# CS330: Operating Systems

Process

# Recap

- OS bridges the *semantic gap* between the notions of application execution and real execution
- How?
  - By virtualizing the physical resources
  - Creating abstractions with well defined interfaces

Agenda: CPU $\longrightarrow$ Process (OSTEP Ch4)

# The process abstraction

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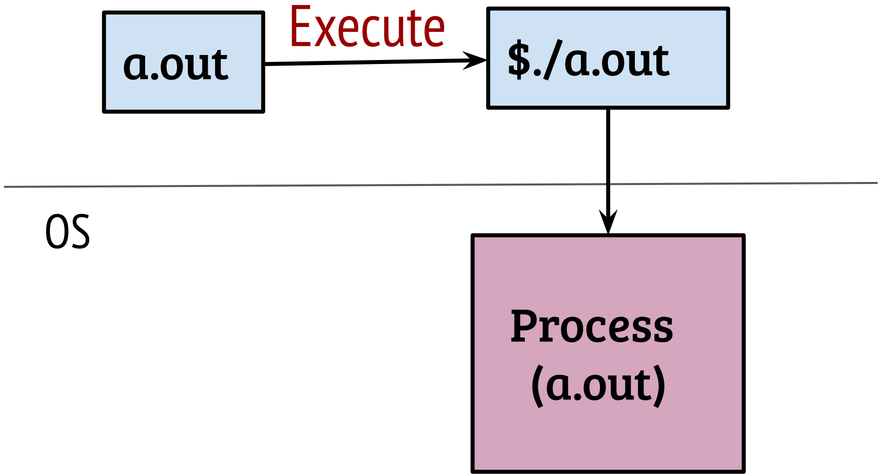

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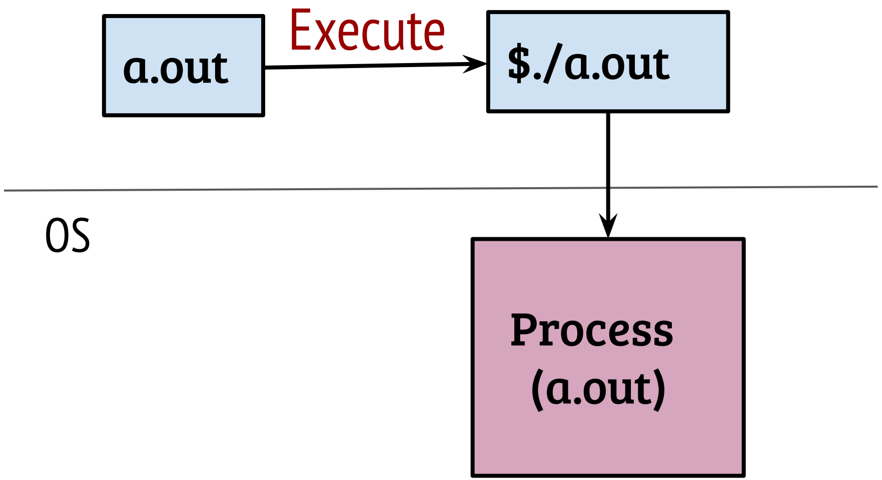


- Process is represented by a data structure commonly known as process control block (PCB)
- Linux ⟶ task_struct
- gemOS ⟶ exec_context

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What about virtualizing the CPU?

# Virtualization of the CPU

MPlayer

$./a.out

Browser

Everything is running! My program (a.out) is printing output and music is on!

Process (Mplayer)

