

COMP90054 Workshop 1

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High Level Picture

Different AI Research directions

- Only focus on AI especially AI planning -> acting rationally
- ML/NLP/CV -> acting like humans

3 approaches:

- Programming-based
- learning-based: RL/TD (2nd half of this semester)
- models-based: AI planning

What is AI planning?

Classical Planning Problem

Not every problem belongs to classical planning problem

Deterministic action: $S - a \rightarrow S'$

- Every action only has a certain outcome, and you know what that outcome will be
- Counterexample: coin toss \rightarrow probabilistic actions
- Single-agent
- Static environment
-

How can we solve a Classical Planning Problem

- The idea of general AI to solve the problem: Problem -> solver -> solution
- Comes to AI planning: Problem (Model) -> Planner -> Plan

Model

- State-space model: any Classical Planning Problem can be represented by a state-space model
- STRIPS: PDDL

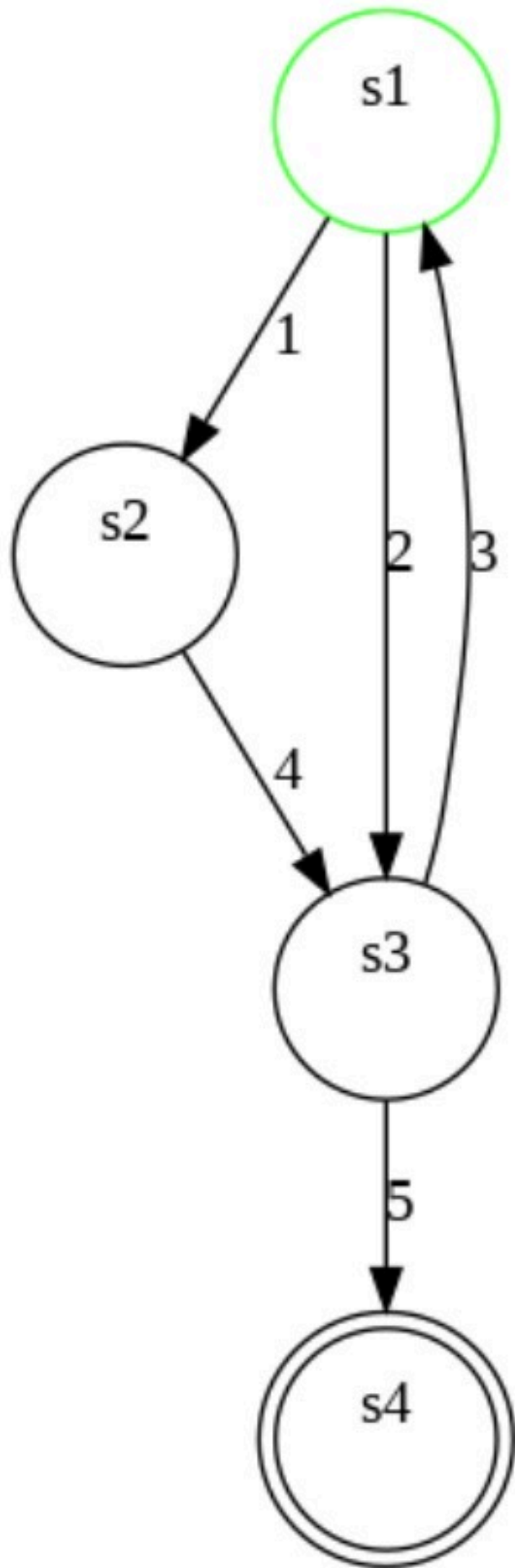
Planner: powered by the search algorithms

- Blind search: BFS, DFS, ID, Uniform-Cost, IW....
- Heuristic Search (Informed search)

