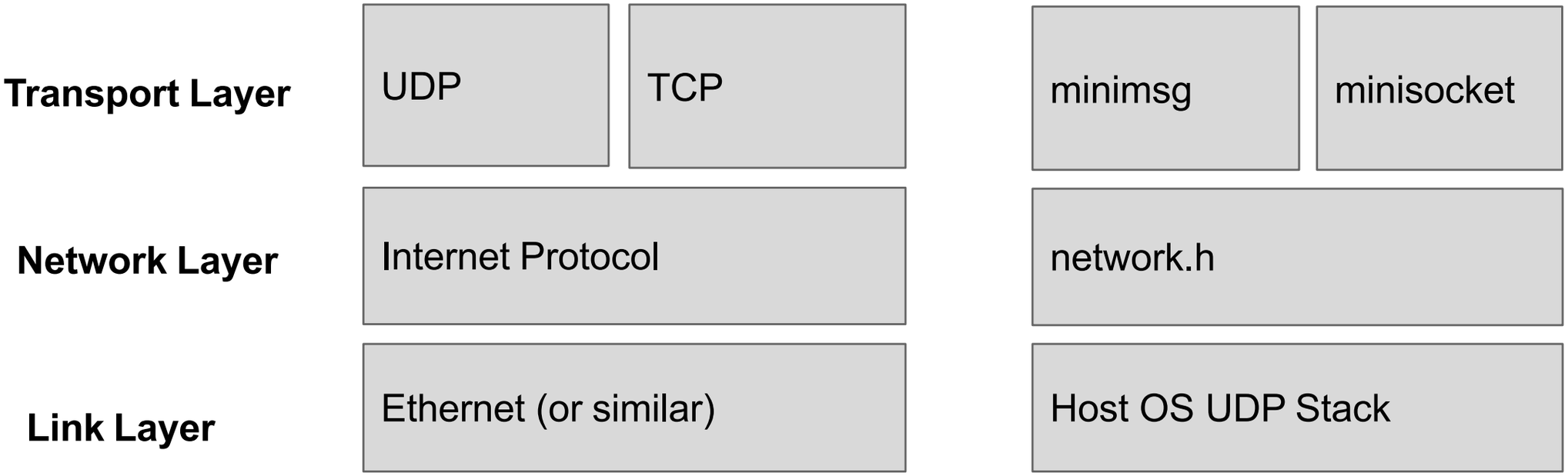
Project 4:
Reliable Networking

Slide heritage: Previous TAs

Announcements

- Project 4 has been released
- I assume you've read the project description
- Due **Tue, Apr 24th**
- This is a pretty complex project ⇨ Start early!

