



**TECHNISCHE
UNIVERSITÄT
DRESDEN**

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

SPPEXA TEACHLET: GETTING STARTED WITH L4RE

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- first contact with a microkernel OS
- getting to know QEMU
- compile Fiasco
- compile minimal system environment
- talk about system booting
- the usual „Hello World“
- review some stuff and play with the system

- developing your own kernel usually requires a dedicated machine
- we will use a virtual machine
- QEMU is open-source software providing a virtual machine by binary translation
- it emulates a complete x86 PC
- available for other architectures as well
- our QEMU will boot from an ISO image

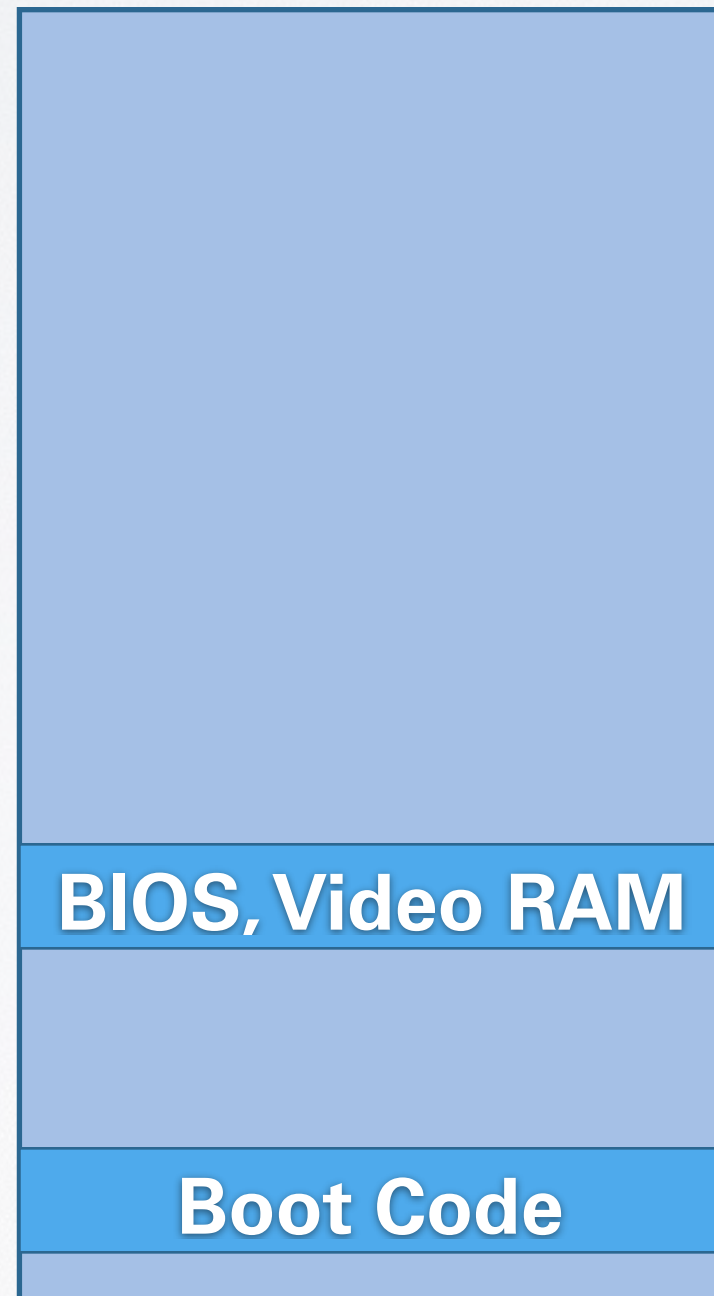
BOOTING

- Basic Input Output System
- fixed entry point after „power on“ and „reset“
- initializes the CPU in 16-bit real-mode
- detects, checks and initializes some platform hardware (like RAM, PCI, ATA)
- finds the boot device

**BIOS**

- first sector on boot disk
- 512 bytes
- contains first boot loader stage and partition table
- BIOS loads code into RAM and executes it
- problem: How to find and boot an OS in 512 bytes?

