Network Programming

Lecture 1—Introduction and TCP/IP

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Nov 10, 2015

Part 1. Introduction and TCP/IP

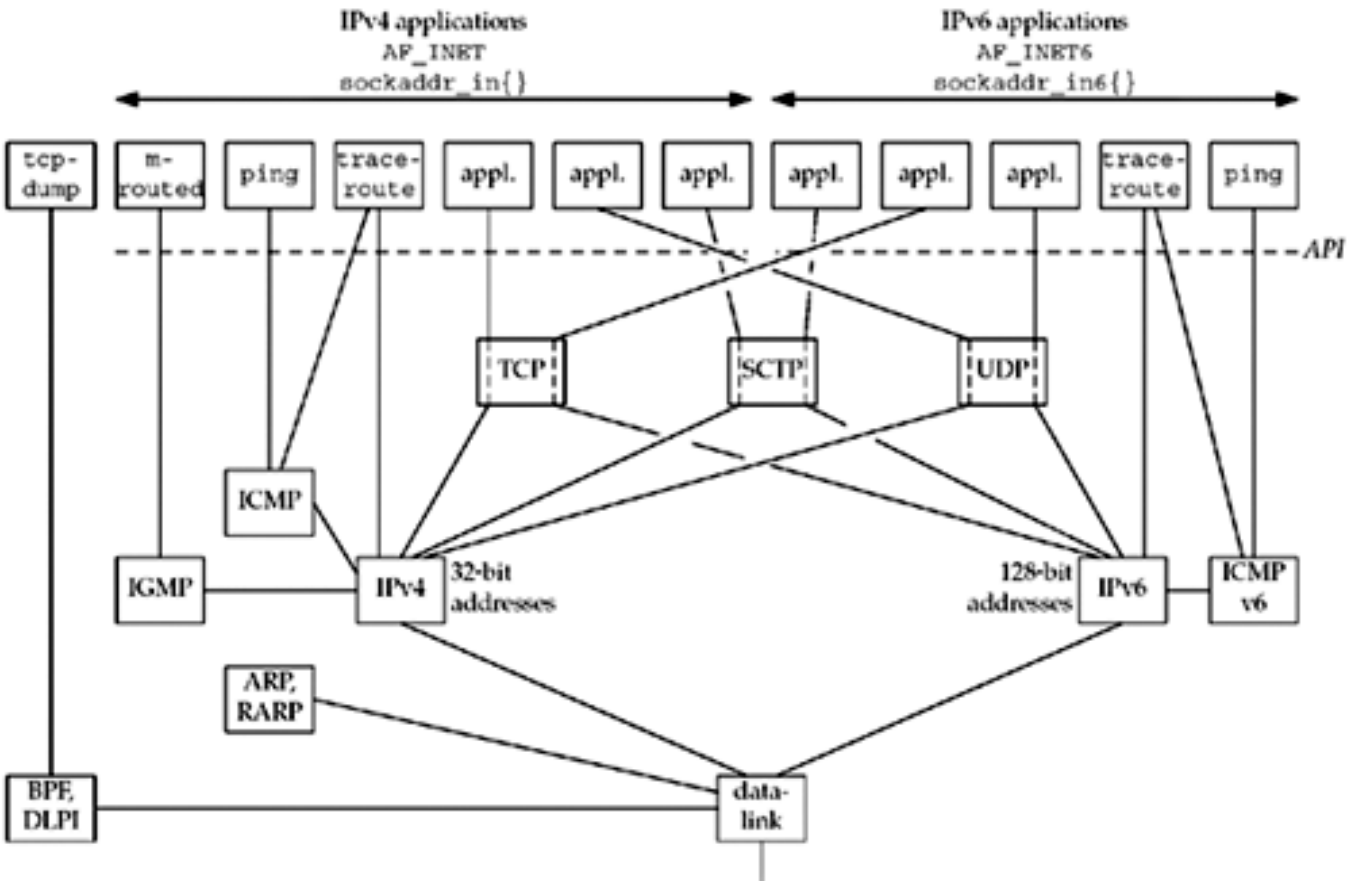
A Simple Daytime Client

```
      ...
 8    if (argc != 2)
 9        err_quit("usage: a.out <IPaddress>");

10    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0)
11        err_sys("socket error");

12    bzero(&servaddr, sizeof(servaddr));
13    servaddr.sin_family = AF_INET;
14    servaddr.sin_port = htons(13);  /* daytime server */
15    if (inet_pton(AF_INET, argv[1], &servaddr.sin_addr) <= 0)
16        err_quit("inet_pton error for %s", argv[1]);

17    if (connect(sockfd, (SA *) &servaddr, sizeof(servaddr)) < 0)
18        err_sys("connect error");

19    while ( (n = read(sockfd, recvline, MAXLINE)) > 0) {
20        recvline[n] = 0;        /* null terminate */
21        if (fputs(recvline, stdout) == EOF)
22            err_sys("fputs error");
23    }
24    if (n < 0)
25        err_sys("read error");

26    exit(0);
27 }
```

