Homework 8 - Spring 2023

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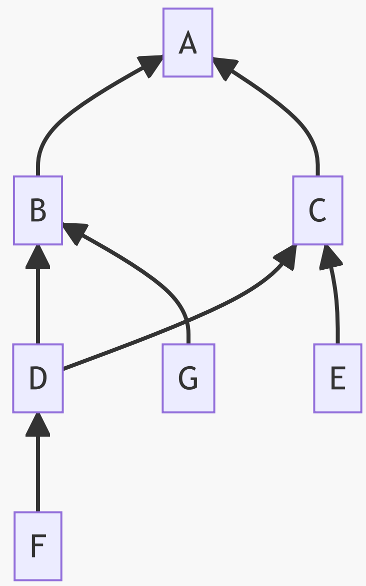
- [UID REDACTED]
- Section 1D

Question 1

Question 1a

We can model the inheritance relationships as a DAG:



The supertype relationships can then be found by simply traversing the subgraph rooted at the class/interface we're interested in.

- Interface `A` has no supertypes.
- Interface `B` has a supertype of `A`.
- Interface `C` has a supertype of `A`.
- Class `D` has supertypes of `B`, `C`, and `A`.
- Class `E` has supertypes of `C` and `A`.
- Class `F` has supertypes of `D`, `B`, `C`, and `A`.
- Class `G` has supertypes of `B` and `A`.

Question 1b

It would be able to take objects with types that are `B` or subtypes of `B`, which are: `B`, `D`, `G`, `F`.

Question 1c

No. `C` is a subtype of `A`, so `A` cannot be used in place of a parameter that expects type `C`. This makes sense because if we recall from the definition of a subtype/supertype definition, `C` supports all the operations that `A` does but possibly more. This means that the implementation of `bar` might call a method that exists for `C` but not `A`, resulting in undefined behavior. Thus, parameter `a` in `bletch` should not be allowed to be passed into `bar`.

Question 3

Inheritance is a mechanism where a class can derive from another class, giving it access to its interface and/or implementation in its own definition without having to rewrite that code. Subtype polymorphism is a mechanism where a subtype can be used anywhere its supertype(s) is expected and work identically. Dynamic dispatch is a mechanism where when a method is called on a polymorphic object, it is determined at runtime which version of that method to execute.

Dynamic dispatch is necessary *because* of inheritance and subtype polymorphism. These allow objects to have multiple versions of a method whose choice often cannot be resolved at compile time. Dynamic dispatch, as its name implies, is also strictly a runtime concept. Conversely, subtype polymorphism checks for type compatibility at compile time. Subtype polymorphism also only makes sense in statically typed languages. On the other hand, inheritance and dynamic dispatch apply to both statically and dynamically typed languages.

Question 4

Subtype polymorphism doesn't work in a dynamically typed language because variables don't have types. Thus, it doesn't make sense to check if a variable of a certain type can be used in place of a variable with another type. Dynamic dispatch can work in dynamically typed languages for a different reason. Many such languages support dynamically adding or removing methods that aren't part of the original class definition from which the object was instantiated, so it cannot be determined before runtime what a method call will result in. The solution to this is have every object maintain its own vtable, and since objects are dynamic in nature, method lookup must occur at runtime.

Question 5

This question is optional, but I used ChatGPT to see if I could understand the answer (or what looks like one). The prompt I used was the question itself. Below is my paraphrased version of its answer.

Firstly, it claims that `ElectricVehicle` violates the **Dependency Inversion Principle (DIP)** because it depends directly on `SuperCharger`, which is a concrete implementation. Instead, it should depend on an abstraction from which `SuperCharger` derives such that `ElectricVehicle` is decoupled from the specific implementation of a low-level module like `SuperCharger`, making the code more resilient to change. The solution would be to define an interface to sit between `SuperCharger` and `ElectricVehicle`:

```
// Full ABC that functions like an interface in C++.
class PowerProvider {
public:
    virtual void get_power() = 0;
    virtual double get_max_amps() const = 0;
    virtual double check_price_per_kwh() const = 0;
};
```

```
class SuperCharger : public PowerProvider {
public:
    void get_power() override { ... }
    double get_max_amps() const override { ... }
    double check_price_per_kwh() const override { ... }
};

class ElectricVehicle {
public:
    void charge(PowerProvider& pp) { ... }
};
```

Secondly, ChatGPT claims that the `SuperCharger` violates the **Single Responsibility Principle (SRP)** because it's in charge of two distinct responsibilities, power-related operations (`get_power` and `get_max_amps`) and price-related operations (`check_price_per_kwh`). I personally would argue that all three are related closely enough to be included under one class, but if we were to fix this problem, we would split `check_price_per_kwh` from our previous `PowerProvider` interface off into its own interface and then have the concrete class `SuperCharger` inherit from that too:

```
class PowerProvider {
public:
    virtual void get_power() = 0;
    virtual double get_max_amps() const = 0;
};

class PriceChecker {
public:
    virtual double check_price_per_kwh() const = 0;
};

class SuperCharger : public PowerProvider, public PriceChecker {
public:
    void get_power() override { ... }
    double get_max_amps() const override { ... }
    double check_price_per_kwh() const override { ... }
};

class ElectricVehicle {
public:
    void charge(PowerProvider& pp) { ... }
};
```

Question 6

I would argue that the **Liskov substitution principle (LSP)** still applies to dynamically typed languages. While the notion of subtype polymorphism doesn't apply to them due to variables not having types, programmers are still interested in the typing and implications of inheritance on the *values* they operate with. For example, to reuse the problem from Question 5, we might model an `ElectricVehicle` with a class that has a `charge` method that accepts some `PowerProvider` parameter:

```python
class ElectricVehicle:
    def charge(self, pp: PowerProvider) -> None:
        ...
```

While the language itself does not enforce `pp` to be a `PowerProvider` type, the semantics of the code expect it to be. This implies that any subtype of `PowerProvider` defined elsewhere in the code should be allowed to be passed in as `pp` and work in the expected way.