Artificial Intelligence

Mayank Vatsa

Planning (and scheduling)

- Logic

- Planning + Reasoning

- Scheduling

Planning Applications

- Can you give a real world example?

Planning

- We studied how to take actions in the world: search

- We studied how to represent objects, relations, etc: logic

- PLANNING (and Scheduling): Combines the two

STRIPS - Language

- Stanford Research Institute Problem Solver

- Automated planner - built in 1971

STRIPS - Language

- An initial state;

- The specification of the goal states - situations which the planner is trying to reach;

- A set of actions. For each action, the following are included:

  - preconditions (what must be established before the action is performed);

  - postconditions (what is established after the action is performed)
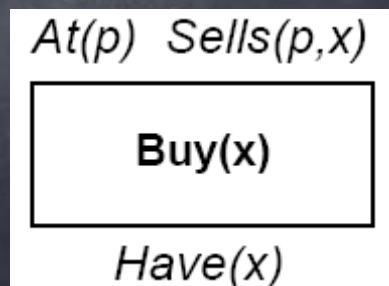
STRIPS - Language

- A restricted language for planning that describes actions and descriptions of objects in a system

-
  Example
  -
    Action: Buy(x)

    Precondition: At(p), Sells(p, x)

    Effect: Have(x)

At(p) Sells(p,x)
Buy(x)
Have(x)

An Action

- TakeObject(location, x)

- Preconditions:

  - HandEmpty

  - CanBeCarried(x)

  - At(location)

  - IsAt(x, location)

- Effects ("NOT something" means that that something should be removed from state):

  - Holding(x)

  - NOT(HandEmpty)

  - NOT(IsAt(x, location))

Another Action

- WalkWithUmbrella(location1, location2, umbr)

- Preconditions:

  - At(location1)

  - Holding(umbr)

  - IsUmbrella(umbr)

- Effects:

  - At(location2)

  - NOT(At(location1))

One more example

- WalkWithoutUmbrella(location1, location2)

- Preconditions:

  - At(location1)

- Effects:

  - At(location2)

  - NOT(At(location1))

  - NOT(Dry)

A goal and a plan

- Goal: At(Work) AND Dry

- initial state:

  - At(Home) AND IsAt(Umbrella, Home) AND CanBeCarried(Umbrella) AND IsUmbrella(Umbrella) AND HandEmpty AND Dry

- TakeObject(Home, Umbrella)

  At(Home) AND CanBeCarried(Umbrella) AND IsUmbrella(Umbrella) AND Dry AND Holding(Umbrella)

- WalkWithUmbrella(Home, Work, Umbrella)

  At(Work) AND CanBeCarried(Umbrella) AND IsUmbrella(Umbrella) AND Dry AND Holding(Umbrella)

Planning to Write a Paper for AI Conference

- Suppose your goal is to be a co- author on an AI paper with both theorems and experiments, within a year

Planning to Write a Paper for AI Conference

LearnAbout(x,y)

Preconditions: HasTimeForStudy(x)

Effects: Knows(x,y),
    NOT(HasTimeForStudy(x))

HaveNewIdea(x)

Preconditions: Knows(x,AI),
    Creative(x)

Effects: Idea, Contributed(x)

FindExistingOpenProblem(x)

Preconditions: Knows(x,AI)

Effects: Idea

ProveTheorems(x)

Preconditions: Knows(x,AI),
    Knows(x,Math), Idea

Effect: Theorems, Contributed(x)

PerformExperiments(x)

Preconditions: Knows(x,AI),
    Knows(x,Coding), Idea

Effect: Experiments, Contributed(x)

WritePaper(x)

Preconditions: Knows(x,AI),
   Knows(x,Writing), Idea,
    Theorems, Experiments

Effect: Paper, Contributed(x)

Goal: PaperAND Contributed(You)

Can you write some possible start states?

