Threads

Aaron Turon

Systems programming without the hassle

Systems programming without the hassle

crashes

heisenbugs

fear

Parallel!
^Systems programming without the hassle

crashes

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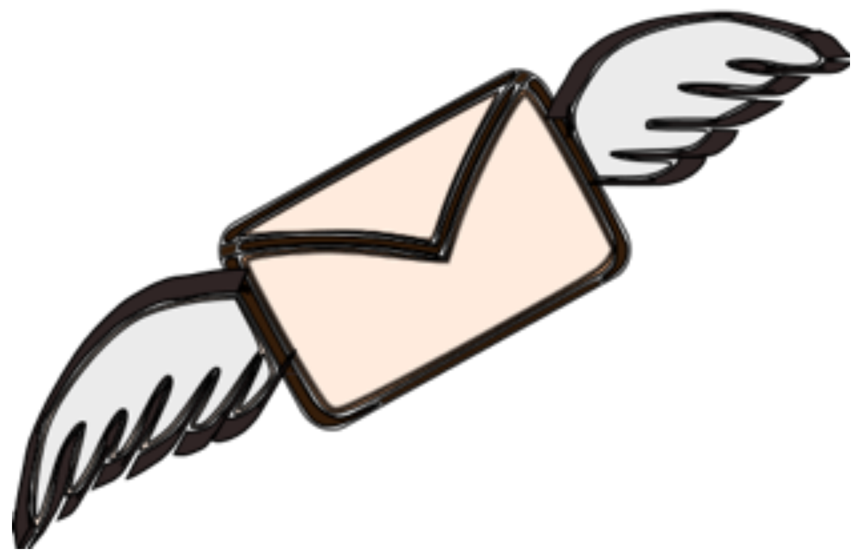
Concurrency and Parallelism

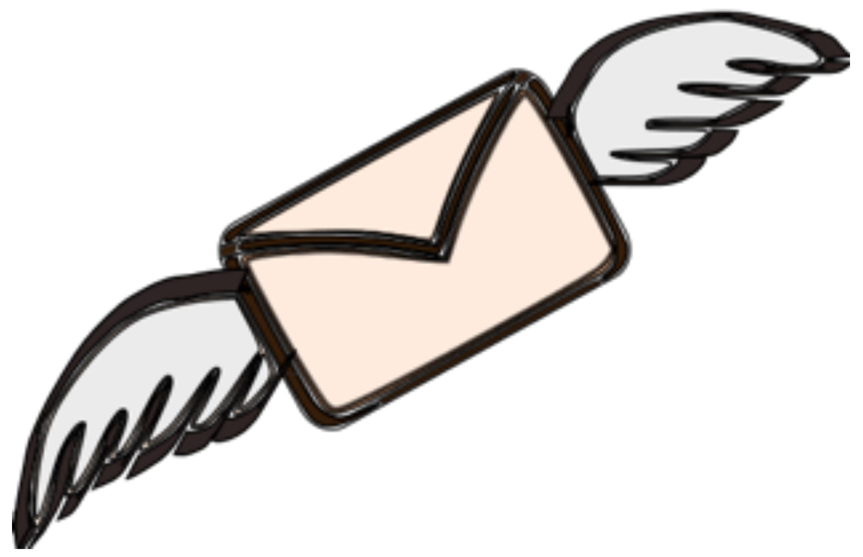
Multiparadigm

Multiparadigm



message-passing

Multiparadigm



message-passing

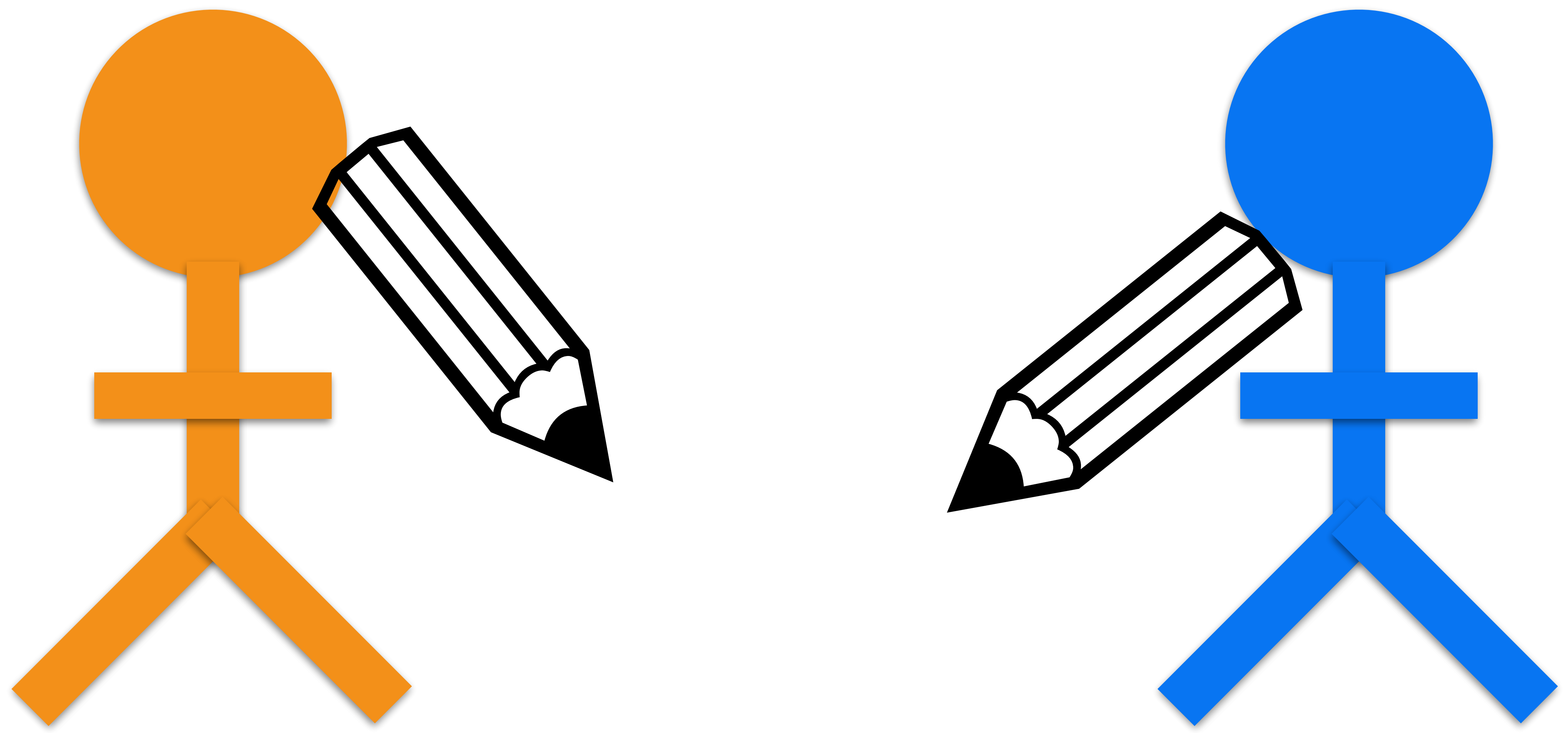
mutable shared memory

No data races,
No matter what.

Data race?

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

Data race?



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

Aliasing

+ Mutation

+ No ordering

Data race

Sound familiar?

Aliasing

+ Mutation

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Data race

No data races =
No accidentally-shared state.

All sharing is explicit!

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No accidentally-shared state.

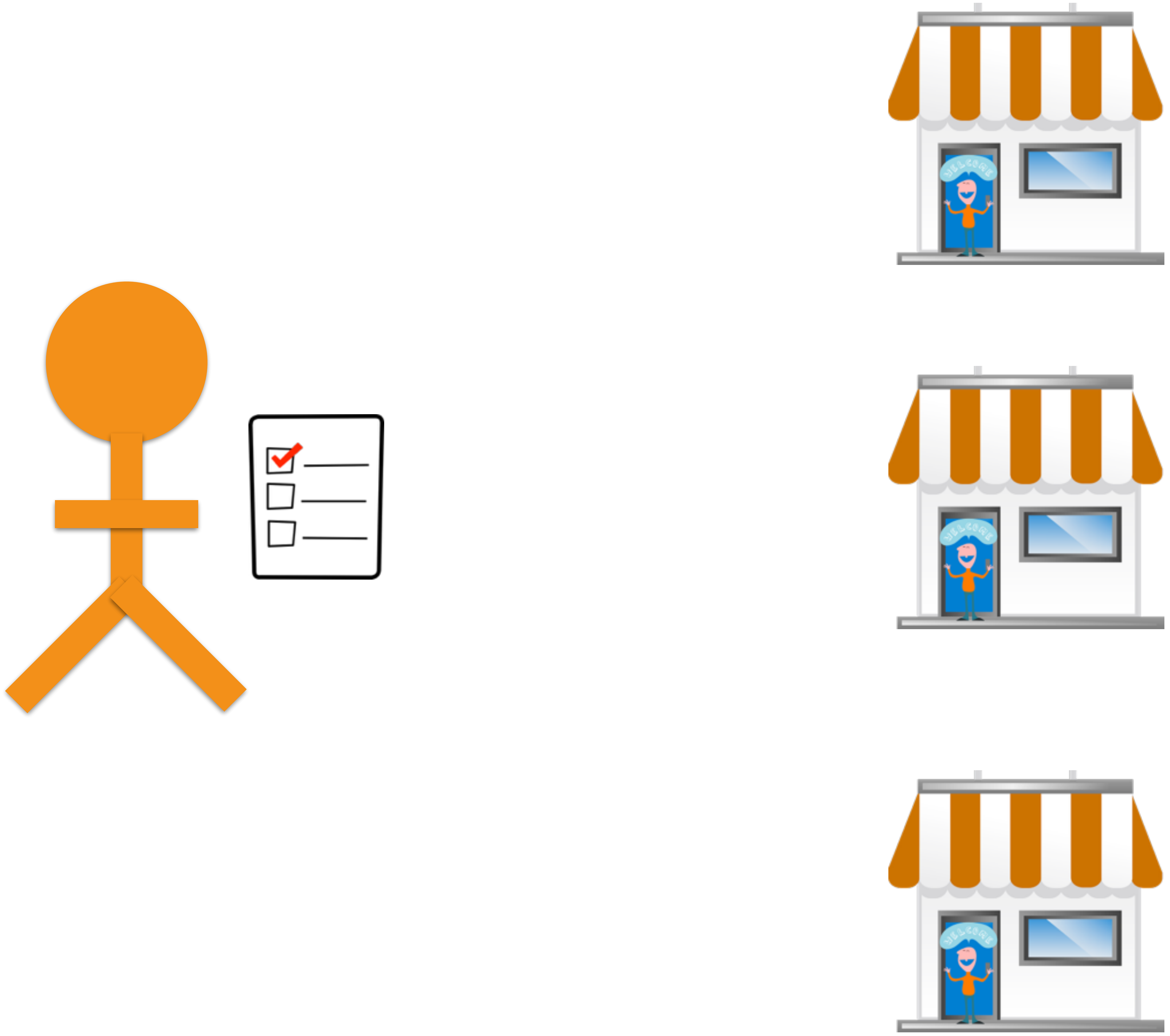
All sharing is explicit!

```
// 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
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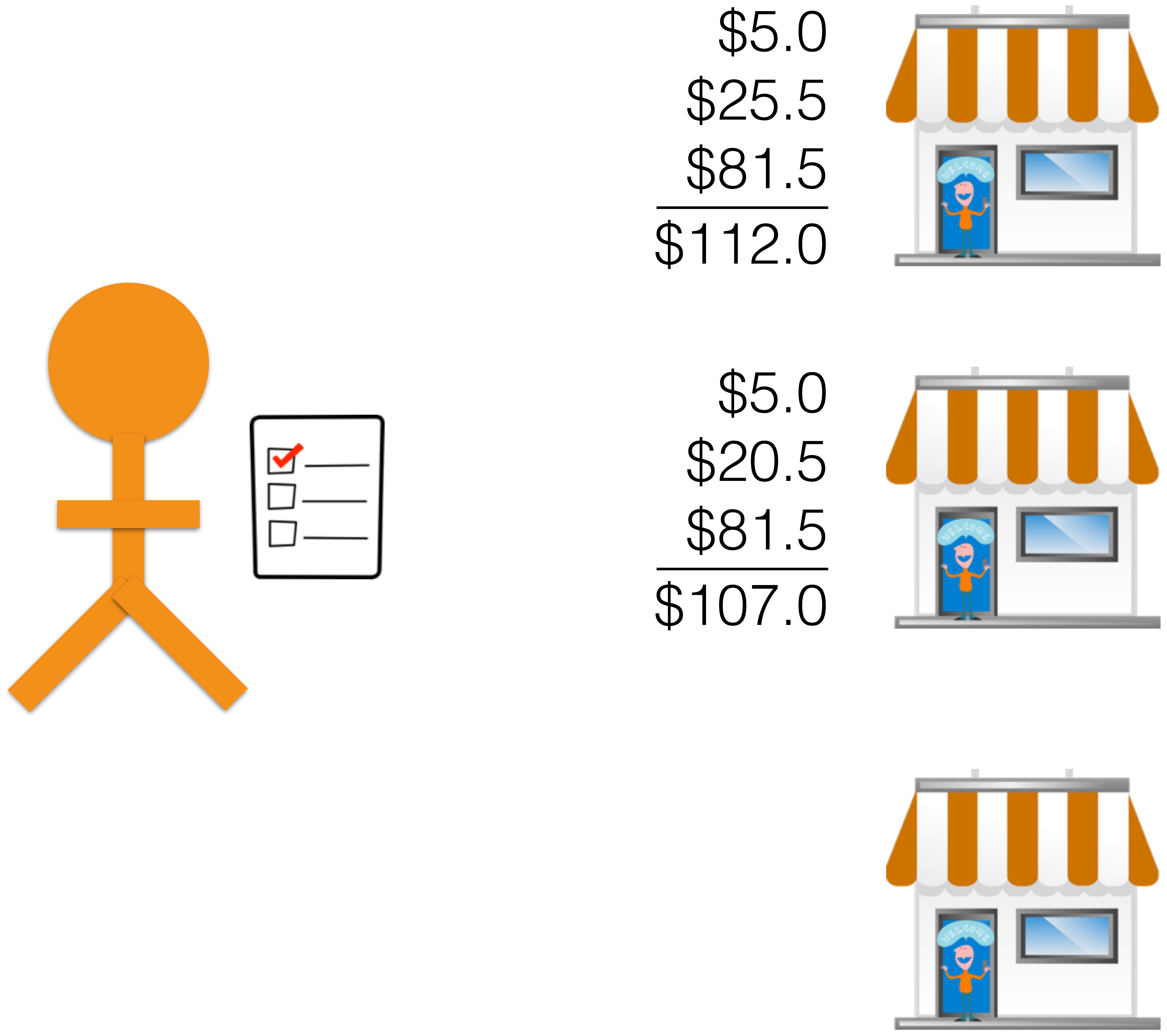
$112.0


$5.0
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XXX
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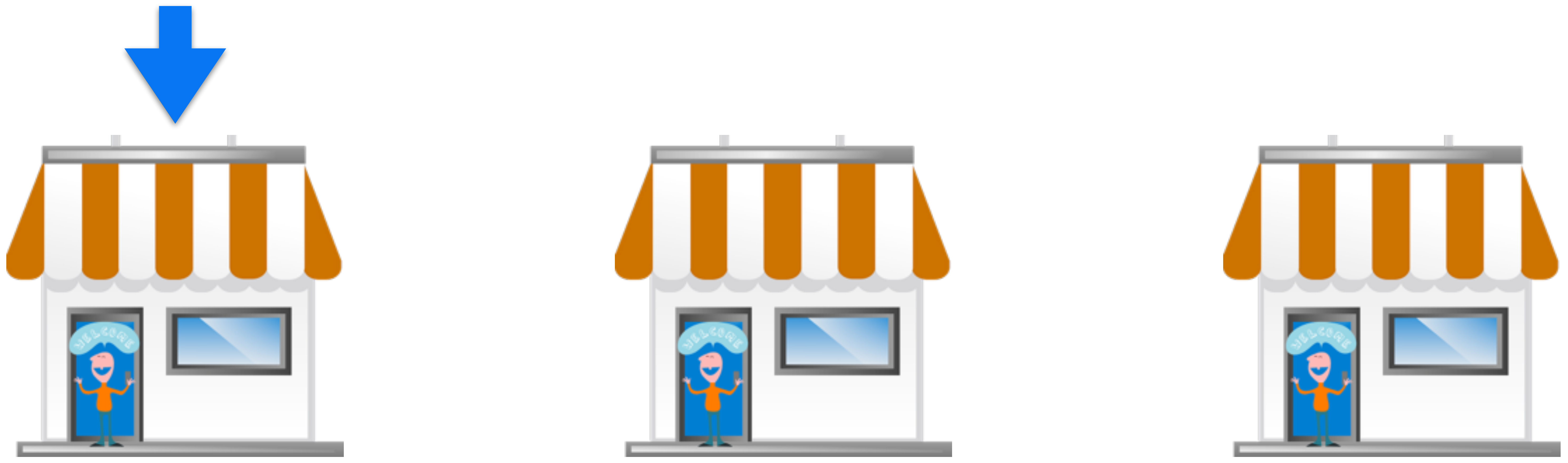

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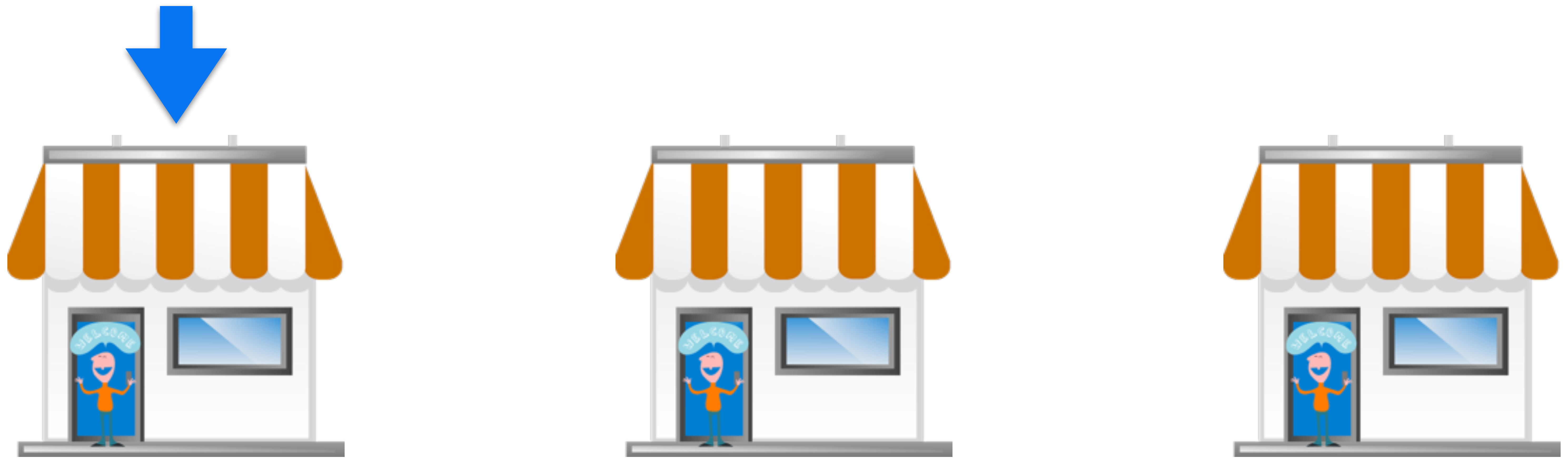

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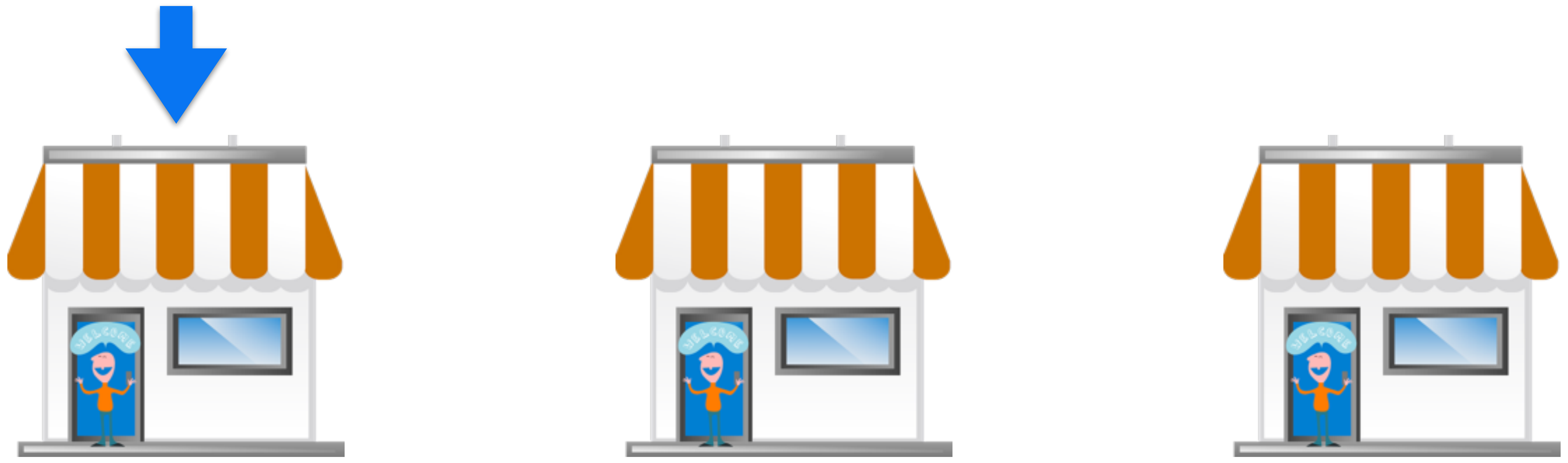

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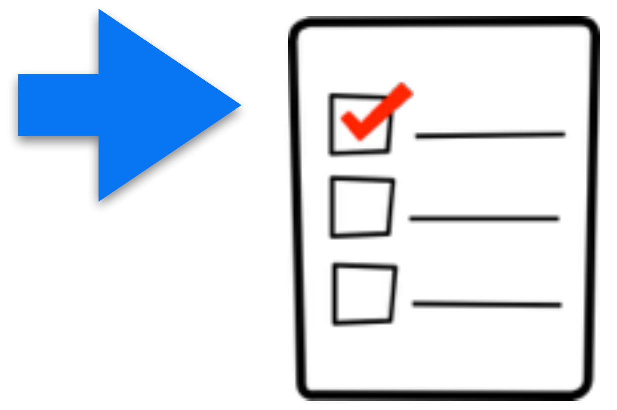

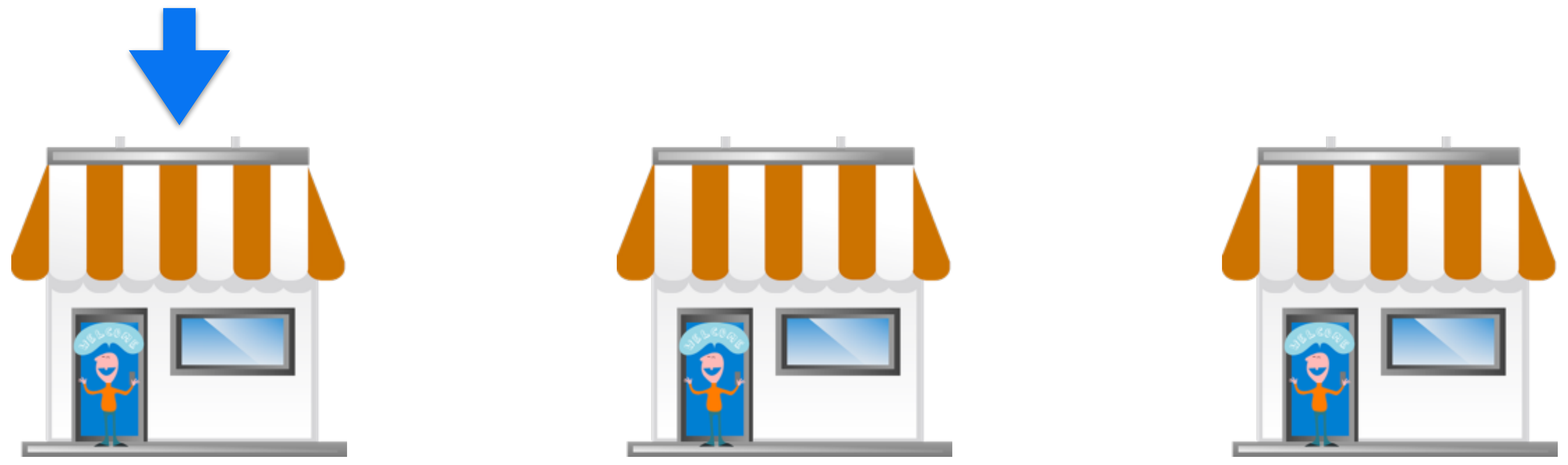

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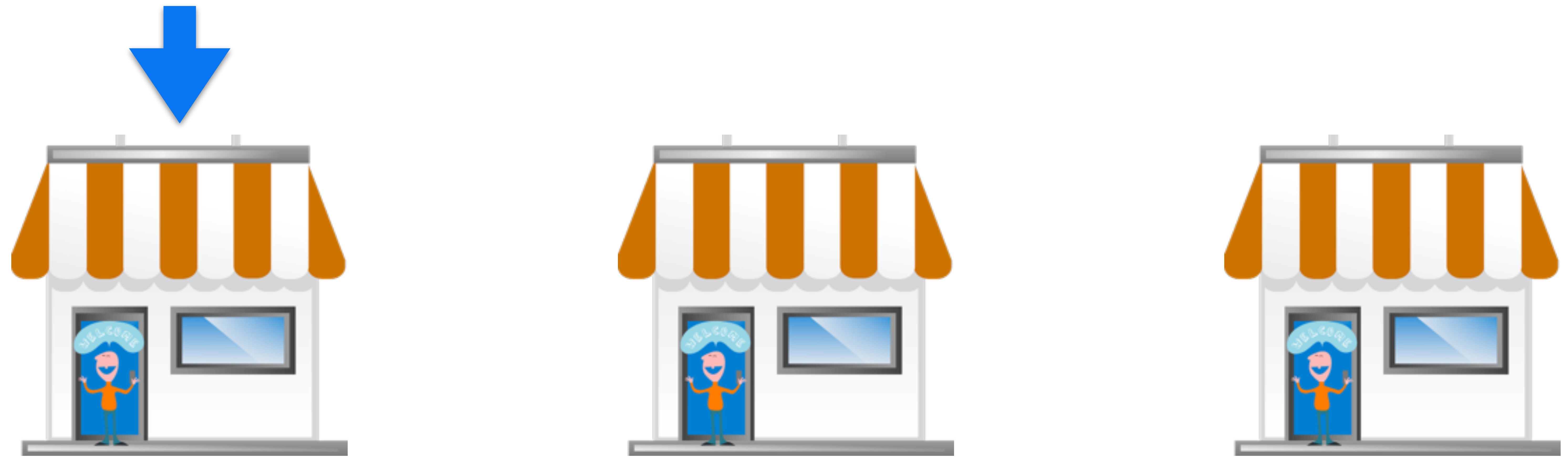

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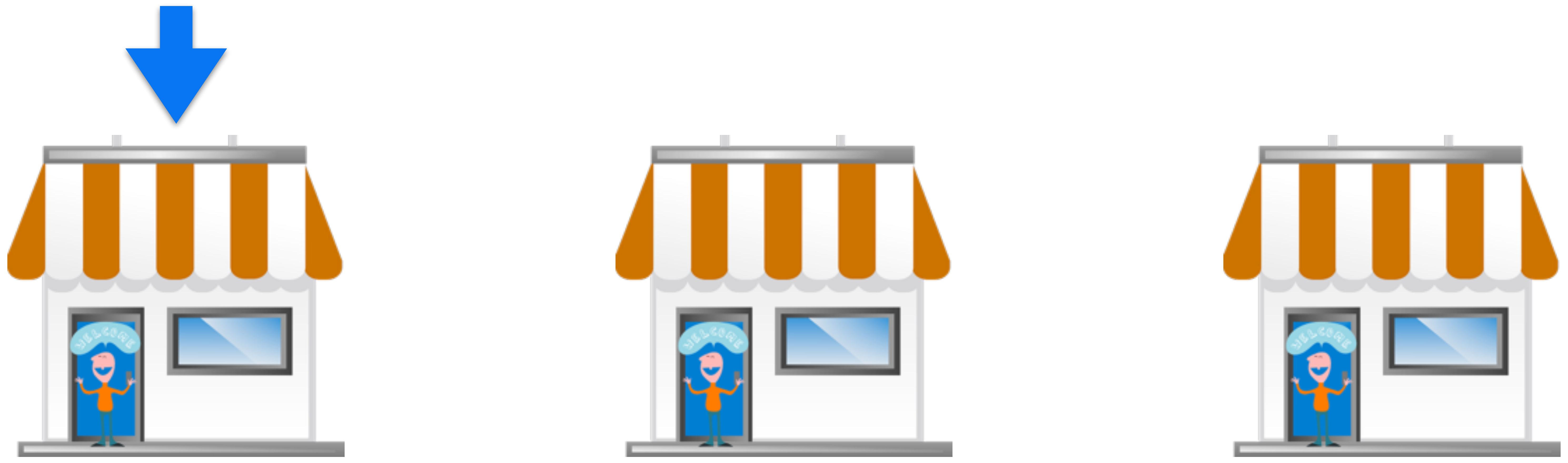

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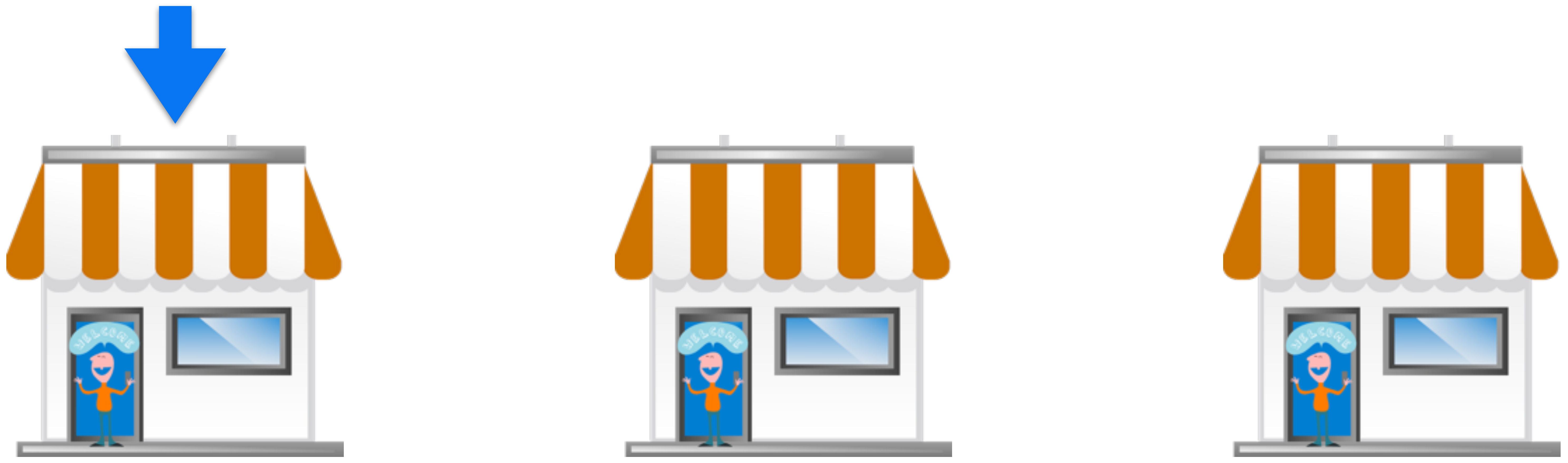

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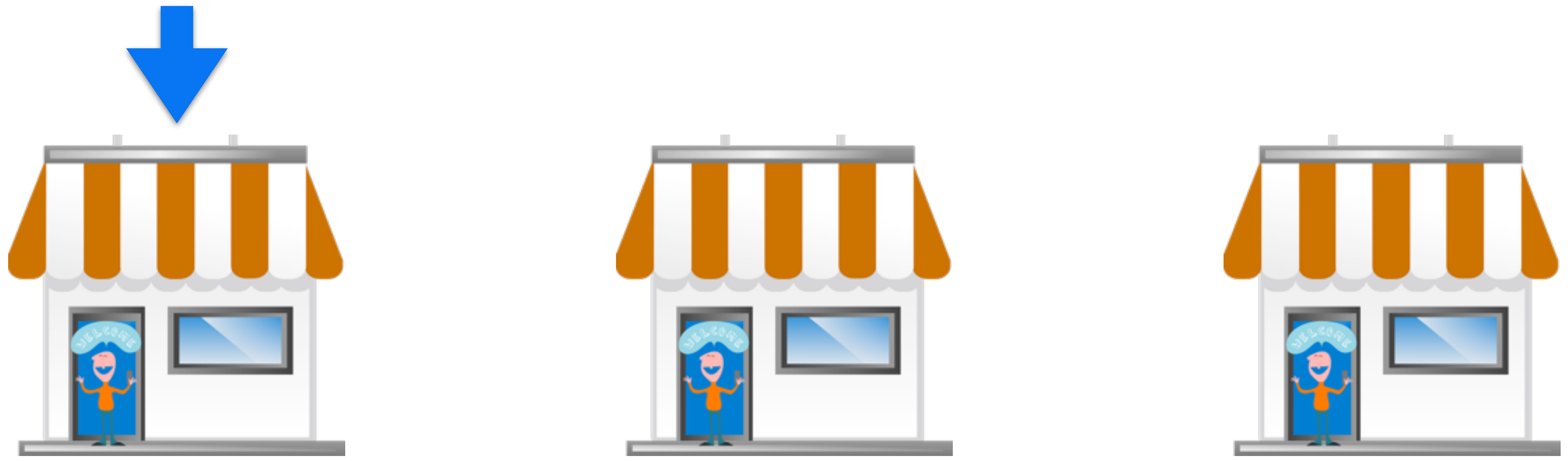

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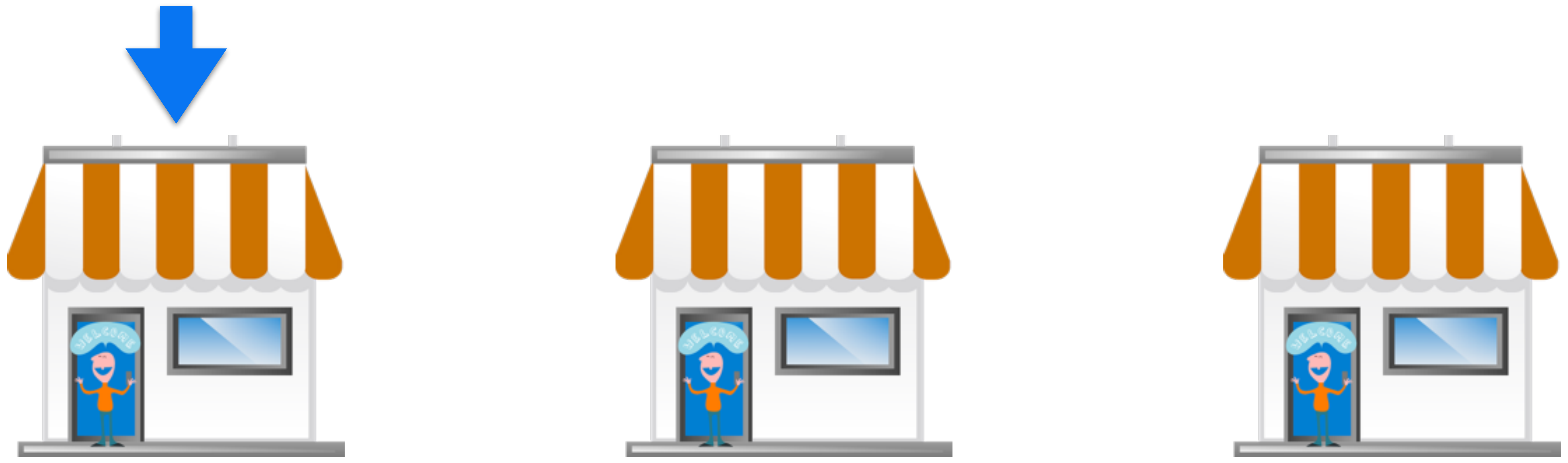

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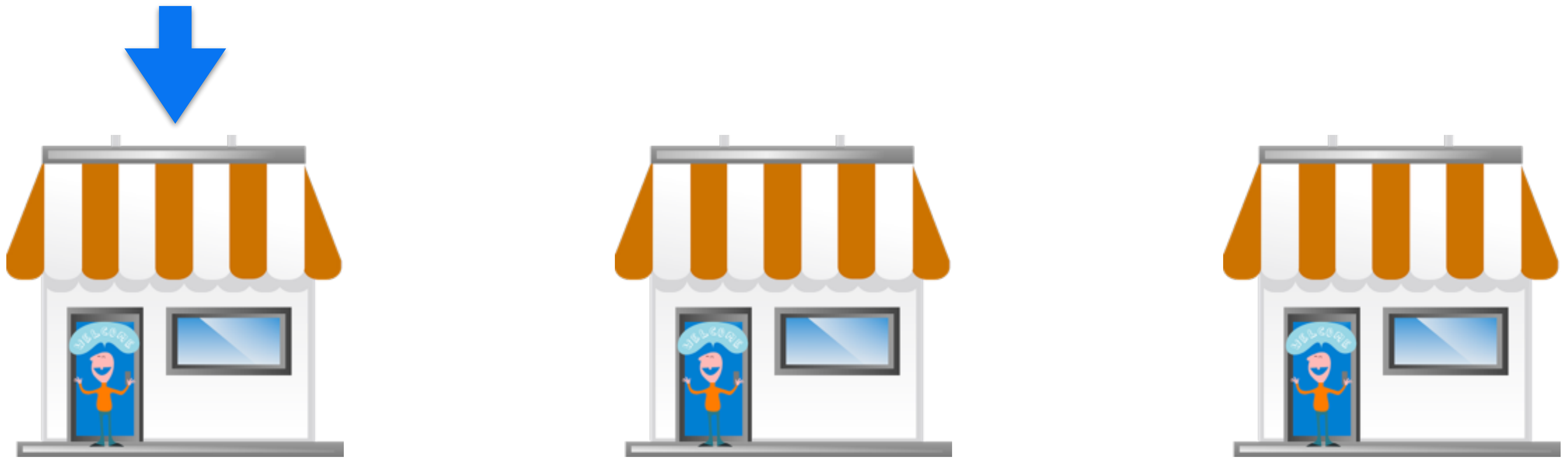

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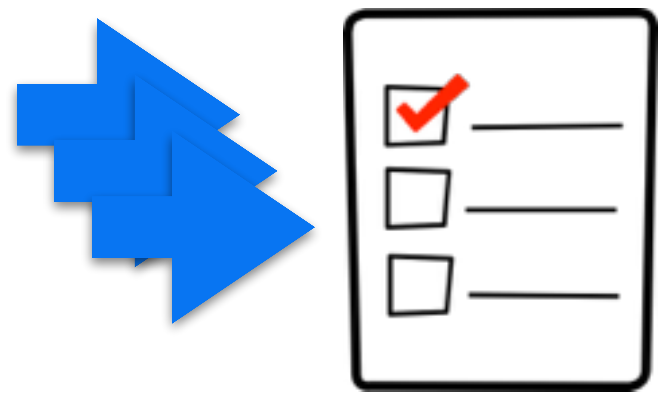

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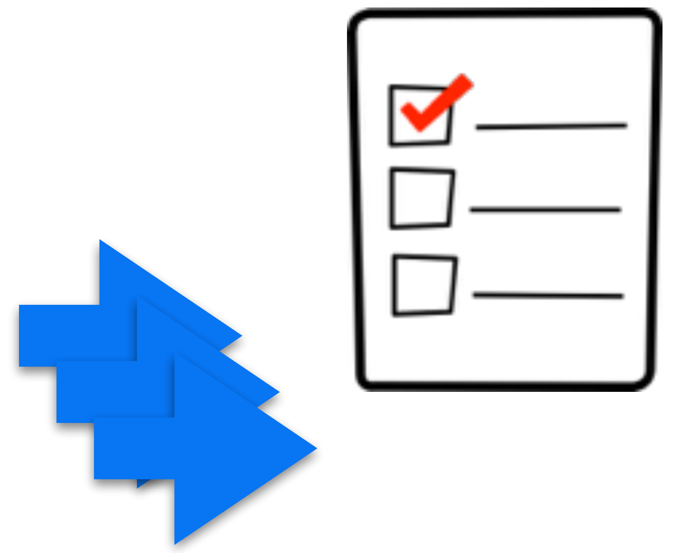

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Closure **takes ownership** of variables it uses.

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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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let handle = thread::spawn(…);
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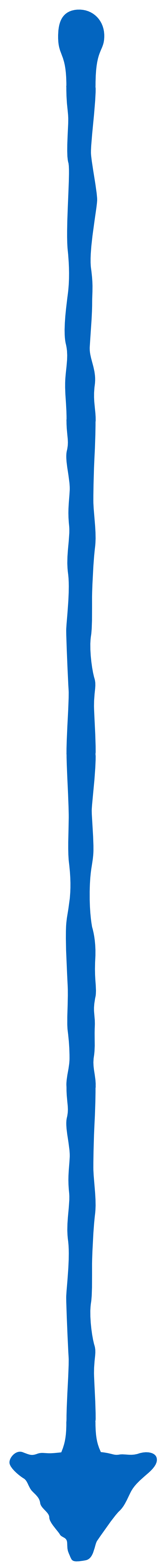

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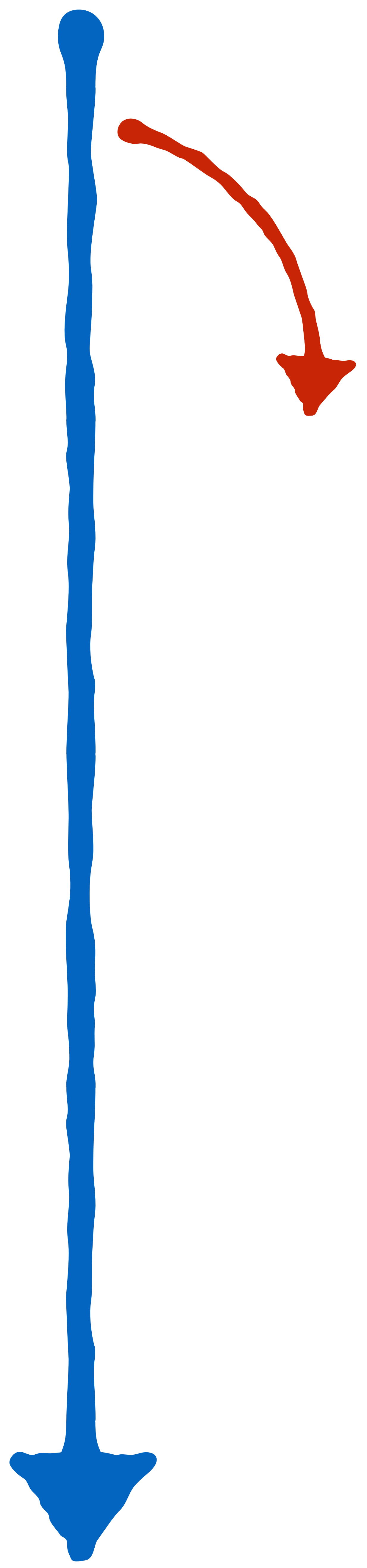

