

CS330: Operating Systems

Limited direct execution

Recap: virtual view of resources

- Process
 - Each running process thinks that it owns the CPU
- Address space
 - Each process feels like it has a huge address space
- File system tree
 - The user feels like operating on the files directly
- What are the OS responsibilities in providing the above virtual notions?

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- What are the OS responsibilities in providing the above virtual notions?
 - The OS performs multiplexing of physical resources efficiently
 - Maintains mapping of virtual view to physical resource

Virtualization: Efficiency/performance

- Resource virtualization should not add any overheads
- Efficient when programs use the resources directly, no OS mediation
 - Example: when a process is scheduled on CPU, it should execute without OS intervention
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Conclusion: Some limits to direct access must be enforced.

Limited direct execution

- Can the OS enforce limits to an executing process by itself?

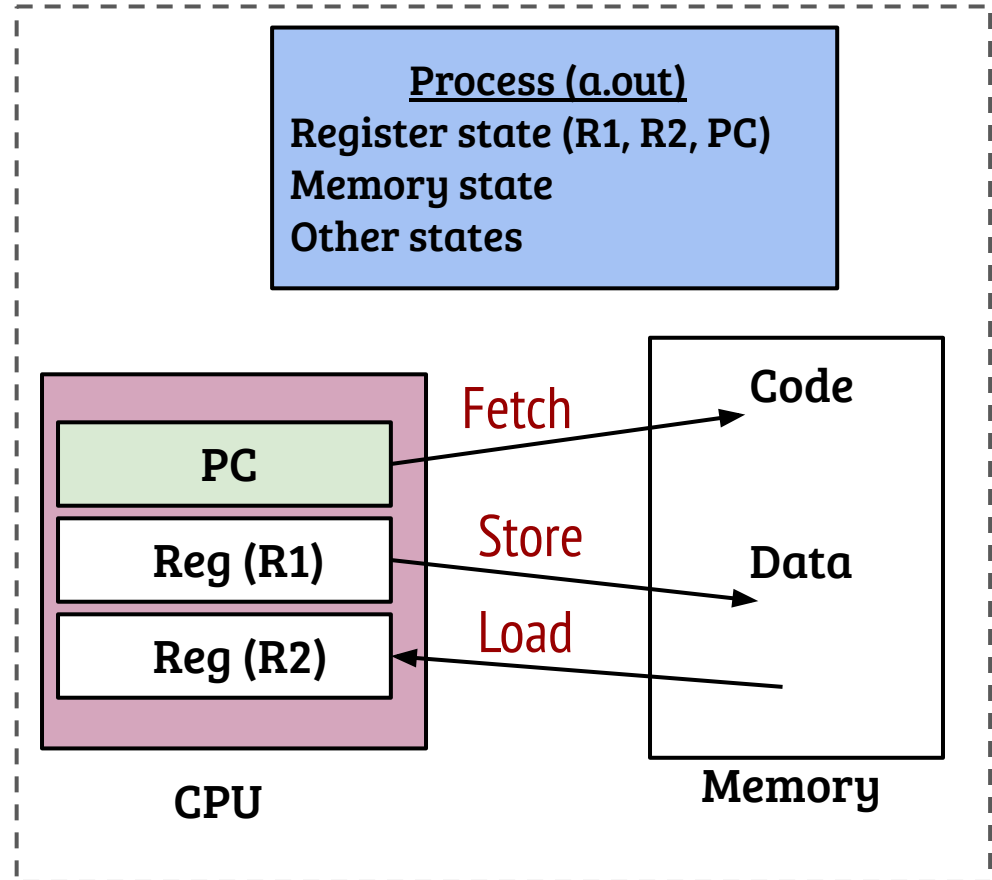
A process in execution

I want to take control of the CPU from this process which is executing an infinite loop, but how?

OS



I want to restrict this process accessing memory of other processes, but how?
Monitoring each memory access is not efficient!



