

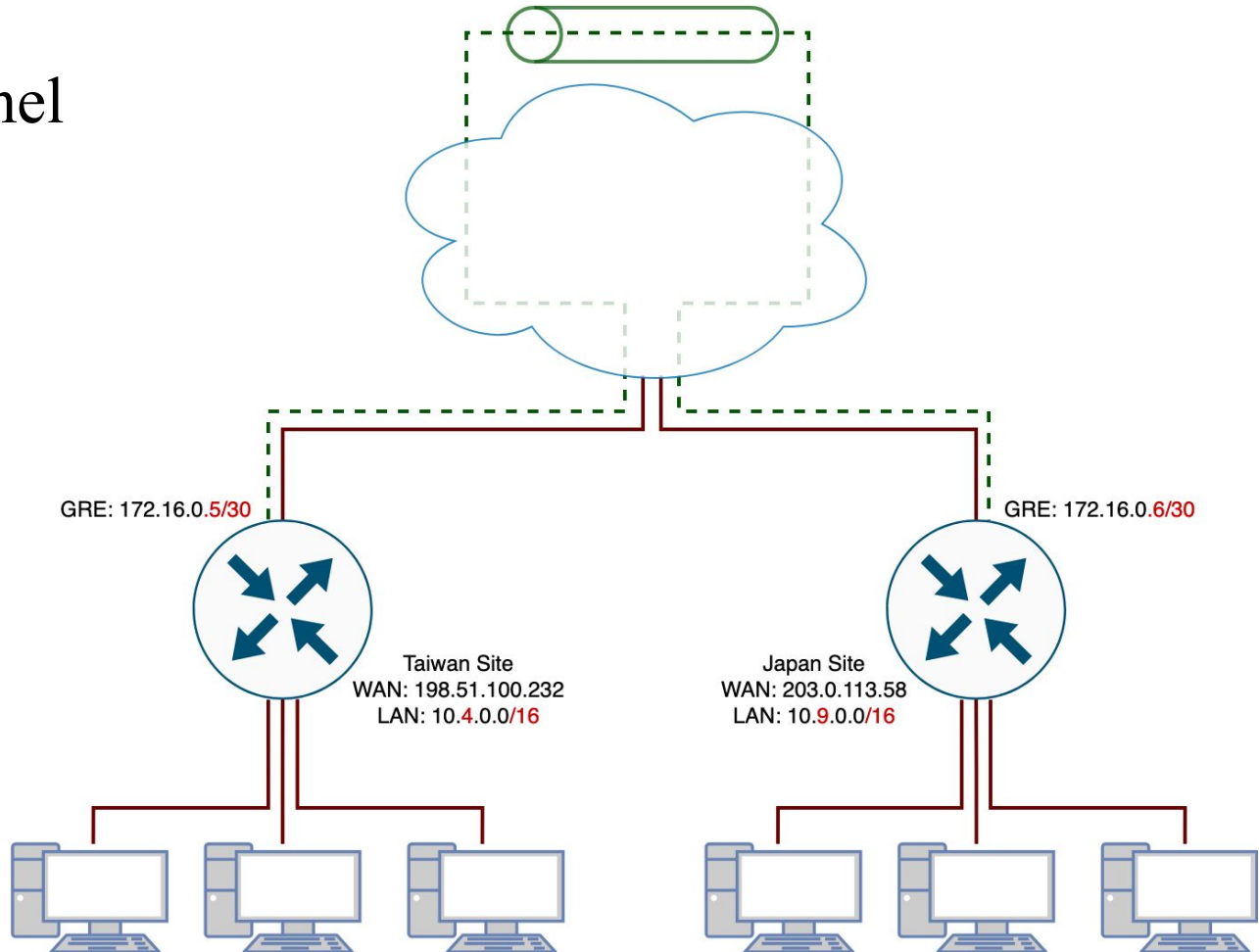
# Lab 14. VyOS, Tunnel, Cable

TA 施羿廷 (ytshih)  
Credit to Sean

# Tunnel

- Create an **overlay network** on an existing network.
- Connects two separated networks (e.g., due to geographic location)
- Encrypts and protects network traffic.
- Include site-to-site tunnels and client-server VPNs.
- Common protocols for Tunnel technology includes:
  - GRE
  - IPsec
  - L2TP
  - PPTP
  - PPPoE
  - VXLAN

