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Lecture 10

Concepts of Mobile Operating Systems

Mobile Business I (WS 2017/18)

Prof. Dr. Kai Rannenberg

Deutsche Telekom Chair of Mobile Business & Multilateral Security
Johann Wolfgang Goethe University Frankfurt a. M.

Overview – Concepts of Mobile Operating Systems

- Functions
- Processes' Management
  - States and elements
  - Scheduling
  - Inter-Process-Communication (IPC)
- Memory Management
  - Mapping
  - Paging
  - Segmentation
  - Examples
- Security & Maintenance

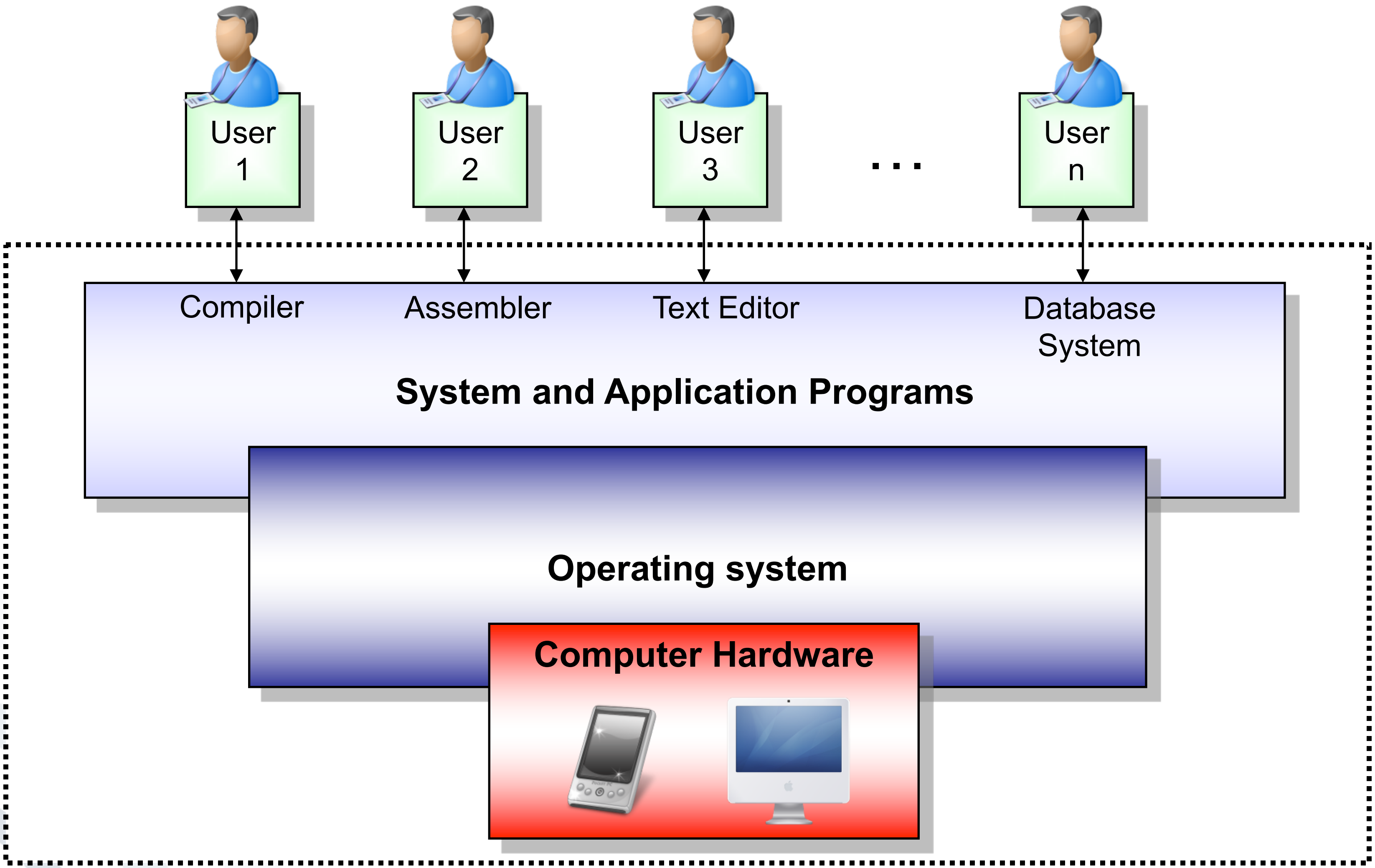
What is an operating system (OS)?

- An OS is a program that serves as a mediator between the user and the hardware.
- It enables the users to execute programs
- *Other properties*: Multi-user, multi-thread, high availability, real-time, …

- ***Primary goal of an OS***: Easy usage of the actual hardware
- ***Secondary goal of an OS***: Efficient usage of the hardware

[SilberGalvin1999]

Operating System



[SilberGalvin1999]

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OS Functions

- Controlling and sharing of resources
  - Computation time, real-time processing
    "Who is computing how much? How long does it take?"
  - Memory (RAM, Disk)
    "Who gets which part of the memory?"

- Security functions
  - Protection of the data (memory, hard disk):
    "Who is allowed to access resources?"
  - Process protection (computation time, code, isolation):
    "Who is allowed to compute?"
  - Security module support

- Communication
  - Allocation of I/O-Resources
  - Processing of the communication
  - User interface (UI)

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Questions

- Several programs (processes) can run simultaneously & concurrently on an OS:
  - *How are processes managed in a system with regard to processing time, memory, etc?*
  - *Which process is allowed to access resources when?*
  - *How are resources (I/O) shared among processes?*
  - *How do processes exchange data among each other?*

Process

- A process is a program “in operation”.
- A process uses resources, such as CPU time, memory, files, and I/O devices.
- The resources of a process are allocated while it is created or when it is running.
- The operating system has to manage the process (creation, resource distribution, etc.).

Components of a Process

- More than simple code!
- Program counter: Indicates on which point in the code the process resides.
- Contents of the process registers:
  - ***Stack***: Contains temporary data, such as subroutine parameters or return addresses, etc.
  - ***Data section:*** Contains the global variables
  - ***Heap***: Dynamically allocated memory

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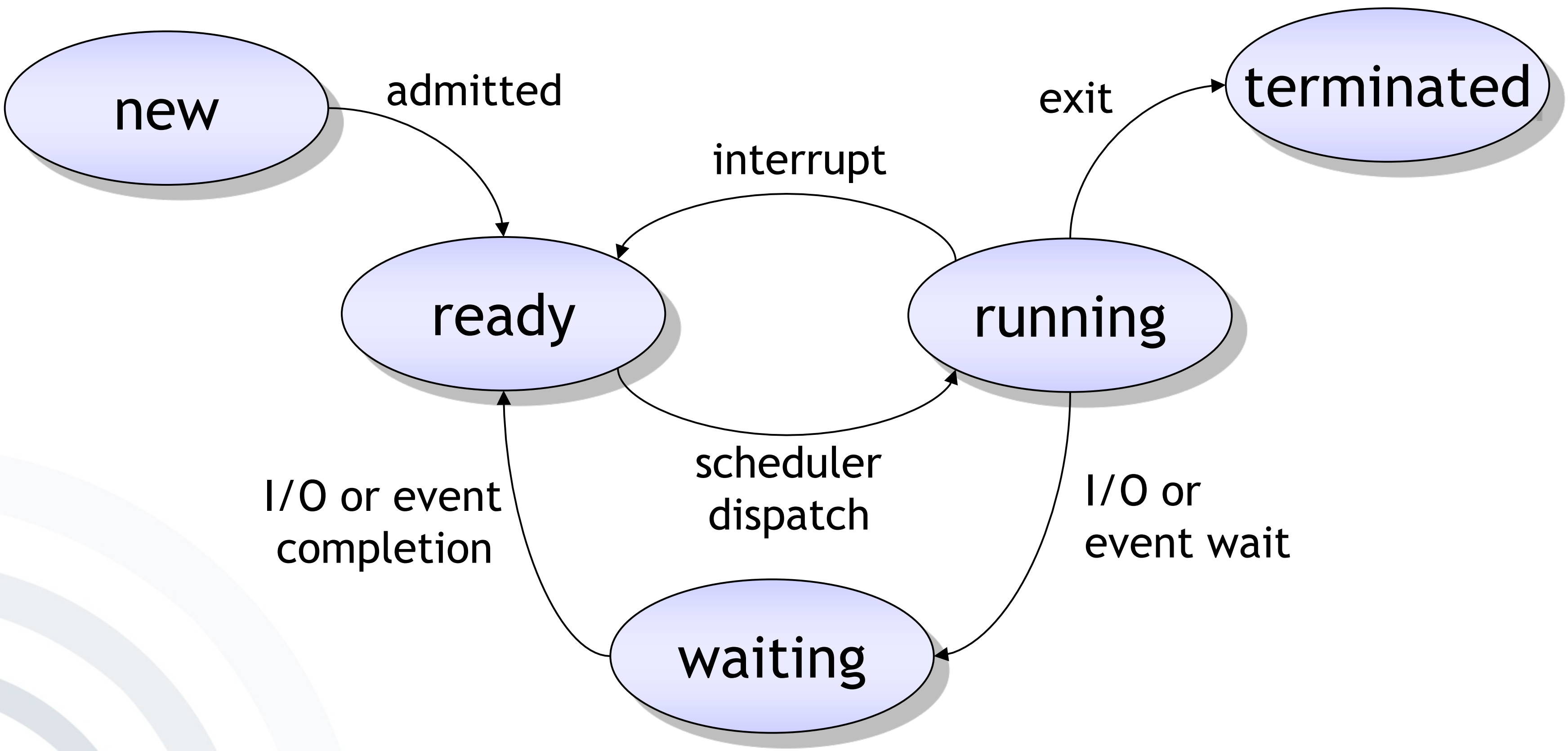
States of a Process



