МИНОБРНАУКИ РОССИИ
САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ
ЭЛЕКТРОТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
«ЛЭТИ» ИМ. В.И. УЛЬЯНОВА (ЛЕНИНА)
Кафедра САПР

ОТЧЕТ

по лабораторной работе 3

по дисциплине «Алгоритмы и структуры данных»

Тема: нахождение кратчайшего пути по алгоритму Беллмана-Форда

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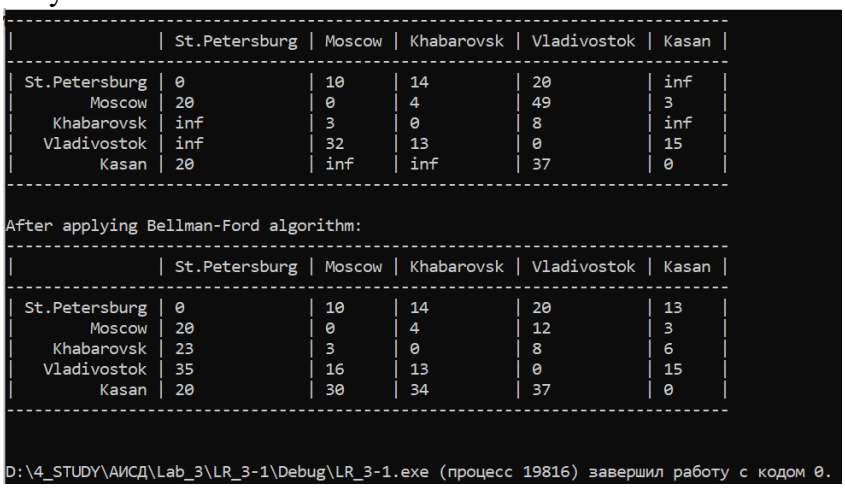
Задача: найти наиболее эффективный по стоимости перелет из города i в город j используя алгоритм Беллмана-Форда.

Описание алгоритмов:
Алгоритм позволяет найти кратчайший путь в ориентированном графе из исходной вершины до любой другой вершины этого графа.

Оценка временной сложности:
Ford_Bellman O(n^4)

Результат:



Листинг:

Main.cpp

```
#include "FB.h"

int main()
{
    setlocale(LC_ALL, "Russian");

    AdjMatrix graph;
    ifstream fin;
    const char filename[] = "input.txt";

    fin.open(filename);
    if (fin.good()) fin >> graph;
    else return 5;

    cout << "Initial graph's adjecent matrix is\n" << graph << "\n";
    cout << "After applying Bellman-Ford algorithm:\n" << graph.FordBellman() << endl;

    fin.close();
    return 0;
    }
```

