

Introduction to Information and Communication Technologies for Development

Communication and Internet (Days 1, 2, and 3)

Abstract

- Introduction
- Brief history of information communication
- **Outline of the Internet Protocols for the Internet**
- History of Internet
- Ethernet
- Internet protocol
- Related protocols (ARP, DHCP, TCP, NAT, DNS, HTTP, SMTP, FTP)

1 Introduction

1.1 Purpose of this lecture

Why do we have to study **Information communication**

- Power of man or a machine is small.
- The size of a problem is large.
 - Environmental pollution
 - Global warming
- We have to cooperate to solve the problem.

- The purpose of Global Engineering for Development, Environment and Society
⇒ **Tackling societal problems in a global era – international development, the environment, resources, and energy**
- **Network technology** is a **basic knowledge** to work globally.
- The construction and maintenance of network are very important for international development.
Assume that fine roads have been constructed in a place. However, it can not be used if there is no network.
- The basic knowledge is important for trouble shooting with respect to network. If a person do not have enough knowledge about network, he cannot understand manuals of network equipment.
- **If you can set network quickly, people think you are smart.**
(Unfortunately, the real world is not so easy.)
- If you can fix trouble of network in your laboratory, I am happy because my work is decreased!

1.2 History of network

- Related transportation by horses (BC6–4, Persha)
- Smoke signal (BC3, China)
- **Postal service system** (Middle ages, Europe)
- Semaphore (1793–, Europe)
- **Telegraph** (1832, UK), Telex (1933– around 2000)
- **Telephone** (1876–, Graham Bell)
- Wireless telegraph (1894–, Guglielmo Marconi)
- Modem with telephone line (Personal computer) (1980–)
ISDN (Integrated Service Digital Network)
- **Internet** (1969–, From 1990, Internet was spread)
All communication are going to be done by Internet.
 - Data communication
 - Telephone and cellphone



Smoke signal



Semaphore



Telegraph



Telex



Telephone



Telephone (Using telephone switchboard (by human))



Telephone (Using telephone exchange (by machine))



Wireless telegraph (Discharge and cohere detector)



Acoustic coupler

1.3 Purpose of information communication

Past:

- **War** : To know situation and send command.
- **Governance** : To know situation send command.

Now:

- To communicate with people in the all over the world.
- To collect and emit information.
 - **Society**: e-mail, Web, e-government, social information
 - **Economy**: e-mail, Web, e-commerce, economical information
 - **Life**: e-mail, Web, amusement(5ch, Niconico video), blog, living information
 - **Academy**: e-mail, web, e-publishing, academic information

1.4 Lecture plan

1. Purpose and abstract of this lecture and roles of information communication (S611) 11/29
2. Outline of the Internet (S611) 12/6
3. Protocols for the Internet (GSIC 3F 1st Practice Room) 12/13
4. Outline of Internet services and their basic technologies (Practice of Html) (GSIC 3F 1st Practice Room) 12/20
5. Information technology in Internet services (Practice of CSS and SQL) (GSIC 3F 1st Practice Room) 1/10
6. Information technology in Internet services (Practice of PHP) (GSIC 3F 1st Practice Room) 1/24
7. Theory and technology of e-Learning (S611) 1/31
8. Practices and Assessment of e-Learning (S611) 2/4 (Tue.)

- For Days 3, 4, 5, and 6 (or latter part of Day 3), the class will hold at information and network practice room 1 on 3F in Global Scientific Information and Computing Center.
- Please make account of GSIC computer for education before Day 3.
- Tokyo Tech student can make the account.

See <http://www.edu.gsic.titech.ac.jp/index.php?アカウント利用開始方法>

2 Brief history of Internet

- **ARPANET** (1969) is a prototype.
 - Networks in universities were connected
 - UCLA, UC Santa Barbara, Stanford Univ., Univ. of Utah
 - Purpose : Load distribution, message service, provide information, remote login,
- Meaning of 'Internet' : Connect networks share programs
- Tohoku University attended ALOHAnet (ARPANET) in 1981.
- **JUNET** (1984) : Univ. of Tokyo, Keio Univ., TokyoTech
- Now, Internet is used by many people owing to World Wide Web
- The huge increase of communication has been supported by optical communication technology.
- Ubiquitous network \Leftarrow Wireless communication

3 Network protocol

- **Protocol**: Regulation, promise
- **Layers** of network protocol:
 - We can send 0 or 1 between two computers connected by a cable directly.
 - We can send a packet (unit of data) between two computers that are very far from each other in the world.
 - We distribute a movie through network.
- **OSI** (Open System Interconnection) model defined by **ISO** (International Standard Organization)
 - OSI is also a protocol for network similarly to Internet.
 - KDDI used it for their network. However it was defeated.
- Old network protocols:
Microsoft network, NetBIOS, DECNet, Token Ring (IBM), and CAMAC (for measurement).

3.1 OSI model

- **Application layer:**
High-level APIs (Application programming interfaces).
- **Presentation layer:**
Data format (Character coding, compression, and encryption)
- **Session layer:**
Management of sessions (Continuous exchange of information)
- **Transport layer:**
Transparent (Communication between applications. Ex. UDP, TCP)
- **Network layer(Layer 3):**
Managing multi-node network (Ex. IP, Internet protocol)
- **Data link layer(Layer 2):**
Transmission between two nodes by a physical layer (Ex. Ethernet, modem)
- **Physical layer:**
Transmission of bit streams over physical medium (Ex. voltage, shape of connector, or RS-232C)

3.2 Ethernet (RFC 894)

- A protocol for **Physical layer** and **Data link layer**
- Xerox and DEC developed for LAN (Local Area Network).
- **CSMA/CD** (Carrier Sense Multiple Access with Collision Detect)
Multiple computers can be connected by a cable
(It was very epoch-making at that time.)
- Packet transmission
- It was standardized by IEEE 802.3
- 10Base-2 : A computer is connected by a T-connector and coaxial cables.
- 10Base-5 : Multiple computers are connected on a coaxial cable.
- 10Base-T : Star connection. A Hub (Switch) and a computer are connected.
 - Hub : The same signal is output to all cables. (Similar to a cable)
 - Switch (Switching hub) : By checking the destination of signal, signal is output to a selected cable. (Layer 2 switch and Layer 3 switch)

- Transfer speed (bps)
 - bps = bit/sec (How many bits can be transferred in a second.)
 - 10Base-2, 10Base-5, and 10Base-T: 10Mbps
 - 100Base-T: 100 Mbps
 - **1000Base-T**: 1000 Mbps = 1 Gbps
 - 10GBase-T: 10 Gbps

3.3 Packet of Ethernet

3.3.1 MAC Address

- **Media Access Control** address
- Example: 00:14:22:0A:1A:D4 (00–14–22–0A–1A–D4)
- The upper 24bit: OUI, Organizationally Unique Identifier
IEEE assigns the number to an organization by paying 1,650 US dollar.
- The lower 24bit: The organization can decide the number freely.
- It is sometimes called “Hardware Address”.
- **In principle**, A MAC address and an Ethernet device have the one to one relation. The same address is never assigned.

Digression:

- Because MAC address is unique in the world, it was used for managing software license and cable TV connection.
- It is rare to specify MAC address directly to communication.

3.3.2 Structure of Ethernet packet

- **Packet**: a unit of data in a communication path
 - A large size of data is divided into a number of packets.
 - Destination, source, serial number, etc. are added to packets.
- Ethernet (RFC 894)
 - RFC (Request For Comments):
The document number for internet specification.
- It was standardized as IEEE 802.2/802.3 (RFC 1042).
- However, many devices follow only the specification of Ethernet.
- This is because Ethernet were widely used before it was standardized.

● Structure of Packet

- Destination address (6 byte, MAC address)
- Source address (6 byte, MAC address)
- Format (2 byte) (0800 : IP datagram, 0806: ARP, 8035: RARA)
Type of data in the packet.
- Data (40~1500 byte)
- CRC (Cyclic Redundancy Check) (0~4 byte)

Digression:

