

## *Lecture 10*

### Concepts of Mobile Operating Systems

Mobile Business I (WS 2020/21)

Prof. Dr. Kai Rannenberg

Chair of Mobile Business & Multilateral Security  
Goethe University Frankfurt a. M.



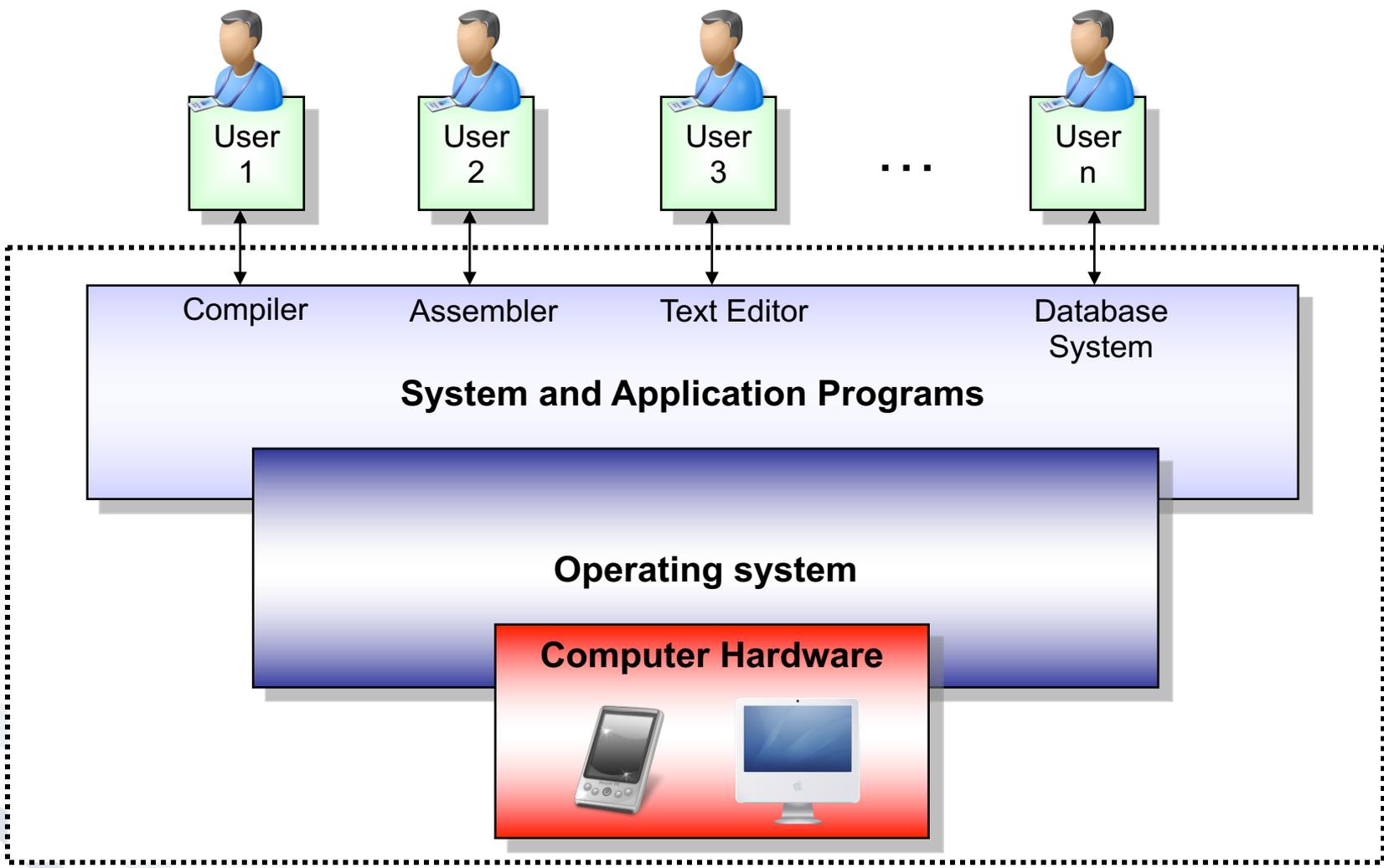
- Functions
- Processes' Management
  - States and elements
  - Scheduling
  - Inter-Process-Communication (IPC)
- Memory Management
  - Mapping
  - Paging
  - Segmentation
  - Examples
- Security & Maintenance



## 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



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- **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)

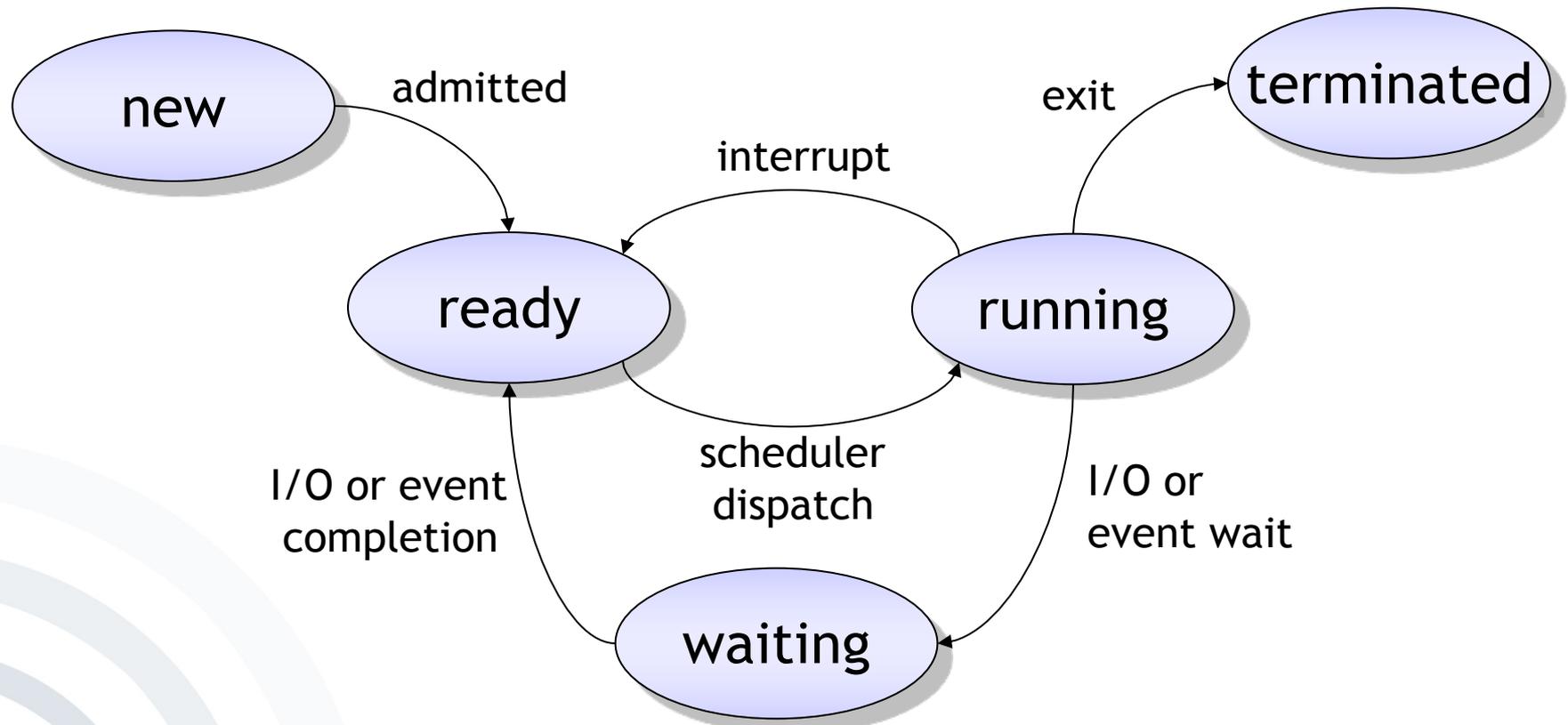
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- Several programs (processes) can run simultaneously & concurrently on an OS: 
- *How are processes managed in a system with regard to processing time, memory, etc?*
- *Which process is allowed to access resources when?*
- *How are resources (I/O)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

- 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.).

