Concurrent Event-driven Programming in occam-pi for the Arduino

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Overview

Introduction

A very brief history occam

1. occam on the Transputer
2. occam on SPARC, Alpha, etc.
3. occam-π on x86
4. occam-π on the Transterpreter
   - PPC, x86, ARM, MSP430, H8, ...
   - Mac, Linux, Windows, ...

The Arduino
Hardware

The Arduino

A very brief overview

- Open hardware
- Based on the ATMega 328
  - 8-bit, 16MHz
  - 32KB flash, 2KB RAM, 1KB EEPROM
  - 6 ADC, 1 USART, SPI/I^2C, 14 GPIO

The Arduino

A very brief overview

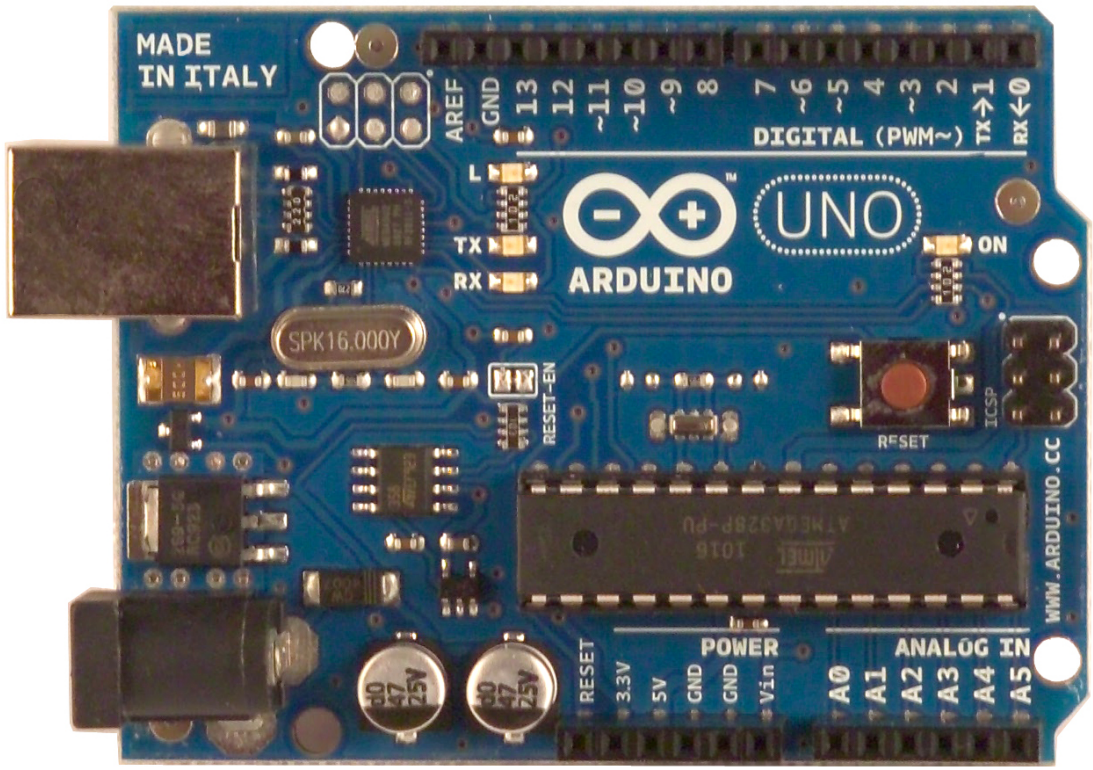


Figure: The Arduino, an open hardware platform.

