Threads

Aaron Turon

Systems programming without the hassle

Systems programming without the hassle

crashes

heisenbugs

fear

Parallel!

Systems programming without the hassle

crashes

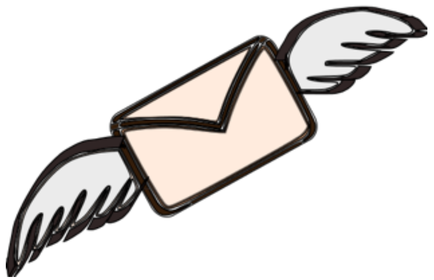
heisenbugs

fear

Concurrency and Parallelism

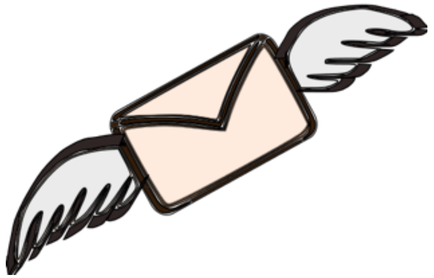
Multiparadigm

Multiparadigm



message-passing

Multiparadigm



message-passing

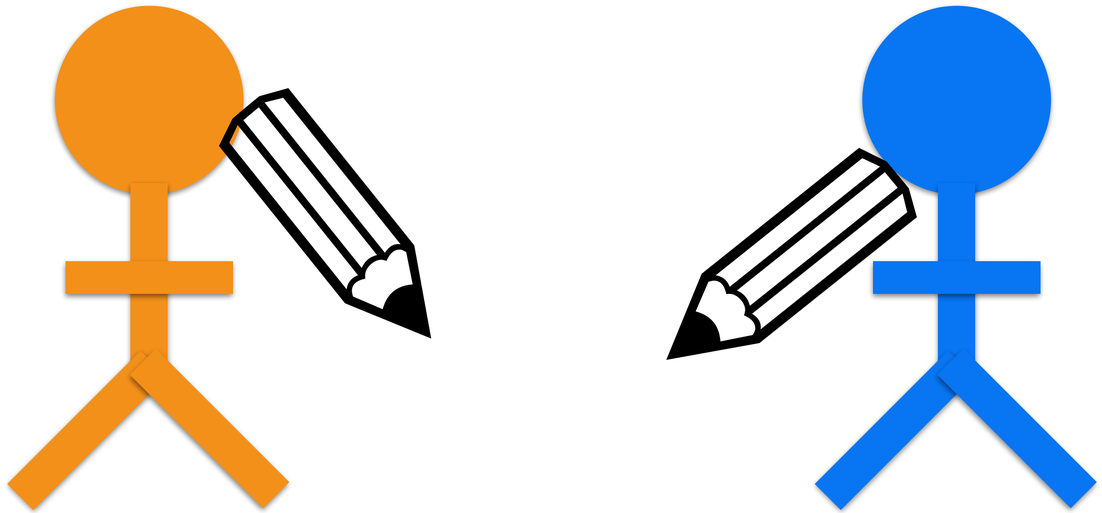
mutable shared memory

No data races,
No matter what.

Data race?

Two **unsynchronized** threads
accessing **same data**
where **at least one writes**.

Data race?



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accessing **same data**
where **at least one writes**.

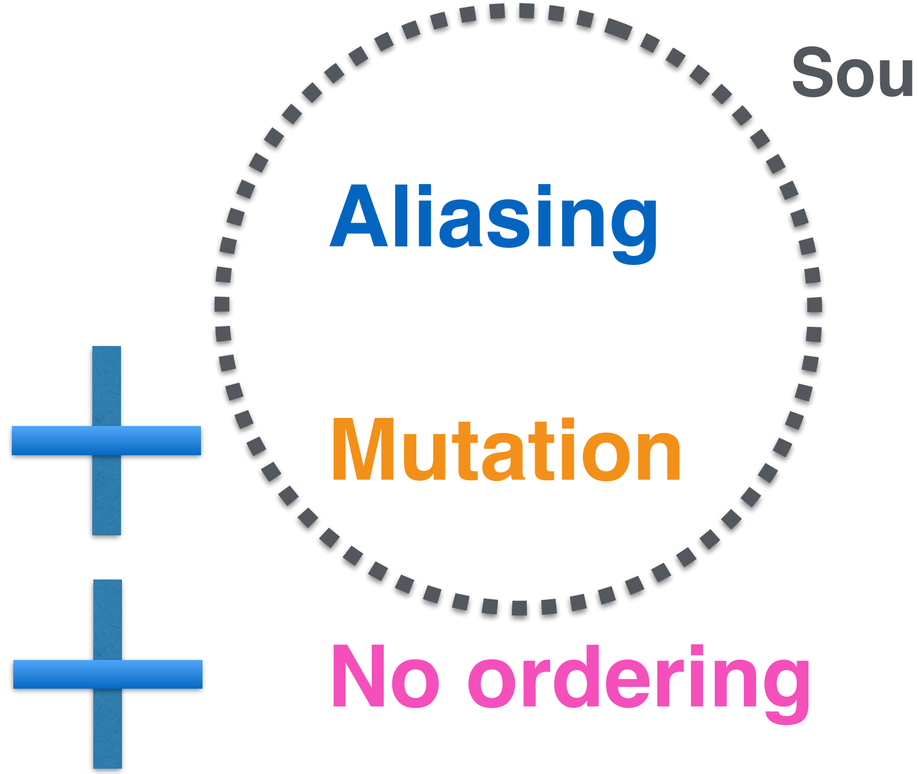
Aliasing

Mutation

No ordering

Data race

Sound familiar?



Data race

No data races =
No accidentally-shared state.

All sharing is explicit!

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No accidentally-shared state.

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```
// Assume some_value: &mut i32

*some_value = 5;
return *some_value == 5;  // ALWAYS true
```

By QuentinUK (Own work), via Wikimedia Commons

Shop till you drop!

$5.0
$25.5
$81.5
$112.0

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$25.5
$81.5
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$5.0
$20.5
$81.5
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$5.0
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XXX

XXX

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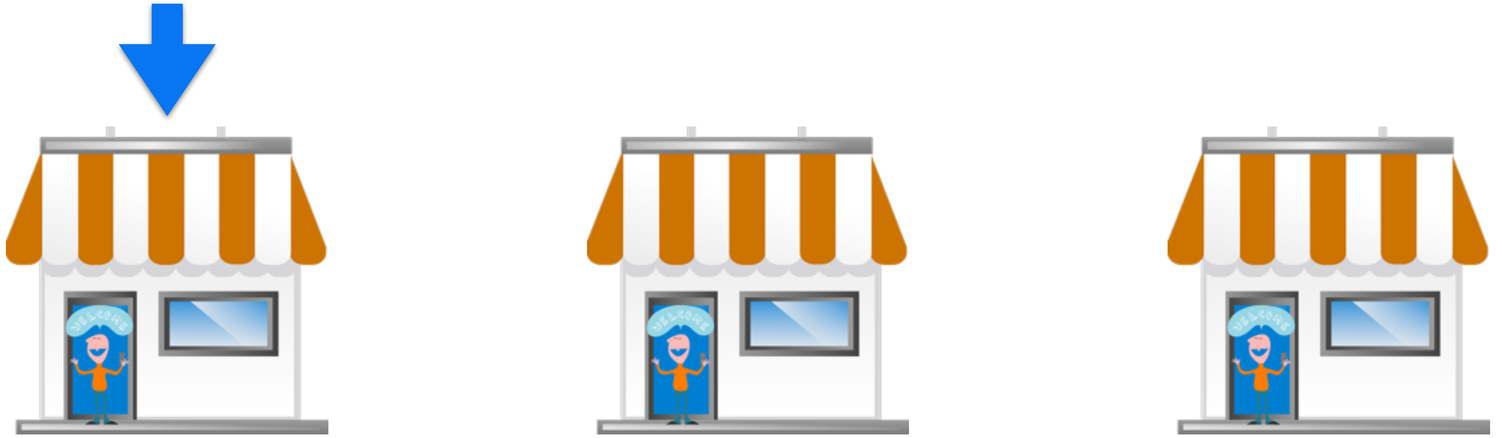

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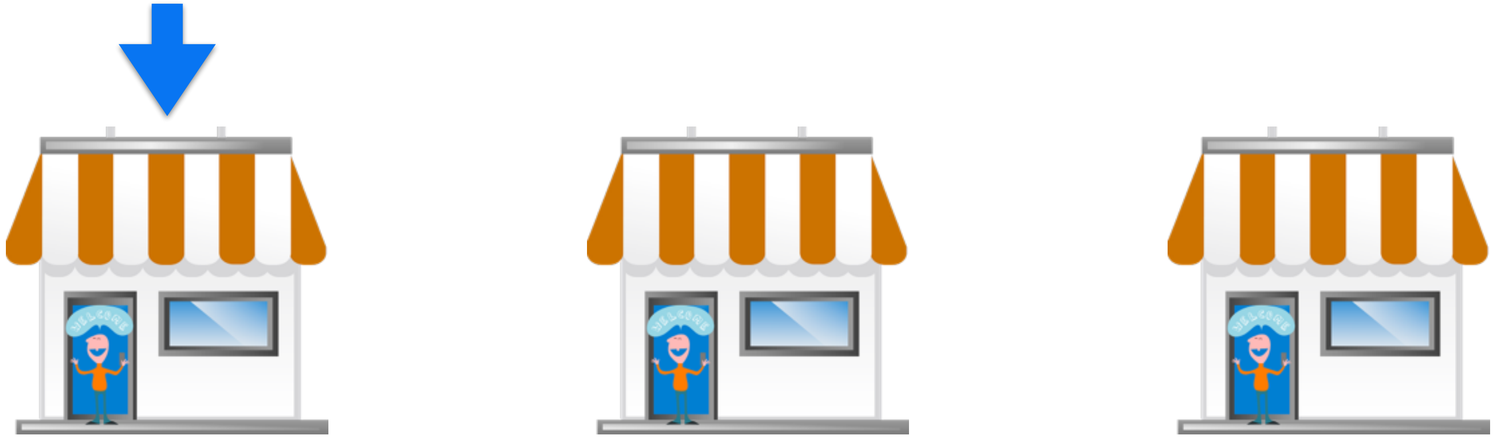

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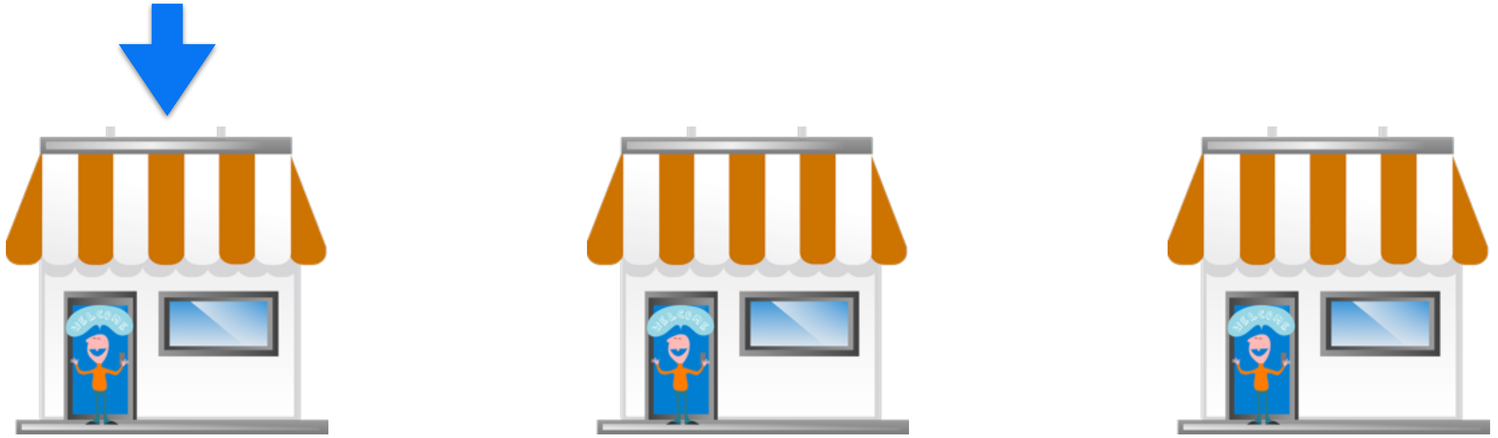

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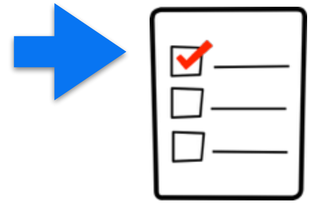

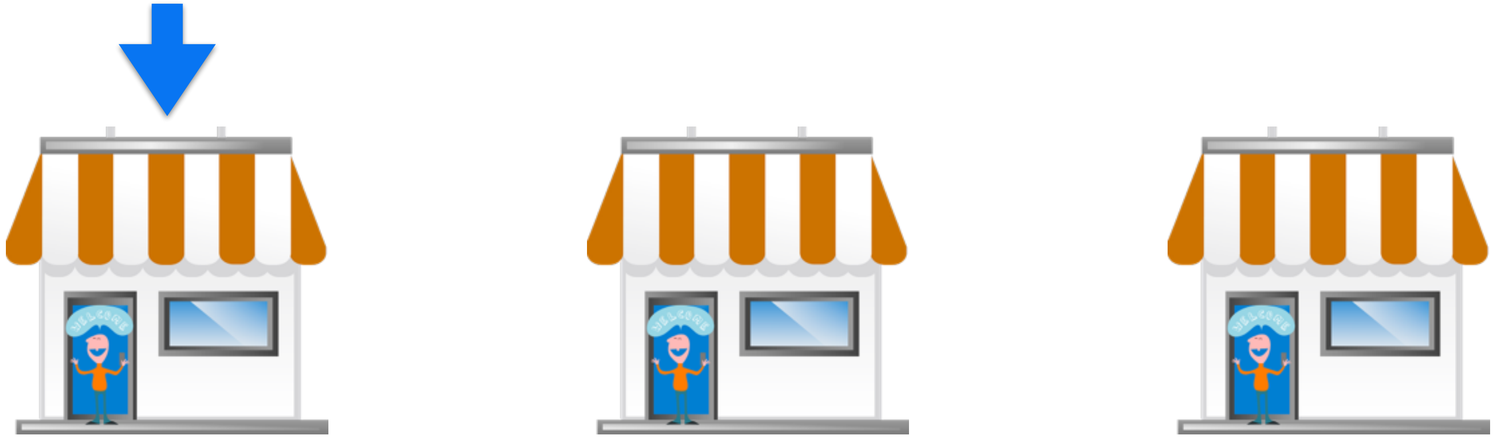

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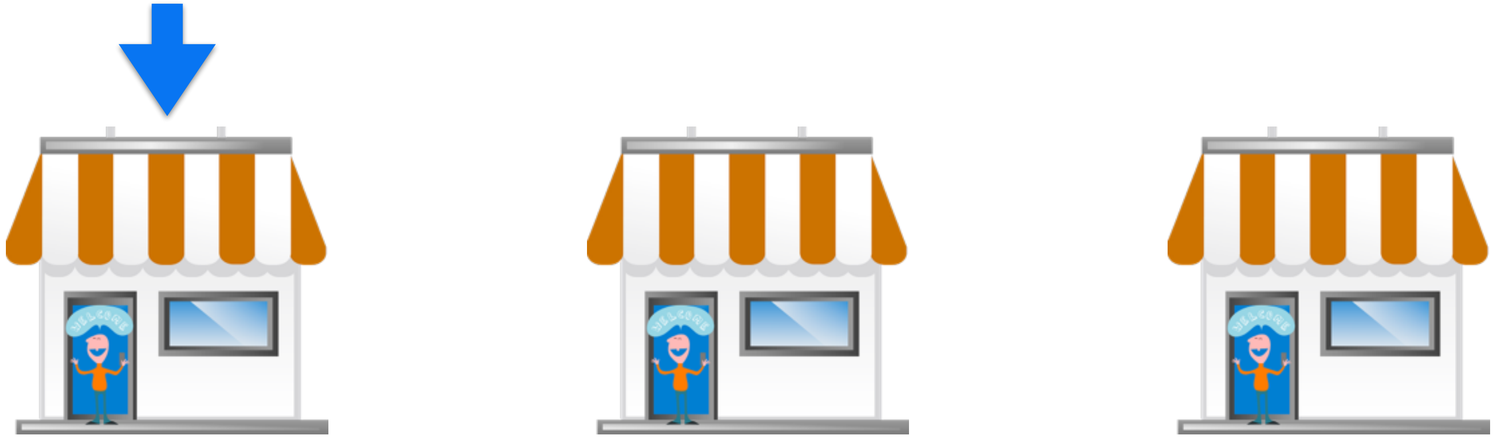

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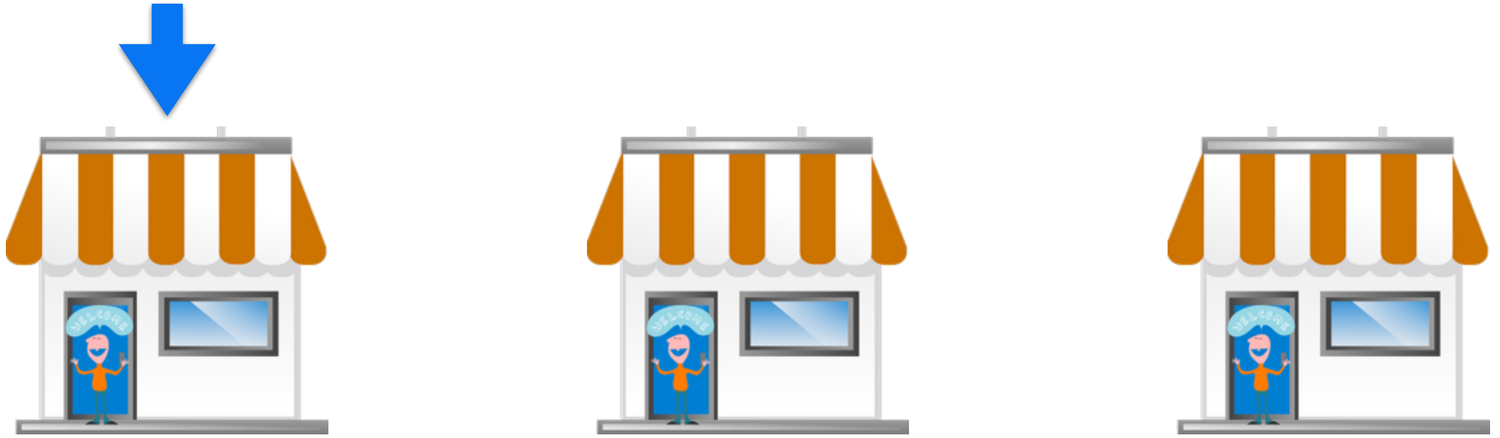

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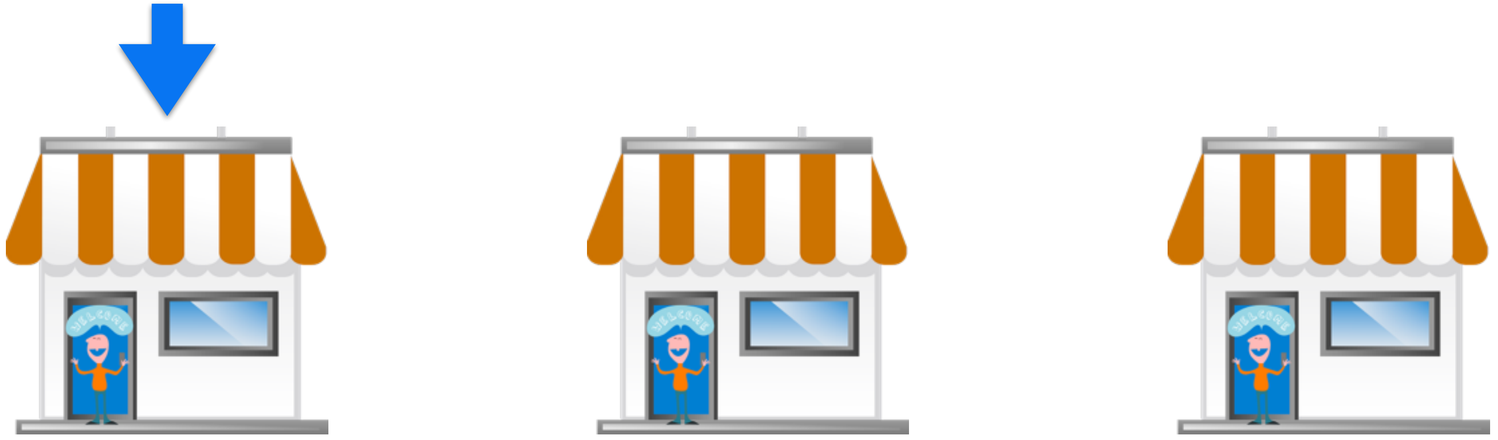

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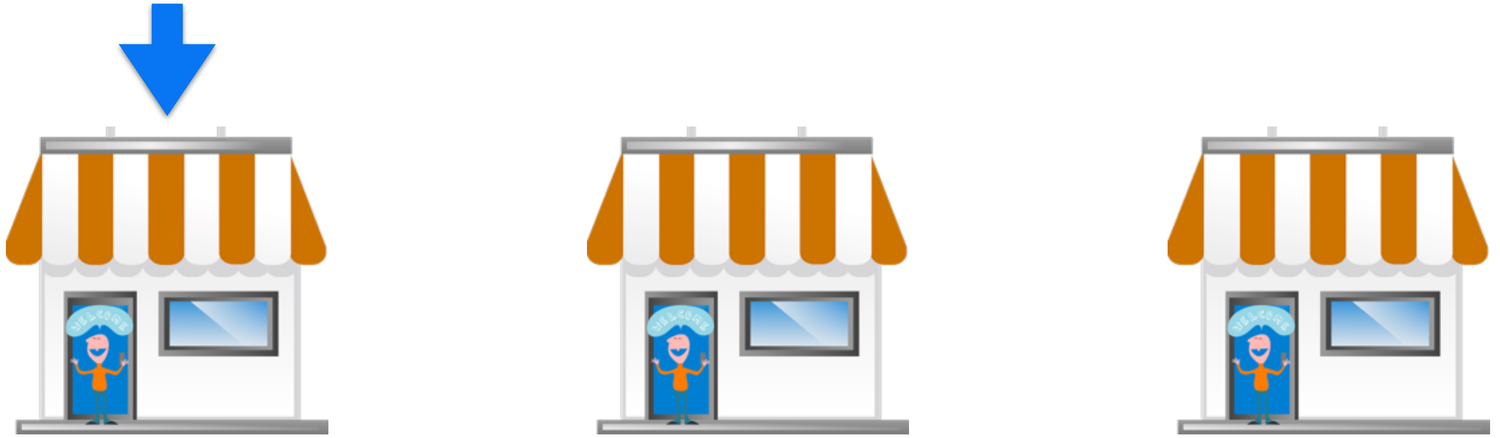

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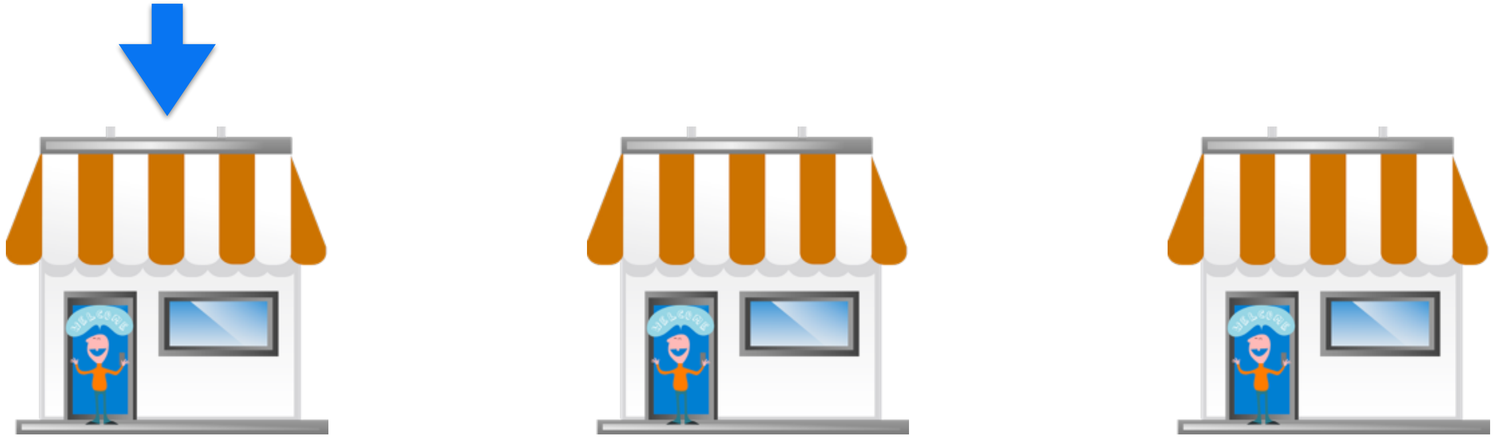

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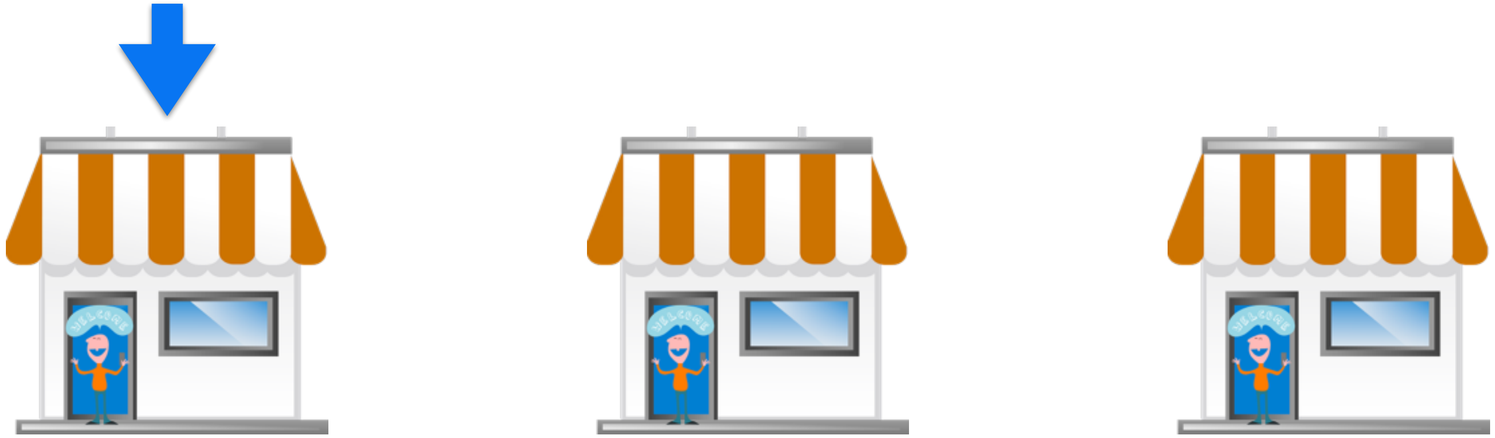

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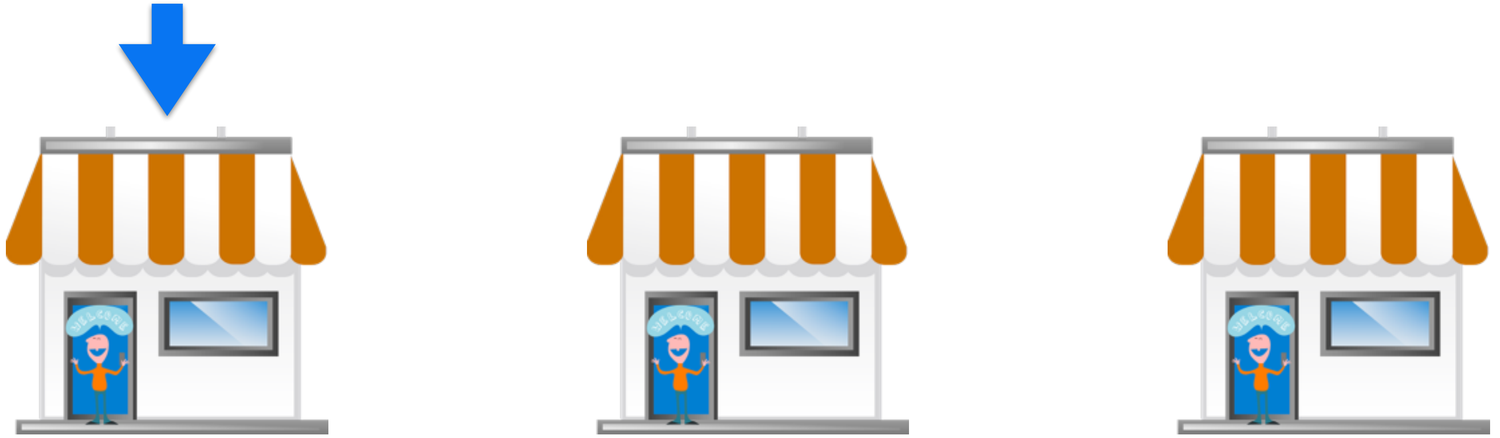

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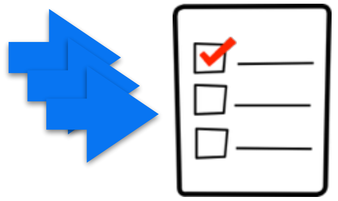

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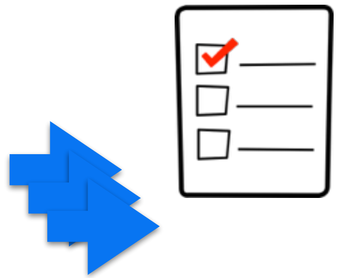

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let mut handles = vec![];
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Closure
takes ownership
of variables it uses.

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Variables used by
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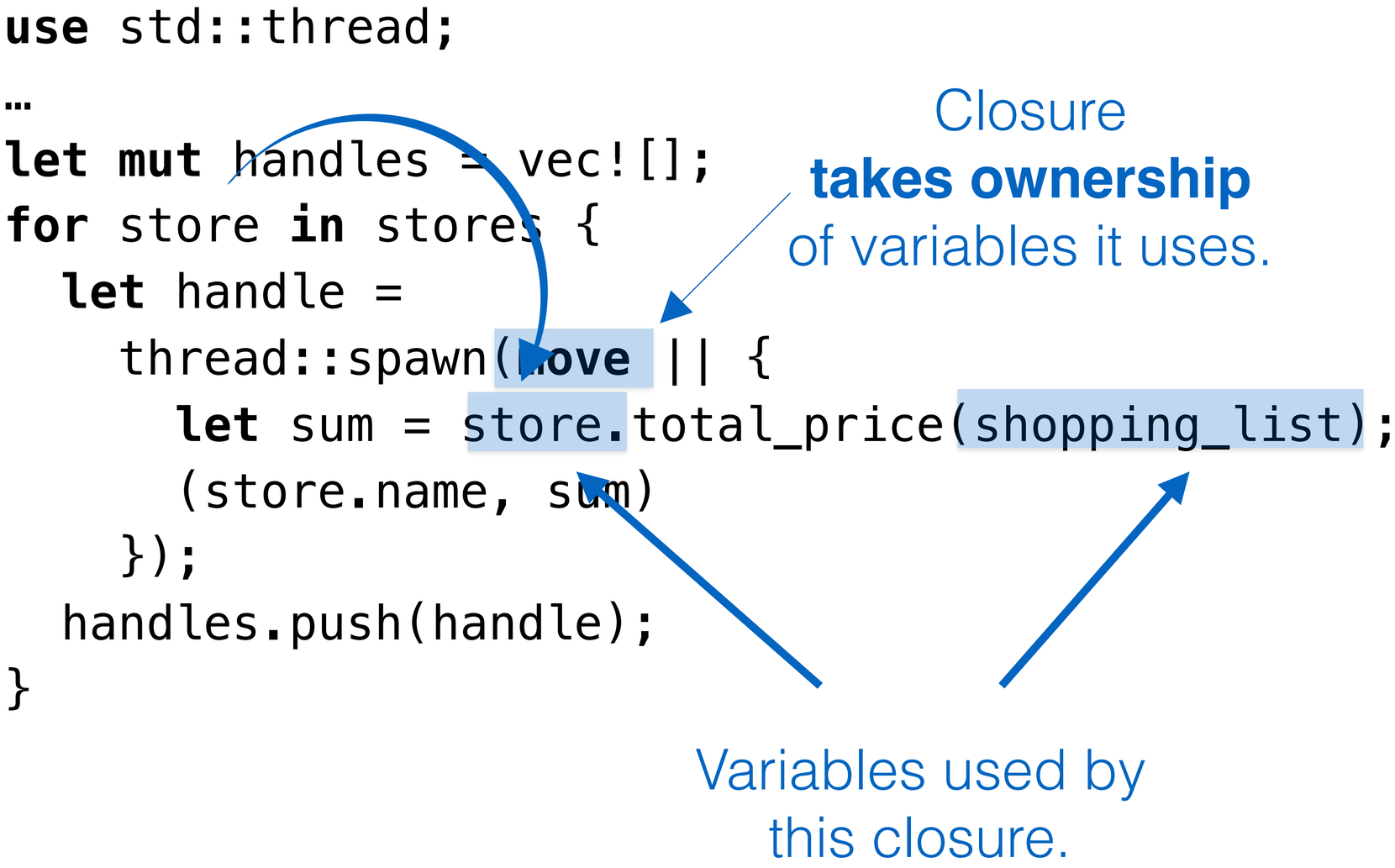
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Handle to the
thread we spawned.

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Closure body **can** produce a result: **(String, Option<f32>)**.

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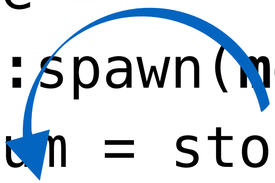

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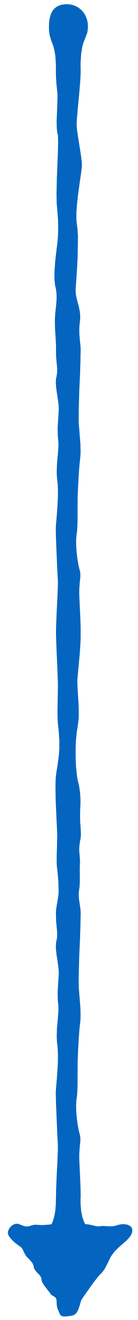

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… // stuff in parallel
  // with new thread
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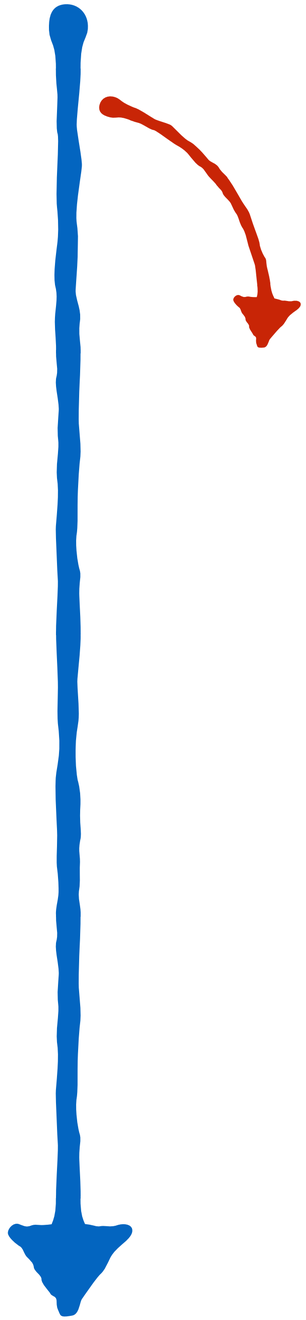
let (name, sum) = handle.join().unwrap();
```



