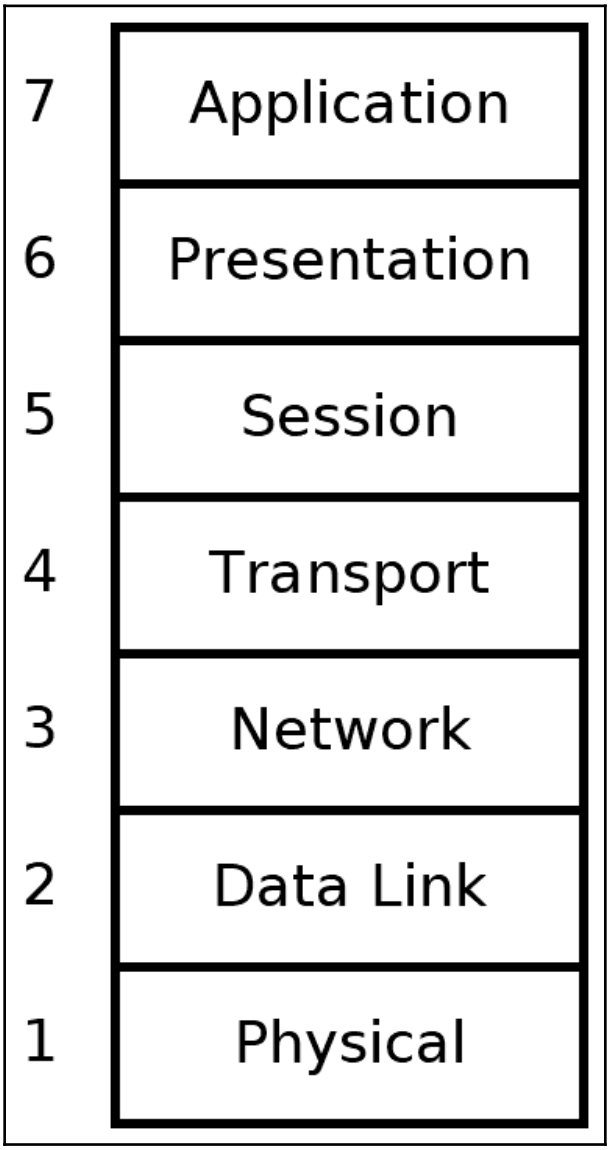
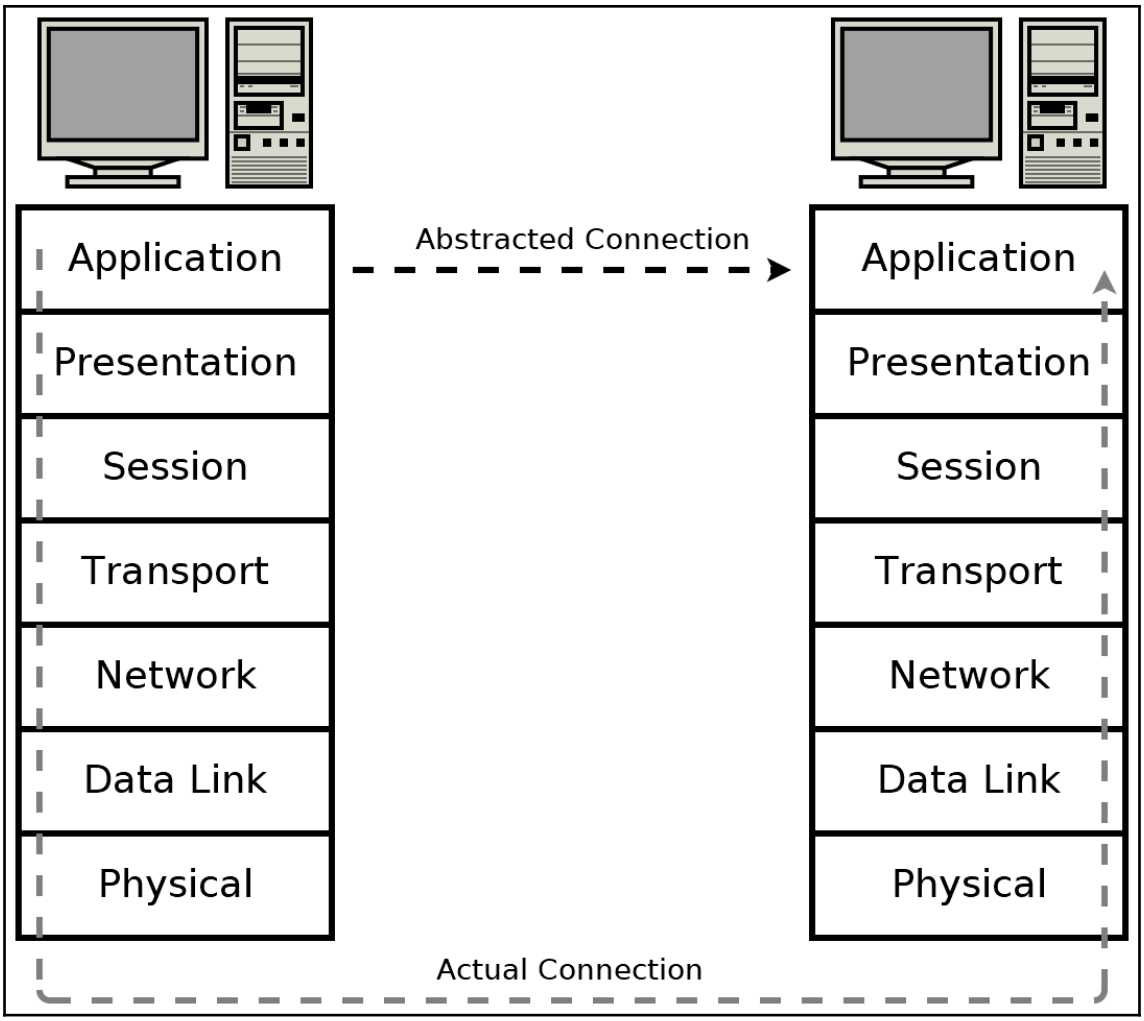
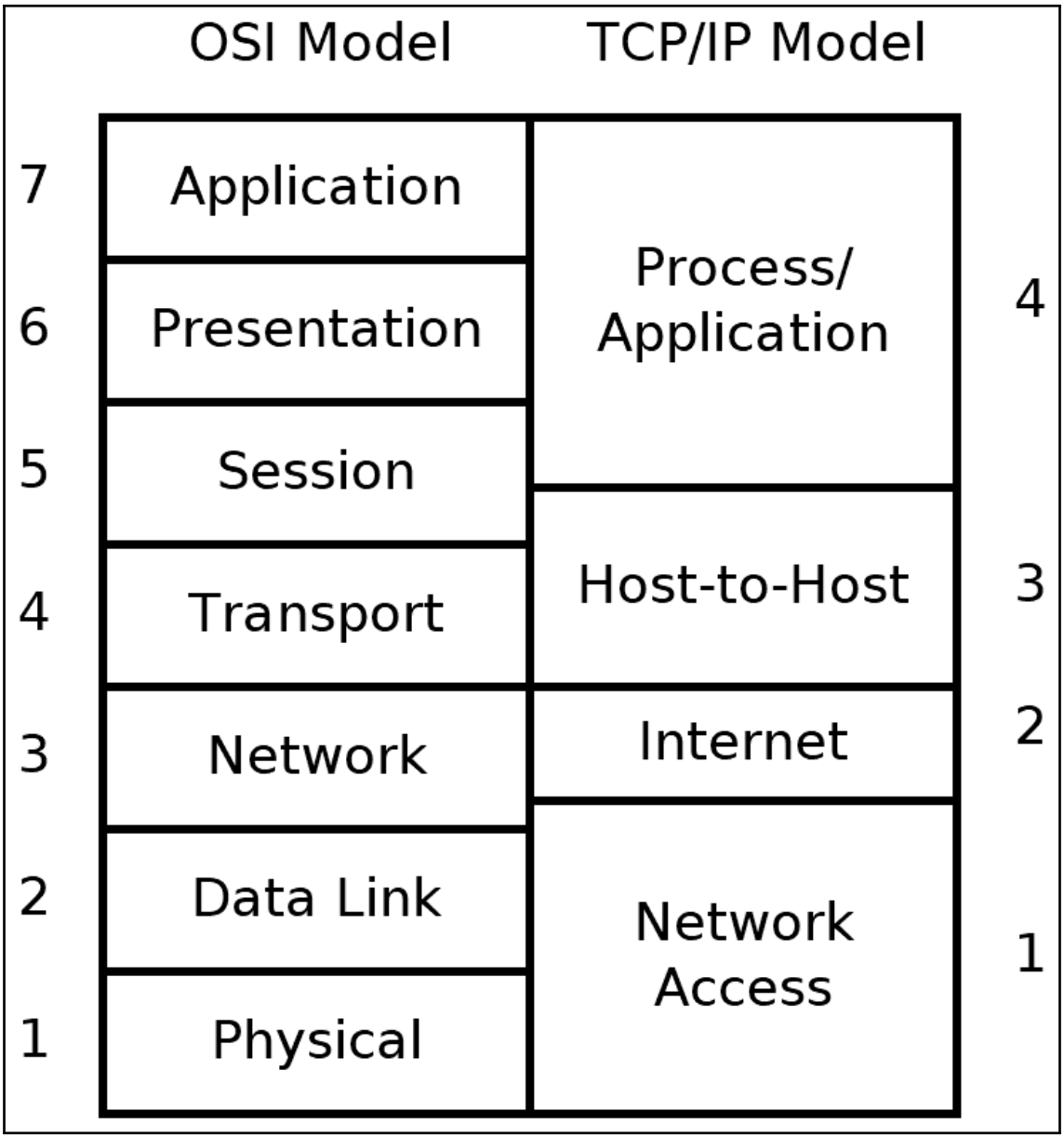
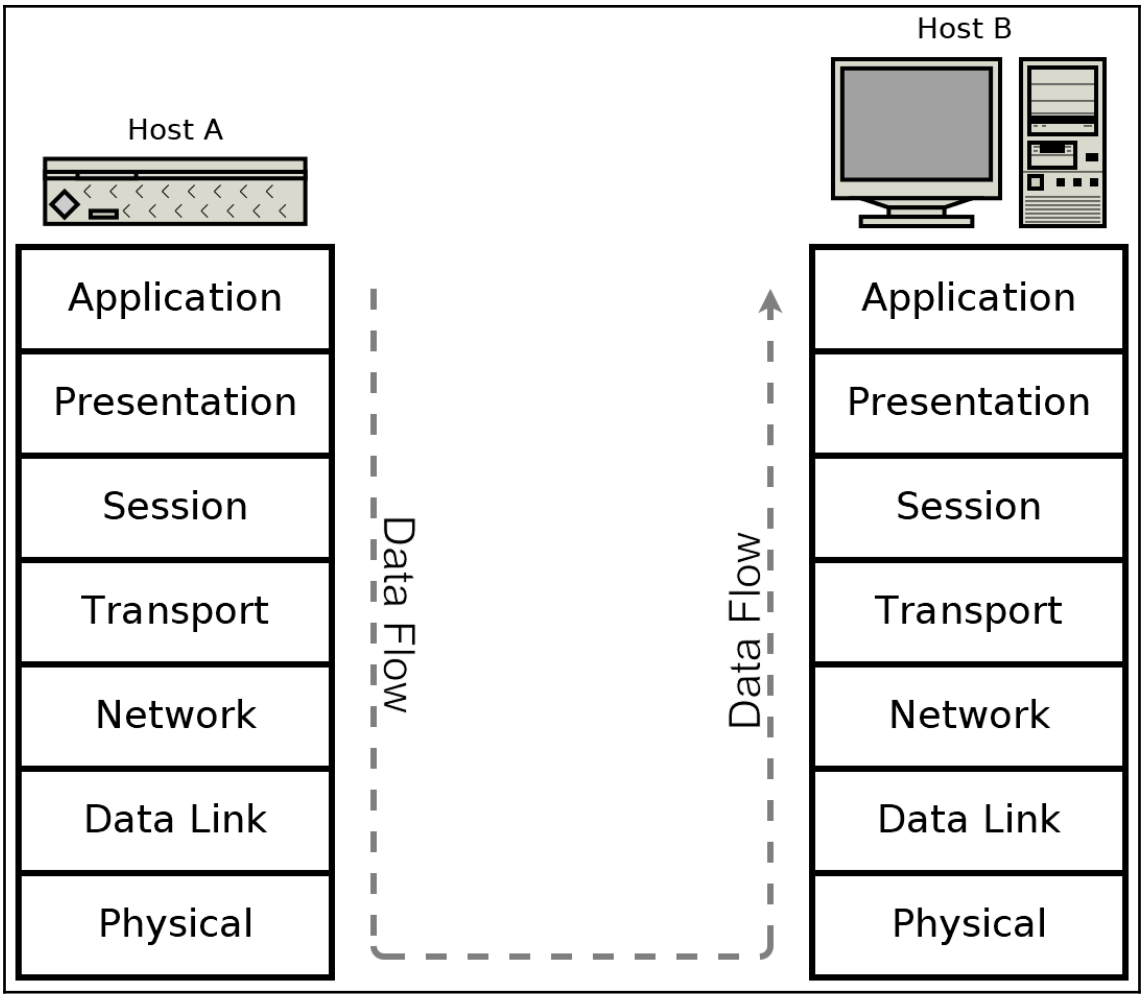
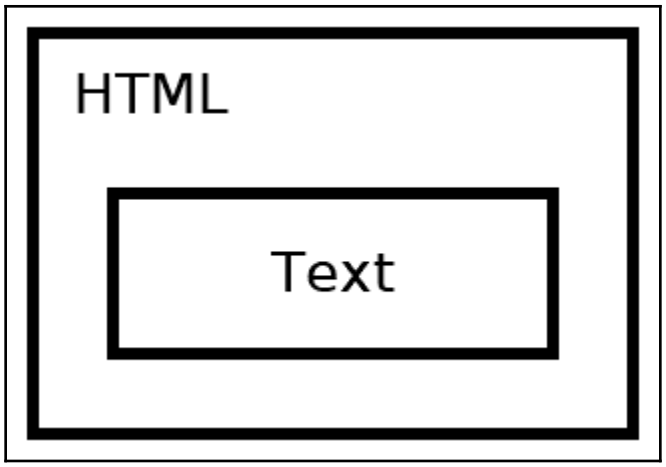
Chapter 1: Introducing Networks and Protocols

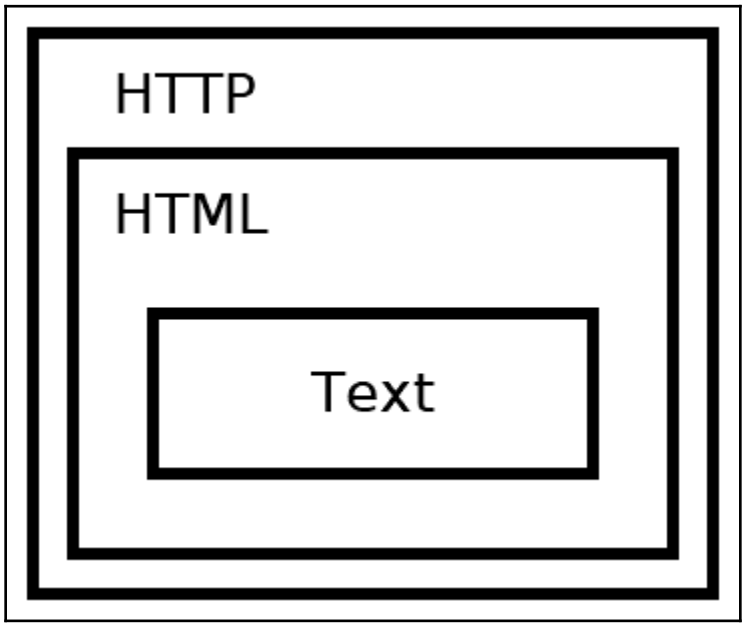


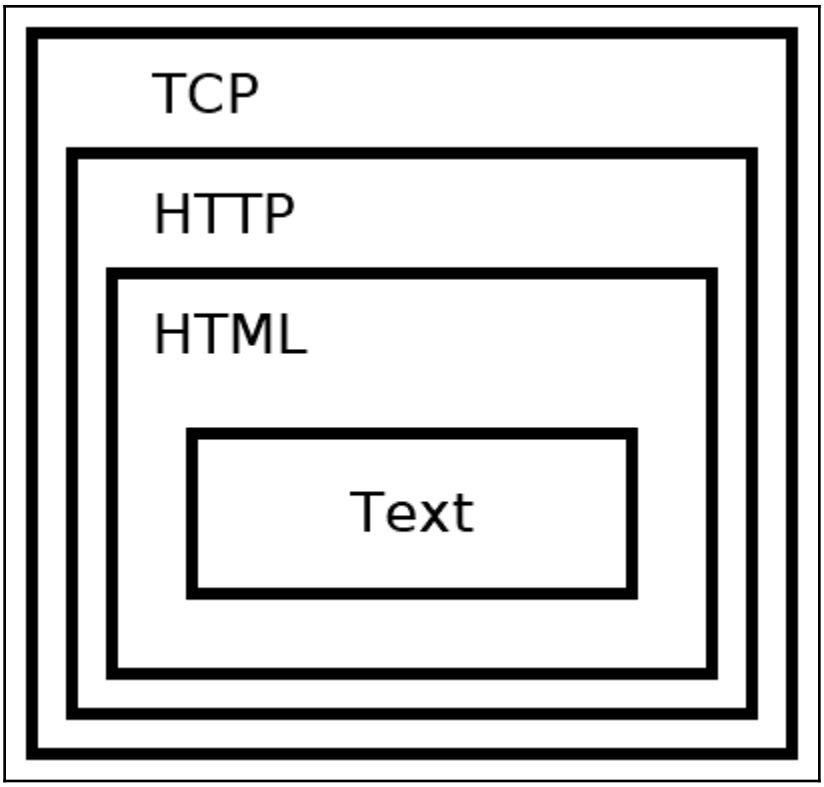

Application
Presentation
Session
Transport
Network
Data Link
Physical
Abstracted Connection
Application
Presentation
Session
Transport
Network
Data Link
Physical
Actual Connection

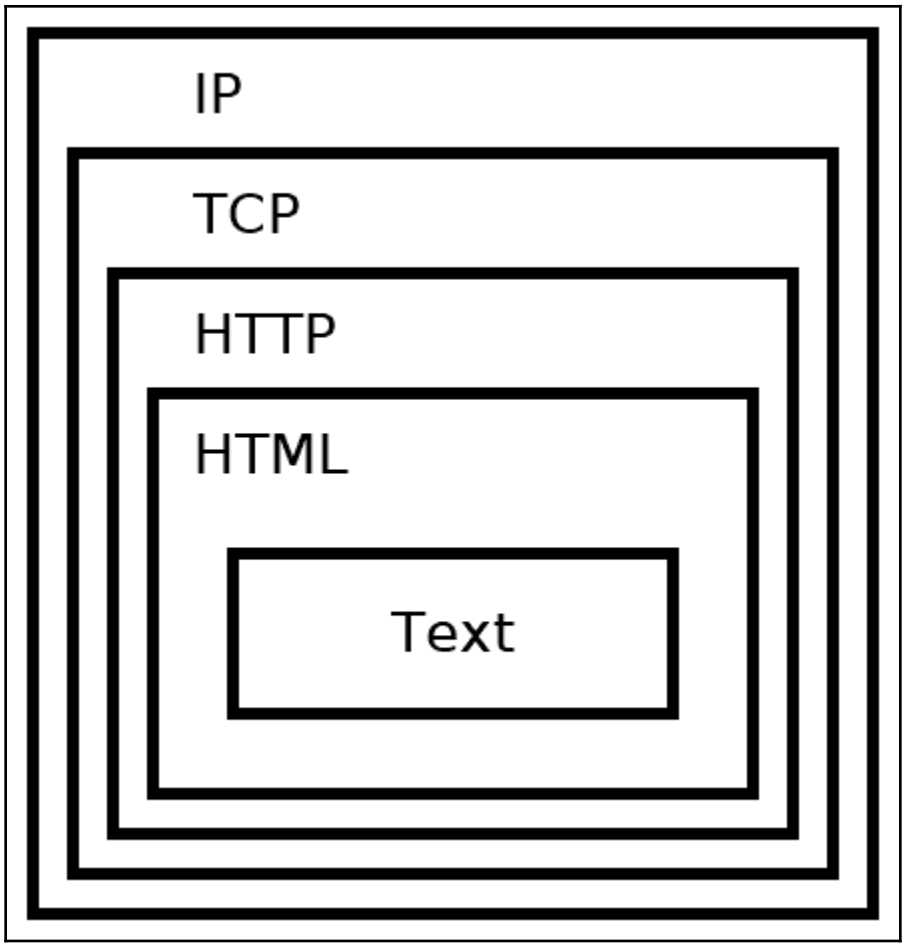

OSI Model
TCP/IP Model
7
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Data Link
1
Physical
Process/
Application
4
Host-to-Host
3
Internet
2
Network
Access
1

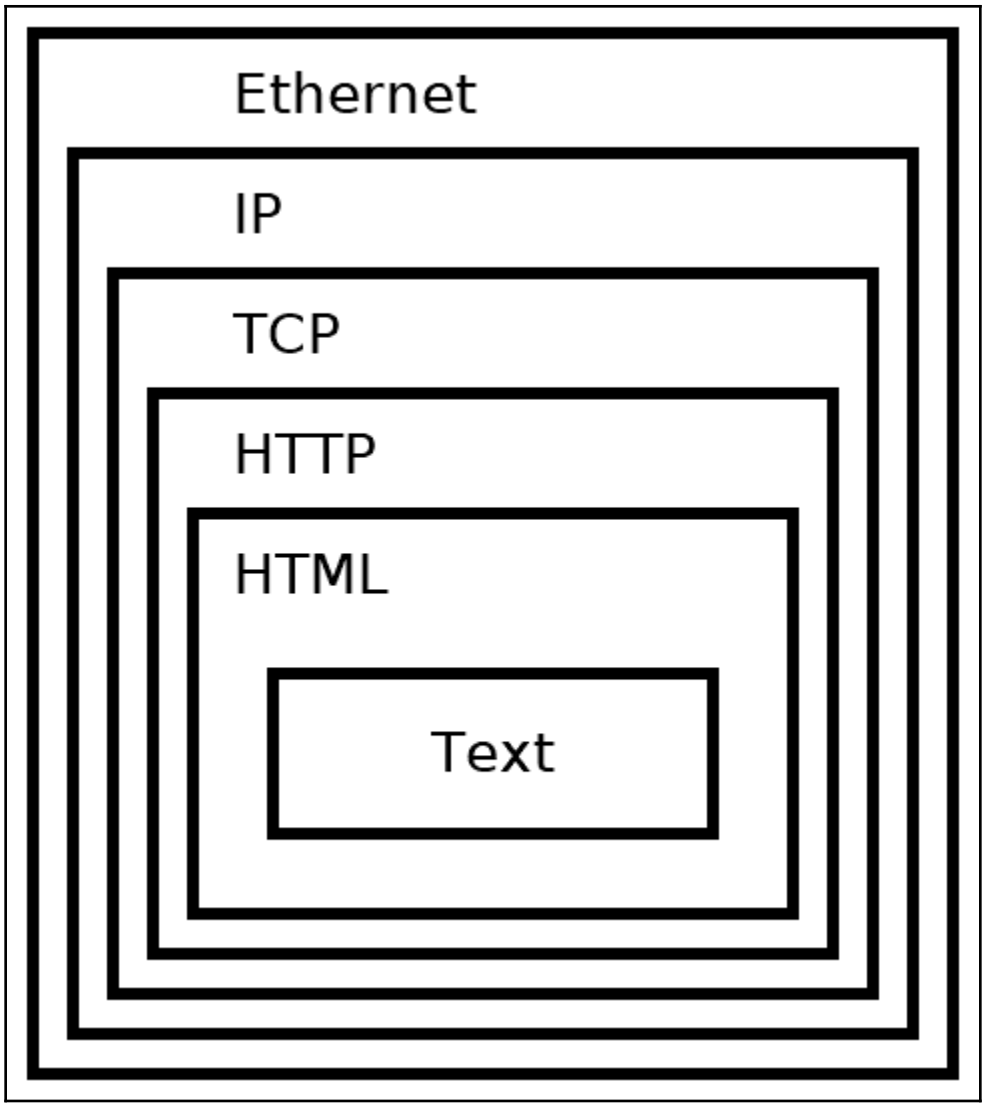

Host A
Host B
Application
Presentation
Session
Transport
Network
Data Link
Physical
Data Flow
Data Flow
Application
Presentation
Session
Transport
Network
Data Link
Physical

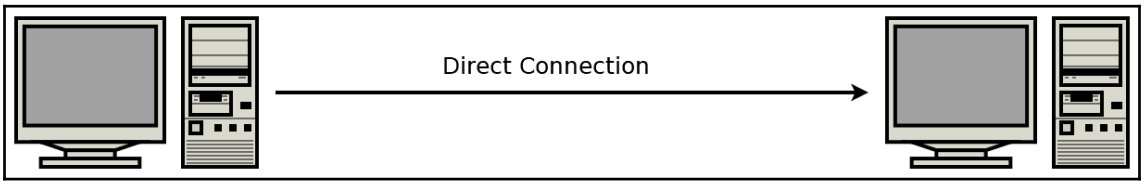

HTML
Text

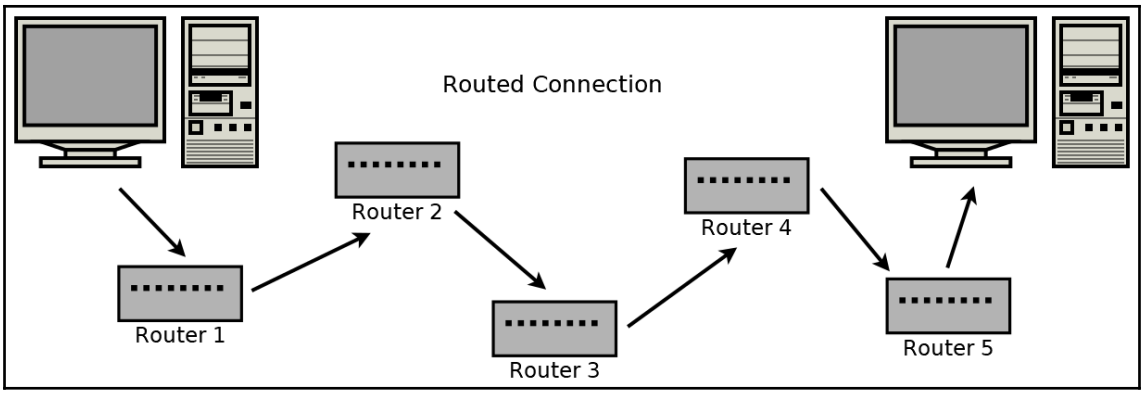

HTTP
HTML
Text

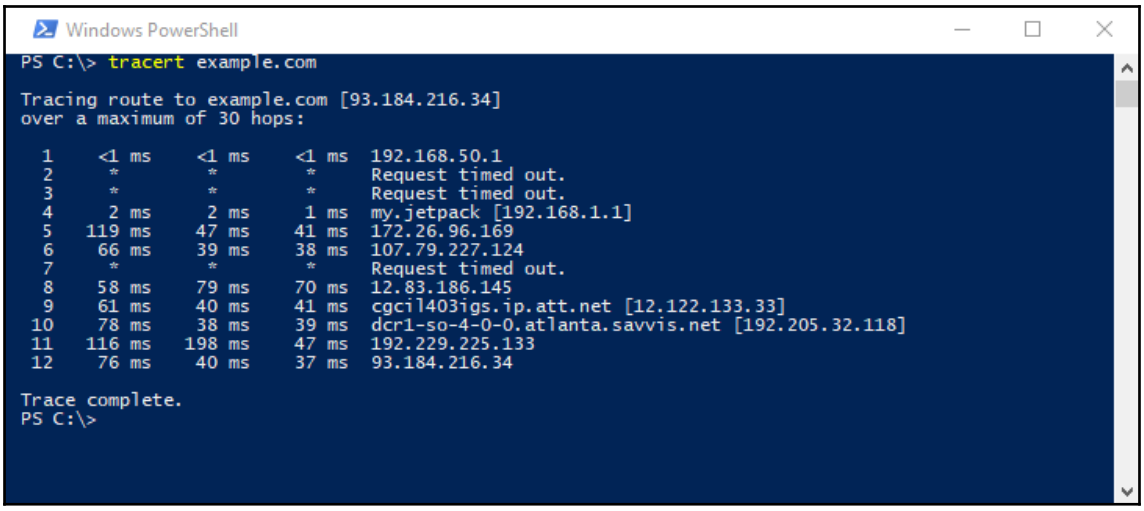

TCP
HTTP
HTML
Text

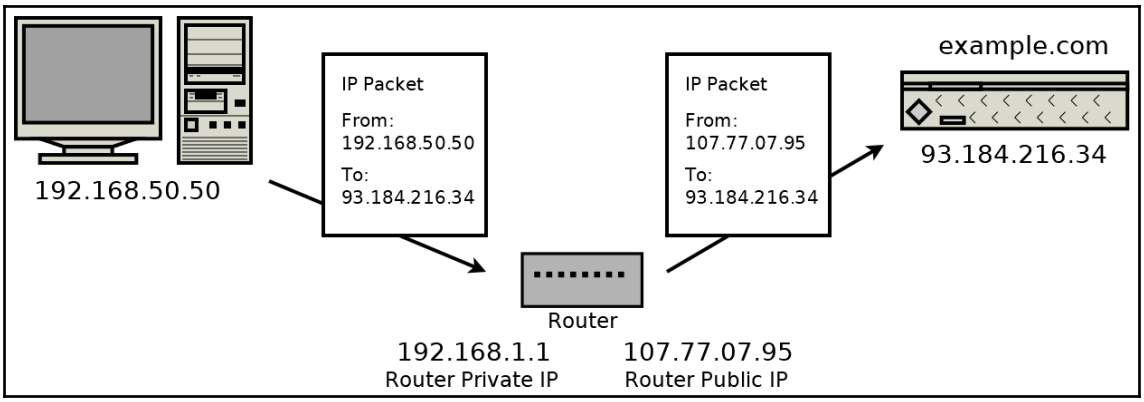

IP
TCP
HTTP
HTML
Text

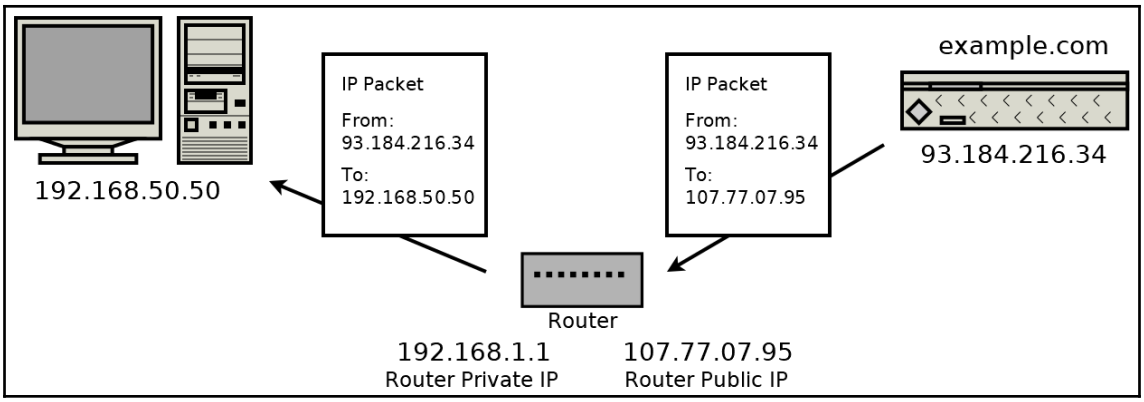

Ethernet
IP
TCP
HTTP
HTML
Text


Direct Connection

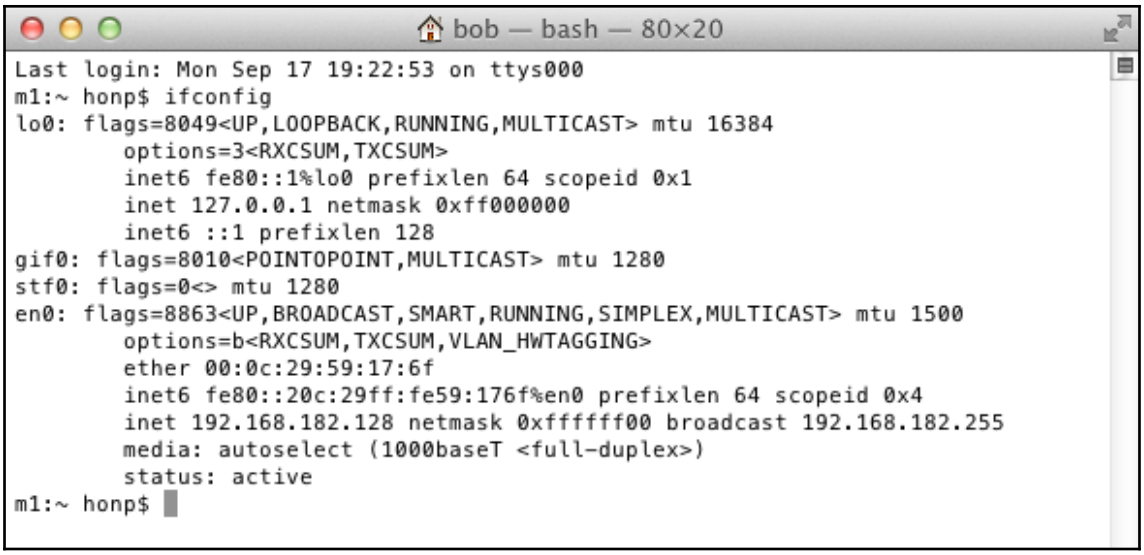

Routed Connection
Router 1
Router 2
Router 3
Router 4
Router 5

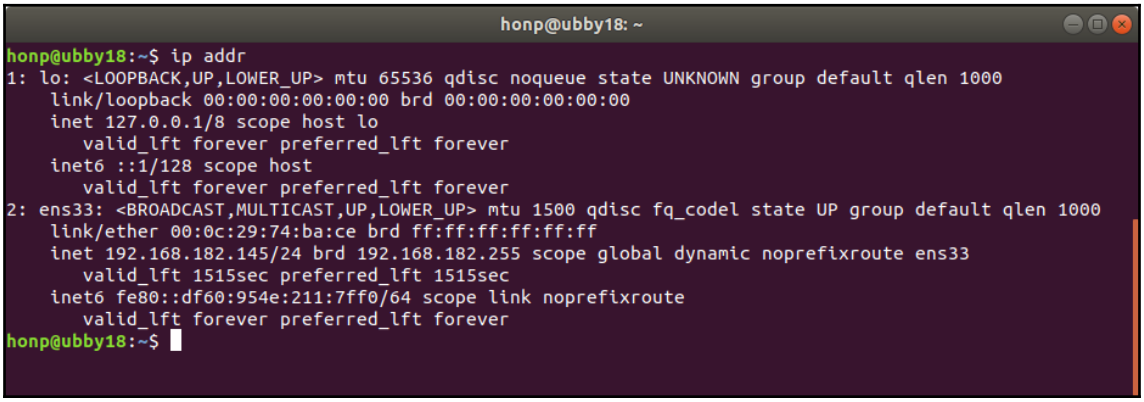

Windows PowerShell
PS C:\> tracert example.com
Tracing route to example.com [93.184.216.34]
over a maximum of 30 hops:
1 <1 ms <1 ms <1 ms 192.168.50.1
2 * * * Request timed out.
3 * * * Request timed out.
4 2 ms 2 ms 1 ms my.jetpack [192.168.1.1]
5 119 ms 47 ms 41 ms 172.26.96.169
6 66 ms 39 ms 38 ms 107.79.227.124
7 * * * Request timed out.
8 58 ms 79 ms 70 ms 12.83.186.145
9 61 ms 40 ms 41 ms cgcil403igs.ip.att.net [12.122.133.33]
10 78 ms 38 ms 39 ms dcr1-so-4-0-0.atlanta.savvis.net [192.205.32.118]
11 116 ms 198 ms 47 ms 192.229.225.133
12 76 ms 40 ms 37 ms 93.184.216.34
Trace complete.
PS C:\>

