CS 101: Computer Programming and Utilization

20-Inheritance

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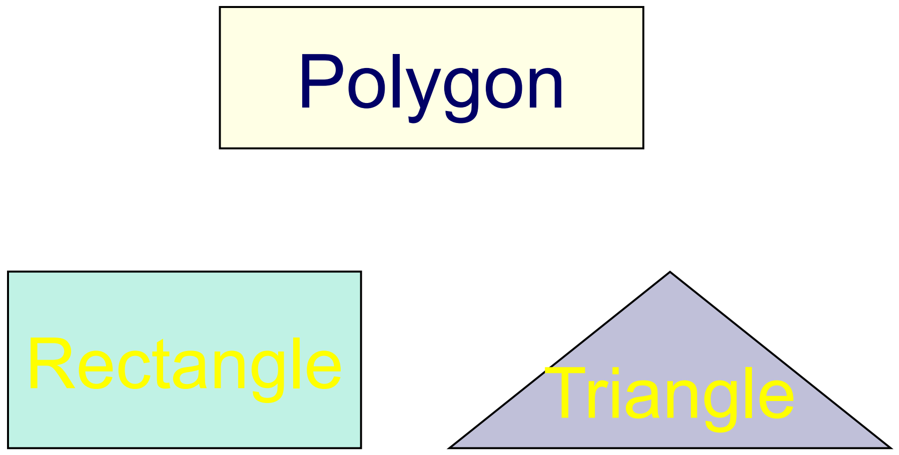
Avoid redundancy in these class definitions

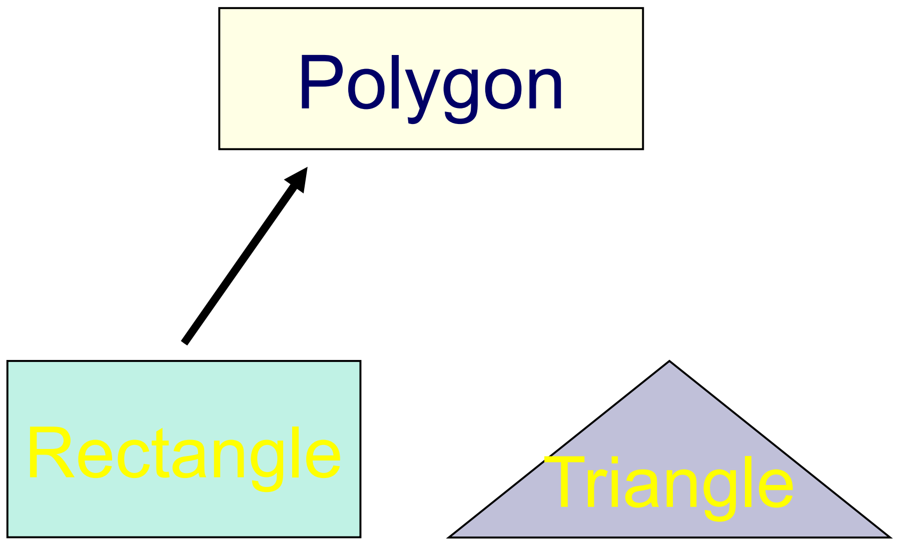


```
class Polygon{
  private:
    int numVertices;
    float *xCoord, *yCoord;
  public:
    void set(float *x, float *y, int nV);
};
```

```
class Rectangle{
    private:
      int numVertices;
      float *xCoord, *yCoord;
    public:
      void set(float *x, float *y, int nV);
      float area();
};
```

```
class Triangle{
   private:
     int numVertices;
     float *xCoord, *yCoord;
   public:
     void set(float *x, float *y, int nV);
     float area();
};
```

