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Java User Group Saxony 2013

Exploration and Verification of Java Applications Using a Graph Database

Dirk Mahler
buschmais GbR

Inhaber
Torsten Busch, Frank Schwarz,
Dirk Mahler und Tobias Israel

dirk.mahler@buschmais.com
http://www.buschmais.de/

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Agenda

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- Introducing A Graph Database: Neo4j
- Modeling Software Structures As A Graph
- Exploring An Application Using Queries
- Live Demo #1
- Structures, Rules and Erosion
- Validation Of Conventions And Constraints
- jQAssistant
- Live Demo #2

Exploration And Verification Of Java Applications Using A Graph Database

Introducing A Graph Database – Neo4j

Introducing A Graph Database – Neo4j

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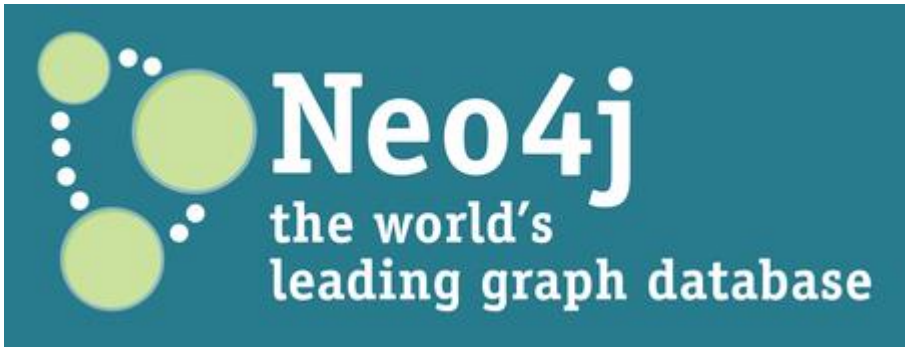
- Just some facts
  - http://www.neo4j.org
  - Latest Stable Release: 1.9.5
  - Upcoming: 2.0.0 (RC1)
  - Implemented in Java(!)
  - Runnding embedded with native Java API…
  - ….or as standalone server via REST
  - Several Language Bindings, e.g. Java, JS, Ruby, PHP, .NET, …
  - HA features
  - Query language: Cypher
  - Comprehensive documentation and online tutorials
  - Community (Open source) and commercial licenses available



Exploration And Verification Of Java Applications
Using A Graph Database

Modeling Software Structures As A Graph

Modeling Software Structures As A Graph

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- Let‘s model a Java class as a graph!

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- Let‘s model a Java class as a graph!

```
public class Customer extends Person {
  private int number;

  public int getNumber() {
    return this.number;
  }
}
```

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- All we need is…
  - Nodes
  - Labels
  - Properties
  - Relationships
- Modeling is just…
  - Taking a pen
  - Drawing the structures on a whiteboard (i.e. the database)
- We don‘t need…
  - Foreign keys
  - Tables and schemas
  - Knowledge in graph theory

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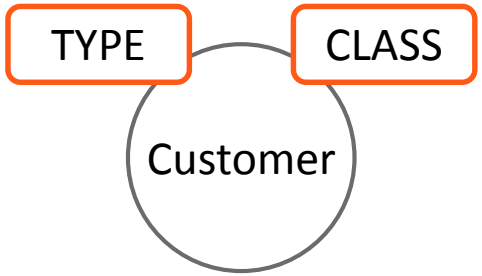

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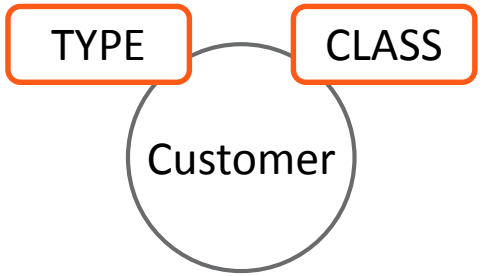

FQN:com.buschmais.model.Customer
VISIBILITY:PUBLIC

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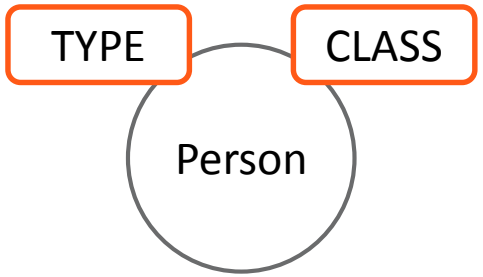

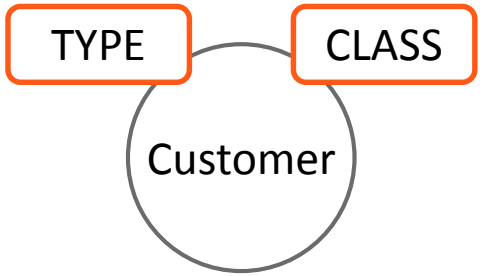

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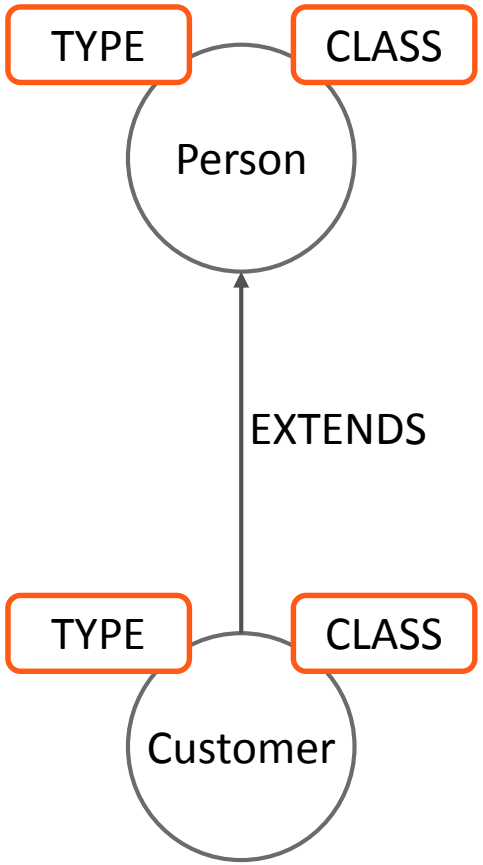

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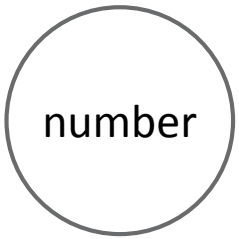

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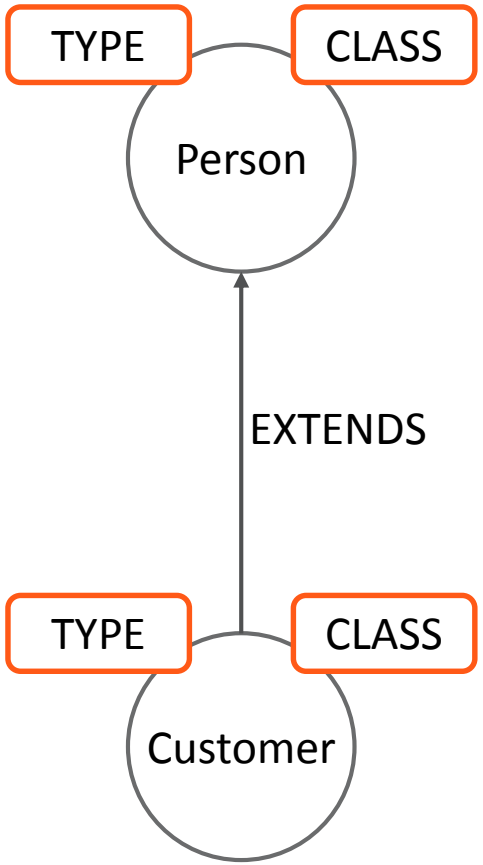

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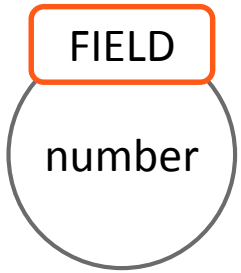

