先修基础知识

Topic 1

Problem Solution

Yang Muyun

MOE-MS Joint Key Lab of NLP&Speech

School of Computer Science and Technology, HIT

A problem

$$\begin{array}{rcccc} & A & B & C \\ + & C & D & C \\ \hline A & B & C & D \end{array}$$

109

989

1098

Contents

1. **State, Operation and Target**
2. **State Graph**
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State, Operation & Target

- Three Characteristics in problems
  - Eg：Three cannibals and three missioners want to cross a river by a boat for only two passengers. On either bank, the priests will be killed if there are more savages. How to cross the river？
- State
  - Number of priest at river banks;
  - Number of savages at river banks;
  - Which bank the boat is available at;

State, Operation&Target

- Initial State

	左　岸	右　岸
传教士(M)	3	0
野　人(C)	3	0
船　　(B)	有	无

- A Simpler Graph

	左　　岸
传教士(M)	3
野　人(C)	3
船　　(B)	有

State, Operation&Target

- State Space
  - Missioners on L-bank: 0，1，2，3
  - Cannibals of L-bank: 0，1，2，3
  - Boat: Left or Right *bank*
  - total：4*4*2=32 situations
- Illegal states: when C kill M
  - (1+2+3)*2=***12*** (think why)
- Impractical states: 4 (why)
  - (3,3,0)/(0,0,1)/(3,0,1)/(0,3,0) (for the left bank)

State, Operation&Target

All acceptable states: 16

可能达到的合法状态

左岸			右岸		
M	C	B	M	C	B
0	1	有	3	2	无
0	2	有有	3	1	无无
0	3	有	3	0	无
1	1	有	2	2	无
2	2	有	1	1	无
3	1	有	0	2	无
3	2	有有	0	1	无无
3	3	有	0	0	无
0	0	无	3	3	有
0	1	无无	3	2	有有
0	2	无	3	1	有
1	1	无	2	2	有
2	2	无	1	1	有
3	0	无	0	3	有
3	1	无无	0	2	有有
3	2	无	0	1	有

State, Operation&Target

- **Operation: what cause the state to change**
  - Operators and Descriptions:

1. 将 1 个传教士从左岸运到右岸
2. 将 1 个野人从左岸运到右岸
3. 将 1 个传教士和 1 个野人从左岸运到右岸
4. 将 2 个传教士从左岸运到右岸
5. 将 2 个野人从左岸运到右岸
6. 将 1 个传教士从右岸运到左岸
7. 将 1 个野人从右岸运到左岸
8. 将 1 个传教士和 1 个野人从右岸运到左岸
9. 将 2 个传教士从右岸运到左岸
10. 将 2 个野人从右岸运到左岸

