Chapter 11
Generic Collections

3rd Edition

Computing Fundamentals with C++

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Chapter 11
A Container with Iterators

- Build your own collection class to store any type of element
- Better understand classes with data members, constructors, and member functions
- Better understand how to develop functions that involve vector processing

Collection classes

- Programmers often use many *collections*
- Collection classes have the main purpose of storing a collection of elements
- Standard collection classes include `vector<type>`, `stack<type>`, `queue<type>`, `list<type>`
- All of these take a type argument, which is the type of elements that the collection stores

Passing Types as Arguments

- C++ has a template mechanism that allow the type of element to be set when compiled
- It is a type enclosed two special symbols <*type*>
- This allows us to have a `vector` of `int`, `double`, `string`, `BankAccount`, `...`
  - The collection can only store that type of element
  - With a type argument, we only need one collection class
- In this presentation, a `Bag` type is implemented with templates to allow for `Bag<int> aBag;`

class Bag<Type>

- The `Bag` class developed here will review class definitions, vector processing, and show it is possible to pass a type like `int` or `double` as an argument
- A bag (aka multi-set) is the most general collection
  - Bags store a collection of elements not in any particular order and are not necessarily unique
  - operations include

```
bag::add
bag::remove
bag::occurrencesOf
bag::size
```

Using a Bag object

- This code should compile, all assertions should pass

```
Bag<int> aBag;
aBag.add(5);
aBag.add(4);
aBag.add(4);
assert(aBag.occurrencesOf(5) == 1);
assert(aBag.occurrencesOf(4) == 2);

assert(aBag.occurrencesOf(99) == 0);
assert(!aBag.remove(99));

assert(aBag.remove(5));
assert(aBag.occurrencesOf(5) == 0);
assert(aBag.remove(4));
assert(aBag.occurrencesOf(4) == 1);
```

The Data Members and Constructor

```
// File name: Bag.h
#include <vector>

template<class Type> // Allow type arguments
class Bag {
private:
  std::vector<Type> elements; // Can be any type
  int n;

public:
  //--constructor
 Bag(){
    elements.resize(20); // size 20 is arbitrary
    n = 0;
 }
```

Bag::add

- The `Bag::add` operation adds all new elements to the "end" of the vector. The vector may be resized

```
// Add element and increase the size (n) by 1
void add(Type const& element) {
  // First make sure there is enough capacity
  if (n == elements.size()) {
    // Grow the vector's capacity by 10
    elements.resize(n + 10);
  }
  // Then add element at the end of the vector
  elements[n] = element;
  // Increase the number of elements
  n++;
}
```

Bag::size

- The `Bag::size` operation simply returns `n`, that increases by 1 in add and will decrease by 1 in remove

```
// Return the number of elements
// that are currently in this Bag
int size() const {
  return n;
}
```

Bag::remove

- The `Bag::remove` operation begins by finding the index of the value to be removed

```
// pre:  removalCandidate must define ==
// post: If found, value is removed from this Bag.
// If object is not in this Bag, return false.
bool remove(Type const& value) {
  // Find the index of the element to remove
  // or let index be out of range when not found
  int index = 0;
  while (index < n && value != elements[index]) {
    index++;
  }
  // . . .
```

Bag::remove

- If not found, return false. If found, overwrite it with the most recently added element

```
// element[subscript] == value if found,
// otherwise subscript == size (not found).
if (index == n) {
  return false;
}
else {
  // Overwrite value with the last element
  elements[index] = elements[n - 1];
  // and decrease size by 1
  n--;
  // Report success to the client
  return true;
}
} // End remove member function
```

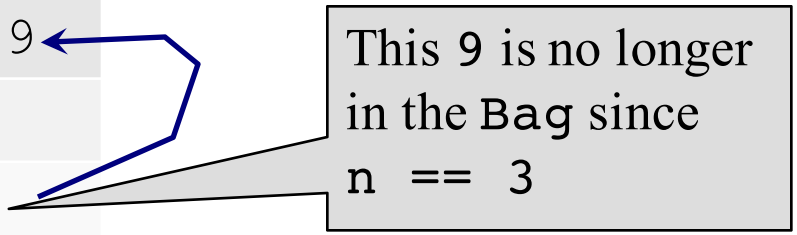
Trace Bag::remove

- Assume this state of `aBag<int>` where `n==4`

vector location	value
`element[0]`	5
`element[1]`	4
`element[2]`	4
`element[3]`	9

- After `aBag.remove(4)` when `n--` makes `n==3`

vector location	value
`element[0]`	5
`element[1]`	~~4~~ 9
`element[2]`	4
`element[3]`	9



Bag::occurrencesOf

- `Bag::occurrencesOf` iterates over the vector to count how often value exists in this `Bag`

```
// Return how often value exists in this Bag
int occurrencesOf(Type const& value) const {
  int result = 0;
  for (int i = 0; i < n; i++) {
    if (value == elements[i])
      result++;
  }
  return result;
}
```