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Lecture 11

Concepts of Mobile
Operating Systems

Mobile Business I (WS 2010/11)

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Overview – Concepts of Mobile Operating Systems

- Functions
- Processes
  - States and elements
  - Scheduling
  - Inter-Process-Communication (IPC)
- Memory Management
  - Mapping
  - Paging
  - Segmentation
  - Examples
- Virtual Machines

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]

Technical Properties

- Operating System (OS) features:
  - Memory protection, file protection, access controls
  - Security module support, secure input and output, protection of applications and the system’s integrity
  - Resource sharing:
    - Memory (RAM, storage)
    - Central Processing Unit (CPU)
    - Input / Output devices (I/O)

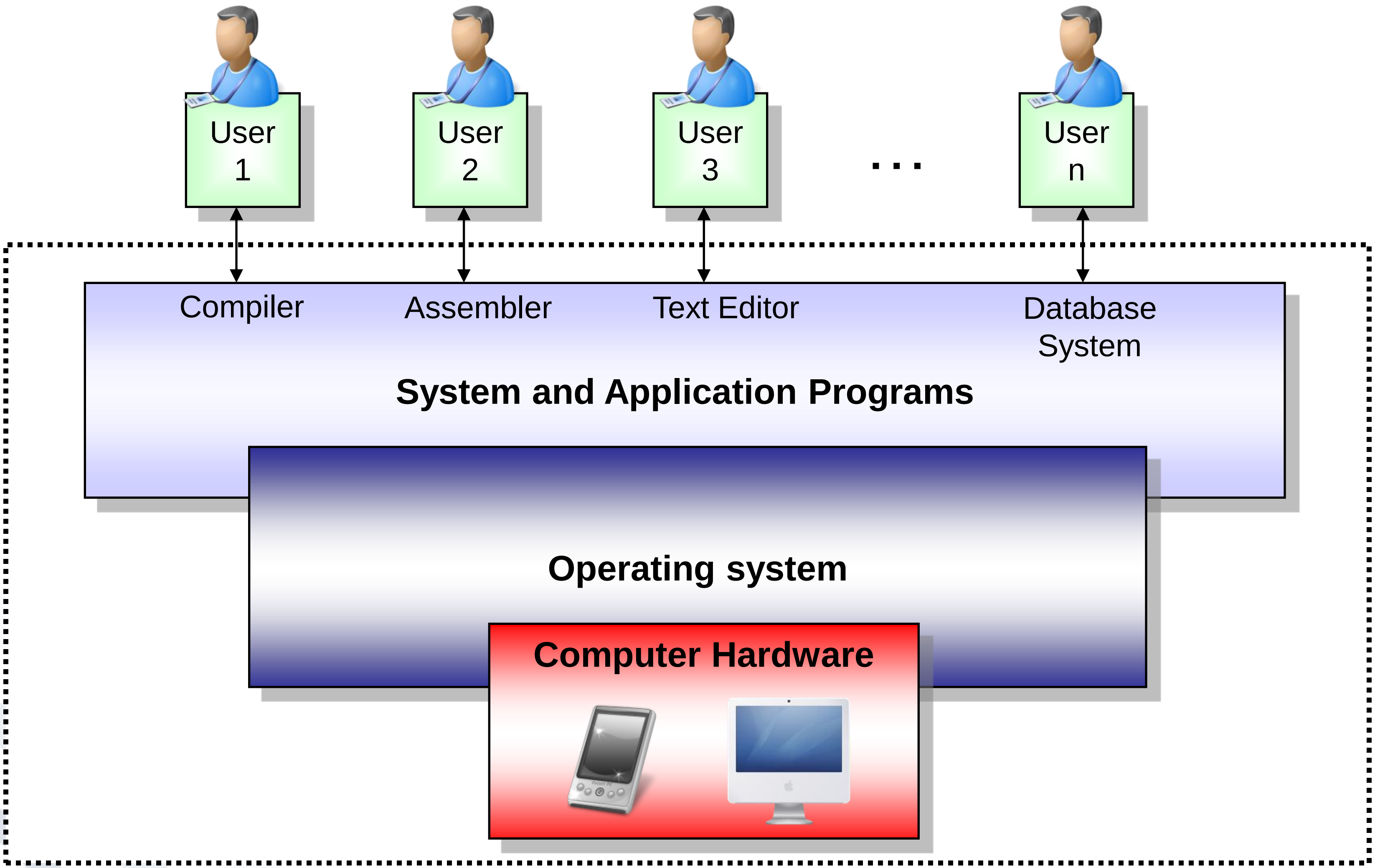
Functions of the Operating System

- **Controlling of the 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?"

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

Operating System



[SilberGalvin1999]

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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?*

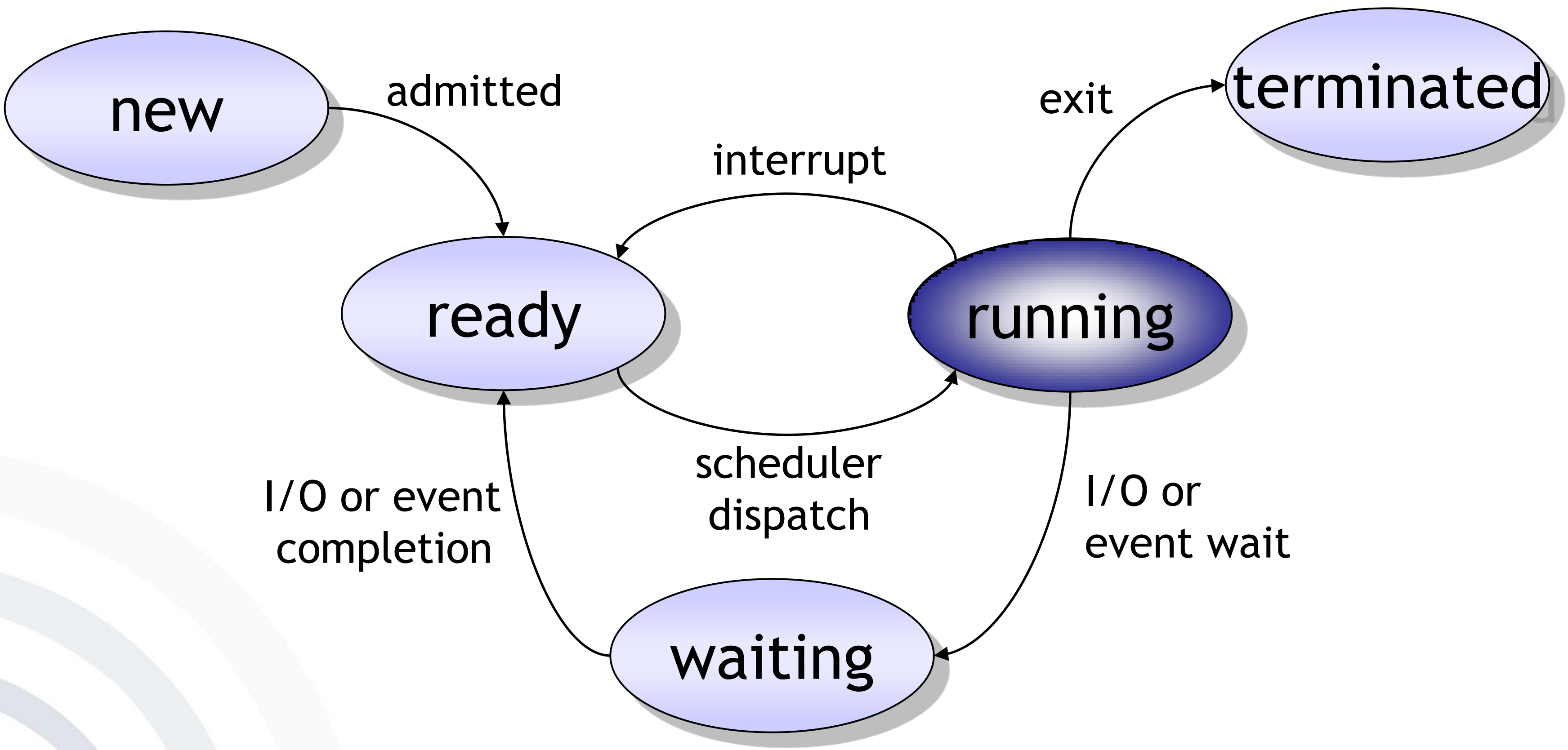
Process

- 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

States of a Process



[SilberGalvin1999]