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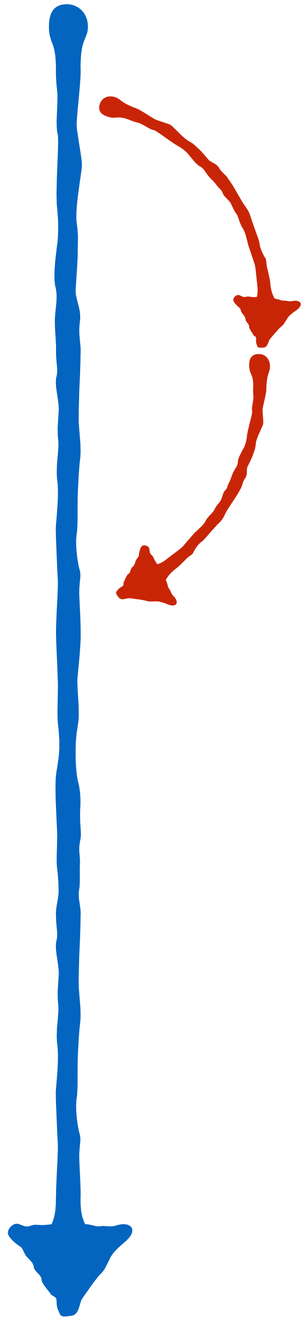

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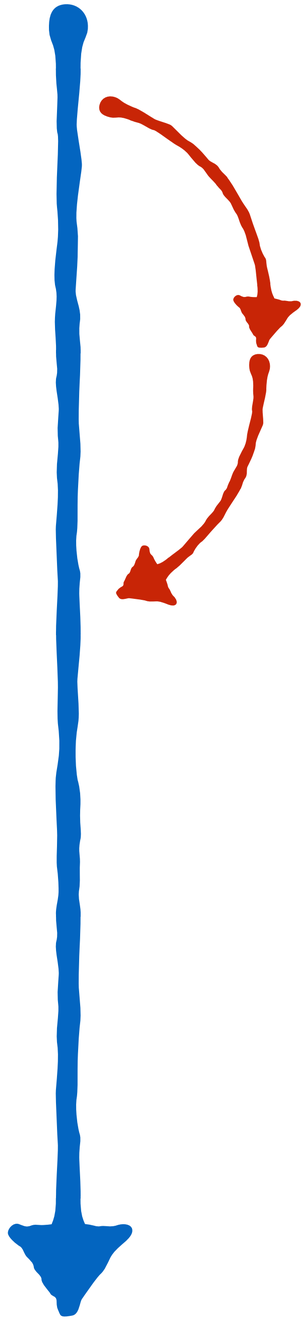
Wait for thread
to finish and
get return value.



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```
Result<(String, Option<f32>), Error>
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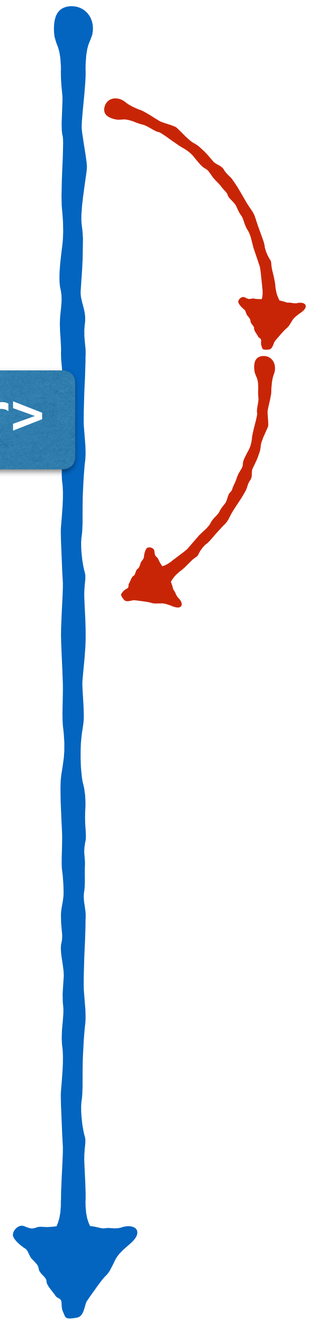

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Thread may have
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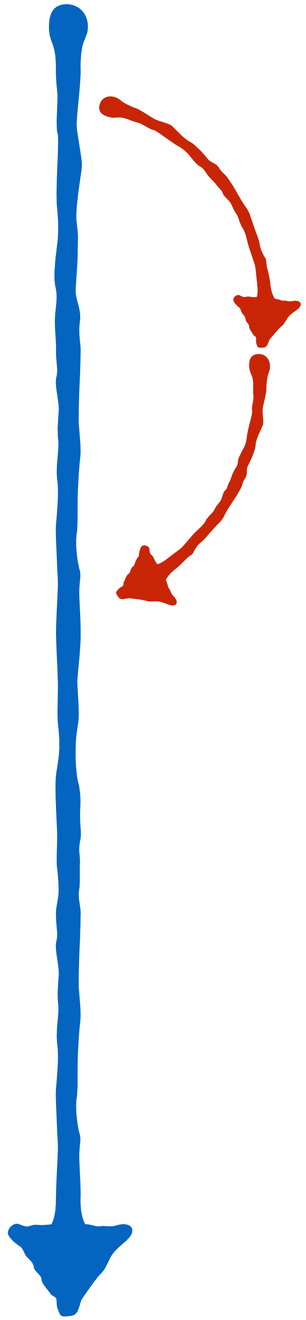

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Result of thread.