# Site-to-Site Tunnel

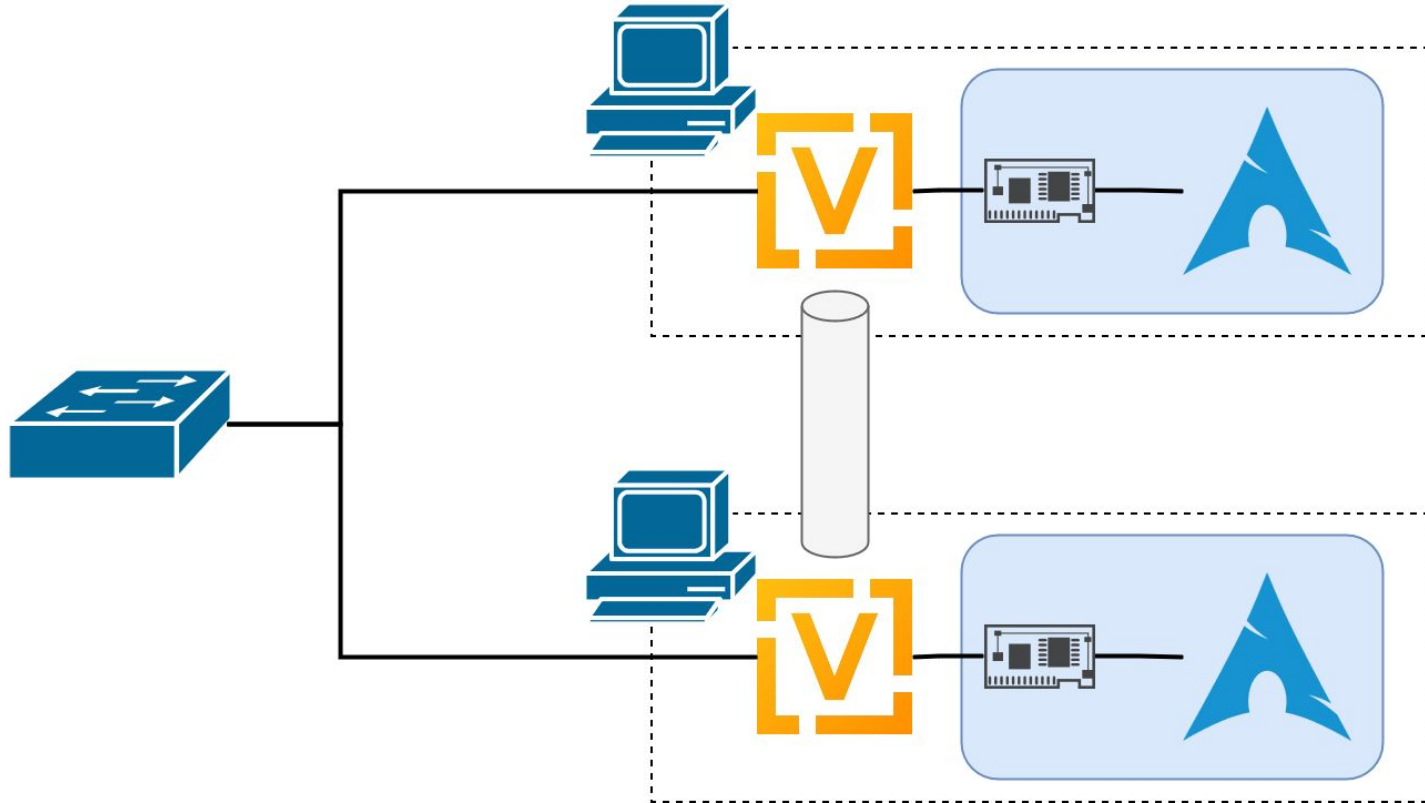


# What is VyOS

- Open source Network Operating System based on Debian
- Operation mode likes Cisco IOS
- Configuration mode likes Juniper Junos OS



# Lab Scenario



# Lab Spec (1/2)

- Interface
  - WAN: EC324's network
    - VirtualBox: Bridged Adapter
    - IP Address: 192.168.24.ID/24 (DHCP)
  - LAN: Gateway for your Intranet (Arch Linux)
    - VirtualBox: Internal Network
    - VyOS IP address: 172.20.ID.254/24
    - DHCP Range: 172.20.ID.{11 - 50}
  - GRE: Interface for GRE Tunnel
    - Your IP address: 10.ID1.ID2.1/30
    - Peer's IP address: 10.ID1.ID2.2/30

# Lab Spec (2/2)

- OSPF
  - Area: **ID**
  - Router ID: 192.168.24.**ID** (Same as WAN address)
  - Interfaces: LAN and GRE
- Passwords
  - VyOS: `vyos / vyos`
  - ArchLinux: `ccna / ccna`

