Programming Abstraction in C++

Eric S. Roberts and Julie Zelenski

Stanford University
2010

Chapter 9. Classes and Objects

Outline

1. Introduction
2. Implementing `stack`
3. Implementing `Scanner`

Outline

1. Introduction
2. Implementing `stack`
3. Implementing `Scanner`

Defining a class

Defining a `Point` class

```
class Point {
public:
    int x, y;
};
```

Similar to defining a structure

```
struct pointT {
    int x, y;
};
```

Hiding implementation

Normally, we want to hide (protect) or restrict the use of the instance variables from clients by exporting getters (accessors). Thus we hide the implementation details (fields `x` and `y`) and future changes in implementation will not affect user programs.

```
class Point {
public:
    int getX();
    int getY();
private:
    int x, y;
};
```

Hiding implementation

Making private instance variables and methods to hide implementation details for simplicity, flexibility, and security.

Hiding implementation

Making private instance variables and methods to hide implementation details for simplicity, flexibility, and security.

Getters (accessors) and setters (mutators).

Immutable classes, impossible to change the values of any instance variables after an object has been constructed, for example, Rational and many more.

Constructors and destructors

```
class Point {
public:
    Point(int xc, int yc);
    ~Point();
    int getX();
    int getY();
private:
    int x, y;
};
```

Constructors and destructors

```
class Point {
public:
    Point(int xc, int yc);
    ~Point();
    int getX();
    int getY();
private:
    int x, y;
};
```

For now, the destructor does nothing, since there is no need to free memory allocated on the heap.

Constructor

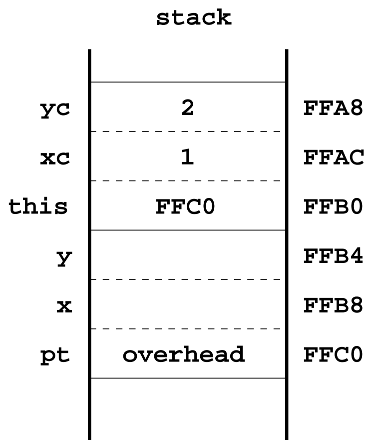
```
Point::Point(int xc, int yc) {
    x = xc;
    y = yc;
}
```

Constructor

```
Point::Point(int xc, int yc) {
    x = xc;
    y = yc;
}
```

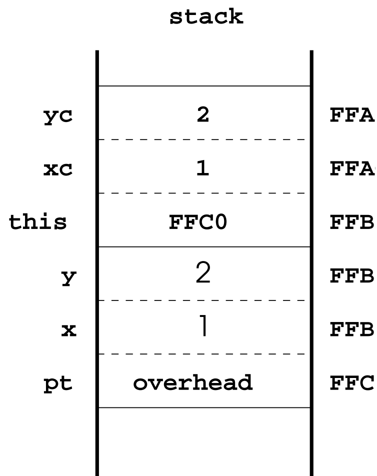
Constructor initializes instance variables.

Constructor (cont.)



Constructor (cont.)

`Point pt(1, 2)`



Constructor (cont.)

An ambiguity

```
Point::Point(int x, int y) {
    x = x;
    y = y;
}
```

Constructor (cont.)

An ambiguity

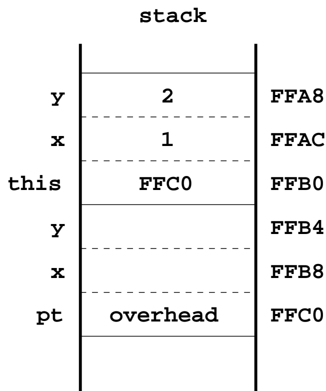
```
Point::Point(int x, int y) {
    x = x;
    y = y;
}
```

Resolve the ambiguity using the keyword `this`

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

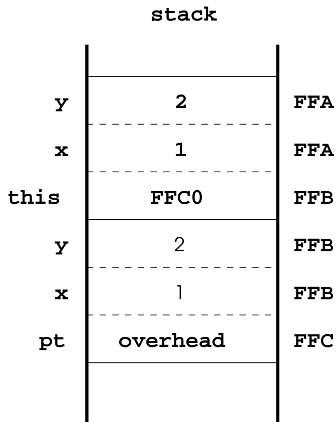
Keyword this

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



Keyword this

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



Destructor

Destructor frees any memory stored within the object that has been allocated on the heap.

