

# Computer Networks

## Project 1 – Network Connectivity

1.

Locally (server, client, tcpdump):

The image shows three terminal windows. The top-left window runs a C++ server (server.cpp) listening on port 8000. The top-right window runs a netcat client (ncat 127.0.0.1 8000) connected to the server. The bottom window shows a tcpdump capture of the network traffic between the server and client, displaying packet details like IP addresses, ports, and flags.

a)

Server:

The image shows a terminal window titled ".server 4099". It displays the output of a C++ server (server.cpp) listening on port 4099. The server is receiving connections from various IP addresses, and the output shows the client's IP, the server's IP, and the port number. The output is as follows:

```
[benjamin18@skel ~/Tolvusamskipti]$ g++ -Wall -std=c++11 server.cpp -o server
[benjamin18@skel ~/Tolvusamskipti]$ ./server 4099
Listening on port: 4099
(range of available ports on skel.ru.is is 4000-4100)
Client connected on server
SYS who

magnusag20 pts/0      2020-08-19 13:09 (89-160-172-29.du.xdsl.is)
jonra20  pts/1      2020-08-20 14:06 (nova-157-097-005-096.cpe.nova.is)
arnaldur20 pts/2      2020-08-20 01:40 (237-129-17-89.fiber.hringdu.is)
andrii17  pts/3      2020-08-20 14:26 (31-209-231-245.dsl.dynamic.simnet.is)
joni20    pts/7      2020-08-20 16:01 (80.249.117.62)
danielg20 pts/8      2020-08-19 09:19 (194.144.153.22)
konrad20  pts/9      2020-08-20 14:22 (89.17.151.145)
antonh20  pts/10     2020-08-20 15:34 (nova-157-097-005-051.cpe.nova.is)
thelma20  pts/11     2020-08-20 15:49 (75-61-19-178.xdsl.sinafelagid.is)
arnit20   pts/12     2020-08-19 22:04 (194-144-0-76.du.xdsl.is)
noi20     pts/14     2020-08-20 15:36 (85-220-97-99.dsl.dynamic.simnet.is)
viktorj18 pts/15     2020-08-20 13:16 (31-209-237-34.dsl.dynamic.simnet.is)
olafur19  pts/16     2020-08-20 15:27 (185.86.223.11)
olafurs20 pts/17     2020-08-20 12:49 (nova-153-092-158-045.cpe.nova.is)
johannj20 pts/18     2020-08-20 11:26 (5.252.13.226)
marvina20 pts/19     2020-08-20 15:15 (nova-046-182-189-165.nat.nova.is)
gudmundurgj20 pts/20 2020-08-20 14:32 (46-239-214-249.du.xdsl.is)
ragnars19 pts/21     2020-08-20 15:59 (89-160-141-113.du.xdsl.is)
andrii18  pts/22     2020-08-20 13:01 (89-160-211-168.du.xdsl.is)
sveinn19  pts/23     2020-08-20 15:29 (31-209-150-169.dsl.dynamic.simnet.is)
eyjolfure19 pts/24 2020-08-20 15:43 (185.86.223.11)
helgal20  pts/25     2020-08-20 13:02 (89-160-216-212.du.xdsl.is)
runar16   pts/27     2020-08-20 13:52 (89-160-166-220.du.xdsl.is)
gylftg    pts/28     2020-08-20 13:57 (89-160-230-105.du.xdsl.is)
bjartur19 pts/29     2020-08-20 15:45 (213.181.116.249)
danielp20 pts/30     2020-08-20 15:47 (130.208.26.10)
rakelo20  pts/31     2020-08-20 15:47 (75-61-19-178.xdsl.sinafelagid.is)
benjamin18 pts/33 2020-08-20 15:52 (85-220-100-53.dsl.dynamic.simnet.is)
palmtg20  pts/34     2020-08-20 14:47 (85-220-104-43.dsl.dynamic.simnet.is)
daniels19 pts/35     2020-08-20 15:55 (31-209-218-88.dsl.dynamic.simnet.is)
bergsteinn20 pts/60 2020-08-19 12:19 (18-147-17-89.fiber.hringdu.is)
SYS w
```

```
16:02:08 up 623 days, 3:58, 30 users, load average: 0.08, 0.10, 0.13
USER      TTY      FROM          LOGIN@      IDLE   JCPU   PCPU WHAT
magnusag  pts/0    89-160-172-29.du mld13      17:55m  11.08s  11.08s -zsh
jonra20   pts/1    nova-157-097-005 14:06      15:28  17.22s  17.22s -zsh
arnaldur  pts/2    237-129-17-89.fi 01:40      14:21m  0.27s   0.27s -zsh
andrii17  pts/3    31-209-231-245.d 14:26      40.00s  17.72s  0.29s sshd: andrii17 [priv]
joni20    pts/7    80.249.117.62    16:01      14.00s  0.09s   0.00s info info
danielg2  pts/8    194.144.153.22   mld09      30:39m  0.70s   0.70s -zsh
konrad20  pts/9    89.17.151.145    14:22      1:36    5.91s   5.91s -zsh
antonh20  pts/10   nova-157-097-005 15:34      27:20   0.13s   0.13s -zsh
thelma20  pts/11   75-61-19-178.xds 15:49      6:40    0.64s   0.64s -zsh
arnit20   pts/12   194-144-0-76.du. mld22      17:57m  0.05s   0.05s -zsh
noi20     pts/14   85-220-97-99.dsl 15:36      2:00    1.99s   1.99s -zsh
viktorj1  pts/15   31-209-237-34.ds 13:16      2:45m   0.07s   0.07s -zsh
olafur19  pts/16   185.86.223.11    15:27      1:04    3.94s   3.94s -zsh
olafurs2  pts/17   nova-153-092-158 12:49      2:31m   2.78s   0.00s less
johannj2  pts/18   5.252.13.226     11:26      4:35m   0.28s   0.28s -zsh
marvina2  pts/19   nova-046-182-189 15:15      3:36    2.89s   0.31s sshd: marvina20 [priv]
gudmundu  pts/20   46-239-214-249.d 14:32      21:44   0.30s   0.00s less
ragnars1  pts/21   89-160-141-113.d 15:59      2:32    0.37s   0.37s -zsh
andrii18  pts/22   89-160-211-168.d 13:01      2:20m   0.43s   0.43s -zsh
sveinni1  pts/23   31-209-150-169.d 15:29      16:00   2.29s   2.29s -zsh
eyjolfur  pts/24   185.86.223.11    15:43      16.00s  2.40s   2.40s -zsh
helgal20  pts/25   89-160-216-212.d 13:02      2:58m   0.34s   0.34s -zsh
runar16   pts/27   89-160-166-220.d 13:52      1:02m   0.16s   0.00s ./server 4043
gylfig    pts/28   89-160-230-105.d 13:57      37:28   0.60s   0.60s -zsh
bjartur1  pts/29   213.181.116.249  15:45      0.00s   2.55s   2.55s -zsh
rakelo20  pts/31   75-61-19-178.xds 15:47      3:04    0.48s   0.48s -zsh
benjamin  pts/33   85-220-100-53.ds 15:52      6:48    0.22s   0.02s w
palmig20  pts/34   85-220-104-43.ds 14:47      2:16    1.67s   1.67s -zsh
daniels1  pts/35   31-209-218-88.ds 15:55      1:04    0.55s   0.00s less
bergstei  pts/60   18-147-17-89.fib mld12      25:37m  5.45s   5.45s -zsh
SYS ls
P1-TSAM.pdf server server.cpp
```

