Spring Professional Exam Tutorial v5.0

Question 01

Question 01 - What is the concept of AOP? Which problem does it solve? What is a cross cutting concern? Name three typical cross cutting concerns. What two problems arise if you don't solve a cross cutting concern via AOP?

Question 01 - What is the concept of AOP?

AOP – Aspect Oriented Programming – A programming paradigm that complements Object-oriented Programming (OOP) by providing a way to separate groups of cross-cutting concerns from business logic code. This is achieved by ability to add additional behavior to the code without having to modify the code itself. This is achieved by specifying:

- Location of the code which behavior should be altered – Pointcut is matched with Join point
- Code which should be executed that implements cross cutting concern – Advice

Question 01 - Which problem does it solve?

Aspect Oriented Programming solves following challenges:

- Allows proper implementation of Cross-Cutting Concerns
- Solves Code Duplications by eliminating the need to repeat the code for functionalities across different layers, such functionalities may include logging, performance logging, monitoring, transactions, caching
- Avoids mixing unrelated code, for example mixing transaction logic code (commit, rollback) with business code makes code harder to read, by separating concerns code is easier to read, interpret, maintain

Question 01 - Name three typical cross cutting concerns.

Common cross-cutting concerns:

- Logging
- Performance Logging
- Caching
- Security
- Transactions
- Monitoring

Question 01 - What two problems arise if you don't solve a cross cutting concern via AOP?

Implementing cross-cutting concerns without using AOP, produces following challenges:

- Code duplications – Before/After code duplicated in all locations when normally Advise would be applied, refactoring by extraction helps but does not fully solve the problem
- Mixing of concerns – business logic code mixed with logging, transactions, caching makes code hard read and maintain

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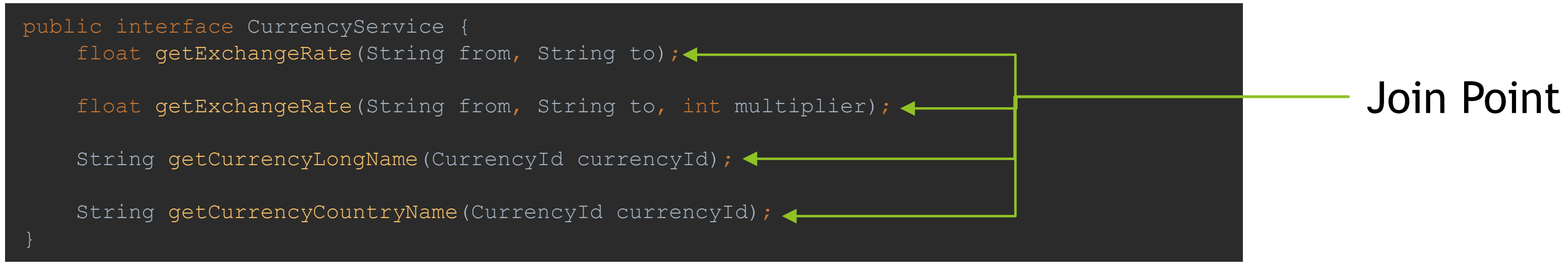
Question 02

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving?

Join Point in aspect oriented programming is a point in execution of a program in which behavior can be altered by AOP.

In Spring AOP Join Point is always method execution.



```
public interface CurrencyService {
    float getExchangeRate(String from, String to);

    float getExchangeRate(String from, String to, int multiplier);

    String getCurrencyLongName(CurrencyId currencyId);

    String getCurrencyCountryName(CurrencyId currencyId);
}
```

Aspect Oriented Programming concept in general, distinguishes additional Join Points, some of them include:

- Method Execution / Invocation
- Constructor Execution / Invocation
- Reference / Assignment to Field
- Exception Handler
- Execution of Advice
- Execution of Static Initializer / Object Initializer

Each method execution from external(!!!) part of a component is considered a JoinPoint
NOTE: self invocation of a method from within a component is not supported and
is not considered a JoinPoint in AOP

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving? (cont.)

Pointcut is a predicate used to match join point. Additional code, called Advice is executed in all parts of the program that are matching pointcut. Spring uses the AspectJ pointcut expression language by default.

Example of Pointcut Expressions:

- execution - Match Method Execution

PointCut is like information in which part of the code, modification should be injected by our own code which is called Advice

```
execution(* com.spring.professional.exam.tutorial.module02.question02.bls.CurrencyService.getExchangeRate(..))
```

- within - Match Execution of given type or types inside package

```
within(com.spring.professional.exam.tutorial.module02.question02.bls.*)
```

- @within – Match Execution of type annotated with annotation

```
@within(com.spring.professional.exam.tutorial.module02.question02.annotations.Secured)
```

- @annotation – Match join points where the subject of the join point has the given annotation

```
@annotation(com.spring.professional.exam.tutorial.module02.question02.annotations.InTransaction)
```

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving? (cont.)

