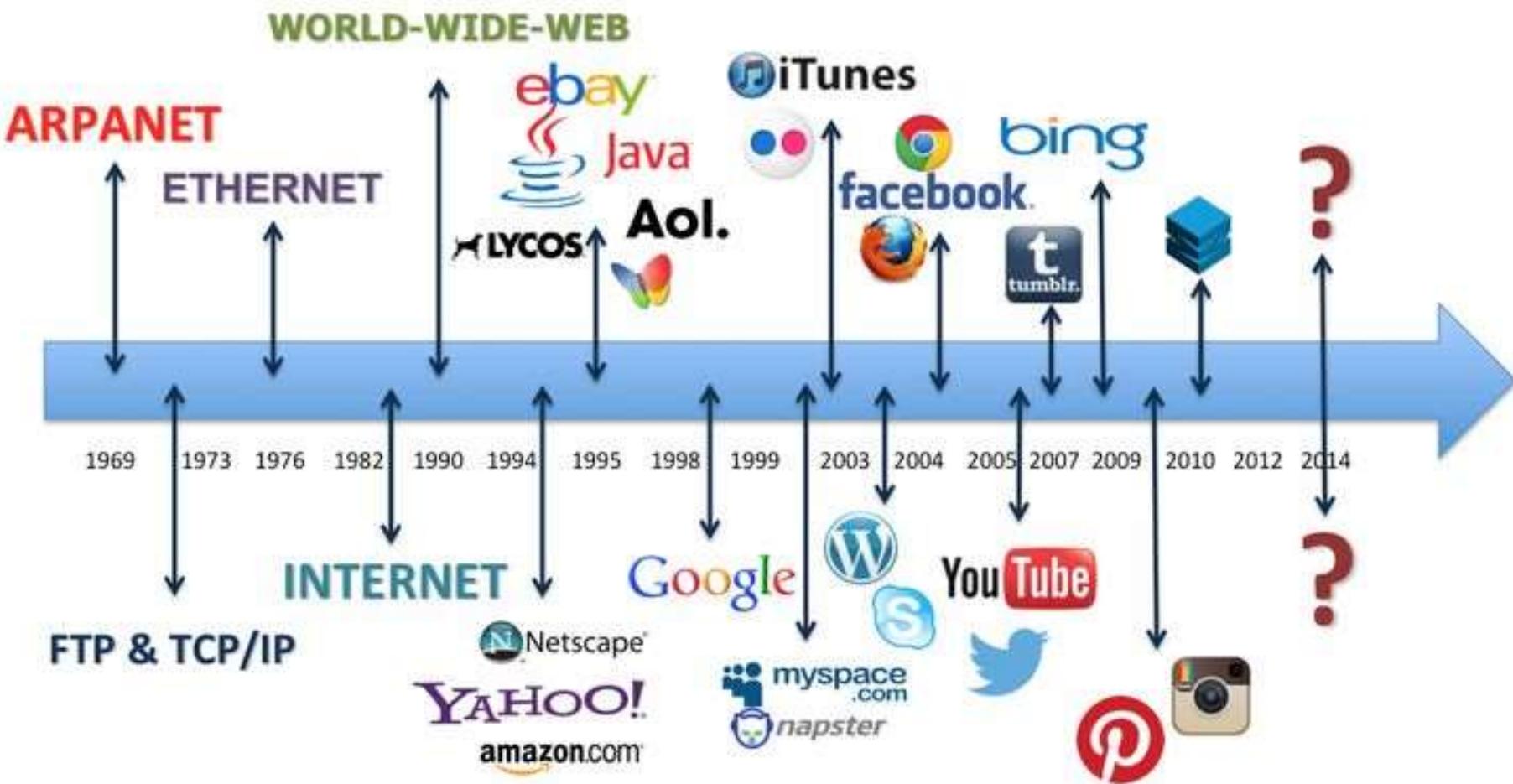


Linux Networking

Bok, JongSoon
javaexpert@nate.com

<https://github.com/swacademy/fss/tree/main/Linux>

History of Internet



<https://www.pinterest.co.kr/pin/505529126900272979/>

ubuntu®

Networking

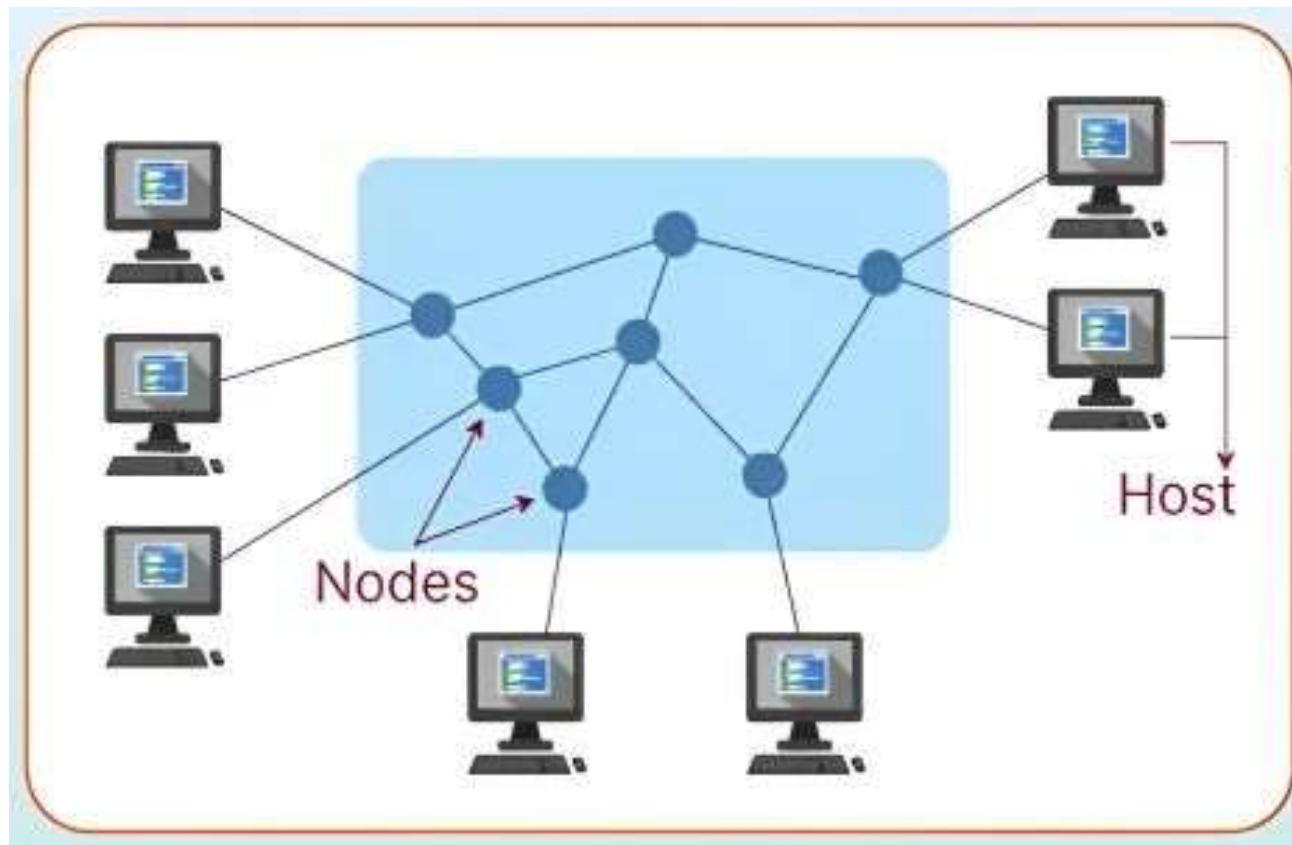
- A network similar to a highway.
- Networking is like a highway system that connects cities and states from one point to another.



ubuntu®

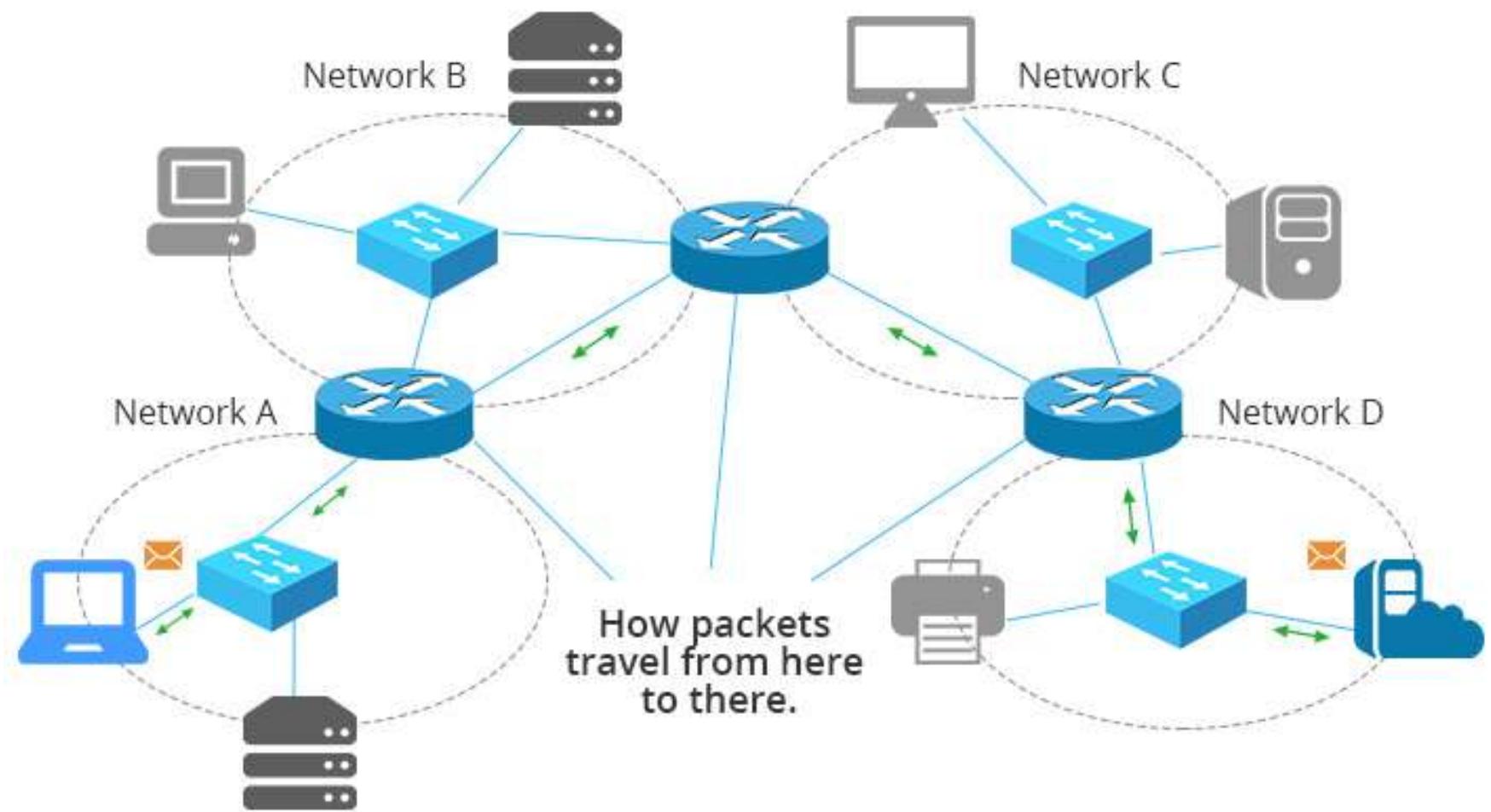
What's Computer Networking?

- Is a collection of computing devices that are logically connected to each other to communicate and share resources.

