To inject or not to inject : CDI is the question

by antonio goncalves

Welcome to a type-safe injection journey

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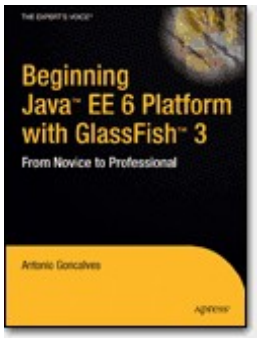
- JCP expert member (Java EE 6, Java EE 7)
- Co-leader of the Paris JUG
- Les Cast Codeurs podcast
- Java Champion

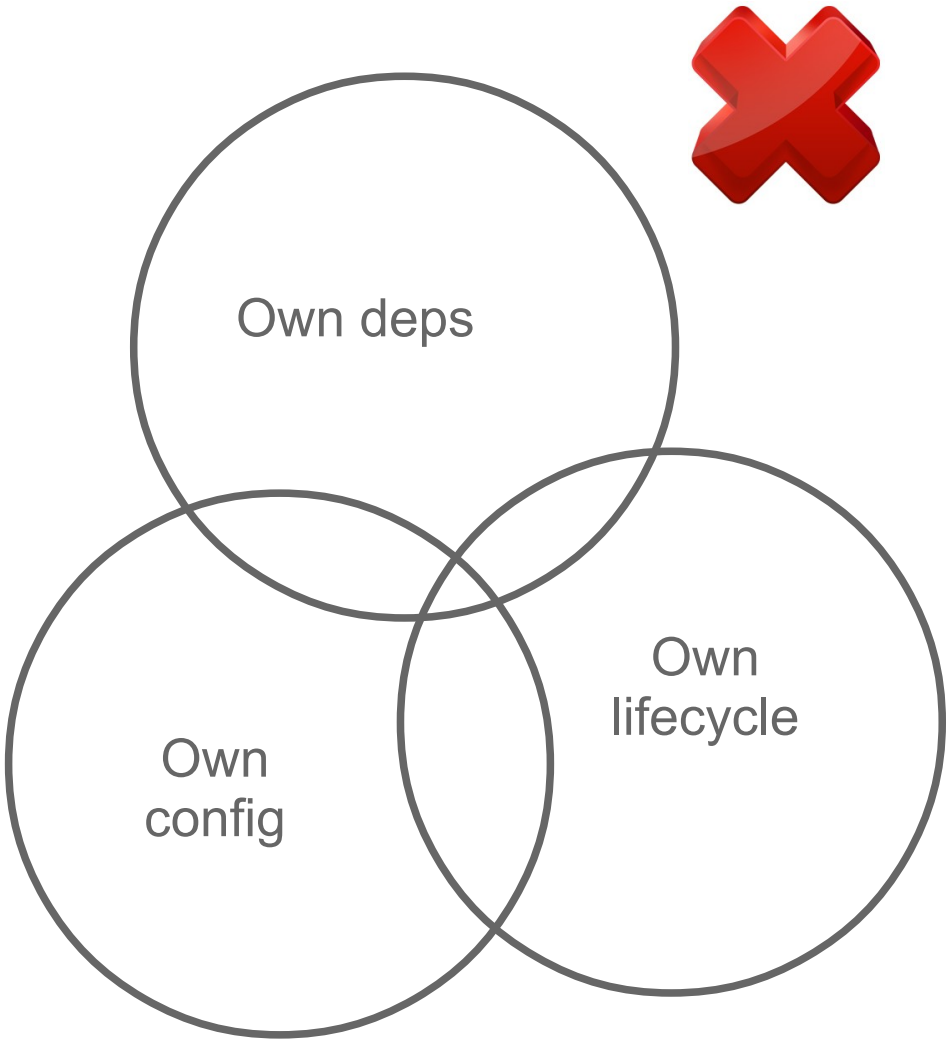


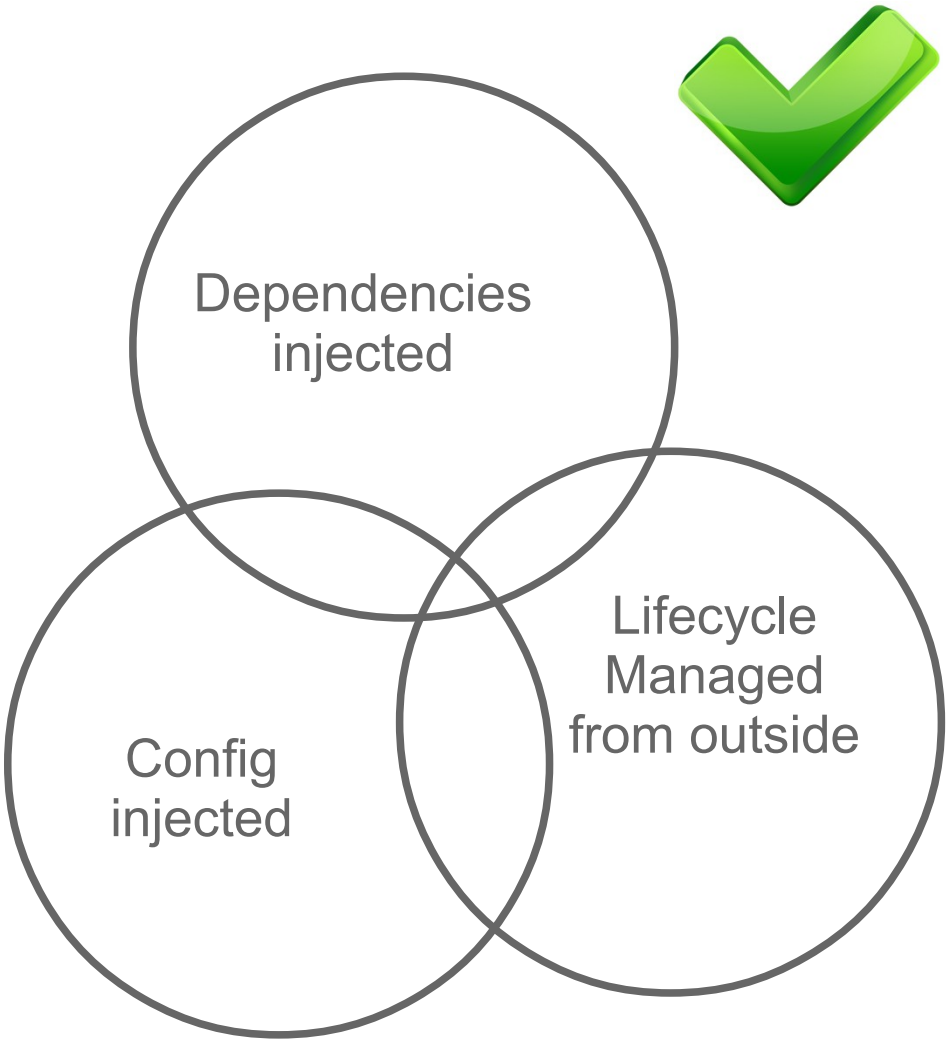
Summary

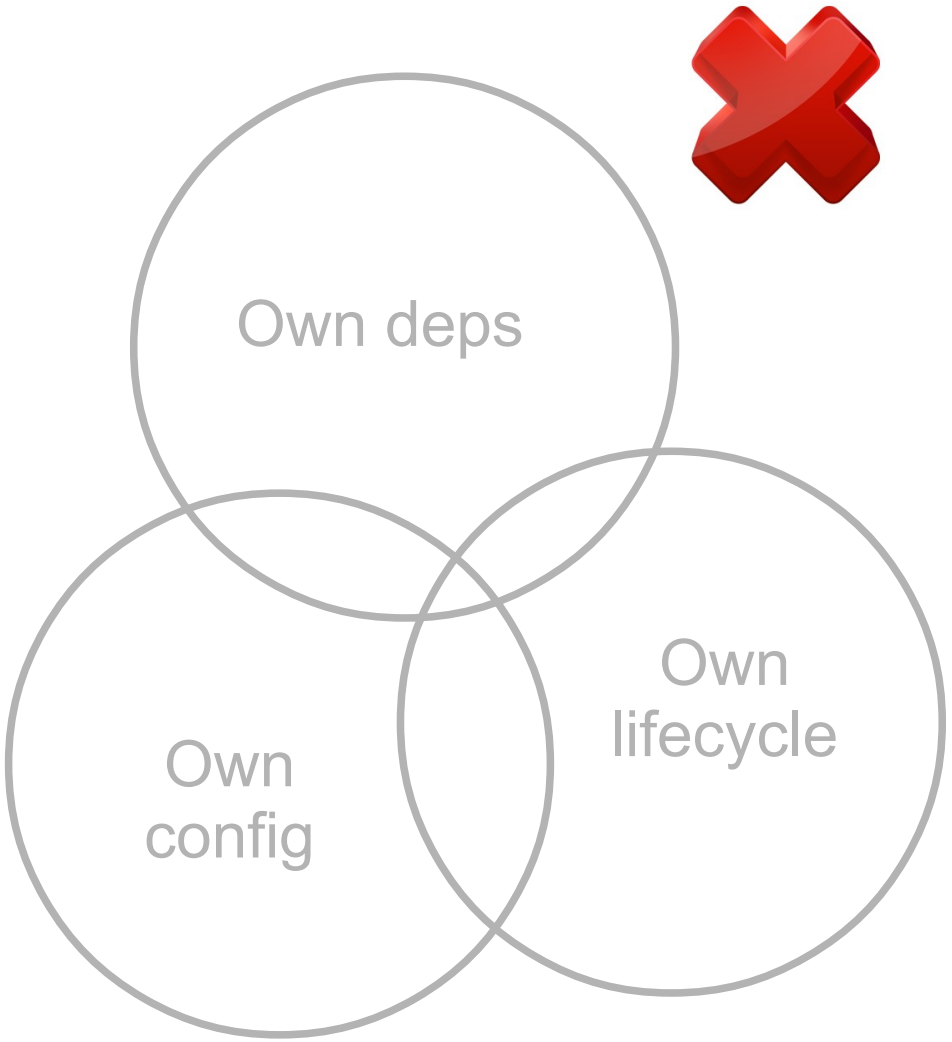
- IoC
- Dependency Injection
- @Inject & CDI
