VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
FAKULTA INFORMAČNÍCH TECHNOLOGIÍ

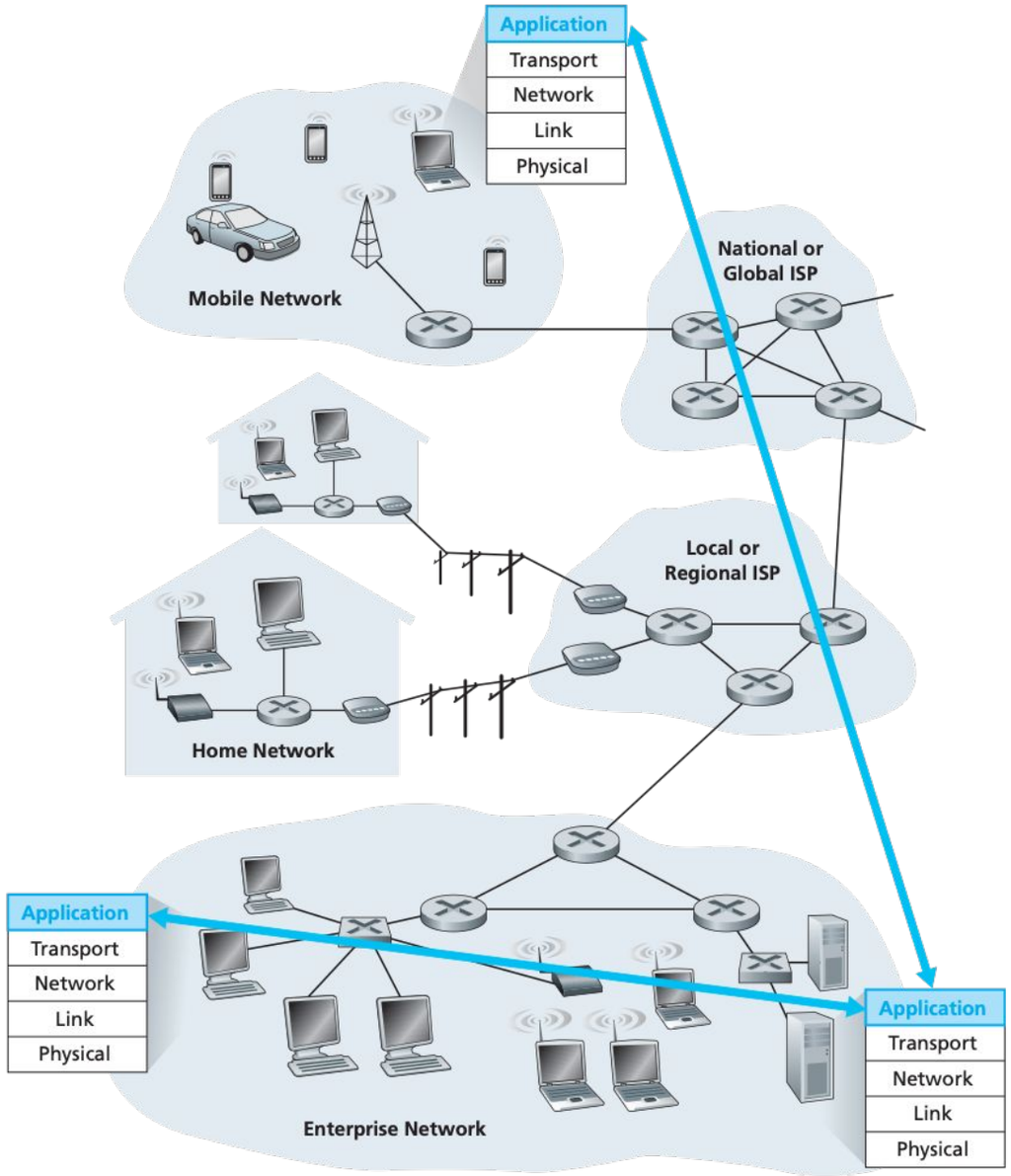
2

Síťové aplikace

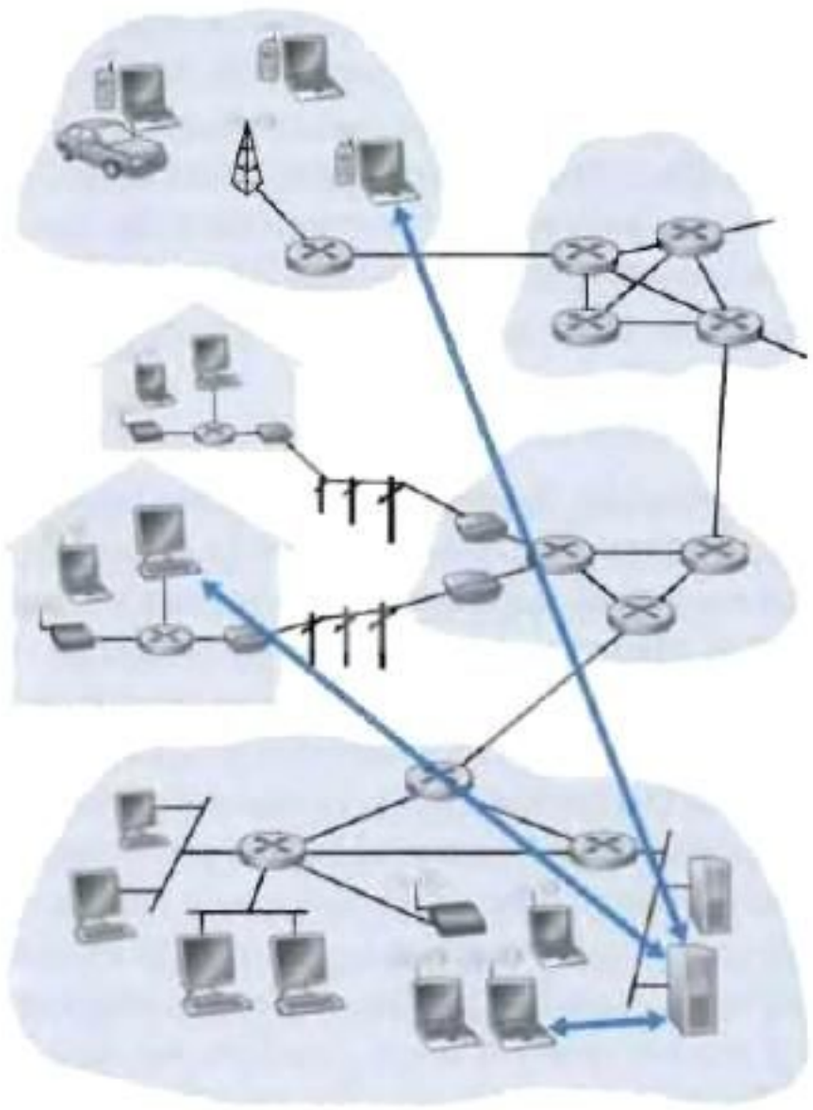
IPK/2021L

Obsah

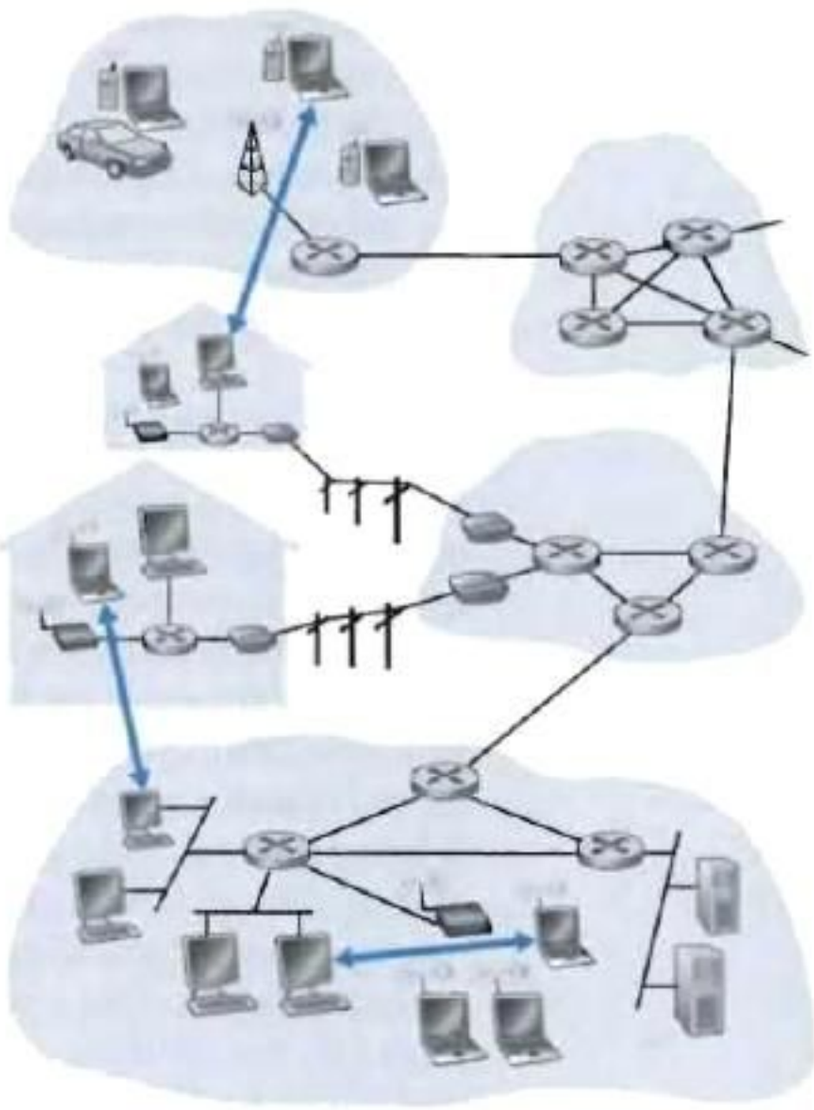
Síťové aplikace



Klient-server / Peer-to-peer



a. Client-server architecture



b. Peer-to-peer architecture

Požadavky na přenos dat

Application	Data Loss	Throughput	Time-Sensitive
File transfer/download	No loss	Elastic	No
E-mail	No loss	Elastic	No
Web documents	No loss	Elastic (few kbps)	No
Internet telephony/ Video conferencing	Loss-tolerant	Audio: few kbps–1Mbps Video: 10 kbps–5 Mbps	Yes: 100s of msec
Streaming stored audio/video	Loss-tolerant	Same as above	Yes: few seconds
Interactive games	Loss-tolerant	Few kbps–10 kbps	Yes: 100s of msec
Instant messaging	No loss	Elastic	Yes and no

Figure 2.4 ♦ Requirements of selected network applications

Transportní protokoly

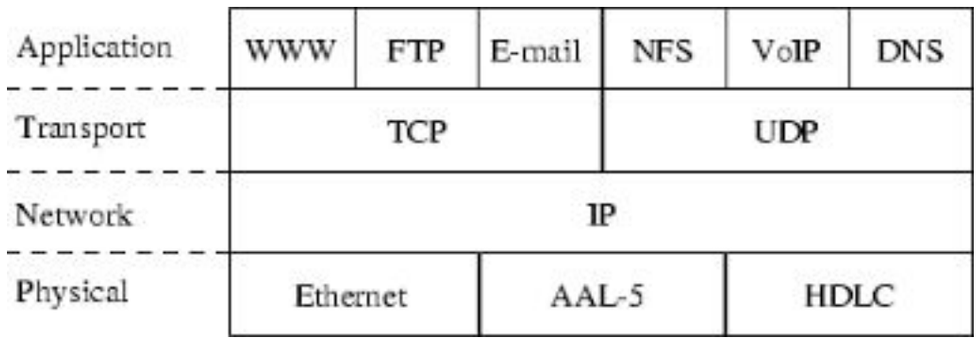
TCP	UDP
Keeps track of lost packets. Makes sure that lost packets are re-sent	Doesn't keep track of lost packets
Adds sequence numbers to packets and reorders any packets that arrive in the wrong order	Doesn't care about packet arrival order
Slower, because of all added additional functionality	Faster, because it lacks any extra features
Requires more computer resources, because the OS needs to keep track of ongoing communication sessions and manage them on a much deeper level	Requires less computer resources
Examples of programs and services that use TCP: - HTTP - HTTPS - FTP - Many computer games	Examples of programs and services that use UDP: - DNS - IP telephony - DHCP - Many computer games

TCP Segment Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Sequence Number			
64	Acknowledgment Number			
96	Data Offset	Res	Flags	Window Size
128	Header and Data Checksum		Urgent Pointer	
160…	Options			

UDP Datagram Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Length		Header and Data Checksum	

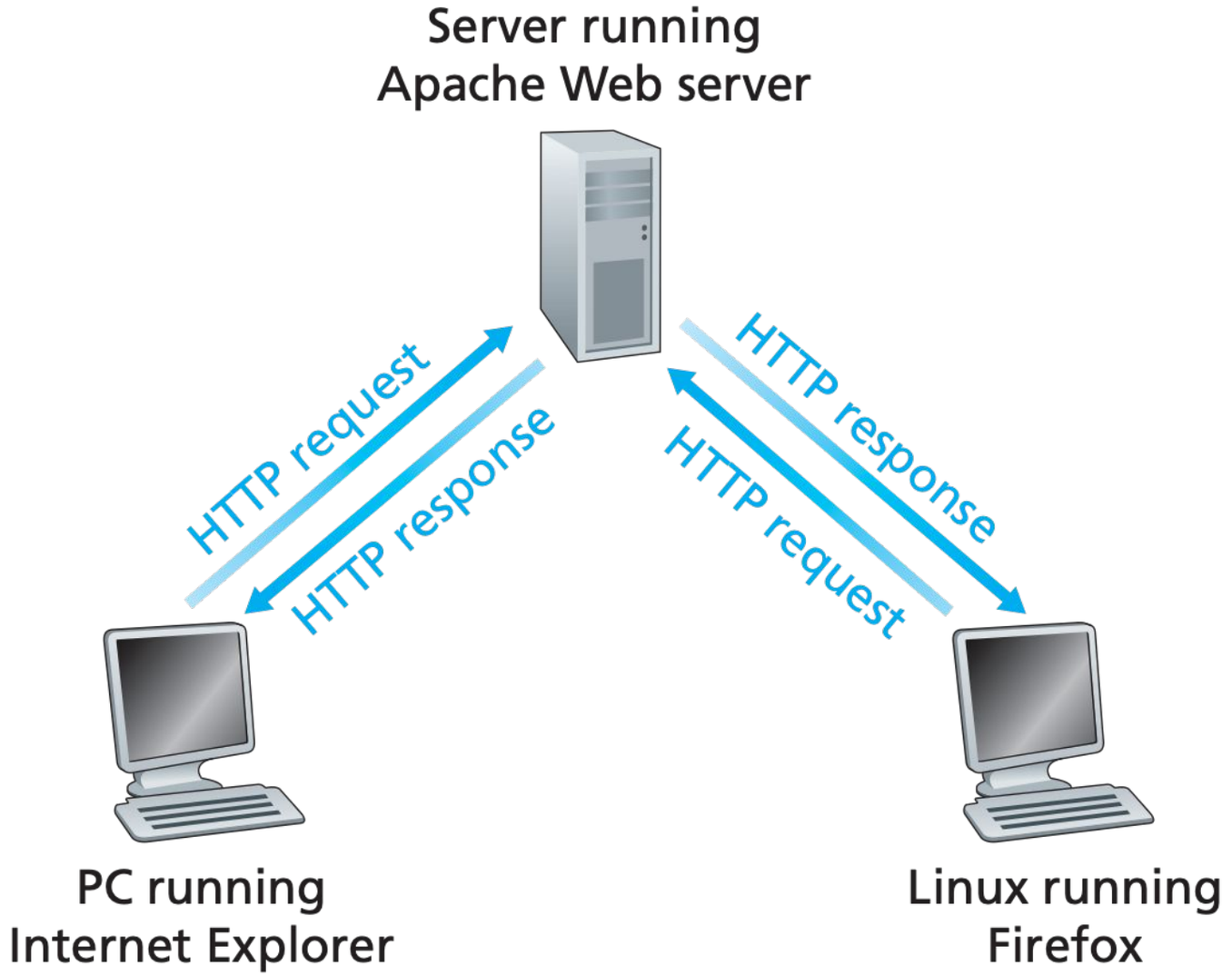


WWW / HTTP(S)

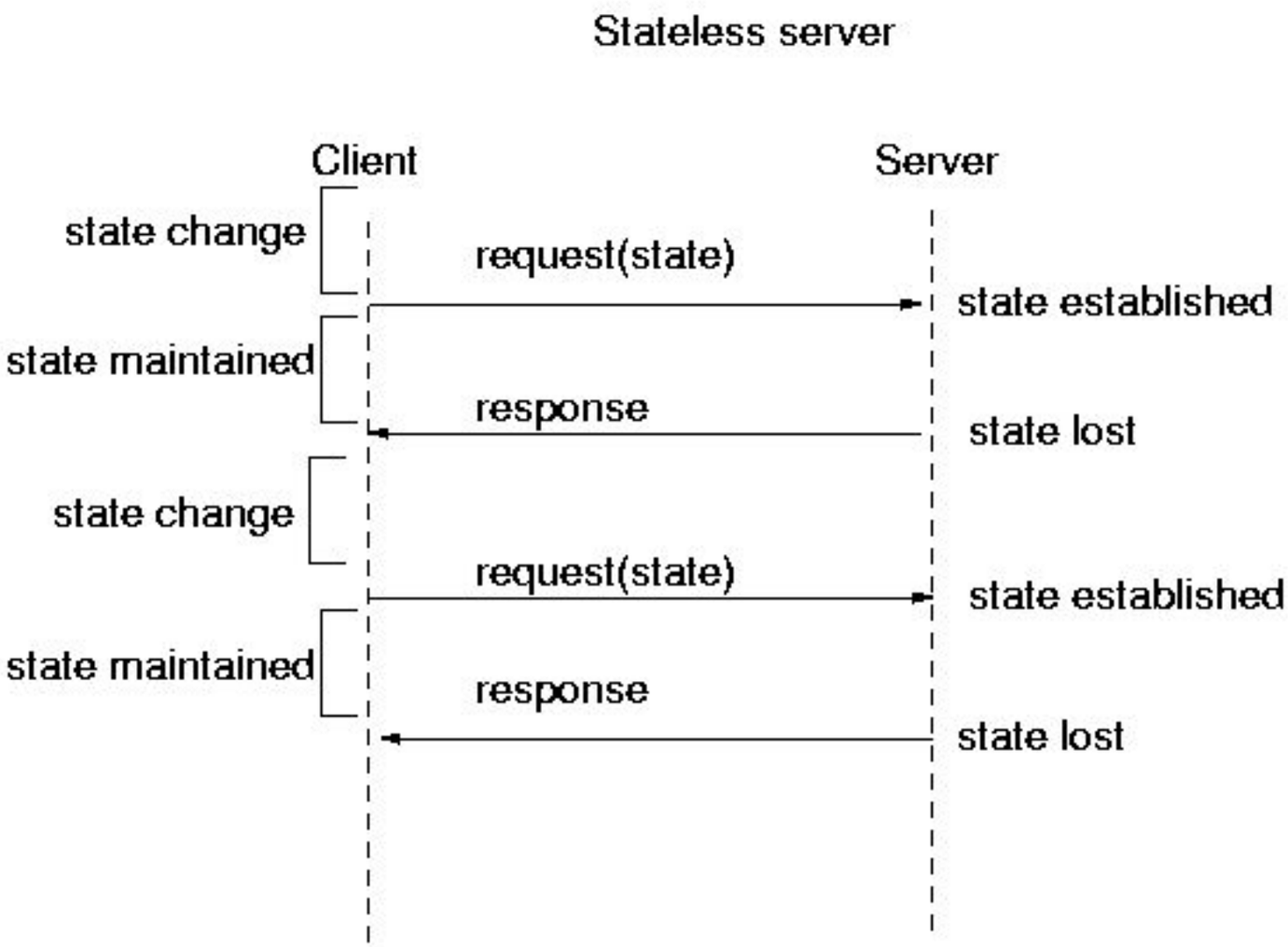
Web

- Web stránka obsahuje objekty
- Objekt může být HTML soubor, JPEG obrázek, Java applet, audio soubor,…
- Web stránka se skládá z bázového HTML souboru, který obsahuje odkazy na další objekty
- Každý objekt je adresovatelný pomocí URL [RFC 1738], obecně podle URI (specifikuje přístup k objektu ~ protokol, RFC 3986)

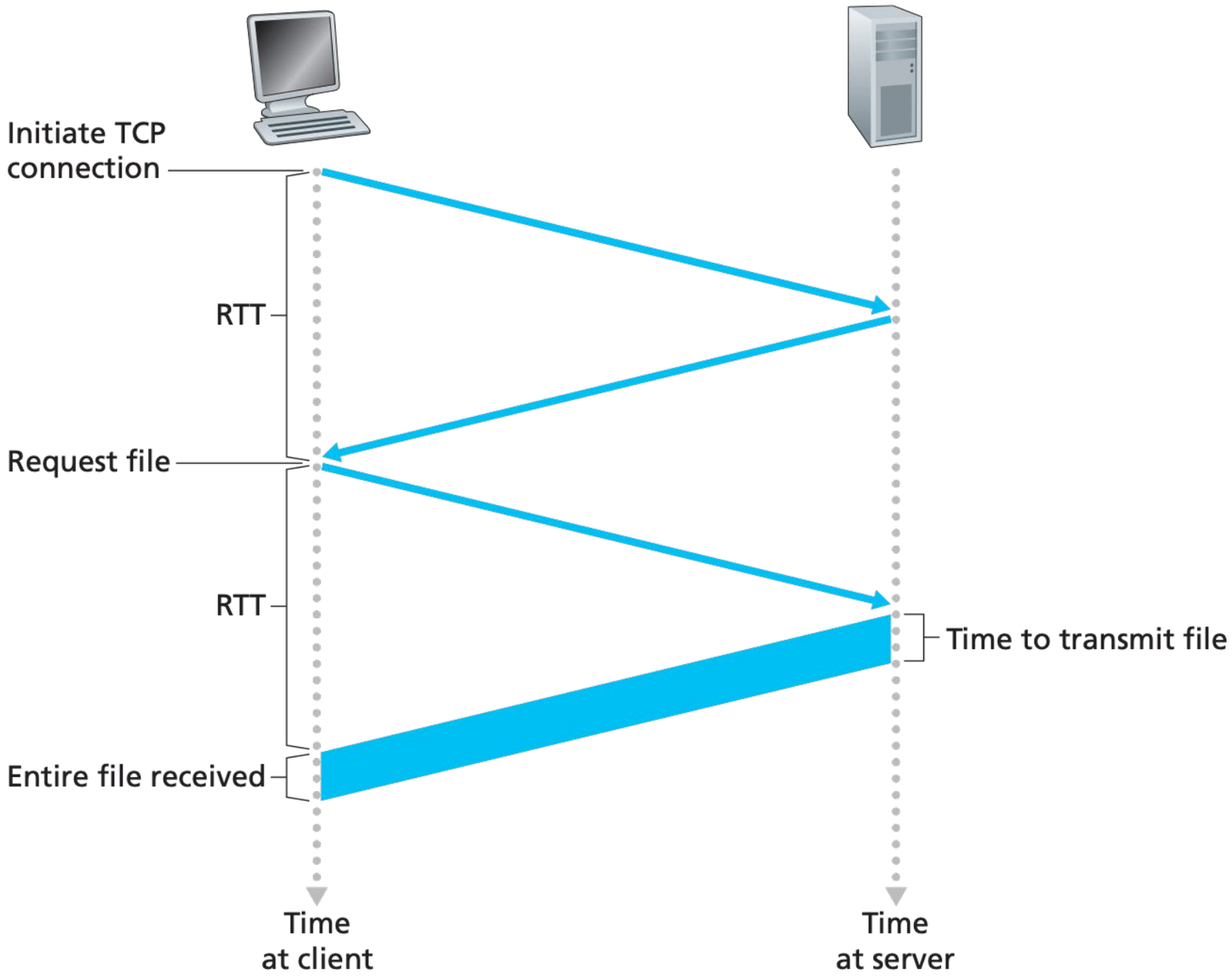
HTTP


Server running
Apache Web server
HTTP request
HTTP response
HTTP request
HTTP response
PC running
Internet Explorer
Linux running
Firefox

