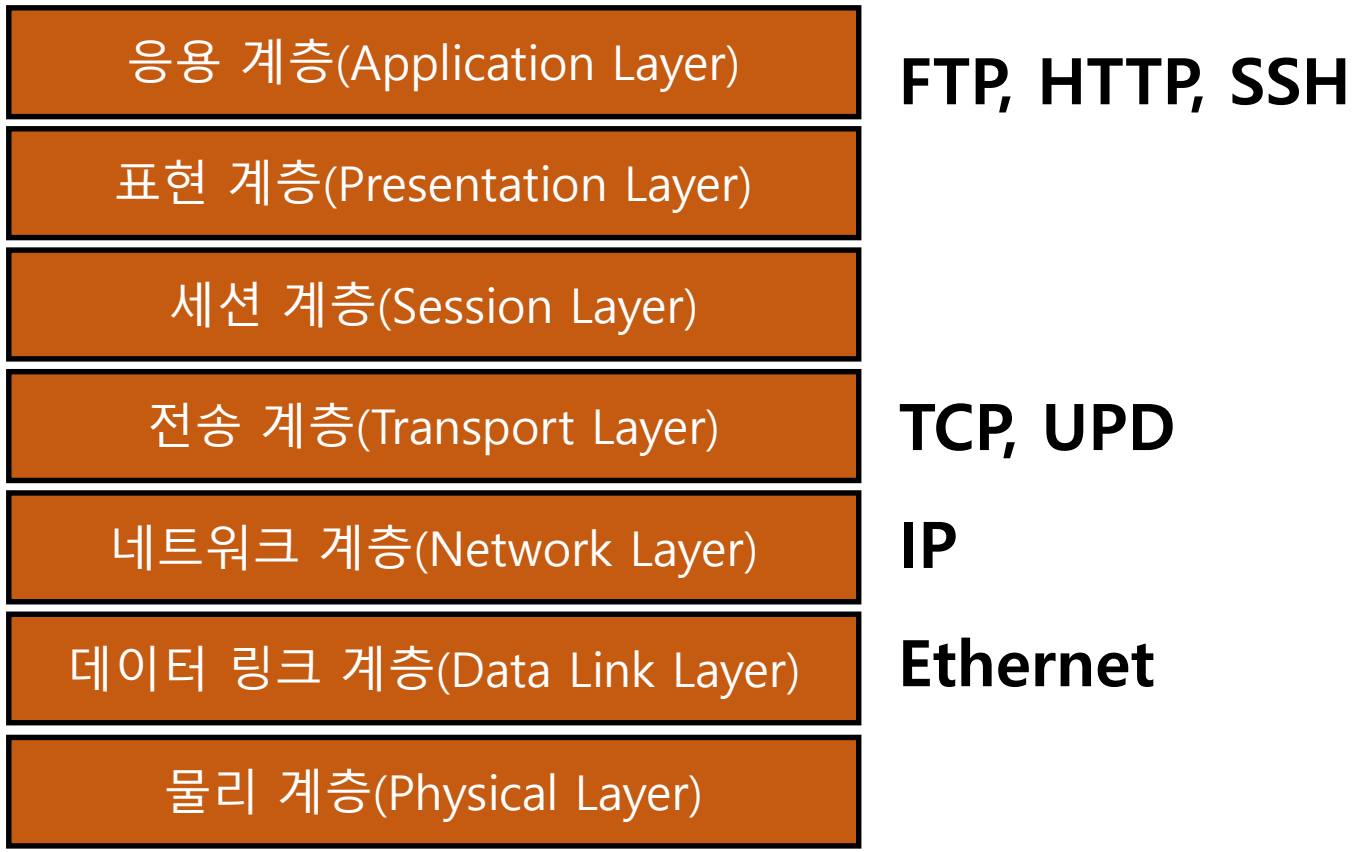
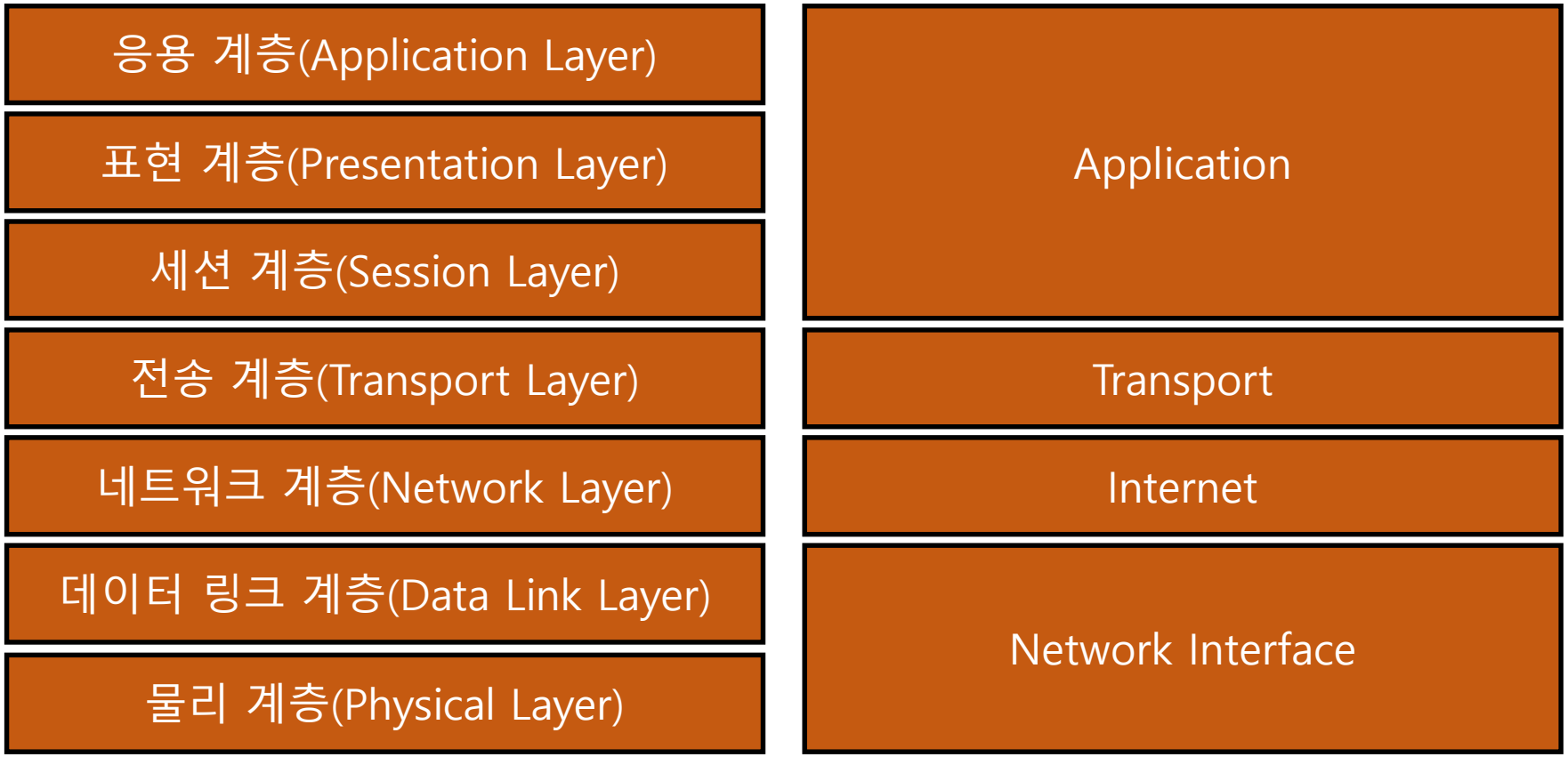
OSI 7 계층


응용 계층(Application Layer)
표현 계층(Presentation Layer)
세션 계층(Session Layer)
전송 계층(Transport Layer)
네트워크 계층(Network Layer)
데이터 링크 계층(Data Link Layer)
물리 계층(Physical Layer)
FTP, HTTP, SSH
TCP, UPD
IP
Ethernet

TCP/IP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데이터 링크 계층(Data Link Layer)
물리 계층(Physical Layer)
Application
Transport
Internet
Network Interface

1. 물리 계층

LAN cable : CAT 5 100Mbps, 10/100 BASE-T(IEEE 802.3)
UTP(Unshielded Twisted Pair)
RJ-45
Repeater : 거리가 멀어지면 노이즈가 생기고 신호가 약해진다
signal 증폭

NIC(network interface card)
: 일반적으로 랜 카드라고 불린다. 네트워크 어댑터

MAC(Media Access Control)
: NIC의 하드웨어 주소
40-49-0F-80-C3-2F
제조사 **NIC 번호**

이더넷 프로토콜

1. Preamble : 7 bytes, NIC에 패킷이 들어온다고 알린다.
2. SFD(start frame delimiter) 1 byte, 10101011 → 최초 패킷
3. **Destination MAC Address : 6 bytes, 패킷 수신 NIC**
4. **Source Mac Address : 6 bytes, 패킷 송신 NIC**
5. Length or Type : 2 bytes
6. Data : 0 ~ 1500 bytes, 전송 데이터,
   MTU(maximum transmission unit) : 1500 bytes
7. Pad : 64 bytes를 맞추기 위해 임의의 데이터를 쓴다
8. FCS(Frame Check Sequence) : 4 bytes, 패킷 오류 검사

3. 네트워크 계층

ARP(Address Resolution Protocol)
: 브로드캐스트로 어떤 IP를 사용하는 호스트의 MAC 주소를 알아낸다.

Request packet
1. target MAC
   00:00:00:00:00:00
2. target IP
   192.168.1.4

Source Host

Broadcast

Local network

Response packet
1. sender MAC
   28:5A:EB:67:44:86
2. sender IP
   192.168.1.4

Destination Host

ARP

- Source Host

1. ARP cache에서 dest NIC 검색 : 있다면 바로 데이터 그램 전송!
2. Cache에 없다면 ARP 요청 프레임 생성
   1) Sender Hardware Address(SHA) : Source MAC address
      Sender Protocol Address(SPA) : Source IP address
   2) Target Hardware Address(THA) : EMPTY!!
      Target Protocol Address(TPA) : Destination IP address
3. ARP request message Broadcast!!