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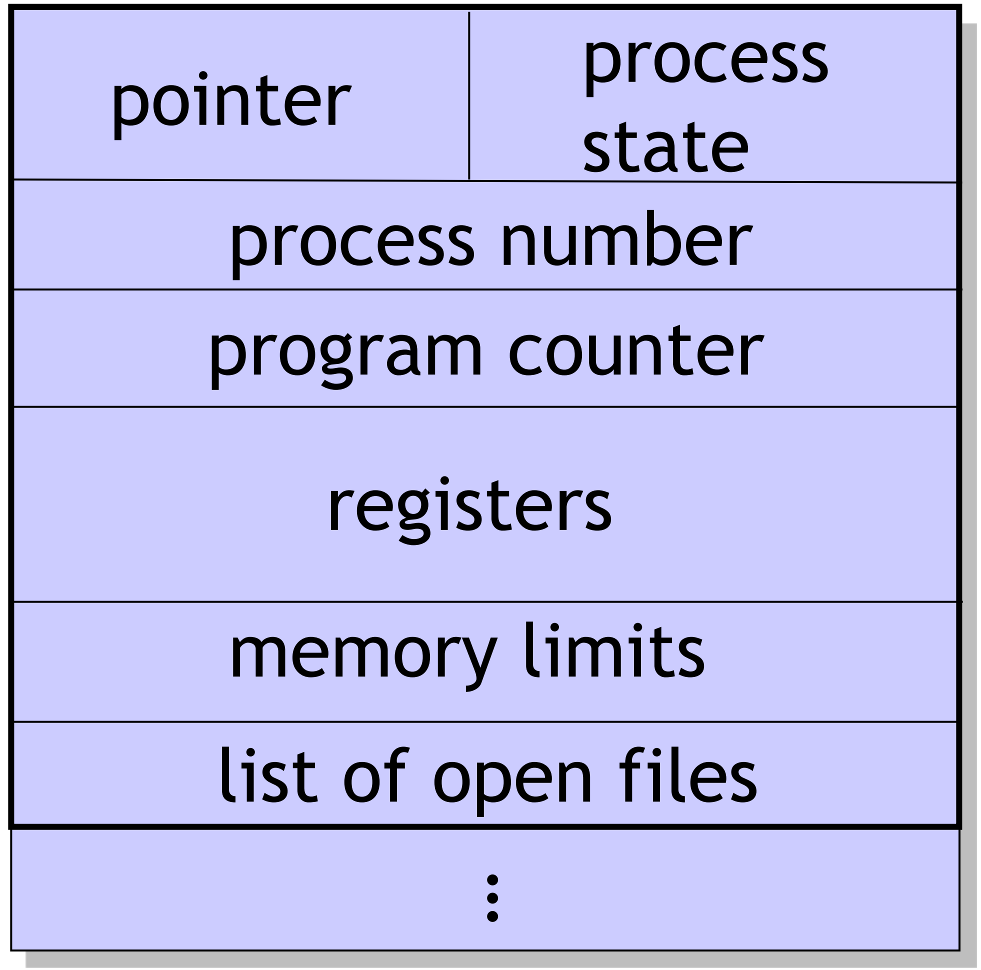
States of a Process

- **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

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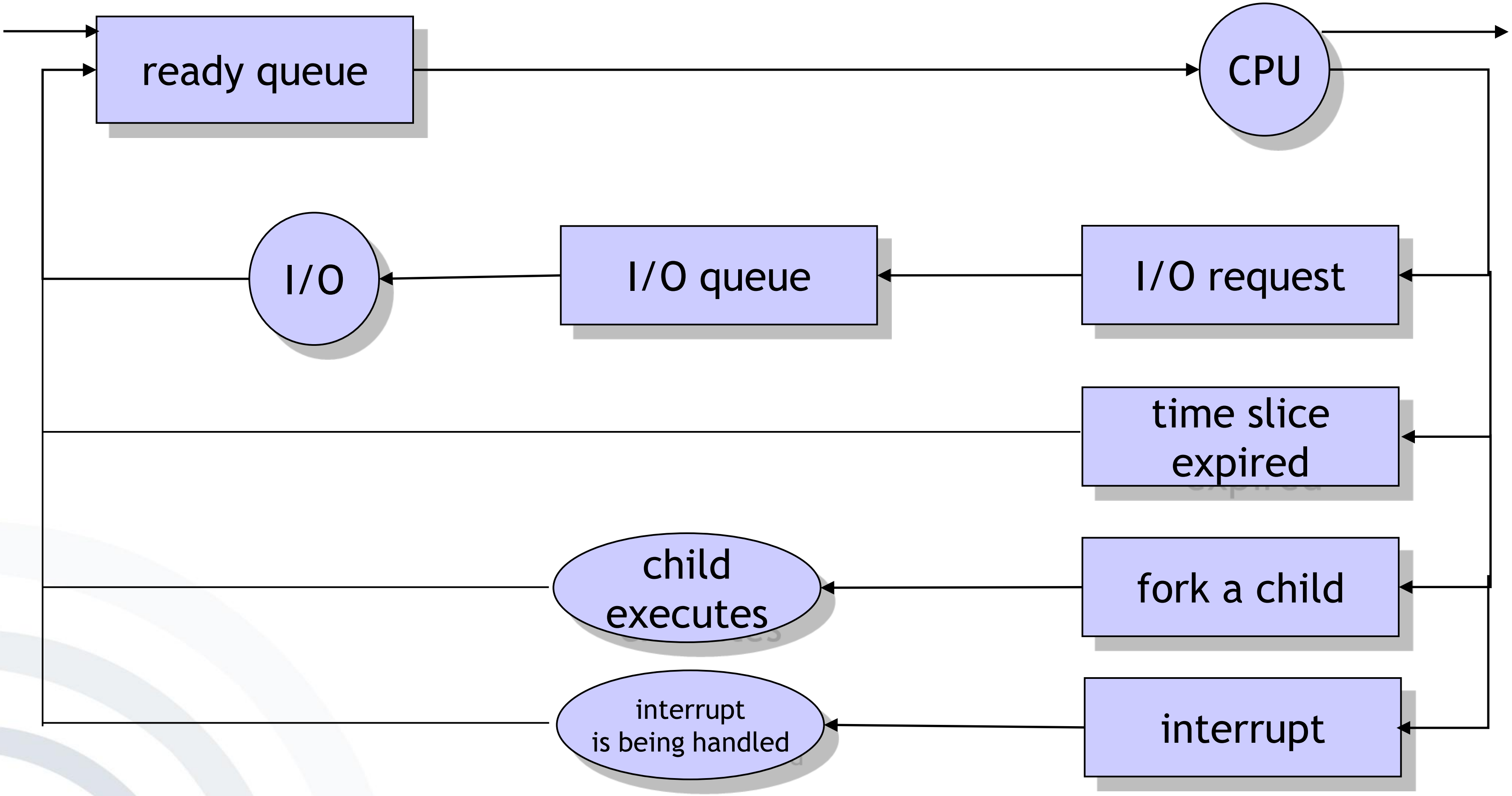
Scheduling

- **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.

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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”.

