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Technical University of Applied Sciences

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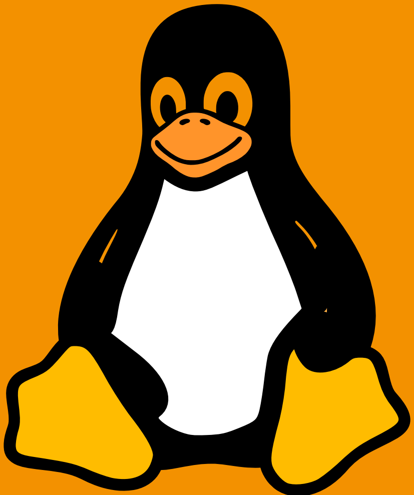
OS 8 – Communication 1



source: iconspng.com

The lecture is based on the work and the documents of Prof. Dr. Ludwig Frank

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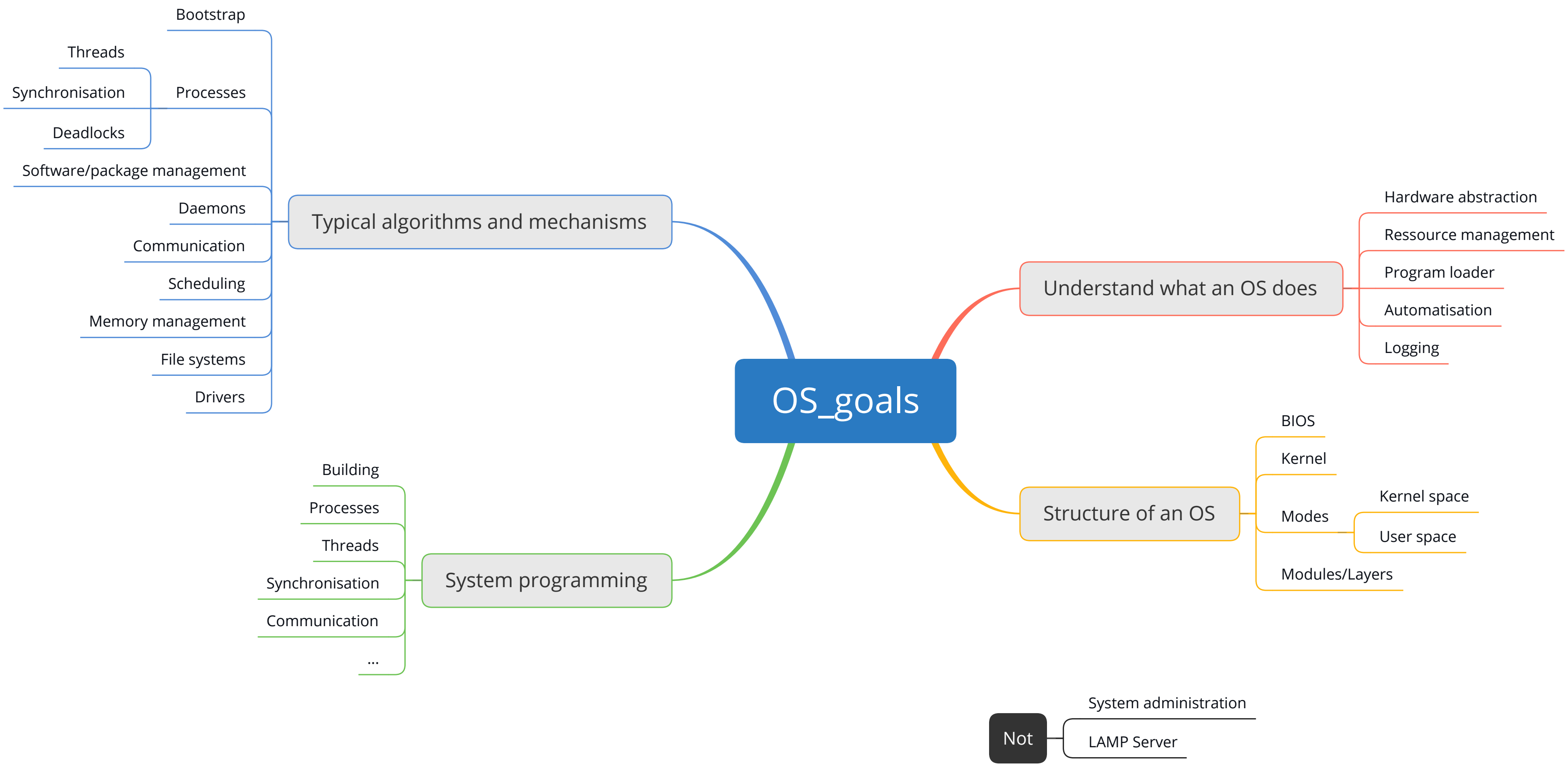
Goal



