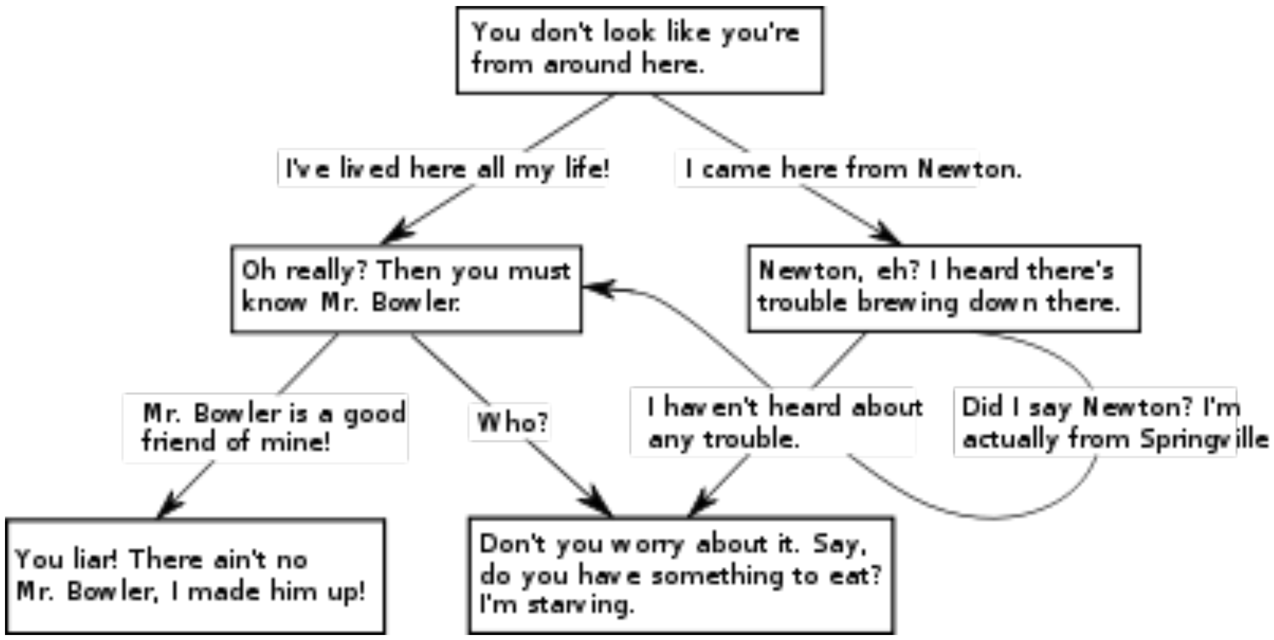
Advanced Tree Searches

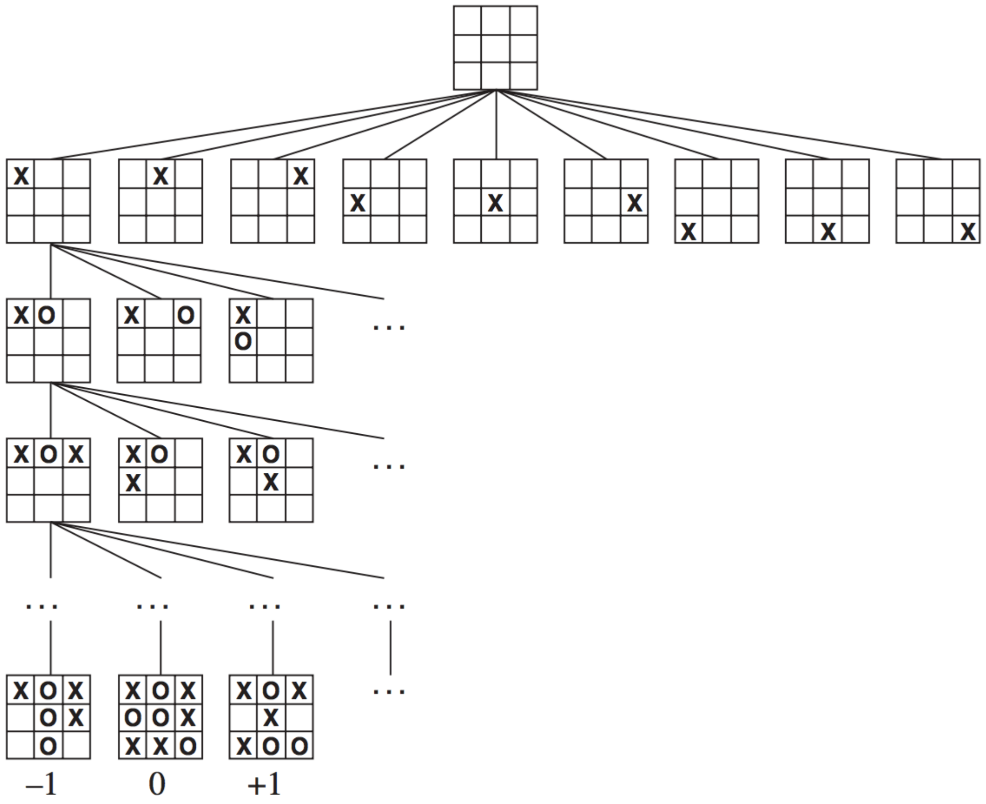
Week 4

Previously on BIME 591

- Conversations as States and Actions
- State and Action Space as Trees
- Depth First Search
- Breadth First Search
- Uniform Cost Search

