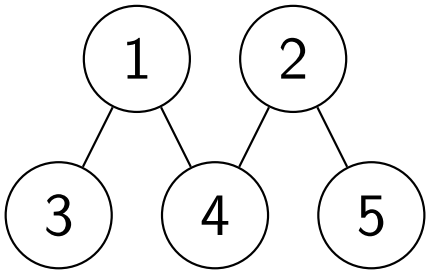
Tree

Arnaud Malapert, Gilles Menez, Marie Pelleau

Master Informatique, Université Côte d'Azur

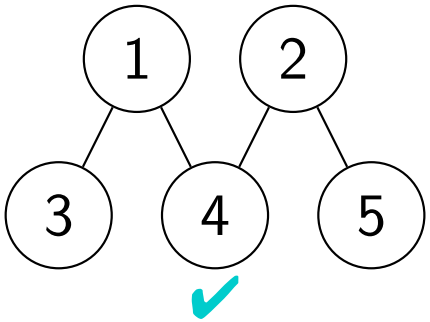
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



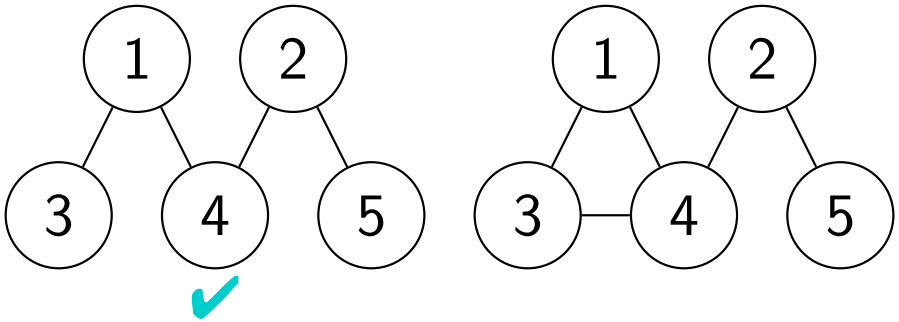
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



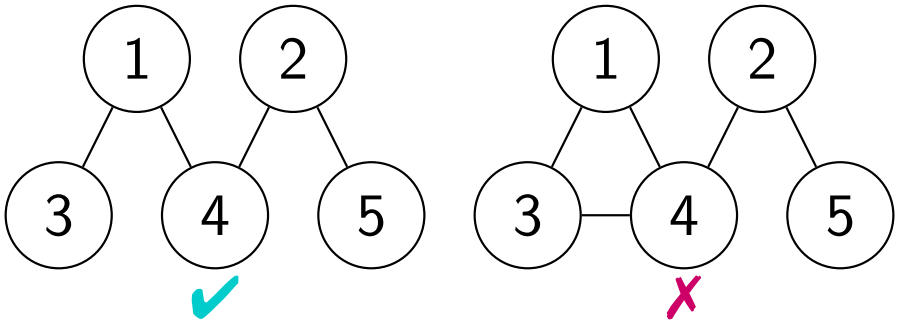
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



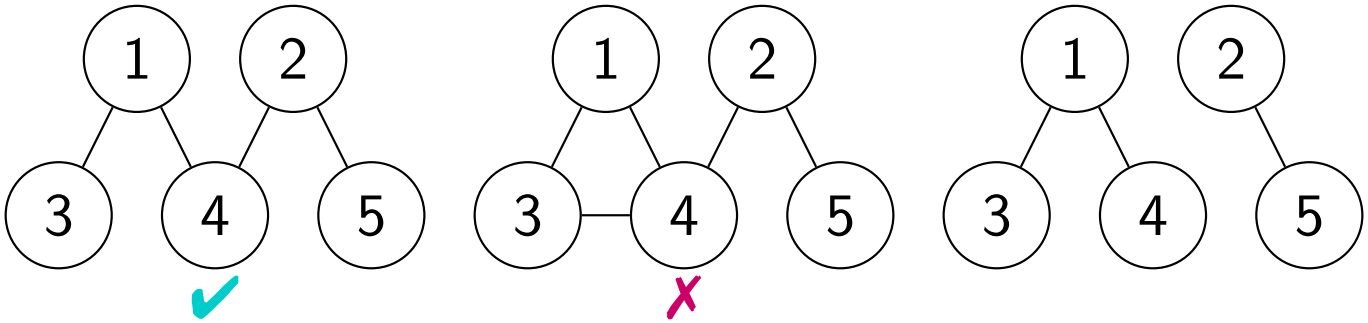
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



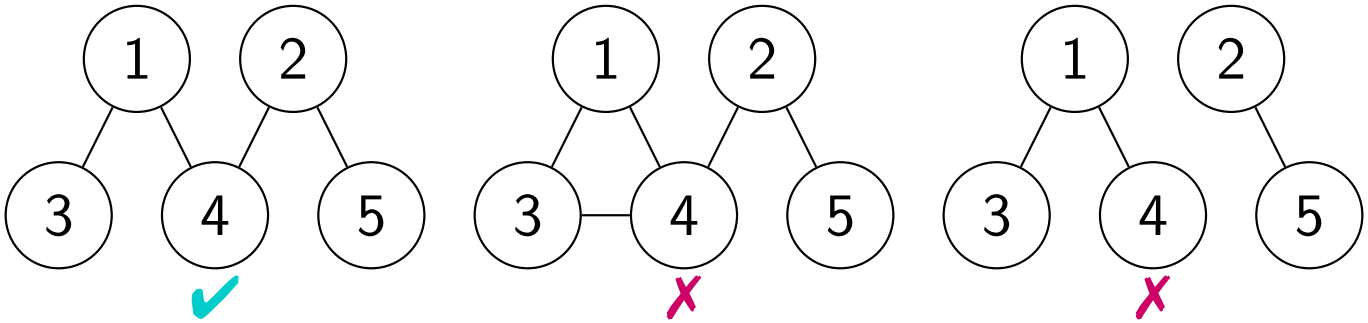
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



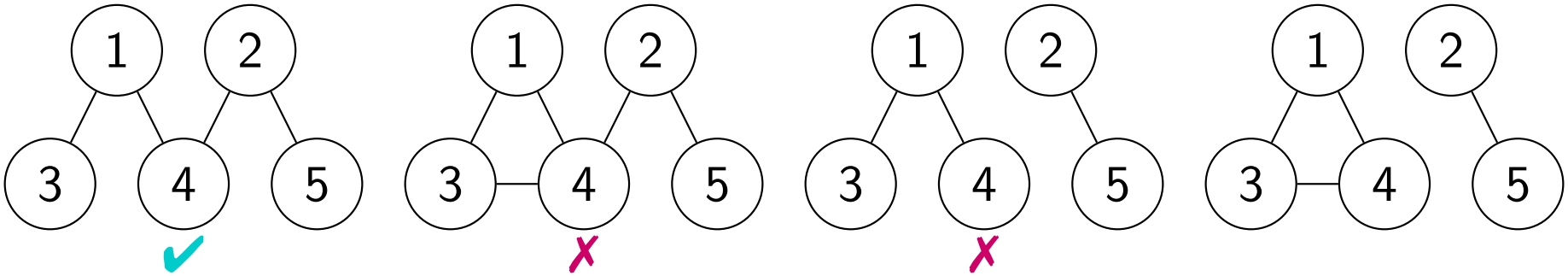
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



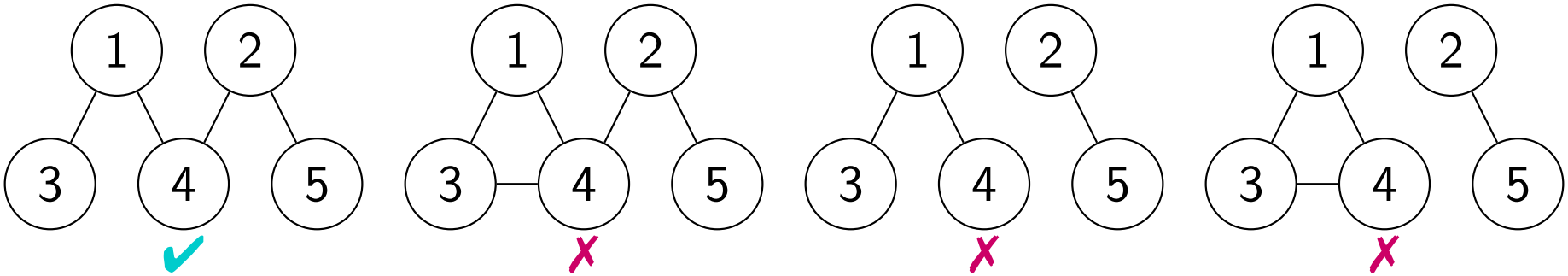
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



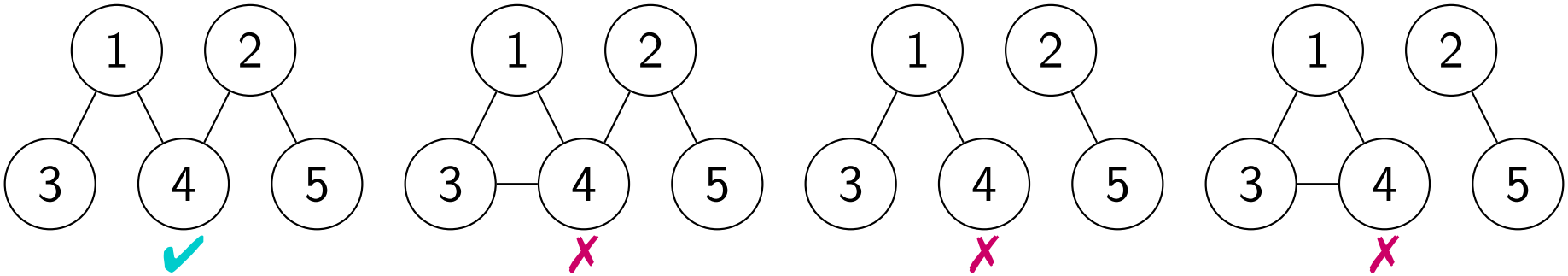
Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



Tree

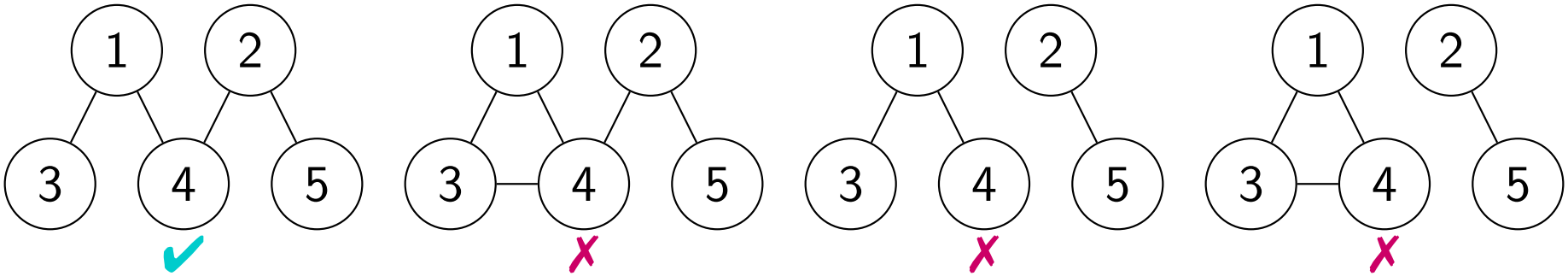
In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



Tree $\Longrightarrow$ n vertices, $n-1$ edges

Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



Tree $\Longrightarrow$ n vertices, $n-1$ edges

Search

- Breadth-first search
- Depth-first search
  - Pre-order
  - In-order
  - Post-order

Depth-first search

For binary trees

Three steps:

(L) Visit the left sub-tree

(R) Visit the right sub-tree

(N) Visit the node

Depth-first search

For binary trees

Three steps:

(L) Visit the left sub-tree

(R) Visit the right sub-tree

(N) Visit the node

Pre-order(v) [NLR]

```
display v
Pre-order(left child of v)
Pre-order(right child of v)
```

Depth-first search

For binary trees

Three steps:

(L) Visit the left sub-tree

(R) Visit the right sub-tree

(N) Visit the node

In-order(v) [LNR]

```
In-order(left child of v)
display v
In-order(right child of v)
```

Depth-first search

For binary trees

Three steps:

(L) Visit the left sub-tree

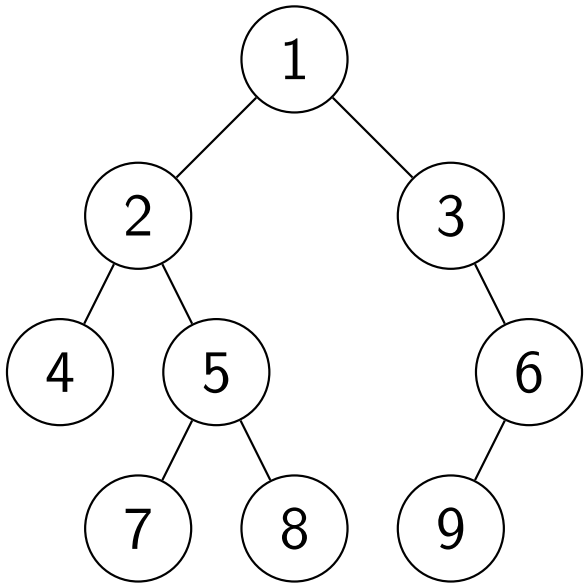
(R) Visit the right sub-tree

(N) Visit the node

Post-order(v) [LRN]

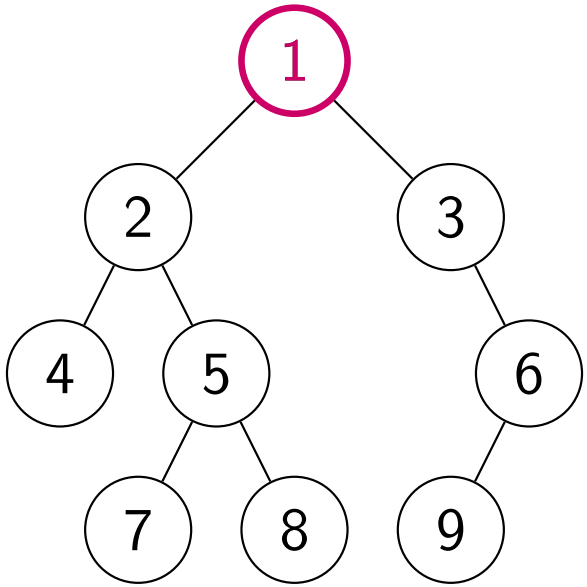
```
Post-order(left child of v)
Post-order(right child of v)
display v
```