A Simple Daytime Server

```
      ...
10    listenfd = Socket(AF_INET, SOCK_STREAM, 0);

11    bzeros(&servaddr, sizeof(servaddr));
12    servaddr.sin_family = AF_INET;
13    servaddr.sin_addr.s_addr = htonl(INADDR_ANY);
14    servaddr.sin_port = htons(13); /* daytime server */

15    Bind(listenfd, (SA *) &servaddr, sizeof(servaddr));

16    Listen(listenfd, LISTENQ);

17    for ( ; ; ) {
18        connfd = Accept(listenfd, (SA *) NULL, NULL);

19        ticks = time(NULL);
20        snprintf(buff, sizeof(buff), "%.24s\r\n", ctime(&ticks));
21        Write(connfd, buff, strlen(buff));

22        Close(connfd);
23    }
24 }
```

The Big Picture



User Datagram Protocol (UDP)

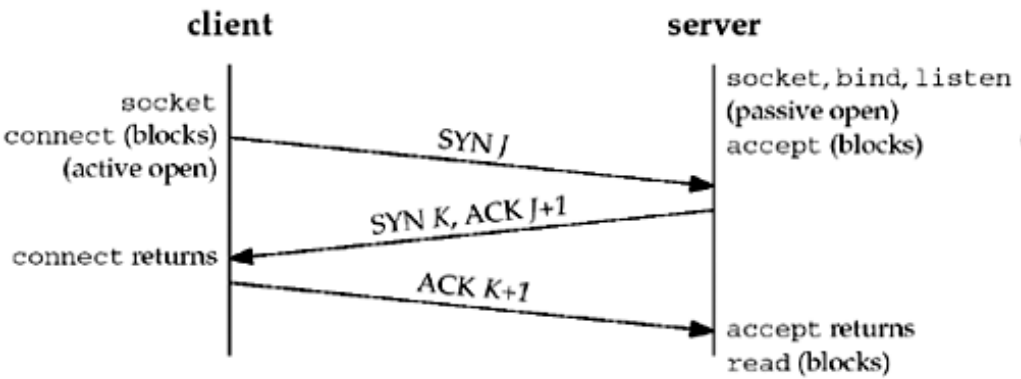
- The application writes a datagram to a UDP socket, which is encapsulated as either a IPv4 of a IPv6 datagram, which is sent to its destination.
- UDP provides a connectionless service.
- Each UDP datagram has a length and we can consider a datagram as a record.
- RFC 768 [Postel 1980]

