Laboratorio de Programación

2016 -2

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Outline

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Function Pointers

Basics

- Is a characteristic of the *Third Generation* of programming languages ▸ Read More!

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- The pointer points to executable code within memory
- The function can be executed just by calling the pointer as a normal function
- Invocation is known as *Indirect Call*
- Functions passed as an argument are widely known as *Callbacks*
- The function is expected to be called back at some convenient time

Function Pointers

```
int myFunction(double a, char b)
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int myFunction(double a, char b)
int (*pointer) (double, char)
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Declaring a pointer

- `int (*pointer)` $\rightarrow$ `int myFunction`
  The pointer type has to be equal to the function return type

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  Types of the function members
- `int (*pointer) (double, char) = myFunction`
  The pointer points to `myFunction`
- `void process(void (*funcp)(int), int a, int b)`
  A function which receives a function as a parameter

Function Pointers

Test the code

```
#include <stdio.h>

void callback(int value)
{
    printf("This Callback function prints the value = %i", value);
}
void process(void (*funcp)(int), int a, int b)
{
    int c = a + b;
    funcp(c);
}
int main()
{
    void (*functionPointer)(int);
    functionPointer = callback;
    process(functionPointer, 2, 3);
}
```

Function Pointers

Test the code

```
#include <stdio.h>
void callback()
{
    printf("The process has finished!!!\n");
}
void process(void (*funcp)(), int *a, int b)
{
    *a = (*a * *a) + b;
    funcp();
}
int main()
{
    int var = 5;
    void (*functionPointer)();
    functionPointer = callback;
    process(functionPointer, &var, 3);
    printf("a = %d", var);
}
```

Function Pointers

Test the code

```c
#include <stdio.h>
int sumCallback(int a, int b)
{
    return a + b;
}
void process(int (*funcp)(int, int), int a, int b)
{
    printf("a = %d, b = %d, res = %d", a, b, funcp(a, b));
}
int main()
{
    int (*functionPointer)(int, int);
    functionPointer = sumCallback;
    process(functionPointer, 5, 3);
}
```

Function Pointers

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int* map(int (*fun)(int value), int *array, int size)
```

The map function

- Is a *High-order* function

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Function Pointers

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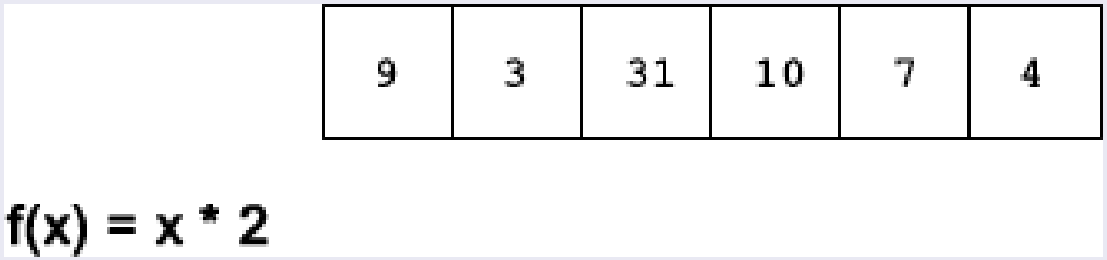
The map function

- Is a *High-order* function
- A high-order function is the one who takes functions as arguments
- The map function applies the input function over all the elements in an array
- *Keep in mind:* It works also for sequential *containers*

Function Pointers

The map function - How it works?



Function Pointers

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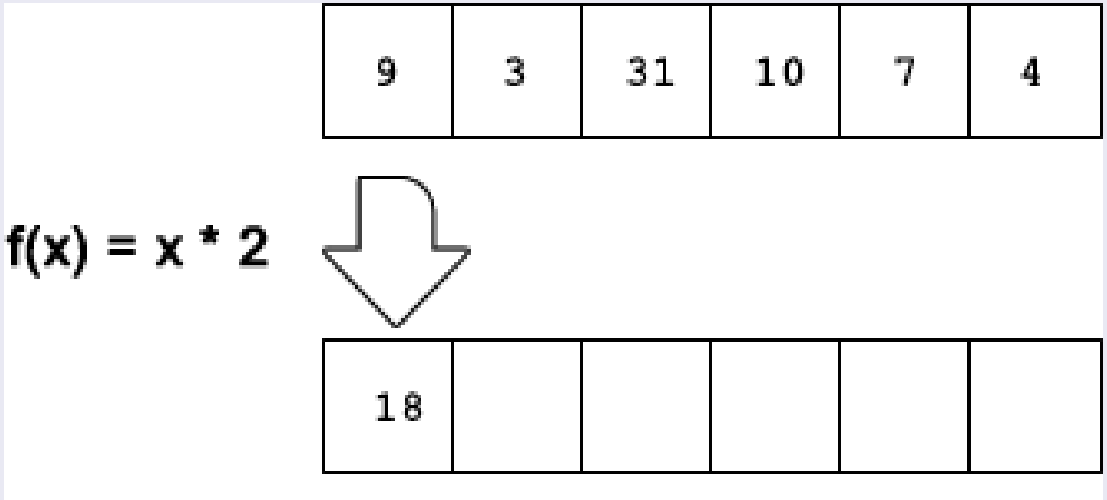

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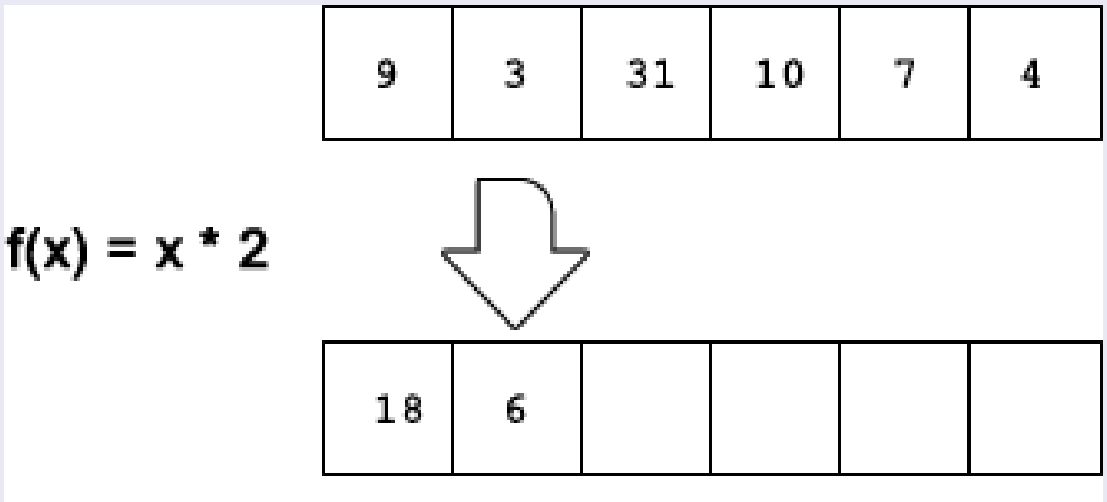

Function Pointers

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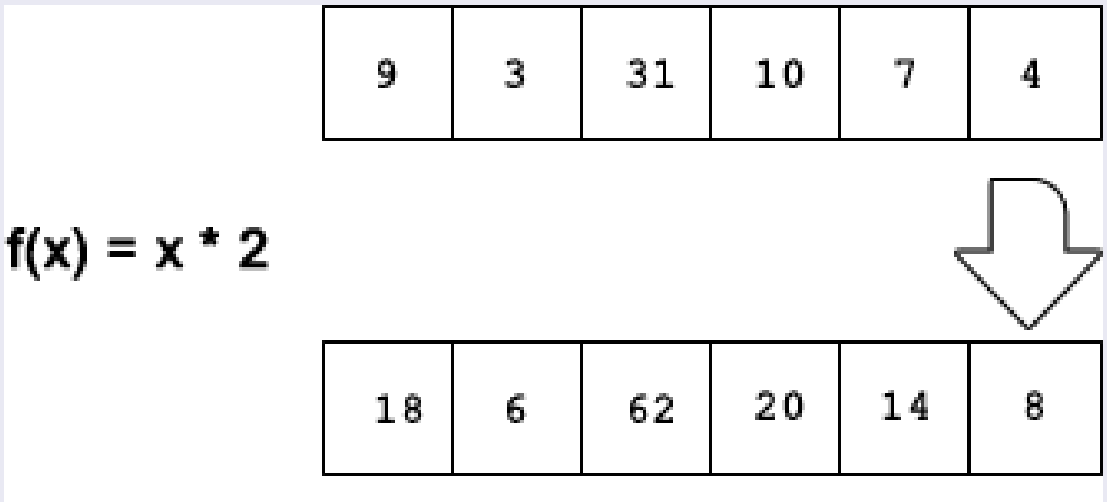

Function Pointers

The map function - Implementation

```
int* map(int (*funPtr)(int), int* ptr, int size)
{
    int* ptrRes = calloc(size, sizeof(int));
    for (int i=0; i<size; i++)
    {
        *(ptrRes+i) = funPtr(ptr[i]);
    }
    return ptrRes;
}
```

Function Pointers - Test the code with the map function

```c
#include <stdio.h>
#include <stdlib.h>

int getDouble(int a)
{
    return a*2;
}


int main()
{
    int *a = calloc(2, sizeof(int));
    int (*fun)(int) = getDouble;
    a[0] = 5;
    a[1] = 9;

    int* array = map(fun, a,2);

    printf("%d, %d", array[0], array[1]);
}
```

Outline

Functions in structures

The Queue structure

```
#include <stdio.h>
#include <stdlib.h>

struct queue
{
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The basic structure contains:

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The basic structure contains:

- A pointer to the head of the queue
- A pointer to the tail of the queue

Functions in structures

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#include <stdio.h>
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- What if we want to *encapsulate* all the queue functions inside the structure?

Functions in structures

The Queue structure

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#include <stdio.h>
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struct queue
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```

- What if we want to *encapsulate* all the queue functions inside the structure?
- We can use pointers to functions

Functions in structures

The Queue structure

```
    Node * tail;
};

struct queue
{
    Node * head;
    Node * tail;

    void (*enqueue)(struct queue *, int);
```

- `void (*enqueue)(struct queue *, int);`

Functions in structures

The Queue structure

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    Node * tail;
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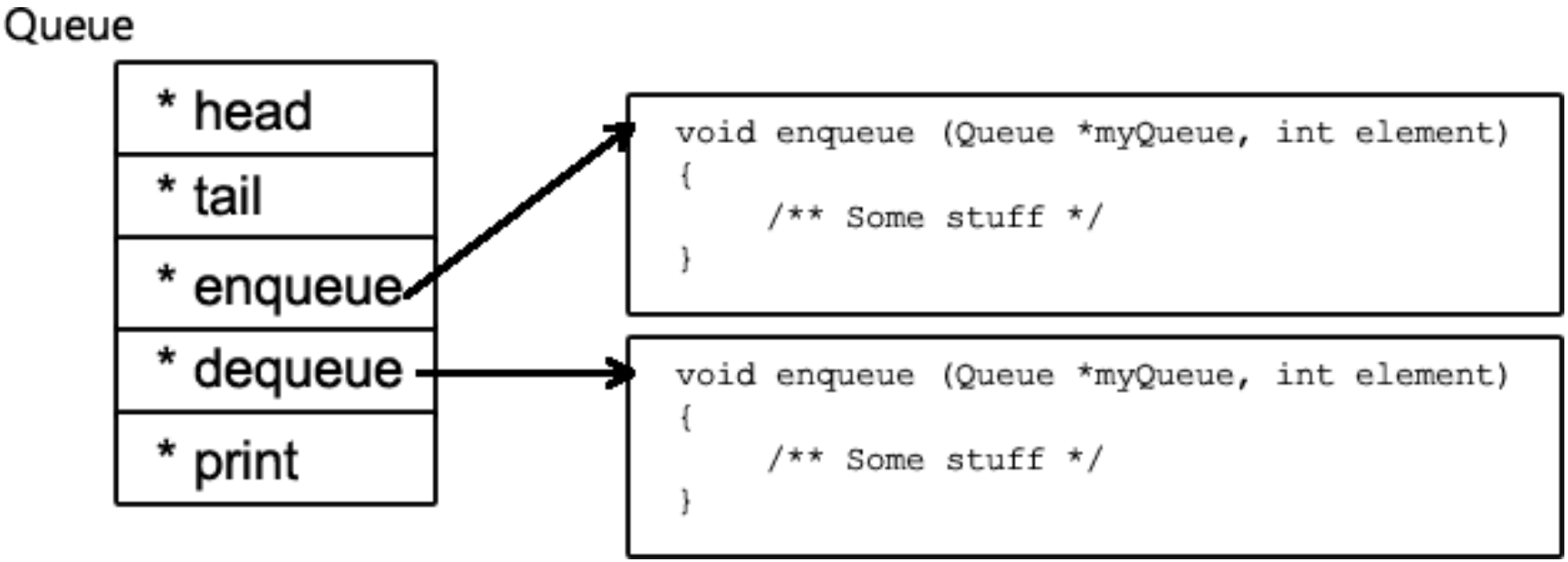
- `void (*enqueue)(struct queue *, int);`
- We create three new pointers to every handled operation

Functions in structures



Functions in structures

The Queue structure - The Constructor function

```
    void (*print)(struct queue *);
};
typedef struct queue Queue;

void enqueue (Queue *myQueue, int element)
{
```

- The constructor will provide us an instance of a Queue

Functions in structures

The Queue structure - The Constructor function

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    void (*print)(struct queue *);
};

typedef struct queue Queue;

void enqueue (Queue *myQueue, int element)
{
```

- The constructor will provide us an instance of a Queue
- We must associate every pointer to its respective function

Functions in structures

The Queue structure - The Constructor function

```
myNode->value = element;
myNode->next = NULL;
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- All the functions has to be called with the `->` operator

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Functions in structures

The Queue structure - The Constructor function

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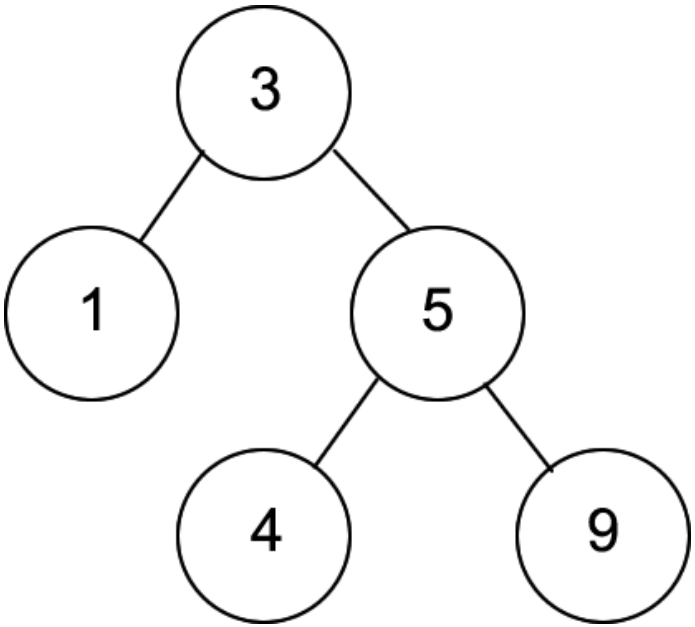
myNode->value = element;
myNode->next = NULL;
```

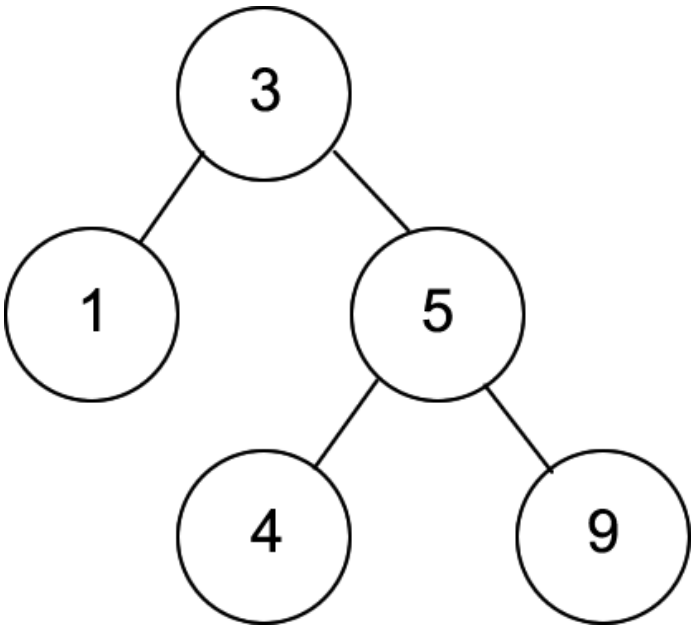
Be careful!. The pointer to every function can be modified so, it can be unsafe!!!

Outline

Trees



Trees



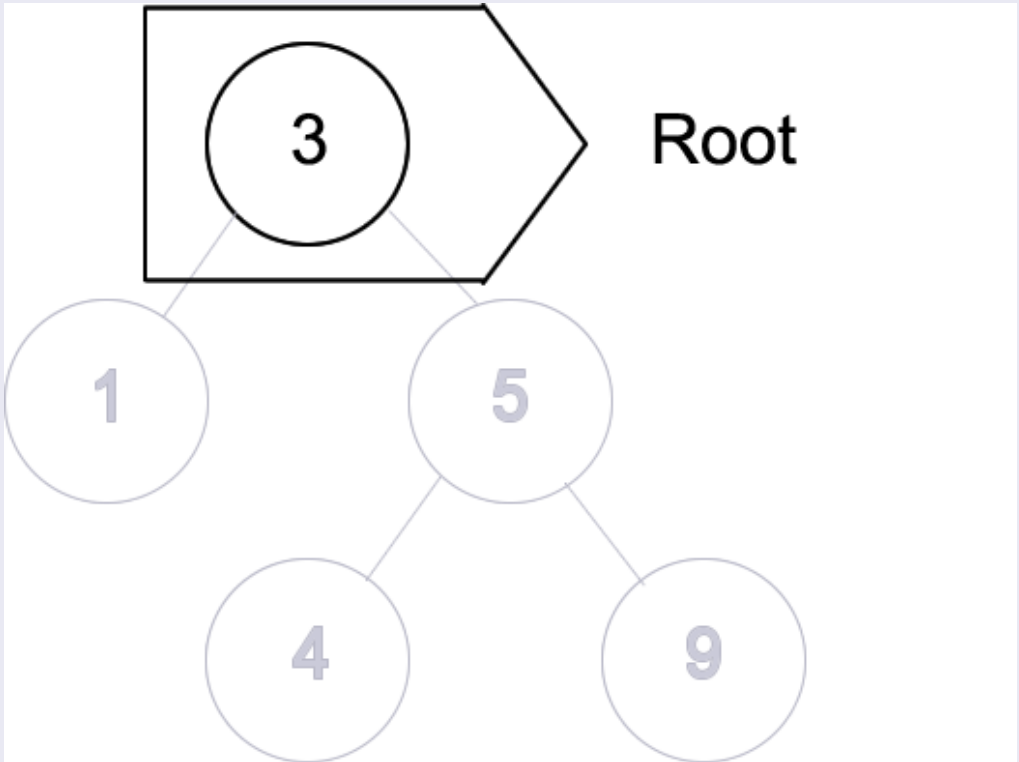
Trees

Trees can be defined as a

- *Nonlinear, two-dimensional data structure*

Trees

Parts



Trees

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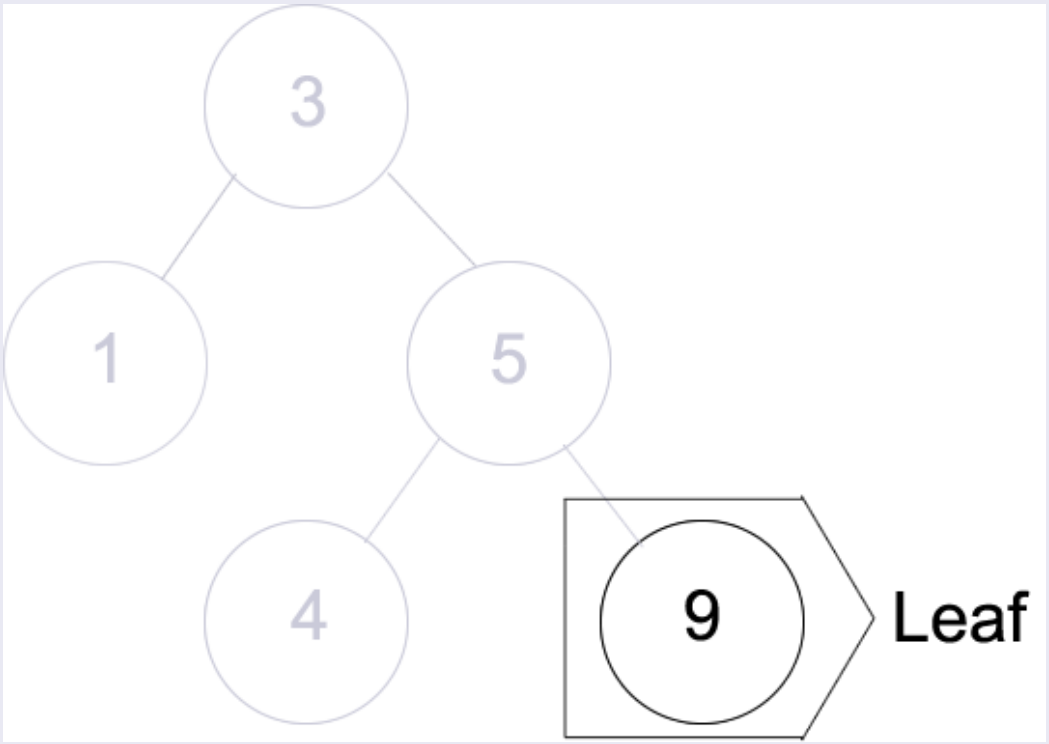

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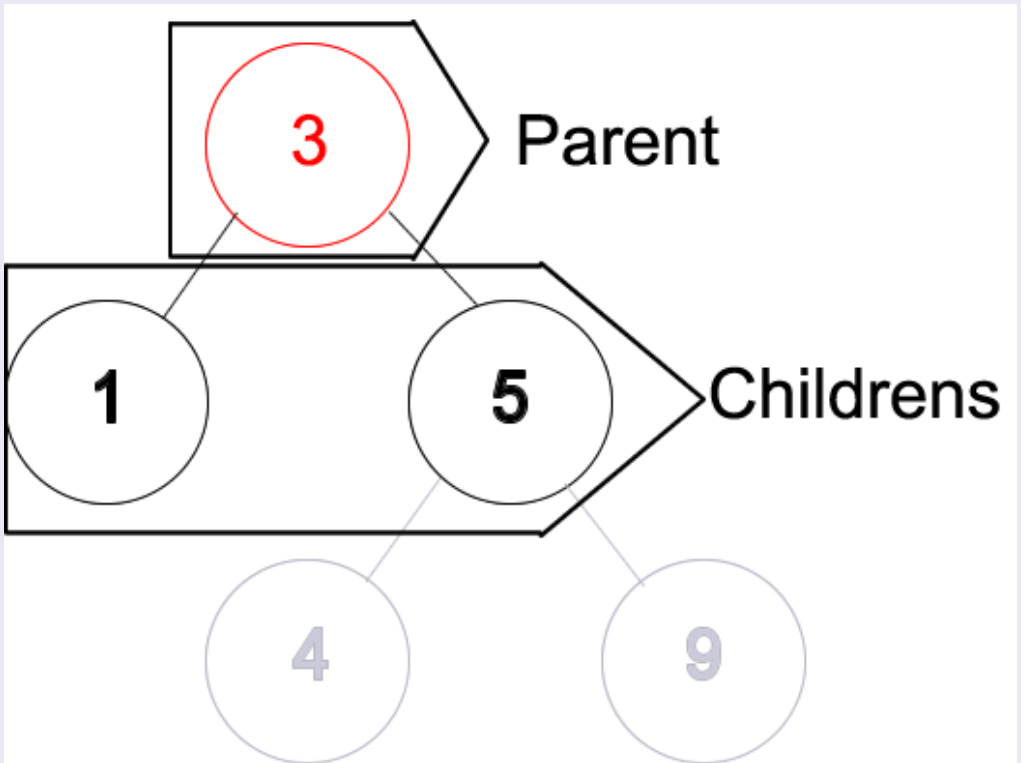

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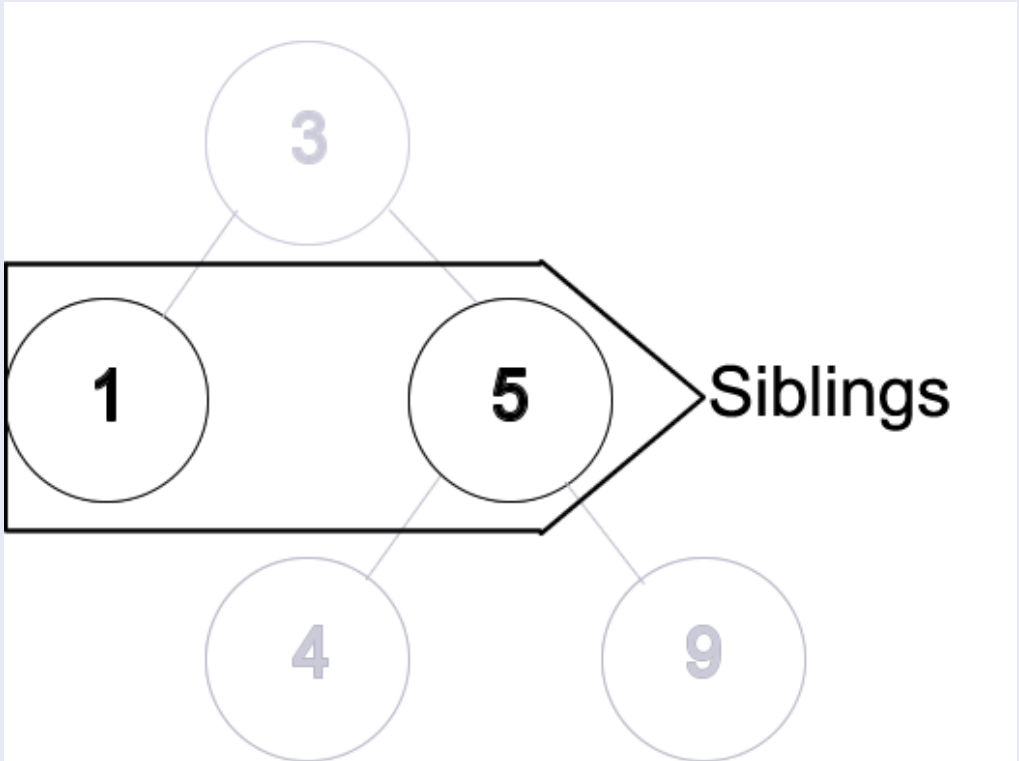

Trees

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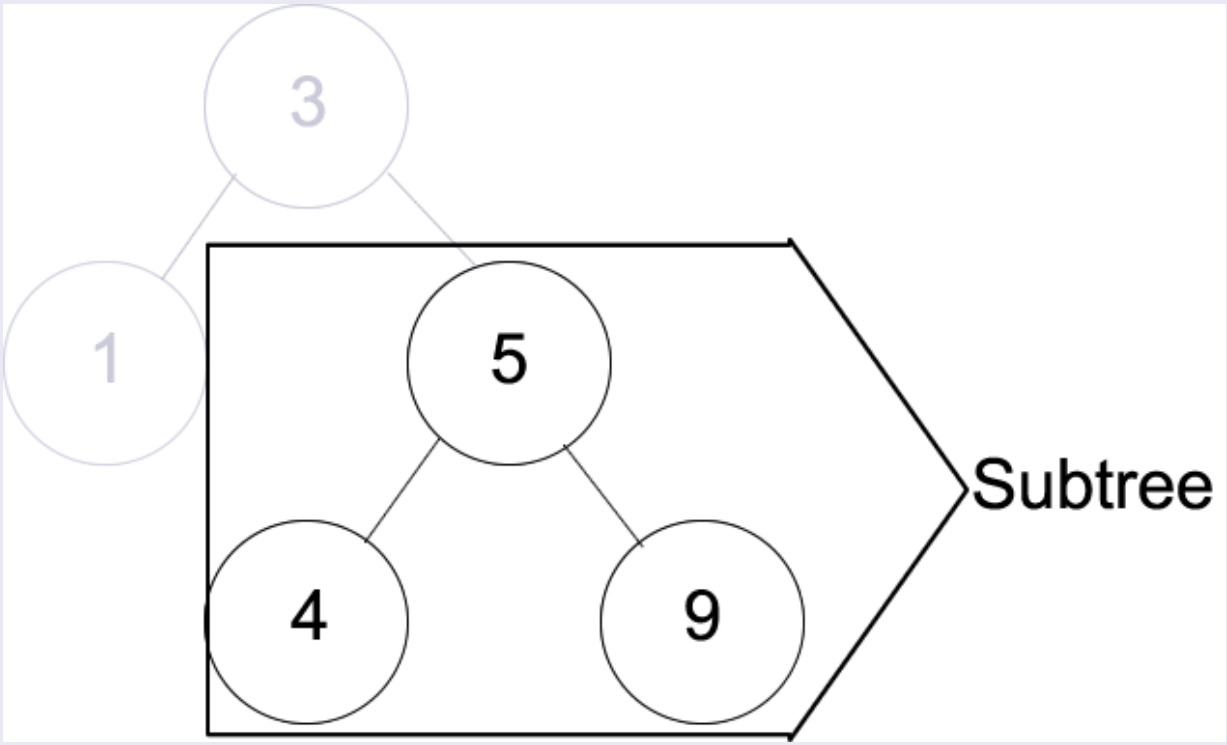

