Exercises in System Level Programming (SLP) – Summer Term 2024

Exercise 8

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Chair in Distributed Systems
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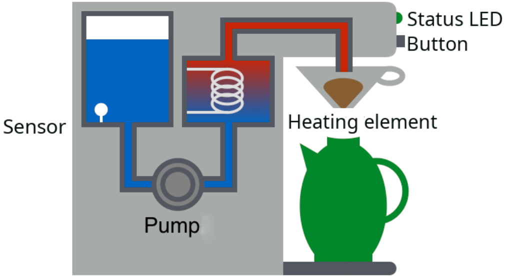
FACULTY OF ENGINEERING

Presentation Assignment 4

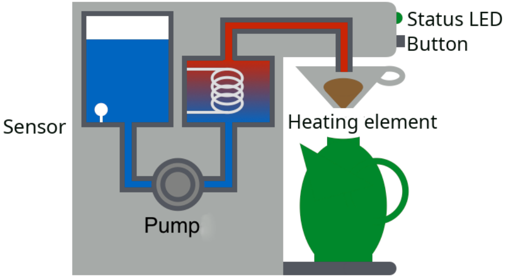
Hands-on: Coffee Machine

Hands-on: Coffee Machine (1)



- Learning goals:
  - Finite state machines
  - Timers and alarms
  - Interrupts & sleep modes

Hands-on: Coffee Machine (1)



- Wiring:
  - Pump & heating: Port D, Pin 5 (active-low)
  - Button: `INT0` an Port D, Pin 2 (active-low)
  - Sensor: `INT1` an Port D, Pin 3 (water: high; no water: low)
  - State LED:
    - `BLUE0`: **STANDBY**
    - `GREEN0`: **ACTIVE**
    - `RED0`: **NO_WATER**

Hands-on: Coffee Machine (2)

STANDBY

- Machine is switched off
- Pump and heating are off
- User can start making coffee by pressing the button
- Initial state

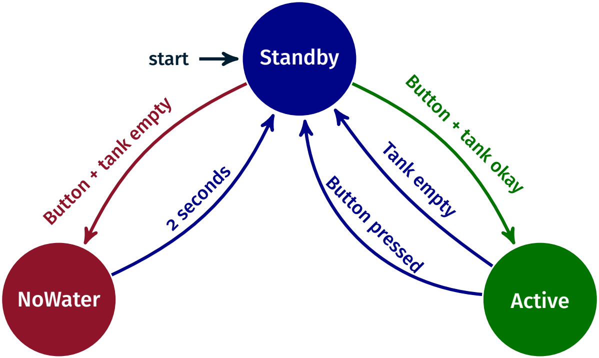
ACTIVE

- Machine is switched on
- Pump and heating are on
- Water tank is not empty
- User can stop the machine by pressing the button

NO_WATER

- Coffee machine shows that not enough water is in the tank
- Pump and heating are off
- Time period: 2 seconds

Hands-on: Coffee Machine (2)



- Hints:
  - Pressed button & change of water level by interrupts
  - State LED: `void setLEDState(state_t state)`
  - Waiting phases can be implemented using the single-shot alarms
  - During waiting phases always enter a power-saving mode

Hands-on: Coffee Machine (3)

`DDRx` Configuration of pin i of port x as in-/output

- `Bit i = 1` → Pin i as output
- `Bit i = 0` → Pin i as input

`PORTx` Mode of operation **depends on DDRx**:

- If pin i is **configured as output**, then bit i in the `PORTx` register controls whether a high level or a low level has to be generated at pin i
  - `Bit i = 1` → high level at pin i
  - `Bit i = 0` → low level a pin i
- If pin i is **configured as input**, then the internal pull-up resistor can be activated
  - `Bit i = 1` → pull-up resistor at pin i (level is pulled high)
  - `Bit i = 0` → pin i configured as tri-state

`PINx` Bit i returns the current level of pin i at port x (read only)

- Interrupt sense control (ISC) bits of the ATmega328PB are located at the external interrupt control register A (EICRA)
- Position of the ISC-bits inside the register defined by macros

Interrupt INT0		Interrupt on	Interrupt INT1	
ISC01	ISC00		ISC11	ISC10
0	0	low level	0	0
0	1	either edge	0	1
1	0	falling edge	1	0
1	1	rising edge	1	1

- ATmega328PB: External interrupt mask register (EIMSK)
- The position of the bits in this register is also defined by macros INTn