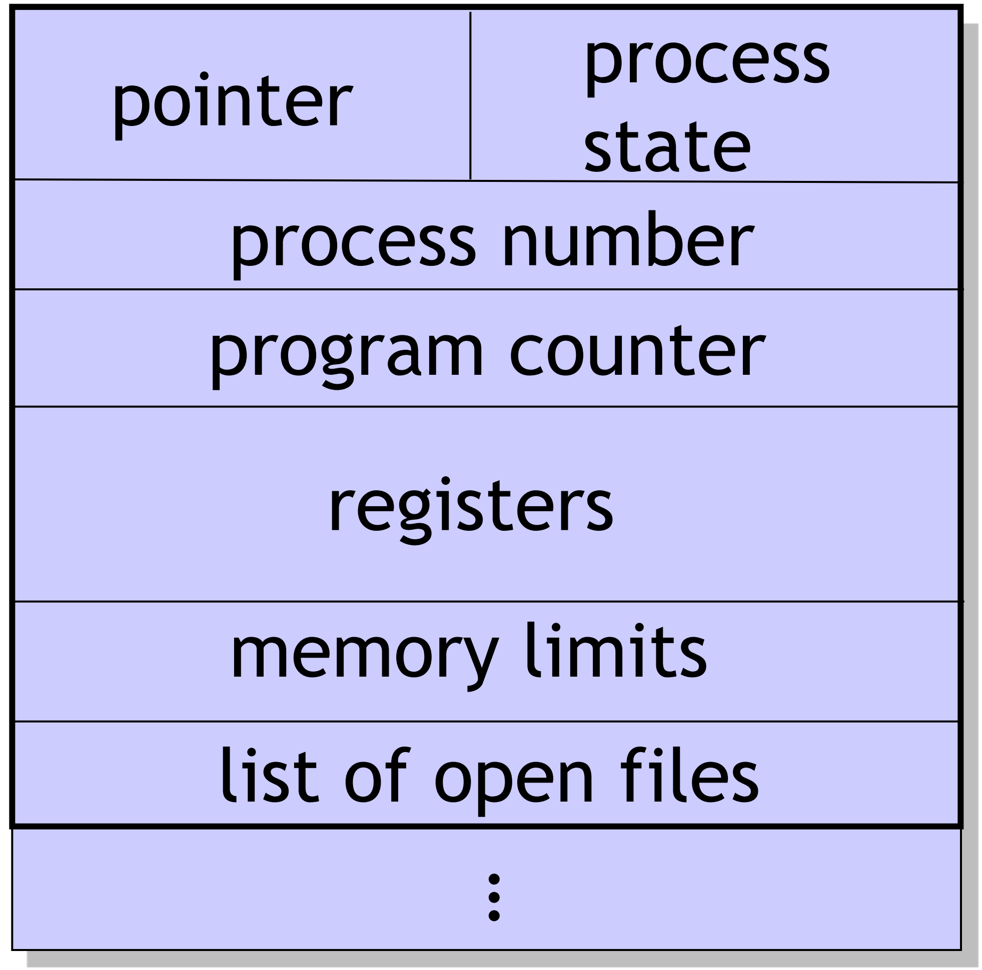
[SilberGalvin1999]

States of a Process

- **New:** Process is created.
- **Ready:** Process is waiting for being executed.
- **Running:** Process is running.
- **Waiting:** Process is waiting for results:
  - Completion of an I/O-operation
  - An event
- **Terminated:** Process is terminated.

Abstracted View on a Process: Process Control Block (PCB)

- Abstracted representation of the contents of a process control block (PCB), needed by an operating system.



[SilberGalvin1999]

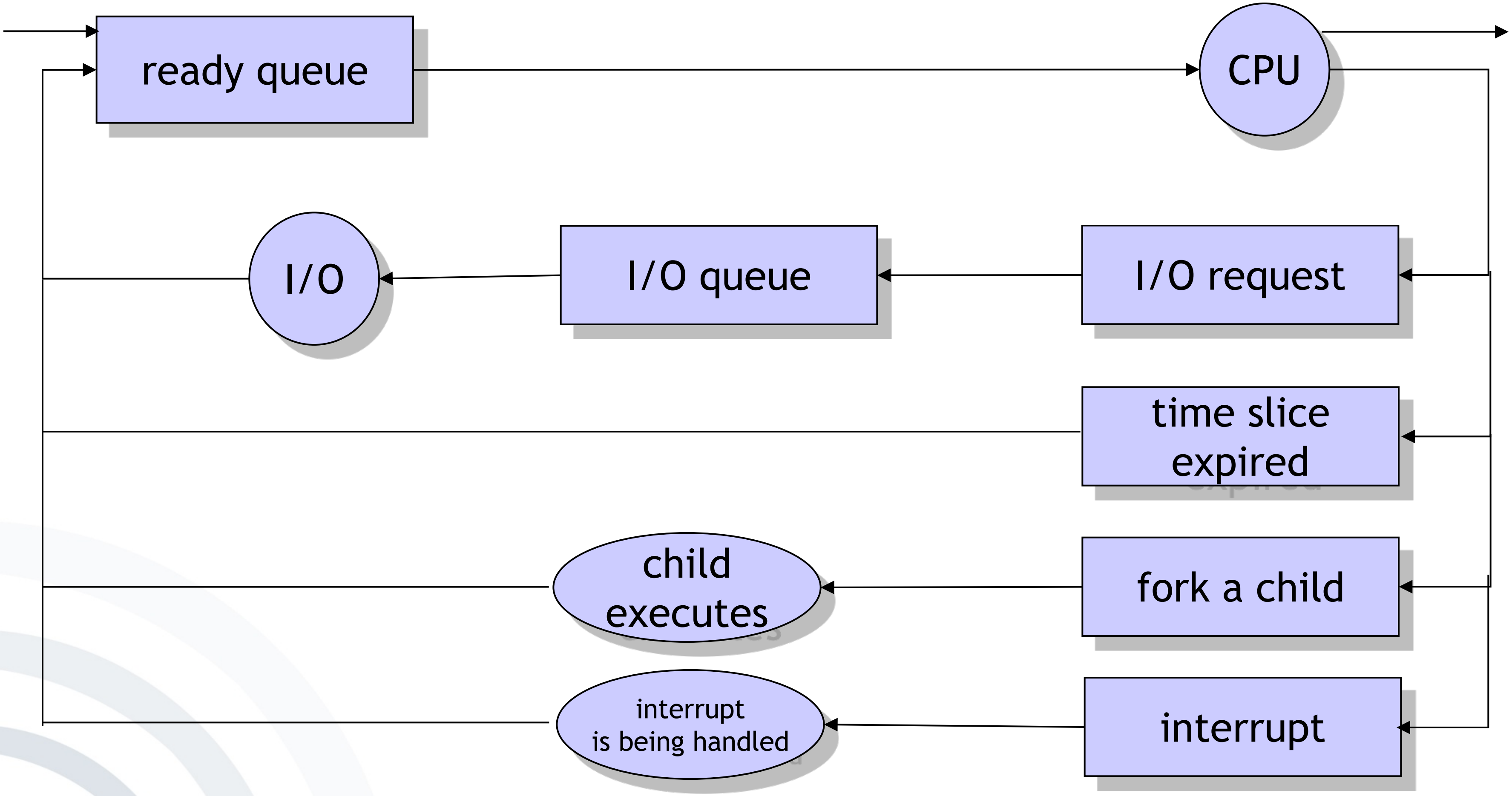
Abstracted View on a Process: Process Control Block (PCB)

- **Process State**: *new*, *ready*, *running*, *waiting*, …
- **Program Counter**: Address of the next command to be executed
- **CPU Registers:** Accumulator, Index Register, Stack Pointer and general registers
- **Information for:**
  - CPU-Scheduling
  - Memory-Management
  - Accounting
  - I/O Status

Scheduling

- **Multiprogramming**: Several processes are being run in parallel for:
  - Maximisation of the CPU usage
  - Enabling users to operate several programs simultaneously
  - Enabling several users to work on the same machine simultaneously
- On a CPU only one process is running at a time.
- The process switching must be fast, to enable the user to interact with all running programs.
- Queues are used to handle this task.