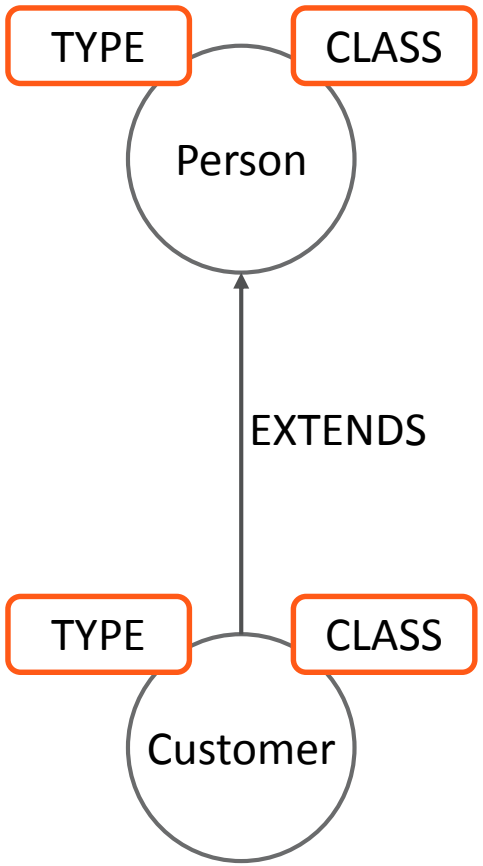

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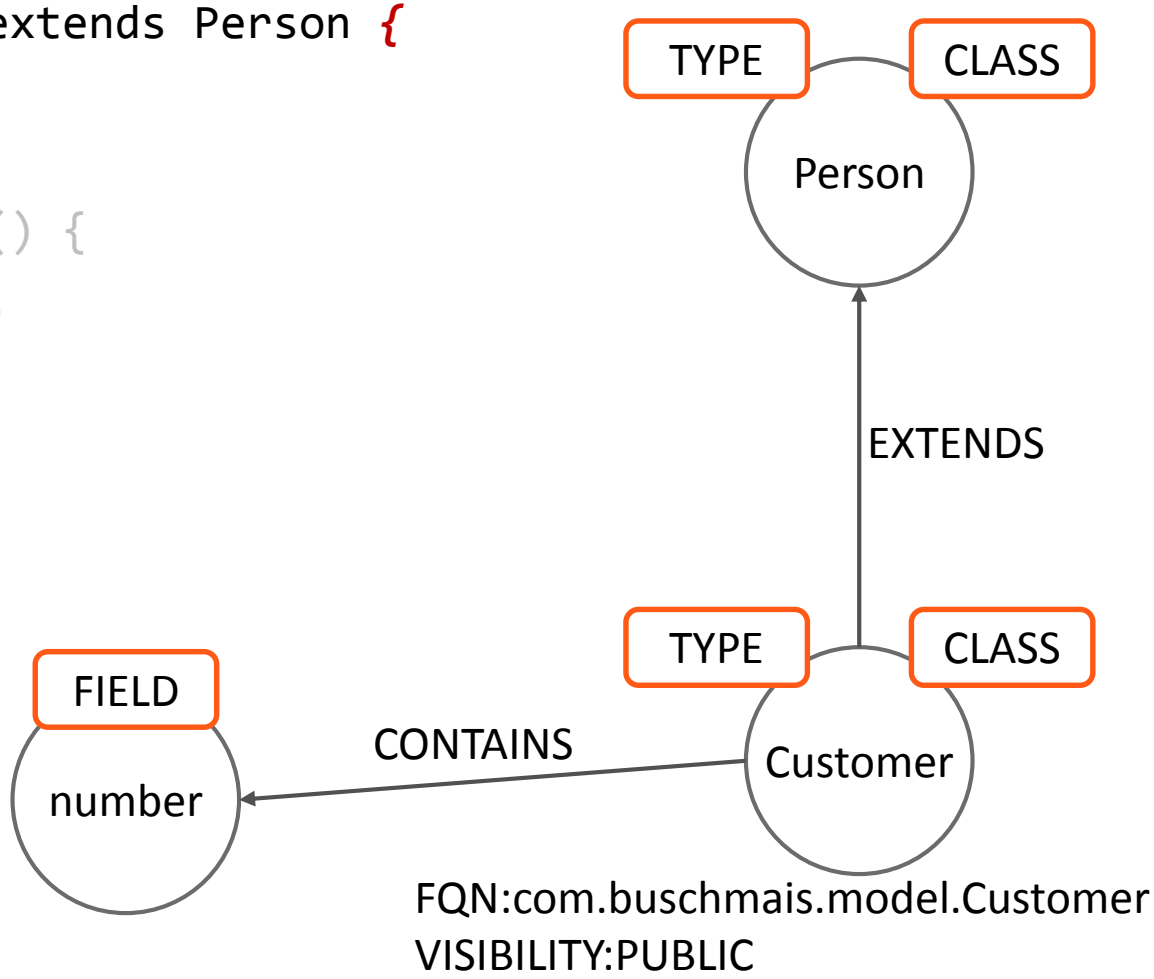

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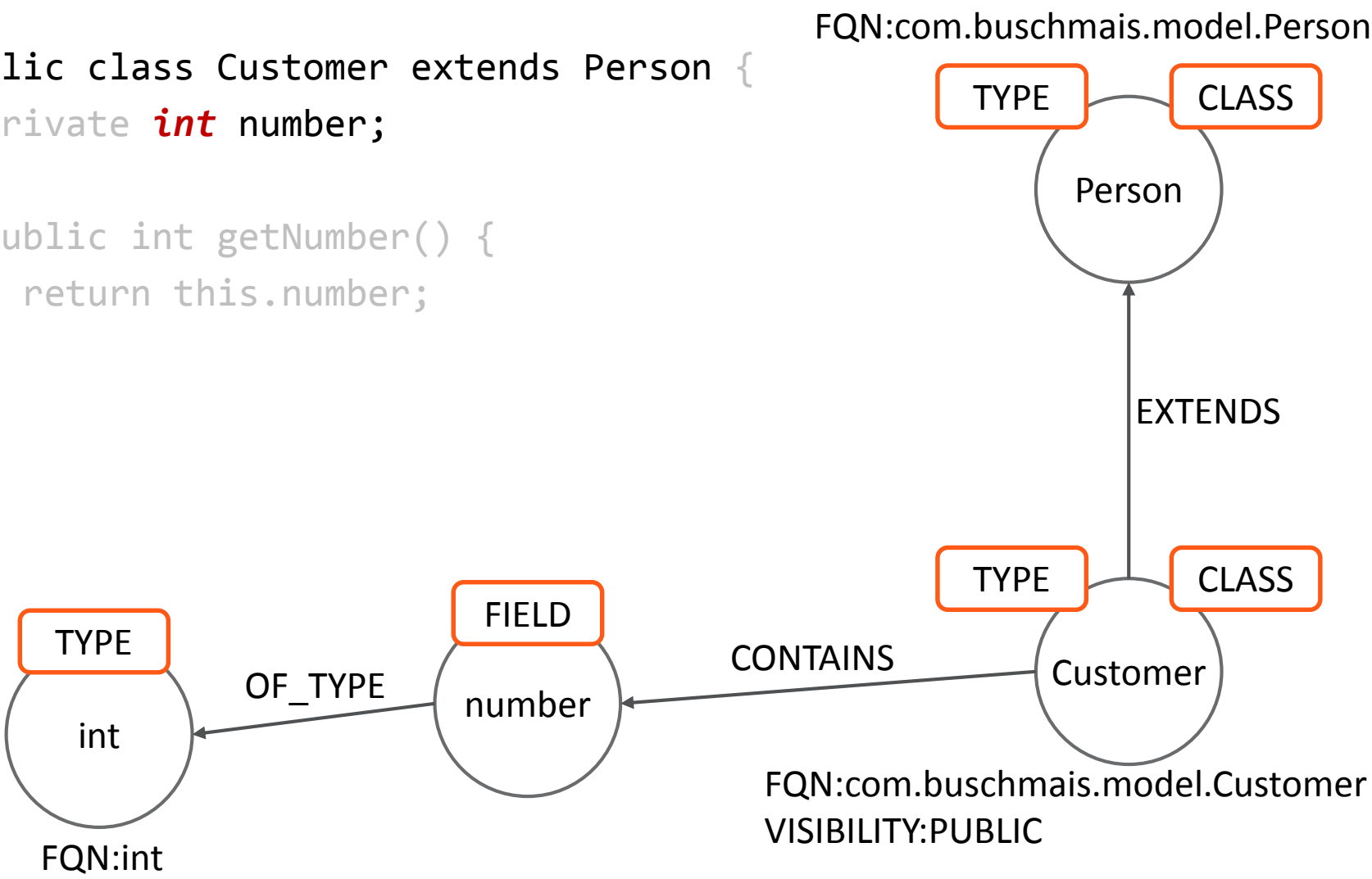

