Networking in Linux

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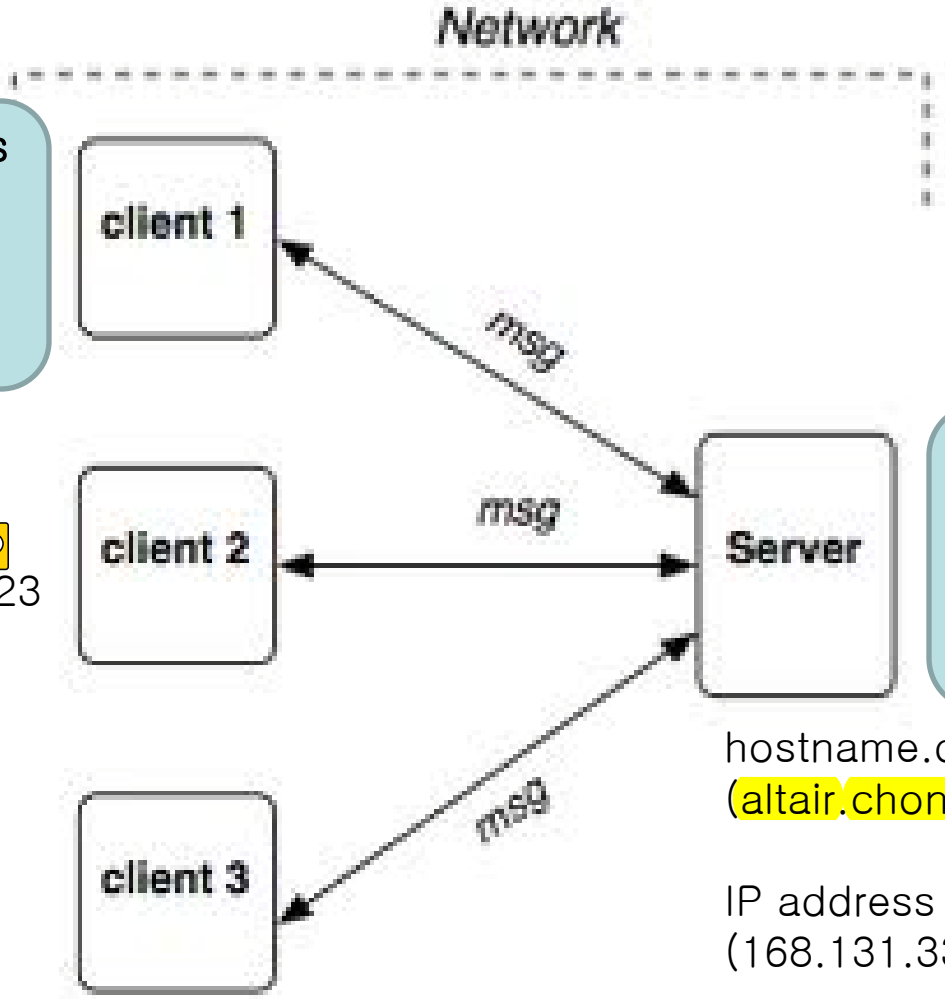
Remote Access to Linux

- Remote Access
  - Text based
  - Window based
- Using applications and protocols based on IP network
  - telnet, ssh
  - xrdp
- Connection Privileges
  - Guest : logins are not required
  - Full : requires username and password

Before using the applications

- We need to know the basic concept of IP networking
  - Client/Server
  - Hostname/Domain
  - IP address
  - Network Interface
  - Port
  - Session

Client / Server



Programs or services accessing remote services on other computer system through networks

Server computers or server programs providing various services to clients through networks

Connect to altair.chonnam.ac.kr:23

Same Meaning

Connect to 168.131.33.33:23

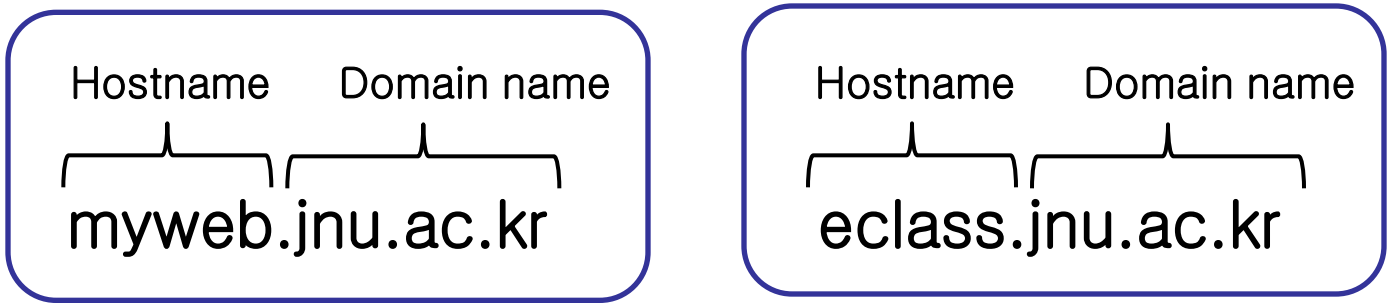
hostname.domainname
(altair.chonnam.ac.kr)

IP address
(168.131.33.33)

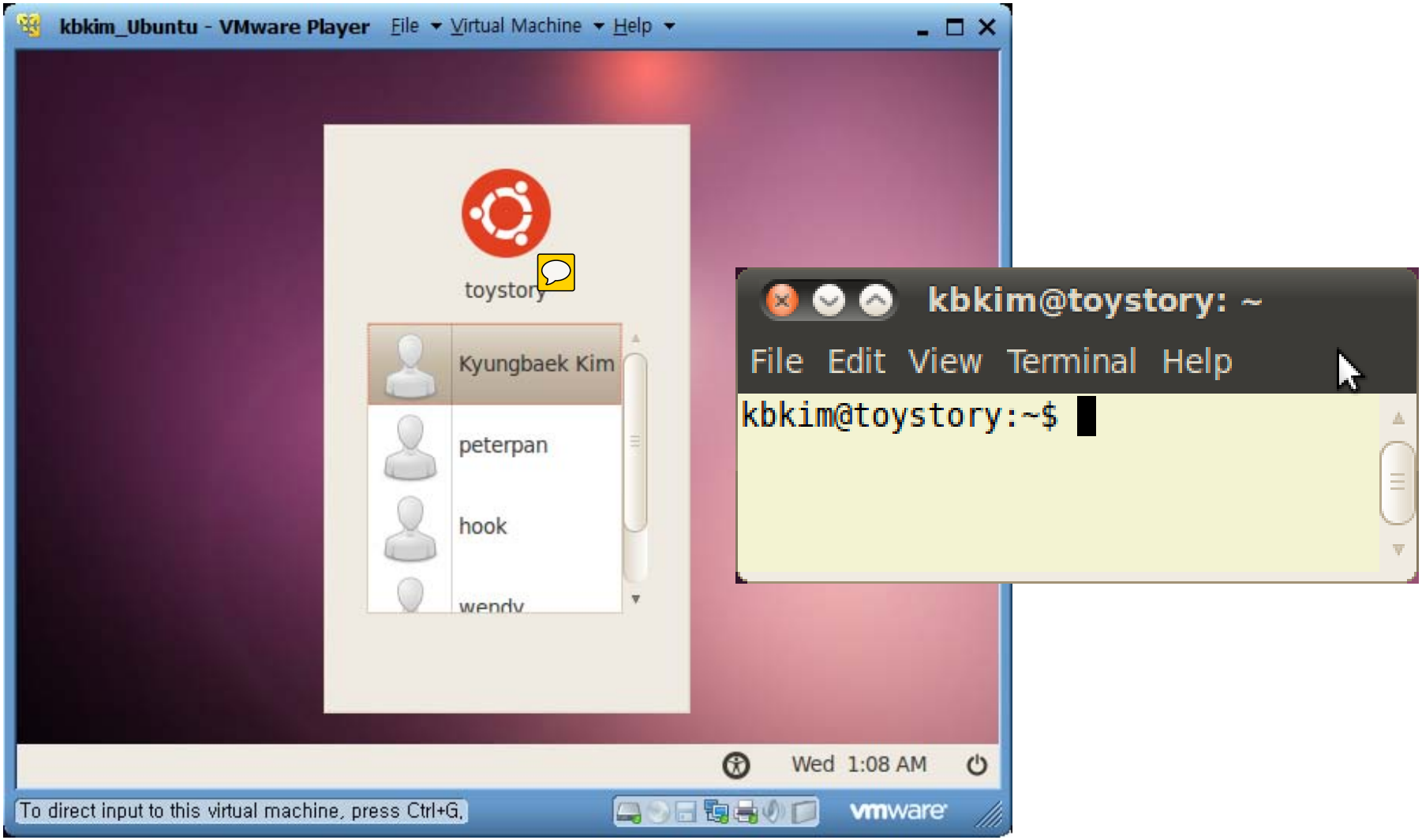
Port
(23 → telnet)

Host name and Domain name

- Host name
  - The name of the system
  - Returned by “gethostname” function or “hostname” command
- Domain name
  - The NIS domain name of the system
  - Group the hosts into a domain
  - NIS : Network Information System
    - i.e.) Network naming system



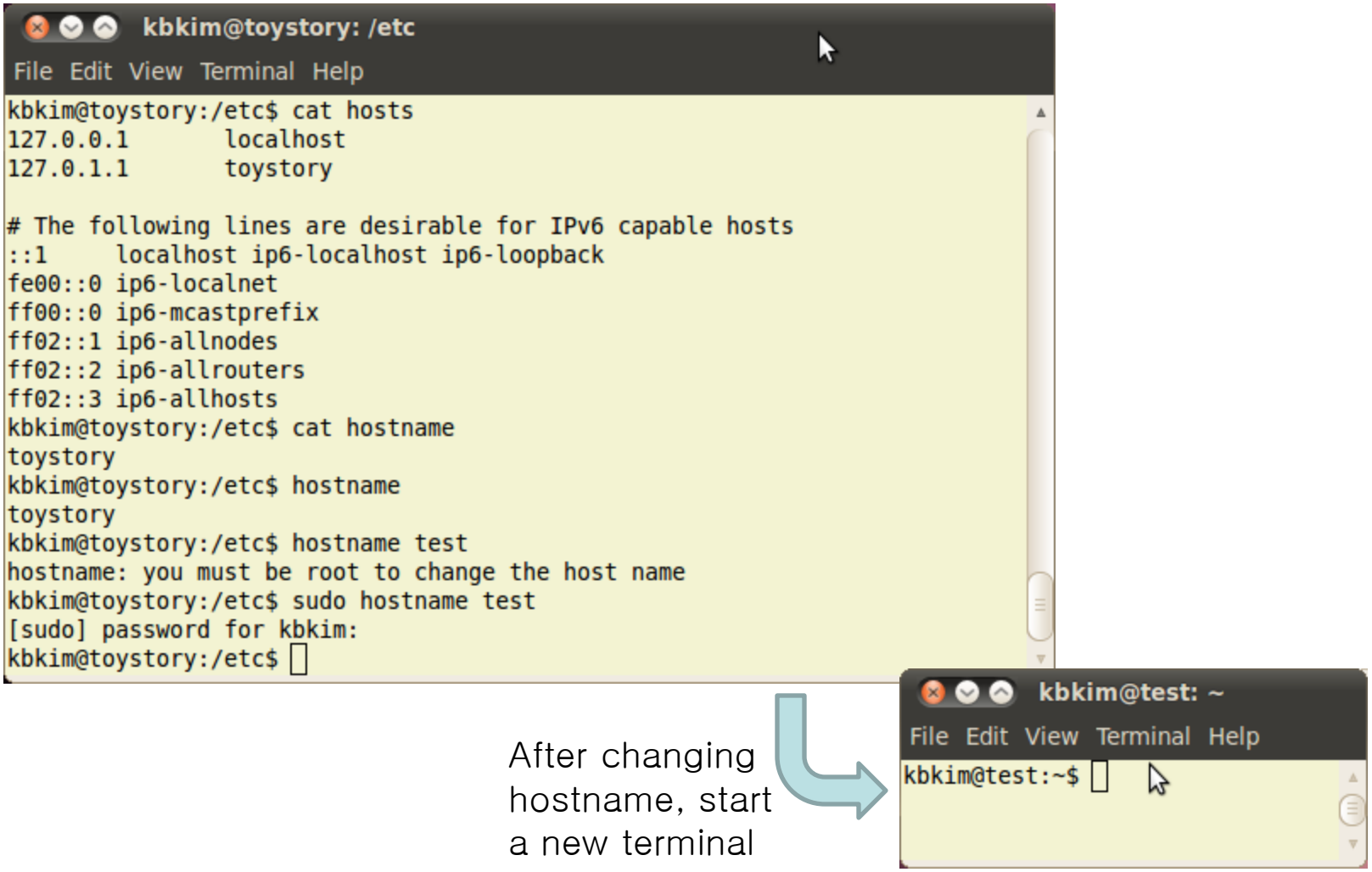
Example of hostname



How to set hostname

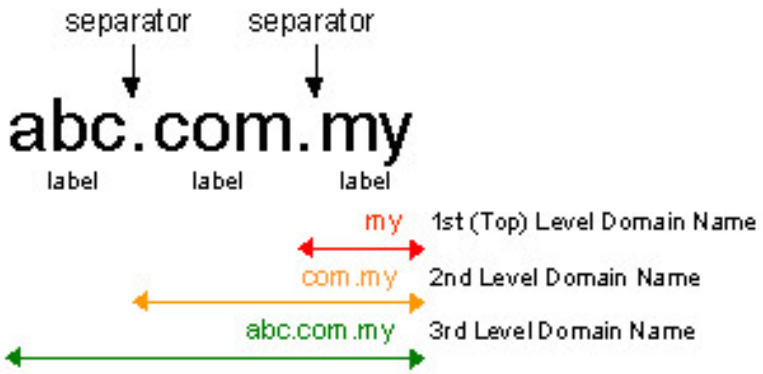
- $ hostname <new_host_name>
  - Set hostname as “new_host_name”
  - **Temporally** set the hostname
  - After rebooting, the hostname sets back to the old host name
- Edit “/etc/hosts” file and “/etc/hostname” file
  - **Permanently** change the hostname

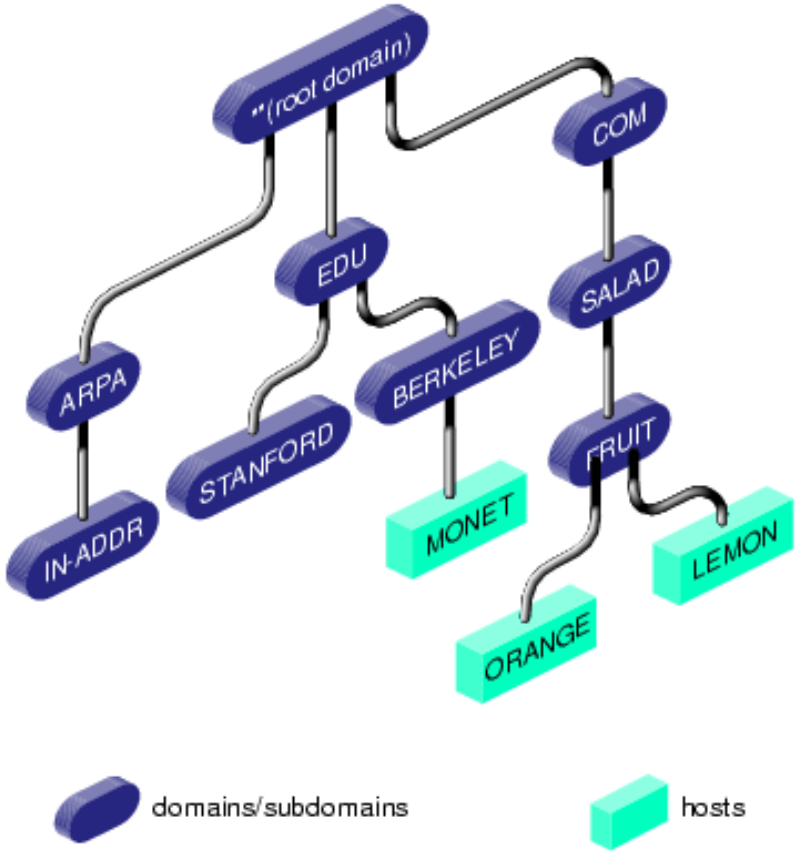
Example of changing hostname



Domain name

- Domain name is managed by multiple levels
  - Grouping purpose
  - Better management

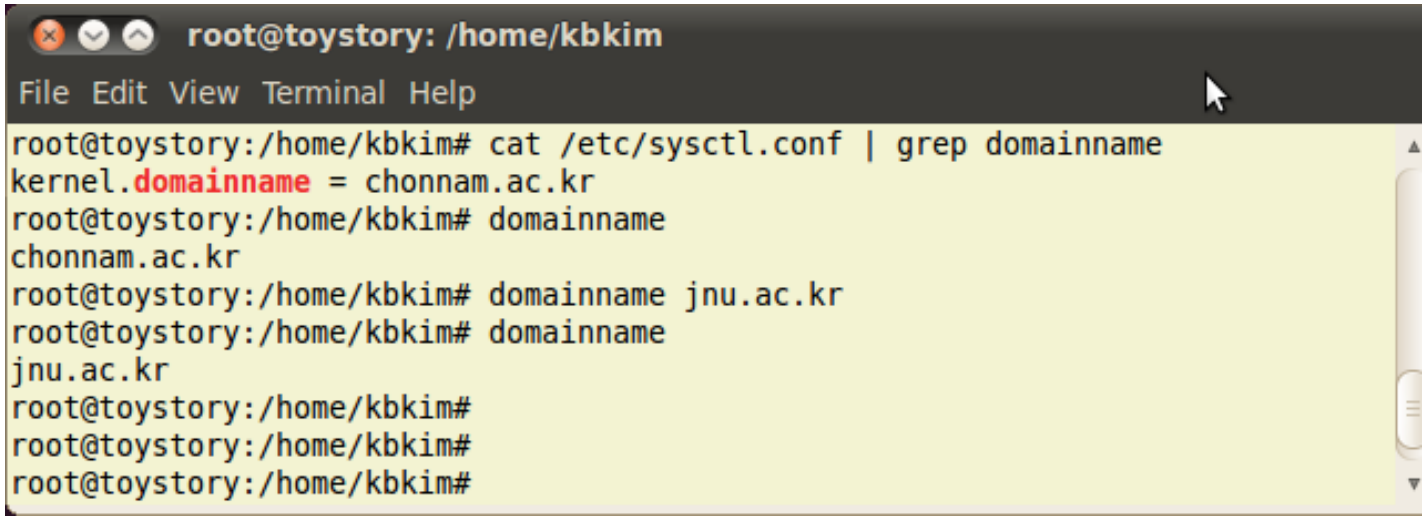




How to set domain name

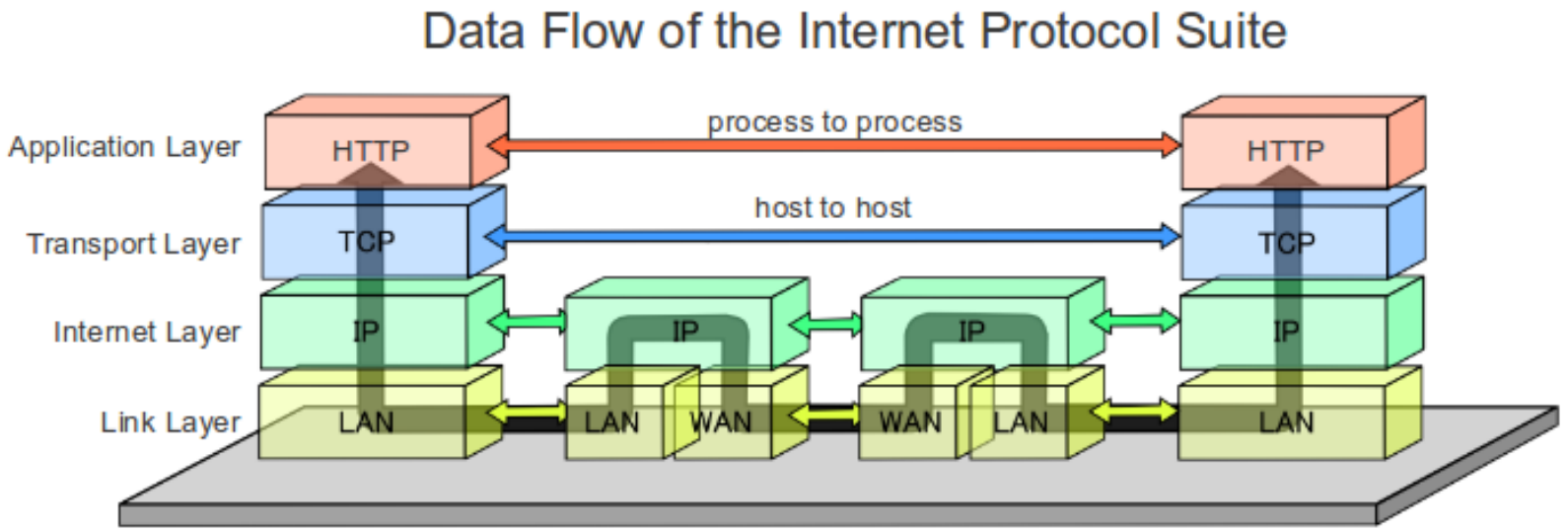
- $ domain <new_domain_name>
  - Set domain name as “new_domain_name”
  - **Temporally** set the domain name
  - After rebooting, the domain name set back to the old domain name
- Edit “/etc/sysctl.conf” file
  - e.g.) kernel.domainname = chonnam.ac.kr
  - **Permanently** change the domainname