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Goal

OS::Communication

- Process communication concept
- Signals
- Sockets (Unix, network)

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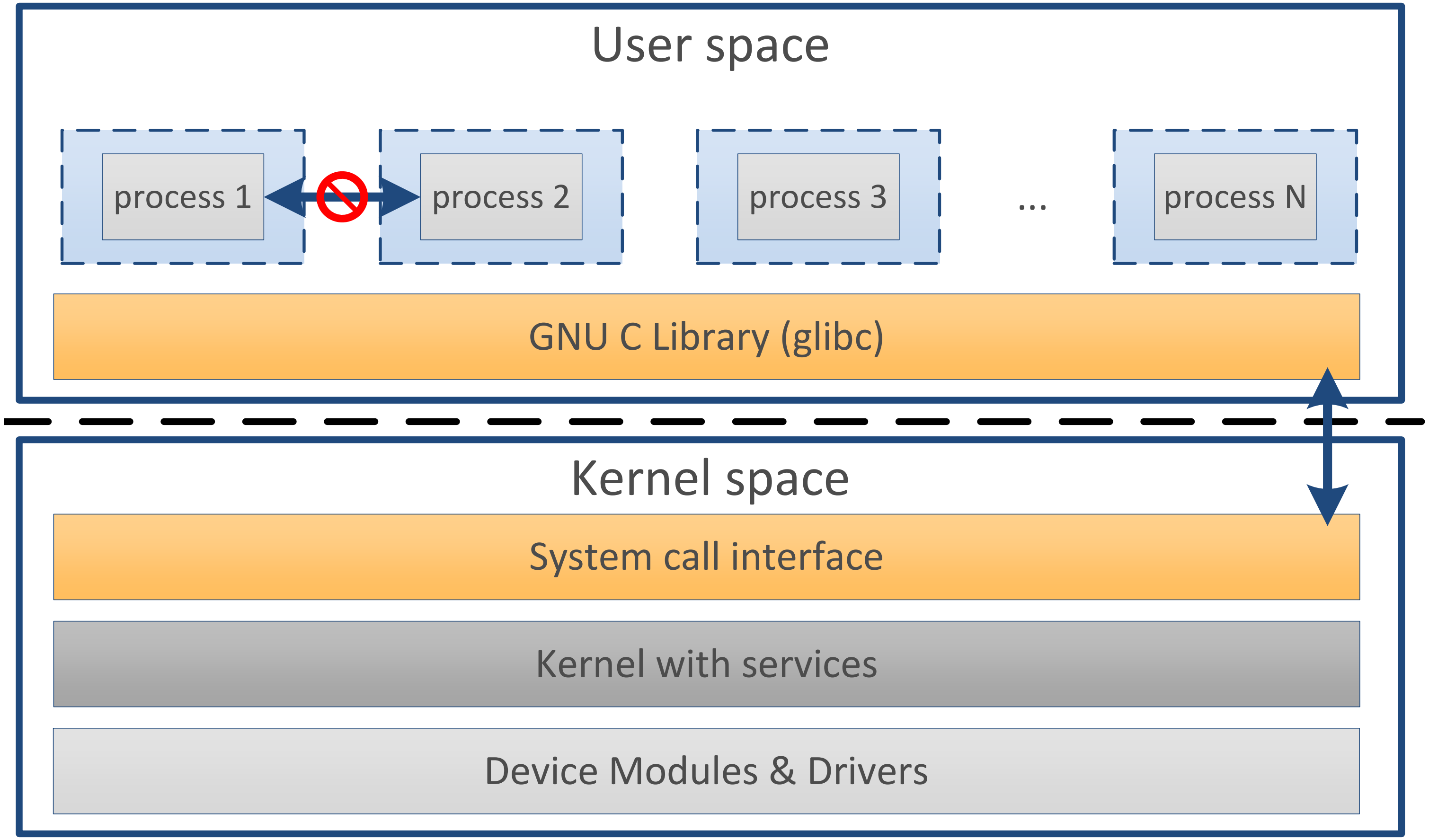
Process isolation ⇒ no communication



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Intro

Why do you want to communicate with a process?

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Intro

How can we communicate with a process?