Depth-first search



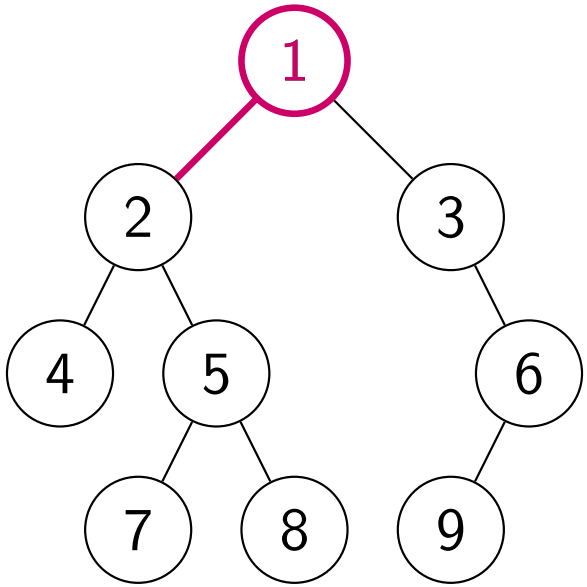
Pre-order (NLR)

Depth-first search



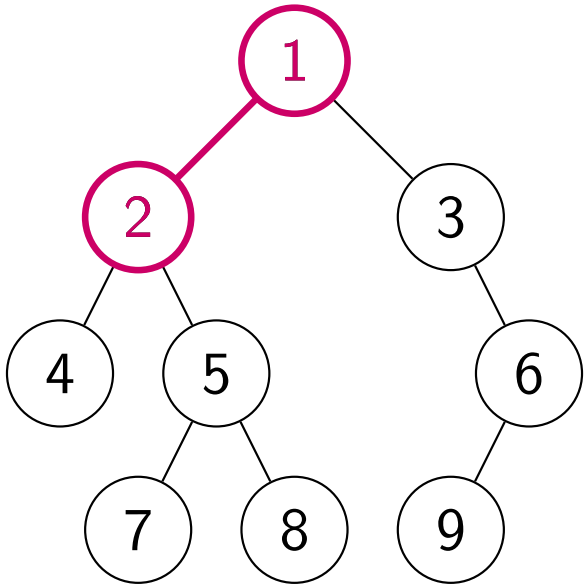
Pre-order (NLR) **1**

Depth-first search



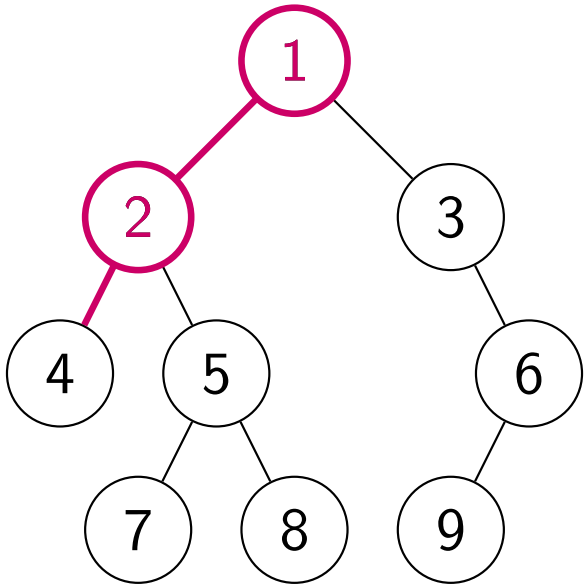
Pre-order (NLR) 1

Depth-first search



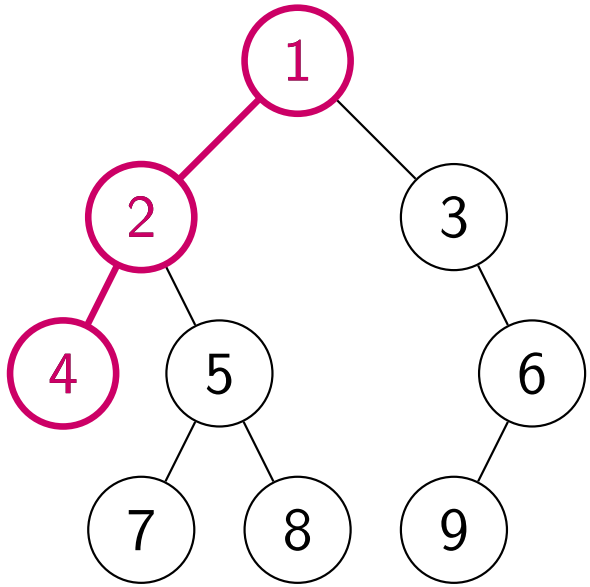
Pre-order (NLR) 1 **2**

Depth-first search



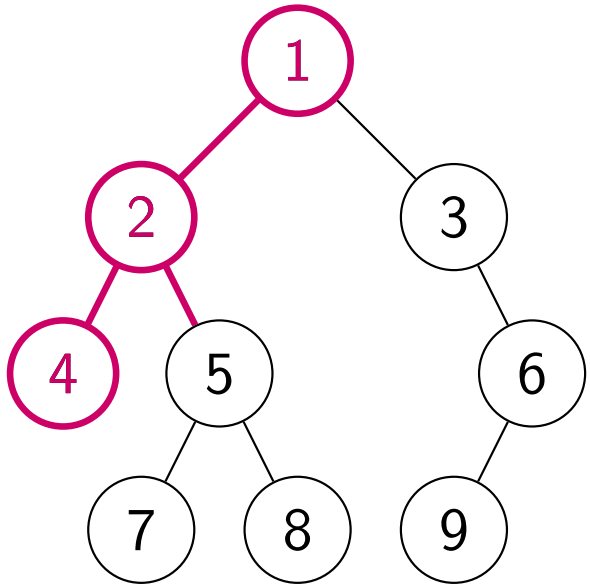
Pre-order (NLR) 1 2

Depth-first search



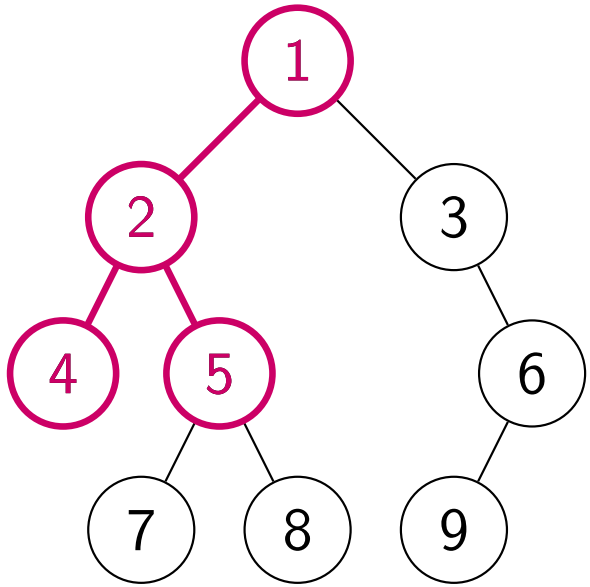
Pre-order (NLR) 1 2 **4**

Depth-first search



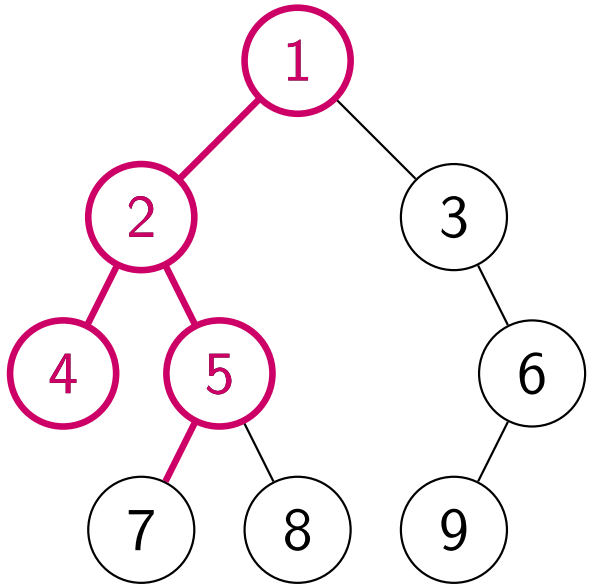
Pre-order (NLR) 1 2 4

Depth-first search



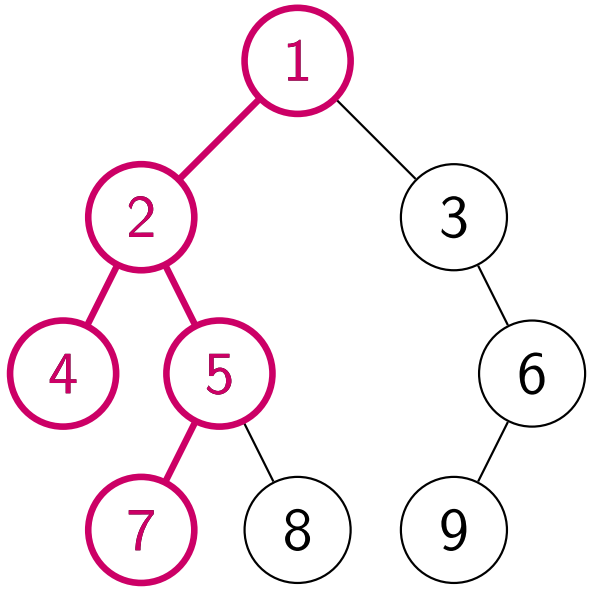
Pre-order (NLR) 1 2 4 **5**

Depth-first search



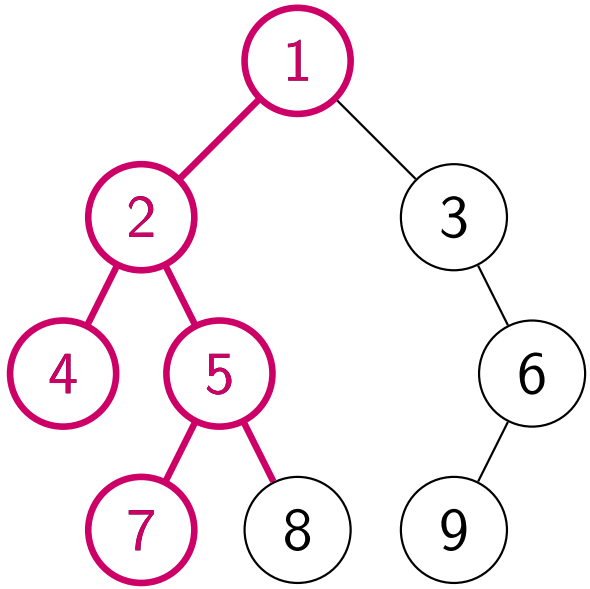
Pre-order (NLR) 1 2 4 5

Depth-first search



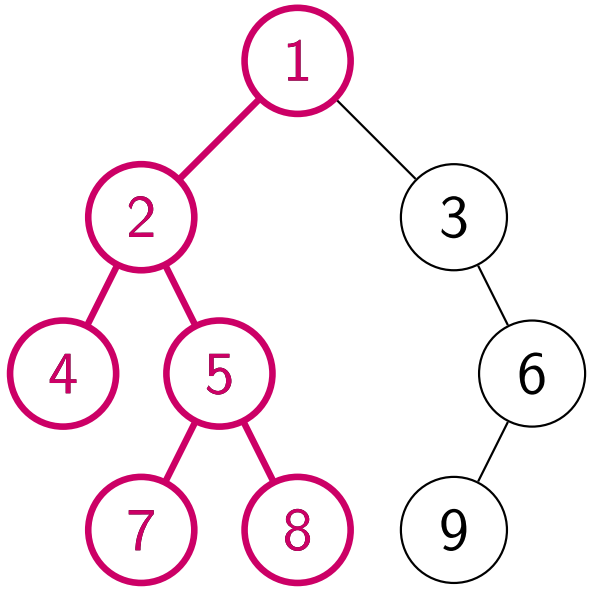
Pre-order (NLR) 1 2 4 5 **7**

Depth-first search



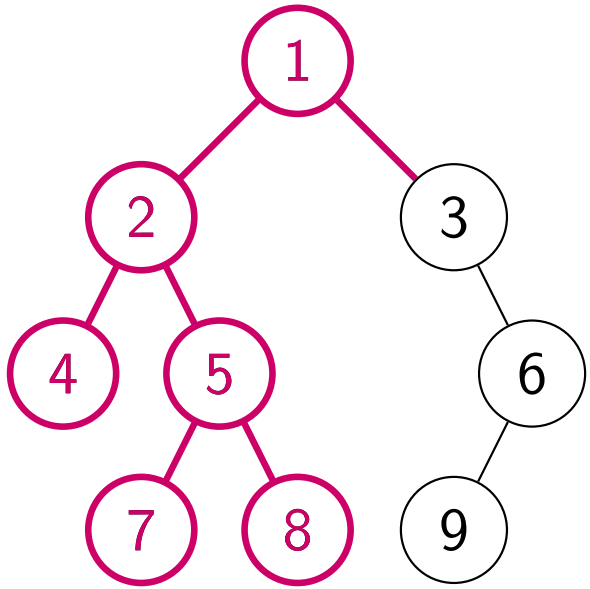
Pre-order (NLR) 1 2 4 5 7

Depth-first search



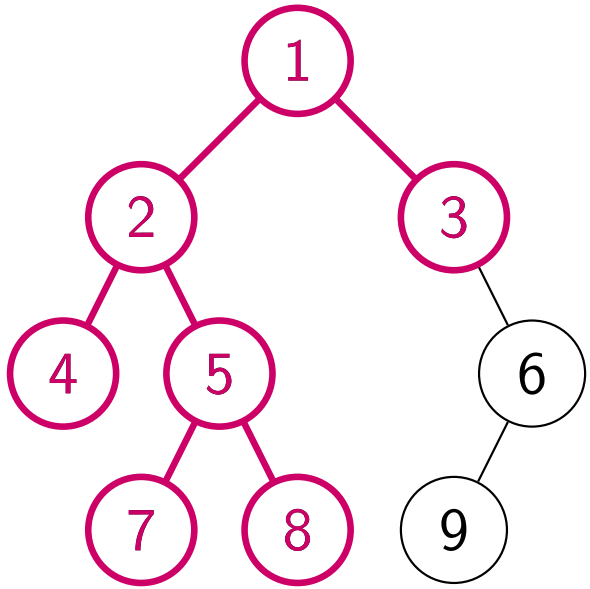
Pre-order (NLR) 1 2 4 5 7 **8**

Depth-first search



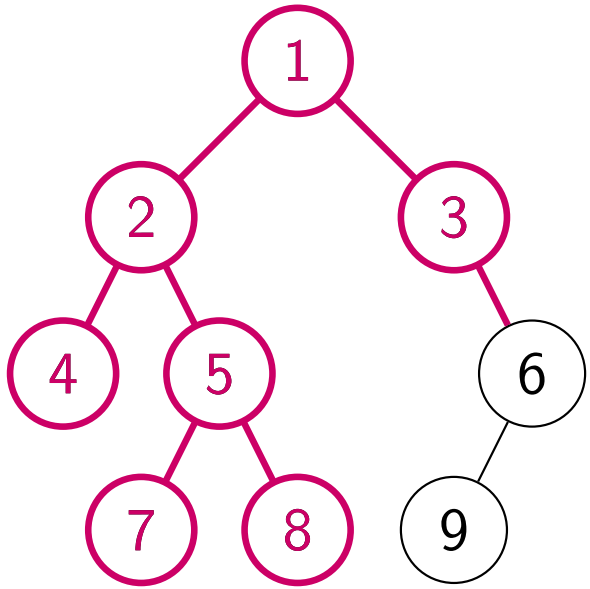
Pre-order (NLR) 1 2 4 5 7 8

Depth-first search



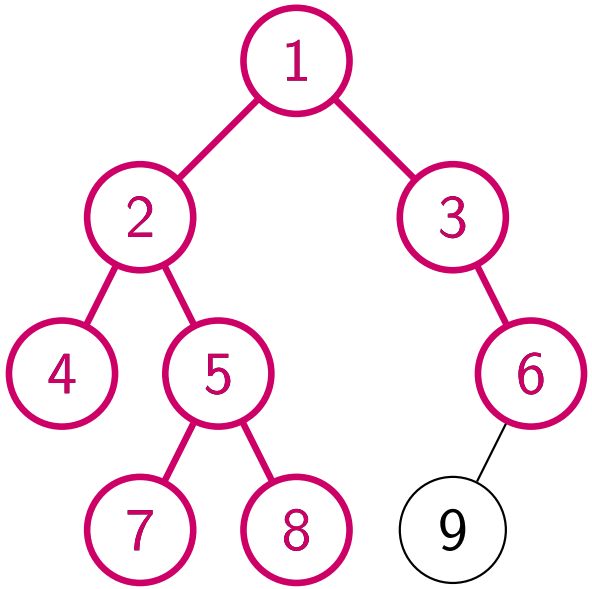