State, Operation&Target

- Target: the desired state by applying operations

	左　岸	右　岸
传教士(M)	0	3
野　人(C)	0	3
船　(B)	无	无

State, Operation&Target

A Solution to MC problem

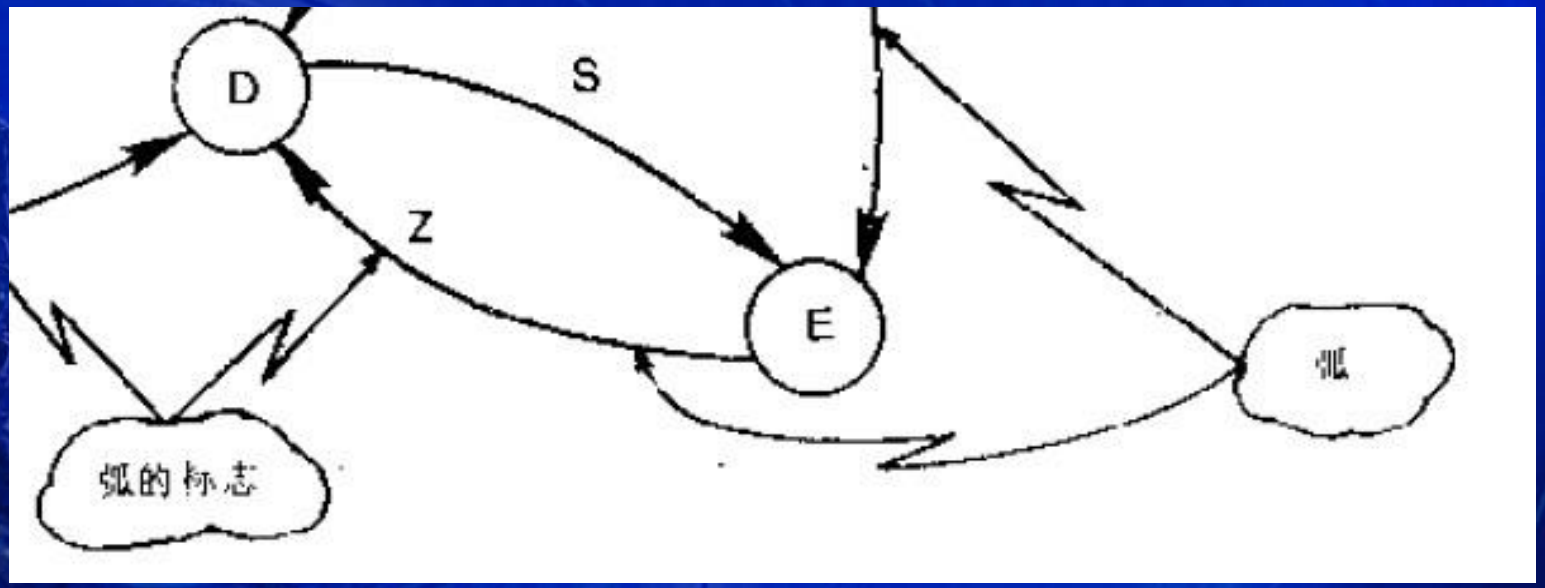
种解答

解　　答	状态					
	左岸			右岸		
	M	C	B	M	C	B
初始位置	3	3	有	0	0	无
将1个传教士和1个野人从左岸运到右岸	2	2	无	1	1	有
将1个传教士从右岸运到左岸	3	2	有	0	1	无
将2个野人从左岸运到右岸	3	0	无	0	3	有
将1个野人从右岸运到左岸	3	1	有	0	2	无
将2个传教士从左岸运到右岸	1	1	无	2	2	有
将1个传教士和1个野人从右岸运到左岸	2	2	无	1	1	无
将2个传教士从左岸运到右岸	0	2	无	3	1	有
将1个野人从右岸运到左岸	0	3	有	3	0	无
将2个野人从左岸运到右岸	0	1	无	3	2	有
将1个传教士从右岸运到左岸	1	1	有	2	2	无
将1个传教士和1个野人从左岸运到右岸	0	0	无	3	3	有