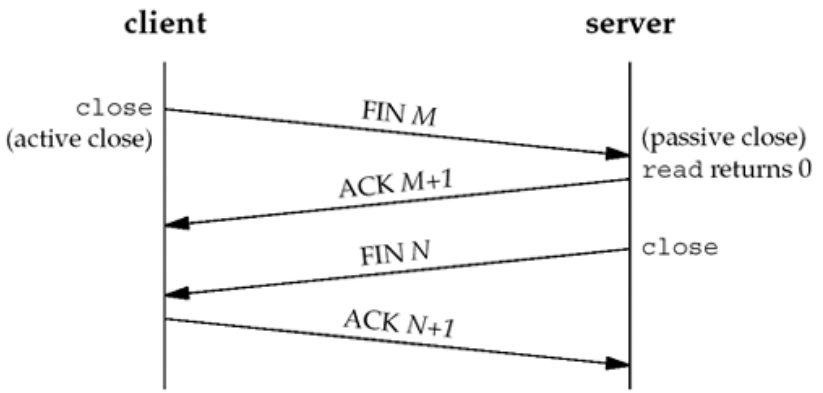
Transmission Control Protocol (TCP)

- Connection-oriented
- Reliable
- ***Sequence*** the data by associating a sequence number with every byte that it sends.
- TCP provides ***flow control***. —**window**
- A TCP connection is also ***full-duplex***.

TCP Connection Establishment and Termination

- Three-Way Handshake (SYN, ACK)
- Four-Way Termination (FIN, ACK)





TCP Limitations

- TCP provides both reliable data transfer and strict order-of-transmission delivery of data. Some applications need reliable transfer without sequence maintenance, while others would be satisfied with partial ordering of the data.
- The stream-oriented nature of TCP is often an inconvenience. Applications must add their own record marking.
- The limited scope of TCP sockets complicates the task of providing highly-available data transfer capability using multi-homed hosts.
- Vulnerable to denial-of-service attacks, e.g. SYN attacks.

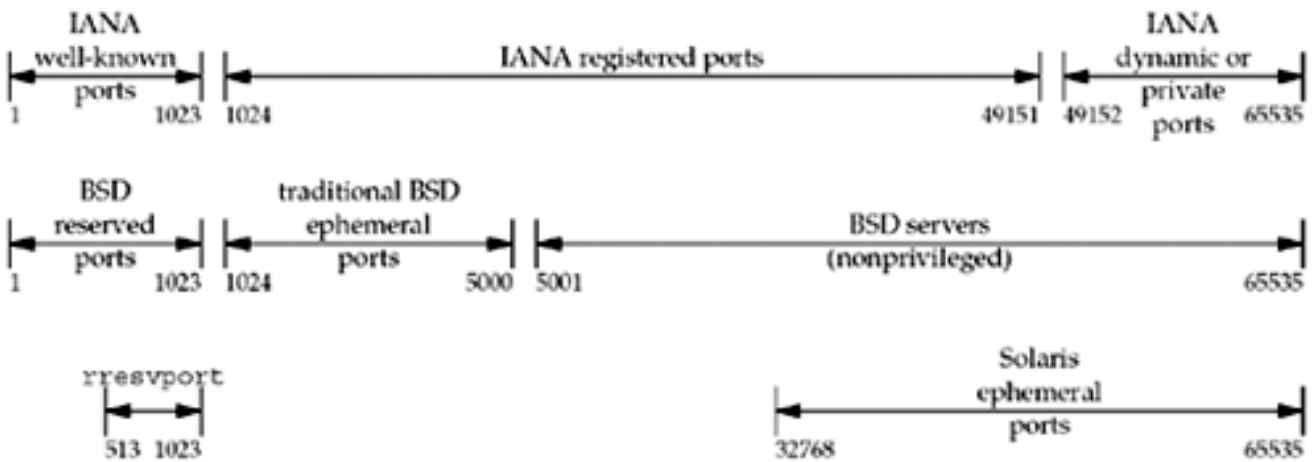
These limitations affect the performance of IP over public switched telephone networks.