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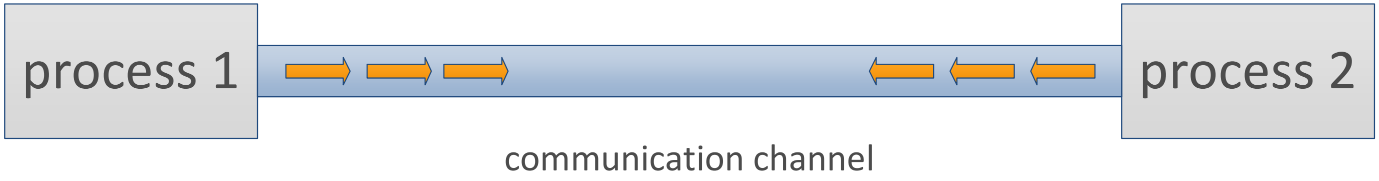
Process communication



- The communication channel is provided by the OS
- Different types of communication channels exist

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Process communication

Important concepts

Function/concept	**Description**
`send(destination, message)`	**Send** a message **to** the **destination**.
`recv(source, &message)`	**Receive** a message **from** the **source**.
Blocking/synchron	`send()/recv()` **blocks** until the data is fully transferred.
Non-blocking/asynchron	`send()/recv()` **immediately returns** and the process can proceed.
Protocol required	A **protocol** defines the **order of `send()/recv()`** between processes and the message format.
Half-duplex/unidirectional	Communication over a "channel" **only in one** direction.
Full-duplex/bidirectional	Communication over a "channel" **in both** directions.

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Signals

Idea: Signals are **asynchronous events** that interrupt a process.

It is like an **interrupt** request at **process level**.

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Signals overview

List of signals: `kill -l`

```
 1) SIGHUP       2) SIGINT       3) SIGQUIT      4) SIGILL       5) SIGTRAP
 6) SIGABRT      7) SIGBUS       8) SIGFPE       9) SIGKILL     10) SIGUSR1
11) SIGSEGV     12) SIGUSR2     13) SIGPIPE     14) SIGALRM     15) SIGTERM
16) SIGSTKFLT   17) SIGCHLD     18) SIGCONT     19) SIGSTOP     20) SIGTSTP
21) SIGTTIN     22) SIGTTOU     23) SIGURG      24) SIGXCPU     25) SIGXFSZ
26) SIGVTALRM   27) SIGPROF     28) SIGWINCH    29) SIGIO       30) SIGPWR
31) SIGSYS      34) SIGRTMIN    35) SIGRTMIN+1  36) SIGRTMIN+2  37) SIGRTMIN+3
38) SIGRTMIN+4  39) SIGRTMIN+5  40) SIGRTMIN+6  41) SIGRTMIN+7  42) SIGRTMIN+8
43) SIGRTMIN+9  44) SIGRTMIN+10 45) SIGRTMIN+11 46) SIGRTMIN+12 47) SIGRTMIN+13
48) SIGRTMIN+14 49) SIGRTMIN+15 50) SIGRTMAX-14 51) SIGRTMAX-13 52) SIGRTMAX-12
53) SIGRTMAX-11 54) SIGRTMAX-10 55) SIGRTMAX-9  56) SIGRTMAX-8  57) SIGRTMAX-7
58) SIGRTMAX-6  59) SIGRTMAX-5  60) SIGRTMAX-4  61) SIGRTMAX-3  62) SIGRTMAX-2
63) SIGRTMAX-1  64) SIGRTMAX
```

Signals: some important signals

Nr	Signal	Key	Blockable	Description
1	SIGHUP		Y	Hangup detected on controlling terminal or death of controlling process
2	SIGINT	CTRL+C	Y	Interrupt from keyboard
3	SIGQUIT	CTRL+\	Y	Quit from keyboard
4	SIGILL		Y	Illegal Instruction
6	SIGABRT		Y	Abort signal from `abort()`
8	SIGFPE		Y	Floating-point exception
9	SIGKILL		N	Kill signal
14	SIGALRM		Y	Timer signal from `alarm()`
15	SIGTERM		Y	Termination signal
10	SIGUSR1		Y	User-defined signal 1
12	SIGUSR2		Y	User-defined signal 2
18	SIGCONT		Y	Continue if stopped
19	SIGSTOP		N	Stop process
20	SIGTSTP	CTRL+Z	Y	Stop typed at terminal

More details: `http://man7.org/linux/man-pages/man7/signal.7.html`

Signals: handling

- If a process receives a signal: the **signal** is **saved** in the **PCB**.
- If the process state changes to “**running**” the **process** will be **interrupted**.
- The operating system looks if there is a registered handler for the received signal
  - If there is a **registered handler**, then **this function** will be called.
  - If there **no handler** registered, the **default handler** will be called.
- If the handler hasn’t exited the process, the **process proceeds** exactly at the **position before** it was **interrupted**.