Traversing Decisions Trees





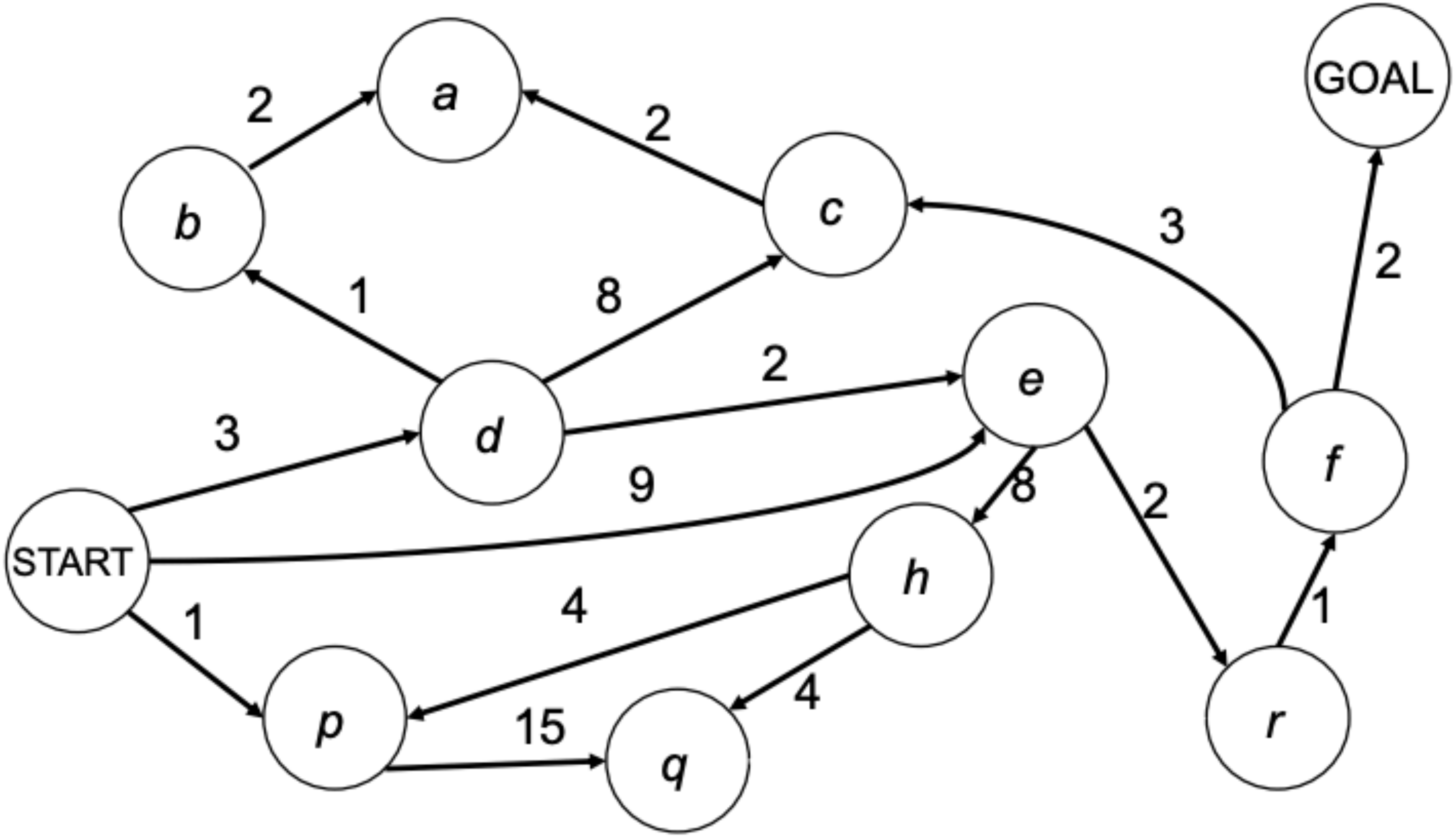
Hierarchal Dialogue Management

Table 4.2: An example of multi-domain dialogue, adapted from Cuayáhuitl et al. (2016). The first column specifies which domain is triggered in the system, based on user utterances received so far.

Domain	Agent	Utterance
`meta`	system	"Hi! How can I help you?"
	user	"I'm looking for a hotel in Seattle on January 2nd for 2 nights."
`hotel`	system	"A hotel for 2 nights in Seattle on January 2nd?"
	user	"Yes."
	system	"I found Hilton Seattle."
`meta`	system	"Anything else I can help with?"
	user	"I'm looking for cheap Japanese food in the downtown."
`restaurant`	system	"Did you say cheap Japanese food?"
	user	"Yes."
	system	"I found the following results."
	...	

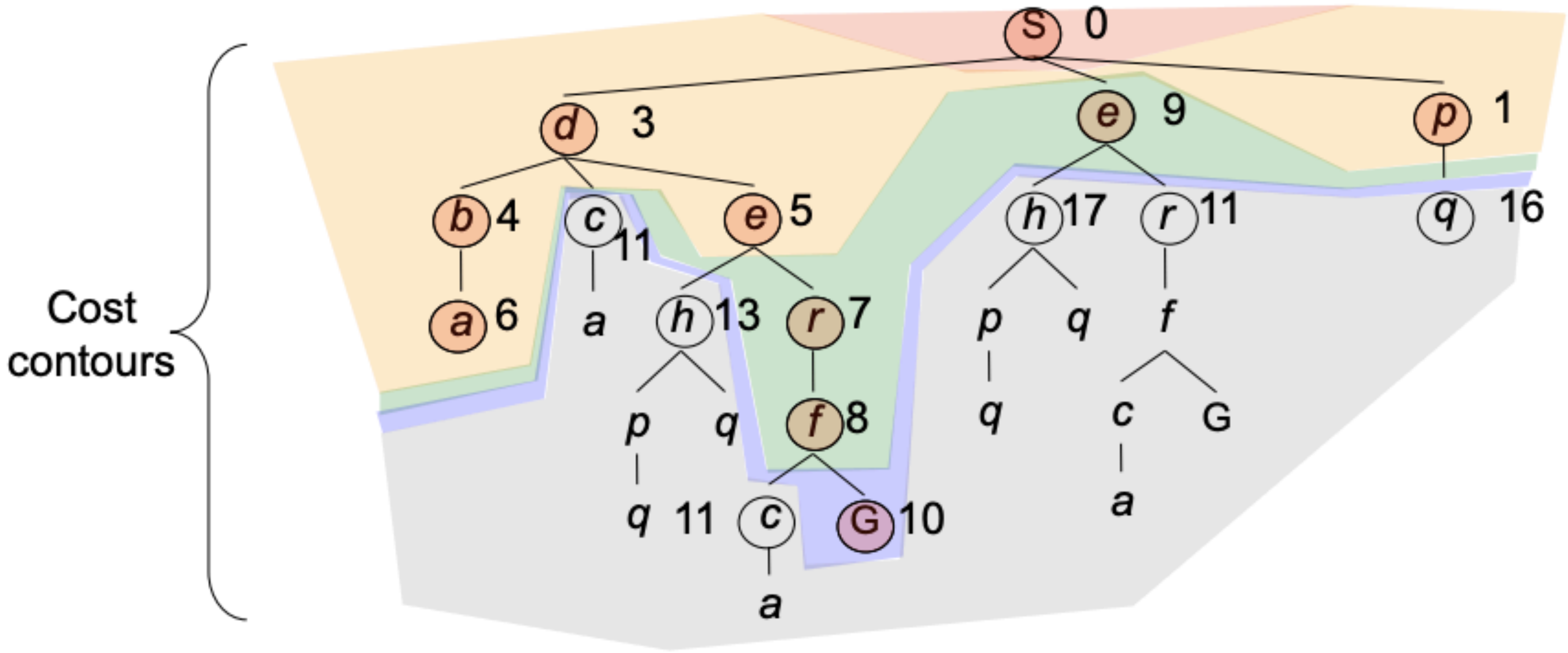
Gao et al, 2018. Neural Approaches to Conversational AI