Hands-on: Ticker

In Depth: Strings

- `char`: Single character (e. g. `'a'`)
- String: Array of `char`s (e. g. `"Hello"`)
- C: Last char of a string: `'\0'`
  - ⇒ Memory requirement: strlen(s) `+ 1`

```c
char s[] = "World\n";
char c = s[0];
c = s[4];
char *s2 = s + 2;
c = s2[1];
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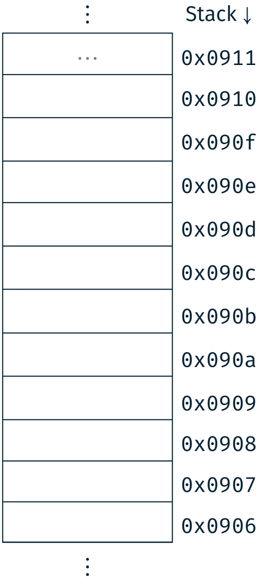

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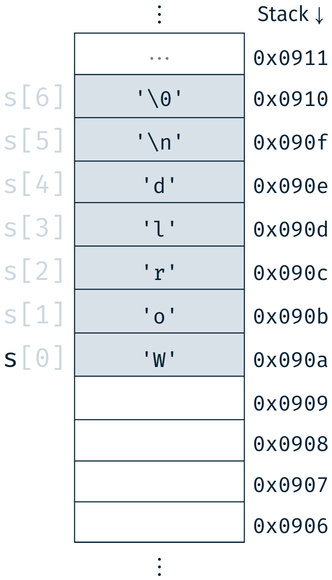

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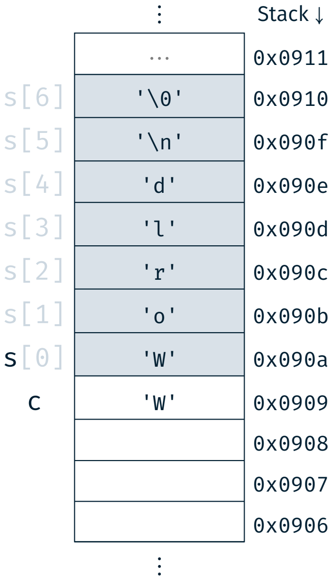

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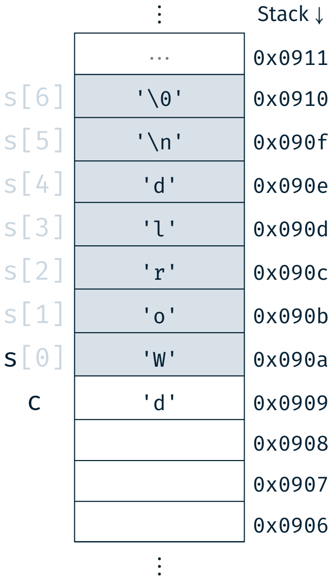

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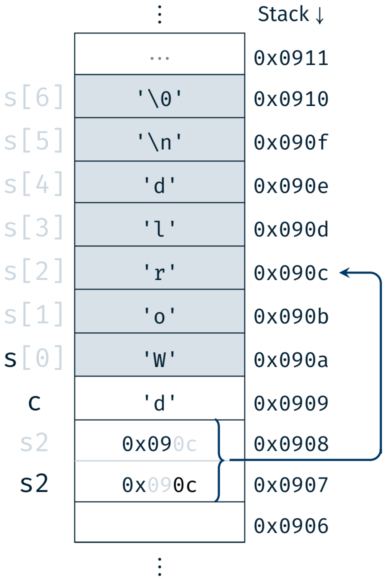

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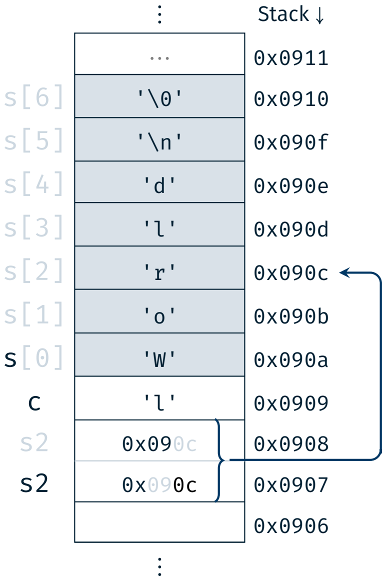

Hands-on: Ticker

- Functionality:
  Displaying a text step-by-step on the 7-segment display
- Learning goals:
  - Strings in C
  - Pointers & pointer arithmetic
  - Alarms & sleep modes
- Procedure:
  - Recurring alarms with `TIMER0`
  - Combining the current substring
  - Output via the 7-segment display
  - During waiting phases, the microcontroller has to enter a sleep mode (passive waiting)

Hands-on: Ticker – Determine Substrings