Inheritance Concept



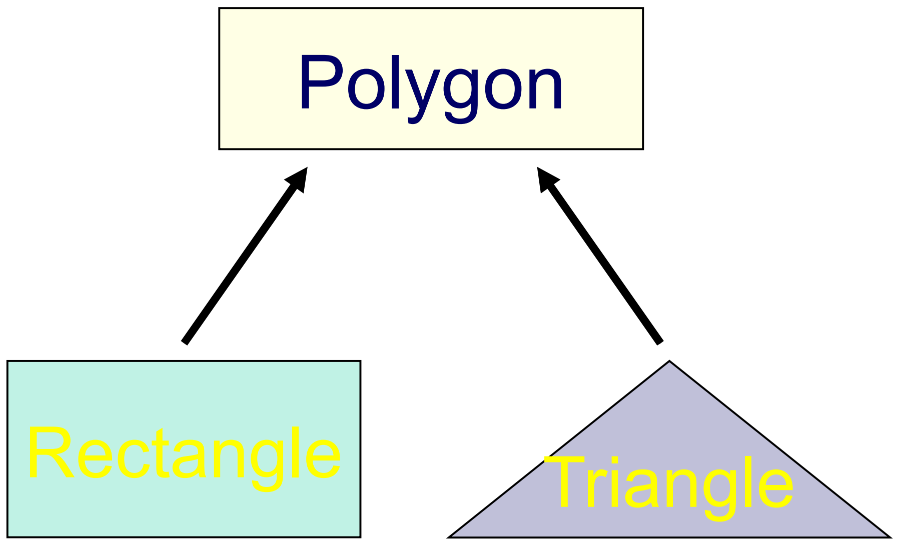
```
class Polygon{
    protected:
      int numVertices;
      float *xCoord, float *yCoord;
    public:
       void set(float *x, float *y, int nV);
};
```

```
class Rectangle : public Polygon{
    public:
       float area();
};
```

⟺

```
class Rectangle{
    protected:
      int numVertices;
      float *xCoord, float *yCoord;
    public:
       void set(float *x, float *y, int nV);
       float area();
};
```

Inheritance Concept



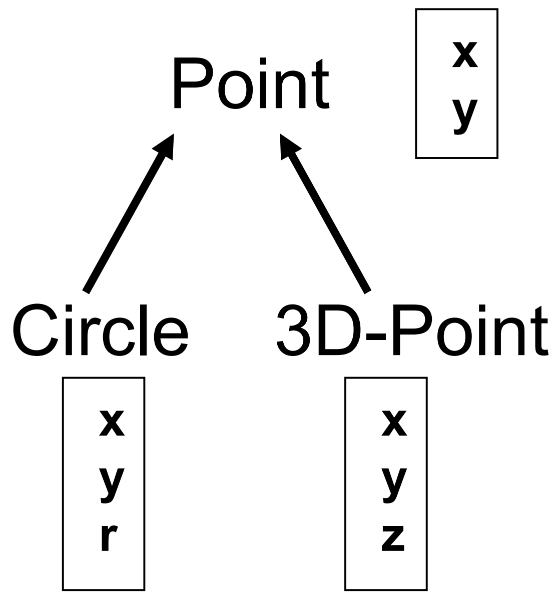
```
class Polygon{
    protected:
      int numVertices;
      float *xCoord, float *yCoord;
    public:
       void set(float *x, float *y, int nV);
};
```

```
class Triangle : public Polygon{
    public:
     float area();
};
```

⟺

```
class Triangle{
    protected:
      int numVertices;
      float *xCoord, float *yCoord;
    public:
       void set(float *x, float *y, int nV);
       float area();
};
```

Inheritance: Another Example



```
class Point{
    protected:
      int x, y;
    public:
      void set (int a, int b);
};
```

```
class Circle : public Point{
    private:
          double r;
};
```

```
class 3D-Point: public Point{
    private:
          int z;
};
```

Why Inheritance ?

Inheritance is a mechanism for building class types from existing class types

- A way to establish Is-a relationship between objects
    - Polygon – base class.
    - Rectangle – Derived class.
    - http://www.cplusplus.com/doc/tutorial/inheritance/
- A way to reuse the existing code of base class.