A dark teal rectangular box with the word "BIOS" in white, bold, sans-serif capital letters.



Physical Memory



- popular boot loader
- used by most (all?) Linux distributions
- uses a two-stage-approach
 - first stage fits in one sector
 - has hard-wired sectors of second stage files
 - second stage can read common file systems

Boot Loader

BIOS

- second stage loads a menu.lst config file to present a boot menu
- from there, you can load your kernel
- supports loading multiple modules
- files can also be retrieved from network

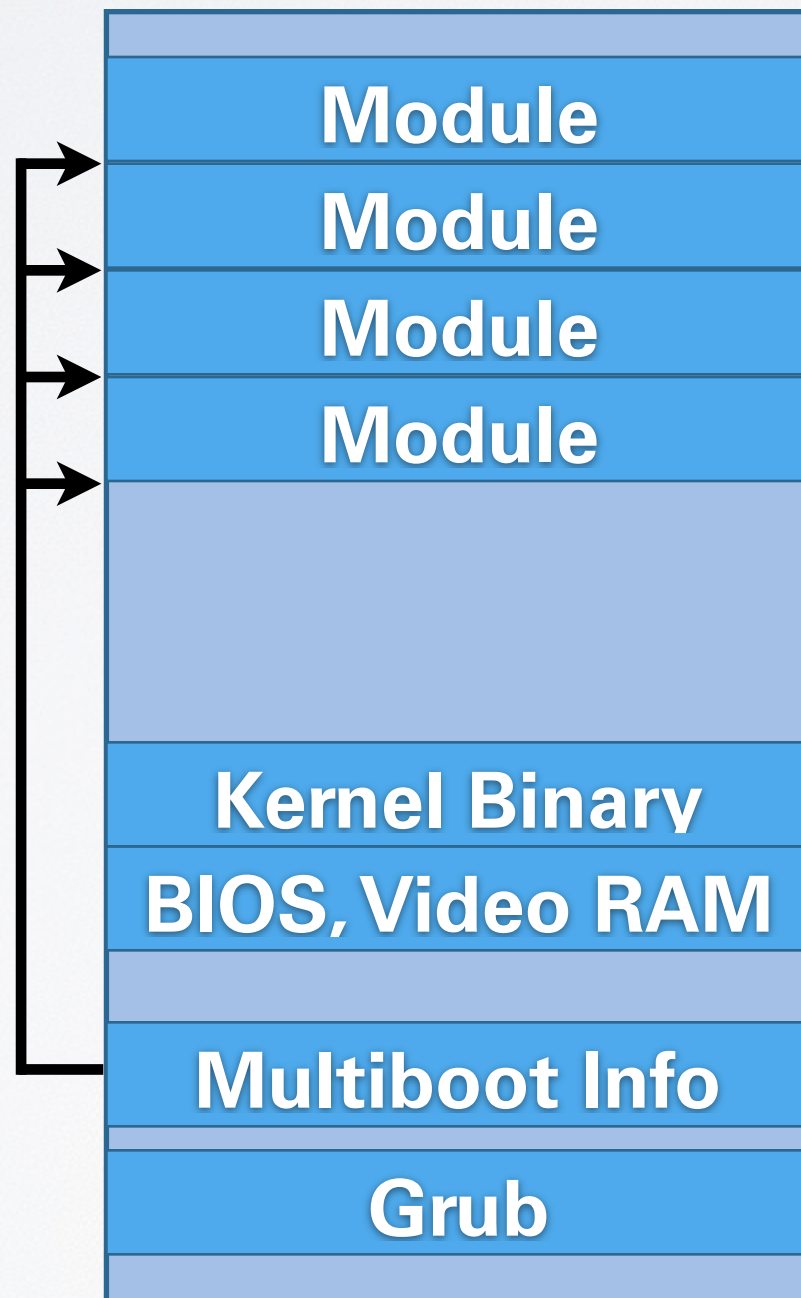
Boot Loader

BIOS

- switches CPU to 32-bit protected mode
- loads and interprets the „kernel“ binary
- loads additional modules into memory
- sets up multiboot info structure
- starts the kernel

