2690. Infinite Method Object

Easy

Problem Description

The problem requires us to create a function that constructs and returns an *infinite-method object*. An infinite-method object is a special type of object that can handle calls to any method, even if that method was not explicitly defined on the object. Whenever any method is called on this object, it should return the name of that method as a string.

For instance, if you have an object named `obj` and you call `obj.someMethodName()`, it should return the string `"someMethodName"`. This behavior should apply universally to any method name provided when calling the object.

This problem tests one's understanding of dynamic properties and methods in object-oriented programming, as well as the implementation of such behavior in the specific programming language required by the problem, which in this case is TypeScript.

Intuition

To create this infinite-method object, we make use of the `Proxy` object which is a feature in JavaScript and TypeScript that allows us to define custom behavior for fundamental operations (e.g., property lookup, assignment, enumeration, function invocation, etc.). By creating a `Proxy`, we can control the behavior of the object when a method is called that does not exist on the object.

The intuition behind the solution is to capture all method calls on the fly and return a function that, when invoked, returns the name of the non-existent method. The `get` trap in the `Proxy` is useful for this purpose. This trap will fire every time a property on the target object is accessed. Here's how we can break down the key points of the solution:

1. We create and return a `Proxy` object.
2. The target object of the `Proxy` is an empty object `{}`.
3. Whenever any property (in our use case, a function name) is accessed on the `Proxy` object, the `get` trap is triggered.
4. The `get` trap is a function that takes the target object and the property being accessed (in our case, the method name).
5. The `get` trap returns a new arrow function.
6. This arrow function, when called, returns the name of the property accessed, which corresponds to the method name.

Solution Approach

The implementation of the solution follows a distinct approach using a design pattern called Proxy, which is inherently provided in JavaScript and TypeScript languages. The Proxy pattern creates an object that wraps around another object and intercepts its fundamental operations, such as property access or function invocation. Here's how the solution is achieved step by step:

1. **Create a Proxy**: The solution defines a function `createInfiniteObject()` that returns a new Proxy object.
2. **Define the target object**: The Proxy is initialized with an empty object `{}` as its target. This object would normally not have any properties or methods.
3. **Define the Proxy handlers**: A handler object is provided as the second argument to the Proxy constructor. This handler object contains the `get` trap, a function that will be invoked every time a property on the Proxy (which includes methods) is accessed.
4. **Implement the `get` trap**: The `get` trap is a function that accepts two parameters: `target`, which is the target object, and `prop`, the name of the property that is being accessed. Since we want to capture function calls, `prop` will be the name of the method being invoked.
5. **Return a function dynamically**: Inside the `get` trap, we return an arrow function `() => prop.toString()`. This ensures that no matter what property name (or method name) is accessed, a function is returned that, when called, will return the name of that property as a string.
6. **Leverage anonymous functions**: Every time a method on the Proxy is called, like `obj.someMethod()`, the `get` trap executes and returns a new anonymous function that contains the code to simply return the `prop` as a string.

By following these steps, we harness the power of the Proxy pattern to dynamically intercept method calls and return the expected name of the method without explicitly defining those methods. It's a powerful way to create objects with behavior that is determined at runtime rather than compile-time. This opens up possibilities for dynamic and flexible code structures.

Here is the code of the function for reference:

```
function createInfiniteObject(): Record<string, () => string> {
    return new Proxy(
        {},
        {
            get: (_, prop) => () => prop.toString(),
        },
    );
}
```

When this function is used to create an object, it will inherently have the described infinite-method behavior, as desired.

Example Walkthrough

To better understand the solution approach described above, let's walk through a small example using the `createInfiniteObject()` function.

First, we call `createInfiniteObject()` to create a new object:

```
let obj = createInfiniteObject();
```

At this point, `obj` is an instance of a Proxy object that is set to respond to any method invocation using the rules defined in the `get` trap. Let's see what happens when we try to call a method that hasn't been defined:

```
console.log(obj.helloWorld());
```

Following the steps of the solution approach:

1. We attempt to access the property `helloWorld` on `obj`. Since `obj` is a Proxy, the `get` trap is triggered instead of a typical property access.
2. The `get` trap function is called with the `target` (which is an empty object) and the `prop` (which is the string `"helloWorld"`).
3. Inside the `get` trap, it returns an anonymous arrow function: `() => prop.toString()`.
4. This arrow function is immediately invoked (because we have used parentheses `()` after `obj.helloWorld`).
5. The invoked arrow function returns the string `"helloWorld"`.
6. The `console.log` statement outputs the string `"helloWorld"` to the console.

This behavior illustrates that any method name we try to call on `obj` will result in the name of the method being returned as a string. It works exactly the same for any other method name:

```
console.log(obj.anotherMethod());  // Outputs: "anotherMethod"
console.log(obj.yetAnotherOne());  // Outputs: "yetAnotherOne"
console.log(obj['any.method']());  // Outputs: "any.method"
```

In each case, the Proxy intercepts the method call, the `get` trap provides an anonymous function, the function is called, and the method name is returned as a string. Through this example, we've seen first-hand how the Proxy pattern allowed us to handle dynamic method calls in a generic way without ever defining any actual methods on the object.