Circuit switching (Traditional telephone) \Leftrightarrow Packet switching

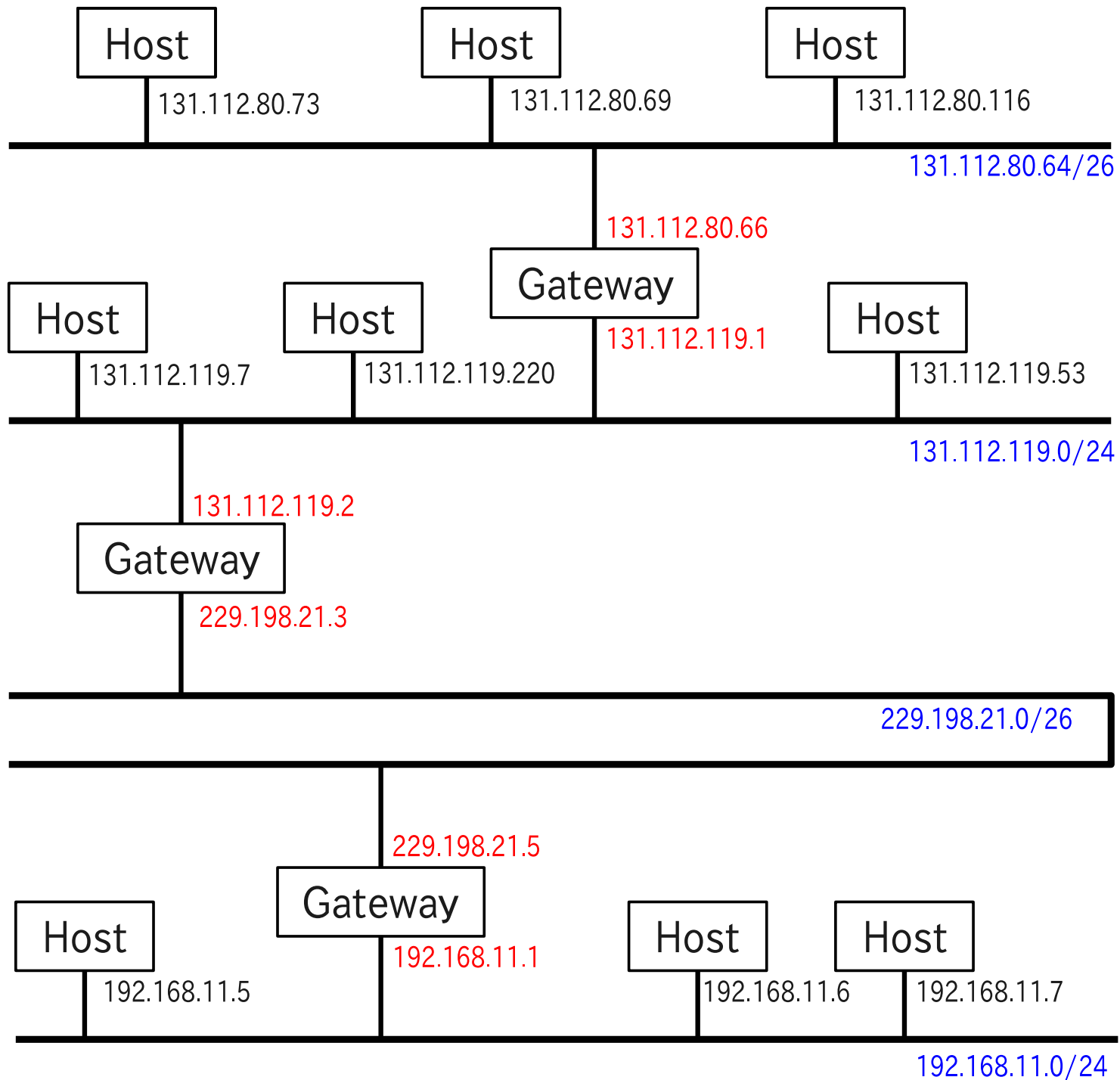
3.4 Internet protocol (IP)

- A protocol in **Network layer (Layer 3)**
- It was researched with support of Advanced Research Project Agency (ARPA)
- The origin of Internet is ARPANET (1969-).
- Internet implies “connect networks”.
- **Purpose:** Load balancing, message service, share of information, share of program, remote login.
- Packet switching is adopted.
- The first university in Japan that connected to ARPANET is Tohoku University. It participated ALOHAnet (Hawaii) in 1981.
- The first network in Japan (named **JUNET**) was build by Tokyo University, Keio University, and Tokyo Tech in 1984.
- For transfer of IP packets among three university, UUCP (Unix to Unix Copy Protocol) that are a group of Unix commands for data transfer was used.

- My first e-mail address: yamasita@cs.titech.junet
- The machine named koudai is the gateway to external networks.
- After **WWW**(World Wide Web, 1989–) is invented and used widely, Internet has spread explosively.

Digression:

- The article of Time is not true describing Internet was developed in order that communication survives under nuclear war.
- After Windows 95, Microsoft started to say “Use Microsoft software for Internet.”
Before that, they criticize Internet.



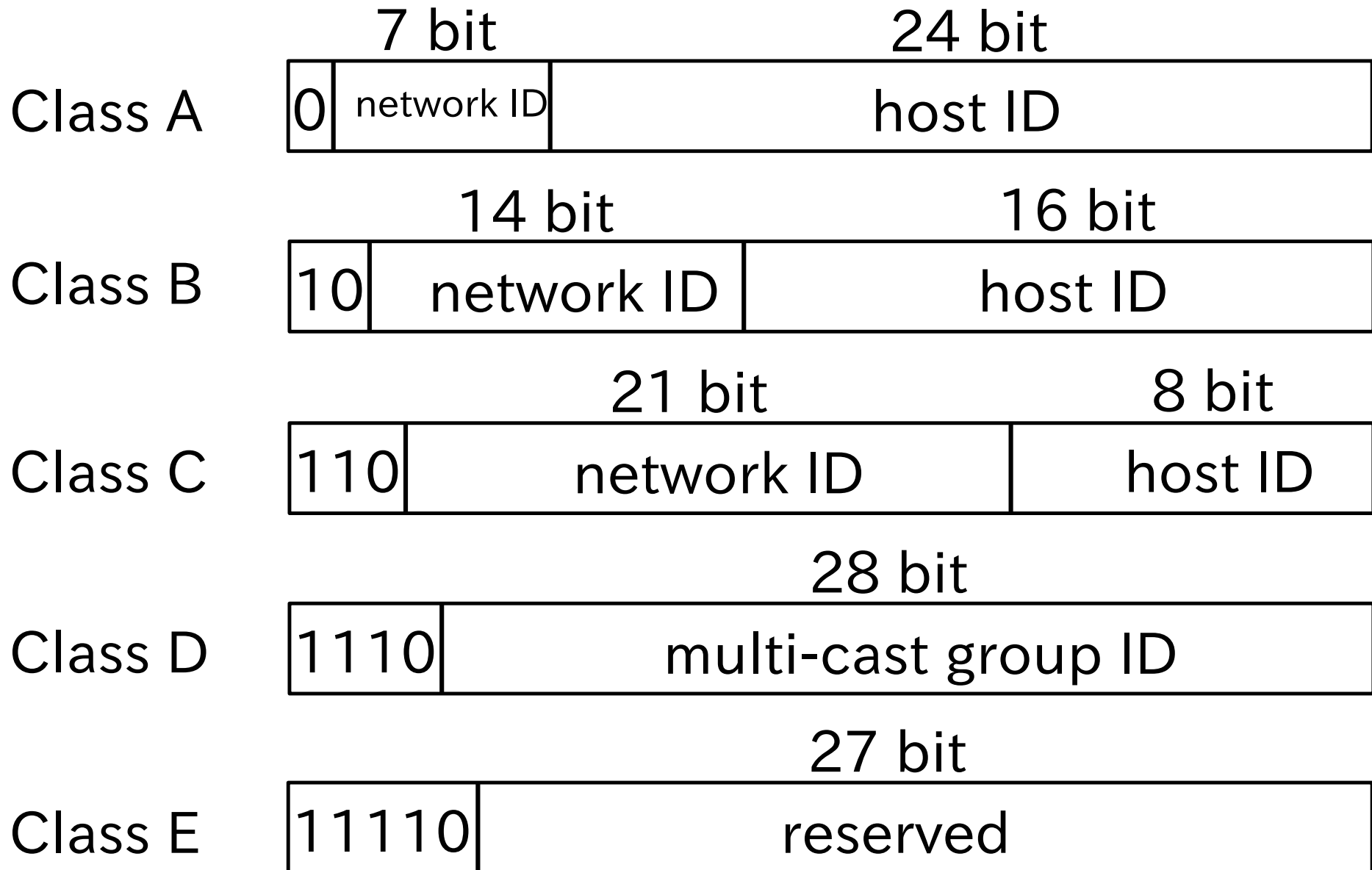
3.5 Internet Protocol (IP) Packet

3.5.1 IP Address (Version 4)

- **IP address**: Identification number for a computer in a network.
- 32 bit (Maximally 4294967296)
- It consists of Network ID and Host ID.
- Classes to classify the bit lengths of the two IDs were made.

Digression:

- In Internet, Japan has to pay to US for communication both from Japan to US and from US to Japan.
- About 15 years ago, Japan and the Philippines have to pay to US for communication between the Philippines and Japan.
- **Tier 1** Internet providers (10 companies).
- Networks in Japan and in the Philippines are connected to one of the companies.
- IPv4 addresses that have not been assigned yet are few.
- Tokyo Tech has class B addresses (65536 addresses)



- **Subnet mask**

- Flexibility by classification is too low.
- Now the separation of Network ID and Host ID is done by the subnet mask.
- The subnet mask is 32 bit and the value of each digit should be 1 in the former part and 0 in the latter part.
(Ex. 11111111110000000000000000000000)
- The set of digits of which value is 1 indicates **Network ID** in IP address. That of 0 indicates **Host ID** in IP address.
- Value of subnet mask is often expressed by 4 decimal numbers for 4 integers of which length is 8 bit (255.255.192.0), or the length of network ID with IP Address and slash (131.112.80.200/26).
- Practice: When a host has IP Address of 131.112.80.201 and subnet mask of 255.255.255.192, answer Network ID and Host ID.

- **Network address**

- When all bits in Host ID are 0, the IP Address expresses the network.