The Arduino

A very brief overview

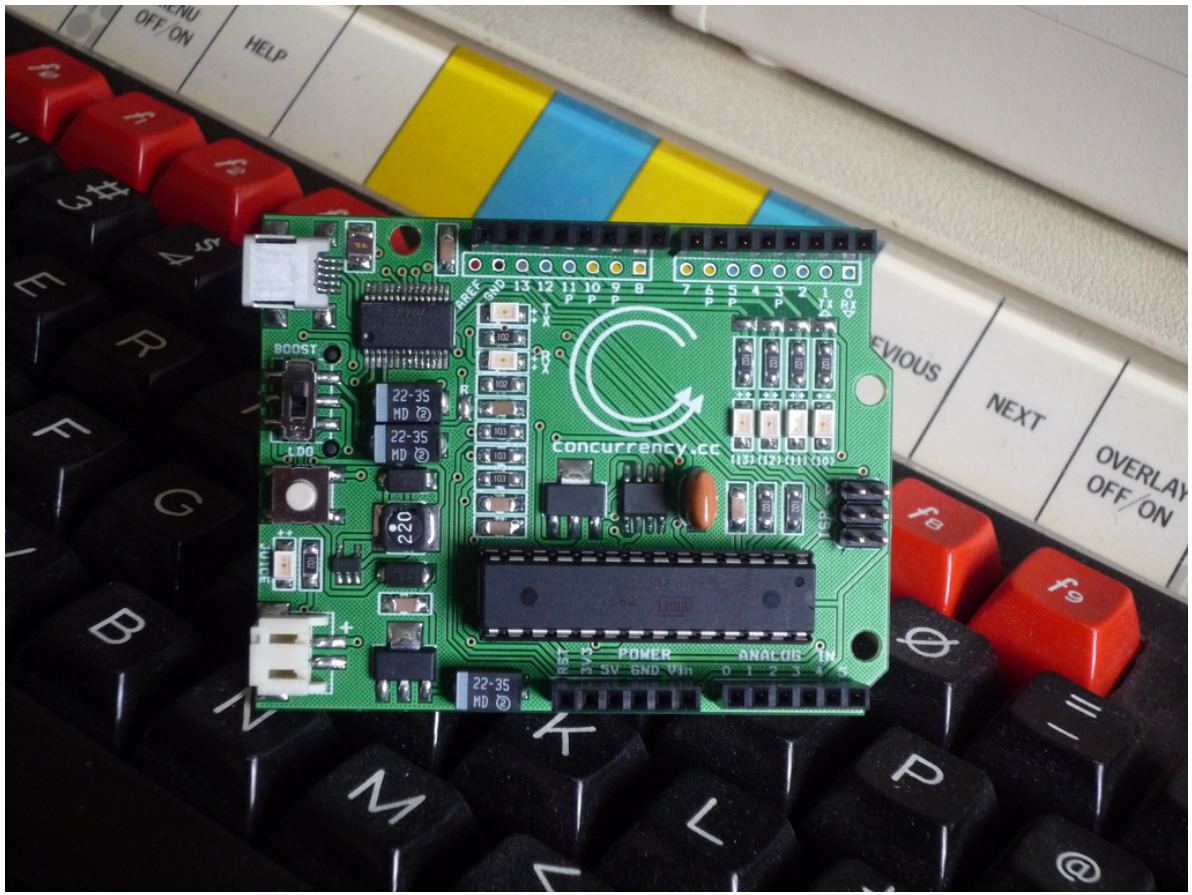


Figure: Concurrency.cc board

The Arduino

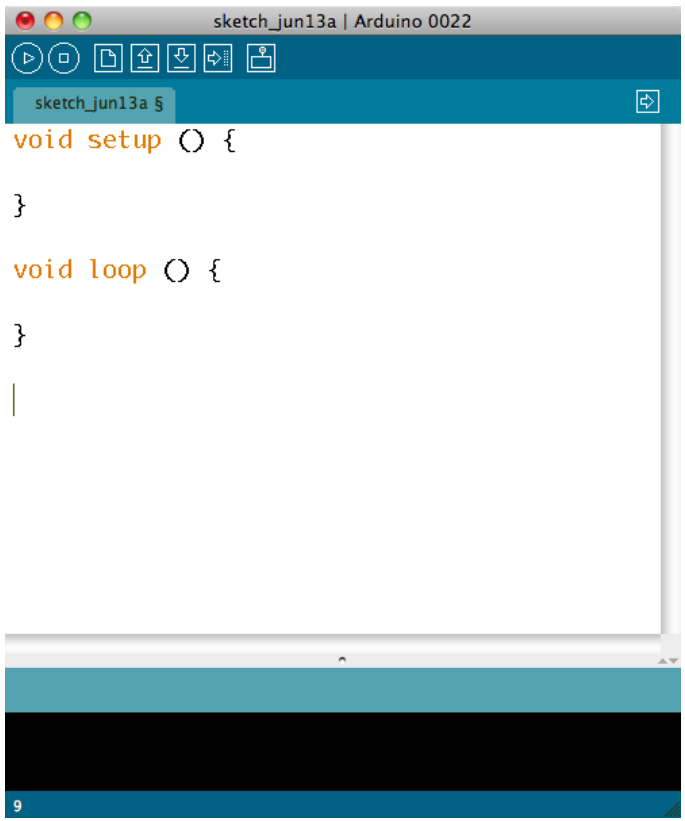
Goals in porting to the Arduino

- Provide challenging environments for exploring concurrent control.
- Provide authentic educational context for learning about concurrency.
- Increase project awareness by engaging a large community of artists and makers.

