Communicating Objects

Think of the “Borg”on Star Trek.

Borg crew member = 1 object

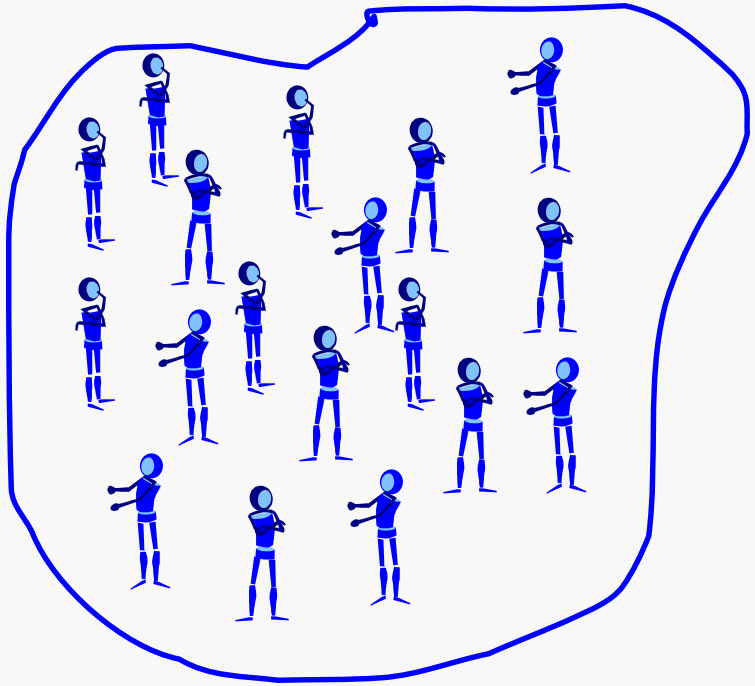
Borg Collective = composition of objects

To achieve the purpose of the Collective, each Borg must continually communicate with other Borg. A Borg can be a “sender” or a “receiver”, and may play both roles at different times.

Similarly, objects can be senders or receivers. Objects can also serve as messages!

The resulting software system is viewed as a collection of collaborating objects.

Collaboration requires communication…



Communication Involving Objects

Kinds:

by name	implicit communication that can occur when one object is in a scope where its name is visible to other object
by parameter passing	a method of a class take an object as a parameter
by return value	a method returns an object

Parameters and return values allow two-way interaction

Object may be communicated by:

- Copying
- Identity
  - Reference
  - Pointer

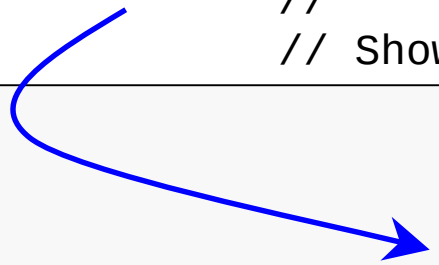
May want to control whether receiver can modify the object, and if so, whether the sender sees any changes made by the receiver.

Inter-Object Communication

By name: sender “knows the name” of the receiver and uses the name to access the public interface of the receiver.

```
DisplayableNumber D(42, &cout);

D.Show();   // The function accesses D by name,
            //     passing the object cout by address,
            // Show()accesses cout by a pointer member
```



```
void DisplayableNumber::Show() const {

   *Out << Count << endl;
}
```

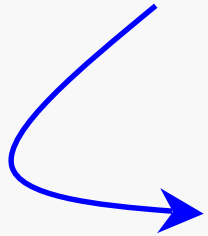
The "name" may be the identifier associated with the object, or a pointer to the object.

Passing an Object as a Parameter

An object may be passed as a function parameter:

```
DisplayableNumber D(42, &cout);
ofstream oFile("output.text");

D.ShowIn(&oFile);   // D receives oFile as a parameter
```



```
void DisplayableNumber::ShowIn(ostream* setOut) {

   Out = setOut;  // store address of oFile
}
```

As is always the case in C++, by default an object parameter is passed by value to the called function.

Returning an Object

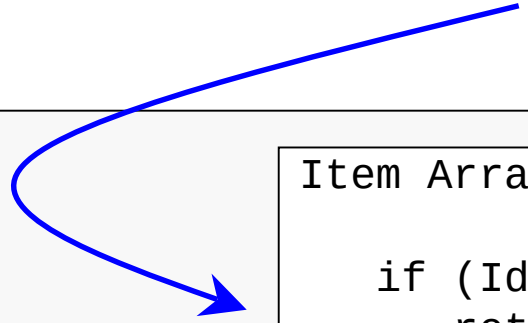
An object may be the return value from a function:

```
typedef DisplayableNumber Item;        // define an alias
const int Digits = 10;
Array LCD(Digits, Item(0, &cout));     // array of DNs

. . .

DisplayableNumber Digit4 = LCD.Retrieve(4);  // shallow copy

. . .
```



```
Item Array::Retrieve(int Idx) const {

   if (Idx >= Usage)
      return -1;
   else
      return List[Idx];
}
```

Using an object as the return value provides a mechanism for encapsulating a body of related heterogeneous data.