Weighted Trees



Hajishirzi, 2018. CSE 573

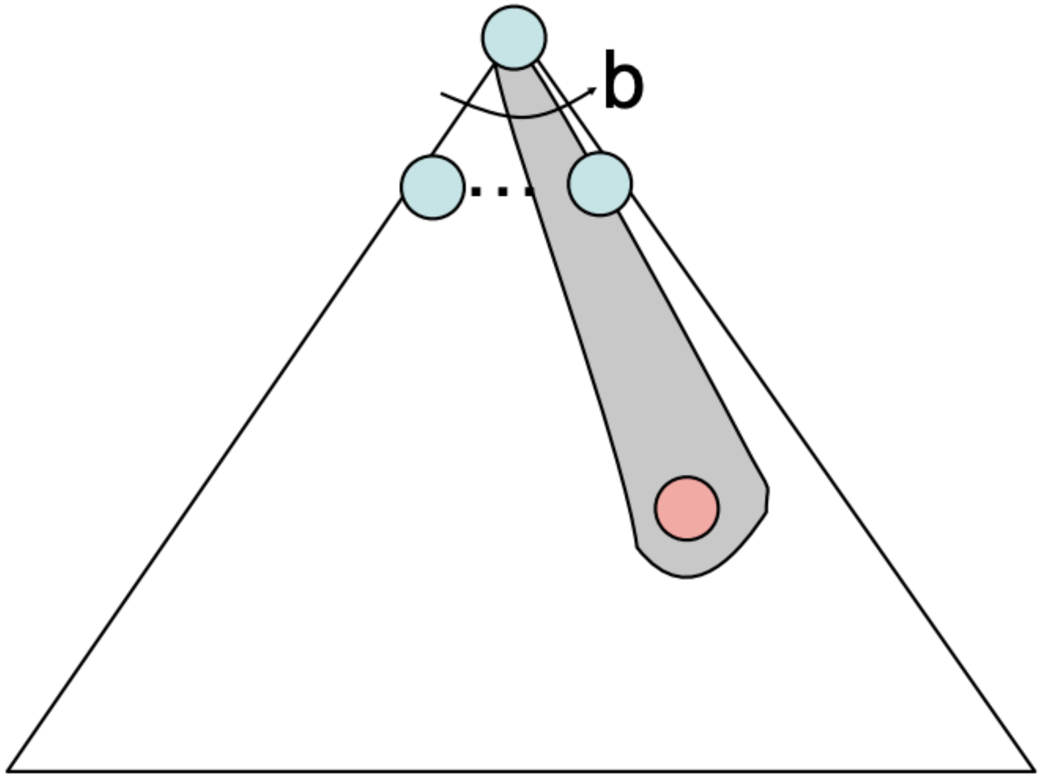
Problems with Uniform Cost Search



Hajishirzi, 2018. CSE 573

Greedy Alternative

- Strategy
  - Search the best node at each step.
- Implementation.
  - Priority Queue



Greedy Alternative

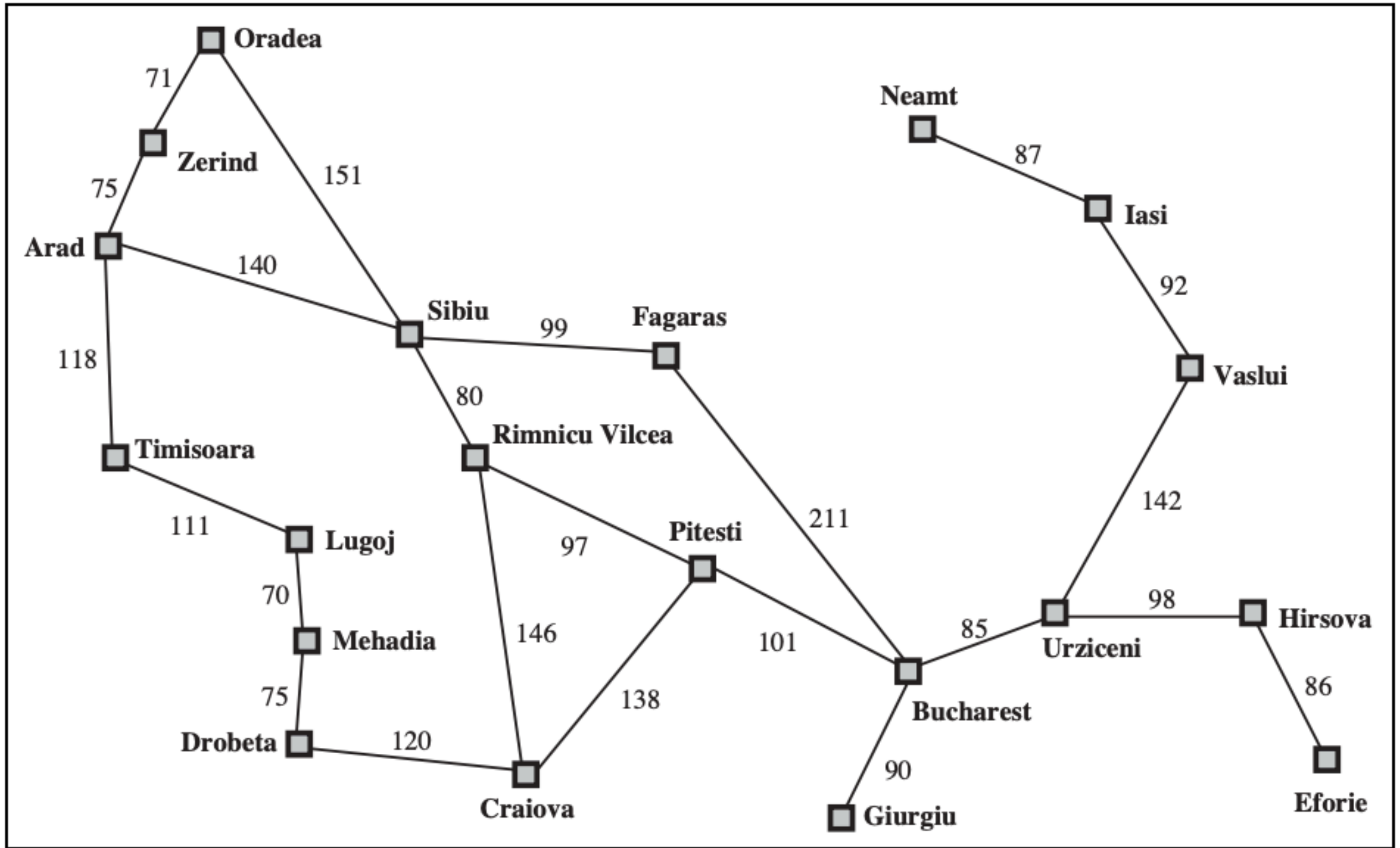


Figure 3.2 A simplified road map of part of Romania.

