# Comp151

## C++:
## Data Abstraction & Classes

# A Brief History of C++

- Bjarne Stroustrup of AT&T Bell Labs extended C with Simula-like classes in the early 1980s; the new language was called “C with Classes”.

- C++, the successor of “C with Classes”, was designed by Stroustrup in 1986; version 2.0 was introduced in 1989.

- The design of C++ was guided by three key principles:
  1. The use of classes should not result in programs executing any more slowly than programs not using classes.
  2. C programs should run as a subset of C++ programs.
  3. No run-time inefficiency should be added to the language.

# Topics in Today's Lecture

- Data Abstraction
- Classes: Name Equivalence vs. Structural Equivalence
- Classes: Restrictions on Data Members
- Classes: Location of Function declarations/definitions
- Classes: Member Access Control
- Implementation of Class Objects

# Data Abstraction

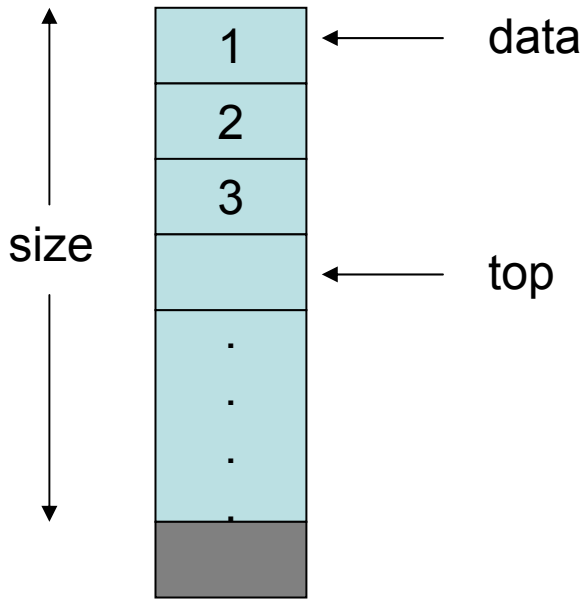
- Questions:
  - What is a ‘‘car"?
  - What is a ‘‘stack"?

- A **data abstraction** is a simplified view of an object that includes only features one is interested in while hiding away the unnecessary details.

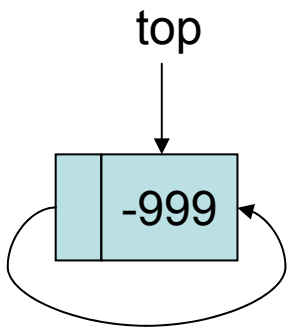
- In programming languages, a data abstraction becomes an **abstract data type** (**ADT**) or a **user-defined type**.

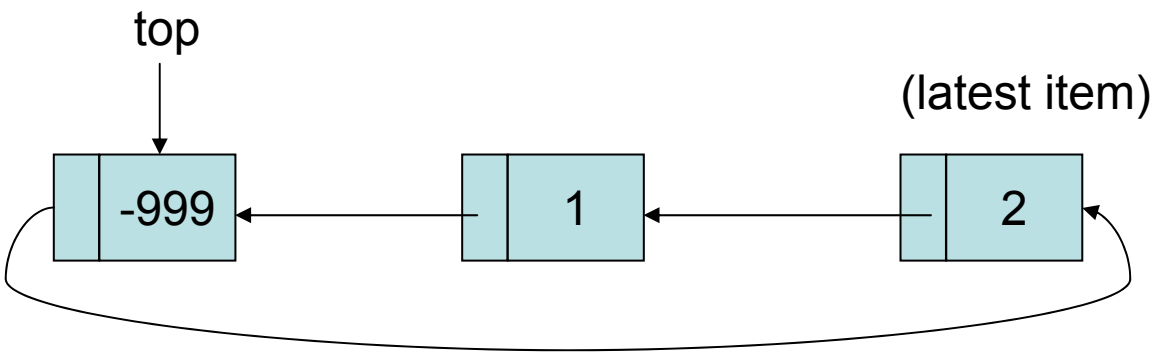
- In OOP, an ADT is implemented as a **class**.

# Example: Implement a Stack with an Array



# Example: Implement a Stack with a Linked List



# Information Hiding

- An **abstract specification** tells us the behavior of an object independent of its implementation. i.e. It tells us what an object does independent of how it works.