```
let handle = thread::spawn(…);

… // stuff in parallel
  // with new thread
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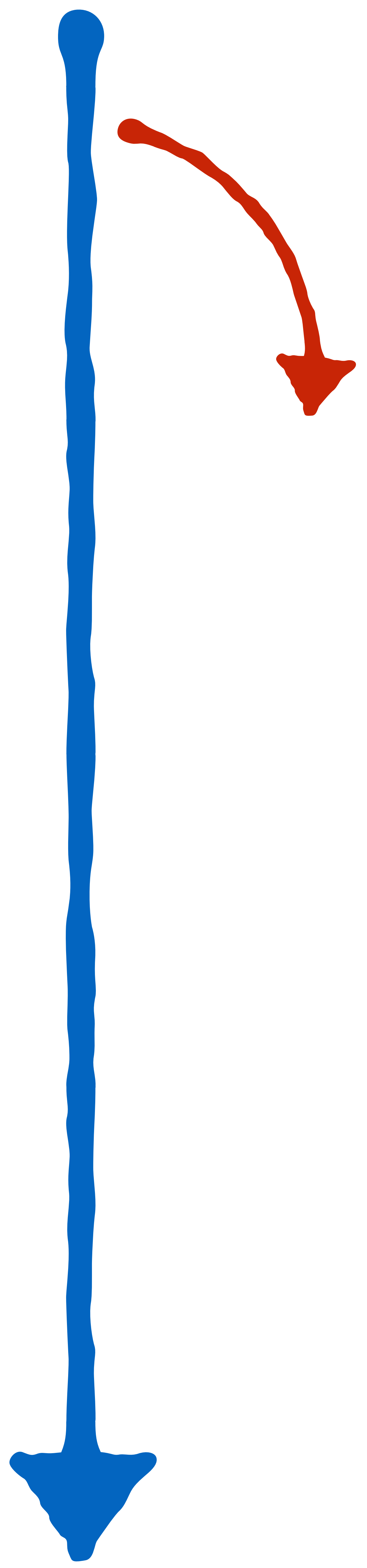

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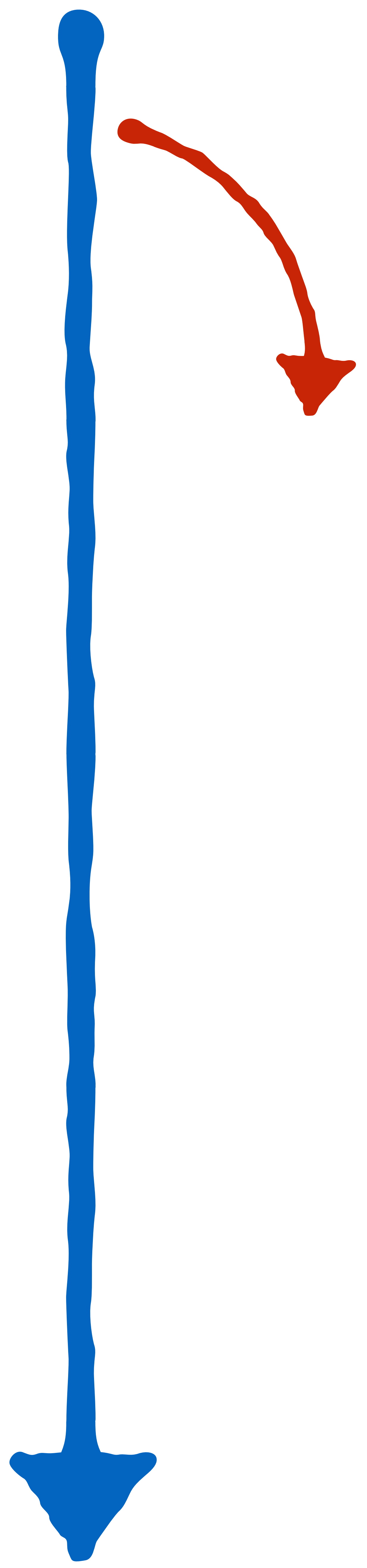

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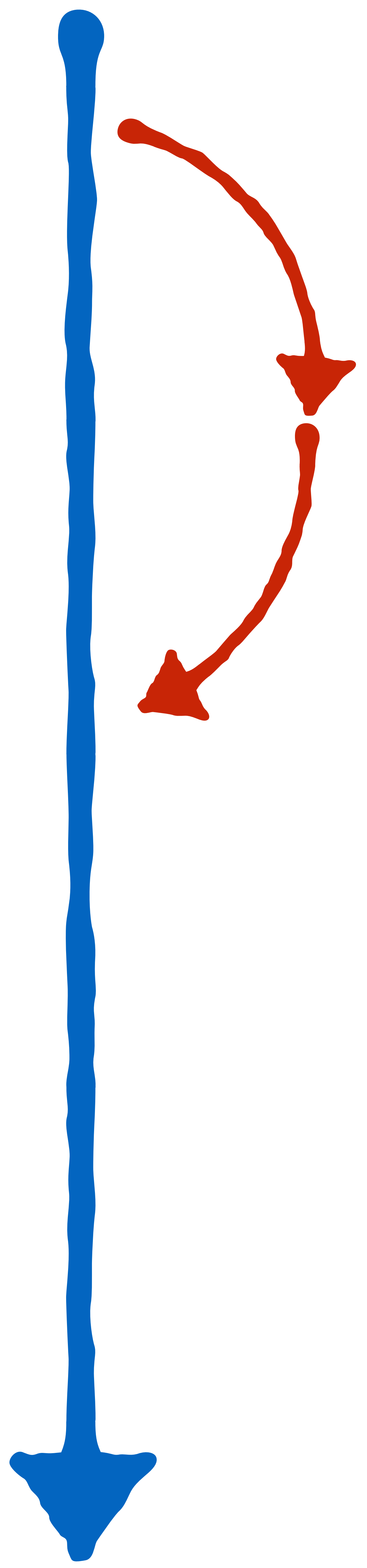

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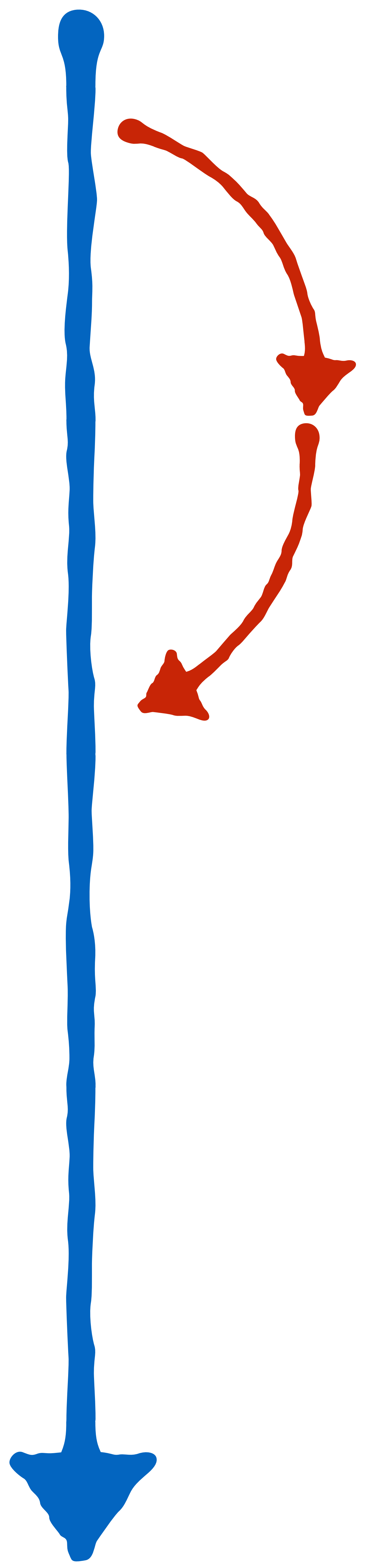
Wait for thread
to finish and
get return value.



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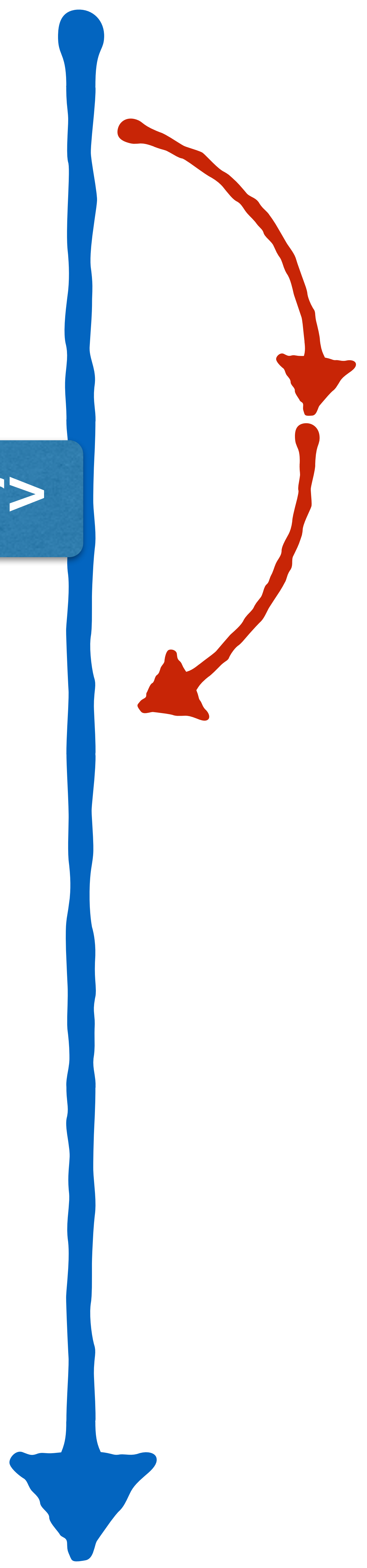

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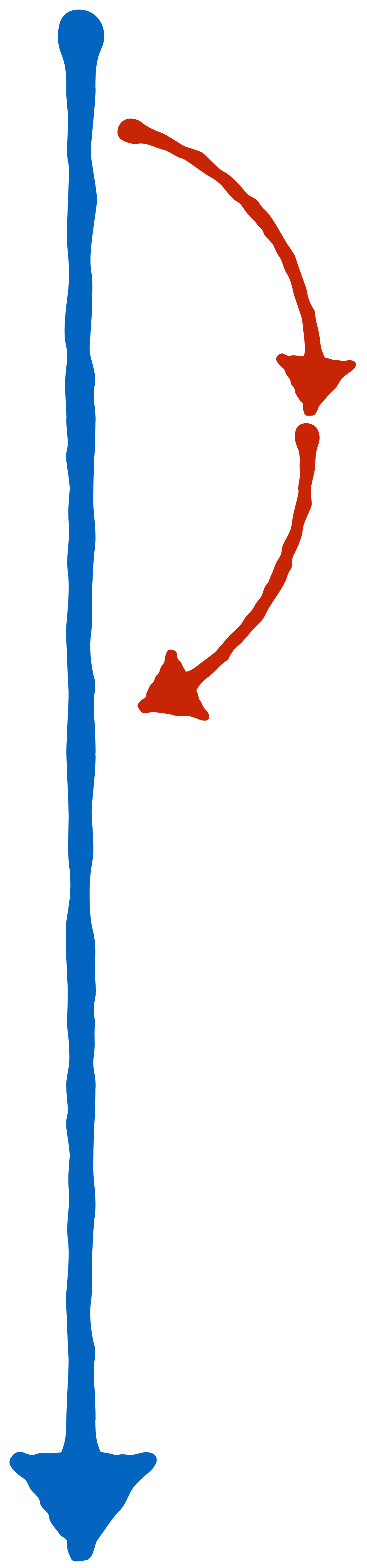

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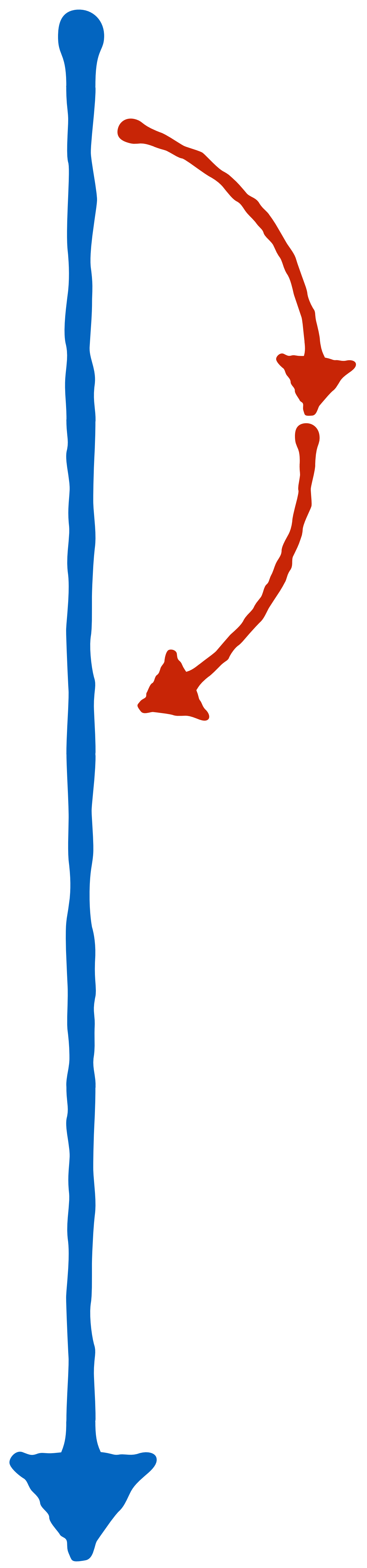
Result of thread.



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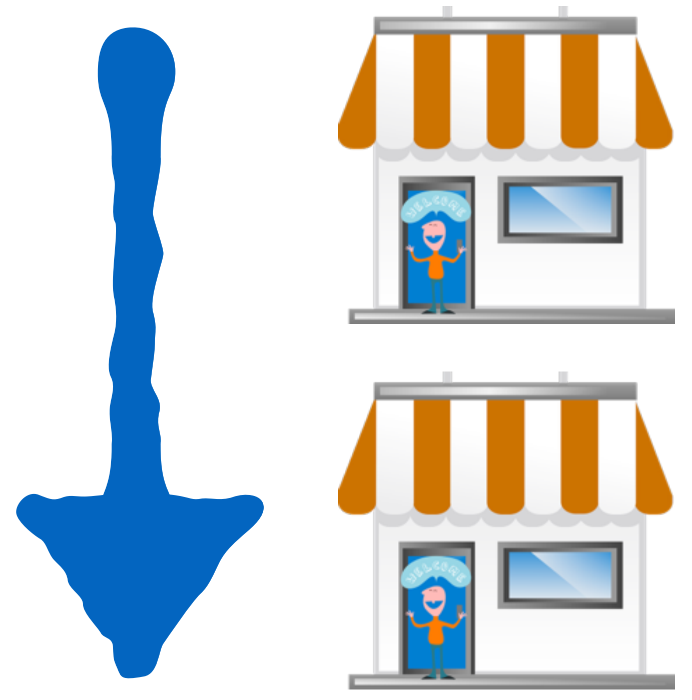

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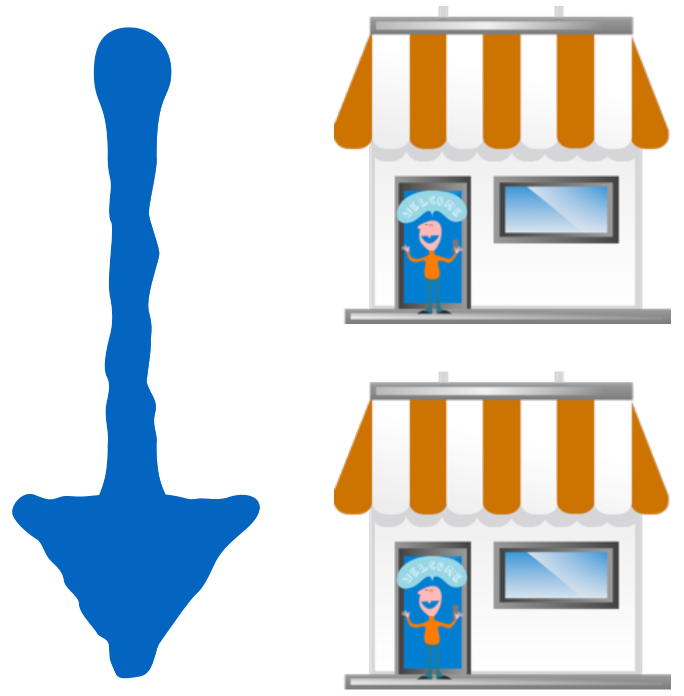

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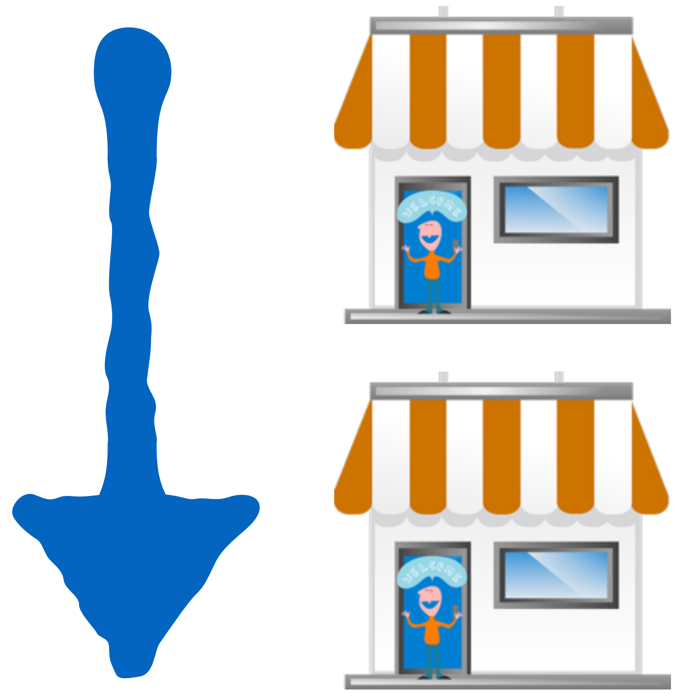