Norvig et al. 2009, Artificial Intelligence: A Modern Approach

Greedy Alternative

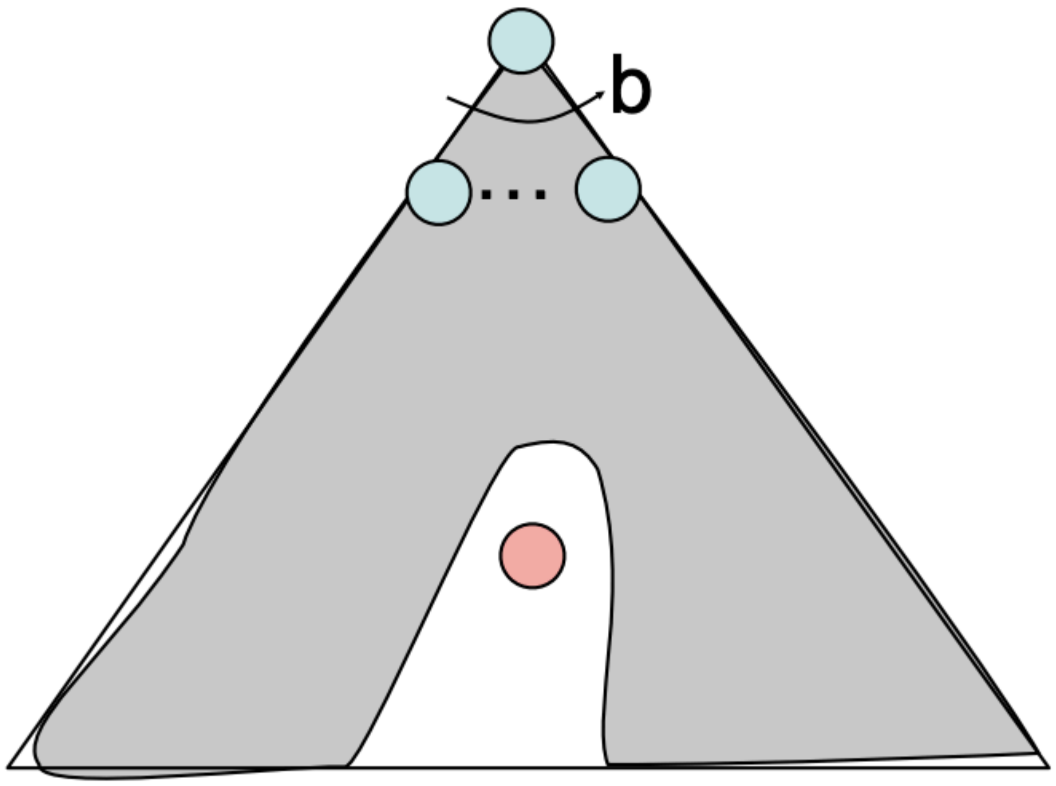
Arad	366	**Mehadia**	241
Bucharest	0	**Neamt**	234
Craiova	160	**Oradea**	380
Drobeta	242	**Pitesti**	100
Eforie	161	**Rimnicu Vilcea**	193
Fagaras	176	**Sibiu**	253
Giurgiu	77	**Timisoara**	329
Hirsova	151	**Urziceni**	80
Iasi	226	**Vaslui**	199
Lugoj	244	**Zerind**	374

Figure 3.22 Values of h_{SLD}—straight-line distances to Bucharest.

Norvig et al. 2009, Artificial Intelligence: A Modern Approach

Properties of Greedy Search

- Complete
  - Yes
- Optimal
  - No
- Time Complexity
  - $O(b^m)$
- Space Complexity
  - $O(bm)$



Combining UCS and Greedy Search

- Uniform Cost Search
  - $f(n) = c(n)$
- Greedy Search
  - $f(n) = h(n)$
- A* Search
  - $f(n) = c(n) + h(n)$

A* Search

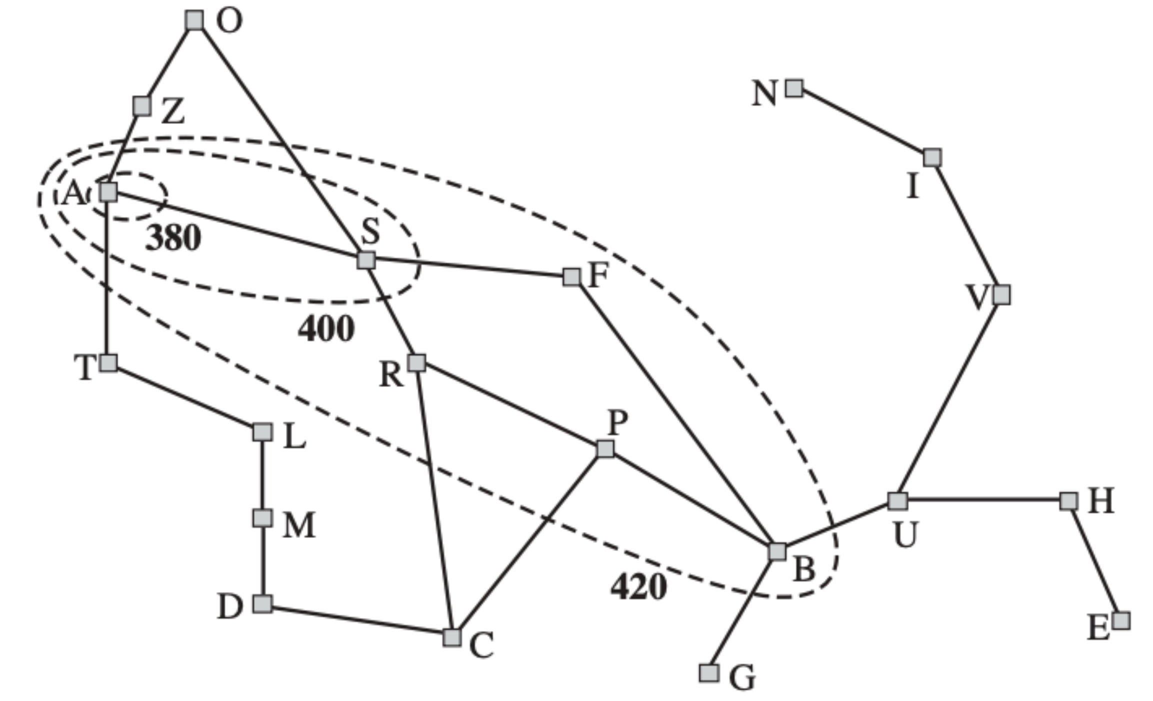
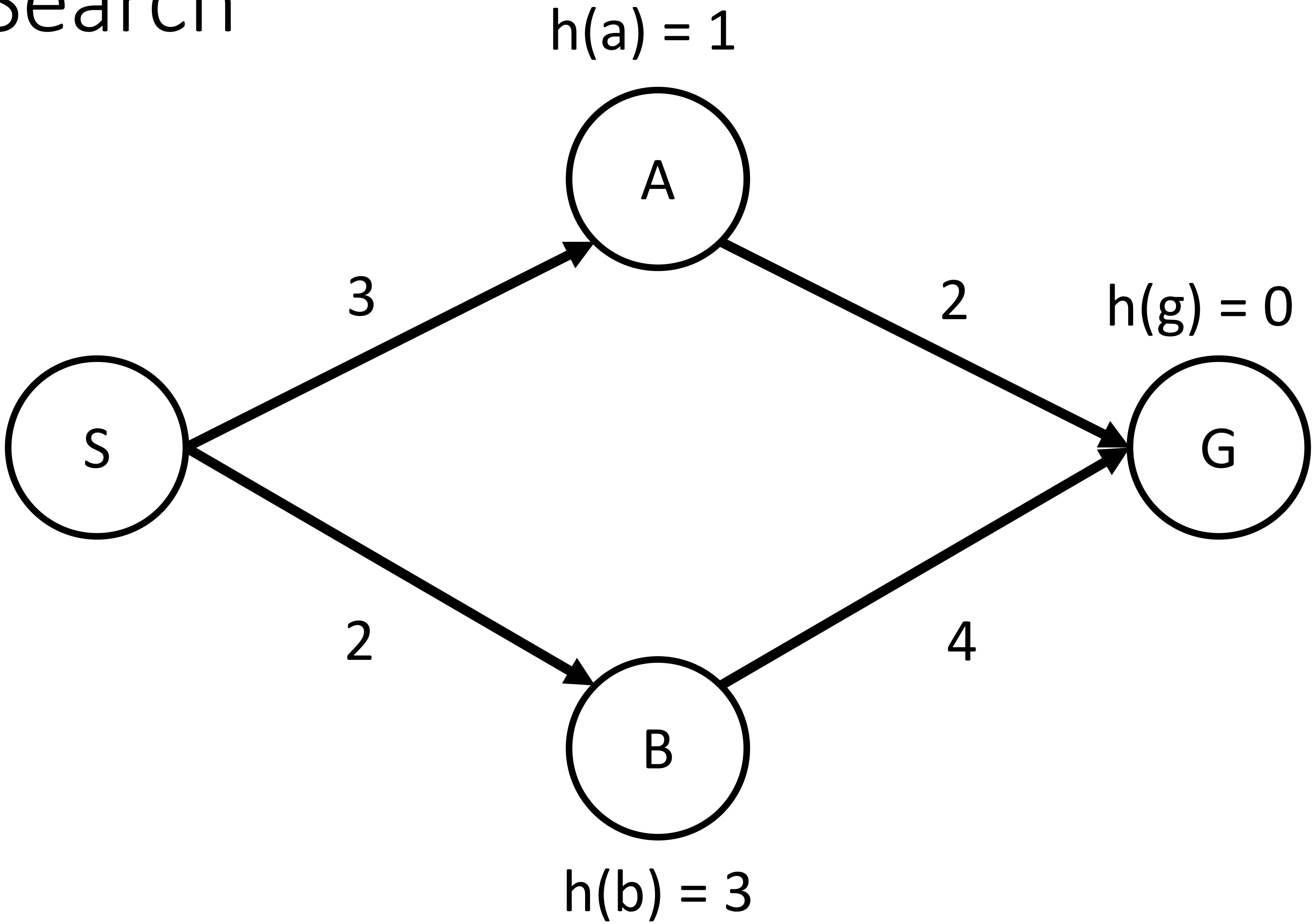