Scheduling in Queues



based on [SilberGalvin1999]

Scheduling – Algorithms

- If the CPU is idle (no process is running), the scheduler invokes a process from the ready-queue to be run on the CPU.
- There are different methods (algorithms) to make the choice, which process to invoke.
- Methods are optimised towards different criteria.

Scheduling – Criteria

- **CPU utilisation:** The goal is to maximise the CPU usage.
- **Throughput:** Number of finished processes per time unit.
- **Turnaround-time**: Time interval between the beginning and the end of a process
- **Latency time**: Sum of all the waiting time of all processes in the queue.
- **Response time**: Time span of a process to answer a user's request and to generate the answer.

First Come, First Serve (FCFS)

- Processes are executed by the CPU one after another in order of their occurrence.
- FIFO-principles (First In First Out)
- ***Pros/Cons:***
  - The throughput is not optimal.
  - Average response time is very high
  - No optimal utilisation of the CPU (Convoy-Effect)
  - Not appropriate for Time-Sharing-Systems

Shortest Job First

- The processes are executed in order of their execution time.
- Processes that can be finished fast are executed first.
- ***Pros/Cons:***
  - ***Optimal*** with regard to the average latency time
  - Not fair ➲ Complex processes can “starve to death”.

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Priority Scheduling

- Processes get an assigned priority number.
- Process execution in the order of the assigned priority.
- Deadlocks or “starvation” of processes with low priority numbers is possible.

➲Aging: Gradually raising the priority of a process

Round Robin Scheduling

- Especially used for Time-Sharing-Systems and one of the simplest scheduling algorithms
- Similar to FCFS, assigning time slices of a time interval to a process being held in the scheduling queue.
- After the time slice of a process is expired, the CPU is revoked from the process and the process is placed at the end of the scheduling queue.
- The efficiency of this method depends on the size of a time interval.

Inter-Process-Communication

- Processes are able to interact with each other (data exchange)
- Several methods are possible
  - Direct or indirect
  - Symmetric or asymmetric
  - Automatic or by explicit buffering
  - Handover as copy or reference
  - Fixed or variable size of communication packets

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  - Mapping
  - Paging
  - Segmentation
  - Examples
- Security & Maintenance

Memory Management

- The CPU retrieves instructions from the memory depending on the program counter.
- Thereby it might be necessary to read or write data from certain memory-addresses.
- The operating system has an address space where the data and the programs reside.
- The whereabouts of a process in the memory can be unknown by the time of the actual programming.

➲ Usage of symbolic addresses during programming that get mapped to physical addresses later on (***Mapping***)

➲ ***Binding:*** The conversion of symbolic addresses to logical addresses in the memory of an operating system.

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Mapping
Logical vs. Physical Addresses

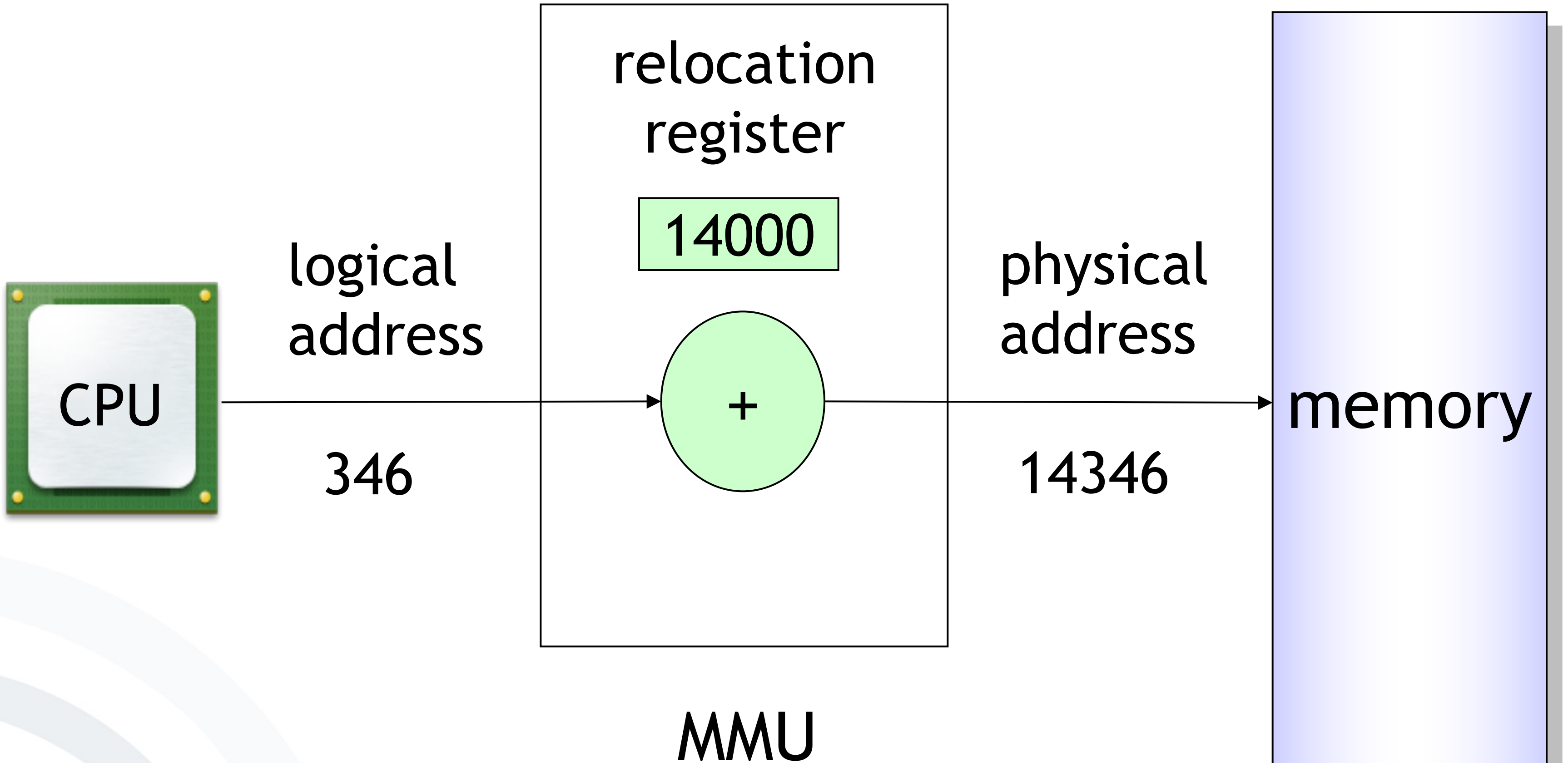
- **Logical Addresses:**
  Generated by the CPU

- **Physical Addresses:**
  Sent to the memory unit

Mapping
Memory Management Unit

- The mapping is done by a so called MMU (Memory Management Unit).
- Usage of a relocation register that contains the base address for a process.
- The base address is added to the logical address, resulting in the physical address.