Class derivation hierarchy

$$\begin{tikzcd}
\text{Point} \\
\text{3D-Point} \arrow[u] \\
\text{Sphere} \arrow[u]
\end{tikzcd}$$

```
class Point{
    protected:
        int x, y;
    public:
        void set (int a, int b);
};
```

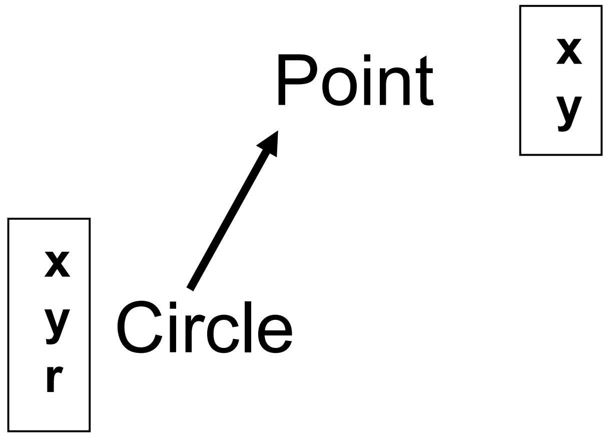
```
class 3D-Point : public Point{
    protected:
        double z;
    … …
};
```

```
class Sphere : public 3D-Point{
    private:
        double r;
    … …
};
```

Point is the base class of 3D-Point; 3D-Point is the base class of Sphere

Derived Class: Members

The derived class can define its own members, in addition to the members inherited from the base class



```
class Circle : public Point{
    private:
            double r;
    public:
            void set_r(double c);
};
```

```
class Point{
    protected:
       int x, y;
    public:
       void set(int a, int b);
};
```

```
class Circle{
    protected:
       int x, y;
    private:
       double r;
    public:
       void set(int a, int b);
       void set_r(double c);
};
```

Derived Class: Function Overriding

- A derived class can override methods defined in its parent class. With overriding,
  - the method in the subclass has the identical signature to the method in the base class.
  - a subclass implements its own version of a base class method.

```
class A {
   protected:
     int x, y;
   public:
     void print ()
             {cout<<"From A"<<endl;}
};
```

```
class B : public A {
   public:
     void print ()
         {cout<<"From B"<<endl;}
};
```

Derived Class: Example

```
class Point{
    protected:
      int x, y;
    public:
      void set(int a, int b)
          {x=a; y=b;}
      void foo ();
      void print();
};
```

```
class Circle : public Point{
  private:  double r;
  public:
    void set (int a, int b, double c) {
        Point :: set(a, b); //same name function call
        r = c;
    }
    void print();  };
```

```
Point A;
A.set(30,50);  // from base class Point
A.print(); // from base class Point
```

```
Circle C;
C.set(10,10,100);   // from class Circle
C.foo ();  // from base class Point
C.print(); // from class Circle
```

Activity: Inheritance and Multiple files

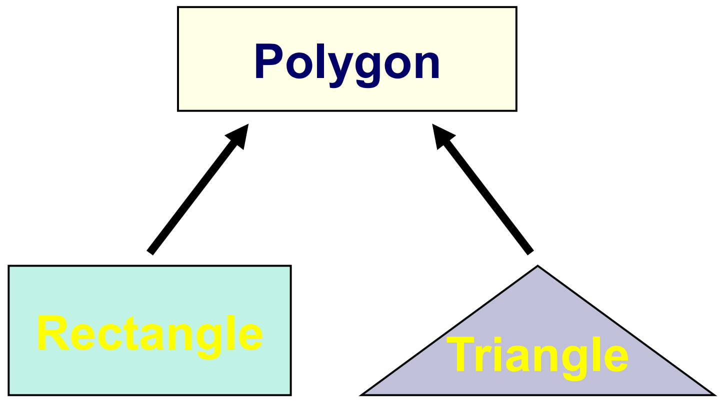
- Code walk-through – demo19-point.h
- Build and run – demo19-point.cpp

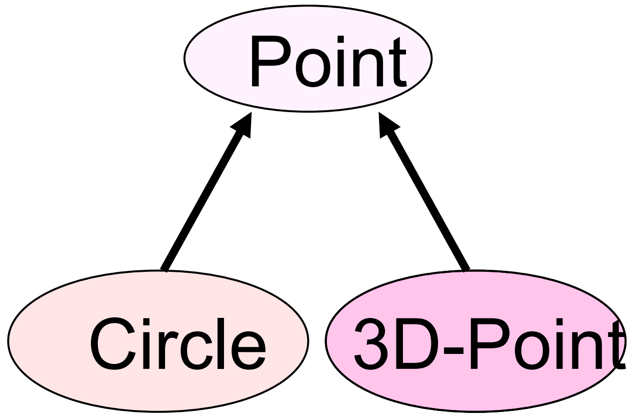
- Code walk-through – demo19-circle.h
- Build and run – demo19-circle.cpp