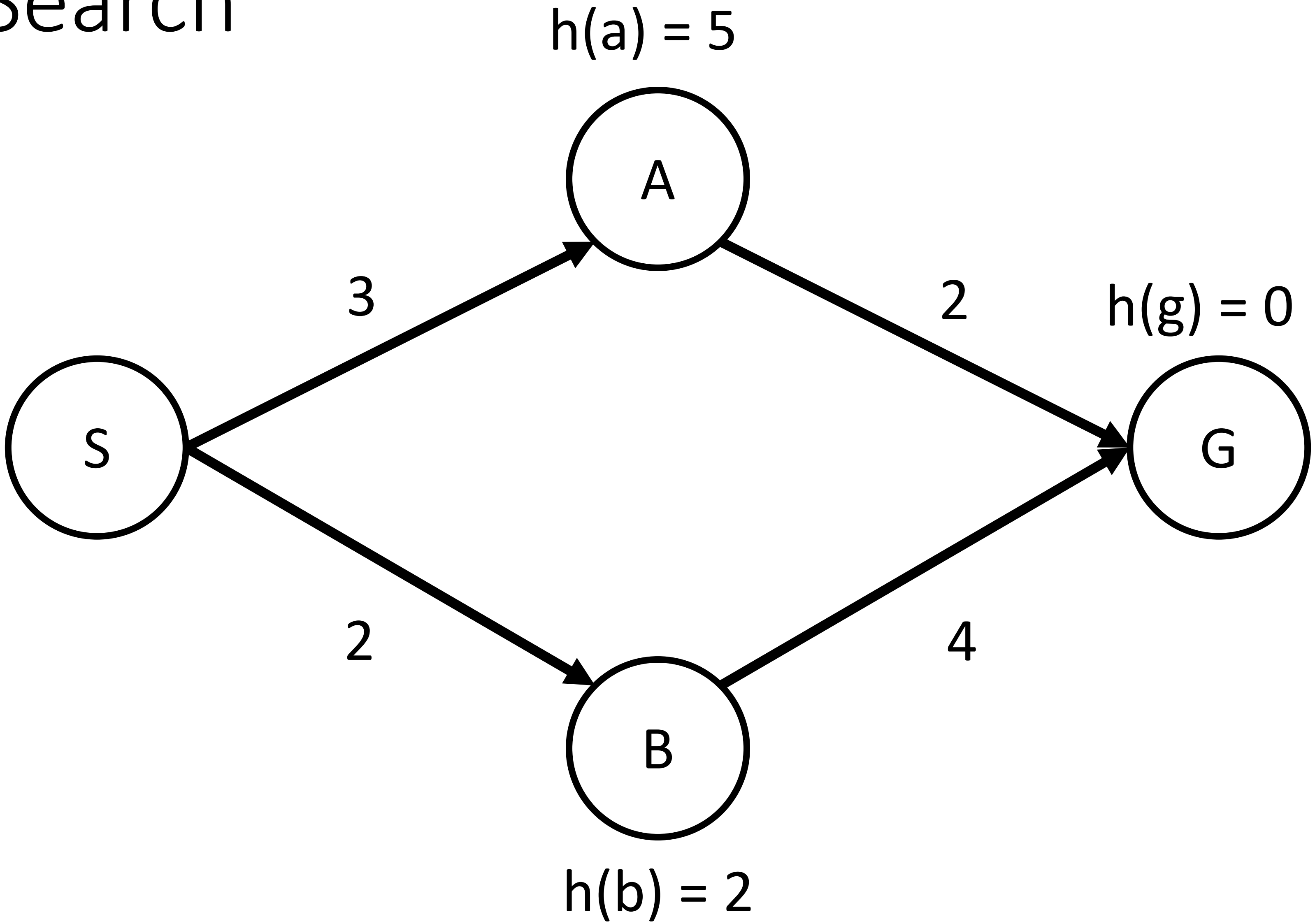
Figure 3.25 Map of Romania showing contours at $f = 380$, $f = 400$, and $f = 420$, with Arad as the start state. Nodes inside a given contour have f-costs less than or equal to the contour value.