```
const char *string = "HELLO SPIC";
const char *current = string;
// current[0] == 'H' && current[1] == 'E'
++current;
// current[0] == 'E' && current[1] == 'L'
// [...]
// current[0] == '\0', current[1] == ??
current = string;
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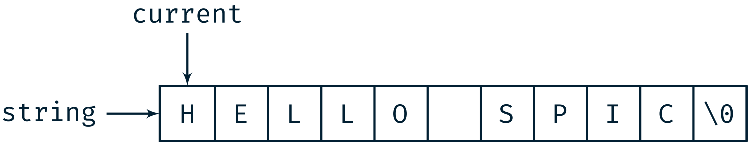

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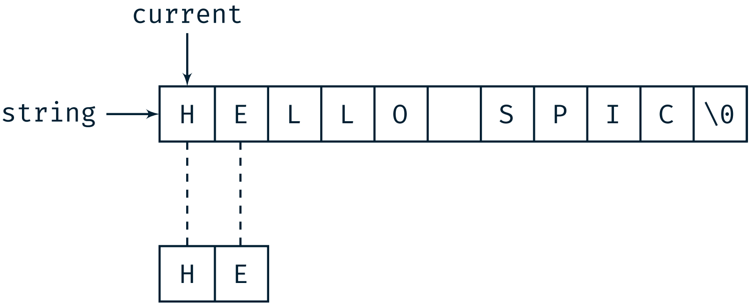

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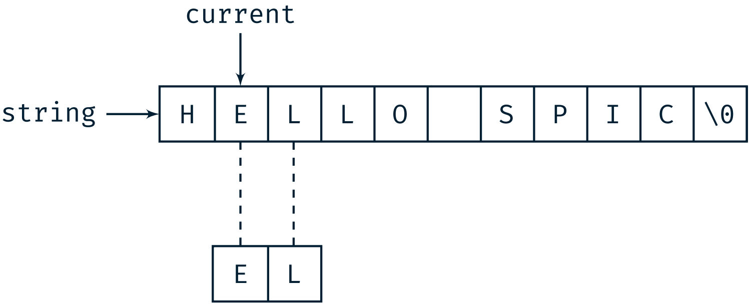

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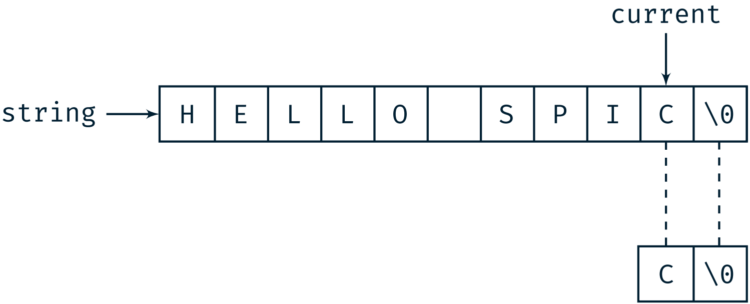

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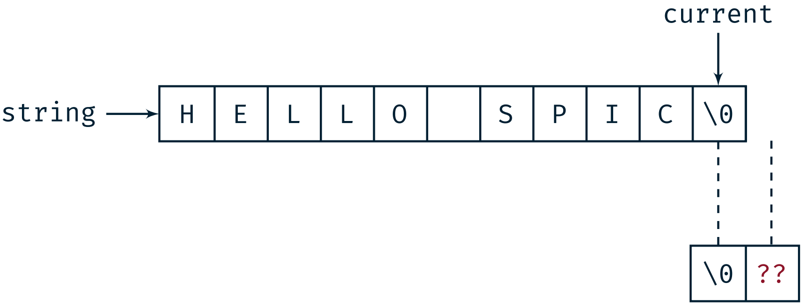

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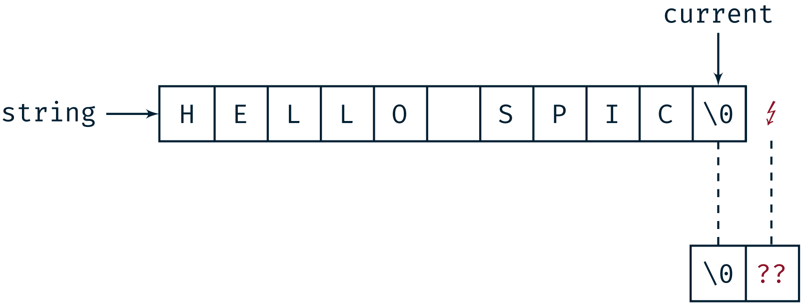

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