Pre-order (NLR) 1 2 4 5 7 8 **3**

Depth-first search



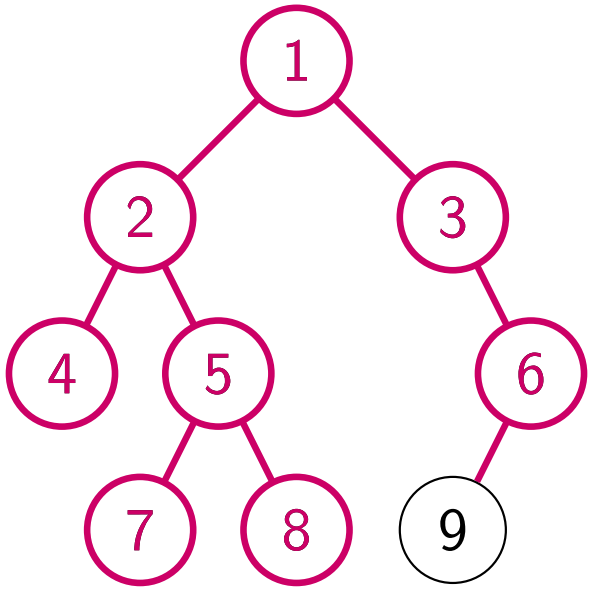
Pre-order (NLR) 1 2 4 5 7 8 3

Depth-first search



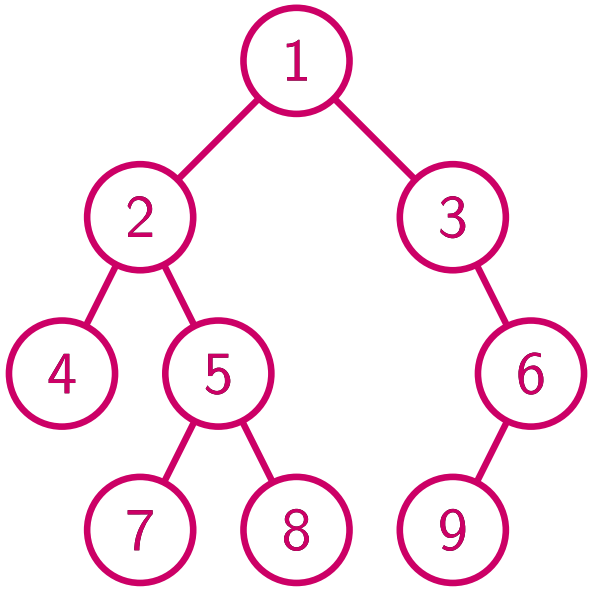
Pre-order (NLR) 1 2 4 5 7 8 3 **6**

Depth-first search



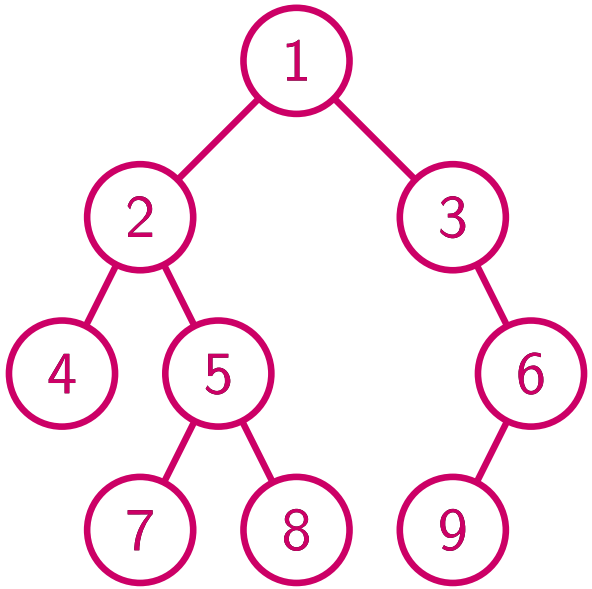
Pre-order (NLR) 1 2 4 5 7 8 3 6

Depth-first search



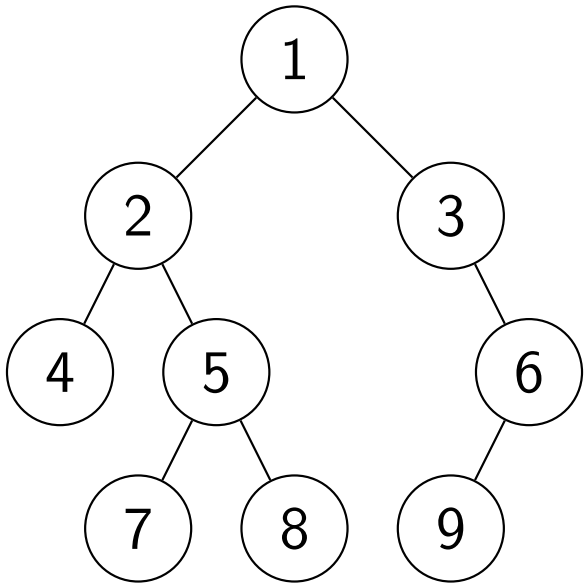
Pre-order (NLR) 1 2 4 5 7 8 3 6 **9**

Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

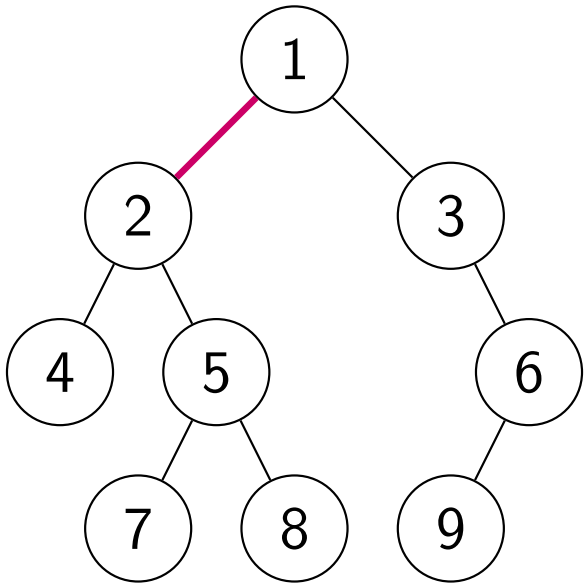
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR)

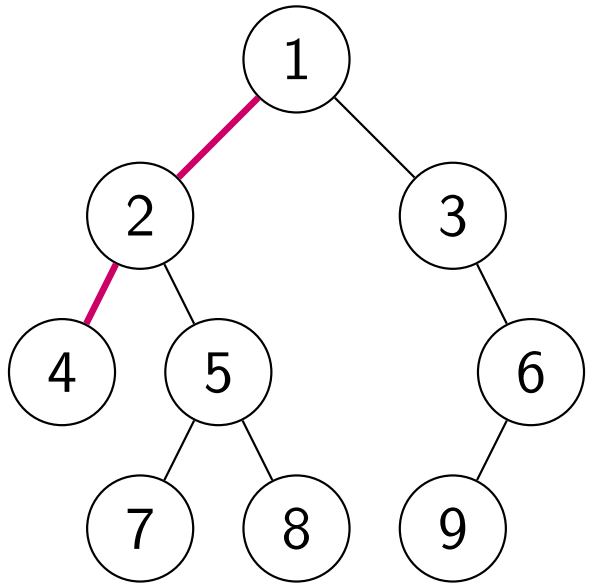
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR)

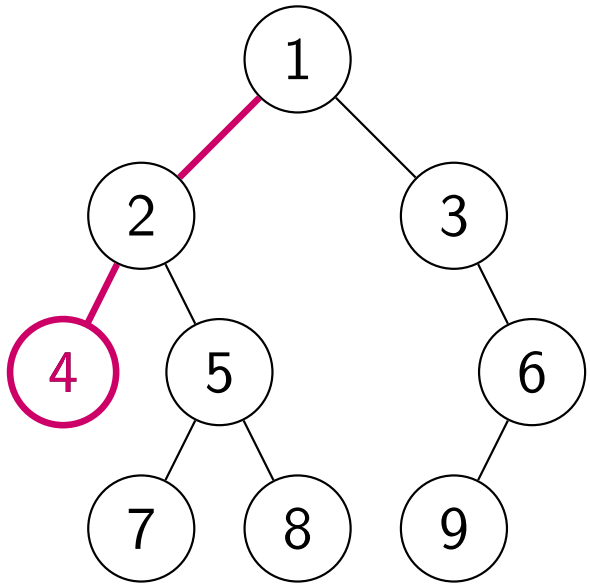
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR)

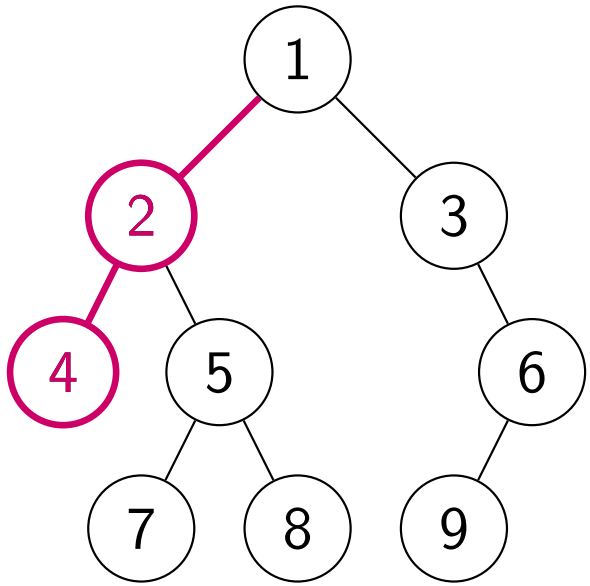
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) **4**

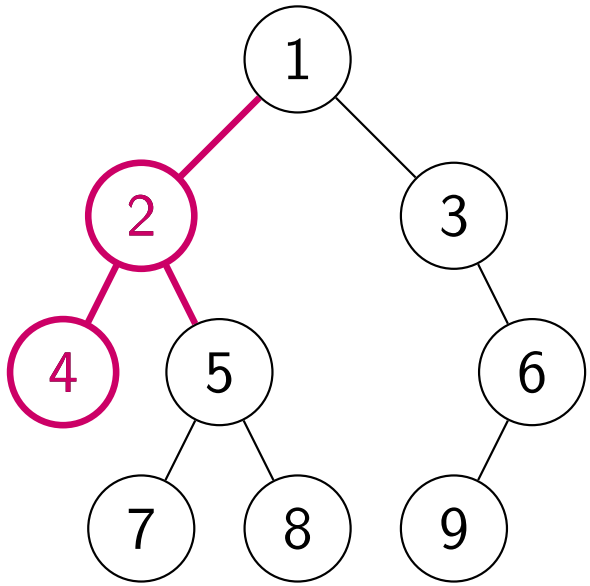
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 **2**

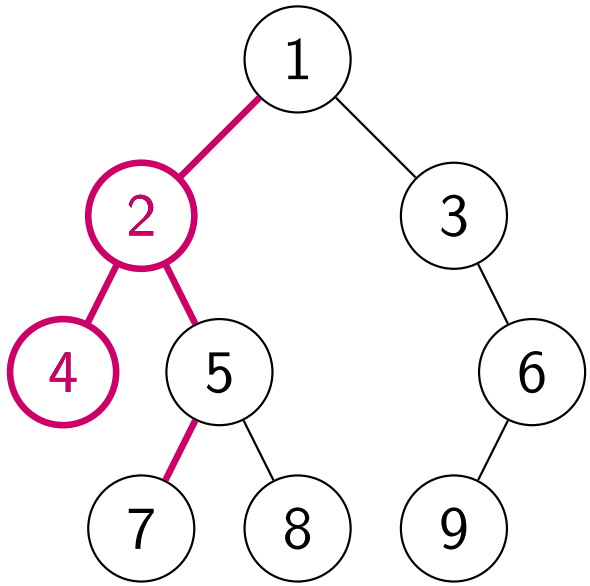
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2

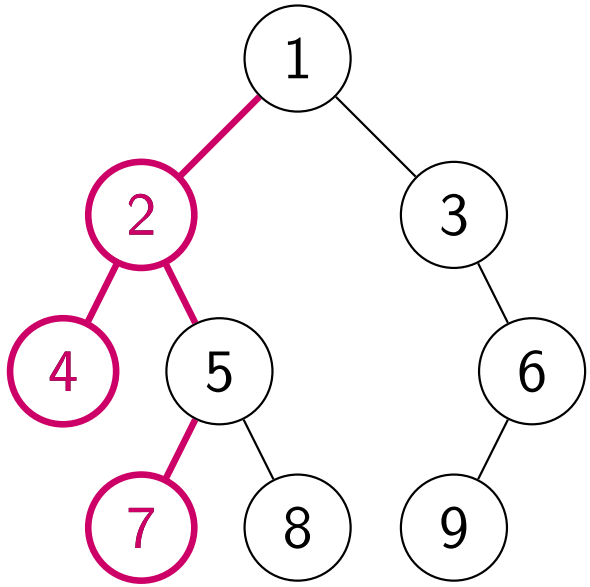
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2