Norvig et al. 2009, Artificial Intelligence: A Modern Approach

A* Search



A* Search



A* Heuristics

- A heuristic *h* is *admissible* if:
  - $h(n) \leq c(g^*) - c(n)$

- Heuristic is always less than real cost.

- Admissible heuristics are difficult to find!

A* Properties

- Complete
  - Yes
- Optimal
  - Yes
- Time Complexity
  - $O(b^d)$
- Space Complexity
  - $O(b^d)$

A* Optimality

A* and NLP

Joint A* CCG Parsing and Semantic Role Labeling

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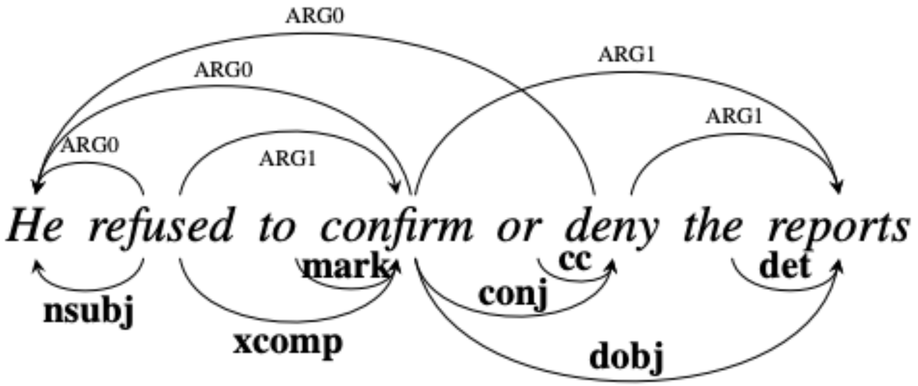
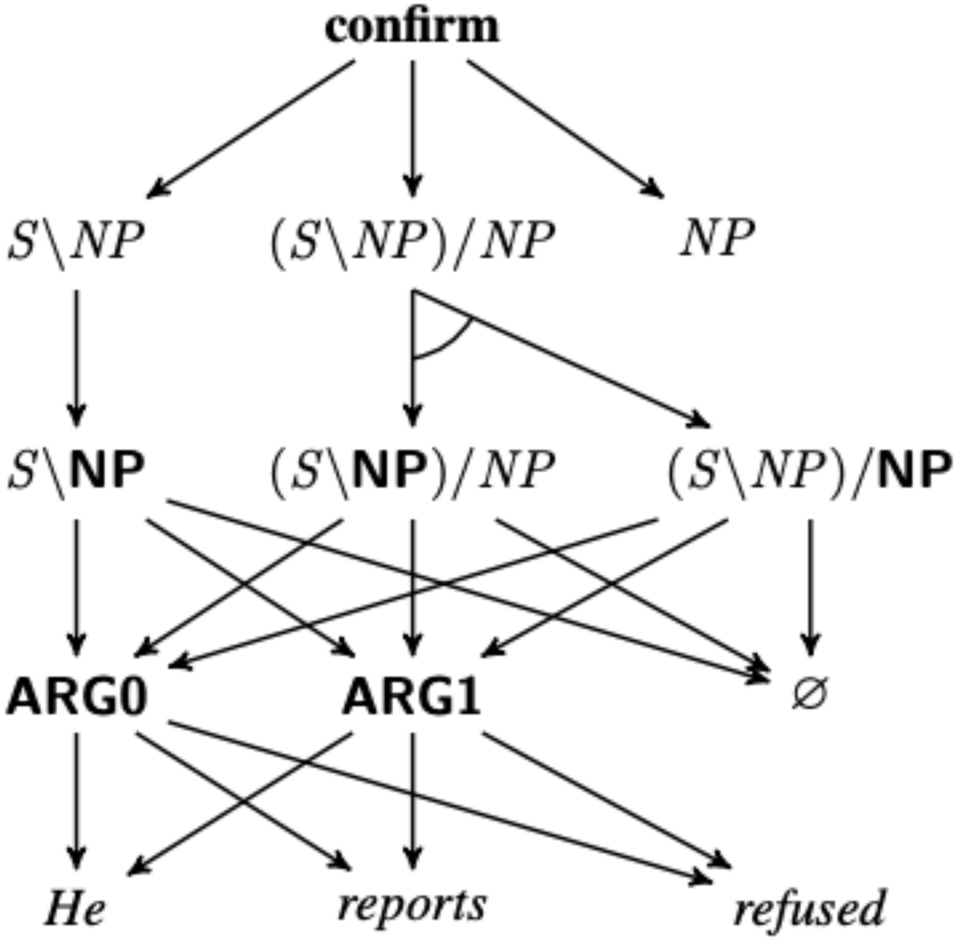


Figure 1: Mismatch between syntactic and semantic dependencies.

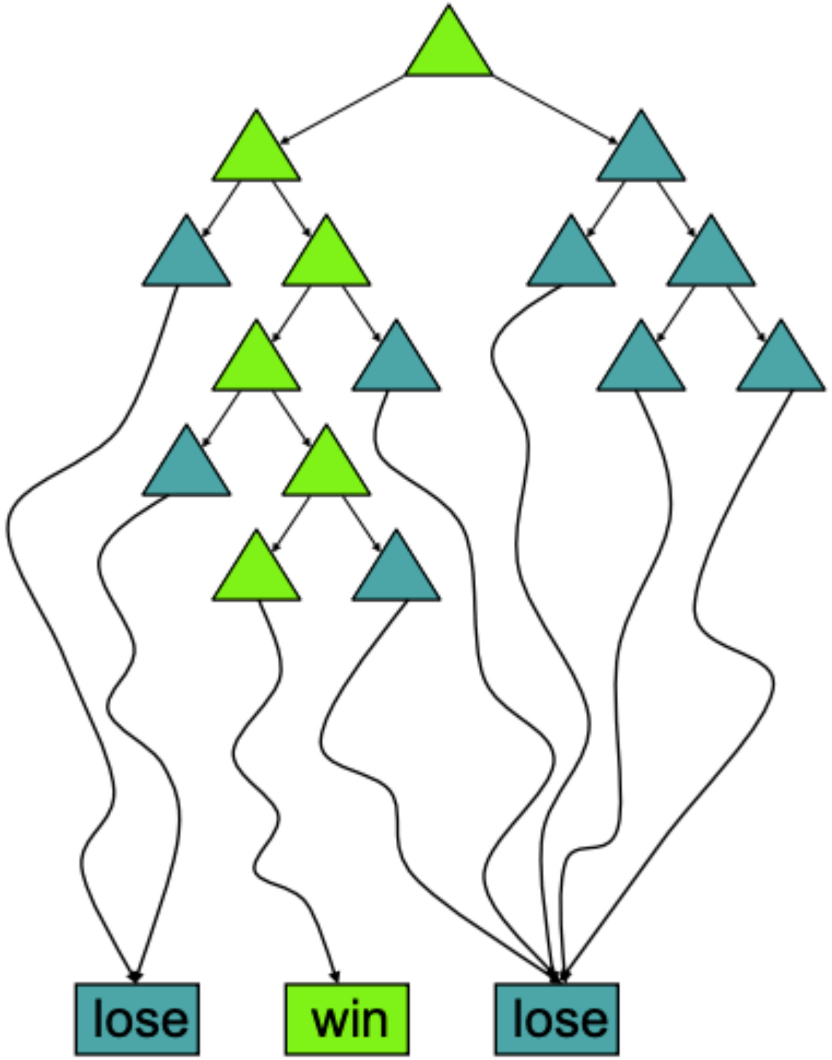


Single-Agent

- One Agent Acting in Environment
  - Deterministic
  - Fully Observable
  - Discrete Spaces

- Just a Search!

