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**Лабораторна робота №2**

**з курсу: «Системне програмування»**

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**Тема**: Аллокатор пам’яті загального призначення (частина 1).

**Мета**: розробити аллокатор загального призначення.

**Лістинг:**

**Allocator.h**

#pragma once

struct LBlockDescriptor{

size\_t nextFreeBlock;//shift

};

struct PageDescriptor{

size\_t next; //list of pages with the same state

LBlockDescriptor\* firstFree; //free block in state 1

size\_t bsize; // size of lBlock in state 1 or number of blocks in state 2

char state; //0-free, 1-lblock, 2-mblock

};

class Allocator {

public:

Allocator(const size\_t ms, const size\_t ps);

//return addr on begin of allocated block or NULL

void\* mem\_alloc(size\_t size);

//return addr on begin of reallocated block or NULL

void\* mem\_realloc(void \*addr, size\_t size);

//free block by this address

void mem\_free(void \*addr);

//out blocks characteristic in table on console

void mem\_dump();

private:

//begin of control information

size\_t\* begin;

//begin of pages in memory

size\_t\* pagesBegin;

size\_t size;

size\_t pages;

size\_t pageSize;

//array of all page descriptors

PageDescriptor\* pageDescriptors;

//array of pages with state 1

size\_t\* lBlocks;

size\_t lBlocksLength;

size\_t firstFreePage;

//define what type of state rigth for this size

PageDescriptor defineCategory(size\_t s);

//round s to minimal need size power of 2

size\_t defineBlockSize(size\_t s);

//initial all pages as free

void initPages();

// return free block with size bs

size\_t\* getFreeLBlock(size\_t bs);

//return index for lBlocks array

size\_t getIndex(size\_t s);

size\_t createLBlockPage(size\_t bs);

//size\_t getLBlockPage(size\_t bs);

//not use :/

size\_t getFreePage();

//return page`s address from index of pages array

size\_t\* getAbsolutePageAddr(size\_t index);

//set all blocks in page to free state

void setAllFree(PageDescriptor pd);

//return big block with length ps\*pageSize

size\_t\* getFreeMBlock(size\_t ps);

//check is this block alst free in this page

bool freeLBlockIsLast(PageDescriptor pd);

//return number of page from her addr

size\_t findPageByAddress(size\_t\* addr);

//return number of block from his addr

size\_t findBlockByAddress(size\_t\* addr, size\_t bs);

//copy data from old pos to new

void copyData(size\_t\* from, size\_t\* to, size\_t length);

};

**Allocator.cpp**

#include <Windows.h>

#include <iostream>

#include "Allocator.h"

using namespace std;

Allocator::Allocator(const size\_t n, const size\_t ps){

pages = n / ps;

size\_t pds = sizeof(PageDescriptor)/sizeof(size\_t);

cout << pds << endl;

size\_t spaseForPD = pds\*pages;

size\_t maxbs = ps >> 1;

size\_t minbs = 16;

lBlocksLength = 1;

while(maxbs != minbs){

maxbs >>= 1;

lBlocksLength++;

}

size\_t needControlSpase = lBlocksLength + spaseForPD;

size\_t \*mas = new size\_t[n+needControlSpase];

size = n;

begin = mas;

pagesBegin = mas + needControlSpase;

pageSize = ps;

pageDescriptors = (PageDescriptor\*)begin;

lBlocks = begin + spaseForPD;

for(int i = 0; i < pages; i++){

pageDescriptors[i].state = 0;

}

for(int i = 0; i < lBlocksLength; i++){

lBlocks[i] = pages+1;

}

initPages();

cout << begin << endl;

cout << pagesBegin << endl;

cout << size << endl;

cout << pageSize << endl;

cout << pages << endl;

cout << lBlocksLength << endl;

cout << pageDescriptors << endl;

cout << lBlocks << endl;