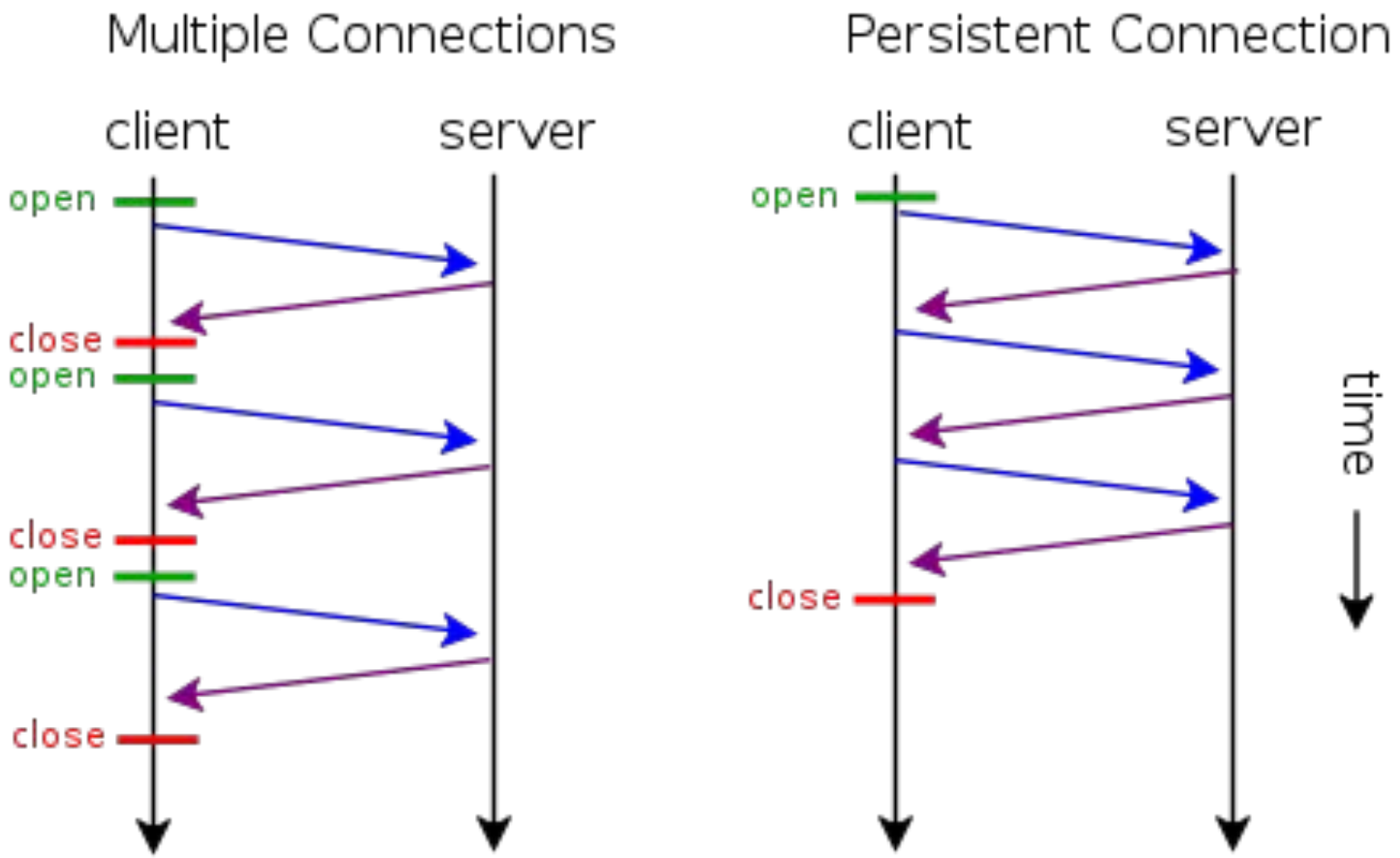
HTTP server


Stateless server
Client
Server
state change
request(state)
state established
state maintained
response
state lost
state change
request(state)
state established
state maintained
response
state lost

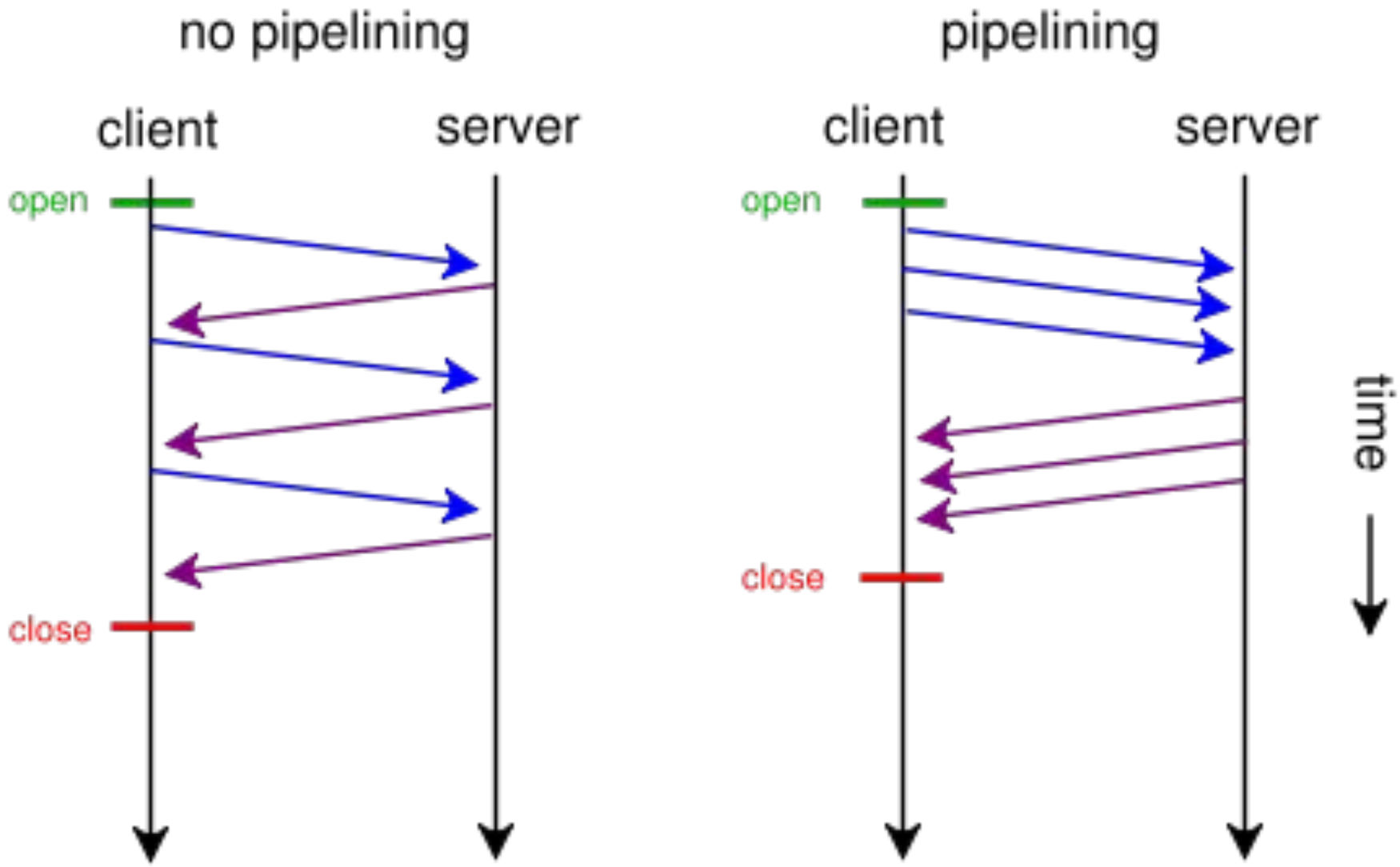
HTTP Spojení



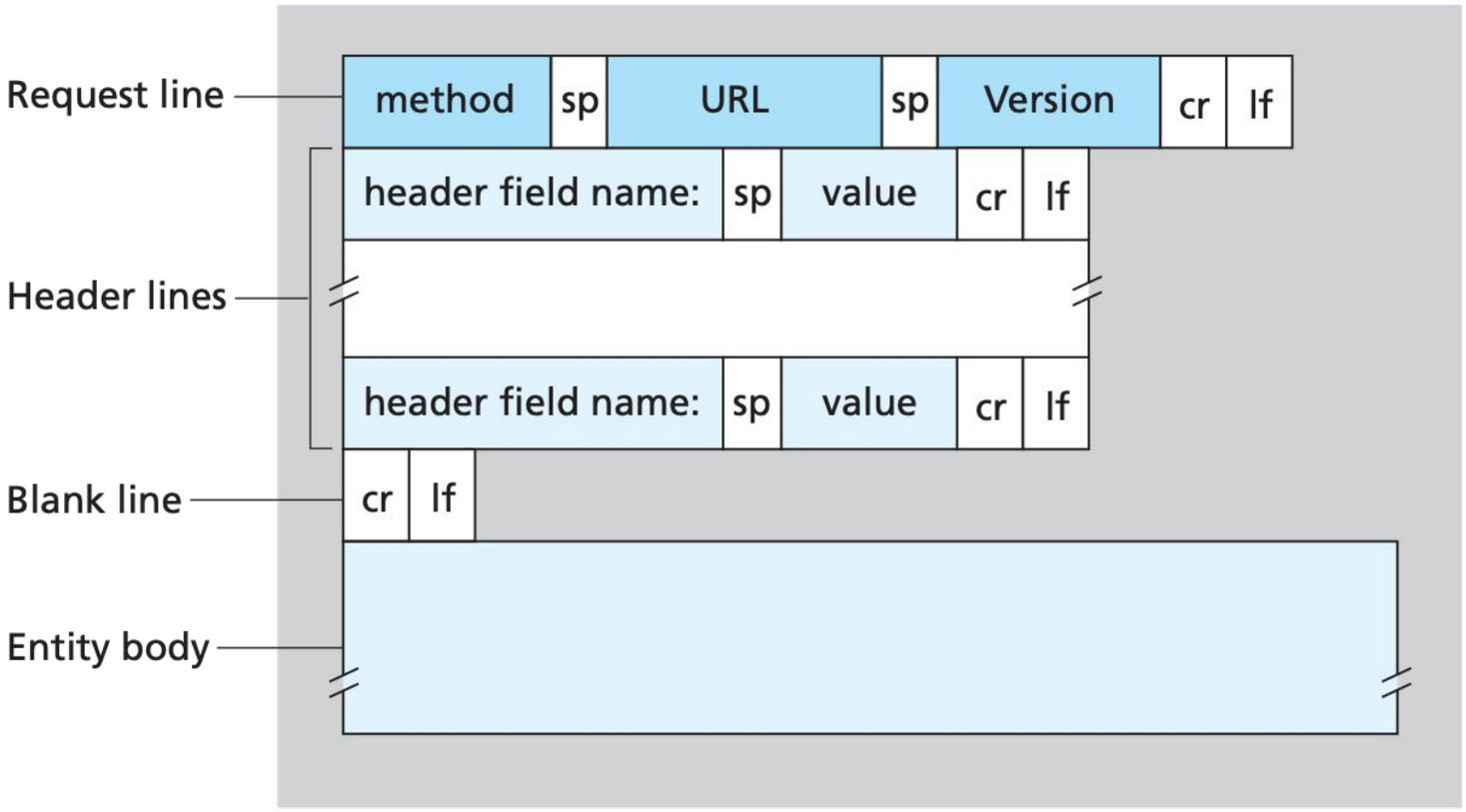
Perzistentní spojení



Pipelining

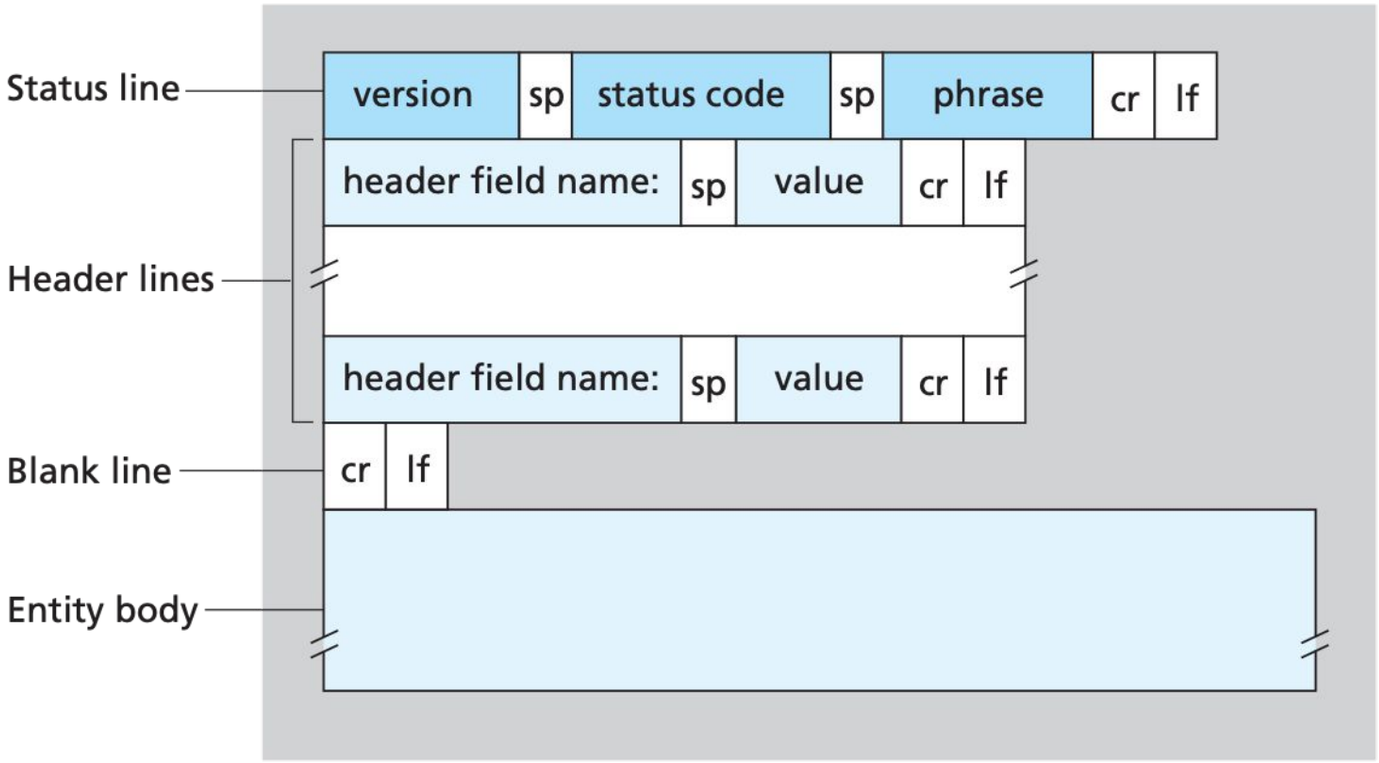

no pipelining
client
server
open
close
pipelining
client
server
open
close
time

HTTP Request




```
GET /somedir/page.html HTTP/1.1
Host: www.someschool.edu
Connection: close
User-agent: Mozilla/5.0
Accept-language: fr
```

HTTP Response

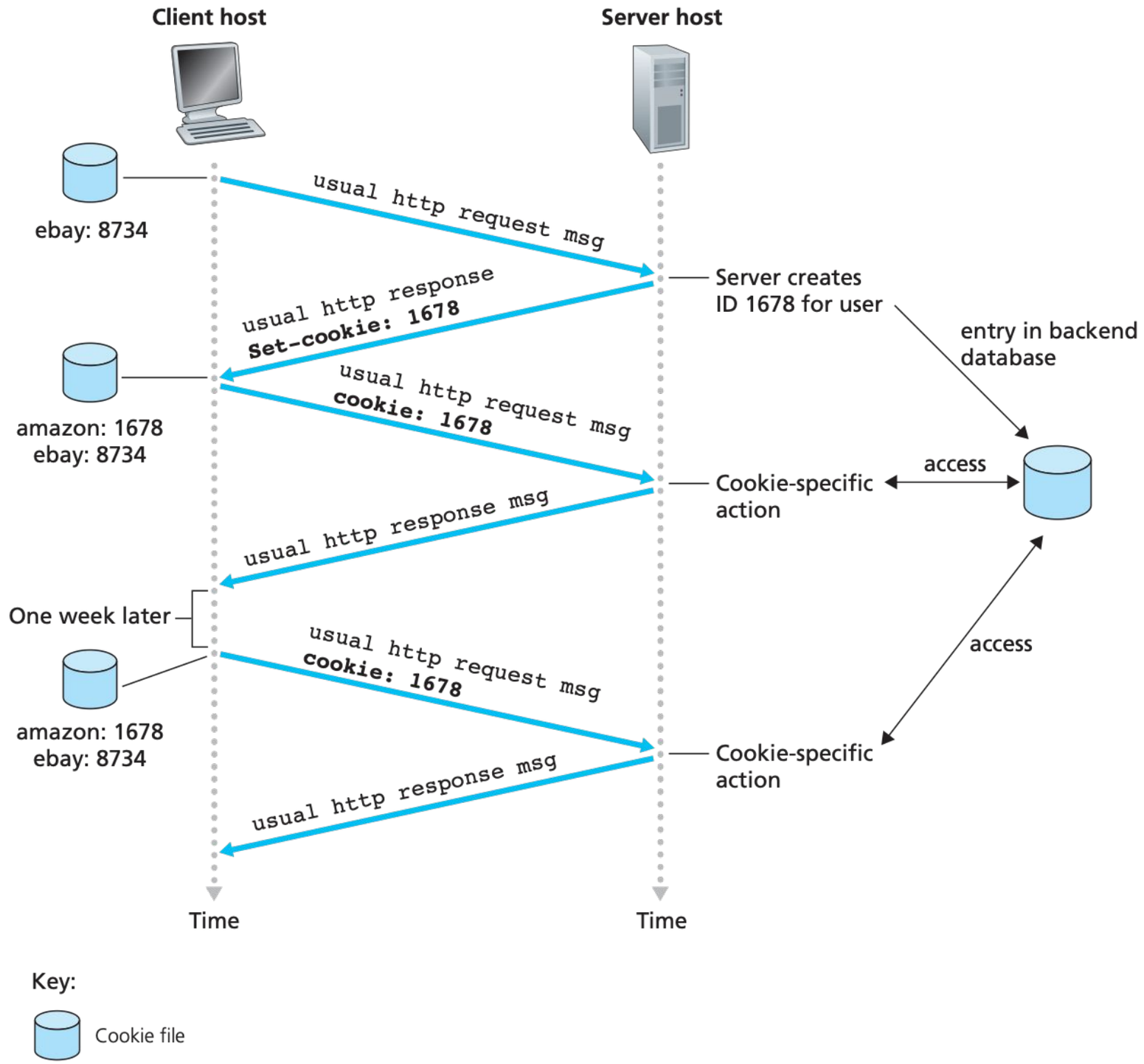



```
HTTP/1.1 200 OK
Connection: close
Date: Tue, 09 Aug 2011 15:44:04 GMT
Server: Apache/2.2.3 (CentOS)
Last-Modified: Tue, 09 Aug 2011 15:11:03 GMT
Content-Length: 6821
Content-Type: text/html

(data data data data data ...)
```