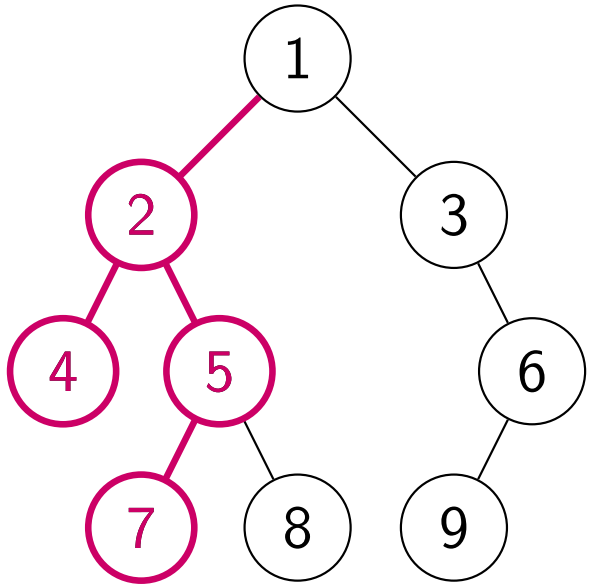
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 **7**

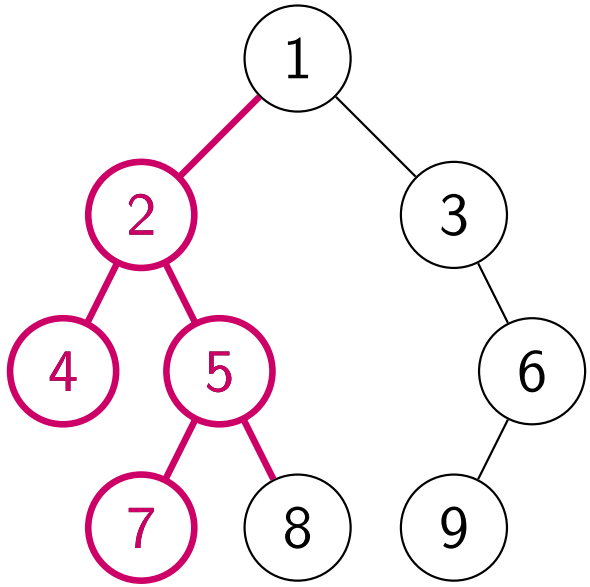
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 **5**

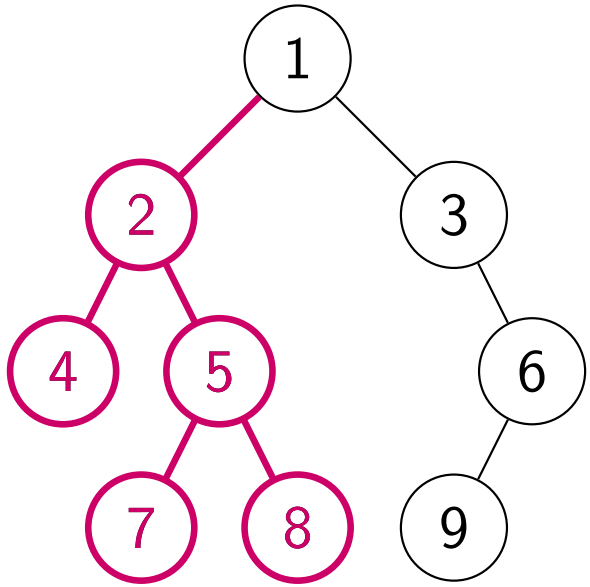
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5

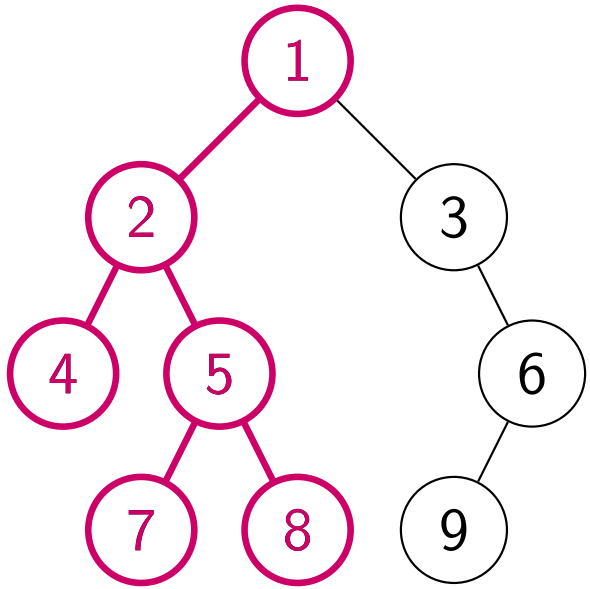
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 **8**

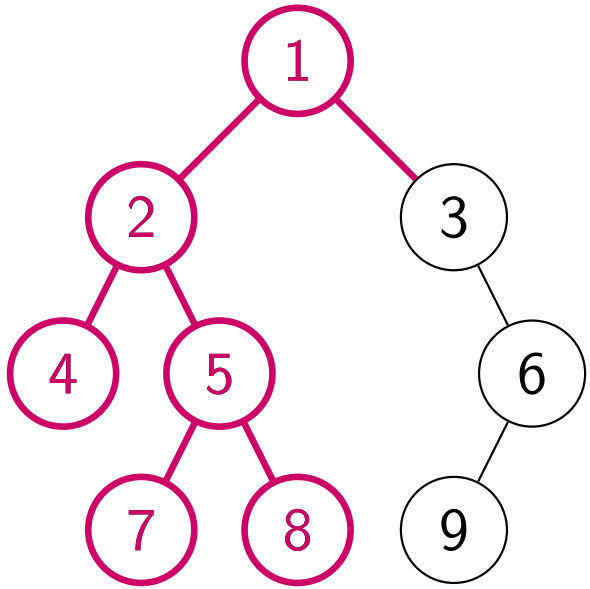
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 **1**

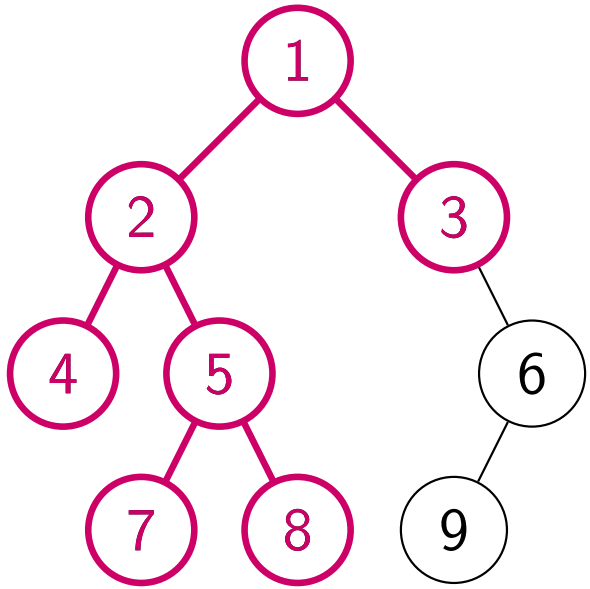
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1

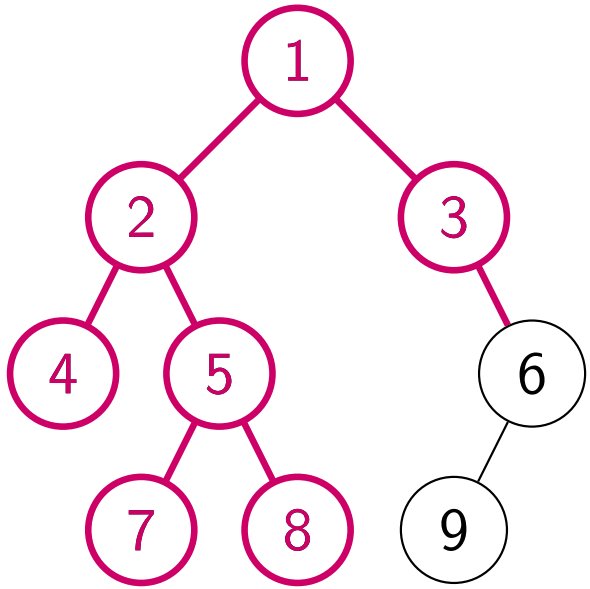
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 **3**

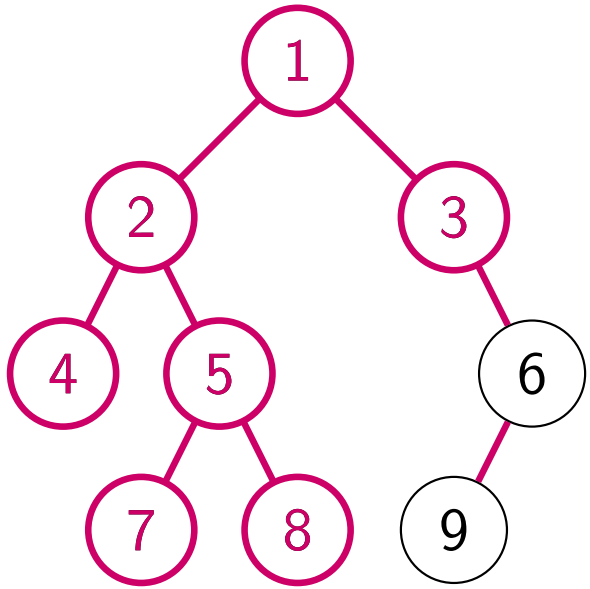
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3

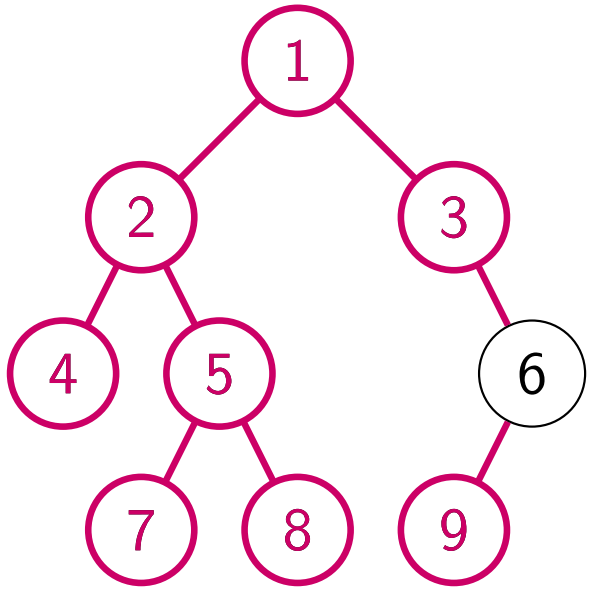
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3

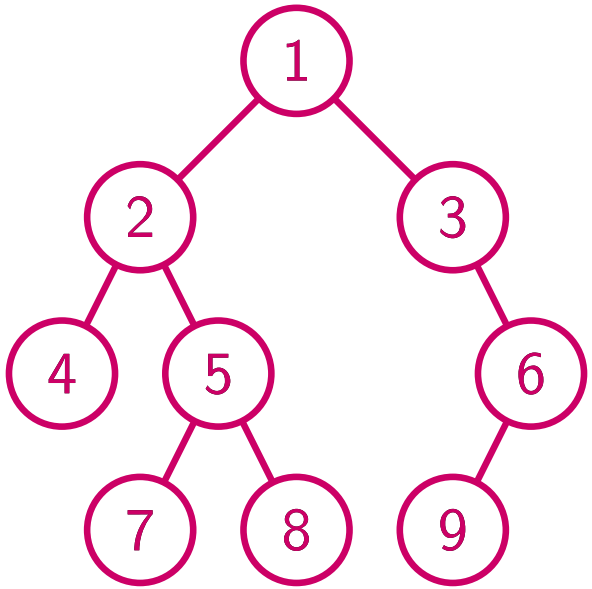
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 **9**

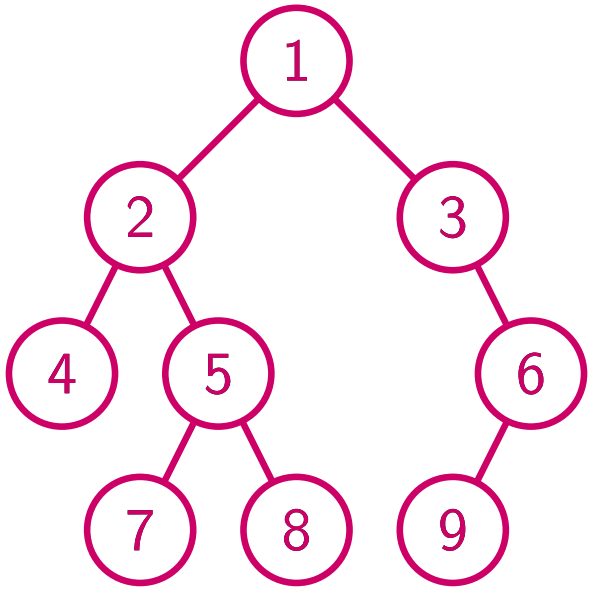
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 **6**

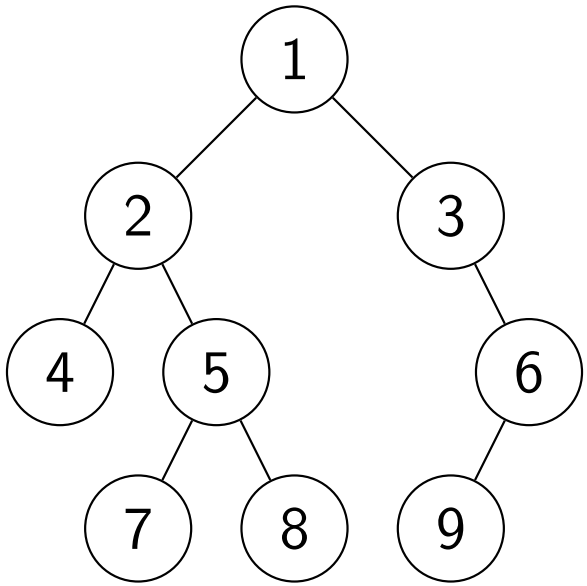
Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Depth-first search

