Review and Conclusions

What have you learned? What else could you still learn?

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The purpose of this chapter

- review subjects presented during the OS course (this semester)
- draw some conclusions
- presents future OS-related courses





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Outline

OS Subject Review

- Conclusions
 - Past
 - Future





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- 2 Conclusions
 - Past
 - Future





- system software placed between hardware and user software (applications)
- roles
 - virtual machine provider (hide hardware and provide abstractions)
 - resource manager
- every resource access / need must be required from OS
 - by calling SO services, i.e. system calls
- OS protects itself from user applications based on different CPU execution modes
 - privileged: kernel mode
 - non-privileged: user mode
- architectures
 - monolith
 - micro-kernel





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- When is the OS code executed on an uni-processor system? Give examples of at least two situations.
- How is the system call mechanism implemented?
- Which software is run in kernel and user mode respectively in the following two cases?
 - monolithic OS
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- usually a simple application
- takes user requests and translated them in system calls
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 - graphical
 - text. named command interpreter
- command interpreter functionality
 - get user's command line
 - split it in tokens, i.e. command line and arguments
 - create a new process to execute the specified command
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- command line
 - a string of characters separated by spaces
 - first item: command name, actually an executable path
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- read n < file
- ls -R / 1>good 2>err
- cat dict.txt | sort





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file concept

- basic unit of data allocation
- unstructured stream of bytes
- file contents managed by user applications, not by OS
- components: data and meta-data
- security: too much permissions vulnerability

directory concept

- used for organizing the file system space
- impose file system hierarchy
- paths: absolute and relative
- security: path traversal vulnerability

FS system calls

- file: open, read, write, Iseek, close
- directory: opendir, readdir, stat, unlink, link

allocation aspects

- contiguous allocation ⇒ external fragmentation
- any-free-block allocation ⇒ internal fragmentation
- i-nodes, directory entries, links, files with hales → ◆ ▶ ◆ ▶ ◆

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- How is usually the file provided like to the user applications?
- Which of the following extensions usually correspond to text and binary files respectively: html, pdf, c, zip?
- What is an i-node in Linux?
- What does 0640 means in terms of permission rights in Linux?
- Which is the most probable file descriptor returned (and displayed) by the following Linux program? Explain your answer.

```
main()
{
   int fd = open ("/etc/passwd", O_RDONLY);
   printf("fd = %d\n", fd);
}
```

- Write in one line the C code to read a text line from a file, whose file descriptor is given.
- Write the C code to read an integer from offset 16 from a file NUMBER file descriptor is given.

process

- models execution: abstractizes the machine (CPU, memory)
- describe execution and resources needed for that execution
- isolates (separates) resources / executions
- states: running, ready, blocked, terminated

thread

- models execution in a process
- more threads = more concurrent executions in the same process.
- threads of a process share all resources of that processes
- threads useful and effective when
 - logical parallelism exist in the application
 enough hardware resources available

scheduling

- decides who runs and for how long
- preemptive vs. non-preemptive
 - preemptiveness based on timer interrupt.
- first-come first-served (FCFS), shortest job first (SJB), routest (SJB), route



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Practice: Process Related Questions

 How many times is each message in the code below displayed on the screen? Explain your answer.

```
int fd[2];
pipe(fd);
printf("Step 1\n");
fork();
fork();
fork();
printf("Step 2\n");
```

- How many readers and writers, respectively, will exist in the system for the created pipe after the execution of the given code, supposing no process is terminated at that moment?
- Which is the optimum number of threads that should be created by an application to get the best performance (i.e. execution time) when running on a uni-process system and copying a file from one disk another disk, by encrypting the file contents during the copy operation?

- problem: race conditions of concurrent threads sharing resources
- synchronization means imposing access rules
 - leads to waiting (blocking) ⇒ reduce parallelism
- synchronization needs OS and hardware support to get atomicity
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 - lock ⇒ mutual exclusion
 - semaphore
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Practice: Synchronization Related Questions

- Use semaphores to allow just 10 threads run simultaneously a given function's body.
- Rendezvous: synchronize threads executing functions boy() and girl() respectively, such that to allow them returning from that functions only in pairs of a "boy" and a "girl".
- Synchronize two concurrent threads executing the two functions below respectively, such that to make them display on the screen the message "Life is wonderful, isn't is?"





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 - address space
 - virtual address space structure: code, data, heap, stack
- memory binding / translation
 - compile-time (very limited), load-time, run-time (most flexible
 - need translation tables
- contiguous allocation
 - simple, efficient
 - leads to external fragmentation
 - base and limit registers
- segmentation
 - one contiguous area for each segment (area)
 - segment table
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Practice: Memory Mng Related Questions

- Which is the size in bytes of a process' virtual address space on a system using 64 bits for a memory address?
- How may page table entries must be used by such a system to map a process VAS, supposing the page size to be 4MB?
- Illustrate on such a system the part of a process' VAS and page table (entries) used for mapping the memory required be the following code:

 Which page does the following instruction refer to? Could it be executed successfully or not?

```
p[4*1024*1024] = 10;
```



- untrusted application environment
 - untrusted PATH variable
- file system
 - too much permissions
 - path traversal
- memory-related: bad / wrong memory accesses
 - NULL-pointer usage
 - use-after free
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Outline

1 OS Subject Review

- Conclusions
 - Past
 - Future





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What did we talk about?

- OS's place and role (and definition), relative to hardware and other software
- OS structure
- Shell, i.e. command interpreter
- File System
- Process Management
- Memory Management
- Security Aspects

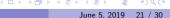




What have we learned?

- basic concepts like
 - process, thread execution, resources, isolation, scheduling
 - file: storage, sequence of bytes (no format), meta-data (i-node), links, fragmentation, open files
 - directory: organization, file tree, collection of directory entries
 - synchronization: locks (mutex), semaphores, condition variables, producers/consumers, readers/writers, barrier
 - memory: address space, virtual/physical memory addresses, ELF, paging
 - IPC mechanisms: pipes, shared memory
 - fragmentation: external (contiguous allocation, best-fit, worst-fit), internal
 - basic security issues: buffer overflow, path traversal
- system calls to access various OS (Linux) services
- write C programs to have access to Linux system calls





- explain OS functionality and concepts
- understand better applications functionality, their relationship with the OS and some of their crash reasons
- write (if needed) C programs to access low-level OS services
- choose the appropriate OS for a particular purpose
- tune better an OS for particular applications/context/purposes





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Outline

1 OS Subject Review

- Conclusions
 - Past
 - Future





Will I need OS knowledge?

• all the time: understand, explain, evaluate, configure





Will I use OS system calls?

- sometimes, especially when you need a particular (efficient, lower-level) functionality
- all the time, if you work at low-level (in C, asm)





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- what about: internals of an OS, design/implementation alternatives of
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 - user processes and threads
 - system calls for open files, processes and threads
 - memory management, virtual memory, page replacement algorithms
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usefulness

- an OS is a complex management software; all the management algorithms and techniques work for many other complex management software even at higher levels
- understanding low-level mechanisms makes you understand better higher-level ones' behavior
- it is an 4th year optional subject
- students' myth: (highly) difficult
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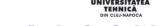
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- kernel driver development
- build virtualization security-oriented OS (hypervisor)

many security-related aspects

- secure coding
- Web security
- mobile systems (Android) security
- big-data and security
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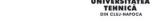
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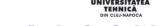
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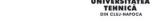
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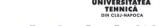




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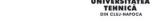
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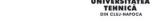
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Finish

That's all folks! So long, folks!