ARP

- Destination Host

1. ARP 응답 프레임 생성
   1) Sender Hardware Address(SHA) : Destination MAC address
      Sender Protocol Address(SPA) : Destination IP address
   2) Target Hardware Address(THA) : Source Mac address
      Target Protocol Address(TPA) : Source IP address
2. ARP cache 갱신
3. ARP response message UNICAST!!

ARP

- Source Host
1. ARP cache 갱신!!

ARP-request

8	13.664678	Apple_51:57:fe	Broadcast	ARP	42	Who has 192.168.0.2? Tell 192.168.0.11
9	13.664759	HonHaiPr_80:c3:2f	Apple_51:57:fe	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
25	25.499945	EfmNetwo_cc:33:c8	HonHaiPr_80:c3:2f	ARP	42	Who has 192.168.0.2? Tell 192.168.0.1
26	25.499989	HonHaiPr_80:c3:2f	EfmNetwo_cc:33:c8	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
79	49.640470	EfmNetwo_cc:33:c8	HonHaiPr_80:c3:2f	ARP	42	Who has 192.168.0.2? Tell 192.168.0.1
80	49.640539	HonHaiPr_80:c3:2f	EfmNetwo_cc:33:c8	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
89	53.627227	HonHaiPr_80:c3:2f	Apple_51:57:fe	ARP	42	Who has 192.168.0.11? Tell 192.168.0.2
90	53.884931	Apple_51:57:fe	HonHaiPr_80:c3:2f	ARP	42	192.168.0.11 is at 78:4f:43:51:57:fe

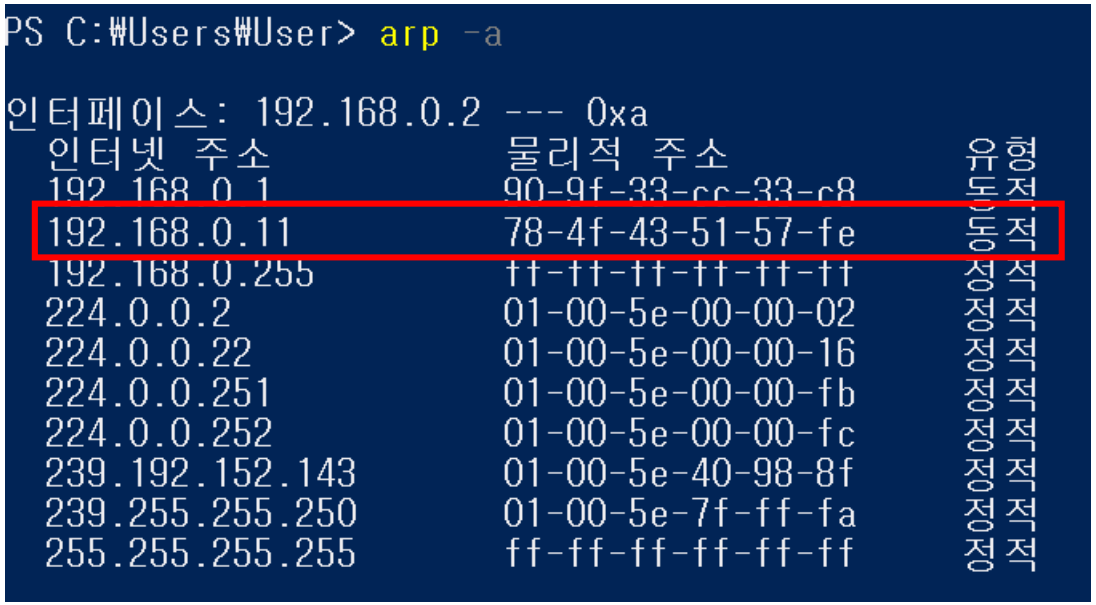
```
> Ethernet II, Src: Apple_51:57:fe (78:4f:43:51:57:fe), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
v Address Resolution Protocol (request)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: request (1)
    Sender MAC address: Apple_51:57:fe (78:4f:43:51:57:fe)
    Sender IP address: 192.168.0.11
    Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Target IP address: 192.168.0.2
```

ARP-response

8	13.664678	Apple_51:57:fe	Broadcast	ARP	42	Who has 192.168.0.2? Tell 192.168.0.11
9	13.664759	HonHaiPr_80:c3:2f	Apple_51:57:fe	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
25	25.499945	EfmNetwo_cc:33:c8	HonHaiPr_80:c3:2f	ARP	42	Who has 192.168.0.2? Tell 192.168.0.1
26	25.499989	HonHaiPr_80:c3:2f	EfmNetwo_cc:33:c8	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
79	49.640470	EfmNetwo_cc:33:c8	HonHaiPr_80:c3:2f	ARP	42	Who has 192.168.0.2? Tell 192.168.0.1
80	49.640539	HonHaiPr_80:c3:2f	EfmNetwo_cc:33:c8	ARP	42	192.168.0.2 is at 40:49:0f:80:c3:2f
89	53.627227	HonHaiPr_80:c3:2f	Apple_51:57:fe	ARP	42	Who has 192.168.0.11? Tell 192.168.0.2
90	53.884931	Apple_51:57:fe	HonHaiPr_80:c3:2f	ARP	42	192.168.0.11 is at 78:4f:43:51:57:fe

```
> Ethernet II, Src: HonHaiPr_80:c3:2f (40:49:0f:80:c3:2f), Dst: Apple_51:57:fe (78:4f:43:51:57:fe)
v Address Resolution Protocol (reply)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: reply (2)
    Sender MAC address: HonHaiPr_80:c3:2f (40:49:0f:80:c3:2f)
    Sender IP address: 192.168.0.2
    Target MAC address: Apple_51:57:fe (78:4f:43:51:57:fe)
    Target IP address: 192.168.0.11
```

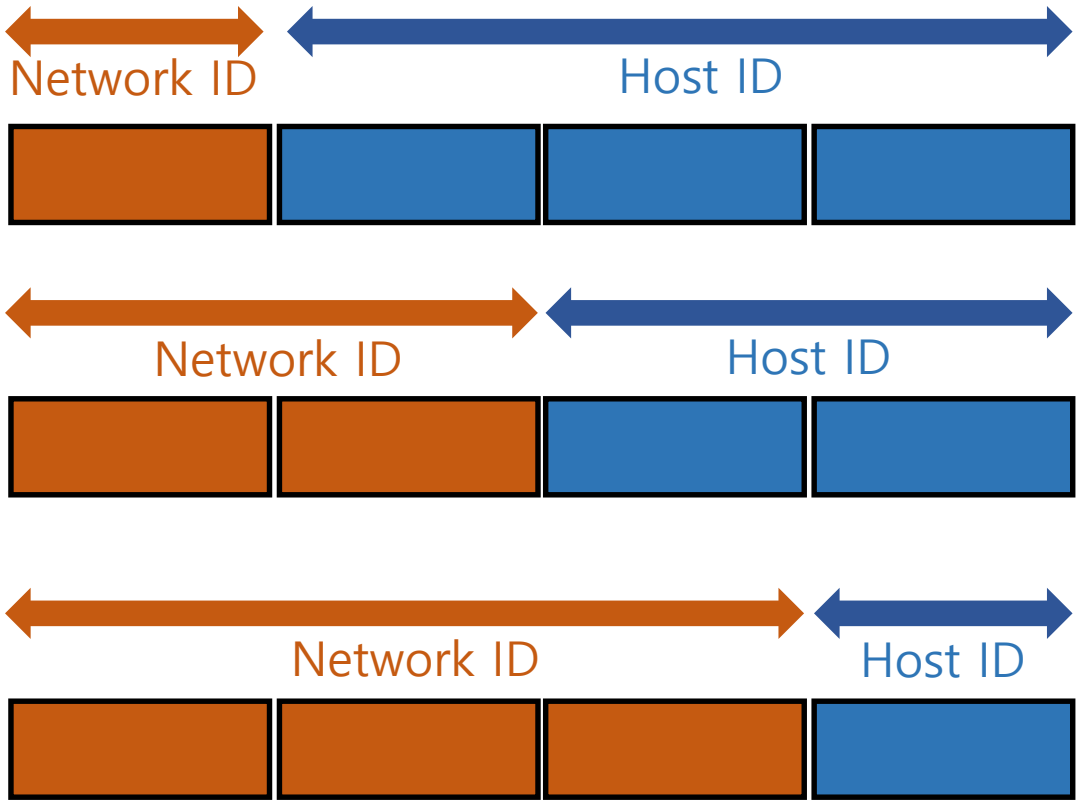
ARP-cache


PS C:₩Users₩User> arp -a
인터페이스: 192.168.0.2 --- 0xa
인터넷 주소 물리적 주소 유형
192.168.0.1 90-9f-33-cc-33-c8 동적
192.168.0.11 78-4f-43-51-57-fe 동적
192.168.0.255 ff-ff-ff-ff-ff-ff 정적
224.0.0.2 01-00-5e-00-00-02 정적
224.0.0.22 01-00-5e-00-00-16 정적
224.0.0.251 01-00-5e-00-00-fb 정적
224.0.0.252 01-00-5e-00-00-fc 정적
239.192.152.143 01-00-5e-40-98-8f 정적
239.255.255.250 01-00-5e-7f-ff-fa 정적
255.255.255.255 ff-ff-ff-ff-ff-ff 정적

IP

1. Version : 4bits, IPv4 → 0x4
2. TTL : 1byte, Time to live, 몇 개 라우터를 지나면 패킷을 버릴 것인가?
3. Protocol: 1byte, 상위 프로토콜, 6:TCP, 17:UDP
4. **Source Address : 4 bytes, 송신 IP**
5. **Destination Address : 4 bytes, 수신 IP**
6. Data : 전송 데이터