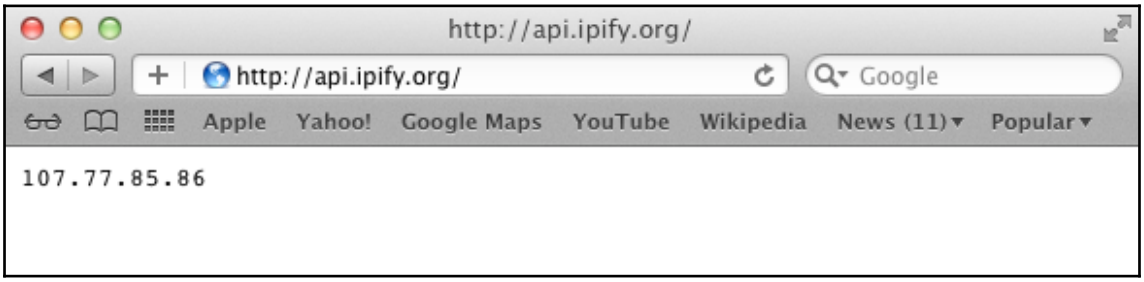

192.168.50.50
IP Packet
From:
192.168.50.50
To:
93.184.216.34
IP Packet
From:
107.77.07.95
To:
93.184.216.34
example.com
93.184.216.34
Router
192.168.1.1
Router Private IP
107.77.07.95
Router Public IP



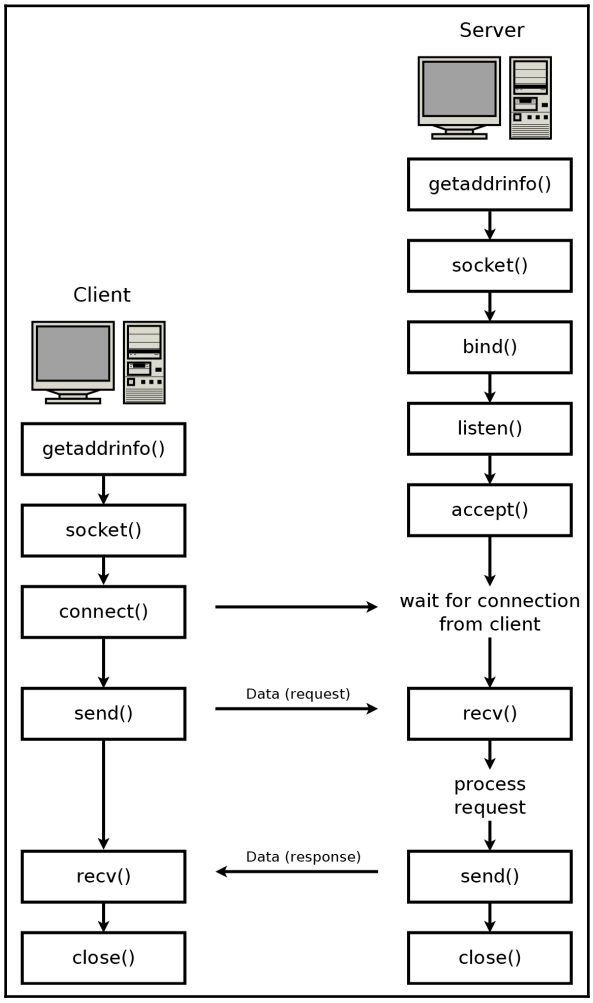

```
Windows PowerShell
PS C:\Users\honp> ipconfig

Windows IP Configuration


Ethernet adapter Ethernet0:

   Connection-specific DNS Suffix  . : localdomain
   Link-local IPv6 Address . . . . . : fe80::cd70:e700:5486:fb1a%5
   IPv4 Address. . . . . . . . . . . : 192.168.182.133
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.182.2

Tunnel adapter isatap.localdomain:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . : localdomain

Tunnel adapter Local Area Connection* 2:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:0:9d38:6ab8:8ba:2c5a:5950:c03c
   Link-local IPv6 Address . . . . . : fe80::8ba:2c5a:5950:c03c%2
   Default Gateway . . . . . . . . . : ::
PS C:\Users\honp>
```

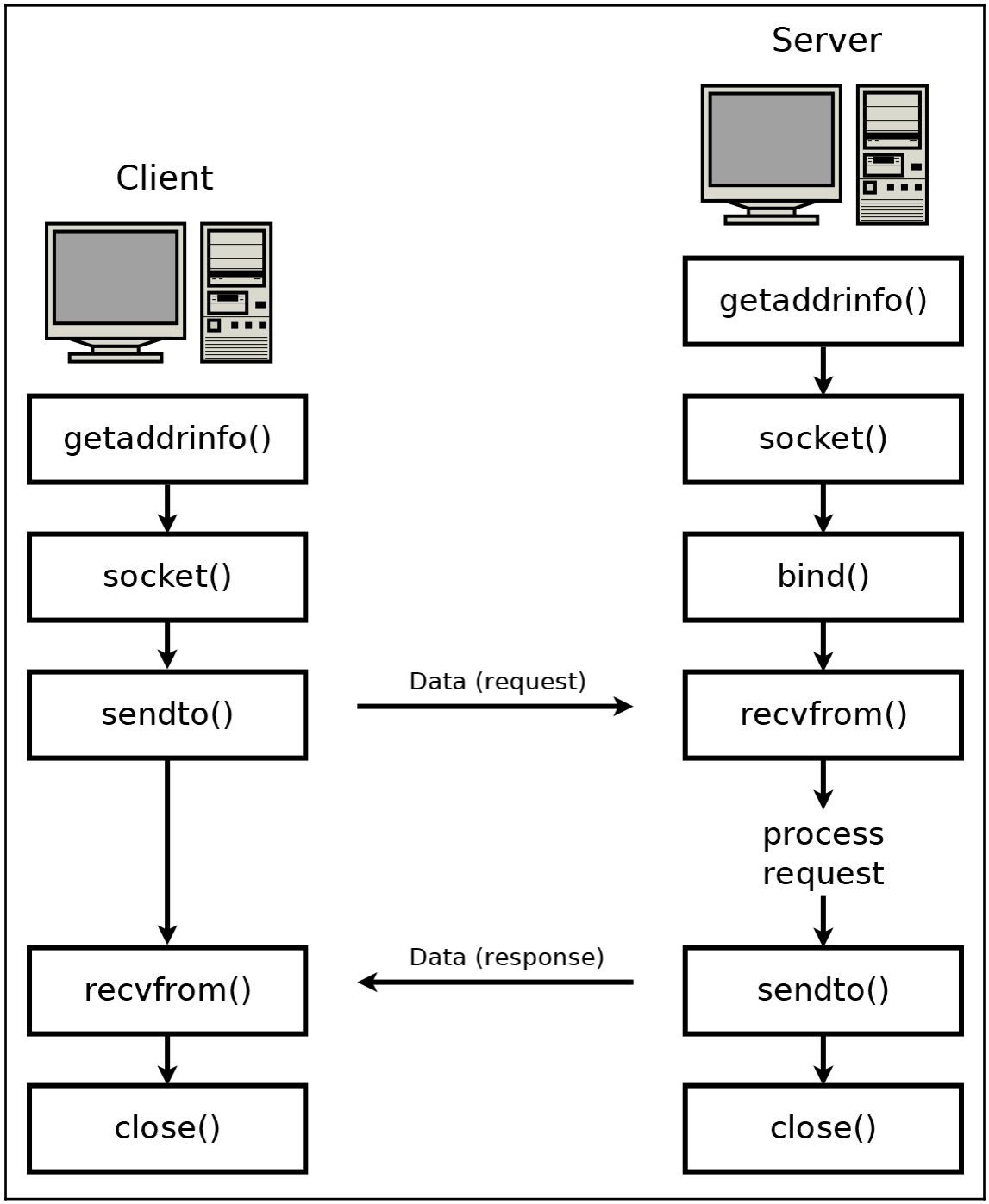

bob — bash — 80×20
Last login: Mon Sep 17 19:22:53 on ttys000
m1:~ honp$ ifconfig
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
options=3<RXCSUM,TXCSUM>
inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
inet 127.0.0.1 netmask 0xff000000
inet6 ::1 prefixlen 128
gif0: flags=8010<POINTOPOINT,MULTICAST> mtu 1280
stf0: flags=0<> mtu 1280
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=b<RXCSUM,TXCSUM,VLAN_HWTAGGING>
ether 00:0c:29:59:17:6f
inet6 fe80::20c:29ff:fe59:176f%en0 prefixlen 64 scopeid 0x4
inet 192.168.182.128 netmask 0xffffff00 broadcast 192.168.182.255
media: autoselect (1000baseT <full-duplex>)
status: active
m1:~ honp$

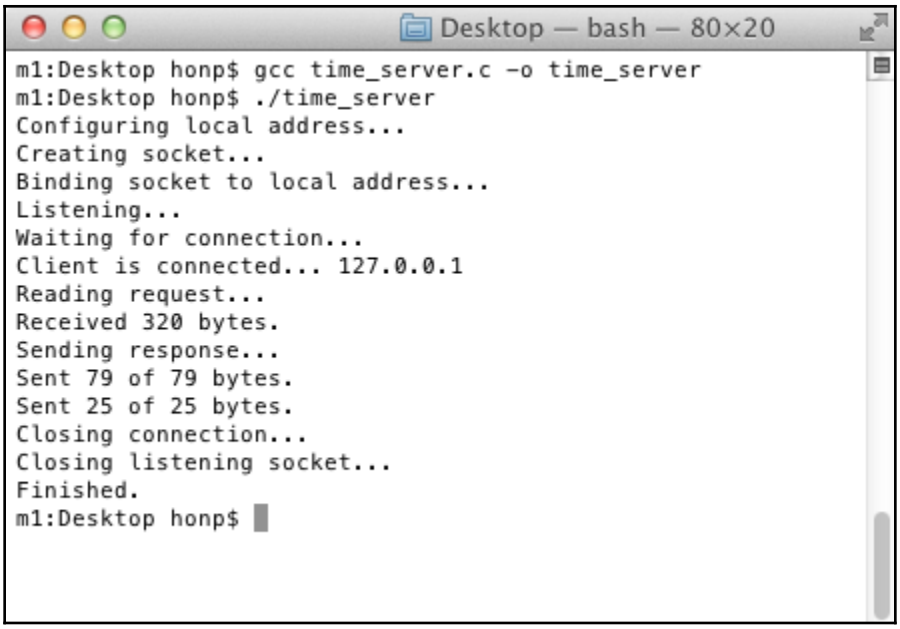

honp@ubby18: ~
honp@ubby18:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
inet 127.0.0.1/8 scope host lo
valid_lft forever preferred_lft forever
inet6 ::1/128 scope host
valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
link/ether 00:0c:29:74:ba:ce brd ff:ff:ff:ff:ff:ff
inet 192.168.182.145/24 brd 192.168.182.255 scope global dynamic noprefixroute ens33
valid_lft 1515sec preferred_lft 1515sec
inet6 fe80::df60:954e:211:7ff0/64 scope link noprefixroute
valid_lft forever preferred_lft forever
honp@ubby18:~$

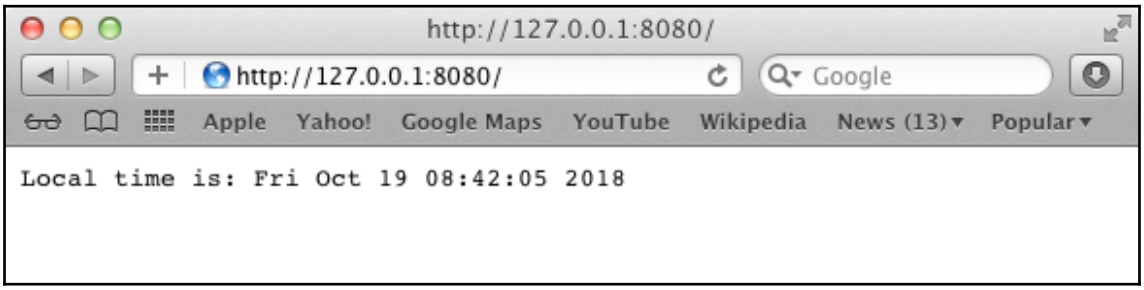

http://api.ipify.org/
http://api.ipify.org/
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (11)
Popular
107.77.85.86

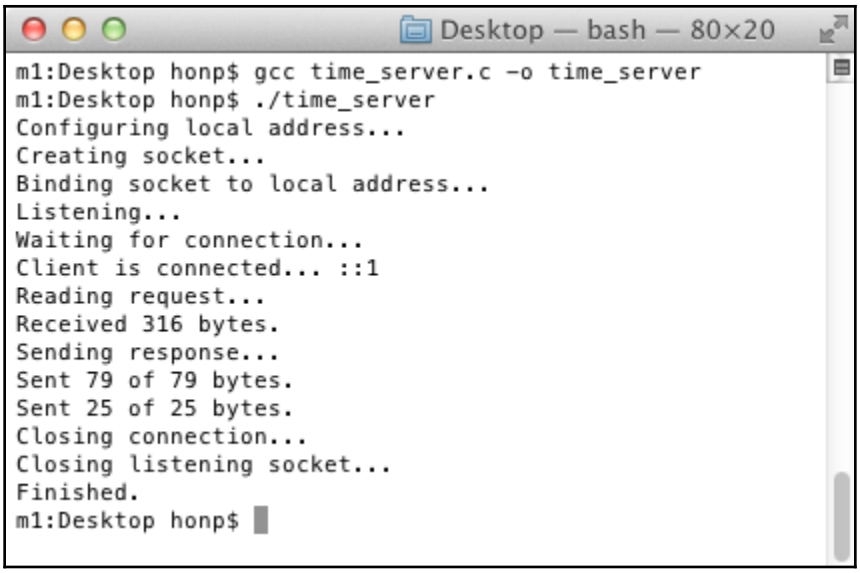
Chapter 2: Getting to Grips with Socket APIs

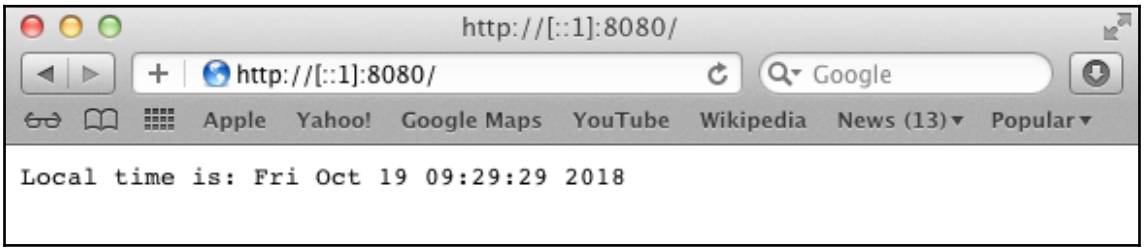


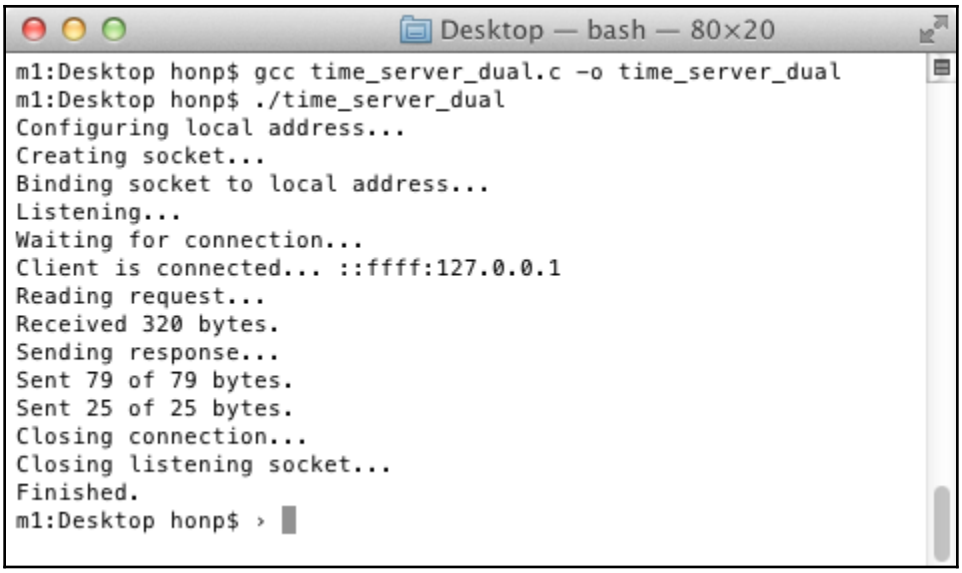

Server
Client
getaddrinfo()
socket()
bind()
recvfrom()
process request
sendto()
close()
getaddrinfo()
socket()
sendto()
recvfrom()
close()
Data (request)
Data (response)

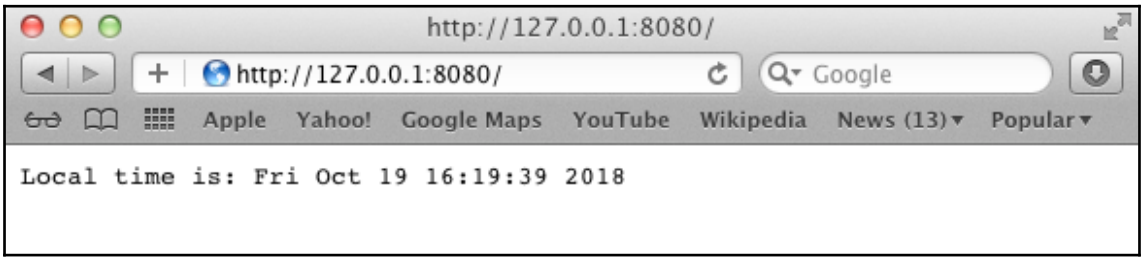

Desktop — bash — 80×20
m1:Desktop honp$ gcc time_server.c -o time_server
m1:Desktop honp$ ./time_server
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connection...
Client is connected... 127.0.0.1
Reading request...
Received 320 bytes.
Sending response...
Sent 79 of 79 bytes.
Sent 25 of 25 bytes.
Closing connection...
Closing listening socket...
Finished.
m1:Desktop honp$


http://127.0.0.1:8080/
http://127.0.0.1:8080/
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (13)
Popular
Local time is: Fri Oct 19 08:42:05 2018

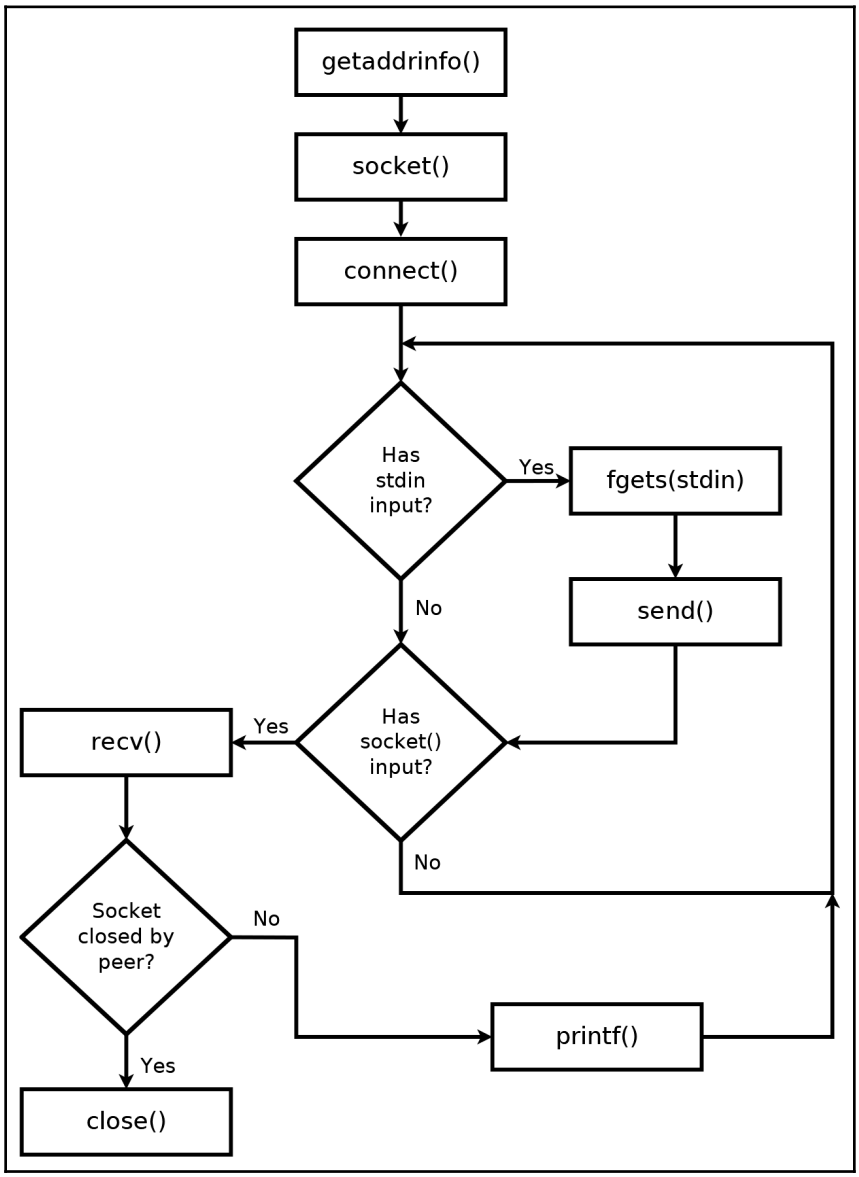

Desktop — bash — 80×20
m1:Desktop honp$ gcc time_server.c -o time_server
m1:Desktop honp$ ./time_server
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connection...
Client is connected... ::1
Reading request...
Received 316 bytes.
Sending response...
Sent 79 of 79 bytes.
Sent 25 of 25 bytes.
Closing connection...
Closing listening socket...
Finished.
m1:Desktop honp$


http://[::1]:8080/
http://[::1]:8080/
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (13)
Popular
Local time is: Fri Oct 19 09:29:29 2018

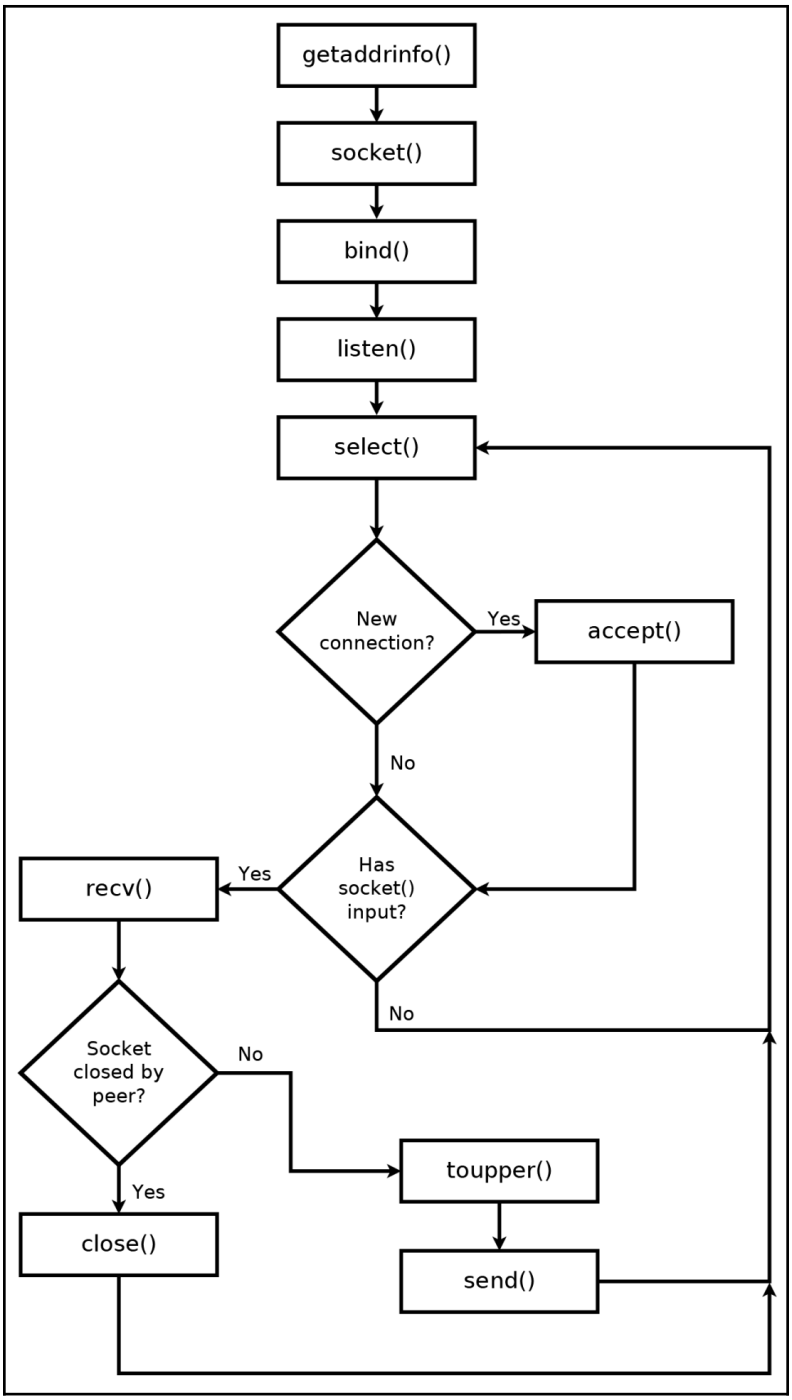

Desktop — bash — 80×20
m1:Desktop honp$ gcc time_server_dual.c -o time_server_dual
m1:Desktop honp$ ./time_server_dual
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connection...
Client is connected... ::ffff:127.0.0.1
Reading request...
Received 320 bytes.
Sending response...
Sent 79 of 79 bytes.
Sent 25 of 25 bytes.
Closing connection...
Closing listening socket...
Finished.
m1:Desktop honp$

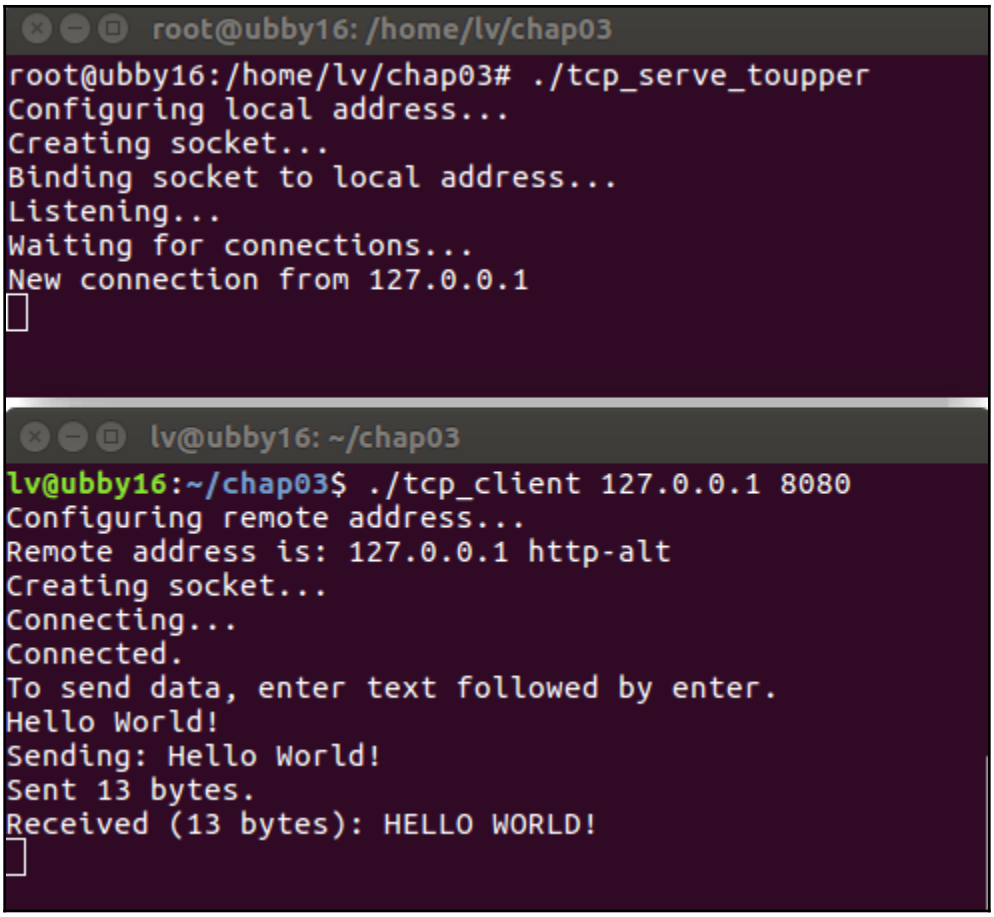

http://127.0.0.1:8080/
http://127.0.0.1:8080/
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (13)
Popular
Local time is: Fri Oct 19 16:19:39 2018

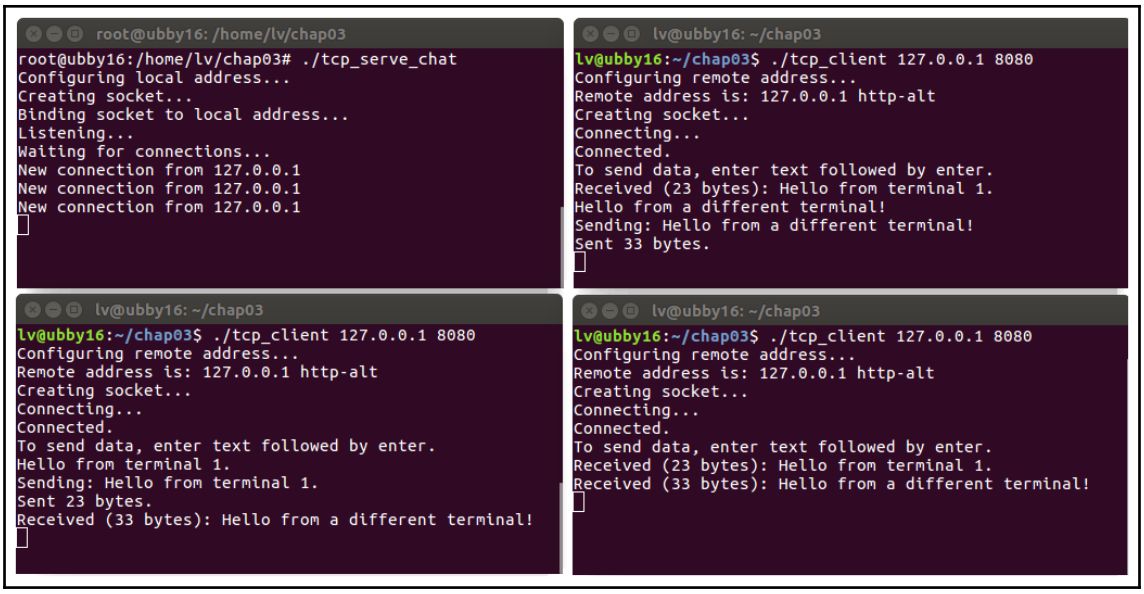
Chapter 3: An In-Depth Overview of TCP Connections