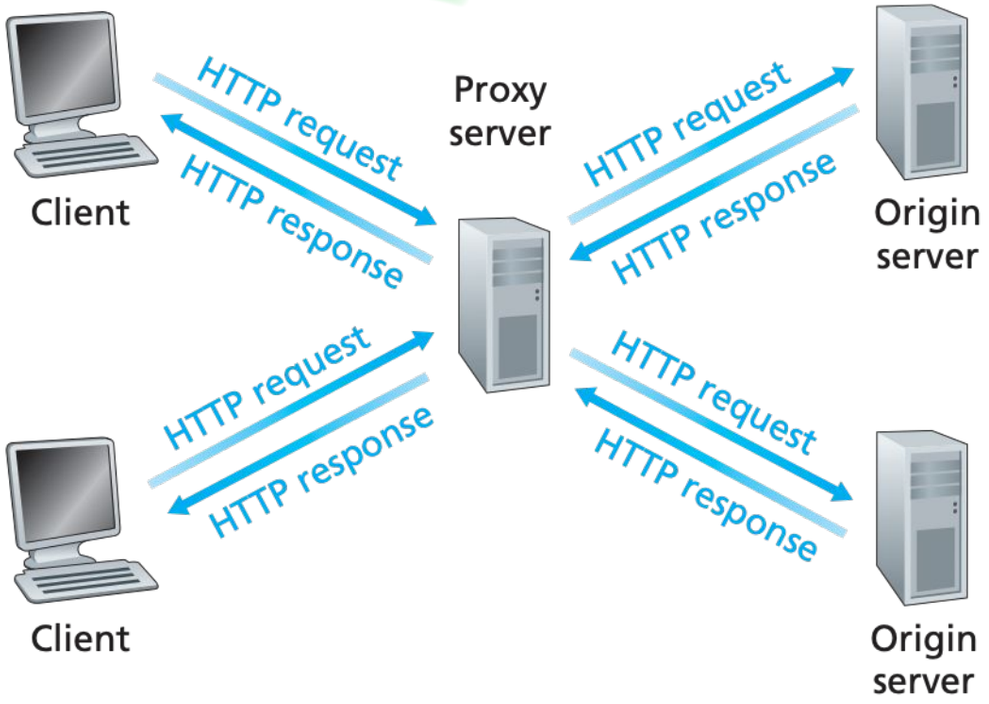
Vyzkoušejte si…

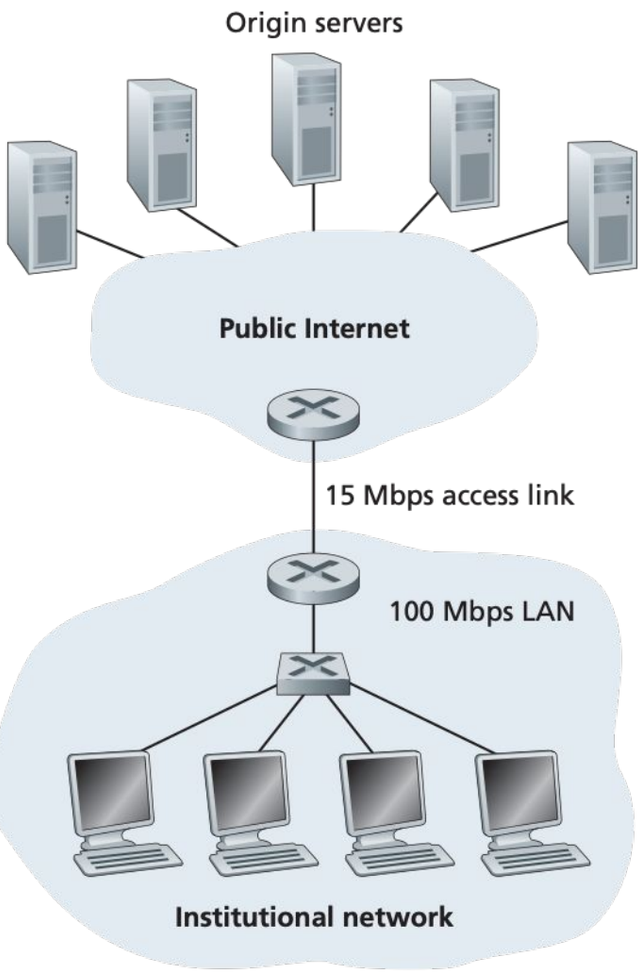
```
kazi:~> telnet www.fit.vutbr.cz 80
Trying 2001:67c:1220:809::93e5:917...
Connected to www.fit.vutbr.cz.
Escape character is '^]'.
GET / HTTP/1.1
Host: www.fit.vutbr.cz

HTTP/1.1 200 OK
Date: Mon, 12 Feb 2018 09:43:56 GMT
Server: Apache
Content-Location: index.php.cz
Vary: negotiate,accept-language
TCN: choice
```

Cookies


Client host
Server host
ebay: 8734
usual http request msg
usual http response
Set-cookie: 1678
Server creates
ID 1678 for user
entry in backend
database
amazon: 1678
ebay: 8734
usual http request msg
cookie: 1678
access
Cookie-specific
action
usual http response msg
One week later
usual http request msg
cookie: 1678
access
amazon: 1678
ebay: 8734
Cookie-specific
action
usual http response msg
Time
Time
Key:
Cookie file

Web Cache

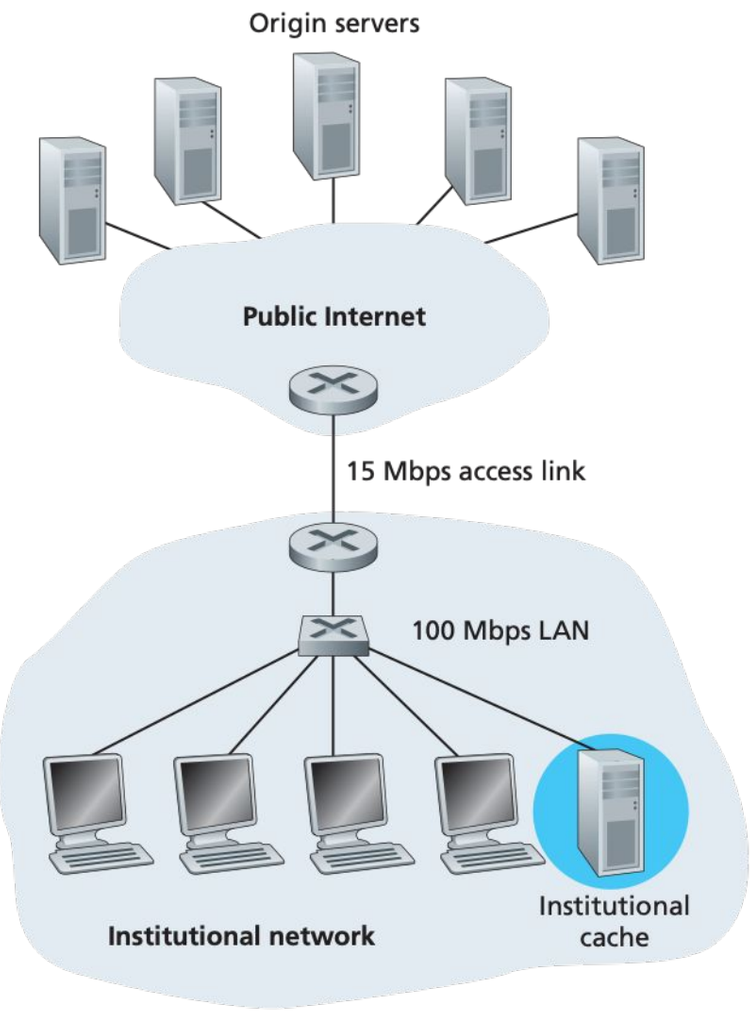




The traffic intensity

$$(15 \text{ requests/sec}) \cdot (1 \text{ Mbits/request})/(15 \text{ Mbps}) = 1$$

$$(15 \text{ requests/sec}) \cdot (1 \text{ Mbits/request})/(100 \text{ Mbps}) = 0.15$$



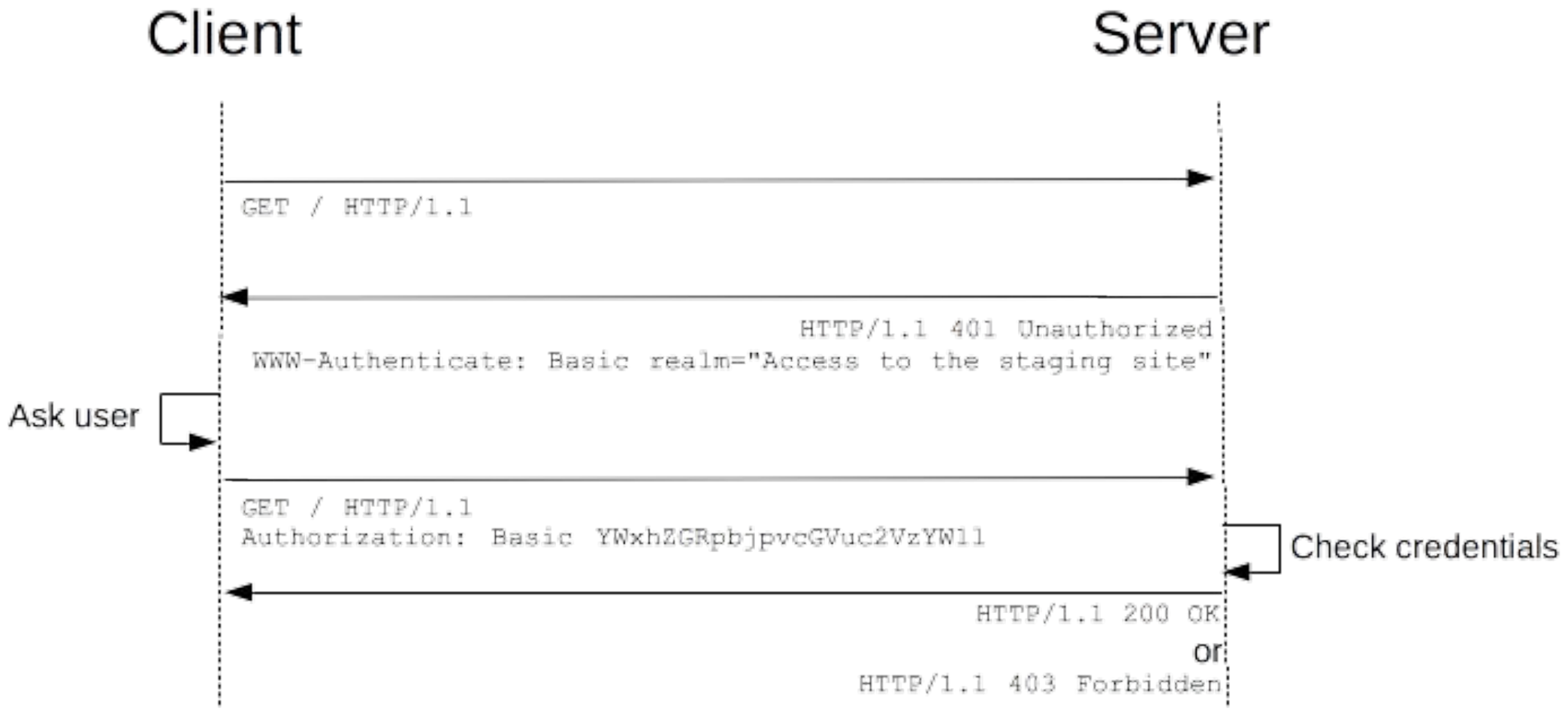
Podmíněný GET

```
GET /fruit/kiwi.gif HTTP/1.1
Host: www.exotiquecuisine.com
```

```
GET /fruit/kiwi.gif HTTP/1.1
Host: www.exotiquecuisine.com
If-modified-since: Wed, 7 Sep 2011
```

```
HTTP/1.1 304 Not Modified
Date: Sat, 15 Oct 2011 15:39:29
Server: Apache/1.3.0 (Unix)
```

HTTP authentication

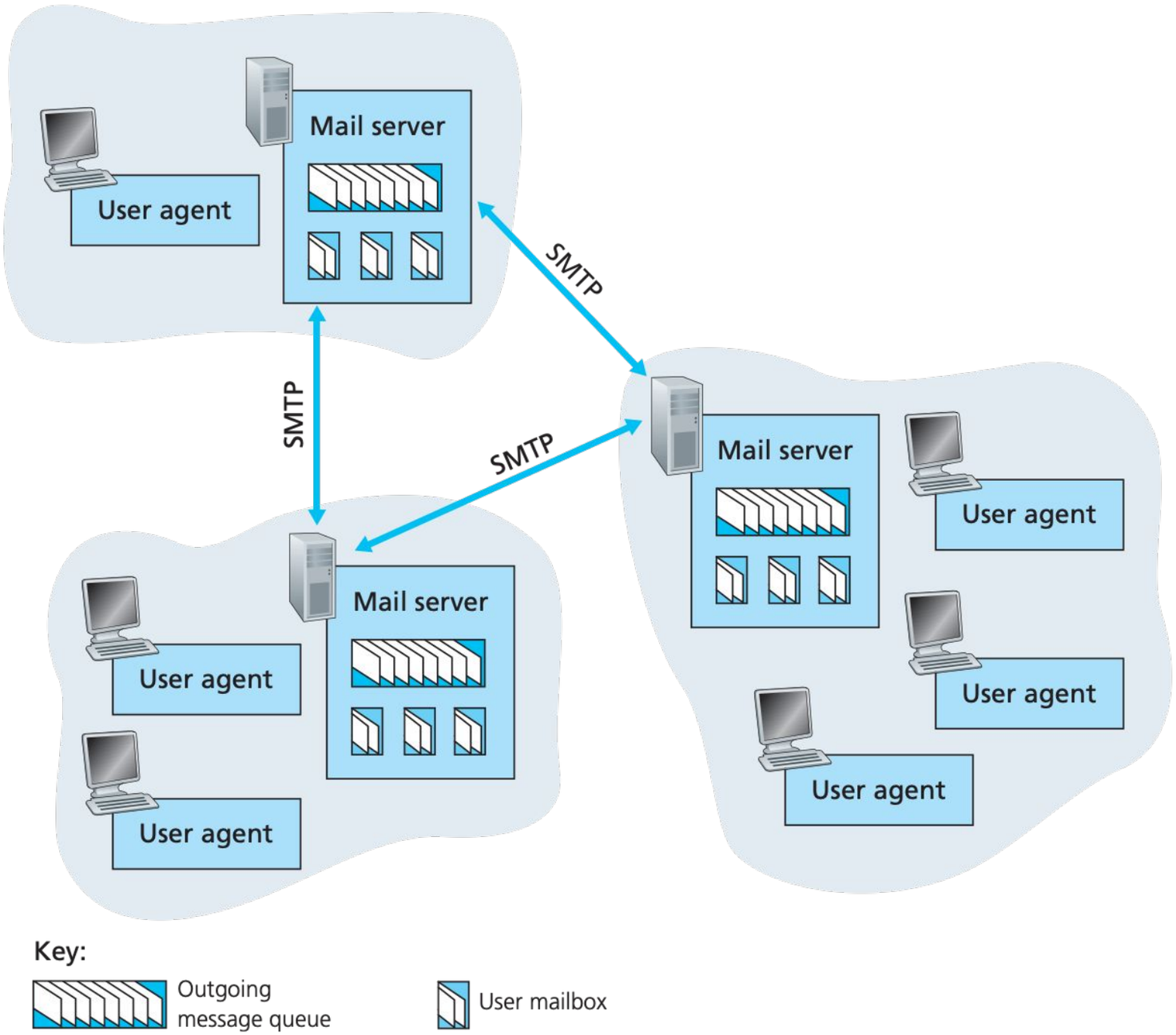


WIRESHARK DEMO

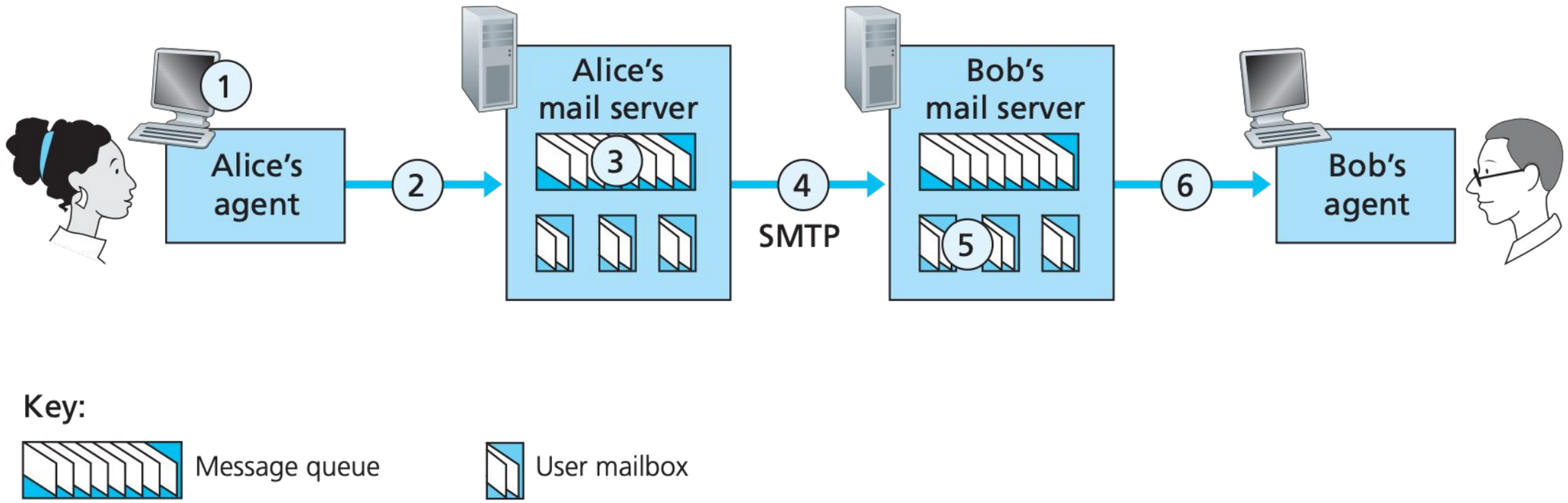
- http.cap
- http-cookies.pcap
- http-authorization.pcap

SMTP

Architektura



Přenos zprávy



Protokol

```
S: 220 hamburger.edu
C: HELO crepes.fr
S: 250 Hello crepes.fr, pleased to meet you
C: MAIL FROM: <alice@crepes.fr>
S: 250 alice@crepes.fr ... Sender ok
C: RCPT TO: <bob@hamburger.edu>
S: 250 bob@hamburger.edu ... Recipient ok
C: DATA
S: 354 Enter mail, end with “.” on a line by itself
C: Do you like ketchup?
C: How about pickles?
C: .
S: 250 Message accepted for delivery
C: QUIT
S: 221 hamburger.edu closing connection
```

Formát zpráv (RFC 2822)

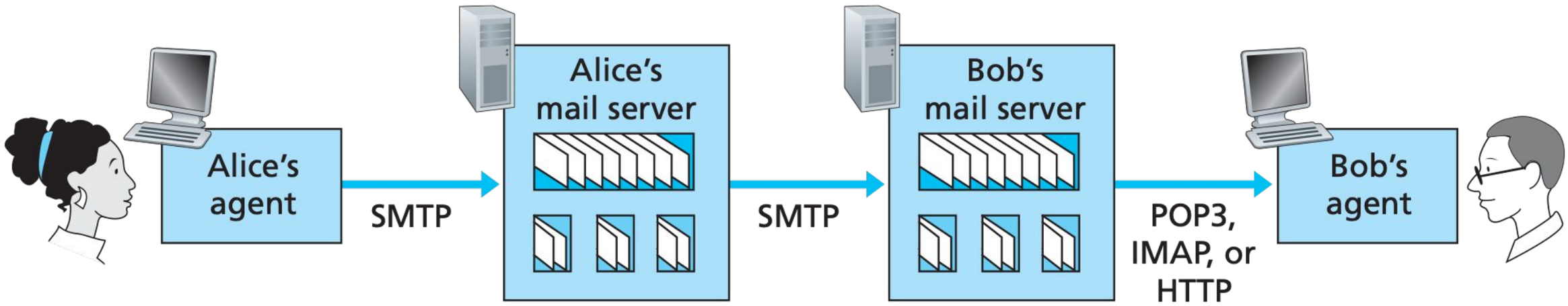
Hlavička	From matousp@fit.vutbr.cz Wed Oct 21 22:25:13 2009 Return-Path: <matousp@fit.vutbr.cz> Received: from [192.168.15.101] (ip4-83-240-62-147.cust.nbox.cz [83.240.62.147]) (user=matousp mech=PLAIN bits=0) by kazi.fit.vutbr.cz for <rysavy@fit.vutbr.cz>; Wed, 21 Oct 2009 22:25:12 +0200 (CEST) Message-ID: <4ADF6E2B.3050709@fit.vutbr.cz> Date: Wed, 21 Oct 2009 22:25:15 +0200 From: Petr Matousek <matousp@fit.vutbr.cz> User-Agent: Thunderbird 2.0.0.23 (Windows/20090812) MIME-Version: 1.0 To: Ondrej Rysavy <rysavy@fit.vutbr.cz> Subject: [Fwd: [Ideal-ist] New EOI Confirmation for PS-ES-3816] Content-Type: text/plain; charset=ISO-8859-2 Content-Transfer-Encoding: quoted-printable
Tělo	Ondro, to jsi bajecne napsal! Diky. Cau. Petr

MIME (RFC 2045, 2046)

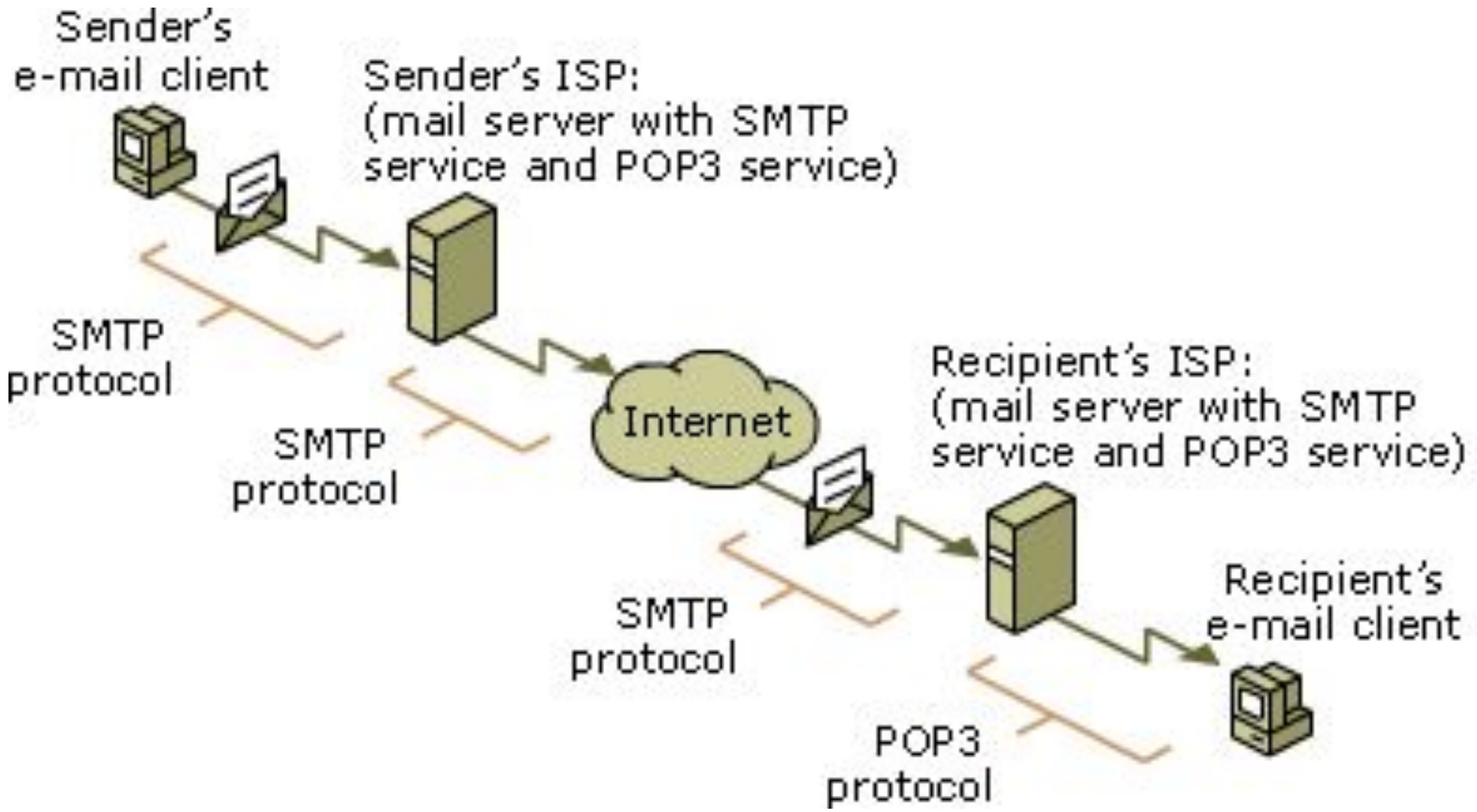
```
From: Petr Matousek <matousp@fit.vutbr.cz>
MIME-Version: 1.0
To: Ondrej Rysavy <rysavy@fit.vutbr.cz>
Subject: Dokument ve Wordu
Content-Type: application/msword; name="dokument.doc"
Content-Transfer-Encoding: base64

0M8R4KGxGuEAAAAAAAAAAAAAAAAAAAAAPgADAP7/CQAGAAAAAAAA
AAAAAAAAAgEAAAEAAAD+////AAAAAAEQBAABFAQAARgEAAP////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
////////////////ASgEAAAE/////////////////////////////////
////////////////////////////////////////////////////////
////////////////////////////////////////////////////////
```

```
From: Petr Matousek <matousp@fit.vutbr.cz>
User-Agent: Thunderbird 2.0.0.23 (Windows/20090812)
MIME-Version: 1.0
To: Ondrej Rysavy <rysavy@fit.vutbr.cz>
Subject: [Fwd: [Ideal-ist] New EOI Confirmation for PS-ES-3816]

This is a multi-part message in MIME format.
--------------070303080205000303010908
Content-Type: text/plain; charset=windows-1252; format=flowed
Content-Transfer-Encoding: 8bit

Ondro,

  to jsi bajecne napsal! Diky.
Cau.

        Petr

--------------070303080205000303010908
Content-Type: application/msword;
 name="Work distribution.doc"
Content-Transfer-Encoding: base64
Content-Disposition: inline;
 filename="Work distribution.doc"

0M8R4KGxGuEAAAAAAAAAAAAAAAAAAAAAPgADAP7/CQAGAAAAAAAAAA
AAAAEAAASgEAAAEAAAD+////
```