IP – 클래스 단위 주소 지정



0~127 0으로 시작

128~191 10으로 시작

192~223 110으로 시작

IP – 서브넷 주소 지정

IP address : **201.175.122.74**
Subnet mask : **255.255.255.192**

201은 class C

Subnet mask

11111111.11111111.11111111.11000000

IP – 서브넷 주소 지정

IP address : **201.175.122.74**
Subnet mask : **255.255.255.192**

IP address : **201.175.122.74/26**

11001001.10101111.01111010.01001010

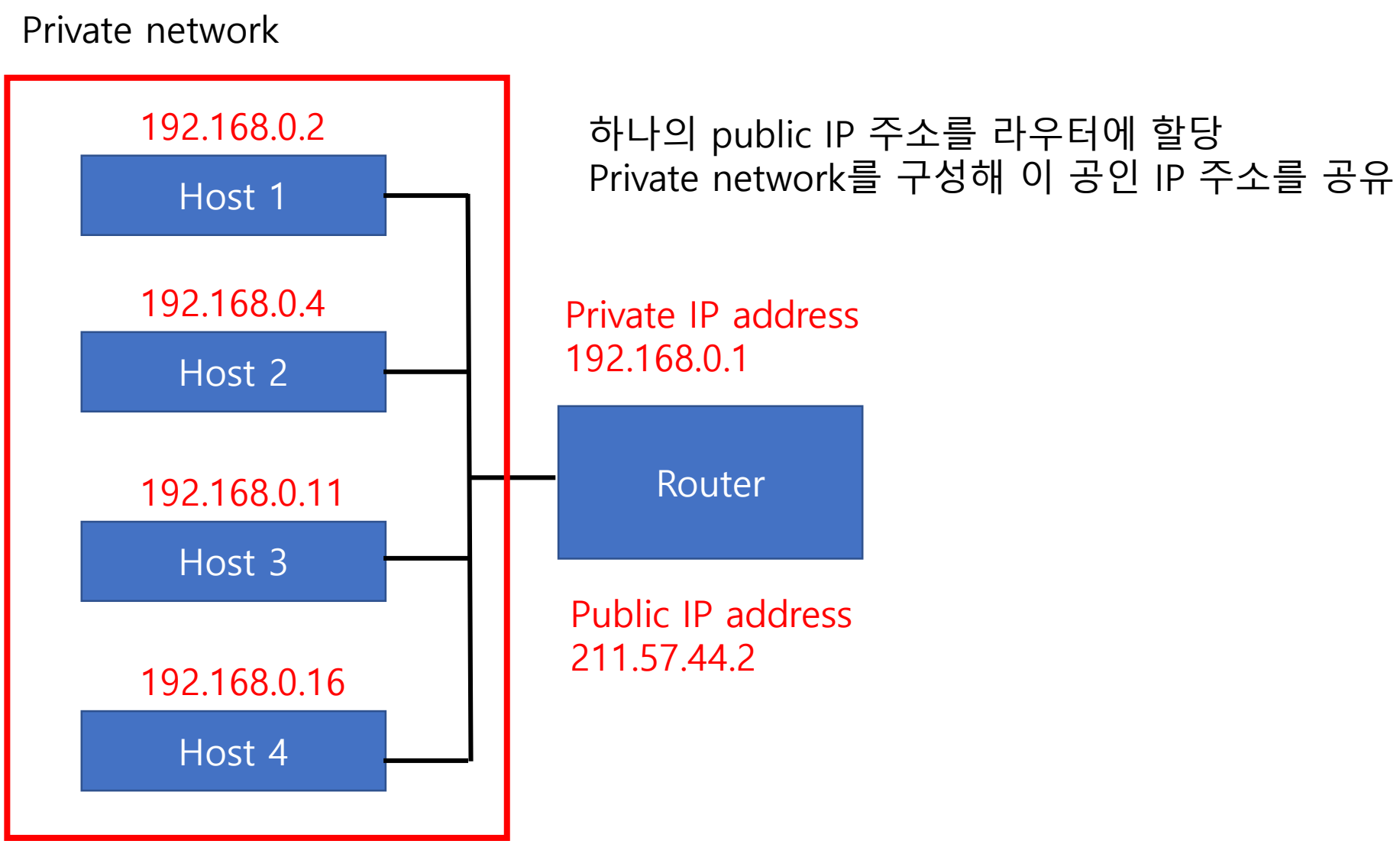
11111111.11111111.11111111.11000000

11001001.10101111.01111010.01000000

IP

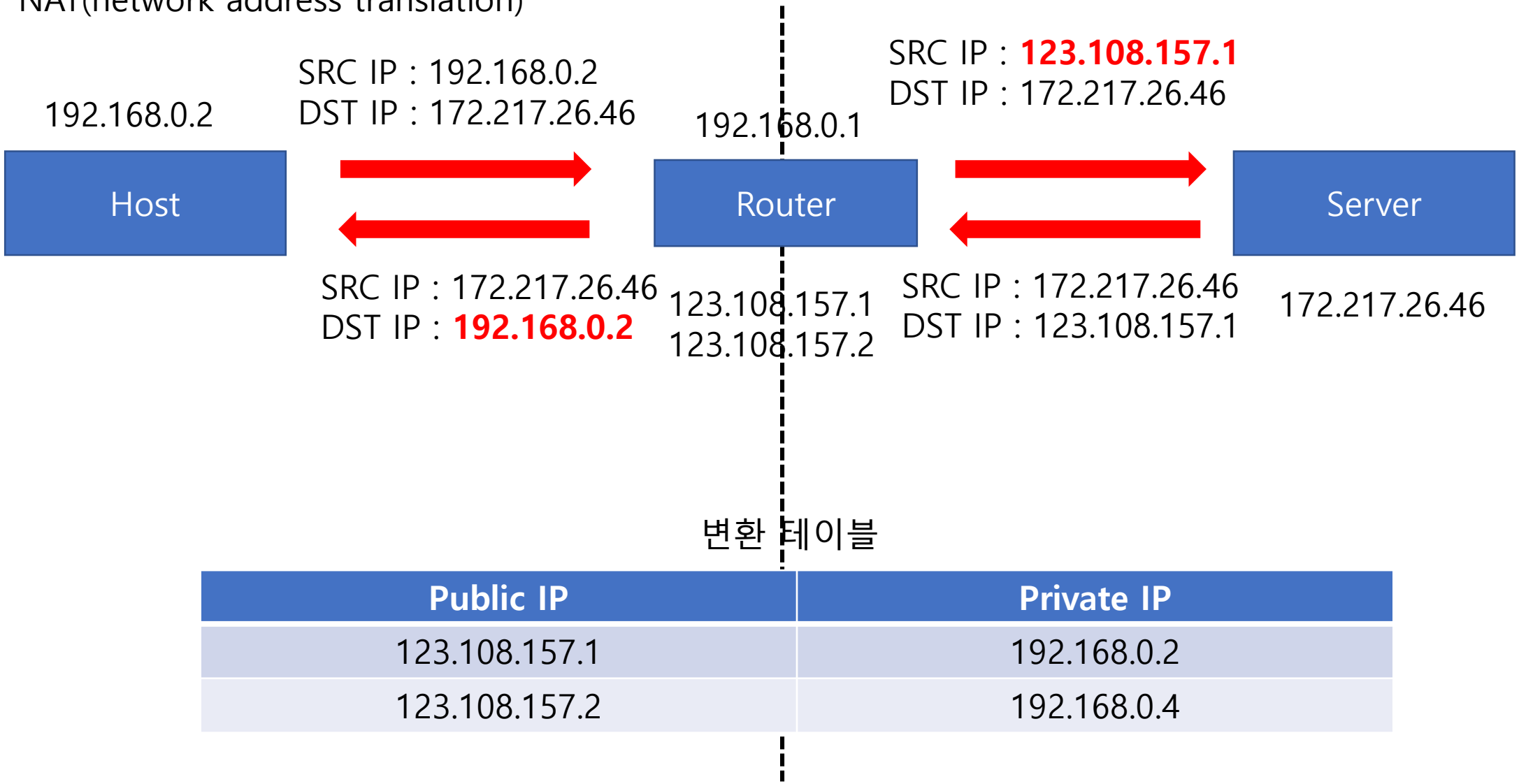
Public IP(공인 IP 주소)
: globally unique IP
Private UP(사설 IP 주소)
: Private network 상에 존재
NAT를 통해 인터넷에 connect 가능
하지만 인터넷에서 Private IP address로 connect 불가능

구분	Private network
CLASS A	10.0.0.0 ~ 10.255.255.255
CLASS B	172.16.0.0 ~ 172.31.255.255
CLASS C	192.168.0.0 ~ 192.168.255.255



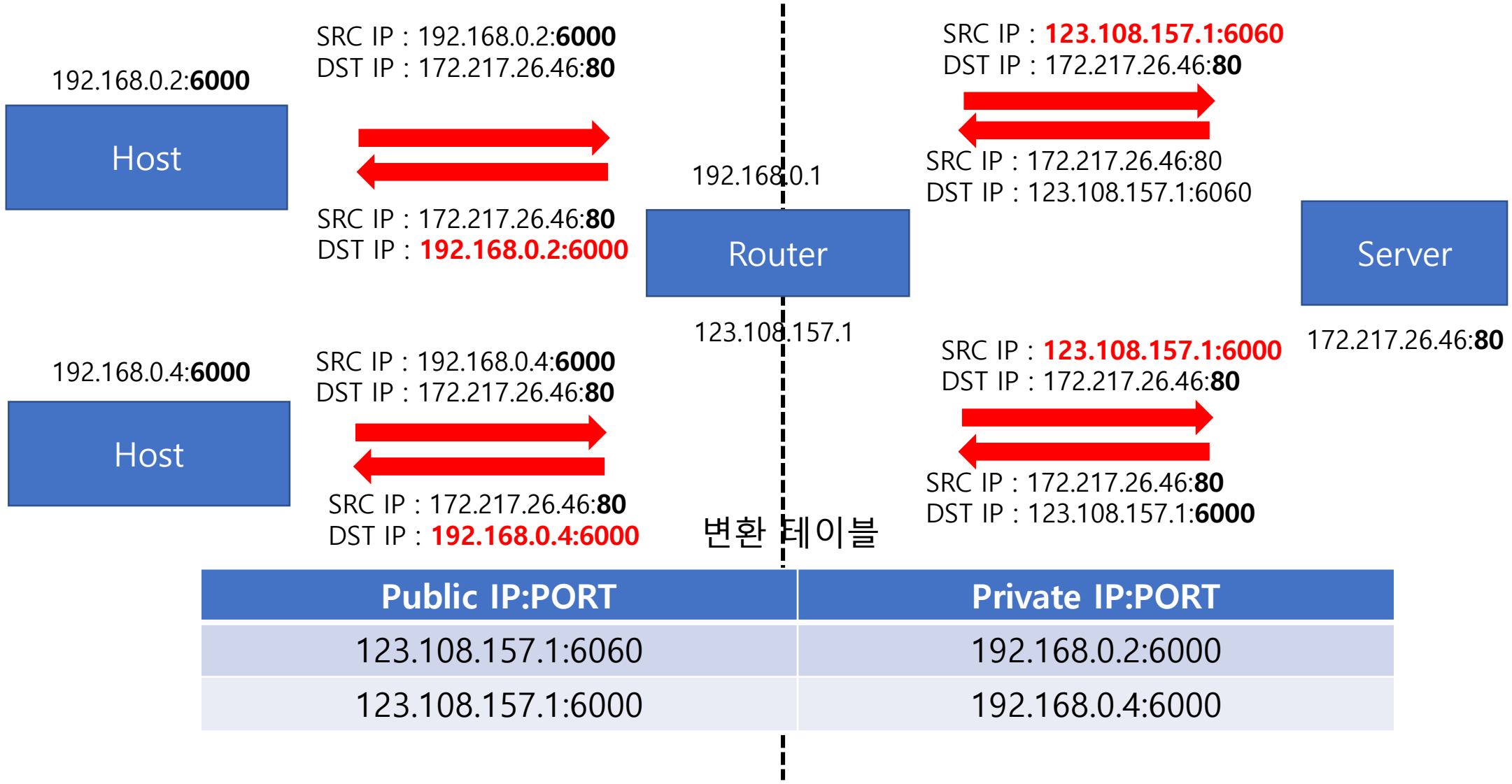
하나의 public IP 주소를 라우터에 할당
Private network를 구성해 이 공인 IP 주소를 공유

