Task Scheduling and Programming Tips for FIFOS

CS552 – Operating Systems
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Agenda

- Today:
  - Organization of task scheduler
  - Non-preemptive task switching
  - Setup of GDT
- Next lab:
  - Preemptive task switching
  - Interrupt handling (PIC)
  - Setup of the system timer (PIT)

Overview

Kernel Initialization

- **GDT** w/ at least kernel code and data descriptor
- (*) **IDT**: to handle hardware exceptions and IRQs
- (*) **PIC**: to deliver timer interrupts to the scheduler
- (*) **PIT**: to set preemption points
- Initialize a pool of (up to constant N) tasks
- Start the scheduler to launch the first task

(*) Preemption support requirements

Scheduler Functionalities

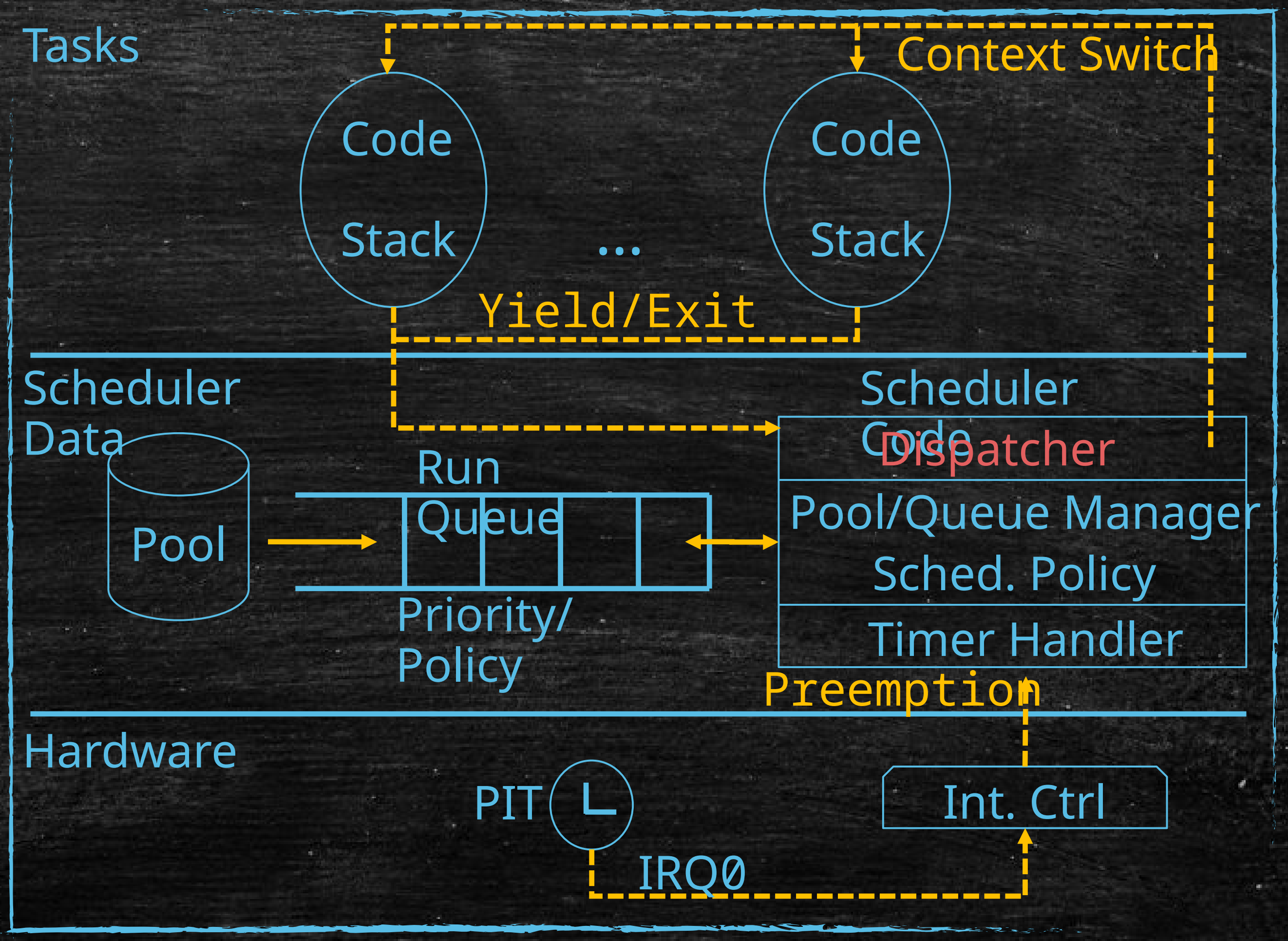
- Scheduler's Public Interface
  - thread_create(func, stack)
  - thread_yield()
- Scheduler's Private Interface
  - current_thread()
  - find_next_thread()
  - switch_thread(from, to)
  - launch_thread(t)
  - exit_thread()
  - (*) preempt_thread()

TCBs: Task Control Block

- A thread is a function with a private stack
- What information do we keep in TCB
  - State: New, Ready, Active, Dead, etc.
    - Affects the behavior of the scheduler and dispatcher
    - E.g. Switching to a newly created task w/o an initial state to restore
  - Next Instruction to run: EIP
    - call addr;
    - pushl addr; ret;
  - Stack top: ESP
  - Machine State (minimally the following)
    - General registers: EAX, EBX, ECX, EDX, ESI, EDI, EBP (pushl/popl, pushal/popal)
    - Flags: EFLAGS (pushf/ popf)

