UNDETERMINISTIC SEARCH EXAMPLE

INTRODUCTION TO ARTIFICIAL INTELLIGENT (AI)

REV: 22.04.2024

Example: The goal of the puzzle is to reach the red square from the most upper-lefter square by moving horizantally or vertically up to the number in the square that you are present. However, if you present on a square labelled by 2 and have a legal move, then you may sometimes move only one square. The agent does not remember its past.

Under this conditions, search on tree by using

1. Breadth-First search
2. Greedy search (use Manhattan Distance)

2	1	2
3	1	1
3	3	

Ex 1: Breadth First Search

Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

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Sonuca ulaştıysak ve bu sonuç tek çizgili bir yapraktaysa yani kesin hamlelerden biriyle ulaşılıyorsa burada 1 kademe yukarı çıkabiliriz.

Eğer kesin hamlelerden değil buradaki 2 gibi 1 adım ya da 2 adım attıracak şekildeyse yani çemberli yapraktaysa, yapraktaki kardeşi de onunla beraber yukarı çıkabilmeli tek başına çıkamaz.

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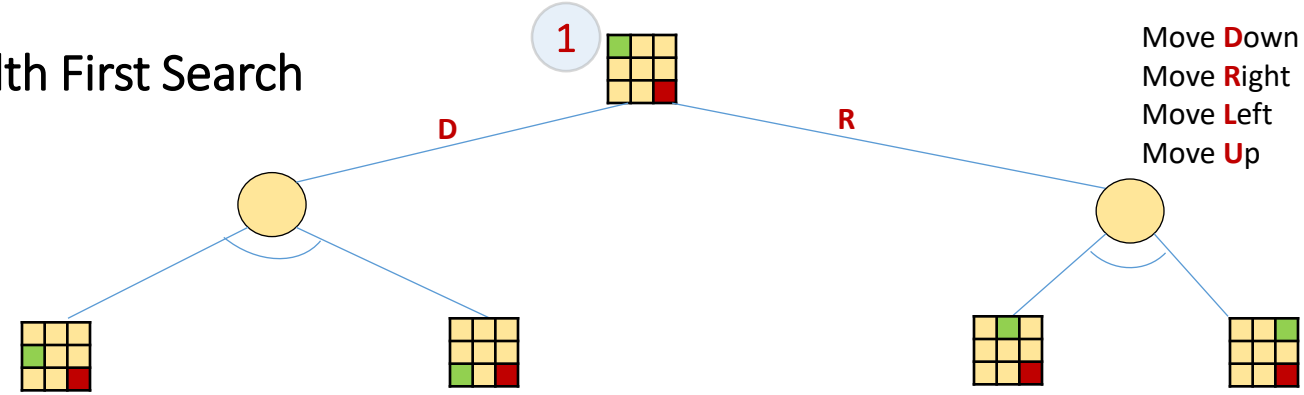

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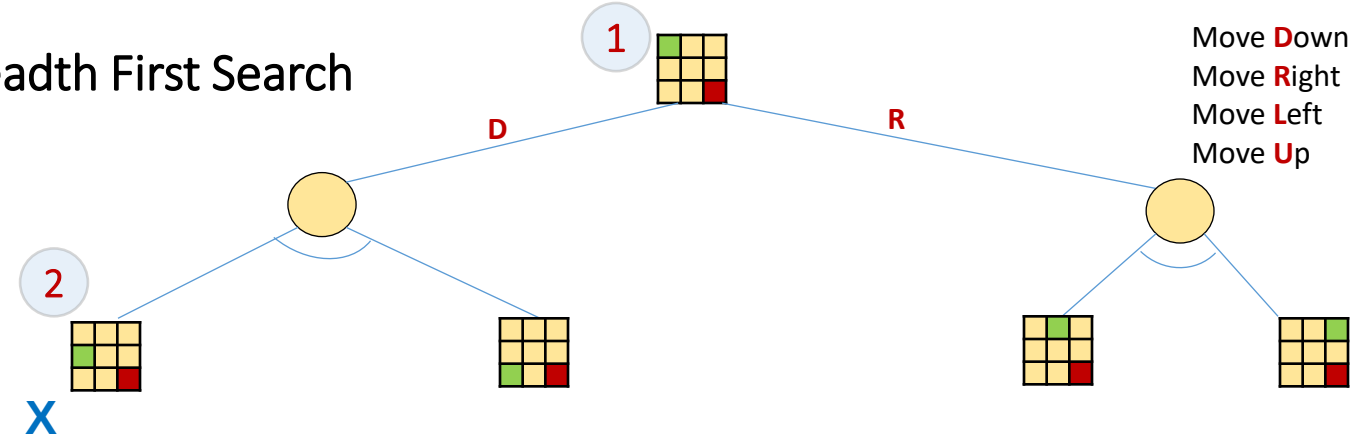

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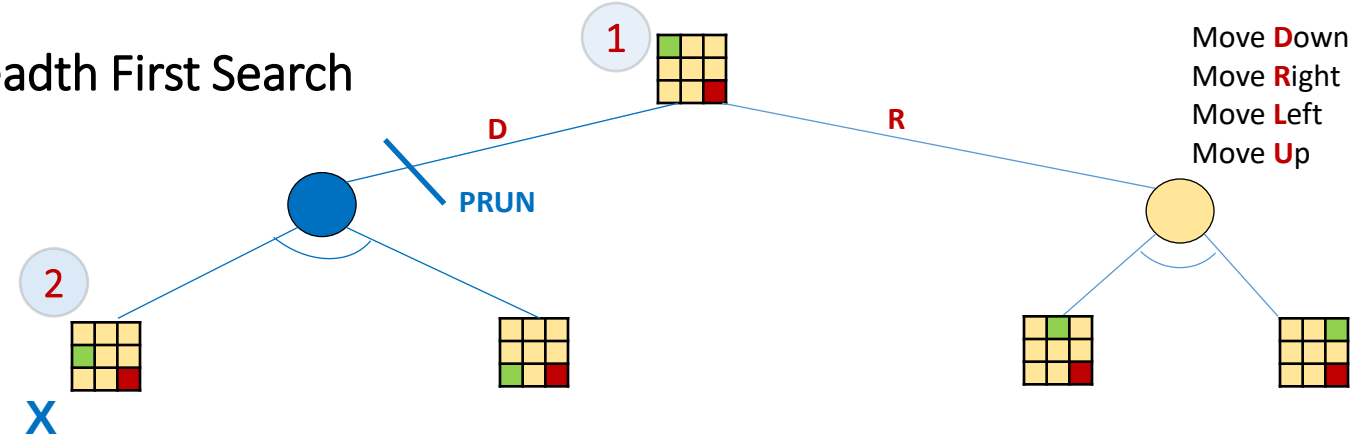

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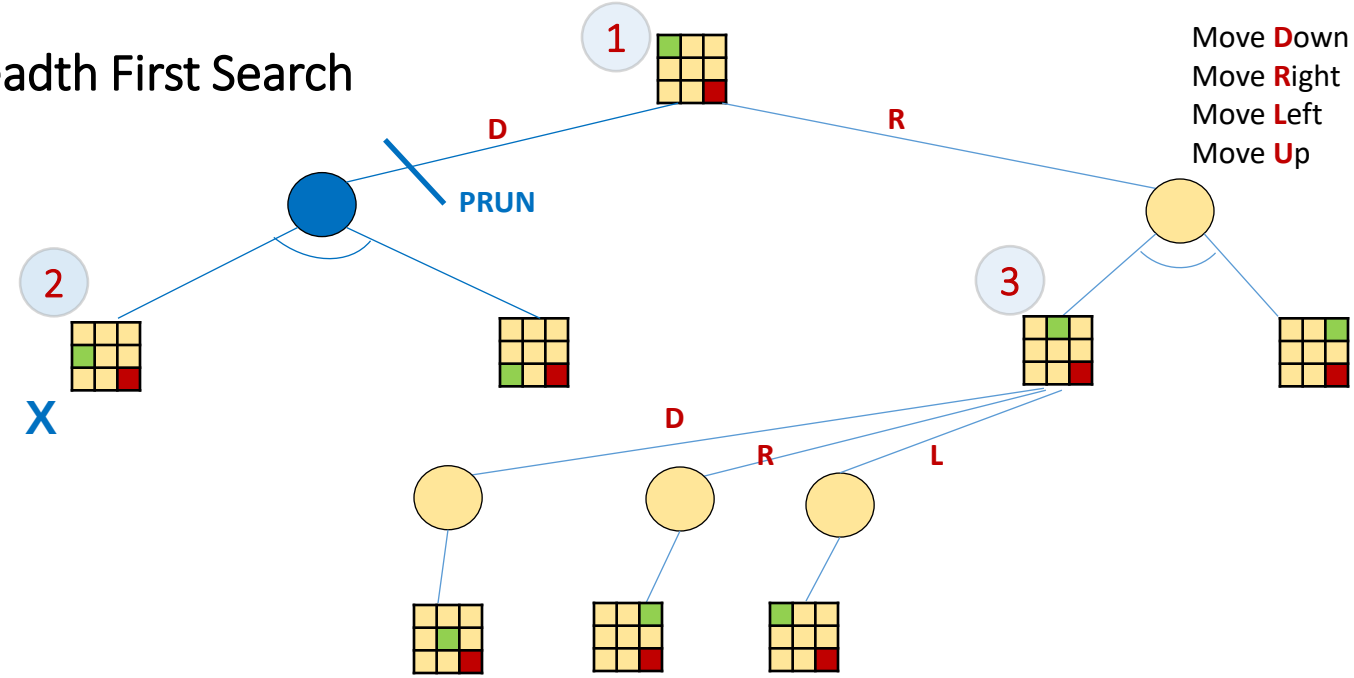

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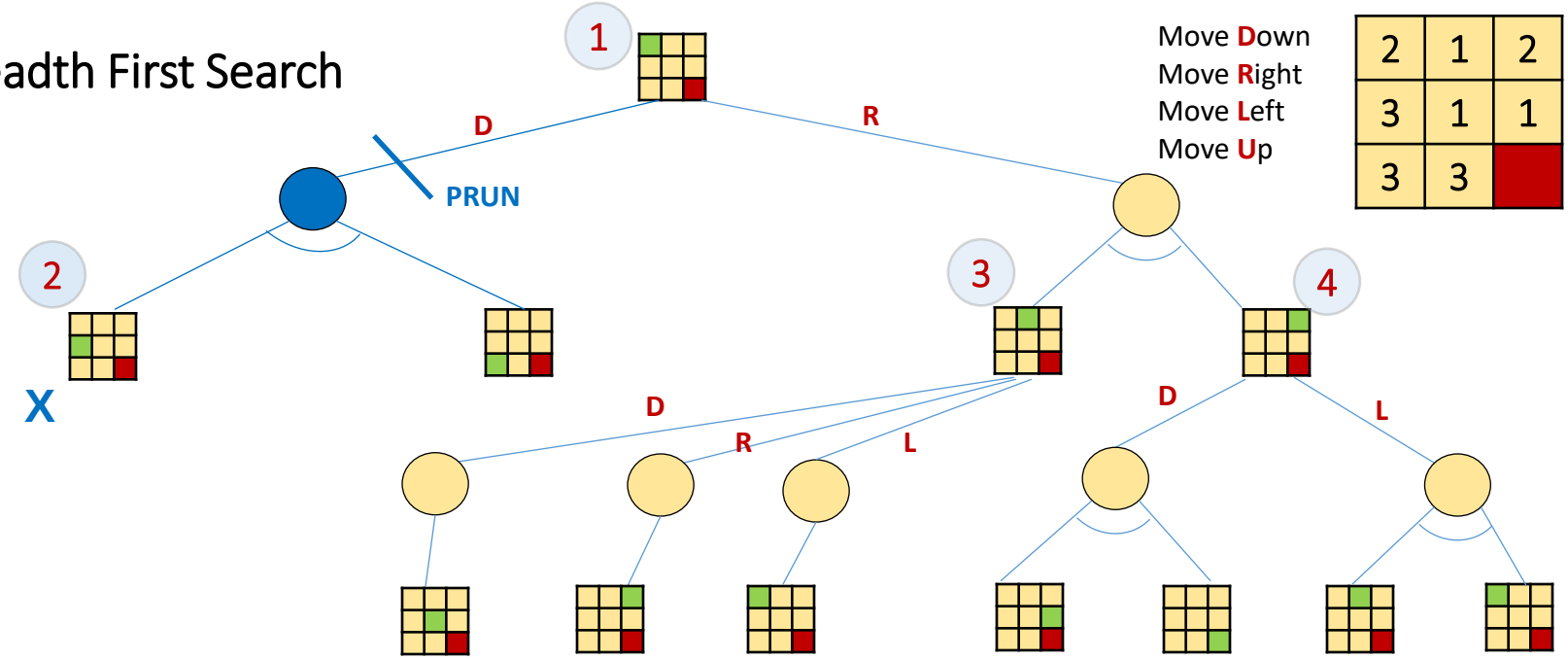

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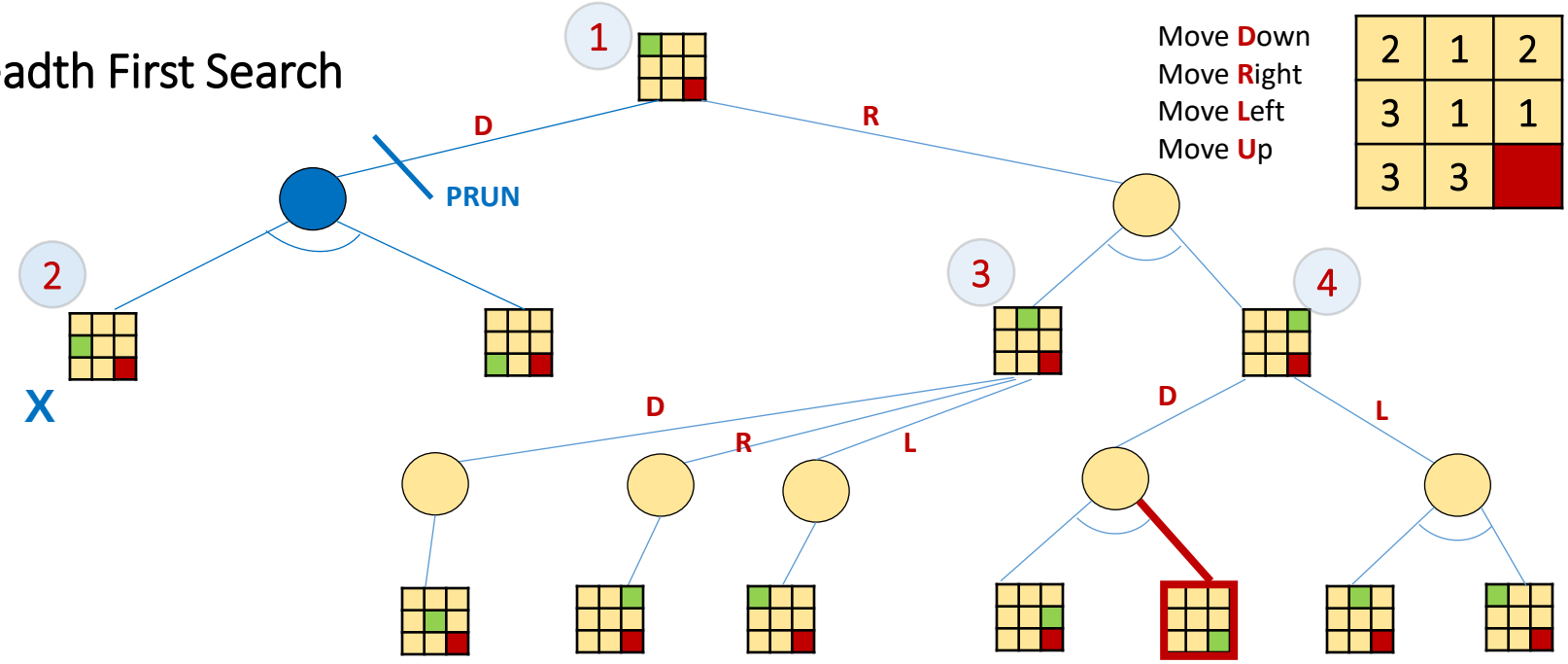

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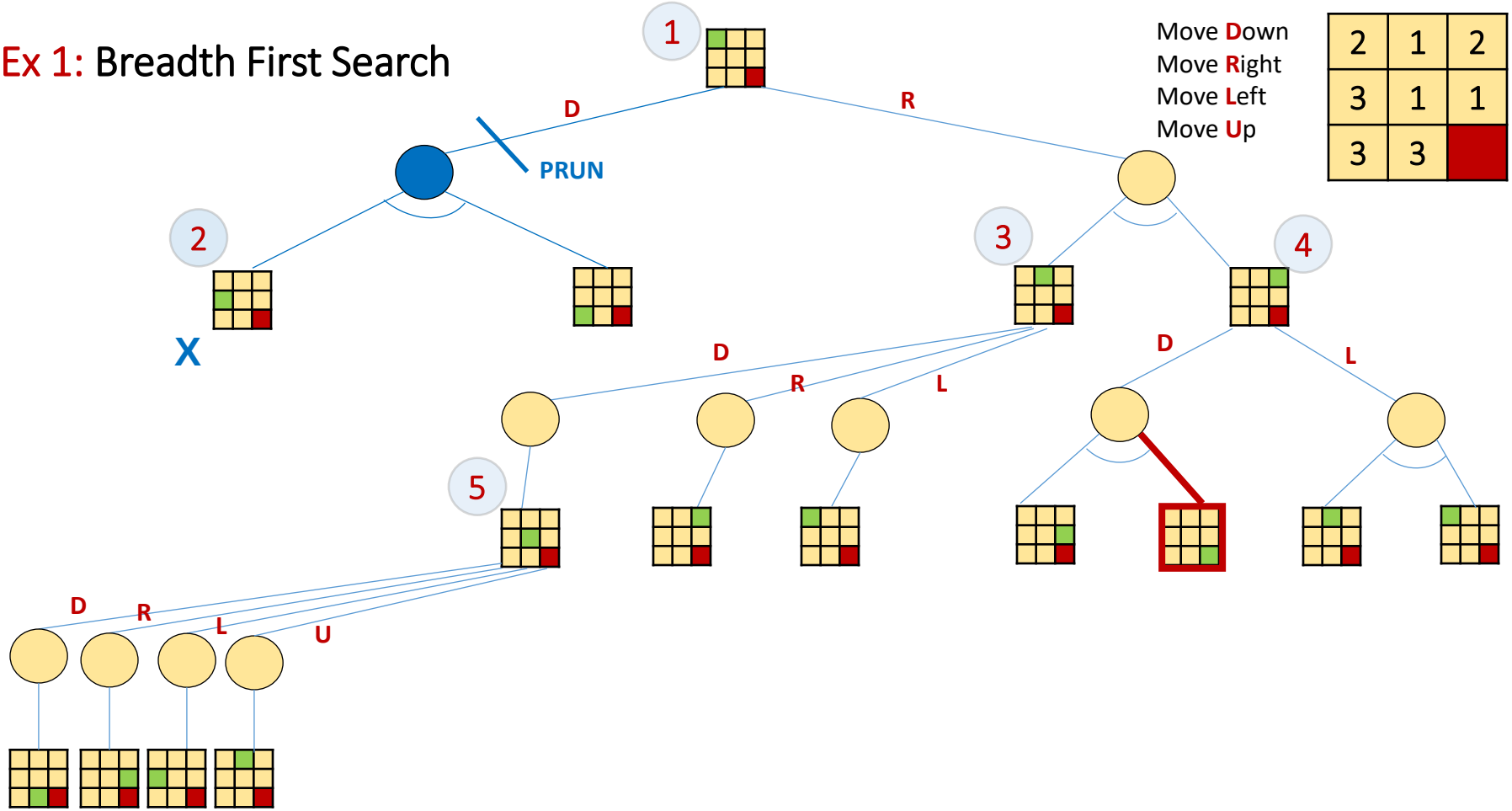

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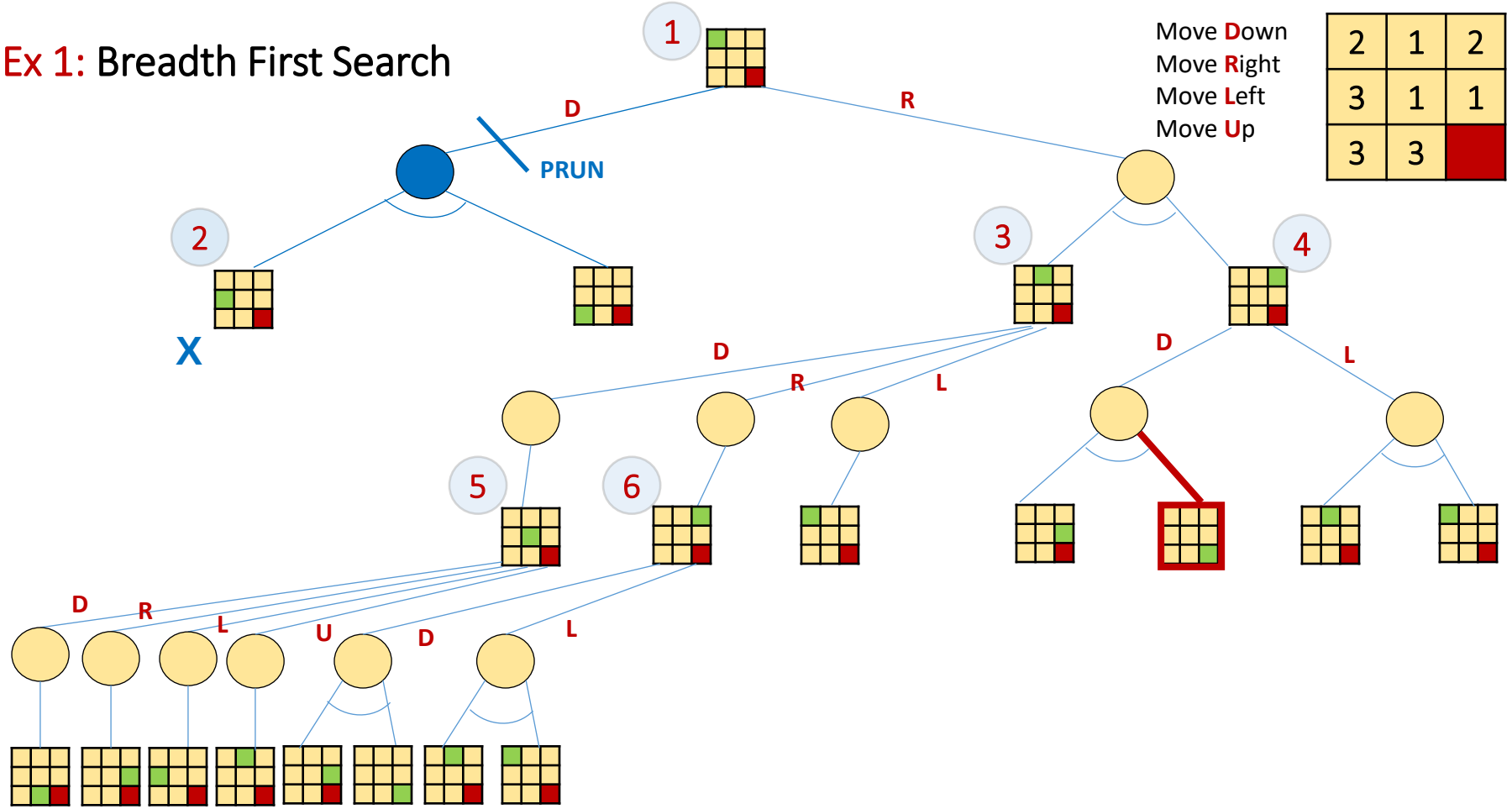

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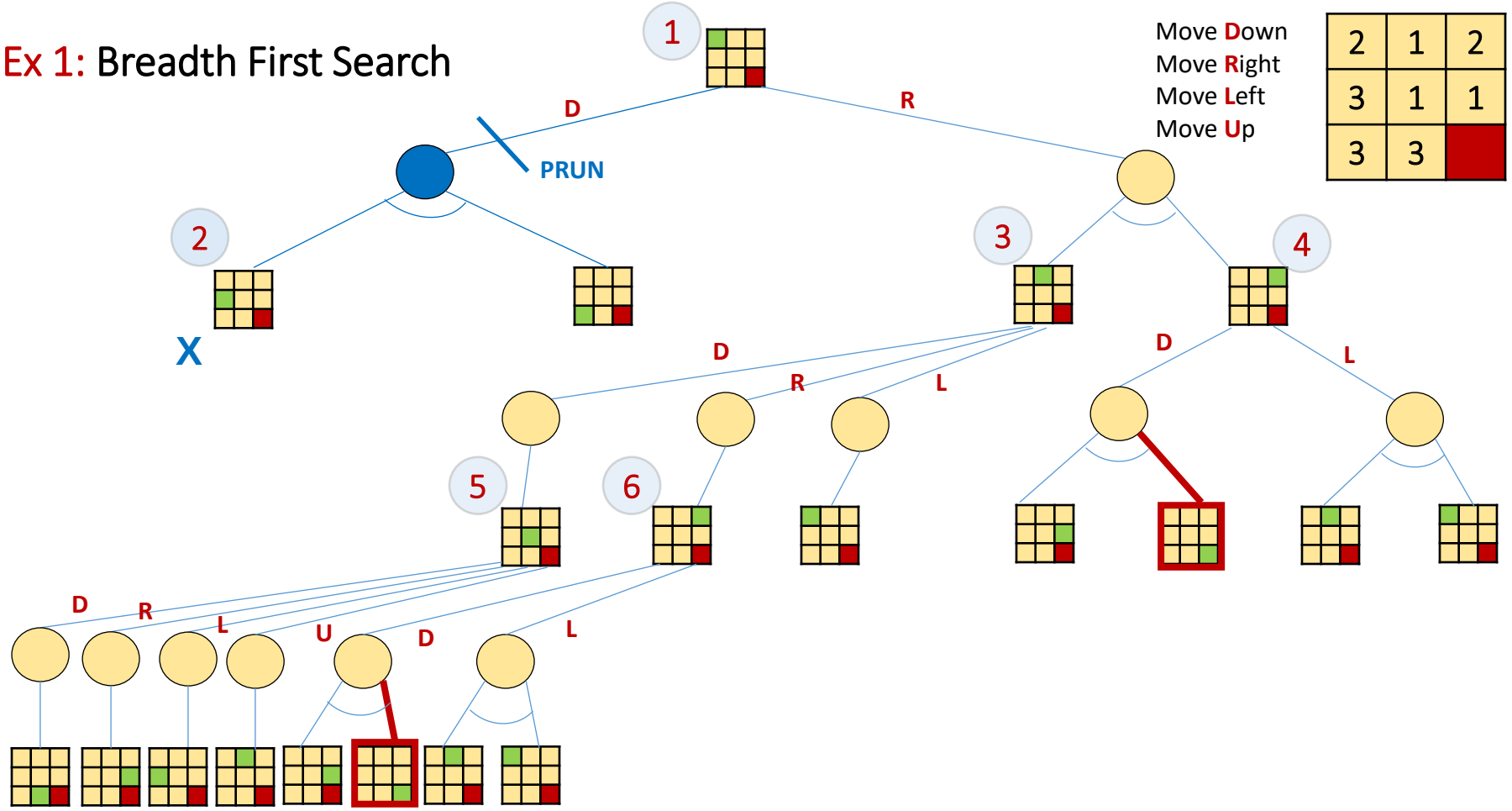

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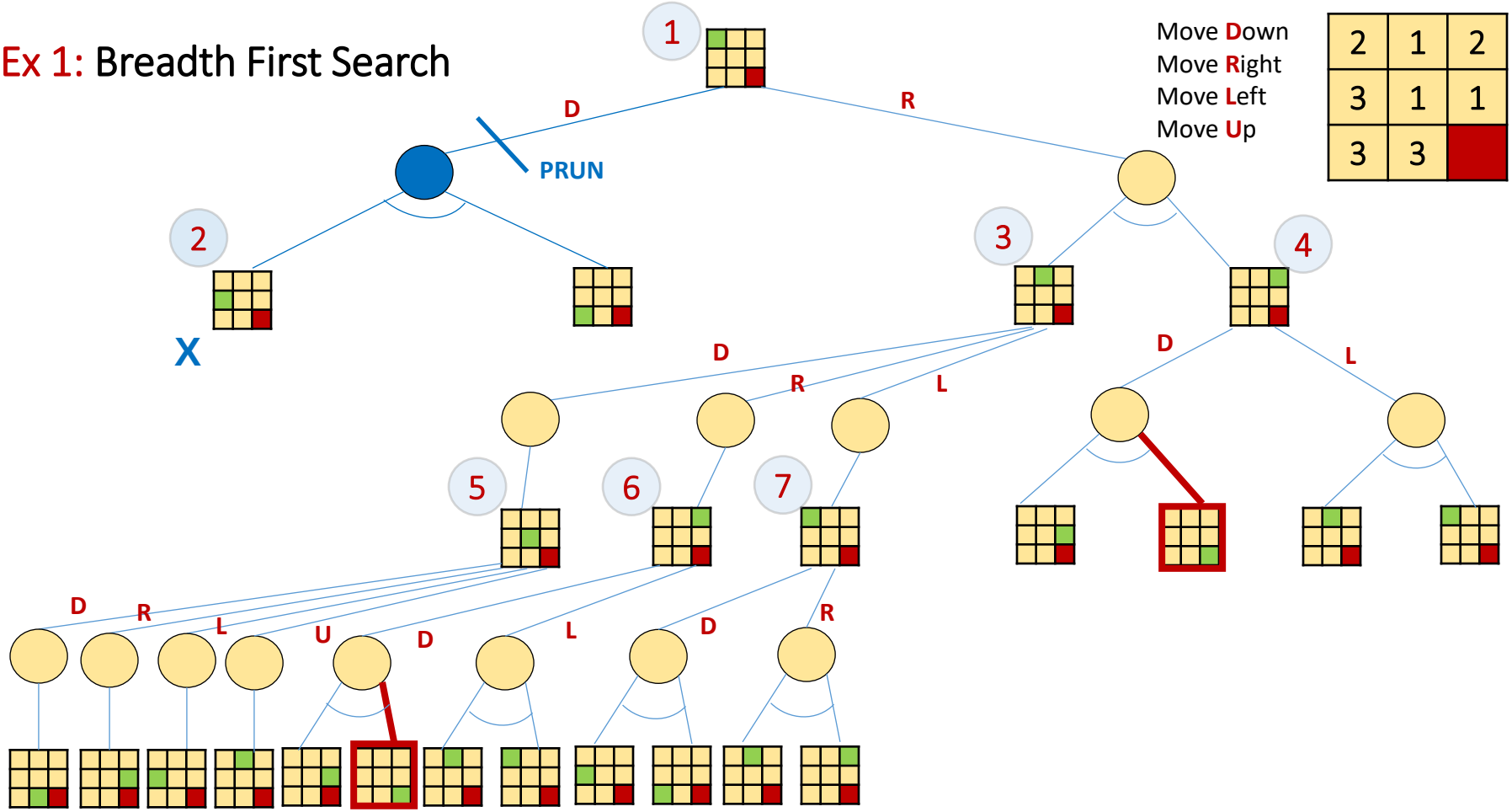

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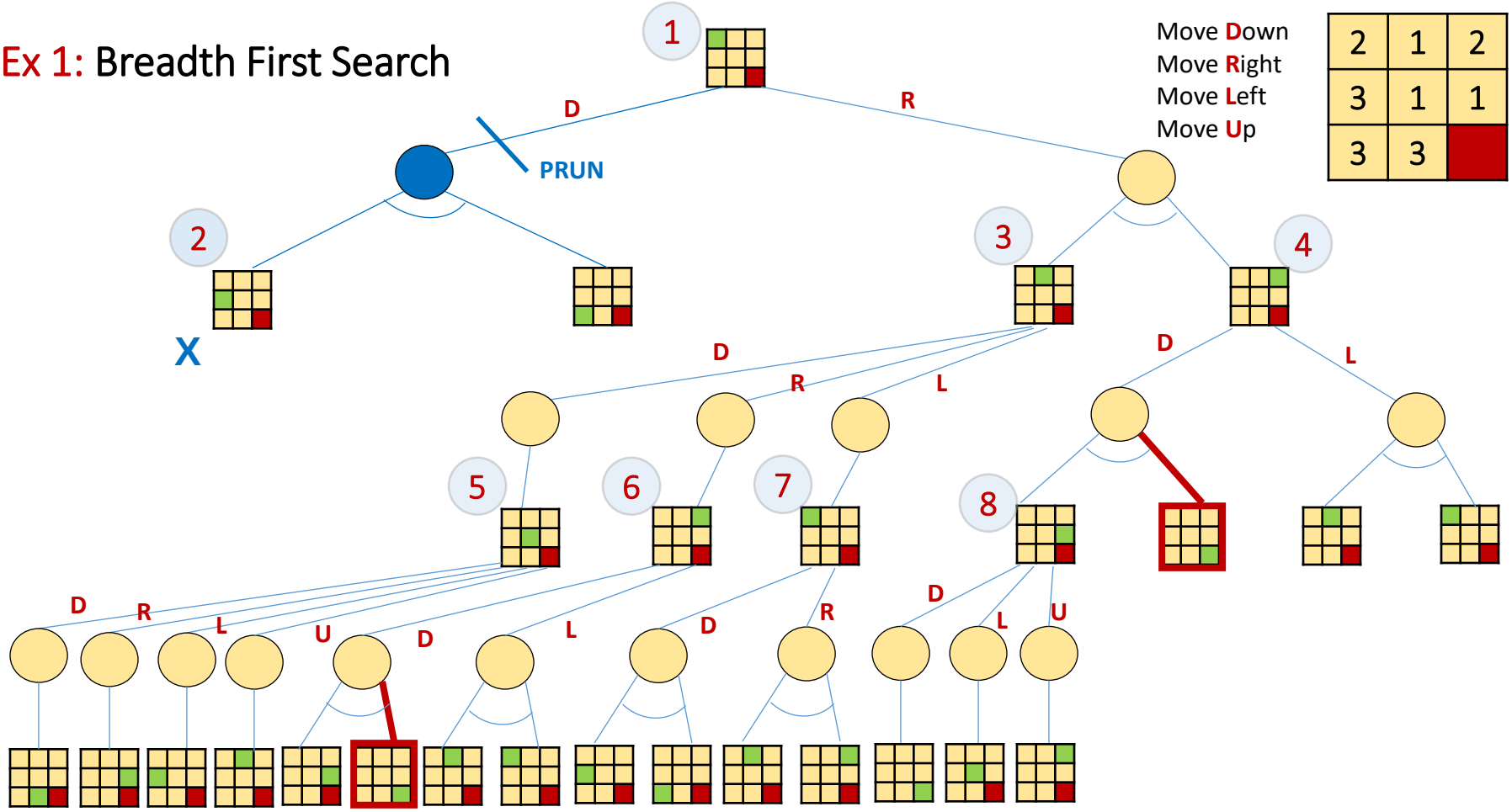