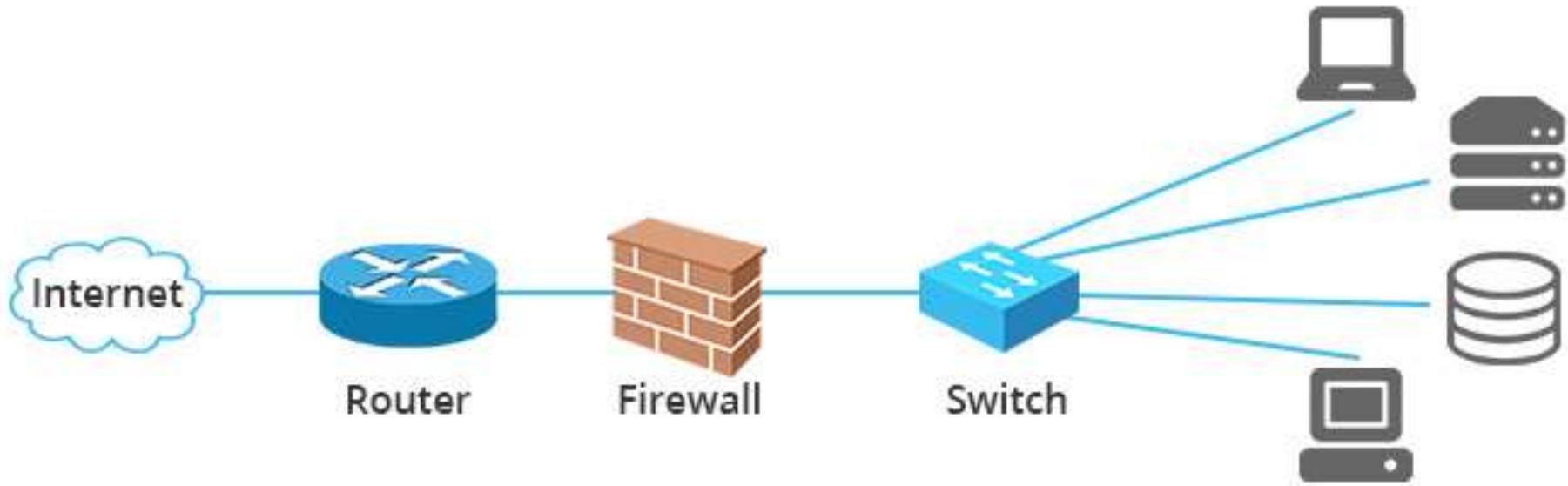


ubuntu®

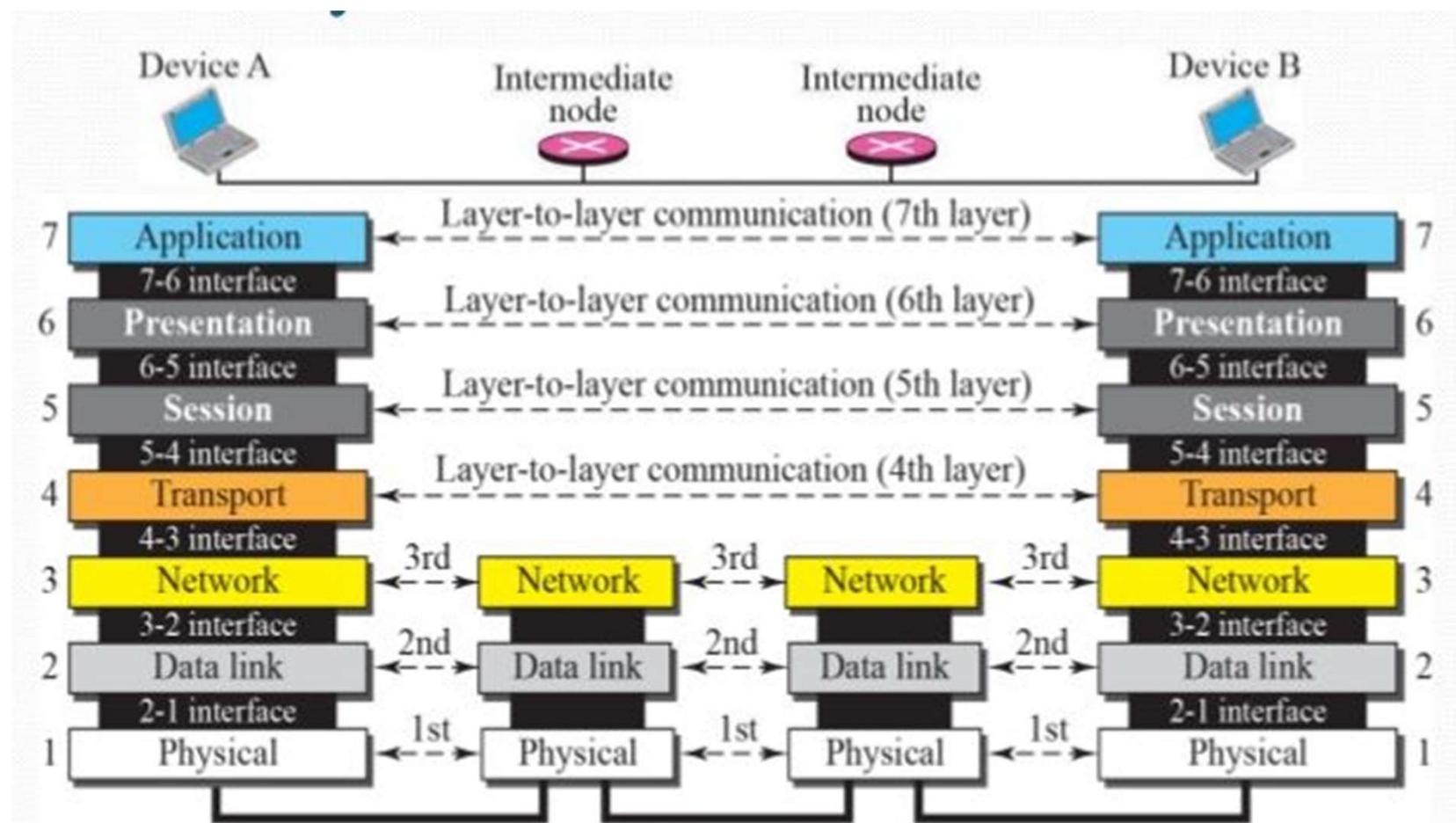
Basic Computer Network



Basic Computer Network (Cont.)

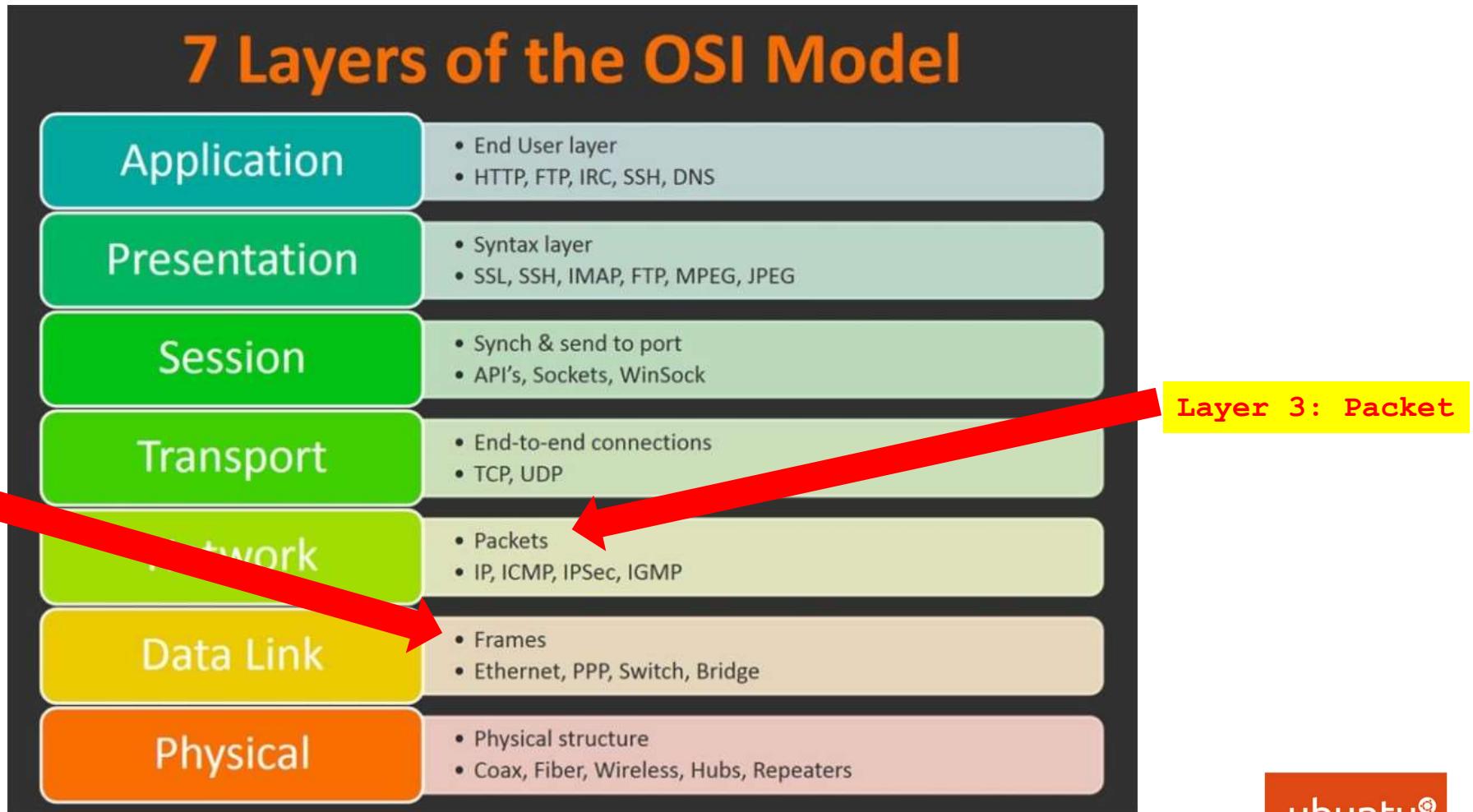


OSI Layers



ubuntu®

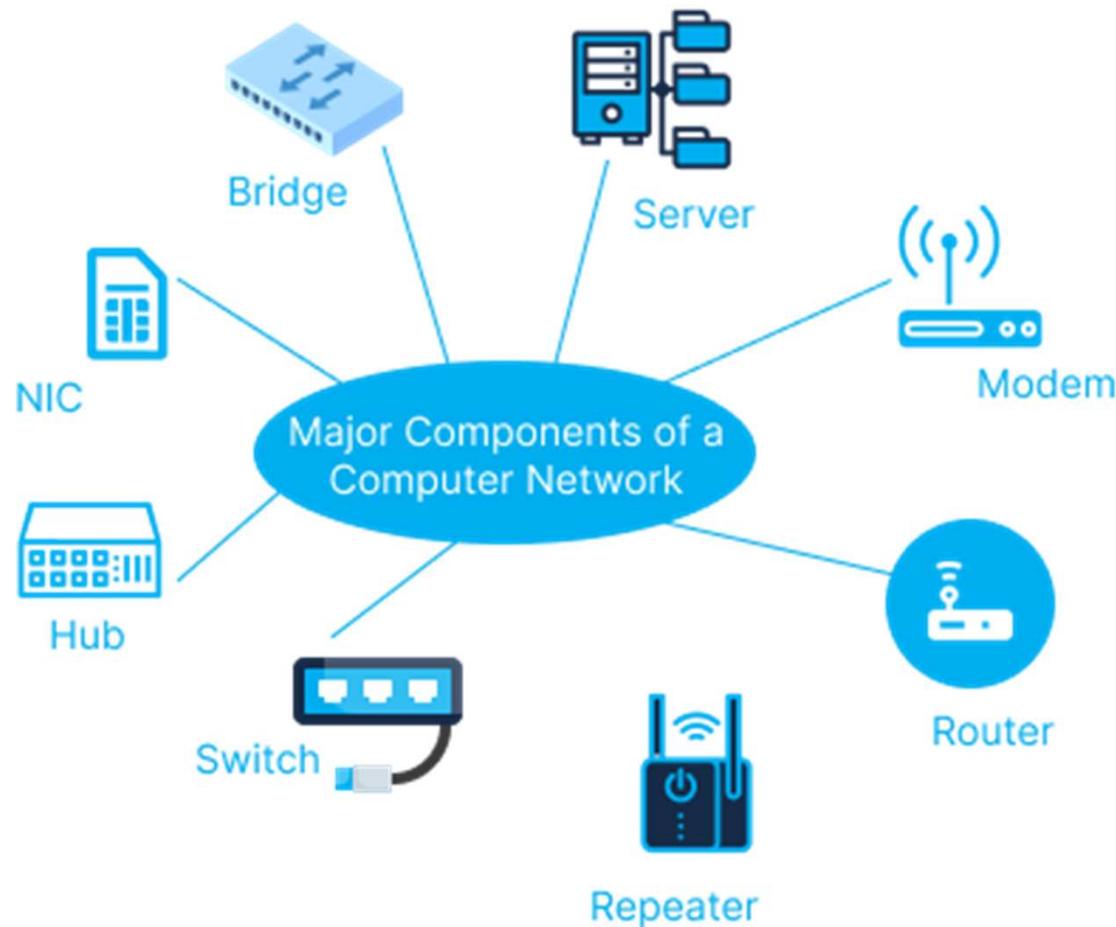
OSI Layers (Cont.)



ubuntu®

Network Major Components

- NIC
- Repeater
- Hub
- Bridge
- Switch
- Router
- Gateway

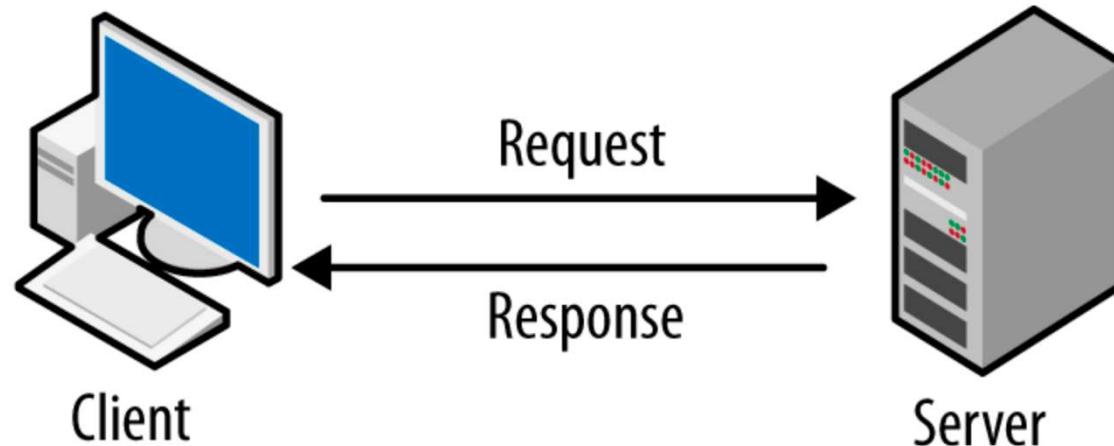


ubuntu®

Client vs Server

■ Clients

- Refers to a software program or device that accesses a service provided by a server.
- The client initiates *requests* to servers for data or services, and the server responds to these *requests*.