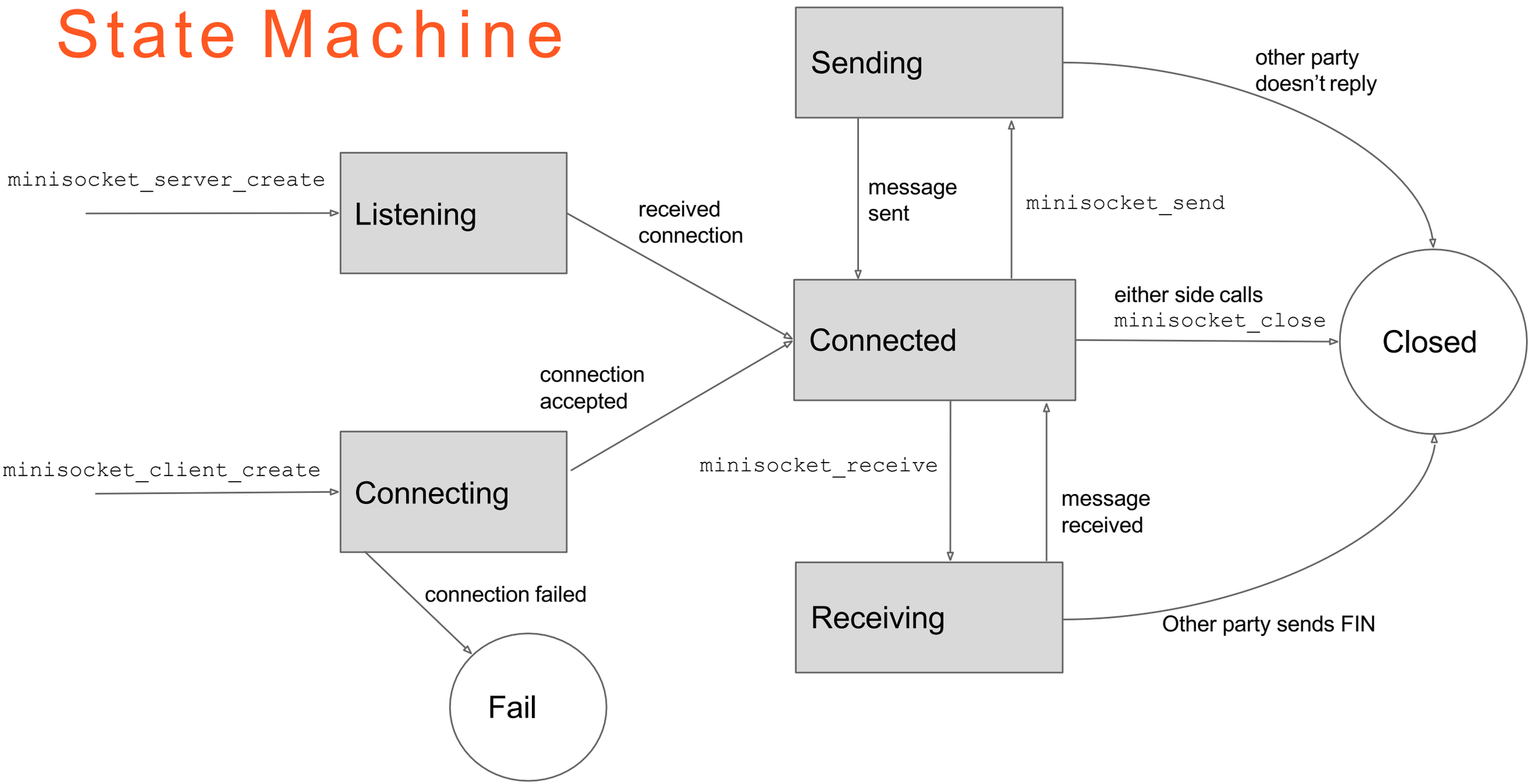
Our network stack vs. the real world



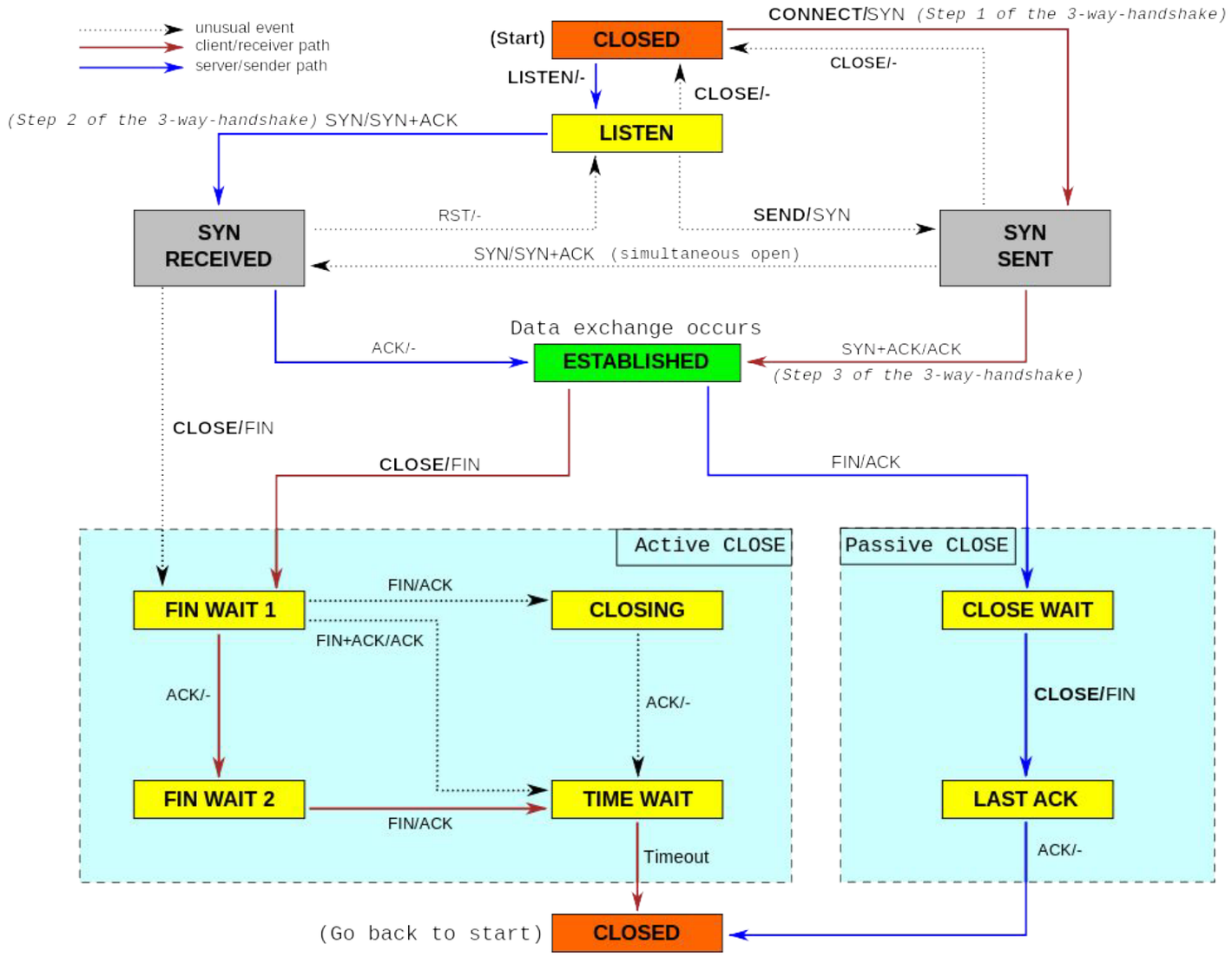
Minisocket is a simplified TCP

- Protocol is connection oriented
  - You must find a way to establish a connection between two endpoints
- Data is sent as a continuous stream of bytes
  - Messages are an application level concept
  - Minisocket must maintain correct ordering
- No limit on message sizes
  - You must fragment and reassemble the data

State Machine



Of course, it's much more complicated...



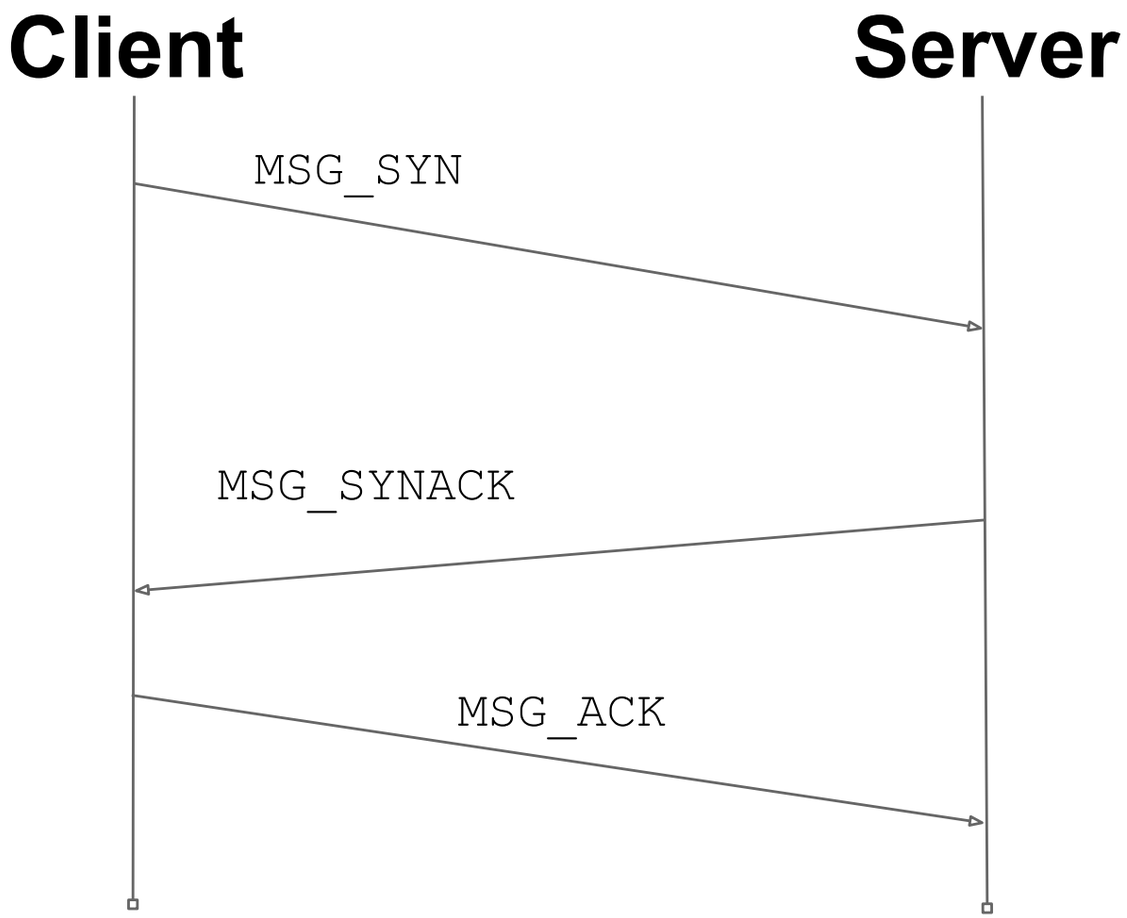
TCP State Machine
Source: Wikipedia/Cube00
License: CC BY-SA 3.0

What can go wrong?

