Actions and Planning

- Agents reason in time
- Agents reason about time

Time passes as an agent acts and reasons.

Given a goal, it is useful for an agent to think about what it will do in the future to determine what it will do now.

Representing Time

Time can be modeled in a number of ways:

- **Discrete time** Time can be modeled as jumping from one time point to another.
- **Continuous time** You can model time as being dense.
- **Event-based time** Time steps don't have to be uniform; you can consider the time steps between interesting events.
- **State space** Instead of considering time explicitly, you can consider actions as mapping from one state to another.

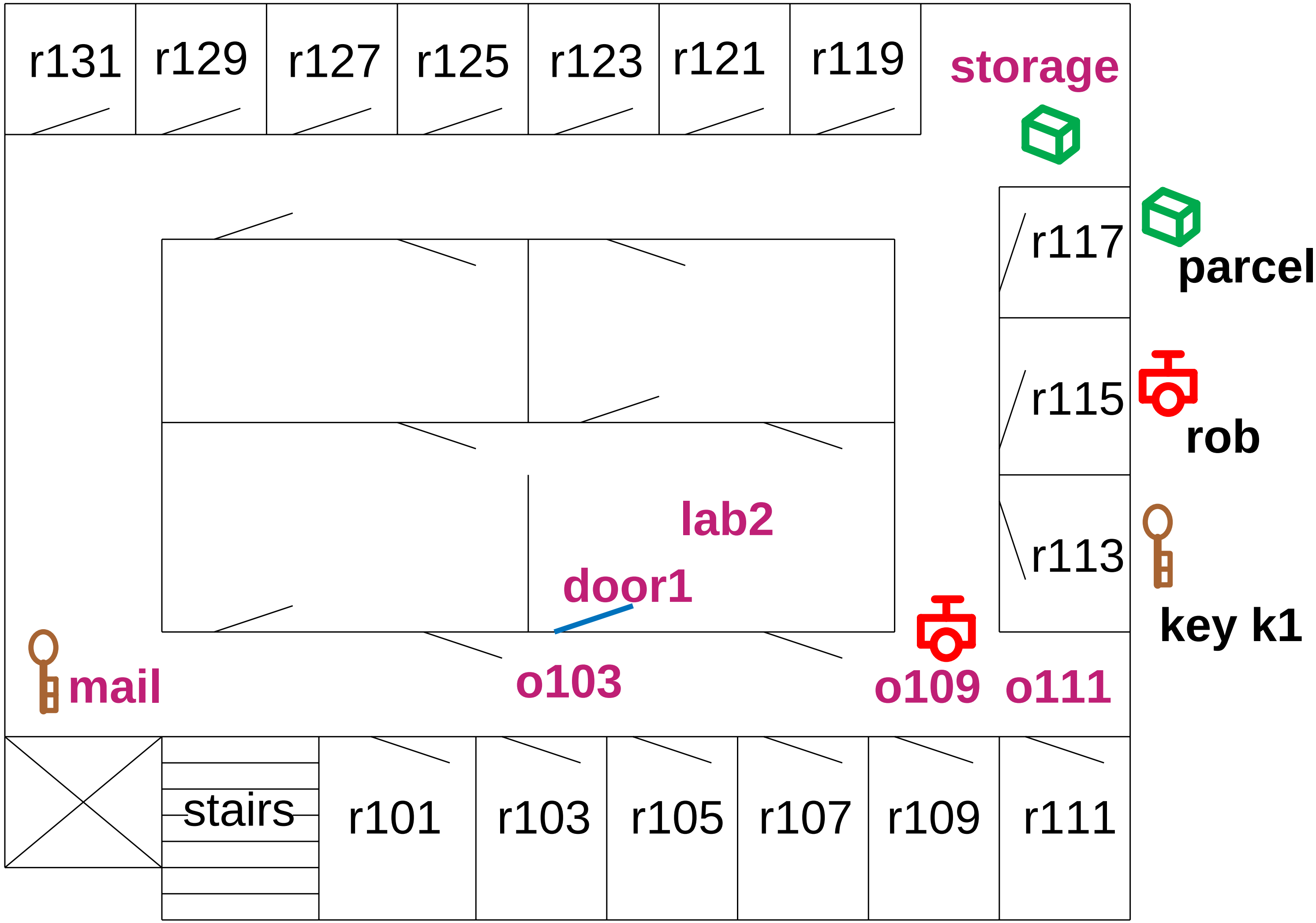
You can model time in terms of **points** or **intervals.**

Time and Relations

When modeling relations, you distinguish two basic types:

- **Static relations** are those relations whose value does not depend on time.
- **Dynamic relations** are relations whose truth values depends on time. Either
  - **derived relations** whose definition can be derived from other relations for each time,
  - **primitive relations** whose truth value can be determined by considering previous times.

The Delivery Robot World



Modeling the Delivery Robot World

Individuals: rooms, doors, keys, parcels, and the robot.

Actions:

- move from room to room
- pick up and put down keys and packages
- unlock doors (with the appropriate keys)

Relations: represent

- the robot's position
- the position of packages and keys and locked doors
- what the robot is holding

Example Relations

- *at*(*Obj*, *Loc*) is true in a situation if object *Obj* is at location *Loc* in the situation.

- *carrying*(*Ag*, *Obj*) is true in a situation if agent *Ag* is carrying *Obj* in that situation.

- *sitting_at*(*Obj*, *Loc*) is true in a situation if object *Obj* is sitting on the ground (not being carried) at location *Loc* in the situation.

- *unlocked*(*Door*) is true in a situation if door *Door* is unlocked in the situation.

- *autonomous*(*Ag*) is true if agent *Ag* can move autonomously. This is static.

- $opens(Key, Door)$ is true if key Key opens door $Door$. This is static.
- $adjacent(Pos_1, Pos_2)$ is true if position Pos_1 is adjacent to position Pos_2 so that the robot can move from Pos_1 to Pos_2 in one step.
- $between(Door, Pos_1, Pos_2)$ is true if $Door$ is between position Pos_1 and position Pos_2. If the door is unlocked, the two positions are adjacent.

Actions

- *move(Ag, From, To):* agent *Ag* moves from location *From* to adjacent location *To*. The agent must be sitting at location *From*.
- *pickup(Ag, Obj)* agent *Ag* picks up *Obj*. The agent must be at the location that *Obj* is sitting.
- *putdown(Ag, Obj)* the agent *Ag* puts down *Obj*. It must be holding *Obj*.
- *unlock(Ag, Door)* agent *Ag* unlocks *Door*. It must be outside the door and carrying the key to the door.

Initial Situation

$sitting\_at(rob, o109).$

$sitting\_at(parcel, storage).$

$sitting\_at(k1, mail).$

Static Facts

$between(door1, o103, lab2).$

$opens(k1, door1).$

$autonomous(rob).$

Derived Relations

$$at(Obj, Pos) \leftarrow sitting\_at(Obj, Pos).$$

$$at(Obj, Pos) \leftarrow carrying(Ag, Obj) \wedge at(Ag, Pos).$$

$$adjacent(o109, o103).$$

$$adjacent(o103, o109).$$

$$\ldots$$

$$adjacent(lab2, o109).$$

$$adjacent(P_1, P_2) \leftarrow$$

$$between(Door, P_1, P_2) \wedge$$

$$unlocked(Door).$$