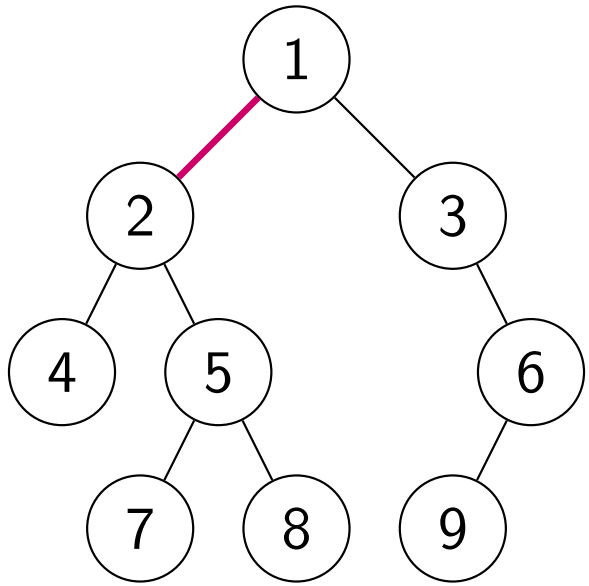


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN)

Depth-first search

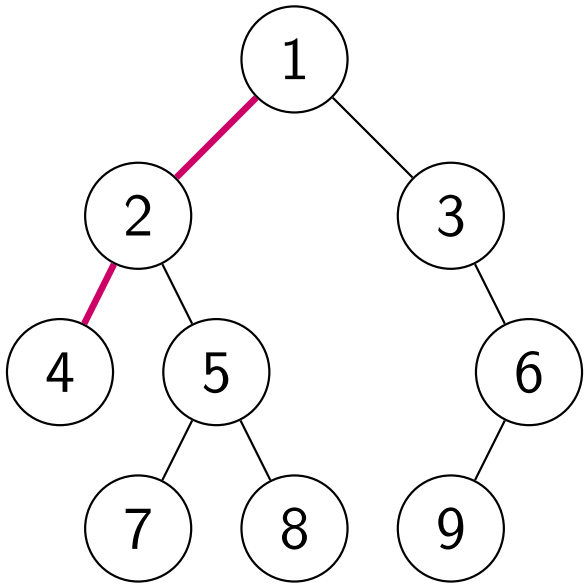


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN)

Depth-first search

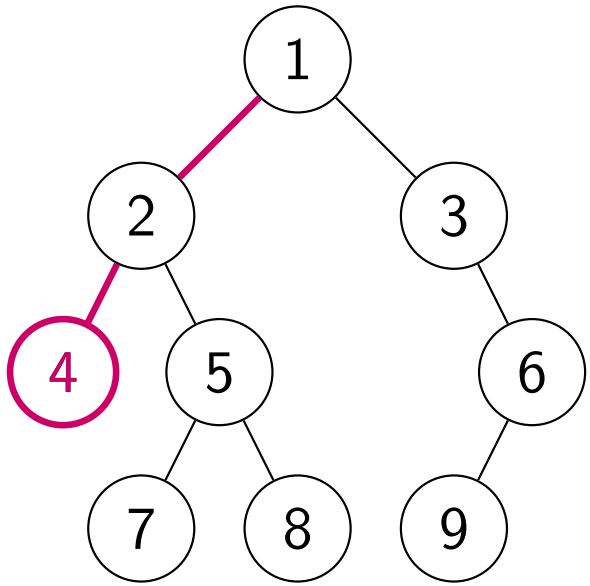


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN)