Mapping Relocation Register

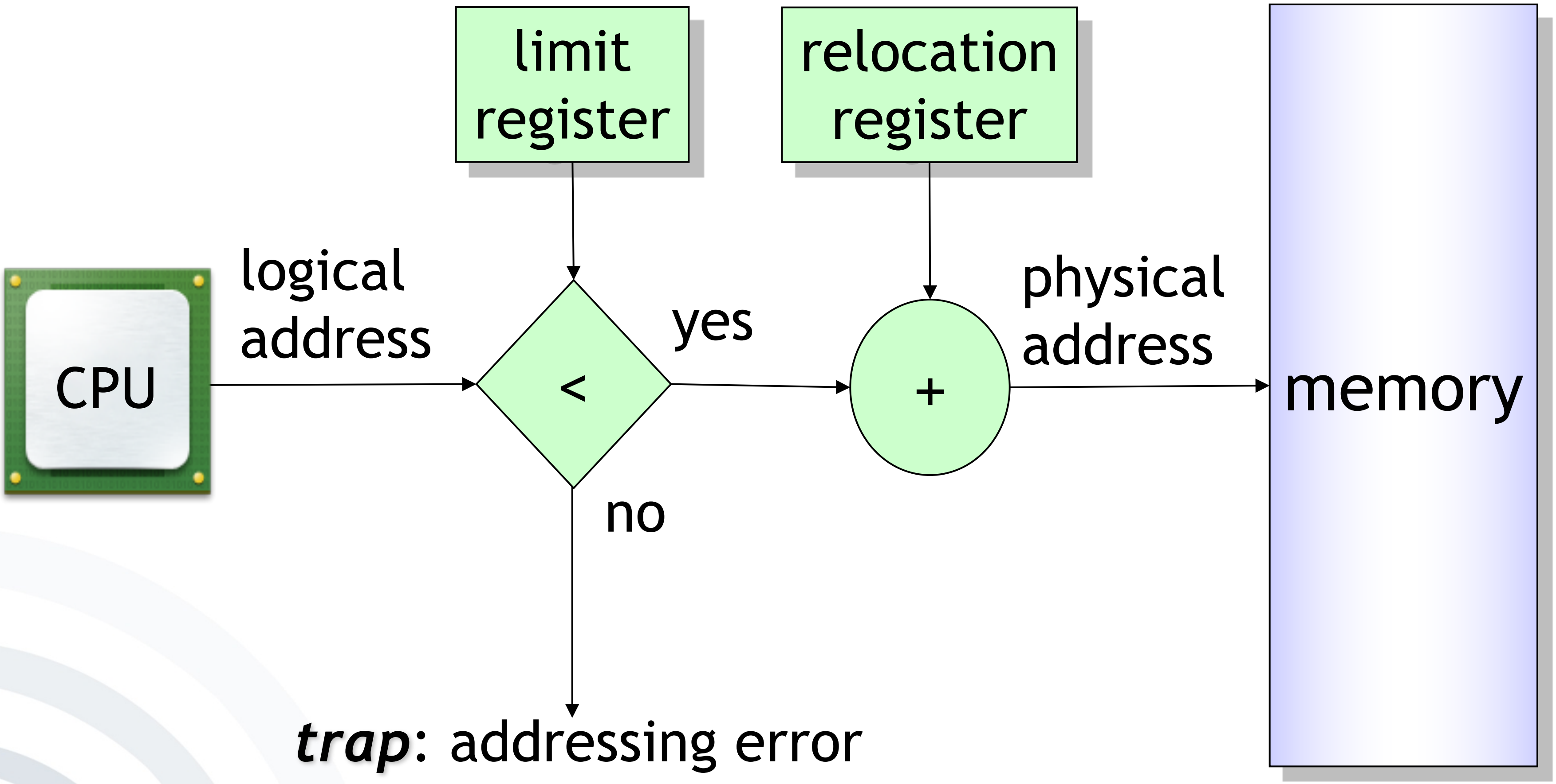


[SilberGalvin1999]

Mapping
Limit Register

- The memory of a system also contains the actual operating system.
- The access of other processes onto the code of the operating systems needs to be prevented.
- Furthermore, the processes need to be protected against each other.
- Solution: Usage of so called „Limit Registers“

Mapping
Limit Register



[SilberGalvin1999]

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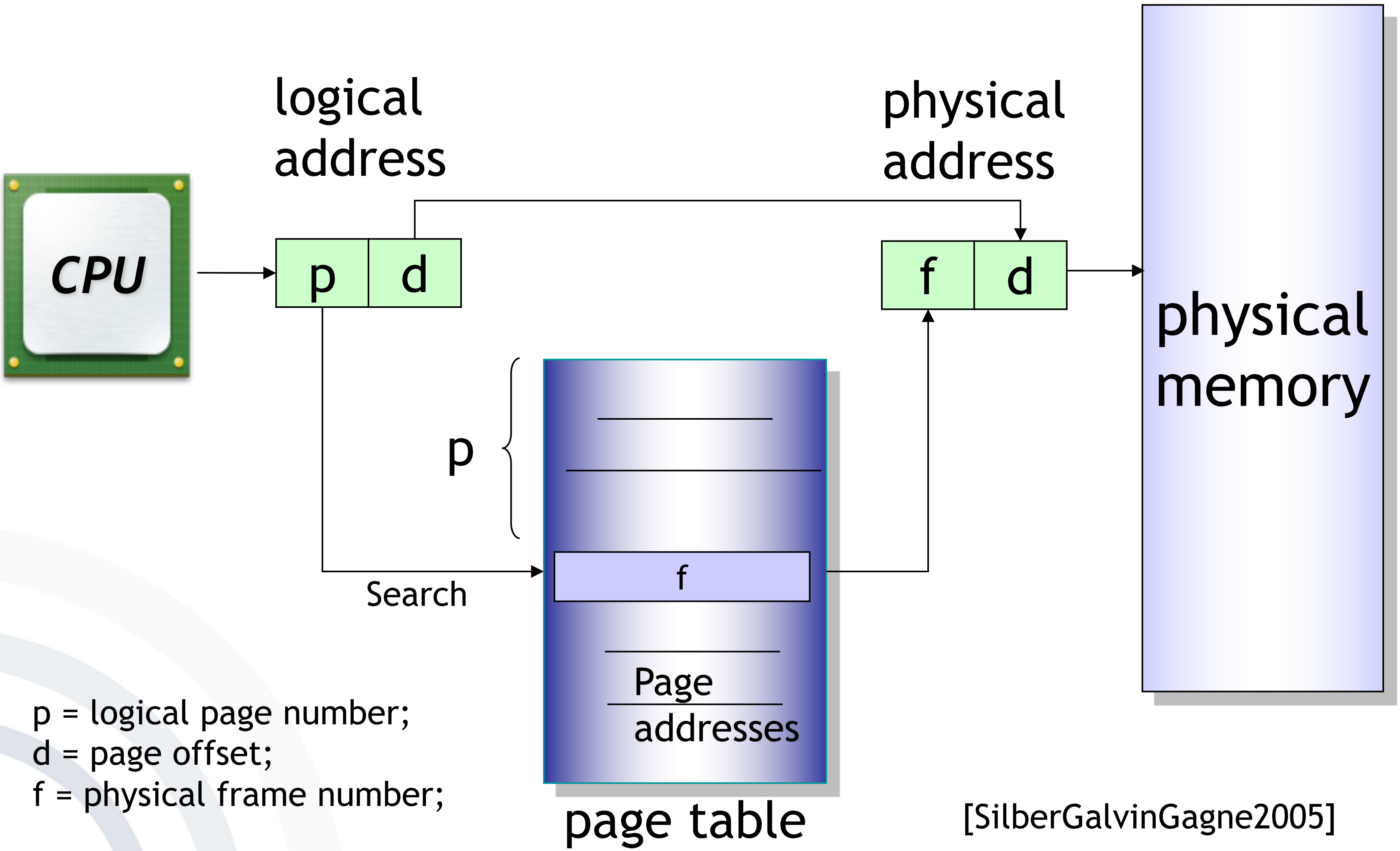
Paging Overview

- The memory contains several processes of varying size.
- When a process is loaded or removed from the memory, the free memory will be fragmented.
- One solution is the so called ***paging***, putting the process into several separate memory chunks of a defined size, instead of putting it into the memory in one single piece.

Paging
Overview

- The ***physical memory*** is divided into blocks of a defined size, the so called *frames*.
- The ***logical memory*** gets divided into blocks of the same size, the so called (memory) *pages*.
- Every address created by a CPU is divided into a *page number* [p] and an *offset* [d].
- The page number is used as the index for the page table, containing the base address for all (memory) pages.
- The base address is combined with the offset resulting in the physical address.

Paging Schematics



p = logical page number;
d = page offset;
f = physical frame number;

[SilberGalvinGagne2005]