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

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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 packet

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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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Logical vs. Physical Addresses

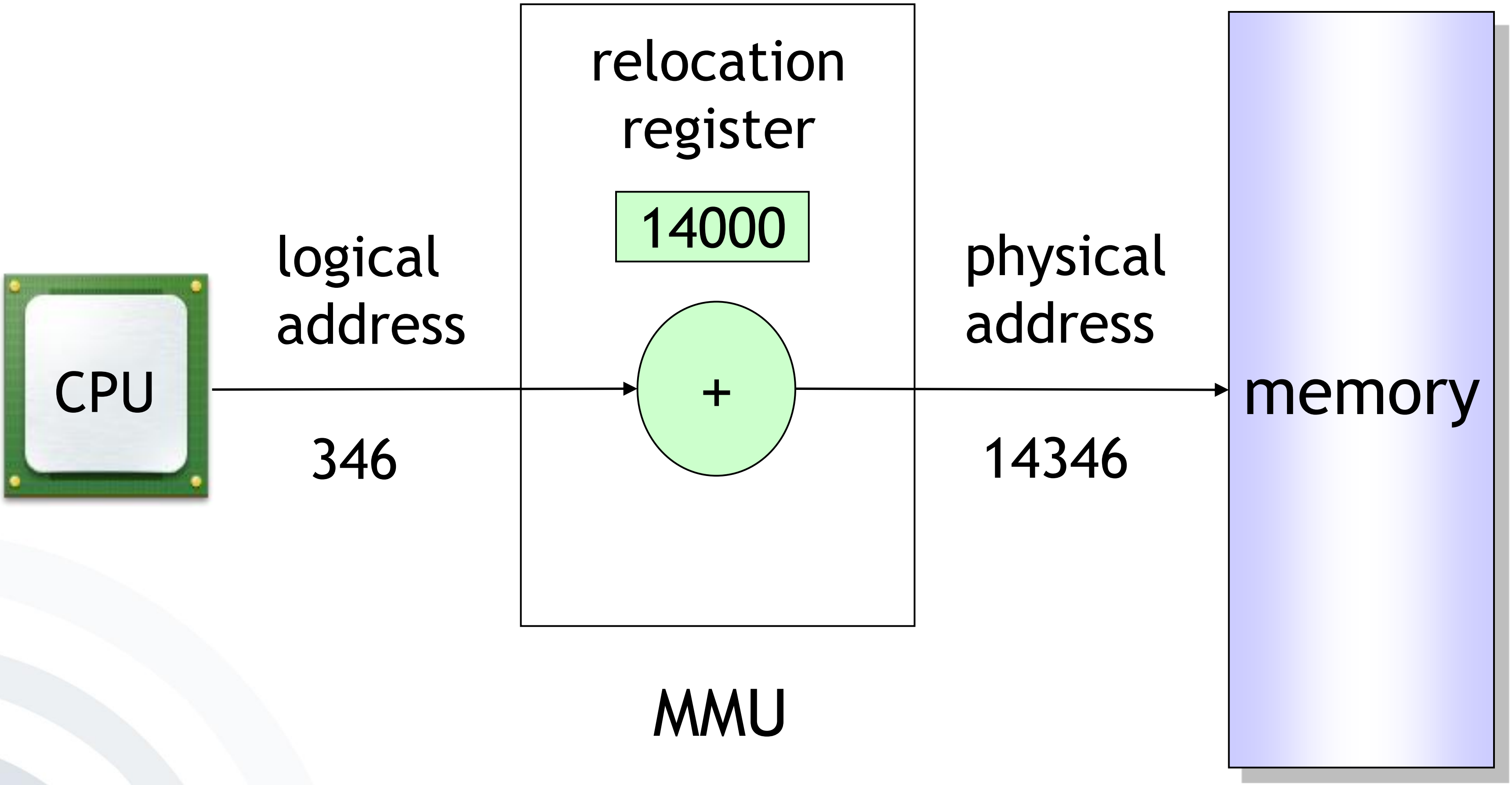
- **Logical Addresses:**
  Generated by the CPU

- **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

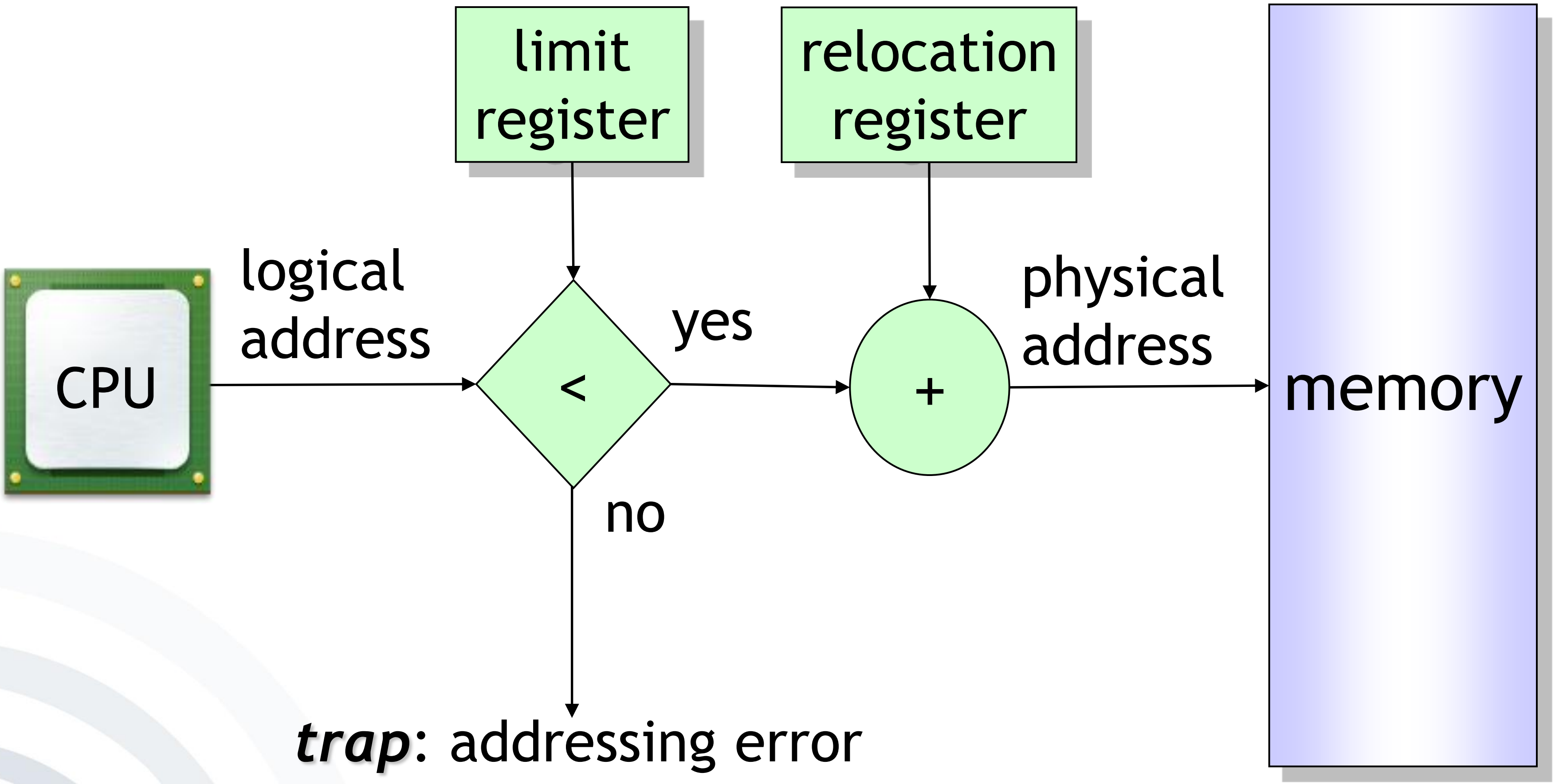


[SilberGalvin1999]

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.

