Building on Lists

- we will look at how our `slist` class can be extended to include
  - `length`, `reverse` methods
- use recursion and functional programming where appropriate
- we will notice a problem with C++ when applying this technique

Tutorial answers: length

- firstly we add two helper methods to our class `slist`
- **c++/lists/single-list/int/slist.h**

```
...
private:
  element *e_tail (element *l);
  int *e_length (element *l);
...
```


e_tail

- **c++/lists/single-list/int/slist.cc**

```
/*
 *  e_tail - given a list, l, return the list without the
 *           head element.
 *           pre-condition:   non empty list.
 *           post-condition:  return the list without the
 *                            first element.
 *                            The original list is unalte
 */

element *slist::e_tail (element *l)
{
  return l->next;
}
```


e_tail

- **c++/lists/single-list/int/slist.cc**

```
/*
 *  e_length - return the length of element list, l.
 */

int slist::e_length (element *h)
{
  if (h == 0)
    return 0;
  else
    return (1 + e_length (e_tail (h)));
}
```

e_tail

- c++/lists/single-list/int/slist.cc

```
/*
 *  length - return the length of list, l.
 */

int slist::length (void)
{
  return e_length (head_element);
}
```


reverse

- must return the list with its contents reversed
  - not a new list with a copy of the contents reversed!
- c++/lists/single-list/int/slist.cc

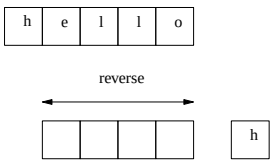
```
slist slist::reverse (void)
{
  if (is_empty ())
    return *this;
  else
    return tail ().reverse().cons (empty().cons (head ()))
}
```


reverse

- notice the use of recursion
- notice that `tail` removes and deletes a datum
- `head` obtains the first element
- `cons` appends the first element to an empty list
  - ie creates a list with one element
- this single element list is added to the end of the reversed list
  - the reversed list comes from the tail of the original list

reverse

-



cons (slist l)

- c++/lists/single-list/int/slist.cc

```
/*
 *  cons - concatenate list, l, to the end of the current
 *         pre-condition :  none.
 *         post-condition:  returns the current list with
 *                          contents of list, l, appended
 */

slist slist::cons (slist l)
{
  if (l.is_empty ())
    return *this;
  else
    return cons (duplicate_elements (l.head_element));
}
```


Recursive version of cons (slist l)

- c++/lists/single-list/int/slist.cc

```
/*
 *  cons - concatenate list, l, to the end of the current
 *         pre-condition :  none.
 *         post-condition:  returns the current list with
 *                          contents of list, l, appended
 */

slist slist::cons (slist l)
{
  if (l.is_empty ())
    return *this;
  else
    {
      int h = l.head ();  // use h to force evaluation or
      return cons (h).cons (l.tail ());
    }
}
```


Recursive version of cons (slist l)

- notice the *gotya*
  - we must use a temporary variable `h` to contain an intermediate result containing the result of `l.head()`
  - it ensure that the call to `head` occurs before `l.tail()`

Recursive version of cons (slist l)

- if the code were re-written as:

- c++/lists/single-list/int/slist.cc

```
slist slist::cons (slist l)
{
  if (l.is_empty ())
    return *this;
  else
    return cons (l.head()).cons (l.tail ());
}
```

Recursive version of cons (slist l)

- it would fail, as `l.tail()` is executed before `l.head()`

Further tutorial questions

- write some test code to generate a large list and perform reverse on the list several times
  - compare the execution time between the iterative and recursive solutions
  - which is faster, why?
- hint use `-pg` flags to `g++` and analyse the execution time with `gprof`
- see week 1 notes for further hints on using the compiler

Further tutorial questions

- enable debugging in the `slist.cc` file and watch for the addresses of the new elements created and deleted
- when reverse is called - how many new elements are created when the
  - recursive version is run
  - when the iterative version is run