CSE 374: Programming Concepts and Tools

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Lecture 23: C++: Vtables

Administrivia

- Homework 6 is due this Thursday
  - Use turn in instructions in assignment
    - Come get help in office hours! We can make your life better
- Homework 7 out on Friday (smaller, in C++)
- No class next Monday (Memorial Day)
- Final is June 7 at 2:30pm-4:20pm in this room

Object Oriented Programming (OOP)

- Popular programming paradigm
- Everything is an object
- Every object owns its own implementation, usually given by its class
- In order to modify an existing program, a programmer extends classes, overrides methods, and so on
- Every part of a program can be extended, everything is very open

C++ = C + OOP

- C++ was originally called C with Classes
- C was a useful language, but more modern object oriented features were desired
- Many of the features were more “nice to have” features, but Classes are core to C++
- Classes were controversial: some thought too slow
    - Computers are much faster now, other criticisms more common

Building Classes

- It is possible to write code with the exact same behavior as a C++ virtual method call in C

- Today, in order to understand how C++ works, we'll do just that

Today's Class

C++

```
class Point {
 protected:
   int x;
   int y;
 public:
   Point();
   Point(int x, int y);
   int getX();
   int getY();
};
```

Normal Functions

C

- Class attempt #1:

```
typedef struct Point {
   int x;
   int y;
} Point;

Point Point_Constr(int x, int y) {
   point* p = (point*)malloc(sizeof(point));
   p->x = x;
   p->y = y;
   return p;
}
```

Normal Functions

C

- Class attempt #1:

```
Point* Point_ConstrD() {
   return Point_Constr(0,0);
}

int getX(Point* p) {
   return p->x;
}

int getY(Point* p) {
   return p->y;
}
```

Normal Functions

- Class attempt #1:

```
Point* p = Point_Constr(3,2);
printf("(%d,%d)\n",getX(p),getY(p));
```

Today's Class

C++

```
class Point {
 protected:
   int x;
   int y;
 public:
   Point();
   Point(int x, int y);
   int getX();
   int getY();
};
```

Normal Functions

- Class attempt #1:

```
typedef struct Point {
   int x;
   int y;
} Point;
```

```
typedef struct PolarPoint {
   int x;
   int y;
   float r;
   float theta;
} PolarPoint;
```

Normal Functions

C

- Class attempt #1:

```
int getX(Point* p) {
  return p->x;
}

int getY(Point* p) {
  return p->y;
}
```

```
int getXP(PolarPoint* p) {
  return p->x;
}

int getYP(PolarPoint* p) {
  return p->y;
}
```

Normal Functions

C

- Class attempt #1:

```
PolarPoint* p = PolarPoint_Constr(3,2);
printf("(%d,%d)\n",getXP(p),getYP(p));
```

Dynamic Dispatch

- Core of object oriented programming
- Allows for the code of method calls to be chosen at run time, based on the dynamic type of the receiver object
    - This is *necessary* to make getX, getY work with our new PolarPoint class

How would you implement this?

C++

How it is implemented

```
class Point {
 protected:
  int x;
  int y;
 public:
  Point();
  //Point class
  int getX();
  int getY();
};
```

1 per class

```
int y);
```

```
//Point object
vtable pointer;
int x;
int y;
```

C++

How it is implemented

```
class PolarPoint : public Point {
 private:
  float r,theta;
 public:
  PolarPoint(float r, float t);
  float getR();
  //PolarPoint
};int getX();
  int getY();
  float getR();
  float getTheta();
```

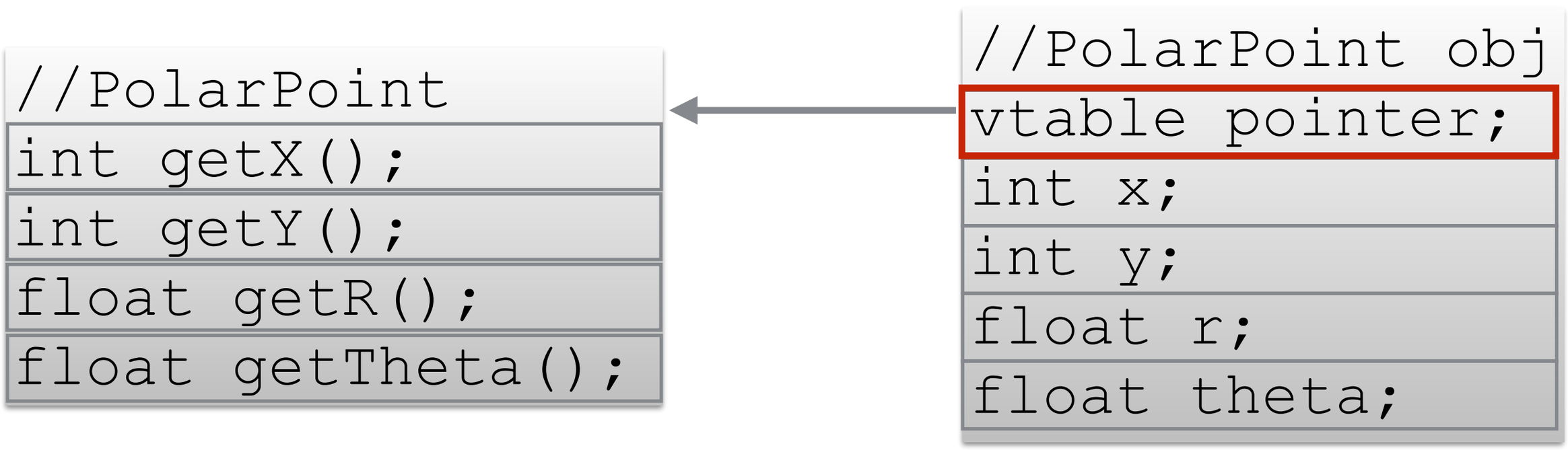


```
//PolarPoint obj
vtable pointer;
int x;
int y;
float r;
float theta;
```

C++

How it is implemented

```
Point* p = new PolarPoint(3,2);
std::cout << p->getX() << std::endl;
```



Questions?

Pros

- If classes are extended, no need to recompile code which uses objects of that class

- Cost of virtual method call is low: 2 pointer lookups, likely in cache anyway, virtually no difference with normal function calls

Cons

- A field of your object now exclusively determines what code gets called

- This is a security hole which has lead to at least one zero-day vulnerability in practice