- Start1: HasTimeForStudy(You) AND Knows(You,Math) AND Knows(You,Coding) AND Knows(You,Writing)

- Start2: HasTimeForStudy(You) AND Creative(You) AND Knows(Advisor,AI) AND Knows(Advisor,Math) AND Knows(Advisor,Coding) AND Knows(Advisor,Writing)

  - (Good luck with that plan...)

- Start3: Knows(You,AI) AND Knows(You,Coding) AND Knows(OfficeMate,Math) AND HasTimeForStudy(OfficeMate) AND Knows(Advisor,AI) AND Knows(Advisor,Writing)

- Start4: HasTimeForStudy(You) AND Knows(Advisor,AI) AND Knows(Advisor,Math) AND Knows(Advisor,Coding) AND Knows(Advisor,Writing)
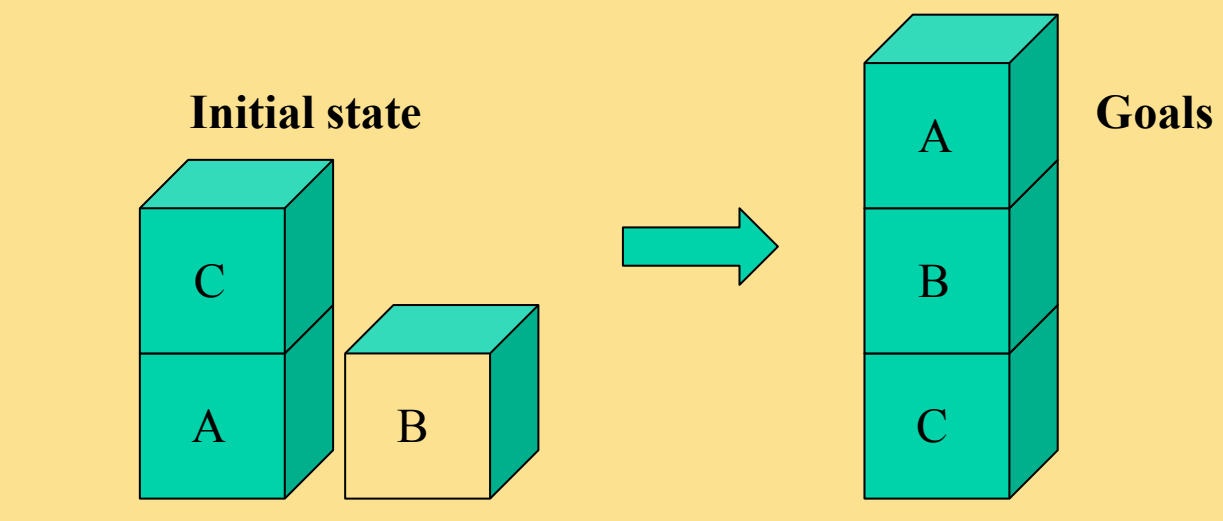
The Blocks World

