State Space
&
Breadth-First Search

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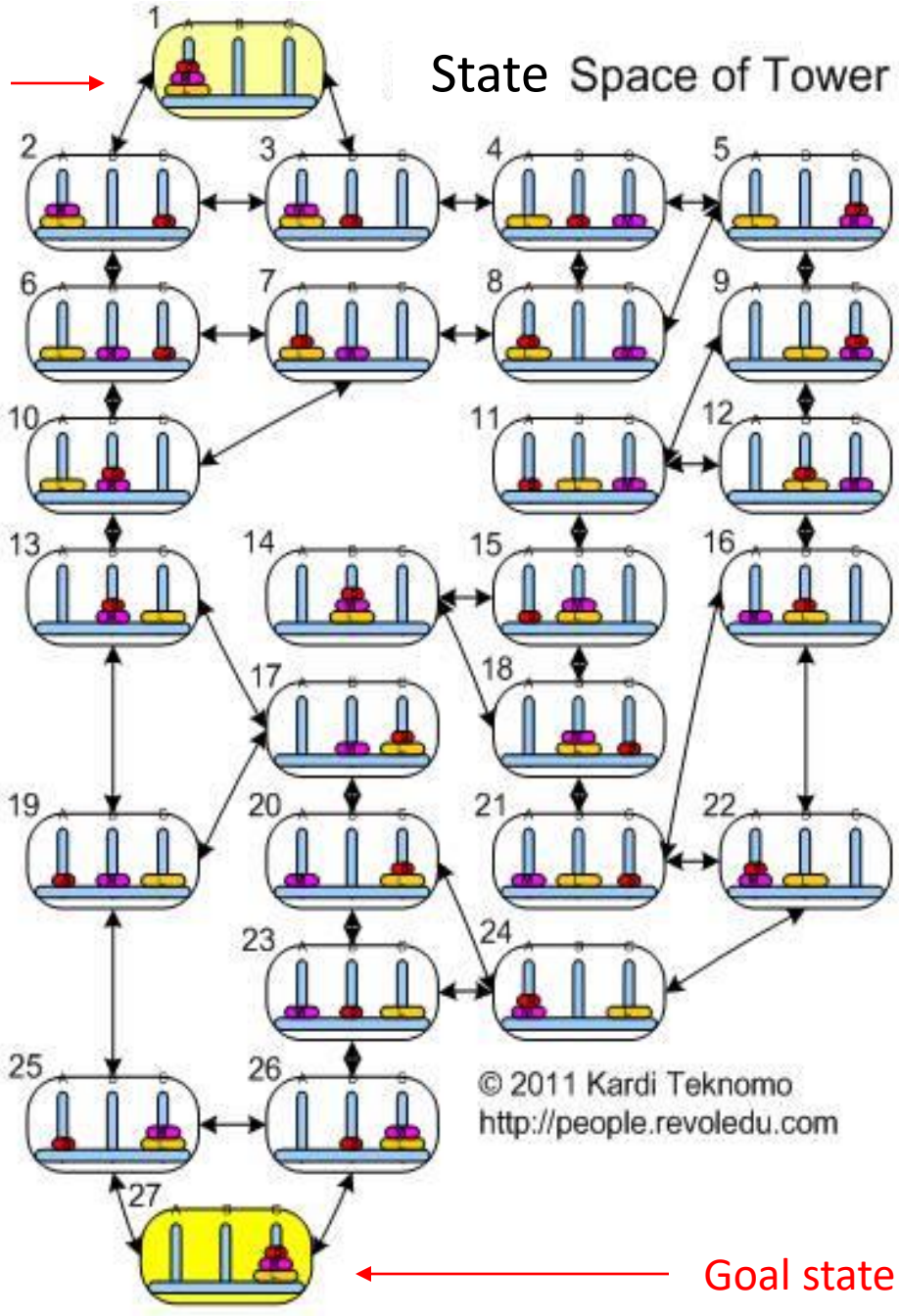
Initial state →

