

CS322 W'05 Lecture Notes
Lecture 9.2

Implementing Object-oriented Features

Object-oriented languages permit procedures and data to be packaged together into **objects**.

Example (C++)

```
class text {
    char *contents;
    int size;
    text (char *s) {contents = s; size = 12;}
    void show()
        { ...display(contents,Courier,size);...}
    int changesize (int d) {return size += d;}
};

text x("abc");
... x.show(); ...
... x.changesize(-1) + 17 ...
```

Note that class functions (like `show`) have **implicit** access to the data elements of the class (like `contents`).

Naive Implementation

Just add implicit `this` pointer parameter to each class function. Then can represent class in ordinary C (or close).

```
struct text {
    char *contents;
    int size;
};
```

```
struct text text_constructor (char *s) {
    struct text this;
    this.contents = s;
    this.size = 12;
    return this;
}
```

```
void text_show (struct text *this)
    {display(this->contents, Courier,
            this->size);}
```

```
int text_changesize (struct text *this,
                    int d)
    {return this->size += d;}
```

```
struct text x = text_constructor("abc");
... text_show (&x);...
... text_changesize(&x, -1) + 17;...
```

Inheritance

If a class B **inherits** from another class A, B contains all the data fields and functions that A does, plus more. Any B object can be used wherever an A object can be used.

Example: fancytext is subclass of text.

```
class fancytext : text {
    font fnt;
    fancytext(char *, font) {...};
    void emphasize() {fnt = Italic;}
};
```

- Represent each subclass object by record that **extends** superclass object.

```
struct fancytext {
    char *contents;
    int size;
    font fnt;
}
```

(**Multiple inheritance** is considerably harder.)

Inheritance (cont.)

- Superclass functions work on subclass objects too, because offsets of data fields they can see are the same!

```
struct fancytext y;
text_changesize((struct text *) &y, -1);
```

- Subclass functions work only on subclass objects, since they may reference fields that only exist in subclass:

```
void
fancytext_emphasize(struct fancytext *this)
{this->fnt = Italic;}
```

- Since superclass and subclass have different **sizes**, direct **assignment** or pass-by-value of object records won't work properly. Instead, should always manipulate **pointers** to class records. (C++ is unusual in not requiring this implicitly anyhow.)

```
struct text x, *p;
struct fancytext y, *q;
x = (struct text) y; /* Bad */
p = (struct text *) q; /* OK */
```

Virtual Functions

Sometimes it is appropriate to **redefine** the behavior of a function within a subclass:

```
class text {
    ...
    virtual void show()
        {display(contents,Courier,size);}
};

class fancytext : text {
    font fnt;
    virtual void show()
        {display(contents,fnt,size);}
};

text *x = new text("abc");
fancytext *y = new fancytext("def",Arial);
if (???) x = y;
x->show();
```

Invokes fancytext_show if x is actually a fancy text; otherwise invokes text_show.

We can't tell at compile time which function should be invoked!

Solution: Function Pointers in Objects

```
struct text {
    char *contents;
    int size;
    void (*show)(struct text *this);
};

struct fancytext {
    ..as above, followed by...
    font fnt;
};

void text_show()
    {display(contents,Courier,size);}

void fancytext_show()
    {display(contents,fnt,size);}

struct text text_constructor (char *s) {
    ...
    result.show = &text_show;
    ...
}

struct fancytext fancytext_constructor
    (char *s, font f) {
    ...
    result.show = &fancytext_show;
    ...
}

struct text *x;
struct fancytext *y;
if (???) x = y;
(*(x->show)) (x);
```


Dispatch Tables

If there are many virtual functions in class, it's better to separate out the function pointers for each defined subclass into a function **dispatch table**, which is pointed to from each object record for that subclass.

- The tables for all related classes are organized so that a given function always appears at the same table offset.
- Advantage: saves space in object records (though still uses lots of duplicate space in deep class hierarchies).
- Disadvantage: virtual function calls require an extra dereference.

This is essentially the implementation model used by C++, Java, Smalltalk, etc.

Multiple inheritance (C++) or interfaces (Java) requires more work, because we can't maintain field or function entries in the same slot as the superclass when there are multiple superclasses!