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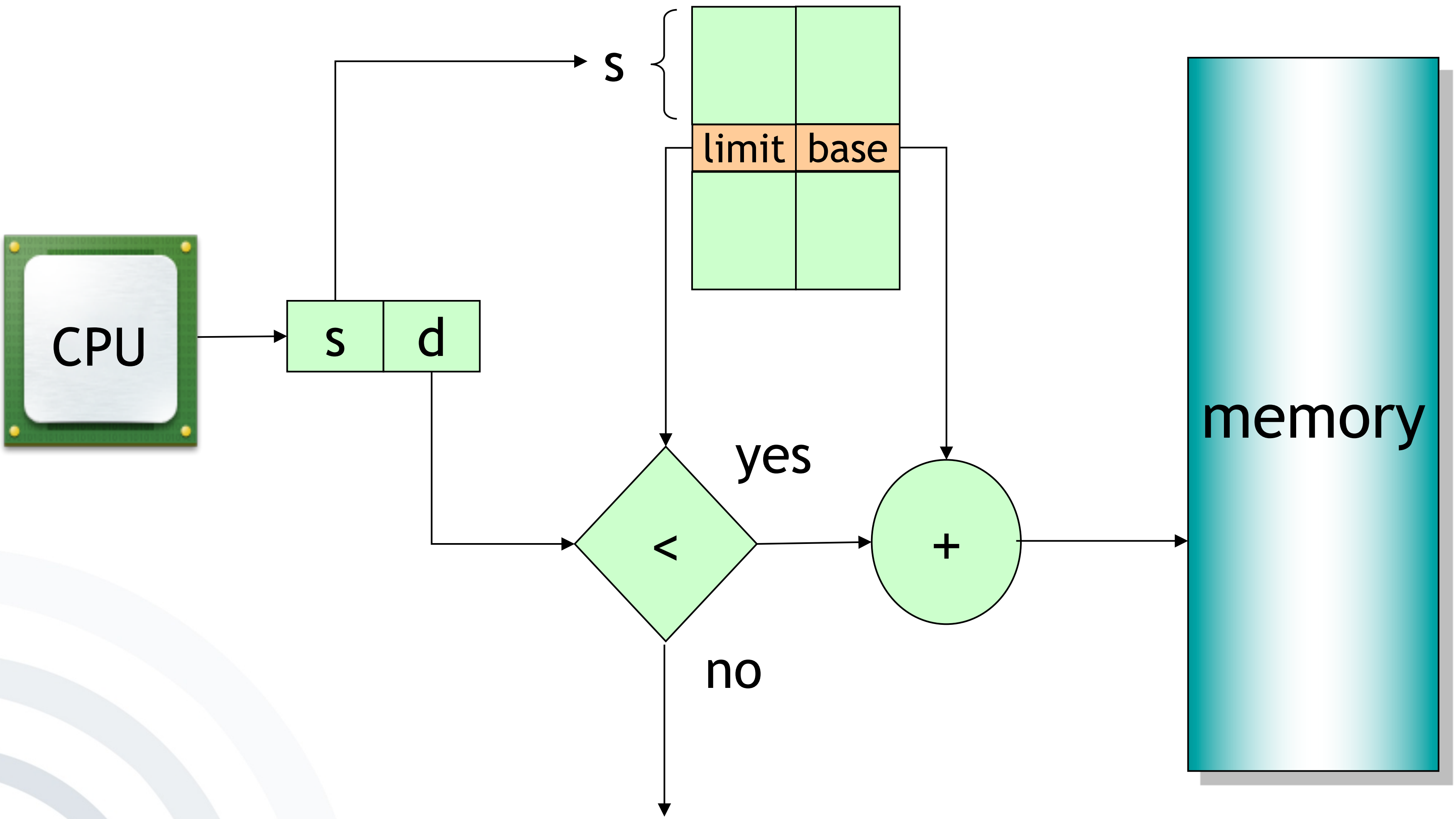
Segmentation Overview

- The memory is partitioned into segments of variable length.
- Every segment has a name and a defined length.
- A segment table is used to store the base address and the limit of the segments.
- The logical address consists of a segment number [s] and the offset [d].

Segmentation Schematics



[SilberGalvin1999]

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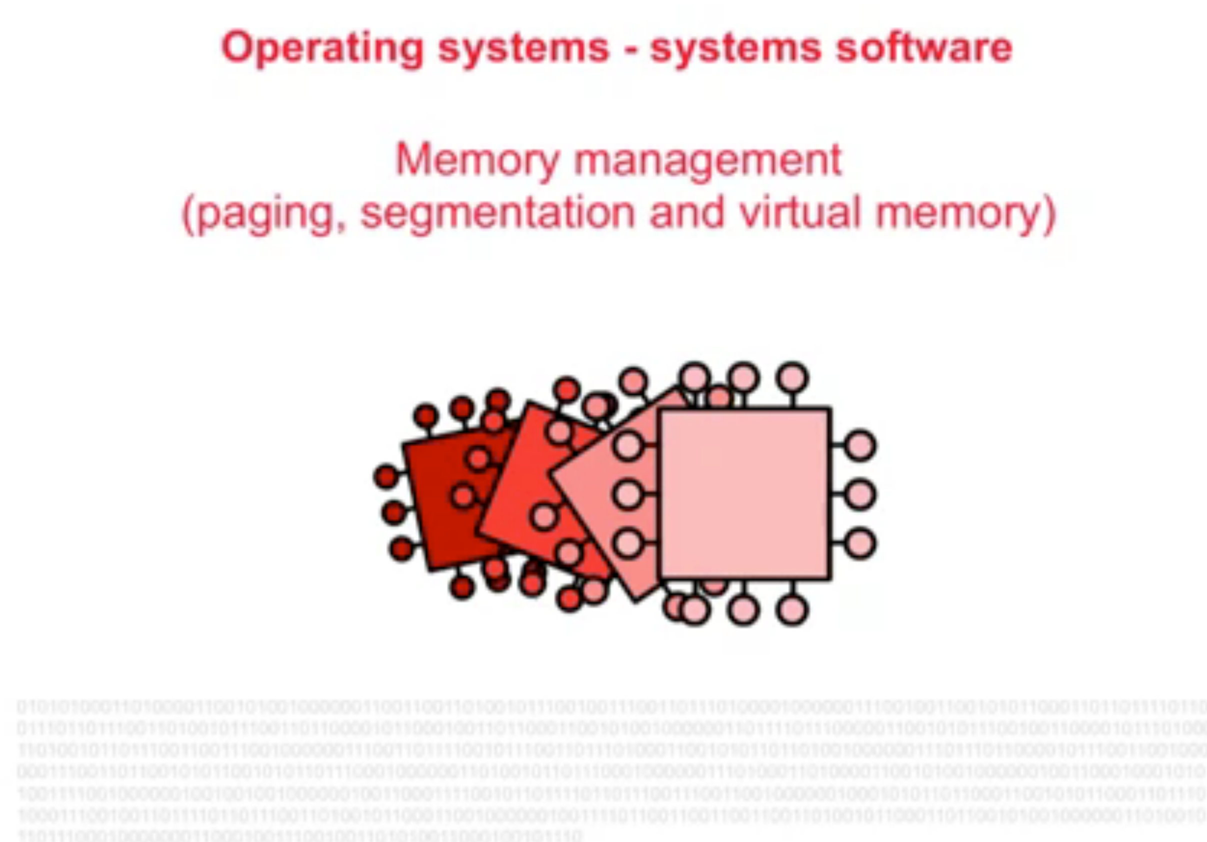
Memory Management Examples Overview

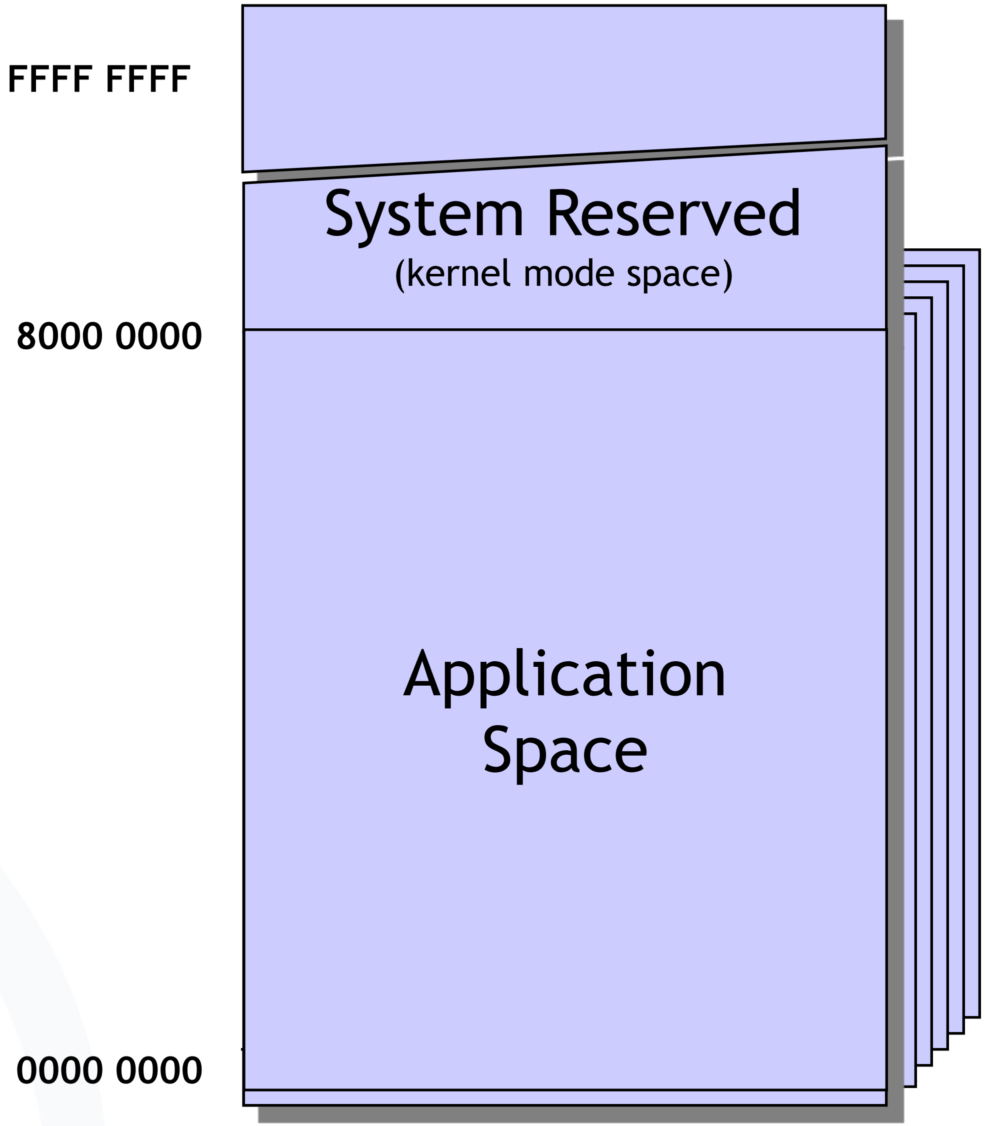
- Paging, segmentation and virtual memory
- Windows CE Dynamic Link Libraries (DLL) positioning