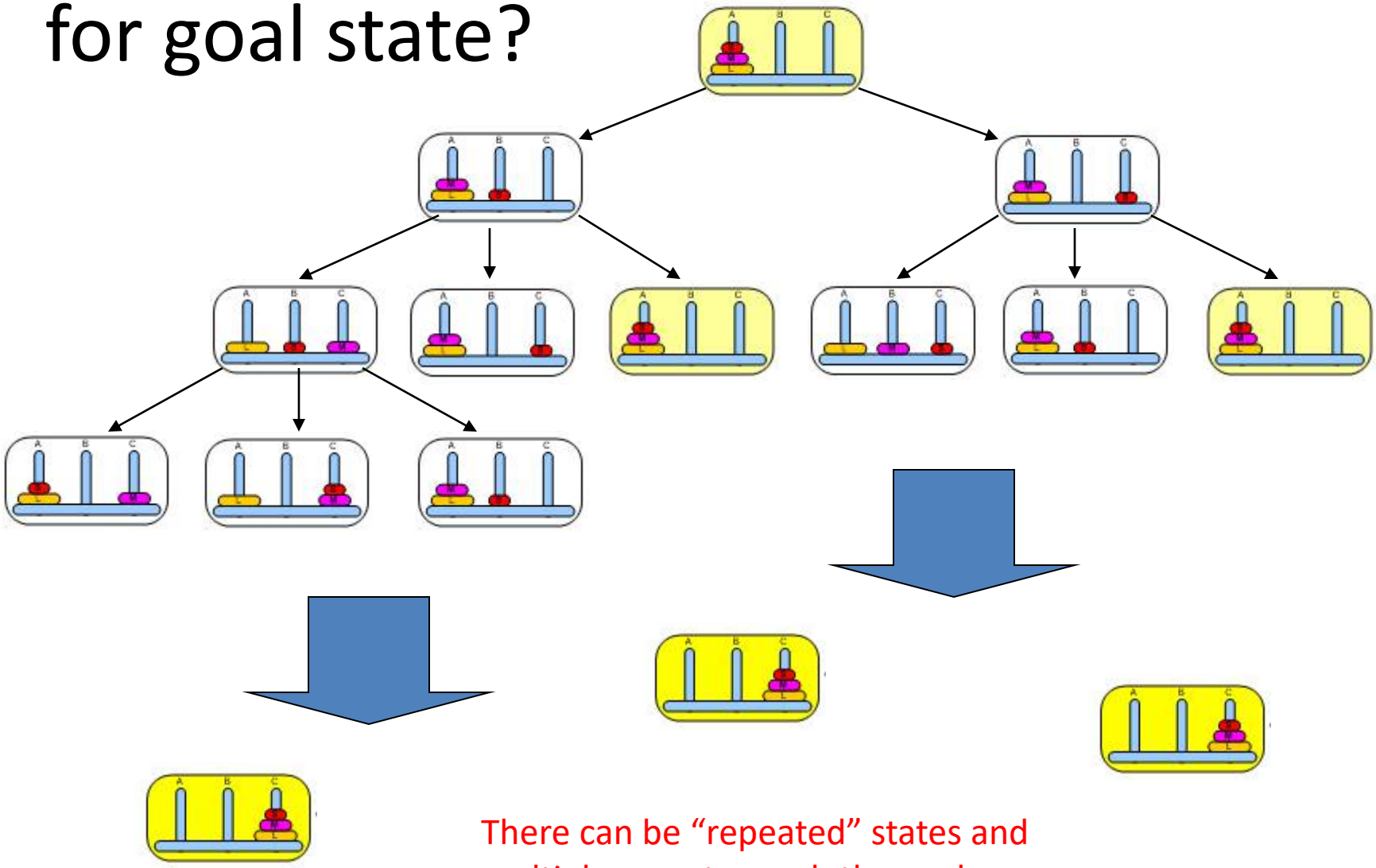
State Space of Tower of Hanoi (3 disks)



Goal state ←

If you've never known about Tower of Hanoi problem, learn about it briefly here.

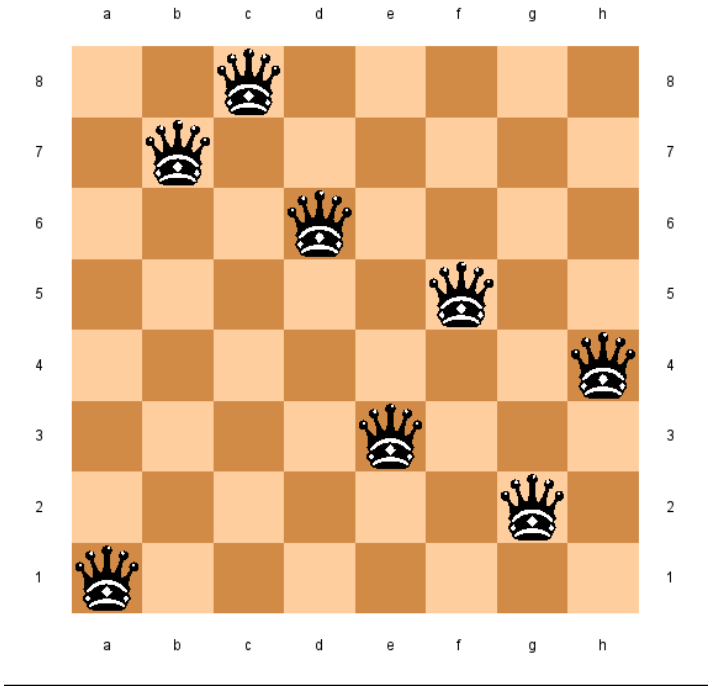
How to search for goal state?



