnel	IP Tunnel	GRE Tunnel	VLAN	VRRP	Bonding	LTE
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Name	Type	MTU	L2 MTU	Tx	Rx	Tx Pac...	R	
R <v> vlan35_IPTV	VLAN	1500	1516	0 bps	3.1 Mbps	0		
R <v> vlan36_SIP	VLAN	1500	1516	0 bps	0 bps	0		

Interface <vlan36_SIP>

General Traffic

Name:

Type:

MTU:

L2 MTU:

MAC Address:

ARP:

VLAN ID:

Interface:

Use Service Tag

OK

Cancel

Apply

Disable

Comment

Copy

Remove

Torch

2 items out of 13

Create Bridge-interfaces for IPTV and VoIP services

The screenshot displays the Mikrotik WinBox interface. On the left, the 'Interfaces' menu is open, with 'Bridge' highlighted. A red box highlights the '+' icon in the Bridge toolbar. A red arrow points from this icon to the 'bridge_SIP' configuration window. The main window shows the 'Bridge' configuration table with the following data:

Name	Type	L2 MTU	Tx	Rx
Bridge_IPTV	Bridge	1516	0 bps	3.0 Mbps
Bridge_LAN	Bridge	1520	76.6 kbps	139.5 kbps
bridge_EoIP	Bridge		0 bps	0 bps
bridge_SIP	Bridge	65535	0 bps	0 bps

The 'Interface <bridge_SIP>' configuration window is open, showing the following settings:

- Name: bridge_SIP
- Type: Bridge
- MTU: 1500
- L2 MTU: 65535
- MAC Address: (empty)
- ARP: enabled
- Admin. MAC Address: (empty)

The 'Interface <Bridge_IPTV>' configuration window is also open, showing the following settings:

- Name: Bridge_IPTV
- Type: Bridge
- MTU: 1500
- L2 MTU: 1516
- MAC Address: 00:0C:42:AD:05:9F
- ARP: enabled
- Admin. MAC Address: (empty)

At the bottom of the 'Interface <Bridge_IPTV>' window, the status is shown as 'enabled', 'running', and 'slave'.

Add ethernet ports to Bridge-interfaces

admin@192.168.88.1 (MyMKT) - WinBox v5.19 on RB750G (mipsbe) CPU:5% Uptime:15:18:18 Memory:11.2 MiB

Safe Mode

Interfaces

- Wireless
- Bridge
- PPP
- Switch
- Mesh
- IP
- IPv6
- MPLS
- Routing
- System
- Queues
- Files
- Log
- Radius
- Tools
- New Terminal
- MetaROUTER
- Make Supout.tif
- Manual
- Exit

Bridge

Interface	Bridge	Priority	Path Cost	Horizon	Role
†† ether1_tunne1	bridge_EoIF	80	10		
†† ether2_LAN	Bridge_LAN	80	10		designated port
†† ether3_LAN	Bridge_LAN	80	10		disabled port
†† ether4_LAN	Bridge_SIP	80	10		disabled port
†† ether5_IPTV	Bridge_IPTV	80	10		designated port
†† vlan35_IPTV	Bridge_IPTV	80	10		designated port
†† vlan36_SIP	Bridge_SIP	80	10		designated port

Bridge Port <ether5_IPTV>

General Status

Interface: ether5_IPTV

Bridge: Bridge_IPTV

Priority: 80

Path Cost: 10

Horizon:

Edge: auto

Point To Point: auto

Bridge Port <vlan35_IPTV>

General Status

Interface: vlan35_IPTV

Bridge: Bridge_IPTV

Priority: 80

Path Cost: 10

Horizon:

Edge: auto

Point To Point: auto

Bridge Port <ether4_LAN>

General Status

Interface: ether4_LAN

Bridge: Bridge_SIP

Priority: 80

Path Cost: 10

Horizon:

Edge: auto

Point To Point: auto

External FDB: auto

Bridge Port <vlan36_SIP>

General Status

Interface: vlan36_SIP

Bridge: Bridge_SIP

Priority: 80

Path Cost: 10

Horizon:

Edge: auto

Point To Point: auto

External FDB: auto

inactive

Laboratory work

Схема внедрения услуг
Triple-Play over FTTB (FTTH)
Data+VoIP+IPTV