Depth-first search

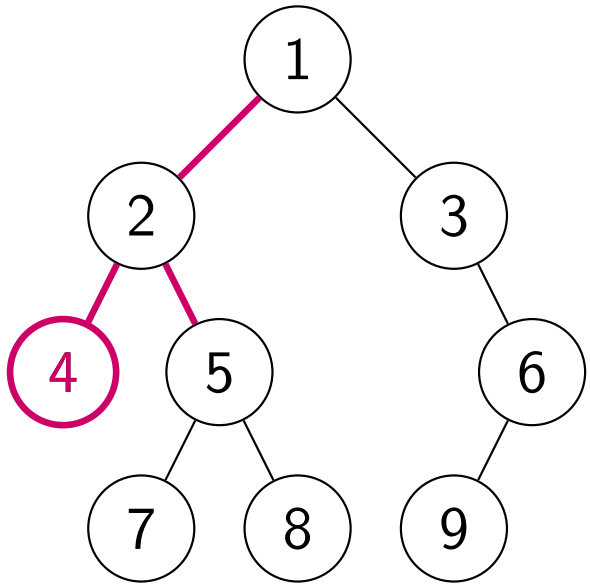


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) **4**

Depth-first search

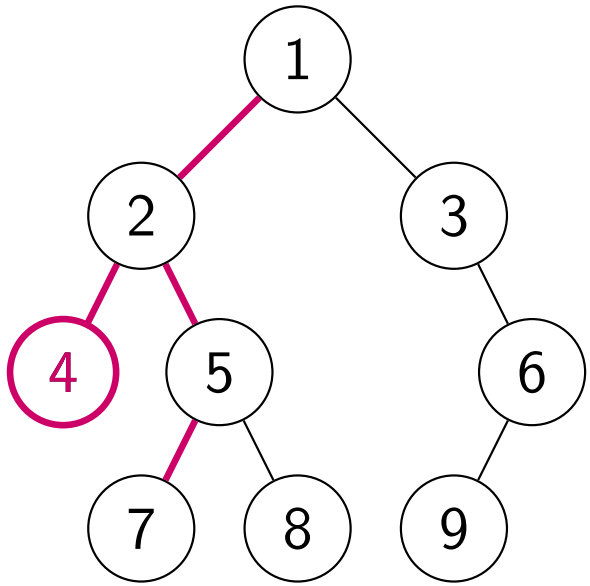


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4

Depth-first search

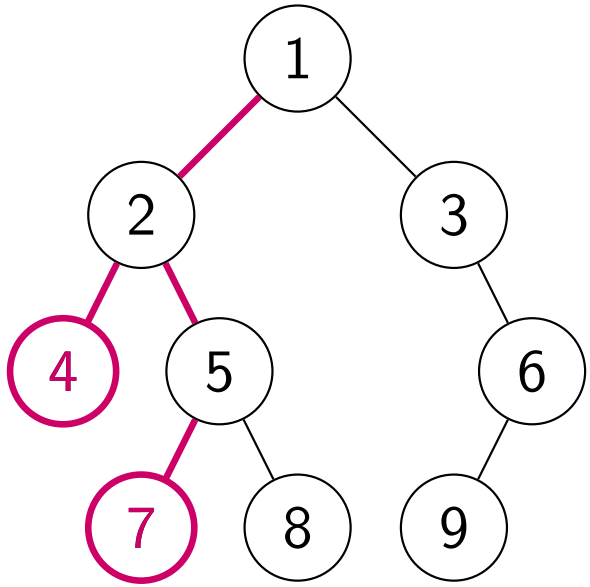


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4

Depth-first search

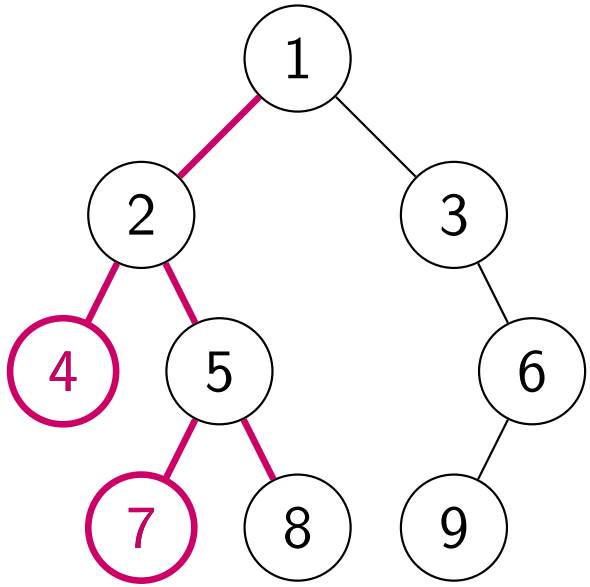


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 **7**

Depth-first search

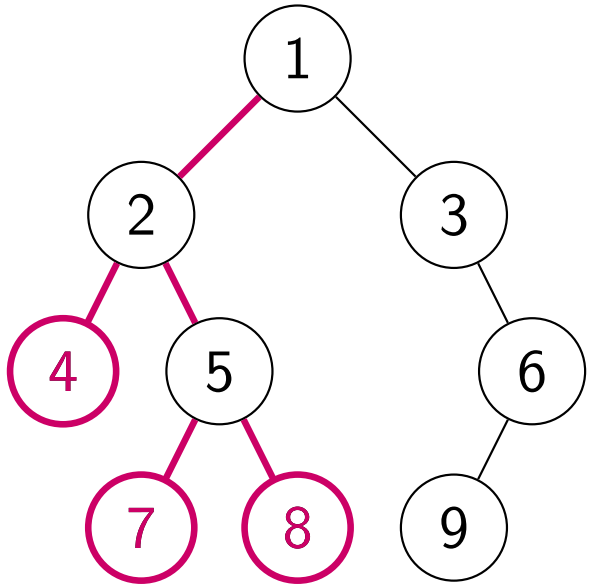


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7

Depth-first search

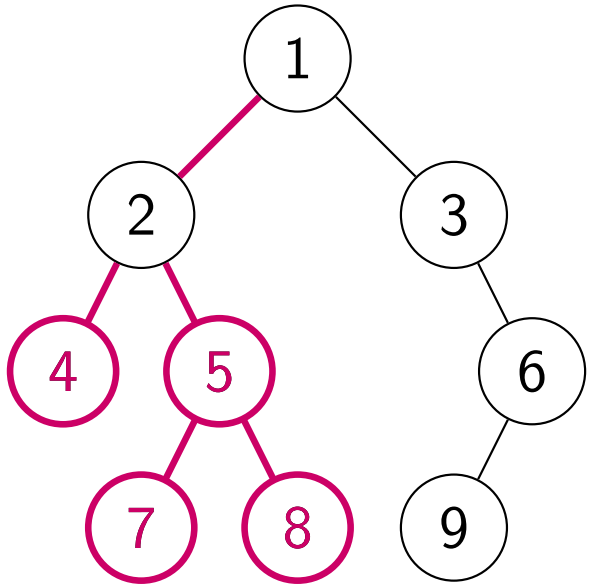


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 **8**

Depth-first search

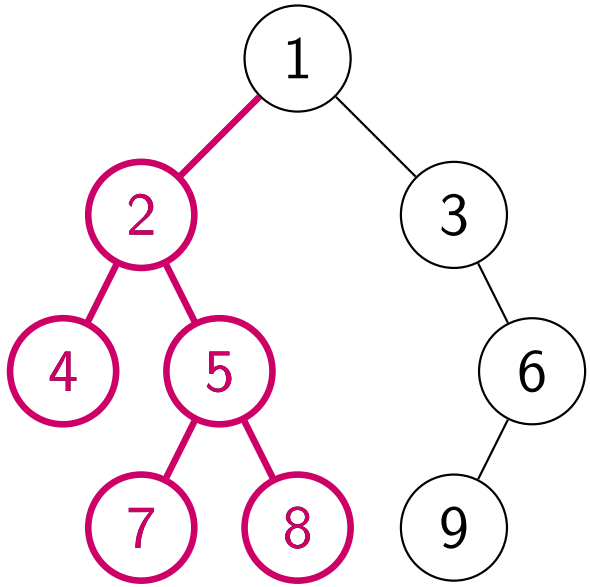


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 **5**

Depth-first search

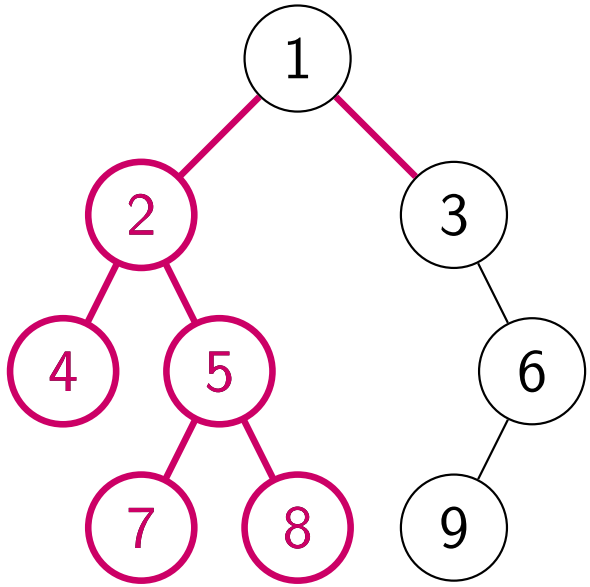


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 **2**

Depth-first search

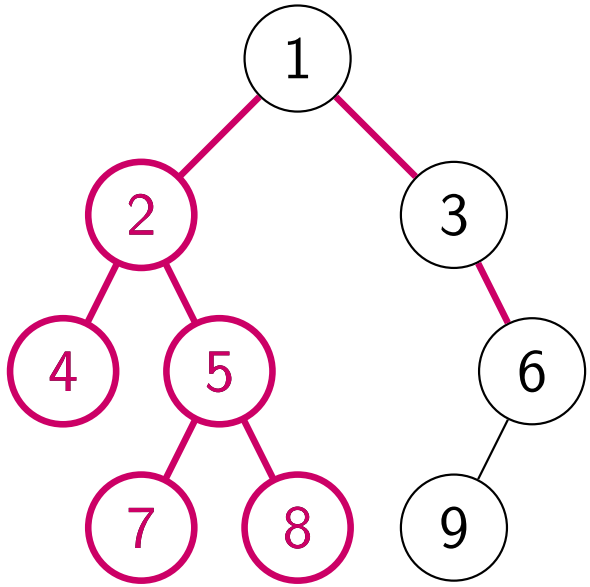


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2

Depth-first search

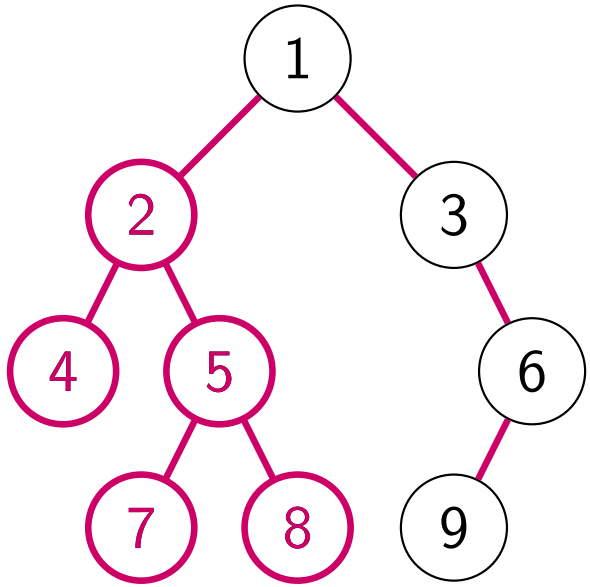


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2

Depth-first search

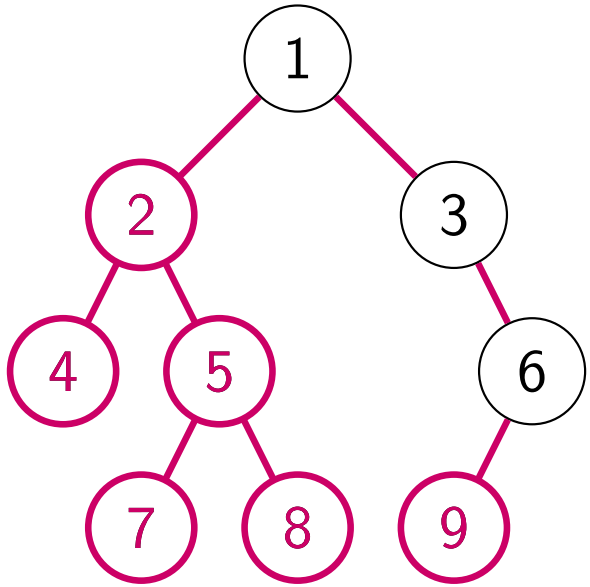


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2

Depth-first search

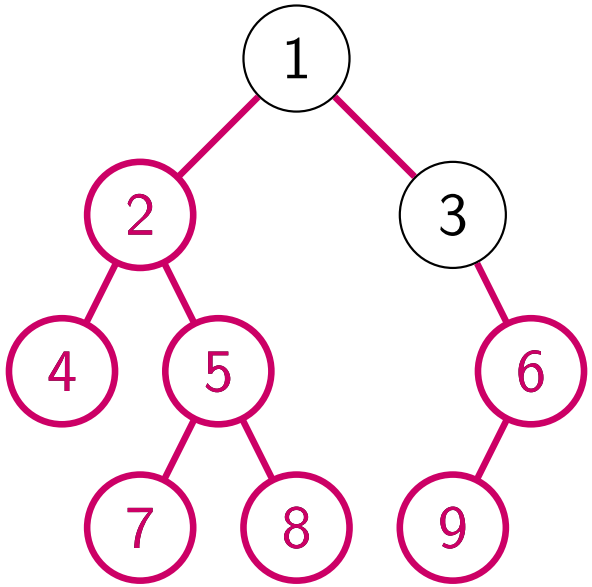


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 **9**

Depth-first search

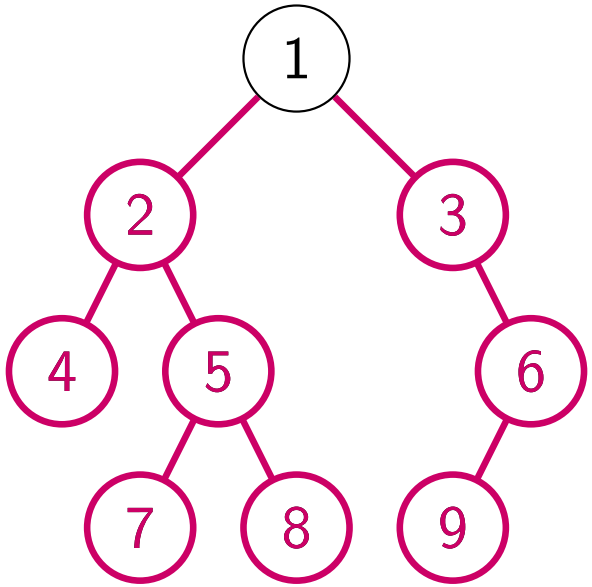


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 9 **6**

Depth-first search

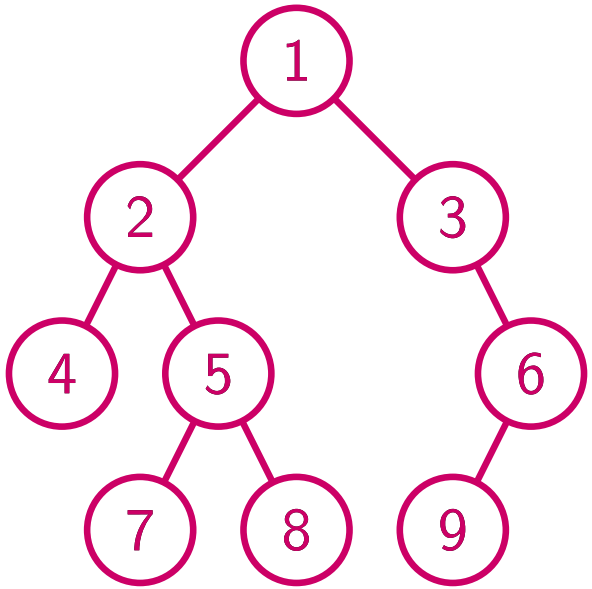


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 9 6 **3**

Depth-first search

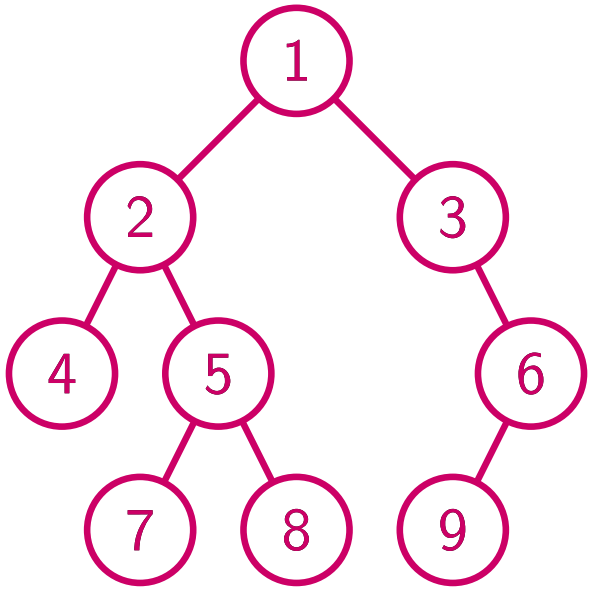


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 9 6 3 **1**

Depth-first search

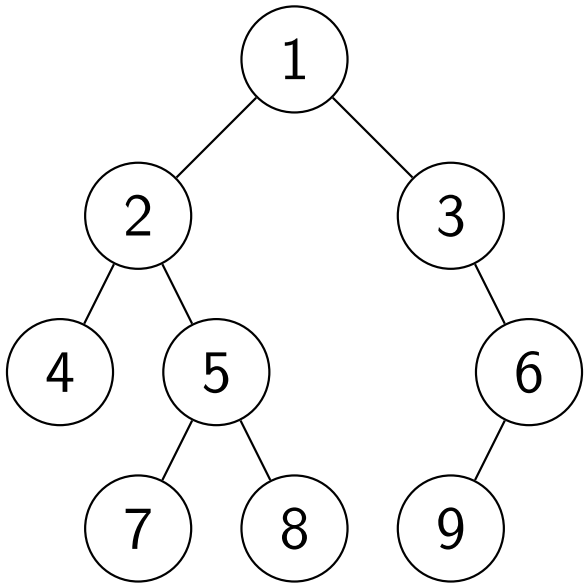


Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 9 6 3 1

Depth-first search



Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

Post-order (LRN) 4 7 8 5 2 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR)	1 2 4 5 7 8 3 6 9
In-order (LNR)	4 2 7 5 8 1 3 9 6

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR)	**1** 2 4 5 7 8 3 6 9
In-order (LNR)	4 2 7 5 8 1 3 9 6

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR)	**1** 2 4 5 7 8 3 6 9
In-order (LNR)	4 2 7 5 8 1 3 9 6

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) **1** 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 **1** 3 9 6

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) **1** 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 **1** 3 9 6

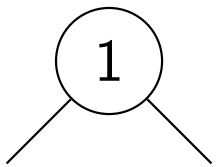
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6



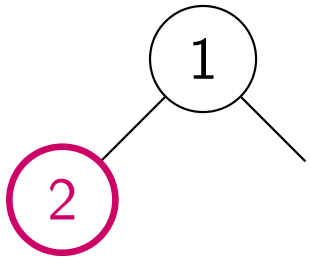
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 **2** 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

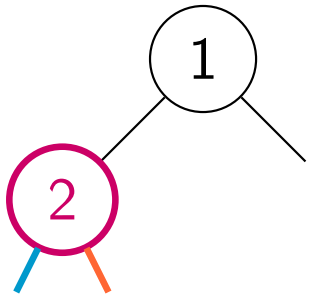


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6



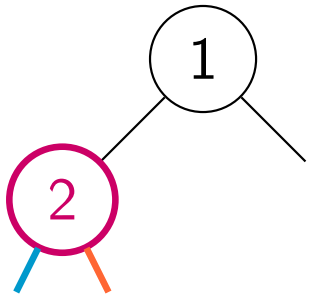
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

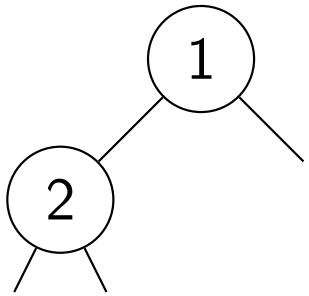


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

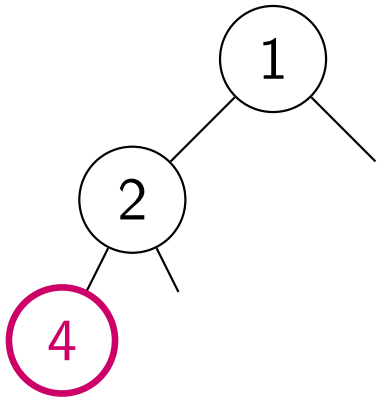


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6



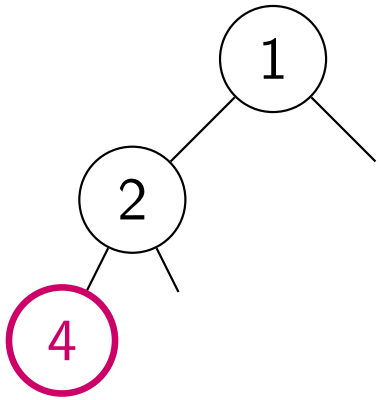
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 **4** 5 7 8 3 6 9

In-order (LNR) **4** 2 7 5 8 1 3 9 6

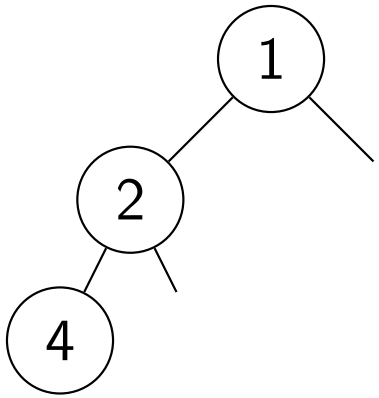


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

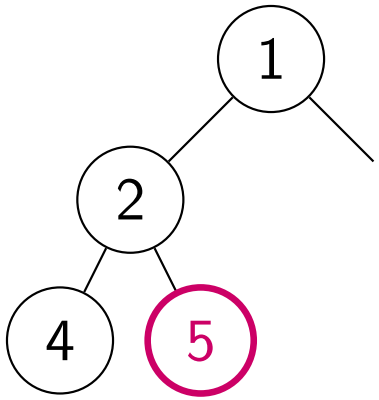


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 **5** 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

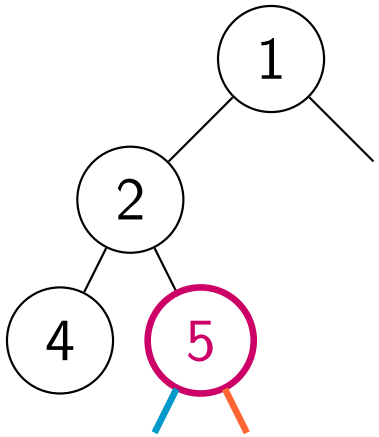


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 **5** 7 8 3 6 9
In-order (LNR) 4 2 7 **5** 8 1 3 9 6

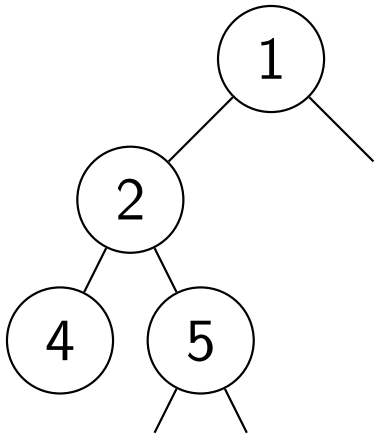


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

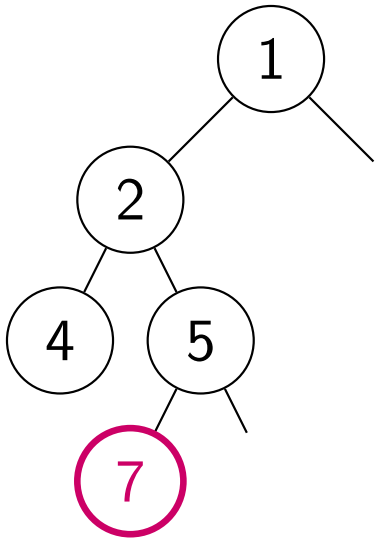


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

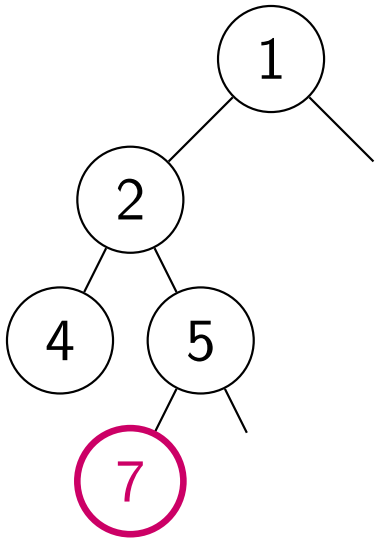


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

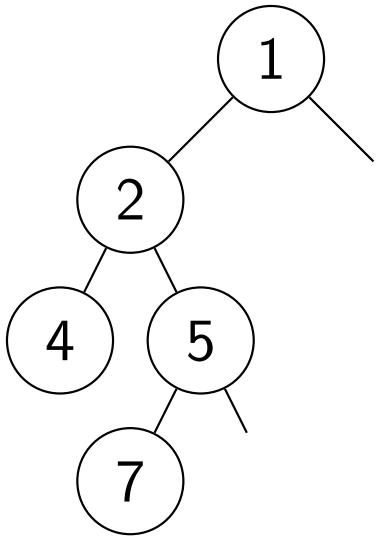


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

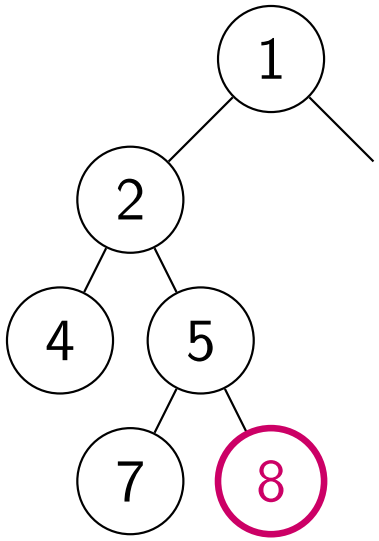


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 **8** 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