Example



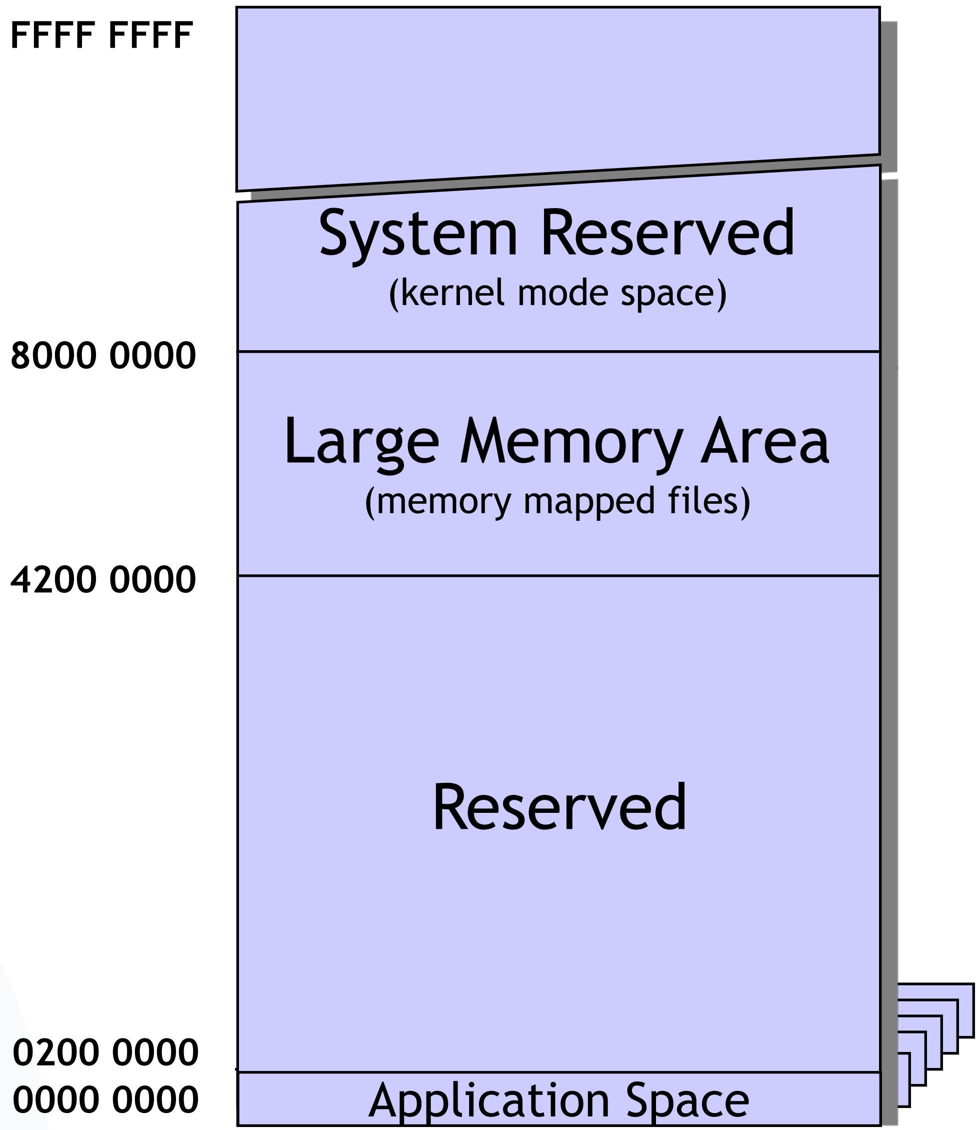
[Craigndave2015]

Memory Management Examples
Windows XP Memory Map



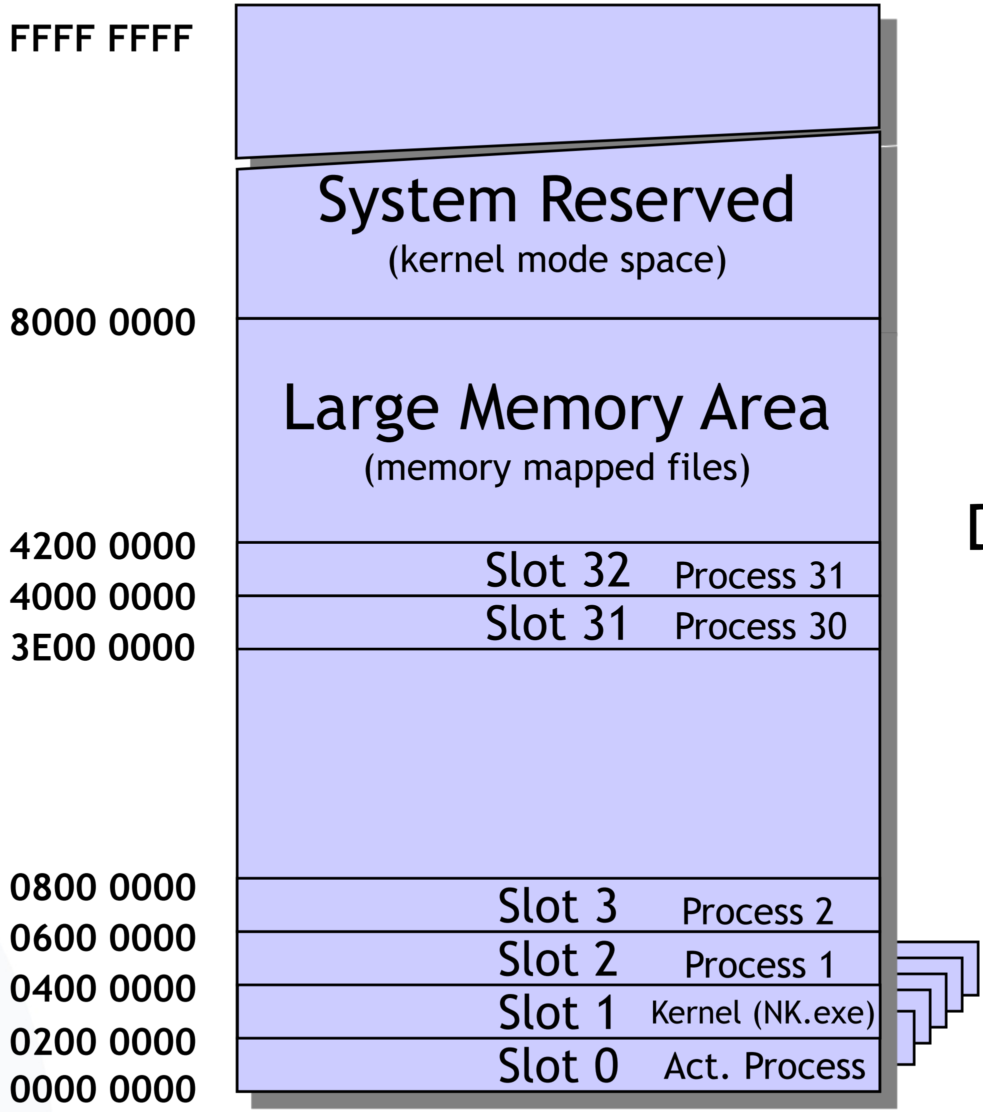
[Hall2002]

Memory Management Examples
Windows CE Memory Map



[Hall2002]