- Decision Trees
  - Costs



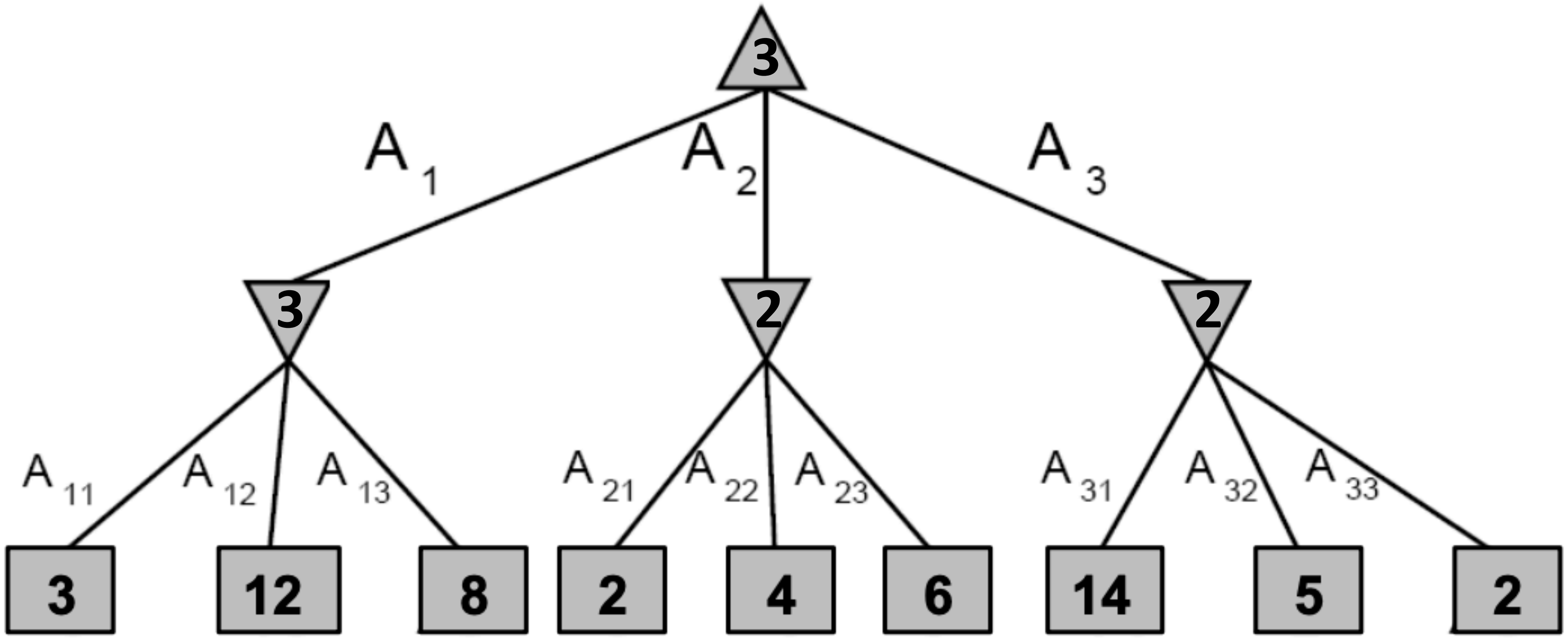
Multi-Agent

- Examples
  - Conversations
  - Most Games
  - Self-Driving
  - Etc.
- Modeling Other Agents

Rational Agents

- Everyone makes the best decision
- Centipede Problem
  - 1981 by Robert Rosenthal
  - $1 Million Dollar Rounds
  - After $10 Million split the Pot

Min Max Algorithm



Player 1

Player 2

Norvig et al. 2009, Artificial Intelligence: A Modern Approach

Min Max Algorithm

- Strategy
  - Traverse to leaf nodes.
  - Alternate between min and max levels.
  - Propagate scores up the tree.
- Implementation
  - DFS or BFS

Min Max Algorithm

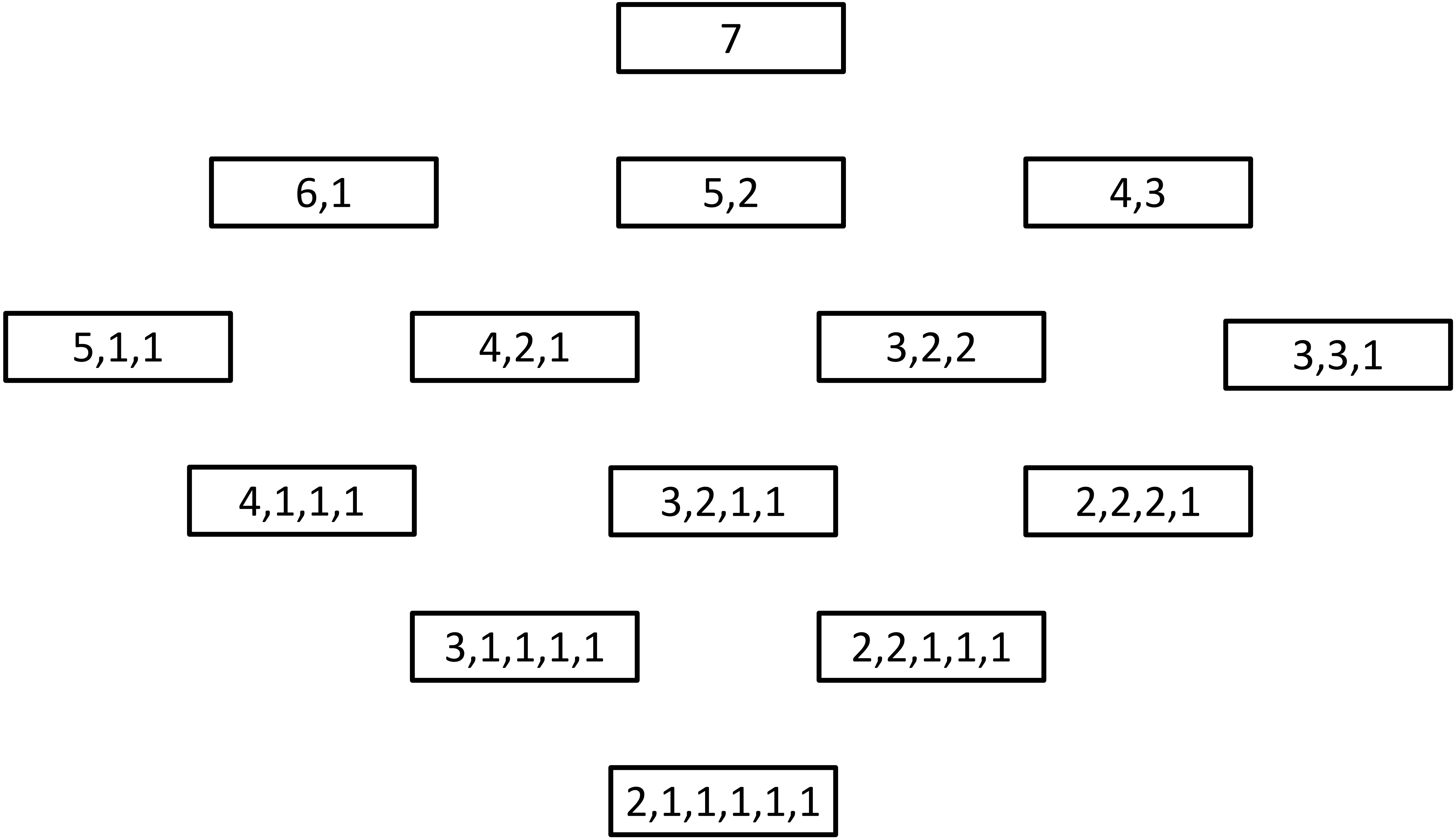
- Complete
  - Yes
- Optimal
  - Yes
- Time Complexity
  - $O(b^m)$
- Space Complexity
  - $O(bm)$