NAT(network address translation)



Public IP	Private IP
123.108.157.1	192.168.0.2
123.108.157.2	192.168.0.4

NAPT(network address port translation)



Public IP:PORT	Private IP:PORT
123.108.157.1:6060	192.168.0.2:6000
123.108.157.1:6000	192.168.0.4:6000

4. 전송 계층

Port : 소켓에 할당된 주소
특정 프로세스로 데이터를 전달할 수 있다.

well-known port : 0~1023 (server)
dynamic port : 49152~65535 (client)

Well-known port	Service
21	FTP
22	ssh
23	Telnet
25	SMTP
53	DNS
80	http

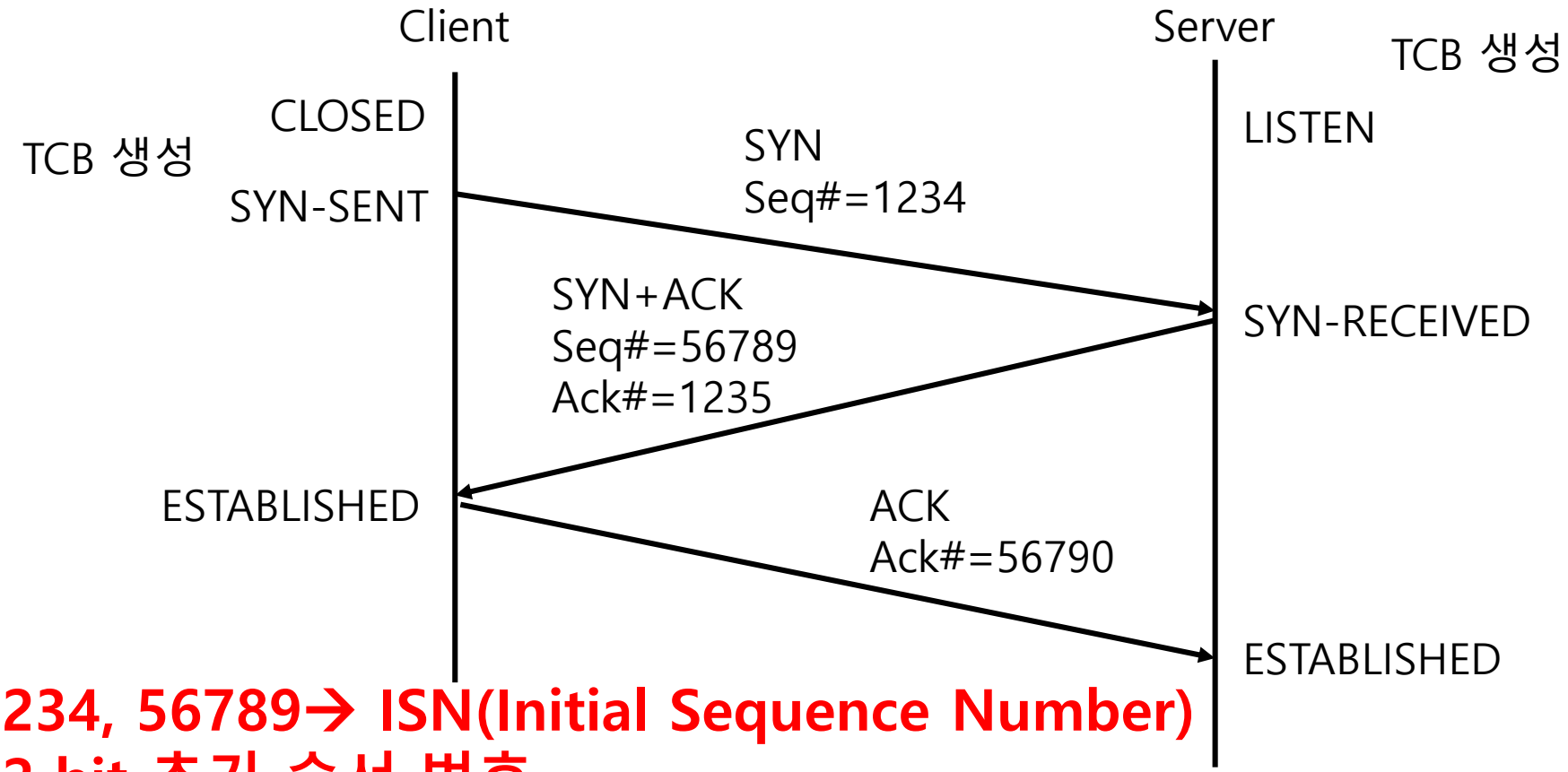
TCP(Transmission Control Protocol)

1. 연결 지향형 프로토콜
2. 높은 신뢰성
3. 수신 호스트가 응답하지 않으면 일정 시간 후 데이터를 재전송

TCB(Transmission Control Block)

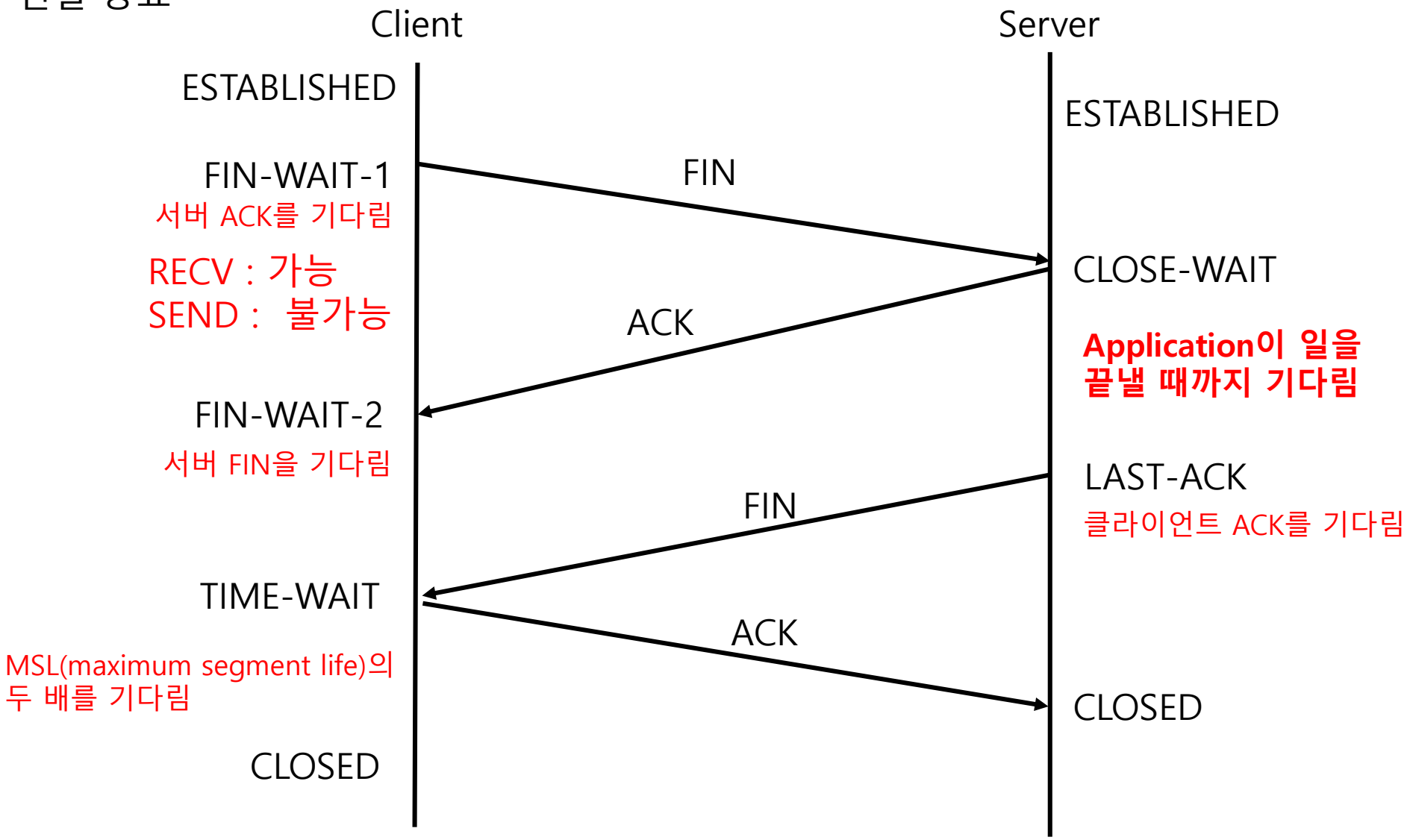
1. 연결을 구분하기 위한 소켓 쌍 번호
2. Send buffer와 receive buffer에 대한 포인터
3. Sent+ACK, Sent+NOT ACK, window 크기