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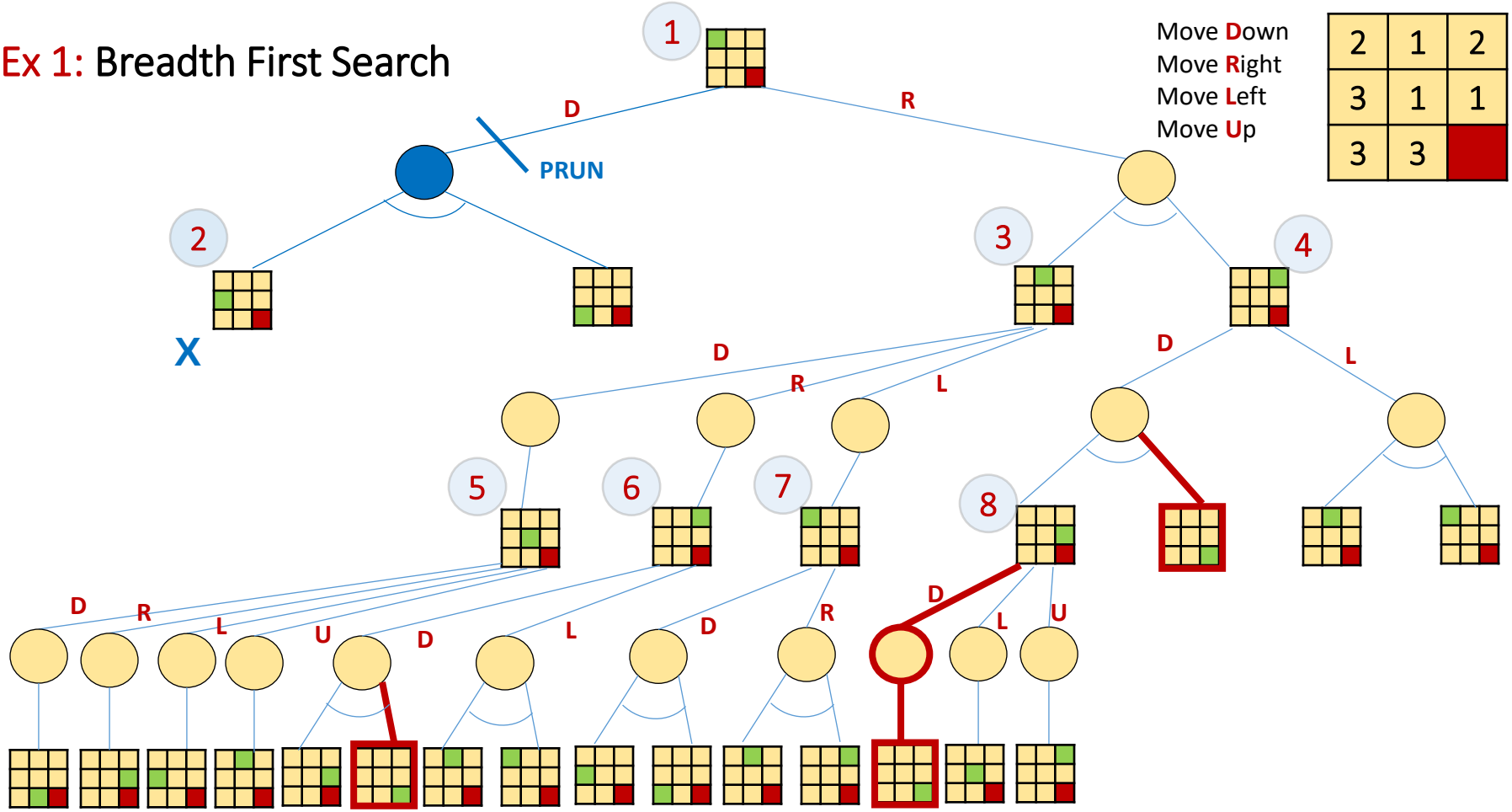

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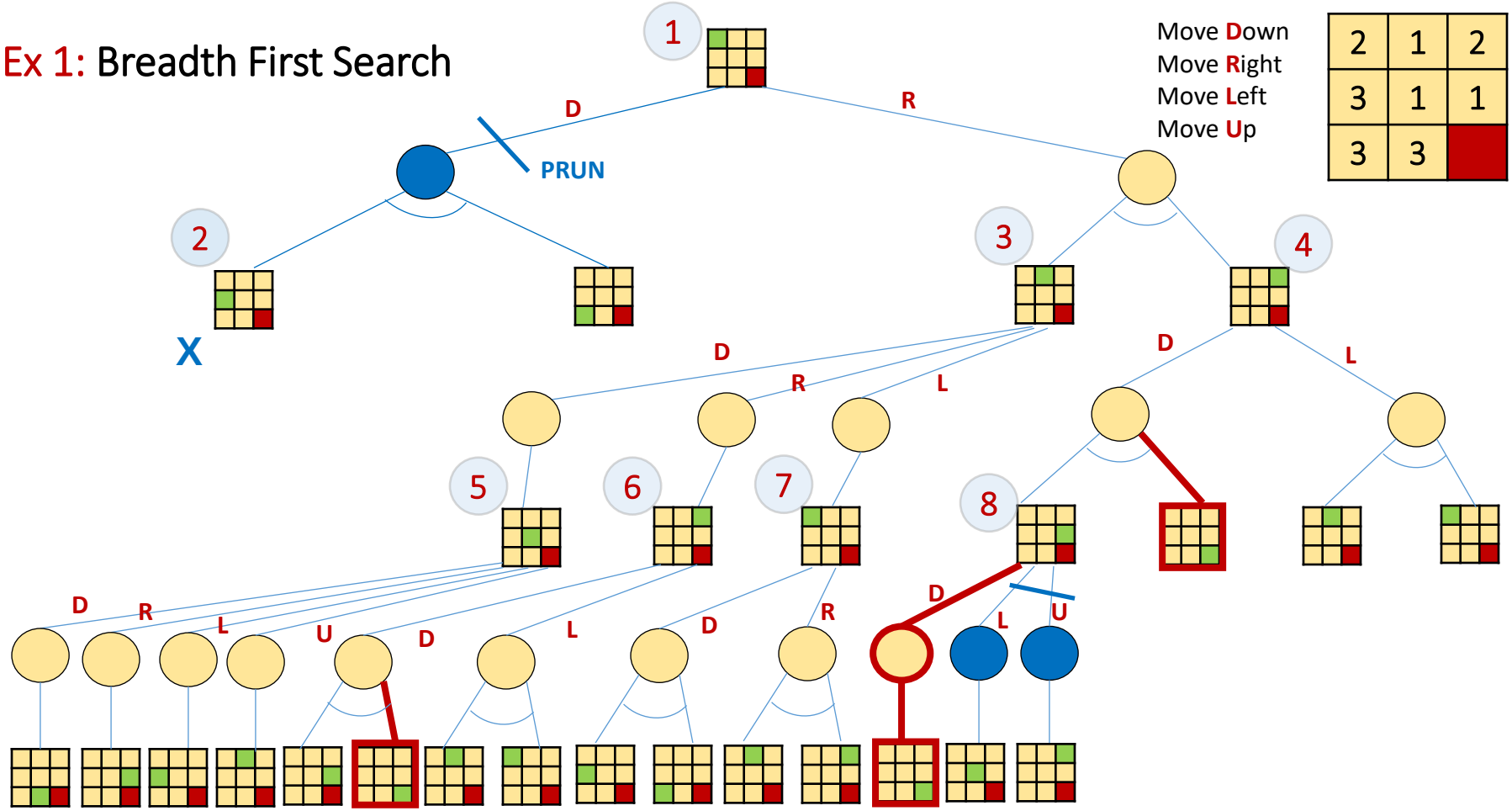

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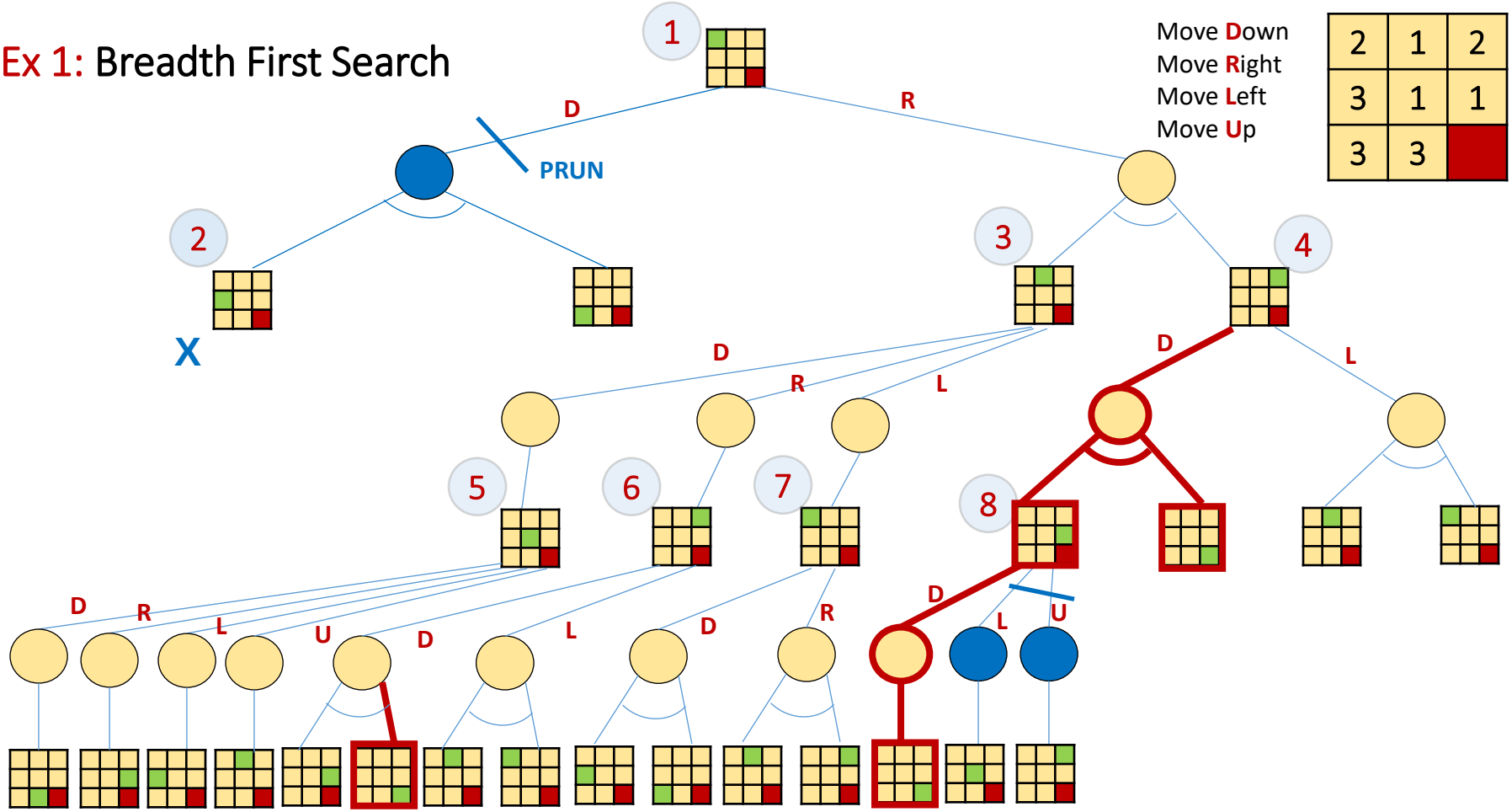

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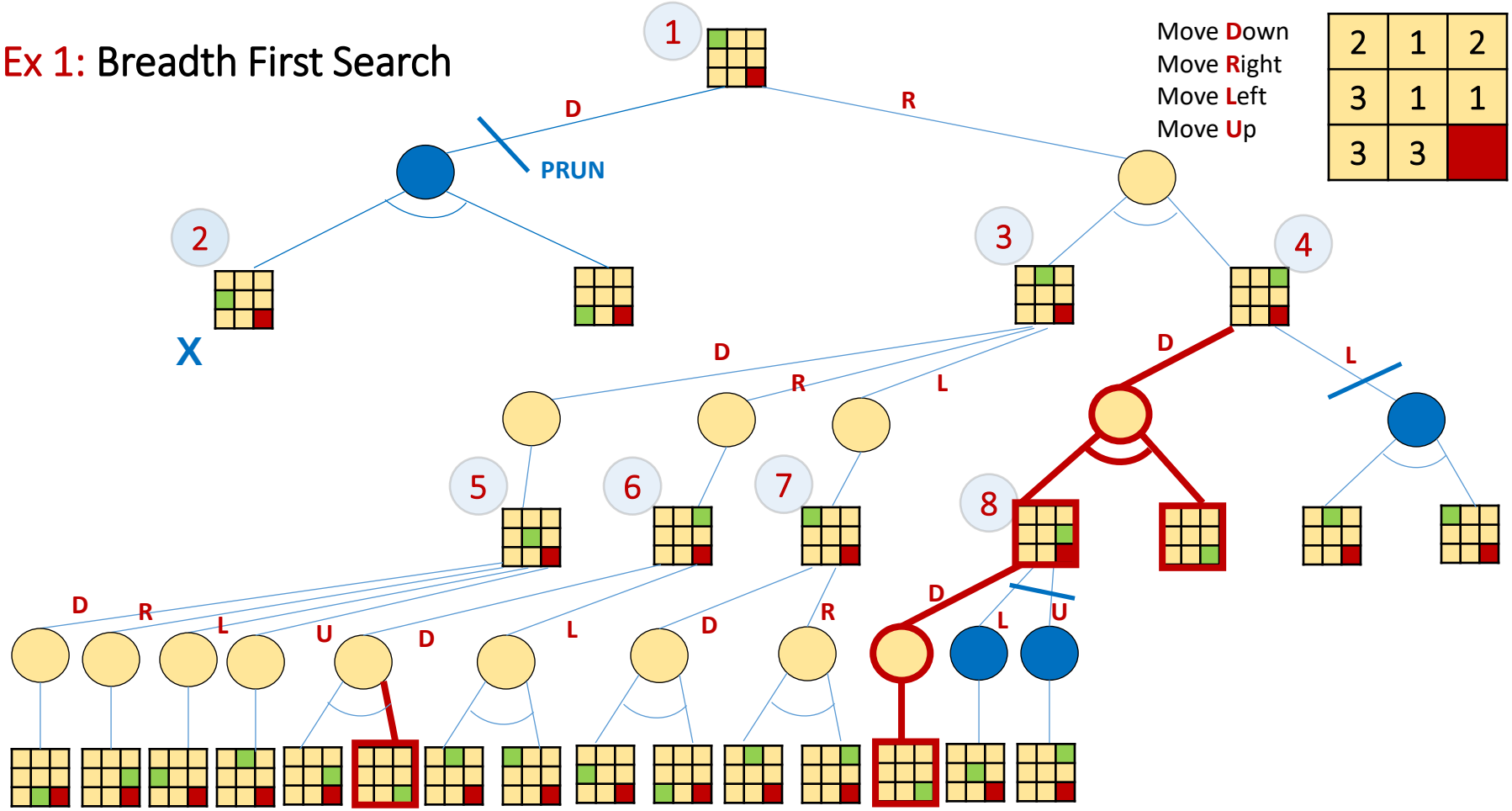

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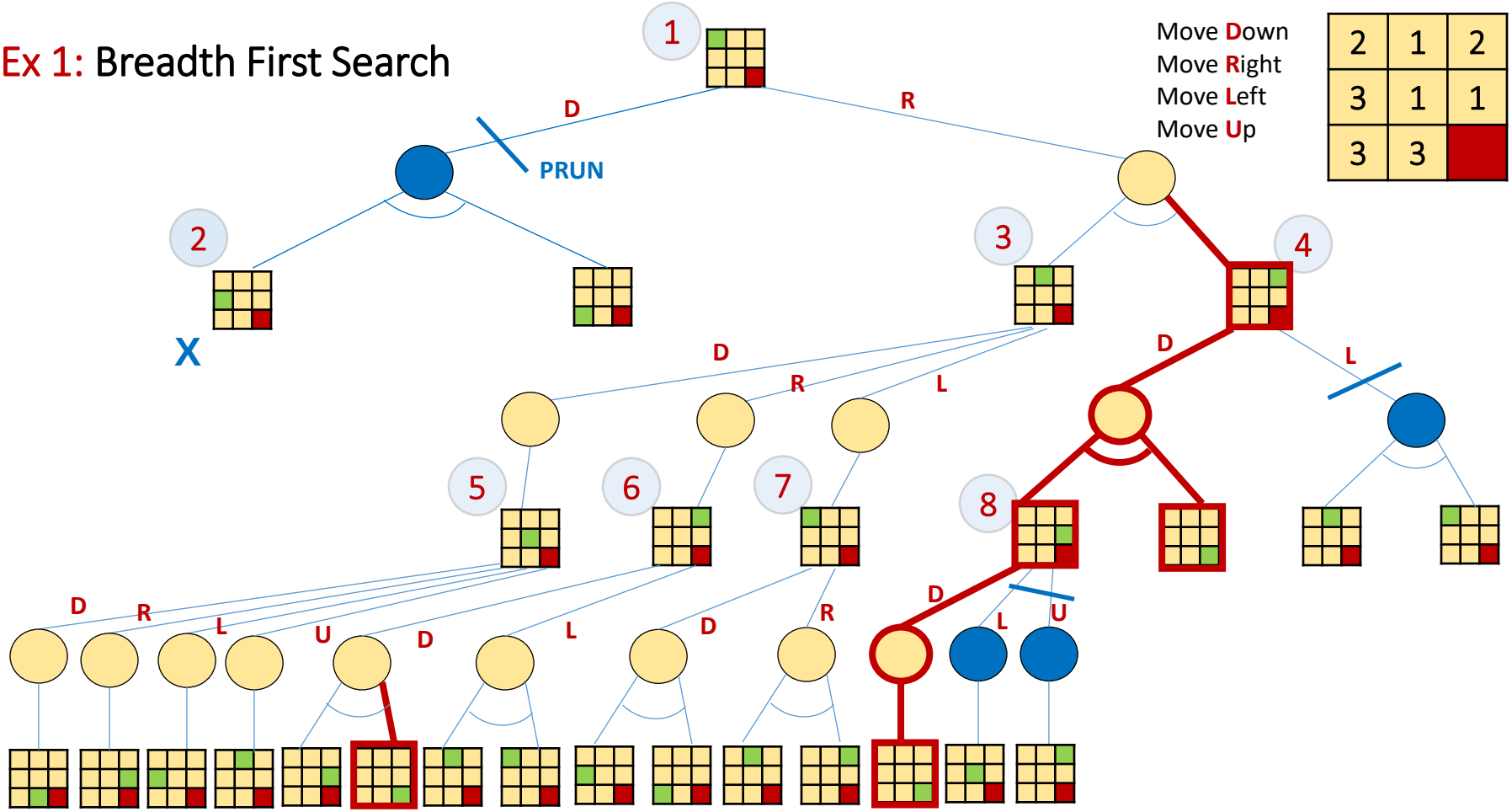

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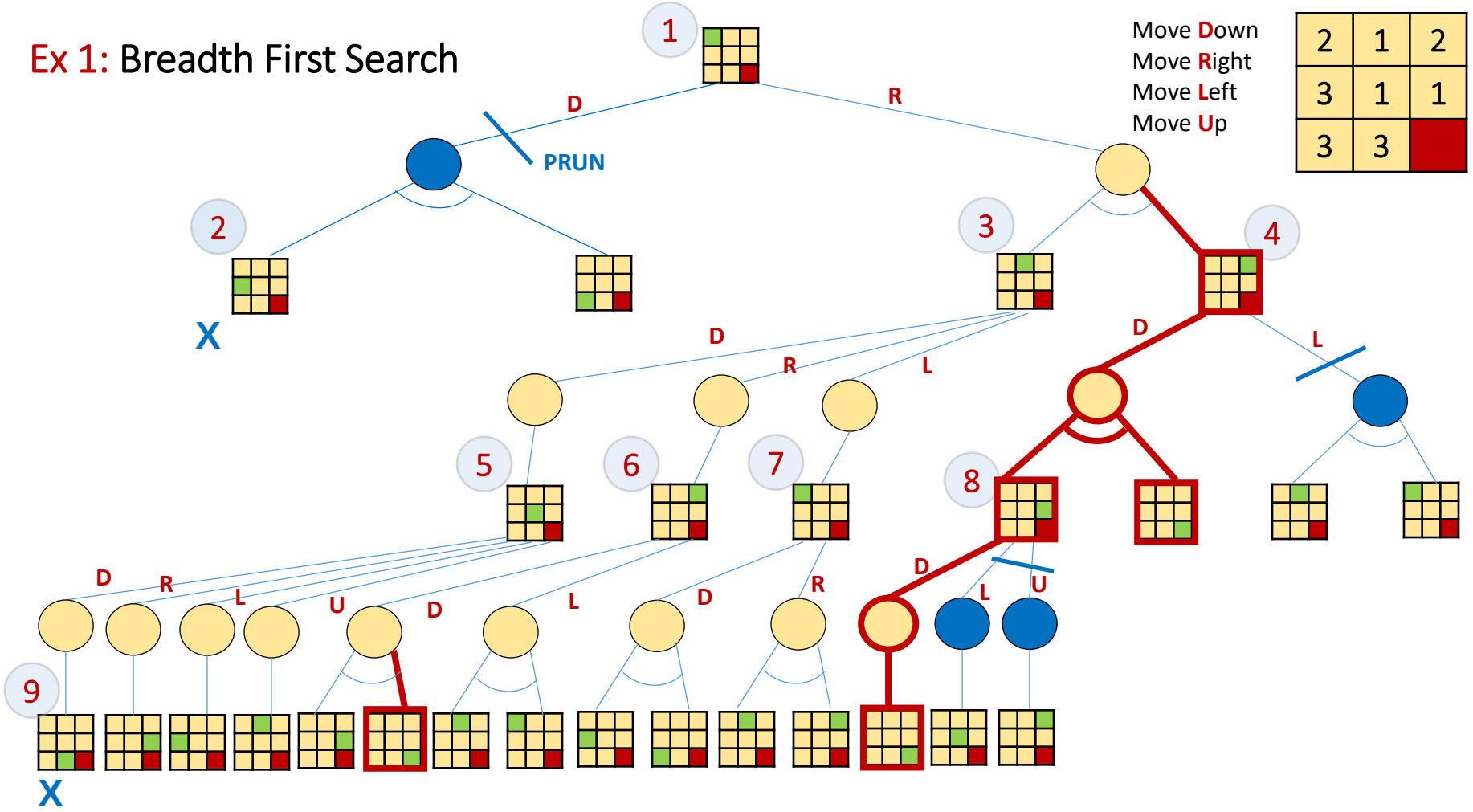

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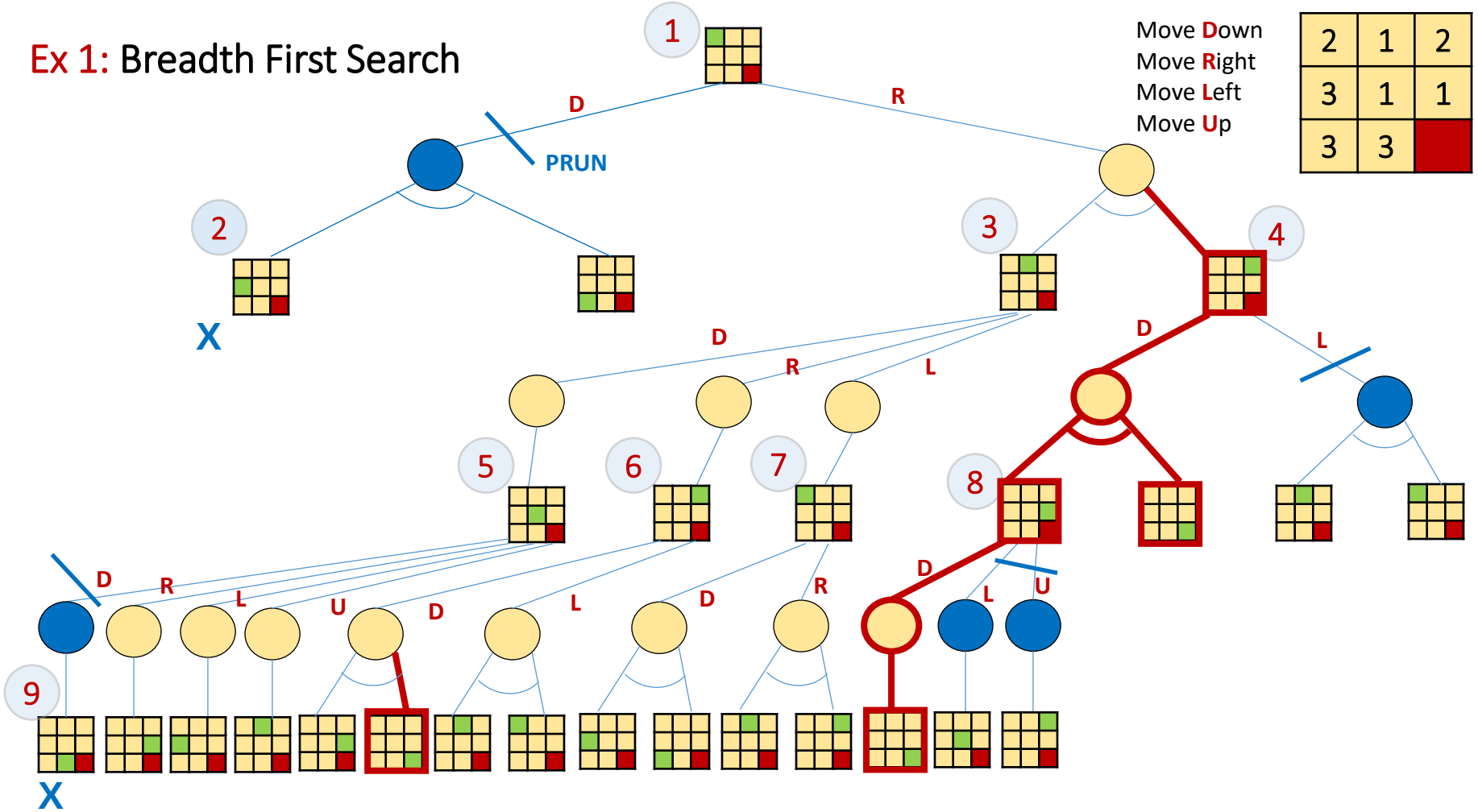

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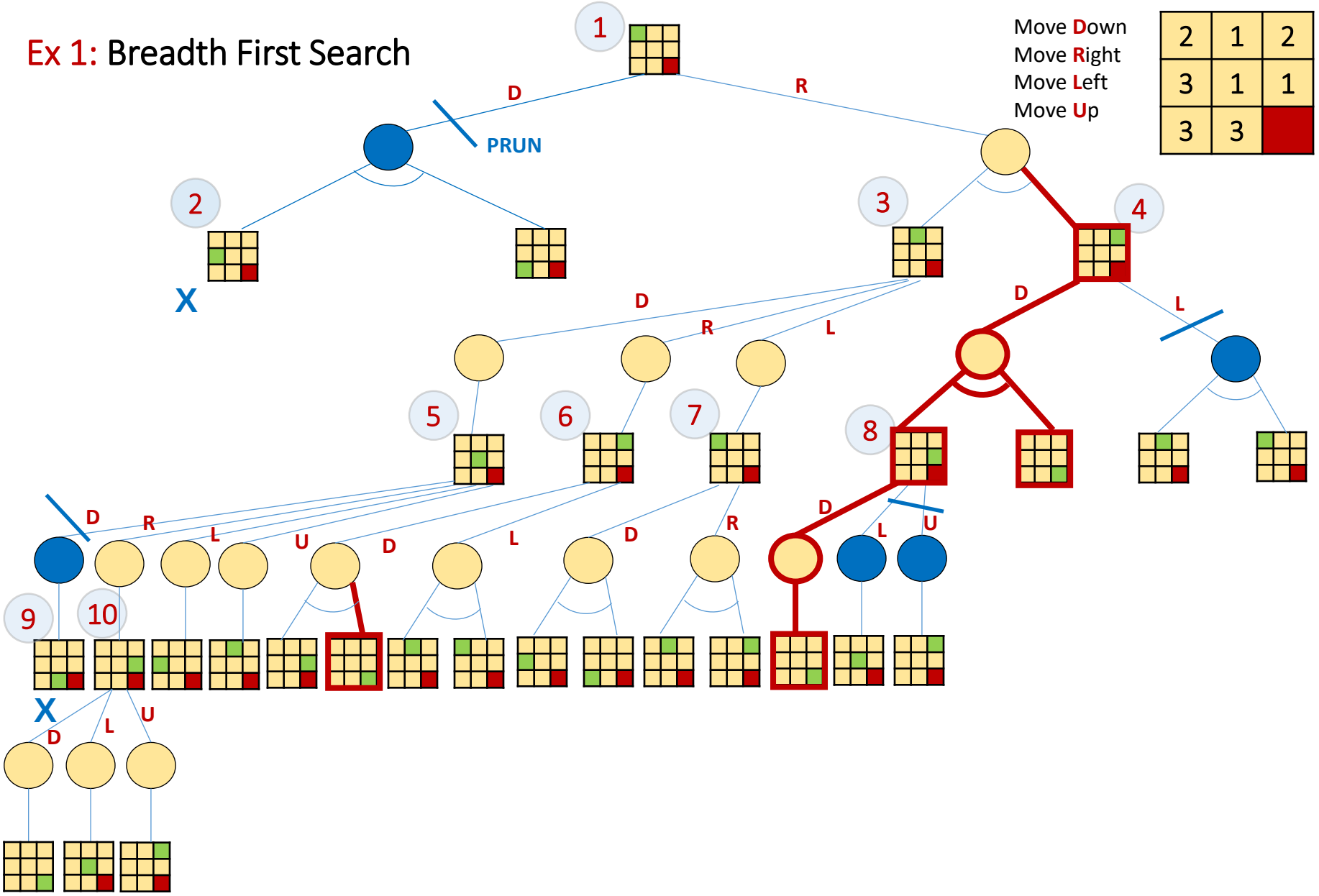

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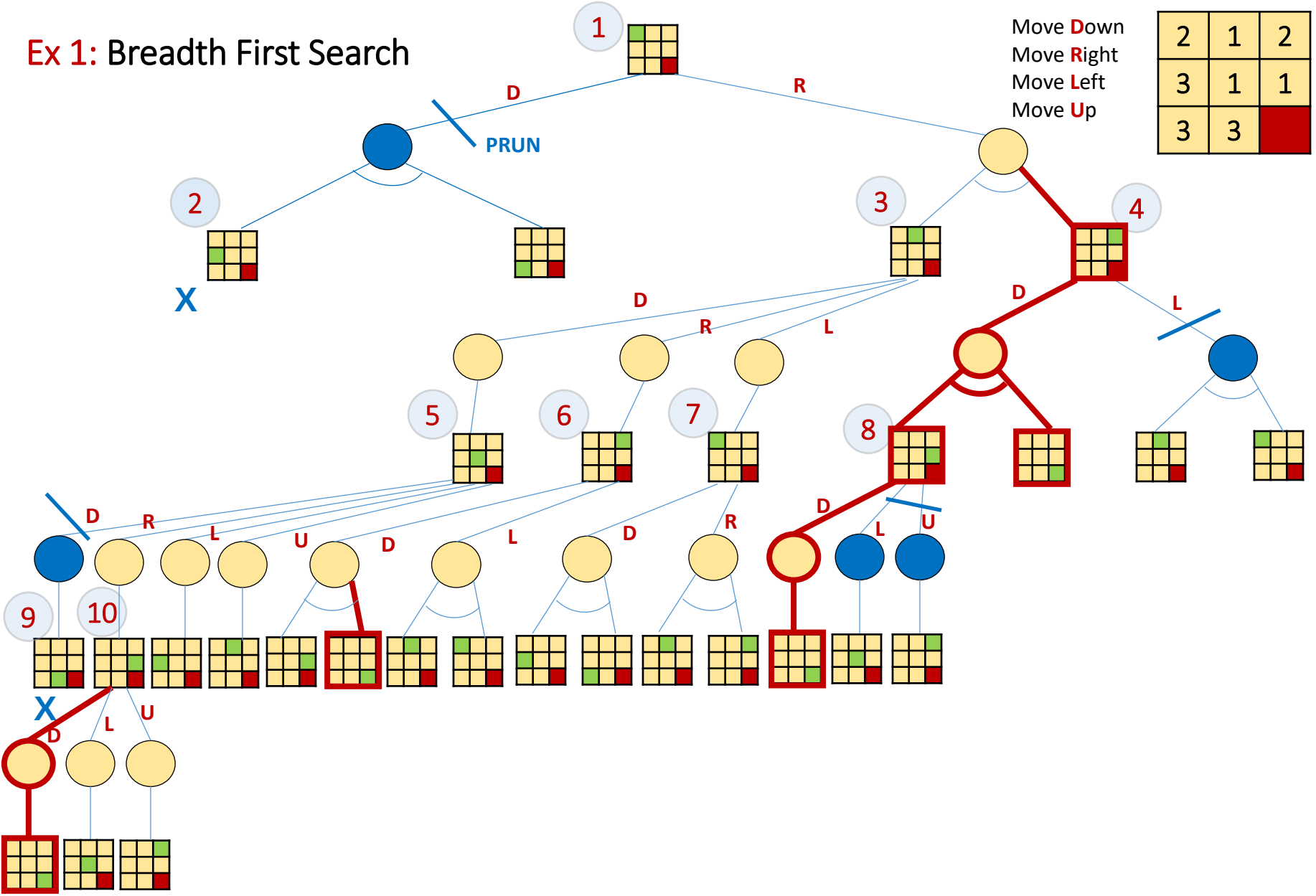