Client:

```
benjamin@benjamin-FX503VM: ~
benjamin@benjamin-FX503VM:~$ ncat 130.208.243.61 4099
SYS who
SYS w
SYS ls
```

Tcpdump:

```
benjamin@benjamin-FX503VM: ~
benjamin@benjamin-FX503VM:~$ tcpdump -D
1.wlp4s0 [Up, Running]
2.lo [Up, Running, Loopback]
3.any (Pseudo-device that captures on all interfaces) [Up, Running]
4.enp2s0 [Up]
5.bluetooth-monitor (Bluetooth Linux Monitor) [none]
6.nflog (Linux netfilter log (NFLOG) interface) [none]
7.nfqueue (Linux netfilter queue (NFQUEUE) interface) [none]
8.bluetooth0 (Bluetooth adapter number 0) [none]
benjamin@benjamin-FX503VM:~$ sudo tcpdump -X -i wlp4s0 host 130.208.243.61 and p
ort 4099
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlp4s0, link-type EN10MB (Ethernet), capture size 262144 bytes
16:01:55.493222 IP 192.168.1.112.50452 > 130.208.243.61.4099: Flags [S], seq 191
7206683, win 64240, options [mss 1460,sackOK,TS val 599566193 ecr 0,nop,wscale 7
], length 0
0x0000: 4500 003c 7146 4000 4006 914f c0a8 0170 E...<qf@.0...p
0x0010: 82d0 f33d c514 1003 7246 409b 0000 0000 ...=....rF@....
0x0020: a002 faf0 c1c1 0000 0204 05b4 0402 080a .....
0x0030: 23bc a771 0000 0000 0103 0307 #..q.....
16:01:55.513676 IP 130.208.243.61.4099 > 192.168.1.112.50452: Flags [S.], seq 31
52211919, ack 1917206684, win 28960, options [mss 1380,sackOK,TS val 2301573458
ecr 599566193,nop,wscale 7], length 0
0x0000: 4500 003c 0000 4000 3706 0b96 82d0 f33d E...<.@.7.....=
0x0010: c0a8 0170 1003 c514 bbe2 efcf 7246 409c ...p.....rF@....
0x0020: a012 7120 dd9c 0000 0204 0564 0402 080a ..q.....d....
0x0030: 892f 3952 23bc a771 0103 0307 ./9R#..q....
16:01:55.513696 IP 192.168.1.112.50452 > 130.208.243.61.4099: Flags [.], ack 1,
win 502, options [nop,nop,TS val 599566213 ecr 2301573458], length 0
0x0000: 4500 0034 7147 4000 4006 9156 c0a8 0170 E..4qG@.0.V...p
0x0010: 82d0 f33d c514 1003 7246 409c bbe2 efd0 ...=....rF@....
0x0020: 8010 01f6 7b2f 0000 0101 080a 23bc a785 ....{/.....#...
0x0030: 892f 3952 ./9R
```

```
16:02:03.450662 IP 192.168.1.112.50452 > 130.208.243.61.4099: Flags [P.], seq 1:
9, ack 1, win 502, options [nop,nop,TS val 599574150 ecr 2301573458], length 8
0x0000: 4500 003c 7148 4000 4006 914d c0a8 0170 E..<qH@.0..M...p
0x0010: 82d0 f33d c514 1003 7246 409c bbe2 efd0 ...=...rF@....
0x0020: 8018 01f6 cf31 0000 0101 080a 23bc c686 .....1.....#...
0x0030: 892f 3952 5359 5320 7768 6f0a ./9RSYS.who.
16:02:03.471326 IP 130.208.243.61.4099 > 192.168.1.112.50452: Flags [.], ack 9,
win 227, options [nop,nop,TS val 2301581416 ecr 599574150], length 0
0x0000: 4500 0034 f38b 4000 3706 1812 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 1003 c514 bbe2 efd0 7246 40a4 ...p.....rF@.
0x0020: 8010 00e3 3e23 0000 0101 080a 892f 5868 .....>#...../Xh
0x0030: 23bc c686 #...
16:02:08.248401 IP 192.168.1.112.50452 > 130.208.243.61.4099: Flags [P.], seq 9:
15, ack 1, win 502, options [nop,nop,TS val 599578948 ecr 2301581416], length 6
0x0000: 4500 003a 7149 4000 4006 914e c0a8 0170 E..:qI@.0..N...p
0x0010: 82d0 f33d c514 1003 7246 40a4 bbe2 efd0 ...=...rF@....
0x0020: 8018 01f6 0cc0 0000 0101 080a 23bc d944 .....#...D
0x0030: 892f 5868 5359 5320 770a ./XhSYS.w.
16:02:08.274073 IP 130.208.243.61.4099 > 192.168.1.112.50452: Flags [.], ack 15,
win 227, options [nop,nop,TS val 2301586216 ecr 599578948], length 0
0x0000: 4500 0034 f38c 4000 3706 1811 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 1003 c514 bbe2 efd0 7246 40aa ...p.....rF@.
0x0020: 8010 00e3 189f 0000 0101 080a 892f 6b28 ...../k(
0x0030: 23bc d944 #..D
16:02:10.910854 IP 192.168.1.112.50452 > 130.208.243.61.4099: Flags [P.], seq 15:
22, ack 1, win 502, options [nop,nop,TS val 599581610 ecr 2301586216], length 7
0x0000: 4500 003b 714a 4000 4006 914c c0a8 0170 E..;qJ@.0..L...p
0x0010: 82d0 f33d c514 1003 7246 40aa bbe2 efd0 ...=...rF@....
0x0020: 8018 01f6 f029 0000 0101 080a 23bc e3aa .....#...
0x0030: 892f 6b28 5359 5320 6c73 0a ./k(SYS.ls.
16:02:10.930882 IP 130.208.243.61.4099 > 192.168.1.112.50452: Flags [.], ack 22,
win 227, options [nop,nop,TS val 2301588876 ecr 599581610], length 0
0x0000: 4500 0034 f38d 4000 3706 1810 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 1003 c514 bbe2 efd0 7246 40b1 ...p.....rF@.
0x0020: 8010 00e3 03ce 0000 0101 080a 892f 758c ...../u.
0x0030: 23bc e3aa #...
```