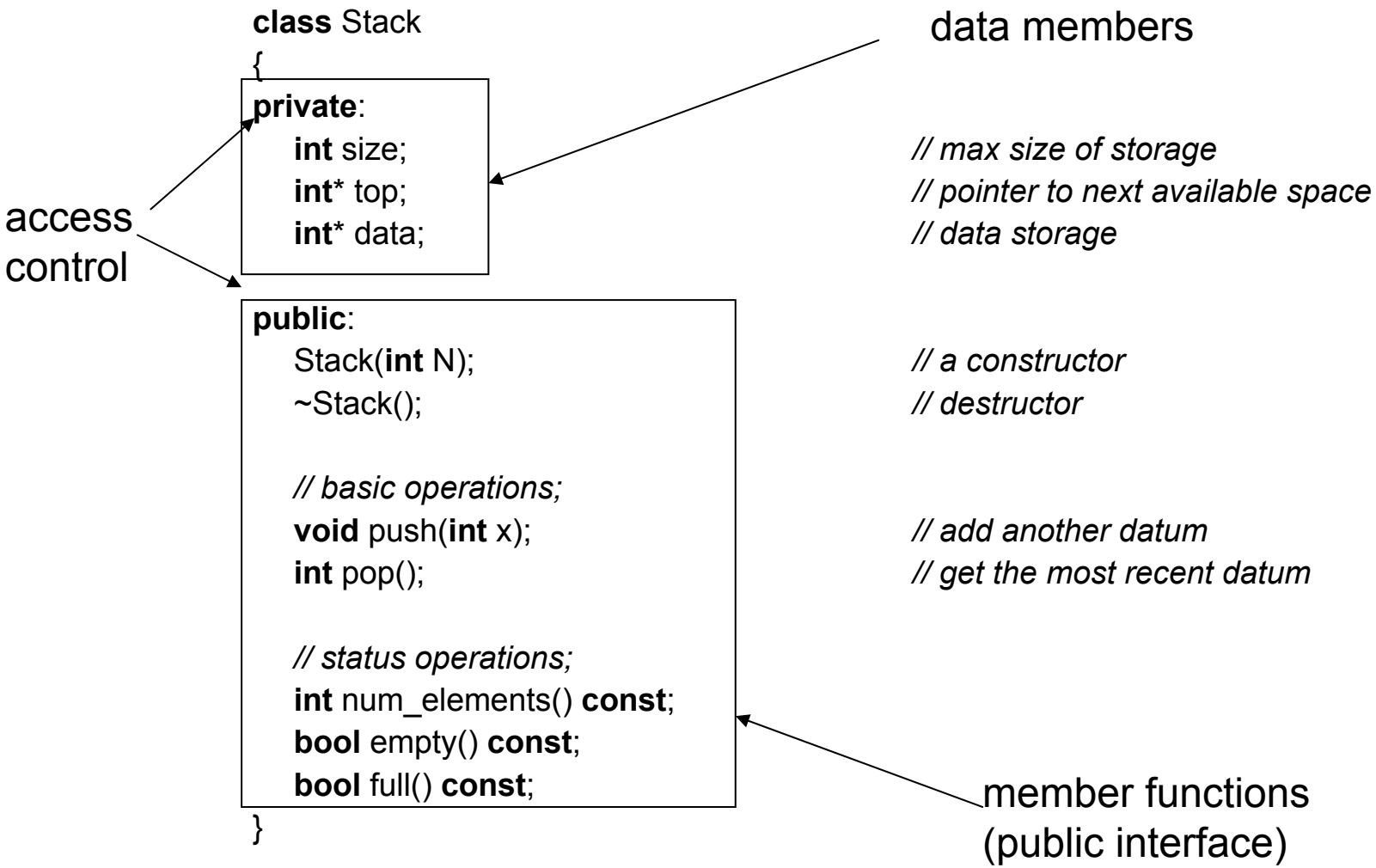
- Information hiding is also known as **data encapsulation**, or **representation independence**.