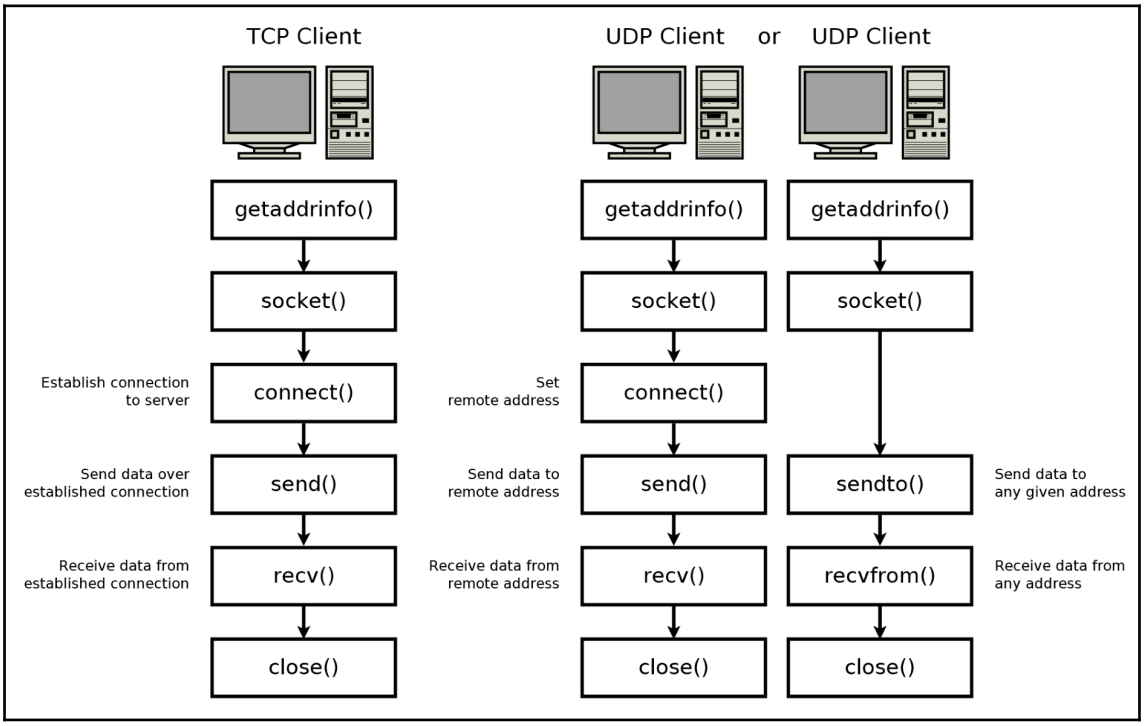
```
root@ubby16: /home/lv/chap03
root@ubby16:/home/lv/chap03# ./tcp_client example.com http
Configuring remote address...
Remote address is: 93.184.216.34 http
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
GET / HTTP/1.1
Sending: GET / HTTP/1.1
Sent 15 bytes.
Host: example.com
Sending: Host: example.com
Sent 18 bytes.

Sending:
Sent 1 bytes.
Received (1592 bytes): HTTP/1.1 200 OK
Cache-Control: max-age=604800
Content-Type: text/html; charset=UTF-8
Date: Tue, 30 Oct 2018 19:59:46 GMT
Etag: "1541025663+ident"
Expires: Tue, 06 Nov 2018 19:59:46 GMT
Last-Modified: Fri, 09 Aug 2013 23:54:35 GMT
Server: ECS (ord/4CD5)
Vary: Accept-Encoding
X-Cache: HIT
Content-Length: 1270

<!doctype html>
<html>
<head>
    <title>Example Domain</title>

    <meta charset="utf-8" />
    <meta http-equiv="Content-type" content="text/html; charset=utf-8" />
    <meta name="viewport" content="width=device-width, initial-scale=1" />
    <style type="text/css">
    body {
        background-color: #f0f0f2;
        margin: 0;
        padding: 0;
        font-family: "Open Sans", "Helvetica Neue", Helvetica, Arial, sans
-serif;

    }
```

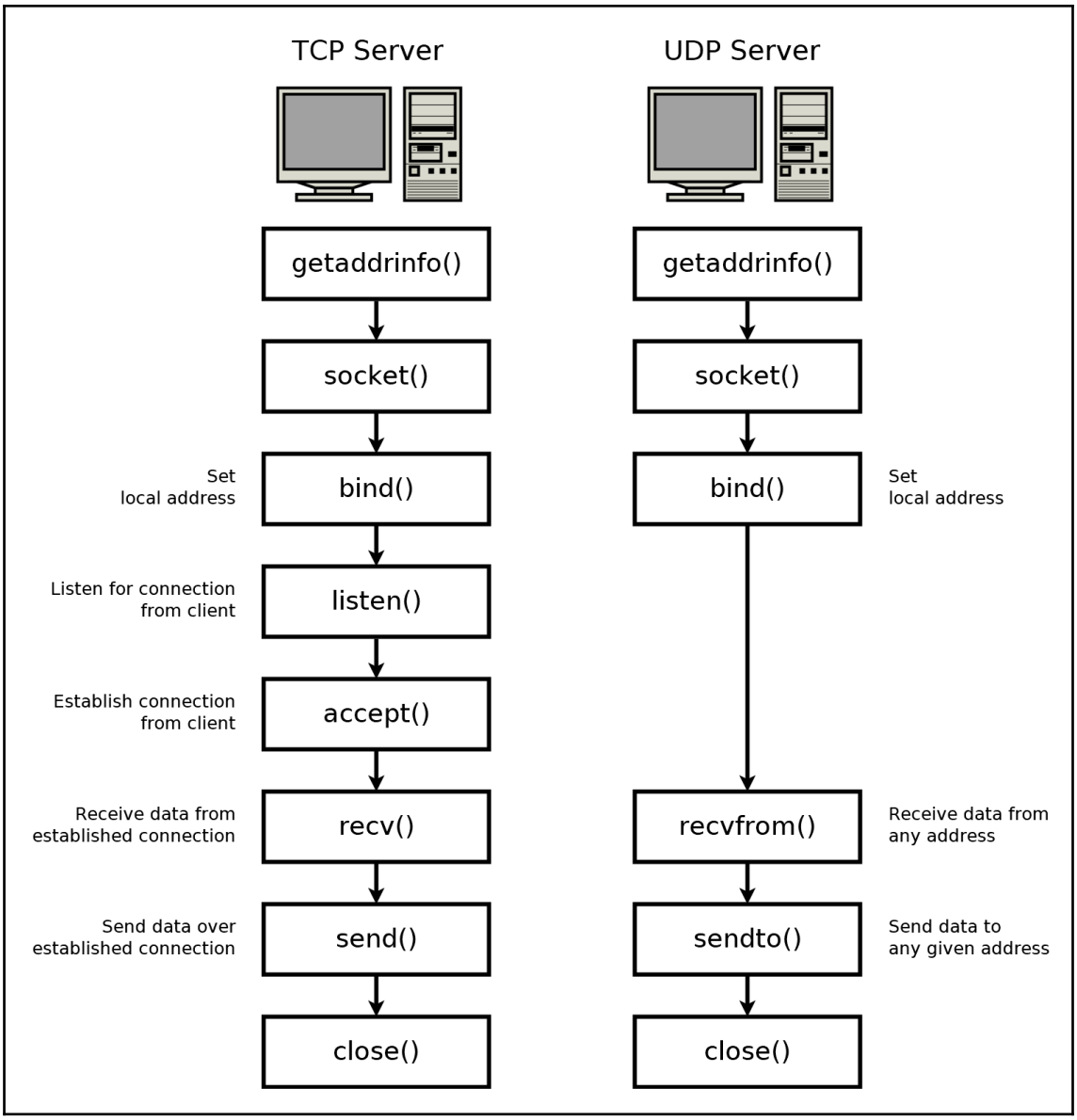

getaddrinfo()
socket()
bind()
listen()
select()
New connection?
Yes
accept()
No
Has socket() input?
Yes
recv()
No
Socket closed by peer?
No
toupper()
Yes
close()
send()

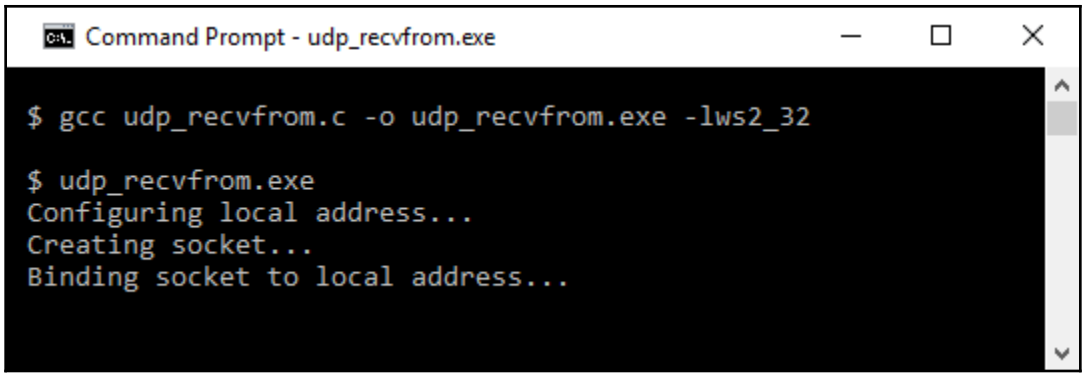

root@ubby16: /home/lv/chap03
root@ubby16:/home/lv/chap03# ./tcp_serve_toupper
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connections...
New connection from 127.0.0.1
lv@ubby16: ~/chap03
lv@ubby16:~/chap03$ ./tcp_client 127.0.0.1 8080
Configuring remote address...
Remote address is: 127.0.0.1 http-alt
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
Hello World!
Sending: Hello World!
Sent 13 bytes.
Received (13 bytes): HELLO WORLD!

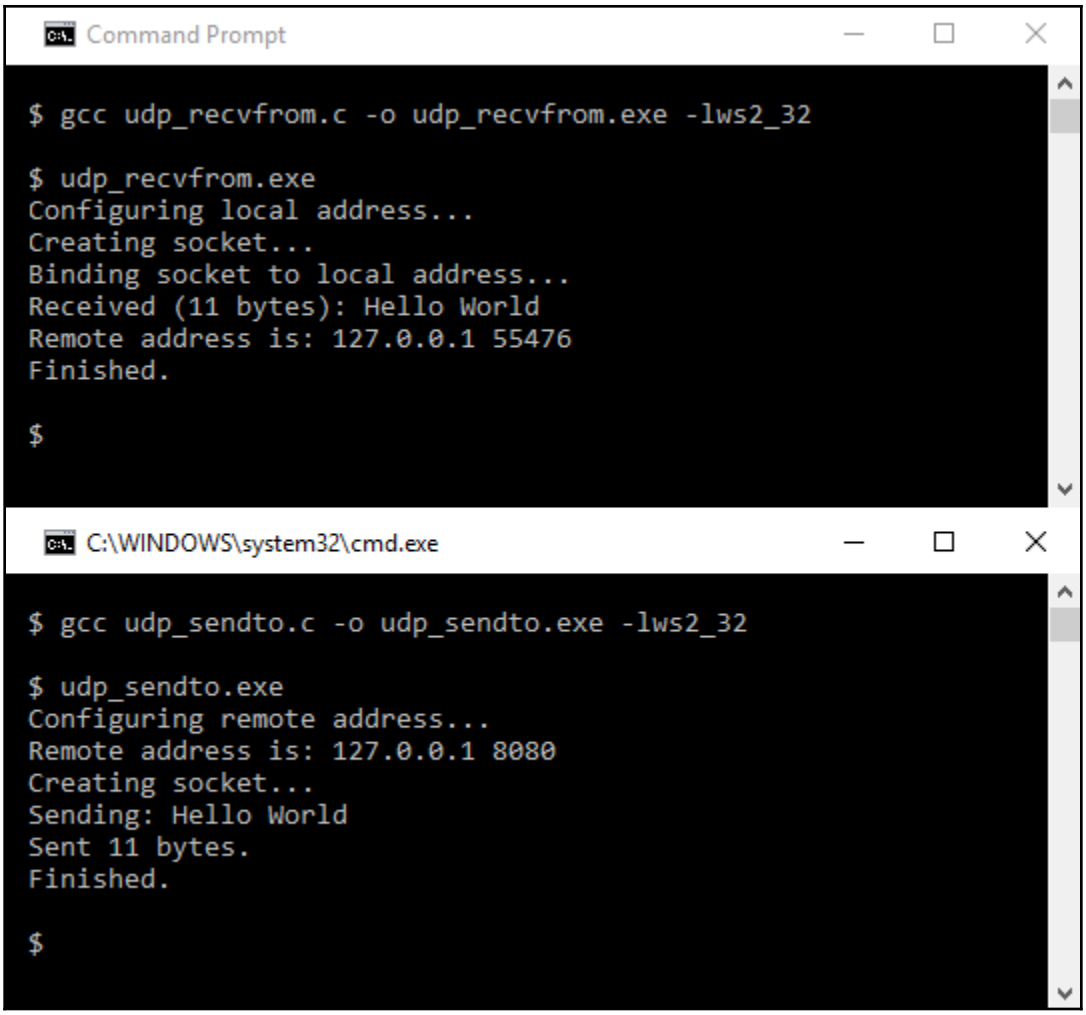

root@ubby16: /home/lv/chap03
root@ubby16:/home/lv/chap03# ./tcp_serve_chat
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connections...
New connection from 127.0.0.1
New connection from 127.0.0.1
New connection from 127.0.0.1
lv@ubby16: ~/chap03
lv@ubby16:~/chap03$ ./tcp_client 127.0.0.1 8080
Configuring remote address...
Remote address is: 127.0.0.1 http-alt
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
Received (23 bytes): Hello from terminal 1.
Hello from a different terminal!
Sending: Hello from a different terminal!
Sent 33 bytes.
lv@ubby16: ~/chap03
lv@ubby16:~/chap03$ ./tcp_client 127.0.0.1 8080
Configuring remote address...
Remote address is: 127.0.0.1 http-alt
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
Hello from terminal 1.
Sending: Hello from terminal 1.
Sent 23 bytes.
Received (33 bytes): Hello from a different terminal!
lv@ubby16: ~/chap03
lv@ubby16:~/chap03$ ./tcp_client 127.0.0.1 8080
Configuring remote address...
Remote address is: 127.0.0.1 http-alt
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
Received (23 bytes): Hello from terminal 1.
Received (33 bytes): Hello from a different terminal!

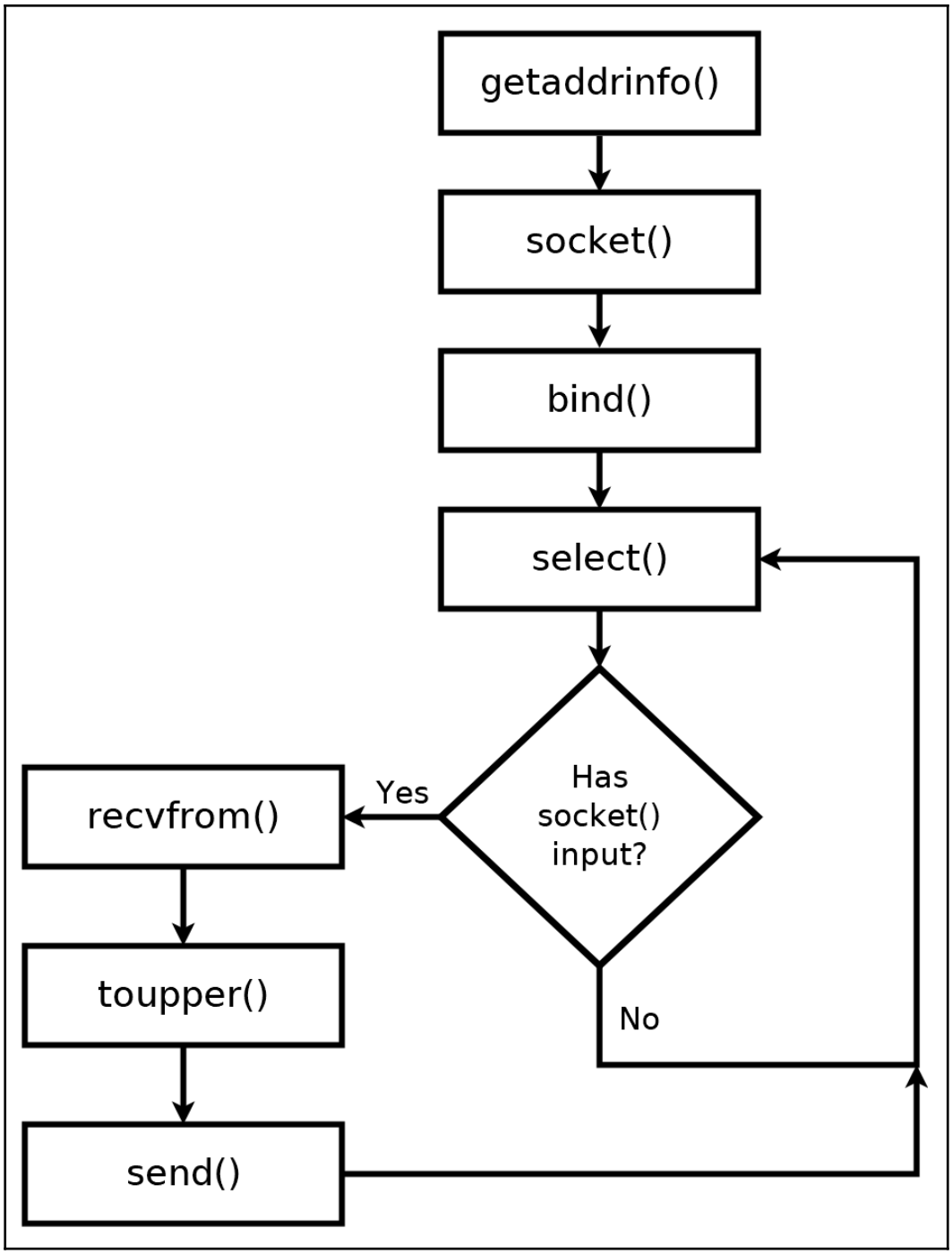
Chapter 4: Establishing UDP Connections

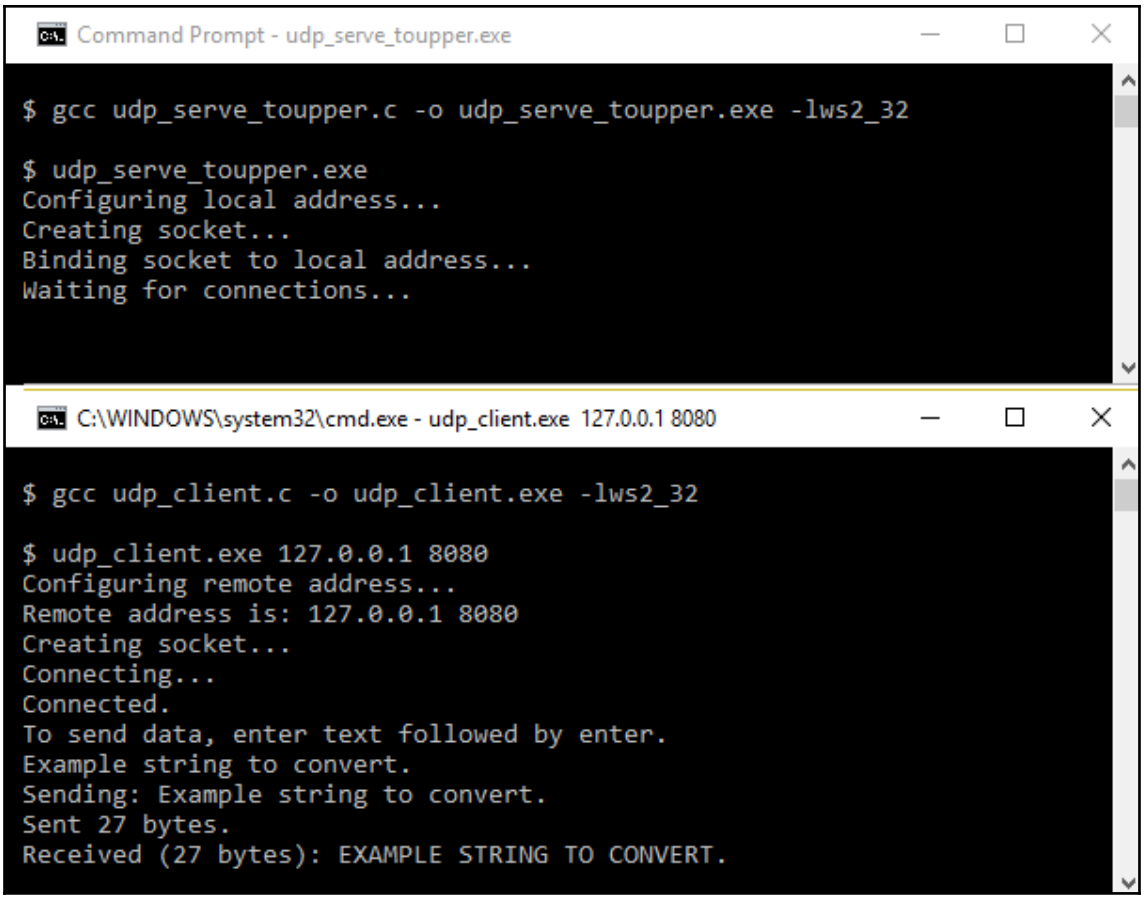



TCP Server
UDP Server
getaddrinfo()
socket()
Set
local address
bind()
Listen for connection
from client
listen()
Establish connection
from client
accept()
Receive data from
established connection
recv()
Send data over
established connection
send()
close()
getaddrinfo()
socket()
bind()
Set
local address
recvfrom()
Receive data from
any address
sendto()
Send data to
any given address
close()

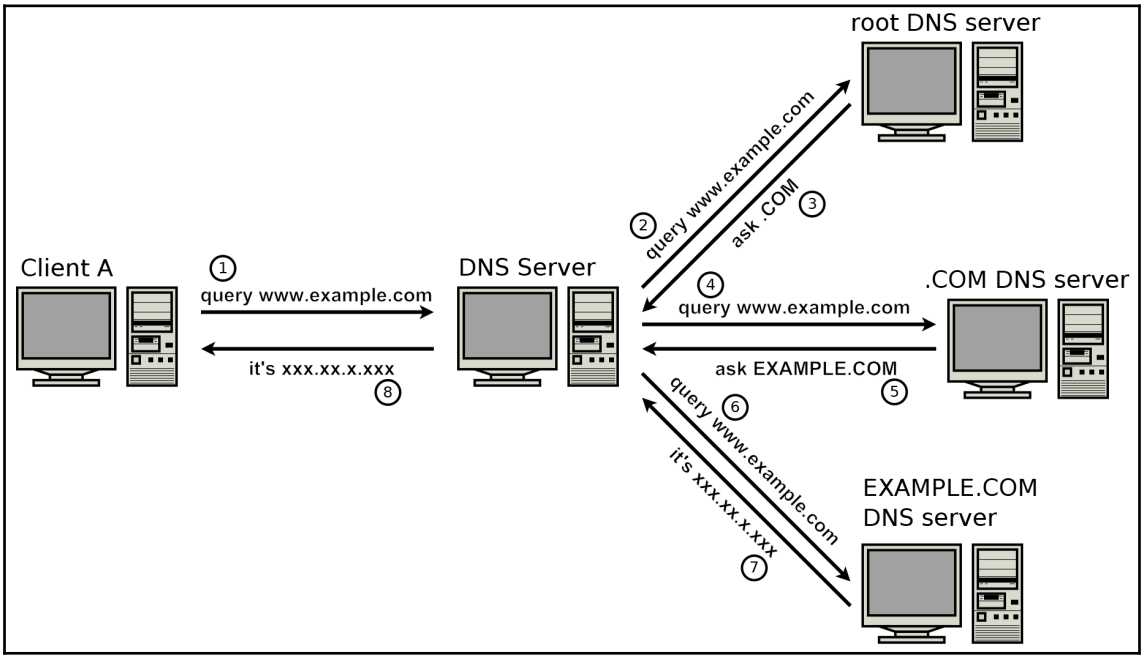

Command Prompt - udp_recvfrom.exe
$ gcc udp_recvfrom.c -o udp_recvfrom.exe -lws2_32
$ udp_recvfrom.exe
Configuring local address...
Creating socket...
Binding socket to local address...

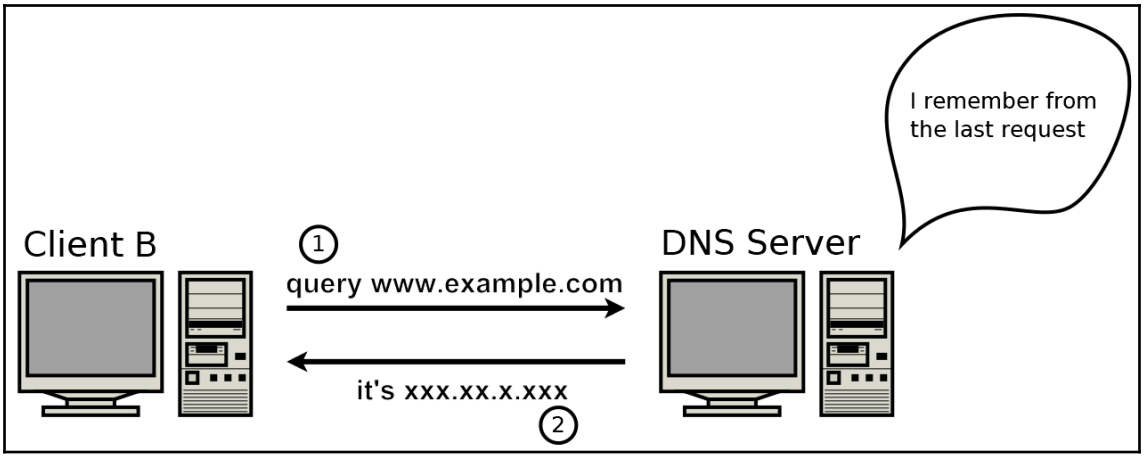

Command Prompt
$ gcc udp_recvfrom.c -o udp_recvfrom.exe -lws2_32
$ udp_recvfrom.exe
Configuring local address...
Creating socket...
Binding socket to local address...
Received (11 bytes): Hello World
Remote address is: 127.0.0.1 55476
Finished.
$
C:\WINDOWS\system32\cmd.exe
$ gcc udp_sendto.c -o udp_sendto.exe -lws2_32
$ udp_sendto.exe
Configuring remote address...
Remote address is: 127.0.0.1 8080
Creating socket...
Sending: Hello World
Sent 11 bytes.
Finished.
$


getaddrinfo()
socket()
bind()
select()
Has socket() input?
Yes
recvfrom()
toupper()
send()
No

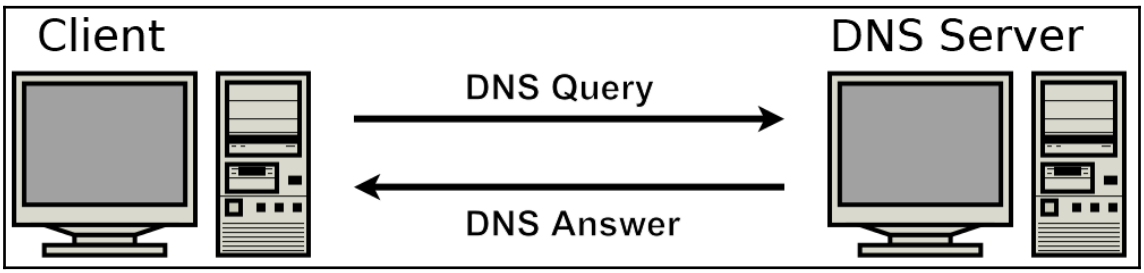

Command Prompt - udp_serve_toupper.exe
$ gcc udp_serve_toupper.c -o udp_serve_toupper.exe -lws2_32
$ udp_serve_toupper.exe
Configuring local address...
Creating socket...
Binding socket to local address...
Waiting for connections...
C:\WINDOWS\system32\cmd.exe - udp_client.exe 127.0.0.1 8080
$ gcc udp_client.c -o udp_client.exe -lws2_32
$ udp_client.exe 127.0.0.1 8080
Configuring remote address...
Remote address is: 127.0.0.1 8080
Creating socket...
Connecting...
Connected.
To send data, enter text followed by enter.
Example string to convert.
Sending: Example string to convert.
Sent 27 bytes.
Received (27 bytes): EXAMPLE STRING TO CONVERT.

