

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
МОСКОВСКИЙ АВИАЦИОННЫЙ ИНСТИТУТ
(НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ)

ЛАБОРАТОРНАЯ РАБОТА №6

по курсу “Объектно-ориентированное программирование» 1 семестр,
2021/22 уч. год

Студент: Колпакова Диана Саргаевна, группа М8О-208Б-20
Преподаватель: Дорохов Евгений Павлович

Задание

1. Используя структуру данных, разработанную для лабораторной работы №5, спроектировать и разработать аллокатор памяти для динамической структуры данных.

Цель построения аллокатора – минимизация вызова операции **malloc**. Аллокатор должен выделять большие блоки памяти для хранения фигур и при создании новых фигур-объектов выделять место под объекты в этой памяти.

Алокатор должен хранить списки использованных/свободных блоков. Для хранения списка свободных блоков нужно применять динамическую структуру данных (контейнер 2-го уровня, согласно варианту задания).

Для вызова аллокатора должны быть переопределены оператор **new** и **delete** у классов-фигур. Нельзя использовать:

Стандартные контейнеры `std`.

Программа должна позволять:

- Вводить произвольное количество фигур и добавлять их в контейнер;
- Распечатывать содержимое контейнера;
- Удалять фигуры из контейнера.

Вариант 9:

Фигура №1	Имя класса	Фигура №2	Имя класса	Фигура №3	Имя класса
Треугольник	Triangle	Квадрат	Square	Прямоугольник	Rectangle

Описание программы

Исходный код лежит в 14 файлах:

1. `main.cpp`: часть программы, отвечающая за взаимодействие с пользователем через консоль. В ней происходит инициализация объектов и вызов функций работы с ними, заполнение стандартного контейнера вектор введенными объектами и печать его содержимого;
2. `point.h`: описание класса `Point` точек $A(a_1, a_2)$;
3. `point.cpp`: реализация класса `Point`;

4. figure.h: описание абстрактного класса-родителя Figure;
5. figure.cpp: реализация класса Figure;
6. triangle.h: описание класса Triangle треугольников, заданных по трем точкам, наследника Figure;
7. triangle.cpp: реализация класса Triangle;
8. tlinkedlist.h
9. tlinkedlist.cpp
10. tlinkedlistitem.h
11. tlinkedlistitem.cpp
12. titerator.h
13. titerator.cpp
14. TVector.h
15. TVector.cpp
16. CMakeLists.txt

Также используется файл CMakeLists.txt с конфигурацией CMake для автоматизации сборки программы.

Дневник отладки

Проблем не возникло

Вывод

Выполняя лабораторную работу, я начала разбираться в устройстве алокаторов и работе с блоками памяти в C++. Хотя и в начале использовать аллокаторы было непривычно, в этой лабораторной мне удалось поработать с памятью напрямую. И мой аллокатор помог избежать лишних системных вызовов для выделения небольшого блока памяти.

Исходный код

main.cpp:

```
// OOP, Lab 3 variant 9, Diana Kolpakova  
// Triangle, TLinkedList, shared_ptr
```

```

#include <iostream>

#include "figure.h"
#include "triangle.h"
#include "tlinkedlist.h"

using namespace std;

int main()
{
    cout.setf(ios_base::boolalpha);
    cout << "oop_exercise_3 (c) Diana Kolpakova" << endl;
    cout << "Triangles, TLinkedList, shared_ptr" << endl;

    shared_ptr<TLinkedList> pList(new TLinkedList());

    for (;;)
    {
        cout << endl;
        cout << "Select an action for the linked list of triangles" << endl;
        cout << "1) Is the list empty?" << endl;
        cout << "2) Get number of triangles in the list" << endl;
        cout << "3) Show the first triangle from the list" << endl;
        cout << "4) Show the last triangle from the list" << endl;
        cout << "5) Show the triangle at a specified position in the list" <<
endl;
        cout << "6) Show areas of all triangles in the list" << endl;
        cout << "7) Add a new triangle to the beginning of the list" << endl;
        cout << "8) Add a new triangle to the end of the list" << endl;
        cout << "9) Add a new triangle to a specified position in the list" <<
endl;
        cout << "a) Remove the first triangle from the list" << endl;
        cout << "b) Remove the last triangle from the list" << endl;
        cout << "c) Remove the triangle at a specified position in the list" <<
endl;
        cout << "d) Remove all triangles from the list" << endl;
        cout << "l) Show all triangles from the list" << endl;
        cout << "x) End the program" << endl;

        try
        {
            shared_ptr<Triangle> pTriangle;
            size_t position;

            char ch;
            cin >> ch;
            switch (ch)
            {
                case '1':
                    cout << "Is the list empty: " << pList->Empty() << endl;
                    break;
                case '2':
                    cout << "Length of the list: " << pList->Length() << endl;
                    break;
                case '3':
                    pTriangle = pList->First();

