Web Server Design

Lecture 2 – Socket Programming

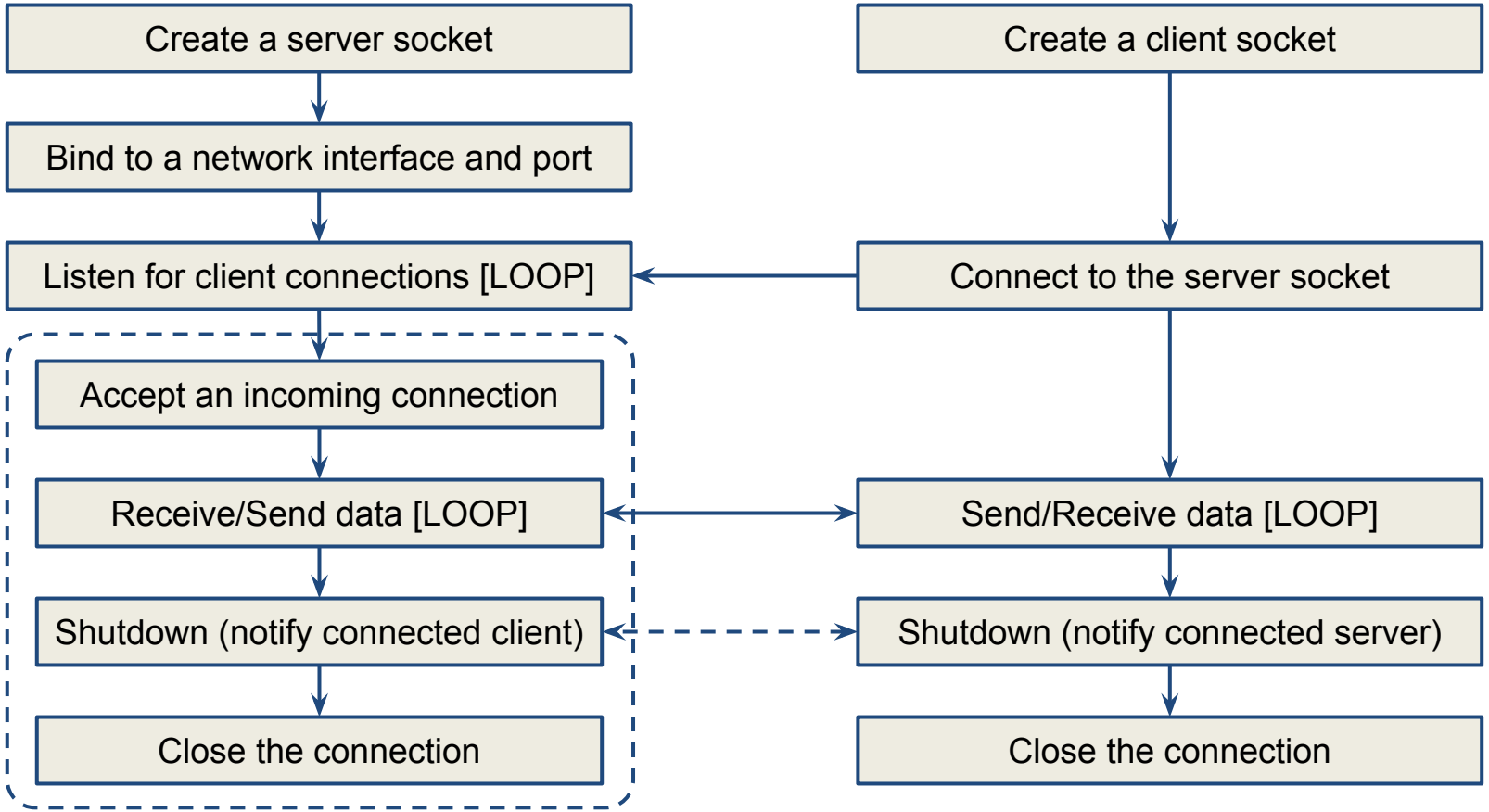
Old Dominion University
Department of Computer Science
CS 431/531 Fall 2022
Sawood Alam <salam@cs.odu.edu>

2019-09-07

Interprocess Communication (IPC)

- File
- Shared memory
- Memory-mapped file
- Message passing
- Pipe
- Message queue
- Signal
- Unix socket
- Network socket