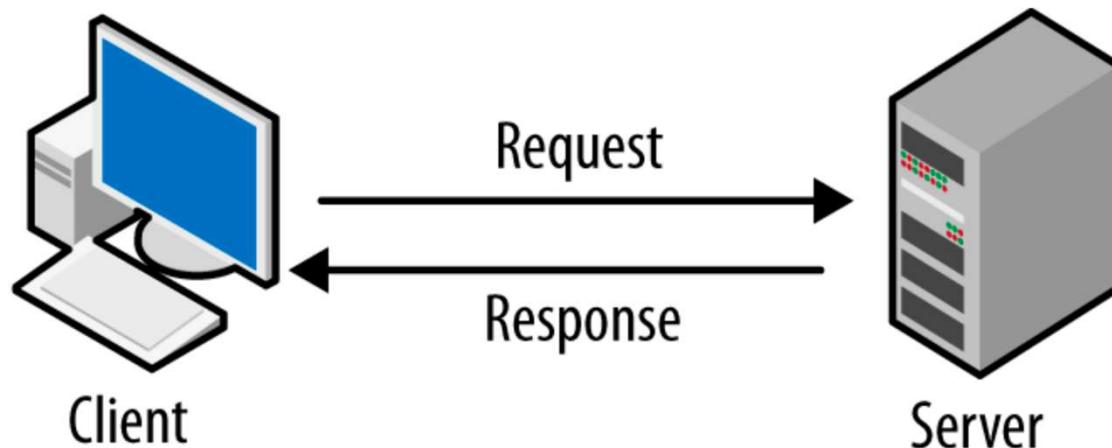


ubuntu®

Client vs Server (Cont.)

■ Servers

- Is a computer or system that provides resources, data, services, or programs to other computers, known as clients, over a network.



ubuntu®

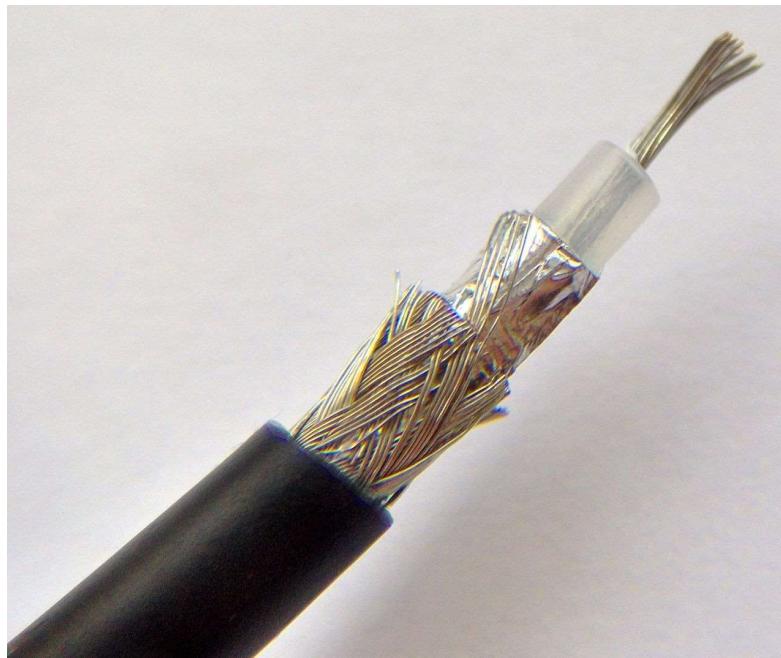
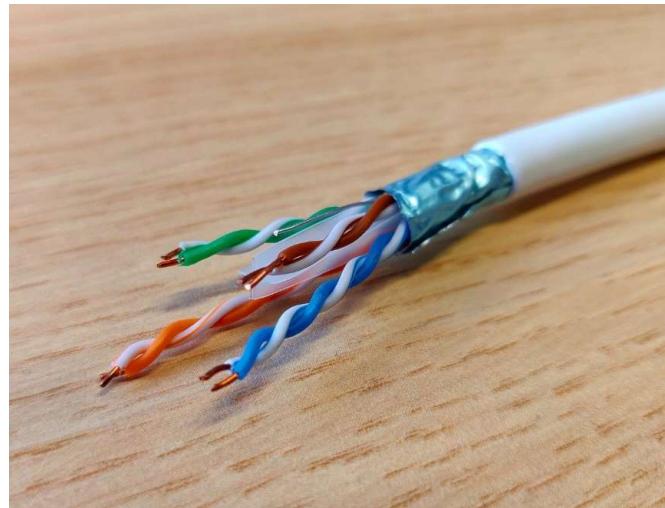
Network Interface Card (NIC)

- Connects computer to a computer network.
- In some cases, it is also called a *network adapter*.
- Uses a cable connected to a hub or switch.
- Each NIC has a unique Media Access Control (*MAC*) address.
- A *MAC* address is a unique physical (hardware) identifier assigned by the manufacturer and used to identify the sender and receiver of data.
- NICs have physical components, but they also have *MAC* addresses, so they operate at layer 2.



Network Cables

- Twisted pair
- Coaxial cable
- Fiber optic cable

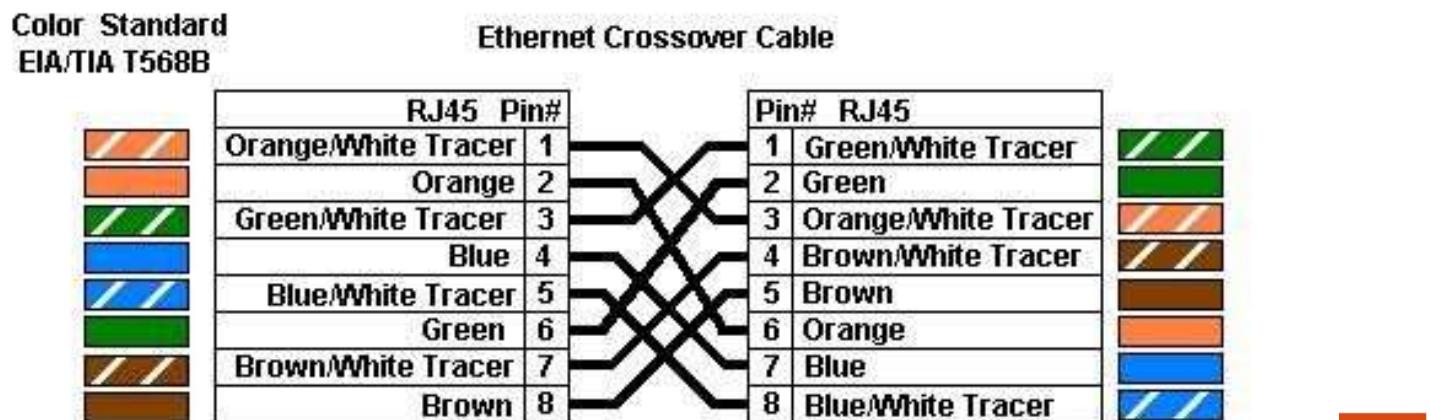
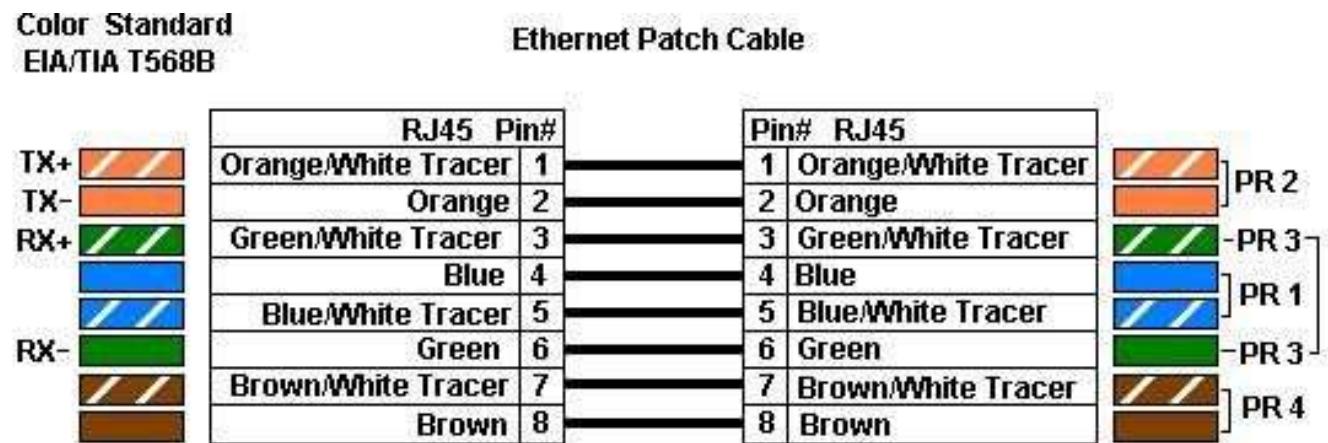


https://en.wikipedia.org/wiki/Networking_cable

ubuntu®

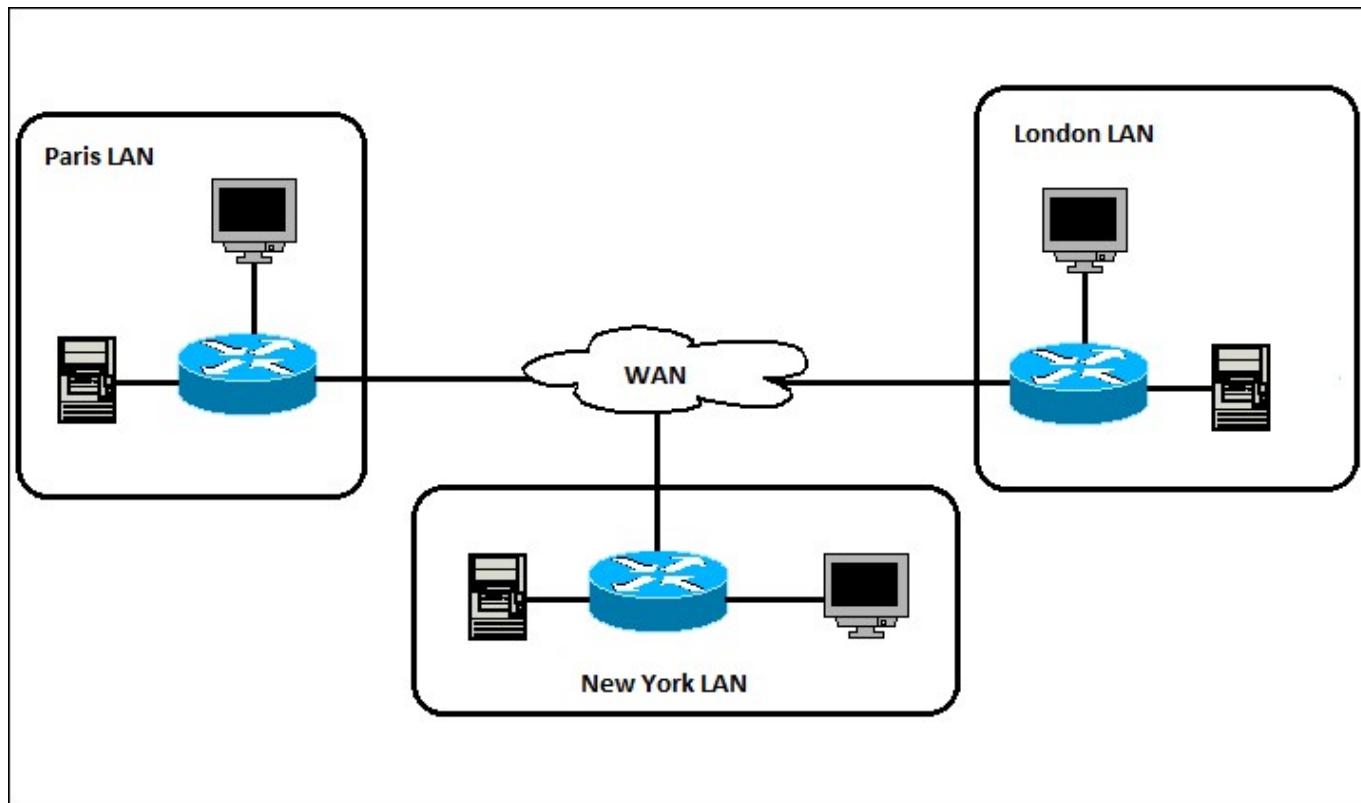
Network Cables (Cont.)