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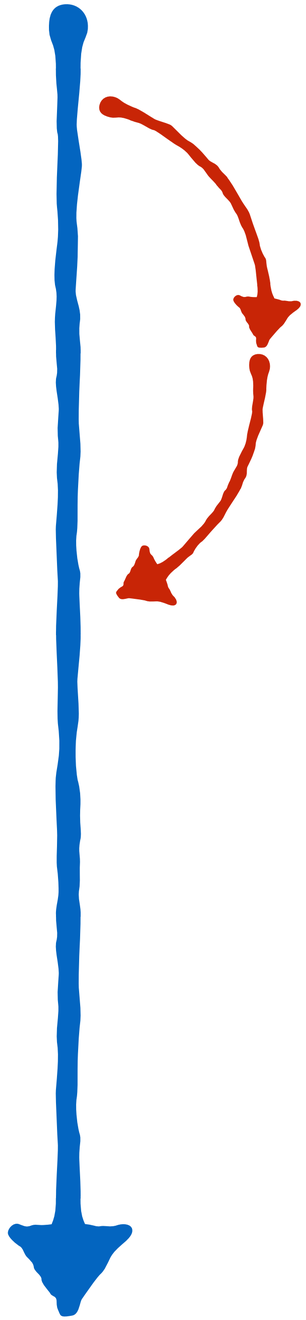

```
let shopping_list = vec![…];
let mut handles = vec![];
for store in stores {
  handles.push(
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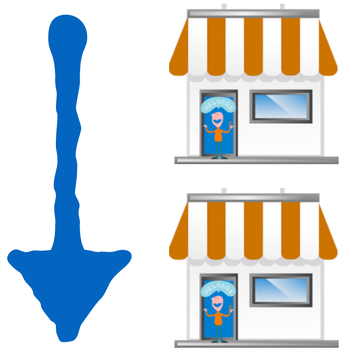

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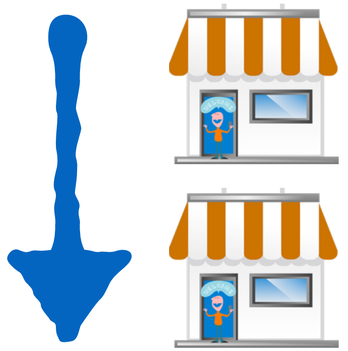

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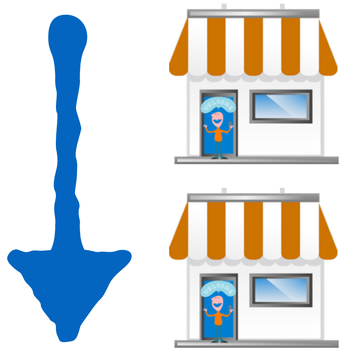

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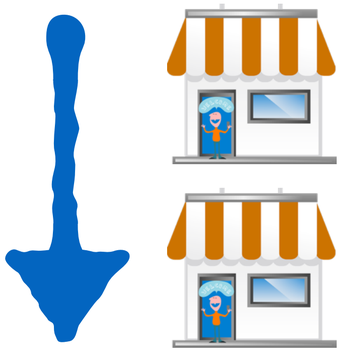

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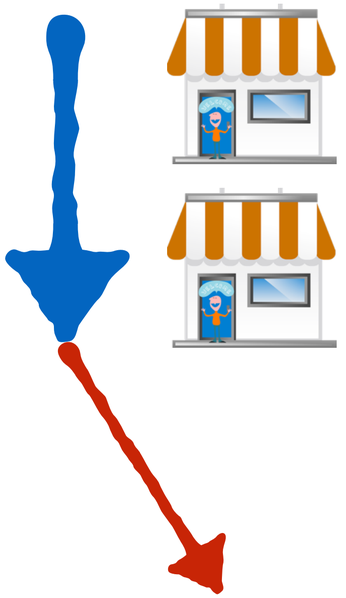

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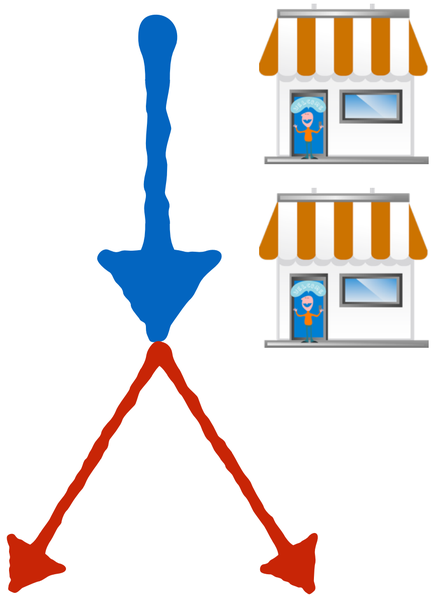

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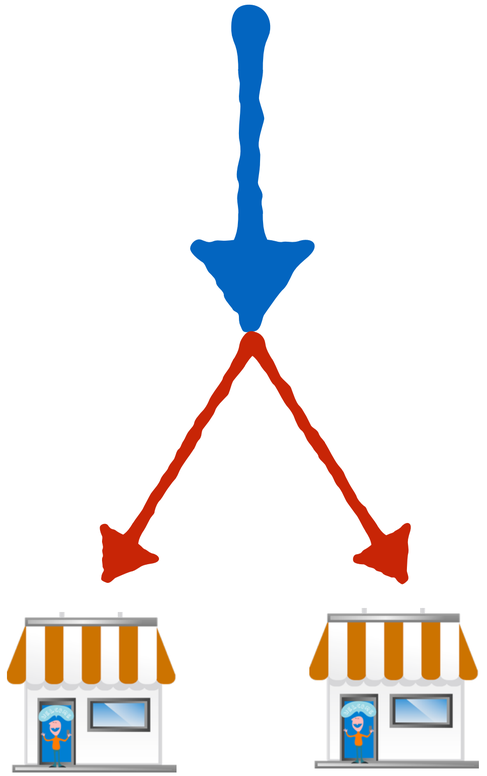

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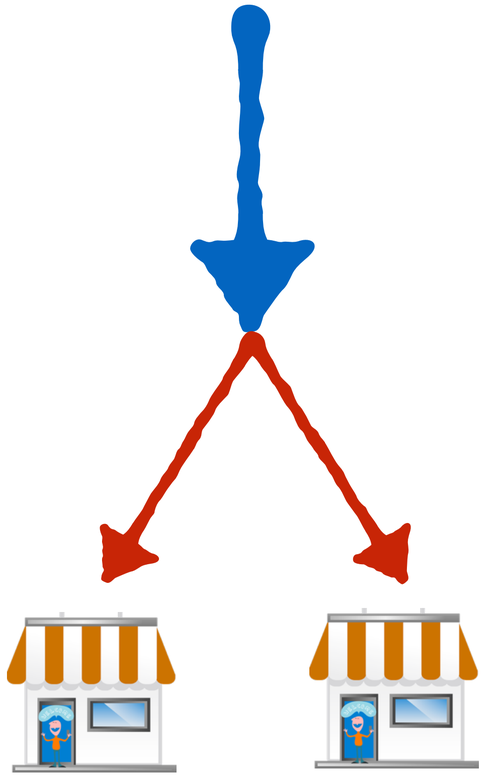

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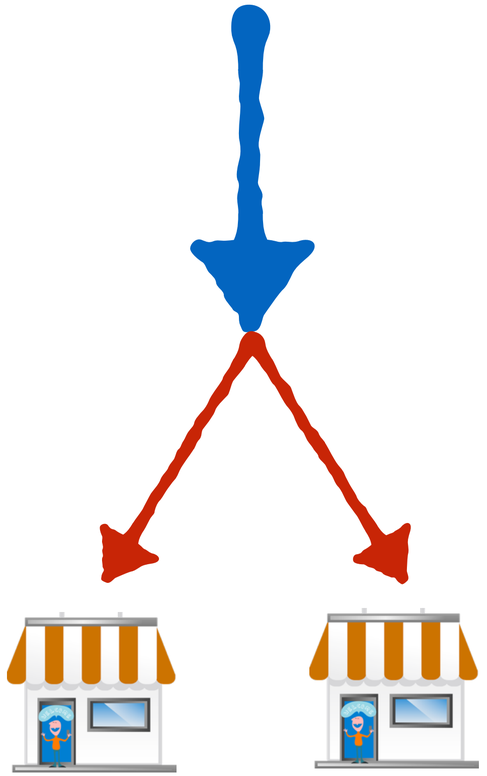

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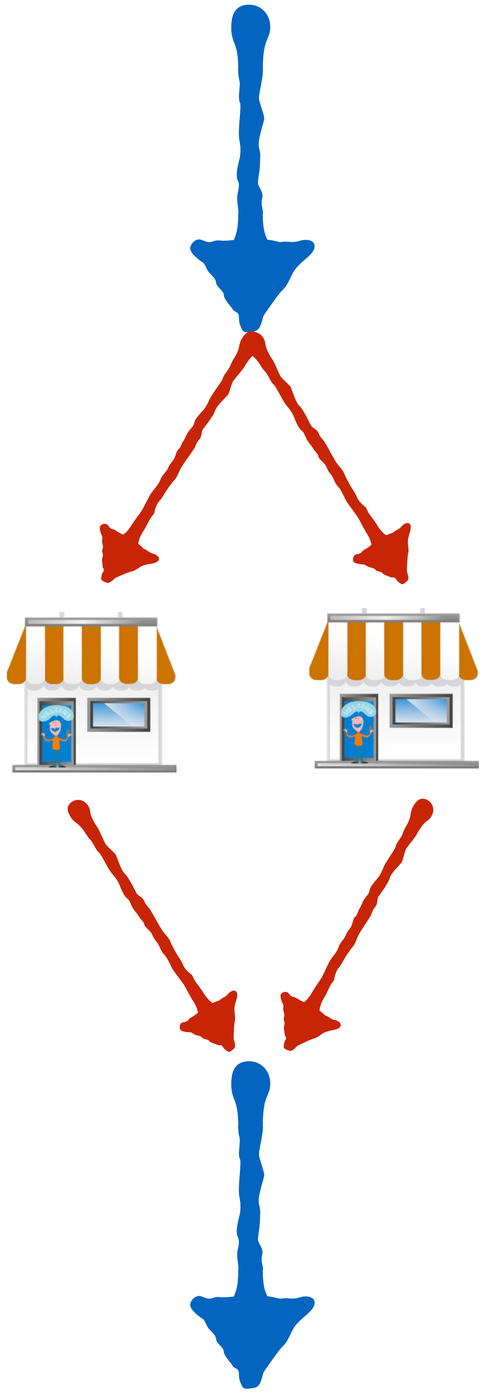

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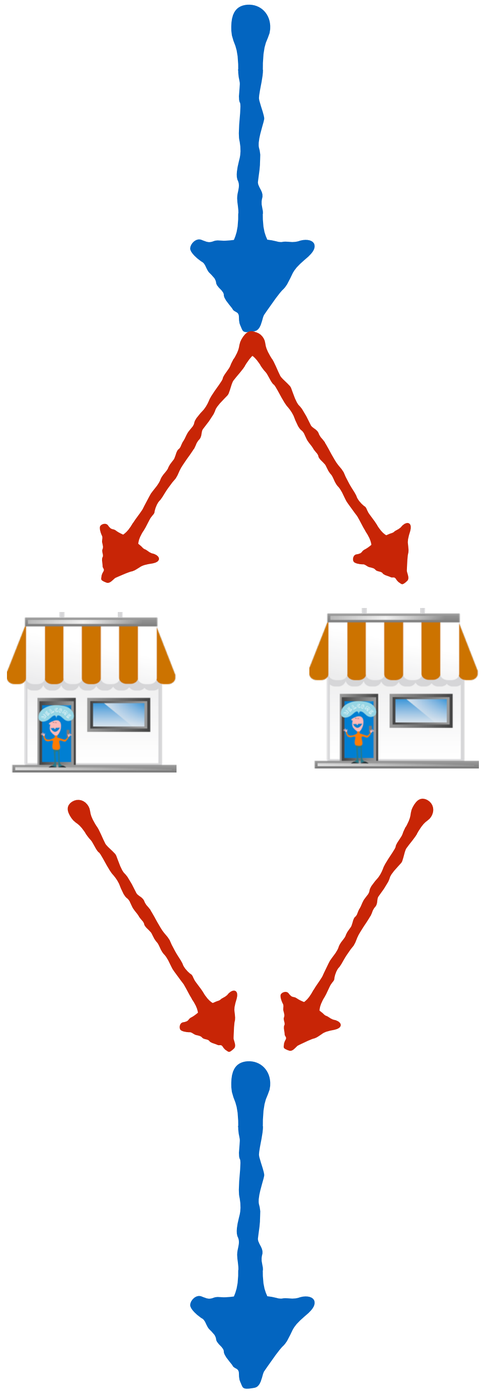

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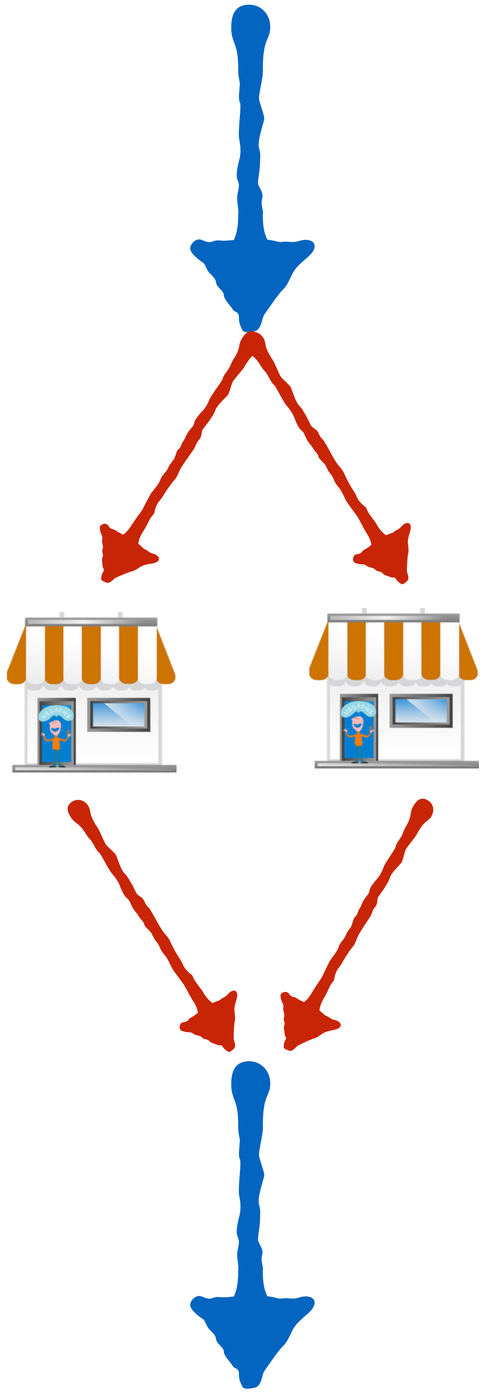

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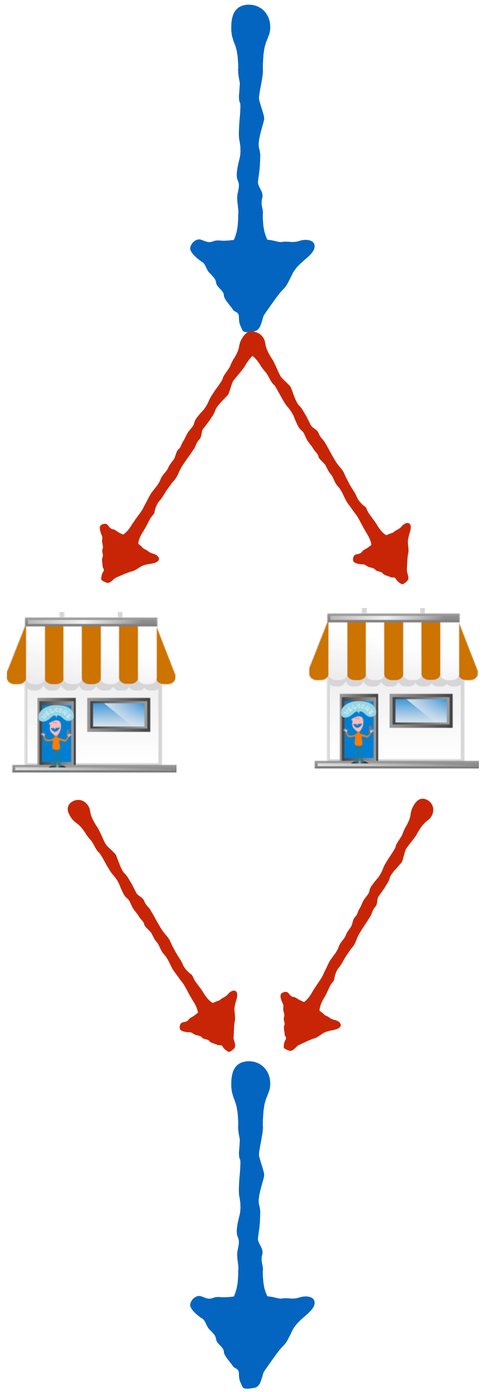

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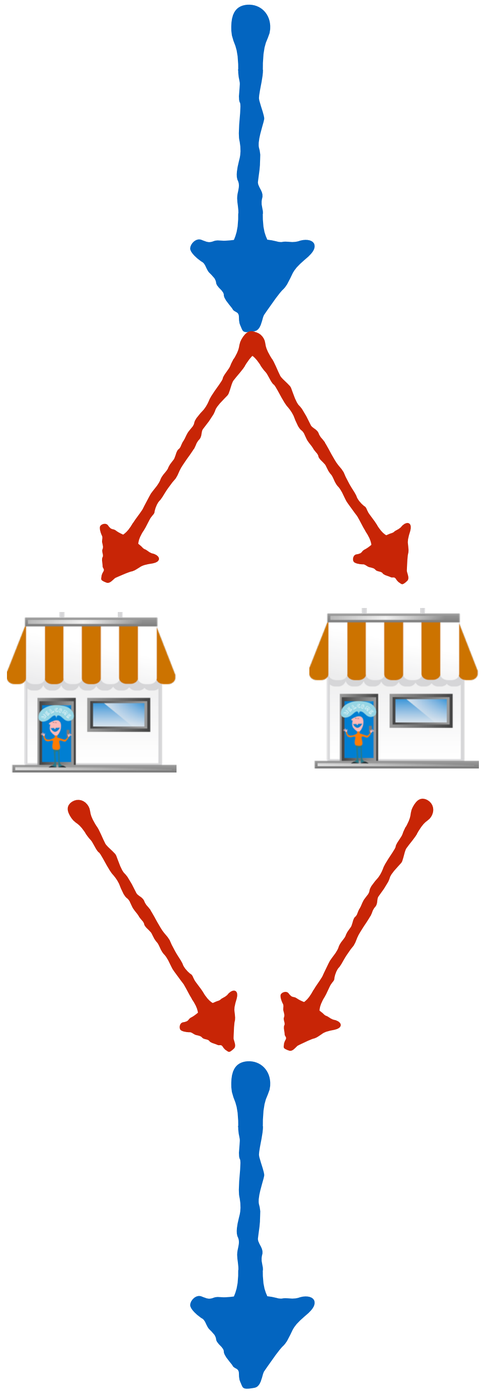

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Variables used by this closure.

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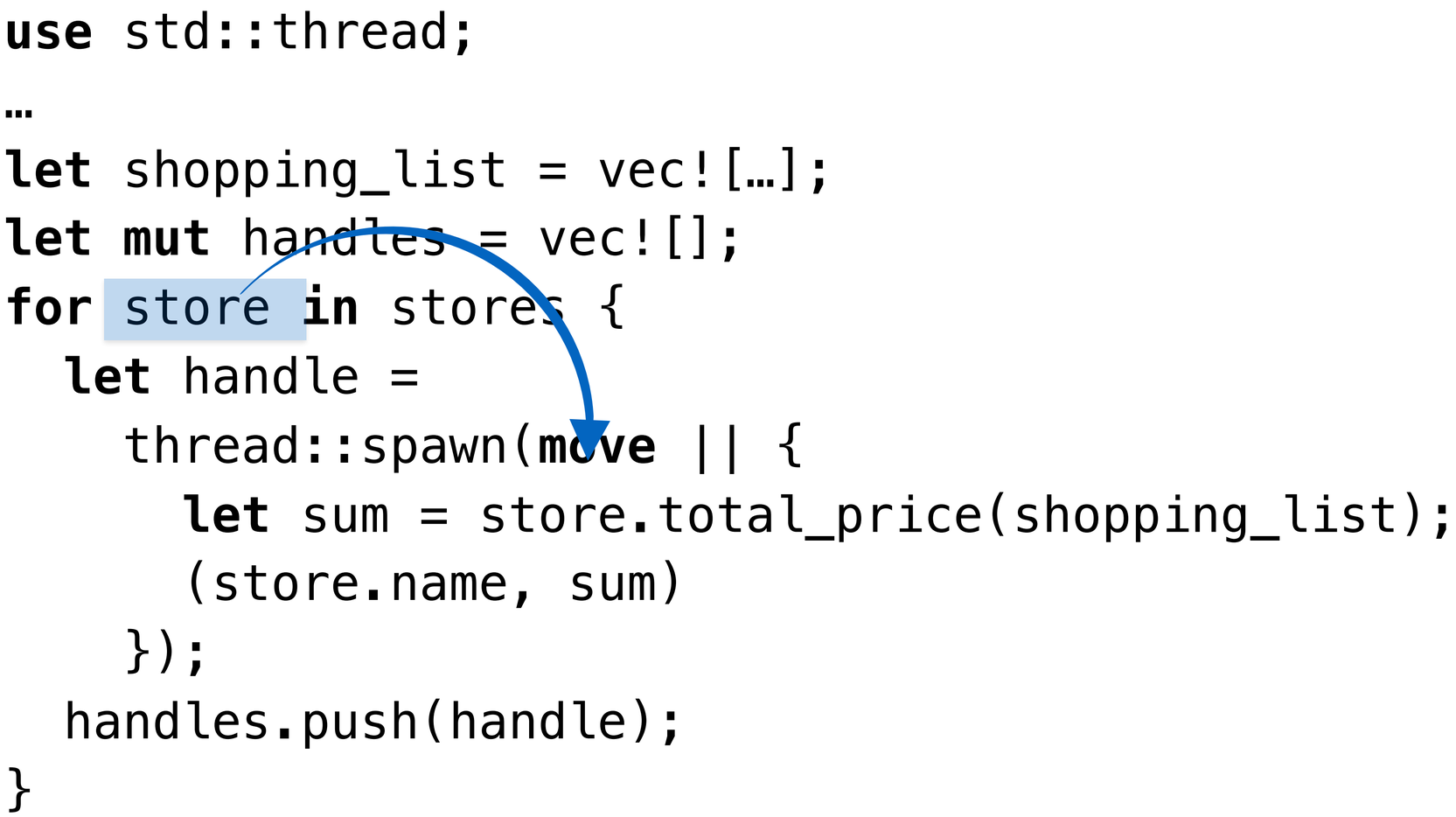
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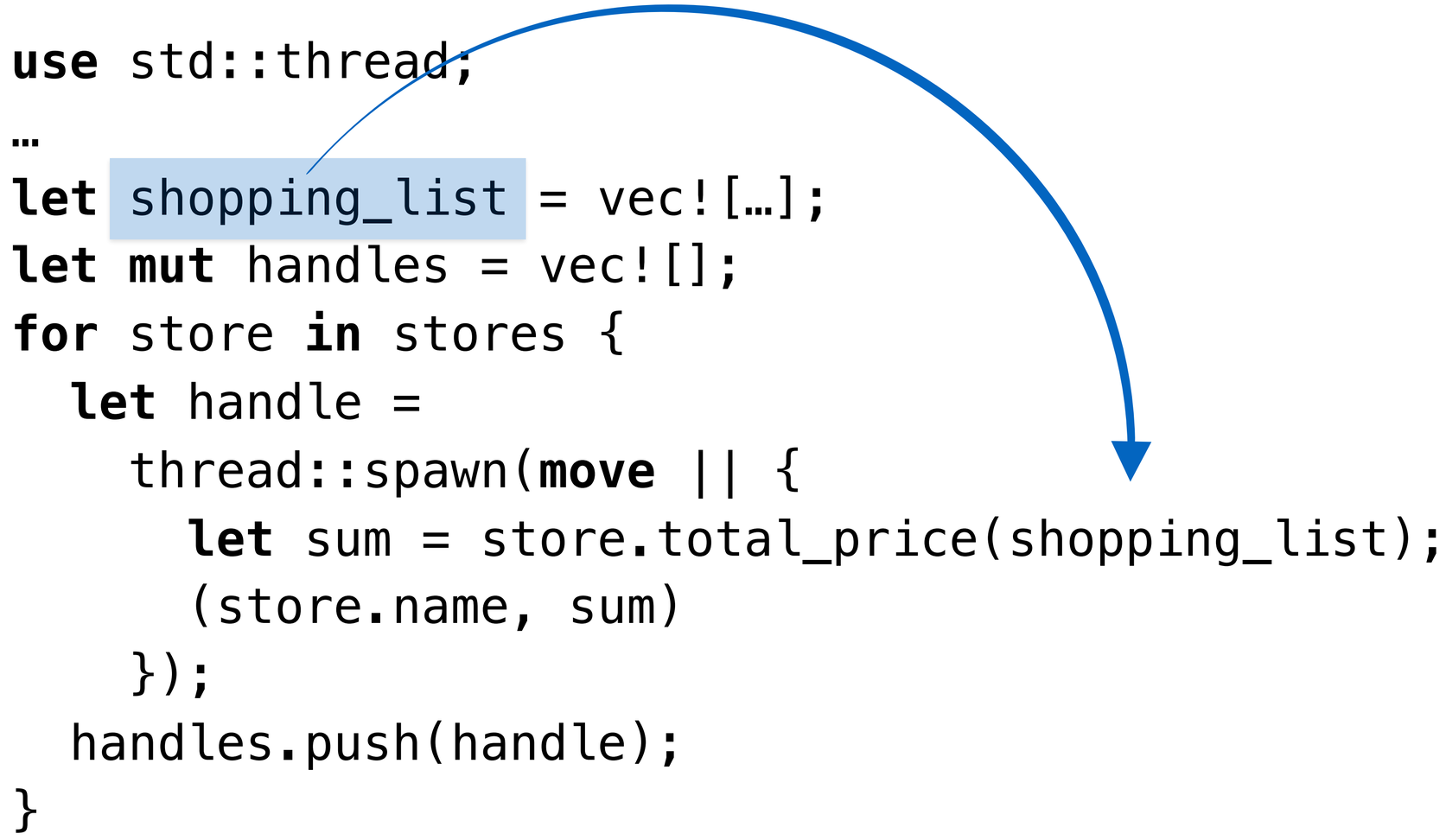
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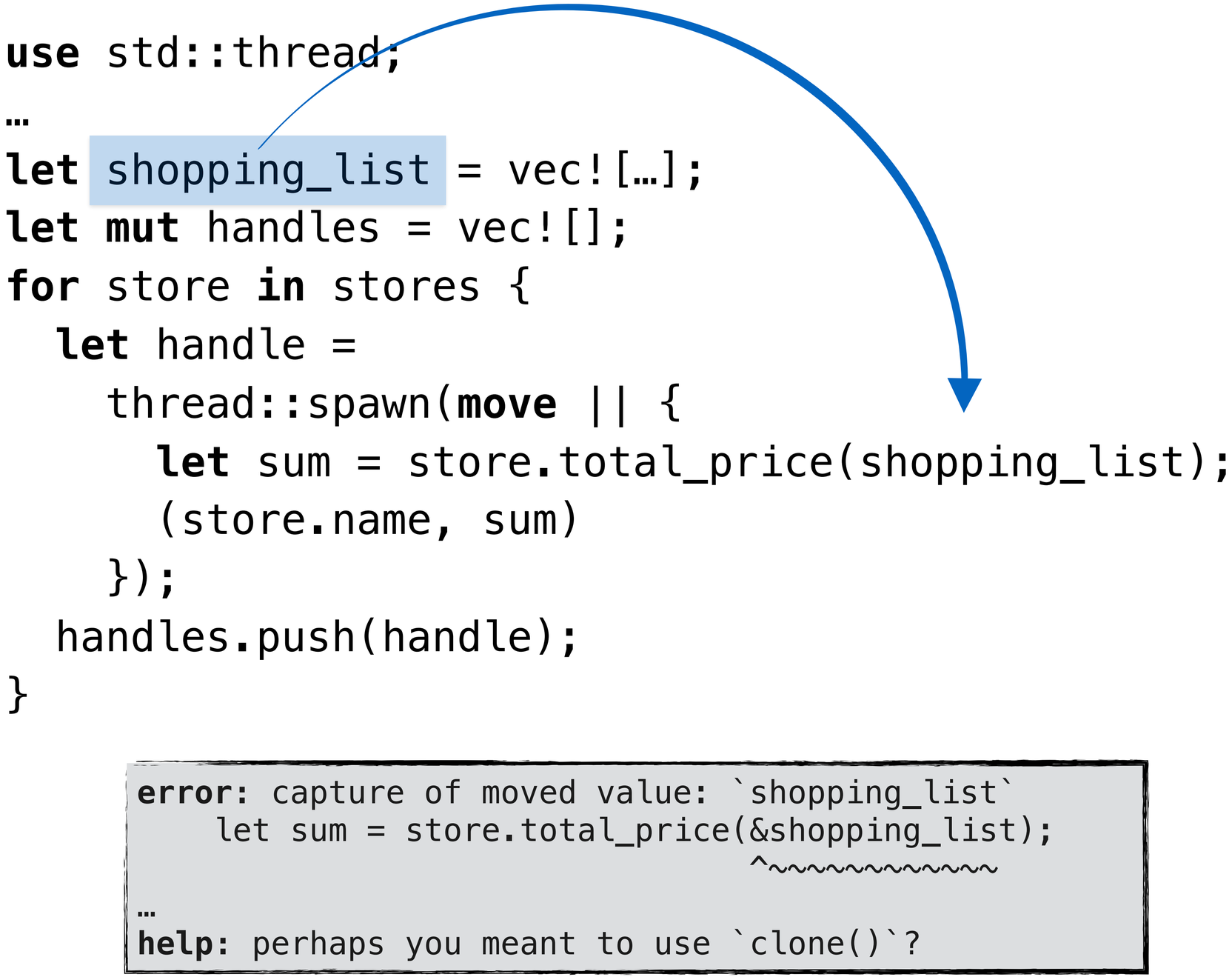


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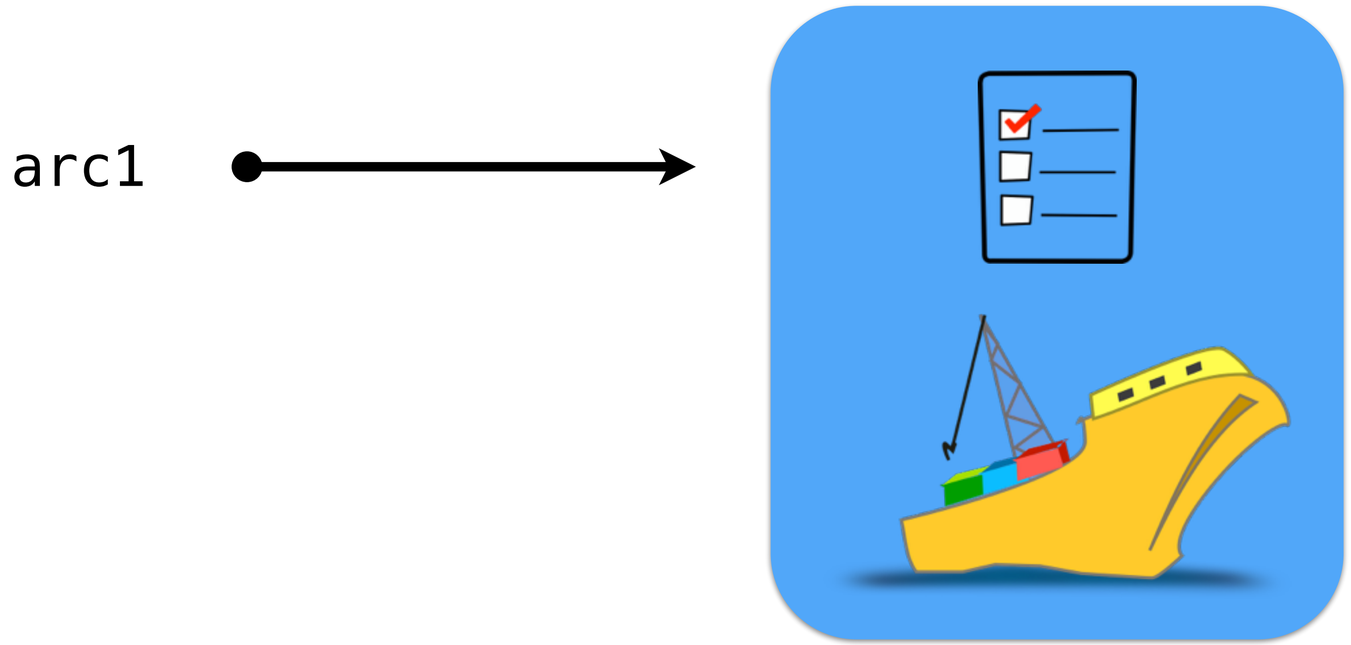

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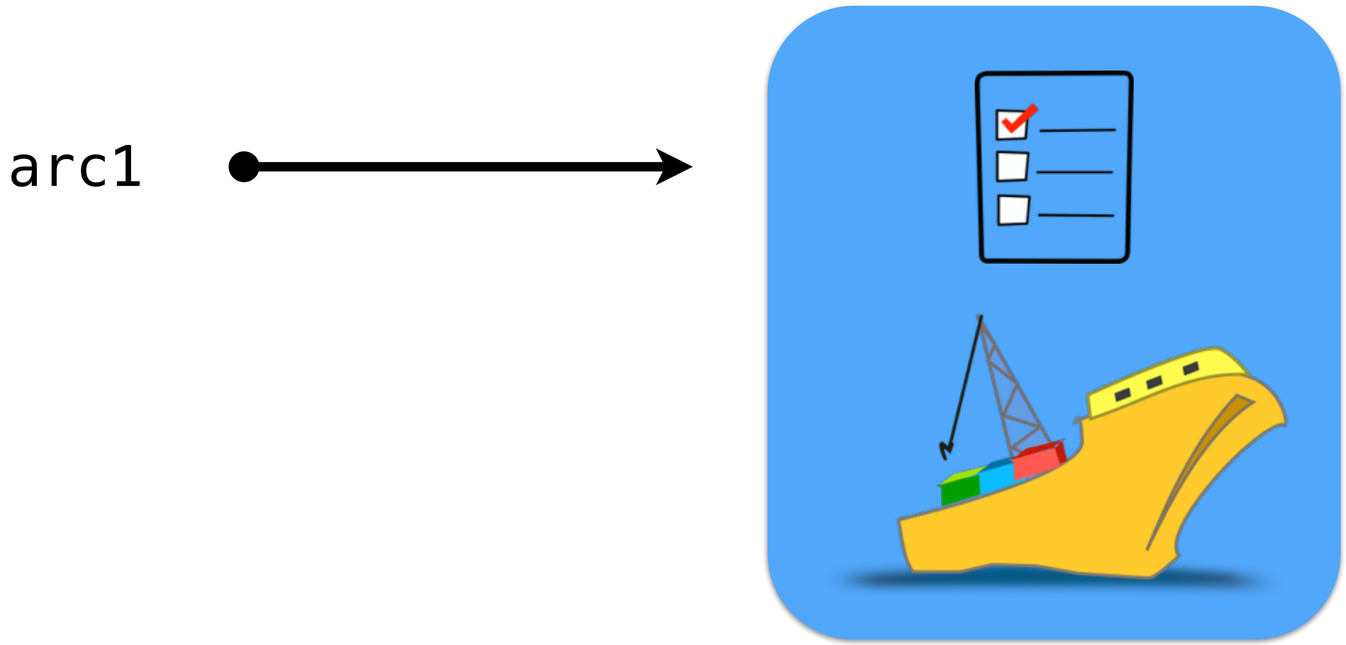

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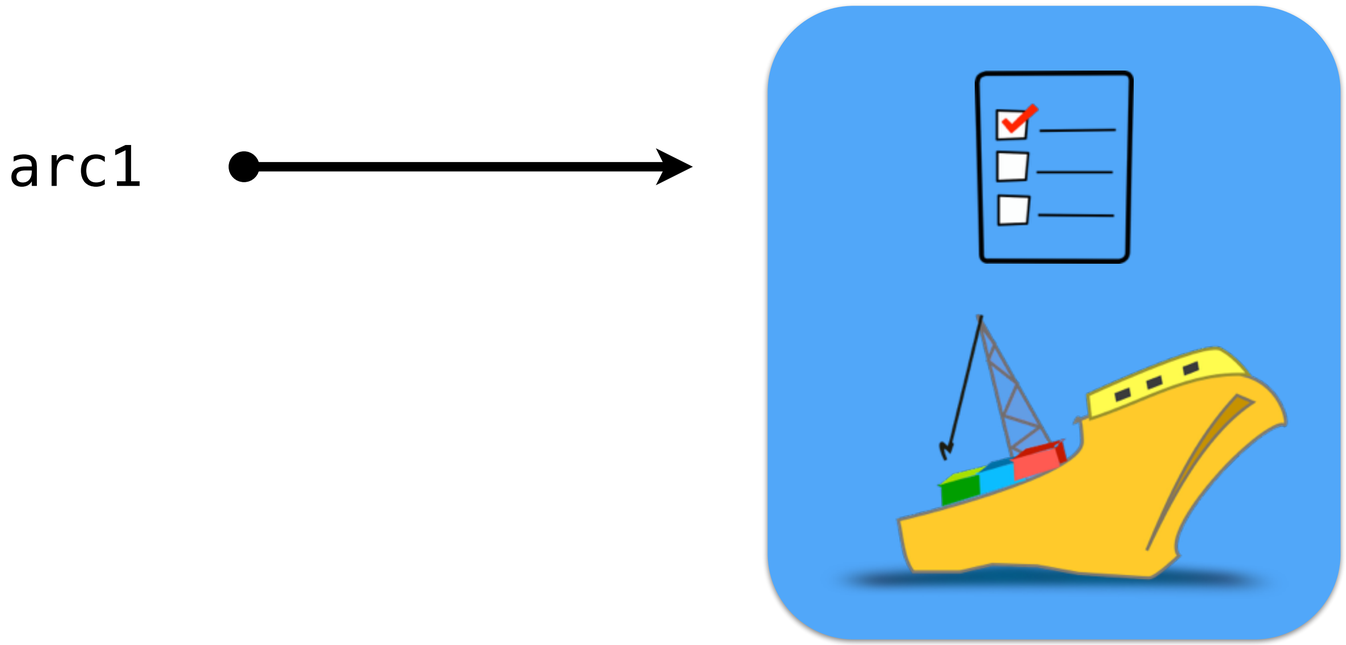

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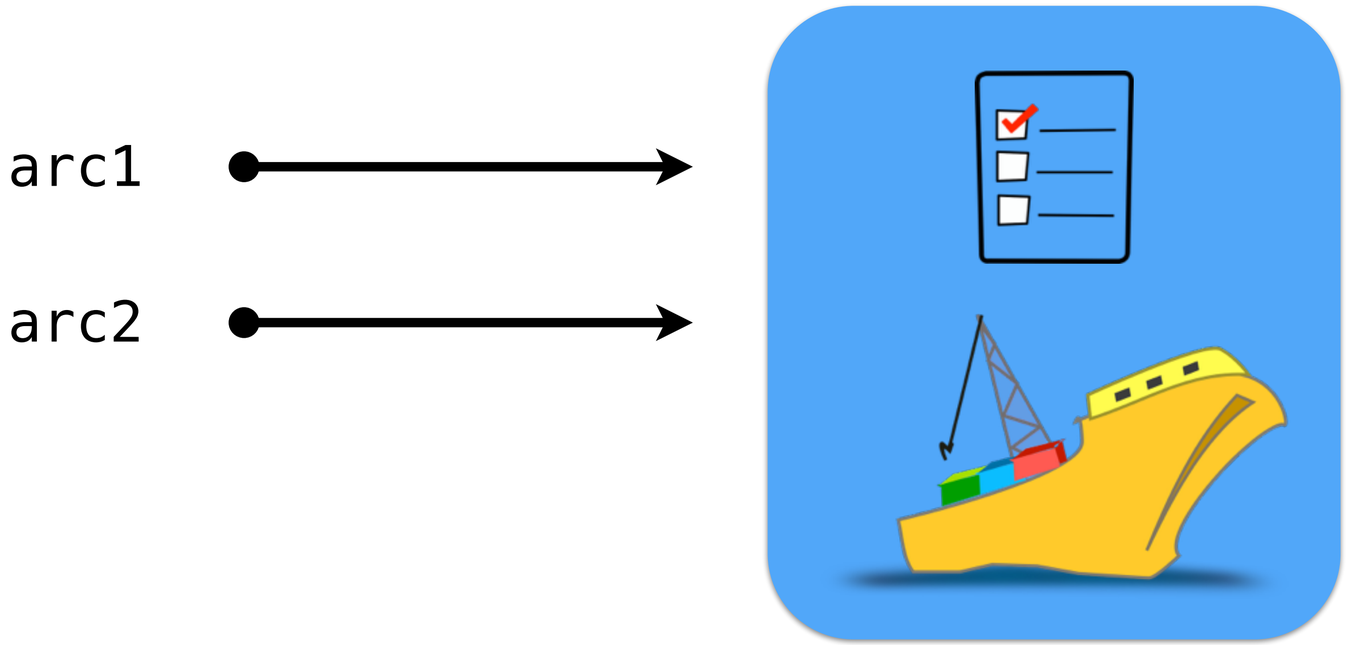

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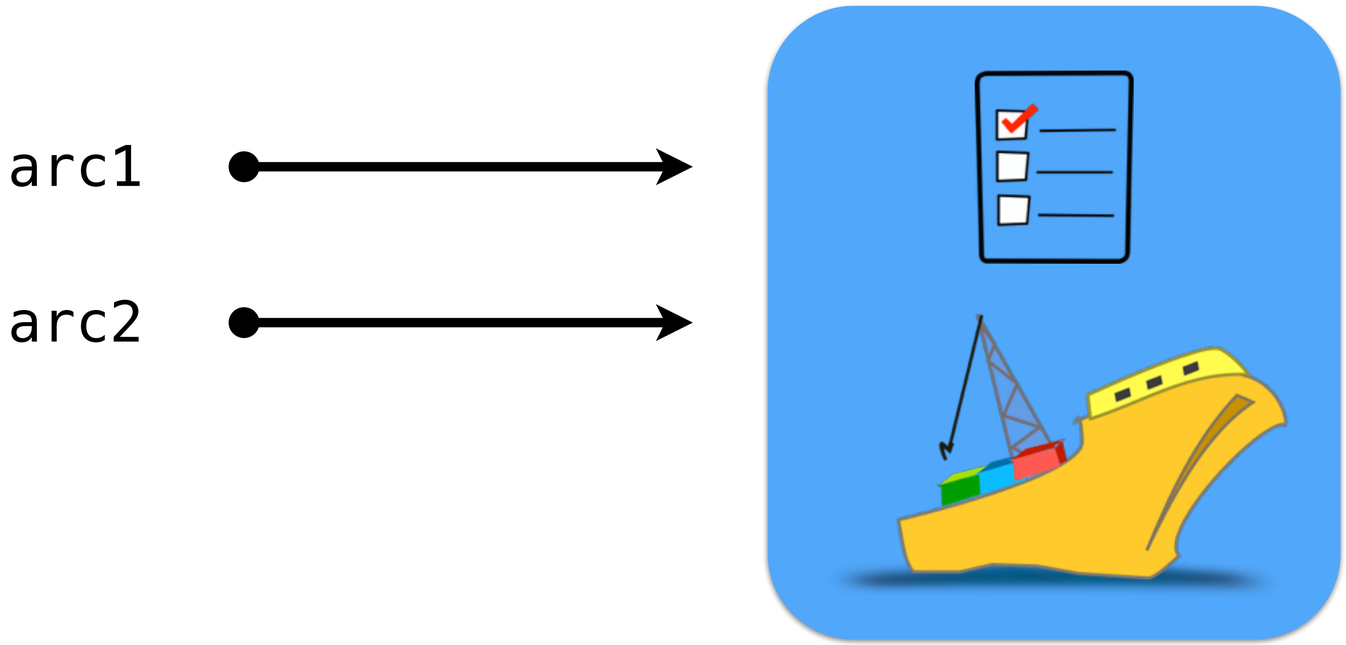

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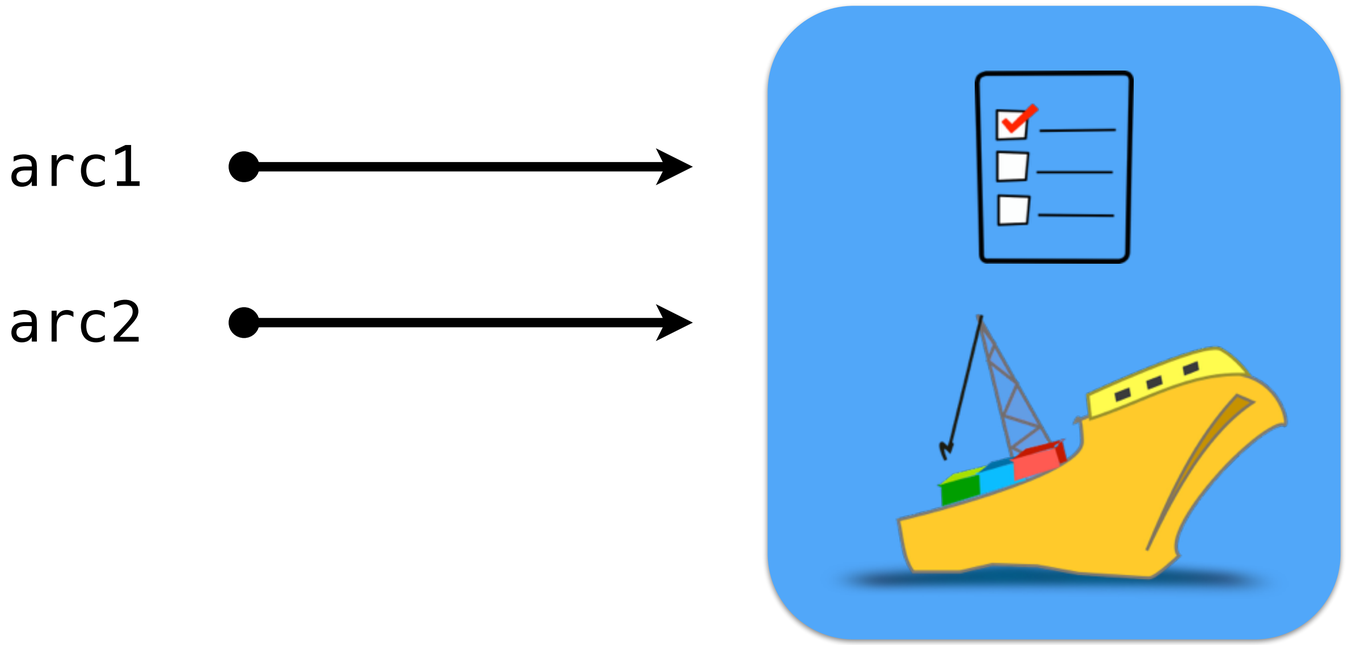

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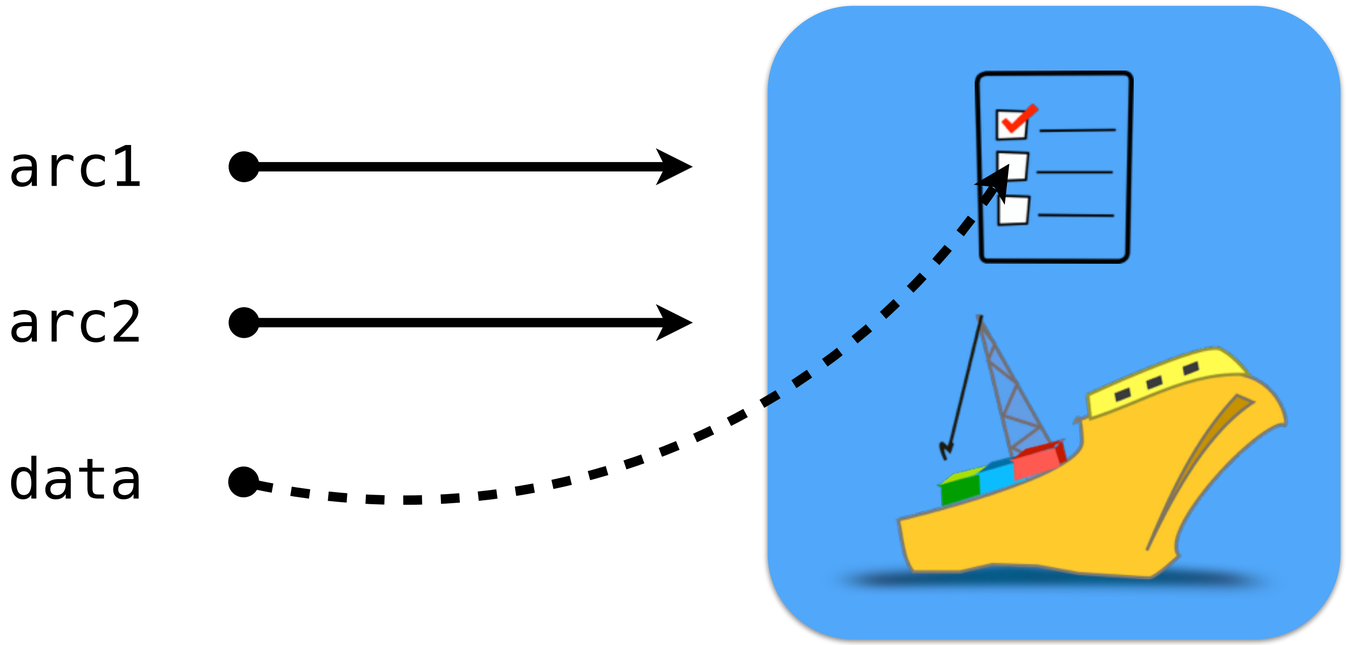

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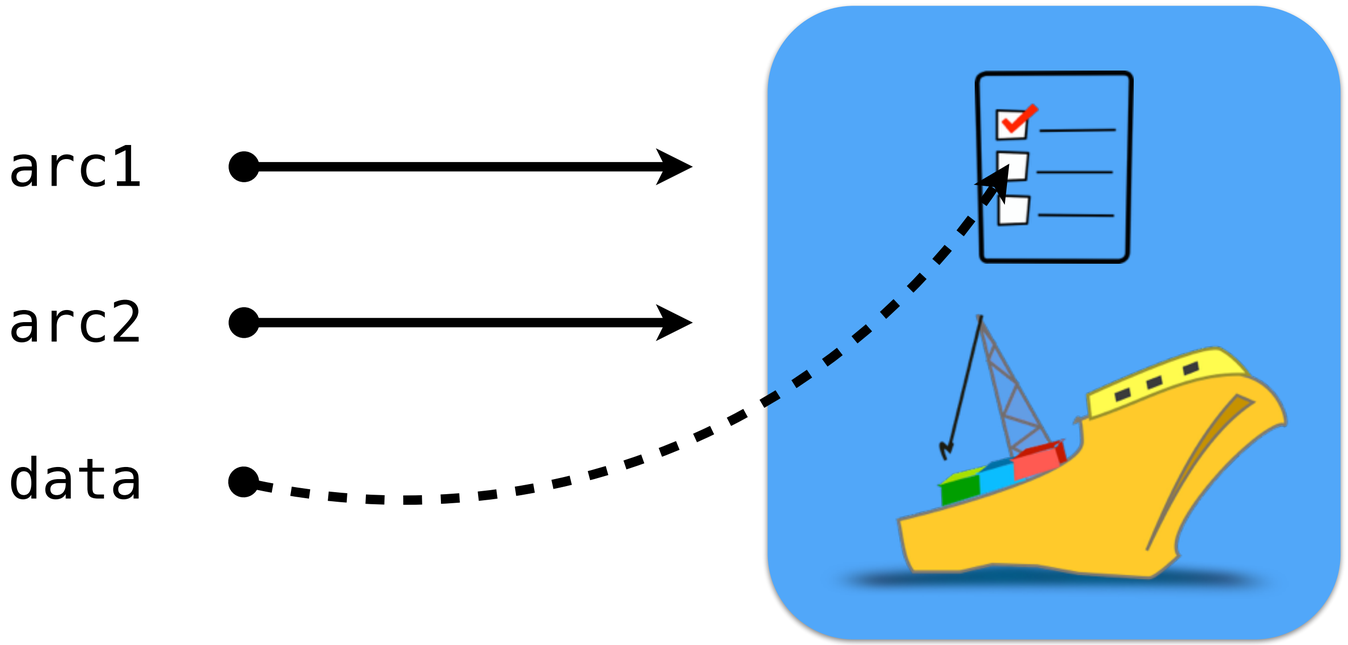

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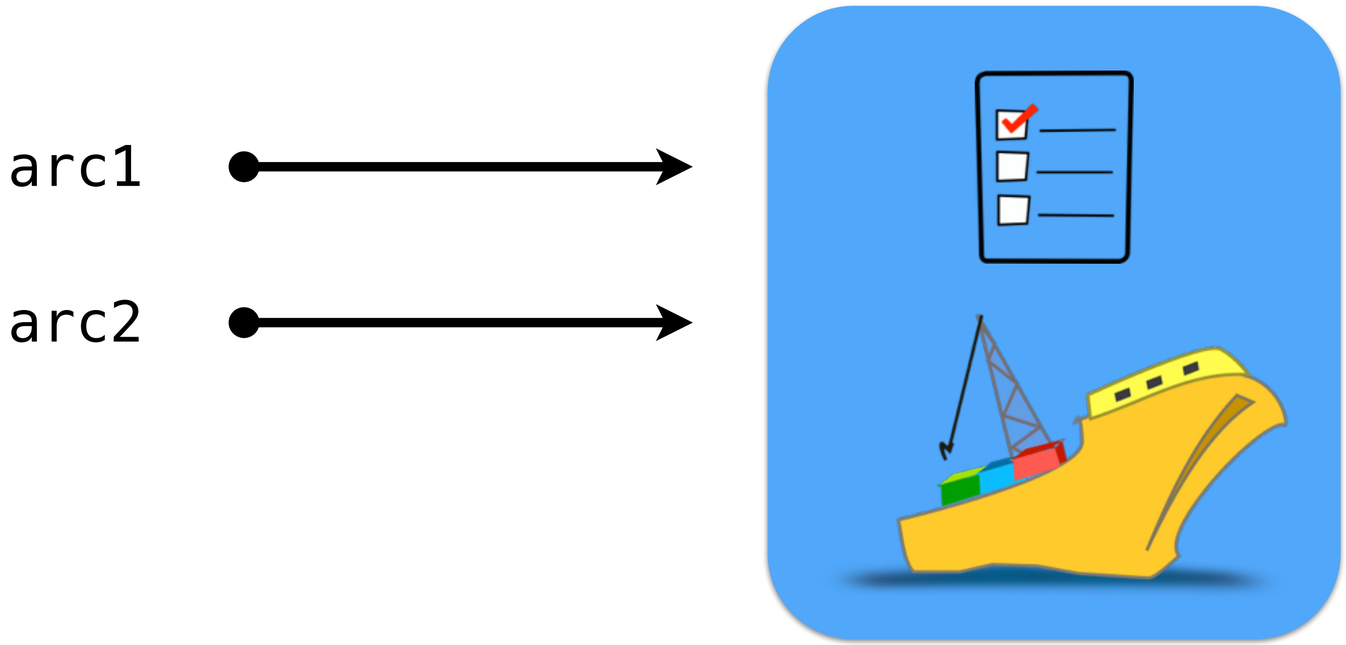

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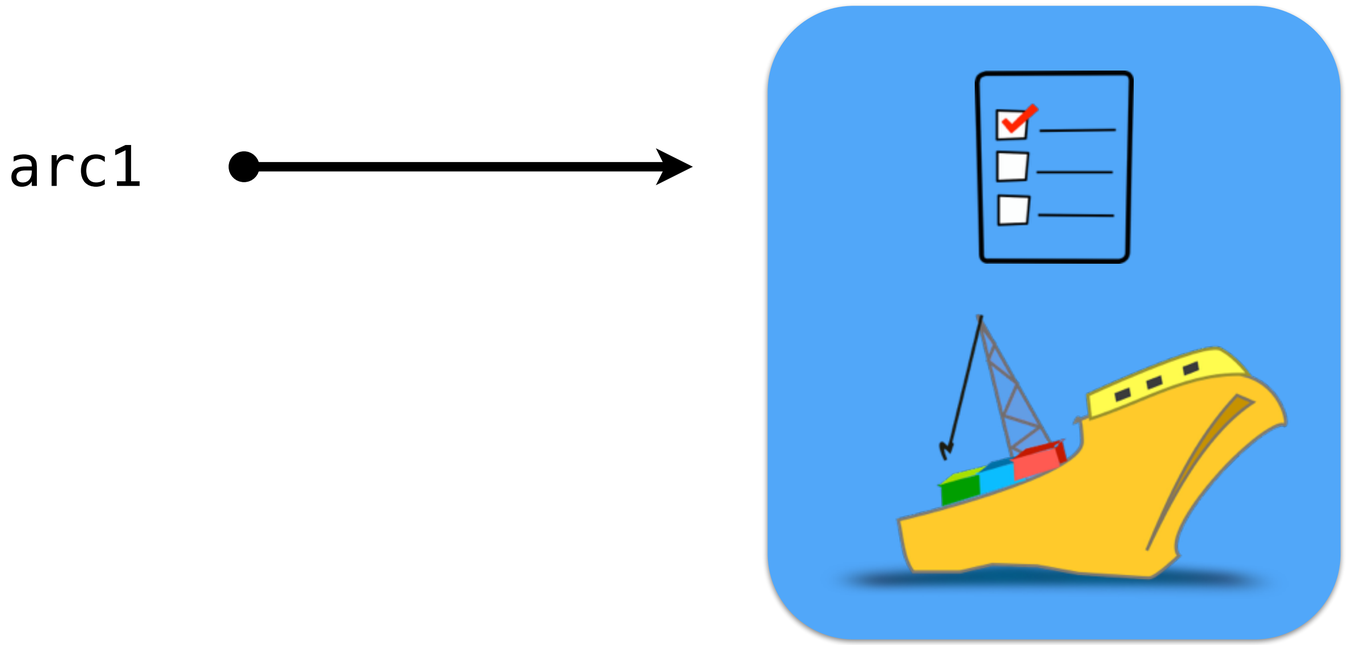

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Arc => Immutable

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http://is.gd/nP3Pvb

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```
<anon>:6:21: 6:24 error: cannot borrow immutable borrowed
                         content as mutable
<anon>:6     let data = &mut arc[0];
                            ^~~
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http://is.gd/nP3Pvb

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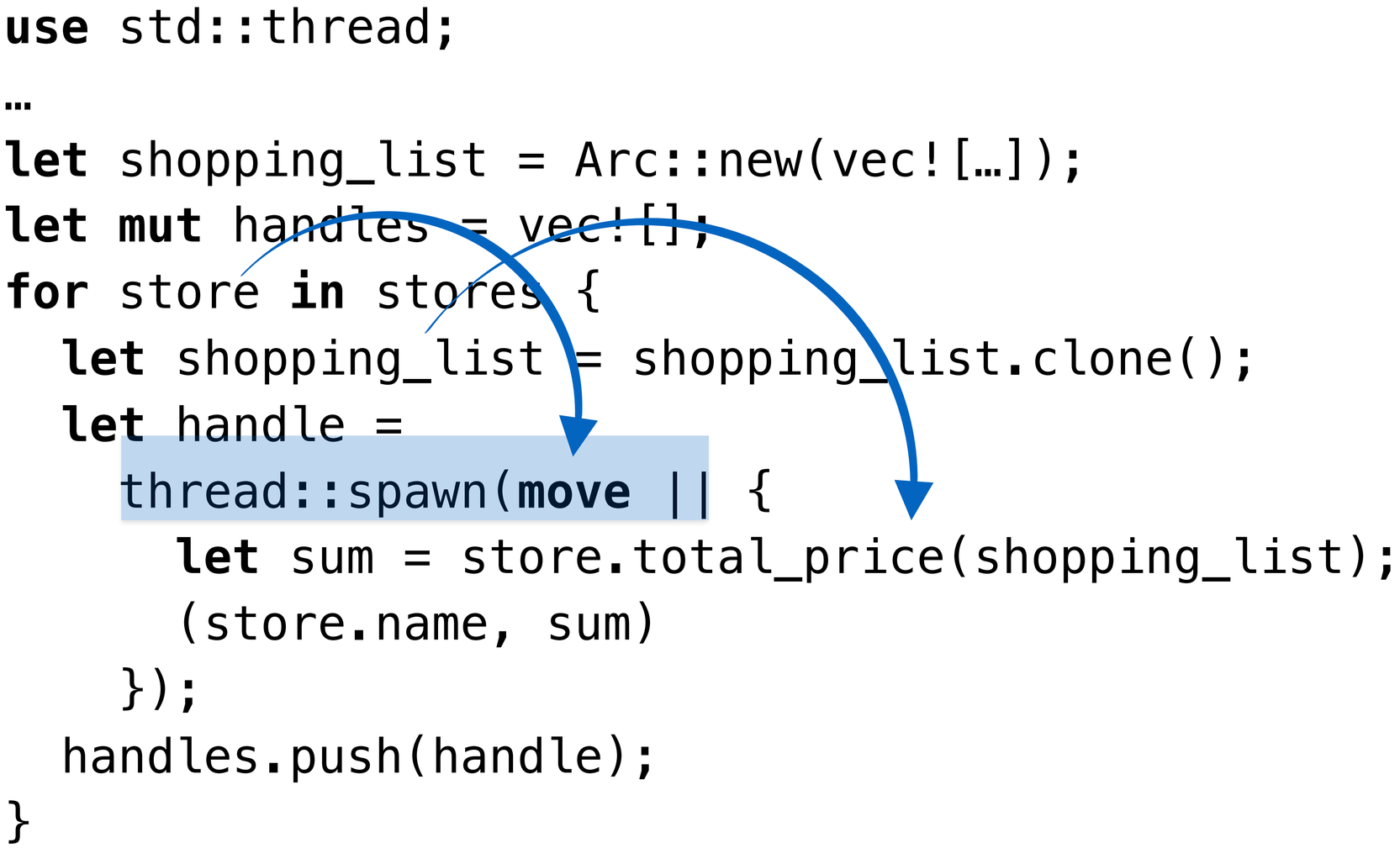
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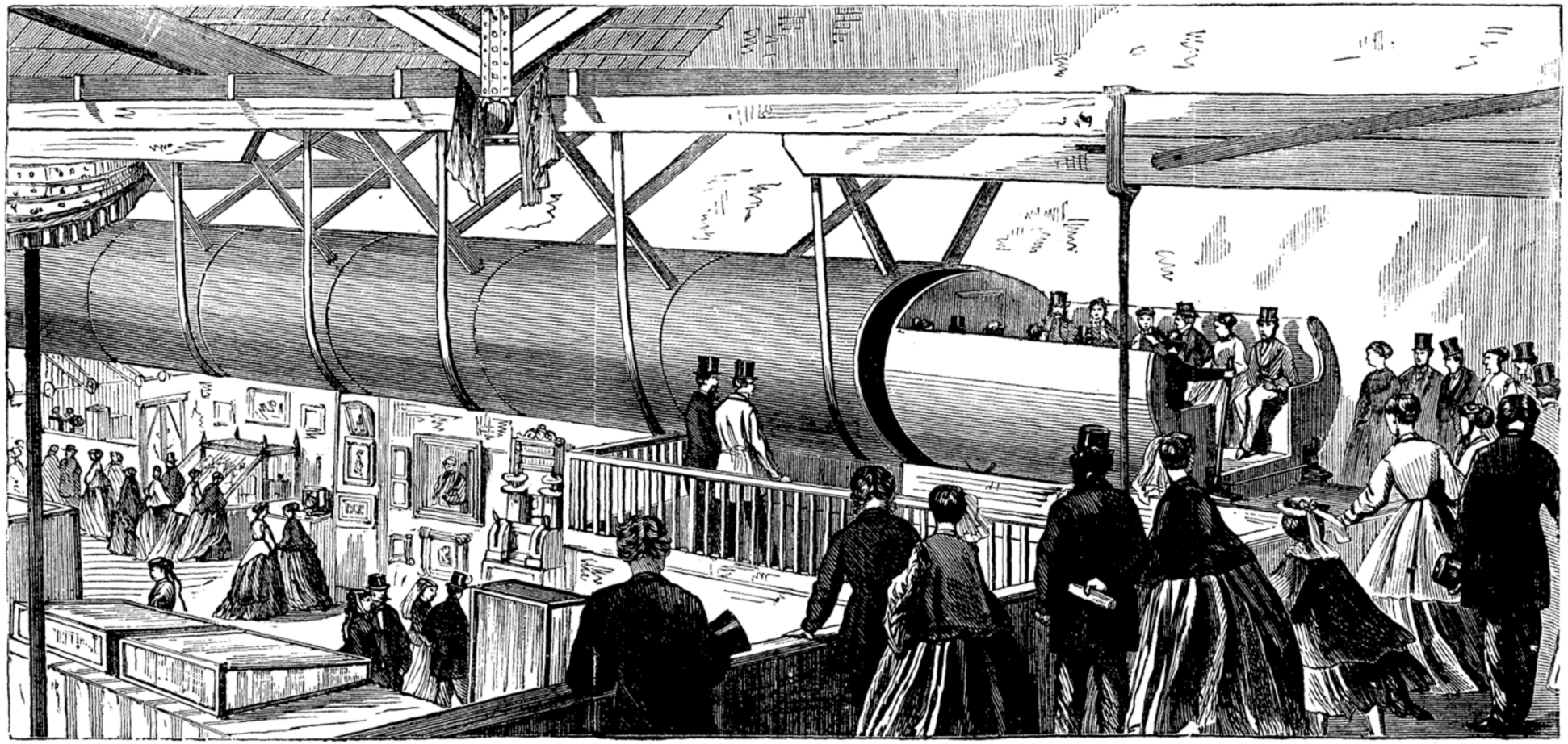
// exercise (in a bit): join the handles!
```