- **Broadcast address**

- When all bits in Host ID are 1, the IP address is Broadcast address in the network. The packet is sent to all hosts in the network.
- That is, all hosts in the network receive a packet of which destination address is Broadcast address.

- **Network and Broadcast addresses cannot be used as Host ID.**

- **Multi-cast address**

- The address is decided according to the purpose of packet. Multiple hosts matching to the purpose receive it.
 - It is efficient since the information can be sent to multiple hosts by one packet.
- The arrival of IP packet is not insured.
That is, the sender dose not know directly whether the packet is received or not.

Structure of IP packet

- Version (4 bit)
- Header length (4 bit)
- Type of service (**TOS**, 8 bit)
- Total length in unit of byte (16 bit)
- Identifier (of packet for the source host, 16 bit)
- Bit Flag (2 bits are used among 3 bits.):
 More Fragment bit, Don't Fragment bit)
- Fragment offset (The distance between the top of total data and the top of this fragmented data is shown in unit of 8 bytes. (13 bit))
- Time to live (TTL, Recommended initial value is 64, 8 bit): The number is decremented when the packet moves to another network.
- Protocol (TCP:6, UDP:17, ICMP:1, etc.,8 bit):
 The protocol number of the data.
- Header checksum (16 bit)
- Source address (32 bit)

- Destination address (32 bit)
- Option (0 or more bytes)
- Data (The length is restricted by the maximum packet length)

Type of service (TOS, 8bit)

- Not used (3bit)
- Minimum delay (1bit)
- Maximum throughput (1bit)
- Maximum reliability (1bit)
- Minimum cost (1bit)
- 0 (1bit)

Version	Header Length	TOS	Total Length	
Identifier			Bit Flag	Fragment Offset
TTL	Protocol		Header Check Sum	
Source IP Address				
Destination IP Address				
<h1>Data</h1>				

Fragment frag

- Ethernet packet can contain data of 1500byte at maximum.
MTU (Maximum Transmission Unit) is 1500byte
- If the size of IP packet excesses 1500byte, it should be divided.
- An Ethernet packet contains a divided IP packet.
- Header is added to a divided IP packet.
- Not used (1bit)
- Fragment Prohibition flag (1bit)
- More flag (Show that a more fragmented packet exists, 1bit)

3.6 ARP (Address Resolution Protocol)

- Communication between hosts on the same Ethernet by IP packet.
 - When we send a data, we divide the data and make IP packets with destination IP address, etc.
 - And we make Ethernet packets containing the IP packets.
 - **MAC address is necessary for it.**
Without MAC address, we cannot send the data.

Broadcast address of Ethernet:

- All hosts connected directly are selected by the address.
- A packet with the address for destination is received by all hosts and processed on them.
- The broadcast address of MAC address is FF-FF-FF-FF-FF-FF. (All bits are 1)

(The broadcast address of IP address is the address of which bits in Host ID are 1.)

- By using ARP (Address Resolution Protocol, included in the protocol of Ethernet) we can **find MAC address from IP address**.
- The format of ARP packet is decided by the protocol of Ethernet.
- An ARP packet, one of Ethernet packet, containing destination IP address is sent by using the broadcast address of Ethernet for destination.
- The packet is received by all hosts in the Ethernet.
- If the IP address in the packet is the same as the IP address of a host, the host makes an Ethernet packet containing its Ethernet address and replies to the host.
- When the former host receives the packet, it makes Ethernet packets containing (divided) IP packet and send it by using the Ethernet address.
- The relations between IP address and MAC address are cached (temporally stored).

Digression:

- **RARP (Reverse Address Resolution Protocol)**: By the protocol, a host can ask its own IP address to other hosts from its MAC address. It is used by thin client system (diskless system).

3.7 IPv6

- **IPv4** (Internet Protocol Version 4)
 - Address of current Internet protocol is an only 32bit integer. We can have about 4 billion address at most.
- **IPv6** (Internet Protocol Version 6)
- 128 bit (hexadecimal numbers of 32 digits. It is described by separating by 4 digits with colon.)
 - Example: FE80:CD00:0000:1234:00CD:0000:2342:DC2F

- In each a number of 4 digits, the leading 0s are abbreviated.
FE80:CD00:0:1234:CD:0:2342:DC2F
- There is a method to described when 0s continue. Loop back
0000:0000:0000:0000:0000:0000:0000:0001 is denoted by ::1/128
- **Uni cast**: The unique interface corresponding to the number.
- **Any cast**: The nearest interface corresponding to the number.
- **Multi cast**: Multiple interfaces corresponding to the number.
- Uni cast address consists of subnet prefix of the upper 64bit and interface identifier of the lower 64bit.
- The subnet prefix consists of global routing prefix of the upper 48bit and subnet identifier of lower 16bit.
- Their length can be changed.
- Since Windows uses the letter colon to indicate drives (ex. **C:**), - is used.
(It is the same as the MAC address.)
- 3G/4G cellphone and a smart phone have a IPv6 address.
- In Asian Pacific region, all IPv4 addresses are used and a new address

cannot be obtained.

- The reason is similar to environmental problem, it is difficult to move to IPv6.

4 TCP and UDP

- TCP : Transmission Control Protocol
- UDP : User Datagram Protocol
- They are protocols of transport layer.
- TCP/IP or UDP/IP

4.1 TCP

- TCP packet including TCP header and data is stored into the data region of IP packet.
- Connection oriented:
 - Large size of data is divided automatically.
Applications do not have to concern about packet length.
 - When a TCP packet is received, the receiver sends its acknowledgement packet to the sender.
 - If the sender does not receive the acknowledgement packet of a packet in a fixed period after it was sent, the sender resends the packet.

That is, the sender sends the same packet again.

- The receiver checks a received TCP packet if its checksum is correct or not. If it is not correct, it does not send its acknowledgement packet.
- The order of packet may be changed in transmission line.
- In that case, the software of TCP in a receiver reorders them in order and gives them to the application.
- According to the destination port number, the received packet is provided to an application.
- Data are buffered since transmission time are not constant.
- If the packets of the same content were received, packets except one are discarded.

4.1.1 TCP Header

- Source port number (16 bit)
- Destination port number (16 bit)
- Sequence number (32 bit): It indicates the bytes of data that is already sent in total.
- Acknowledge number (32 bit): It indicates the bytes of data that is already received in total.
- Header length (4 bit)
- Reserved (6 bit)
- Flag (URG, ACK, PSH, RST, SYN, FIN, 各1 bit)
 - URG: Urgent
 - ACK: The acknowledge number is valid.
 - PSH: Transfer the data to the application directly.
 - RST: TCP connection is interrupted or denied.
 - SYN: TCP connection is required.
 - FIN: TCP connection is finished.

- Window size (16 bit): Buffer size of receiver.
- TCP checksum (16 bit)
- Emergency pointer (16 bit)
- Option (16 bit)

Note:

- A pseudo header including destination and source IP addresses can be added.
- Its reason is to check in TCP level whether the packet reaches to a correct host or not and increase reliability.

Source port no.		Destination port no.	
Sequence no.			
Acknowledgement no. (if ACK set)			
Header length	Reserved	Flag	Window size
Checksum		Urgent point (if URG set)	
<h1>Data</h1>			

4.2 UDP

- UDP packet including UDP header and data is stored into the data region of IP packet.
- Datagram oriented (like packet):
 - A target application can be specified by the destination port number.
 - Communication error can be detected by checksum.
When error is detected, the packet is discarded
 - UDP does not concern whether data is received or not.
 - Data is not divided automatically.

4.2.1 UDP Header

- Source port number (16 bit)
- Destination port number (16 bit)
- UDP data length (16 bit)
- UDP checksum (16 bit)

4.3 Port number

- Even if a computer have received a packet, it do not know to which program in the computer it should be sent because many programs work in the computer.
- By the destination port number, a computer knows which application has to receive the data.
- By the source port number, the application in the source computer that sent the packet is known.
- Therefore, by using the source port number as the destination port number of reply packets, the correct application can be receive the reply packet.
- Example:
 - 15/tcp: netstat: NETwork STATstics
 - 20/tcp: ftp-data: data of File Transfer Protocol
 - 21/tcp: ftp: control of File Transfer Protocol
 - 22/tcp: ssh: Secure Shell
 - 23/tcp: telnet: TELE-NETwork login

- 25/tcp: smtp: Simple Mail Transform Protocol
- 53/tcp,udp: DNS: Domain Name Server
- 80/tcp,udp: http: Hyper Text Transfer Protocol
- 995/tcp,udp: pop3: Post Office Protocol V.3
- 443/tcp,udp: https: Hypertext Transfer Protocol over SSL
- 995/tcp,udp: pop3s: pop3 over SSL

5 Gateway and router

- Internet is an aggregate of networks.
- The meaning of a network in Internet:
 - Hosts in a network have the same network address.
(The value of IP address at digits at which the value of the subnet mask is 1.)
 - By using the broadcast address, a host can send a packet to all hosts in a network.
- Gateway
 - A gateway has not less than two IP addresses.
 - An adapter connected to LAN (Local area network) communicates by IP address for LAN.
 - An adapter connected to WAN (Wide area network) communicates by IP address for WAN.
Note: names of LAN and WAN are relative.
 - Gateways transfer packets between two networks.