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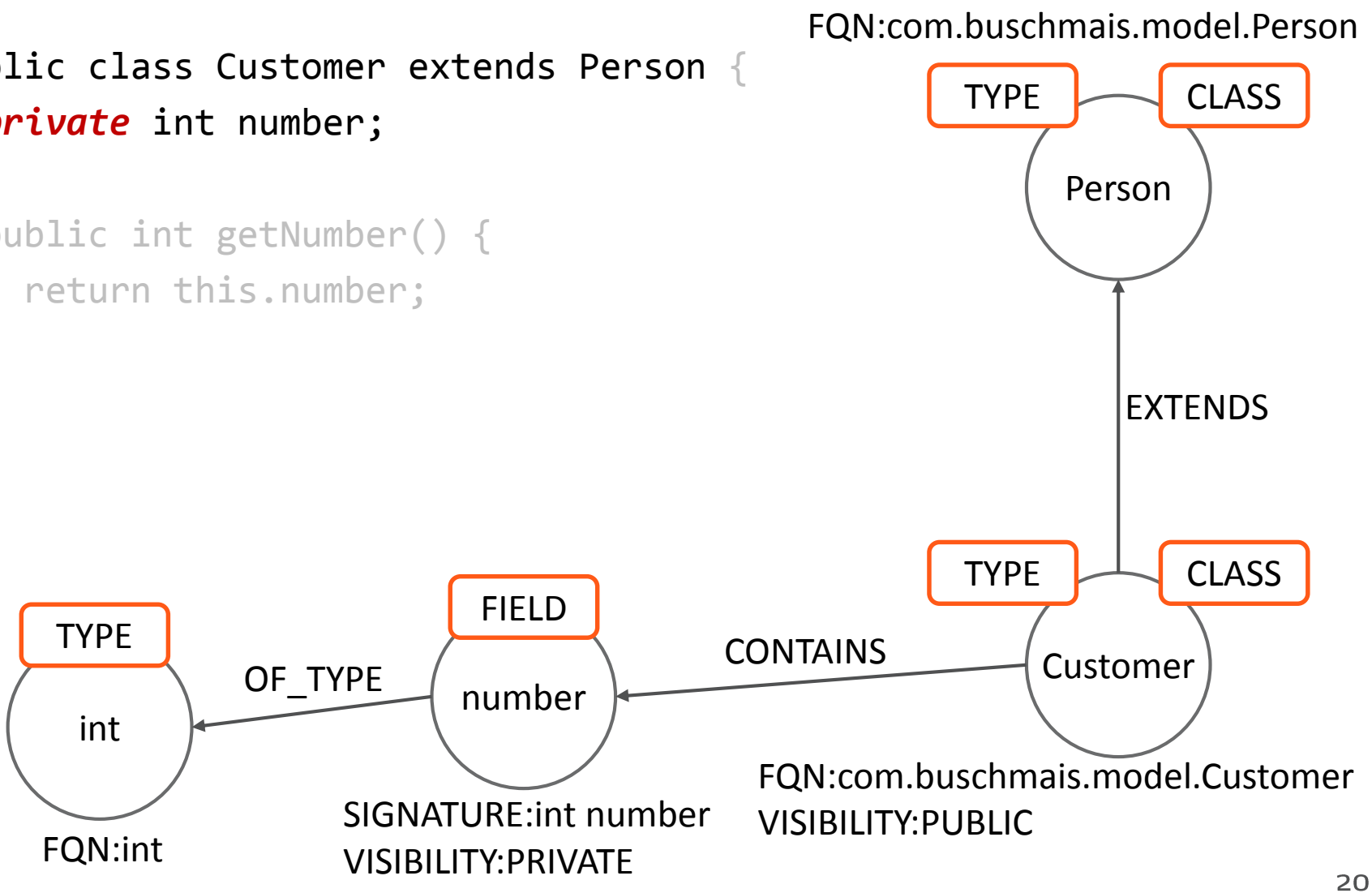

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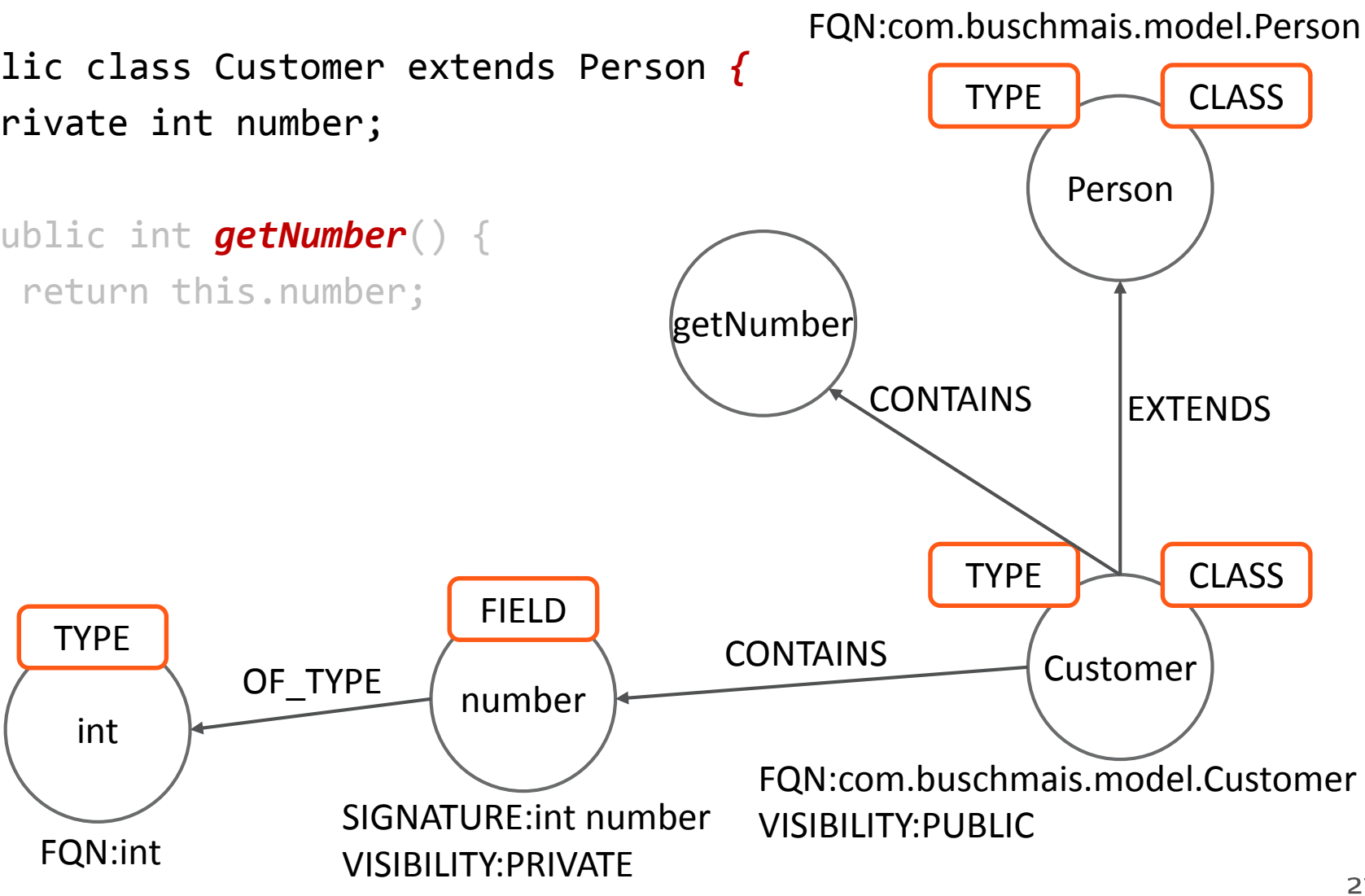

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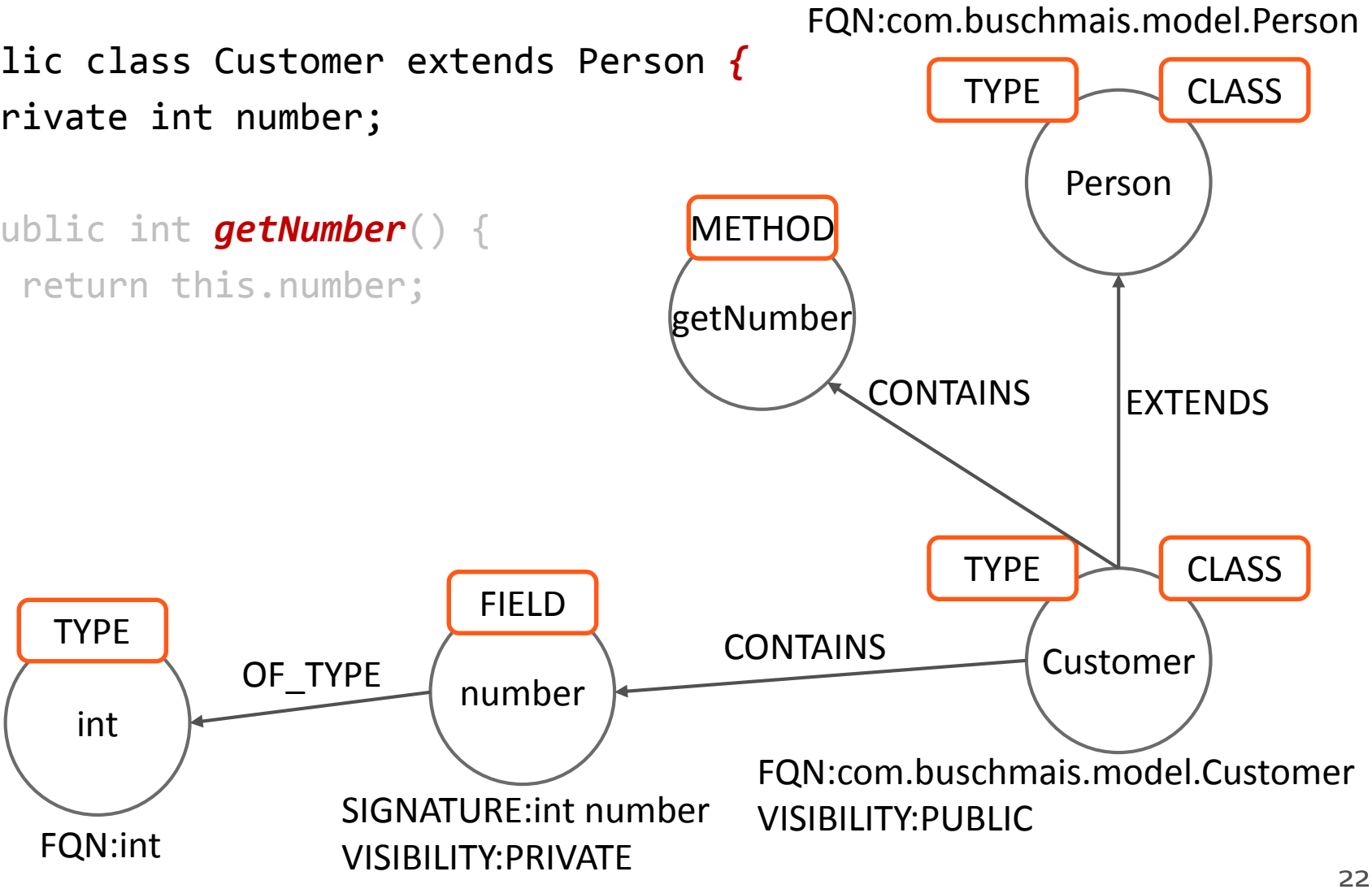