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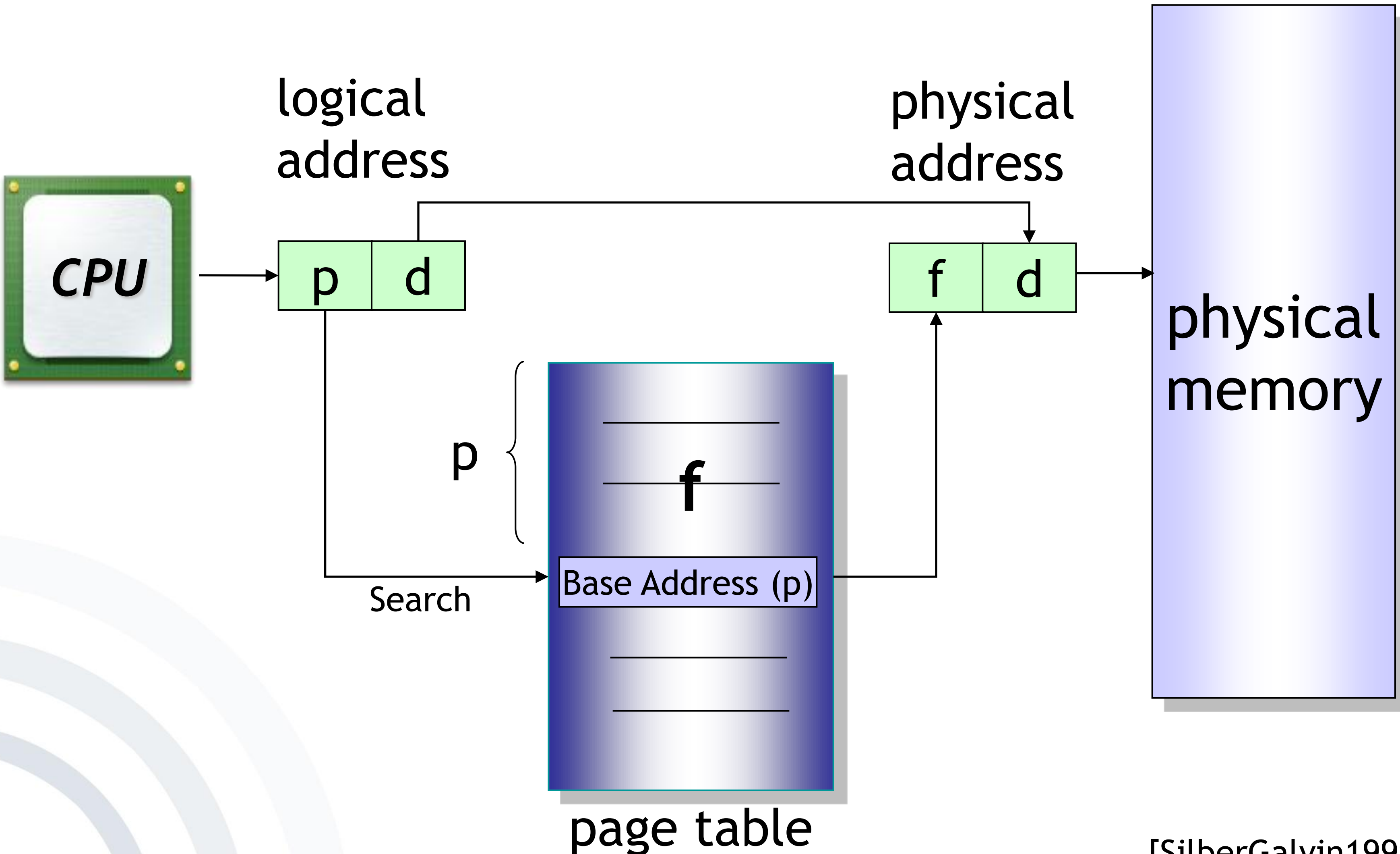
Paging Schematics



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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].

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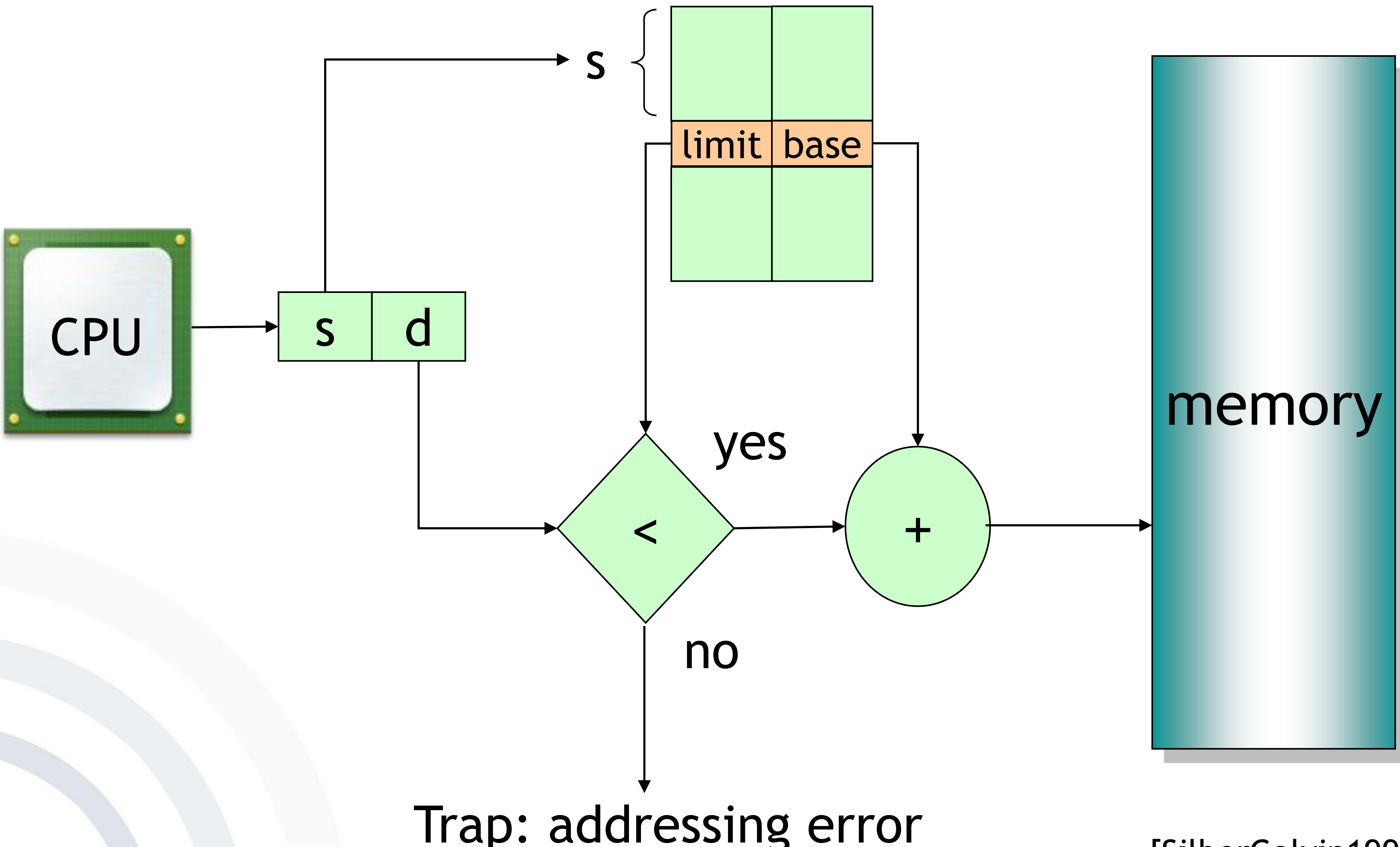
Segmentation Schematics