注：M 传教士　C 野人　B 船

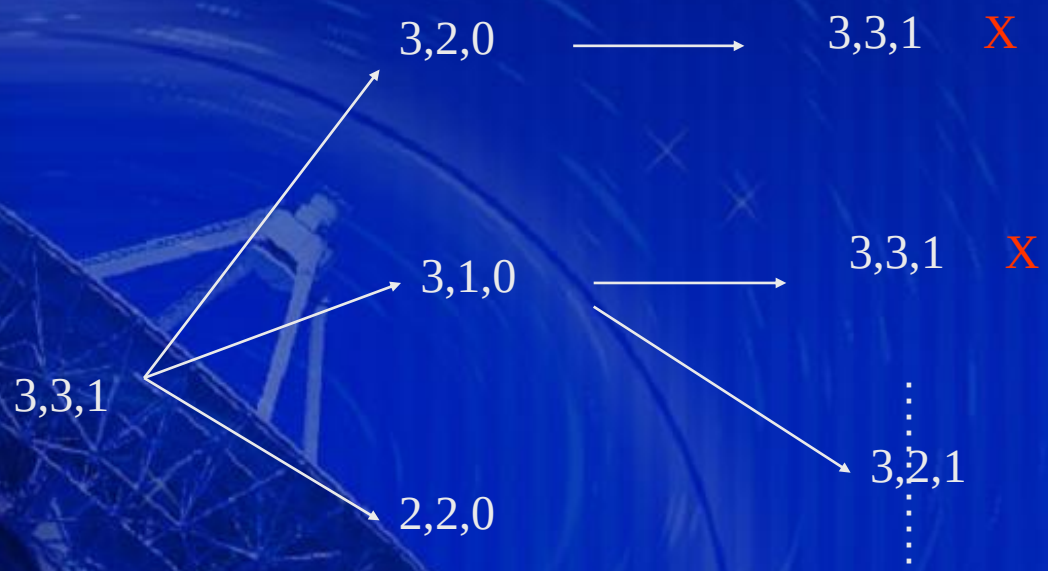
State Graph

- Definition for Graph
  - Composed by ***dot*** and ***arc***
  - Not function graph or data graph
- Directed & Undirected Graph
  - *arc representing operation*