- 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

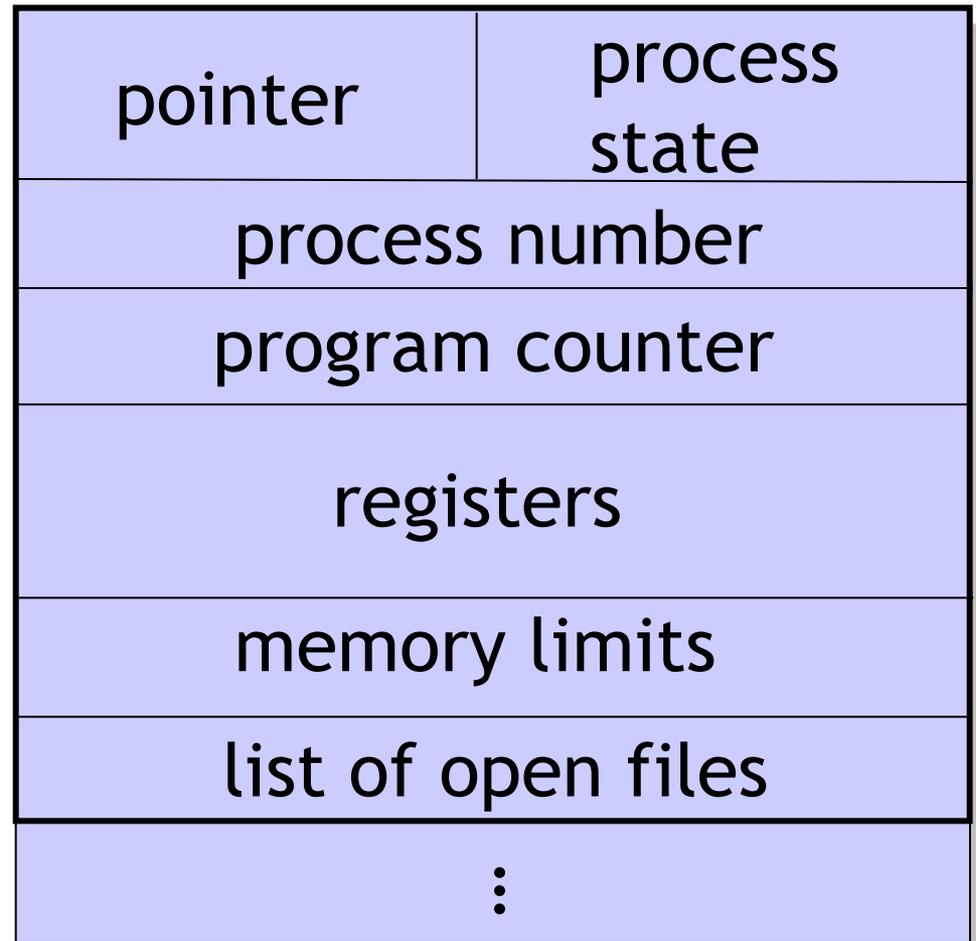
# States of a Process



- **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)

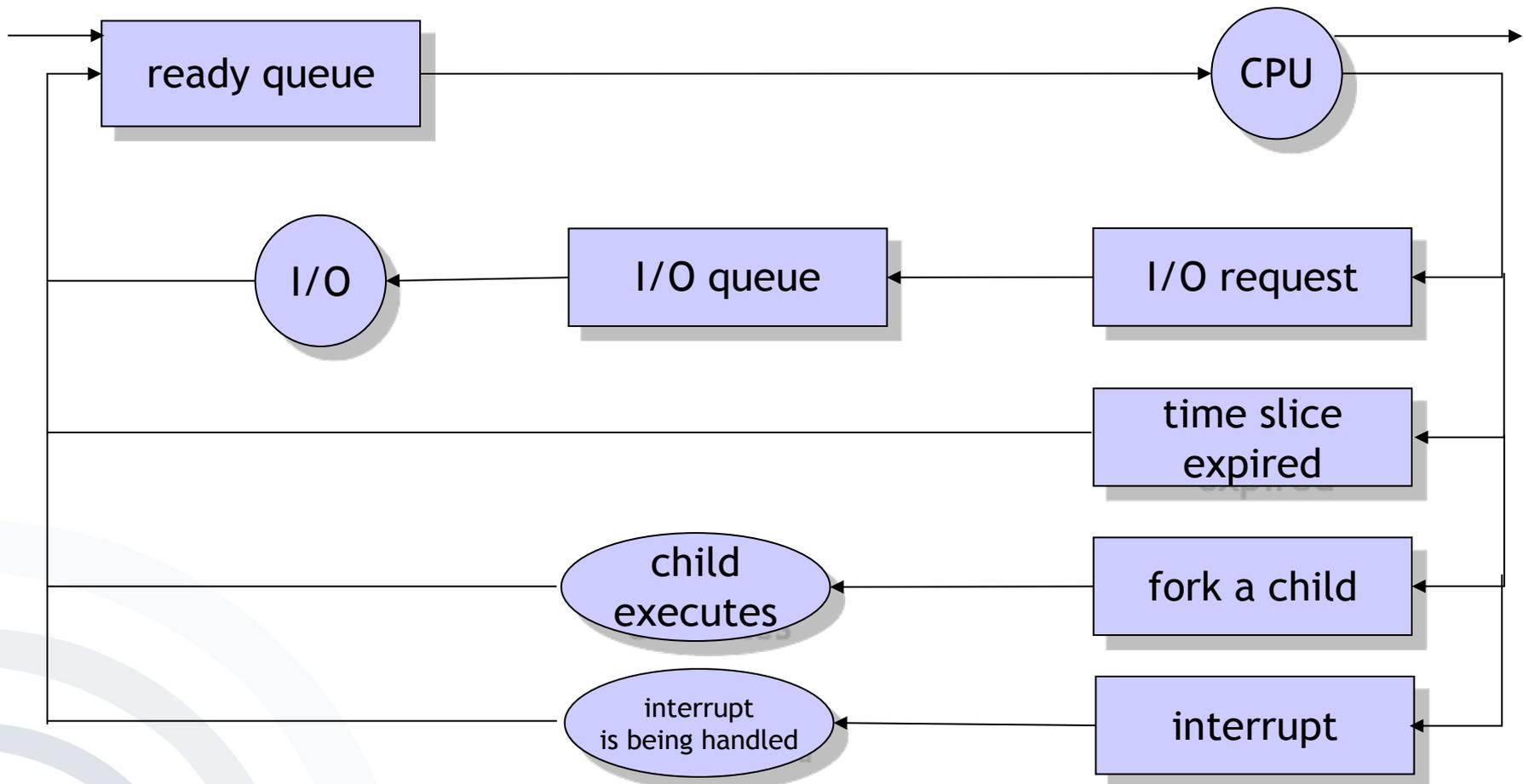
- Abstracted representation of the contents of a process control block (PCB), needed by an operating system.



