Complex Lab – Operating Systems
Sessions and Dynamic Memory

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We are here

Pong Server

Paddle Client 1

Paddle Client 2

Moe

Sigma0

Fiasco Kernel
Today’s goal
Scenario:

- Multiple clients per server
- Server stores per-client data, needs to distinguish between clients
Sessions

- **Scenario:**
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- **Poor man’s solution:**
  - Assign dynamic ID, which clients sends with each call
  - Problem: IDs can be faked
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Better (actual) solution: Sessions
- One IPC gate per client
- Clients can be distinguished by the gate label
- Preferably clients should not even know about sessions
Sessions in L4Re

Ned

create gate
Sessions in L4Re

start server

Ned

Server
Sessions in L4Re

Ned

call Factory::create()

Server
Sessions in L4Re

Server -> create -> Ned
Sessions in L4Re

start client

Server – Ned – Client
Sessions in L4Re

Diagram:
- Server
- Ned
- Client

Arrows indicate the flow of communication between Server and Client.
Lua Example: Simple

```lua
local L4 = require("L4");

local ld = L4.default_loader;
local log = ld:new_channel();

ld:start({ caps = { log_server = log:svr() },
           log = { "server", "blue" } },
           "rom/logging");

ld:start({ caps = { log_server = log },
           log = { "client", "green" } },
           "rom/logging_client");
```
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local log = ld:new_channel();

ld:start({ caps = { log_server = log:svr() },
            log = { "server", "blue" } },
           "rom/logging");

ld:start({ caps = { log_server = log:create(0, "args") },
            log = { "client", "green" } },
           "rom/logging_client");
```
Sessions Implementation

- Clients don’t change at all (that’s what we wanted, remember?)
- Servers need to handle the create call.
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A short tour of the L4Re IPC server framework
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▸ L4::Server implements the basic server loop:

```c
void loop() {
    while (1) {
        m = recv_message();
        ret = dispatch(m, utcb);
        reply(m, ret);
    }
}
```
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- For each IPC gate there is a L4::Epiface, which
  - keeps the capability to the IPC gate,
  - handles messages from this gate (implements dispatch())
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► For each IPC gate there is a L4::Epiface, which
  ► keeps the capability to the IPC gate,
  ► handles messages from this gate (implements dispatch())

► How does the server know which Epiface it should call?
IPC tour: Epiface registry

- L4::Epifaces are stored in a per-server registry.
- The registry can find Epifaces by an ID (label of IPC gate)
- L4::Basic_registry: ID is pointer to object
- L4::Util::Object_registry provides a convenient interface:

```cpp
L4::Cap<void> register_obj(L4::Epiface *o,
                            char const *service);
L4::Cap<void> register_obj(L4::Epiface *o);
bool unregister_obj(L4::Epiface *o);
```
IPC tour: Registry server

L4Re::Util::Registry_server is a L4::Server that maintains a
L4Re::Util::Object_registry

    static L4Re::Util::Registry_server<> server;

class MyServer : public L4::Epiface_t<MyServer, MyInterface>
{ ... };

    // When you need a new session object
server.registry()->register_obj(new MyServer());
```cpp
class SessionServer : L4::Epiface_t<SessionServer, L4::Factory>
{
public:
    int op_create(L4::Factory::Rights, L4::Ipc::Cap<void>& res,
        L4_mword_t type, L4::Ipc::Varg_list<> const& args) {
        if (type != 0) return -L4_ENODEV;

        L4::Ipc::Varg tag = args.next();
        if (!tag.is_of<char const *>()) return -L4_EINVAL;

        auto helloserver = new HelloServer
            (tag.value<char const *>());
        server.registry() -> register_obj(helloserver);
        res = L4::Ipc::make_cap_rw(helloserver -> obj_cap());
        return L4_EOK;
    }
};
```
With that you can add support for multiple clients in the hello server.
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Assignment 1.5:
- Make your hello server a logging server that supports multiple clients
- Client messages should be prefixed with an id string, that is passed to the server in the create call.
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- Make your hello server a logging server that supports multiple clients
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Problem: Now you need dynamic memory, but malloc and free are missing.
Memory Allocation

- Memory allocation is (currently not) implemented in a backend of L4Re’s C library (in src/l4/pkg/l4re-core/libc_backends/)
- You can get new pages from Moe:
  - Allocate a dataspace capability
  - Get a dataspace from Moe:
    ```
    L4Re::Env::env() -> mem_alloc() -> alloc(size, ds);
    ```
  - Attach dataspace to local address space:
    ```
    L4Re::Env::env() -> rm() -> attach(&addr, size, flags, ds);
    ```
- To free unused pages:
  ```
  L4Re::Env::env() -> rm() -> detach(addr, nullptr);
  L4Re::Env::env() -> mem_alloc() -> free(ds);
  ```
void *malloc(unsigned size) {
    L4::Cap<L4Re::Dataspace> ds
        = L4Re::Util::cap_alloc.alloc<L4Re::Dataspace>();

    if (!ds.is_valid()) return 0;

    long err = L4Re::Env::env()->mem_alloc()->alloc(size, ds);
    if (err) return 0;

    void *addr = 0;
    err = L4Re::Env::env()->rm()->attach(&addr, size, L4Re::Rm::Search_addr, ds);
    if (err) return 0;

    return addr;
}
Memory Management – Lists

- Idea:
  - Keep list of (address, size) pairs
  - In `malloc`, search for an appropriate entry

- Problem: You’d need dynamic memory for that list.

- Typical Solution: Inlining
  - Put size and next-pointer directly into your memory
  - Do not hand out the memory where size is stored – it’s needed for free.
  - That’s what most libC-implementations do.
Memory Management – bitmaps

- Manage memory as pool of fixed-sized chunks.
- Use bitmap to store available chunks.
Memory Management – problems

- You will need some initial memory. You can use L4Re’s memory allocator for that.
- As soon as you have multiple threads (you will), you need proper locking.
- There are more options for the implementation. Come up with something yourself, or have a look in some book / the internet.
- **Important**: If you end up writing a memory allocator that does not have the size right in front of each block (which is ok), contact me.
Assignmen t 2

- Implement a session-capable hello server (that’s going to be our logging server)
- For that you’ll need to implement malloc and free.
- From there on, you should be able to use C++’s STL.