

At the end of the class you should be able to:

- explain the model of deterministic planning
- represent a problem using the STRIPs representation of actions.

# State-space Search

- **deterministic** or stochastic dynamics
- **fully observable** or partially observable
- **explicit states** or features or individuals and relations
- static or finite stage or **indefinite stage** or infinite stage
- **goals** or complex preferences
- **perfect rationality** or bounded rationality
- **flat** or modular or hierarchical
- **single agent** or multiple agents
- **knowledge is given** or knowledge is learned
- **reason offline** or reason while interacting with environment

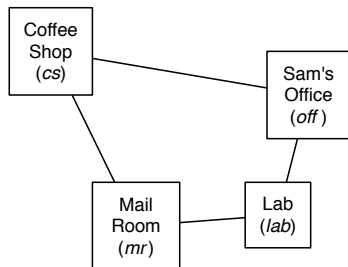
# Classical Planning

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- Planning is deciding what to do based on an agent's ability, its goals, and the state of the world.
- Initial assumptions:
  - ▶ The world is deterministic. There are no exogenous events outside of the control of the robot that change the state of the world.
  - ▶ The agent knows what state it is in. (Fully observable)
  - ▶ Time progresses discretely from one state to the next.
  - ▶ Goals are predicates of states that need to be achieved.
- Planning is finding a sequence of actions to solve a goal.

- A deterministic **action** is a partial function from states to states.
- The **preconditions** of an action specify when the action can be carried out.
- The **effect** of an action specifies the resulting state.

# Delivery Robot Example



## Features:

*RLoc* – Rob's location

*RHC* – Rob has coffee

*SWC* – Sam wants coffee

*MW* – Mail is waiting

*RHM* – Rob has mail

## Actions:

*mc* – move clockwise

*mcc* – move counterclockwise

*puc* – pickup coffee

*dc* – deliver coffee

*pum* – pickup mail

*dm* – deliver mail

# Explicit State-space Representation

State	Action	Resulting State
$\langle lab, \neg rhc, swc, \neg mw, rhm \rangle$	$mc$	$\langle mr, \neg rhc, swc, \neg mw, rhm \rangle$
$\langle lab, \neg rhc, swc, \neg mw, rhm \rangle$	$mcc$	$\langle off, \neg rhc, swc, \neg mw, rhm \rangle$
$\langle off, \neg rhc, swc, \neg mw, rhm \rangle$	$dm$	$\langle off, \neg rhc, swc, \neg mw, \neg rhm \rangle$
$\langle off, \neg rhc, swc, \neg mw, rhm \rangle$	$mcc$	$\langle cs, \neg rhc, swc, \neg mw, rhm \rangle$
$\langle off, \neg rhc, swc, \neg mw, rhm \rangle$	$mc$	$\langle lab, \neg rhc, swc, \neg mw, rhm \rangle$
...	...	...

What happens when we also want to model its battery charge?

Want “elaboration tolerance”.

# STRIPS Representation

The state is a function from features into values. So it can be represented as a set of feature-value pairs.

For each action:

- **precondition** a set of feature-value pairs that must be true for the action to be carried out.
- **effect** a set of a feature-value pairs that are made true by this action.

STRIPS assumption: every feature not mentioned in the effect is unaffected by the action.



# Example STRIPS representation

Pick-up coffee (*puc*):

- **precondition:**  $\{RLoc = cs, RHC = False\}$ . “The robot needs to be at the coffee shop and not holding coffee in order to pick up coffee.”
- **effect:**  $\{RHC = True\}$ . “After the robot picks up coffee, it is holding coffee. Nothing else has changed.”

Deliver coffee (*dc*):

- **precondition:**  $\{Rloc = off, RHC = True\}$  “The robot needs to be at the office and holding coffee in order to deliver coffee.”
- **effect:**  $\{RHC = False, SWC = False\}$  “After the robot delivers coffee, it is not holding coffee, and Sam no longer wants coffee. Nothing else has changed.”

Given:

- A description of the effects and preconditions of the actions
- A description of the initial state
- A goal to achieve

find a sequence of actions that is possible and will result in a state satisfying the goal.