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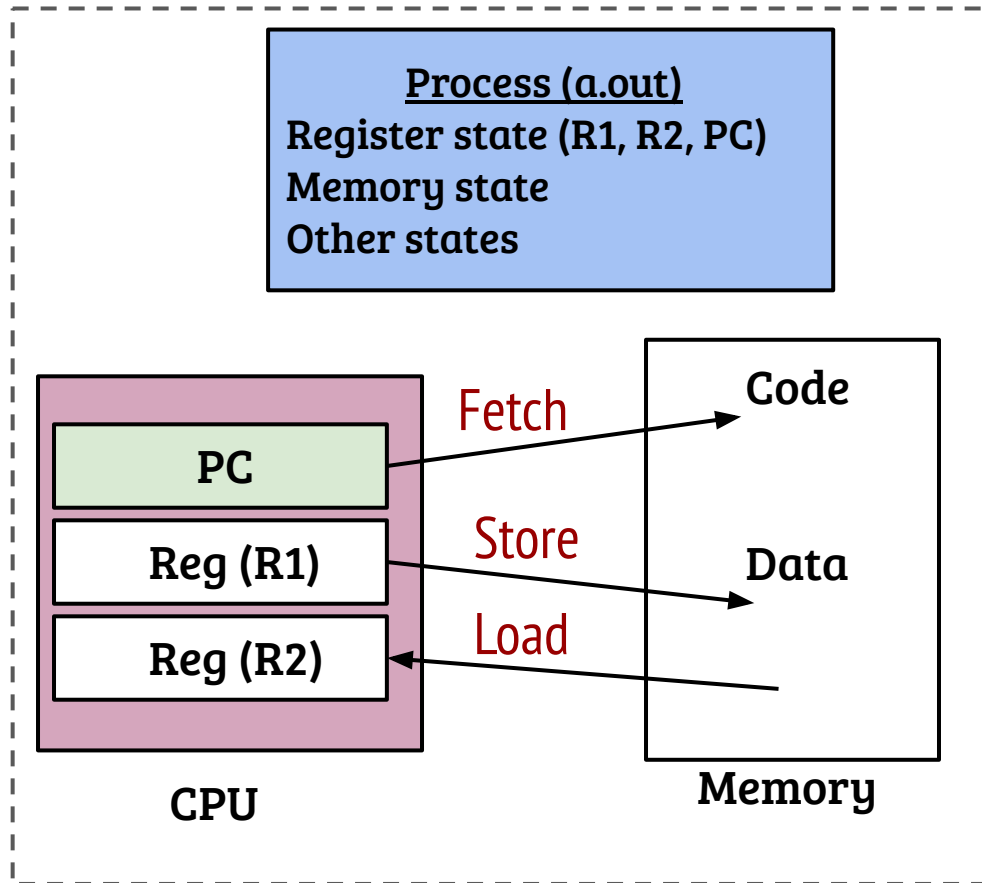
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Help me!

OS



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Limited direct execution

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- No, the OS can not enforce limits by itself and still achieve efficiency
- OS requires support from hardware!

Limited direct execution

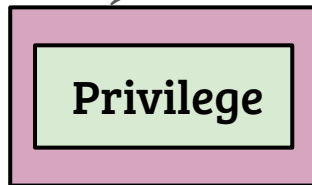
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- What kind of support is needed from the hardware?