There can be “repeated” states and multiple ways to reach the goal

Modeling a problem

- N queens



Complete-State Formation:

- **States:** any arrangement of 8 queens on the board
- **Actions:** move a queen to any square
- **Goal test**: 8 queens on the board, none attacked

Each queen can take any of the 64 positions
→ 64^8 states with 8 queens (2.81 x 10^14)

Incremental Formulation I

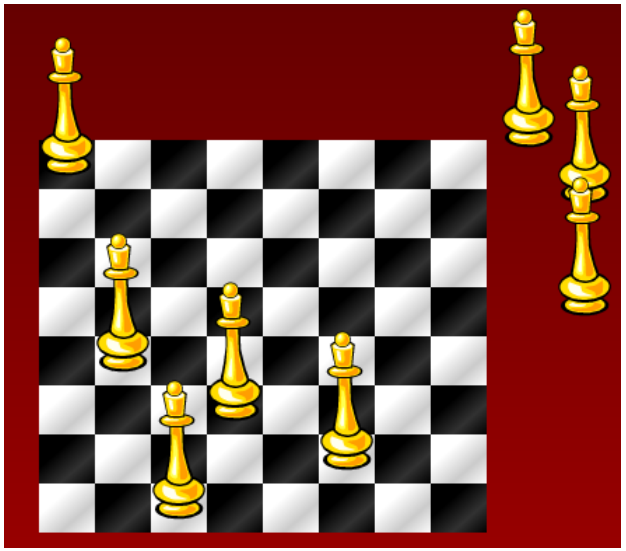
- **States:** Any arrangement of 0 to 8 queens on the board
- **Initial state:** No queens
- **Actions:** Add queen in empty square

First queen: 64 choices of position
Second queen: 63 choices of position
…

Total number of possible states : 64 x 63 x 62 x 61 x 60 x 59 x 58 x 57

1.785×10^{14} states

Incremental Formulation II



States: Any arrangement of 0 to 8 queens on the board

Initial state: No queens

Actions: Add queen in *leftmost empty column* such that is not attacking other queens

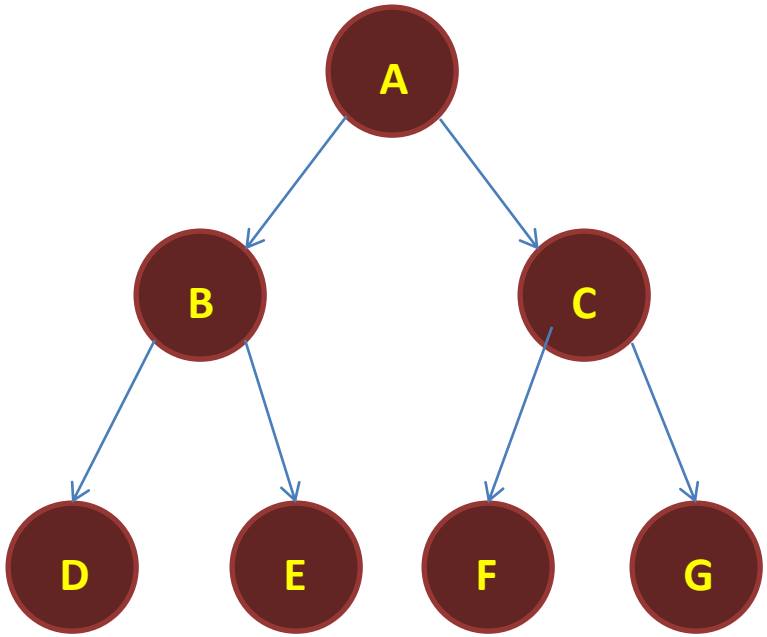
First queen : 8 choices of rows
Second queen : 5 or 6 choices of rows
(must not be the same row as the first,
must not be in diagonal with the first)
…

A lot fewer choices for the rest of the queens

2057 states

Breadth First Search

Analogous to the diagram in page 3
(searching for goal state of Tower of Hanoi)



Click through animation to see sequence of states being searched

Algorithm structure of BFS

```
s = initial_state
while not Goal(s)
    for each successor_state x of s
        enqueue(x)
    s = dequeue()
```

4-Queens