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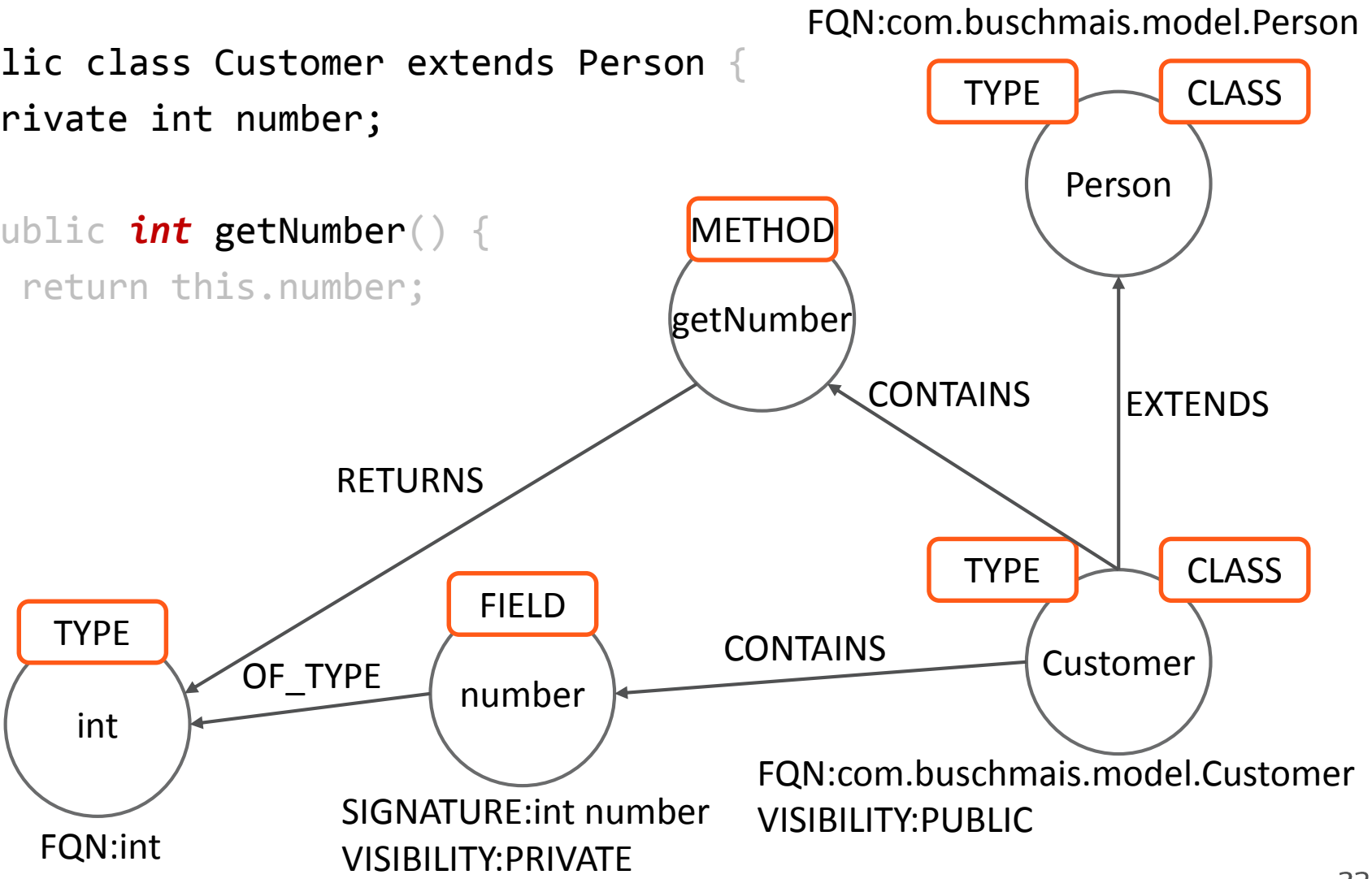

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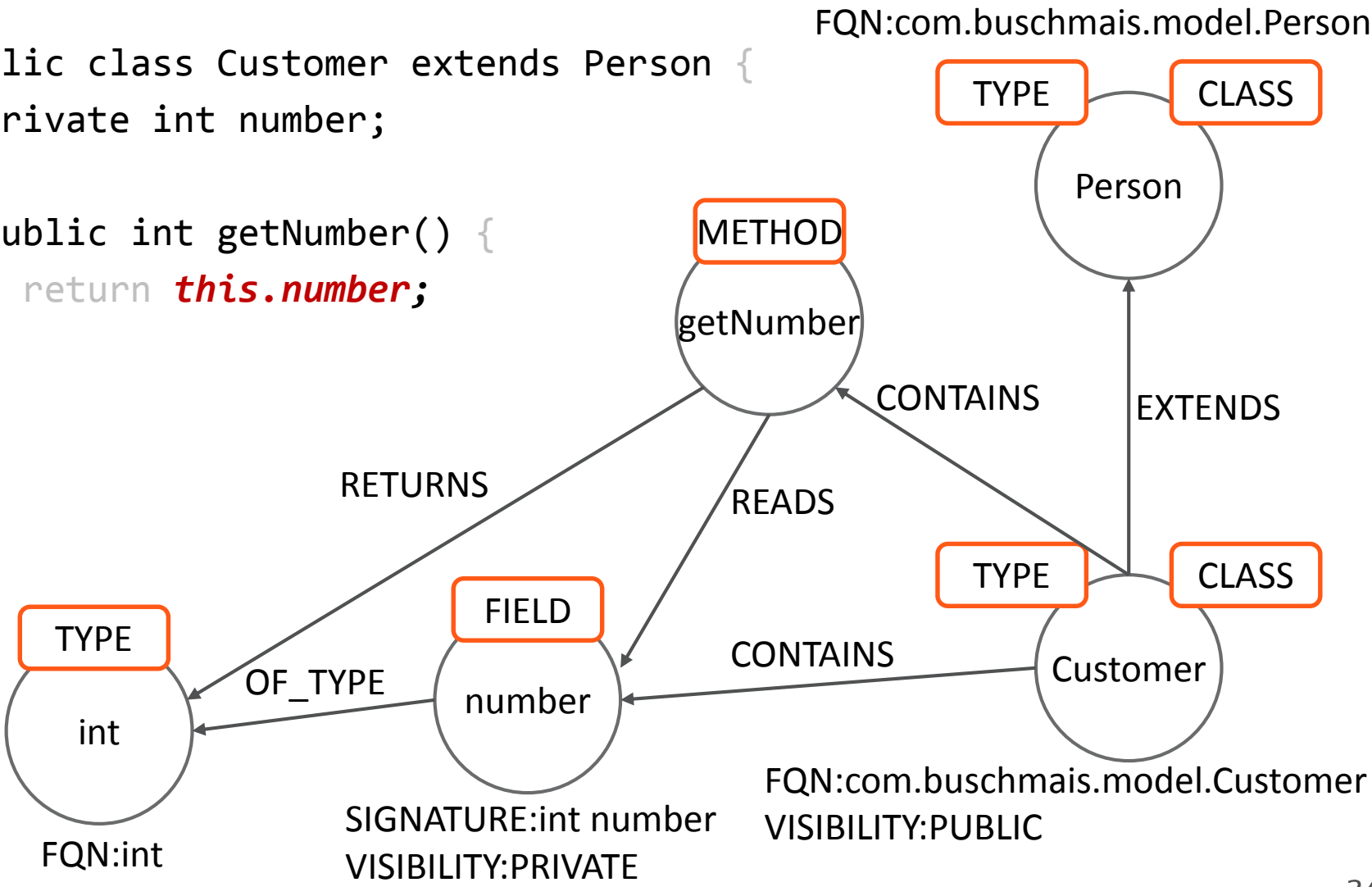