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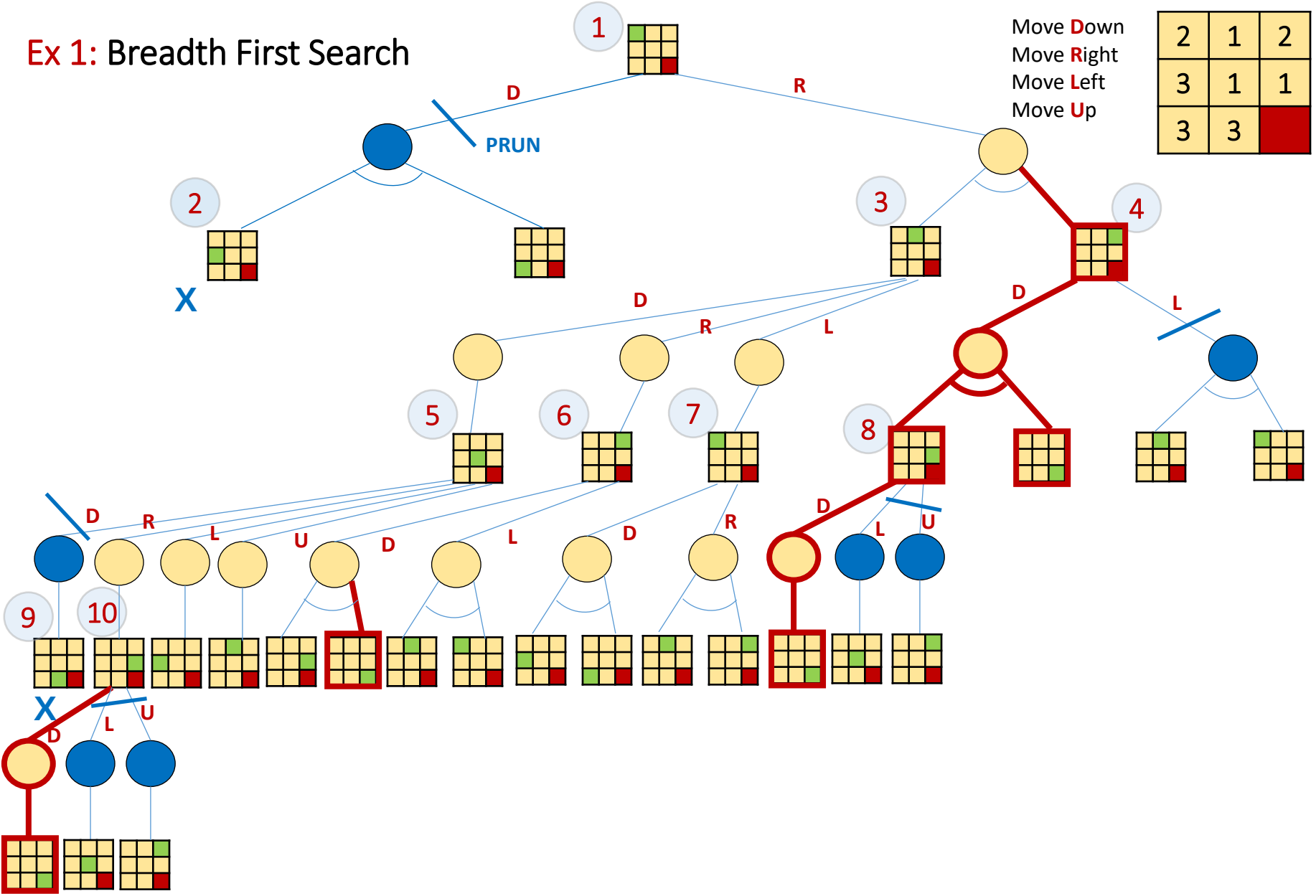

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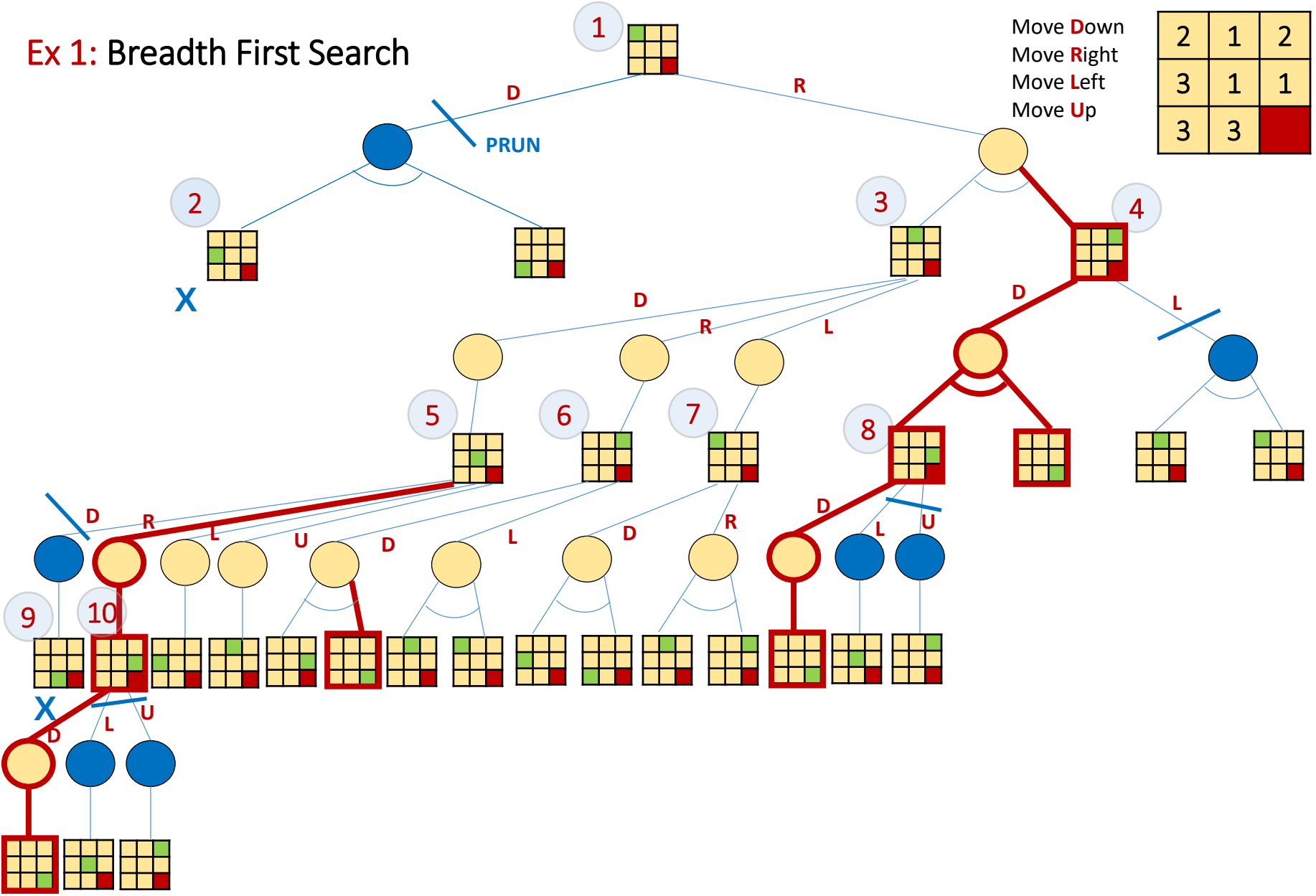

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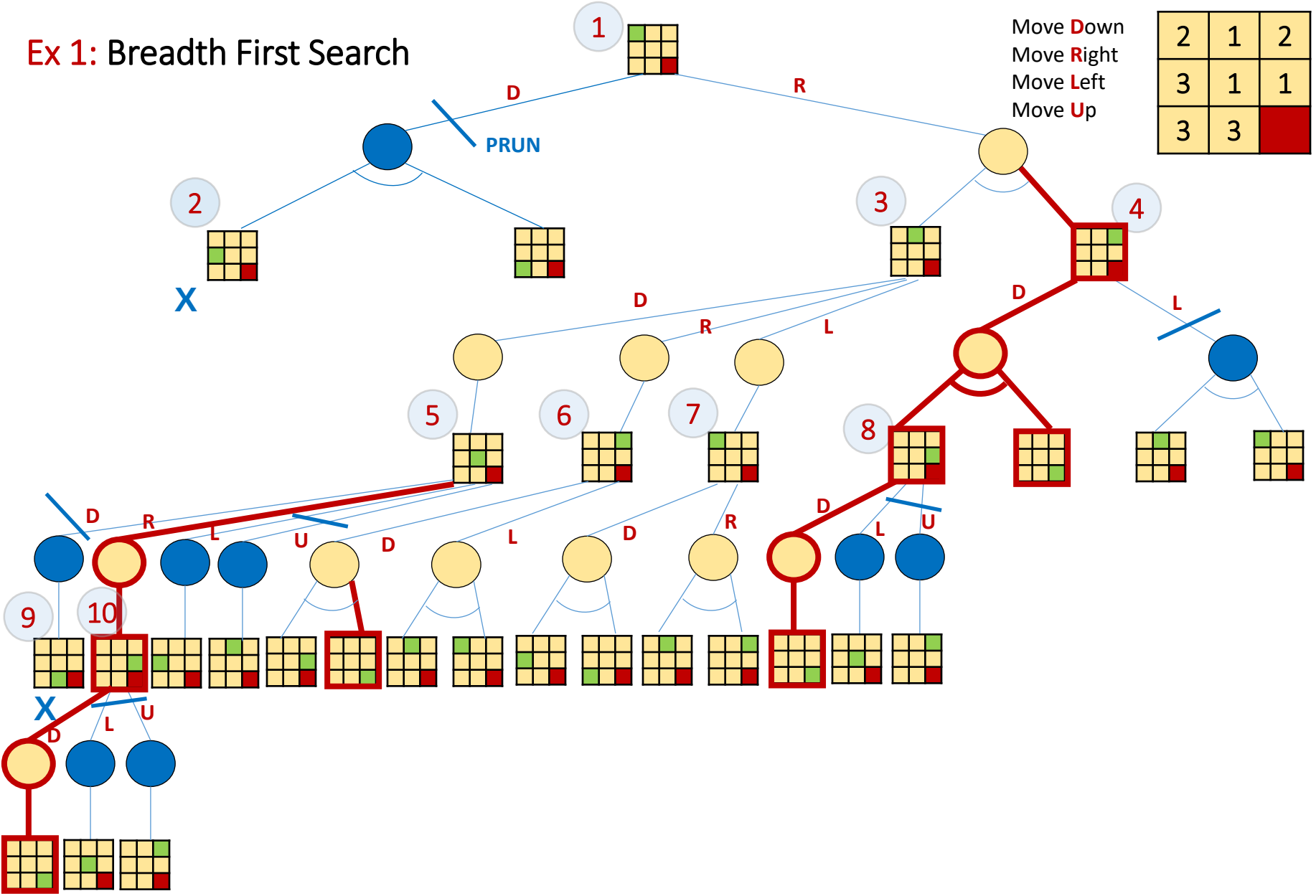

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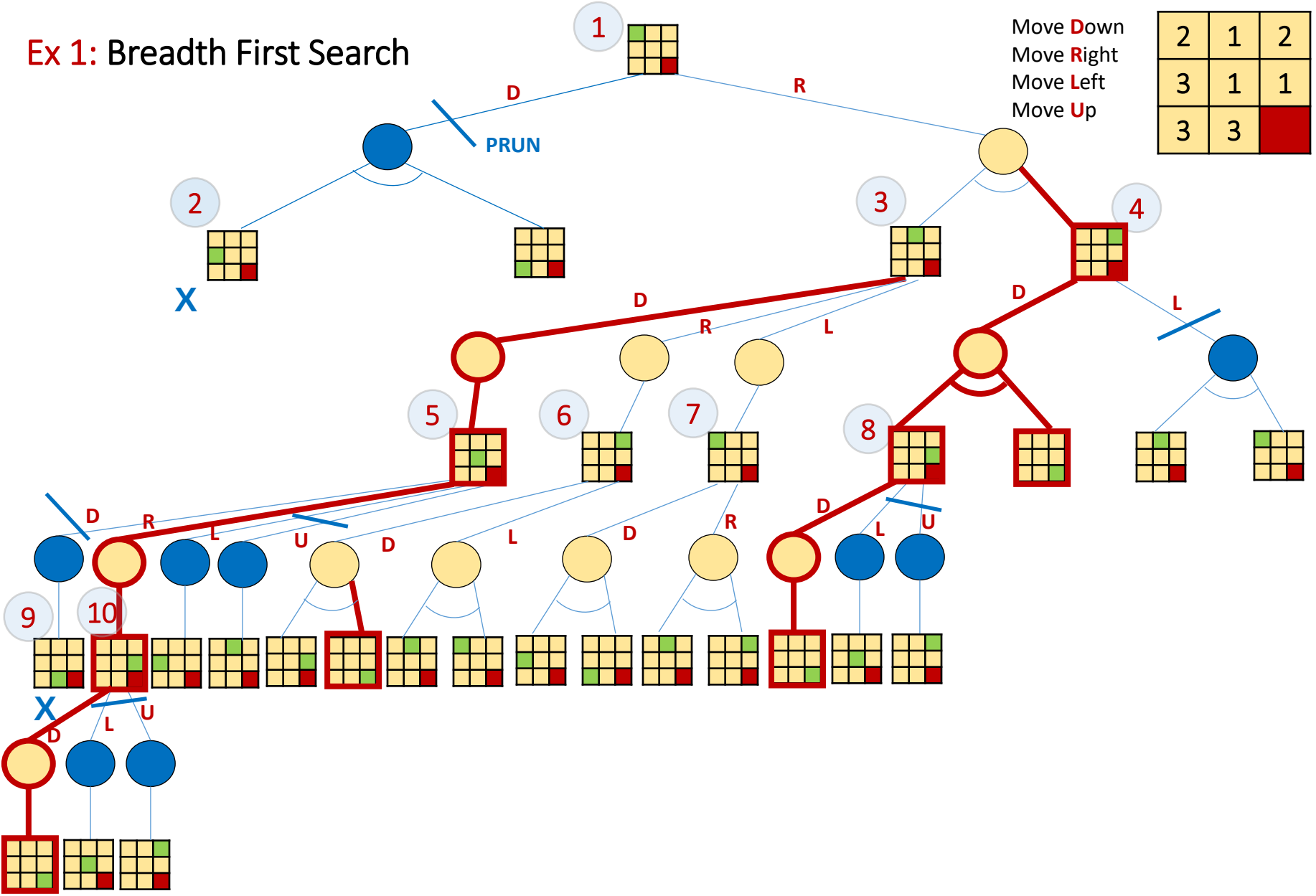

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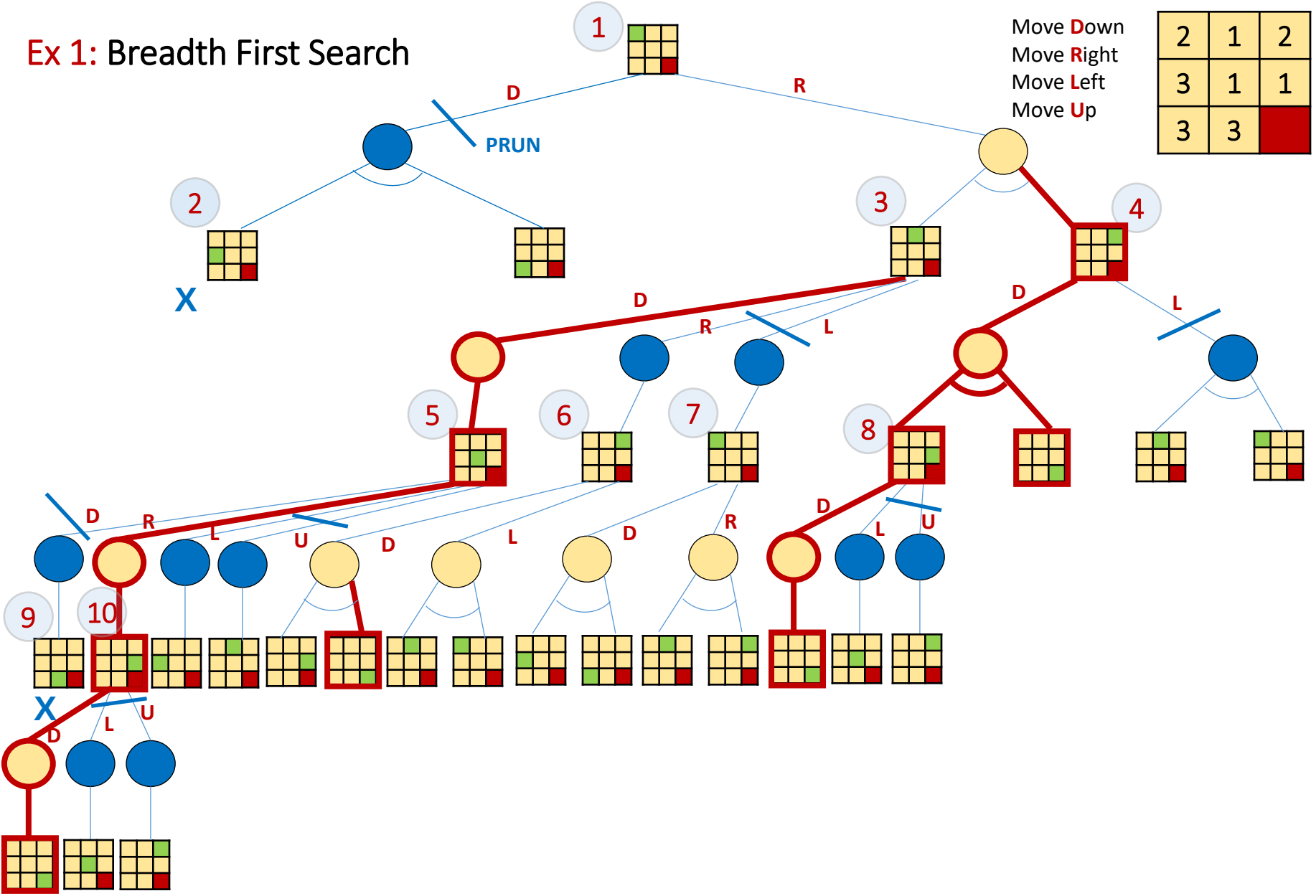

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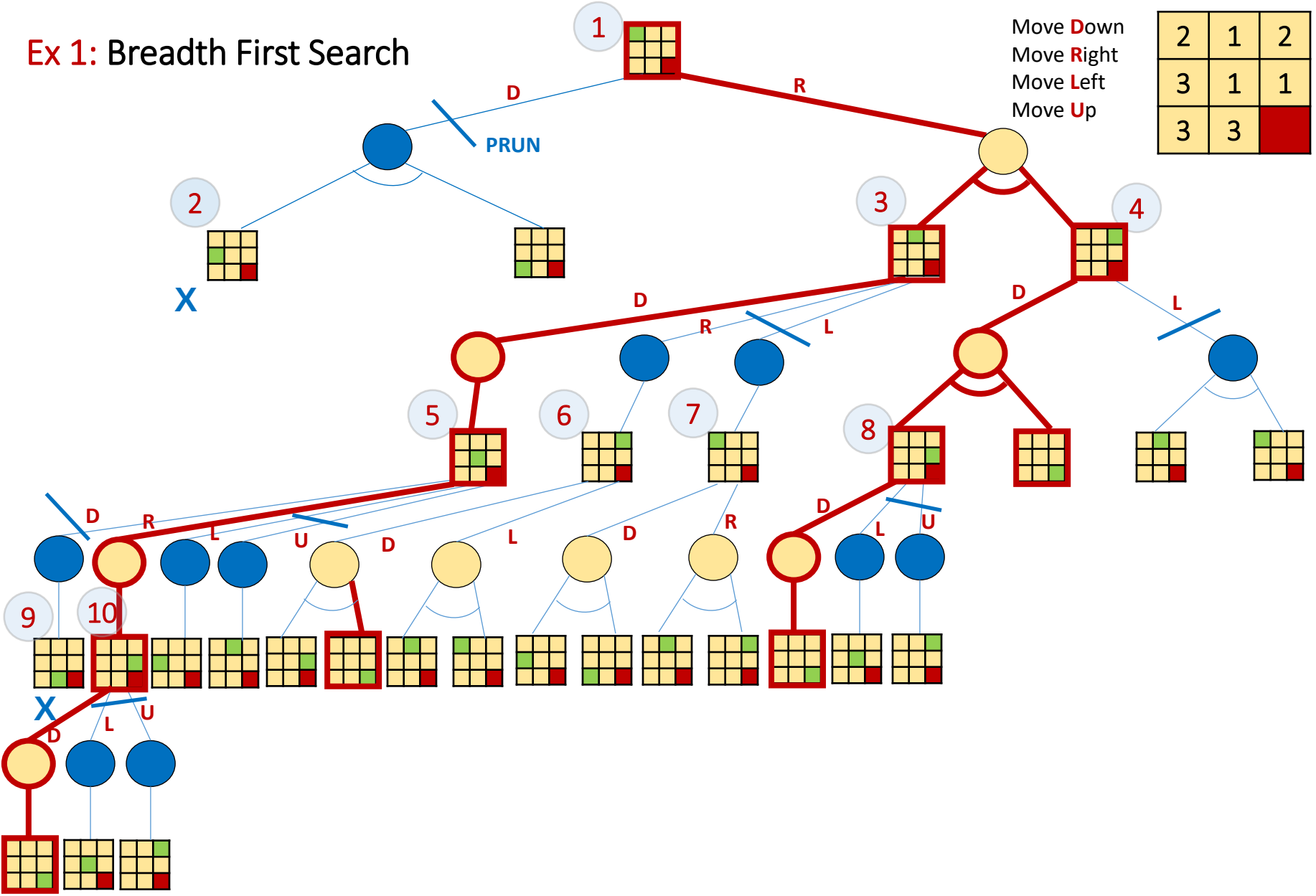

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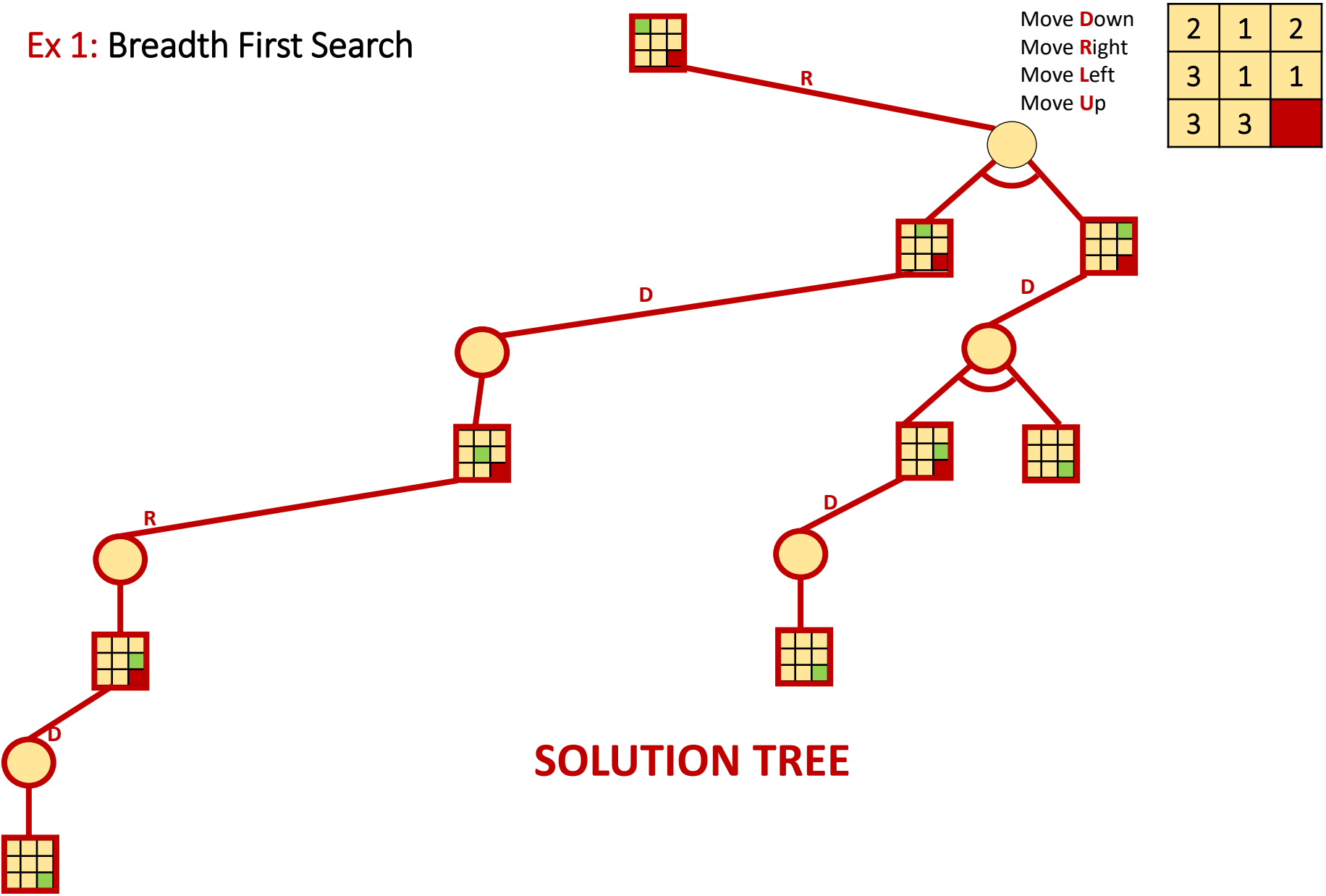
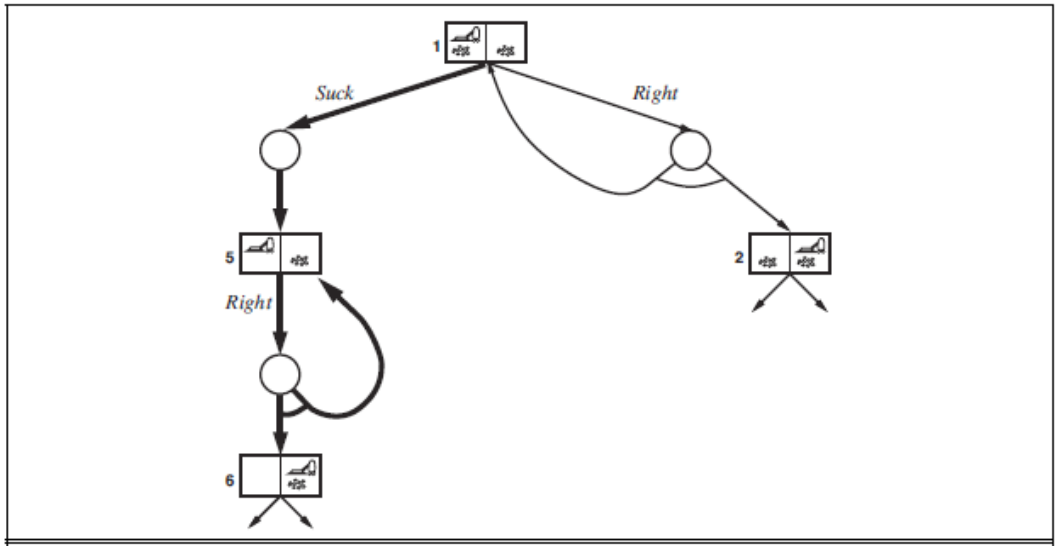


Consider the problem when the agent remembers its past!!

The problem becomes complicated. Assume that the following agent remembers its past. Does the agent find a solution?



Part of the search graph for the slippery vacuum world, where we have shown (some) cycles explicitly. All solutions for this problem are cyclic plans because there is no way to move reliably.

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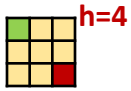

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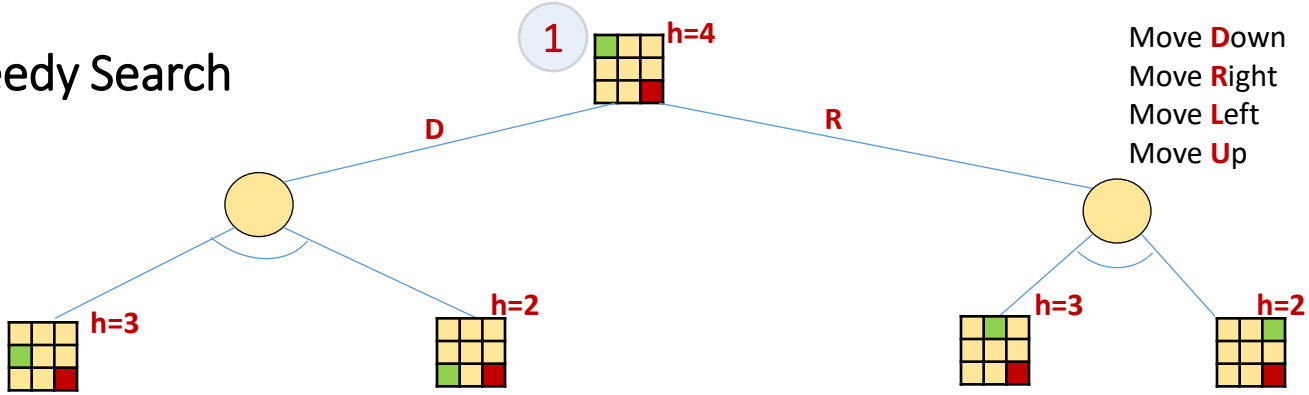

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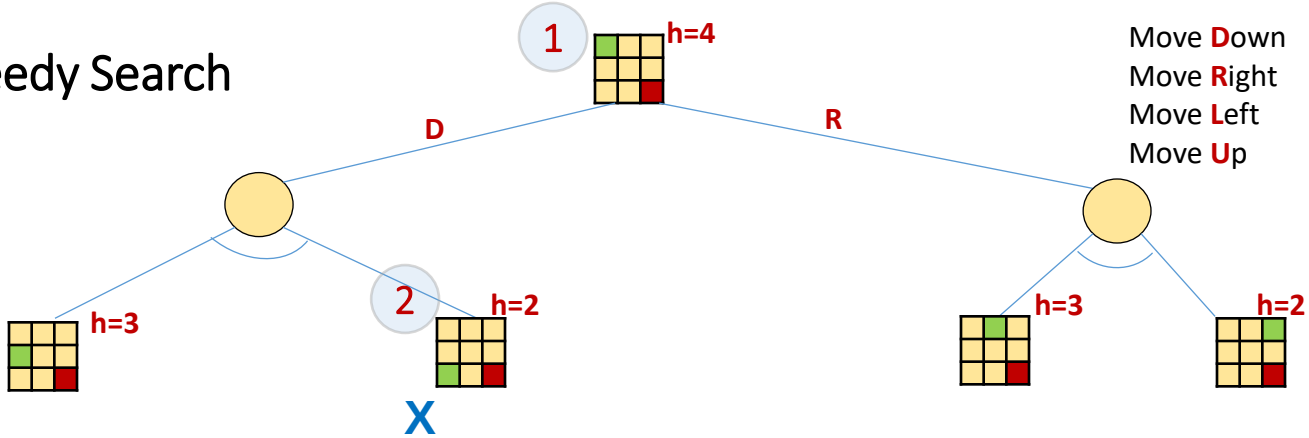

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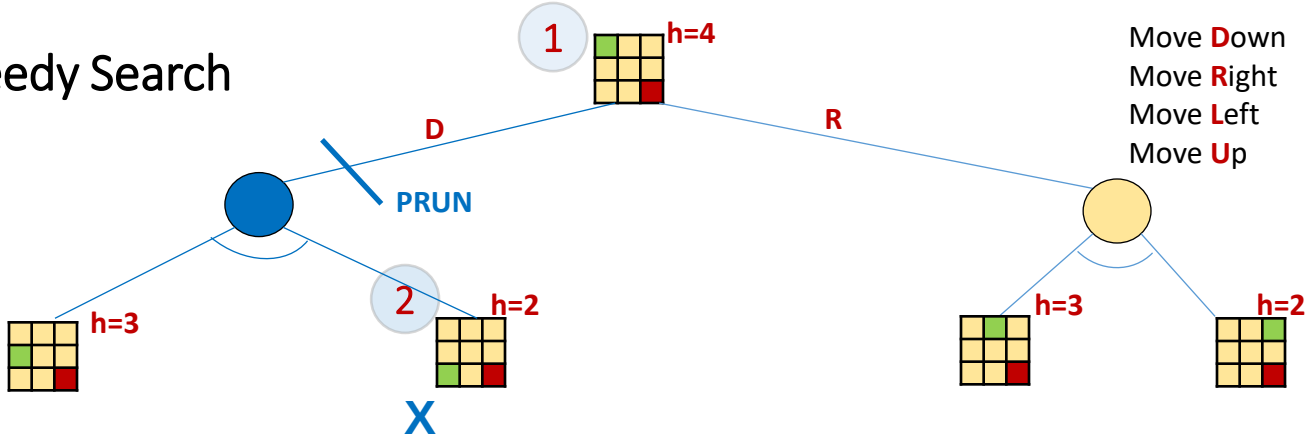