Plan

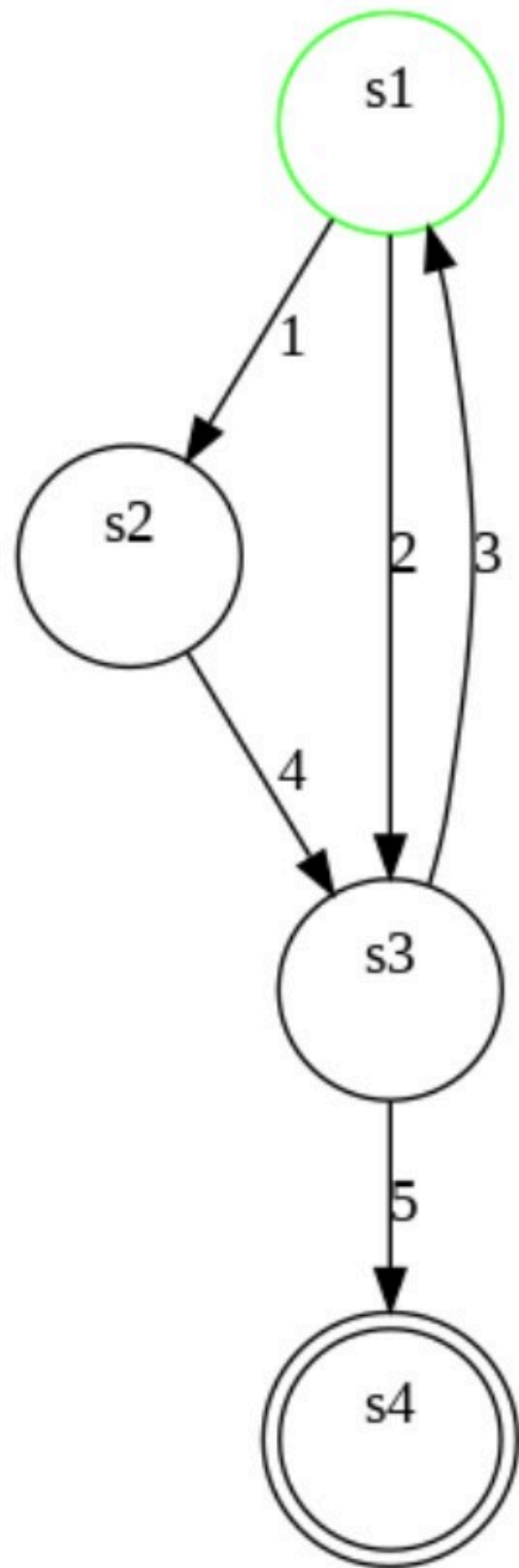
- A sequence of actions: $a_1 \rightarrow a_2 \rightarrow \dots$
- Not a set of actions

Problem 1: State-transition graph



- State space $S = \{ ? \}$
- Initial State = ?
- Goal State = $\{ ? \}$
- Action
- Transition Function
- Cost Function