Organization

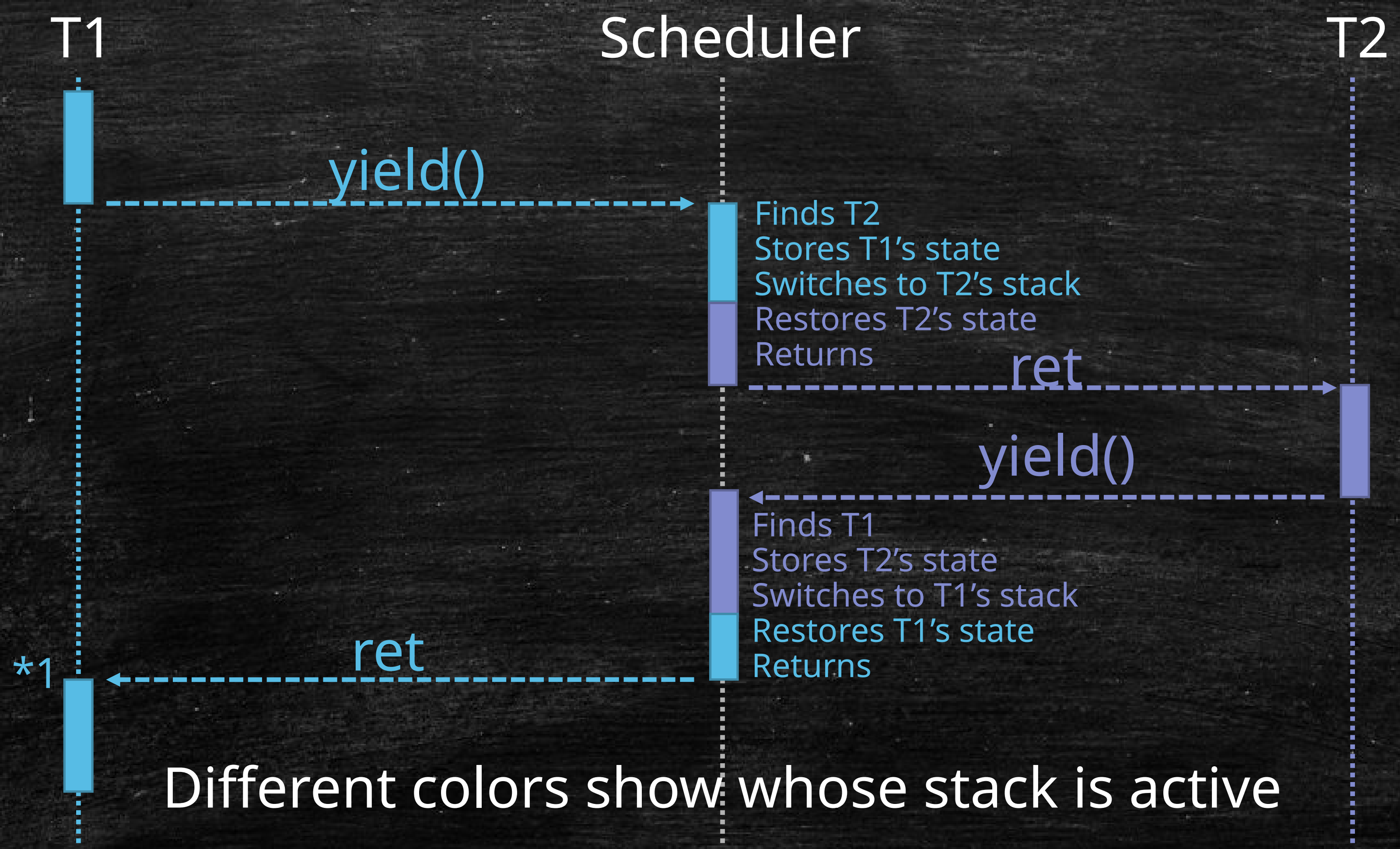
- Functionalities
  - Add/Remove tasks
  - Find the next task to run
  - Handle state transitions
  - Context switching
- Main components
  - Task pool
  - Run Queue
  - Dispatcher



