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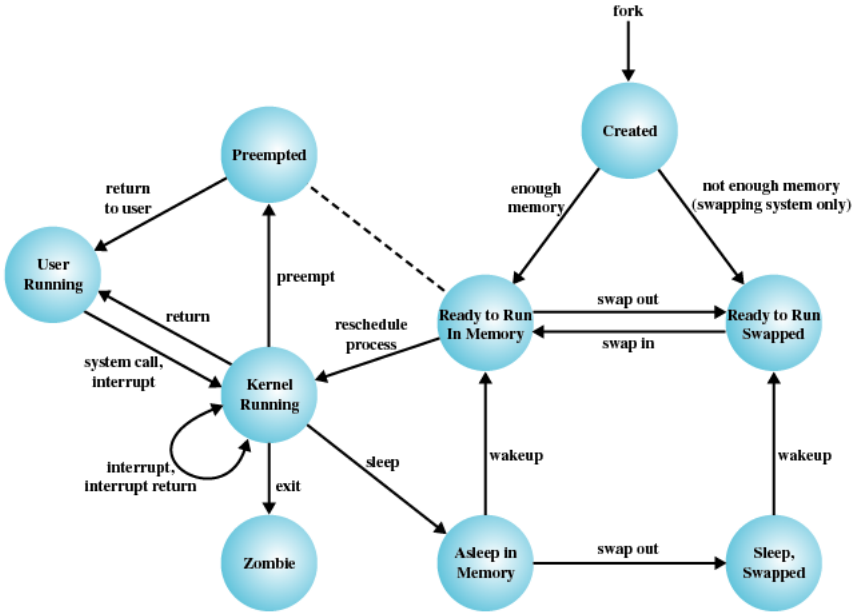
TI III: Operating Systems & Computer Networks

Introduction and Motivation



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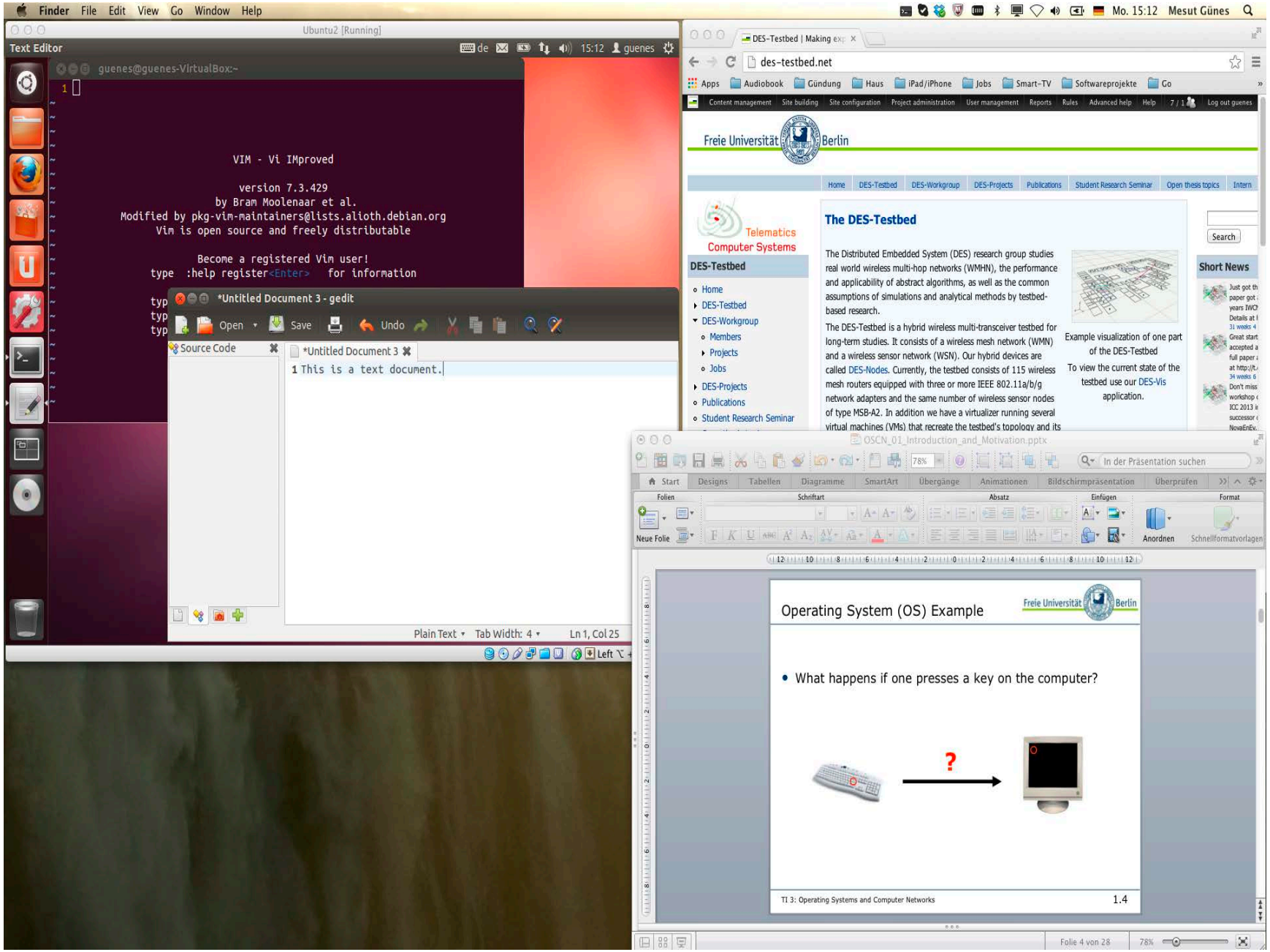
Computer Systems & Telematics
Freie Universität Berlin, Germany

Content

1. **Introduction and Motivation**
2. Subsystems, Interrupts and System Calls
3. Processes
4. Memory
5. Scheduling
6. I/O and File System
7. Booting, Services, and Security

Motivation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Ubuntu2 [Running]
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guenes@guenes-VirtualBox:~
VIM - Vi IMproved
version 7.3.429
by Bram Moolenaar et al.
Modified by pkg-vim-maintainers@lists.alioth.debian.org
Vim is open source and freely distributable
Become a registered Vim user!
type :help register<Enter> for information
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OSCN_01_Introduction_and_Motivation.pptx
Operating System (OS) Example
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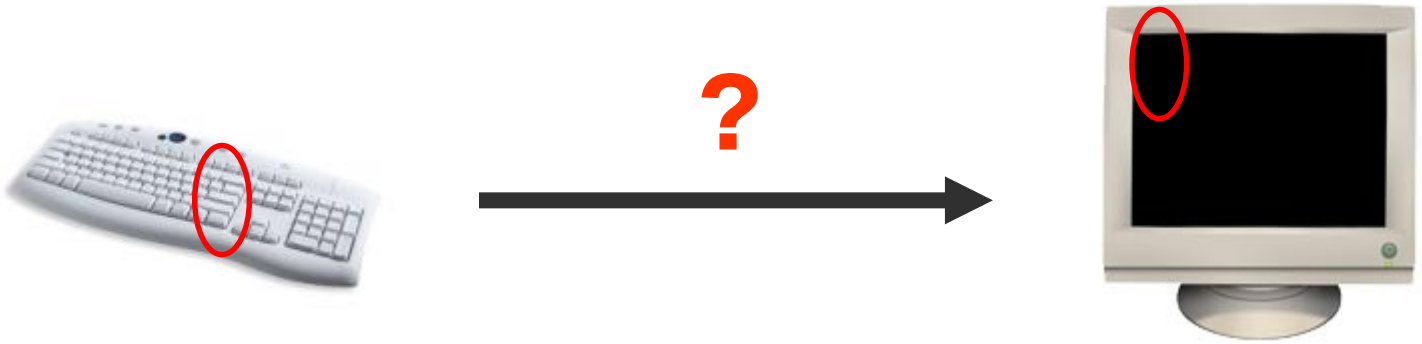
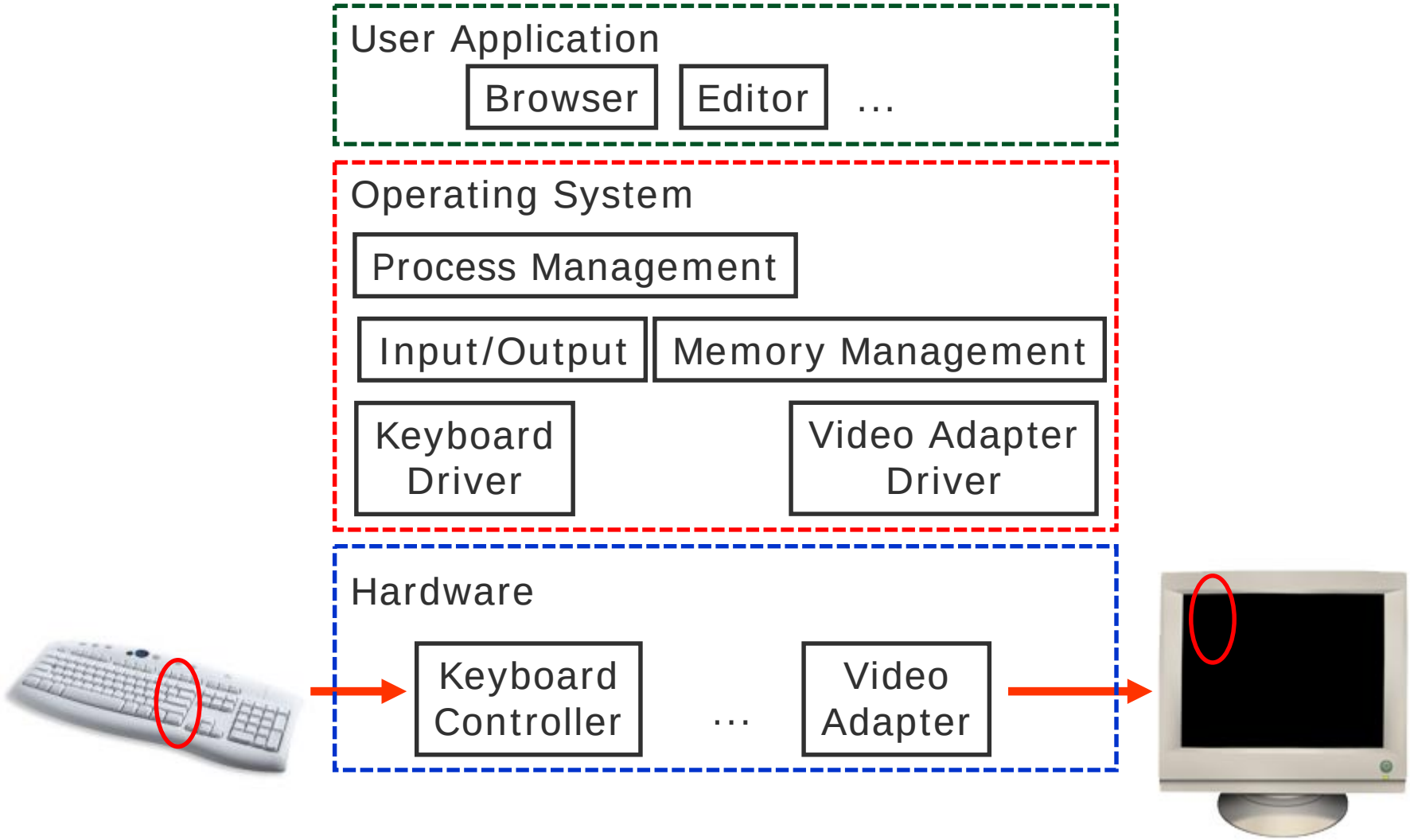
What happens if one presses a key on the computer?
TI 3: Operating Systems and Computer Networks
1.4