Problem 1: State-transition graph

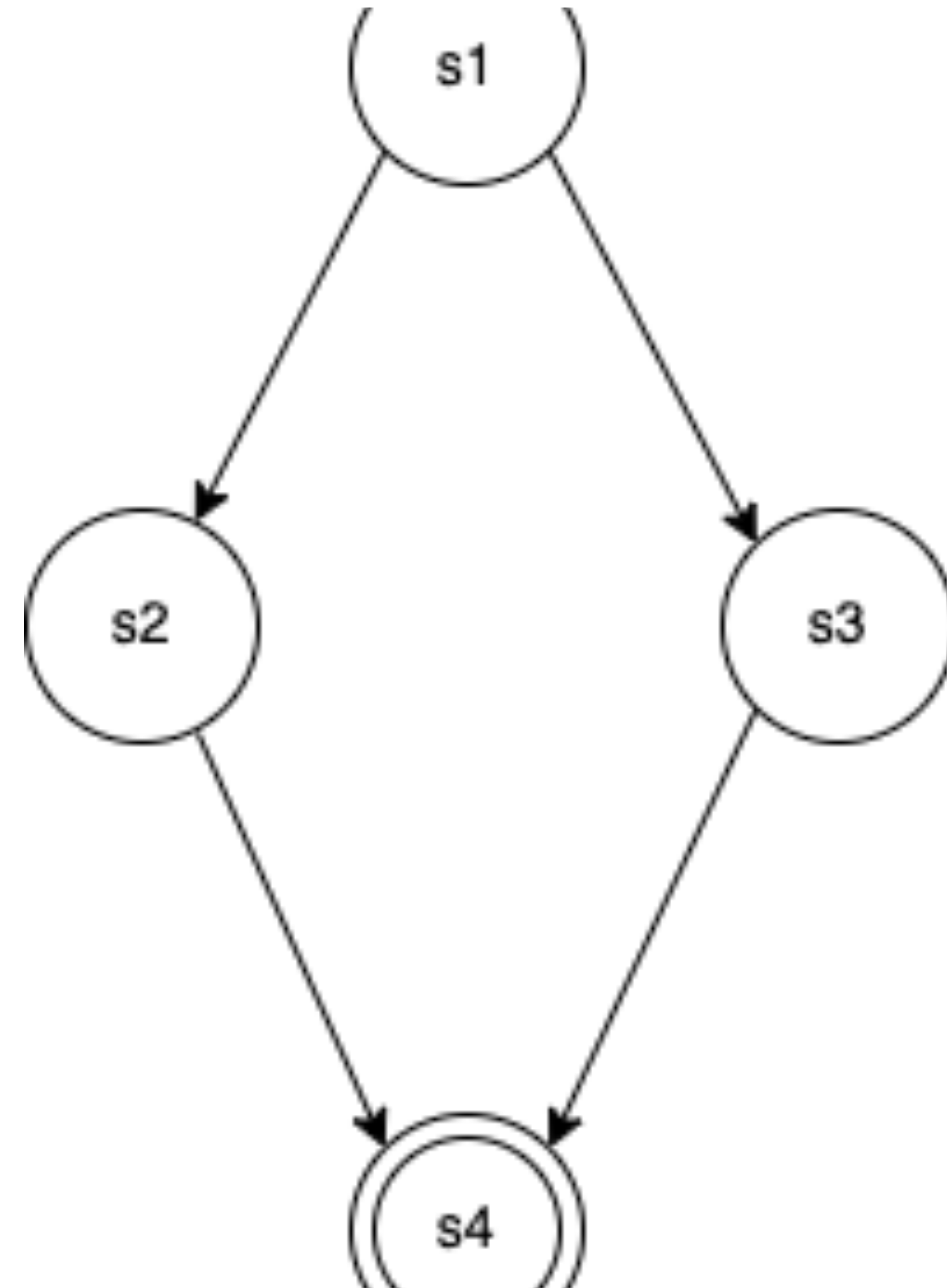


- State space $S = \{s1, s2, s3, s4\}$
- Initial State
- Goal State
- Action
- Transition Function
- Cost Function

