PLANNING GRAPHS

- A planning graph is a sequence of levels corresponding to “time steps,” alternating between “state levels” Si and “action levels” Ai.
- It starts with state level S0, which contains the literals true of the initial state.
- An action is in Ai if its preconds. are in Si.
- It has edges from its preconds. in Si and to its effects in Si+1.
- Also, each literal in Si has a persistence edge to the same literal in Si+1.

CONT…

- Mutual Exclusion (Mutex) Links Two actions in Ai have a mutex link if a precondition or effect of one action conflicts with a precondition or effect of the other action.

- Two literals in Si+1 have a mutex link if one negates the other or if every pair of actions in Ai achieving them are mutex. An action cannot be in Ai if any two preconds. in Si are mutex

CONT…

- “Simple” Planning Graph
- Example
- Init(have(Cake))
- Goal(have(Cake) ∧ eaten(Cake))
- Action(eat(Cake),
- Precond: have(Cake)
- Effect: eaten(Cake) ∧ ¬have(Cake))
- Action(bake(Cake),
- Precond: ¬have(Cake)
- Effect: have(Cake))

Planning and Acting in the Real World

- *Planning and scheduling the operations*
  - Spacecraft
  - Factories
  - Military campaigns

CONT…

- **Time, Schedules, and Resources**
- Classical planning representation is about
  - *What to do*
  - *In what order*
  - *Cannot talk about time*
    - How long an action takes
    - When the action occurs

CONT…

- Planning to produce schedules
  - *Assign initial and final times*
  - *Schedule for an airline, assign planes to flights, departure and arrival times*
- Resource constraints
  - *Limited number of staff in an airline (i.e. pilots)*
  - *Staf cannot be in two places at the same time*
-

CONT…

- A **job-shop scheduling problem**
  - *Consists of a set of **jobs***
    - Each job consists of a set of **actions**
  - *Actions have ordering constraints among them*
  - *Actions (each of them) have a **duration** and a set of **resource constraints***

CONT…

$Jobs(\{AddEngine1 \prec AddWheels1 \prec Inspect1\},$
$\{AddEngine2 \prec AddWheels2 \prec Inspect2\})$

$Resources(EngineHoists(1), WheelStations(1), Inspectors(2), LugNuts(500))$

$Action(AddEngine1, \text{DURATION:}30,$
$\text{USE:} EngineHoists(1))$
$Action(AddEngine2, \text{DURATION:}60,$
$\text{USE:} EngineHoists(1))$
$Action(AddWheels1, \text{DURATION:}30,$
$\text{CONSUME:} LugNuts(20), \text{USE:} WheelStations(1))$
$Action(AddWheels2, \text{DURATION:}15,$
$\text{CONSUME:} LugNuts(20), \text{USE:} WheelStations(1))$
$Action(Inspect_i, \text{DURATION:}10,$
$\text{USE:} Inspectors(1))$

Figure 1 A job-shop scheduling problem for assembling two cars, with resource constraints. The notation $A \prec B$ means that action A must precede action B.