Chapter 5: Hostname Resolution and DNS





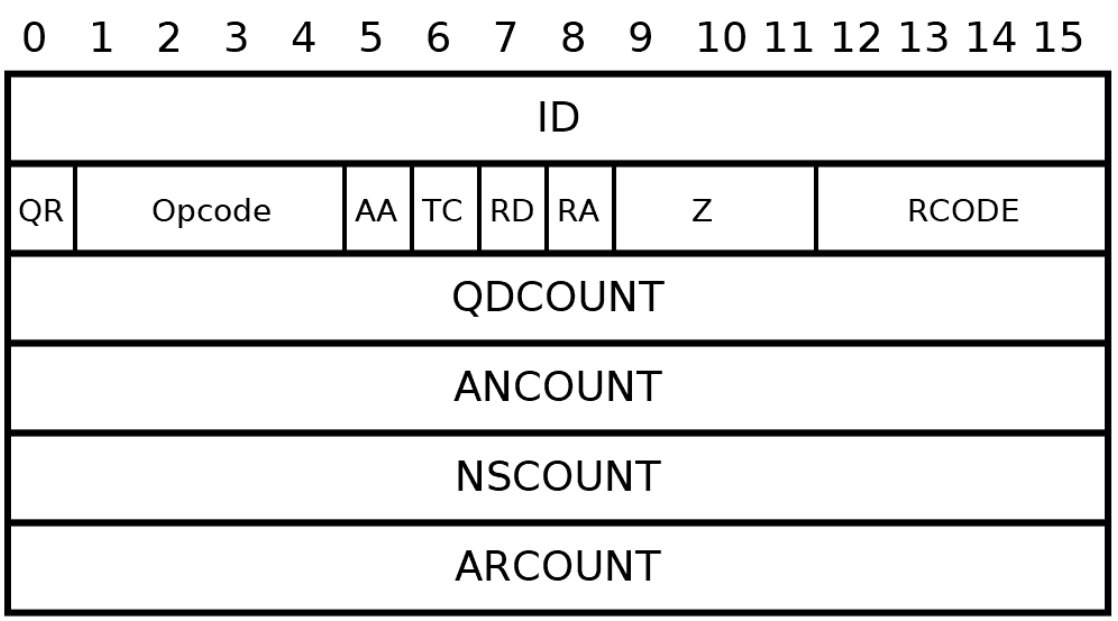
```
Command Prompt

$ gcc lookup.c -o lookup.exe -lws2_32

$ lookup example.com
Resolving hostname 'example.com'
Remote address is:
        93.184.216.34
        2606:2800:220:1:248:1893:25c8:1946

$
```



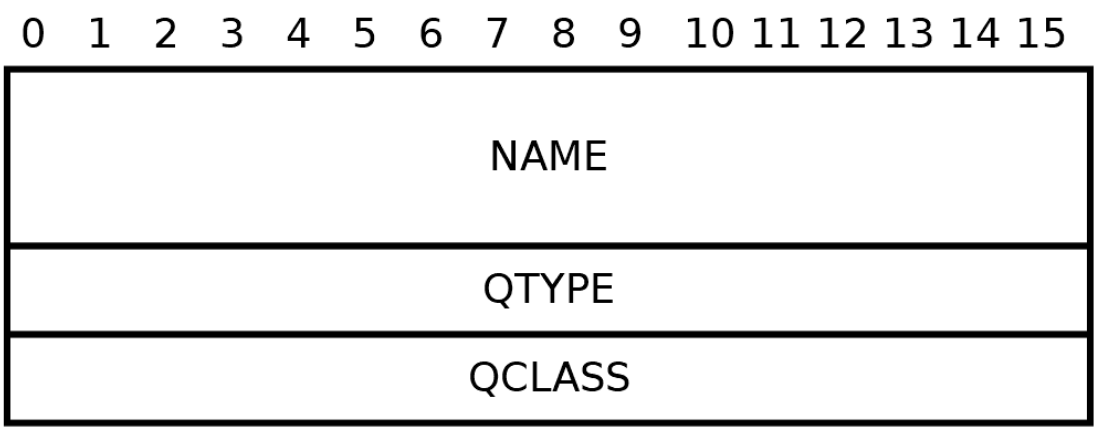
DNS Message Format

Header	Information about the message
Question	Question for the name server
Answer	Answer(s) to the question
Authority	Pointers to other name servers
Additional	Additional information

Header Format

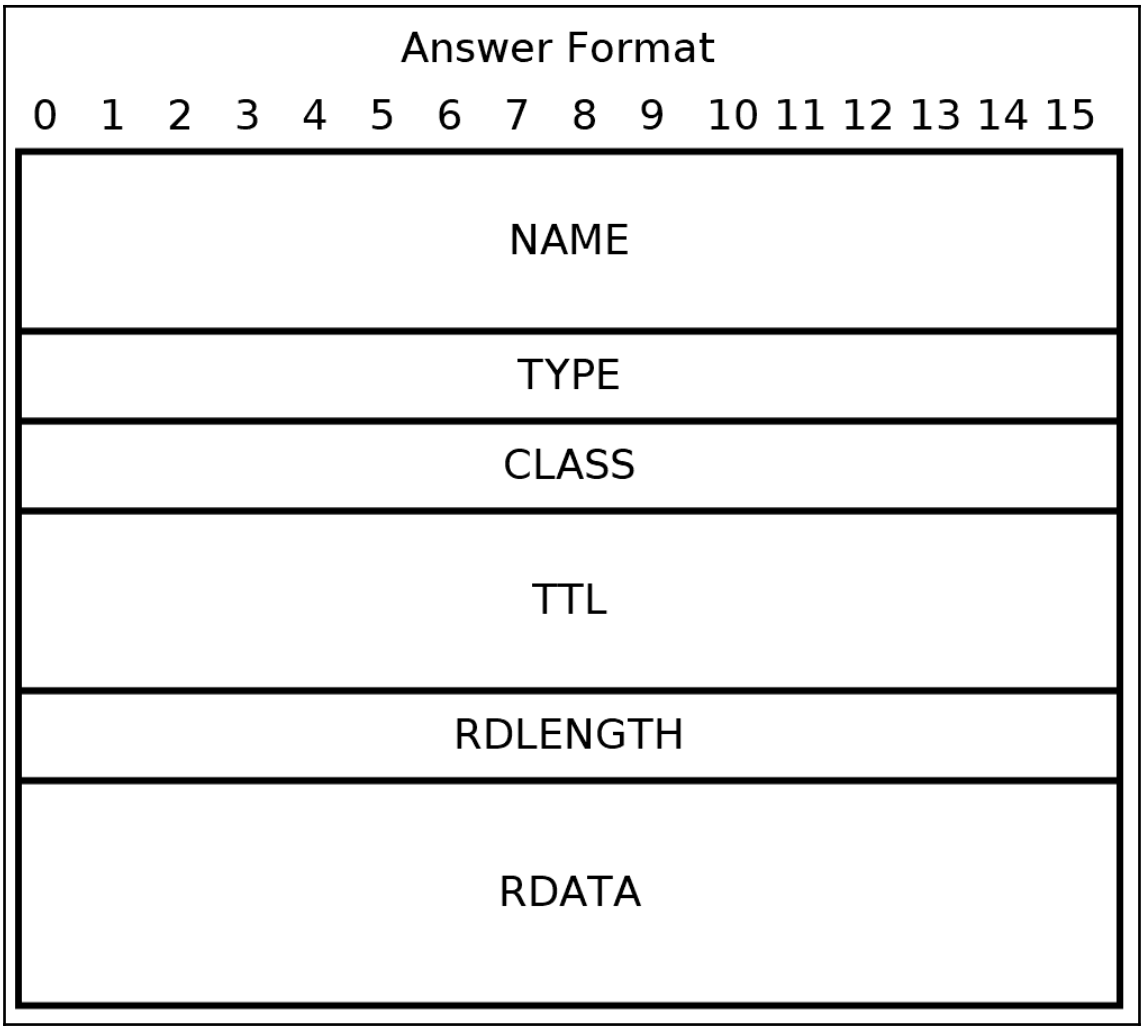


Question Format

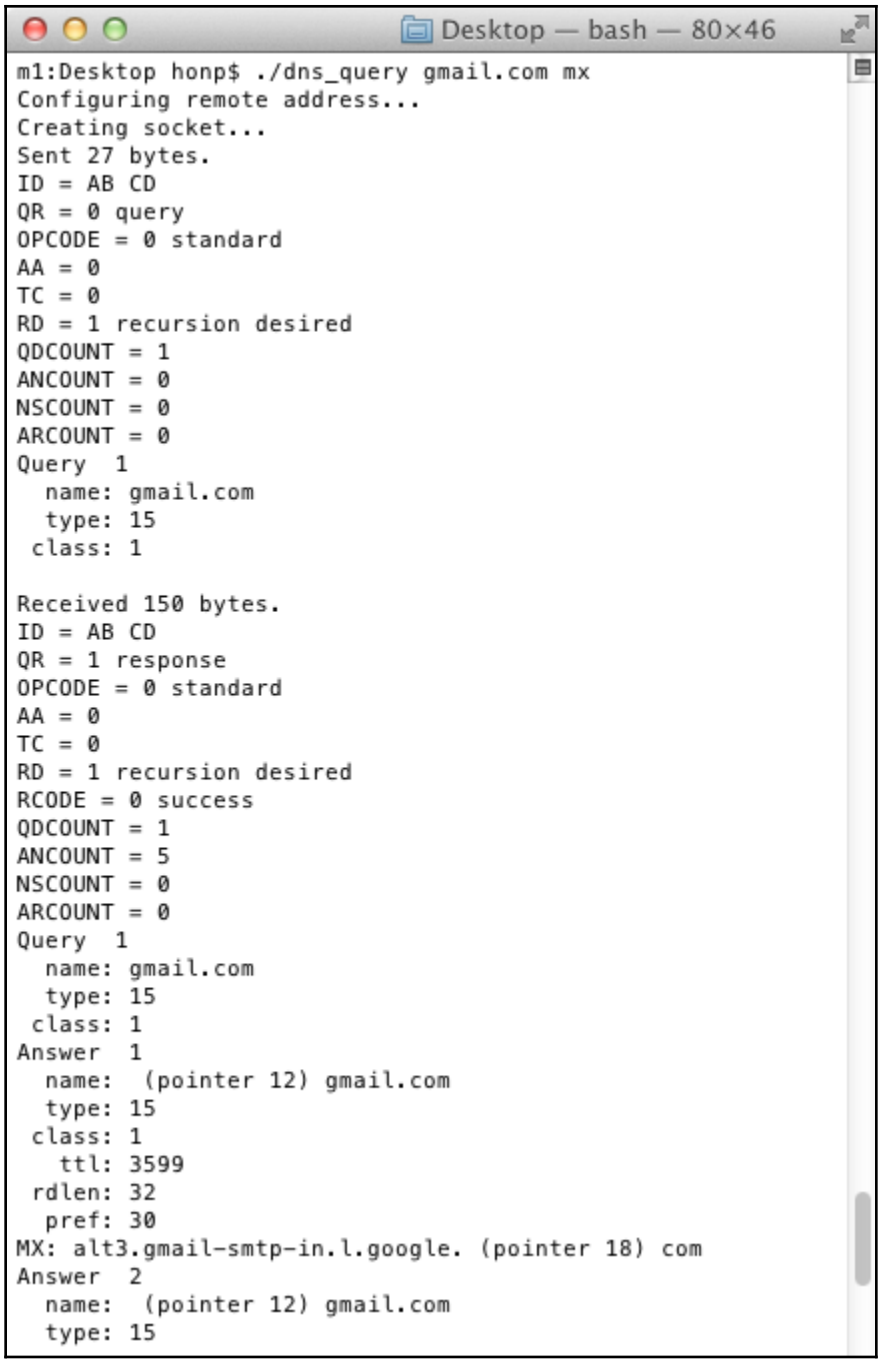


Name Example

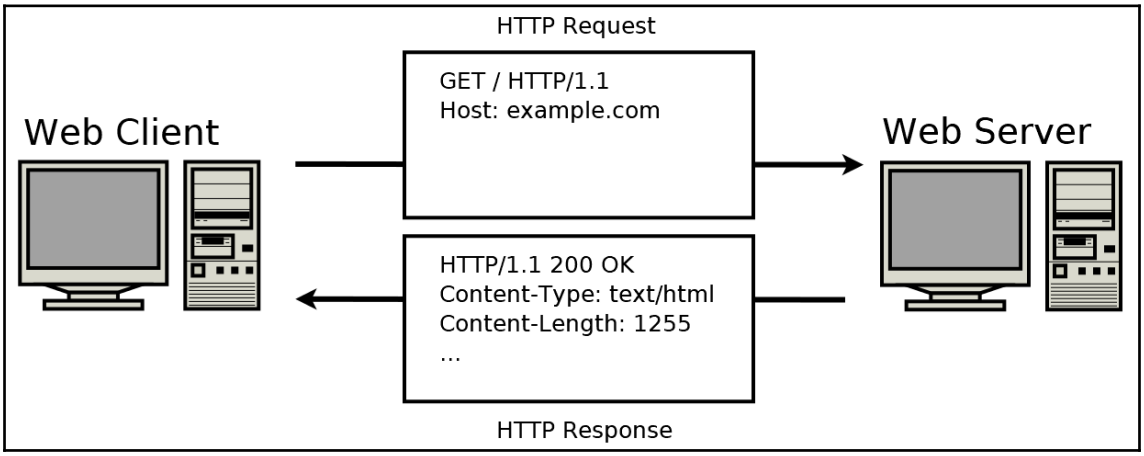
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3								'w'							
'w'								'w'							
7								'e'							
'x'								'a'							
'm'								'p'							
'l'								'e'							
3								'c'							
'o'								'm'							
0															

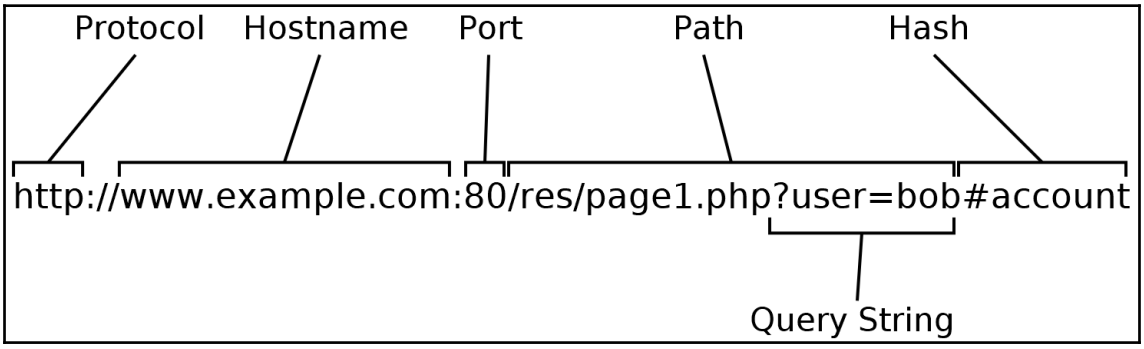

Answer Format
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
NAME
TYPE
CLASS
TTL
RDLENGTH
RDATA

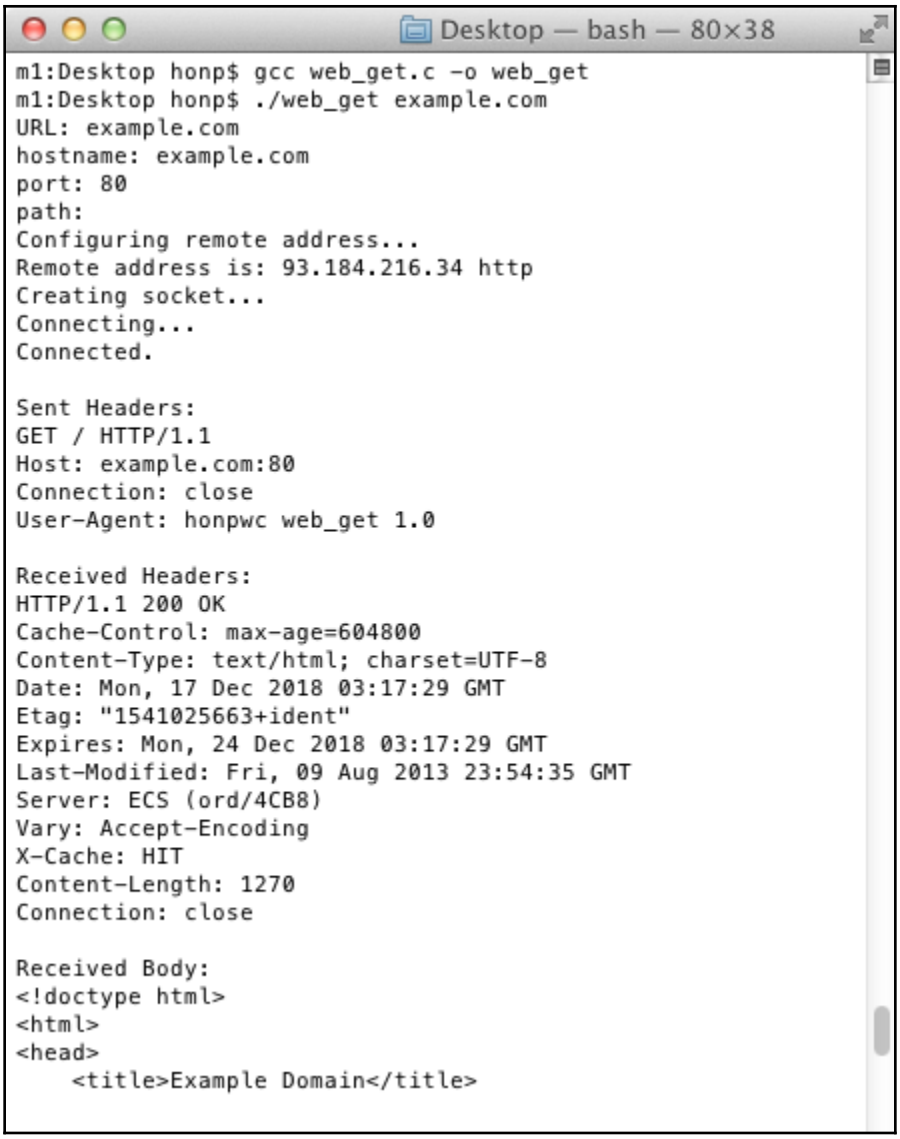

Desktop — bash — 80×46
m1:Desktop honp$ gcc dns_query.c -o dns_query
m1:Desktop honp$ ./dns_query example.com a
Configuring remote address...
Creating socket...
Sent 29 bytes.
ID = AB CD
QR = 0 query
OPCODE = 0 standard
AA = 0
TC = 0
RD = 1 recursion desired
QDCOUNT = 1
ANCOUNT = 0
NSCOUNT = 0
ARCOUNT = 0
Query 1
  name: example.com
  type: 1
 class: 1
Received 45 bytes.
ID = AB CD
QR = 1 response
OPCODE = 0 standard
AA = 0
TC = 0
RD = 1 recursion desired
RCODE = 0 success
QDCOUNT = 1
ANCOUNT = 1
NSCOUNT = 0
ARCOUNT = 0
Query 1
  name: example.com
  type: 1
 class: 1
Answer 1
  name: (pointer 12) example.com
  type: 1
 class: 1
   ttl: 20576
 rdlen: 4
Address 93.184.216.34
m1:Desktop honp$


Desktop — bash — 80×46
m1:Desktop honp$ ./dns_query gmail.com mx
Configuring remote address...
Creating socket...
Sent 27 bytes.
ID = AB CD
QR = 0 query
OPCODE = 0 standard
AA = 0
TC = 0
RD = 1 recursion desired
QDCOUNT = 1
ANCOUNT = 0
NSCOUNT = 0
ARCOUNT = 0
Query 1
  name: gmail.com
  type: 15
 class: 1
Received 150 bytes.
ID = AB CD
QR = 1 response
OPCODE = 0 standard
AA = 0
TC = 0
RD = 1 recursion desired
RCODE = 0 success
QDCOUNT = 1
ANCOUNT = 5
NSCOUNT = 0
ARCOUNT = 0
Query 1
  name: gmail.com
  type: 15
 class: 1
Answer 1
  name: (pointer 12) gmail.com
  type: 15
 class: 1
   ttl: 3599
 rdlen: 32
  pref: 30
MX: alt3.gmail-smtp-in.l.google. (pointer 18) com
Answer 2
  name: (pointer 12) gmail.com
  type: 15

Chapter 6: Building a Simple Web Client

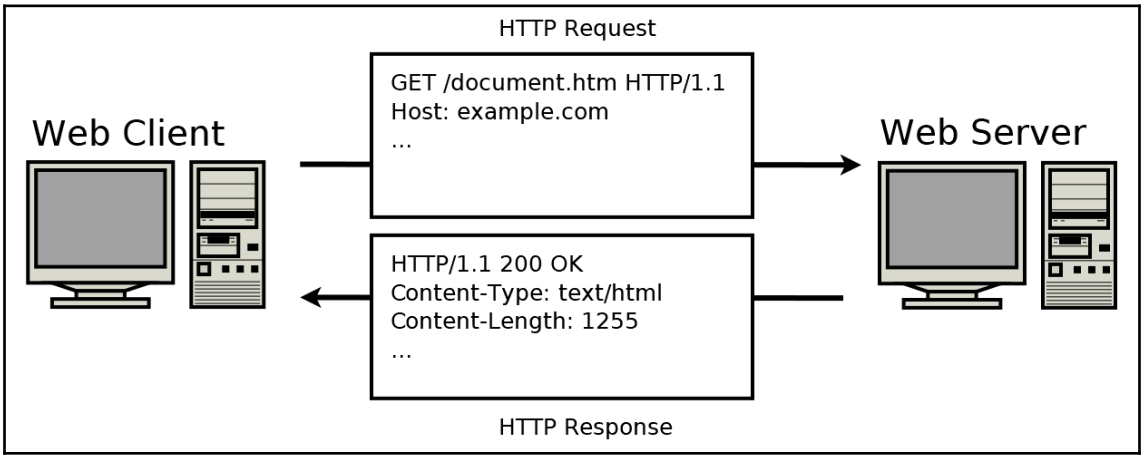





Desktop — bash — 80×38
m1:Desktop honp$ gcc web_get.c -o web_get
m1:Desktop honp$ ./web_get example.com
URL: example.com
hostname: example.com
port: 80
path:
Configuring remote address...
Remote address is: 93.184.216.34 http
Creating socket...
Connecting...
Connected.
Sent Headers:
GET / HTTP/1.1
Host: example.com:80
Connection: close
User-Agent: honpwc web_get 1.0
Received Headers:
HTTP/1.1 200 OK
Cache-Control: max-age=604800
Content-Type: text/html; charset=UTF-8
Date: Mon, 17 Dec 2018 03:17:29 GMT
Etag: "1541025663+ident"
Expires: Mon, 24 Dec 2018 03:17:29 GMT
Last-Modified: Fri, 09 Aug 2013 23:54:35 GMT
Server: ECS (ord/4CB8)
Vary: Accept-Encoding
X-Cache: HIT
Content-Length: 1270
Connection: close
Received Body:
<!doctype html>
<html>
<head>
<title>Example Domain</title>


Example Form
http://127.0.0.1:8080/form.html
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (13)
Popular
Example Form
You can fill out this form to make a POST request.
Name:
Alice
Comment:
Well Done!
submit

Chapter 7: Building a Simple Web Server

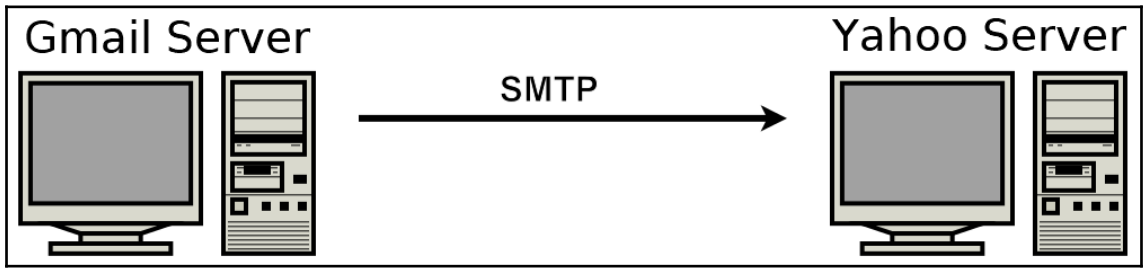


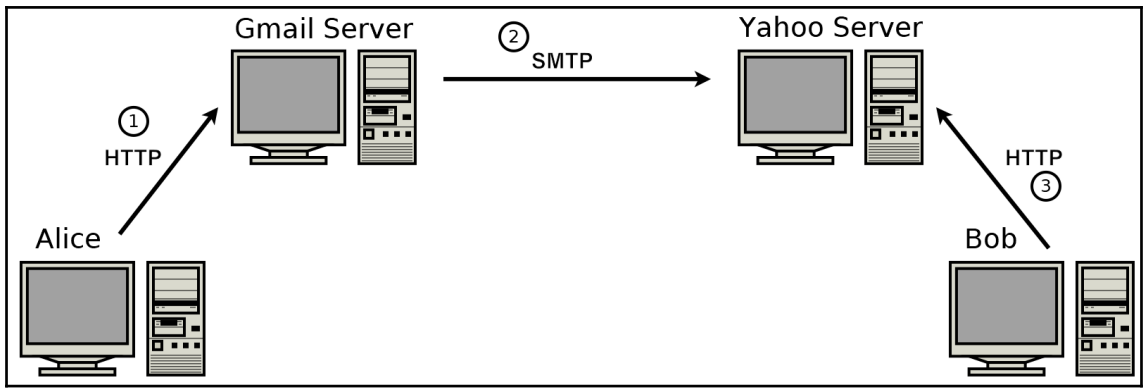

```
chap07 — bash — 80×15
m1:chap07 honp$ file --mime-type public/index.html
public/index.html: text/html
m1:chap07 honp$ file --mime-type public/smile.png
public/smile.png: image/png
m1:chap07 honp$ file --mime-type public/test.txt
public/test.txt: text/plain
m1:chap07 honp$
```

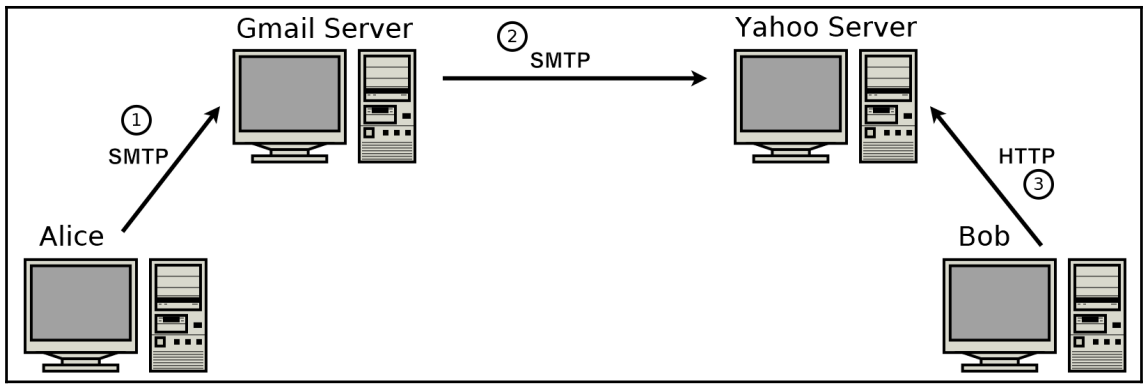
```
chap07 — web_server — 80×15
m1:chap07 honp$ gcc web_server.c -o web_server
m1:chap07 honp$ ./web_server
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
New connection from 127.0.0.1.
serve_resource 127.0.0.1 /index.html
New connection from 127.0.0.1.
serve_resource 127.0.0.1 /smile.png
```

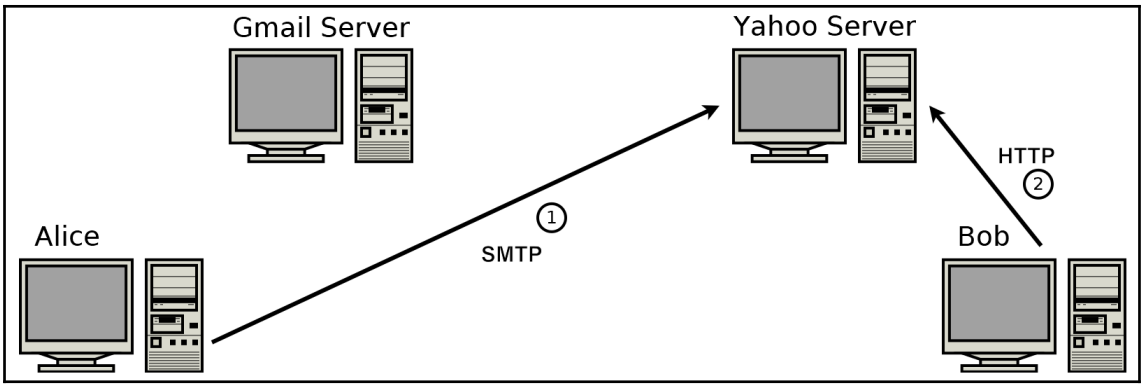

Example Page
http://127.0.0.1:8080/
Google
Apple
Yahoo!
Google Maps
YouTube
Wikipedia
News (13)
Popular
Example Page
This page is only an example.
Click here to see another page, or click here to download a text file.

Chapter 8: Making Your Program Send Email

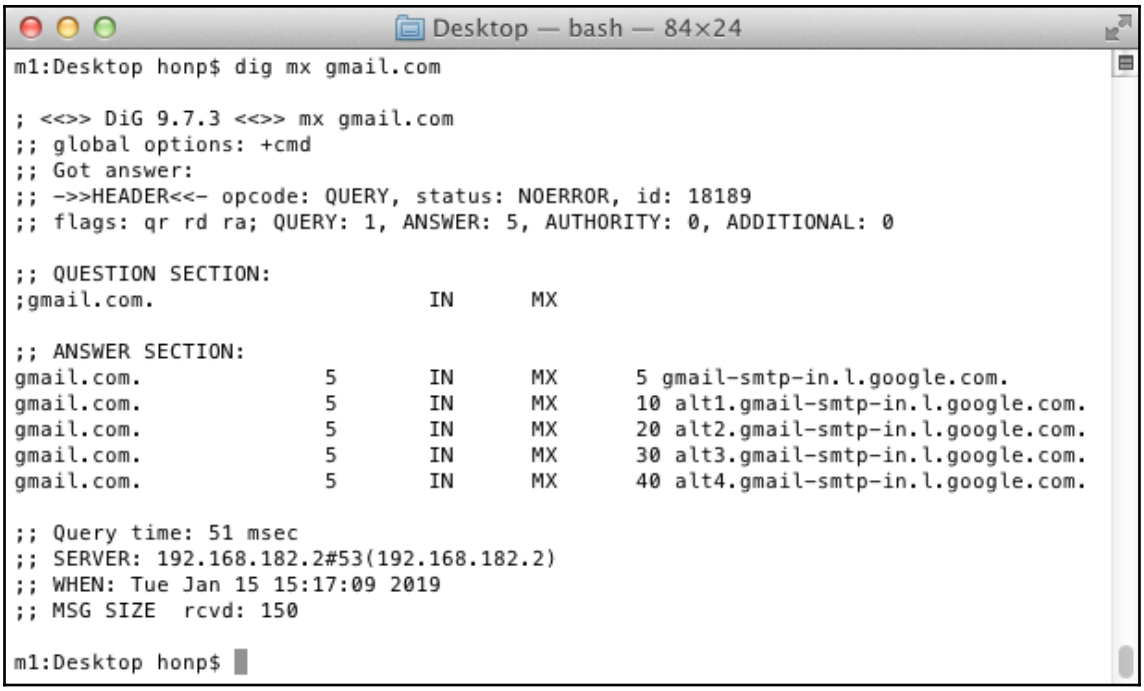


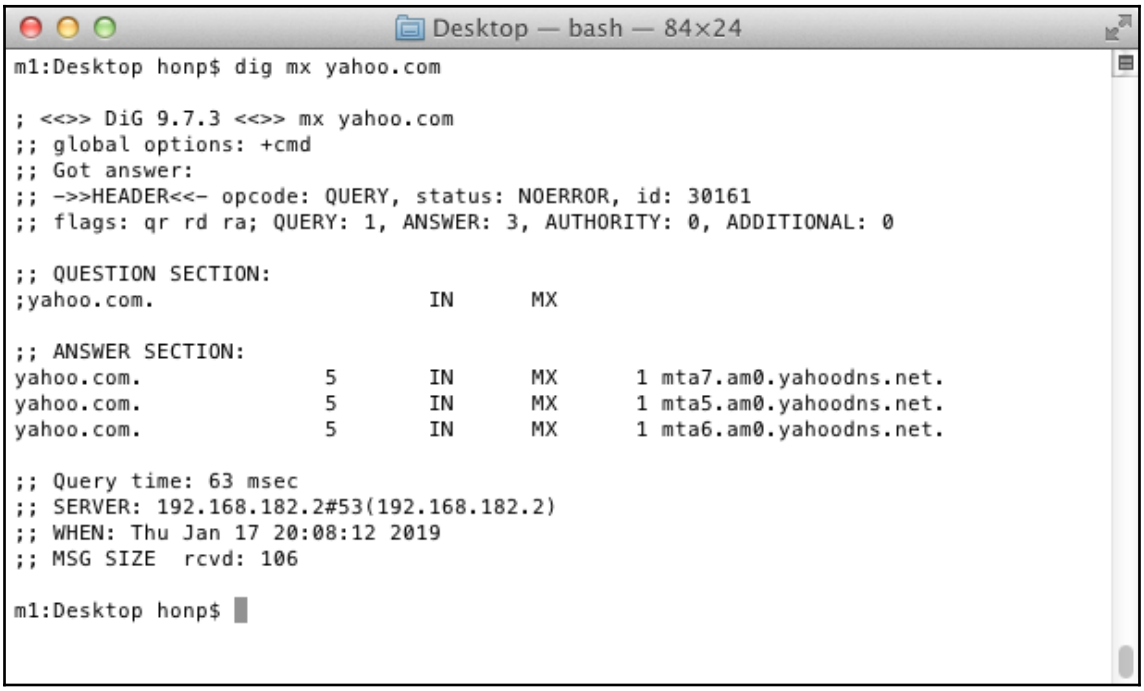


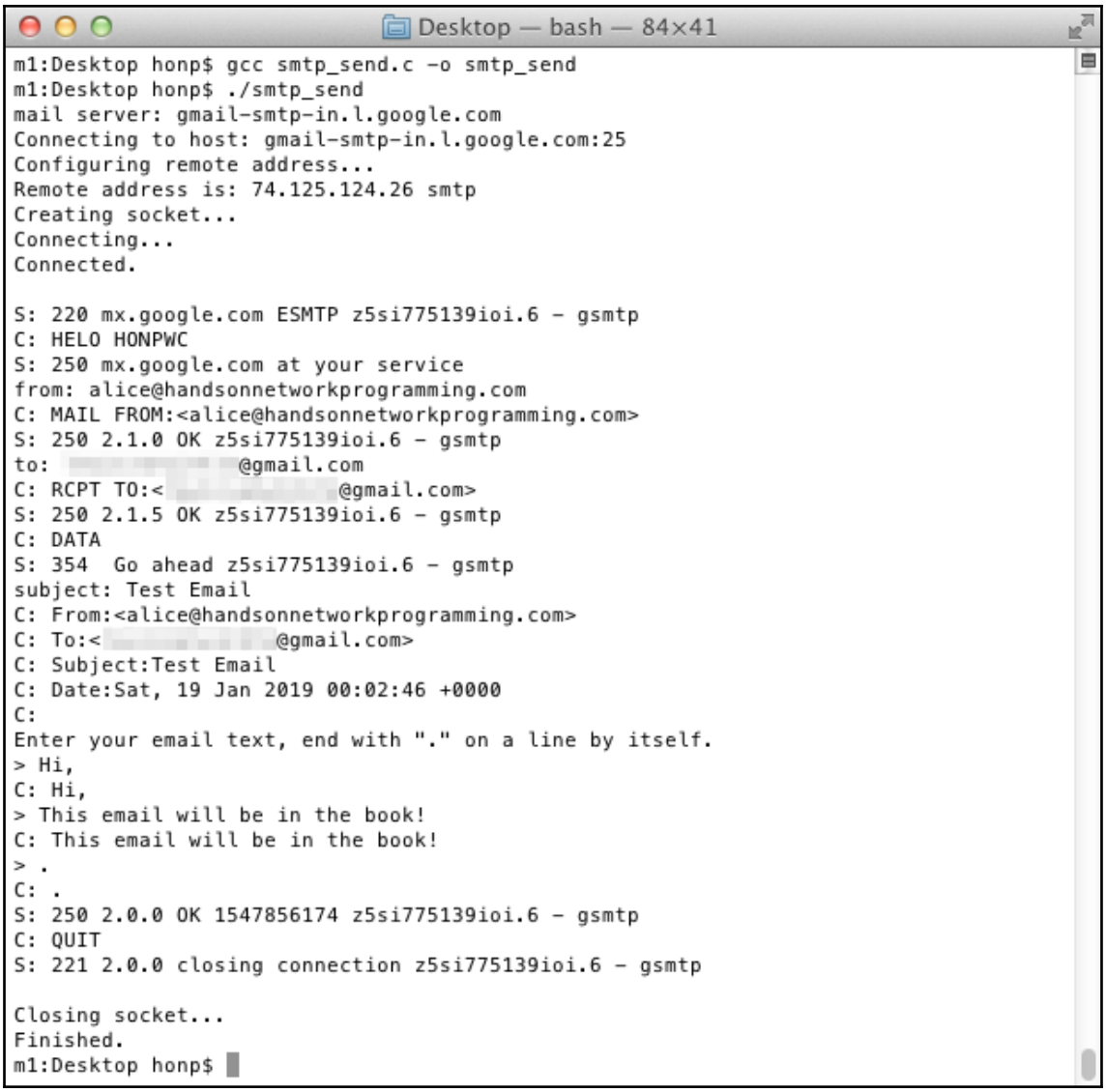




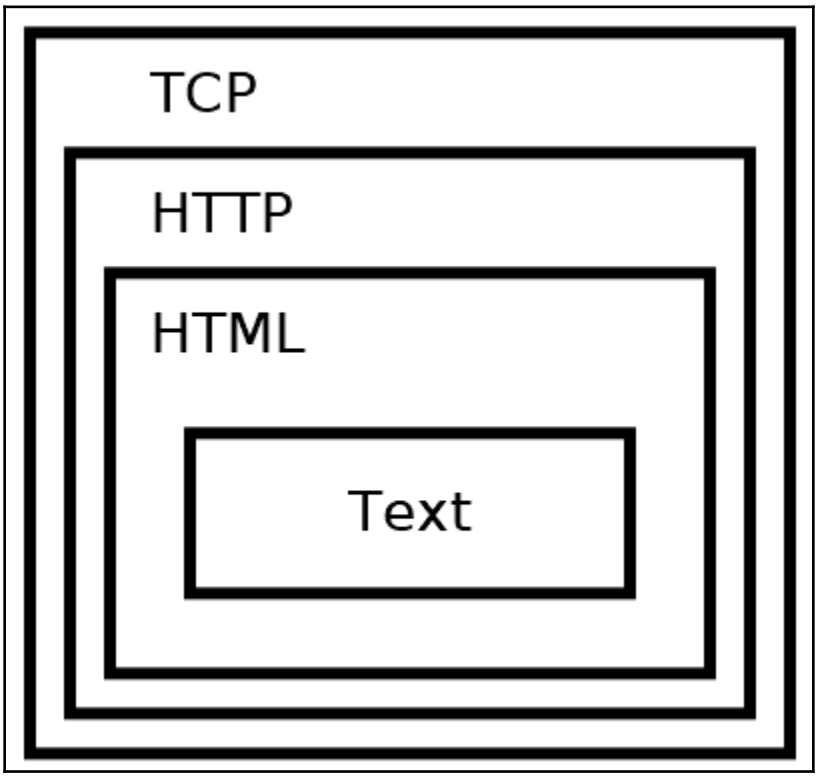

```
Windows PowerShell
PS C:\> nslookup -type=mx gmail.com
Server:  UnKnown
Address:  192.168.182.2

Non-authoritative answer:
gmail.com       MX preference = 40, mail exchanger = alt4.gmail-smtp-in.l.google.com
gmail.com       MX preference = 5, mail exchanger = gmail-smtp-in.l.google.com
gmail.com       MX preference = 10, mail exchanger = alt1.gmail-smtp-in.l.google.com
gmail.com       MX preference = 20, mail exchanger = alt2.gmail-smtp-in.l.google.com
gmail.com       MX preference = 30, mail exchanger = alt3.gmail-smtp-in.l.google.com
PS C:\>
```