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    });
}

for handle in handles {
  let (name, sum) =
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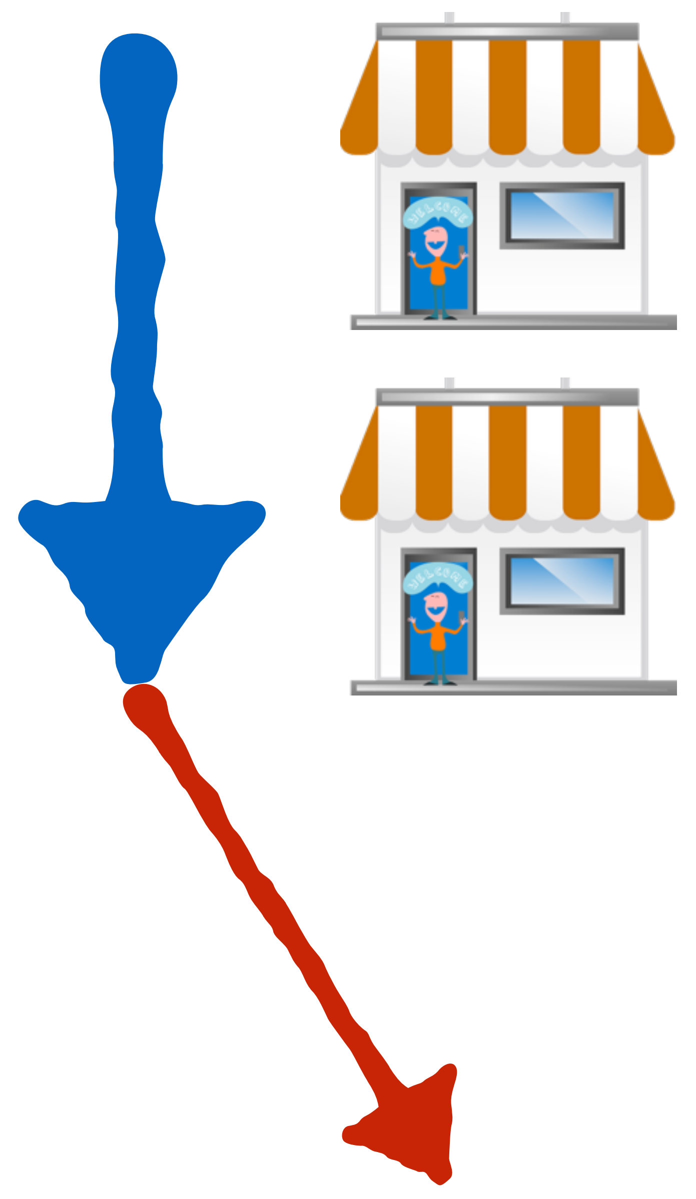
  // find best price
}
```



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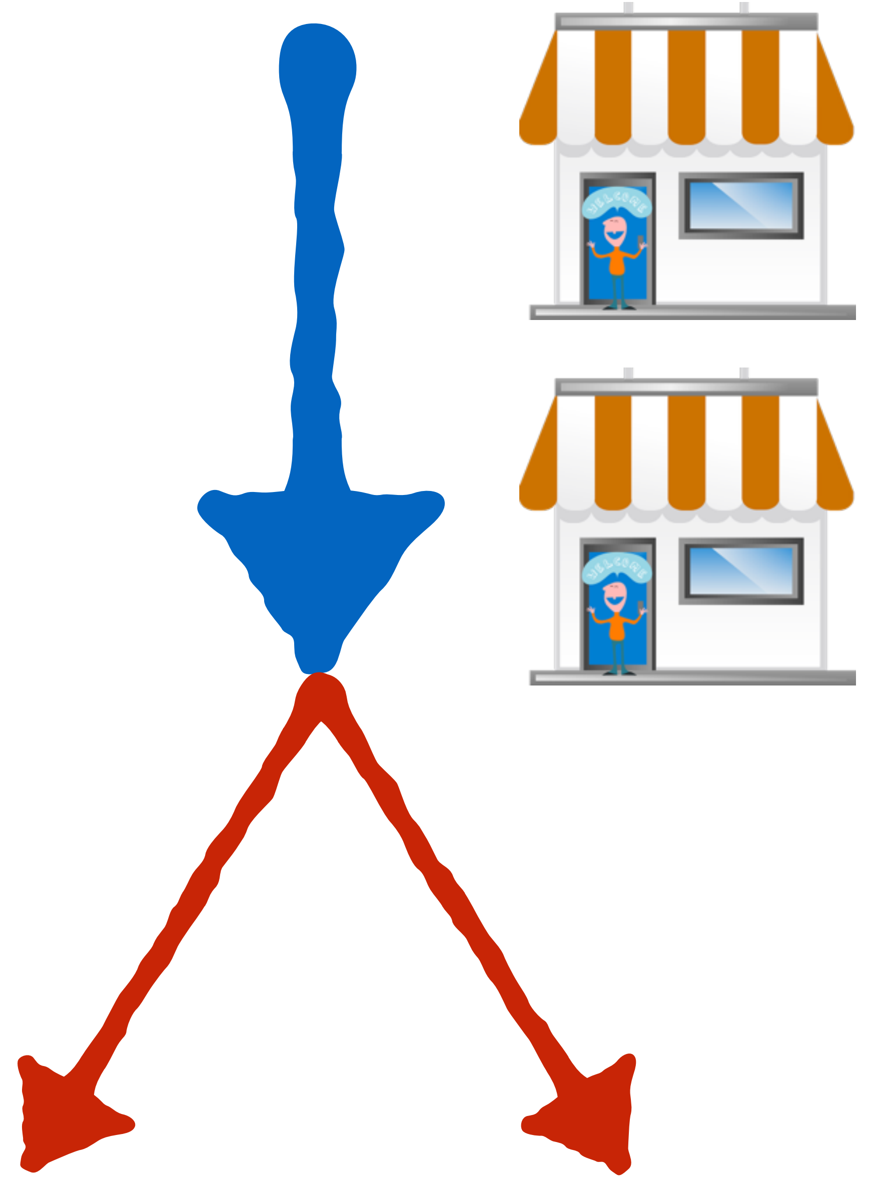

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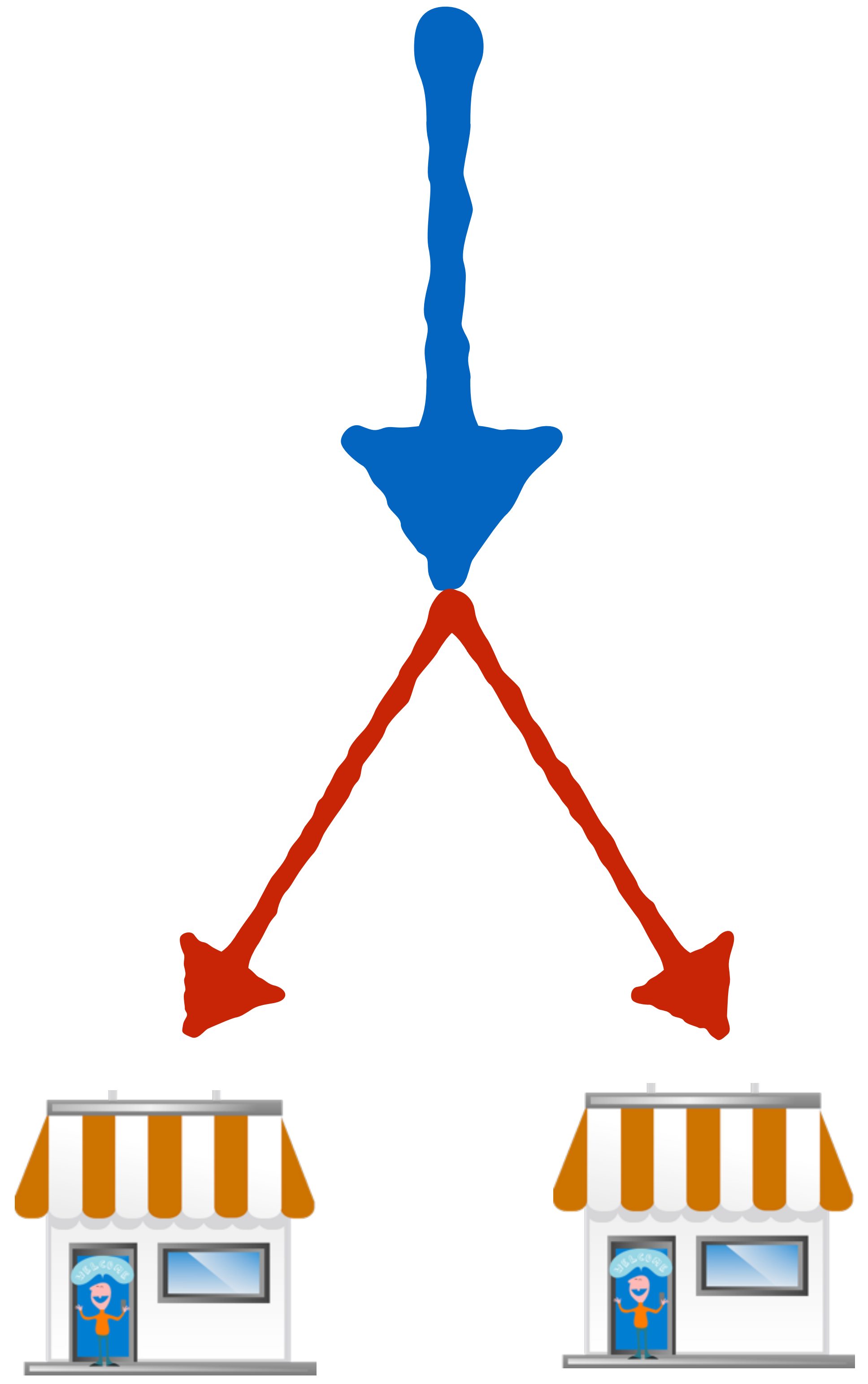

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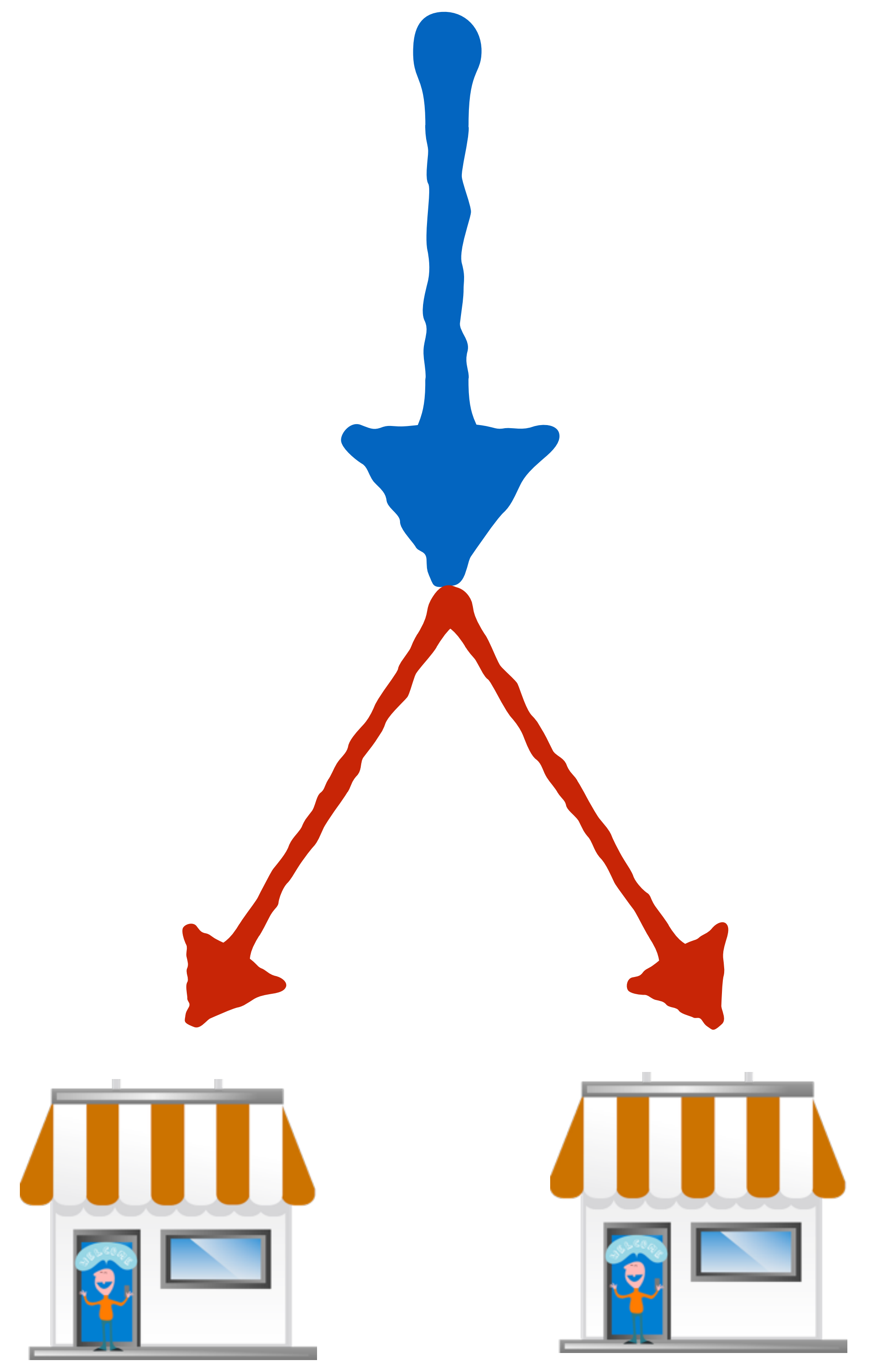

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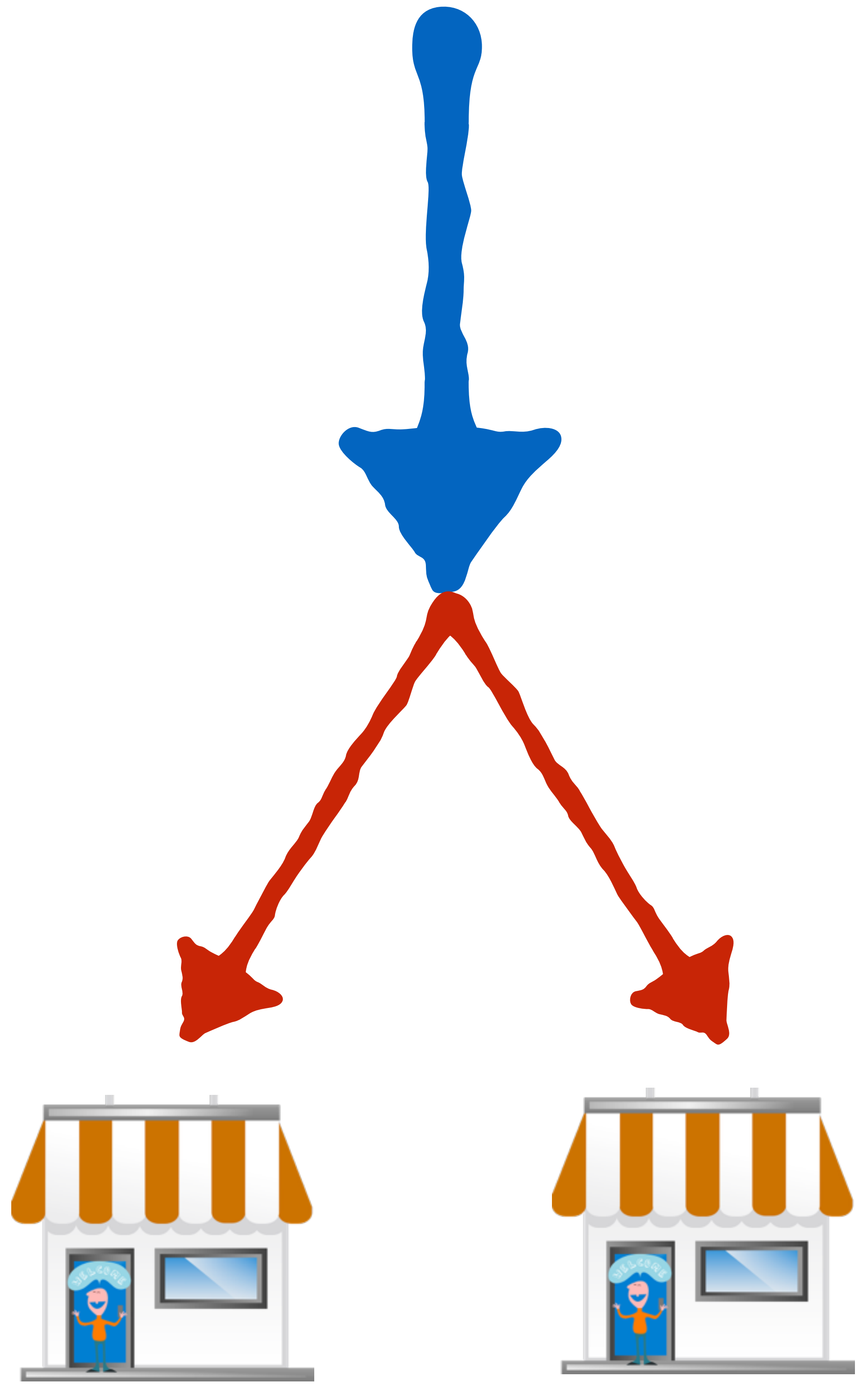

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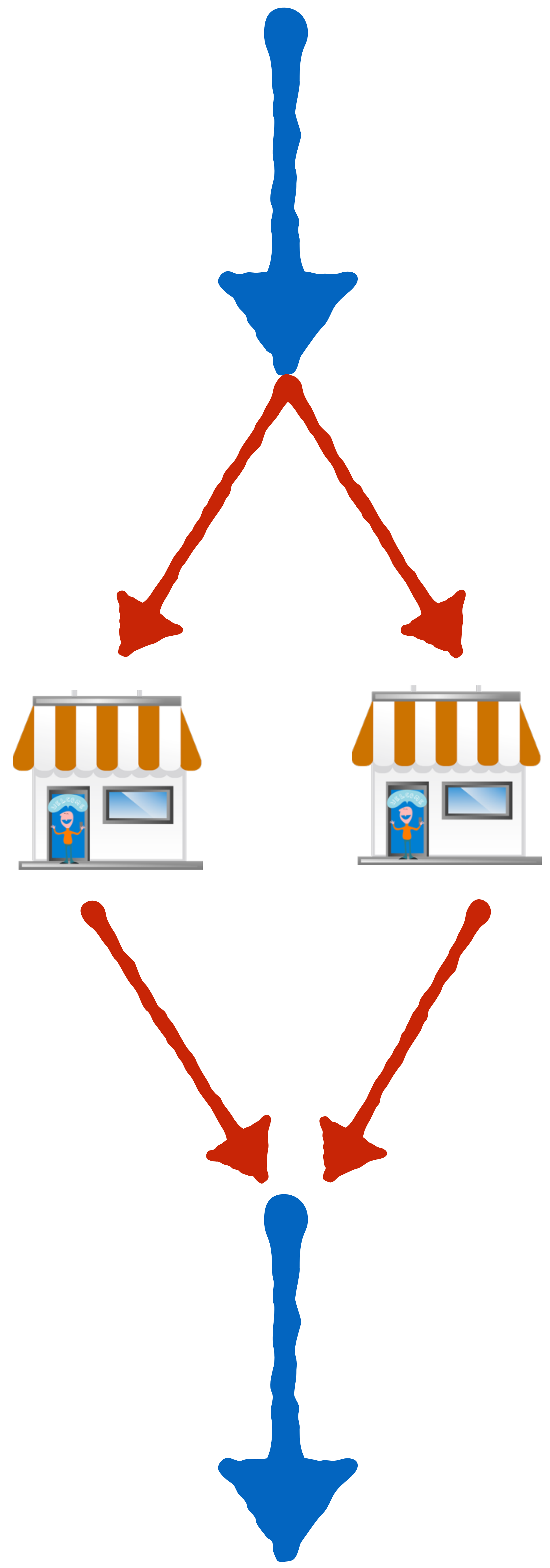

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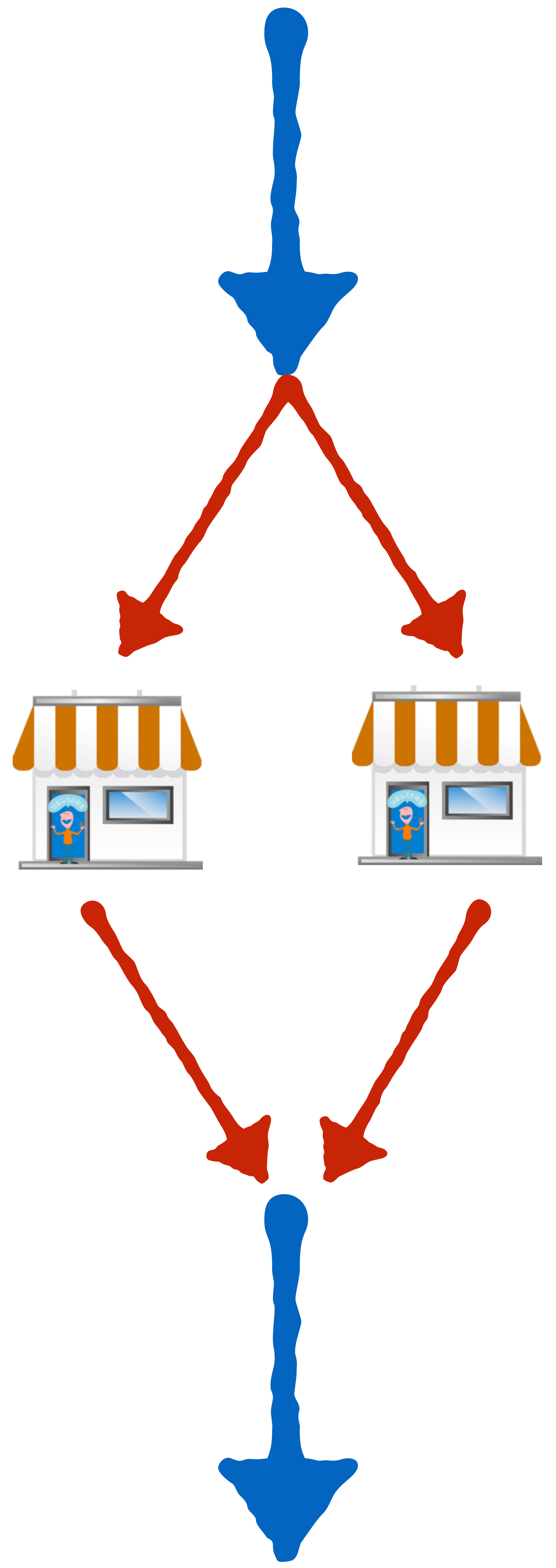

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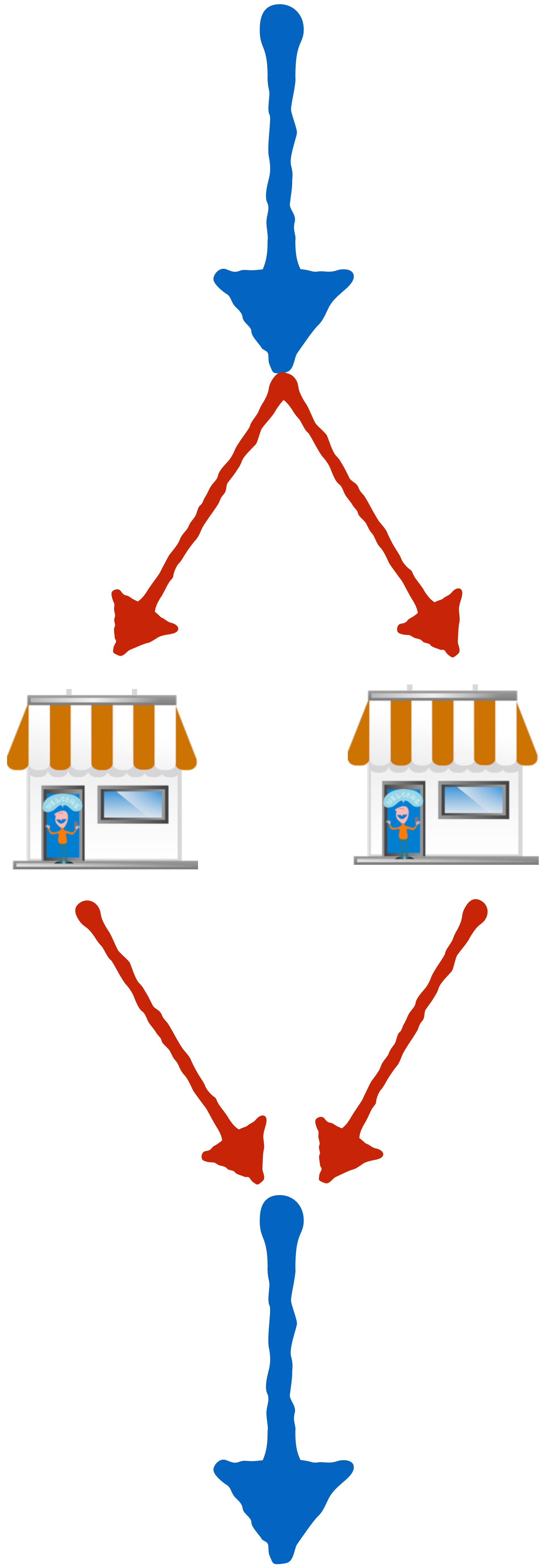

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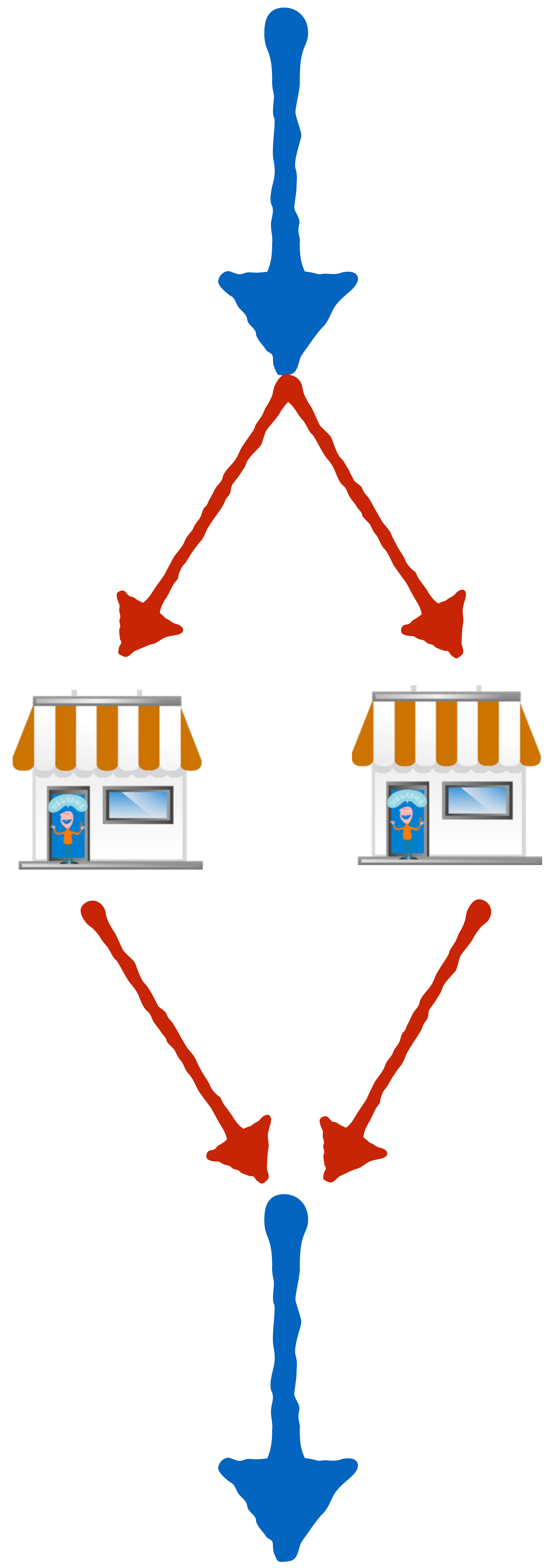

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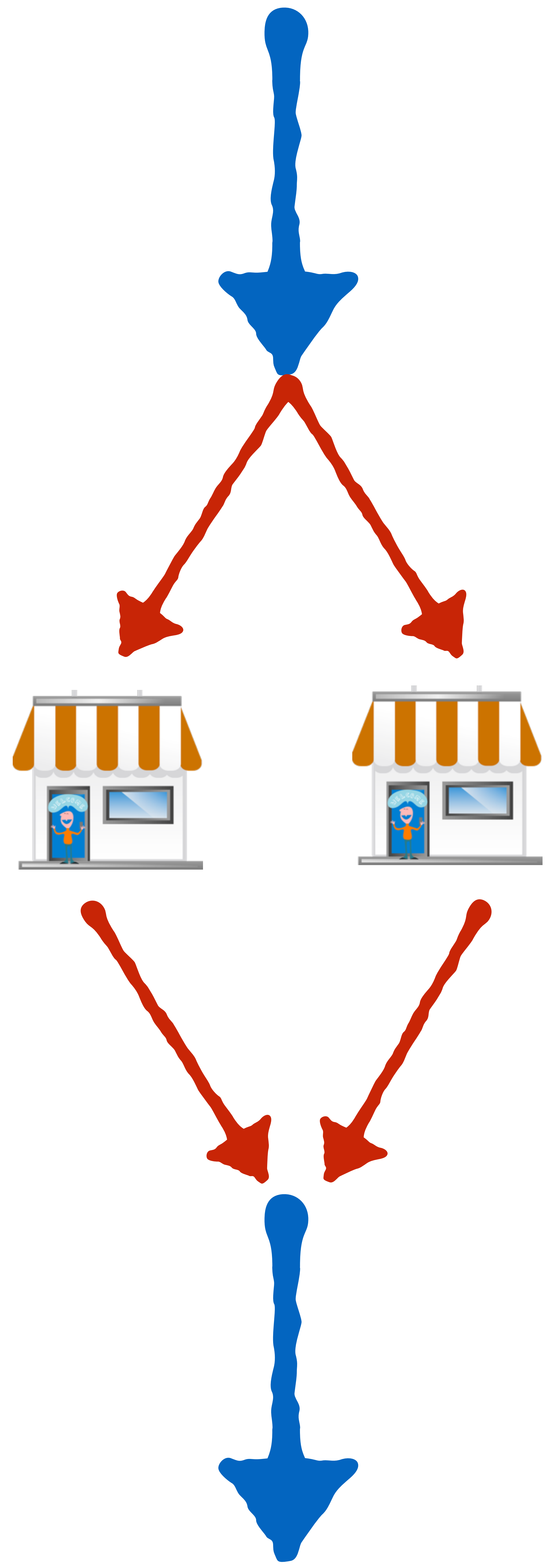

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Variables used by
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    let sum = store.total_price(&shopping_list);
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use std::sync::Arc;
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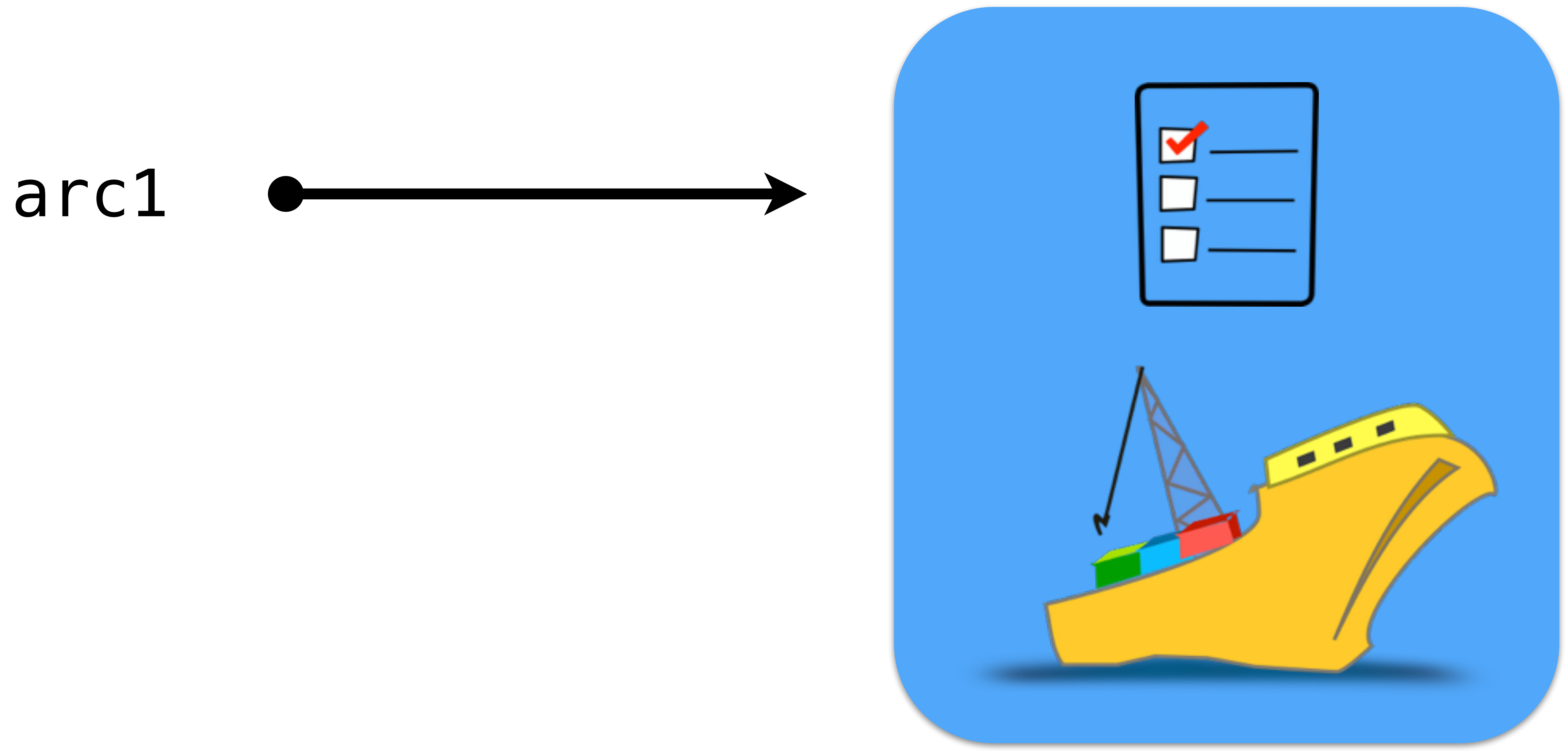

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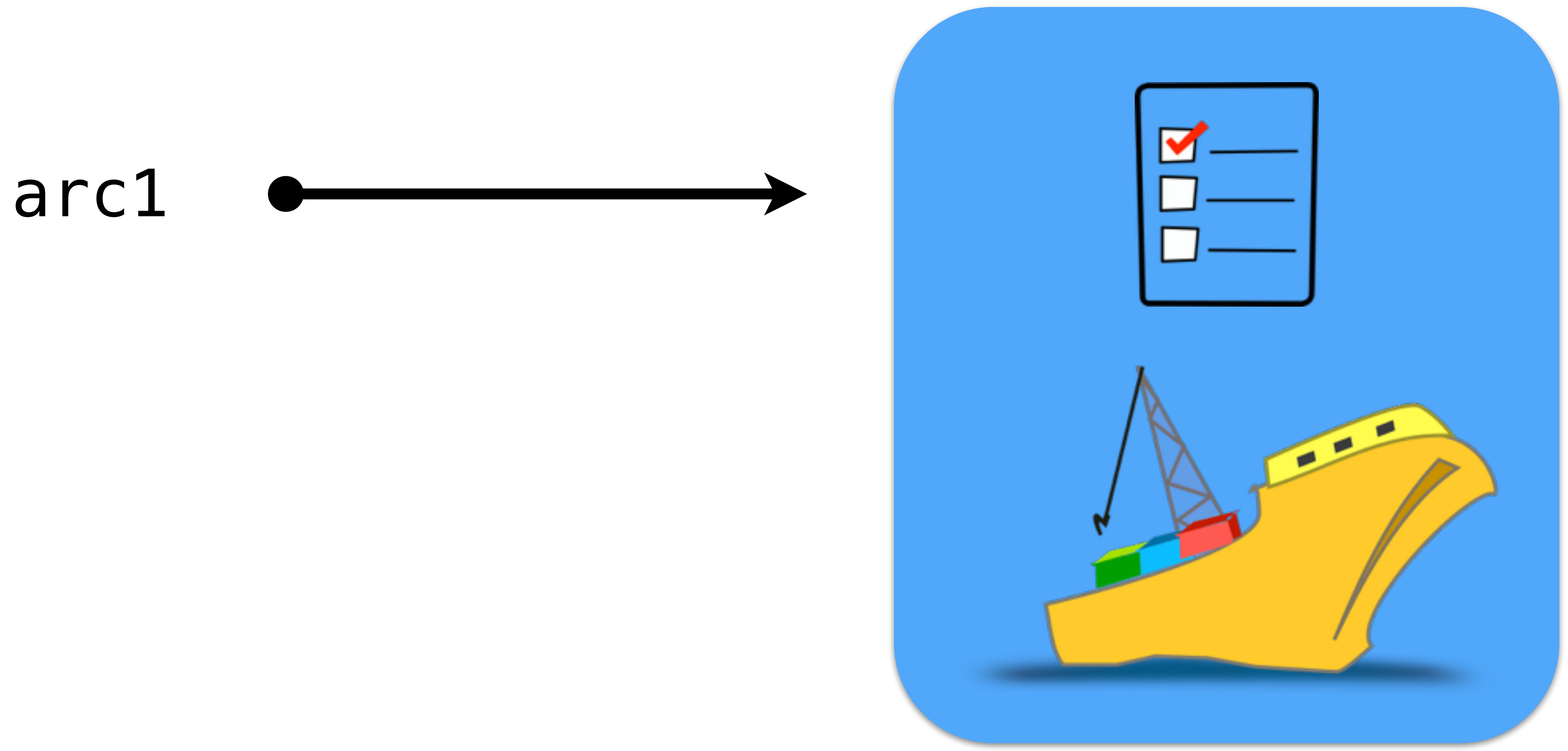

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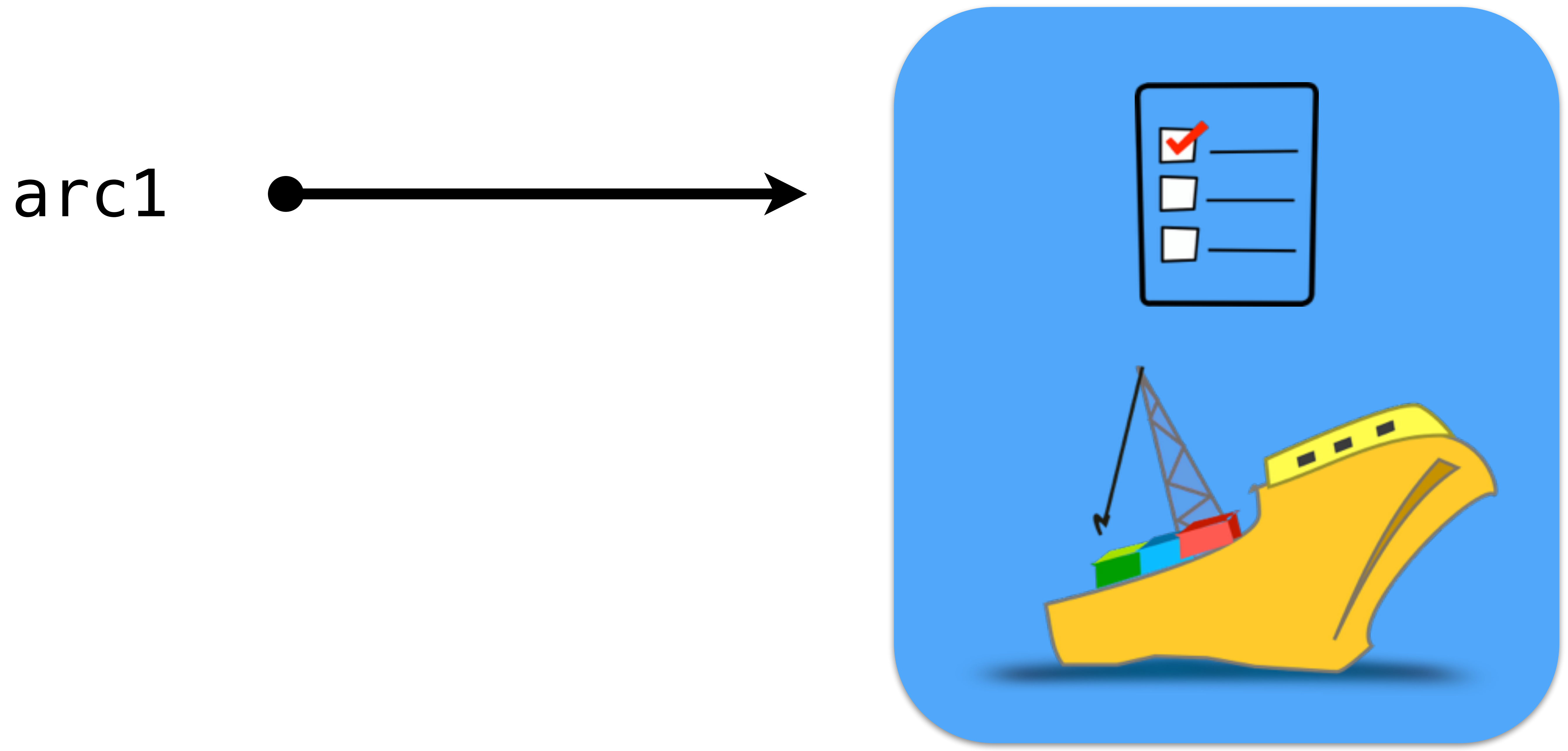

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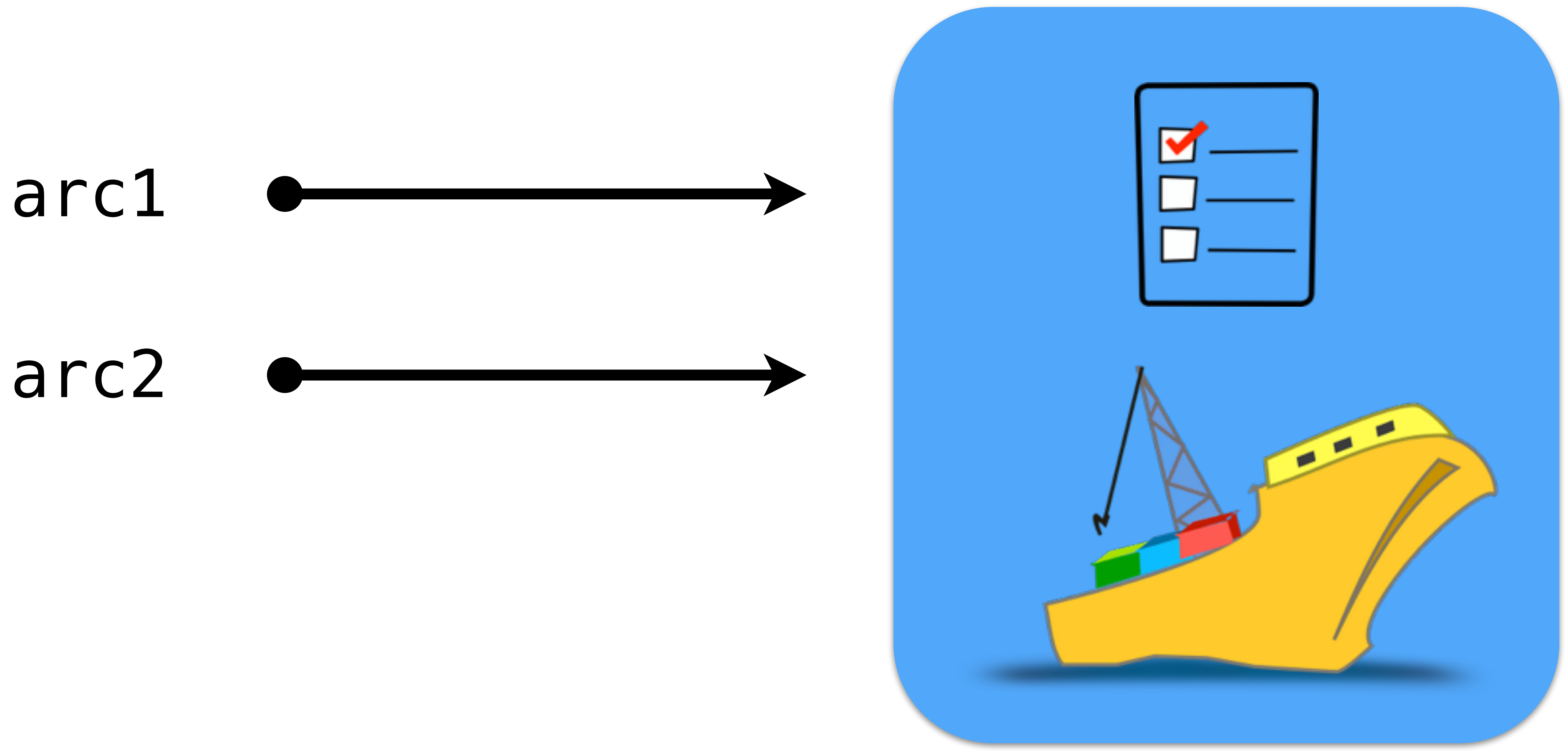

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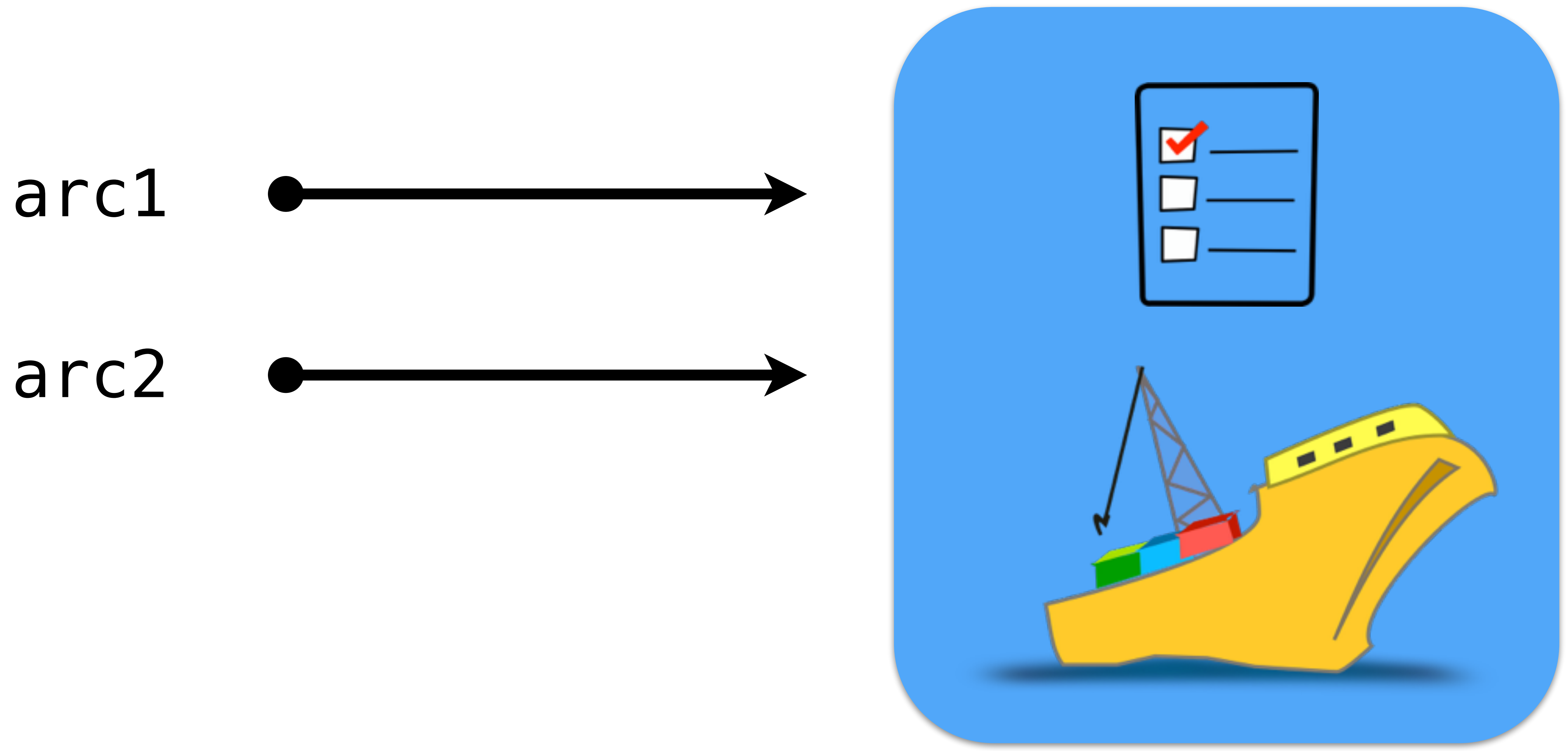

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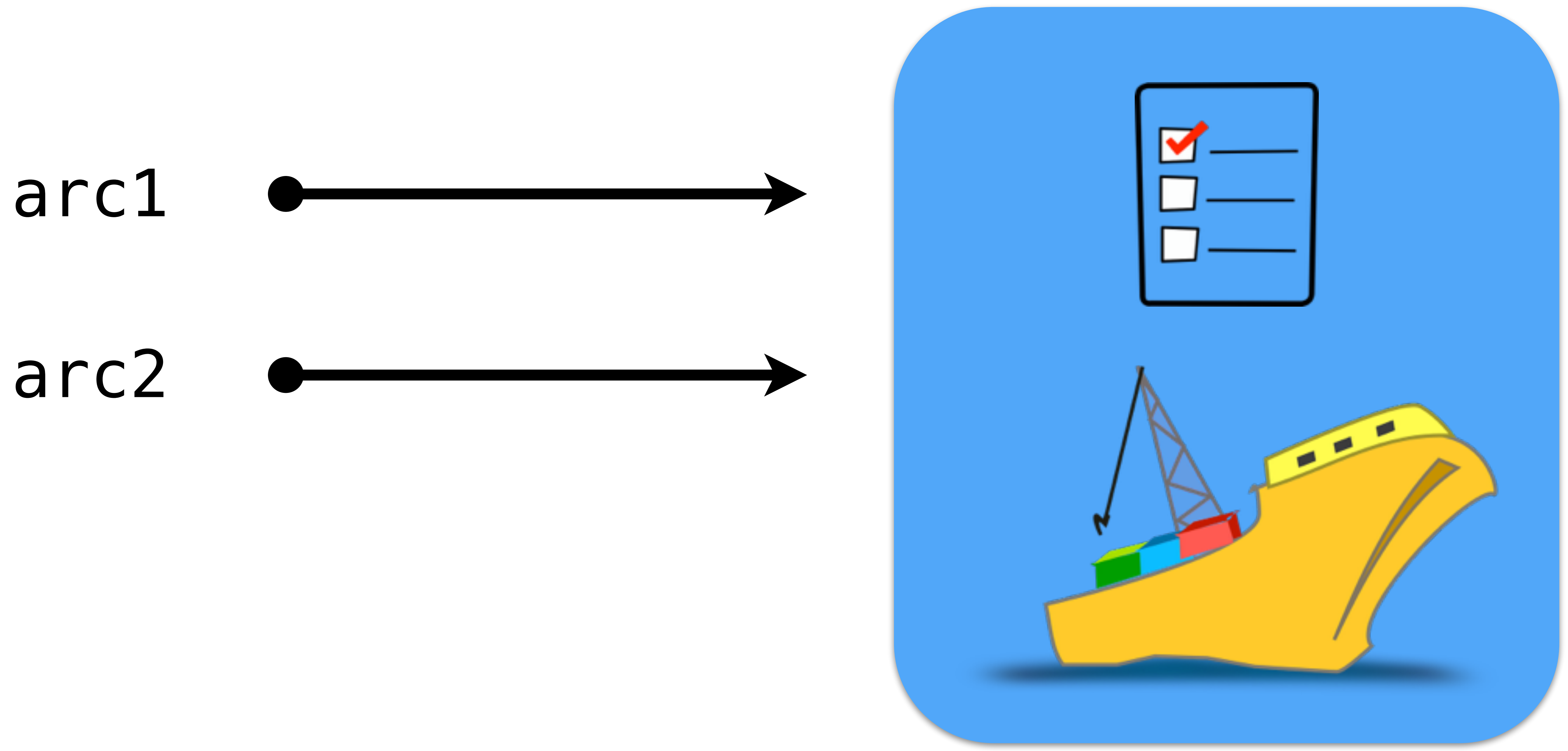

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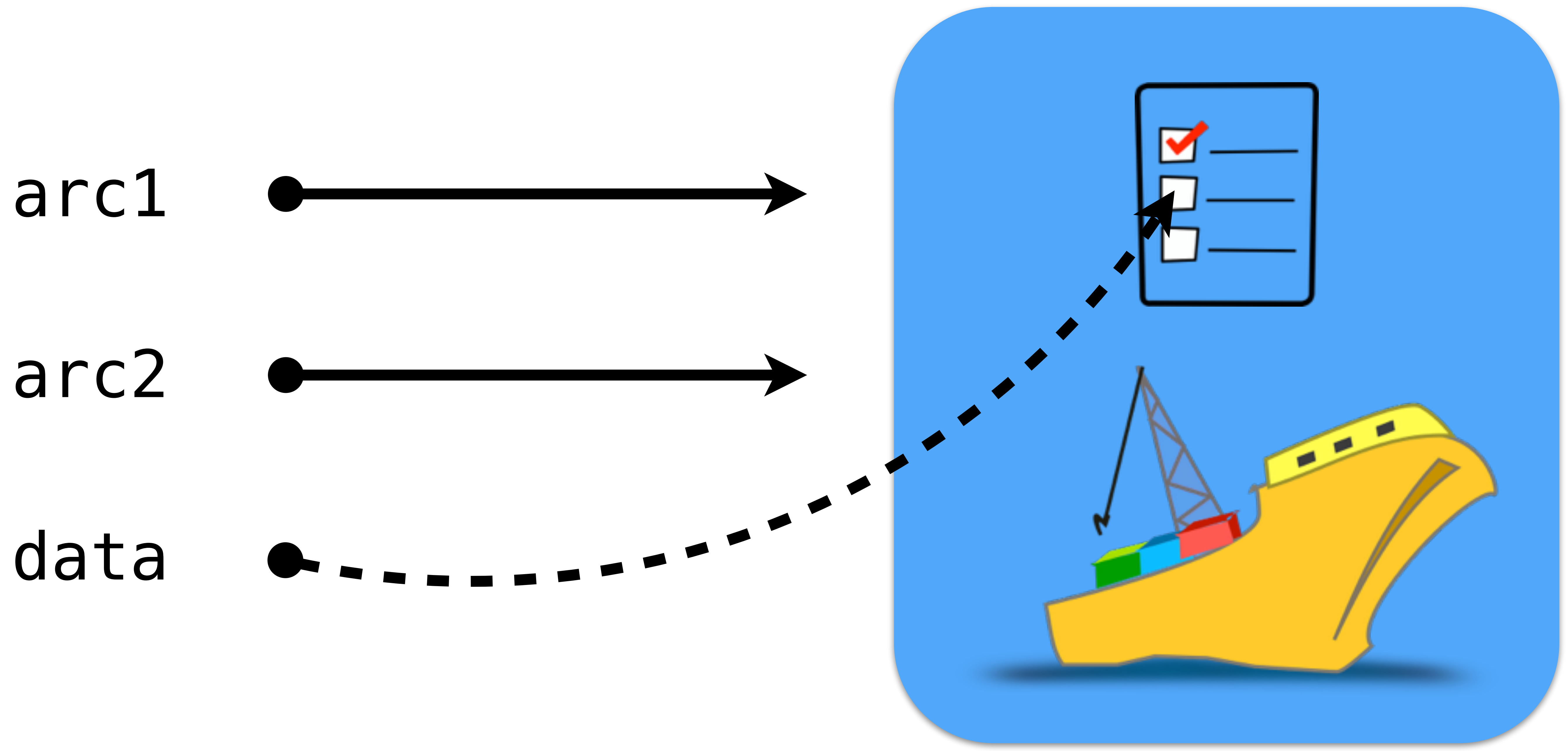

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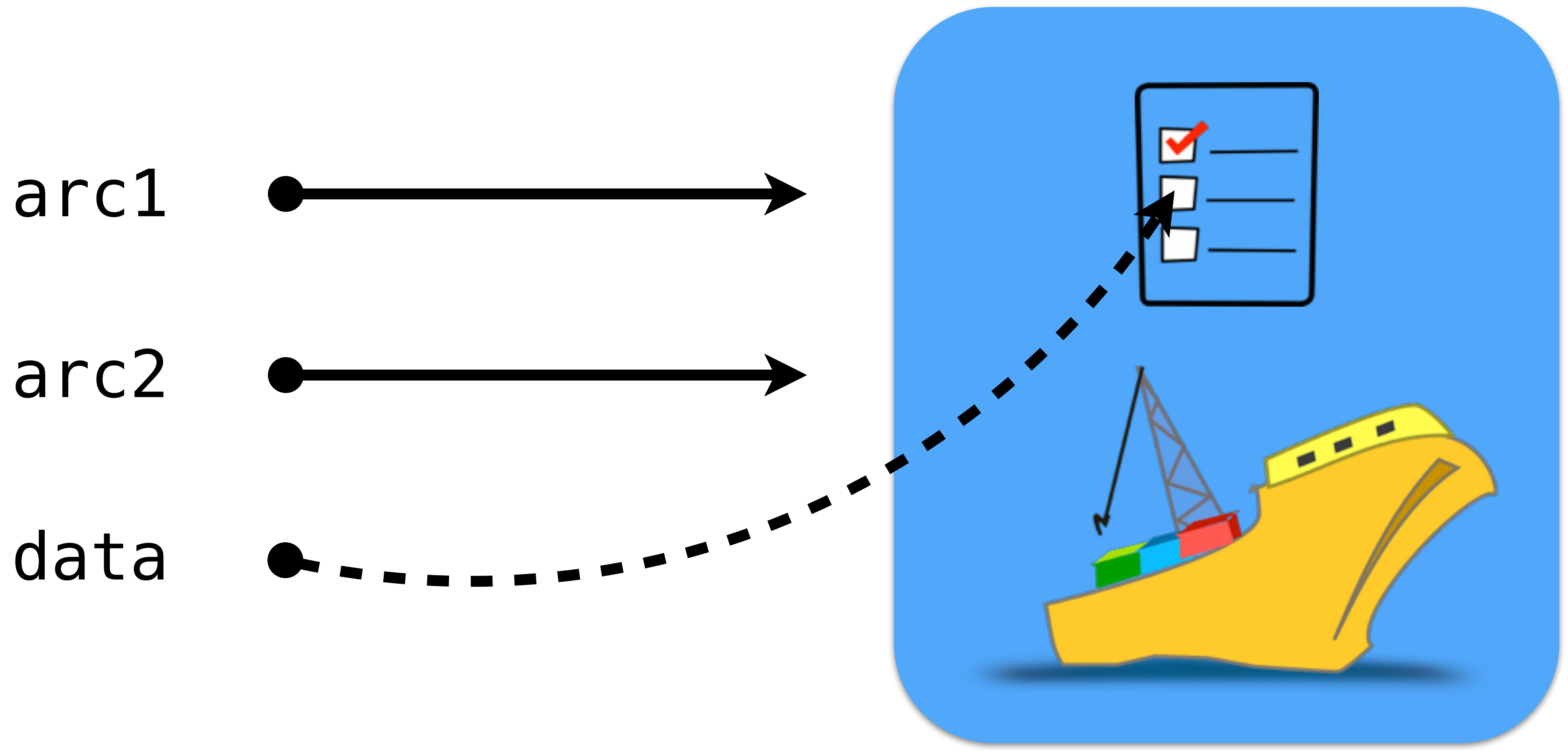

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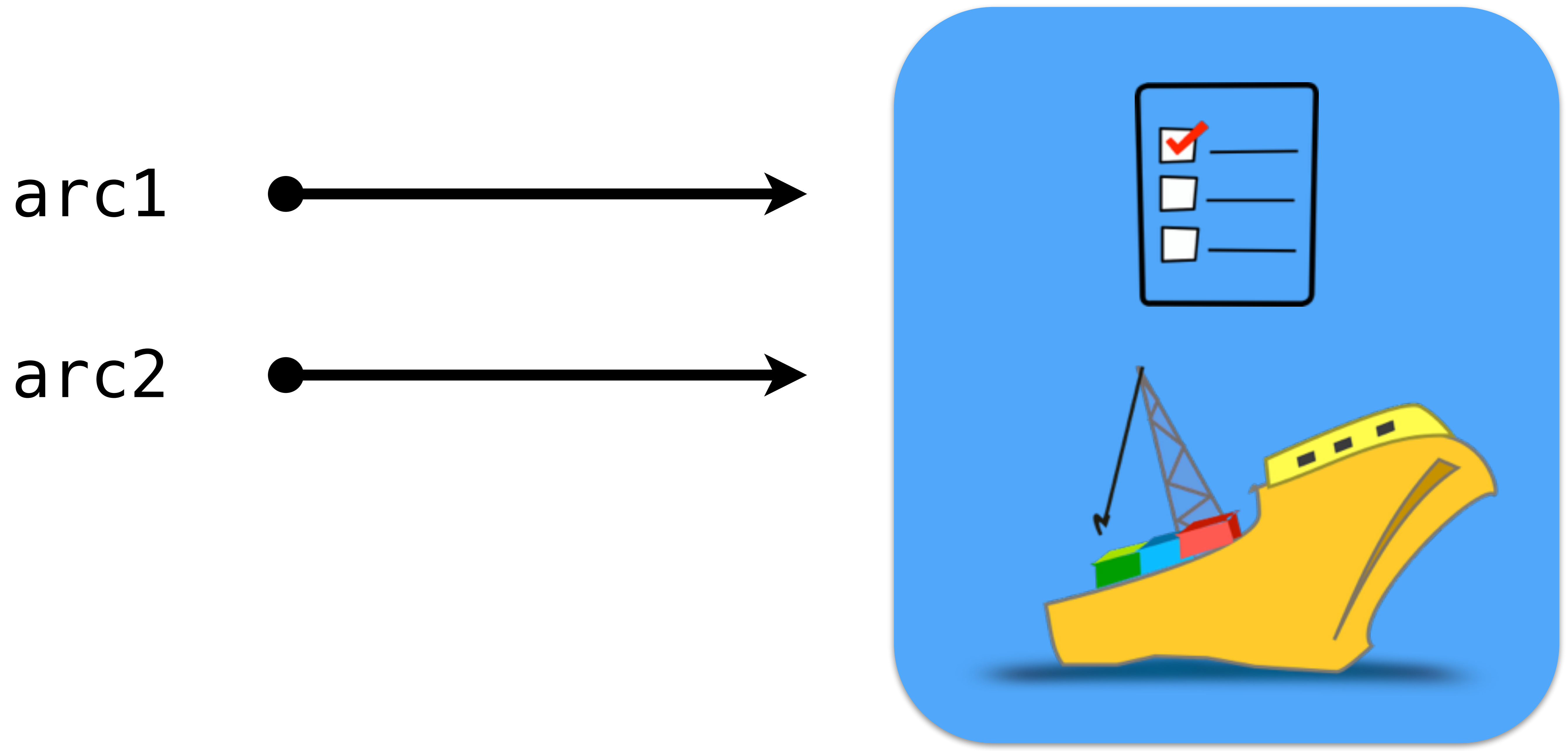

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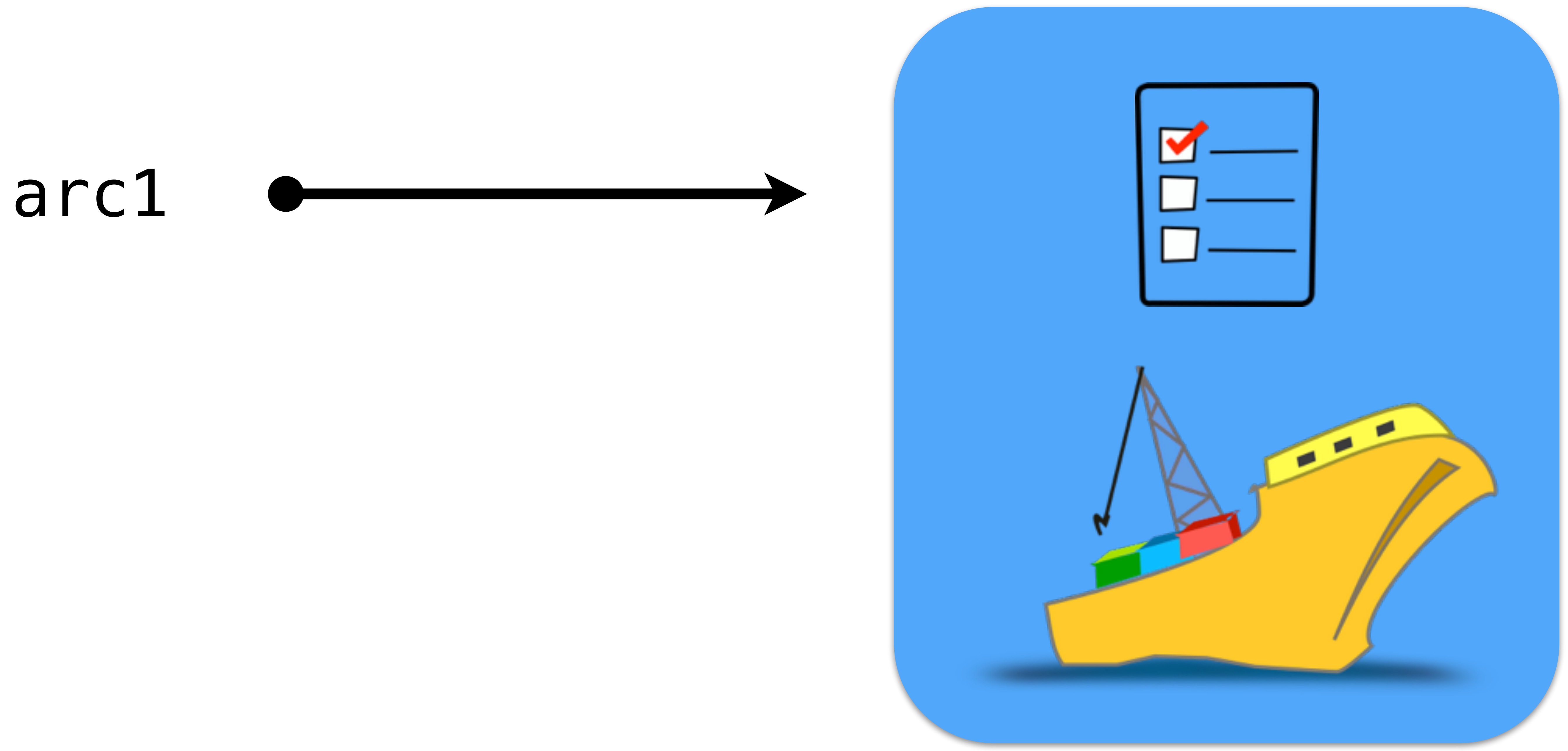

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Arc => Immutable

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

http://is.gd/nP3Pvb

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let shopping_list = Arc::new(vec![…]);
let mut handles = vec![];
for store in stores {
  let shopping_list = shopping_list.clone();
  let handle =
    thread::spawn(move || {
      let sum = store.total_price(shopping_list);
      (store.name, sum)
    });
  handles.push(handle);
}
```