2.

a)

Client code connecting can be found in the file: **"client.cpp"**

```
benjamin@benjamin-FX503VM: ~/TSAM
benjamin@benjamin-FX503VM:~/TSAM$ g++ -Wall -std=c++11 client.cpp -o client
benjamin@benjamin-FX503VM:~/TSAM$ ./client 130.208.243.61 4055
> SYS w
benjamin@benjamin-FX503VM:~/TSAM$
```

b)

Server receiving command and executing it:

```
./server 4055
[benjamin18@skel ~/Tolvusamskipti]$ g++ -Wall -std=c++11 server.cpp -o server
[benjamin18@skel ~/Tolvusamskipti]$ ./server 4055
Listening on port: 4055
(range of available ports on skel.ru.is is 4000-4100)
Client connected on server
SYS w
10:57:30 up 625 days, 22:53, 10 users, load average: 0,11, 0,08, 0,09
USER      TTY      FROM          LOGIN@      IDLE   JCPU   PCPU WHAT
arnit20   pts/0    194-144-0-76.du. 00:22      10:26m  3.04s  3.04s -zsh
thorgils  pts/1    41-133-17-89.fib f0s22      25:45m  0.76s  0.68s -zsh
isabella  pts/2    nova-153-092-130 09:09       1:38   3.21s  3.21s -zsh
runarf18  pts/3    nova-157-097-014 09:28       2:58   9.11s  9.11s -zsh
benedikt  pts/5    89-160-199-59.du 10:03      49:38   0.32s  0.30s sshd: benedikt
ragnheid  pts/7    116-150-17-89.fi 10:47       1:06   0.49s  0.00s less
danielg2  pts/8    194.144.153.22   mid09      4days    0.70s  0.70s -zsh
benjamin  pts/9    85-220-100-53.ds 10:48       2:50   0.54s  0.03s w
marcin15  pts/10   89-160-137-89.du 10:51       5:22   0.18s  0.18s -zsh
skarphed  pts/11   89-160-178-121.d fim17      43:28m 10.80s  0.39s sshd: skarphedi
```