Initial state
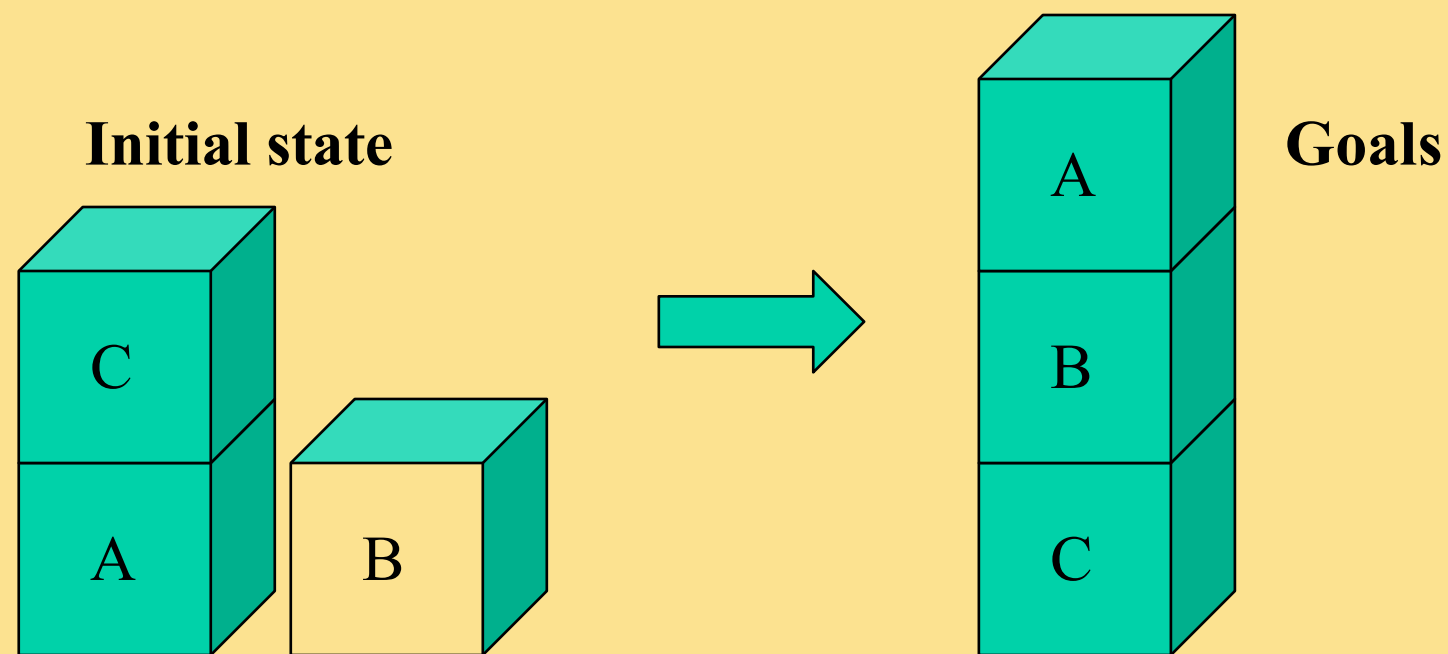
Goals

- **Initial state**: (on A Table) (on C A) (on B Table) (clear B) (clear C)
- **Goals**: (on C Table) (on B C) (on A B) (clear A)