Example of Pointcut Expressions (cont.):

- bean – Match by spring bean name

```
bean(currency_service)
```

- args – Match by method arguments

```
args(String, String, int)
```

- @args – Match by runtime type of the method arguments that have annotations of the given type

```
@args(com.spring.professional.exam.tutorial.module02.question02.annotations.Validated)
```

- this – Match by bean reference being an instance of the given type (for CGLIB-based proxy)

```
this(com.spring.professional.exam.tutorial.module02.question02.bls.CurrencyService)
```

- target – Match by target object being an instance of the given type

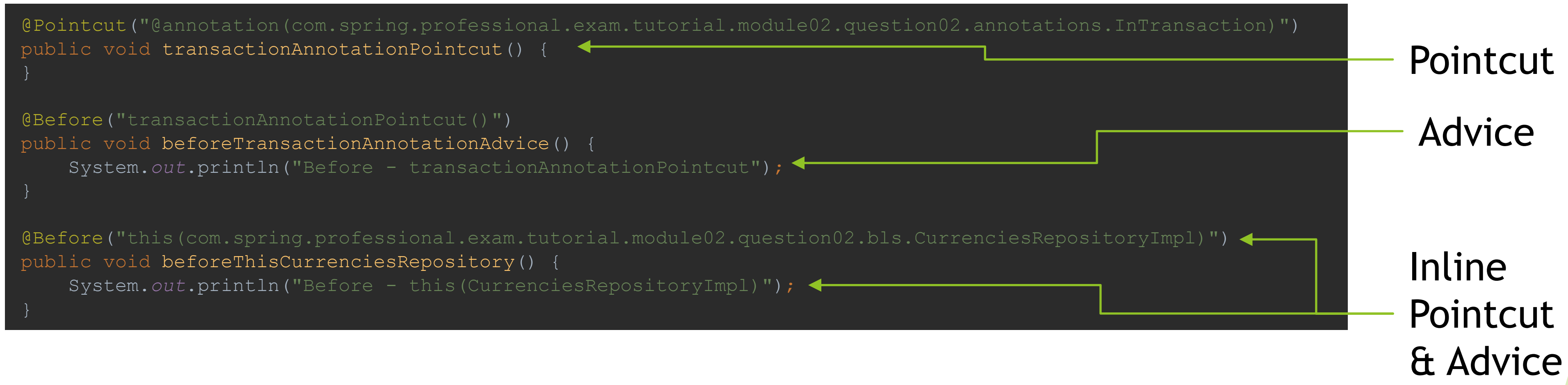
```
target(com.spring.professional.exam.tutorial.module02.question02.bls.CurrencyService)
```

- @target – Match by class of the executing object having an annotation of the given type

```
@target(com.spring.professional.exam.tutorial.module02.question02.annotations.Secured)
```

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving? (cont.)

Advice is additional behavior that will be inserted into the code, at each join point matched by pointcut.



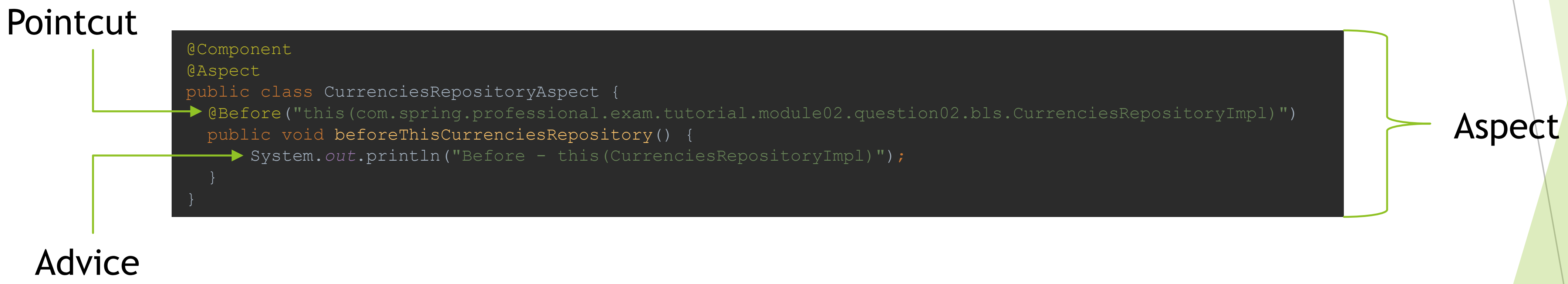
```
@Pointcut("@annotation(com.spring.professional.exam.tutorial.module02.question02.annotations.InTransaction)")
public void transactionAnnotationPointcut() {
}

@Before("transactionAnnotationPointcut()")
public void beforeTransactionAnnotationAdvice() {
    System.out.println("Before - transactionAnnotationPointcut");
}

@Before("this(com.spring.professional.exam.tutorial.module02.question02.bls.CurrenciesRepositoryImpl)")
public void beforeThisCurrenciesRepository() {
    System.out.println("Before - this(CurrenciesRepositoryImpl)");
}
```

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving? (cont.)

Aspect brings together Pointcut and Advice. Usually it represents single behavior implemented by advice that will be added to all join points matched by pointcut.



```java
@Component
@Aspect
public class CurrenciesRepositoryAspect {
  @Before("this(com.spring.professional.exam.tutorial.module02.question02.bls.CurrenciesRepositoryImpl)")
  public void beforeThisCurrenciesRepository() {
      System.out.println("Before - this(CurrenciesRepositoryImpl)");
  }
}
```

Question 02 - What is a pointcut, a join point, an advice, an aspect, weaving? (cont.)

Weaving is the process of applying aspects, which modifies code behavior at join points that have matching pointcuts and associated advices. During weaving aspects and application code is combined which enables execution of cross-cutting concerns.

Types of weaving:

- Compile Time Weaving – byte code is modified during the compilation, aspects are applied, code is modified at join points matching pointcuts by applying advices
- Load Time Weaving – byte code is modified when classes are loaded by class loaders, during class loading aspects are applied, code is modified at join points matching pointcuts by applying advices
- Runtime Weaving – used by Spring AOP, for each object/bean subject to aspects, proxy object is created (JDK Proxy or CGLIB Proxy), proxy objects are used instead of original object, at each join point matching pointcut, method invocation is changed to apply code from advice

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Question 03

Question 03 - How does Spring solve (implement) a cross cutting concern?

Spring Implements cross-cutting concerns with usage of Spring AOP module. Spring AOP uses AspectJ expression syntax for Pointcut expressions, which are matched against Join Point, code is altered with logic implemented in advices. In Spring AOP Joint Point is always method invocation.