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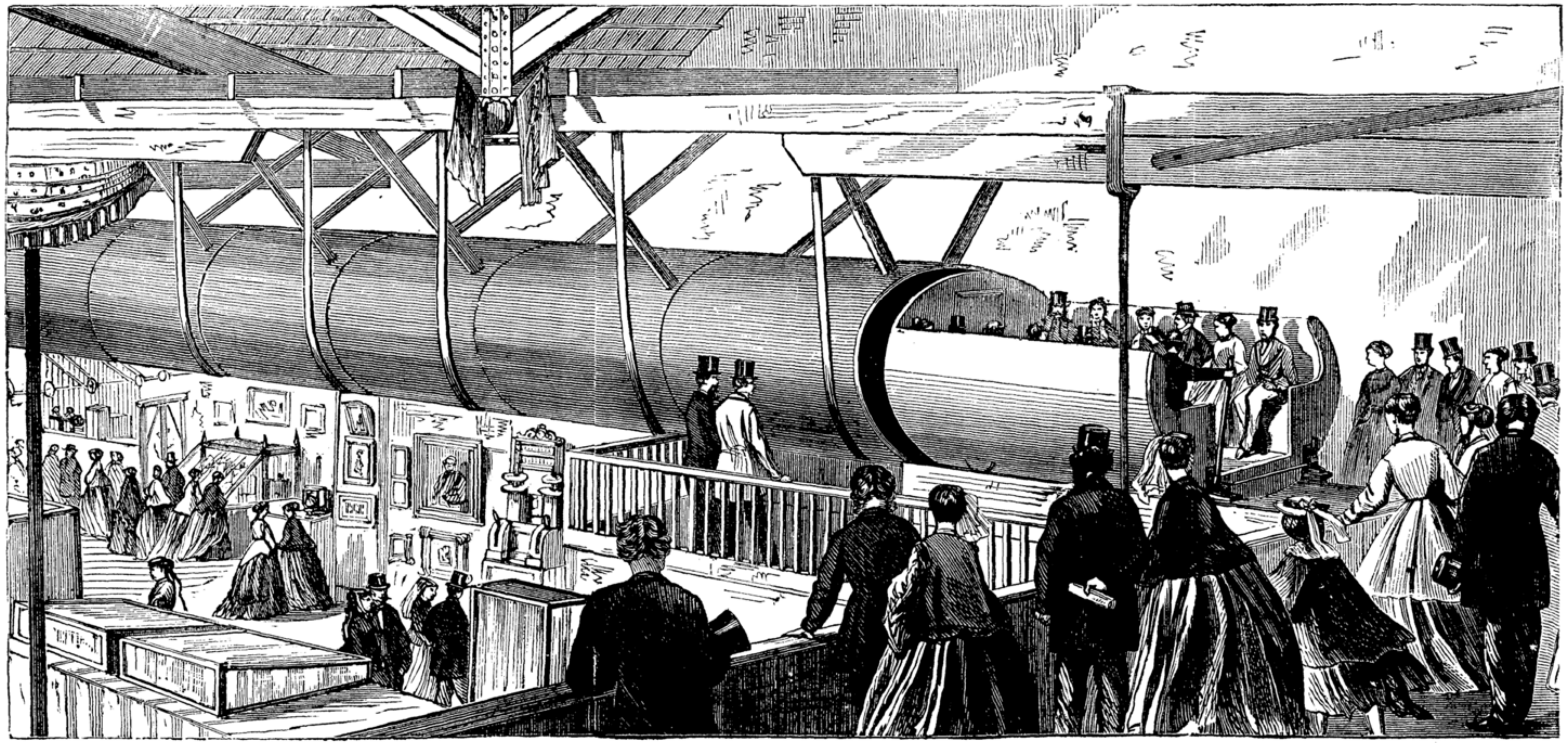
  handles.push(handle);
}


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

Channels



Joining a thread allows
thread to send **one result.**

What if we wanted
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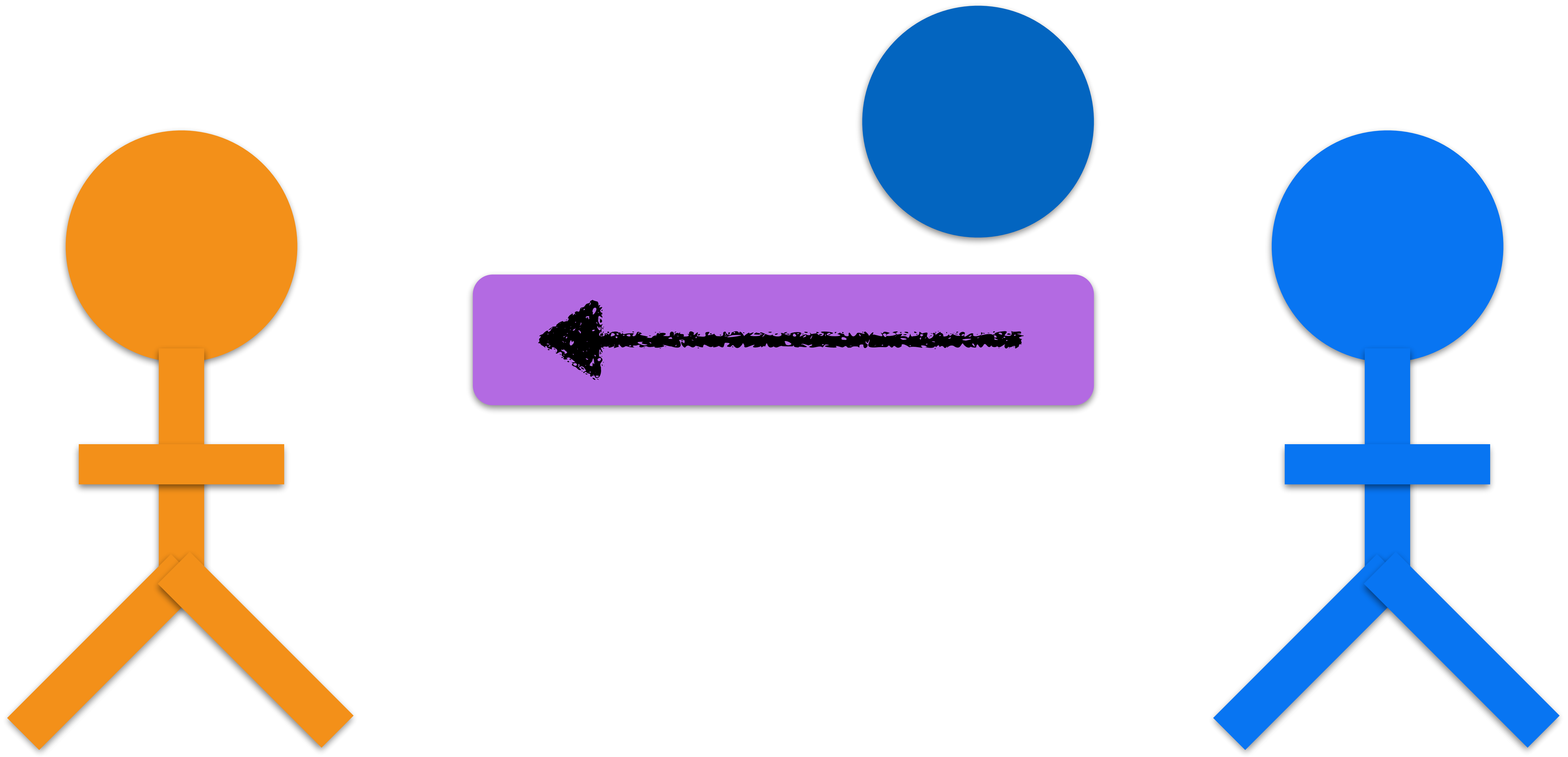

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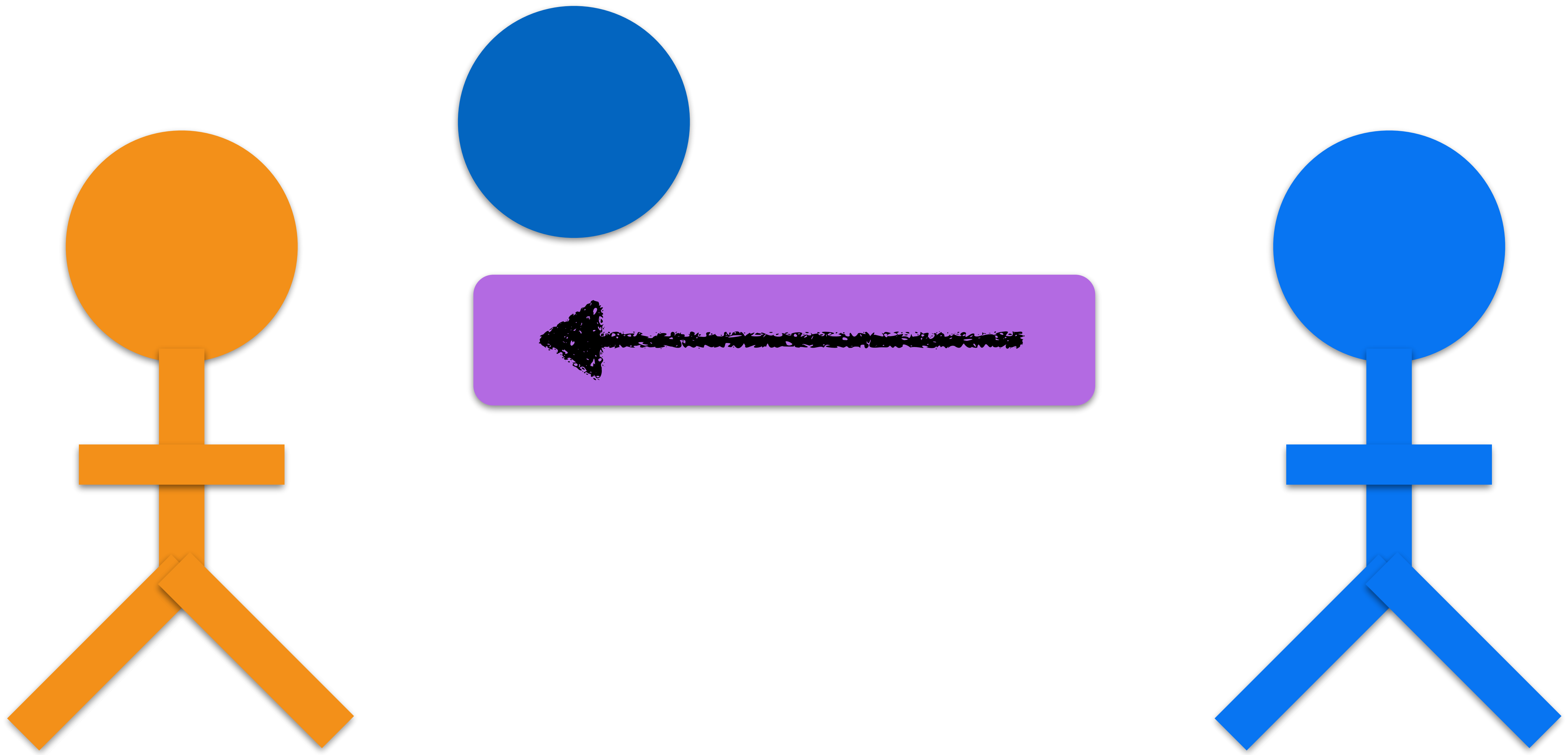