Channels



Joining a thread allows
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What if we wanted
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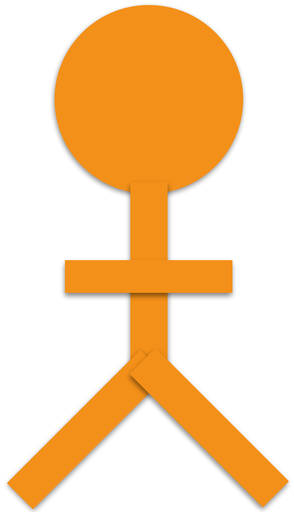

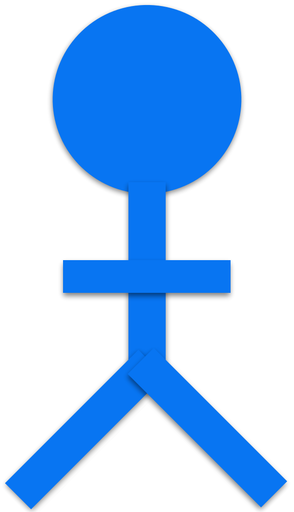

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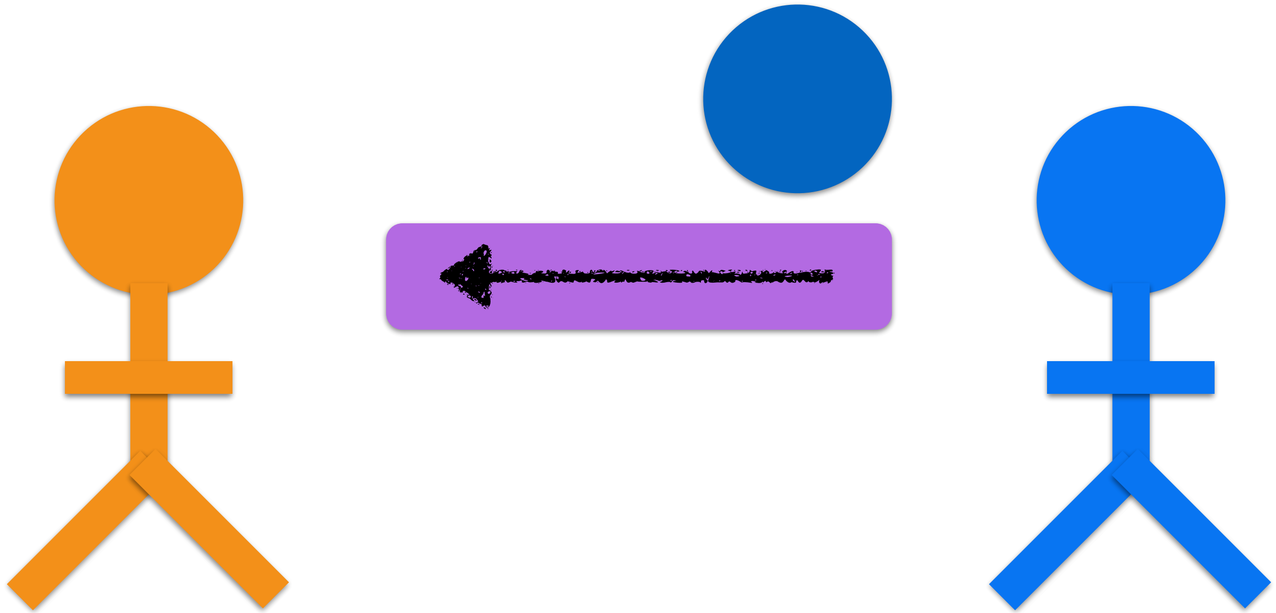

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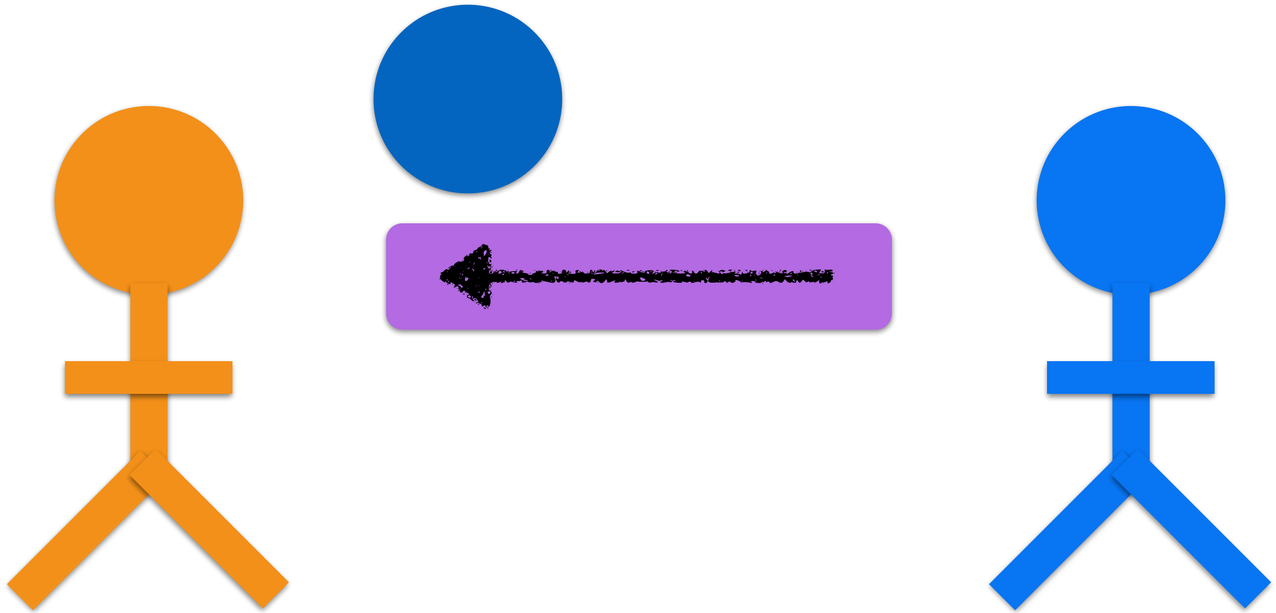

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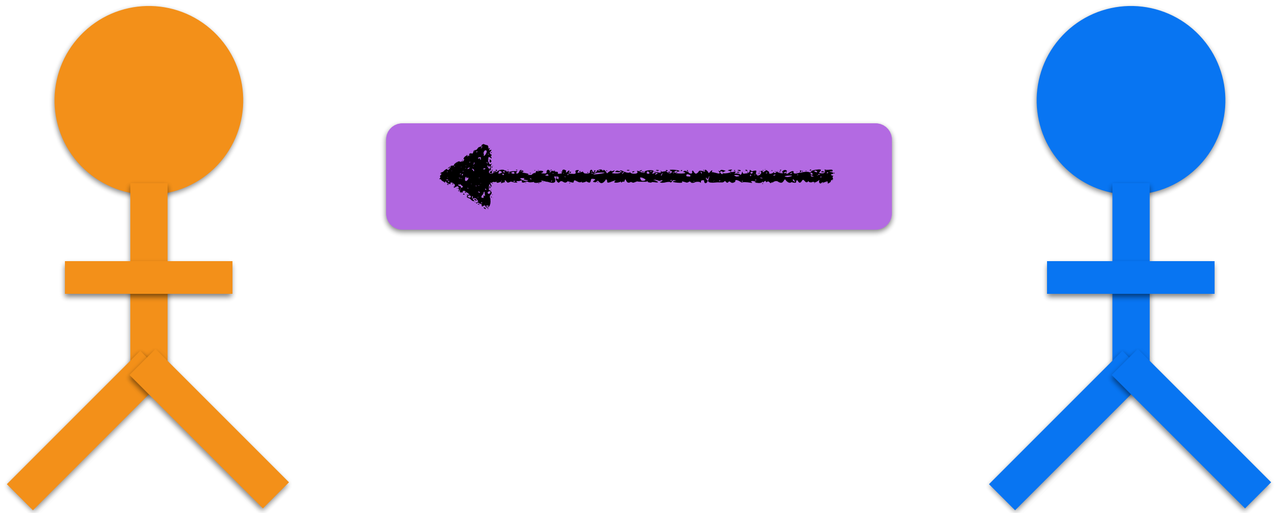

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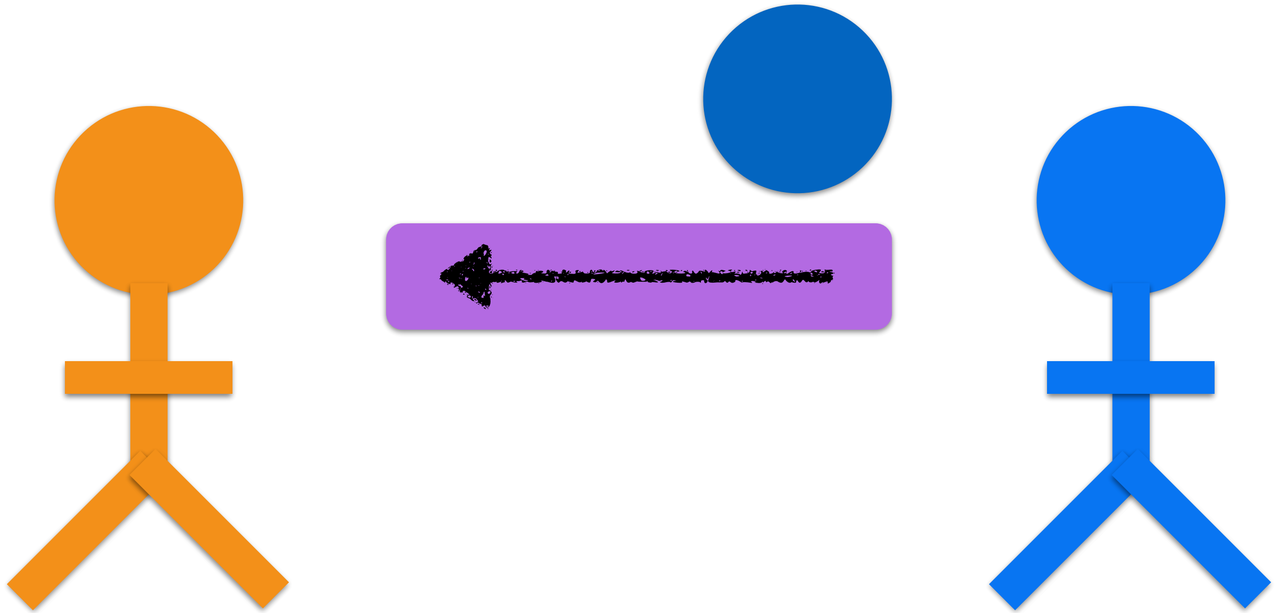