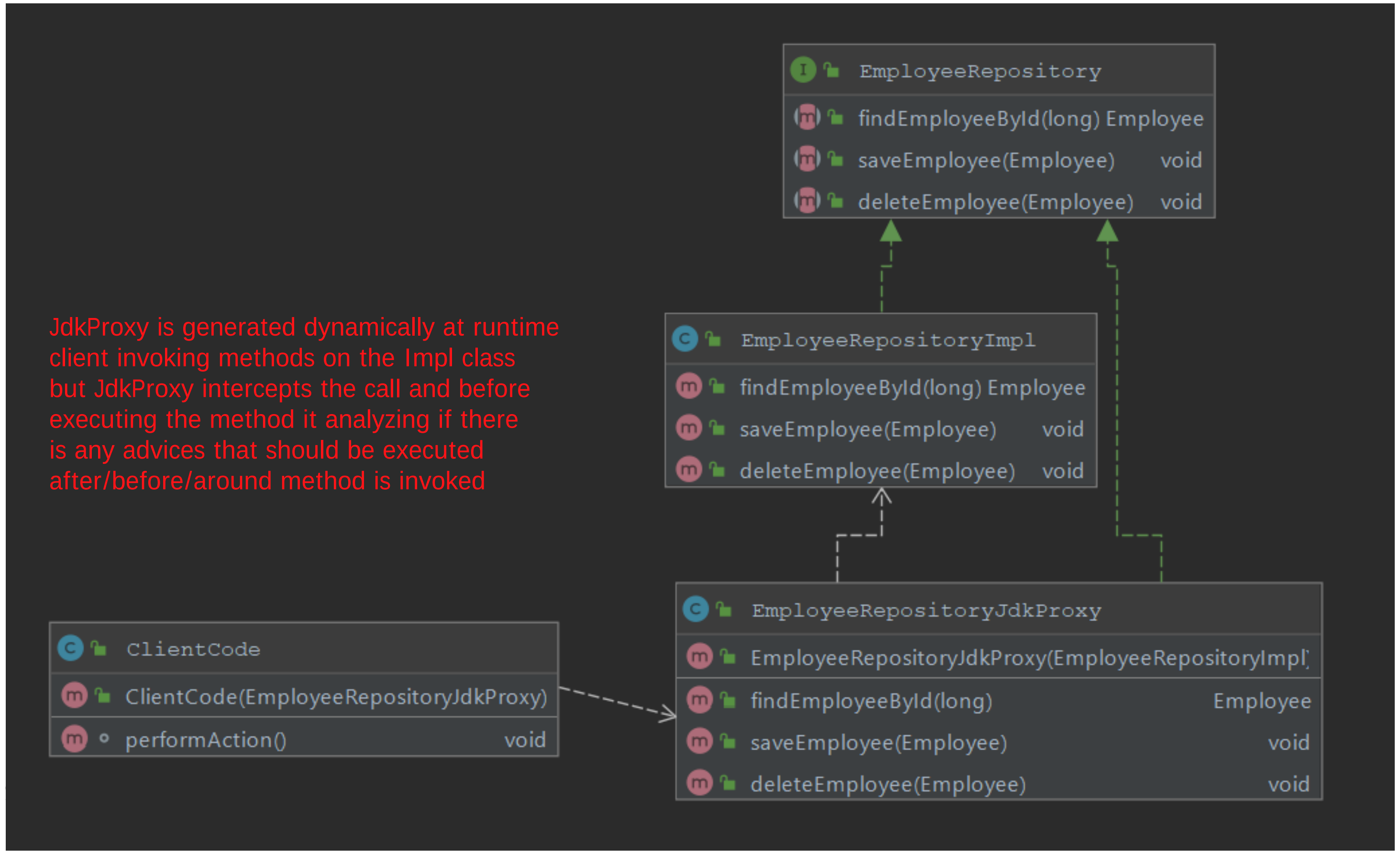
Spring AOP uses Runtime Weaving, and for each type subject to aspects, to intercepts calls, spring creates one type of proxy:

- JDK Proxy – created for classes that implements interface
- CGLIB Proxy – created for class that are not implementing any interface

It is possible to force Spring to use CGLIB Proxy with usage of
`@EnableAspectJAutoProxy(proxyTargetClass = true)`

Question 03 - How does Spring solve (implement) a cross cutting concern? (cont.)