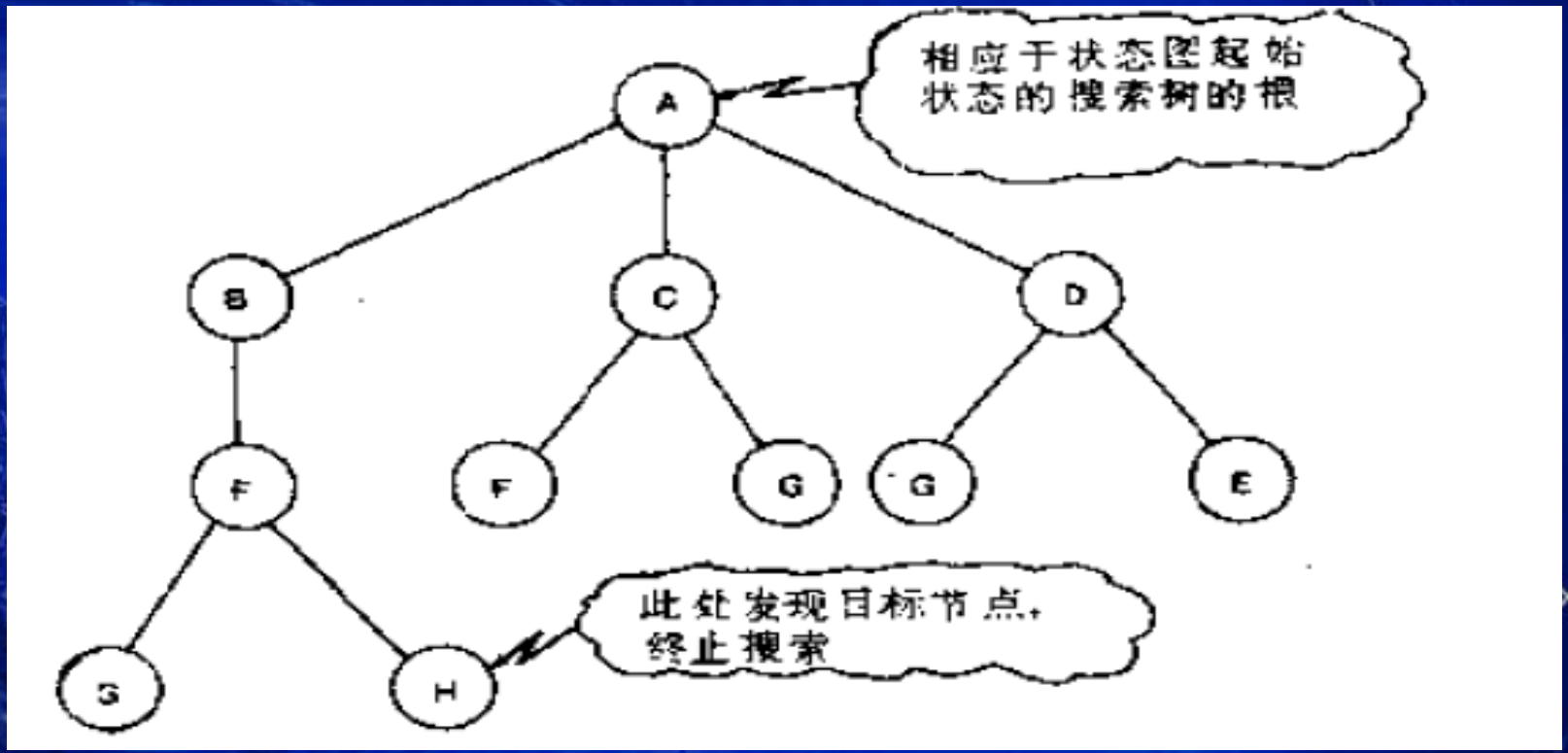
State Graph

Directed graph represented by *Tree*



State Graph Search

- Search Tree
  - Root node: initial state
  - Leaf node: where targets exist



State Graph Search

- Problem solution by tree searching
  - Each tree node represents a state;
  - Root node: initial state
  - Search: expand children nodes from the father node according to conditions, i.e. node expansion corresponds to state search;
  - Node expansion sequence represents search strategy;
  - When the target node is expanded, the solution is found;

State Graph Search

- Width-first search
  - 首先扩展根节点
  - 接着扩展根节点的所有后继节点
  - 然后再扩展后继节点的后继，依此类推
  - 在下一层任何节点扩展之前搜索树上的本层深度的所有节点都已经被扩展
- Performance
  - 总能找到一个解
  - 如果每步扩展的耗散相同时，广度优先搜索能找到最优解
  - 内存消耗是比执行时间消耗更大的问题
  - 指数级的时间消耗

State Graph Search

- Depth-first search
  - 总是扩展搜索树的当前扩展分支(边缘)中最深的节点
  - 搜索直接伸展到搜索树的最深层，直到那里的节点没有后继节点
  - 那些没有后继节点的节点扩展完毕就从边缘中去掉
  - 然后搜索算法回退下一个还有未扩展后继节点的上层节点继续扩展
- Performance
  - 内存需求少—如分支因子=b/最大深度=m的状态空间深度优先搜索只需要存储bm+1个节点(比较广度优先 $O(b^{d+1})$)
  - 不是完备的 / 不是最优的
  - 最坏情况下时间复杂性也很高$O(b^m)$

State Graph Search

- Other search strategies
  - Heuristic search: use heuristics
  - Greedy: hill climbing
  - A* /AO* algorithm

Implementation in Computer

- State: Variable-value

例如，我们可以令 M 代表传教士的数目，用 C 代表野人的数目，如果船在左岸，我们可以令 B 的值为 1（或 Yes），如果船在右岸则 B 值为 0（或 NO），那么下表所列的值：

变　量	值
M	3
C	1
B	1

Implementation in Computer

- Operation： operation/calcualtion

1. 将 1 个传教士从左岸运到右岸	M= M – 1, B= 0
2. 将 1 个野人从左岸运到右岸	S= S - 1, B= 0
3. 将 1 个传教士和 1 个野人从左岸运到右岸	M= M-1, S= S-1, B= 0
4. 将 2 个传教士从左岸运到右岸	M= M - 2, B= 0
5. 将 2 个野人从左岸运到右岸	S= S - 2, B= 0
6. 将 1 个传教士从右岸运到左岸	M= M + 1, B= 1
7. 将 1 个野人从右岸运到左岸	S= S + 1, B= 1
8. 将 1 个传教士和 1 个野人从右岸运到左岸	M= M+1, S= S+1 ,B= 1
9. 将 2 个传教士从右岸运到左岸	M= M+2, B= 1
10. 将 2 个野人从右岸运到左岸	S= S+2, B= 1

Implementation in Computer

- Get target: search among operations

4. B=1 AND((M=3 AND C=1) OR(M=2 AND C=2))	LET M=M−2 LET B=0
5. B=1 AND C>2 AND(M=0 OR M=3	LET C=C−2 LET B=0

Summary

- Problem solution is the process to search for the target.
- Problem solution is often referred as search technology.
- This chapter introduces the problem solution via state space search.

Assignment

```
    A  B  C
+   C  D  C
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  A  B  C  D
```

Illustrate how to solve the above problem by state search method. Please indicate what are the states, operations and targets, specifying the search strategy adopted in your method.