- Any party can die
- Messages can get lost
- Data might be reordered
- Network might be partitioned

Welcome to the fun world of distributed systems!

Connecting: Three-Way Handshake

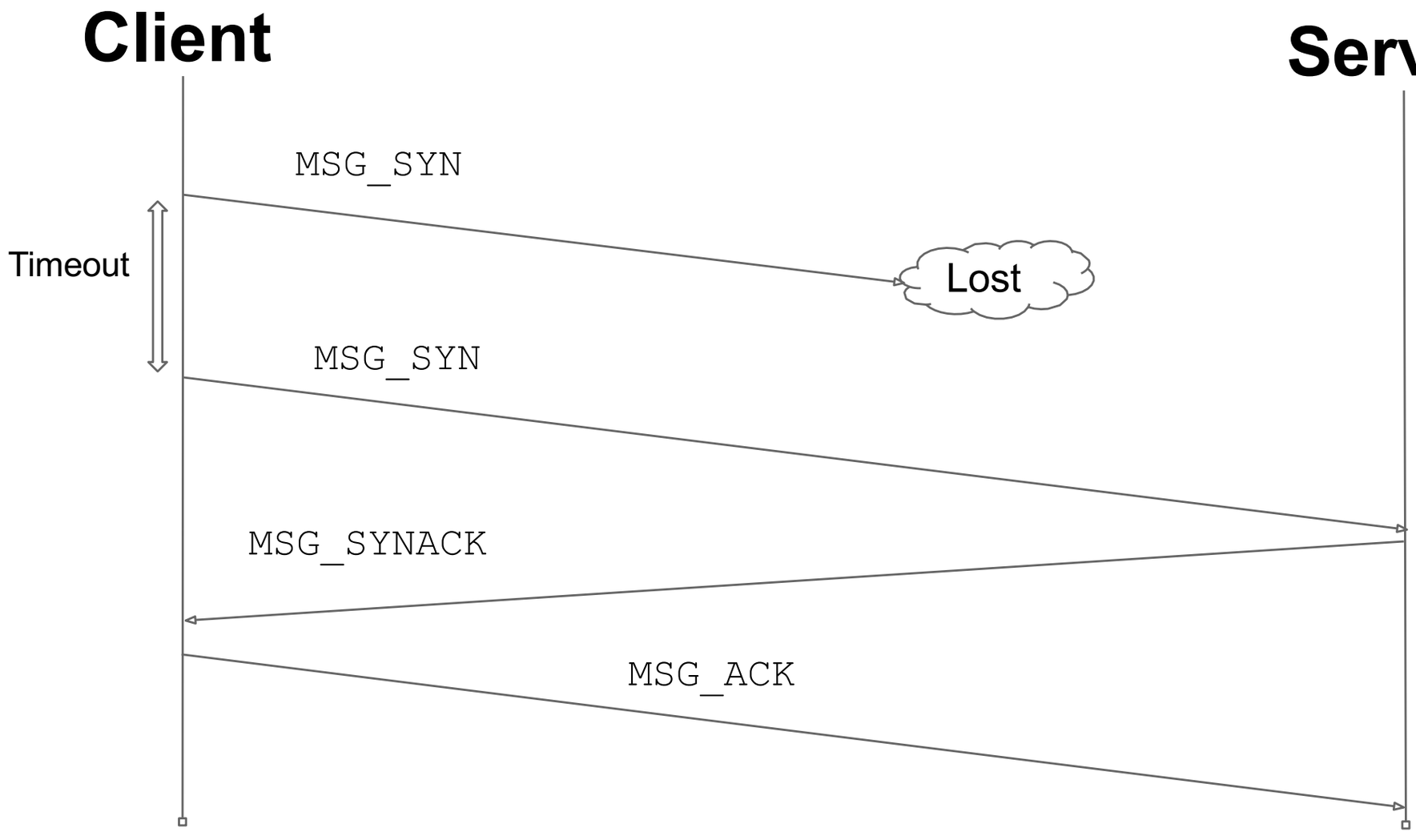


Non-blocking protocol

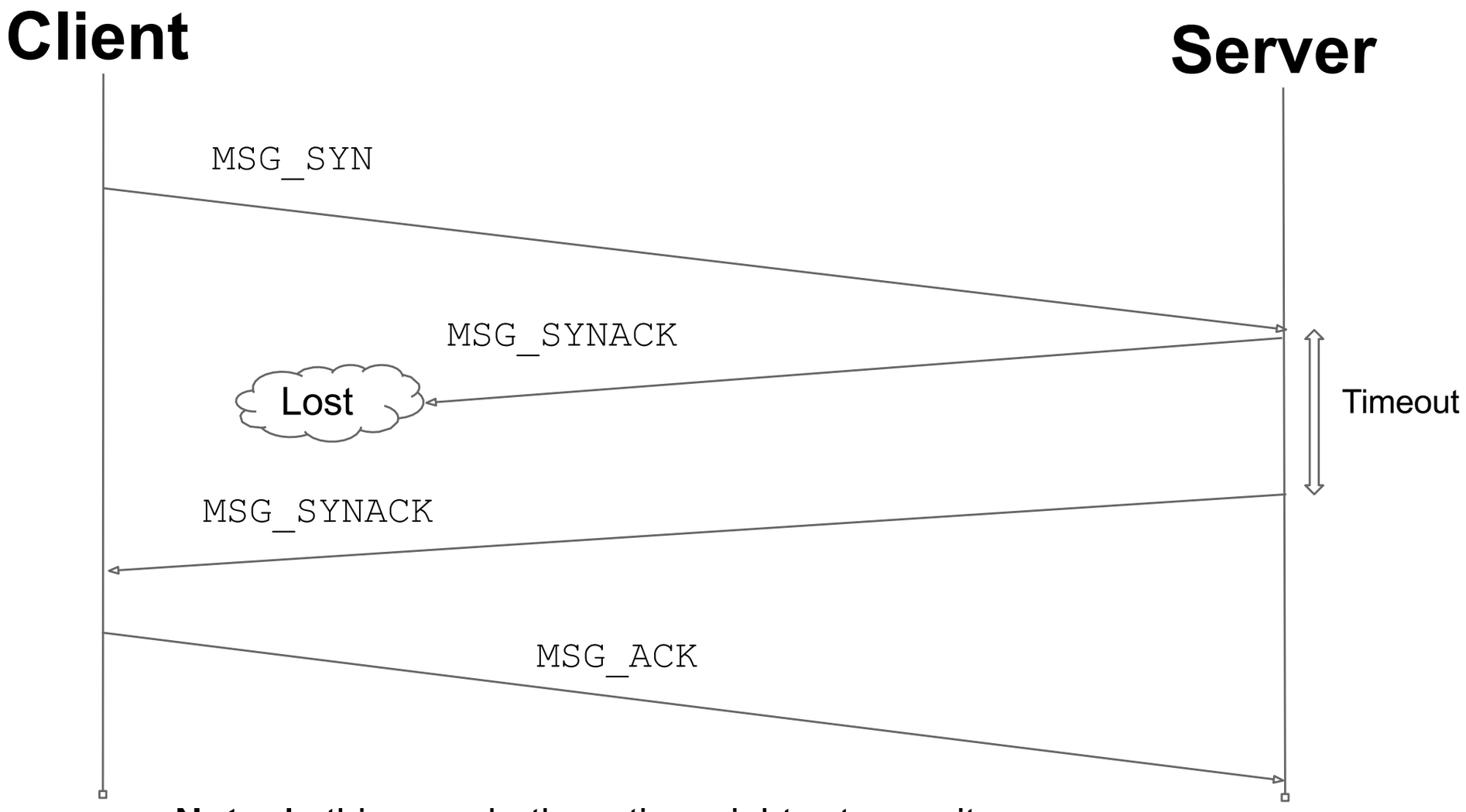
- Any packet might be lost
- Will be resent up to seven times
- Timeout doubles every time