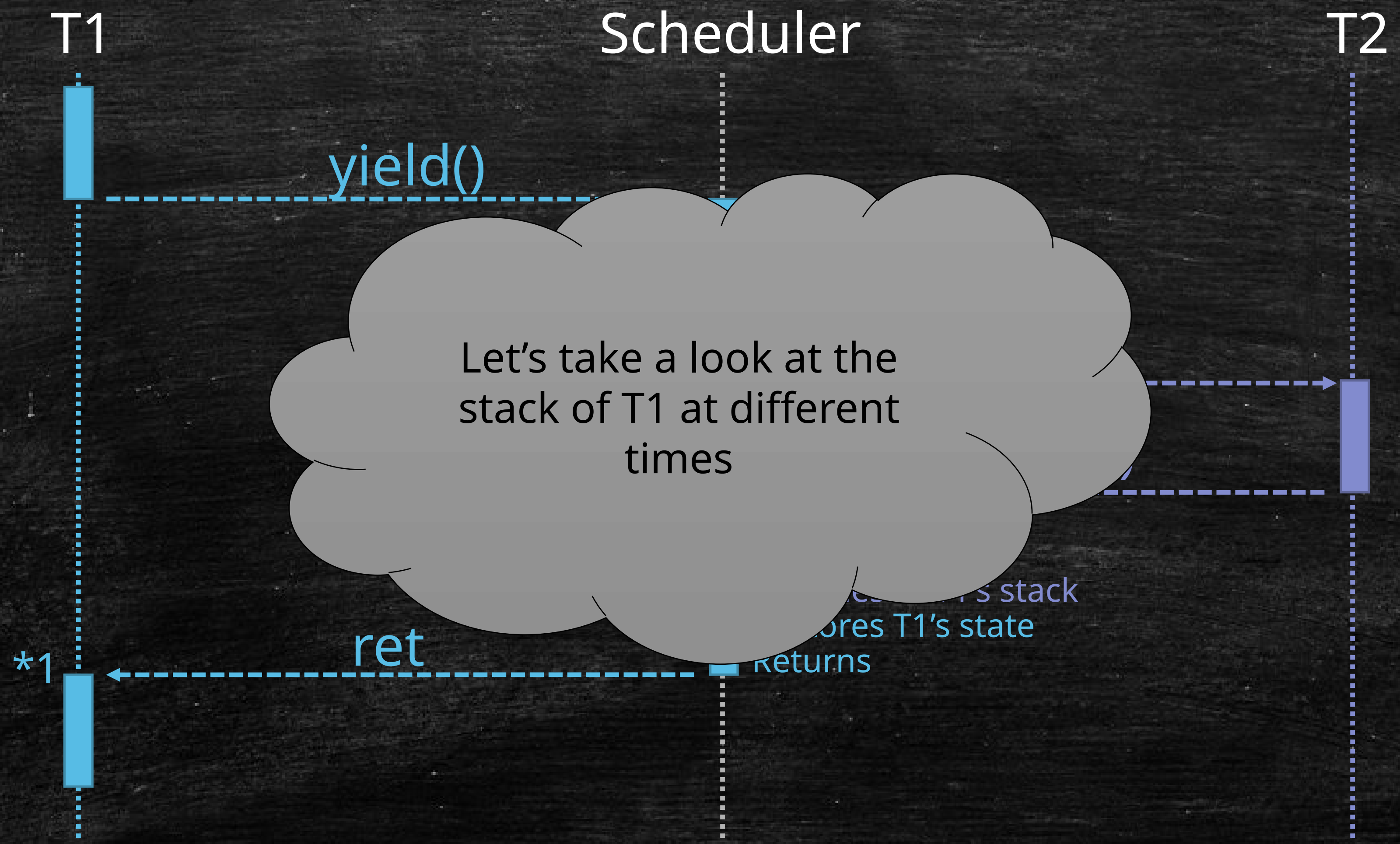
Non-preemptive Context Switch

- A context switch happens when:
  - The current running task finishes execution
  - Explicitly yields execution
- What should happen?
  - The current task goes to the scheduler's code
  - The scheduler finds the next task to run
  - Pushes the machine state on the stack
  - Updates the TCB of the current (ESP, EIP, State)
  - Switches to the stack of the next thread (mov next->esp, %esp)
  - Pops the machine state from the new stack
  - Returns to the new current task

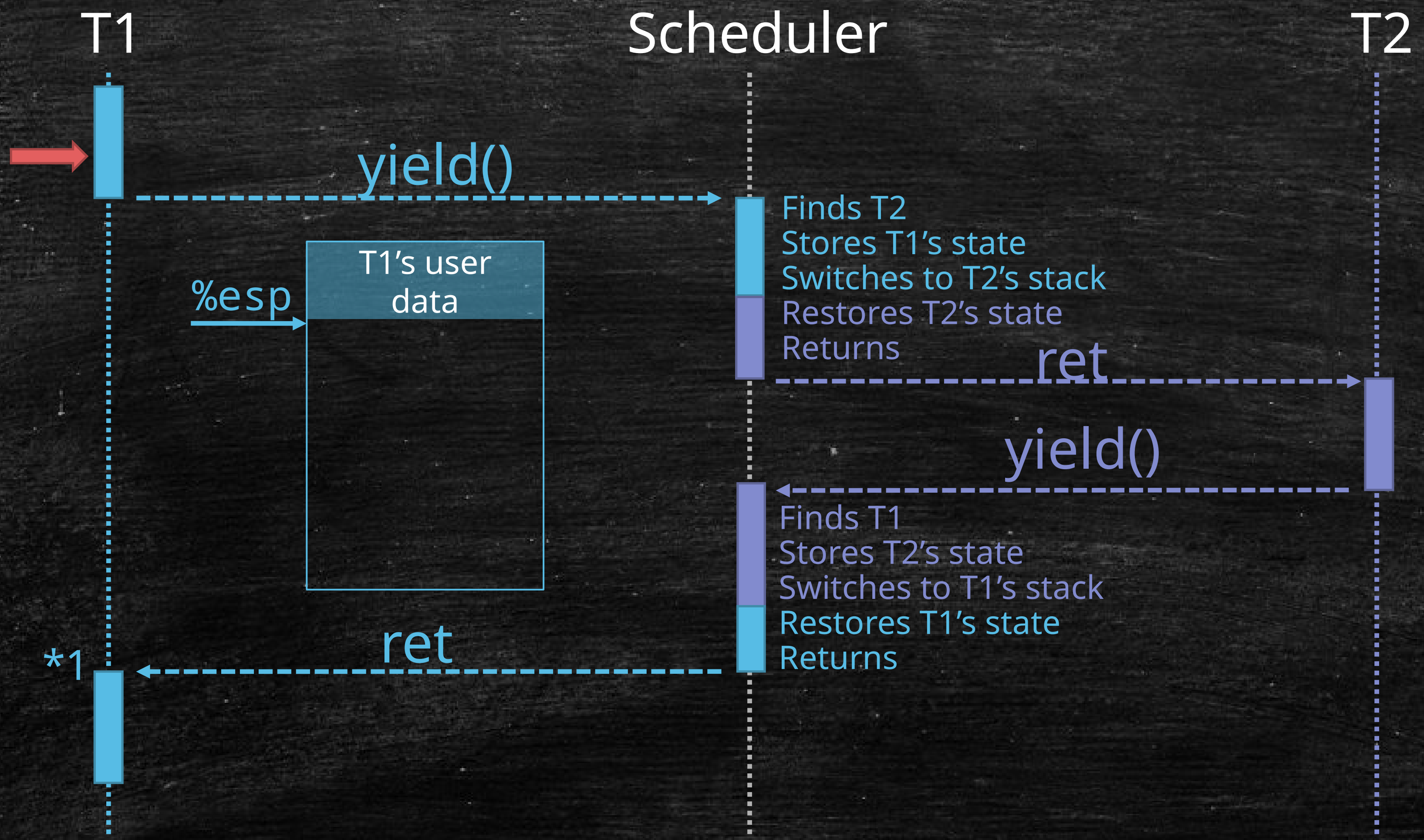
Example (T1 -> T2 -> T1)