# VyOS - Installation



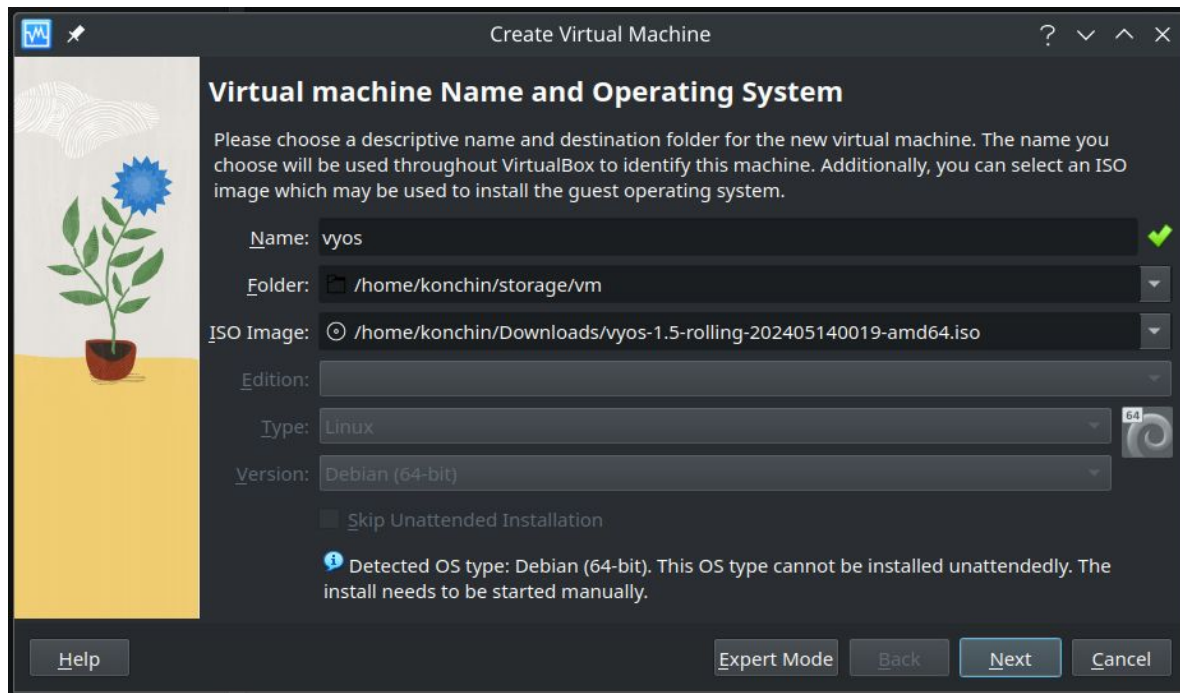
# VyOS - VM Setting

The VyOS rolling release iso is in D:/

RAM: 1024MB

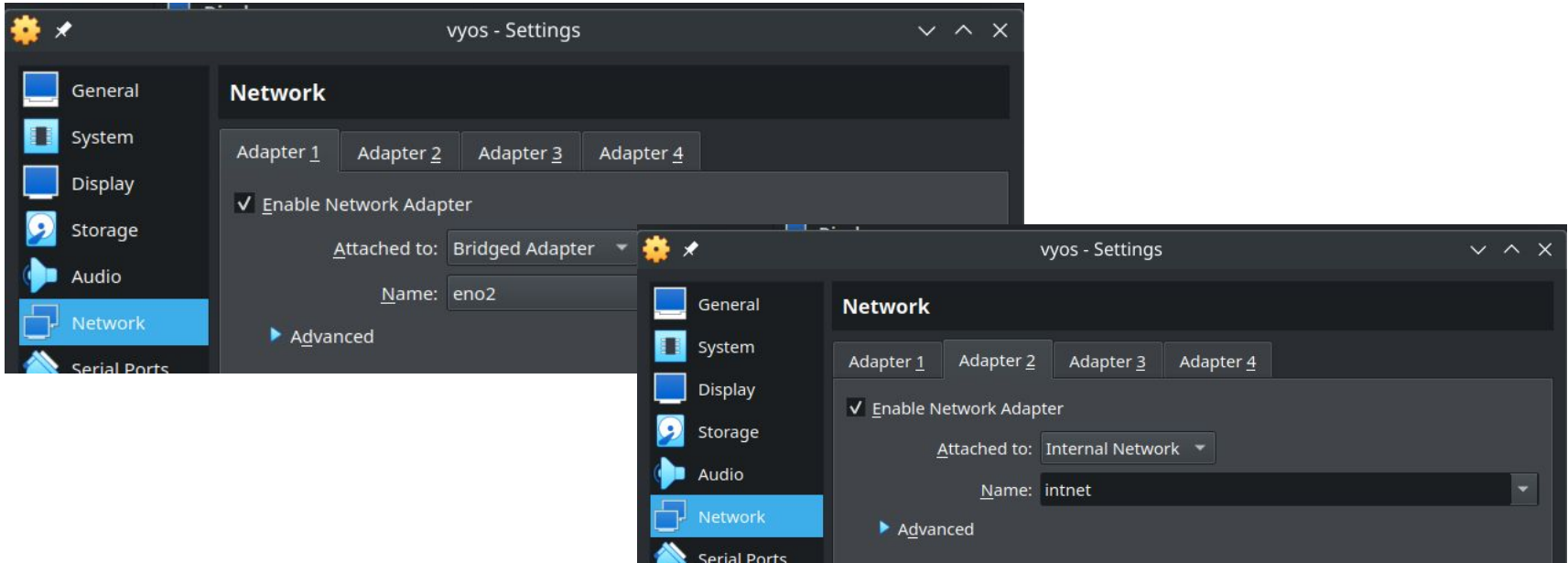
Processor: 1

Disk: 8G



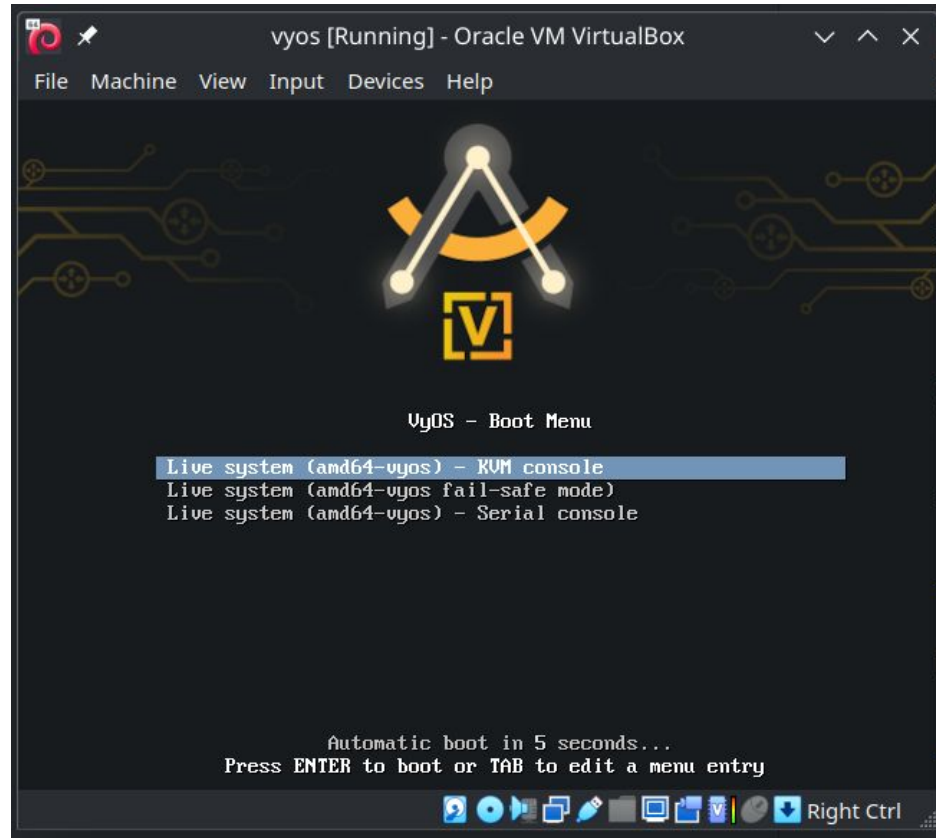
# VyOS - Network Setting

- Adapter 1 - Bridged Adapter
- Adapter 2 - Internal Network



# VyOS - ISO Boot up

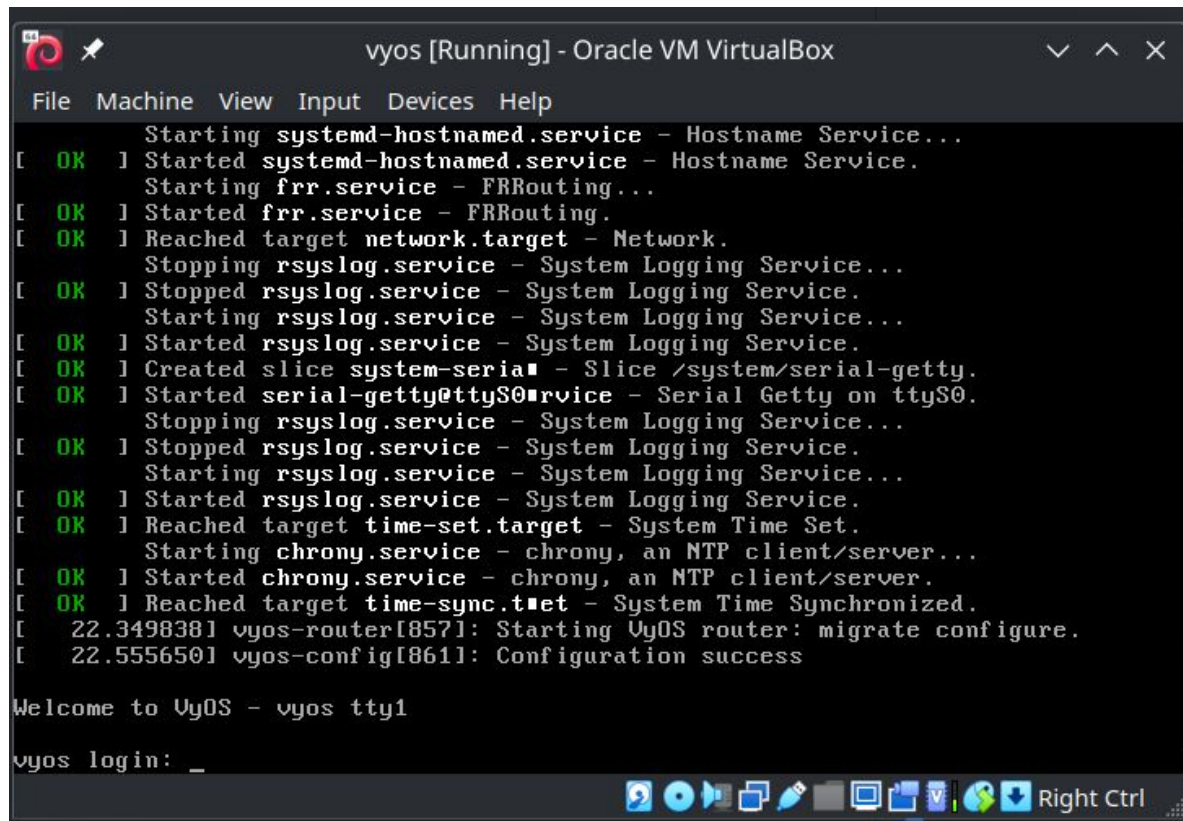
Choose the first one



# VyOS - ISO Login

User: vyos

Passwd: vyos



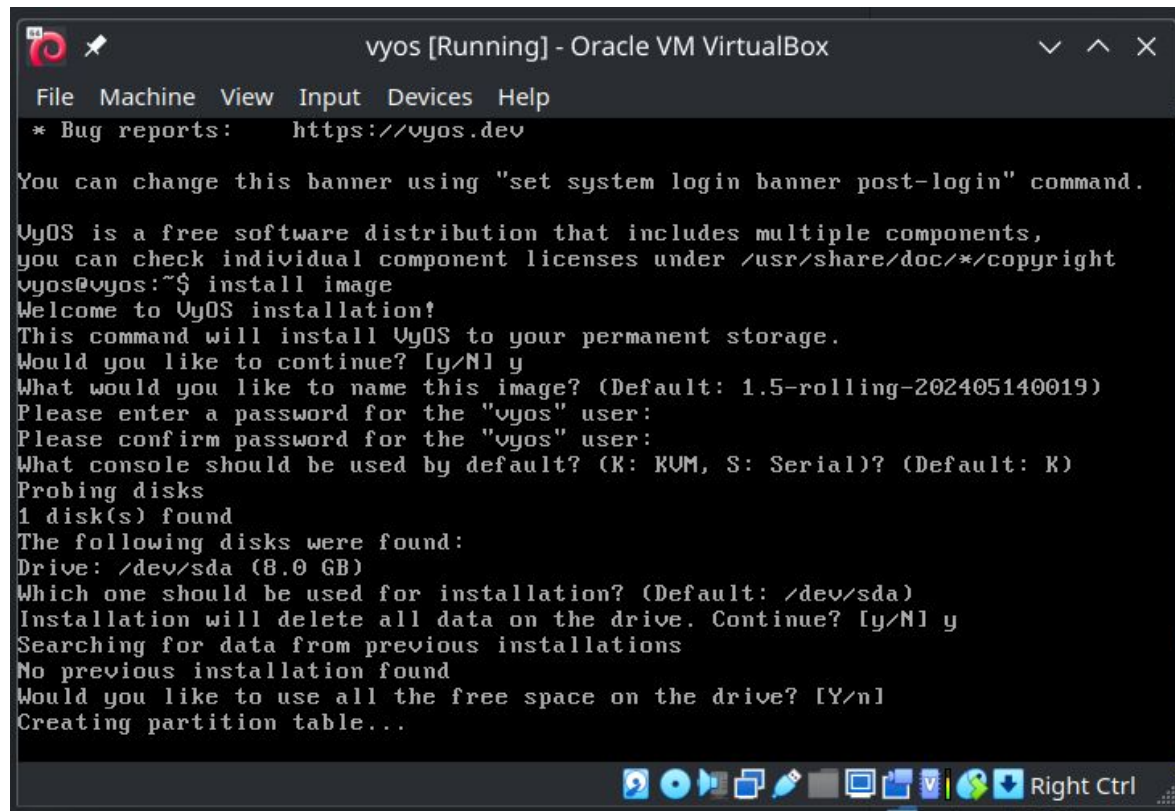
```
vyos [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Starting systemd-hostnamed.service - Hostname Service...
[ OK ] Started systemd-hostnamed.service - Hostname Service.
Starting frr.service - FRRouting...
[ OK ] Started frr.service - FRRouting.
[ OK ] Reached target network.target - Network.
Stopping rsyslog.service - System Logging Service...
[ OK ] Stopped rsyslog.service - System Logging Service.
Starting rsyslog.service - System Logging Service...
[ OK ] Started rsyslog.service - System Logging Service.
[ OK ] Created slice system-serial - Slice /system/serial-getty.
[ OK ] Started serial-getty@ttyS0.service - Serial Getty on ttyS0.
Stopping rsyslog.service - System Logging Service...
[ OK ] Stopped rsyslog.service - System Logging Service.
Starting rsyslog.service - System Logging Service...
[ OK ] Started rsyslog.service - System Logging Service.
[ OK ] Reached target time-set.target - System Time Set.
Starting chrrony.service - chrrony, an NTP client/server...
[ OK ] Started chrrony.service - chrrony, an NTP client/server.
[ OK ] Reached target time-sync.target - System Time Synchronized.
[ 22.349838] vyos-router[857]: Starting VyOS router: migrate configure.
[ 22.555650] vyos-config[861]: Configuration success

Welcome to VyOS - vyos tty1

vyos login: _
```