Trees

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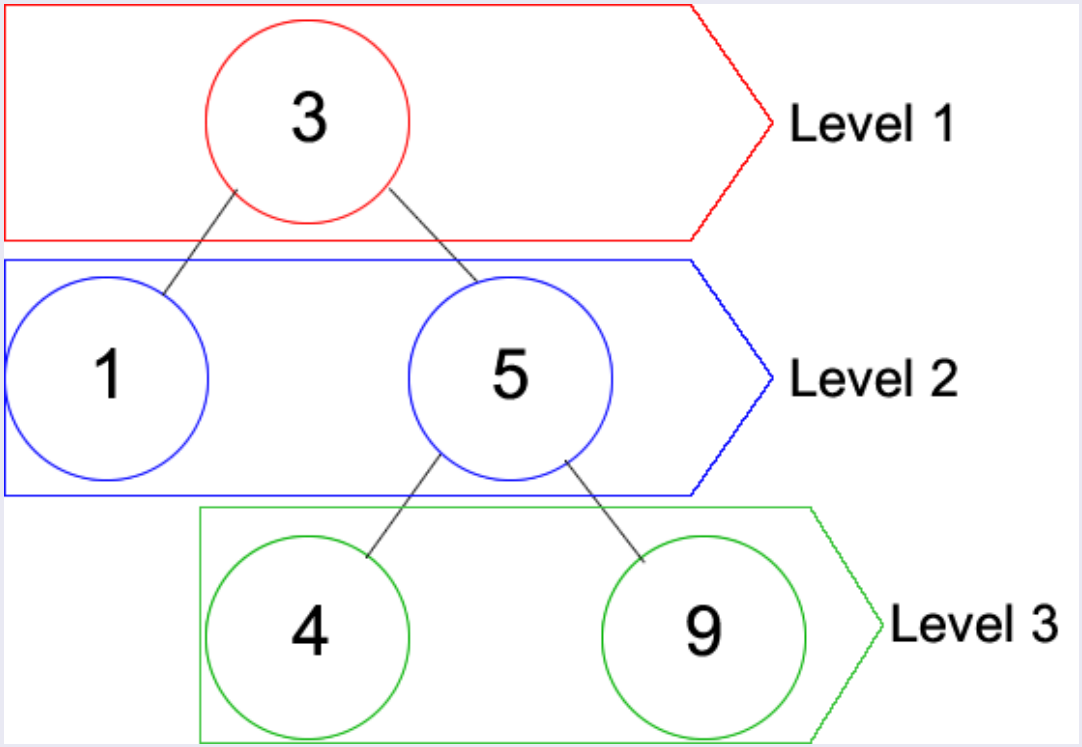
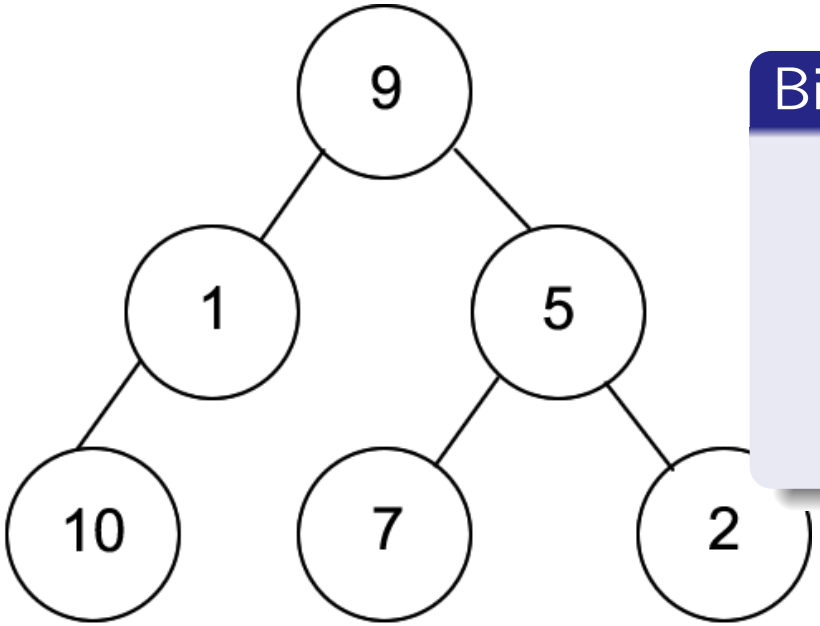


Outline

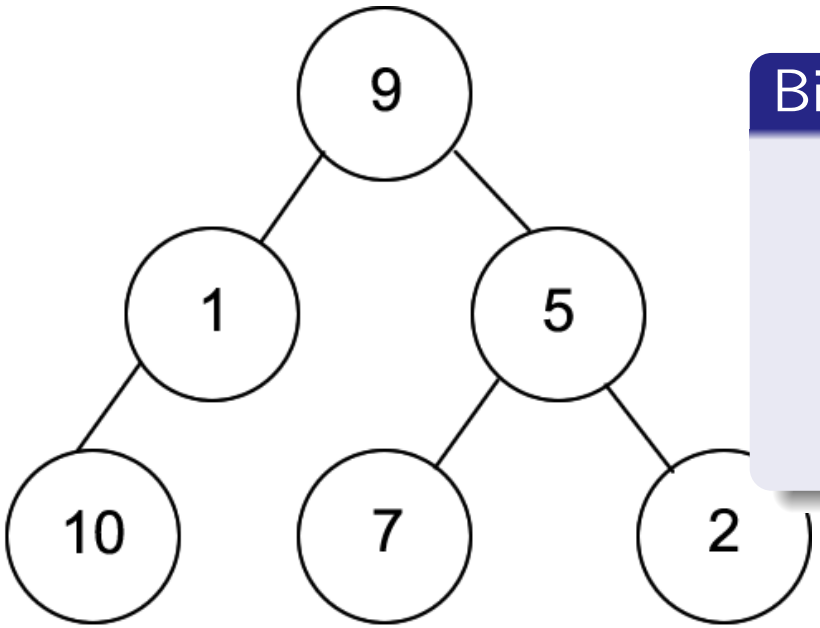
Trees



Binary Tree

- Each node has at most two childrens

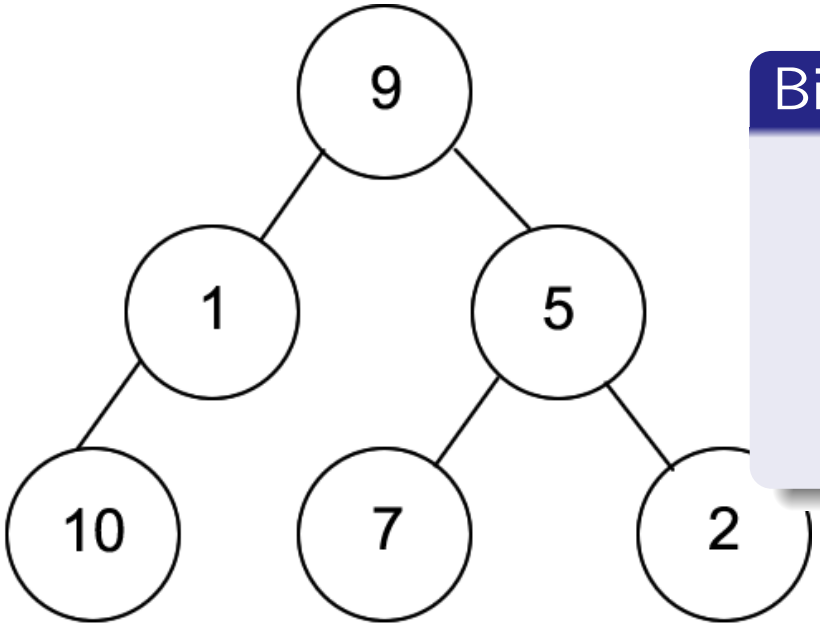
Trees



Binary Tree

- Each node has at most two childrens
- Left child

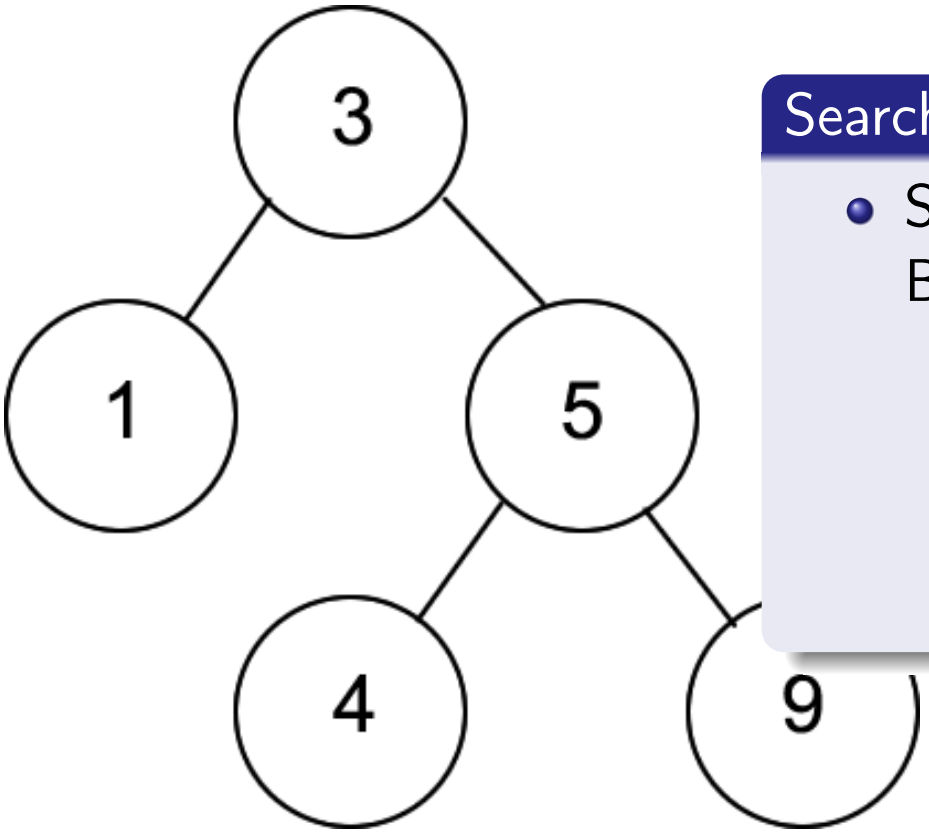
Trees



Binary Tree

- Each node has at most two childrens
- Left child
- Right child

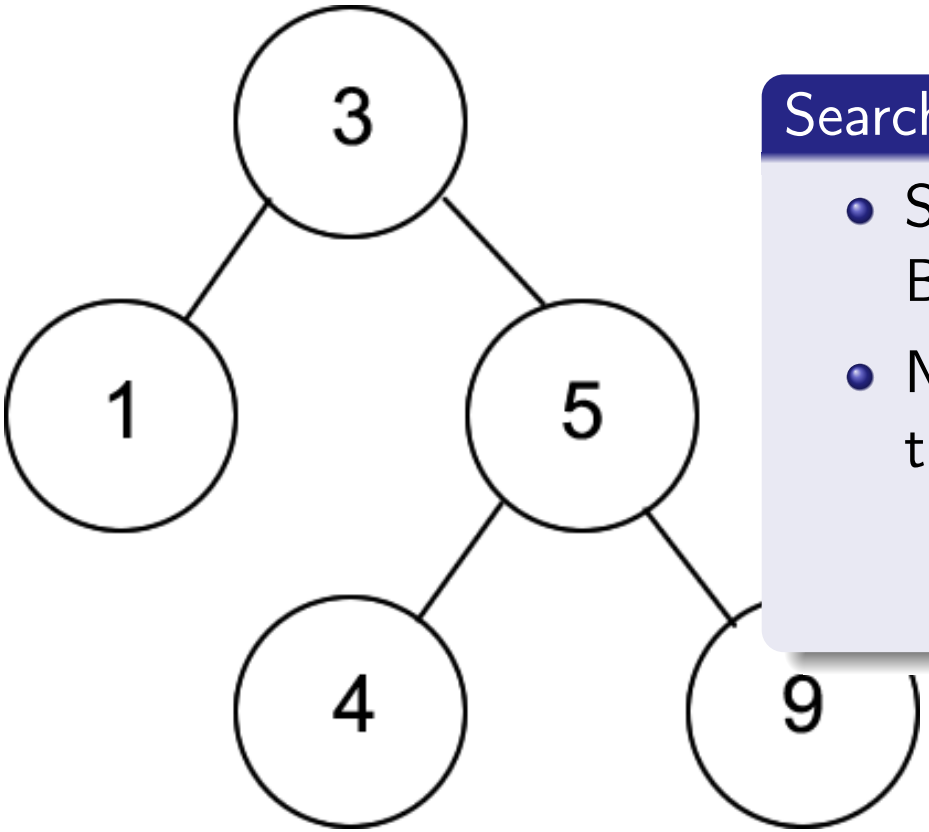
Trees



Search Binary Tree

- Share the basic characteristics of a Binary Tree

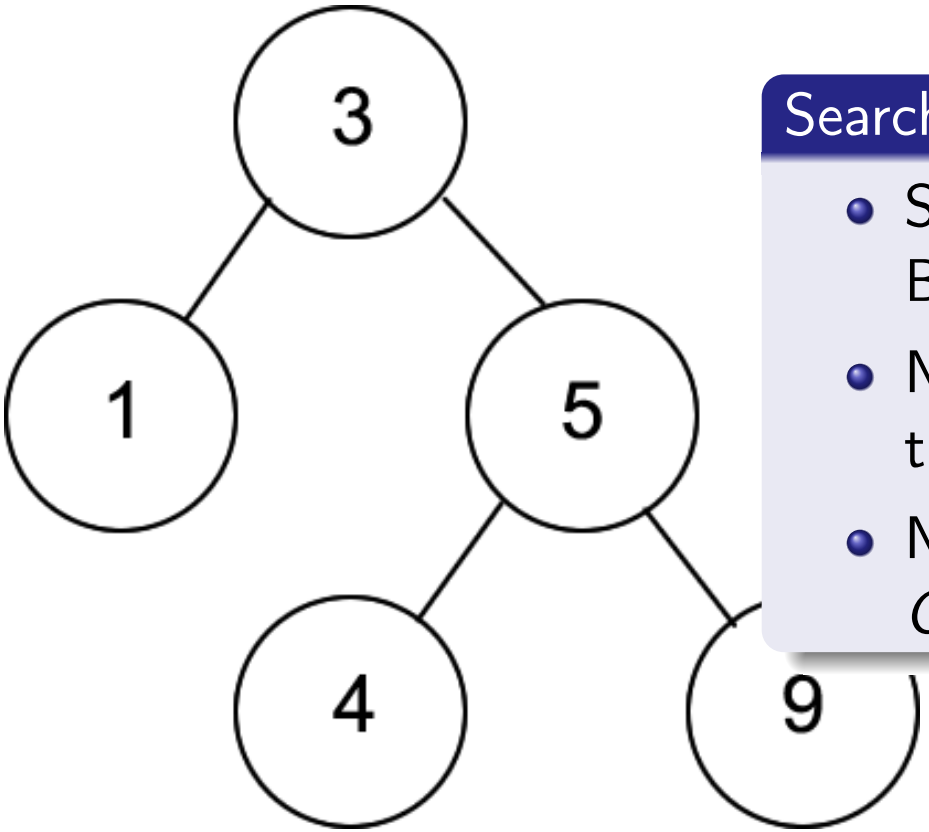
Trees



Search Binary Tree

- Share the basic characteristics of a Binary Tree
- Nodes at the left subtree are *Lower* than the root value

Trees



Search Binary Tree

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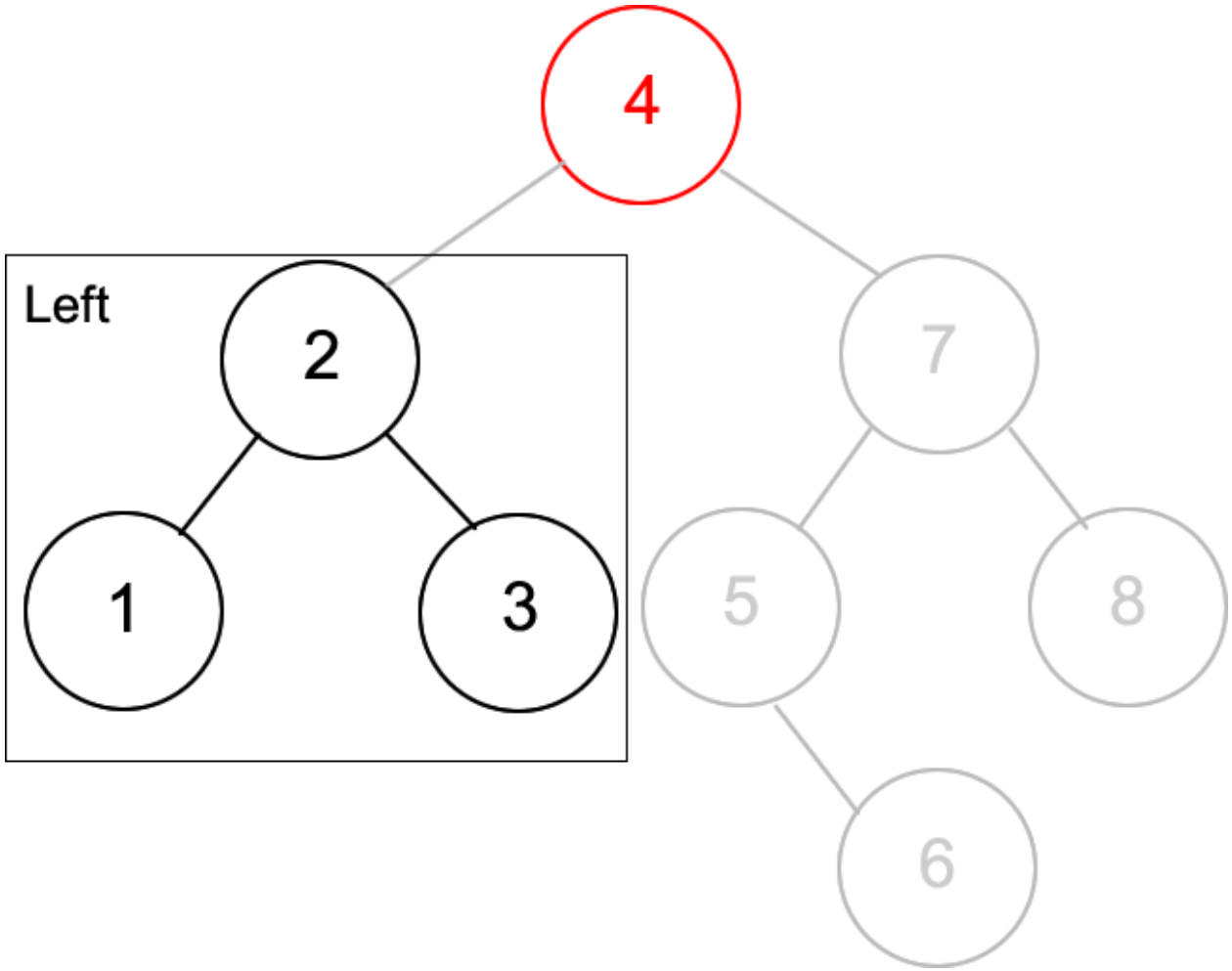
- Nodes at the right subtree are *Greater* than the root value

Trees



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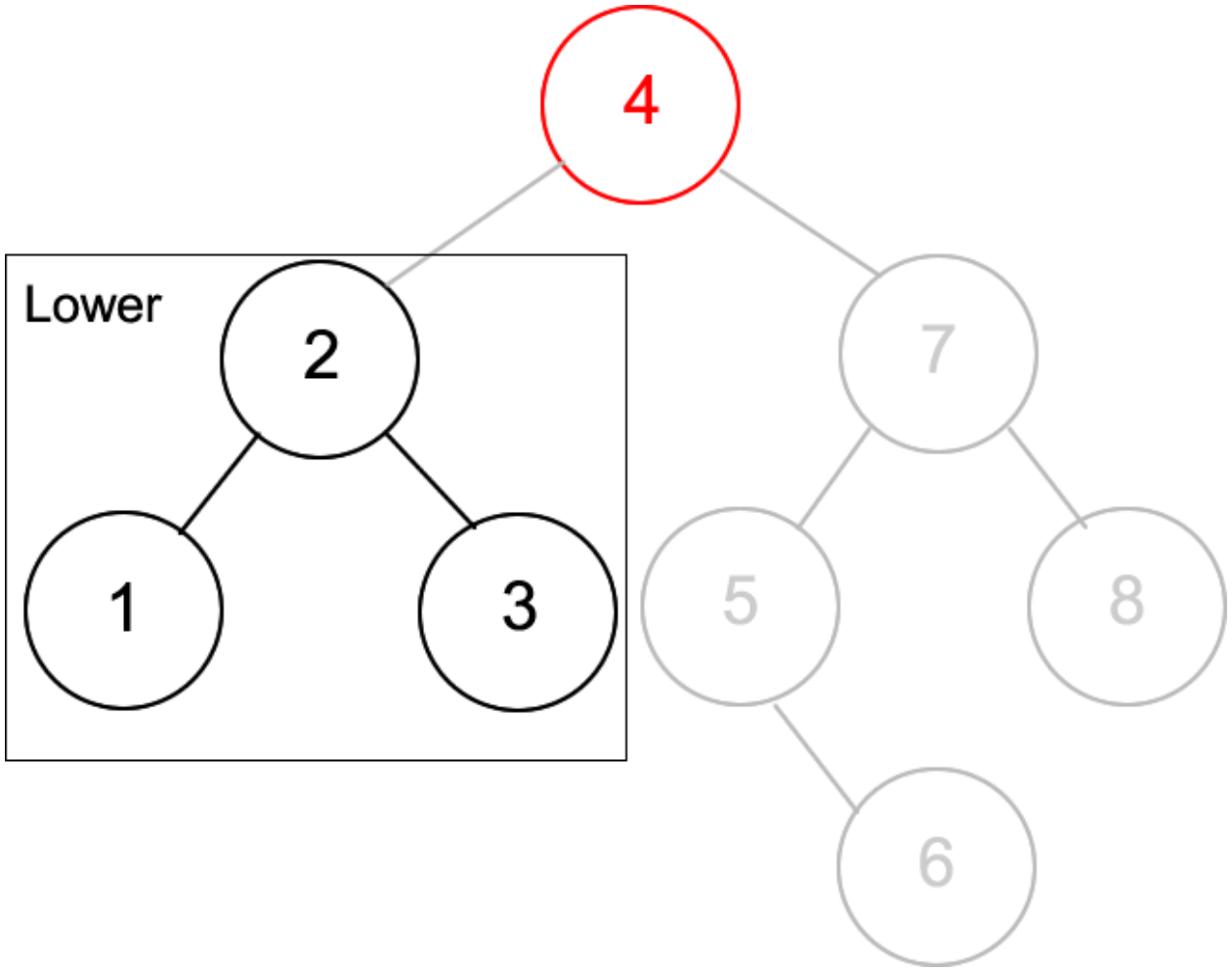

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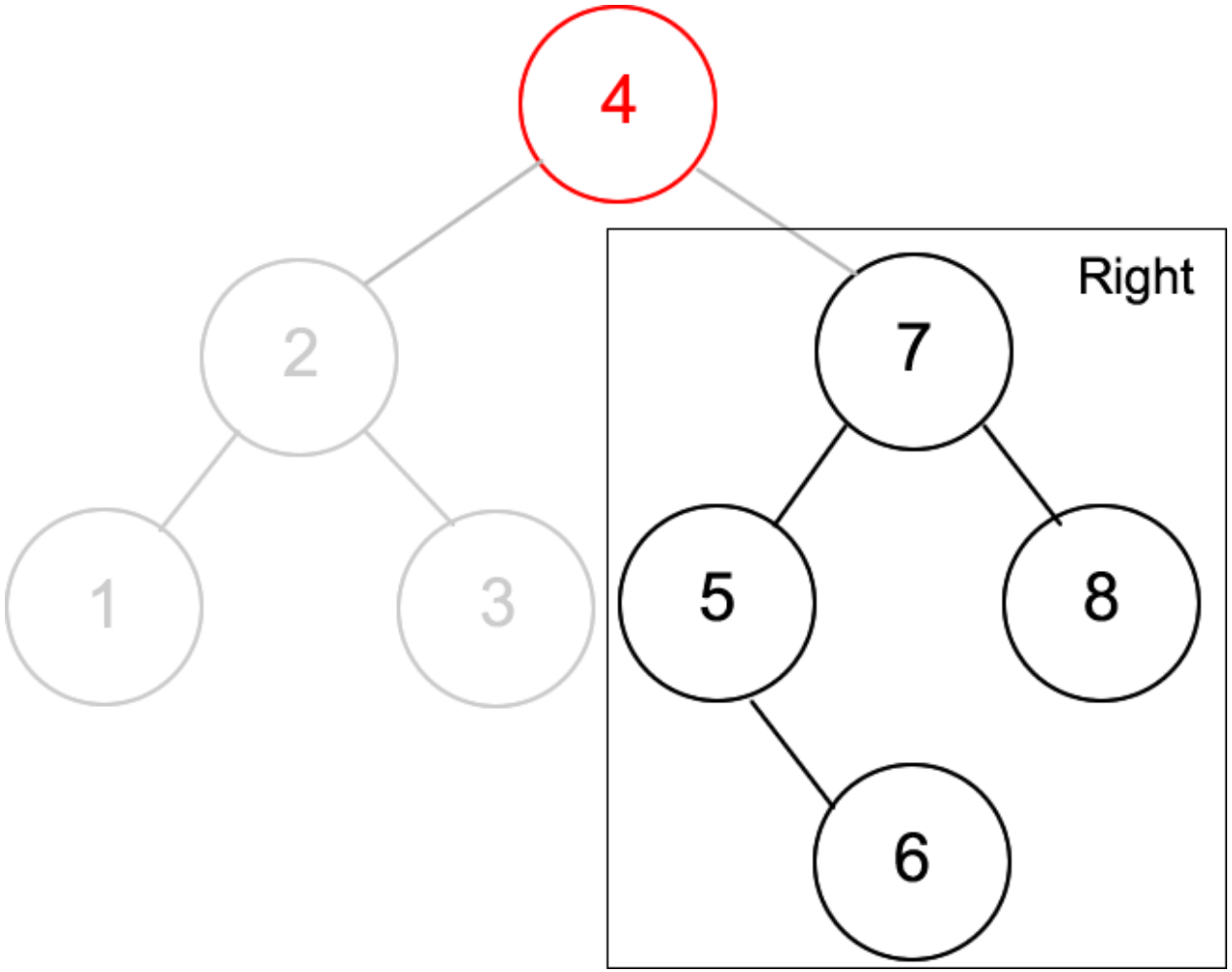

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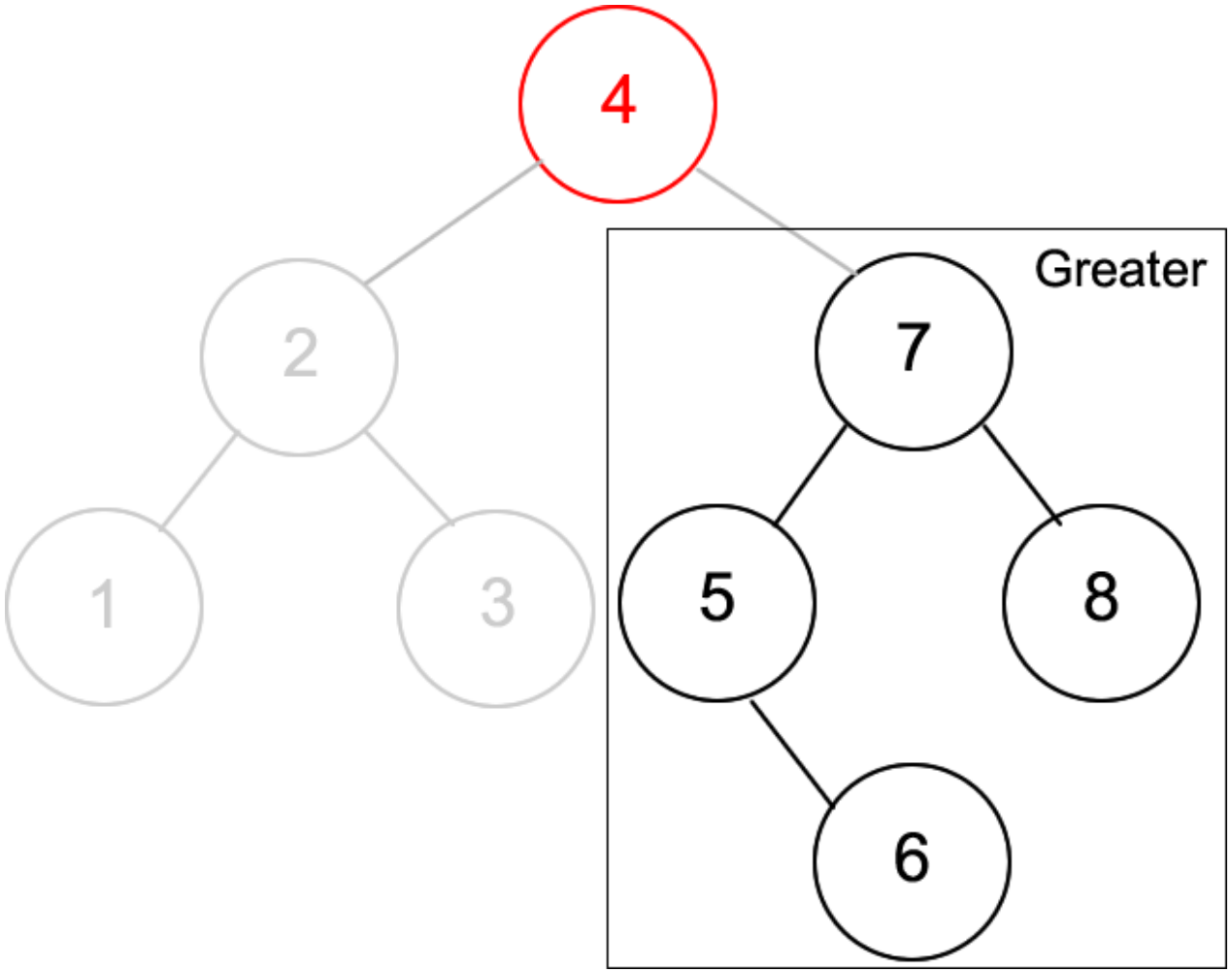

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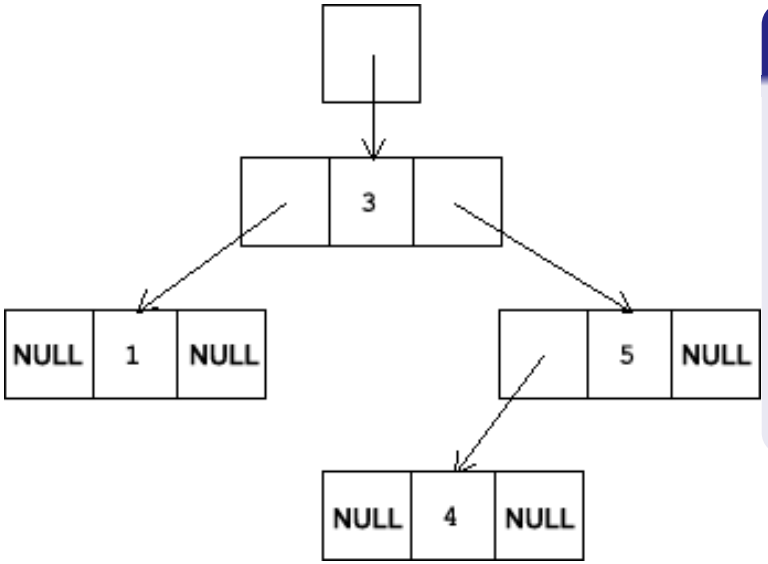
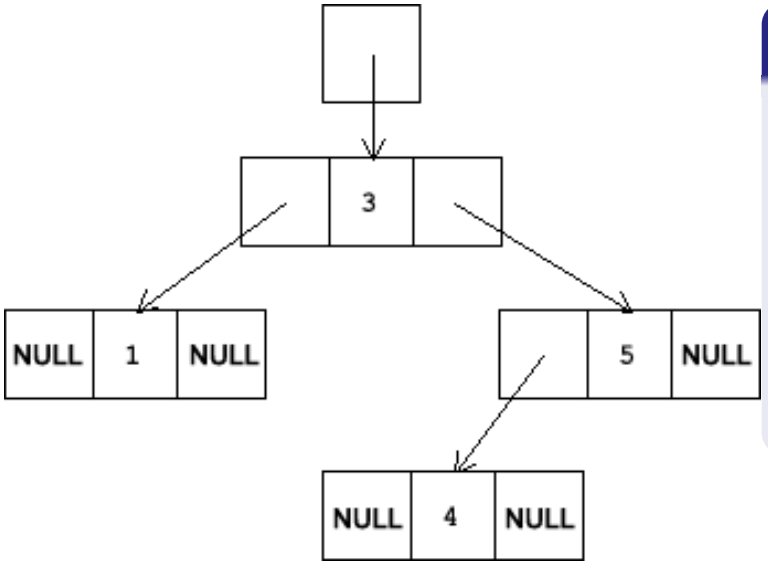


Structure

Parts of the `Node` structure:

- The value to store

Trees



Structure

Parts of the `Node` structure:

- The value to store
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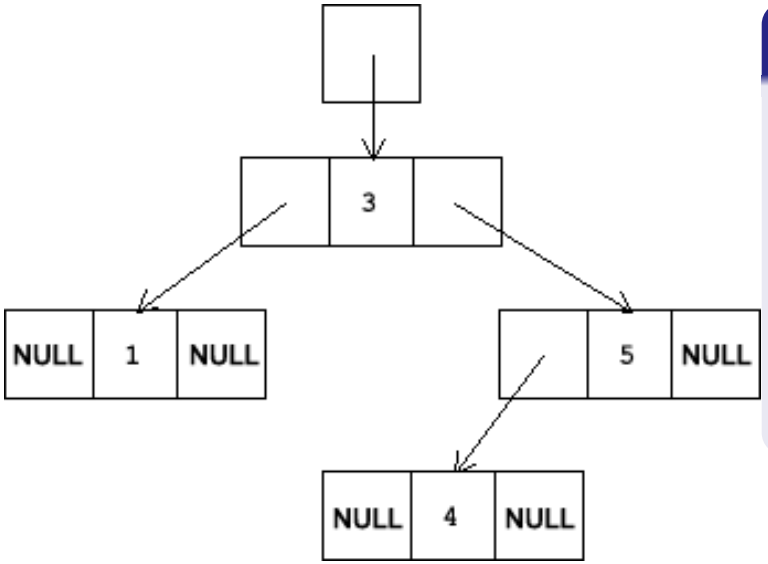
Trees



Structure

Parts of the `Node` structure:

- The value to store
- `left` pointer to a `Node`
- `right` pointer to a `Node`

Trees

Node (Leaf)

Queue

Operations

- `insert`
  Input: A pointer to the tree, and the element to insert
  Do: Inserts the element in the tree

Queue

Operations

- `insert`
  Input: A pointer to the tree, and the element to insert
  Do: Inserts the element in the tree
- Traversing/Searching an element
  Input: A pointer to the tree, and the element to search
  Do: Transerverse the tree searching the element
  Return: True/False (If the element was found). Return (Alt): A pointer to the node where the value is the searched one

Queue

Insert

- Let `tree` a pointer to the root of the tree, and `value` the value to insert

Queue

Insert

- Let `tree` a pointer to the root of the tree, and `value` the value to insert
- Check if the input node is `null`

Queue

Insert

- Let `tree` a pointer to the root of the tree, and `value` the value to insert
- Check if the input node is `null`
- If so, create a new `Node` with the input value, and point the input `tree` to the created `Node`

Queue

Insert

- Let `tree` a pointer to the root of the tree, and `value` the value to insert
- Check if the input node is `null`
- If so, create a new `Node` with the input value, and point the input `tree` to the created `Node`
- Else. Check if the `value` to insert is lower than the value of the `Node`. If so, call the `insert` function with the left subtree

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- Else if the `value` to insert is greater than the value of the `Node`, call the `insert` function with the right subtree

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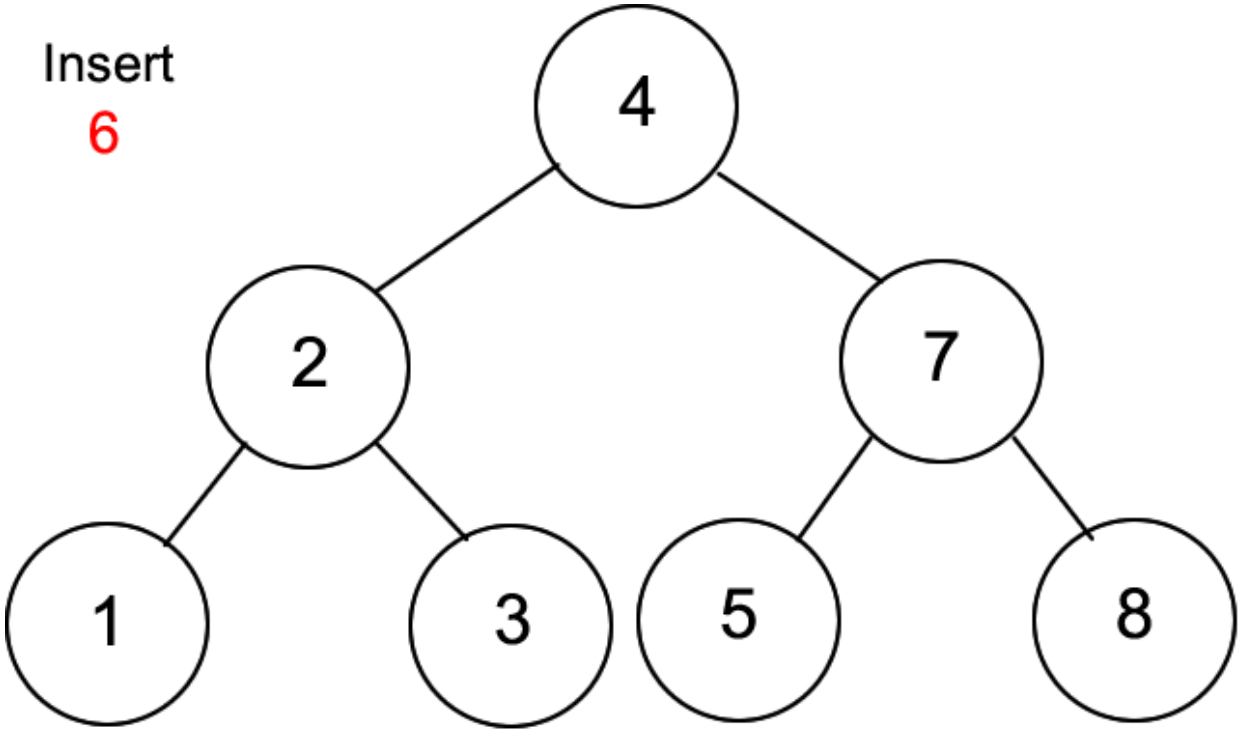
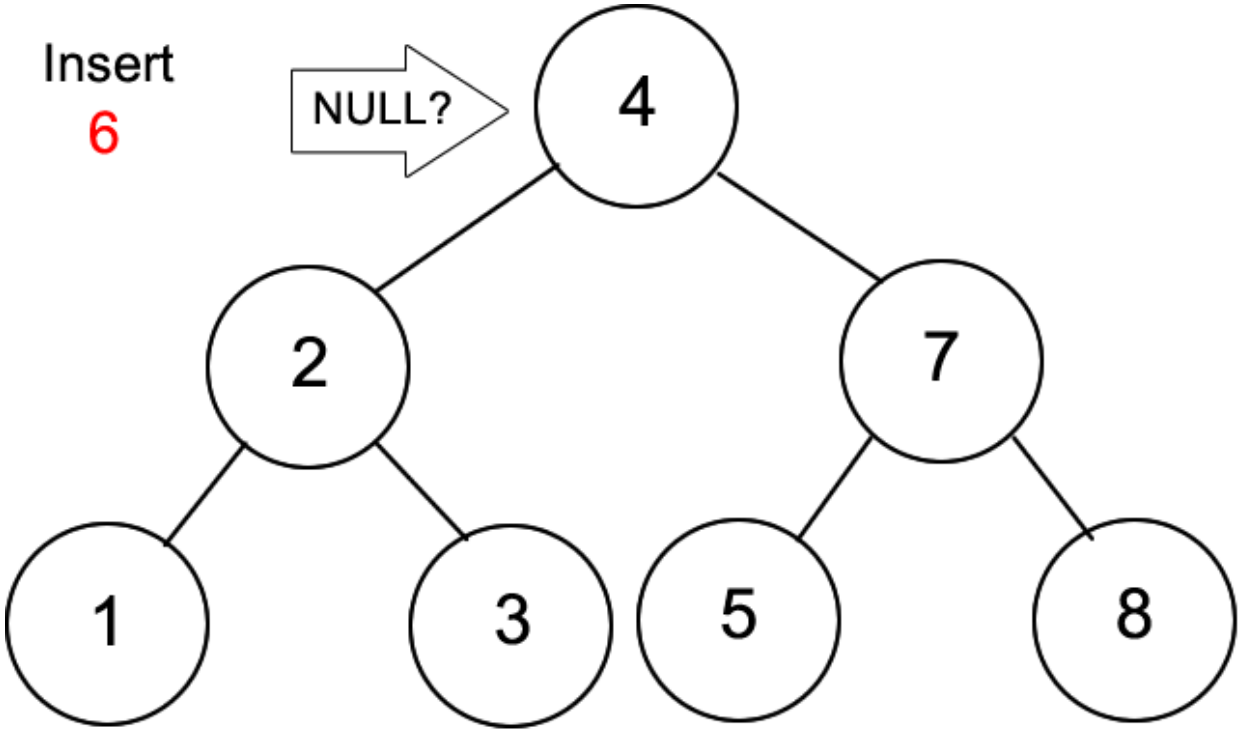
- Else if the `value` to insert is greater than the value of the `Node`, call the `insert` function with the right subtree
- If the `value` to insert is equal to the value of the `Node`, discard the value and stop the algorithm