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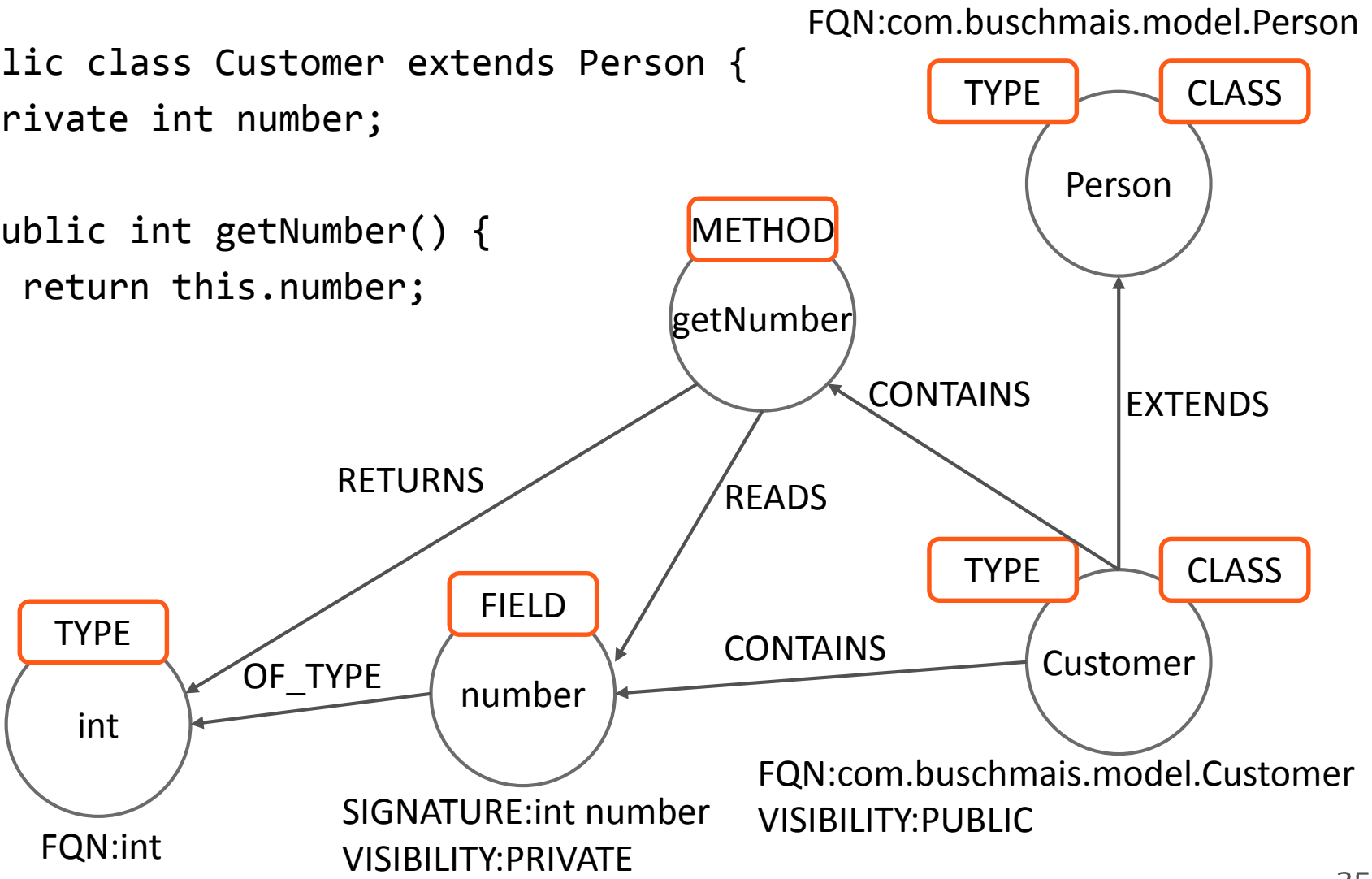

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- Core elements of the „Java software graph model“
  - Nodes and their labels (but without properties)
    - ARTIFACT
    - PACKAGE
    - TYPE, CLASS, INTERFACE, ANNOTATION, ENUM
    - METHOD, CONSTRUCTOR, PARAMETER
    - FIELD
    - VALUE, CLASS, ANNOTATION, ENUM, PRIMITIVE, ARRAY
  - Relationships
    - CONTAINS
    - EXTENDS, IMPLEMENTS
    - RETURNS, THROWS, INVOKES, HAS
    - ANNOTATED_BY, OF_TYPE

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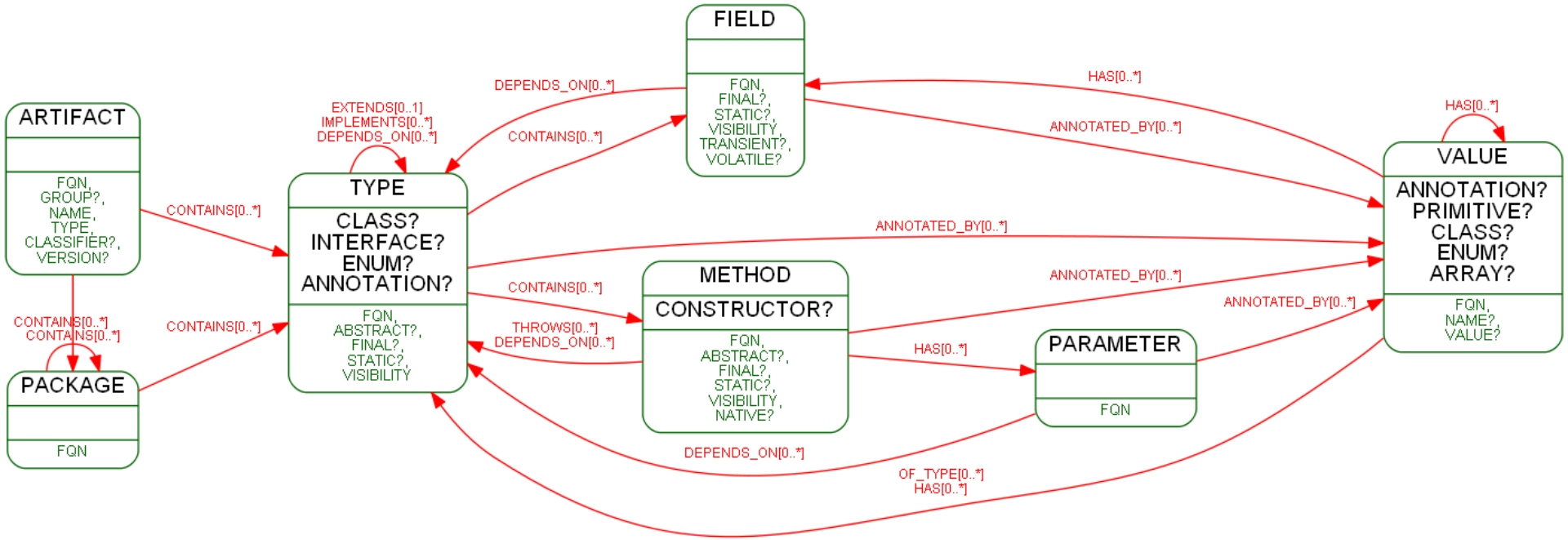

Modeling Software Structures As A Graph

- The model is stored as at has been modeled!

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- The model is stored as at has been modeled!
- Embedded API of Neo4j:

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- Embedded API of Neo4j:

```
Node node = graphDatabaseService.createNode();
```

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- The model is stored as at has been modeled!
- Embedded API of Neo4j:

```
Node node = graphDatabaseService.createNode();
node.addLabel(MyLabels.TYPE);
```

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- The model is stored as at has been modeled!
- Embedded API of Neo4j:

```
Node node = graphDatabaseService.createNode();
node.addLabel(MyLabels.TYPE);
node.setProperty("SIGNATURE", "int number")
```

Modeling Software Structures As A Graph

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- The model is stored as at has been modeled!
- Embedded API of Neo4j:

```
Node node = graphDatabaseService.createNode();
node.addLabel(MyLabels.TYPE);
node.setProperty("SIGNATURE", "int number")
node.createRelationshipTo(otherNode,
MyRelations.OF_TYPE)
```

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- The model is stored as at has been modeled!
- Embedded API of Neo4j:

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node.addLabel(MyLabels.TYPE);
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- All operations (and even more!) also possible via
  - Cypher
  - REST

Exploration And Verification Of Java Applications

Using A Graph Database

Exploring An Application Using Queries

Exploring An Application Using Queries

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- Let‘s execute a query on the graph!