Example of changing domain name



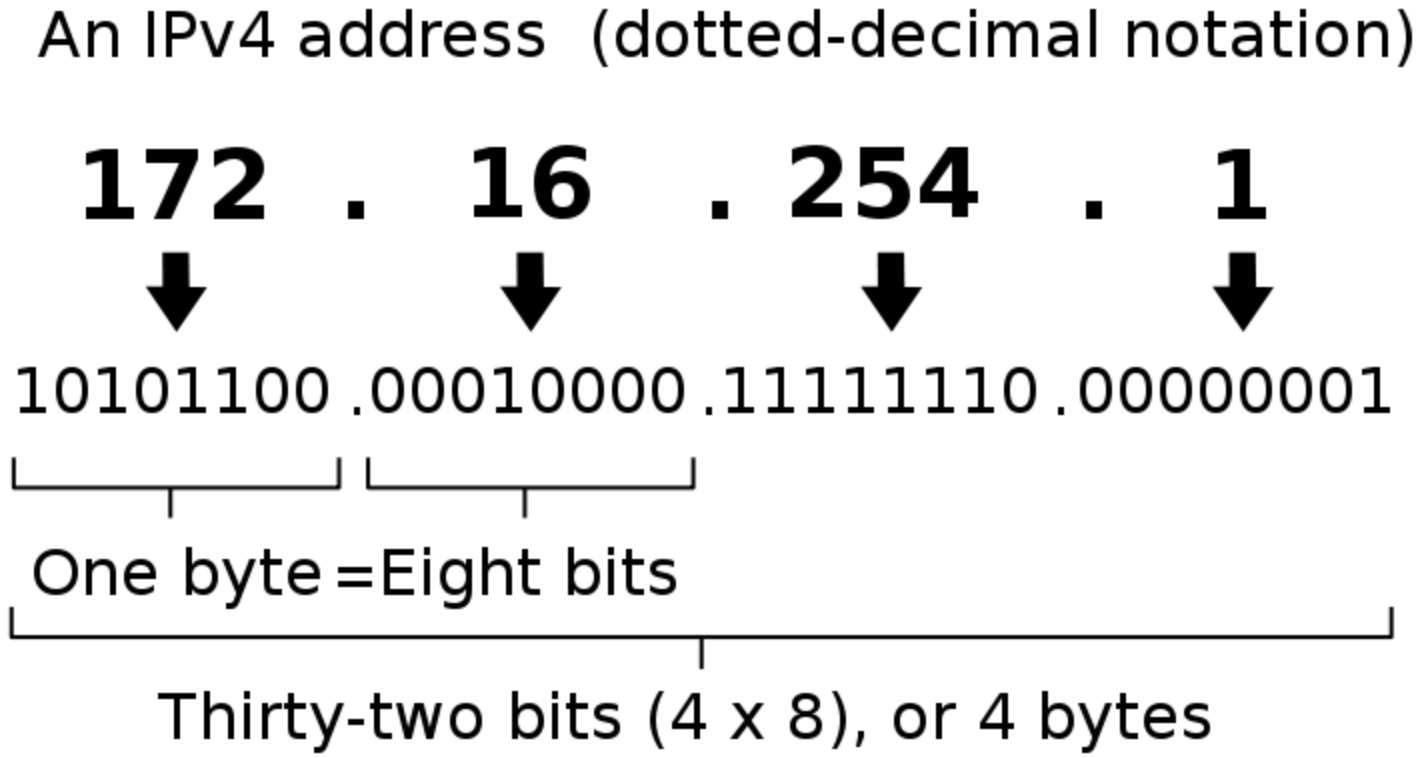
IP addressing

- In these days, computer hosts are addressed by using Internet Protocol (IP) in general.
  - Transport Protocols(TCP/UDP) and Application protocols (HTTP, STP, SOAP..) identify a computer host by using IP address

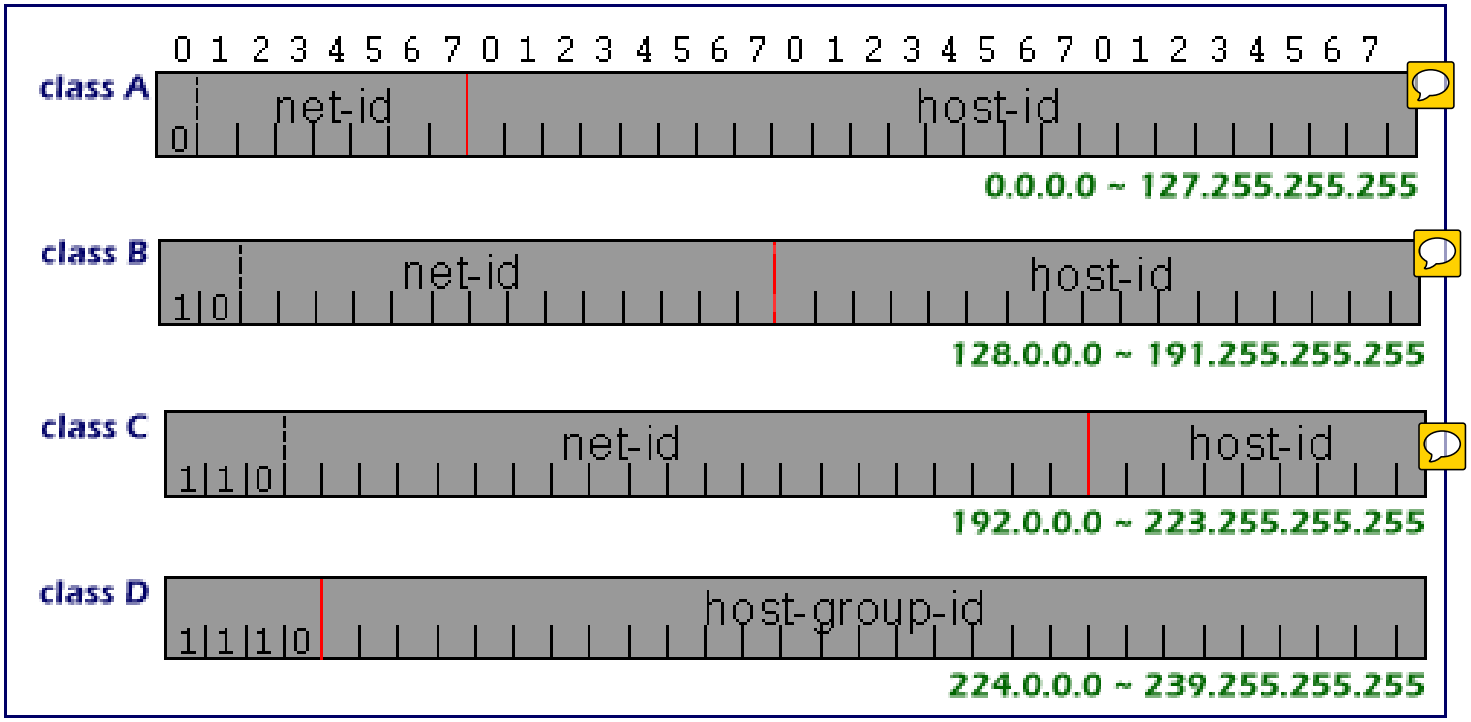


Anatomy of IPv4 address

- TCP/IP addressing is known as IPv4 addressing
  - Internet Protocol version 4 : 32 bits
    - c.f.) IPv6 is for future needs : 128 bits



IPv4 address class ranges



Internet Assigned Numbers Authority (IANA) manages the IP address space allocation

Subnetting

- Class A and B may have sub-network.
  - Since host ID portion is very big
- Subnets can be helpful for separating workgroups within a big organizations
  - e.g.) subnet : 128.10.*.* ("*" means any value)
    ➔ range : 128.10.0.0 ~ 128.10.255.255
- Example
  - 128.10.10.10 and 128.10.200.20
    - In the same network 128.10.*.*
    - But in different sub-networks
      →128.10.10.* and 128.10.200.*

Subnet Masks

- Identify which part of an IP address is the network portion
  - That is, Identify which part is the host
- Refered to as "*netmasks*"
  - For class B, default Netmasks → 255.255.0.0
  - For class C, default Netmasks → 255.255.255.0
  - For a subnet whose range is between 192.168.10.128 and 192.168.10.255
    →255.255.255.128 (*.*.*.10000000)
  - For a subnet whose range is between 192.168.1.192 and 192.168.1.255
    →255.255.255.192 (*.*.*.11000000)

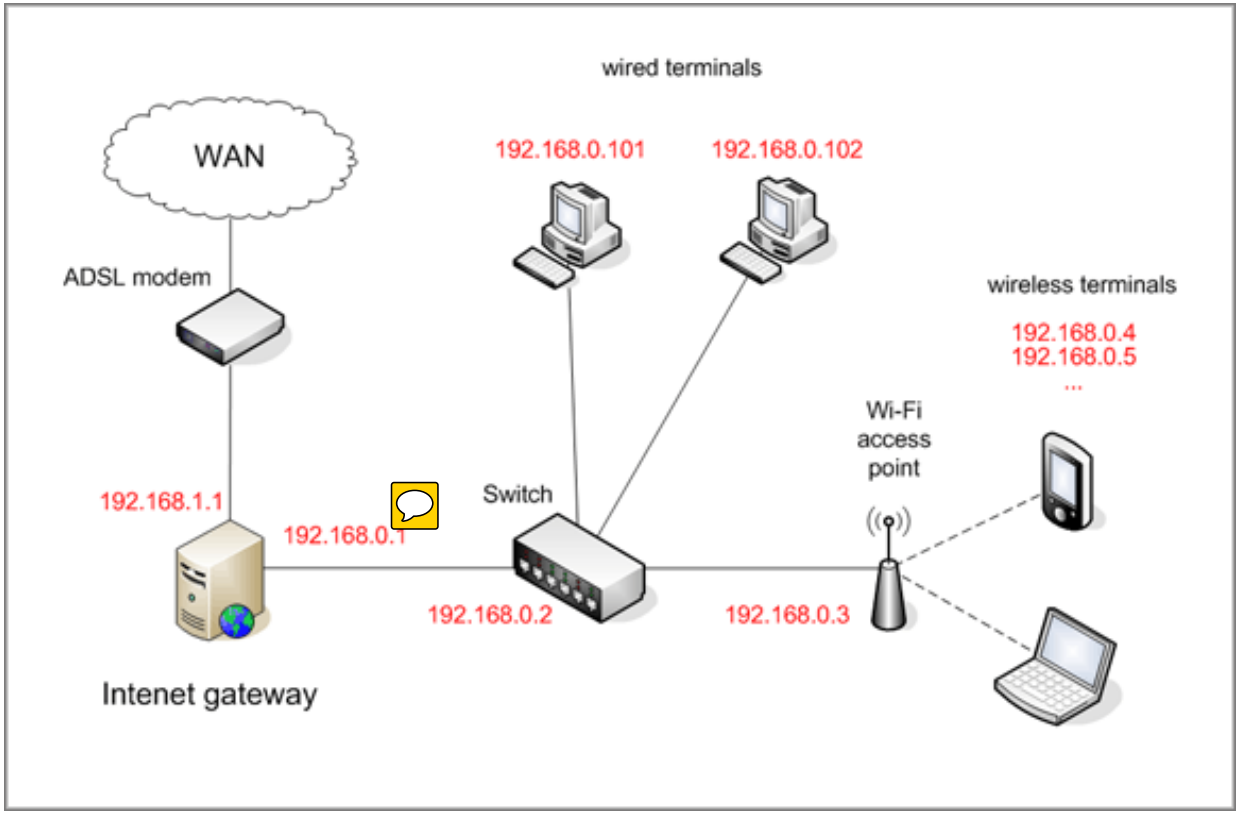
CIDR notation

- Specify how many bits of IPv4 address are used for subnet portion.
  - /8 : 8 bits are used for subnet mask, Class A
  - /16 : 16 bits are used for subnet mask, Class B

CIDR notation	Netmask notation	2^(32-n)	Available hosts	Note
/0	0.0.0.0	4,294,967,296	4,294,967,294	The whole Internet
/8	255.0.0.0	16,777,216	16,777,214	Class A
/16	255.255.0.0	65,535	65,533	Class B
/24	255.255.255.0	256	254	Class C
/25	255.255.255.128	128	126	
/26	255.255.255.192	64	62	
/27	255.255.255.224	32	30	
/28	255.255.255.240	16	14	
/29	255.255.255.248	8	6	
/30	255.255.255.252	4	2	
/31	255.255.255.254	2	2*	
/32	255.255.255.255	0	1*	

Gateway

- A point (IP address) to forward data to Internet



How to obtain IP addresses

- A machine may have multiple IP addresses
  - Based on the number of network interfaces
  - A machine with “n” network interfaces can obtain “n” different IP addresses
- That is, a network interface obtains an IP address
  - Designated IP address
  - Dynamic IP address
    - DHCP : Dynamic Host Configuration Protocol

What is a network interface

- Network device for communicating with other machine (interface)
  - Wired LAN card
  - Wireless LAN card
  - Loopback device
- Representation
  - eth* : eth0, eth1, …
  - lo : loopback

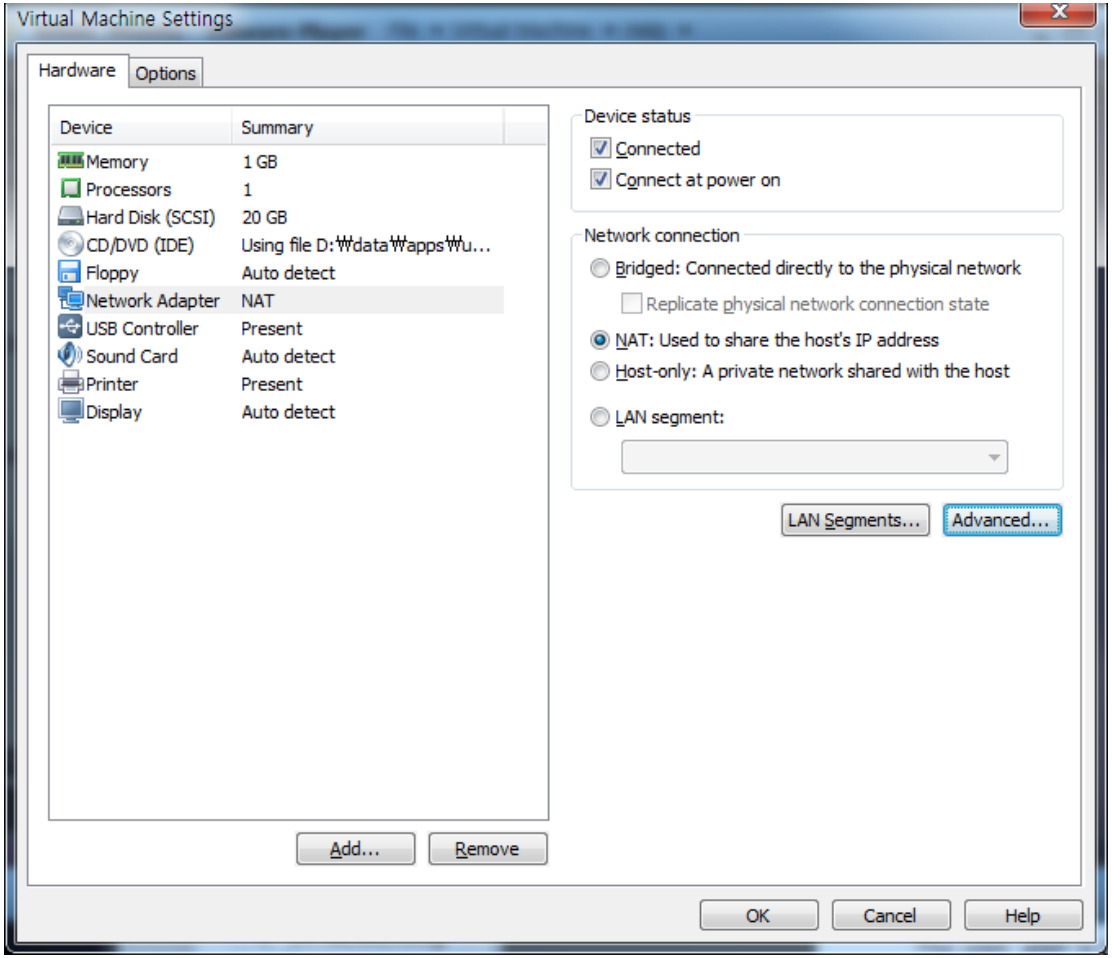
Network Interface Cards (NIC)

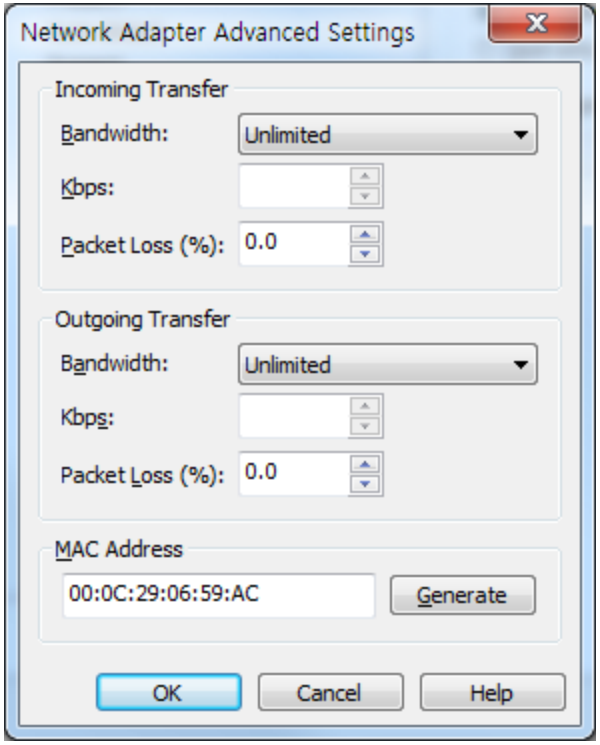
- A computer must have a network interface card to connect to a network
- Each NIC has a unique address
  - The hardware address, known as **MAC address** (Media access control)
  - e.g. 00:60:08:8F:5A:D9
- MAC address is used by DHCP (Dynamic Host Configuration Protocol) to identify a specific host
- Also used by the ARP (Address Resolution Protocol)
  - To map hosts to IP addresses

Virtual Network Interfaces

- Sometimes you need a network interface which emulates a network interface card
  - e.g. NIC of VMWare
- VMWare virtually create a network interface card and assign a network interface

Example

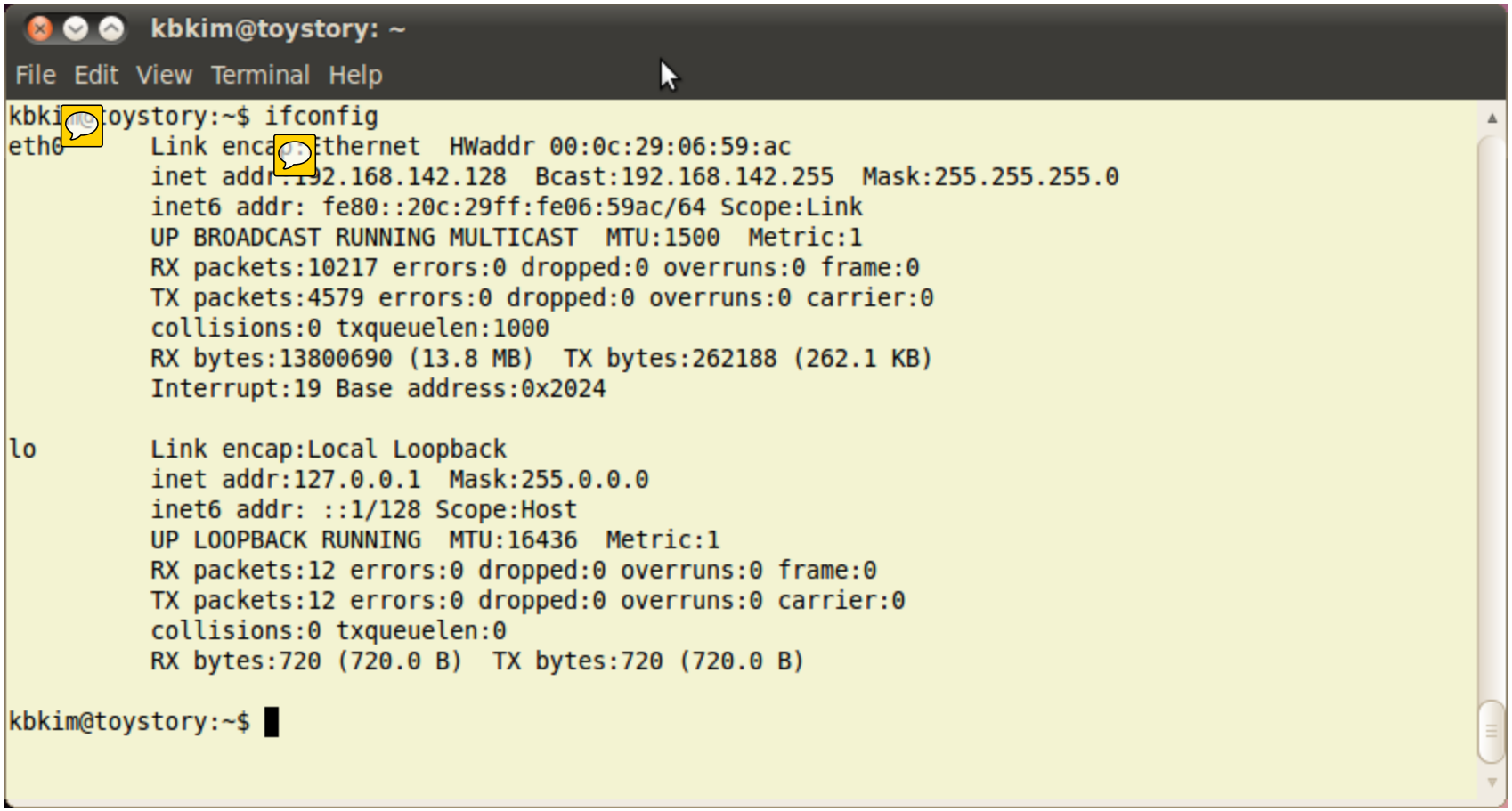

Virtual Machine Settings
Hardware
Options
Device
Summary
Memory
1 GB
Processors
1
Hard Disk (SCSI)
20 GB
CD/DVD (IDE)
Using file D:₩data₩apps₩u...
Floppy
Auto detect
Network Adapter
NAT
USB Controller
Present
Sound Card
Auto detect
Printer
Present
Display
Auto detect
Add...
Remove
Device status
Connected
Connect at power on
Network connection
Bridged: Connected directly to the physical network
Replicate physical network connection state
NAT: Used to share the host's IP address
Host-only: A private network shared with the host
LAN segment:
LAN Segments...
Advanced...
OK
Cancel
Help