Operating System (OS) Example

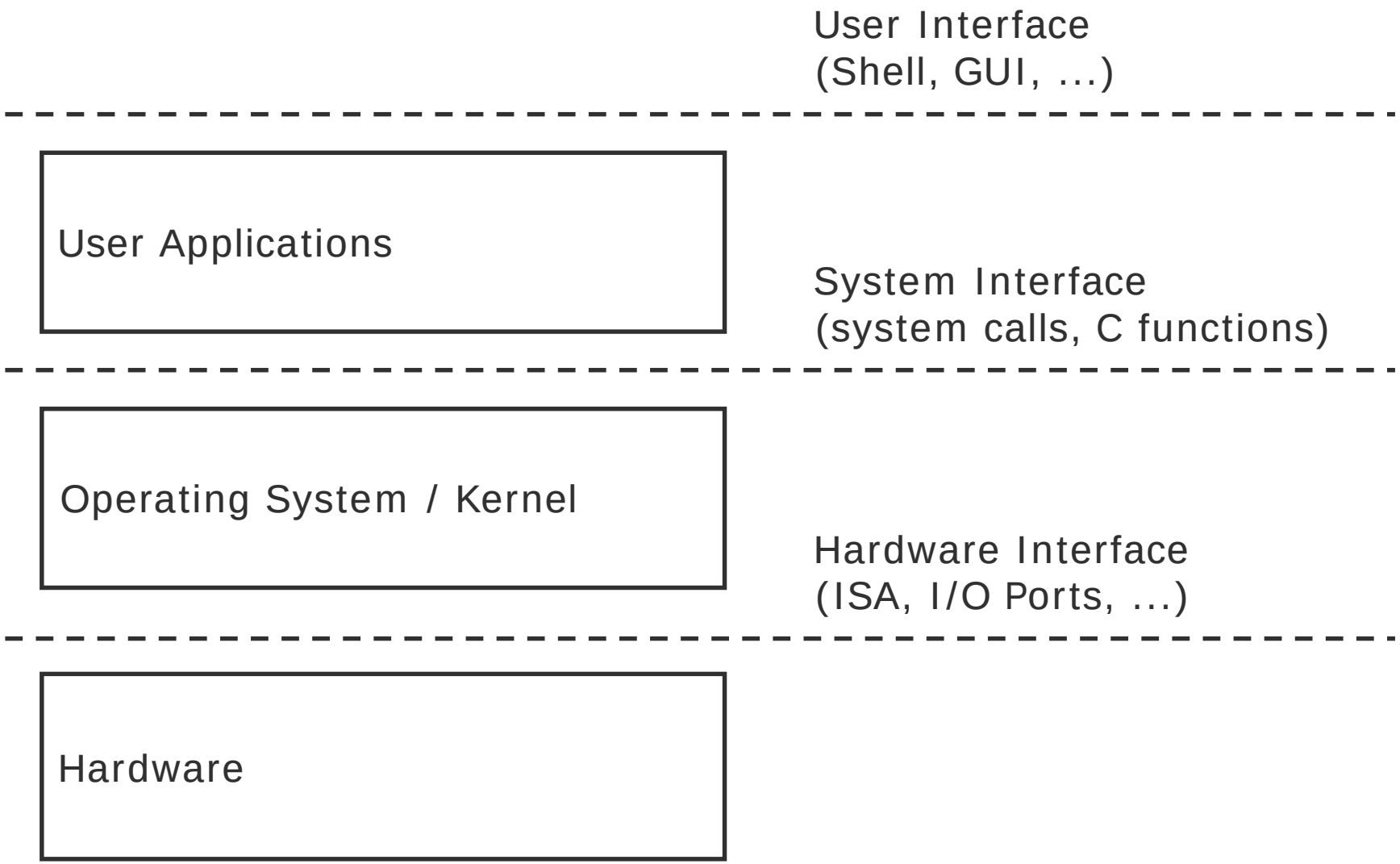
What happens if one presses a key on the computer?



Operating System Example



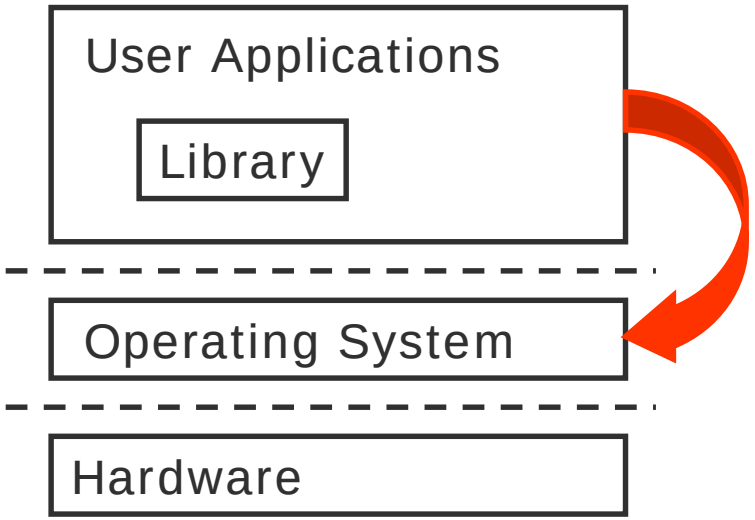
Layers of Abstraction



System Interface and System Calls

System interface is the only way for user applications to interact with the operating system.

System interface consists of system calls (supervisor calls) → POSIX.



High-level programming languages hide systems calls in library routines.

POSIX

Portable Operating System Interface (POSIX)

- E.g. https://standards.ieee.org/standard/1003_1,2013Edition.html

POSIX defines

- Application programming interface (API)
- Command line shells
- Utilities

UNIX like Operating Systems

POSIX oriented operating systems

- Unix
- Linux
- Windows
- Mac OS X
- …

Questions & Tasks

- Why are there so many different operating systems? What are differences?
- What are benefits of layering? Are there any drawbacks?
- Do you know other examples of layering?
- Check out your favorite programming language for system calls. Are there any?
  - That‘s one of the reasons we use the language C here …
- Read about POSIX
  - Check IEEE, e.g. https://standards.ieee.org/standard/1003_1,2013Edition.html
  - or at least Wikipedia…
- Go to RIOT and check out an OS for the IoT
  - https://riot-os.org/

Tasks of an Operating System

Typical services of a **general** purpose OS includes:

- Program execution
- Access to I/O-devices
  - Hardware abstraction
- Controlled access to files
  - Non-volatile memory
- Access control
  - Security / user management
- Error detection and error handling
  - Both hardware and software
- Logging

Special purpose operating systems focus on different services, e.g., real-time or communication requirements.

