#12: Iterators

February 11, 2018 · Fagen-Ulmschneider, Zilles

Data Structures Review

- List ADT
  - Linked Memory Implementation (“Linked List”)
    - \(O(1)\) insert/remove at front/back
    - \(O(1)\) insert/remove after a given element
    - \(O(n)\) lookup by index
  - Array Implementation (“Array List”)
    - \(O(1)\) insert/remove at front/back
    - \(O(n)\) insert/remove at any other location
    - \(O(1)\) lookup by index

<table>
<thead>
<tr>
<th>Operations + Data Order:</th>
<th>Queue</th>
<th>Stack</th>
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</thead>
<tbody>
<tr>
<td>Implementation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runtime:</td>
<td></td>
<td></td>
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</tbody>
</table>

Example 1

```c
// Example 1
Queue<int> q;
qu.push_back(3);
qu.push_back(8);
qu.push_back(4);
qu.back();
qu.pop_back();
qu.push_back(2);
qu.push_back(1);
qu.push_back(3);
qu.push_back(5);
qu.back();
qu.pop_back();
qu.push_back(9);
```

Example 2

```c
// Example 2
Queue<char> q;
qu.enqueue('m');
qu.enqueue('o');
qu.enqueue('n');
... 
qu.enqueue('d');
qu.enqueue('a');
qu.enqueue('y');
qu.enqueue('i');
qu.enqueue('s');
qu.pop_front();
qu.push_front('h');
qu.push_front('a');
```

Three designs for data storage in data structures:

1. \(T \& \text{data}\)
2. \(T * \text{data}\)
3. \(T \text{data}\)

Tradeoffs between our data store strategies:

1. Who manages the lifecycle of the data?
2. Is it possible to store a NULL as the data?
3. If the data is manipulated by user code while stored in our data structure, are the changes reflected within our data structure?
4. What is the relative speed compared to other methods?

<table>
<thead>
<tr>
<th>Lifecycle management of data?</th>
<th>Storage by Reference</th>
<th>Storage by Pointer</th>
<th>Storage by Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible to insert NULL?</td>
<td></td>
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<tr>
<td>External data manipulation?</td>
<td></td>
<td></td>
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<tr>
<td>Speed</td>
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</table>
Accessing Every Element in Our List / Queue / [Anything]
Suppose we want to look through every element in our data structure. What if we don’t know what our data structure even looks like?

<table>
<thead>
<tr>
<th>Type</th>
<th>Cur. Location</th>
<th>Current Data</th>
<th>Next</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked List</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypercube</td>
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</tr>
</tbody>
</table>

Iterators
In C++, iterators provide an interface for client code access to data in a way that abstracts away the internals of the data structure.

An instance of an iterator is a current location in a pass through the data structure:

The iterator minimally implements three member functions:
- `operator*`, Returns the current data
- `operator++`, Advance to the next data
- `operator!=`, Determines if the iterator is at a different location

Implementing an Iterator
A class that implements an iterator must have two pieces:

1. [Implementing Class]:

2. [Implementing Class’ Iterator]:
   A separate class (usually an internal public member class) that extends `std::iterator` and implements an iterator.

Using an Iterator

```
#include <vector>
#include <string>
#include <iostream>

struct Animal {
    std::string name, food;
    bool big;
    Animal(std::string name = "blob", std::string food = "you", bool big = true) :
        name(name), food(food), big(big) { /* nothing */ }
};

int main() {
    Animal g("giraffe", "leaves", true), p("penguin", "fish", false), b("bear");
    std::vector<Animal> zoo;
    zoo.push_back(g);
    zoo.push_back(p);   // std::vector's insertAtEnd
    zoo.push_back(b);
    for ( std::vector<Animal>::iterator it = zoo.begin(); it != zoo.end(); it++ ) {
        std::cout << (*it).name << " " << (*it).food << std::endl;
    }
    return 0;
}
```

Q: What does the above code do?

For-Each loop with Iterators

```
for ( const Animal & animal : zoo ) {
    std::cout << animal.name << " " << animal.food << std::endl;
}
```

CS 225 – Things To Be Doing:

1. Programming Exam A starts Thursday
2. MP2 due tonight; MP3 released tomorrow
3. lab_quacks released on Wednesday
4. Daily POTDs