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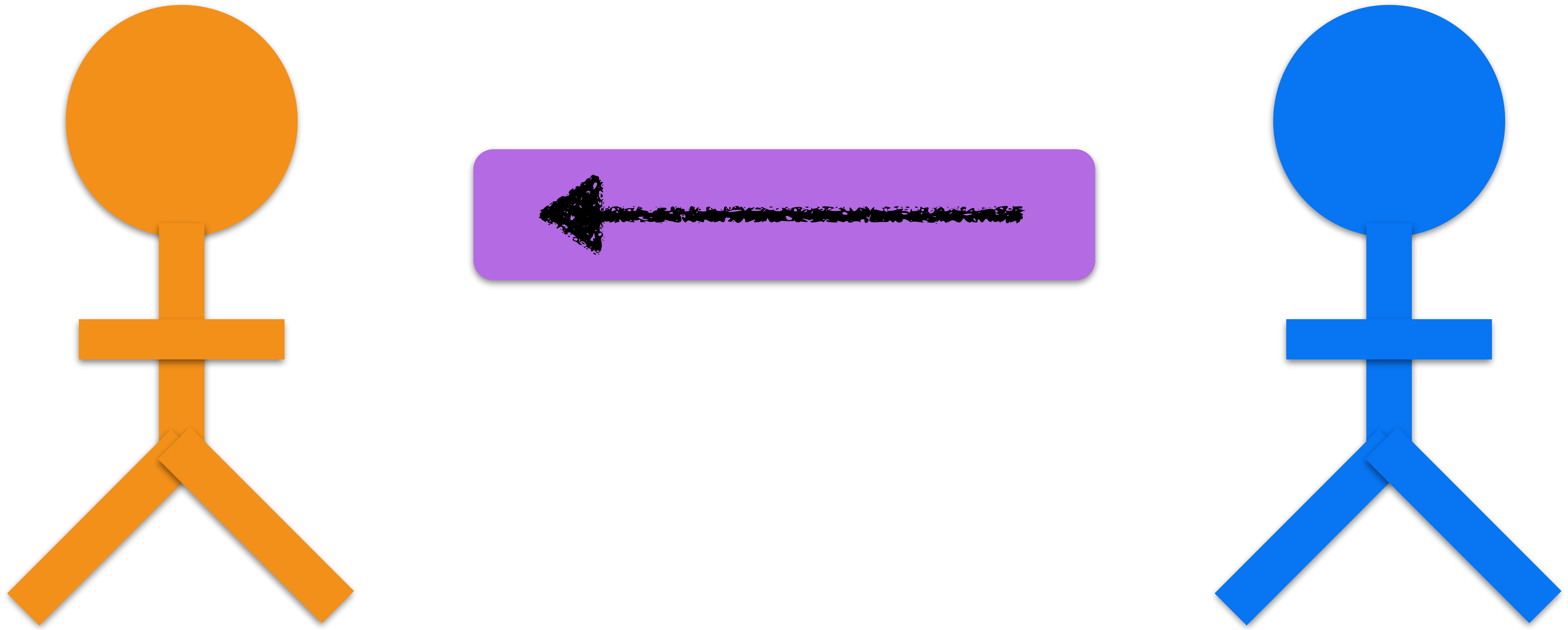

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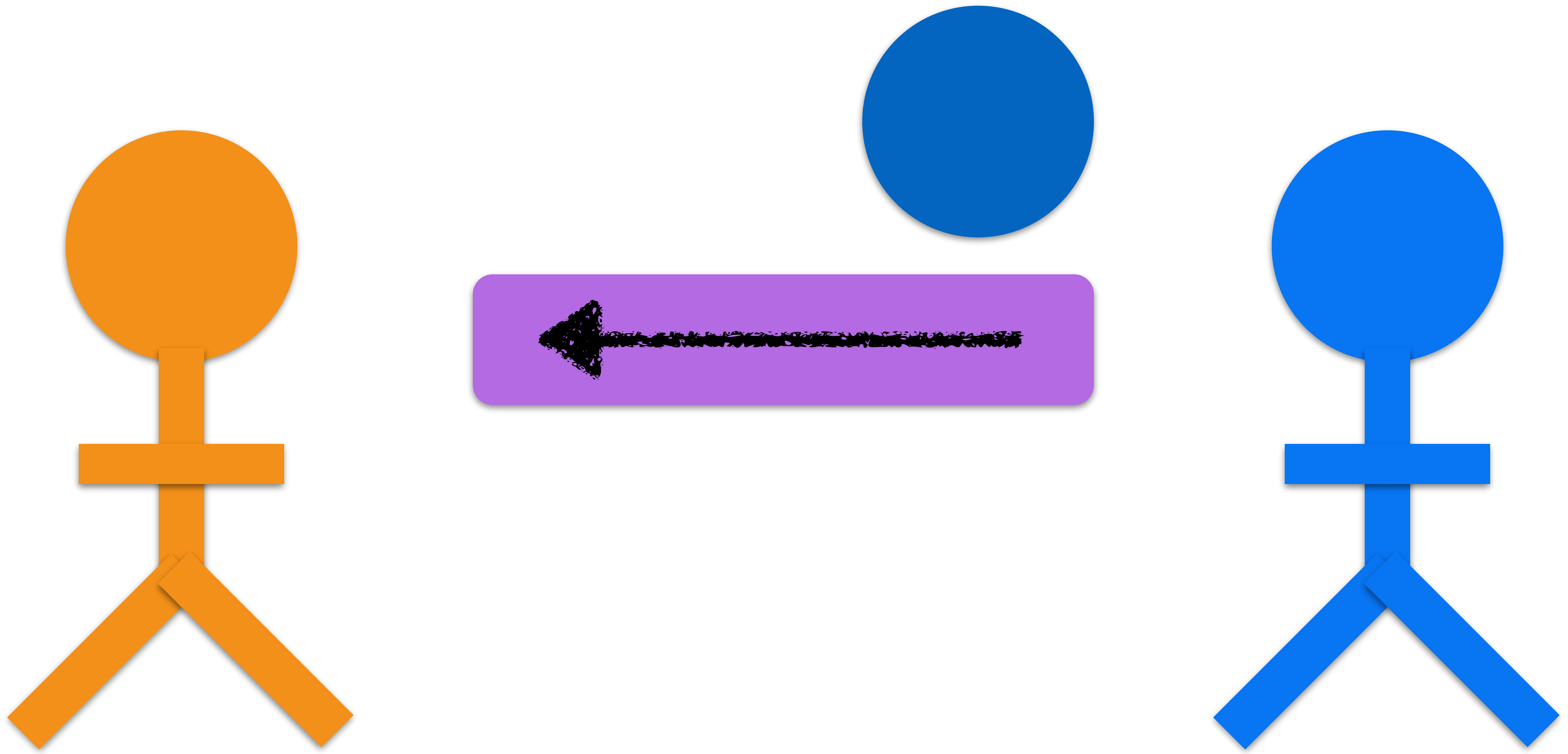

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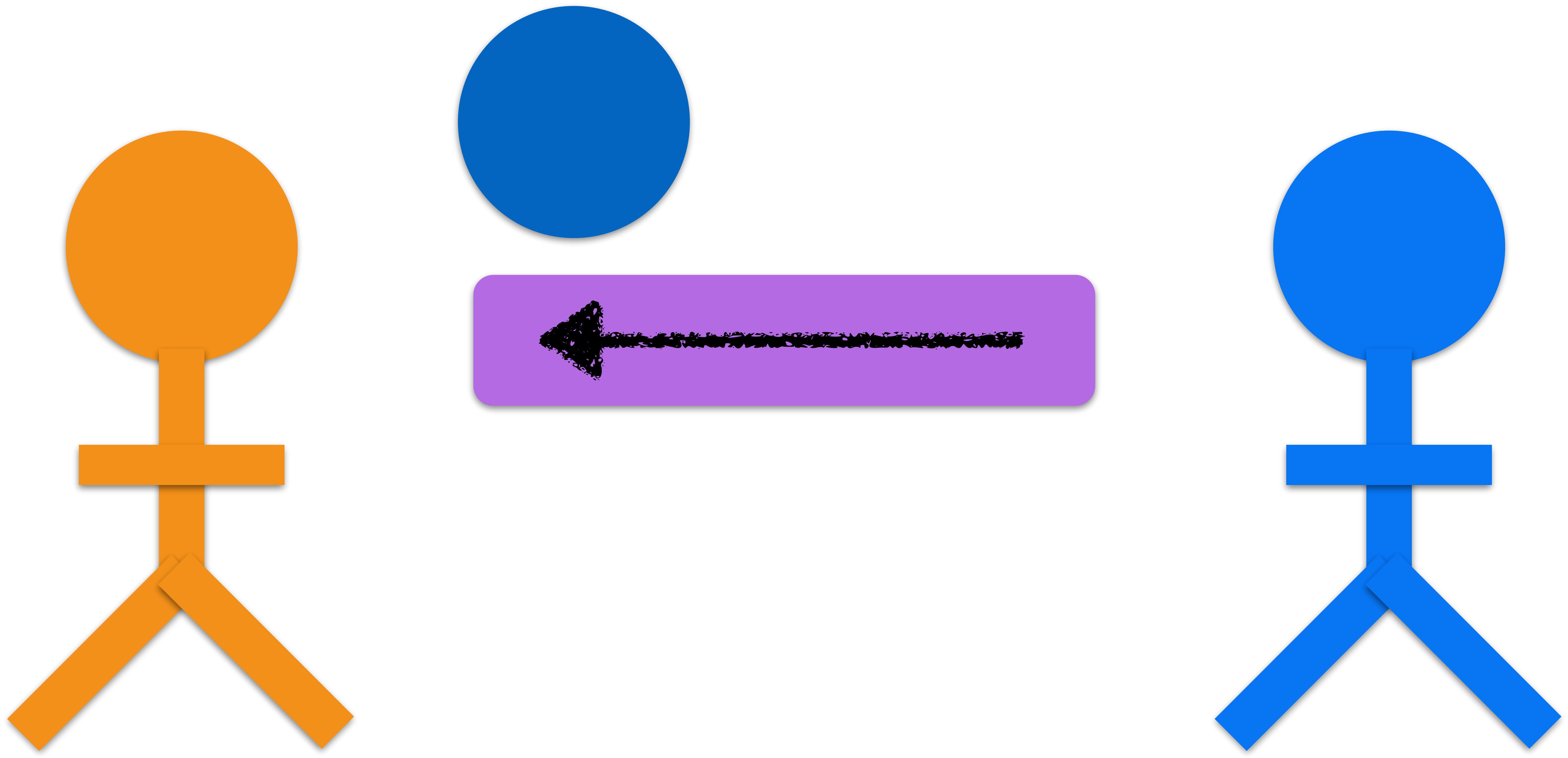

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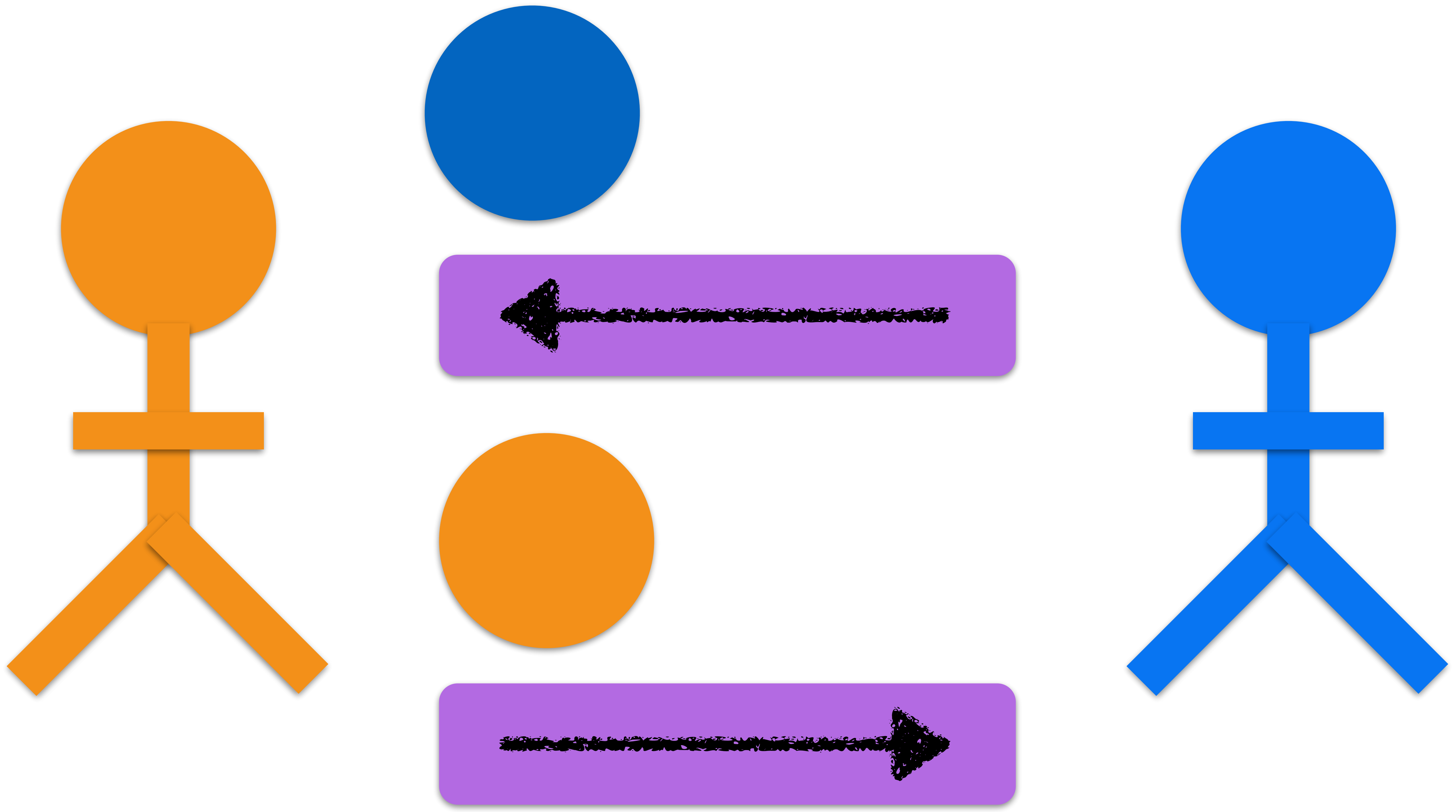

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What if we wanted
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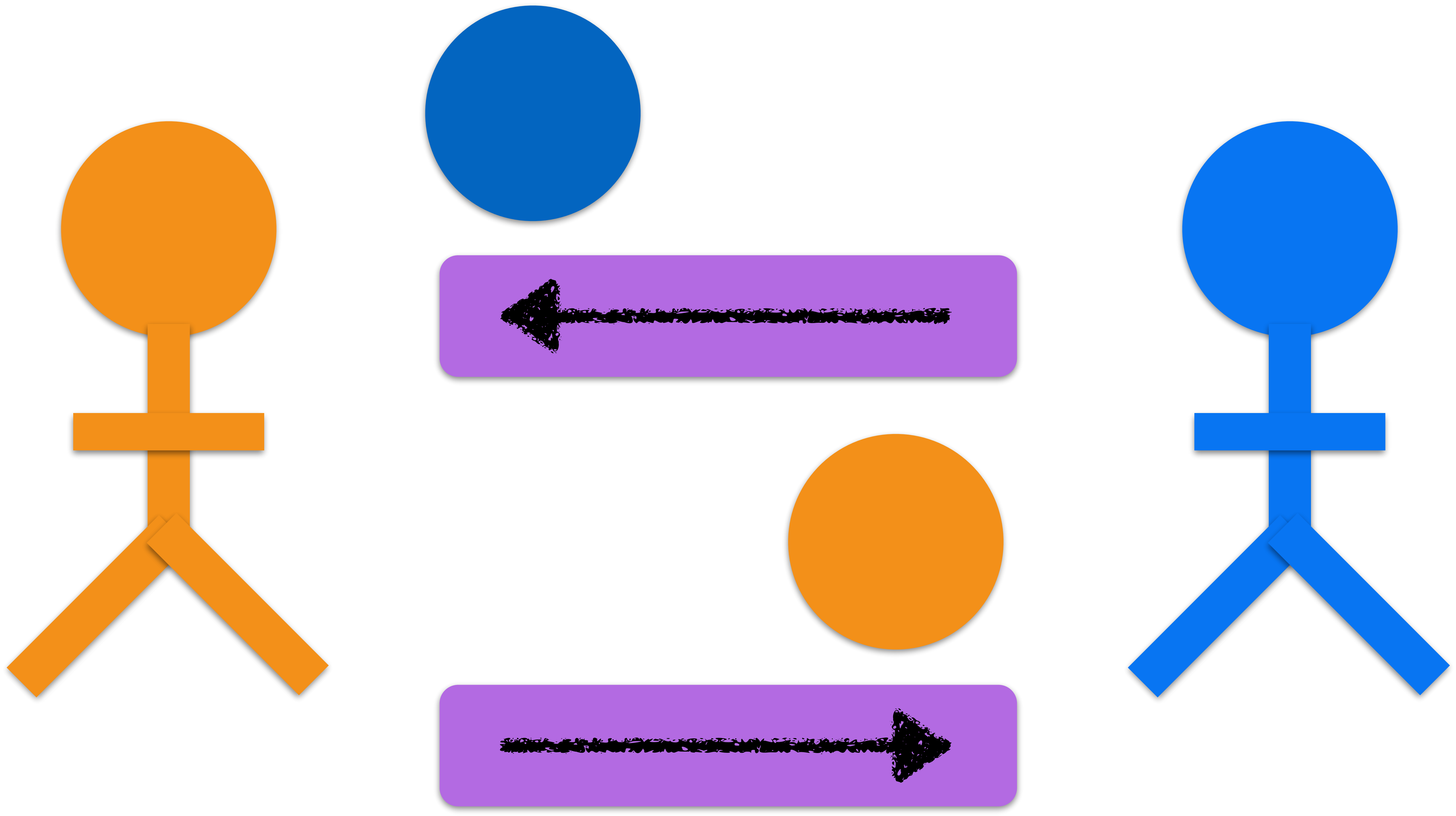

```
fn parent() {
  let (tx, rx) = channel();
  spawn(move || {…});
  let m = rx.recv().unwrap();
}
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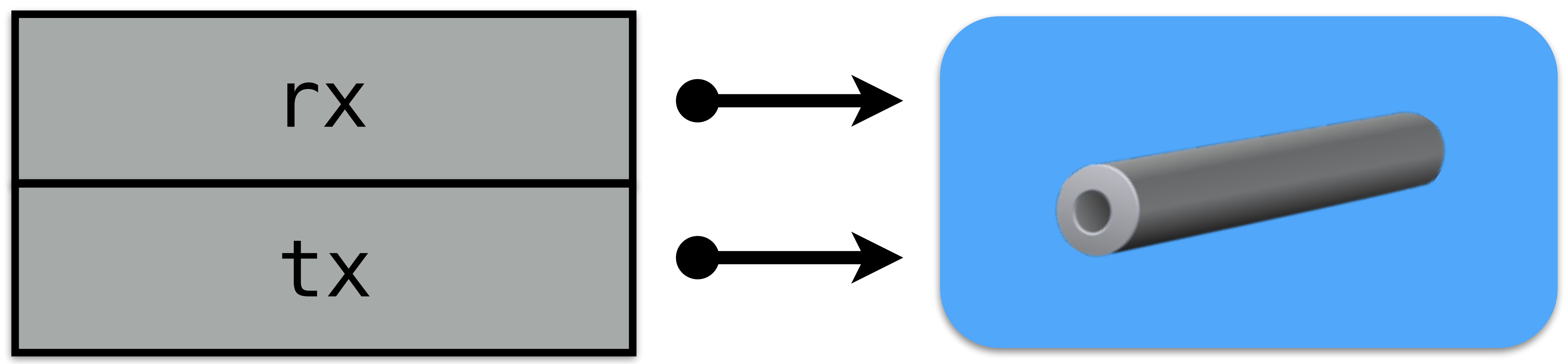

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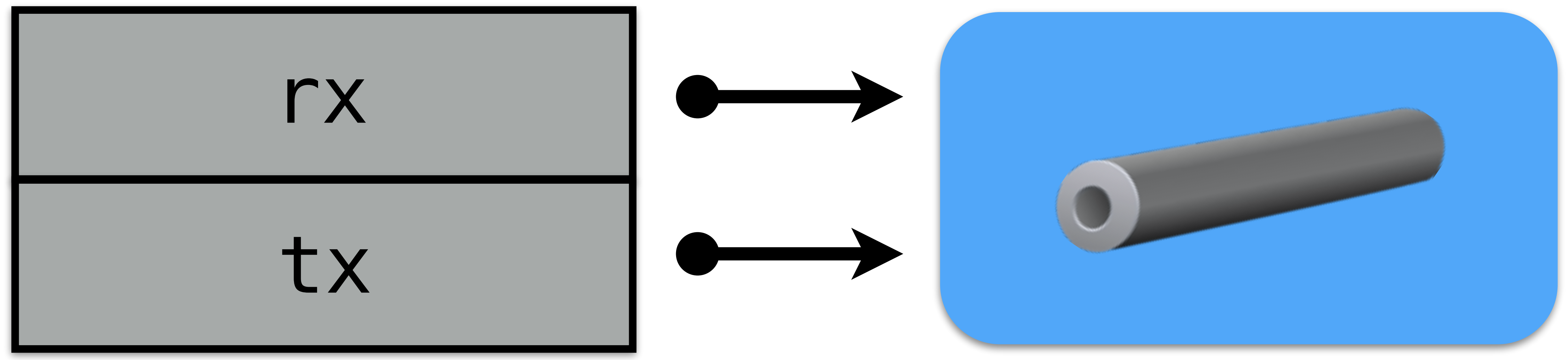

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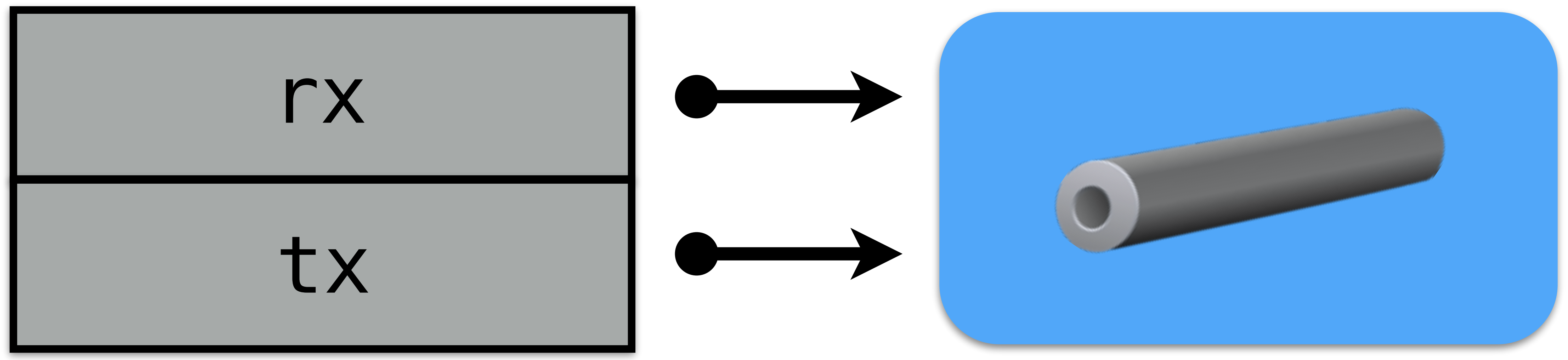

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```
move || {
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  …
  tx.send(m).unwrap();
}
```

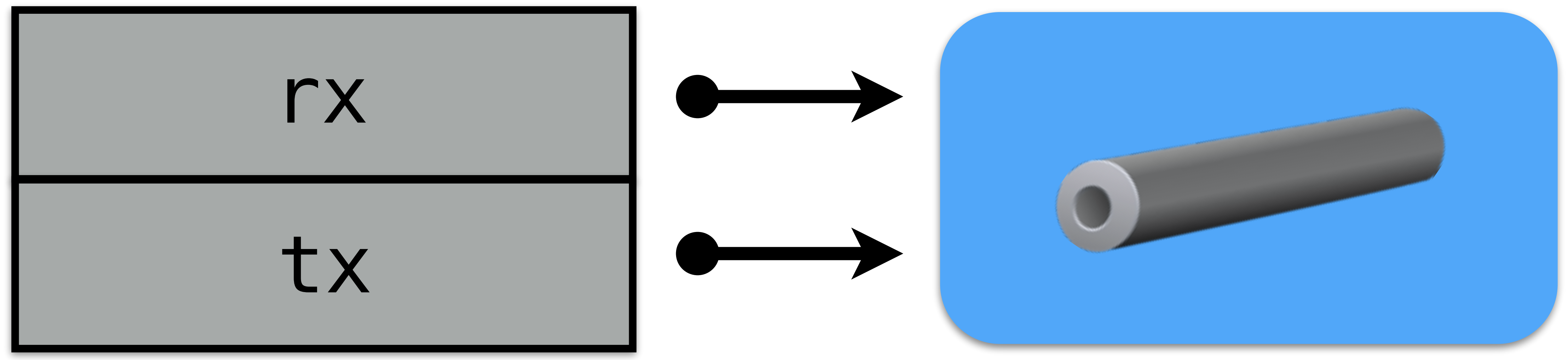

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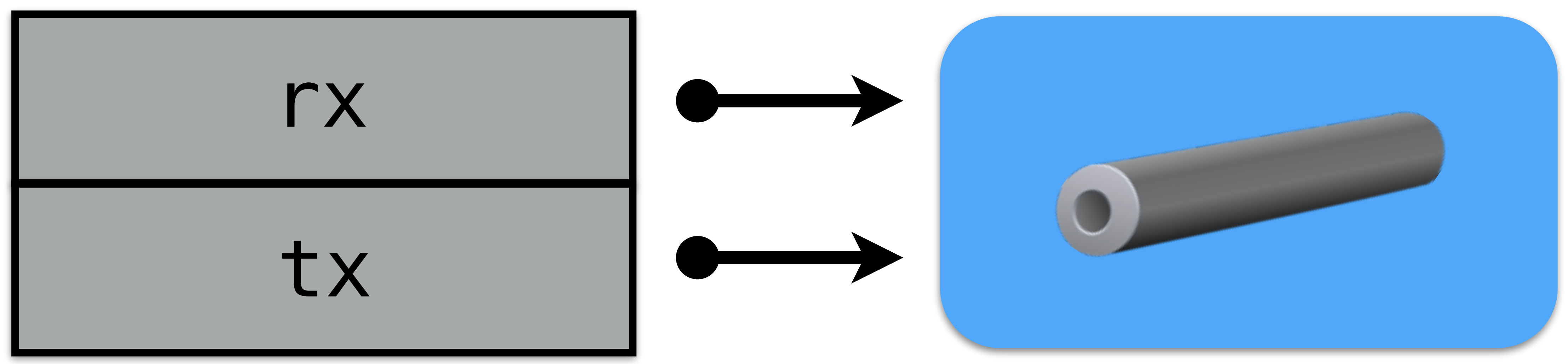

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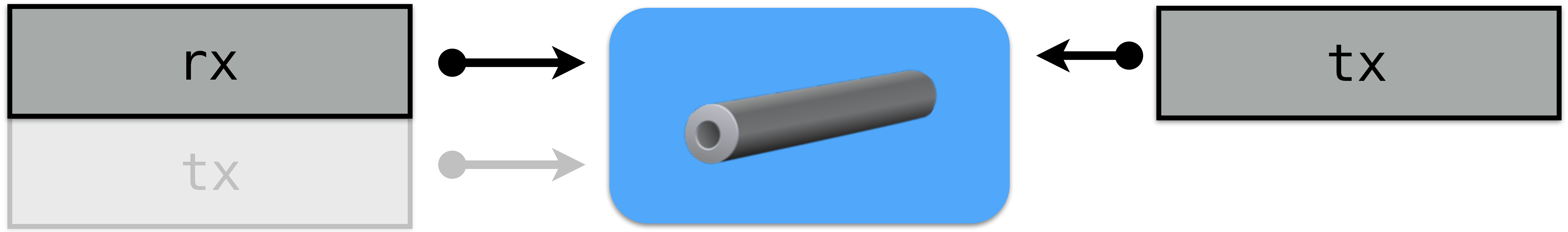

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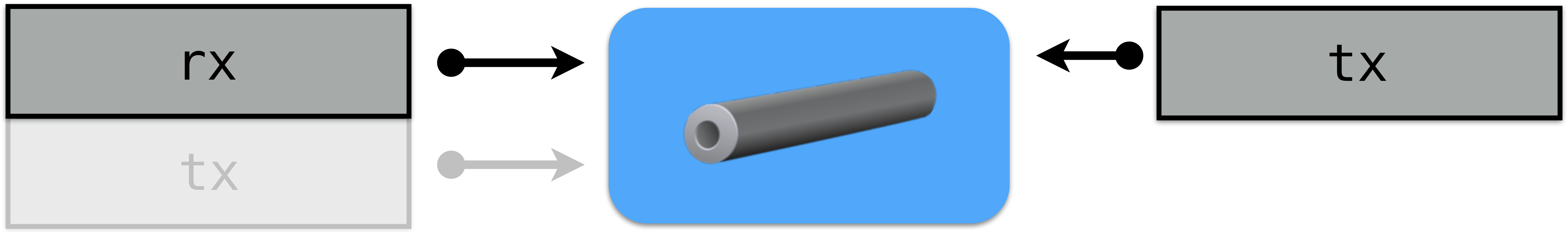

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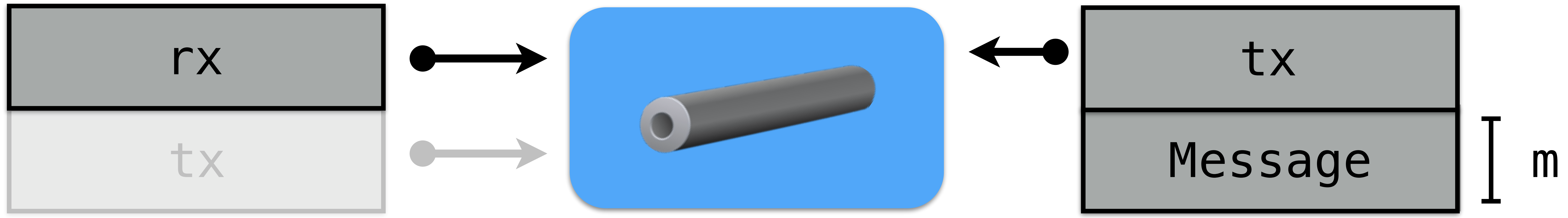

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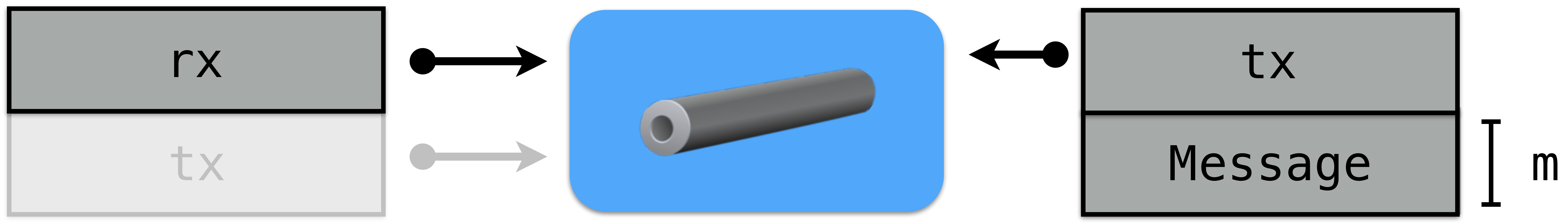

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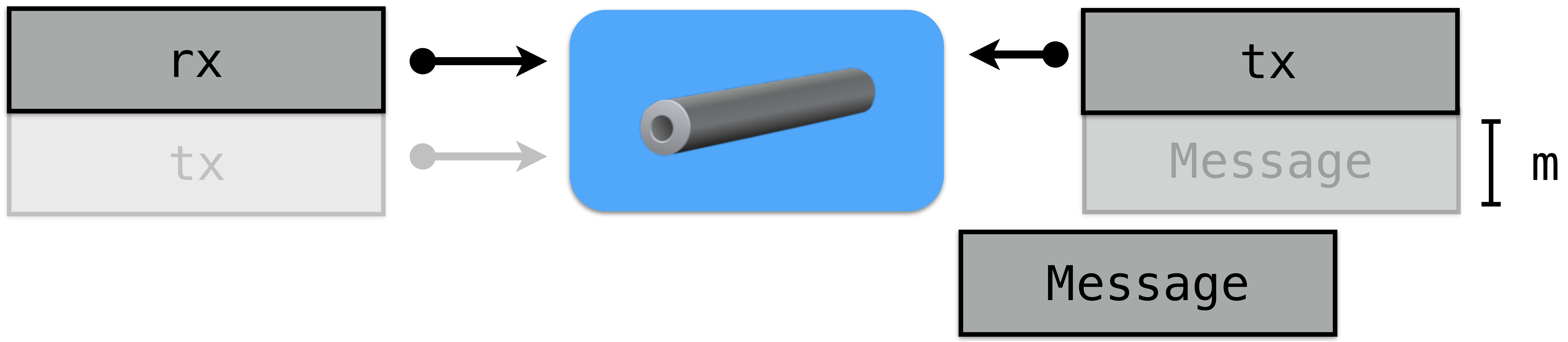