- Patch cable
- Crossover cable



LAN vs WAN

- Local Area Network (LAN)
- Wide Area Network (WAN)



<https://lightyear.ai/blogs/wan-versus-lan-whats-lan-got-to-do-with-it>

ubuntu®

Network Topology



Point to Point



Bus



Ring



Star



Tree



Mesh

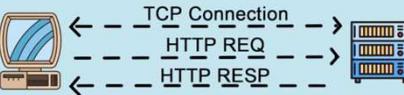
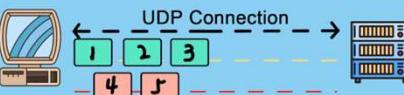
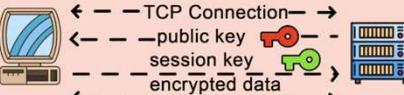
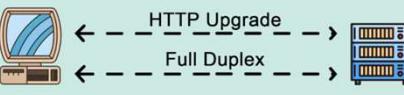
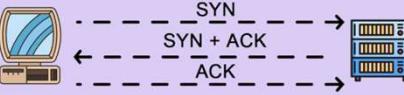
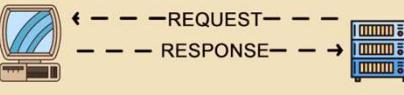
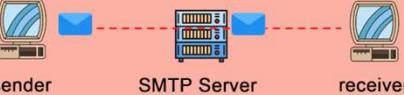
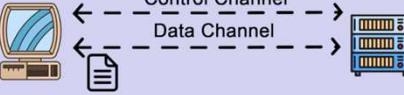


Hybrid

Network Protocols

8 Popular Network Protocols

blog.bytebytego.com

Protocol	How does It Work?	Use Cases
HTTP		 Web Browsing
HTTP/3 (QUIC)		 IoT  Virtual Reality
HTTPS		 Web Browsing
WebSocket		 Live Chat  Real-Time Data Transmission
TCP		 Web Browsing  Email Protocols
UDP		 Video Conferencing
SMTP		 Sending/Receiving Emails
FTP		 Upload/Download Files

<https://blog.bytebytego.com/p/ep80-explaining-8-popular-network>

ubuntu®

Network Protocols (Cont.)

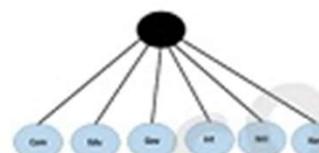
ARP (Address Resolution Protocol)



Border Gateway Protocol (BGP)



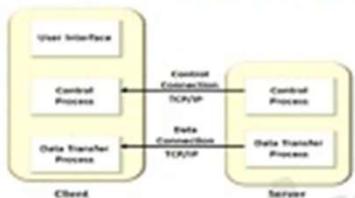
Domain Name System (DNS)



Dynamic Host Configuration Protocol (DHCP)



File Transfer Protocol (FTP)



Hypertext Transfer Protocol (HTTP)



Internet Protocol (IP)



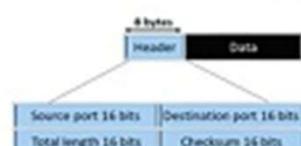
Transmission Control Protocol (TCP)



Open Shortest Path First (OSPF)



User Datagram Program (UDP)



Telnet



Simple Mail Transfer Protocol (SMTP)



Network Protocols (Cont.)

■ ARP: Address Resolution Protocol

- Is a communication layer protocol used for identification of Media access control (*MAC*) address given the IP address basically mapping between data link layer and network layer.
- Translates IP address into MAC address.

■ IP: Internet Protocol

- Is used for sending packets from source location to destination location.
- The main task is to deliver the packets from source to destination based on IP addresses available in the packet header.

Network Protocols (Cont.)

■ TCP: Transmission Control Protocol

- Is a transport layer protocol which facilitates transmission of packets from source to destination.
- Is a *connection-oriented protocol* which establishes connection prior to communication.
- Takes data from the application layer and divides it into several packets and numbers them before transmission.

■ UDP: User Datagram Program

- Is also a transport layer network protocol but it is unreliable as it is a connectionless state and does not provide an acknowledgement mechanism unlike its counterpart TCP.
- Works by encapsulating the data into a packet and providing its own header then it is encapsulated to the IP packet and sent to destination.

Connection-oriented vs Connection-less

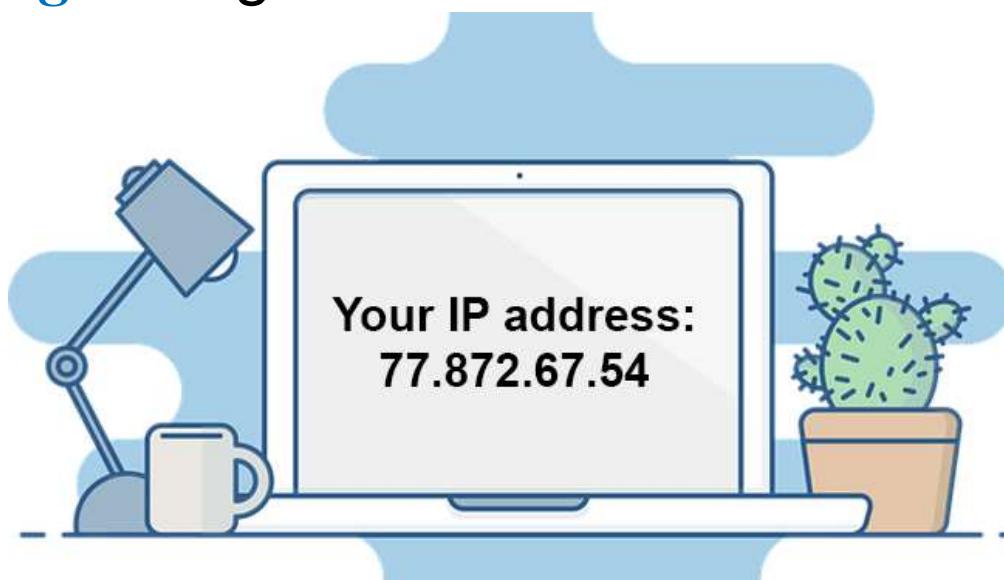


<u>Connection Oriented Service</u>	<u>Connectionless Service</u>
- Reliable mode of service.	- Unreliable mode of service.
- Packets arrive at destination in order.	- No sequencing of packets is done.
- Acknowledgement is required about the delivery of the message.	- No acknowledgement is done.
- Example: TCP	- Example: UDP
- Ensure error free delivery of packets at destination.	- Packets are not guaranteed to be error free.
- Slow communication.	- Fast communication.



Internet Protocol: IP

- Is a network protocol that sets rules for forwarding and relaying data on the Internet.
- Identify device using its IP address.
- The port number is used to identify the endpoint.
- Supports *subnetting* to segment network.

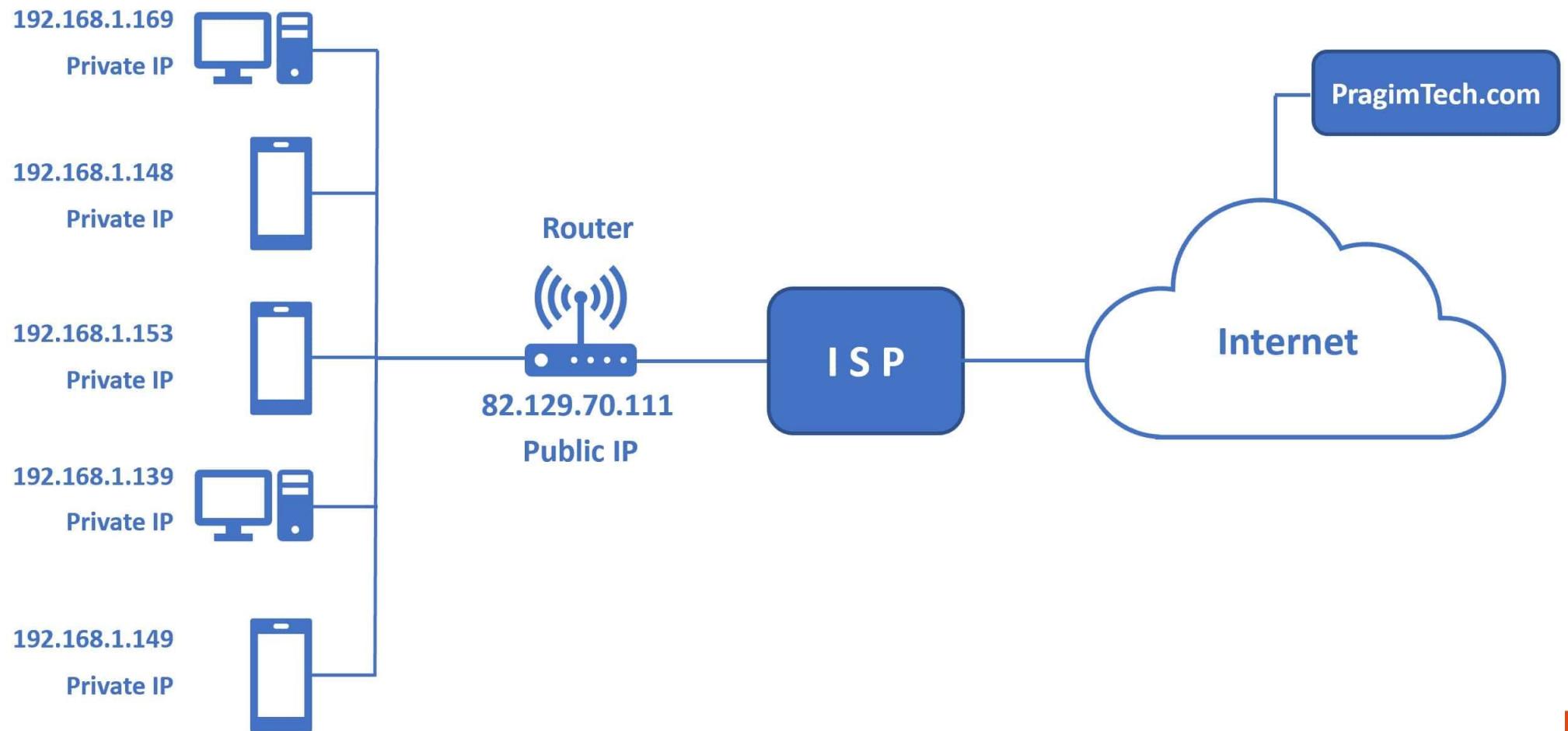


IP Address

- Is a unique element that identifies a device on a network.
- Each device on a network has an IP address, and an IP address performs two main functions:
 - Identify hosts and networks.
 - Also used in location addresses.



Private IP Address vs Public IP Address



Private IP Address vs Public IP Address (Cont.)

Category	Public IP Address	Private IP Address
Scope	Has a global reach.	Only local reach.
Communication	Used to communicate over the Internet.	Used to communicate within a private network.
Uniqueness	A unique address not used by other devices on the Internet.	An address from a smaller range used by other devices in other local networks.
Origin	Assigned by the ISP.	Assigned by the router to a specific device on the local network.
Range	Any IP not in the private IP address ranges.	Any address from the following ranges: 10.0.0.0 - 10.255.255.255; 172.16.0.0 - 172.31.255.255; 192.168.0.0 - 192.168.255.255
Security	Public IPs require additional security measures, they are prone to attacks.	Private IPs are secure.
Example	82.129.73.111	10.0.0.0

<https://phoenixnap.com/kb/public-vs-private-ip-address>

ubuntu®

Private IP Address vs Public IP Address (Cont.)

