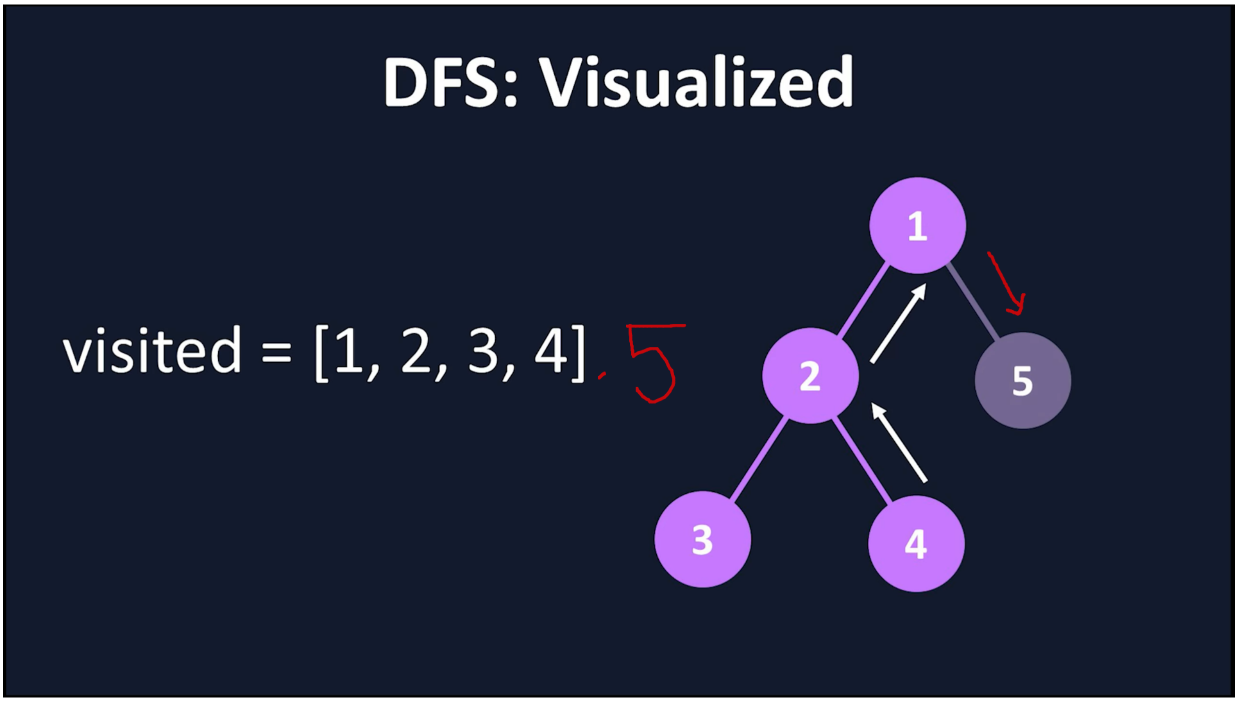
# Overview of important Algorithms

- Searching
  - Binary Search
  - Depth First Search for trees and graphs
    - start from the top of a tree and go as deep as possible along the same branch
    - once you are at the bottom then go to nearest unvisited node usually a sibling of the deepest node
      - this process is called **Backtracking**
    - used to solve a maze
    - `O(number of nodes + number of branches)`
    - 

  - Breadth First Search for trees and graphs
    - you don't go to deepest point like DFS
    - instead you make sure that the sibling node has been visited
    - once you are on a node look at its children and add them to a queue and then you visit the node in the queue and add them to visited array and remove them from sibling queue
    - if the node in the queues has more children then add them to queue when marking it visited
    - used in chess
    - `O(number of nodes + number of branches)`
- Sorting

- Insertion Sort
    - compares the nth element with (n+1)th element and swaps them if nth element is larger
    - best case `O(n)` if everything is already sorted
    - worst case `O(n^2)` when nothing is sorted beforehand
- Merge Sort
    - divide and conquer and conquer by divide and conquer and so on
    - recursion
    - splits array in half till we have pairs of 2
    - then all pairs of 2 are sorted and then 2 pairs of 2 are merged and sorted till the array is completely merged back again
    - best and worst case are same `O(n log n)`
- Quick Sort
    - recursive like merge sort so divides and conquers
    - we choose a pivot element of the array which is closest to the median of the array elements
    - then we split the lists into 2 such that one list has elements less than the pivot element and one where all elements are greater than the pivot element
    - we repeat the same on these 2 lists
    - we move the pivot element to the end of the list
    - we place 2 pointers one on the 0th index and the 2nd on the 2nd last element and compare the two if the 0th one is larger we swap
    - deep doing it till the 2 pointers meet
    - when they meet replace that element with the last one
    - we know have 2 lists like we wanted and we can do the same thing on them individually
    - best case `O(n log n)`
    - worst case `O(n^2)`
    - still can be 2 to 3 times faster than merge sort by reducing the chances of worst case
    - needs less memory `O(log n)` than merge sort `O(n)`

