Search Problem

Definition

- Task of finding the sequence of actions/steps
- Leads to desired goal

Components of Search Problem

A **search problem** contains the following

Component	Description
State	Set of all possible configurations
Successor function	Given a state, returns **list of possible actions** + **their corres. cost and resultant states**
Start State	The initial state the **agent** begins
Goal Test	Check wether a given state is in a goal state

A **solution** is **a sequence of actions (plan)** which transform the start state to the goal state

Solving Search Problems

General pipeline of **problem formulation**

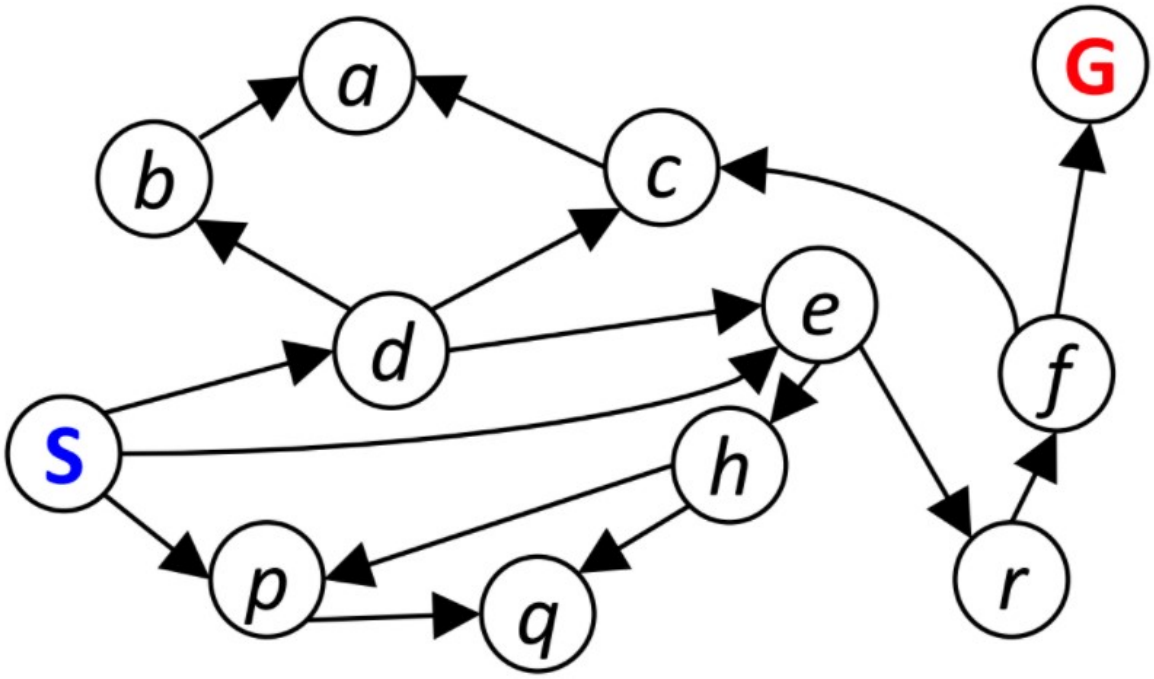
1. Goal Formulation
   - Agent **adopts goal**
   - **Goal** : A set of world states in which the goal is satisfied
2. Problem Formulation (Define the following)
   - State
   - Successor Function (actions, cost)
   - Start and Goal State

3. Search for sol^n
    - Use **search algo.** to find the **best sequence of actions** that lead from **start state** to **goal state**
4. Execution
    - Agent executes the actions specified by the solution found

Use the pipeline for the river crossing problem (Slide 8 and Slide 9)