■ RFC 1918

- <https://datatracker.ietf.org/doc/html/rfc1918>

Network Working Group
Request for Comments: 1918
Obsoletes: [1627](#), [1597](#)
BCP: 5
Category: Best Current Practice

Y. Rekhter
Cisco Systems
B. Moskowitz
Chrysler Corp.
D. Karrenberg
RIPE NCC
G. J. de Groot
RIPE NCC
E. Lear
Silicon Graphics Inc

Address Allocation for Private Internets

Status of this Memo

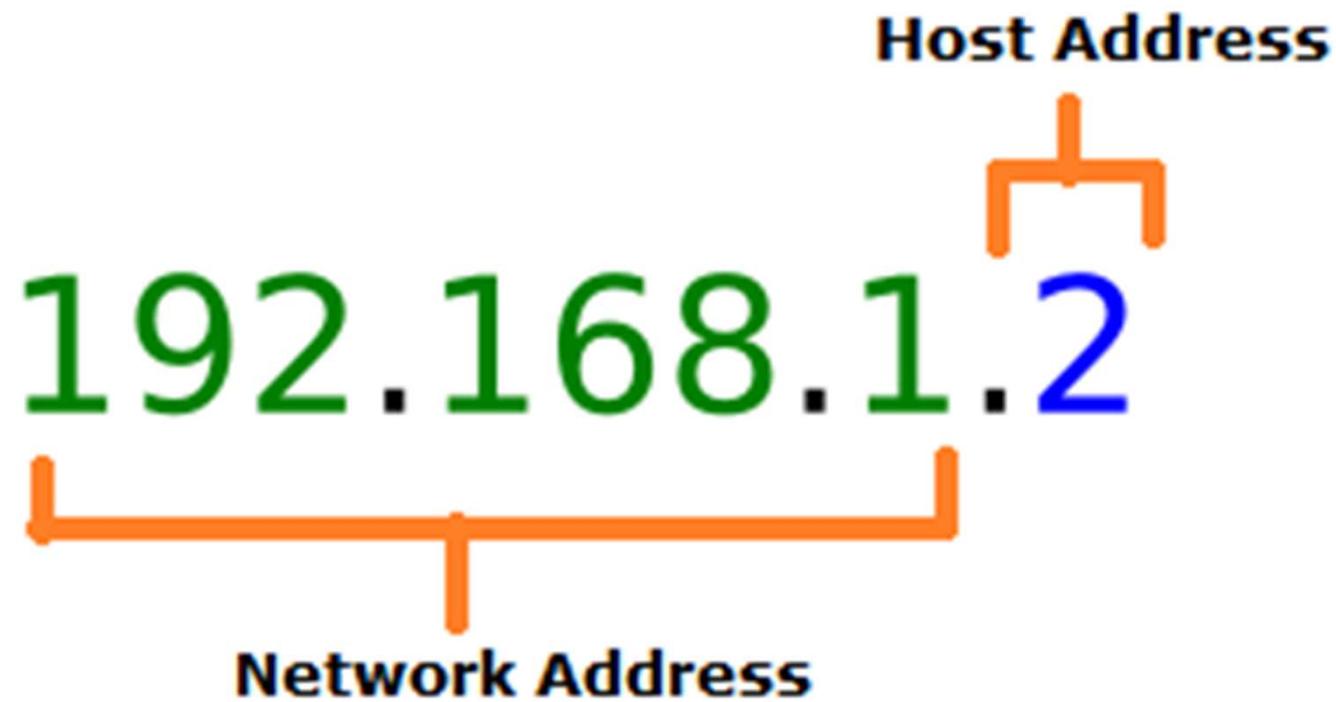
This document specifies an Internet Best Current Practice for the Internet Community, and requests discussion and suggestions for improvements. Distribution of this memo is unlimited.

3. Private Address Space

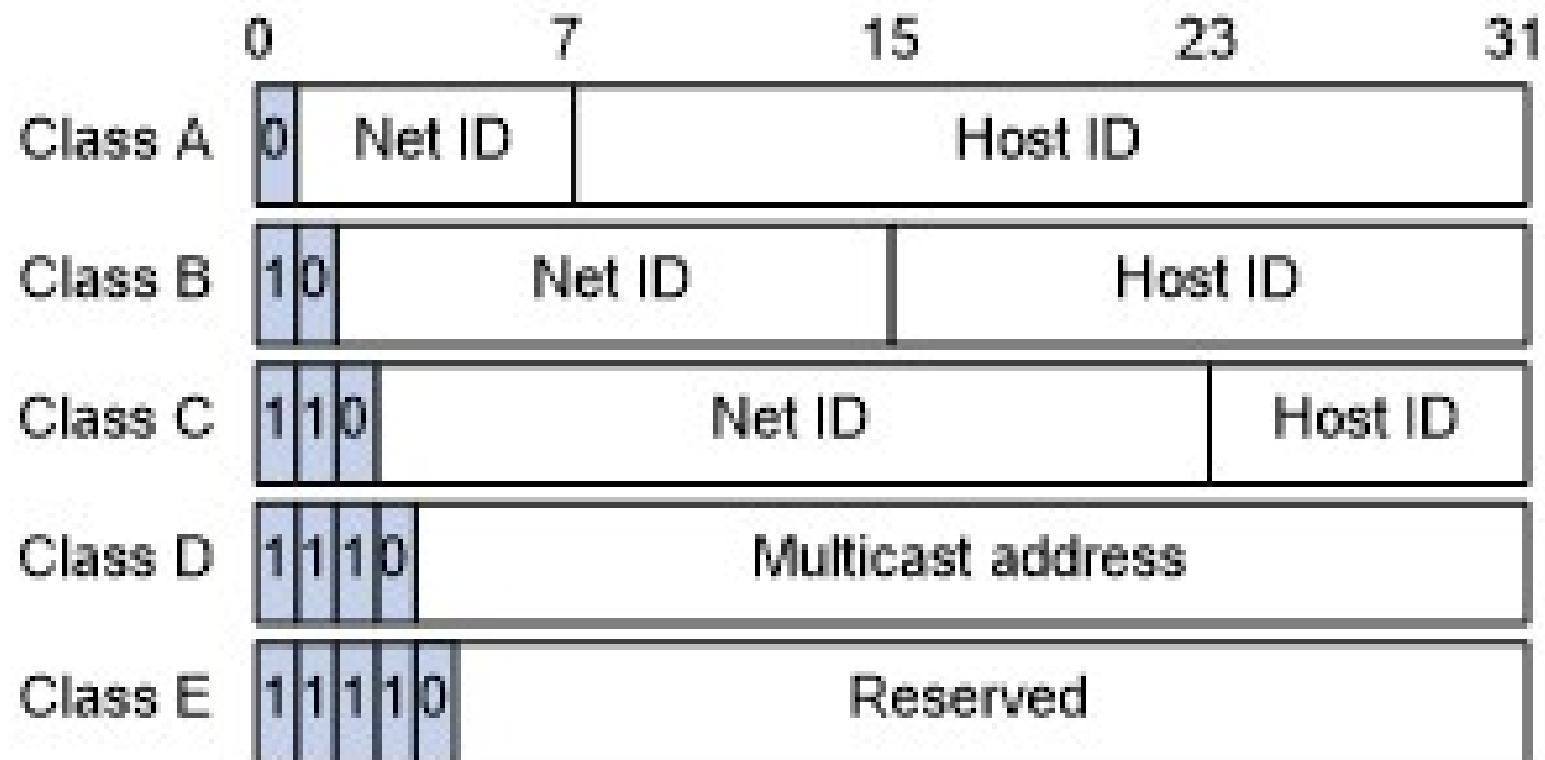
The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of the IP address space for private internets:

10.0.0.0	-	10.255.255.255 (10/8 prefix)
172.16.0.0	-	172.31.255.255 (172.16/12 prefix)
192.168.0.0	-	192.168.255.255 (192.168/16 prefix)

IP Address (Cont.)



IP Address (Cont.)



IP Address (Cont.)

Class	Leading bits	Size of <i>network number</i> bit field	Size of <i>rest</i> bit field	Number of networks	Addresses per network	Start address	End address
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	0.0.0.0	127.255.255.255
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	128.0.0.0	191.255.255.255
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	192.0.0.0	223.255.255.255
Class D (multicast)	1110	not defined	not defined	not defined	not defined	224.0.0.0	239.255.255.255
Class E (reserved)	1111	not defined	not defined	not defined	not defined	240.0.0.0	255.255.255.255

ubuntu®

CIDR Notation

- Classless Inter-Domain Routing (CIDR)
 - Is an IP addressing system that replaced the previous system of using Class A, B, and C networks.

The first type of address, or class A, has a 7-bit network number and a 24-bit local address. The highest-order bit is set to 0. This allows 128 class A networks.

The second type of address, class B, has a 14-bit network number and a 16-bit local address. The two highest-order bits are set to 1-0. This allows 16,384 class B networks.

The third type of address, class C, has a 21-bit network number and a 8-bit local address. The three highest-order bits are set to 1-1-0. This allows 2,097,152 class C networks.

CIDR Notation (Cont.)

| Network Bits || Host Bits |

174.16.0.0

10101110. 00010000. 00000000. 00000000

CIDR Notation (Cont.)

Bit Counting System

128 64 32 16 8 4 2 1

174.16.0.0

10101110. 00010000. 00000000. 00000000



1. 0. 1. 0. 1. 1. 1. 0

128. 0. 32. 0. 8. 4. 2. 0 = 174

ubuntu®

CIDR Notation (Cont.)

174.16.0.0 /24

10101110. 00010000. 00000000. 00000000

11111111. 11111111. 11111111. 00000000
255.255.255.0

CIDR Notation (Cont.)

172.16.0.0 /24

What are the first and last assignable IPs?

	10101100.	00010000.	00000000.	00000000	
First	10101100.	00010000.	00000000.	00000001	172.16.0.1
Last	10101100.	00010000.	00000000.	11111110	172.16.0.254

152.2.136.0 /26

	10011000.	00000010.	10001000.	00000000	
First	10011000.	00000010.	10001000.	00000001	152.2.136.1
Last	10011000.	00000010.	10001000.	00111110	152.2.136.62

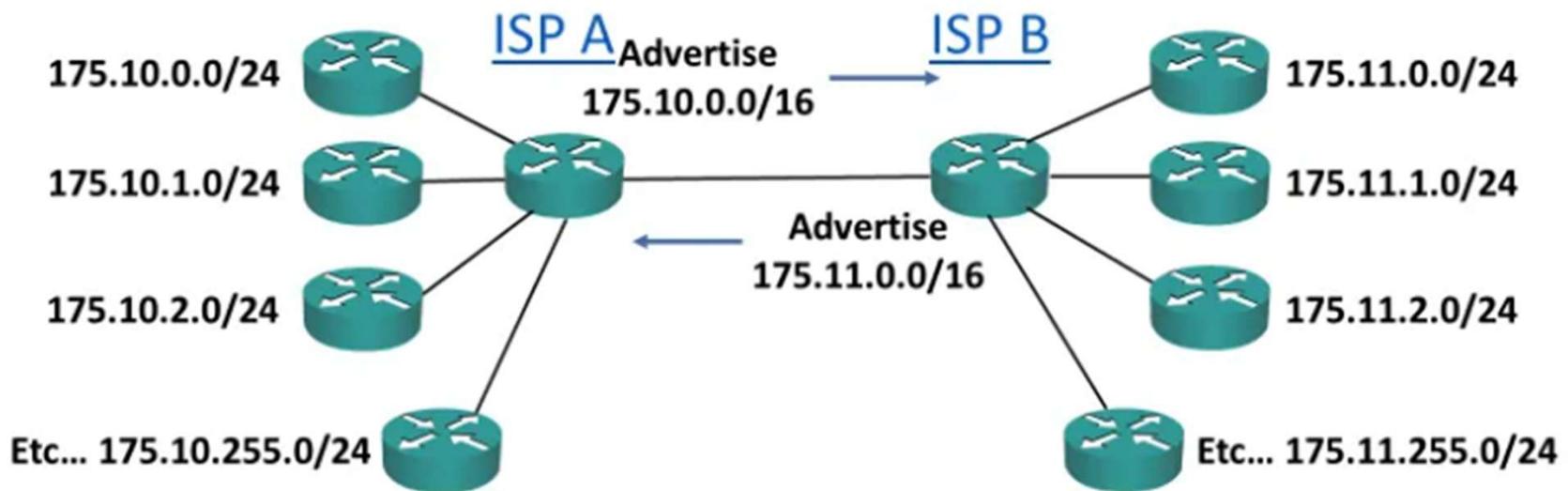
CIDR Notation

CIDR Block Size	Exponential Notation	Number of Addresses
/24	2^8	256
/23	2^9	512
/22	2^{10}	1,024
/21	2^{11}	2,048
/20	2^{12}	4,096
/19	2^{13}	8,192
/18	2^{14}	16,384
/17	2^{15}	32,768
/16	2^{16}	65,536

<https://www.salesforce.com/blog/cidr-block-in-anypoint-platform/>

ubuntu®

CIDR Notation (Cont.)



