Going Further with CDI 2.0

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- A talk about **advanced** CDI
- Might be hard for beginners
- Don’t need to be a CDI guru

Should I stay or should I go?

If you know most of these you can stay

- @Inject
- Event<T>
- @Qualifier
- @Produces
- @Observes
- InjectionPoint

More concretely

- What's included:

  1. Introduction to **portable extensions**
  2. **Real** use cases from **real** projects
  3. **Code** in IDE with **tests**

- What's not included:

  1. Introduction to CDI
  2. Existing content on CDI extensions
  3. Work with contexts (need 2 more hours)

Arquillian

1. Arquillian is an integration testing platform
2. It integrates with JUnit
3. Create your SUT in a dedicated method
4. Run tests in the target containers of your choice
5. We'll use the `arquillian-weld-embedded` container adapter
6. The proper solution to test Java EE code
7. More info on arquillian.org

Agenda

Slides available at astefanutti.github.io/further-cdi

- Meet CDI SPI
- CDI Extensions
- Metrics CDI
- CDI Quizz
- Camel CDI

Meet CDI SPI

SPI can be split in 4 parts

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- Type meta-model

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- Type meta-model
- CDI meta-model

SPI can be split in 4 parts

- Type meta-model
- CDI meta-model
- CDI entry points

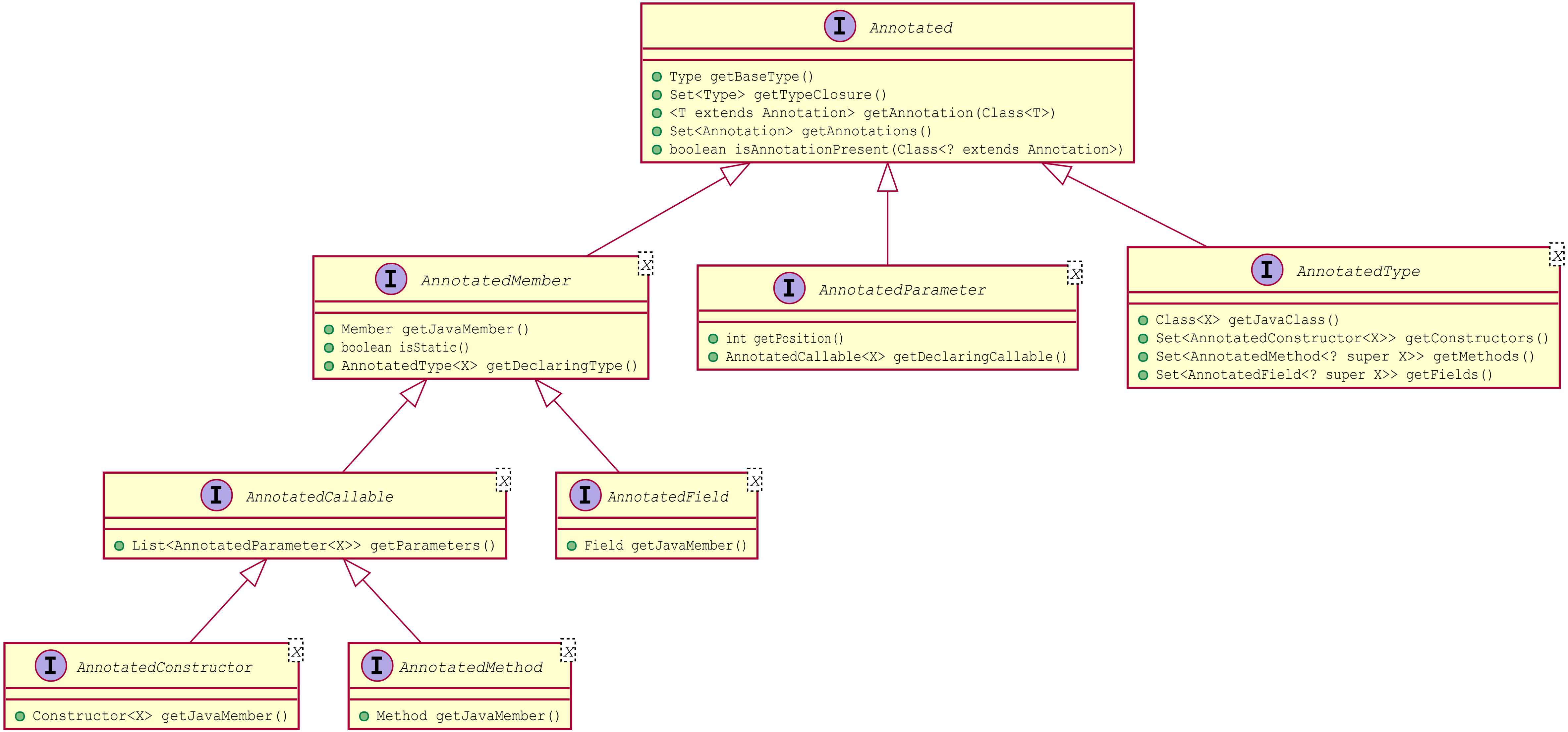
SPI can be split in 4 parts

- Type meta-model
- CDI meta-model
- CDI entry points
- SPI dedicated to extensions

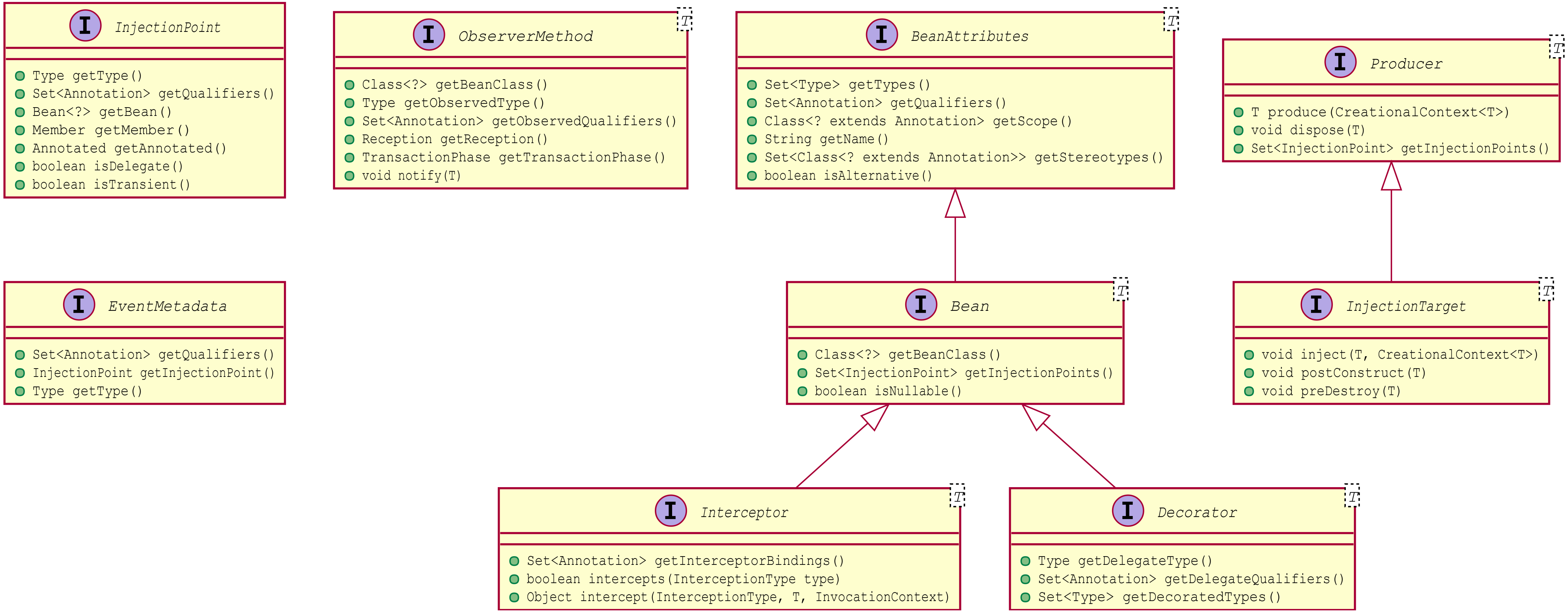
Why having a type meta-model?

- Because `@Annotations` are configuration
- but they are also read-only
- So to configure we need a mutable meta-model…
- …for annotated types

SPI for type meta-model



SPI dedicated to CDI meta-model



This SPI can be used in your code (1/2)

`InjectionPoint` can be used to get info about what's being injected

```
@Qualifier
@Retention(RetentionPolicy.RUNTIME)
public @interface HttpParam {
    @Nonbinding String value();
}
```

```
@Produces @HttpParam("")
String getParamValue(InjectionPoint ip, HttpServletRequest req) {
    return req.getParameter(ip.getAnnotated().getAnnotation(HttpParam.class).value());
}
```

