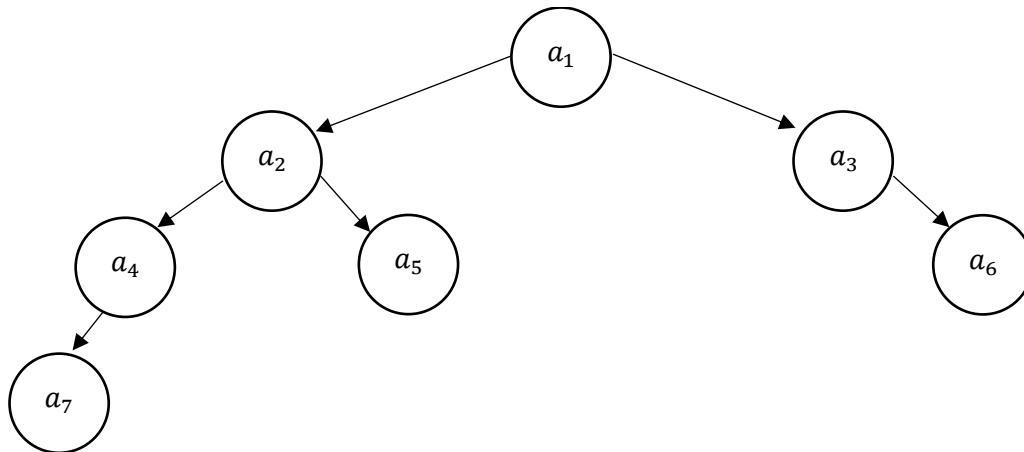


ADT Binary Search Tree

Binary Search Tree = $\{a_1, a_2, a_3, a_4, \dots, a_n\}$

Where a_1 is the root of the tree, the elements a_2 and a_3 are the children of a_1 , and in addition to this, they are also subtrees, that they have children

Graphic Representation

$$a_7 < a_4 < a_2 < a_3 < a_1 < a_6$$

$$inv = \{a_1 > a_2, a_1 < a_3 \rightarrow a_2 < a_1 < a_3\}$$

Primitive Operations

Name	Input	Output
BinarySearchTree	...	BinarySearchTree
Add	BinarySearchTree x Key	BinarySearchTree
InOrder	BinarySearchTree	String
Search	BinarySearchTree x Key	Node (any a)
Minimum	BinarySearchTree x Key	Node (the smallest a)
Maximum	BinarySearchTree x Key	Node (the greatest a)
Successor	BinarySearchTree x Key	Node (the largest of those smaller than a)
Add	BinarySearchTree x Key x Value	BinarySearchTree
Delete	BinarySearchTree x Key	BinarySearchTree

BinarySearchTree(): Constructor

Create the binary tree by initializing the root

$pre = \{true\}$

$pos = \{root\ initialized\}$

InOrder(): Analyzer
Traversing the binary search tree in order
$pre = \{root \neq null\}$ $pos = \{BinarySearchTree\}$

Search(Key k): Analyzer
Searches for an element passed by parameter in the binary search tree
$pre = \{root \neq null \wedge k \in tree\}$ $pos = \{a \text{ node with key } k\}$

Minimum(Key k): Analyzer
Gets the smallest element in the binary search tree according to the value of k
$pre = \{root \neq null \wedge k \in tree\}$ $pos = \{the \text{ smallest node}\}$

Maximum(Key k): Analyzer
Gets the largest element in the binary search tree according to the value of k
$pre = \{root \neq null \wedge k \in tree\}$ $pos = \{the \text{ largest node}\}$

Successor(Key k): Analyzer
Gets the smallest element in the set of elements greater than the key k
$pre = \{root \neq null \wedge k \in tree\}$ $pos = \{the \text{ successor of } k\}$

Add(Key k, Value v): Modifier
Adds a node to the binary search tree, this node is added according to the order criterion established in the invariant
$pre = \{true\}$ $pos = \{true, the \text{ nodo was added}\}$

Delete (Key k): Modifier
Deletes an element belonging to the binary search tree, then re-sorts the tree
$pre = \{root \neq null \wedge k \in \text{in the tree}\}$ $pos = \{new \text{ order of nodes and one less element}\}$