- Interceptors, Decorators, Events

Inversion of control

- Term popilarised in 1998
- The control of :
  - dependency resolution (DI)
  - lifecycle
  - configuration
- Is given to an external component (eg. container)
- ...not the component itself
- It brings loose coupling


Own deps
Own config
Own lifecycle


Dependencies injected
Config injected
Lifecycle Managed from outside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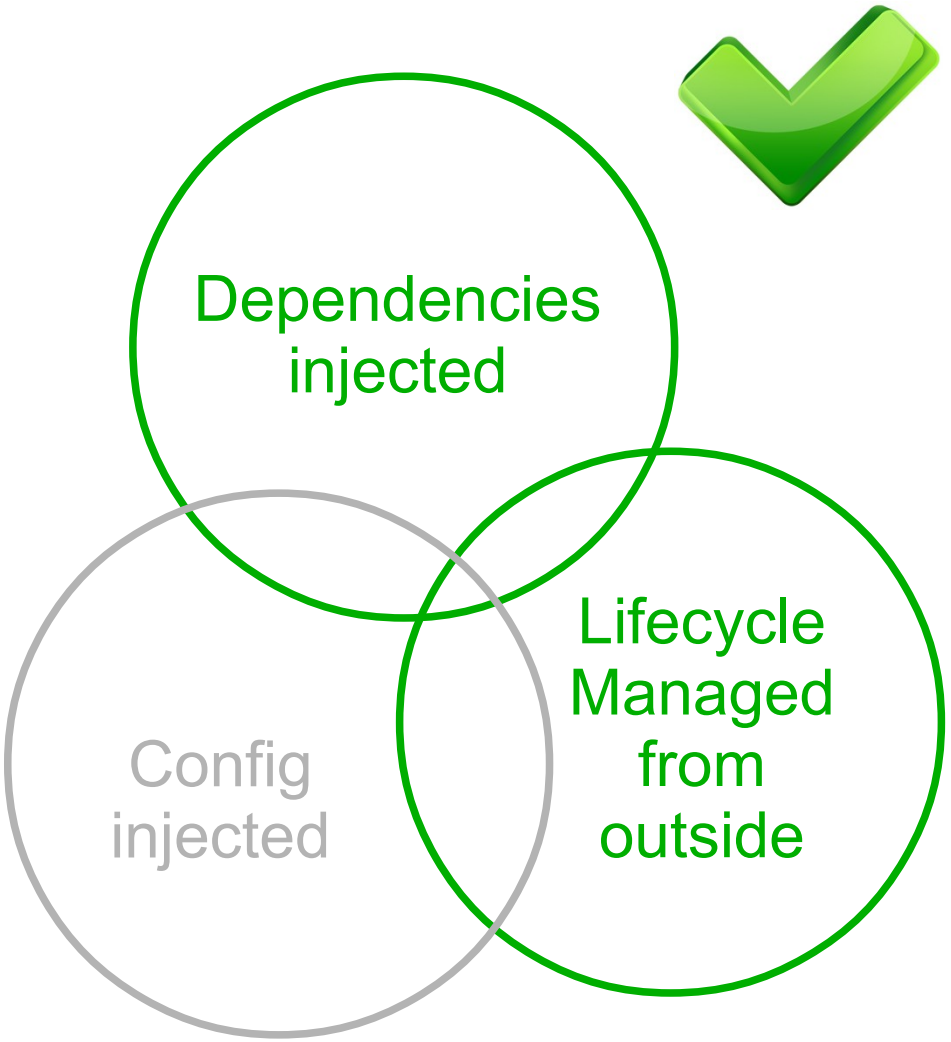
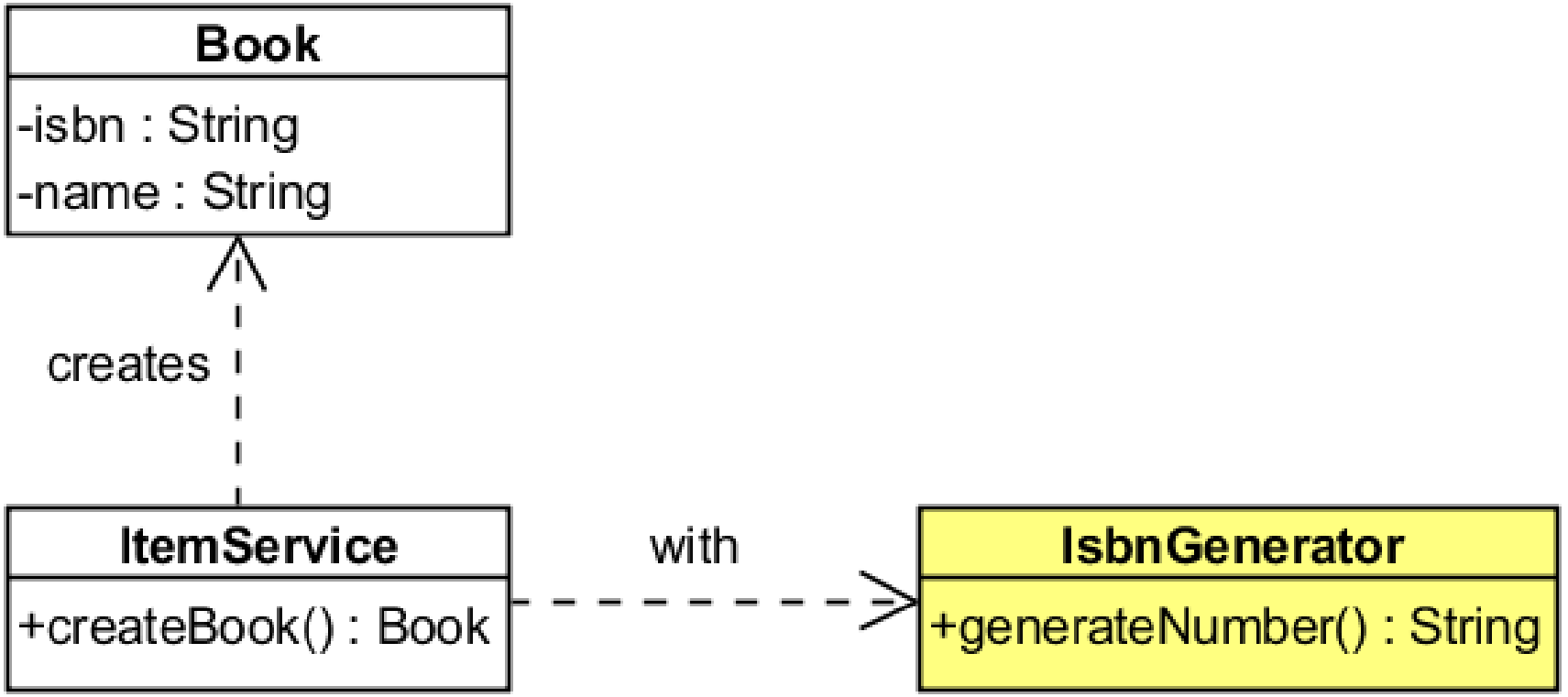