c) tcpdump of command being sent to server:

```
benjamin@benjamin-FX503VM: ~
benjamin@benjamin-FX503VM:~$ sudo tcpdump -X -i wlp4s0 host 130.208.243.61 and port 4055
[sudo] password for benjamin:
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on wlp4s0, link-type EN10MB (Ethernet), capture size 262144 bytes
10:57:22.157554 IP 192.168.1.112.56430 > 130.208.243.61.4055: Flags [S], seq 1018814185, win 64240, options [mss 1460,sackOK,TS val 3352164595 ecr 0,nop,wscale 7], length 0
0x0000: 4500 003c a383 4000 4006 5f12 c0a8 0170 E..<..@.0....p
0x0010: 82d0 f33d dc6e 0fd7 3cb9 dee9 0000 0000 ...=.n.<.....
0x0020: a002 faf0 4c3e 0000 0204 05b4 0402 080a ....L>.....
0x0030: c7cd f8f3 0000 0000 0103 0307 .....
10:57:22.178651 IP 130.208.243.61.4055 > 192.168.1.112.56430: Flags [S.], seq 3845161429, ack 1018814186, win 28960, options [mss 1380,sackOK,TS val 2542500124 ecr 3352164595,nop,wscale 7], length 0
0x0000: 4500 003c 0000 4000 3706 0b96 82d0 f33d E..<..@.7.....=
0x0010: c0a8 0170 0fd7 dc6e e530 81d5 3cb9 deea ...p...n.0.<...
0x0020: a012 7120 5e9f 0000 0204 0564 0402 080a ...Q.^.....d....
0x0030: 978b 791c c7cd f8f3 0103 0307 ..Y.....
10:57:22.178701 IP 192.168.1.112.56430 > 130.208.243.61.4055: Flags [.], ack 1, win 502, options [nop,nop,TS val 3352164617 ecr 2542500124], length 0
0x0000: 4500 0034 a384 4000 4006 5f19 c0a8 0170 E..4..@.0....p
0x0010: 82d0 f33d dc6e 0fd7 3cb9 deea e530 81d6 ...=.n.<.....0..
0x0020: 8010 01f6 fc2f 0000 0101 080a c7cd f909 ...y./.....
0x0030: 978b 791c .....
10:57:30.181574 IP 192.168.1.112.56430 > 130.208.243.61.4055: Flags [P.], seq 1:7, ack 1, win 502, options [nop,nop,TS val 3352172619 ecr 2542500124], length 6
0x0000: 4500 0034 a385 4000 4006 5f12 c0a8 0170 E...@.0....p
0x0010: 82d0 f33d dc6e 0fd7 3cb9 deea e530 81d6 ...=.n.<.....0..
0x0020: 8010 01f6 bf65 0000 0101 080a c7ce 184b ....e.....K
0x0030: 978b 791c 5359 5320 7700 ..y.SYS.w.
10:57:30.181629 IP 192.168.1.112.56430 > 130.208.243.61.4055: Flags [F.], seq 7, ack 1, win 502, options [nop,nop,TS val 3352172619 ecr 2542500124], length 0
0x0000: 4500 0034 a386 4000 4006 5f17 c0a8 0170 E..4..@.0....p
0x0010: 82d0 f33d dc6e 0fd7 3cb9 def0 e530 81d6 ...=.n.<.....0..
0x0020: 8011 01f6 dce6 0000 0101 080a c7ce 184b .....K
0x0030: 978b 791c ..y.
10:57:30.202036 IP 130.208.243.61.4055 > 192.168.1.112.56430: Flags [.], ack 7, win 227, options [nop,nop,TS val 2542508148 ecr 3352172619], length 0
0x0000: 4500 0034 83e7 4000 3706 87b6 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 0fd7 dc6e e530 81d6 3cb9 def0 ...p...n.0.<...
0x0020: 8010 00e3 bea2 0000 0101 080a 978b 9874 .....t
0x0030: c7ce 184b ...K
10:57:30.242638 IP 130.208.243.61.4055 > 192.168.1.112.56430: Flags [.], ack 8, win 227, options [nop,nop,TS val 2542508189 ecr 3352172619], length 0
0x0000: 4500 0034 83e8 4000 3706 87b5 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 0fd7 dc6e e530 81d6 3cb9 def1 ...p...n.0.<...
0x0020: 8010 00e3 be78 0000 0101 080a 978b 989d .....X.....
0x0030: c7ce 184b ...K
10:57:30.260184 IP 130.208.243.61.4055 > 192.168.1.112.56430: Flags [F.], seq 1, ack 8, win 227, options [nop,nop,TS val 2542508206 ecr 3352172619], length 0
0x0000: 4500 0034 83e9 4000 3706 87b4 82d0 f33d E..4..@.7.....=
0x0010: c0a8 0170 0fd7 dc6e e530 81d6 3cb9 def1 ...p...n.0.<...
0x0020: 8011 00e3 be66 0000 0101 080a 978b 98ae .....f.....
0x0030: c7ce 184b ...K
10:57:30.260219 IP 192.168.1.112.56430 > 130.208.243.61.4055: Flags [.], ack 2, win 502, options [nop,nop,TS val 3352172698 ecr 2542508206], length 0
0x0000: 4500 0034 0000 4000 4006 029e c0a8 0170 E..4..@.0....p
0x0010: 82d0 f33d dc6e 0fd7 3cb9 def1 e530 81d7 ...=.n.<.....0..
0x0020: 8010 01f6 bd04 0000 0101 080a c7ce 189a .....
0x0030: 978b 98ae ....
```

3.

a) Modified server code can be found in the file: **“server\_modified.cpp”**

b) Modified client code can be found in the file: **“client\_modified.cpp”**

c) tcpdump of (at least) two commands being sent to server and response being received:

tcpdump:

5



6

7

client:

8



```
arnorg20 pts/43      2020-08-26 13:55 (130.208.24.155)
garpur19 pts/44      2020-08-26 14:39 (186-138-17-89.fiber.hringdu.is)
bjarnid19 pts/45      2020-08-26 13:05 (10.1.17.40)
palmig20 pts/47      2020-08-26 13:56 (85-220-104-43.dsl.dynamic.sinnet.is)
arnarg  pts/49      2020-08-26 14:04 (89-160-158-17.du.xdsl.is)
eydis13 pts/50      2020-08-26 14:04 (89-160-229-40.du.xdsl.is)
johanng20 pts/52      2020-08-26 13:25 (ipnet-gw.157.157.10.179.sinnet.is)
thoranna18 pts/53      2020-08-26 14:39 (124-137-17-89.fiber.hringdu.is)
magnusi18 pts/54      2020-08-26 13:36 (nova-153-092-135-098.cpe.nova.is)
elnarp18 pts/55      2020-08-26 13:37 (81-227-142-95-no519.tbcn.tella.com)
benedikt13 pts/56      2020-08-26 13:38 (89-160-199-59.du.xdsl.is)
daniel19 pts/57      2020-08-26 14:06 (31-209-218-88.dsl.dynamic.sinnet.is)
benedikt13 pts/58      2020-08-26 13:40 (89-160-199-59.du.xdsl.is)
annaa17 pts/59      2020-08-26 14:13 (89-160-146-234.du.xdsl.is)
stefant17 pts/60      2020-08-26 13:40 (81-15-110-218.du.xdsl.is)
kristinnk18 pts/61      2020-08-26 14:23 (b7-217.gardur.hl.is)
daniel18 pts/62      2020-08-26 14:26 (85-220-118-209.dsl.dynamic.sinnet.is)
nina19 pts/63      2020-08-26 14:31 (nova-157-097-023-241.cpe.nova.is)
hinrik20 pts/64      2020-08-26 14:33 (89-160-207-115.du.xdsl.is)
birna17 pts/66      2020-08-26 14:40 (89-160-167-205.du.xdsl.is)
evap19 pts/67      2020-08-26 14:40 (10.2.27.138)

> SYS W
Output:
14:49:46 up 629 days, 2:45, 55 users, load average: 0.13, 0.15, 0.22
USER      TTY      FROM          LOGIN@      IDLE   JCPU   PCPU   WHAT
aronp20   pts/0     89-160-244-142.d 12:40      1:52m   0.35s   0.35s   -zsh
johannb1  pts/1     72-129-17-89.fib 12:40      2days   0.07s   0.07s   -zsh
gudrunf1  pts/2     157-157-161-140. 12:38      2:11m   0.15s   0.00s   ./server 4013
arone20   pts/5     246-138-17-89.f 13:47      2.00s   9.62s   9.62s   -zsh
eggerte1  pts/7     nova-157-097-020 12:09      2:58    6.45s   0.32s   sshd: eggerte19 [priv]
danielg2  pts/8     194-144-153-22. 19:20      1:42m   26.06s  26.06s  -zsh
ulfars20  pts/9     46-239-211-182.d 12:20      18:01m   0.07s   0.07s   -zsh
arnort20  pts/10    31-209-193-84.ds 10:14      1:18m   5.26s   5.26s   -zsh
tomast20  pts/11    194.144.235.141 11:40      2.00s   7.14s   7.14s   -zsh
thelma06  pts/12    239-149-17-89.f 12:29      16:58   2.57s   2.57s   -zsh
stefans2  pts/14    157-157-208-16.d 12:50      43:06   9.56s   9.51s   -zsh
helgal20  pts/16    89-160-216-212.d 11:33      1:25m   8.23s   8.23s   -zsh
sarals17  pts/17    5.252.12.61      09:19      1:04m   2.57s   2.57s   -zsh
gudmundu  pts/18    89-160-211-200.d 09:03      5:11m   0.28s   0.28s   -zsh
hallnar1  pts/19    31-209-234-67.ds 14:23      2.00s   0.77s   0.07s   vim list.sh
ofelgur2  pts/20    89-160-150-150.d 13:00      10:42    7.95s   7.95s   -zsh
arnthor1  pts/21    85-220-115-205.d 13:17      1:30m   0.15s   0.00s   ./server 4014
hafsteinn pts/22    157-157-214-183. 13:00      24:42    7.83s   7.83s   -zsh
arnarg  pts/23    89-160-158-17.du 12:22      2:19m   0.38s   0.00s   ./server 4040
smarb20   pts/24    212-30-203-49.st 14:15      32:10   0.18s   0.18s   -zsh
baldurb2  pts/25    157-157-72-237.d 12:40      23:54   3.67s   3.67s   -zsh
benjamin  pts/27    85-220-100-53.ds 14:35      34.00s   0.71s   0.01s   w
hordurh2  pts/28    10.2.27.143      13:45      1:38    4.21s   4.21s   -zsh

kristinnk pts/29    105-108-22-46.fl 14:46      3:06    0.13s   0.00s   ./server 4500
annan20   pts/30    10.3.27.151       12:03      2:11m   1.04s   1.04s   -zsh
benedikt  pts/31    89-160-199-59.du 10:18      4:16m   0.42s   0.42s   -zsh
svanfrid  pts/33    46-239-214-57.du 14:19      19:46   3.97s   3.97s   -zsh
grtmurg2  pts/34    nova-046-182-188 14:36      11:22   0.26s   0.26s   -zsh
bjorgvinn pts/35    10-106-22-46.fib 13:31      18:58   0.51s   0.33s   sshd: bjorgvinn17 [priv]
unnur19   pts/36    77.83.110.119     14:20      27:14   0.34s   0.34s   -zsh
hol20     pts/37    85-220-97-99.dsl 14:10      9:06    3.44s   3.44s   -zsh
ragnars1  pts/39    89-160-141-113.d 11:17      18:12m   15.14s   15.14s  -zsh
arnark18  pts/40    dsl-149-104-7.hl 14:21      8:50    0.08s   0.00s   ./server 4100
sigurdur  pts/41    31-209-220-154.d 13:06      1:14    5.01s   5.01s   -zsh
arnorg20  pts/43    130.208.24.155    13:55      45:54   0.34s   0.34s   -zsh
garpur19  pts/44    186-138-17-89.f 14:39      10.00s   2.11s   2.11s   -zsh
bjarnid1  pts/45    10.1.17.40         13:05      4:58    0.85s   0.85s   -zsh
palmig20  pts/47    85-220-104-43.ds 13:56      33:54   1.53s   1.53s   -zsh
arnarg  pts/49    89-160-158-17.du 14:04      21:06   0.55s   0.55s   -zsh
eydis13   pts/50    89-160-229-40.du 14:04      5:30    0.18s   0.18s   -zsh
johanng2  pts/52    ipnet-gw.157.157 13:25      1:21m   0.71s   0.71s   -zsh
thoranna  pts/53    124-137-17-89.f 14:39      4:26    0.31s   0.00s   who
magnusi1  pts/54    nova-153-092-135 13:36      32:50   0.21s   0.21s   -zsh
elnarp18  pts/55    81-227-142-95-no 13:37      1:08m   0.45s   0.45s   -zsh
benedikt  pts/56    89-160-199-59.du 13:38      1:04m   0.11s   0.11s   -zsh
daniel19  pts/57    31-209-218-88.ds 14:06      18.00s   4.04s   4.04s   -zsh
benedikt  pts/58    89-160-199-59.du 13:40      1:08m   1.08s   1.08s   -zsh
annaa17   pts/59    89-160-146-234.d 14:13      8:02    0.21s   0.21s   -zsh
stefant1  pts/60    81-15-110-218.du 13:40      1:07m   0.20s   0.20s   -zsh
kristinn  pts/61    b7-217.gardur.hl 14:23      10.00s   0.74s   0.74s   -zsh
daniel18  pts/62    85-220-118-209.d 14:26      5:30    0.73s   0.00s   ./server 4096
nina19    pts/63    nova-157-097-023 14:31      10:02    3.24s   3.24s   -zsh
hinrik20  pts/64    89-160-207-115.d 14:33      2.00s   0.33s   0.02s   vim
birna17   pts/66    89-160-167-205.d 14:40      3:46    0.30s   0.30s   -zsh
evap19    pts/67    10.2.27.138       14:40      7:22    0.42s   0.42s   -zsh

> blablaba
Output:
Unknown command --> 'blablaba'
> 
```

