TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Computer Science Institute for System Architecture, Operating Systems Group

Complex Lab — Operating Systems 2012 Winter Term

Introduction

Requirements

Basic Operating Systems Know-How

- Virtual Memory (Paging/Page Tables)
- Memory Management
- File Systems
- Device Drivers
- Processes and Threads
- Operating System Structures (What is a microkernel?)

Experience with UNIX/Linux

- Editor (for Programming)
- Using a command shell
- Development Tools (GNU Make, Binutils, GCC)

Experience with C/C++ Programming Language

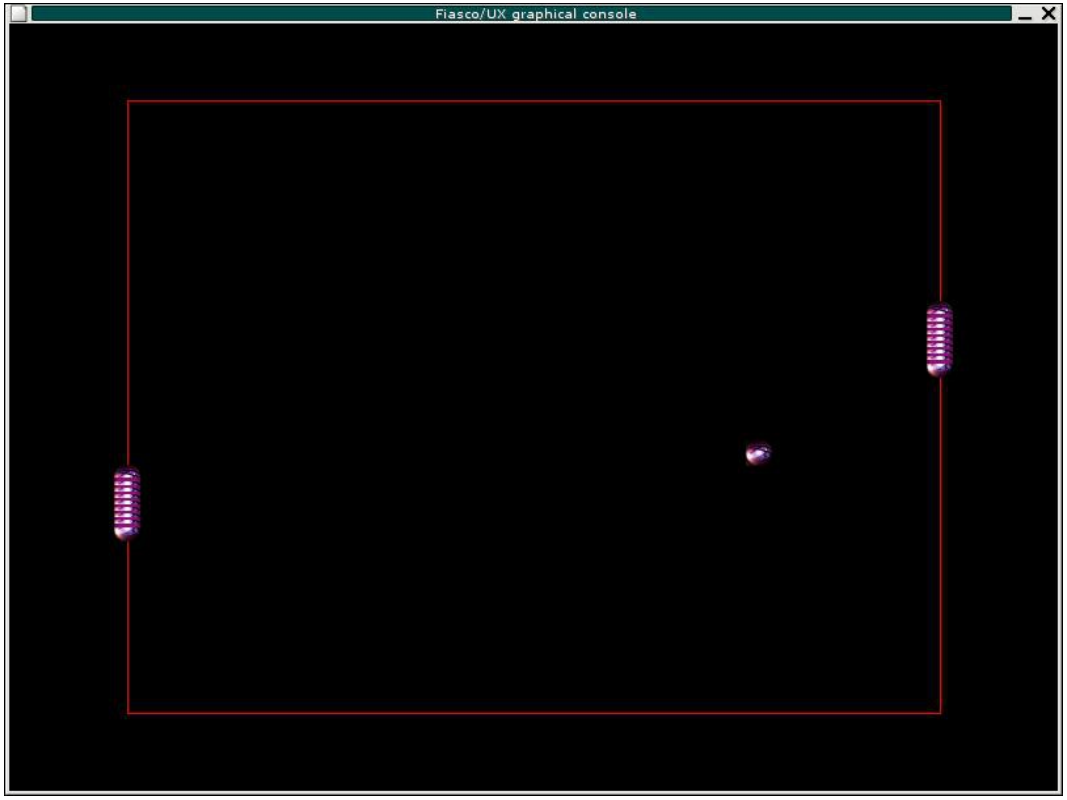
- Writing C Programs
- Using Pointers (Pointer Arithmetics)
- What is the Stack?

Administration

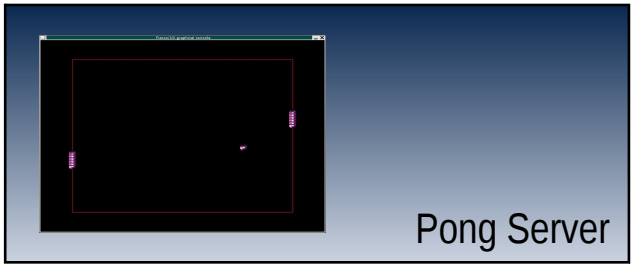
- Consultation roughly bi-weekly (Tue. 2.50PM, INF E08)
- Website:
  http://os.inf.tu-dresden.de/Studium/Praktikum/
- Mailinglist (Announcements, Discussions):
  http://os.inf.tu-dresden.de/mailman/listinfo/kpr2012
- Presentation to your tutor in the end
- System requirements
  - Linux (Debian/Ubuntu at best)
  - QEMU
  - ~600 MB disk space
- Deadline for Final Assignment: 31.03.2013
  - Results containing your source codes and documentation have to be sent to the tutor