- **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

- **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]

- 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.

- **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.

Process scheduling algorithms include:

- First Come, First Serve (FCFS)
- Shortest Job First
- Priority Scheduling
- Round Robin Scheduling

## 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

- 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”.

- 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

- 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.

- 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

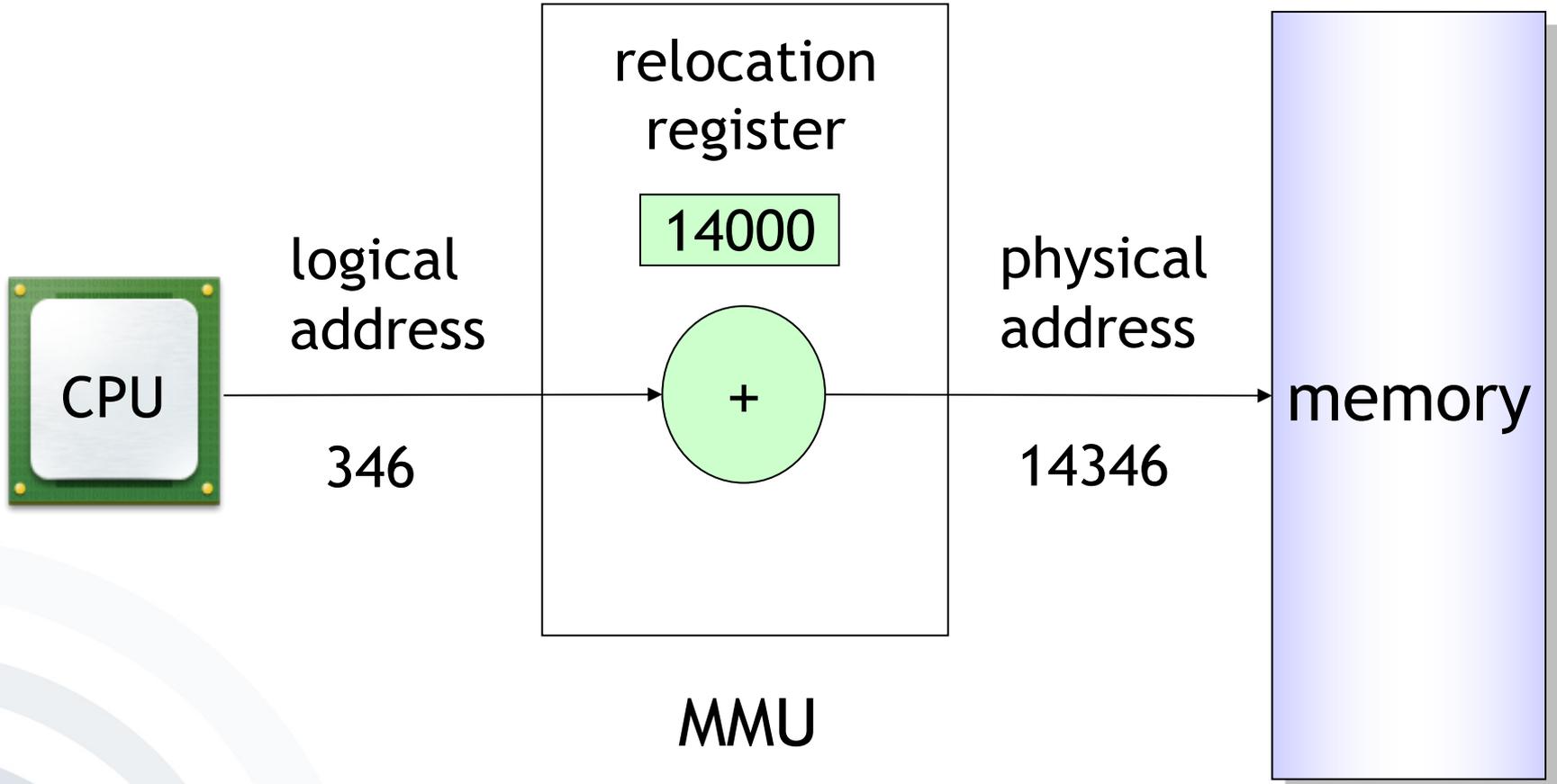
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- The CPU retrieves instructions from the memory depending on the program counter.
- Thereby it might be necessary to read or write data from certain memory-addresses.
- The operating system has an address space where the data and the programs reside.
- 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.

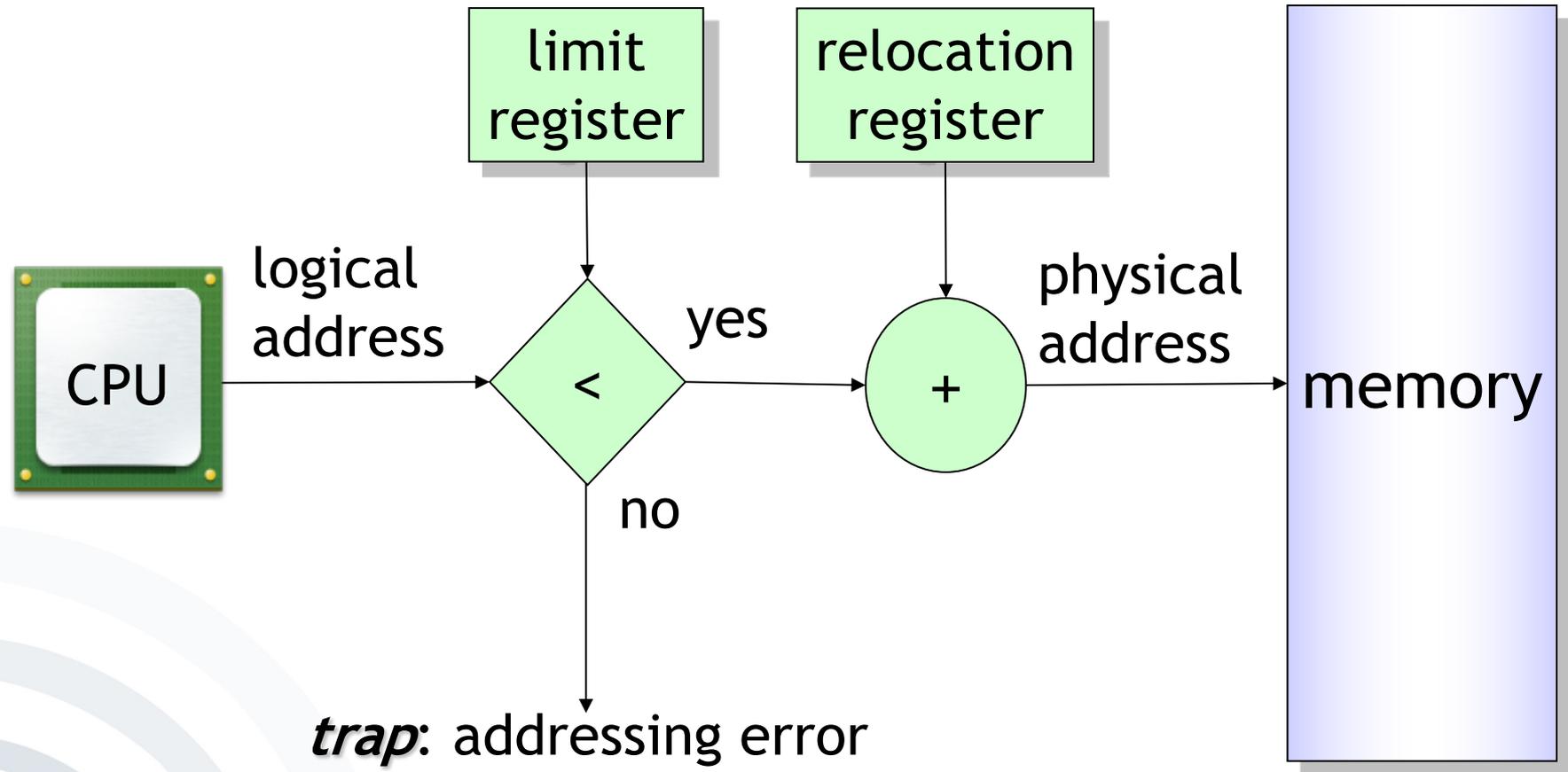
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- **Logical Addresses:**  
Generated by the CPU
- **Physical Addresses:**  
Sent to the memory unit

