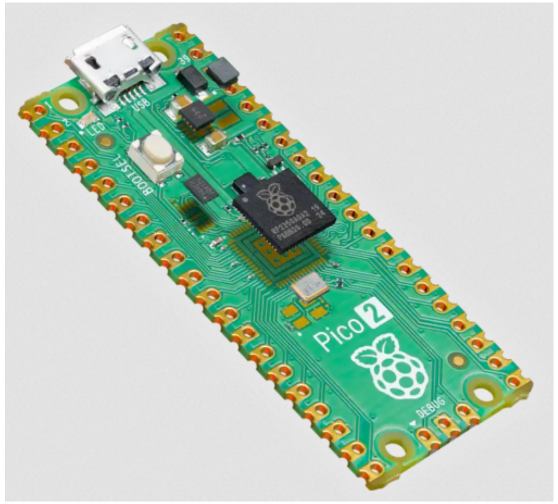
Tock Goes *Multicore*

Gongqi Huang, Princeton 🐯

Multicore MCUs are Useful



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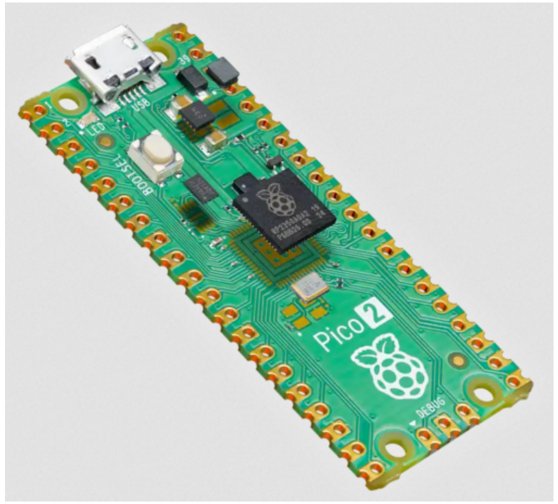

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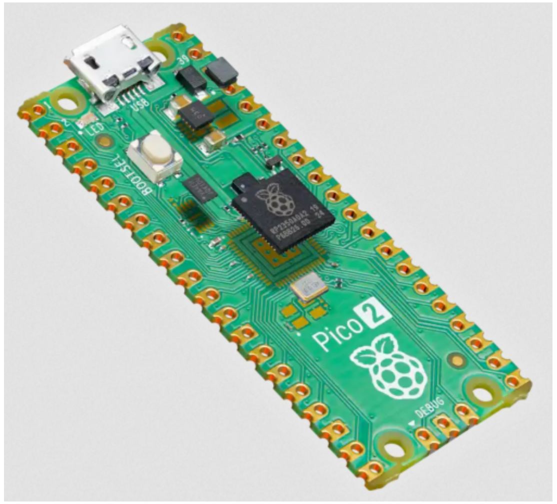

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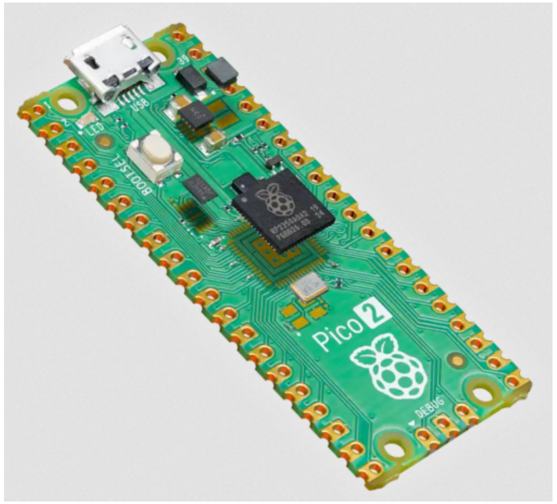

