CO324: Network and Web Application Design

Network Programming

TCP

- TCP is a *stream protocol* in which packet boundaries are invisible to the application. Data is received and transmitted as a sequence of bytes.
- It provides
  1. Reliability
  2. Ordering
  3. Flow control

TCP clients

1. Create and open a client socket
2. Open and input stream and an output stream to the socket
3. Read and write to the stream according to the server's protocol
4. Close the streams and then close the socket

- The Java Socket class represents a TCP socket.

```
Socket socket = new Socket();
InputStream sin = socket.getInputStream();
OutputStream sout = socket.getOutputStream();
```

- Binary data is read and written to the socket via the associated I/O streams.

Sending and receiving text

Establish socket connection between client and server and opens a PrintStream and a Scanner on the socket (input and output streams)

```
try (
   Socket socket = new Socket(address, TCPServer.PORT);
   Scanner sin = new Scanner(socket.getInputStream());
   PrintStream sout = new
     PrintStream(socket.getOutputStream() ) ) {
   sout.println("client says hello to server "+address);
   System.out.println(sin.nextLine());
}
```

- Note that application messages must be properly *framed* e.g. using a delimiter like \n.

TCP Servers

1. Create and open a server socket
2. Wait for client request
3. Open and input stream and an output stream to the client
4. Communicate with the client
5. Close the stream and then close the socket

- Java uses a separate ServerSocket class to bind to a port and accept connections from clients.

```
ServerSocket ss = new ServerSocket(PORT);
```

Create and open server socket

```
Socket socket = ss.accept();
```

Wait for the client request

- accept returns a new socket connected to the client.

Server example

```
try( ServerSocket ss = new ServerSocket(PORT)) {
  while (true)
    try (Socket socket = ss.accept();
      Scanner sin = new Scanner(socket.getInputStream() );
      PrintStream sout = new PrintStream(
        socket.getOutputStream()) ) {
          sout.println("server says world");
          System.out.println(sin.nextLine());
  }
}
```

Establish socket connection between client and server and opens a PrintStream and a Scanner on the socket (input and output streams)

Send data to the client

Reading one line at a time

- What happens if multiple clients try to connect at once?

Messages on streams

- Suppose a client sends two consecutive messages, and the server does a read. Will it get

1. both messages at once?
2. the first message only?
3. part of the first message?

- It depends on network conditions and the TCP/IP stacks!

Framing

- TCP can only send to and receive from a byte stream, but application protocols are built with discrete messages.
- We must define a method of *framing* application messages, so that message boundaries are unambiguous.
- Method used depends on the kind of data
  - Text
  - Binary

Text protocols

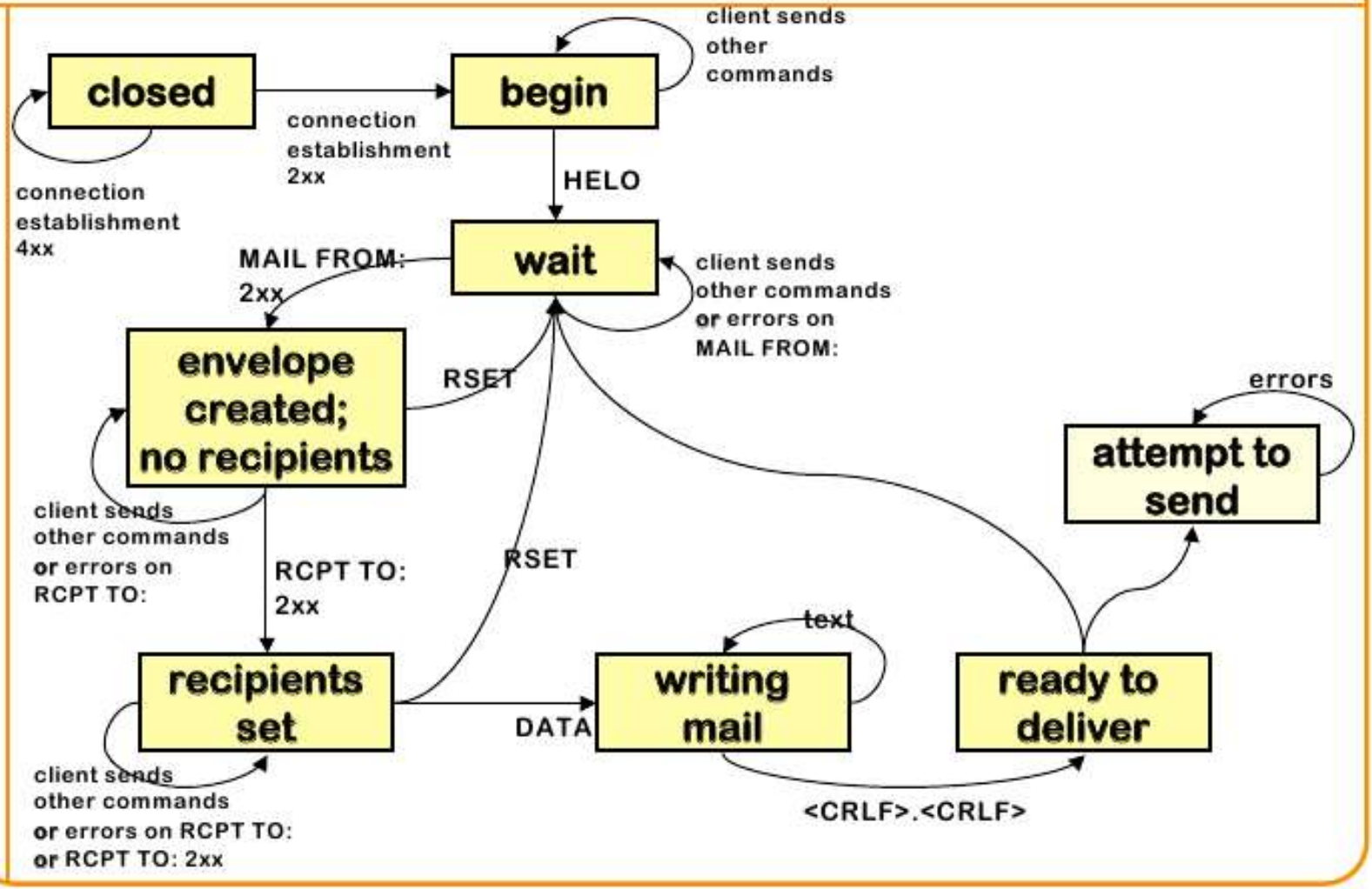
- Most application protocols on the Internet are textual.
  - Human readable — so easy to debug.
  - Historically, the most applications were textual e.g., Telnet, Email
- Disadvantages:
  - Vulnerable to security attacks like buffer overflows.
  - Bandwidth and CPU inefficient.