Initial Timeout: 100ms
* Give up after 12.7s

Messages can get lost

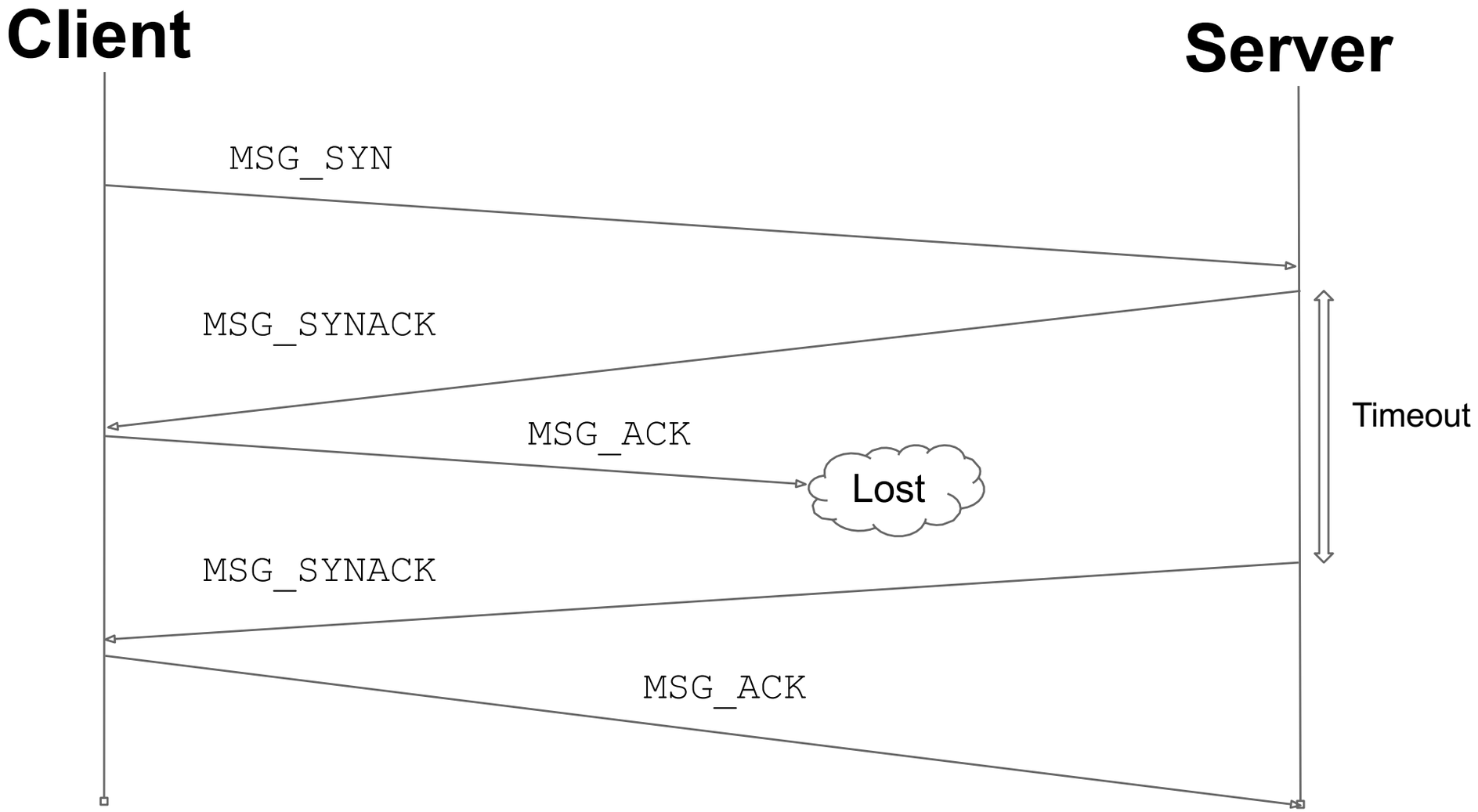


Messages can get lost

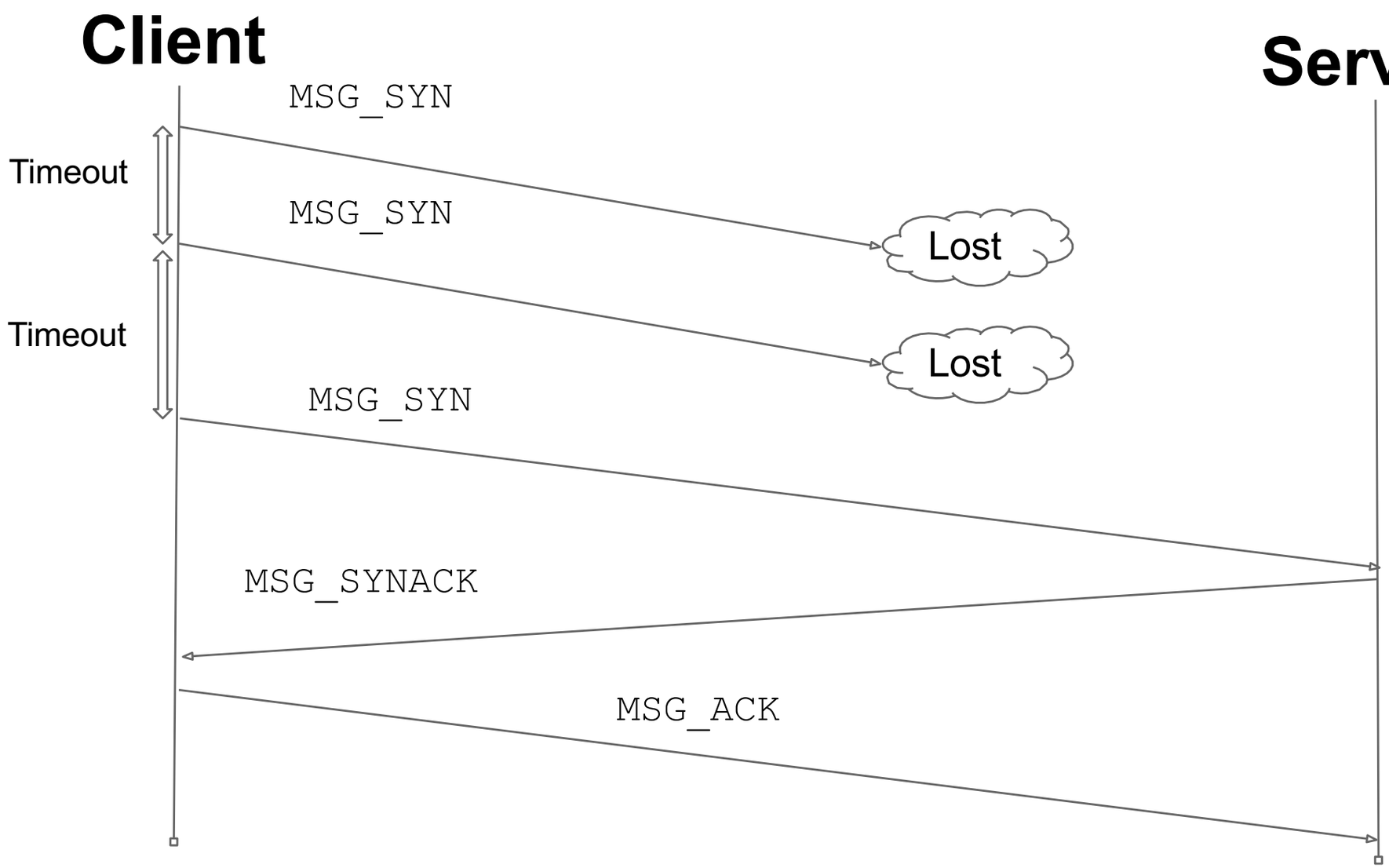


Note: In this case both parties might retransmit