# VyOS - Install

- RUN install image
- Use default options
- Enter a password
- Poweroff
- Disconnect ISO



The screenshot shows a terminal window titled "vyos [Running] - Oracle VM VirtualBox". The terminal displays the following text:

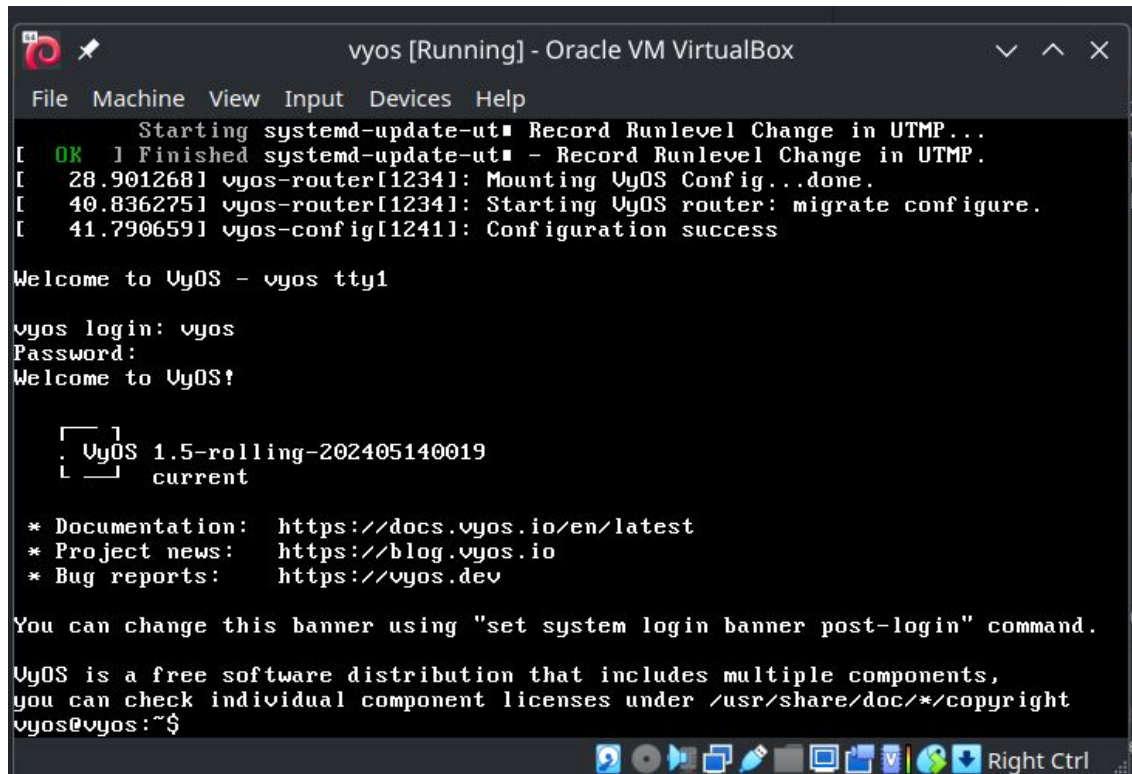
```
* Bug reports:      https://vyos.dev

You can change this banner using "set system login banner post-login" command.

VyOS is a free software distribution that includes multiple components,
you can check individual component licenses under /usr/share/doc/*/copyright
vyos@vyos:~$ install image
Welcome to VyOS installation!
This command will install VyOS to your permanent storage.
Would you like to continue? [y/N] y
What would you like to name this image? (Default: 1.5-rolling-202405140019)
Please enter a password for the "vyos" user:
Please confirm password for the "vyos" user:
What console should be used by default? (K: KVM, S: Serial)? (Default: K)
Probing disks
1 disk(s) found
The following disks were found:
Drive: /dev/sda (8.0 GB)
Which one should be used for installation? (Default: /dev/sda)
Installation will delete all data on the drive. Continue? [y/N] y
Searching for data from previous installations
No previous installation found
Would you like to use all the free space on the drive? [Y/n]
Creating partition table...
```

The terminal window has a menu bar with "File", "Machine", "View", "Input", "Devices", and "Help". The bottom of the window shows a taskbar with various icons and the text "Right Ctrl".