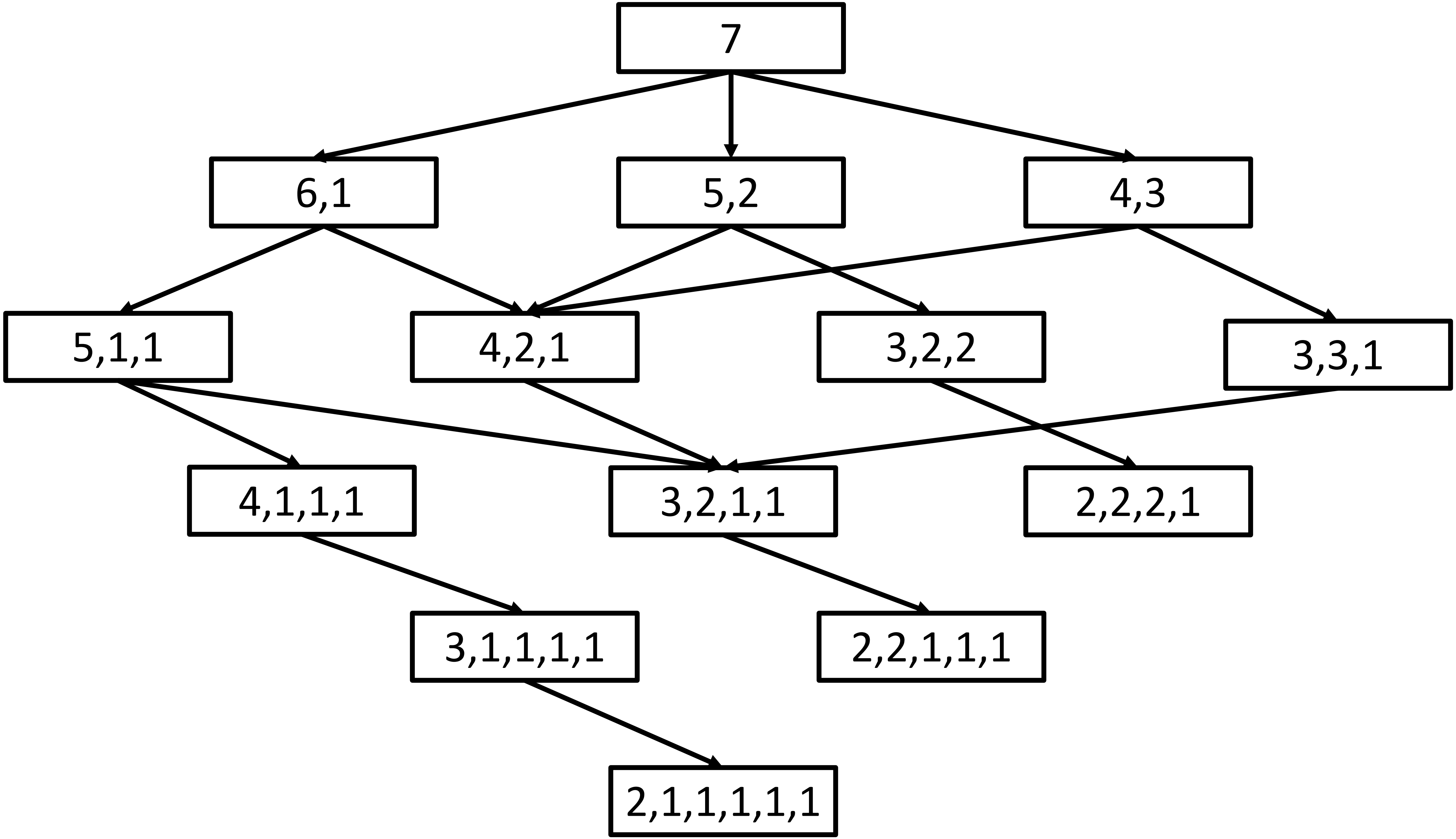
Min Max in the World

- Chess Engines until Recently
- Intermediate Heuristic Calculations
- Alpha-Beta Pruning
- Heuristic Pruning

Today’s Exercise

- Grundy’s Game of Nim
  - 1935 and 1939 by Sprague and Grundy
  - Start with a stack of 7 tiles
  - Split a stack into uneven piles
  - First person who can’t make a move loses
- Draw the Full Game Tree
  - Run the Min-Max Algorithm
  - Determine Optimal Strategy


7
6,1
5,2
4,3
5,1,1
4,2,1
3,2,2
3,3,1
4,1,1,1
3,2,1,1
2,2,2,1
3,1,1,1,1
2,2,1,1,1
2,1,1,1,1,1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3,2,2
3,3,1
4,1,1,1
3,2,1,1
2,2,2,1
3,1,1,1,1
2,2,1,1,1
2,1,1,1,1,1

Sneak Peak

- What happens when actions have probabilistic outcomes?
- Expected Value Trees
  - Markov Decision Processes
  - Bellman Equations
- Dialogue Management with Markov Models