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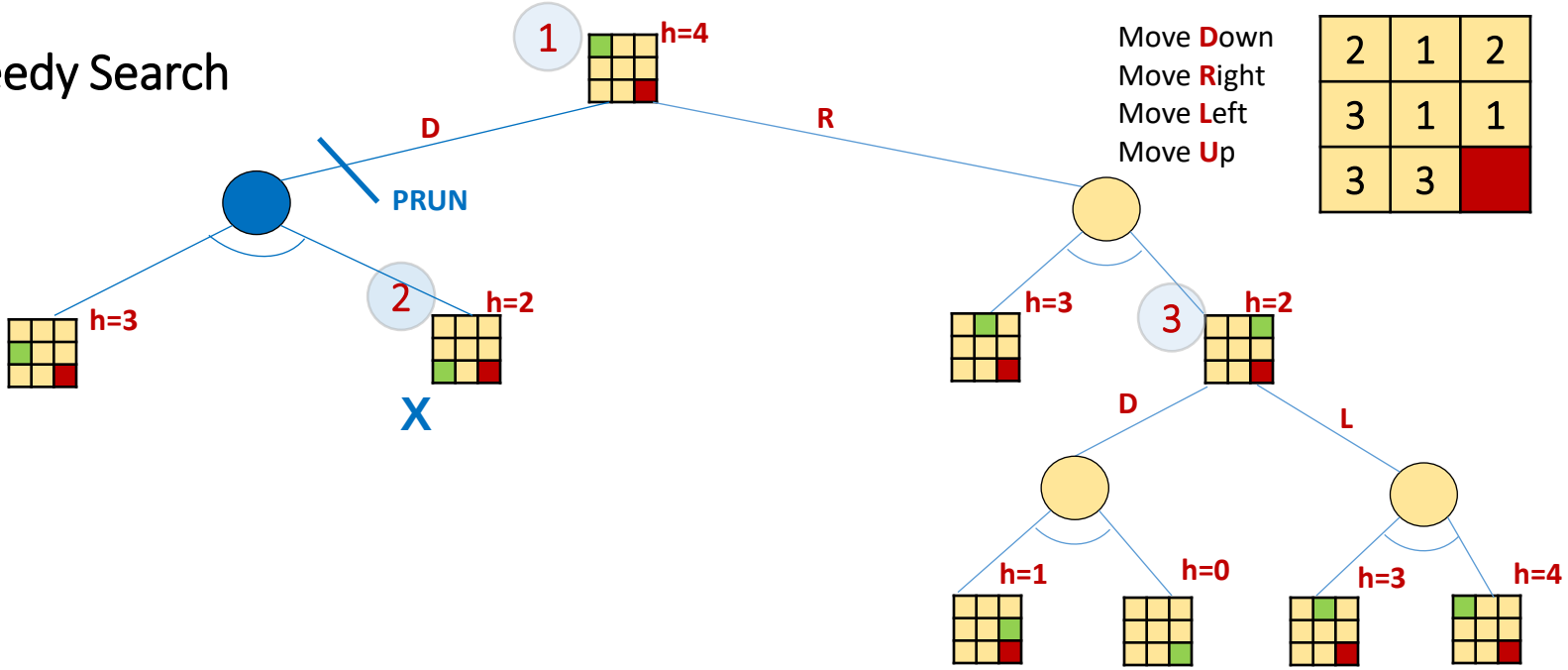

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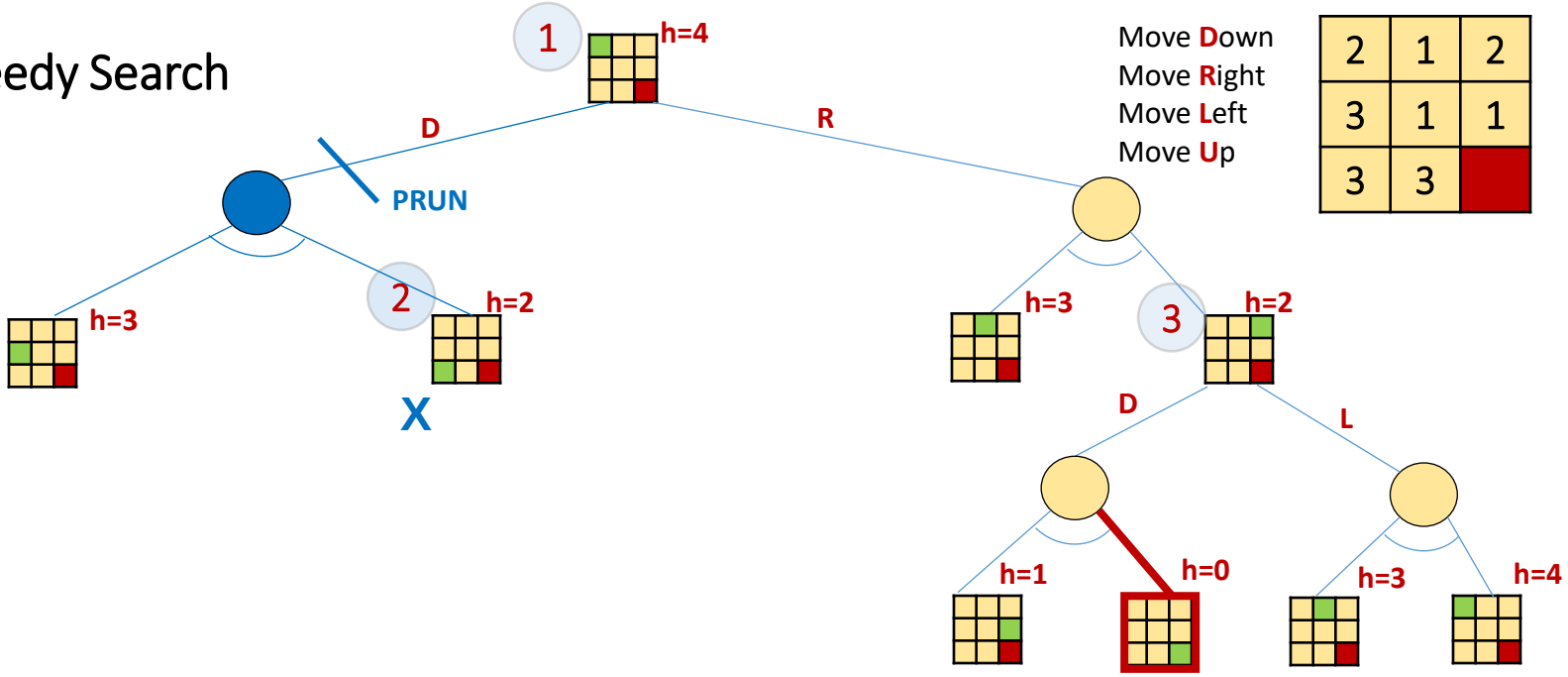

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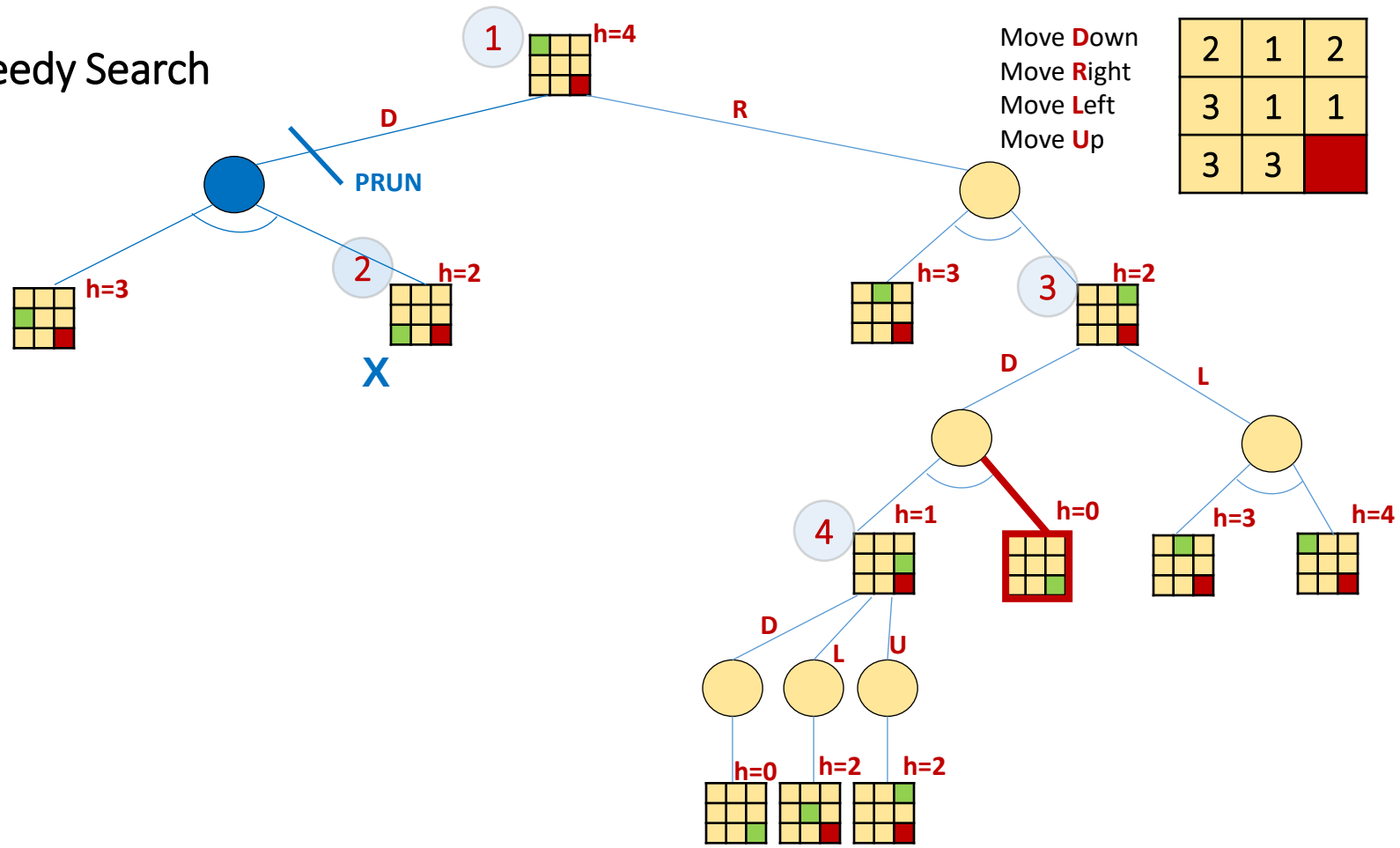

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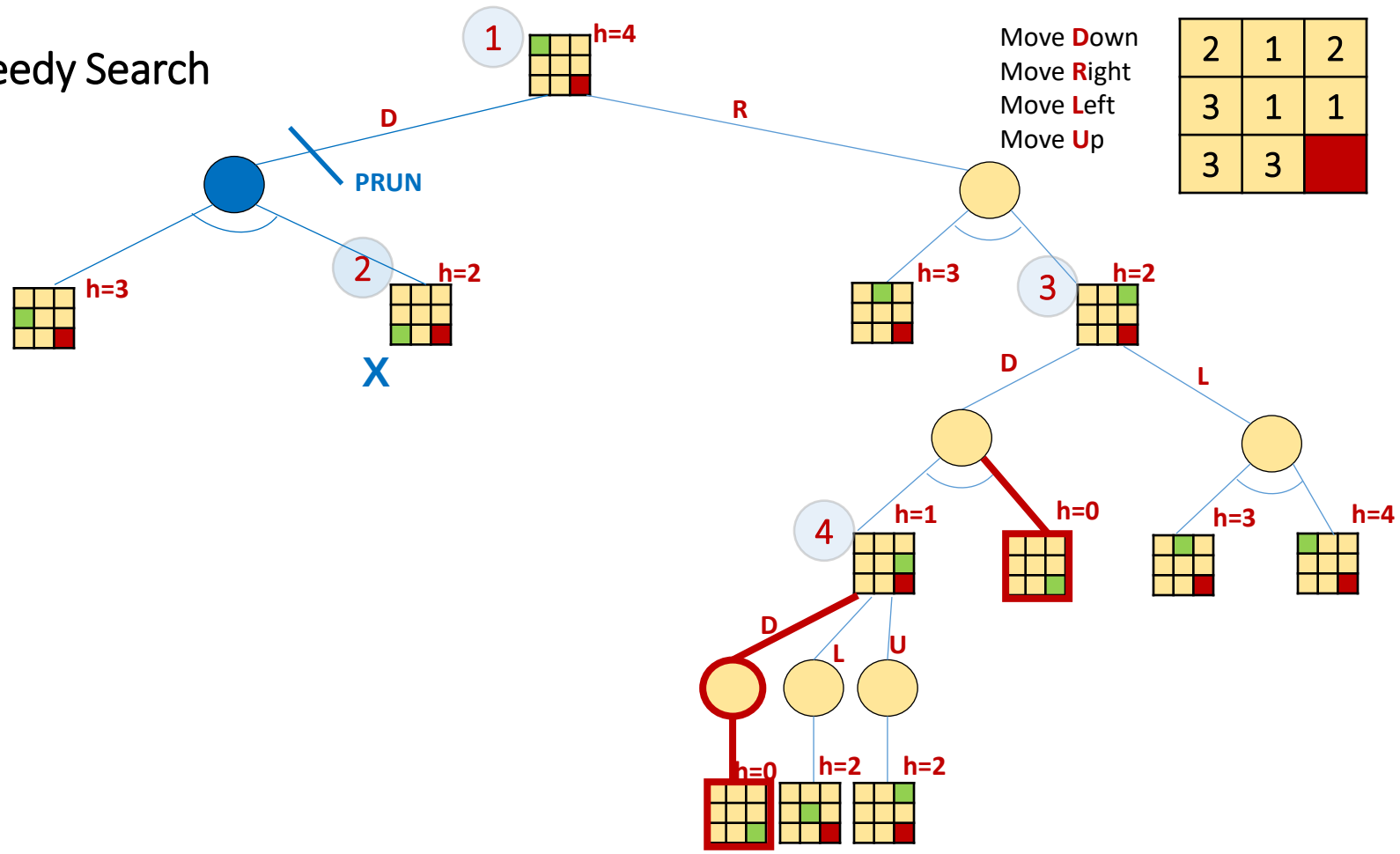

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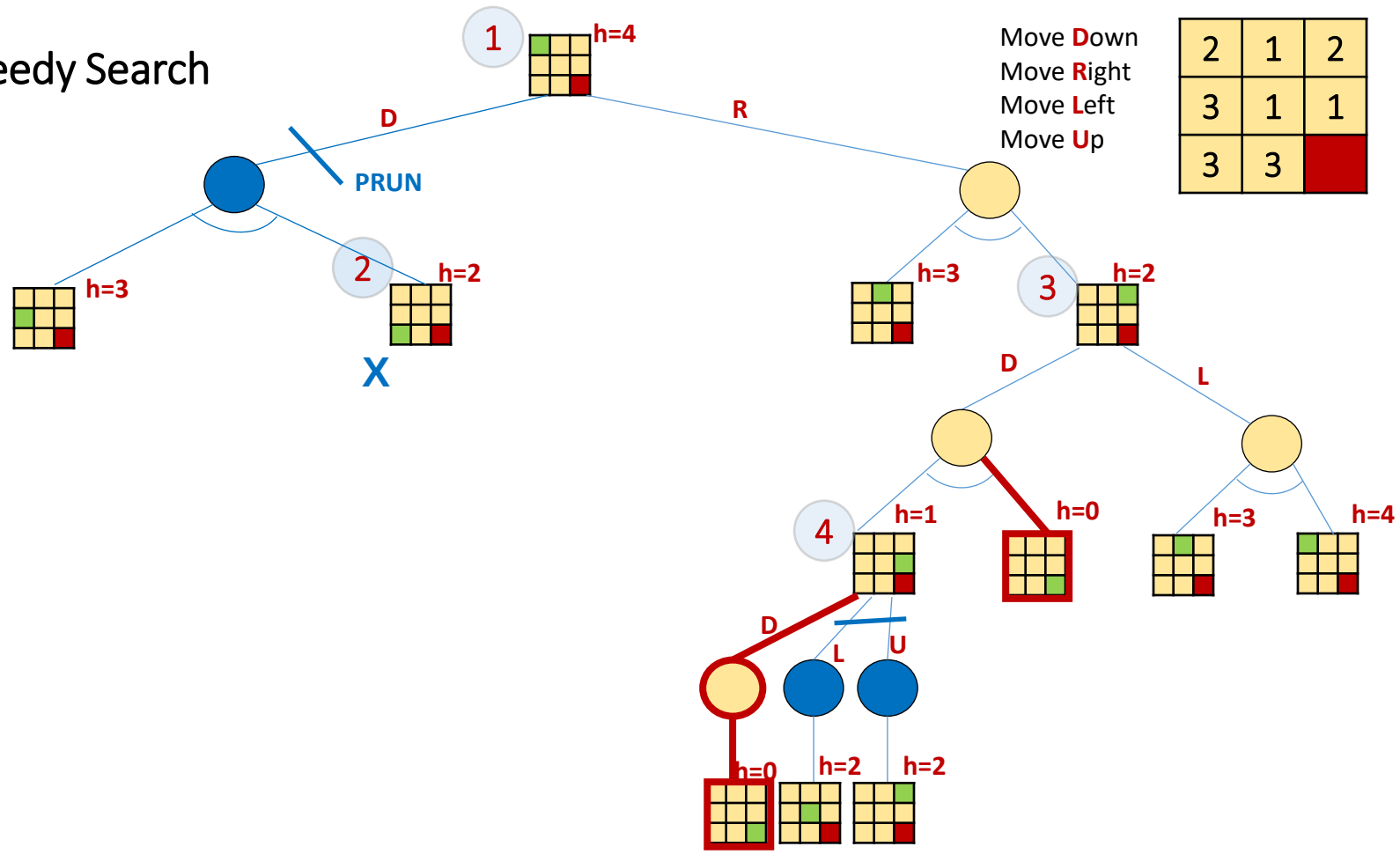

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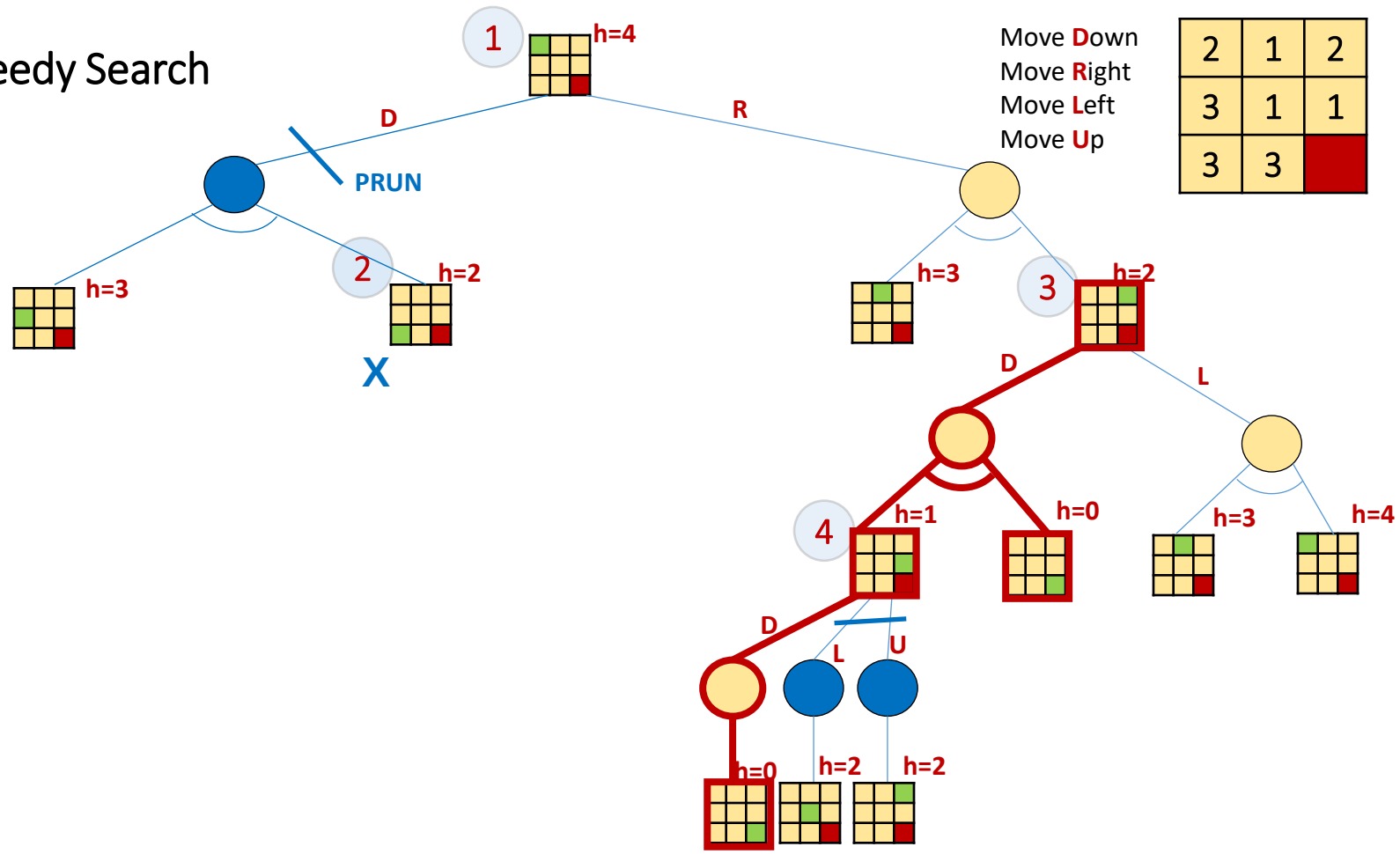

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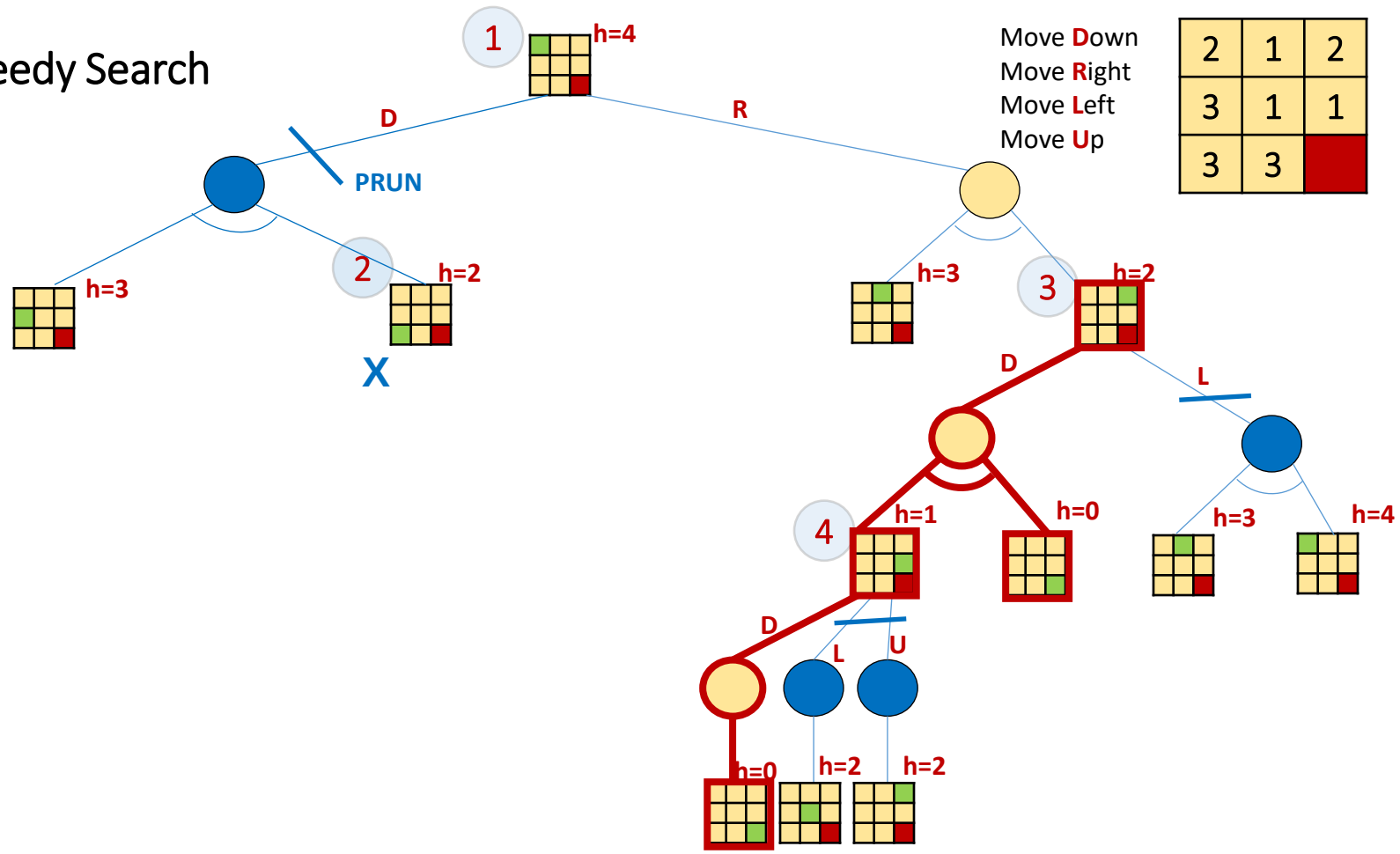

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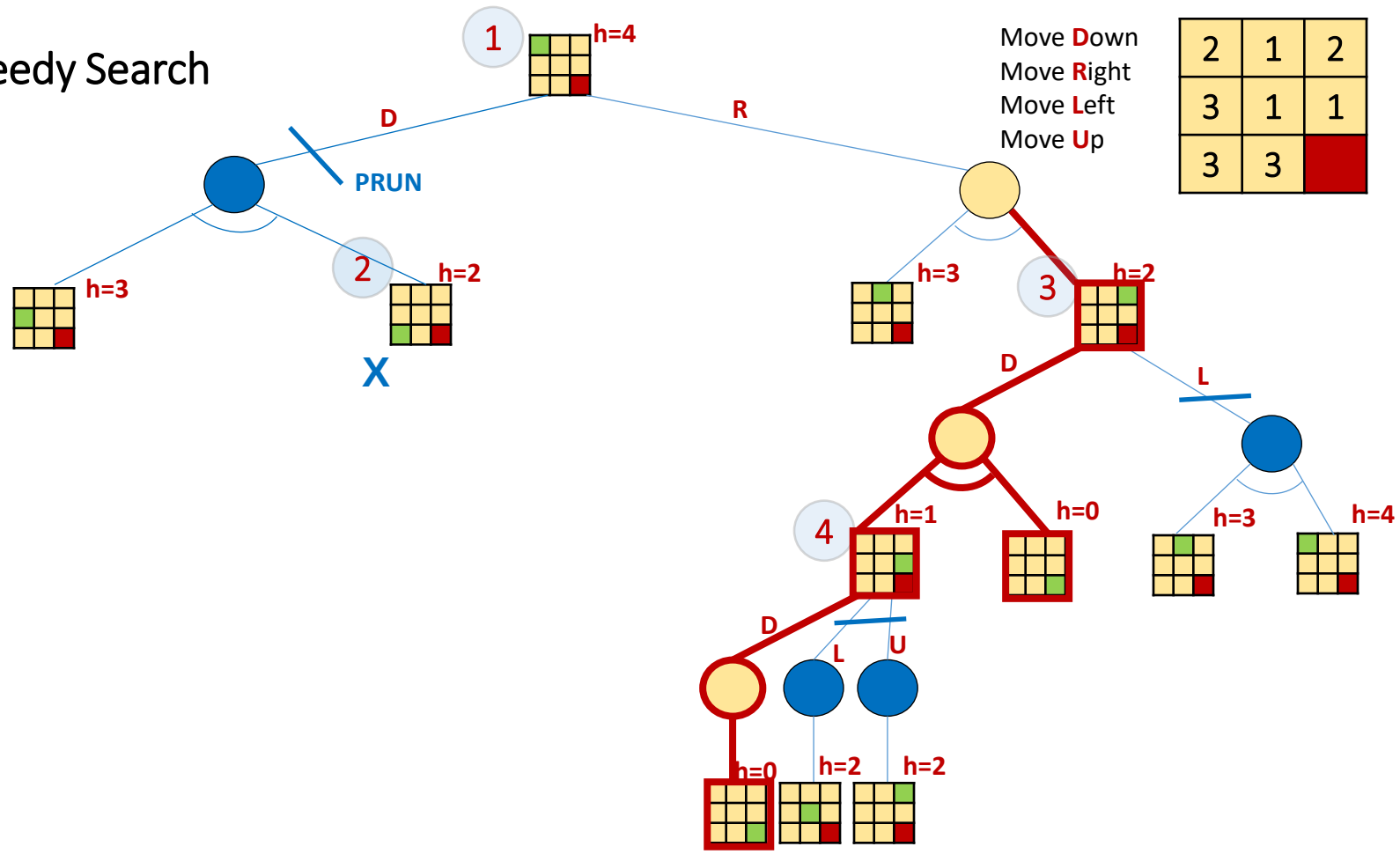

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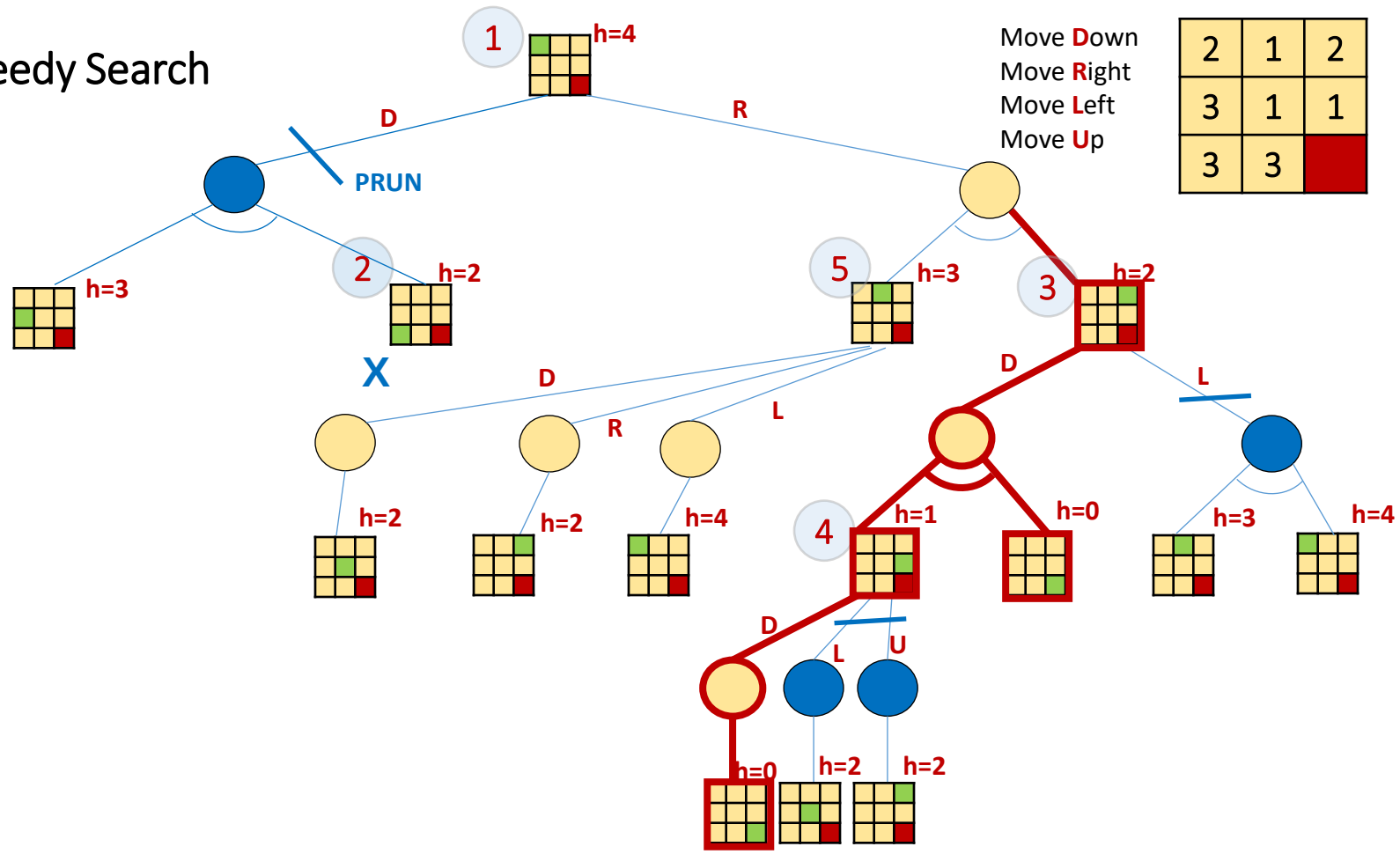