Planning
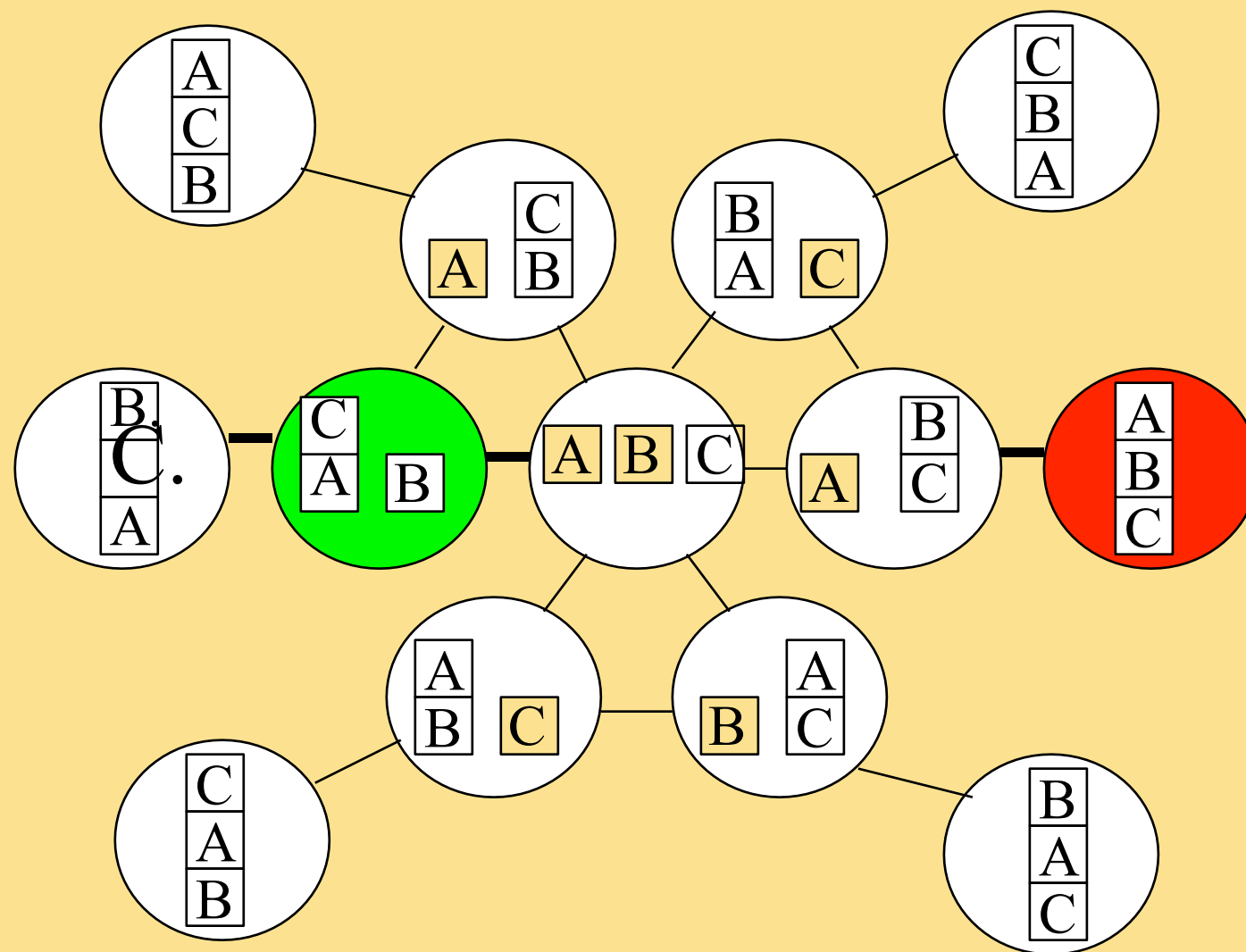
How to approach?

Initial state → **Goals**

- **Initial state**: (on A Table) (on C A) (on B Table) (clear B) (clear C)
- **Goals**: (on C Table) (on B C) (on A B) (clear A)
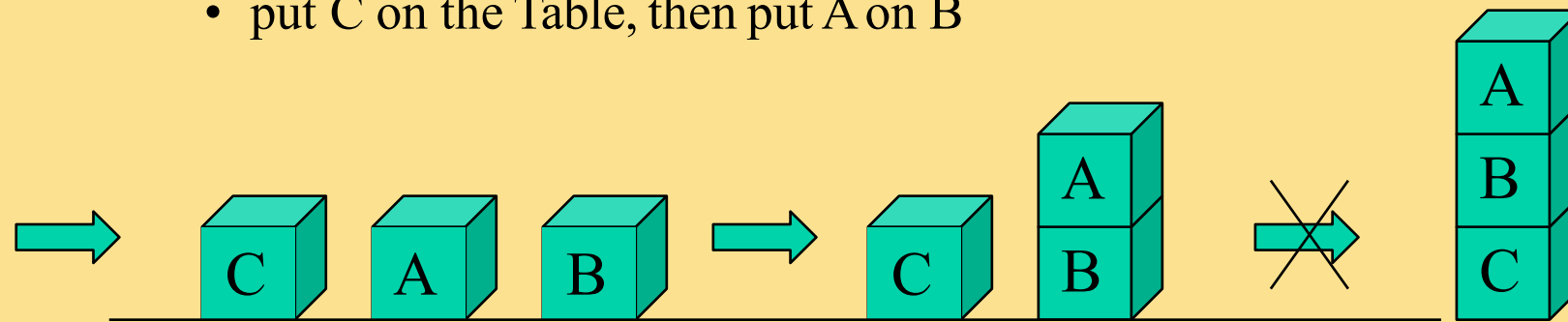
Two subproblems: (on B C) (on A B)

What would be the problem

- Can you figure out a problem with sub-problem approach?

