Module M24
Partha Pratim Das
Objectives & Outlines
ISA Hierarchy Design by Inheritance
Helper Classes
Hierarchy of Phones by Interfaces
Interfaces & State Variables of Phones
Landline Phone
Mobile Phone
Smart Phone
Refactoring
Hierarchy Integration
Extended Hierarchy of Phones
Module Summary

Programming in Modern C++

Module M24: Inheritance: Part 4: Phone Hierarchy

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All url's in this module have been accessed in September, 2021 and found to be functional

Module Recap

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Module Summary

- Understood the need and use of `protected` access specifier
- Discussed the Construction and Destruction process of class hierarchy and related Object Lifetime

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Module Objectives

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Module Summary

- Model a hierarchy of phones using inheritance

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Module Outline

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1. Objectives & Outlines
2. ISA Hierarchy Design by Inheritance
3. Helper Classes
4. Hierarchy of Phones by Interfaces
5. Interfaces & State Variables of Phones
   - Landline Phone
   - Mobile Phone
   - Smart Phone
6. Refactoring
7. Hierarchy Integration
   - Extended Hierarchy of Phones
8. Module Summary

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ISA Hierarchy Design by Inheritance

Approach to Modeling Hierarchy

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Module Summary

- Identify the **Concepts and their ISA relationships** to define the hierarchy: model with public inheritance
- Identify and model **Helper classes** - lower level UDTs to define components
- Identify the **Interface** of each concept: signatures of public member functions
- Identify the **State Variables** of each concept: types of of private / protected data members (also member functions used for ease of implementation)
- **Refactor** common data members and member functions between specialized and generalized classes to link the classes by inheritance
- **Integrate the hierarchy** with abstract (pure) interface
- Explore **extendability**
- *We illustrate with the phone hierarchy*

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Helper Classes

Helper Classes

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Module Summary

Class	Description
`class PhoneNumber`	12-digit phone number
`class Name`	Subscriber Name (as `string`)
`class Photo`	Image & Subscriber Name as alt text
`class RingTone`	Audio & ring tone name
`class Contact`	`PhoneNumber`, `Name`, and `Photo` (optional) of a contact
`class AddressBook`	List of contacts

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Hierarchy of Phones by Interfaces

Hierarchy of Phones

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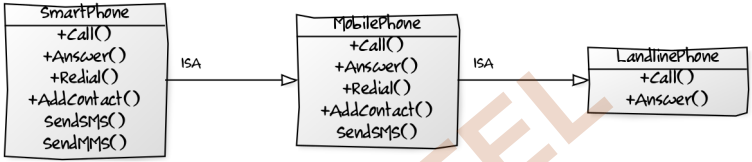

- `MobilePhone` **ISA** `LandlinePhone`
  - `LandlinePhone` is *generalization*
  - `MobilePhone` is *specialization*
  - `MobilePhone` inherits the properties of `LandlinePhone`
- `SmartPhone` **ISA** `MobilePhone`
  - `MobilePhone` is *generalization*
  - `SmartPhone` is *specialization*
  - `SmartPhone` inherits the properties of `MobilePhone`
- **ISA** is *transitive*

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Interfaces of Phones

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- **Landline Phone**
  - Call: By dial / keyboard
  - Answer
  - Caller ID (with special attached device)
- **Mobile Phone**
  - Call: By keyboard – shows number
    - By Number
    - By Name
  - Answer
  - Caller ID
  - Redial
  - Set Ring Tone
  - Add Contact
    - Number
    - Name
- **Smart Phone**
  - Call: By touchscreen – shows number & photo
    - By Number
    - By Name
  - Answer
  - Caller ID
  - Redial
  - Set Ring Tone
  - Add Contact
    - Number
    - Name
    - Photo

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- There exists a substantial overlap between the functionalities of the phones
- A mobile phone is more capable than a land line phone and can perform (almost) all its functions
- A smart phone is more capable than a mobile phone and can perform (almost) all its functions
- **These phones belong to a Specialization / Generalization Hierarchy**

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Interfaces & State Variables of Phones