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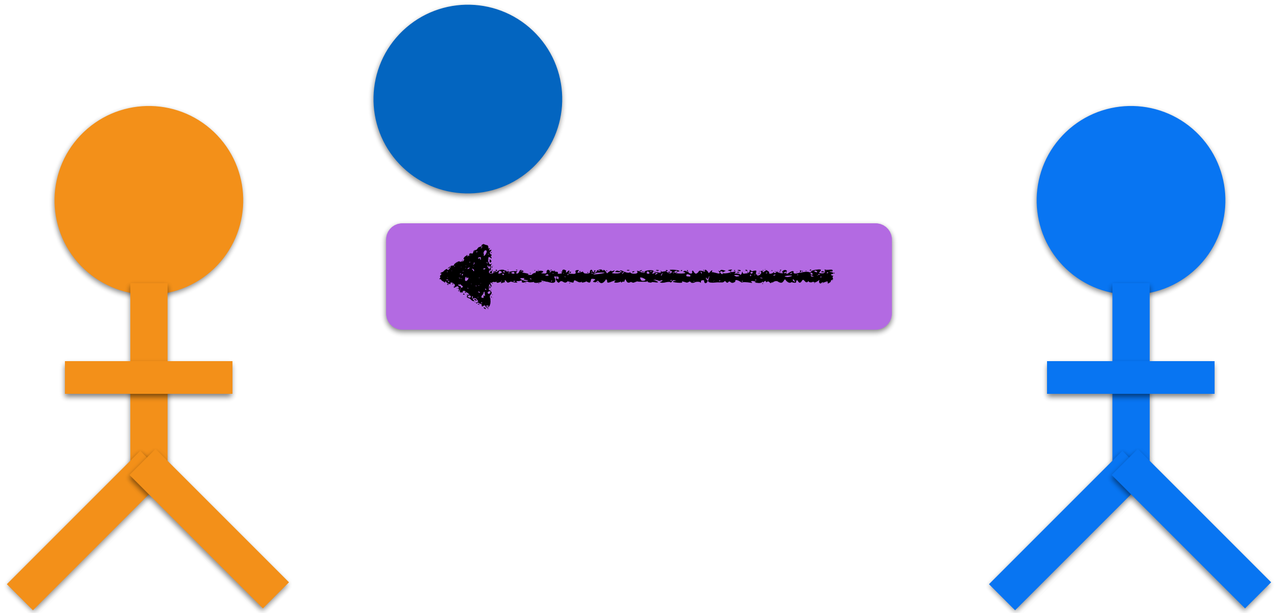

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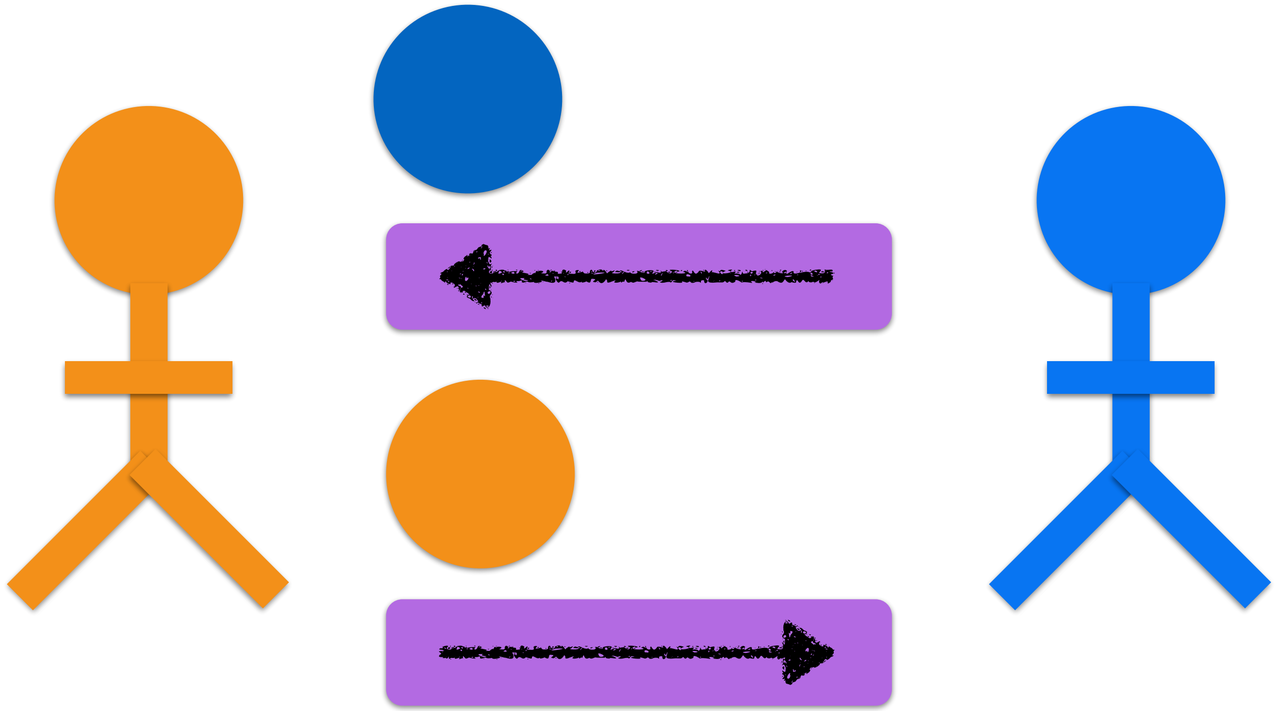

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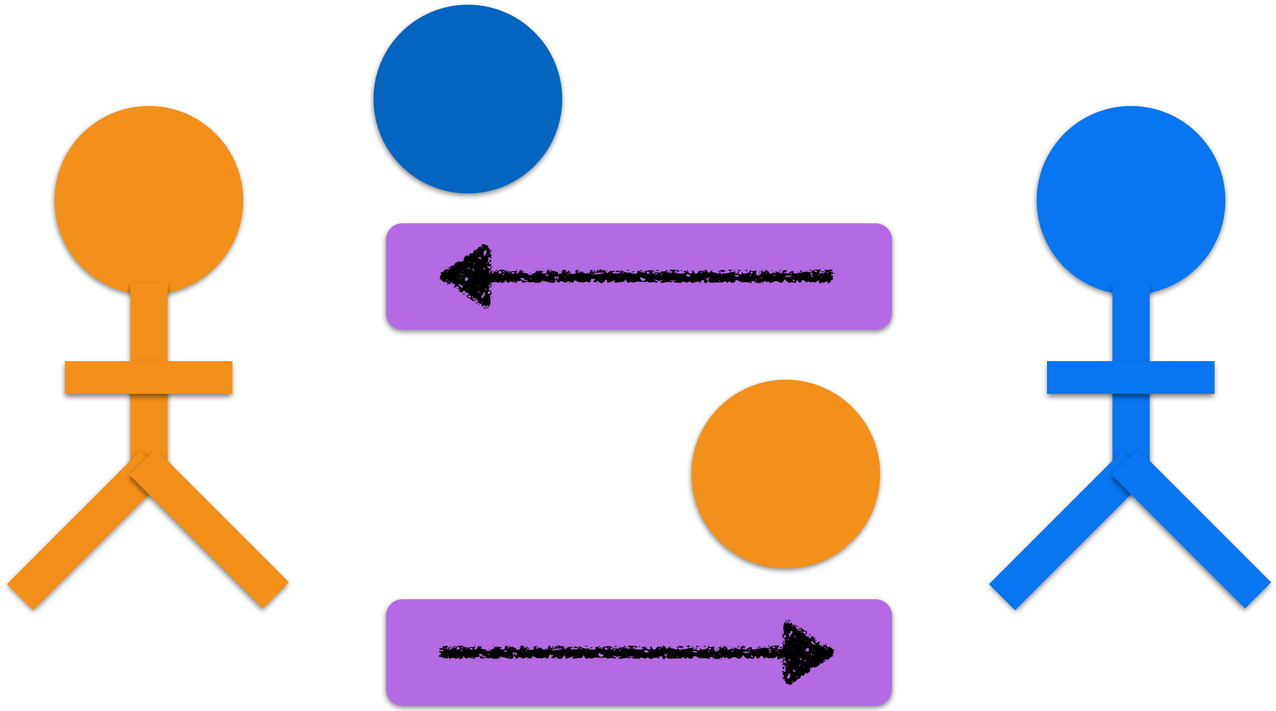

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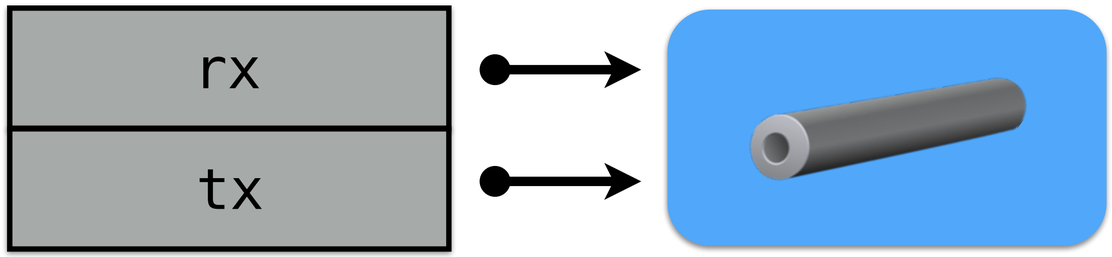

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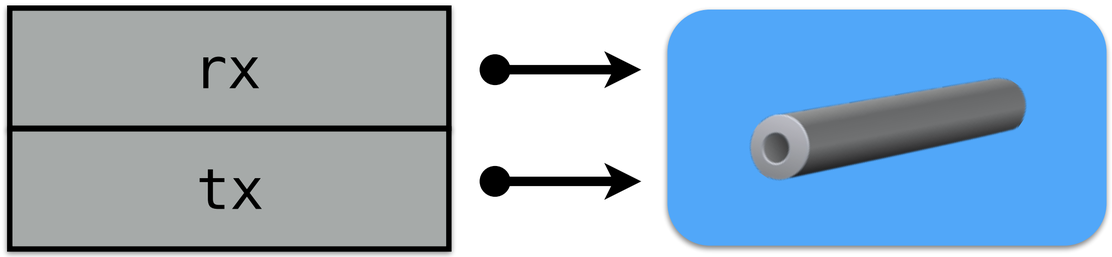

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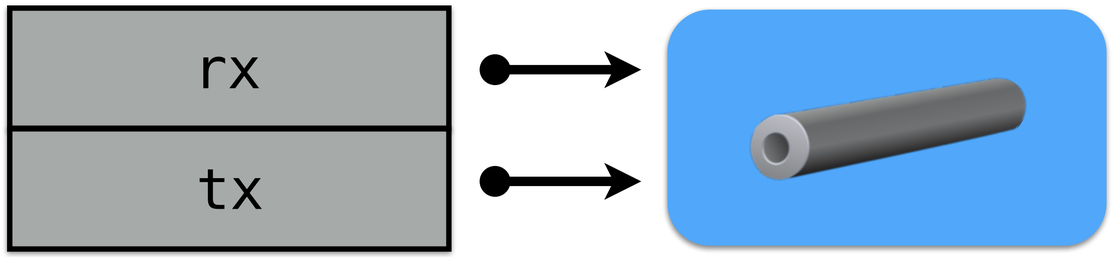

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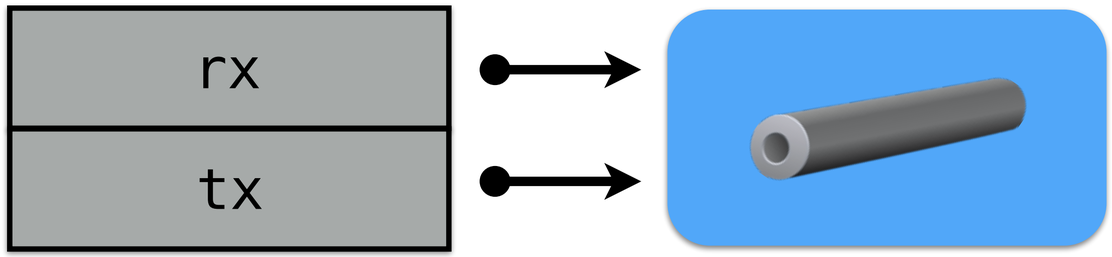

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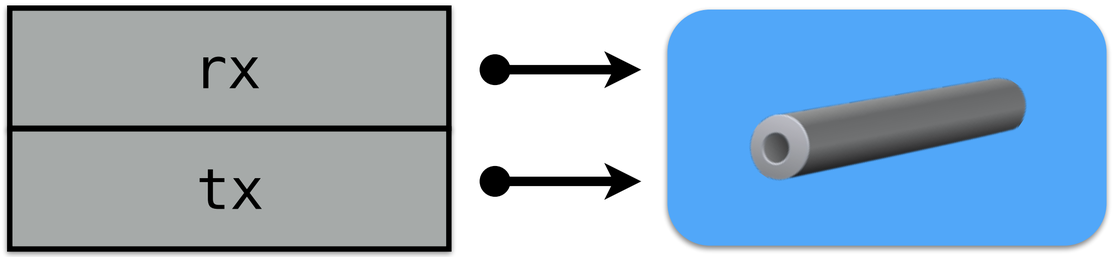

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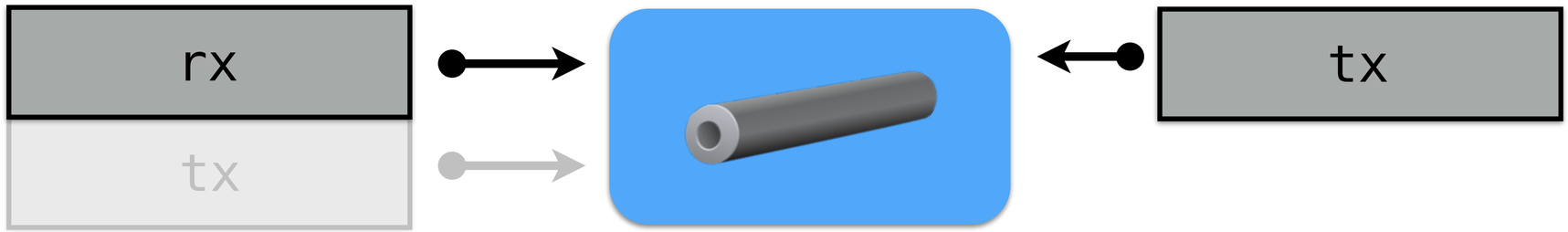

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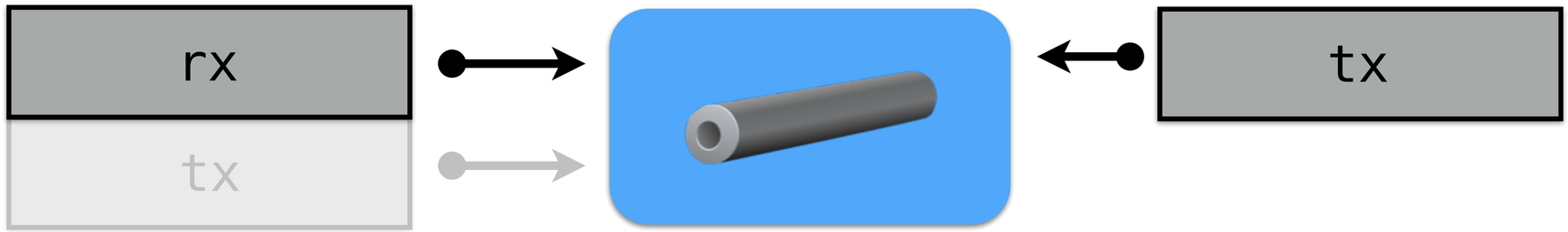

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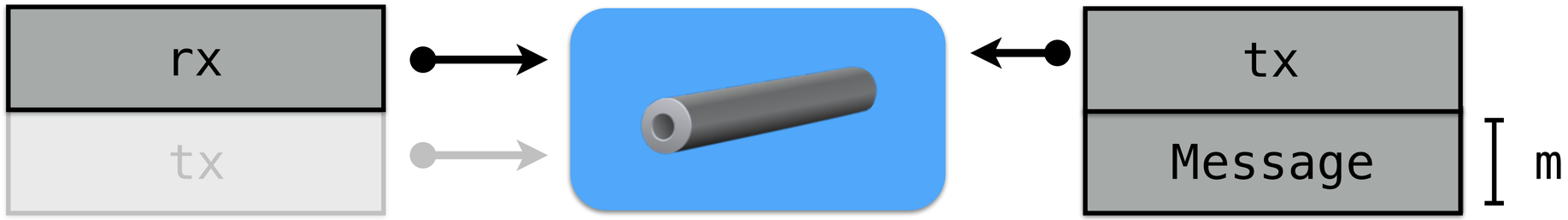

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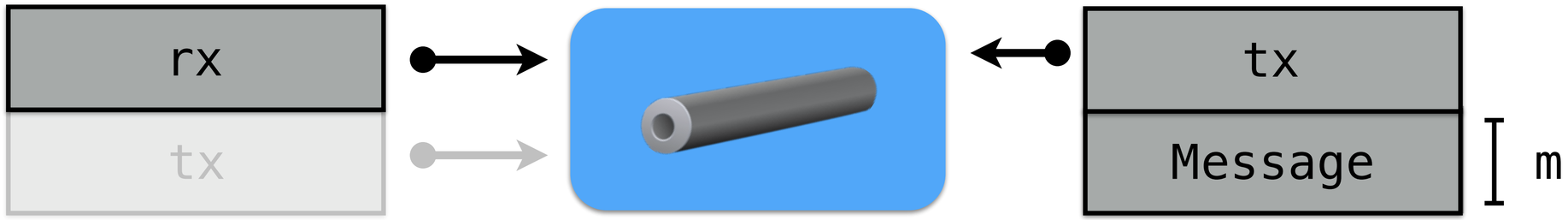

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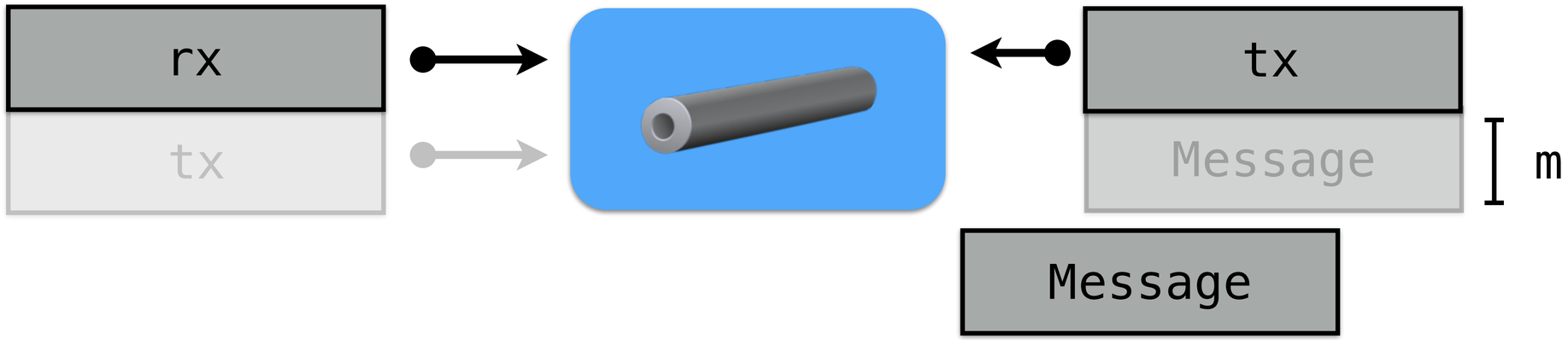

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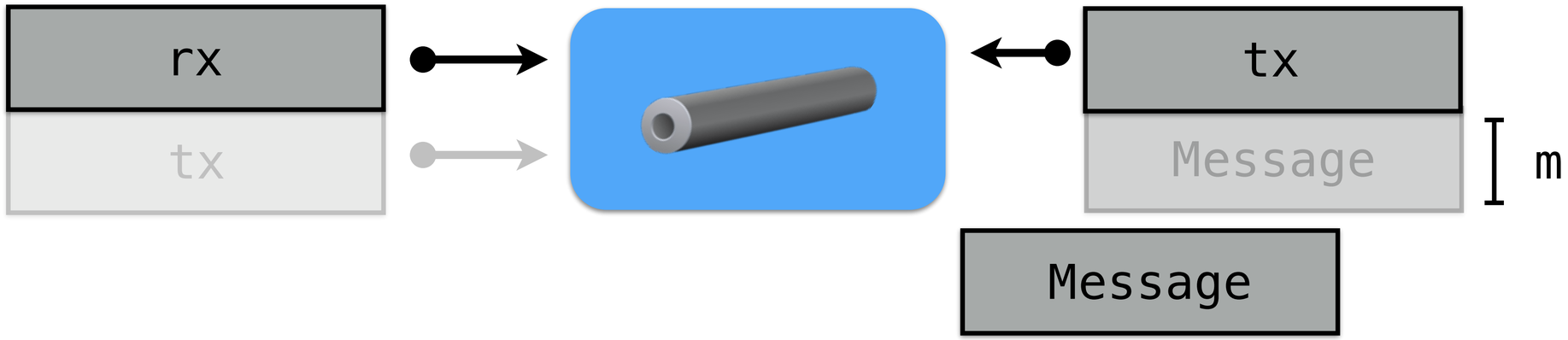

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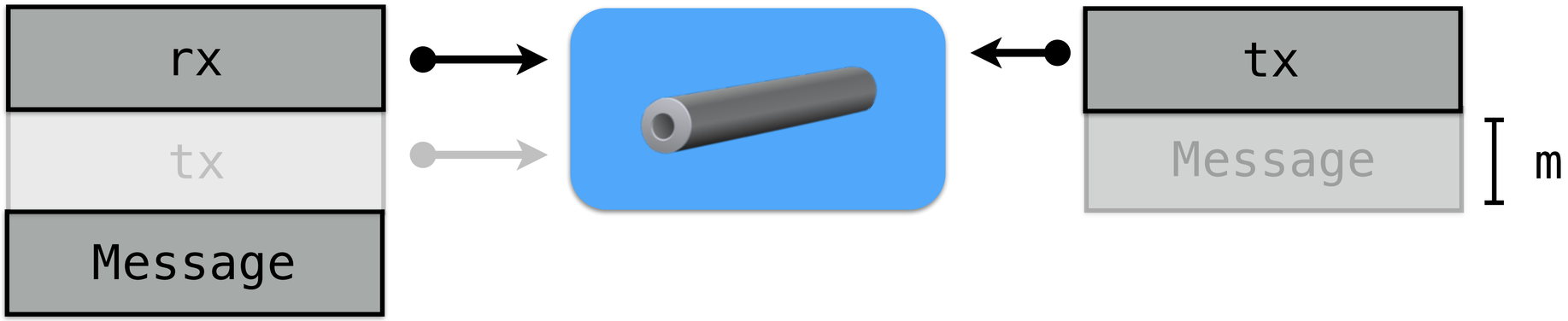

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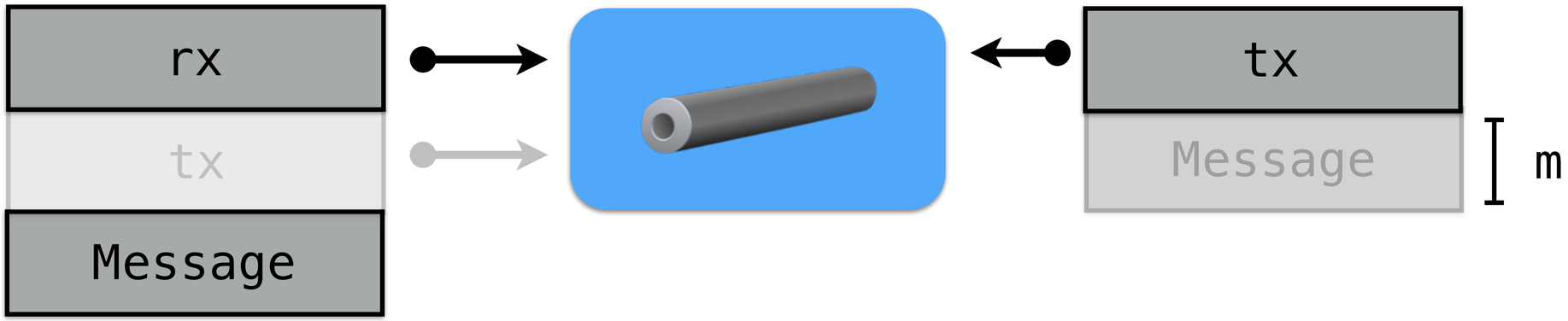

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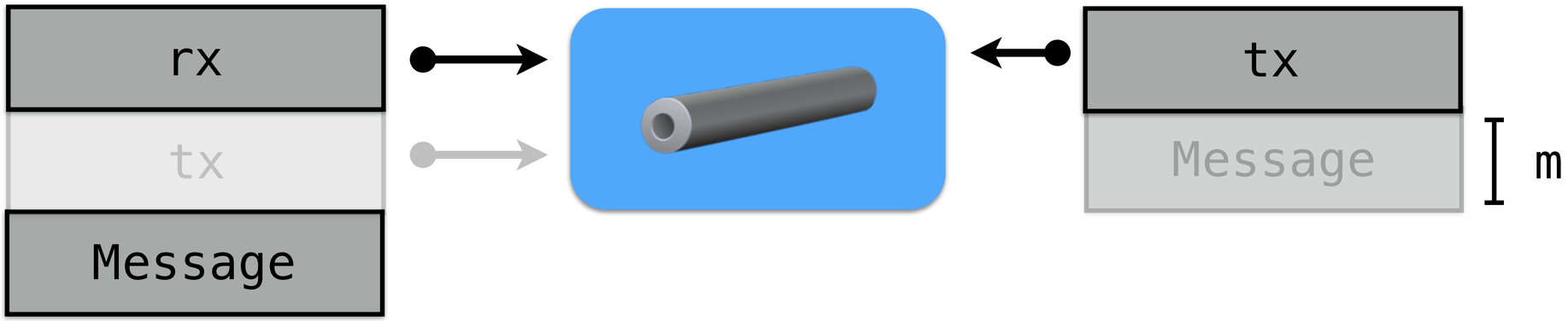

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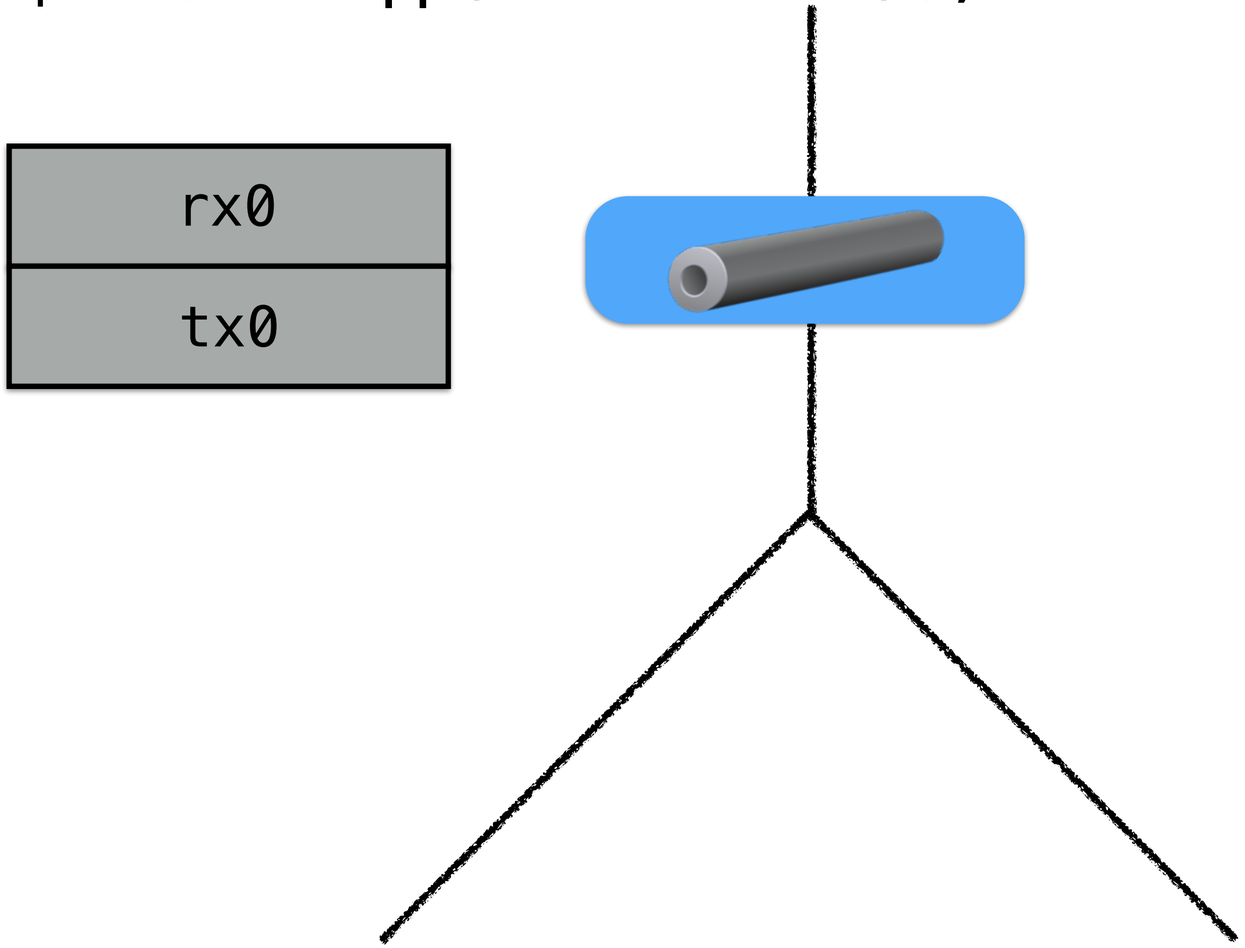