Solution Implementation

Python

```
class StringReturningFunction:
    def __call__(self) -> str:
        """
        When this function is called, it needs to return the name of the property.
        This behavior will be defined in the InfiniteObject to ensure it returns
        the correct property name.
        """
        # The actual implementation will be provided in the InfiniteObject.__getattr__ method.
        pass


class InfiniteObject:
    def __getattr__(self, name: str) -> StringReturningFunction:
        """
        This method is called when an attribute is accessed that doesn't exist
        in the object's dictionary. It returns a callable that returns the attribute's name.

        :param name: The name of the attribute being accessed.
        :return: A callable object that returns the name of the property when called.
        """
        # Define a function that will act as the StringReturningFunction callable.
        def string_returning_function() -> str:
            """
            This function will return the name of the property when it is called.

            :return: The name of the property as a string.
            """
            return name

        # Return the above-defined function as a StringReturningFunction.
        return string_returning_function


# Usage example of InfiniteObject class
# infinite_object = InfiniteObject()
# print(infinite_object.abc123())  # Outputs: "abc123"
```

Java

```
import java.lang.reflect.InvocationHandler;
import java.lang.reflect.Method;
import java.lang.reflect.Proxy;
import java.util.HashMap;
import java.util.Map;
import java.util.function.Supplier;

/**
 * A functional interface that represents a function that returns a String.
 */
interface StringReturningFunction extends Supplier<String> {
}

/**
 * The InfiniteObject interface acts similarly to a map,
 * where the methods (properties in JavaScript) return StringReturningFunction instances.
 */
interface InfiniteObject {
    StringReturningFunction get(String property);
}

/**
 * Creates a proxy object that dynamically generates methods such that any method call will return
 * a StringReturningFunction that, when called, returns the name of the method as a String.
 *
 * @return An InfiniteObject with dynamically generated methods.
 */
public static InfiniteObject createInfiniteObject() {
    // Create an InvocationHandler that defines the behavior of the proxy instance.
    InvocationHandler handler = new InvocationHandler() {
        // The invoke method is called whenever a method on the proxy instance is invoked.
        @Override
        public Object invoke(Object proxy, Method method, Object[] args) throws Throwable {
            // We return a lambda function if the invoked method is 'get'
            // and takes one argument of type String.
            if ("get".equals(method.getName()) && args.length == 1 && args[0] instanceof String) {
                // This lambda function takes a property name and returns it when called.
                String propertyName = (String) args[0];
                return (StringReturningFunction) () -> propertyName;
            }
            return null;
        }
    };

    // Create and return the proxy instance that implements the InfiniteObject interface.
    return (InfiniteObject) Proxy.newProxyInstance(
        InfiniteObject.class.getClassLoader(),
        new Class<?>[]{InfiniteObject.class},
        handler
    );
}

/**
 * Usage example of the createInfiniteObject method.
 */
public static void main(String[] args) {
    // Create an infinite object instance.
    InfiniteObject infiniteObject = createInfiniteObject();

    // Access the properties using the get method and execute the returned function.
    System.out.println(infiniteObject.get("abc123").get());  // Outputs: "abc123"
}
```

C++

```
#include <iostream>
#include <string>
#include <functional>
#include <unordered_map>

// Define a function pointer that returns a std::string
using StringReturningFunction = std::function<std::string()>;

// Define the InfiniteObject class
class InfiniteObject {
public:
    // This operator overloads the '[]' operator to provide the ability to access string properties
    StringReturningFunction operator[](const std::string& propertyKey) {
        // Return a lambda that captures the property key and returns it when called
        return [propertyKey]() -> std::string {
            // When the function is called, it returns the property key
            return propertyKey;
        };
    }
};

// Usage example of InfiniteObject class
int main() {
    InfiniteObject infiniteObject;
    // The overloaded '[]' operator returns a lambda function that returns the key
    std::string result = infiniteObject["abc123"]; // This calls the lambda function and outputs: "abc123"
    std::cout << result << std::endl;

    return 0;
}
```

TypeScript

```
// Define a type that represents a function that returns a string
type StringReturningFunction = () => string;

// Define the InfiniteObject type as a Record where the keys are strings
// and the values are functions that return strings.
type InfiniteObject = Record<string, StringReturningFunction>;

/**
 * Creates an object that returns functions from property access, where the function, when called,
 * returns the name of the property as a string.
 *
 * @returns {InfiniteObject} An object with infinite properties using a Proxy.
 */
function createInfiniteObject(): InfiniteObject {
    // Return a Proxy object. Proxies enable creating objects with custom behavior for
    // property access, assignment, enumeration, function invocation, etc.
    return new Proxy(
        {}, // The target object, which is an empty object in this case.
        {
            // The handler object, containing traps for various operations.
            // The 'get' trap is used to intercept property access.
            get: (_, propertyKey) =>
                // Return a function that, when called, returns the property key as a string.
                // The '_' is a commonly used convention to indicate that the parameter is not used.
                () => propertyKey.toString(),
            },
        }
    );
}

// Usage example of createInfiniteObject function (uncomment to execute)
// const infiniteObject = createInfiniteObject();
// console.log(infiniteObject['abc123']()); // Outputs: "abc123"

class StringReturningFunction:
    def __call__(self) -> str:
        """
        When this function is called, it needs to return the name of the property.
        This behavior will be defined in the InfiniteObject to ensure it returns
        the correct property name.
        """
        # The actual implementation will be provided in the InfiniteObject.__getattr__ method.
        pass


class InfiniteObject:
    def __getattr__(self, name: str) -> StringReturningFunction:
        """
        This method is called when an attribute is accessed that doesn't exist
        in the object's dictionary. It returns a callable that returns the attribute's name.

        :param name: The name of the attribute being accessed.
        :return: A callable object that returns the name of the property when called.
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        # Define a function that will act as the StringReturningFunction callable.
        def string_returning_function() -> str:
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        # Return the above-defined function as a StringReturningFunction.
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# Usage example of InfiniteObject class
# infinite_object = InfiniteObject()
# print(infinite_object.abc123())  # Outputs: "abc123"
```

Time and Space Complexity

The time complexity of the `createInfiniteObject` function call itself is O(1) because it returns a proxy object without performing any computation. When any property on the resulting proxy object is accessed and the function returned is called, it performs this action in constant time, resulting in a time complexity of O(1) per property access.