Hardware support: Privilege levels



OS

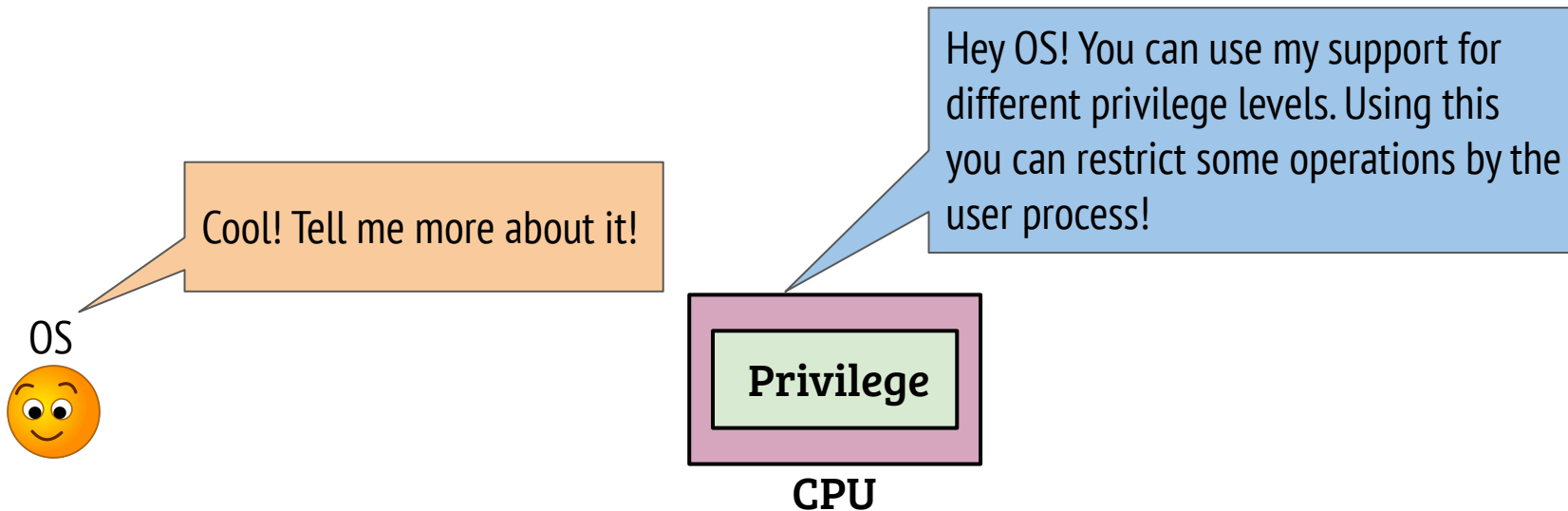
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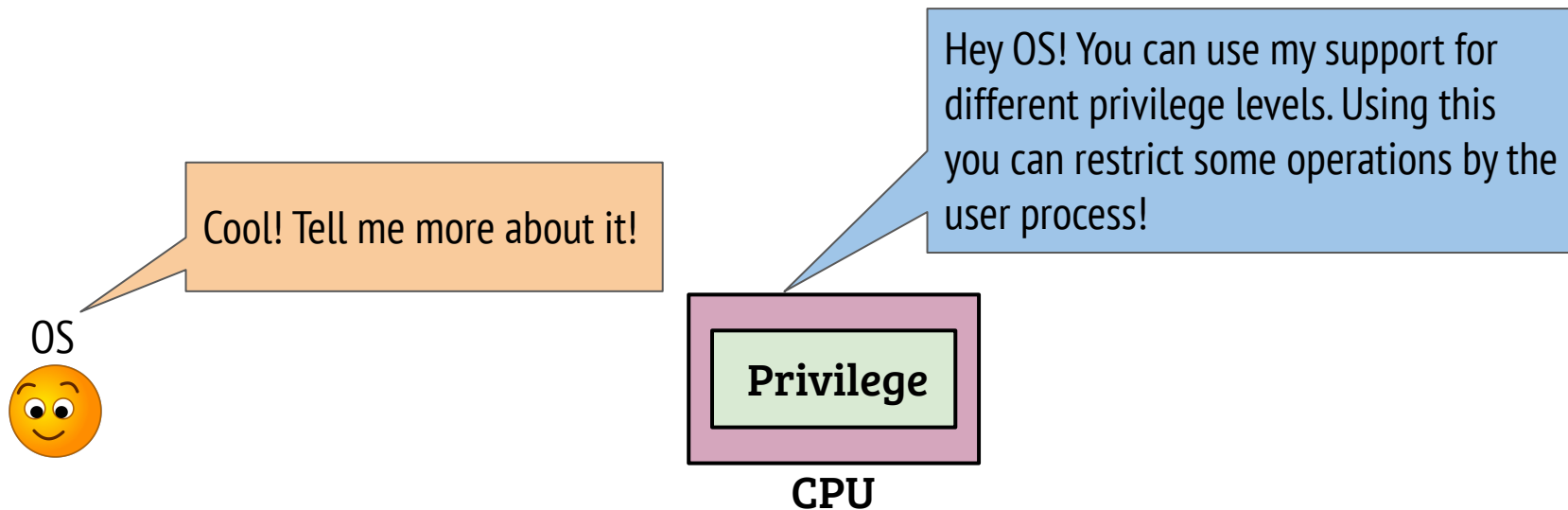
CPU

Hey OS! You can use my support for different privilege levels. Using this you can restrict some operations by the user process!