For example,

expandable character stack

dynamic allocation.

Outline

1. Introduction
2. Implementing `stack`
3. Implementing `Scanner`

Implementing `stack`

Study `CharStack.h`, Figure 9-1, p. 320-321

- Documentation.
- Class definition.
- Interface design.
  - Use public methods to hide implementation, object encapsulation.
  - The private part on p. 323 can be replaced by the private part in Figure 9-3, p. 325, along with some changes in the method implementations on p. 326, but the public interface remains the same. Thus user programs are not affected.
  - Make private part “invisible” by including the private data file in the header file (p. 322).

Class definition

charstack.h

```
class Charstack {

public:

    Charstack();         // usage: Charstack cstk
    ~Charstack();

    int size();
    bool isEmpty();    // usage: cstk.isEmpty()
    void clear();
    void push(char ch);
    char pop();
    char peek();

private:
    ...
};
```

Implementation (static array)

charstack.h

```
private:
    static const int MAX_STACK_SIZE = 100;
    char elements[MAX_STACK_SIZE];
    int count;
```

Implementation (static array)

charstack.h

```
private:
    static const int MAX_STACK_SIZE = 100;
    char elements[MAX_STACK_SIZE];
    int count;
```

charstack.cpp

```
Charstack::Charstack() {
    count = 0;
}

Charstack::~Charstack() {
    /* Empty */
}
```

When an object is constructed, everything is allocated on (system) stack.

Implementation (static array)

charstack.cpp

```
void Charstack::push(char ch) {
    if (count == MAX_STACK_SIZE)
        Error("push: Stack is full");
    elements[count++] = ch;
}


char Charstack::pop() {
    if (isEmpty())
        Error("pop: Stack is empty");
    return elements[--count];
}
```

Note: `elements[count - 1]` is the top.

Implementation (dynamic array)

```
private:
    #include "cstkpriv.h"
```

cstkpriv.h

```
static const int INITIAL_CAPACITY = 100;

char *elements;    // dynamic array
int capacity;
int count;

void expandCapacity();
```

Implementation (dynamic array)

Constructor and destructor

```
Charstack::Charstack() {
    elements = new char[INITIAL_CAPACITY];
    capacity = INITIAL_CAPACITY;
    count = 0;
}

Charstack::~Charstack() {
    delete[] elements;
}
```

Array `elements` is allocated on heap.

Implementation (dynamic array)

```
void Charstack::expandCapacity() {
    capacity *= 2;
    char *array = new char[capacity];
    for (int i = 0; i < count; i++) {
        array[i] = elements[i];
    }
    delete[] elements;
    elements = array;
}
```

Copy `elements` to the newly allocated location.
Free up memory.

Implementation (dynamic array)

```
void Charstack::push(char ch) {
    if (count == capacity)
        expandCapacity();

    elements[count++] = ch;
}
```

Implementing stack

Three files

- `charstack.h`
  - constructor, destructor
  - public: (public methods)
  - private:
    `#include "cstkpriv.h"`
- `cstkpriv.h` (private instance variables, private function prototypes)
- `charstack.cpp` (implementations)

Object copying

Copying an object that has at least one data memeber of pointer type, such as the one in `cstkpriv.h`, Figure 9-3, p. 325.

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
first.push('C');
second.push('Z');

cout << first.pop() << endl;
```

Object copying

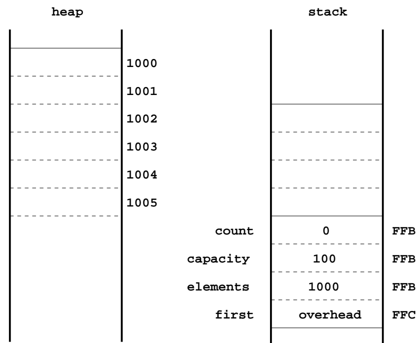
Copying an object that has at least one data memeber of pointer type, such as the one in `cstkpriv.h`, Figure 9-3, p. 325.

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
first.push('C');
second.push('Z');

cout << first.pop() << endl;
```

What is the output?

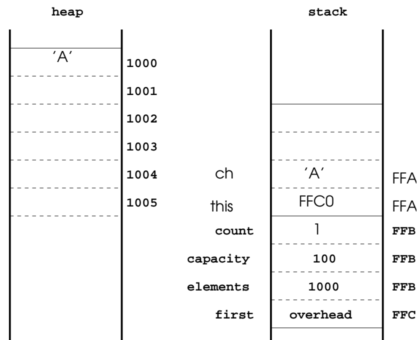
Object copying (cont.)