State Space Graph

Def : Shows how states are related to each other in a search problem



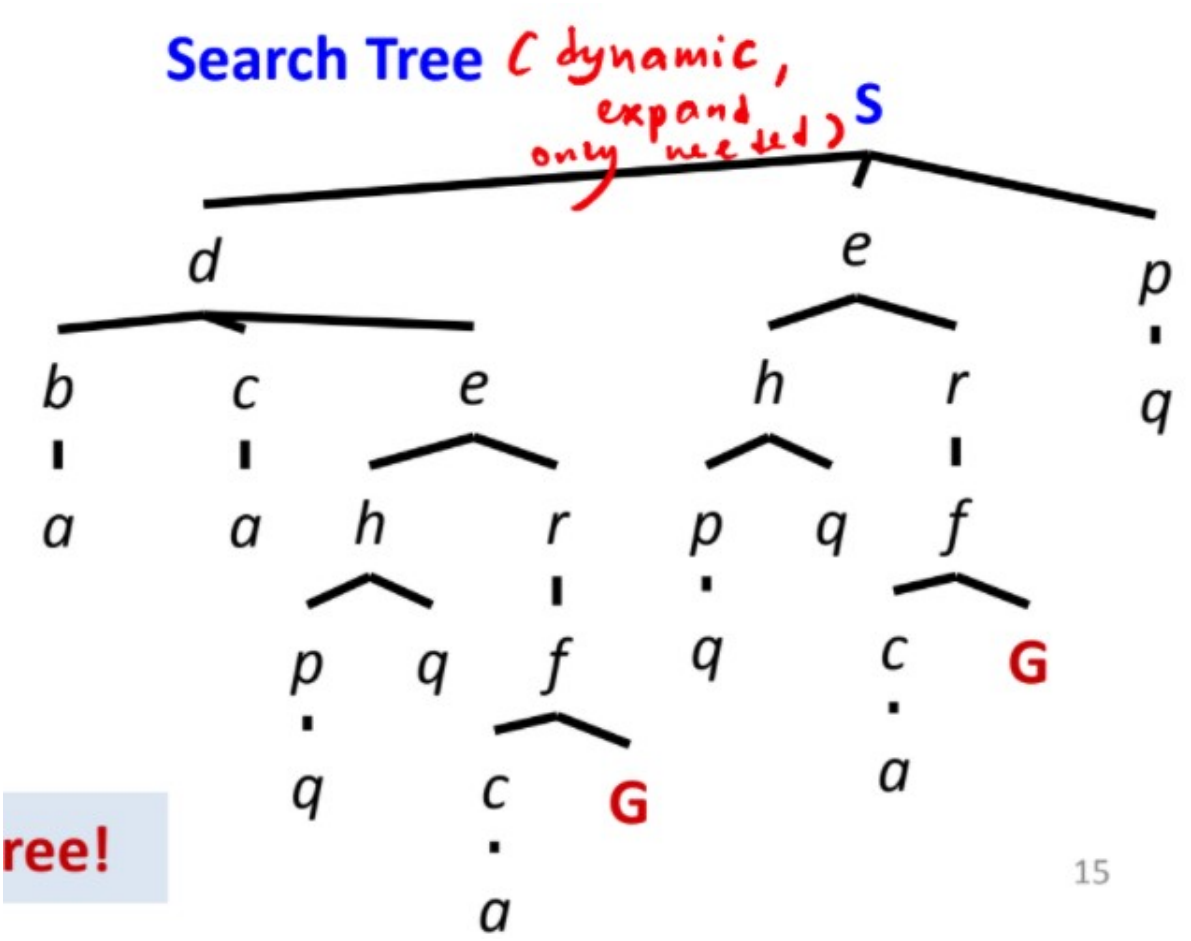
Element	Description
Nodes	Represents (abstracted) states
Arcs	Successors (possible actions and costs)
Goal	Set of goal nodes (can be only one)