The Arduino

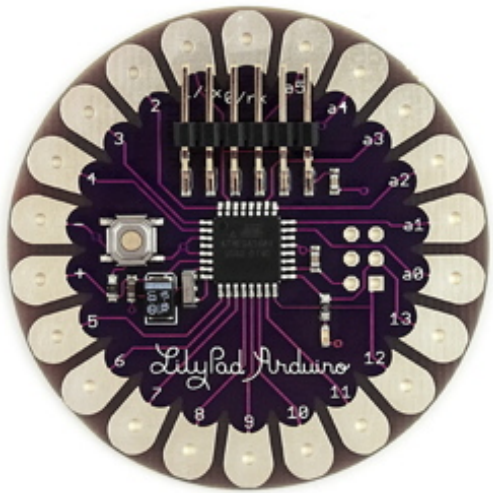
The IDE is key

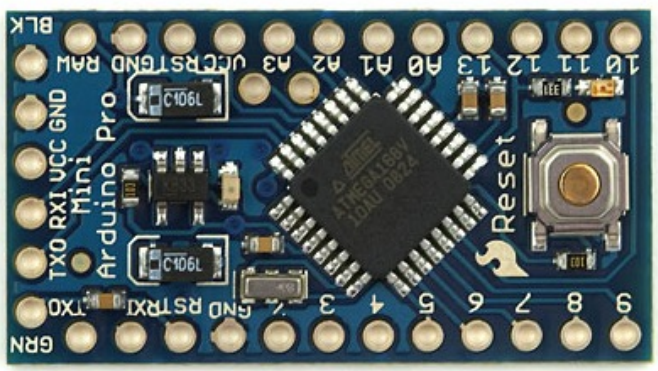
An IDE with a simplified hardware programming model and libraries to support the platform are a critical part of adoption and learning for newcomers.



The Arduino

Variants, community, businesses





sparkfun ELECTRONICS

A Program

How do we code for the Arduino?

A Program

In C

```
boolean state[4] = {false, false, false, false};
unsigned long prev = 0;

void setup () {
  Serial.begin(9600);
  for (int i = 0; i < 4; i++) {
    pinMode(10+i, OUTPUT);
  }
}

void toggle (int pin) {
  boolean val = state[pin - 10];
  digitalWrite(pin, !val);
  state[pin - 10] = !val;
}
```

A Program

In C

```
void loop () {
  unsigned long time = millis();

  if (time != prev) {
    if ((time % 200) == 0) { toggle(13); }
    if ((time % 300) == 0) { toggle(12); }
    if ((time % 400) == 0) { toggle(11); }
    if ((time % 500) == 0) { toggle(10); }
    prev = time;
  }
}
```

A Program

In occam

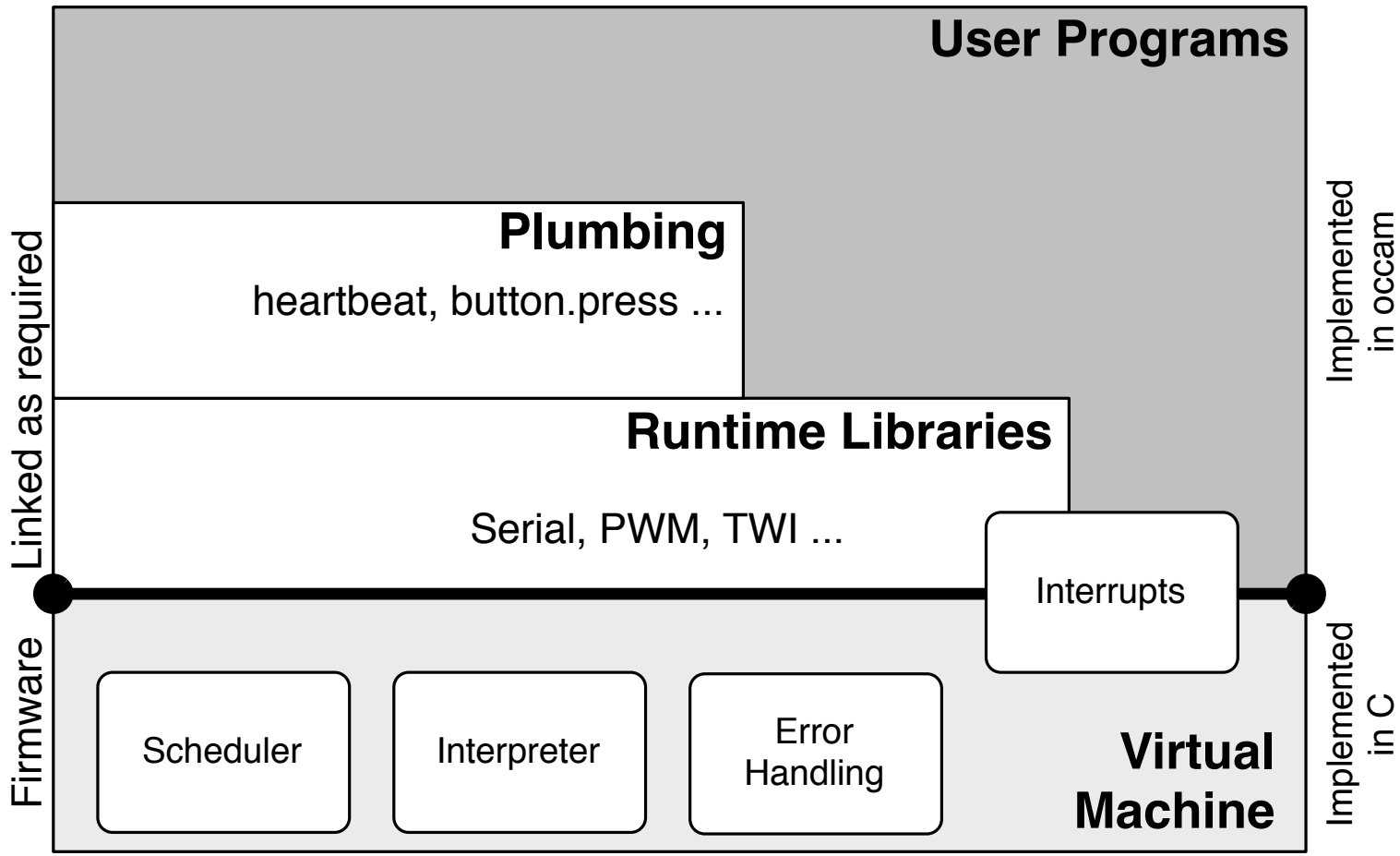
```
#INCLUDE "plumbing.module"

PROC main ()
  PAR
    blink (13, 500)
    blink (12, 400)
    blink (11, 300)
    blink (10, 200)
:
```