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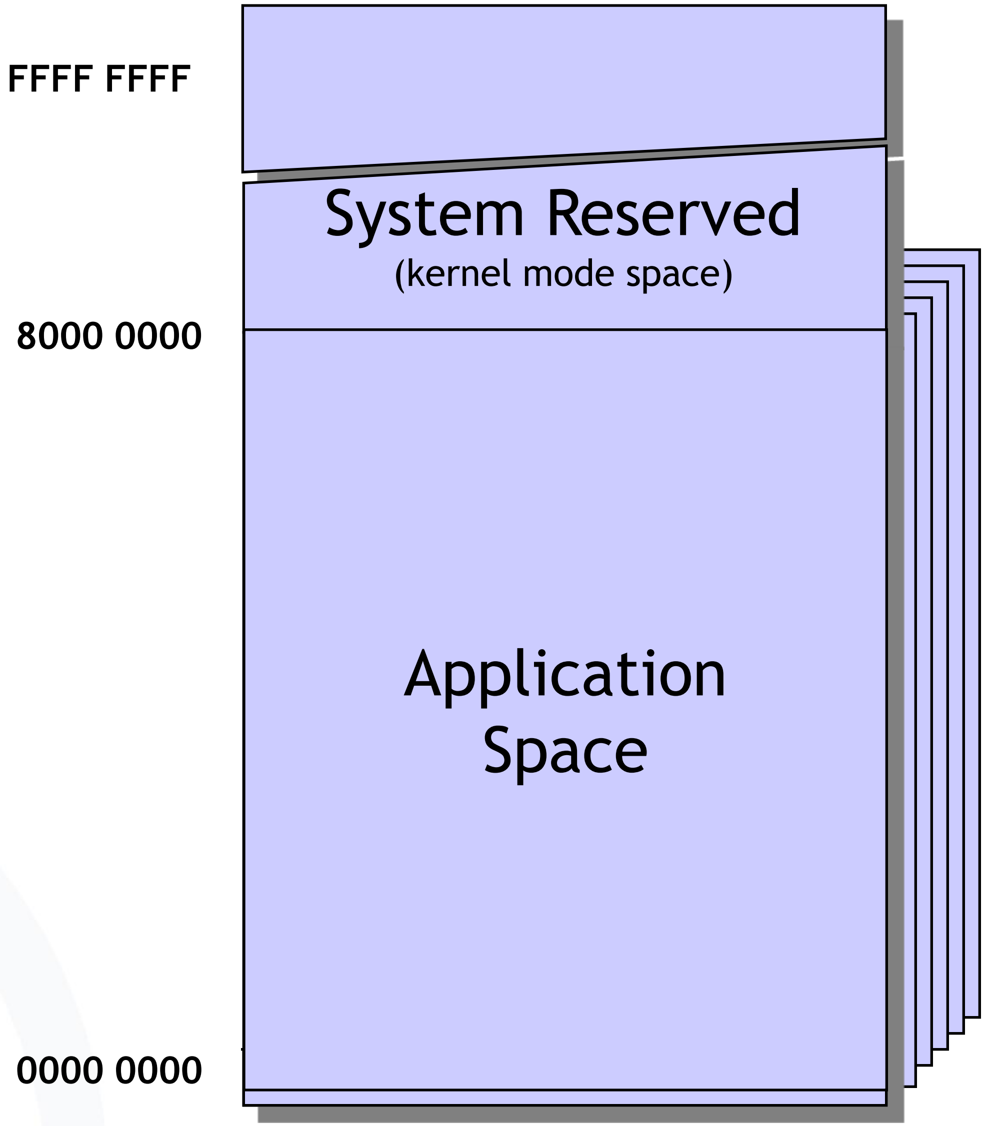
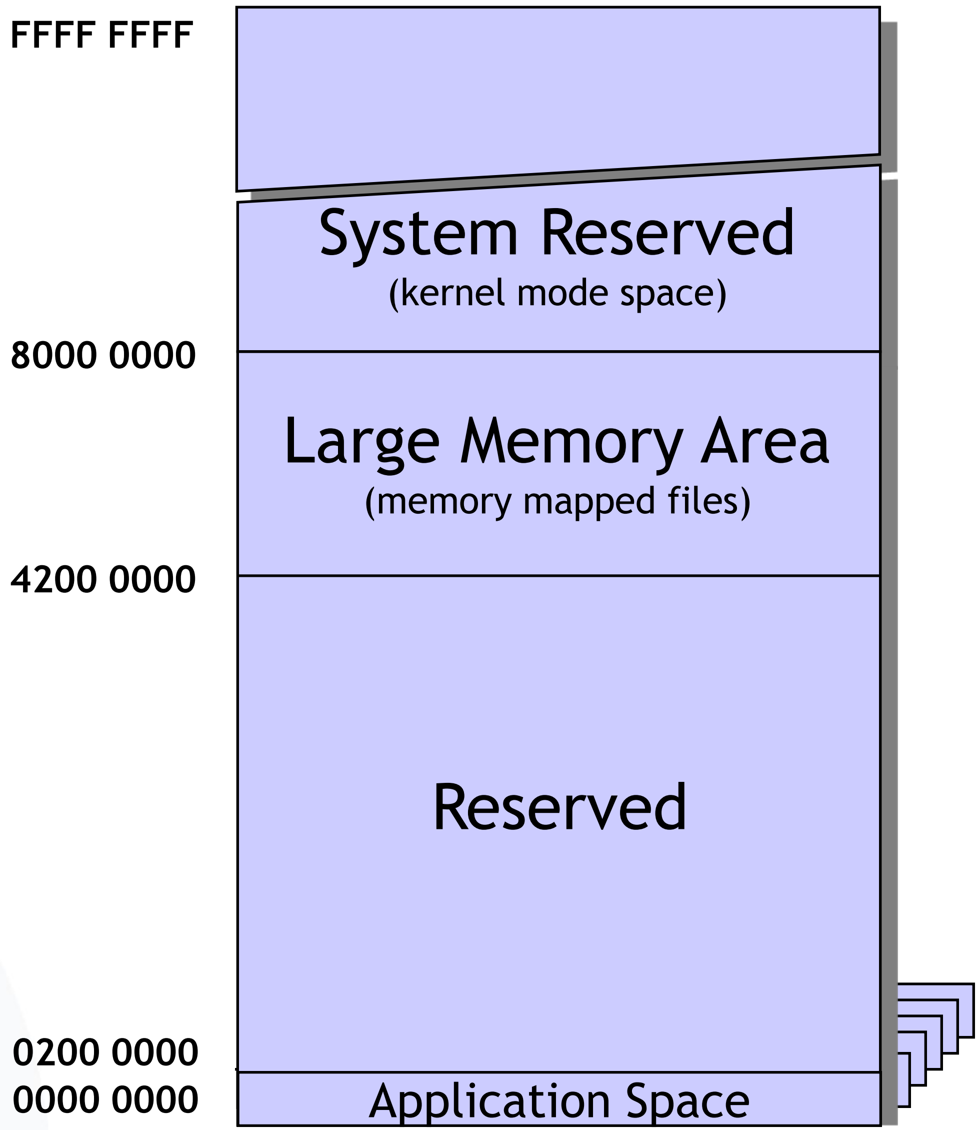
Memory Management Examples
Windows XP Memory Map