Dependencies injected
Config injected
Lifecycle Managed from outside

Example of dependency



The good old `new`

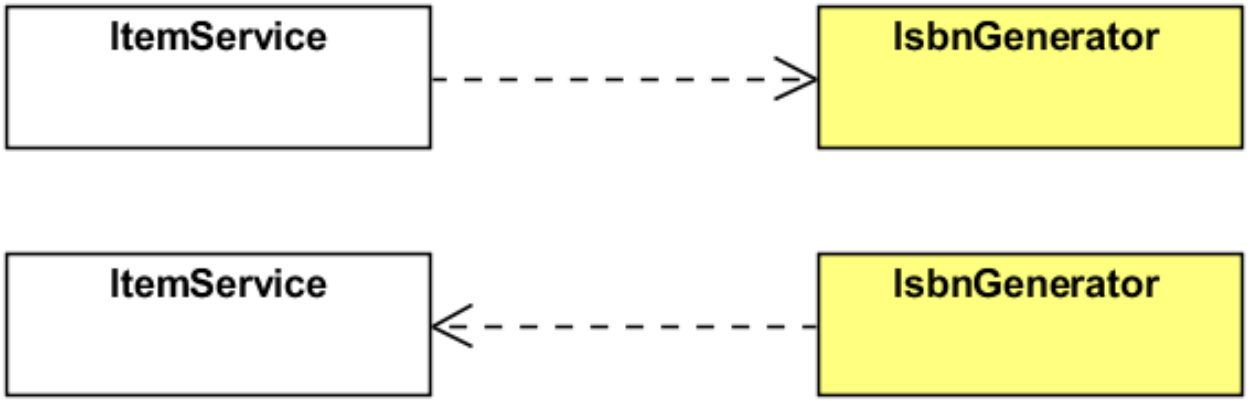
```
public class ItemService {
  private IsbnGenerator isbnGenerator;

  public ItemService() {
    this.isbnGenerator = new IsbnGenerator();
  }

  public Book createBook(Book book) {
    ...
    book.setIsbn(isbnGenerator.generateNumber());
  }
}
```

What's wrong with that ?

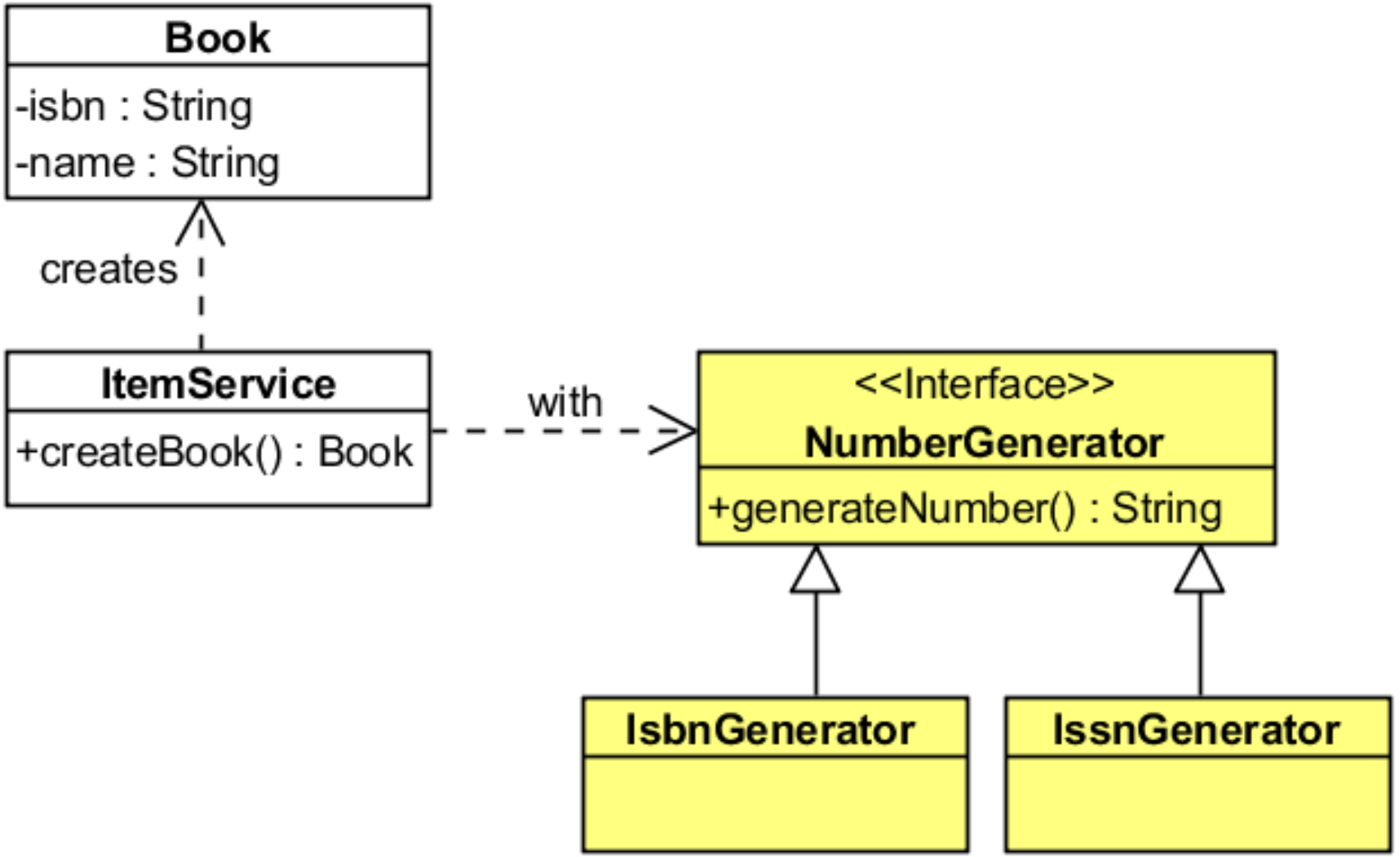
- Strong coupling
  - Impossible to change implementations
  - Impossible to MOCK if needed
- Lifecycle done by the component
  - Sometimes `new()` is not enough
  - Creating an instance, opening, closing

That's why we need DI

- Design pattern (coined by Martin Fowler)
- Decouples dependent components
  - Loose coupling
- Hollywood Principle
  - "don’t call us, we’ll call you!"



How to choose implementation?



Constructor (or setter) injection

```
public class ItemService {
  private NumberGenerator numberGenerator;

  public ItemService(NumberGenerator numberGenerator) {
    this.numberGenerator = numberGenerator;
  }

  public Book createBook(Book book) {
    ...
    book.setIsbn(numberGenerator.generateNumber());
  }
}
```

With the good old `new` again

```
// With constructor injection
ItemService itemService = new ItemService(
                                  new IsbnGenerator());
ItemService itemService = new ItemService(
                                  new IssnGenerator());


// With setter injection
ItemService itemService = new ItemService();
itemService.setNumberGenerator(new IsbnGenerator());
itemService.setNumberGenerator(new IssnGenerator());
```

Using factories

- Graph dependency can be complex
- Factory design pattern (GoF)
- Everywhere in Java
  - `java.util.Calendar#getInstance()`
  - `java.util.Arrays#asList()`
  - `java.sql.DriverManager#getConnection()`
  - `java.lang.Class#newInstance()`
  - `java.lang.Integer#valueOf()`

With a Factory

```
public class ItemServiceFactory {


  public ItemService newIsbnGenerator() {
    return new ItemService(new IsbnGenerator());
  }
  public ItemService newIssnGenerator() {
    return new ItemService(new IssnGenerator());
  }
}


// Client
ItemService itemService =
        new ItemServiceFactory().newIsbnGenerator();
```