Boot Loader

BIOS



Physical Memory

Boot Loader

BIOS

- our modules are ELF files:
executable and linkable
format
- contain multiple sections
 - code, data, BSS
- bootstrap interprets the ELF
modules
- copies sections to final
location in physical memory

Bootstrap

Boot Loader

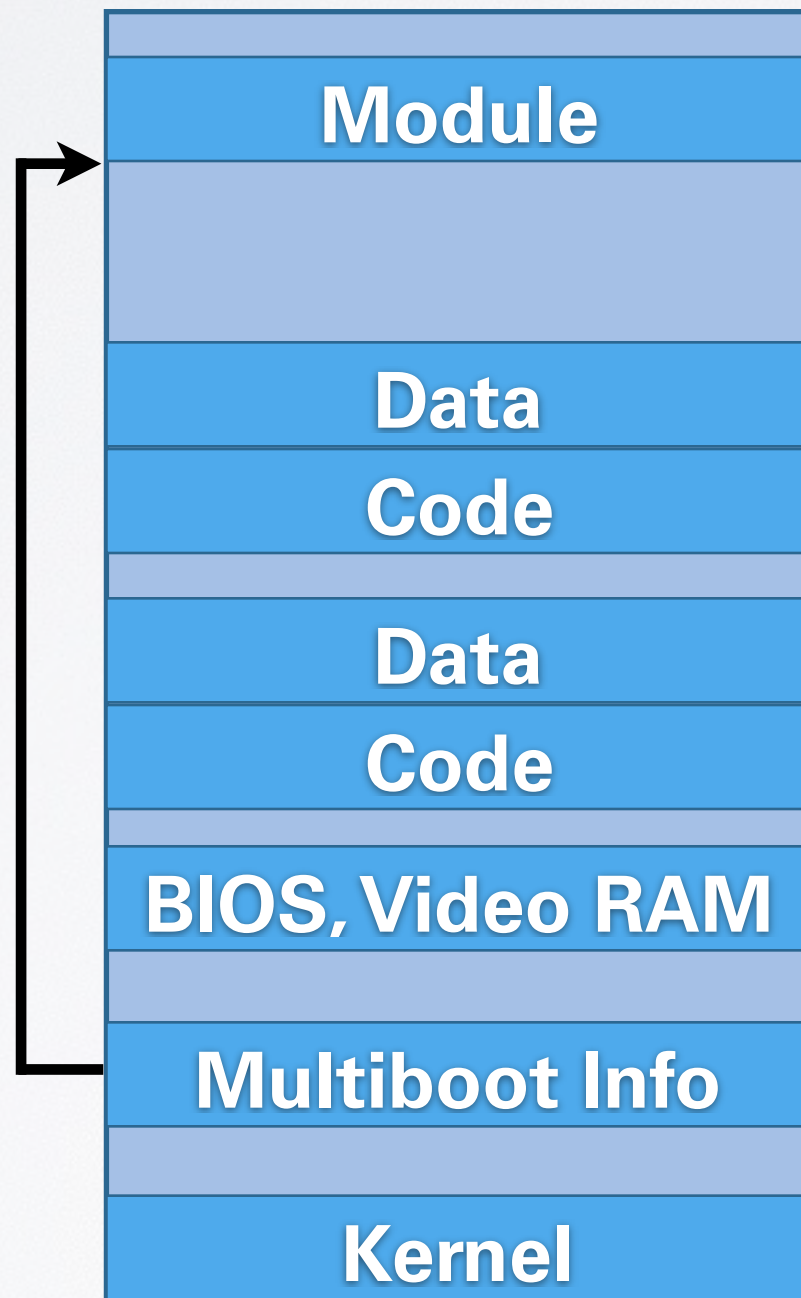
BIOS

- actual kernel is the first of the modules
- must know about the other modules
- bootstrap sets up a kernel info page
 - contains entry point and stack pointer of sigma0 and moe
- passes control to the kernel

