WELCOME

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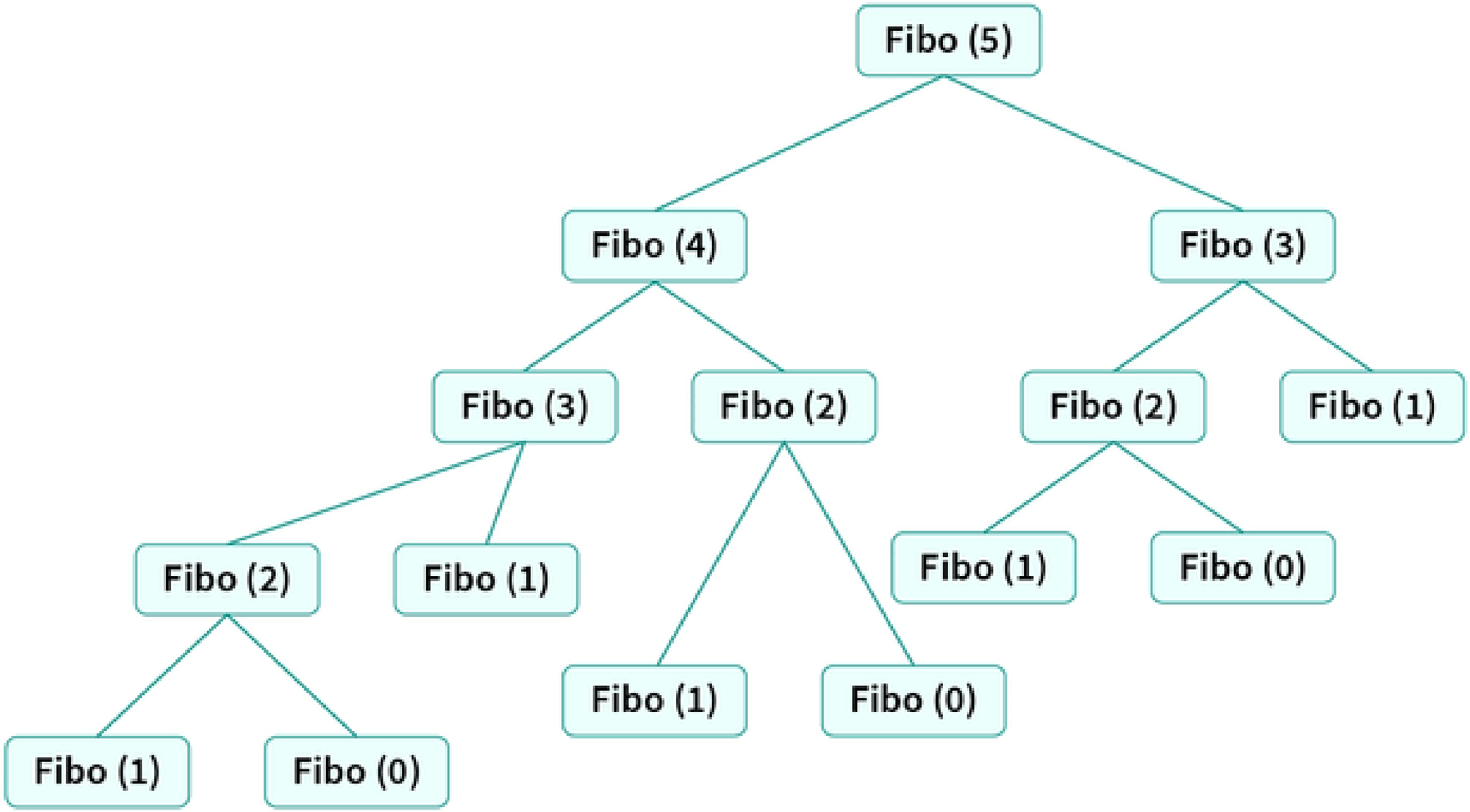
Dynamic programming

Dynamic programming is a technique that breaks the problems into sub-problems, and saves the result for future purposes so that we do not need to compute the result again.

Example


Fibo (5)
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Fibo (1)
Fibo (0)

Example

```
int fib(int n)
{
    if (n <= 1)
        return n;
    return fib(n - 1) + fib(n - 2);
}
```

Time complexity : O(2^n)

space complexity : O(n)

How does the dynamic programming approach work?