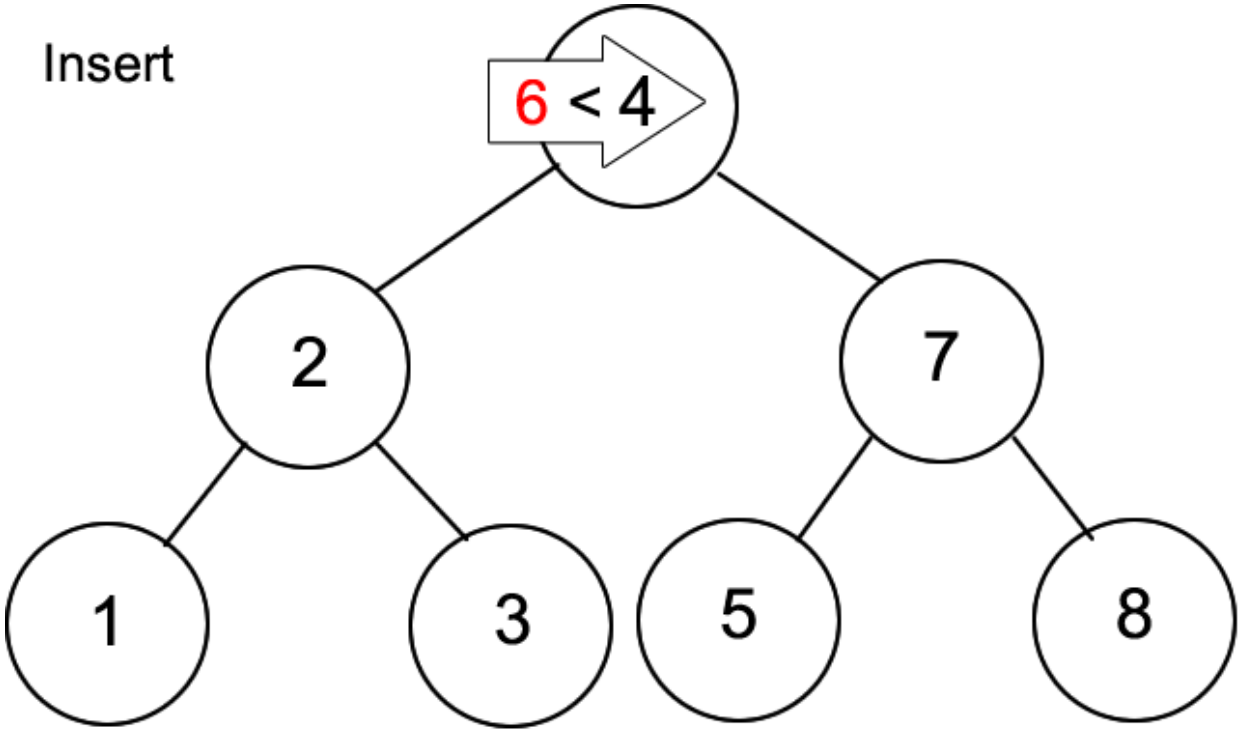
Binary Search Tree - Insert



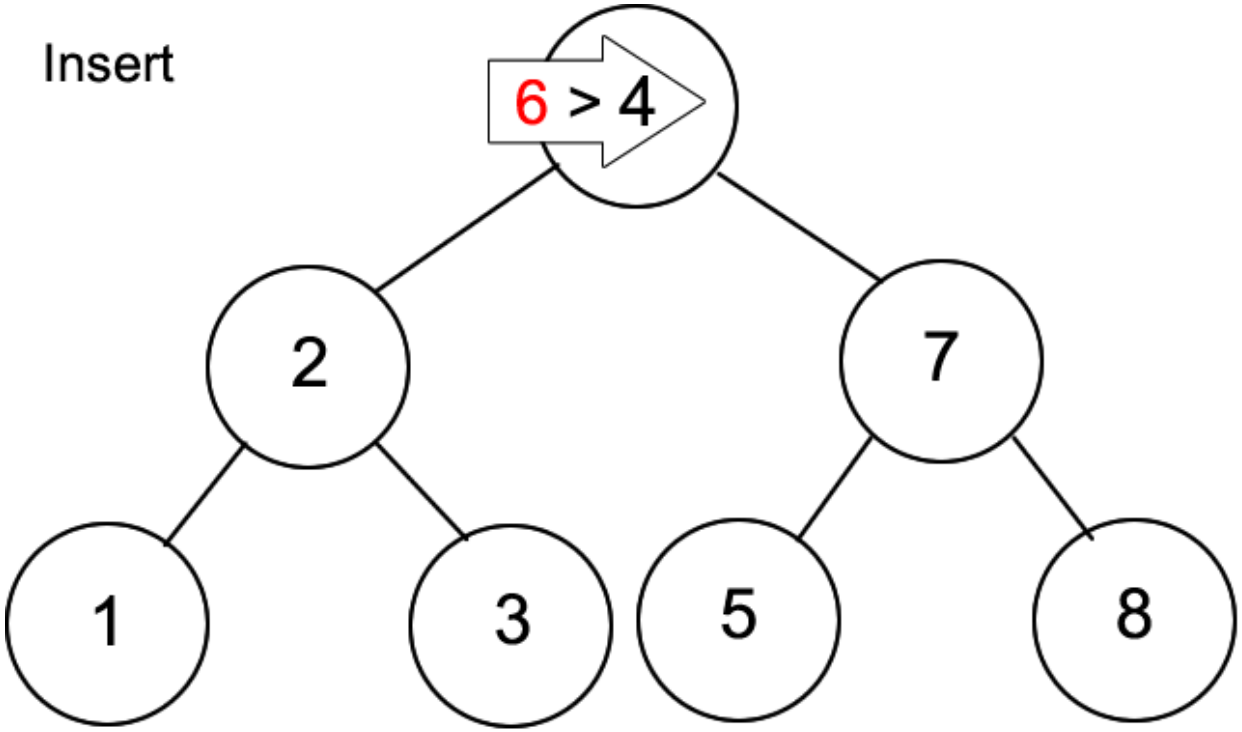
Binary Search Tree - Insert



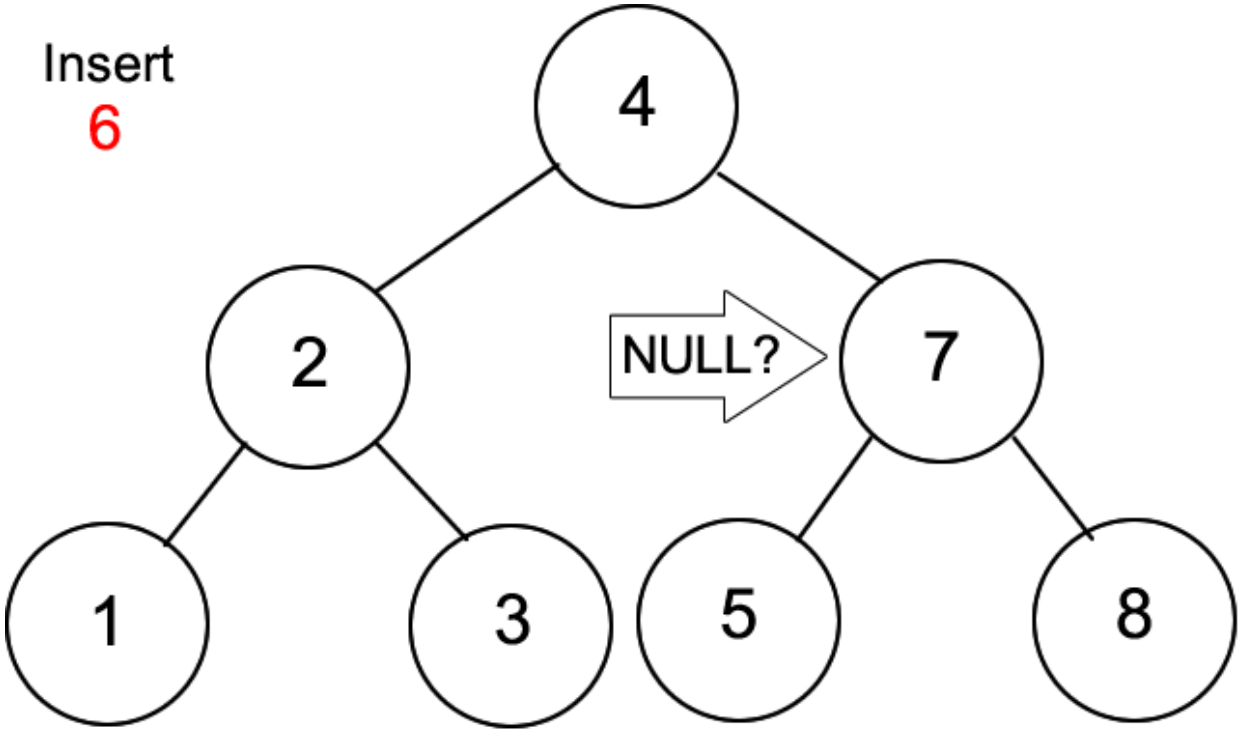
Binary Search Tree - Insert



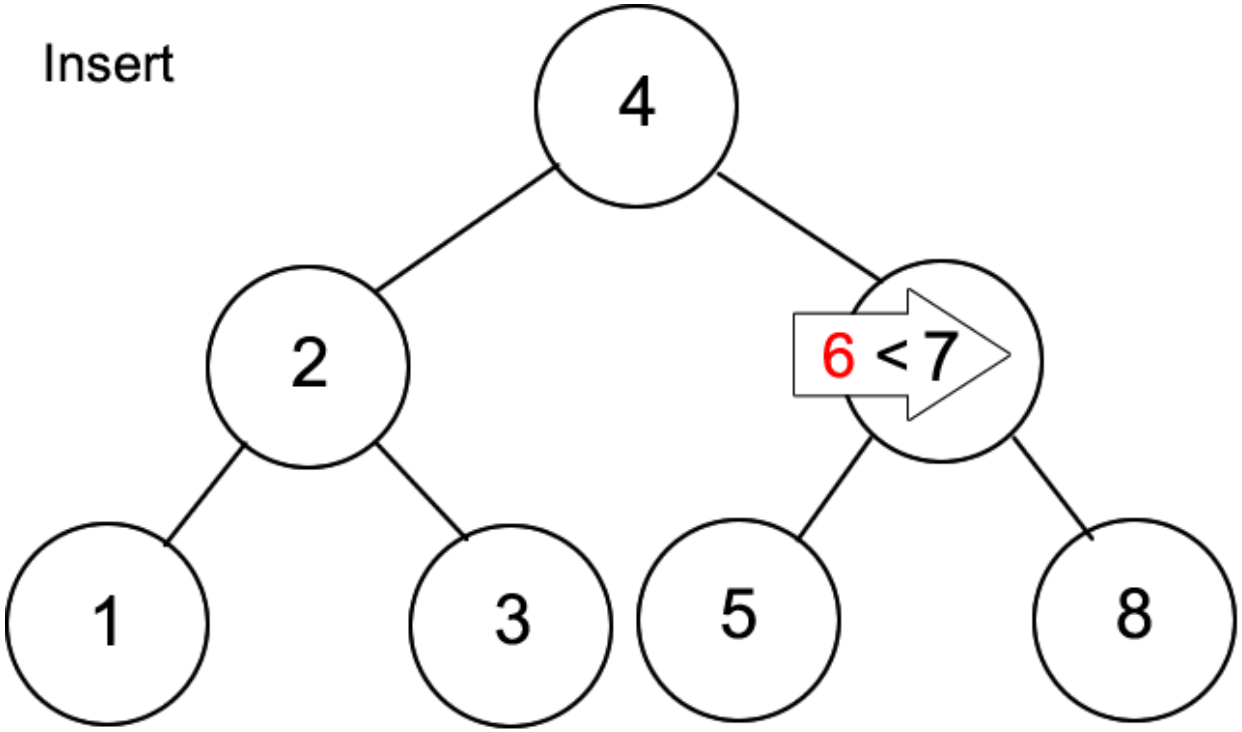
Binary Search Tree - Insert



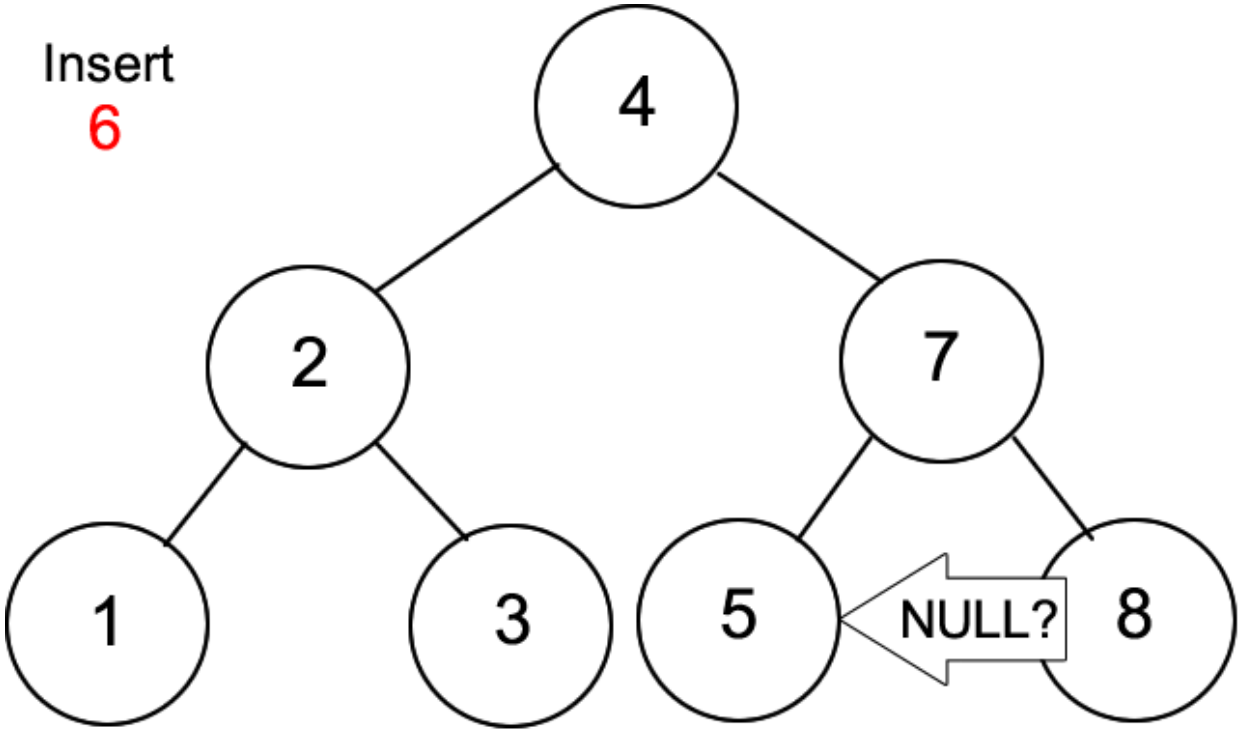
Binary Search Tree - Insert



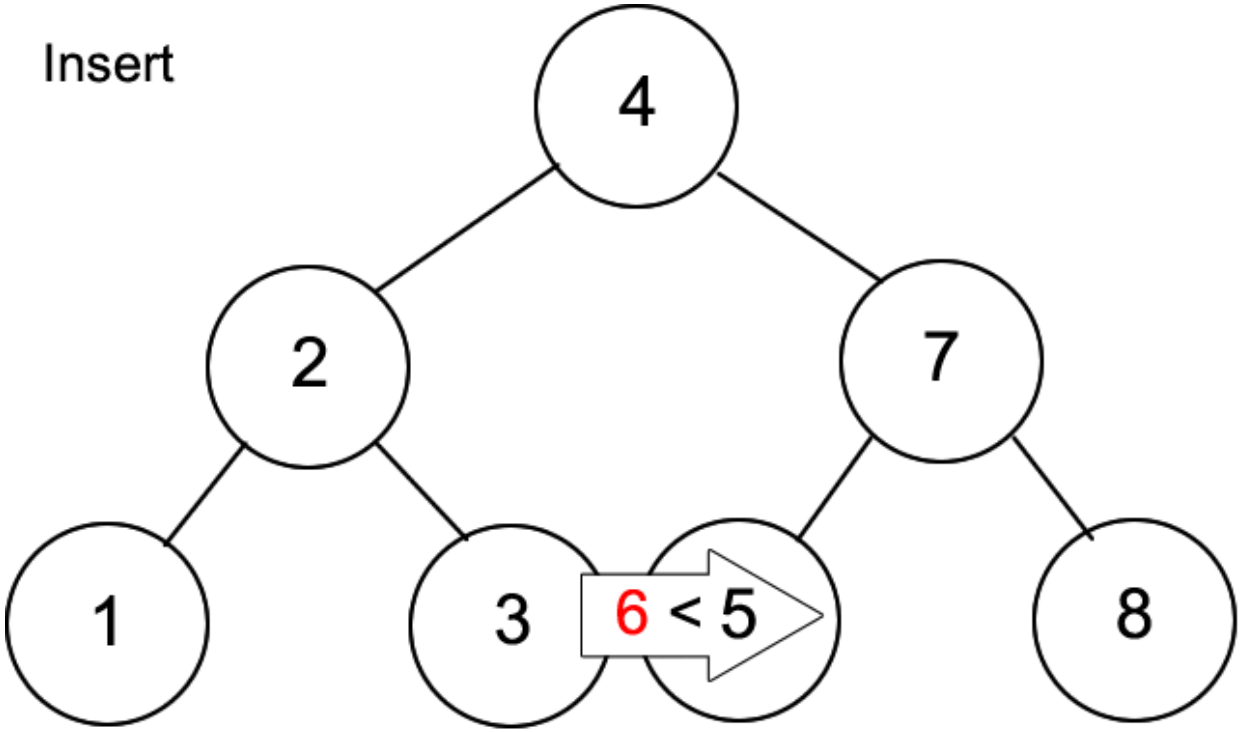
Binary Search Tree - Insert



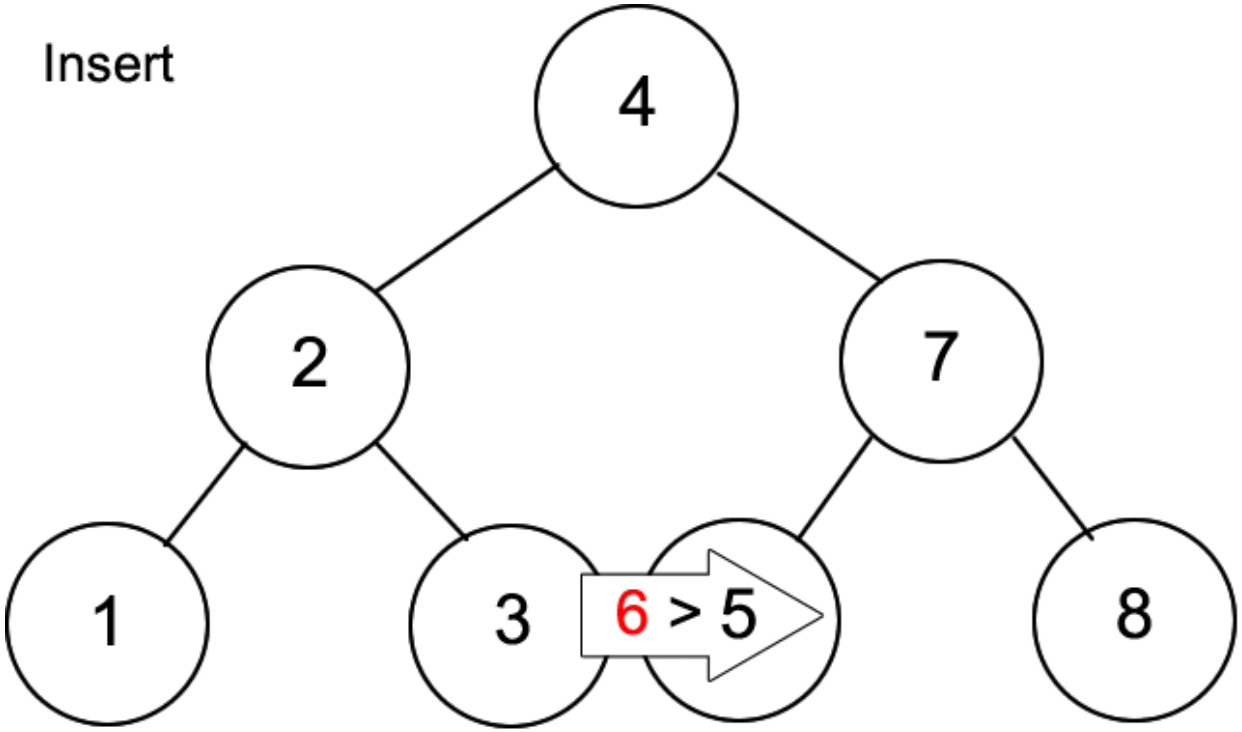
Binary Search Tree - Insert



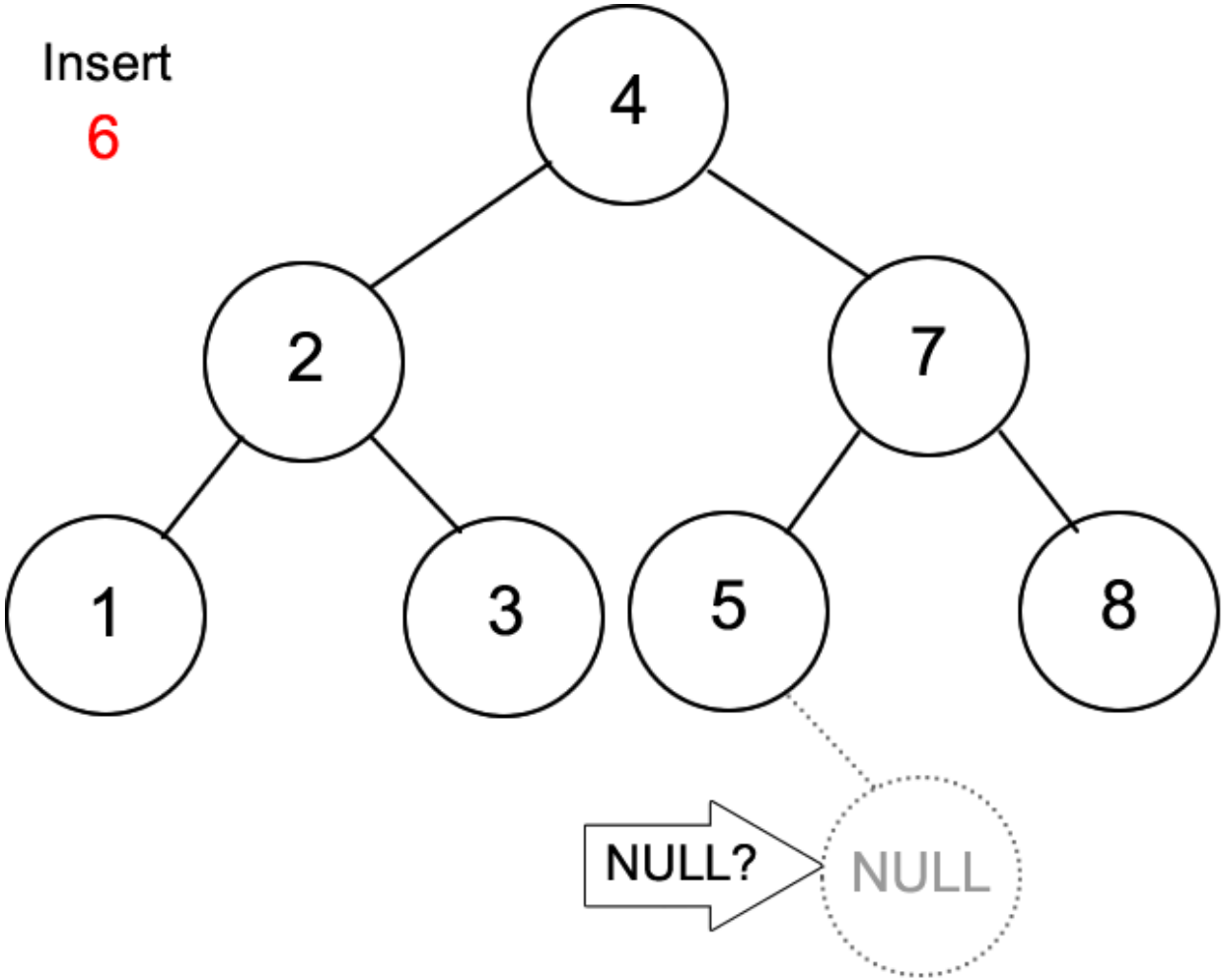
Binary Search Tree - Insert



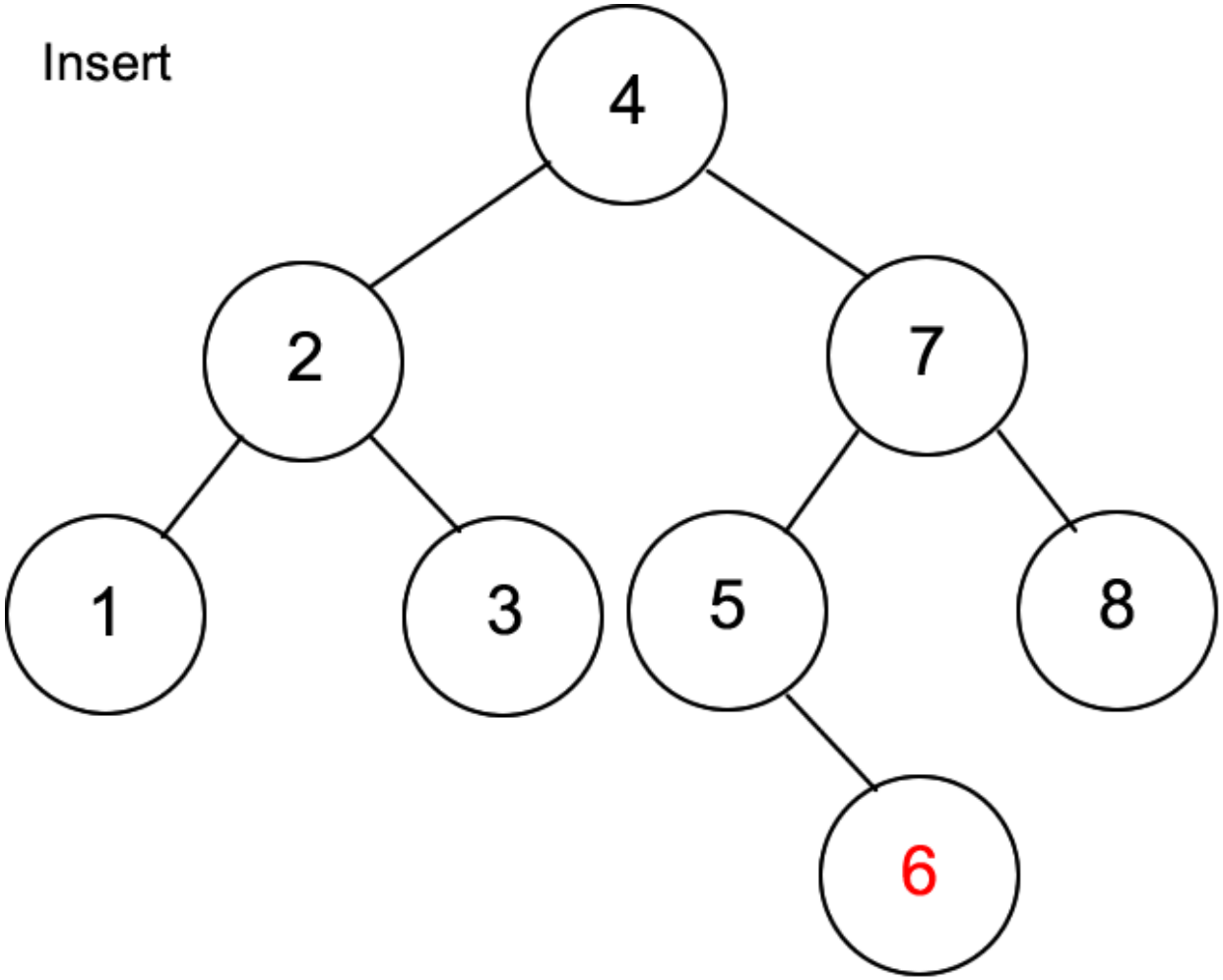
Binary Search Tree - Insert



Binary Search Tree - Insert



Binary Search Tree - Insert



Trees - Traversing

Depth-first search

Is an algorithm for traversing a tree. Exploration starts at the root node and made a depth exploration as far as possible before *backtracking*. Algorithm vary according the exploration order:

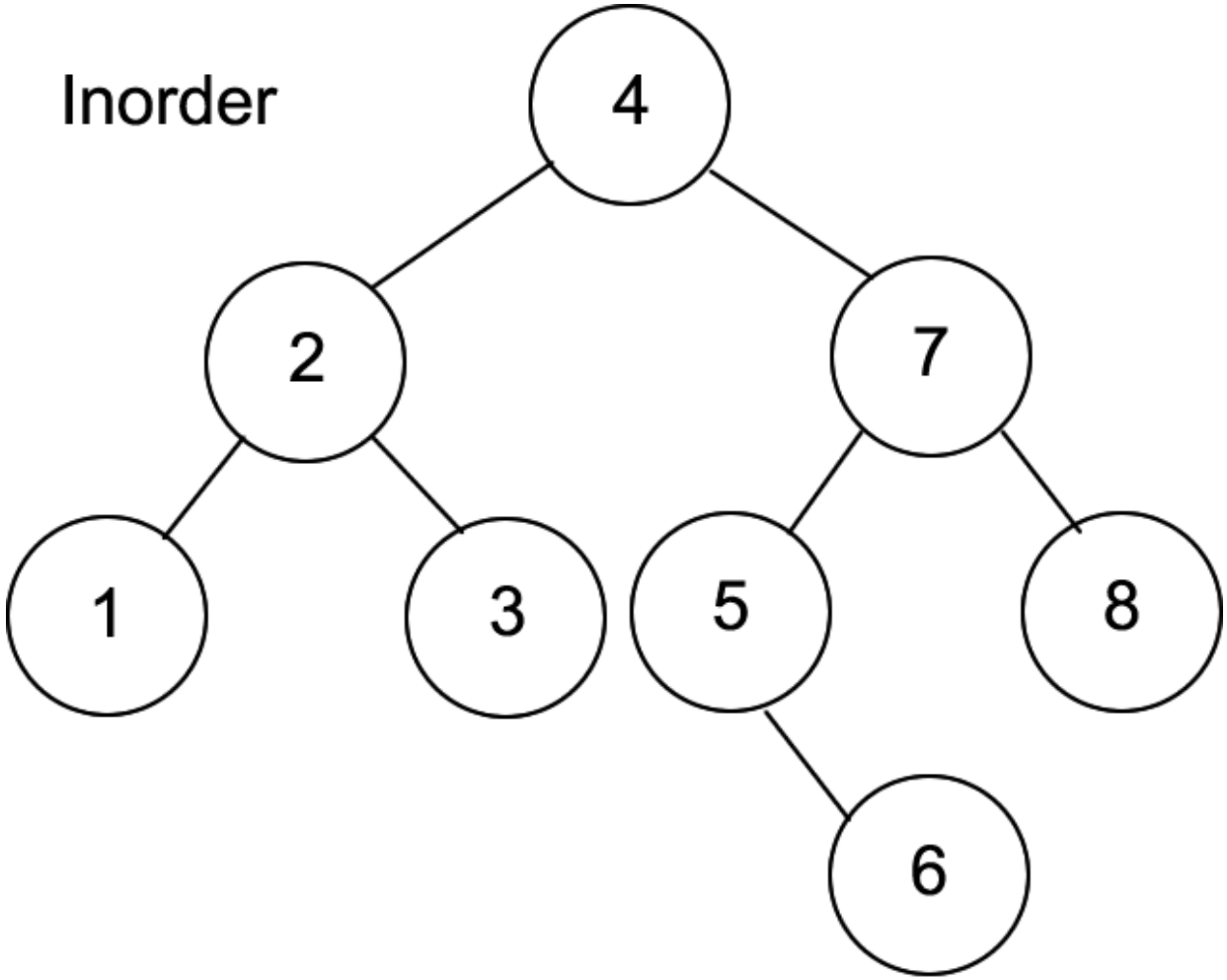
- `In-order`
- `Pre-order`
- `Post-order`

Trees - InOrder

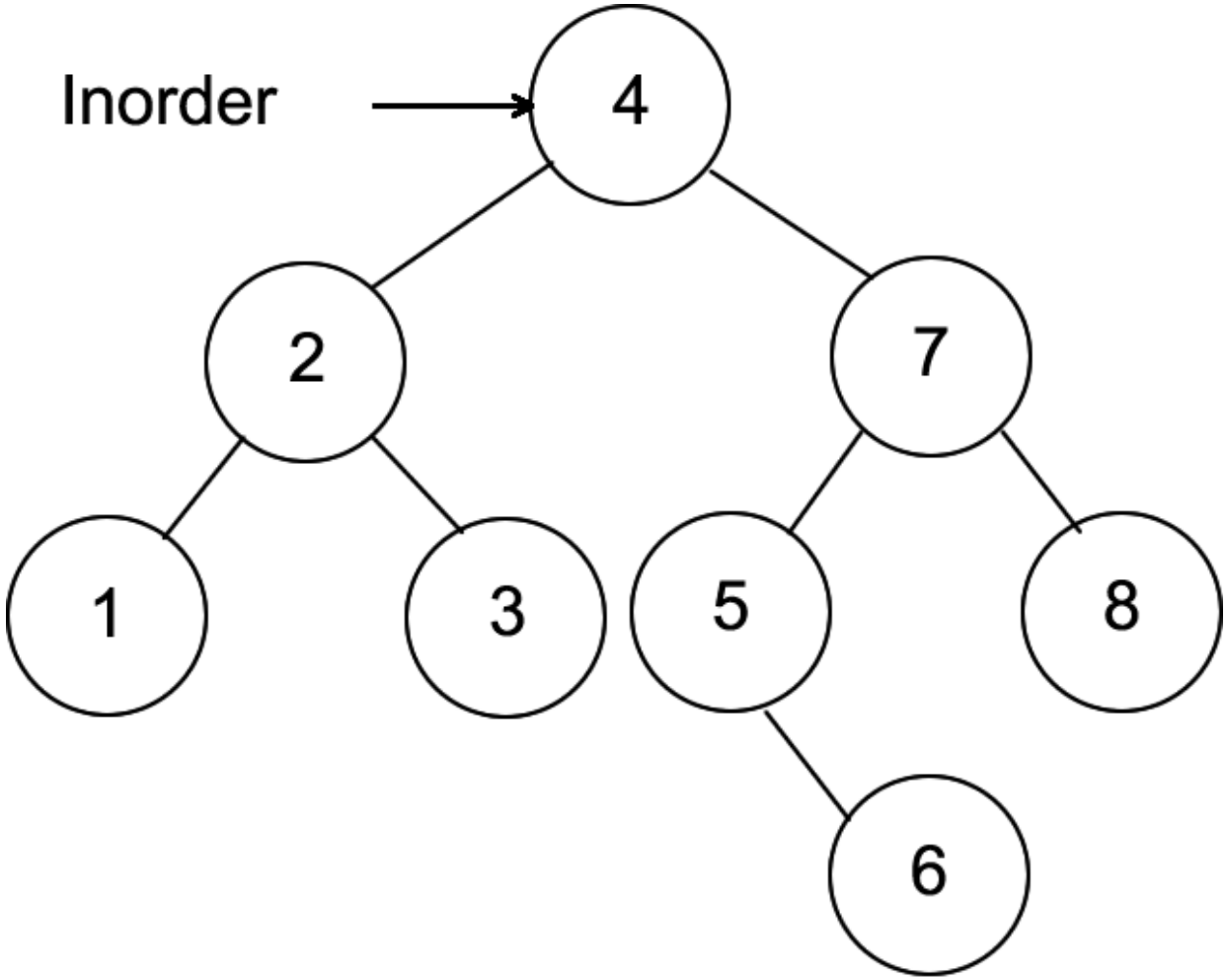
Traversing a tree `In-order`

- Check if the node is null
- Traverse the left subtree `InOrder`
- Display the data at the node
- Traverse the right subtree `InOrder`