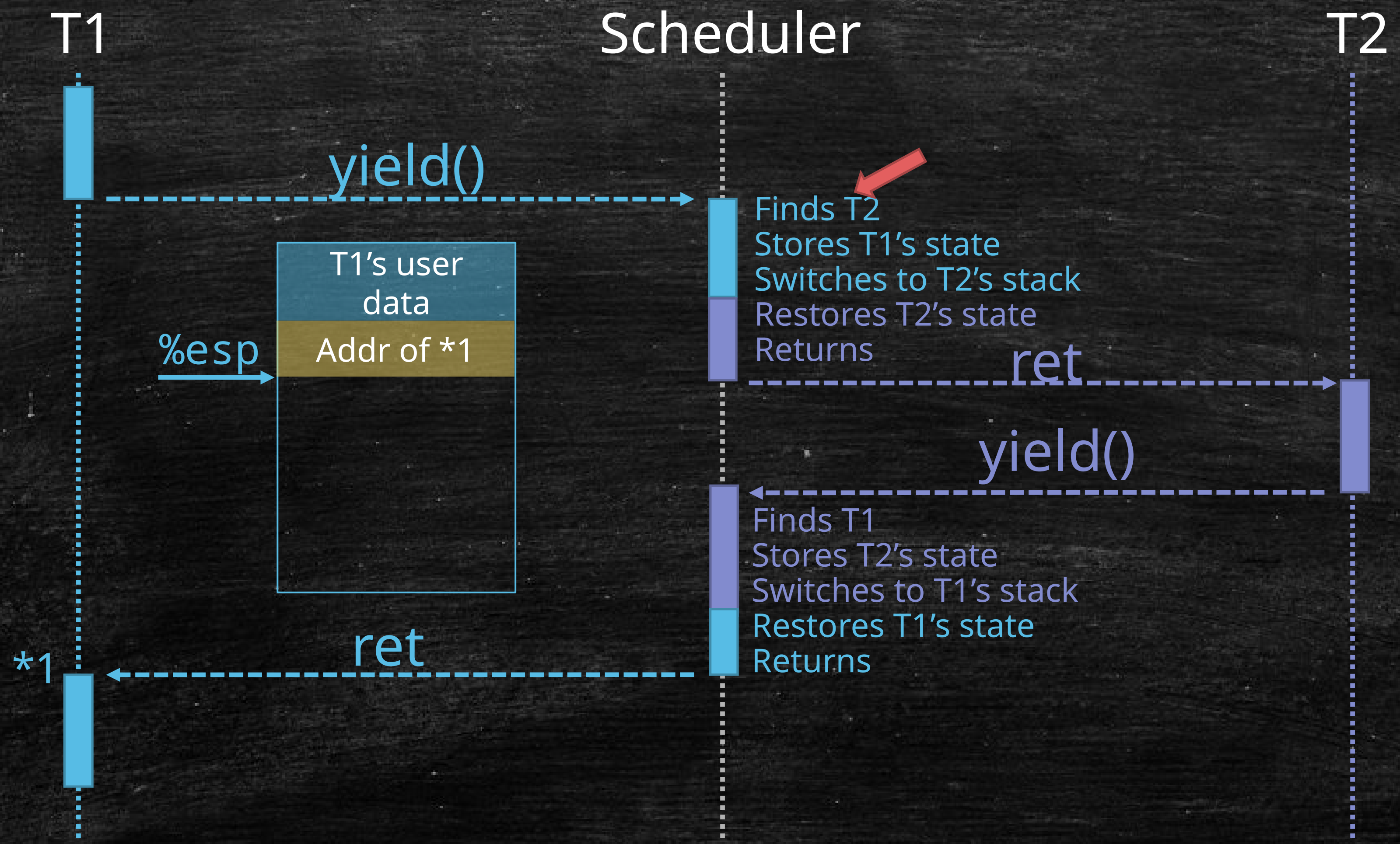
Example (T1 -> T2 -> T1)



