Lab Class
Protocol-Design

P2P-Overlay
Management of Multiple Connections

- Problem:
  - how to check if there is data ready to read on a connection?
  - how to additionally handle user input and incoming connections?

- Solution: IO::Select / select()
Use of IO::Select

use IO::Select;
$sel = IO::Select->new();
$sel->add(STDIN);
@handles = $sel->can_read();

see perldoc IO::Select
IO::Select and Sending/Receiving of Data

- IO::Select->can_read() looks for data in system buffers
- <$handle> reads data from system buffer into a PERL buffer
- Problem: can_read() cannot see data in PERL buffers
  - blocks with unread data in PERL buffer!
IO::Select and Sending/Receiving of Data

Possible Solutions:
1. sysread()/syswrite(), with selfwritten function to isolate lines.
2. Switch to non-blocking I/O
Non-Blocking I/O

- Enabling by:
  `$handle->blocking(0);`
- Effect:
  - `<$handle> returns empty string if no complete line is available or end-of-file or error!`
  - No implicit detection of connection end, has to be checked explicitly with `$handle->eof()`
Non-Blocking I/O

- Sending data:
  ```perl
  print $handle "protocol message\n";
  ```

- Wait for I/O event:
  ```perl
  @handles = $sel->can_read();
  foreach $h ( @handles ) { ... }
  ```

- Distinguishing between events:
  - by comparison with handles,
  - by checking for end-of-file (end of connection, connection died)
Non-Blocking I/O

- Need loop for reading entire PERL buffer:
  ```perl
  while ($line = $handle->getline()) {
    # process line
  }
  ```

- Loop terminates when `getline()` cannot return entire line. Rest stays in PERL buffer, but that's OK.
Program-Kernel - Initialization

# listen socket
$listen_sock = IO::Socket::INET->new();

# tastatur/STDIN
$stdin = IO::Handle->new();
$stdin->fdopen(fileno(STDIN), "r");
$stdin->blocking(0);

# select
$sel = IO::Select->new();
$sel->add($listen_sock);
$sel->add($stdin);
# Main loop

while (defined @handles = $sel-&gt;can_read() ) {
    foreach $h ( @handles ) {
        # keyboard
        if($h == $stdin) { ... }
        # listen-Socket
        elsif($h == $listen_sock) {
            ...
            $new = accept(...);
            $sel-&gt;add($new)
        }
        else ...
    }
}
# peer-connection
else {
    # Test for end-of-file/error
    if(...) {
        close($h);
        $sel->remove($h)
        ...
    } else {
        # read message
        ...
        # process message
        ...
    }
}
P2P-Protokol, Version 0.1

- Uses TCP
- General message format
  - single lines
  - lines terminated by "\r\n"
  - Requests end with "P2P/0.1" (and "\r\n", of course!)
  - Replies start with "P2P/0.1" and a numeric reply code, e.g., "200"
P2P-Protokol, Version 0.1

- Node connected by direct TCP connection is 'neighbour'
- Max. 4 \textit{active} connections, unlimited accept()s

- Needs session setup and teardown handshake to exchange node IDs and neighbour lists
- Multiple connections between same two neighbours is \textit{not} allowed!

- \textit{Never} forward handshake messages
- Other messages \textit{for now} forwarded by flooding
Broadcasting vs. Flooding

- Forwarding messages without knowledge of paths:
  - Broadcasting: forward to \textit{all} neighbours
  - Flooding: Like broadcasting, but don't forward into the direction, the message was received from (slight optimization).
Broadcast
Broadcast
Flooding
Flooding
P2P-Protokol, Version 0.1

- Request-Reply matching using message ID. Has together with node ID to be globally unique to detect message duplicates.

- Message have maximum travel distance of 3 hops using TTL field (decreased on receiving, forward if >0)
P2P-Protokol, Version 0.1

- Special handshake to initialize protocol session in order to exchange node IDs:
  - Request: HELLO NODE-ID viper:2000 P2P/0.1
  - Reply: P2P/0.1 200 NODE-ID boa:3000

- Only *after* the handshake, other messages are allowed to be sent over a connection!

- Handshake messages are *never* forwarded to other nodes!
**P2P-Protokol, Version 0.1**

- Ending a session:
  - DISCONNECT P2P/0.1
  - P2P/0.1 210 GOODBYE

- After that, close the TCP connection and delete all session related information (e.g., routing paths, ...)
**P2P-Protokol, Version 0.1**

- Mapping of session setup and teardown onto a state machine
- Edges (state transitions): `<event> "/" <action>`

Diagram:
- **NEW**
  - `connect() / send(HELLO)`
  - `recv(HELLO) / send(NODE-ID)`
- **UP**
  - `disconnect() / send(DISCONNECT)`
  - `recv(DISCONNECT) / send(GOODBYE)`
- **CLOSING**
  - `recv(GOODBYE)`
- **DOWN**
  - `recv(GOODBYE)`
P2P/0.1 State Machine in PERL

- new session in state 'new' after connect()/accept()
- On receipt of a message:

```perl
if($state{$h} eq 'new') {
    # here only HELLO is allowed!
    # send reply message
    $state{$h} = 'up';
} elsif ($state{$h} eq 'hello_sent') {
    # only reply to a HELLO message allowed!
    $state{$h} = 'up';
} elsif ($state{$h} eq 'up') {
    # other messages
    ...
}
```

- Adjust state also when sending messages, e.g., after sending a HELLO message.
Command Input

- Reading short commands from keyboard:
  - connect viper:2100
  - list connections
  - disconnect viper:2100