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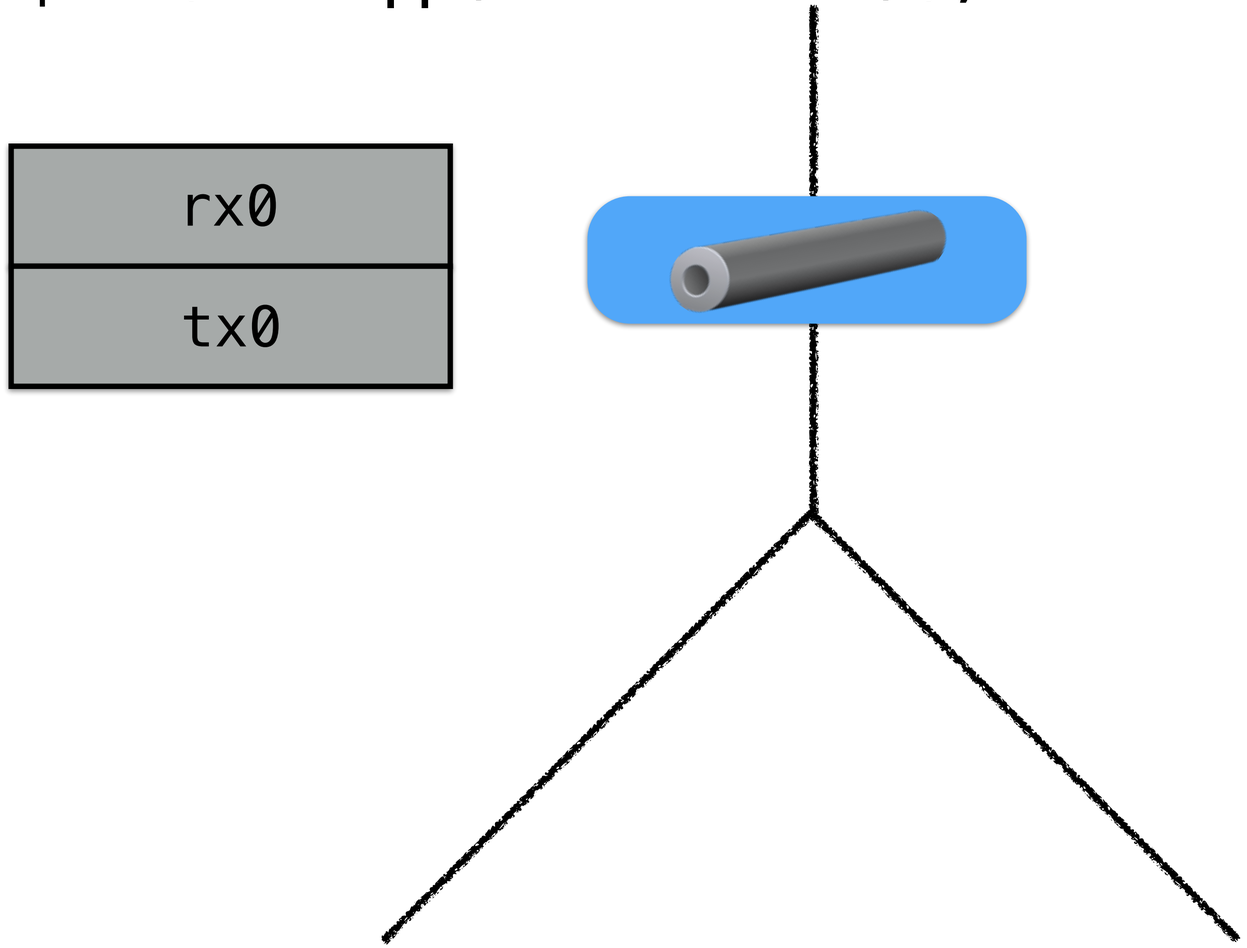

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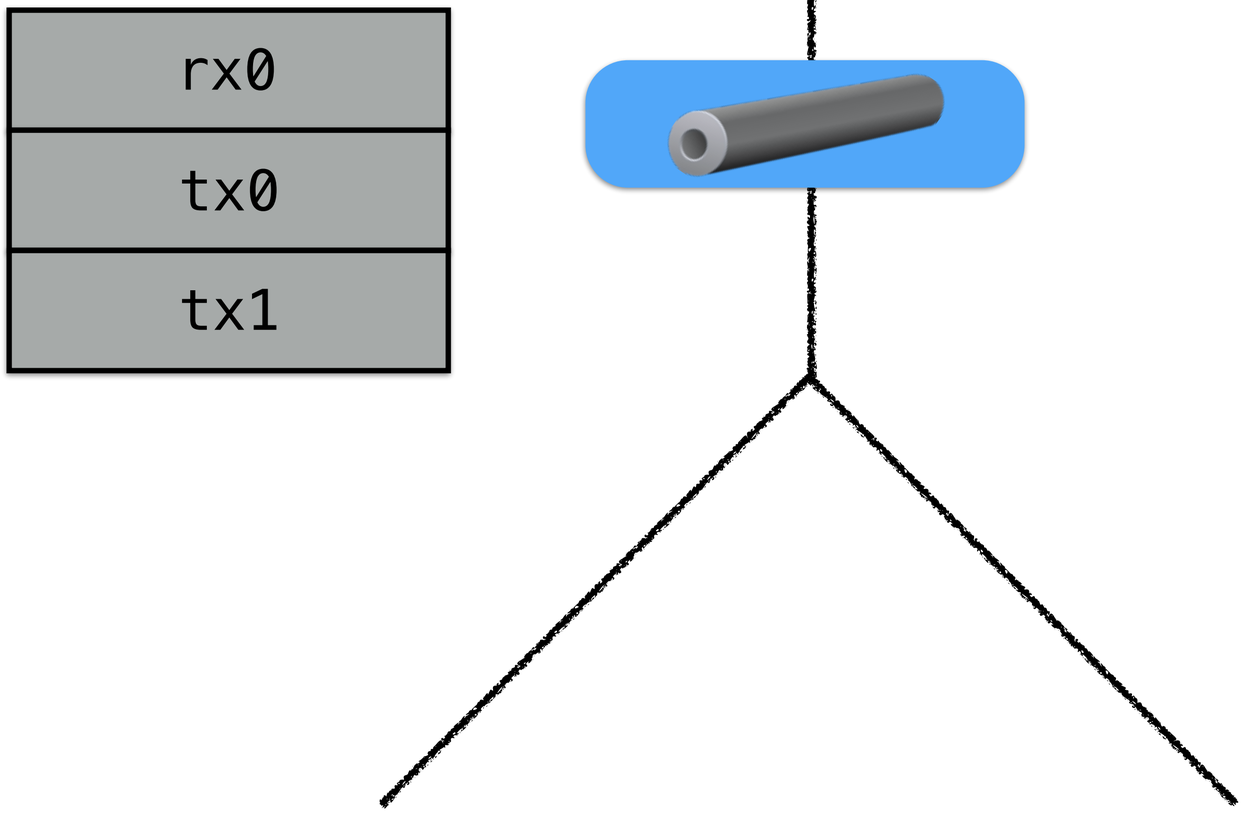

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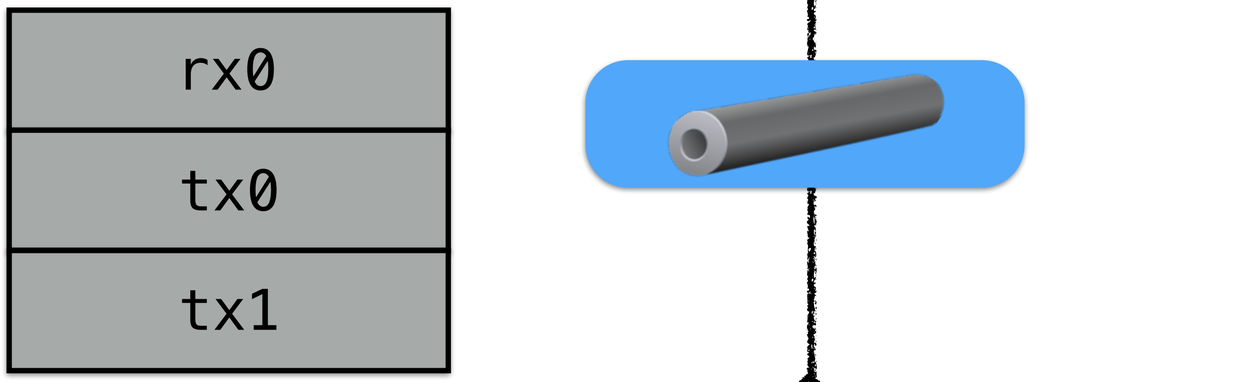

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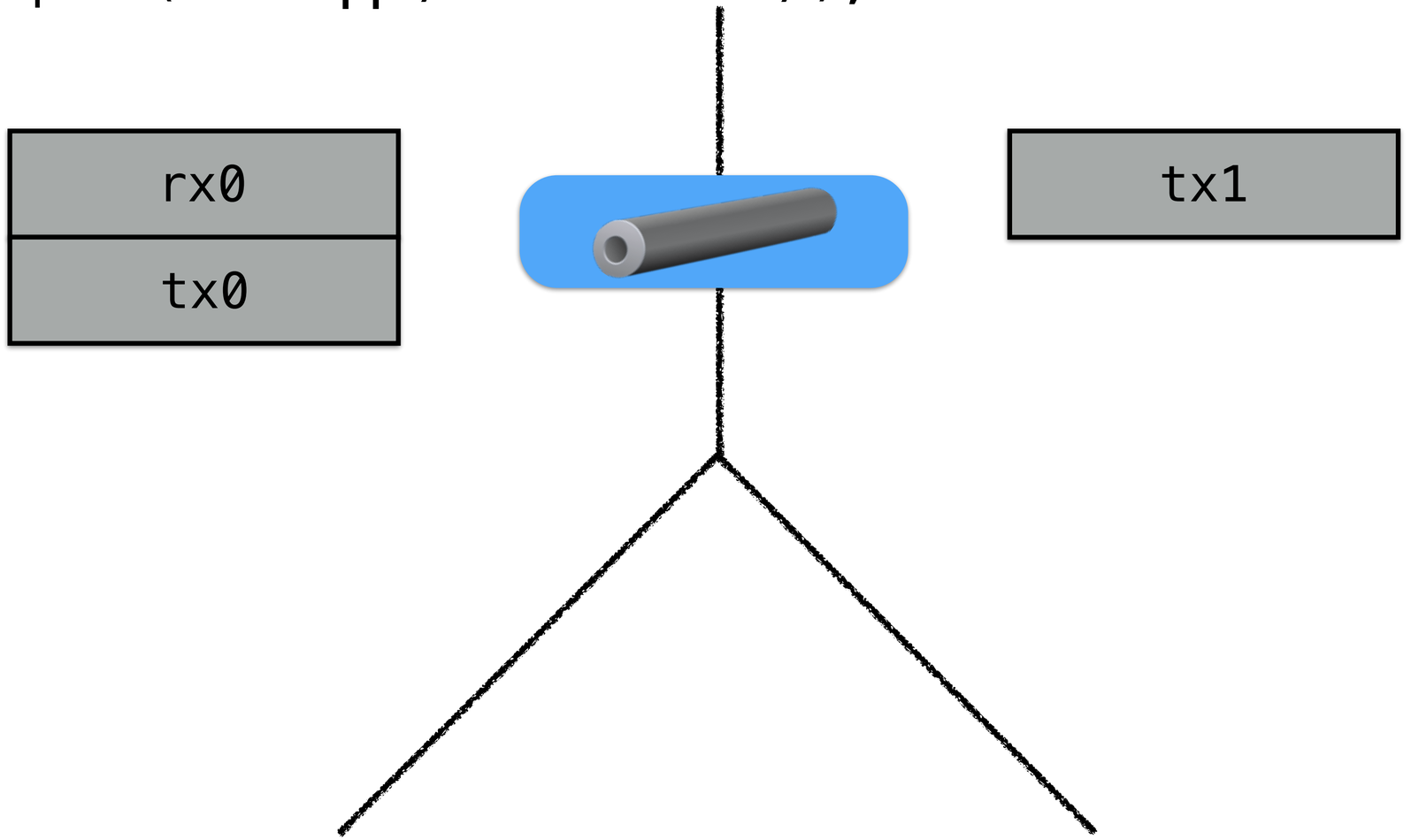

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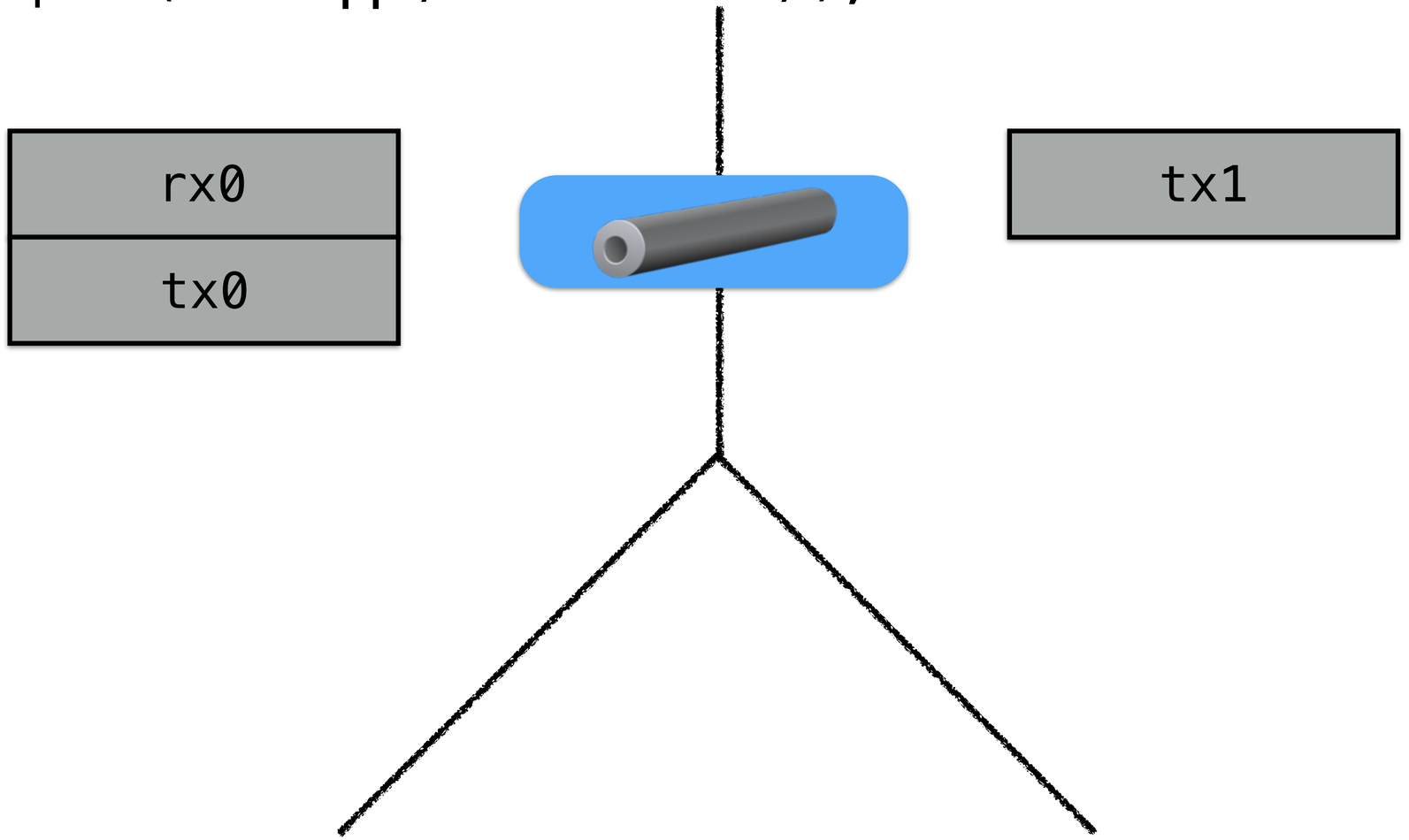

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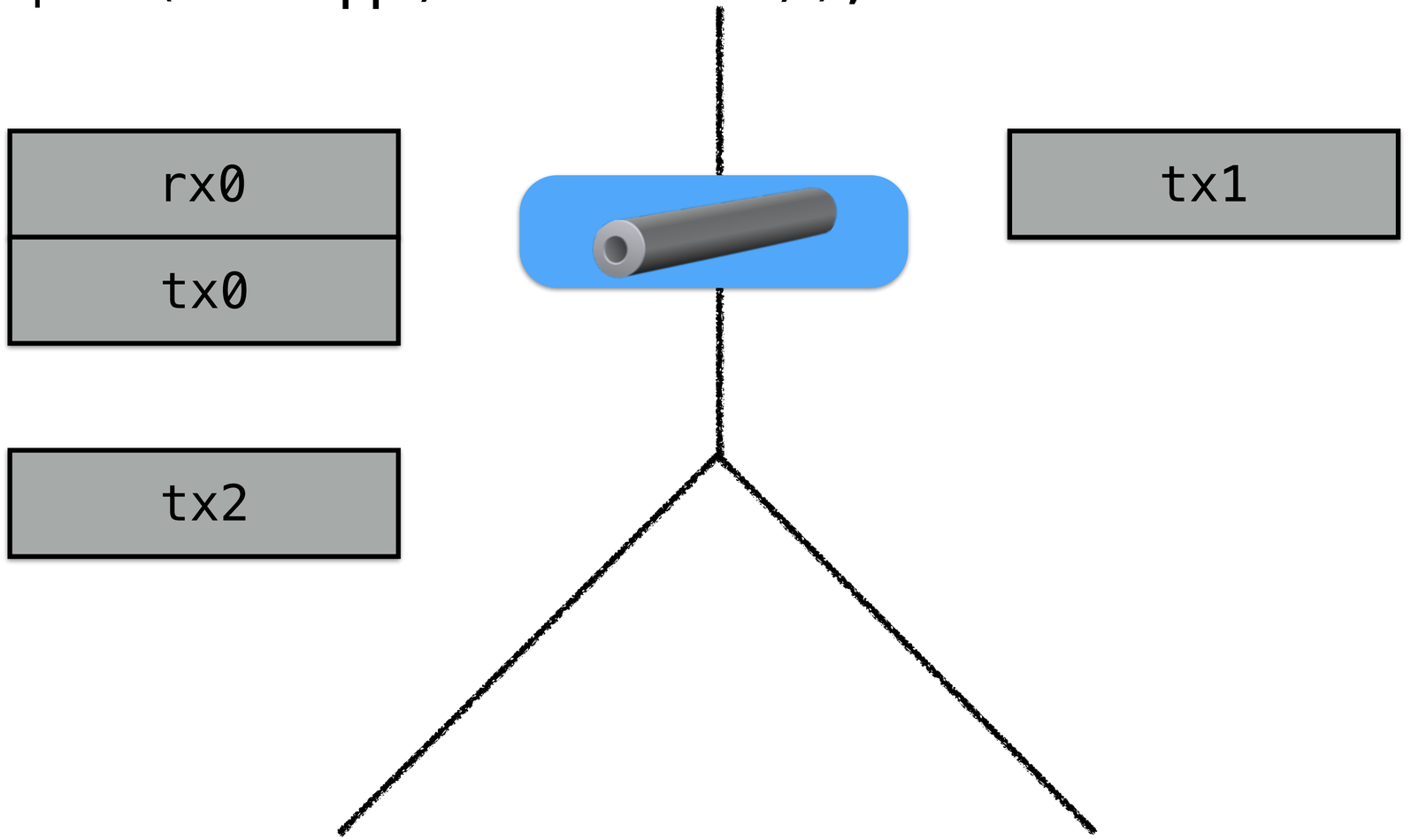

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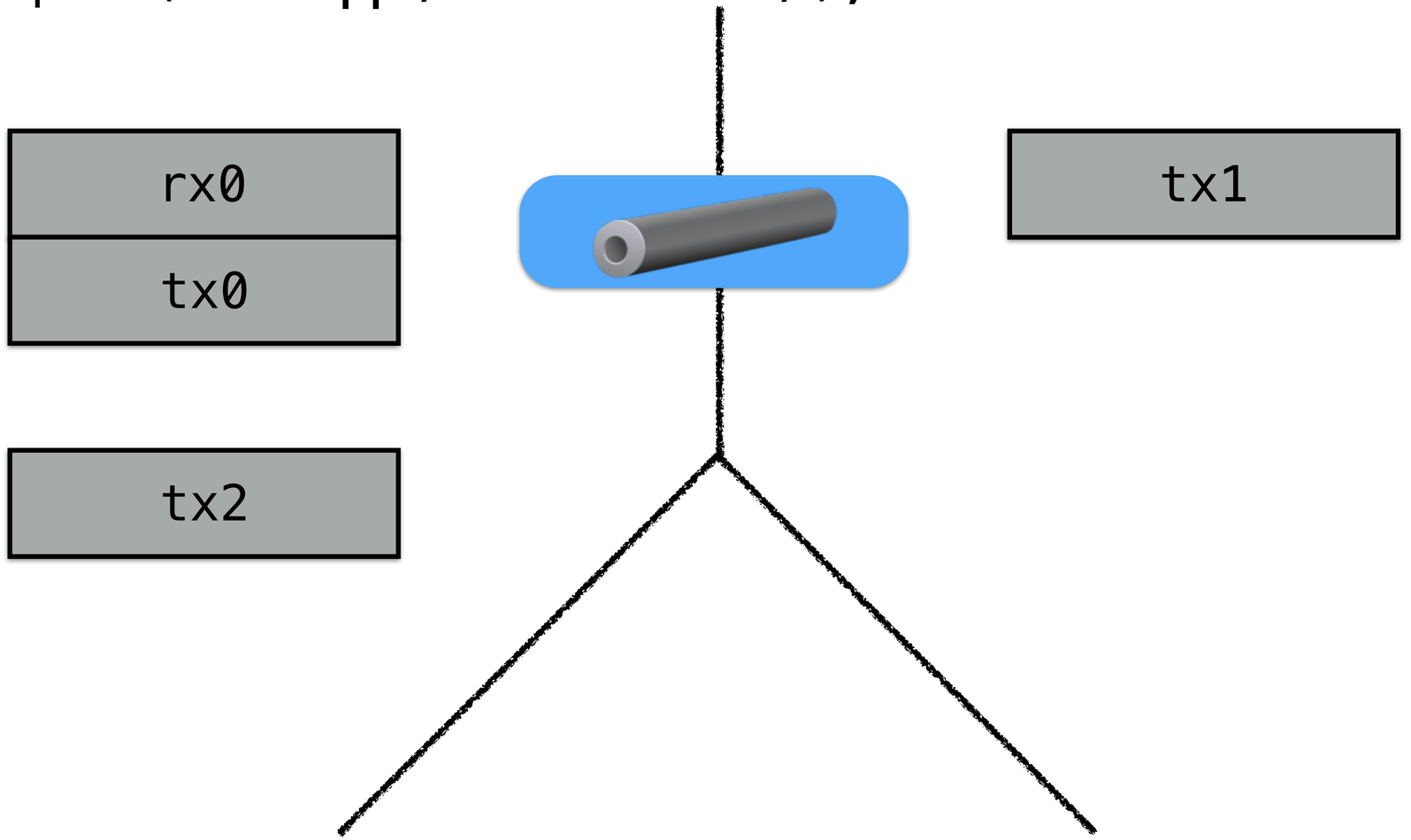

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let tx1 = tx0.clone();
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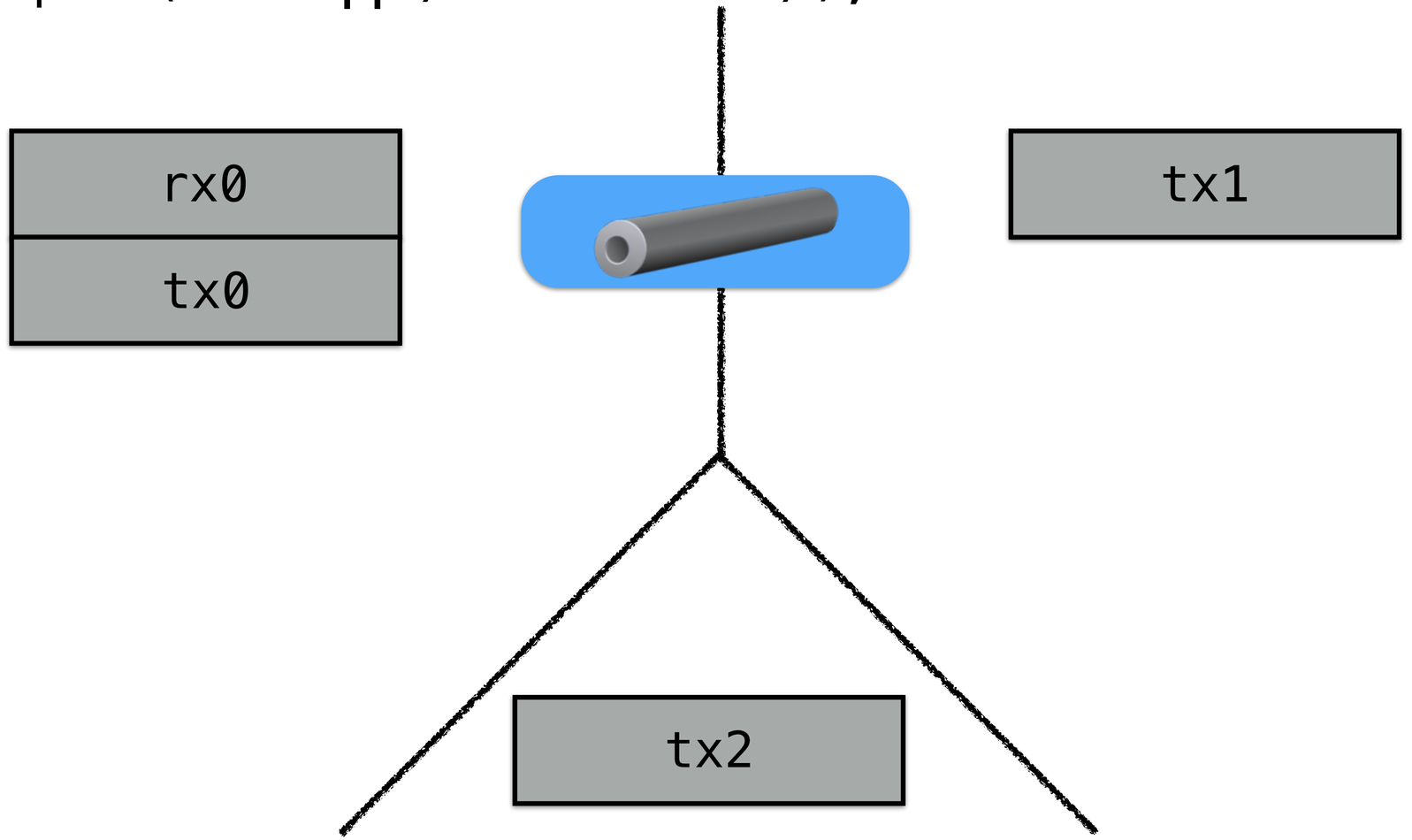

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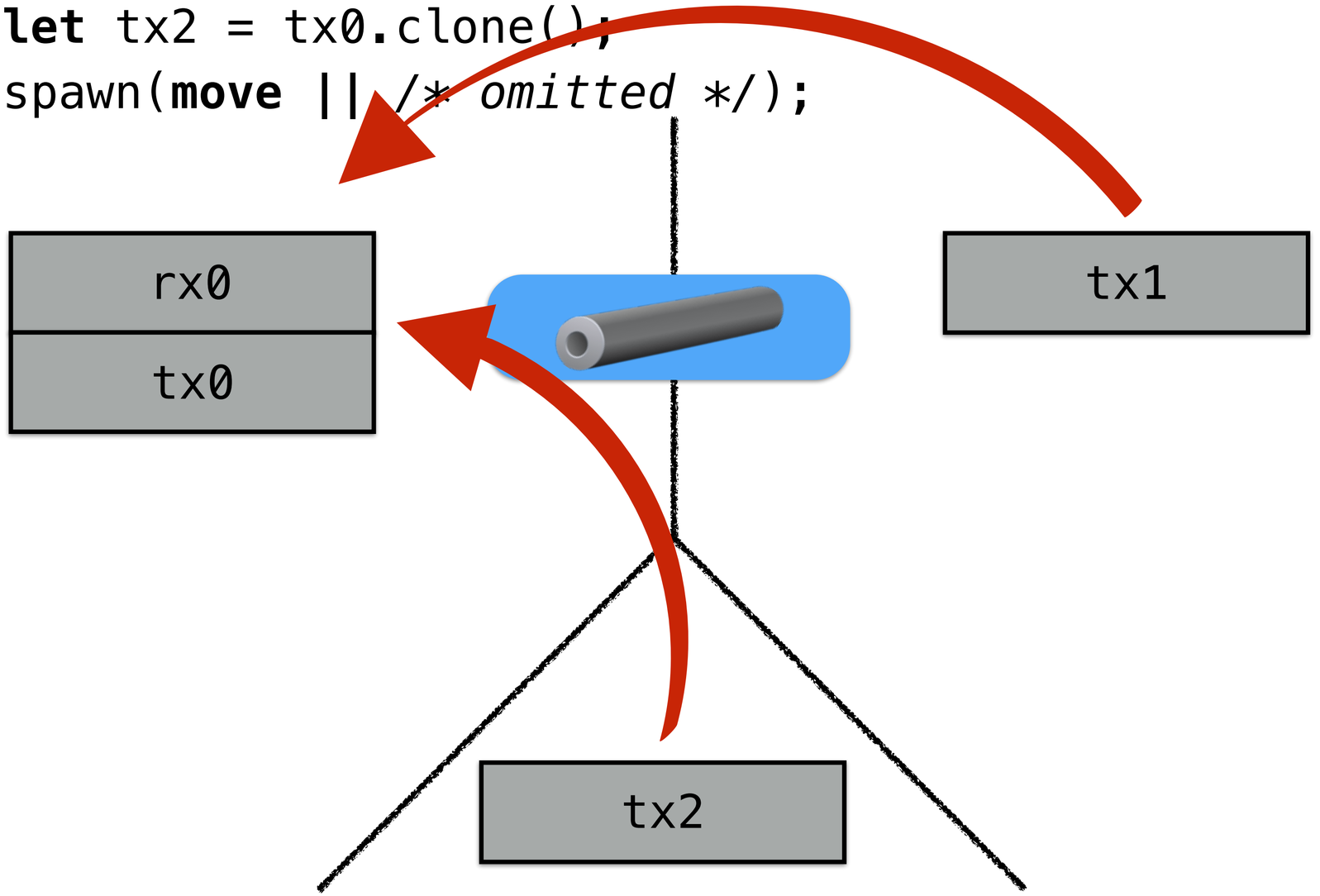