Network Adapter Advanced Settings
Incoming Transfer
Bandwidth:
Unlimited
Kbps:
Packet Loss (%):
0.0
Outgoing Transfer
Bandwidth:
Unlimited
Kbps:
Packet Loss (%):
0.0
MAC Address
00:0C:29:06:59:AC
Generate
OK
Cancel
Help

Configure the network interfaces

- "ifconfig" command
  - Configure the kernel-resident network interfaces
  - Activate or Deactivate NIC
  - Change linux machine's IP address, netmask, or broadcast address
  - Create an IP alias to allow more than one IP address on your NIC
  - Set a destination address for a point to point connection

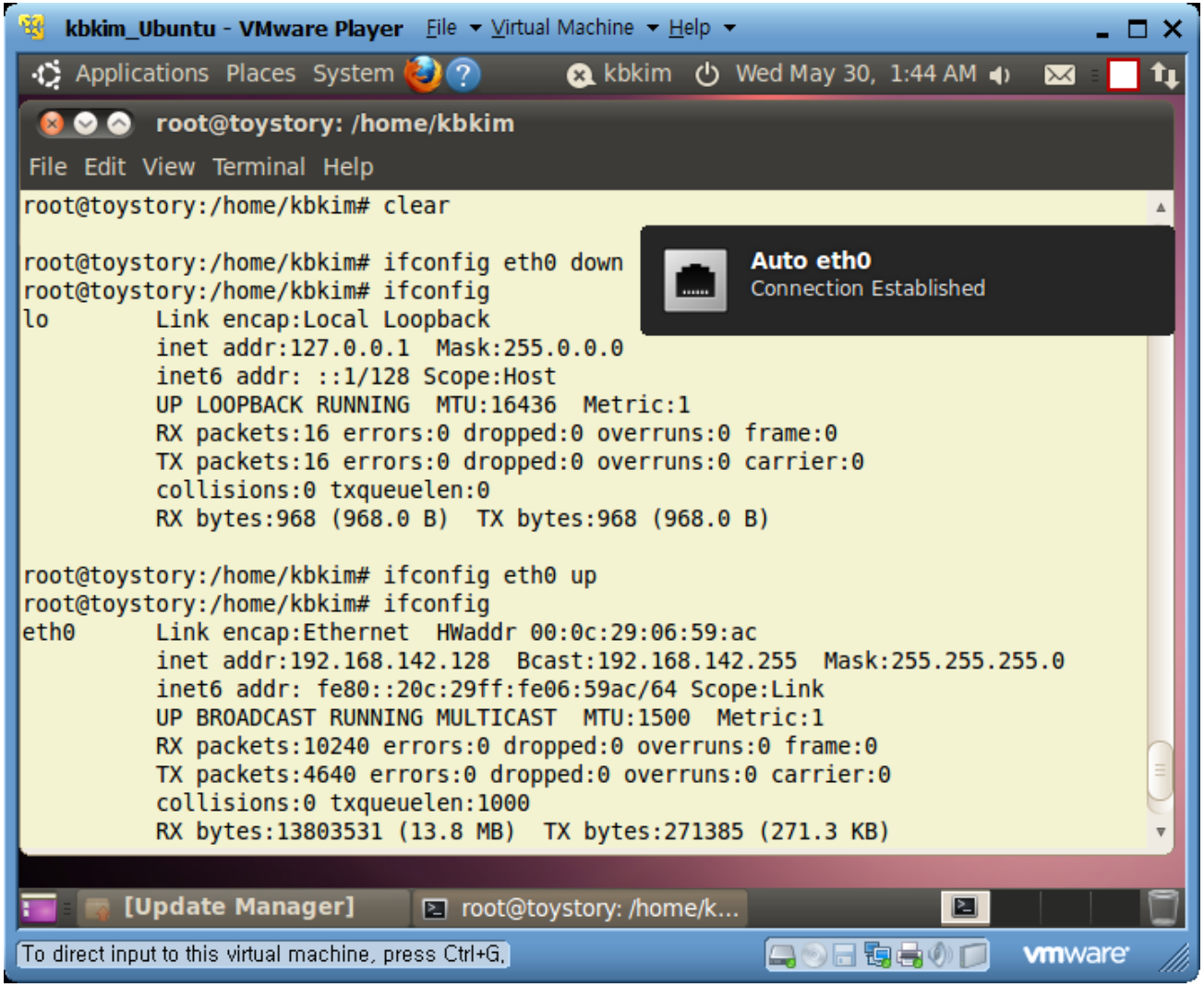
Checking the status of network interfaces – “ifconfig”



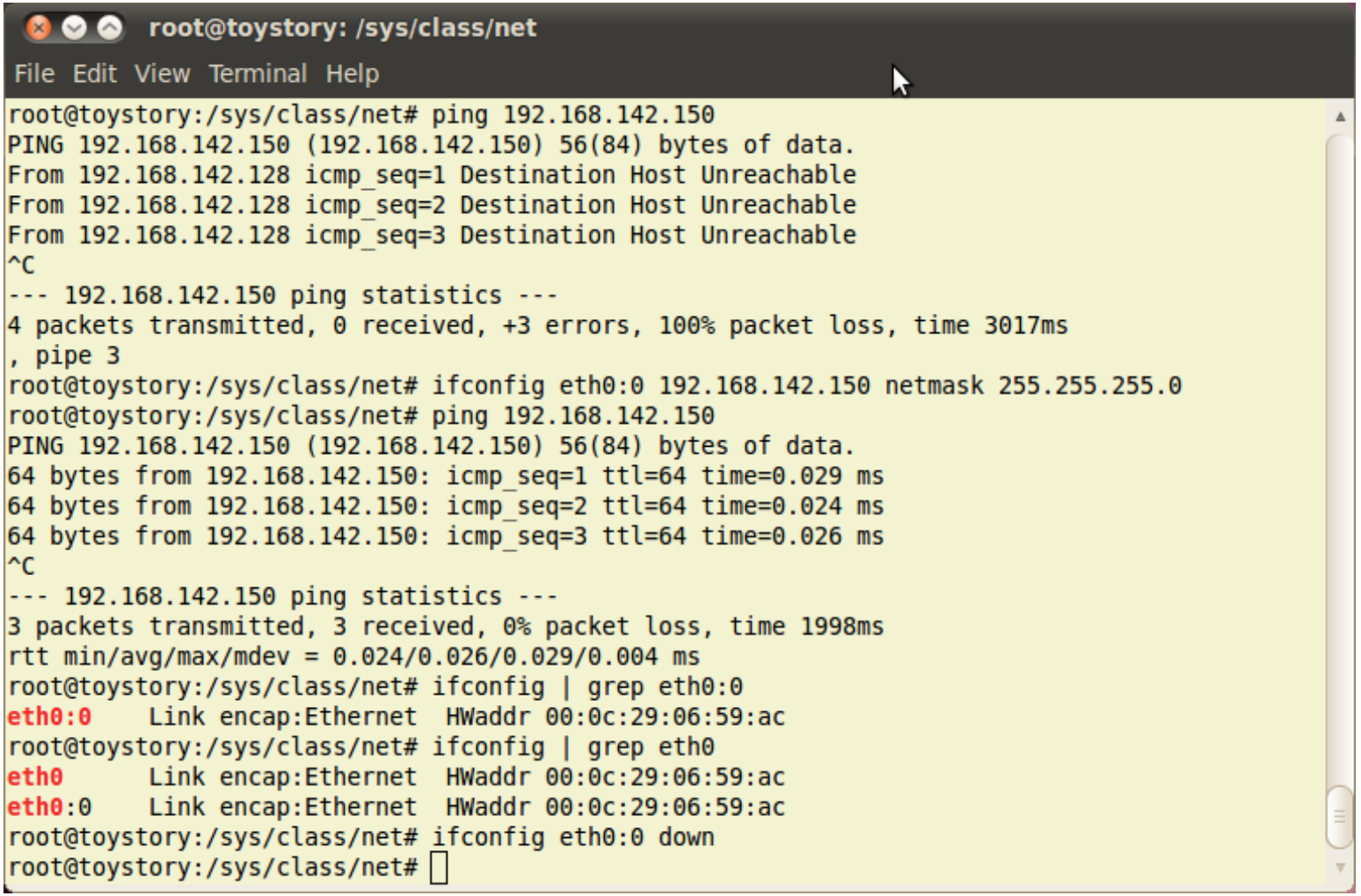
ifconfig Options

Use	Option	Example
Create alias	`[network device]`	`ifconfig eth0:0_:[number]`
Change IP address		`ifconfig eth0 10.10.10.12`
Change the netmask	`netmask [netmask]`	`fconfig eth0 netmask 255.255.255.0`
Change the broadcast	`broadcast [address]`	`ifconfig eth0 broadcast 10.10.10.255`
Take interface down	`down`	`ifconfig eth0 down`
Bring interface up	`up (add IP address)`	`ifconfig eth0 up (ifconfig eth0 10.10.10.10)`

Example – up and down NIC



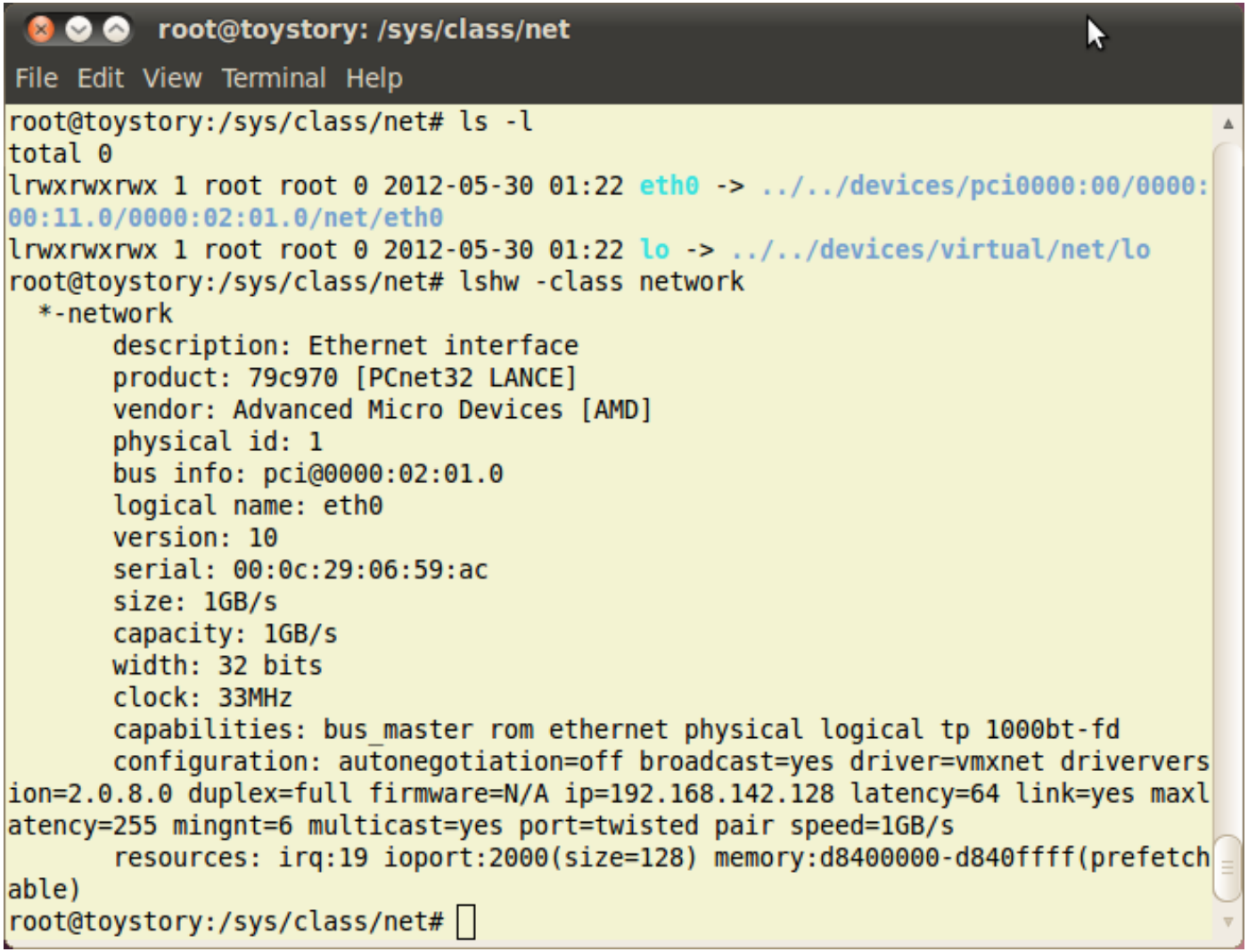
Example – Creating virtual interface by aliasing



Available Network Interfaces

- To figure out the available network interfaces
- "lshw" command
  - e.g. lshw –class network
- "/sys/class/net" directory

Example

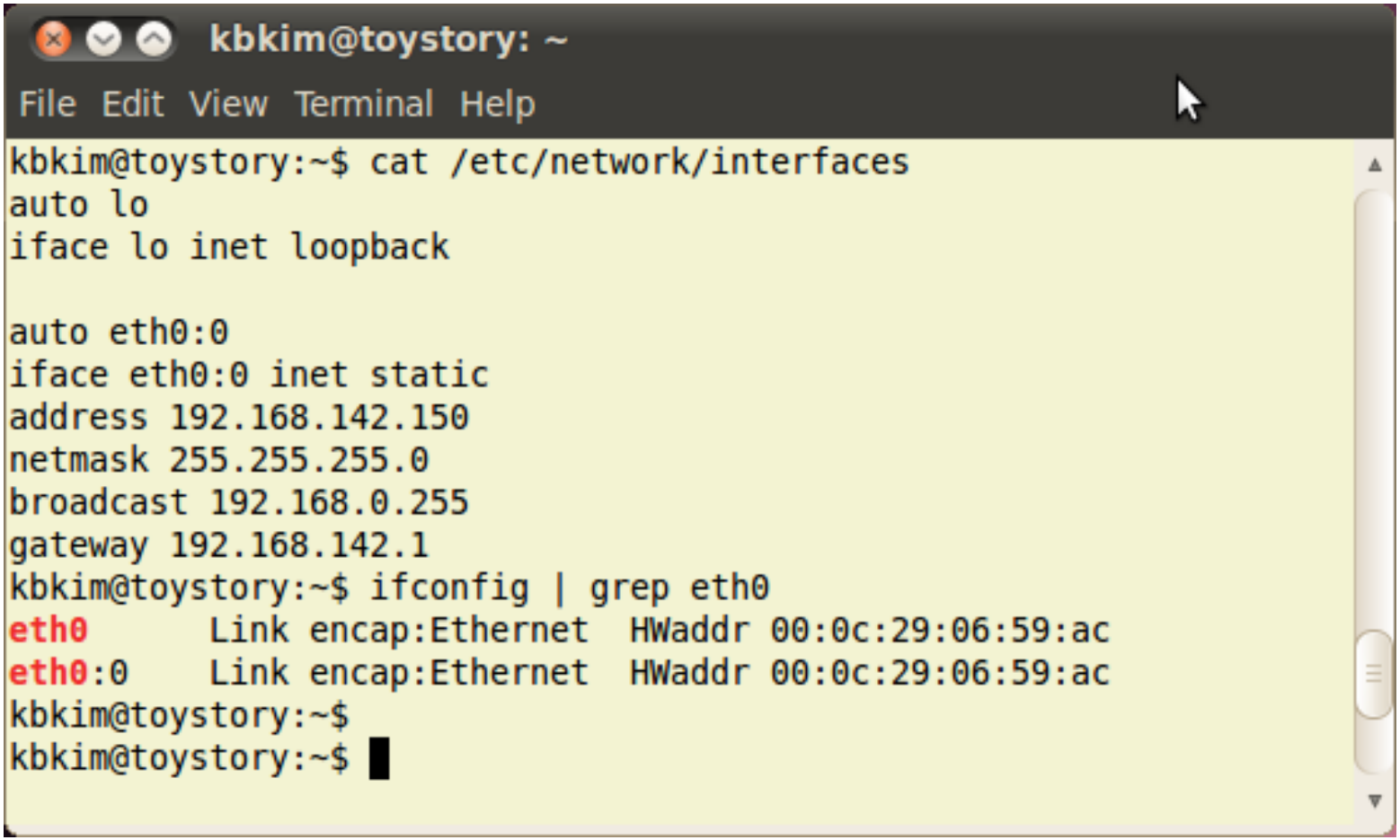

root@toystory: /sys/class/net
File Edit View Terminal Help
root@toystory:/sys/class/net# ls -l
total 0
lrwxrwxrwx 1 root root 0 2012-05-30 01:22 eth0 -> ../../devices/pci0000:00/0000:00:11.0/0000:02:01.0/net/eth0
lrwxrwxrwx 1 root root 0 2012-05-30 01:22 lo -> ../../devices/virtual/net/lo
root@toystory:/sys/class/net# lshw -class network
*-network
description: Ethernet interface
product: 79c970 [PCnet32 LANCE]
vendor: Advanced Micro Devices [AMD]
physical id: 1
bus info: pci@0000:02:01.0
logical name: eth0
version: 10
serial: 00:0c:29:06:59:ac
size: 1GB/s
capacity: 1GB/s
width: 32 bits
clock: 33MHz
capabilities: bus_master rom ethernet physical logical tp 1000bt-fd
configuration: autonegotiation=off broadcast=yes driver=vmxnet driverversion=2.0.8.0 duplex=full firmware=N/A ip=192.168.142.128 latency=64 link=yes maxlatency=255 mingnt=6 multicast=yes port=twisted pair speed=1GB/s
resources: irq:19 ioport:2000(size=128) memory:d8400000-d840ffff(prefetchable)
root@toystory:/sys/class/net#