FB.h

```
#include "linear.h"
#include <fstream>
#include <iomanip>

#define INF ((double)(1e300 * 1e300))

const string NOT_AVAILABLE = "N/A";

class AdjMatrix
{
       size_t size;
```

```
        string* names;
        double** values;

        void outputline(ostream& stream, AdjMatrix& matrix, size_t maxwidth)
        {
                stream << "--";
                for (size_t i = 0; i < maxwidth; i++) stream << '-';
                stream << "---";
                for (size_t i = 0; i < matrix.size; i++)
                {
                        const size_t len = matrix.names[i].length();
                        for (size_t j = 0; j < len; j++)
                        {
                                stream << '-';
                        }
                        stream << "--" << (i == matrix.size - 1 ? '\n' : '-');
                }
        }

public:
        AdjMatrix() : values(nullptr), names(nullptr), size(0) {}
        AdjMatrix(size_t size, string* names, double** values) : values(values), names(names),
size(size) {}
        ~AdjMatrix()
        {
                if (values != nullptr)
                {
                        for (size_t i = 0; i < size; i++)
                        {
                                delete[] values[i];
                        }
                        delete[] values;
                }
        }

        friend bool operator==(AdjMatrix& gr1, AdjMatrix& gr2)
        {
                if (gr1.size != gr2.size) return false;
                for (size_t i = 0; i < gr1.size; i++) if (gr1.names[i] != gr2.names[i]) return
false;
                for (size_t i = 0; i < gr1.size; i++)
                {
                        for (size_t j = 0; j < gr1.size; j++)
                        {
                                if (gr1.values[i][j] != gr2.values[i][j]) return false;
                        }
                }
                return true;
        }

        friend ifstream& operator>>(ifstream& stream, AdjMatrix& matrix)
        {
                string name1_buffer, name2_buffer;
                double value1_buffer, value2_buffer;
                List<string> names;
                while (!stream.eof())
                {
                        string temp;
                        stream >> name1_buffer >> name2_buffer >> value1_buffer >> value2_buffer;
                        if (names.Find(name1_buffer) < 0) names.PushBack(name1_buffer);
                        if (names.Find(name2_buffer) < 0) names.PushBack(name2_buffer);
                        if (value1_buffer == 0)
                        {
                                stream.clear();
                                stream >> temp >> value2_buffer;
                        }
                        if (value2_buffer == 0)
                        {
                                stream.clear();
```

```
                        if (temp == NOT_AVAILABLE) throw invalid_argument("Wrong input");
                        stream >> temp;
                }
        }
        matrix.size = names.GetSize();
        matrix.names = new string[matrix.size];
        matrix.values = new double* [matrix.size];
        for (size_t i = 0; i < matrix.size; i++)
        {
                matrix.names[i] = names.GetData();
                names.PopFront();
                matrix.values[i] = new double[matrix.size];
                for (size_t j = 0; j < matrix.size; j++)
                {
                        matrix.values[i][j] = (i == j ? 0 : INF);
                }
        }

        stream.seekg(ios::beg);
        while (!stream.eof())
        {
                string temp;
                stream >> name1_buffer >> name2_buffer >> value1_buffer >> value2_buffer;
                if (value1_buffer == 0)
                {
                        stream.clear();
                        stream >> temp >> value2_buffer;
                        value1_buffer = INF;
                }
                if (value2_buffer == 0)
                {
                        stream.clear();
                        stream >> temp;
                        value2_buffer = INF;
                }

                size_t i = 0, j = 0, k;
                for (k = 0; k < matrix.size; k++)
                {
                        if (matrix.names[k] == name1_buffer) i = k;
                        if (matrix.names[k] == name2_buffer) j = k;
                }
                matrix.values[i][j] = value1_buffer;
                matrix.values[j][i] = value2_buffer;
        }
        return stream;
}

friend ostream& operator<<(ostream& stream, AdjMatrix& matrix)
{
        size_t maxwidth = 0;
        for (size_t i = 0; i < matrix.size; i++)
        {
                if (matrix.names[i].length() > maxwidth) maxwidth =
matrix.names[i].length();
        }
        matrix.outputline(stream, matrix, maxwidth);
        stream << "| ";
        for (size_t i = 0; i < maxwidth; i++)
        {
                stream << ' ';
        }
        stream << " | ";
        for (size_t i = 0; i < matrix.size; i++)
        {
                stream << setw(matrix.names[i].length()) << left << matrix.names[i] << "
| ";
        }
        stream << "\n";
```

```
		matrix.outputline(stream, matrix, maxwidth);
		for (size_t i = 0; i < matrix.size; i++)
		{
			stream << "| " << setw(maxwidth) << right << matrix.names[i] << " | ";
			for (size_t j = 0; j < matrix.size; j++)
			{
				stream << setw(matrix.names[j].length()) << left <<
matrix.values[i][j] << " | ";
			}
			stream << "\n";
		}
		matrix.outputline(stream, matrix, maxwidth);
		return stream;
	}

	AdjMatrix& FordBellman()
	{
		if (size == 0) throw logic_error("Adjecent matrix does not have a graph yet");
		AdjMatrix* newMatrix = new AdjMatrix();
		newMatrix->size = size;
		newMatrix->names = names;
		newMatrix->values = new double* [size];

		// Choosing the vertex to calculate from
		for (size_t vertex = 0; vertex < size; vertex++)
		{
			// Initializing array with 0 on a current vertex and +INF on other
vertexes
			double* distances = new double[size];
			for (size_t i = 0; i < size; i++)
			{
				distances[i] = (i == vertex ? 0 : INF);
			}

			// Repeating algorithm [vertex count - 1] times (enough)
			for (size_t step = 0; step < size; step++)
			{
				// Relaxing edges
				for (size_t i = 0; i < size; i++)
				{
					for (size_t j = 0; j < size; j++)
					{
						if (i != j && values[i][j] < INF && distances[i] +
values[i][j] < distances[j])
						{
							if (step == size - 1) throw
logic_error("Graph has negative cycles");
							else distances[j] = distances[i] +
values[i][j];
						}
					}
				}
			}
			newMatrix->values[vertex] = distances;
		}

		return *newMatrix;
	}

	inline double** GetValues() { return values; }
};
```