- Code walk-through – demo19-cylinder.h
- Build and run - demo19-cylinder.cpp

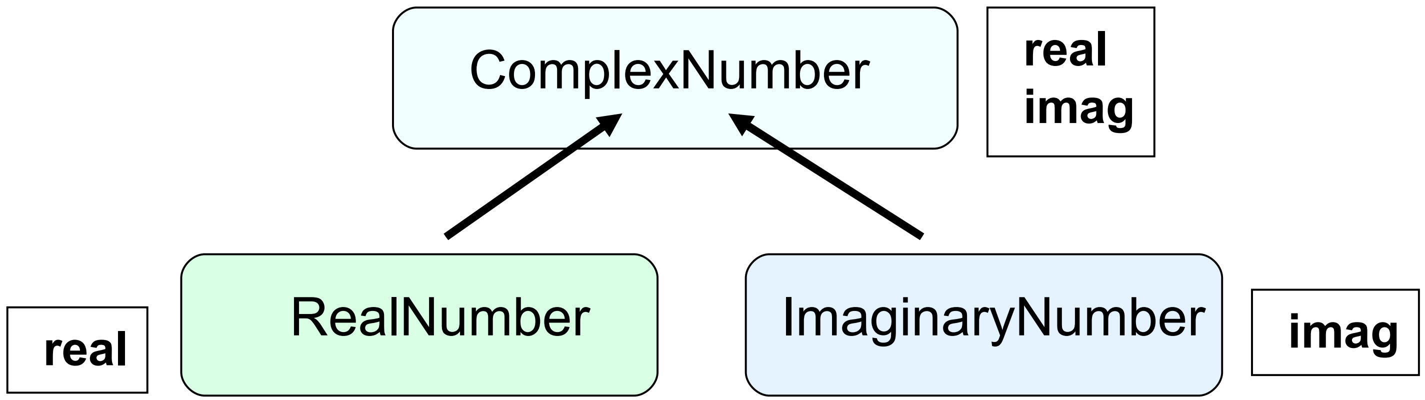
Notes: Inheritance – Purpose (Optional Reading)

- Augmenting the original class

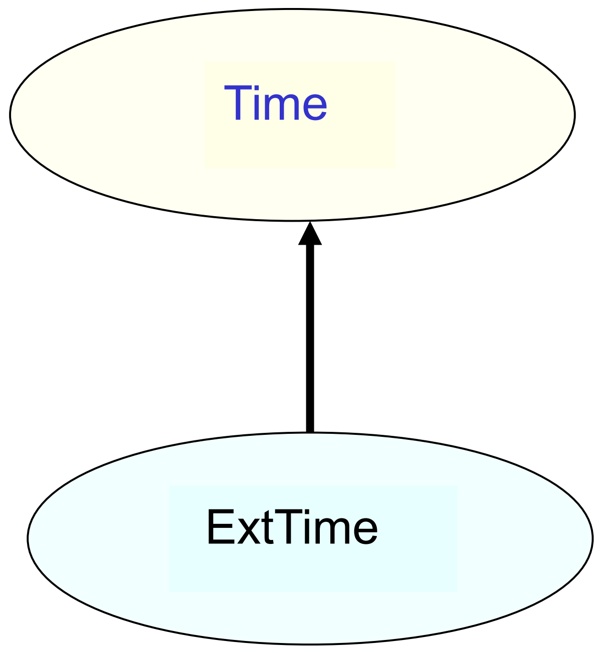




- Specializing the original class



Notes: Another example



- Time is the base class
- ExtTime is the derived class with public inheritance that has the notion of timezones.