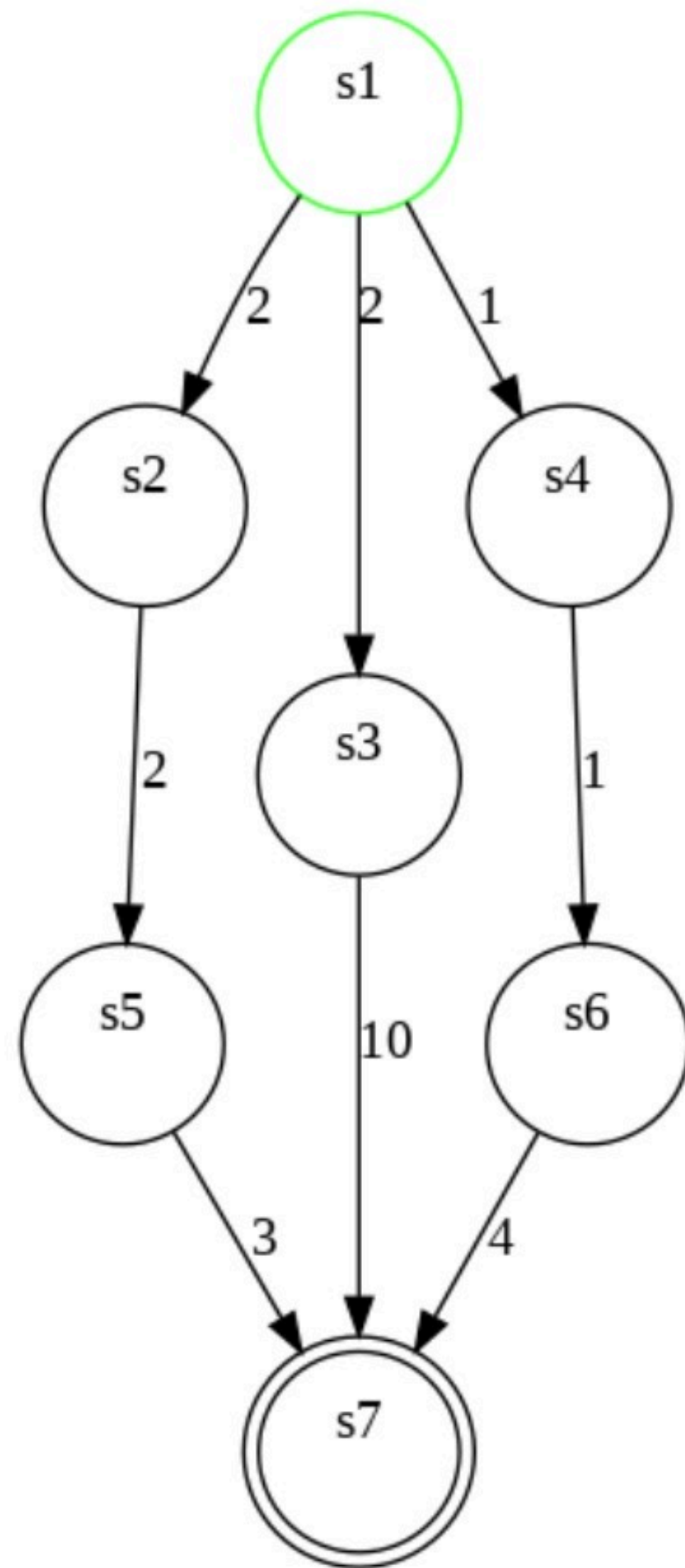
$$\begin{aligned}
 s_0 &= s_1 \\
 S_G &= \{s_4\} \\
 A &\Rightarrow \begin{cases} A(s_1) = \{(s_1, s_2), (s_1, s_3)\} \\ A(s_4) = \{\} \\ \vdots \end{cases} \\
 T(s_1, (s_1, s_2)) &= s_2 \quad T(s_1, (s_1, s_3)) = s_3 \quad \dots \\
 C: \quad C &= 1 \quad C(\alpha) = ? \quad C(s, \alpha) = ? \\
 \begin{cases} C(s_1, s_2) = 1 \\ C(s_1, s_3) = 2 \end{cases} \quad C(s, \alpha, s')
 \end{aligned}$$

Search Node vs State

- Differences between nodes and states
- Node : (state, accumulated cost, parent information)
- Why node?