Network Socket Workflow



Host and Port

- Host
  - An IP address (IPv4 or IPv6)
  - A domain name mapped to an IP address
  - Identifies a host/machine on a network
- Port
  - A number from 0 to 65535
  - 0-1023 ranges is reserved (needs privileged access)
  - Identifies a process on a host for socket communication
  - Not every process is bound to a port

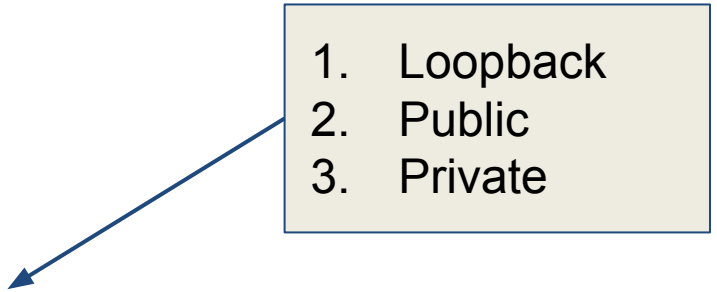
Common Default Port Numbers

Port Number	Service
20/21	File Transfer Protocol (FTP)
22	Secure Shell (SSH)
23	Telnet
25	Simple Mail Transfer Protocol (SMTP)
53	Domain Name System (DNS)
80	Hypertext Transfer Protocol (HTTP)
110	Post Office Protocol (POP3)
123	Network Time Protocol (NTP)
143	Internet Message Access Protocol (IMAP)
194	Internet Relay Chat (IRC)
443	HTTP Secure (HTTPS)

https://en.wikipedia.org/wiki/Port_(computer_networking)

Network Interfaces

```
$ host cs531.cs.odu.edu
cs531.cs.odu.edu has address 128.82.7.233
$ ssh cs531.cs.odu.edu
$ host localhost
localhost has address 127.0.0.1
$ ip -4 a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
2: ens160: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default qlen 1000
    inet 128.82.7.233/24 brd 128.82.7.255 scope global ens160
       valid_lft forever preferred_lft forever
3: docker0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN group default
    inet 172.17.0.1/16 brd 172.17.255.255 scope global docker0
       valid_lft forever preferred_lft forever
```



Loopback Address: localhost

```
$ cat /etc/hosts
127.0.0.1 localhost.localdomain    localhost

# The following lines are desirable for IPv6 capable hosts
::1       localhost6.localdomain6  localhost6
::1       localhost                ip6-localhost       ip6-loopback
```

127.0.0.1 vs. 0.0.0.0

- 127.0.0.1 (or localhost)
  - Listening on loopback interface only (unless tunneled)
- 0.0.0.0
  - Listening on all network interfaces
  - Not a resolvable address

Processes running in Docker containers listening on loopback interface will not be accessible from outside of the container, run them on 0.0.0.0 instead.

Hello Server: Python

```python
#!/usr/bin/env python3

import socket

HOST = "0.0.0.0"
PORT = 8080

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
s.bind((HOST, PORT))
s.listen()
print(f"Listening on {HOST}:{PORT} for HTTP connections")

while True:
    conn, addr = s.accept()
    print(f"Connected to {addr}")
    conn.sendall(b"Hello from server\n")
    conn.close()
```

Hello Server: Ruby

```ruby
#!/usr/bin/env ruby

require "socket"

host = "0.0.0.0"
port = 8080

socket = TCPServer.new(host, port)
puts "Listening on #{host}:#{port} for HTTP connections")

loop do
    client = socket.accept
    puts "Connected to #{client}"
    client.write("Hello from server\n")
    client.close
end
```

Concurrency

```ruby
#!/usr/bin/env ruby

require "socket"

host = "0.0.0.0"
port = 8080

socket = TCPServer.new(host, port)
puts "Listening on #{host}:#{port} for HTTP connections")

loop do
    Thread.start(socket.accept) do |client|
        puts "Connected to #{client}"
        client.write("Hello from server\n")
        client.close
    end
end
```

Run the Hello Server

```
$ ./server.py
Listening on 0.0.0.0:8080 for HTTP connections
Connected to ('127.0.0.1', 46930)
```

```
$ telnet localhost 8080
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Hello from server
Connection closed by foreign host.
```