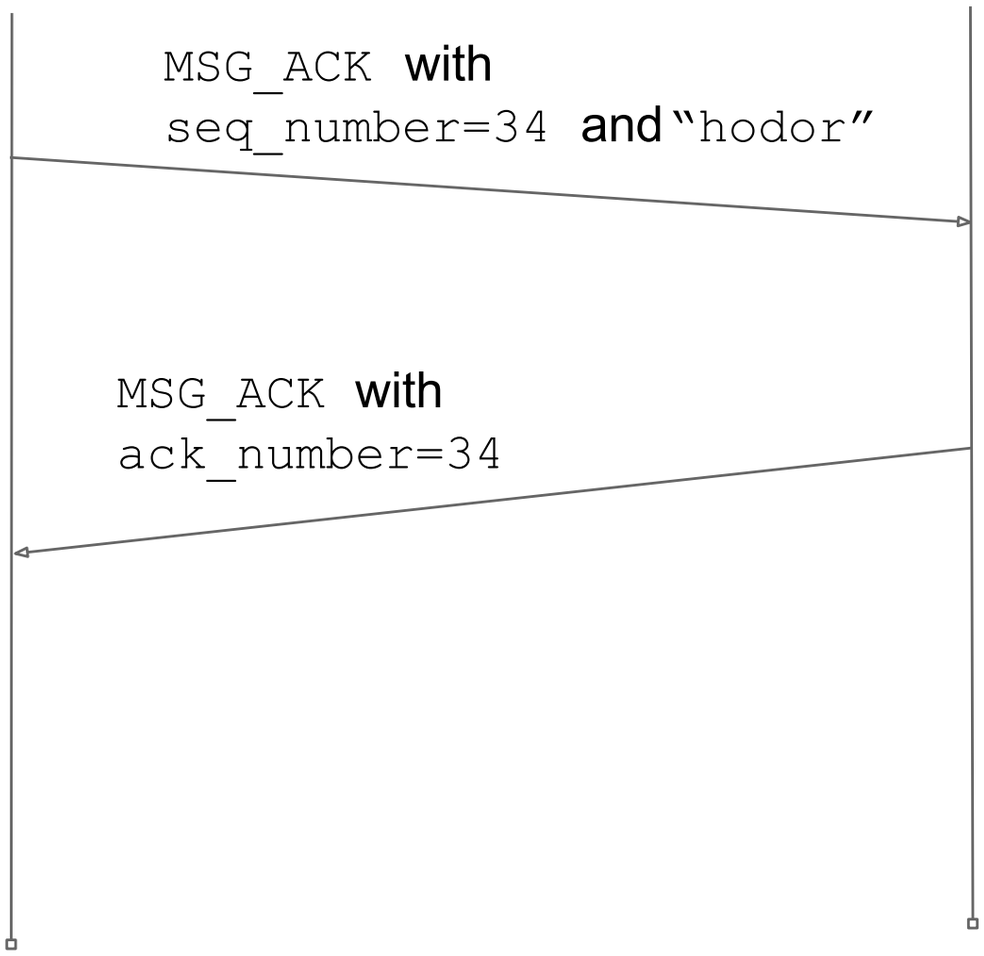
Messages can get lost



Messages can get lost multiple times



Sending Data: SEQ and ACK Numbers

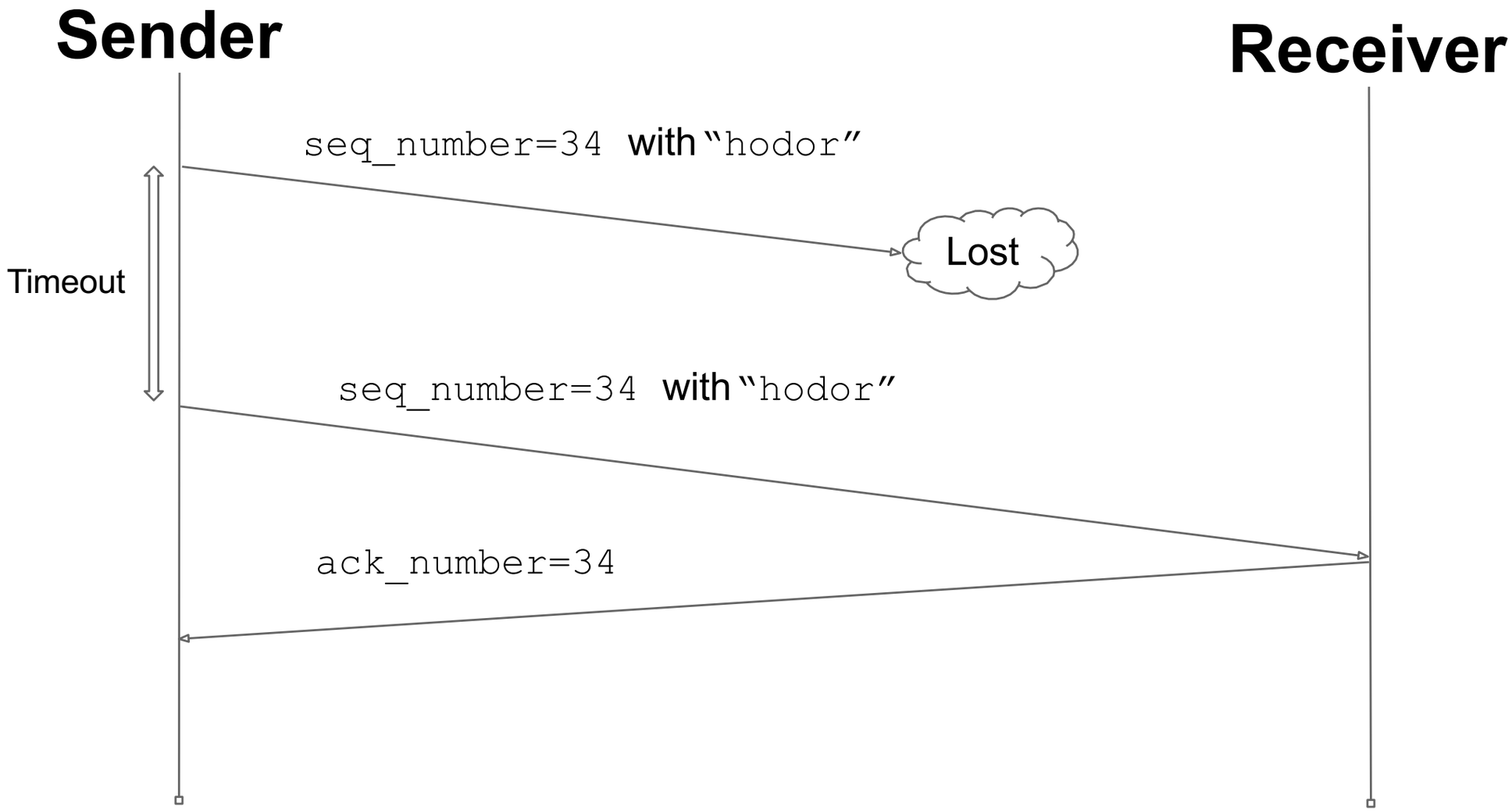


`seq_number` represents how many packets have been sent