IPv4 vs IPv6

IPv4

Deployed 1981

32-bit IP address

4.3 billion addresses

Addresses must be reused and masked

Numeric dot-decimal notation

192.168.5.18

DHCP or manual configuration

IPv6

Deployed 1998

128-bit IP address

7.9x10²⁸ addresses

Every device can have a unique address

Alphanumeric hexadecimal notation

50b2:6400:0000:0000:6c3a:b17d:0000:10a9

(Simplified - 50b2:6400::6c3a:b17d:0:10a9)

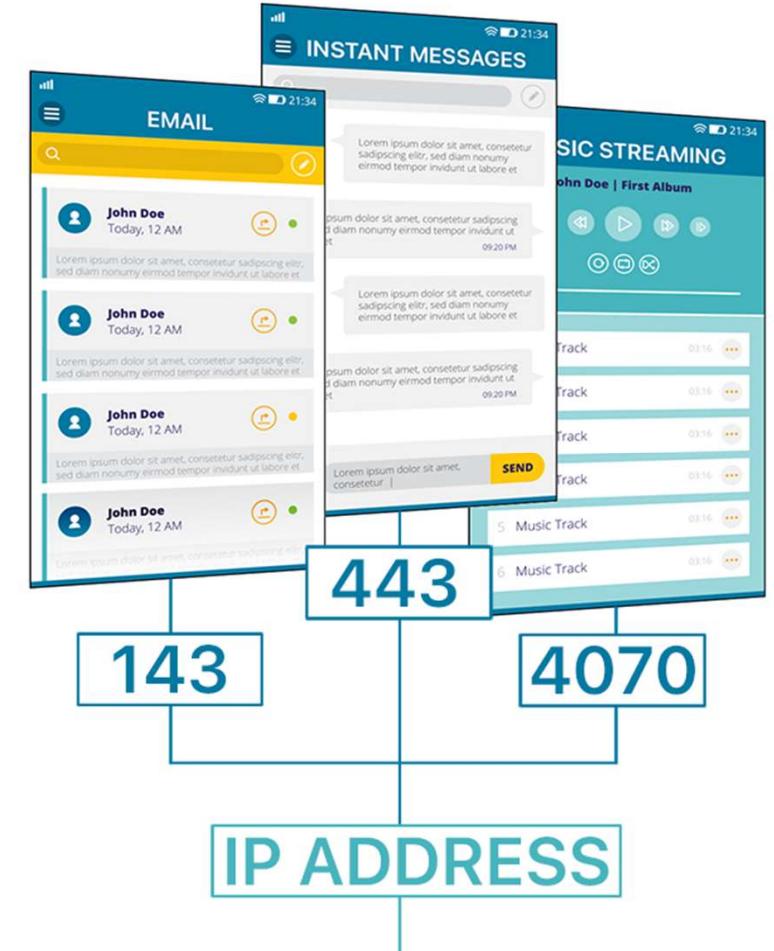
Supports autoconfiguration

Static IP Address vs Dynamic IP Address



Port Number

- Is a numerical label assigned to specific processes or network services within an operating system.
- Serves as a communication endpoint for networked devices and applications, facilitating the targeting and routing of data to specific services running on a computer.



ubuntu®

Port Number (Cont.)

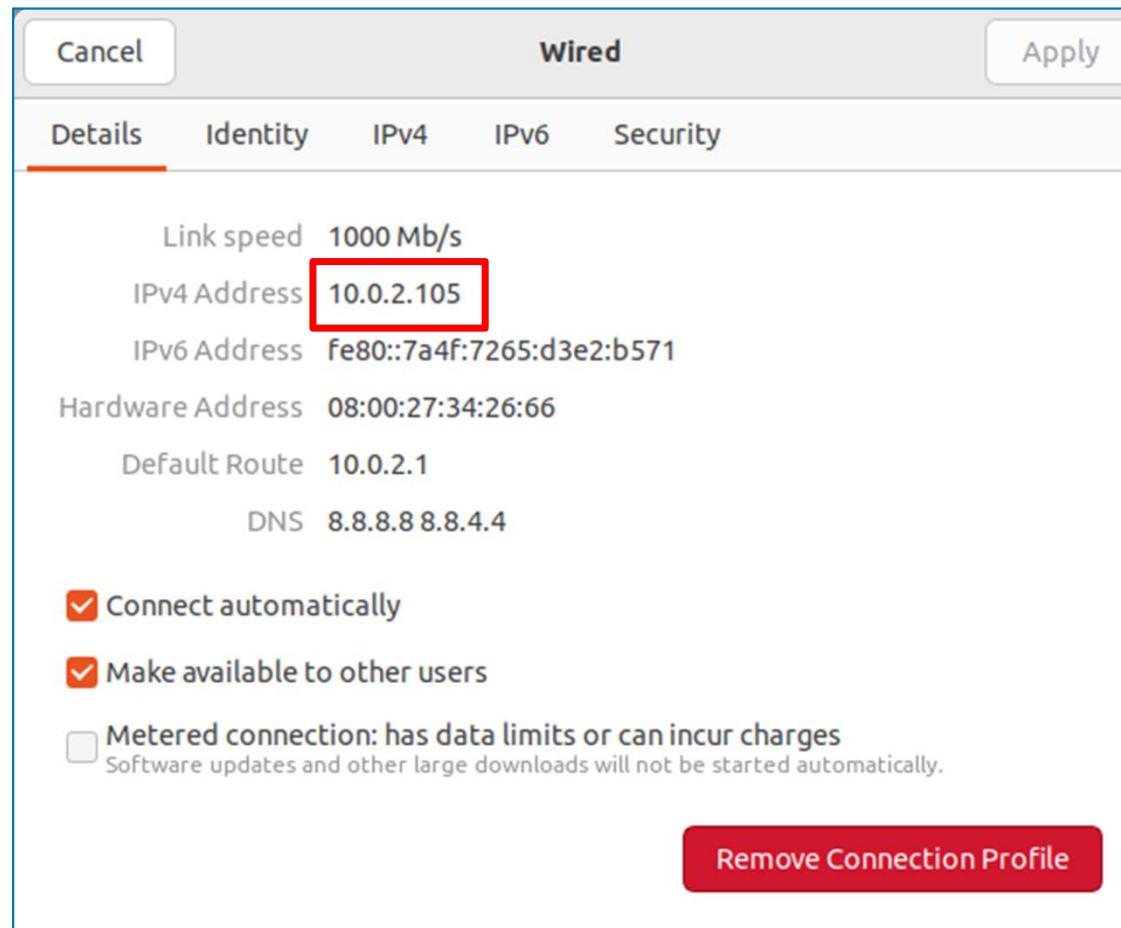
TCP/UDP Port Numbers

7 Echo	554 RTSP	2745 Bagle.H	6891-6901 Windows Live
19 Chargen	546-547 DHCPv6	2967 Symantec AV	6970 Quicktime
20-21 FTP	560 rmonitor	3050 Interbase DB	7212 GhostSurf
22 SSH/SCP	563 NNTP over SSL	3074 XBOX Live	7648-7649 CU-SeeMe
23 Telnet	587 SMTP	3124 HTTP Proxy	8000 Internet Radio
25 SMTP	591 FileMaker	3127 MyDoom	8080 HTTP Proxy
42 WINS Replication	593 Microsoft DCOM	3128 HTTP Proxy	8086-8087 Kaspersky AV
43 WHOIS	631 Internet Printing	3222 GLBP	8118 Privoxy
49 TACACS	636 LDAP over SSL	3260 iSCSI Target	8200 VMware Server
53 DNS	639 MSDP (PIM)	3306 MySQL	8500 Adobe ColdFusion
67-68 DHCP/BOOTP	646 LDP (MPLS)	3389 Terminal Server	8767 TeamSpeak
69 TFTP	691 MS Exchange	3689 iTunes	8866 Bagle.B
70 Gopher	860 iSCSI	3690 Subversion	9100 HP JetDirect
79 Finger	873 rsync	3724 World of Warcraft	9101-9103 Bacula
80 HTTP	902 VMware Server	3784-3785 Ventrilo	9119 MXit
88 Kerberos	989-990 FTP over SSL	4333 mSQL	9800 WebDAV
102 MS Exchange	993 IMAP4 over SSL	4444 Blaster	9898 Dabber
110 POP3	995 POP3 over SSL	4664 Google Desktop	9988 Rbot/Spybot

ubuntu®

How to Find IP address in Linux

■ Finding your IP address in the GNOME desktop



ubuntu®

How to Find IP address in Linux (Cont.)

- The following commands will get the *private IP address* of interfaces:

- `ifconfig -a`
- `ip address` (or `ip addr` or `ip a`)
- `hostname -I | awk '{print $1}'`
- `ip route get 1.2.3.4 | awk '{print $7}'`
- `nmcli -p device show`

How to Find IP address in Linux (Cont.)

- **ifconfig, ipconfig -a, ipconfig enp0s3**

```
ubuntu@ubuntu-desktop:/tmp$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 10.0.2.105 netmask 255.255.255.0 broadcast 10.0.2.255
        inet6 fe80::7a4f:7265:d3e2:b571 prefixlen 64 scopeid 0x20<link>
        ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
        RX packets 225005 bytes 304242556 (304.2 MB)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 29474 bytes 2510515 (2.5 MB)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ubuntu@ubuntu-desktop:/tmp$
```

How to Find IP address in Linux (Cont.)

■ ifconfig, ipconfig -a, ipconfig enp0s3 (Cont.)

- [enp0s3] : 네트워크 인터페이스
- [flags] : 네트워크 카드의 상태 표시
- [mtu] : 네트워크 인터페이스의 최대 전송 단위(Maximum Transfer Unit)
- [inet] : 네트워크 인터페이스에 할당된 IP 주소
- [netmask] : 네트워크 인터페이스에 할당된 넷마스크 주소
- [broadcast] : 네트워크 인터페이스에 할당된 브로드캐스트 주소
- [inet6] : 네트워크 인터페이스에 할당된 IPv6 주소
- [prefixlen] : IP 주소에서 서브 넷 마스크로 사용될 비트 수
- [scopeid] : IPv6의 범위. LOOPBACK / LINKLOCAL / SITELOCAL / COMPATv4 / GLOBAL
- [ether] : 네트워크 인터페이스의 하드웨어 주소
- [RX packets] : 받은 패킷 정보
- [TX packets] : 보낸 패킷 정보
- [collision] : 충돌된 패킷 수
- [Interrupt] : 네트워크 인터페이스가 사용하는 인터럽트 번호

```
ubuntu@ubuntu-desktop:/tmp$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 10.0.2.105 netmask 255.255.255.0 broadcast 10.0.2.255
        inet6 fe80::7a4f:7265:d3e2:b571 prefixlen 64 scopeid 0x20<link>
          ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
            RX packets 225005 bytes 304242556 (304.2 MB)
            RX errors 0 dropped 0 overruns 0 frame 0
            TX packets 29474 bytes 2510515 (2.5 MB)
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ubuntu@ubuntu-desktop:/tmp$
```

How to Find IP address in Linux (Cont.)

- `ipconfig enp0s3 | grep inet`

```
ubuntu@ubuntu-desktop:/tmp$ ifconfig enp0s3 | grep inet
    inet 10.0.2.105  netmask 255.255.255.0  broadcast 10.0.2.255
    inet6 fe80::7a4f:7265:d3e2:b571  prefixlen 64  scopeid 0x20<link>
ubuntu@ubuntu-desktop:/tmp$ █
```

How to Find IP address in Linux (Cont.)

- **hostname -I**

```
ubuntu@ubuntu-desktop:/tmp$ hostname -I  
10.0.2.105  
ubuntu@ubuntu-desktop:/tmp$ █
```

```
ubuntu@ubuntu-desktop:~$ hostname -I | awk '{print $1}'  
10.0.2.105  
ubuntu@ubuntu-desktop:~$
```

How to Find IP address in Linux (Cont.)

■ **ip address (ip addr , ip a)**

```
ubuntu@ubuntu-desktop:/tmp$ ip address
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host
            valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:34:26:66 brd ff:ff:ff:ff:ff:ff
        inet 10.0.2.105/24 brd 10.0.2.255 scope global noprefixroute enp0s3
            valid_lft forever preferred_lft forever
        inet6 fe80::7a4f:7265:d3e2:b571/64 scope link noprefixroute
            valid_lft forever preferred_lft forever
ubuntu@ubuntu-desktop:/tmp$
```

How to Find IP address in Linux (Cont.)

- `ip route get 1.2.3.4 | awk '{print $7}'`

```
ubuntu@ubuntu-desktop:~$ ip route get 1.2.3.4 | awk '{print $7}'  
10.0.2.105
```

```
ubuntu@ubuntu-desktop:~$ █
```

How to Find IP address in Linux (Cont.)

■ `nmcli -p device show`

```
ubuntu@ubuntu-desktop:~$ nmcli -p device show
=====
              Device details (enp0s3)
=====
GENERAL.DEVICE:          enp0s3
-----
GENERAL.TYPE:            ethernet
-----
GENERAL.HWADDR:          08:00:27:34:26:66
-----
GENERAL.MTU:              1500
-----
GENERAL.STATE:            100 (connected)
-----
GENERAL.CONNECTION:      Wired connection 1
-----
GENERAL.CON-PATH:         /org/freedesktop/NetworkManager/ActiveConnection/1
-----
WIRED-PROPERTIES.CARRIER: on
-----
IP4.ADDRESS[1]:           10.0.2.105/24
IP4.GATEWAY:              10.0.2.1
IP4.ROUTE[1]:             dst = 10.0.2.0/24, nh = 0.0.0.0, mt = 100
IP4.ROUTE[2]:             dst = 169.254.0.0/16, nh = 0.0.0.0, mt = 1000
IP4.ROUTE[3]:             dst = 0.0.0.0/0, nh = 10.0.2.1, mt = 100
IP4.DNS[1]:                8.8.8.8
IP4.DNS[2]:                8.8.4.4
-----
```



How to Find IP address in Linux (Cont.)