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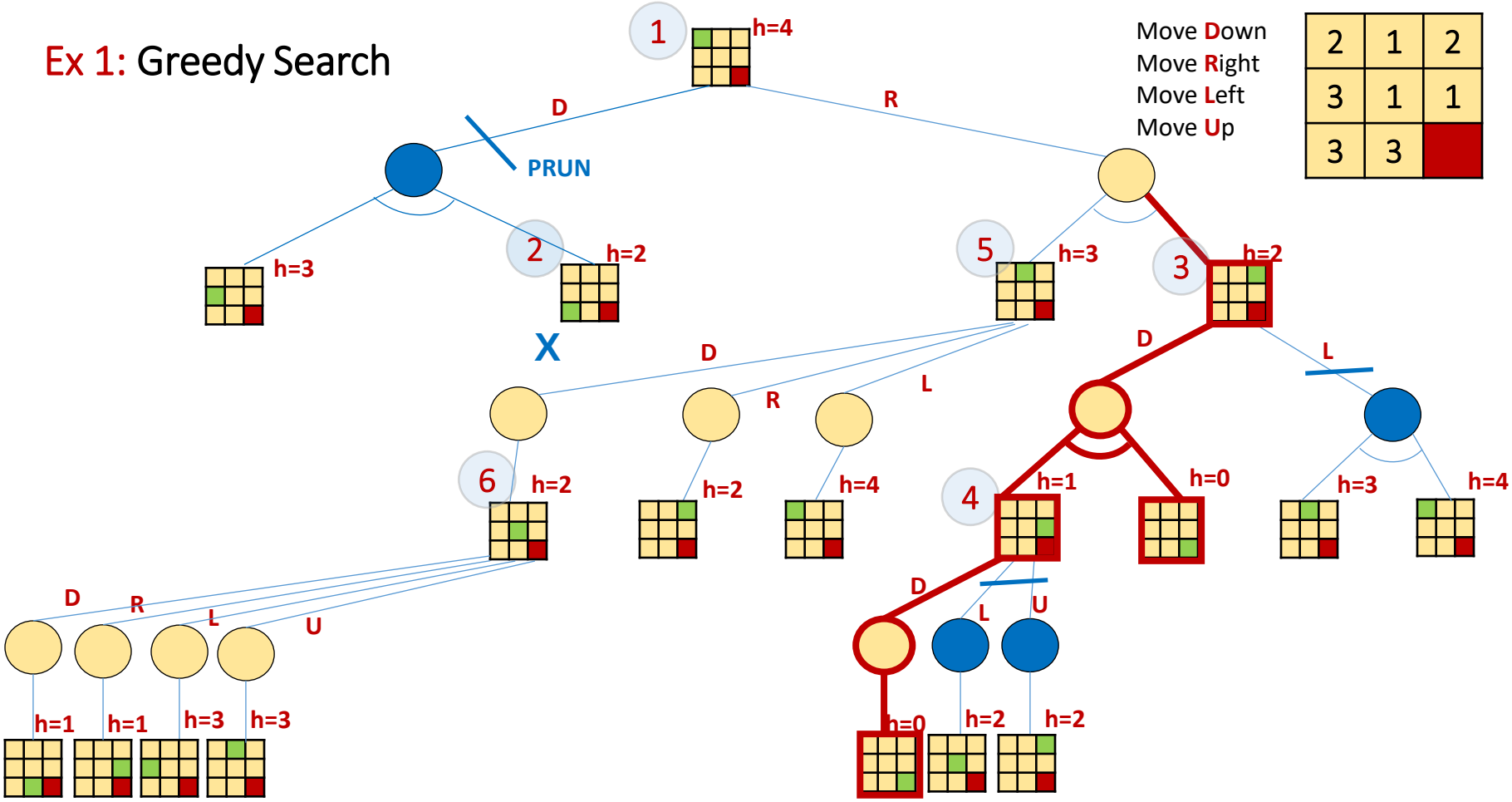

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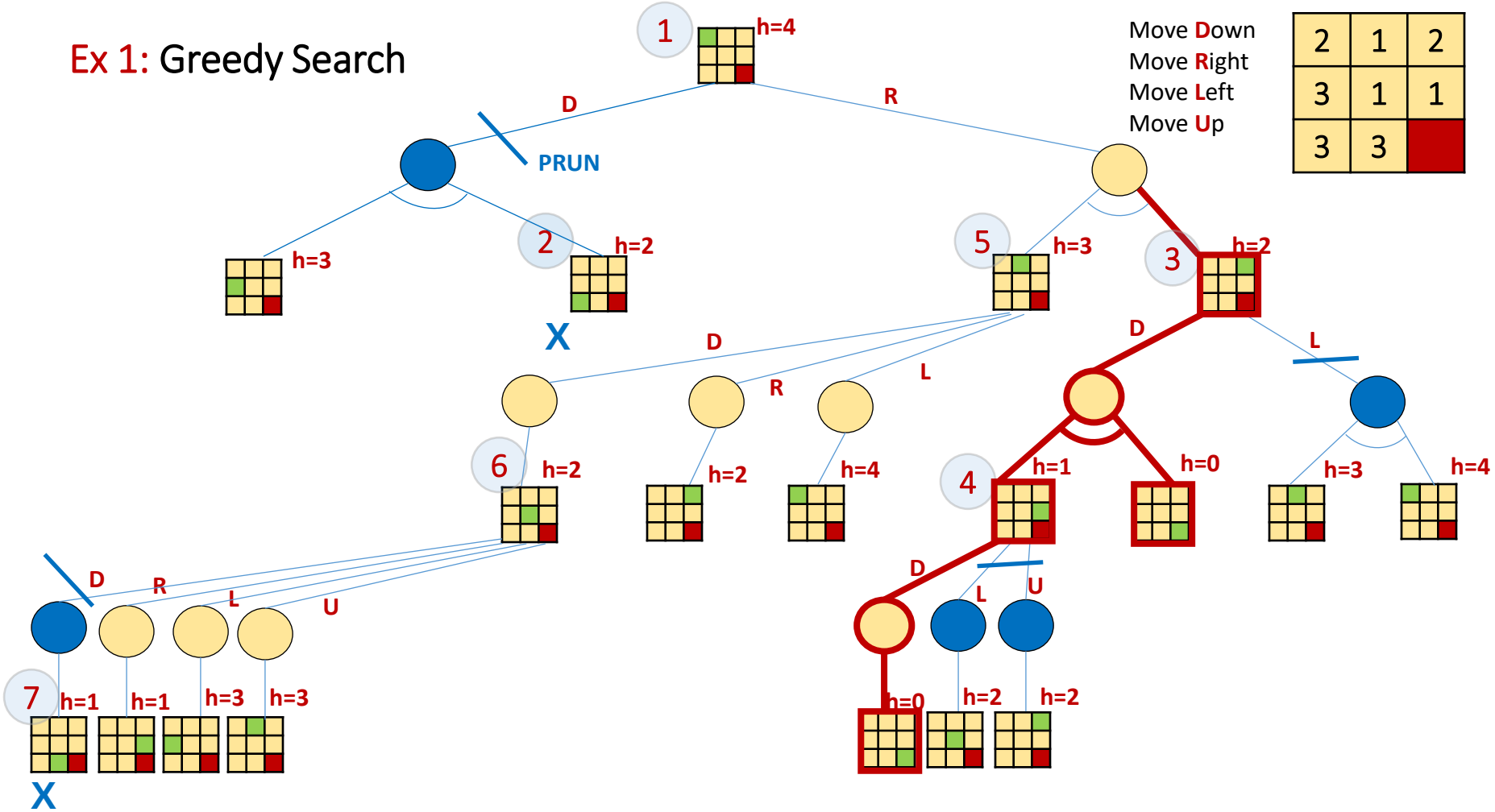

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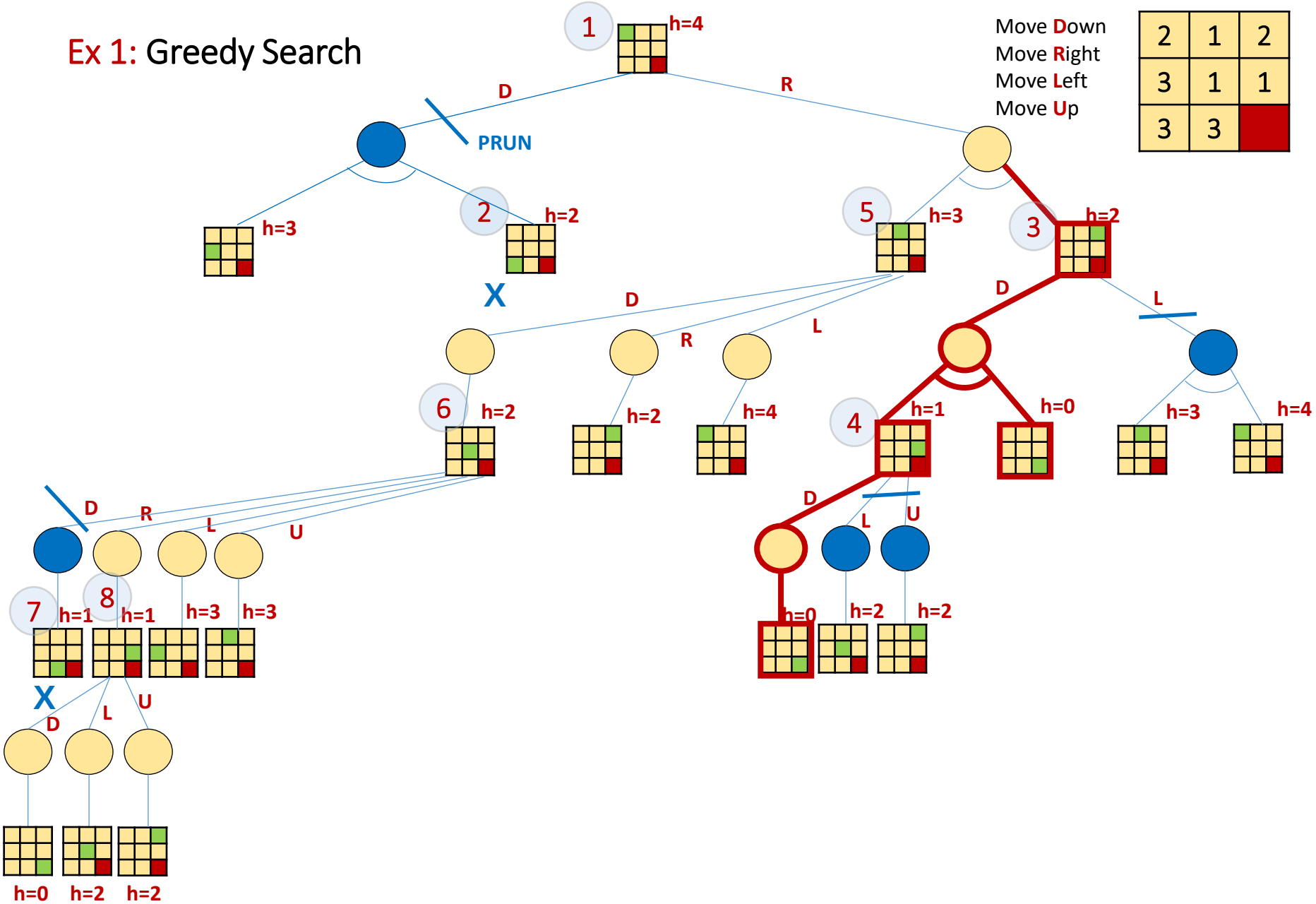
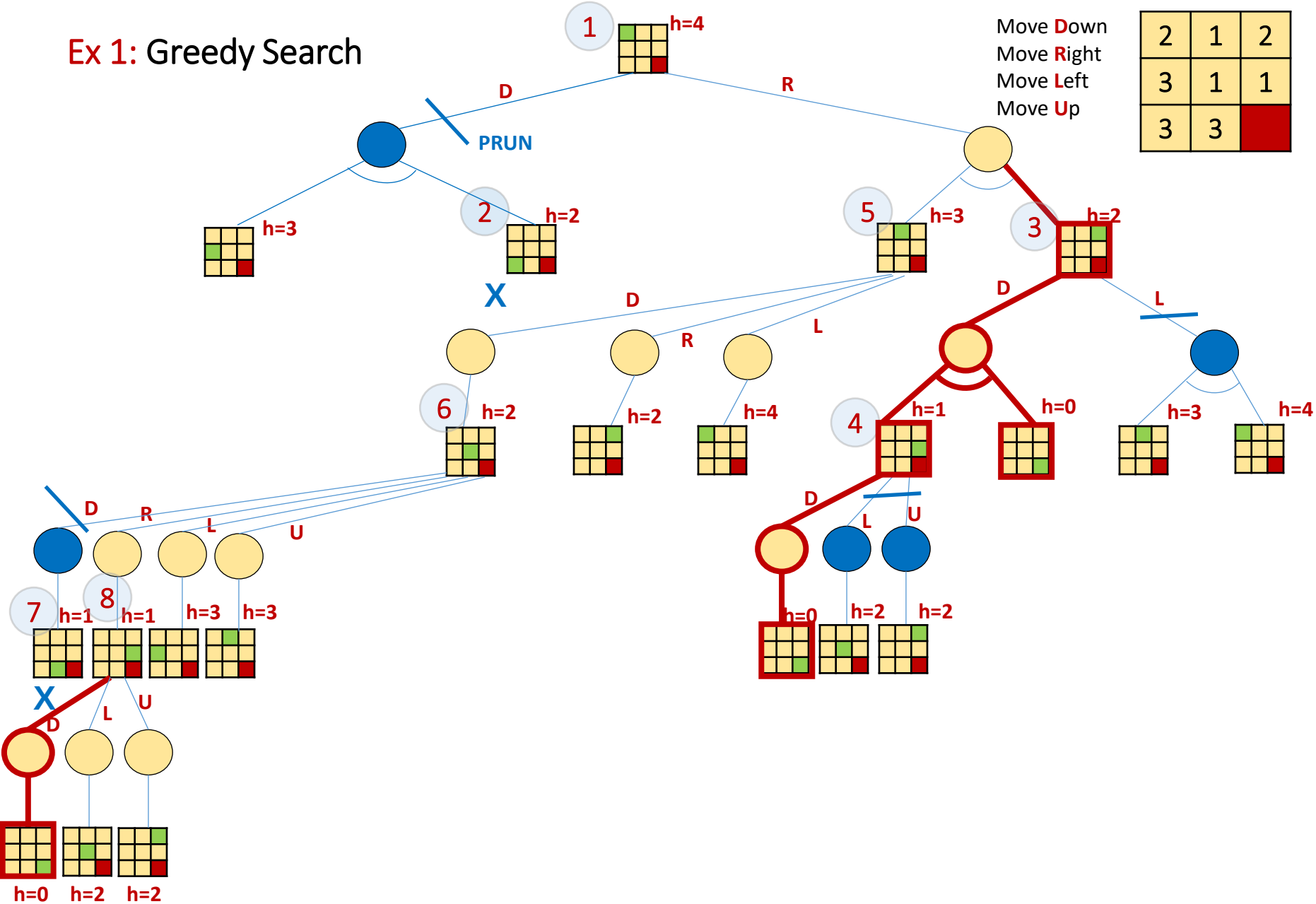
3	3	