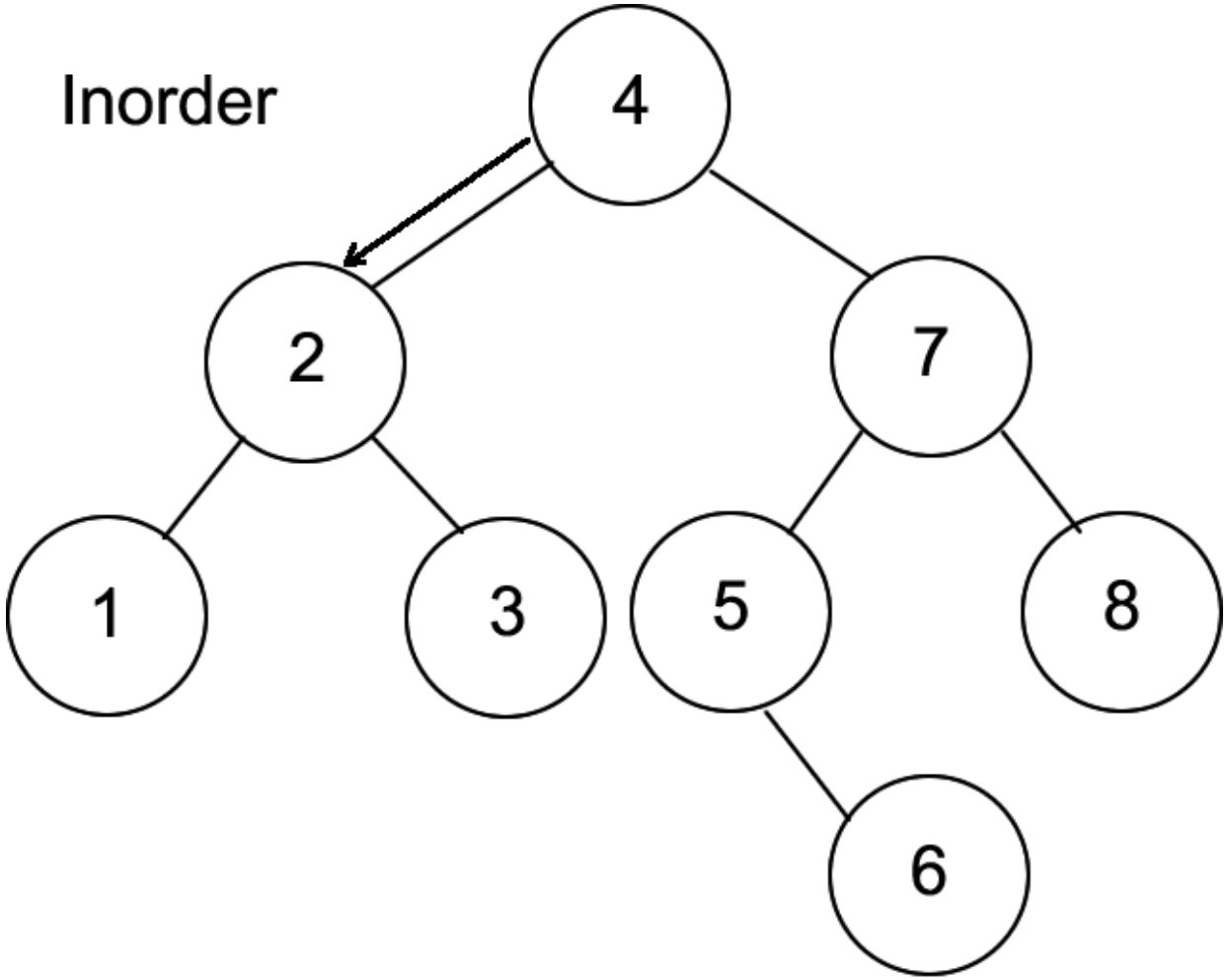
Trees - InOrder



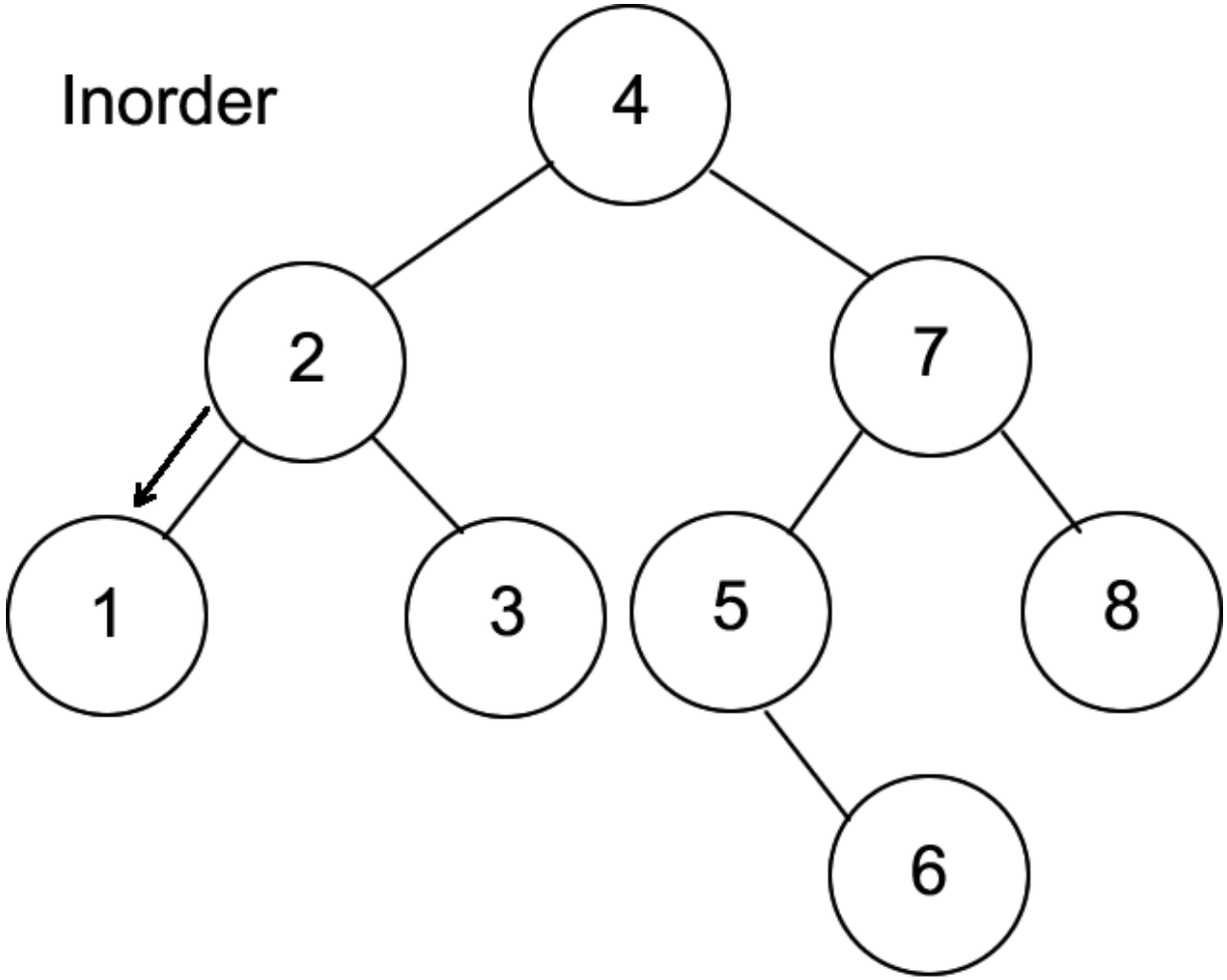
Trees - InOrder



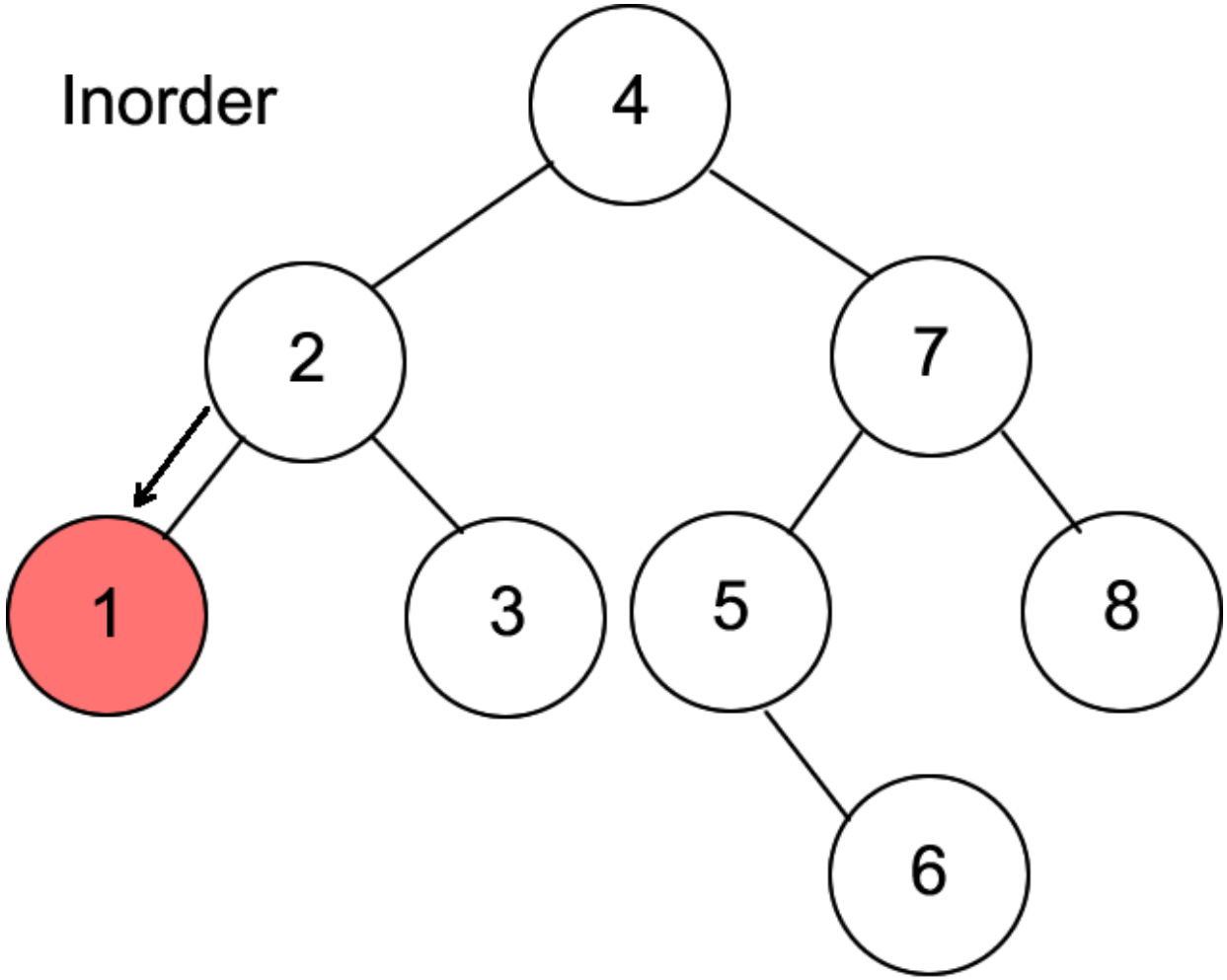
Trees - InOrder



Trees - InOrder

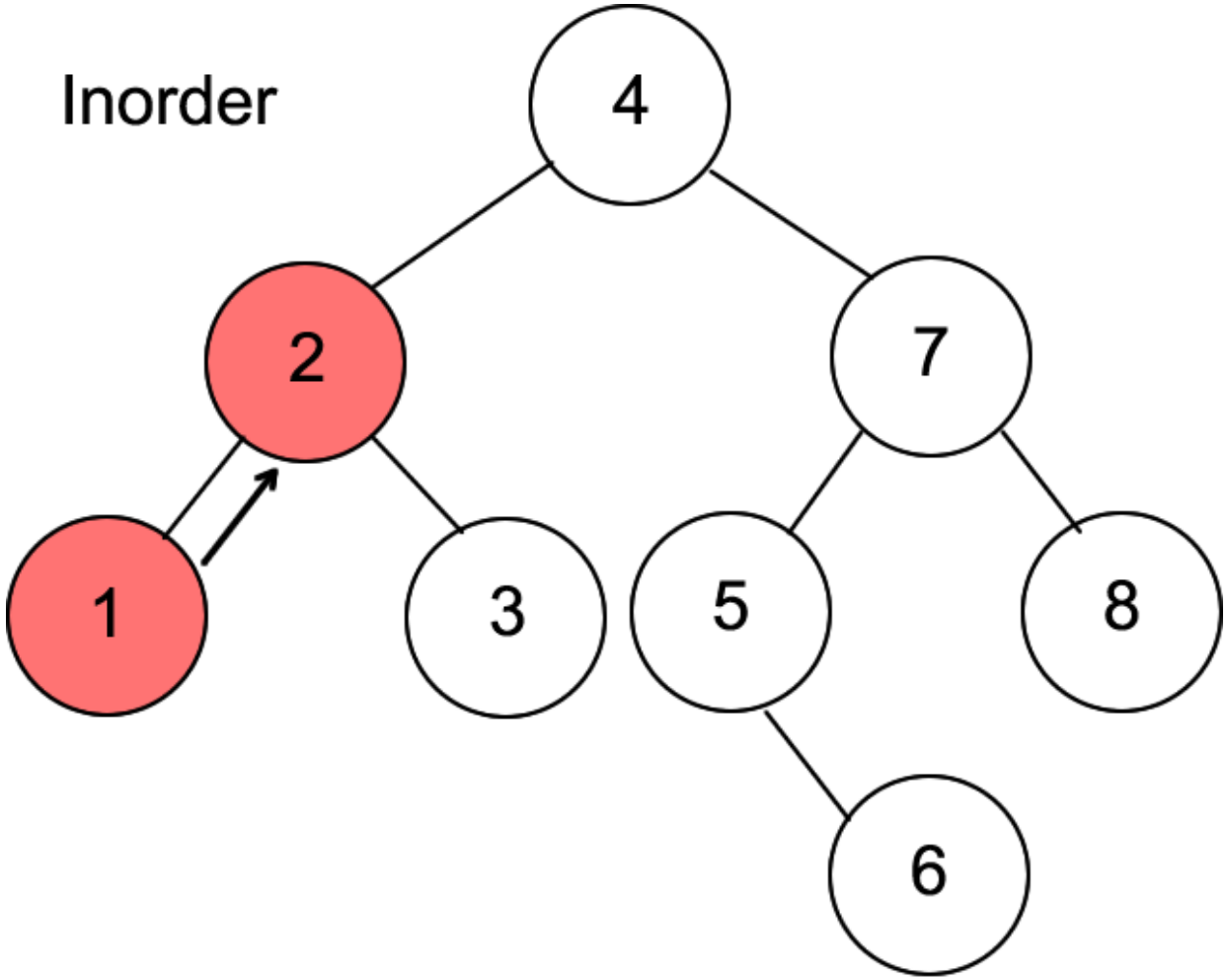


Trees - InOrder



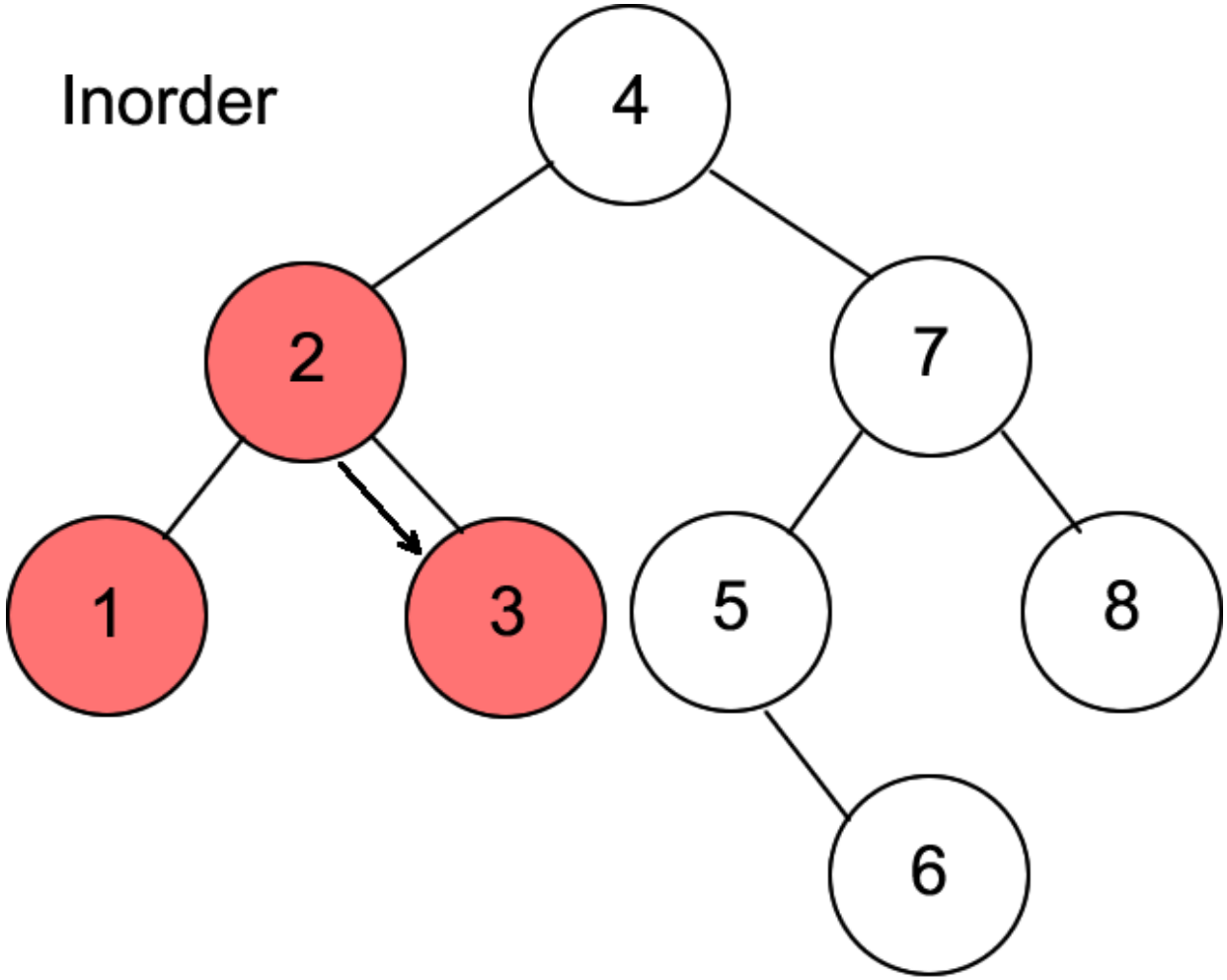
1

Trees - InOrder

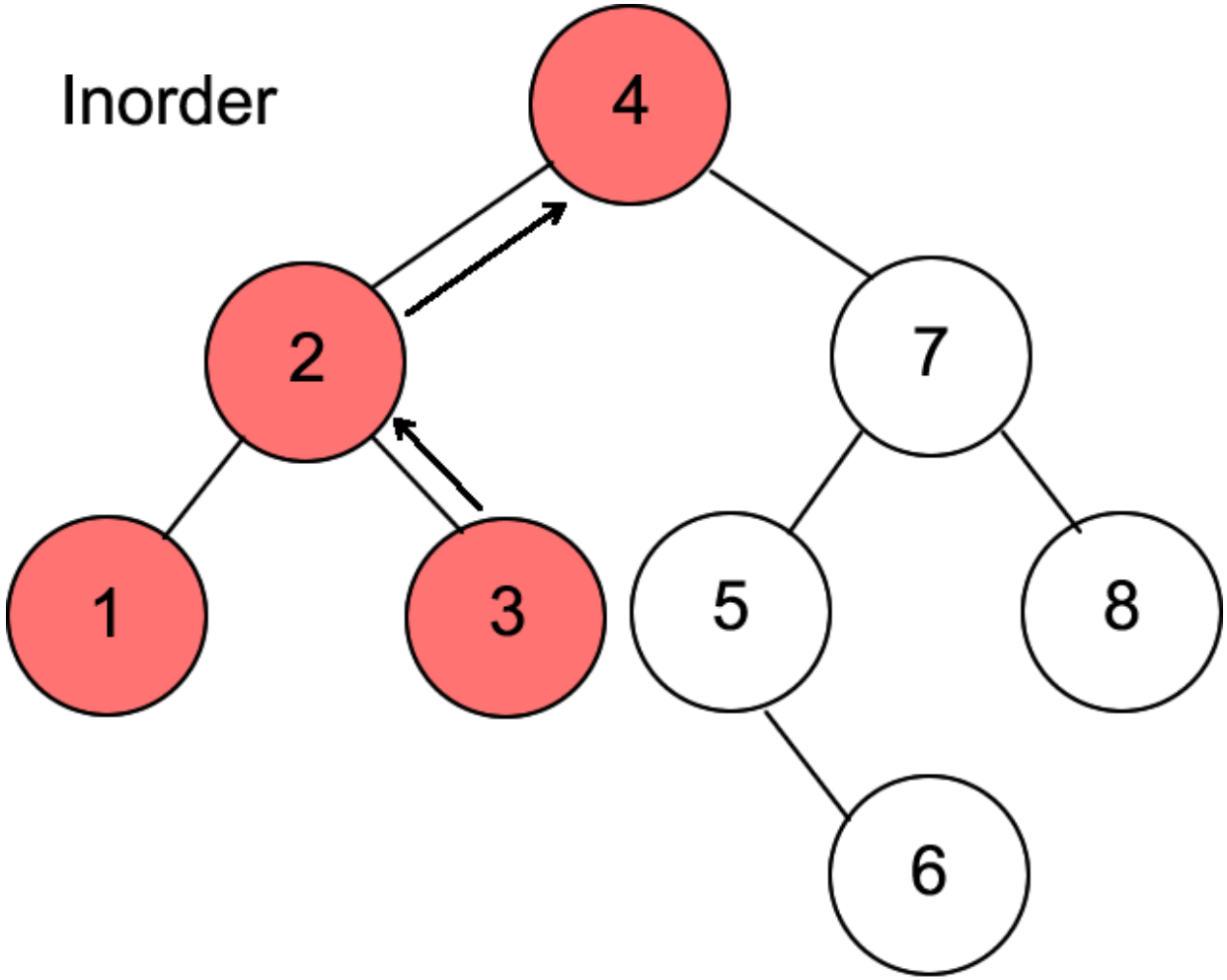


1 - 2

Trees - InOrder

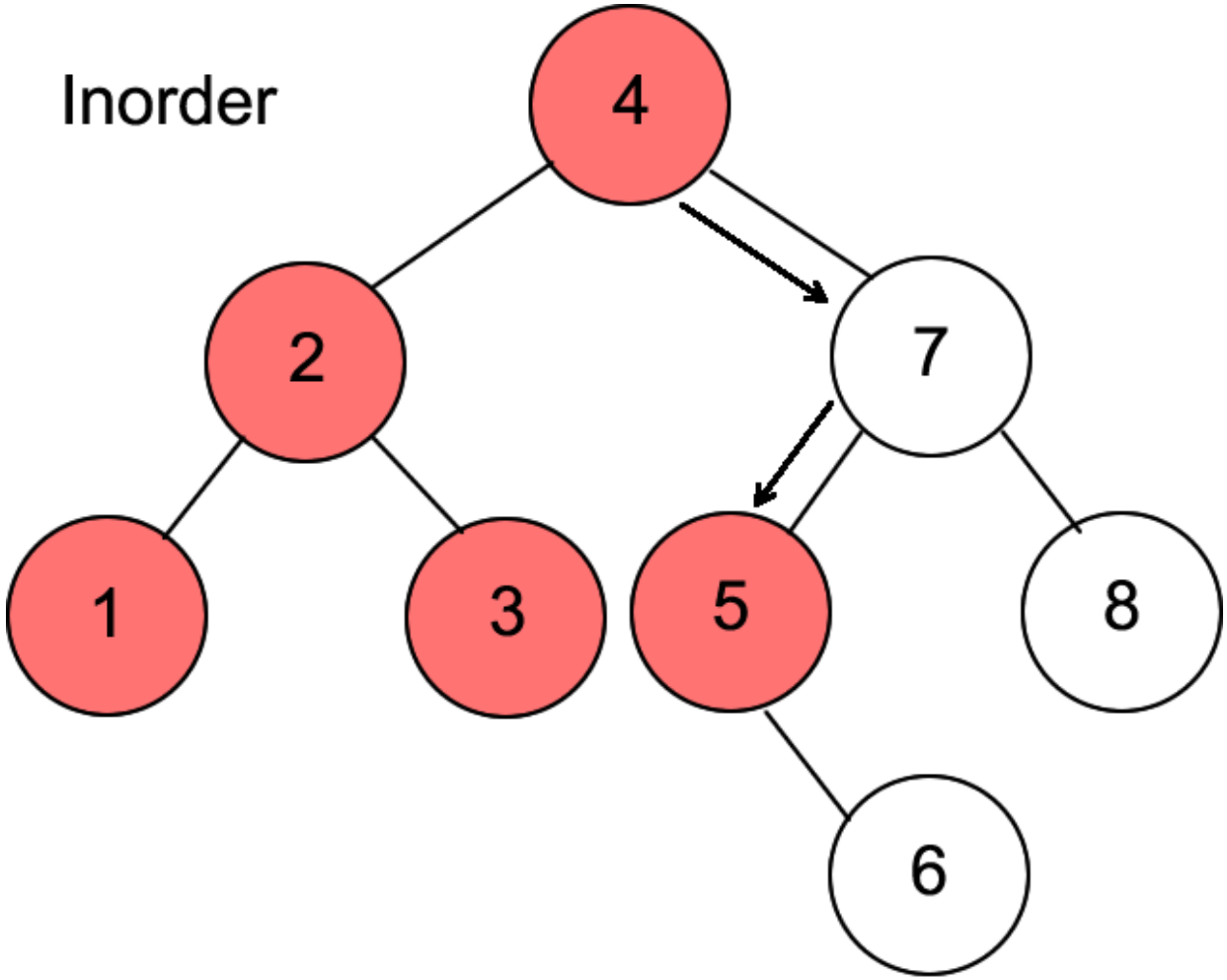


Trees - InOrder



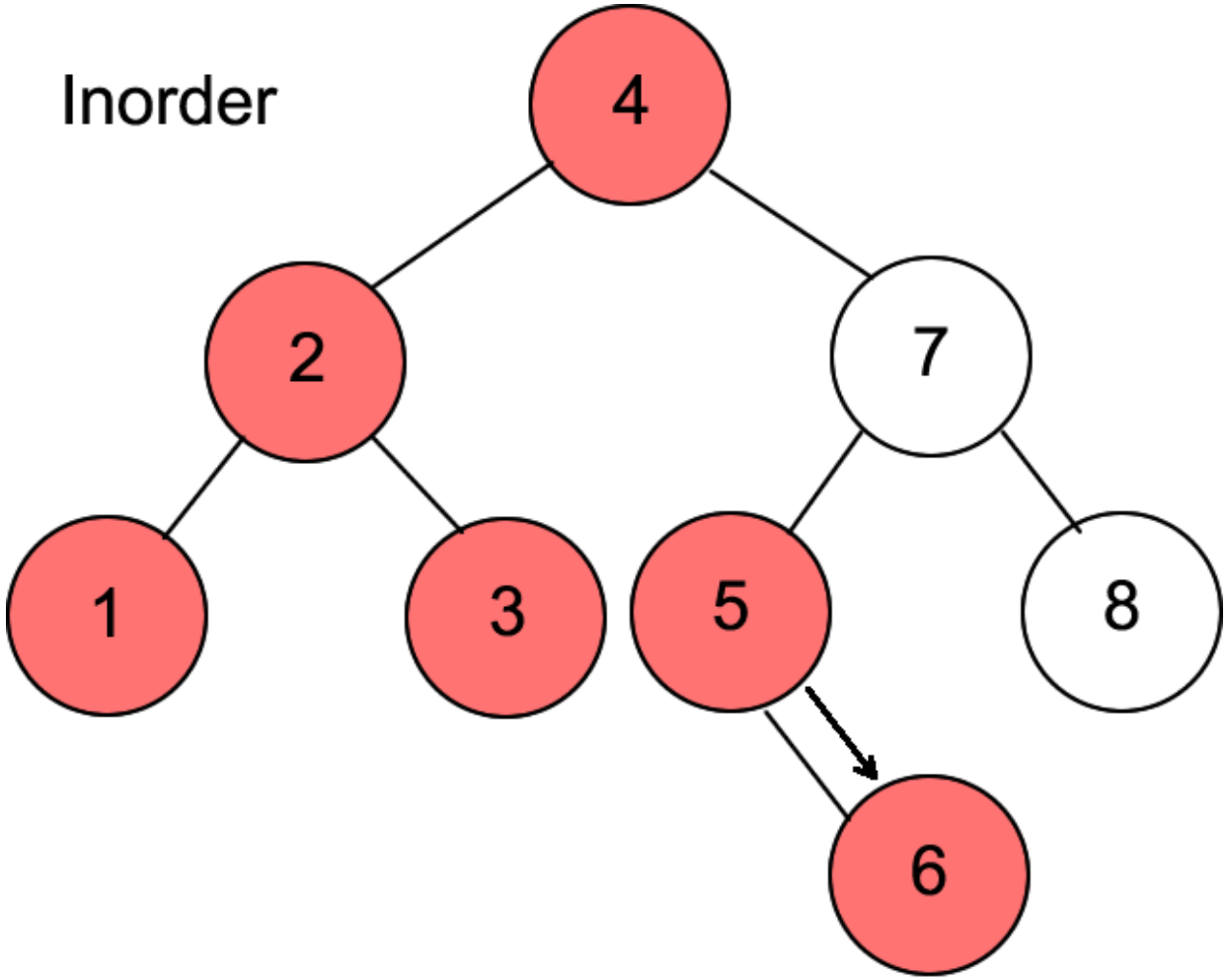
1 - 2 - 3 - 4

Trees - InOrder



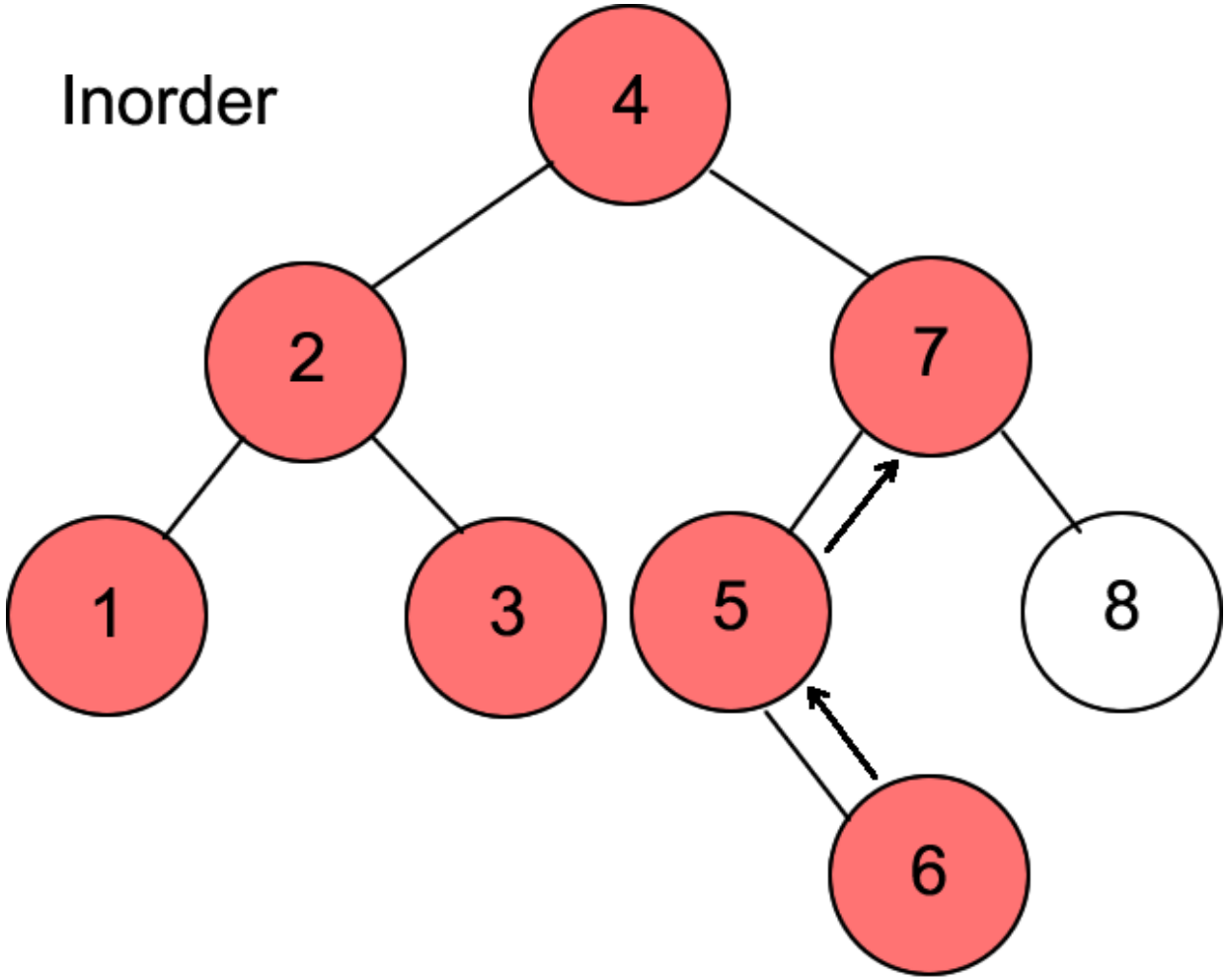
1 - 2 - 3 - 4 - 5

Trees - InOrder



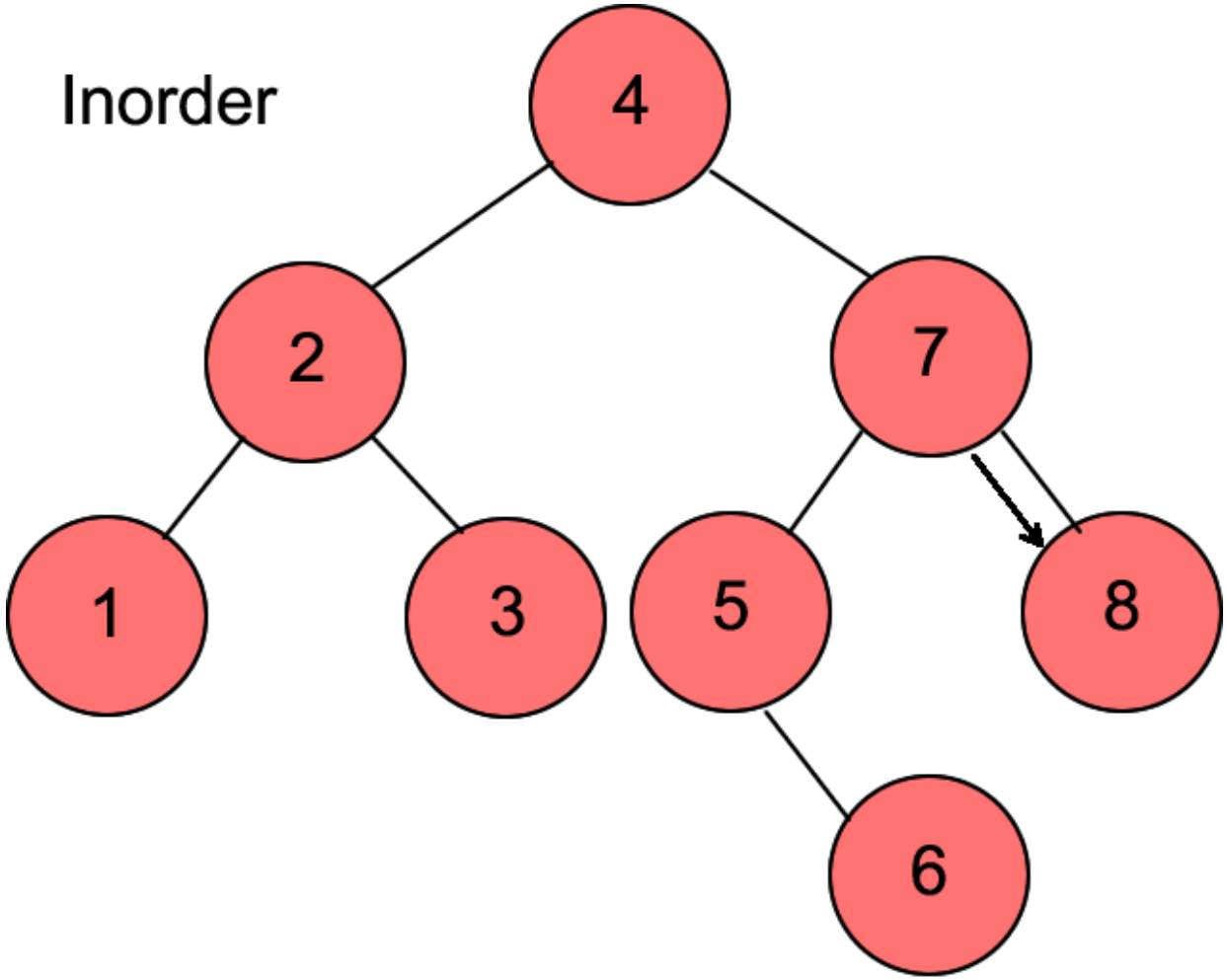
1 - 2 - 3 - 4 - 5 - 6

Trees - InOrder



1 - 2 - 3 - 4 - 5 - 6 - 7

Trees - InOrder



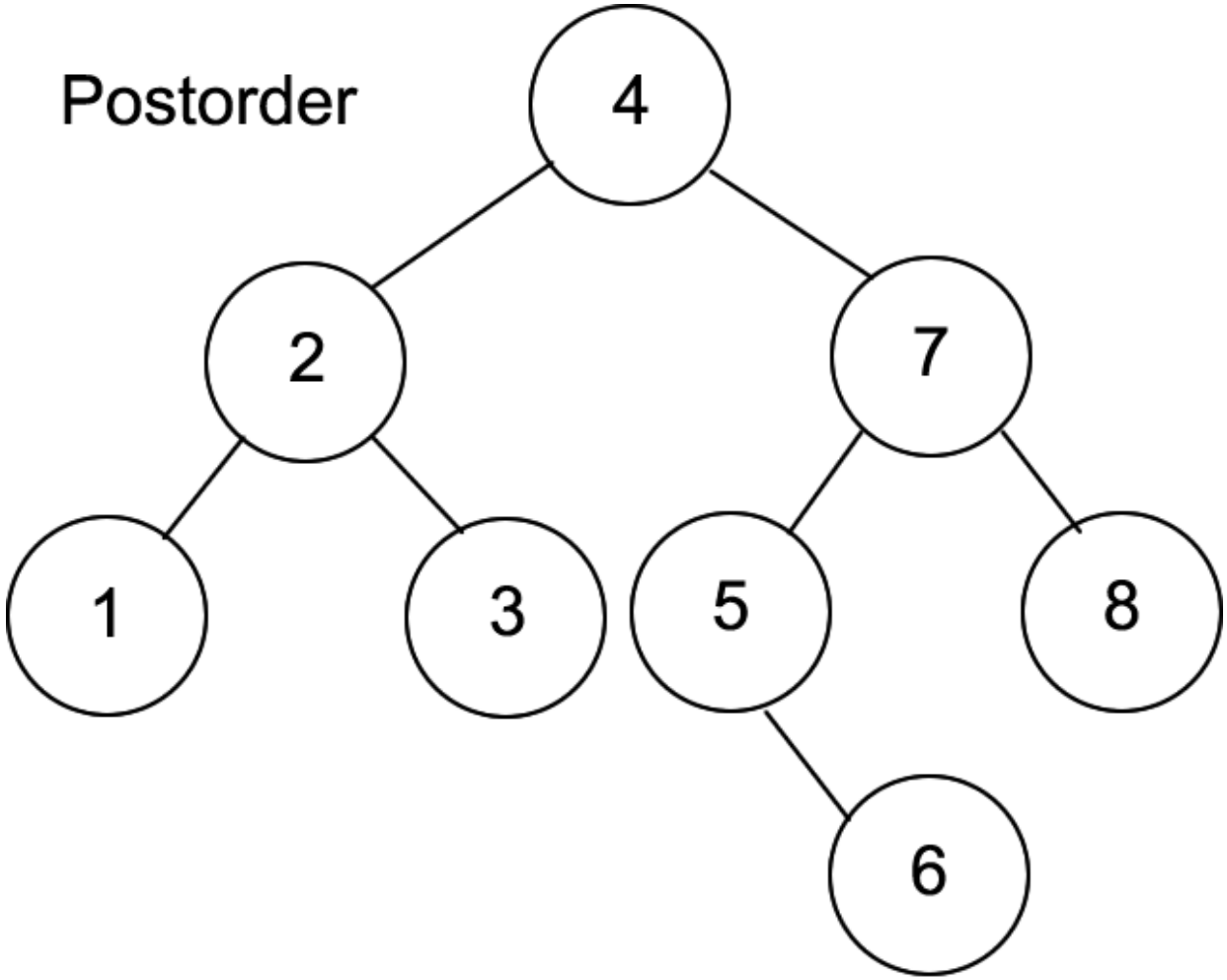
1 - 2 - 3 - 4 - 5 - 6 - 7 - 8

Trees - PostOrder

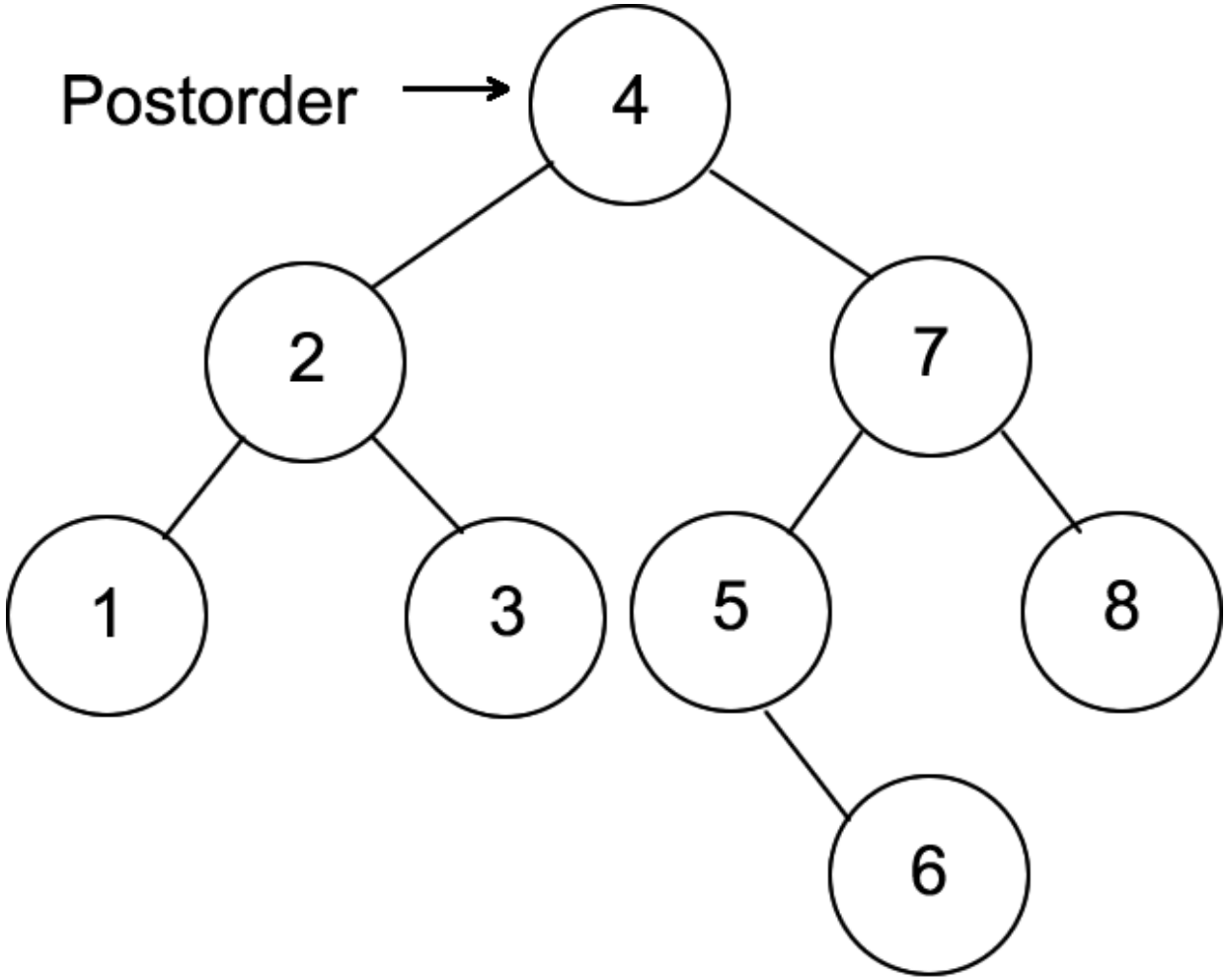
Traversing a tree `Post-order`

- Check if the node is null
- Traverse the left subtree `PostOrder`
- Traverse the right subtree `PostOrder`
- Display the data at the node