Greedy Algorithm
- It makes the best possible decision at every local step
- when not to be greedy
    - not meant for efficiency

- when to be greedy
  - when you don't want to find the most efficient way out of millions of permutations then greedy might be a good enough solution
  - when optimal solution not possible and brute force is not acceptable become greedy

# Recursion

- a recursive function should have a terminating condition also called as a base condition

  - the values in the scope of the function can be used before(ascending) or after(descending) the termination condition and recursive call

```cpp
#include <iostream>
using namespace std;

void head(int n)
{
    if (n > 0)
    {
        head(n - 1);
        cout << n << " ";
    }
}

void tail(int n)
{
    if (n > 0)
    {
        cout << n << " ";
        tail(n - 1);
    }
}

int main()
{
    head(10);
    cout << endl;
    tail(10);

    return 0;
```

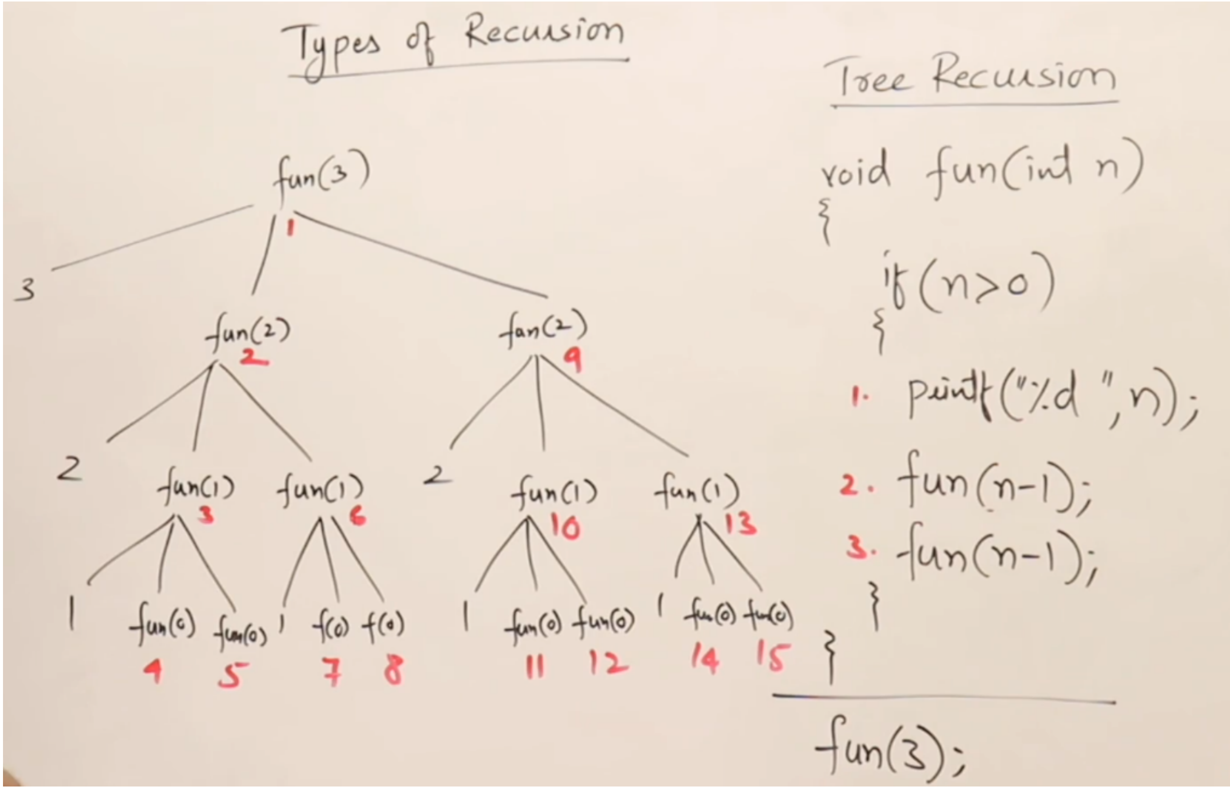
```
}
// 1 2 3 4 5 6 7 8 9 10
// 10 9 8 7 6 5 4 3 2 1
```

- use static variables in recursive function if you need a counter and don't want the counter to reset on every recursive call
  - static variable will have a single copy for all recursive calls and will not be a local variable of the scope of a recursive function
  - it is like global but more restrictive
- types of recursion
  - tail
    - when the function calls itself in the last line of the function
    - easier to convert recursive logic to iterative
  - head
    - when the function calls itself in the first line of the function
    - harder to convert recursive logic to iterative
  - tree
    - opposite of tree recursion is linear recursion when the recursive function calls itself only one time
    - in tree recursion the recursive function calls itself more than one times

```
#include <iostream>
using namespace std;
void tree(int n)
{
    if (n > 0)
    {
        cout << n << " ";
        tree(n - 1);
        tree(n - 1);
    }
}

int main()
{
```

```cpp
    tree(3);
    return 0;
}
// 3 2 1 1 2 1 1
// Time O(2^n)
// Space O(n)
```