Hardware support: Privilege levels

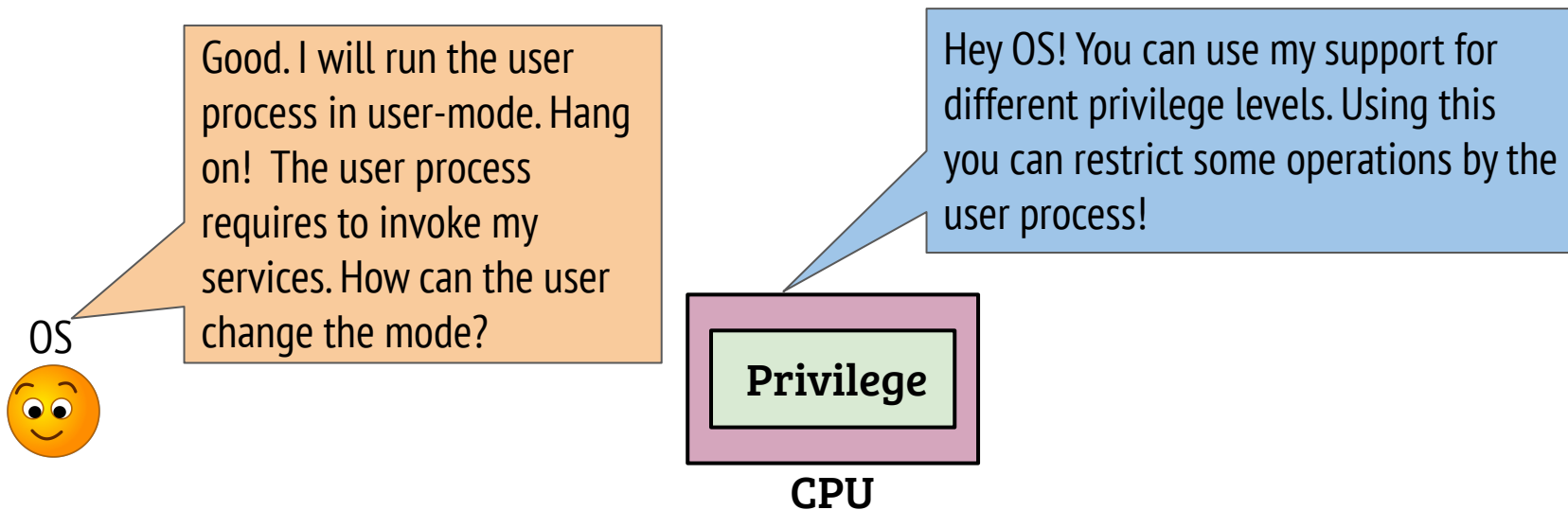


Hardware support: Privilege levels

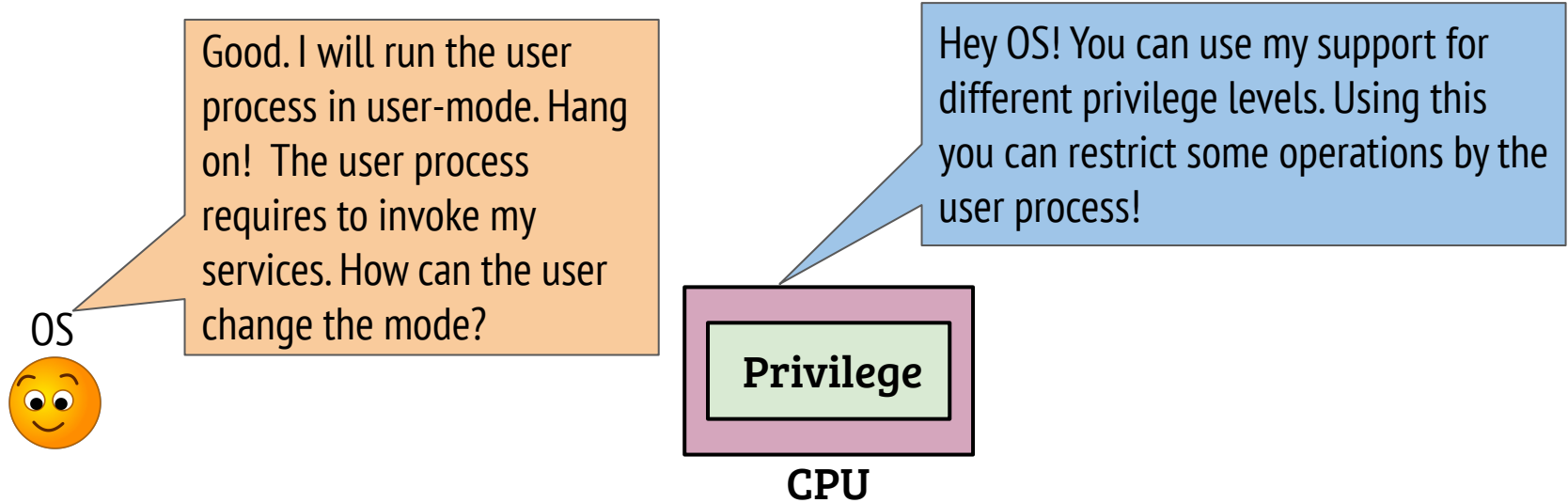


- CPU can execute in two modes: *user-mode* and *kernel-mode*
- Some operations are allowed only from kernel-mode (privileged OPs)
 - If executed from user mode, hardware will notify the OS by raising a fault/trap