Assignment

Multi-User Pong game



Course Starting Point



Paddle Client 1

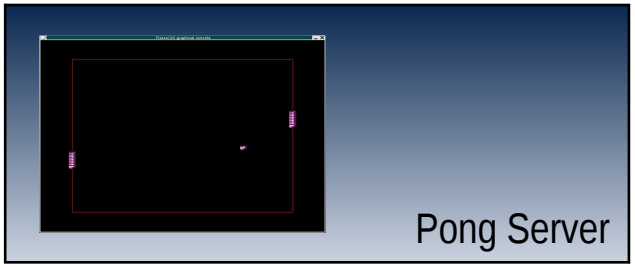
Paddle Client 2

Moe

Sigma0

Fiasco Kernel

Course Goal



Paddle Client 1

Paddle Client 2

Keyboard Driver

Graphical Console

Memory Management

Moe

Sigma0

Fiasco Kernel

Course Goal

- Memory management
  - malloc() / free()
- Console
  - Graphical in/output, multiplexing
- Keyboard driver
  - Handle keyboard in/output
- File system
  - CD-ROM ISO file system
  - Store binaries, highscores etc.

SVN, Documentation

- Subversion repository containing all source code:
  - http://os.inf.tu-dresden.de/Studium/Praktikum/src/trunk/kpr/
- Get acquainted to SVN – we may push updates throughout the semester.
  - No, we will not switch to git. Feel free to use git-svn, though.
- Documentation:
  - doc/html/index.html

Components of the Framework

- Fiasco microkernel
- The Sigma0 memory manager
- Basic C/C++ Environment
  - LibC, IPC Streams, IPC Server Framework, ...
- Moe root server
- Ned – the init script interpreter
- Pong-Server and Pong-Example Client
- GNU make based build system
  - For the Fiasco kernel
  - For the user-level applications (BID)

Building the KPR snapshot

- Building stuff:

```
$> make setup
$> make
```

- obj/l4/x86 — build directory
- doc/ — HTML documentation
- src/kernel/ — Fiasco microkernel sources
- src/l4/ — L4 sources
  - src/l4/mk — BID – the build infrastructure
  - src/l4/pkg — source packages
- bin/

Build Infrastructure (BID)

BID is a collection of Makefiles and Makefile templates

- Support easy building of
  - Applications
  - Libraries
- Simple Makefiles for applications and libraries

Simple package Makefiles:

```
# directories we need to know
PKGDIR ?=       ../..
L4DIR  ?=       $(PKGDIR)/../..

# source files
SRC_C   =       main.c          # C sources
SRC_CC  =       extension.cc    # C++ sources

# build target
TARGET  =       my_prog
# additional libraries
REQUIRES_LIBS =

# include BID prog rule (compile an
application)
include $(L4DIR)/mk/prog.mk
```

Build Infrastructure (BID)

BID templates for new packages:

```
kpr/src/l4/pkg> mkdir my_pkg
kpr/src/l4/pkg> cd my_pkg
kpr/src/l4/pkg/my_pkg> ../../mk/tmpl/inst
```

Installs package directory structure and template Makefiles

Build Infrastructure (BID) – Headers

Package include files:

```
kpr/src/l4/pkg/my_pkg/include/my_header.h
```

will be installed to:

```
kpr/obj/l4/x86/include/l4/my_pkg/my_header.h
```

can be used by other packages using:

```
#include <l4/my_pkg/my_header.h>
```

The build directory

- All compiled files are kept outside the source directories
  - Default: kpr/obj/l4/x86
- You can compile stuff in 3 ways:
  1. `make` in kpr/ root → builds everything
  2. `make` in kpr/obj/l4/x86/pkg/my_pkg
     → builds single pkg
  3. `make O=<builddir>` in kpr/src/l4/pkg/my_pkg
     → builds single pkg
- Special build target: `make qemu [E=<entry>]`
  - Launches Fiasco in Qemu
  - <entry> is the menu.lst entry to boot
  - Omitting E=<> brings up a menu