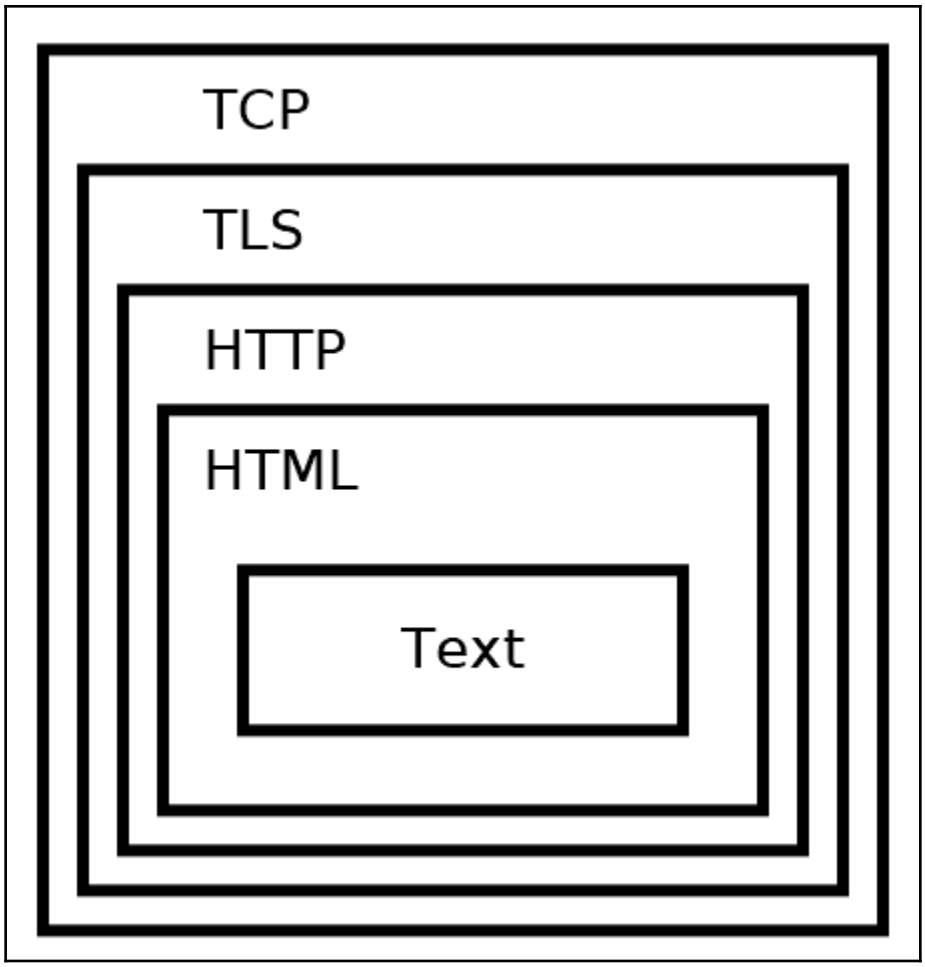

Desktop — bash — 84×24
m1:Desktop honp$ dig mx gmail.com
; <<>> DiG 9.7.3 <<>> mx gmail.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 18189
;; flags: qr rd ra; QUERY: 1, ANSWER: 5, AUTHORITY: 0, ADDITIONAL: 0
;; QUESTION SECTION:
;gmail.com. IN MX
;; ANSWER SECTION:
gmail.com. 5 IN MX 5 gmail-smtp-in.l.google.com.
gmail.com. 5 IN MX 10 alt1.gmail-smtp-in.l.google.com.
gmail.com. 5 IN MX 20 alt2.gmail-smtp-in.l.google.com.
gmail.com. 5 IN MX 30 alt3.gmail-smtp-in.l.google.com.
gmail.com. 5 IN MX 40 alt4.gmail-smtp-in.l.google.com.
;; Query time: 51 msec
;; SERVER: 192.168.182.2#53(192.168.182.2)
;; WHEN: Tue Jan 15 15:17:09 2019
;; MSG SIZE rcvd: 150
m1:Desktop honp$

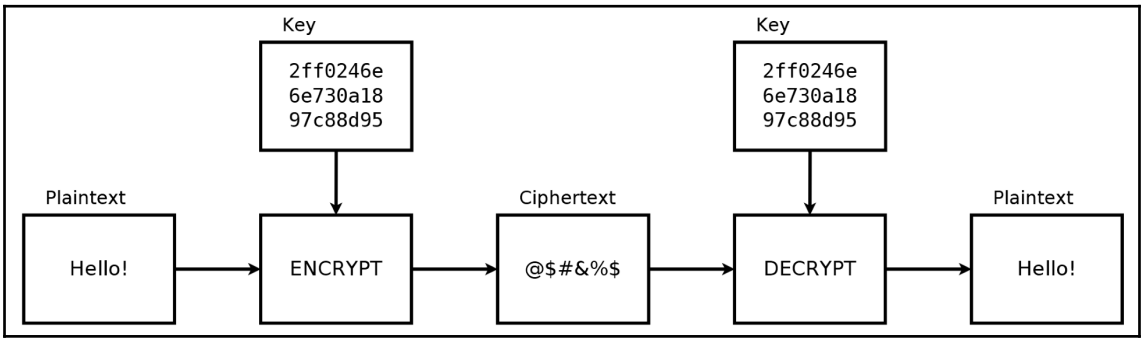

Desktop — bash — 84×24
m1:Desktop honp$ dig mx yahoo.com
; <<>> DiG 9.7.3 <<>> mx yahoo.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 30161
;; flags: qr rd ra; QUERY: 1, ANSWER: 3, AUTHORITY: 0, ADDITIONAL: 0
;; QUESTION SECTION:
;yahoo.com. IN MX
;; ANSWER SECTION:
yahoo.com. 5 IN MX 1 mta7.am0.yahoodns.net.
yahoo.com. 5 IN MX 1 mta5.am0.yahoodns.net.
yahoo.com. 5 IN MX 1 mta6.am0.yahoodns.net.
;; Query time: 63 msec
;; SERVER: 192.168.182.2#53(192.168.182.2)
;; WHEN: Thu Jan 17 20:08:12 2019
;; MSG SIZE rcvd: 106
m1:Desktop honp$

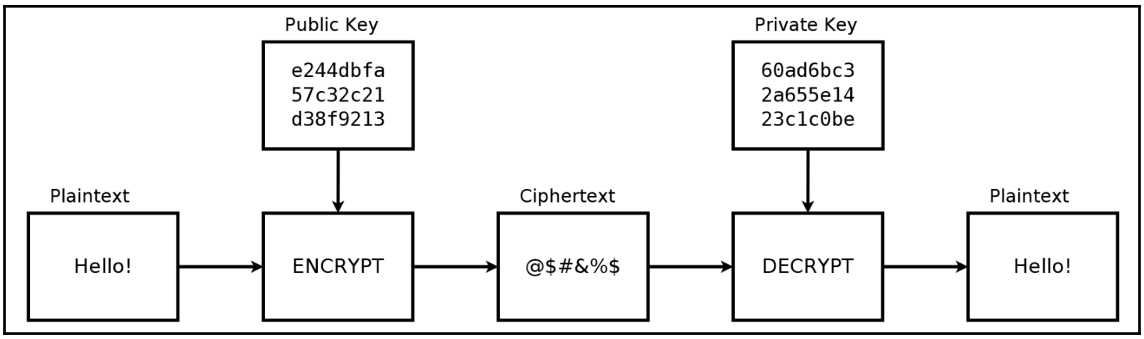

Desktop — bash — 84×41
m1:Desktop honp$ gcc smtp_send.c -o smtp_send
m1:Desktop honp$ ./smtp_send
mail server: gmail-smtp-in.l.google.com
Connecting to host: gmail-smtp-in.l.google.com:25
Configuring remote address...
Remote address is: 74.125.124.26 smtp
Creating socket...
Connecting...
Connected.
S: 220 mx.google.com ESMTP z5si775139ioi.6 - gsmtp
C: HELO HONPWC
S: 250 mx.google.com at your service
from: alice@handsonnetworkprogramming.com
C: MAIL FROM:<alice@handsonnetworkprogramming.com>
S: 250 2.1.0 OK z5si775139ioi.6 - gsmtp
to: @gmail.com
C: RCPT TO:< @gmail.com>
S: 250 2.1.5 OK z5si775139ioi.6 - gsmtp
C: DATA
S: 354 Go ahead z5si775139ioi.6 - gsmtp
subject: Test Email
C: From:<alice@handsonnetworkprogramming.com>
C: To:< @gmail.com>
C: Subject:Test Email
C: Date:Sat, 19 Jan 2019 00:02:46 +0000
C:
Enter your email text, end with "." on a line by itself.
> Hi,
C: Hi,
> This email will be in the book!
C: This email will be in the book!
> .
C: .
S: 250 2.0.0 OK 1547856174 z5si775139ioi.6 - gsmtp
C: QUIT
S: 221 2.0.0 closing connection z5si775139ioi.6 - gsmtp
Closing socket...
Finished.
m1:Desktop honp$

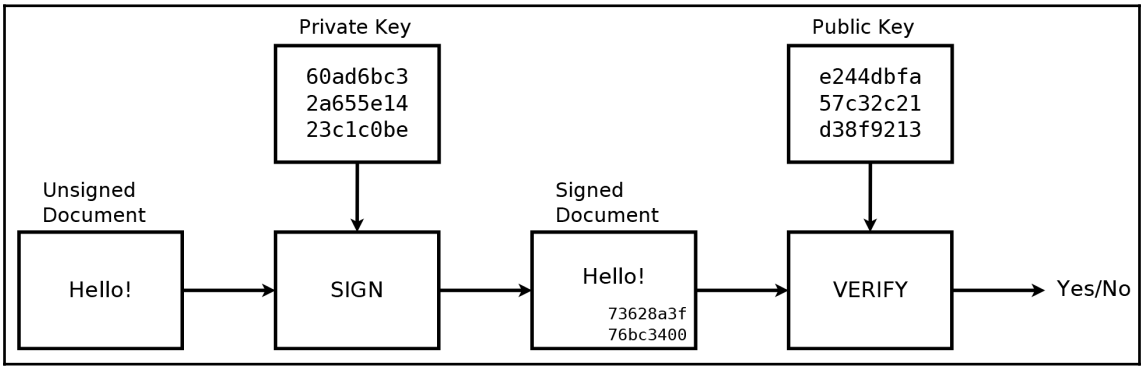
Chapter 9: Loading Secure Web Pages with HTTPS and OpenSSL

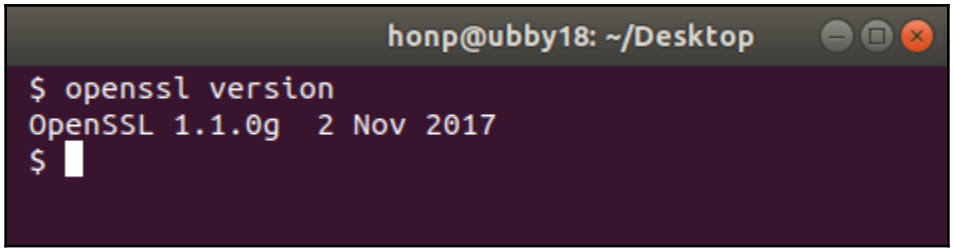


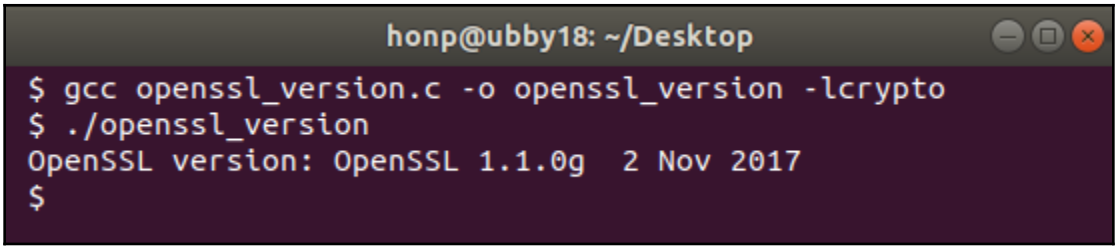

TCP
TLS
HTTP
HTML
Text

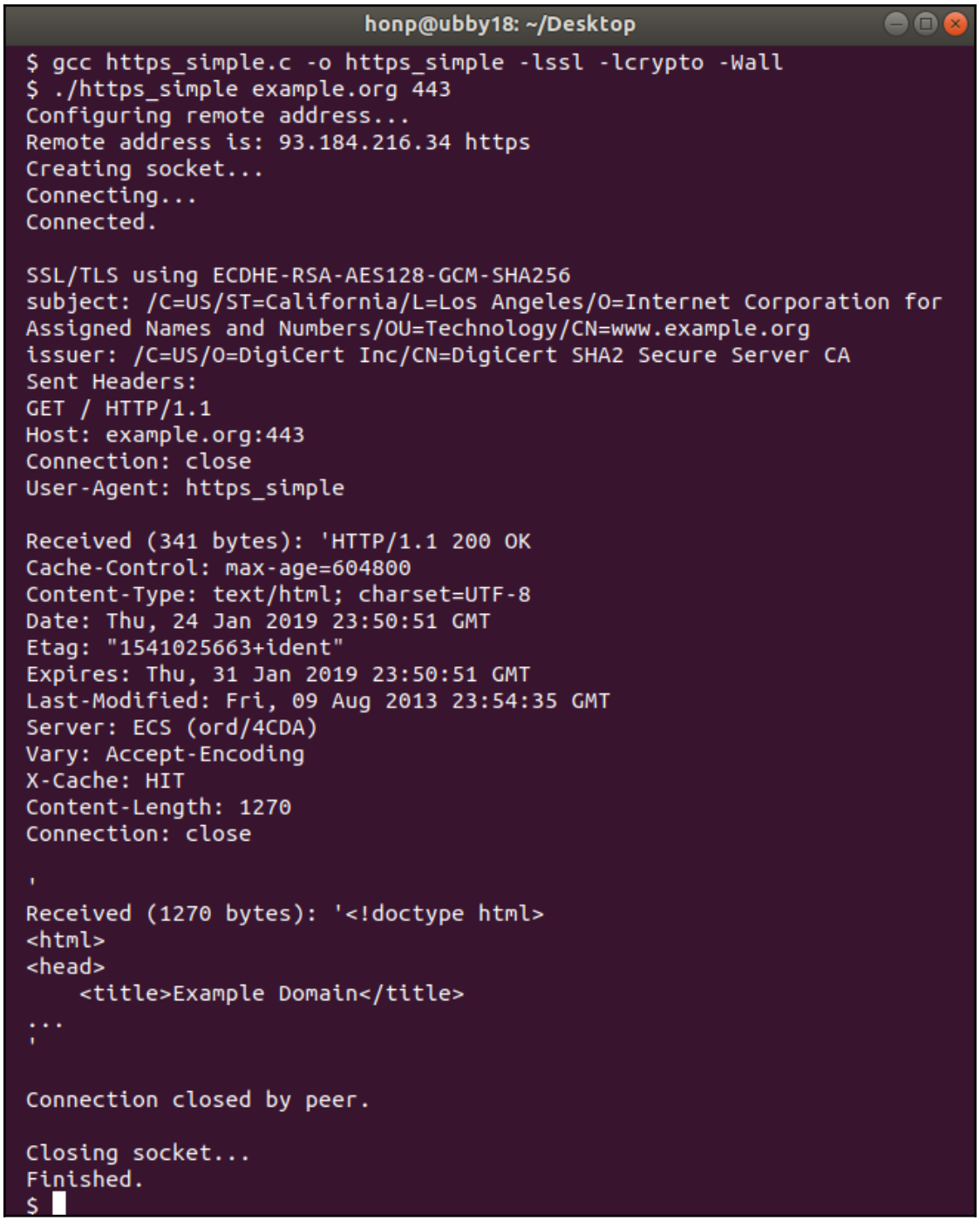

Key
2ff0246e
6e730a18
97c88d95
Key
2ff0246e
6e730a18
97c88d95
Plaintext
Hello!
ENCRYPT
Ciphertext
@$#&%$
DECRYPT
Plaintext
Hello!


Public Key
e244dbfa
57c32c21
d38f9213
Private Key
60ad6bc3
2a655e14
23c1c0be
Plaintext
Hello!
ENCRYPT
Ciphertext
@$#&%$
DECRYPT
Plaintext
Hello!

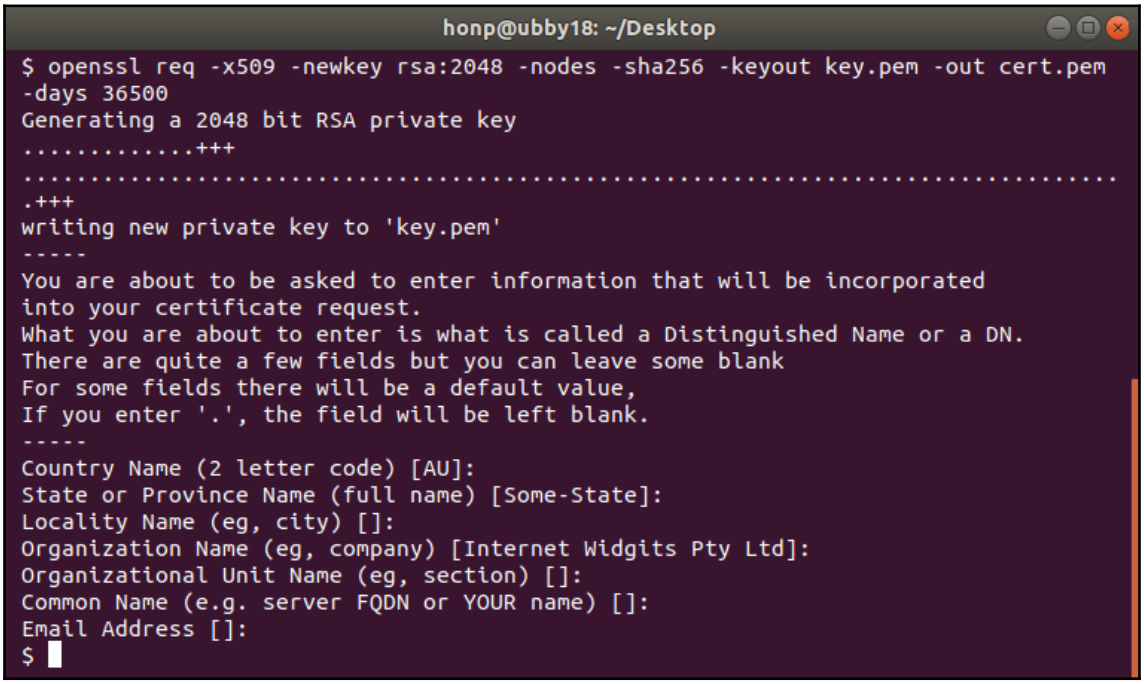

Private Key
60ad6bc3
2a655e14
23c1c0be
Public Key
e244dbfa
57c32c21
d38f9213
Unsigned
Document
Hello!
SIGN
Signed
Document
Hello!
73628a3f
76bc3400
VERIFY
Yes/No

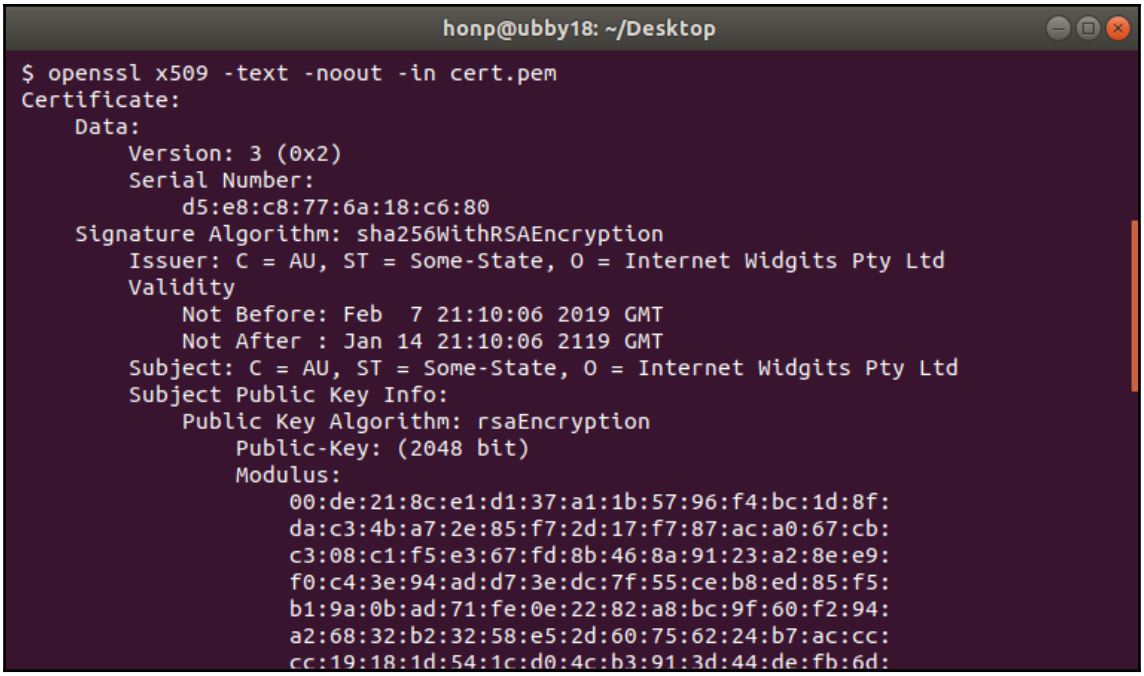

honp@ubby18: ~/Desktop
$ openssl version
OpenSSL 1.1.0g 2 Nov 2017
$

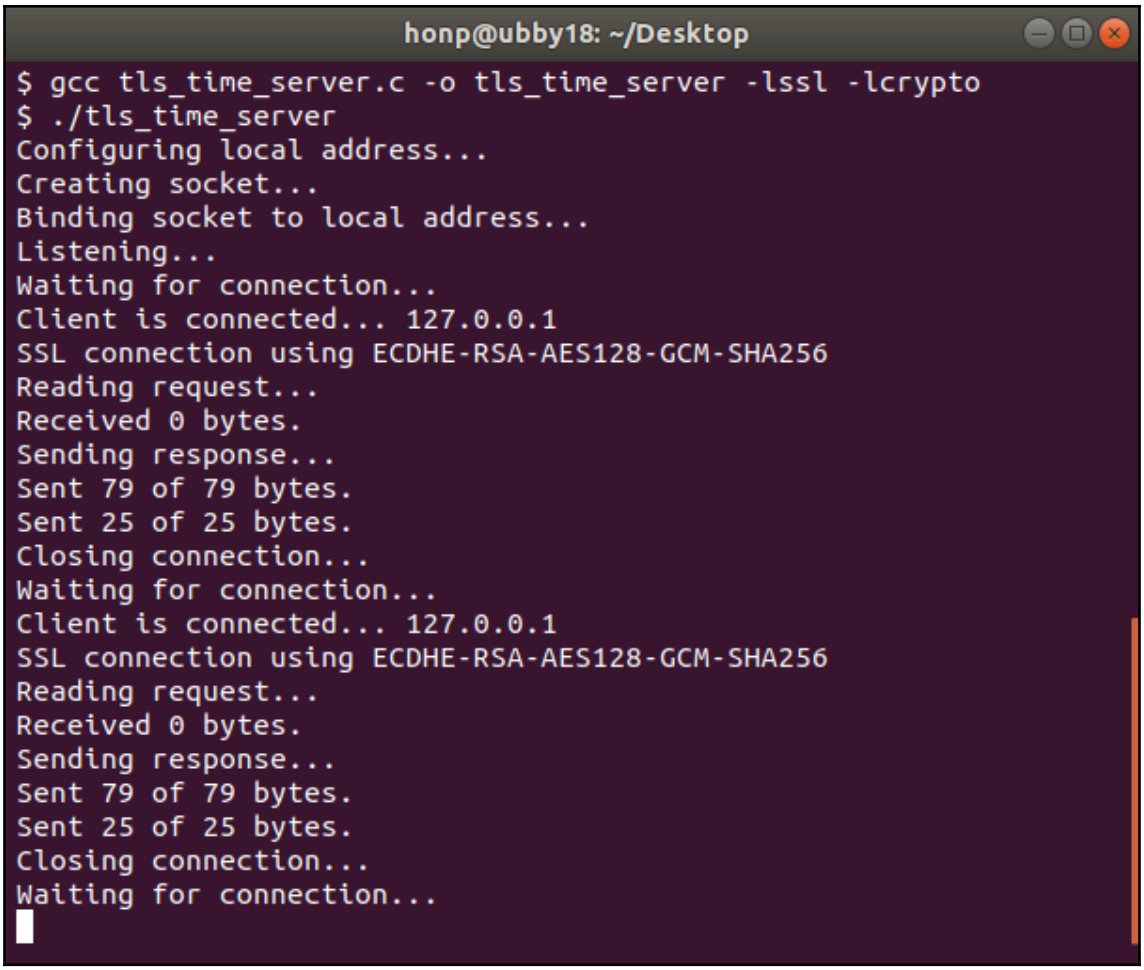

honp@ubby18: ~/Desktop
$ gcc openssl_version.c -o openssl_version -lcrypto
$ ./openssl_version
OpenSSL version: OpenSSL 1.1.0g 2 Nov 2017
$

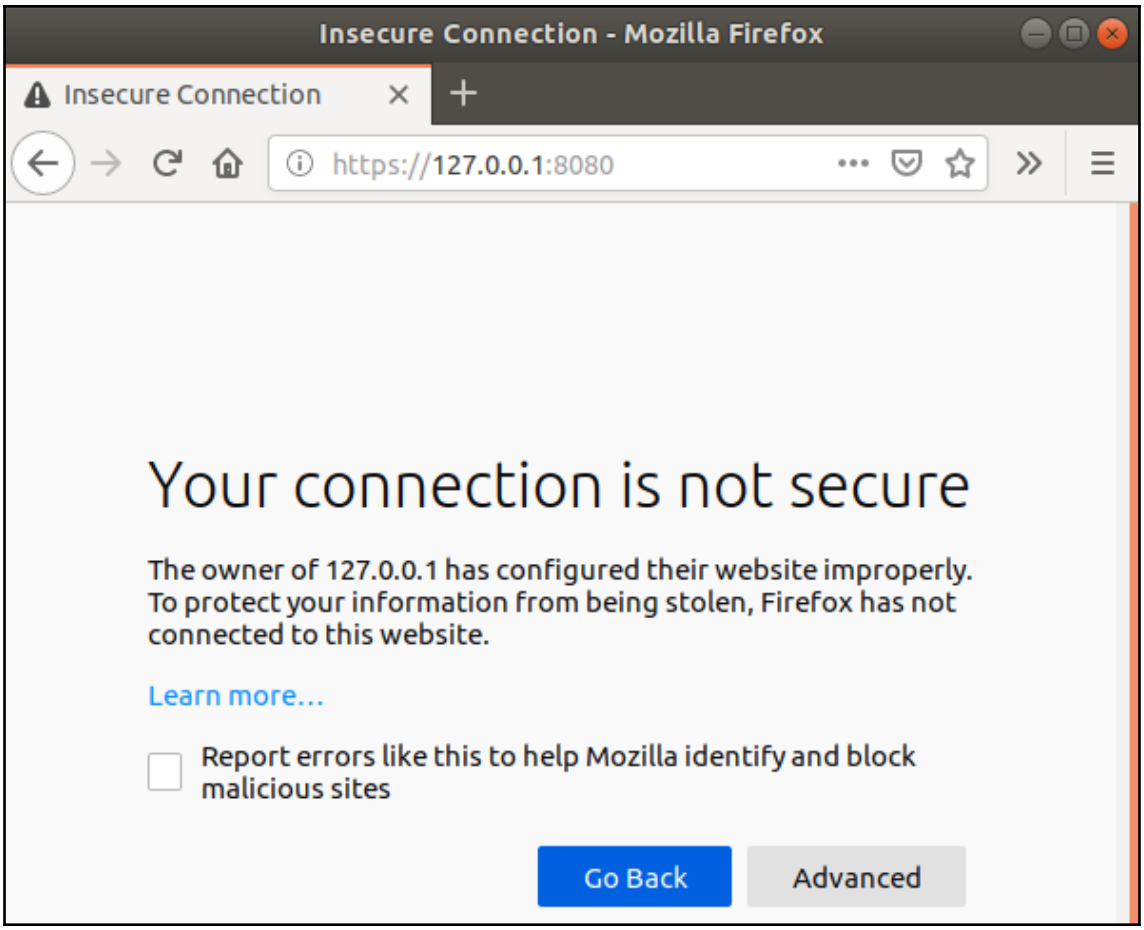

honp@ubby18: ~/Desktop
$ gcc https_simple.c -o https_simple -lssl -lcrypto -Wall
$ ./https_simple example.org 443
Configuring remote address...
Remote address is: 93.184.216.34 https
Creating socket...
Connecting...
Connected.
SSL/TLS using ECDHE-RSA-AES128-GCM-SHA256
subject: /C=US/ST=California/L=Los Angeles/O=Internet Corporation for
Assigned Names and Numbers/OU=Technology/CN=www.example.org
issuer: /C=US/O=DigiCert Inc/CN=DigiCert SHA2 Secure Server CA
Sent Headers:
GET / HTTP/1.1
Host: example.org:443
Connection: close
User-Agent: https_simple
Received (341 bytes): 'HTTP/1.1 200 OK
Cache-Control: max-age=604800
Content-Type: text/html; charset=UTF-8
Date: Thu, 24 Jan 2019 23:50:51 GMT
Etag: "1541025663+ident"
Expires: Thu, 31 Jan 2019 23:50:51 GMT
Last-Modified: Fri, 09 Aug 2013 23:54:35 GMT
Server: ECS (ord/4CDA)
Vary: Accept-Encoding
X-Cache: HIT
Content-Length: 1270
Connection: close
'
Received (1270 bytes): '<!doctype html>
<html>
<head>
<title>Example Domain</title>
...
'
Connection closed by peer.
Closing socket...
Finished.
$

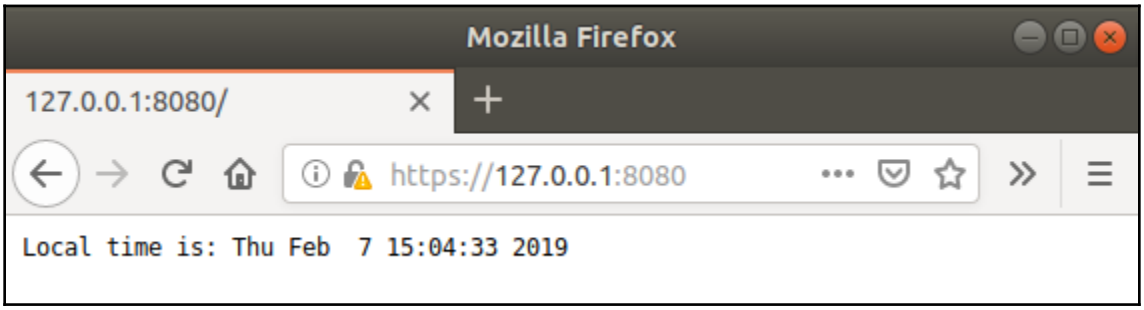
Chapter 10: Implementing a Secure Web Server




honp@ubby18: ~/Desktop
$ openssl x509 -text -noout -in cert.pem
Certificate:
Data:
Version: 3 (0x2)
Serial Number:
d5:e8:c8:77:6a:18:c6:80
Signature Algorithm: sha256WithRSAEncryption
Issuer: C = AU, ST = Some-State, O = Internet Widgits Pty Ltd
Validity
Not Before: Feb 7 21:10:06 2019 GMT
Not After : Jan 14 21:10:06 2119 GMT
Subject: C = AU, ST = Some-State, O = Internet Widgits Pty Ltd
Subject Public Key Info:
Public Key Algorithm: rsaEncryption
Public-Key: (2048 bit)
Modulus:
00:de:21:8c:e1:d1:37:a1:1b:57:96:f4:bc:1d:8f:
da:c3:4b:a7:2e:85:f7:2d:17:f7:87:ac:a0:67:cb:
c3:08:c1:f5:e3:67:fd:8b:46:8a:91:23:a2:8e:e9:
f0:c4:3e:94:ad:d7:3e:dc:7f:55:ce:b8:ed:85:f5:
b1:9a:0b:ad:71:fe:0e:22:82:a8:bc:9f:60:f2:94:
a2:68:32:b2:32:58:e5:2d:60:75:62:24:b7:ac:cc:
cc:19:18:1d:54:1c:d0:4c:b3:91:3d:44:de:fb:6d:


honp@ubby18: ~/Desktop
$ gcc tls_time_server.c -o tls_time_server -lssl -lcrypto
$ ./tls_time_server
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connection...
Client is connected... 127.0.0.1
SSL connection using ECDHE-RSA-AES128-GCM-SHA256
Reading request...
Received 0 bytes.
Sending response...
Sent 79 of 79 bytes.
Sent 25 of 25 bytes.
Closing connection...
Waiting for connection...
Client is connected... 127.0.0.1
SSL connection using ECDHE-RSA-AES128-GCM-SHA256
Reading request...
Received 0 bytes.
Sending response...
Sent 79 of 79 bytes.
Sent 25 of 25 bytes.
Closing connection...
Waiting for connection...