What would be the problem

- Problem of state-space search:
  - Try (on A B) first:
    - put C on the Table, then put A on B

- Accidentally wind up with A on B when B is still on the Table
- We can not get B on C without taking A off B
- Try to solve the first subgoal first appears to be mistaken

- Not every problem can be solved using sub-problem approach
- Sequence matters

Universal Classical Planning (UCP)
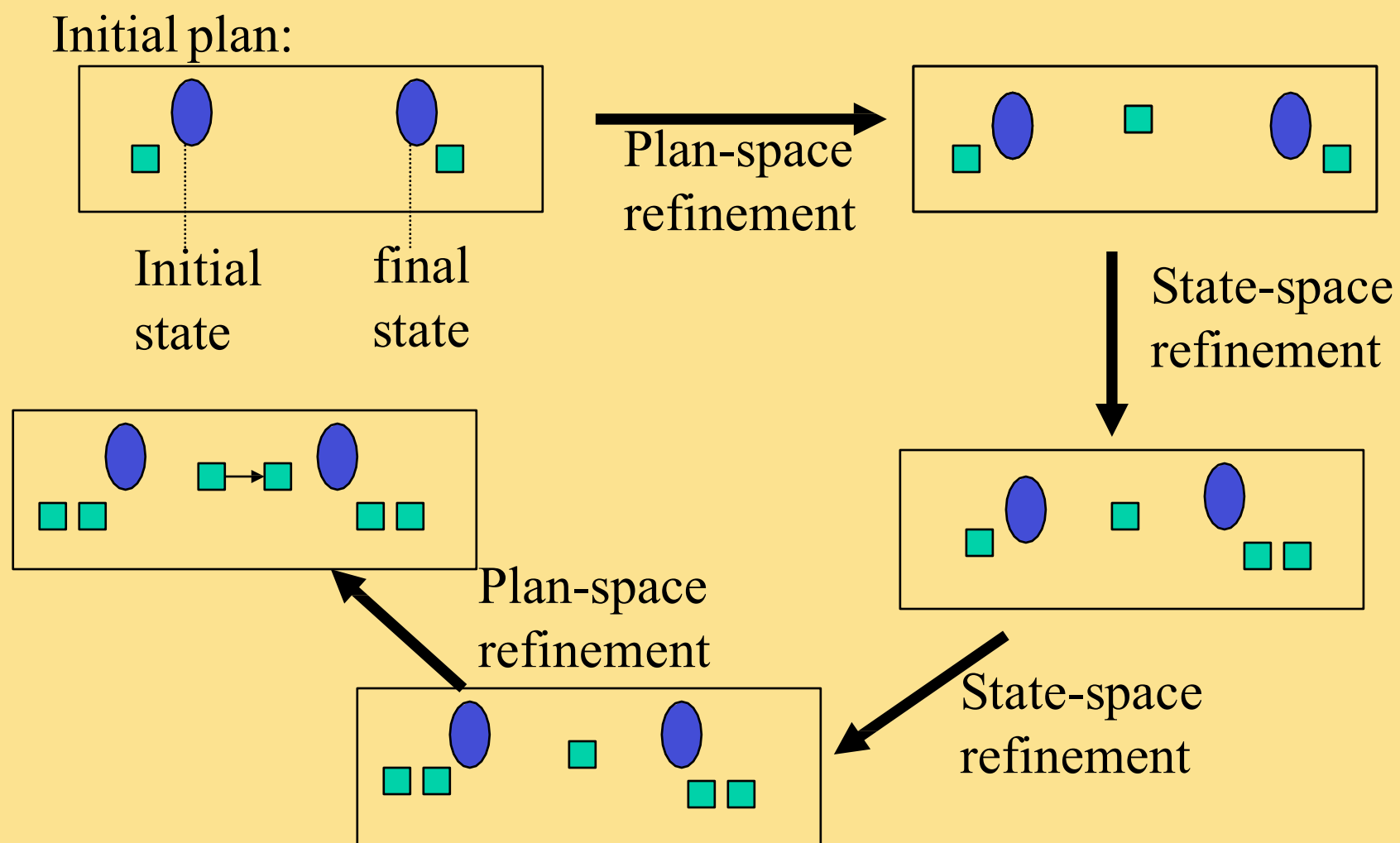
Partially Ordered Plans