Another pattern: Service Locator

- J2EE Design pattern
- Used to find services
- May reside in the same application, machine or network
- JNDI is a perfect service locator

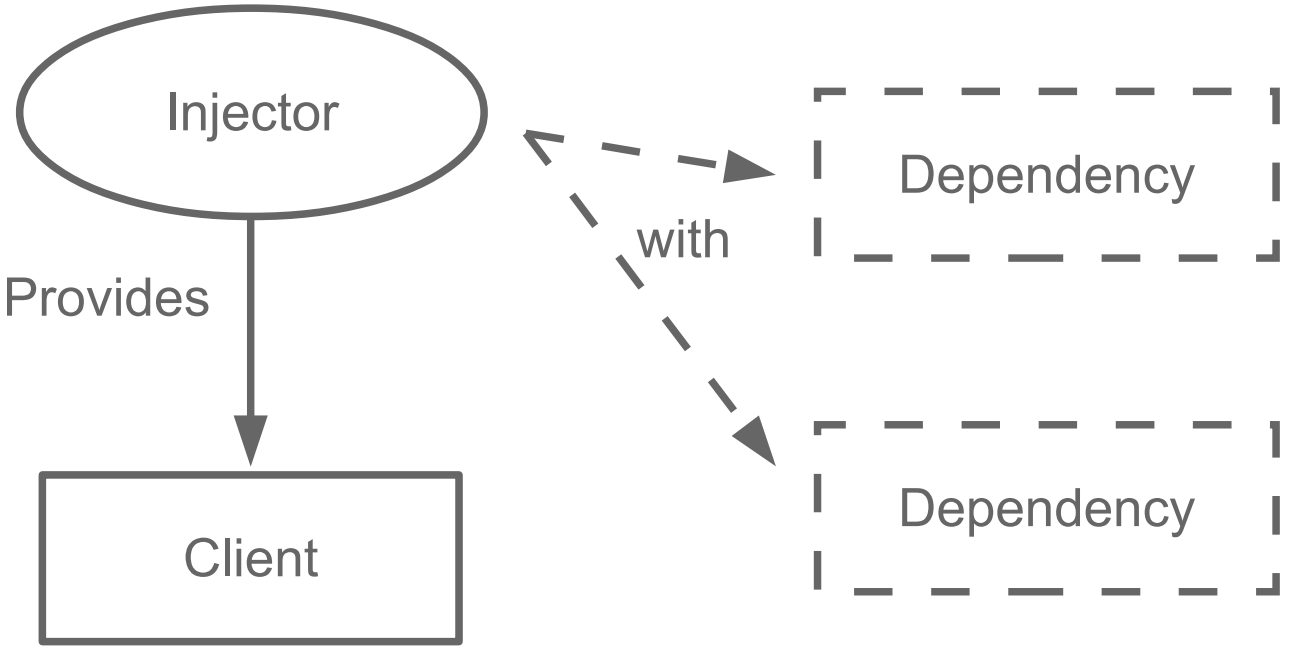
```
ItemService itemService =
        new ServiceLocator().get("IsbnGeneratorService");
```

All that is constructing by hand

```
// new()
public ItemService() {
  this.isbnGenerator = new IsbnGenerator();
}

// Factory
ItemService itemService =
        new ItemServiceFactory().newIsbnGenerator();

// Service locator
ItemService itemService =
        new ServiceLocator().get("IsbnGeneratorService");
```

Give control to an injector

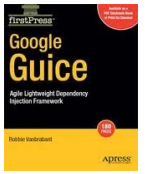
- Injector aka container aka provider
- Creating, assembling and wiring done by an external framework



Dependency injector

- *Apache Avalon*
- Spring framework
- Pico container
- Nano container
- Apache Hivemind
- Seam
- Google Guice
- Contexts and Dependency Injection (CDI)

A bit of history



Project JPE

May 1998

J2EE 1.2

Servlet/JSP
EJB
JMS
RMI/IIOP

Dec 1999

J2EE 1.3

CMP
JCA

Sept 2001

J2EE 1.4

WS
Management
Deployment

Nov 2003

Resource injection

Java EE 5

Annotations
EJB 3
JPA 1.0
WS-*
JSF

May 2006

Dependency injection

Java EE 6

EJB 3.1
JPA 2.0
Servlet 3.0
JSF 2.0
JAX-RS 1.1
CDI 1.0
@Inject
Bean Validat°

Web Profile

Managed Bean

Q4 2009

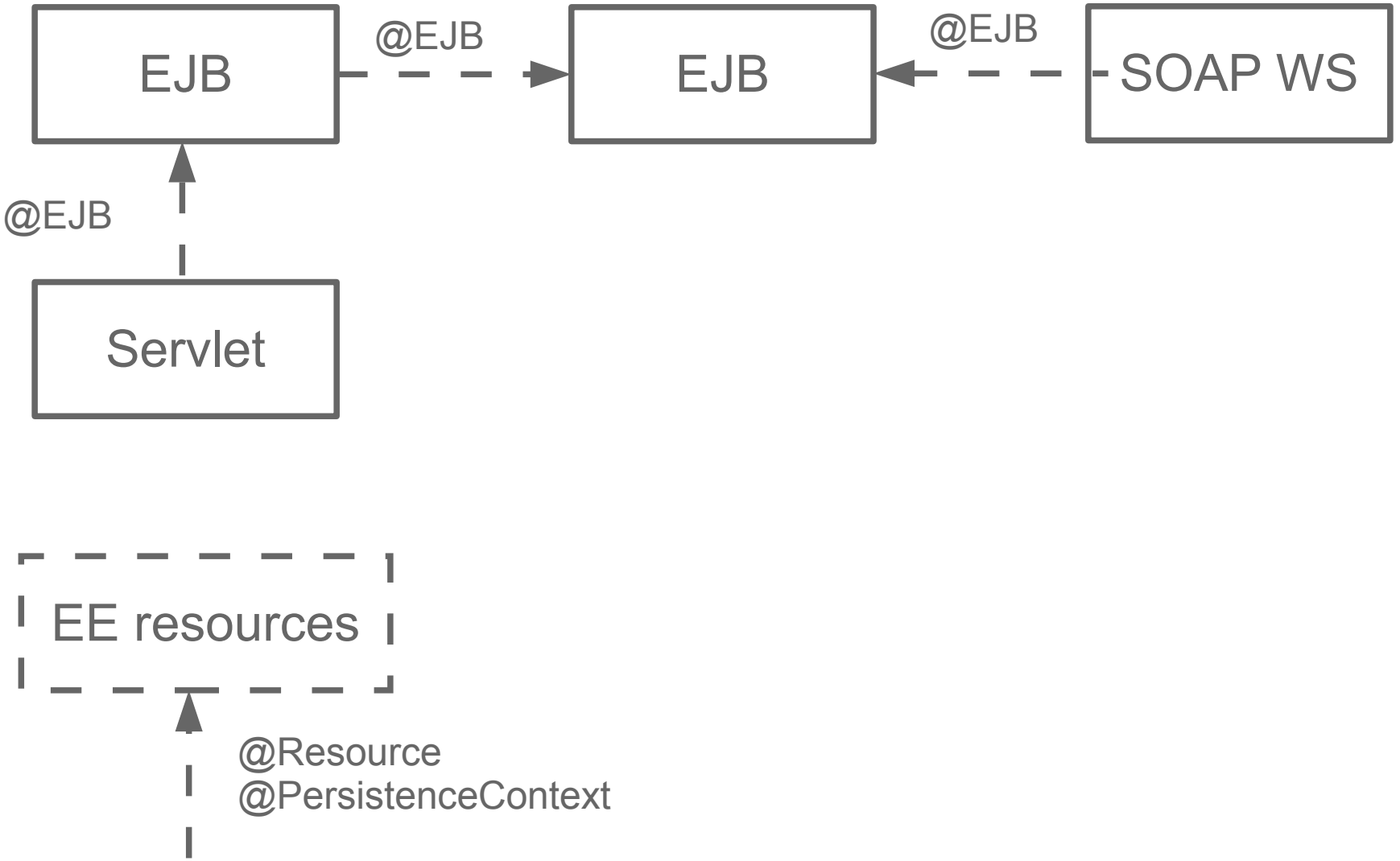
Resource injection in EE 5

- Only inject container resources
  - EJBs, entity manager, datasources, JMS factories & destinations
- To certain components
  - EJBs, servlets, JSF managed beans
- Several annotations
  - `@Resource`, `@PersistenceContext`, `@PersistenceUnit`, `@EJB` & `@WebServiceRef`
- No POJOs