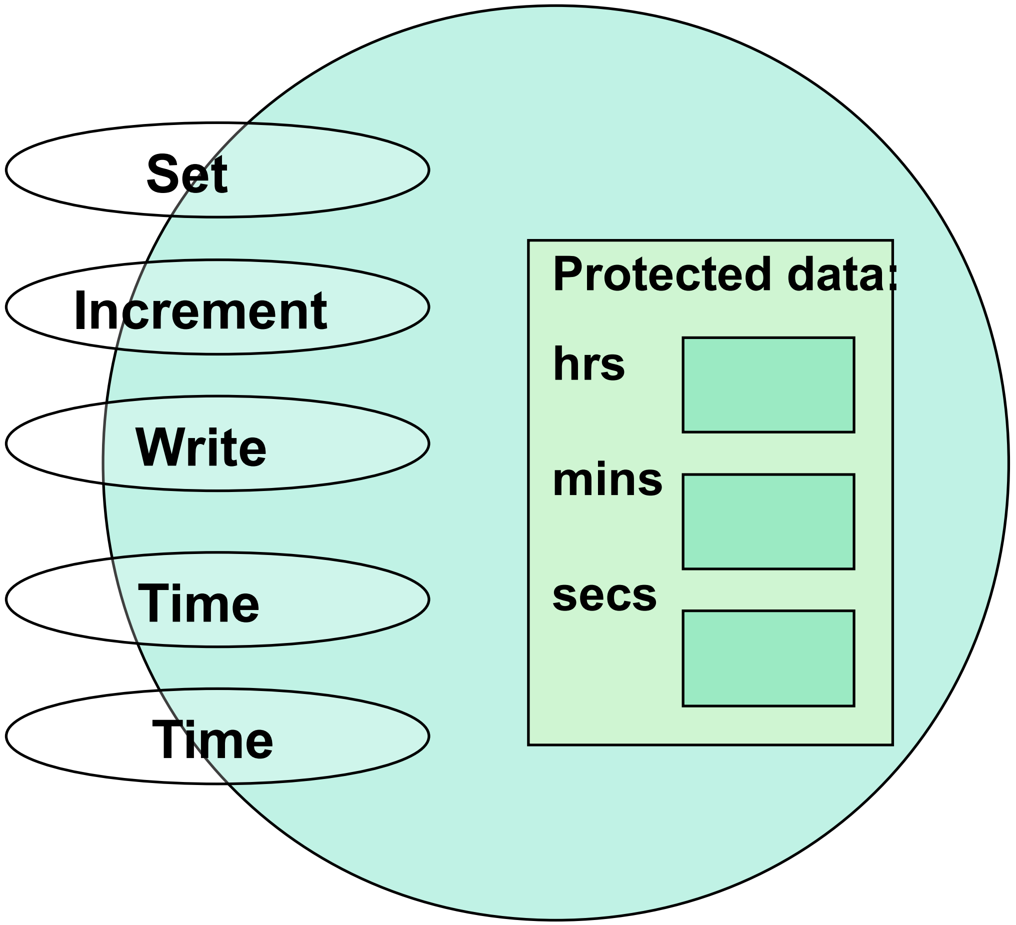
- The derived class can
  - inherit all members from the base class, except the constructor
  - access all public and protected members of the base class
  - define its private data member
  - provide its own constructor
  - define its public member functions
  - override functions inherited from the base class

class **`Time`** Specification

```
 // SPECIFICATION   FILE                                   ( time.h)

class  Time{

 public :

   void     Set ( int h, int m, int s ) ;
   void     Increment ( ) ;
   void     Write ( )  const ;
   Time     ( int initH, int initM, int initS ) ;   //  constructor
   Time     ( ) ;                                   //  default constructor

 protected :

   int          hrs ;
   int          mins ;
   int          secs ;
} ;
```