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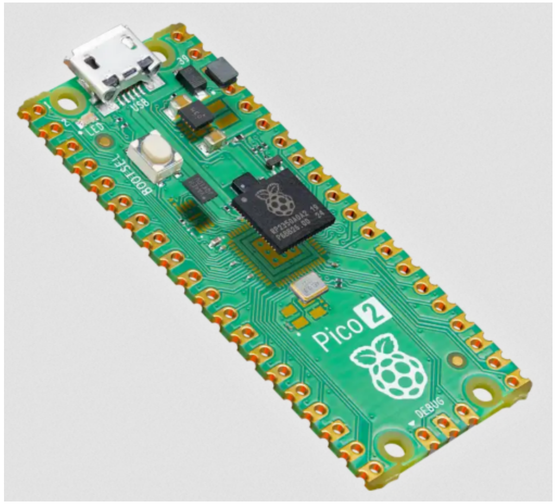

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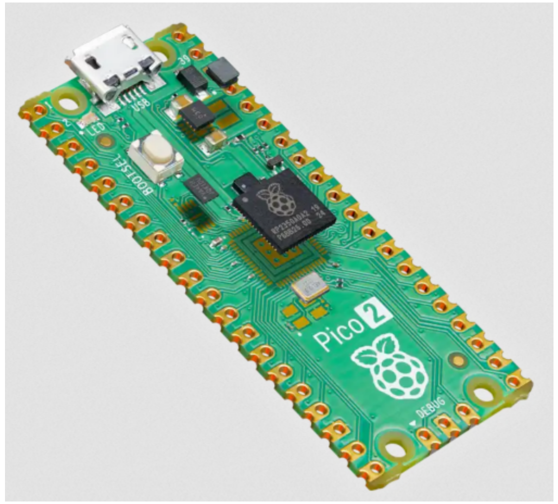
  - Performance boost with hardware parallelism



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- Sharing all (RP2350) or part of peripherals (nRF5340)

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- The single-core assumption manifests in many of Tock's design
  - Use of interior mutability
  - Single-threaded asynchronous drivers
  - …

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  - Security
    - Capsules are fully trusted to maintain liveness of the system
    - Not necessary in a multi-core setting

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- Avoiding deadlocks and contention
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- Predictable resource utilization
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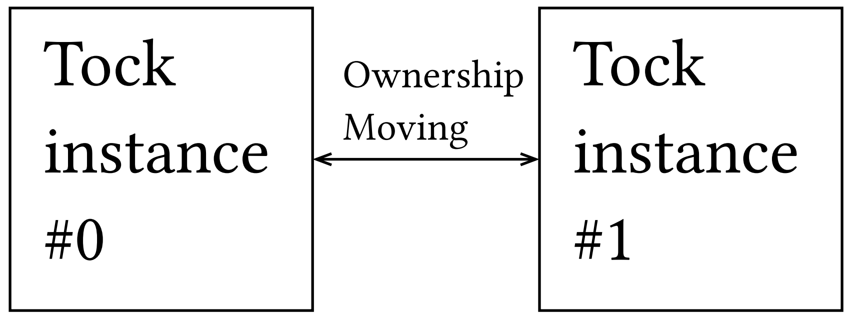
- Isolation between process, capsules, and kernel
  - Maintain the soundness of Rust
- Easy-to-write device drivers
  - No concurrent state

Multikernel Tock

Architecture



Architecture

- Each instance manages an *exclusive* set of peripherals
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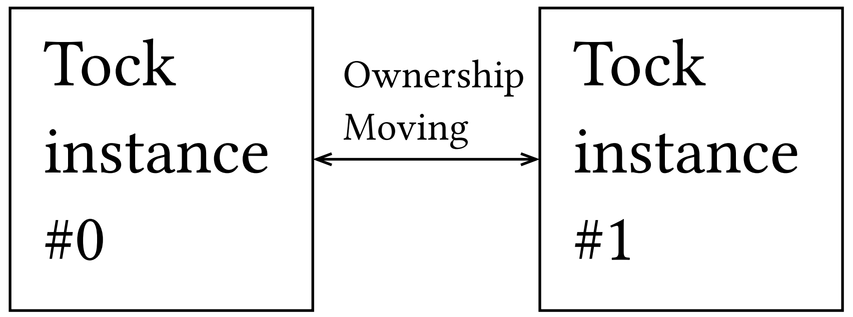