- The **principle of information hiding**:

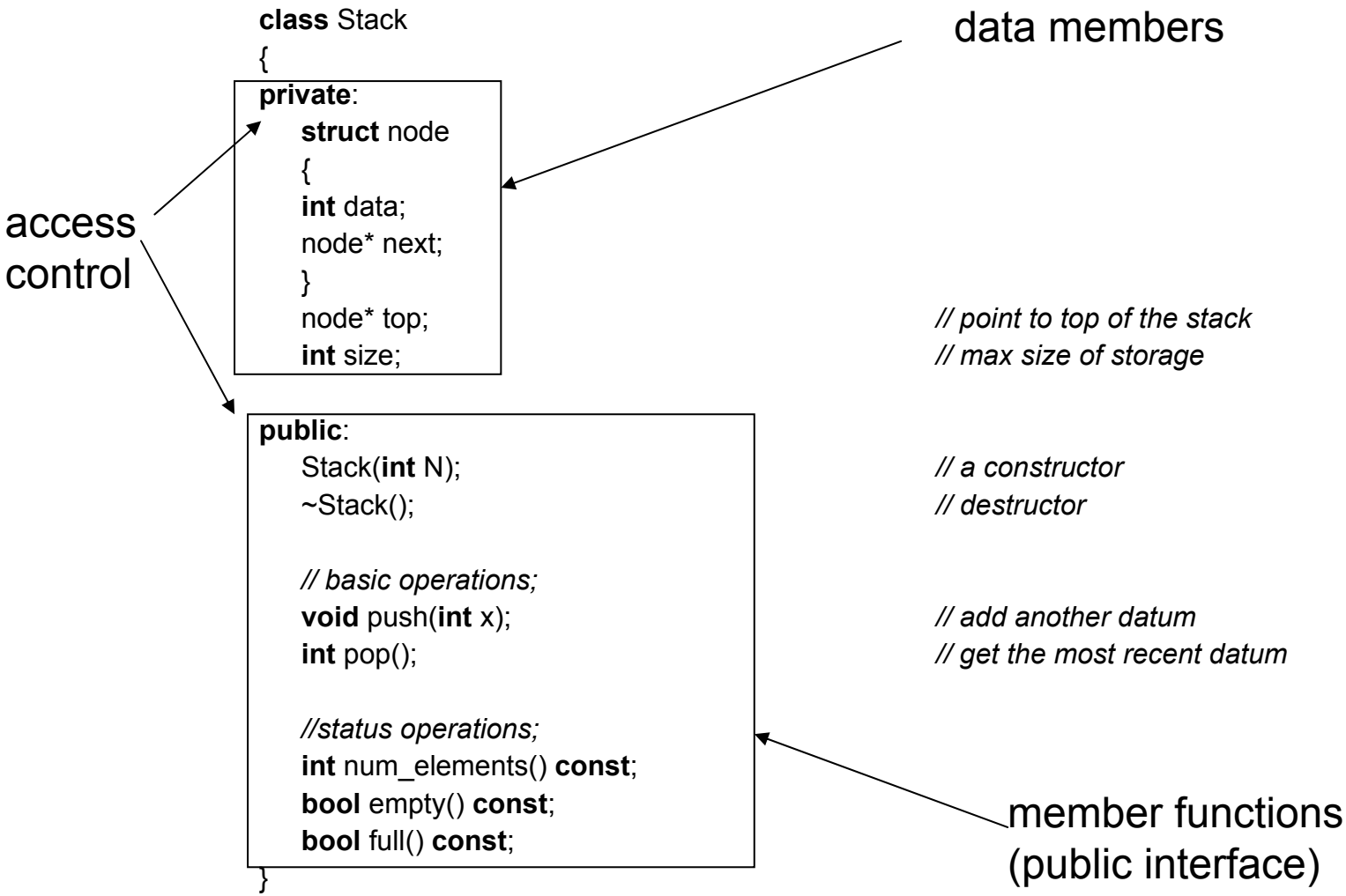
  Design a program so that the implementation of an object can be changed without affecting the rest of the program.

  – e.g., changing the implementation of a stack from an array to a linked list should have no effect on users' programs.

# Example: stack_ar.h



# Example: stack_ll.h



# Class Name: Name Equivalence

- A class definition introduces a new abstract data type.
- C++ class definitions rely on name equivalence, NOT structure equivalence.
- E.g., the program below does not compile:

```
#include <iostream.h>
class X { public: int a; };
class Y { public: int a; };
void main()
{
   X x; Y y;
   x.a = 1;
   y.a = 2;
   cout << " x.a = " << x.a << ", y.a = " << y.a << endl;
   y = x;
   cout << " x.a = " << x.a << ", y.a = " << y.a << endl;
}
```

# Class Name: Name Equivalence

- A class definition introduces a new abstract data type.
- C++ class definitions rely on name equivalence, NOT structure equivalence.
- On the other hand, this program compiles and works:

```
#include <iostream.h>
class X { public: int a; };
void main()
{
   X x1, x2;
   x1.a = 1;
   x2.a = 2;
   cout << " x1.a = " << x1.a << ", x2.a = " << x2.a << endl;
   x2 = x1;
   cout << " x1.a = " << x1.a << ", x2.a = " << x2.a << endl;
}
```

# Data Members of a Class

- Data members can be any basic type, or any user-defined types that have already been "seen" (defined).