- 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.



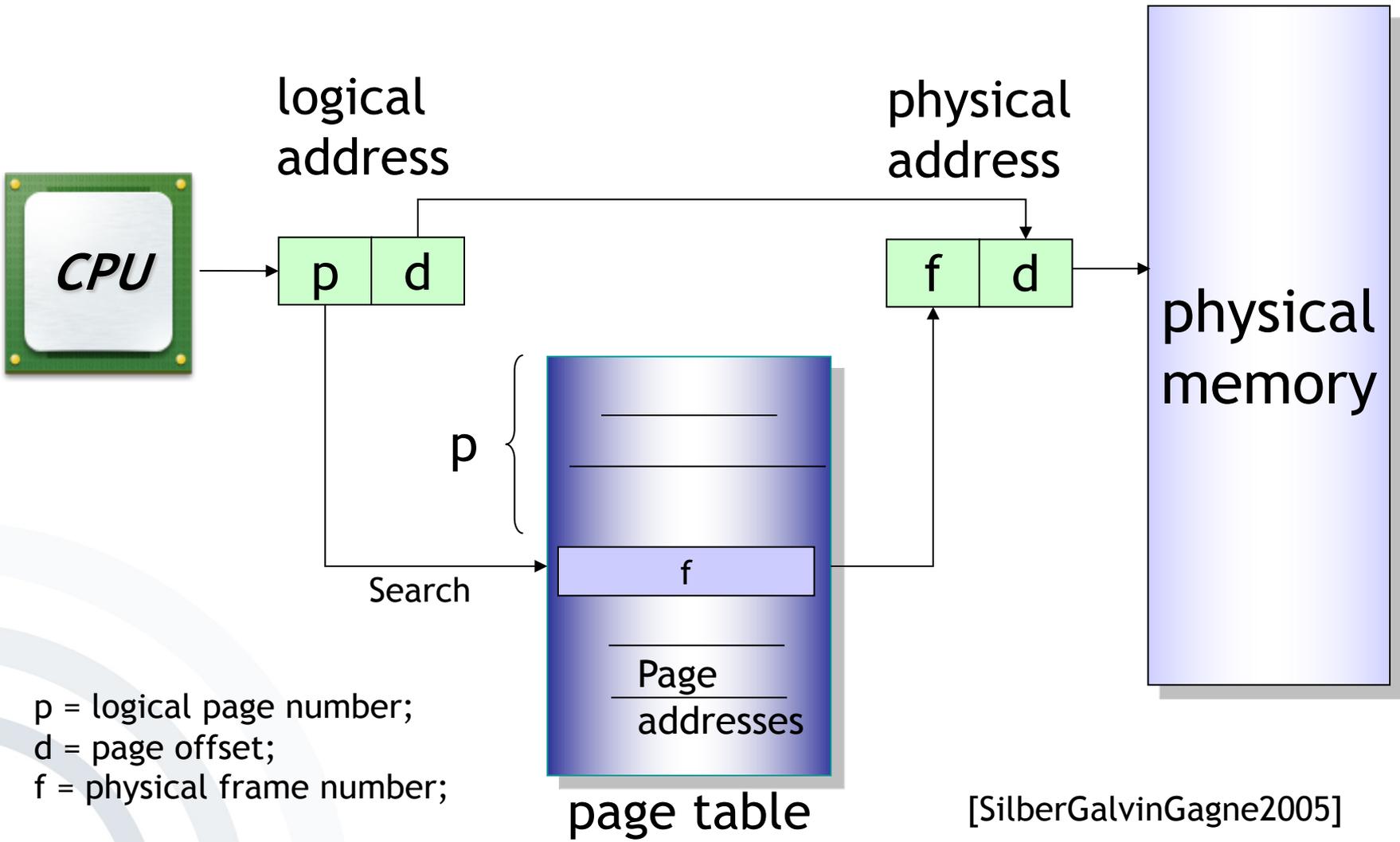
- The memory of a system also contains the actual operating system.
- The access of other processes onto the code of the operating systems needs to be prevented.
- Furthermore, the processes need to be protected against each other.
- Solution: Usage of so called „Limit Registers“



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- 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.

- 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.