⇨ is used to order messages

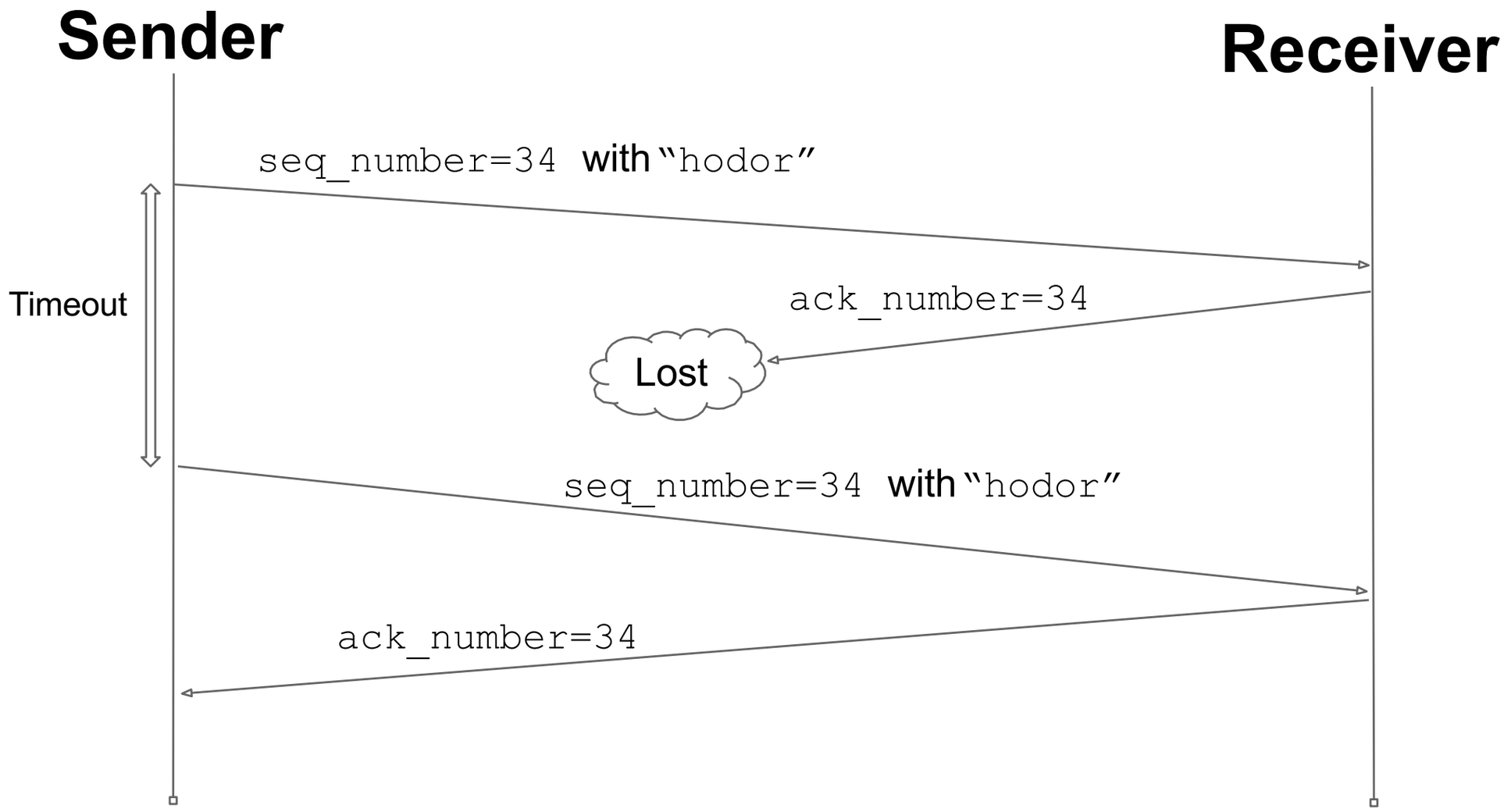
`ack_number` shows total received packets
⇨ is used to resend lost messages

Note: This is a symmetric channel. Both parties can send and receive.