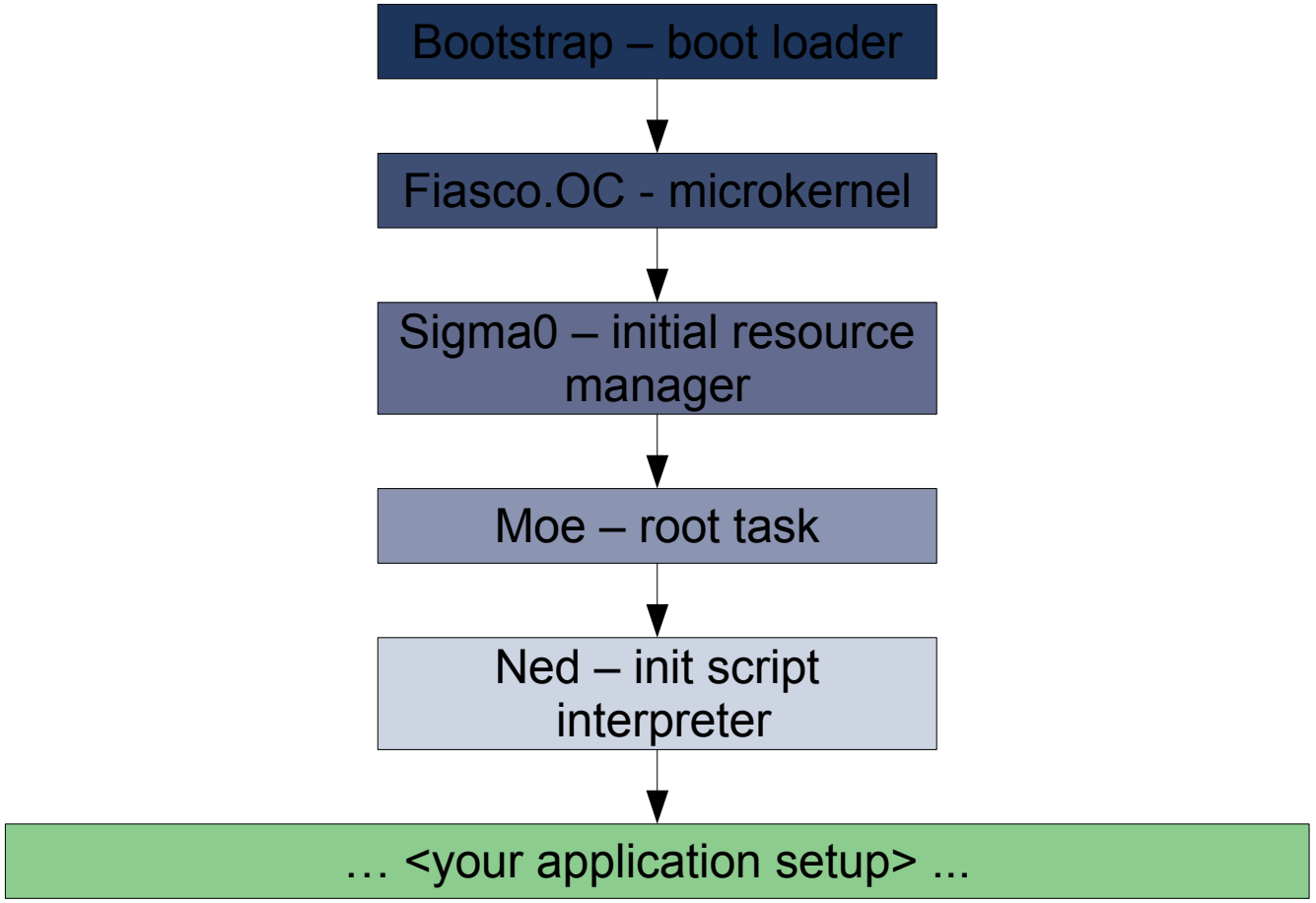
Qemu

- kpr/obj/l4/x86/Makeconf.local
  - QEMU settings
    - MODULE_SEARCH_PATH – where to look for binaries, config files, etc.
    - QEMU_OPTIONS – command line parameters for Qemu
- kpr/src/l4/conf/modules.list
  - Applications to boot for a given setup.
  - Similar to a GRUB menu.lst