Implementation

How do we run on the Arduino?

Implementation

... in one slide...



Interrupts

Interrupts

```
INITIAL INT vintr IS (-1):
SEQ
  set.interrups (avr.pin, vintr)
  WHILE TRUE
    ...
    wait.for.interrupt (vintr, any)
    ...
```

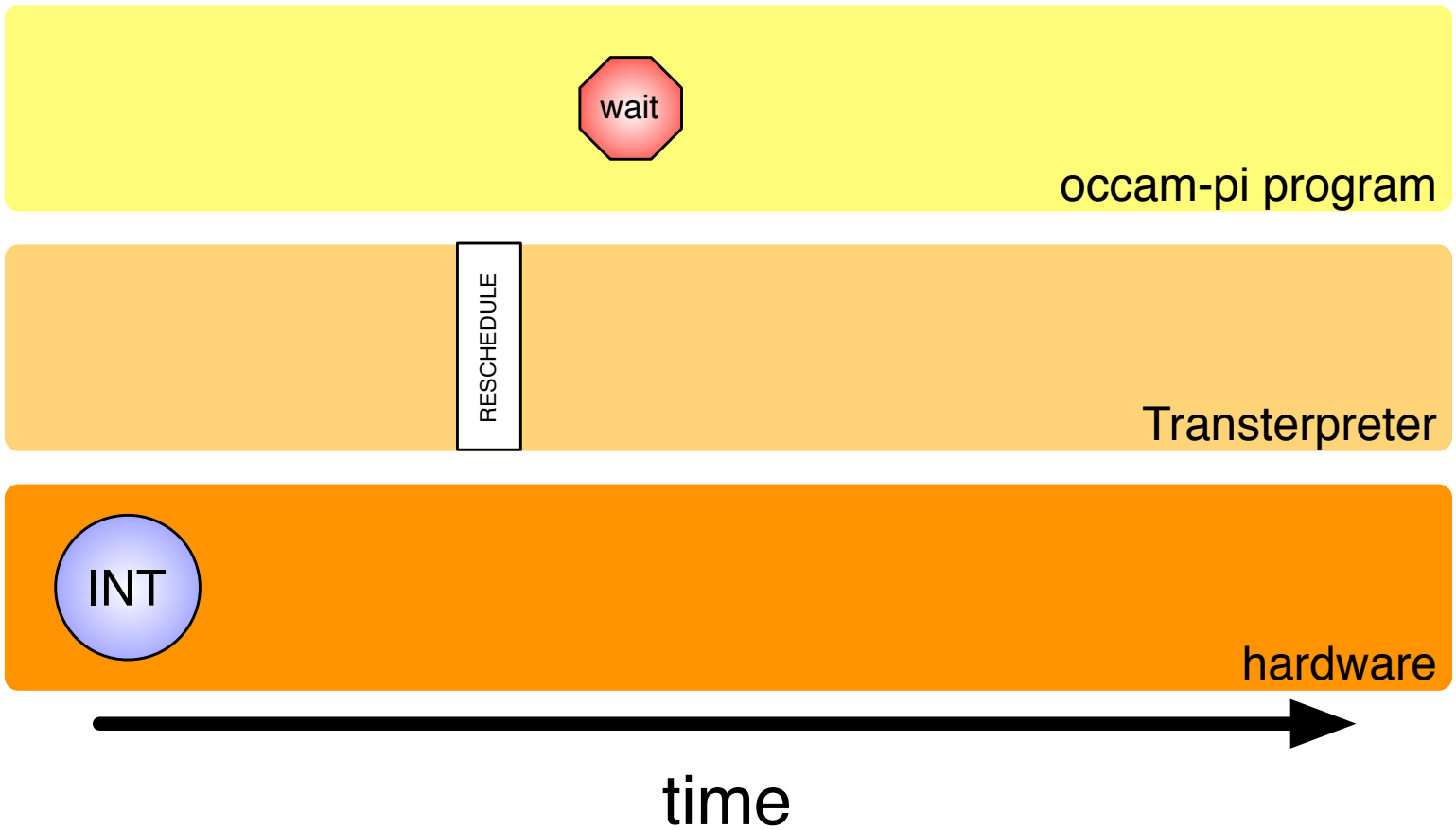
Interrupts

Power Consumption

- The VM is not busy-waiting for external events
- It can tell if there is nothing to run (but there are processes waiting on timers or interrupts)
- The VM can then enter one of the AVRs power down modes automagically

