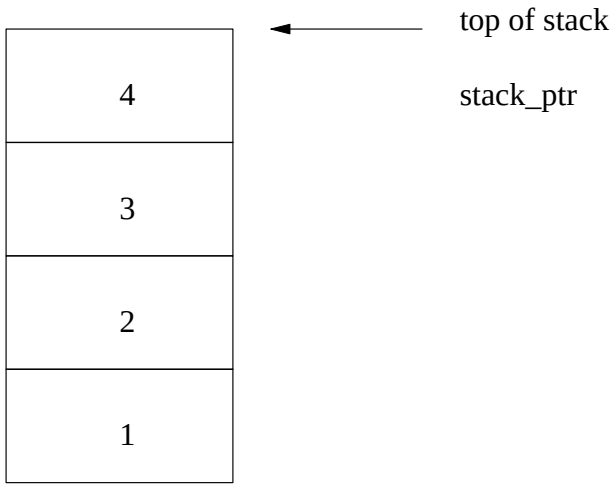
# Stacks

- the behaviour of stack methods are to:
  - `push` to the top of a stack
  - remove from the top of a stack, via `pop`



# Stacks

- here we have

```
push(1)
push(2)
push(3)
push(4)
```

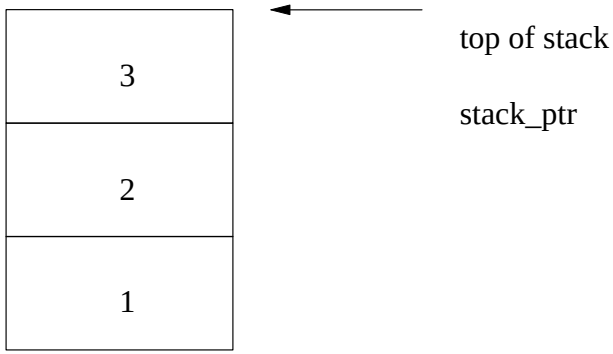
- and then executing

```
i = pop()
```

- yields the value `4` in `i`

# Stacks

- and the stack now looks like this:




- we note that stacks and lists are isomorphic

# Stacks

- for example if we needed a stack of integers we could use our lecture 2 implementation of a single linked list
- `push(i)` is equivalent to `l.cons(i)`
- `i = pop()` is equivalent to `i = l.head(); l = tail();`
- we might be tempted to conclude here :-)
  - however stacks are often used right at the center of many systems and performance can be critical

# Stacks

- it should be noted that the operations `push` and `pop` are expected to be used very frequently

# Stack definition

- **examples/c++/stacks/int/v1/stack.h**

```
class element
{
 public:
  element *next;
  int      data;
};

class stack
{
 private:
  element *head_element;
  element *duplicate_elements (element *e);
  element *delete_elements (void);
  friend std::ostream& operator<< (std::ostream& os, const stack& l);
```

# Stack definition

- **examples/c++/stacks/int/v1/stack.h**

```
 public:
  stack (void);
  ~stack (void);
  stack (const stack &from);
  stack& operator= (const stack &from);

  stack empty (void);
  bool  is_empty (void);
  stack push (int i);
  int   top (void);
  int   pop (void);
};
```

# Stack definition

- notice its similarity to the single linked list class

# Stack definition

- examples/c++/stacks/int/v1/stack.cc

```
/*
 *  push - push i to stack.
 *         pre-condition:   none.
 *         post-condition:  returns the stack which has i at its head
 *                          and the remainer of contents as, stack.
 */

stack stack::push (int i)
{
  element *e = new element;

  e->data = i;
  e->next = head_element;
  head_element = e;
  return *this;
}
```

# Stack definition

**examples/c++/stacks/int/v1/stack.cc**

```
/*
 *  pop - opposite of cons.  Remove the head value and return it.
 *        pre-condition:   non empty stack.
 *        post-condition:  remove and return value from top of stack.
 */

int stack::pop (void)
{
  element *e = head_element;
  int value = e->data;

  assert (! is_empty());
  head_element = head_element->next;
  if (debugging)
    printf ("wanting to delete 0x%p0, e);
  else
    delete e;
  return value;
}
```

# Version 2: Stack

- notice that if `push` and `pop` are used many times when we will have many calls to `new` and `delete`
  - these last two functions may be very costly, as they are generic for any data type
  - probably using complex memory management algorithms