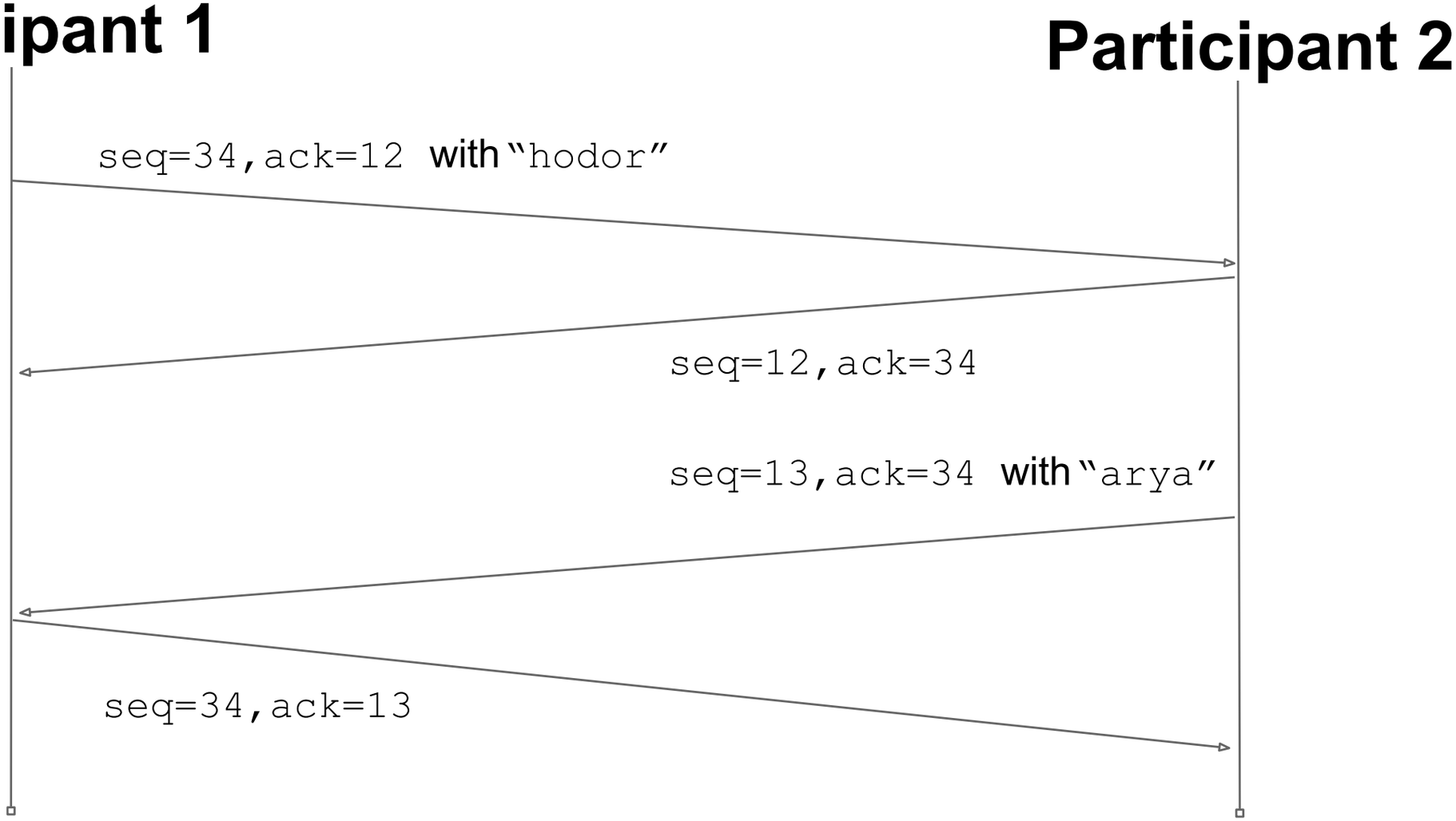
Again, messages can get lost



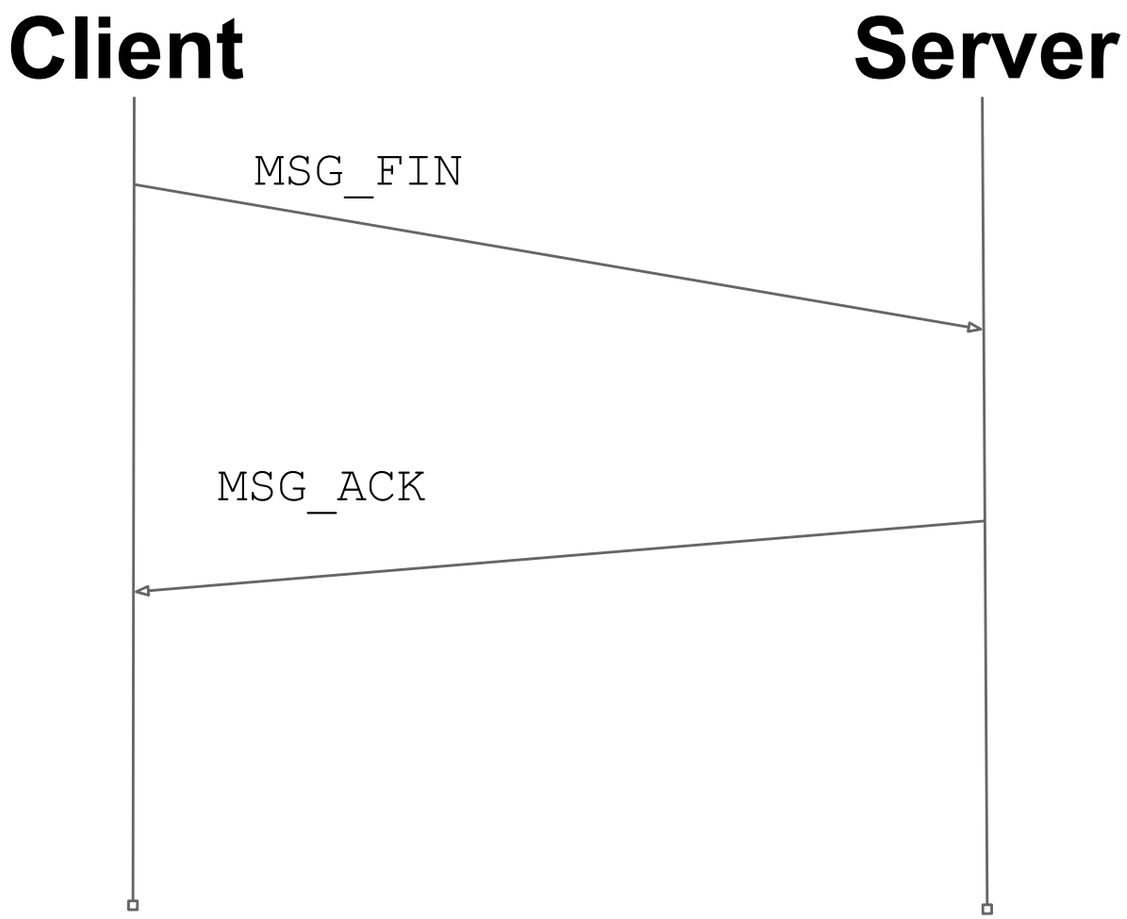
Again, messages can get lost



Either side can send and receive!