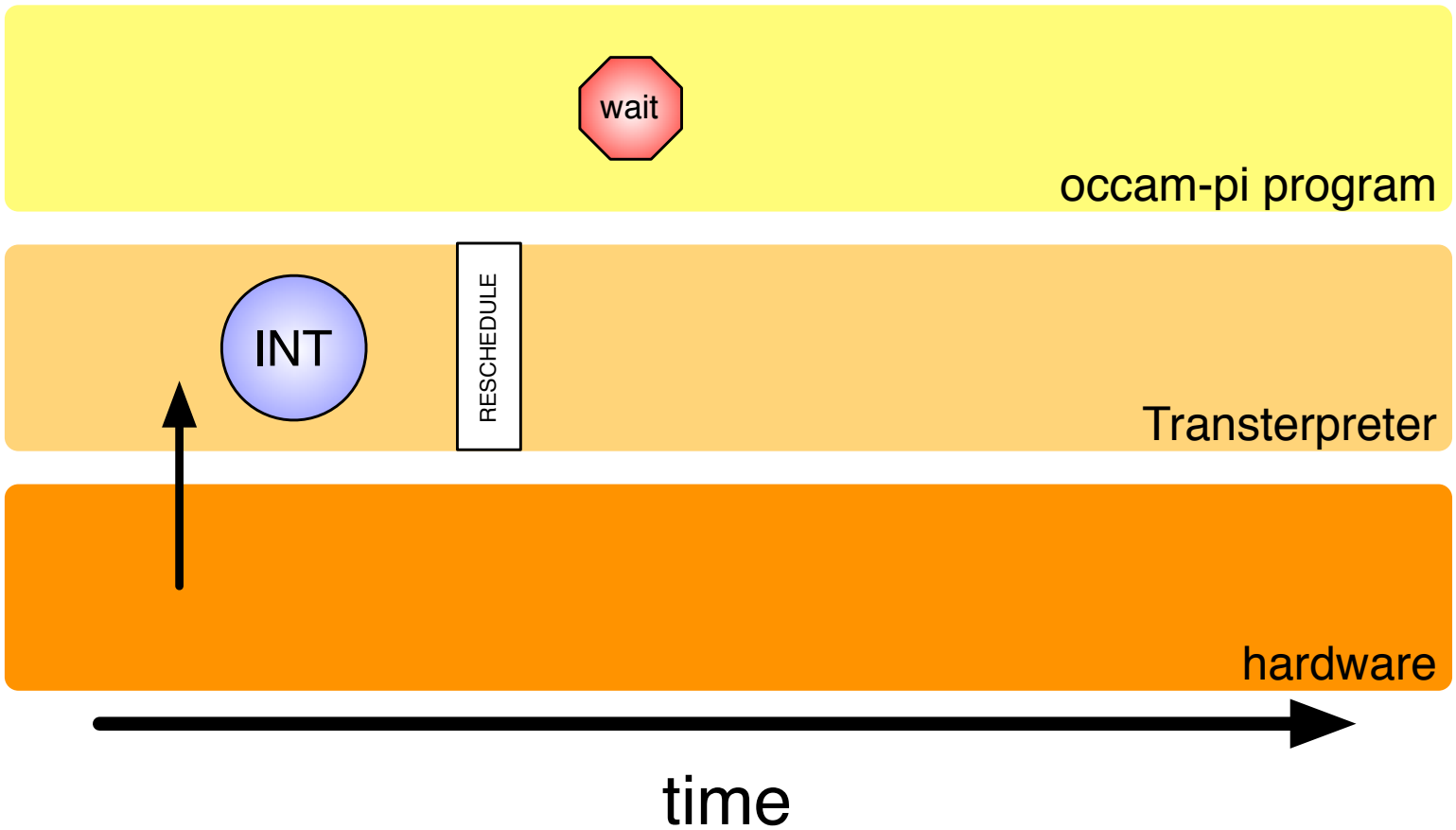
Interrupts

A hardware interrupt is raised.