Čtení zprávy



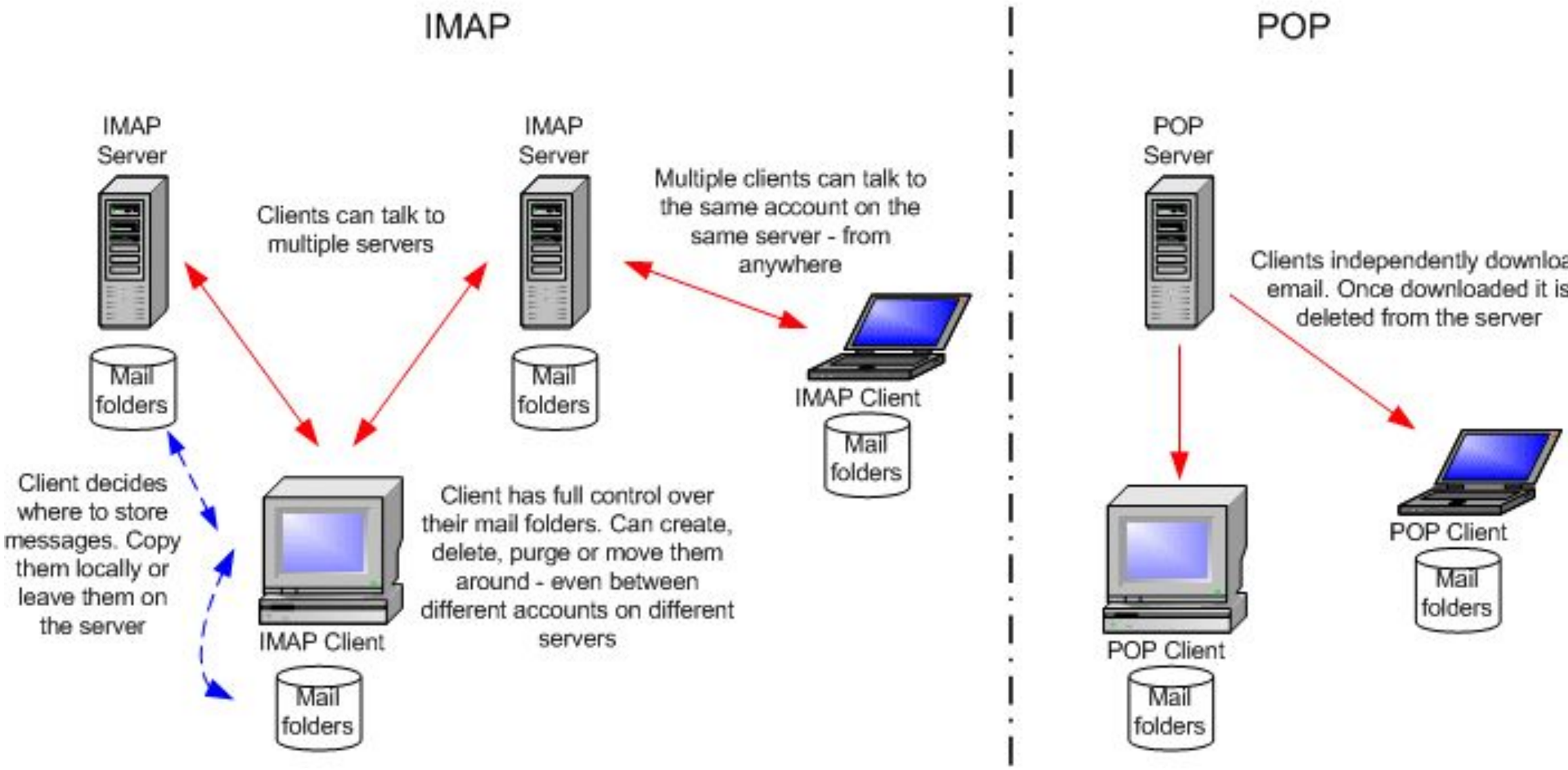
POP3


Sender's
e-mail client
Sender's ISP:
(mail server with SMTP
service and POP3 service)
SMTP
protocol
SMTP
protocol
Internet
Recipient's ISP:
(mail server with SMTP
service and POP3 service)
SMTP
protocol
Recipient's
e-mail client
POP3
protocol

POP3

```
C: list
S: 1 498
S: 2 912
S: .
C: retr 1
S: (blah blah ...
S: ..................
S: ..........blah)
S: .
C: dele 1
C: retr 2
S: (blah blah ...
S: ..................
S: ..........blah)
S: .
C: dele 2
C: quit
S: +OK POP3 server signing off
```

POP / IMAP


IMAP
IMAP Server
Mail folders
Clients can talk to multiple servers
IMAP Server
Mail folders
Multiple clients can talk to the same account on the same server - from anywhere
IMAP Client
Mail folders
Client decides where to store messages. Copy them locally or leave them on the server
IMAP Client
Mail folders
Client has full control over their mail folders. Can create, delete, purge or move them around - even between different accounts on different servers
POP
POP Server
Clients independently download email. Once downloaded it is deleted from the server
POP Client
Mail folders
POP Client
Mail folders

WIRESHARK DEMO

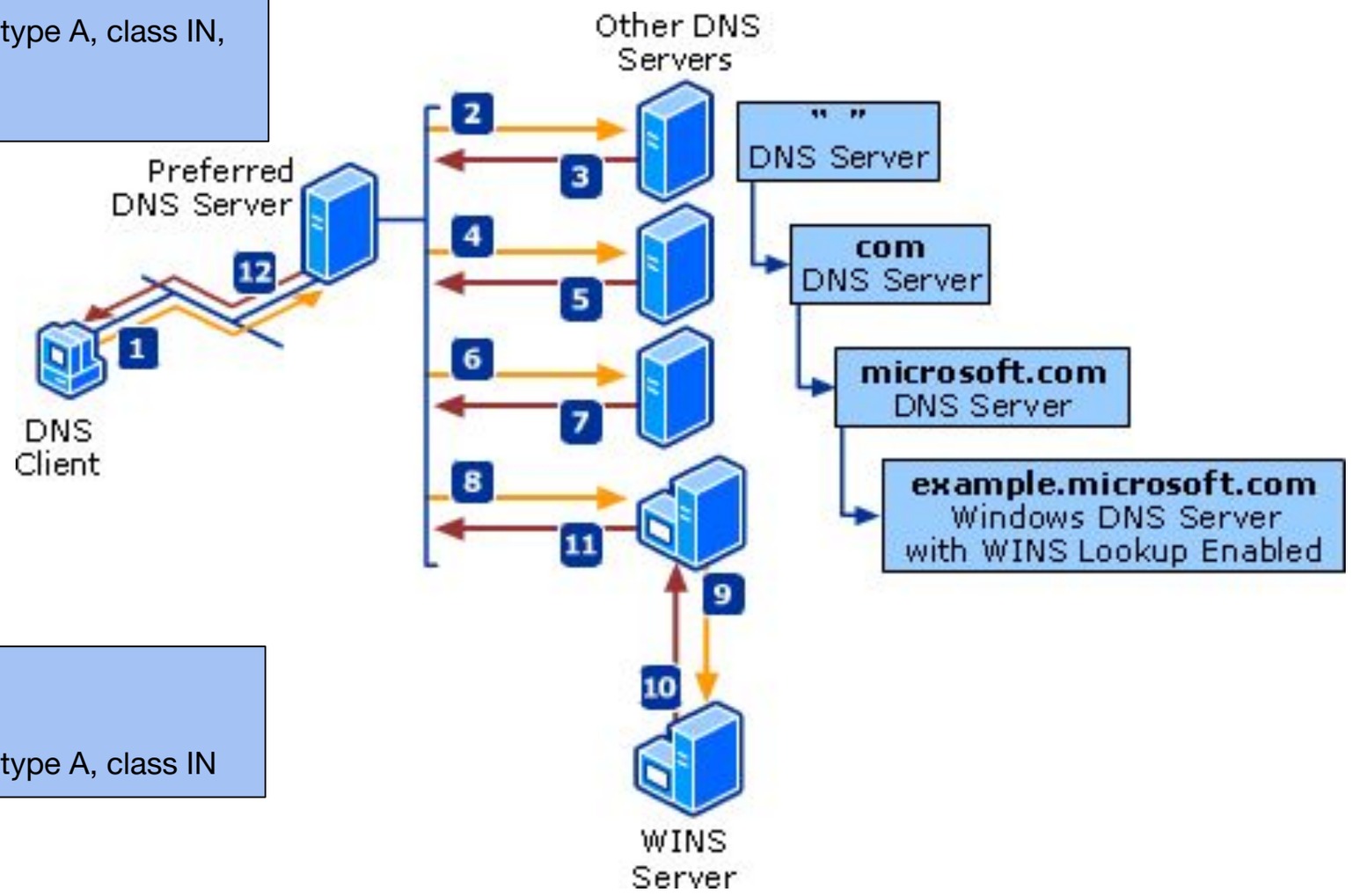
- smtp.pcap

DNS

DNS komunikace

DNS Response:

example.microsoft.com: type A, class IN, 40.112.72.205



DNS Query:

example.microsoft.com: type A, class IN

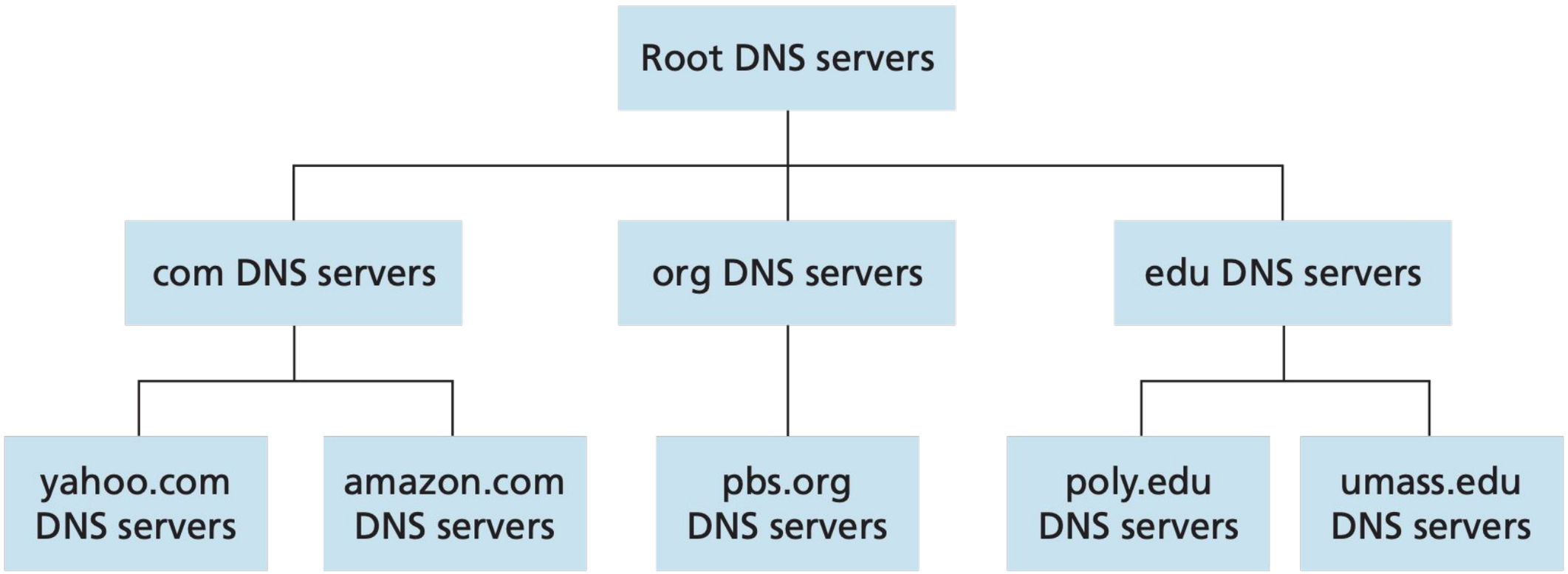
DNS záznam

Common Resource Record Types

RR Type	Name	Functions
A	Address record	Maps domain name to IP address `www.apnic.net. IN A 203.176.189.99`
AAAA	IPv6 address record	Maps domain name to an IPv6 address `www.apnic.net. IN AAAA 2001:db8::1`
NS	Name server record	Used for delegating zone to a nameserver `apnic.net. IN NS ns1.apnic.net.`
PTR	Pointer record	Maps an IP address to a domain name `99.189.176.203.in-addr.arpa. IN PTR www.apnic.net.`
CNAME	Canonical name	Maps an alias to a hostname `web IN CNAME www.apnic.net.`

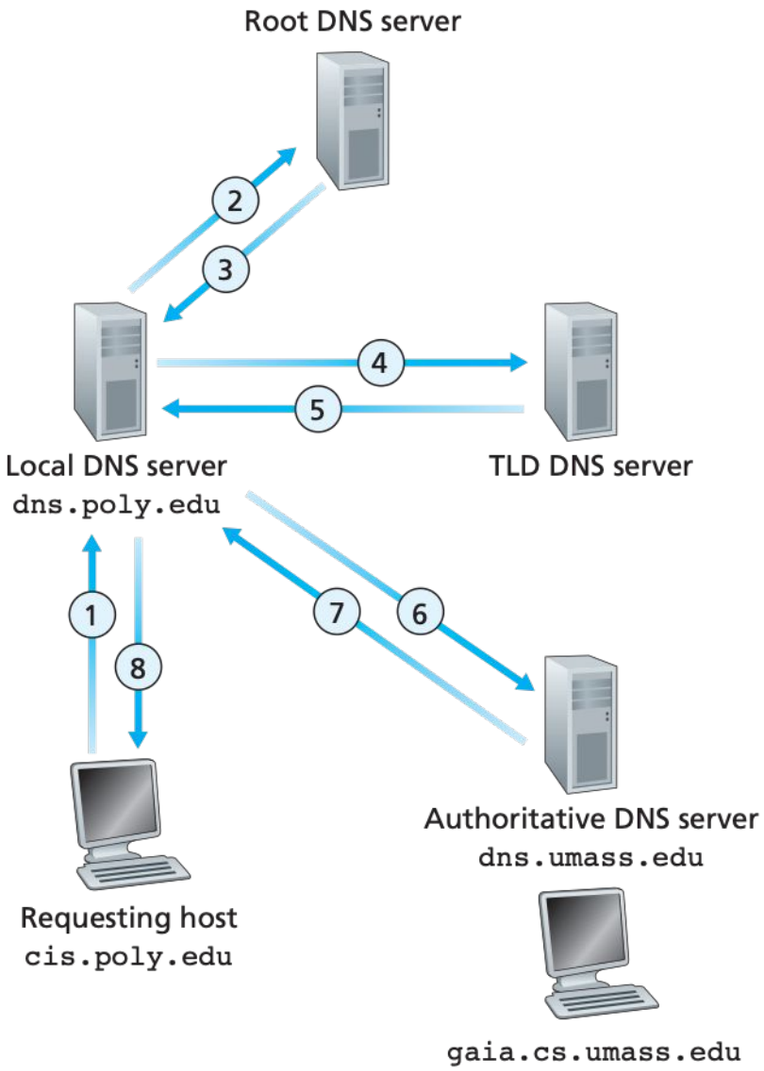
MX	Mail Exchanger	Defines where to deliver mail for user @ domain
		`apnic.net. IN MX 10 mail01.apnic.net.`
		`IN MX 20 mail02.apnic.net.`

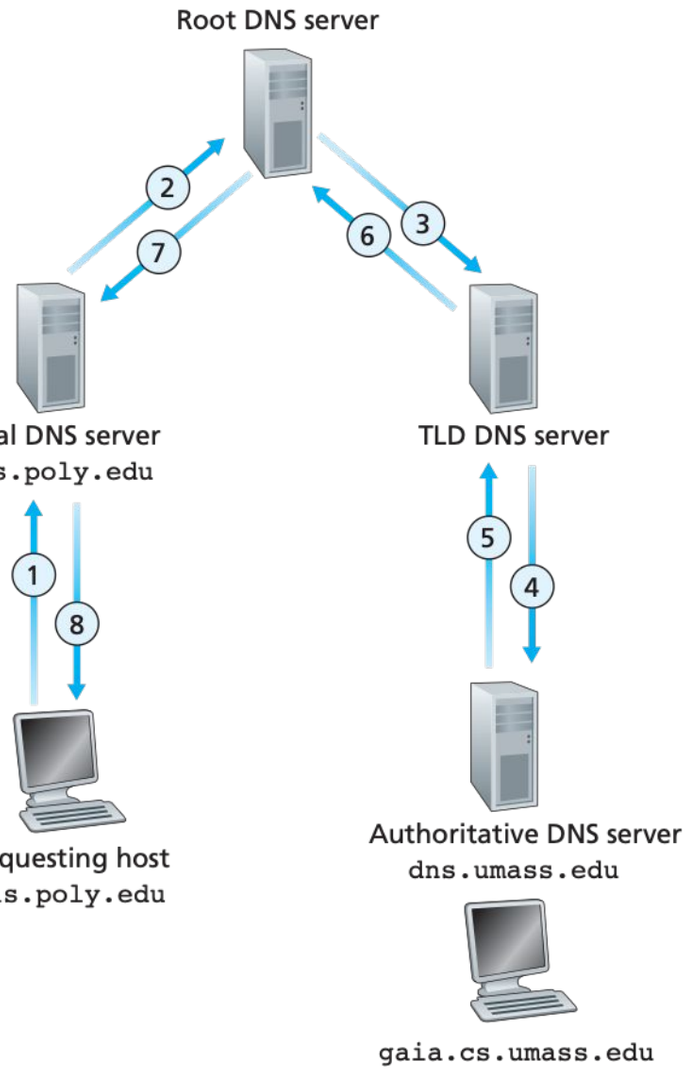
DNS


Root DNS servers
com DNS servers
org DNS servers
edu DNS servers
yahoo.com DNS servers
amazon.com DNS servers
pbs.org DNS servers
poly.edu DNS servers
umass.edu DNS servers

DNS Root Name Server Locations

DNS Rezoluce





DNS Zpráva

Identification	Flags	12 bytes
Number of questions	Number of answer RRs	
Number of authority RRs	Number of additional RRs	
Questions (variable number of questions)		Name, type fields for a query
Answers (variable number of resource records)		RRs in response to query
Authority (variable number of resource records)		Records for authoritative servers
Additional information (variable number of resource records)		Additional "helpful" info that may be used

Zónové soubory

```
$TTL 1d
```
Default TTL of 1 day

```
$ORIGIN example.com.
```
Default FQDN to attach

```
@ IN SOA ns1.example.com. admin.example.com. (
              2013091200 ; se = serial number
              12h ; ref = refresh
              15m ; ret = refresh retry
              3w ; ex = expiry
              2h ; nx = nxdomain ttl
              )
```
SOA (Start of Authority)