Interface & State Variable: Landline Phone

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Module Summary

- **Landline Phone**
  - Call: By dial / keyboard
  - Answer

```
class LandlinePhone {
    PhoneNumber number_;
    Name subscriber_;
    RingTone rTone_;

public:
    LandlinePhone(const char *num, const char *subs);

    void Call(const PhoneNumber *p);

    void Answer();

    friend ostream& operator<<(ostream& os, const LandlinePhone& p);
};
```

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Interface & State Variable: Mobile Phone

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- **Mobile Phone**
  - Call: By keyboard – shows number
    - By Number
    - By Name
  - Answer
  - Redial
  - Set Ring Tone
  - Add Contact
    - Number
    - Name

```
class MobilePhone {
    PhoneNumber number_;
    Name subscriber_;
    RingTone rTone_;
    AddressBook aBook_;
    PhoneNumber *lastDial_;
    void SetLastDialed(const PhoneNumber& p);
    void ShowNumber();

public:
    MobilePhone(const char *num, const char *subs);

    void Call(PhoneNumber *p);
    void Call(const Name& n);

    void Answer();

    void ReDial();
    void SetRingTone(RingTone::RINGTONE r);
    void AddContact(const char *num = 0,
        const char *subs = 0);

    friend ostream& operator<<(ostream& os, const MobilePhone& p);
};
```

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Interface & State Variable: Smartphone

- **Smart Phone**
  - Call: By touchscreen – shows number & photo
    - By Number
    - By Name
  - Answer
  - Redial
  - Set Ring Tone
  - Add Contact
    - Number
    - Name
    - Photo

```
class SmartPhone {
    PhoneNumber number_;
    Name subscriber_;
    RingTone rTone_;
    AddressBook aBook_;
    PhoneNumber *lastDial_;
    void SetLastDialed(const PhoneNumber& p);
    void ShowNumber();
    unsigned int size_;
    void DisplayPhoto();

public:
    SmartPhone(const char *num, const char *subs);

    void Call(PhoneNumber *p);
    void Call(const Name& n);

    void Answer();

    void ReDial();
    void SetRingTone(RingTone::RINGTONE r);
    void AddContact(const char *num = 0,
        const char *subs = 0);

    friend ostream& operator<<(ostream& os, const MobilePhone& p);
};
```

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Refactoring

MobilePhone **ISA** LandlinePhone

```
class LandlinePhone { protected:
    PhoneNumber number_;
    Name subscriber_;
    RingTone rTone_;



public:
    LandlinePhone(const char *num,
        const char *subs) :
        number_(num), subscriber_(subs),
        rTone_() { }
    void Call(const PhoneNumber *p);

    void Answer();



    friend ostream& operator<<(ostream& os,
        const LandlinePhone& p);
};
```

```
class MobilePhone : public LandlinePhone { protected:
    //PhoneNumber number_;
    //Name subscriber_;
    //RingTone rTone_;
    AddressBook aBook_;
    PhoneNumber *lastDial_;
    void SetLastDialed(const PhoneNumber& p);
    void ShowNumber();
public:
    MobilePhone(const char *num,
        const char *subs) :
        LandlinePhone(num, subs), // Base ctor
        lastDial_(0) { }
    void Call(const PhoneNumber *p); // Override
    void Call(const Name& n);        // Overload
    //void Answer();                 // Inherited
    void ReDial();
    void SetRingTone(RingTone::RINGTONE r);
    void AddContact(const char *num = 0,
        const char *subs = 0);
    friend ostream& operator<< (ostream& os,
        const MobilePhone& p);
};
```

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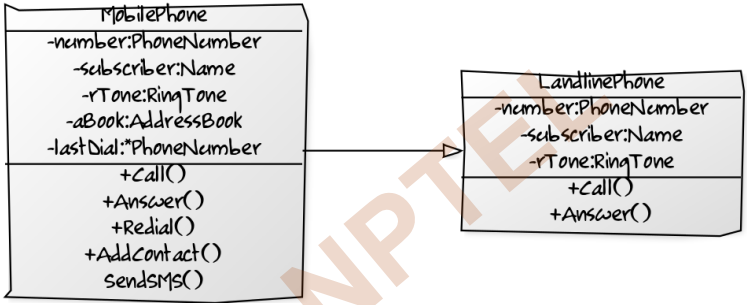
MobilePhone **ISA** LandlinePhone