Hardware support: Privilege levels

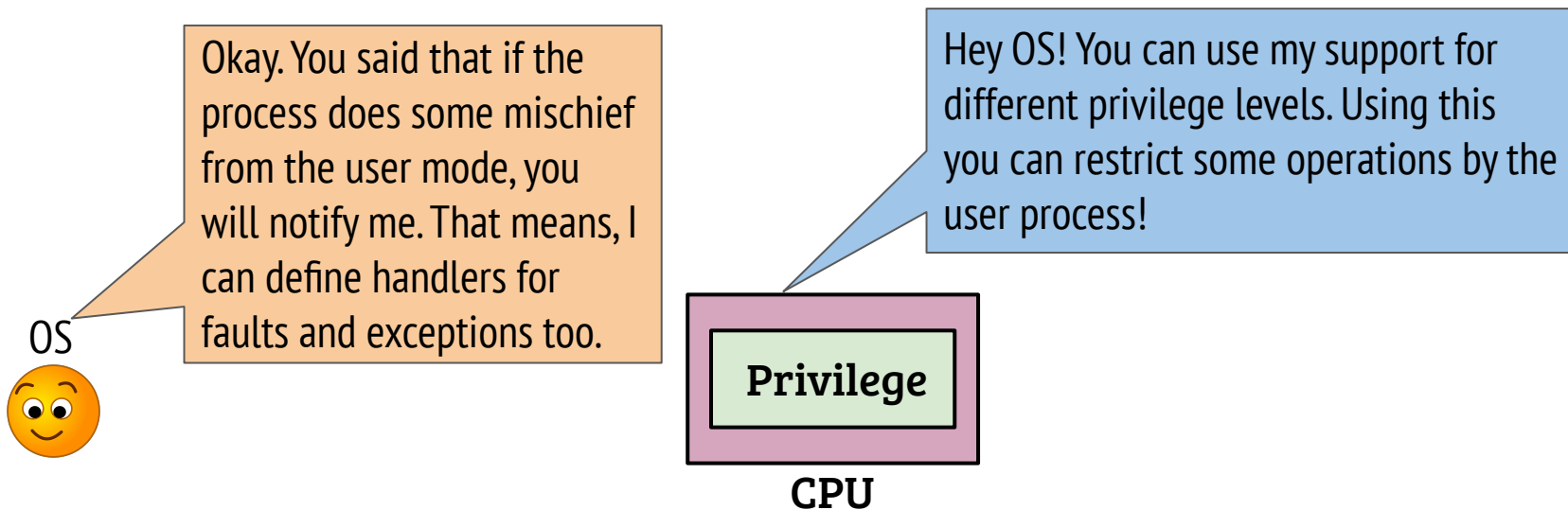


Hardware support: Privilege levels

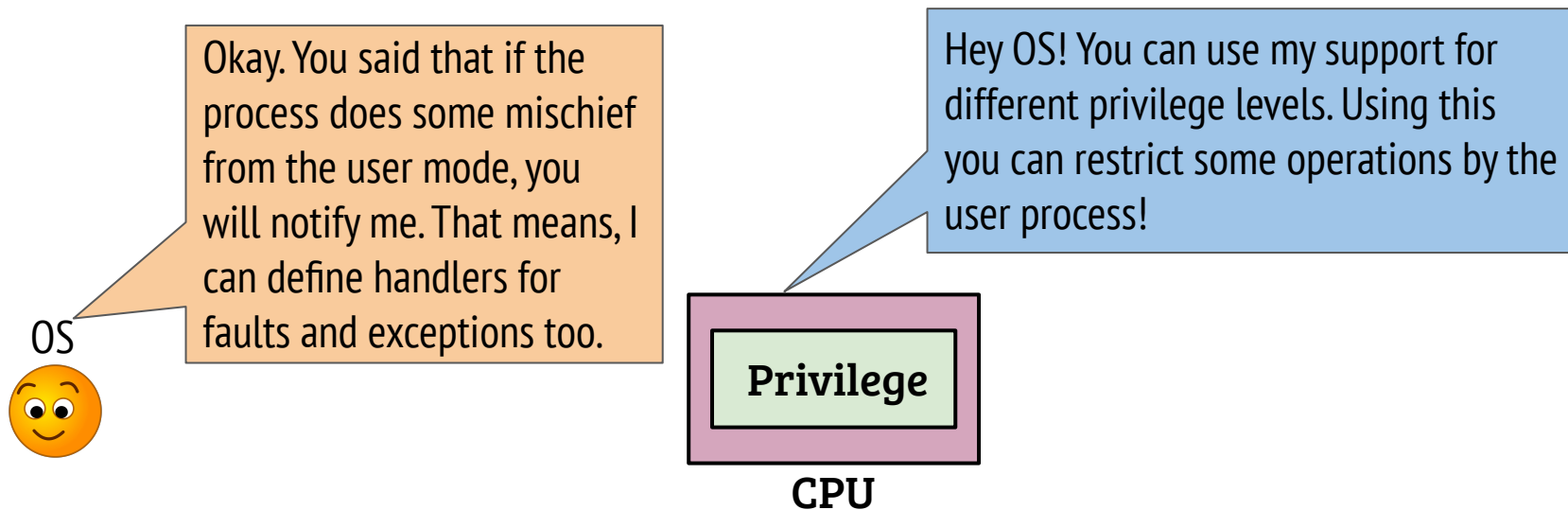


- From user-mode, privilege level of CPU can not be changed directly
- The hardware provides entry instructions from the user-mode which causes a mode switch
- The OS can define the handler for different entry gates