Linear.h

```
#ifndef LINEAR_STRUCT
#define LINEAR_STRUCT
#include <iostream>
using namespace std;
```

```
template <class T>
class List
{
protected:
	struct ListElement
	{
		ListElement* previous, * next;
		T data;

		ListElement(T& data, ListElement* next = nullptr, ListElement* previous =
nullptr) : data(data), previous(previous), next(next) {}
		~ListElement() {}
	};

public:
	ListElement* head, * tail;

	List() : head(nullptr), tail(nullptr) {}

	List(const size_t size, T* arr) : head(nullptr), tail(nullptr)
	{
		for (size_t i = 0; i < size; i++) this->PushBack(arr[i]);
	}

	List(List<T>& ref) : head(nullptr), tail(nullptr)
	{
		const size_t size = ref.GetSize();
		for (size_t i = 0; i < size; i++)
		{
			T newElem = ref.GetData(i);
			this->PushBack(newElem);
		}
	}

	template <typename... Args> List(Args... list) : head(nullptr), tail(nullptr) { this-
>PushBack(list...); }

	template <typename... Args>
	void PushBack(T first, Args&... rest)
	{
		this->PushBack(first);
		this->PushBack(rest...);
	}

	~List()
	{
		if (head != nullptr) Clear();
	}

	List<T>& operator+(List<T>& l)
	{
		List<T>* newList = new List<T>();
		for (size_t i = 0; i < GetSize(); i++) newList->PushBack(GetData(i));
		for (size_t i = 0; i < l.GetSize(); i++) newList->PushBack(l.GetData(i));
		return *newList;
	}

	void operator+=(List<T>& l)
	{
		*this = *this + l;
	}

	friend bool operator==(List<T>& list1, List<T>& list2)
	{
		ListElement* current1 = list1.head;
		ListElement* current2 = list2.head;
		while (current1 != nullptr)
		{
			if (current2 != nullptr)
```

```
                {
                        if (current1->data != current2->data) return false;
                }
                else return false;
                current1 = current1->next;
                current2 = current2->next;
        }
        if (current2 != nullptr) return false;
        return true;
}

friend ostream& operator<<(ostream& stream, List<T>& list)
{
        ListElement* current = list.head;
        stream << "[";
        while (current != nullptr)
        {
                stream << current->data;
                if (current->next != nullptr) stream << " ";
                current = current->next;
        }
        stream << "]";
        return stream;
}

void Clear()
{
        if (head == nullptr) throw logic_error("List is already empty");
        while (head != nullptr)
        {
                if (head->next == nullptr) break;
                head = head->next;
                delete head->previous;
        }
        delete head;
}

size_t GetSize()
{
        int size = 0;
        ListElement* current = head;
        while (current != nullptr)
        {
                size++;
                current = current->next;
        }
        return size;
}

int Find(T element)
{
        ListElement* current = head;
        int index = 0;
        while (current != nullptr)
        {
                if (current->data == element) return index;
                current = current->next;
                index++;
        }
        return -1;
}

virtual void PushFront(T element)
{
        ListElement* newElement = new ListElement(element, head);
        if (head == nullptr)
        {
                head = newElement;
                tail = head;
```

```
		}
		else
		{
			head->previous = newElement;
			head = head->previous;
		}
		return;
	}

	virtual void PushBack(T element)
	{
		ListElement* newElement = new ListElement(element, nullptr, tail);
		if (tail == nullptr)
		{
			tail = newElement;
			head = tail;
		}
		else
		{
			tail->next = newElement;
			tail = tail->next;
		}
		return;
	}

	virtual void Push(T element)
	{
		throw logic_error("Push is undefinable, use PushFront/PushBack/PushIndex");
	}

	virtual void PushIndex(int index, T element)
	{
		const size_t lastIndex = GetSize() - 1;
		if (index == 0) PushFront(element);
		else if (index == lastIndex + 1) PushBack(element);
		else if (index > lastIndex + 1 || index < 0) throw out_of_range("Stated index is
invalid");
		else
		{
			int currentIndex = 1;
			ListElement* current = head->next;
			while (currentIndex != index)
			{
				current = current->next;
				currentIndex++;
			}