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SmartPhone **ISA** MobilePhone

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```
class MobilePhone : public LandlinePhone { protected:
    //PhoneNumber number_;
    //Name subscriber_;
    //RingTone rTone_;
    AddressBook aBook_;
    PhoneNumber *lastDial_;
    void SetLastDialed(const PhoneNumber& p);
    void ShowNumber();


public:
    MobilePhone(const char *num,
        const char *subs) :
        LandlinePhone(num, subs), // Base ctor
        lastDial_(0) { }
    void Call(const PhoneNumber *p); // Override
    void Call(const Name& n);        // Overload
    //void Answer();                 // Inherited
    void ReDial();
    void SetRingTone(RingTone::RINGTONE r);
    void AddContact(const char *num = 0,
        const char *subs = 0);
    friend ostream& operator<< (ostream& os,
        const MobilePhone& p);
};
```

```
class SmartPhone : public MobilePhone { protected:
    //PhoneNumber number_;
    //Name subscriber_;
    //RingTone rTone_;
    //AddressBook aBook_;
    //PhoneNumber *lastDial_;
    //void SetLastDialed(const PhoneNumber& p);
    //void ShowNumber();
    unsigned int size_;
    void DisplayPhoto()
public:
    SmartPhone(const char *num,
        const char *subs) :
        MobilePhone(num, subs), // Base ctor
        lastDial_(0) { }
    void Call(const PhoneNumber *p); // Override
    void Call(const Name& n);        // Override
    //void Answer();
    void ReDial();                   // Override
    //void SetRingTone(RingTone::RINGTONE r);
    //void AddContact(const char *num = 0,
        //const char *subs = 0);
    friend ostream& operator<< (ostream& os,
        const SmartPhone& p);
};
```

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Hierarchy Integration

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```
// Abstract Base Class - A Pure Interface
class Phone { public:
    virtual void Call(const PhoneNumber *p) = 0;
    virtual void Answer() = 0;
    virtual void ReDial() = 0;
};
class LandlinePhone: public Phone {
protected:
    PhoneNumber number_;
    Name subscriber_;
    RingTone rTone_;
public:
    LandlinePhone(const char *num,
        const char *subs) :
        number_(num), subscriber_(subs),
        rTone_() { }
    // Implementations for interfaces
    void Call(const PhoneNumber *p);
    void Answer();
    // Dummy implementation not for use
    void ReDial()
    { cout << "Not implemented" << endl; }
    friend ostream& operator<<(ostream& os,
        const LandlinePhone& p);
};
```

```
class MobilePhone : public LandlinePhone { protected:
    AddressBook aBook_;
    PhoneNumber *lastDial_;
    void SetLastDialed(const PhoneNumber& p);
    void ShowNumber();
public:
    MobilePhone(const char *num, const char *subs) :
        LandlinePhone(num, subs), lastDial_(0) { }
    void Call(const PhoneNumber *p); // Override
    void Call(const Name& n);        // Overload
    void ReDial();                   // Override
    friend ostream& operator<< (ostream& os,
        const MobilePhone& p);
};
class SmartPhone : public MobilePhone {
protected: unsigned int size_;
    void DisplayPhoto();
public:
    SmartPhone(const char *num, const char *subs) :
        MobilePhone(num, subs), lastDial_(0) { }
    void Call(const PhoneNumber *p); // Override
    void Call(const Name& n);        // Override
    void ReDial();                   // Override
    friend ostream& operator<< (ostream& os,
        const SmartPhone& p);
};
```

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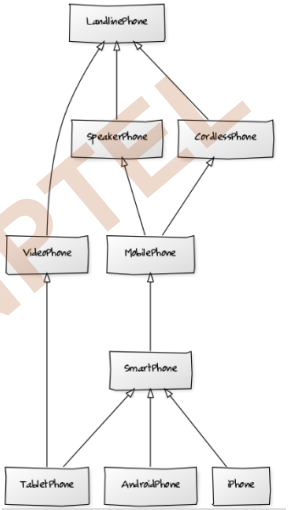
Extended Hierarchy of Phones



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- Using the Phone Hierarchy as an example analyzed the design process with inheritance

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