```

```

        cout << *pTriangle << endl;
        break;
    case '4':
        pTriangle = pList->Last();
        cout << *pTriangle << endl;
        break;
    case '5':
        cout << "Enter position in the list:";
        cin >> position;
        pTriangle = pList->GetItem(position);
        cout << *pTriangle << endl;
        break;
    case '6':
        cout << "Triangle areas:" << endl;
        if (pList->Empty())
        {
            cout << "Empty list" << endl;
        }
        else
        {
            cout << *pList << endl;
        }
        break;
    case '7':
        pTriangle = shared_ptr<Triangle>(new Triangle());
        cout << "Enter 3 points of triangle (6 numbers):";
        cin >> *(pTriangle);
        pList->InsertFirst(pTriangle);
        cout << *pTriangle << endl;
        break;
    case '8':
        pTriangle = shared_ptr<Triangle>(new Triangle());
        cout << "Enter 3 points of triangle (6 numbers):";
        cin >> *(pTriangle);
        pList->InsertLast(pTriangle);
        cout << *pTriangle << endl;
        break;
    case '9':
        cout << "Enter 3 points of triangle (6 numbers):";
        pTriangle = shared_ptr<Triangle>(new Triangle());
        cin >> *(pTriangle);
        cout << "Enter position in the list:";
        cin >> position;
        pList->Insert(pTriangle, position);
        cout << *pTriangle << endl;
        break;
    case 'a':
    case 'A':
        pList->RemoveFirst();
        cout << "Removed the first triangle" << endl;
        break;
    case 'b':
    case 'B':
        pList->RemoveLast();
        cout << "Removed the last triangle" << endl;
        break;
    case 'c':

```

```

        case 'C':
            cout << "Enter position in the list:";
            cin >> position;
            pList->Remove(position);
            cout << "Removed the triangle at specified position" <<
endl;

            break;
        case 'd':
        case 'D':
            pList->Clear();
            cout << "Removed all" << endl;
            break;
        case 'l':
        case 'L':
            cout << "Triangles:" << endl;
            if (pList->Empty())
            {
                cout << "Empty list" << endl;
            }
            else
            {
                for (size_t i = 0; i < pList->Length(); i++)
                {
                    pTriangle = pList->GetItem(i);
                    cout << "#" << i << " " << *pTriangle << endl;
                }
            }
            break;
        case 'q':
        case 'Q':
        case 'x':
        case 'X':
            cout << "Exiting" << endl;
            return 0;
        default:
            cout << "Error: invalid action selected" << endl;
            break;
    }
}
catch (exception& ex)
{
    cout << "Exception: " << ex.what() << endl;
}
}
}

```

point.h:

```

#pragma once
#include <iostream>

using namespace std;

class Point
{
private:
    double x;

```

```

        double y;

public:
    Point();
    Point(double x, double y);

    static double Distance (const Point& point1, const Point& point2);

    friend istream& operator>>(istream& is, Point& point);
    friend ostream& operator<<(ostream& os, Point& point);

    bool operator==(const Point& other);
};