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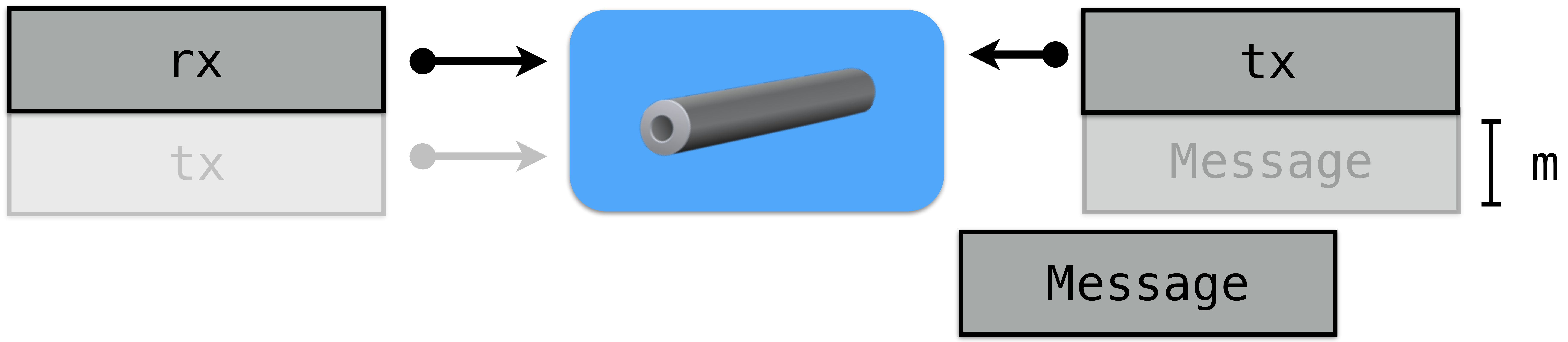

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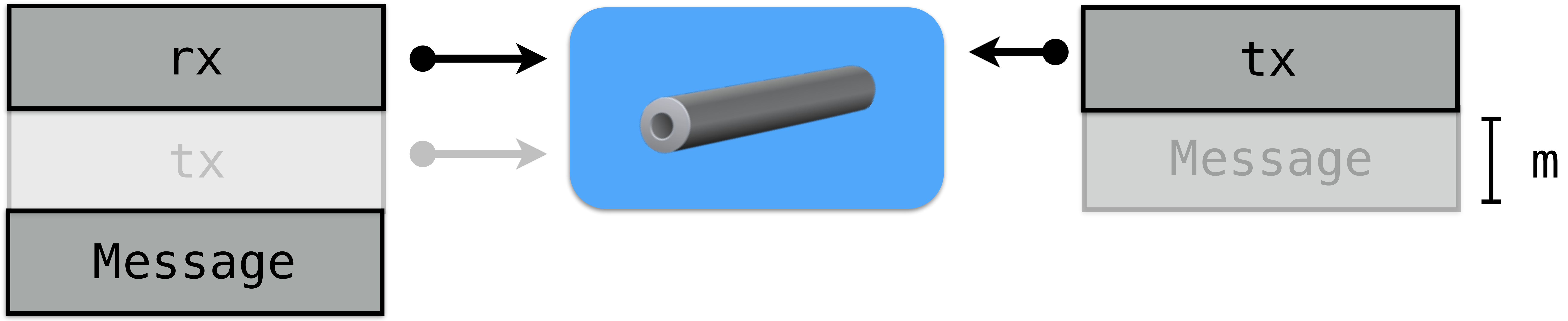

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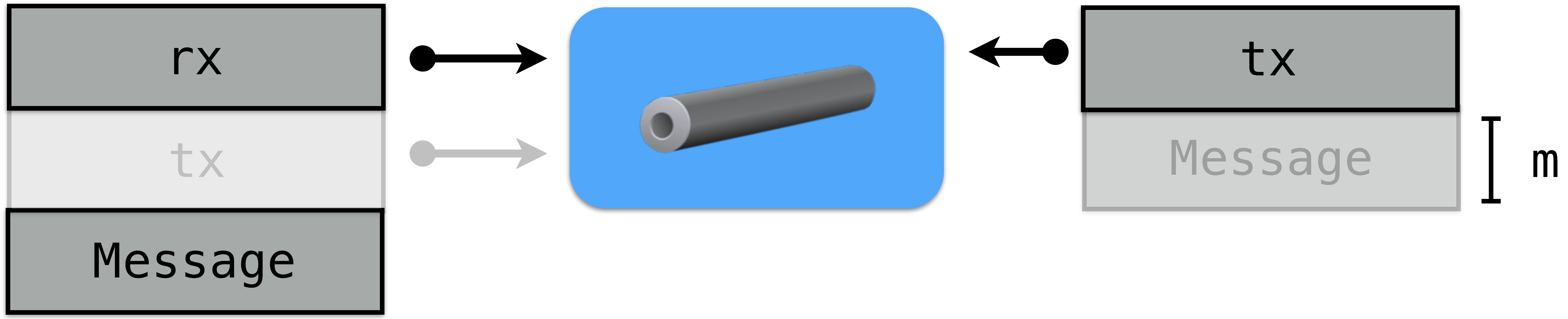

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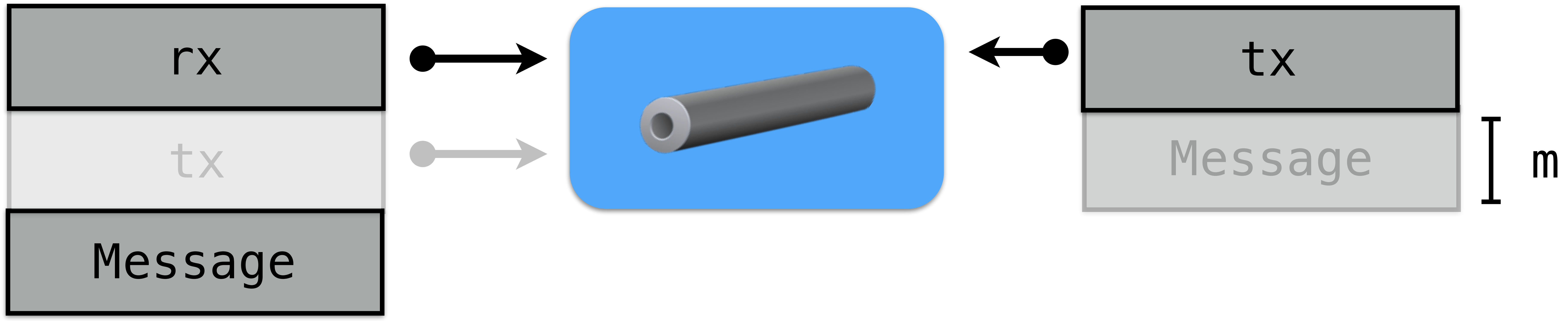

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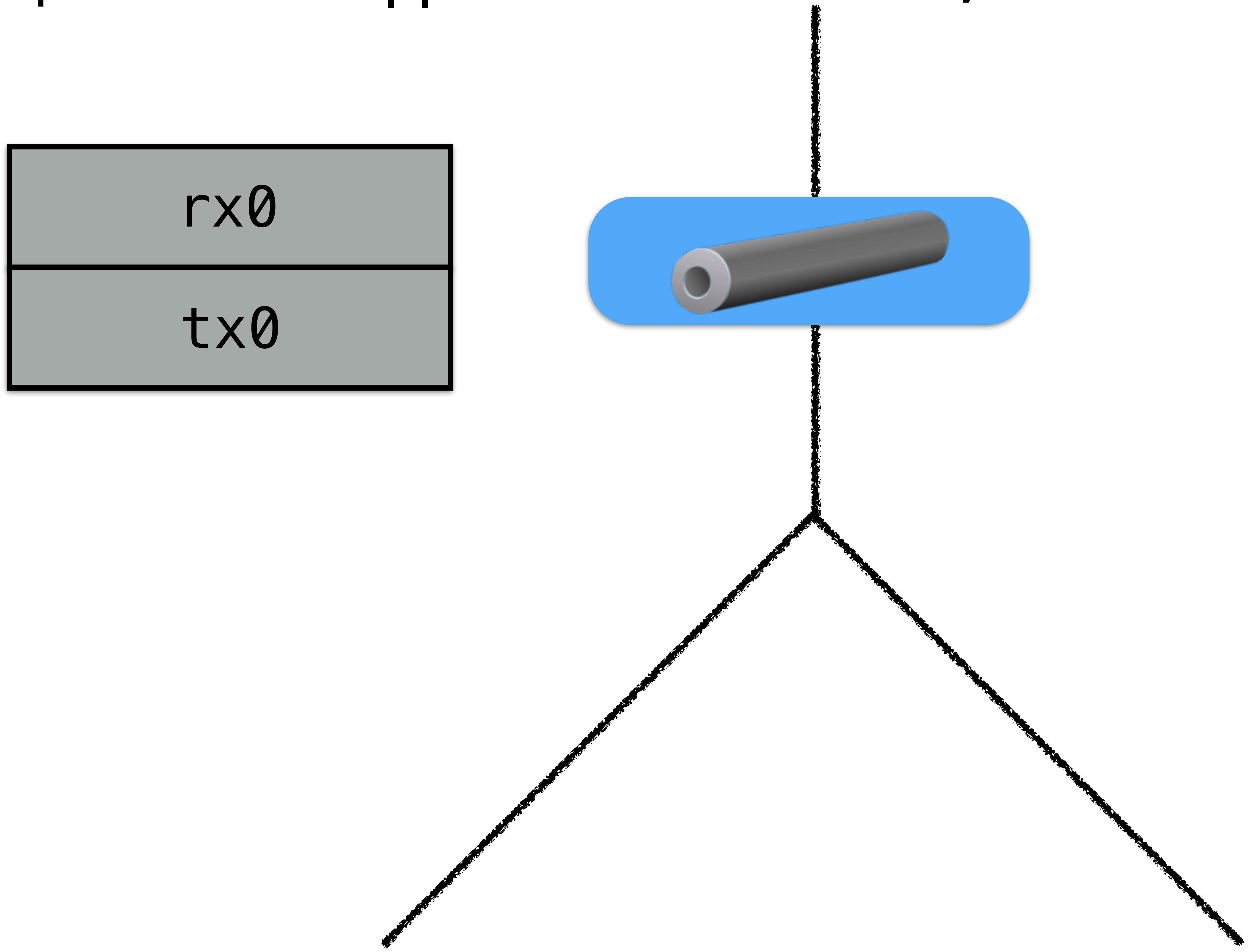

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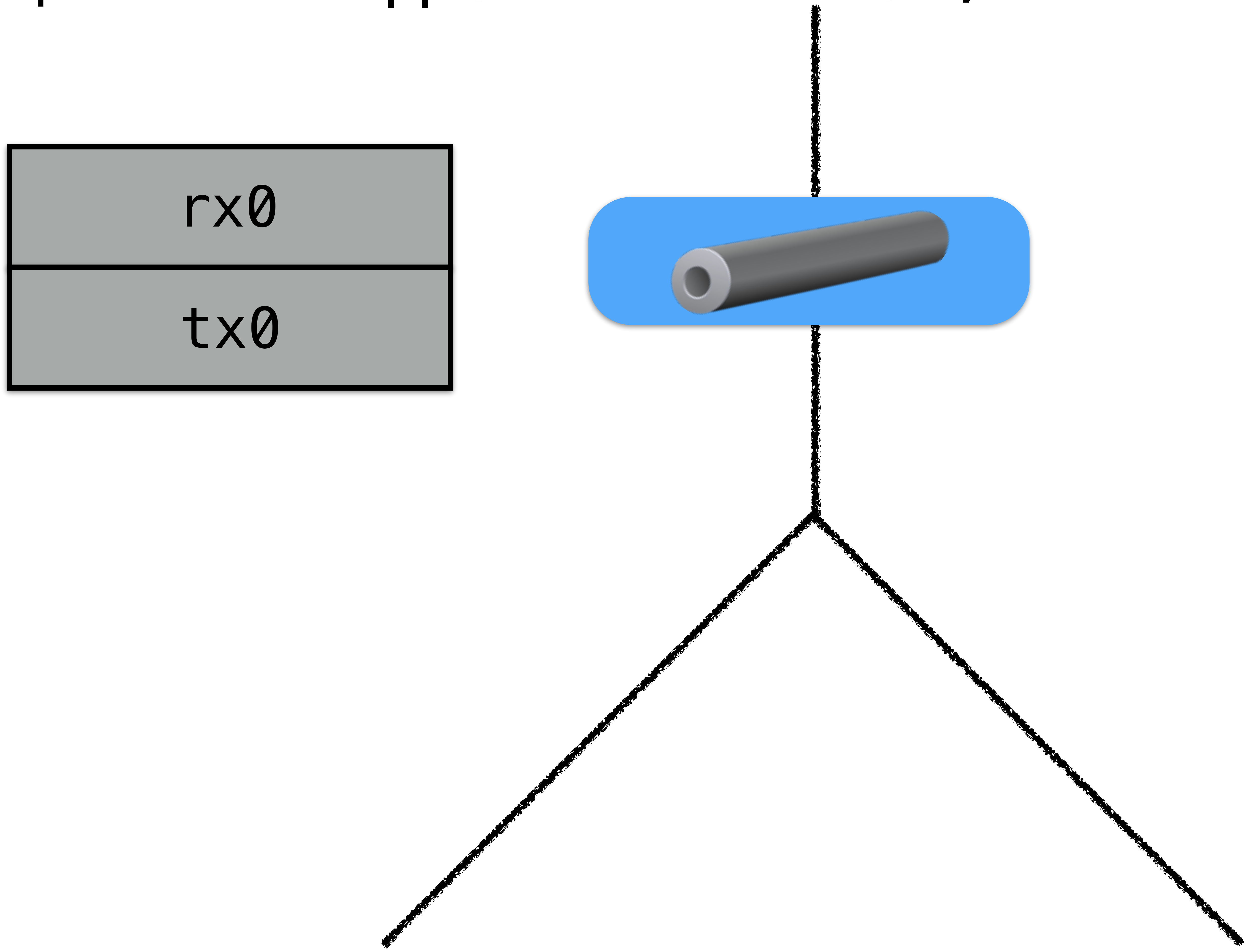

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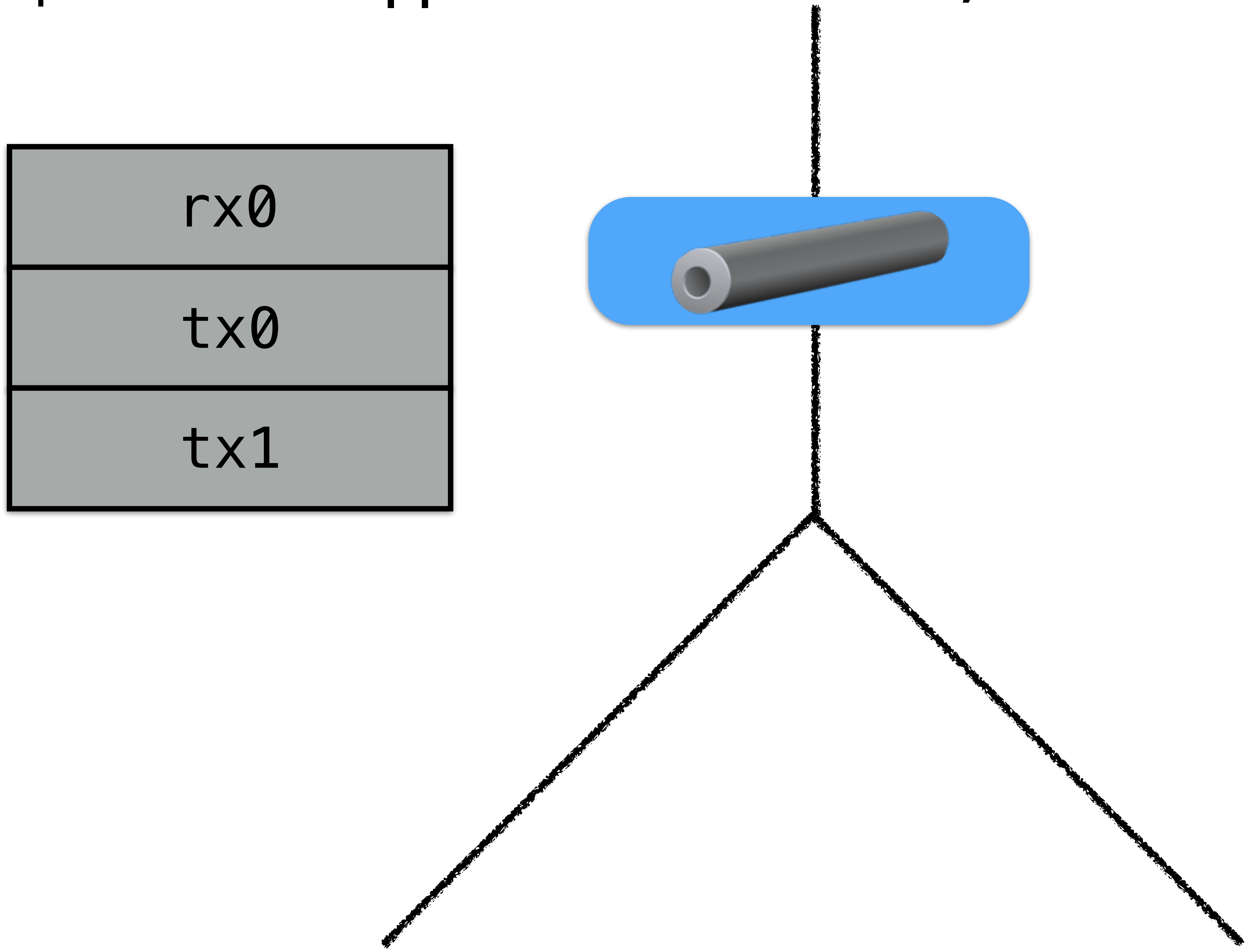

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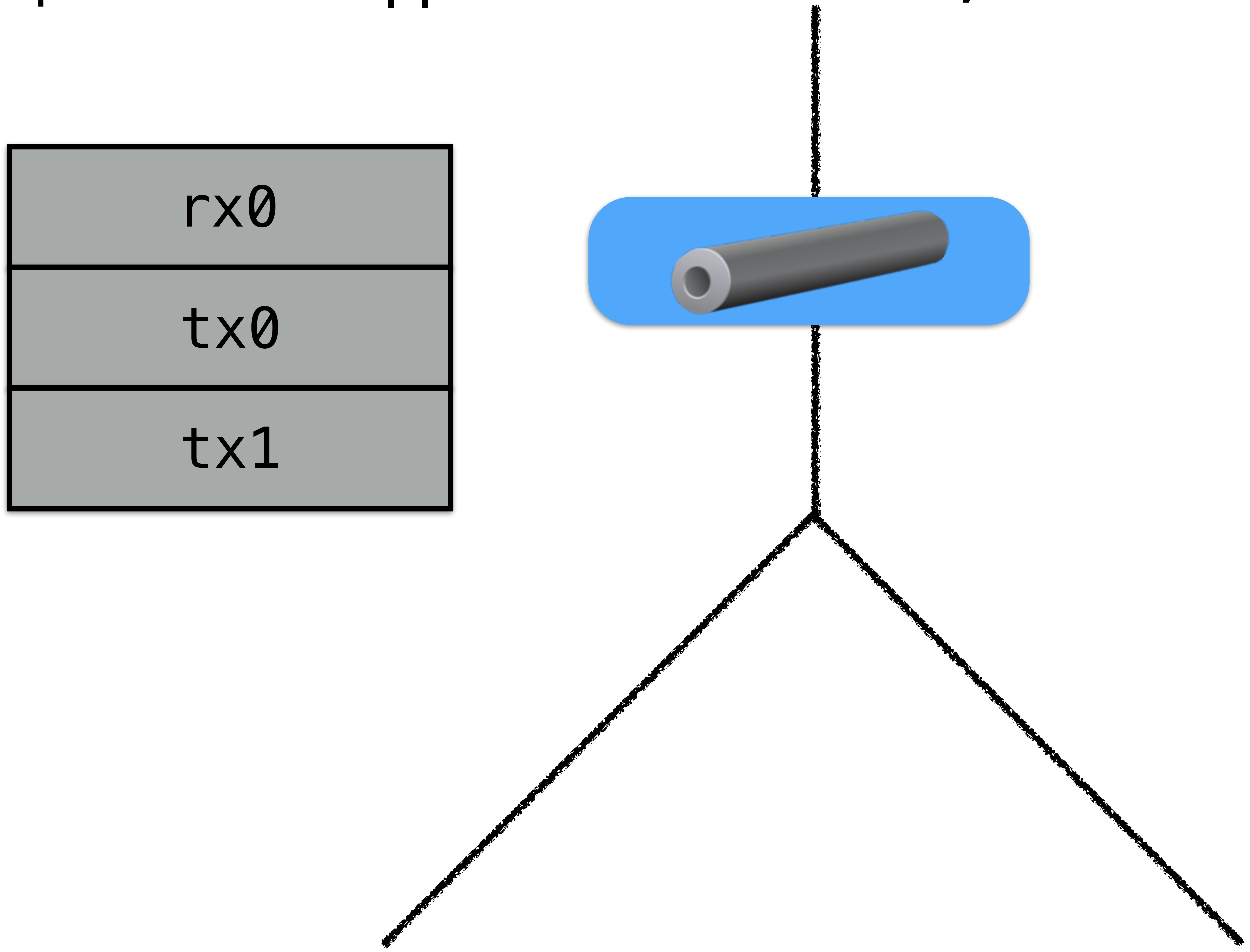

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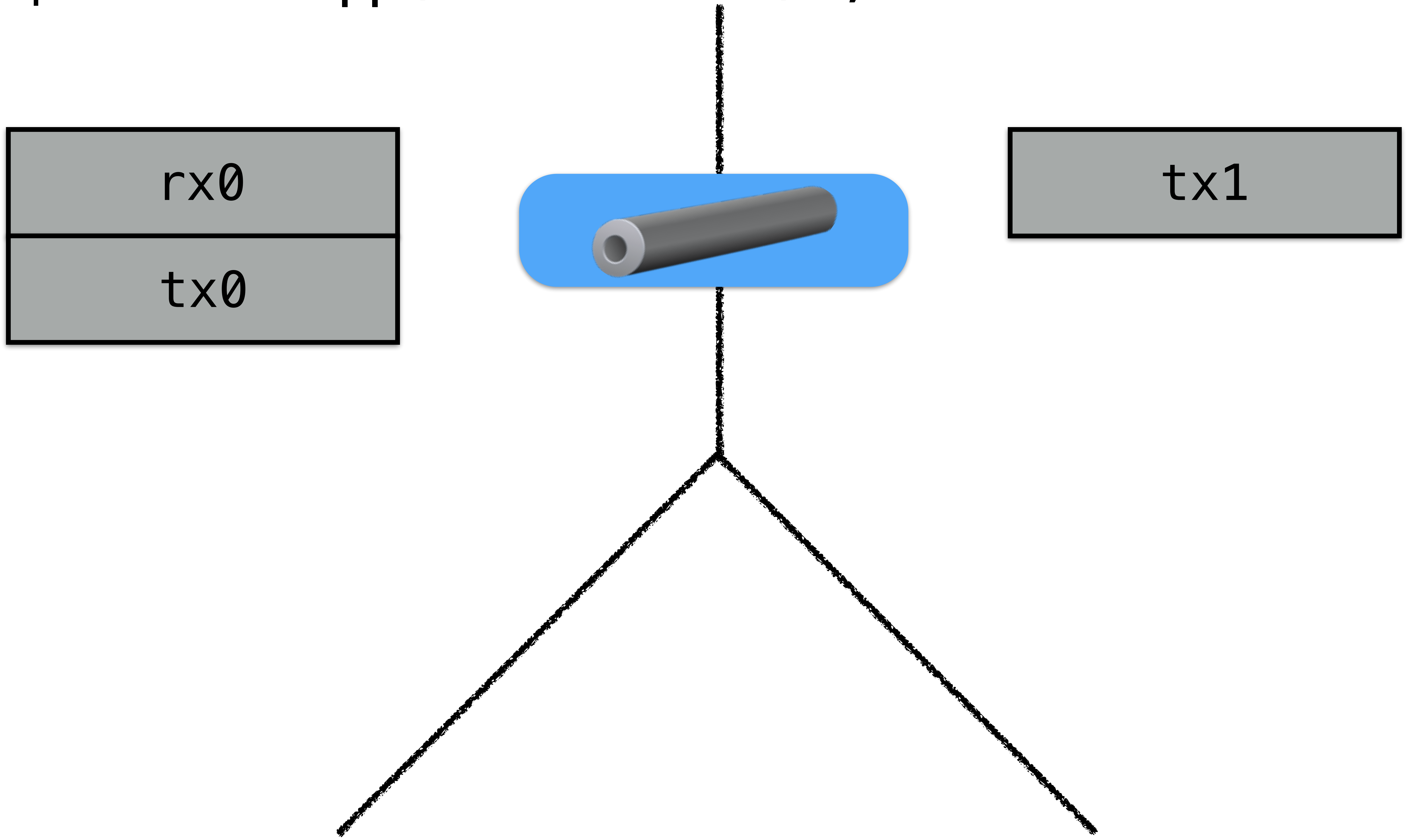

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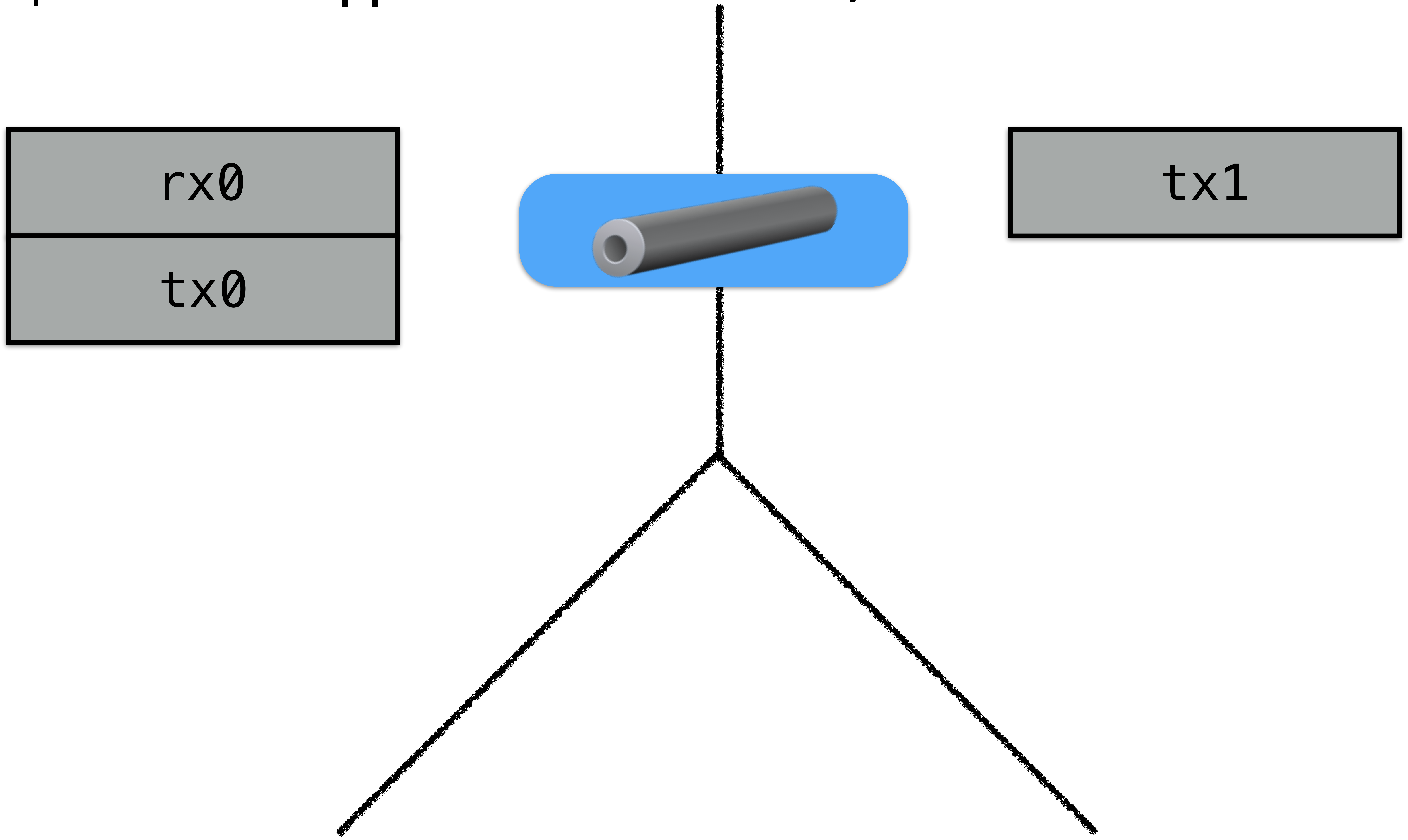

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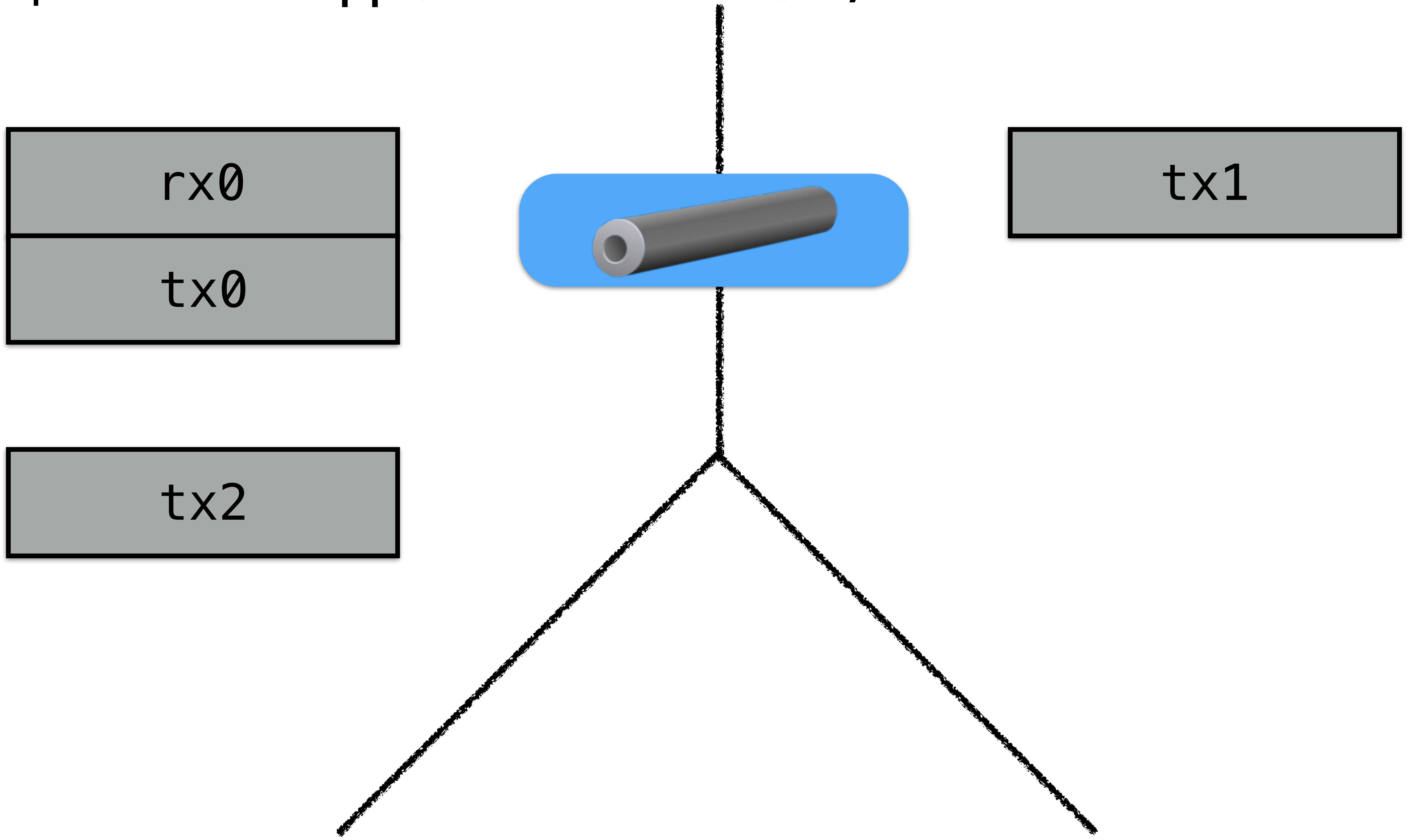

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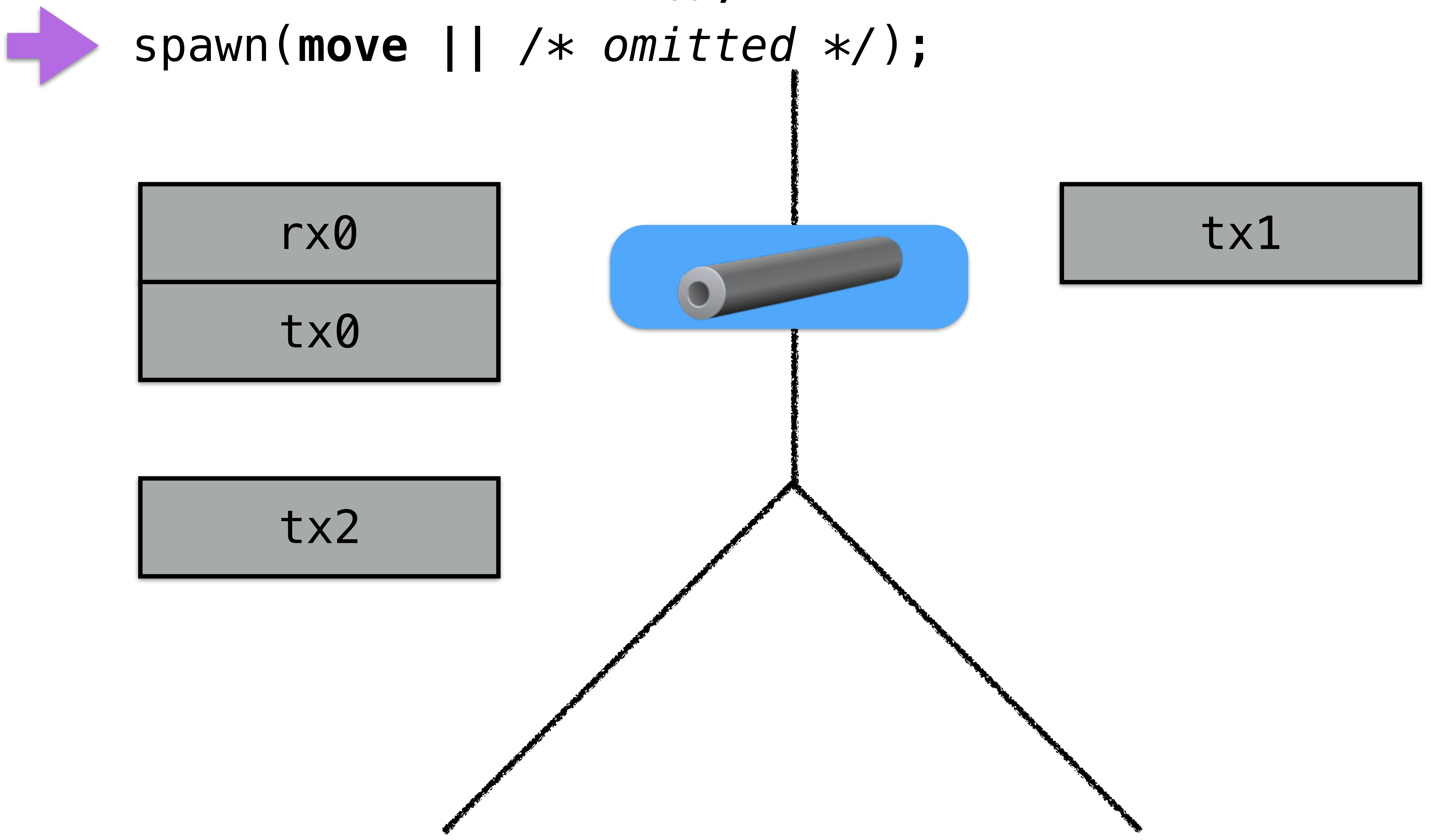