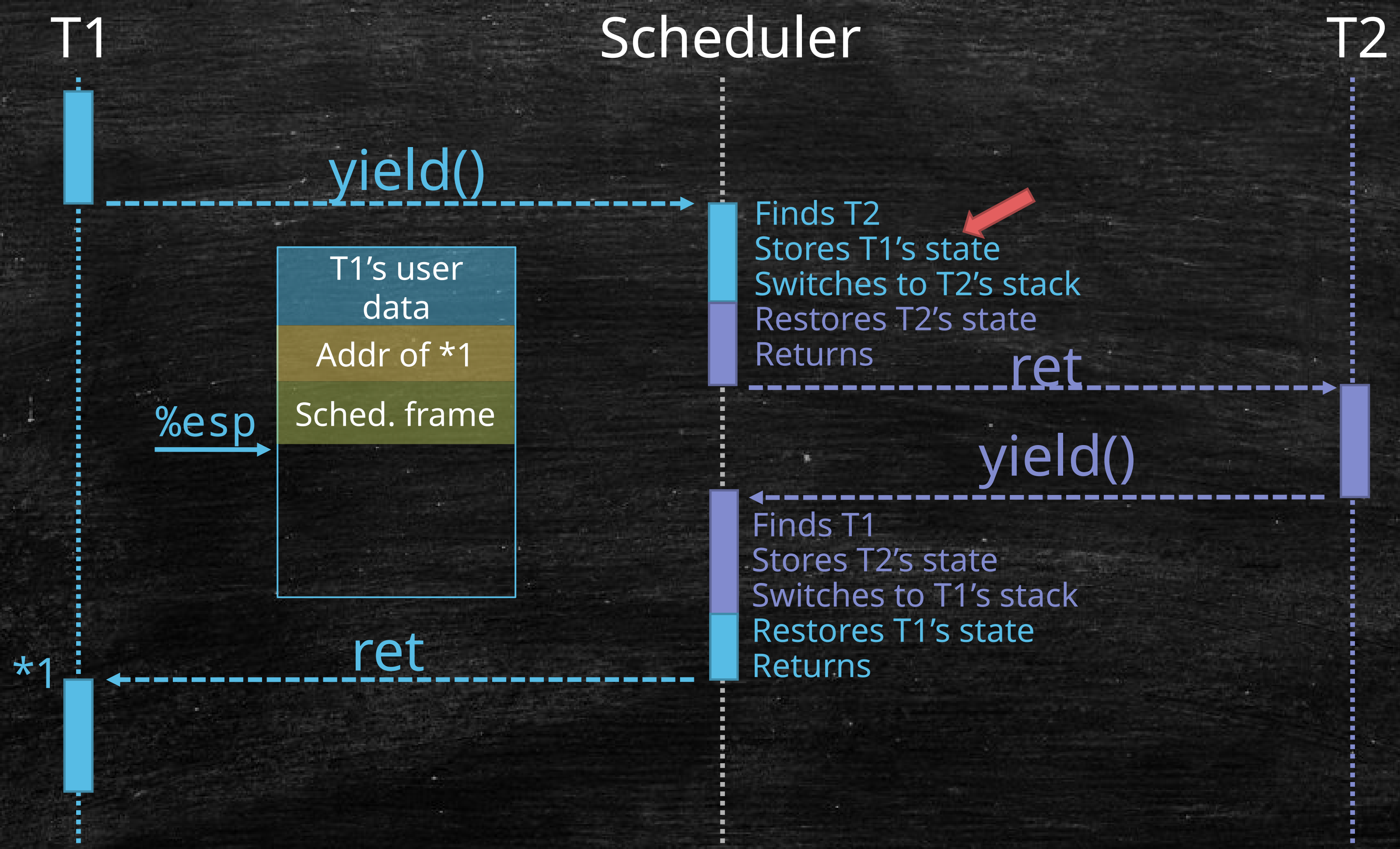
Example – Before T1 yields



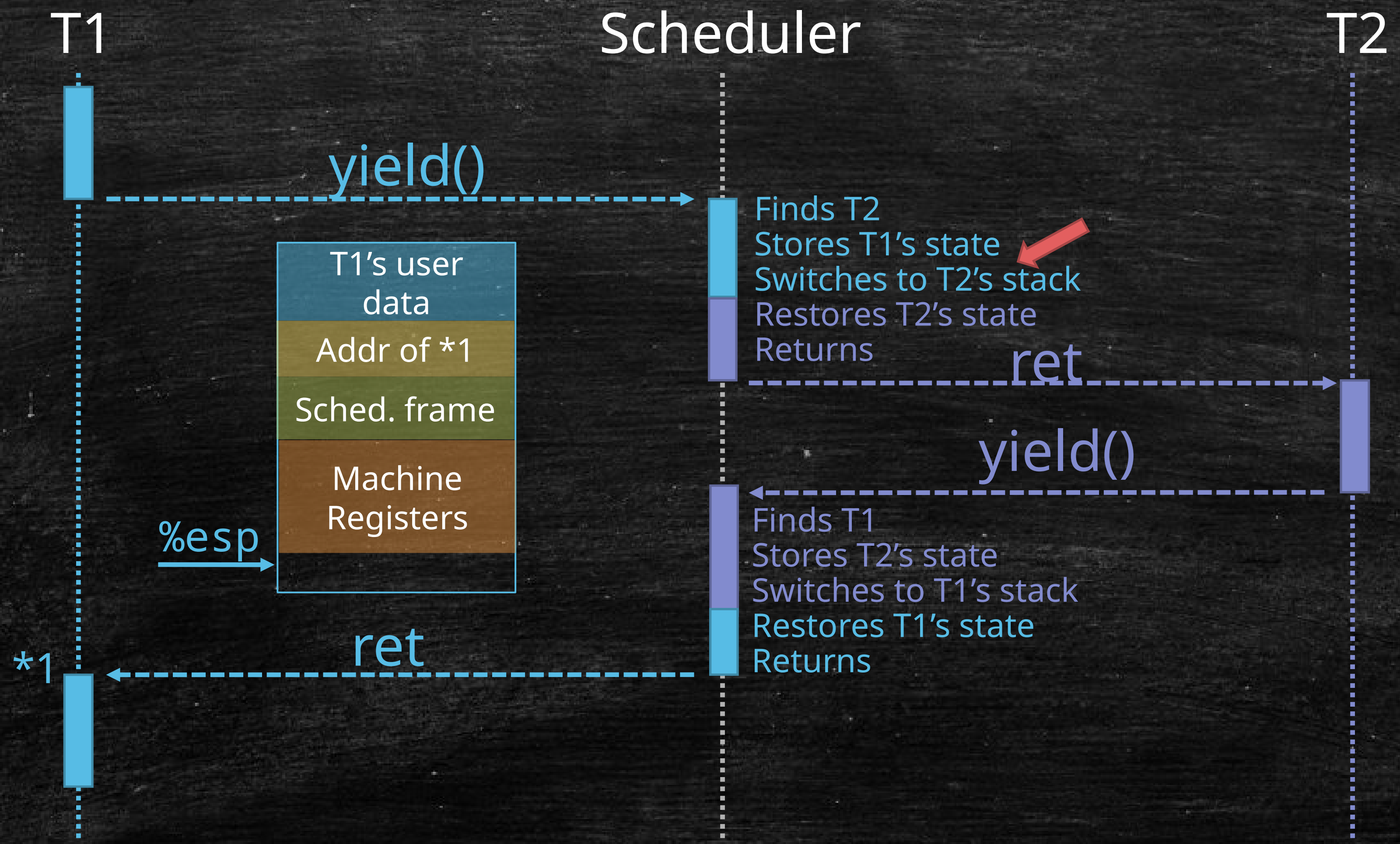
Example – After T1 yields



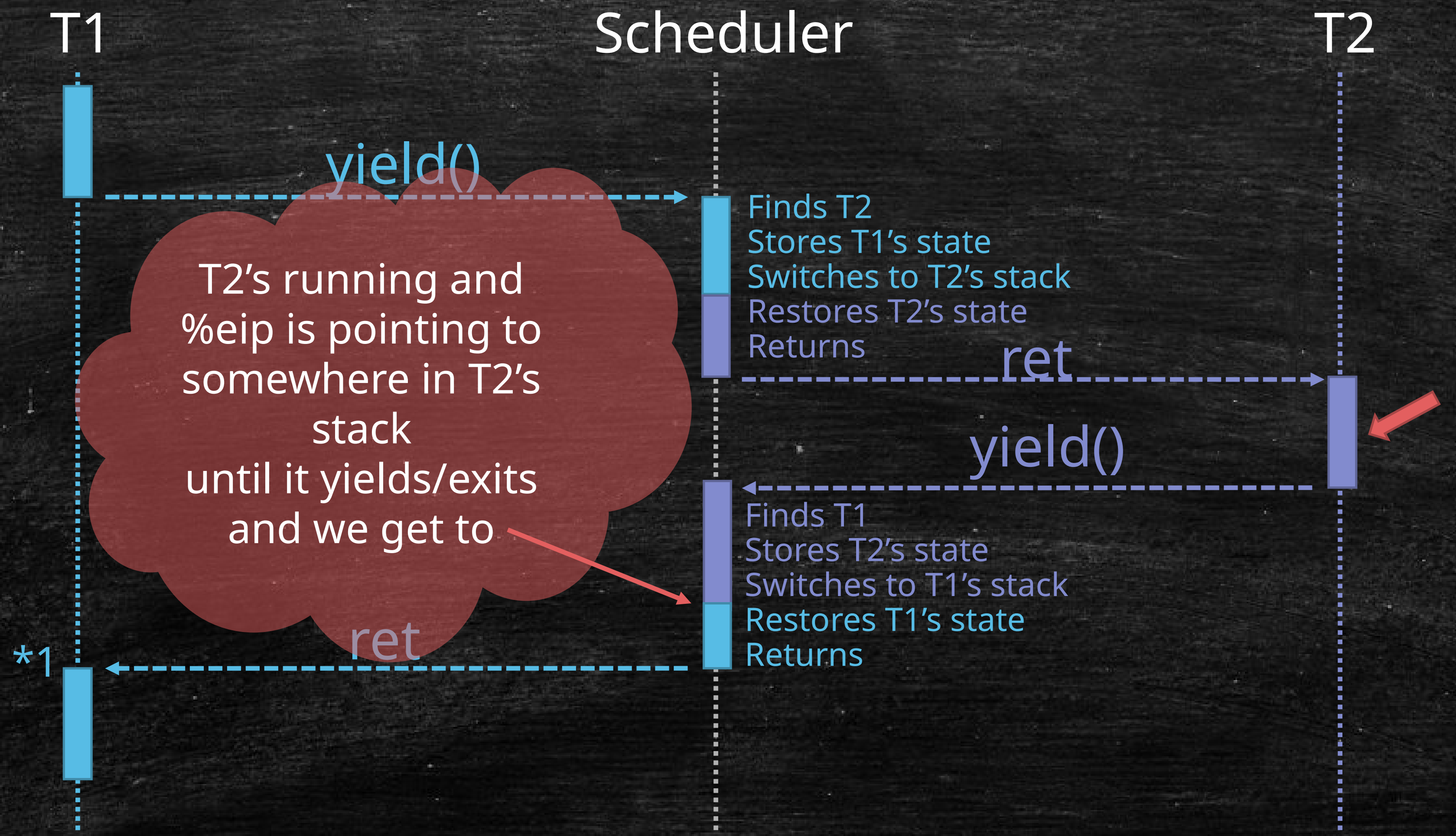
Example – T1's executing the sched. code