```

point.cpp:

```

#include <cmath>
#include "point.h"

using namespace std;

Point::Point()
{
    this->x = 0.0;
    this->y = 0.0;
}

Point::Point(double x, double y)
{
    this->x = x;
    this->y = y;
}

double Point::Distance(const Point& point1, const Point& point2)
{
    double dx = point1.x - point2.y;
    double dy = point1.y - point2.y;
    double distance = sqrt(dx * dx + dy * dy);
    return distance;
}

bool Point::operator==(const Point& other)
{
    return (this->x == other.x)
        && (this->y == other.y);
}

istream& operator>>(istream& is, Point& point)
{
    is >> point.x >> point.y;
    return is;
}

ostream& operator<<(ostream& os, Point& point)
{
    os << "(" << point.x << ", " << point.y << ")";
}

```

```
    return os;
}
```

figure.h:

```
#pragma once
#include "point.h"

class Figure
{
public:
    virtual size_t VertexesNumber() = 0;
    virtual double Area() = 0;
};
```

triangle.h:

```
#pragma once
#include "figure.h"

class Triangle : public Figure
{
private:
    Point point1;
    Point point2;
    Point point3;

public:
    Triangle();
    Triangle(Point point1, Point point2, Point point3);
    Triangle(const Triangle& other);

    virtual size_t VertexesNumber() override;
    virtual double Area() override;

    friend istream& operator>>(istream& is, Triangle& triangle);
    friend ostream& operator<<(ostream& os, Triangle& triangle);

    Triangle& operator=(const Triangle& other);
    bool operator==(const Triangle& other);
};
```

triangle.cpp:

```
#include "triangle.h"

using namespace std;

Triangle::Triangle()
{
    this->point1 = Point();
    this->point2 = Point();
    this->point3 = Point();
}

Triangle::Triangle(Point point1, Point point2, Point point3)
```



```

{
    this->point1 = point1;
    this->point2 = point2;
    this->point3 = point3;
}

Triangle::Triangle(const Triangle& other)
{
    this->point1 = other.point1;
    this->point2 = other.point2;
    this->point3 = other.point3;
}

size_t Triangle::VertexesNumber()
{
    return 3;
}

double Triangle::Area()
{
    double length12 = Point::Distance(point1, point2);
    double length23 = Point::Distance(point2, point3);
    double length31 = Point::Distance(point3, point1);
    double semiPerimeter = (length12 + length23 + length31) / 2.0;
    return sqrt(semiPerimeter * (semiPerimeter - length12) * (semiPerimeter -
length23) * (semiPerimeter - length31));
}

istream& operator>>(istream& is, Triangle& triangle)
{
    is >> triangle.point1 >> triangle.point2 >> triangle.point3;
    return is;
}

ostream& operator<<(ostream& os, Triangle& triangle)
{
    os << "Triangle: " << triangle.point1 << ", " << triangle.point2 << ", " <<
triangle.point3;
    return os;
}

Triangle& Triangle::operator=(const Triangle& other)
{
    this->point1 = other.point1;
    this->point2 = other.point2;
    this->point3 = other.point3;
    return *this;
}

bool Triangle::operator==(const Triangle& other)
{
    return (this->point1 == other.point1)
        && (this->point2 == other.point2)
        && (this->point3 == other.point3);
}

```

tlinkedlist.h:

```

#pragma once
#include "triangle.h"

class TLinkedList
{
private:
    struct Item
    {
        shared_ptr<Triangle> pTriangle;
        shared_ptr<Item> pNextItem;
    };

    size_t length;
    shared_ptr<Item> pFirstItem;
    shared_ptr<Item> pLastItem;

public:
    TLinkedList();
    TLinkedList(const TLinkedList& other);
    virtual ~TLinkedList();

    shared_ptr<Triangle> First();
    shared_ptr<Triangle> Last();
    shared_ptr<Triangle> GetItem(size_t position);

    void InsertFirst(shared_ptr<Triangle> pTriangle);
    void InsertLast(shared_ptr<Triangle> pTriangle);
    void Insert(shared_ptr<Triangle> pTriangle, size_t position);

    void RemoveFirst();
    void RemoveLast();
    void Remove(size_t position);

    void Clear();
    bool Empty();
    size_t Length();

    friend std::ostream& operator<<(std::ostream& os, const TLinkedList& list);
};