Memory Management Examples
Windows CE Memory Map



Detailed View

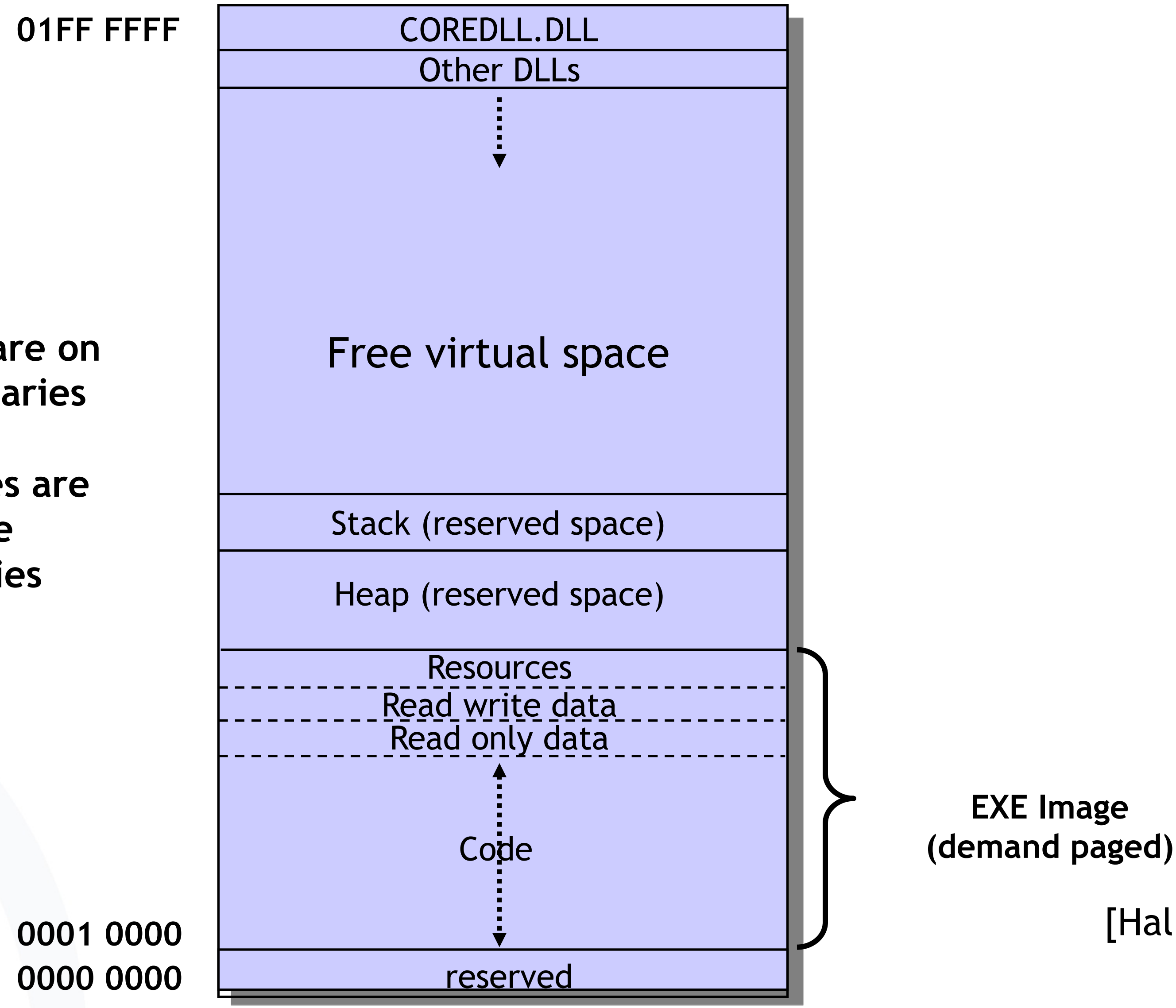
[Hall2002]

Memory Management Examples
System Memory Map

- Memory (RAM) is divided into 33 slots.
- One process per slot
  - Slot 2 to Slot 32
  - A process only has access to his own slot
    - … and to slot 0, when it is active.
- Active process is placed into Slot 0.
- Kernel (NK.exe) is placed into Slot 1.

- Remaining memory is shared.

Memory Management Examples
Application Memory Map (Slot 0)



Solid lines are on 64K boundaries

Dashed lines are on page boundaries

[Hall2002]

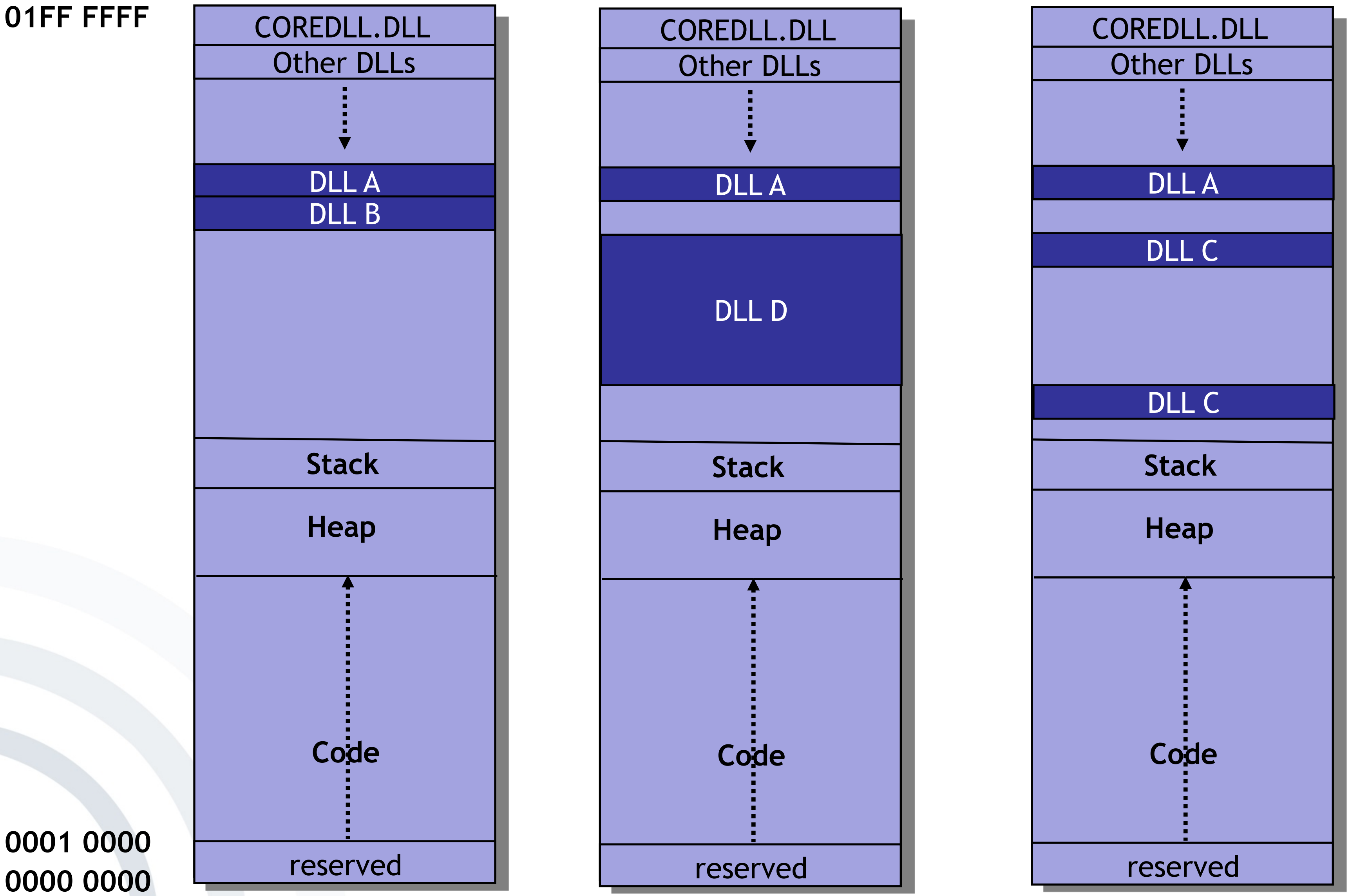
Memory Management Examples
Virtual Memory

- Maximum of 32 MB for virtual memory
  - Virtual memory is used for the code and the data.
- Memory is:
  - Allocated on the basis of pages
  - Reserved in blocks of 64 KB

Memory Management Examples
Dynamic Link Libraries (DLL)

- Software library, containing a collection of functions and sub-programs that can be used by other independent programs.
- This methodology offers the following advantages:
  - Reutilisation of existing code
  - Distribution of the development process
  - Etc.