}

void\* Allocator::mem\_alloc(size\_t s){

PageDescriptor def = defineCategory(s);

size\_t\* res;

if(def.state == 1){

res = getFreeLBlock(def.bsize);

} else {

res = getFreeMBlock(def.bsize);

}

return res;

}

PageDescriptor Allocator::defineCategory(size\_t s){

PageDescriptor pd;

if (s > (pageSize >> 1)){

pd.state = 2;

pd.bsize = s / pageSize;

pd.bsize += ((s % pageSize) > 0)? 1 : 0;

} else {

pd.state = 1;

pd.bsize = defineBlockSize(s);

}

return pd;

}

size\_t Allocator::defineBlockSize(size\_t s){

size\_t res = 16;

while(s > res){

res <<=1;

}

return res;

}

size\_t\* Allocator::getFreeMBlock(size\_t ps){

PageDescriptor pd = pageDescriptors[firstFreePage];

size\_t firstPage = firstFreePage;

size\_t thisPage = firstFreePage;

size\_t nextPage;

size\_t counter = 0;

while(pd.next <= pages && counter < ps){

nextPage = pd.next;

if(nextPage - 1 == thisPage){

counter++;

} else {

counter = 0;

firstPage = nextPage;

}

thisPage = nextPage;

pd = pageDescriptors[thisPage];

nextPage = pd.next;

}

if(counter == ps){

firstFreePage = nextPage;

return getAbsolutePageAddr(firstFreePage);

} else {

return NULL;

}

}

bool Allocator::freeLBlockIsLast(PageDescriptor pd){

LBlockDescriptor\* desc = pd.firstFree;

if(desc->nextFreeBlock){

return false;

} else {

return true;

}

}

size\_t\* Allocator::getFreeLBlock(size\_t bs){

size\_t numberOfPage = lBlocks[getIndex(bs)];

size\_t index;

if(numberOfPage > pages){

index = createLBlockPage(bs);

} else {

index = numberOfPage;

}

PageDescriptor pd = pageDescriptors[index];

LBlockDescriptor\* numberOfBlock = pd.firstFree;

if(numberOfBlock->nextFreeBlock == 0){

pd.firstFree = NULL;

lBlocks[index] = pages+1;

} else {

pd.firstFree = (LBlockDescriptor\*)((size\_t\*)(numberOfBlock) + numberOfBlock->nextFreeBlock);

}

return (size\_t\*)pd.firstFree;

}

size\_t Allocator::createLBlockPage(size\_t bs){

size\_t index = getFreePage();

if(index <= pages){

PageDescriptor pd = pageDescriptors[index];

pd.state = 1;

pd.bsize = bs;

size\_t\* addr = getAbsolutePageAddr(index);

for(int i = 0; i < pages/bs; i++){

LBlockDescriptor\* des = (LBlockDescriptor\*)addr[i\*pd.bsize];

des->nextFreeBlock = 1;

if(i == pages/bs - 1)

des->nextFreeBlock = 0;

}

pd.firstFree = 0;

pd.next = pages+1;

lBlocks[getIndex(bs)] = index;

}

return index;

}

size\_t\* Allocator::getAbsolutePageAddr(size\_t index){

size\_t\* res = NULL;

if(index <= pages){

res = &(pagesBegin[pageSize\*index]);

}

return res;

}

size\_t Allocator::getFreePage(){

PageDescriptor pd = pageDescriptors[firstFreePage];

firstFreePage = pd.next;

return pages+1;

}

void Allocator::setAllFree(PageDescriptor pd){

size\_t bs = pd.bsize;

size\_t blocks = pageSize / bs;

for(int i = 0; i < blocks; i++){

}

}

void Allocator::initPages(){

for(int i = 0; i < pages; i++){

pageDescriptors[i].state = 0;

pageDescriptors[i].next = i+1;

}

}

size\_t Allocator::getIndex(size\_t s){

size\_t counter = 0;

while(s > 1){

counter++;

s >>= s;

}

counter -= 4;

return counter;