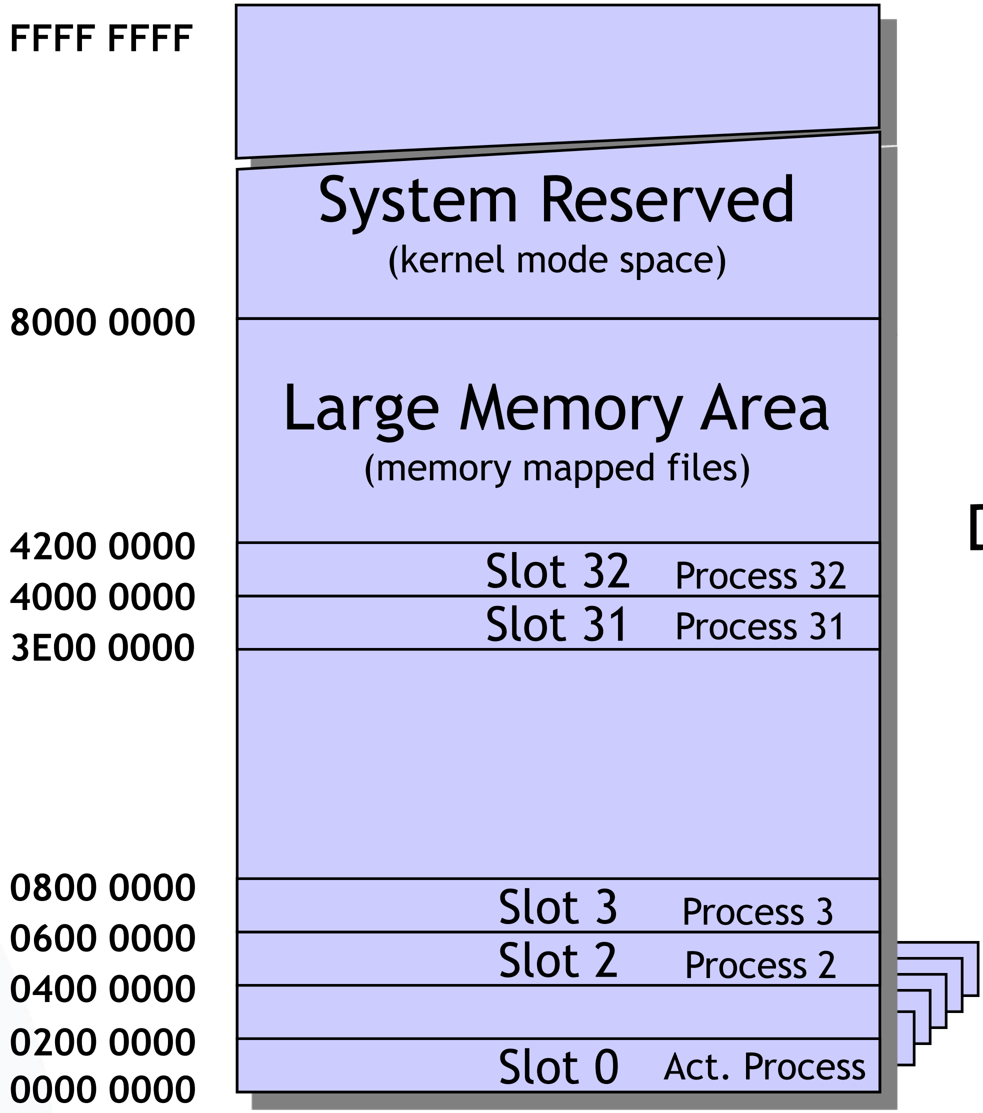
[Hall2002]

Memory Management Examples
Windows CE Memory Map



[Hall2002]

Memory Management Examples
Windows CE Memory Map



Detailed View

[Hall2002]

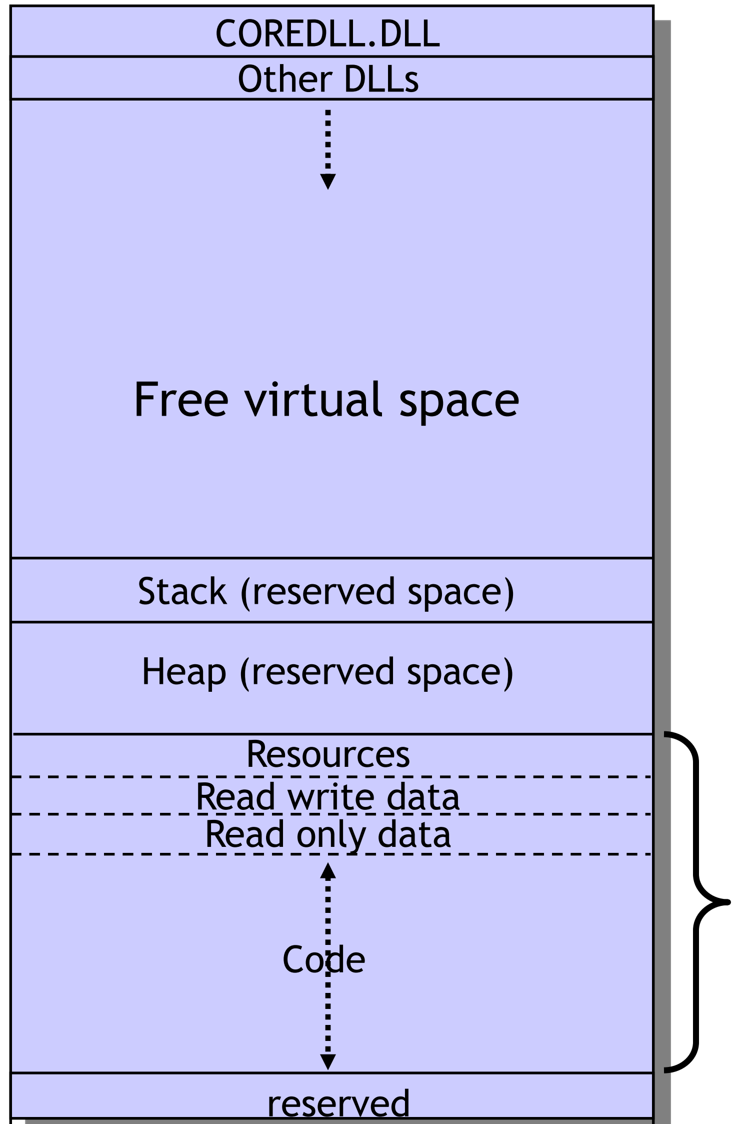
Memory Management Examples
System Memory Map

- Memory (RAM) is divided into 33 slots.
- One process per slot
  - Slot 1 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.

- Remaining memory is shared.

Memory Management Examples
Application Memory Map (Slot 0)

01FF FFFF



0001 0000
0000 0000

Solid lines are on 64K boundaries

Dashed lines are on page boundaries

EXE Image (demand paged)

[Hall2002]