Three-Way Handshaking



1234, 56789→ ISN(Initial Sequence Number)
32 bit 초기 순서 번호

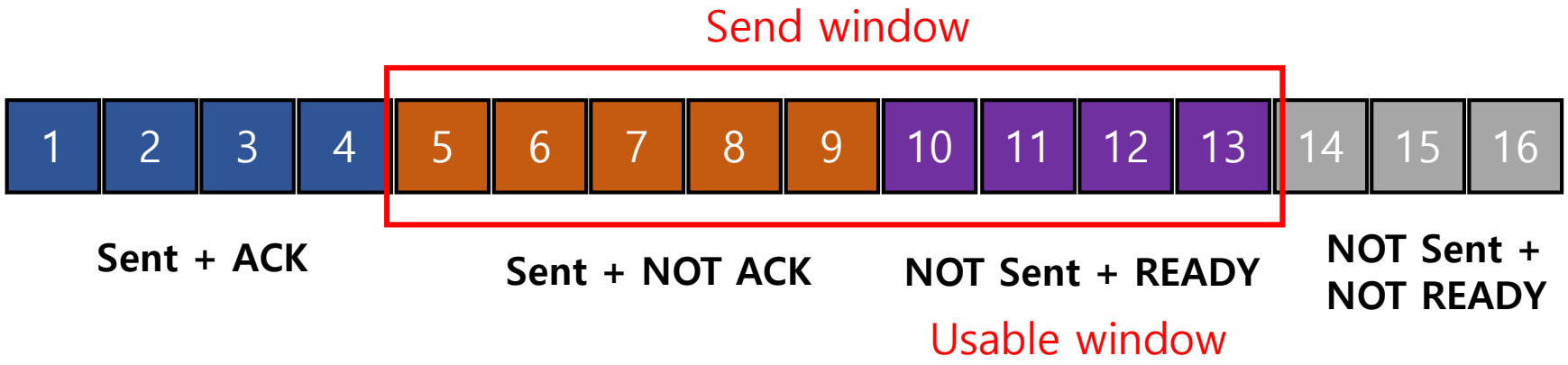
TCP 연결 종료


Client
Server
ESTABLISHED
ESTABLISHED
FIN-WAIT-1
서버 ACK를 기다림
FIN
RECV : 가능
SEND : 불가능
CLOSE-WAIT
ACK
Application이 일을
끝낼 때까지 기다림
FIN-WAIT-2
서버 FIN을 기다림
LAST-ACK
클라이언트 ACK를 기다림
FIN
TIME-WAIT
ACK
MSL(maximum segment life)의
두 배를 기다림
CLOSED
CLOSED

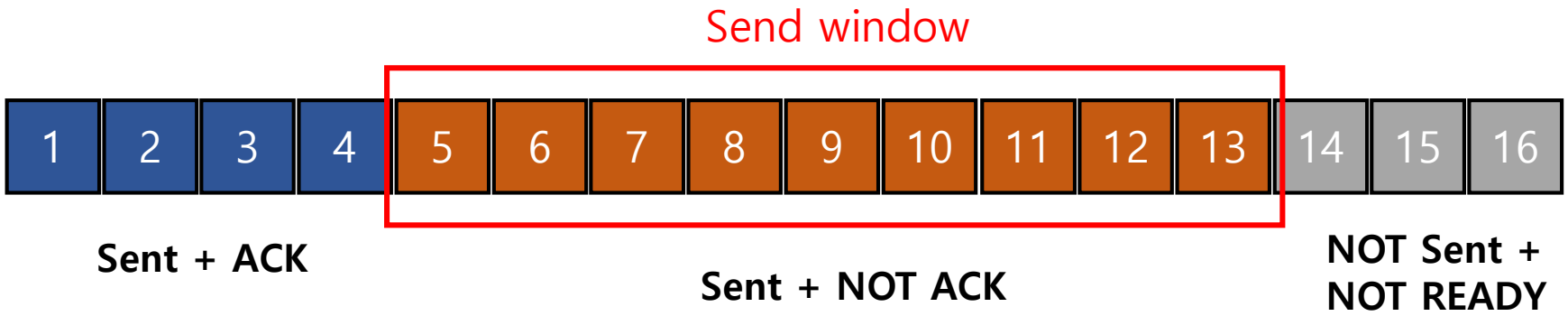
TCP 헤더

1. Source Port : 2 bytes, 송신 Port
2. Destination Port : 2 bytes, 수신 Port
3. Sequence Number : 4 bytes, 이번에 보내는 데이터의 첫번째 바이트 순서 번호
4. Acknowledgement Number : 4 bytes, 그 이전 데이터는 모두 받았다!!
5. Window : 2 bytes, 송신자의 수신 윈도우 크기, 수신자의 송신 윈도우 크기와 같다