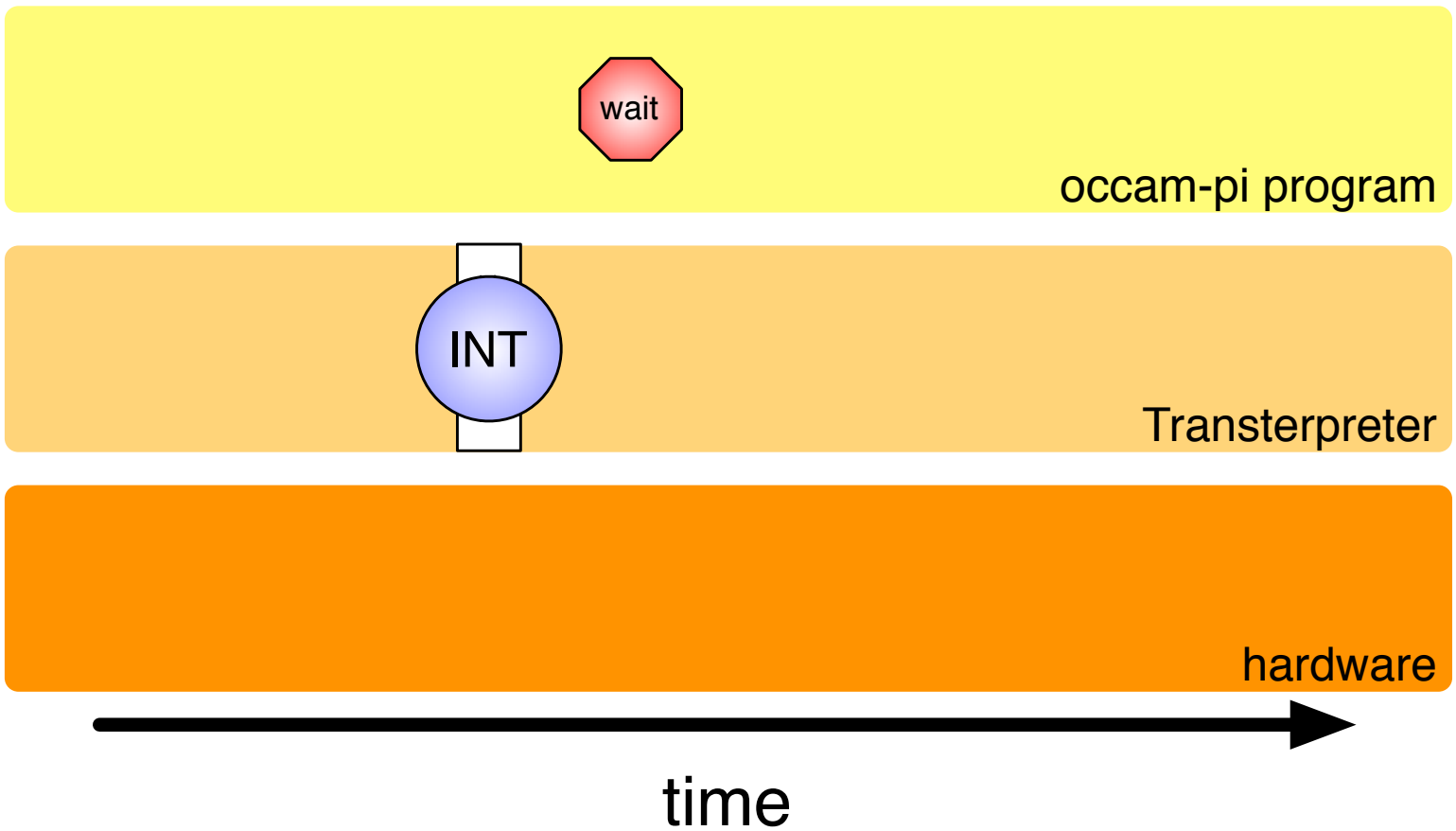
Interrupts

It is lifted into a "soft interrupt" in the VM.