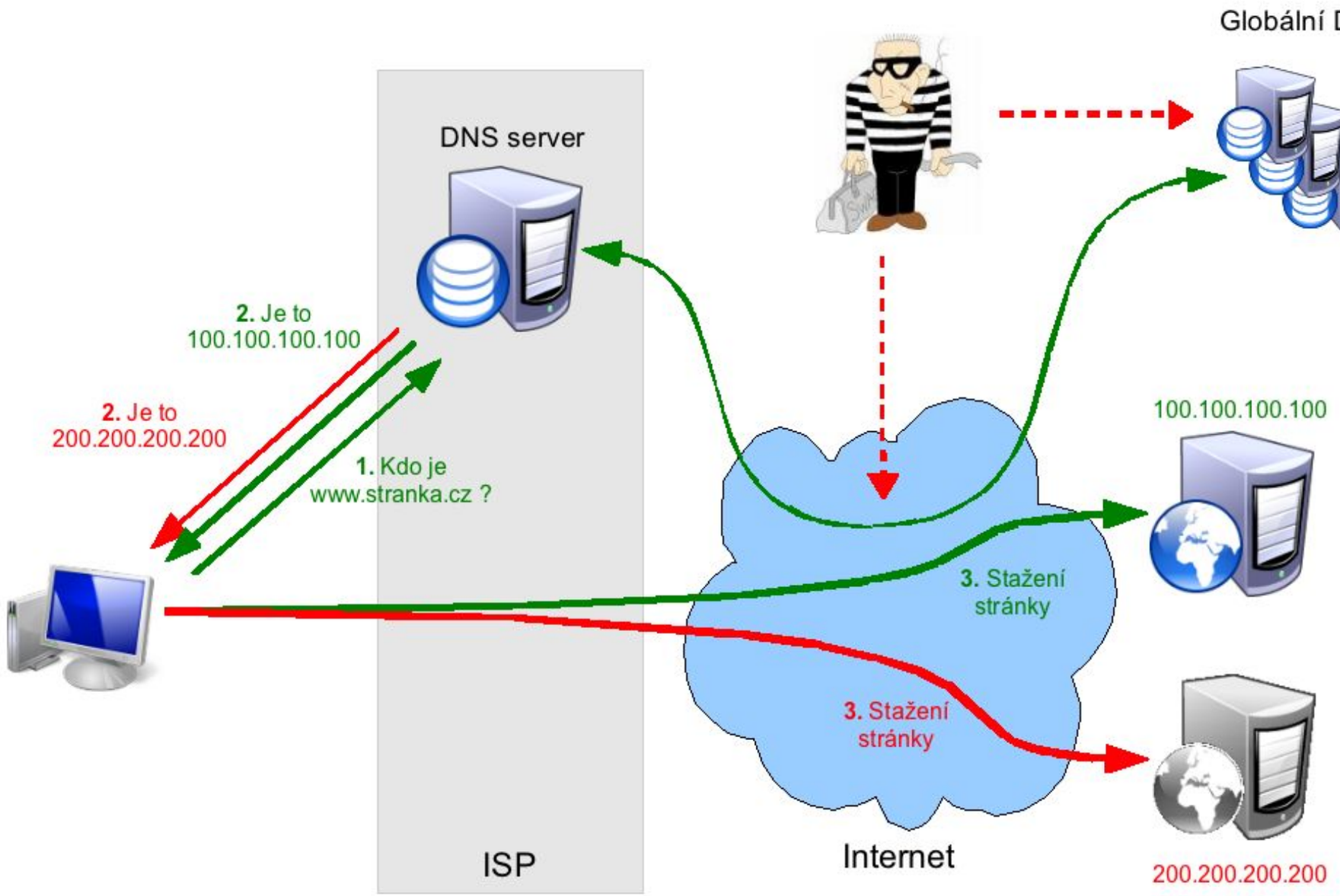
```
      IN   NS    ns1.example.com.
      IN   NS    ns2.example.net.
```
NS record

```
3w   IN MX 10 mail.example.com.

      IN MX 20 mail.example.net.
```
MX record

```
ns1          IN     A      172.16.140.41
mail         IN     A      172.16.140.42
joe          IN     A      172.16.140.43
www          IN     A      172.16.140.44
```
A record

```
ftp          IN CNAME      ftp.example.net.
```
CNAME record

DNS bezpečnost

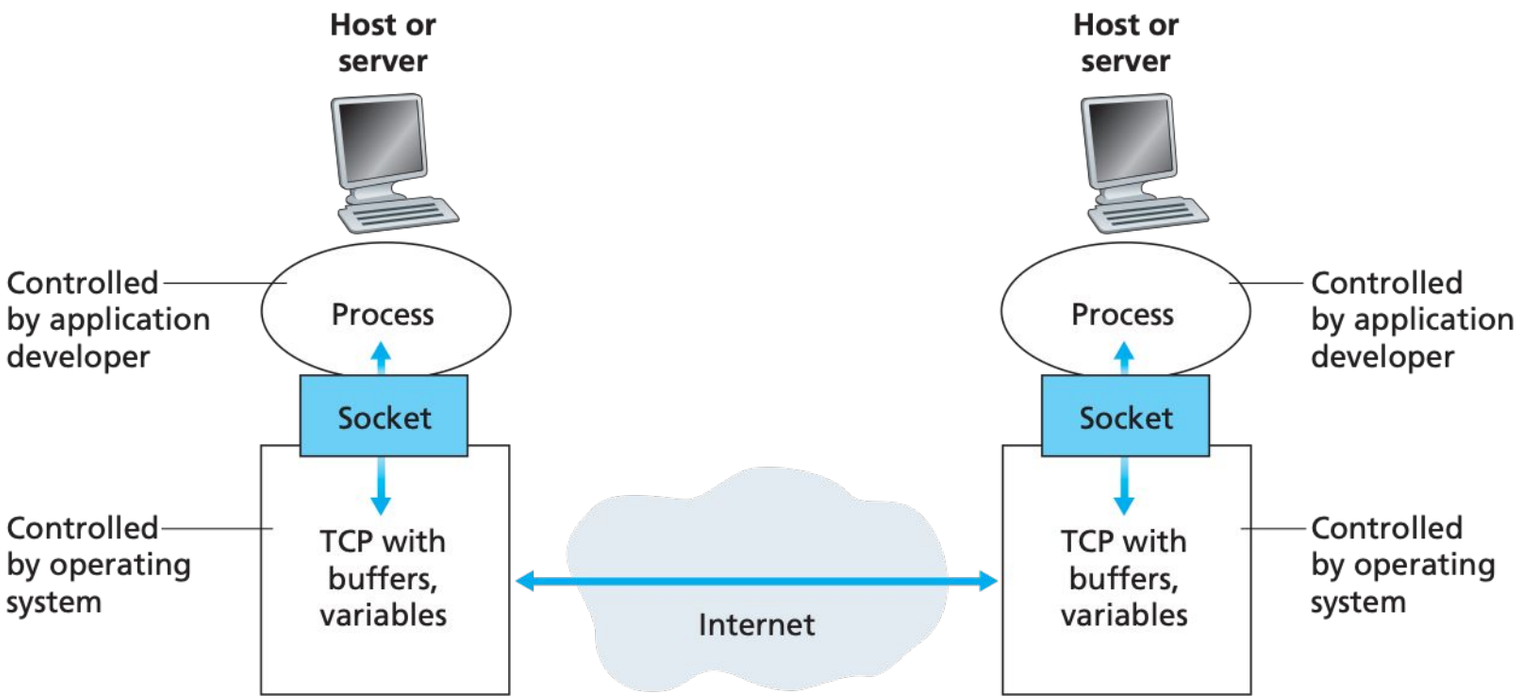


WIRESHARK DEMO

- dns.pcap

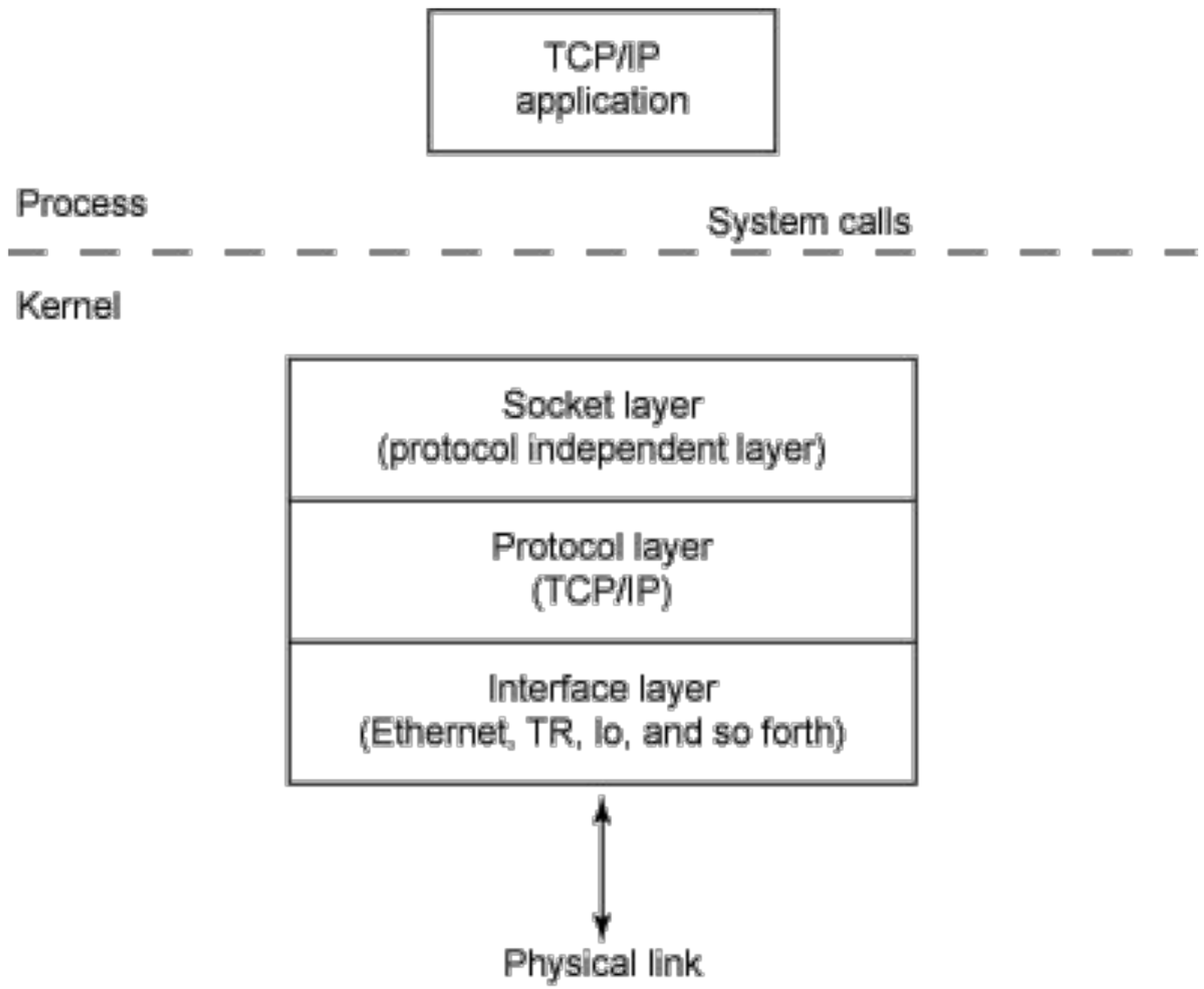
Programování

Schránky



Socket Pair	
Socket	Socket
Address	Address
Port	Port

Socket


TCP/IP
application
Process
System calls
Kernel
Socket layer
(protocol independent layer)
Protocol layer
(TCP/IP)
Interface layer
(Ethernet, TR, lo, and so forth)
Physical link

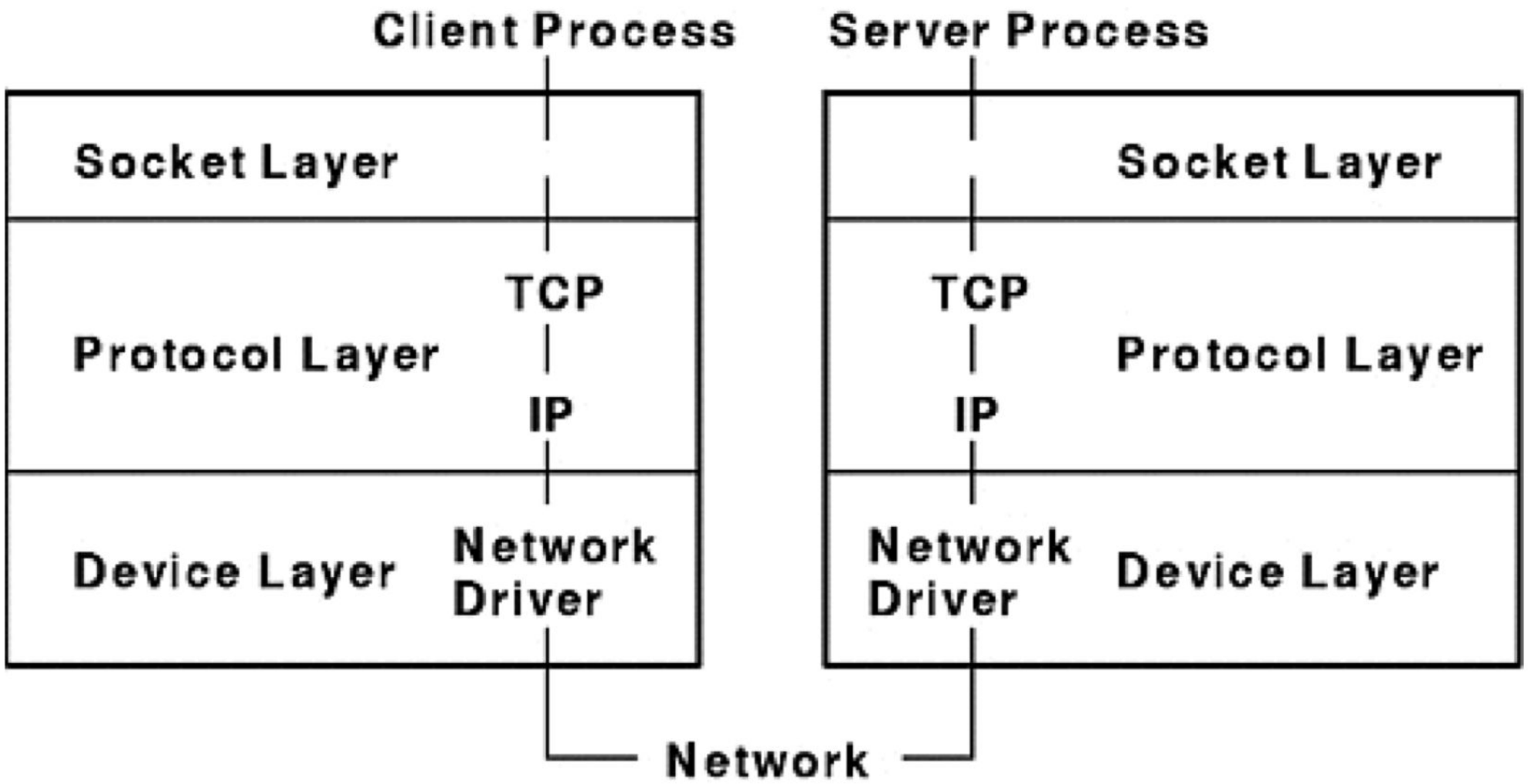
Identifikace spojení

IP adresa : Port **IP adresa : Port**

Protokol

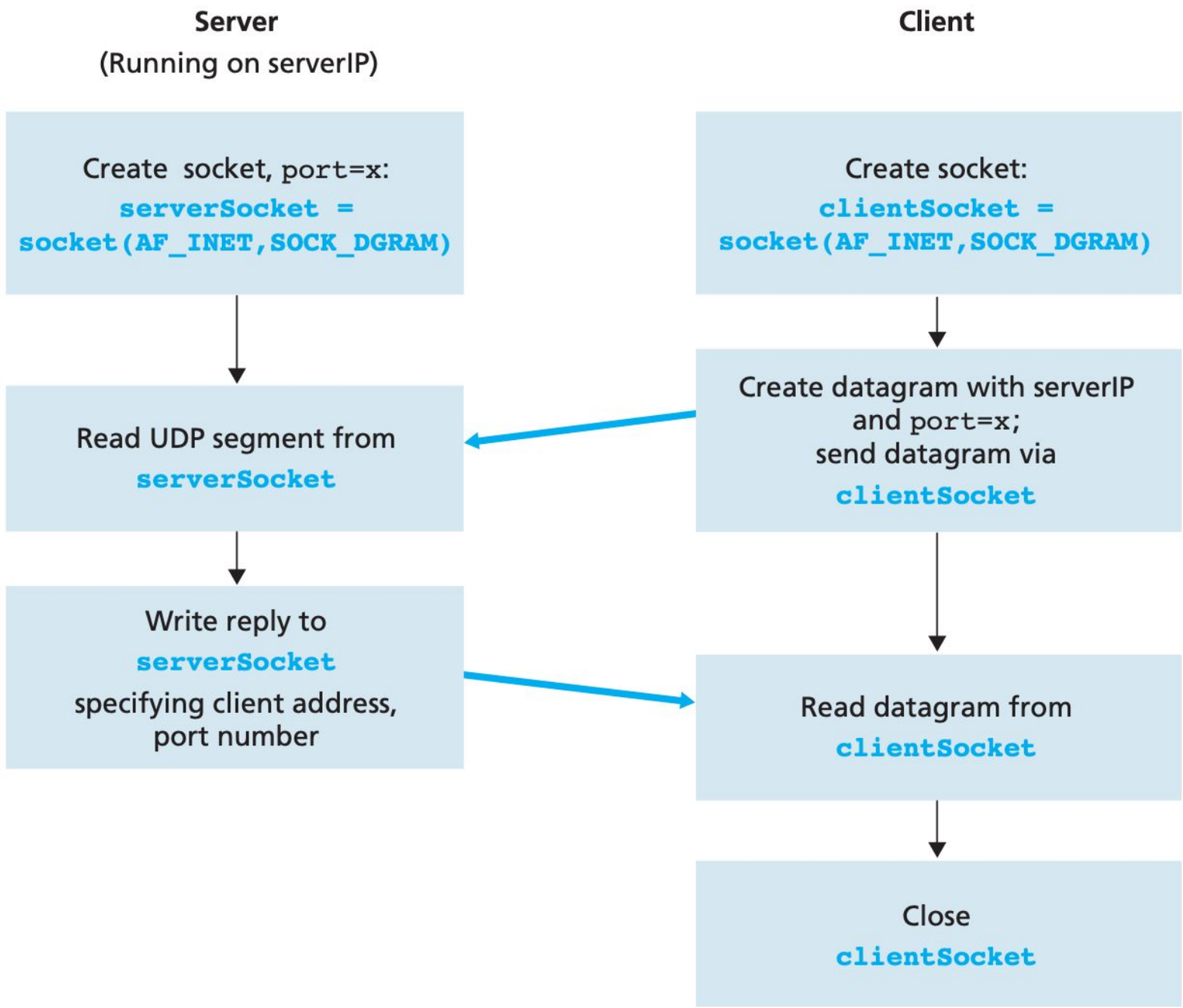
```
tcp4       0      0  192.168.88.133.57243   192.30.252.126.https   LAST_ACK
tcp4       0      0  192.168.88.133.57242   192.30.252.126.https   LAST_ACK
tcp4       0      0  192.168.88.133.57241   192.30.252.126.https   LAST_ACK
tcp4       0      0  192.168.88.133.57192   msnbot-191-232-1.https ESTABLISHED
tcp4       0      0  192.168.88.133.57191   msnbot-191-232-1.https ESTABLISHED
tcp4       0      0  192.168.88.133.57180   live.github.com.https  ESTABLISHED
tcp4       0      0  192.168.88.133.57177   server25004.team.5938  ESTABLISHED
tcp4       0      0  192.168.88.133.57164   17.172.232.12.5223     ESTABLISHED
tcp4       0      0  192.168.88.133.57163   17.143.161.164.5223    ESTABLISHED
```

Architektura

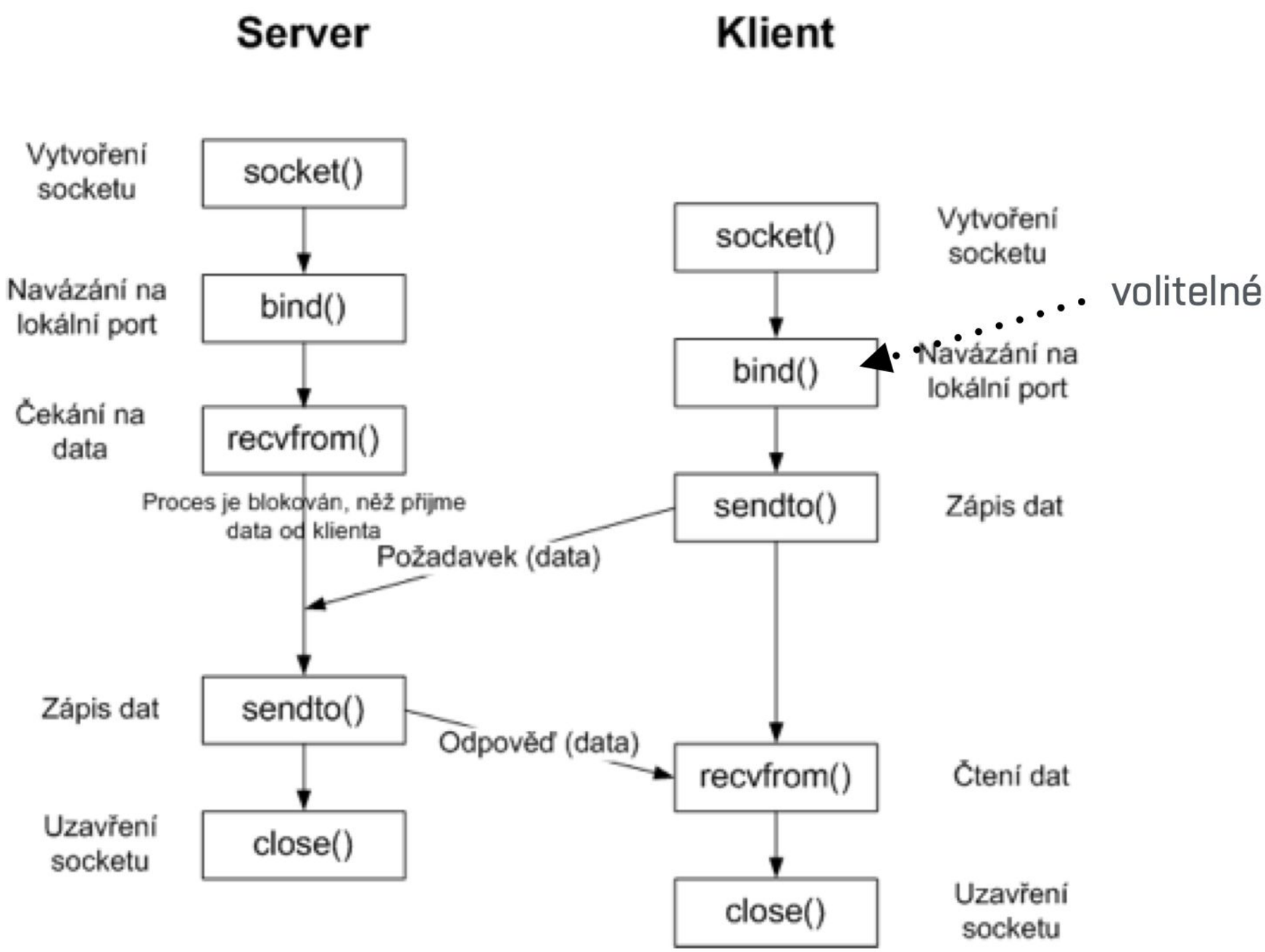


UDP komunikace

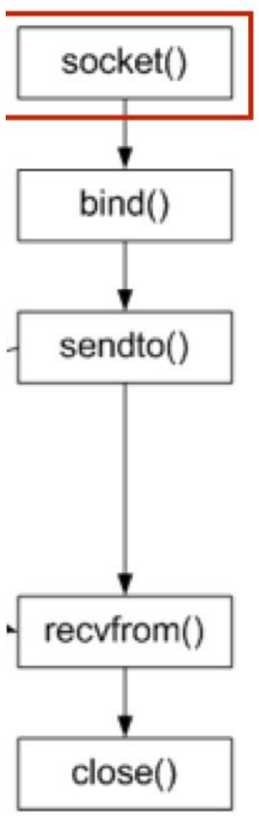
UDP Klient-server



Systémová volání

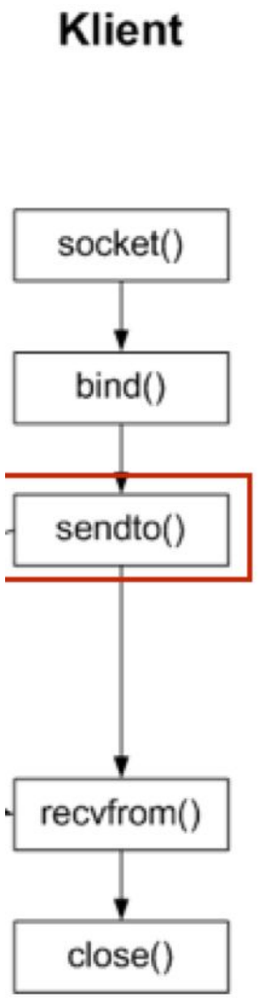


Vytvoření socketu




```
if ((client_socket = socket(AF_INET, SOCK_DGRAM, 0)) <= 0)
{
        perror("ERROR in socket");
        exit(EXIT_FAILURE);
}
```