Bootstrap

Boot Loader

BIOS



Physical Memory



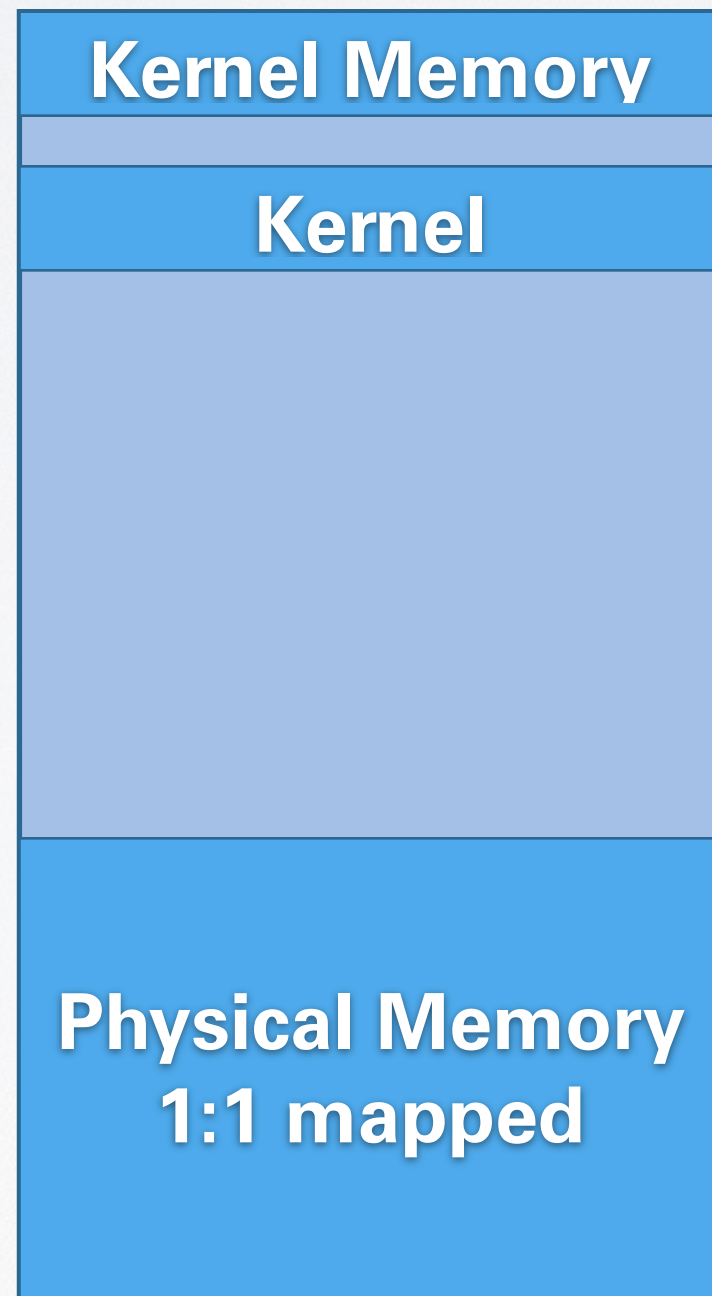
- initial kernel code
- basic CPU setup
 - detecting CPU features
 - setup various CPU-tables
- sets up basic page table
- enables virtual memory mode
- runs the actual kernel code

