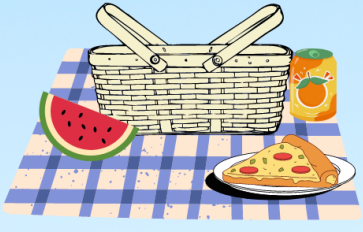
Picnic with Professors

12pm March 3rd & 17th @ HFH

First year + transfer students are invited to join CS professors for a casual picnic at/outside Harold Frank Hall (HFH)! Bring your own drink, we'll bring the pizza! Follow link or scan QR code to fill out sign-up form!



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STACK
C++ STL & TEMPLATES
INTERVIEW PRACTICE

Problem Solving with Computers-II

Announcements

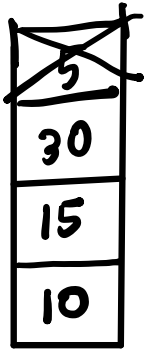
- Pa02 released, **due 3/14** (Tuesday of Week 10)!
  - Choose data structures to answer questions about a movie data set
  - Analyze and optimize time and space complexity
  - Start early!
- Midterm grades released!
  - Max: 100% (13 students)
  - Median: 87%
  - Mean: 85%

Stack ADT

- Uses the Last In First Out (LIFO) principle
- Methods

i. push() O(1)
ii. pop() O(1)
iii. top() O(1)
iv. empty() O(1)

10, 15, 30, 5



C++STL

- The C++ Standard Template Library is a handy set of three built-in components:
  - Containers: Data structures
  - Iterators: Standard way to search containers
  - Algorithms: These are what we ultimately use to solve problems

C++ STL container classes

array
vector
forward_list
list
set
stack
↳ queue
↳ priority_queue

---

multiset (non unique keys)
deque
unordered_set
map
unordered_map
multimap
bitset

single linked-list
double linked list
balanced BST
H = O(log N)

130 AB

Finding the Maximum of Two Integers

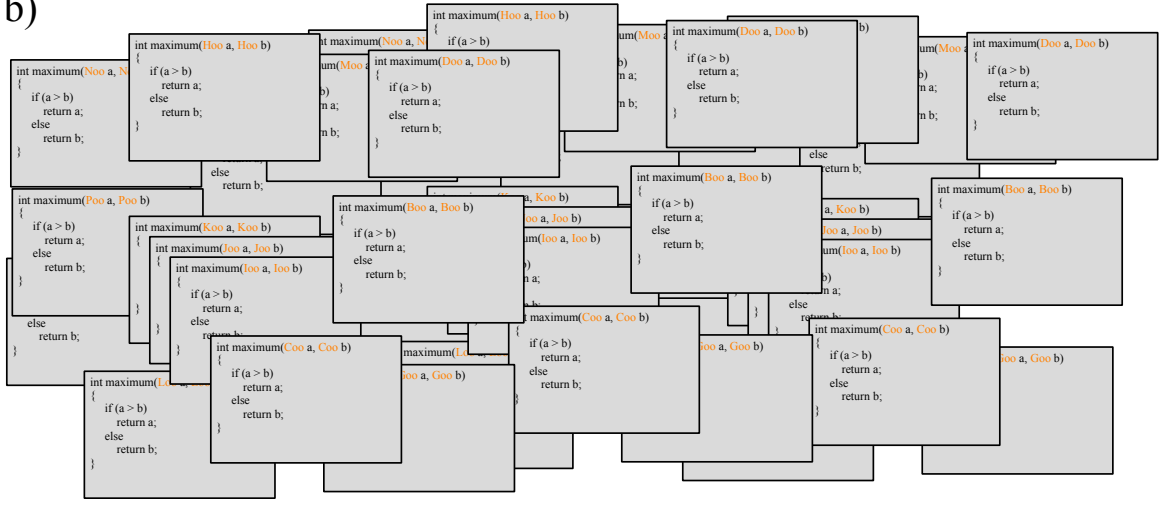
- Here's a small function that you might write to find the maximum of two integers.

```
int maximum(int a, int b)
{
    if (a > b)
        return a;
    else
        return b;
}
```

One Hundred Million Functions...

Suppose your program uses 100,000,000 different data types, and you need a maximum function for each...

```
int maximum(int a, int b)
{
    if (a > b)
        return a;
    else
        return b;
}
```



A Template Function for Maximum

When you write a template function, you choose a data type for the function to depend upon...

```
template <class Item>
Item maximum(Item a, Item b)
{
    if (a > b)
        return a;
    else
        return b;
}
```

maximum (10, 20) ;
maxima ("Apple", "Banana")

Lab05 - BST with templates

BST, without templates:

```
class BSTNode {
public:
  BSTNode* left;
  BSTNode* right;
  BSTNode* parent;
  int const data;

  BSTNode( const int& d ) :
     data(d) {
    left = right
         = parent = nullptr;
  }

};
```

BST, with templates:

```
template<class Data>
class BSTNode {
public:
  BSTNode<Data>* left;
  BSTNode<Data>* right;
  BSTNode<Data>* parent;
  Data const data;

  BSTNode( const Data & d ) :
     data(d) {
    left = right
         = parent = nullptr;
  }

};
```

BSTNode<int> n;

BST, with templates:

```
template<class Data>
class BSTNode {
public:
  BSTNode<Data>* left;
  BSTNode<Data>* right;
  BSTNode<Data>* parent;
  Data const data;

  BSTNode( const Data & d ) :
     data(d) {
    left = right = parent = nullptr ;
  }

};
```

How would you create **a BSTNode object** on the runtime stack?