Configuring – modules

- Specify a set of modules to boot
  - src/l4/conf/modules.list
  - Used to build a suitable config for your target
    - GRUB menu.lst entry
    - Qemu multiboot command line
    - Fiasco/UX command line
    - …
- Basically: list all files to be loaded
  - **entry** → title
  - **kernel** → fiasco + command line
  - **roottask** → moe + parameters
  - **module** → everything else (no parameters here!)

Short overview: bootup sequence



Configuring L4Re

- Moe gets 1 command line parameter
  - binary or startup script
- All boot modules available through ROM file system
- Startup script:
  - Scripting language: Lua (don't worry...)
  - Global config options
  - Name space definitions
    - Application's local view on its resources
    - Establish communication channels between apps
  - Applications
    - Command line parameters
    - L4Re options

Lua – seeing is believing

- Package 'ned' contains documentation
  - pkg/ned/doc/hello.lua → shortest possible script
  - pkg/ned/doc/tutorial.lua → tutorial on how to setup things like channels etc.
  - pkg/ned/doc/Aw.lua → some complex thingy

Preview: IPC

- Capability system
- Applications have a name space containing capabilities
- Some appear by magic (at startup)
  - Parent, memory allocator, name service, ... → L4Re::Env::env()
- Others configured at startup/runtime
- IPC gates
- Server:
  - register IPC gate at name service
  - Run IPC server loop
  - Handle request (dispatch function)
- Client:
  - Query IPC gate at name service → capability
  - Invoke capability with arguments

IPC: The UTCB

- UTCB contains message data
- C:
  - Obtain UTCB pointer using l4_utcb()
  - Fill in data into utcb->mr[0]
    to utcb->mr[L4_UTCB_GENERIC_DATA_SIZE]
  - Use l4_ipc_call() to invoke server
- C++:
  - Create Ipc_iostream and pass the UTCB as parameter
  - Write data using stream operators
- Special: Buffers and Flexpages – see the docs

Server Interfaces

Interfaces are based on IPC messages

- C++ stream syntax to generate/read messages
- Server Framework to handle server objects
- Client Stub code to provide a client side API

Examples in kpr/l4/pkg/

./hello	simple Hello World Application, no IPC
./clntsrv	client/server IPC example

Demo: Starting client-server examples

Server Implementation

- Server
- Registry
- Server_object

Server Interface:

dispatch Function of server object

- Interesting parameter: L4::Ipc_iostream& ios
  - Contains all parameters
- 1st parameter: message tag (protocol id + message descriptor)
- 2nd parameter: opcode
  - determines the method to call
- Write return values to ios again

Client

- Allocate capability slot
- Query for server capability name
  - This is the name you put into the client's name space!
  - Result: cap slot filled with valid capability (check!)
- Create L4::Ipc_iostream and fill in parameters:

```
L4::Ipc_iostream ios(l4_utcb());
ios << param1 << param2;
```

- Call server through stream interface:

```
ios.call(server.cap(), Protocol::Foo);
```

Assignments

- Make familiar with source archive
- Try out Fiasco on Qemu
- Build client-server version of “hello”:

```
class Hello {
    void show(char const * str);
};
```

- Server has to implement `Hello_server::dispatch(...)` function (print the string <str>)
- Client has to call the server (`Hello::show(...)` function)
- Try other interfaces
- **Deadline for this Assignment is November 19th**

Next Consultation

- November 20th
- Topics:
  - Discussion about the solutions for the first practical assignment
  - Kick-off for next assignment: Implementing malloc()/free() and sessions

Literature

Operating System Basics:

- Modern Operating Systems – Andrew S. Tanenbaum (OS Concepts, OS Structures, Virtual Memory)

L4 Specific Documentation:

- BID, Fiasco, Environment (kpr/doc/...)

- Mailing Lists (kpr2012)
- https://auditorium.inf.tu-dresden.de

- Doxygen comments in source code (HEADERS!)

- There's always a tutor to ask as the last resort.