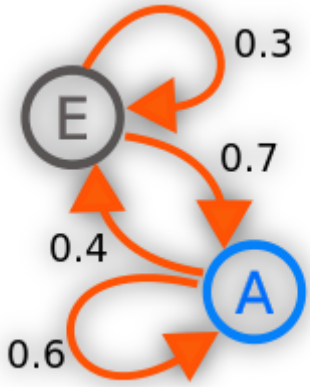
Due on Tuesday, February 7th at midnight.

Assignment #1: Markov Text Generator **version** 1.1

In probability theory, Markov Process is used to determine the next state based on the only available information of the current state. In this process the current state and the probabilities for each transition from the current state to one of the possible next states are known. Randomly following the transitions with respect to their probabilities a Markov Chain is generated. Following figure shows an example Markov process [https://en.wikipedia.org/wiki/Markov_chain] where the numbers represent the probabilities of changing the state from A to E or vice versa depending on the direction of arrow. If the current state of the Markov Process is A then the probability of transitioning to the state E is 0.4 while the probability of staying in the same state is 0.6.



In this assignment, you are asked to implement a program using several data structures to extend an existing text using Markov Process model. You are first going to train your program with the possible states and the probabilities for each state for transitioning to other states. In this training process, the distinct words in the input text are going to represent your state space. For each distinct word, w, you are supposed to find the list of words that come after w in the text. Therefore, number of occurrences of a particular word w1 after the word w will represent the probability of transitioning from state w to state w1. Once the training is done and the required data structures are created, you are then supposed to generate a new line with a specified number of words by randomly transitioning between states or words.

There are several different list structures you can use to accomplish this task. You are required to implement the given IMarkov interface to create each list structure as described below.

```
template<class T>
class IMarkov {
	public:
		virtual void add(T, T)=0;
		virtual T generate(int)= 0;
		virtual ~IMarkov(){}
};
```

PART 1: DATA STRUCTURES TO IMPLEMET

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1. **Doubly Linked List (DLL_Markov):** In this approach you are required to implement the DLL_Markov class. As shown in DLL_Markov_Node, every node of the doubly linked list includes a list of words that come after this node.
   Doubly Linked List Node: The node structure in this case looks like this:

```
template<class T>
class DLL_Markov_Node {
	public:
		T getRandom();
		void addNew(T t);
		T info;
		Vector<T> v;
		DLL_Markov_Node<T> *next, *prev;
};
```

   addNew method is used during training to add a new successor to the node. getRandom generates a random number, i, between 0 and size of v and returns the ith element of the vector v. This vector contains all words in the original text that appear after the word represented by info member of this node. The vector v may contain the same word, w1, more than once depending on whether that word, w1, appears after the word w (value of info) more than once in the text.
   Doubly Linked List Methods: The add(T t1, T t2) and generate(int i) methods are the two pure virtual functions that you are required to implement in every concrete list class. For doubly linked list add method first searches through the list and finds the node with the value of t1. If this node does not exists, it creates a new one with this value and adds t2 to the vector v. add is used only in training process, while generate is used to generate random text. Generate method randomly picks one node in the list and calls getRandom on this node. It stores the value returned by getRandom and finds the node that has this returned node. This process is repeated until i number of words are randomly generated. The DLL_Markov will look like this (it will include other members to implement a doubly linked list):

```
template <class T>
class DLL_Markov :public IMarkov<T> {
	public:
		void add(T t1, T t2);
		T generate(int);
	private:
		DLL_Markov_Node<T> *head, *tail;
};
```

2. **Multi Linked List (ML_Markov):** This is essentially another doubly linked list based approach. Compared to the DLL_Markov list, a node with value w1 includes a list of pointers to each node with value w2 such that w2 comes after w1 in the text.
   Multi Linked List Node: The node in this case is similar to this:

```
template<class T>
class ML_Markov_Node {
	public:
		ML_Markov_Node<T>* getRandom();
		void addNew(ML_Markov_Node<T>* t;
		T info;
		Vector<ML_Markov_Node<T>*> v;
		ML_Markov_Node<T> *next, *prev;
```

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```
};
```

Multi Linked List Methods: You are required to implement the following ML_Markov class. The add(T t1, T t2) method in this case first finds the node, n1, with the value of t1 (creates if it does not exists), then finds the node, n2, with the value of t2 (creates if it does not exists), then adds the address of n2 in n1's v vector. generate(int i) method randomly picks a node, stores its info, then calls getRandom on this node. getRandom returns a node address. It stores the value of the returned node (info) and then calls getRandom again. This process continues until i number of random words are generated.