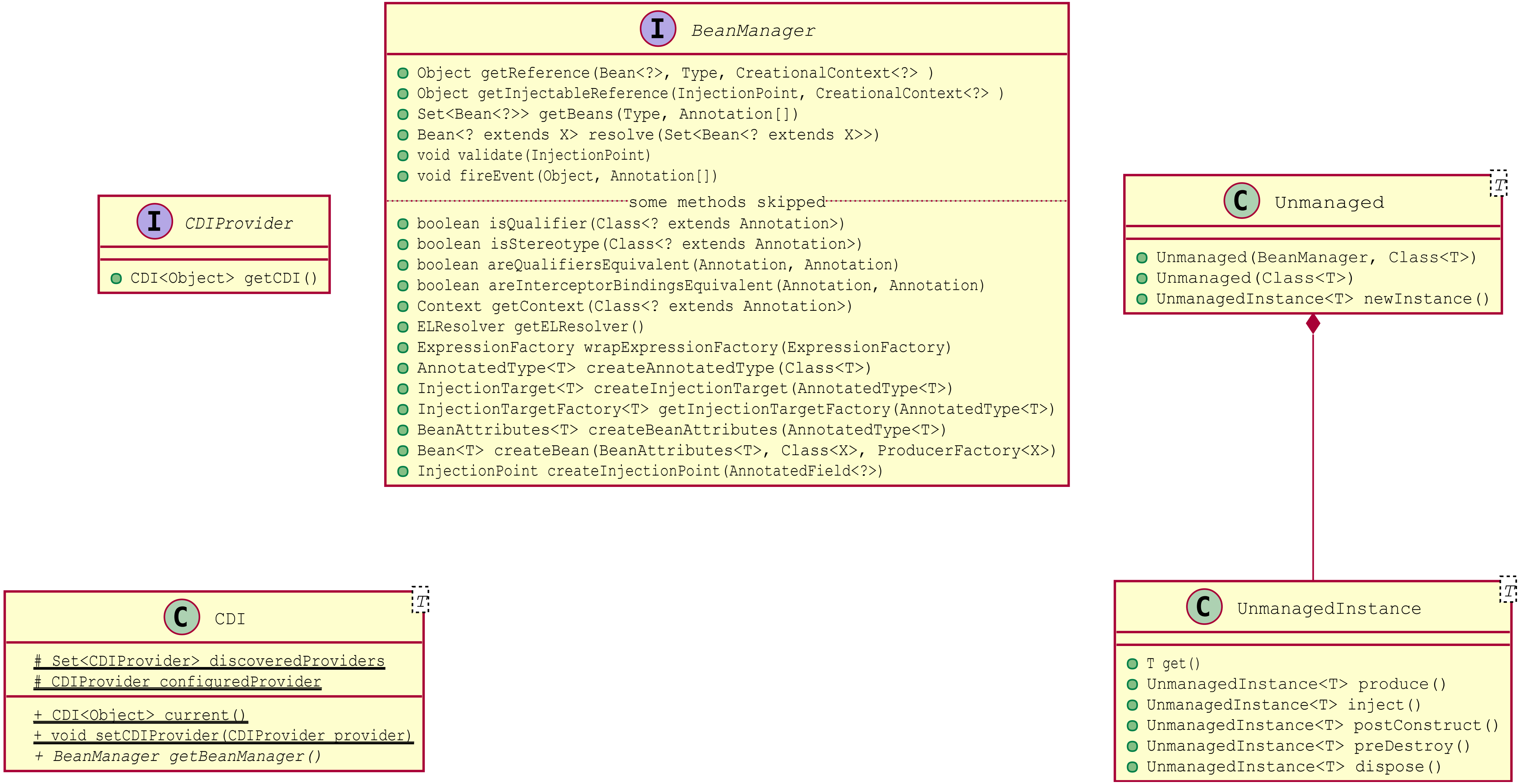
```
@Inject
@HttpParam("productId")
String productId;
```

This SPI can be used in your code (2/2)

`InjectionPoint` contains info about requested type at `@Inject`

```
class MyMapProducer() {

    @Produces
    <K, V> Map<K, V> produceMap(InjectionPoint ip) {
        if (valueIsNumber(((ParameterizedType) ip.getType())))
            return new TreeMap<K, V>();
        return new HashMap<K, V>();
    }

    boolean valueIsNumber(ParameterizedType type) {
        Class<?> valueClass = (Class<?>) type.getActualTypeArguments()[1];
        return Number.class.isAssignableFrom(valueClass)
    }
}
```

SPI providing CDI entry points

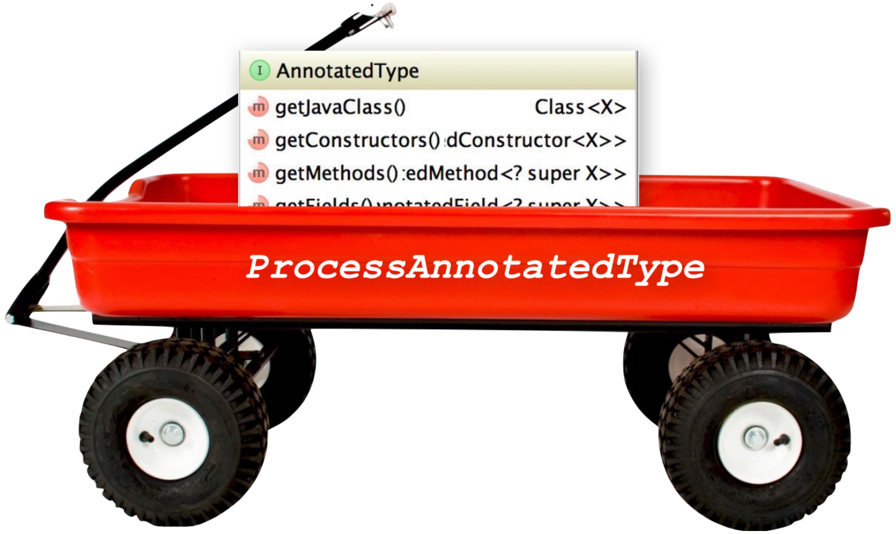


SPI dedicated to extensions

All these SPI interfaces are events containing meta-model SPI

- These events fired at boot time can only be observed in CDI extensions

- For instance:



- A `ProcessAnnotatedType<T>` event is fired for each type being discovered at boot time

- Observing `ProcessAnnotatedType<Foo>` allows you to prevent `Foo` to be deployed as a bean by calling `ProcessAnnotatedType#veto()`

CDI Extensions

Portable extensions

- One of the most powerful feature of the CDI specification

- Not really popularized, partly due to:

1. Their high level of abstraction
2. The pre-requisite knowledge about basic CDI and SPI
3. Lack of information (CDI is often perceived as a basic DI solution)

Extensions, what for?

- To integrate 3rd party libraries, frameworks or legacy components
- To change existing configuration or behavior
- To extend CDI and Java EE
- Thanks to them, Java EE can evolve between major releases

Extensions, how?

- Observing SPI events at boot time related to the bean manager lifecycle
- Checking what meta-data are being created
- Modifying these meta-data or creating new ones

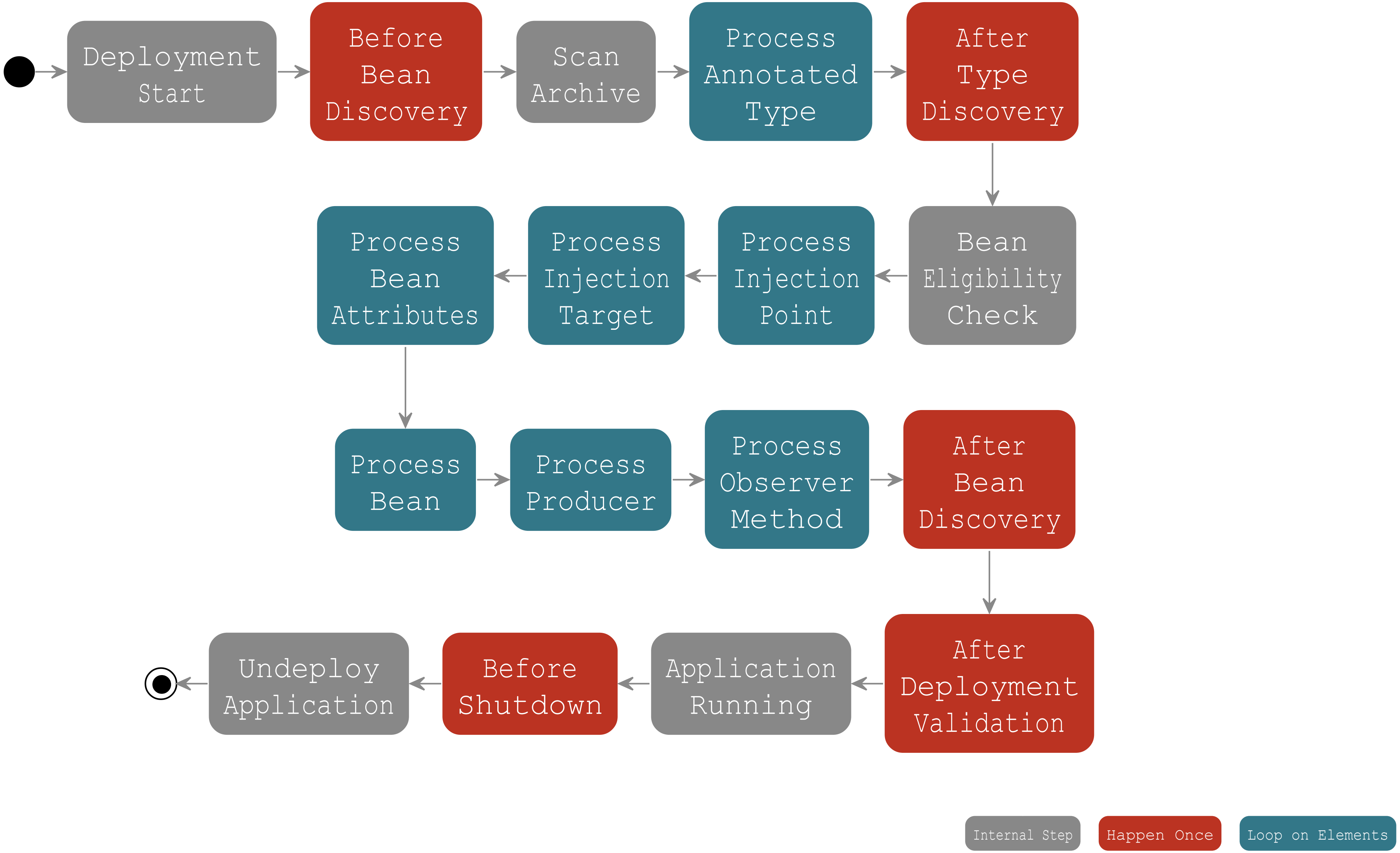
More concretely

Service provider of the service `javax.enterprise.inject.spi.Extension` declared in `META-INF/services`

Just put the fully qualified name of your extension class in this file

```
import javax.enterprise.event.Observes;
import javax.enterprise.inject.spi.Extension;

public class CdiExtension implements Extension {

    void beforeBeanDiscovery(@Observes BeforeBeanDiscovery bbd) {
    }
    // ...
    void afterDeploymentValidation(@Observes AfterDeploymentValidation adv) {
    }
}
```

Bean manager lifecycle



Example: Ignoring JPA entities

The following extension prevents CDI to manage entities

This is a commonly admitted good practice

```
public class VetoEntity implements Extension {

    void vetoEntity(@Observes @WithAnnotations(Entity.class) ProcessAnnotatedType<?> pat) {
        pat.veto();
    }
}
```