server:

```
./server_mod 4052

[benjamin@skel ~]$ ./server_mod 4052
[benjamin@skel ~]$ ./server_mod 4052
Listening on port: 4052
Client connected on server
SYS is
Client modified.cpp pi-TSMN.pdf server server.cpp server_mod server_modified.cpp
Output on server side done!

Starting for-loop to get tokens into string...
Done processing for-loop, tokens are as string now!
Executing popen() command...
popen() and invoking shell finished!
Reading characters from stream into string...
File closed and string created to send to client!
Sending message over to client side...
Message sent over to client!

SYS who
aronp20   pts/0     89-160-244-142.du 12:40      1:52m   0.35s   0.35s   -zsh
johannb1  pts/1     72-129-17-89.fib 12:40      2days   0.07s   0.07s   -zsh
gudrunf1  pts/2     157-157-161-140. 12:38      2:11m   0.15s   0.00s   ./server 4013
arone20   pts/5     246-138-17-89.f 13:47      2.00s   9.62s   9.62s   -zsh
eggerte1  pts/7     nova-157-097-020 12:09      2:58    6.45s   0.32s   sshd: eggerte19 [priv]
danielg2  pts/8     194-144-153-22. 19:20      1:42m   26.06s  26.06s  -zsh
ulfars20  pts/9     46-239-211-182.d 12:20      18:01m   0.07s   0.07s   -zsh
arnort20  pts/10    31-209-193-84.ds 10:14      1:18m   5.26s   5.26s   -zsh
tomast20  pts/11    194.144.235.141 11:40      2.00s   7.14s   7.14s   -zsh
thelma06  pts/12    239-149-17-89.f 12:29      16:58   2.57s   2.57s   -zsh
stefans2  pts/14    157-157-208-16.d 12:50      43:06   9.56s   9.51s   -zsh
helgal20  pts/16    89-160-216-212.d 11:33      1:25m   8.23s   8.23s   -zsh
sarals17  pts/17    5.252.12.61      09:19      1:04m   2.57s   2.57s   -zsh
gudmundu  pts/18    89-160-211-200.d 09:03      5:11m   0.28s   0.28s   -zsh
hallnar1  pts/19    31-209-234-67.ds 14:23      2.00s   0.77s   0.07s   vim list.sh
ofelgur2  pts/20    89-160-150-150.d 13:00      10:42    7.95s   7.95s   -zsh
arnthor1  pts/21    85-220-115-205.d 13:17      1:30m   0.15s   0.00s   ./server 4014
hafsteinn pts/22    157-157-214-183. 13:00      24:42    7.83s   7.83s   -zsh
arnarg  pts/23    89-160-158-17.du 12:22      2:19m   0.38s   0.00s   ./server 4040
smarb20   pts/24    212-30-203-49.st 14:15      32:10   0.18s   0.18s   -zsh
baldurb2  pts/25    157-157-72-237.d 12:40      23:54   3.67s   3.67s   -zsh
benjamin  pts/27    85-220-100-53.ds 14:35      34.00s   0.71s   0.01s   w
hordurh2  pts/28    10.2.27.143      13:45      1:38    4.21s   4.21s   -zsh

kristinnk pts/29    105-108-22-46.fl 14:46      3:06    0.13s   0.00s   ./server 4500
annan20   pts/30    10.3.27.151       12:03      2:11m   1.04s   1.04s   -zsh
benedikt  pts/31    89-160-199-59.du 10:18      4:16m   0.42s   0.42s   -zsh
svanfrid  pts/33    46-239-214-57.du 14:19      19:46   3.97s   3.97s   -zsh
grtmurg2  pts/34    nova-046-182-188 14:36      11:22   0.26s   0.26s   -zsh
bjorgvinn pts/35    10-106-22-46.fib 13:31      18:58   0.51s   0.33s   sshd: bjorgvinn17 [priv]
unnur19   pts/36    77.83.110.119     14:20      27:14   0.34s   0.34s   -zsh
hol20     pts/37    85-220-97-99.dsl 14:10      9:06    3.44s   3.44s   -zsh
ragnars1  pts/39    89-160-141-113.d 11:17      18:12m   15.14s   15.14s  -zsh
arnark18  pts/40    dsl-149-104-7.hl 14:21      8:50    0.08s   0.00s   ./server 4100
sigurdur  pts/41    31-209-220-154.d 13:06      1:14    5.01s   5.01s   -zsh
arnorg20  pts/43    130.208.24.155    13:55      45:54   0.34s   0.34s   -zsh
garpur19  pts/44    186-138-17-89.f 14:39      10.00s   2.11s   2.11s   -zsh
bjarnid1  pts/45    10.1.17.40         13:05      4:58    0.85s   0.85s   -zsh
palmig20  pts/47    85-220-104-43.ds 13:56      33:54   1.53s   1.53s   -zsh
arnarg  pts/49    89-160-158-17.du 14:04      21:06   0.55s   0.55s   -zsh
eydis13   pts/50    89-160-229-40.du 14:04      5:30    0.18s   0.18s   -zsh
johanng2  pts/52    ipnet-gw.157.157 13:25      1:21m   0.71s   0.71s   -zsh
thoranna  pts/53    124-137-17-89.f 14:39      4:26    0.31s   0.00s   who
magnusi1  pts/54    nova-153-092-135 13:36      32:50   0.21s   0.21s   -zsh
elnarp18  pts/55    81-227-142-95-no 13:37      1:08m   0.45s   0.45s   -zsh
benedikt  pts/56    89-160-199-59.du 13:38      1:04m   0.11s   0.11s   -zsh
daniel19  pts/57    31-209-218-88.ds 14:06      18.00s   4.04s   4.04s   -zsh
benedikt  pts/58    89-160-199-59.du 13:40      1:08m   1.08s   1.08s   -zsh