# VyOS - Installation Complete



```
Starting systemd-update-utmp - Record Runlevel Change in UTMP...
[ OK ] Finished systemd-update-utmp - Record Runlevel Change in UTMP.
[ 28.901268] vyos-router[1234]: Mounting VyOS Config...done.
[ 40.836275] vyos-router[1234]: Starting VyOS router: migrate configure.
[ 41.790659] vyos-config[1241]: Configuration success

Welcome to VyOS - vyos tty1

vyos login: vyos
Password:
Welcome to VyOS!

┌───┐
└─ VyOS 1.5-rolling-202405140019
└─ current

* Documentation: https://docs.vyos.io/en/latest
* Project news: https://blog.vyos.io
* Bug reports: https://vyos.dev

You can change this banner using "set system login banner post-login" command.

VyOS is a free software distribution that includes multiple components,
you can check individual component licenses under /usr/share/doc/*/copyright
vyos@vyos:~$
```

# VyOS - Basic Config

# Operation Mode

- Default mode after login
- Works like Cisco IOS

```
vyos login: vyos  
Password: *****  
Welcome to VyOS!
```

```
Check out project news at https://blog.vyos.io  
and feel free to report bugs at https://vyos.dev
```

```
You can change this banner using "set system login banner post-login" command.
```

```
VyOS is a free software distribution that includes multiple components,  
you can check individual component licenses under /usr/share/doc/*/copyright
```

```
vyos@vyos:~$
```



# Configuration Mode

- Enter by **configure** command in operation mode.
- Works like Juniper Junos OS, try `edit`, `up`, `top` and `show` commands.

```
vyos@vyos:~$ configure
```

```
[edit]
```

```
vyos@vyos# edit interfaces
```

```
[edit interfaces]
```

```
vyos@vyos#
```

```
[edit interfaces]
```

```
vyos@vyos# show
```

```
  ethernet eth0 {
```

```
    hw-id 08:00:27:cc:7a:42
```

```
  }
```

# How to Config

- Use **set** and **delete** to configure.
- The config will apply AFTER **commit** command.

```
[edit interfaces]
vyos@vyos# show
  ethernet eth0 {
    hw-id 08:00:27:cc:7a:14
  }

[edit interfaces]
vyos@vyos# set ethernet eth0 address dhcp

[edit interfaces]
vyos@vyos# commit
```

# Save Config

- The config will apply AFTER **commit** command.
- Use **save** command, just like `write` in Cisco IOS.

```
[edit interfaces]
vyos@vyos# set ethernet eth0 address dhcp

[edit interfaces]
vyos@vyos# commit

[edit interfaces]
vyos@vyos# save
Saving configuration to '/config/config.boot'...
Done

[edit]
vyos@vyos#
```

# Commit with Confirm

- Use 2-steps **commit-confirm** and **confirm** instead of `commit`.
- If disconnected, the VyOS will reboot and reset in 10 minutes.

```
[edit]
vyos@vyos# commit-confirm
commit-confirm will automatically reboot in 10 minutes unless changes
are confirmed.
Proceed ? [Y/n] y
Initialized commit-confirm; 10 minutes to confirm before reboot
```

```
[edit]
vyos@vyos# confirm
Reboot timer stopped
```

```
[edit]
vyos@vyos#
```

# Run Operation Commands in Config Mode

- Use **run** cmd just like `do cmd` in Cisco IOS.
- It support Tab and ? for auto complete.

```
[edit]
```

```
vyos@vyos# run show interfaces
```

```
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
```

Interface	IP Address	S/L	Description
eth0	192.168.24.101/24	u/u	

```
[edit]
```

```
vyos@vyos# run show arp
```

Address	Interface	Link layer address	State
192.168.24.254	eth0	00:02:c9:4f:a3:00	REACHABLE

# Enable SSH Service

- Set the hostname to your name. (Need to login again to take effect)
- Activate SSH service for all interfaces.

```
[edit]
vyos@router101# set system host-name router101

[edit]
vyos@router101# set service ssh listen-address 0.0.0.0

[edit]
vyos@router101# commit

[edit]
vyos@router101# save
Saving configuration to '/config/config.boot'...
Done
```

# VyOS - LAN Config

# Config LAN IP Address

- Use `eth1` as LAN interface.
- The IP address should be `172.20.ID.254/24` (with CIDR).

```
[edit]
vyos@router101# edit interfaces ethernet eth1

[edit interfaces ethernet eth1]
vyos@router101# set address 172.20.101.254/24

[edit interfaces ethernet eth1]
vyos@router101# set description "My internal network"

[edit interfaces ethernet eth1]
vyos@router101# commit
```



# Config DHCP Service

- Enable DHCP server for 172.20.ID.0/24 subnet.
- We use 172.20.ID.{11 - 50} as DHCP IP address pool.

```
[edit]
vyos@router101# edit service dhcp-server shared-network-name ccna subnet 172.20.101.0/24

[edit service dhcp-server shared-network-name ccna subnet 172.20.101.0/24]
vyos@router101# set default-router 172.20.101.254

[edit service dhcp-server shared-network-name ccna subnet 172.20.101.0/24]
vyos@router101# set range 0 start 172.20.101.11

[edit service dhcp-server shared-network-name ccna subnet 172.20.101.0/24]
vyos@router101# set range 0 stop 172.20.101.50
```

# Verify DHCP Config

```
vyos@router101:~$ show interfaces
```

Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down

Interface	IP Address	S/L	Description
-----	-----	---	-----
eth0	192.168.24.101/24	u/u	
eth1	172.20.101.254/24	u/u	My internal network

```
vyos@router101:~$ show dhcp server statistics
```

Pool	Size	Leases	Available	Usage
-----	-----	-----	-----	-----
ccna	40	1	39	2%

```
vyos@router101:~$ show dhcp server leases
```

IP Address	MAC address	State	Lease start	Lease expiration	Remaining	Pool	Hostname
-----	-----	-----	-----	-----	-----	-----	-----
172.20.101.11	08:00:27:a1:b1:7e	active	2023/05/18 11:05:00	2023/05/19 11:05:00	23:59:30	ccna	arch