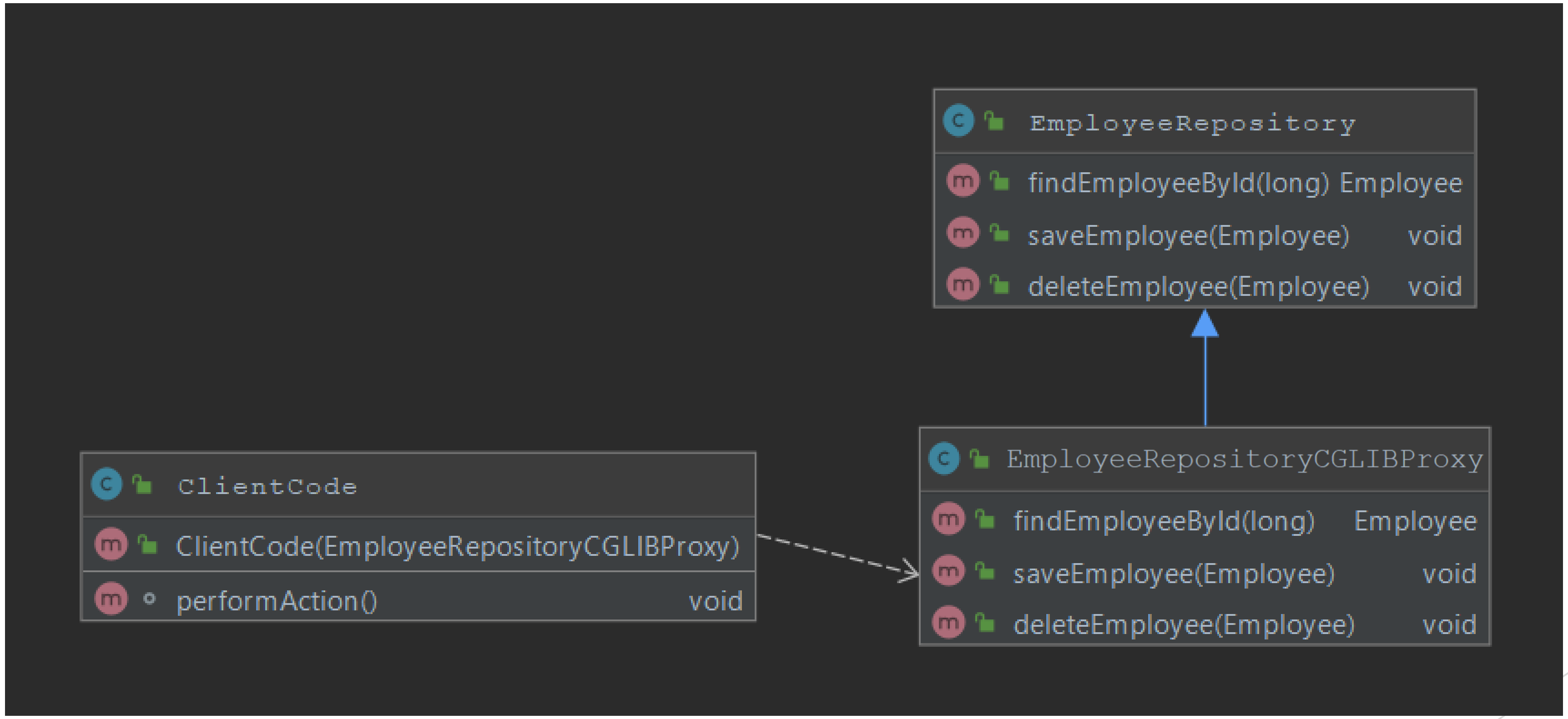
JDK Proxy


EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryImpl
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryJdkProxy
EmployeeRepositoryJdkProxy(EmployeeRepositoryImpl)
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryJdkProxy)
performAction() void

JdkProxy is generated dynamically at runtime
client invoking methods on the Impl class
but JdkProxy intercepts the call and before
executing the method it analyzing if there
is any advices that should be executed
after/before/around method is invoked

Question 03 - How does Spring solve (implement) a cross cutting concern? (cont.)

CGLIB Proxy


EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryCGLIBProxy
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryCGLIBProxy)
performAction() void

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Question 04

Question 04 - Which are the limitations of the two proxy-types? What visibility must Spring bean methods have to be proxied using Spring AOP?

JDK Dynamic Proxy Limitations:

- Does not support self-invocation when method is invoked from within the component itself Spring AOP support only method invocations from the external
- Class must implement interface
- Only method implementing the interface will be proxied

CGLIB Proxy Limitations:

- Does not support self-invocation
- Class for which proxy should be created cannot not be final because CGLIB proxy must extend the proxied class can override the methods
- Method which should be proxied cannot be final method will be overridden and advices will be set before the original method will be invoked
- Only public/protected/package methods will be proxied, private methods are not proxied This is because methods must be overridden and private methods are not visible to extending class

Question 04 - Which are the limitations of the two proxy-types? What visibility must Spring bean methods have to be proxied using Spring AOP?