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Signals: shell

Commands

Command	Description
`kill PID`	Sends the signal **15 (SIGTERM)** to the process.
`kill -1 PID`	Sends the signal **1 (SIGHUP)** to the process.
`kill -SIGHUP PID`	Sends the signal **1 (SIGHUP)** to the process.
`killall process_name`	Sends the signal **15 (SIGTERM)** to the process.
`killall -s HUP process_name`	Sends the signal **15 (SIGTERM)** to the process.

Signals: signal handling C example

```c
#include <stdio.h>  //printf
#include <stdlib.h> //EXIT_SUCCESS
#include <signal.h> //signal
#include <unistd.h> //sleep

void signal_handler(int signal) {
    printf("No, I don't want to terminate right now!\n");
}

int main(int argc, char** argv) {
    //register the signal handler
    signal(SIGTERM, signal_handler);

    for(long long int i = 0; i < __LONG_LONG_MAX__; ++i) { //do something usefull...
        printf("sleeping!!\n");
        sleep(5);
    }

    printf("%s exits main() now!\n", argv[0]);
    return EXIT_SUCCESS;
}
```

Signals: C function overview

Function*	Description
`raise(int sig);`	**Sends** a **signal** to the calling process or thread.
`kill(pid_t pid, int sig);`	**Sends** a **signal** to the process with the specified pid.
`pause(void);`	Causes the calling process or thread to **sleep until a signal is delivered**.
`sleep(unsigned int seconds);`	**Sleeps** for the **specified seconds** or **until a signal delivered**.
`alarm(unsigned int seconds);`	**Sends an alarm** to the calling process or thread in the specified seconds.
`signal(int signum, sighandler_t handler);`	**Registers** a **signal handler** for signum.
`signal(int signum, SIG_IGN);`	**Ignores** signals for signum, by setting a `SIG_IGN` handler, which doesn't exits the process.
`signal(int signum, SIG_DFL);`	**Sets** the **default handler** for signum.

*return types not shown here!

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Questions?

All right? ⇒ ✓

Question? ⇒ ✋ and use **chat**

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Sockets

Socket concept

- Endpoint for sending or receiving data
- Inter-process communication (IPC)
- Byte oriented data transfer
- Full-duplex -> `send()`/`recv()` over the same socket

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Sockets

Connection oriented vs connectionless.

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Socket: connection oriented

Pseudo C code

```
void server() {
  socket(...); //create comm. interface
  bind(...);   //connect address with socket
  listen(...); //create a queue
  accept(...); //wait until client connects


  //unblock the server


  //receive data: wait for data
  recv(...)
  //...



  //close socket and connection
  close(...);
}
```

```
void client() {




  socket(...);  //create comm. interface
  connect(...); //connect to server

  //send data: wait until data are sent
  send(...)


  //...

  //close socket and connection
  close(...);


}
```

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Sockets

Unix vs network sockets.

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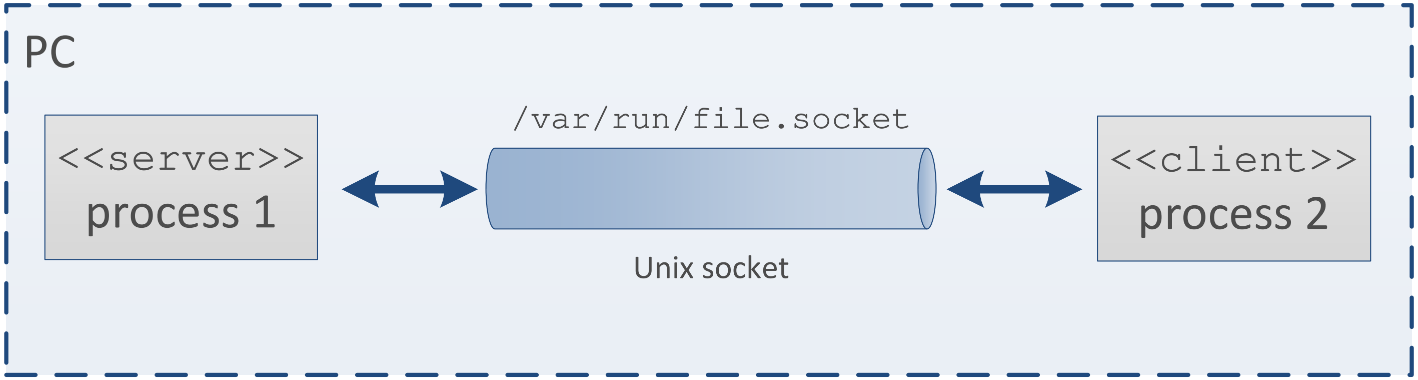
Unix sockets