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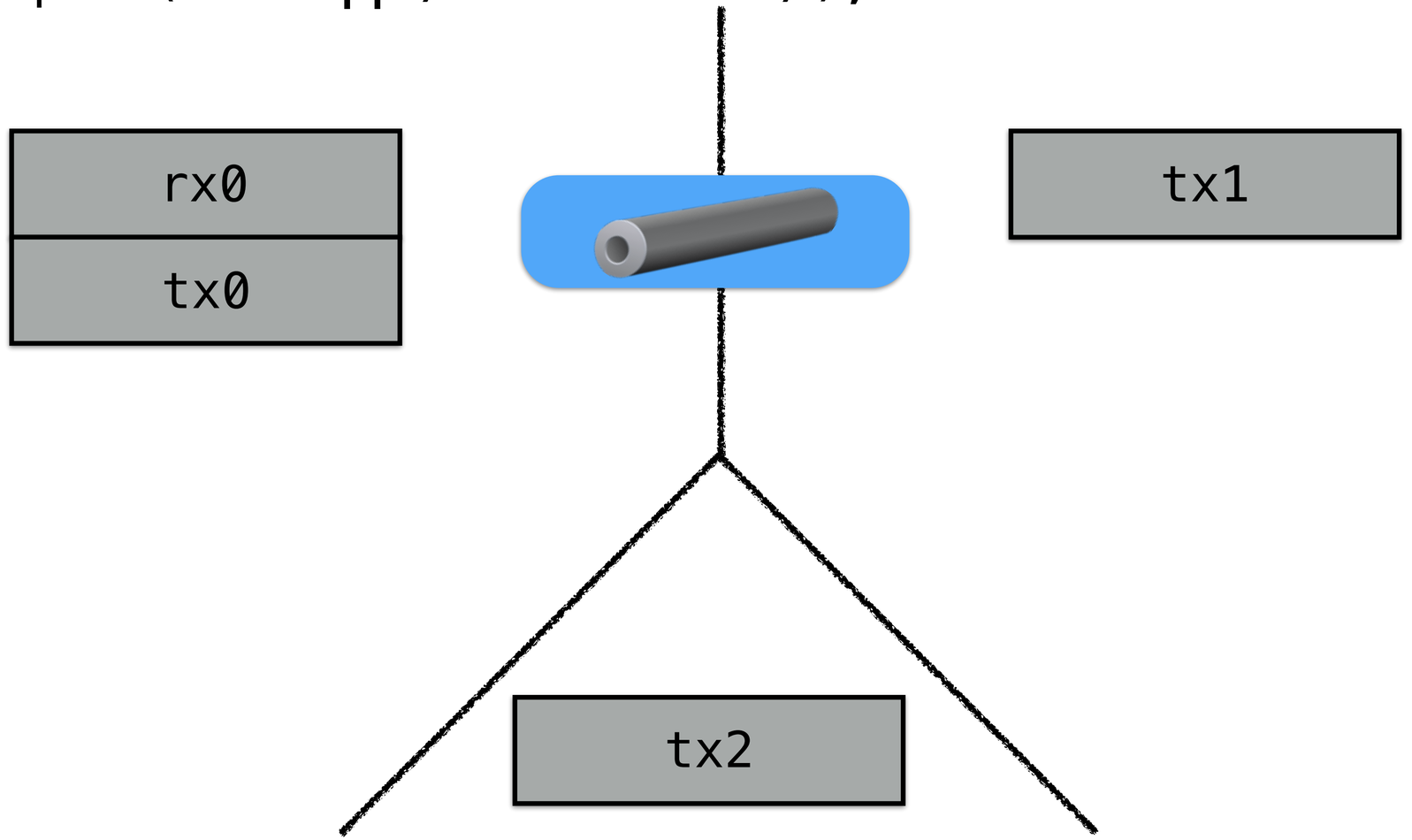

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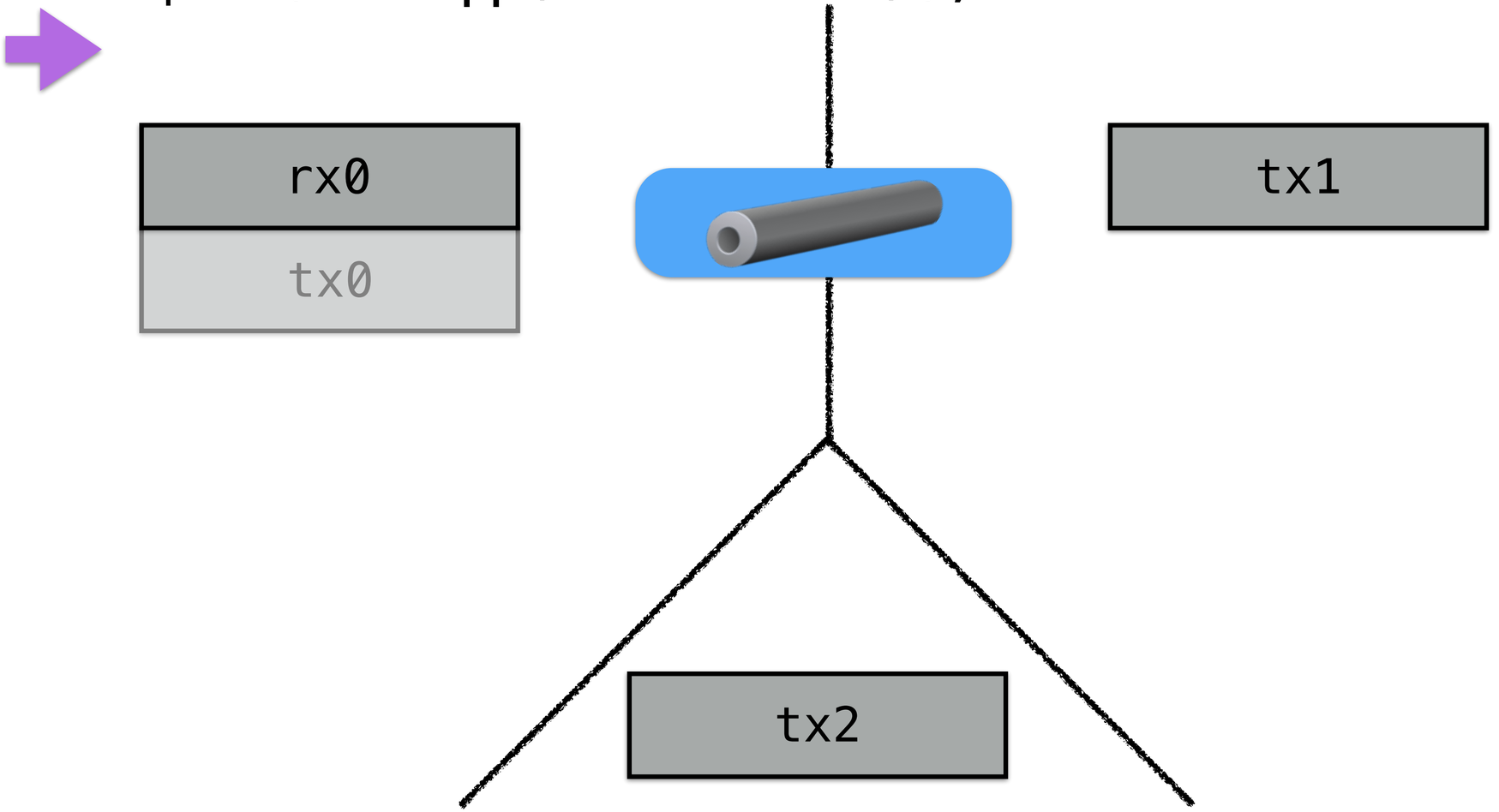

Locks

```
fn sync_inc(counter: &Arc<Mutex<i32>>) {
  let mut data = counter.lock().unwrap();
  *data += 1;
}
```

https://commons.wikimedia.org/wiki/File:No-DRM_lock.svg

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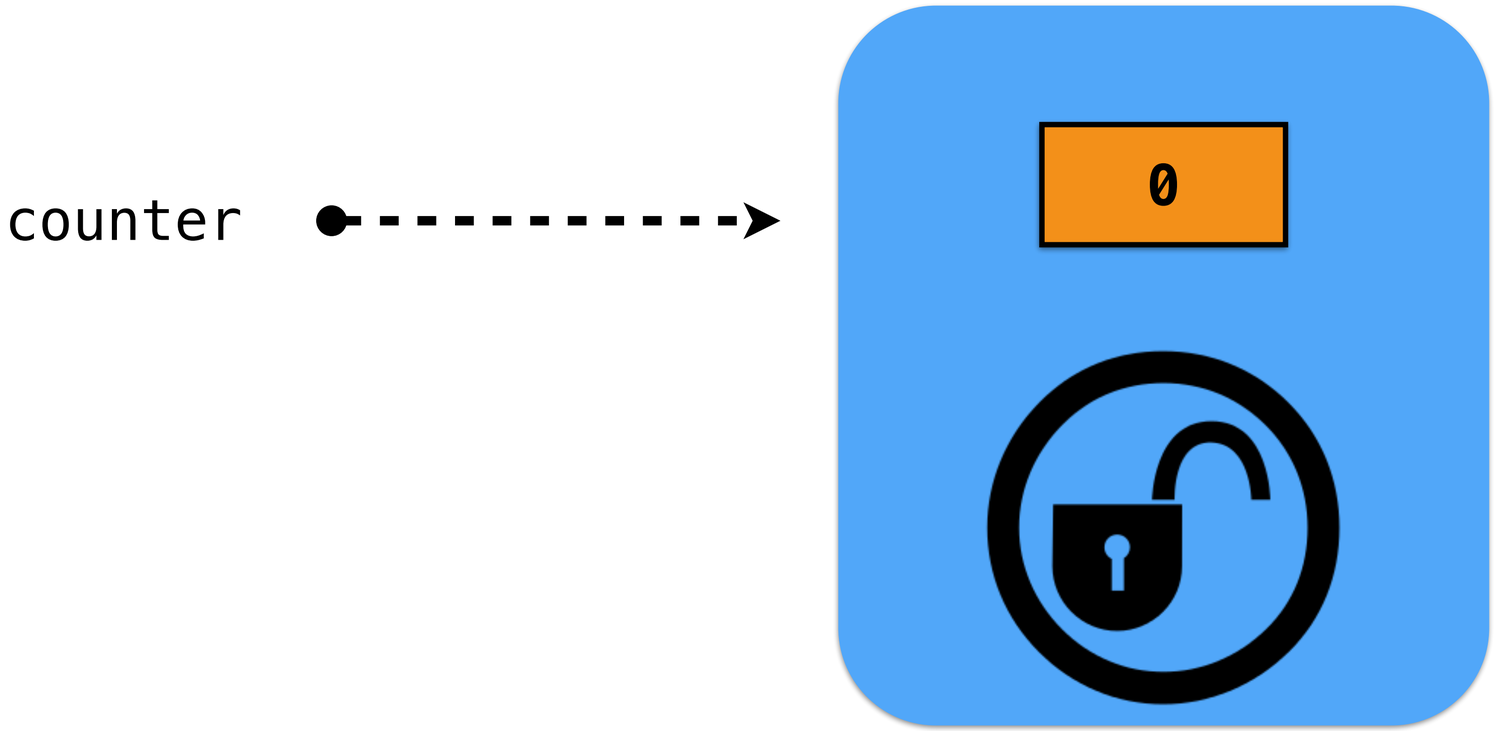

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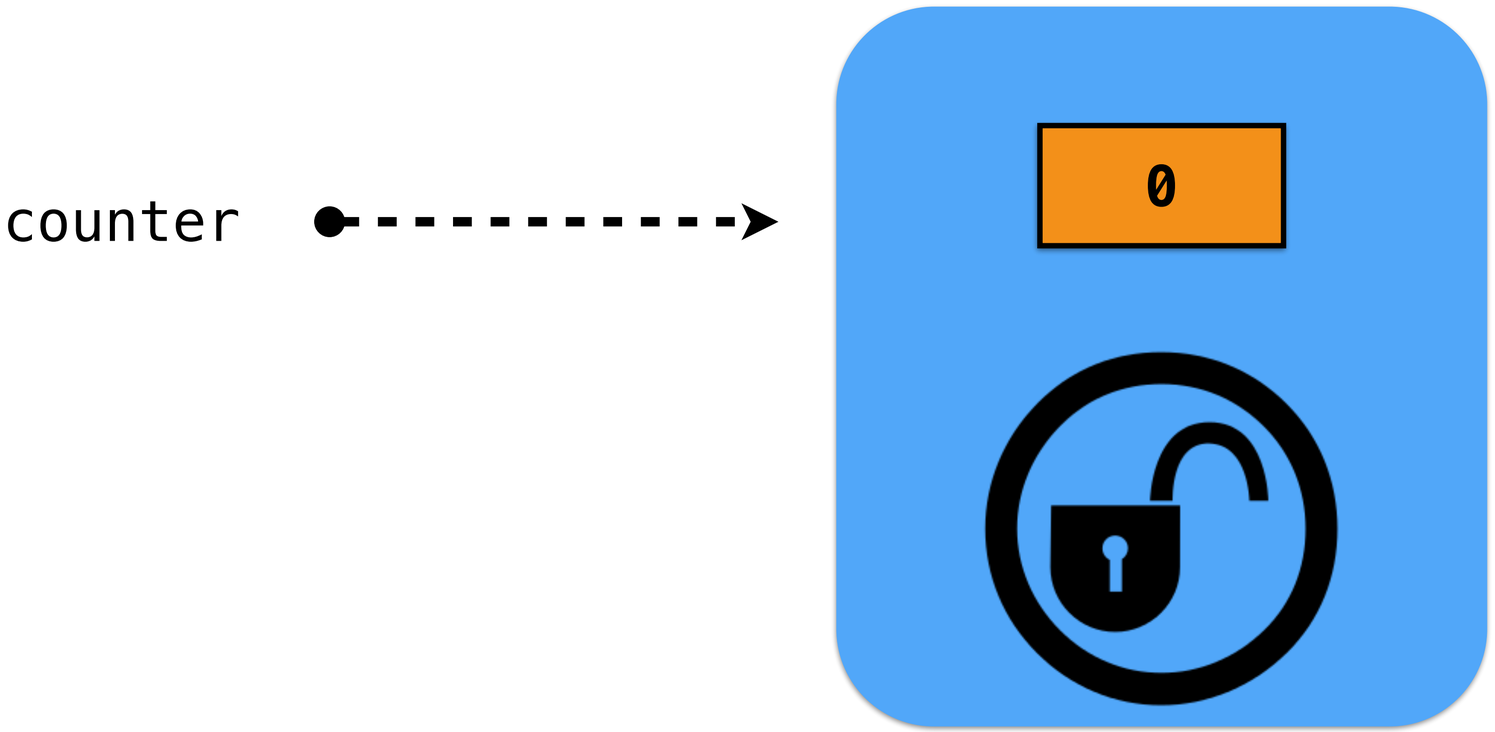

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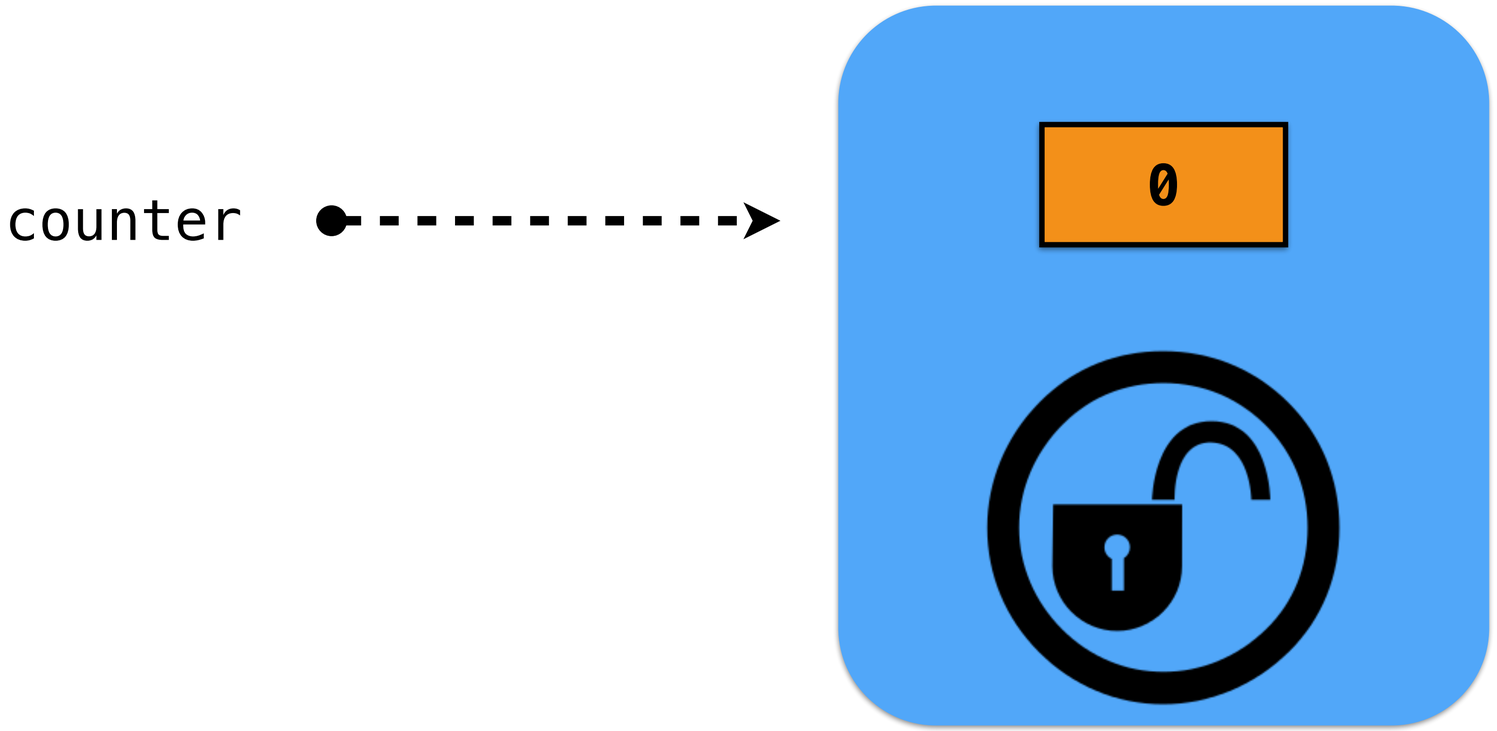

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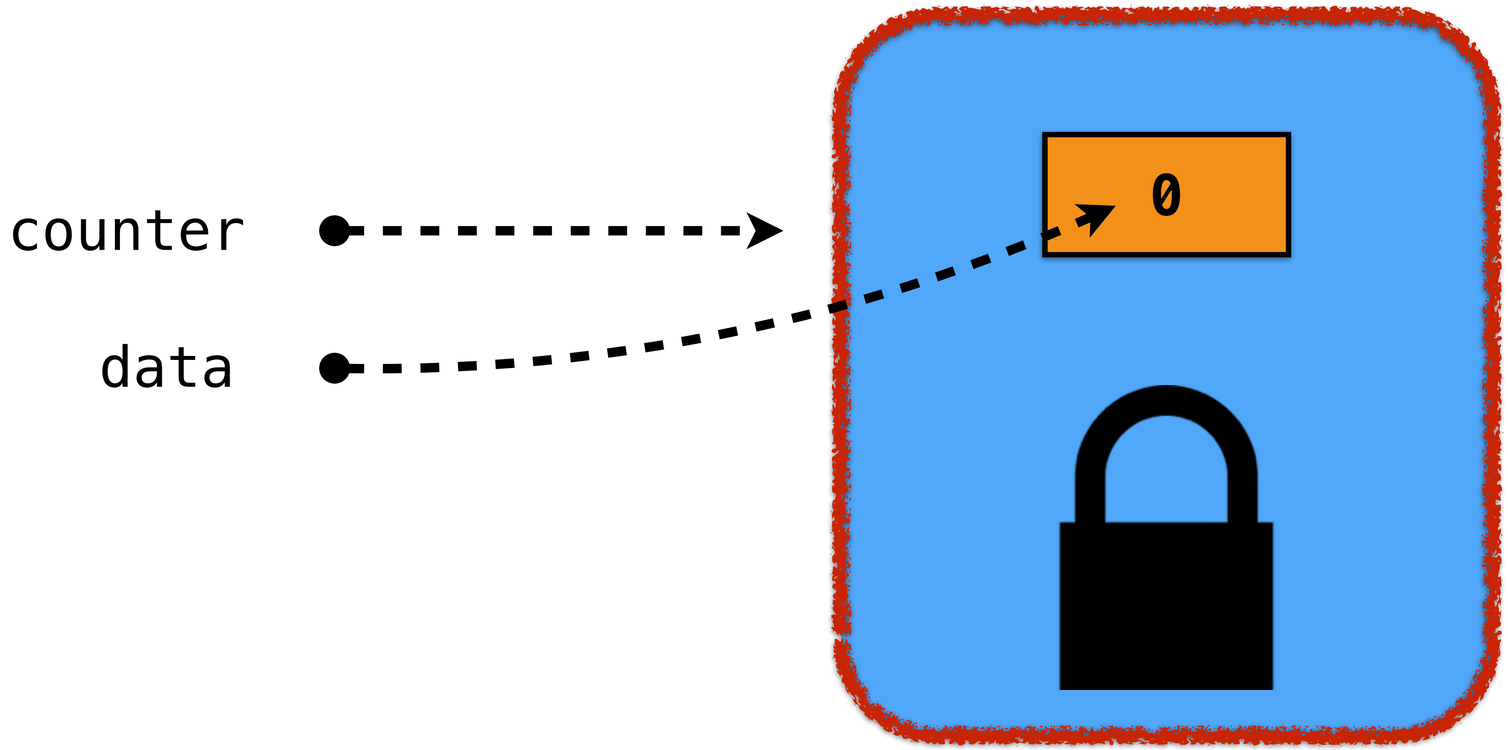

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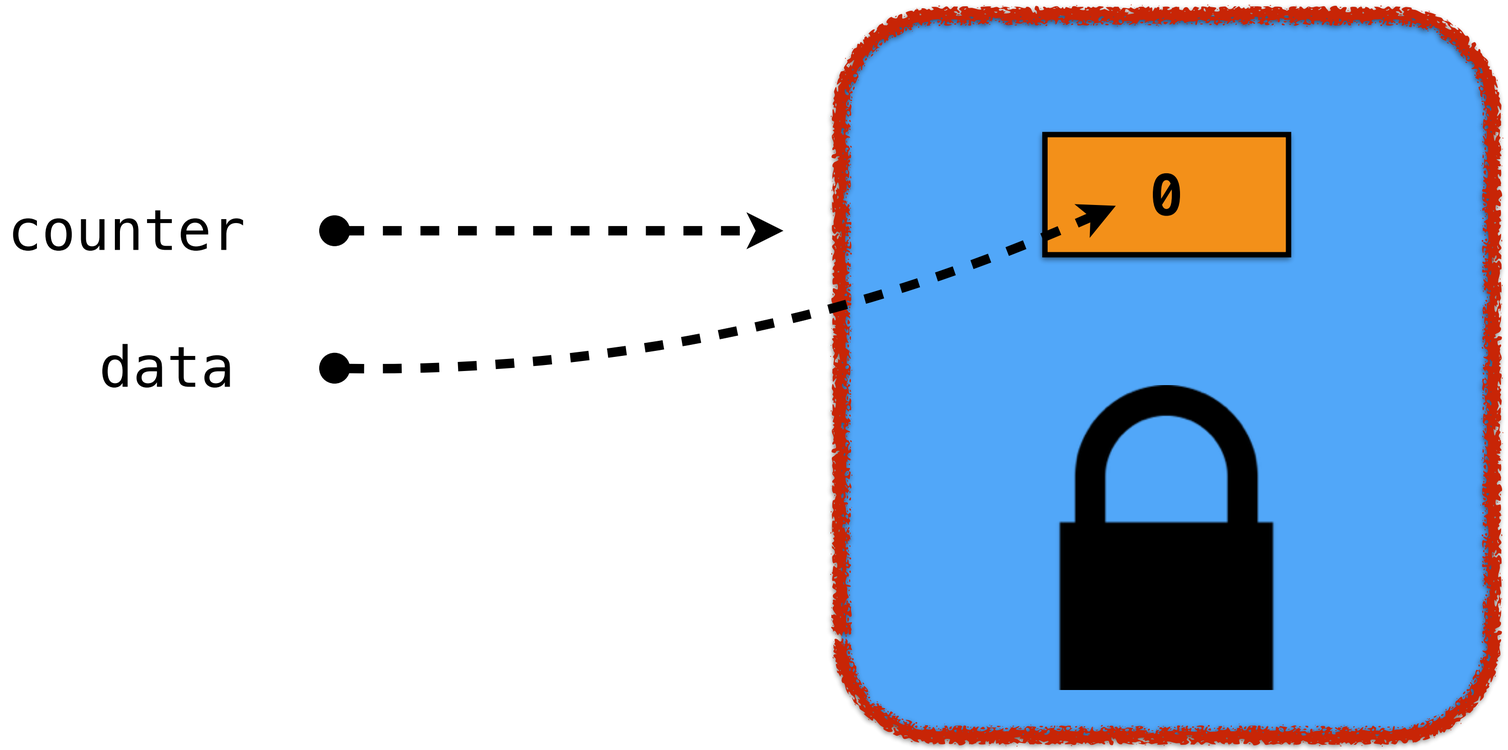

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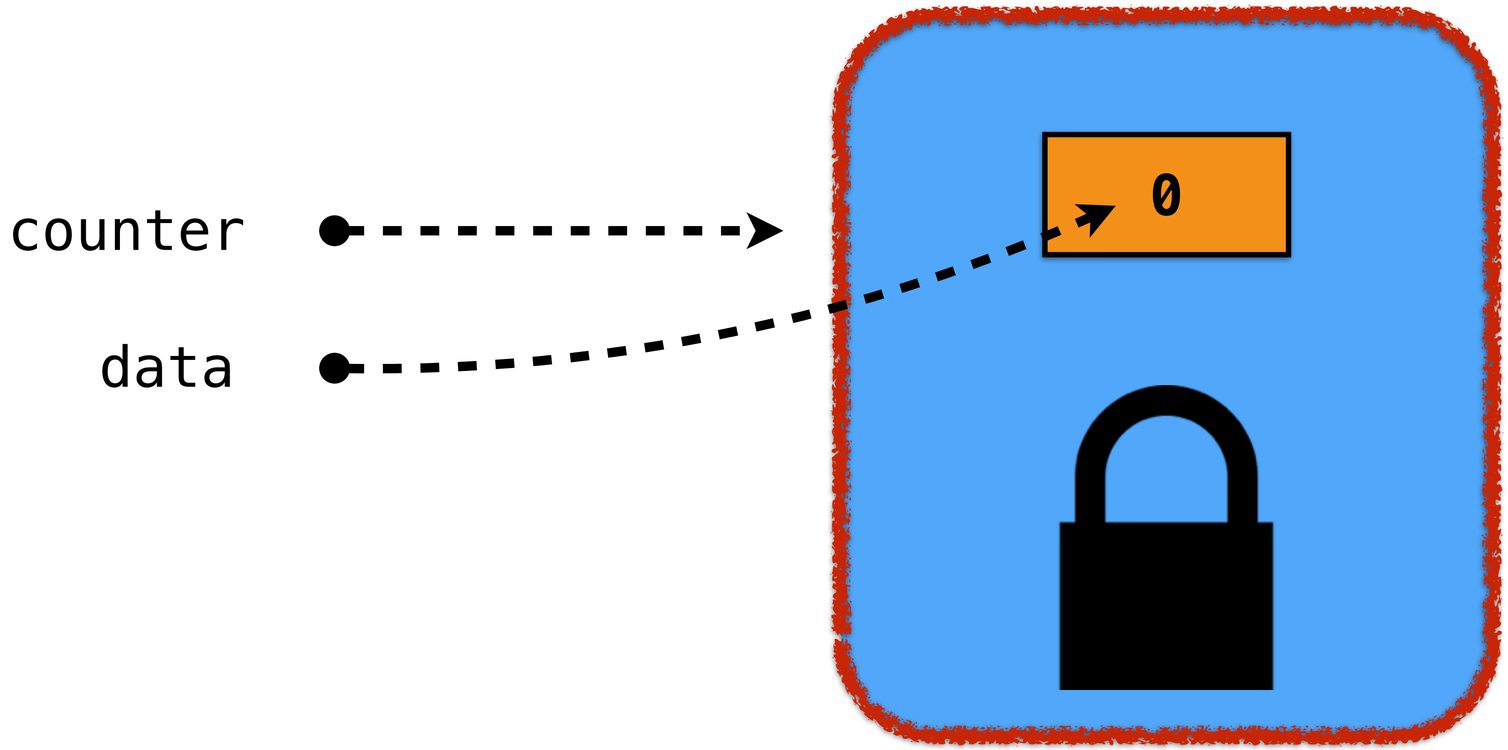