Loopback address and interface

Permanently setting NIC

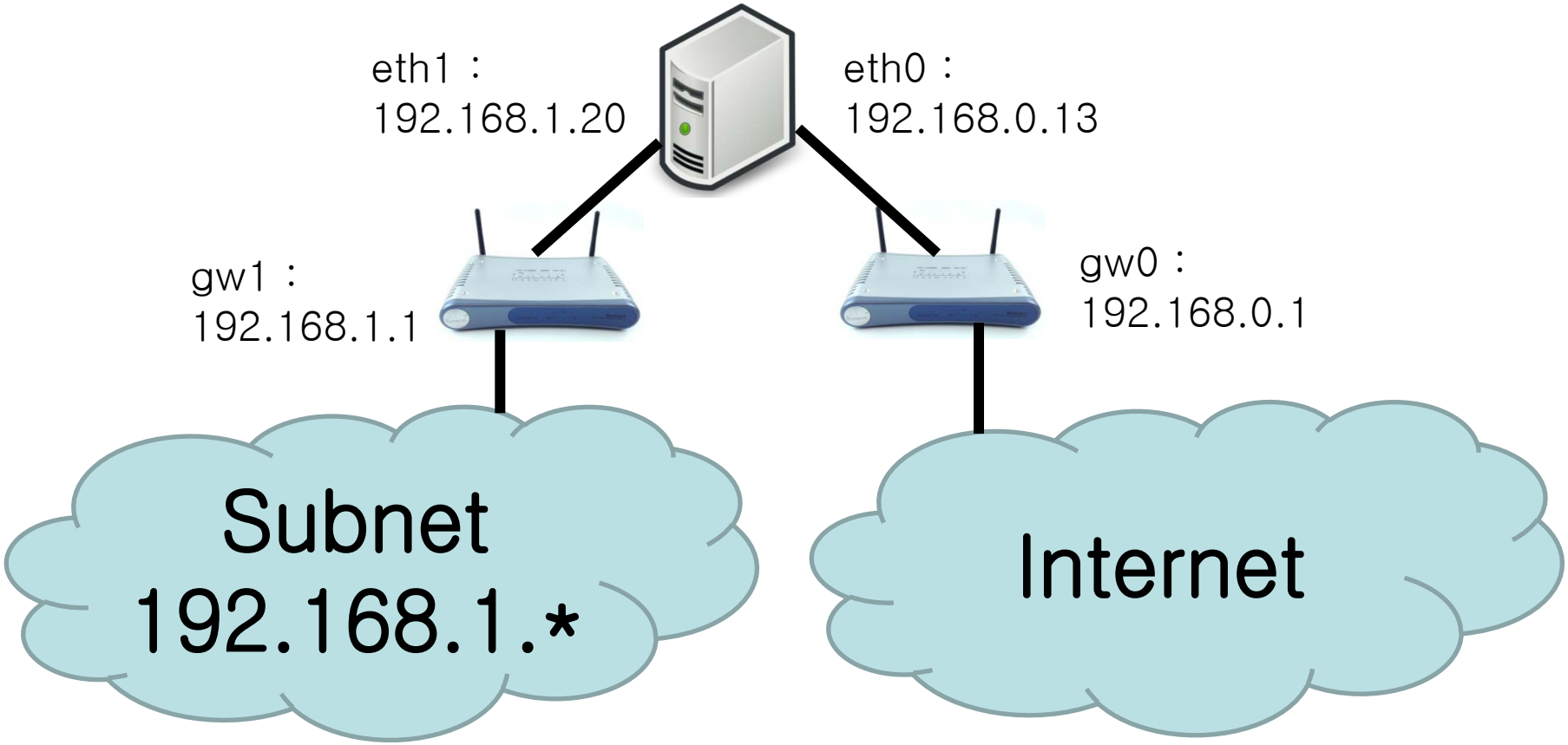
- Modify “/etc/network/interfaces” file
  - Network interface configuration for ifup and ifdown commands
  - Line starting with “#” is ignored.
  - Using DHCP
    → iface eth0 inet dhcp
  - Using static setting
    → auto eth0:0
    iface eth0:0 inet static
    address 192.168.142.150
    netmask 255.255.255.0
    broadcast 192.168.142.255
    gateway 192.168.142.1
- “/etc/init.d/networking restart” for restart the network

Example


kbkim@toystory: ~
File Edit View Terminal Help
kbkim@toystory:~$ cat /etc/network/interfaces
auto lo
iface lo inet loopback
auto eth0:0
iface eth0:0 inet static
address 192.168.142.150
netmask 255.255.255.0
broadcast 192.168.0.255
gateway 192.168.142.1
kbkim@toystory:~$ ifconfig | grep eth0
eth0 Link encap:Ethernet HWaddr 00:0c:29:06:59:ac
eth0:0 Link encap:Ethernet HWaddr 00:0c:29:06:59:ac
kbkim@toystory:~$
kbkim@toystory:~$

Route setup

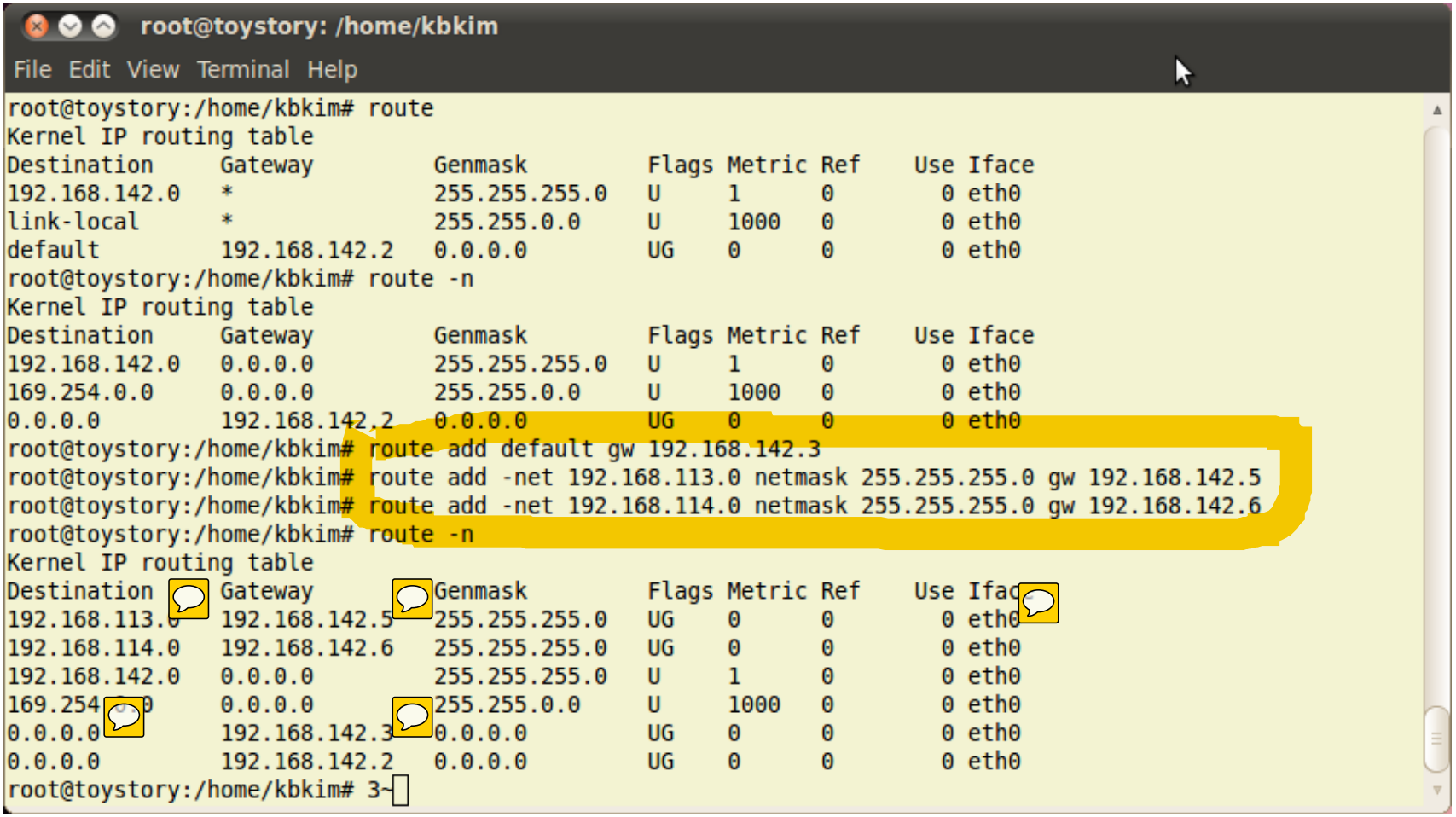
* Routing : finding a path to reach a destination
  - Which gateway is used to reach a machine with IP 192.168.1.30? ➔ gw1
  - Which gateway is used to reach a machine with IP 169.254.10.15? ➔ gw0
  - Which gateway is used to reach machines in a subnet 192.168.1.*? ➔ gw1



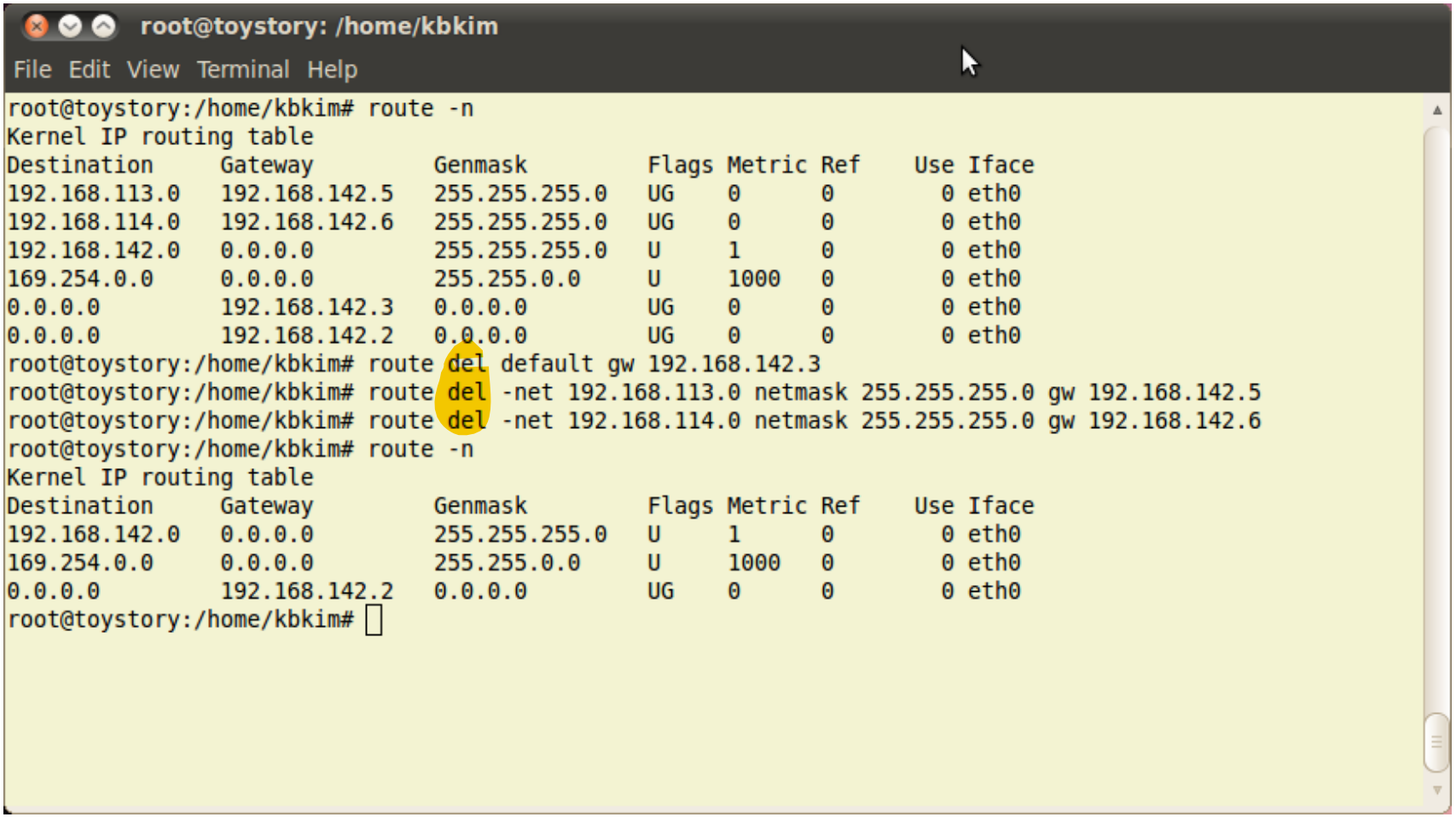
Configure Route

- “route” command
  - Builds/shows the routing tables (in memory) implemented for routing packets
  - c.f. “ifconfig” initialized the interface
- Syntax
  - route [commands] [options] target [parameters]
  - “add/del” command → add/delete a target
  - “-n” option → numerical representation
  - “default” option → to set default gateway (no need target)
  - “-net” or “-host” option → target is network or host
  - “gw GW” parameter → gateway GW(IP address)
  - “dev if” parameter → interface (e.g. eth0)

Example


root@toystory: /home/kbkim
File Edit View Terminal Help
root@toystory:/home/kbkim# route
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
192.168.142.0 * 255.255.255.0 U 1 0 0 eth0
link-local * 255.255.0.0 U 1000 0 0 eth0
default 192.168.142.2 0.0.0.0 UG 0 0 0 eth0
root@toystory:/home/kbkim# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
192.168.142.0 0.0.0.0 255.255.255.0 U 1 0 0 eth0
169.254.0.0 0.0.0.0 255.255.0.0 U 1000 0 0 eth0
0.0.0.0 192.168.142.2 0.0.0.0 UG 0 0 0 eth0
root@toystory:/home/kbkim# route add default gw 192.168.142.3
root@toystory:/home/kbkim# route add -net 192.168.113.0 netmask 255.255.255.0 gw 192.168.142.5
root@toystory:/home/kbkim# route add -net 192.168.114.0 netmask 255.255.255.0 gw 192.168.142.6
root@toystory:/home/kbkim# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
192.168.113.0 192.168.142.5 255.255.255.0 UG 0 0 0 eth0
192.168.114.0 192.168.142.6 255.255.255.0 UG 0 0 0 eth0
192.168.142.0 0.0.0.0 255.255.255.0 U 1 0 0 eth0
169.254.0.0 0.0.0.0 255.255.0.0 U 1000 0 0 eth0
0.0.0.0 192.168.142.3 0.0.0.0 UG 0 0 0 eth0
0.0.0.0 192.168.142.2 0.0.0.0 UG 0 0 0 eth0
root@toystory:/home/kbkim# 3~

Example of deletion



Check the status of network

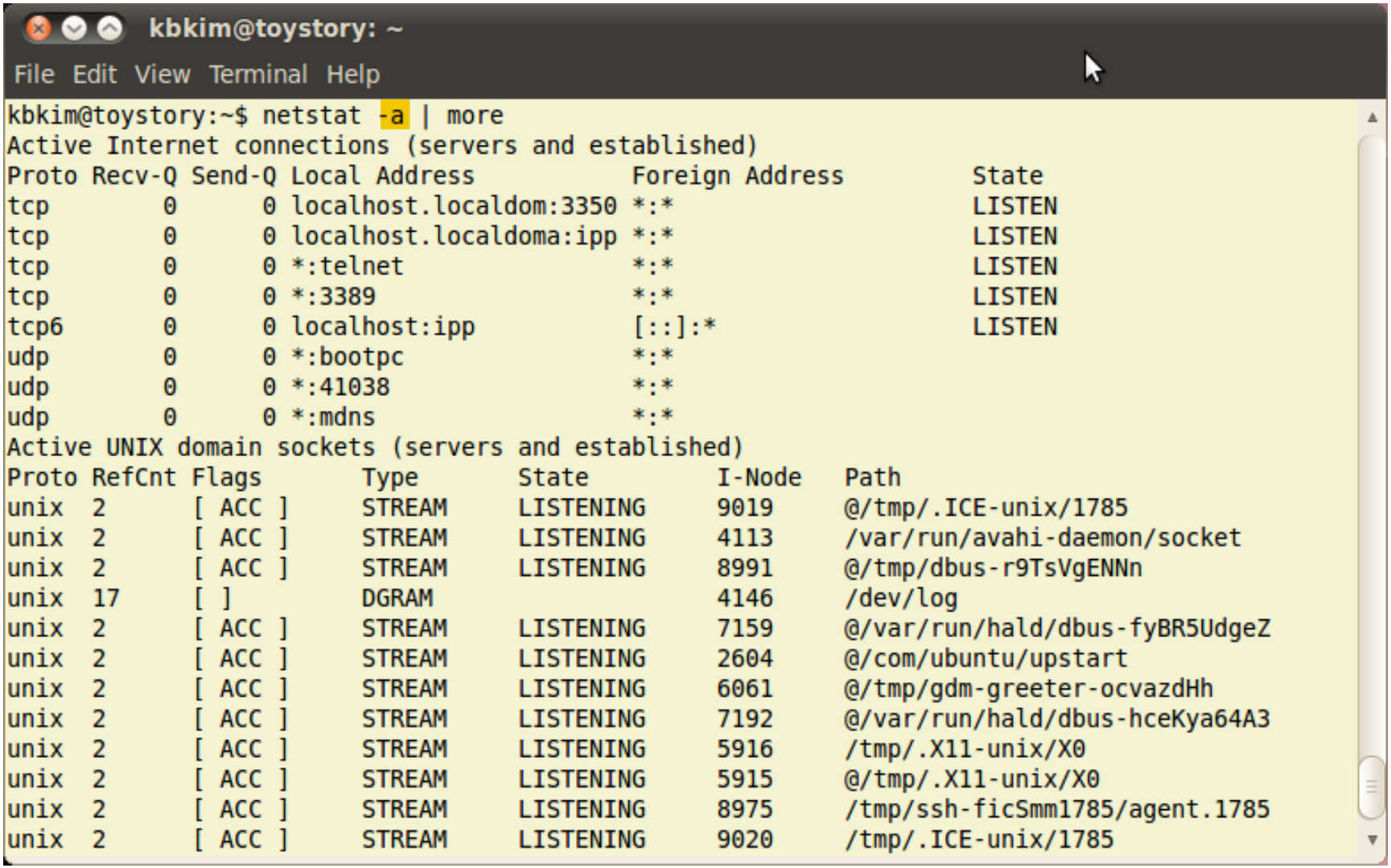
- "netstat" command
  - Display the status of the network

Option	Output
-g	Displays the multicast groups configured
-i	Displays the interfaces configured by `ifconfig`
-s	Lists a summary of activity for each protocol
-v	Gives verbose output, listing both active and inactive sockets
-c	Updates output every second (good for testing and troubleshooting)
-e	Gives verbose output for active connections only
-C	Displays information from the route cache and is good for looking at past connections

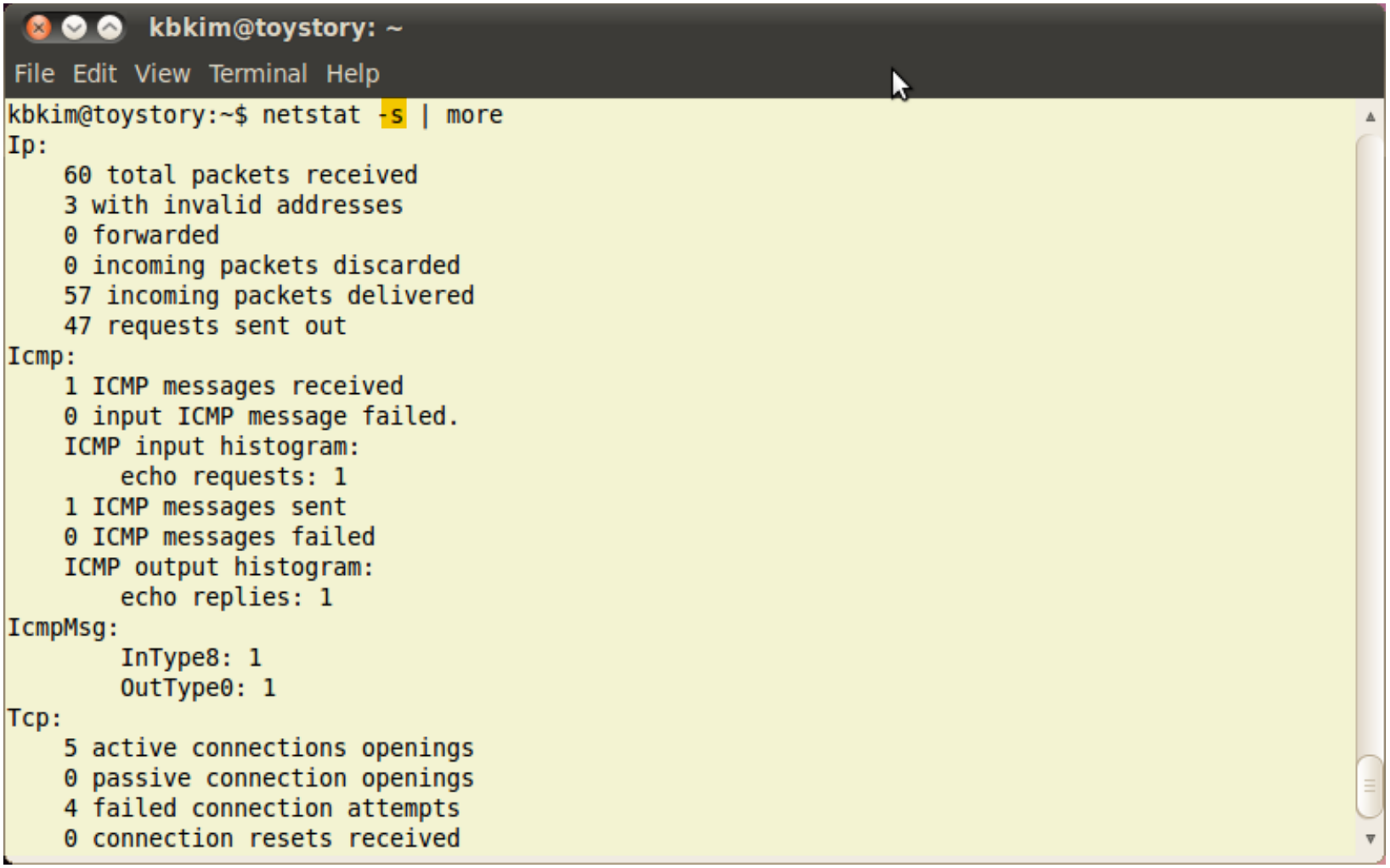
More options of netstat

- “netstat –a” → List all Ports
- “netstat –at” → List all TCP Ports
- “netstat –au” → List all UDP Ports
- “netstat –l” → List all Listen sockets
- “netstat –lt” → List all TCP Listen sockets
- “netstat –lu” → List all UDP Listen sockets
- “netstat –lx” → List all UNIX Listen socket
- “netstat –r” → Display the kernel routing information