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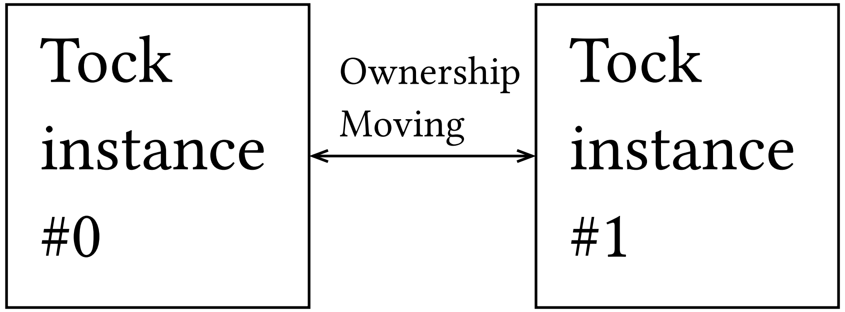

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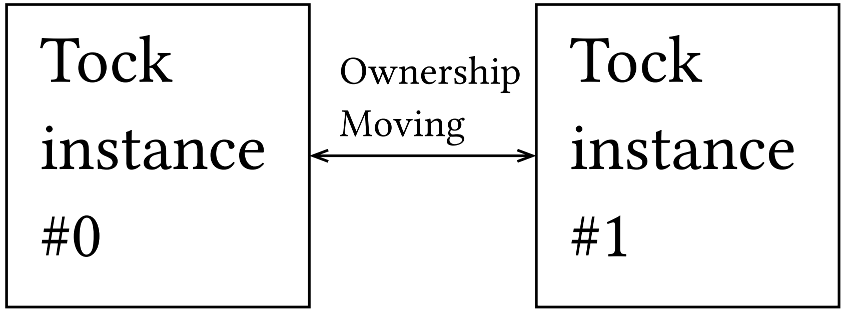

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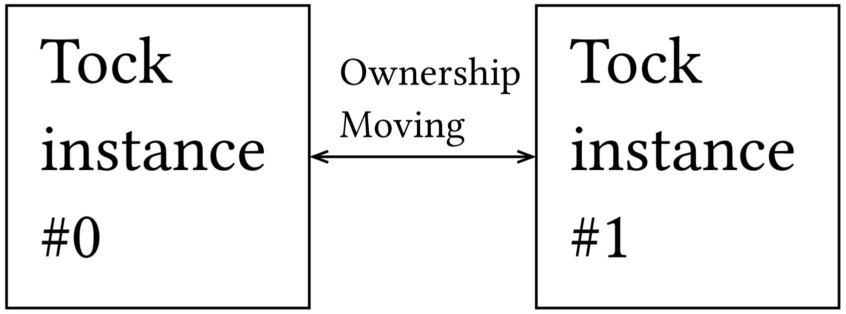

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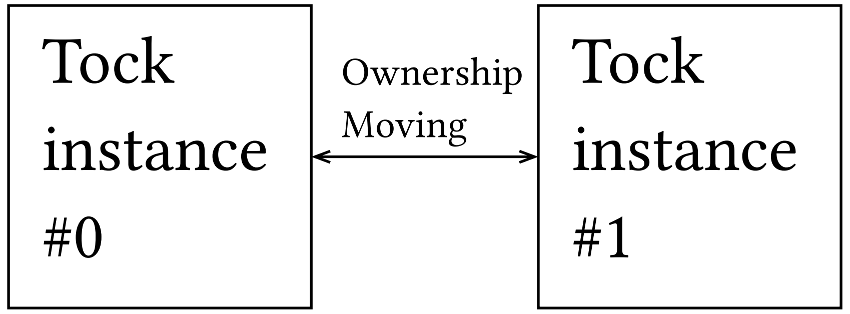