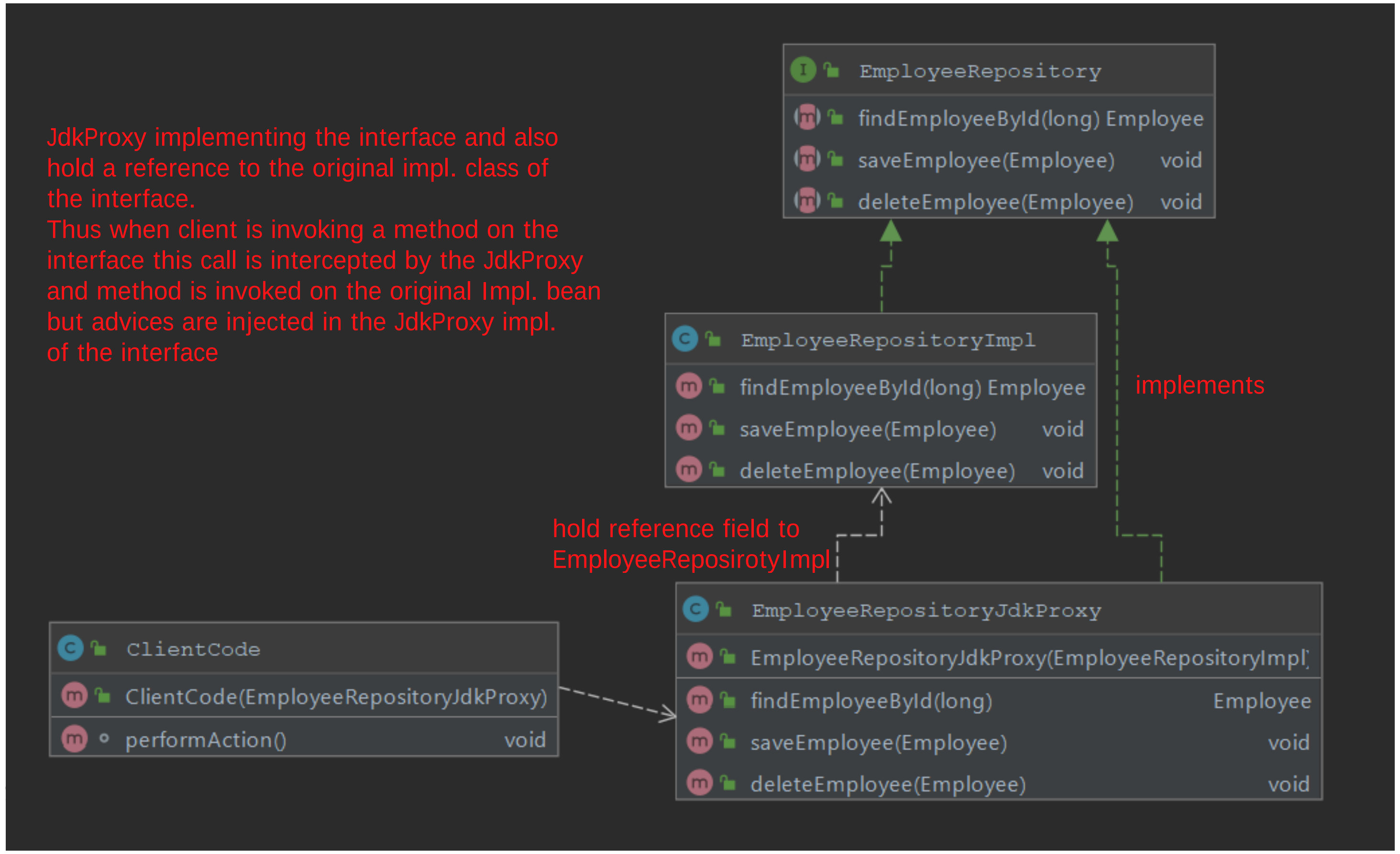
Spring Bean Method needs to have following visibility level to be proxied:

- JDK Dynamic Proxy – public
- CGLIB Proxy – public/protected/package

On top of requirement above, for call to be proxied, it needs to come from outside, both JDK Dynamic Proxy and CGLIB proxy does not support self-invocation.

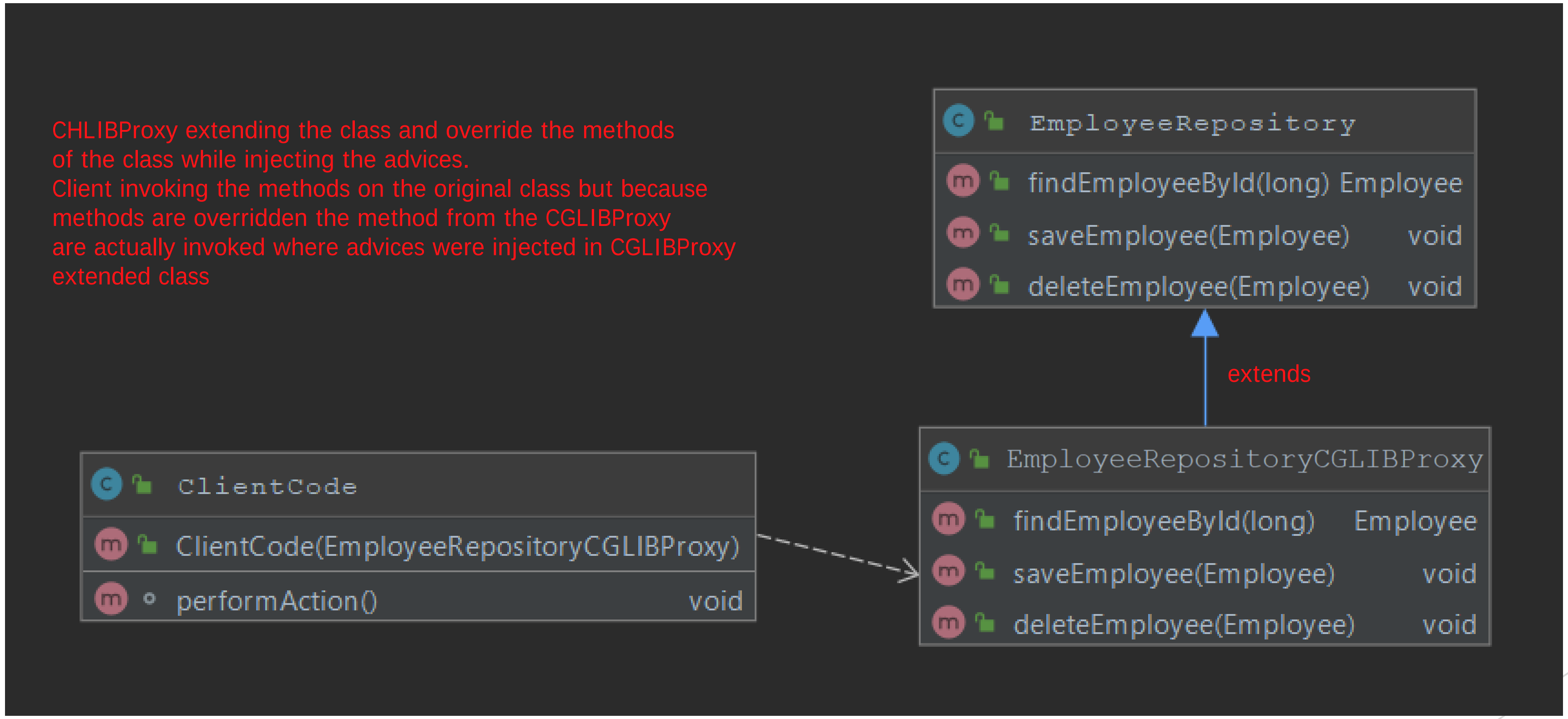
Question 04 - Which are the limitations of the two proxy-types? What visibility must Spring bean methods have to be proxied using Spring AOP?