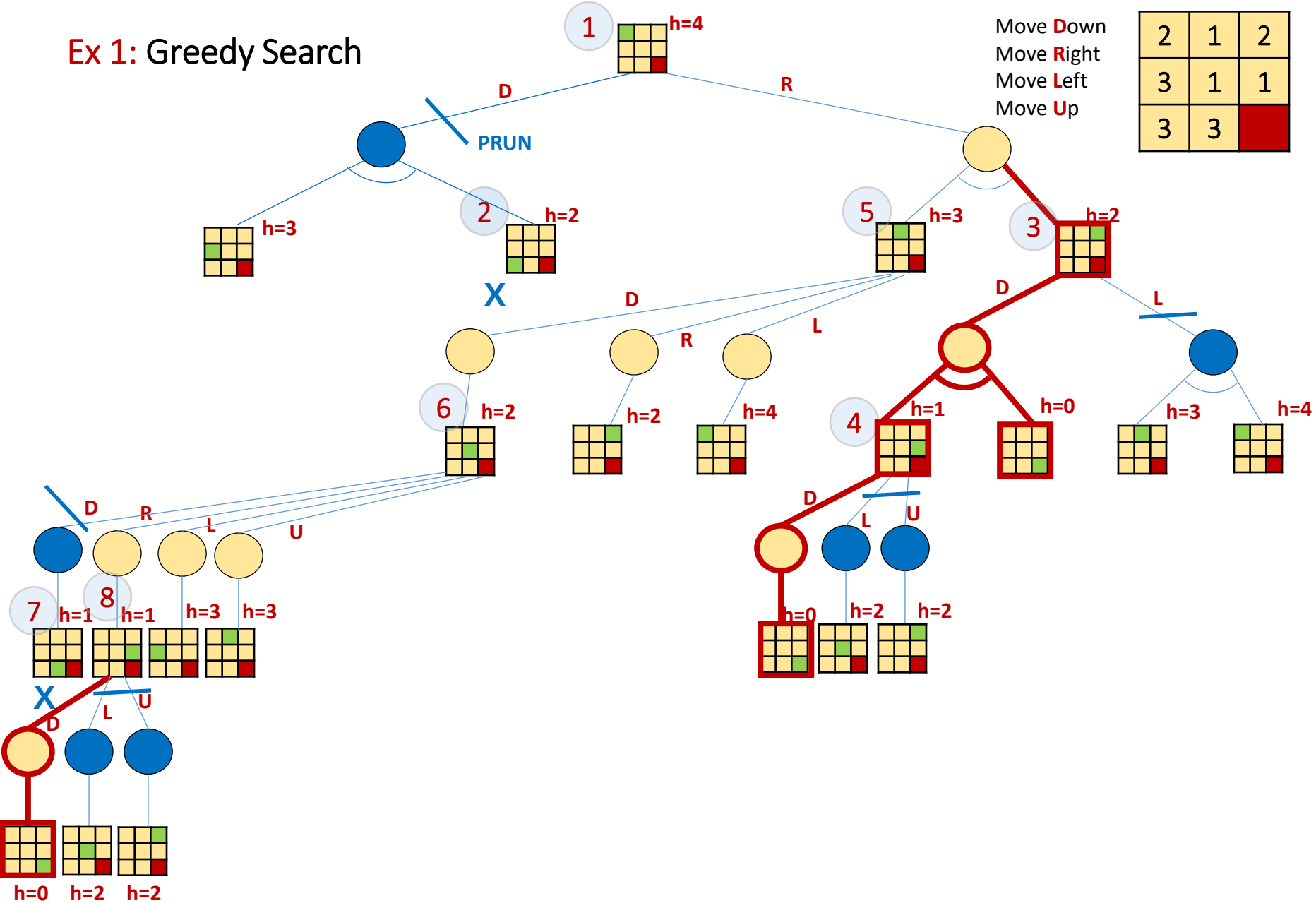
Ex 1: Greedy Search



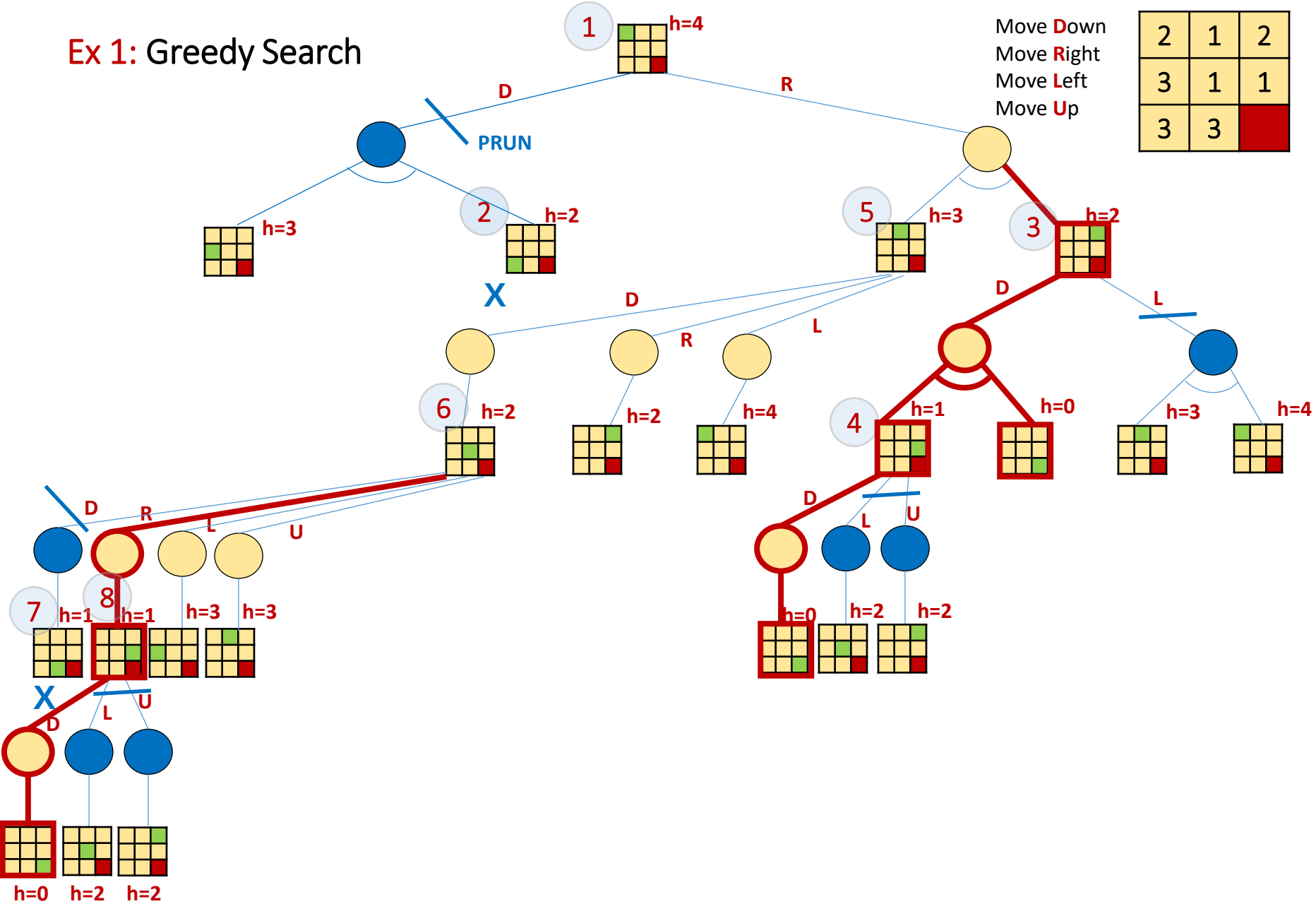
Ex 1: Greedy Search



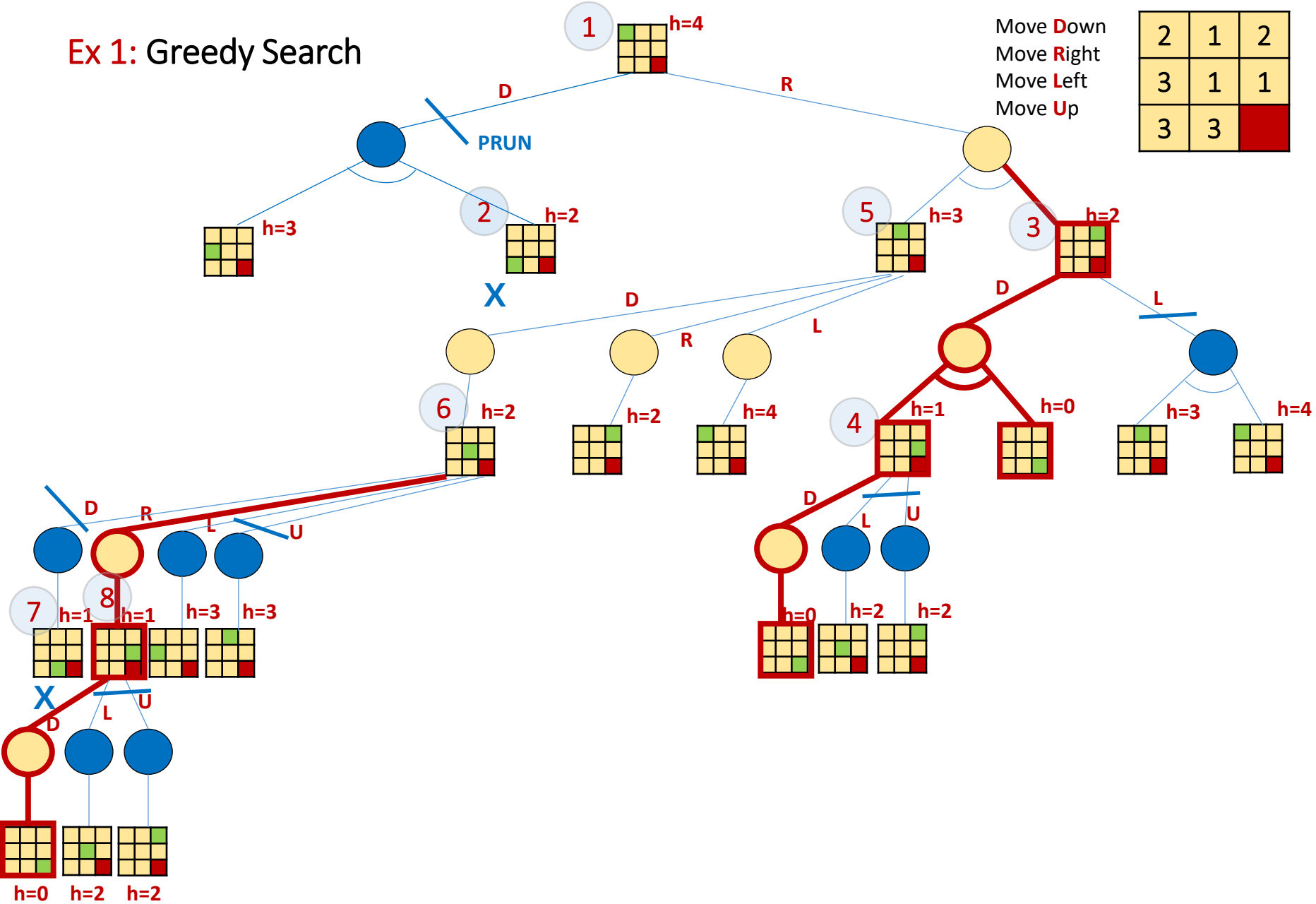
Ex 1: Greedy Search



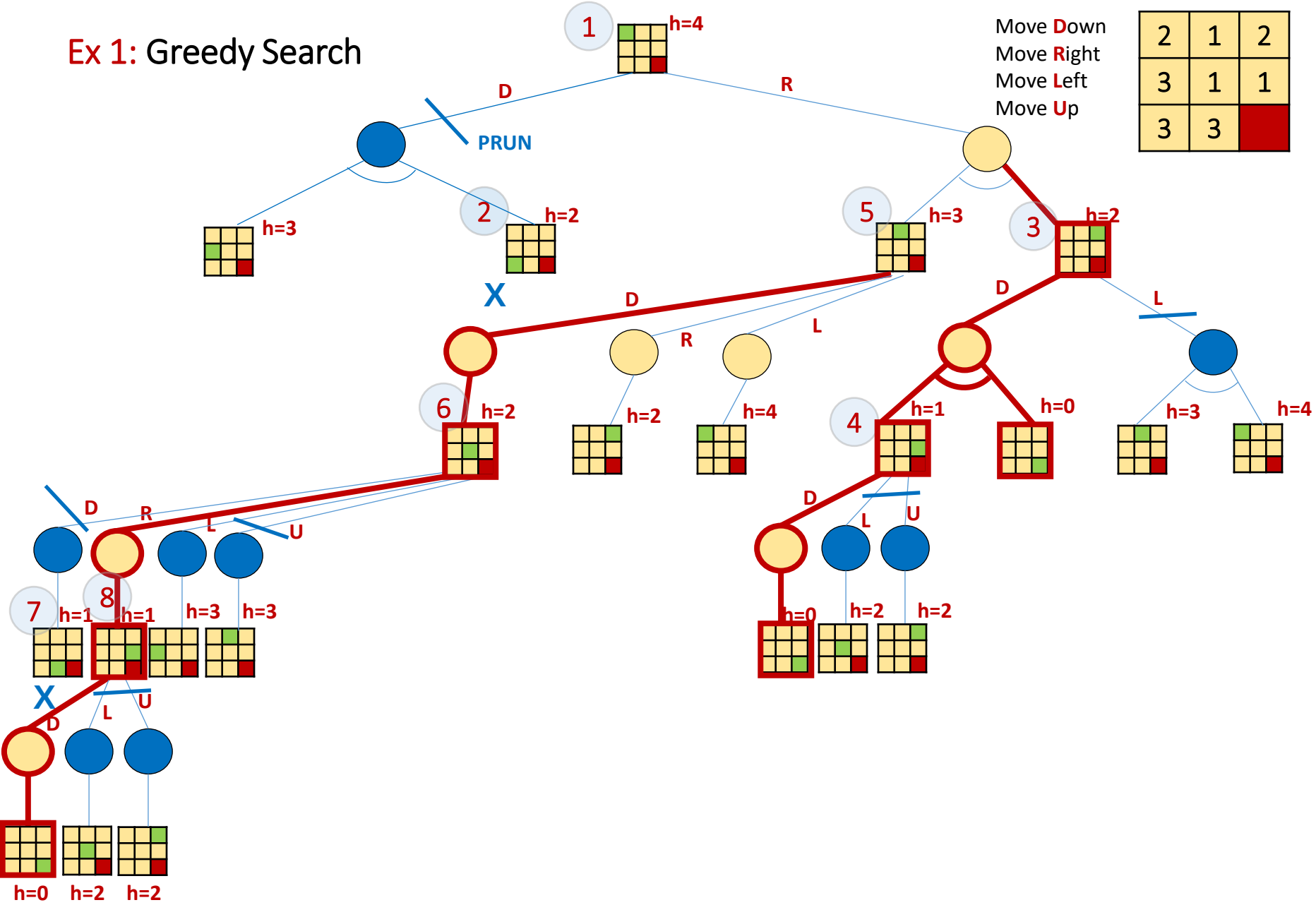
Ex 1: Greedy Search



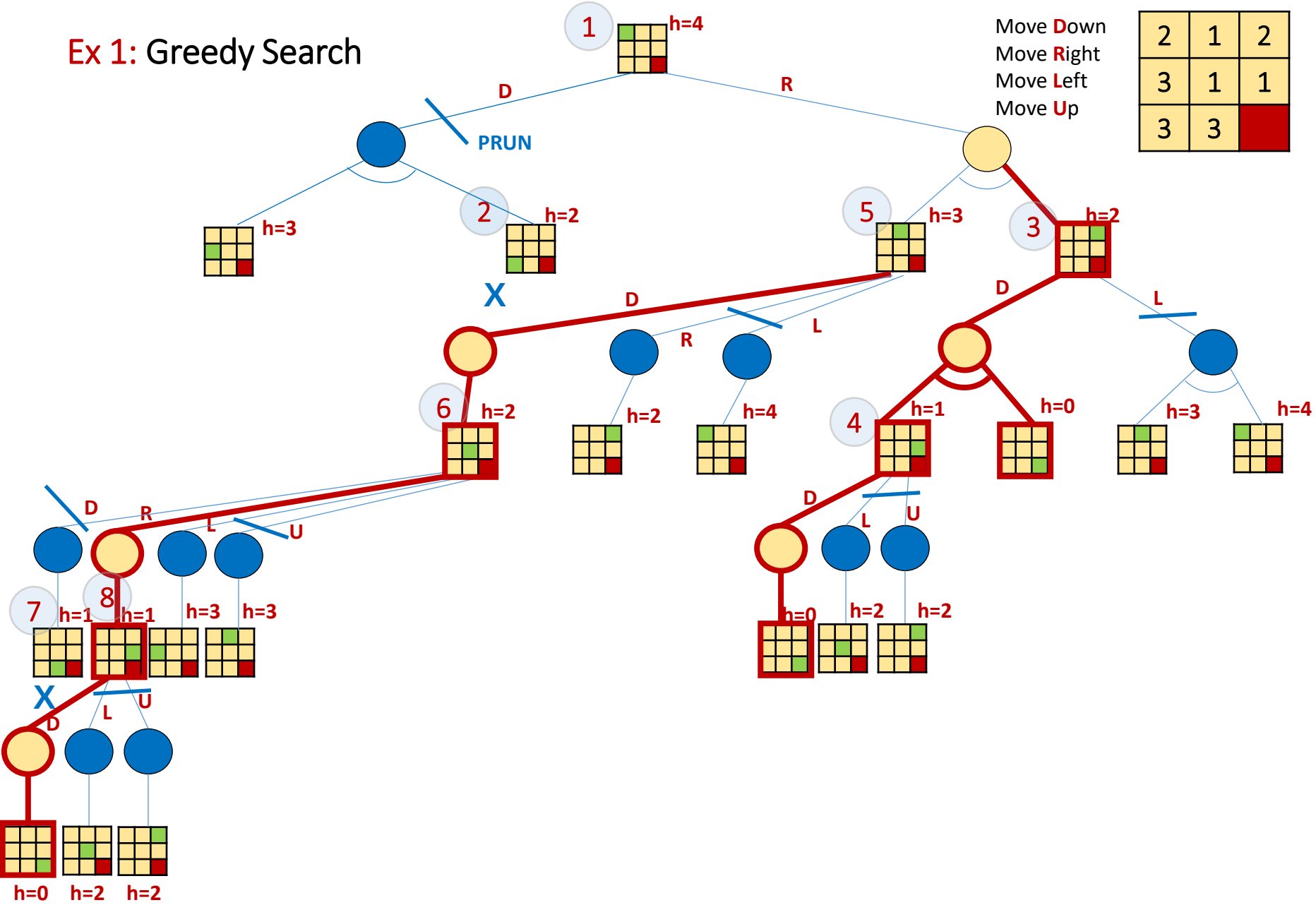
Ex 1: Greedy Search



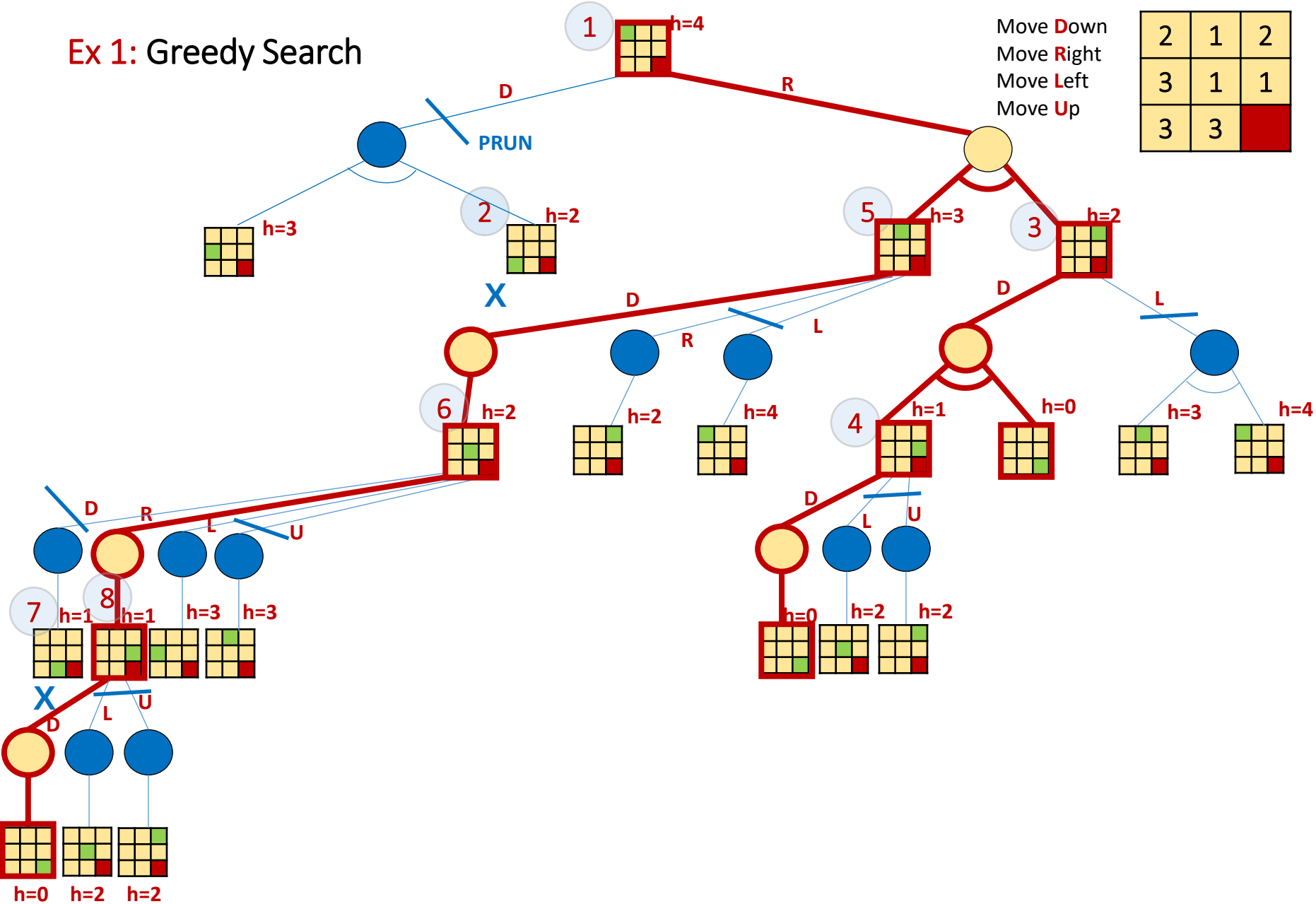
Ex 1: Greedy Search



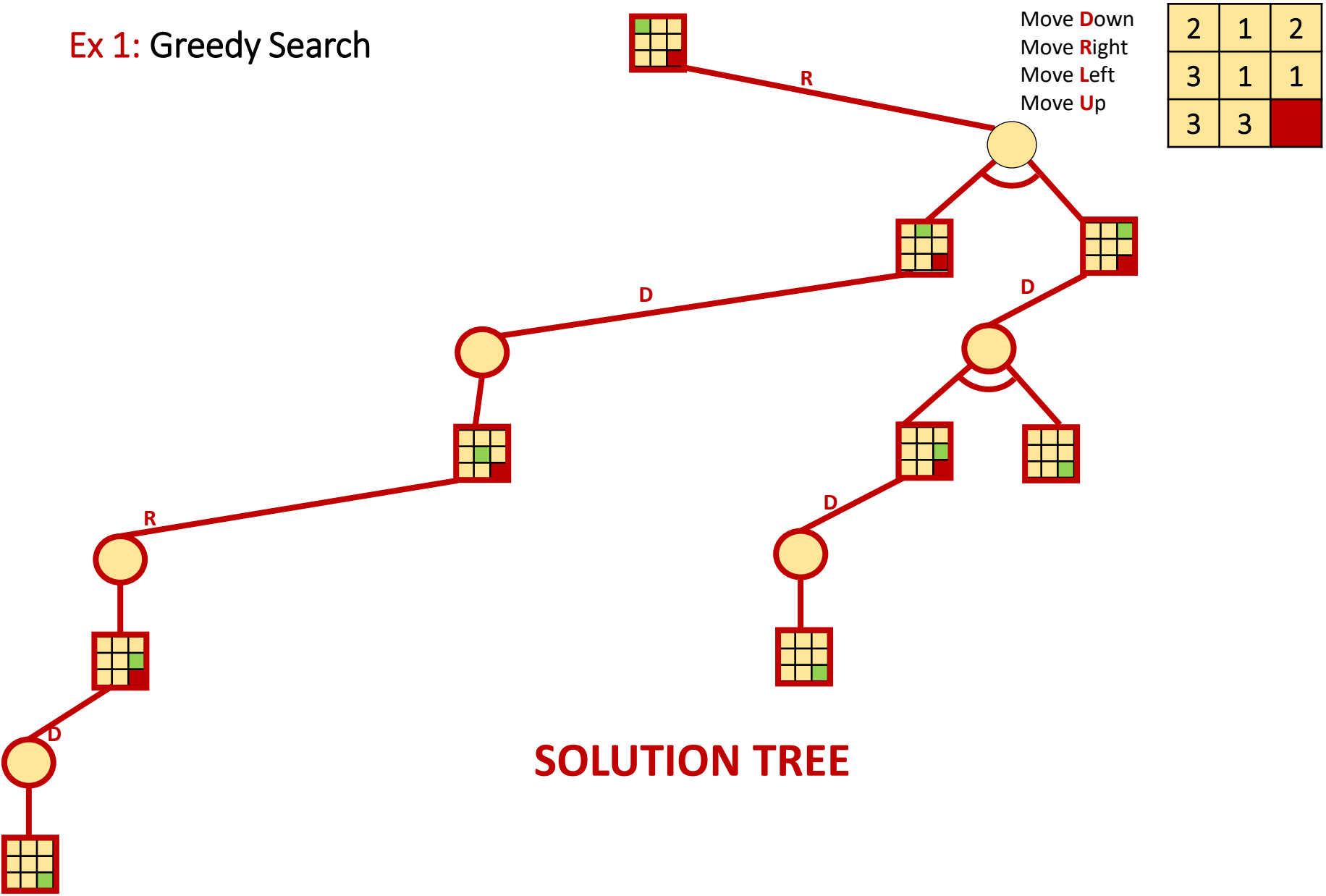
Ex 1: Greedy Search



Ex 1: Greedy Search



Ex 1: Greedy Search



What is the optimal solution for undeterministic problems?

Consider the solution trees $T_1, T_2, T_3, \ldots$.

Let C_n^* be the cost of a solution tree T_n and defined as the worst (the longest) path cost in tree T_n, $n = 1,2,3, \ldots$. Then the optimal cost is

$$\min\{C_1^*, C_2^*, C_3^*, \ldots\}$$

- For the above definition of optimality, solve the example through A* search with the heuristic function defined as Manhattan Distance.

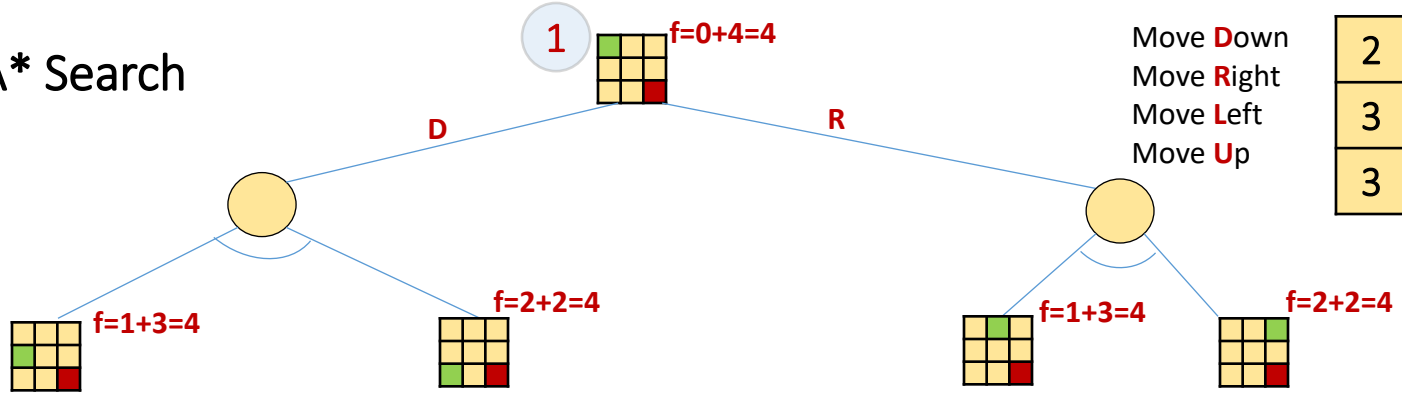
Ex 1: A* Search

f=0+4=4

Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

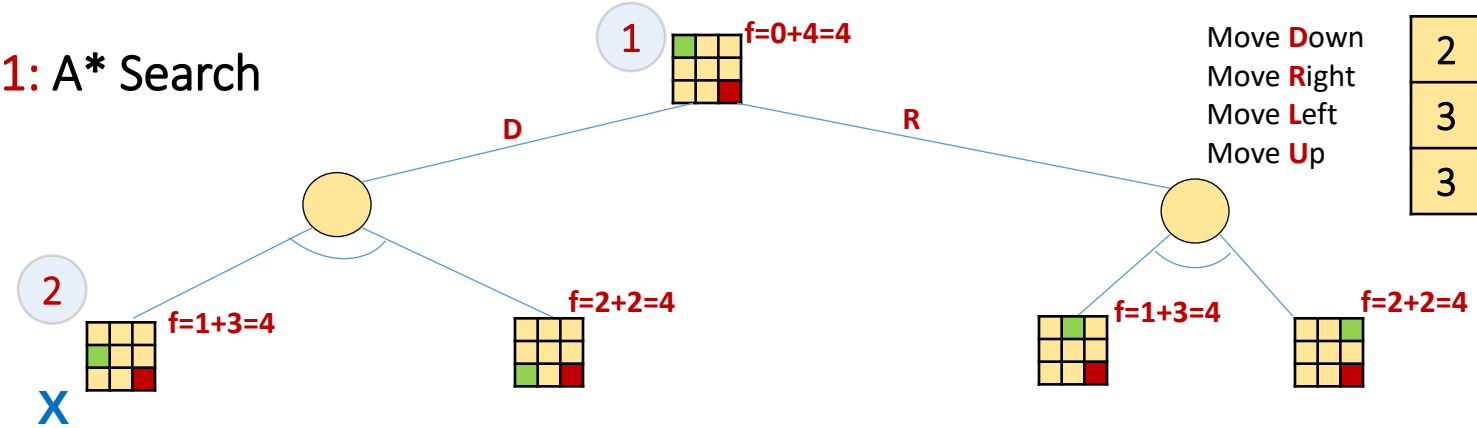
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

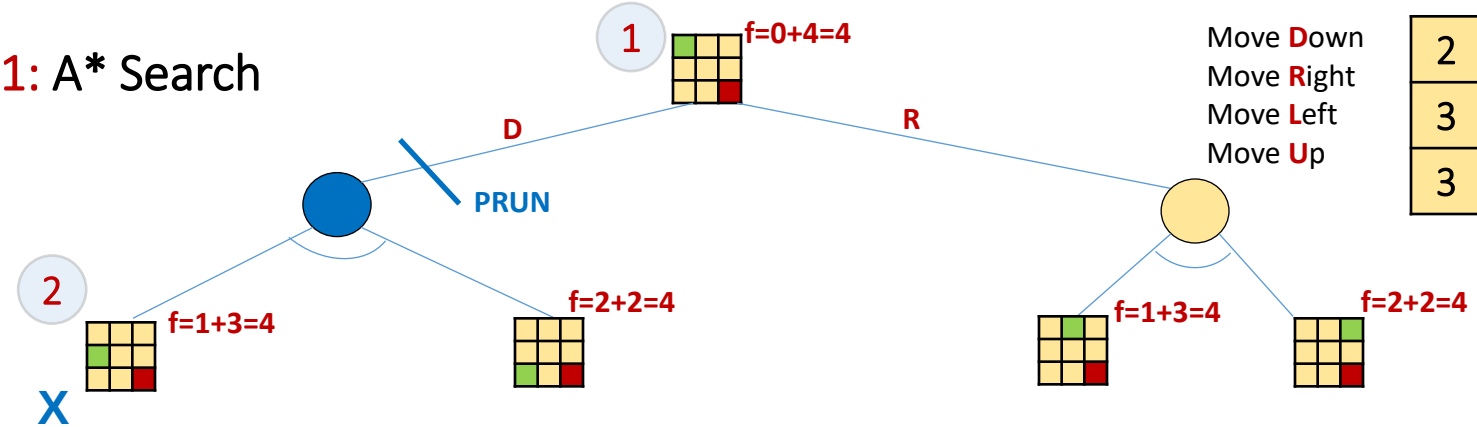
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

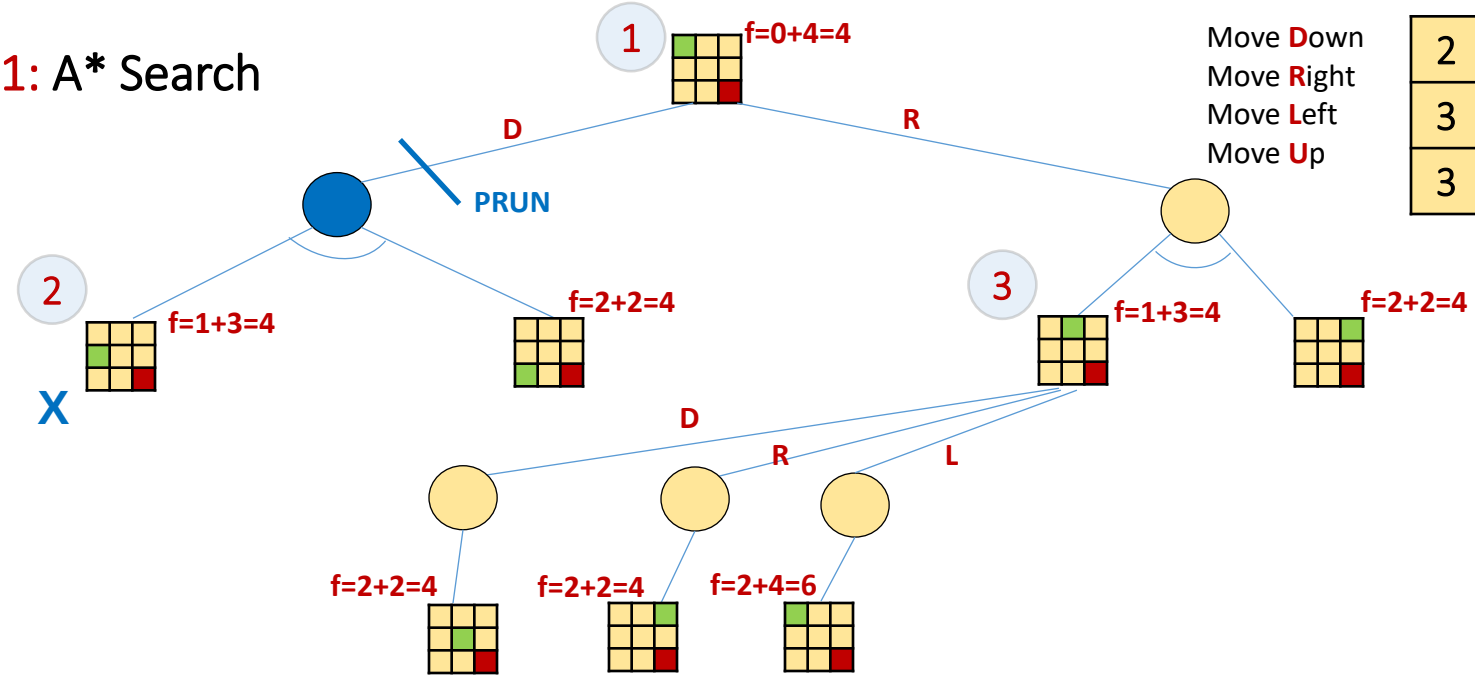
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

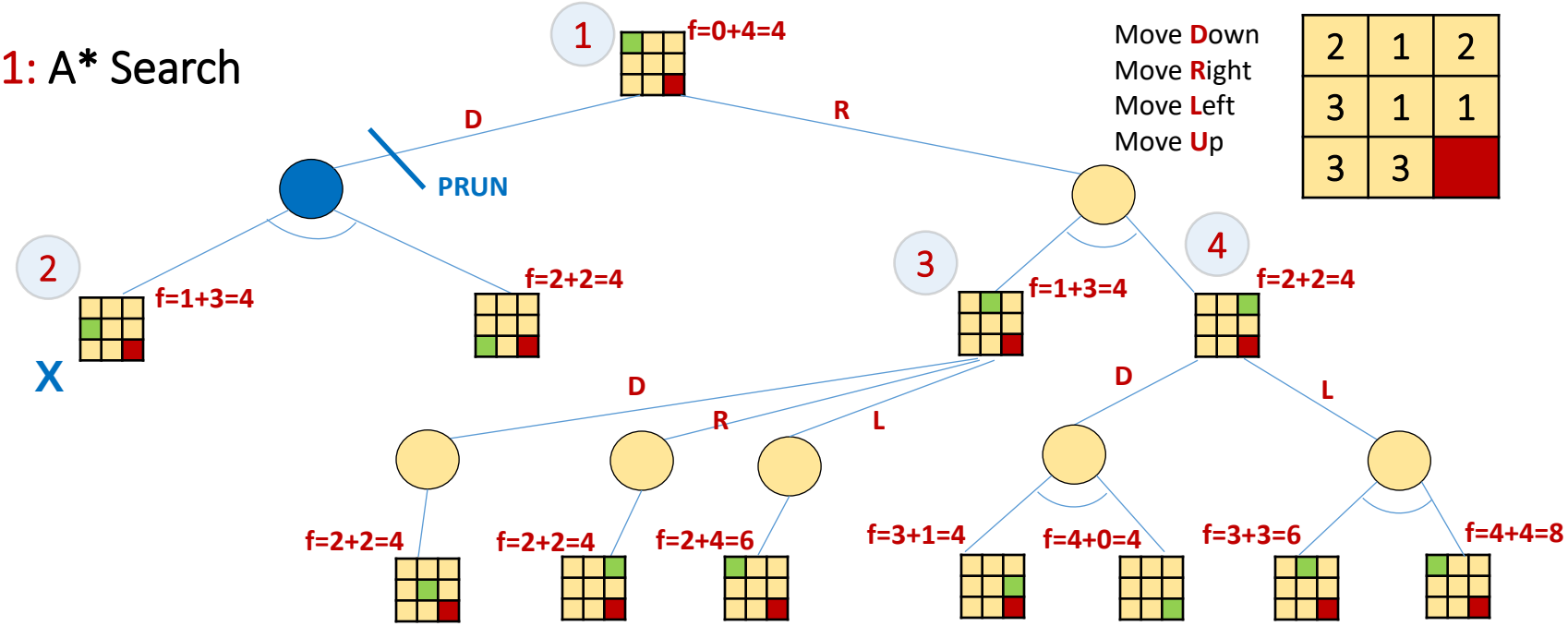
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

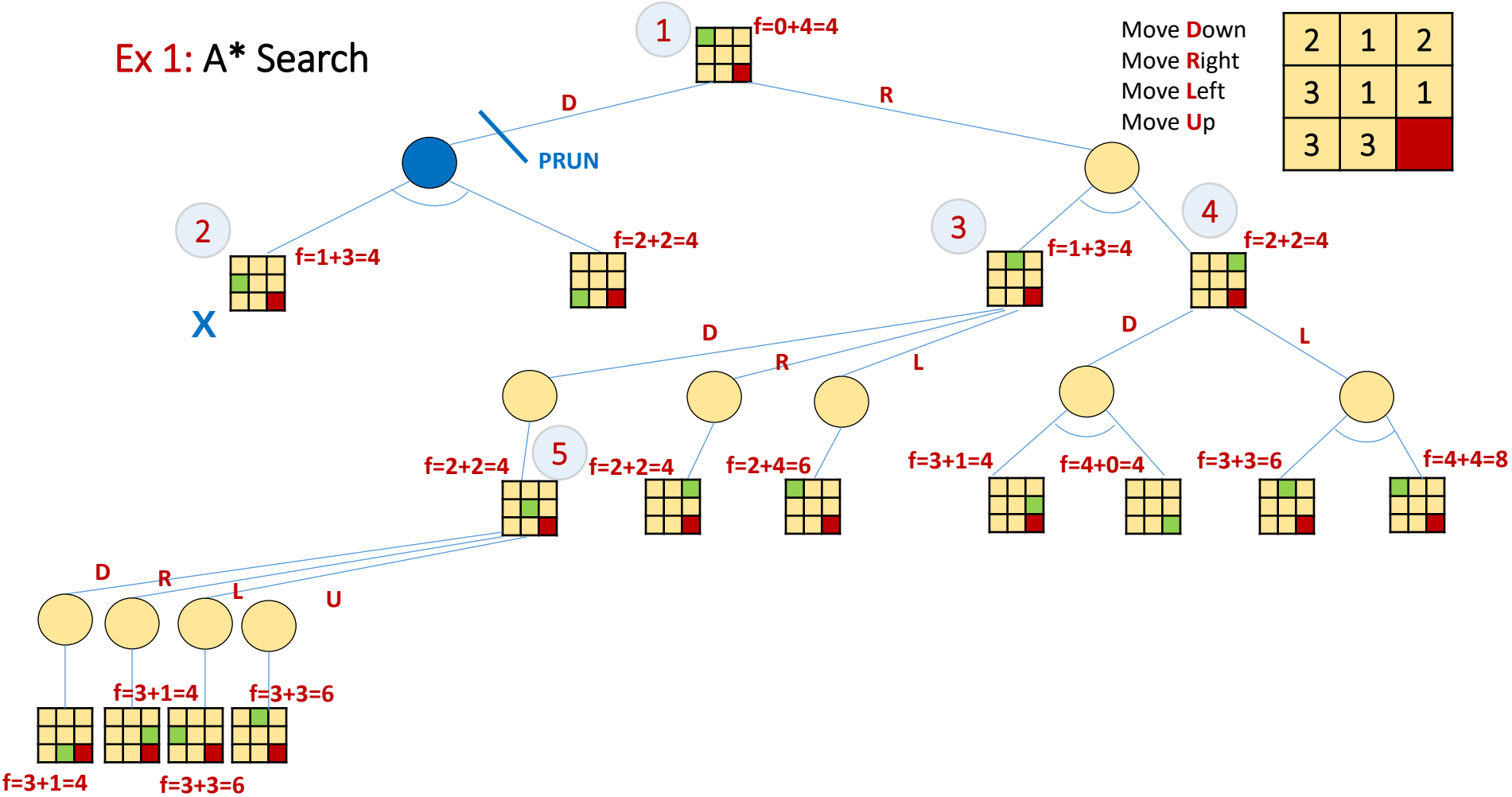
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

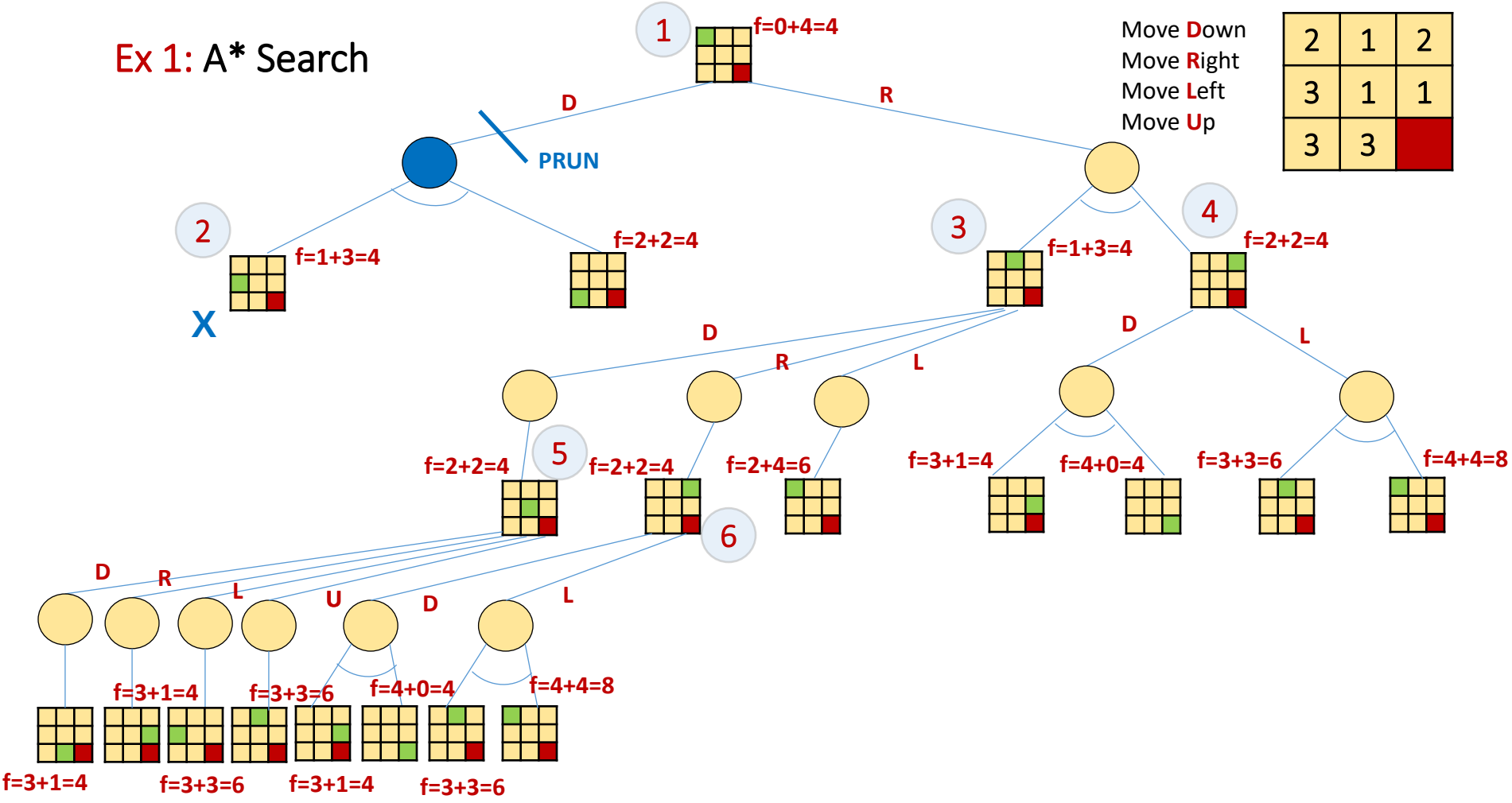
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

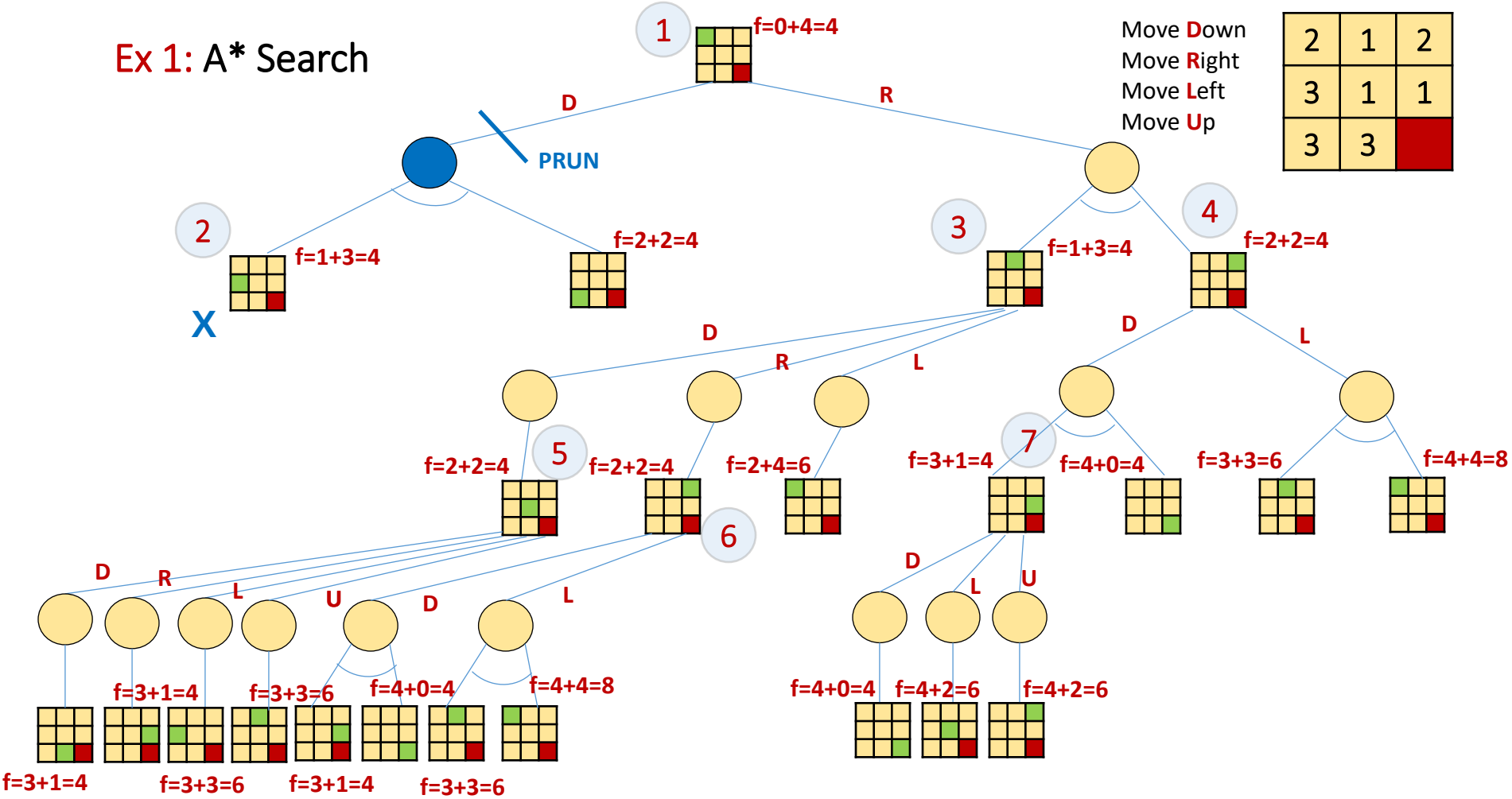
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

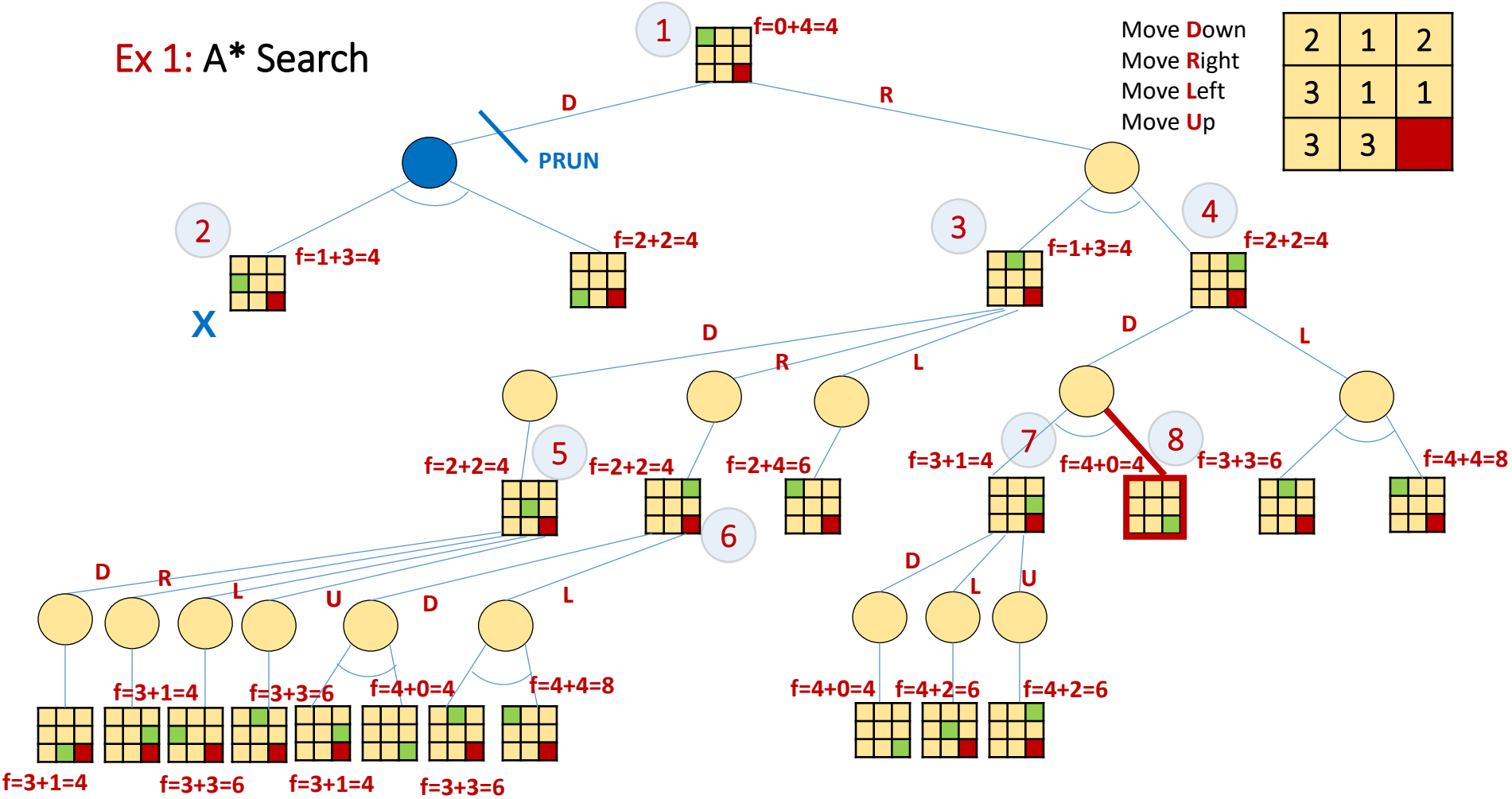
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