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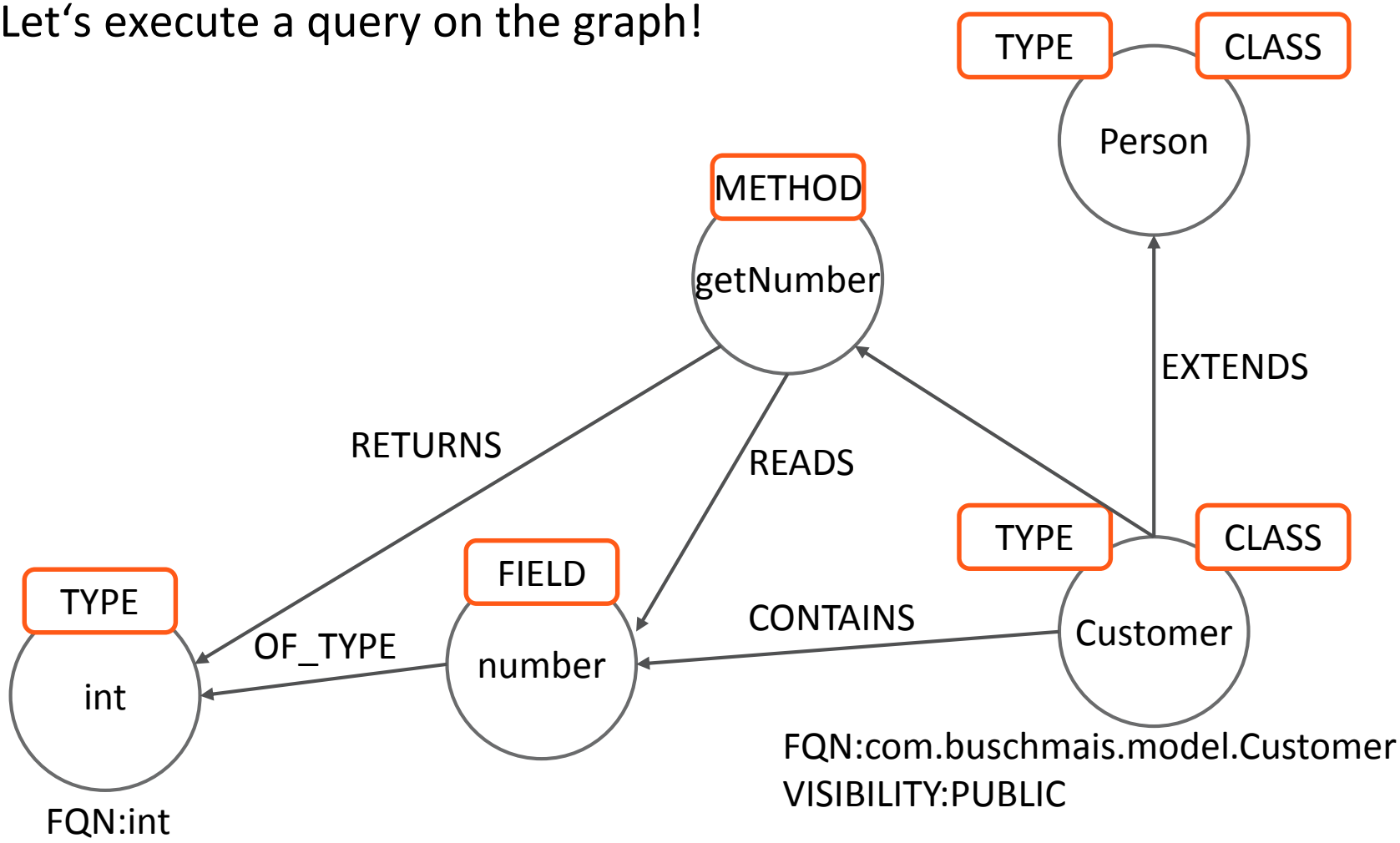

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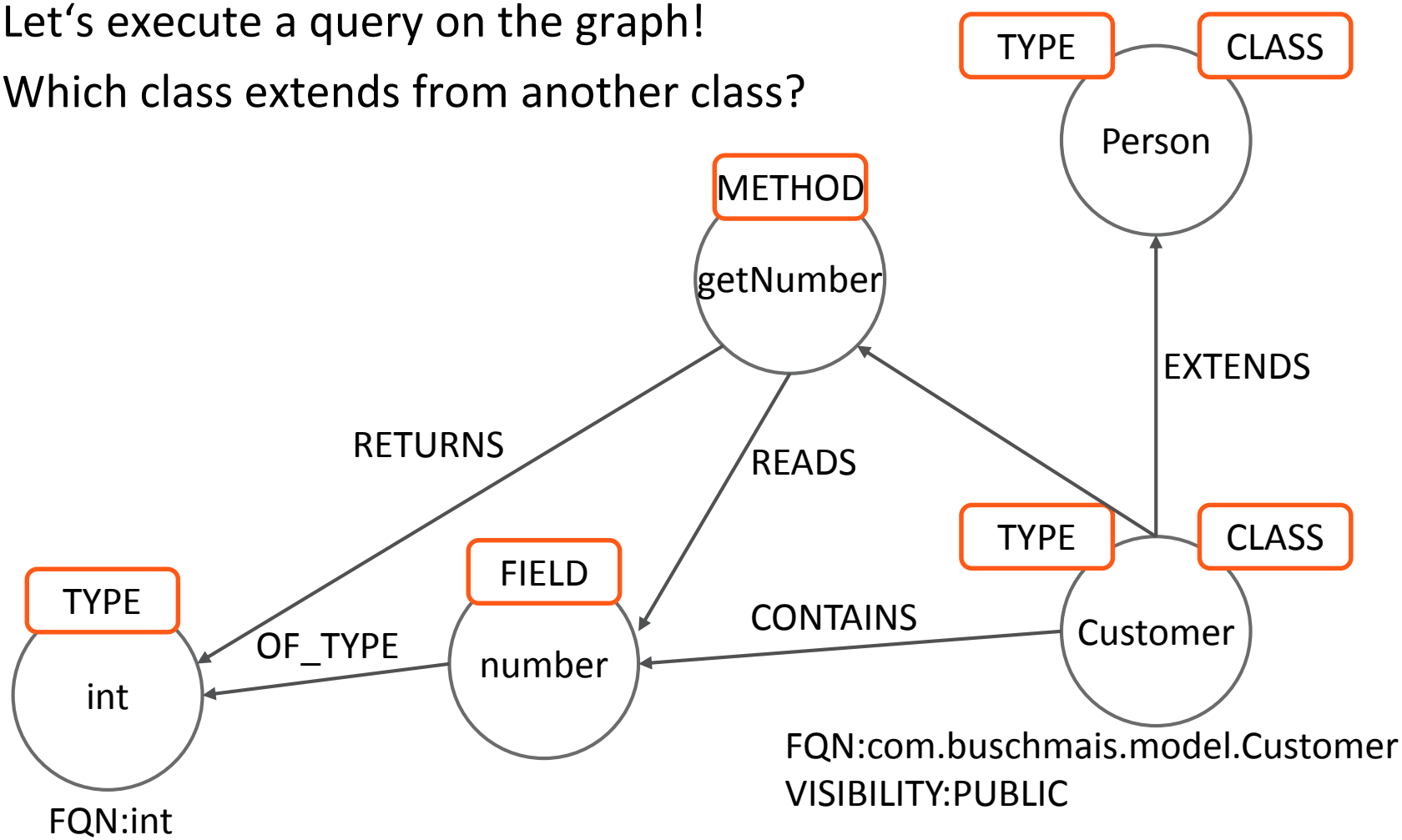
- Let‘s execute a query on the graph!
- Which class extends from another class?