Kernel Loader

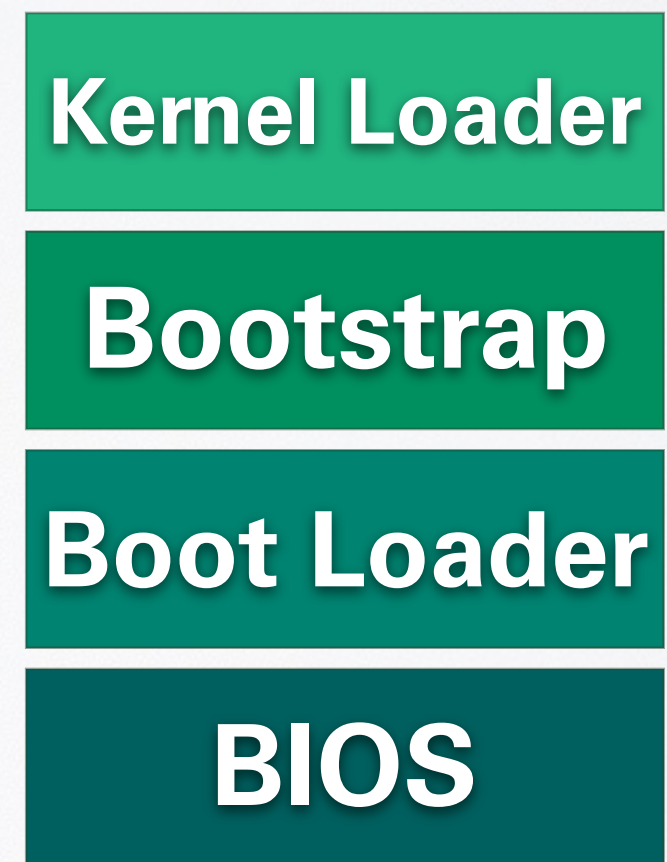
Bootstrap

Boot Loader

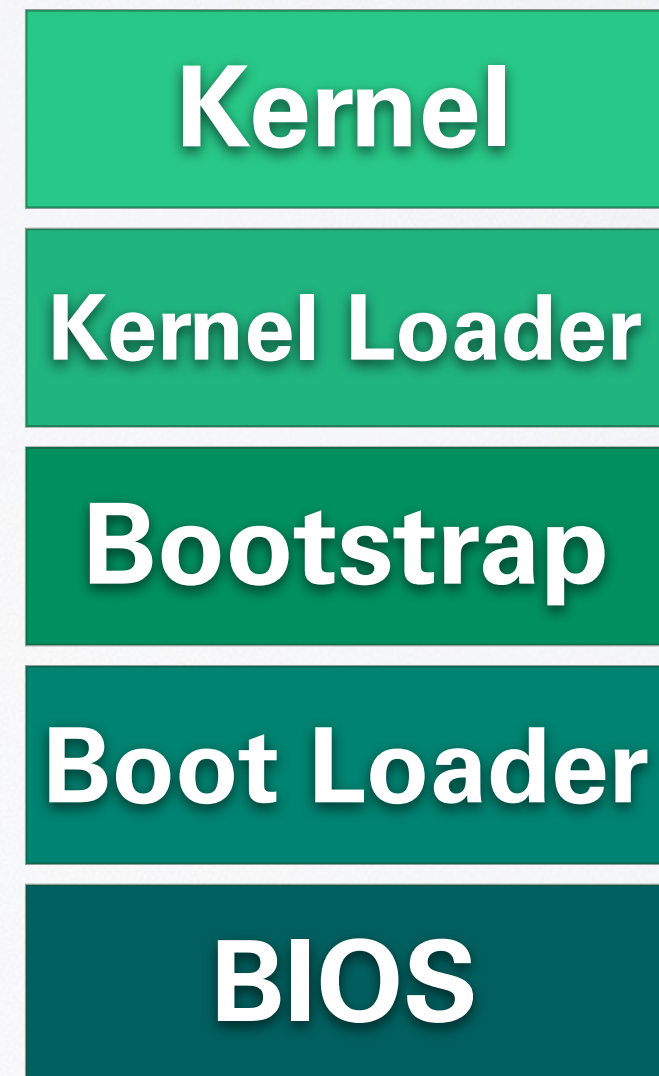
BIOS



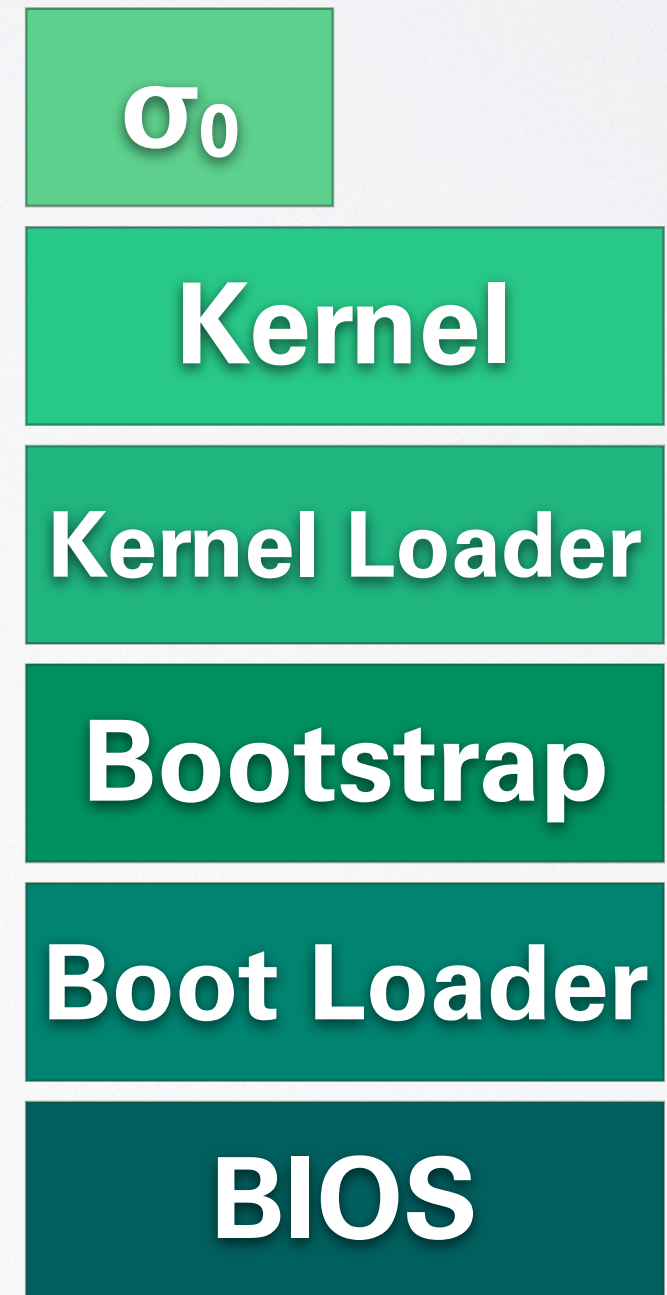
Virtual Memory