- Partially Ordered Plan

- A partially ordered collection of steps

  - <u>Start step</u> has the initial state description and its effect

  - <u>Finish step</u> has the goal description as its precondition

  - <u>Causal links</u> from outcome of one step to precondition of another step

  - <u>Temporal ordering</u> between pairs of steps

An Example
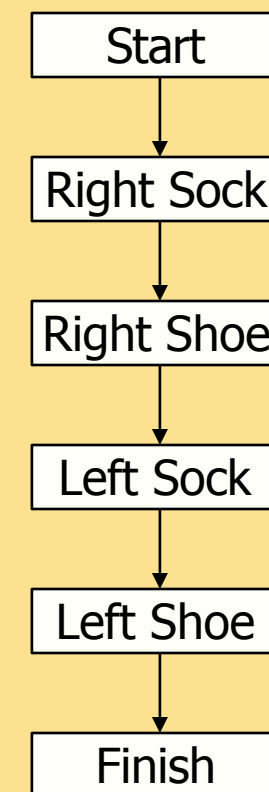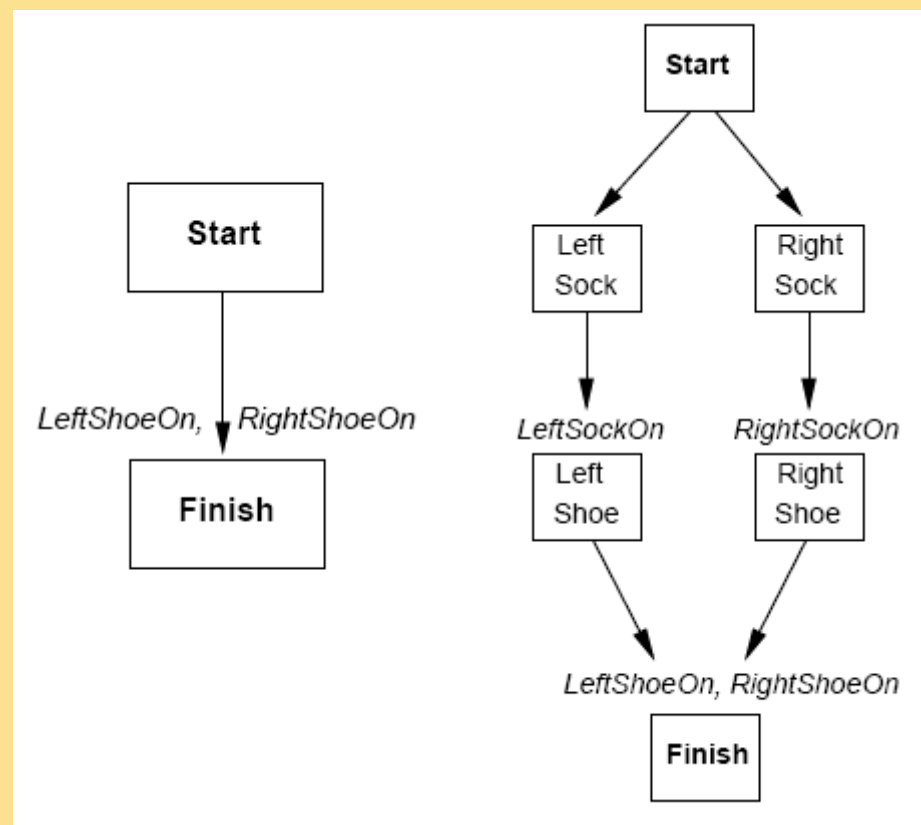
Scheduling

- What is scheduling?

Three main algorithms

1. FCFS

2. Round Robin

3. Priority Scheduling

Next Lecture

Intro to RL (Dr. Sanjit)

Quiz 3 on Oct 25