Example: SMTP

```
S: 220 smtp.server.com Simple Mail Transfer Servi
C: HELO client.example.com
S: 250 Hello client.example.com
C: MAIL FROM:<jane@yahoo.com>
S: 250 OK
C: RCPT TO:<john@gmail.com>
S: 250 OK
C: DATA
S: 354 Send message content; end with <CRLF>.<CRL
C: <The message data (body text, subject, e-mail
C: .
S: 250 OK, message accepted for delivery: queued
C: QUIT
S: 221 Bye
```

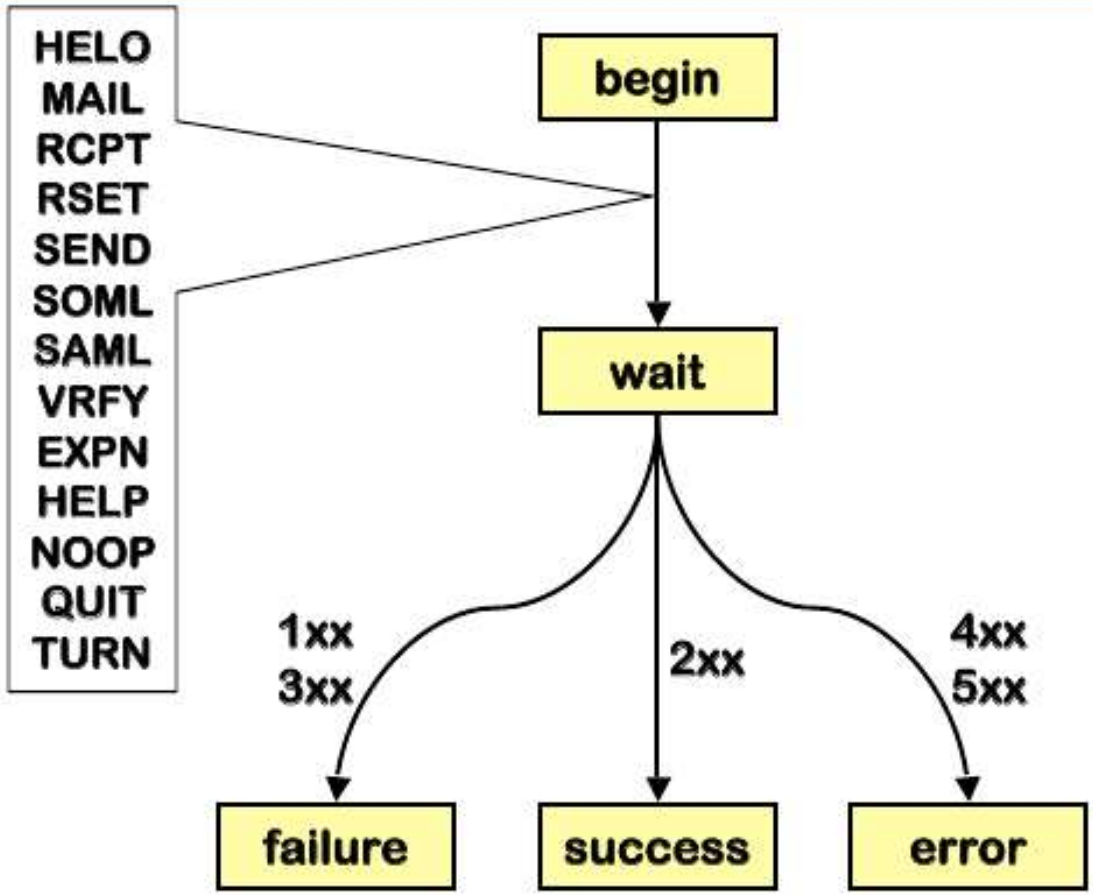
SMTP State Diagram

Server States



SMTP State Diagram

Command States



Delimiters

- We can *delimit* text protocol messages using a special character. The usual delimiter used in Internet protocols are the line termination characters CR, LF or CRLF.

```
Socket socket = new Socket(address, PORT);
BufferedReader sin = new BufferedReader (