annaa17   pts/59    89-160-146-234.d 14:13      8:02    0.21s   0.21s   -zsh
stefant1  pts/60    81-15-110-218.du 13:40      1:07m   0.20s   0.20s   -zsh
kristinn  pts/61    b7-217.gardur.hl 14:23      10.00s   0.74s   0.74s   -zsh
daniel18  pts/62    85-220-118-209.d 14:26      5:30    0.73s   0.00s   ./server 4096
nina19    pts/63    nova-157-097-023 14:31      10:02    3.24s   3.24s   -zsh
hinrik20  pts/64    89-160-207-115.d 14:33      2.00s   0.33s   0.02s   vim
birna17   pts/66    89-160-167-205.d 14:40      3:46    0.30s   0.30s   -zsh
evap19    pts/67    10.2.27.138       14:40      7:22    0.42s   0.42s   -zsh
```

```

bjorgvinj17 pts/35      2020-08-26 13:31 (46-106-22-46.fiber.hr.lingdu.is)
umurl19 pts/36         2020-08-26 14:20 (77.83.110.119)
no120 pts/37           2020-08-26 14:18 (85-220-97-99.dsl.dynamic.sinnet.is)
egnar19 pts/39         2020-08-25 17:51 (89-160-141-113.du.xdsl.is)
arnark18 pts/40         2020-08-26 14:21 (dsl-149-104-7.hive.is)
sigurdur19 pts/41      2020-08-26 13:06 (31-209-220-154.dsl.dynanlc.sinnet.is)
arnorg18 pts/43         2020-08-26 13:55 (130-200-24-155)
garpur19 pts/44         2020-08-26 14:39 (186-138-17-89.fiber.hr.lingdu.is)
bjarnid19 pts/45        2020-08-26 13:05 (10.1.17.40)
eolnig18 pts/47         2020-08-26 13:56 (85-220-104-51.dsl.dynamic.sinnet.is)
arnarg pts/49           2020-08-26 14:04 (89-160-158-17.du.xdsl.is)
eydis11 pts/50          2020-08-26 14:04 (89-160-229-40.du.xdsl.is)
lohnang20 pts/52        2020-08-26 13:25 (ipnet-qw-157-157-179.sinnet.is)
thoranna18 pts/53       2020-08-26 14:39 (124-137-17-89.fiber.hr.lingdu.is)
nagnus18 pts/54         2020-08-26 13:36 (nova-153-092-135-cpe.nova.is)
etnarp18 pts/55         2020-08-26 13:37 (81-227-142-95-nov19.tbcn.telta.com)
benedikt113 pts/56      2020-08-26 13:38 (89-160-199-59.du.xdsl.is)
daniel19 pts/57         2020-08-26 14:06 (31-209-218-88.dsl.dynamic.sinnet.is)
benedikt113 pts/58      2020-08-26 13:40 (89-160-199-59.du.xdsl.is)
anna17 pts/59           2020-08-26 14:11 (89-160-146-234.du.xdsl.is)
stefant17 pts/60        2020-08-26 13:40 (81-15-110-218.du.xdsl.is)
kristinnk18 pts/61      2020-08-26 14:23 (b7-217.gardur.hi.is)
daniel18 pts/62         2020-08-26 14:26 (85-220-118-209.dsl.dynamic.sinnet.is)
etnarp19 pts/63         2020-08-26 14:31 (nova-157-097-021-241-cpe.nova.is)
hinrik20 pts/64         2020-08-26 14:33 (89-160-207-115.du.xdsl.is)
bjrnal17 pts/66         2020-08-26 14:40 (89-160-167-205.du.xdsl.is)
evap19 pts/67           2020-08-26 14:40 (10.2.27.138)
Output on server side done!

Starting for-loop to get tokens into string...
Done processing for-loop, tokens are as string now!
Executing popen() command...
popen() and invoking shell finished!
Reading characters from stream into string...
File closed and string created to send to client!
Sending message over to client side...
Message sent over to client!

SYS W
14:49:46 up 629 days, 2:45, 55 users, load averages: 0.11, 0.15, 0.22
USER      TTY      FROM              LOGIN@   IDLE   XCPU  PCPU  WHAT
arong20 pts/0      89-160-244-142.d 12:40    1:52m  0.35s  0.35s -zsh
johann18 pts/1     72-129-17-89.fib 04:03    20:5s  0.97s  0.97s -zsh
jodrunf1 pts/2     157-157-161-140 12:38    2:11m  0.15s  0.00s /server 4013
arone20 pts/5     246-138-17-89.f 13:47    2:00s  9.62s  9.62s -zsh
eggert19 pts/7     nova-157-092-12 09:09    2:16s  0.45s  0.32s zsh: eggert19 [priv]

daniel14 157-22-139g20 1:12:22 20:00s 20:00s -zsh
ulfars20 pts/9     46-239-211-182.d 01:20    10:01m 0.07s  0.07s -zsh
arnort20 pts/10    31-209-193-84.ds 10:14    1:18m  5.26s  5.26s -zsh
tonast20 pts/11    104-144-235-141 11:40    2:00s  7.54s  7.54s -zsh
thelma06 pts/12    239-149-17-89.f 12:29    10:58  2.57s  2.57s -zsh
stefanz20 pts/14    157-157-208-16.d 12:50    43:06  9.56s  9.55s -zsh
helgala20 pts/16    89-160-216-212.d 11:33    1:15m  0.23s  0.23s -zsh
sarals17 pts/17    5.252.12.61      09:19    1:04m  2.57s  2.57s -zsh
gudmund20 pts/18    89-160-211-208.d 09:03    5:11m  0.28s  0.28s -zsh
hallmar19 pts/19    31-209-234-67.ds 14:23    2:00s  0.77s  0.07s vln.lst.sh
ofetpur20 pts/20    89-160-150-150.d 13:08    10:42  7.95s  7.95s -zsh
arnthor20 pts/21    85-220-115-205.d 13:17    1:30m  0.15s  0.00s /server 4014
hafsste1n pts/22    157-157-214-183 13:00    24:42  7.83s  7.83s -zsh