```
template <class T>
class ML_Markov :public IMarkov<T> {
	public:
		void add(T t1, T t2);
		T generate(int);
	private:
		int size;
		ML_Markov_Node<T> *head, *tail;
};
```

3. **SkipList:** Lastly you are required to implement the IMarkov interface using a skiplist structure. Similar to the first doubly linked list implementation, the nodes in this case will include a vector of successor words.

   SkipList Node: In this case, your node structure will be similar to this:

```
struct Node {
	Vector<T> v;
	T x;
	int height;
	Node *next[];
	T getRandom();
};
```

   We just added a vector to the node that includes all the successor words of the word x.

   SkipList_Markov Methods: This class will also implement the same interface as well as any other methods for the skiplist operations. add and generate methods will work exactly like the the add and method of the **DLL_Markov** class, except for the fact that find operation in this case implemets a skiplist find method which is not sequential.

```
template<class T>
class Skiplist_Markov :public IMarkov<T> {
	public:
		T generate(int i);
		void add(T t1, T t2);
};
```

PART 2: TESTING YOUR CODE

In order to demo that you have implemented and met all the requirements correctly, you need to read an arbitrary text file and create a vector of strings, ws, that includes all words in the text. Then iterate through ws calling add(ws[i],ws[i+1]). Once this training is done, you need to call generate(i) and print out whatever is returned by generate method (a string with i words in this case).

```
void split(const std::string &s, char delim, Vector<std::string> &elems) {
	string temp;
	for (size_t i = 0; i <s.size(); i++)
```

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```
	{
		if (s.at(i) != delim)
		{
			temp.append(s, i, 1);
			if (i == s.size()-1)
				elems.addBack(temp);
		}
		else if (temp != "")
		{
			elems.addBack(temp);
			temp = "";
		}
	}
}
int main(){
	srand(time(0));
	IMarkov<string>* markov = new DLL_Markov<string>();
	std::ifstream file("text.txt");
	std::string str;
	Vector<std::string> elems;
	while (std::getline(file, str))
	{
		split(str, ' ', elems);
	}
	for (int i = 0; i < elems.size()-1; i++)
	{
			markov->add(elems.get(i), elems.get(i + 1));
	}
	cout<<markov->generate(20);

}
```

PART 3: WHAT TO SUBMIT?

You are required to submit one compressed (rar) file that includes your Visual Studio solution that demonstrates that you have implemented all the requirements. We will test your code with our own text file to create a new line with 20 words. In your project you are required to create a modular structure. For that you need to include each structure in its own file. You are not allowed to use any STL container such as STL vector or list. You are required to implement your own vector as well as the markov lists described above. Your solution shall include at least the following packages (a package is a set of .h and .cpp files with the same name)

1. I Marhov package: This includes the IMarkov interface.
2. IVector: This include you own vector class.
3. DLL_Markov: This includes your doubly linked list based IMarkov implementation.
4. ML_Markov: This includes your multi linked list based IMarkov implementation.
5. SkipList_Markov: This includes you skiplist based IMarkov implementation.
6. Test: This includes your main function and other helper functions to test your structures. It will include all necessary parts to read the input file, to construct the vector of the words, to train your data structures and generate a new line with 20 words.

You are also required to include a bigO.pdf file in your submission where you discuss and compare the big-O time complexities of your three data structures' add and generate methods.

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Submit you file before 12:00AM, on Tuesday February 7, 2017. A late penalty of 5 point will be applied per day late. Submission will not be accepted after Tuesday February 7, 2017.