⚠ Extensions are launched during bootstrap and are based on CDI events

⚠ Once the application is bootstrapped, the Bean Manager is in read-only mode (no runtime bean registration)

⚠ You only have to `@Observes` built-in CDI events to create your extensions

Remember

Metrics CDI

Dropwizard Metrics provides

- Different metric types: `Counter`, `Gauge`, `Meter`, `Timer`, …
- Different reporter: JMX, console, SLF4J, CSV, servlet, …
- `MetricRegistry` object which collects all your app metrics
- Annotations for AOP frameworks: `@Counted`, `@Timed`, …
- … but does not include integration with these frameworks
- More at dropwizard.github.io/metrics

Discover how we created CDI integration module for Metrics

Metrics out of the box (without CDI)

```
class MetricsHelper {
    public static MetricRegistry REGISTRY = new MetricRegistry();
}
```

```
class TimedMethodClass {

    void timedMethod() {
        Timer timer = MetricsHelper.REGISTRY.timer("timer"); (1)
        Timer.Context time = timer.time();
        try {
            /*...*/
        } finally {
            time.stop();
        }
    }
}
```

1 Note that if a `Timer` named `"timer"` doesn't exist, `MetricRegistry` will create a default one and register it

Basic CDI integration

```
class MetricRegistryBean {
    @Produces
    @ApplicationScoped
    MetricRegistry registry = new MetricRegistry();
}
```

```
class TimedMethodBean {

    @Inject MetricRegistry registry;

    void timedMethod() {
        Timer timer = registry.timer("timer");
        Timer.Context time = timer.time();
        try {
            /*...*/
        } finally {
            time.stop();
        }
    }
}
```

We could have a lot more with advanced **CDI** features

Our goals to achieve full CDI integration

- Produce and inject multiple **metrics** of the same type
- Enable Metrics with the provided annotations
- Access same `Metric` instances through `@inject` or `MetricRegistry` API

GOAL 1 Produce and inject multiple metrics of the same type

What’s the problem with multiple Metrics of the same type?

⚠ This code throws a deployment exception (ambiguous dependency)

```
@Produces
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, MINUTES)); (1)

@Produces
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, HOURS)); (2)

@Inject
Timer timer; (3)
```

1. This timer that only keeps measurement of last minute is produced as a bean of type `Timer`
2. This timer that only keeps measurement of last hour is produced as a bean of type `Timer`
3. This injection point is ambiguous since 2 eligible beans exist

Solving the ambiguity

We could use the provided `@Metric` annotation to qualify our beans

```
@Produces
@Metric(name = "my_timer")
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, MINUTES));

@Produces
@Metric(name = "my_other_timer")
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, HOURS));

@Inject
@Metric(name = "my_timer")
Timer timer;
```

That won't work out of the box since `@Metric` is not a qualifier

How to declare `@Metric` as a qualifier?

- By observing the `BeforeBeanDiscovery` lifecycle event in an extension

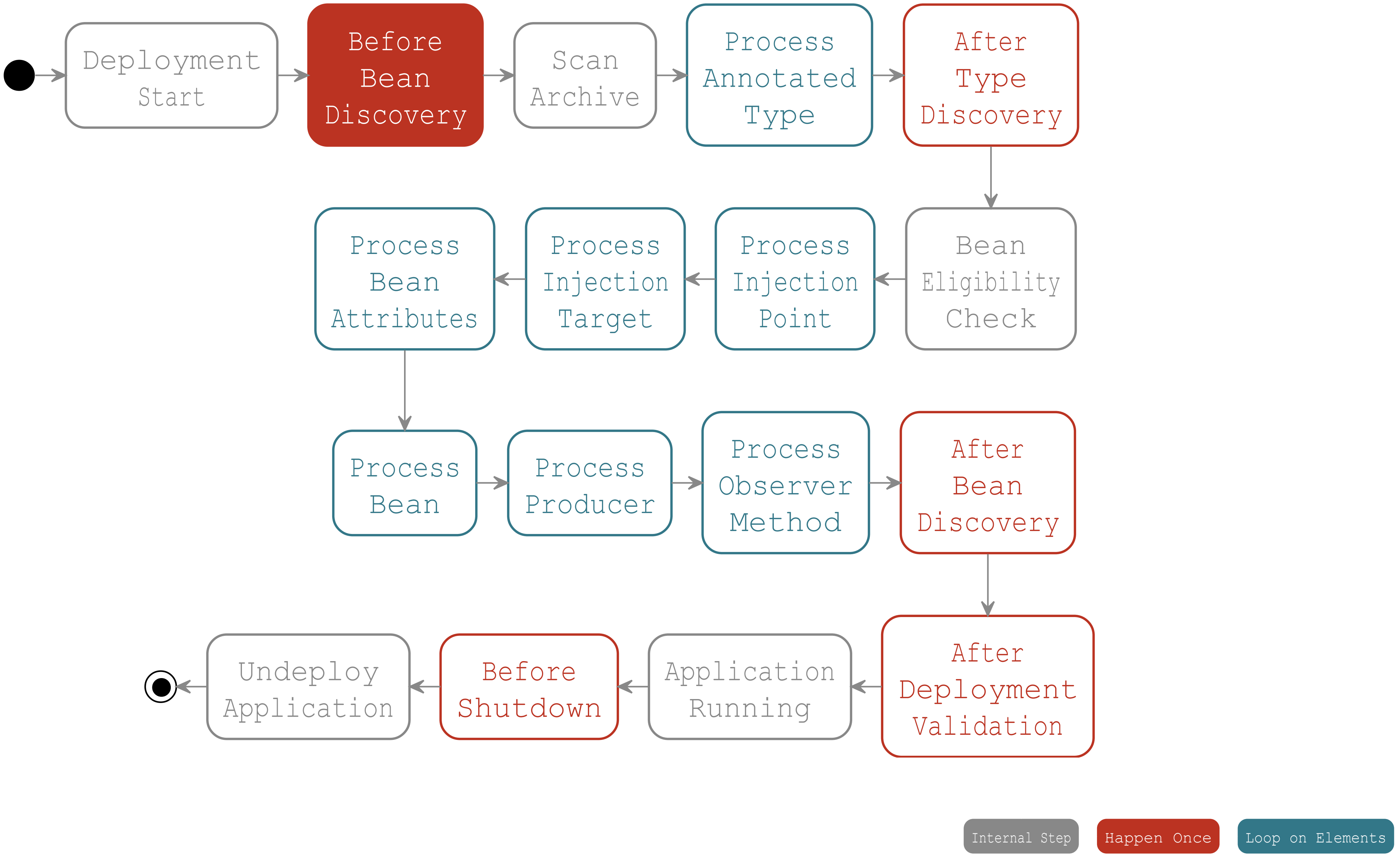
`javax.enterprise.inject.spi.BeforeBeanDiscovery`

```
public interface BeforeBeanDiscovery {
    void addQualifier(Class<? extends Annotation> qualifier); (1)
    void addQualifier(AnnotatedType<? extends Annotation> qualifier);
    void addScope(Class<? extends Annotation> scopeType, boolean normal, boolean passivation);
    void addStereotype(Class<? extends Annotation> stereotype, Annotation... stereotypeDef);
    void addInterceptorBinding(AnnotatedType<? extends Annotation> bindingType);
    void addInterceptorBinding(Class<? extends Annotation> bindingType, Annotation... bindingTypeDef);
    void addAnnotatedType(AnnotatedType<?> type);
    void addAnnotatedType(AnnotatedType<?> type, String id);
    <T> AnnotatedTypeConfigurator<T> addAnnotatedType(Class<T> type, String id);
    <T extends Annotation> AnnotatedTypeConfigurator<T> configureQualifier(Class<T> qualifier);
    <T extends Annotation> AnnotatedTypeConfigurator<T> configureInterceptorBinding(Class<T> bindingType);
}
```

(1) The method we need to declare the `@Metric` annotation as a CDI qualifier

- And use `addQualifier()` method in the event

`BeforeBeanDiscovery` is first in lifecycle



Our first extension

- A CDI extension is a class implementing the `Extension` tag interface

`org.cdi.further.metrics.MetricsExtension`

```
public class MetricsExtension implements Extension {

    void addMetricAsQualifier(@Observes BeforeBeanDiscovery bdd) {
        bdd.addQualifier(Metric.class);
    }
}
```

- Extension is activated by adding this file to `META-INF/services`

`javax.enterprise.inject.spi.Extension`

```
org.cdi.further.metrics.MetricsExtension
```

Goal 1 achieved

- We can now write:

```
@Produces
@Metric(name = "my_timer")
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, MINUTES));

@Produces
@Metric(name = "my_other_timer")
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, HOURS));

@Inject
@Metric(name = "my_timer")
Timer timer;
```

- And have the `Timer` injection points satisfied

GOAL 2 Apply Metrics with the provided annotations

Goal 2 in detail

- We want to be able to write:

```java
@Timed("timer") // (1)
void timedMethod() {
    // Business code
}
```

- And have the timer `"timer"` activated during method invocation

- The solution is to declare an interceptor and bind it to `@Timed`

Goal 2 step by step

- Create an interceptor for the timer's technical code
- Make `@Timed` (provided by Metrics) a valid interceptor binding
- Programmatically add `@Timed` as an interceptor binding

Preparing interceptor creation

We should find the technical code that will wrap the business code

```
class TimedMethodBean {

    @Inject
    MetricRegistry registry;

    void timedMethod() {
        Timer timer = registry.timer("timer");
        Timer.Context time = timer.time();
        try {
            // Business code
        } finally {
            time.stop();
        }
    }
}
```

Interceptor code is highlighted below

```
@Interceptor
class TimedInterceptor {
    @Inject MetricRegistry registry; (1)

    @AroundInvoke
    Object timedMethod(InvocationContext context) throws Exception {
        Timer timer = registry.timer(context.getMethod().getAnnotation(Timed.class).name());
        Timer.Context time = timer.time();
        try {
            return context.proceed(); (2)
        } finally {
            time.stop();
        }
    }
}
```

1. In CDI an interceptor is a bean, you can inject other beans in it
2. Here the **business code** of the application is called. All the code around is the **technical code**.

