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

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Overview

1 Introduction

- 2 The Arduino
- **3** Implementation
- 4 Implementation
- **5** Interrupts
- 6 Case Study: A Room Usage Monitor
- **7** Conclusions and Future Work

8 Questions

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Introduction

A very brief history occam

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

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The Arduino Hardware

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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/I²C, 14 GPIO

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A very brief overview



Figure: The Arduino, an open hardware platform.

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6 / 30

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A very brief overview



Figure: Concurrency.cc board

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7 / 30

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.

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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.



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Variants, community, businesses









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A Program How do we code for the Arduino?

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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;
}
```

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A Program

```
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;
```

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13 / 30

A Program In occam

#INCLUDE "plumbing.module"

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

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 14 / 30

Implementation

Implementation How do we run on the Arduino?

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Implementation

... in one slide...



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16 / 30

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Interrupts

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

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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

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A hardware interrupt is raised.



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20 / 30

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



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21 / 30

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A natural occam-pi rescheduling point is reached.



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22 / 30

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wait.for.interrupt is unblocked.



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Monitoring Room Usage

Monitoring Room Usage

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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.

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Monitoring Room Usage Sensor



Figure: The Environmental Sensor

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26 / 30

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Monitoring Room Usage Results

Question

How much energy is wasted by lighting in empty rooms?

Answer

Up to 47%.

Outcome

Changes to automation configuration and future building configuration.

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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.

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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

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29 / 30

Q & A

Thanks for listening.

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