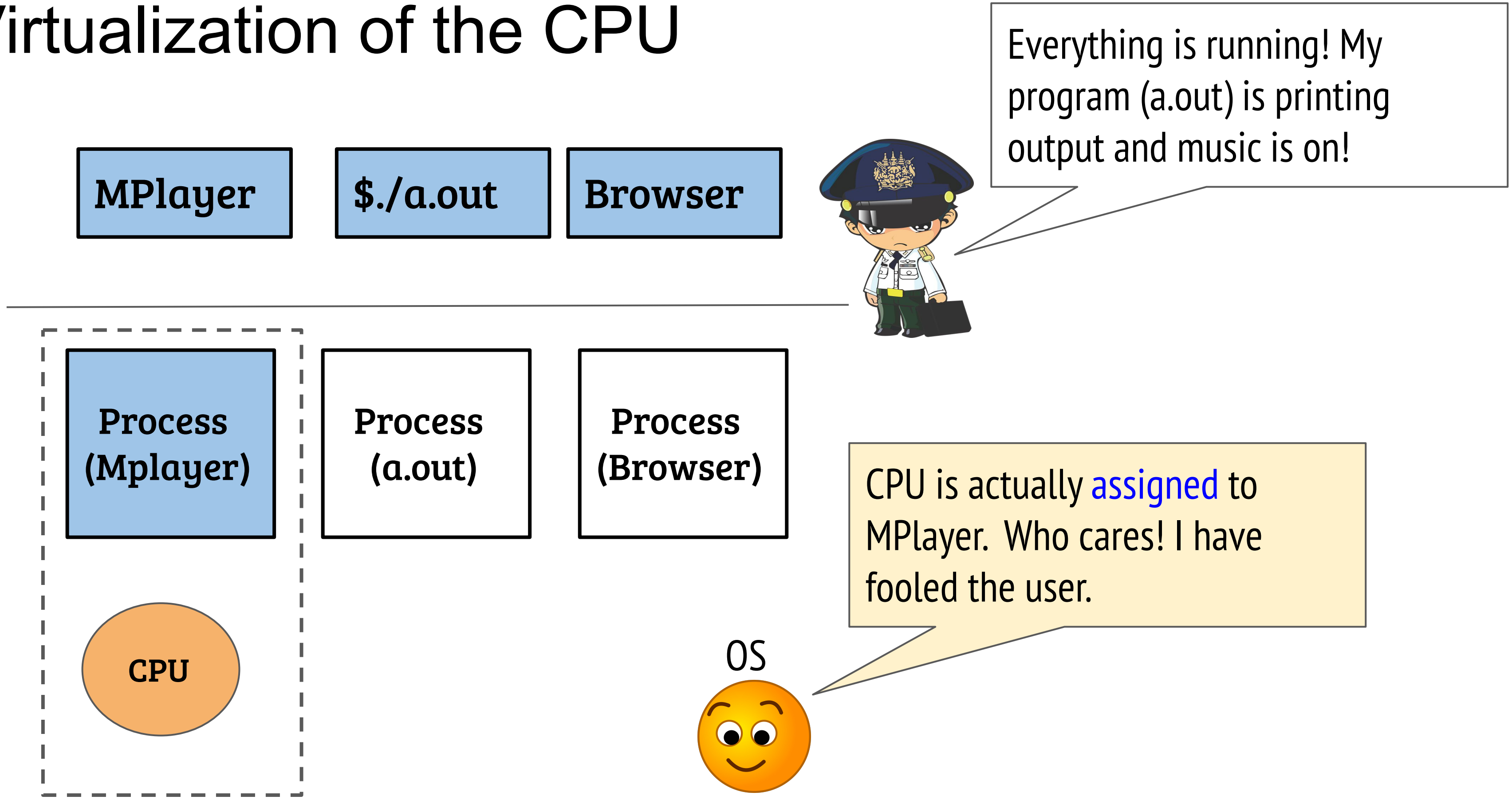
Process (a.out)

Process (Browser)