Hardware support: Privilege levels

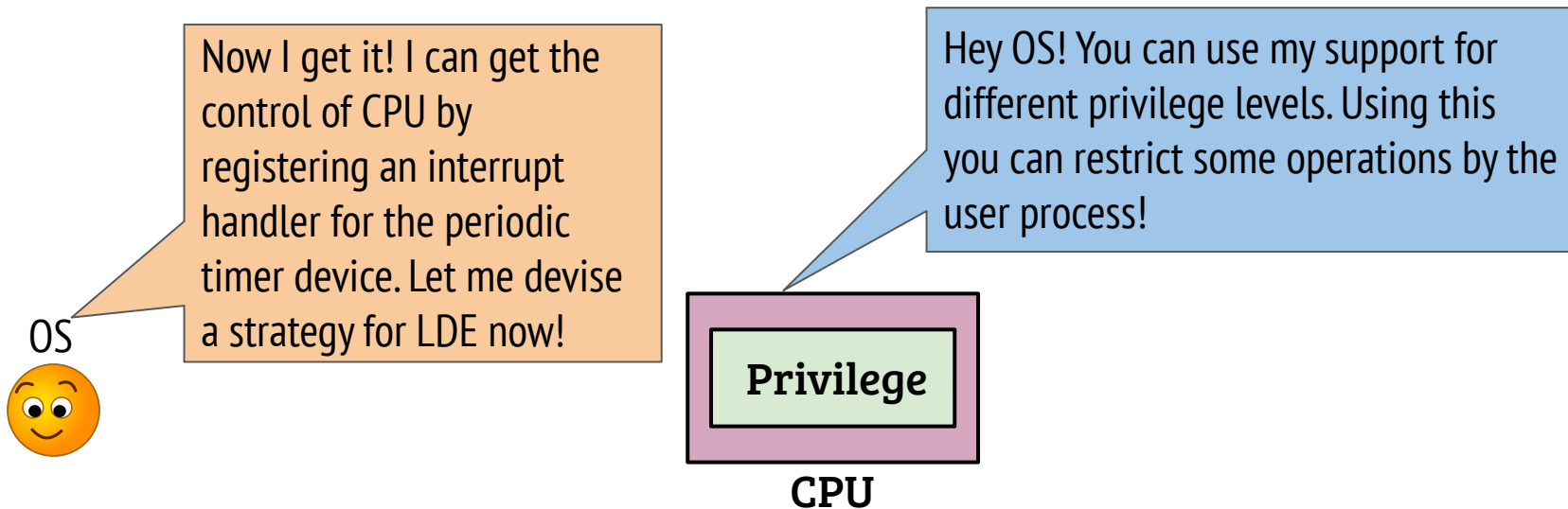


Hardware support: Privilege levels

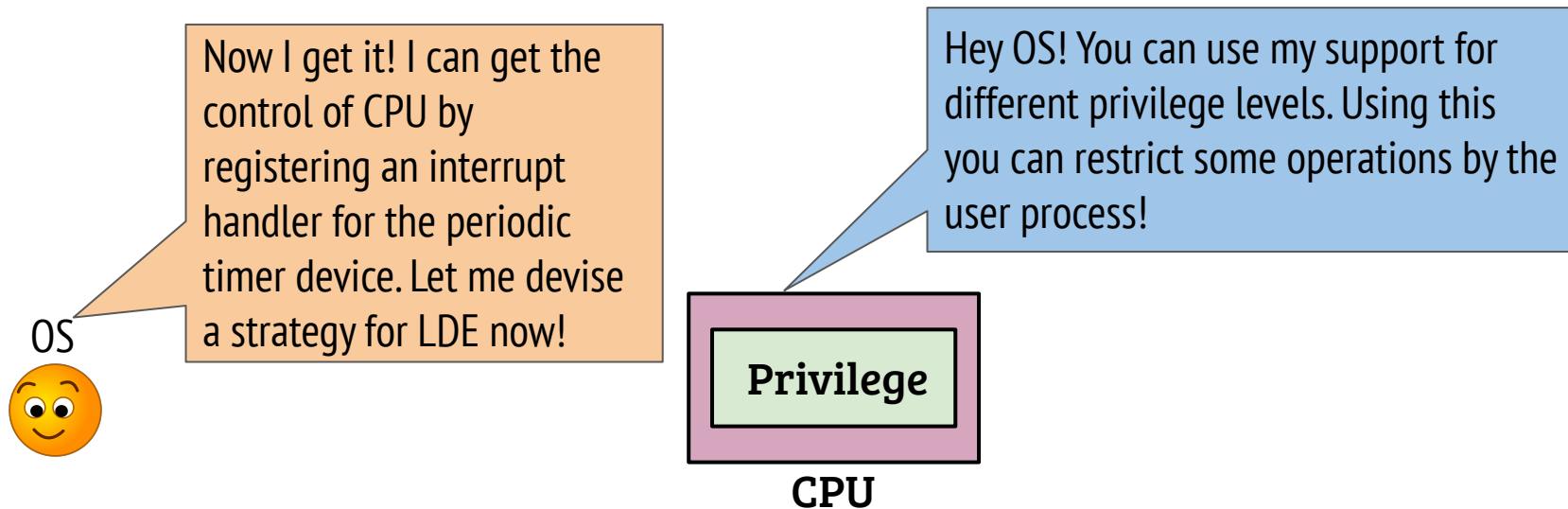


- The OS can register the handlers for faults and exceptions
- The OS can also register handlers for device interrupts
- *Registration of handlers is privileged!*

Hardware support: Privilege levels



Hardware support: Privilege levels



- After the boot, the OS needs to configure the handlers for system calls, exceptions/faults and interrupts
- The handler code is invoked by the hardware when user invokes a system call or an exception or an external interrupt

Limited direct execution

- Can the OS enforce limits to an executing process?
- No, the OS can not enforce limits by itself and still achieve efficiency
- OS requires support from hardware!
- What kind of support is needed from the hardware?
- CPU privilege levels: user-mode vs. kernel-mode
- Switching between modes, entry points and handlers