- Router

- When, a host, which only has an IP address for LAN, wants to communicate with a machine in an external network, packets from the host are sent to gateway.
- The gateway sends the packet to another gateway that is nearer to the destination.
- The process to decide a next gateway is called routing.
- We call a machine router that does routing.
- Each gateway should decide a host with which it can communicate directly for every packet.
- Therefore, gateways are usually routers.
- In general, it decides the destination according to its routing table.
- Default gateway: the next gateway to which packets are sent when the next gateway for the packet is not specified.
- For a usual hosts, what we have to do for setting with respect to routing is set the IP address of its default gateway.
- Gateways in backbone rewrite the content of their routing table dynam-

ically.

(Gateway of TokyoTech that connects to external networks has more than 100,000 tuples consisted mainly of a network address and gateway address to for routing).

- The number of gateways in a network may be larger than one.

`traceroute` or `tracert` (for Windows) command:

- Command to know at which gateways packets pass for the connection.
- Only the case when a gateway sends its information to the host, the host can know the gateways in the route.
- Nowadays for the sake of security, gateways do not send their information.

```

yamasita@white:~$ traceroute www.stanford.edu
 1:  black.ide.titech.ac.jp                0.097ms pmtu 1500
 1:  sekisho.ide.titech.ac.jp              0.612ms
 1:  sekisho.ide.titech.ac.jp              0.585ms
 2:  131.112.80.66                          2.256ms
 3:  131.112.254.246                       2.325ms
 4:  131.112.254.254                       2.942ms
 5:  131.112.255.106                       1.515ms
 6:  131.112.255.118                       1.358ms
 7:  131.112.254.233                       1.051ms asymm  8
 8:  150.99.186.229                        1.515ms
 9:  tokyo-dc-gm2-ae0-vlan10.s4.sinet.ad.jp 1.624ms
10:  lax-dc-gm1-xe1-1-0-vlan10.s4.sinet.ad.jp 102.183ms
11:  cenichpr-1-lo-jmb-702.lsanca.pacificwave.net 102.717ms
12:  svl-hpr2--lax-hpr2-10g.cenic.net       110.399ms
13:  hpr-stanford--svl-hpr2-10ge.cenic.net  111.048ms
14:  boundarya-rtr.Stanford.EDU            111.231ms
15:  no reply
16:  no reply
17:  www-v6.Stanford.EDU                    111.552ms reached
Resume: pmtu 1500 hops 17 back 239

```

5.1 NAT

- Network Address Translation

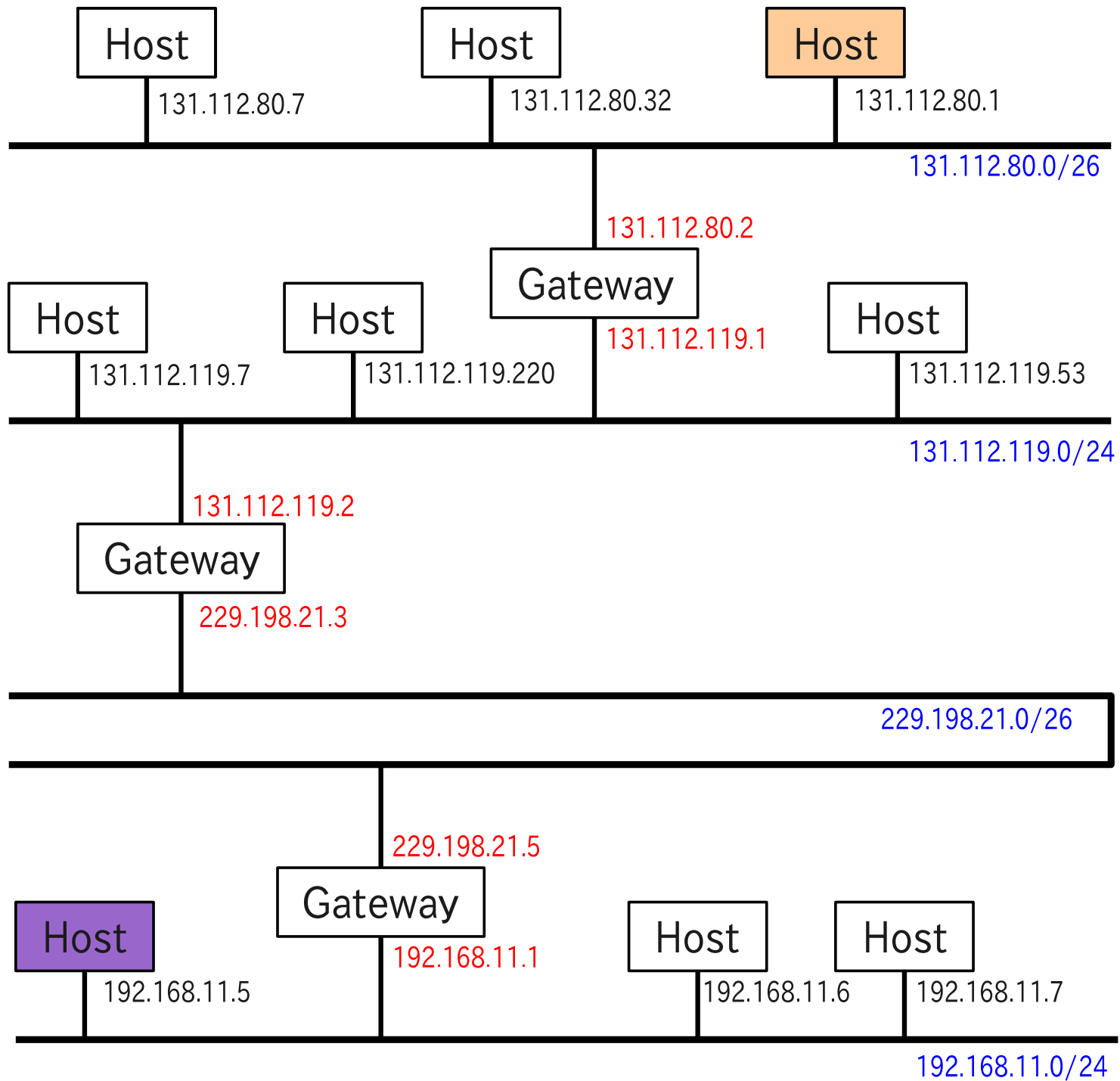
5.1.1 Purpose

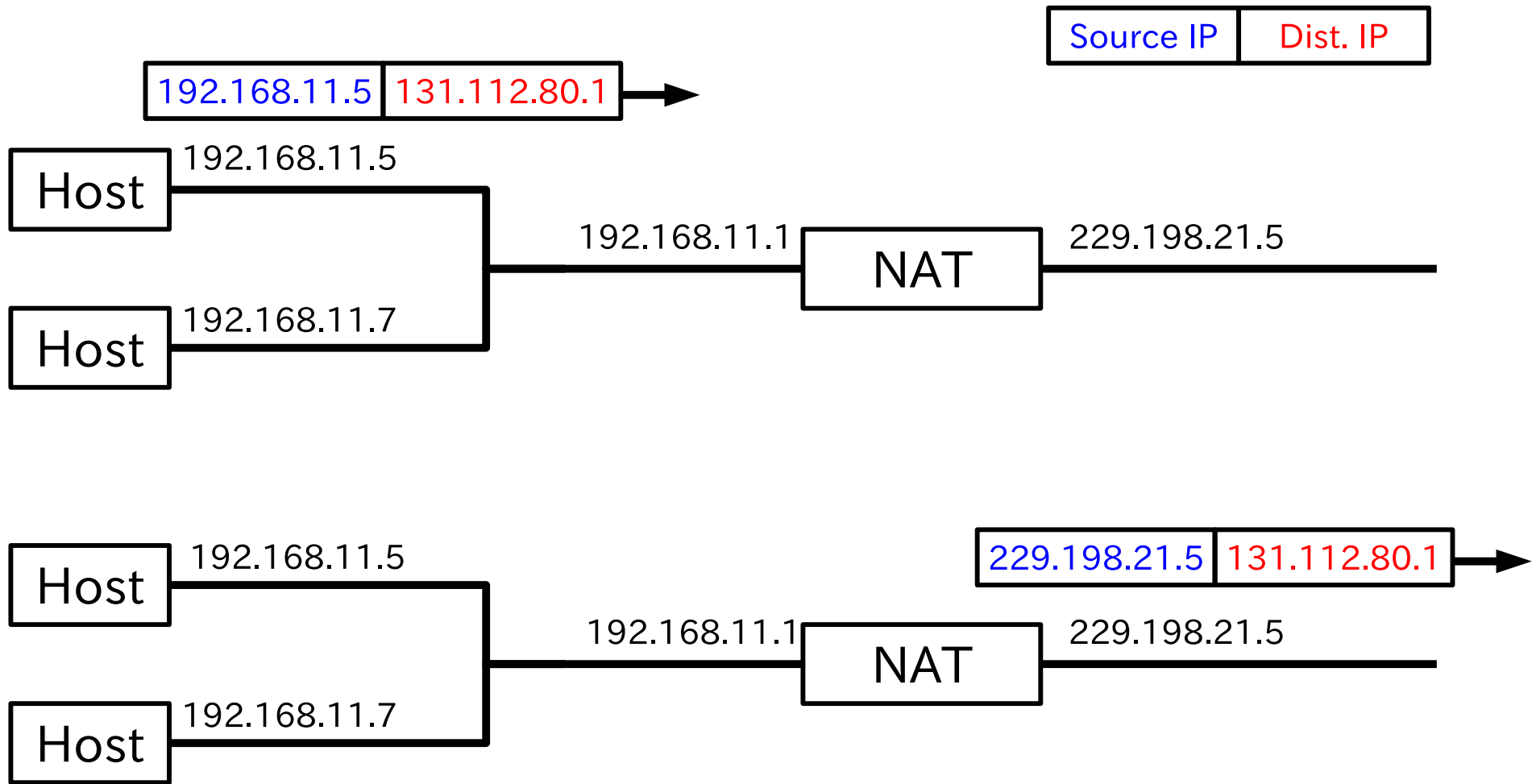
- Shortage of IP addresses
 - The number of addresses of IPv4 2^{32} at maximum.
 - The way to assign addresses is not efficient.
Because IP addresses are used by the unit of networks. (Although Tokyo Tech has 65536 IPv4 addresses, the number of computers is not so many.)
- Security: To forbid access from an external machine to a host in the network directly.