Stream Control Transmission Protocol (SCTP)

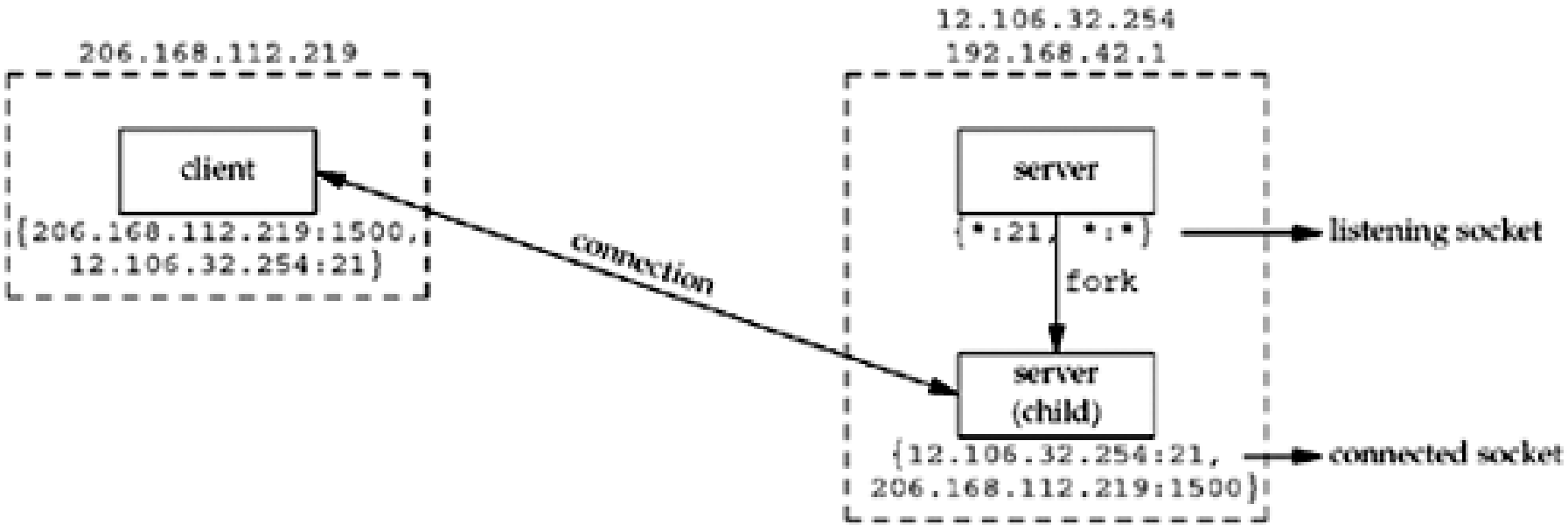
- Multihoming support, where one (or both) endpoints of a connection can consist of more than one IP address, fail-over between redundant network paths.
- Delivery of data in chunks within independent streams.
- Path Selection and Monitoring.
- Validation and Acknowledgment mechanisms—Protects against flooding attacks and provides notification of duplicated or missing data chunks.
- Improved error detection suitable for jumbo Ethernet frames.