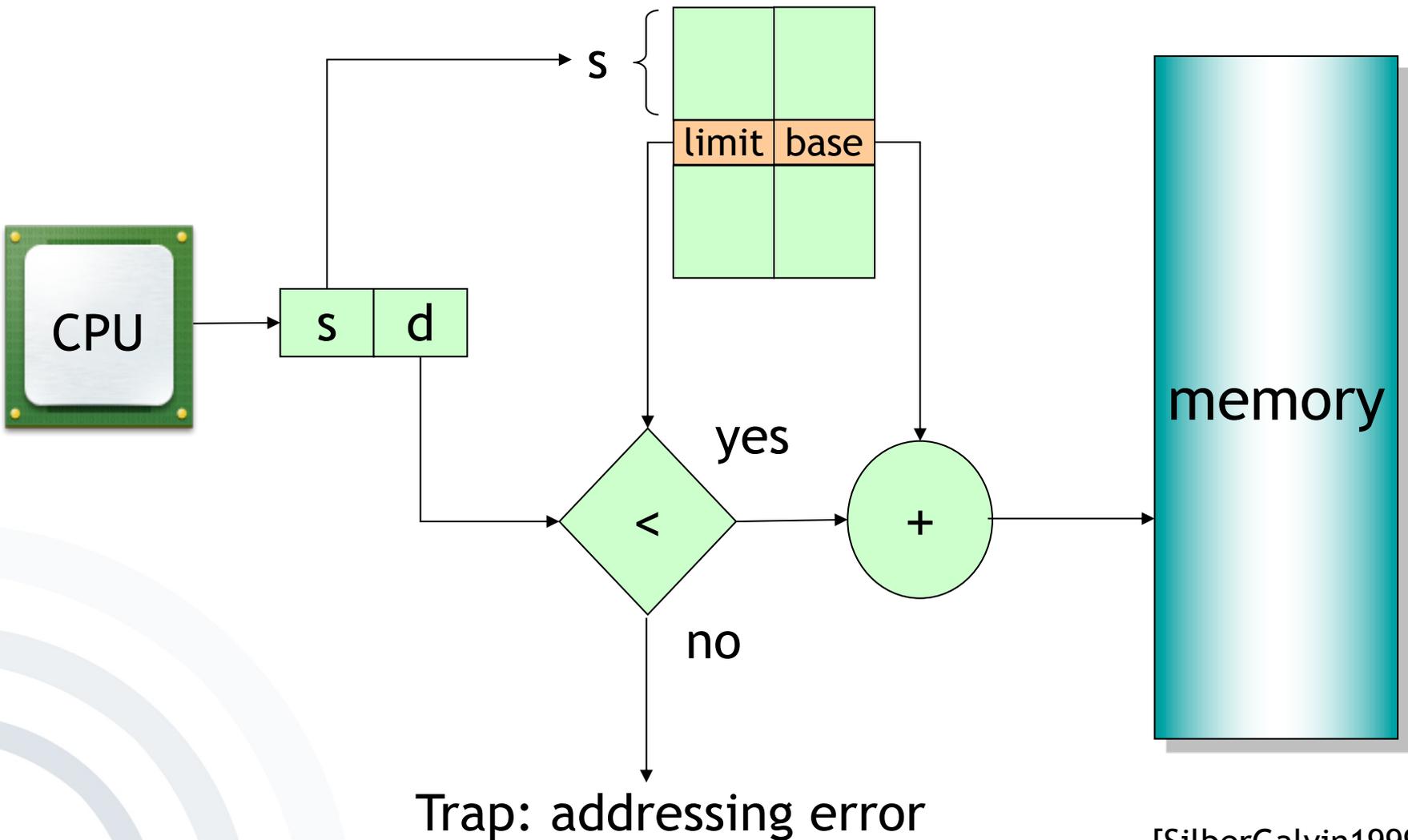


p = logical page number;  
d = page offset;  
f = physical frame number;

[SilberGalvinGagne2005]

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- 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  $[d]$ .

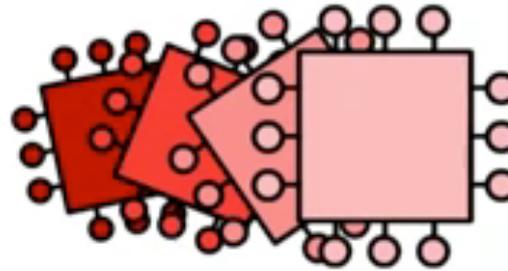


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- Paging, segmentation and virtual memory
- Windows CE Dynamic Link Libraries (DLL) positioning

## Operating systems - systems software

Memory management  
(paging, segmentation and virtual memory)

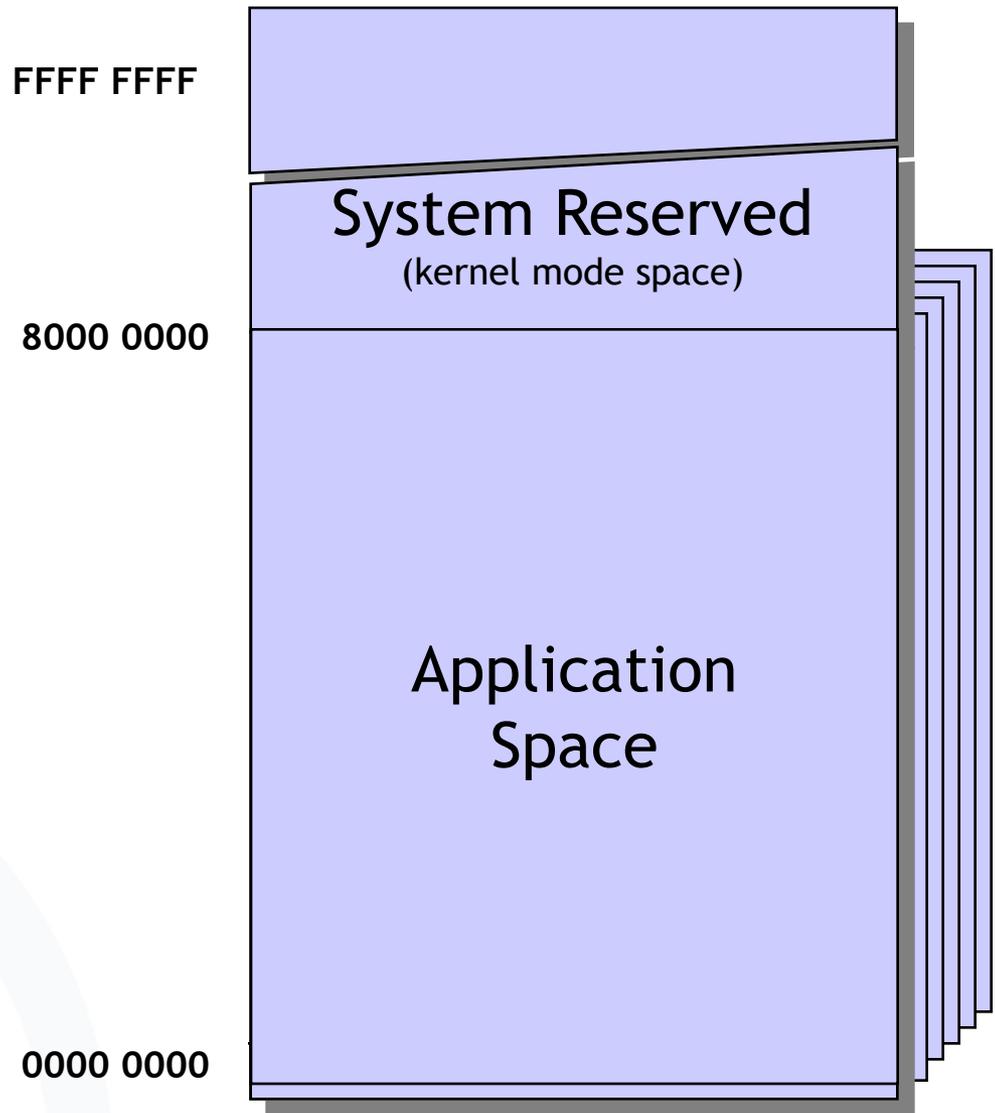


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010101000110100001100101001000000110011001101001011100100111001101110100001000000110010011001010110001101101110110  
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110111000100000011000100111001001101010011000100101110
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[Craigdave2015]