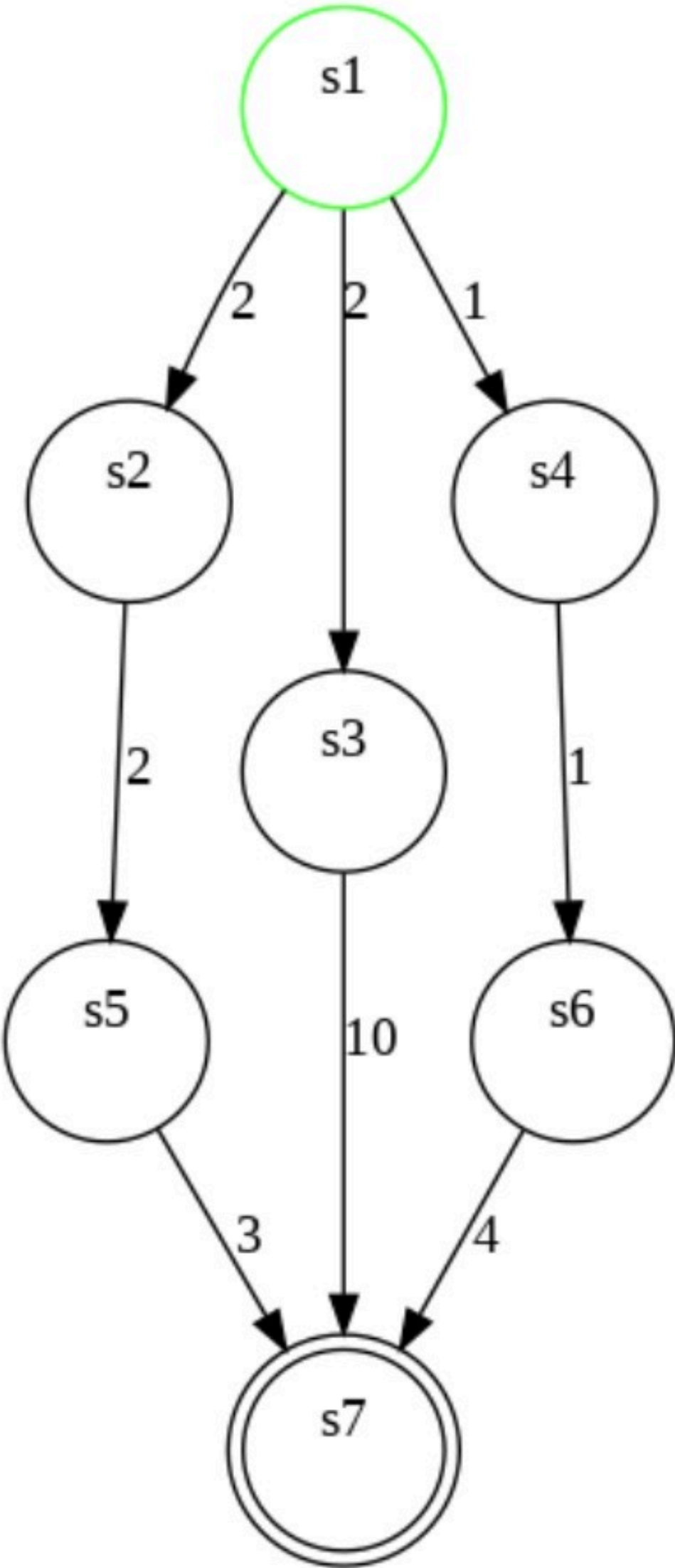
Problem 2



Task 1

Discuss with others, and finish the node expansion order for each algorithm

BFS Expansion



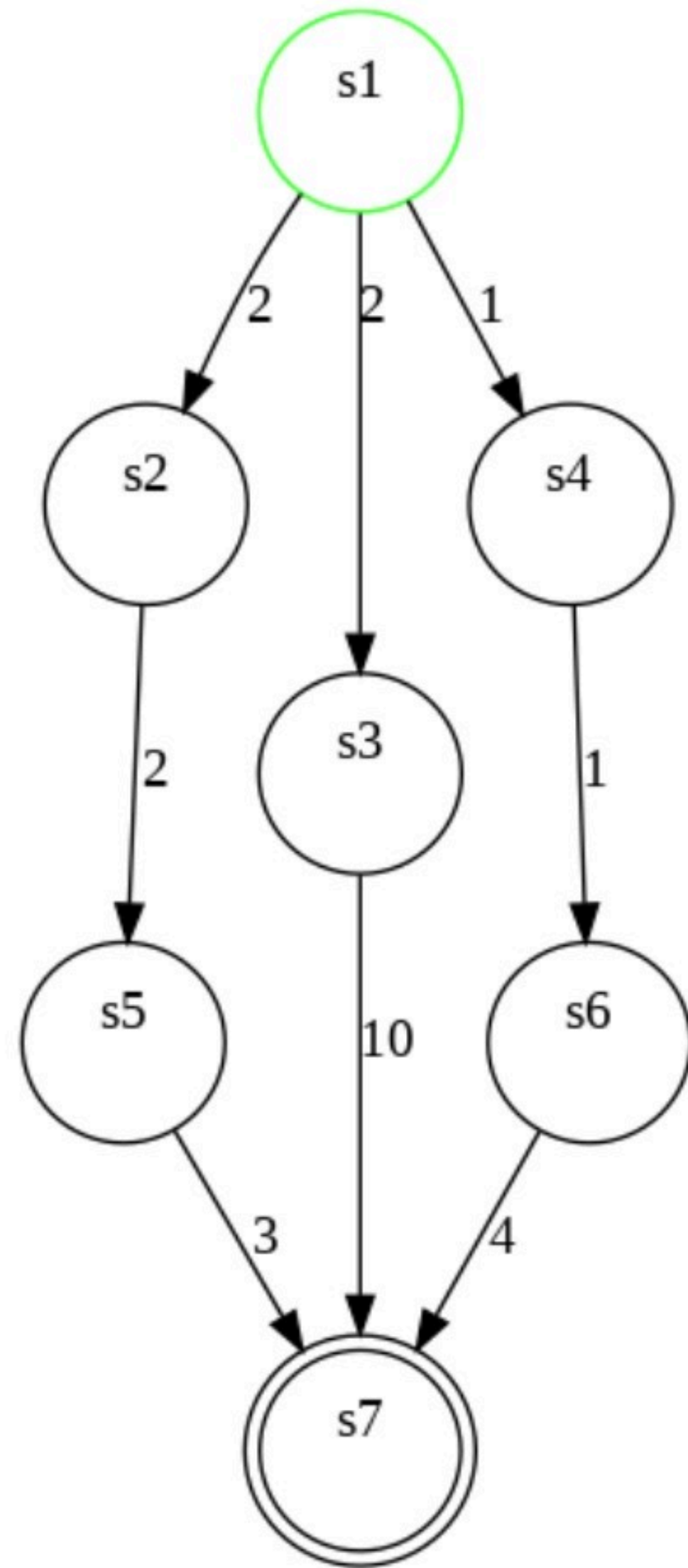
	Iteration 0	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Iteration 6
Open	$n_0 = \langle s_1, 0, \text{null} \rangle$	$n_1 = \langle s_2, 2, s_1 \rangle$ $n_2 = \langle s_3, 2, s_1 \rangle$ $n_3 = \langle s_4, 1, s_1 \rangle$	n_2 n_3 $n_4 = \langle s_5, ? , s_2 \rangle$	n_3 n_4 $n_5 = \langle s_7, 12, s_3 \rangle$	n_4 n_5 $n_6 = \langle s_6, 2, s_4 \rangle$	n_5 n_6 $n_7 = \langle s_6, 2, s_4 \rangle$	n_6 n_7
Closed		n_0	n_0, n_1	n_0, n_1, n_2	n_0, n_1, n_2, n_3	n_0, n_1, n_2, n_3, n_4	$n_0, n_1, n_2, n_3, n_4, \mathbf{n_5}$

Queue: $n_0, n_1, n_2, n_3, n_4, \mathbf{n_5}, n_6, n_7$

When pop up a node from the queue:

1. Check if current node n contains the goal state
2. Generate children nodes, and put into data structure

Problem 2 Task 1

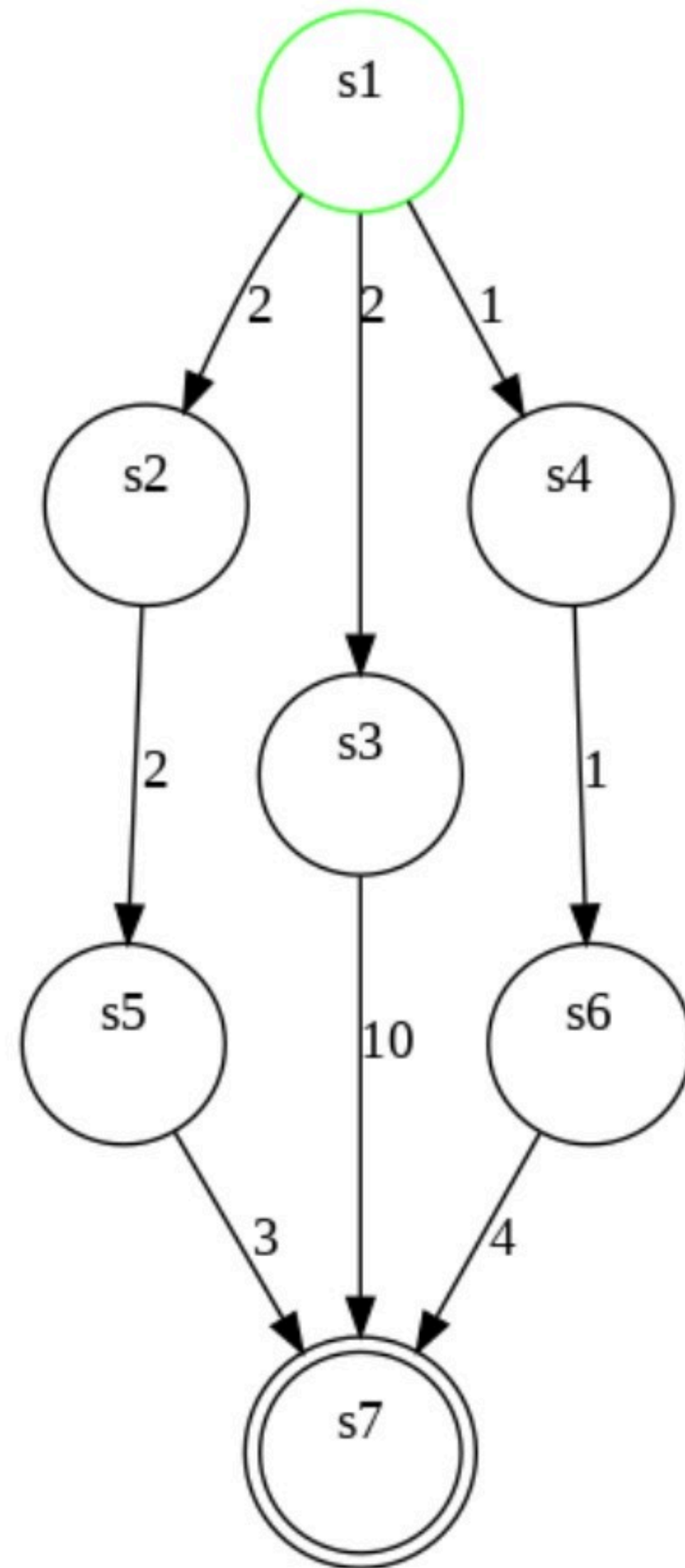


- **Depth-First Search**

Nodes = [
('s1', 0, None),
('s2', 2, 0),
('s5', 4, 1),
('s7', 7, 2)]

- # (state, accumulated cost, id of parent node)