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  - Retain *a*
- Ownershi
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    - *Bring*
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ck
stance

Runs on

- QEMU RISC-V Dual-Core Configuration
- Custom Dual-Core VexRiscv LiteX SoC

Teleporting Ownership with Care

```rust
pub trait Portal<'a, T: Send> {
…                                      …
    fn teleport(
        &self,
        traveler: &'static mut T,
    ) -> Result<(), (ErrorCode, &'static mut T)>; }
```

Teleporting Ownership with Care

1. Traveler must implement `Send`

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Teleporting Ownership with Care

1. Traveler must implement `Send`
2. `&mut T` is `Send` when `T: Send`
3. A Tock instance is a `'static` “thread”

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Teleporting Ownership with Care

- Receiving the `traveler` back through callbacks

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```rust
pub trait Portal<'a, T: Send> {
    fn set_portal_client(&self, client: &'a dyn
    PortalClient<T>);
…                                          …
```

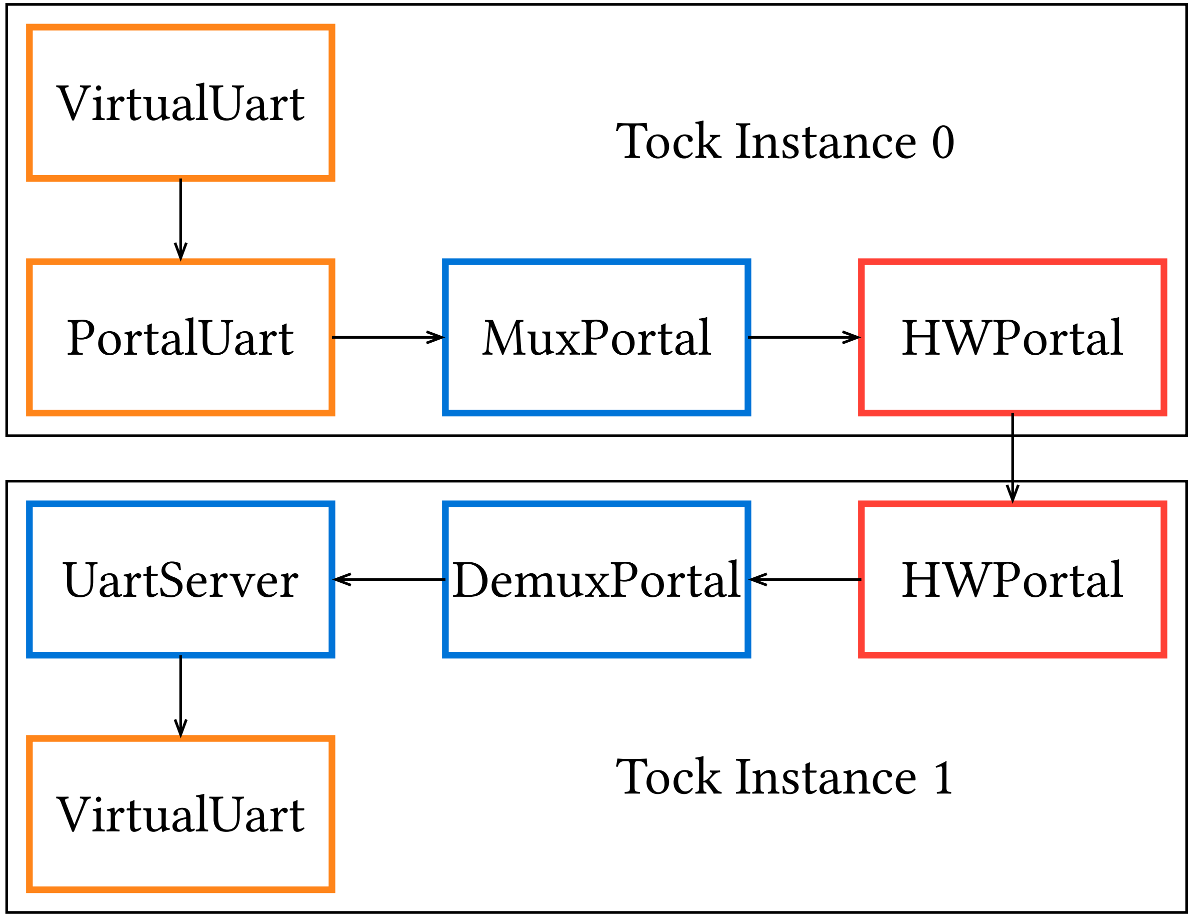
```rust
pub trait PortalClient<T: Send> {
    fn teleported(
        &self,
        traveler: &'static mut T,
        rcode: Result<(), ErrorCode>, ); }
```

Example: Sharing UART Through RPCs

🟧 `impl Uart`

🟦 `impl Portal`

🟥 `impl Portal` with `unsafe`



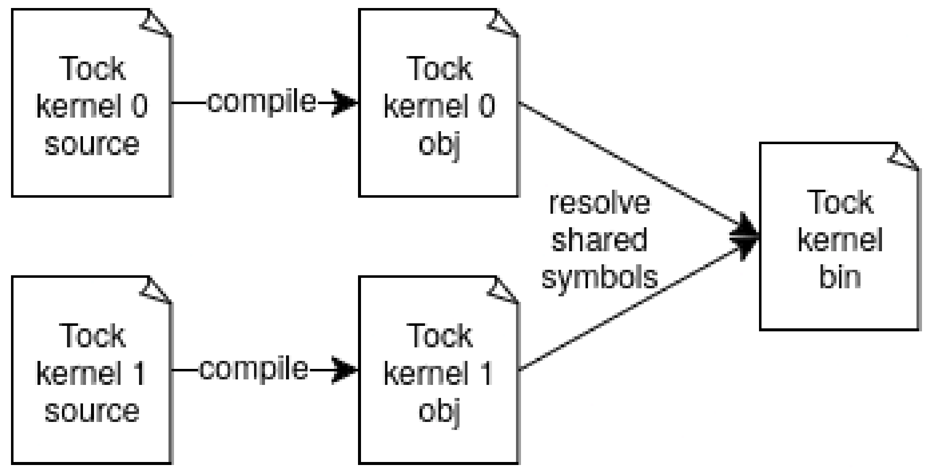
Sharing Raw Peripherals

- `Portal` permits transferring ownership of a raw device
  - E.g., Memory-mapped controller

Sharing Raw Peripherals

- `Portal` permits transferring ownership of a raw device
  - E.g., Memory-mapped controller
- Problem: *when* it is safe to transfer?