- 

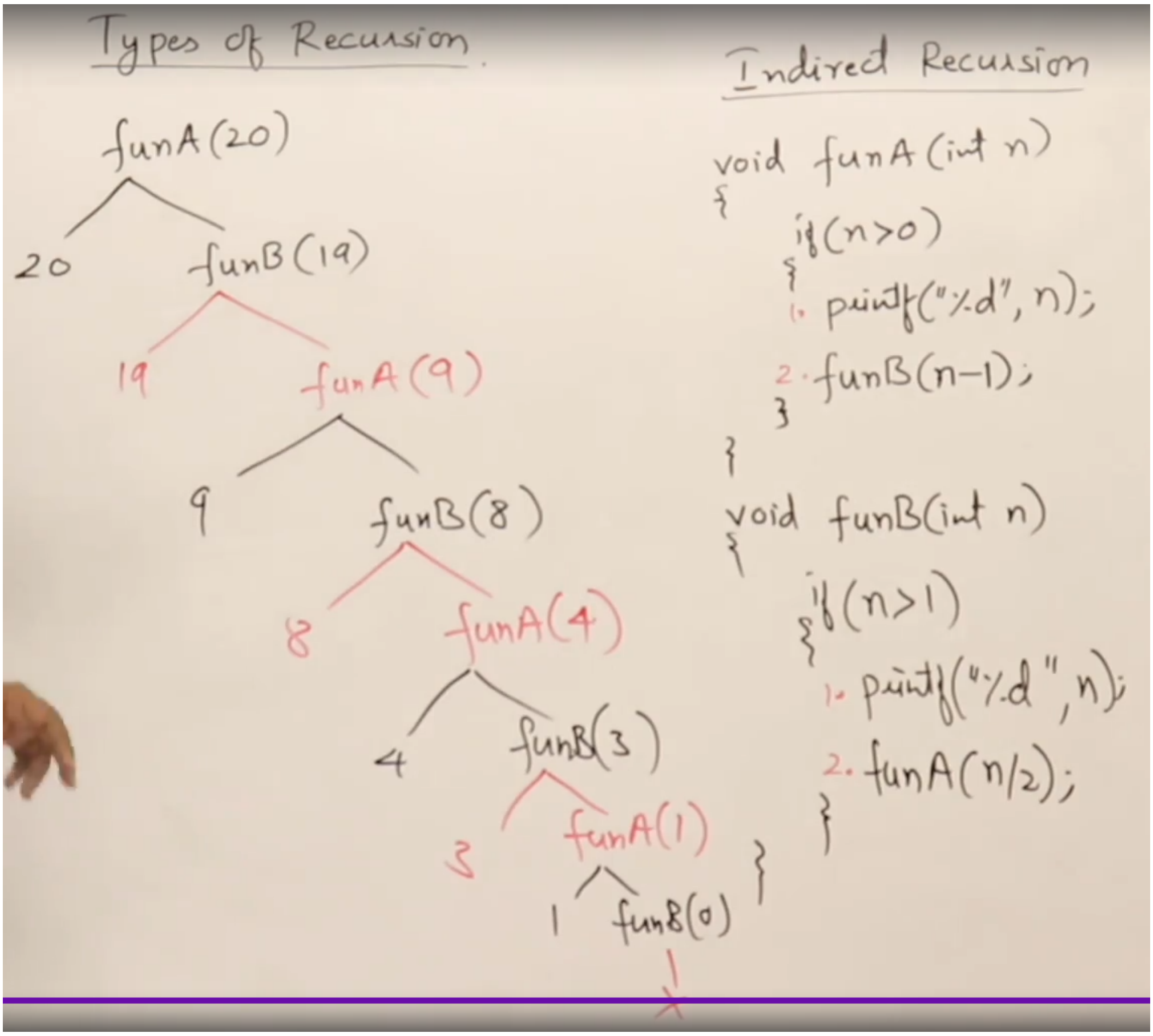

- indirect
  - when a function A calls B and B calls C and C calls A

```cpp
#include <iostream>
using namespace std;
void funB(int n);

void funA(int n)
{
    if (n > 0)
    {
        cout << n << " ";
        funB(n - 1);
    }
}
void funB(int n)
{
    if (n > 1)
    {
```

```
            cout << "\n"
                 << n << " ";
            funA(n / 2);
        }
}

int main()
{
    funA(20);
    return 0;
}
// 20
// 19 9
// 8 4
// 3 1
```

- 


- nested
    - parameter of a recursive call function is the same function

```cpp
#include <iostream>
using namespace std;
int fun(int n)
{
    if (n > 100)
        return n - 10;
    return fun(fun(n + 11));
}
int main()
{
    cout << fun(95); // 91
        return 0;
}
```

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