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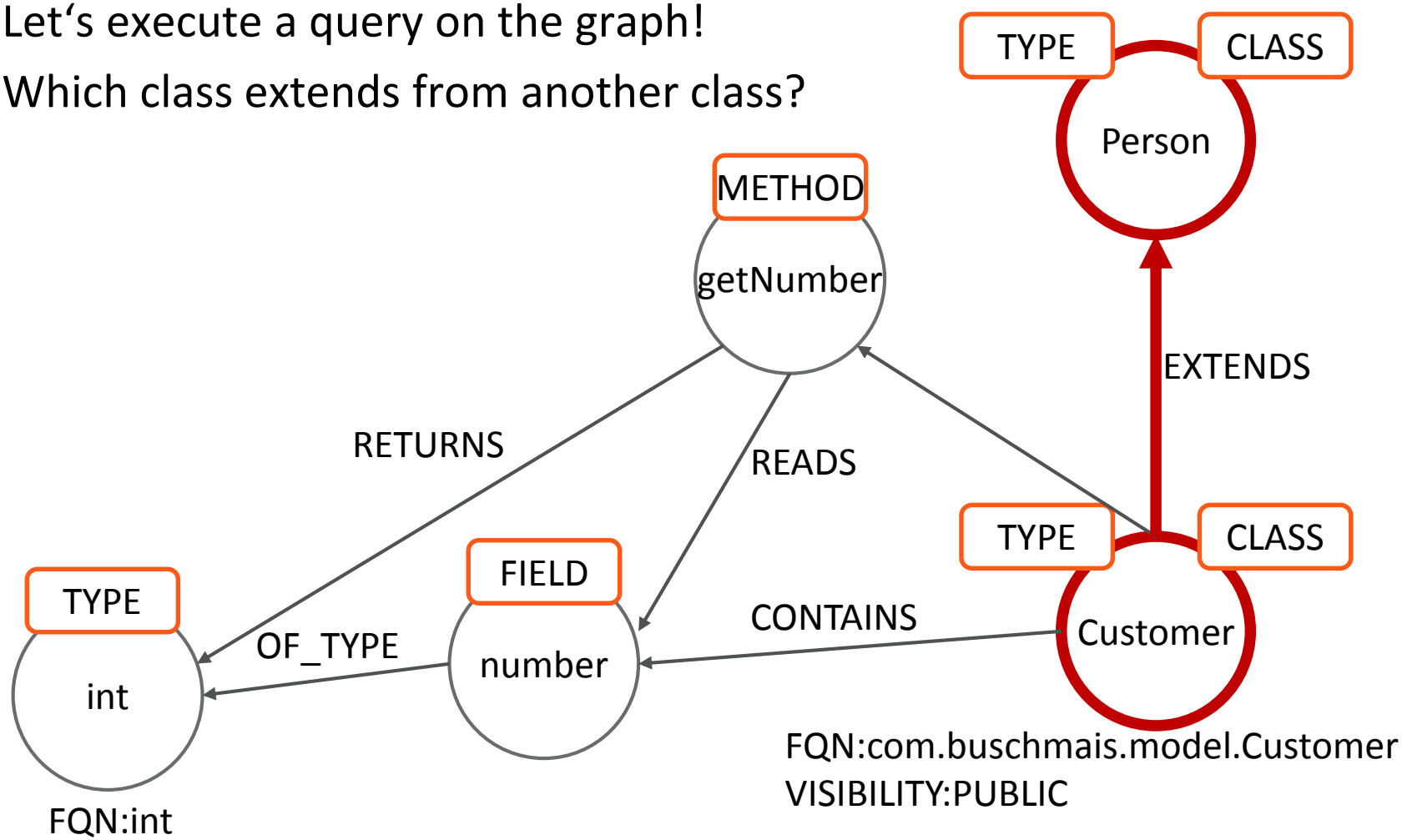

Exploring An Application Using Queries

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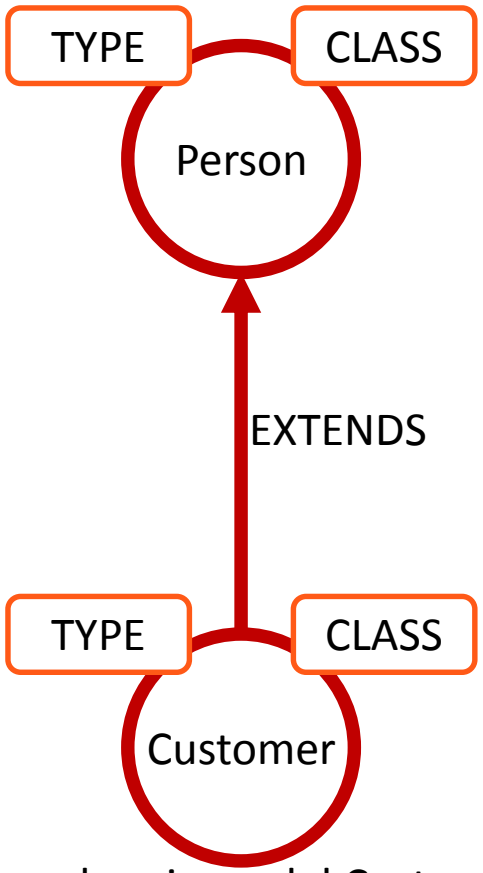
- Let‘s execute a query on the graph!
- Which class extends from another class?
- How can we express a query on this pattern?



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- Let‘s convert this to ASCII art…

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- Let‘s convert this to ASCII art…
  - () as nodes

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- Let‘s convert this to ASCII art…
  - () as nodes
  - -[]-> as directed relationships

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()-[]->()

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(c1)-[]->(c2)

Exploring An Application Using Queries

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- Let‘s convert this to ASCII art…
  - () as nodes
  - -[]-> as directed relationships

(c1)-[:EXTENDS]->(c2)

Exploring An Application Using Queries

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- Let‘s convert this to ASCII art…
  - () as nodes
  - -[]-> as directed relationships

```
(c1:CLASS)-[:EXTENDS]->(c2:CLASS)
```

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- Pattern matching is the core principle of Cypher!

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- Pattern matching is the core principle of Cypher!

```
MATCH
  (c1:CLASS)-[:EXTENDS]->(c2:CLASS)
RETURN
  c1.FQN, c2.FQN
```

Exploring An Application Using Queries

- Which classes contain the highest number of methods?

Exploring An Application Using Queries

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- Which classes contain the highest number of methods?

```
MATCH
  (class:CLASS)-[:CONTAINS]->(method:METHOD)
```

Exploring An Application Using Queries

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- Which classes contain the highest number of methods?

```
MATCH
  (class:CLASS)-[:CONTAINS]->(method:METHOD)
RETURN
  class.FQN, count(method) as Methods
```

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- Which classes contain the highest number of methods?

```
MATCH
  (class:CLASS)-[:CONTAINS]->(method:METHOD)
RETURN
  class.FQN, count(method) as Methods
ORDER BY
  Methods DESC
```

Exploring An Application Using Queries

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- Which classes contain the highest number of methods?

```
MATCH
  (class:CLASS)-[:CONTAINS]->(method:METHOD)
RETURN
  class.FQN, count(method) as Methods
ORDER BY
  Methods DESC
LIMIT 20
```

Exploring An Application Using Queries

- Which class has the deepest inheritance hierarchy?

Exploring An Application Using Queries

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- Which class has the deepest inheritance hierarchy?

```
MATCH
   h=(class:CLASS)-[:EXTENDS*]->(super:CLASS)
```

Exploring An Application Using Queries

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- Which class has the deepest inheritance hierarchy?

```
MATCH
  h=(class:CLASS)-[:EXTENDS*]->(super:CLASS)
RETURN
  class.FQN, length(h) as Depth
```

- Which class has the deepest inheritance hierarchy?

```
MATCH
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RETURN
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ORDER BY
  Depth desc
```

Exploring An Application Using Queries

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- Which class has the deepest inheritance hierarchy?

```
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RETURN
  class.FQN, length(h) as Depth
ORDER BY
  Depth desc
LIMIT 20
```

Exploring An Application Using Queries

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- Queries on graph structures allow…

Exploring An Application Using Queries

- Queries on graph structures allow…
  - Calculation of metrics, e.g.
    - Classes per package, fields/methods per class
    - Depth of inheritance hierarchies
    - Fan in/out of artifacts, packages, classes

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  - Impact-Analysis, e.g.
    - Which methods/classes/packages/artifacts are potentially affected by changes on an element?

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- Queries on graph structures allow…
  - Calculation of metrics, e.g.
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    - Fan in/out of artifacts, packages, classes
  - Impact-Analysis, e.g.
    - Which methods/classes/packages/artifacts are potentially affected by changes on an element?
  - Validation of constraints and conventions, e.g.
    - Naming rules
    - Cyclic dependencies (types, packages)
    - Internal and external dependencies
      - Modules
      - Frameworks and libraries

Exploration And Verification Of Java Applications
Using A Graph Database

Live Demo #1

Exploration And Verification Of Java Applications

Using A Graph Database

Software, Rules and Erosion

- At the beginning of a new project…
  - Draft of the application architecture
  - Definition of conventions and constraints
    - Modules, layers, internal and external dependencies
    - Naming rules
  - Initial setup of the project structure

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  - Draft of the application architecture
  - Definition of conventions and constraints
    - Modules, layers, internal and external dependencies
    - Naming rules
  - Initial setup of the project structure
- Goals
  - Breaking down complexity of problems
  - „Accessibility“ for developers
    - Similar structures and approaches for similar problems
  - Extensibility
    - Defined extension points
  - etc.