Goals of an Operating System

Ease of use for users and programmers

Efficiency when managing limited resources

Possibility to evolve

- New hardware standards
- Changing user requirements

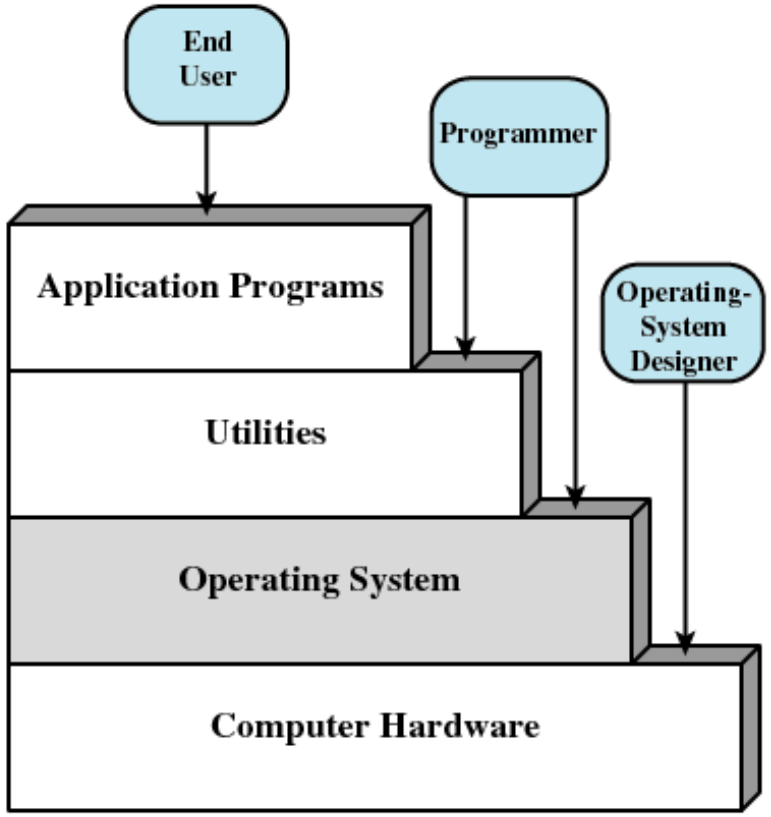
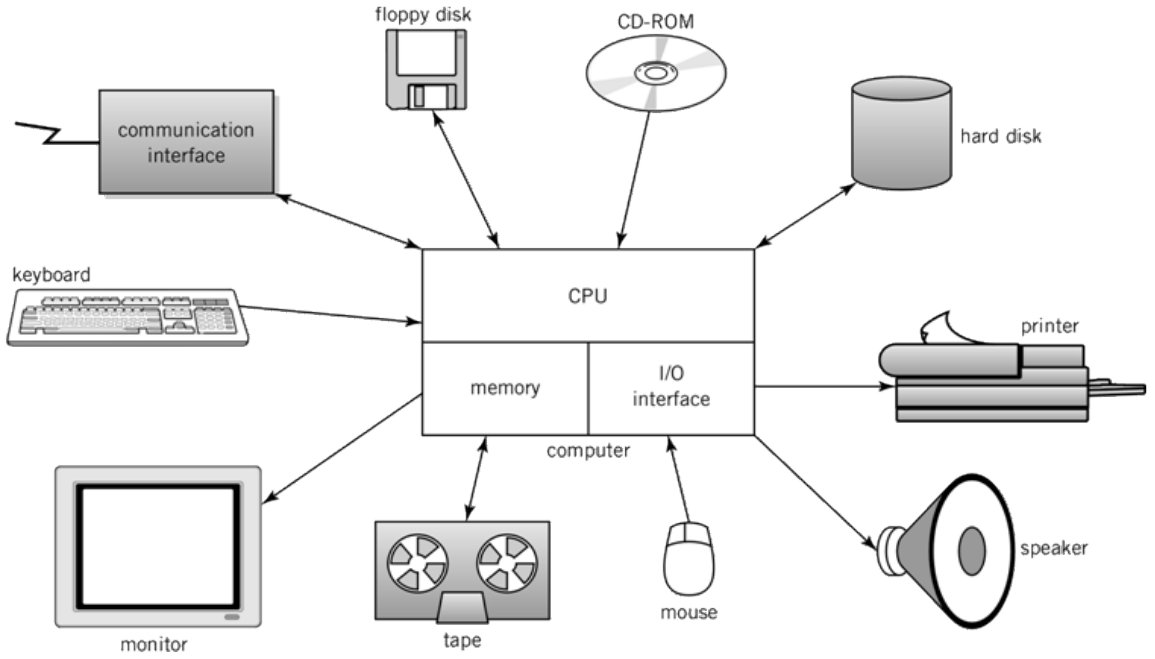


Figure 2.1 Layers and Views of a Computer System

Managing Resources

Hardware provides the basic computing resources such as

- Processor(s)
- Memory
- Persistent storage
- Network connection



Englander: The Architecture of Computer Hardware and Systems Software, 2nd edition
Chapter 1, Figure 01-06

OS **virtualizes** resources to permit controlled sharing and isolation

- virtual instances of a resource are created

OS provides virtual resources for user applications

Computer Components

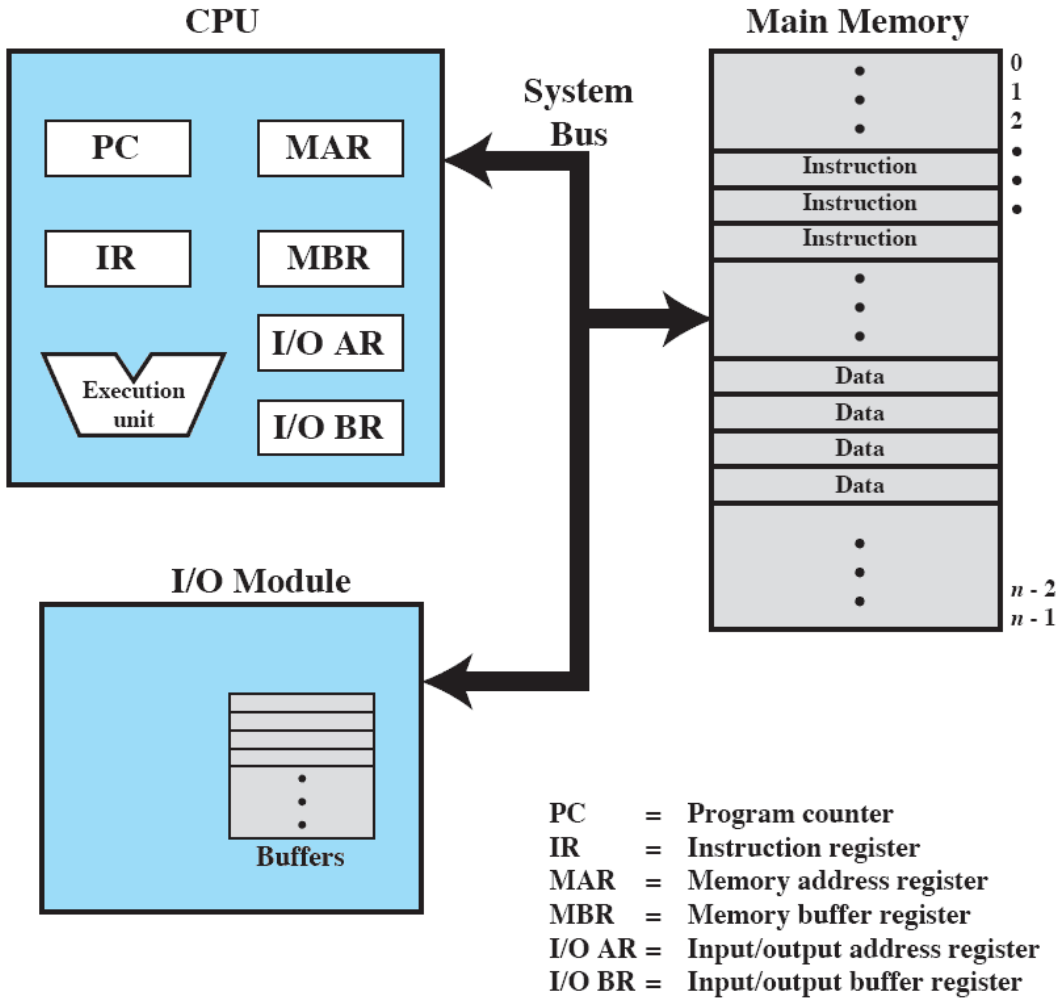


Figure 1.1 Computer Components: Top-Level View

Virtual Resources

Virtual resources and corresponding real resources:

- Processes — processor(s)
- Virtual Memory — main memory
- Files — persistent memory
- Ports — network adapter

Advantages:

- Easy to use through procedural interface (system calls)
- Secure against hardware and software errors or manipulation