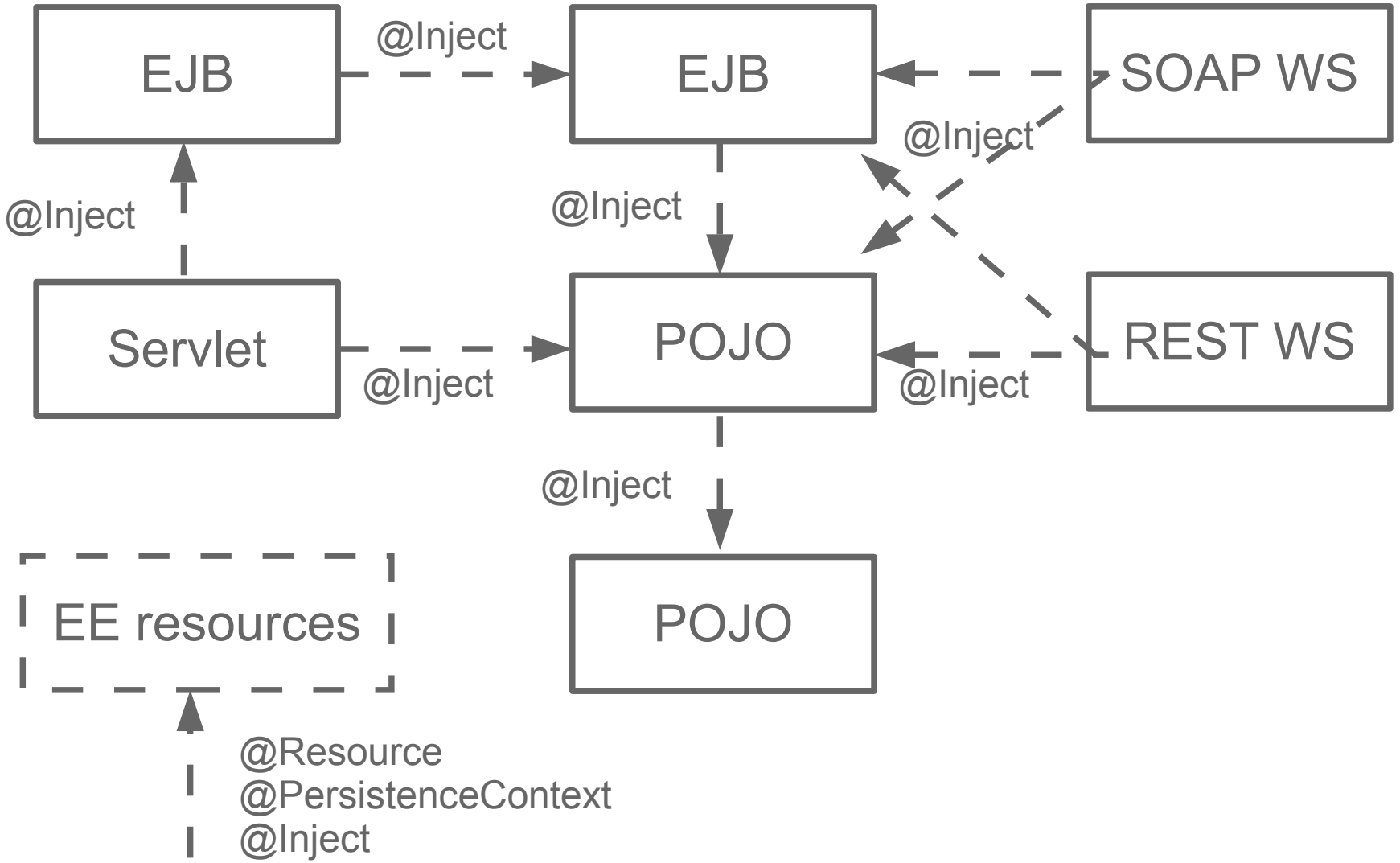
Dependency injection in EE 6

- Two seperate specifications
  - Context & Dependency Injection (CDI) JSR 299
  - DI (aka @Inject) JSR 330
- Bean container for Java EE
- … and even outside Java EE

EE 5 resource injection



EE 6 dependency injection

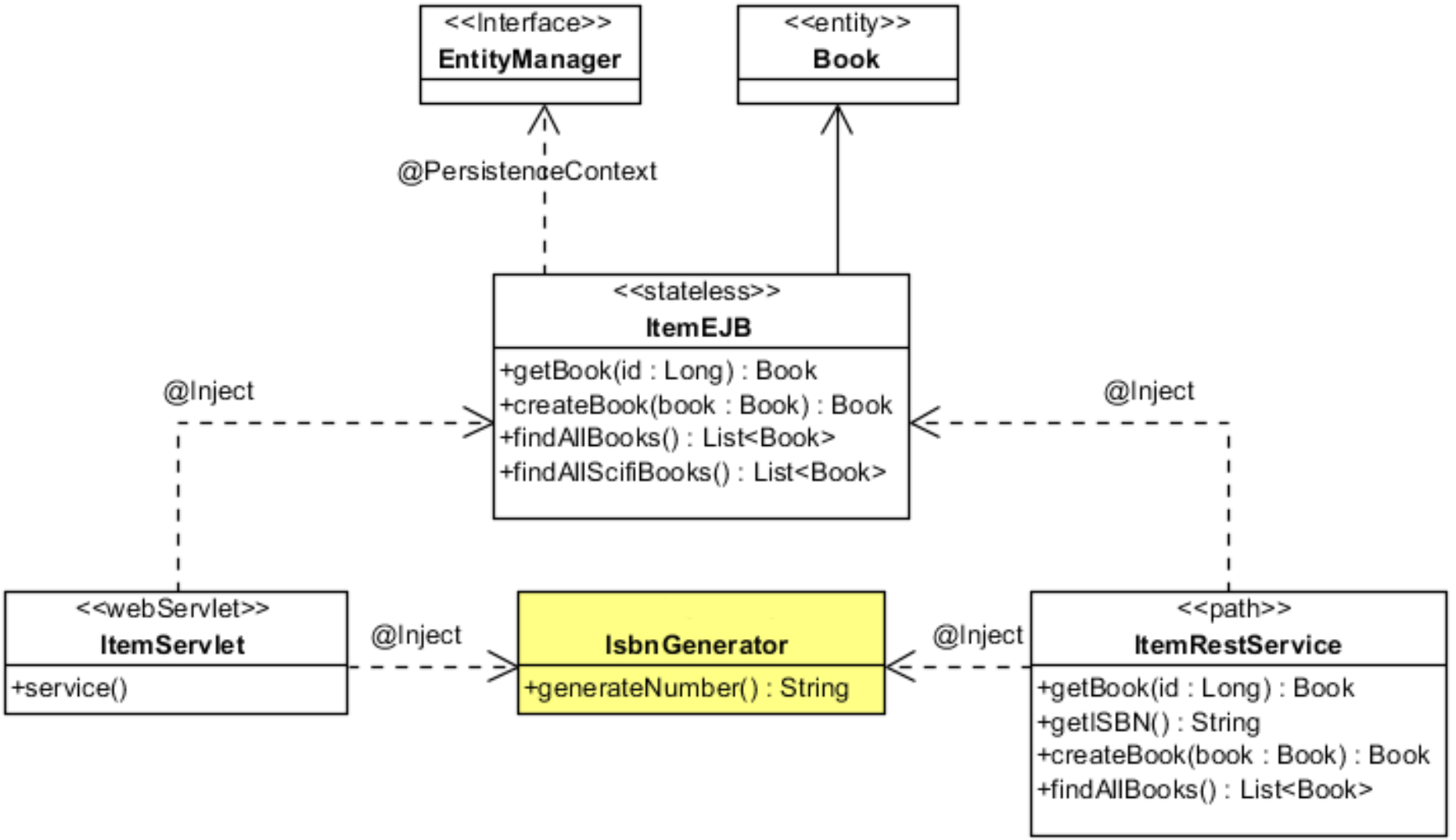


2 specs to archieve it

- DI (@Inject)
- JSR 330
- **`javax.inject`**
- `@Inject`
- `@Named`
- `@Singleton`
- `@Qualifier`
- `@Scope`