Class Interface Diagram

Time class

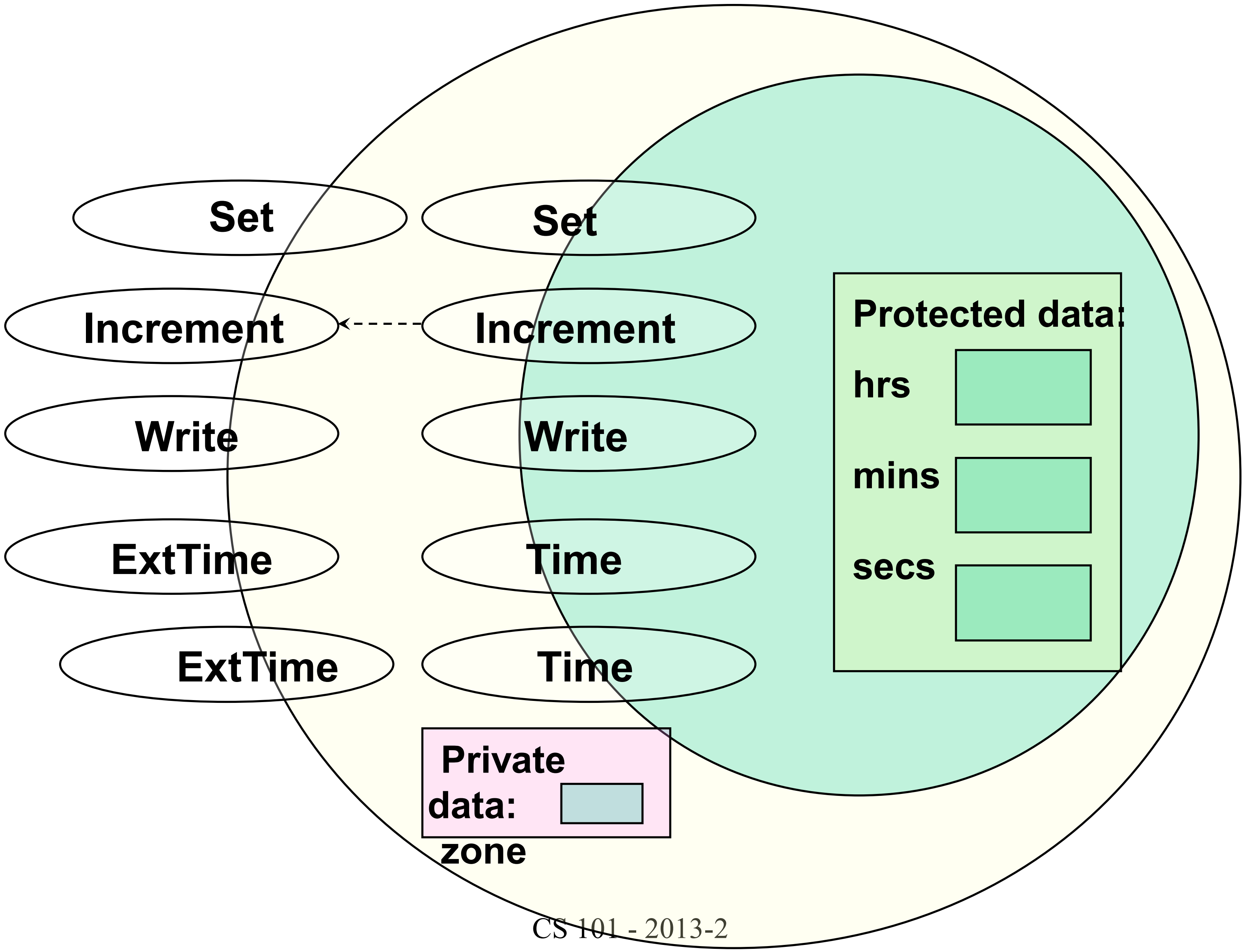


Derived Class `ExtTime`

```
// SPECIFICATION   FILE                        ( exttime.h)

#include   “time.h”
enum  ZoneType {EST, CST, MST, PST, EDT, CDT, MDT, PDT } ;

class  ExtTime  :  public  Time
          // Time is the base class and use public inheritance
{
  public :
    void        Set ( int h, int m, int s, ZoneType timeZone ) ;
    void        Write ( )  const;    //overridden
    ExtTime     (int initH, int initM, int initS, ZoneType initZone ) ;
    ExtTime     ();   // default constructor

private :
    ZoneType  zone ;     //  added data member
} ;
```

Class Interface Diagram

`ExtTime` class



Implementation of **`ExtTime`**

Default Constructor

```
ExtTime :: ExtTime (  )
{
     zone  =  EST ;
}
```

```
ExtTime et1;
```