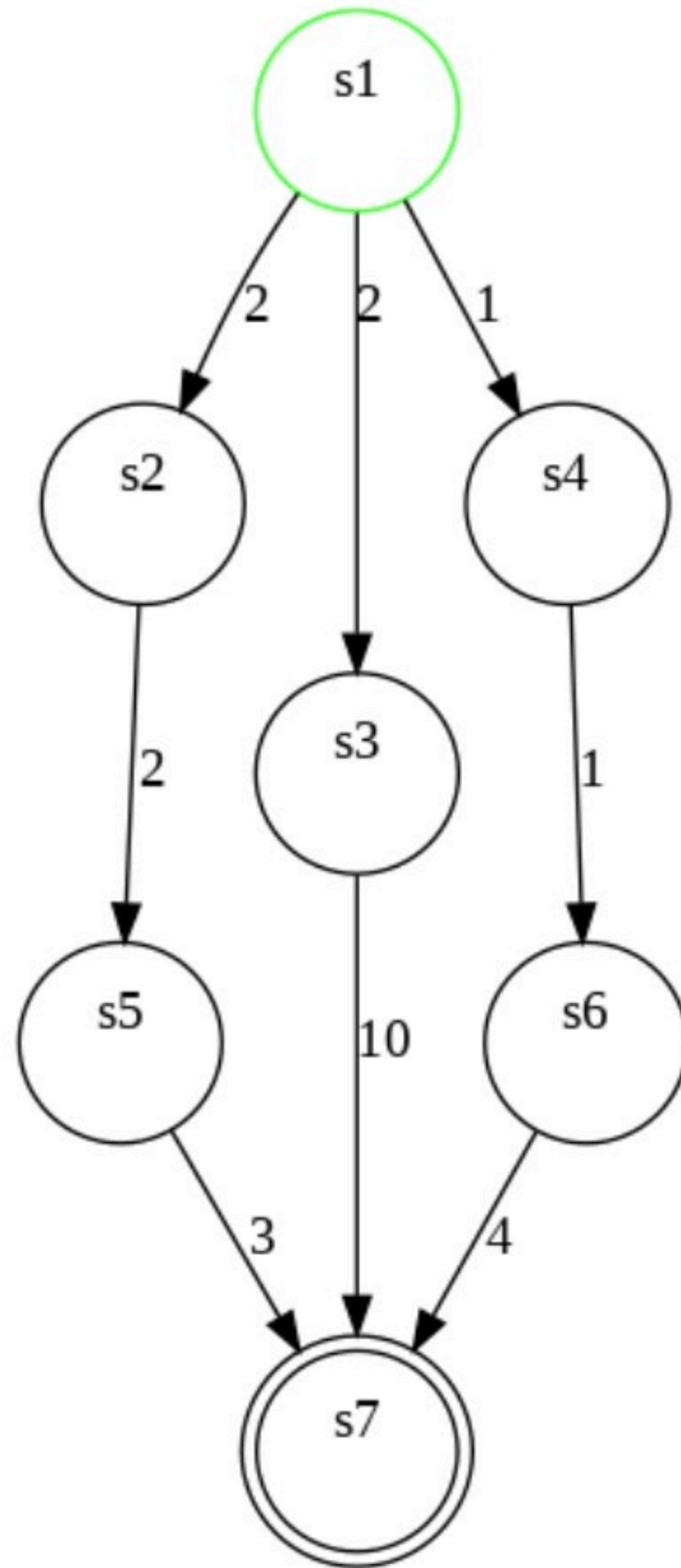
Problem 2 Task 1



- **ID (iterative deepening)**

```
Nodes = [  
  ( 's1' , 0 , None ) , #depth limit = 1  
  ( 's2' , 2 , 1 ) ,  
  ( 's3' , 2 , 1 ) ,  
  ( 's4' , 1 , 1 ) ,  
  ( 's1' , 0 , None ) , #depth limit = 2  
  ( 's2' , 2 , 5 ) ,  
  ( 's5' , 4 , 6 ) ,  
  ( 's3' , 2 , 5 ) ,  
  ( 's7' , 12 , 8 ) ]
```

Problem 2



Task 2

Q1: What is the solution found by each algorithm?

Q2: What is the actual optimal solution?

Q3: Explain under which conditions the algorithms guarantee optimality.

Q4: Can any of the previous algorithms be adapted to account for $g(n)$ in order to make it optimal?

	Complete	Optimal	Time Complexity	Space Complexity
BFS	T	T*	$O(b^d)$	$O(b^d)$
DFS	F	F	infinity	$O(b^*d)$
ID	T	T*	$O(b^d)$	$O(b^*d)$

b = branching factor
d = depth of the optimal path

Problem 3

Describe a simple example of *Travelling Salesman Problem* along with its corresponding **State Space Model**.

Definition should be brief, clear, and *compact* (*compact* means using mathematical notation to define sets, i.e. $S = \{x | x \in V\}$ to define that there are as many states as elements in the set V , and pseudo-code, i.e. to define the transition function.)

1. State space S
2. Initial state $s_0 \in S$
3. Set of goal states $S_G \subseteq S$
4. Applicable actions function $A(s)$ for each state $s \in S$
5. Transition function $f(s, a)$ for $s \in S$ and $a \in A(s)$
6. Cost of each action $c(a)$ for $a \in A(s)$

Hint: Consider a set of cities V to visit in any order, a starting city location v_{start} , and a set of edges E specifying if there's an edge from two cities $\langle v_1, v_2 \rangle$. Let V' be the set of cities has been visited.

Problem 3

Let V' be the set contain visited cities:

- $S = \{\langle v_{current}, V' \rangle \mid v_{current} \in V \wedge V' \subseteq V\}$
- $s_0 = \langle v_{start}, \{v_{start}\} \rangle$
- $S_G = \{\langle v_{current}, V \rangle \mid v_{current} \in V\}$
- $A(\langle v_{current}, V' \rangle) = \{\langle v_{current}, v_{next} \rangle \mid \langle v_{current}, v_{next} \rangle \in E\}$
- $f(\langle v_{current}, V' \rangle, \langle v_{current}, v_{next} \rangle) = \langle v_{next}, V' \cup \{v_{next}\} \rangle$
- $c(\langle v_{current}, v_{next} \rangle) = cost(\langle v_{current}, v_{next} \rangle)$