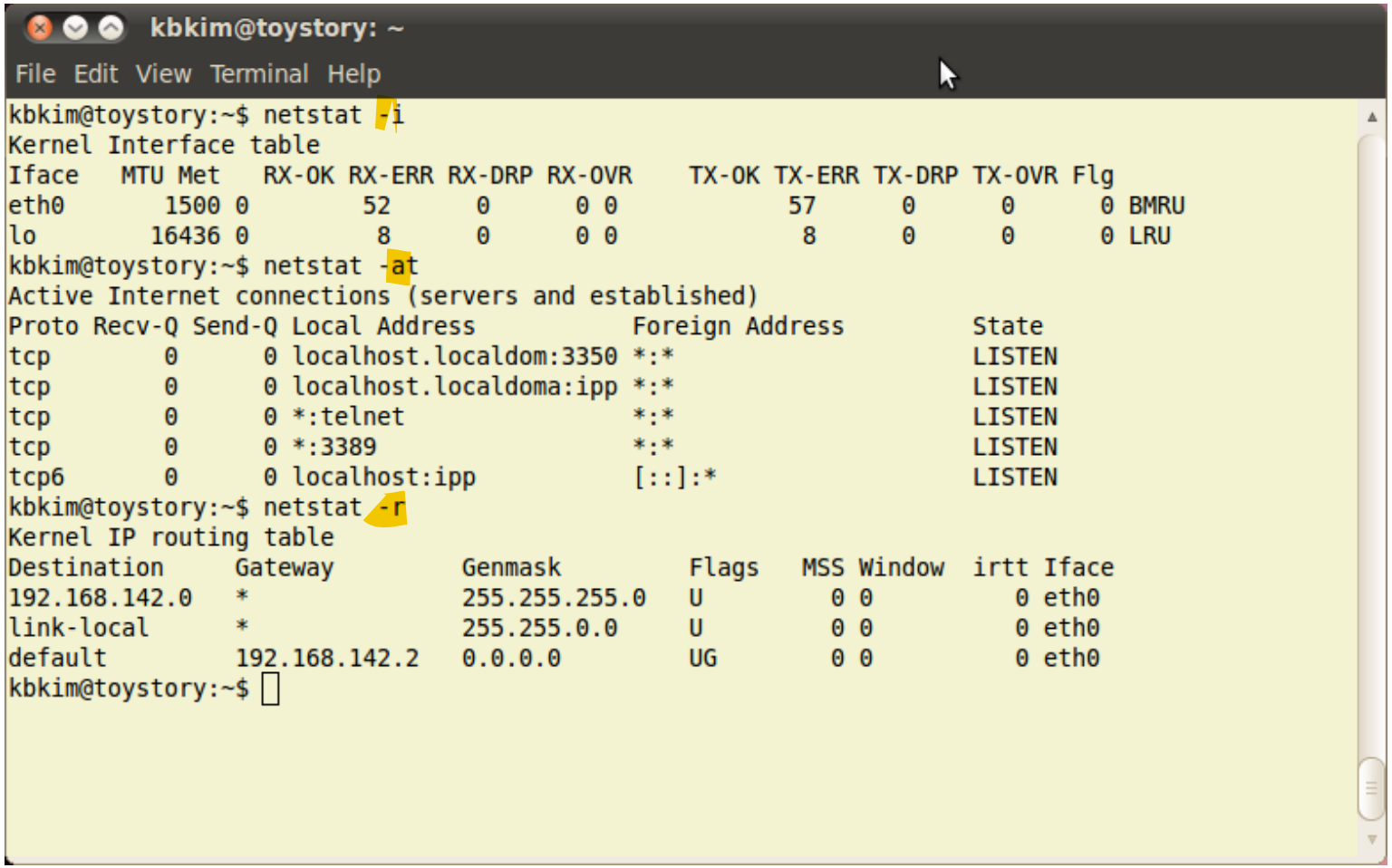
Example of “netstat”



Example of “netstat”



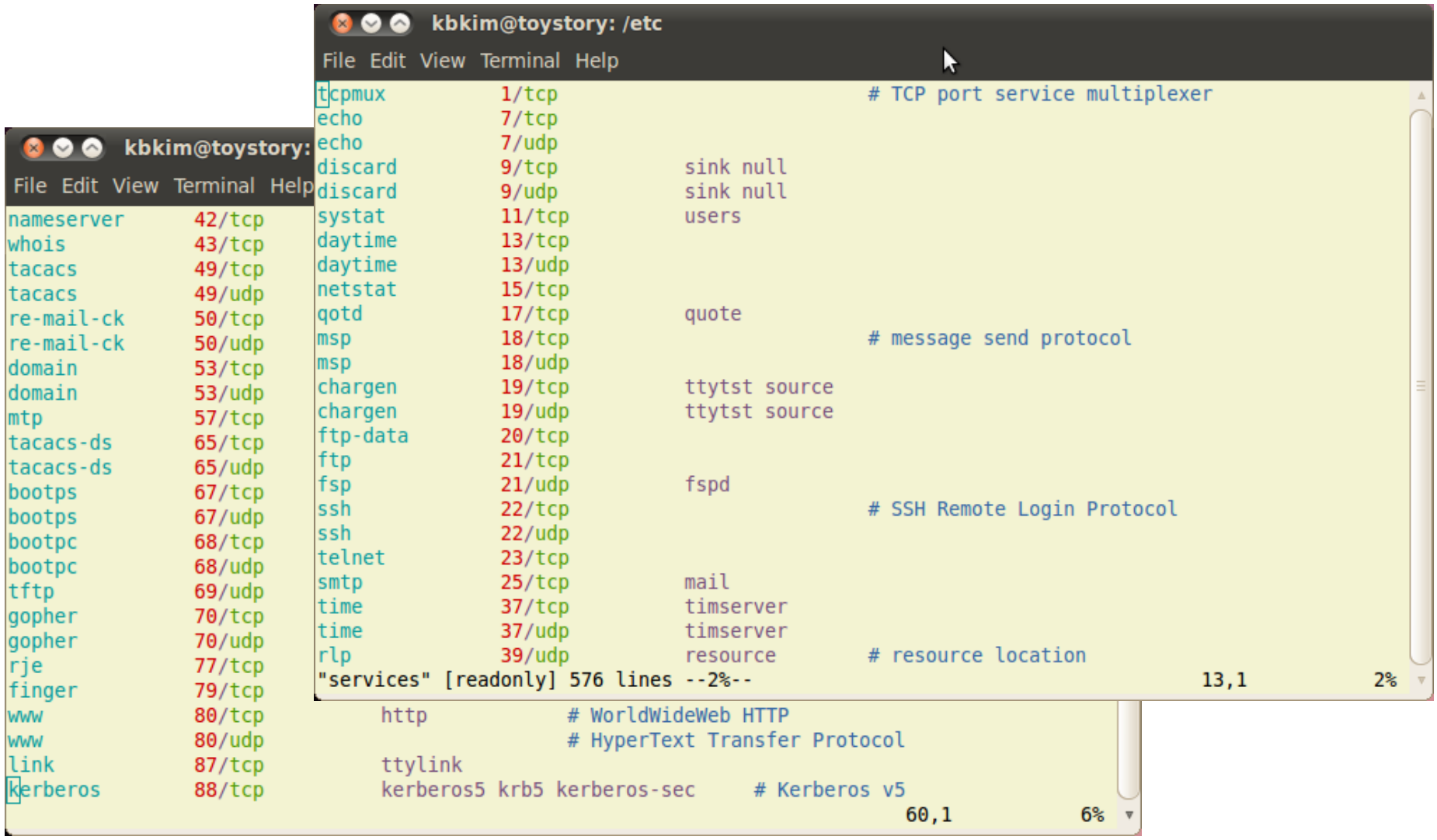
Example of “netstat”



Port and Services

- IP address → identify a host
- Port → identify a service
  - Used by a socket of TCP or UDP
  - Different services use different ports
  - The information of assigned ports are described in /etc/services file
  - e.g.) ftp : 21/tcp for control
    ftp-data : 20/tcp for data
    www : 80/tcp or 80/udp for http

/etc/services



Popular TCP/UDP ports

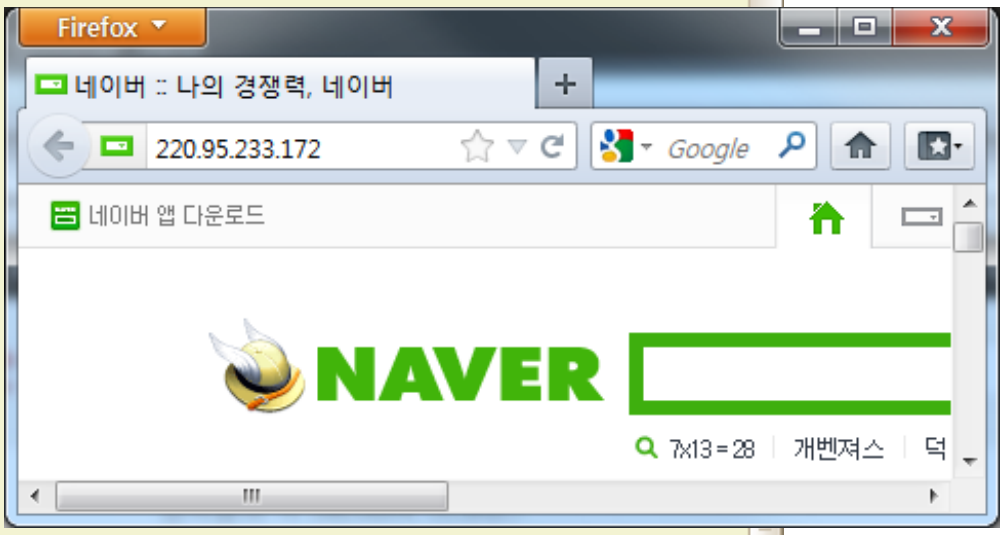
Port Number	Protocol	Application
20	TCP	FTP Data
21	TCP	FTP Control
22	TCP	SSH
23	TCP	Telnet
25	TCP	SMTP
53	UDP,TCP	DNS
67,68	UDP	DHCP
69	UDP	TFTP
80	TCP	HTTP
110	TCP	POP3
161	UDP	SNMP
443	TCP	SSL
16,384-32,767	UDP	RTP-based Voice and Video

Using DNS

- Translate a hostname to an IP address
  - In C language : gethostbyname() function
- "nslookup" command
  - Query Internet name service interactively
- The local name server is set in "/etc/resolve.conf" file
  - If using DHCP, this file be set automatically
  - You can set a designated domain name server as well.
    - e.g. Google Public DNS → 8.8.8.8 and 8.8.4.4

Example

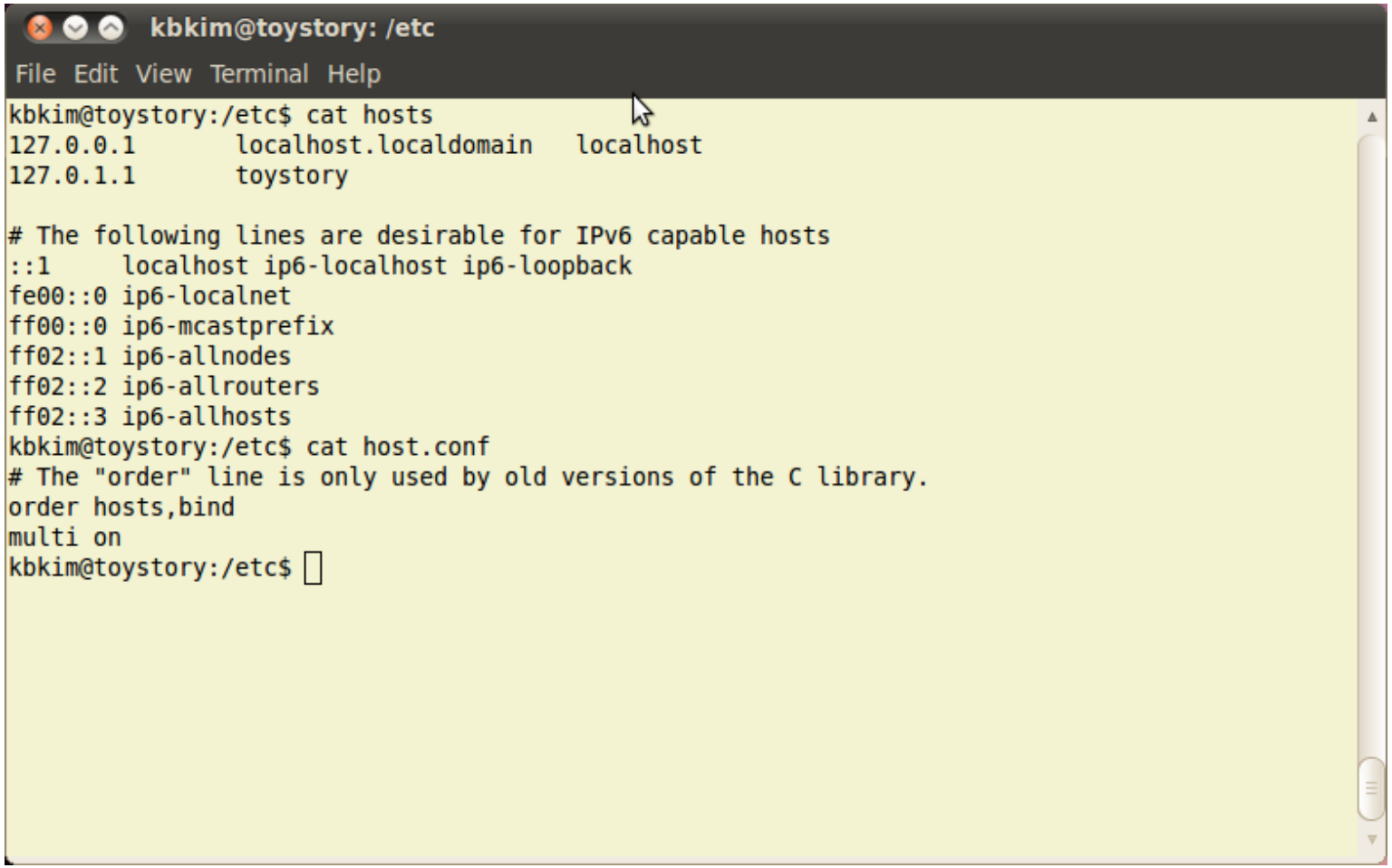
```
kbkim@toystory: /etc
File  Edit  View  Terminal  Help
kbkim@toystory:/etc$ cat resolv.conf
# Generated by NetworkManager
domain localdomain
search localdomain
nameserver 192.168.142.2
kbkim@toystory:/etc$ nslookup altair.chonnam.ac.kr
Server:         192.168.142.2
Address:        192.168.142.2#53

Non-authoritative answer:
Name:   altair.chonnam.ac.kr
Address: 168.131.33.33

kbkim@toystory:/etc$ nslookup www.naver.com
Server:         192.168.142.2
Address:        192.168.142.2#53

Non-authoritative answer:
www.naver.com   canonical name = www.g.naver.com.
Name:   www.g.naver.com
Address: 202.131.30.11
Name:   www.g.naver.com
Address: 220.95.233.172

kbkim@toystory:/etc$
```



Local information of hosts

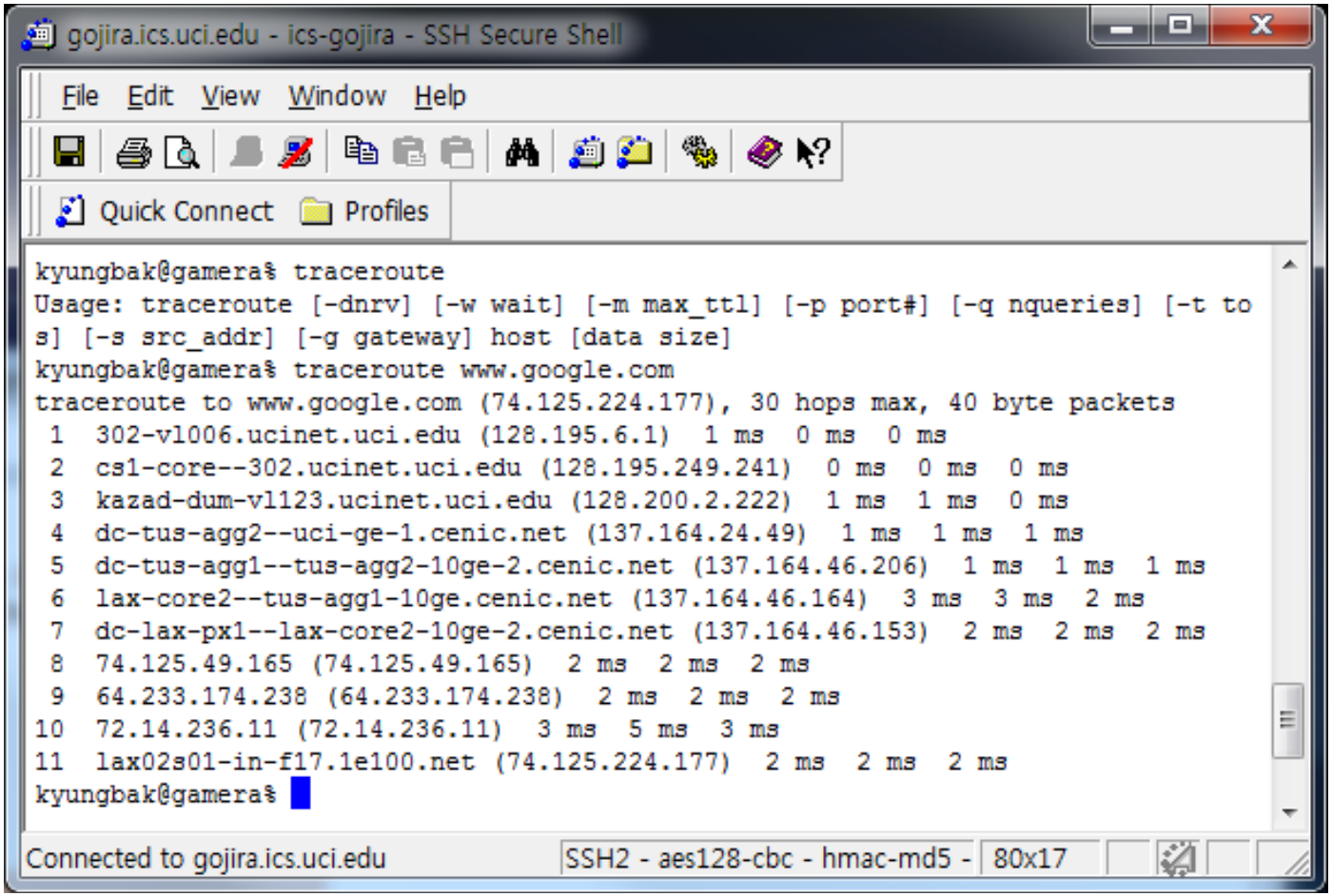
- “/etc/hosts” file contains the information of local hosts
  - A map of IP to hostnames
  - Usually used for managing internal sub networks
- Order of searching a IP address of a hostname
  - Defined in “/etc/host.conf”
  - General order → hosts, then DNS

Example


kbkim@toystory: /etc
File Edit View Terminal Help
kbkim@toystory:/etc$ cat hosts
127.0.0.1 localhost.localdomain localhost
127.0.1.1 toystory
The following lines are desirable for IPv6 capable hosts
::1 localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
ff02::3 ip6-allhosts
kbkim@toystory:/etc$ cat host.conf
The "order" line is only used by old versions of the C library.
order hosts,bind
multi on
kbkim@toystory:/etc$

Check whether IP addres/Hostname is reachable

- “traceroute” command



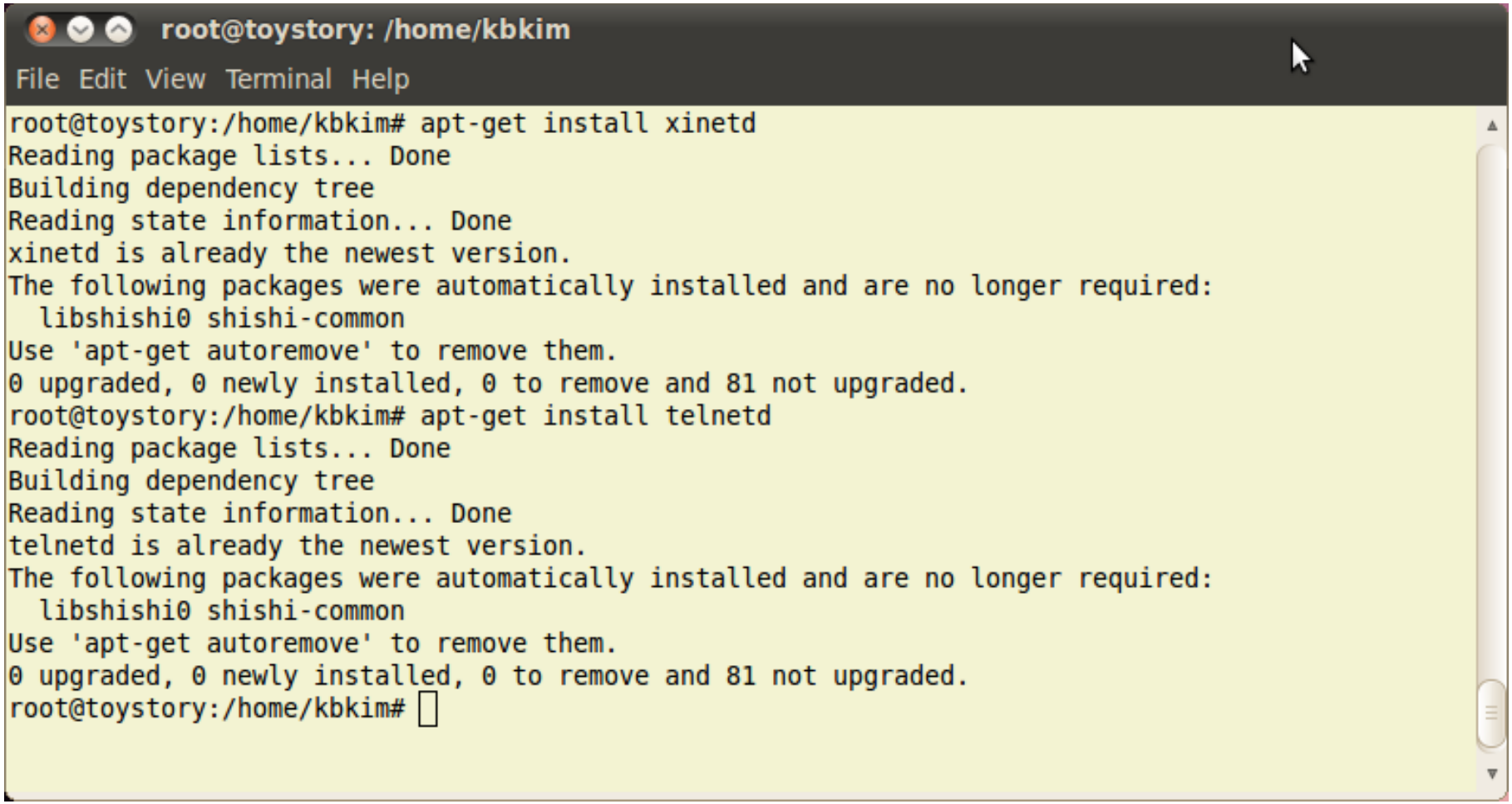
Session

- Identify the connection between a client and a server
- A server assigns a **session ID** to a connection of a client
- Until the session ID is valid, a server identify a client which accessed the server before and re-access the server.
- Usually used in http with cookie.