et1

```
hrs = 0
mins = 0
secs = 0
zone = EST
```

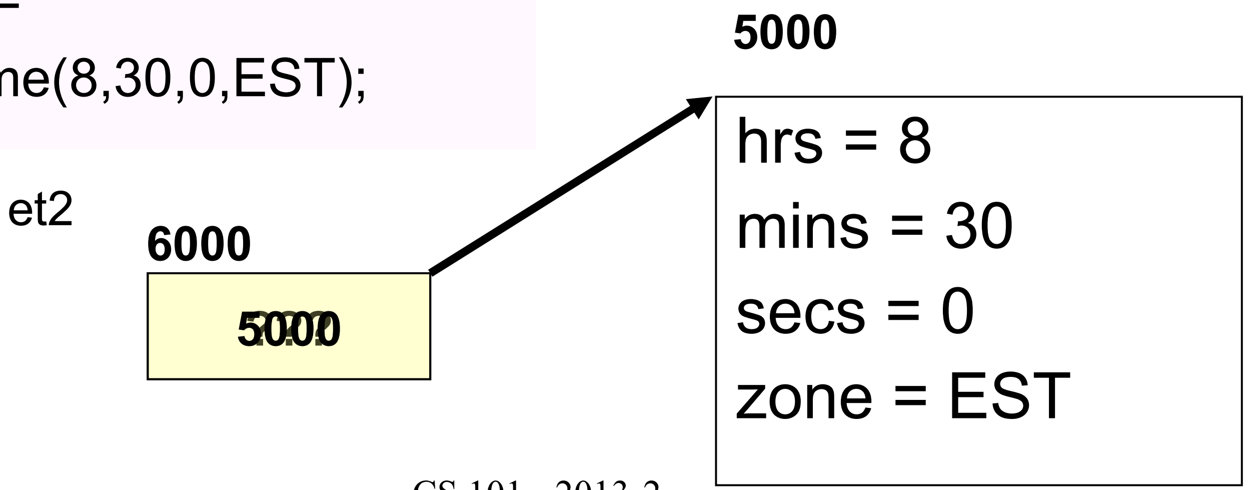
The default constructor of base class, Time(), is automatically called, when an ExtTime object is created.

Implementation of `ExtTime`

Another Constructor

```
ExtTime :: ExtTime (int initH, int initM, int initS, ZoneType initZone)
            : Time (initH, initM, initS)
            // constructor initializer
{
         zone  = initZone ;
}
```

```
ExtTime *et2 =
    new ExtTime(8,30,0,EST);
```



Implementation of `ExtTime`

```
void  ExtTime :: Set (int h, int m, int s, ZoneType timeZone)
{
      Time :: Set (hours, minutes, seconds);  // same name function call
      zone  = timeZone ;
}
```

```
void  ExtTime :: Write ( )   const  // function overriding
{
   string  zoneString[8] =
            {“EST”, “CST”, MST”, “PST”, “EDT”, “CDT”, “MDT”, “PDT”} ;

  Time :: Write ( ) ;
  cout  <<‘  ‘<<zoneString[zone]<<endl;
}
```

Working with `ExtTime`

```
#include  "exttime.h"
… …
int main()
{
      ExtTime    thisTime ( 8, 35, 0, PST ) ;
      ExtTime    thatTime ;                  // default constructor called

      thatTime.Write( ) ;                    // outputs 00:00:00 EST

      thatTime.Set (16, 49, 23, CDT) ;
      thatTime.Write( ) ;                    // outputs 16:49:23 CDT

      thisTime.Increment ( ) ;
      thisTime.Increment ( ) ;
      thisTime.Write ( ) ;                   // outputs 08:35:02  PST
}
```

Constructor rules for Derived Classes

The default constructor and the destructor of the base class are always called when a new object of a derived class is created or destroyed.

```
class A {
  public:
   A ( )
     {cout<< “A:default”<<endl;}
   A (int a)
     {cout<<“A:parameter”<<endl;}
};
```

```
class B : public A
{
  public:
   B (int a)
       {cout<<“B”<<endl;}
};
```

```
B test(1);
```

output:

```
A:default
B
```

Constructor rules for Derived Classes

You can also specify a constructor of the base class other than the default constructor

```
DerivedClassCon ( derivedClass args ) : BaseClassCon ( baseClass args )

      {  DerivedClass constructor body   }
```

```
class A {
  public:
    A ( )
      {cout<< “A:default”<<endl;}
    A (int a)
      {cout<<“A:parameter”<<endl;}
};
```

```
class C : public A {
  public:
    C (int a) : A(a)
        {cout<<“C”<<endl;}
};
```

```
C test(1);
```

output:

```
A:parameter
C
```