Activating the interceptor

```
@Interceptor
@Priority(Interceptor.Priority.LIBRARY_BEFORE)  1
class TimedInterceptor {

    @Inject
    MetricRegistry registry;

    @AroundInvoke
    Object timedMethod(InvocationContext context) throws Exception {
        Timer timer = registry.timer(context.getMethod().getAnnotation(Timed.class).name());
        Timer.Context time = timer.time();
        try {
            return context.proceed();
        } finally {
            time.stop();
        }
    }
}
```

1 Giving a `@Priority` to an interceptor activates and orders it

Add a binding to the interceptor

```
@Timed ①
@Interceptor
@Priority(Interceptor.Priority.LIBRARY_BEFORE)
class TimedInterceptor {

    @Inject
    MetricRegistry registry;

    @AroundInvoke
    Object timedMethod(InvocationContext context) throws Exception {
        Timer timer = registry.timer(context.getMethod().getAnnotation(Timed.class).name());
        Timer.Context time = timer.time();
        try {
            return context.proceed();
        } finally {
            time.stop();
        }
    }
}
```

① We’ll use Metrics `@Timed` annotation as interceptor binding

Back on interceptor binding

- An **interceptor binding** is an annotation used in 2 places:

1. On the interceptor class to bind it to this annotation
2. On the methods or classes to be intercepted by this interceptor

- An interceptor binding should have the `@InterceptorBinding` annotation or should be declared programmatically

- If the interceptor binding annotation has members:

1. Their values are taken into account to resolve interceptor
2. Unless members are annotated with `@NonBinding`

`@Timed` annotation is not an interceptor binding

```
@Documented
@Retention(RetentionPolicy.RUNTIME)
@Target({ ElementType.TYPE, ElementType.CONSTRUCTOR, ElementType.METHOD,
ElementType.ANNOTATION_TYPE }) (1)
public @interface Timed {

    String name() default ""; (2)

    boolean absolute() default false; (2)
}
```

1. Lack the `@InterceptorBinding` annotation
2. None of the members have the `@NonBinding` annotation, so `@Timed(name = "timer1")` and `@Timed(name = "timer2")` will be 2 different interceptor bindings

The required `@Timed` source code to make it an interceptor binding

```
@Documented
@Retention(RetentionPolicy.RUNTIME)
@Target({ ElementType.TYPE, ElementType.CONSTRUCTOR, ElementType.METHOD,
ElementType.ANNOTATION_TYPE })
@InterceptorBinding
public @interface Timed {

    @NonBinding String name() default "";

    @NonBinding boolean absolute() default false;
}
```

❓ How to achieve the required `@Timed` declaration?

🚫 We cannot touch the component source / binary!

Using the `AnnotatedTypeConfigurator` SPI

- We observe `BeforeBeanDiscovery` to add a new interceptor binding
- Use the `AnnotatedTypeConfigurator<T>` API introduced in **CDI 2.0**

```
public class MetricsExtension implements Extension {

    void addTimedInterceptorBinding(@Observes BeforeBeanDiscovery bdd) {
        bbd.configureInterceptorBinding(Timed.class).methods()
            .forEach(method -> method.add(Nonbinding.Literal.INSTANCE)); (1)
    }
}
```

1. `@NonBinding` is added to all members of the `@Timed` annotation

Goal 2 achieved

We can now write:

```
@Timed("timer")
void timedMethod() {
    // Business code
}
```

And have a Metrics `Timer` applied to the method

1. Interceptor code should be enhanced to support `@Timed` on classes
2. Other interceptors should be developed for other metric types

Our goals

1. Apply a metric with the provided annotation in AOP style

```
@Timed("timer") ❶
void timedMethod() {
    // Business code
}
```

2. Register automatically produced custom metrics

```
@Produces
@Metric(name = "my_timer") ❶
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, MINUTES));
// ...
@Timed("my_timer") ❶
void timedMethod() { /*...*/ }
```

❶ Annotations provided by Metrics

GOAL 3 Access same `Metric` instances through `@Inject` or `MetricRegistry` API

Goal 3 in detail

- When writing:

```
@Inject
@Metric(name = "my_timer")
Timer timer1;

@Inject
MetricRegistry registry;
Timer timer2 = registry.timer("my_timer");
```

- ... We want that `timer1 == timer2`

Goal 3 in detail

```
@Produces
@Metric(name = "my_timer") (1)
Timer timer = new Timer(new SlidingTimeWindowReservoir(1L, TimeUnit.MINUTES));

@Inject
@Metric(name = "my_timer")
Timer timer;

@Inject
MetricRegistry registry;
Timer timer = registry.timer("my_timer"); (2)
```

1. Produced `Timer` should be added to the Metrics registry when produced
2. When retrieved from the registry, a `Metric` should be identical to the produced instance and vice versa

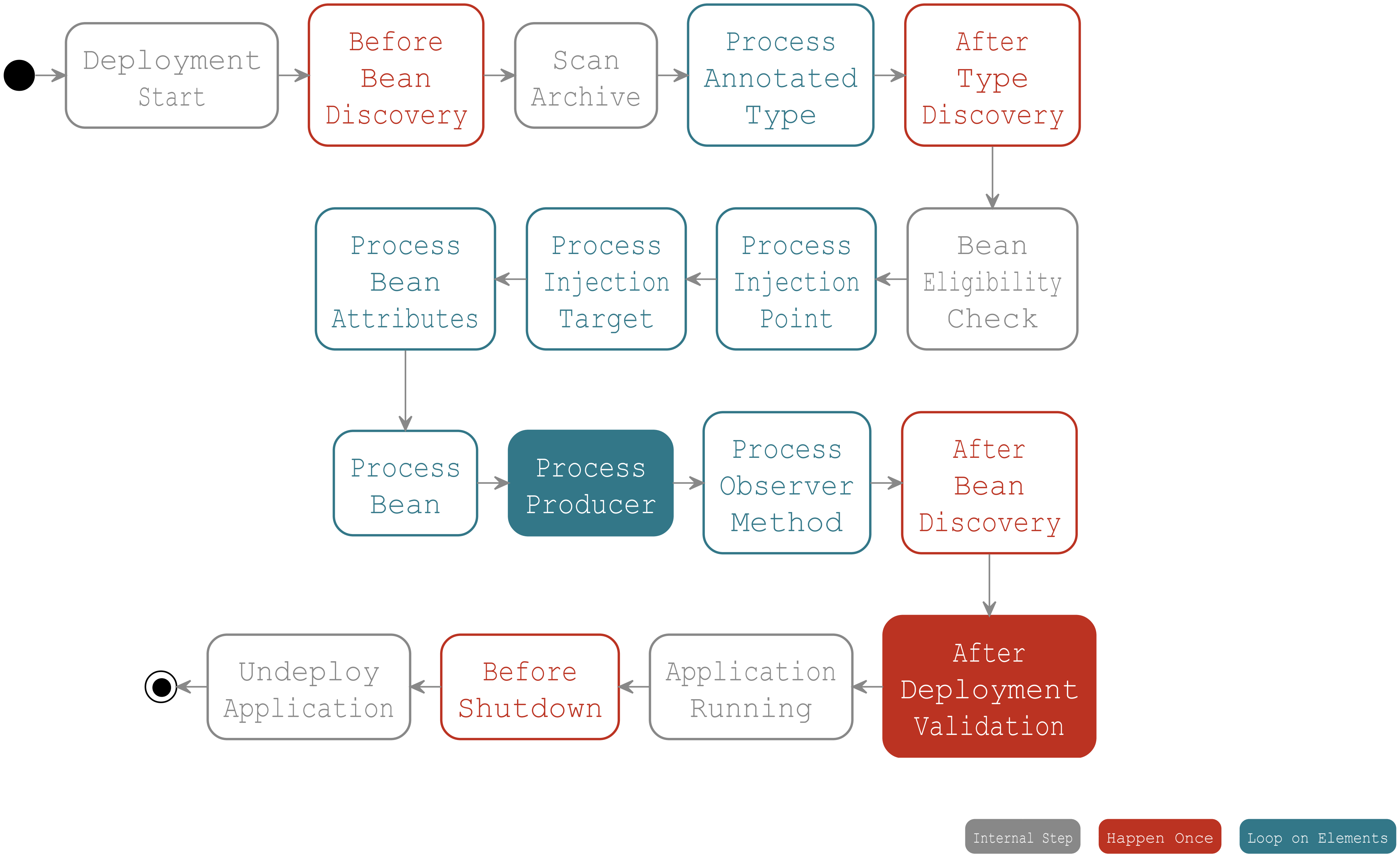
There are 2 `Metric` classes, the `com.codahale.metrics.Metric` interface and the `com.codahale.metrics.annotation.Metric` annotation

Goal 3 step by step

We need to write an extension that will:

1. Change how a `Metric` instance is produced by looking it up in the registry first and producing (and registering) it only if it’s not found. We’ll do this by:
    1. observing the `ProcessProducer` lifecycle event
    2. decorating Metric `Producer` to add this new behavior
2. Produce all `Metric` instances at the end of bootstrap to have them in registry for runtime
    1. we’ll do this by observing the `AfterDeploymentValidation` event

So we will `@Observes` these 2 events to add our features



Customizing `Metric` producing process

Observe the `ProcessProducer` lifecycle event to override the original producer using the `ProducerConfigurator<T>` API introduced in **CDI 2.0**

`javax.enterprise.inject.spi.ProcessProducer`

```java
public interface ProcessProducer<T, X> {
    AnnotatedMember<T> getAnnotatedMember(); // (1)
    Producer<X> getProducer(); // (2)
    void setProducer(Producer<X> producer);
    ProducerConfigurator<X> configureProducer(); // (3)
    void addDefinitionError(Throwable t);
}
```

1. Gets the `AnnotatedMember` associated to the `@Produces` field or method
2. Gets the default producer (useful to decorate it)
3. Overrides the producer

Customizing `Metric` producing process (end)

```
public class MetricsExtension implements Extension {
    // ...
    <T extends c.c.m.Metric> void decorateMetricProducer(@Observes ProcessProducer<?, T> pp, BeanManager manager) {
       if (pp.getAnnotatedMember().isAnnotationPresent(Metric.class)) {
           String name = pp.getAnnotatedMember().getAnnotation(Metric.class).name(); (1)
           Producer<T> producer = pp.getProducer();
           pp.configureProducer().produceWith(context -> { (2)
               MetricRegistry registry = manager.createInstance().select(MetricRegistry.class).get();
               if (registry.getMetrics().containsKey(name))
                   return (T) registry.getMetrics().get(name);
               return registry.register(name, producer.produce(context)); (3)
           });
       }
    }
    // ...
}
```