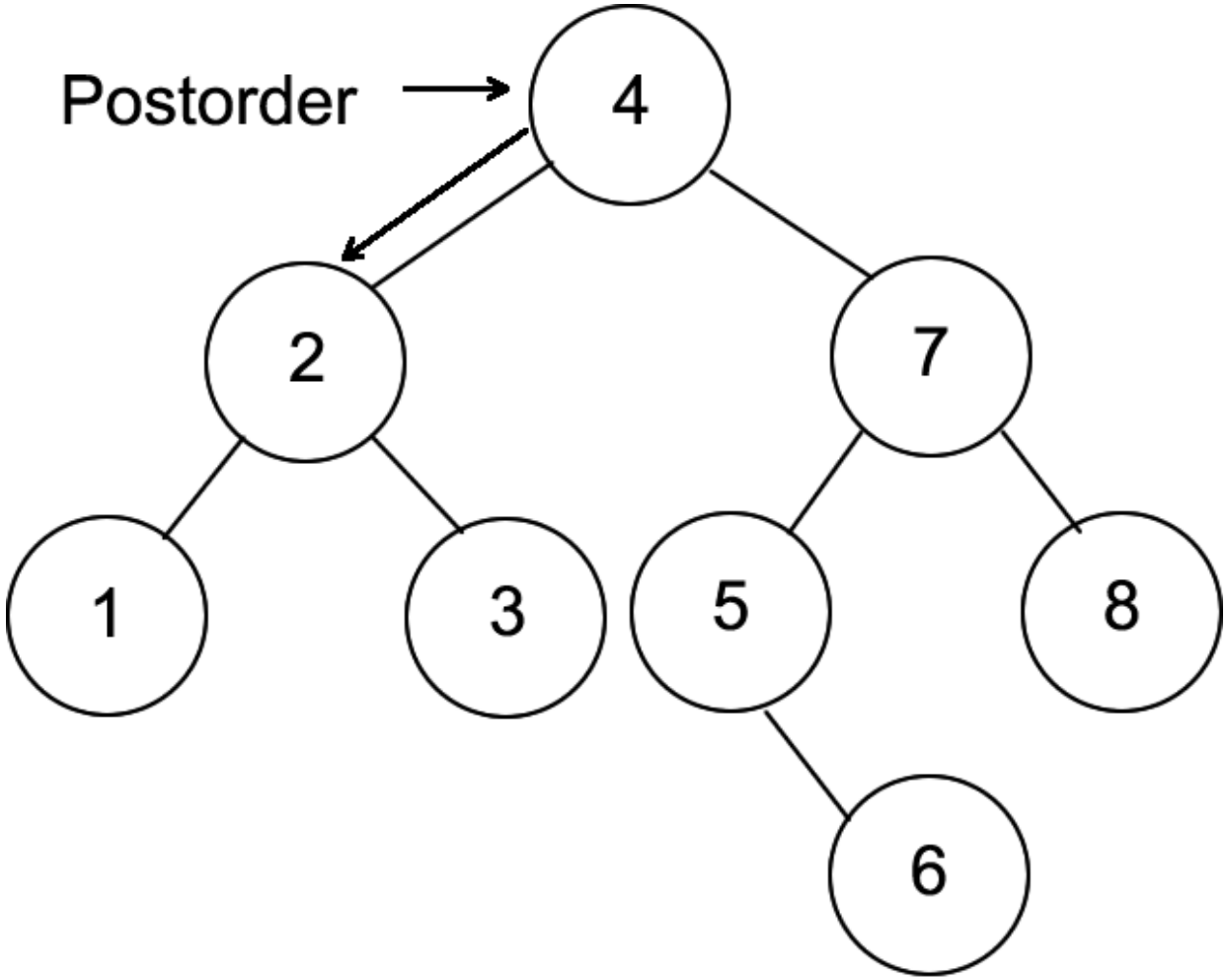
Trees - PostOrder



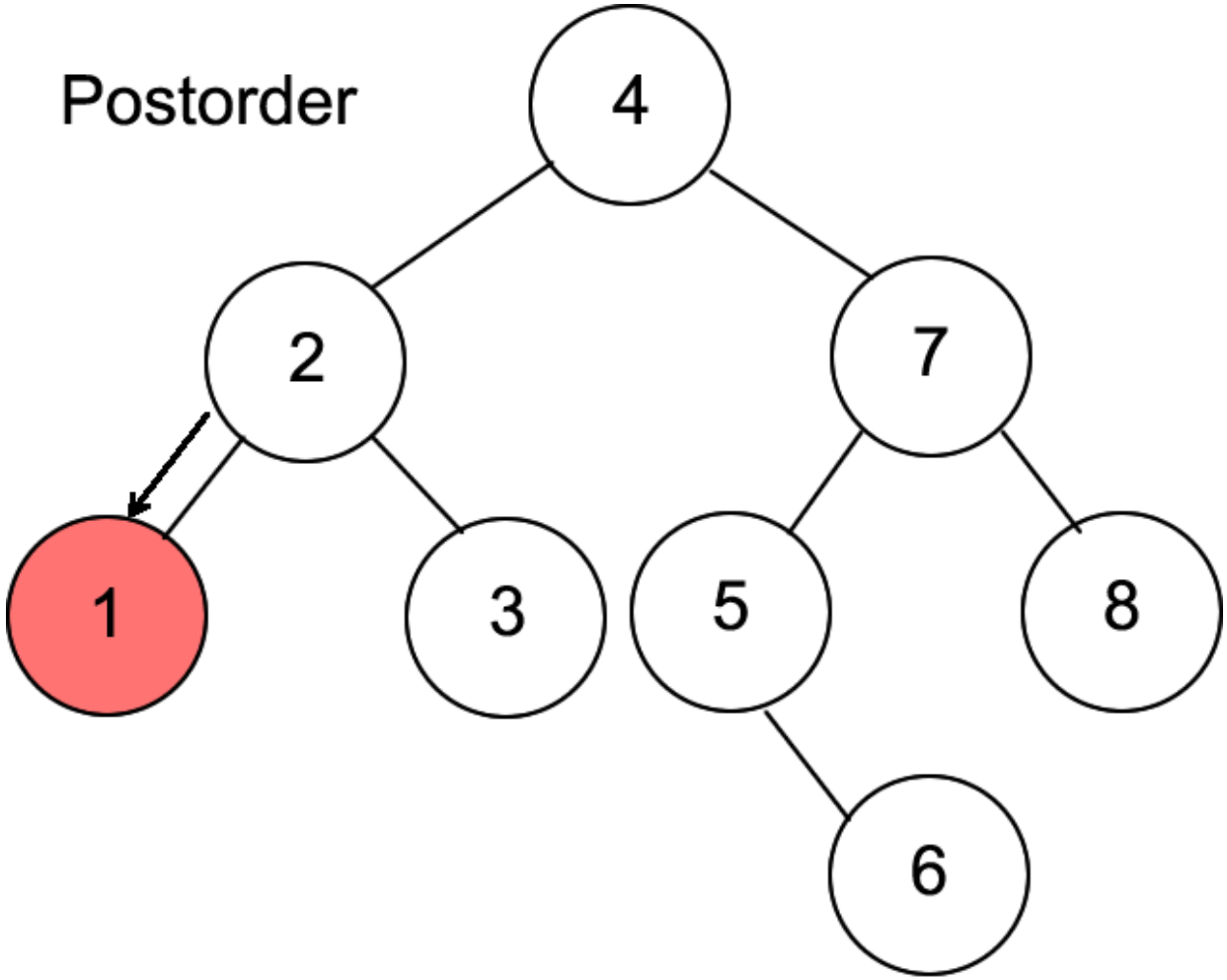
Trees - PostOrder



Trees - PostOrder

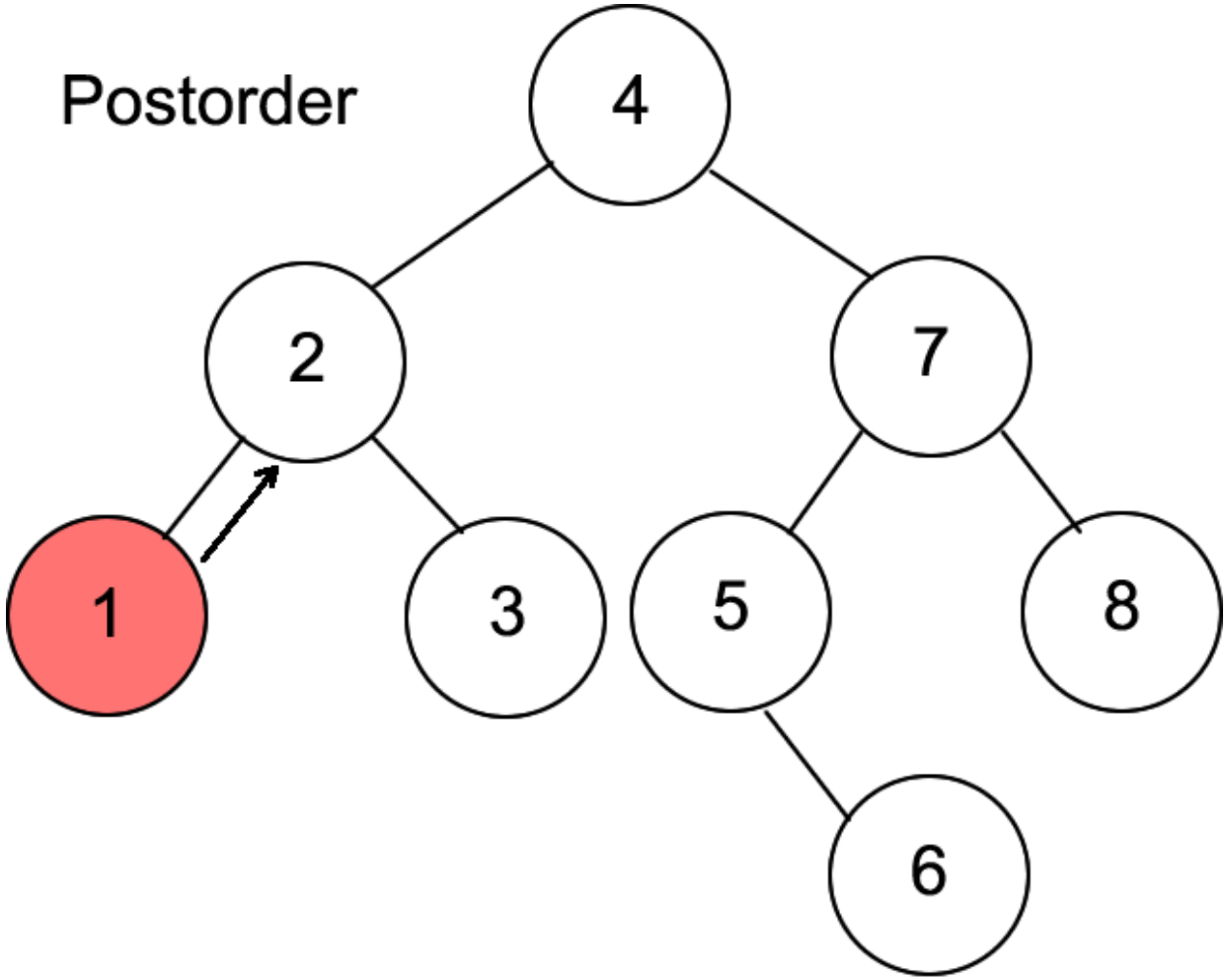


Trees - PostOrder



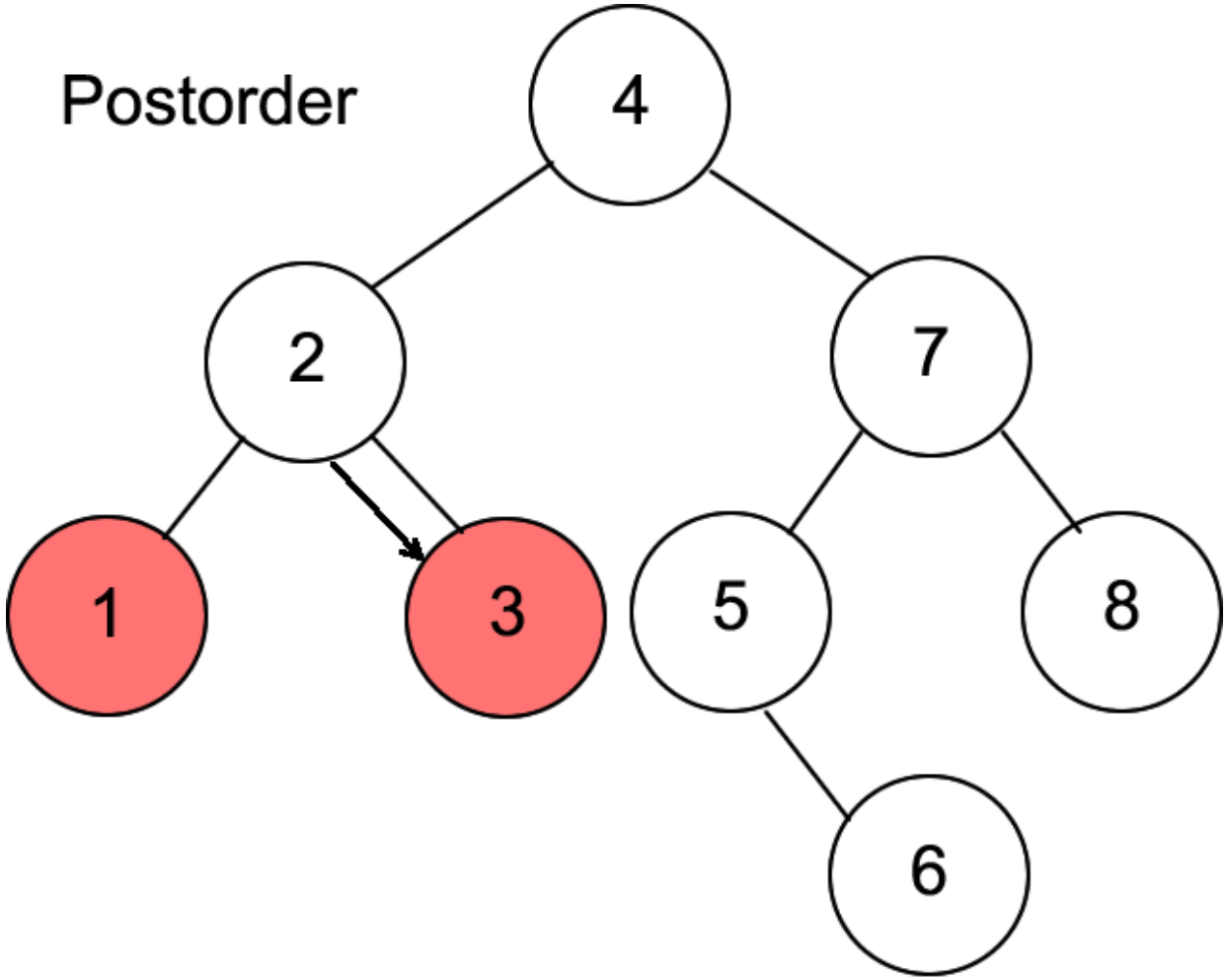
1

Trees - PostOrder



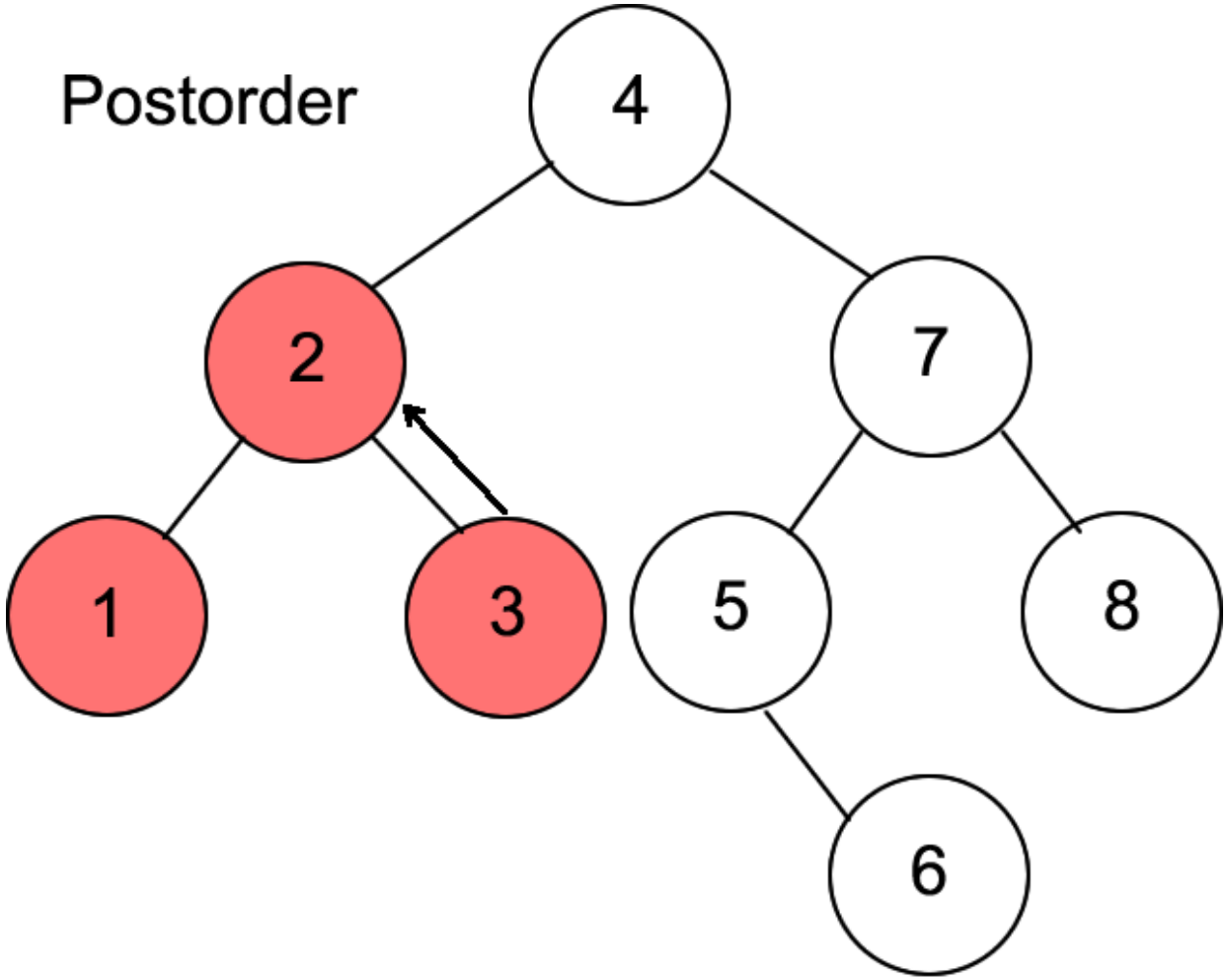
1

Trees - PostOrder



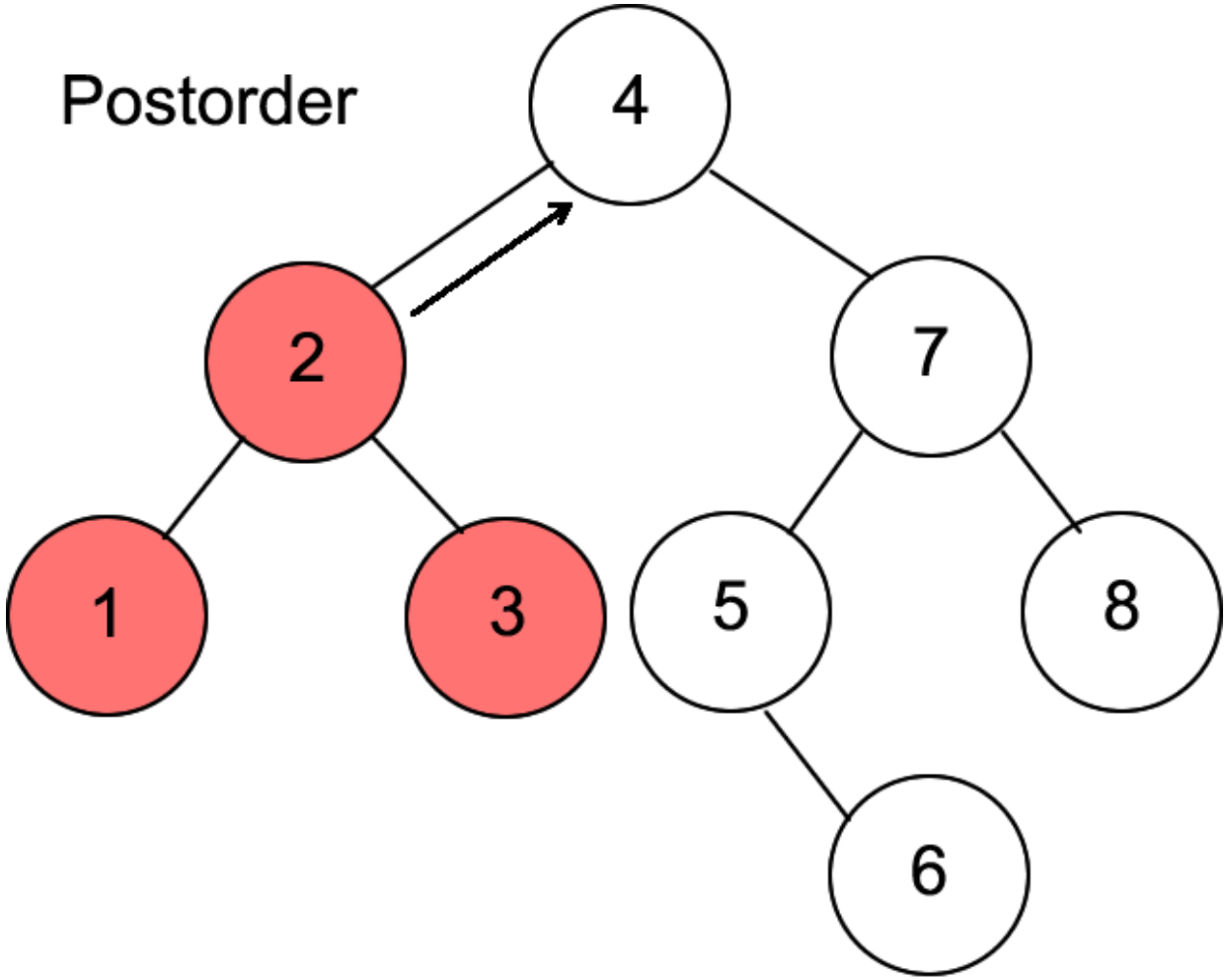
1 - 3

Trees - PostOrder



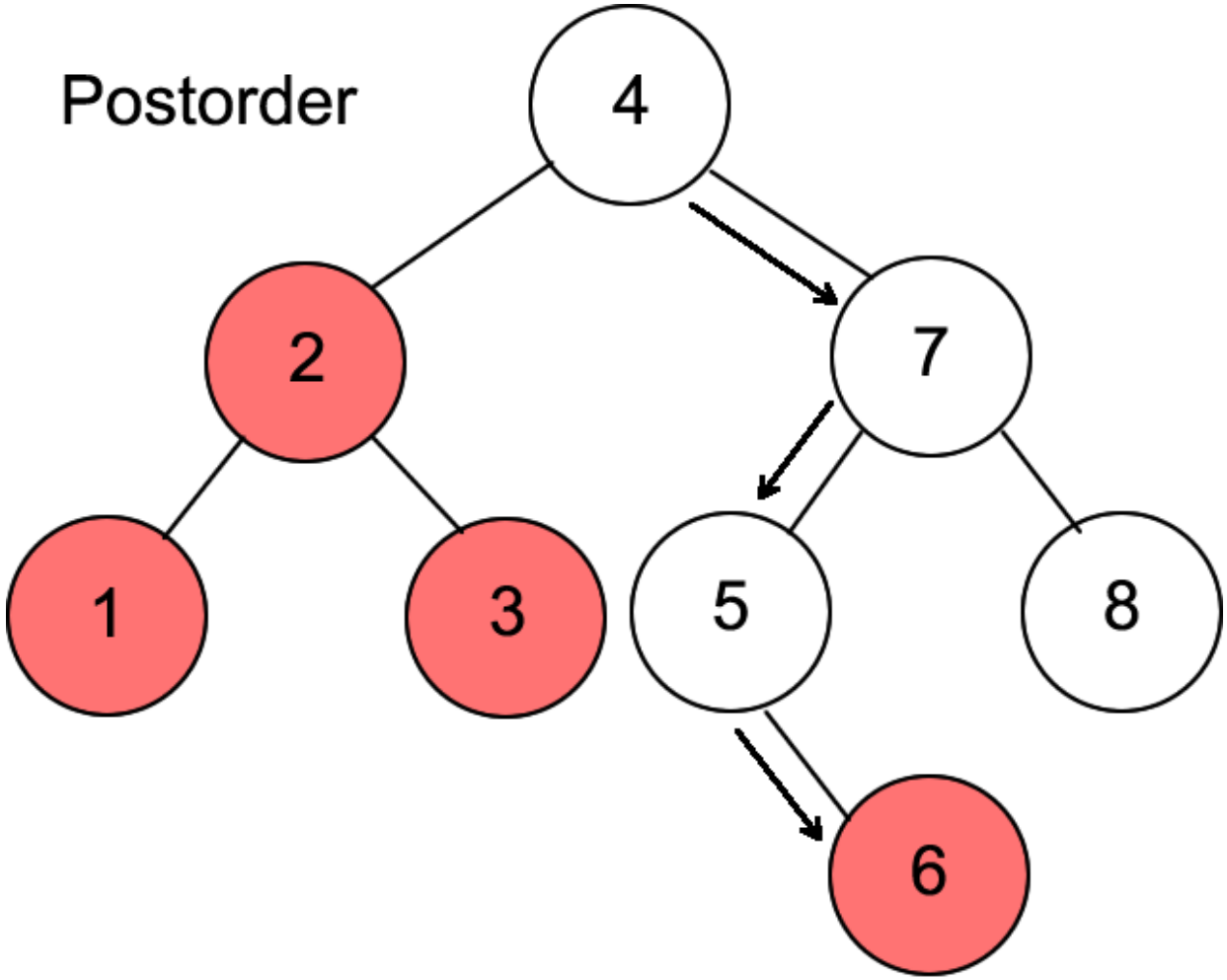
1 - 3 - 2

Trees - PostOrder



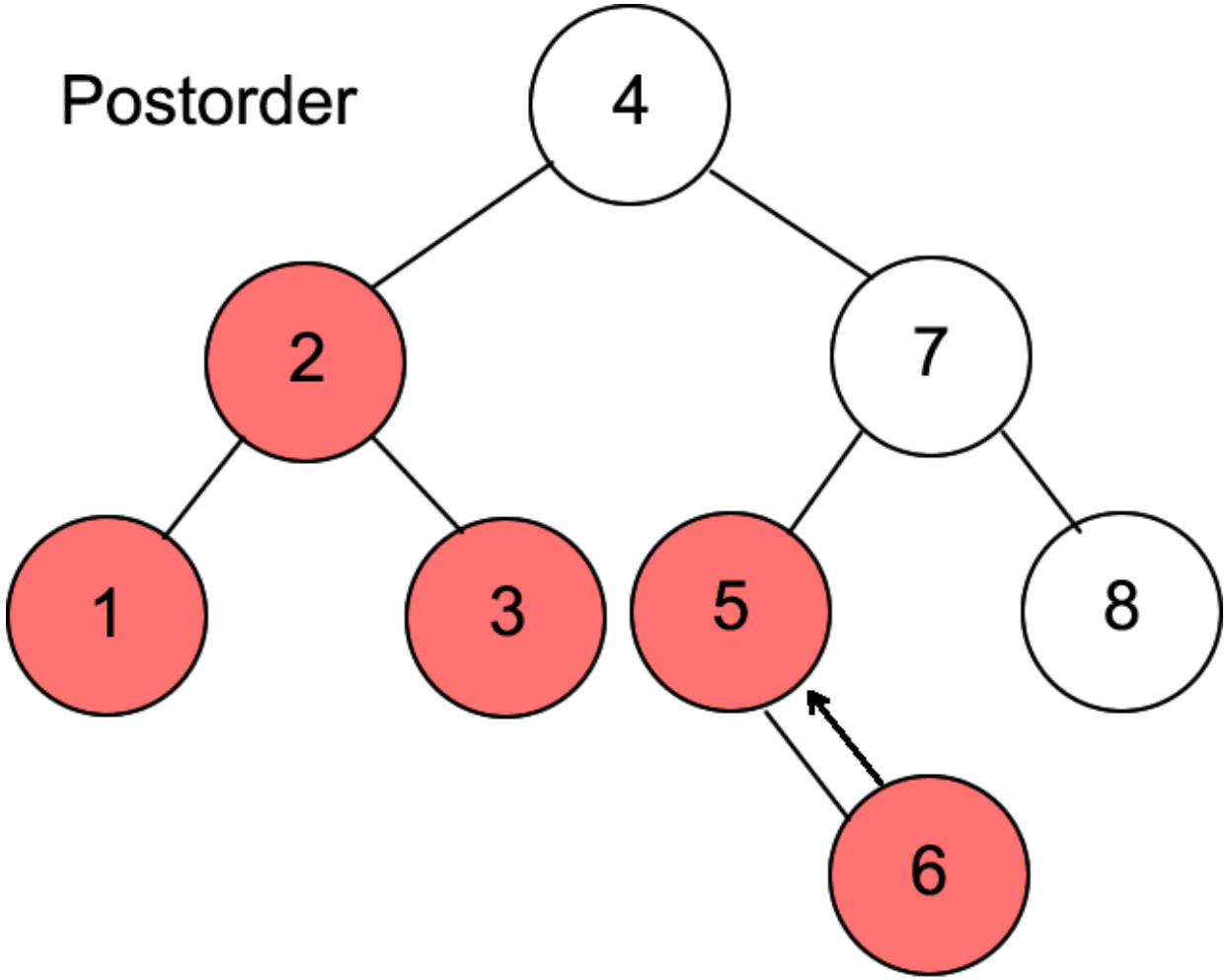
1 - 3 - 2

Trees - PostOrder