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
...
```



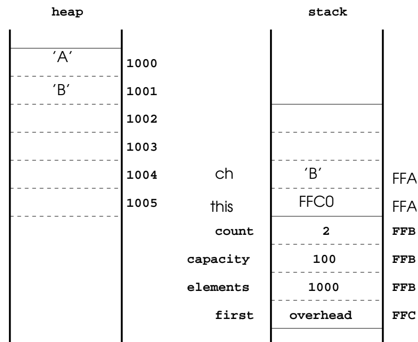
Object copying (cont.)

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
...
```



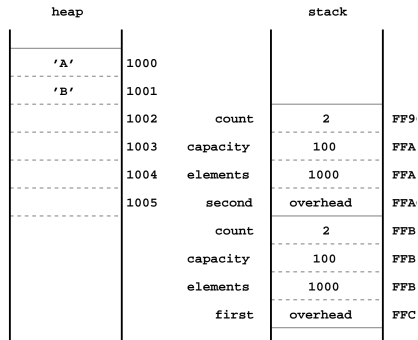
Object copying (cont.)

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
...
```



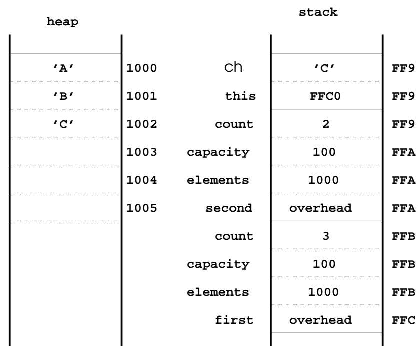
Object copying (cont.)

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
...
```



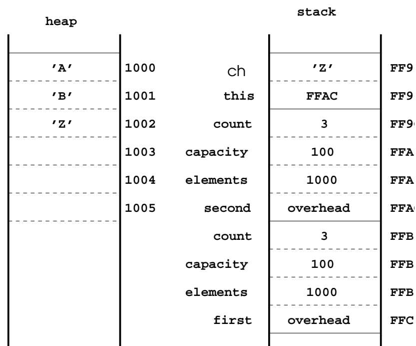
Object copying (cont.)

```
CharStack first;
first.push('A');
first.push('B');

CharStack second = first;
first.push('C');
...
```



Object copying (cont.)

```
CharStack first;
...

CharStack second = first;
first.push('C');
second.push('Z');
...
```



Object copying (cont.)

Use DISALLOW_COPYING macro to prevent inadvertent copying: assignment, parameter passing, or function return.

Add

```
DISALLOW_COPYING(CharStack)
```

to the cstkpriv.h file.

Outline

1. Introduction
2. Implementing `stack`
3. Implementing `Scanner`

Implementing the `Scanner` class

Three files

`scanner.h`

Interface, Figure 9-4, p. 329-330

Constructor, destructor

public: (methods)
A setter `setSpaceOption`
A getter `getSpaceOption`

private:
`#include "scanpriv.h"`

Hiding implementation.

Implementing the Scanner class

scanpriv.h, Figure 9-5, p. 331

Hides the implementation (string)

```
/* instance variables */
    string buffer;
    int len;
    int cp;                      /* index */
    spaceOptionT spaceOption;    /* space option */

/* private method prototypes */
    ...
```

Implementing the Scanner class

scanner.cpp, Figure 9-6, p. 332-333

```
Scanner::Scanner() {
    buffer = "";
    spaceOption = PreserveSpaces; /* default */
    cp = -1;  /* input string not set */
}


void Scanner::setInput(string str) {
    buffer = str;
    len = buffer.length();
    cp = 0;
}
```

Implementing the Scanner class

scanner.cpp, Figure 9-6, p. 332-333

```
string Scanner::nextToken() {
    if (cp == -1) {
        Error("setInput not called");
    }
    if (spaceOption == IgnoreSpaces) skipSpaces();
    int start = cp;
    if (start >= len) return "";
    if (isalnum(buffer[cp])) {
        int finish = scanToEndOfIndetifier();
        return buffer.substr(start, finish - start + 1);
    }
    cp++;
    return buffer.substr(start, 1);
}
```