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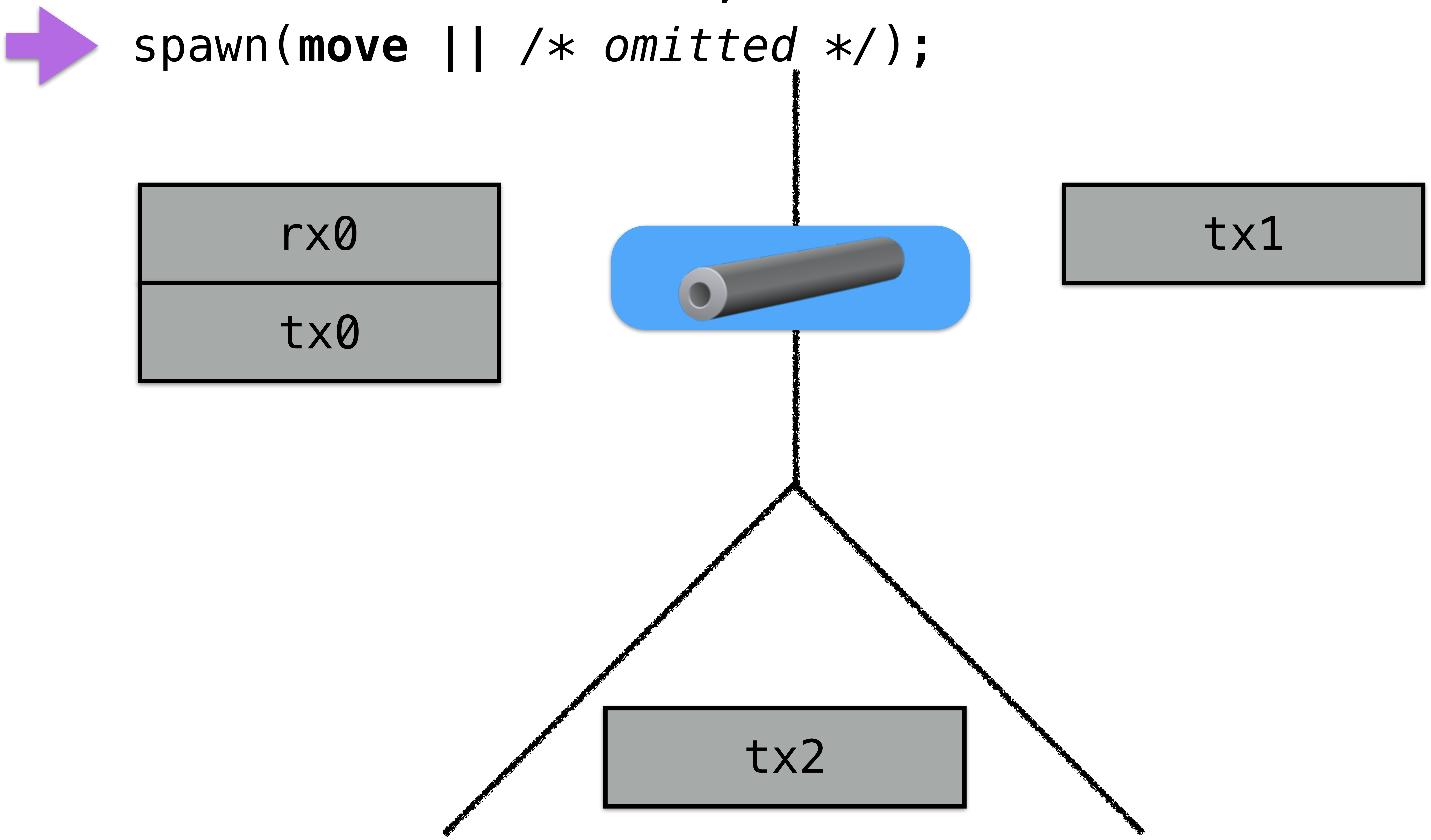

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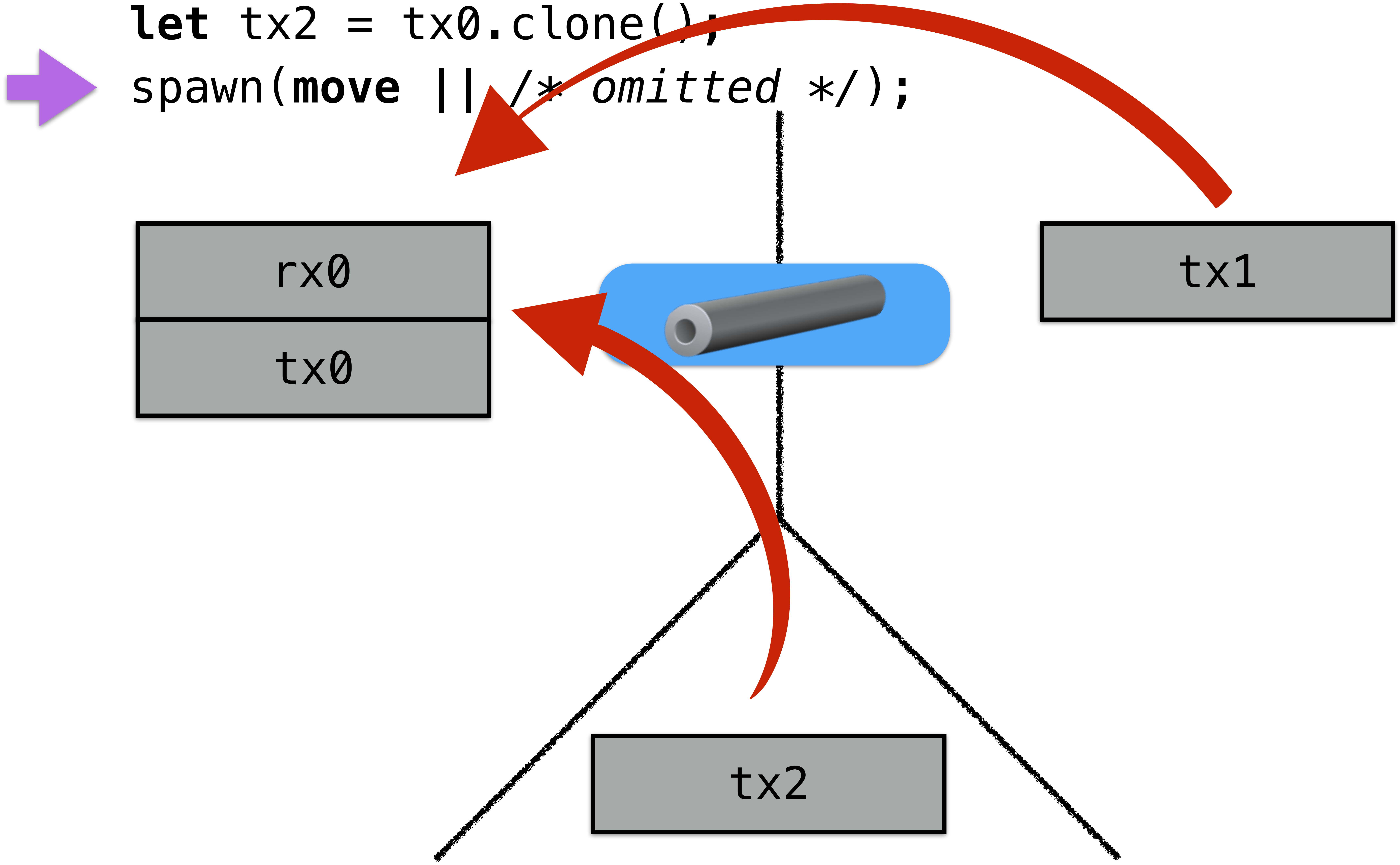

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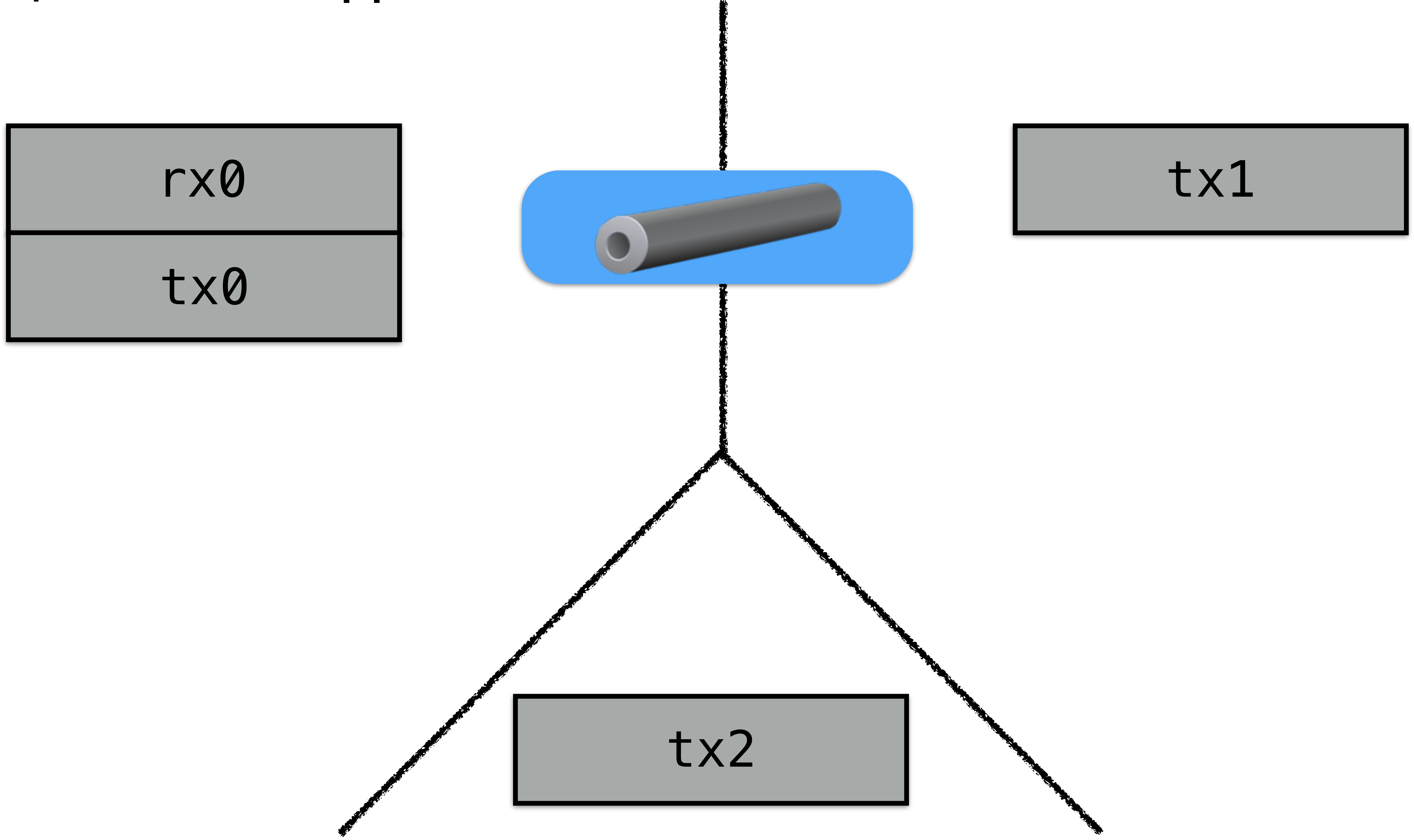

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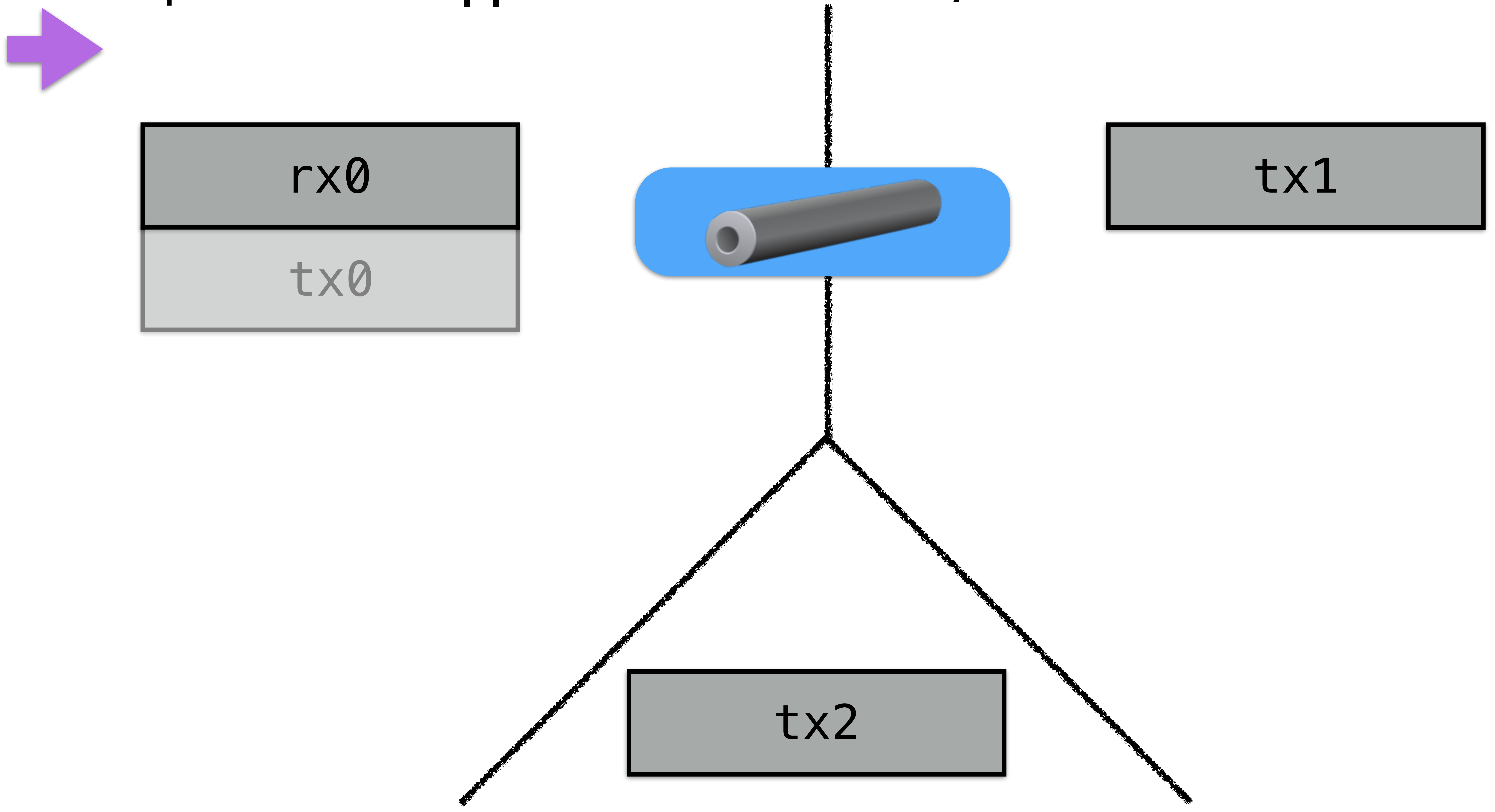