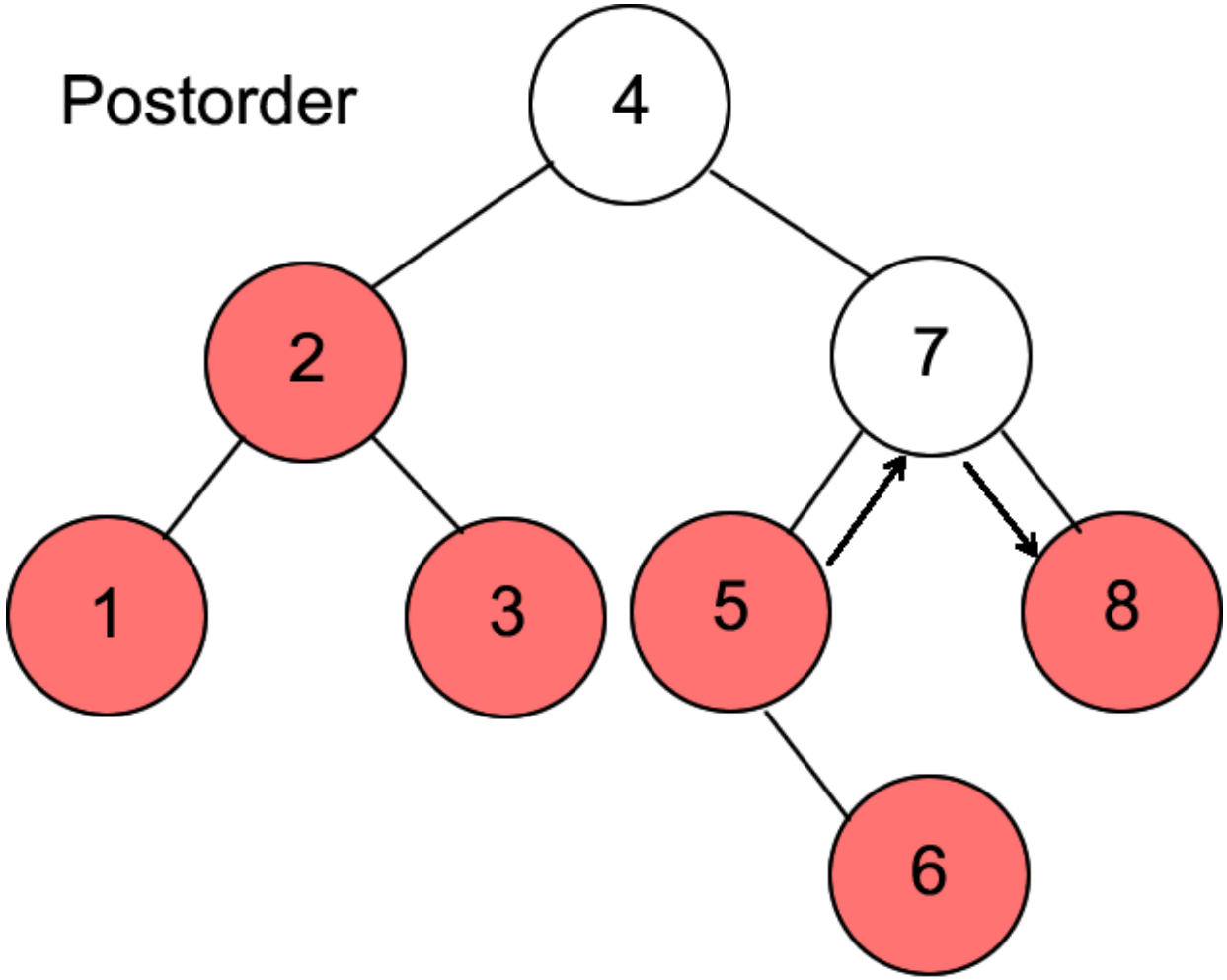
1 - 3 - 2 - 6

Trees - PostOrder



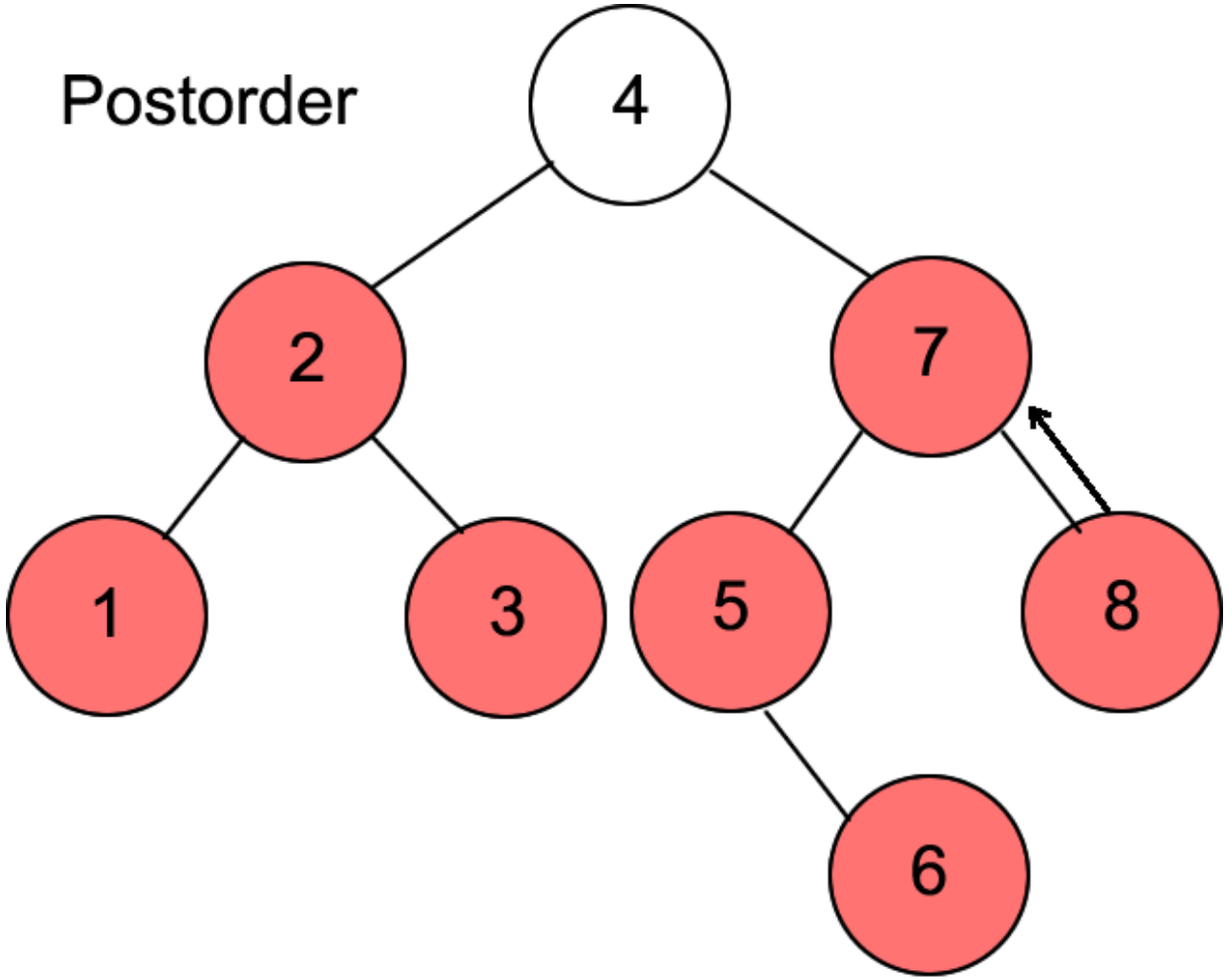
1 - 3 - 2 - 6 - 5

Trees - PostOrder



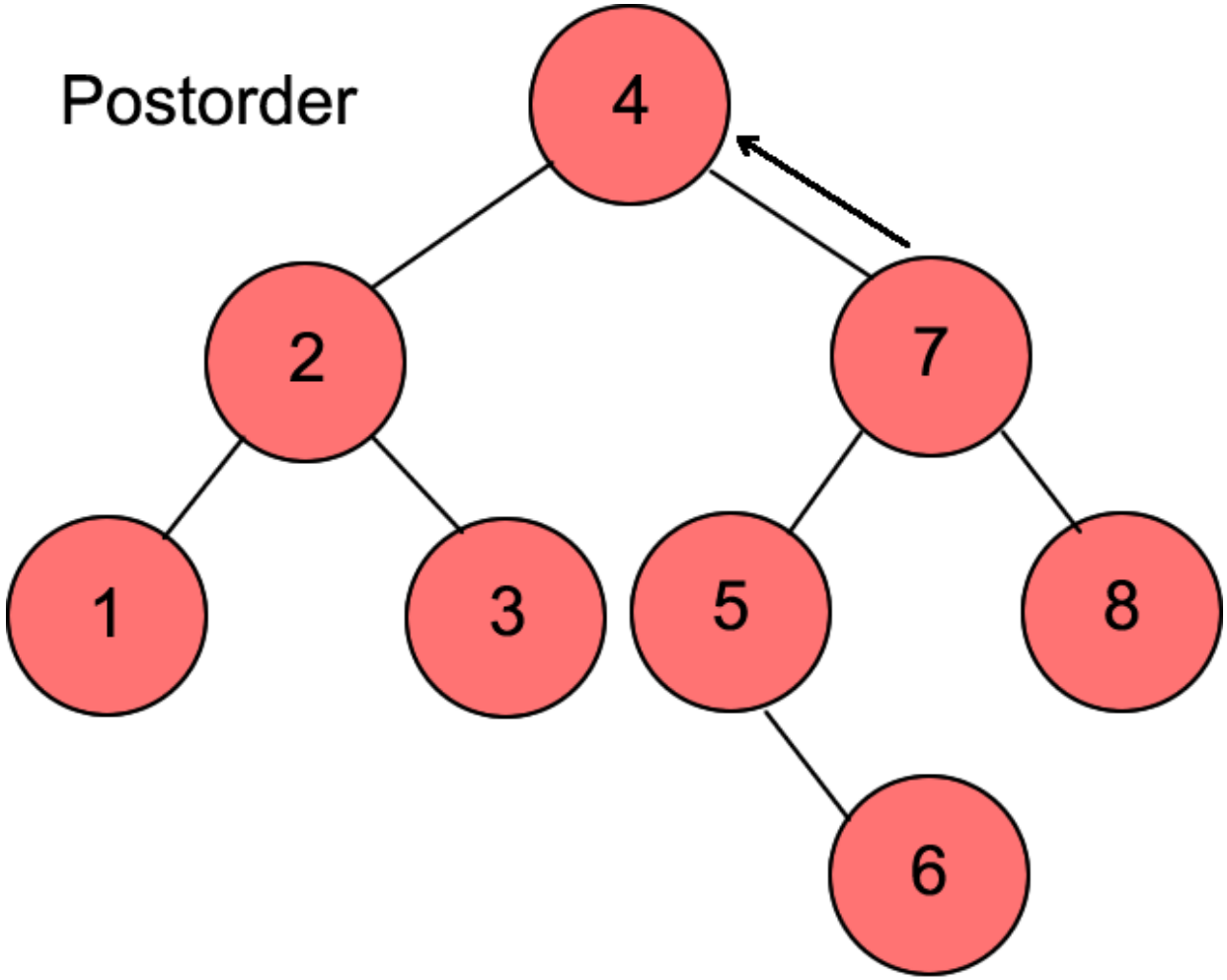
1 - 3 - 2 - 6 - 5 - 8

Trees - PostOrder



1 - 3 - 2 - 6 - 5 - 8 - 7

Trees - PostOrder



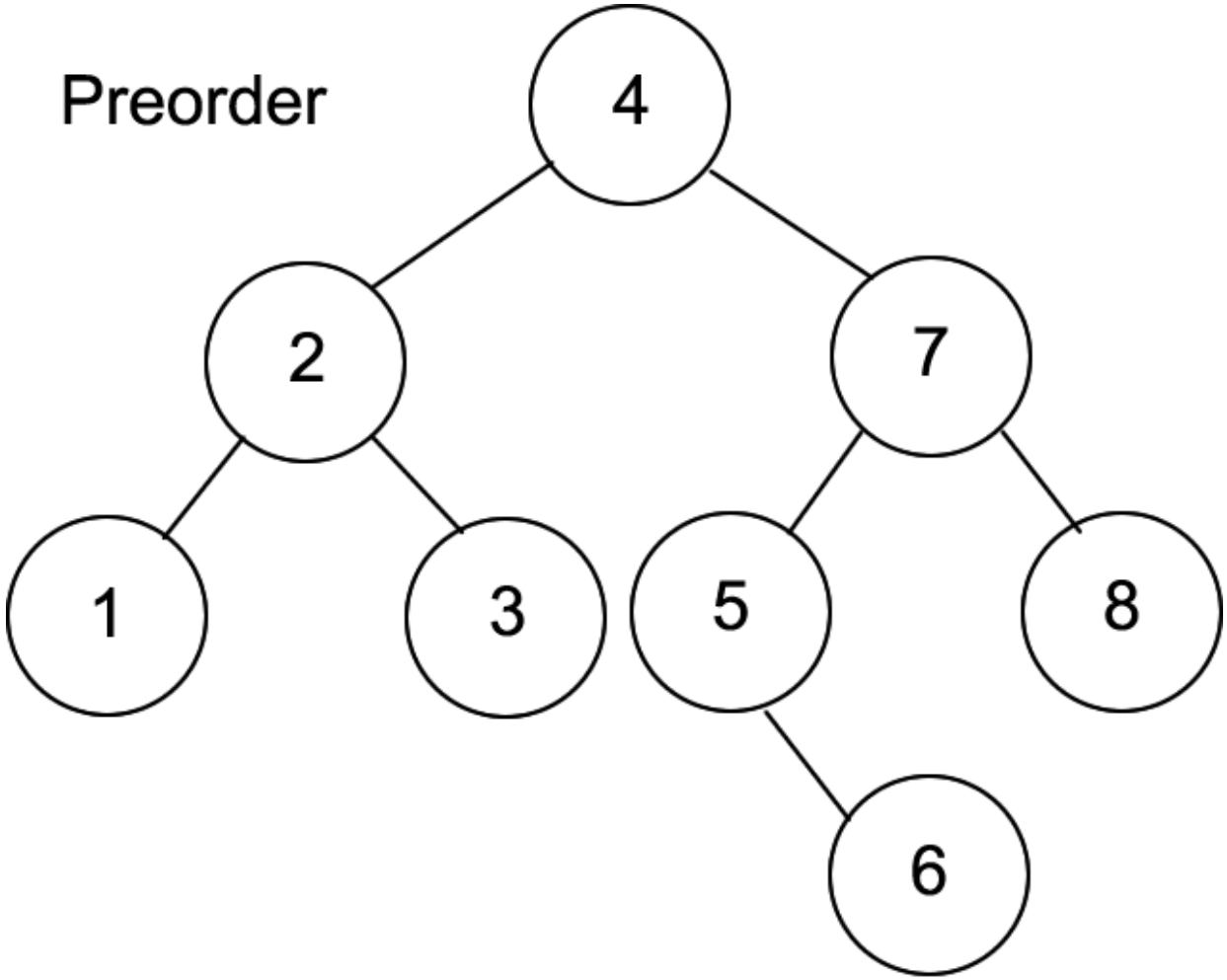
1 - 3 - 2 - 6 - 5 - 8 - 7 - 4

Trees - PreOrder

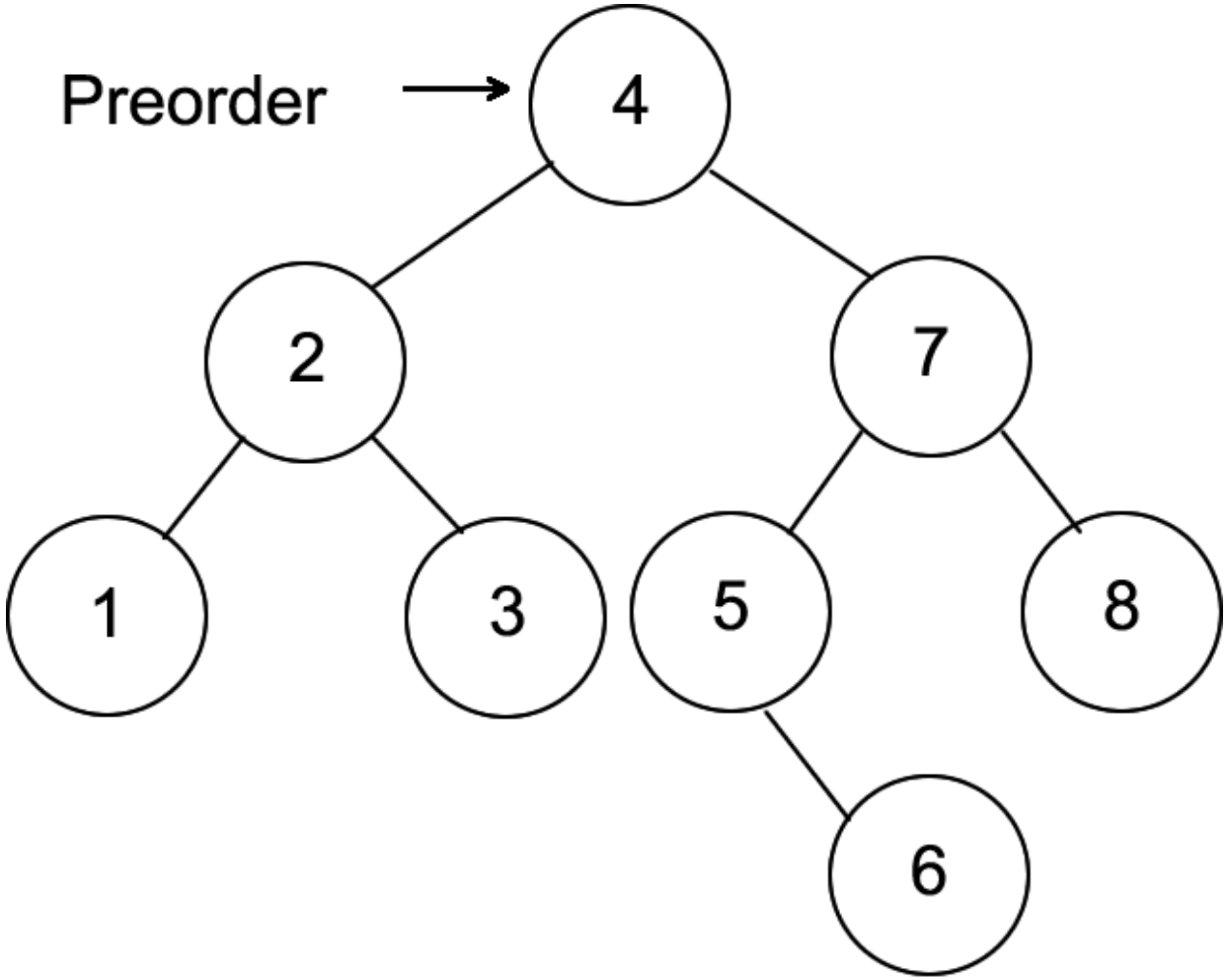
Traversing a tree `Pre-order`

- Check if the node is null
- Display the data at the node
- Traverse the left subtree `PreOrder`
- Traverse the right subtree `PreOrder`