Unix sockets

Unix socket concept

- Unix domain
- Communication only on same PC
- Is faster than network (TCP/IP or UDP/IP) socket
- Use file system as address name space
- User ID can be determined
- Access control via file system

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Unix sockets

Example

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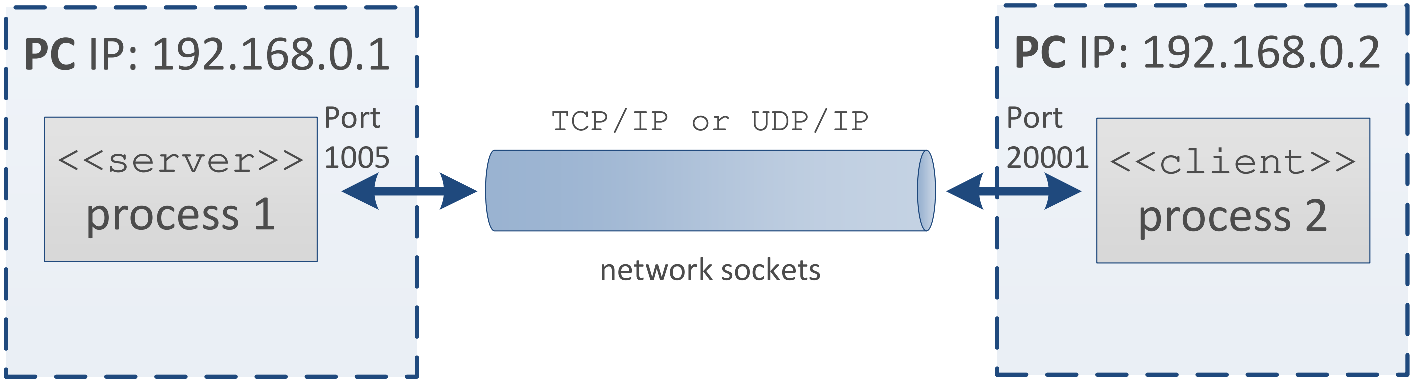
Network sockets: remote



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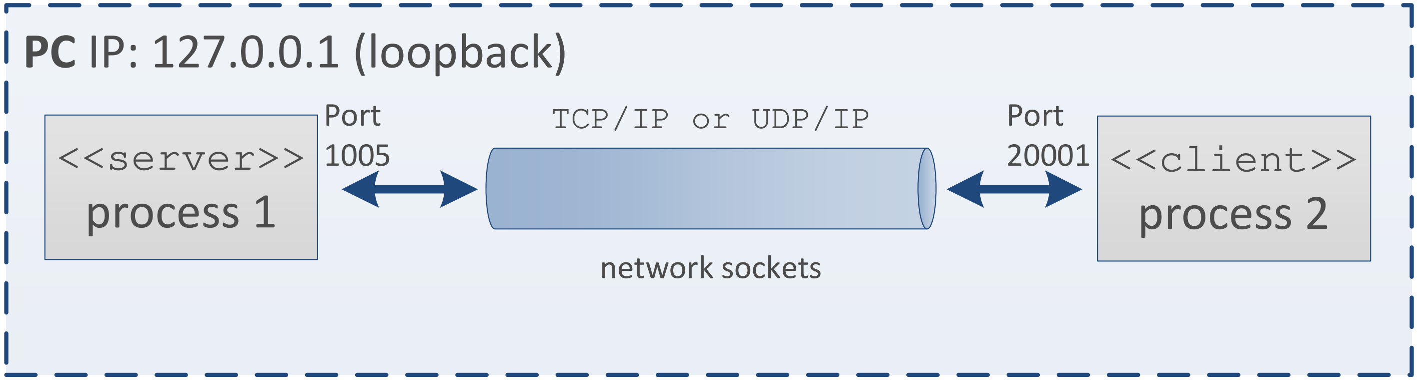
Network sockets: local



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Network sockets

Network socket concept

- Internet/network domain
- Communication over the network
- Communication on same PC over loopback
- TCP/IP: connection oriented
- UDP/IP: simple connectionless communication
- Access control on package filter level

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Network sockets

C example

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Summary and outlook

Summary

- Process communication concept
- Signals
- Sockets (Unix, network)

Outlook

- Message queues
- Shared memory