- CDI
- JSR 299
- **`javax.enterprise.context`**
- Alternatives
- Producers
- Scopes & context
- Stereotypes
- Decorators, Events
- Extensions

Injection with @Inject



@Inject

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject
    private IsbnGenerator numberGenerator;
    ...
    book.setIsbn(isbnGenerator.generateNumber());
}
```

Servlet

Injection point

```
public class IsbnGenerator {
    public String generateNumber () {
        return "13-84356-" + nextNumber());
    }
}
```

POJO

What's needed to make it work ?

- A container
- CDI
- An empty `beans.xml` file
  - `META-INF`
  - `WEB-INF`

@Inject

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject
    private IsbnGenerator numberGenerator;
    ...
    book.setIsbn(isbnGenerator.generateNumber());
}


public class IsbnGenerator {
    public String generateNumber () {
        return "13-84356-" + nextNumber());
    }
}
```

@Default @Inject

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject @Default
    private IsbnGenerator numberGenerator;
    ...
    book.setIsbn(isbnGenerator.generateNumber());
}
```

Every injection point has a `@Default` qualifier

Every bean has a `@Default` qualifier

```
@Default
public class IsbnGenerator {
    public String generateNumber () {
        return "13-84356-" + nextNumber());
    }
}
```

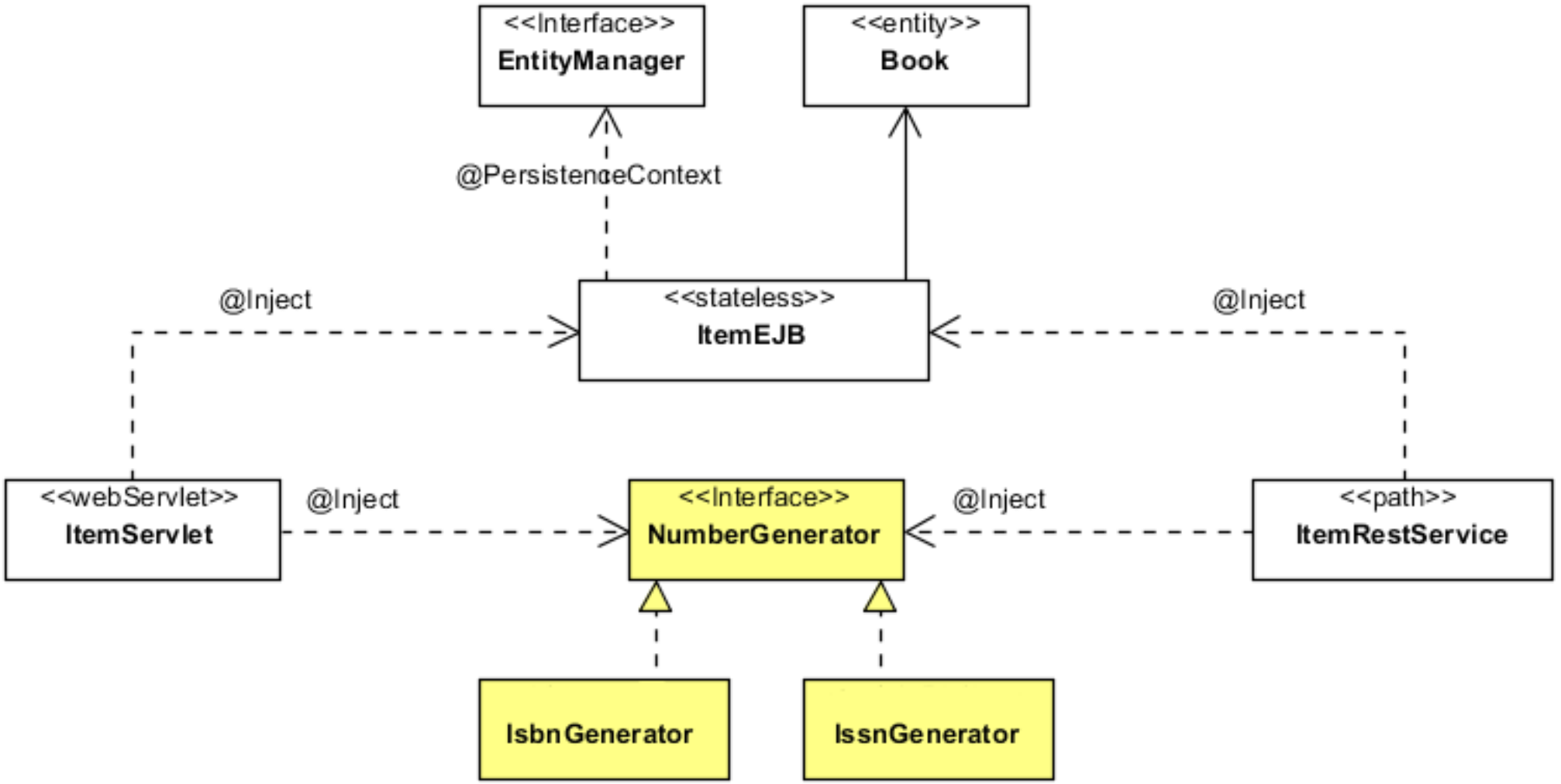
Use your own qualifier

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject @MyOwnQualifier
    private IsbnGenerator numberGenerator;
    ...
    book.setIsbn(isbnGenerator.generateNumber());
}

@MyOwnQualifier
public class IsbnGenerator {
    public String generateNumber () {
        return "13-84356-" + nextNumber());
    }
}
```

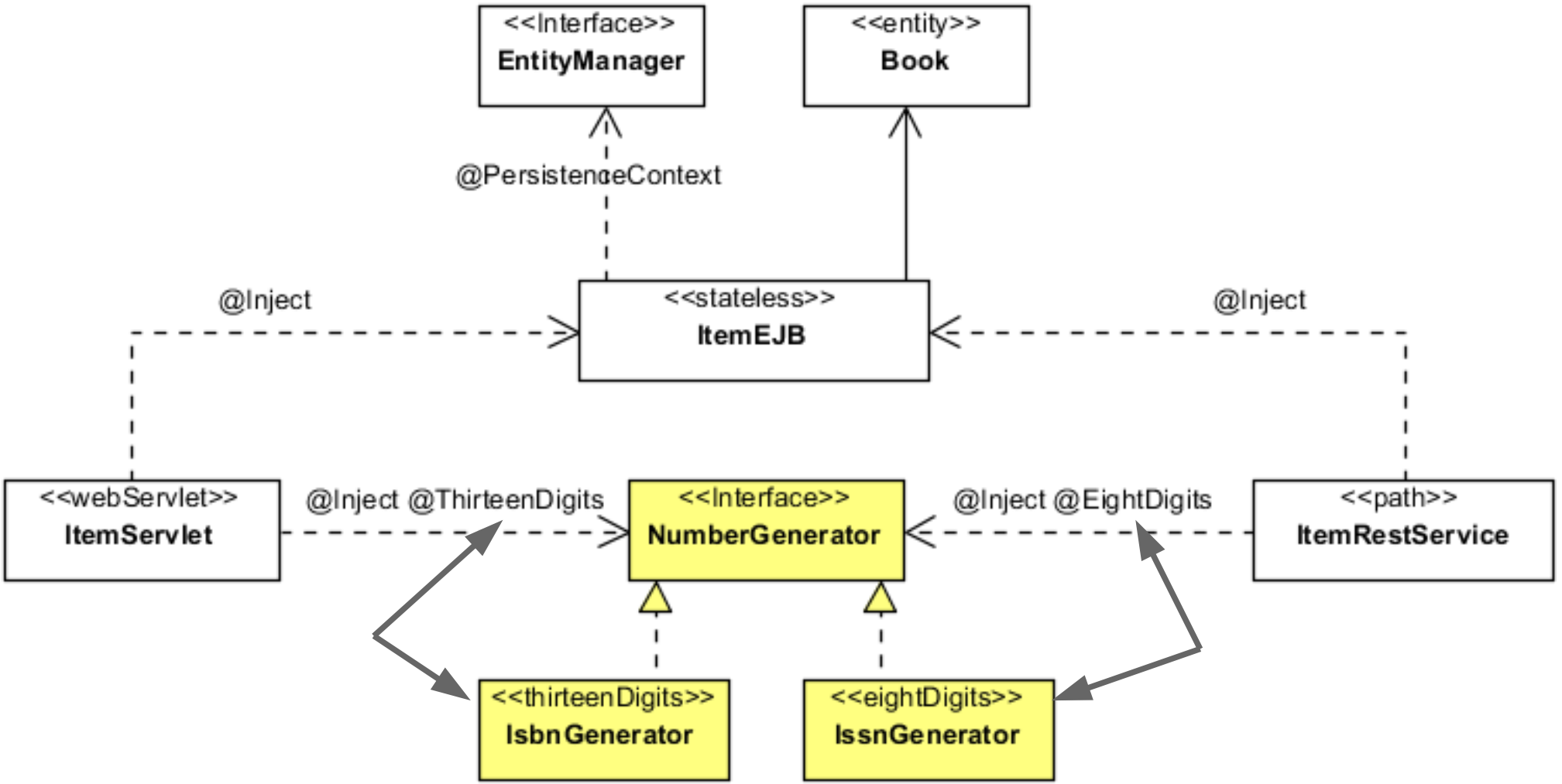
@MyOwnQualifier

```
@Qualifier
@Retention(RUNTIME)
@Target({FIELD, TYPE, METHOD, PARAMETER})
public @interface MyOwnQualifier {
}
```