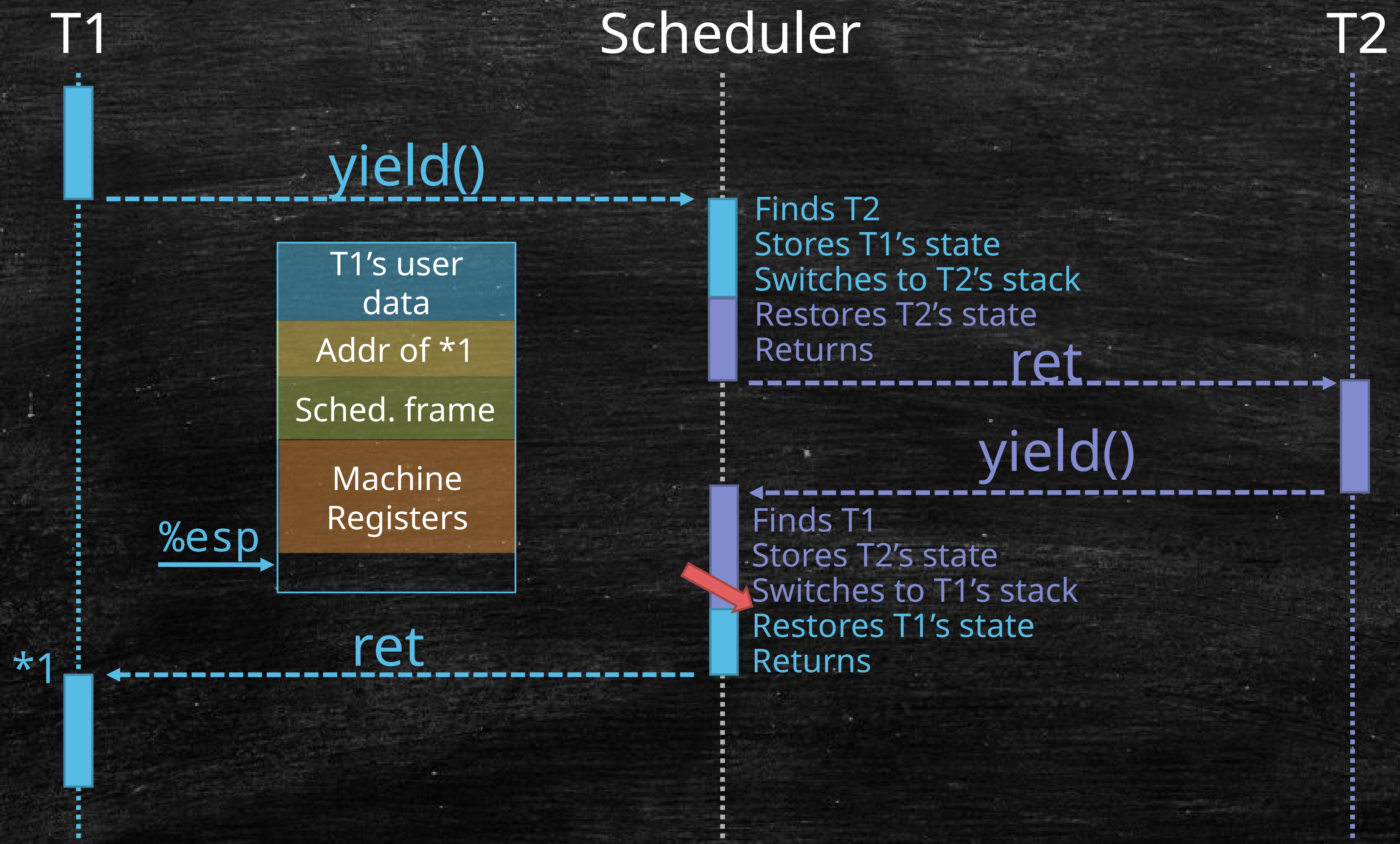
Example – Before switching to T2's stack