			ListElement* newElement = new ListElement(element, current, current-
>previous);
			current->previous->next = newElement;
			current->previous = newElement;
		}
	}

	virtual void PopFront()
	{
		if (head == nullptr) throw logic_error("List is already empty");
		if (head->next == nullptr)
		{
			delete head;
			head = nullptr;
			tail = nullptr;
		}
		else
		{
			head = head->next;
			delete head->previous;
			head->previous = nullptr;
		}
		return;
```

```
	}

	virtual void PopBack()
	{
		if (tail == nullptr) throw logic_error("List is already empty");
		if (tail->previous == nullptr)
		{
			delete tail;
			head = nullptr;
			tail = nullptr;
		}
		else
		{
			tail = tail->previous;
			delete tail->next;
			tail->next = nullptr;
		}
		return;
	}

	virtual void PopIndex(int index)
	{
		const size_t lastIndex = GetSize() - 1;
		if (index == 0) PopFront();
		else if (index == lastIndex) PopBack();
		else if (index > lastIndex || index < 0) throw out_of_range("Stated index is
invalid");
		else
		{
			int currentIndex = 1;
			ListElement* current = head->next;
			while (currentIndex != index)
			{
				current = current->next;
				currentIndex++;
			}
			ListElement* next = current->next, * previous = current->previous;
			delete current;
			next->previous = previous;
			previous->next = next;
		}
	}

	virtual void Pop()
	{
		throw logic_error("Push is undefinable, use PopFront/PopBack/PopIndex");
	}

	T& GetData(size_t index = 0)
	{
		ListElement* current = head;
		size_t i = 0;
		while (current != nullptr)
		{
			if (i == index) return current->data;
			i++;
			current = current->next;
		}
		throw out_of_range("Index is incorrect");
	}

	inline void PrintData() { cout << *this; }
};

template <typename T>
class Queue : public List<T>
{
public:
	List<T>::Clear;
```

```
        List<T>::GetSize;

        void PushFront(T element) override
        {
                throw logic_error("Queue structure has no access to execute PushFront");
        }

        List<T>::PushBack;

        void PushIndex(int index, T element) override
        {
                if (index == GetSize()) PushBack(element);
                else throw logic_error("In queue structure pushing index can only be the last
one");
                return;
        }

        void Push(T element) override
        {
                PushBack(element);
                return;
        }

        List<T>::PopFront;

        void PopBack() override
        {
                throw logic_error("Queue structure has no access to execute PopBack");
        }

        void PopIndex(int index) override
        {
                if (index == 0) PopFront();
                else throw logic_error("In queue structure popping index can only be zero");
                return;
        }

        void Pop() override
        {
                PopFront();
                return;
        }

        List<T>::GetData;

        List<T>::PrintData;
};

template <typename T>
class Stack : public List<T>
{
public:
        List<T>::Clear;

        List<T>::GetSize;

        List<T>::PushFront;

        void PushBack(T element) override
        {
                throw logic_error("Stack structure has no access to execute PushFront");
        }

        void PushIndex(int index, T element) override
        {
                if (index == 0) PushFront(element);
                else throw logic_error("In stack structure pushing index can only be zero");
                return;
```

```
        }

        void Push(T element) override
        {
                PushFront(element);
                return;
        }

        List<T>::PopFront;

        void PopBack() override
        {
                throw logic_error("Stack structure has no access to execute PopBack");
        }

        void PopIndex(int index) override
        {
                if (index == 0) PopFront();
                else throw logic_error("In stack structure popping index can only be zero");
                return;
        }

        void Pop() override
        {
                PopFront();
                return;
        }

        List<T>::GetData;

        List<T>::PrintData;
};
#endif // LINEAR_STRUCT
```