  - E.g., UART in the middle of a transmission
  - Currently unsupported :*(

Building Multikernel Tock



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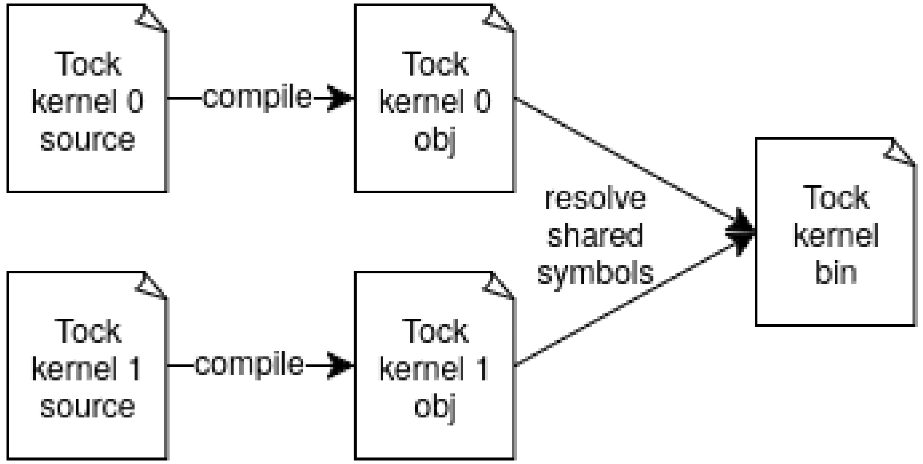

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- Build each kernel instance separately
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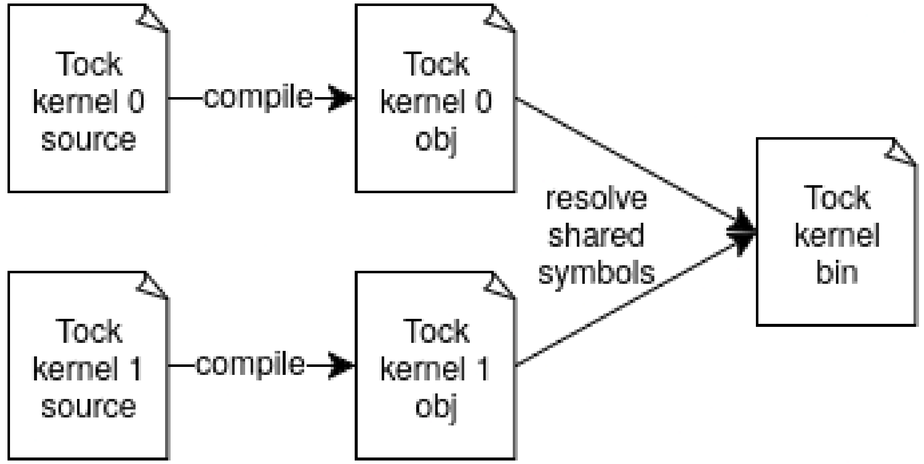
  - Hardware portals communicate through shared memory



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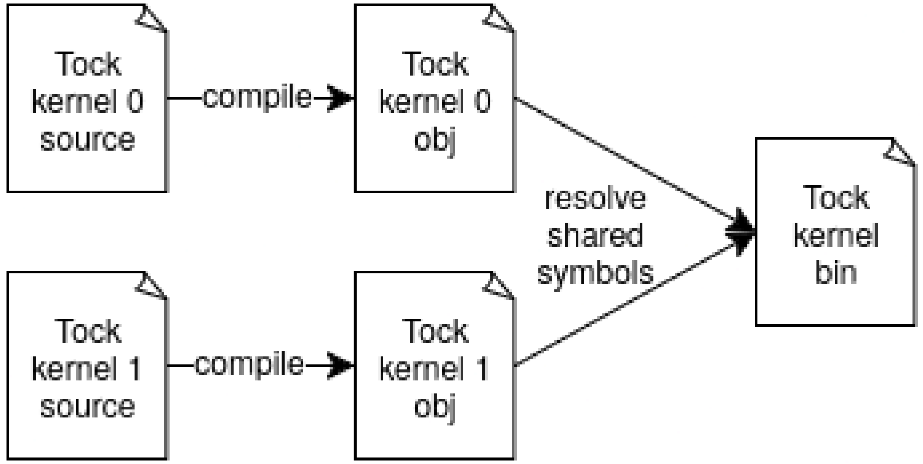
- Prepare the final image (board-dependent)



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  - Instance 0 is responsible for the shared memory
- `Portals` are available *iff all instances are ready*
  - A (one and only) spin lock is used

Future Work

- Safely sharing physical devices
  - *When* it is OK to move a device?
- Process Migration?

Questions?