Odeslání dat




```
ssize_t
    sendto(int socket,
           const void *buffer,
           size_t length,
           int flags,
           const struct sockaddr *dest_addr,
           socklen_t dest_len);
```

```
serverlen = sizeof(server_address);
bytestx = sendto(client_socket, buf, strlen(buf), 0,
         (struct sockaddr *) &server_address, serverlen);

if (bytestx < 0)
   perror("ERROR in sendto");
```

Adresa serveru

```
char *server_hostname;
struct hostent *server;
int port_number;


if ((server = gethostbyname(server_hostname)) == NULL) {
    fprintf(stderr,"ERROR, no such host as %s\n", server_hostname);
    exit(EXIT_FAILURE);
}
```

```
bzero((char *) &server_address, sizeof(server_address));

server_address.sin_family = AF_INET;

bcopy((char *)server->h_addr, (char *)&server_address.sin_addr.s_addr,
      server->h_length);

server_address.sin_port = htons(port_number);
```

Adresové struktury

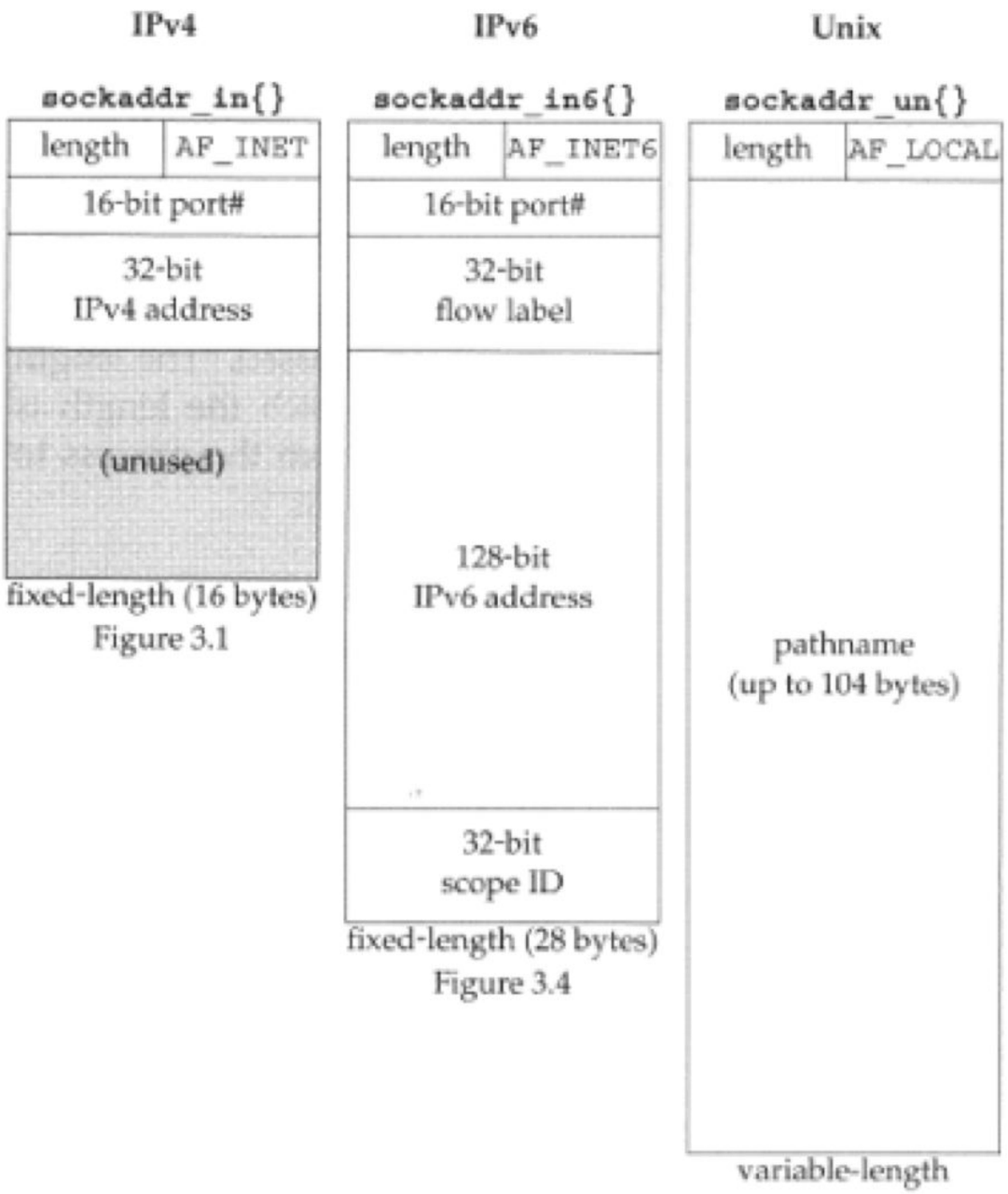
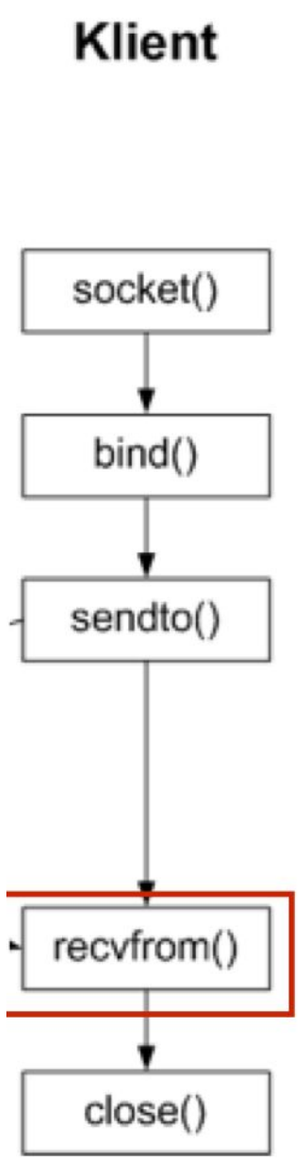


Figure 3.1

Figure 3.4

```
struct in_addr {
  in_addr_t    s_addr;          /* 32-bit IPv4 address */
                                /* network byte ordered */
};

struct sockaddr_in {
  uint8_t          sin_len;     /* length of structure (16) */
  sa_family_t      sin_family;  /* AF_INET */
  in_port_t        sin_port;    /* 16-bit TCP or UDP port number */
                                /* network byte ordered */
  struct in_addr   sin_addr;    /* 32-bit IPv4 address */
                                /* network byte ordered */
  char             sin_zero[8]; /* unused */
};
```

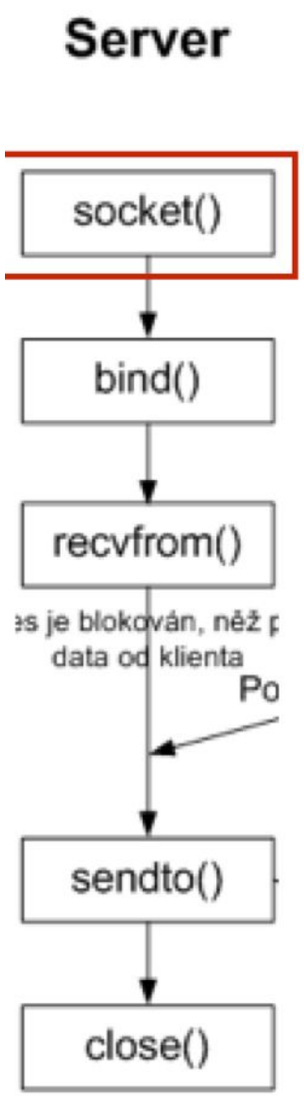
Přijetí dat




```
ssize_t
recvfrom(int socket,
         void * buffer,
         size_t length,
         int flags,
         struct sockaddr * address,
         socklen_t * address_len);
```

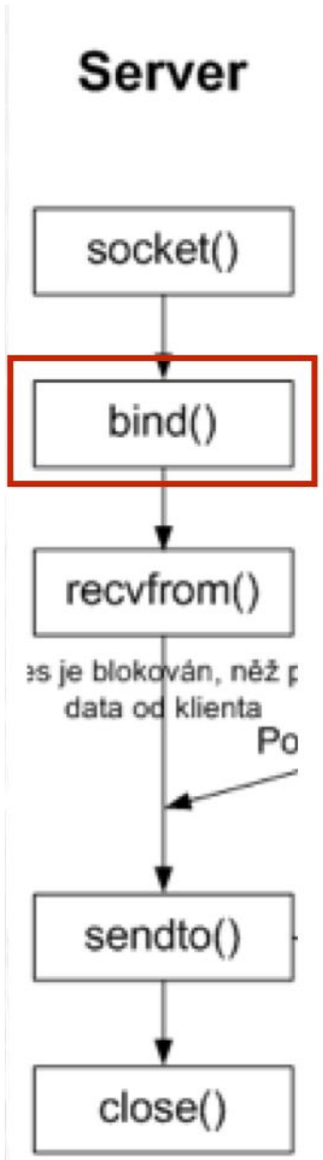
```
bytesrx = recvfrom(client_socket, buf, BUFSIZE, 0,
    (struct sockaddr *) &server_address, &serverlen);

if (bytesrx < 0)
    perror("ERROR in recvfrom");
```

Server: vytvoření socketu




```
if ((server_socket = socket(AF_INET, SOCK_DGRAM, 0)) <= 0)
{
   perror("ERROR in socket");
   exit(EXIT_FAILURE);
}

optval = 1;
setsockopt(server_socket, SOL_SOCKET, SO_REUSEADDR,
    (const void *)&optval , sizeof(int));
```

Server: Bind

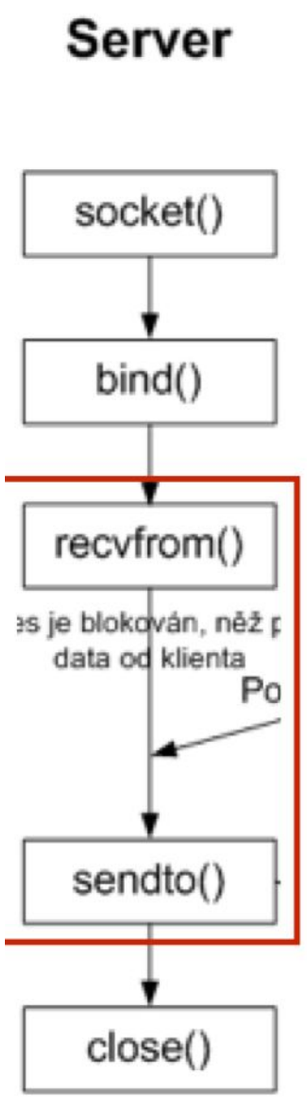



```
struct sockaddr_in server_address;
int port_number;
```

```
bzero((char *) &server_address, sizeof(server_address));
server_address.sin_family = AF_INET;
server_address.sin_addr.s_addr = htonl(INADDR_ANY);
server_address.sin_port = htons((unsigned short)port_number);
```

```
if (bind(server_socket, (struct sockaddr *) &server_address,
     sizeof(server_address)) < 0)
{
     perror("ERROR: bind");
     exit(EXIT_FAILURE);
}
```

Server smyčka




```
while(1)
{
    clientlen = sizeof(client_address);
    bytesrx = recvfrom(server_socket, buf, BUFSIZE, 0,
        (struct sockaddr *) &client_address, &clientlen);

    if (bytesrx < 0)
        perror("ERROR: recvfrom:");



    bytestx = sendto(server_socket, buf, strlen(buf), 0,
        (struct sockaddr *) &client_address, clientlen);

    if (bytestx < 0)
        perror("ERROR: sendto:");
}
```

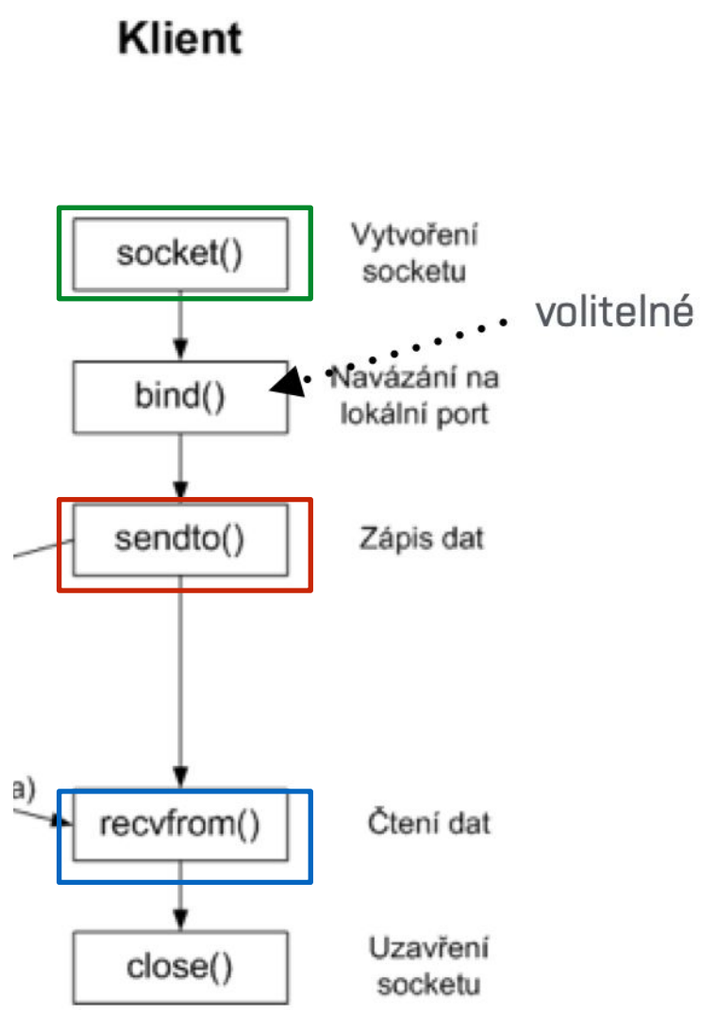
Klient

```
if ((client_socket = socket(AF_INET, SOCK_DGRAM, 0)) <= 0)
{
        perror("ERROR in socket");
        exit(EXIT_FAILURE);
}
```

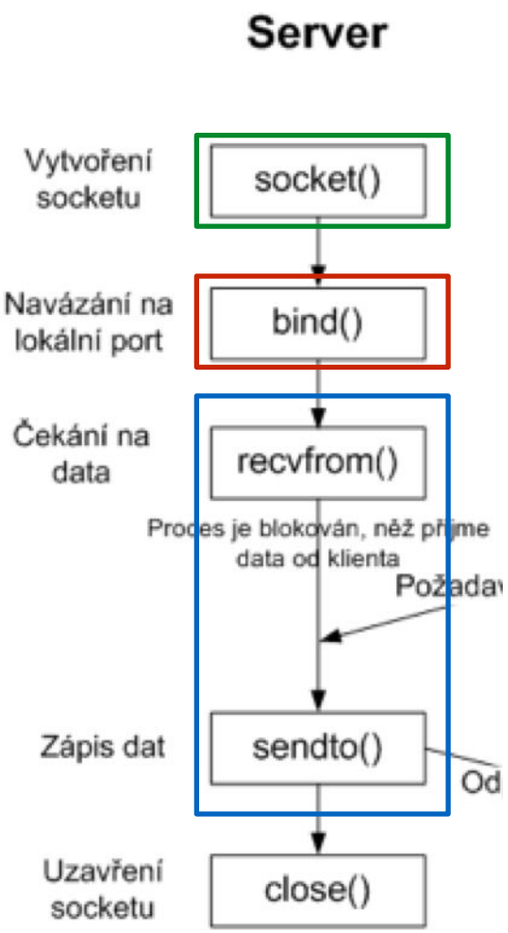
```
if ((server = gethostbyname(server_hostname)) == NULL) {
    fprintf(stderr,"ERROR, no such host as %s\n", server_hostname);
    exit(EXIT_FAILURE);
}


bzero((char *) &server_address, sizeof(server_address));

server_address.sin_family = AF_INET;

bcopy((char *)server->h_addr, (char *)&server_address.sin_addr.s_addr,
      server->h_length);

server_address.sin_port = htons(port_number);
```

```
serverlen = sizeof(server_address);
bytestx = sendto(client_socket, buf, strlen(buf), 0,
         (struct sockaddr *) &server_address, serverlen);

if (bytestx < 0)
   perror("ERROR in sendto");
```

```
bytesrx = recvfrom(client_socket, buf, BUFSIZE, 0,
    (struct sockaddr *) &server_address, &serverlen);

if (bytesrx < 0)
    perror("ERROR in recvfrom");
```



Server




```
if ((server_socket = socket(AF_INET, SOCK_DGRAM, 0)) <= 0)
{
   perror("ERROR in socket");
   exit(EXIT_FAILURE);
}

optval = 1;
setsockopt(server_socket, SOL_SOCKET, SO_REUSEADDR,
    (const void *)&optval , sizeof(int));
```

```
struct sockaddr_in server_address;
int port_number;
```

```
bzero((char *) &server_address, sizeof(server_address));
server_address.sin_family = AF_INET;
server_address.sin_addr.s_addr = htonl(INADDR_ANY);
server_address.sin_port = htons((unsigned short)port_number);


if (bind(server_socket, (struct sockaddr *) &server_address,
    sizeof(server_address)) < 0)
{
    perror("ERROR: bind");
    exit(EXIT_FAILURE);
}
```

```
while(1)
{
    clientlen = sizeof(client_address);
    bytesrx = recvfrom(server_socket, buf, BUFSIZE, 0,
        (struct sockaddr *) &client_address, &clientlen);

    if (bytesrx < 0)
        perror("ERROR: recvfrom:");



    bytestx = sendto(server_socket, buf, strlen(buf), 0,
        (struct sockaddr *) &client_address, clientlen);

    if (bytestx < 0)
        perror("ERROR: sendto:");
}
```

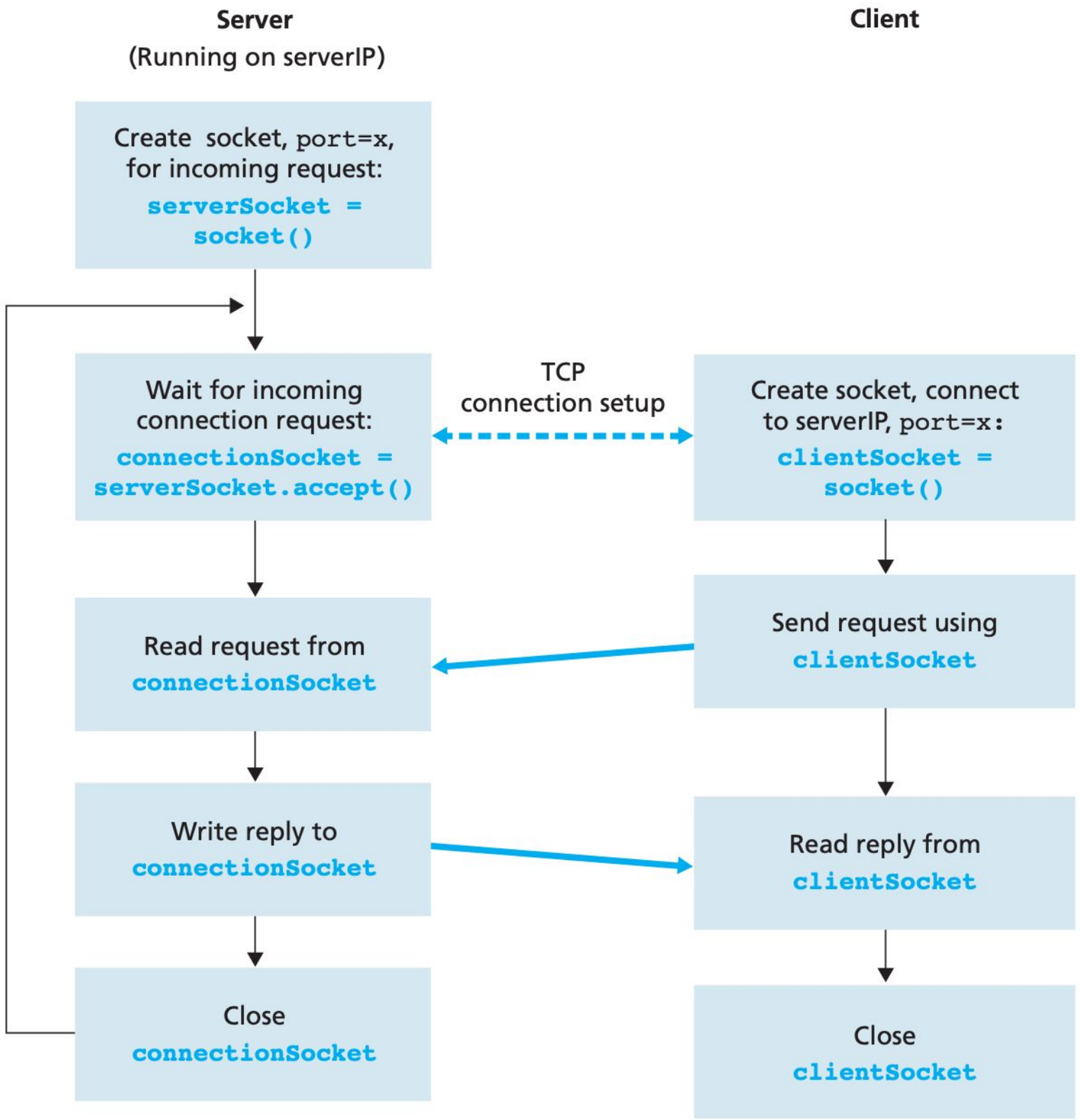
Python

```python
from socket import *
serverName = 'loacalhost'
serverPort = 12000
clientSocket = socket(socket.AF_INET, socket.SOCK_DGRAM)
message = raw_input('Input:')
clientSocket.sendto(message,(serverName,serverPort))
receivedMessage, serverAddress = clientSocket.recvfrom(2048)
print modifiedMessage
clientSocket.close()
```

