Stacks: Implementation in C

Computer Science Department
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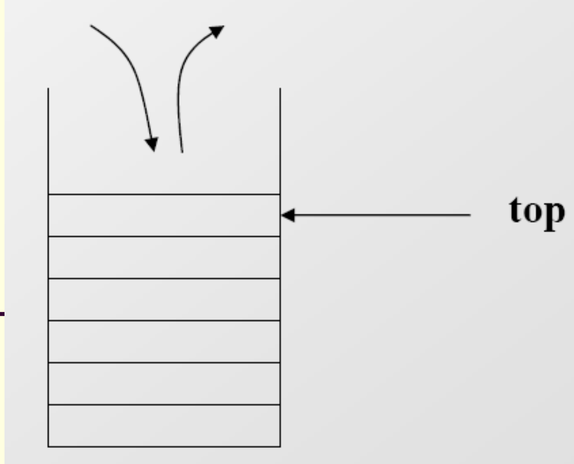
COP 3502 – Computer Science I

Stacks – An Overview

- Stacks:
  - Stacks are an Abstract Data Type
    - They are NOT built into C
  - We must define them and their behaviors
  - So what is a stack?
    - A data structure that stores information in the form of a stack.
    - Consists of a variable number of homogeneous elements
      - i.e. elements of the same type

Stacks – An Overview



- Stacks:
  - Access Policy:
    - The access policy for a stack is simple: the first element to be removed from the stack is the last element that was placed onto the stack
      - The main idea is that the last item placed on to the stack is the first item removed from the stack
    - Known as the "Last in, First out" access policy
      - LIFO for short
    - The classical example of a stack is cafeteria trays.
      - New, clean trays are added to the top of the stack.
      - and trays are also taken from the top
      - So the last tray in is the first tray taken out

Stacks – An Overview

- Stacks:
  - Basic Operations:
    - PUSH:
      - This PUSHes an item on top of the stack
    - POP:
      - This POPs off the top item in the stack and returns it
  - Other important tidbit:
    - The end of the stack,
      - where PUSHes and POPs occur,
    - is usually referred to as the TOP of the stack

Stacks – An Overview

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Stacks – An Overview

- Stacks:
  - Other useful operations:
    - empty:
      - Typically implemented as a boolean function
      - Returns TRUE if no items are in the stacck
    - full:
      - Returns TRUE if no more items can be added to the stack
      - In theory, a stack should NEVER become full
      - Actual implementations do have limits on the number of elements a stack can store
    - top:
      - Simply returns the value at the top of the stack <u>without</u> actually popping the stack.

Stacks: Implementation in C

- Implementation of Stacks in C:
  - As discussed on the previous lecture, there are two obvious was to implement stacks:
  1) Using arrays
  2) Using linked lists

  - We will go over both…

Stacks: Implementation in C

- Array Implementation of Stacks:
  - What components will we need to store?
  1) The array storing the elements
     - The actual stack

  - What else?
  2) An index to the top of the stack
     - We assume the bottom of the stack is index 0
       - Meaning, the 1st element will be stored in index 0
     - and we move up from there

Stacks: Implementation in C

- Array Implementation of Stacks:
  - Here is the struct (skeleton) for our stack:

```
struct stack {
       int items[SIZE];
       int top;
};
```

  - SIZE clearly represents the max number of items in the stack
  - If the stack becomes full, at that point, the top item will be stored at index 'SIZE-1'

Stacks: Implementation in C

- Array Implementation of Stacks:
  - Here are the functions we will need to control our stack behavior:
  - `void initialize(struct stack* stackPtr);`
  - `int empty(struct stack* stackPtr);`
  - `int full(struct stack* stackPtr);`
  - `int push(struct stack* stackPtr, int value);`
  - `int pop(struct stack* stackPtr);`
  - `int top(struct stack* stackPtr);`

Stacks: Implementation in C

- Array Implementation of Stacks:
  - `initialize`:
    - The `initialize` function has one line of code
    - It sets the "top" equal to -1
    - Remember, the first element will be at index 0
    - So if the top is set to -1
    - You know that the stack is empty
  - Here's the code:

```
void initialize(struct stack* stackPtr) {
      stackPtr->top = -1;
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - `empty`:
    - The `empty` function simply checks if the stack has no elements
    - Based on what you know thus far, how would you determine if the stack is empty?
    - If the top currently equals -1
  - Here's the code:

```
int empty(struct stack* stackPtr) {
      return (stackPtr->top == -1);
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - `full`:
    - The `full` function checks to see if the stack is full
    - How would we do this?
    - Remember, SIZE is the max # of elements in the stack
      - Item 1 goes at index 0
      - If the stack is full, the top item will be at index ‘SIZE-1’
  - Here’s the code:

```
int full(struct stack* stackPtr) {
      return (stackPtr->top == SIZE - 1);
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - push:
    - Remember, we can only push if the stack is not full
      - Meaning, if there is room to push
    - So if the stack is full
      - We return 0 showing the push could not be done
    - If there is room
      - we simply copy the value into the next location for the top of the stack
      - Then we adjust the top accordingly
      - Finally, we return 1 showing the push was successful

Stacks: Implementation in C

- Array Implementation of Stacks:
  - push:
    - To push an element, we simply copy the value into the next location for the top of the stack
    - Then we adjust the top accordingly
  - Here's the code:

```
int push(struct stack* stackPtr, int value) {
      if (full(stackPtr))
            return 0;
      stackPtr->items[stackPtr->top+1] = value;
      (stackPtr->top)++;
      return 1;
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - pop:
    - Remember, we can only pop if the stack is not empty
      - Meaning, there is at least one element to pop
    - So if the stack is empty
      - We return -1 showing that we cannot pop (stack empty)
    - If the stack has at least one element:
      - We save the value at the top of the stack into a temporary variable
      - We change the value for top
        - Meaning if top was 20 before the pop, it will now be 19
        - Meaning it will now reference index 19
      - Finally, we return the temporary variable (the popped off top)

Stacks: Implementation in C

- Array Implementation of Stacks:
  - pop:
    - To pop an element, we simply copy the top into a temporary variable, adjust the top accordingly, and return the temporary variable.
  - Here's the code:

```
int pop(struct stack* stackPtr) {
       int retval;
       if (empty(stackPtr))
              return -1;
       retval = stackPtr->items[stackPtr->top];
       (stackPtr->top)--;
       return retval;
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - `top`:
    - The `top` function is very similar to pop
    - Remember, we can only check for the top of the stack if the stack is not empty
      - Meaning, there is at least one element in the stack
    - So if the stack is empty
      - We return -1 showing that there is no top to check for
    - If the stack has at least one element:
      - We simply return the topmost element

Stacks: Implementation in C

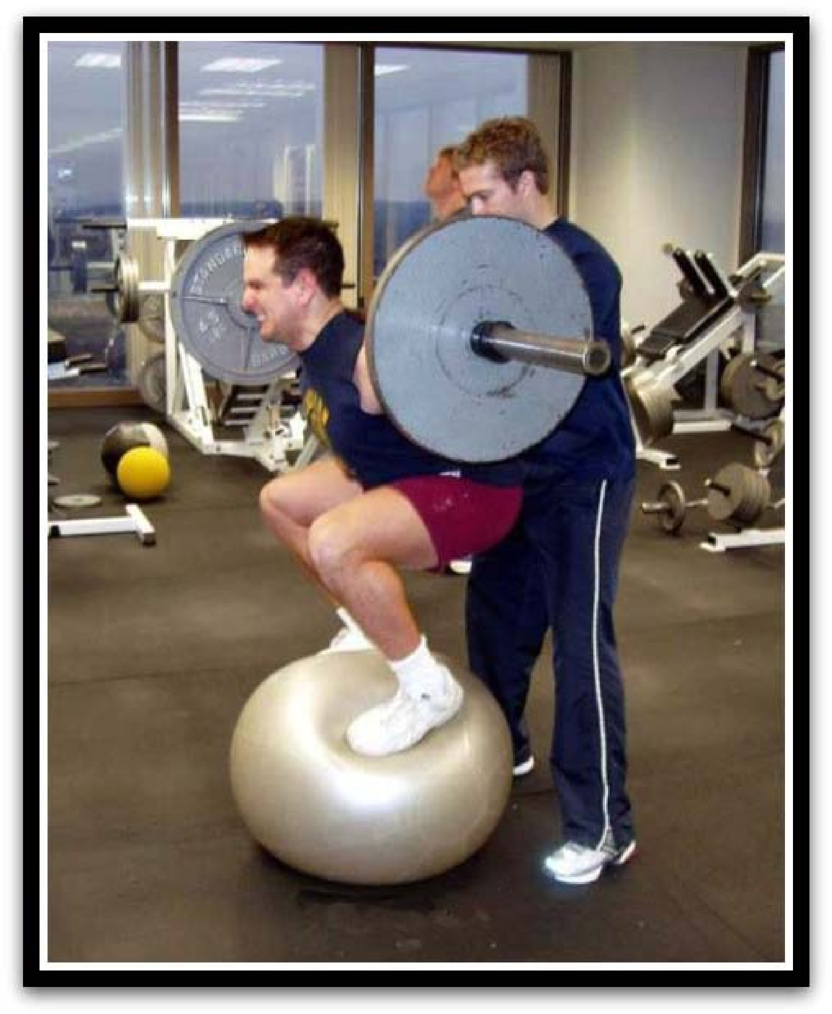
- Array Implementation of Stacks:
  - `top`:
    - Simply returns the top item in the stack
  - Here's the code:

```
int top(struct stack* stackPtr) {
       if (empty(stackPtr))
              return -1;
       return stackPtr->items[stackPtr->top];
}
```

Stacks: Implementation in C

- Array Implementation of Stacks:
  - Here the link to this code on the site:
  - http://www.cs.ucf.edu/courses/cop3502/spr2012/programs/stacksqueues/stack.c

Brief Interlude: Human Stupidity



Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - We essentially use a standard linked list
  - But we limit the functionality of a linked list
    - Thus creating the behavior required of a stack
  - A push is simply designated as **inserting into the front** of the linked list
  - A pop would be **deleting the front node**
  - So we basically create just one struct for the stack
    - It acts similar to the struct defined for use with linked lists

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - So each node will be an element of the stack
  - Each node has a data value
  - Each node also has a next
  - We simply push (insert at front)
  - And pop (delete the front node)

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - Here's the struct for the stack (for each node)

```
struct stack {
       int data;
       struct stack *next;
};
```

  - Notice that we do not have a 'top'
  - Why?
    - The top will ALWAYS be the first node
    - And we don't need to worry about the size getting too large since this is a linked list (in heap memory)

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - Here are the functions we will need to control our stack behavior:
  - `void init(struct stack **front);`
  - `int empty(struct stack *front);`
  - `int push(struct stack **front, int num);`
  - `struct stack* pop(struct stack **front);`
  - `int top(struct stack *front);`

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - `initialize`:
    - The `initialize` function has one line of code
    - It simply sets the pointer of the list to NULL
      - Specifying that the list is empty at this point
  - Here's the code:

```
void init(struct stack **front) {
      *front = NULL;
}
```

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - `empty`:
    - The lists is empty when the main list pointer is NULL
    - So if `front` equals NULL
      - Return 1 showing the list is empty
    - Else, return 0 showing that the list is not empty
  - Here's the code:

```
int empty(struct stack *front) {
        if (front == NULL)
                return 1;
        else
                return 0;
}
```

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - `push`:
    - Remember, `push` means that we add a new node at the front of the list
    - So we need to allocate this node
    - We need to save the data value into this node
    - We then need to update pointers accordingly
      - The new node will now be the FIRST node
      - So the address of the current front node needs to be saved into the `next` of this new node
        - Allowing the new node to point to the previous first node
      - The pointer to the front of the list needs to get updated
    - Finally, we return 1 to show a successful `push`

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - push:
  - Here's the code:

```
int push(struct stack **front, int num) {
       struct stack *temp;
       temp = (struct stack *)malloc(sizeof(struct stack));
       if (temp != NULL) {
              temp->data = num;
              temp->next = *front;
              *front = temp;
              return 1;
       }
       else
              return 0;
}
```

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - pop:
    - Assuming that there is at least one node to pop
    - We make a temp pointer to point to the front node
      - The node we will pop
    - We then update our pointers accordingly
      - The 2^{nd} node now becomes the first node
    - Finally, we return the address of the temp pointer

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - pop:
  - Here's the code:

```
struct stack* pop(struct stack **front) {
       struct stack *temp;
       temp = NULL;

       if (*front != NULL) {
              temp = (*front);
              *front = (*front)->next;
              temp -> next = NULL;
       }
       return temp;
}
```

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - `top`:
    - Assuming that there is at least one node
    - We simply return the data value of that node
    - Otherwise,
      - If there is no nodes
    - We return -1 showing that the list is empty

Stacks: Implementation in C

- Linked Lists Implementation of Stacks :
  - `top`:
  - Here's the code:

```
int top(struct stack *front) {
       if (front != NULL) {
              return front->data;
       }
       else
              return -1;
}
```

Stacks: Implementation in C

- Linked Lists Implementation of Stacks:
  - Here the link to this code on the site:
  - http://www.cs.ucf.edu/courses/cop3502/spr2012/programs/stacksqueues/stackll.c

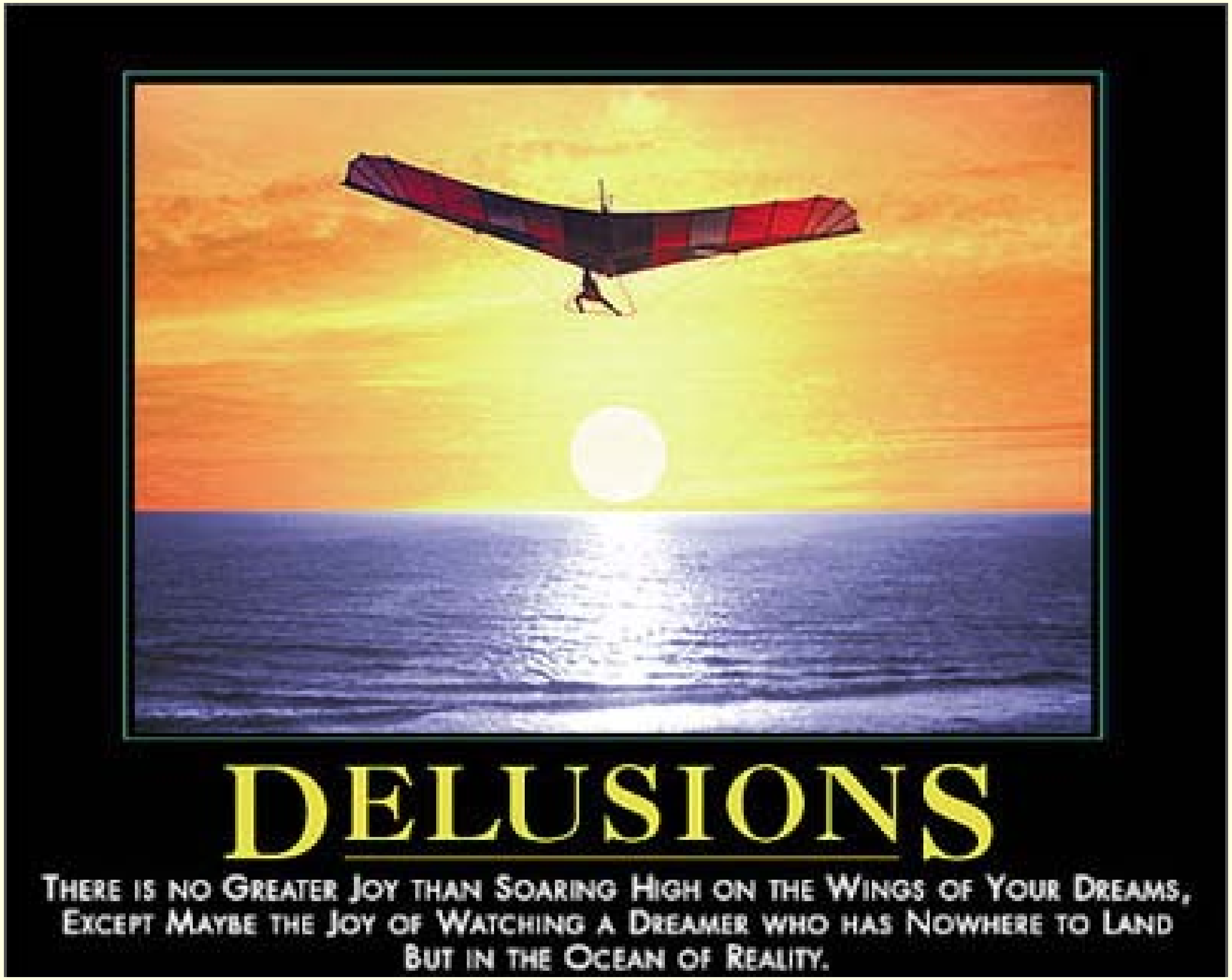
Stack Application(s)

WASN'T

THAT

SPLENDID!

Daily Demotivator



Stacks: Implementation in C

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