Insecure Connection - Mozilla Firefox
Insecure Connection
https://127.0.0.1:8080
Your connection is not secure
The owner of 127.0.0.1 has configured their website improperly. To protect your information from being stolen, Firefox has not connected to this website.
Learn more...
Report errors like this to help Mozilla identify and block malicious sites
Go Back
Advanced


Mozilla Firefox
127.0.0.1:8080/
https://127.0.0.1:8080
Local time is: Thu Feb 7 15:04:33 2019

```
honp@ubby18: ~/Desktop
$ gcc https_server.c -o https_server -lssl -lcrypto
$ ./https_server
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
New connection from 127.0.0.1.
SSL connection using ECDHE-RSA-AES128-GCM-SHA256
serve_resource 127.0.0.1 /
New connection from 127.0.0.1.
SSL connection using ECDHE-RSA-AES128-GCM-SHA256
serve_resource 127.0.0.1 /smile.png
```

Example Page - Mozilla Firefox

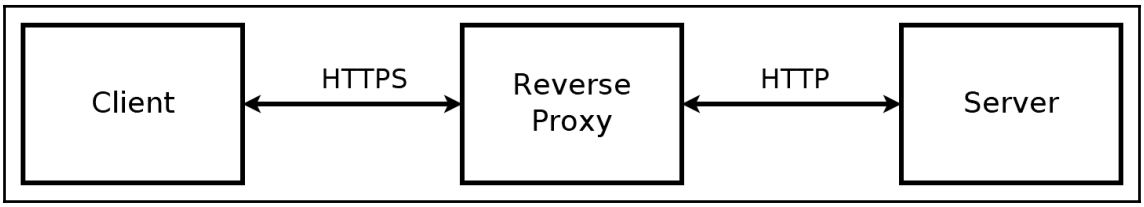
Example Page

https://127.0.0.1:8080

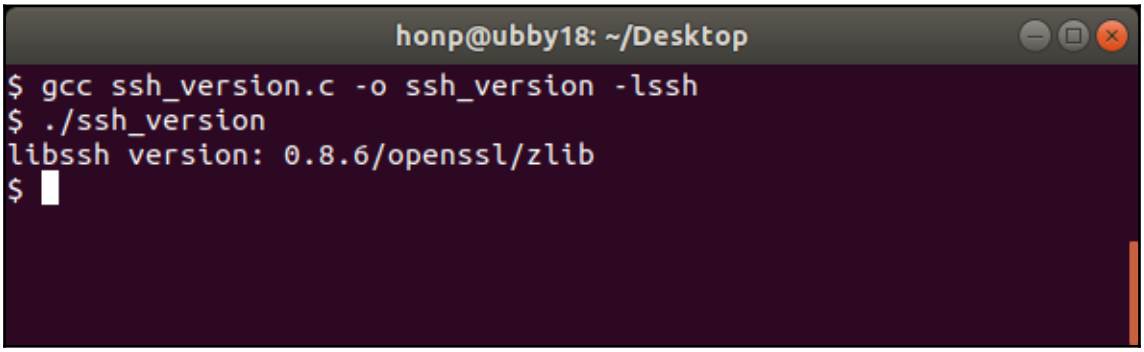
Example Page

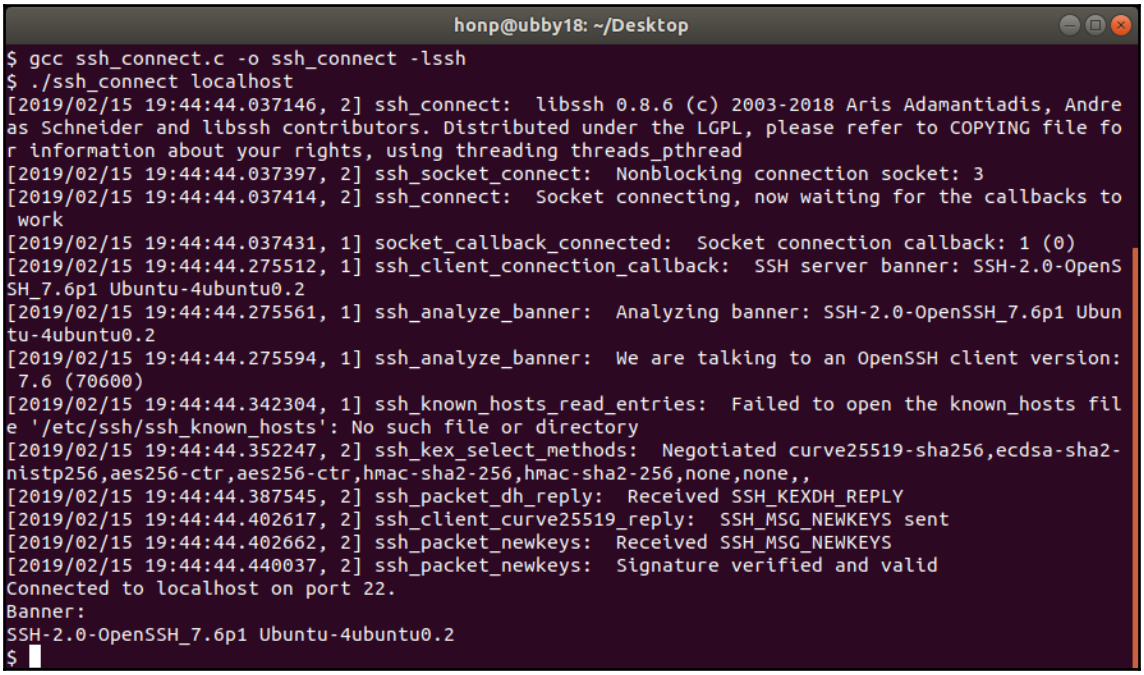
This page is only an example.

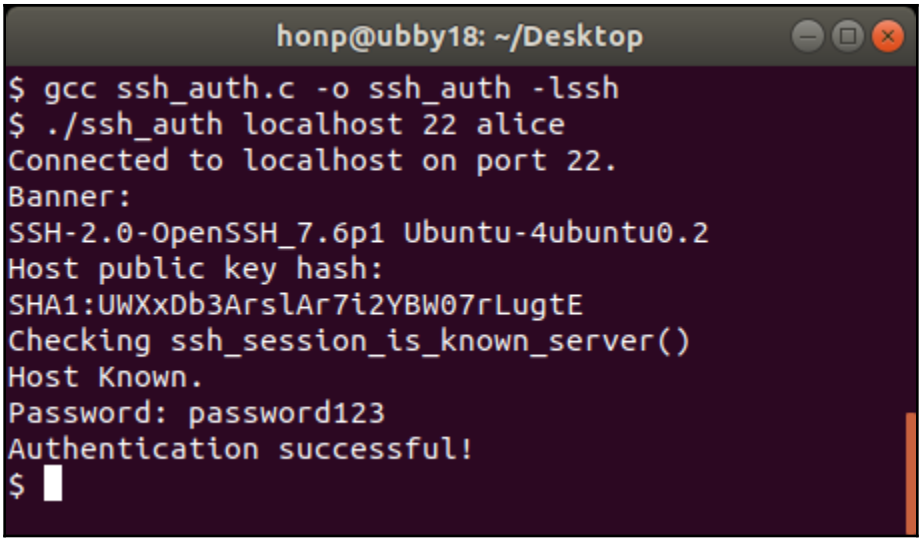
Click here to see another page, or click here to download a text file.

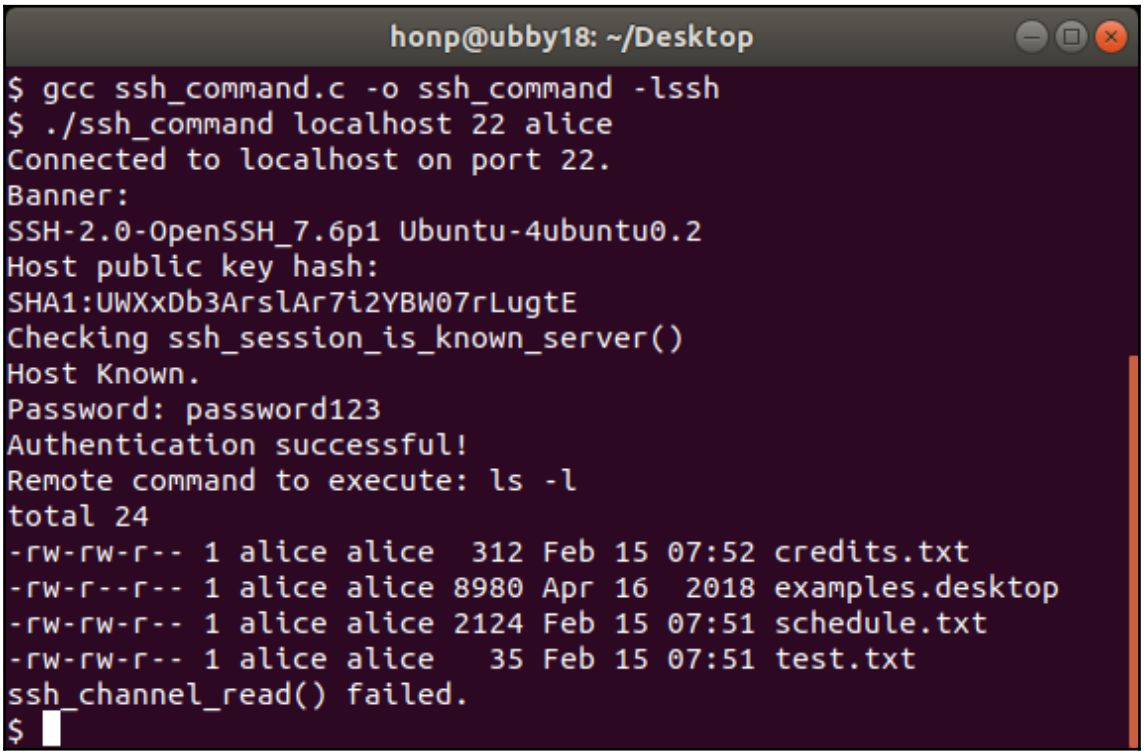

Client
HTTPS
Reverse
Proxy
HTTP
Server

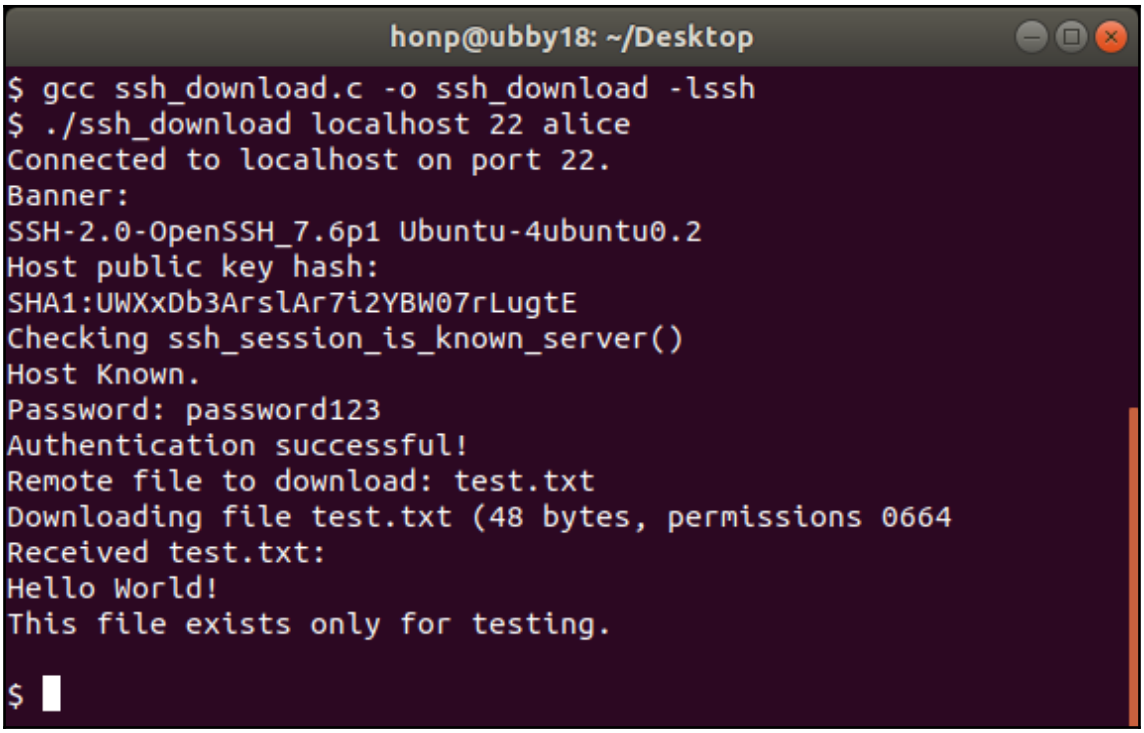
Chapter 11: Establishing SSH Connections with libssh



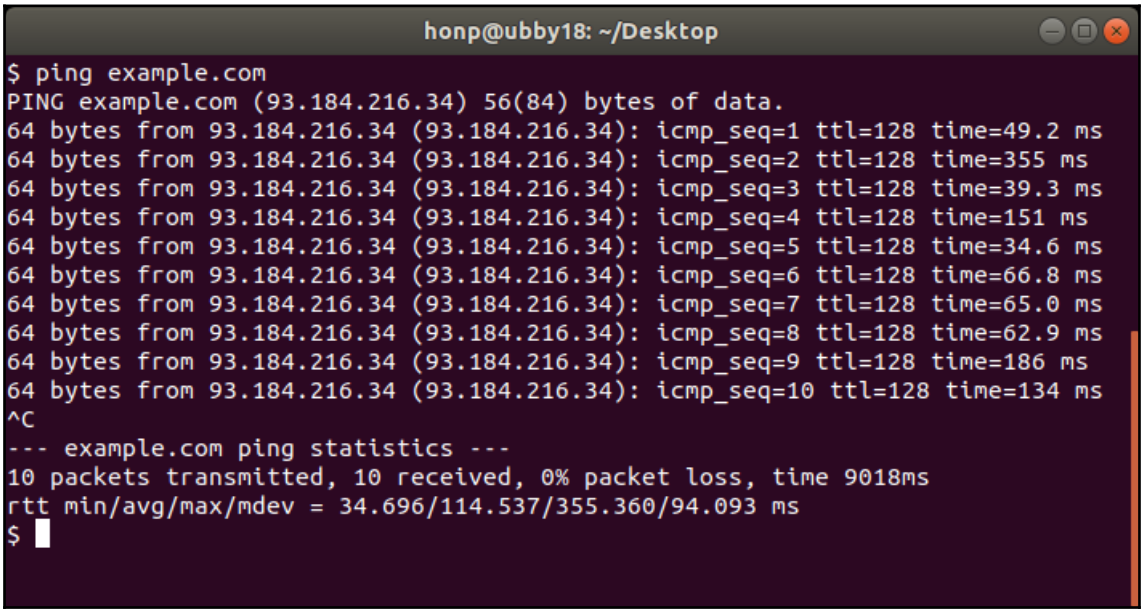


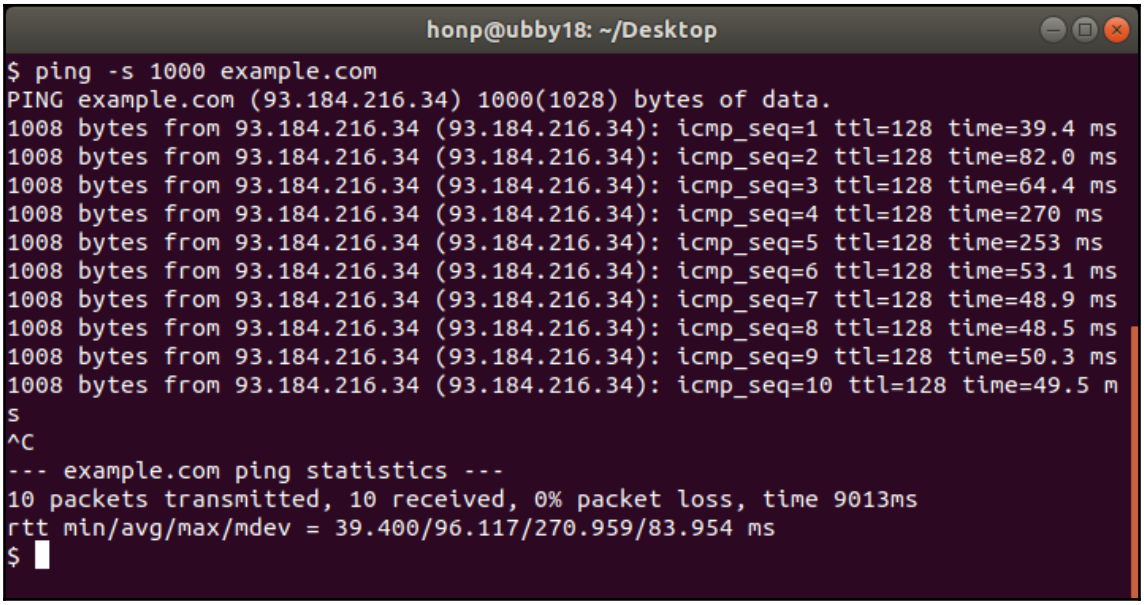

honp@ubby18: ~/Desktop
$ gcc ssh_auth.c -o ssh_auth -lssh
$ ./ssh_auth localhost 22 alice
Connected to localhost on port 22.
Banner:
SSH-2.0-OpenSSH_7.6p1 Ubuntu-4ubuntu0.2
Host public key hash:
SHA1:UWXxDb3ArslAr7i2YBW07rLugtE
Checking ssh_session_is_known_server()
Host Known.
Password: password123
Authentication successful!
$

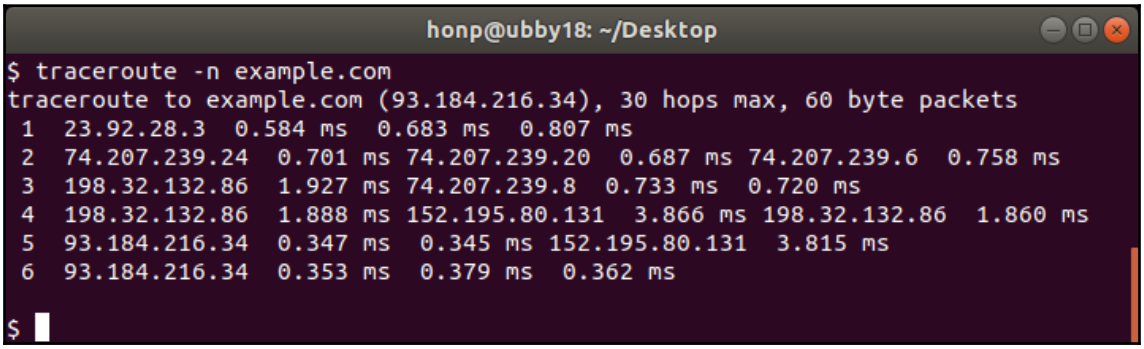

honp@ubby18: ~/Desktop
$ gcc ssh_command.c -o ssh_command -lssh
$ ./ssh_command localhost 22 alice
Connected to localhost on port 22.
Banner:
SSH-2.0-OpenSSH_7.6p1 Ubuntu-4ubuntu0.2
Host public key hash:
SHA1:UWXxDb3ArslAr7i2YBW07rLugtE
Checking ssh_session_is_known_server()
Host Known.
Password: password123
Authentication successful!
Remote command to execute: ls -l
total 24
-rw-rw-r-- 1 alice alice 312 Feb 15 07:52 credits.txt
-rw-r--r-- 1 alice alice 8980 Apr 16 2018 examples.desktop
-rw-rw-r-- 1 alice alice 2124 Feb 15 07:51 schedule.txt
-rw-rw-r-- 1 alice alice   35 Feb 15 07:51 test.txt
ssh_channel_read() failed.
$

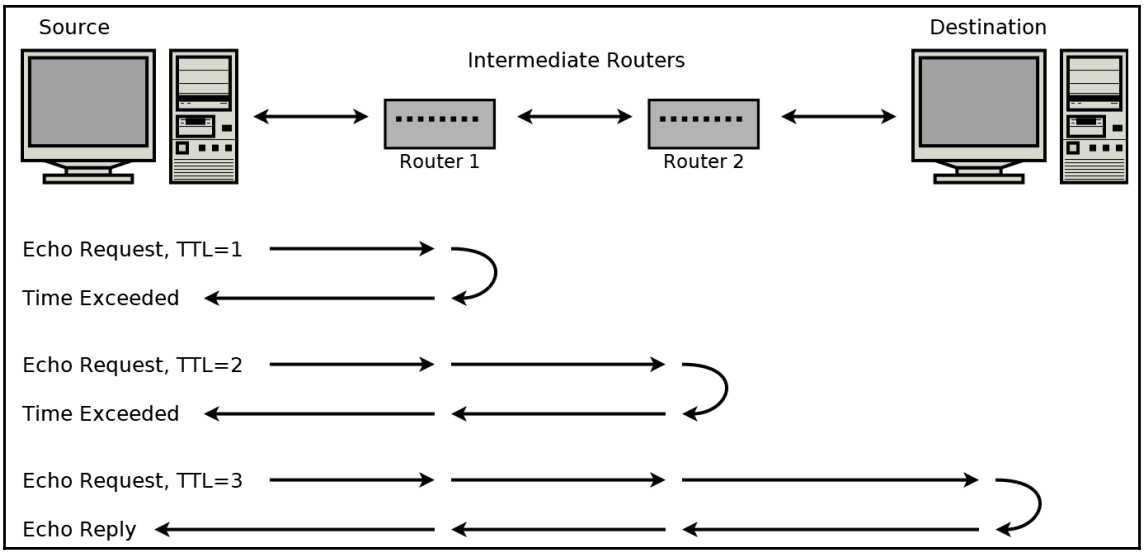

honp@ubby18: ~/Desktop
$ gcc ssh_download.c -o ssh_download -lssh
$ ./ssh_download localhost 22 alice
Connected to localhost on port 22.
Banner:
SSH-2.0-OpenSSH_7.6p1 Ubuntu-4ubuntu0.2
Host public key hash:
SHA1:UWXxDb3ArslAr7i2YBW07rLugtE
Checking ssh_session_is_known_server()
Host Known.
Password: password123
Authentication successful!
Remote file to download: test.txt
Downloading file test.txt (48 bytes, permissions 0664
Received test.txt:
Hello World!
This file exists only for testing.
$

Chapter 12: Network Monitoring and Security



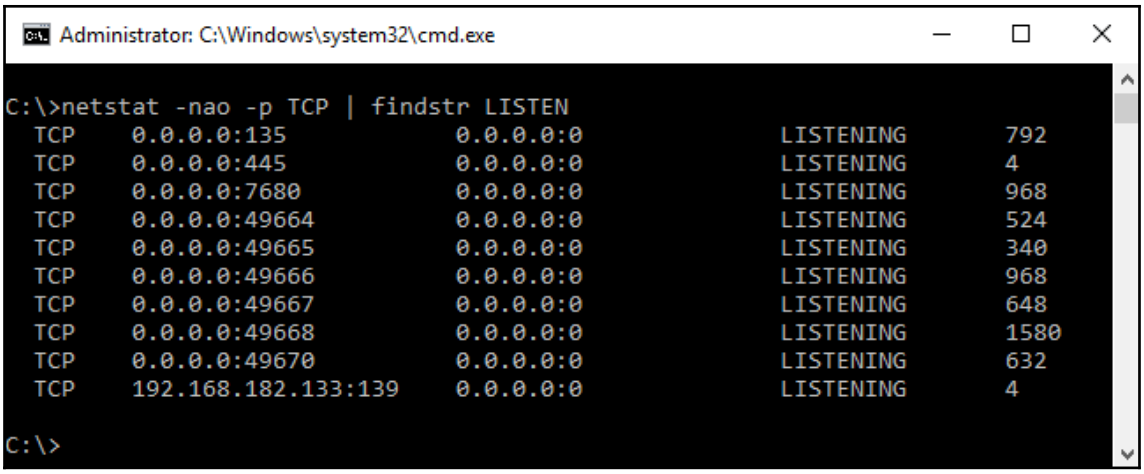

honp@ubby18: ~/Desktop
$ ping -s 1000 example.com
PING example.com (93.184.216.34) 1000(1028) bytes of data.
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=1 ttl=128 time=39.4 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=2 ttl=128 time=82.0 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=3 ttl=128 time=64.4 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=4 ttl=128 time=270 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=5 ttl=128 time=253 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=6 ttl=128 time=53.1 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=7 ttl=128 time=48.9 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=8 ttl=128 time=48.5 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=9 ttl=128 time=50.3 ms
1008 bytes from 93.184.216.34 (93.184.216.34): icmp_seq=10 ttl=128 time=49.5 m
s
^C
--- example.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 39.400/96.117/270.959/83.954 ms
$

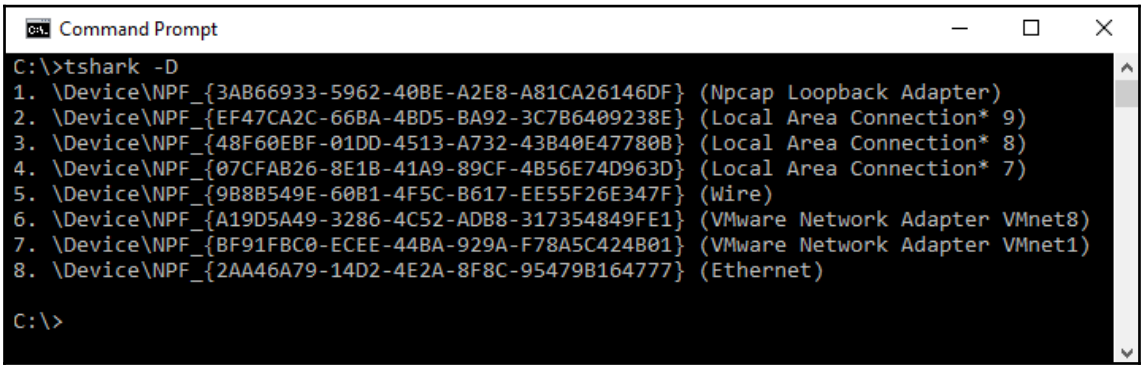

honp@ubby18: ~/Desktop
$ traceroute -n example.com
traceroute to example.com (93.184.216.34), 30 hops max, 60 byte packets
 1 23.92.28.3 0.584 ms 0.683 ms 0.807 ms
 2 74.207.239.24 0.701 ms 74.207.239.20 0.687 ms 74.207.239.6 0.758 ms
 3 198.32.132.86 1.927 ms 74.207.239.8 0.733 ms 0.720 ms
 4 198.32.132.86 1.888 ms 152.195.80.131 3.866 ms 198.32.132.86 1.860 ms
 5 93.184.216.34 0.347 ms 0.345 ms 152.195.80.131 3.815 ms
 6 93.184.216.34 0.353 ms 0.379 ms 0.362 ms
$

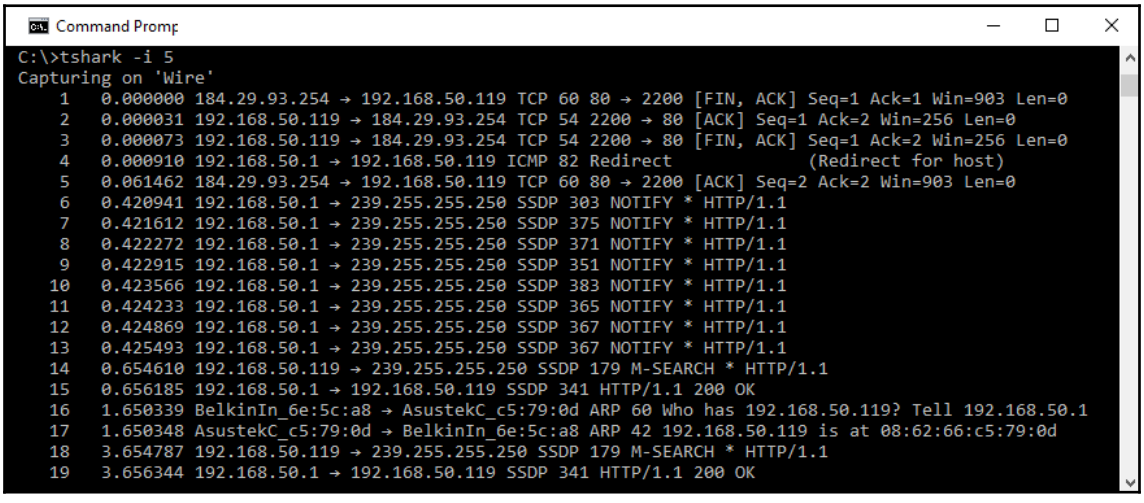


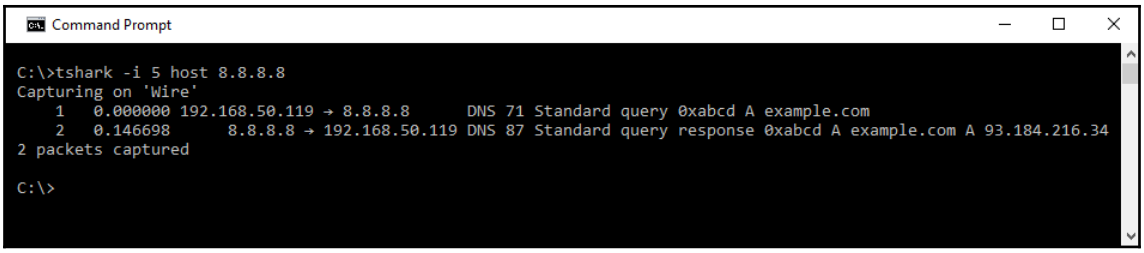

```
honp@ubby18: ~/Desktop
$ netstat -nt
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 192.168.182.140:57926   93.184.216.34:80        ESTABLISHED
tcp        0      0 192.168.182.140:57922   93.184.216.34:80        TIME_WAIT
tcp        0      0 192.168.182.140:37488   216.58.192.174:80       ESTABLISHED
$
```