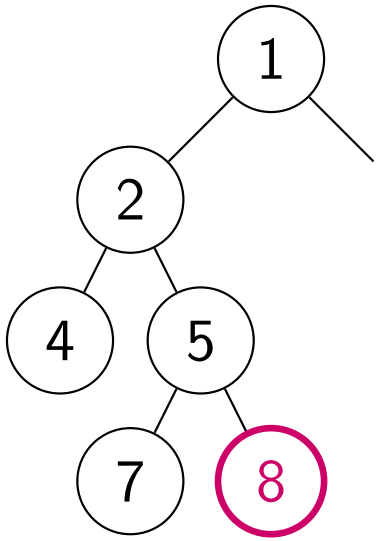


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 **8** 3 6 9
In-order (LNR) 4 2 7 5 **8** 1 3 9 6

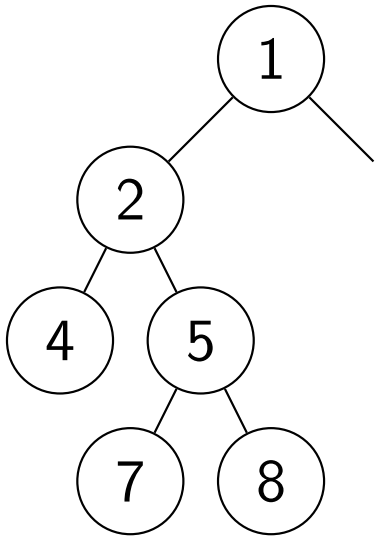


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

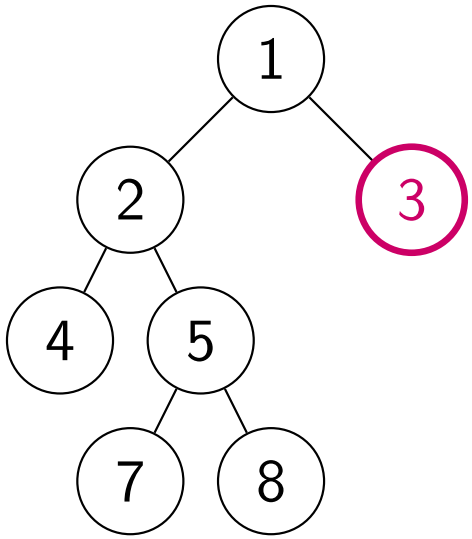


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 **3** 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

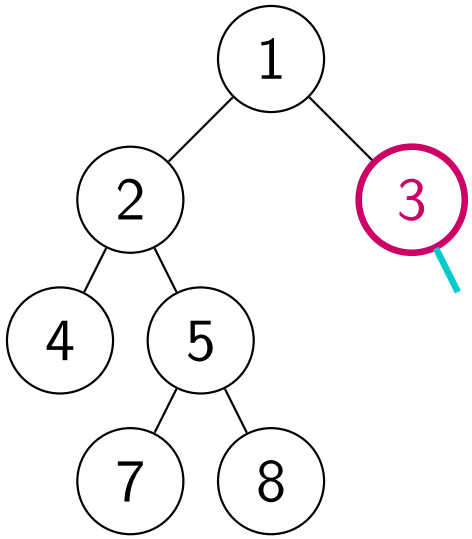


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 **3** 6 9
In-order (LNR) 4 2 7 5 8 1 **3** 9 6

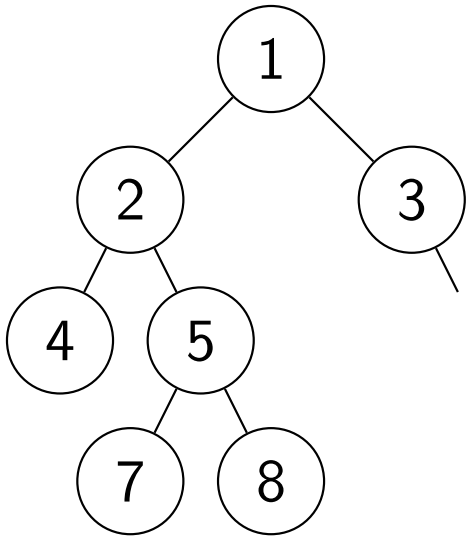


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

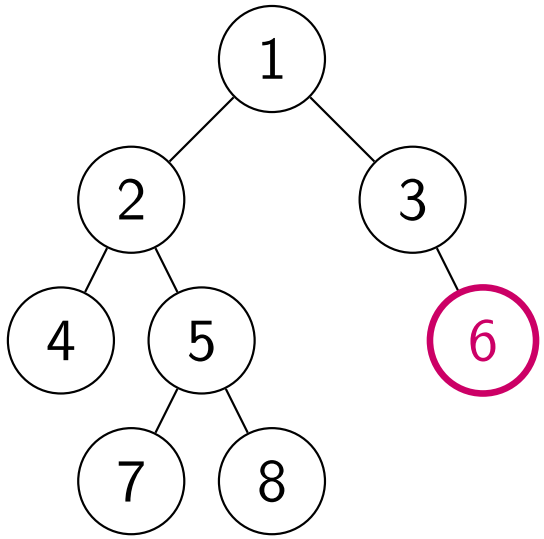


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 **6** 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

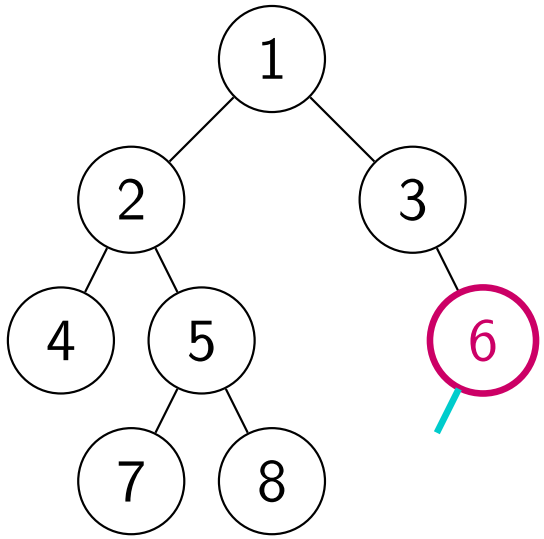


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 **6** 9
In-order (LNR) 4 2 7 5 8 1 3 9 **6**



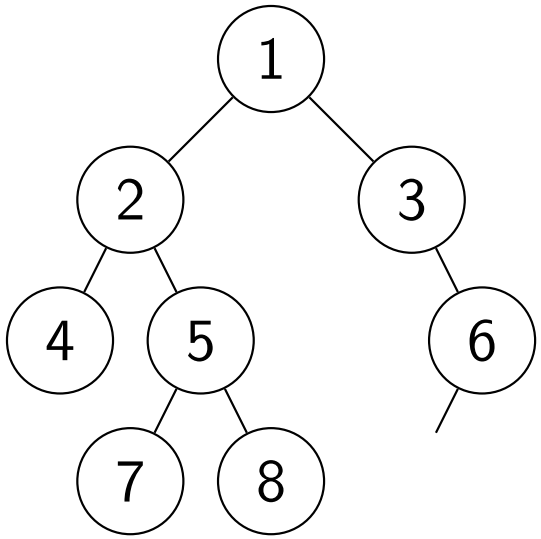
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9

In-order (LNR) 4 2 7 5 8 1 3 9 6

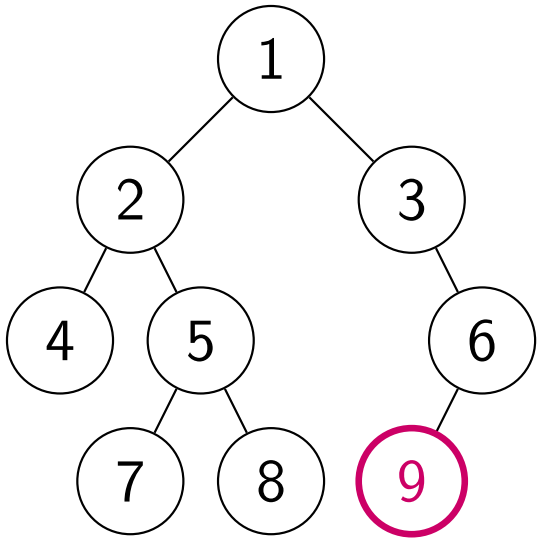


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 **9**
In-order (LNR) 4 2 7 5 8 1 3 9 6

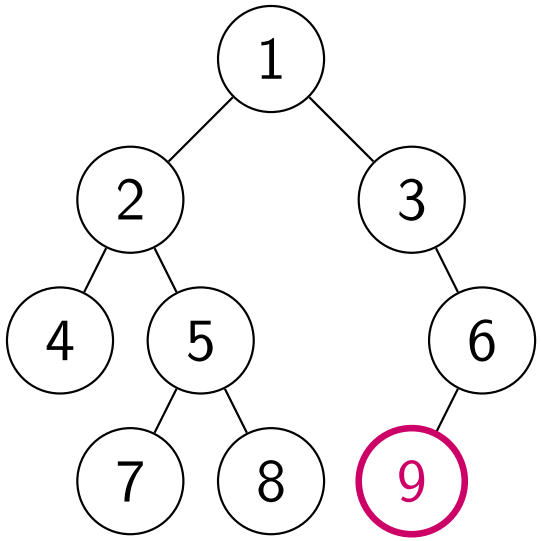


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 **9**
In-order (LNR) 4 2 7 5 8 1 3 **9** 6

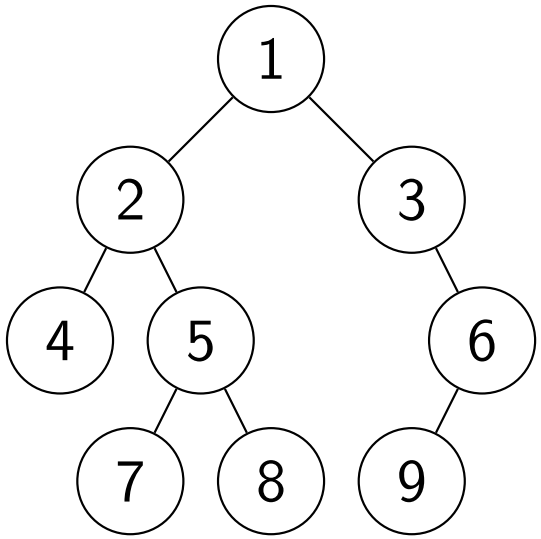


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 1 3 9 6

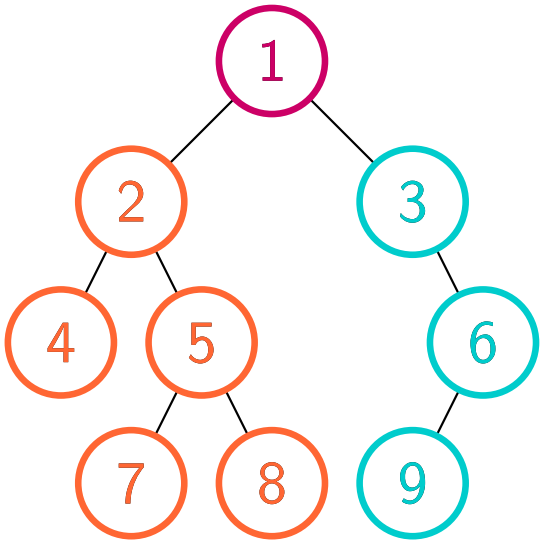


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔

Pre-order (NLR) **1** 2 4 5 7 8 3 6 9
In-order (LNR) 4 2 7 5 8 **1** 3 9 6



Depth-first search

Given two traversals can a tree be retrieved?

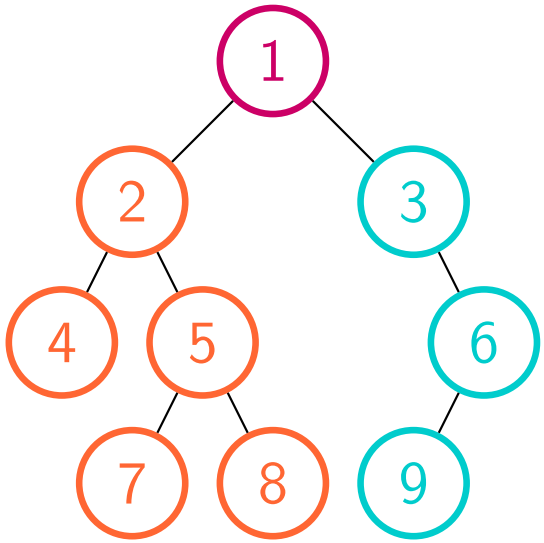
- Pre-order and In-order ✔
- Post-order and In-order

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔

Post-order (LRN) 4 7 8 5 2 9 6 3 **1**
In-order (LNR) 4 2 7 5 8 **1** 3 9 6



Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR)	1 2 4 5 7 8 3 6 9
Post-order (LRN)	4 7 8 5 2 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR)	**1** 2 4 5 7 8 3 6 9
Post-order (LRN)	4 7 8 5 2 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR)	**1** 2 4 5 7 8 3 6 9
Post-order (LRN)	4 7 8 5 2 9 6 3 **1**

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) **1** 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 **1**

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 **2** 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

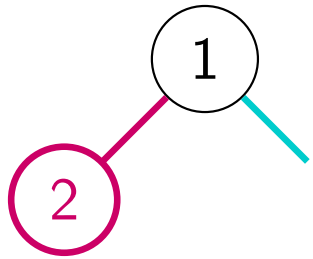
Pre-order (NLR) 1 **2** 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 **2** 9 6 3 1

Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 **2** 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 **2** 9 6 3 1

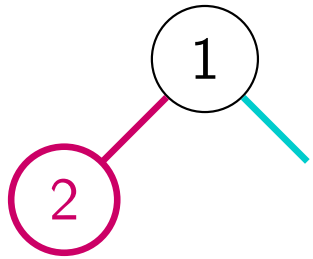


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 **2** 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 **2** 9 6 3 1

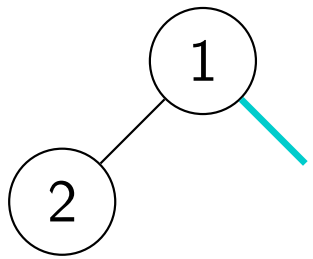


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1



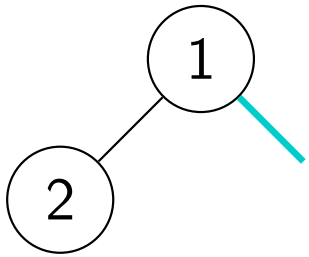
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 **4** 5 7 8 3 6 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1