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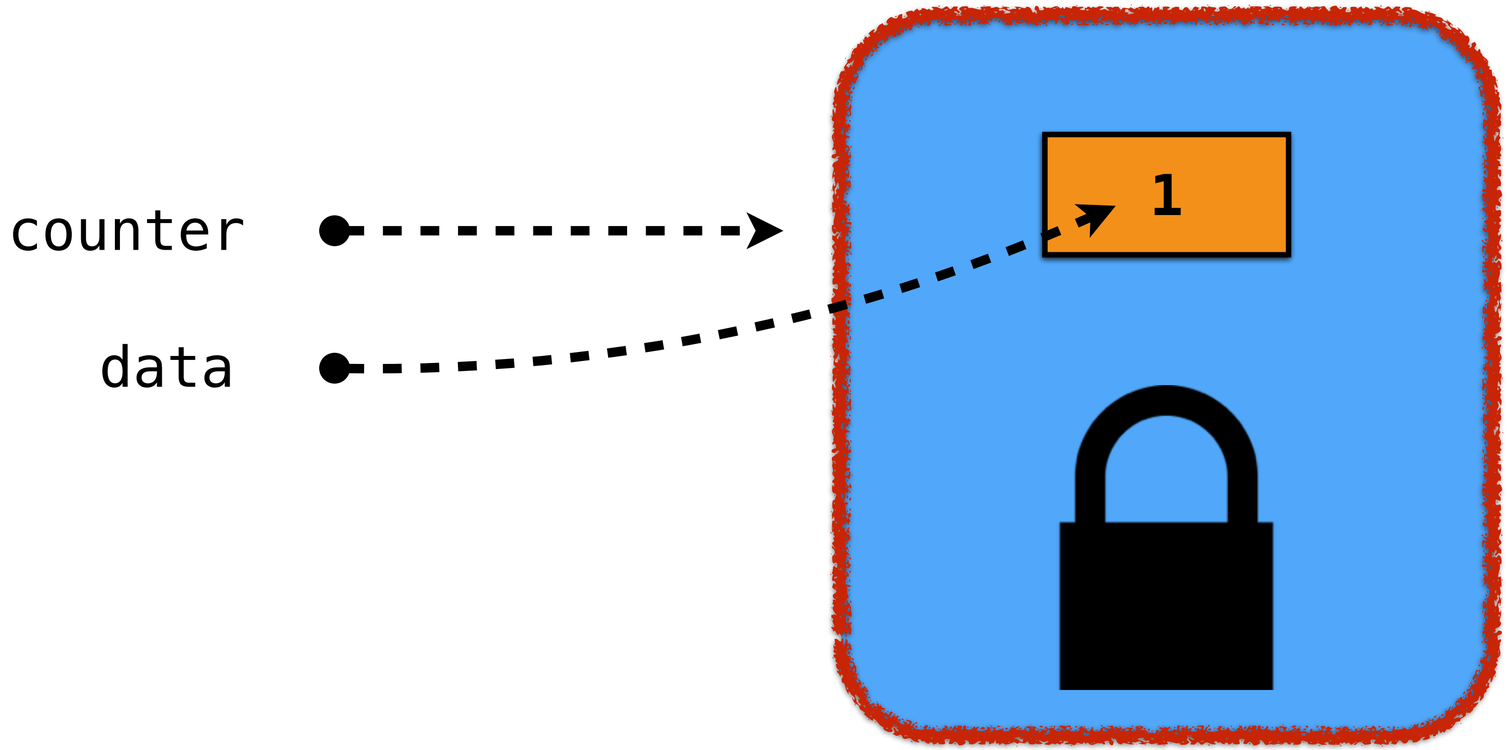

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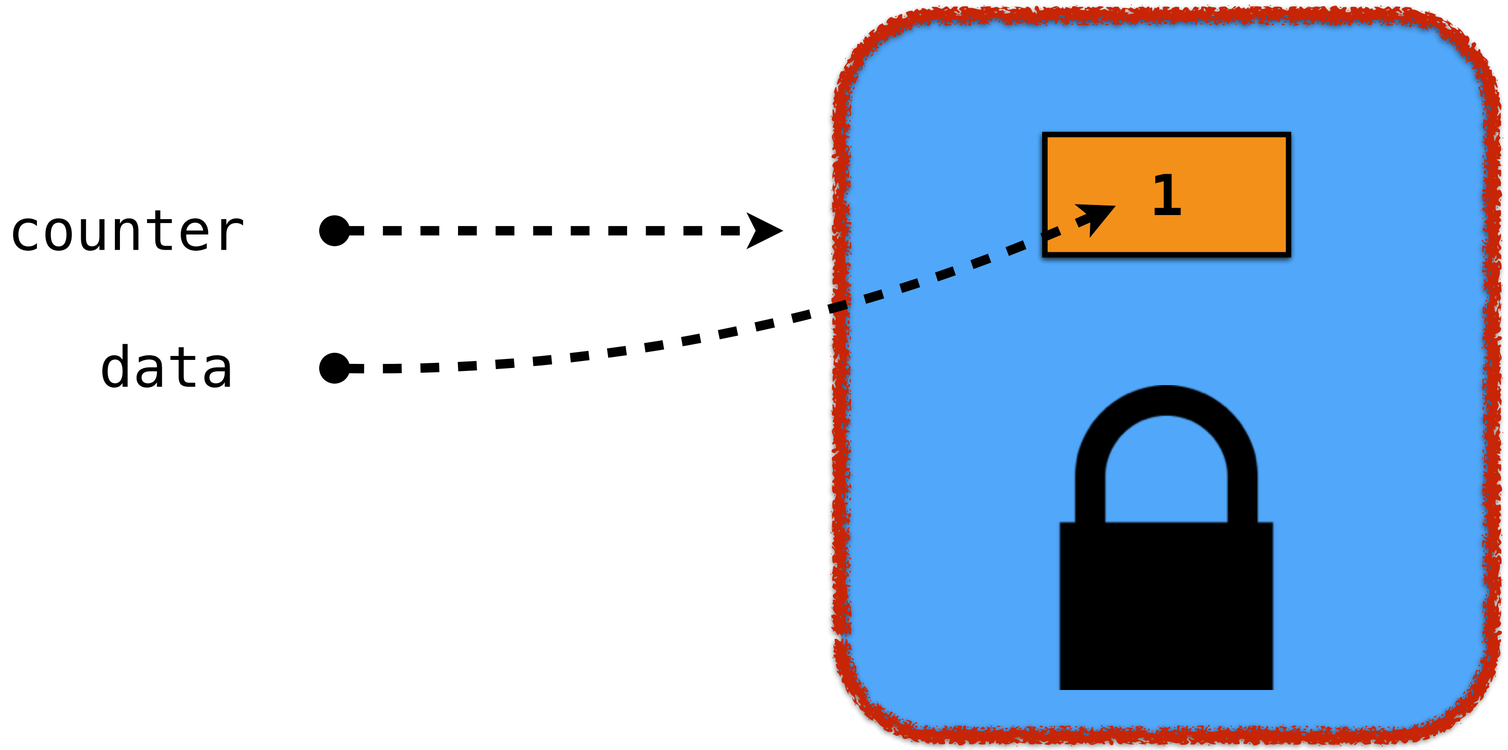

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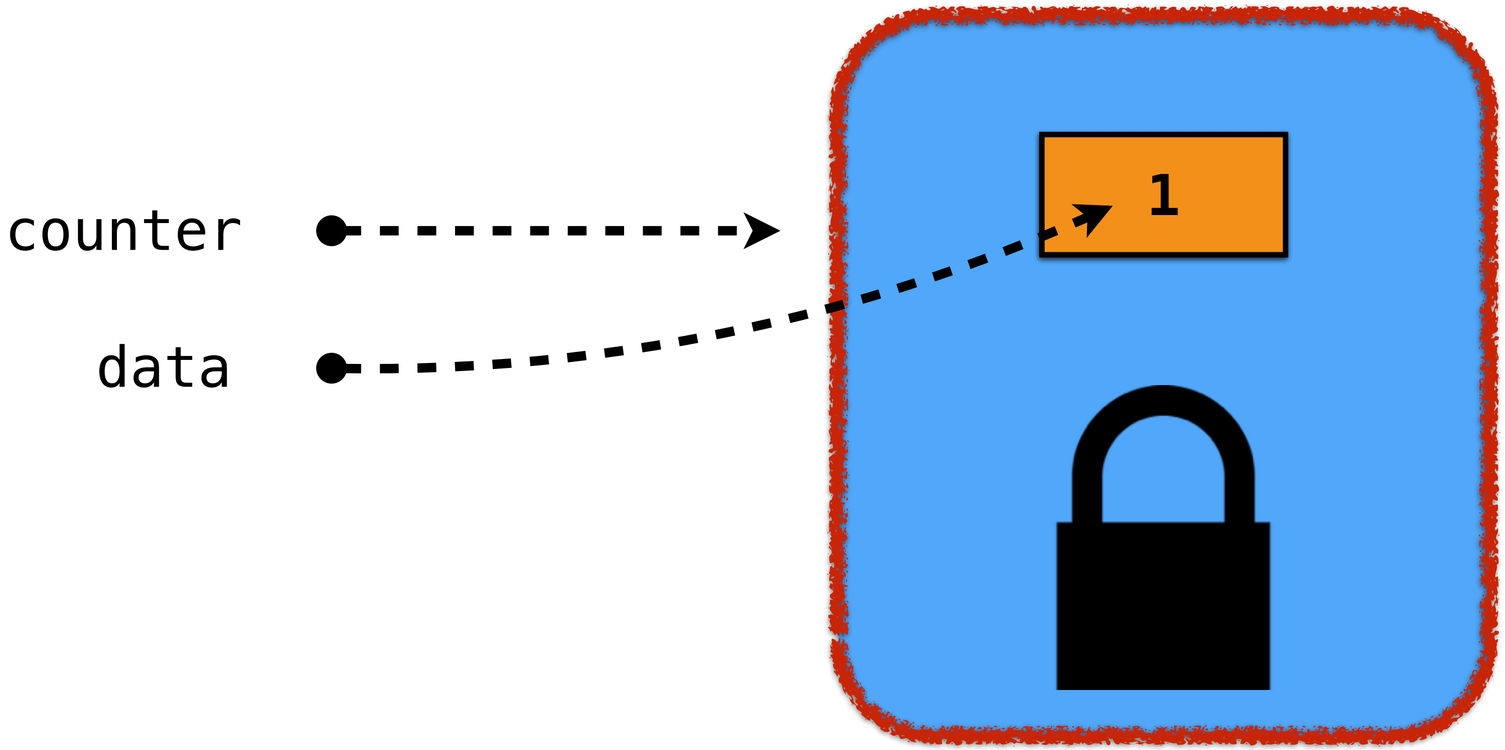

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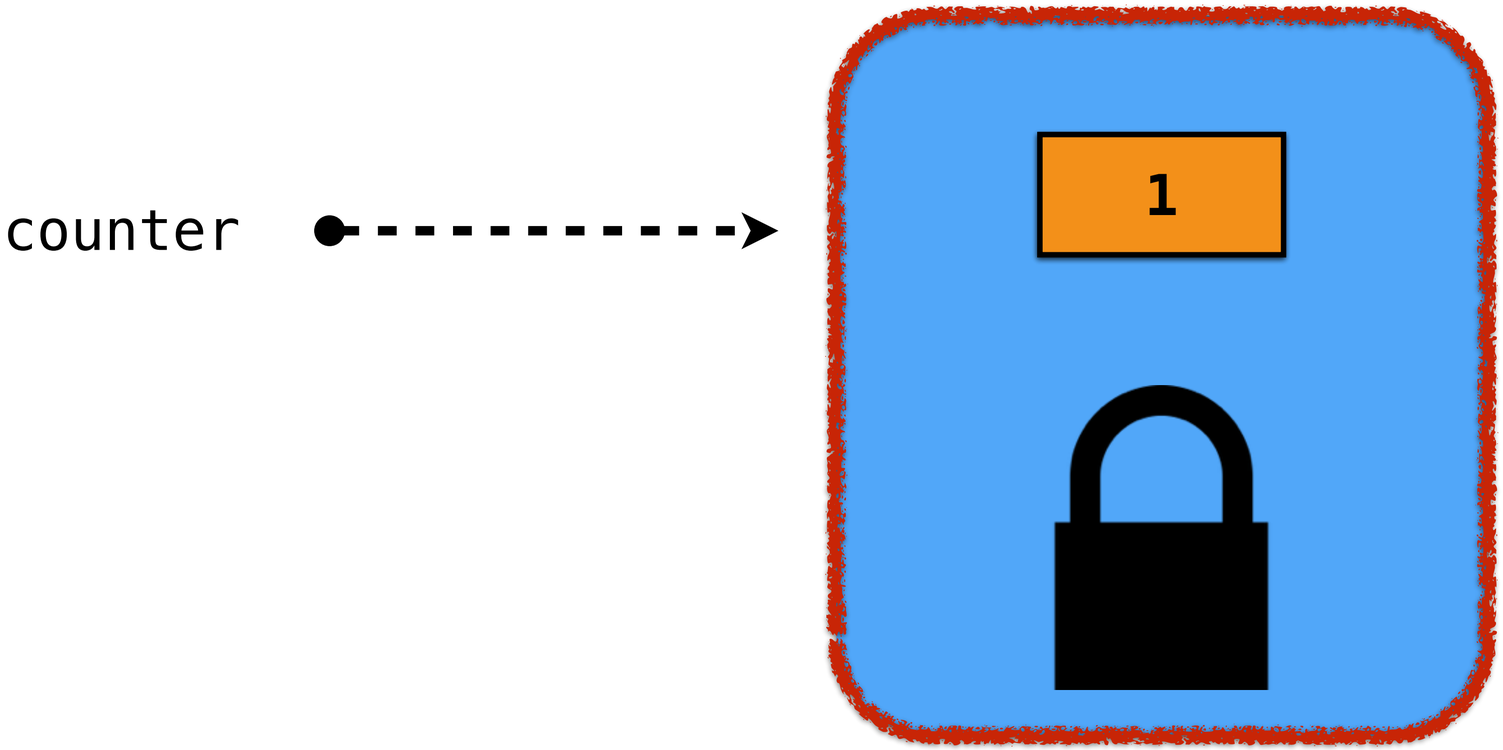

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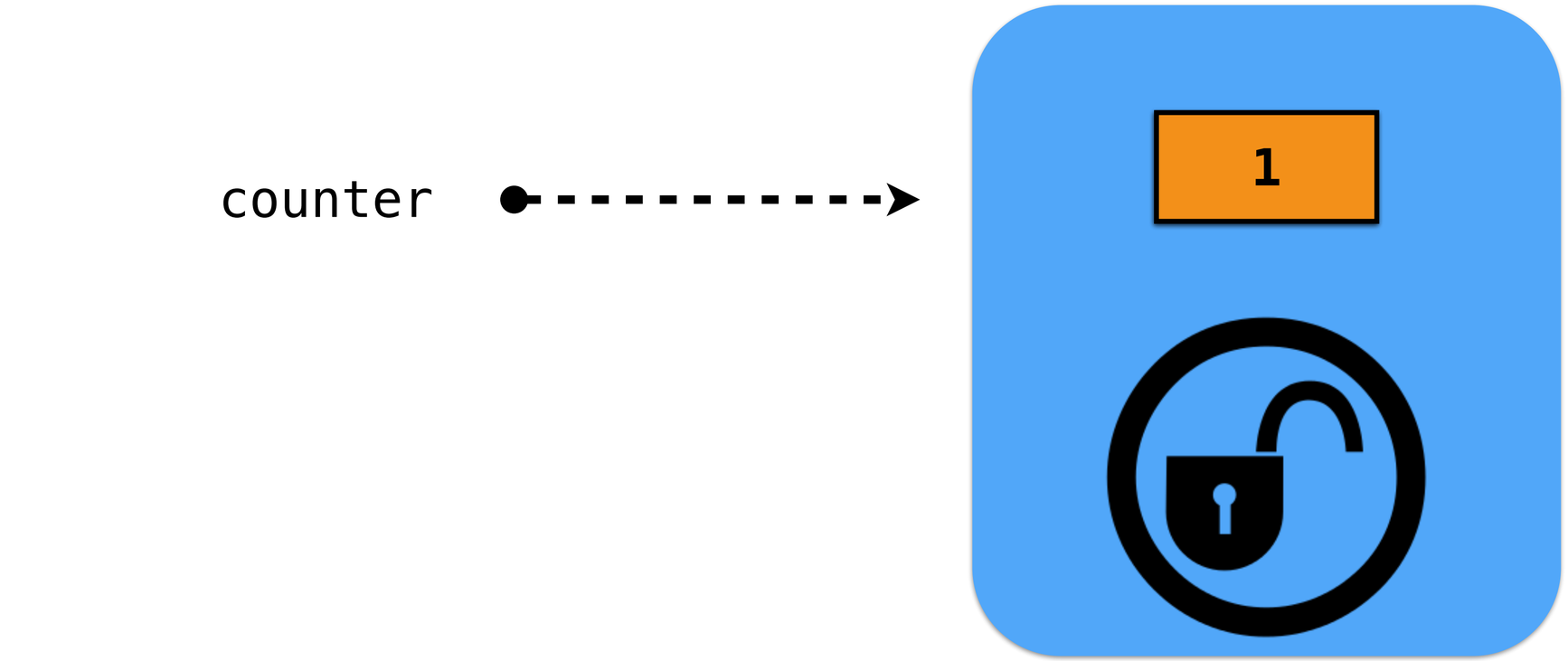

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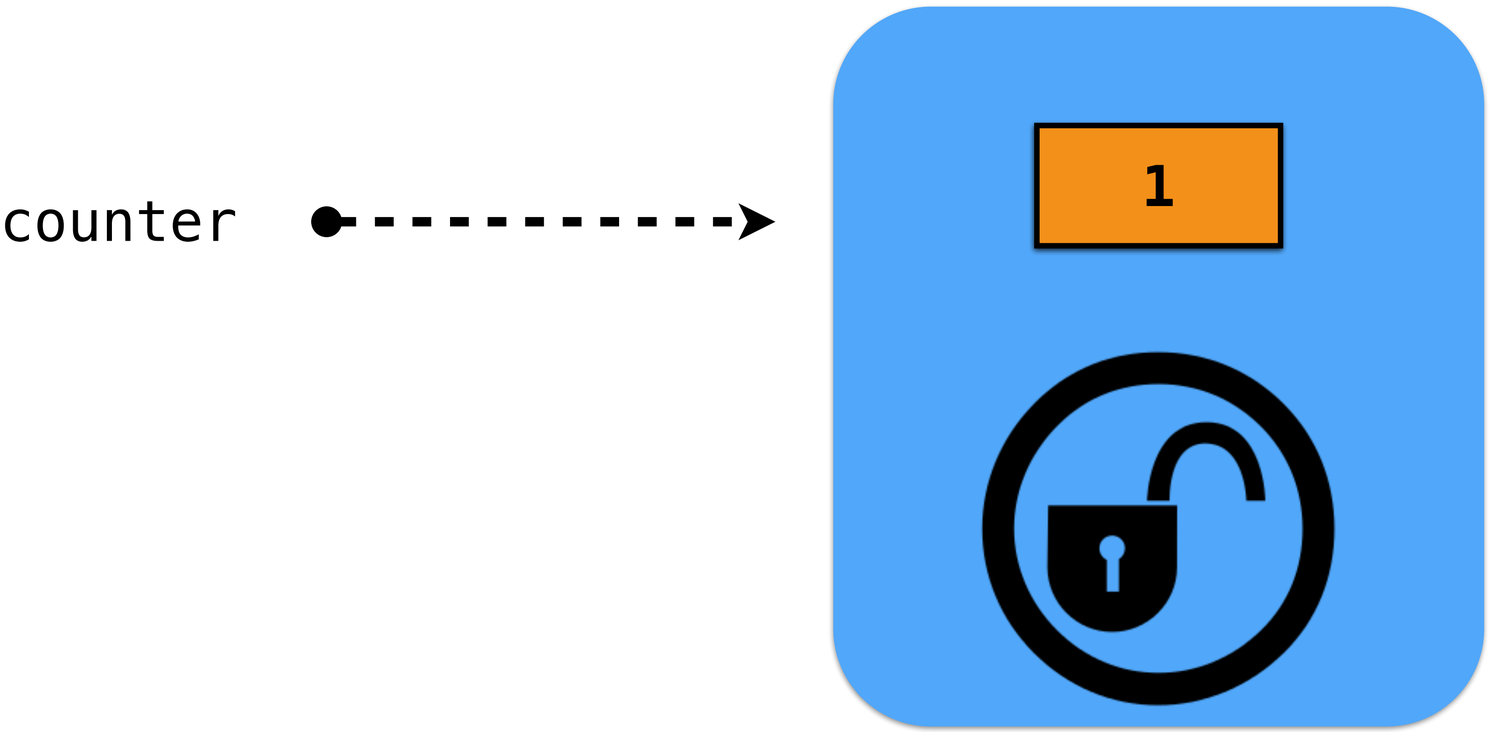

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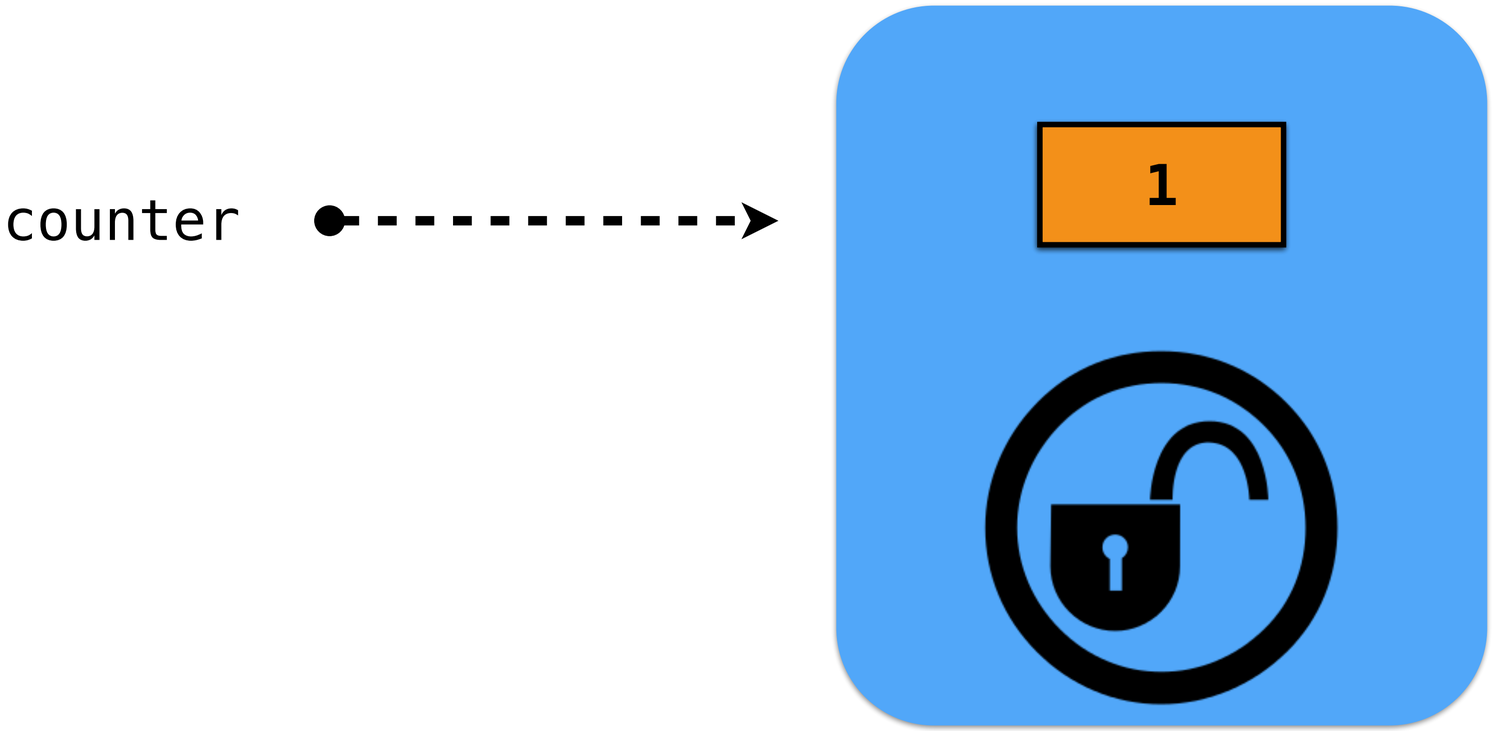

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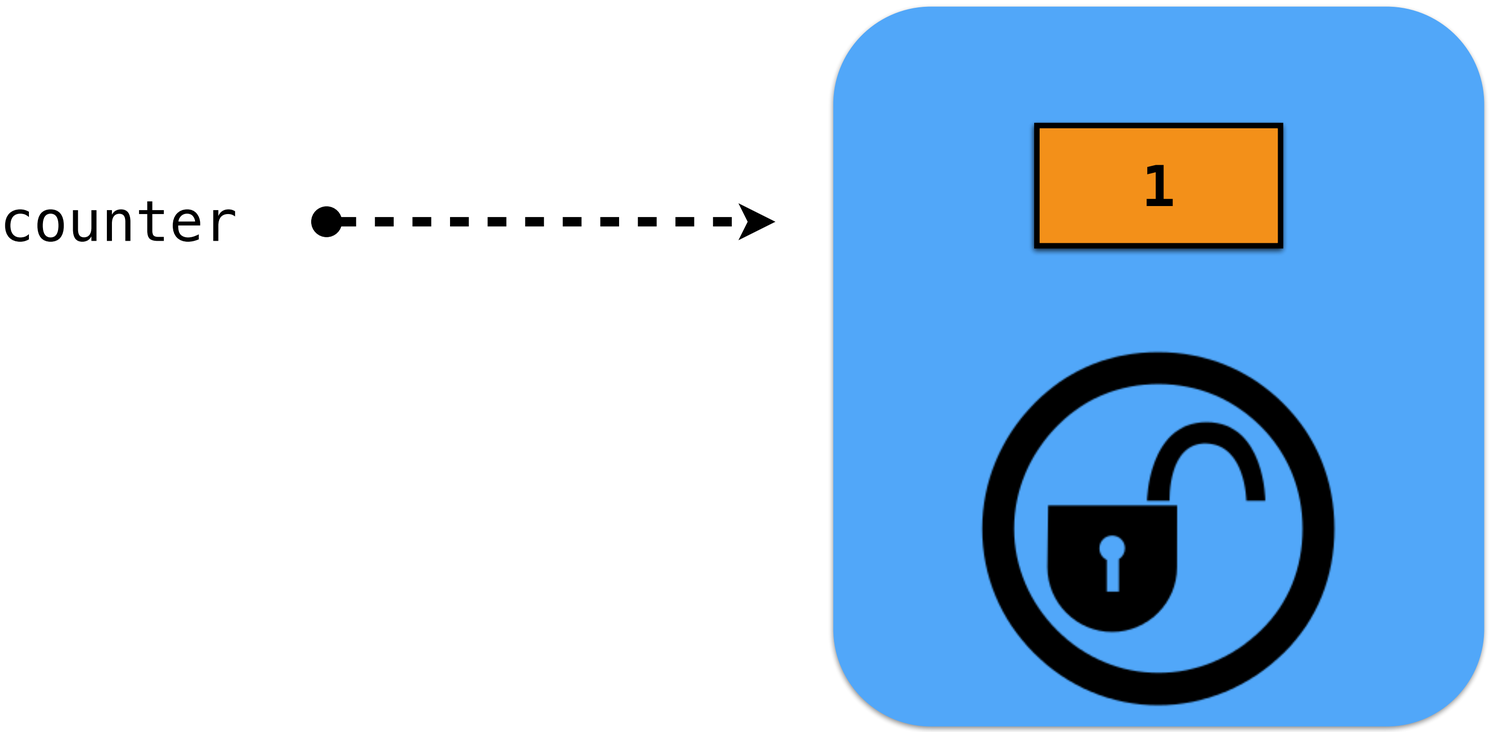

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Exercise: **threads**

http://rust-tutorials.com/exercises

Cheat sheet:

```
let (name, sum) = thread.join().unwrap();
```

```
use std::sync::mpsc::channel;
let (rx, tx) = channel();
tx.send(value).unwrap();
let value = rx.recv().unwrap();
```

```
use std::sync::{Arc, Mutex};
let mutex = Arc::new(Mutex::new(data));
let data = mutex.lock().unwrap();
```

http://doc.rust-lang.org/std

Static checking for thread safety

```
fn send<T: Send>(&self, t: T)
```

Only “sendable” types

Static checking for thread safety

```
fn send<T: Send>(&self, t: T)
```

Only “sendable” types

```
Arc<Vec<int>>: Send
Rc<Vec<int>> : !Send
```

Thanks for listening!