Memory Management Examples
DLL Load Positioning



[Hall02]

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Memory Management Examples
DLL Load Positioning

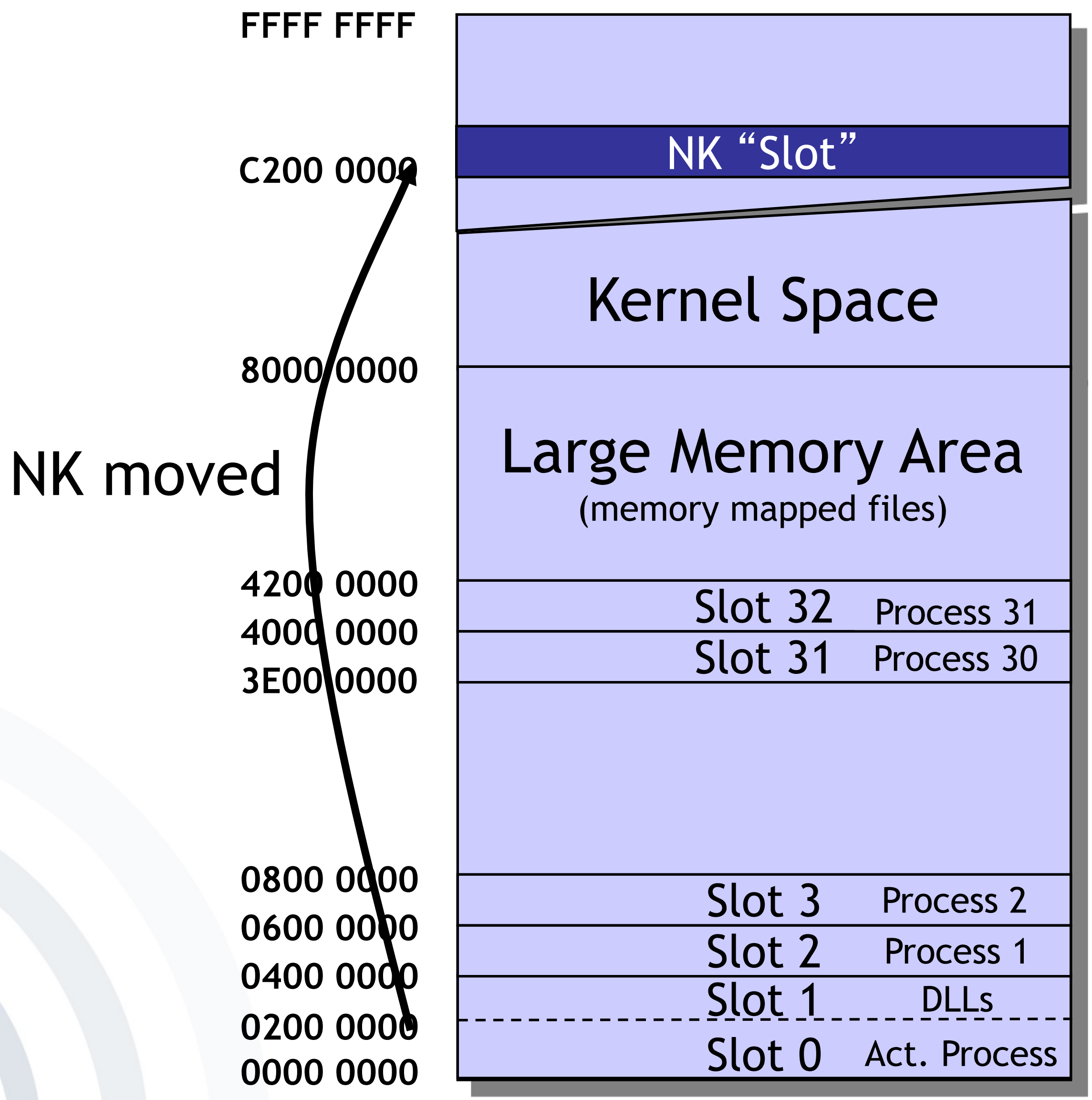
- Any DLL being loaded by any process allocates memory of other processes, regardless if the DLL is used by other processes or not.
- The address the DLL is loaded to is dependent on the other DLLs being loaded by other processes.
- All DLLs are loaded/stored into memory blocks of 64K.

➲ The more DLLs loaded, the bigger the problem

Memory Management Examples
Solution in Windows CE .NET

- Windows CE .NET solves the DLL load problem by modifying the memory map.
- The kernel (NK.EXE) is relocated from Slot 1 into the kernel space starting from address 0xC200 0000.
- Slot 1 is used for the DLLs:
  - Is connected with all applications for Slot 0

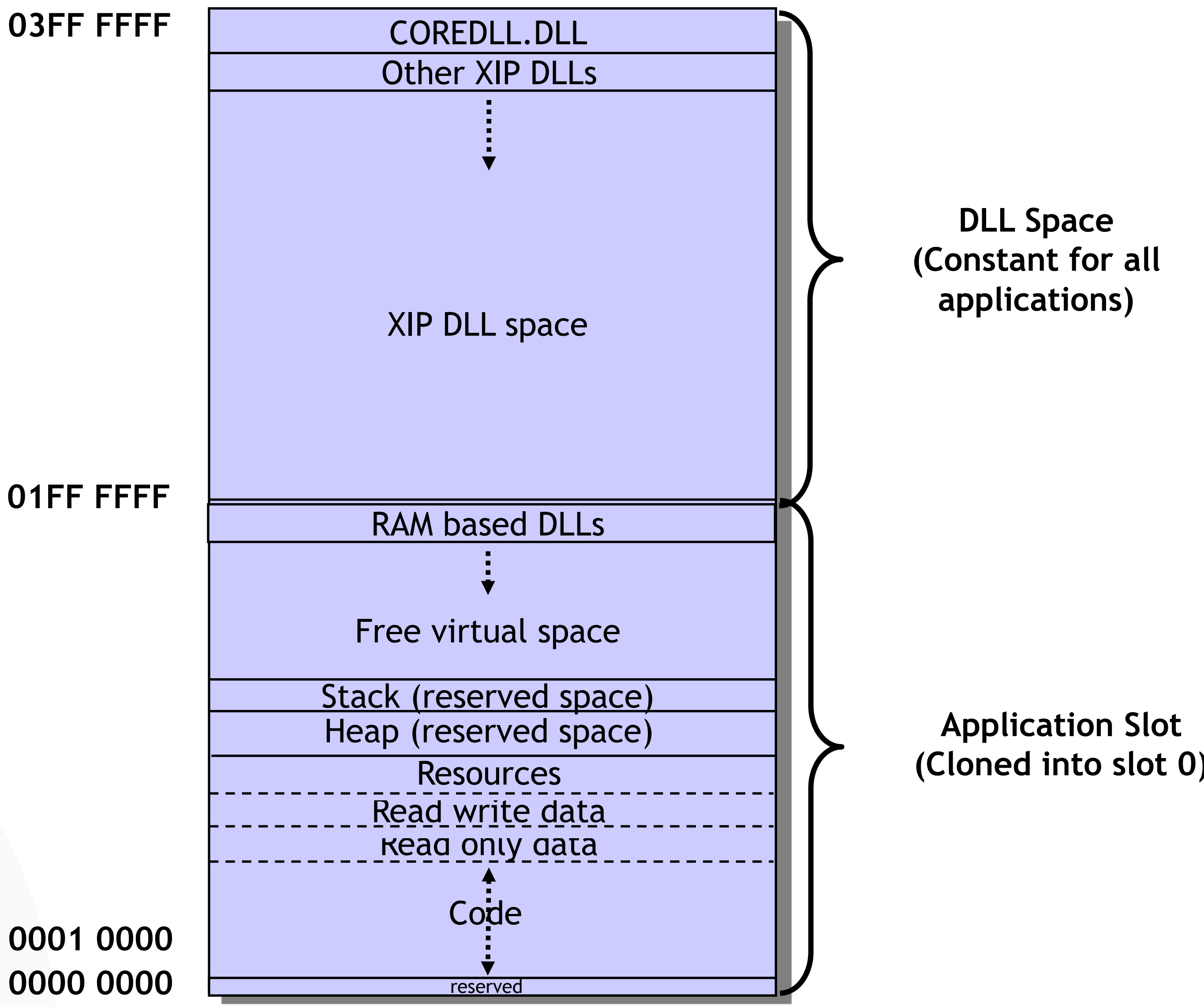
Memory Management Examples
Windows CE .NET Memory Map



[Hall2002]

Memory Management Examples

Windows CE .NET Application Memory Map



[Hall2002]

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- Windows CE .NET Application Memory Map
  - Application memory is now extended to 64 MB (from 0000 0000 up to 03FF FFFF).
  - DLLs are loaded into the upper 32 MB (from 0200 0000 up to 03FF FFFF).
  - Executable (EXE) code, heaps and stacks are using the lower 32 MB (from 0000 0000 up to 01FF FFFF).
  - There is no possibility for loaded applications to allocate memory above 32 MB.

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Sandboxing

- Security mechanism provided by all mobile operating systems
  - Separation of running programs
  - Memory Management allocates well-defined memory areas for every sandboxed application at runtime.
  - Protection of device's resources from mobile applications in the sandbox
  - Untested (program) code cannot cause damage to the outside from within the sandbox.
- Examples
  - Network-access restrictions
  - Restricted file system access

Mobile Device Management

- Software to secure, monitor, manage and support mobile devices

- Over-the-air distribution of
  - Applications
  - Data
  - Configuration settings

➲ Higher security level, lower cost and fewer downtimes

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