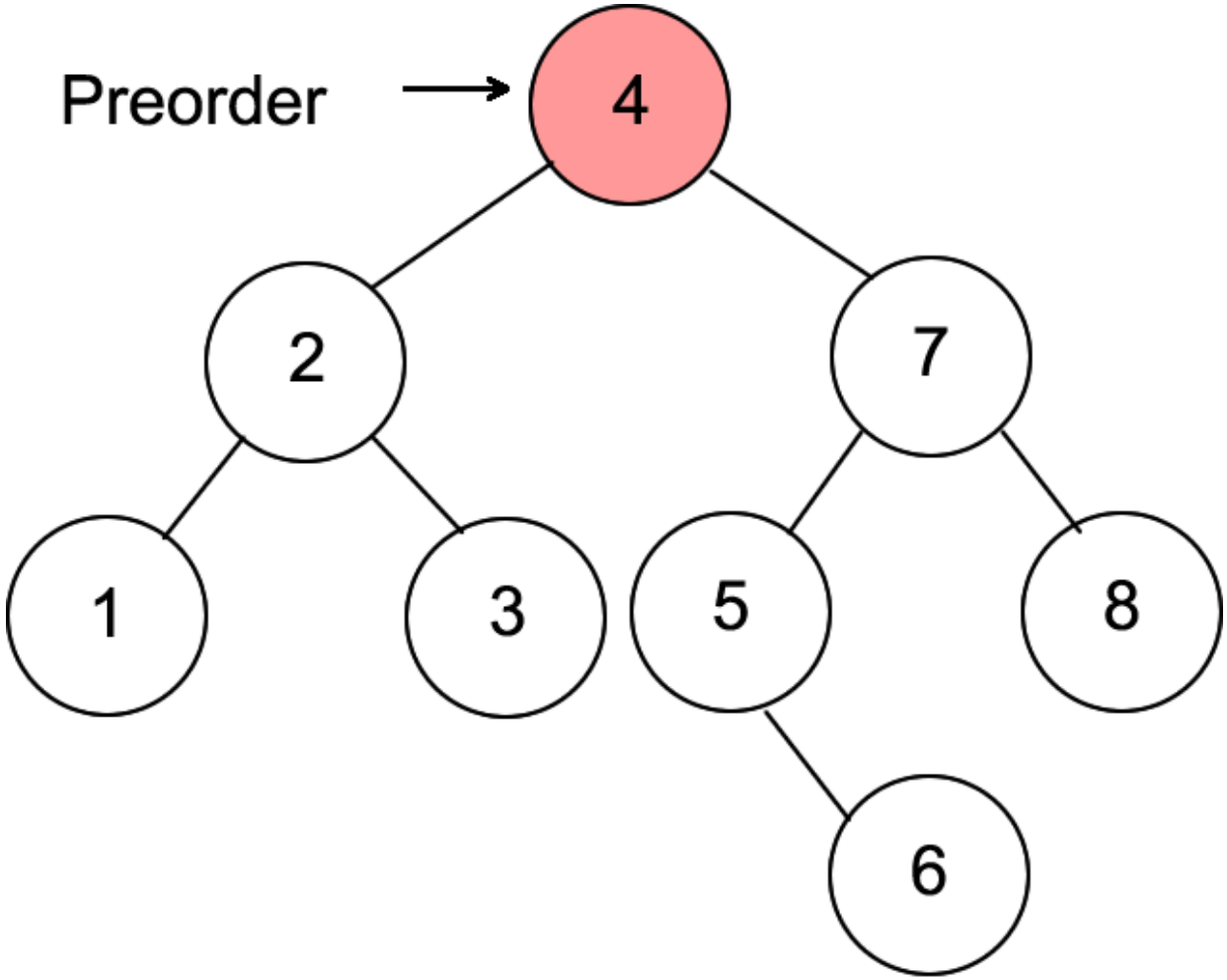
Trees - PreOrder



Trees - PreOrder

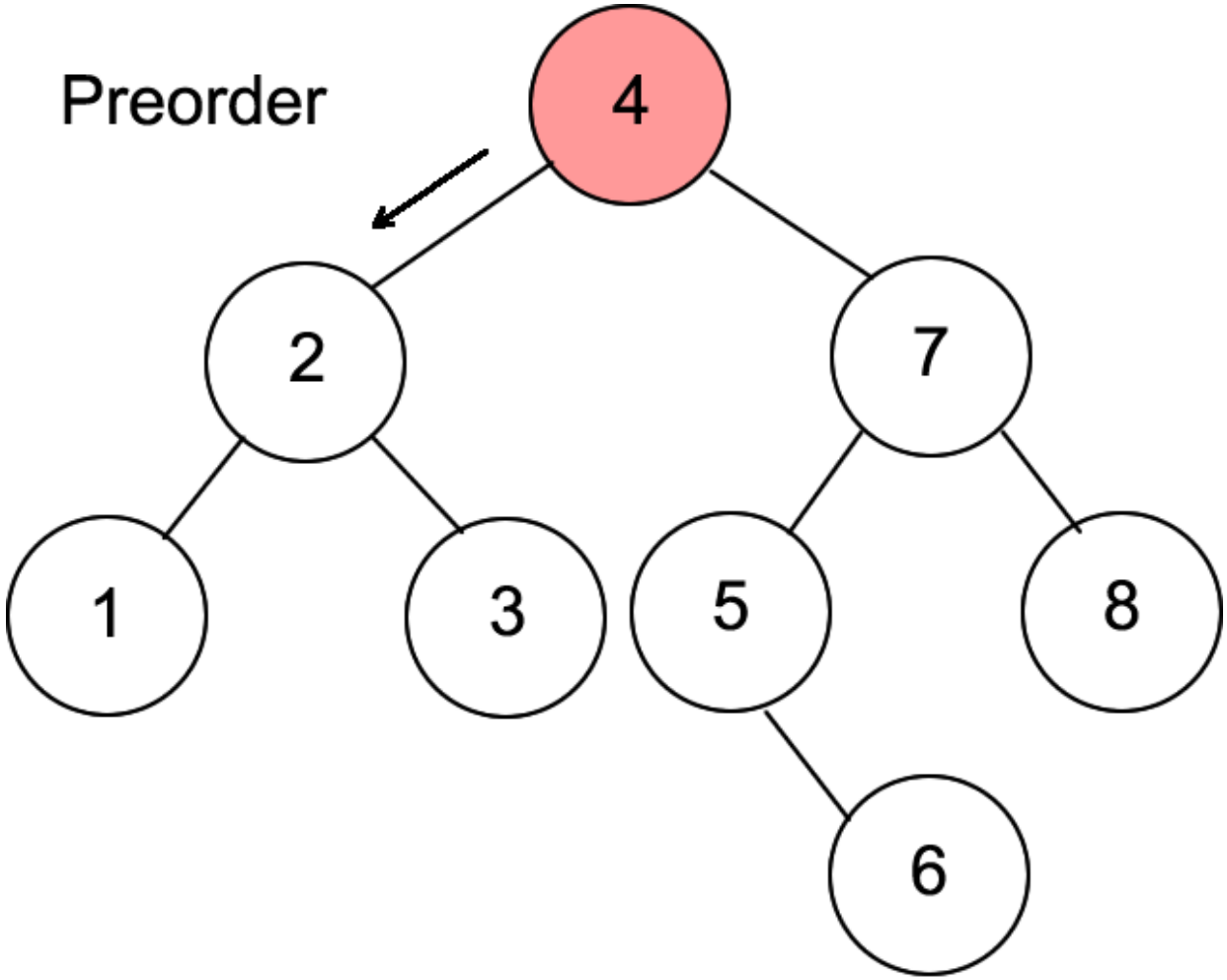


Trees - PreOrder



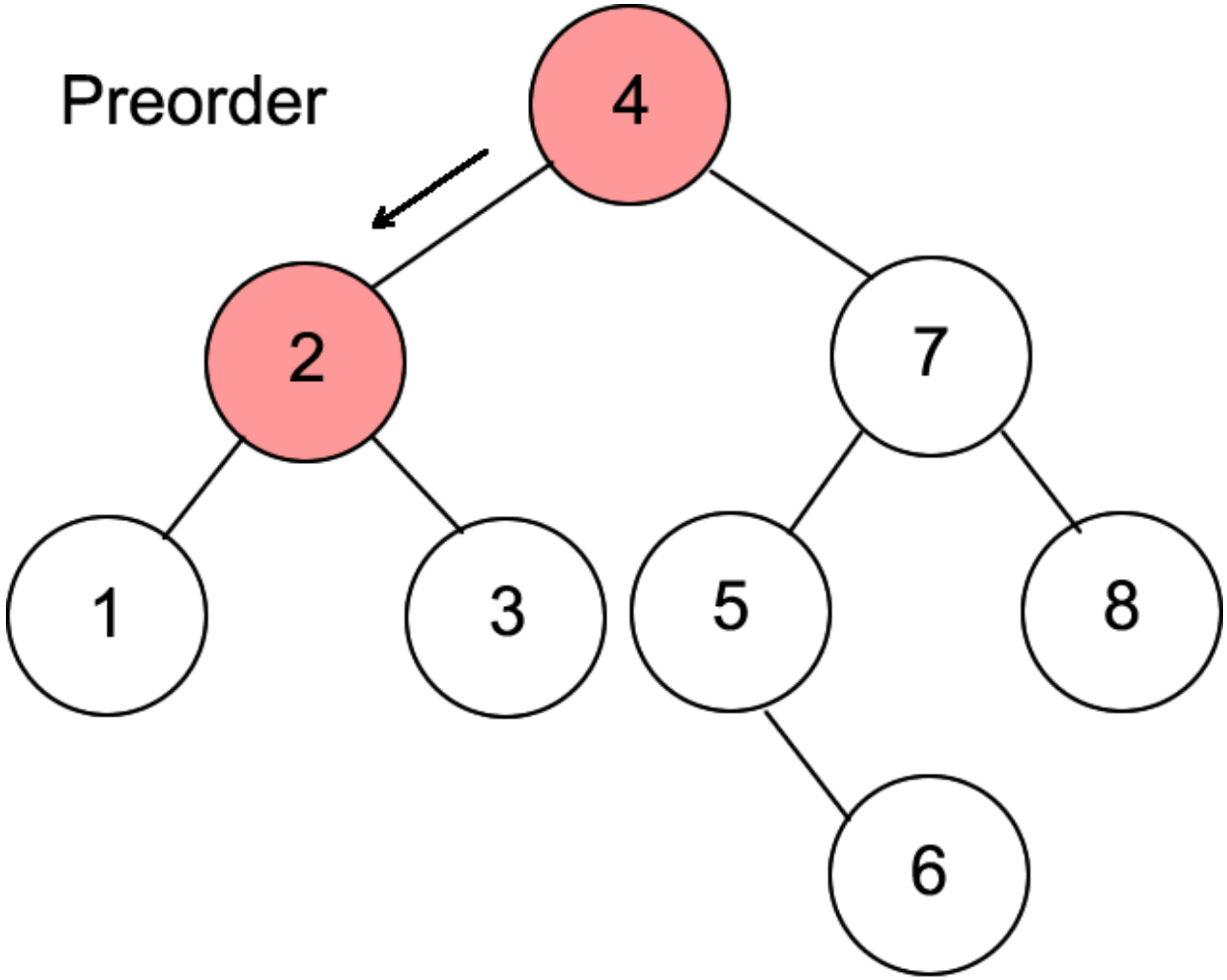
4

Trees - PreOrder



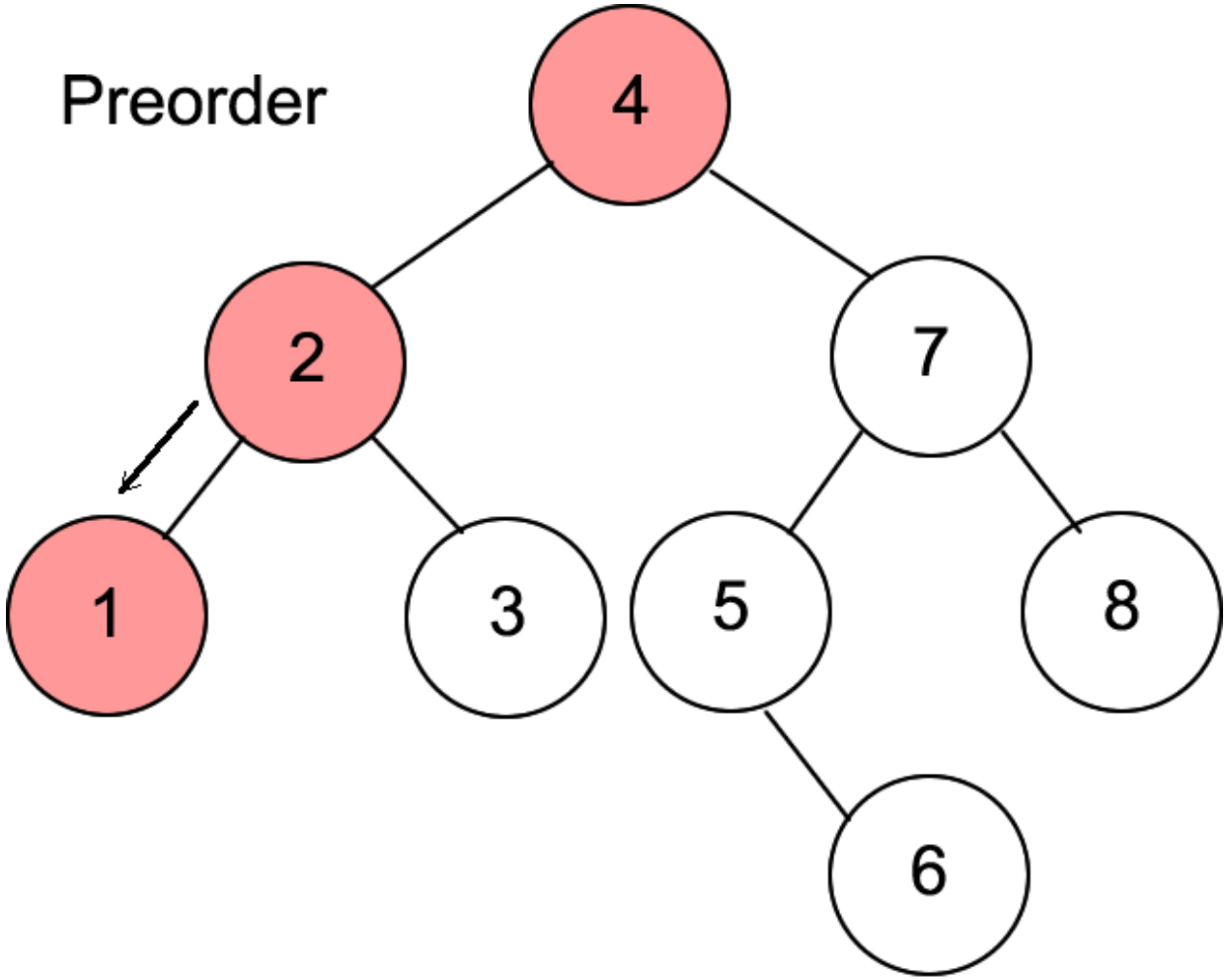
4

Trees - PreOrder



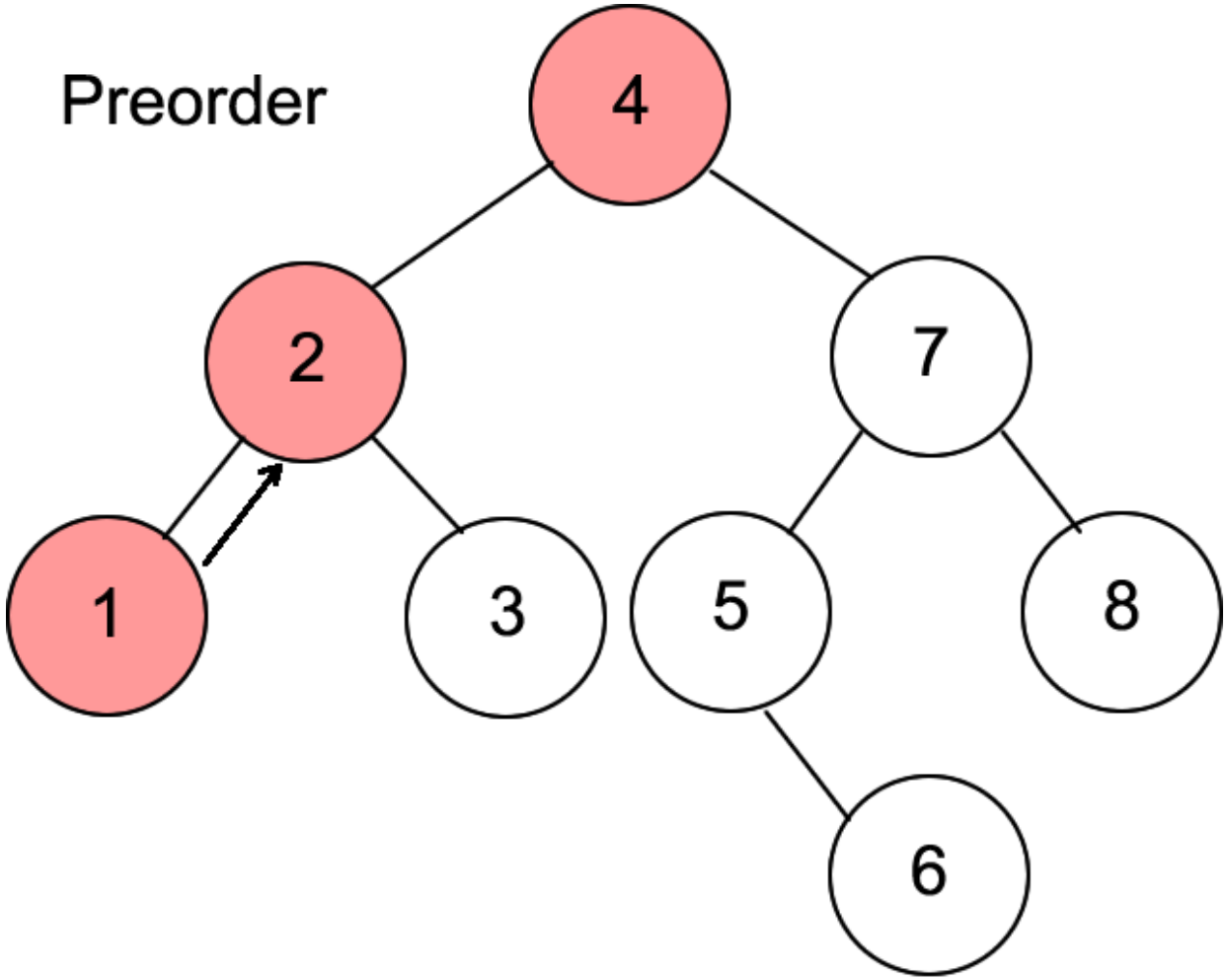
4 - 2

Trees - PreOrder



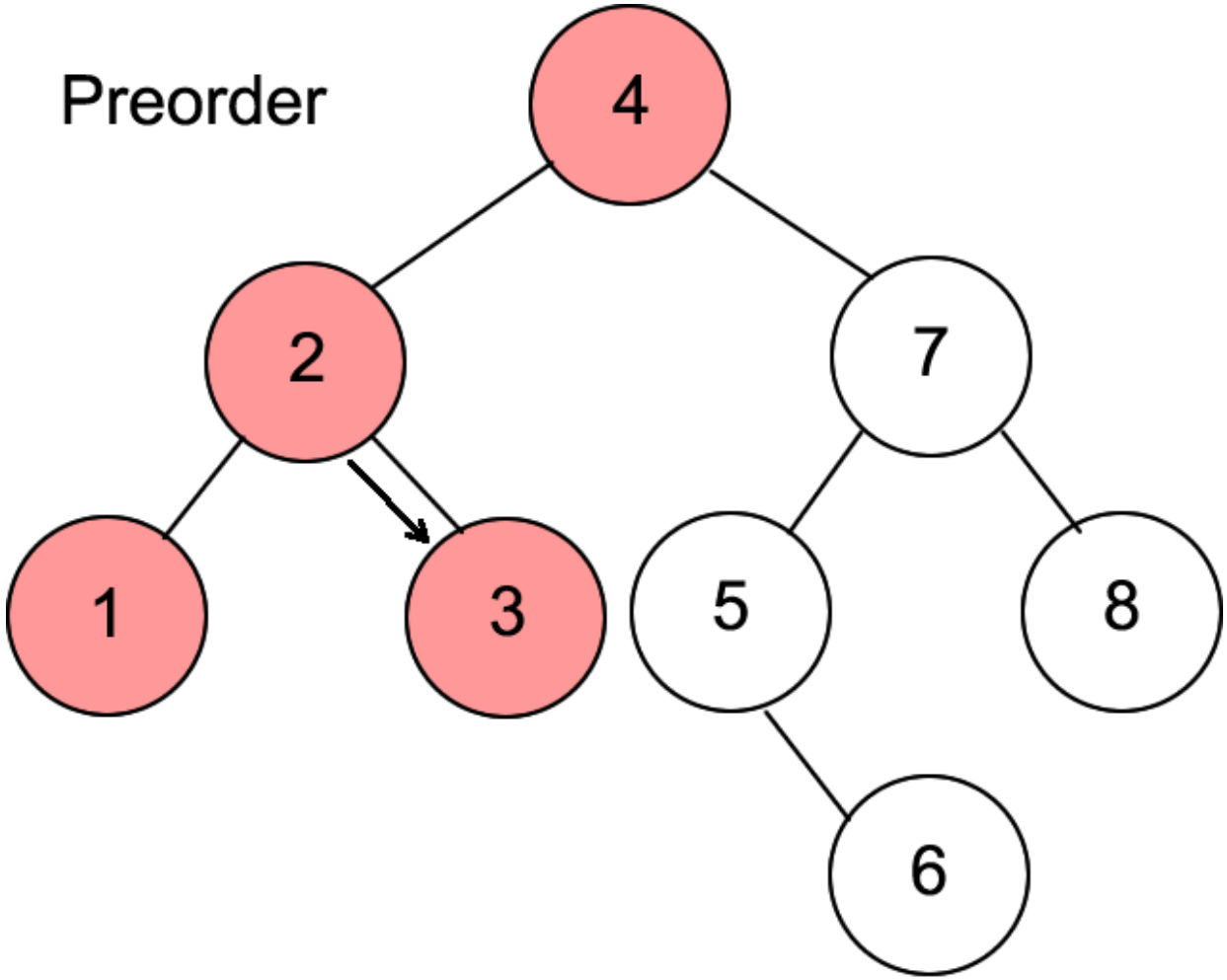
4 - 2 - 1

Trees - PreOrder



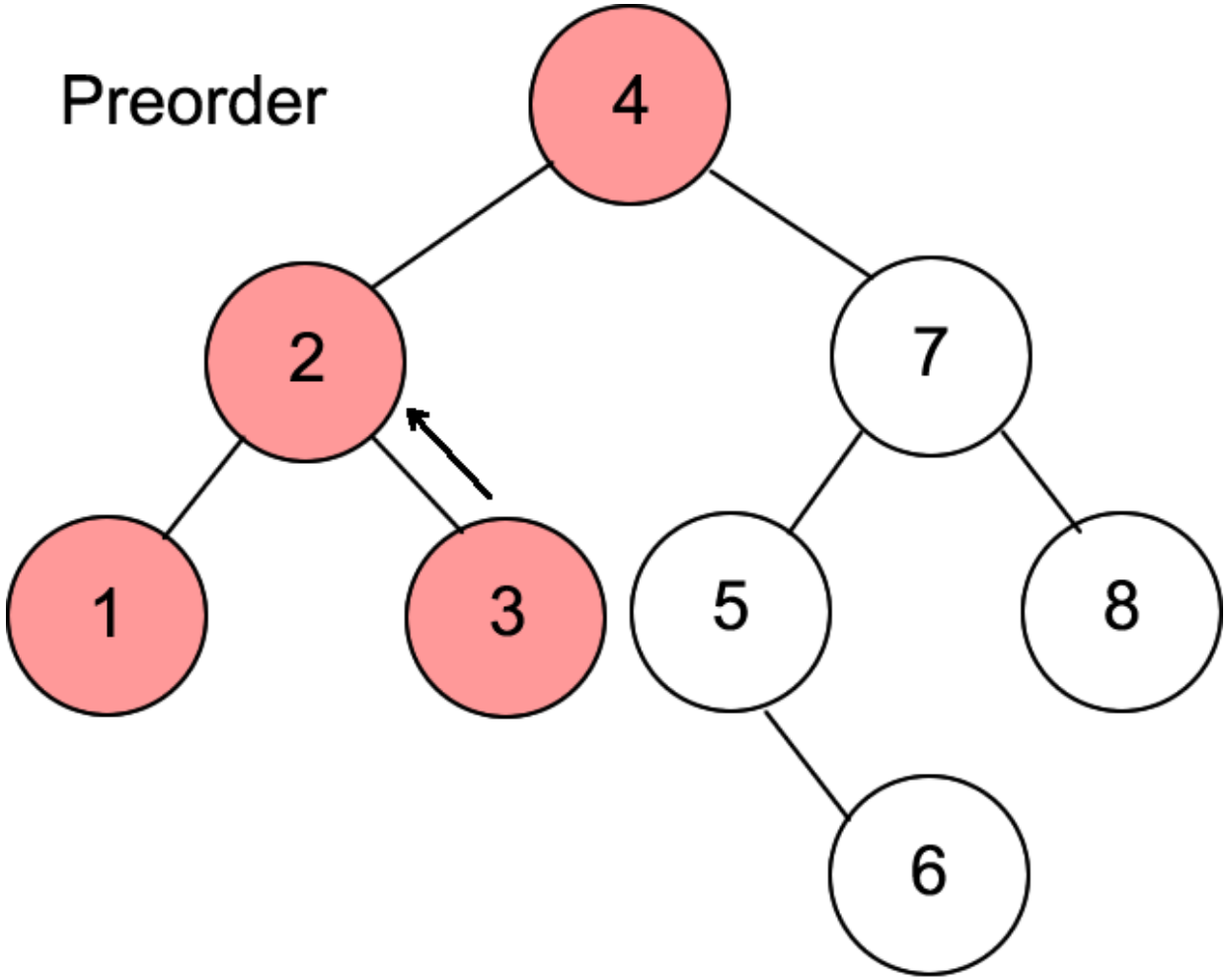
4 - 2 - 1

Trees - PreOrder



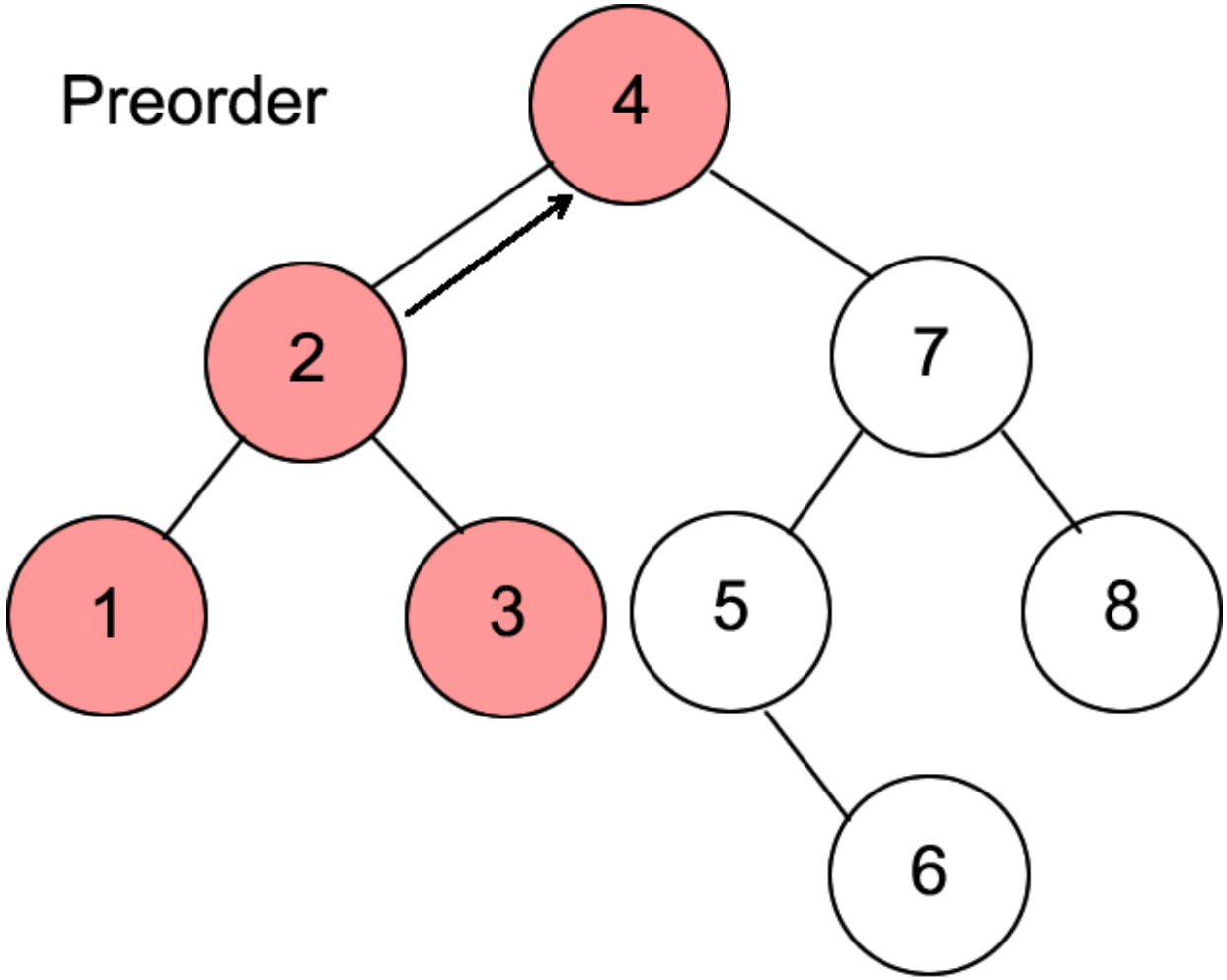
4 - 2 - 1 - 3

Trees - PreOrder



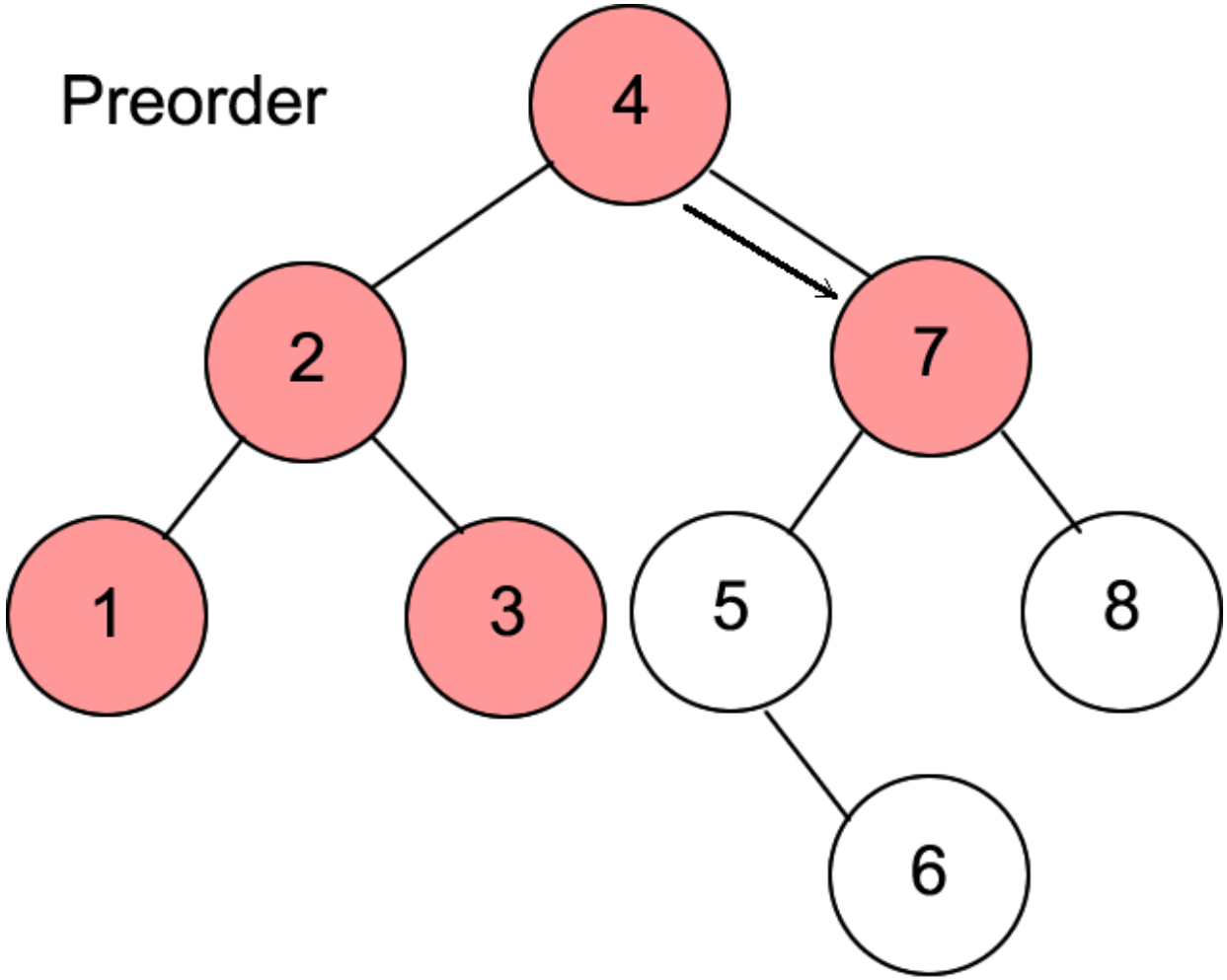
4 - 2 - 1 - 3

Trees - PreOrder



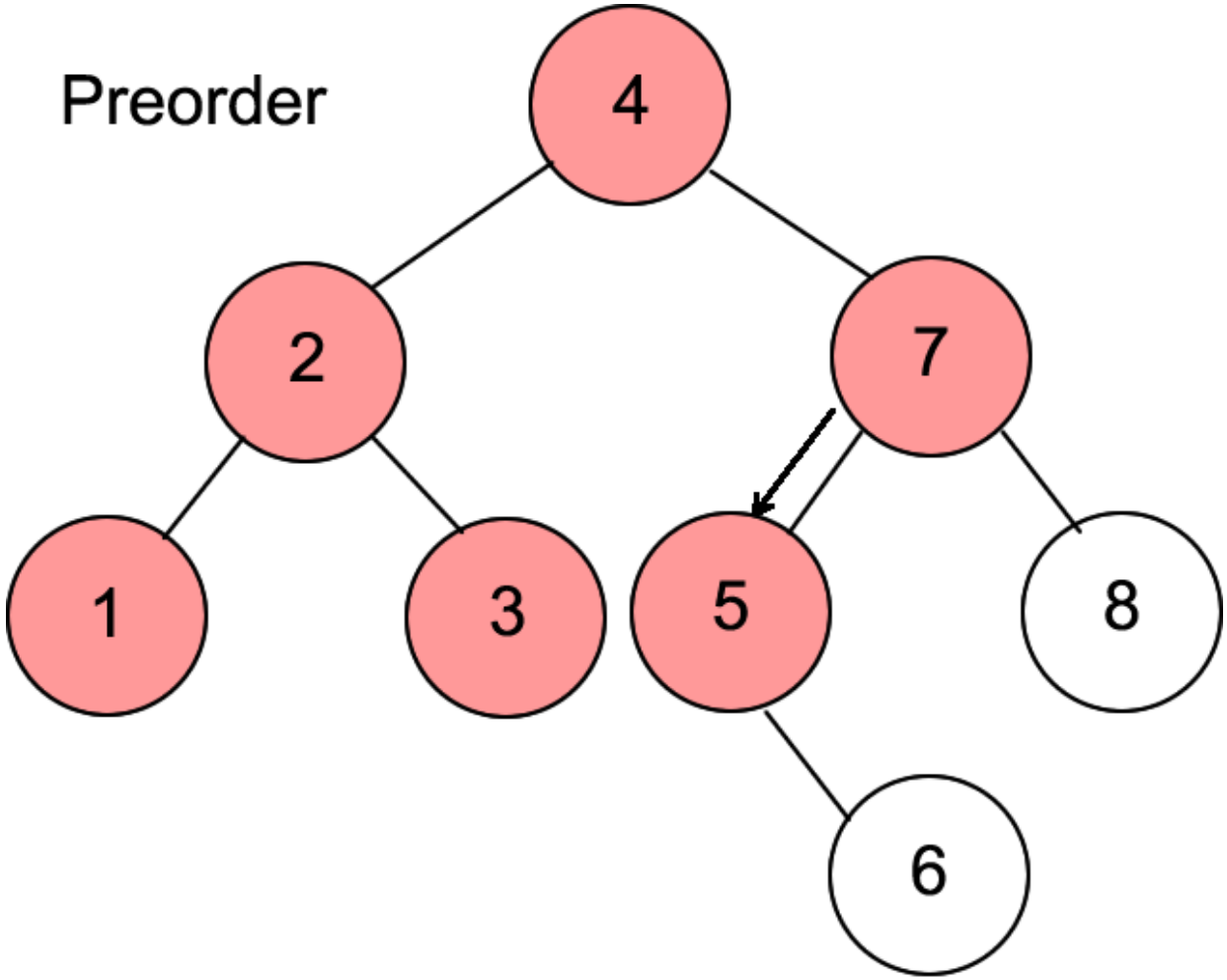
4 - 2 - 1 - 3

Trees - PreOrder



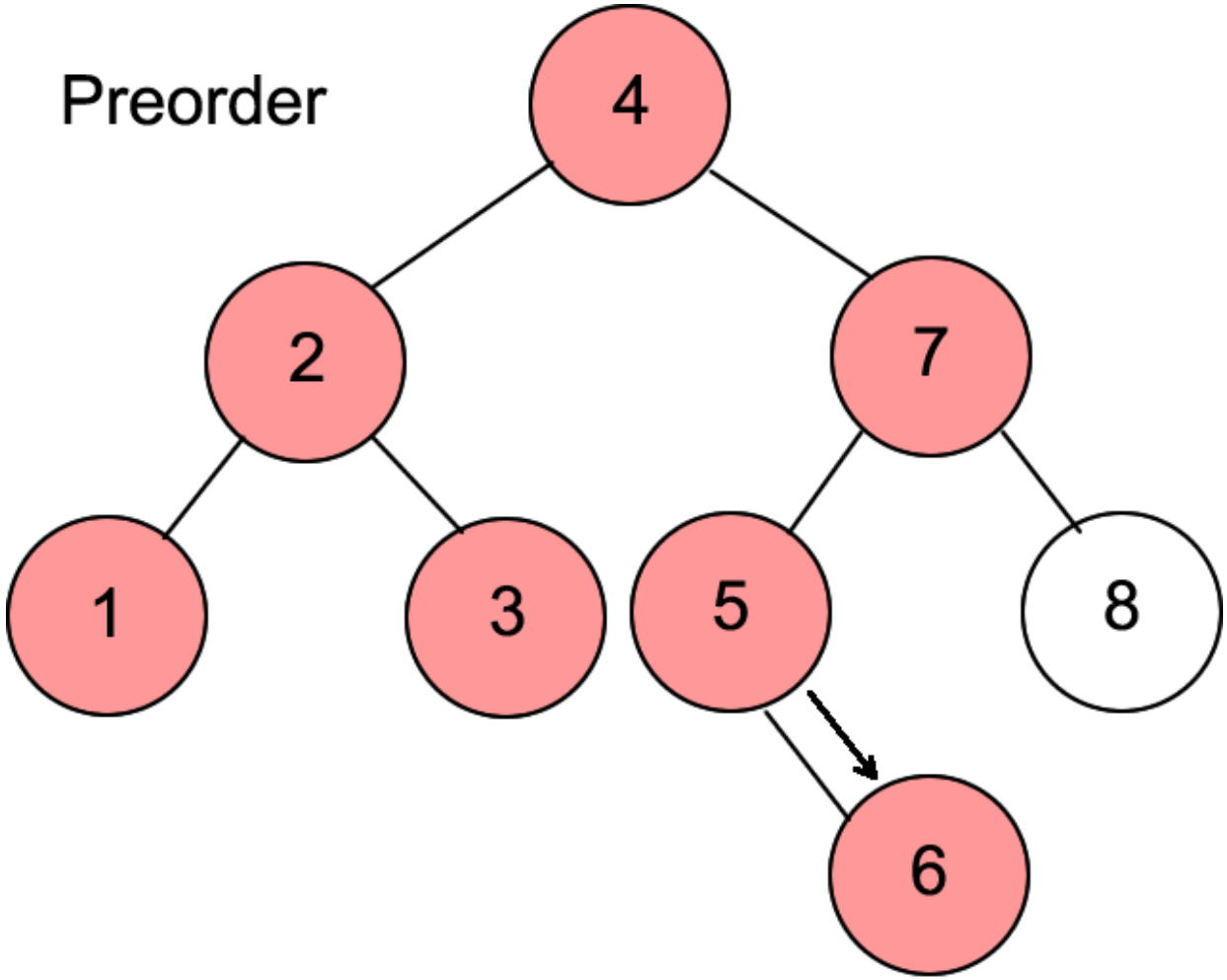
4 - 2 - 1 - 3 - 7

Trees - PreOrder



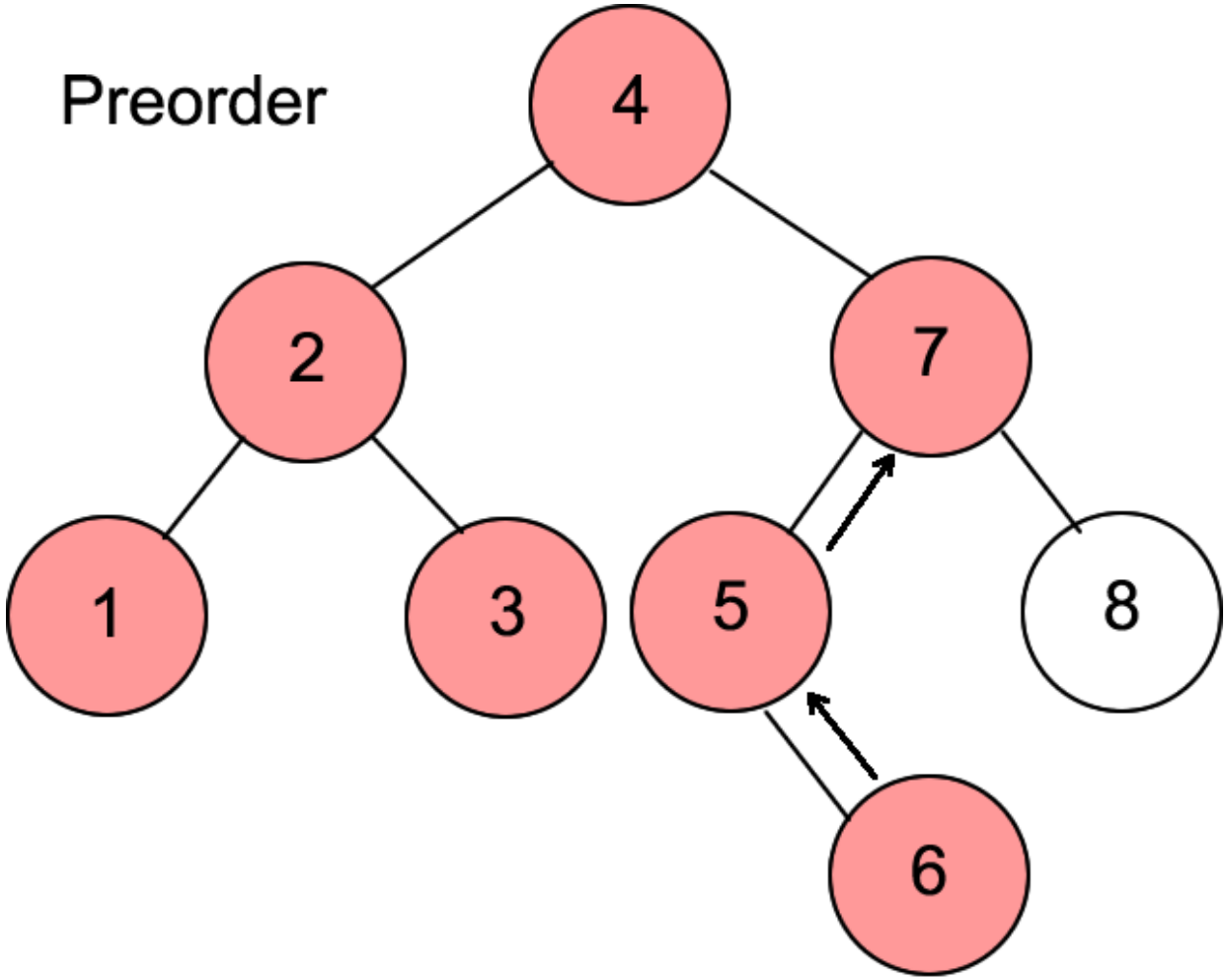
4 - 2 - 1 - 3 - 7 - 5

Trees - PreOrder



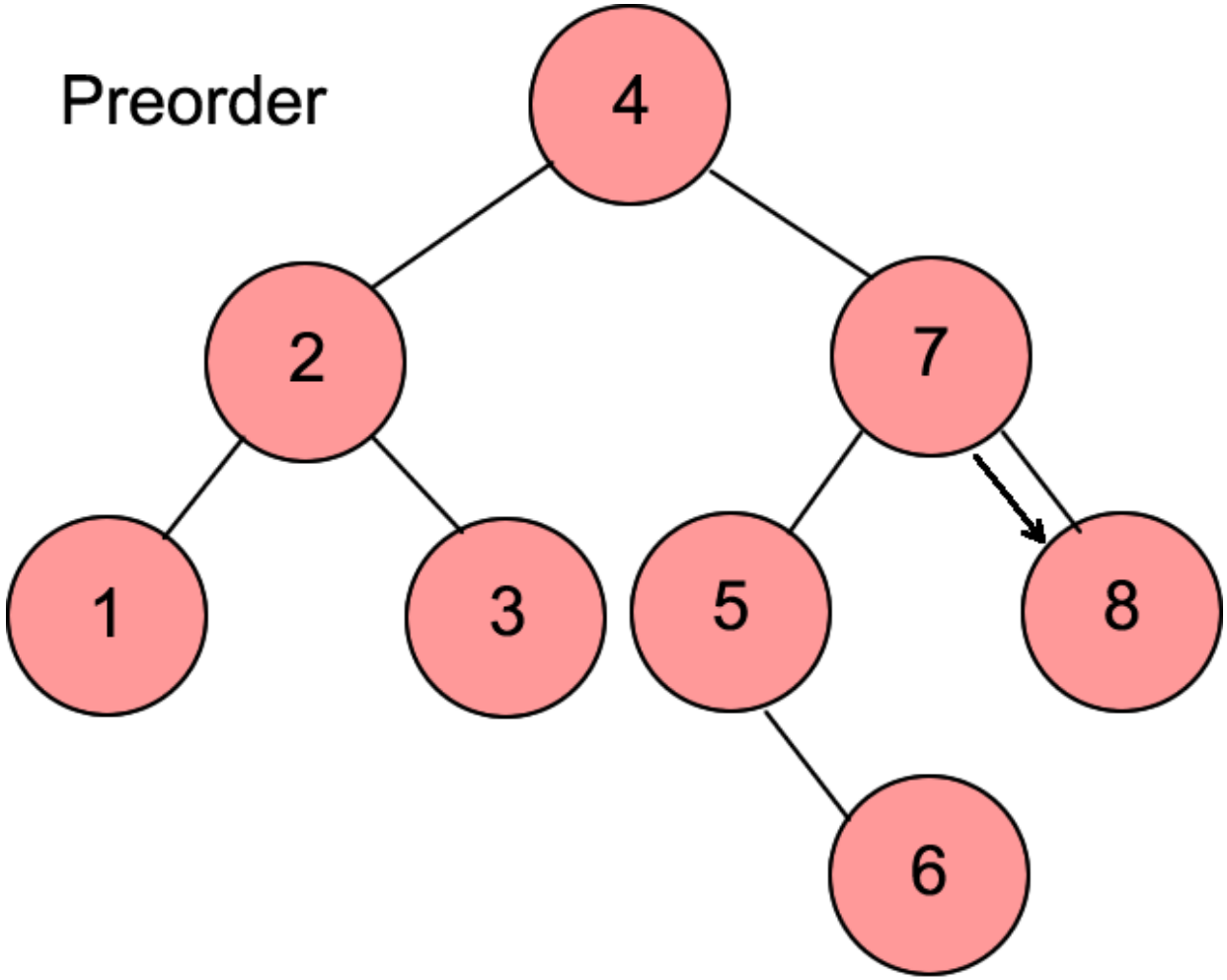
4 - 2 - 1 - 3 - 7 - 5 - 6

Trees - PreOrder



4 - 2 - 1 - 3 - 7 - 5 - 6

Trees - PreOrder



4 - 2 - 1 - 3 - 7 - 5 - 6 - 8