JDK Proxy


JdkProxy implementing the interface and also hold a reference to the original impl. class of the interface.
Thus when client is invoking a method on the interface this call is intercepted by the JdkProxy and method is invoked on the original Impl. bean but advices are injected in the JdkProxy impl. of the interface
EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryImpl
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
implements
hold reference field to EmployeeReposirotyImpl
EmployeeRepositoryJdkProxy
EmployeeRepositoryJdkProxy(EmployeeRepositoryImpl)
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryJdkProxy)
performAction() void

Question 04 - Which are the limitations of the two proxy-types? What visibility must Spring bean methods have to be proxied using Spring AOP?

CGLIB Proxy


CHLIBProxy extending the class and override the methods
of the class while injecting the advices.
Client invoking the methods on the original class but because
methods are overridden the method from the CGLIBProxy
are actually invoked where advices were injected in CGLIBProxy
extended class
EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
extends
EmployeeRepositoryCGLIBProxy
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryCGLIBProxy)
performAction() void

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Question 05

Question 05 - How many advice types does Spring support. Can you name each one? What are they used for? Which two advices can you use if you would like to try and catch exceptions?

Question 05 - How many advice types does Spring support. Can you name each one? […]

Spring supports following advice types:

- @Before – executed before joint point matched by pointcut is executed
- @After – executed after joint point matched by pointcut is executed
- @AfterThrowing – executed when exception is thrown from joint point matched by pointcut
- @AfterReturning – executed after joint point matched by pointcut is executed successfully without any exception
- @Around – allows you to take full control over joint point matched by pointcut, most powerful advice, allows you to implement all advices from above, you need to call `ProceedingJoinPoint::proceed()` to execute original code

Question 05 – […] What are they used for? […]

Some examples of usage for each Advice type:

- @Before
  - Authorization, Security block method execution if detected that current user role is not authorized (role no sufficient) to execute current method
  - Logging
  - Data Validation
- @After
  - Logging log end of method execution i.e. performance logging of the method
  - Resource Cleanup close resources that were opened for the method execution
- @AfterThrowing
  - Logging
  - Error Handling

    log current exception
    wrap current exception with different exception
    handle the exception
- @AfterReturning
  - Logging
  - Data Validation for method result
- @Around
  - Transactions
  - Distributed Call Tracing
  - Authorization, Security

Question 05 – […] Which two advices can you use if you would like to try and catch exceptions?

To catch exceptions you can use two advices:

- @AfterThrowing with `throwing` field set and exception passed as argument
- @Around with `try … catch` block implemented

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Question 06

Question 06 - What do you have to do to enable the detection of the @Aspect annotation? What does @EnableAspectJAutoProxy do?

To enable detection of `@Aspect` annotation you need to:

- Have `@Configuration` class with `@EnableAspectJAutoProxy`
  - Without `@EnableAspectJAutoProxy` Spring will not scan for `@Aspect`
- Have beans for `@Aspect` annotated classes created
  - Use `@ComponentScan` with `@Component` at class annotated with `@Aspect`
  - Use `@Bean` in Configuration class and create Spring Aspect Bean manually
- Have `aspectjweaver/spring-aop` on classpath
  - It is easiest to use `org.springframework:spring-aspects` dependency to have those included
  - Without required dependencies on classpath spring will fail with `ClassNotFoundException/NoClassDefFoundError` during creation of Proxy objects for Spring Beans subject to aspects

Question 06 - What do you have to do to enable the detection of the @Aspect annotation? What does @EnableAspectJAutoProxy do?

Annotation `@EnableAspectJAutoProxy` enables detection of `@Aspect` classes and creates proxy object for beans subject to aspects. Internally process of creating proxies is done by `AnnotationAwareAspectJAutoProxyCreator`. By creating a proxy for each bean subject to aspects, spring intercepts the calls and implements Before / After / AfterReturning / AfterThrowing / Around advices. It is important to remember that `@Aspect` will not create Spring Beans on it's own, you need to use Component Scanning or manually create beans for `@Aspect` classes.

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Question 07

Question 07 - If shown pointcut expressions, would you understand them? For example, what would be the correct pointcut expression to match both getter and setter methods?

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator types supported by Spring AOP:

- `execution`
- `within`
- `args`
- `bean`
- `this`
- `target`
- `@annotation`
- `@args`
- `@within`
- `@target`

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `execution` - matches method execution

General Form:

```
execution([visibility modifiers] [return type] [package].[class].[method]([arguments]) [throws exceptions])
```

Description:

- `[visibility modifiers]` - public/protected, if omitted all are matched, can be used with negation, for example `!protected`
- `[return type]` - void, primitive or Object type, cannot be omitted, can be used with wildcard `*`, can be used with negation, for example `!int`
- `[package]` - package in which class is located, may be omitted if class is located within same package as aspect, wildcard `*` may be used to match all packages, wildcard `..` may be used to match all sub-packages
- `[class]` - Class name to match against, may be omitted, may be used with `*` wildcard, matches subclasses of the class as well
- `[method]` - Name of the method, whole or partial method name can be used with `*` wildcard
- `[arguments]` - May be empty to match methods without any arguments, may be used with wildcard `..` to match zero or more arguments, may be used with wildcard `*` to match all types of specific argument, may be used with ! Negation
- `[throws exceptions]` - Match method that throws exceptions from given list, can be used with negation !

