Computer Programming: Skills & Concepts (CP1)
Stacks and Queues (in C)

23rd November 2010

Two Special List Structures (in C)

Stack

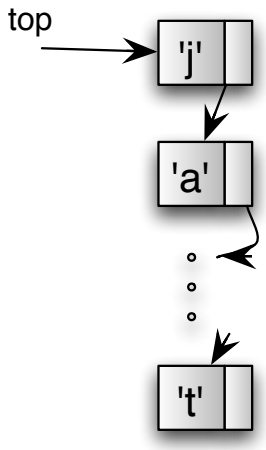
- Last-in First-out (*lifo*)
- Key operations are `push`, `pop`, `top` and `empty`

Queue

- First-in First-out (*fifo*)
- Key operations are `enqueue`, `dequeue`, `front`, `empty`

Both Stack and Queue are simpler to implement than a general linked list

picture of Stack



`struct` for Stacks

Each "cell" of the structure carries the following two things:

- A piece of data
- A pointer to the "cell" below it in the stack

We can "package" this as a *recursive* `struct` declaration.

```
struct elem {        /* structure of an element on the  */
  data        d;     /* stack: just one piece of data, and */
  struct elem *next; /* pointer to 'next' cell */
};
typedef  struct elem   elem;
```

stack.h - constants, enums, structs

```
#define    EMPTY    0
#define    FULL     10000
typedef    char                 data;
typedef    enum {false, true}   boolean;

struct elem {        /* structure of an element on the stack: */
  data        d;     /* just one piece of data, and pointer */
  struct elem *next; /* to 'next' cell */
};
typedef  struct elem   elem;

typedef struct {     /* Stack is just one element (the 'top'  */
  int       count;   /* one) plus also a count of items in    */
  elem     *top;     /* entire Stack.  */
} stack;
```


stack.h - function declarations

```
void       initialize(stack *stk);
void       push(data d, stack *stk);
data       pop(stack *stk);
data       top(const stack *stk);
boolean    empty(const stack *stk);
boolean    full(const stack *stk);
```


Memory allocation

No idea how many items we will get (range 0 to 10000)

- Allocate memory on a **cell-by-cell** basis with `malloc`
- `free` the space used by a cell whenever it is 'pop'-ed

`malloc` `free`

push - stack is *growing*

pre-requisite: Must know that stack is NOT "full".

```
void push(data d, stack *stk) {
  elem *p;

  p = malloc(sizeof(elem));
  (*p).d = d;
  (*p).next = (*stk).top;
  (*stk).top = p;
  (*stk).count++;
}
```

Precedence of * vs .

Our `push` function (and other functions) takes as parameter a *pointer* to a stack structure.
The `.` operator (used to access a part of a struct) has *higher* precedence than the `*` operator (used to de-reference a pointer). For this reason, in the code above,

we *need* the parentheses in statements

```
(*p).d = d;,
(*p).next = (*stk).top;
...
```

So we usually use C's abbreviation `->` :
`x->y` means `(*x).y`
And if you're doing 'pointer chasing' (often considered bad style),
`x->y->z` means `(x->y)->z` means `(*(*x).y).z`

push again

```
void push(data d, stack *stk) {
  elem *p;

  p = malloc(sizeof(elem));
  p->d = d;
  p->next = stk->top;
  stk->top = p;
  stk->count++;
}
```


pop - stack is shrinking

What happens if we pop an empty stack?
Chaos and despair! So we'll use `assert` to crash the program right now.
User should check with `empty` before calling `pop`.

```
data pop(stack *stk) {
  data d;
  elem *p;

  assert(stk->count > 0);
  p = stk->top;
  d = p->d;
  stk->top = p->next;
  stk->count--;
  free(p);
  return d;
}
```


initialize

```
void initialize(stack *stk) {
  stk->count = 0;
  stk->top = NULL;
}
```

top, empty, full operations

```
/* User should check stack is not empty */
data top(const stack *stk) {
  assert(stk->count > 0);
  return stk->top->d;
}

boolean empty(const stack *stk) {
  return ((boolean) (stk->count == EMPTY));
}

boolean full(const stack *stk) {
  return ((boolean) (stk->count == FULL));
}
```


Example of applying Stack

Reverse a string

- Go through the string, push-ing each character onto the stack.
- Now pop each item off the stack, direct onto standard output.

DEMO!!!

queue.h- differences to stack.h

```
.......
typedef struct {     /* Queue has pointers to two 'elems's:  */
  int       cnt;     /* the 'front' where items are taken off, */
  elem     *front;   /* and 'rear' where items put on.  */
  elem     *rear;
} queue;

.....

void       initialize(queue *q);
void       enqueue(data d, queue *q);
data       dequeue(queue *q);
data       front(const queue *q);
boolean    empty(const queue *q);
boolean    full(const queue *stk);
```


Summary

- Rules of Stacks and Queues
- Implementation of Stacks
- Application of Stacks - reversing a string
- Go to **course webpage** for code (Stacks and Queues).

THURSDAY – we start REVISION!!!!