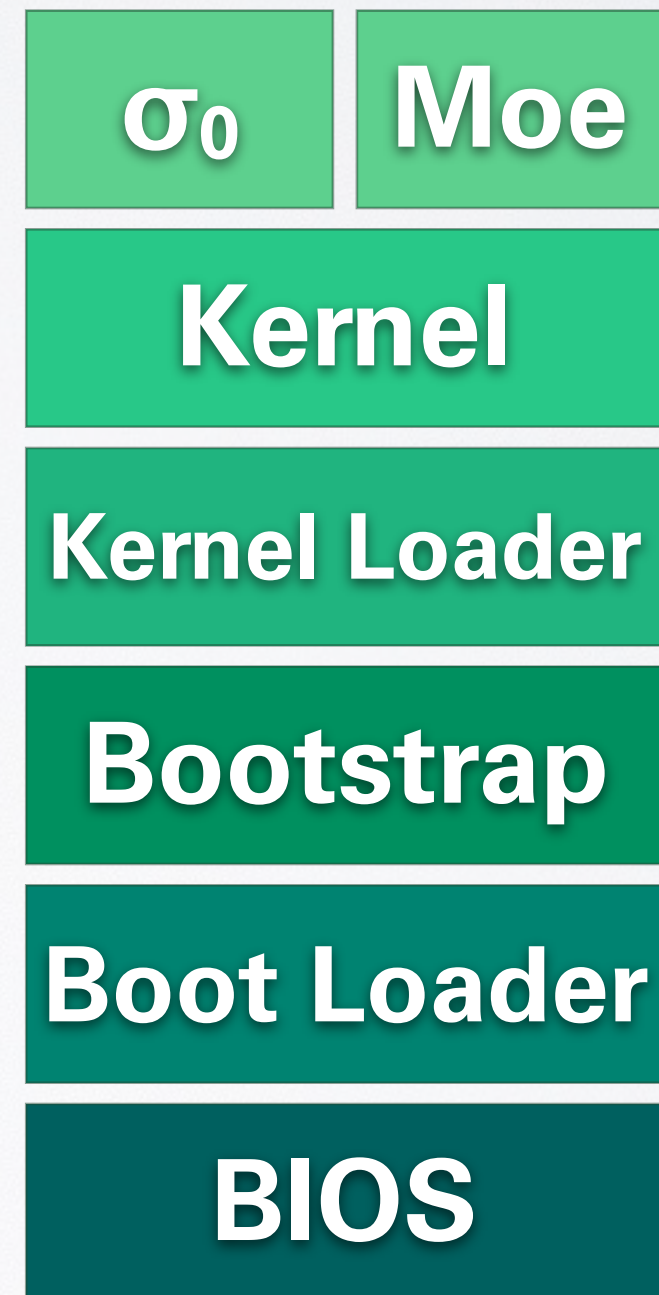
- sets up kernel structures
- sets up scheduling timer
- starts first pager
- starts first task
- starts scheduling
- scheduler hands control to userland for the first time