- given that `push` and `pop` occur so frequenty we will maintain our own free list

# Version 2: Stack

- **examples/c++/stacks/int/v2/stack.h**

```
class stack
{
 private:
  element *head_element;
  element *free_list;
  element *duplicate_elements (element *e);
  element *delete_elements (element *h);
  friend std::ostream& operator<< (std::ostream& os, const stack& l);
  element *new_element (void);
  void     delete_element (element *e);
```

# Version 2: Stack

- examples/c++/stacks/int/v2/stack.h

```
 public:
  stack (void);
  ~stack (void);
  stack (const stack &from);
  stack& operator= (const stack &from);

  stack empty (void);
  bool  is_empty (void);
  stack push (int i);
  int   top (void);
  int   pop (void);
};
```

# Version 2: Stack

- **examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  delete_elements - delete all elements of stack.
 *                    pre-condition : none.
 *                    post-condition: all elements are deleted
 *                                    and zero is returned.
 */
element *stack::delete_elements (element *h)
{
  while (h != 0) {
    element *t = h;
    h = h->next;
    if (debugging)
      printf ("wanting to delete 0x%p\n", t);
    else
      delete t;
  }
  return 0;
}
```

# Version 2: Stack

- examples/c++/stacks/int/v2/stack.cc

```
/*
 *  delete_element - pre-condition :  e, must not be on the stack.
 *                   post-condition:  places, e, onto the free_list.
 */

void stack::delete_element (element *e)
{
  e->next = free_list;
  free_list = e;
}
```

# Version 2: Stack

- **examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  new_element - pre-condition :  none.
 *                post-condition:  return an element either
 *                                 from the free_list or from the heap.
 */

element *stack::new_element (void)
{
  element *e;

  if (free_list == 0)
    e = new element;
  else
    {
      e = free_list;
      free_list = free_list->next;
    }
  return e;
}
```

# Version 2: Stack

- examples/c++/stacks/int/v2/stack.cc

```
/*
 *  push - push i to stack.
 *         pre-condition:   none.
 *         post-condition:  returns the stack which has i at its head
 *                          and the remainer of contents as, stack.
 */

stack stack::push (int i)
{
  element *e = new_element ();

  e->data = i;
  e->next = head_element;
  head_element = e;
  return *this;
}
```

# Version 2: Stack

**examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  pop - opposite of cons.  Remove the head value and return it.
 *        pre-condition:   non empty stack.
 *        post-condition:  remove and return value from top of stack.
 */

int stack::pop (void)
{
  element *e = head_element;
  int value = e->data;

  assert (! is_empty());
  head_element = head_element->next;
  if (debugging)
    printf ("wanting to delete 0x%p\n", e);
  else
    delete_element (e);
  return value;
}
```

# Version 2: deconstructor

- examples/c++/stacks/int/v2/stack.cc

```
/*
 *  ~stack - deconstructor, releases the memory attached to the stack.
 *           pre-condition:    none.
 *           post-condition:   stack is empty.
 */

stack::~stack (void)
{
  head_element = delete_elements (head_element);
  free_list = delete_elements (free_list);
}
```

# Version 2: copy

- **examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  copy operator - redefine the copy operator.
 *                  pre-condition :  a stack.
 *                  post-condition:  a copy of the stack and its elements.
 */

stack::stack (const stack &from)
{
  head_element = duplicate_elements (from.head_element);
  free_list = 0;
}
```

# Version 2: assignment

- **examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  operator=  - redefine the assignment operator.
 *               pre-condition :  a stack.
 *               post-condition:  a copy of the stack and its elements.
 *                                We delete 'this' stacks elements.
 */

stack& stack::operator= (const stack &from)
{
  if (this->head_element == from.head_element)
    return *this;

  head_element = delete_elements (head_element);
  head_element = duplicate_elements (from.head_element);
  free_list = 0;
}
```

# Version 2: constructor

- **examples/c++/stacks/int/v2/stack.cc**

```
/*
 *  stack - constructor, builds an empty stack.
 *          pre-condition:   none.
 *          post-condition:  stack is created and is empty.
 *                           free_list is empty.
 */

stack::stack (void)
  : head_element(0), free_list(0)
{
}
```