OS

CPU

# Virtualization of the CPU



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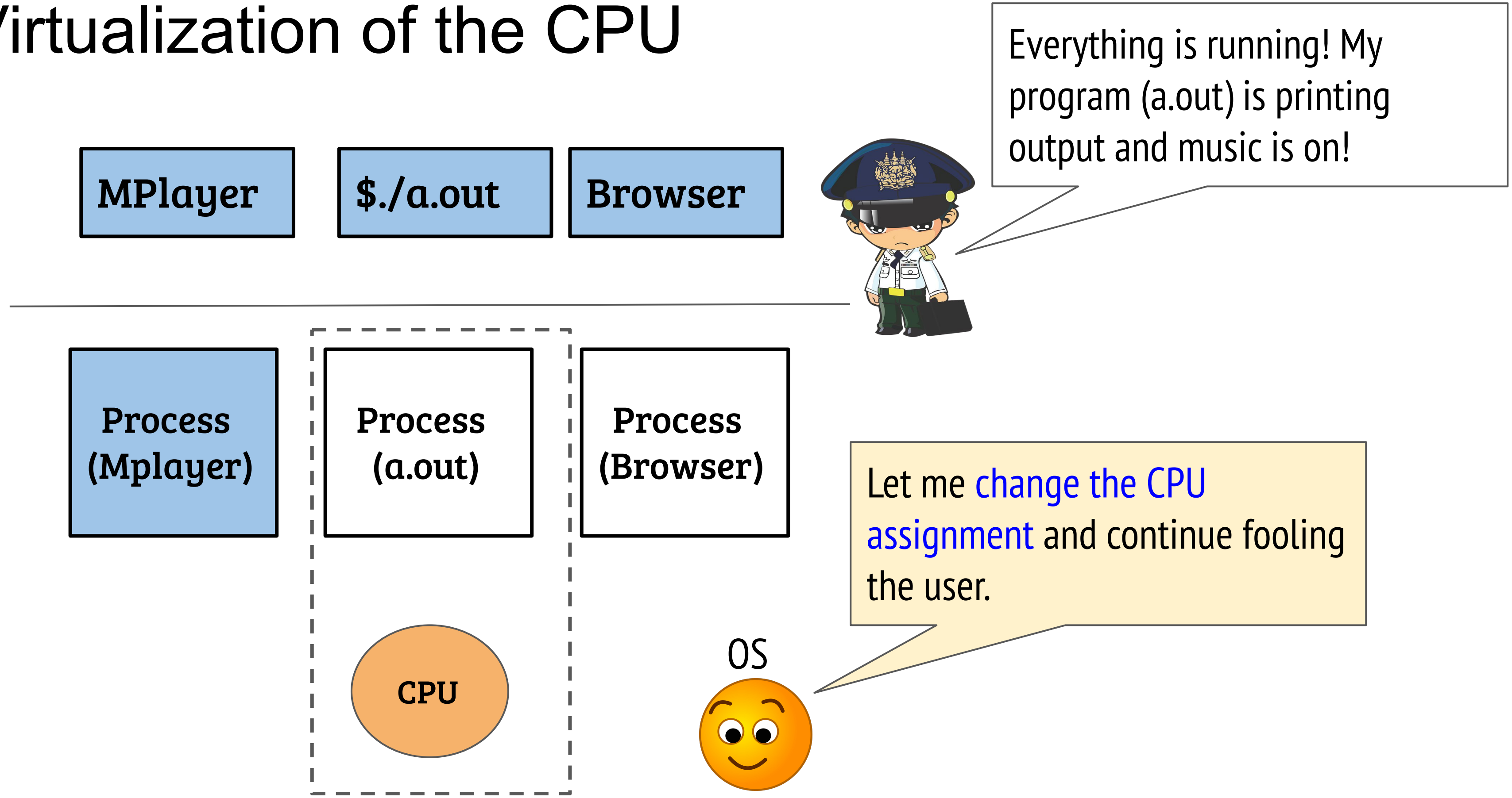