1. We retrieve metric's name by calling the `name()` member from `@Metric`
2. The `produceWith` method is used by the container at runtime to decorate declared producer with our logic
3. If metric name is not in the registry, the original producer is called and its result is added to the registry

Producing all the `Metric` instances at the end of boot time

We do that by observing the `AfterDeploymentValidation` event

```
public class MetricsExtension implements Extension {
  // ...
  void registerProducedMetrics(@Observes AfterDeploymentValidation adv, BeanManager manager) {
      manager.createInstance().select(com.codahale.metrics.Metric.class, Any.Literal.INSTANCE)
        .forEach(Object::toString);
  }
  // ...
}
```

Goal 3 achieved

- We can now write:

```
@Produces
@Metric(name = "my_timer")
Timer timer1 = new Timer(new SlidingTimeWindowReservoir(1L, MINUTES));

@Inject
@Metric(name = "my_timer")
Timer timer2;

@Inject
MetricRegistry registry;
Timer timer3 = registry.timer("my_timer");
```

- And make sure that `timer1 == timer2 == timer3`

Complete extension code

```java
public class MetricsExtension implements Extension {

    void addMetricAsQualifier(@Observes BeforeBeanDiscovery bdd) {
        bdd.addQualifier(Metric.class);
    }

    void addTimedInterceptorBinding(@Observes BeforeBeanDiscovery bbd) {
        bbd.configureInterceptorBinding(Timed.class).methods().forEach(method -> method.add(Nonbinding.Literal.INSTANCE));
    }

    <T extends com.codahale.metrics.Metric> void decorateMetricProducer(@Observes ProcessProducer<?, T> pp, BeanManager manager) {
        if (pp.getAnnotatedMember().isAnnotationPresent(Metric.class)) {
            String name = pp.getAnnotatedMember().getAnnotation(Metric.class).name();
            Producer<T> producer = pp.getProducer();
            pp.configureProducer().produceWith(context -> {
                MetricRegistry registry = manager.createInstance().select(MetricRegistry.class).get();
                if (registry.getMetrics().containsKey(name))
                    return (T) registry.getMetrics().get(name);
                return registry.register(name, producer.produce(context));
            });
        }
    }

    void registerProduceMetrics(@Observes AfterDeploymentValidation adv, BeanManager manager) {
        manager.createInstance().select(com.codahale.metrics.Metric.class, Any.Literal.INSTANCE).forEach(Object::toString);
    }
}
```

Test your CDI knowledge

Quizz time

Find the valid injections points

```
class MySuperBean {

    @Inject
    Bean<MySuperBean> myMeta;                                   // A [ ]

    @Inject
    Bean<MyService> serviceMeta;                                // B [ ]

    public MySuperBean(@Inject MyService service) {/*...*/}     // C [ ]

    @Inject
    private void myInitMethod(MyService service) {/*...*/}      // D [ ]

    @Inject
    @PostConstruct
    public void myInitMethod2(MyService service) {/*...*/}      // E [ ]
}
```

Solution

```
class MySuperBean {

    @Inject
    Bean<MySuperBean> myMeta;                                       // A [X]

    @Inject
    Bean<MyService> serviceMeta;                                    // B [ ]

    public MySuperBean(@Inject MyService service) {/*...*/}         // C [ ]

    @Inject
    private void myInitMethod(MyService service) {/*...*/}          // D [X]

    @Inject
    @PostConstruct
    public void myInitMethod2(MyService service) {/*...*/}          // E [ ]
}
```

Find Beans candidates without `beans.xml` in JAR (CDI 1.2)

```
@Decorator
public abstract class MyDecorator implements MyService {/*...*/}        // A [ ]

@Stateless
public class MyServiceImpl implements MyService {/*...*/}               // B [ ]

public class MyBean {/*...*/}                                           // C [ ]

@Model
public class MyBean {/*...*/}                                           // D [ ]

@Singleton
public class MyBean {/*...*/}                                           // E [ ]

@ConversationScoped
public class MyBean {/*...*/}                                           // F [ ]
```

Solution

```
@Decorator
public abstract class MyDecorator implements MyService {/*...*/}         // A [X]

@Stateless
public class MyServiceImpl implements MyService {/*...*/}                // B [X]

public class MyBean {/*...*/}                                            // C [ ]

@Model
public class MyBean {/*...*/}                                            // D [X]

@Singleton
public class MyBean {/*...*/}                                            // E [ ]

@ConversationScoped
public class MyBean {/*...*/}                                            // F [X]
```

Find the valid producers

```java
@ApplicationScoped
public class MyBean {

  @Produces
  Service produce1(InjectionPoint ip, Bean<Service> myMeta) {/*...*/}   // A [ ]

  @Produces
  @SessionScoped
  Service produce2(InjectionPoint ip) {/*...*/}                         // B [ ]

  @Produces
  Map<K, V> produceMap(InjectionPoint ip) {/*...*/}                     // C [ ]

  @Produces
  Map<String, ? extends Service> produceMap2() {/*...*/}                // D [ ]
}
```

Solution

```
@ApplicationScoped
public class MyBean {

  @Produces
  Service produce1(InjectionPoint ip, Bean<Service> myMeta) {/*...*/}   // A [X]

  @Produces
  @SessionScoped
  Service produce2(InjectionPoint ip) {/*...*/}                         // B [ ]

  @Produces
  Map<K, V> produceMap(InjectionPoint ip) {/*...*/}                     // C [X]

  @Produces
  Map<String, ? extends Service> produceMap2() {/*...*/}                // D [ ]
}
```

Which observers will be triggered?

```java
class FirstBean {

    @Inject
    Event<Post> postEvent;

    public void saveNewPost(Post myPost) {
        postEvent.select(new AnnotationLiteral()<French> {}).fire(myPost);
    }
}

class SecondBean {

    void listenFrPost(@Observes @French Post post) {/*...*/}              // A [ ]
    void listenPost(@Observes Post post) {/*...*/}                        // B [ ]
    void listenEnPost(@Observes @English Post post) {/*...*/}             // C [ ]
    void listenObject(@Observes Object obj) {/*...*/}                     // D [ ]
}
```

Solution

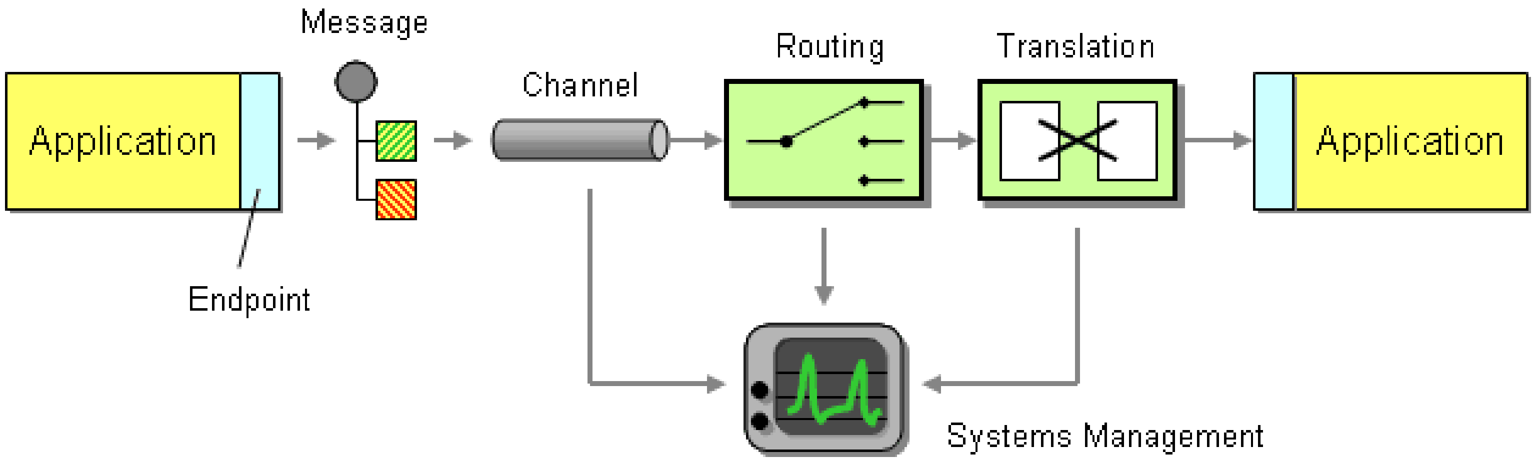
```
class FirstBean {

    @Inject
    Event<Post> postEvent;

    public void saveNewPost(Post myPost) {
        postEvent.select(new AnnotationLiteral()<French> {}).fire(myPost);
    }
}

class SecondBean {

    void listenFrPost(@Observes @French Post post) {/*...*/}          // A [X]
    void listenPost(@Observes Post post) {/*...*/}                    // B [X]
    void listenEnPost(@Observes @English Post post) {/*...*/}         // C [ ]
    void listenObject(@Observes Object obj) {/*...*/}                 // D [X]
}
```

How to use CDI as dependency injection container for an integration framework (Apache Camel)

Camel CDI

About Apache Camel

- Open-source integration framework based on known Enterprise Integration Patterns
- Provides a variety of DSLs to write routing and mediation rules
- Provides support for bean binding and seamless integration with DI frameworks