# VyOS - GRE Config

# Setup GRE Tunnel

- Use `tun1` as interface name.
- The `remote` and `source-interface` should be WAN of VyOS.

```
[edit]
vyos@router101# edit interfaces tunnel tun1

[edit interfaces tunnel tun1]
vyos@router101# set address 10.101.102.1/30 # Your peer should use 10.101.102.2/30

[edit interfaces tunnel tun1]
vyos@router101# set encapsulation gre

[edit interfaces tunnel tun1]
vyos@router101# set source-interface eth0

[edit interfaces tunnel tun1]
vyos@router101# set remote 192.168.24.102 # Peer's VyOS WAN IP address
```

# Config Static Route

- Connect LAN for both side.
- Don't forget to commit in both side.

```
[edit]
vyos@router101# set protocols static route 172.20.102.0/24 next-hop 10.101.102.2

[edit]
vyos@router101# commit

[edit]
vyos@router101# save
Saving configuration to '/config/config.boot'...
Done
```

# Verify GRE Tunnel

- Check for peering IP address.
- Try to ping each other from Arch Linux.

```
vyos@router101:~$ show interfaces
```

Interface	IP Address	S/L	Description
-----	-----	---	-----
tun1	10.101.102.1/30	u/u	

```
vyos@router101:~$ ping 10.101.102.2 # Peer's tunnel IP address
```

```
PING 10.101.102.2 (10.101.102.2) 56(84) bytes of data.  
64 bytes from 10.101.102.2: icmp_seq=1 ttl=64 time=0.512 ms
```

```
vyos@router101:~$ ping 172.20.102.254 # Peer's LAN gateway
```

```
PING 172.20.102.254 (172.20.102.254) 56(84) bytes of data.  
64 bytes from 172.20.102.254: icmp_seq=1 ttl=64 time=0.198 ms  
64 bytes from 172.20.102.254: icmp_seq=2 ttl=64 time=0.964 ms
```

# GRE Tunnel

Ethernet  
Header

Outer IP  
Header

GRE  
Header

Inner IP  
Header

...

The image shows a Wireshark packet capture window titled '\*virbr0'. The packet list on the left shows four ICMP packets. The packet details pane on the right shows the structure of frame 624, which is an ICMP echo reply. The packet bytes pane on the right shows the raw data of the packet.

No.	icmp	Source	Destination	Protocol	Length	Info
625	icmpv6	192.168.122.10	192.168.122.10	ICMP	122	Echo (ping) request id=0x0001, seq=1/256, ttl=63 (reply in 625)
626	icmpv6	192.168.122.10	192.168.122.10	ICMP	122	Echo (ping) reply id=0x0001, seq=1/256, ttl=63 (request in 624)
725	icmpv6	192.168.122.10	192.168.122.10	ICMP	122	Echo (ping) request id=0x0001, seq=2/512, ttl=63 (reply in 726)
726	icmpv6	192.168.122.10	192.168.122.10	ICMP	122	Echo (ping) reply id=0x0001, seq=2/512, ttl=63 (request in 725)

Frame 624: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface virbr0, id 0

- Ethernet II, Src: 08:12:34:00:00:01 (08:12:34:00:00:01), Dst: 08:12:34:00:00:02 (08:12:34:00:00:02)
- Internet Protocol Version 4, Src: 192.168.122.215, Dst: 192.168.122.216
- Generic Routing Encapsulation (IP)
- Internet Protocol Version 4, Src: 172.20.10.10, Dst: 172.20.20.10
- Internet Control Message Protocol

Packet bytes (hex): 0000 08 12 34 00 00 02 08 12 34 00 00 01 0010 00 6c 12 38 40 00 40 2f b1 2a c0 a8 0020 7a d8 00 00 08 00 45 00 00 54 09 17 0030 bc 55 ac 14 0a 0a ac 14 14 0a 08 00 0040 00 01 97 17 f7 65 00 00 00 00 ad 6b 0050 00 00 10 11 12 13 14 15 16 17 18 19 0060 1e 1f 20 21 22 23 24 25 26 27 28 29 0070 2e 2f 30 31 32 33 34 35 36 37

Internet Control Message Protocol: Protocol Packets: 1065 · Displayed: 4 (0.4%) Profile: Default

# VyOS - OSPF Config



# Remove the Static Route

- Now we are ready to setup OSPF.

```
[edit]
vyos@router101# delete protocols static route

[edit]
vyos@router101# commit

[edit]
vyos@router101# run ping 172.20.102.254
PING 172.20.102.254 (172.20.102.254) 56(84) bytes of data.

^C
--- 172.20.102.254 ping statistics ---
10 packets transmitted, 0 received, 100% packet loss, time 9916ms
```

# Setup OSPF

- We connect to peer use GRE tunel instead of WAN IP address.
- Q: What happen if we missed network 10.101.102.0/30 statement?

```
[edit]
vyos@router101# edit protocols ospf

[edit protocols ospf]
vyos@router101# set parameters router-id 192.168.24.101           # Your WAN IP address

[edit protocols ospf]
vyos@router101# set neighbor 10.101.102.2                       # Peer's tunnel IP address

[edit protocols ospf]
vyos@router101# set area 10.101.102.0 network 172.20.101.0/24 # Your LAN network

[edit protocols ospf]
vyos@router101# set area 10.101.102.0 network 10.101.102.0/30 # Network of GRE tunnel
```

# Verify OSPF

- Wait up to 20 seconds if the route doesn't appear.
- Try to ping each other from ArchLinux again.

```
vyos@router101:~$ show ip ospf neighbor
```

Neighbor ID	Pri	State	Up Time	Dead Time	Address	Interface	RXmtL	RqstL	DBsmL
192.168.24.102	1	Full/Backup	32.768s	37.220s	10.101.102.2	tun1:10.101.102.1	0	0	0

```
vyos@router101:~$ show ip route
```