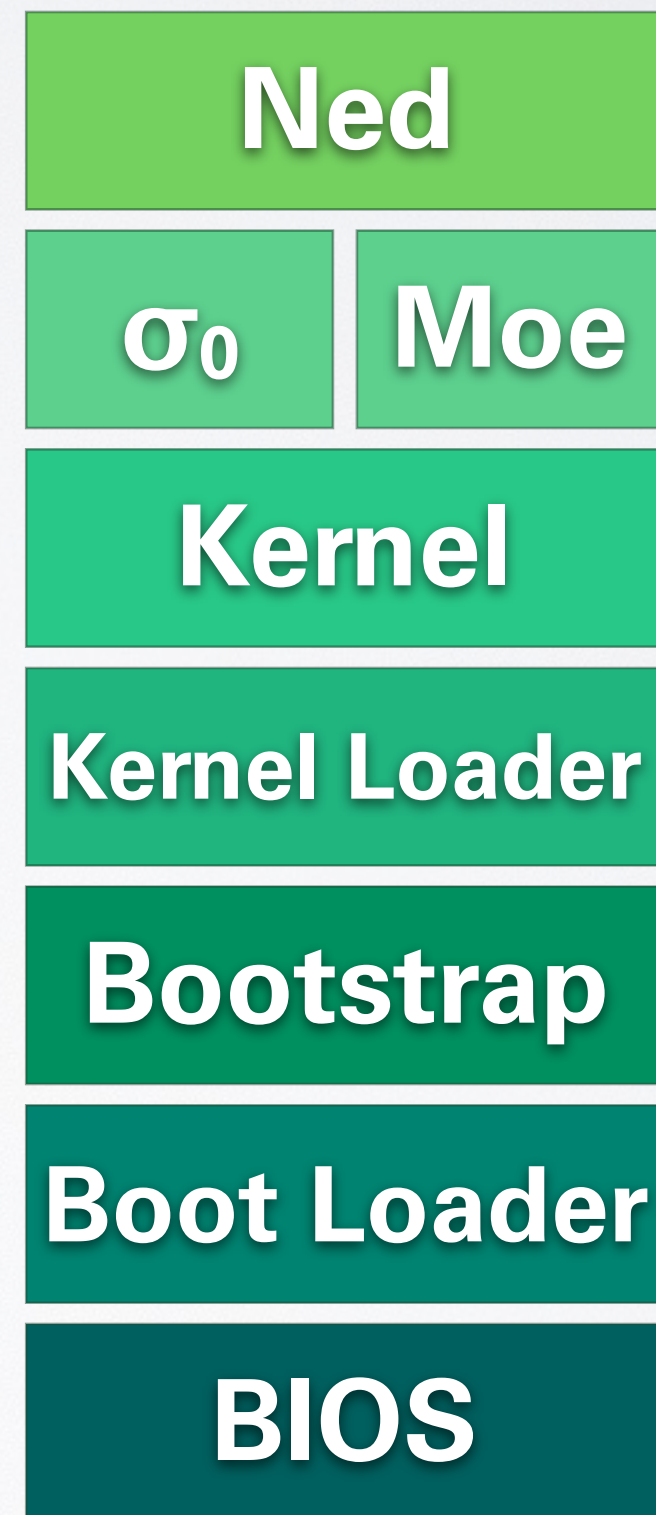
- is the first pager in the system
- initially receives a 1:1 mapping of physical memory
- ... and other platform-level resources (IO ports)
- sigma0 is the root of the pager hierarchy
- pager for moe