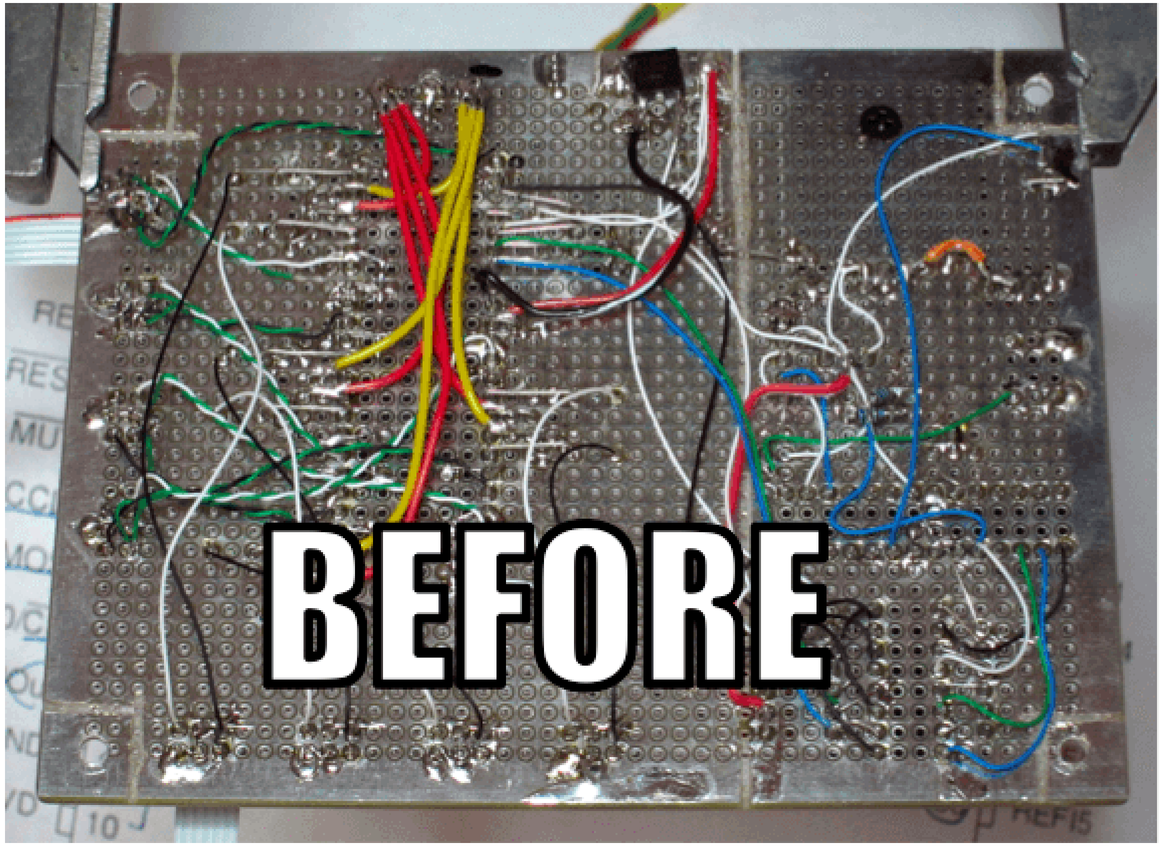
Discover how we created CDI integration module for Camel

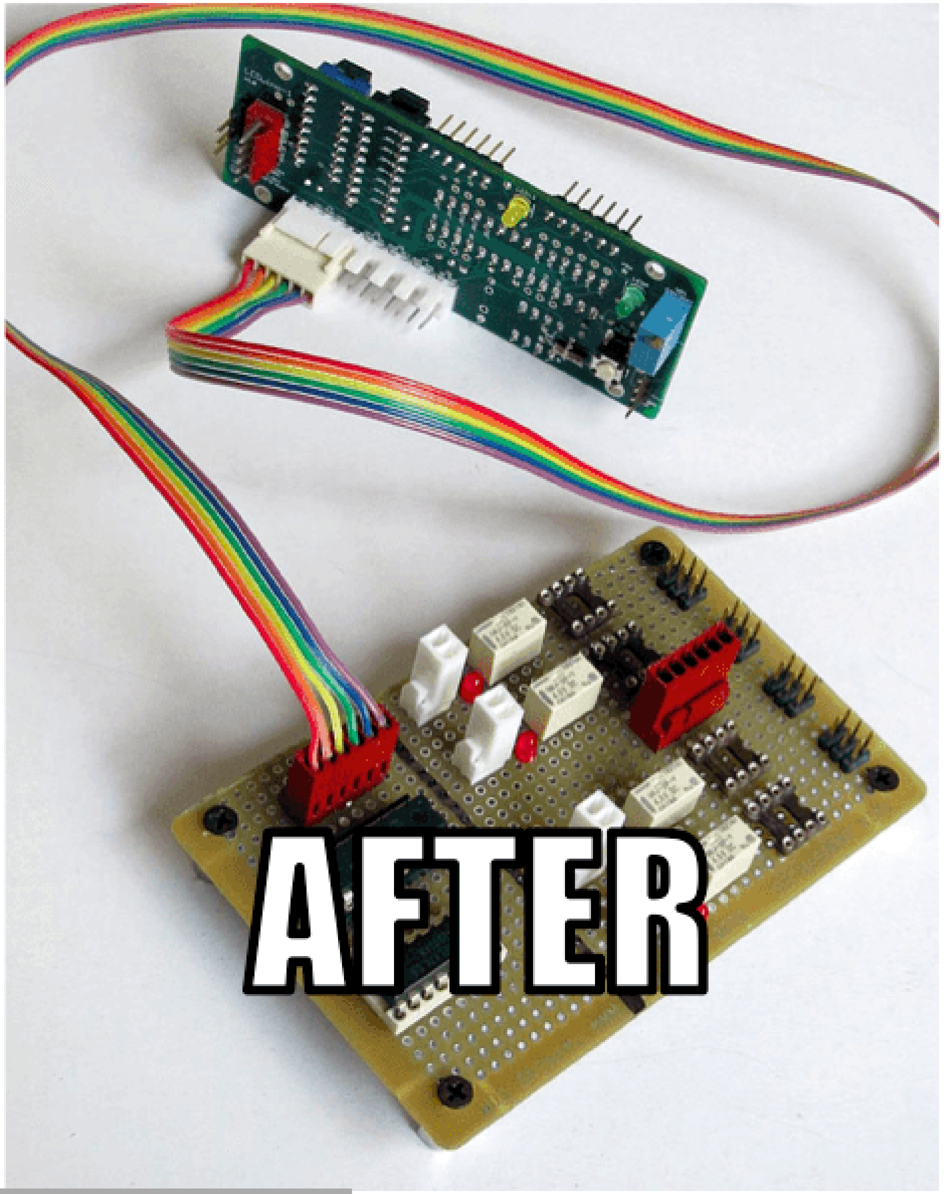
Camel out of the box (without CDI)

```
public static void main(String[] args) {
    CamelContext context = new DefaultCamelContext();
    context.addRoutes(new RouteBuilder() {
      public void configure() {
        from("file:target/input?delay=1s")
          .log("Sending message [${body}] to JMS ...")
          .to("sjms:queue:output"); (1)
      }
    });

    PropertiesComponent properties = new PropertiesComponent();
    properties.setLocation("classpath:camel.properties");
    context.addComponent("properties", properties); // Registers the "properties" component

    SjmsComponent component = new SjmsComponent();
    component.setConnectionFactory(new ActiveMQConnectionFactory("vm://broker?broker.persistent=false"));
    jms.setConnectionCount(Integer.valueOf(context.resolvePropertyPlaceholders("{{jms.maxConnections}}")));
    context.addComponent("sjms", jms); // Registers the "sjms" component

    context.start();
}
```

(1) This route watches a directory every second and sends new files content to a JMS queue

Why CDI?





Basic CDI integration (1/3)

1. Camel components and route builder as CDI beans
2. Bind the Camel context lifecycle to that of the CDI container

```java
class FileToJmsRouteBean extends RouteBuilder {

    @Override
    public void configure() {
        from("file:target/input?delay=1s")
            .log("Sending message [${body}] to JMS...")
            .to("sjms:queue:output");
    }
}
```

Basic CDI integration (2/3)

```java
class PropertiesComponentFactoryBean {

    @Produces @ApplicationScoped
    PropertiesComponent propertiesComponent() {
        PropertiesComponent properties = new PropertiesComponent();
        properties.setLocation("classpath:camel.properties");
        return properties;
    }
}
```

```java
class JmsComponentFactoryBean {

    @Produces @ApplicationScoped
    SjmsComponent sjmsComponent(PropertiesComponent properties) throws Exception {
        SjmsComponent jms = new SjmsComponent();
        jms.setConnectionFactory(new ActiveMQConnectionFactory("vm://broker?broker.persistent=false"));
        jms.setConnectionCount(Integer.valueOf(properties.parseUri("{{jms.maxConnections}}")));
        return component;
    }
}
```

Basic CDI integration (3/3)

```java
@ApplicationScoped
class CamelContextBean extends DefaultCamelContext {

    @Inject
    CamelContextBean(FileToJmsRouteBean route, SjmsComponent jms, PropertiesComponent properties) {
        addComponent("properties", properties);
        addComponent("sjms", jms);
        addRoutes(route);
    }

    @PostConstruct
    void startContext() {
        super.start();
    }

    @PreDestroy
    void preDestroy() {
        super.stop();
    }
}
```

We could have a lot more with advanced **CDI** features

Our goals

1. Avoid assembling and configuring the `CamelContext` manually
2. Access CDI beans from the Camel DSL automatically

```
.to("sjms:queue:output"); // Lookup by name (sjms) and type (Component)

context.resolvePropertyPlaceholders("{{jms.maxConnections}}");
// Lookup by name (properties) and type (Component)
```

3. Support Camel annotations in CDI beans

```
@PropertyInject(value = "jms.maxConnections", defaultValue = "10")
int maxConnections;
```