Codes: K - kernel route, C - connected, S - static, R - RIP,

  O - **OSPF**, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,

  > - selected route, \* - FIB route, q - queued, r - rejected, b - backup

```
S>* 0.0.0.0/0 [210/0] via 192.168.24.254, eth0, weight 1, 01:15:20
```

```
O 10.101.102.0/30 [110/1] is directly connected, tun1, weight 1, 00:06:40
```

```
C>* 10.101.102.0/30 is directly connected, tun1, 01:10:00
```

```
O>* 172.20.102.0/24 [110/2] via 10.101.102.2, tun1, weight 1, 00:00:24
```

```
C>* 192.168.24.0/24 is directly connected, eth0, 01:15:30
```

# Physical Cable

# Twisted Pair Cable

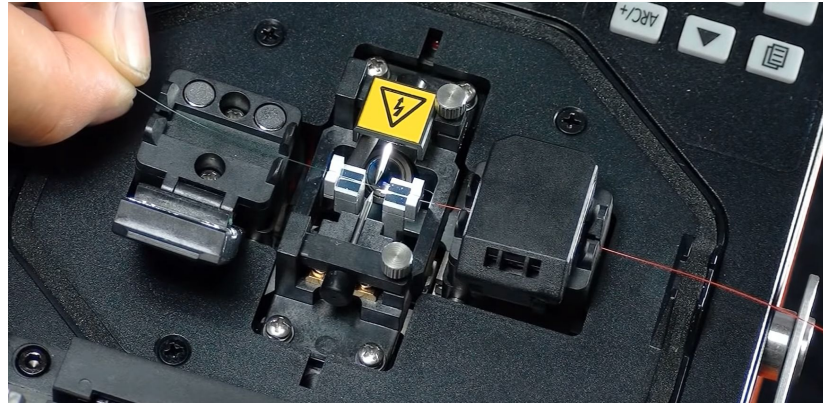
- Connector
  - RJ11: 6P2C
  - RJ45: 8P8C
- Wire
  - Cat 5, Cat 5e, Flat Cable
  - Cat 6, Cat 6a, (Cat 6e)
  - Shielded or not: UTP, STP




Source: [cablesys](#)

# Fiber Optic Cable

- Connector: SC, LC, etc.
- Single Mode: **OS1**, **OS2** (Optical Single-mode Fiber)
- Multimode: **OM1**, **OM2**, **OM3**, **OM4**, **OM5**
- Use SFP / QSFP+ transceiver module



Source: [promax](#)


 Cable Matters

Fiber Optic Connector Types

LC

**Lucent Connectors**


- Square shape, duplex
- Small-form-factor (1.25mm thick)



SC

**Standard Connectors**


- Square-shaped, duplex
- 2.5mm ferrule
- Push-pull mechanism



ST

**ST Connectors**


- 2.5mm ferrule
- Spring-loaded, half-turn bayonet-style lock



FC

**Ferrule Core Connectors**


- Stainless steel screw mechanism
- Ceramic ferrule



MPO

**Multi-Position Connectors**


- Simplex connector
- Push/pull latch system




MT-RJ

**MT-RJ Connectors**

- Tubular locking mechanism



 Cable Matters

Source: [cablematters](#)

# Coaxial Cable

- Common for TV
- Wire: RG-6, RG-59, RG-62 (Radio Guide)
- RF Connectors



Source: [Wikimedia](#)

# HiNet Boardband

## HiNet 光世代 非固定制

最高速率 (下載/上傳)	2G/1G	1G/600M	500M/250M	300M/150M	100M/40M	60M/20M	35M/6M	16M/3M
上網費牌價 (元/月)	\$1,219	\$845	\$622	\$576	\$466	\$459	\$435	\$360
電路費牌價 (元/月)	\$1,850	\$1,054	\$677	\$623	\$442	\$389	\$366	\$293
總金額 (元/月)	\$3,069	\$1,899	\$1,299	\$1,199	\$908	\$848	\$801	\$653

Source: [HiNet](#)



Source: [Mobile01](#)

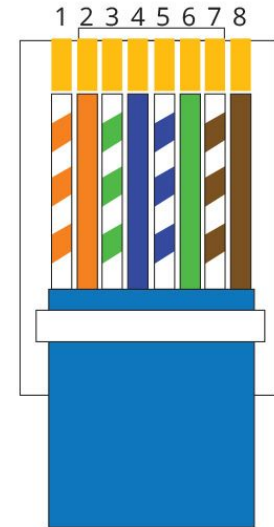
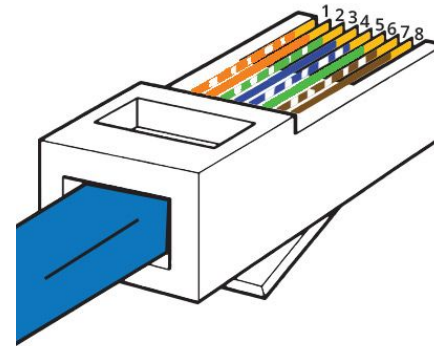




# Crimp your own Network Cable

- Things we need:
  - Cat 5e cable: 30 - 90 cm
  - RJ45 connector: 2 pcs
  - Strain Relief Boots: 2 pcs
- Shared tools:
  - Scissor
  - Mini Cable Stripper
  - Crimping tool
  - Cable Tester

## RJ45 Pinout T-568B



- |                 |                |
|-----------------|----------------|
| 1. White Orange | 5. White Blue  |
| 2. Orange       | 6. Green       |
| 3. White Green  | 7. White Brown |
| 4. Blue         | 8. Brown       |

# Thanks

Any questions?

# Related files

- VirtualBox: <https://www.virtualbox.org/wiki/Downloads>
- VyOS: <https://vyos.net/get/nightly-builds/>
- ArchLinux: <https://archlinux.org/download>