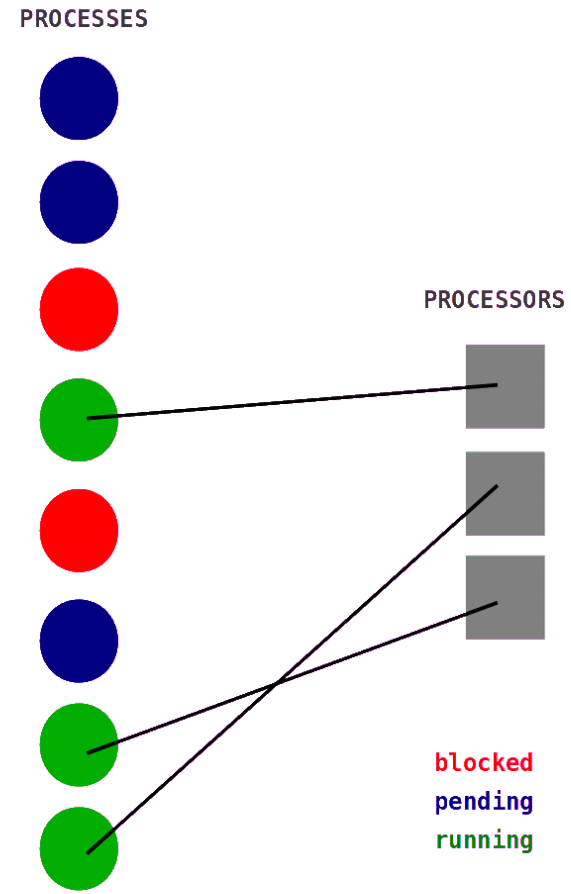
Processes

Number of processes is not limited by the number of processors: **Multitasking**

Processor is used efficiently:
- Time is not wasted by processes that are waiting on I/O devices

Reduced latency (=response time)

Different **process states**, e.g.,
- running – executing
- pending – ready to execute
- blocked – not ready to execute



Virtual Memory

Managed by the Memory Management Unit (MMU)

Transportability:

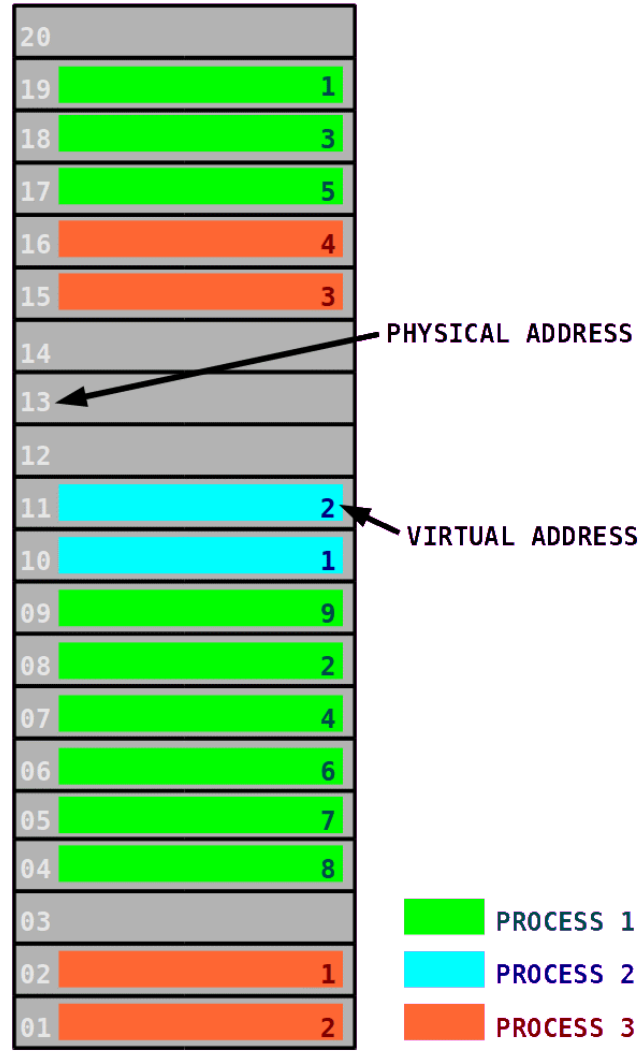
- position independent code – program does not depend on memory architecture

Security:

- memory access is restricted to memory units “owned” by a process

Efficiency:

- external fragmentation is avoided



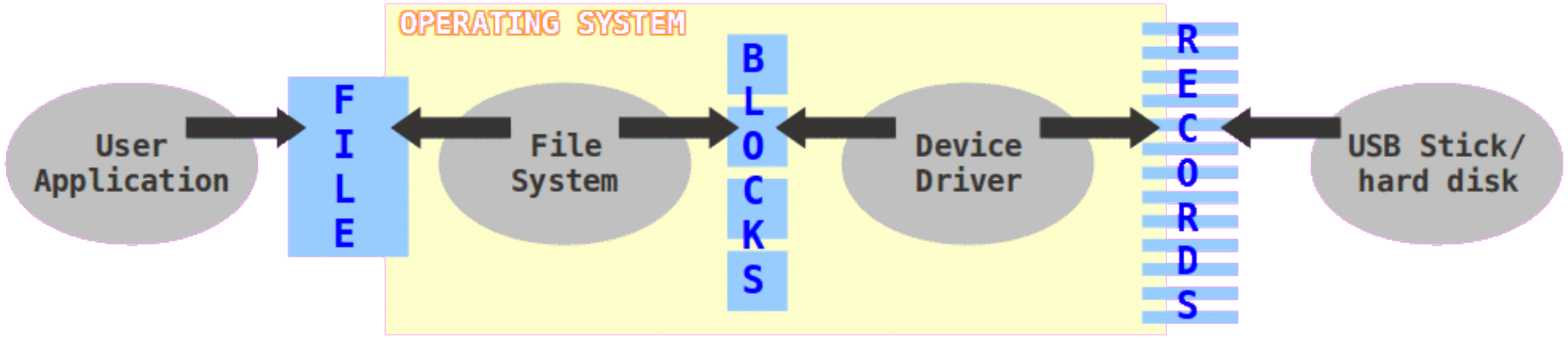
Files

Managed by a file system

Persistent objects for long-term data storage

Stored in secondary memory (e.g., tape, hard disk, USB flash drive)

Similar to virtual memory - file name instead of virtual address

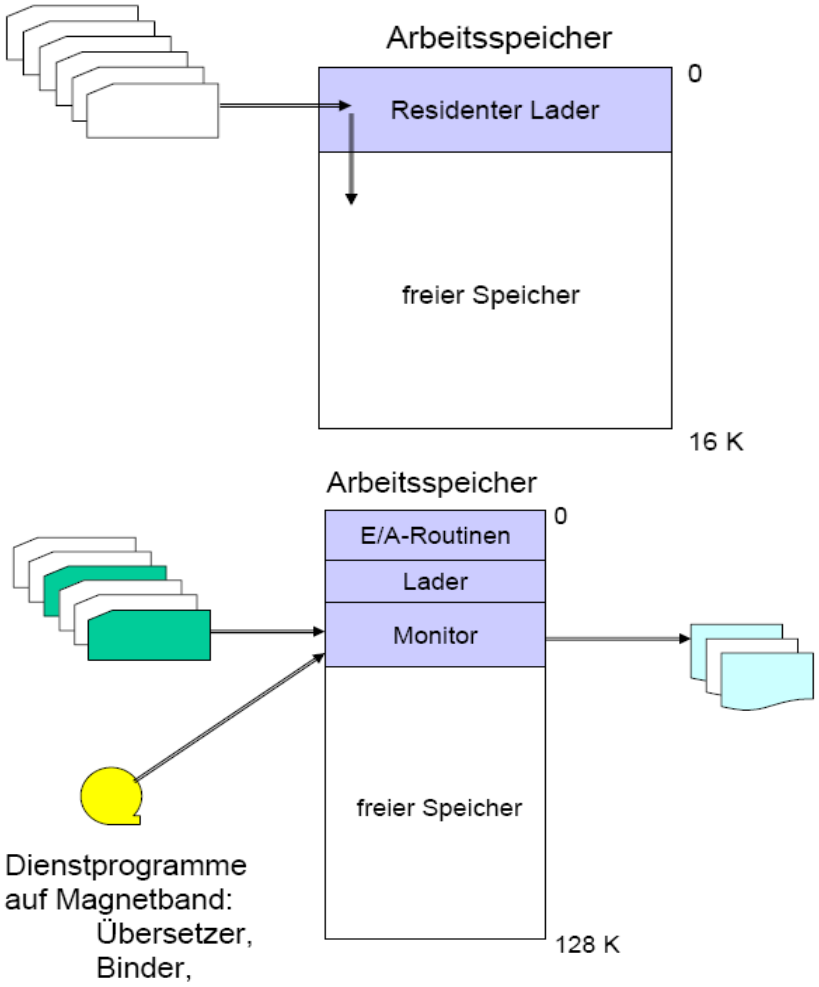


History of Operating Systems

Development of operating systems follows changes in computer architecture

Loader (1950, IBM 704)
- Loads programs into memory

Batch System
(1960,IBM 7090, Zuse Z 23, Telefunken TR4)
- Processing of jobs stored on punch cards
- Manual job control by human operator



