# Regression Planning

Idea: search backwards from the goal description: nodes correspond to subgoals, and arcs to actions.

- Nodes are propositions: a formula made up of assignments of values to features
- Arcs correspond to actions that can achieve one of the goals
- Neighbors of a node N associated with arc A specify what must be true immediately before A so that N is true immediately after.
- The start node is the goal to be achieved.
- goal(N) is true if N is a proposition that is true of the initial state.



## Defining nodes and arcs

 A node N can be represented as a set of assignments of values to variables:

$$[X_1 = v_1, \dots, X_n = v_n]$$

This is a set of assignments you want to hold.

- The last action is one that achieves one of the  $X_i = v_i$ , and does not achieve  $X_j = v'_j$  where  $v'_j$  is different to  $v_j$ .
- The neighbor of *N* along arc *A* must contain:
  - ► The prerequisites of action A
  - All of the elements of N that were not achieved by A

N must be consistent.



# Formalizing arcs using STRIPS notation

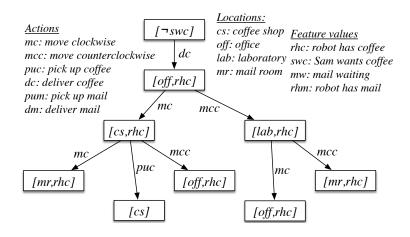
$$\langle G, A, N \rangle$$

where G is  $[X_1 = v_1, \dots, X_n = v_n]$  is an arc if

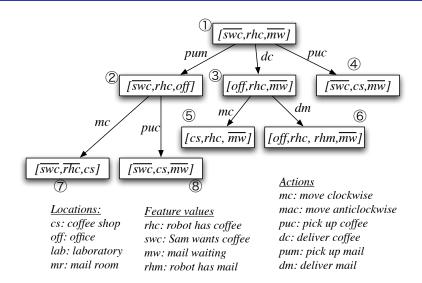
- $\exists i \ X_i = v_i$  is on the effects list of action A
- $\forall j \ X_j = v'_j$  is not on the effects list for A, where  $v'_j \neq v_j$
- *N* is  $preconditions(A) \cup \{X_k = v_k : X_k = v_k \notin effects(A)\}$  and *N* is consistent in that it does not assign different values to any variable.



### Regression example



#### Find the errors



# Loop detection and multiple-path pruning

- Goal  $G_1$  is simpler than goal  $G_2$  if  $G_1$  is a subset of  $G_2$ .
  - ▶ It is easier to solve [cs] than [cs, rhc].
- If you have a path to node N have already found a path to a simpler goal, you can prune the path N.

# Improving Efficiency

- You can define a heuristic function that estimates how difficult it is to solve the goal from the initial state.
- You can use domain-specific knowledge to remove impossible goals.
  - It is often not obvious from an action description to conclude that an agent can only hold one item at any time.

## Comparing forward and regression planners

- Which is more efficient depends on:
  - ► The branching factor
  - How good the heuristics are
- Forward planning is unconstrained by the goal (except as a source of heuristics).
- Regression planning is unconstrained by the initial state (except as a source of heuristics)