Steps to integrate Camel and CDI

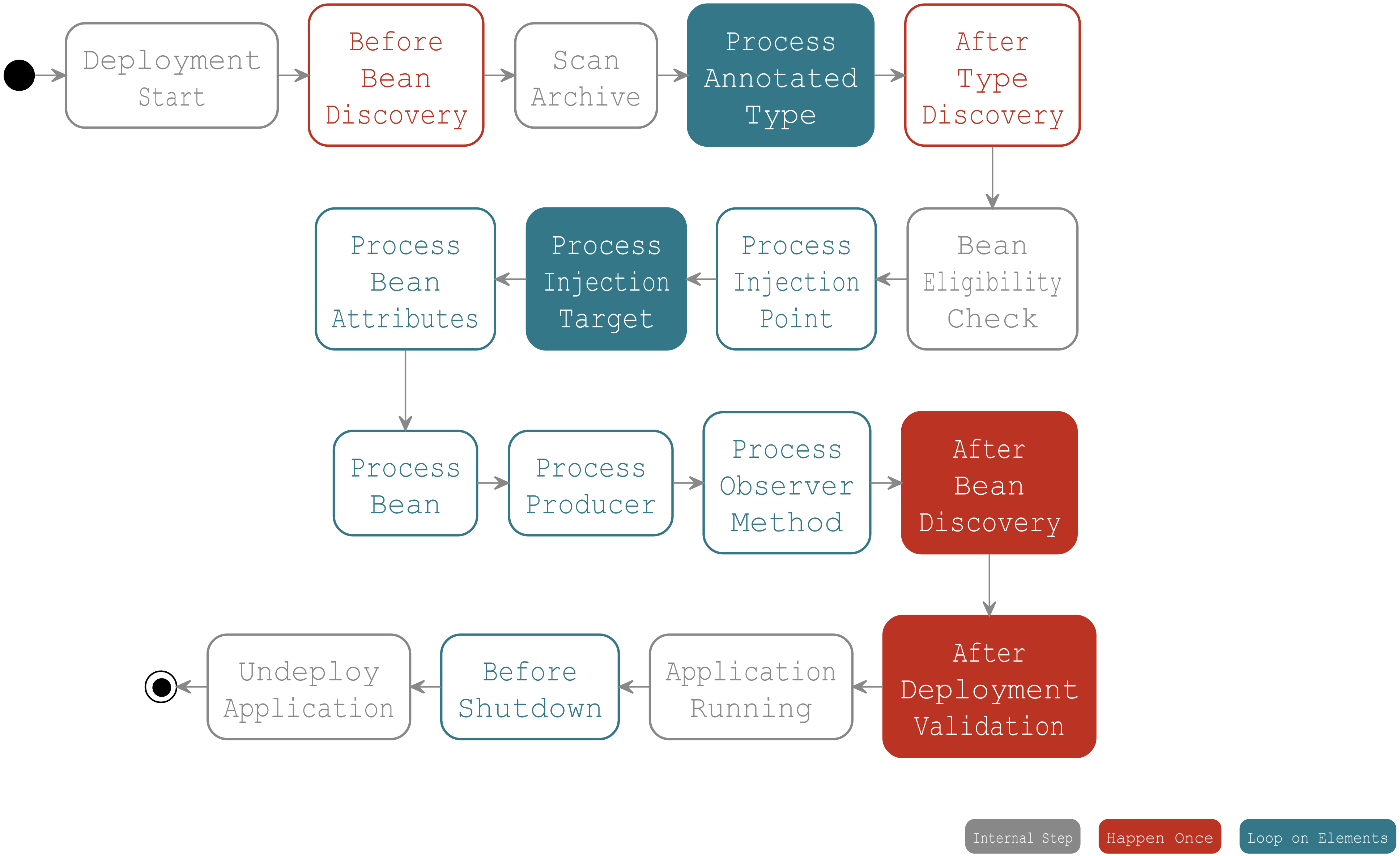
- Manage the creation and the configuration of the `CamelContext` bean
- Bind the `CamelContext` lifecycle to that of the CDI container
- Implement the Camel registry SPI to look up CDI bean references
- Use a custom `InjectionTarget` for CDI beans containing Camel annotations

How to achieve this?

We need to write an extension that will:

1. Declare a `CamelContext` bean by observing the `AfterBeanDiscovery` lifecycle event
2. Instantiate the beans of type `RouteBuilder` and add them to the Camel context
3. Start (resp. stop) the Camel context when the `AfterDeploymentValidation` event is fired (resp. the bean `destroy` method is called)
4. Customize the Camel context to query the `BeanManager` to lookup CDI beans by name and type
5. Detect CDI beans containing Camel annotations by observing the `ProcessAnnotatedType` event and modify how they get injected by observing the `ProcessInjectionTarget` lifecycle event

So we will `@Observes` these 4 events to add our features



- Automatically add a `CamelContext` bean in the deployment archive

How to add a bean programmatically?

Declaring a bean programmatically

Use the `BeanConfigurator<T>` API introduced in **CDI 2.0**

`javax.enterprise.inject.spi.configurator.BeanConfigurator<T>`

```
public interface BeanConfigurator<T> {
    BeanConfigurator<T> beanClass(Class<?> beanClass);
    <U extends T> BeanConfigurator<U> createWith(Function<CreationalContext<U>, U> callback);
    <U extends T> BeanConfigurator<U> produceWith(Function<Instance<Object>, U> callback);
    BeanConfigurator<T> destroyWith(BiConsumer<T, CreationalContext<T>> callback);
    BeanConfigurator<T> disposeWith(BiConsumer<T, Instance<Object>> callback);
    <U extends T> BeanConfigurator<U> read(AnnotatedType<U> type);
    BeanConfigurator<T> read(BeanAttributes<?> beanAttributes);
    BeanConfigurator<T> addType(Type type);
    BeanConfigurator<T> scope(Class<? extends Annotation> scope);
    BeanConfigurator<T> addQualifier(Annotation qualifier);
    BeanConfigurator<T> name(String name);
    // ...
}
```

Adding a programmatic bean to the deployment

- Access the `BeanConfigurator<T>` API by observing the `AfterBeanDiscovery` lifecycle event

```java
public class CamelExtension implements Extension {

    void addCamelContextBean(@Observes AfterBeanDiscovery abd) {
        abd.addBean()
            .types(CamelContext.class)
            .scope(ApplicationScoped.class)
            .produceWith(instance -> new DefaultCamelContext());
    }
}
```

Instantiate and assemble the Camel context

Instantiate the `CamelContext` bean and the `RouteBuilder` beans in the `AfterDeploymentValidation` lifecycle event

```
public class CamelExtension implements Extension {
    // ...
    void configureContext(@Observes AfterDeploymentValidation adv, BeanManager manager) {
        CamelContext context = manager.createInstance().select(CamelContext.class).get();
        manager.createInstance().select(RoutesBuilder.class).forEach(context::addRoutes);
    }
}
```

Managed the Camel context lifecycle (start)

Start the context when the `AfterDeploymentValidation` event is fired

```
public class CamelExtension implements Extension {
    // ...
    void configureContext(@Observes AfterDeploymentValidation adv, BeanManager manager) {
        CamelContext context = manager.createInstance().select(CamelContext.class).get();
        manager.createInstance().select(RoutesBuilder.class).forEach(context::addRoutes);
        context.start();
    }
}
```

Managed the Camel context lifecycle (stop)

- Stop the context when the associated bean is destroyed

```
public class CamelExtension implements Extension {
    // ...
    void addCamelContextBean(@Observes AfterBeanDiscovery abd) {
        abd.addBean()
            .types(CamelContext.class)
            .scope(ApplicationScoped.class)
            .produceWith(instance -> new DefaultCamelContext())
            .disposeWith((context, instance) -> context.stop());
    }
}
```

First goal achieved

We can get rid of the following code:

```
@ApplicationScoped
class CamelContextBean extends DefaultCamelContext {

    @Inject
    CamelContextBean(FileToJmsRouteBean route, SjmsComponent jms, PropertiesComponent properties) {
        addComponent("properties", propertiesComponent);
        addComponent("sjms", sjmsComponent);
        addRoutes(route);
    }

    @PostConstruct
    void startContext() {
        super.start();
    }

    @PreDestroy
    void stopContext() {
        super.stop();
    }
}
```

How to retrieve CDI beans from the Camel DSL?

```
.to("sjms:queue:output"); // Lookup by name (sjms) and type (Component)
context.resolvePropertyPlaceholders("{{jms.maxConnections}}");
// Lookup by name (properties) and type (Component)

// And also...
.bean(MyBean.class); // Lookup by type and Default qualifier
.beanRef("beanName"); // Lookup by name
```

Implement the Camel registry SPI and use the `BeanManager` to lookup for CDI bean contextual references by name and type

Implement the Camel registry SPI

```
class CamelCdiRegistry implements Registry {

    private final BeanManager manager;

    CamelCdiRegistry(BeanManager manager) {
        this.manager = manager;
    }

    public Object lookupByName(String name) {
        return lookupByNameAndType(name, Object.class);
    }

    @Override
    public <T> T lookupByNameAndType(String name, Class<T> type) {
        return manager.createInstance().select(type, NamedLiteral.of(name)).stream()
            .findAny().orElse(null);
    }
    // ...
}
```

Add `CamelCdiRegistry` to the Camel context

```
public class CamelExtension implements Extension {

    void addCamelContextBean(@Observes AfterBeanDiscovery abd, BeanManager manager) {
        abd.addBean()
            .types(CamelContext.class)
            .scope(ApplicationScoped.class)
            .produceWith(instance -> new DefaultCamelContext(new CamelCdiRegistry(manager)))
            .disposeWith((context, instance) -> context.stop());
    }
}
```

Second goal achieved 1/3

- We can declare the `sjms` component with the `@Named` qualifier

```
class JmsComponentFactoryBean {

    @Produces
    @Named("sjms")
    @ApplicationScoped
    SjmsComponent sjmsComponent(PropertiesComponent properties) {
        SjmsComponent jms = new SjmsComponent();
        jms.setConnectionFactory(new ActiveMQConnectionFactory("vm://broker?..."));
        jms.setConnectionCount(
            Integer.valueOf(properties.parseUri("{{jms.maxConnections}}")));
        return component;
    }
}
```

Second goal achieved 2/3

Declare the `properties` component with the `@Named` qualifier

```
class PropertiesComponentFactoryBean {

    @Produces
    @Named("properties")
    @ApplicationScoped
    PropertiesComponent propertiesComponent() {
        PropertiesComponent properties = new PropertiesComponent();
        properties.setLocation("classpath:camel.properties");
        return properties;
    }
}
```

Second goal achieved 3/3

And get rid of the code related to the components registration:

```
@ApplicationScoped
class CamelContextBean extends DefaultCamelContext {

    @Inject
    CamelContextBean(FileToJmsRouteBean route, SjmsComponent jms, PropertiesComponent properties) {
        addComponent("properties", propertiesComponent);
        addComponent("sjms", sjmsComponent);
        addRoutes(route);
    }

    @PostConstruct
    void startContext() {
        super.start();
    }

    @PreDestroy
    void stopContext() {
        super.stop();
    }
}
```

Third goal: Support Camel annotations in CDI beans

Camel provides a set of DI framework agnostic annotations for resource injection

```
@PropertyInject(value = "jms.maxConnections", defaultValue = "10")
int maxConnections;

// But also...
@EndpointInject(uri = "jms:queue:foo")
Endpoint endpoint;

@BeanInject("foo")
FooBean foo;
```

How to support custom annotations injection?

