Tock Operating System

Safety without Processes for Embedded Systems

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ACCU-CHEK®
Aviva Combo
Last 8 hours
Overall
2 Feb 08
20:06 3.8 66
17:33 7.0 60
16:06 8.6 20
13:52 3.3 60
Back
Graph
nest
V51/IS-1
Sulzer Intermedics
ANGLETON, TEXAS
AXIUS SR
Model 292-65
AAIR VVIR
PHILIPS

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- Sub-1*mA* average current draw
- Order of millisecond timing constraint (O(10000 cycles))

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achieved (primarily) by using a safe language to isolate components in the kernel

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Think Ruby on Rails for your defibrilator

How do we build embedded systems?

1. Build a platform

- MCU
- Radio
- Sensors
- Actuators

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Each platform is a unique snowflake

2. Choose an ”OS”

- Arduino
- TinyOS
- FreeRTOS

3. Pull in drivers for the platform

- Bluetooth driver from Nordic
- 802.15.4 driver from Thingsquare
- Temperature sensor driver from Adafruit

4. Build application(s) on top

5. Optimize for !security

Often modifications to the whole stack to get better performance and energy consumption

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i.e. built from reusable components

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= Bugs, exploits, meyham

Reusing components is a GOOD thing!

- Less engineering effort
- Fewer bugs overall
- Better interoperability
- Don’t roll your own crypto
- ...

What happens when there *is* a bug?

Isolation in operating systems

Typically achieved with a thread/process-like abstraction:

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- Servers in microkernels
- SIPs in Singularity
- HiStar, Docker, etc...
- Hails, Aeolus, etc...

Why processes?

Provides **isolation**

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Provides **concurrency** and **parallelism**

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Convenient to enforce using hardware or language

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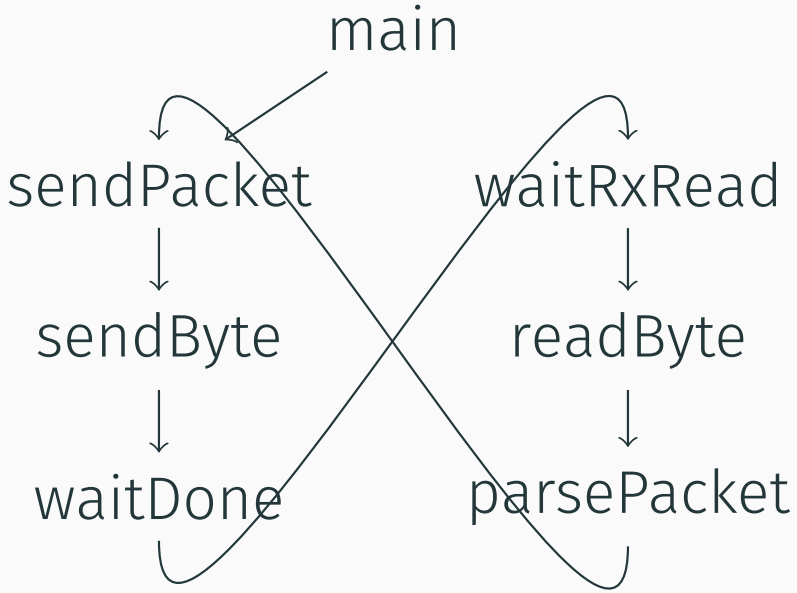
Interaction between components requires communication (message passing, RPC...)

Tradeoff *granularity* for *resources*

What if we give up concurrency?



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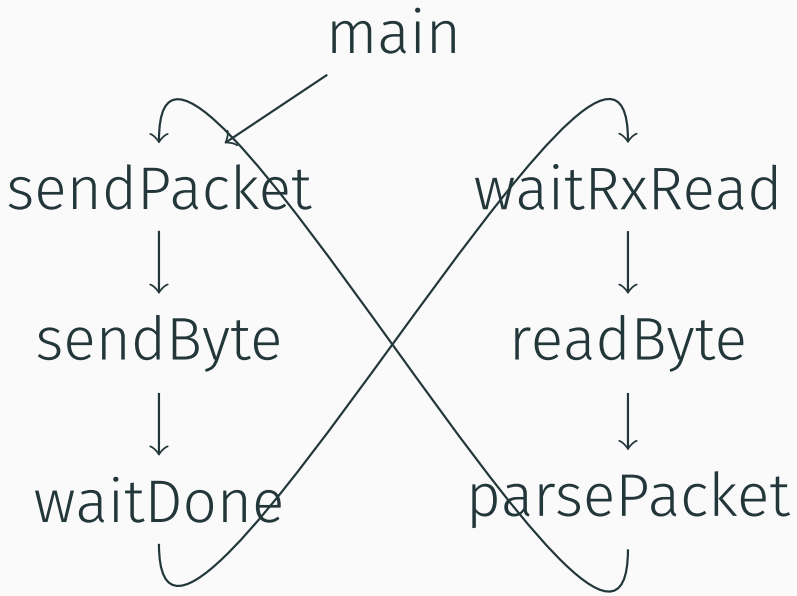

We can isolate components, but we can’t meet timing requirements

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Timing constraints on the order of a few thousand cycles (apprx 1*ms*)

Challenge: How do we isolate concurrent components *without* incurring a memory/performance overhead for each component?

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Key idea: Use a single-threaded event system and isolate using language mechanisms

- Module bounderies
- Strong encapsulation (hidden constructors)
- etc...

Tock Design

An event system:

- Enqueue all hardware interrupts
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Built in Rust: type-safe with no runtime a ”zero-cost” abstractions

Rust manages memory using affine types (ownership) instead of garbage collection

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Most complex components are isolated:

- Peripheral drivers
- Virtualization layers (timers, bus virtualization)
- Applications

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Mutability and circular dependencies don’t mix well:

- Unsafe type coersion
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- Iterator invalidation

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Enforced using Rust's "immutable" references

Tock Implementation

In progress implementations for two platforms:

Firestorm

- SAM4L - 64KB memory
- 802.15.4 and BLE radios
- Sensors - temperature, accelerometer, light intensity

NRF51822

- 16KB memory
- Bluetooth low energy system-on-a-chip

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Performance numbers forthcoming...

Didn’t talk about

Tock also supports a limited number of processes.

- Applications in C
- Legacy drivers

About 8 slots on the SAM4L

Limitations

Legacy code needs to be ported to Rust or take up one of a few processes

Concurrency model does not support parallelism

Conclusion

- Embedded systems need isolation mechanimsms
- Traditional mechanimsms not appropriate
  - Processes: memory overhead
  - Non-concurrent: timing constraints
- Tock is a single-threaded event system
  - Low/no overhead per component
  - Retains concurrency