robotlab scheduler short overview

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Example: cell painting a batch of two plates

Setup:

- Hotel with two racks
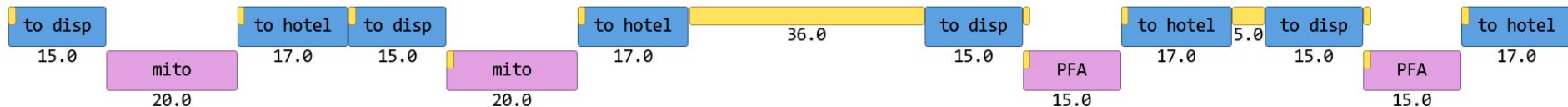- Liquid dispenser
- Robot arm

Simplifying assumptions:

- Only MitoTracker and PFA
- No priming
- No lids
- No incubator
- No washer
- MitoTracker active for only 2 minutes

Blue: robot arm
Purple: dispenser
Yellow: delays from waiting for checkpoints

```
batch [3:59.0]
incu [2:00.0, 2:00.0]
```

Protocol expressed in our Domain-Specific Language (DSL) embedded in Python.
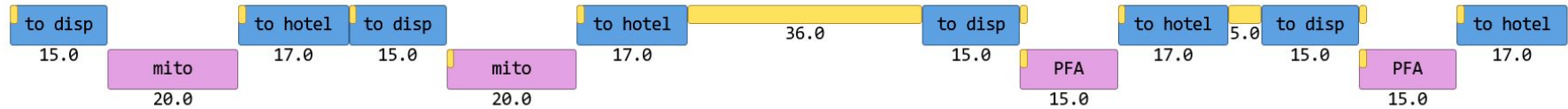
```
cmd ::= RunRobotarm(program_name)
      | RunDispenser(protocol_name)
      | Checkpoint(checkpoint_name)
      | WaitForCheckpoint(checkpoint_name, plus_seconds)
      | Fork(cmd)
      | Sequence(cmd, cmd)
```

Scheduling by translation to SMT (fragment: Quantifier-Free Linear Arithmetic).
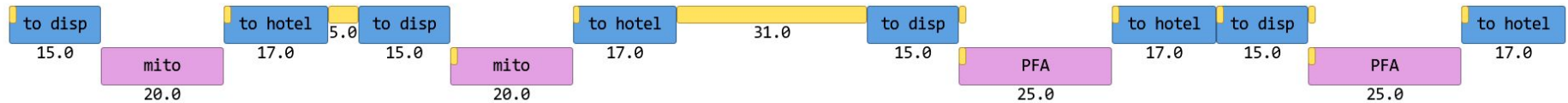
Example non-linearity

Case |PFA| < |Mito|:

```
batch [3:59.0]
incu [2:00.0, 2:00.0]
```


Case |PFA| > |Mito|:

```
batch [4:14.0]
incu [2:00.0, 2:00.0]
```


The delays have to be allocated differently depending on which case we are in.
Formally, this means that the optimization problem is not linear.

Expressing complex protocols

The commands in the DSL can express all of the cell painting protocol. We optimize for:

- minimize time with lid taken off
- maximize time inside incubator
- minimize time from washer to dispenser
- minimize total batch time
- subject to some incubation time like 20:00

Scheduling 14 plates takes about 5 seconds.

Four plates in the MitoTracker cycle of the cell painting protocol.
Green: incubator, Light blue: washer