History of Operating Systems

Multi-User / Time Sharing Systems

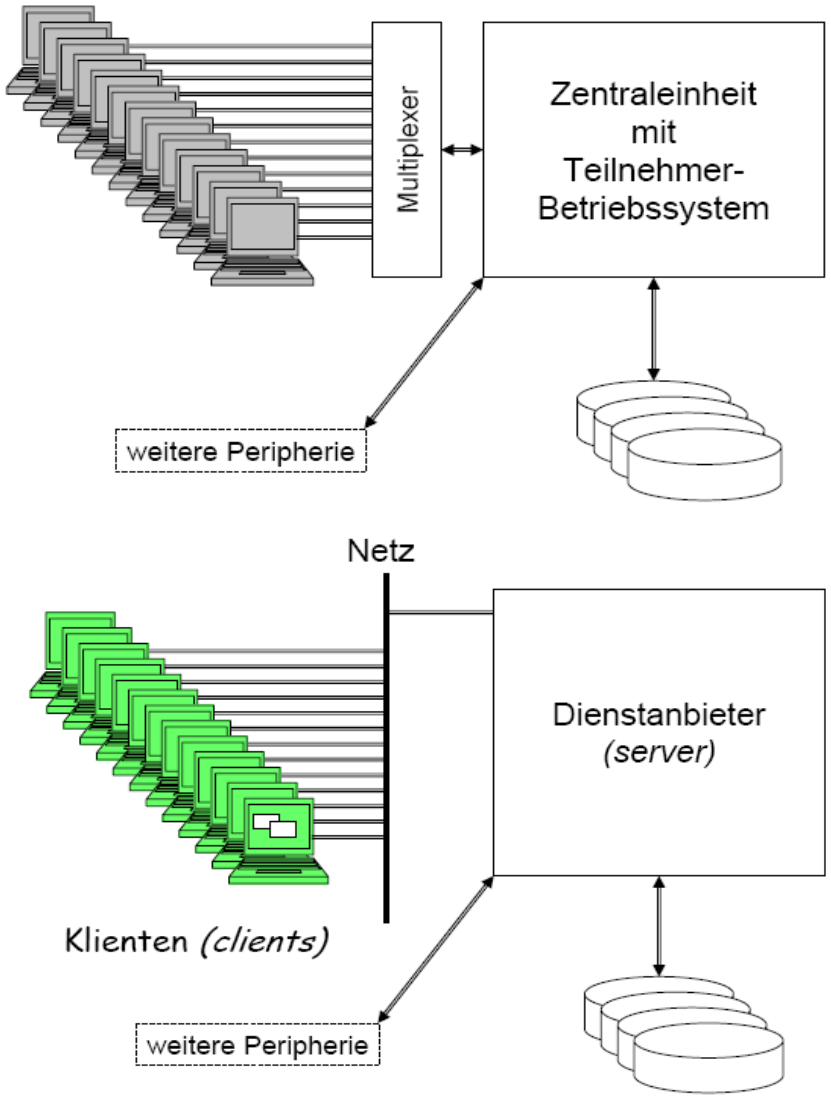
(1970, IBM OS/360, TSS, T.H.E., Multics, UNIX)

- Many terminals connected to one computer
- Interactive control for users
- Multitasking

Personal Computing und Client/Server

(1980/90, Apple Lisa, MS Windows, Linux, Solaris, HP-UX)

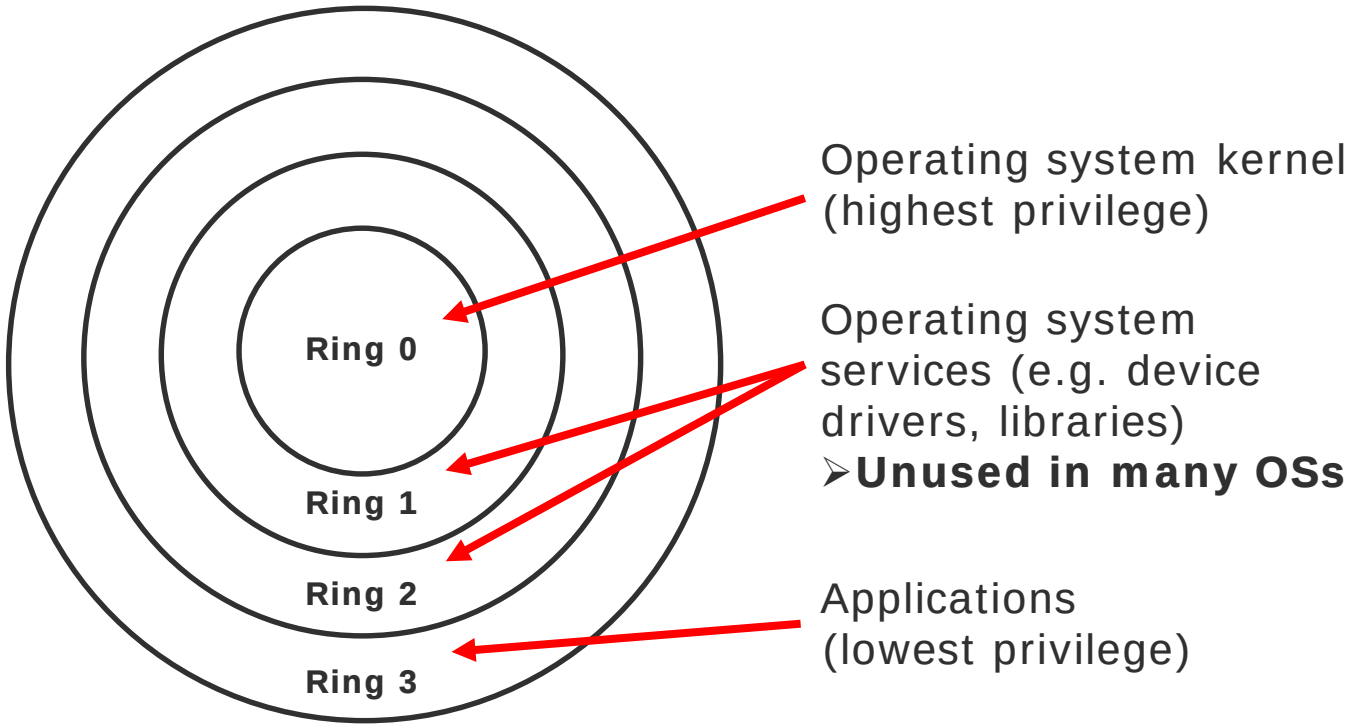
- Intelligent workstations
- GUI / Window mode



Protection Rings

Hardware provides hierarchical privilege levels

- Inner rings have access to outer rings' resources
- Outer rings may access inner rings through predefined gateways



Operating System Kernel

Kernel implements basic layer of abstraction

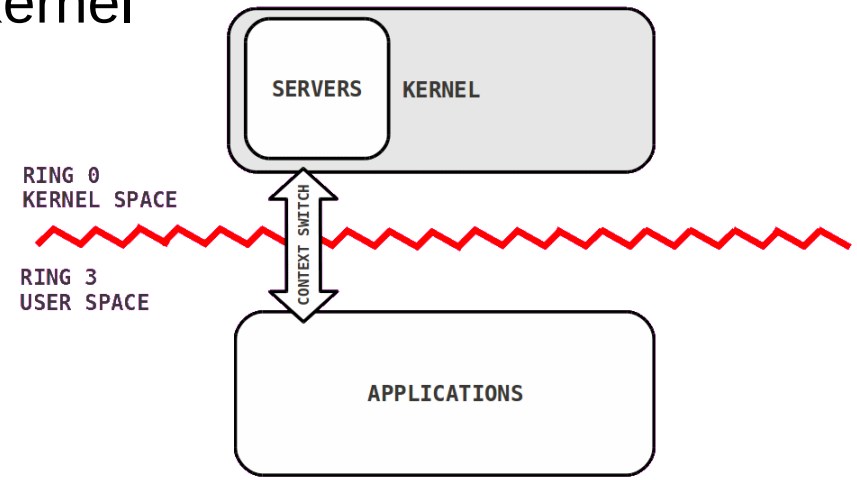
Runs with full access to hardware (Ring 0)

Context Switch: switching from one process to another

- A certain amount of time is required for doing the administration, e.g., saving and loading registers.