Sliding Window



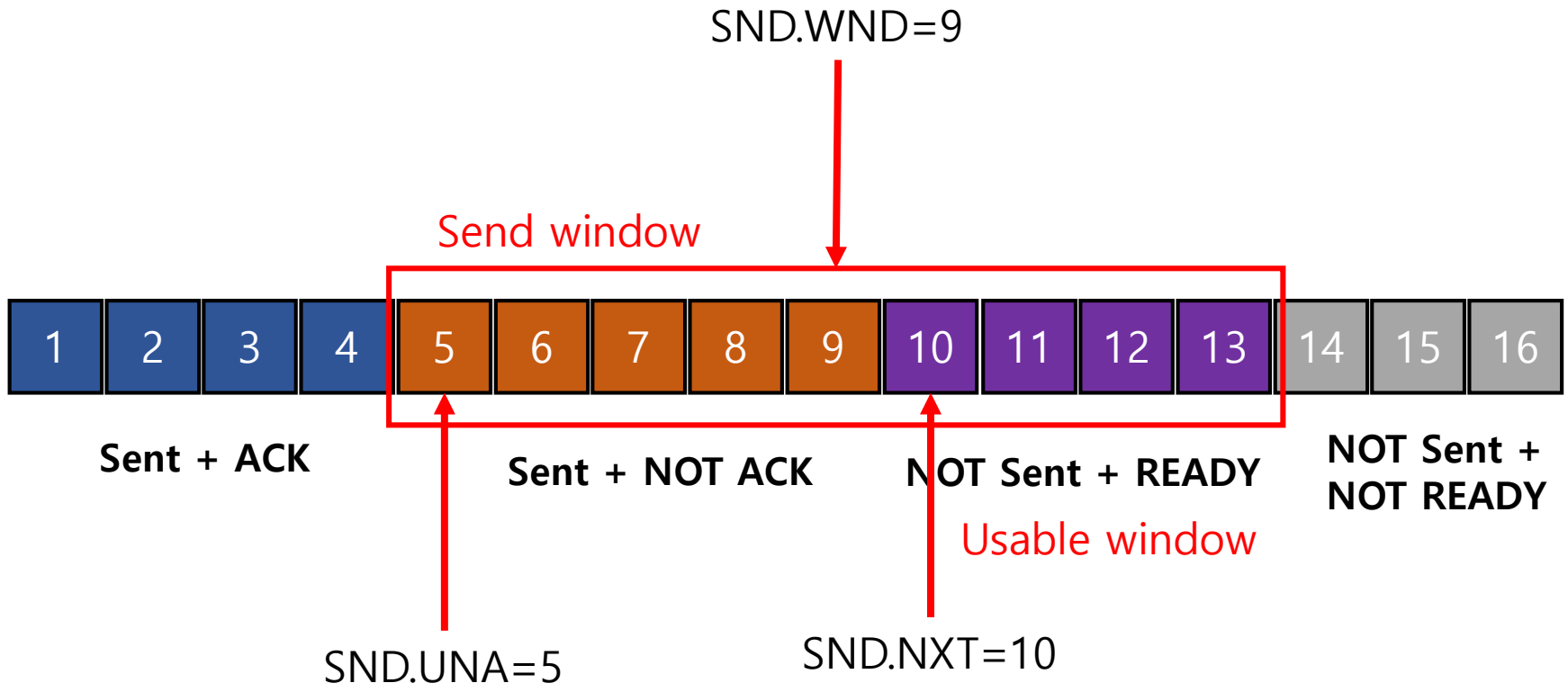
Sliding Window



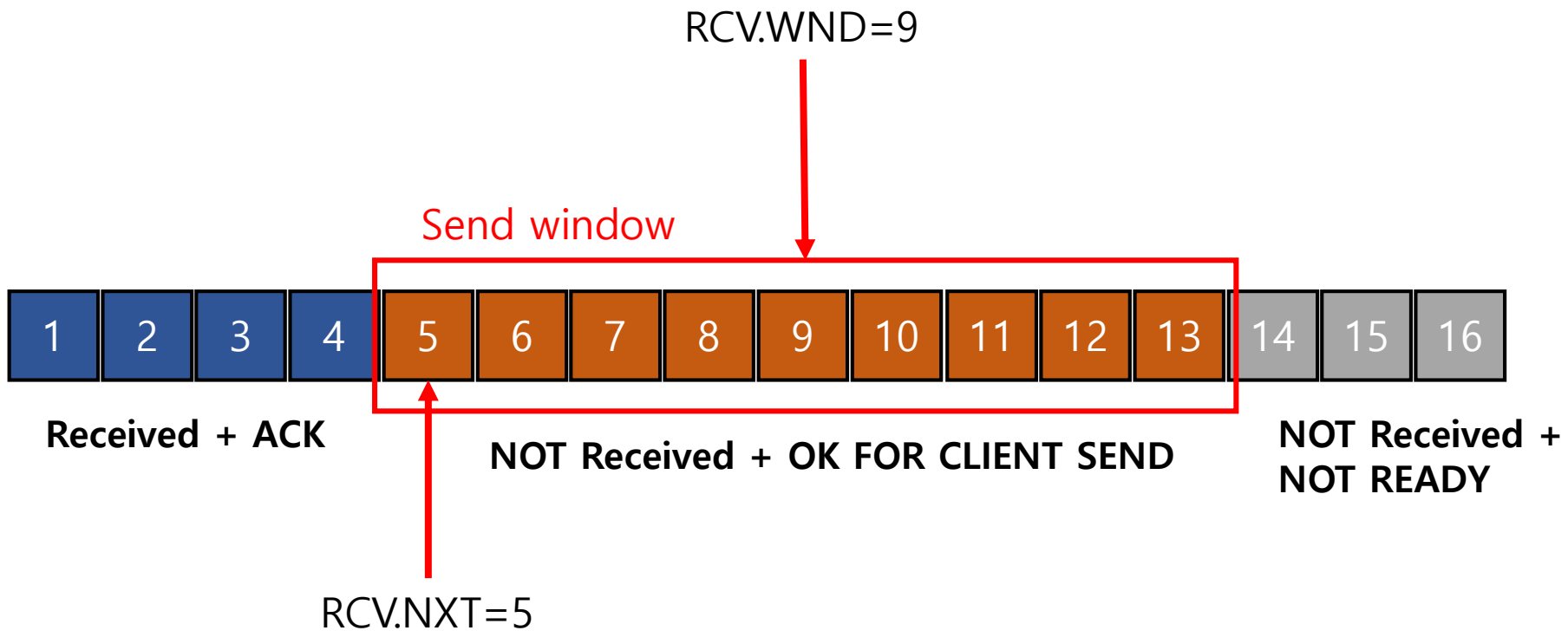
Sliding Window

ACK: #7

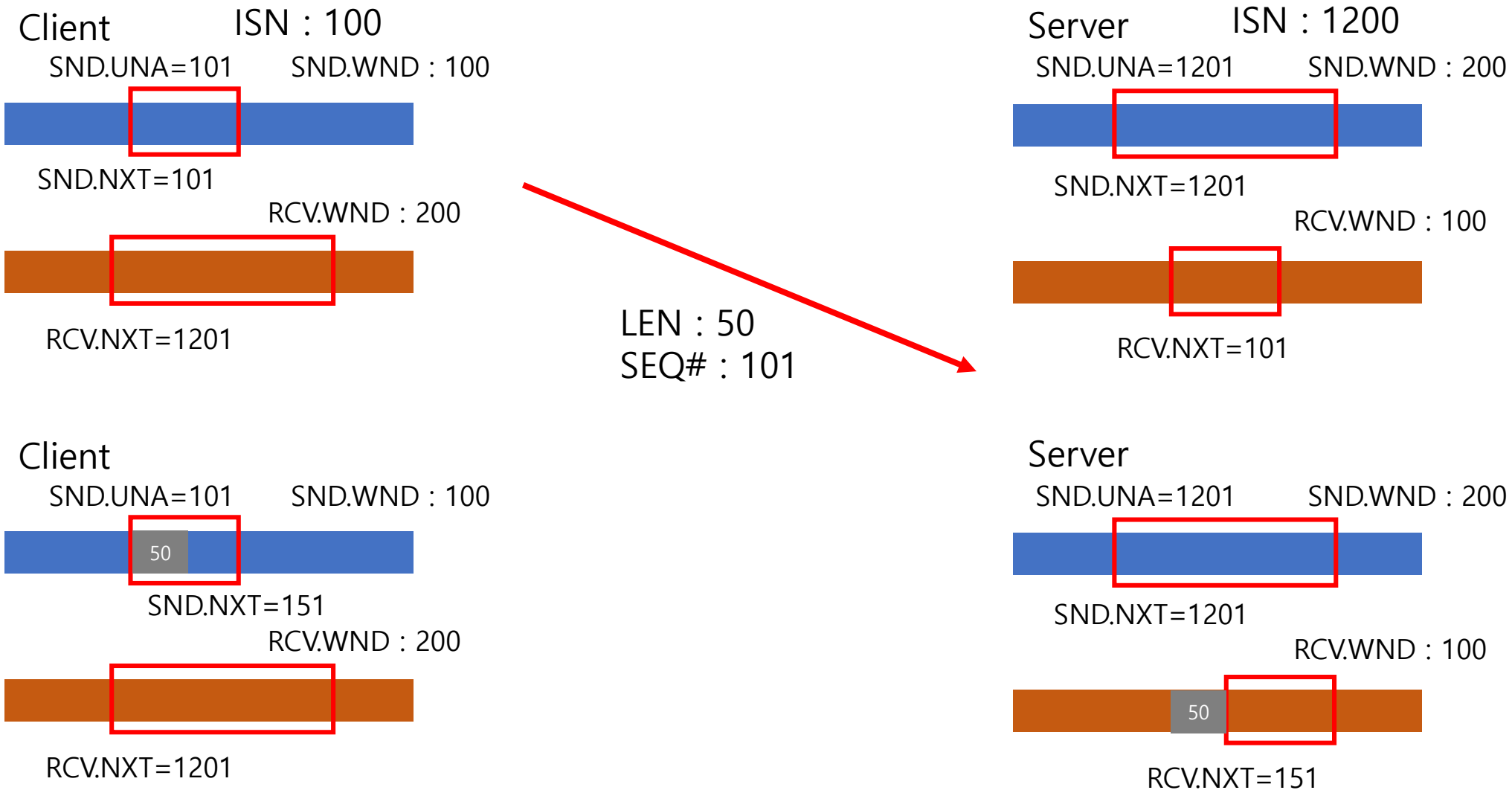
SND 포인터(client)



RCV 포인터(server)