Each state can only **occur once**

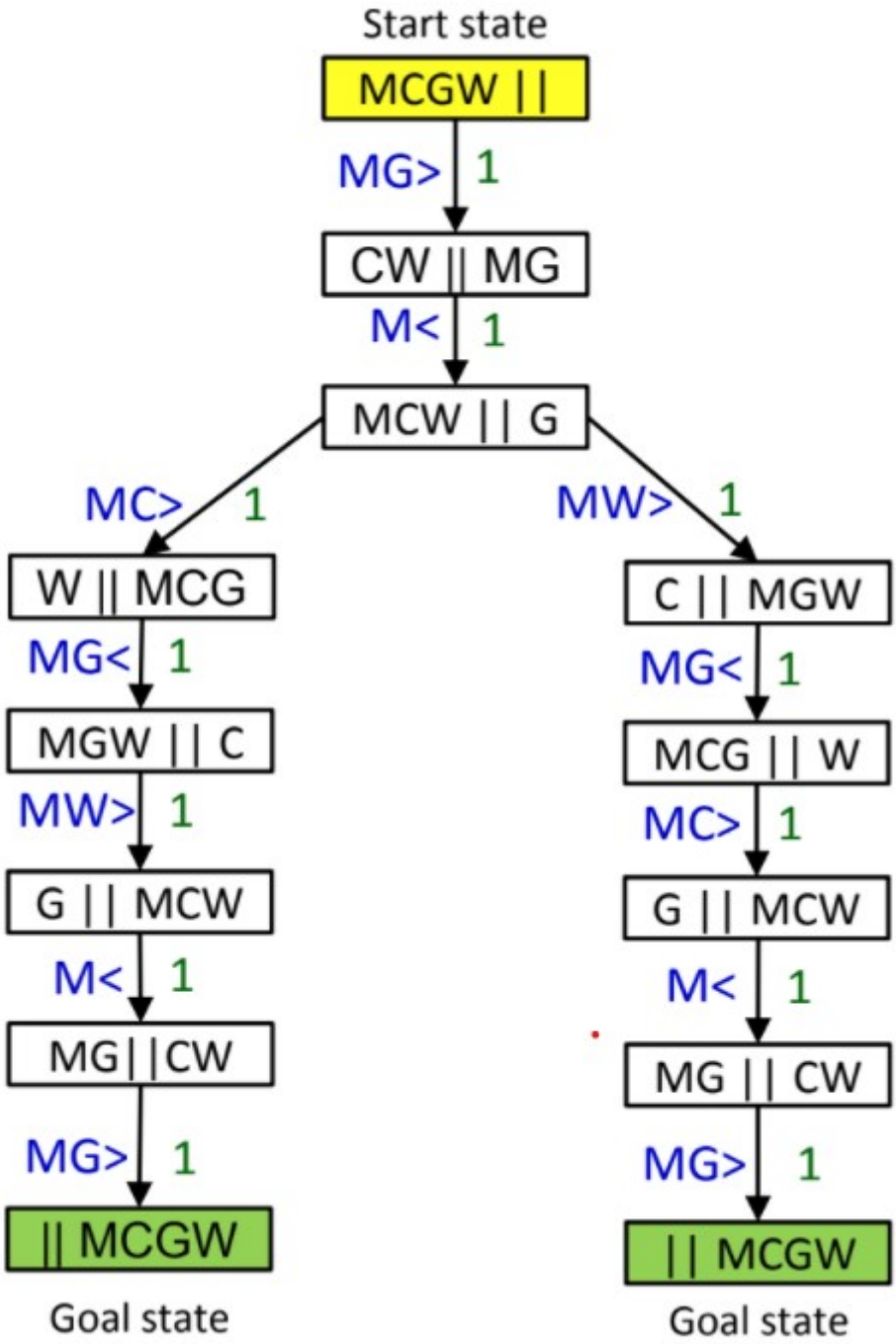
This is very large (not practical)