Monolithic versus Microkernel

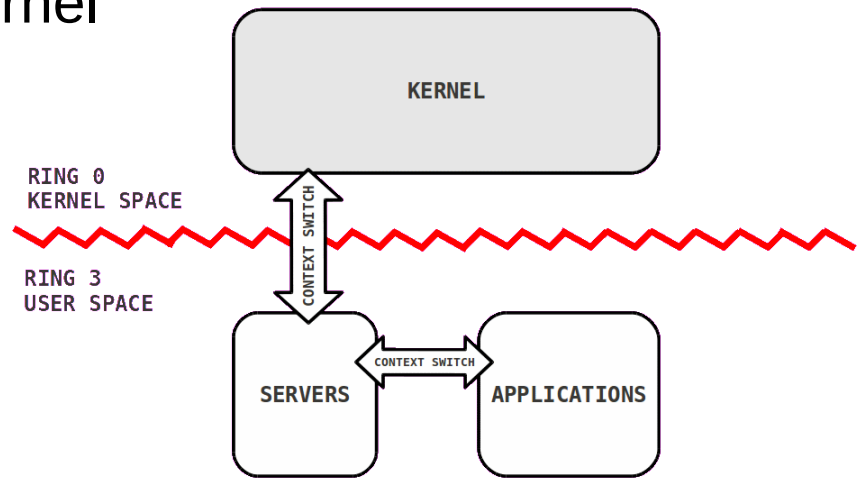
Monolithic Kernel



Pro:
- less context switches
- no expensive communication

Contra:
- complications when exchanging functionality

Microkernel



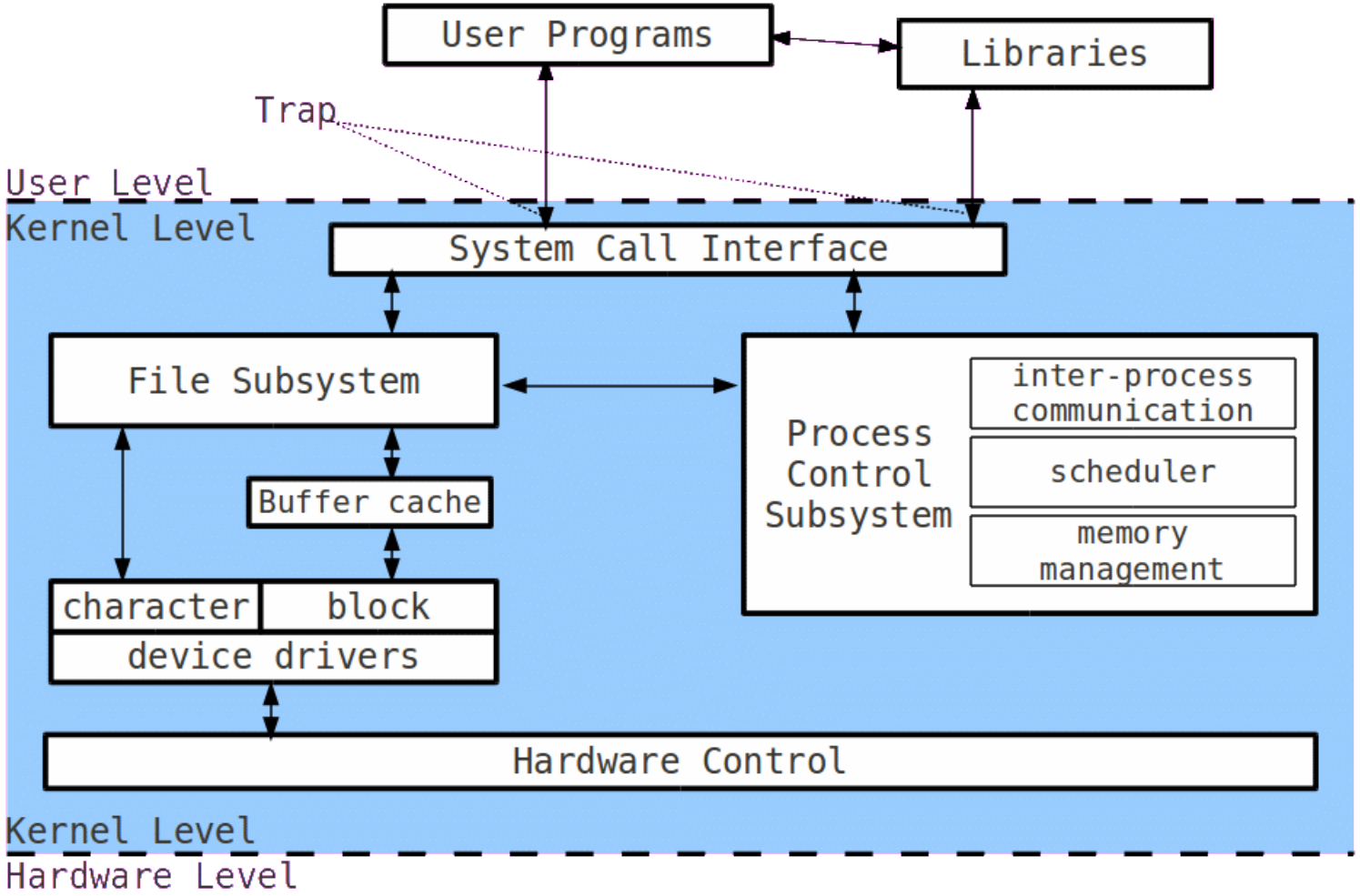
Pro:
- strict interfaces
- less complexity, clear structure

Contra:
- speed
- synchronization

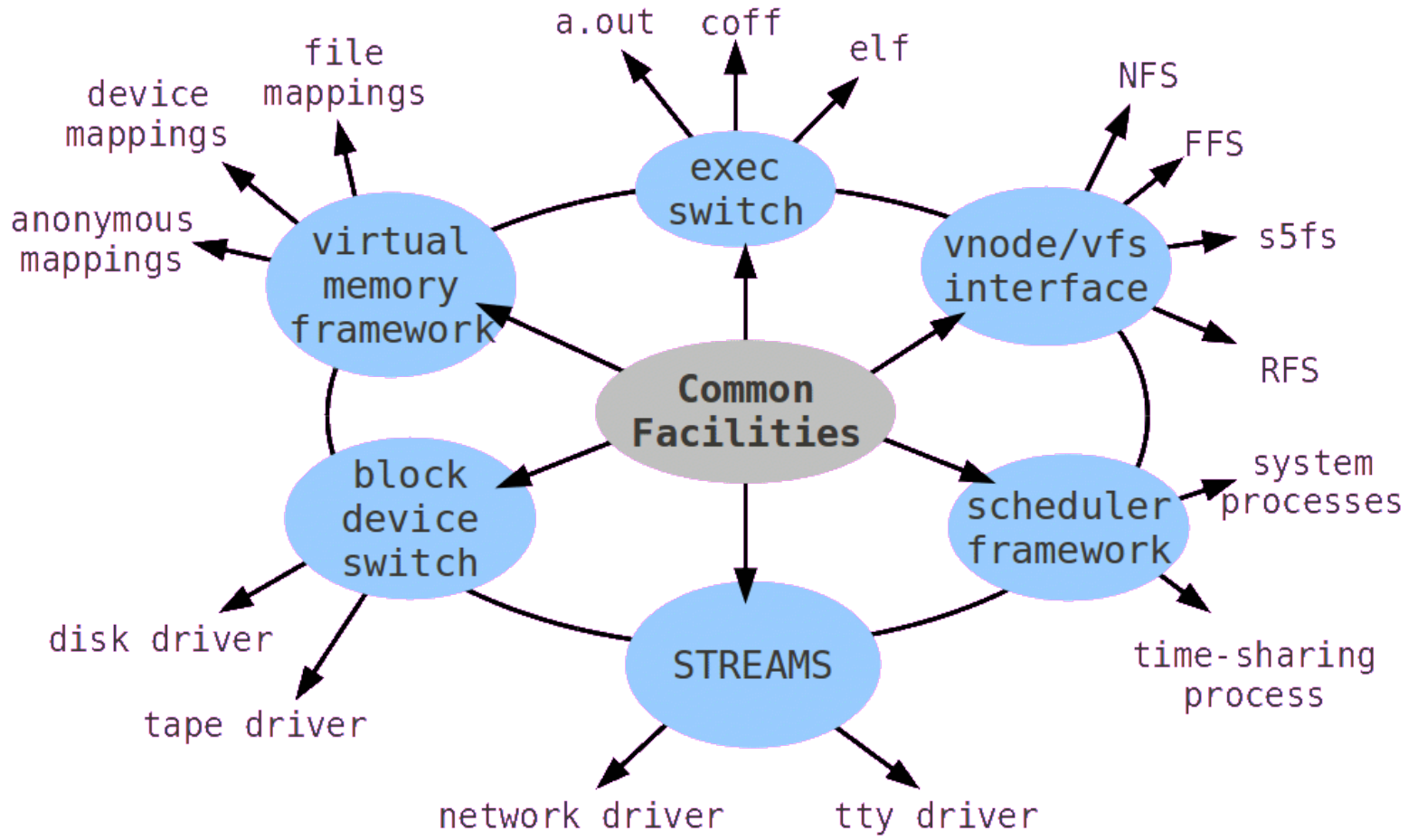
Questions & Tasks

- What is the basic idea of an OS?
- Can we run a computer without an OS?
- How could a VERY simple OS look like?
- What does virtualization in the context of an OS mean? How does it help? Where else do computers use virtualization?
- Check the number of processes, the resources they use, the memory mapping etc. on your computer. Depending on the OS there are many tools for that!
- What could be reasons for not using that many protection rings?
- What do we need to protect the OS? Think of memory protection, HW support, processor mode etc.
- Do we have pure micro kernel OSs today? Do we at least use ideas form micro kernels? Why are many of the famous OSs today rather big monolithic systems?