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `within` - matches execution within specified class/classes, optionally you can specify class package

General Form:

```
within([package].[class])
```

Description:

- `[package]` - package where class is located, may be used with `..` wildcard (includes all sub-packages) or with `*` wildcard, may be omitted
- `[class]` - class against which match should happen, may be used with `*` wildcard

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `args` - matches execution of method with matching arguments

General Form:

```
args([parameter_type1, parameter_type2, ..., parameter_typeN])
```

Description:

- `[parameter_typeN]` - simple or object type, may be `*` to indicate one parameter of any type, may be `..` to indicate zero or more arguments, you can specify type with the package

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator – `bean` – matches execution of method with matching Spring Bean Name

General Form:

```
bean([beanName])
```

Description:

- `[beanName]` – name of the Spring Bean (automatically generated by framework, or set manually),

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator – `this` - matches execution against type of proxy that was generated by Spring AOP

General Form:

```
this([type])
```

Description:

- `[type]` - type of the proxy, matches if generated proxy is of specified type

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `target` - matches execution against type of the target object invoked by proxy

General Form:

```
target([type])
```

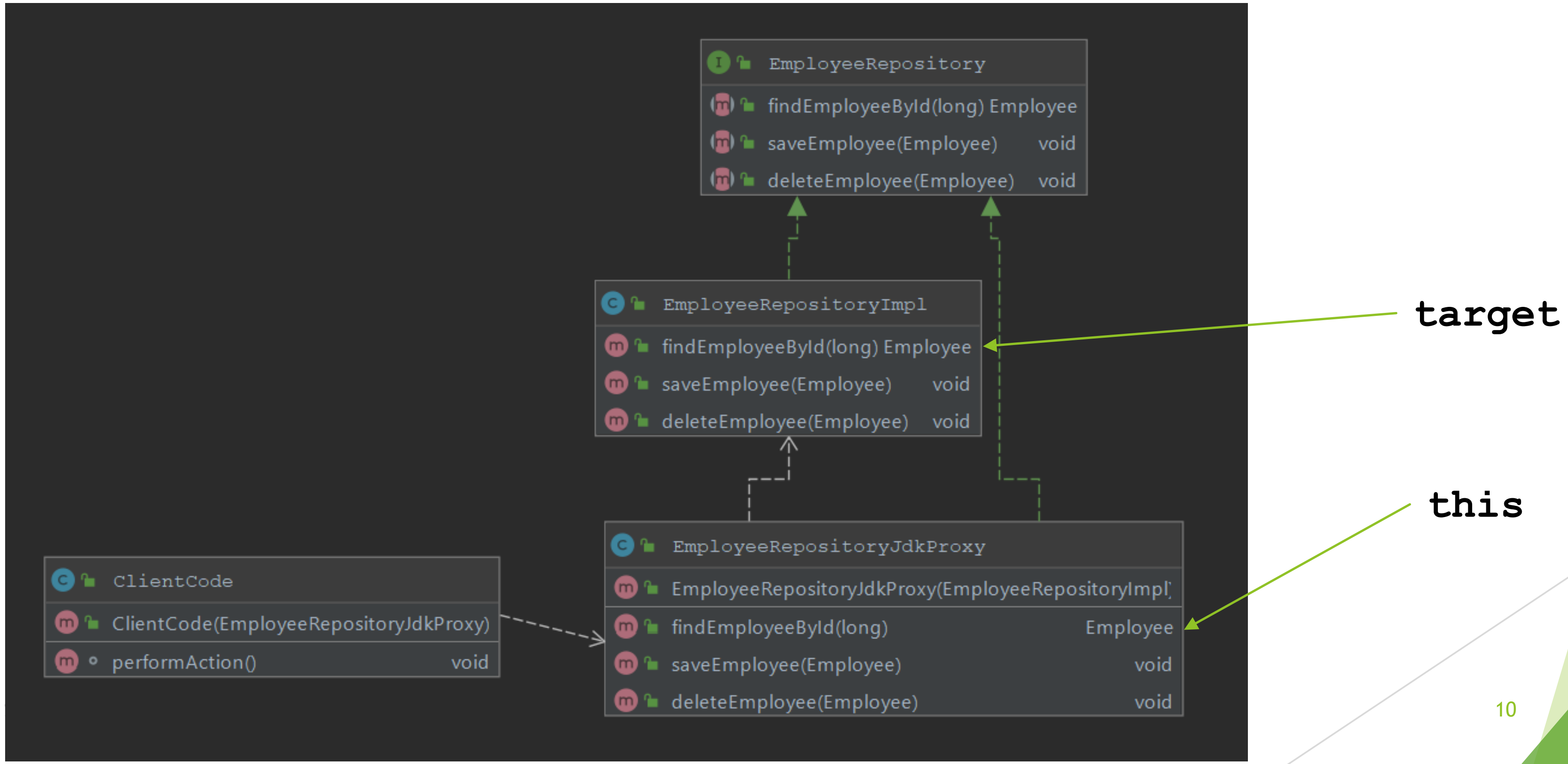
Description:

- `[type]` - type of the target object invoked by proxy, matches if target object is of specified type