Memory Management Examples
Virtual Memory

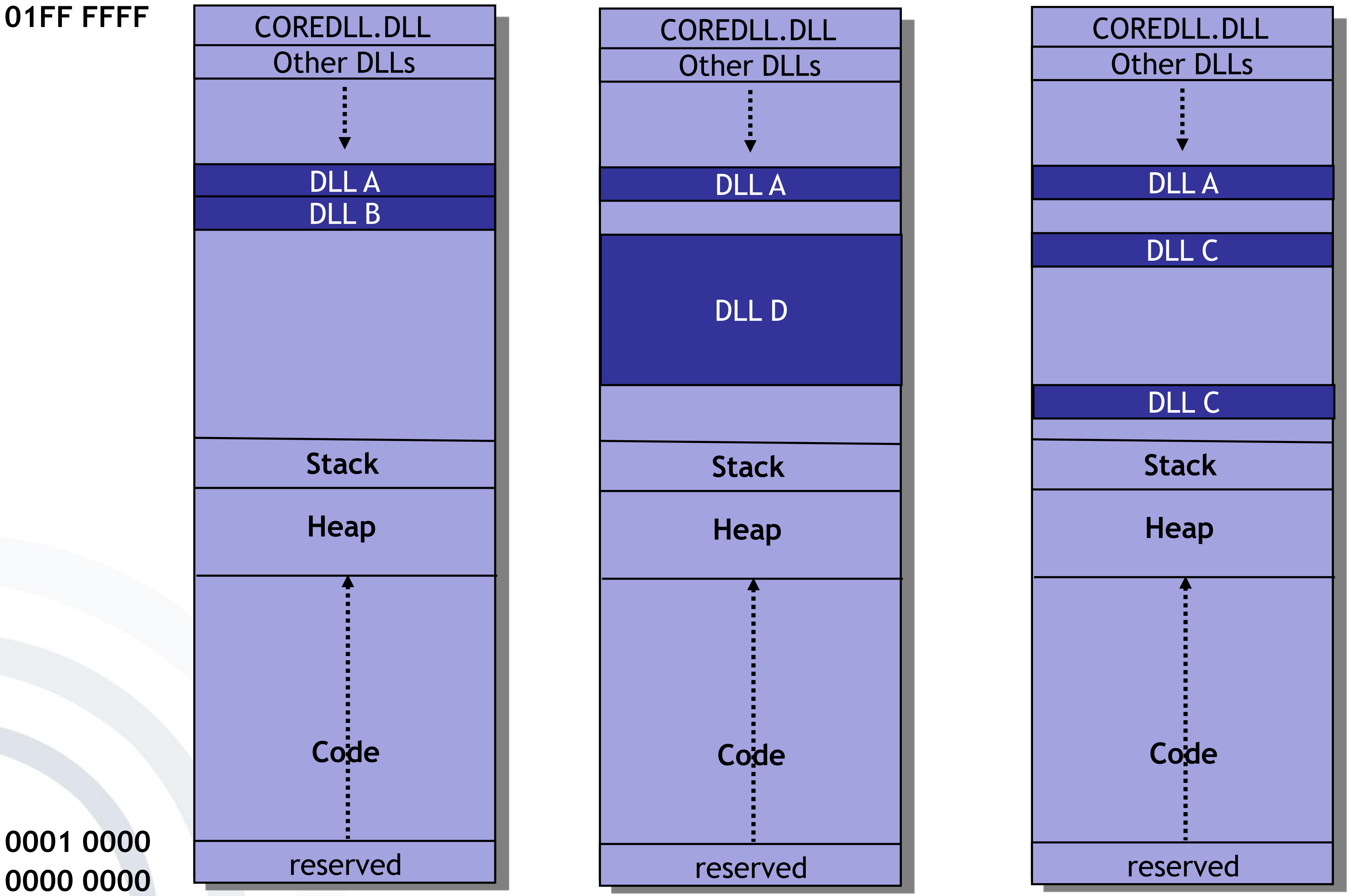
- Maximum of 32 MB for virtual memory
  - Virtual memory is used for the code and the data

- 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]

Memory Management Examples
DLL Load Positioning

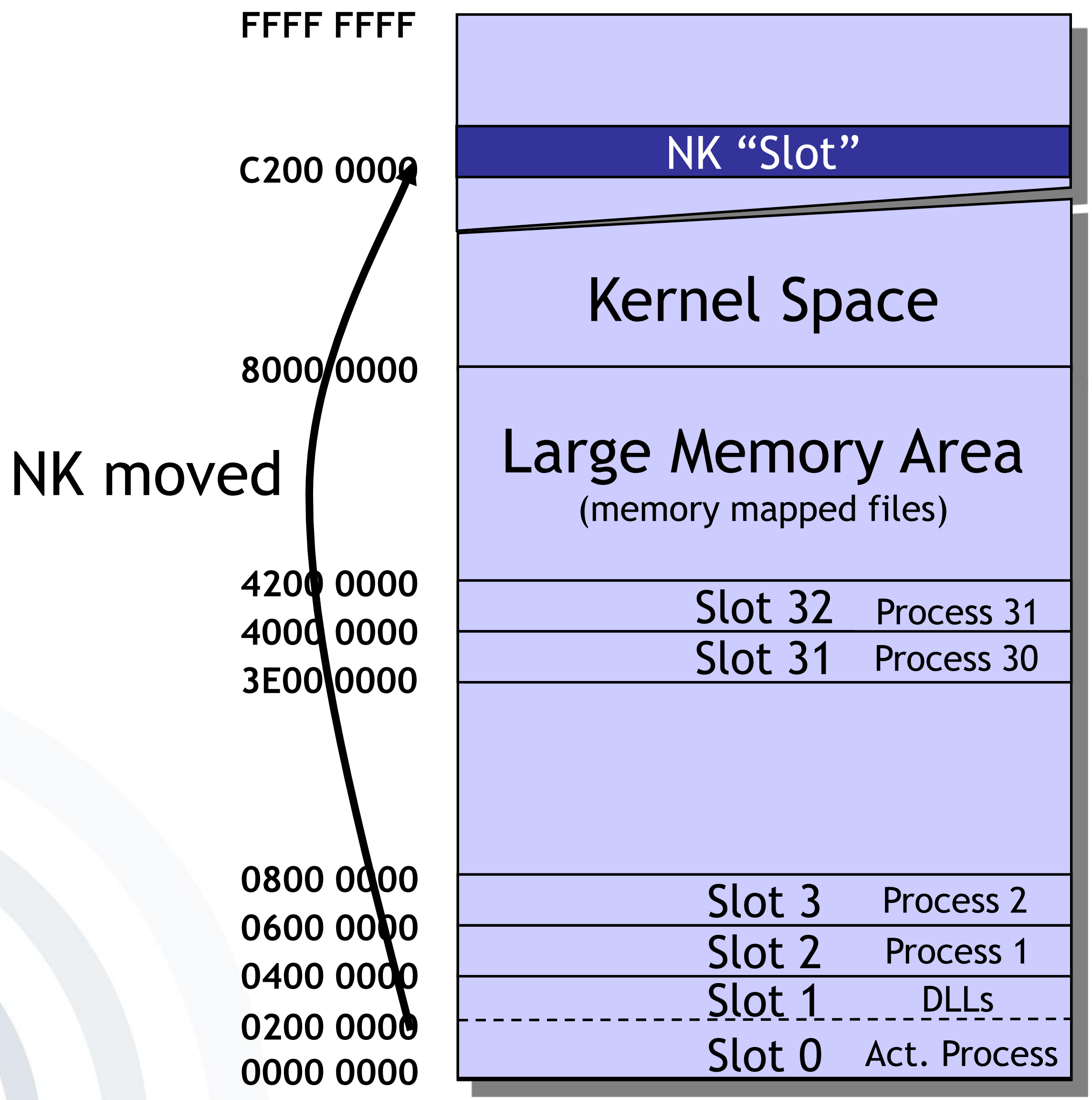
- Any DLL being loaded by any process allocates memory of other processes, regardless if the DLL is used by other processes or not.
- The address, the DLL is loaded to, is dependent on the other DLLs being loaded by other processes.
- All DLLs are loaded/stored into memory blocks of 64K.

➲ The more DLLs are loaded, the bigger is the problem.