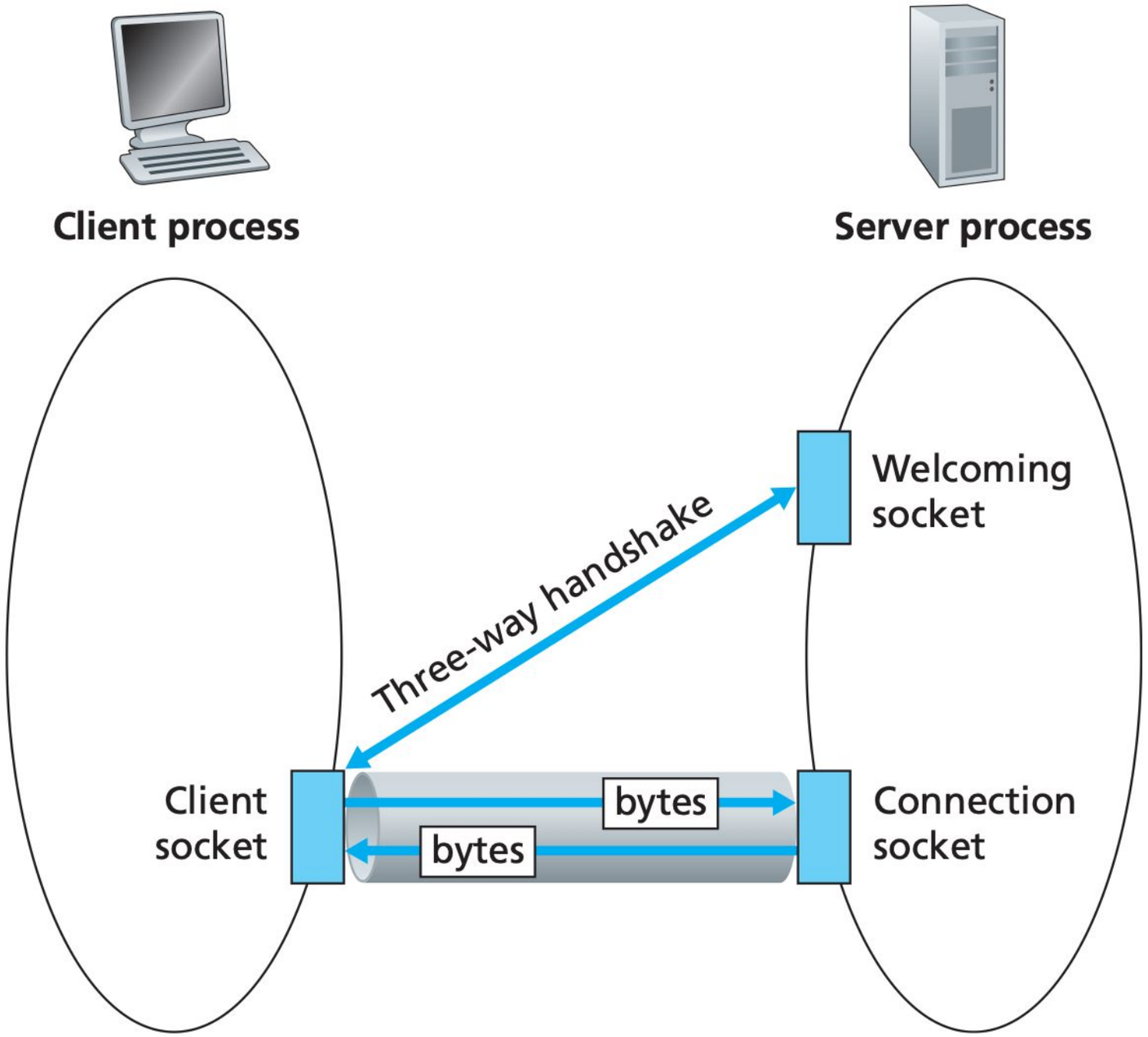
```python
from socket import *
serverPort = 12000
serverSocket = socket(AF_INET, SOCK_DGRAM)
serverSocket.bind(('', serverPort))
print 'server is running'
while 1:
    message, clientAddress = serverSocket.recvfrom(2048)
    modifiedMessage = message.upper()
    serverSocket.sendto(modifiedMessgae, clientAddress)
```

TCP komunikace

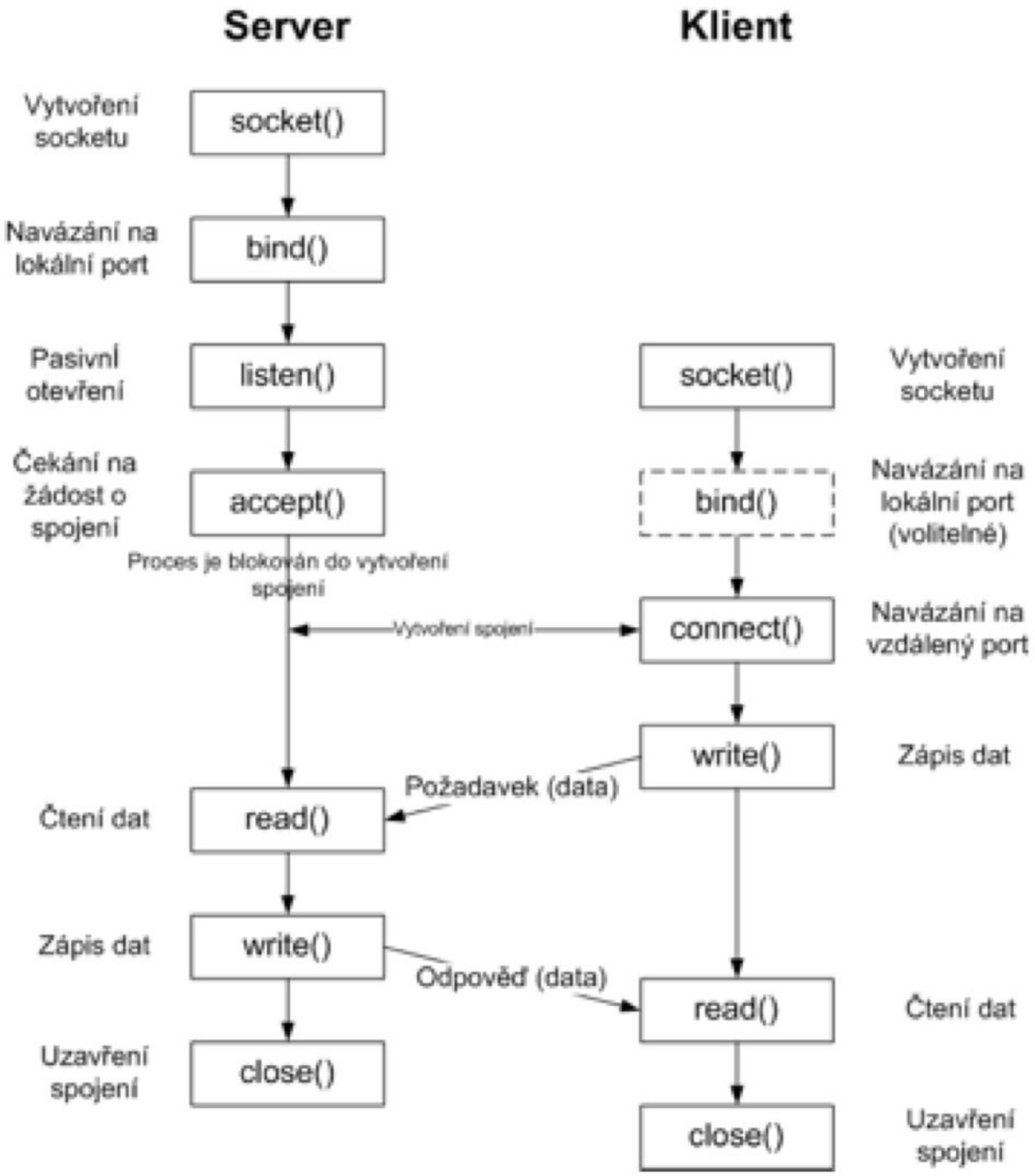
TCP komuikace



Welcome socket

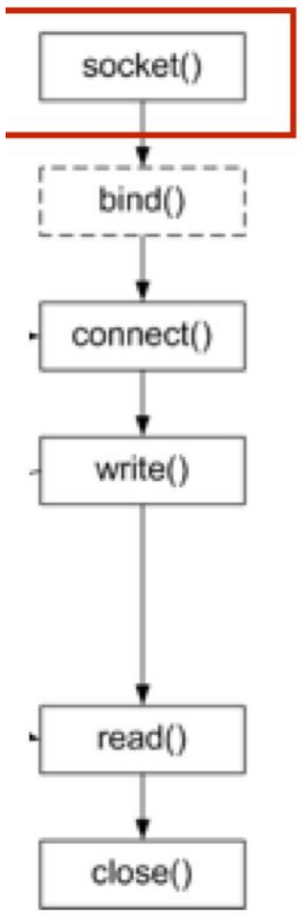


TCP funkce


Server
Klient
Vytvoření socketu
socket()
Navázání na lokální port
bind()
Pasivní otevření
listen()
Čekání na žádost o spojení
accept()
Proces je blokován do vytvoření spojení
socket()
Vytvoření socketu
bind()
Navázání na lokální port (volitelné)
Vytvoření spojení
connect()
Navázání na vzdálený port
write()
Zápis dat
Požadavek (data)
Čtení dat
read()
Zápis dat
write()
Odpověď (data)
read()
Čtení dat
Uzavření spojení
close()
close()
Uzavření spojení

Klient: Vytvoření socketu

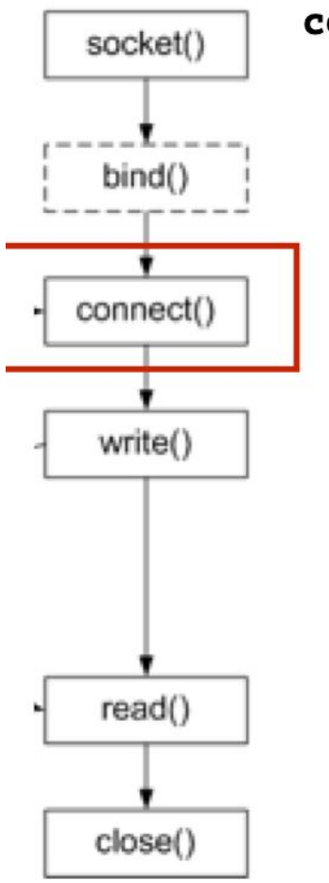
Klient




```
if ((client_socket = socket(AF_INET, SOCK_STREAM, 0)) <= 0)
{
        perror(“ERROR: socket");
        exit(EXIT_FAILURE);
}
```

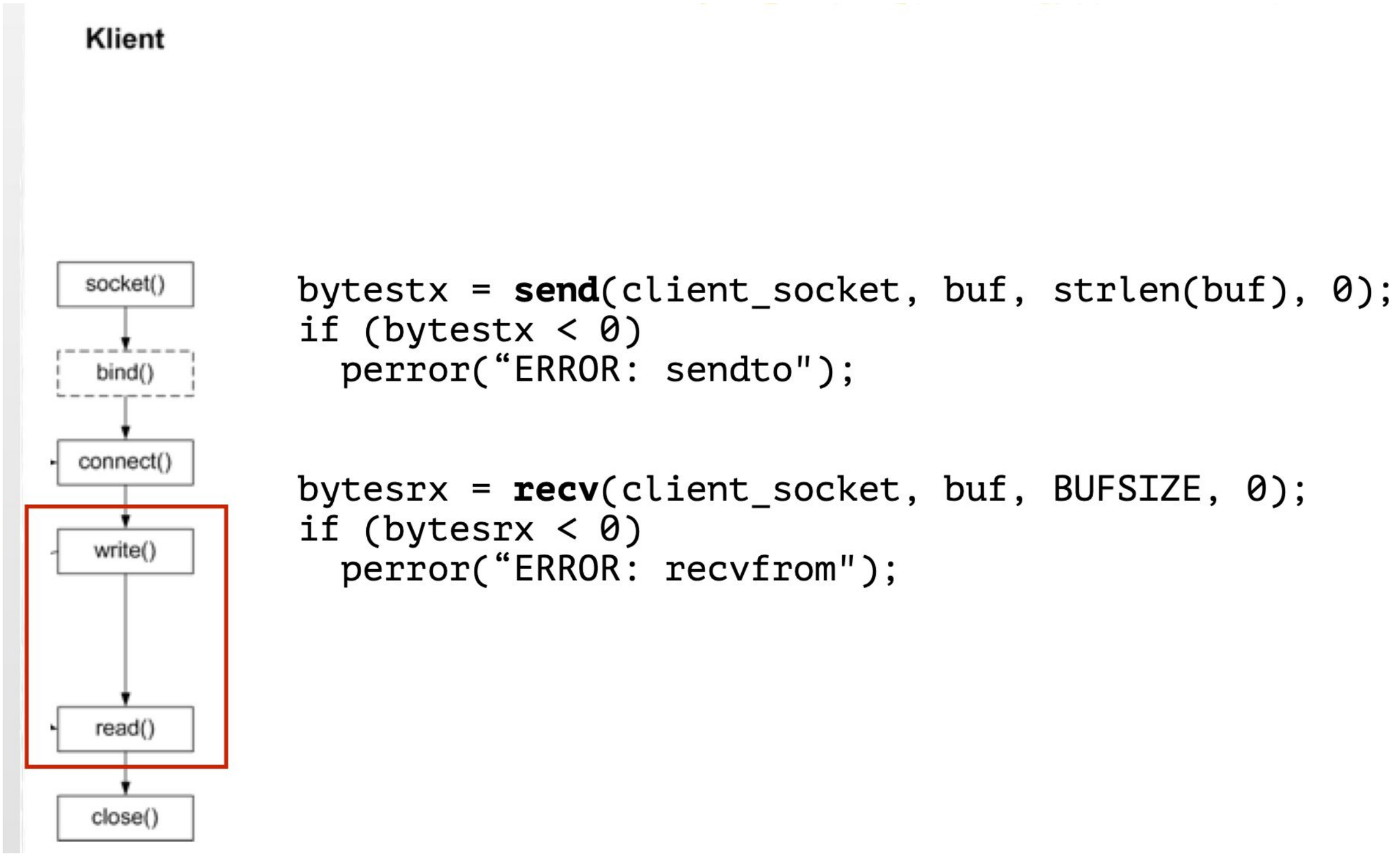
Klient: Connect

```
NAME
     connect -- initiate a connection on a socket

SYNOPSIS
     #include <sys/types.h>
     #include <sys/socket.h>

     int
     connect(int socket, const struct sockaddr *address, socklen_t address_len);
```

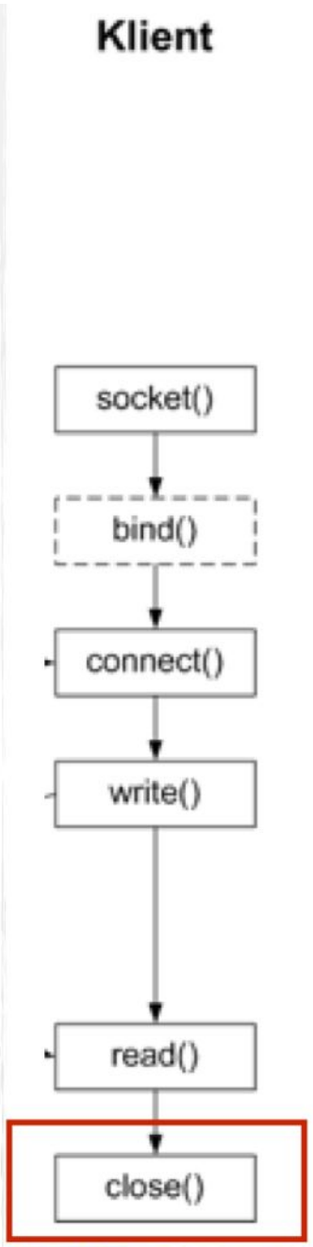



```
if (connect(client_socket,
            (const struct sockaddr *) &server_address,
            sizeof(server_address)) != 0)
{
             perror("ERROR: connect");
             exit(EXIT_FAILURE);
}
```

Klient: Send/recv



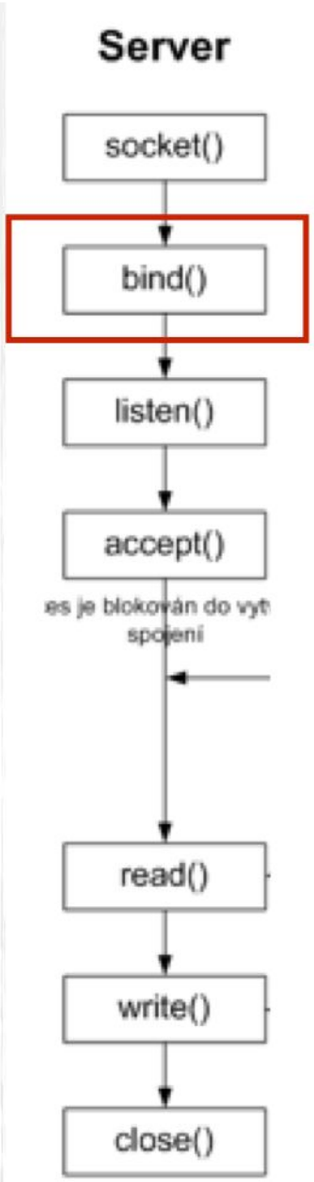
Ukončení spojení




```
NAME
     close -- delete a descriptor

SYNOPSIS
     #include <unistd.h>

     int
     close(int fildes);
```

```
NAME
     shutdown -- shut down part of a full-duplex connection

SYNOPSIS
     #include <sys/socket.h>

     int
     shutdown(int socket, int how);
```

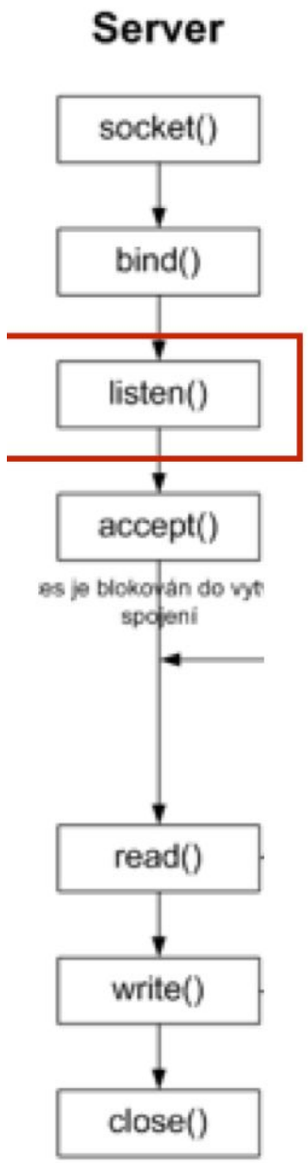
Server: Bind




```
NAME
     bind -- bind a name to a socket

SYNOPSIS
     #include <sys/socket.h>

     int
     bind(int socket, const struct sockaddr *address, socklen_t address_len);
```

```
memset(&sa,0,sizeof(sa));
sa.sin6_family = AF_INET6;
sa.sin6_addr = in6addr_any;
sa.sin6_port = htons(port_number);

if ((rc = bind(welcome_socket, (struct sockaddr*)&sa, sizeof(sa))) < 0)
{
          perror("ERROR: bind");
          exit(EXIT_FAILURE);
}
```

Server: Listen



NAME

listen -- listen for connections on a socket

SYNOPSIS

#include <sys/socket.h>

int
listen(int socket, int backlog);

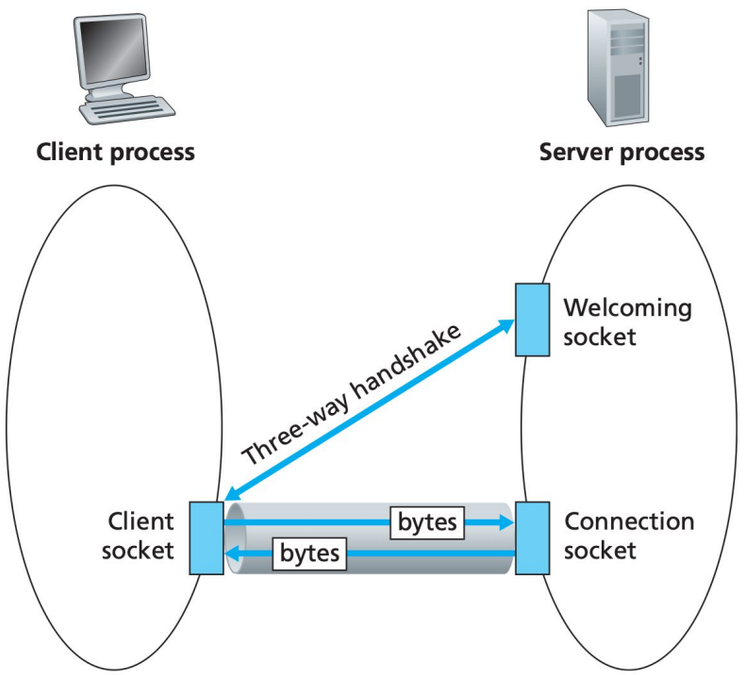
The backlog parameter defines the maximum length for the queue of pending connections.

```
if ((listen(welcome_socket, 1)) < 0)
{
        perror("ERROR: listen");
        exit(EXIT_FAILURE);
}
```