- A class name can be used (but only as a pointer) in its own definition:

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

- It can also be used as a forward declaration for class pointers:

```
class Node;        // forward declaration
class Stack
{
   int size;
   Node* top;      // OK: points to an object with forward declaration
   Node x;         // ERROR: Node not defined!
};
```

# Data Members of a Class

- But, data members can NOT be initialized inside the class definition. E.g., the program below will not compile.

```
class X {
public:
   int a = 1;          // ERROR: can't initialize member variables this way
};

void main()
{
   X x;
   cout << " x.a = " << x.a << endl;
}
```

- Instead, initialization should be done with appropriate constructors, or member functions.

# Member Functions of a Class

- Class **member functions** are the functions declared inside the body of a class (they can be either public or private). They can be defined in two ways:

  (1) within the class body, in which case, they are **inline functions**.

```
class Stack
{  …
   void push(int x) { *top = x; ++top; }
   int pop() { - - top; return (*top); }
};
```

# Member Functions of a Class

(2) outside the class body

```
class Stack
{  …
   void push(int x);
   int pop();
};
void Stack::push(int x) { *top = x; ++top; }
int Stack::pop() { - - top; return (*top); }
```

- Question: Can we add data and function declarations to a class after the end of the class definition?

# Member Access Control

- A member of a class can be:
  - **public** : accessible to anybody
  - **private** : accessible only to member functions and friends of the class → enforces information hiding
  - **protected** : accessible to member functions and friends of the class, as well as to member functions and friends of its derived classes (subclasses). We will discuss this in greater detail later in the course.

* We'll discuss "friends" later.

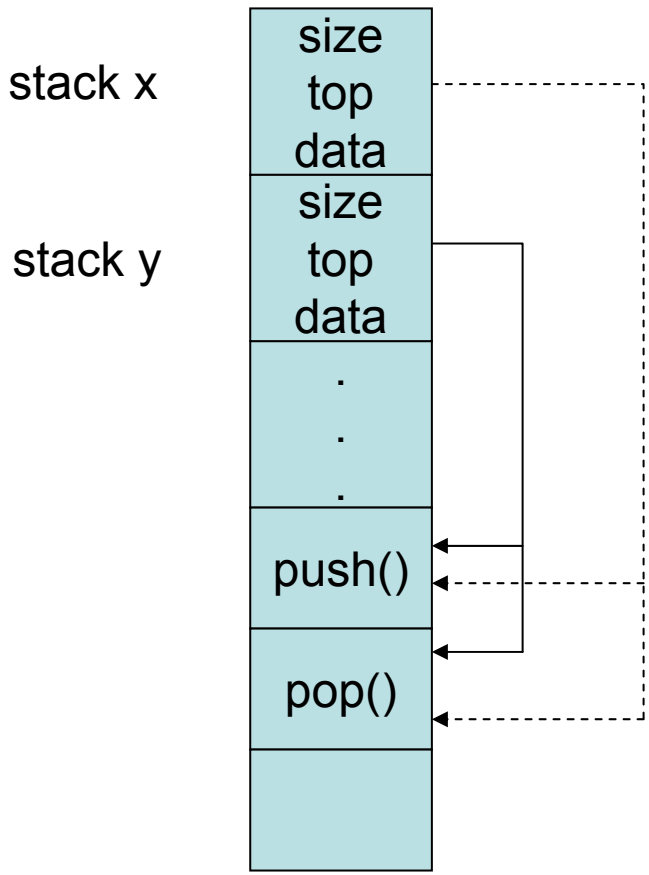
# Example: Member Access Control

```
class Stack
{
private:
   Node* top;
public:
   int size;
…
};

int main()
{
   Stack x;
   cout << x.size;          // OK: size is public
   x.push(2);               // OK: push() is public
   cout << x.top->data;     // ERROR: cannot access top
}
```

# How Are Objects Implemented?

- Each class object gets its own copy of the class data members.
- But all objects of the same class share one single copy of the member functions.




```
int main()
{
    Stack x, y;
    x.push(1);
    y.push(2);
    y.pop();
}
```