# Virtualization of the CPU

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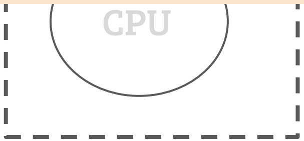
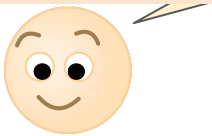
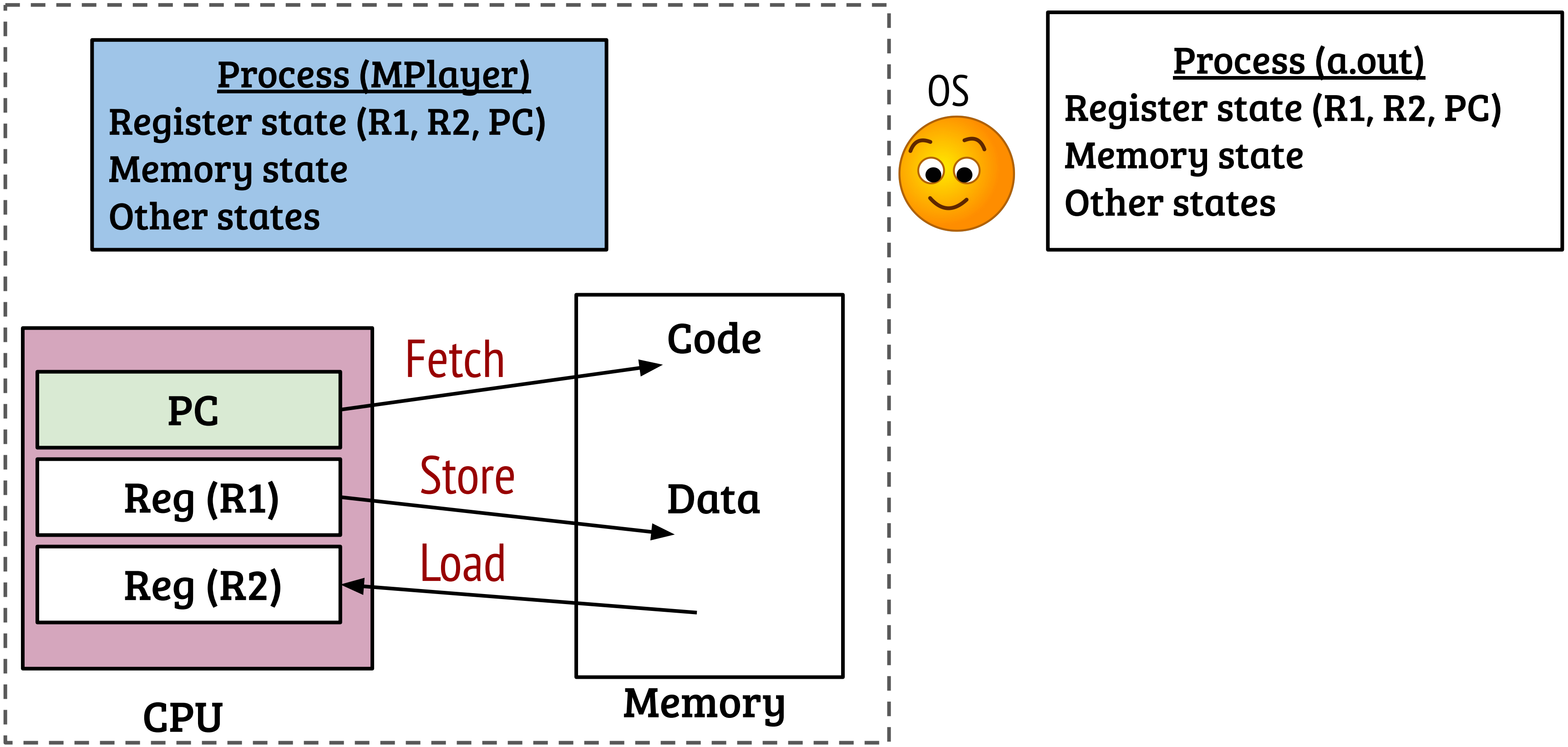
MPlayer | $./a.out | Browser

- How CPU assignment is changed? (OR how context switch is performed?)
  - What happens to outgoing process? How does it come back?
- Overheads of context switch?
- How to decide the incoming process?