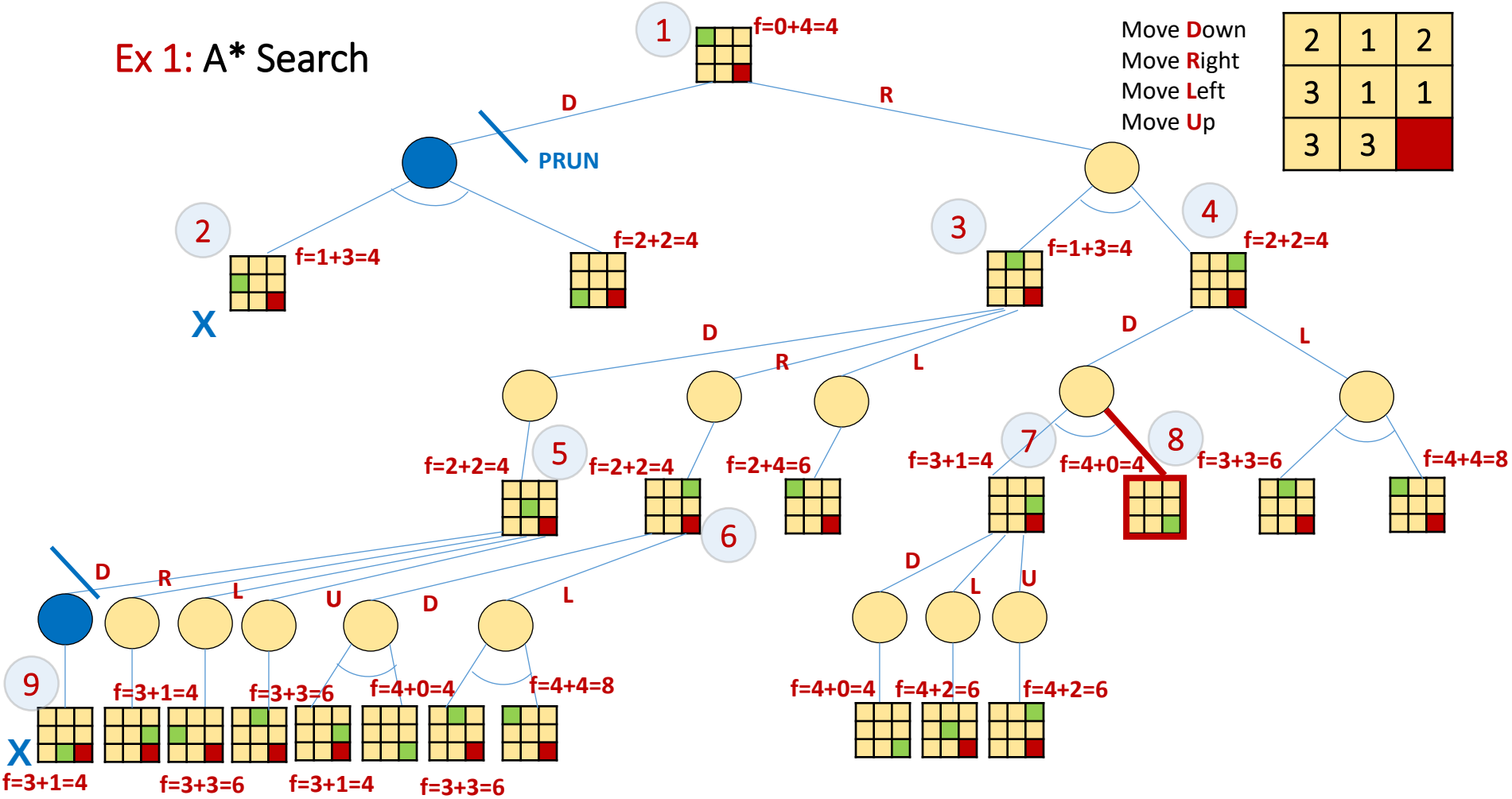
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

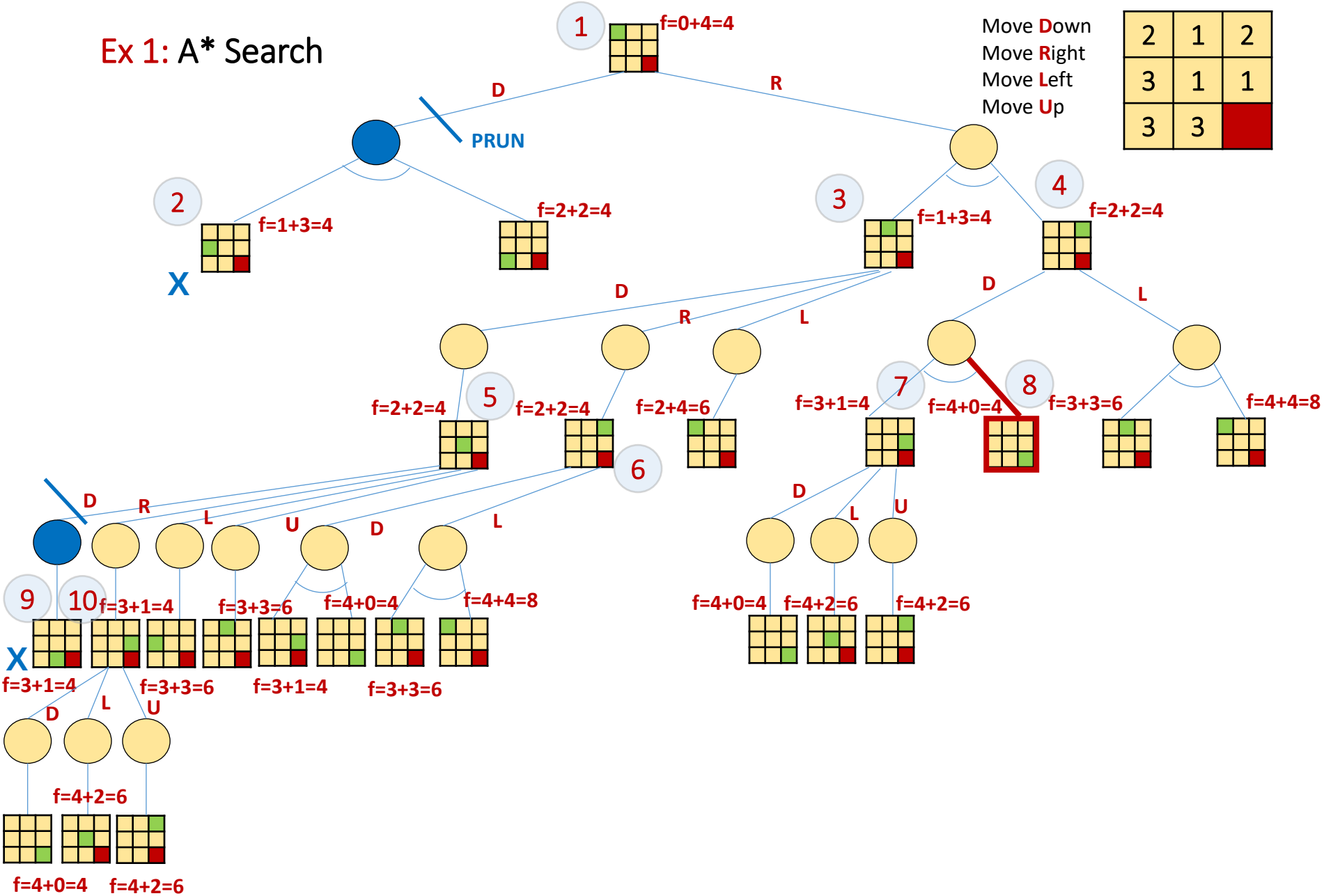
Ex 1: A* Search



Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3	

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
9
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f=3+1=4
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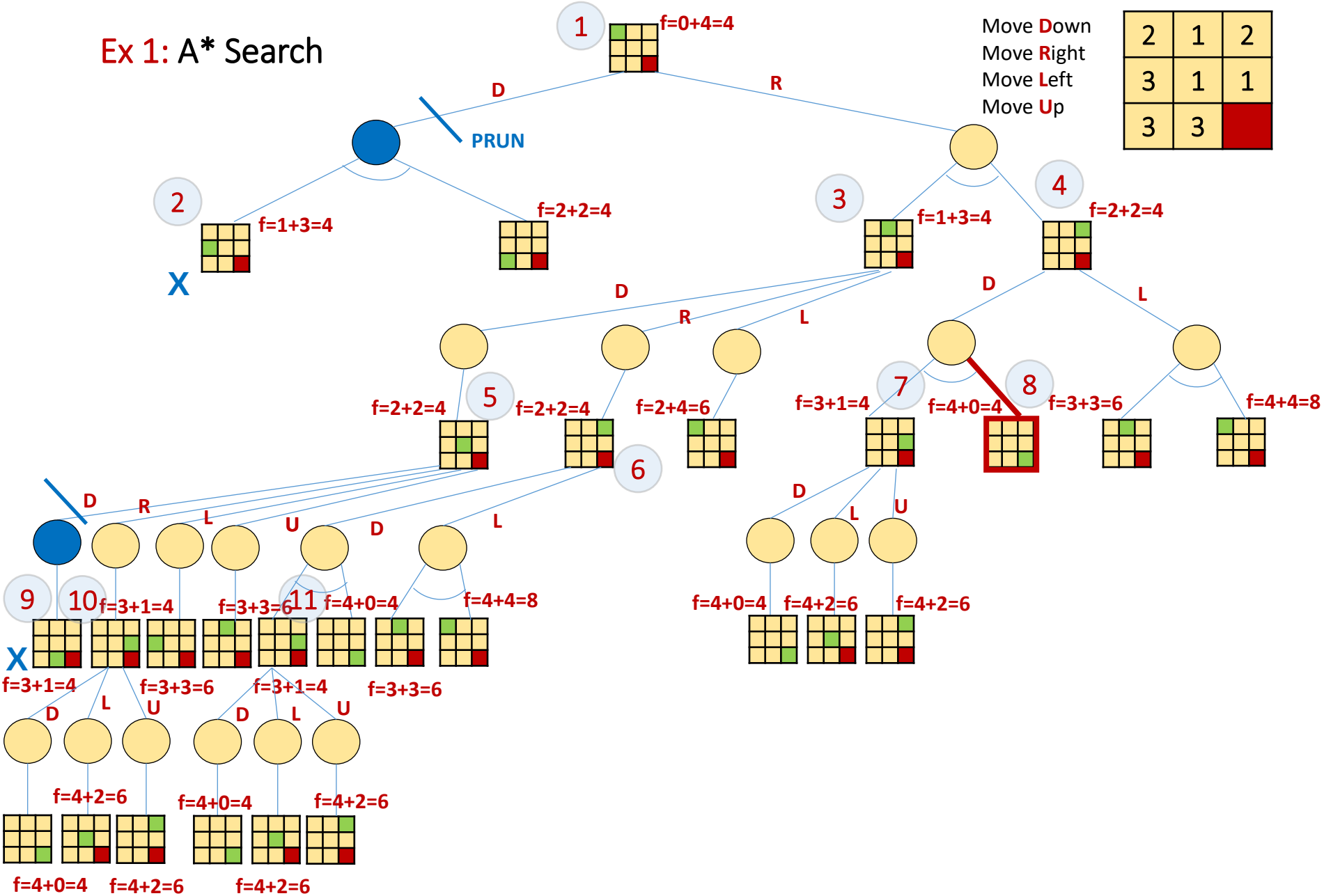
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
f=3+1=4
f=3+3=6
D
L
U
f=4+2=6
f=4+0=4
f=4+2=6
D
L
U
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
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f=3+1=4
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f=4+0=4
f=4+4=8
f=4+0=4
f=4+2=6
f=4+2=6
X
f=3+1=4
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D
L
U
D
L
U
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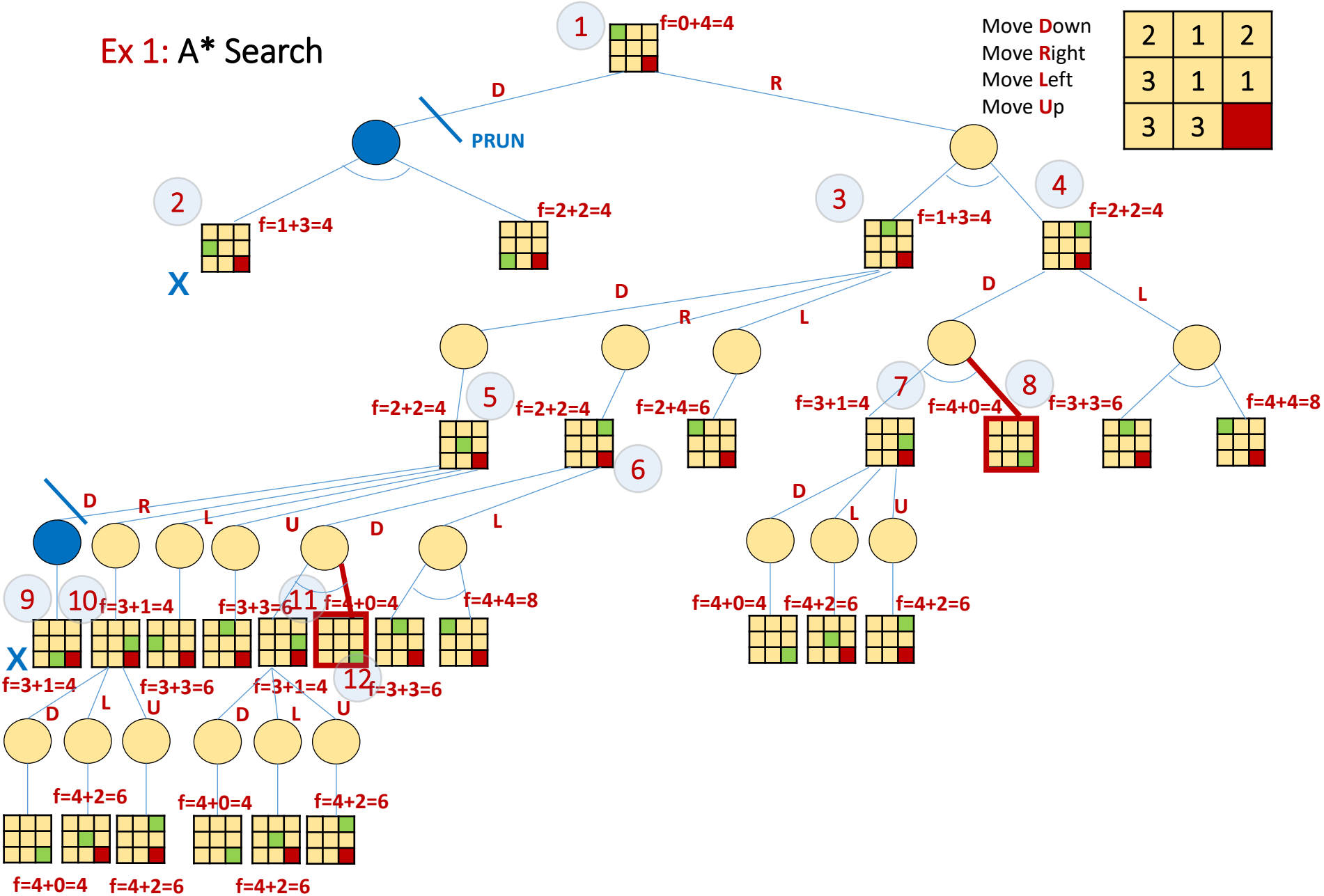
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
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8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
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f=4+0=4
f=4+4=8
f=4+0=4
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f=4+2=6
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D
L
U
D
L
U
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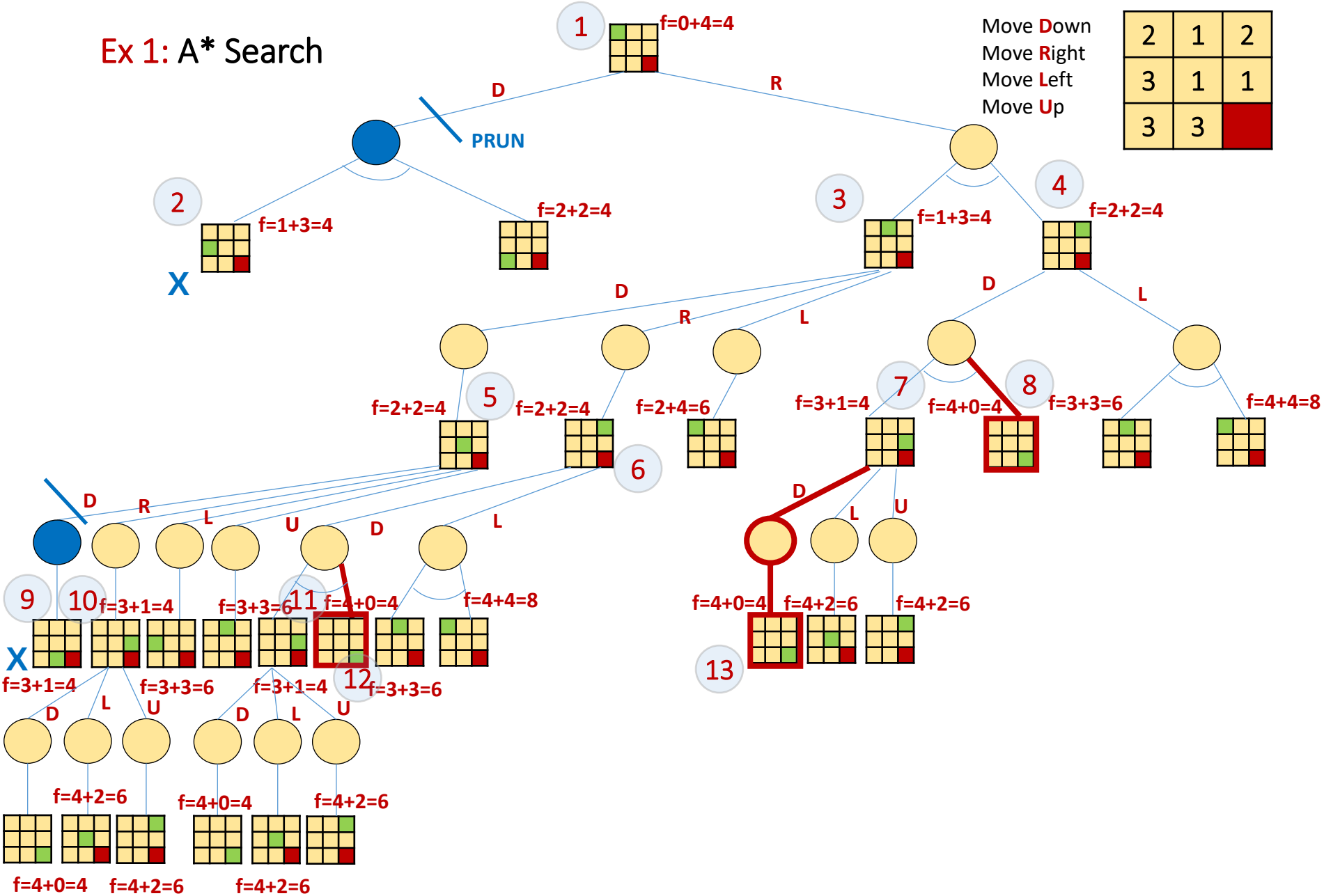
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
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f=4+4=8
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f=4+4=8
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f=3+3=6
f=4+0=4
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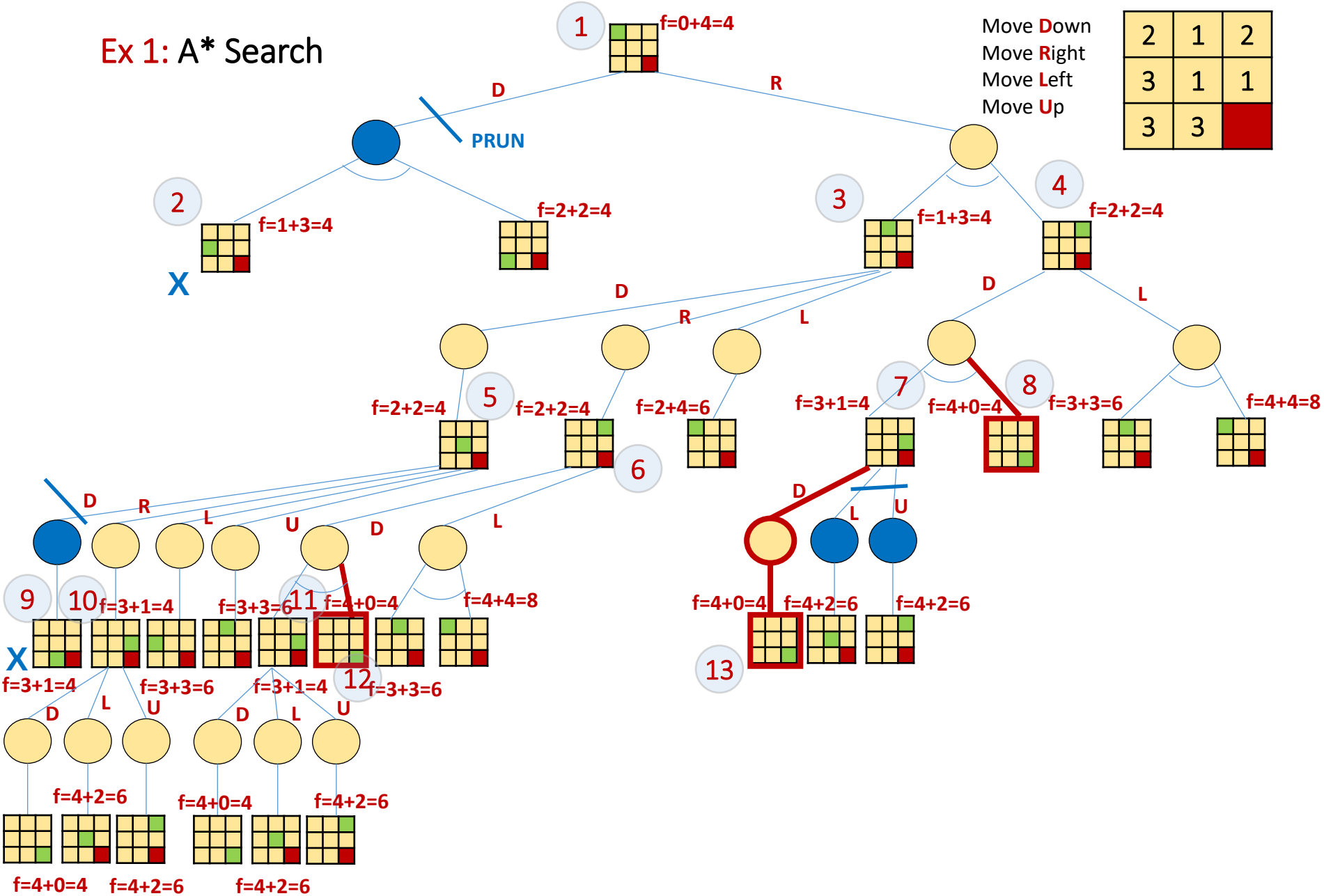
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
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f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
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f=4+0=4
f=4+4=8
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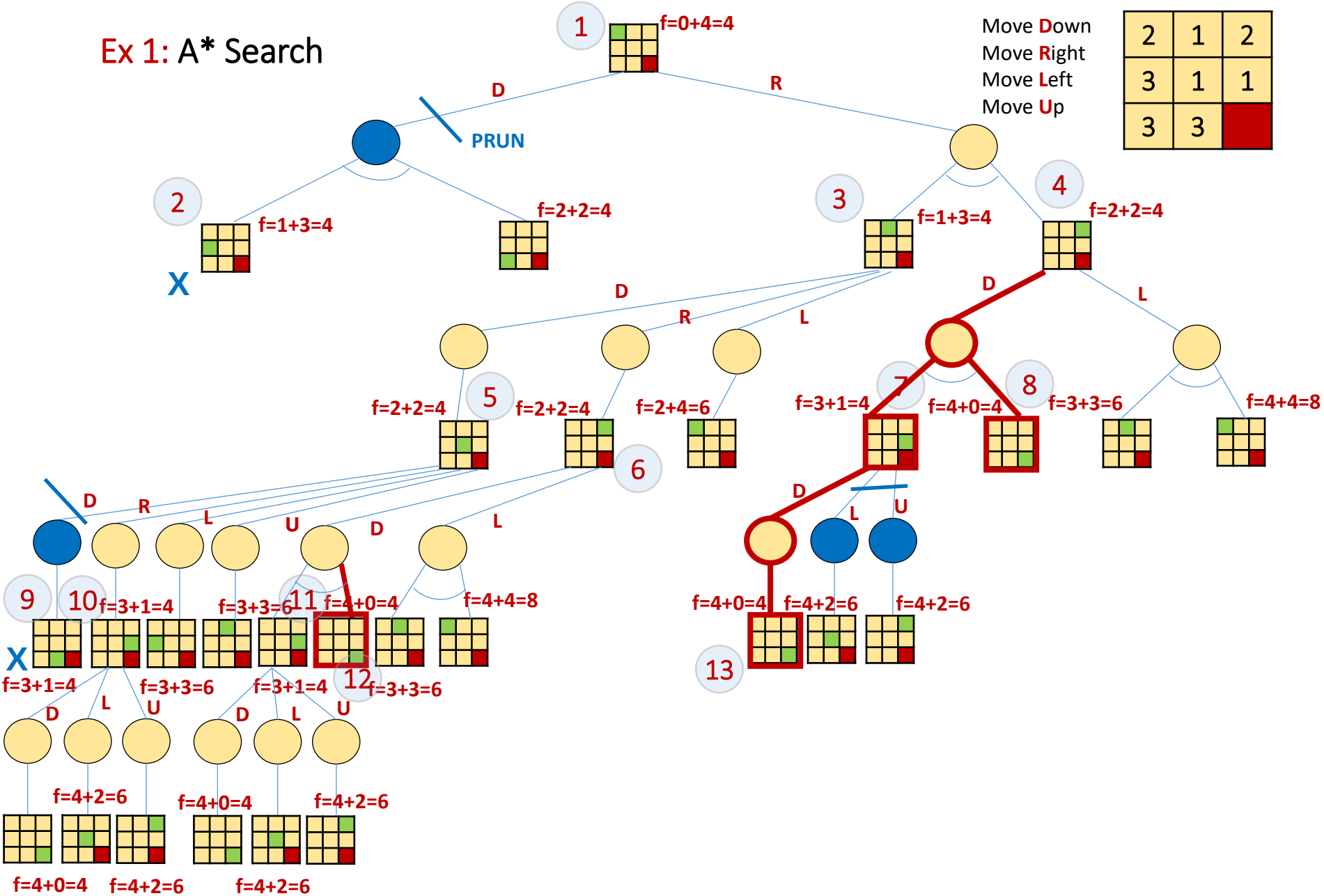
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
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Move Up
2 1 2
3 1 1
3 3
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f=0+4=4
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PRUN
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f=1+3=4
X
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f=1+3=4
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f=2+2=4
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f=3+3=6
f=4+4=8
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U
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f=4+0=4
f=4+4=8
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f=3+1=4
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U
D
L
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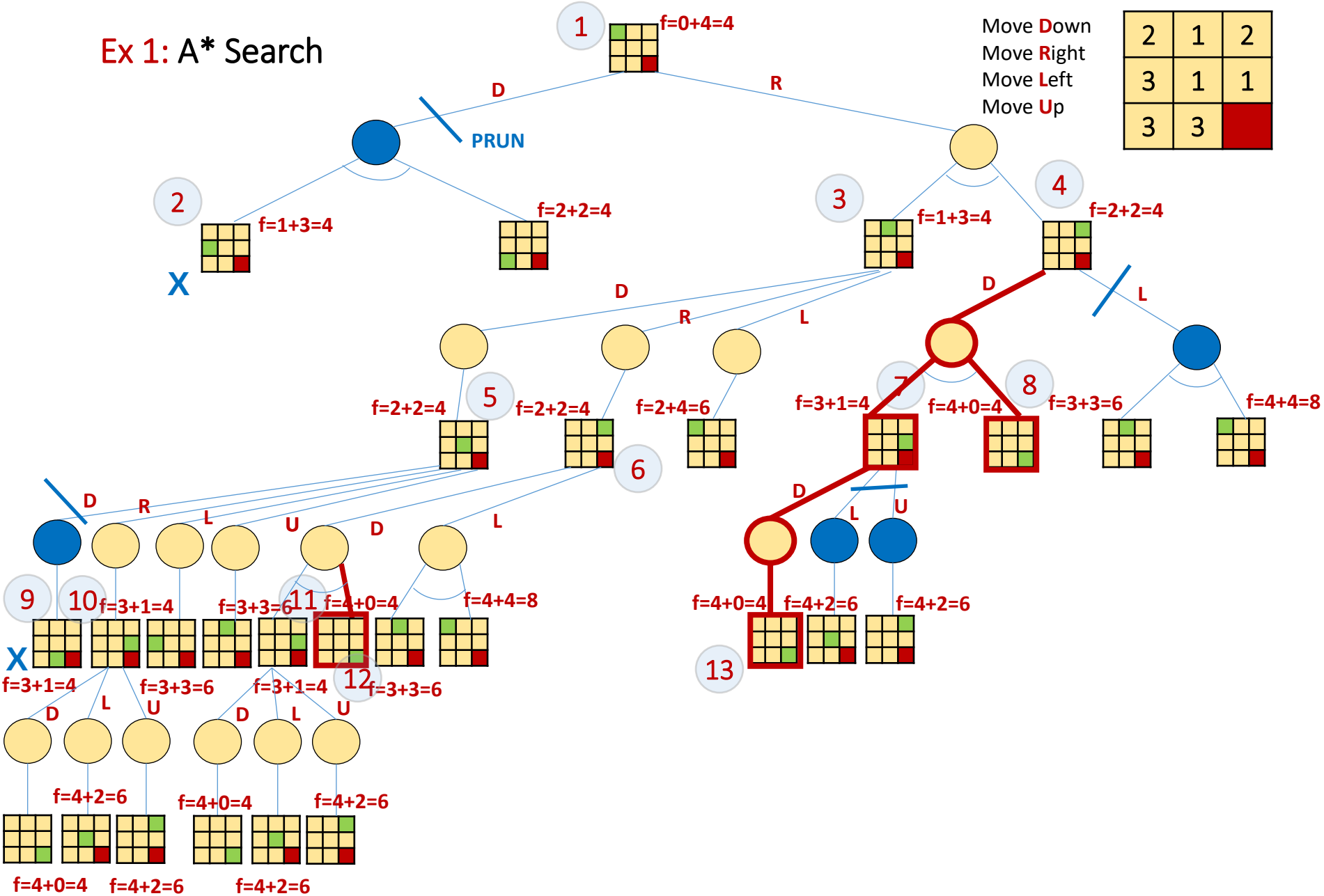
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
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f=2+2=4
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f=2+2=4
f=2+4=6
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f=3+1=4
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f=4+0=4
8
f=3+3=6
f=4+4=8
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f=4+0=4
f=4+4=8
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f=3+1=4
f=3+3=6
12
f=3+1=4
f=3+3=6
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f=4+2=6
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D
L
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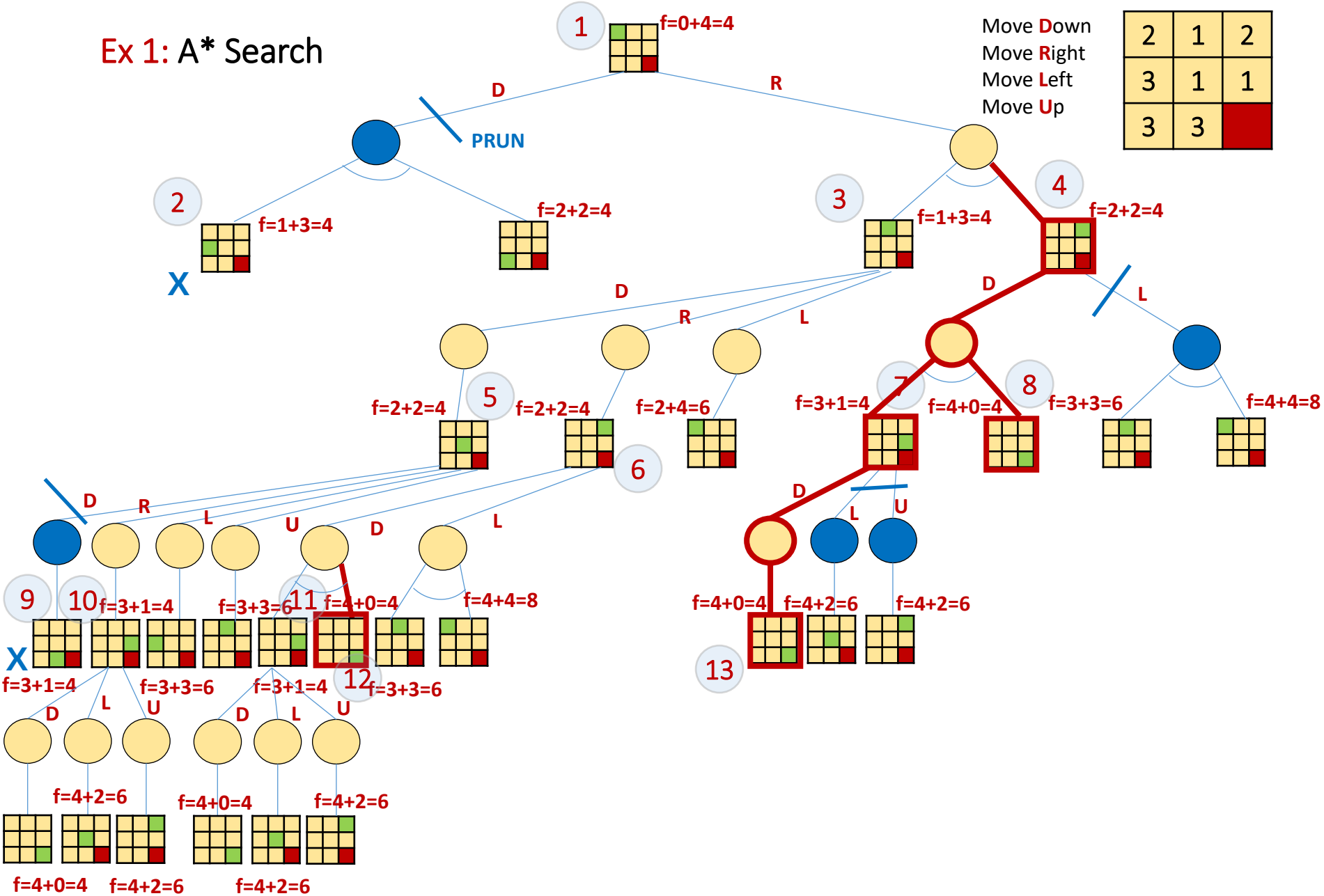
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
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8
f=3+3=6
f=4+4=8
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f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
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f=3+1=4
f=3+3=6
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f=4+2=6
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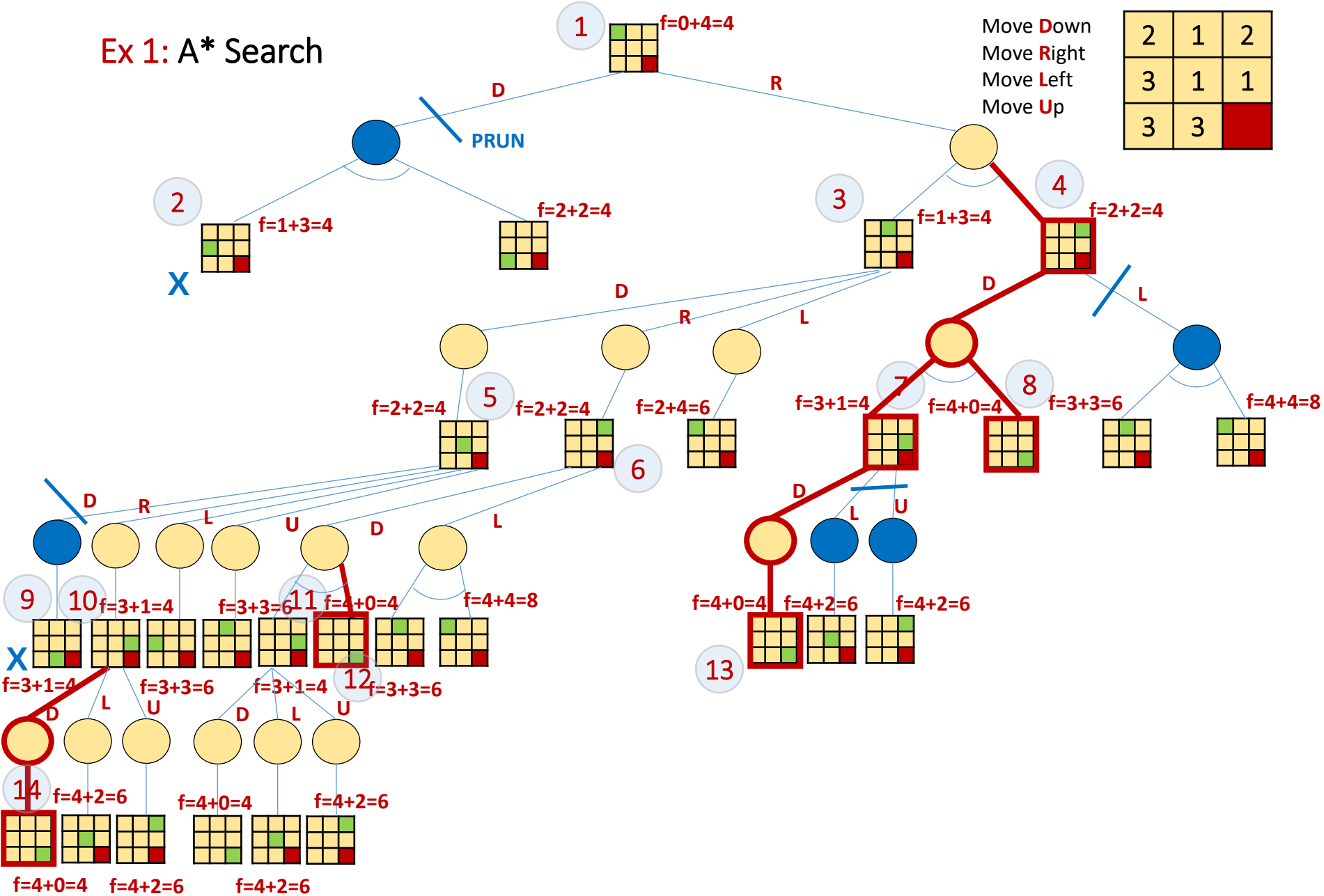
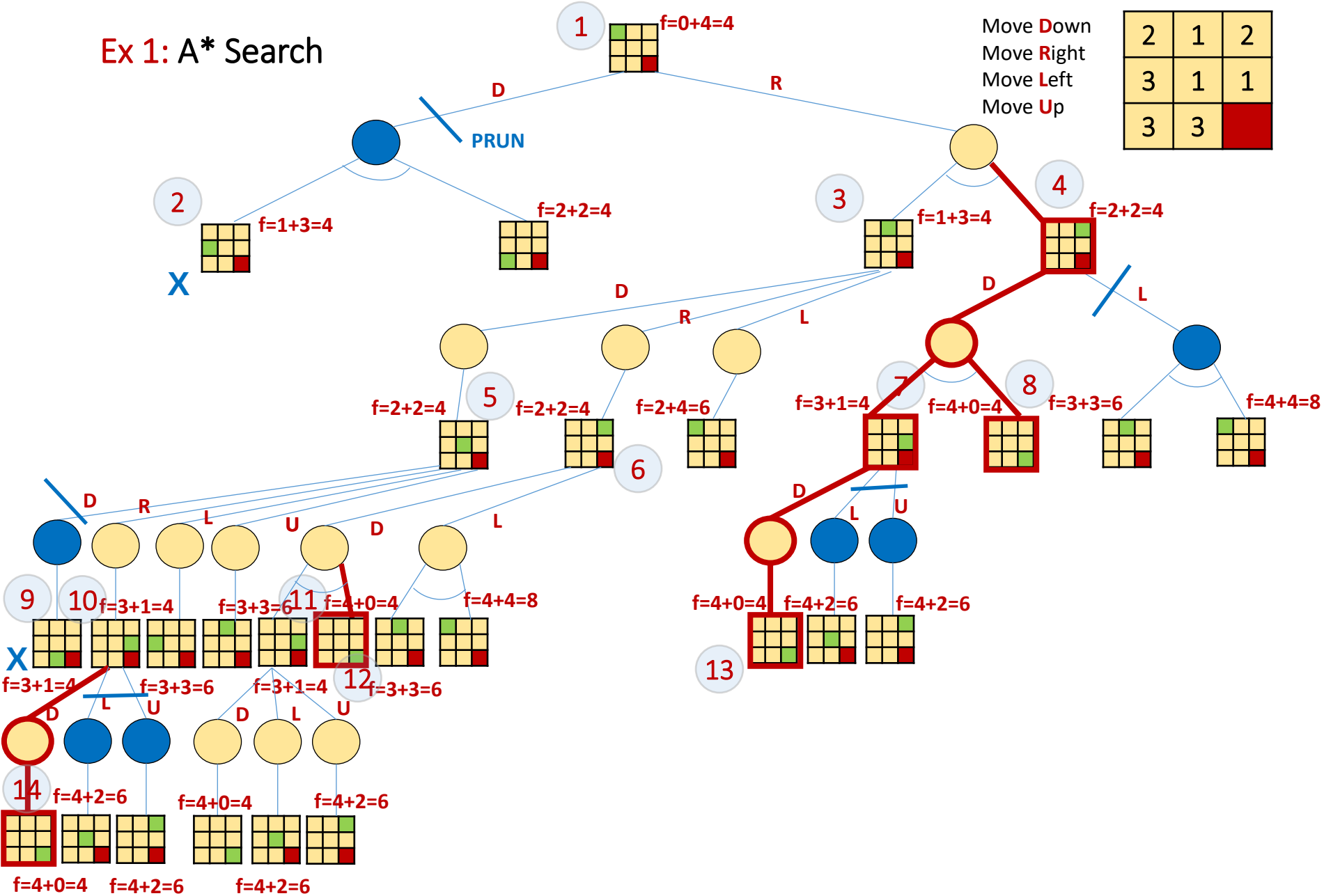
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

