

# Midterm report 2024, Binary Heap

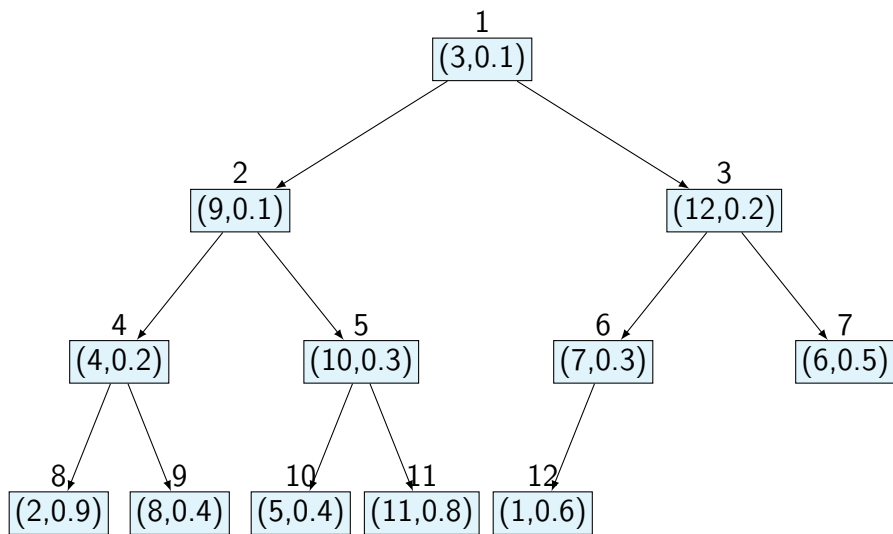
Object Oriented Programming  
2024 First Semester  
Shin-chi Tadaki (Saga University)

- 1 Binary Heap
- 2 Implementation
- 3 Minimum methods

# Binary Heap

- A binary heap is a type of data structure for extracting the minimum element from a data set.
- It is a complete binary tree which satisfies the followings.
  - The top level is denoted as  $\ell = 0$ . The second level (daughters of the root) is denoted as  $\ell = 1$  and so forth.
  - Each level  $\ell$  has  $2^\ell$  nodes, with the exception of the last level  $\ell = L$ .
  - Any remaining nodes at the last level are filled from left to right.

# Image of Binary Heap



# Rules for nodes

- Each node at the level  $\ell < L - 1$  has two lower level nodes, called *daughters* or *subnodes*.
- At the level  $\ell = L - 1$ , there exists a boundary node  $V$ .
  - Nodes positions to the left of  $V$  has two daughters, while the nodes to the rights has none.
  - The node  $V$  may have one or two daughters.
- A node  $v$  must have a value that is not greater than the values of its daughters.

# Implementation

- The binary heap is implemented as an list.
- The root node is  $V_1$ .
- Any node  $V_k$  has two daughters  $V_{2k}$  and  $V_{2k+1}$ .
- The parent of a node  $V_k$  ( $k > 1$ ) is  $V_{\lfloor k/2 \rfloor}$ .

# Minimum methods

- Constructor
- Add a new element
- Extract the minimum element
- Check the emptiness

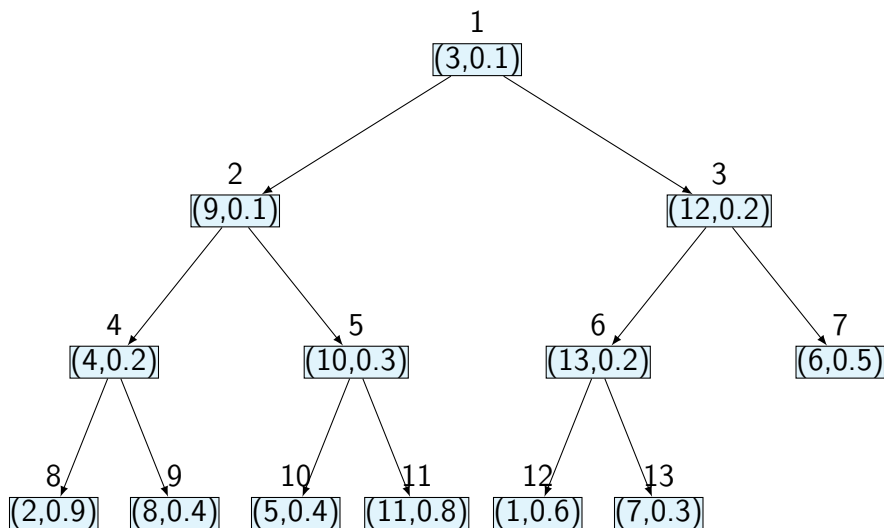
# Constructor

- The constructor initializes the binary heap with an empty list.
- The first element of the list is set to `Null`.
- The number of elements,  $n$  is set to zero.



# Add a new element

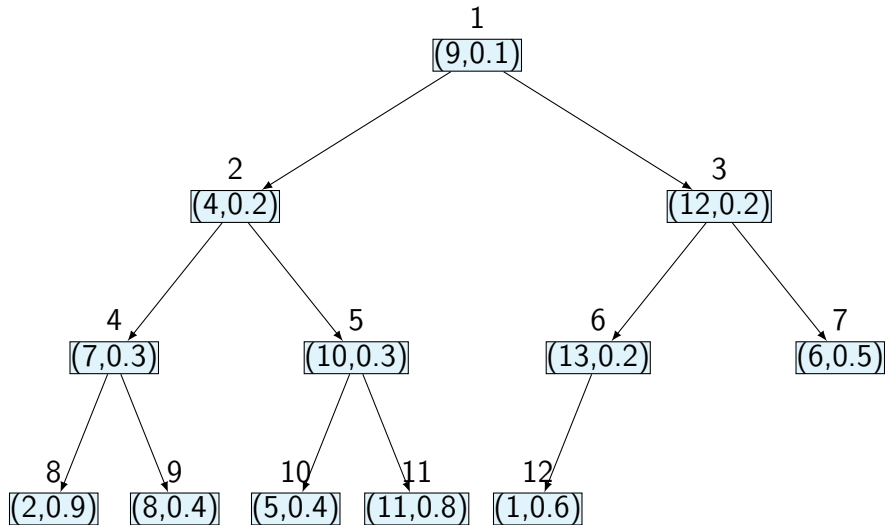
- The new element is added to the end of the list.
- The added element moves up to the adequate position for keeping the binary heap property.



The new element (13, .2) is added at 13-th and moves up to 6-th. The element (7, 0.3) moves down to 13-th by exchanging the positions.

# Extract the minimum element

- The minimum element is the root node.
- After removing the root node, the last element of the list is moved to the root position.
- The new root node moves down to the adequate position for keeping the binary heap property.



# Check the emptiness

- If the list contains only `Null`, the binary heap is empty.