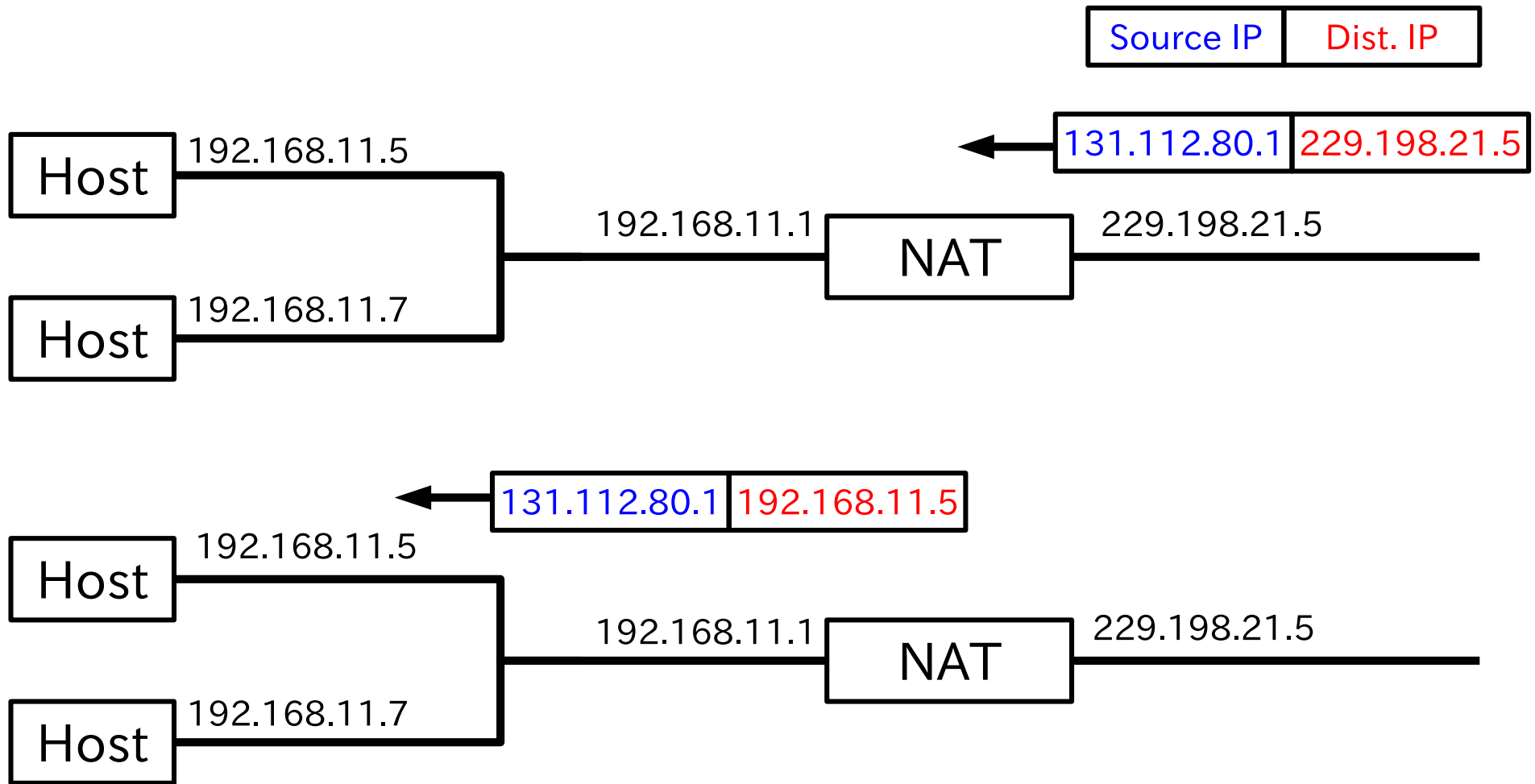
5.1.2 Process of NAT

- Global IP address: A unique IP address in the world.
- Private IP address: It is IP address that is valid and unique in LAN (local area network). It is permitted to use the same IP address in another LAN.
- Hosts in LAN (internal hosts) can communicate by using private IP addresses.
- When a host which only has a private address want to communicate to an external host, what do we do?
 - Not only the gateway transfers a packet, but also it rewrites the source IP address of the packed is rewritten to the global IP address of the gateway.
 - The gateway store information including the original source IP address and the destination IP address.
 - The destination IP address of its reply from the external host is the global IP address of the gateway for WAN.
 - The gateway compares the source IP address of the reply packet with the destination addresses of packets from the hosts in LAN that the gateway transferred.

- When one of the addresses coincide with the destination address, the gateway rewrites the destination address to the source address of the packet corresponding to the information, and sends the packet to the host in LAN.
- When no address coincides with it, the packet is discarded or transferred to a predetermined host in LAN.
- **Advantage:** By using a global IP address, multiple hosts can communicate with an external host.
- **Advantage and disadvantage:** Although internal hosts can start to communicate with external hosts, its opposite is impossible. (It is possible to communicate with a predetermined host in LAN.)
- **Disadvantage:** If more than one hosts communicate to a same external host, the gateway does not know to which host it should transfer the reply packet from the external host.







5.2 NAPT (IP Masquerade)

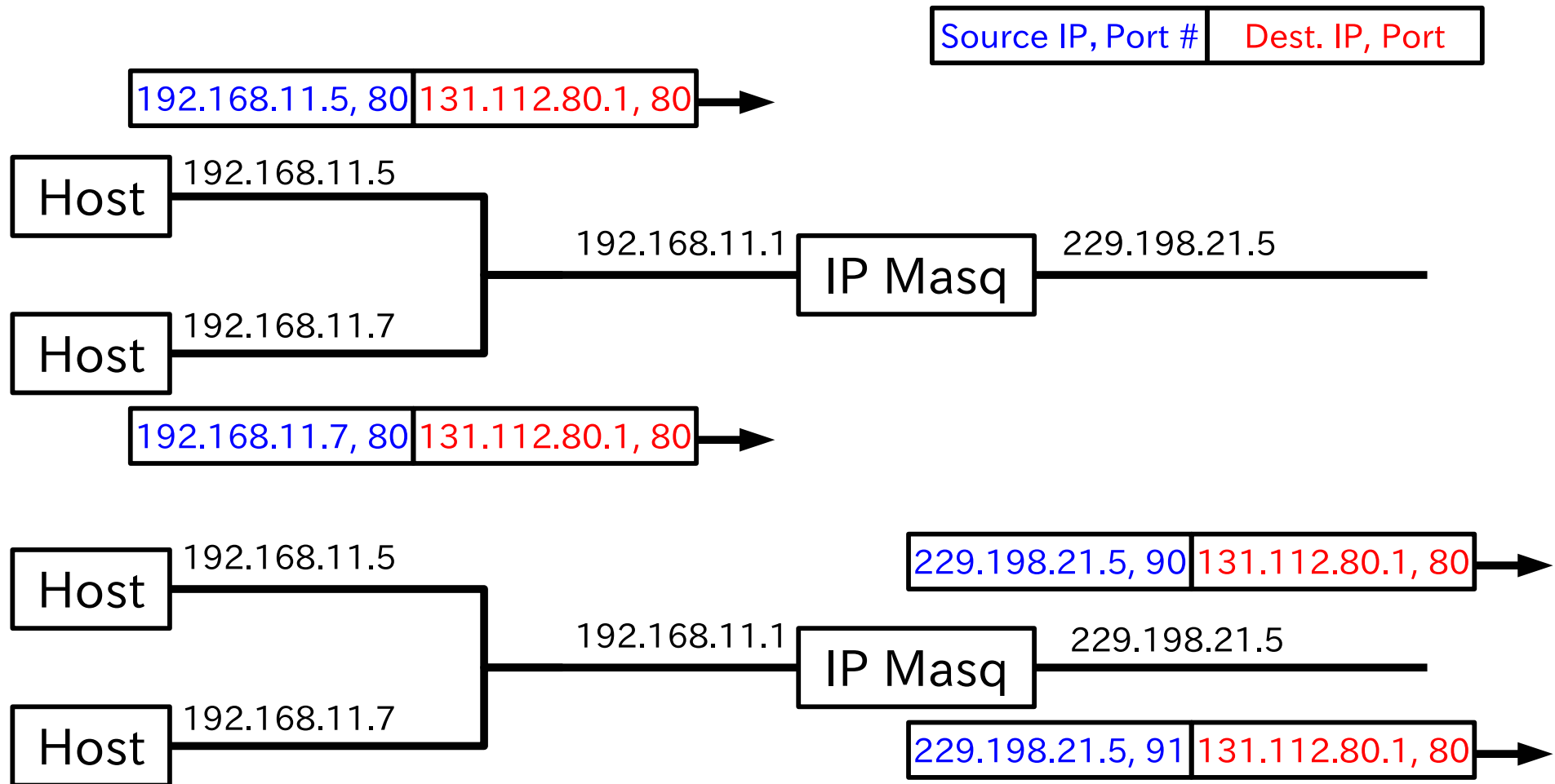
- Network Address Port Translation
- IP Masquerade is the name of implementation of NAPT in Unix.
- However, IP Masquerade was made before its concept is named as NAPT.
- NAPT can solve the problem of NAT that the gateway can not decide the destination of a reply packet when more than one hosts in LAN communicate to the same external host.
- NAPT can apply to communication by UDP/IP or TCP/IP.
- NAPT uses port numbers of UDP or TCP.
- Consider that a packet for communication by UDP/IP or TCP/IP arrived at a host and the host wants to reply it. In general, the destination port number of a reply packet is set to the source port number of the received packet.
- Process of NAPT
 - When different hosts in LAN communicate to the same external host, the gateway rewrite the source port number of the packets from an internal