# Memory Management Examples

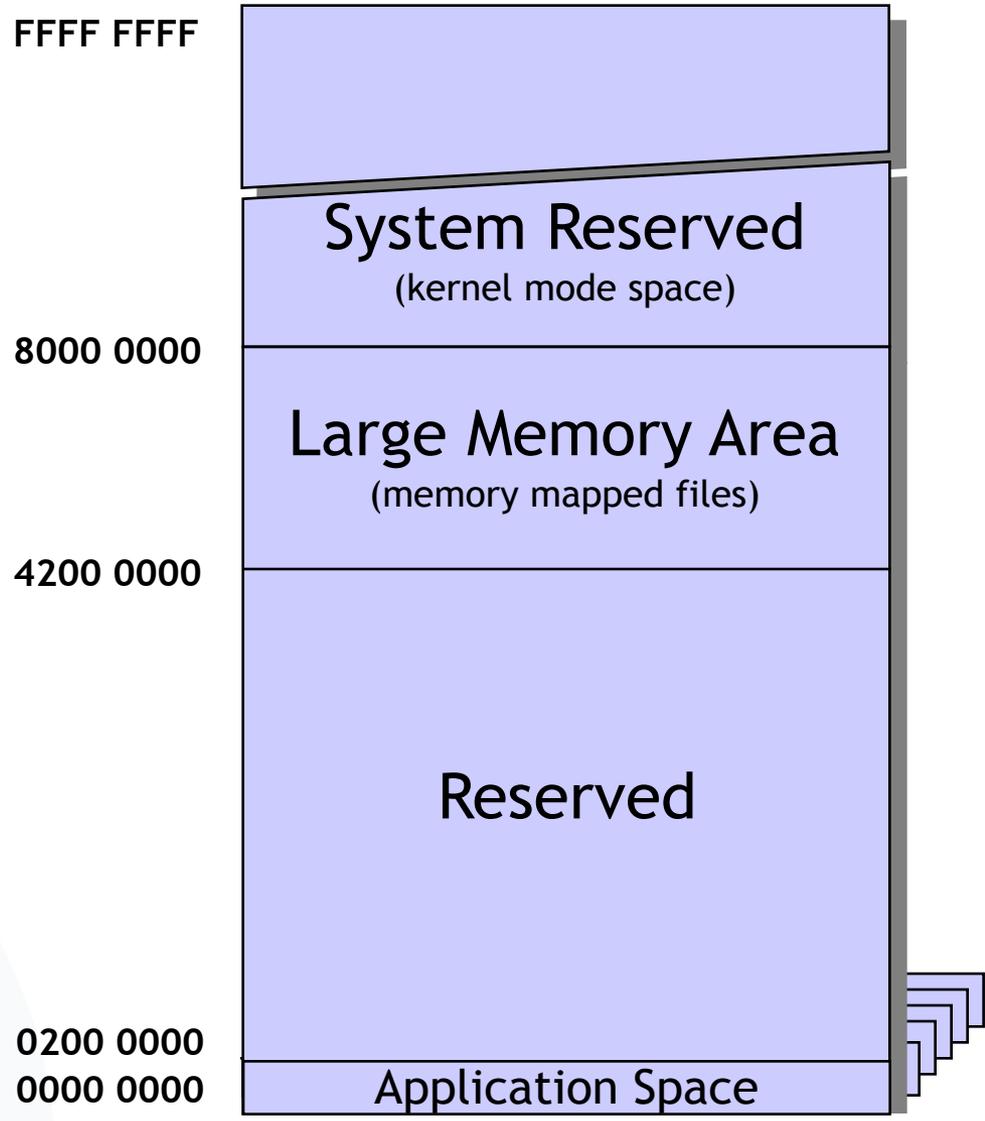
## Windows XP Memory Map



[Hall2002]

# Memory Management Examples

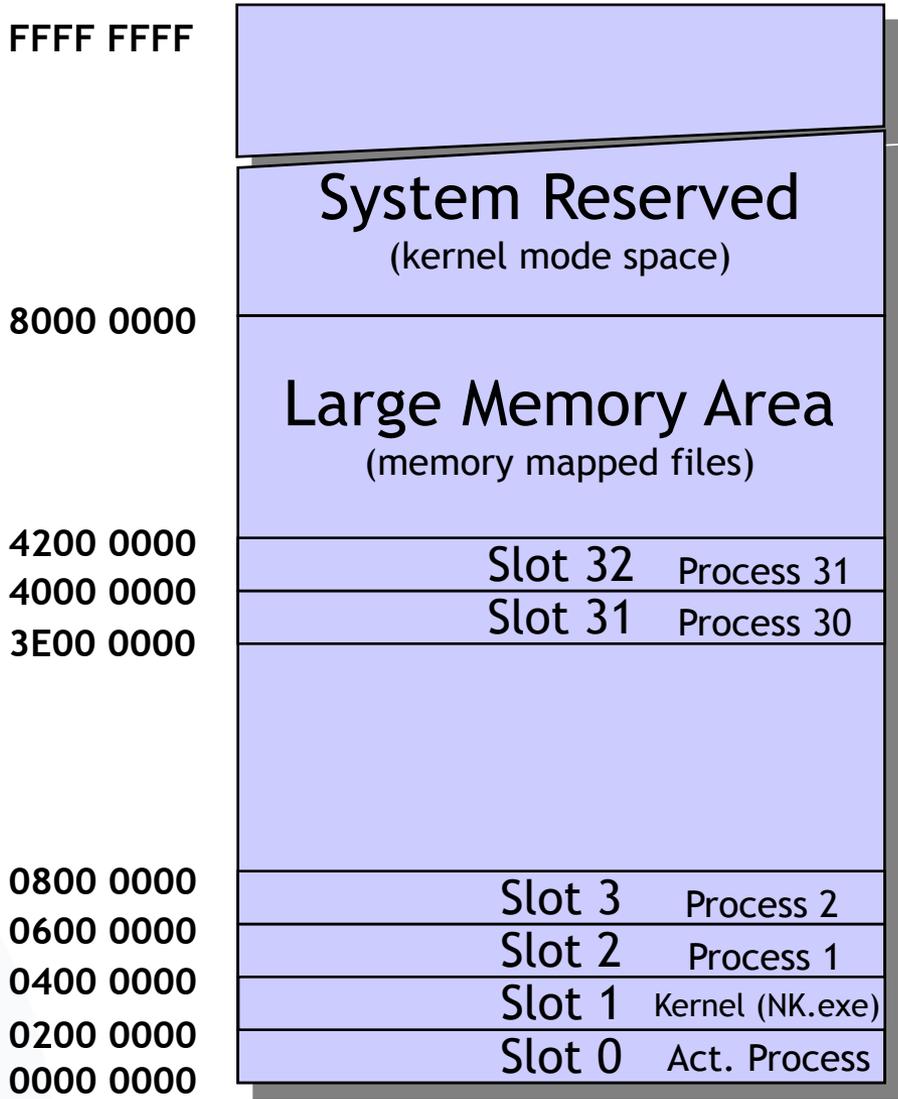
## Windows CE Memory Map



[Hall2002]