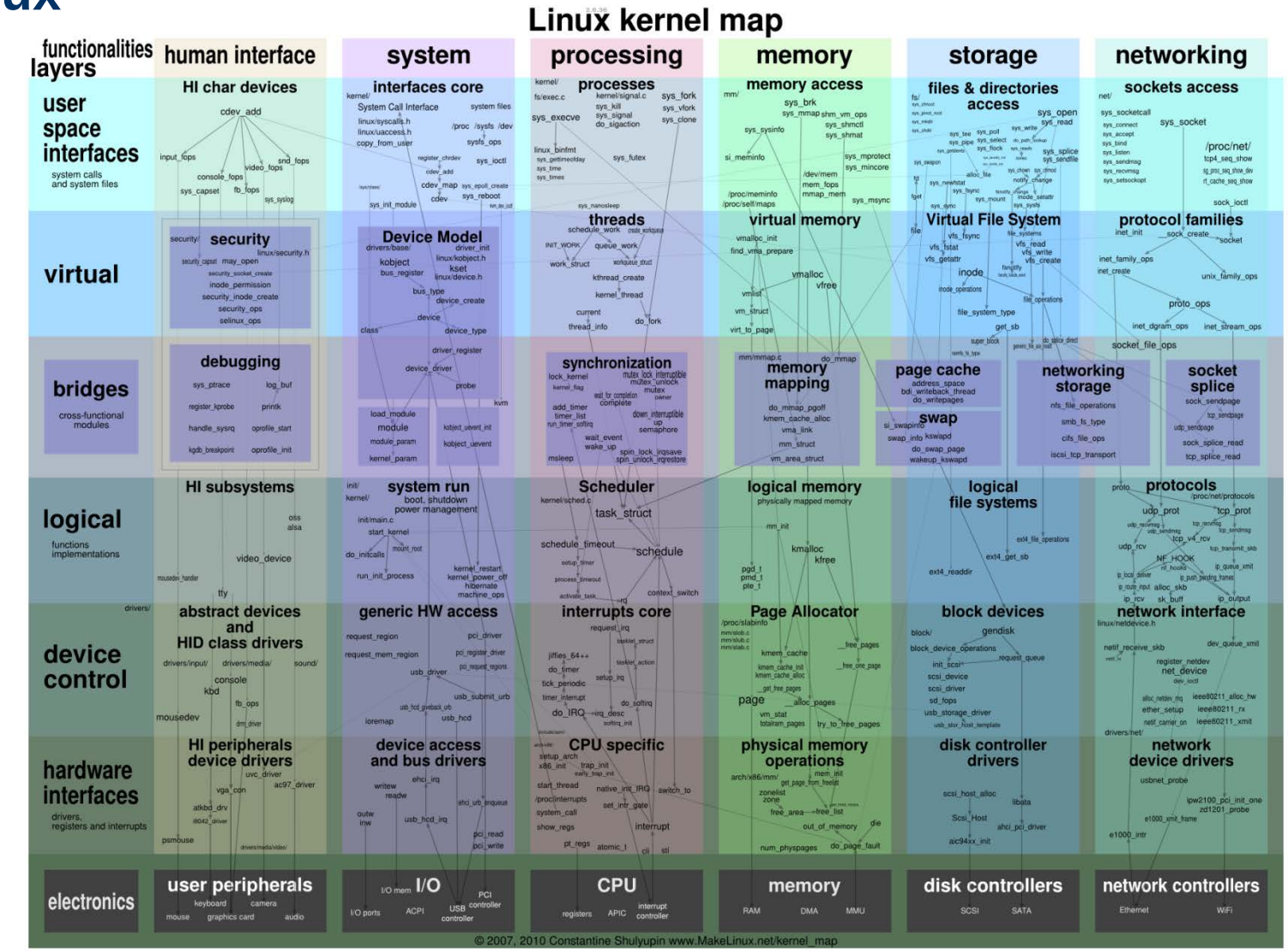
Examples – UNIX



Examples – UNIX by Services



Examples – Linux



Source: http://www.makelinux.net/kernel_map

A Word About Synchronization

Concurrency handling is outside the scope of this lecture – see “Non-sequential programming”

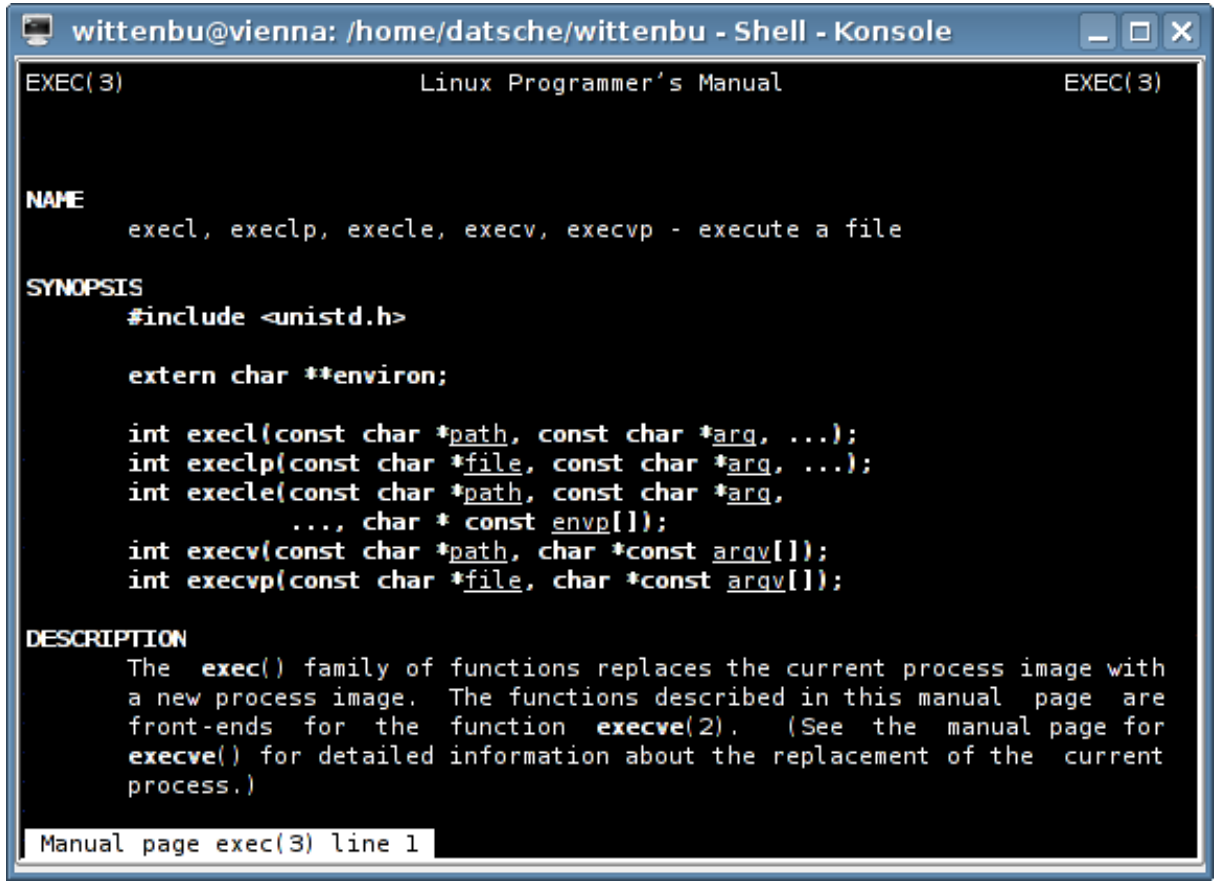
Some pointers/methods/ideas

- In hardware:
  - Atomic operations:
    - ISA instructions that are guaranteed by design to run to completion
  - Interrupts:
    - Enable/disable interrupts via special ISA instructions
    - Allows other interrupt handlers to run to completion
- In software:
  - Spinlocks (busy waiting):
    - Short-term synchronization mechanism
    - Low overhead, avoid re-scheduling, wasteful on resources
  - Semaphores (wait queues):
    - Long-term synchronization mechanism
    - Synchronize for events on special purpose data structures