```

tlinkedlist.cpp:

```

#include "tlinkedlist.h"

TLinkedList::TLinkedList()
{
    pFirstItem = nullptr;
    pLastItem = nullptr;
    length = 0;
}

TLinkedList::TLinkedList(const TLinkedList& other)
{
    pFirstItem = nullptr;
    pLastItem = nullptr;
    length = 0;

    shared_ptr<Item> pCurrentItem = other.pFirstItem;
}

```

```

    while (pCurrentItem != nullptr)
    {
        InsertLast(pCurrentItem->pTriangle);
        pCurrentItem = pCurrentItem->pNextItem;
    }
}

shared_ptr<Triangle> TLinkedList::First()
{
    if (Empty())
        throw runtime_error("Cannon get the item from empty list");
    return pFirstItem->pTriangle;
}

shared_ptr<Triangle> TLinkedList::Last()
{
    if (Empty())
        throw runtime_error("Cannon get the item from empty list");
    return pLastItem->pTriangle;
}

void TLinkedList::InsertFirst(shared_ptr<Triangle> pTriangle)
{
    shared_ptr<Item> pNewItem(new Item());
    pNewItem->pTriangle = pTriangle;
    pNewItem->pNextItem = pFirstItem;

    pFirstItem = pNewItem;
    if (Empty())
        pLastItem = pNewItem;

    length++;
}

void TLinkedList::InsertLast(shared_ptr<Triangle> pTriangle)
{
    shared_ptr<Item> pNewItem(new Item());
    pNewItem->pTriangle = pTriangle;
    pNewItem->pNextItem = nullptr;

    if (pLastItem != nullptr)
        pLastItem->pNextItem = pNewItem;
    pLastItem = pNewItem;
    if (Empty())
        pFirstItem = pNewItem;

    length++;
}

void TLinkedList::Insert(shared_ptr<Triangle> pTriangle, size_t position)
{
    if (position == 0)
    {
        InsertFirst(pTriangle);
        return;
    }
    else if (position == length)

```

```

{
    InsertLast(pTriangle);
    return;
}
else if (position > length)
    throw runtime_error("Specified poition is out of range");

    int i = 0;
    shared_ptr<Item> pCurrentItem = pFirstItem;
    shared_ptr<Item> pPreviousItem = nullptr;
    while (pCurrentItem != nullptr)
    {
        if (i == position)
            break;
        pPreviousItem = pCurrentItem;
        pCurrentItem = pCurrentItem->pNextItem;
        i++;
    }

    shared_ptr<Item> pNewItem(new Item());
    pNewItem->pTriangle = pTriangle;
    pNewItem->pNextItem = pCurrentItem;

    pPreviousItem->pNextItem = pNewItem;

    length++;
}

void TLinkedList::RemoveFirst()
{
    if (Empty())
        throw runtime_error("Cannon remove the item from empty list");
    shared_ptr<Item> pNextItem = pFirstItem->pNextItem;
    pFirstItem = pNextItem;
    length--;
    if (Empty())
        pLastItem = nullptr;
}

void TLinkedList::RemoveLast()
{
    if (Empty())
        throw runtime_error("Cannon remove the item from empty list");

    shared_ptr<Item> pCurrentItem = pFirstItem;
    shared_ptr<Item> pPreviousItem = nullptr;
    while (pCurrentItem != nullptr)
    {
        if (pCurrentItem == pLastItem)
            break;
        pPreviousItem = pCurrentItem;
        pCurrentItem = pCurrentItem->pNextItem;
    }

    if (pPreviousItem != nullptr)
        pPreviousItem->pNextItem = nullptr;
    pLastItem = pPreviousItem;
}