arnarg pts/23       89-160-158-17.d 12:22    2:19m  0.38s  0.00s /server 4040
snarfb20 pts/24    212-30-203-49.st 14:15    32:10  0.18s  0.18s -zsh
baldurk20 pts/25    157-157-72-237.d 12:40    23:14  3.67s  3.67s -zsh
benjam1n pts/27    85-220-100-53.ds 14:35    34:00s 0.73s  0.03s w
hordurk20 pts/28    10.2.27.140      13:45    1:38  4.21s  4.21s -zsh
kristin18 pts/29    185-108-22-46.f 14:46    3:06  0.13s  0.00s /server 4500
annan20 pts/30     10.3.27.151      12:03    2:11m  1.04s  1.04s -zsh
benedikt18 pts/31    89-160-199-59.d 10:18    4:16m  0.42s  0.42s -zsh
svanfru18 pts/33    46-239-214-57.d 14:19    19:46  3.97s  3.97s -zsh
grtnurg20 pts/34    nova-046-182-188 14:36    11:22  0.26s  0.26s -zsh
bjorgvin18 pts/35    16-186-22-46.fib 13:31    18:08  0.51s  0.33s ssh: bjorgvin17 [priv]
umurl19 pts/36      77.83.110.119    14:20    27:14  0.34s  0.34s -zsh
no120 pts/37       85-220-97-99.dsl 14:10    9:06  3.44s  3.44s -zsh
egnar19 pts/39      89-160-141-113.d 01:17    18:12m 15:14s 15:14s -zsh
arnark18 pts/40      dsl-149-104-7.hi 14:21    8:50  0.08s  0.00s /server 4100
sigurdur18 pts/41    31-209-220-154.d 13:06    1:14  5.81s  5.81s -zsh
arnorg18 pts/43      130-200-24-155    13:55    45:54  0.34s  0.34s -zsh
garpur19 pts/44      186-138-17-89.f 14:39    10:00s 2.11s  2.11s -zsh
bjarnid19 pts/45     10.1.17.40        13:05    4:58  0.85s  0.85s -zsh
eolnig18 pts/47      85-220-104-43.ds 13:56    33:54  1.53s  1.53s -zsh
arnarg pts/49        89-160-158-17.d 14:04    21:06  0.55s  0.55s -zsh
eydis11 pts/50       89-160-229-40.d 14:04    5:30  0.18s  0.18s -zsh
lohnang20 pts/52     ipnet-qw-157-157 13:25    1:21m  0.71s  0.71s -zsh
thoranna18 pts/53    124-137-17-89.f 14:39    4:26  0.31s  0.00s who
nagnus18 pts/54      nova-153-092-135 13:36    32:50  0.21s  0.21s -zsh
etnarp18 pts/55      81-227-142-95-no 13:37    1:00m  0.45s  0.45s -zsh
benedikt18 pts/56    89-160-199-59.d 13:38    1:04m  0.11s  0.11s -zsh
daniel19 pts/57      31-209-218-88.ds 14:06    10:00s 4.04s  4.04s -zsh
benedikt18 pts/58    89-160-199-59.d 13:40    1:00m  1.08s  1.08s -zsh
anna17 pts/59        89-160-146-234.d 14:13    8:02  0.21s  0.21s -zsh
stefant17 pts/60     81-15-110-218.d 13:40    1:07m  0.29s  0.29s -zsh
kristinnk18 pts/61    b7-217.gardur.hi 14:23    10:00s 0.74s  0.74s -zsh
daniel18 pts/62      85-220-118-209.d 14:26    5:30  0.73s  0.00s /server 4096
etnarp19 pts/63      nova-157-097-023 14:31    18:02  0.24s  0.24s -zsh
hinrik20 pts/64      89-160-207-115.d 14:33    2:00s  0.33s  0.33s win
bjrnal17 pts/66      89-160-167-205.d 14:40    3:46  0.30s  0.30s -zsh
evap19 pts/67        10.2.27.138       14:40    7:22  0.42s  0.42s -zsh
Output on server side done!

Starting for-loop to get tokens into string...
Done processing for-loop, tokens are as string now!
Executing popen() command...
popen() and invoking shell finished!
Reading characters from stream into string...
File closed and string created to send to client!
Sending message over to client side...
Message sent over to client!

blablaba
Printing out error message on server side...
Unknown command from client: blablaba
Error message on server side done!

Sending error message over to client side...
Error message sent to client!

```

4.

a)

A Makefile is included which compiles the code submitted – see file **Makefile**

b)

README file provided explaining how to compile and run submitted code. File should include command line commands used to compile (IDE's will not be accepted), and instructions on how to run the programs – see in text file **README**

c)

Code compiling using the Makefile, and runs following instructions in README file.

Does not compile, error message given:



```
benjamin18@skel ~/Tolvus/Project_1
[benjamin18@skel ~/Tolvus/Project_1]$ ls
client.cpp  client_modified.cpp  Makefile  P1-TSAM.pdf  server  server.cpp  server_mod  server_modified.cpp
[benjamin18@skel ~/Tolvus/Project_1]$ make all
server client
make: server: Command not found
make: *** [all] Error 127
[benjamin18@skel ~/Tolvus/Project_1]$
```

d)

Code clearly structured, and well commented – see in the three “.cpp” files.

**Name: Benjamín Aage Birgisson**  
**TA Name: Benedikt Hólm Þórðarson**  
**Time Taken: approx. 33 hours**  
*Estimated time: 20 hrs*