Ambiguous injection



Non ambiguous injection



Defining the qualifiers

```
@Qualifier
@Retention(RUNTIME)
@Target({FIELD, TYPE, METHOD, PARAMETER})
public @interface EightDigits {
}

@Qualifier
@Retention(RUNTIME)
@Target({FIELD, TYPE, METHOD, PARAMETER})
public @interface ThirteenDigits {
}
```

Defining the beans

```
@EightDigits
public class IssnGenerator implements NumberGenerator {
    public String generateNumber() {
        return "8-" + nextNumber();
    }
}

@ThirteenDigits
public class IsbnGenerator implements NumberGenerator {
    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

Injection points

```
@Path("/items") @ManagedBean
public class ItemRestService {
    @Inject @EightDigits
    private NumberGenerator numberGenerator;
    ...
}
```

Strong typing
No strings

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject @ThirteenDigits
    private NumberGenerator numberGenerator;
    ...
}
```

Loose coupling
No reference to the implementation

From XML hell to qualifier hell

- What if you need many qualifiers ?
- 13, 8 digits but also 3, 7, 16, 19, 22, 26...
- Use qualifiers with enumerations

Defining the qualifier & enum

```
@Qualifier
@Retention(RUNTIME)
@Target({FIELD, TYPE, METHOD, PARAMETER})
public @interface NumberOfDigits {
    Digits value();
}

public enum Digits {
    TWO,
    EIGHT,
    TEN,
    THIRTEEN
}
```

Defining the beans

```
@NumberOfDigits(Digits.EIGHT)
public class IssnGenerator implements NumberGenerator {
    public String generateNumber() {
        return "8-" + nextNumber();
    }
}

@NumberOfDigits(Digits.THIRTEEN)
public class IsbnGenerator implements NumberGenerator {
    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

Injection points

```
@Path("/items") @ManagedBean
public class ItemRestService {
    @Inject @NumberOfDigits(Digits.EIGHT)
    private NumberGenerator numberGenerator;
    ...
}

@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject @NumberOfDigits(Digits.THIRTEEN)
    private NumberGenerator numberGenerator;
    ...
}
```

Different injection points

- Field
- Constructor
- Setter

Field injection

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    @Inject @ThirteenDigits
    private NumberGenerator numberGenerator;

    @Inject
    private ItemEJB itemEJB;
    ...
}
```

Constructor injection

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    private NumberGenerator numberGenerator;
    private ItemEJB itemEJB;

    @Inject
    public ItemServlet(@ThirteenDigits NumberGenerator
            numberGenerator, ItemEJB itemEJB) {
        this.numberGenerator = numberGenerator;
        this.itemEJB = itemEJB;
    }
    ...
}
```

Setter injection

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {
    private NumberGenerator numberGenerator;
    private ItemEJB itemEJB;

    @Inject
    public void setNumberGenerator(@ThirteenDigits
            NumberGenerator numberGenerator) {
        this.numberGenerator = numberGenerator;
    }
    @Inject
    public void setItemEJB(ItemEJB itemEJB) {
        this.itemEJB = itemEJB;
    }
```

Differences

- Field
- Constructor
  - only one constructor injection point
  - add logic to the constructor
- Setter
  - add logic to the constructor
- *Remember* : the container is the one calling the constructor or the setters

Have you seen any XML so far ?

Alternatives

- Define an alternative implementation
- Vary at deployment time
- By default, alternative beans are disabled
- Enable them with `beans.xml` file

Alternative to @ThirteenDigits

```
@Alternative
@ThirteenDigits
public class MockGenerator implements NumberGenerator {

    public String generateNumber() {
        return "MOCK-" + nextNumber();
    }
}
```

Alternative to both

```
@Alternative
@ThirteenDigits @EightDigits
public class MockGenerator implements NumberGenerator {

    public String generateNumber() {
        return "MOCK-" + nextNumber();
    }
}


@Inject @ThirteenDigits
private NumberGenerator numberGenerator;
```

beans.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://java.sun.com/xml/ns/javaee"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xsi:schemaLocation="
      http://java.sun.com/xml/ns/javaee
      http://java.sun.com/xml/ns/javaee/beans_1_0.xsd">

    <alternatives>
        <class>org.agoncal.cdi.MockGenerator</class>
    </alternatives>

</beans>
```

Does this look too verbose ?

```
@Alternative
@ThirteenDigits @EightDigits
public class MockGenerator implements NumberGenerator {

    public String generateNumber() {
        return "MOCK-" + nextNumber();
    }
}
```

Use stereotypes

```
@MyMock
public class MockGenerator implements NumberGenerator {

    public String generateNumber() {
        return "MOCK-" + nextNumber();
    }
}
@Stereotype
@Retention(RUNTIME) @Target(TYPE)
@Alternative @ThirteenDigits @EightDigits
public @interface MyMock {}
```

Stereotypes

- Models a common role in your application
- You can think of a pattern
  - Modeling recurring concerns
- Stereotypes may declare other stereotypes
- Built-in stereotypes in CDI
  - `@Model` as a replacement of JSF managed beans
- And what is `@Stateless` was a stereotype ?
- And what about `@WebServlet` ?
- And `@WebService` ?

So, we only inject beans ?

Producers

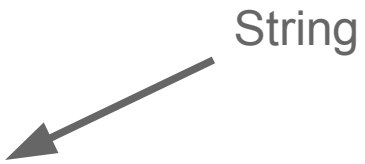
- Producers are a source for objects to be injected
  - these objects are not required to be beans
- For example, producer methods let us:
  - expose a JPA entity as a bean
  - expose any JDK class as a bean

Produce an injectable String

```
public class PrefixGenerator {

    @Produces @ThirteenDigits
    public String getIsbnPrefix() {
        return "13-84356";
    }

    @Produces @EightDigits
    public String getIssnPrefix() {
        return "8";
    }
}
```

Inject the produced String

```
@WebServlet(urlPatterns = "/itemServlet")
public class ItemServlet extends HttpServlet {

    @Inject @ThirteenDigits
    private NumberGenerator numberGenerator;

    @Inject @ThirteenDigits
    private String prefix;

    ...
    book.setIsbn(prefix + isbnGenerator.generateNumber());
}
```

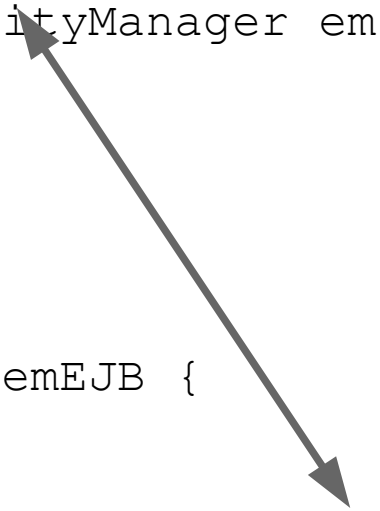


Java EE integration

- Built-in beans in EE :
  - current JTA `UserTransaction`
  - a `Principal` for the current caller identity
  - default Bean Validation `ValidationFactory`
  - a `Validator` for the `ValidationFactory`
- For other beans, use producers

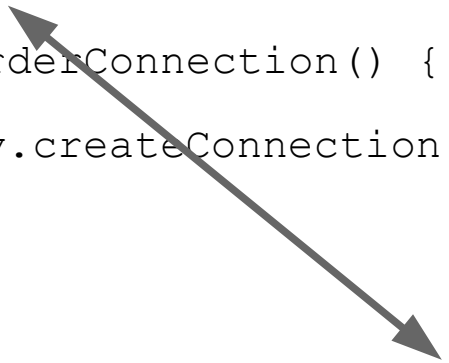
Produce an EntityManager

```
public class DatabaseProducer {

    @Produces @PersistenceContext(unitName = "cdiPU")

    @BookStoreDatabase

    private EntityManager em;

}


@Stateless

public class ItemEJB {


    @Inject @BookStoreDatabase

    private EntityManager em;

    ...