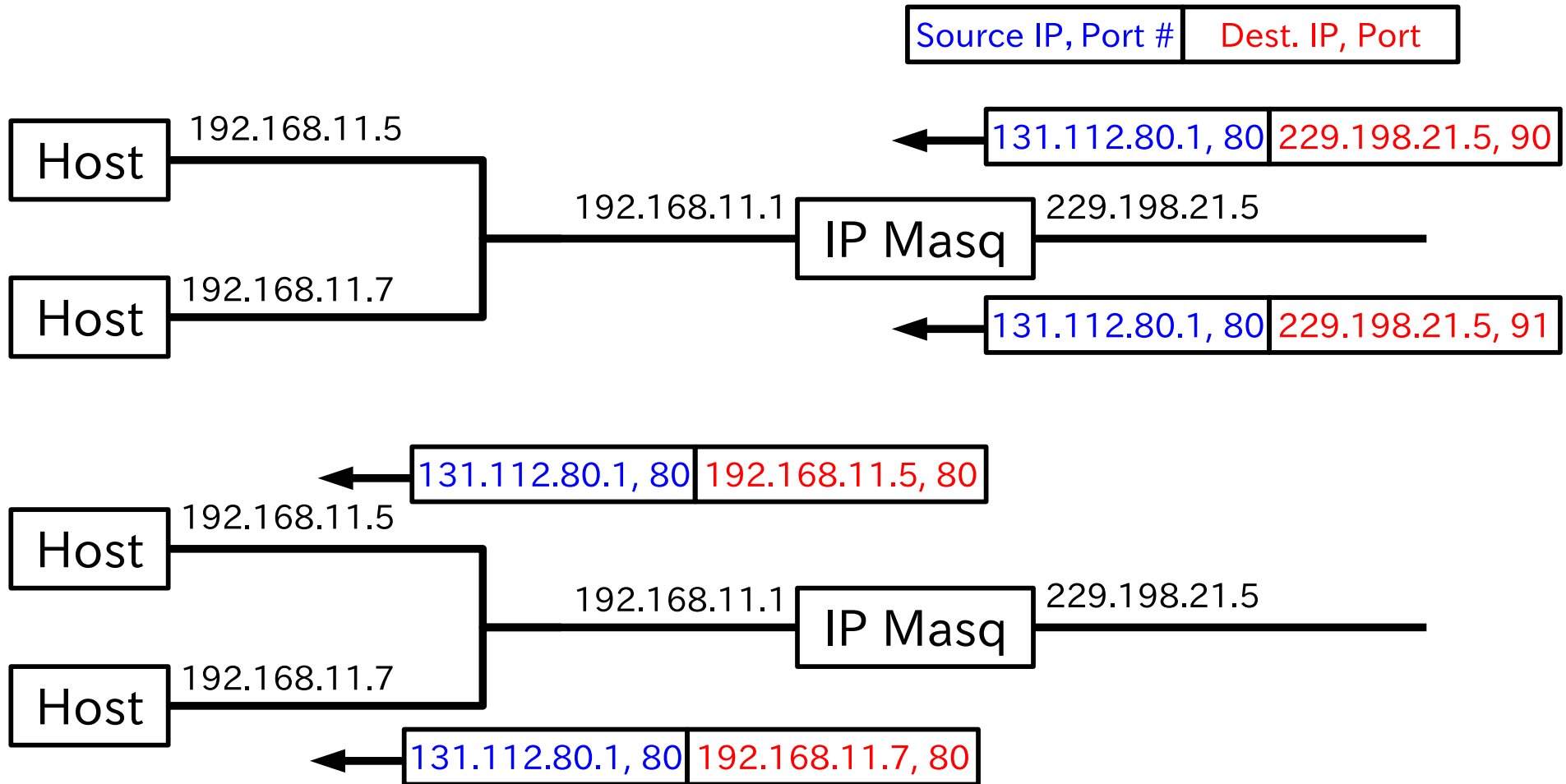
hosts to a unique number. The rewritten source port numbers of packets from different hosts should be the different.

- The gateway stores information including the original source IP address, the destination IP address, destination port number, and original and rewritten source port numbers of packets from an internal host.
- By retrieving memory by the source IP address and the destination port number of the reply packet, the gateway knows to which host it should transfer the reply packet. They should be the same as the destination IP address and the rewritten source port number of the packet to the external host, respectively.
- If the gateway can find them in memory, it rewrites the destination IP address and the destination port number to the source IP address and the source port number of the packet that was sent to the external host, respectively, and send it to the interior host.
- When the gateway cannot find it, the packet is discarded or transferred to a predetermined host in LAN.

Digression:

- Broadband router, which every home has recently, has a function of NATP (IP Masquerade)





6 DHCP

- Dynamic Host Configuration Protocol
- It is complicated and takes time to configure network setting in a computer.
 - IP address
 - Subnet mask
 - Default router
 - DNS server (DNS suffix)
 - NIS server, print server, NTP server, WINS server, etc.
- DHCP is a protocol to set such values automatically.
 - DHCP **server**: A host that sends information for setting.
 - DHCP **client**: A host that receives the information. (In initial state, IP address, etc. have not been set yet.)

- Process

1. In order to search a DHCP server, the client sends a UDP packet (**DISCOVER**) to IP broadcast address (255.255.255.255).
2. All hosts in the network receive the packet.
3. A DHCP server sends a packet (**OFFER**) including their own IP address to the client by using its MAC address. Hosts other than DHCP server discard the packet.
4. The client selects a DHCP server and sends a packet (**REQUEST**) including the IP address of the selected DHCP server to IP broadcast address.
5. The assigned DHCP server receives the packet, select an IP address which has not been used yet among IP addresses that it manages, and send a packet (**PACK**) including the above IP address and other information to MAC address of the client. If no IP address is available, it sent a packet (**PNAK**) to the client.
6. By using information in the PACK packet, the client configures its own

network setting.

7. The client starts to communicate by standard IP protocol.

7 DNS

- Domain Name Service (System)
- It is not convenient to use IP address directly. We would like to use name.
- Ex: `www.tse.ens.titech.ac.jp`, `www.google.co.jp`
- However, not name but IP address is necessary to communicate.
- Domain name: The name of group of hosts in Internet.
- A system is necessary that can retrieve IP address from name. We call such a process 'resolve' and such software 'resolver'.
- To manage simply, domain names have tree-structure.
(On the other hand, IP addresses are not hierarchized for flexibility.)
- `www.tse.ens.titech.ac.jp` consists of 6 layers as `www`, `tse`, `ens`, `titech`, `ac`, `jp`.
 - The host `www.tse.ens.titech.ac.jp` belongs to the domain `tse.ens.titech.ac.jp`.
 - The domain `tse.ens.titech.ac.jp` belongs to the domain `ens.titech.ac.jp`.
 - The domain `ens.titech.ac.jp` belongs to the domain `titech.ac.jp`.
 - The domain `titech.ac.jp` belongs to the domain `ac.jp`.
 - The domain `ac.jp` belongs to the domain `jp`.