# Memory Management Examples

## Windows CE Memory Map



Detailed View

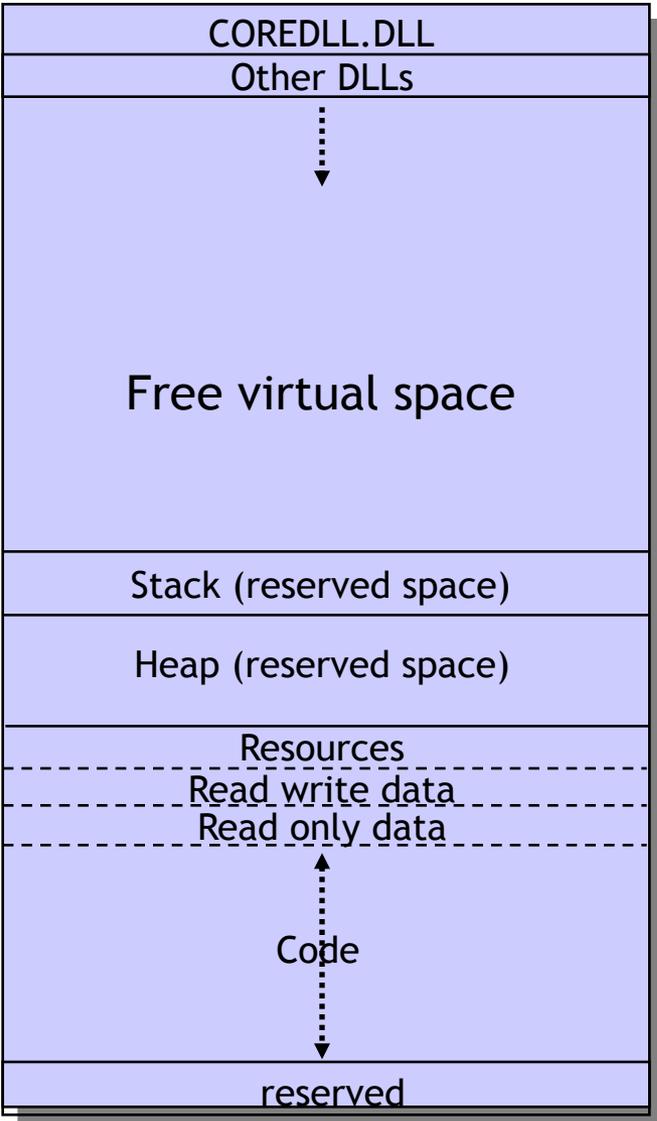
[Hall2002]

- Memory (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)

01FF FFFF



Solid lines are on 64K boundaries

Dashed lines are on page boundaries

0001 0000  
0000 0000

EXE Image (demand paged)

[Hall2002]

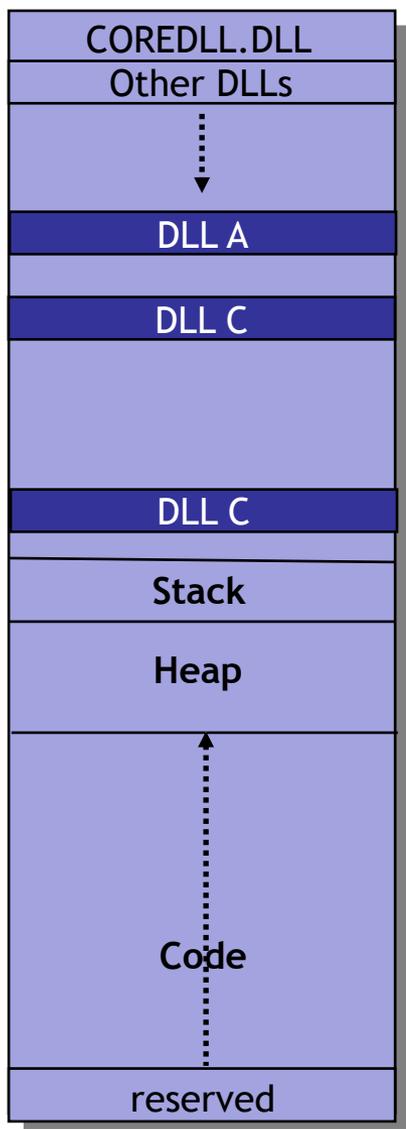
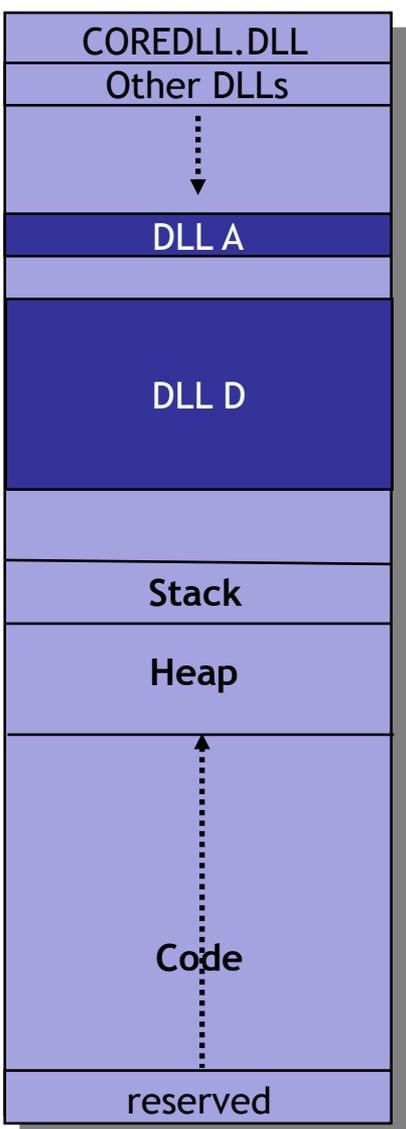
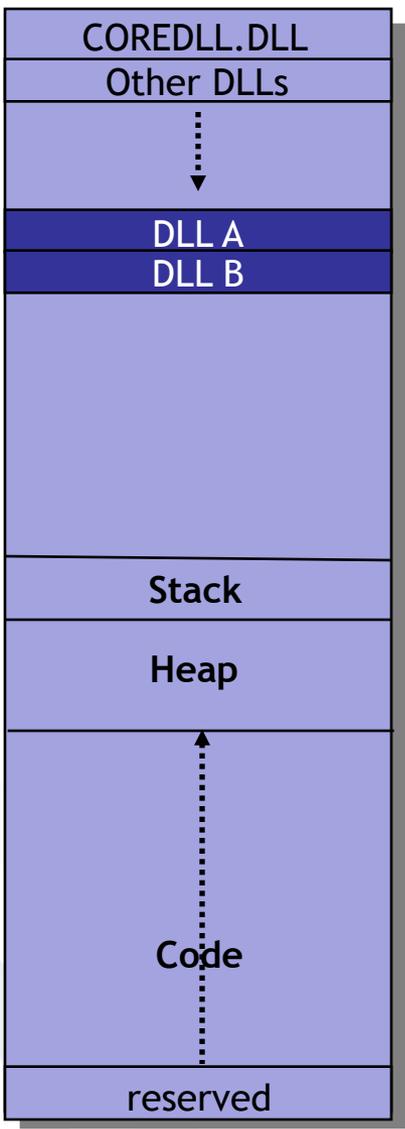
- Maximum of 32 MB for virtual memory
  - Virtual memory is used for the code and the data.
- Memory is:
  - Allocated on the basis of pages
  - Reserved in blocks of 64 KB