```

```

        length--;
        if (Empty())
            pFirstItem = nullptr;
    }

void TLinkedList::Remove(size_t position)
{
    if (Empty())
        throw runtime_error("Cannon remove the item from empty list");
    if (position == 0)
    {
        RemoveFirst();
        return;
    }
    else if (position == length - 1)
    {
        RemoveLast();
        return;
    }
    else if (position >= length)
        throw runtime_error("Specified poition is out of range");

    int i = 0;
    shared_ptr<Item> pCurrentItem = pFirstItem;
    shared_ptr<Item> pPreviousItem = nullptr;
    while (pCurrentItem != nullptr)
    {
        if (i == position)
            break;
        pPreviousItem = pCurrentItem;
        pCurrentItem = pCurrentItem->pNextItem;
        i++;
    }

    pPreviousItem->pNextItem = pCurrentItem->pNextItem;
    length--;
}

shared_ptr<Triangle> TLinkedList::GetItem(size_t position)
{
    if (Empty())
        throw runtime_error("Cannon get the item from empty list");
    if (position >= length)
        throw runtime_error("Specified position is out of range");

    int i = 0;
    shared_ptr<Item> pCurrentItem = pFirstItem;
    while (pCurrentItem != nullptr)
    {
        if (i == position)
            return pCurrentItem->pTriangle;
        pCurrentItem = pCurrentItem->pNextItem;
        i++;
    }

    throw runtime_error("Something went wrong");
}

```

```

bool TLinkedList::Empty()
{
    return length == 0;
}

size_t TLinkedList::Length()
{
    return length;
}

void TLinkedList::Clear()
{
    shared_ptr<Item> pCurrentItem = pFirstItem;
    while (pCurrentItem != nullptr)
    {
        shared_ptr<Item> pNextItem = pCurrentItem->pNextItem;
        pCurrentItem = pNextItem;
    }
    pFirstItem = nullptr;
    pLastItem = nullptr;
    length = 0;
}

TLinkedList::~~TLinkedList()
{
    Clear();
}

std::ostream& operator<<(std::ostream& os, const TLinkedList& list)
{
    shared_ptr<TLinkedList::Item> pCurrentItem = list.pFirstItem;
    while (pCurrentItem != nullptr)
    {
        os << pCurrentItem->pTriangle->Area();
        if (pCurrentItem != list.pLastItem)
            os << " -> ";
        pCurrentItem = pCurrentItem->pNextItem;
    }
    return os;
}

```

TLinkedListItem.h:

```

#pragma once
#include <memory>

using namespace std;

template <class T>
class TLinkedListItem
{
private:
    shared_ptr<T> pValue;
    shared_ptr<TLinkedListItem<T>> pNextItem;

public:

```

```

    TLinkedListItem() {}
    TLinkedListItem(shared_ptr<T> pValue, shared_ptr<TLinkedListItem<T>>
pNextItem);
    virtual ~TLinkedListItem();
    shared_ptr<T> getValuePtr();
    shared_ptr<TLinkedListItem<T>> getNextItemPtr();
    void setNextItemPtr(shared_ptr<TLinkedListItem<T>> pNextItem);
};

```

TLinkedListItem.cpp:

```

#include <memory>
#include "triangle.h"
#include "tlinkedlistitem.h"

using namespace std;

template<class T>
inline TLinkedListItem<T>::TLinkedListItem(shared_ptr<T> pValue,
shared_ptr<TLinkedListItem<T>> pNextItem)
{
    this->pValue = pValue;
    this->pNextItem = pNextItem;
}

template<class T>
TLinkedListItem<T>::~~TLinkedListItem()
{
}

template<class T>
shared_ptr<T> TLinkedListItem<T>::getValuePtr()
{
    return pValue;
}

template<class T>
shared_ptr<TLinkedListItem<T>> TLinkedListItem<T>::getNextItemPtr()
{
    return pNextItem;
}

template<class T>
void TLinkedListItem<T>::setNextItemPtr(shared_ptr<TLinkedListItem<T>>
pNextItem)
{
    this->pNextItem = pNextItem;
}

template class TLinkedListItem<Triangle>;