}

void\* Allocator::mem\_realloc(void\* addr, size\_t size){

if(addr == NULL){

return mem\_alloc(size);

}

size\_t\* beg = (size\_t\*)addr;

size\_t pageNumber = findPageByAddress(beg);

PageDescriptor pd = pageDescriptors[pageNumber];

size\_t usefulMem;

if(pd.state == 1){

usefulMem = pd.bsize;

} else{

usefulMem = pd.bsize \* pageSize;

}

if(size == usefulMem){

return addr;

}

mem\_free(addr);

size\_t\* newAddr = (size\_t\*) mem\_alloc(size);

size\_t length = min(size, usefulMem);

copyData(beg, newAddr, length);

return newAddr;

}

void Allocator::copyData(size\_t\* from, size\_t\* to, size\_t length){

if (from > to){

for(int i = 0; i < length; i++){

to[i] = from[i];

}

} else {

for(int i = length-1; i <= 0; i++){

to[i] = from[i];

}

}

}

void Allocator::mem\_free(void\* addr){

size\_t pageNumber = findPageByAddress((size\_t\*)addr);

PageDescriptor pd = pageDescriptors[pageNumber];

if(pd.state == 1){

size\_t block = findBlockByAddress((size\_t\*)addr, pd.bsize);

if(pd.firstFree == NULL){

pd.firstFree = (LBlockDescriptor\*)(addr);

pd.firstFree->nextFreeBlock = 0;

} else {

size\_t shift = (size\_t\*)addr - (size\_t\*)(pd.firstFree);

pd.firstFree = (LBlockDescriptor\*)(addr);

pd.firstFree->nextFreeBlock = shift;

}

} else {

size\_t pgs = pd.bsize;

for(int i = 0; i < pgs; i++){

pd = pageDescriptors[pageNumber+i];

pd.state = 0;

pd.bsize = 0;

pd.firstFree = NULL;

pd.next = firstFreePage;

firstFreePage = pageNumber+i;

}

}

}

size\_t Allocator::findPageByAddress(size\_t\* addr){

size\_t shiftFromBegin = addr - pagesBegin;

size\_t pageNumber = shiftFromBegin / pageSize;

return pageNumber;

}

size\_t Allocator::findBlockByAddress(size\_t\* addr, size\_t bs){

size\_t shiftFromBegin = addr - pagesBegin;

size\_t shiftFromPageBegin = shiftFromBegin % pageSize;

size\_t number = shiftFromPageBegin / bs;

return number;

}

void Allocator::mem\_dump(){

cout << "begin: " << begin << endl;

cout << "begin of pages: " << pagesBegin << endl;

cout << "number of pages: " << pages << endl;

cout << "page size: " << pageSize << endl;

cout << "page descriptors state: " << endl;

PageDescriptor pd;

cout << "(state, size, next, firstFree)" << endl;

for (int i = 0; i < pages; i++){

pd = pageDescriptors[i];

cout << "["<<i<<"] " << pd.state << " " << pd.bsize << " "

<< pd.next << " " << pd.firstFree << endl;

}

}

**Runner.cpp**

#include <Windows.h>

#include <iostream>

#include "Allocator.h"

using namespace std;

int main(){

size\_t size = 1024\*4096;

size\_t ps = 4096;

int n = 300;

Allocator al(size, ps);

size\_t\*\* addrArray = new size\_t\*[n];

cout << "---------test started--------" << endl;

for(int i = 0; i < n; i++){

addrArray[i] = (size\_t\*)al.mem\_alloc(rand());

if(addrArray[i] == NULL){

cout << "error!!!" << endl;

}

}

al.mem\_dump();

for(int i = 0; i < n/3; i++){

al.mem\_realloc(addrArray[i], rand());

}

al.mem\_dump();

for(int i = n/2; i < n; i++){

al.mem\_free(addrArray[i]);

}

al.mem\_dump();

cout << "--------test\_finished-----------" << endl;

getchar();

return 0;

}