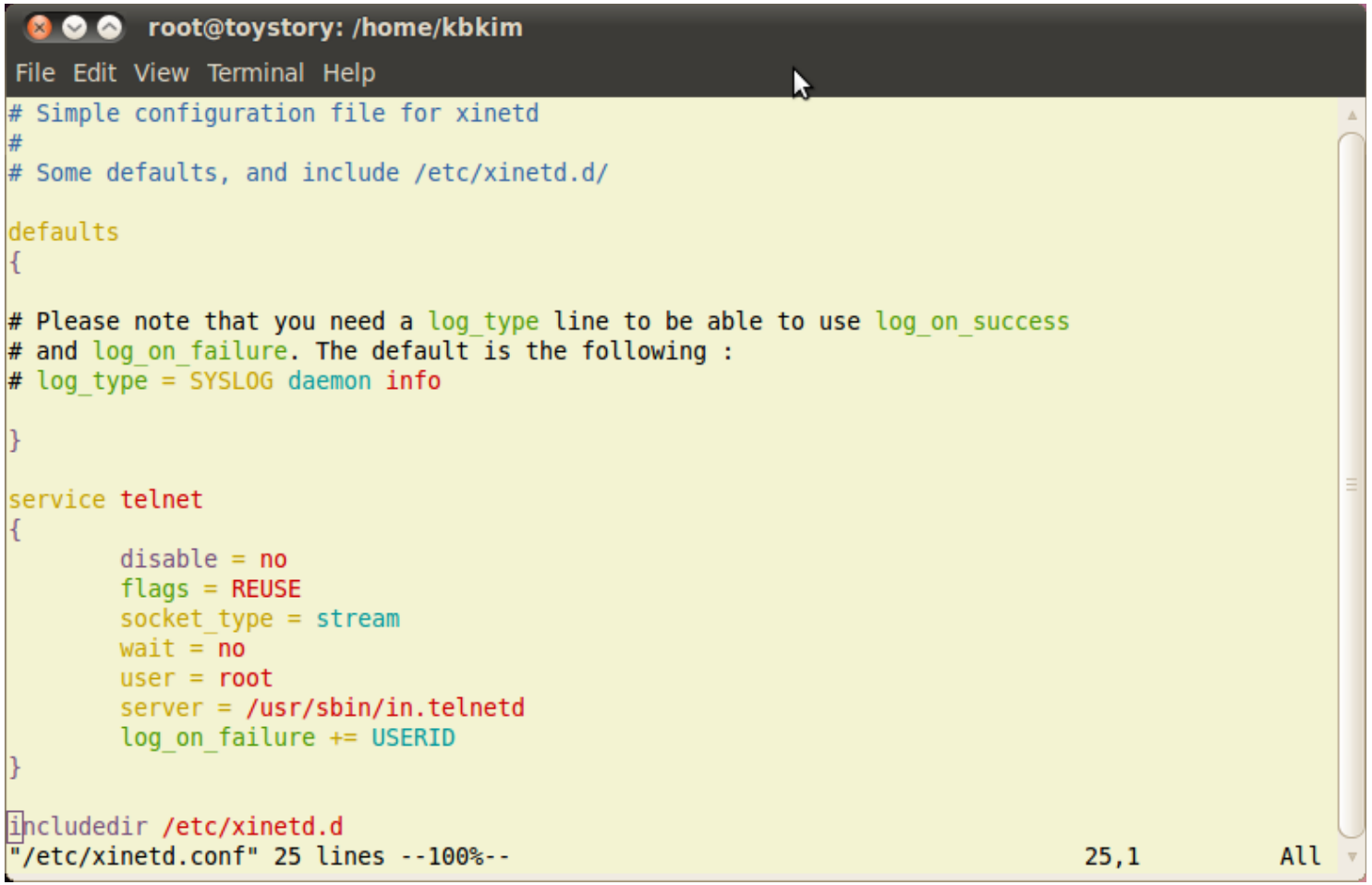
Telnet

- Text based remote access protocol
  - Use 23 port
- Client program
  - “telnet”
    - Usage : o [IP address]
      → connect the machine with the given IP address
  - Basically provided in Linux distribution
- Server program
  - “telnetd”
  - Root needs to install “xinetd” and “telnetd”
  - Also needs to modify xinetd configuration