Manual Pages

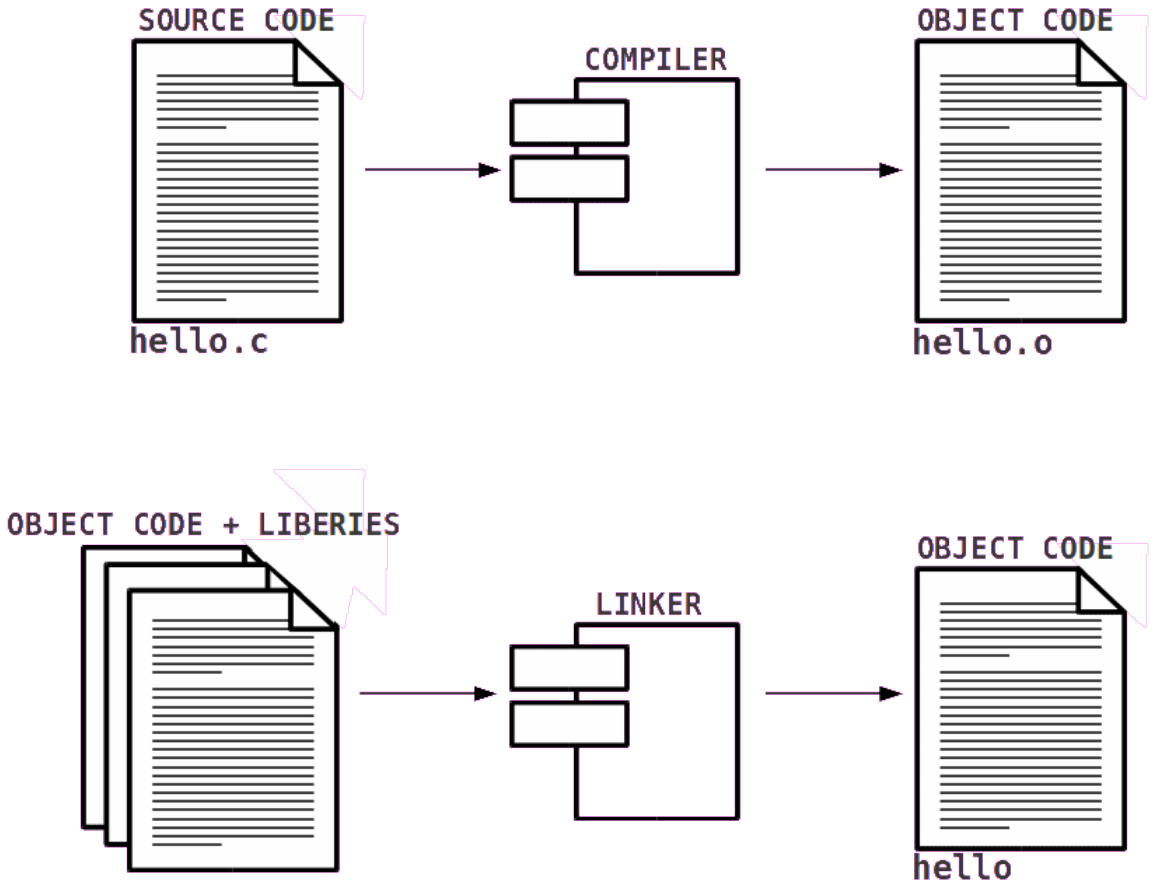
UNIX-utility **man**

e.g. **man exec**



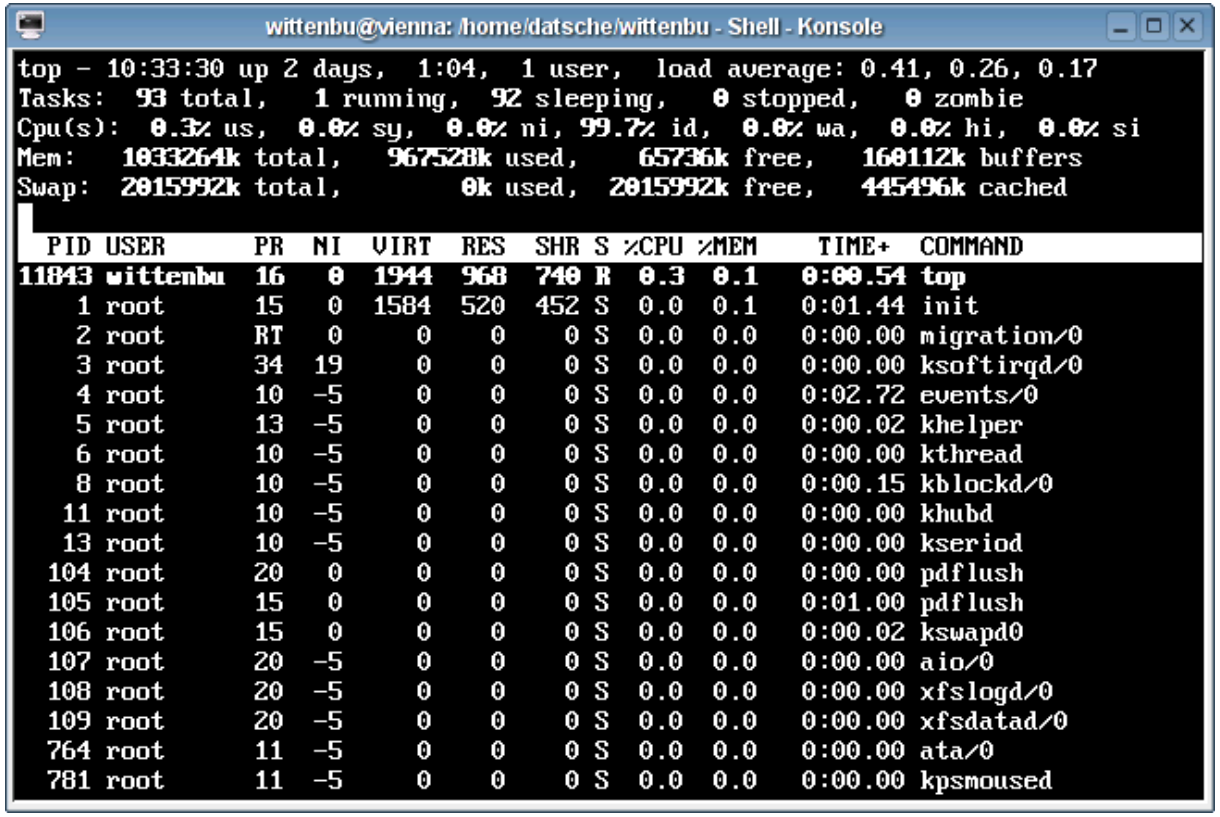
Program Building

Toolchain: set of programming tools that are used to build a product (executable)



Process Monitor

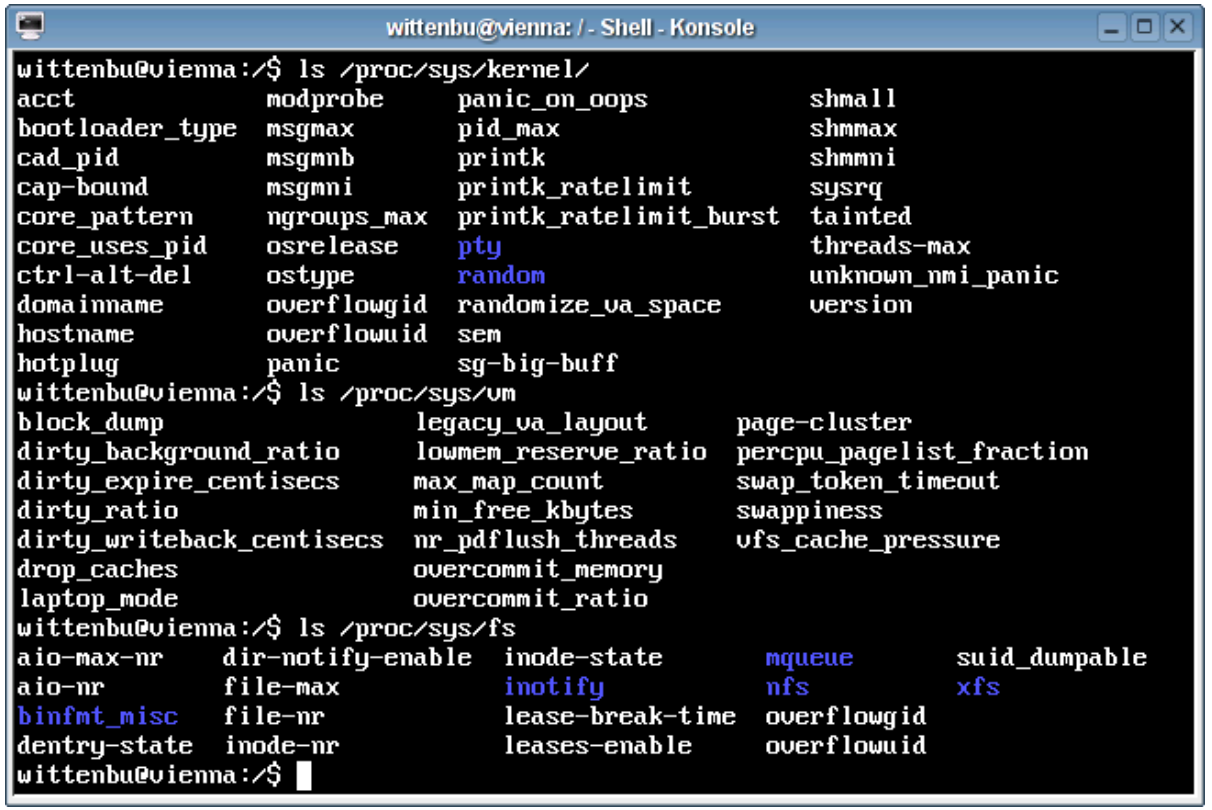
UNIX utility **top**



Kernel Parameters

Directories **`/proc`** and **`/sys`**

- virtual directories that reflect general kernel behaviors (“everything is a file”)



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