Locks

```rust
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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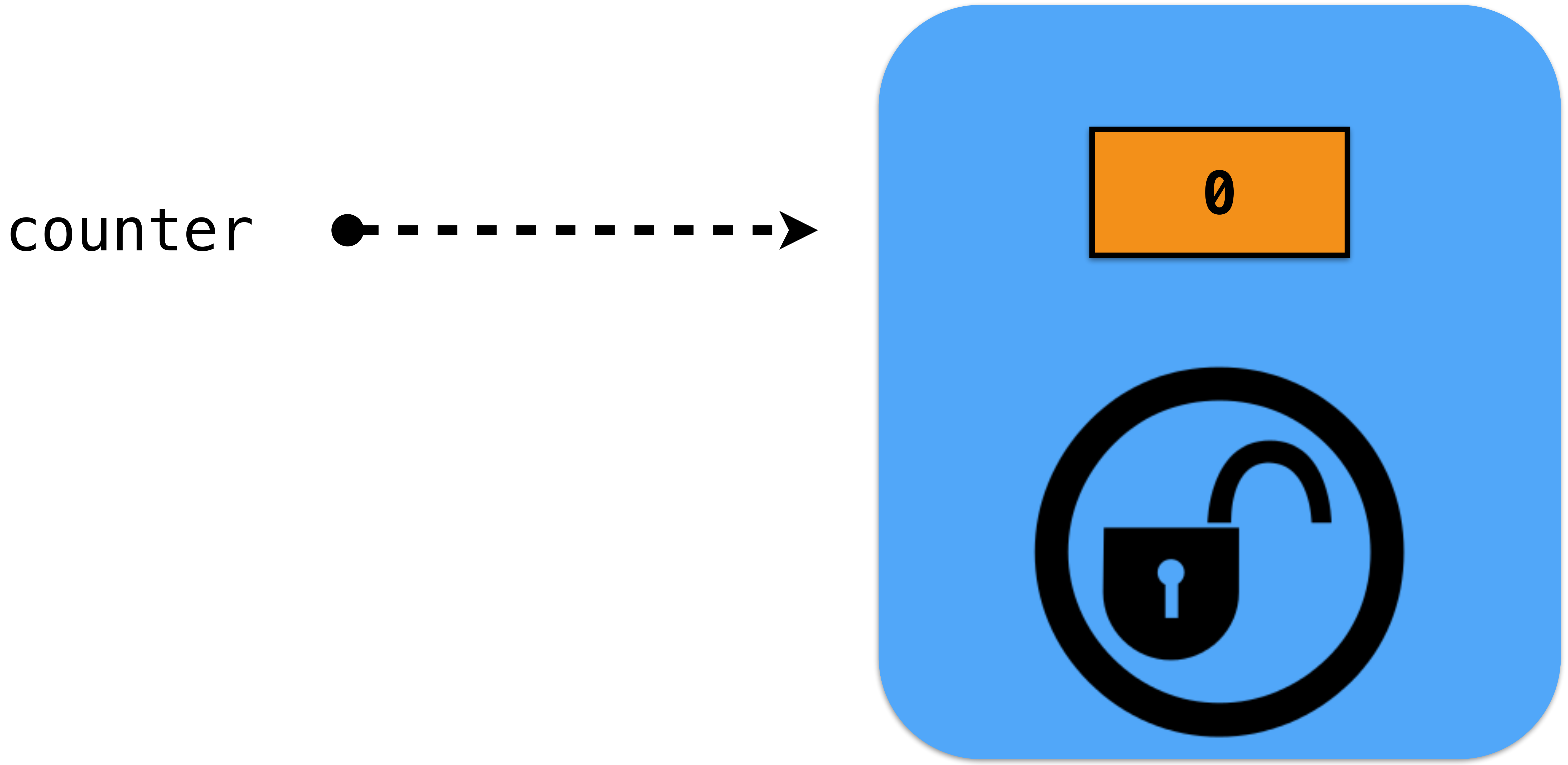

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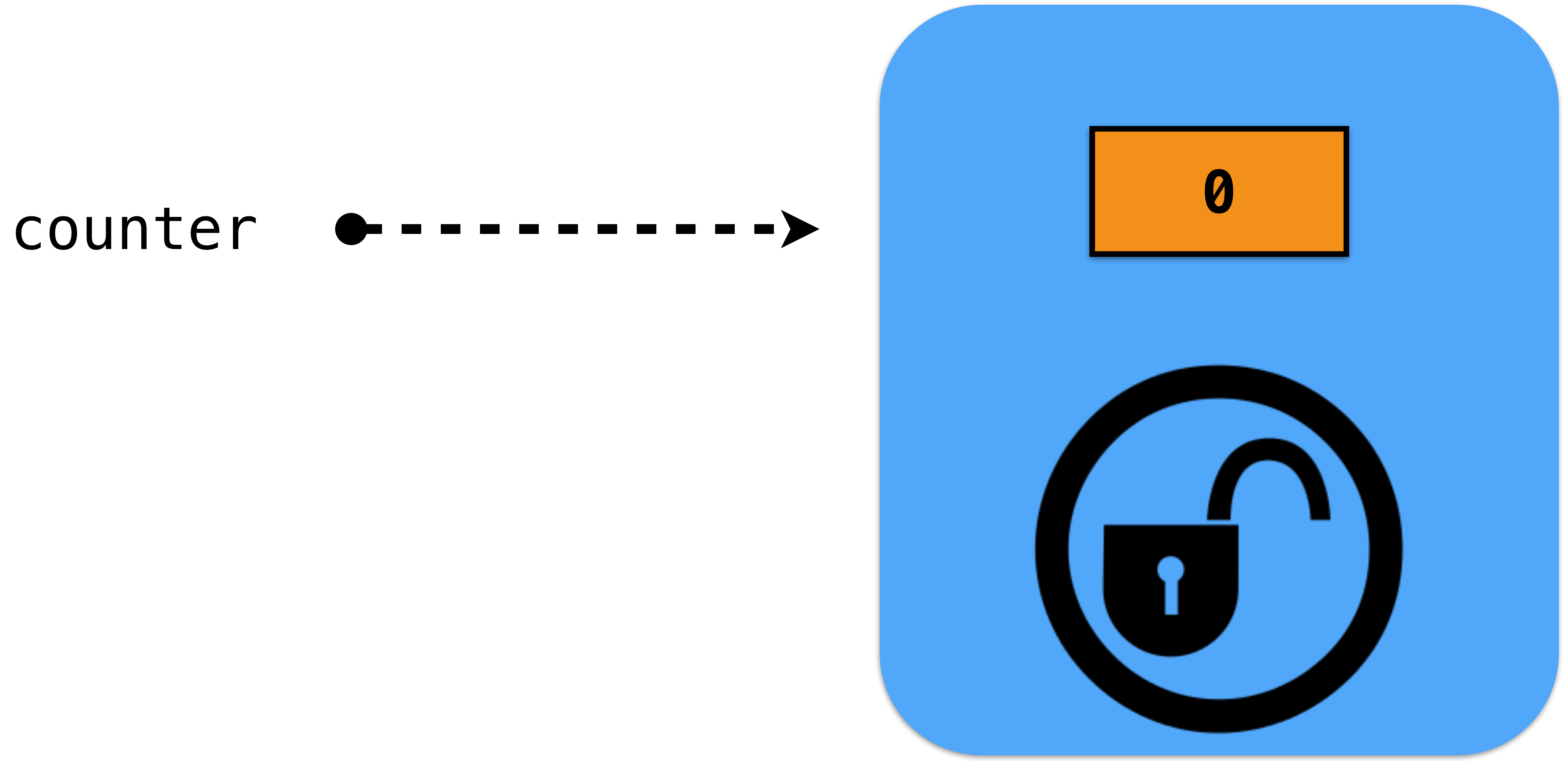

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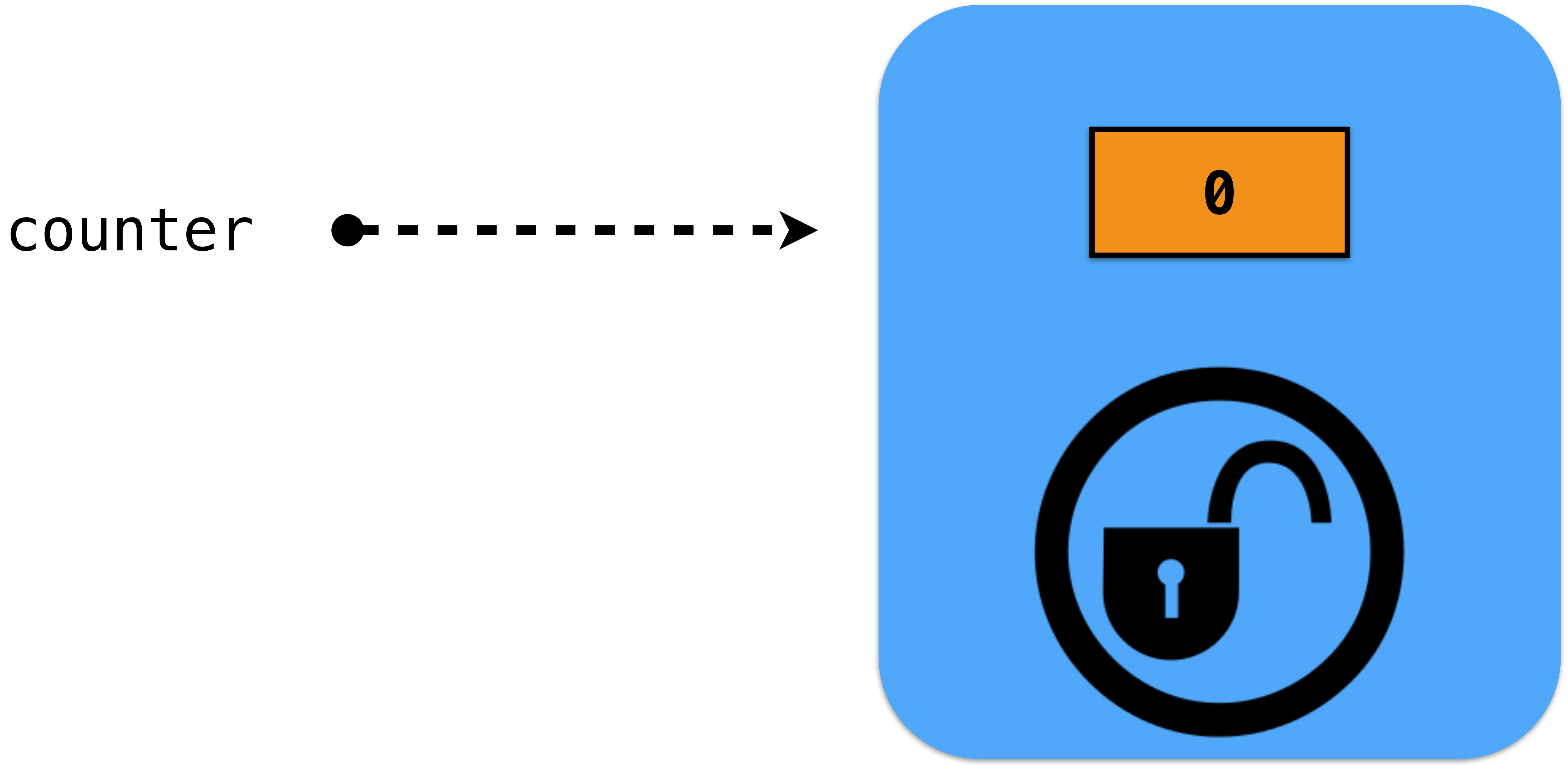

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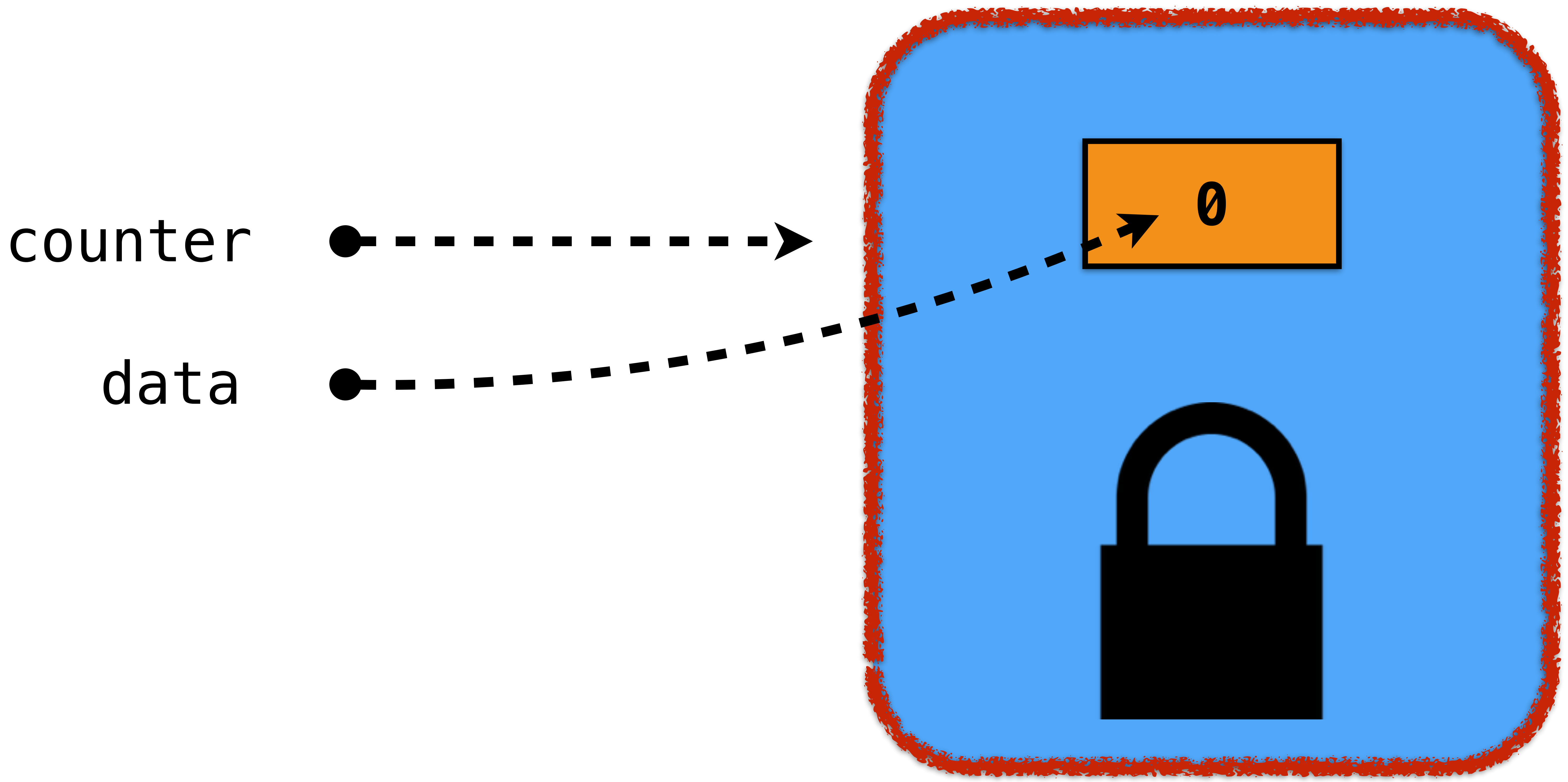

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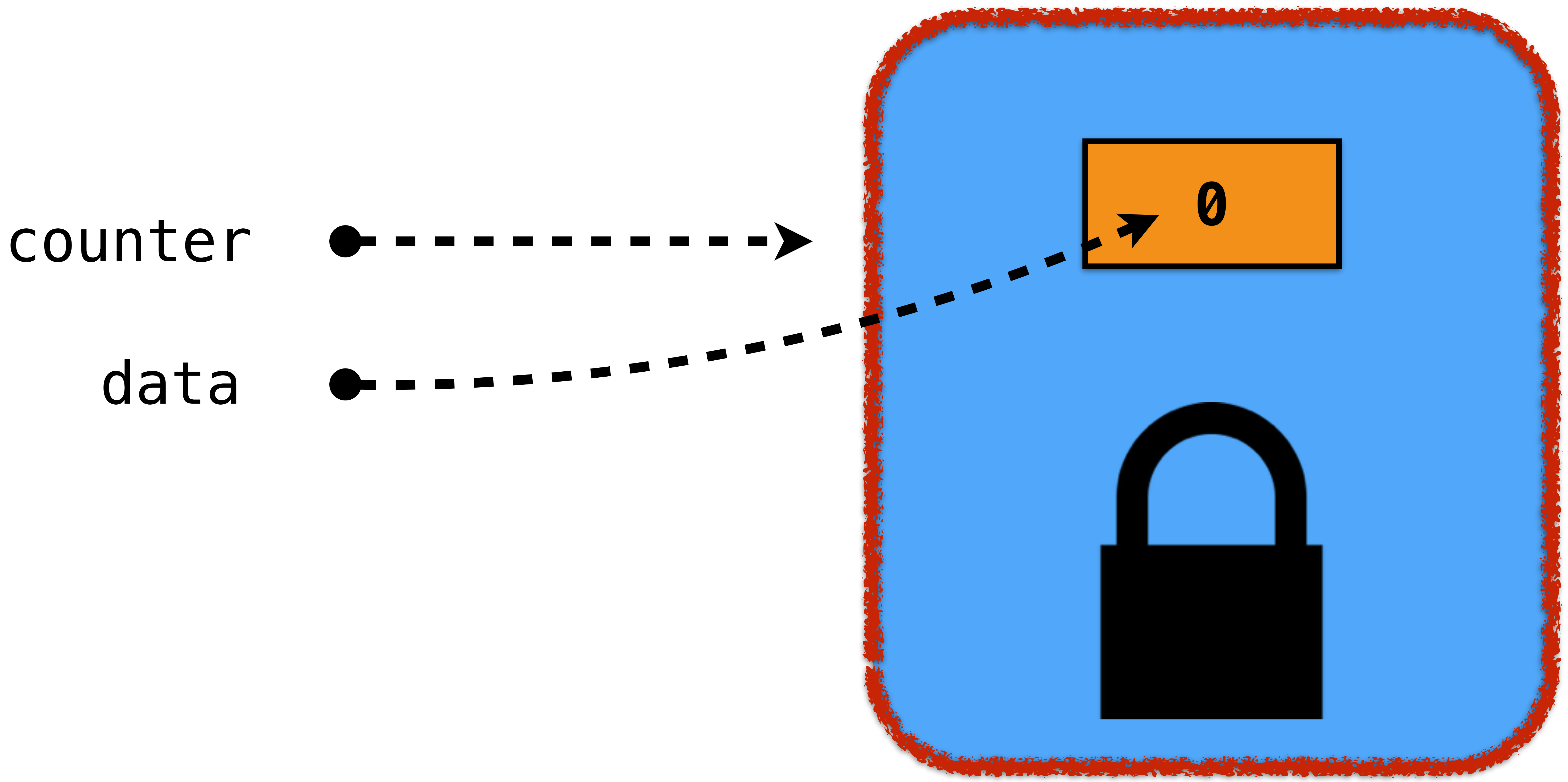

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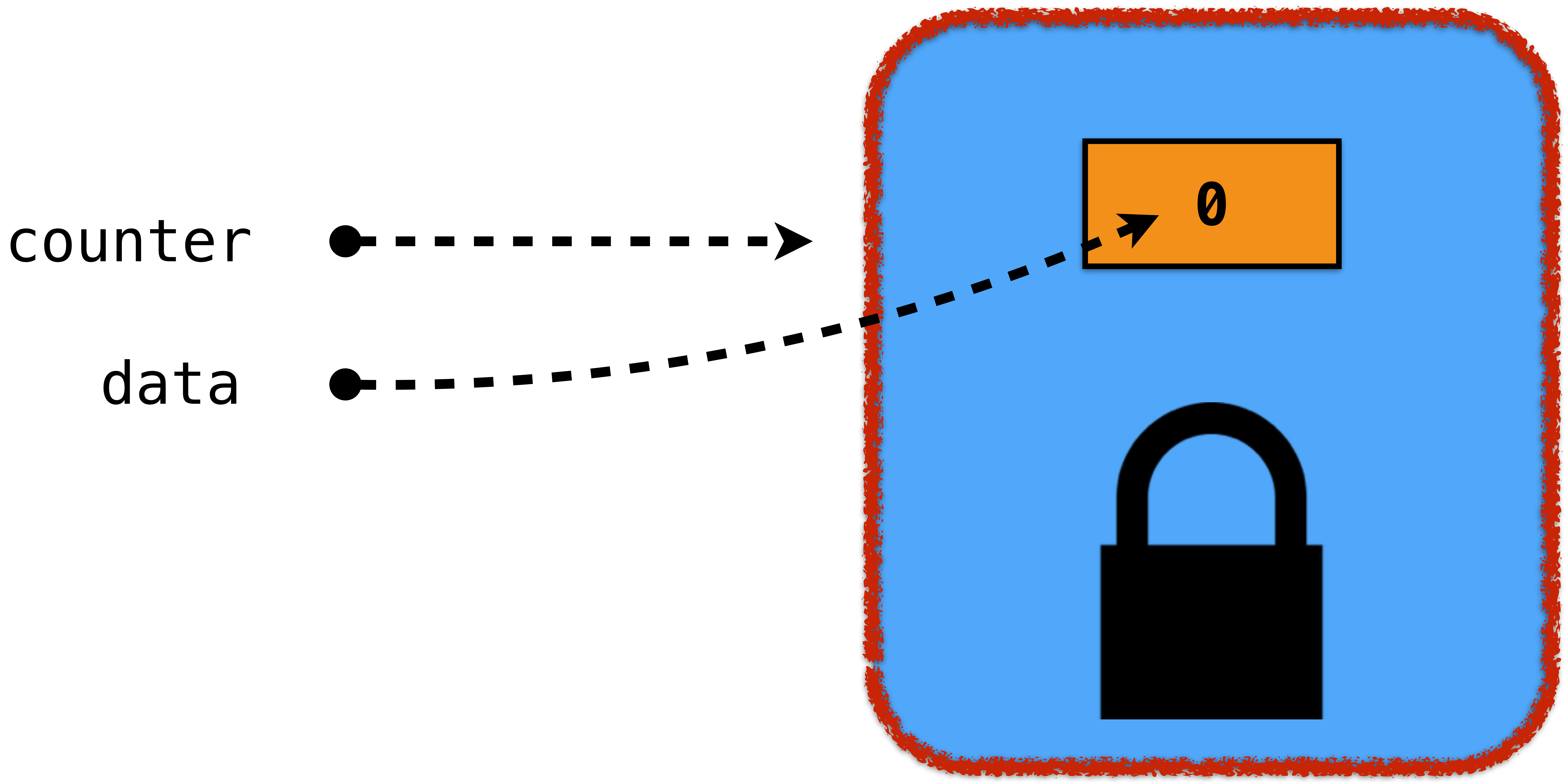

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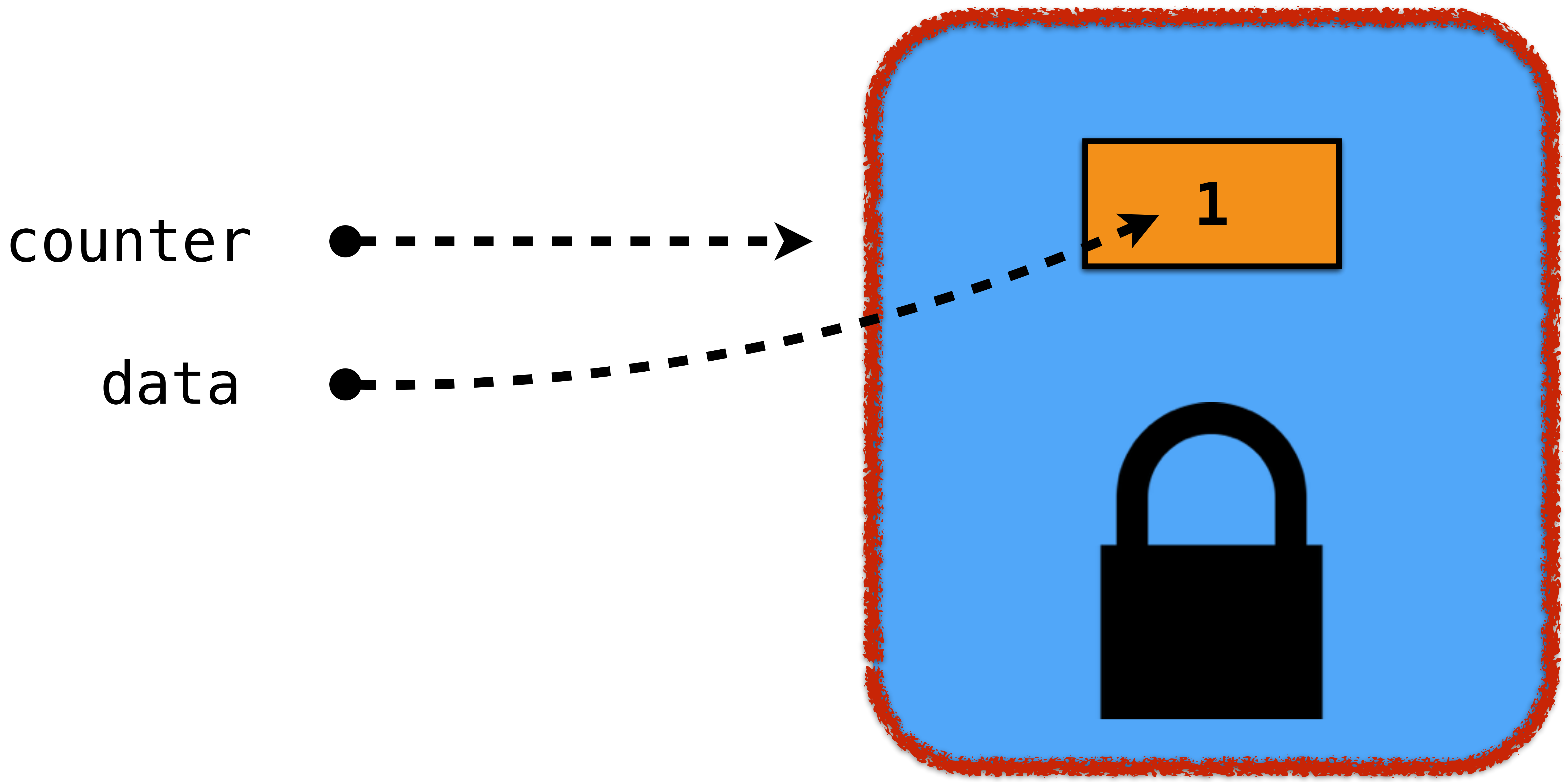

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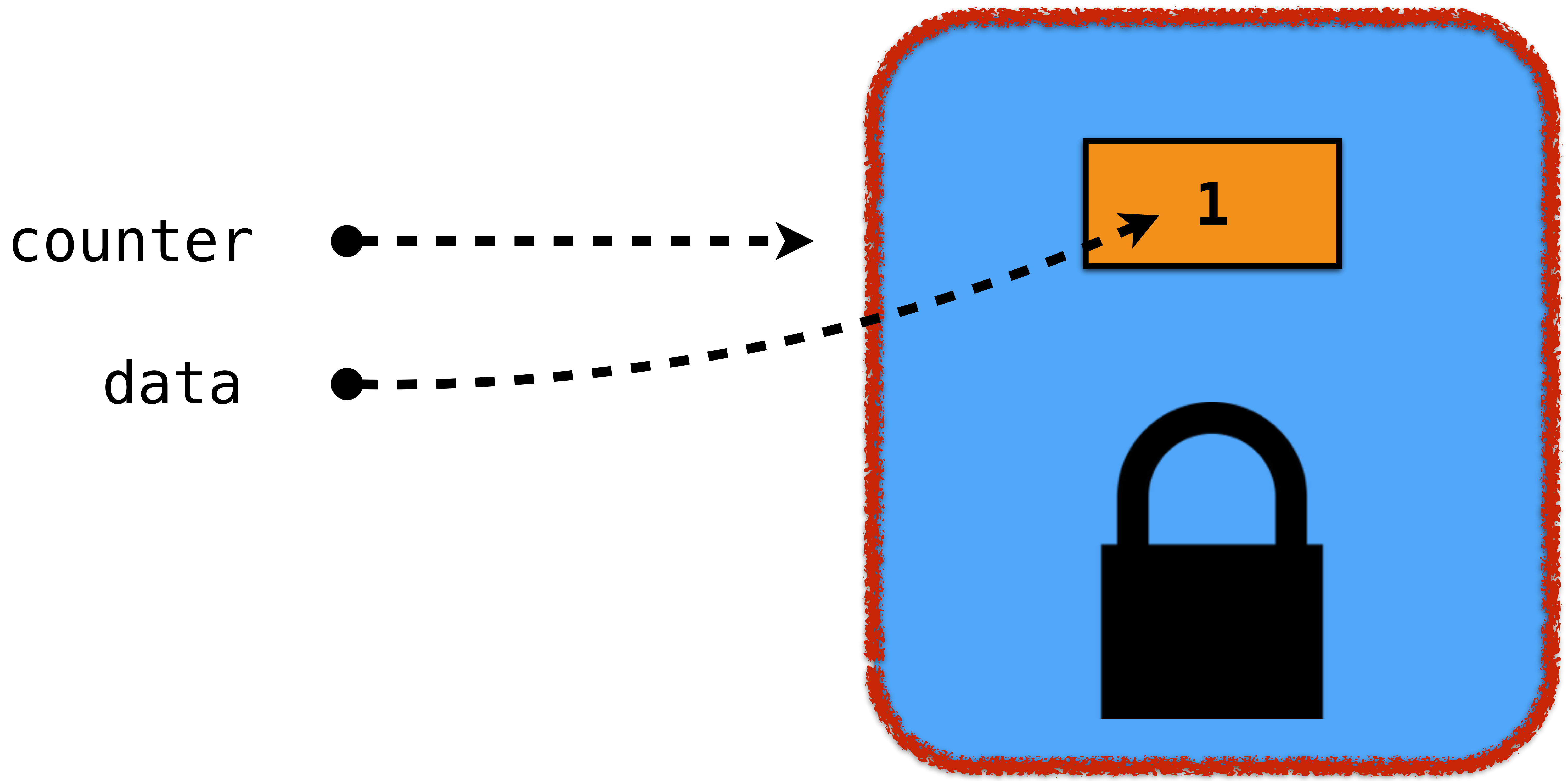

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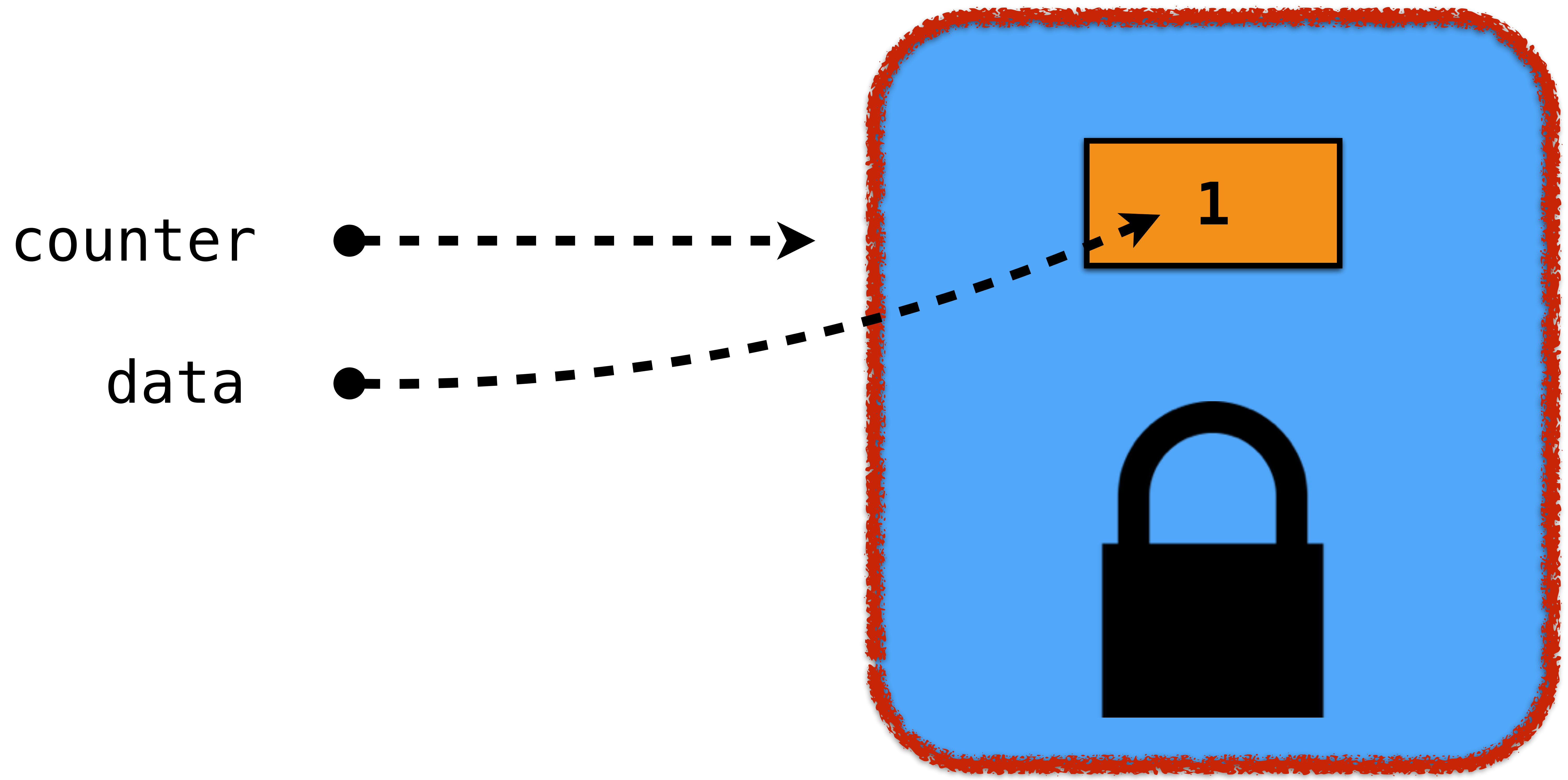

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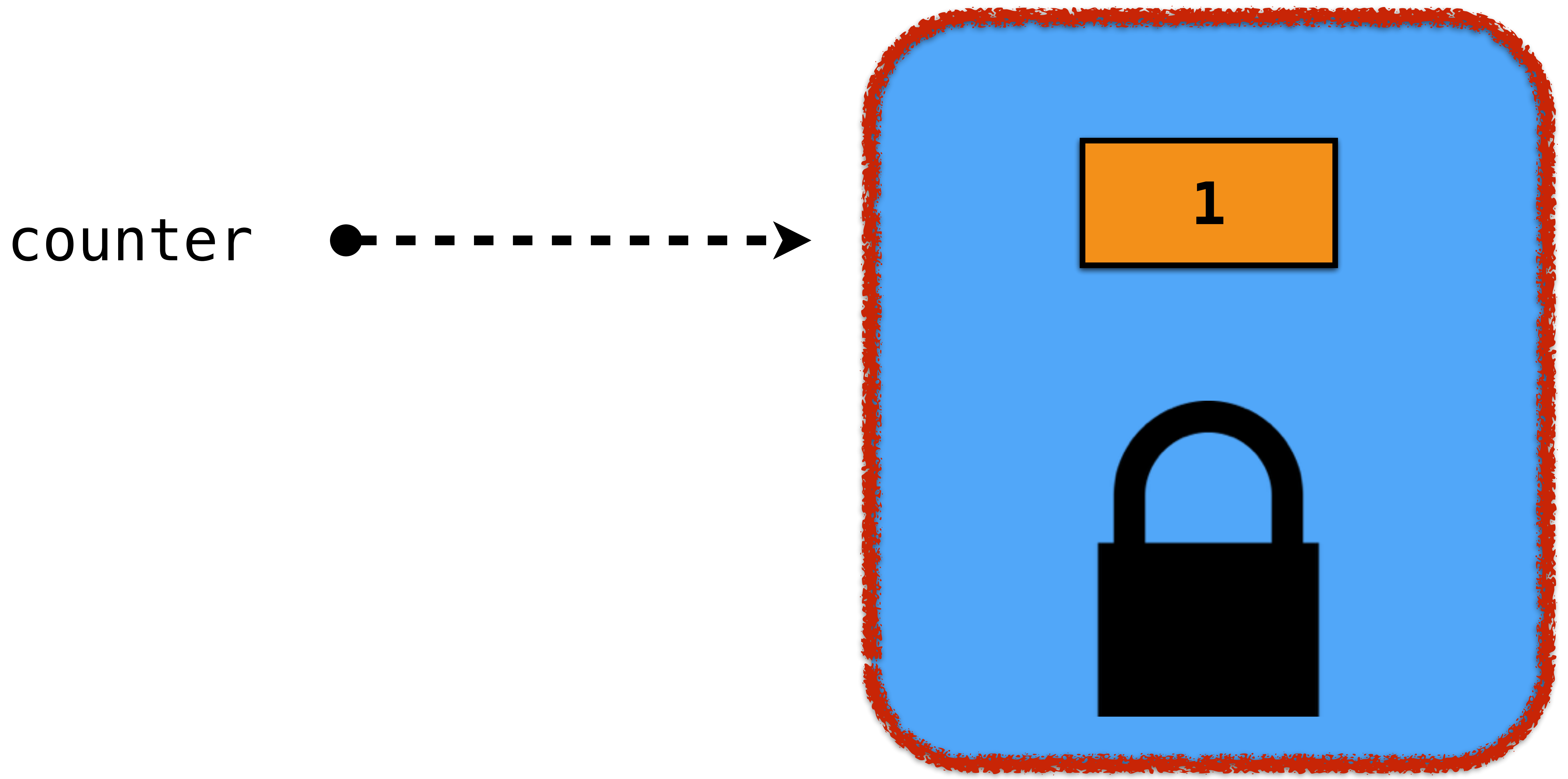

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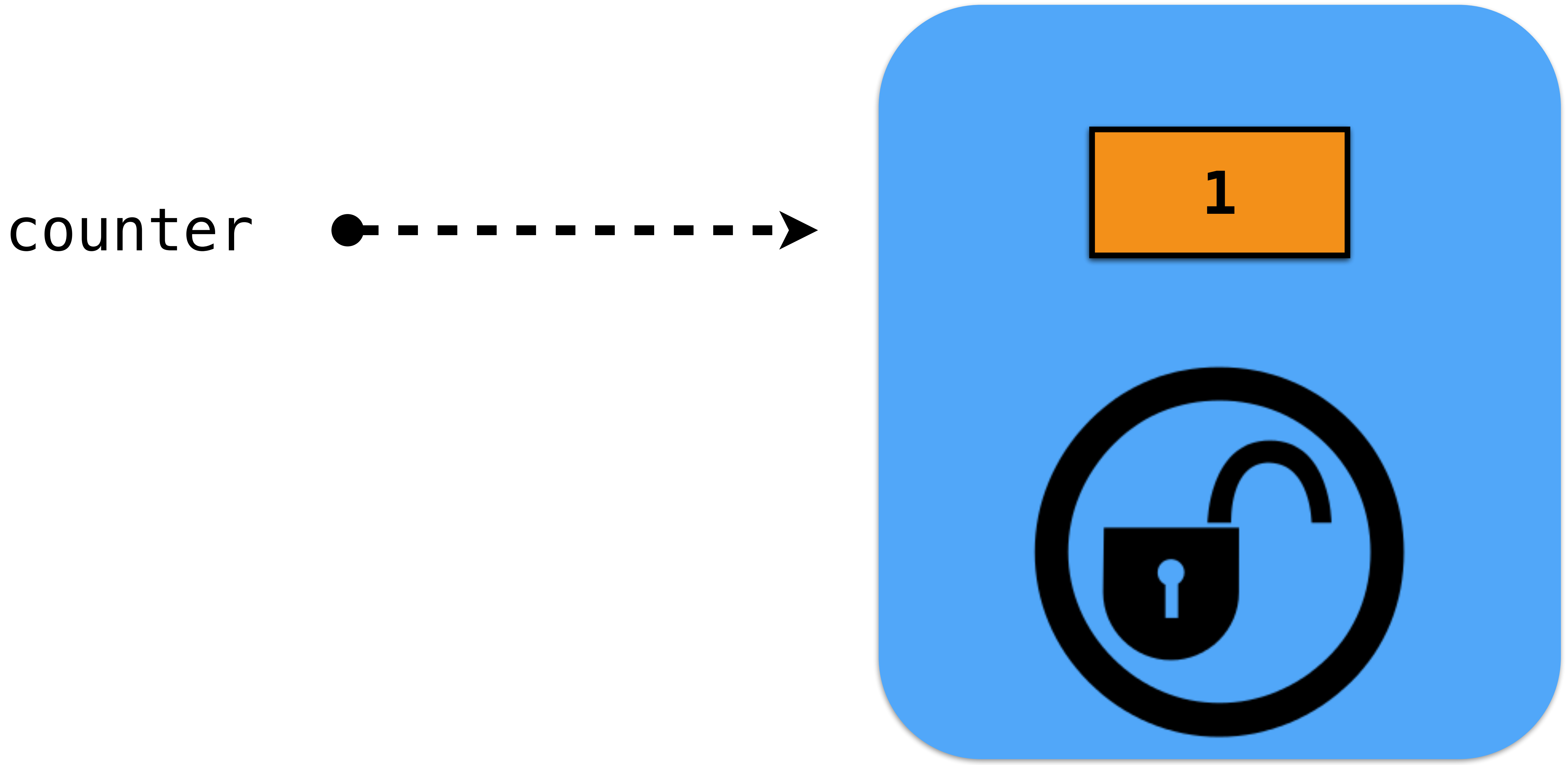

https://commons.wikimedia.org/wiki/File:No-DRM_lock.svg

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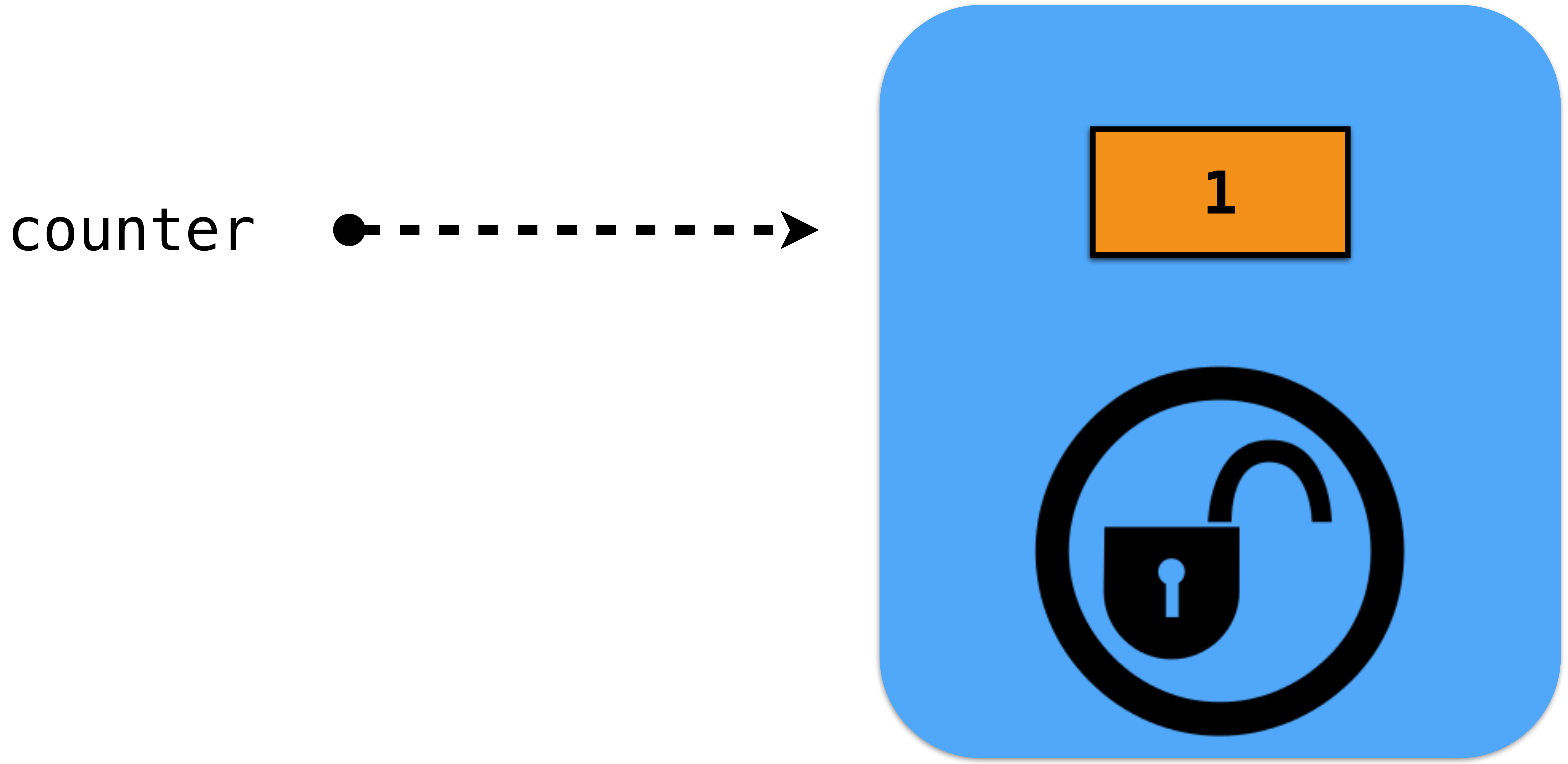
```



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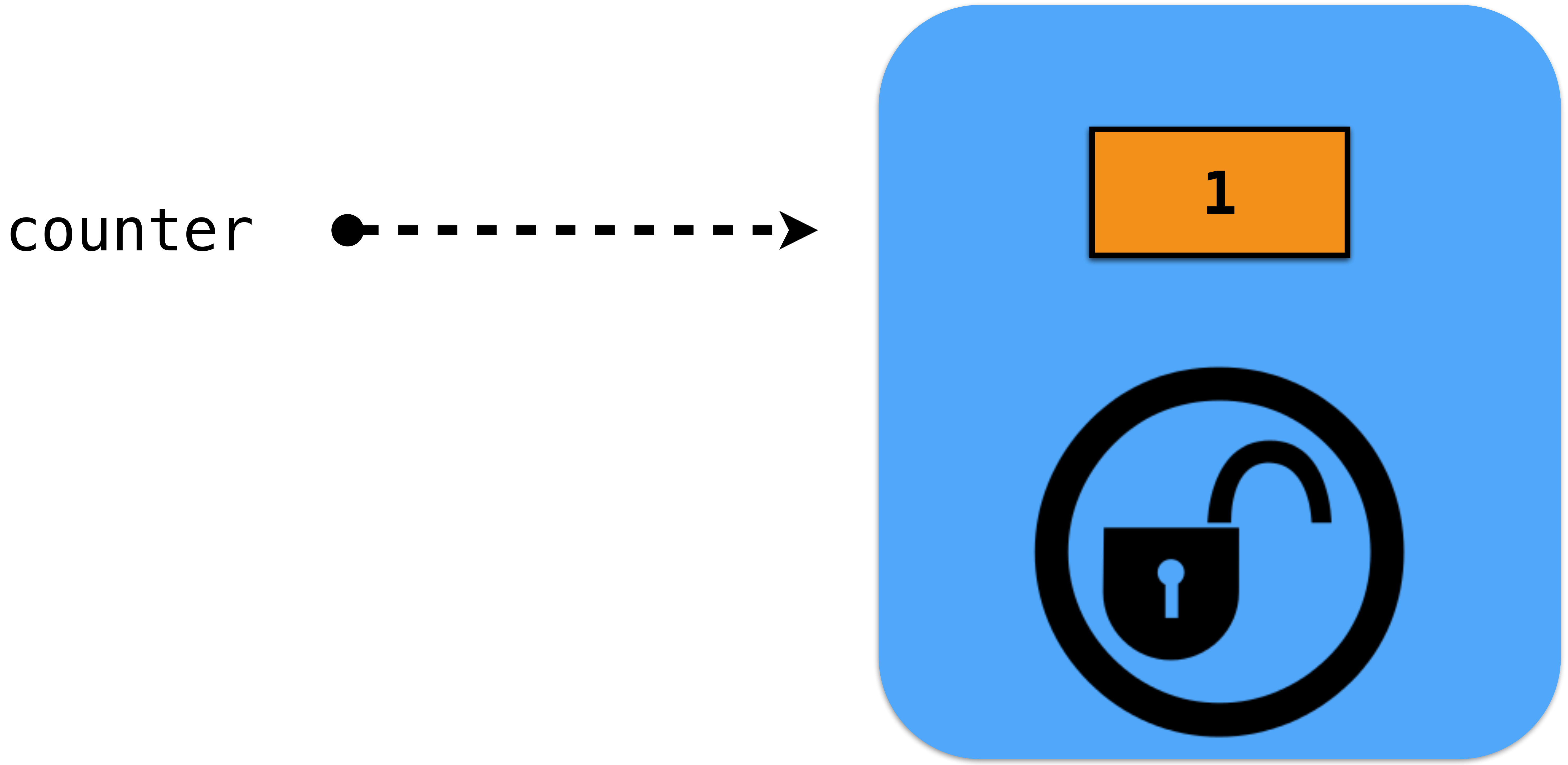

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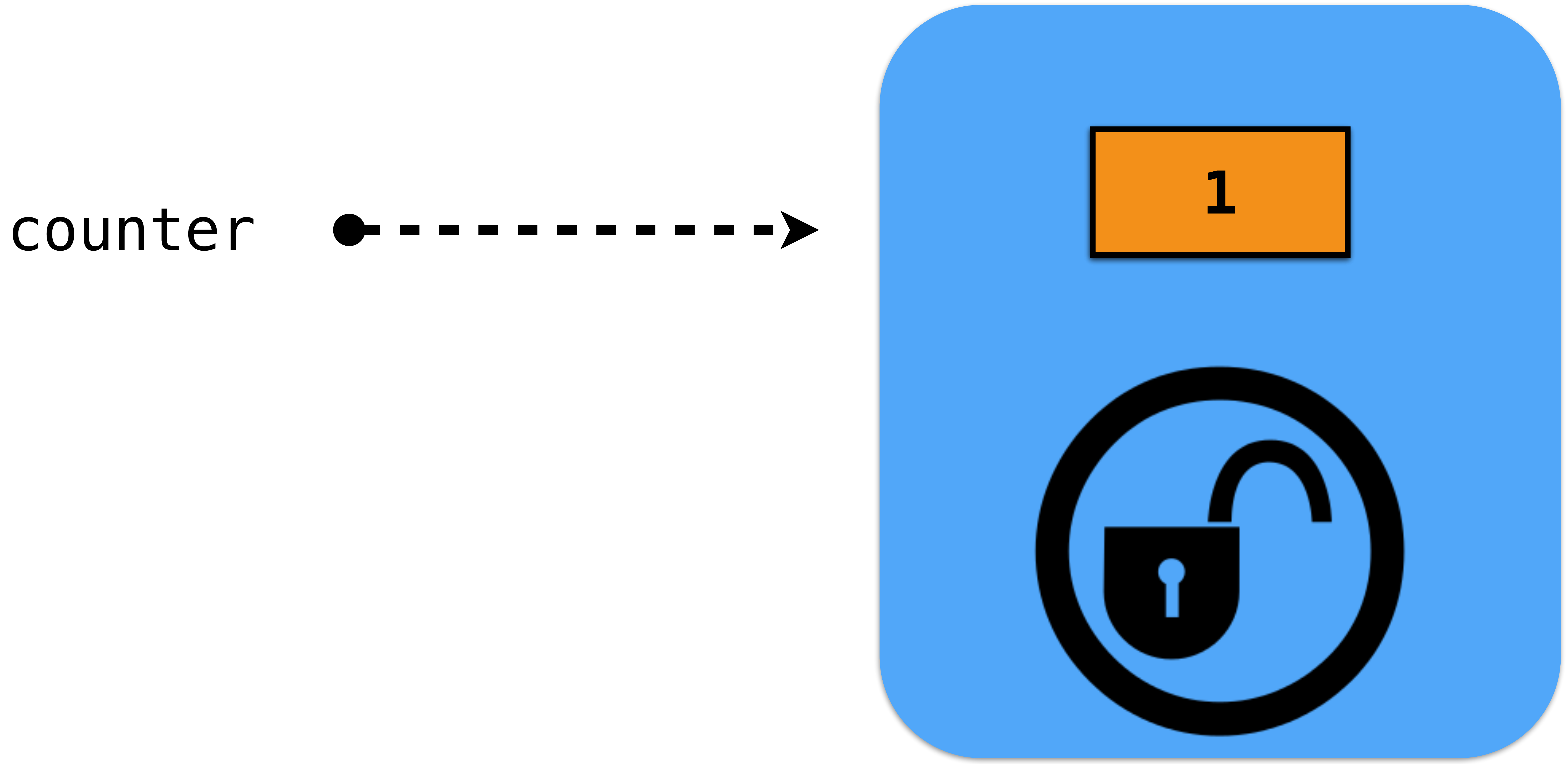

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Exercise: **threads**

http://www.rust-tutorials.com/RustConf17/

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!