Outline

• In this lesson, we will:
  – Explain why the size() function is slow
  – Show how we can speed this up with a size_ member variable
  – Step through all member functions that must be modified to accommodate this variable:
    • The constructor
    • size()
    • push_front(...)
    • pop_front()
  – Determine the cost of adding this member variable

Problem

• To get the size, we must count all the entries in the linked list
  – This could be hundreds, thousands or more

• Could this not potentially slow down an application?
  – Can we speed up the run-time of size()?
Problem

- One solution is to add a size member variable:

```cpp
class Node;
class linked_list;
class linked_list {
    public:
        // ...declarations of public member functions...
    private:
        Node *p_list_head; // Pointer to head node
        std::size_t size_; // List size member variable
};
```

List size member variable

- Now:
  - The size member variable can be immediately returned by the size() member function
  - We must initialize size inside the constructor
  - We must update size whenever we:
    - Push a new node
    - Pop a node from the linked list

Constructor and destructor

- The constructor must initialize the list size:
  ```cpp
  linked_list::linked_list():
      p_list_head(nullptr),
      size_(0) {
          // Nothing else for the constructor to do
      }
  ```
  - In C++, you should initialize all member variables before the body of the constructor executes

Getting the size

- Now the size() function can simply return that variable:
  ```cpp
  void linked_list::size() const {
      return size_;  // Getting the size
  }
  ```
A list size member variable

Inserting a node

- When pushing a new node at the front of the linked list, we must increment the list size:
  ```cpp
  void Linked_list::push_front( double const new_value ) {
    p_list_head_ = new Node{new_value, p_list_head_};
    ++size_;  
  }
  ```

Removing a node

- When popping a node, we must decrement the list size:
  ```cpp
  bool Linked_list::pop_front() {
    if ( empty() ) {
      return false;
    } else {
      assert( size() >= 1 );
      Node *p_current_head{ p_list_head_};
      p_list_head_ = p_list_head_->p_next_node_;
      delete p_current_head;
      p_current_head = nullptr;
      --size_;  
      return true;
    }
  }
  ```

Clearing all nodes in a list

- Why do we not have to update clear()?:
  ```cpp
  bool Linked_list::clear() {
    while (!empty()) {
      pop_front();  
    }
  }
  ```

- We can speed up clear()?:
  ```cpp
  double Linked_list:operator[]( std::size_t const n ) const {
    if ( size() <= n ) {
      return 0.0;
    } else {
      std::size_t k(0);
      Node *p_current_node{ p_list_head_};
      while ( p_current_node != nullptr ) {
        if ( k == n ) {  
          return p_current_node->value_;  
        }  
        ++k;
        p_current_node = p_current_node->p_next_node_;  
      }
      assert( false );  // We should never get here
      return 0.0;
    }
  }
  ```
Our linked list class

- Our public member functions have not changed their behavior:
  - The interface has not changed

```cpp
class Linked_list {
  public:
    Linked_list(); // Constructor
    ~Linked_list(); // Destructor
    bool empty() const;
    std::size_t size() const;
    double front() const;
    std::string to_string() const;
    std::size_t find(double value) const;
    double operator[](std::size_t n) const;
    void push_front(double const new_value);
    bool pop_front();
    void clear();

  private:
    Node *p_list_head; // Pointer to head node
    std::size_t size_;
};
```

Benefit of encapsulation

- Adding this member variable and modifying our member functions in no way affected the way users interact with this class
  - The only differences are:
    - It uses a little more memory (4 to 8 bytes)
    - Some functions are trivially slower (one extra instruction)
    - The size() function is significantly faster now

Summary

- Following this lesson, you now
  - Understand we can modify a class without affecting the user
  - Know how a list size member variable can significantly decrease the execution time of the size() function
  - Understand that the cost is a small increase in memory and run time

References

[1] No references?
Colophon

These slides were prepared using the Georgia typeface. Mathematical equations use Times New Roman, and source code is presented using Consolas.

The photographs of lilacs in bloom appearing on the title slide and accenting the top of each other slide were taken at the Royal Botanical Gardens on May 27, 2018 by Douglas Wilhelm Harder. Please see https://www.rbg.ca/ for more information.

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