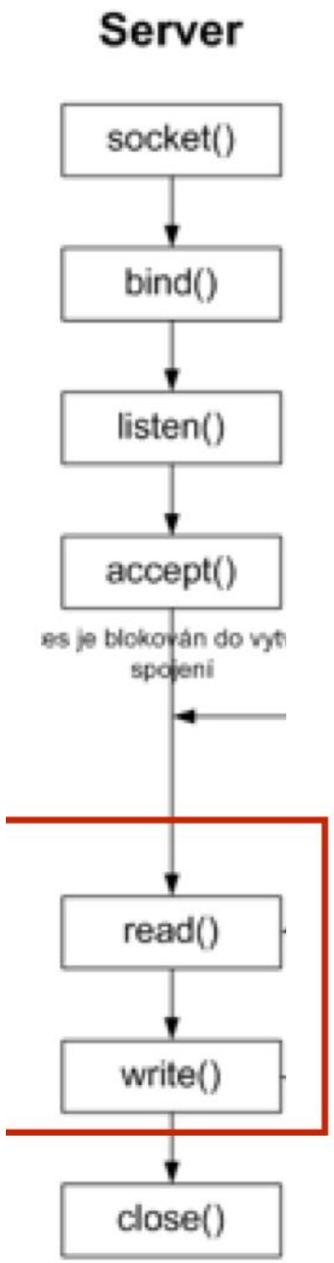
Server: Accept


```
accept -- accept a connection on a socket

SYNOPSIS
     #include <sys/socket.h>

     int
     accept(int socket, struct sockaddr *restrict address,
         socklen_t *restrict address_len);

accept() extracts the first connection request on the queue
of pending connections, creates a new socket with the same
properties of socket, and allocates a new file descriptor
for the socket.
```

```
while(1)
{
    int comm_socket = accept(welcome_socket,
        (struct sockaddr*)&sa_client, &sa_client_len

    if (comm_socket > 0)
    {

        . . .
    }
}
```



Server: read/write




```
char buff[1024];
int res = 0;
for (;;)
{
   res = recv(comm_socket, buff, 1024,0);
   if (res <= 0)
      break;


   send(comm_socket, buff, strlen(buff), 0);
}
```

Získání IP adresy

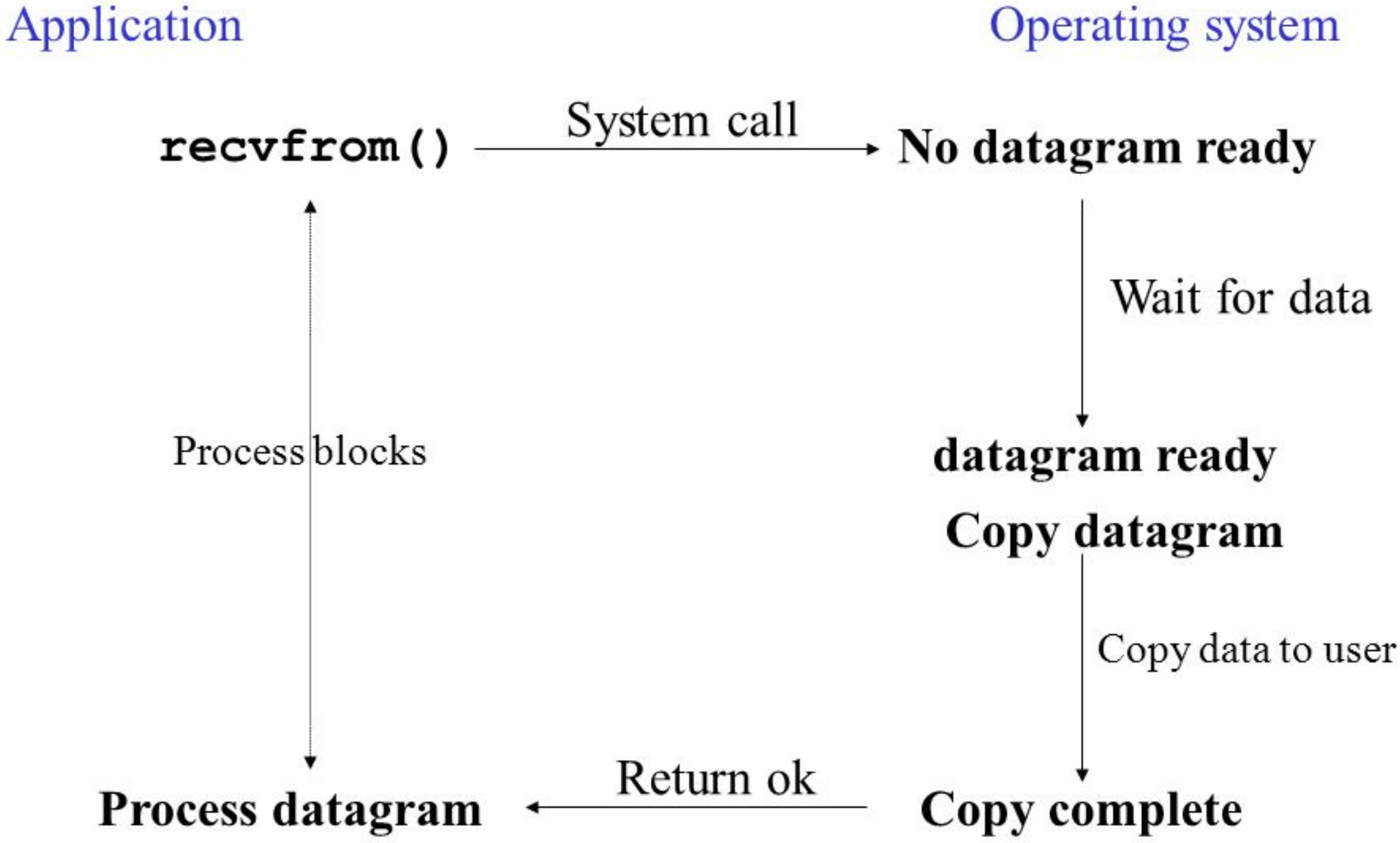
```
NAME
     getaddrinfo, freeaddrinfo - socket address structure to host and service
     name

SYNOPSIS
     #include <sys/types.h>
     #include <sys/socket.h>
     #include <netdb.h>

     int
     getaddrinfo(const char *hostname, const char *servname,
         const struct addrinfo *hints, struct addrinfo **res);

     void
     freeaddrinfo(struct addrinfo *ai);

DESCRIPTION
     The getaddrinfo() function is used to get a list of addresses and port
     numbers for host hostname and service servname.  It is a replacement for
     and provides more flexibility than the gethostbyname(3) and
     getservbyname(3) functions.
```

Pomocné funkce

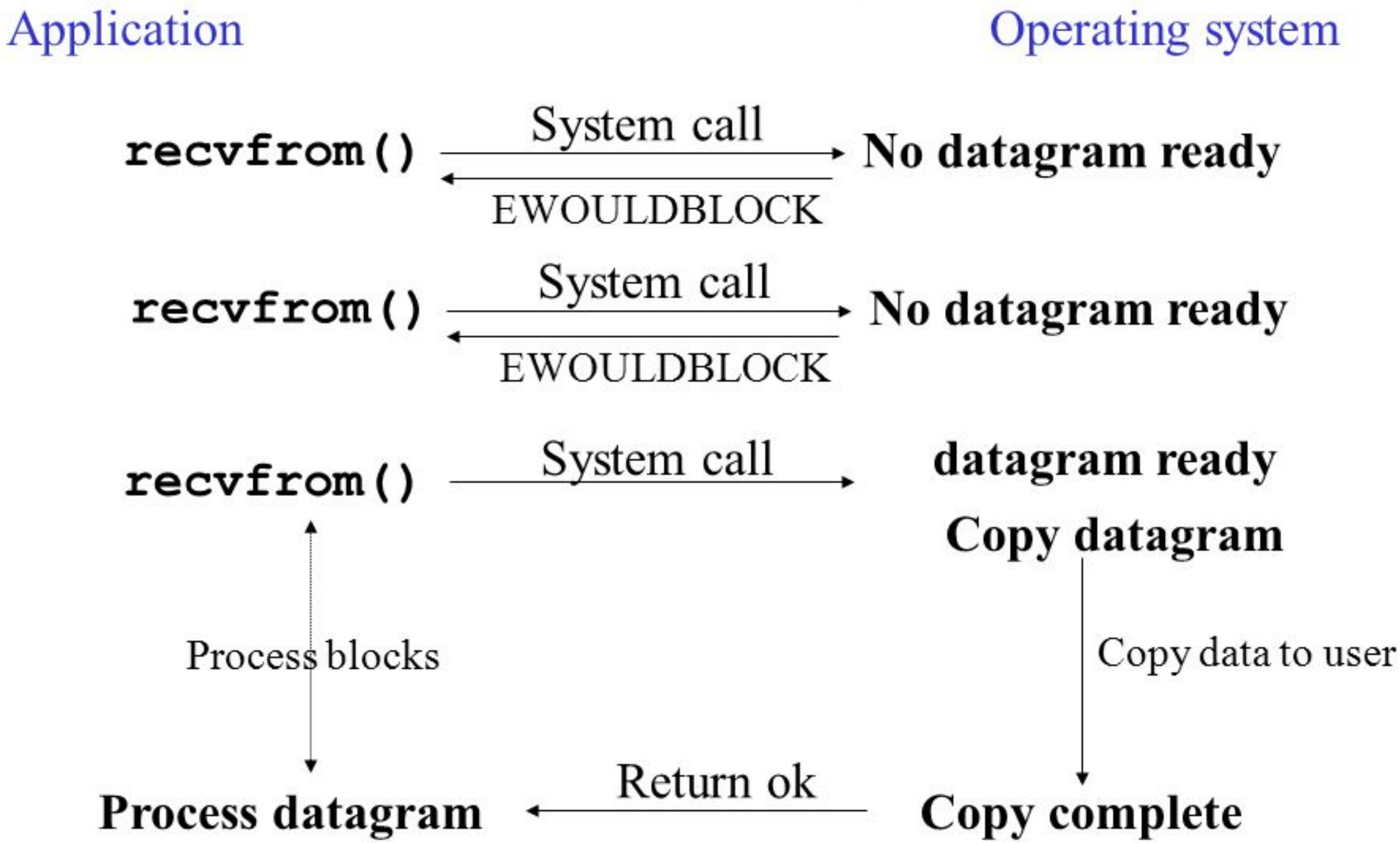
```
NAME
       htonl, htons, ntohl, ntohs - convert values between host and network byte order

SYNOPSIS
       #include <arpa/inet.h>

       uint32_t htonl(uint32_t hostlong);

       uint16_t htons(uint16_t hostshort);

       uint32_t ntohl(uint32_t netlong);

       uint16_t ntohs(uint16_t netshort);

DESCRIPTION
       The htonl() function converts the unsigned integer hostlong from host byte order to network byte order.

       The htons() function converts the unsigned short integer hostshort from host byte order to network byte order.

       The ntohl() function converts the unsigned integer netlong from network byte order to host byte order.

       The ntohs() function converts the unsigned short integer netshort from network byte order to host byte order.
```

Neblokující operace

Blocking I/O


Application
Operating system
recvfrom()
System call
No datagram ready
Wait for data
Process blocks
datagram ready
Copy datagram
Copy data to user
Process datagram
Return ok
Copy complete

Non-Blocking I/O

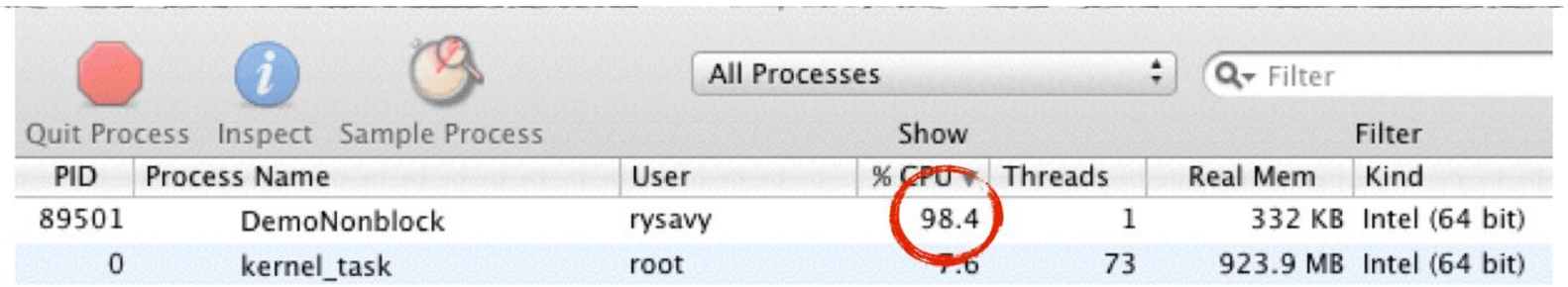


Neblokující socket

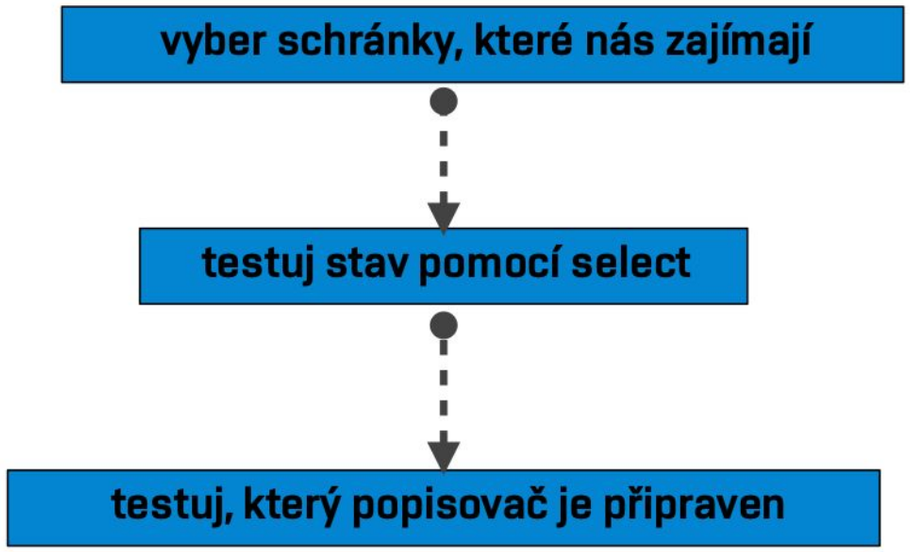
```c
int flags = fcntl(comm_socket, F_GETFL, 0);
rc = fcntl(comm_socket, F_SETFL, flags | O_NONBLOCK);

if (rc < 0)
{
    perror("fcntl() failed");
    exit(EXIT_FAILURE);
}
```

Příklad - aktivní čekání

```
struct timeval *timeoutPtr = NULL;
fd_set read_socks, write_socks;
fcntl(socket, F_SETFL, O_NONBLOCK);

while (1)
{
  if ((len = recv(socket, buffer, BUFFER_LENGTH, 0)) > 0)
  {

  }
  else if (errno == EAGAIN) continue;
  else if (len == 0) { break; }
  else
  {
     perror("ERROR: recv: ");
     exit();
  }
}
```



Neblokující a Select




```
int
  select(int nfds, fd_set *restrict readfds, fd_set *restrict writefds,
      fd_set *restrict errorfds, struct timeval *restrict timeout);
```

Příklad: Select

```
struct timeval *timeoutPtr = NULL;
fd_set read_socks, write_socks;

fcntl(socket, F_SETFL, O_NONBLOCK);

while (1)
{
  FD_ZERO(&read_socks);
  FD_ZERO(&write_socks);

  FD_SET(socket, &read_socks);
  FD_SET(socket, &write_socks);

  select(FD_SETSIZE, &read_socks, &write_socks, (fd_set *) 0,timeoutPtr);

  if (FD_ISSET(socket, &write_socks))
  {
    ...
  }

  if (FD_ISSET(socket, &read_socks))
  {
  ...
  }
}
```

Nástroje

Netstat

NAME

netstat -- show network status

SYNOPSIS

netstat [**-AaLlnW**] [**-f** address_family | **-p** protocol]
netstat [**-gilns**] [**-v**] [**-f** address_family] [**-I** interface]
netstat -i | **-I** interface [**-w** wait] [**-c** queue] [**-abdgqRtS**]
netstat -s [**-s**] [**-f** address_family | **-p** protocol] [**-w** wait]
netstat -i | **-I** interface **-s** [**-f** address_family | **-p** protocol]
netstat -m [**-m**]
netstat -r [**-Aaln**] [**-f** address_family]
netstat -rs [**-s**]

DESCRIPTION

The **netstat** command symbolically displays the contents of various network-related data structures. There are a number of output formats, depending on the options for the information presented. The first form of the command displays a list of active sockets for each protocol. The second form presents the contents of one of the other network data structures according to the option selected. Using the third form, with a wait interval specified, **netstat** will continuously display the information regarding packet traffic on the configured network interfaces. The fourth form displays statistics for the specified protocol or address family. If a wait interval is specified, the protocol information over the last interval seconds will be displayed. The fifth form displays per-interface statistics for the specified protocol or address family. The sixth form displays mbuf(9) statistics. The seventh form displays routing table for the specified address family. The eighth form displays routing statistics.

Netstat příklad

```
eva ~> netstat -Lnap tcp
Current listen queue sizes (qlen/incqlen/maxqlen)
Proto Listen           Local Address
tcp4  0/0/10           *.55555
tcp4  0/0/5            *.45000
tcp4  0/0/128          127.0.0.1.8080
tcp6  0/0/128          ::1.8080
tcp4  0/0/50           147.229.176.14.3306
tcp6  0/0/10           *.465
tcp6  0/0/10           *.587
tcp6  0/0/10           *.25
tcp4  0/0/10           *.465
tcp4  0/0/10           *.587
tcp4  0/0/10           *.25
```

netcat

Nástroj, který umožňuje vytvořit TCP spojení nebo poslat UDP datagram.

```
nc kazi.fit.vutbr.cz 25

220 kazi.fit.vutbr.cz ESMTP Sendmail 8.16.1/8.16.1; Mon, 15 Feb
2021 17:23:36 +0100 (CET)


printf "GET /index.html HTTP/1.0\r\nHost:www.fit.vutbr.cz\r\n\r\n" | nc
www.fit.vutbr.cz 80

HTTP/1.1 404 Not Found
Date: Mon, 15 Feb 2021 16:25:04 GMT
Server: Apache
Connection: close
Content-Type: text/html; charset=iso-8859-2
```

Projekt

Projekt #1

Úkolem je vytvoření serveru v jazyce C/C++ komunikujícího prostřednictvím protokolu HTTP, který bude poskytovat různé informace o systému. Server bude naslouchat na daném portu a podle url bude vracet požadované informace. Server musí správně zpracovávat hlavičky HTTP a vytvářet správné HTTP odpovědi.

Typ odpovědi bude text/plain. Komunikace se serverem by měla být možná jak pomocí webového prohlížeče, tak nástroji typu wget a curl.

Potřebné informace pro odpověď lze v systému získat pomocí některých příkazů systému (uname, lscpu) a/nebo ze souborů v adresáři /proc.

1. Získání doménového jména

Vrací síťové jméno počítače včetně domény, například:

GET http://servername:12345/hostname

merlin.fit.vutbr.cz

2. Získání informací o CPU

Vrací informaci o procesoru, například:

GET http://servername:12345/cpu-name

Intel(R) Xeon(R) CPU E5-2640 0 @ 2.50GHz

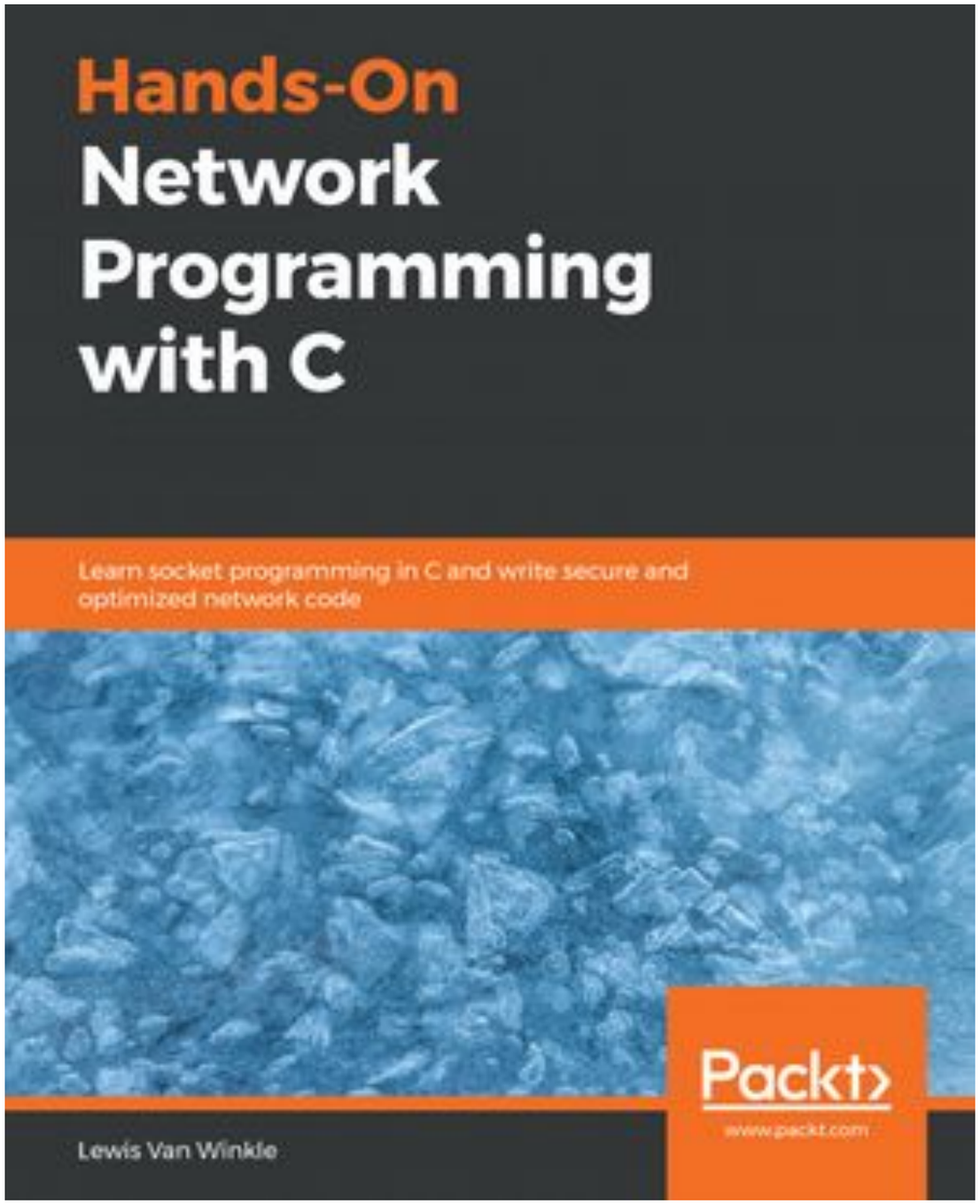
3. Aktuální zátěž

Vrací aktuální informace o zátěži. Tento vyžaduje výpočet z hodnot uvedených v souboru /proc/stat (viz odkaz níže). Výsledek je například:

GET http://servername:12345/load

65%

Zdroje



https://github.com/PacktPublishing/Hands-On-Network-Programming-with-C

2