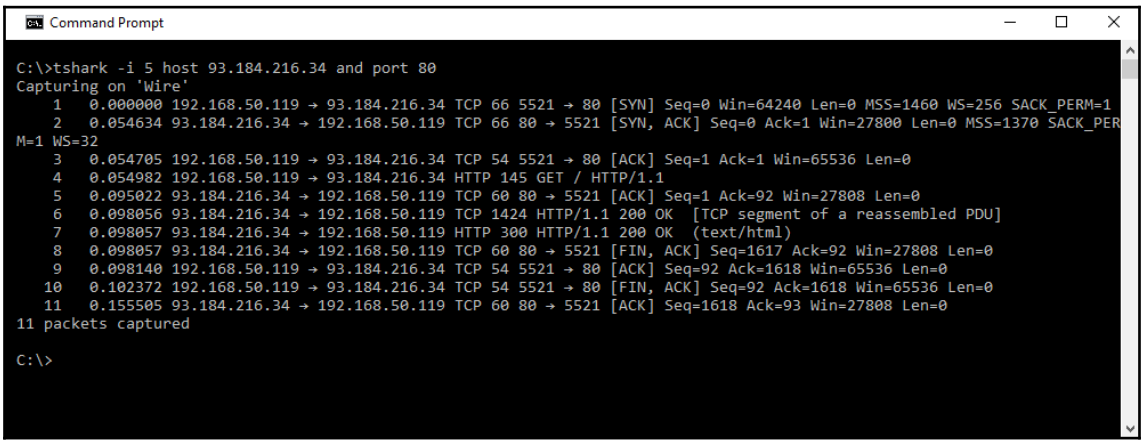
```
honp@ubby18: ~/Desktop
$ sudo netstat -ntlp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 127.0.0.53:53           0.0.0.0:*               LISTEN      434/systemd-resolve
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      72522/sshd
tcp        0      0 127.0.0.1:631           0.0.0.0:*               LISTEN      92531/cupsd
tcp6       0      0 :::80                   :::*                    LISTEN      20762/apache2
tcp6       0      0 :::22                   :::*                    LISTEN      72522/sshd
tcp6       0      0 ::1:631                 :::*                    LISTEN      92531/cupsd
$
```

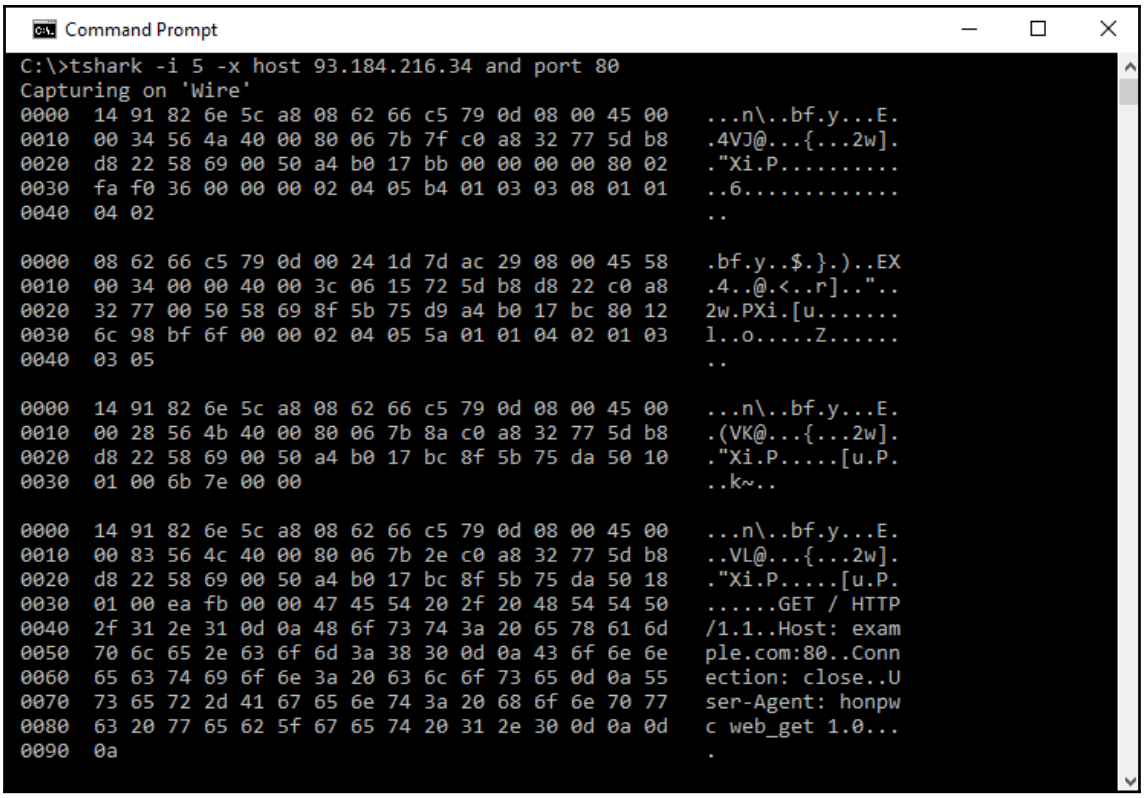

Administrator: C:\Windows\system32\cmd.exe
C:\>netstat -nao -p TCP | findstr LISTEN
TCP 0.0.0.0:135 0.0.0.0:0 LISTENING 792
TCP 0.0.0.0:445 0.0.0.0:0 LISTENING 4
TCP 0.0.0.0:7680 0.0.0.0:0 LISTENING 968
TCP 0.0.0.0:49664 0.0.0.0:0 LISTENING 524
TCP 0.0.0.0:49665 0.0.0.0:0 LISTENING 340
TCP 0.0.0.0:49666 0.0.0.0:0 LISTENING 968
TCP 0.0.0.0:49667 0.0.0.0:0 LISTENING 648
TCP 0.0.0.0:49668 0.0.0.0:0 LISTENING 1580
TCP 0.0.0.0:49670 0.0.0.0:0 LISTENING 632
TCP 192.168.182.133:139 0.0.0.0:0 LISTENING 4
C:\>

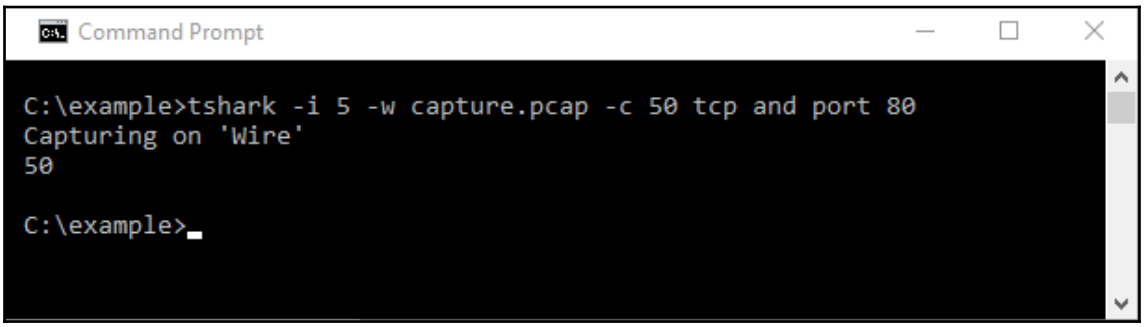

Command Prompt
C:\>tshark -D
1. \Device\NPF_{3AB66933-5962-40BE-A2E8-A81CA26146DF} (Npcap Loopback Adapter)
2. \Device\NPF_{EF47CA2C-66BA-4BD5-BA92-3C7B6409238E} (Local Area Connection* 9)
3. \Device\NPF_{48F60EBF-01DD-4513-A732-43B40E47780B} (Local Area Connection* 8)
4. \Device\NPF_{07CFAB26-8E1B-41A9-89CF-4B56E74D963D} (Local Area Connection* 7)
5. \Device\NPF_{9B8B549E-60B1-4F5C-B617-EE55F26E347F} (Wire)
6. \Device\NPF_{A19D5A49-3286-4C52-ADB8-317354849FE1} (VMware Network Adapter VMnet8)
7. \Device\NPF_{BF91FBC0-ECEE-44BA-929A-F78A5C424B01} (VMware Network Adapter VMnet1)
8. \Device\NPF_{2AA46A79-14D2-4E2A-8F8C-95479B164777} (Ethernet)
C:\>

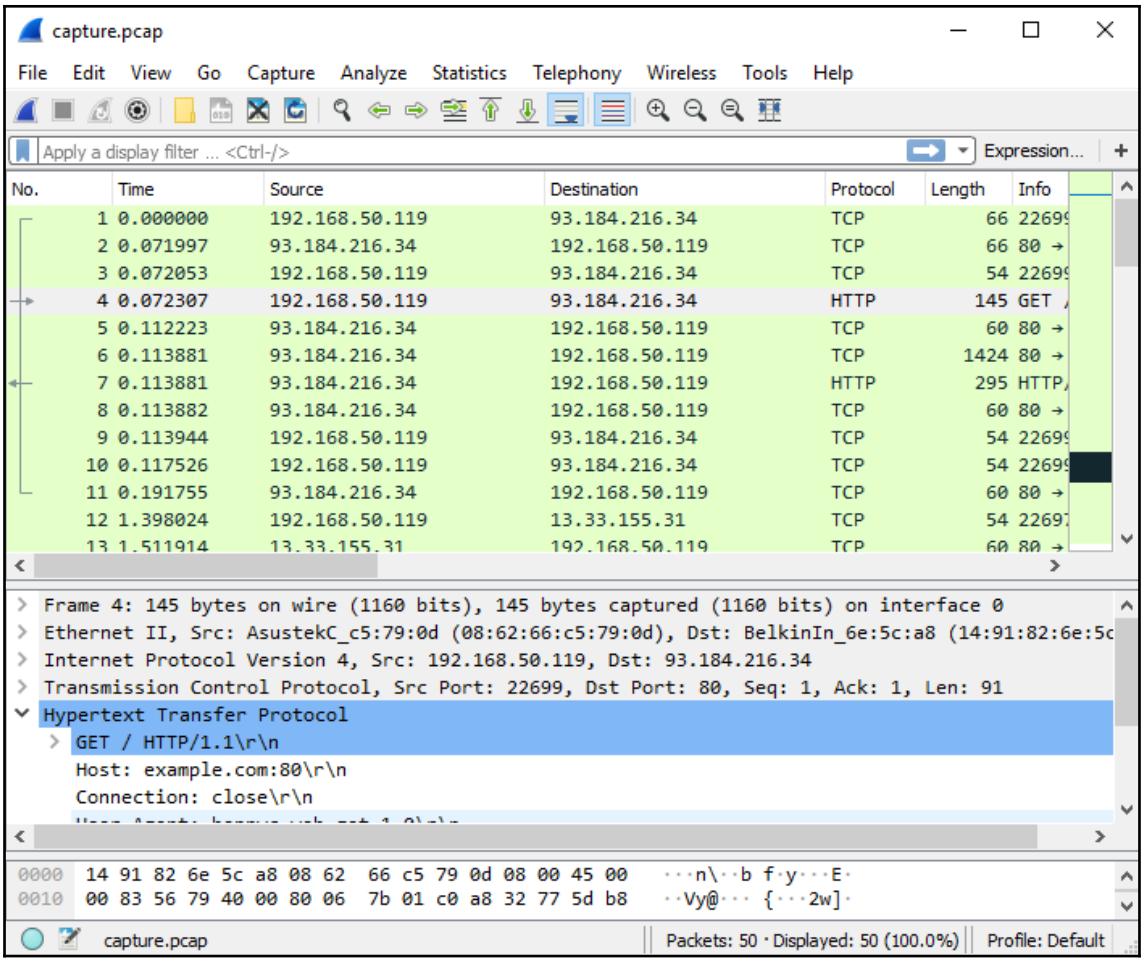

Command Prompt
C:\>tshark -i 5
Capturing on 'Wire'
1 0.000000 184.29.93.254 → 192.168.50.119 TCP 60 80 → 2200 [FIN, ACK] Seq=1 Ack=1 Win=903 Len=0
2 0.000031 192.168.50.119 → 184.29.93.254 TCP 54 2200 → 80 [ACK] Seq=1 Ack=2 Win=256 Len=0
3 0.000073 192.168.50.119 → 184.29.93.254 TCP 54 2200 → 80 [FIN, ACK] Seq=1 Ack=2 Win=256 Len=0
4 0.000910 192.168.50.1 → 192.168.50.119 ICMP 82 Redirect (Redirect for host)
5 0.061462 184.29.93.254 → 192.168.50.119 TCP 60 80 → 2200 [ACK] Seq=2 Ack=2 Win=903 Len=0
6 0.420941 192.168.50.1 → 239.255.255.250 SSDP 303 NOTIFY * HTTP/1.1
7 0.421612 192.168.50.1 → 239.255.255.250 SSDP 375 NOTIFY * HTTP/1.1
8 0.422272 192.168.50.1 → 239.255.255.250 SSDP 371 NOTIFY * HTTP/1.1
9 0.422915 192.168.50.1 → 239.255.255.250 SSDP 351 NOTIFY * HTTP/1.1
10 0.423566 192.168.50.1 → 239.255.255.250 SSDP 383 NOTIFY * HTTP/1.1
11 0.424233 192.168.50.1 → 239.255.255.250 SSDP 365 NOTIFY * HTTP/1.1
12 0.424869 192.168.50.1 → 239.255.255.250 SSDP 367 NOTIFY * HTTP/1.1
13 0.425493 192.168.50.1 → 239.255.255.250 SSDP 367 NOTIFY * HTTP/1.1
14 0.654610 192.168.50.119 → 239.255.255.250 SSDP 179 M-SEARCH * HTTP/1.1
15 0.656185 192.168.50.1 → 192.168.50.119 SSDP 341 HTTP/1.1 200 OK
16 1.650339 BelkinIn_6e:5c:a8 → AsustekC_c5:79:0d ARP 60 Who has 192.168.50.119? Tell 192.168.50.1
17 1.650348 AsustekC_c5:79:0d → BelkinIn_6e:5c:a8 ARP 42 192.168.50.119 is at 08:62:66:c5:79:0d
18 3.654787 192.168.50.119 → 239.255.255.250 SSDP 179 M-SEARCH * HTTP/1.1
19 3.656344 192.168.50.1 → 192.168.50.119 SSDP 341 HTTP/1.1 200 OK


Command Prompt
C:\>tshark -i 5 host 8.8.8.8
Capturing on 'Wire'
1 0.000000 192.168.50.119 → 8.8.8.8 DNS 71 Standard query 0xabcd A example.com
2 0.146698 8.8.8.8 → 192.168.50.119 DNS 87 Standard query response 0xabcd A example.com A 93.184.216.34
2 packets captured
C:\>

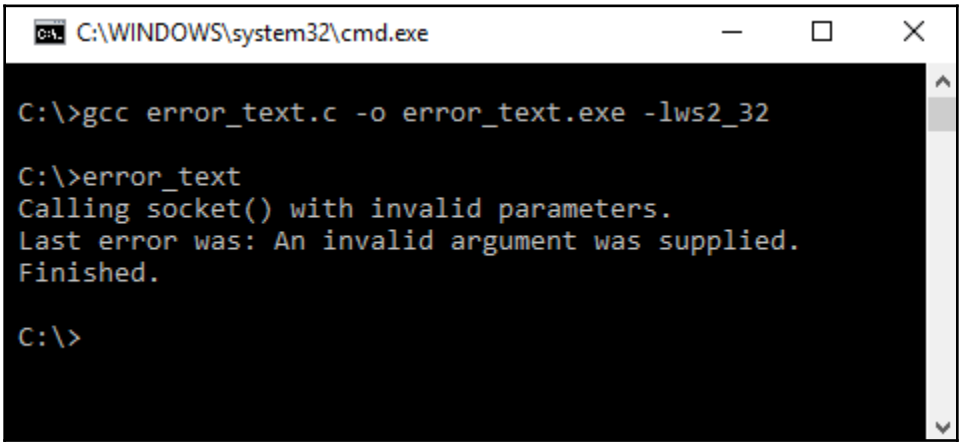

Command Prompt
C:\>tshark -i 5 host 93.184.216.34 and port 80
Capturing on 'Wire'
1 0.000000 192.168.50.119 → 93.184.216.34 TCP 66 5521 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
2 0.054634 93.184.216.34 → 192.168.50.119 TCP 66 80 → 5521 [SYN, ACK] Seq=0 Ack=1 Win=27800 Len=0 MSS=1370 SACK_PER
M=1 WS=32
3 0.054705 192.168.50.119 → 93.184.216.34 TCP 54 5521 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
4 0.054982 192.168.50.119 → 93.184.216.34 HTTP 145 GET / HTTP/1.1
5 0.095022 93.184.216.34 → 192.168.50.119 TCP 60 80 → 5521 [ACK] Seq=1 Ack=92 Win=27808 Len=0
6 0.098056 93.184.216.34 → 192.168.50.119 TCP 1424 HTTP/1.1 200 OK [TCP segment of a reassembled PDU]
7 0.098057 93.184.216.34 → 192.168.50.119 HTTP 300 HTTP/1.1 200 OK (text/html)
8 0.098057 93.184.216.34 → 192.168.50.119 TCP 60 80 → 5521 [FIN, ACK] Seq=1617 Ack=92 Win=27808 Len=0
9 0.098140 192.168.50.119 → 93.184.216.34 TCP 54 5521 → 80 [ACK] Seq=92 Ack=1618 Win=65536 Len=0
10 0.102372 192.168.50.119 → 93.184.216.34 TCP 54 5521 → 80 [FIN, ACK] Seq=92 Ack=1618 Win=65536 Len=0
11 0.155505 93.184.216.34 → 192.168.50.119 TCP 60 80 → 5521 [ACK] Seq=1618 Ack=93 Win=27808 Len=0
11 packets captured
C:\>

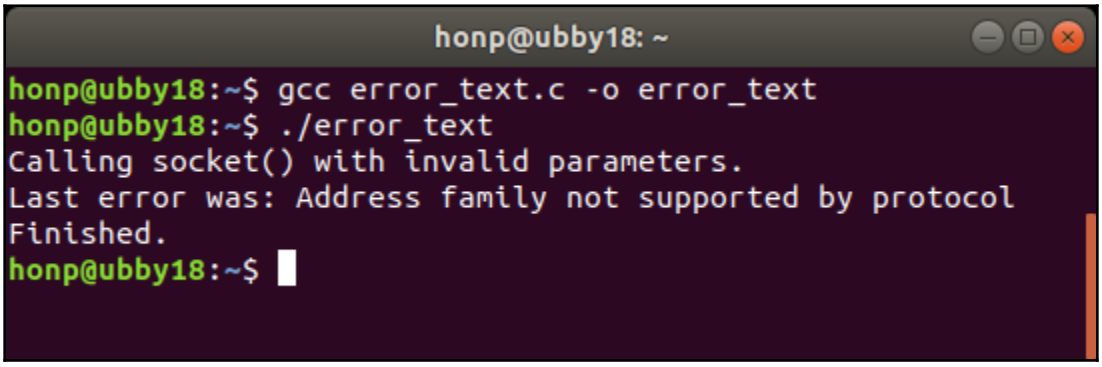

Command Prompt
C:\>tshark -i 5 -x host 93.184.216.34 and port 80
Capturing on 'Wire'
0000 14 91 82 6e 5c a8 08 62 66 c5 79 0d 08 00 45 00   ...n\..bf.y...E.
0010 00 34 56 4a 40 00 80 06 7b 7f c0 a8 32 77 5d b8   .4VJ@...{...2w].
0020 d8 22 58 69 00 50 a4 b0 17 bb 00 00 00 00 80 02   ."Xi.P..........
0030 fa f0 36 00 00 00 02 04 05 b4 01 03 03 08 01 01   ..6.............
0040 04 02   ..
0000 08 62 66 c5 79 0d 00 24 1d 7d ac 29 08 00 45 58   .bf.y..$.}.)..EX
0010 00 34 00 00 40 00 3c 06 15 72 5d b8 d8 22 c0 a8   .4..@.<..r]..".."
0020 32 77 00 50 58 69 8f 5b 75 d9 a4 b0 17 bc 80 12   2w.PXi.[u.......
0030 6c 98 bf 6f 00 00 02 04 05 5a 01 01 04 02 01 03   l..o.....Z......
0040 03 05   ..
0000 14 91 82 6e 5c a8 08 62 66 c5 79 0d 08 00 45 00   ...n\..bf.y...E.
0010 00 28 56 4b 40 00 80 06 7b 8a c0 a8 32 77 5d b8   .(VK@...{...2w].
0020 d8 22 58 69 00 50 a4 b0 17 bc 8f 5b 75 da 50 10   ."Xi.P.....[u.P.
0030 01 00 6b 7e 00 00   ..k~..
0000 14 91 82 6e 5c a8 08 62 66 c5 79 0d 08 00 45 00   ...n\..bf.y...E.
0010 00 83 56 4c 40 00 80 06 7b 2e c0 a8 32 77 5d b8   ..VL@...{...2w].
0020 d8 22 58 69 00 50 a4 b0 17 bc 8f 5b 75 da 50 18   ."Xi.P.....[u.P.
0030 01 00 ea fb 00 00 47 45 54 20 2f 20 48 54 54 50   ......GET / HTTP
0040 2f 31 2e 31 0d 0a 48 6f 73 74 3a 20 65 78 61 6d   /1.1..Host: exam
0050 70 6c 65 2e 63 6f 6d 3a 38 30 0d 0a 43 6f 6e 6e   ple.com:80..Conn
0060 65 63 74 69 6f 6e 3a 20 63 6c 6f 73 65 0d 0a 55   ection: close..U
0070 73 65 72 2d 41 67 65 6e 74 3a 20 68 6f 6e 70 77   ser-Agent: honpw
0080 63 20 77 65 62 5f 67 65 74 20 31 2e 30 0d 0a 0d   c web_get 1.0...
0090 0a   .

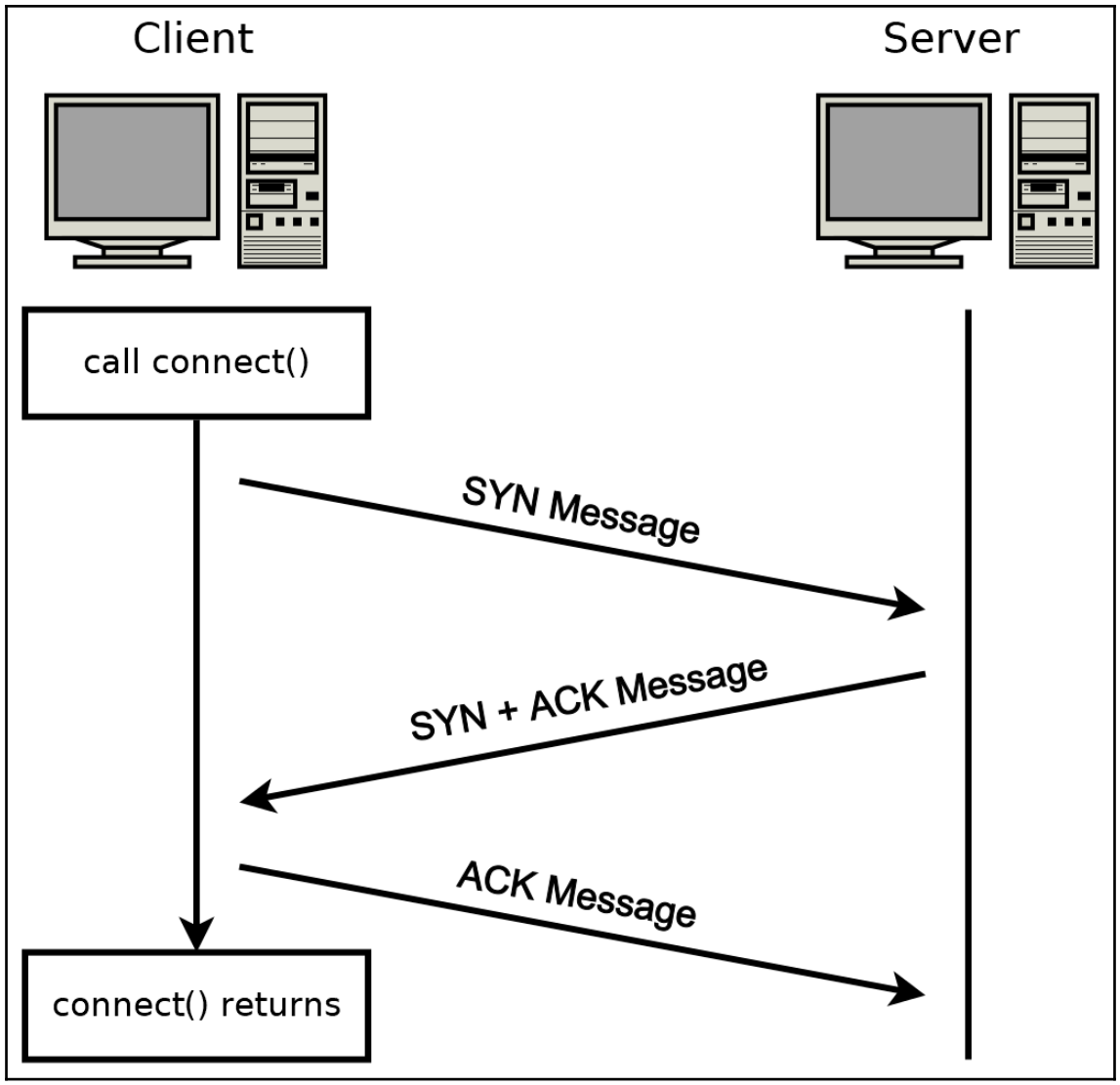

Command Prompt
C:\example>tshark -i 5 -w capture.pcap -c 50 tcp and port 80
Capturing on 'Wire'
50
C:\example>

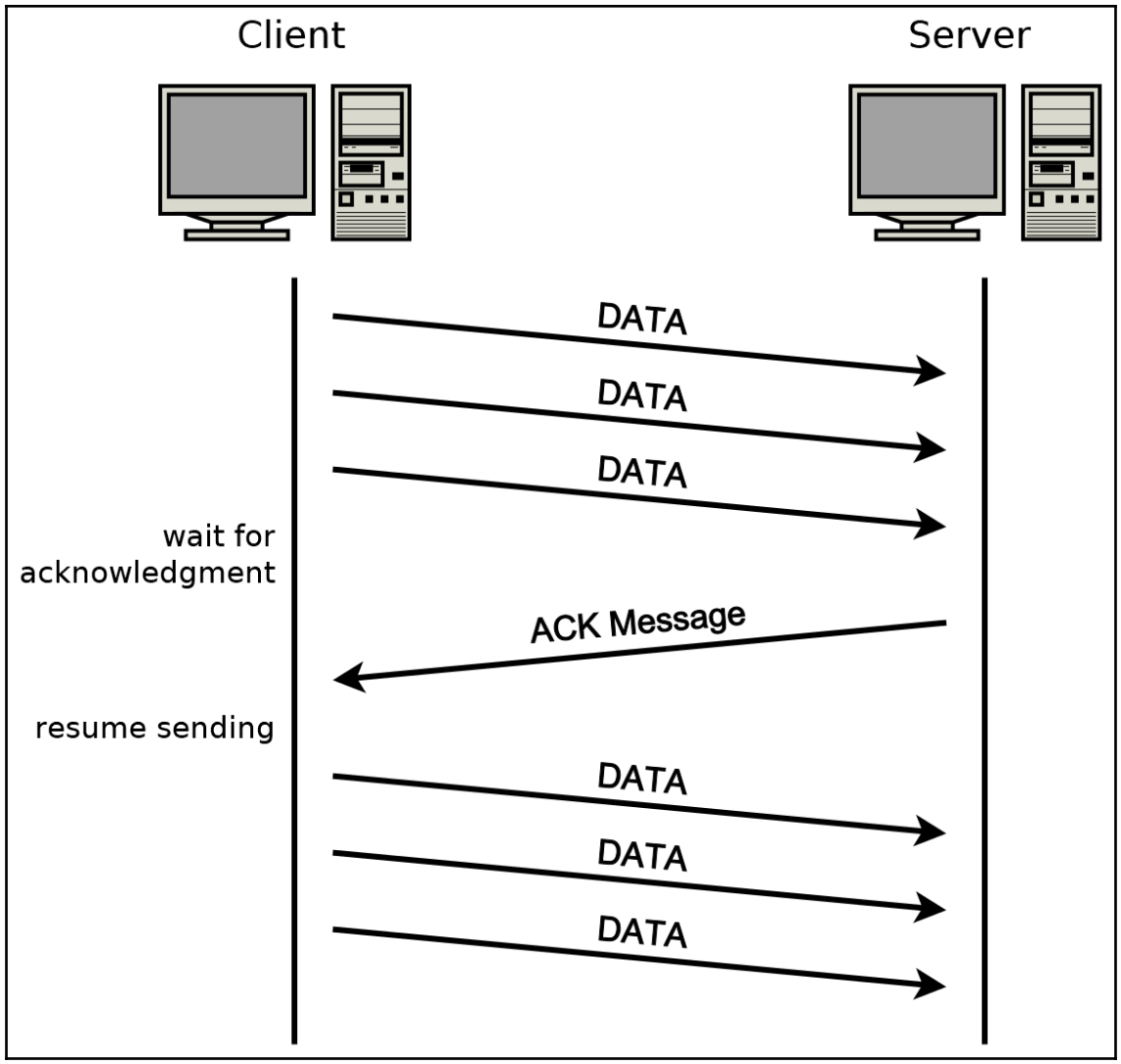

capture.pcap
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...
No. Time Source Destination Protocol Length Info
1 0.000000 192.168.50.119 93.184.216.34 TCP 66 22699
2 0.071997 93.184.216.34 192.168.50.119 TCP 66 80 →
3 0.072053 192.168.50.119 93.184.216.34 TCP 54 22699
4 0.072307 192.168.50.119 93.184.216.34 HTTP 145 GET /
5 0.112223 93.184.216.34 192.168.50.119 TCP 60 80 →
6 0.113881 93.184.216.34 192.168.50.119 TCP 1424 80 →
7 0.113881 93.184.216.34 192.168.50.119 HTTP 295 HTTP/
8 0.113882 93.184.216.34 192.168.50.119 TCP 60 80 →
9 0.113944 192.168.50.119 93.184.216.34 TCP 54 22699
10 0.117526 192.168.50.119 93.184.216.34 TCP 54 22699
11 0.191755 93.184.216.34 192.168.50.119 TCP 60 80 →
12 1.398024 192.168.50.119 13.33.155.31 TCP 54 22697
13 1.511914 13.33.155.31 192.168.50.119 TCP 60 80 →
Frame 4: 145 bytes on wire (1160 bits), 145 bytes captured (1160 bits) on interface 0
Ethernet II, Src: AsustekC_c5:79:0d (08:62:66:c5:79:0d), Dst: BelkinIn_6e:5c:a8 (14:91:82:6e:5c
Internet Protocol Version 4, Src: 192.168.50.119, Dst: 93.184.216.34
Transmission Control Protocol, Src Port: 22699, Dst Port: 80, Seq: 1, Ack: 1, Len: 91
Hypertext Transfer Protocol
GET / HTTP/1.1\r\n
Host: example.com:80\r\n
Connection: close\r\n
0000 14 91 82 6e 5c a8 08 62 66 c5 79 0d 08 00 45 00
0010 00 83 56 79 40 00 80 06 7b 01 c0 a8 32 77 5d b8
capture.pcap
Packets: 50 · Displayed: 50 (100.0%)
Profile: Default