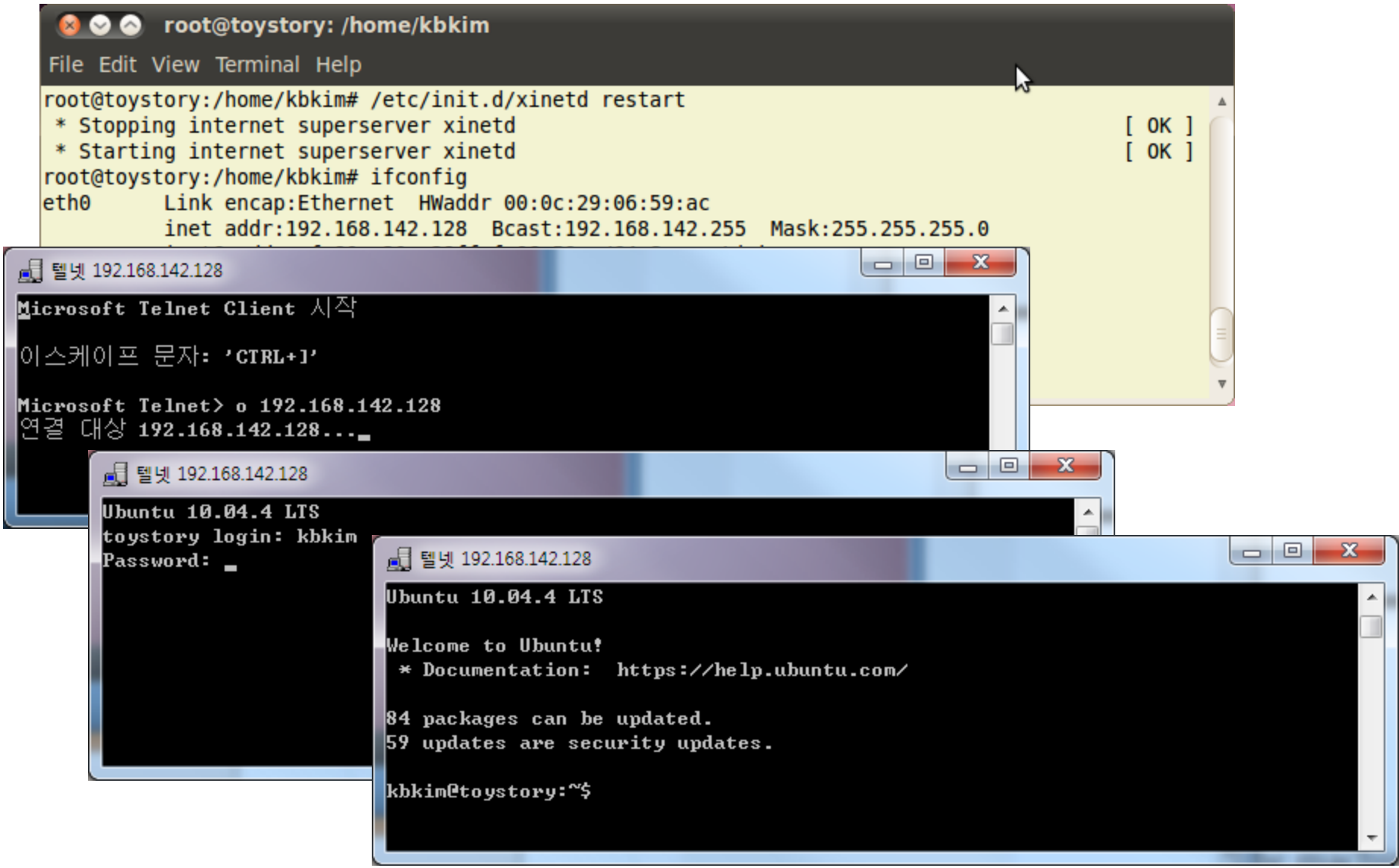
Installing telnet server



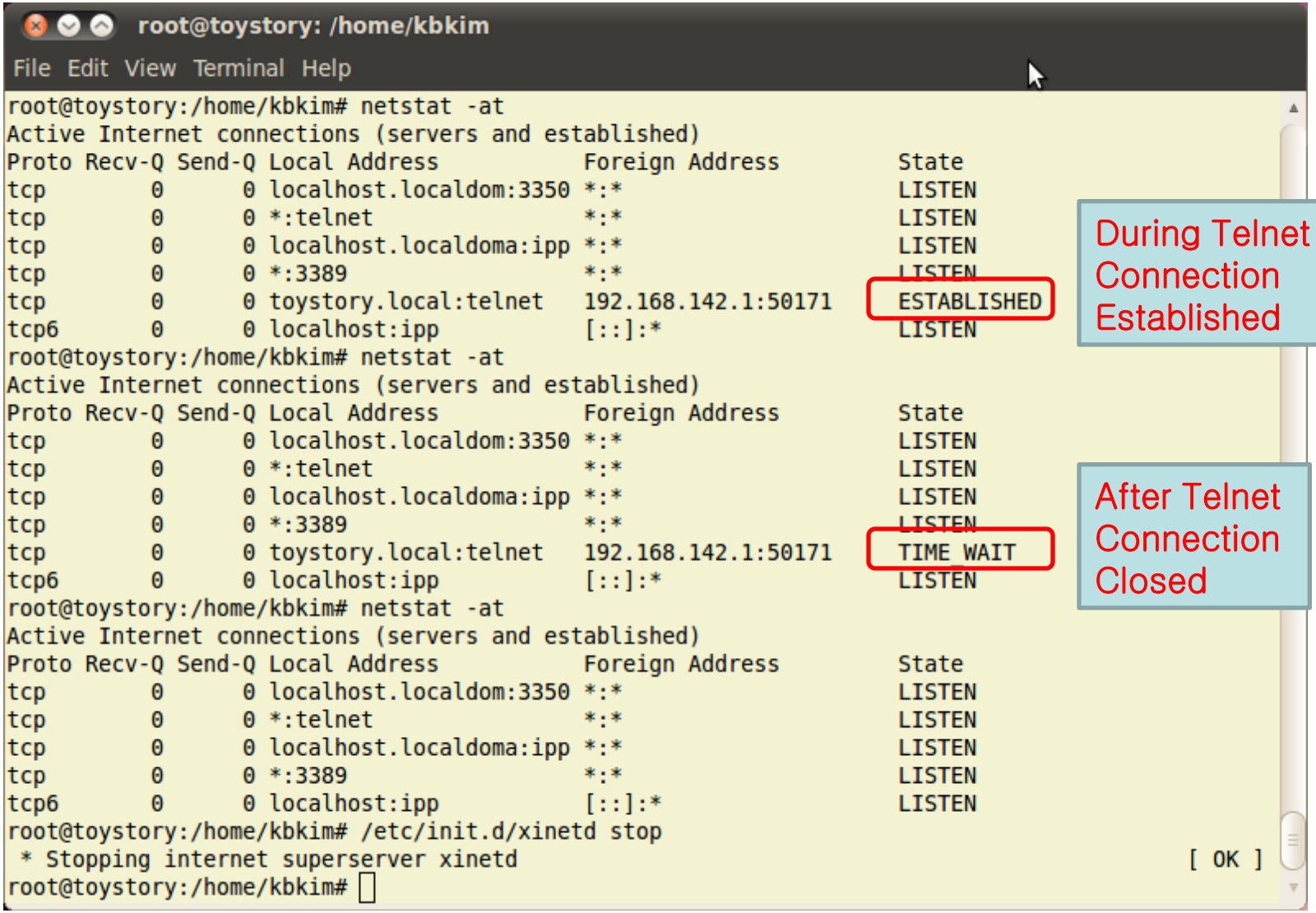
Modify xinetd configuration



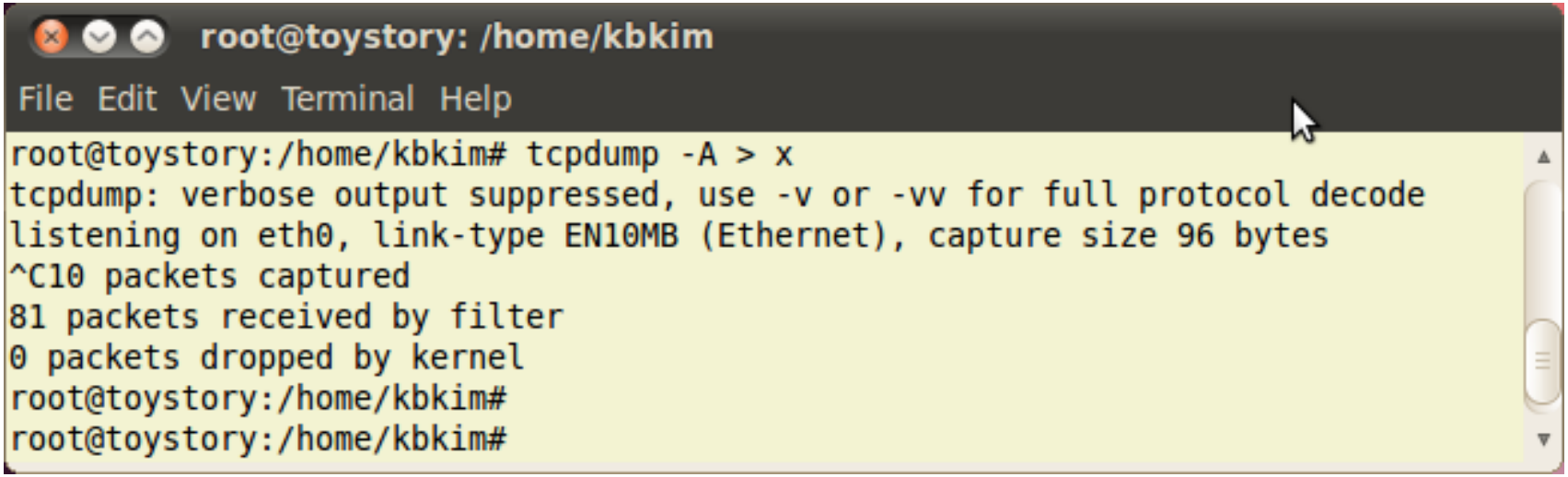
Run telnet server and use telnet



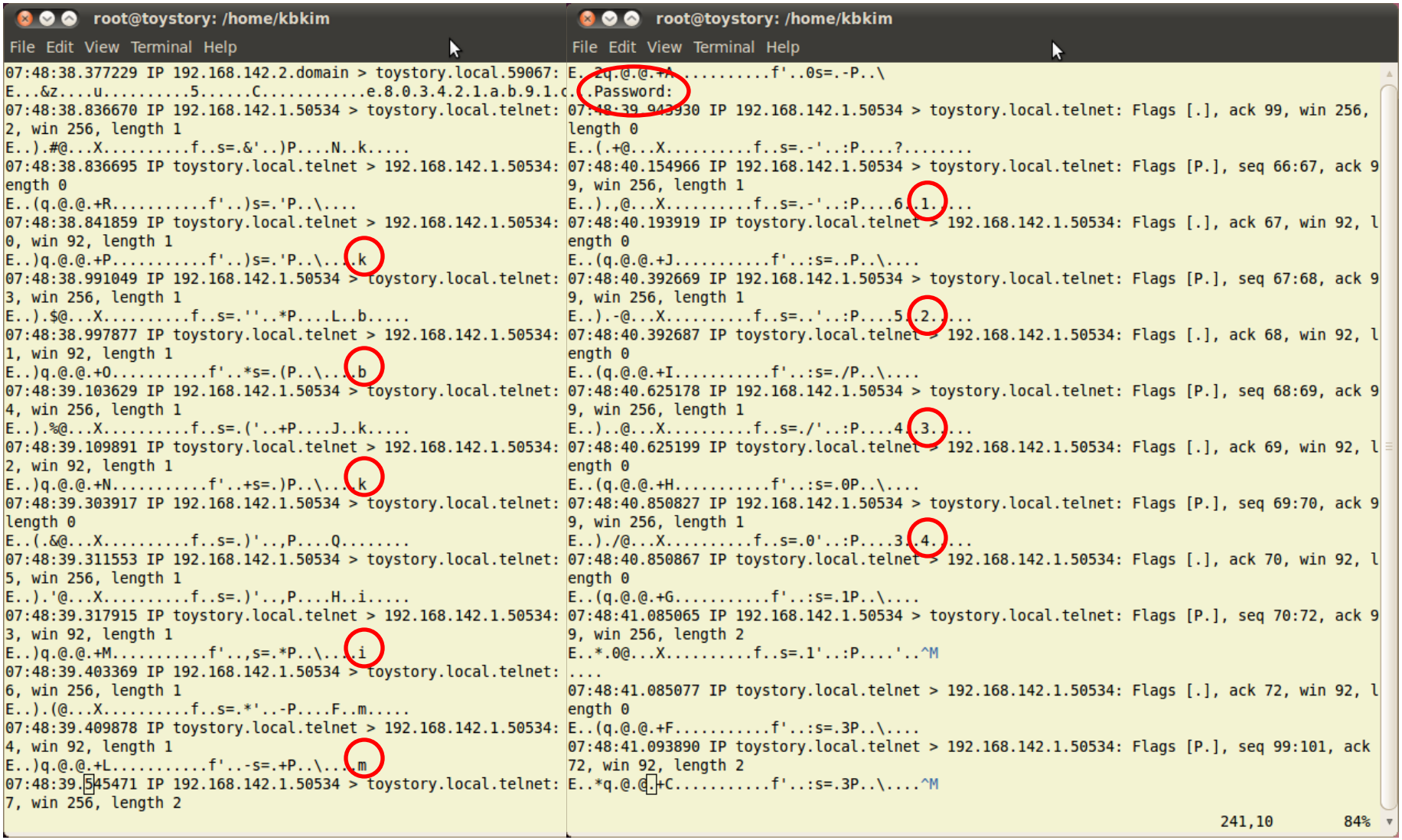
Change of status of network



Eavesdropping password over telnet



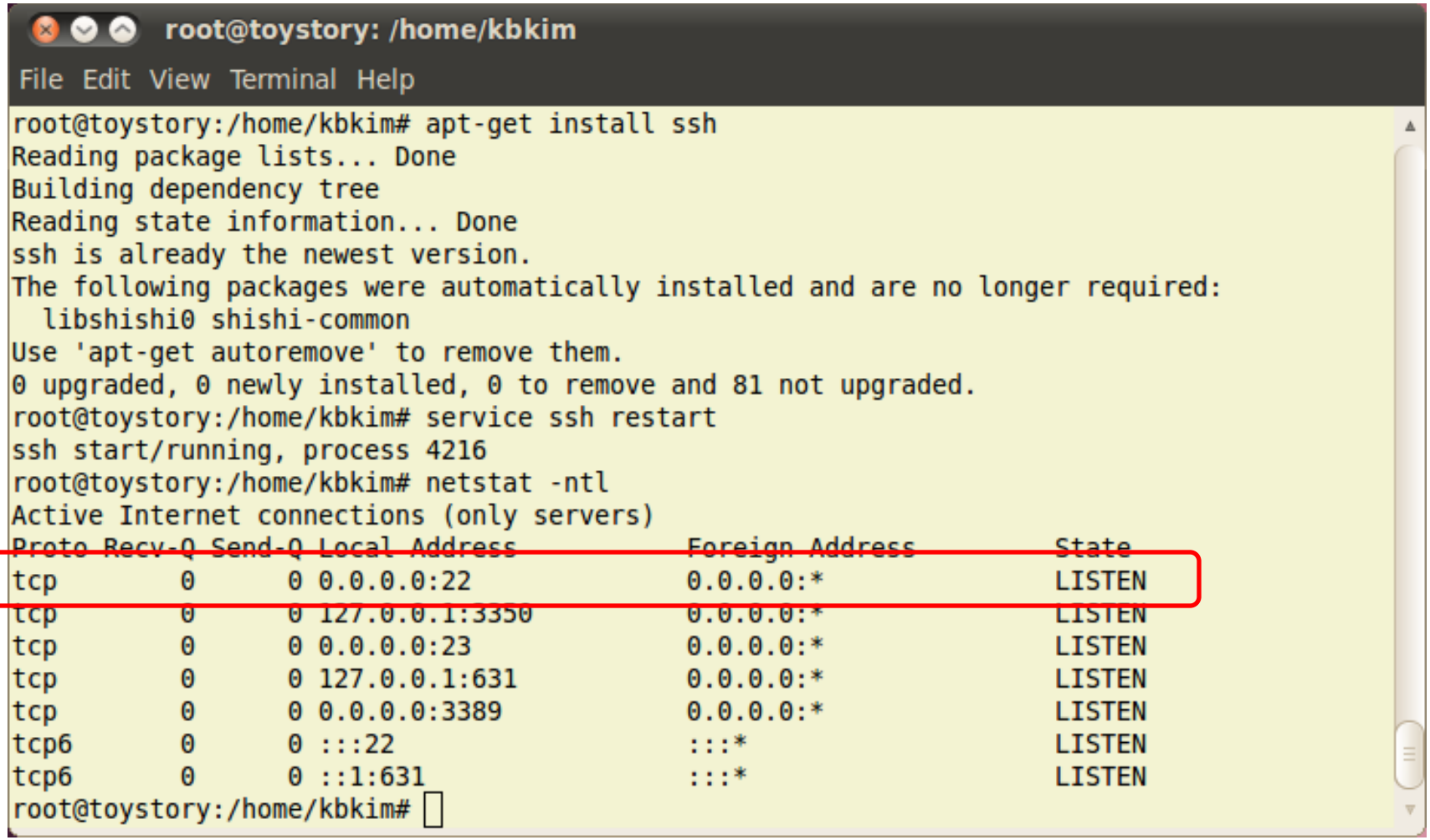
Your Login name and Password are revealed!!



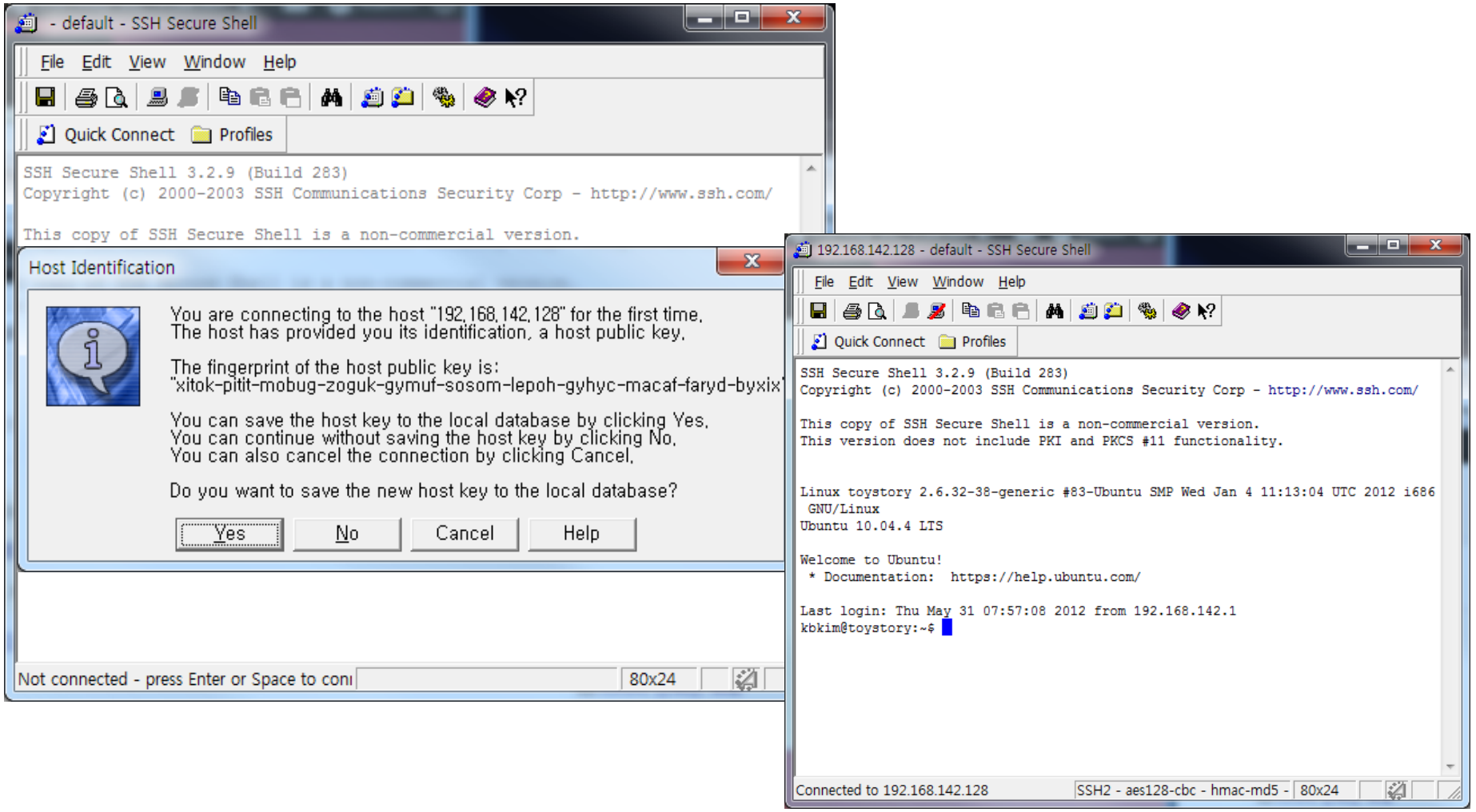
SSH

- Telnet is relatively unsecure protocol
  - Use plain text for passing passwords
- SSH
  - Secure Shell → for secure data communication
    - Use 22 port
  - Establish a secure channel over an insecure network
  - Use public-key cryptography to authenticate the remote computer
    - Entire login session, including transmission of password is encrypted
  - It can be used for other applications
    - ftp → sftp, svn → ssh+svn, cp → scp

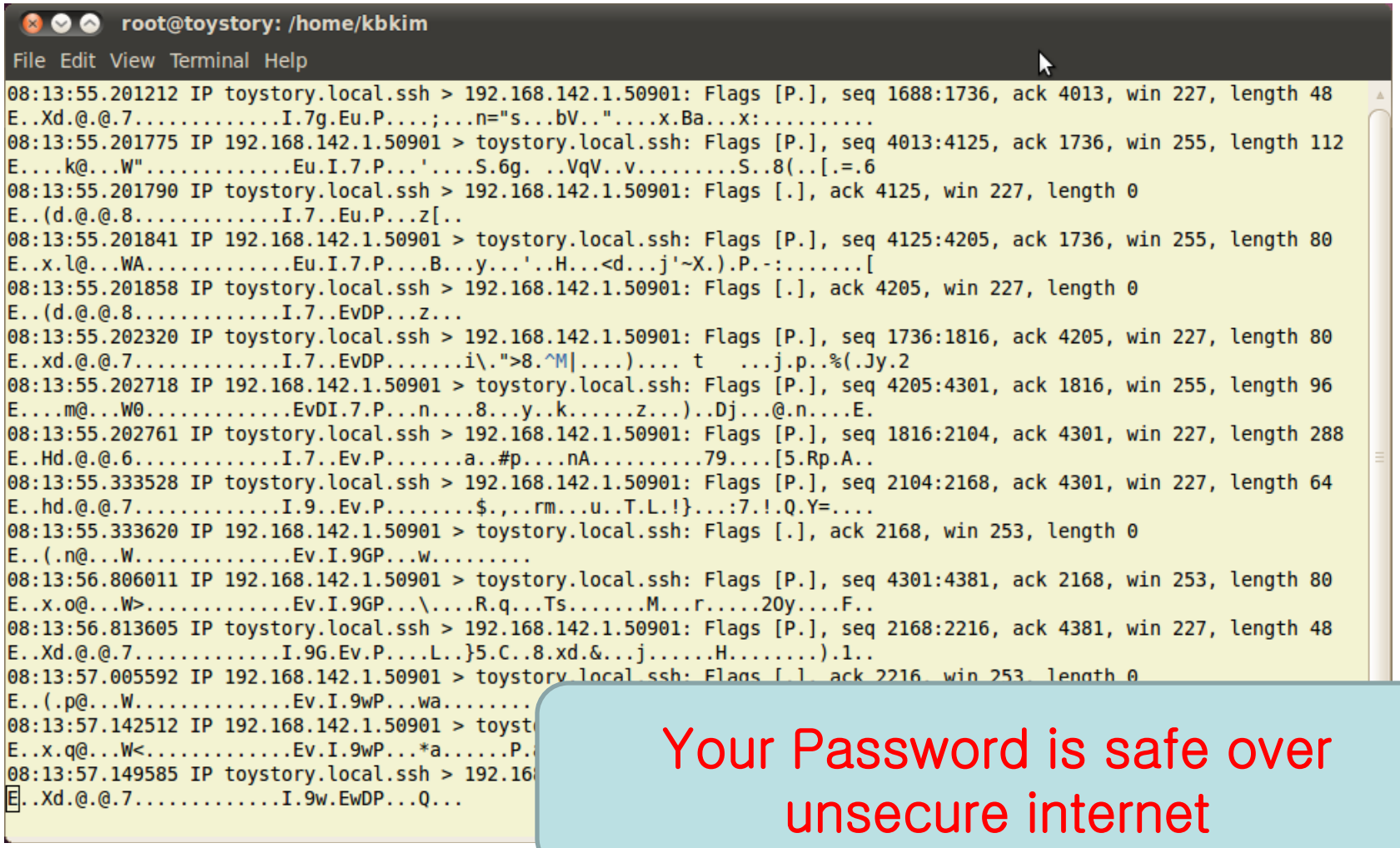
Setup ssh server



ssh client

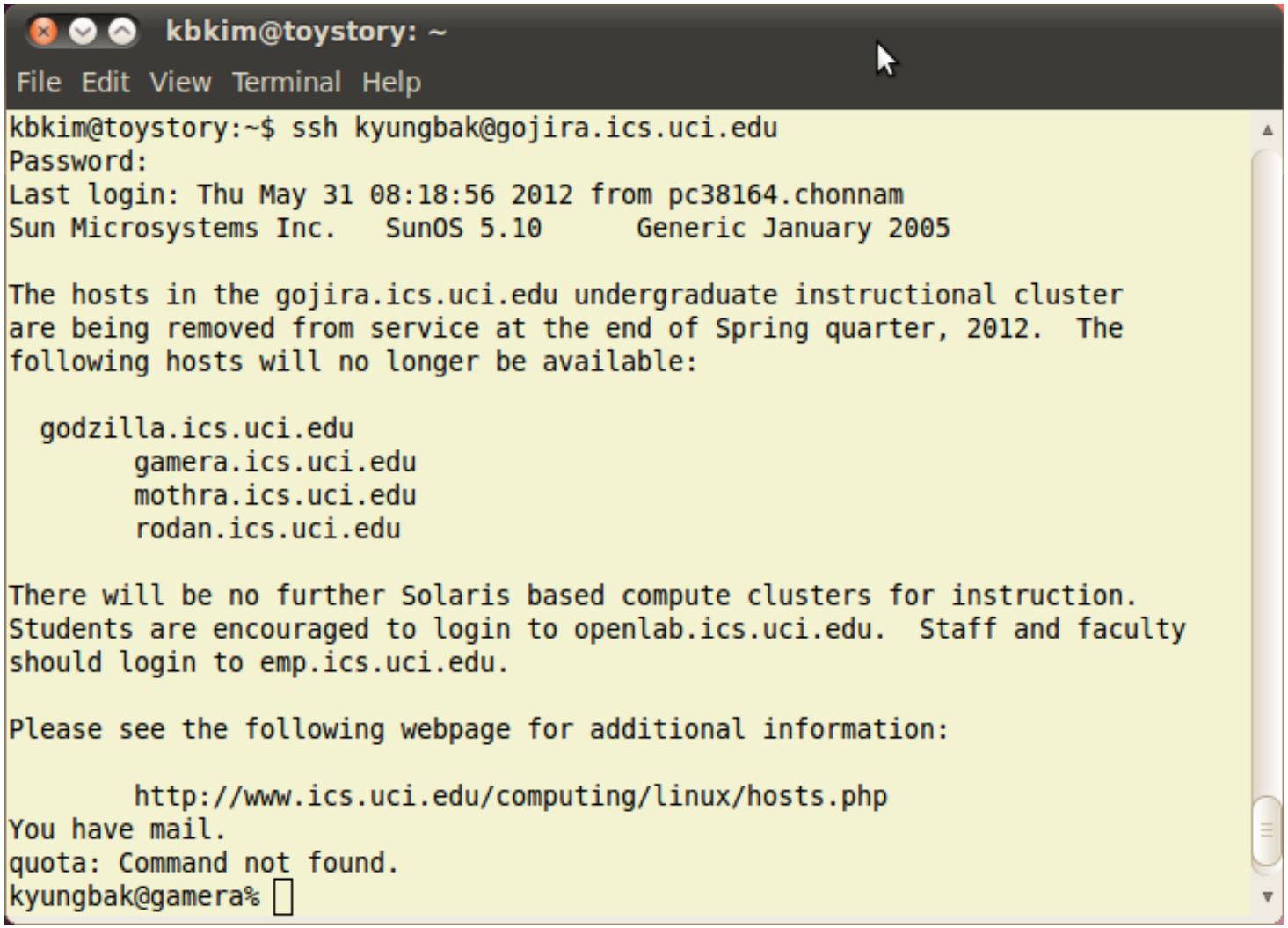

- default - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles
SSH Secure Shell 3.2.9 (Build 283)
Copyright (c) 2000-2003 SSH Communications Security Corp - http://www.ssh.com/
This copy of SSH Secure Shell is a non-commercial version.
Host Identification
You are connecting to the host "192.168.142.128" for the first time.
The host has provided you its identification, a host public key.
The fingerprint of the host public key is:
"xitok-pitit-mobug-zoguk-gymuf-sosom-lepoh-gyhyc-macaf-faryd-byxix"
You can save the host key to the local database by clicking Yes.
You can continue without saving the host key by clicking No.
You can also cancel the connection by clicking Cancel.
Do you want to save the new host key to the local database?
Yes
No
Cancel
Help
Not connected - press Enter or Space to con
80x24
192.168.142.128 - default - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles
SSH Secure Shell 3.2.9 (Build 283)
Copyright (c) 2000-2003 SSH Communications Security Corp - http://www.ssh.com/
This copy of SSH Secure Shell is a non-commercial version.
This version does not include PKI and PKCS #11 functionality.
Linux toystory 2.6.32-38-generic #83-Ubuntu SMP Wed Jan 4 11:13:04 UTC 2012 i686
GNU/Linux
Ubuntu 10.04.4 LTS
Welcome to Ubuntu!
* Documentation: https://help.ubuntu.com/
Last login: Thu May 31 07:57:08 2012 from 192.168.142.1
kbkim@toystory:~$
Connected to 192.168.142.128
SSH2 - aes128-cbc - hmac-md5 -
80x24