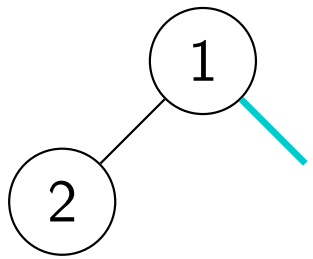
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 **4** 5 7 8 3 6 9

Post-order (LRN) **4** 7 8 5 2 9 6 3 1

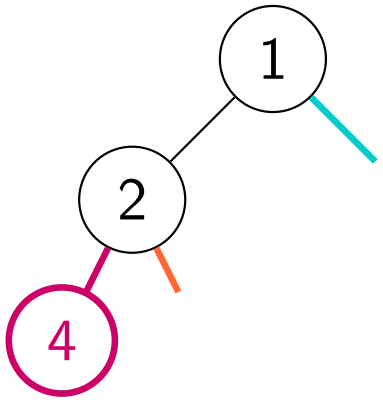


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 **4** 5 7 8 3 6 9
Post-order (LRN) **4** 7 8 5 2 9 6 3 1

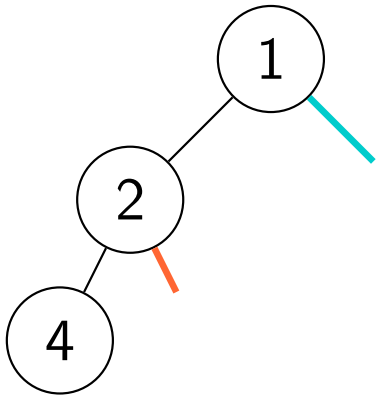


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1



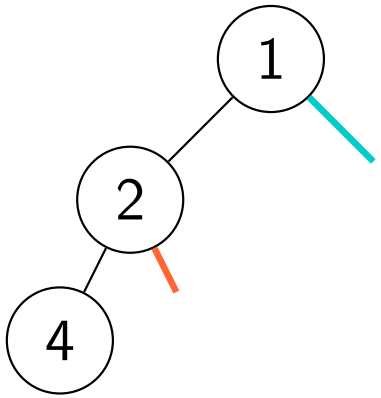
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 **5** 7 8 3 6 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1



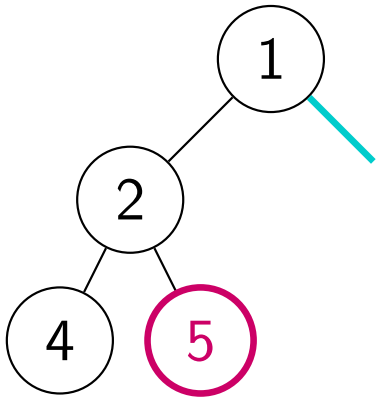
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 **5** 7 8 3 6 9

Post-order (LRN) 4 7 8 **5** 2 9 6 3 1



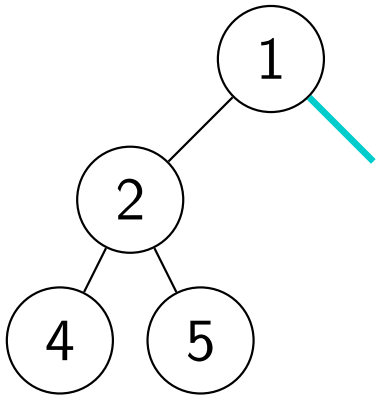
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1



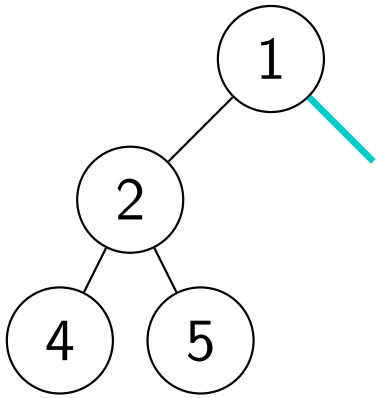
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1

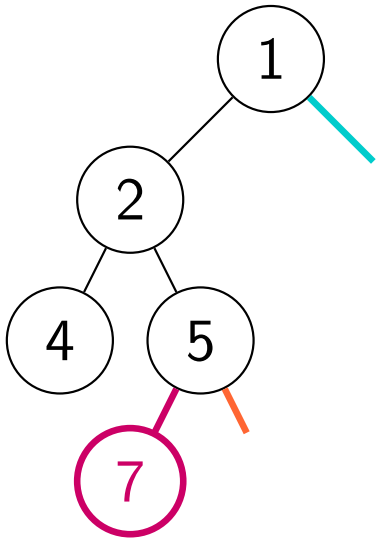


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1

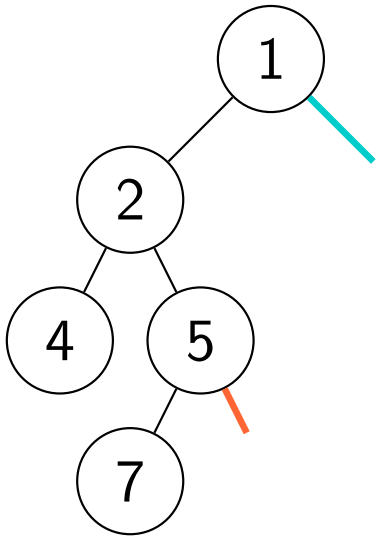


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1



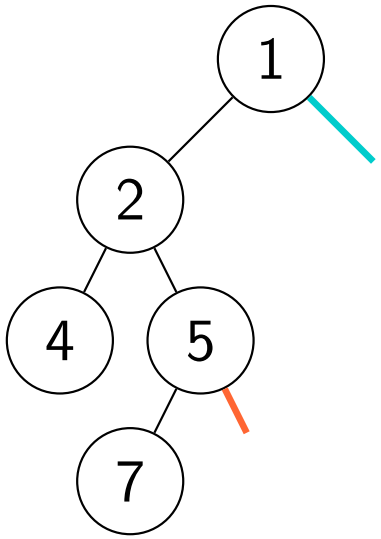
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 **8** 3 6 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1



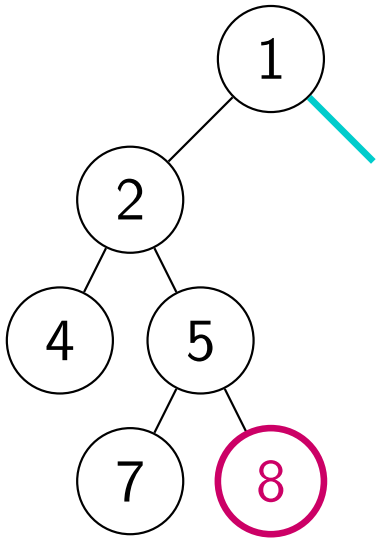
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 **8** 3 6 9

Post-order (LRN) 4 7 **8** 5 2 9 6 3 1

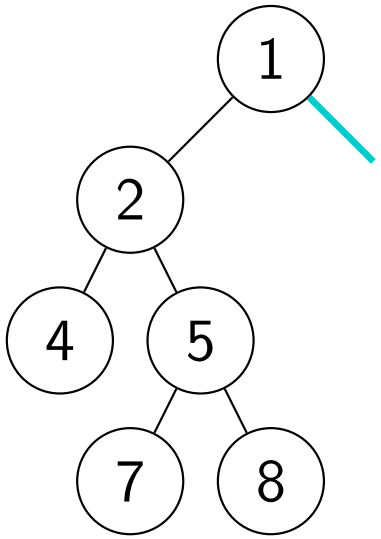


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1

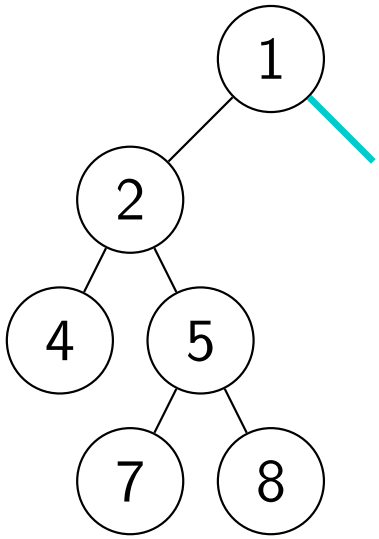


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 **3** 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1

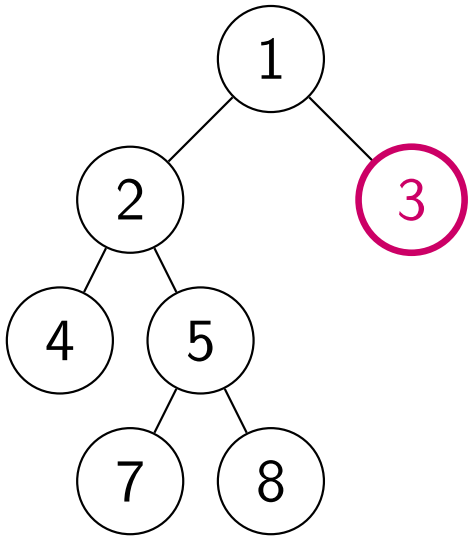


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 **3** 6 9
Post-order (LRN) 4 7 8 5 2 9 6 **3** 1



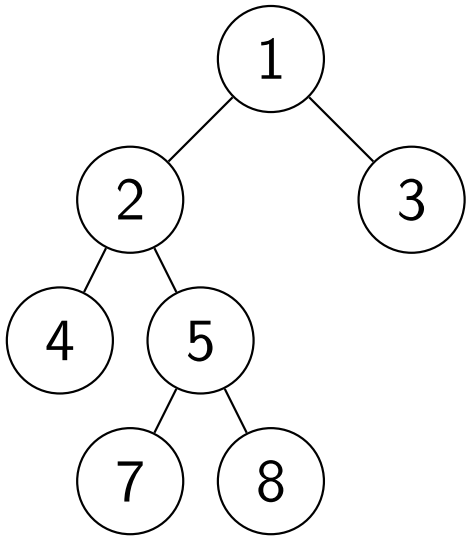
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 **6** 9

Post-order (LRN) 4 7 8 5 2 9 6 3 1



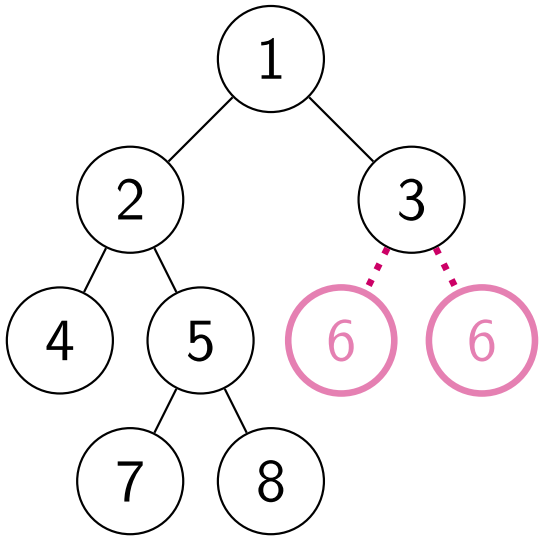
Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order

Pre-order (NLR) 1 2 4 5 7 8 3 **6** 9

Post-order (LRN) 4 7 8 5 2 9 **6** 3 1

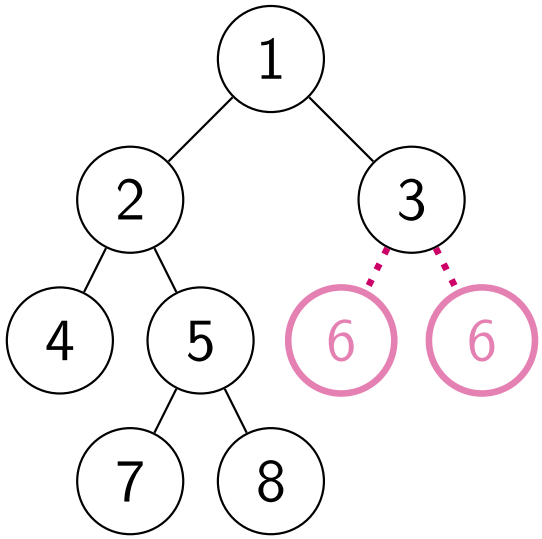


Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✔
- Post-order and In-order ✔
- Pre-order and Post-order ✗

Pre-order (NLR) 1 2 4 5 7 8 3 6 9
Post-order (LRN) 4 7 8 5 2 9 6 3 1



Exercise 1: Is it a tree

Statement

Given N the number of nodes, M the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

Exercise 1: Is it a tree

Statement

Given N the number of nodes, M the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

Example

Input:

3 2
1 2
2 3

Output:

YES

Exercise 1: Is it a tree

Statement

Given N the number of nodes, M the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

What problems can arise?

- What do we know of N?

Exercise 1: Is it a tree

Statement

Given N the number of nodes, M the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

What problems can arise?

- What do we know of N?
- Of M?

Exercise 1: Is it a tree

Solution 1: Build the graph

Build the graph with the list of edges

Check using BFS that all the nodes are visited once

Exercise 1: Is it a tree

Solution 1: Build the graph

Build the graph with the list of edges

Check using BFS that all the nodes are visited once

Solution 2: Check on the list

```
if it can be a tree then
    Maintain a visit array
    Check that all the nodes are visited exactly once
```

Exercise 1: Is it a tree

More test cases

Input:

```
5 4
1 3
1 4
4 2
2 5
```

Output:

YES

Input:

```
5 5
1 3
1 4
4 2
2 5
3 4
```

Output:

NO

Input:

```
5 3
1 3
1 4
2 5
```

Output:

NO

Input:

```
5 4
1 3
1 4
2 5
3 4
```

Output:

NO

Exercise 2: Tree order

Statement

Given pre-order, post-order, and in-order traversals, determine if they can be of the same binary tree

Exercise 2: Tree order

Statement

Given pre-order, post-order, and in-order traversals, determine if they can be of the same binary tree

Example

Input:

6
1 2 4 5 3 6
4 5 2 6 3 1
4 2 5 1 3 6

Output:

yes

Exercise 2: Tree order

Solution 1: Build the tree

Given two traversals build the tree

Generate the third traversal
Check that it matches the given one

Exercise 2: Tree order

Solution 1: Build the tree

Given two traversals build the tree

Generate the third traversal
Check that it matches the given one

Solution 2: Check the orders

Check the three traversals all at once

Exercise 2: Tree order

More test cases

Input:

```
9
1 2 4 5 7 8 3 6 9
4 7 8 5 2 9 6 3 1
4 2 7 5 8 1 3 9 6
```

Output:

yes

Input:

```
9
1 2 4 5 7 8 3 6 9
4 7 5 8 2 9 6 3 1
4 2 7 5 8 1 3 9 6
```

Output:

no