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `this, target`

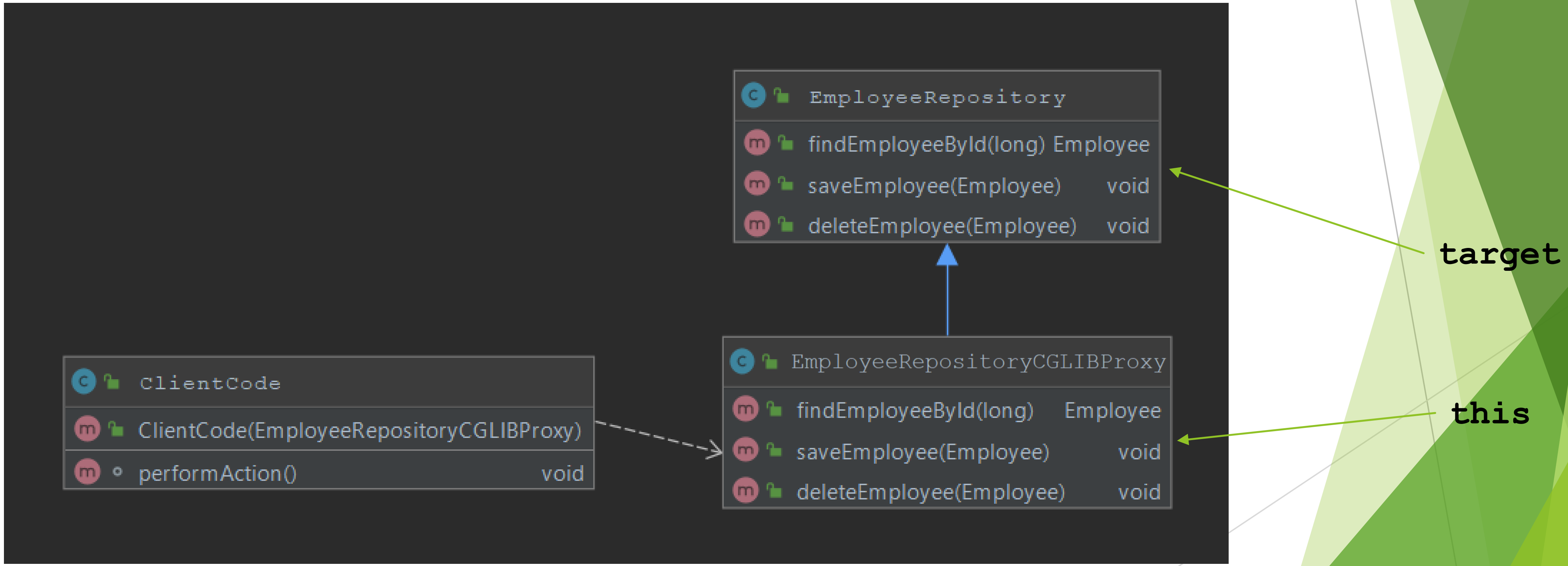
JDK Proxy


EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryImpl
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryJdkProxy
EmployeeRepositoryJdkProxy(EmployeeRepositoryImpl)
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryJdkProxy)
performAction() void
target
this

Question 07 - If shown pointcut expressions, would you understand them? [...]

Pointcut designator - `this, target`

CGLIB Proxy


EmployeeRepository
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
EmployeeRepositoryCGLIBProxy
findEmployeeById(long) Employee
saveEmployee(Employee) void
deleteEmployee(Employee) void
ClientCode
ClientCode(EmployeeRepositoryCGLIBProxy)
performAction() void
target
this

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `@annotation` - matches method execution annotated with specified annotation

General Form:

```
@annotation([annotation_type])
```

Description:

- `[annotation_type]` - type of annotation used to annotated method which should match pointcut expression

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `@args` - matches method execution with argument, which types (classes) are annotated with specified annotation type, note that class should be annotated, not the argument of method itself

General Form:

```
@args([annotation_type])
```

Description:

- `[annotation_type]` - type of annotation used on top of class, which represents type of argument

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `@within` - matches method executions inside classes annotated with specified annotation

General Form:

```
@within([annotation_type])
```

Description:

- `[annotation_type]` - type of annotation used on top of class, inside which method execution should be matched

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut designator - `@target` - matches method executions inside proxied target class that is annotated with specific annotation

General Form:

```
@target([annotation_type])
```

Description:

- `[annotation_type]` - type of annotation used on top of proxied class, inside which method execution should be matched

Question 07 - If shown pointcut expressions, would you understand them? […]

Pointcut expressions can be combined together with usages of logical operators:

- ! – negation
- || - logical or
- && - logical and

Question 07 – [...] For example, what would be the correct pointcut expression to match both getter and setter methods?

To match getters and setter, `execution` Pointcut Expression can be used together with ability to combine them with logical operators.

Expression that will match getters and setter can look like this:

```
execution(* com.beans.EmployeeBean.get*()) ||
   execution(* com.beans.EmployeeBean.set*(*))
```

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Question 08

Question 08 - What is the JoinPoint argument used for?

JoinPoint argument is an object that can be used to retrieve additional information about join point during execution. JoinPoint needs to be the first parameter of Advice, only in that case Spring Framework will inject JoinPoint into advice method.

NOTE: JoinPoint in Spring is method invocation from the external
Behaviour can be modified without changein the code itself on JoinPoints i.e. method invocation
Instead of writing new code we specify an advice which will be injected before/after/around method invocation

Join Point is supported in following advice types:

- Before
- After
- After Returning
- After Throwing

Examples of information that you can retrieve from JoinPoint:

- String representation of Join Point
- Arguments of Joint Point (for example Method Arguments)
- Signature of Joint Point (for example Method Signature)
- Kind / Type of Joint Point
- Target / This object being proxied

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Question 09

Question 09 - What is a ProceedingJoinPoint? When is it used?

ProceedingJoinPoint is an object that can be provided to `@Around` advice as first argument, it is a type of JoinPoint which can be used to change method arguments during method execution in runtime or block execution of original method entirely.

ProceedingJoinPoint is used in `@Around` advice, it contains all methods from JoinPoint and also adds:

- proceed – executes original method
- proceed(args) – executes original method with provided arguments

ProceedingJoinPoint can be used in following use cases:

- Conditionally block method execution
- Filter arguments
- Inject additional argument