Login information is encrypted

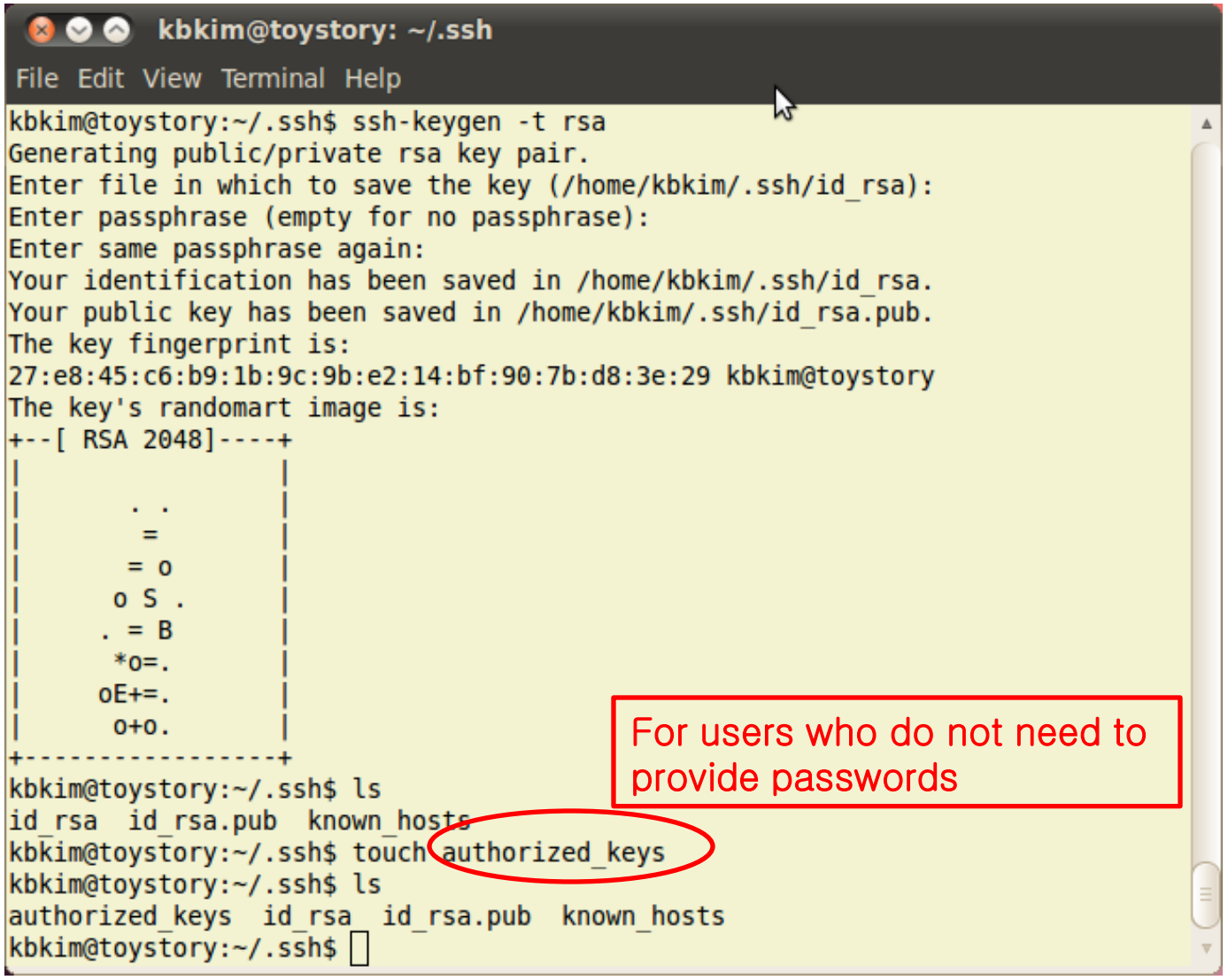


Your Password is safe over unsecure internet

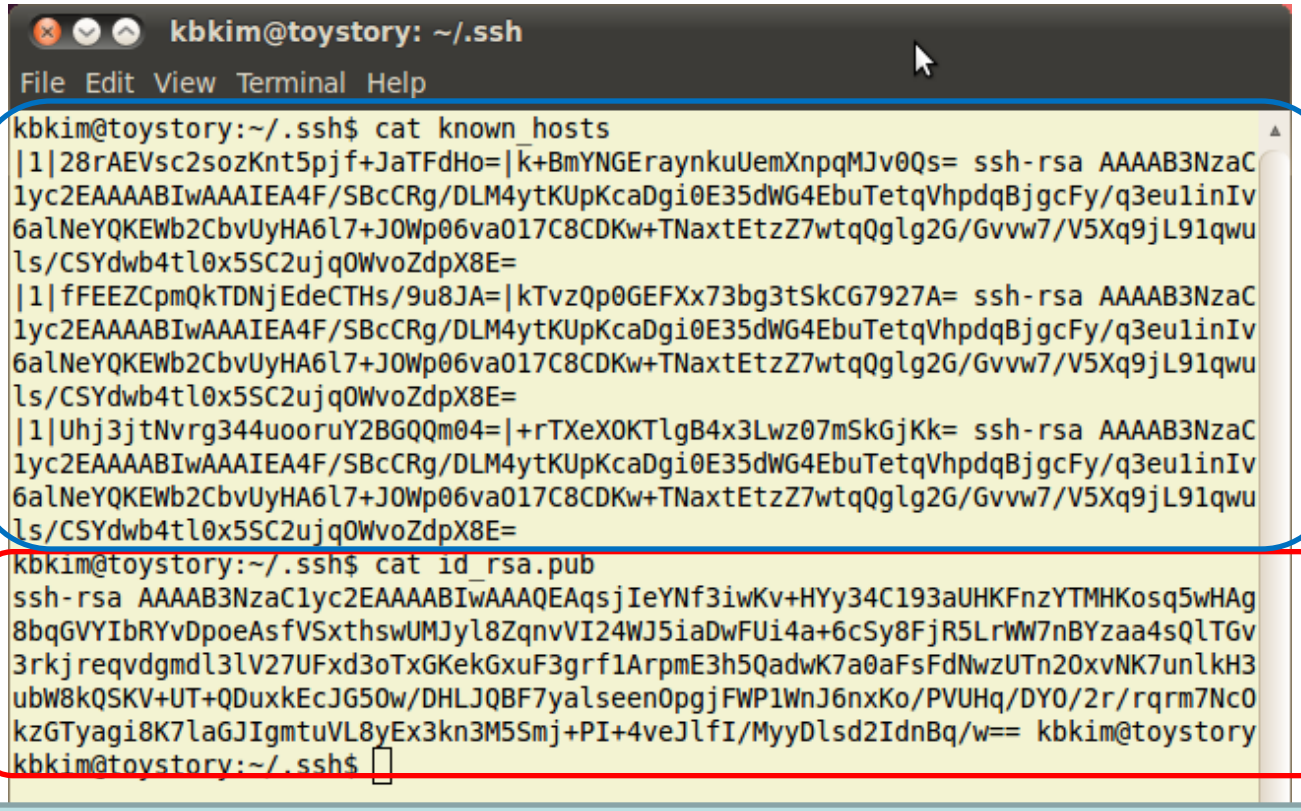
ssh client in Ubuntu



Using public key



Contents of known_hosts and rsa key



Key for Machines

Key for Users

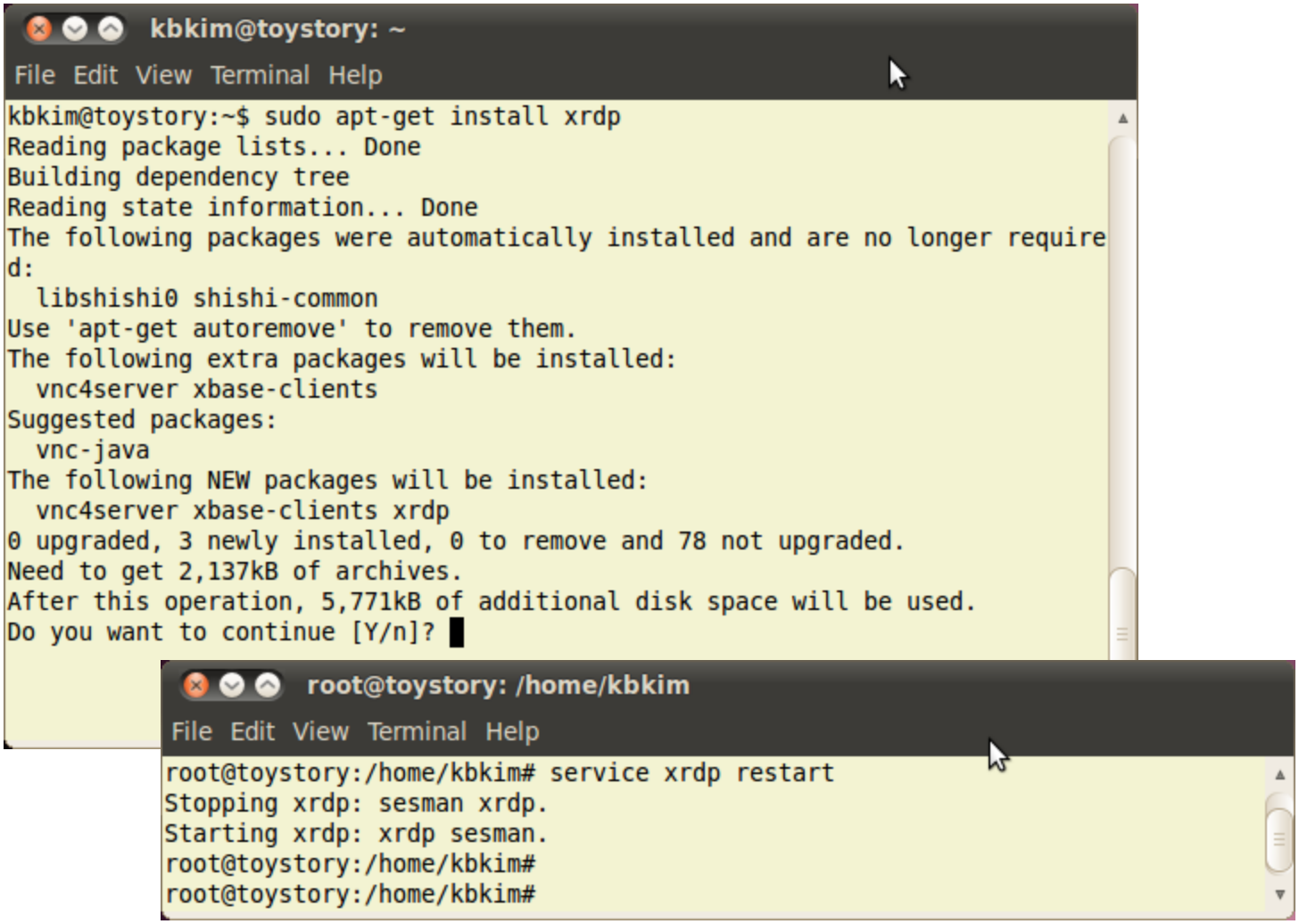
kbkim@toystory$ cat id_rsa.pub >> authorized_keys

➔ After this command user “kbkim” does not need to provide password to establish ssh connection.

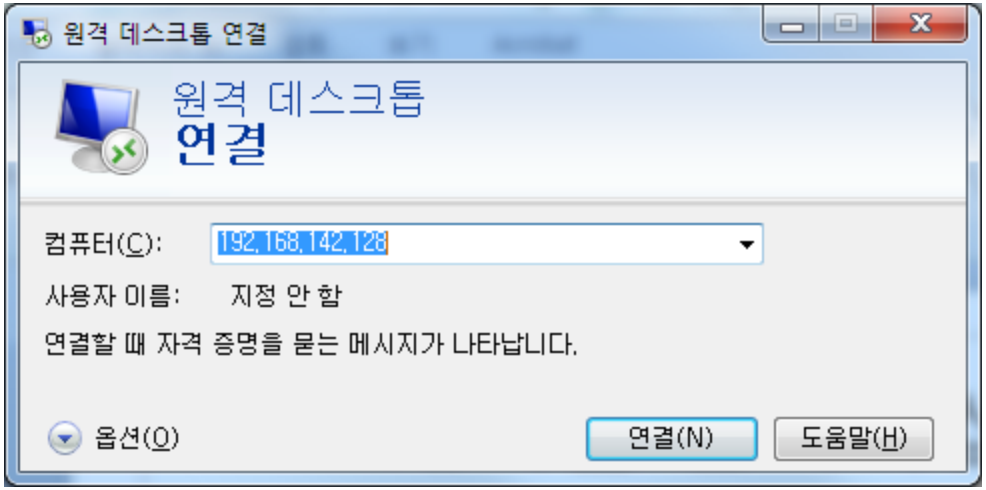
Remote Desktop

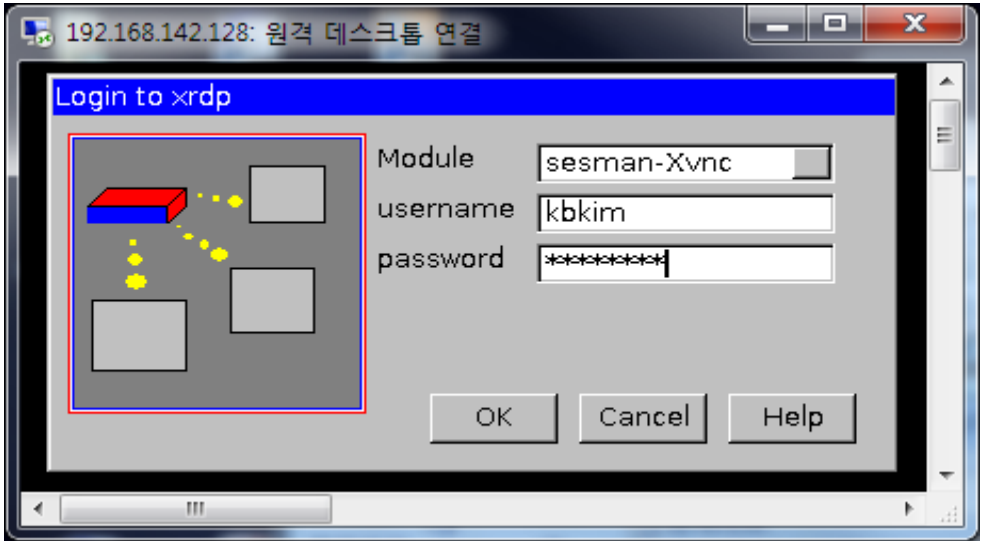
- A client accesses a server machine with a desktop environment
- RDP : Remote Desktop Protocol
  - Developed by Microsoft
  - Client exist for most version of MS windows, Linux, Unix, Mac OS X, Androd
  - TCP port : 3389
- Server deamon in Ubuntu
  - xrdp with sesman (session manager)

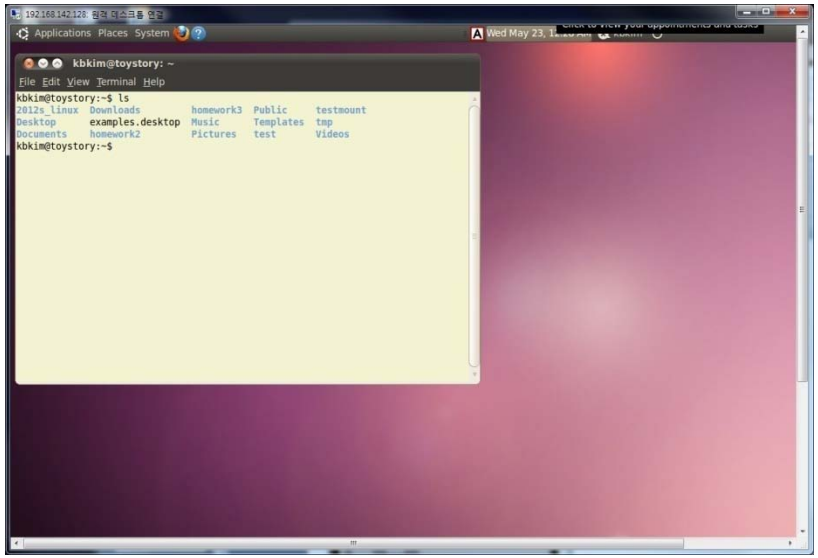
Example of installation of xrdp



Client Side


원격 데스크톱 연결
원격 데스크톱
연결
컴퓨터(C):
192.168.142.128
사용자 이름:
지정 안 함
연결할 때 자격 증명을 묻는 메시지가 나타납니다.
옵션(O)
연결(N)
도움말(H)


192.168.142.128: 원격 데스크톱 연결
Login to xrdp
Module
sesman-Xvnc
username
kbkim
password
OK
Cancel
Help


Applications Places System
kbkim@toystory: ~
File Edit View Terminal Help
kbkim@toystory:~$ ls
2012s_linux Downloads homework3 Public testmount
Desktop examples.desktop Music Templates tmp
Documents homework2 Pictures test Videos
kbkim@toystory:~$

ftp server

- File transfer protocol
- VsFTP server
  - Installation : # apt-get install vsftpd
  - How to run : # service vsftpd start/stop/restart
  - Configuration of vsftp
    - Configuration File : /etc/vsftpd.conf
    - User login : allow users for connecting to ftp server
      - Local_enable = YES
    - Chroot : restrict user directory
      - Chroot_local_user = YES
    - Upload/write option
      - Write_enable=YES

ftp server : anonymous users

- Anonymous user setting
  - Allow anonymous users
    - Anonymous_enable=YES
  - Set the directory of anonymous users
    - Anon_root=/var/ftp
  - Use password for anonymous users
    - Secure_email_list_enable=YES
  - Allow update or write from anonymous users
    - Anon_upload_enable=YES
  - Allow delete or rename from anonymous users
    - Anon_other_write_enable=YES

Samba server

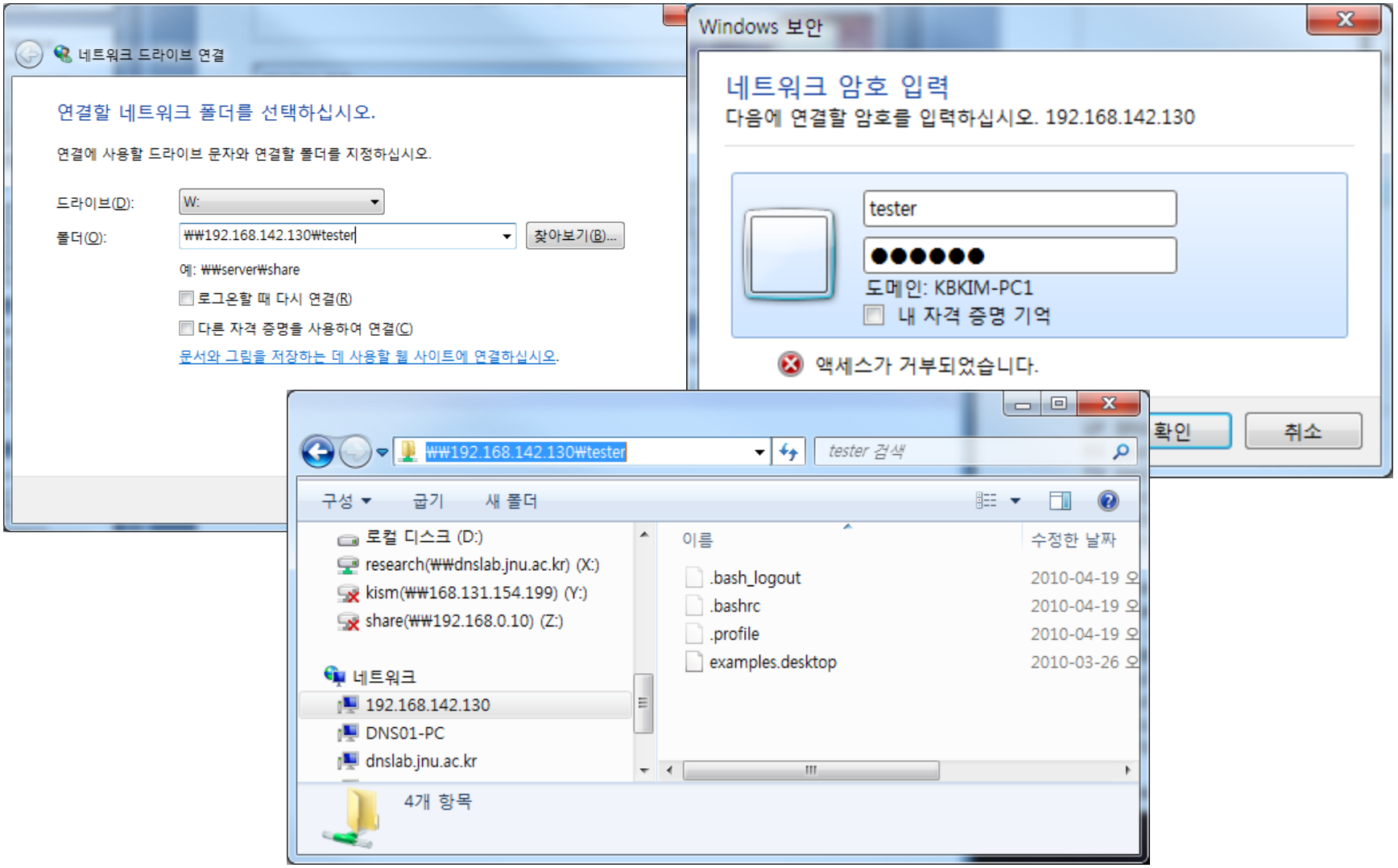
- A free software re-implementation of the SMB/CIFS networking protocol
- Provides file and printer services for various Microsoft Windows clients
- Samba runs on most Unix and Unix-like systems, such as Linux, Solaris, and BSD variants

Using Samba Server

- Installation : # apt-get install samba smbfs
- How to run : # service smbd restart/start/stop
- Configuration of samba server
  - Configuration file : /etc/samba/smb.conf
  - Authentication setting
    - Security=user
    - Username map=/etc/samba/smbusers
      - Need to set samba password for a user and indicate the user on /etc/samba/smbusers file
      - e.g., # smbpasswd –a kbkim
  - Sharing setting
    - [homes]
    - comment = Home Directories
    - browseable = no
    - valid users = %S
    - read only = yes or Writable = yes

```
[any directory]
path = /var/any/directory
valid users = anyuser otheruser
browseable = no
writable = yes
public = yes
create mask = 0660
directory mask = 0770
```

Example of Samba

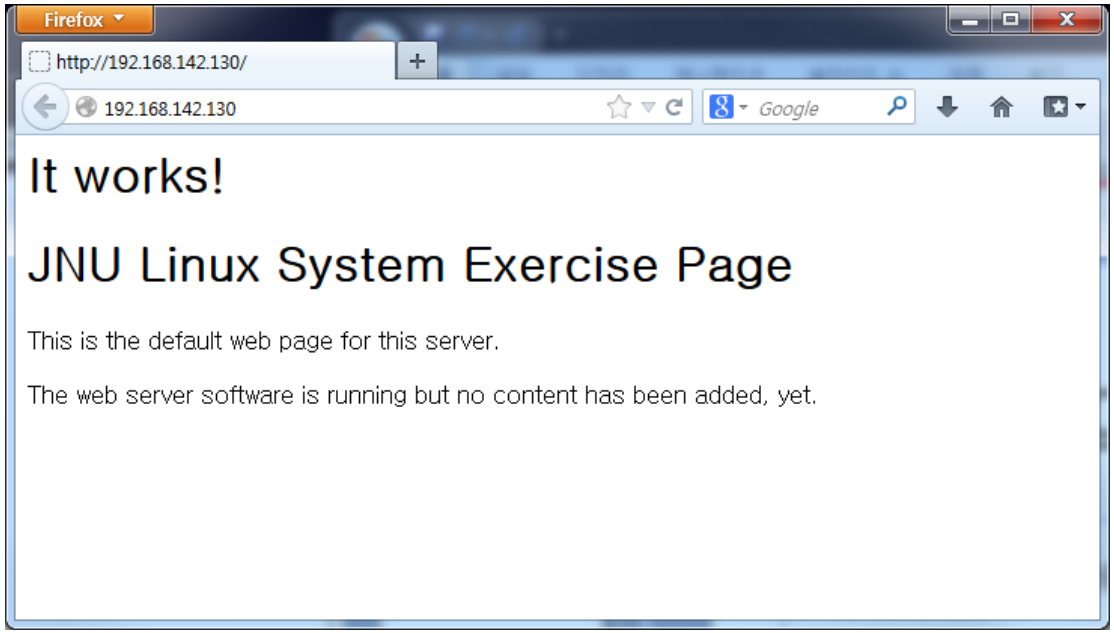


Apache2 http server

- Web server software program, notable for playing a key role in the initial growth of the WWW.
- Typically Apache runs on a Unix-like operating system, and was developed for use on Linux
- Developed and maintained by an open community of developers under the auspices of the Apache Software Foundation

Using Apache Web Server

- Installation : # apt-get install apache2
- How to run : # service apache2 restart/start/stop
- The home location of your web server
  - Default : /var/www
  - You can see the index.html in here



Configuration of Apache Web Server

- Configuration
  - Configuration folder : /etc/apache2
    - Sub directories and files are for configuration of Apache Web Server
    - apache2.conf : main configuration
    - mods-available : available server modules
    - mods-enabled : enabled server modules
      - Symbolic links to point available modules
    - sites-available/sites-enabled : site configuration

Allowing users' web page

- Enable user directory modules
  - # ln –s /etc/apache2/mods-available/userdir.load /etc/apache2/mods-enabled/userdir.load
  - # ln –s /etc/apache2/mods-available/userdir.conf /etc/apache2/mods-enabled/userdir.conf
  - # service apache2 restart
- Prepare web contents at user side
  - Create "public_html" directory under home directory of a user
  - Create "index.html" under "public_html" directory
  - NOTE!! The file permission should be 755 for web directories 644 for web files