```

TIteraror.h:

```

#pragma once
#include <memory>

```

```

using namespace std;

template<typename node, typename T>
class TIterator {
private:
    shared_ptr<node> ptr;

public:
    TIterator(shared_ptr<node> ptr)
    {
        this->ptr = ptr;
    }

    shared_ptr<T> operator*()
    {
        return ptr->getValuePtr();
    }

    shared_ptr<T> operator->()
    {
        return ptr->getValuePtr();
    }

    TIterator<node, T> operator++()
    {
        return ptr = ptr->getNextItemPtr();
    }

    TIterator<node, T> operator++(int)
    {
        TIterator iter(*this);
        ++(*this);
        return iter;
    }

    bool operator==(TIterator<node, T> const& other)
    {
        return ptr == other.ptr;
    }

    bool operator!=(TIterator<node, T> const& other)
    {
        return !(*this == other);
    }
};

```

TVector.h:

```

#pragma once
template <class T>
class TVector
{
private:
    const size_t minCount = 3;
    const size_t maxCount = 10;

    T * data;

```



```

    size_t count;
    size_t length;

public:
    TVector();
    TVector(const TVector& other);
    void InsertLast(T item);
    void RemoveLast();
    T Last();
    T& operator[] (const size_t position);
    bool Empty();
    const size_t Length();
    void Clear();
    virtual ~TVector();

    const size_t Find(T item);
    void RemoveAt(const size_t position);

private:
    void increaseAllocation();
};

```

TVector.cpp:

```

#include <memory>
#include <stdexcept>
#include "tvector.h"

using namespace std;

template<class T>
TVector<T>::TVector()
{
    data = new T[minCount];
    count = minCount;
    length = 0;
}

template<class T>
TVector<T>::TVector(const TVector& other)
{
    // TO DO
    data = new T[minCount];
    count = minCount;
    length = 0;
}

template<class T>
void TVector<T>::InsertLast(T item)
{
    if (length >= maxCount)
        throw runtime_error("cannot add new item to the list as the maximum size
reached");

    if (length >= count)
        increaseAllocation();
}

```

```

        data[length] = item;
        length++;
    }

template<class T>
void TVector<T>::RemoveLast()
{
    if (length == 0)
        throw runtime_error("cannot remove last item in empty list");

    length--;
}

template<class T>
T TVector<T>::Last()
{
    if (length == 0)
        throw runtime_error("cannot get last item from empty list");

    return data[length-1];
}

template<class T>
T& TVector<T>::operator[](const size_t position)
{
    if (position >= length)
        throw runtime_error("invalid position");
    return data[position];
}

template<class T>
bool TVector<T>::Empty()
{
    return length == 0;
}

template<class T>
const size_t TVector<T>::Length()
{
    return length;
}

template<class T>
void TVector<T>::Clear()
{
    length = 0;
}

template<class T>
TVector<T>::~~TVector()
{
    Clear();
    if (data != nullptr)
        delete data;
}

template<class T>

```

```

const size_t TVector<T>::Find(T item)
{
    for (size_t i = 0; i <= length; i++)
    {
        if (data[i] == item)
            return i;
    }
    return (size_t)-1;
}

template<class T>
void TVector<T>::RemoveAt(const size_t position)
{
    if (position >= length)
        throw runtime_error("invalid position");
}

template<class T>
void TVector<T>::increaseAllocation()
{
    size_t newCount = min(2 * count, maxCount);
    T* newData = new T[newCount];
    for (int i = 0; i < count; i++)
        newData[i] = data[i];
    delete data;
    data = newData;
    count = newCount;
}

template class TVector<int>;
template class TVector<byte*>;

```

CMakeLists.txt:

```

cmake_minimum_required(VERSION 3.21)
project(oop_exercise_6)

set(CMAKE_CXX_STANDARD 14)

include_directories(.)

add_executable(oop_exercise_6
    figure.cpp
    figure.h
    main.cpp
    point.cpp
    point.h
    tallocator.cpp
    tallocator.h
    tbinarytree.cpp
    tbinarytree.h
    tbinarytreeitem.cpp
    tbinarytreeitem.h
    titerator.cpp
    titerator.h
    tlinkedlist.cpp
    tlinkedlist.h

```

```
tlinkedlistitem.cpp  
tlinkedlistitem.h  
triangle.cpp  
triangle.h  
tvector.cpp  
tvector.h)
```