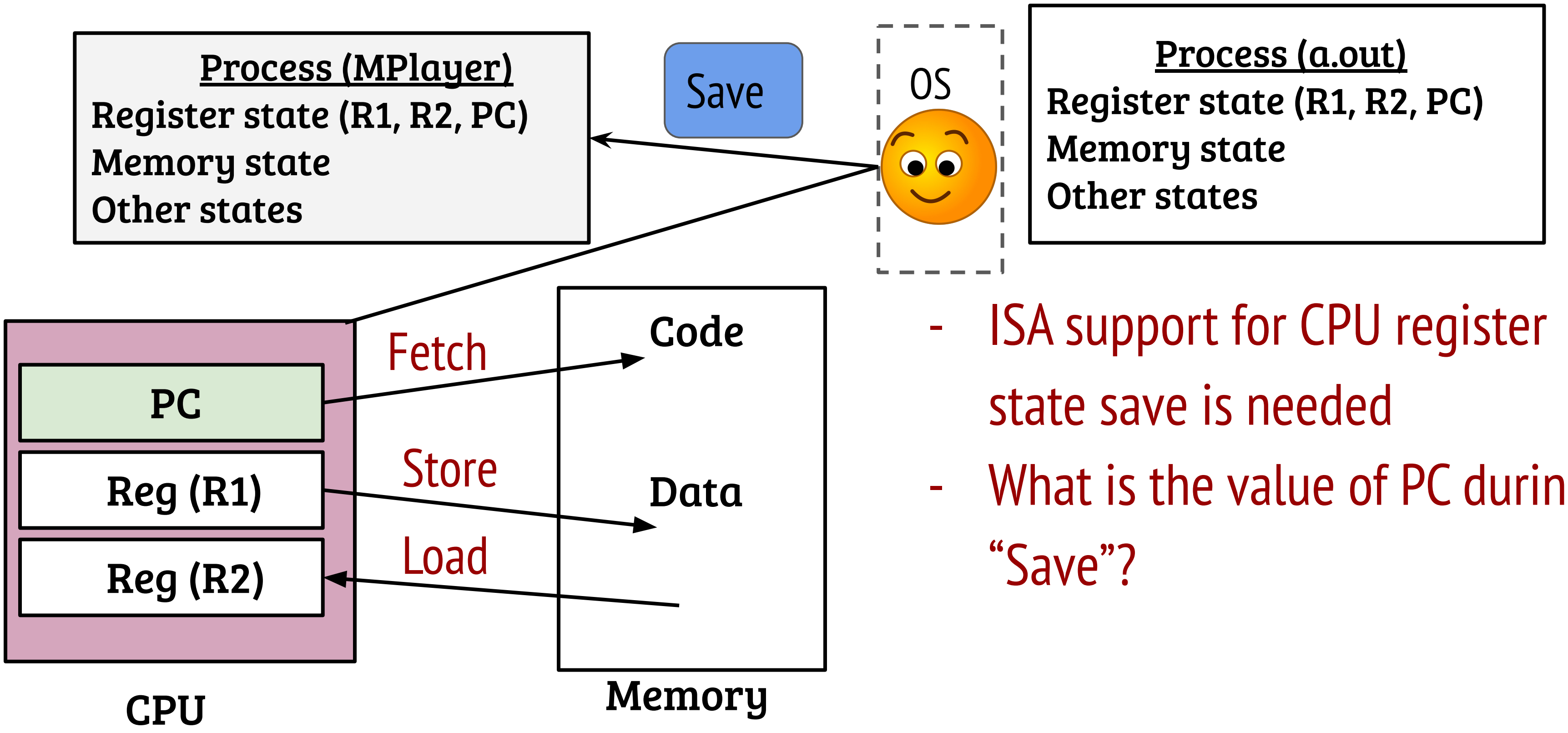


# Context switch: state of a process



# Context switch: saving