A. BSTNode n(10);
B. BSTNode<int> n;
C. BSTNode<int> n(10);
D. BSTNode<int>* n = new BSTNode<int>(10);
E. More than one of these will work

{ } syntax OK too

BST, with templates:

```
template<class Data>
class BSTNode {
public:
  BSTNode<Data>* left;
  BSTNode<Data>* right;
  BSTNode<Data>* parent;
  Data const data;

  BSTNode( const Data & d ) :
     data(d) {
    left = right = parent = nullptr ;
  }

};
```

How would you create a **pointer** to BSTNode with integer data?

A. BSTNode* nodePtr;
B. BSTNode<int> nodePtr;
C. BSTNode<int>* nodePtr;

BST, with templates:

```
template<class Data>
class BSTNode {
public:
  BSTNode<Data>* left;
  BSTNode<Data>* right;
  BSTNode<Data>* parent;
  Data const data;

  BSTNode( const Data & d ) :
     data(d) {
    left = right = parent = nullptr ;
  }

};
```

Write a line of code to create a new BSTNode object with int data on the heap and assign nodePtr to point to it.

```
template<typename Data>
class BST {

private:
  BSTNode<Data>* root;  //Pointer to the root of this BS

public:
  /** Default constructor. Initialize an empty BST. */
  BST() : root(nullptr){  }

  void insertAsLeftChild(BSTNode<Data>* parent, const Data& item){
     // Your code here



  }
```

Working with a BST: Insert

```
//Assume this is inside the definition of the class
void insertAsLeftChild(BSTNode<Data>* parent, const Data& item)
  {
     // Your code here
  }
```

Which line of code correctly inserts the data item into the BST as the left child of the parent parameter.

```
A.parent.left = item;
B.parent->left = item;
C.parent->left = BSTNode(item);
D.parent->left = new BSTNode<Data>(item);
E.parent->left = new Data(item);
```

Working with a BST: Insert

```
void insertAsLeftChild(BSTNode<Data>* parent, const Data& item) {
    parent->left = new BSTNode<Data>(item);

}
```

Is this function complete? (i.e. does it do everything it needs to correctly insert the node?)

A. Yes. The function correctly inserts the data
B. No. There is something missing.

What is difference between templates and typedefs?

```
template <class Item>
Item maximum(Item a, Item b)
{
    if (a > b)
        return a;
    else
        return b;
}
```

```
typedef int item;
item maximum(item a, item b)
{
    if (a > b)
        return a;
    else
        return b;
}
```

Demo maximum.cpp

Template classes: Non-member functions

```
BST operator+(const BST& b1, const BST&b2);
```

```
template <class T>
BST<T> operator+(const BST<T>& b1, const BST<T>&b2);
```

Template classes: Member function definition

For the compiler a name used in a template declaration or definition and that is dependent on a template-parameter is assumed not to name a type *unless* its preceded by a typename

```
template<class T>
class BST{
    //Other code
    Node* getNodeFor(T value, Node* n) const;
};
```

template <class T>

typename BST<T>::Node * BST<T>::getNodeFor(T value, Node * n) const;

Template classes: Including the implementation

```
//In bst.h
class BST{
//code
};

#include "bst.cpp"
```

How to Convert a Container Class to a Template

1. The template prefix precedes each function prototype or implementation.
2. Outside the class definition, place the word `<Item>` with the class name, such as `bag<Item>`.
3. Use the name `Item` instead of `value_type`.
4. Outside of member functions and the class definition itself, add the keyword *typename* before any use of one of the class's type names. For example:

   ```
   typename bag<Item>::size_type
   ```

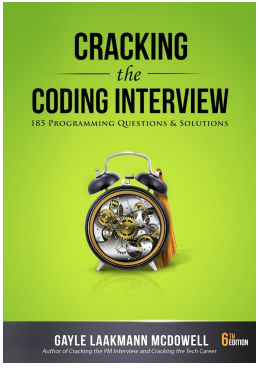
5. The implementation file name now ends with `.template` (instead of `.cxx`), and it is included in the header by an include directive.
6. Eliminate any using directives in the implementation file. Therefore, we must then write `std::` in front of any Standard Library function such as `std::copy`.
7. Some compilers require any default argument to be in both the prototype and the function implementation.

Have you given a technical interview before?

A. Yes

B. No

Tips for Technical Interviews



1. Listen carefully
2. Draw an example
3. State the brute force or a partially correct solution
   - then work to get at a better solution
4. Optimize:
   - Make time-space tradeoffs to optimize runtime
   - Precompute information: Reorganize the data e.g. by sorting
5. Solidify your understanding of your algo before diving into writing code.
6. Start coding!

Small group exercise

Write a ADT called minStack of numbers that provides the following

- push() // inserts an element to the “top” of the minStack
- pop() // removes the last element that was pushed on the stack
- top () // returns the last element that was pushed on the stack
- min() // returns the minimum value of the elements stored so far