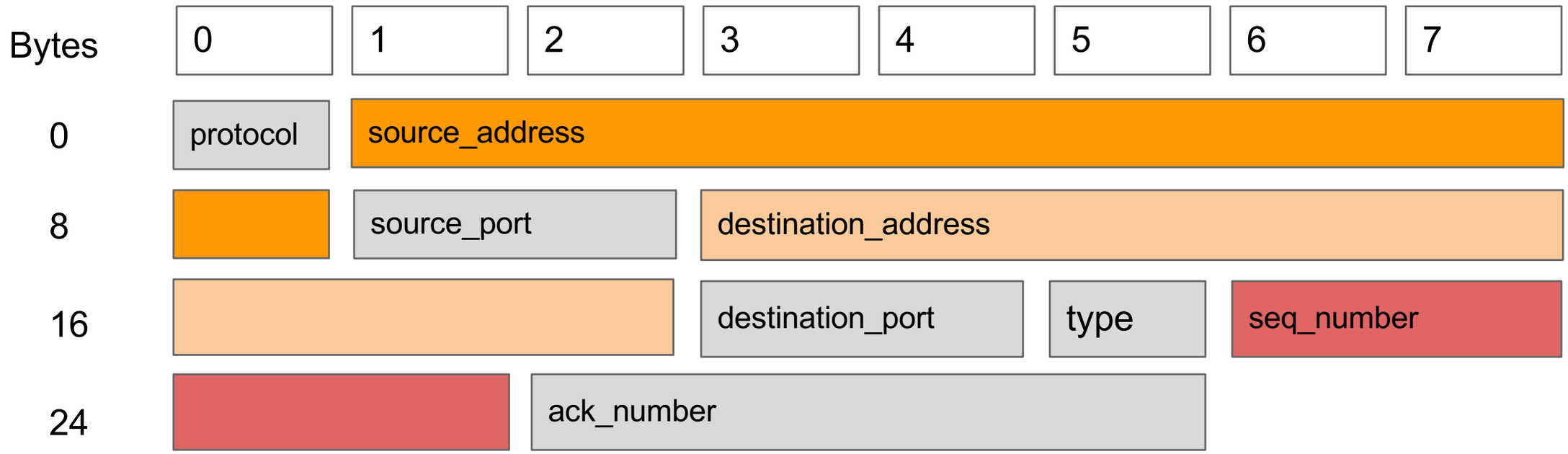


Closing connections



Again, this is a symmetric protocol.
Both sides can close the connection.

Minisocket Header



The first 21 bytes are identical to minimsg_header!

Use protocol field to multiplex protocols.

Tricky Part: How to implement timeout?

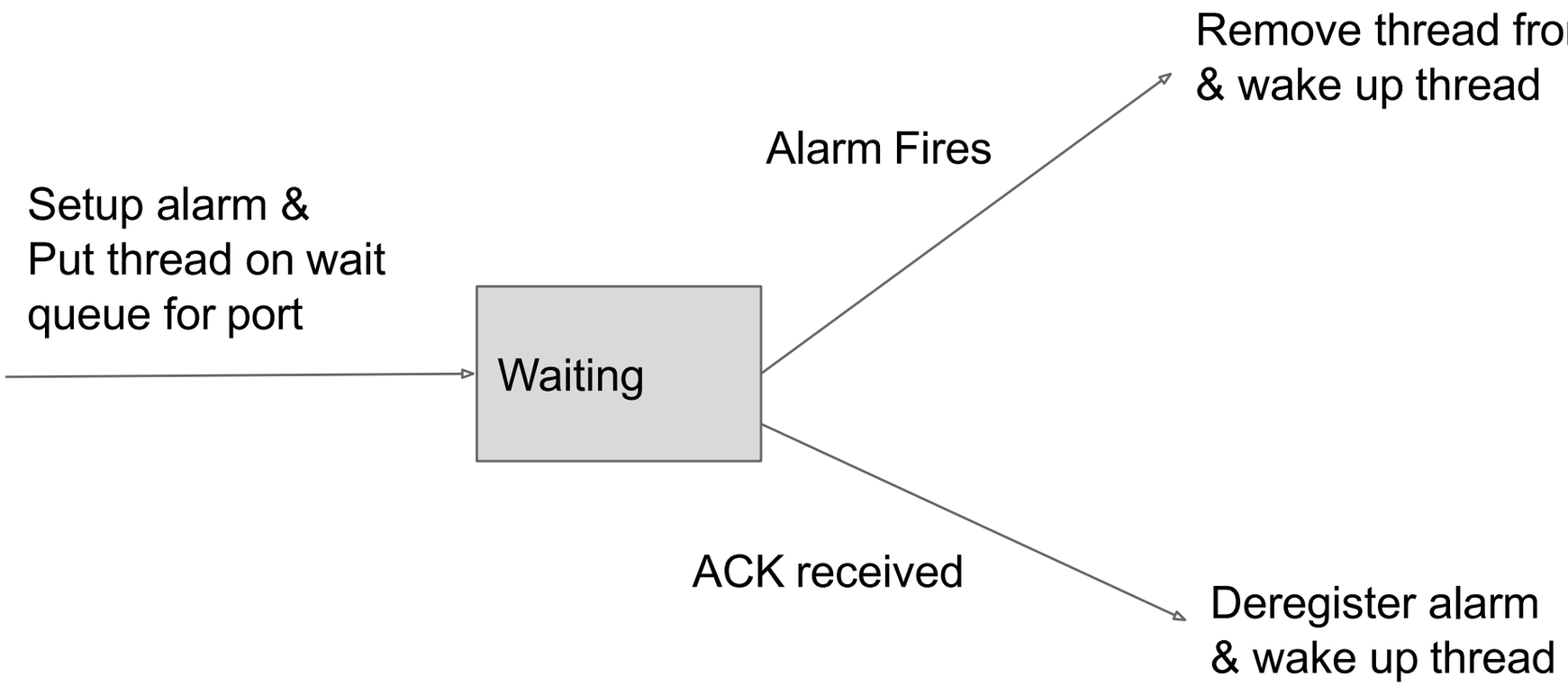
Remember that:

- Parties might never respond
- Multiple threads can call minisocket_receive() on the same port
- At most one thread can call minisocket_send() on a port

Things you must avoid:

- Putting threads on the run queue more than once
- Thread keeps waiting after message is received
- Thread blocks infinitely

Tricky Part: How to implement timeout?



To make it a little easier

- You don’t have to implement congestion control
- Sending one packet at a time is sufficient
- minimsg_send can block until corresponding ACK is received

But you can implement window sizes > 1 if you want to!
(and have the time…)

Where to start

- Think about the state machine from earlier!
- Try to make connection setup and termination work first.
- Test with no loss and single-thread access

Test all the code!

- What happens if you send very large messages?
- Can you handle a lot of messages?
- What if there is loss?
- If one party crashes the other one shouldn’t.
- What if multiple threads are sending/receiving from the same port?

Test all the code!

In network.c:

```
double loss_rate = 0.0;

double duplication_rate = 0.0;
```

These change the behavior of the network

```
bool synthetic_network = false;
```

You have to set this to true for the other values to have any effect!

Good Luck

Questions?

As always, if you need help, come to office hours or post your questions on Piazza!