the state of outgoing process

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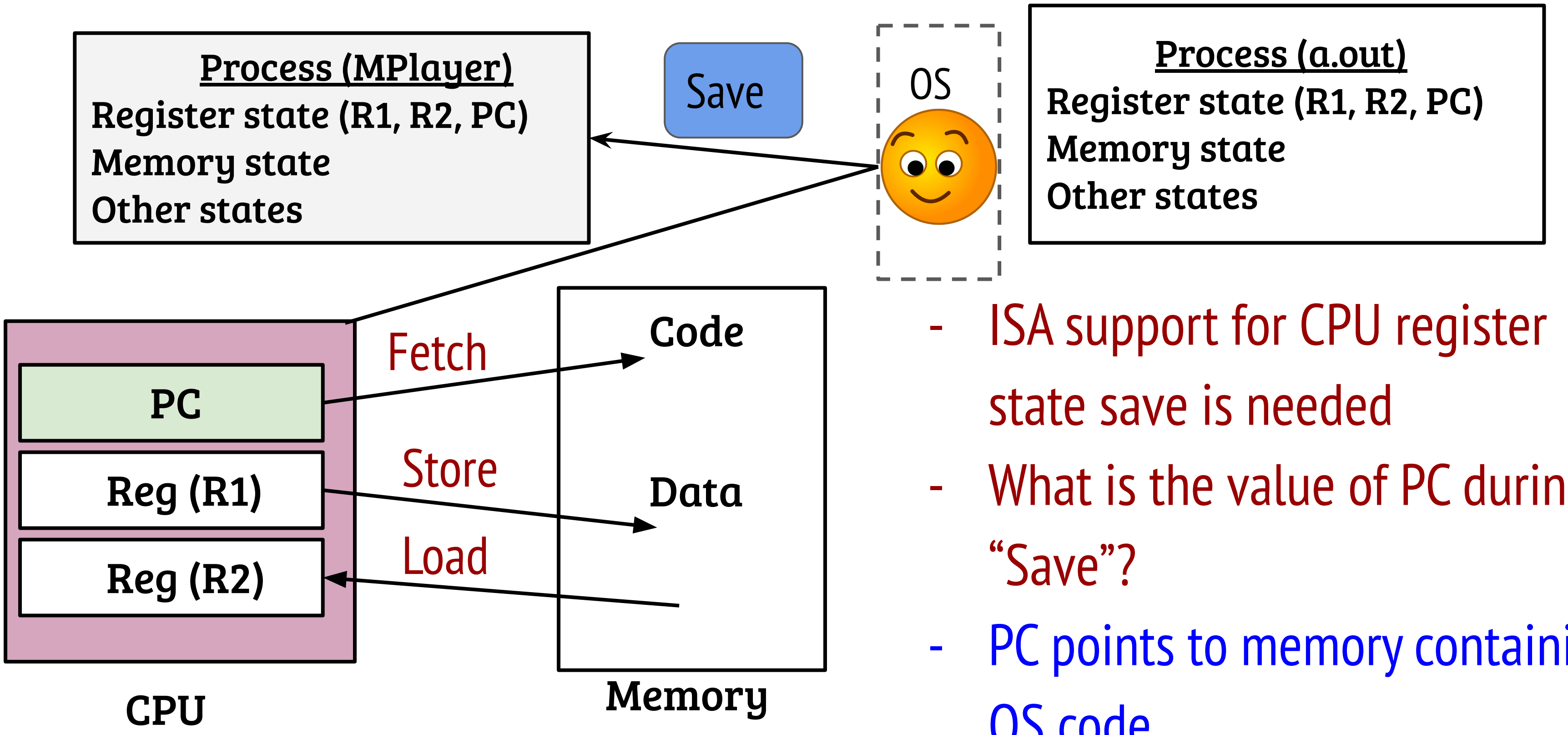
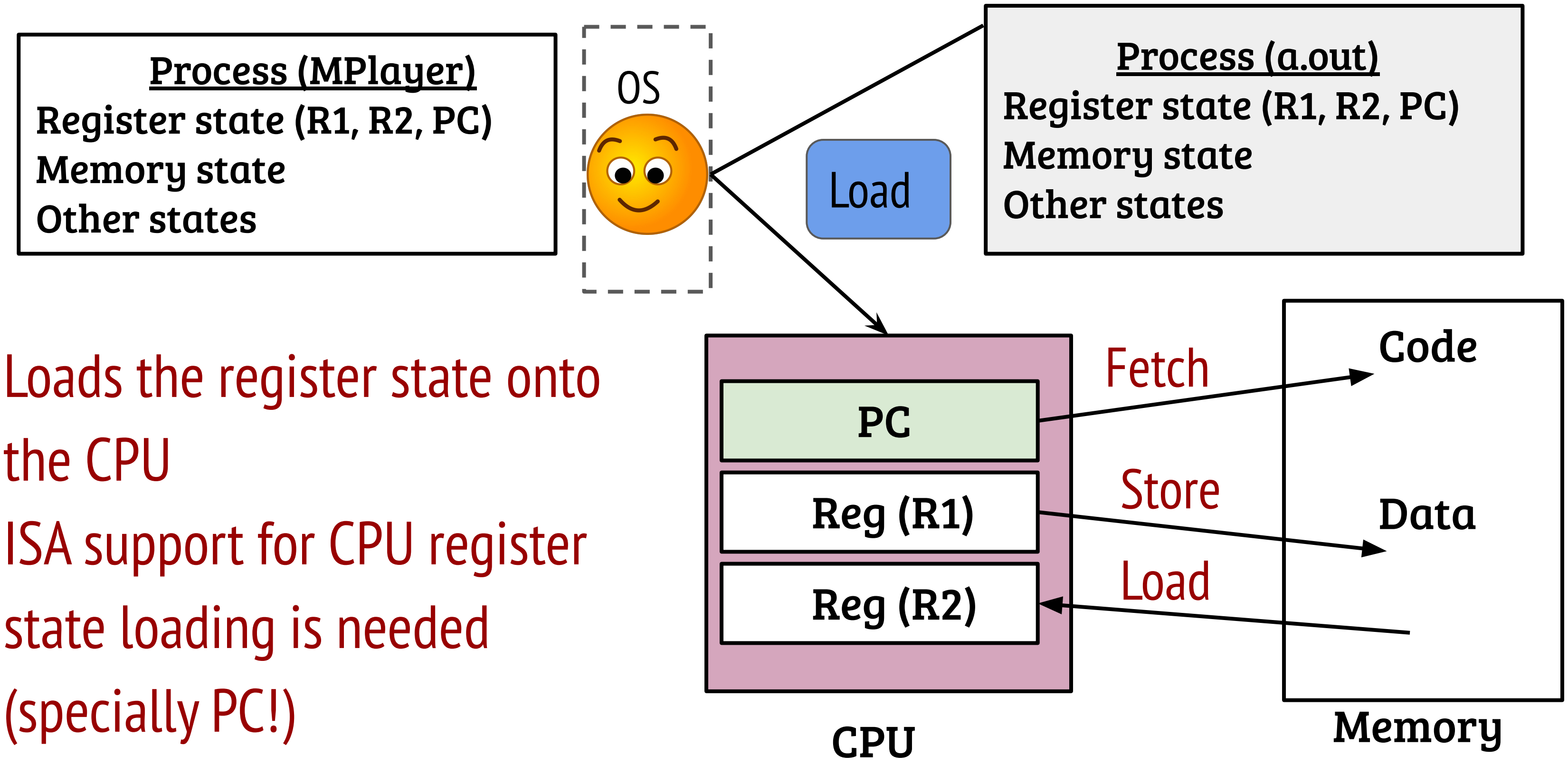
- What is the value of PC during “Save”?

