CMPT 225

Lecture 9 – Stack
Last Lecture

- We did an ...
  - activity about Stack
Learning Outcomes

- At the end of this lecture (and the activity), a student will be able to:
  - Describe Stack
  - Define public interface of Stack ADT
  - Design and implement Stack ADT using various data structures
  - Compare and contrast these various implementations using Big O notation
  - Give examples of real-life applications (problems) where we could use Stack to solve the problem
  - Solve problems using Stack ADT
Today’s menu

- Going over our Stack activity
Step 1 - Problem Statement

Web Browser Back and Forward buttons.

Sample run:
- I did some searching on Google and I am currently looking at Google’s search results
- I click on “wiki” search result and go to “wiki” web page
- From “wiki” web page, I click on Back button, i.e., go back to “Google” web page
- I click on Forward button, i.e., go forward to “wiki” web page
Step 2 - Design

- Solution requires a data collection that allows the following:
  - Add a new element
  - Remove most recently added element
Stack

- What can we do with a stack?

What characterizes a Stack?

- A stack only allows elements to be inserted and removed at one end — **top**
- Access to other elements in the stack is not allowed
- LIFO / FILO
- Linear data collection
- Not a “general-purpose” ADT
Step 2 – Design - Stack operations

- **isEmpty**: Is the stack empty?
- **push**: Insert an element onto the top of the stack
- **pop**: Remove the topmost element of the stack
- **peek**: Retrieve the topmost element of the stack (but do not remove the element)
- **popAll**: Remove all elements of the stack
Step 2 – Design –
Stack public interface – Contract - 1

NOTE: Expressed in C++ and using template
Class invariant: LIFO / FILO

// Description: Returns true if this stack is empty otherwise false.
// Time Efficiency: O(1)
bool isEmpty() const;

// Description: Adds a new element to the top of this stack.
// Returns true if the addition is successful otherwise false.
// Time Efficiency: O(1)
bool push(const ElementType& newElement);
Step 2 – Design –
Stack public interface – Contract - 2

// Description: Removes the top element of this stack.
// Returns true if the removal is successful otherwise false.
// Precondition: The stack is not empty.
// Time Efficiency: O(1)
bool pop();

Alternative:
// Description: Removes and returns the top element of this stack.
// Precondition: The stack is not empty.
// Exceptions: Throws EmptyStackException if this stack is empty.
// Time Efficiency: O(1)
ElementType pop() throw(EmptyStackException);
Step 2 – Design – Stack public interface – Contract - 3

// Description: Removes all elements from this stack.
// Returns true if the removal is successful otherwise false.
// Precondition: The stack is not empty.
bool popAll();

// Description: Returns the top of this stack.
// Precondition: The stack is not empty.
// Postcondition: This stack is unchanged.
// Exceptions: Throws EmptyStackException if this stack is empty.
// Time Efficiency: O(1)
ElementType peek() const throw(EmptyStackException);
Let’s test the Stack public interface

Using our “Web Browser Back and Forward buttons” problem statement

- Currently looking at “google” -> currentURL
- Click on “wiki” -> newURL -> open(newURL )
  - if ( ! back.push(currentURL) ) throw exception
  - currentURL = newURL
  - if ( ! forward.popAll( ) ) throw exception
- Click on Back button, i.e., go back to “google”, currentURL -> “wiki” -> back( )
  - if ( back.isEmpty( ) ) throw exception
  - if ( ! forward.push(currentURL) ) throw exception
  - currentURL = back.pop( )
- Click on Forward button, i.e., go forward to “wiki”, currentURL -> “google” -> forward( )
  - if ( forward.isEmpty( ) ) throw exception
  - if ( ! back.push(currentURL) ) throw exception
  - currentURL = forward.pop( ) ( why not forward.peek( )? )
Step 3 - Implementing Stack as an ADT

- Array-based implementation
Step 3 - Implementing Stack as an ADT

- Link-based implementation
Step 3 - Implementing Stack as an ADT

- List ADT-based implementation
Stack ADT - Comparing both its implementations

- Time efficiency of Stack ADT’s operations (worst case scenario) expressed using the Big O notation

<table>
<thead>
<tr>
<th>Operations</th>
<th>array-based</th>
<th>link-based</th>
<th>List ADT-based</th>
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<tbody>
<tr>
<td>isEmpty</td>
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<td>push</td>
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<td>pop</td>
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<td>peek</td>
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<td>popAll</td>
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When Stack ADT is appropriate

- Examples of problem statements that would be solved using a Stack
  - Compiler: checking for balanced braces while parsing the code in order to verify the syntax
  - Evaluating Postfix expressions
  - Finding our way through a maze
  - Simulating the execution of recursive operations by displaying the call stack, i.e., the activation records (or stack frames) kept in memory and their content
  - Text editing application: Undo and Redo buttons
Learning Check

- We can now ...
  - Describe Stack
  - Define public interface of Stack ADT
  - Design and implement Stack ADT using various data structures
  - Compare and contrast these various implementations using Big O notation
  - Give examples of real-life applications (problems) where we could use Stack to solve the problem
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Next Lecture

- Another linear data collection -> Queue