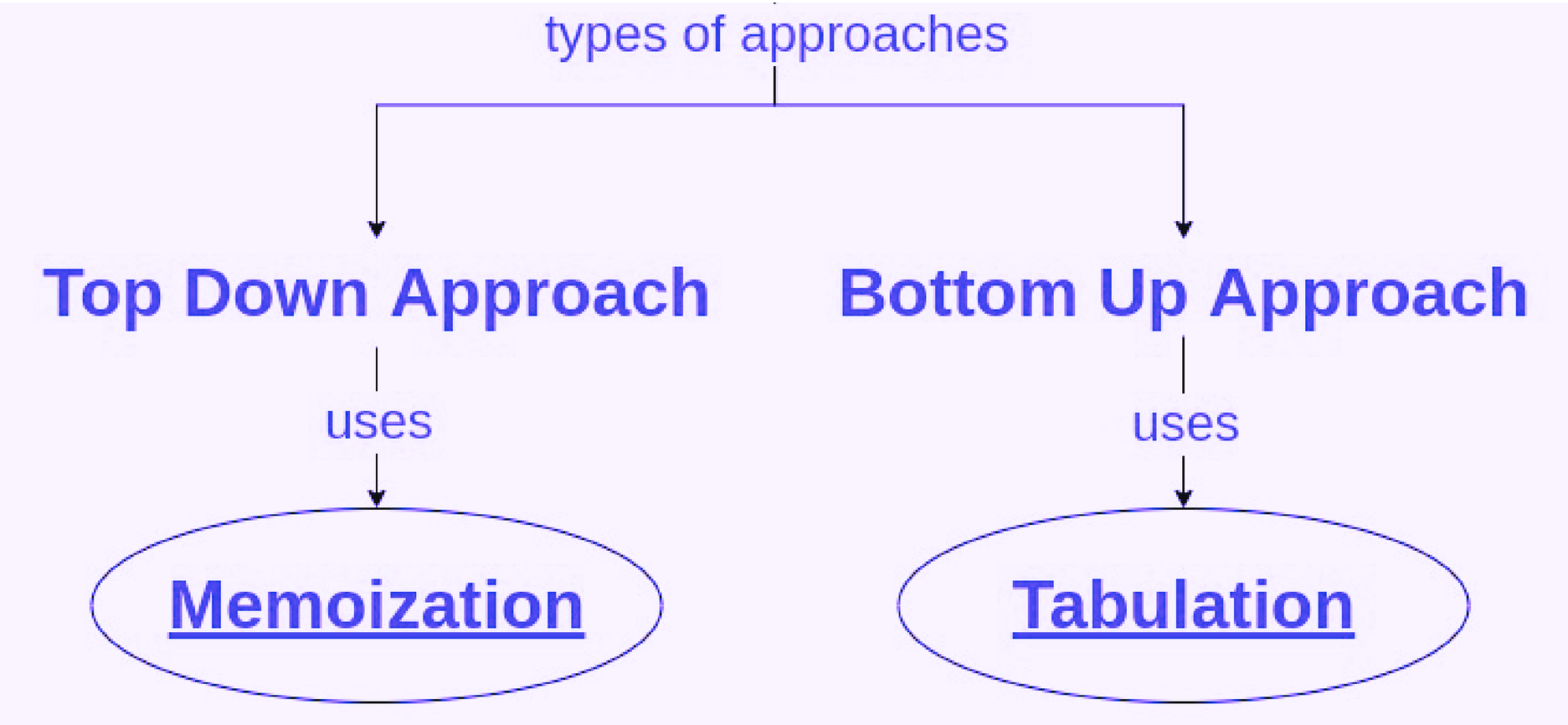
- It breaks down the complex problem into simpler subproblems.
- It finds the optimal solution to these sub-problems.
- It stores the **results of subproblems (memoization).** The process of storing the results of subproblems is known as memorization.
- It reuses them so that same sub-problem is calculated more than once.
- Finally, calculate the result of the complex problem.

Recursion vs Dynamic Programming

Dynamic programming is mostly applied to recursive algorithms. This is not a coincidence, most optimization problems require recursion and dynamic programming is used for optimization.

But not all problems that use recursion can use Dynamic Programming. Unless there is a presence of overlapping subproblems like in the fibonacci sequence problem, a recursion can only reach the solution using a divide and conquer approach.

Approaches of dynamic programming



Bottom UP Approach Code

```
int dp[MAXN];
int dp[0] = 1;
for (int i = 1; i <= n; i++)
{
    dp[i] = dp[i - 1] * i;
}
```

Top Down Approach Code

```
int solve(int x)
{
    if (x == 0)
        return 1;
    if (dp[x] != -1)
        return dp[x];
    return (dp[x] = x * solve(x - 1));
}
```

Characteristics of Dynamic Programming

- Simple subproblems
  - We should be able to break the original problem to **smaller subproblems** that have the **same** structure
- Optimal substructure of the problems
  - The **optimal solution** to the problem contains within **optimal solutions to** its **subproblems**.
- Overlapping sub-problems
  - there exist some places where we solve the **same subproblem** more than **once**.

Where DP can be used

The following computer problems can be solved using dynamic programming approach –

- Fibonacci number series
- Knapsack problem
- Tower of Hanoi
- All pair shortest path by Floyd-Warshall
- Shortest path by Dijkstra
- Project scheduling

Some Resources(To learn)

To know more About DP, follow these articles

1. https://www.shafaetsplanet.com/?p=1022
2. http://www.shafaetsplanet.com/?p=1072
3. http://www.shafaetsplanet.com/?p=1211
4. https://www.topcoder.com/community/competitive-programming/tutorials/dynamic-programming-from-novice-to-advanced/

Some Resources(To Practice)

- https://lightoj.com/problem/hex-a-bonacci
- https://cses.fi/problemset/task/1633
- https://cses.fi/problemset/task/1634
- https://lightoj.com/problem/neighbor-house
- https://lightoj.com/problem/coin-change-i
- https://cses.fi/problemset/task/1635
- https://cses.fi/problemset/task/1636
- https://lightoj.com/problem/rooks
- https://cses.fi/problemset/task/1637

Any Queries

THANK YOU