# Context switch: saving the state of outgoing process



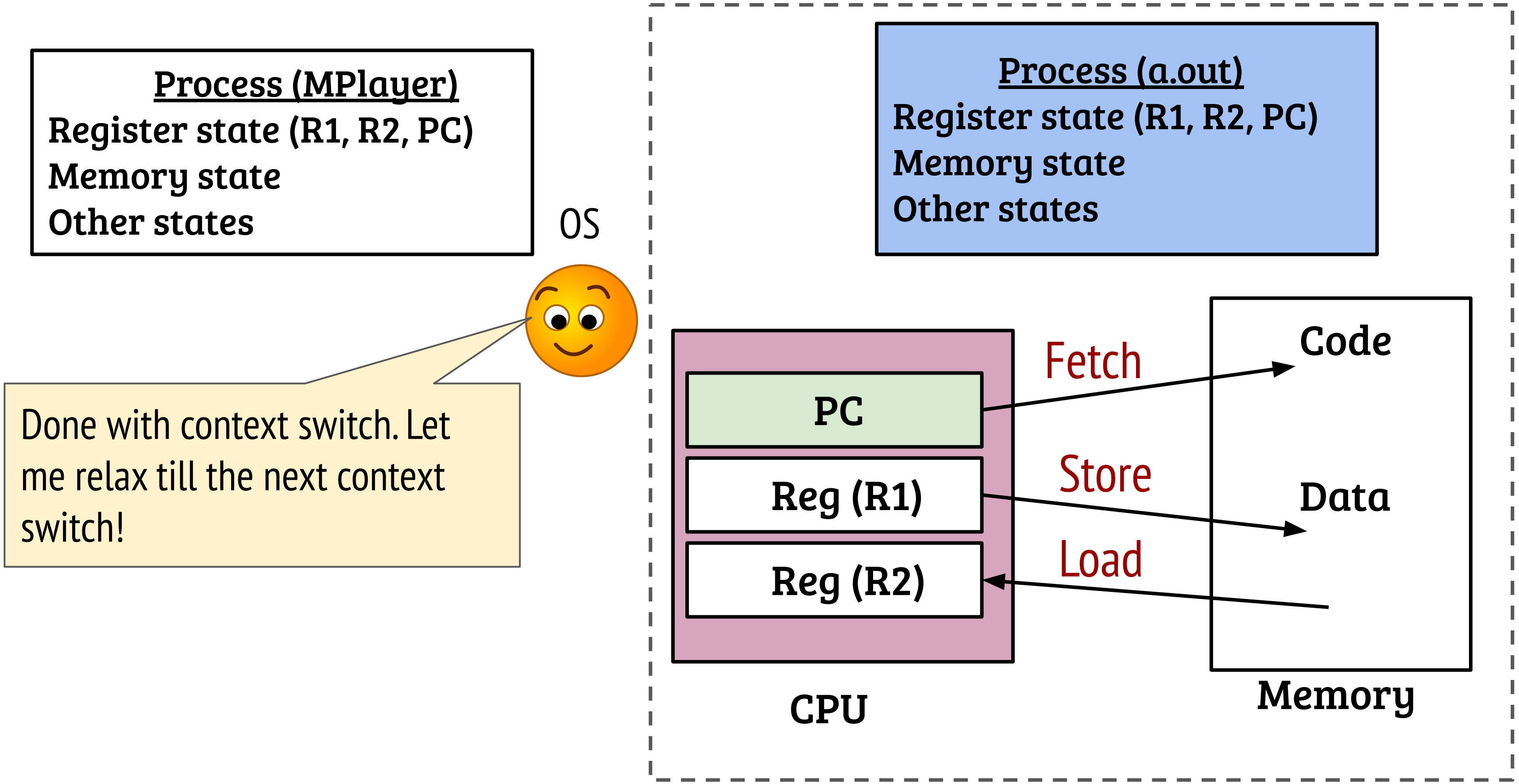

- ISA support for CPU register state save is needed
- What is the value of PC during "Save"?
- PC points to memory containing OS code

# Context switch: load the state of incoming process




- Loads the register state onto the CPU
- ISA support for CPU register state loading is needed (specially PC!)

# Context switch: load the state of incoming process



# Virtualization of the CPU

Everything is running! My program (a.out) is printing

- How CPU assignment is changed? (OR how context switch is performed?)
  - What happens to outgoing process? How does it come back?
- Using process scheduling, saving the *state* of the outgoing process and loading the *state* of the incoming process (will revisit)
- Overheads of context switch?
- State save and restore, cache effects
- How to decide the incoming process?
- OS implements different types of process scheduling policies

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- What is the memory state of a process?
    - How memory state is saved and restored?
- Memory itself virtualized. PCB + CPU registers maintain state (will revisit)

# Example: hardware state of X86_64 (in gemOS)

```
struct user_regs{
u64 rip;        // PC
u64 r15 - r8;
u64 rax, rbx, rcx, rdx, rsi, rdi;
u64 rsp;       // stack pointer
u64 rbp;      // base pointer
};
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- All the registers shown here are used directly/indirectly during program execution
- General purpose registers (r8-r15, rax, rbx etc.) are used for storage and computation
    - Register allocation is an important aspect of a compiler

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- What is a stack pointer in the context of hardware state?
- Points to the TOS address of a stack in memory, operated by *push* and *pop* instructions
- What is the use of stack?
- Makes it easy to implement function call and return, store local variables