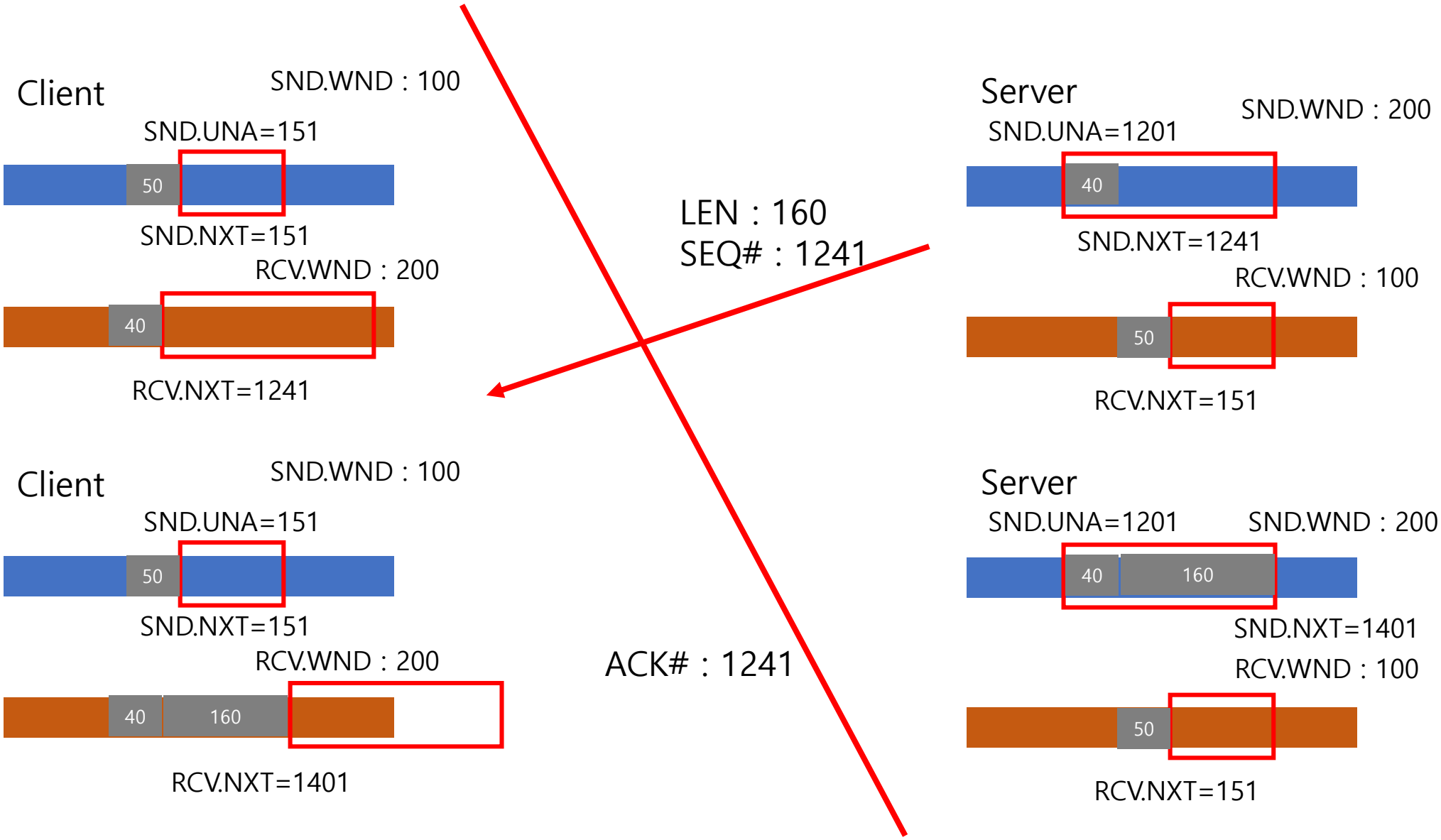


Sliding window

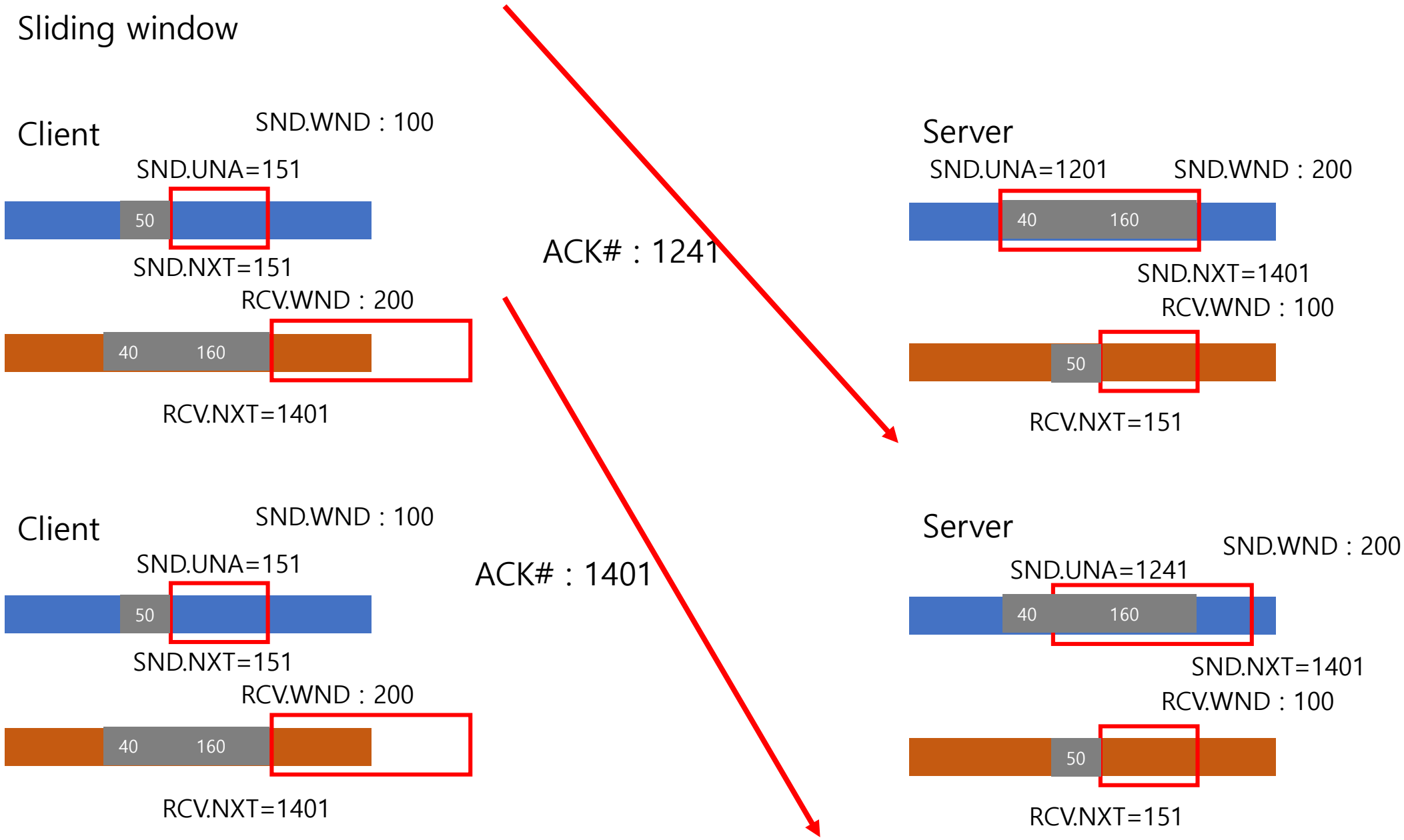


Sliding window

Sliding window



Sliding window



Sliding window

Client

SND.WND : 100

SND.UNA=151

SND.NXT=151

RCV.WND : 200

RCV.NXT=1401

ACK# : 1401

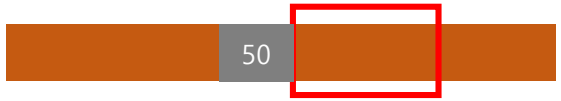
Server

SND.WND : 200

SND.UNA=1241

SND.NXT=1401

RCV.WND : 100



RCV.NXT=151

Client

SND.WND : 100

SND.UNA=151

SND.NXT=151

RCV.WND : 200

RCV.NXT=1401

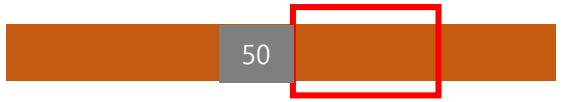
SND.WND : 200

Server

SND.UNA=1401

SND.NXT=1401

RCV.WND : 100



RCV.NXT=151

Sliding window

```
    27 32.892768    192.168.0.11    192.168.0.2     TCP      98 49321 → 3030 [PSH, ACK] Seq=14 Ack=14 Win=262144 Len=44
    28 32.893791    192.168.0.2     192.168.0.11    TCP      98 3030 → 49321 [PSH, ACK] Seq=14 Ack=58 Win=65536 Len=44
    29 32.897180    192.168.0.11    192.168.0.2     TCP      54 49321 → 3030 [ACK] Seq=58 Ack=58 Win=262080 Len=0
    77 48.941455    192.168.0.2     192.168.0.11    TCP      82 3030 → 49321 [PSH, ACK] Seq=58 Ack=58 Win=65536 Len=28
```

```
Transmission Control Protocol, Src Port: 49321, Dst Port: 3030, Seq: 14, Ack: 14, Len: 44
    Source Port: 49321
    Destination Port: 3030
    [Stream index: 2]
    [TCP Segment Len: 44]
    Sequence number: 14    (relative sequence number)
    [Next sequence number: 58    (relative sequence number)]
    Acknowledgment number: 14    (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x018 (PSH, ACK)
    Window size value: 4096
    [Calculated window size: 262144]
```

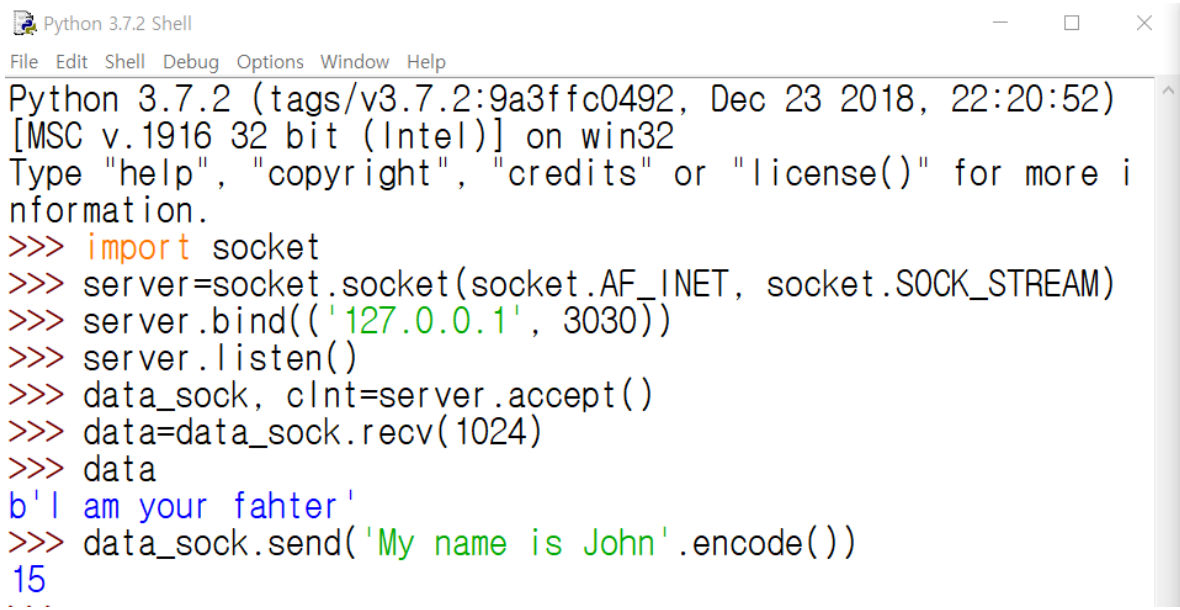
```
0000  40 49 0f 80 c3 2f 78 4f  43 51 57 fe 08 00 45 00   @I···/xO CQW···E·
0010  00 54 00 00 40 00 40 06  b9 46 c0 a8 00 0b c0 a8   ·T··@·@· ·F······
0020  00 02 c0 a9 0b d6 3b 21  6f 67 ba 88 50 f2 50 18   ······;! og··P·P·
0030  10 00 e0 bb 00 00 67 72  65 67 24 24 68 69 7e 20   ·····gr eg$$hi~
0040  4d 79 20 6e 61 6d 65 20  69 73 20 47 72 65 67 21   My name  is Greg!
0050  20 4e 69 63 65 20 74 6f  20 6d 65 65 74 20 79 6f    Nice to  meet yo
0060  75 21                                             u!
```

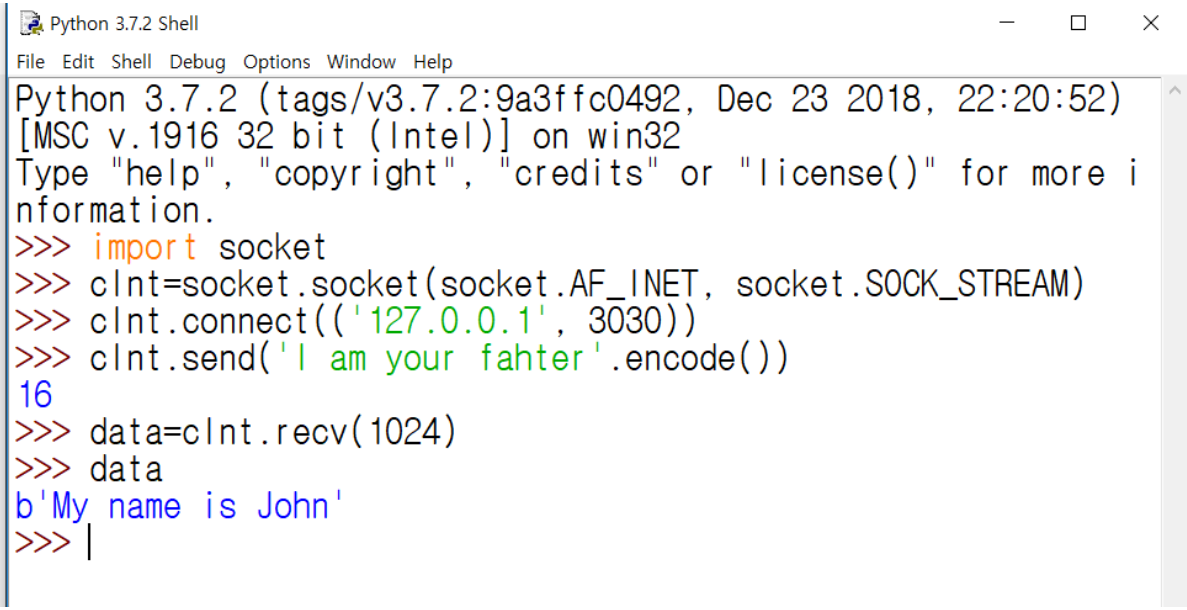
Sliding window

27	32.892768	192.168.0.11	192.168.0.2	TCP	98 49321 → 3030 [PSH, ACK] Seq=14 Ack=14 Win=262144 Len=44
28	32.893791	192.168.0.2	192.168.0.11	TCP	98 3030 → 49321 [PSH, ACK] Seq=14 Ack=58 Win=65536 Len=44
29	32.897180	192.168.0.11	192.168.0.2	TCP	54 49321 → 3030 [ACK] Seq=58 Ack=58 Win=262080 Len=0
77	48.941455	192.168.0.2	192.168.0.11	TCP	82 3030 → 49321 [PSH, ACK] Seq=58 Ack=58 Win=65536 Len=28

```
Transmission Control Protocol, Src Port: 3030, Dst Port: 49321, Seq: 14, Ack: 58, Len: 44
    Source Port: 3030
    Destination Port: 49321
    [Stream index: 2]
    [TCP Segment Len: 44]
    Sequence number: 14    (relative sequence number)
    [Next sequence number: 58    (relative sequence number)]
    Acknowledgment number: 58    (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x018 (PSH, ACK)
    Window size value: 256
    [Calculated window size: 65536]
```