- The domain jp belongs to the root node.
- Root node is expressed by '.'
- TLD (Top Level Domain) : com, org, and jp

7.1 Domain name server (DNS)

- DNS provides information with respect to domain.
- DNS in a layer has following information.
 - **Host names** and their IP addresses belonging to domains in its own and lower layers.
 - **Domain names** and IP addresses of their DNS belonging to domains in lower layers.
- When a DNS receives a query with respect to a host name in its own and lower layers, it looks up the host name, and
 - if the DNS has its information, it replies the information,
 - else, it transfers the query to a DNS in lower layers and returns its reply.

- When the domain name of a query is out of its domain, it transfers the query to the DNSs in root node. 13 IP address (10 in US and 1 in Sweden, Netherlands, and Japan) are registered as DNSs (root servers) in the root node.

7.2 Reverse lookup

- It enables to lookup host name from an IP address.
- In case of IPv4, the domain name **in-addr.arpa** is used.
- For example, for IP address 131.112.80.21, domain name 21.80.112.131.in-addr.arpa is used.
- In case of IPv6, the domain name **ip6.arpa** is used.
- Domain name server used a type of record (PTR record) only for reverse lookup. (It does not use 'A record' to retrieve a host name.)

8 HTTP

- Hyper Text Transfer Protocol
- Hyper link: A link that can refer other documents.
- Hyper text: A text that can embed hyper links.
- HTML (Hyper Text Markup Language) : A format of document for hyper text.
- HTTP is used to send HTML document (document written in HTML).
- The format of data for HTTP
 - Header part
 - Blank line
 - Data part (HTML document)

- Header can be seen (ex.) by Live HTTP headers (Firefox plugin).
- This header is different from header in HTML document.
- An example of **header** from browser to server (<http://www.ide.titech.ac.jp/en/>)

```
GET /en/ HTTP/1.1
```

```
Host: www.ide.titech.ac.jp
```

```
User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:48.0) Gecko/20100101
```

```
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
```

```
Accept-Language: en-US,en;q=0.5
```

```
Accept-Encoding: gzip, deflate
```

```
Connection: keep-alive
```

```
Upgrade-Insecure-Requests: 1
```

- An example of **header** from server to browser

HTTP/1.1 200 OK

Date: Mon, 21 Nov 2016 05:46:32 GMT

Server: Apache

X-Powered-By: PHP/5.3.3

Link: <<http://www.ide.titech.ac.jp/en/wp-json/>>; rel="https://api.w.org/"

Connection: close

Transfer-Encoding: chunked

Content-Type: text/html; charset=UTF-8

- An example of **data** from server to data.

```
<!DOCTYPE html>
<html xmlns="http://www.w3.org/1999/xhtml" lang="en-US">
<head profile="http://gmpg.org/xfn/11">

  <title>Department of International Development Engineering — Tokyo Institute of Technology</title>
  <meta http-equiv="content-type" content="text/html; charset=UTF-8" />

  <link rel="pingback" href="http://www.ide.titech.ac.jp/en/xmlrpc.php" />

  <link rel="stylesheet" type="text/css" href="http://www.ide.titech.ac.jp/en/wp-content/themes/academica/

  <meta name="description" content="Tokyo Institute of Technology" />
<meta name="robots" content="index, follow" />
<link rel="alternate" type="application/rss+xml" title="Department of International Development Engineering
<link rel="alternate" type="application/rss+xml" title="Department of International Development Engineering
  <script type="text/javascript">
    window._wpemojiSettings = {"baseUrl":"https://s.w.org/images/core/emoji/72x72/", "ext": ".png",
    !function(a,b,c){function d(a){var c,d,e,f=b.createElement("canvas"),g=f.getContext&&f.getContext("2
  </script>
  <style type="text/css">
img.wp-smiley,
img.emoji {
  display: inline !important;
  border: none !important;
  box-shadow: none !important;
  height: 1em !important;
```



```

width: 1em !important;
margin: 0 .07em !important;
vertical-align: -0.1em !important;
background: none !important;
padding: 0 !important;
}
</style>
<link rel='stylesheet' id='wpz-shortcodes-css' href='http://www.ide.titech.ac.jp/en/wp-content/themes/aca
<link rel='stylesheet' id='zoom-font-awesome-css' href='http://www.ide.titech.ac.jp/en/wp-content/themes/
<link rel='stylesheet' id='wpzoom-custom-css' href='http://www.ide.titech.ac.jp/en/wp-content/themes/acad
<link rel='stylesheet' id='wzslider-css' href='http://www.ide.titech.ac.jp/en/wp-content/themes/academica
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-includes/js/jquery/jquery.js?ver=1.1
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-includes/js/jquery/jquery-migrate.mi
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-content/themes/academica/js/init.js?
<link rel='https://api.w.org/' href='http://www.ide.titech.ac.jp/en/wp-json/' />
<link rel="EditURI" type="application/rsd+xml" title="RSD" href="http://www.ide.titech.ac.jp/en/xmlrpc.php
<link rel="wlwmanifest" type="application/wlwmanifest+xml" href="http://www.ide.titech.ac.jp/en/wp-include
<meta name="generator" content="WordPress 4.5.4" />
<!-- WPZOOM Theme / Framework -->
<meta name="generator" content="Academica 2.0.3" />
<meta name="generator" content="WPZOOM Framework 1.4.0" />
<style type="text/css"></style>

<script type="text/javascript">
jQuery(function($){
    $("#menuhead ul").css({display:"none"}); // Opera Fix
    $("#menuhead li").hover(function(){

```

```
        $(this).find('ul:first').css({visibility:"visible",display:"none"}).show(268);
    }, function(){
        $(this).find('ul:first').css({visibility:"hidden"});
    });
});
</script>
```

```
</head>
```

```
<body class="home blog">
```

```
    <div id="wrap">
```

```
        <div id="mainNav">
```

```
            <div class="wrap">
```

```
                <ul id="menuhead" class=""><li id="menu-item-19" class="menu-item menu-item-type-custom menu-item-
<li id="menu-item-18" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-18"><a href=
<li id="menu-item-17" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-17"><a href=
<li id="menu-item-22" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-22"><a href=
<li id="menu-item-21" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-21"><a href=
<li id="menu-item-20" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-20"><a href=
<li id="menu-item-5" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-5"><a href="
本語)</a></li>
<li id="menu-item-552" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-552"><a href=
</ul>            </div><!-- end .wrap -->
        </div><!-- end #mainNav -->
```

```
<div id="crumbs">
  <div class="wrap">
    <p></p>
  </div><!-- end .wrap -->
</div>
```

```
<div id="header">
```

```
  <div class="wrap">
```

```
    <div id="logo">
```

```
      <a href="http://www.ide.titech.ac.jp/en" title="Tokyo Institute of Technology">
```

```
        
```

```
      </a>
```

```
    </div>
```

```
    <div id="search"><form method="get" id="searchform" action="http://www.ide.titech.ac.jp/en/">
```

```
      <input type="text" onblur="if (this.value == '') {this.value = 'Search'}" onfocus="if (this.value == 'S
```

```
      <input type="submit" id="searchsubmit" value="Search" />
```

```
    </form>
```

```
  </div>
```

```
  <div id="social">
```

```

<ul>
  </ul>
</div>
  <div class="clear">&nbsp;</div>

</div><!-- end .wrap -->

</div><!-- end #header --><div id="homeGallery">

<div class="wrap">

  <div id="showcase">

    <a class="prev browse" rel="nofollow">prev</a>
    <a class="next browse" rel="nofollow">next</a>

    <ul class="slides">

      <li class="slide">
        
            
                <!-- end .slides -->

```

```
</div><!-- end #showcase -->
```

```
<script type="text/javascript">
```

```
jQuery(document).ready(function() {
```

```
    jQuery('#showcase').css({ display : 'block' });
```

```
    jQuery("#showcase").slides({
```

```
        container: 'slides',
```

```
        play: 0,
```

```
        slideSpeed: 500,
```

```
        generatePagination: false,
```

```
        pause: 1000,
```

```
        effect: 'slide, fade',
```

```
        autoHeight: true,
```

```
        hoverPause: true,
```

```
        preload: true,
```

```
        preloadImage: 'http://www.ide.titech.ac.jp/en/wp-content/themes/academica/images/loading2.gif'
```

```
    });
```

```
});
```

```
</script>
```

```
</div><!-- end .wrap -->
```

```
</div><!-- end #homeGallery -->
```

```
<div id="content">
```

```
<div class="wrap">
```

```
<div class="column column-narrow">&nbsp;</div><!-- end .column-narrow -->
```

```
<div class="column column-double column-content column-last">
```

```
<h1></h1>
```

```
</div>
```

```
<div class="clear">&nbsp;</div>
```

```
<div class="column column-narrow">
```

```
<div class="widget"><div class="menu-sidemenu-container"><ul id="menu-sidemenu" class="menu"><li id="
<li id="menu-item-46" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-46"><a href="
<li id="menu-item-92" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-92"><a href="
<li id="menu-item-44" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-44"><a href="
<li id="menu-item-43" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-43"><a href="
<li id="menu-item-42" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-42"><a href="
<li id="menu-item-114" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-114"><a href="
<li id="menu-item-48" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-48"><a href="
<li id="menu-item-40" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-40"><a href="
<li id="menu-item-39" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-39"><a href="
<li id="menu-item-4" class="menu-item menu-item-type-custom menu-item-object-custom menu-item-4"><a href="
</ul></div></div>
```

```
</div><!-- end .column-narrow -->
```

```
<div class="column column-content">
```

```
<!-- added by referring http://hinagata.biz/how/category-latestposts/ -->
```

```
<h2>News</h2>
```

```
<table>
```