Different Ways to Communicate

Is object communicated by:

- copying
- reference
- pointer

Can the receiver modify the object?

If the receiver does modify the object, does the sender see the changes?

What language syntax is used in receiver to access (`.` or `->`)?

Characteristics of Communicated Objects

Technique	Copied	Changeable	Visible	C++ Access Syntax
by copy	yes	yes	no	.
by reference	no	yes	yes	.
by pointer	no	yes	yes	->
by const reference	no	no	no	.
by pointer to const	no	no	no	->

By Copy:

- ✔ Sender is “isolated” from changes by receiver
- ✘ No good if sender/receiver want to share object
- ✘ Bad if object is large (why?)

By Identity (pointer or reference):

- ✘ No isolation
- ✔ Permits sharing of objects
- ✔ Improves memory cost for large objects

Example: Person Class

`Person` class represents basic characteristics of a person.

A variety of object communications take place in the `Person` interface.

```
enum Gender {MALE, FEMALE, GENDERUNKNOWN};
class Person {
private:
   Name    Nom;       // sub-object
   Address Addr;      // sub-object
   Person* Spouse;    // association link
   Gender  Gen;       // simple data member
public:
. . .
   void changeAddress(const Address& newAddr);
   Address getAddress() const;
. . .
   void setSpouse(Person* const Sp);
   Person* getSpouse() const;
. . .
};
```

Example: an Object as a Parameter

The `Person` member `changeAddr()` receives an `Address` object as a parameter; pass by constant reference is used to avoid copying while safeguarding the actual parameter:

```
void Person::changeAddr(const Address& newAddr) {
   Addr = newAddr;
}
```

The `Person` member `setSpouse()` receives a `Person` object as a parameter; pass by constant pointer is used to avoid copying while safeguarding the actual pointer (but not its target):

```
void Person::setSpouse(Person* const Sp) {
   Spouse = Sp;
}
```

Example: an Object as a return Value

The `Person` member `getAddress()` returns a sub-object:

```
Address Person::getAddress() const {
   return Addr;
}
```

As we've seen, one thing this allows is "chaining" of member function calls:

```
Name JBHName("Joe", "Bob", "Hokie");
Address JBHAddr("Oak Bridge Apts", "#13", "Blacksburg",
                "Virginia", "24060");
Person JBH(JBHName, JBHAddr, MALE);

cout << JBH.changeAddress().getZip() << endl;
```

Example: returning a Reference

Changing the `Person` member `setAddress()`:

```
Person& Person::setAddress(const Address& newAddr) {
   Addr = newAddr;
   return (*this);
}
```

When the return value is a reference, no copying is performed.

Returning a reference to the "implicit" object allows carrying out multiple operations in a single statement:

```
Address MovedTo("3221 Bob Petit Blvd", "Apt 6", "Baton Rouge",
                "Louisiana", "78703");

Person JT(. . .);

JBH.setAddress(MovedTo).setSpouse(&JT);
```

Anonymous Objects

An nameless (i.e., unnamed) object.

Useful:

- for temporary use (parameter in a method call, return, expression term)
- as default value for an object parameter

Anonymous objects are created by a direct invocation of a class constructor.

There's an example of this in the Aggregation notes (slide C08.16).

Anonymous objects are frequently used in conjunction with mutators and constructors when aggregation is involved, providing a cleaner interface to the aggregating class.

Example: Anonymous Objects as Parameters

Without anonymous objects, we have a mild mess:

```
Name    JBHName("Joe", "Bob", "Hokie");
Address JBHAddr("Oak Bridge Apts", "#13", "Blacksburg",
                "Virginia", "24060");
Person JBH(JBHName, JBHAddr, MALE);

. . .
```

With anonymous objects we reduce pollution of the local namespace:

```
Person JBH(Name("Joe", "Bob", "Hokie"),
           Address("Oak Bridge Apts", "#13", "Blacksburg",
                "Virginia", "24060"),
           MALE);

. . .
```

Example: Anonymous Objects as Defaults

Used as default parameter values, anonymous objects provide a relatively simple way to control initialization and reduce class interface clutter:

```
Person::Person(Name    N = Name("I", "M", "Nobody"),
               Address A = Address("No Street", "No Number",
                                   "No City", "No State",
                                   "00000"),
               Gender  G = GENDERUNKNOWN) {
   Nom    = N;
   Addr   = A;
   Spouse = NULL;
   Gen    = G;
}
```