}
```



Produce JMS endpoints

```
public class OrderResources {
  @Resource(name = "jms/ConnectionFactory")
  private ConnectionFactory connectionFactory;
  @Resource(name = "jms/OrderQueue")
  private Queue orderQueue;

  @Produces @OrderConnection
  public Connection createOrderConnection() {
    return connectionFactory.createConnection();
  }
  @Produces @OrderSession
  public Session createOrderSession(@OrderConnection Connection conn){
    return conn.createSession(true, Session.AUTO_ACKNOWLEDGE);
  }
  ...
}
```



Consume JMS endpoints

```
@Inject @OrderSession QueueSession orderSession;


public void sendMessage() {
  MapMessage msg = orderSession.createMapMessage();
  msg.setLong("orderId", order.getId());
  ...
  producer.send(msg);
}
```

Can I use all that from a JSF page ?

@Named

- Reference a bean from the Expression Language
- Gives it a name (a String)
- Most commonly from a JSF view
- Non type safe dependency injection
- Any bean can be named
- Do we still need JSF managed beans ?

Default name

```
@Named
public class IsbnGenerator {

    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

```
<h:outputLabel value="#{isbnGenerator.generateNumber}"/>
```

A different name

```
@Named("generator")
public class IsbnGenerator {

    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

```
<h:outputLabel value="#{generator.generateNumber}"/>
```

Mix a producer and a default name

```
public class IsbnGenerator {
    @Produces @Named
    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

```
<h:outputLabel value="#{generateNumber}"/>
```

Mix a producer and a name

```
public class IsbnGenerator {
    @Produces @Named("isbnNumber")
    public String generateNumber() {
        return "13-84356-" + nextNumber();
    }
}
```

```
<h:outputLabel value="#{isbnNumber}"/>
```

CDI is not just about DI

- Interceptor enhancement
- Decorators
- Events

Interceptors 1.1

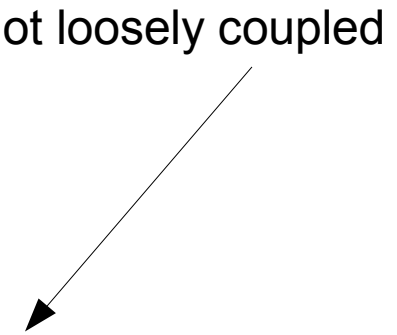
- Address cross-cutting concerns in Java EE
- Were part of the EJB 3.0 spec
- Now a seperate spec shipped with EJB 3.1
- Can be uses in EJBs...
- … as well as ManagedBeans
- `@AroundInvoke`
- `@AroundTimeout` for EJB timers

Interceptors 1.1

```
public class LoggingInterceptor {

  private Logger logger = Logger.getLogger("org.myapp");

  @AroundInvoke
  public Object logMethod(InvocationContext ic) throws Exception {
    logger.entering(ic.getTarget().toString(), ic.getMethod().getName());
    try {
      return ic.proceed();
    } finally {
      logger.exiting(ic.getTarget().toString(), ic.getMethod().getName());
    }
  }
}
```

Interceptors 1.1

```
@Stateless
public class CustomerEJB {

    @PersistenceContext
    private EntityManager em;

    @Interceptors(LoggingInterceptor.class)
    public void createCustomer(Customer customer) {
        em.persist(customer);
    }

    public Customer findCustomerById(Long id) {
        return em.find(Customer.class, id);
    }
}
```



CDI adds interceptor binding

```
@InterceptorBinding
@Target({METHOD, TYPE})
@Retention(RUNTIME)
public @interface Loggable {}
```

CDI adds interceptor binding

```
@Loggable @Interceptor
public class LoggingInterceptor {

  private Logger logger = Logger.getLogger("org.myapp");

  @AroundInvoke
  public Object logMethod(InvocationContext ic) throws Exception {
}
```

```
@Stateless
public class CustomerEJB {

    @Loggable
    public void createCustomer(Customer customer) {
        em.persist(customer);
    }
}
```

Decorators

- Interceptors
  - separate concerns which are orthogonal
  - intercept invocations of any Java type
  - perfect for solving technical concerns
  - unaware of the semantics of the events they intercept
  - not appropriate for separating business concerns
- Use decorators
  - intercepts invocations only for a certain Java interface
  - aware of the semantics attached to that interface

Decorators

```
public interface Account {
  public BigDecimal getBalance();
  public User getOwner();
  public void withdraw(BigDecimal amount);
  public void deposit(BigDecimal amount);
}

public class AccountImpl implements Account {
  public BigDecimal getBalance() {...}
}
```

```
@Decorator
public abstract class LargeTransactionDecorator implements Account
  public BigDecimal getBalance() {...}
}
```

```
@Inject Account account;
// Calls the decorator first
account.getBalance();
```

Events

- Event producers raise events that are delivered to event observers by the container
- Observer/observable pattern
- Typesafe approach
- An event is a `@Qualifier`
- No need to use JMS

Events

```
@Qualifier
@Target({FIELD, PARAMETER})
@Retention(RUNTIME)
public @interface Updated {}
```

```
@Inject @Updated Event<Document> docUpdatedEvent;
docUpdatedEvent.fire(document);
```

```
public void afterDocumentUpdate(@Observes @Updated Document documen
{ ... }
```

And more...

- Scopes & context
- Extensions
  - Finally makes the EE platform extendable

How can I have all these goodies ?

CDI is not just about Java EE 6

- CDI comes for free in Java EE 6 & Web Profile 1.0
- Bootstrap CDI in several environments
- Not standard (yet)
  - Java SE
  - Tomcat 6.x / 7.x
  - Jetty 6.X / 7.x
- Doesn't work ?
  - Application client container (ACC)
  - Spring 3.x

Doesn't work with Spring?

- Spring 3.x
- Only DI is supported (JSR 330)
  - `javax.inject`
  - `@Inject, @Named, @Qualifier`
- Not CDI (JSR 299)
  - `javax.enterprise.context`
  - Alternatives, Producers, Stereotypes, Decorators, Events
- You can replace `@Autowired` with `@Inject`

CDI implementations

- Weld (JBoss)
- Open WebBeans (Apache)
- CanDI (Caucho)

What makes CDI Unique ?

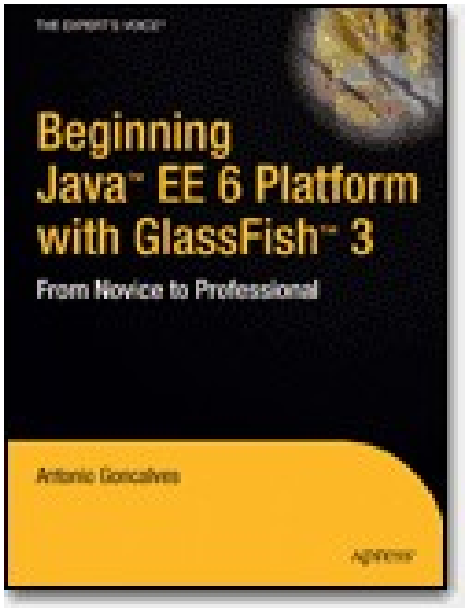
- It's standard
- It's loosely coupled
- It's strongly typed
- It's extensible
- Might even become the platform for EE

And what about the future ?

- Java EE 7
- CDI 1.1 is on the way
  - Embedded mode outside Java EE container
  - Static injection
  - Better support for CDI in certain EE components
  - Application lifecycle events
  - ...

Java EE 6

- A book
  - 450 pages about Java EE 6
  - Second edition
  - Covers most specs
- A training
  - 3 days
  - Most specs
  - Hands on labs
  - Contact me



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