</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	
</td>	

```
</table><br><!-- <p>Thank you for using Academica Theme by <a href="http://www.wpzoom.com">WPZOOM</a></p>
```

```
<p>Please go to <strong>WPZOOM Theme Options > Homepage Options</strong> and select a <strong>stat</strong>  
</div><!-- end .column-content -->
```

```
<div class="column column-narrow column-last">
```

```
<div class="widget"><div class="menu-right_side_menu-container"><ul id="menu-right_side_menu" class="
<li id="menu-item-78" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-78"><a href="
<li id="menu-item-74" class="menu-item menu-item-type-post_type menu-item-object-page menu-item-74"><a href="
</ul></div></div><div class="widget"><p class="heading">Archives</p> <ul>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/08'>August 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/07'>July 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/06'>June 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/05'>May 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/03'>March 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/02'>February 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2016/01'>January 2016</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/12'>December 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/10'>October 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/09'>September 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/08'>August 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/07'>July 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/06'>June 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/05'>May 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/04'>April 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/03'>March 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/02'>February 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2015/01'>January 2015</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2014/12'>December 2014</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2014/09'>September 2014</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2014/07'>July 2014</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2014/06'>June 2014</a></li>
  <li><a href='http://www.ide.titech.ac.jp/en/2014/05'>May 2014</a></li>
```


- [- \[- \\[- \\\[- \\\\[- \\\\\[- \\\\\\[- \\\\\\\[- \\\\\\\\[- \\\\\\\\\[- \\\\\\\\\\[- \\\\\\\\\\\[- \\\\\\\\\\\\[- \\\\\\\\\\\\\[-\\\\\\\\\\\\\]\\\\\\\\\\\\\(http://www.ide.titech.ac.jp/en/2012/07\\\\\\\\\\\\\)\\\\\\\\\\\\]\\\\\\\\\\\\(http://www.ide.titech.ac.jp/en/2012/09\\\\\\\\\\\\)\\\\\\\\\\\]\\\\\\\\\\\(http://www.ide.titech.ac.jp/en/2012/10\\\\\\\\\\\)\\\\\\\\\\]\\\\\\\\\\(http://www.ide.titech.ac.jp/en/2012/12\\\\\\\\\\)\\\\\\\\\]\\\\\\\\\(http://www.ide.titech.ac.jp/en/2013/01\\\\\\\\\)\\\\\\\\]\\\\\\\\(http://www.ide.titech.ac.jp/en/2013/02\\\\\\\\)\\\\\\\]\\\\\\\(http://www.ide.titech.ac.jp/en/2013/03\\\\\\\)\\\\\\]\\\\\\(http://www.ide.titech.ac.jp/en/2013/05\\\\\\)\\\\\]\\\\\(http://www.ide.titech.ac.jp/en/2013/09\\\\\)\\\\]\\\\(http://www.ide.titech.ac.jp/en/2013/10\\\\)\\\]\\\(http://www.ide.titech.ac.jp/en/2013/12\\\)\\]\\(http://www.ide.titech.ac.jp/en/2014/01\\)\]\(http://www.ide.titech.ac.jp/en/2014/02\)](http://www.ide.titech.ac.jp/en/2014/04)

</div>

</div><!-- end .column-narrow -->

<div class="clear"> </div>

</div><!-- end .wrap -->

</div><!-- end #content -->

<div id="footer">

```
<div class="wrap">

  <div id="footerColumn"></div>

  <p class="copy">Copyright &copy; 2016 Department of International Development Engineering. All rights reserved.

  <div class="clear">&nbsp;</div>

</div><!-- end .wrap -->

</div><!-- end #footer -->

</div><!-- end #wrap -->

  <script>(function($){$(document).ready(function(){});})(jQuery);</script><script type='text/javascript'
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-content/themes/academica/functions/w
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-content/themes/academica/functions/w
<script type='text/javascript' src='http://www.ide.titech.ac.jp/en/wp-includes/js/wp-embed.min.js?ver=4.5.

</body>
</html>
```

9 SMTP

- Simple Mail Transfer Protocol
- **MTA** (Mail Transfer Agent): Mail server
 - Mails are transferred between MTAs by using SMTP.
 - SMTP supports not only direct connection between two MTAs but also mail transfer through multiple MTAs
(Recently, the necessity of such transfer has been decreased.)
- **MUA** (Mail User Agent): Mail client (Outlook, Thunderbird)
 - When an MUA asks an MTA to send a mail, SMTP is used.
 - When an MUA gets mails from an MTA, **POP** (Post office protocol) or **IMAP** (Internet Message Access Protocol) is used.
 - The mail address is given by (user name)@(domain name).
 - This domain name for the mail is not the domain name of MTA.
 - MTA corresponding to a domain name of mail is known from the information of the **MX record** in DNS.
- The communication by SMTP is based on texts. (Example by Linux)

telnet mx1.mail.yahoo.co.jp 25

Trying 124.83.171.244...

Connected to mx1.mail.yahoo.co.jp.

Escape character is '^]'.

220 mta303.mail.ogk.yahoo.co.jp ESMTP YSmtplib service ready

HELO goat.ide.titech.ac.jp

250 mta303.mail.ogk.yahoo.co.jp

MAIL FROM: <yamasita@ide.titech.ac.jp>

250 sender <yamasita@ide.titech.ac.jp> ok

RCPT TO: <idetokyotech@yahoo.co.jp>

250 recipient <idetokyotech@yahoo.co.jp> ok

DATA

354 go ahead

To: idetokyotech@yahoo.co.jp

Subject: testtest

From: yamasita@ide.titech.ac.jp

kougino test

.

250 ok dirdel

QUIT

221 mta303.mail.ogk.yahoo.co.jp

Connection closed by foreign host.

10 FTP

- File Transfer Protocol
- I guess, some of students may use it to upload files to a rental server.
- Anonymous FTP: Anyone can access to it.
- File type (client assigns it.)
 - ASCII
 - Binary
- SFTP (secure FTP)
 - Data is encrypted for communication.

10.1 Active FTP

- Old version of FTP
- Abstract of process
 1. A client starts to communicate to a FTP server by destination port number 21. It send login information, the port number of the client for data transfer, and file name to be transferred.
 2. The port number of a server for data transfer is fixed to be 20.
 3. (The port number of the client has been already sent)
 4. When start to data transfer, the demand for transfer (SYN) is issued by server.
 5. Data transfer
 6. End of communication
- Originally, the protocol enables an efficient data transfer. That is, multiple servers have the same data, and they transfer data to clients separately in order to decrease load of a server..
- Recently, many of clients can not be connected from external network di-

rectly because of NAT, NAPT, and firewall. Therefore, this active FTP can not be used for such clients.

10.2 Passive FTP

- Abstract of process
 1. A client starts to communicate a FTP server by destination port number 21. It send login information,
 2. From server with source port number 21, IP address of server from which the client can get data and the destination port number for the communication.
 3. The client demands data by using the IP address and the destination port number.
 4. The client sends the file name which it want to get.
 5. Data transfer
 6. End of communication
- Since the client starts the data transfer, it can pass through NAT, NAPT,

and firewall.

10.3 Proxy

- For mainly security reason, many hosts in LAN are forbidden to connect to external networks directly.
- Use of NAT or NAPT is also forbidden.
- If NAT or NAPT is allowed, it can be used to attack external hosts and to transfer illegal data by P2P access.
- Actually, several laboratories in this department forbid it.
- Proxy relays the communication of HTTP, HTTPS, and FTP between machines in internal and in external networks.
- Although proxy is similar to NAPT, it watches the content of data. It can cache html documents temporally to avoid getting the same data from a server several times.

11 Settings of network

- Connection to Internet is very important for study and research.
- In case of telephone, professional agents do settings. However, in case of Internet, we often do setting by ourselves.
- In this department: Cannot connect \Rightarrow Ask senior \Rightarrow Ask professor $\Rightarrow \dots \Rightarrow$ Ask me.
- In order to decrease my extra work, please study basic knowledge of network. If we do not know it, we cannot even understand manual of network instruments.

11.1 Basic setting of internet

- IP address
- Subnet mask
- Default gateway
- DNS (Domain Name Server)
- Proxy

11.2 Setting in Tokyo Tech

- In Titanet 3
 - IP address: 131.112.*.*
 - Subnet mask: 255.255.255.192
 - DNS : 131.112.125.58(O-okayama), 131.112.181.2(Suzukakedai)
- In Lab. (They depend on lab.)
 - IP address: 192.168.x.* (x=0, 10, 11)
 - Subnet mask: 255.255.255.0
 - DNS : 192.168.x.1
 - Default gateway : 192.168.x.1
- Proxy: proxy.noc.titech.ac.jp Port number: 3128
- NTP (Network Time Protocol): ntp1.noc.titech.ac.jp, ntp2.noc.titech.ac.jp

11.3 Conclusion

- Basic knowledge of network is very important.
- IP address, subnet mask, default gateway, DNS, HTTP, SMTP, FTP, etc.