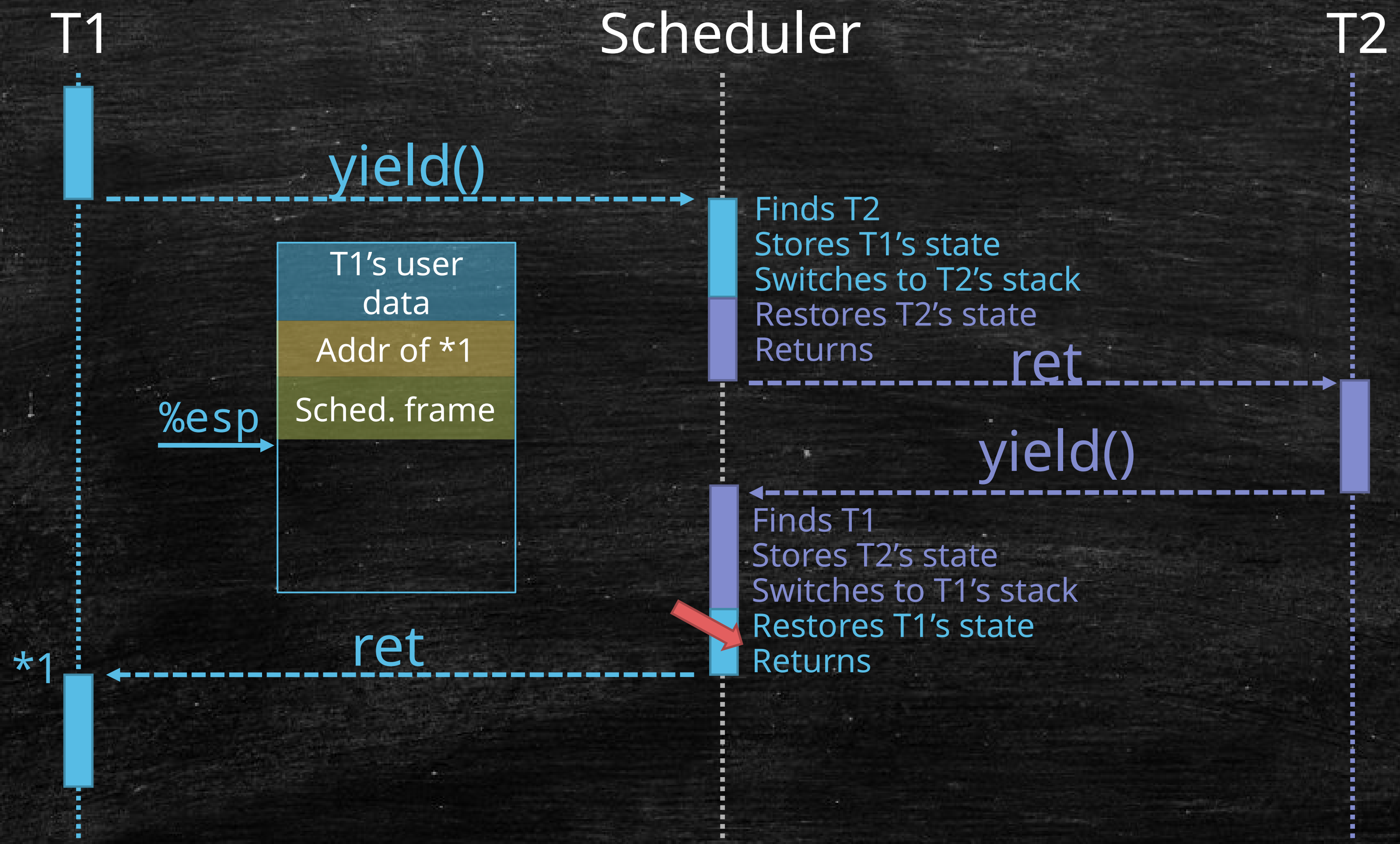
Example – Running in T’2 context



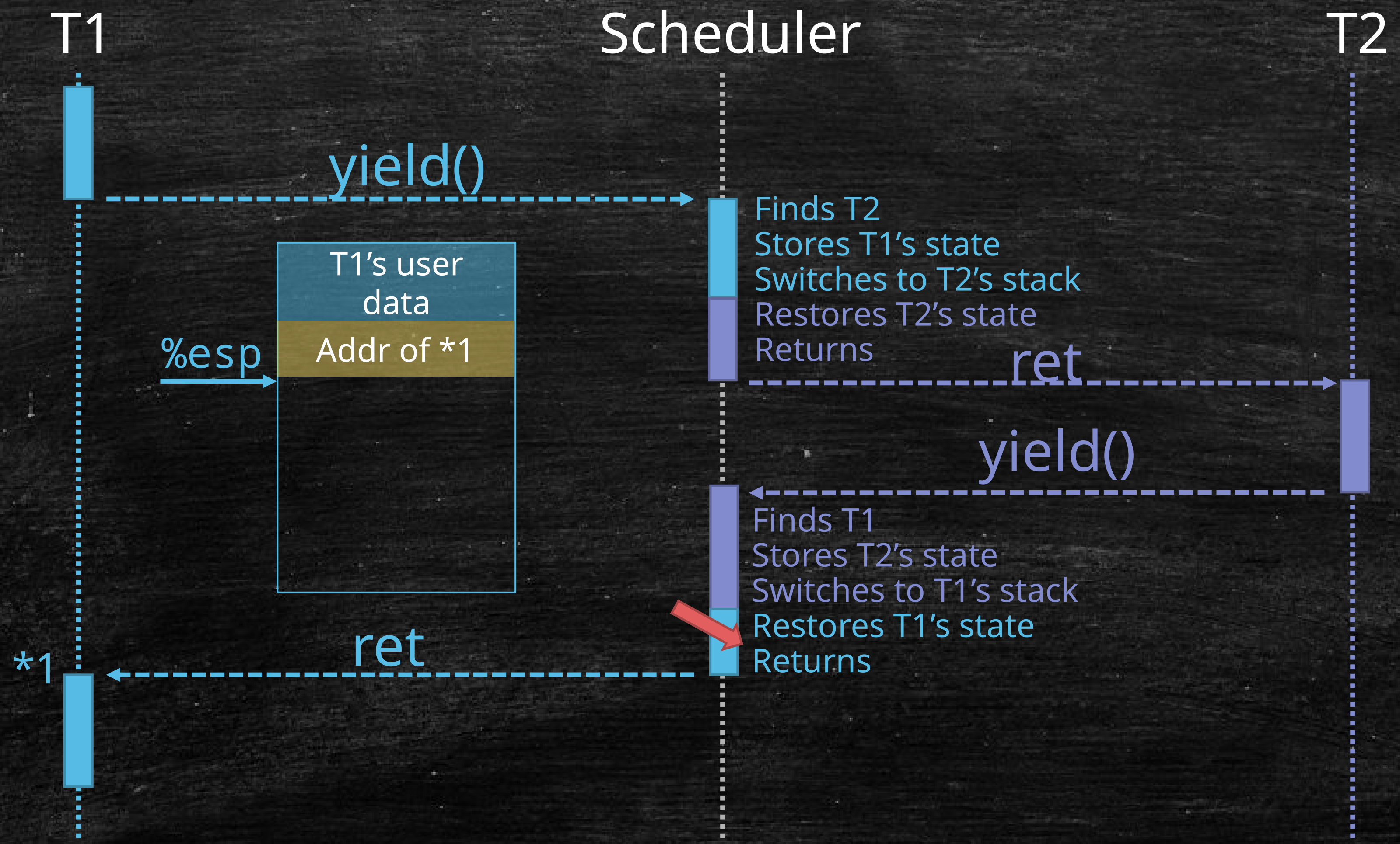
Example – After switching to T1's stack



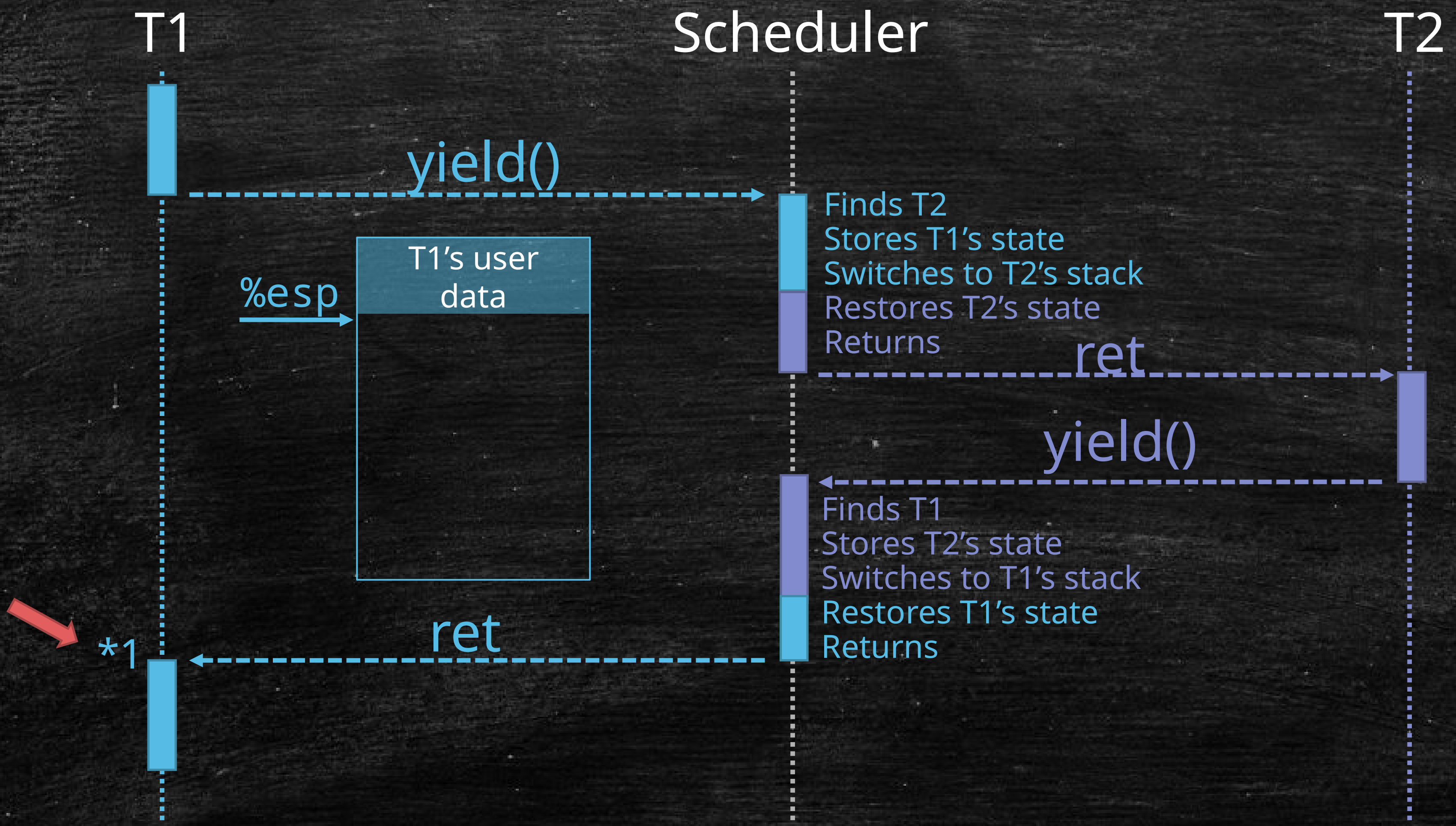
Example – After restoring T1’s state



Example – At the end of sched.'s code



Example – After the scheduler returns



Setting up a GDT for your OS!

- GRUB sets up a default GDT and hands over control to us after setting the CPU mode to Protected Mode.
- Can we rely on that default table?...No since we don't know the base address of the table itself!
- Set up our own GDT since we need it to refer to memory segments
- GDT
  - Each GDT table entry is 8 byte. It decides the accessible memory range.
  - GDT is too complex! Just use the very basic feature of it!
  - Setting up the GDT first: at least three entries: **one empty**, **one for code**, **one for data**
  - GDT Tutorial
  - Tell CPU where GDT is: length of GDT - 1 and the linear address of the GDT
    - The `lgdt` instruction and a GDT pointer structure
  - Reload all the segment registers to point to the GDT entry
  - Neither POP nor MOV can place a value in the code-segment register CS; only the far control-transfer instructions can change CS.

Format of GDT entries

- An array of 64-bit entries – Look here for definitions