Memory Management Examples Solution in Windows CE .NET

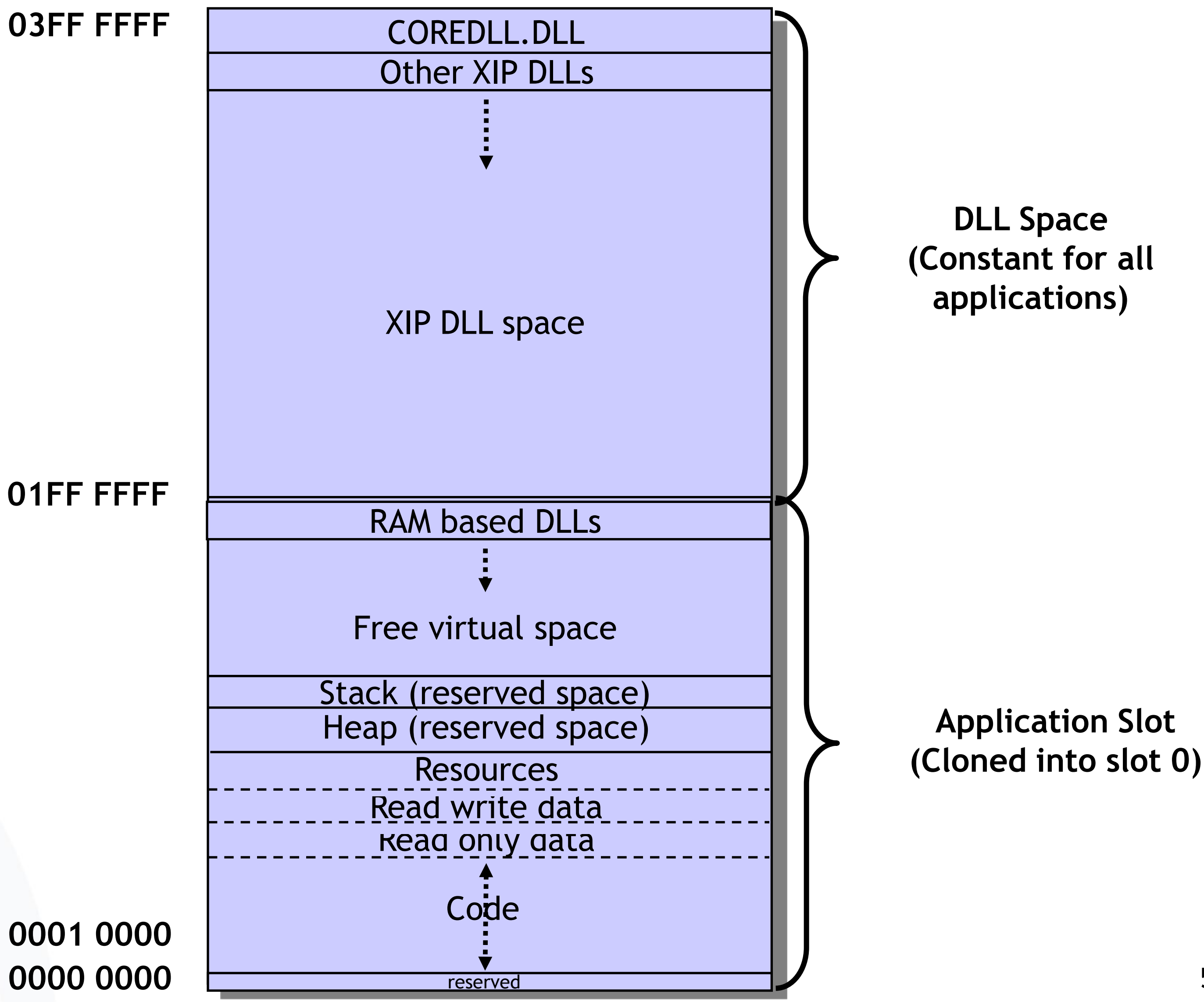
- Windows CE .NET solves the DLL load problem by modifying the memory map.
- The kernel (NK.EXE) is relocated from slot 1 into the kernel space starting from address 0xC200 0000.
- Slot 1 is used for the DLLs:
  - Is connected with all applications for slot 0

Windows CE .NET Memory Map



[Hall2002]

Memory Management Examples
Windows CE .NET Application Memory Map



[Hall2002]

Memory Management Examples
Application Memory Map

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

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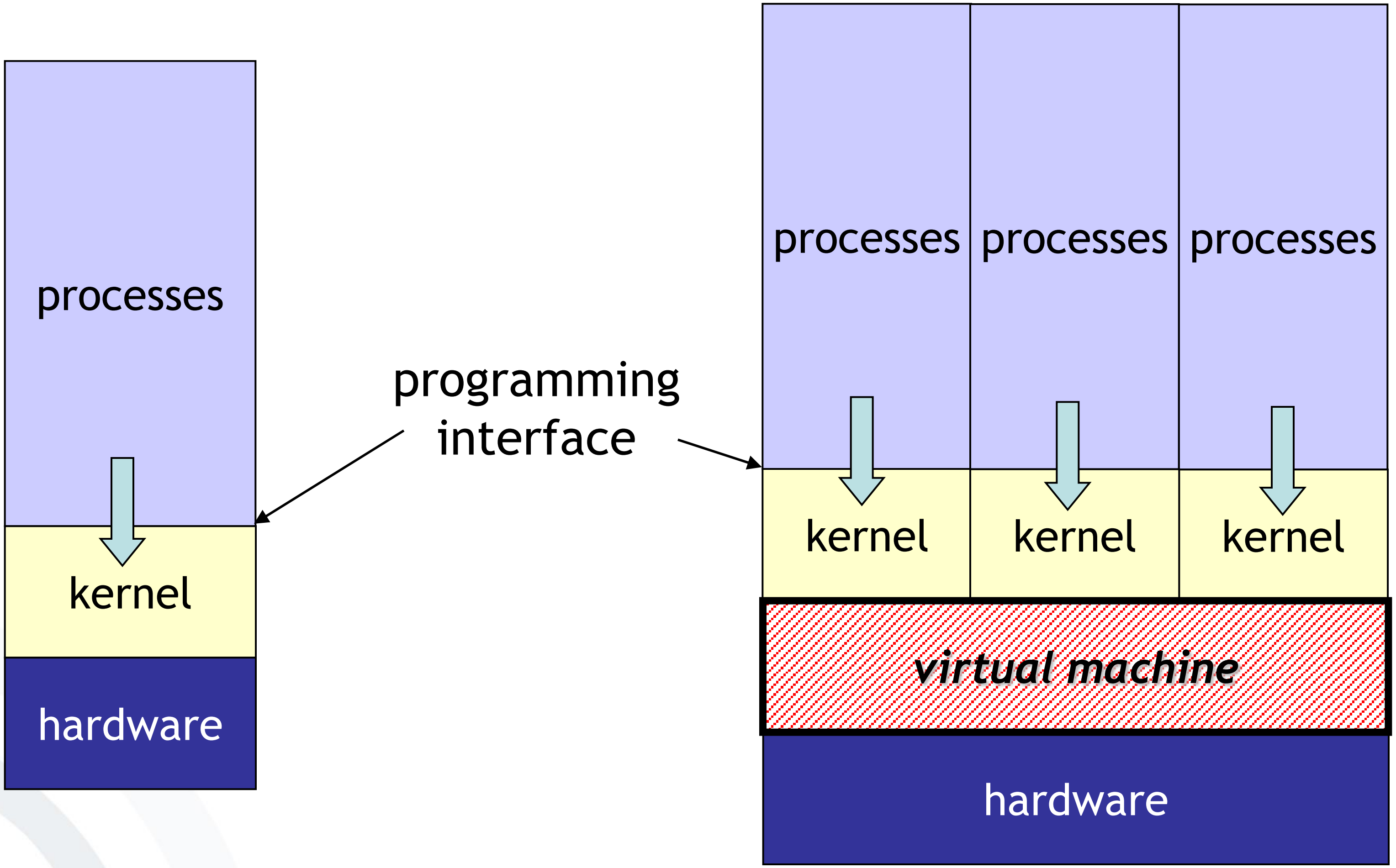
Virtual Machines

- Intermediate layer between an operating system and a software application.
- The system creates the impression that every process has its own machine, having a separate CPU and its own memory.
- Protection of the resources (sandboxing)
- Complete isolation between the different virtual machines running on the host system.
- ***Examples:***
  - Java Virtual Machine
  - VMWare
  - Virtual PC 2004
  - IBM z/VM
  - Emulators (e.g. ScummVM or PocketPC Emulator ➲ exercise course)

Virtual Machines



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