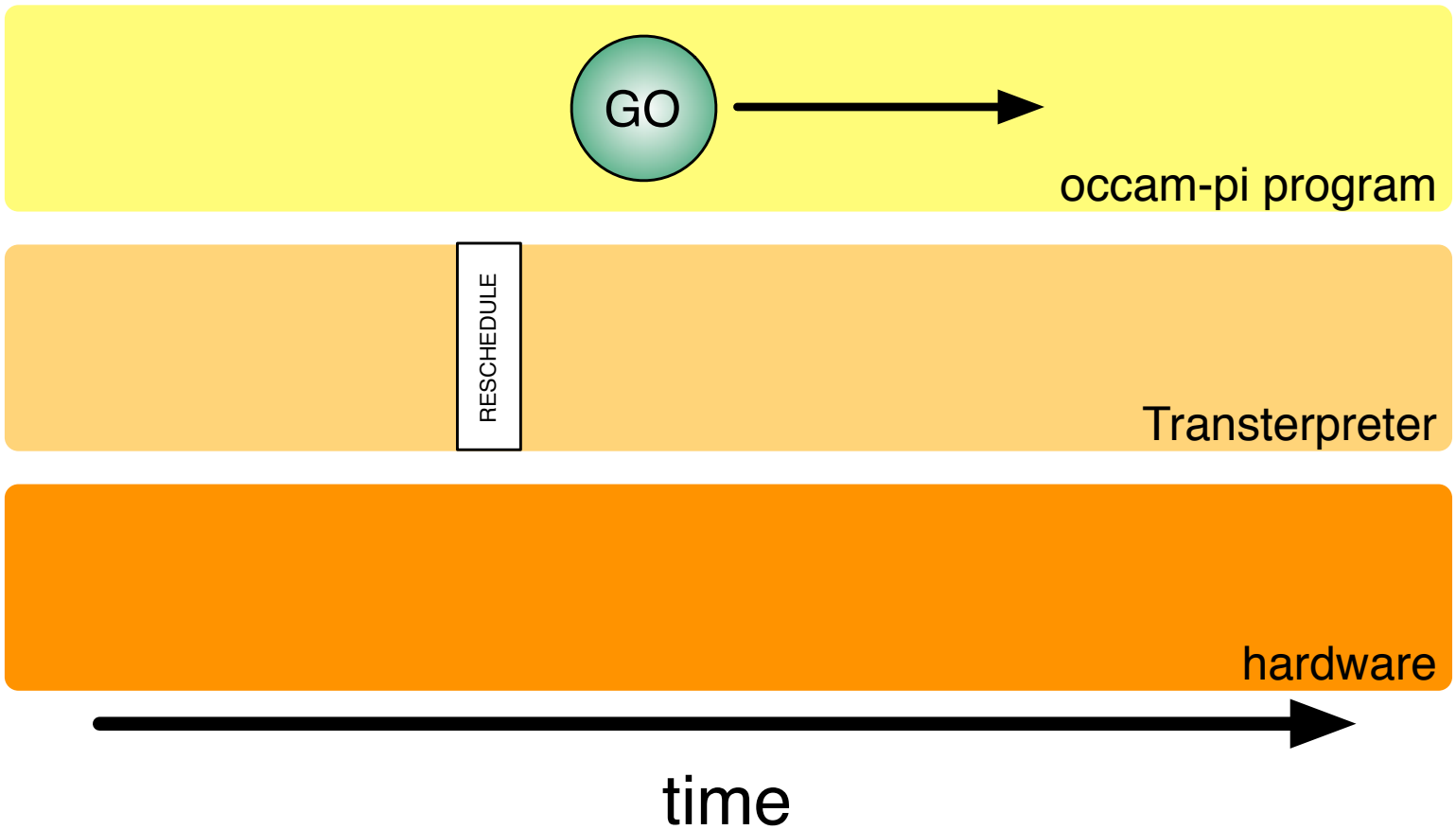
Interrupts

A natural occam-pi rescheduling point is reached.



Interrupts

`wait.for.interrupt` is unblocked.