Port Numbers

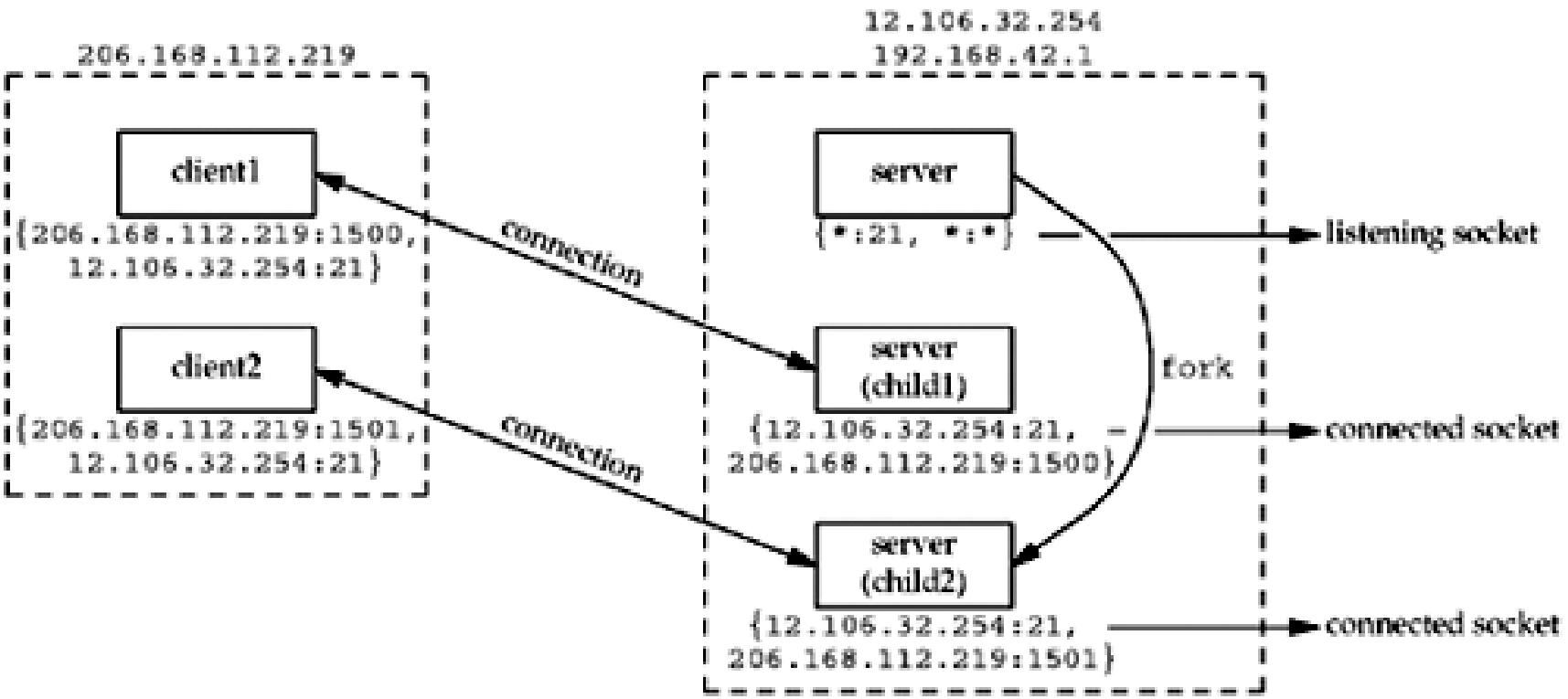
- The ***well-known*** ports: 0 through 1023
- The ***registered*** ports: 1024 through 49151
- The ***dynamic*** or ***private ports***: 49152 through 65535



TCP Port Numbers and Concurrent Servers



TCP Port Numbers and Concurrent Servers



Protocol Usage by Common Internet Applications

Application	IP	ICMP	UDP	TCP	SCTP
ping		•			
traceroute		•	•		
OSPF (routing protocol)	•				
RIP (routing protocol)			•		
BGP (routing protocol)				•	
BOOTP (bootstrap protocol)			•		
DHCP (bootstrap protocol)			•		
NTP (time protocol)			•		
TFTP			•		
SNMP (network management)			•		
SMTP (electronic mail)				•	
Telnet (remote login)				•	
SSH (secure remote login)				•	
FTP				•	
HTTP (the Web)				•	
NNTP (network news)				•	
LPR (remote printing)				•	
DNS			•	•	
NFS (network filesystem)			•	•	
Sun RPC			•	•	
DCE RPC			•	•	
IUA (ISDN over IP)					•
M2UA,M3UA (SS7 telephony signaling)					•
H.248 (media gateway control)			•	•	•
H.323 (IP telephony)			•	•	•
SIP (IP telephony)			•	•	•

UDP vs TCP vs SCTP

Feature Name	UDP	TCP	SCTP
Connection oriented	No	Yes	Yes
Reliable transport	No	Yes	Yes
Preserve message boundary	Yes	No	Yes
Ordered delivery	No	Yes	Yes
Unordered delivery	Yes	No	Yes
Data checksum	Yes	Yes	Yes
Checksum size (bits)	16	16	32
Path MTU	No	Yes	Yes
Congestion control	No	Yes	Yes
Multiple streams	No	No	Yes
Multi-homing support	No	No	Yes
Bundling / Nagle	No	Yes	Yes