  - In Assembly: Check out .byte, .short and .long directives here
  - In C: Check out packed data structures and GNU inline assembly
- Format of each GDT entry:

31 – 16	15 – 0
Base[15:0]	Limit[15:0]

63 – 56	55 – 52	51 – 48	47 – 40	39 – 32
Base[31:24]	Flags	Limit [19:16]	Access Byte	Base[23:16]

Format of GDT Entries

- Base: A 32-bit value indicating the linear address where the segment begins.
- Limit: A 20-bit value indicating size of the segment with a granularity specified by the flags field, bit 55 of the entry
- Flags.Granularity (Bit 55):
  - 0 : 1-byte granularity -> W/ a limit of 0xFFFFF can address up to 1MB after the base
  - 1: 4-KB granularity -> W/ a limit of 0xFFFFF can address up to 4GB
- Flags.CodeSize (Bit 54):
  - 0: 16-bit code in Protected Mode (you won't need it)
  - 1: 32-bit code in Protected Mode
- Flags (Bits 52 to 53): Reserved, must be Zero

Example: Setting up your GDT in assembly

```
# Somewhere in your assembly code:
lgdt  gdt_pointer

# Somewhere your assembly data:
gdt_base:
### Null descriptor
.long   0x0
.long   0x0
### Flat 4 GB code segment descriptor (ring 0)
… bit definitions for your kernel's code segment
### Flat 4 GB data segment descriptor
… bit definitions for your kernel's data segment
### End of my GDT
gdt_pointer:
.short  gdt_pointer - gdt_base - 1
.long   gdt_base
```