  new InputStreamReader(socket.getInputStream() ));
BufferedWriter sout = new BufferedWriter (
  new OutputStreamWriter(socket.getOutputStream() ));
sout.write("hello world\n");
sin.readLine();
```

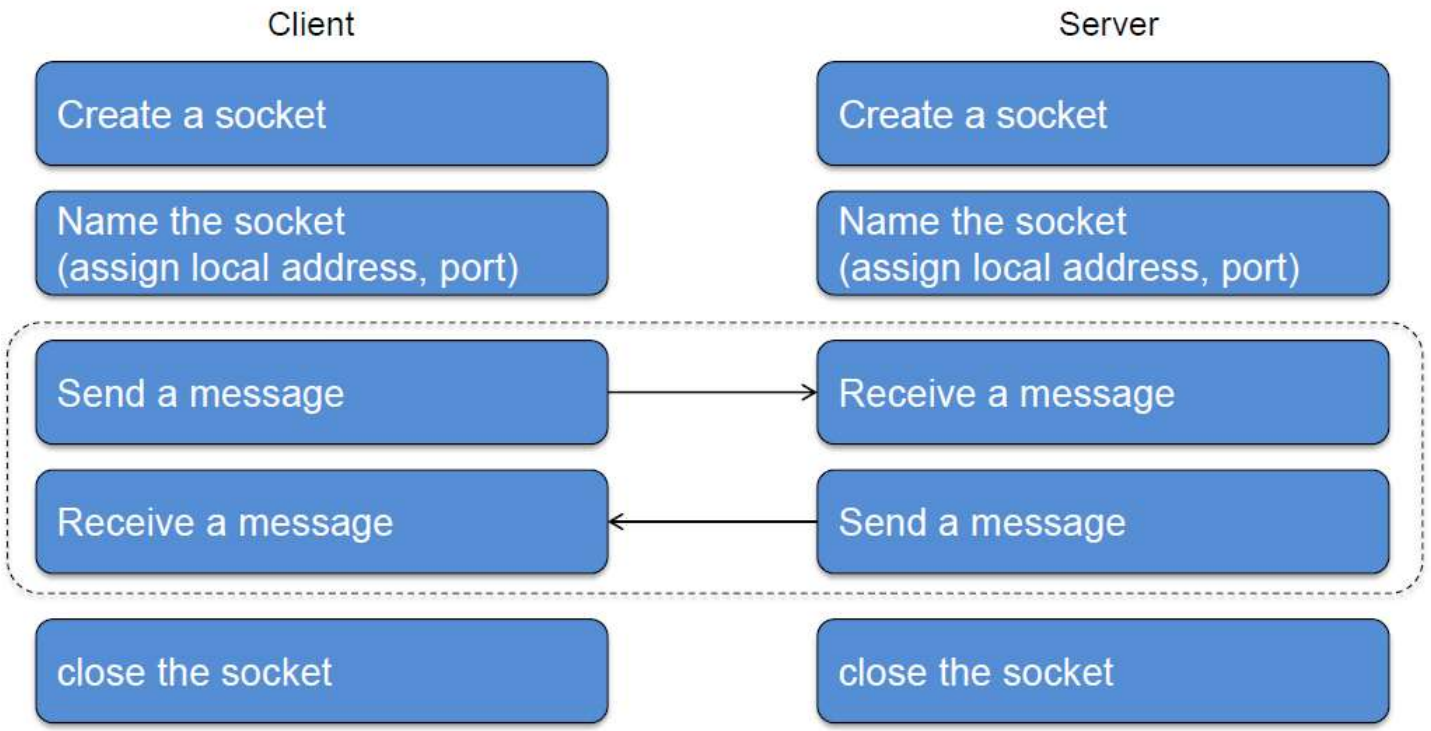
- BufferedReader.readline splits the apart newline delimited messages in a stream.

Binary protocols

- Binary protocols support transmission of arbitrary data. Usually contains a fixed-format *header* that describes the *payload*.
  - Suited to describing structured data.
  - Easier to *parse* — metadata received before payload.
  - Efficient use of bandwidth.
- Example: Basic encoding rules for ASN.1, an OSI standard used in protocols such as LDAP.

Type	Length	Value	End-of-content

Connectionless (UDP) socket operations



Connection-Oriented (TCP) socket operations