CSC 255

Unit 5 Programming Assignment 2 [50 points]

Skip Lists

Create a class that implements the skip list data structure that stores keys in ascending order and allows repeats. **[40 points]**

The following skip list functions must be implemented and tested in a driver program: constructor, insert, remove, search, and display.

Use the provided pseudocode for the skip list data structure, and driver for testing.

Use alternate sentinels in place of the theoretical $-\infty$ and $+\infty$. For example, use "inf+" instead of $+\infty$.

Use a template style as necessary for the various data stored in the associated values.

Skip list class pseudocode:

```
class SkipListNode
    -Define the structure for each node in the skip list
    Data members:
        -Key for the node
         key: int
        -Value associated with the key
         value: Any
        -Pointers to the next nodes in different levels
         forward: Array of SkipListNode
        -Level of the node in the skip list
         level: int

class SkipList
    -Define the skip list data structure
    Data members:
        -Head node of the skip list
         head: SkipListNode
        -Maximum level of the skip list
         max_level: int
        -Probability for a node to be included at a higher level
         probability: float

    Member functions:
        function constructor():
            -Initialize the skip list
            -Create the head node with maximum level and initialize pointers
            -Set probability for node inclusion at higher levels
            -Set other initializations as required

        function search(K):
            -Search for a node with the given key (K) in the skip list
            -Traverse through the levels starting from the highest level
            -Update pointers to move forward or down based on key comparison
            -Return true if the value (of type Any) associated with the key is found,
            -otherwise return false
```

```
function insert(K, V):
     -Insert a node with the given key (K) and value (V) into the skip list
     -Generate a random level for the new node: if the randomly generated value
     -is less than the probability threshold, then add one (1) to the level;
     -repeat until the threshold or max level is reached.
     -Create the new node and initialize its pointers
     -Traverse through the levels starting from the highest level
     -Update pointers to insert the new node at appropriate positions
     -Update the maximum level if necessary

function remove(K):
     -Remove a node with the given key (K) from the skip list
     -Traverse through the levels starting from the highest level
     -Update pointers to bypass the node to be removed
     -Adjust the maximum level if necessary
     -Return true if K is removed, and false if K is not found

function display():
     -Display the contents of the skip list
     -Traverse through the levels starting from the highest level
     -Print key-value pairs of each node in each level
```

Driver pseudocode:

```
-Initialize a skip list so that it can hold at most 500 items.
skip_list = SkipList()

-Insert ten (10) items with a random key in the range of 1 to 2000
-into the skip list.
size = 10
i = 1
while i < size + 1 do
       key = random int in range of 1 to 2000
       skip_list.insert(key, "Value" + i)
       i = i + 1
-Search for some nodes.
-For example:
result = skip_list.search(10)
if result is true then
    output "Value found"
else
    output "Value not found"
-Remove some nodes.
-For example:
skip_list.remove(5)

-Display the skip list
skip_list.display()
```

The structure of the resulting skip list would look like this figure (**Figure 1**):

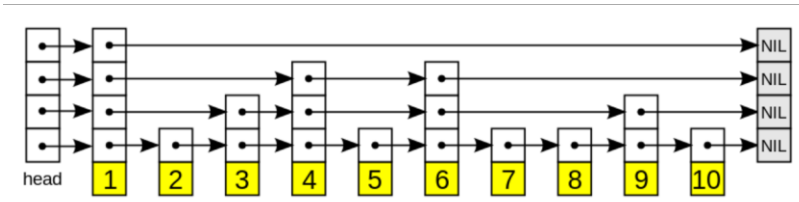

Figure 1

Now, let's consider some questions about our skip list.

1. Is it important to know the expected size of the skip list? Why? **[2 points]**
2. How can we calculate the max level used for a skip list? Why? **[2 points]**
3. Is the random generator used suitable for determining the random level used for an insertion? Can we find a better option? The answer will be related to the random library used. **[4 points]**
4. Why would using a skip list be a bad idea if duplicate keys were not allowed? **[2 points]**