- The following commands will get the IP address list to find *public IP addresses* for machine:

- curl ifconfig.me
- curl -4/-6 iканhazip.com
- curl ipinfo.io/ip
- curl api.ipify.org
- curl checkip.dyndns.org
- dig +short myip.opendns.com @resolver1.opendns.com
- host myip.opendns.com resolver1.opendns.com
- curl ident.me
- curl bot.whatismyipaddress.com
- curl ipecho.net/plain

ubuntu®

How to Find IP address in Linux (Cont.)

- curl ifconfig.me

```
ubuntu@ubuntu-desktop:~$ curl ifconfig.me  
182.208.131.42ubuntu@ubuntu-desktop:~$ █
```

Setting Hostname

■ Check hostname

- `hostname`
- `uname -n`
- `cat /etc/sysconfig/network` (CentOS)
- `cat /etc/hostname` (Ubuntu)

■ Change hostname temporarily

```
ubuntu@ubuntu-desktop:~$ hostname os2
hostname: you must be root to change the host name
ubuntu@ubuntu-desktop:~$ sudo hostname os2
[sudo] password for ubuntu:
ubuntu@ubuntu-desktop:~$ uname -n
os2
ubuntu@ubuntu-desktop:~$ cat /etc/hostname
ubuntu-desktop
ubuntu@ubuntu-desktop:~$
```

ubuntu®

Setting Hostname (Cont.)

■ **hostnamectl** command

- Is used to set the hostname in the terminal without even opening and editing in the *etc/hostname* file of a system.

■ Syntax

- **hostnamectl [options...] [command...]**

```
ubuntu@ubuntu-desktop:~$ hostnamectl --version
systemd 249 (249.11-0ubuntu3.11)
+PAM +AUDIT +SELINUX +APPARMOR +IMA +SMACK +SECCOMP +GCRYPT +GNUTLS +OPENSSL +ACL +BLKID +CURL +ELFUTILS +FIDO2 +IDN2 -IDN +IPTC +KMO
D +LIBCRYPTSETUP +LIBFDISK +PCRE2 -PWQUALITY -P11KIT -QRENCODE +BZIP2 +LZ4 +XZ +ZLIB +ZSTD -XKBCOMMON +UTMP +SYSVINIT default-hierarc
hy=unified
ubuntu@ubuntu-desktop:~$
```

Setting Hostname (Cont.)

■ `hostnamectl`

```
ubuntu@ubuntu-desktop:~$ hostnamectl
    Static hostname: ubuntu-desktop
    Transient hostname: os2
            Icon name: computer-vm
            Chassis: vm
        Machine ID: a4697077275749408a3e46004c672b1e
            Boot ID: 86d139c1b78e44a5ab19ead0e67947e0
        Virtualization: oracle
Operating System: Ubuntu 22.04.3 LTS
            Kernel: Linux 6.2.0-39-generic
        Architecture: x86-64
    Hardware Vendor: innotek GmbH
    Hardware Model: VirtualBox
ubuntu@ubuntu-desktop:~$
```

ubuntu®

Setting Hostname (Cont.)

■ **hostnamectl set-hostname newName**

```
ubuntu@ubuntu-desktop:~$ hostnamectl set-hostname linux-desktop
ubuntu@ubuntu-desktop:~$ cat /etc/hostname
linux-desktop
ubuntu@ubuntu-desktop:~$ hostnamectl
  Static hostname: linux-desktop
    Icon name: computer-vm
    Chassis: vm
   Machine ID: a4697077275749408a3e46004c672b1e
      Boot ID: 86d139c1b78e44a5ab19ead0e67947e0
Virtualization: oracle
Operating System: Ubuntu 22.04.3 LTS
          Kernel: Linux 6.2.0-39-generic
      Architecture: x86-64
Hardware Vendor: innotek GmbH
  Hardware Model: VirtualBox
ubuntu@ubuntu-desktop:~$ █
```

Setting Hostname (Cont.)

- `nmcli g[eneral] hostname newName`

```
ubuntu@ubuntu-desktop:~$ hostname  
ubuntu-desktop  
ubuntu@ubuntu-desktop:~$ nmcli g hostname  
ubuntu-desktop  
ubuntu@ubuntu-desktop:~$ sudo nmcli g hostname webserver  
[sudo] password for ubuntu:  
ubuntu@ubuntu-desktop:~$ hostname  
webserver  
ubuntu@ubuntu-desktop:~$ cat /etc/hostname  
webserver  
ubuntu@ubuntu-desktop:~$ █
```

List Network Interfaces in Ubuntu

■ ip link show

```
ubuntu@ubuntu-desktop:~$ ip link show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP mode DEFAULT group default qlen 1000
    link/ether 08:00:27:34:26:66 brd ff:ff:ff:ff:ff:ff
ubuntu@ubuntu-desktop:~$ █
```

List Network Interfaces in Ubuntu (Cont.)

■ `nmcli device status`

```
ubuntu@ubuntu-desktop:~$ nmcli device status
DEVICE  TYPE      STATE      CONNECTION
enp0s3  ethernet  connected  Wired connection 1
lo      loopback  unmanaged  --
ubuntu@ubuntu-desktop:~$ █
```

■ `netstat -I`

```
ubuntu@ubuntu-desktop:~$ netstat -i
Kernel Interface table
Iface      MTU     RX-OK RX-ERR RX-DRP RX-OVR    TX-OK TX-ERR TX-DRP TX-OVR Flg
enp0s3    1500     4403     0     0 0        3426     0     0     0 BMRU
lo        65536   16229     0     0 0        16229     0     0     0 LRU
ubuntu@ubuntu-desktop:~$ █
```

■ `ls /sys/class/net/`

```
ubuntu@ubuntu-desktop:~$ ls /sys/class/net/
enp0s3  lo
ubuntu@ubuntu-desktop:~$ █
```

ubuntu®

List Network Interfaces in Ubuntu (Cont.)

■ **lshw -C network**

```
ubuntu@ubuntu-desktop:~$ lshw -C network
WARNING: you should run this program as super-user.
*-network
      description: Ethernet interface
      product: 82540EM Gigabit Ethernet Controller
      vendor: Intel Corporation
      physical id: 3
      bus info: pci@0000:00:03.0
      logical name: enp0s3
      version: 02
      serial: 08:00:27:34:26:66
      size: 1Gbit/s
      capacity: 1Gbit/s
      width: 32 bits
      clock: 66MHz
      capabilities: bus_master cap_list ethernet physical tp 10bt 10bt-fd 100bt 100bt-fd 1000bt-fd autonegotiation
      configuration: autonegotiation=on broadcast=yes driver=e1000 driverversion=6.2.0-39-generic duplex=full ip=10.0.2.105 latency=
64 link=yes mingnt=255 multicast=yes port=twisted pair speed=1Gbit/s
      resources: irq:19 memory:f0200000-f021ffff ioport:d020(size=8)
WARNING: output may be incomplete or inaccurate, you should run this program as super-user.
ubuntu@ubuntu-desktop:~$ █
```

Disable & Enable Network Interfaces Temporarily

- `sudo ip link set enp0s3 down`

```
ubuntu@ubuntu-desktop:~$ sudo ip link set enp0s3 down
ubuntu@ubuntu-desktop:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host
            valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST> mtu 1500 qdisc fq_codel state DOWN group default qlen 1000
    link/ether 08:00:27:34:26:66 brd ff:ff:ff:ff:ff:ff
ubuntu@ubuntu-desktop:~$ █
```

Disable & Enable Network Interfaces Temporarily (Cont.)

■ **sudo ip link set enp0s3 up**

```
ubuntu@ubuntu-desktop:~$ sudo ip link set enp0s3 up
ubuntu@ubuntu-desktop:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host
            valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:34:26:66 brd ff:ff:ff:ff:ff:ff
        inet 10.0.2.105/24 brd 10.0.2.255 scope global noprefixroute enp0s3
            valid_lft forever preferred_lft forever
        inet6 fe80::7a4f:7265:d3e2:b571/64 scope link noprefixroute
            valid_lft forever preferred_lft forever
ubuntu@ubuntu-desktop:~$
```

Change Network Interfaces Temporarily

- **sudo ifconfig enp0s3 newIp netmask newMask broadcast newBroadcast**

```
ubuntu@ubuntu-desktop:~$ sudo ifconfig enp0s3 192.168.0.100 netmask 255.255.255.0 broadcast 192.168
.0.255
ubuntu@ubuntu-desktop:~$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 192.168.0.100 netmask 255.255.255.0 broadcast 192.168.0.255
        inet6 fe80::7a4f:7265:d3e2:b571 prefixlen 64 scopeid 0x20<link>
        ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
        RX packets 11388 bytes 9608032 (9.6 MB)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 4706 bytes 479813 (479.8 KB)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Remove Network Interfaces Temporarily

■ **sudo ip addr del removeIp dev enp0s3**

```
ubuntu@ubuntu-desktop:~$ sudo ip addr add 172.16.10.5 dev enp0s3
ubuntu@ubuntu-desktop:~$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 10.0.2.105 netmask 255.255.255.0 broadcast 10.0.2.255
        inet6 fe80::157c:e486:aab9:e244 prefixlen 64 scopeid 0x20<link>
              ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
              RX packets 11406 bytes 9611116 (9.6 MB)
              RX errors 0 dropped 0 overruns 0 frame 0
              TX packets 4928 bytes 502790 (502.7 KB)
              TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

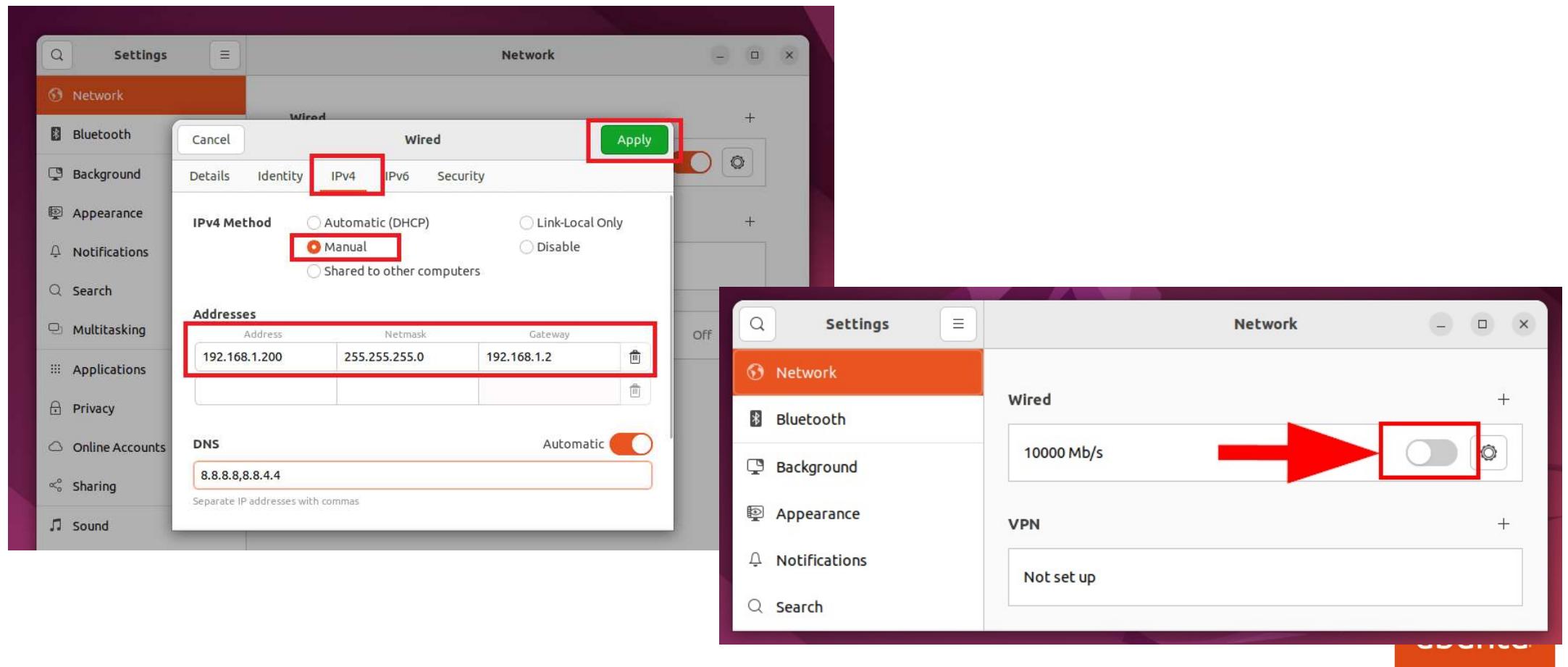
ubuntu@ubuntu-desktop:~$ sudo ip addr del 10.0.2.105/24 dev enp0s3
ubuntu@ubuntu-desktop:~$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 172.16.10.5 netmask 255.255.255.255 broadcast 0.0.0.0
        inet6 fe80::157c:e486:aab9:e244 prefixlen 64 scopeid 0x20<link>
              ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
              RX packets 11408 bytes 9611444 (9.6 MB)
              RX errors 0 dropped 0 overruns 0 frame 0
              TX packets 4937 bytes 503827 (503.8 KB)
              TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Remove Network Interfaces Temporarily (Cont.)

```
ubuntu@ubuntu-desktop:~$ sudo ip link set enp0s3 down
ubuntu@ubuntu-desktop:~$ sudo ip link set enp0s3 up
ubuntu@ubuntu-desktop:~$ ifconfig enp0s3
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 10.0.2.105 netmask 255.255.255.0 broadcast 10.0.2.255
        inet6 fe80::f21d:6e4b:2617:3b2 prefixlen 64 scopeid 0x20<link>
        ether 08:00:27:34:26:66 txqueuelen 1000 (Ethernet)
        RX packets 11411 bytes 9612292 (9.6 MB)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 4986 bytes 509567 (509.5 KB)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Change Network Interfaces Permanently in Ubuntu

■ Setting in GNOME



Change Network Interfaces Permanently in Ubuntu (Cont.)

- Refer to <https://ostechnix.com/configure-static-ip-address-ubuntu/>
- Edit the *Netplan* configuration files, typically found in `/etc/netplan/`.
 1. Open the terminal.
 2. Identify network interface name using `ip a` or `ifconfig`.
 3. Locate the Netplan configuration file in `/etc/netplan/`. It usually has a `.yaml` extension.
 4. Edit the file using a text editor, like `sudo nano /etc/netplan/01-netcfg.yaml`.
 5. Modify or add the configuration with your desired IP address, gateway, and DNS settings under the appropriate network interface.
 6. Apply the changes with `sudo netplan apply`.
 7. Verify the new settings with `ip a` or by pinging external addresses.



Change Network Interfaces Permanently in Ubuntu (Cont.)