How to support custom annotations injection?

- Create a custom `InjectionTarget` that uses the default Camel bean post processor `DefaultCamelBeanPostProcessor`

`javax.enterprise.inject.spi.InjectionTarget`

```java
public interface InjectionTarget<T> extends Producer<T> {
    void inject(T instance, CreationalContext<T> ctx);
    void postConstruct(T instance);
    void preDestroy(T instance);
}
```

- Hook it into the CDI injection mechanism by observing the `ProcessInjectionTarget` lifecycle event

- Only for beans containing Camel annotations by observing the `ProcessAnnotatedType` lifecycle and using `@WithAnnotations`

Create a custom `InjectionTarget`

```
class CamelInjectionTarget<T> implements InjectionTarget<T> {

    final InjectionTarget<T> delegate;

    final DefaultCamelBeanPostProcessor processor;

    CamelInjectionTarget(InjectionTarget<T> target, final BeanManager manager) {
        delegate = target;
        processor = new DefaultCamelBeanPostProcessor() {
            public CamelContext getOrLookupCamelContext() {
                return manager.createInstance().select(CamelContext.class).get();
            }
        };
    }

    public void inject(T instance, CreationalContext<T> ctx) {
        processor.postProcessBeforeInitialization(instance, null); (1)
        delegate.inject(instance, ctx);
    }
    //...
}
```

(1) Call the Camel default bean post-processor before CDI injection

Register the custom `InjectionTarget`

- Observe the `ProcessInjectionTarget` event and set the `InjectionTarget`

`javax.enterprise.inject.spi.ProcessInjectionTarget`

```
public interface ProcessInjectionTarget<X> {
    AnnotatedType<X> getAnnotatedType();
    InjectionTarget<X> getInjectionTarget();
    void setInjectionTarget(InjectionTarget<X> injectionTarget);
    void addDefinitionError(Throwable t);
}
```

- To decorate it with the `CamelInjectionTarget`

```
public class CamelExtension implements Extension {

    <T> void camelBeansPostProcessor(@Observes ProcessInjectionTarget<T> pit, BeanManager manager) {
        pit.setInjectionTarget(new CamelInjectionTarget<>(pit.getInjectionTarget(), manager));
    }
}
```

But only for beans containing Camel annotations

```
public class CamelExtension implements Extension {

    final Set<AnnotatedType<?>> camelBeans = new HashSet<>();

    void camelAnnotatedTypes(@Observes @WithAnnotations(PropertyInject.class)
      ProcessAnnotatedType<?> pat) { (1)
        camelBeans.add(pat.getAnnotatedType());
    }

    <T> void camelBeansPostProcessor(@Observes ProcessInjectionTarget<T> pit,
      BeanManager manager) {
      if (camelBeans.contains(pit.getAnnotatedType())) (2)
        pit.setInjectionTarget(new CamelInjectionTarget<>(pit.getInjectionTarget(), manager));
    }
}
```

1. Detect all the types containing Camel annotations with `@WithAnnotations`
2. Decorate the `InjectionTarget` corresponding to these types

Third goal achieved 1/2

Instead of injecting the `PropertiesComponent` bean to resolve a configuration property

```
class JmsComponentFactoryBean {

    @Produces
    @Named("sjms")
    @ApplicationScoped
    SjmsComponent sjmsComponent(PropertiesComponent properties) {
        SjmsComponent jms = new SjmsComponent();
        jms.setConnectionFactory(new ActiveMQConnectionFactory("vm://broker?..."));
        jms.setConnectionCount(Integer.valueOf(properties.parseUri("{{jms.maxConnections}}")));
        return component;
    }
}
```

Third goal achieved 2/2

- We can directly rely on the `@PropertyInject` Camel annotation in CDI beans

```
class JmsComponentFactoryBean {

    @PropertyInject("jms.maxConnections")
    int maxConnections;

    @Produces
    @Named("sjms")
    @ApplicationScoped
    SjmsComponent sjmsComponent() {
        SjmsComponent component = new SjmsComponent();
        jms.setConnectionFactory(new ActiveMQConnectionFactory("vm://broker?..."));
        component.setConnectionCount(maxConnections);
        return component;
    }
}
```

Bonus goal: Camel DSL AOP

AOP instrumentation of the Camel DSL

```
from("file:target/input?delay=1s")
    .log("Sending message [${body}] to JMS...")
    .to("sjms:queue:output");
```

With CDI observers

```
from("file:target/input?delay=1s").to("sjms:queue:output").id("join point");
```

```
void advice(@Observes @Node("join point") Exchange exchange) {
    logger.info("Sending message [{}] to JMS...", exchange.getIn().getBody(String.class));
}
```

How to achieve this?

- We can create a CDI qualifier to hold the Camel node id metadata:

```
@Qualifier
@Retention(RetentionPolicy.RUNTIME)
public @interface Node {
    String value();
}
```

- And create an extension that will:

1. Detect the CDI beans containing observer methods with the `@Node` qualifier by observing the `ProcessObserverMethod` event and collect the Camel processor nodes to be instrumented
2. Customize the Camel context by providing an implementation of the Camel `InterceptStrategy` interface that will fire a CDI event each time an `Exchange` is processed by the instrumented nodes

Detect the Camel DSL AOP observer methods

- Observe the `ProcessObserverMethod` lifecycle event

`javax.enterprise.inject.spi.ProcessObserverMethod`

```
public interface ProcessObserverMethod<T, X> {
    AnnotatedMethod<X> getAnnotatedMethod();
    ObserverMethod<T> getObserverMethod();
    void addDefinitionError(Throwable t);
}
```

- And collect the observer method metadata

```
public class CamelExtension implements Extension {

    final Set<Node> nodePointcuts = new HashSet<>();

    void camelNodePointcuts(@Observes ProcessObserverMethod<Exchange, ?> pom) {
        pom.getObserverMethod().getObservedQualifiers().stream()
            .filter(q -> q instanceof Node).map(Node.class::cast).forEach(nodePointcuts::add);
    }
}
```

Intercept matching nodes and fire a CDI event

```
void configureCamelContext(@Observes AfterDeploymentValidation adv, BeanManager manager) {
    CamelContext context = manager.createInstance().select(CamelContext.class).get();
    context.addInterceptStrategy((camel, definition, target, next) -> definition.hasCustomIdAssigned()
        ? nodePointcuts.stream().filter(node -> definition.getId().equals(node.value())).findFirst() 1
            .map(node -> (Processor) new DelegateAsyncProcessor(target) {
                public boolean process(Exchange exchange, AsyncCallback callback) {
                    manager.fireEvent(exchange, node); 2
                    return super.process(exchange, callback);
                }
            }).orElse(target) 2
        : target);
    manager.createInstance().select(RoutesBuilder.class).forEach(context::addRoutes);
    context.start();
}
```

1. Checks if there is a `@Node` qualifier matching the processor id (with `customIdAssigned`)
2. Returns a delegate processor that fires a event whenever an exchange is processed, or returns the default processor

Bonus goal achieved

- We can define join points in the Camel DSL

```
from("file:target/input?delay=1s").to("sjms:queue:output").id("join point");
```

- And advice them with CDI observers

```
void advice(@Observes @Node("join point") Exchange exchange) {
    List<MessageHistory> history = exchange.getProperty(Exchange.MESSAGE_HISTORY,
                                                        List.class);
    logger.info("Sending message [{}] to [{}]...",
                exchange.getIn().getBody(String.class),
                history.get(history.size() - 1).getNode().getLabel());
}
```

Complete extension code

```java
public class CamelExtension implements Extension {
  Set<AnnotatedType<?>> camelBeans = new HashSet<>(); Set<Node> nodes = new HashSet<>();
  void camelAnnotatedTypes(@Observes @WithAnnotations(PropertyInject.class) ProcessAnnotatedType<?> pat) {
      camelBeans.add(pat.getAnnotatedType());
  }
  <T> void camelBeansPostProcessor(@Observes ProcessInjectionTarget<T> pit, BeanManager m) {
    if (camelBeans.contains(pit.getAnnotatedType())) pit.setInjectionTarget(new CamelInjectionTarget<>(pit.getInjectionTarget(), m));
  }
  void camelNodePointcuts(@Observes ProcessObserverMethod<Exchange, ?> pom) {
    pom.getObserverMethod().getObservedQualifiers().stream().filter(q -> q instanceof Node).map(Node.class::cast).forEach(nodes::add);
  }
  void addCamelContext(@Observes AfterBeanDiscovery abd, BeanManager m) {
    abd.addBean().types(CamelContext.class).scope(ApplicationScoped.class)
      .produceWith(instance -> new DefaultCamelContext(new CamelCdiRegistry(m))).disposeWith((context, instance) -> context.stop());
  }
  void configureCamelContext(@Observes AfterDeploymentValidation adv, BeanManager manager) {
    CamelContext context = manager.createInstance().select(CamelContext.class).get();
    context.addInterceptStrategy((camel, definition, target, next) -> definition.hasCustomIdAssigned() ? nodes.stream()
      .filter(node -> definition.getId().equals(node.value())).findFirst().map(node -> new DelegateAsyncProcessor(target) {
        public boolean process(Exchange exchange, AsyncCallback callback) {
          manager.fireEvent(exchange, node);
          return super.process(exchange, callback);
        }
      }).orElse(target) : target);
    manager.createInstance().select(RoutesBuilder.class).forEach(context::addRoutes);
    context.start();
  }
}
```

Conclusion

References

- CDI Specification - cdi-spec.org
- Slides sources - github.com/astefanutti/further-cdi
- Metrics CDI sources - github.com/astefanutti/metrics-cdi
- Camel CDI sources - github.com/astefanutti/camel-cdi
- Slides generated with Asciidoctor, PlantUML and DZSlides backend
- Original slide template - Dan Allen & Sarah White

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Annexes

Complete lifecycle events