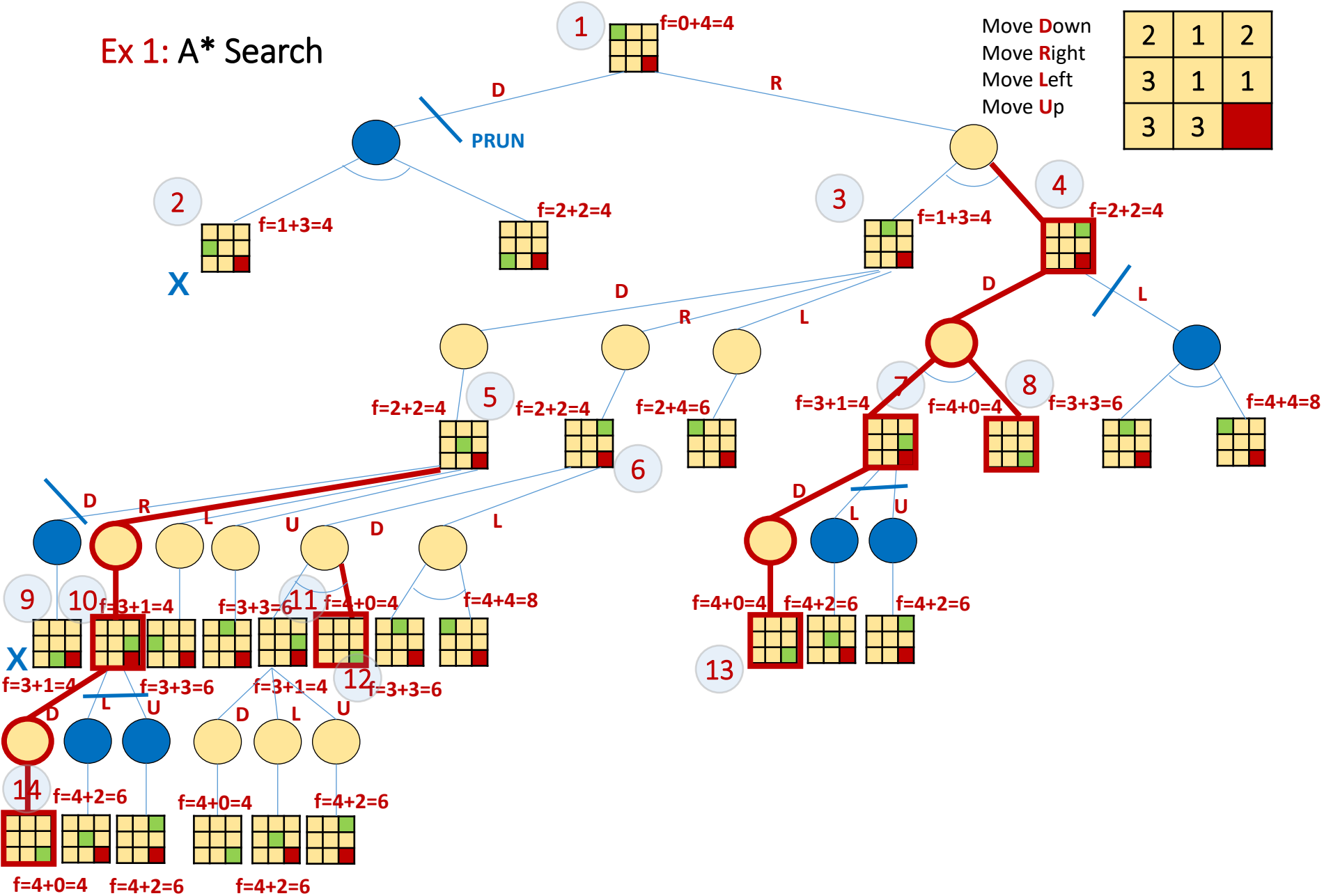
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
f=3+1=4
12
f=3+3=6
f=4+0=4
f=4+2=6
f=4+2=6
13
D
L
U
D
L
U
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

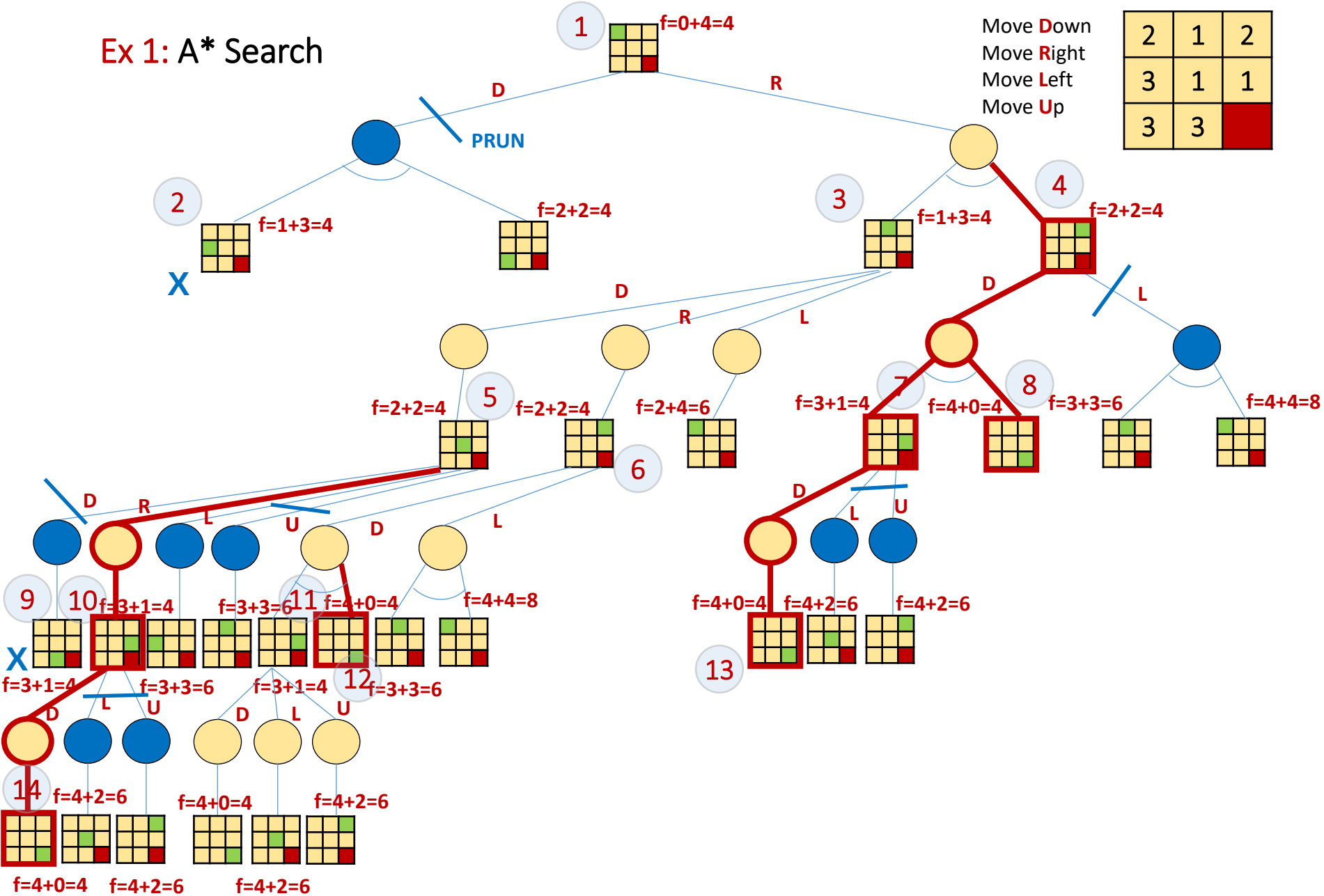
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
12
f=3+3=6
f=3+1=4
D
L
U
D
L
U
f=4+0=4
f=4+2=6
f=4+2=6
13
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

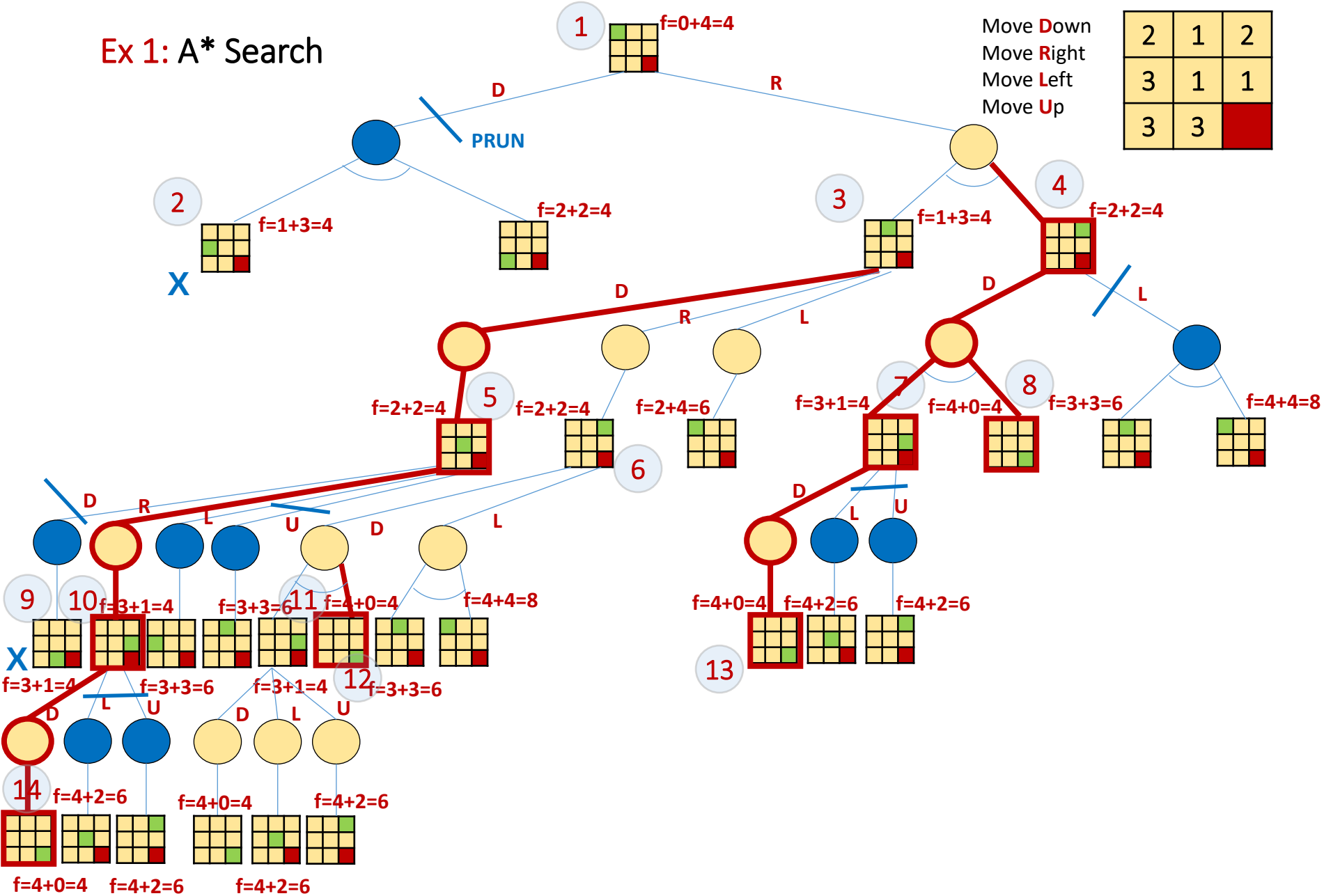
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
12
f=3+3=6
f=3+1=4
D
L
U
D
L
U
f=4+0=4
f=4+2=6
f=4+2=6
13
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

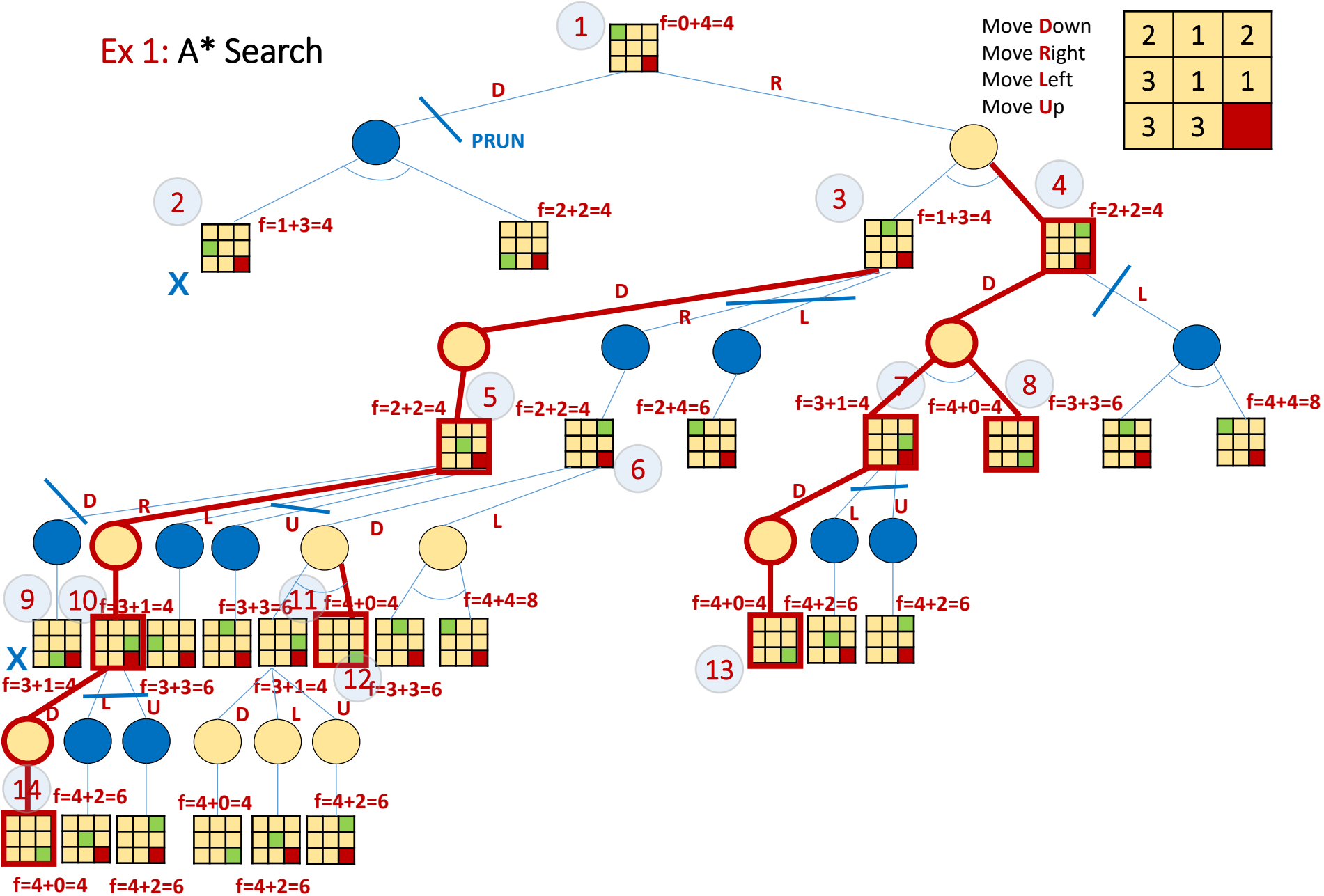
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
12
f=3+1=4
f=3+3=6
D
L
U
D
L
U
f=4+0=4
f=4+2=6
f=4+2=6
13
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

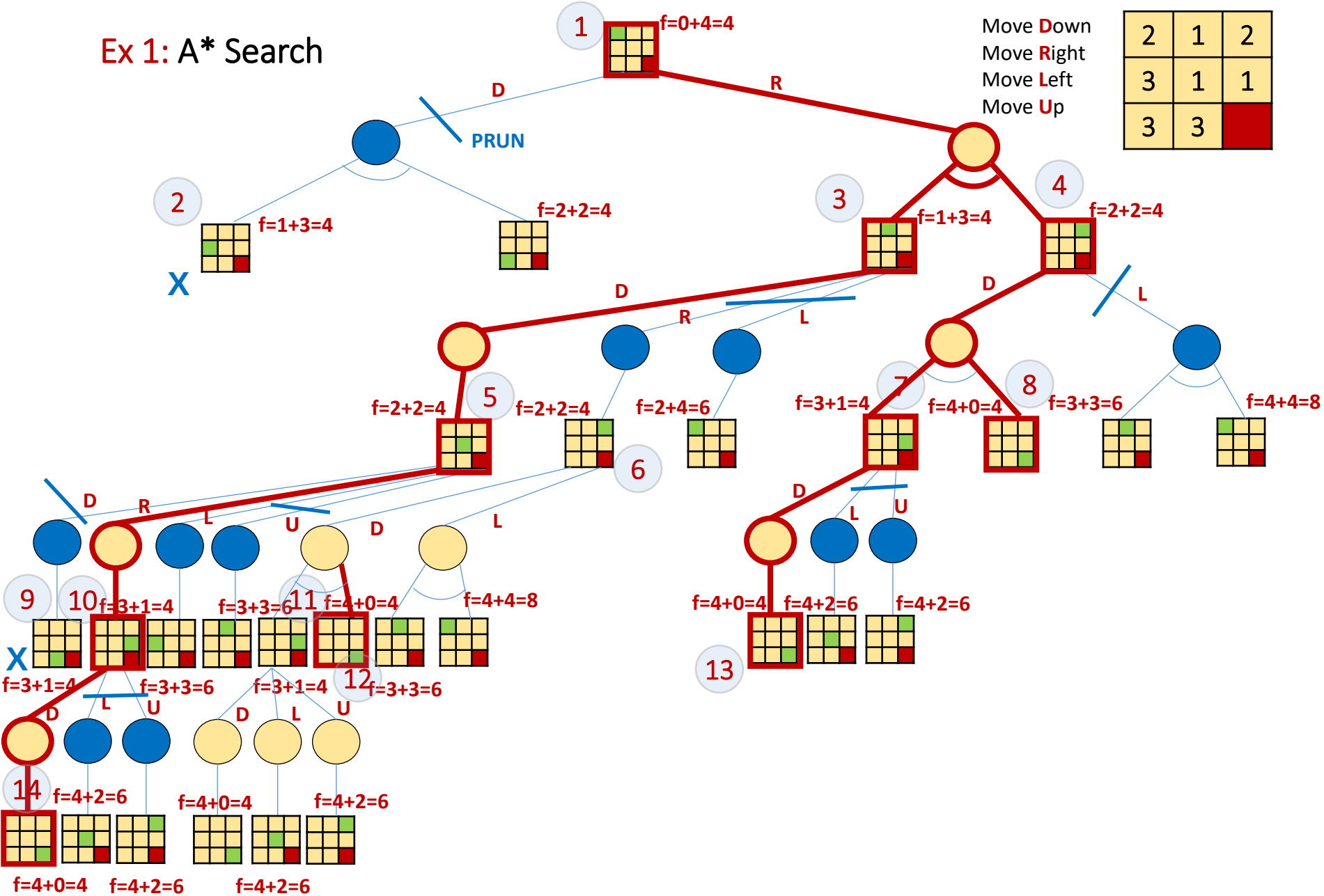
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
12
f=3+3=6
f=3+1=4
f=4+0=4
f=4+2=6
f=4+2=6
13
D
L
U
D
L
U
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

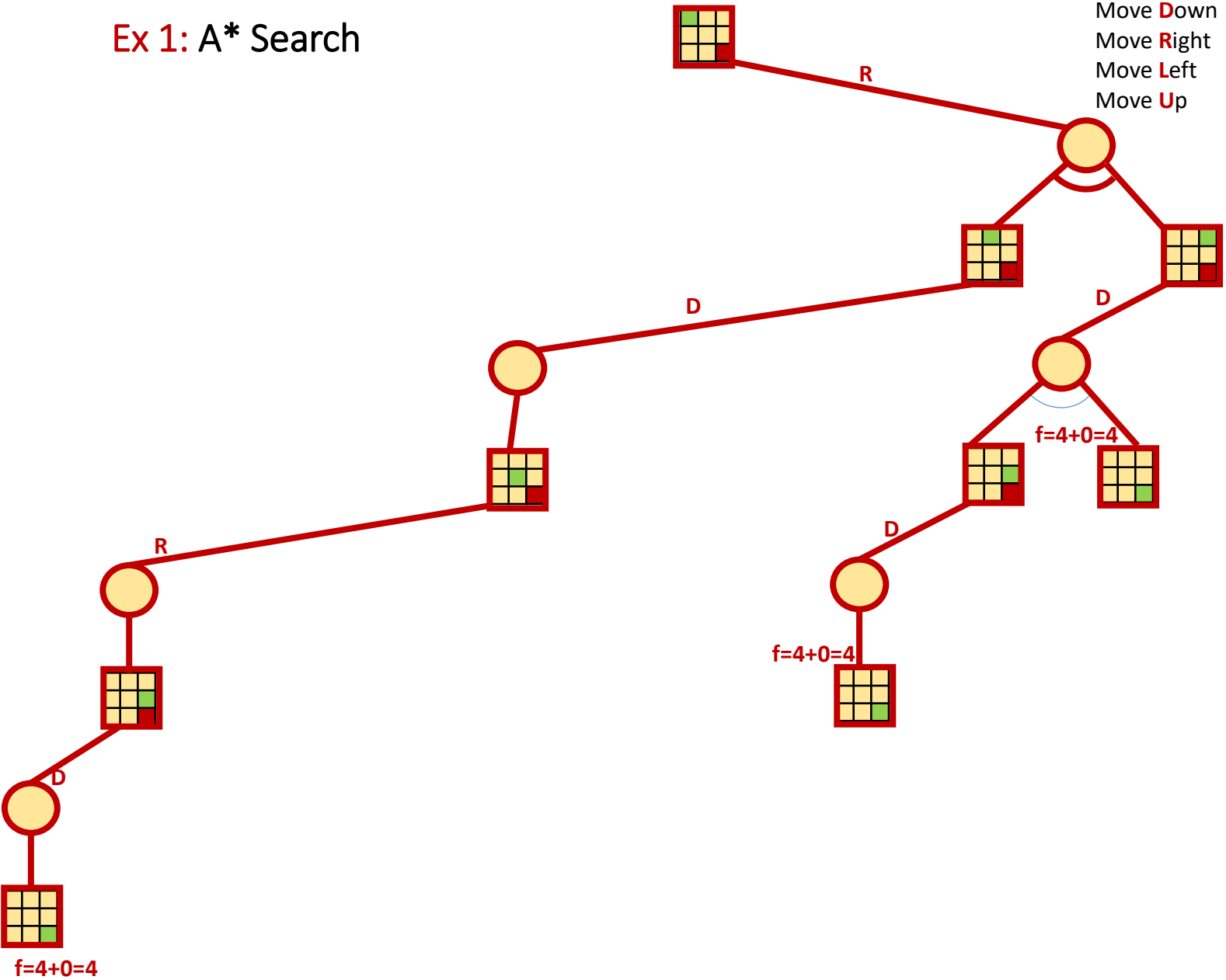
Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
f=4+0=4
f=4+2=6
f=4+2=6
13
X
f=3+1=4
f=3+3=6
f=3+1=4
12
f=3+3=6
D
L
U
D
L
U
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search


Move Down
Move Right
Move Left
Move Up
2 1 2
3 1 1
3 3
1
f=0+4=4
D
R
PRUN
2
f=1+3=4
X
f=2+2=4
3
f=1+3=4
4
f=2+2=4
D
R
L
D
L
f=2+2=4
5
f=2+2=4
f=2+4=6
6
f=3+1=4
7
f=4+0=4
8
f=3+3=6
f=4+4=8
D
R
L
U
D
L
D
L
U
9
10
f=3+1=4
f=3+3=6
11
f=4+0=4
f=4+4=8
X
f=3+1=4
f=3+3=6
12
f=3+3=6
f=3+1=4
f=4+0=4
f=4+2=6
f=4+2=6
13
D
L
U
D
L
U
14
f=4+2=6
f=4+0=4
f=4+2=6
f=4+0=4
f=4+2=6
f=4+2=6

Ex 1: A* Search

Move **D**own
Move **R**ight
Move **L**eft
Move **U**p

2	1	2
3	1	1
3	3