Search Tree

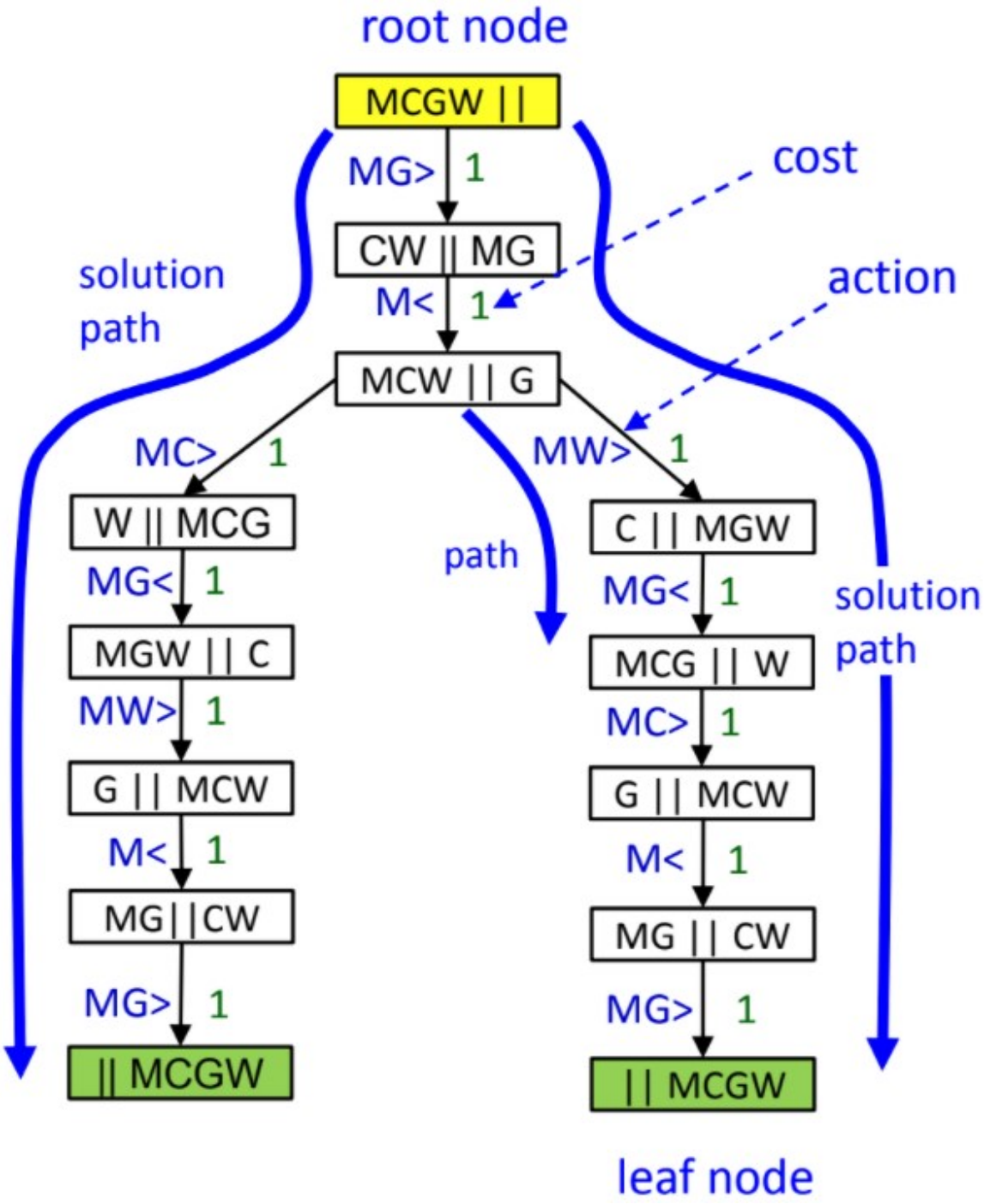
Expands Dynamically



Full Search Tree



Compenents of Search Tree



Component	Description
Root	Start State
Leaf	Goal State
Cost	Comes with the Action
Action	Represented by edge/arc
Solution Path	Path from Start to Goal
Optimal Solution Path	Solution path with lowest cost
Path	Series of actions between 2 nodes

Effective Search Tree

Built by the searching algorithm

> The smaller the better

Effective Formulation

To reduce search time, use

1. Effective Search Algorithms
2. Effective Problem Formulation
    - Consider the search strategy
    - Don't generate invalid states

Consider the Queens Puzzle

We have 2 methods

1. **Complete State Formulation**
2. **Incremental Formulation**

Evaluating Search Algorithms

Consider **4 factors**

1. Time Complexity
    - How long does it take to find a solution?
    - Measured in terms of no. of nodes generated during search
2. Space Complexity
    - How much mem needed?
    - Maximum no. of nodes stored in mem at a particular time
3. Completeness
    - Will a solution be guaranteed if it exists?
    - Measured whether the search tree is complete?
4. Optimality
    - Is the best solution found if several exists?
    - Measured in terms of **total search cost**

Evaluating Search Tree

Params affecting the size of the tree

- **depth**
- **branching factor**

> **Depth :** The longest path from root to the deepest leaf node
> **Branching Factor :** A constant number indicating the amount of ndoes that are expanded at a given depth in a ST

Example (Branching Factor):

Assuming branching factor b, the no. of nodes that are expanded at depth d is given by

$1 + b + b^2 + b^3 + \ldots + b^d$

So assuming $b = 2$ and $d = 2$, the no.of nodes that are expanded at depth 2 are:

$1 + 2 + 2^2 = 7$ nodes (Cumulative no. of nodes from root to that depth)