- manages initial resources
 - namespace
 - memory
 - VESA framebuffer
- provides logging facility
- mini-filesystem for read-only access to boot-modules



- script-driven loader for further programs
 - startup-scripts written in Lua
- additional software can be loaded by retrieving binaries via disk or network drivers
- ned injects a common service kernel into every task



Install Development Packages

- On 64-bit Debian or Ubuntu run the following command:

```
sudo apt-get install pkg-config g++  
g++-multilib libncurses5-dev make gawk  
dialog mkisofs qemu
```
- On 32-bit installs, `g++-multilib` is not needed
- Other Linux distributions work, too, but package names may differ from DebianUbuntu

Setup

- download the source tarball from <https://os.inf.tu-dresden.de/Studium/KMB/WS2015/Exercise1.tar.bz2>
- unpack the tarball
 - it comes with a working directory
 - `cd` in there and have a look around
- initialize the environment with `make setup` in the toplevel directory you unpacked and select `x86-32` as build target

Compiling the System

- run `make` within the toplevel directory

Test-Driving QEMU

- create a bootable ISO image
 - the `iso` subdirectory is for the ISO's content
 - run `isocreator` from `src/14/tool/bin` on this directory
- your ISO will contain a minimal grub installation
- launch QEMU with the resulting ISO:
`qemu-system-i386 -cdrom boot.iso`

Booting Fiasco

- copy some files to the ISO directory
 - `fiasco` from the Fiasco build directory
`obj/fiasco/ia32/`
 - `bootstrap` from
`obj/14/x86/bin/x86_586/`
 - `sigma0`, `moe`, `14re` and `ned` from
`obj/14/x86/bin/x86_586/14f/`

Booting Fiasco

- edit `iso/boot/grub/menu.lst`:
 `title Getting Started`
 `kernel /bootstrap -modaddr 0x01100000`
 `module /fiasco`
 `module /sigma0`
 `module /moe`
 `module /14re`
 `module /ned`
- rebuild the ISO and run `qemu`

Preparing for Hello

- create the file `hello.lua` in the `iso` directory with this content:

```
L4.default_loader:start({},  
"rom/hello");
```

- pass `ned` this new startup script
 - add this line to `menu.lst`:
`module /hello.lua`
 - pass `rom/hello.lua` as parameter to `moe`
- load the future `hello` module in `menu.lst`

Exercise 1: Hello World

- create a directory for your hello-project
- create a Makefile with the following content:

```
PKGDIR          ?= .
L4DIR           ?= absolute path to
                  L4 source tree
OBJ_BASE        = absolute path to L4 build tree
TARGET          = hello
SRC_C           = hello.c
include $(L4DIR)/mk/prog.mk
```

- fill in `hello.c` and compile with `make`
- run in `qemu`

Exercise 2: Ackermann Function

- write a program that spawns six threads
 - you can use pthreads in our system
 - add the line
`REQUIRES_LIBS = libpthread`
to your `Makefile`
- each thread should calculate one value $a(3, 0..5)$ of the Ackermann function:
 - $a(0, m) = m + 1$
 - $a(n, 0) = a(n - 1, 1)$
 - $a(n, m) = a(n - 1, a(n, m - 1))$

Have fun!



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More information: www.sppexa.de

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