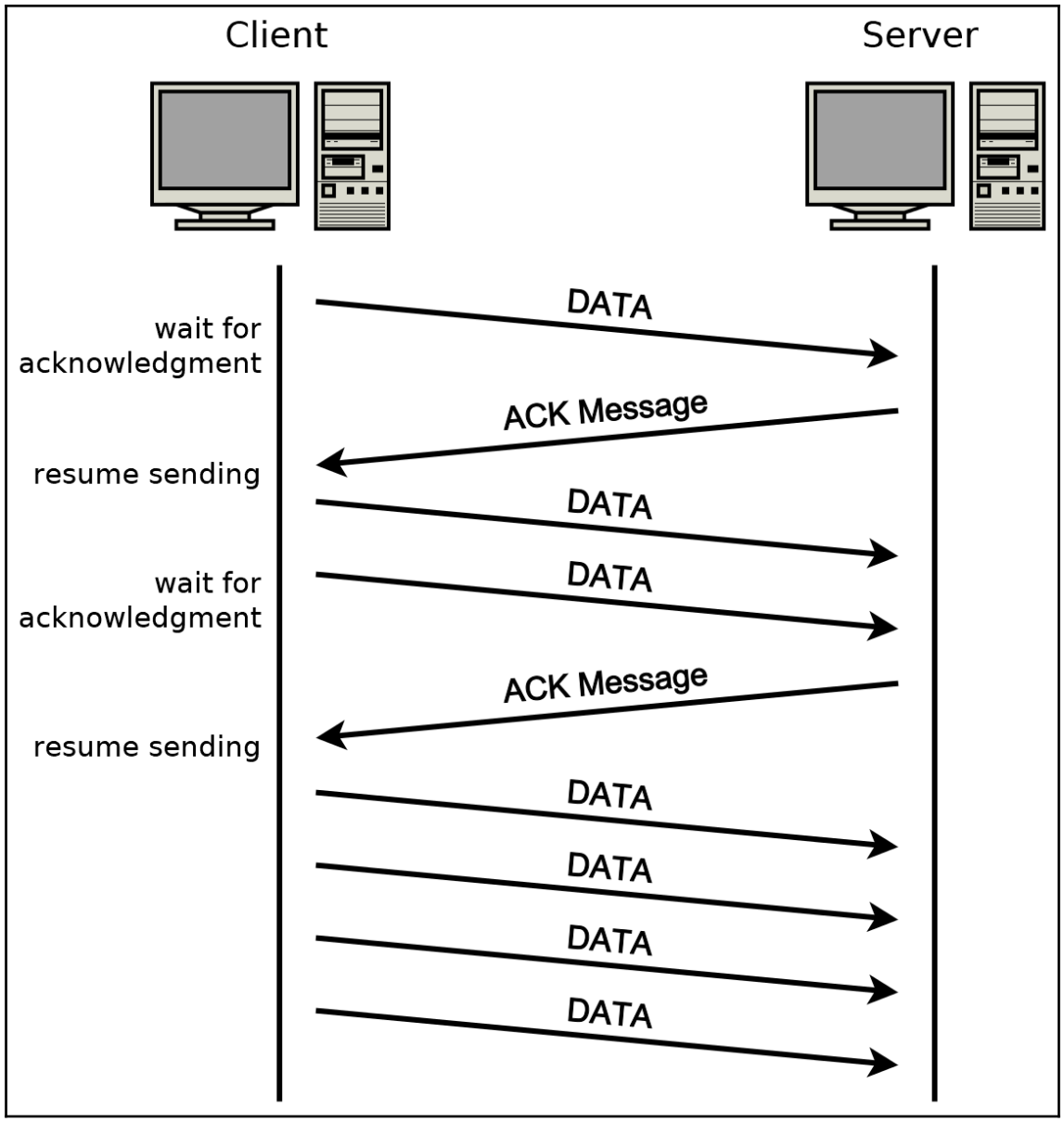
Chapter 13: Socket Programming Tips and Pitfalls

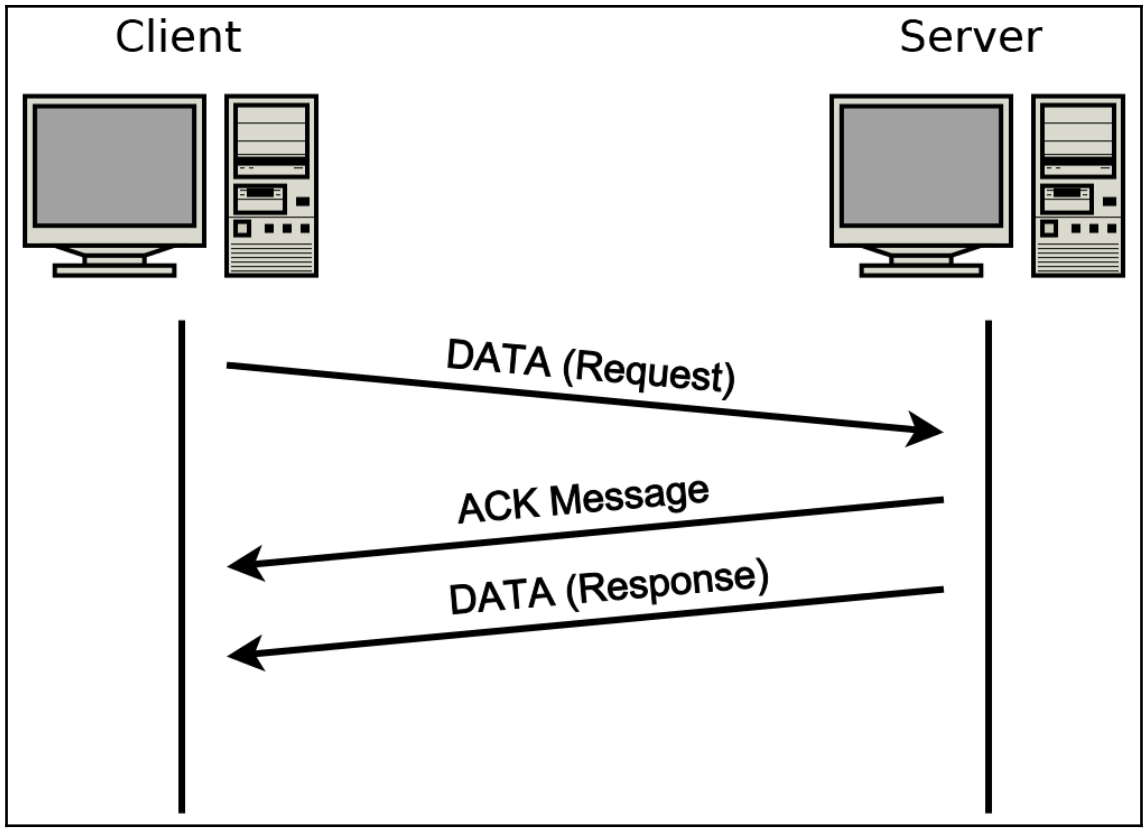


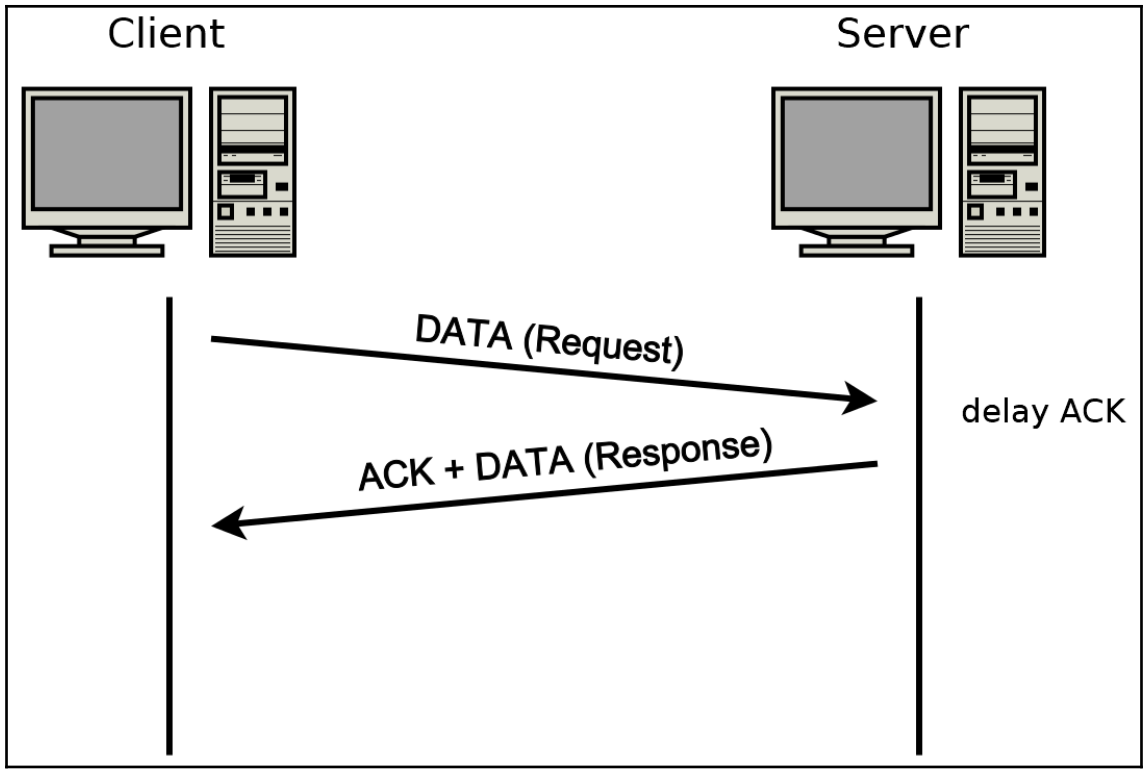


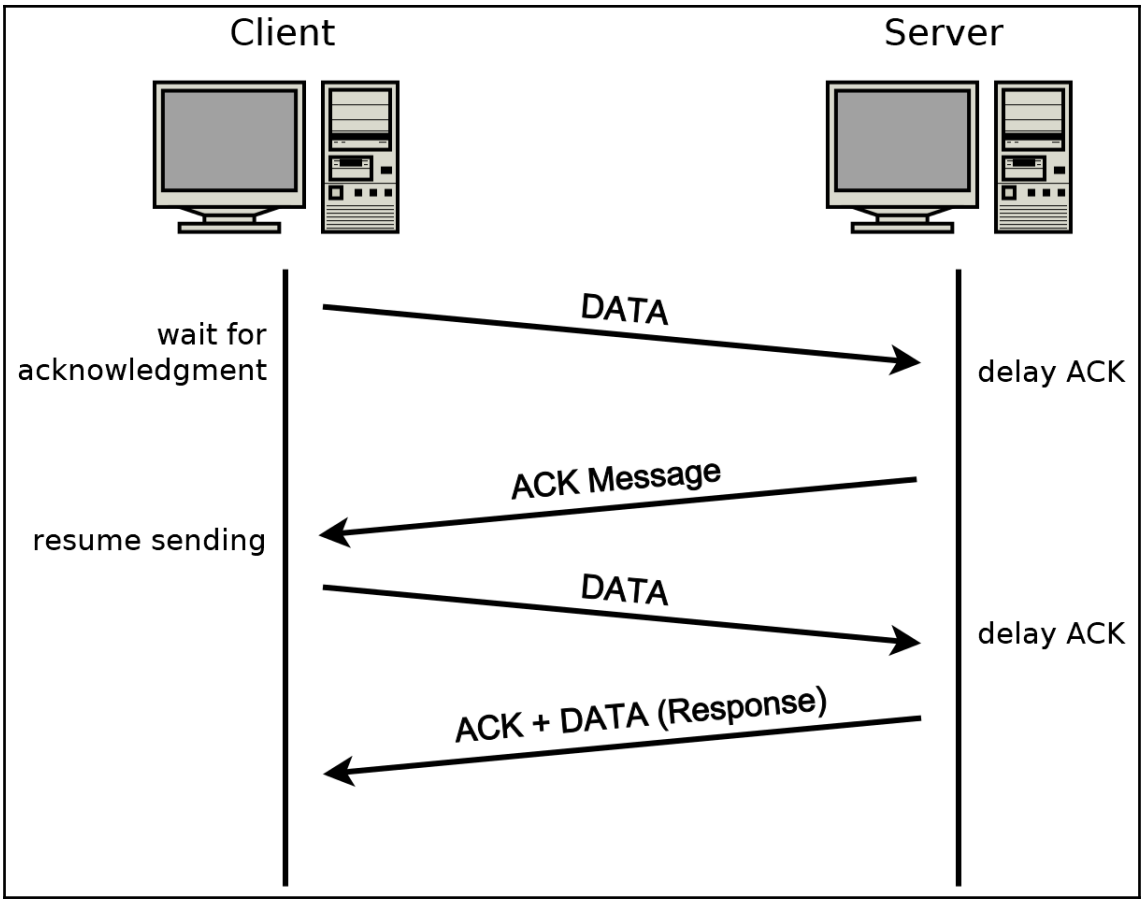

Client
Server
call connect()
SYN Message
SYN + ACK Message
ACK Message
connect() returns

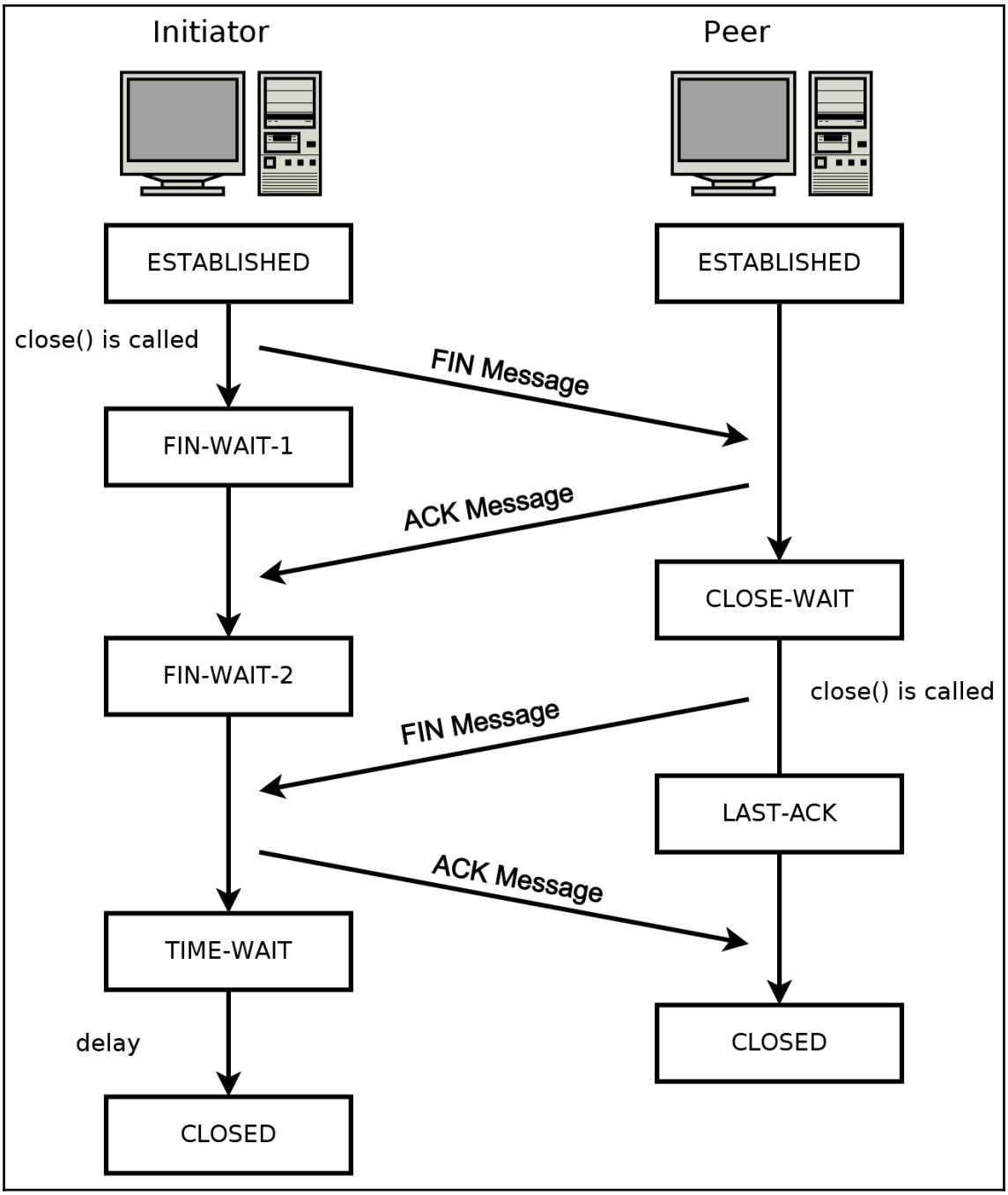

Client
Server
DATA
DATA
DATA
wait for
acknowledgment
ACK Message
resume sending
DATA
DATA
DATA

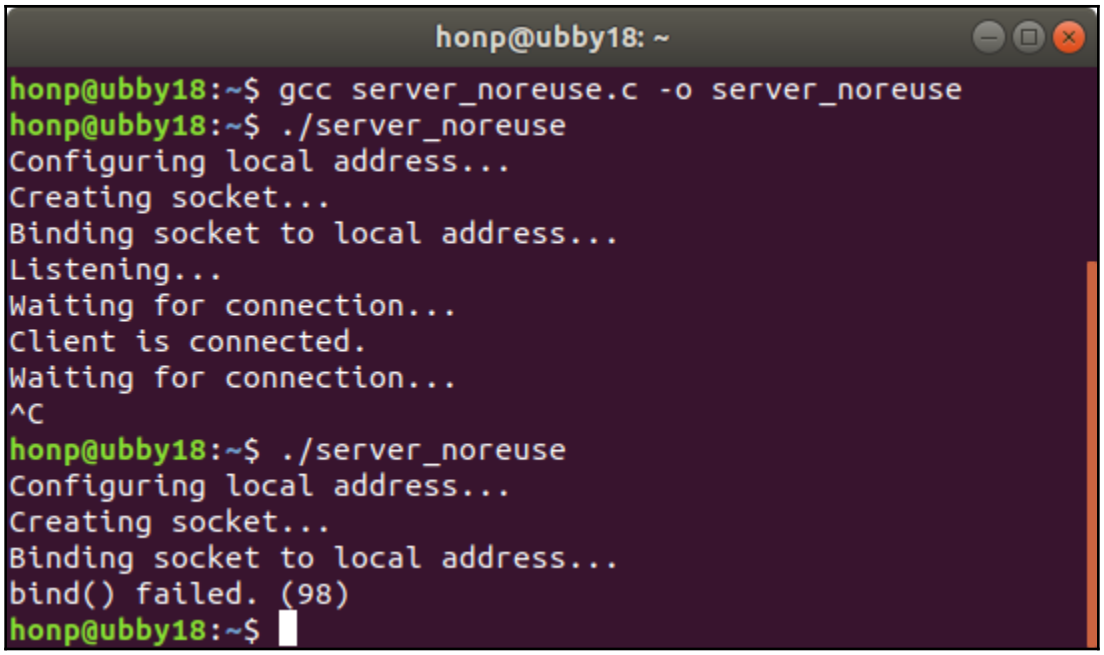

Client
Server
DATA
wait for acknowledgment
ACK Message
resume sending
DATA
DATA
wait for acknowledgment
ACK Message
resume sending
DATA
DATA
DATA
DATA

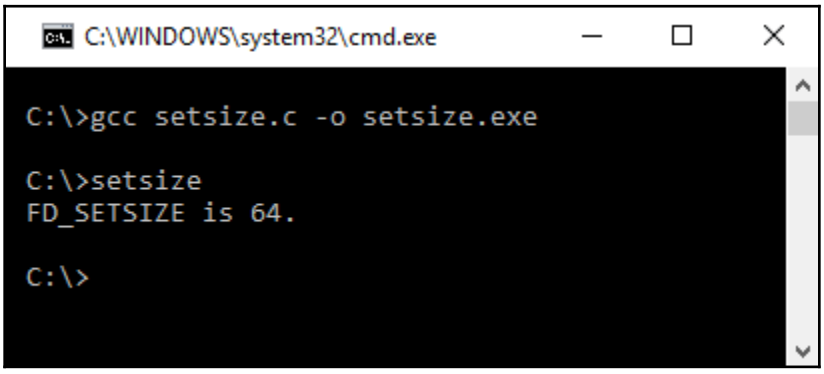

Client
Server
DATA (Request)
ACK Message
DATA (Response)


Client
Server
DATA (Request)
delay ACK
ACK + DATA (Response)

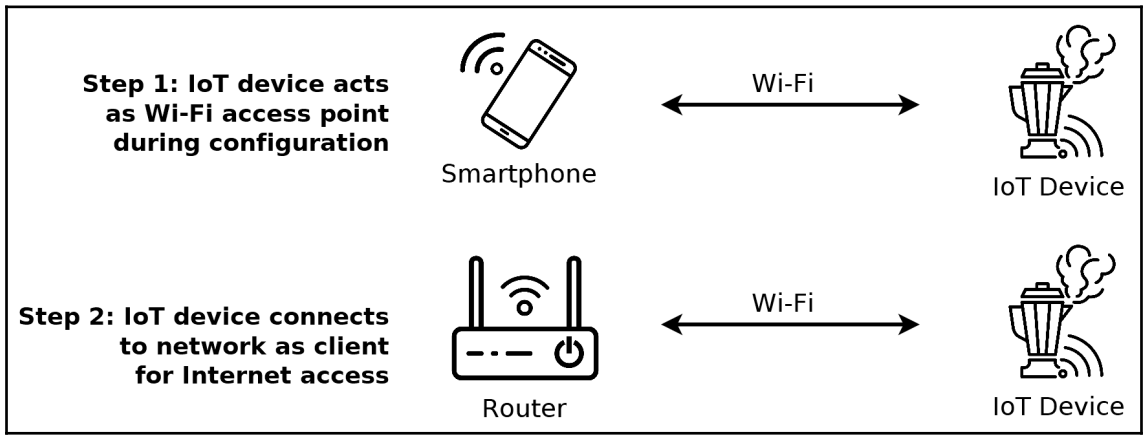

Client
Server
DATA
wait for acknowledgment
delay ACK
ACK Message
resume sending
DATA
delay ACK
ACK + DATA (Response)

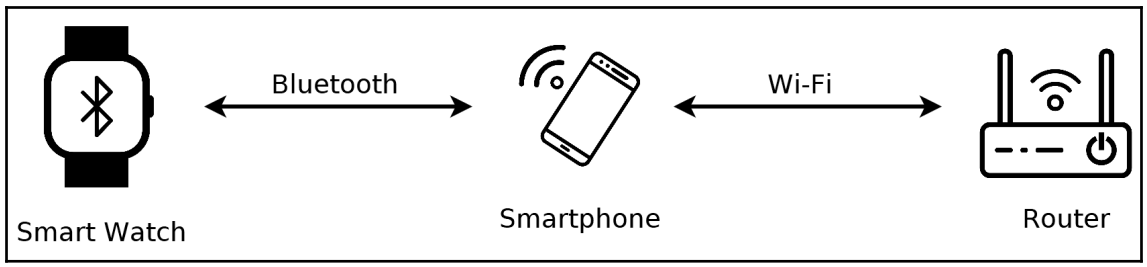

Initiator
Peer
ESTABLISHED
ESTABLISHED
close() is called
FIN Message
FIN-WAIT-1
ACK Message
CLOSE-WAIT
FIN-WAIT-2
close() is called
FIN Message
LAST-ACK
ACK Message
TIME-WAIT
delay
CLOSED
CLOSED

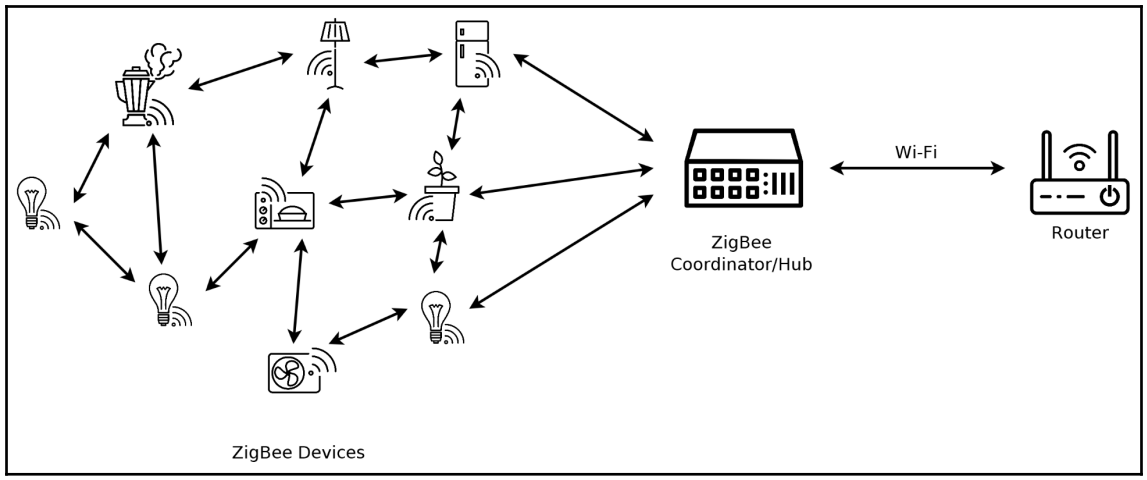

honp@ubby18: ~
honp@ubby18:~$ gcc server_noreuse.c -o server_noreuse
honp@ubby18:~$ ./server_noreuse
Configuring local address...
Creating socket...
Binding socket to local address...
Listening...
Waiting for connection...
Client is connected.
Waiting for connection...
^C
honp@ubby18:~$ ./server_noreuse
Configuring local address...
Creating socket...
Binding socket to local address...
bind() failed. (98)
honp@ubby18:~$

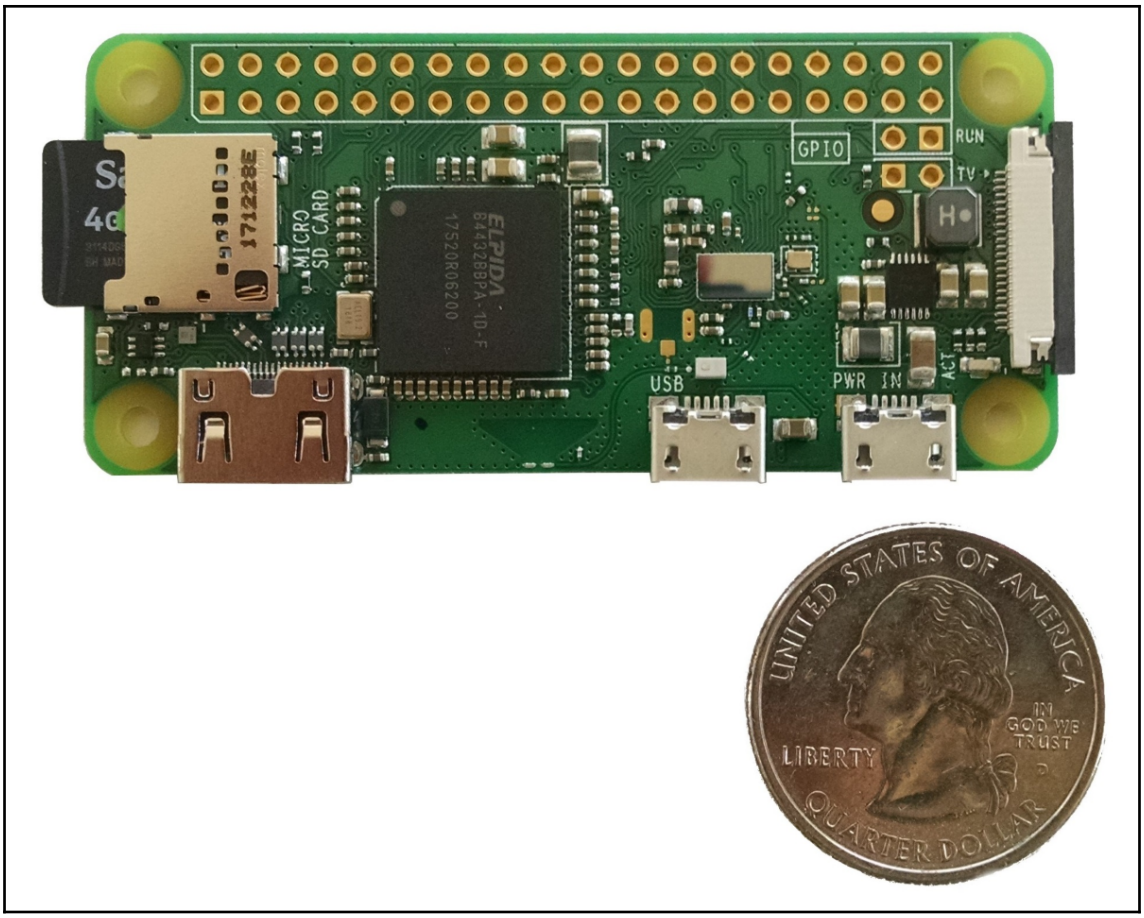

C:\WINDOWS\system32\cmd.exe
C:\>gcc setsize.c -o setsize.exe
C:\>setsize
FD_SETSIZE is 64.
C:\>

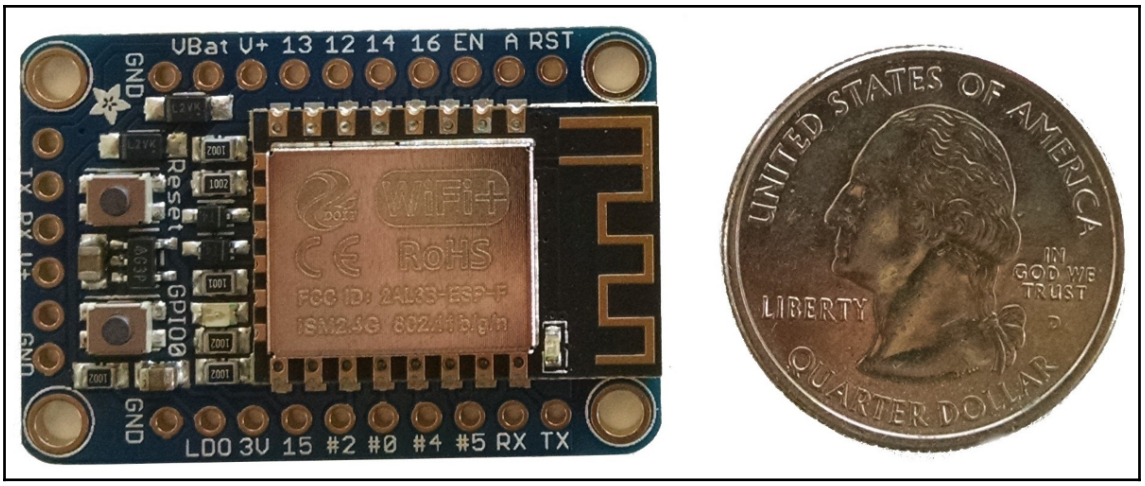
Chapter 14: Web Programming for the Internet of Things



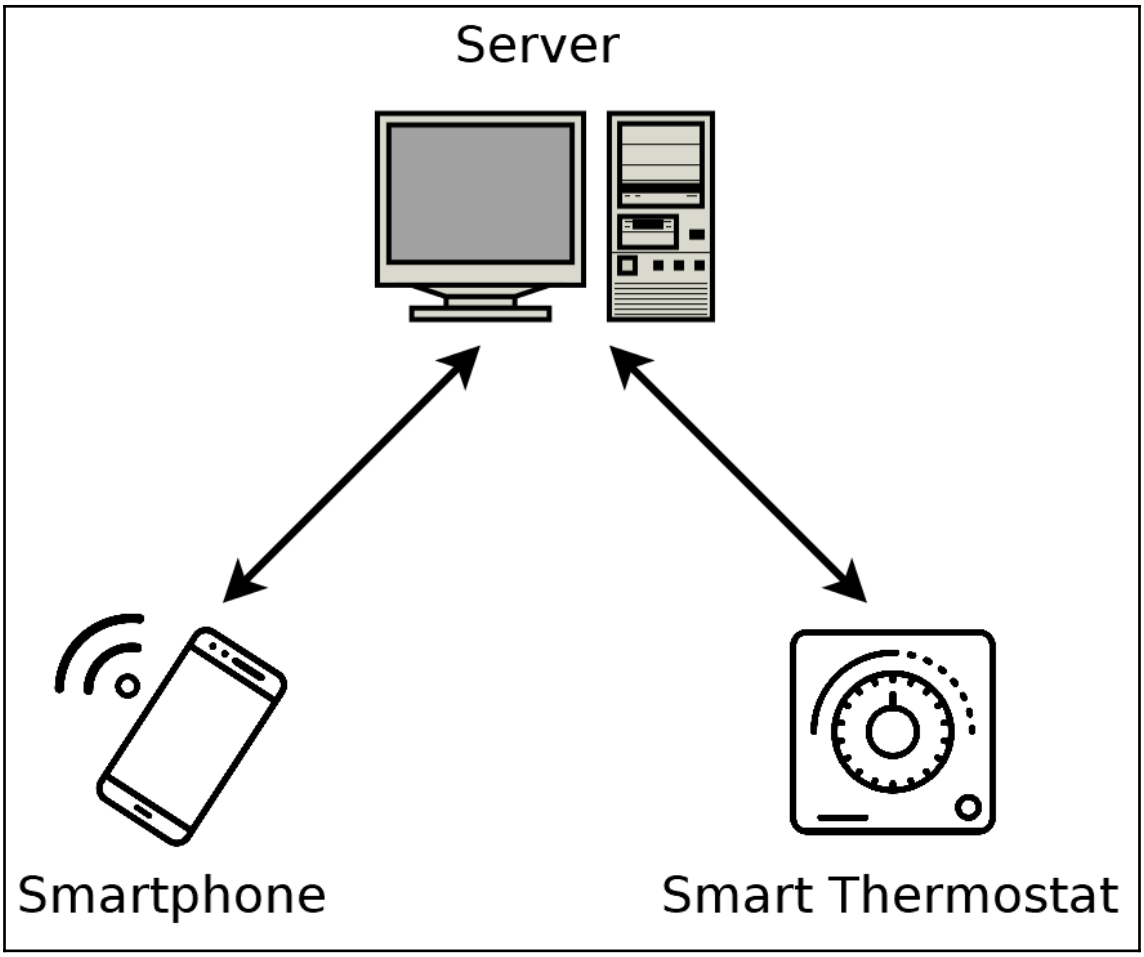





MICRO
SD CARD
ELPIDA
B4432BBPA-1D-F
GPIO
RUN
TV
USB
PWR IN
ACT
UNITED STATES OF AMERICA
LIBERTY
IN GOD WE TRUST
QUARTER DOLLAR


VBat V+ 13 12 14 16 EN A RST
GND
Reset
GPIO0
WiFi
RoHS
LDO 3V 15 #2 #0 #4 #5 RX TX
UNITED STATES OF AMERICA
LIBERTY
IN GOD WE TRUST
QUARTER DOLLAR


Model MTSMC-C2
FCC ID
SKU #
Serial#
MEID
DOM
E150299


Server
Smartphone
Smart Thermostat