Monitoring Room Usage

Monitoring Room Usage

Context

- 25 Environmental Science students.
- Goal: Build, deploy, and analyze results from a sensor.
- Time: 4 weeks to design, prototype, develop, and ship.

Monitoring Room Usage

Sensor

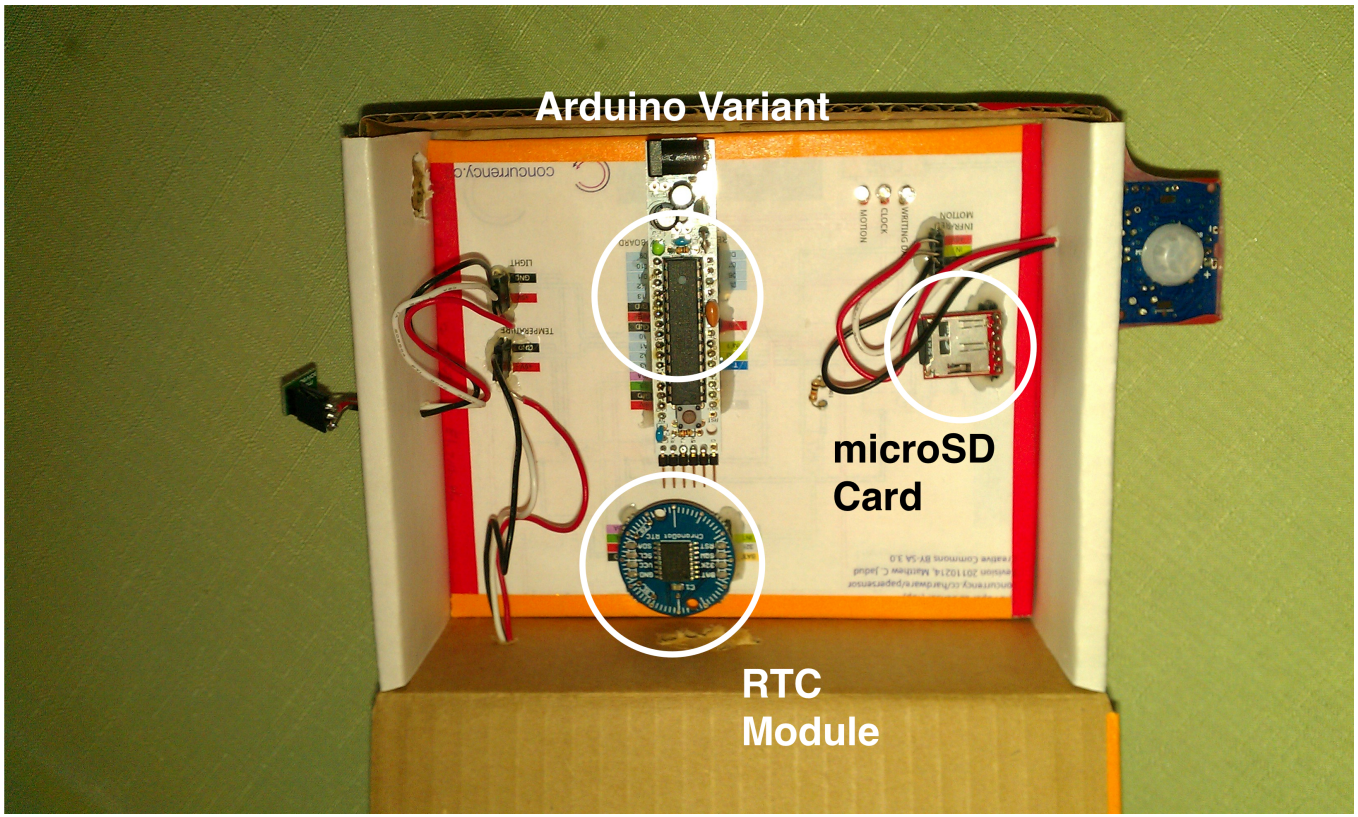


Figure: The Environmental Sensor

Question

How much energy is wasted by lighting in empty rooms?

Answer

Up to 47%.

Outcome

Changes to automation configuration and future building configuration.

Monitoring Room Usage

The role of interrupts

Motion detection.

A $7 passive IR motion sensor used to indicate room occupancy.

Scheduled readings.

A $15 real-time clock module to schedule periodic checks of light levels in the room.

Design pattern.

A data collection pipeline with two possible triggers.

Conclusions and Future Work

We have:

- occam-pi on a cheap popular piece of hardware
- interrupts exposed to the user
- high level plug-and-play interface (Plumbing)
- small case studies

And want to look more at:

- power consumption
- performance
- bigger cases
- plug-and-play programming

Q & A

Thanks for listening.