TCP socket

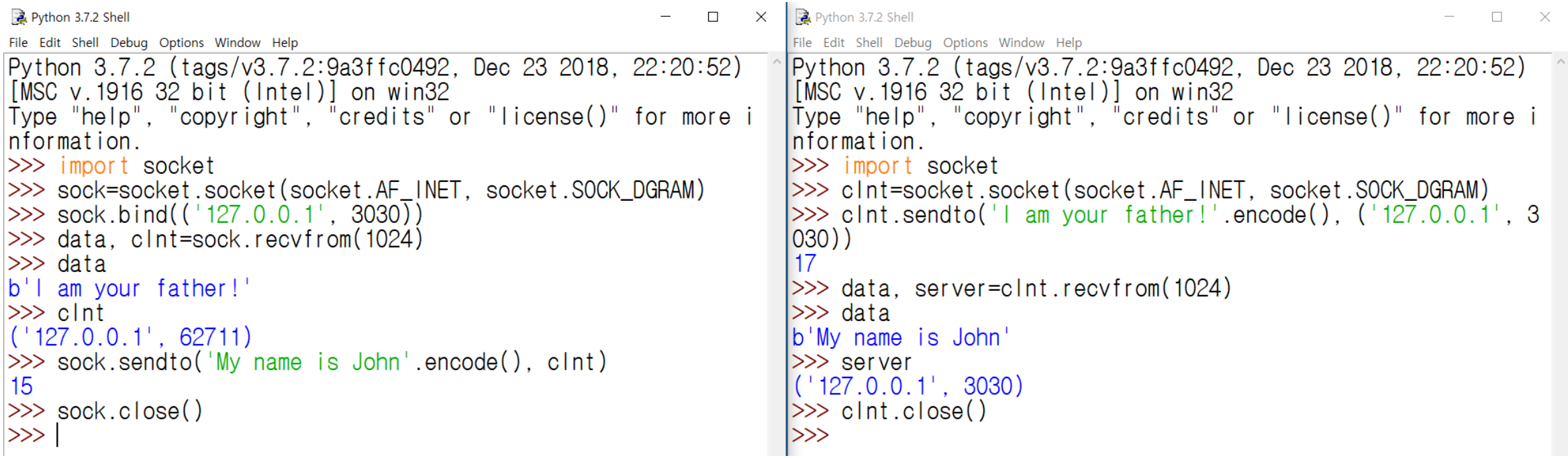

Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:52)
[MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more i
nformation.
>>> import socket
>>> server=socket.socket(socket.AF_INET, socket.SOCK_STREAM)
>>> server.bind(('127.0.0.1', 3030))
>>> server.listen()
>>> data_sock, clnt=server.accept()
>>> data=data_sock.recv(1024)
>>> data
b'I am your fahter'
>>> data_sock.send('My name is John'.encode())
15


Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:52)
[MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more i
nformation.
>>> import socket
>>> clnt=socket.socket(socket.AF_INET, socket.SOCK_STREAM)
>>> clnt.connect(('127.0.0.1', 3030))
>>> clnt.send('I am your fahter'.encode())
16
>>> data=clnt.recv(1024)
>>> data
b'My name is John'
>>>

UDP(User Datagram Protocol)

1. 비 연결 지향형 프로토콜
2. 신뢰할 수 없다.
3. 데이터를 재전송하지 않는다.
4. 전송된 데이터 일부가 손실될 수 있다.

UDP socket


Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:52)
[MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more i
nformation.
>>> import socket
>>> sock=socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
>>> sock.bind(('127.0.0.1', 3030))
>>> data, clnt=sock.recvfrom(1024)
>>> data
b'I am your father!'
>>> clnt
('127.0.0.1', 62711)
>>> sock.sendto('My name is John'.encode(), clnt)
15
>>> sock.close()
>>>
Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:52)
[MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more i
nformation.
>>> import socket
>>> clnt=socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
>>> clnt.sendto('I am your father!'.encode(), ('127.0.0.1', 3
030))
17
>>> data, server=clnt.recvfrom(1024)
>>> data
b'My name is John'
>>> server
('127.0.0.1', 3030)
>>> clnt.close()
>>>

UDP 헤더

1. Source Port : 2 bytes, 송신 Port
2. Destination Port : 2 bytes, 수신 Port
3. Length : 2 bytes, UDP 헤더와 데이터 필드를 모두 포함한 전체 패킷의 길이

5. 응용 계층

1. FTP : File Transfer Protocol(20, 21), 파일 전송을 위한 프로토콜
2. Telnet : 23번 포트, 유저가 원격에 있는 서버에 로그인
3. SSH : 22번 포트, 텔넷과 유사하나 암호화를 통해 보안을 강화했다.
4. SMTP : Simple Mail Transfer Protocol(25) : 메일 서비스
5. DNS : Domain Name System(53) : 도메인 이름을 IP 주소로 변환하는 프로토콜
6. HTTP : HyperText Transfer Protocol(80) : 웹에서 데이터를 주고 받을 수 있는 프로토콜
7. HTTPS : HTTP over Secure Socket Layer(443), 텍스트를 SSL/TLS로 암호화해 보안을 강화했다.

URL

http://<user>:<password>@<host>:<port>/<urlpath>?<query>#<bookmark>

잘 쓰이지 않음

기본으로 80을 쓰므로
일반적으로 생략

HTTP/1.0

- 일시적 연결

HTTP/1.1

- 지속적 연결(Persistent Connection)
- 효율적인 캐싱과 프록싱
- 컨텐트 협상

HTTP

1. 일시적 연결 (HTTP/1.0)
   : TCP 연결 후 하나의 요청/응답 후 연결을 끊는다
2. 지속적 연결 (HTTP/1.1)
   : TCP 연결을 그대로 유지한다.
   Connection: Close 헤더를 포함해 일시적 연결을 할 수 있다.

일반 메시지 형식(generic message format)
<시작줄(start-line)>
<메시지 헤더> : Host 헤더는 HTTP/1.1 필수
<빈 줄>
[<메시지 본문>]
[<메시지 트레일러>] : chunking에서 메시지 본문 뒤에 위치

HTTP 요청

GET /index.html HTTP/1.1
Date: Sun, 25 March 2019 00:15:45 GMT
Host: www.csbootcamp.com
Accept: text/html, text/plain
<CRLF>

요청 줄

헤더

빈 줄

메시지 본문

HTTP 응답

```
 HTTP/1.1 200 OK
Date: Sun, 25 March 2019 00:15:45 GMT
Connection: close
Content-type: text/html
<CRLF>
<html>
<head></head>
<body></body>
</html>
```

상태 줄

헤더

빈 줄

메시지 본문

메서드

1. GET
   - URL이 지정하는 자원을 찾아 클라이언트에 전송
2. HEAD
   - GET과 같으나 메시지 본문이 없다. 테스트, 확인 용도
3. POST
   - 클라이언트가 임의의 데이터를 서버로 보낸다.
   - 주로 form 형식을 사용하며 서버의 프로그램에 전달

메서드

1. PUT
   - 지정한 URL에 요청의 본문 내용을 저장
   - 서버로 파일을 복사할 수 있게 한다 → 잘 쓰이지 않는 이유
2. DELETE
   - 지정한 자원을 지우도록 요청
3. TRACE
   - 클라이언트가 서버에 보낸 요청의 복사본을 돌려받는다

상태 코드

1. 1XX – 정보 제공 메시지
   : 일반적인 정보를 제공
2. 2XX – 성공
   : 서버가 메소드를 받아 수행했다
3. 3XX – 리다이렉션
   : 자원이 여러 종류가 있다거나 새로운 URL로 이동하는 등
   추가 행동이 필요
4. 4XX – 클라이언트 에러
   : 요청이 잘못되었거나 자원을 찾을 수 없다
5. 5XX – 서버 에러
   : 요청은 유효하나 수행 방법을 모르거나 서버 문제로 처리 불가

컨텐트 협상

1. **서버 주도(Server-driven) 협상**
   : 최선 추측(best guess) → 항상 클라이언트가 원하는 형식 데이터를 받는 것은 아님.
2. **에이전트 주도(Agent-driven) 협상**
   : 클라이언트가 자원을 고를 수 있다.
   자료에 접근하는데 두번의 요청과 응답이 필요 → 효율성이 떨어짐

Accept(매체 유형)
Accept-Charset(문자 집합)
Accept-Encoding(컨텐트 인코딩)
Accept-Language(언어)

Accept-Language: en, sp

컨텐트 협상

Accept : text/html, text/*;q=0.5, */*;q=0.2

default : 1

Accept-Language : kr;q=0.7, fr;q=0, en;q=0.4

청킹(chunking)

이미 본문 내용을 알고 있을 때
Content-Length 헤더를 이용

HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 114
Expires: Mon, 26 Mar 2019 00:30:40 GMT

<html><head></head><body>This is generated by Django app. So this length of this Content is dynamic.</body></html>

청킹(chunking)

본문 내용이 동적으로 생성될 때
Transfer-Encoding: chunked

```
HTTP/1.1 200 OK
Content-Type: text/html
Transfer-Encoding: chunked
Trailer: Expires

20
<html><head></head><body>This is
26
generated by Django app. So this length
2A
 of this Content is dynamic.</body></html>
0
Expires: Mon, 26 Mar 2019 00:30:40 GMT
```