- 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

01FF FFFF

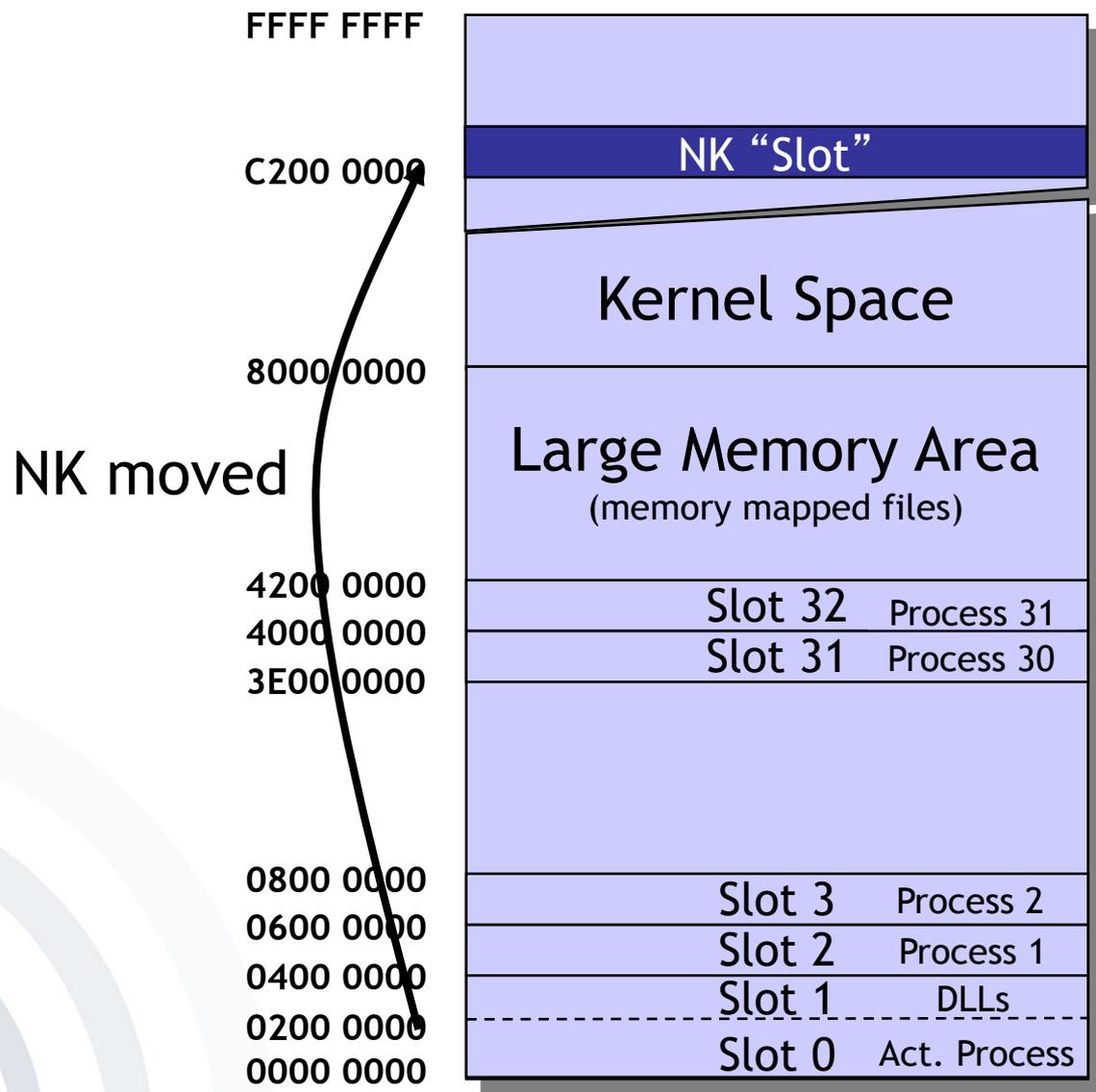


0001 0000  
0000 0000

- 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

- 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

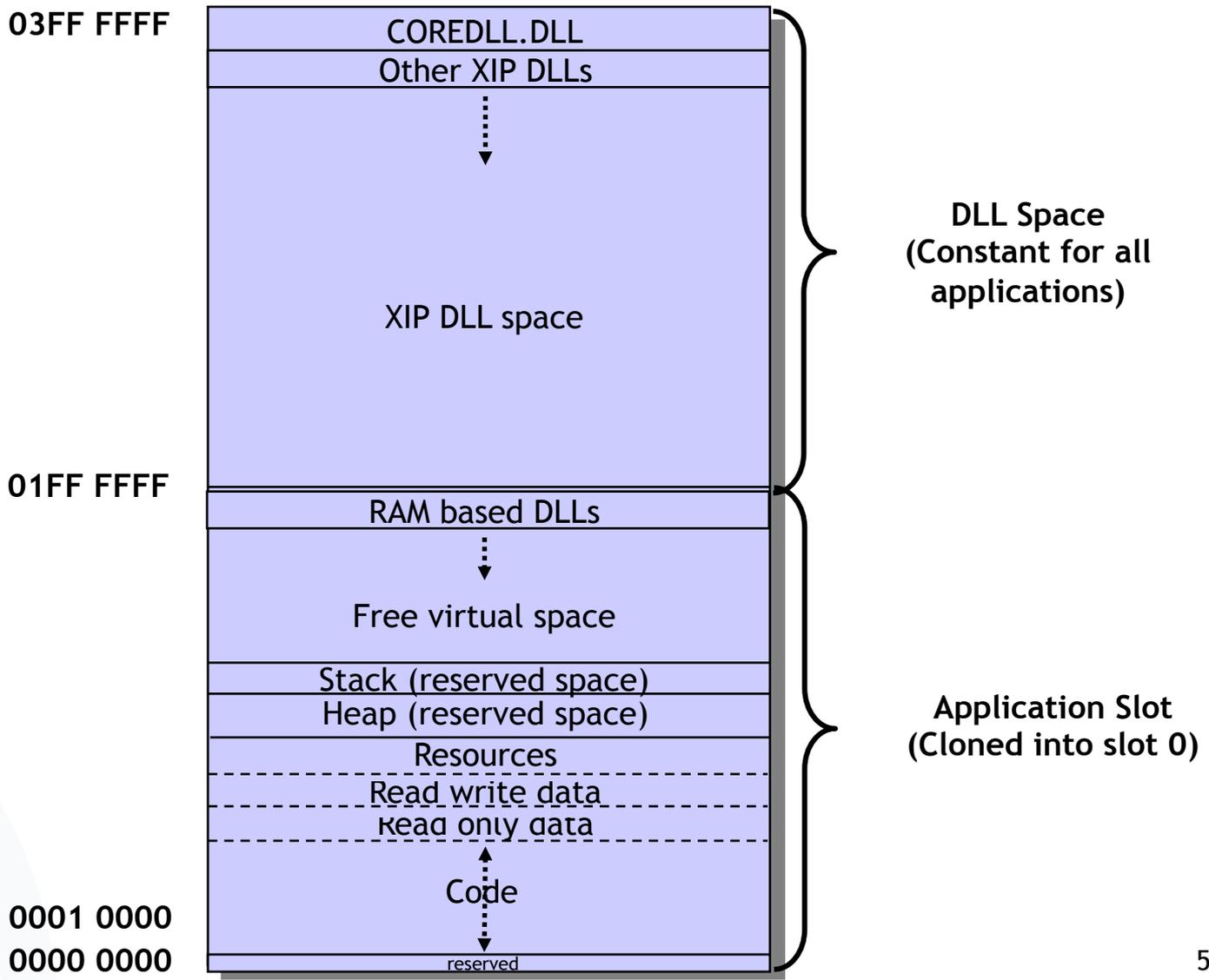
# Memory Management Examples Windows CE .NET Memory Map



[Hall2002]

# Memory Management Examples

## Windows CE .NET Application Memory Map



[Hall2002]

- 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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- 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



- 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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