```
network:
  version: 2
  renderer: networkd
  ethernets:
    ens18:
      dhcp4: no
      addresses:
        - 192.168.1.22/24
        - 192.168.1.23/24
        - 192.168.1.24/24
      routes:
        - to: default
          via: 192.168.1.101
      nameservers:
        addresses: [8.8.8.8, 8.8.4.4]
```



Change DNS Information

■ Name Resolution Sequence:

- `/etc/hosts`
- `/etc/resolv.conf`

■ Change `/etc/resolv.conf` for Name Resolution → Global Setting

- `echo "nameserver 8.8.8.8" > /etc/resolv.conf`

■ Verify Name Resolution

- `nslookup`

```
ubuntu@ubuntu-desktop:~$ nslookup
> www.naver.com
Server:      127.0.0.53
Address:     127.0.0.53#53

Non-authoritative answer:
www.naver.com canonical name = www.naver.com.nheos.com.
www.naver.com.nheos.com canonical name = www.naver.com.edgekey.net.
www.naver.com.edgekey.net    canonical name = e6030.a.akamaiedge.net.
Name:   e6030.a.akamaiedge.net
Address: 23.201.36.184
```

Confirmation of Network Status

■ Ping Test

- Checks whether communication is possible up to Layer 3 between two computers.
- This is to find the path to the remote computer and check whether communication is possible.
- A successful **ping** means the remote computer is turned on, but that does not mean the remote computer is turned on.
- It does not guarantee that can access computer services (web, ftp).

Confirmation of Network Status (Cont.)

■ Ping Test (Cont.)

- **ping** test without options

```
ping www.google.com
```

- **ping** test with numbers of packages

```
ping -c 4 www.google.com
```

Confirmation of Network Status (Cont.)

- Verify route path
 - **tracert** (for Windows), **traceroute** (for POSIX)
 - Traces the route of packets to destination host from our server
- ping -c 4 www.google.com**

```
prabhakar@Inspiron-3542:~$ traceroute google.com
traceroute to google.com (172.217.26.206), 30 hops max, 60 byte packets
 1  192.168.43.45 (192.168.43.45)  2.014 ms  2.313 ms  2.588 ms
 2  * * *
 3  10.45.1.230 (10.45.1.230)  75.449 ms  115.244 ms  115.224 ms
 4  10.45.8.178 (10.45.8.178)  93.856 ms  115.138 ms  93.822 ms
 5  10.45.8.187 (10.45.8.187)  115.116 ms  115.106 ms  115.070 ms
 6  * * *
 7  218.248.235.141 (218.248.235.141)  120.589 ms  108.033 ms  106.962 ms
 8  218.248.235.142 (218.248.235.142)  114.489 ms  * *
 9  72.14.211.114 (72.14.211.114)  98.076 ms  93.232 ms  93.781 ms
10  108.170.253.113 (108.170.253.113)  98.688 ms  91.388 ms  108.170.253.97 (108.170.253.97)  107.241 ms
11  74.125.253.69 (74.125.253.69)  95.120 ms  72.14.237.165 (72.14.237.165)  102.594 ms  103.137 ms
12  maa03s23-in-f14.1e100.net (172.217.26.206)  101.794 ms  97.987 ms  97.165 ms
prabhakar@Inspiron-3542:~$
```

Confirmation of Network Status (Cont.)

- Print out Network Status Information
 - **netstat**
 - Network connection status, routing table information
 - Statistical information about interfaces and ports currently open on the system.

Confirmation of Network Status (Cont.)

■ **netstat** (Cont.)

- Verify Routing Table : **-r**

\$ netstat -r

\$ ip route

\$ netstat -rn

```
ubuntu@ubuntu-desktop:~$ netstat -r
Kernel IP routing table
Destination     Gateway         Genmask        Flags   MSS Window irtt Iface
default         _gateway       0.0.0.0        UG      0 0          0 enp0s3
10.0.2.0        0.0.0.0       255.255.255.0  U        0 0          0 enp0s3

ubuntu@ubuntu-desktop:~$ ip route
default via 10.0.2.1 dev enp0s3 proto static metric 100
10.0.2.0/24 dev enp0s3 proto kernel scope link src 10.0.2.105 metric 100

ubuntu@ubuntu-desktop:~$ netstat -rn
Kernel IP routing table
Destination     Gateway         Genmask        Flags   MSS Window irtt Iface
0.0.0.0          10.0.2.1      0.0.0.0        UG      0 0          0 enp0s3
10.0.2.0         0.0.0.0       255.255.255.0  U        0 0          0 enp0s3

ubuntu@ubuntu-desktop:~$
```

Confirmation of Network Status (Cont.)

■ **netstat** (Cont.)

- Verify currently open(servicing) port number: **-a**

netstat -a, netstat -an, netstat -an | grep LISTEN

```
ubuntu@ubuntu-desktop:~$ netstat -an | grep LISTEN
tcp      0      0 0.0.0.0:22          0.0.0.0:*          LISTEN
tcp      0      0 127.0.0.1:61209    0.0.0.0:*          LISTEN
tcp      0      0 127.0.0.1:8125      0.0.0.0:*          LISTEN
tcp      0      0 127.0.0.1:19999    0.0.0.0:*          LISTEN
tcp      0      0 127.0.0.53:53      0.0.0.0:*          LISTEN
tcp      0      0 127.0.0.1:631      0.0.0.0:*          LISTEN
tcp6     0      0 :::80             ::*:              LISTEN
tcp6     0      0 :::22             ::*:              LISTEN
tcp6     0      0 ::1:631           ::*:              LISTEN
unix  2      [ ACC ]    STREAM      LISTENING        23036   /tmp/netdata-ipc
unix  2      [ ACC ]    STREAM      LISTENING        26565   /run/user/1000/systemd/private
unix  2      [ ACC ]    STREAM      LISTENING        26578   /run/user/1000/bus
unix  2      [ ACC ]    STREAM      LISTENING        26811   /run/user/1000/gnupg/S.dirmngr
unix  2      [ ACC ]    STREAM      LISTENING        26813   /run/user/1000/gnupg/S.gpg-agent.browser
unix  2      [ ACC ]    STREAM      LISTENING        26815   /run/user/1000/gnupg/S.gpg-agent.extra
unix  2      [ ACC ]    STREAM      LISTENING        27525   /tmp/.ICE-unix/1986
unix  2      [ ACC ]    STREAM      LISTENING        26817   /run/user/1000/gnupg/S.gpg-agent.ssh
unix  2      [ ACC ]    STREAM      LISTENING        26819   /run/user/1000/gnupg/S.gpg-agent
unix  2      [ ACC ]    STREAM      LISTENING        28927   /tmp/.X11-unix/X0
unix  2      [ ACC ]    STREAM      LISTENING        26821   /run/user/1000/pipewire-0
unix  2      [ ACC ]    STREAM      LISTENING        26822   /run/user/1000/pk_dhclient.socket
```



Confirmation of Network Status (Cont.)

■ **netstat** (Cont.)

- Verify currently connected computer: **-p**

netstat -p, ss

Netid	State	Recv-Q	Send-Q	Local Address:Port	Peer Address:Port	Process
u_str	ESTAB	0	0	/run/user/1000/bus 29497	*	29496
u_str	ESTAB	0	0	*	27274	*
u_str	ESTAB	0	0	*	30472	*
u_str	ESTAB	0	0	*	25134	*
u_str	ESTAB	0	0	@/tmp/.X11-unix/X1 35702	*	35701
u_str	ESTAB	0	0	*	29689	*
u_str	ESTAB	0	0	*	29963	*
u_str	ESTAB	0	0	/run/systemd/journal/stdout 29842	*	29519
u_dgr	ESTAB	0	0	*	26681	*
u_str	ESTAB	0	0	@/home/ubuntu/.cache/ibus/dbus-tXiTOXmE 35705	*	36568
u_str	ESTAB	0	0	/run/user/1000/at-spi/bus 29377	*	29376
u_str	ESTAB	0	0	*	28141	*
u_str	ESTAB	0	0	*	20380	*
u_str	ESTAB	0	0	/run/user/1000/at-spi/bus 31073	*	31924
u_str	ESTAB	0	0	*	29228	*
u_str	ESTAB	0	0	@/tmp/.X11-unix/X1 35592	*	36524
u_str	ESTAB	0	0	*	29595	*

Confirmation of Network Status (Cont.)

■ **netstat** (Cont.)

- Verify currently connected computer: **-p**

netstat -p, ss

Proto	Recv-Q	Send-Q	Local Address	Foreign Address	State	PID/Program name
tcp	0	0	ubuntu-desktop:ssh	10.0.2.2:56863	ESTABLISHED	-
tcp	1	0	localhost:60366	localhost:http	CLOSE_WAIT	-
tcp	1	0	localhost:60396	localhost:http	CLOSE_WAIT	-
tcp	0	0	localhost:35766	localhost:http	ESTABLISHED	-
tcp	1	0	localhost:60410	localhost:http	CLOSE_WAIT	-
tcp	1	0	localhost:60390	localhost:http	CLOSE_WAIT	-
tcp	1	0	localhost:60350	localhost:http	CLOSE_WAIT	-
tcp	1	0	localhost:60378	localhost:http	CLOSE_WAIT	-
tcp6	0	0	localhost:http	localhost:35766	ESTABLISHED	-
tcp6	1	0	ip6-localhost:42258	ip6-localhost:http	CLOSE_WAIT	-

Confirmation of Network Status (Cont.)

■ **netstat** (Cont.)

- Verify network statistics information by interface: **-i**

netstat -i, ip -s link

```
ubuntu@ubuntu-desktop:~$ netstat -i
Kernel Interface table
Iface      MTU     RX-OK RX-ERR RX-DRP RX-OVR     TX-OK TX-ERR TX-DRP TX-OVR Flg
enp0s3    1500    16286     0     0 0        8885     0     0     0 BMRU
lo        65536   44394     0     0 0        44394     0     0     0 LRU

ubuntu@ubuntu-desktop:~$ ip -s link
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    RX: bytes packets errors dropped missed mcast
        20866798 44406     0     0     0     0
    TX: bytes packets errors dropped carrier collsns
        20866798 44406     0     0     0     0
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP mode DEFAULT group default qlen 1000
    link/ether 08:00:27:34:26:66 brd ff:ff:ff:ff:ff:ff
    RX: bytes packets errors dropped missed mcast
        10141159 16307     0     0     0     0
    TX: bytes packets errors dropped carrier collsns
        1167592  8900     0     0     0     0
ubuntu@ubuntu-desktop:~$
```

Confirmation of Network Status

■ **netstat** (Cont.)

- Verify network statistics information by protocol: **-s**

netstat -s

```
ubuntu@ubuntu-desktop:~$ netstat -s
Ip:
Forwarding: 2
55391 total packets received
25 with invalid addresses
0 forwarded
0 incoming packets discarded
55360 incoming packets delivered
53039 requests sent out
19 outgoing packets dropped
Icmp:
59 ICMP messages received
1 input ICMP message failed
ICMP input histogram:
destination unreachable: 49
timeout in transit: 9
echo replies: 1
51 ICMP messages sent
0 ICMP messages failed
ICMP output histogram:
destination unreachable: 49
echo requests: 2
IcmpMsg:
InType0: 1
```