Structures, Rules and Erosion

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- Sketch of an architecture

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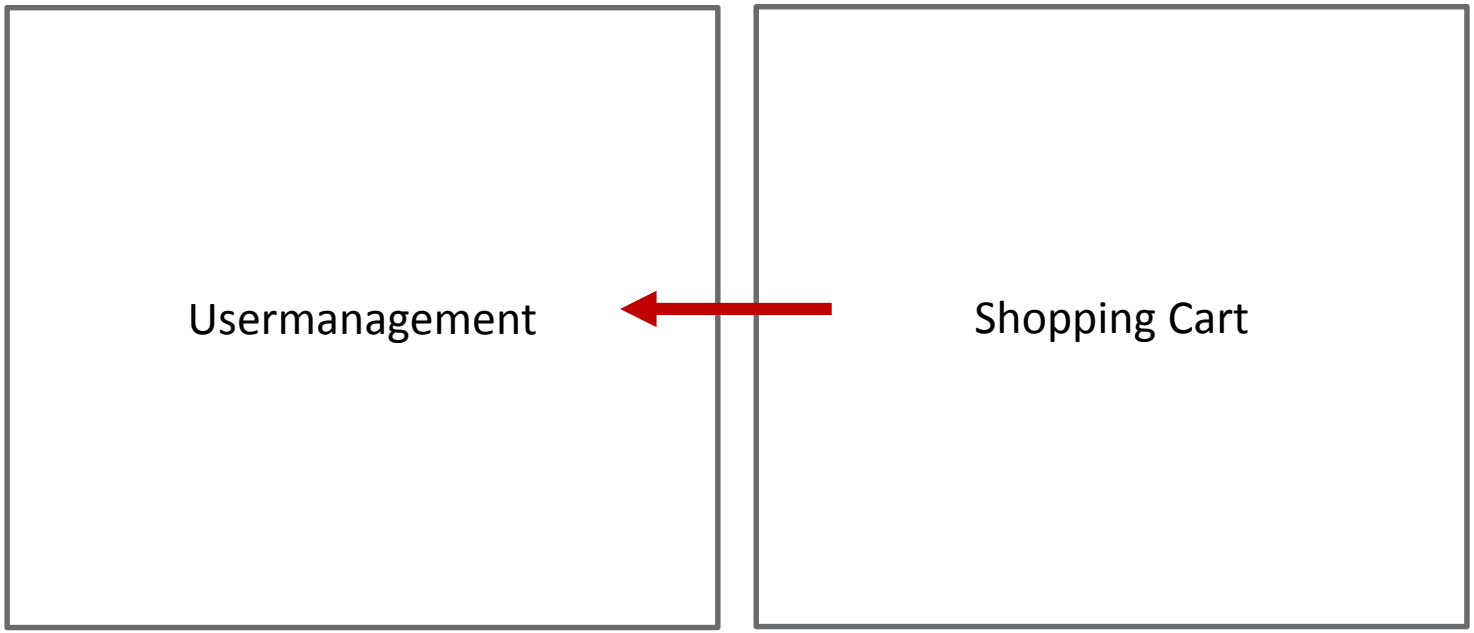
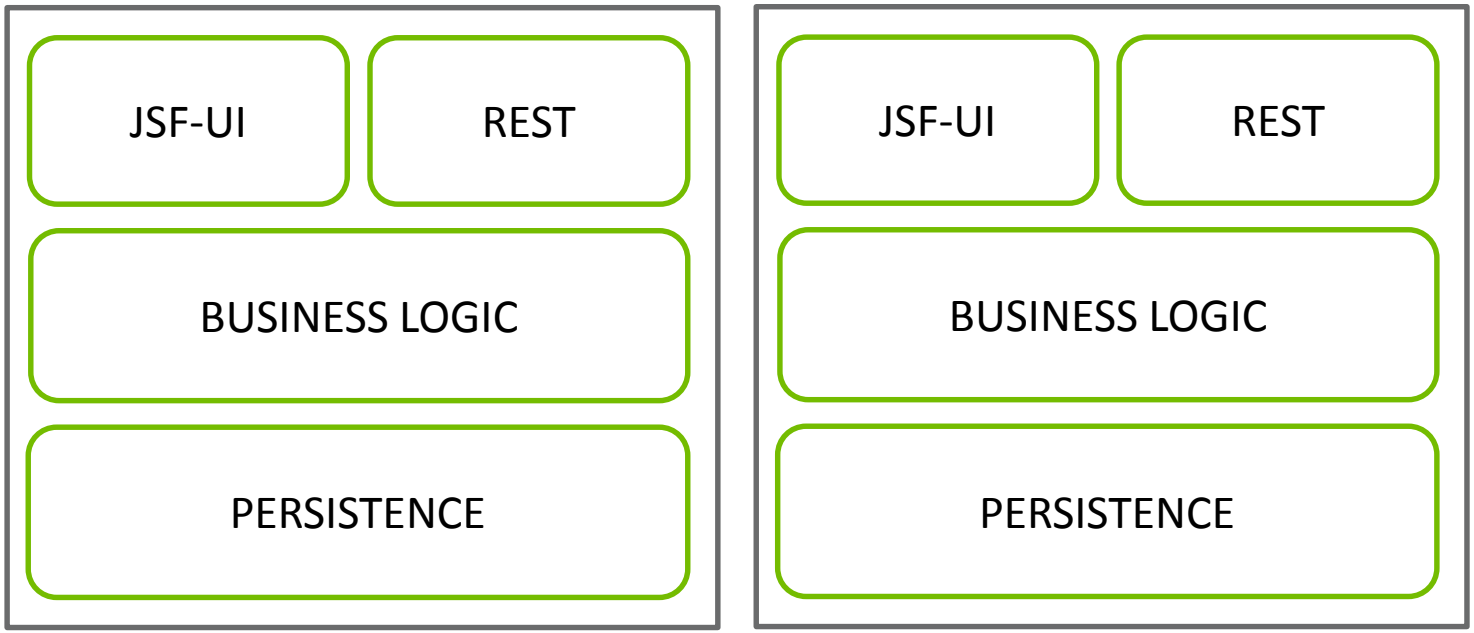
- Sketch of an architecture
  - Business modules

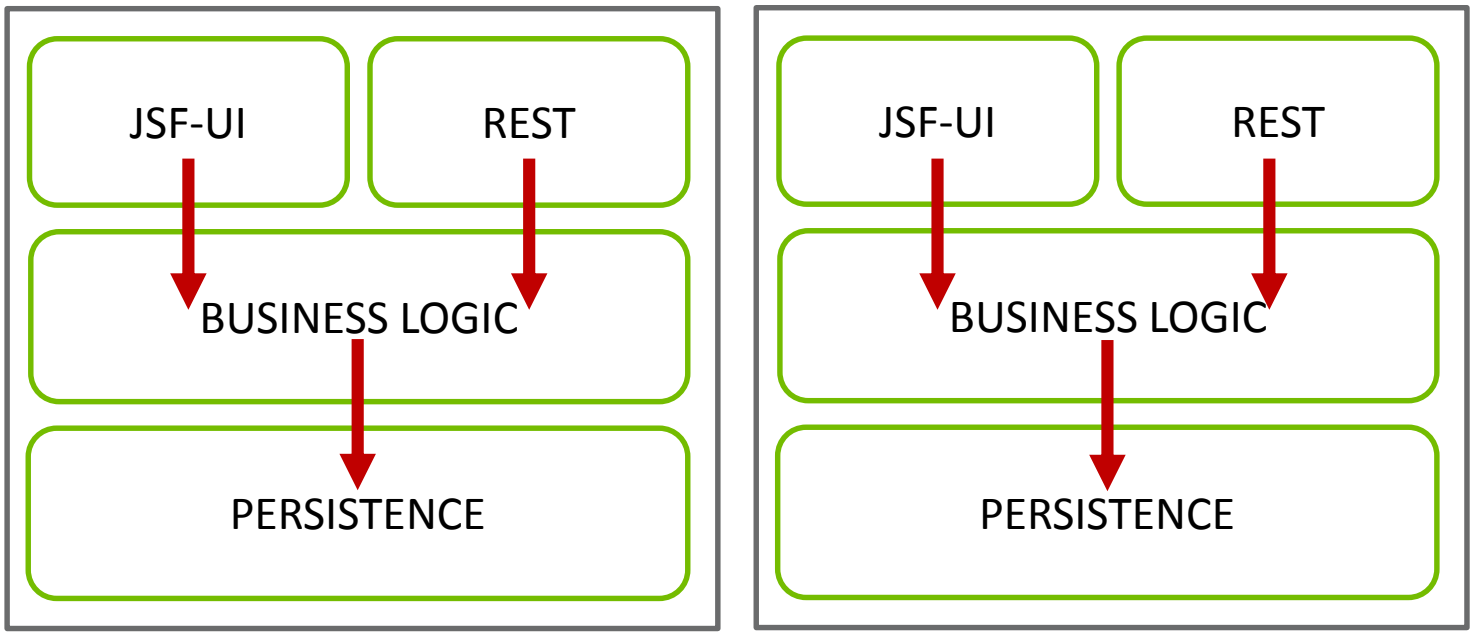
- Sketch of an architecture
  - Defined dependencies between business modules



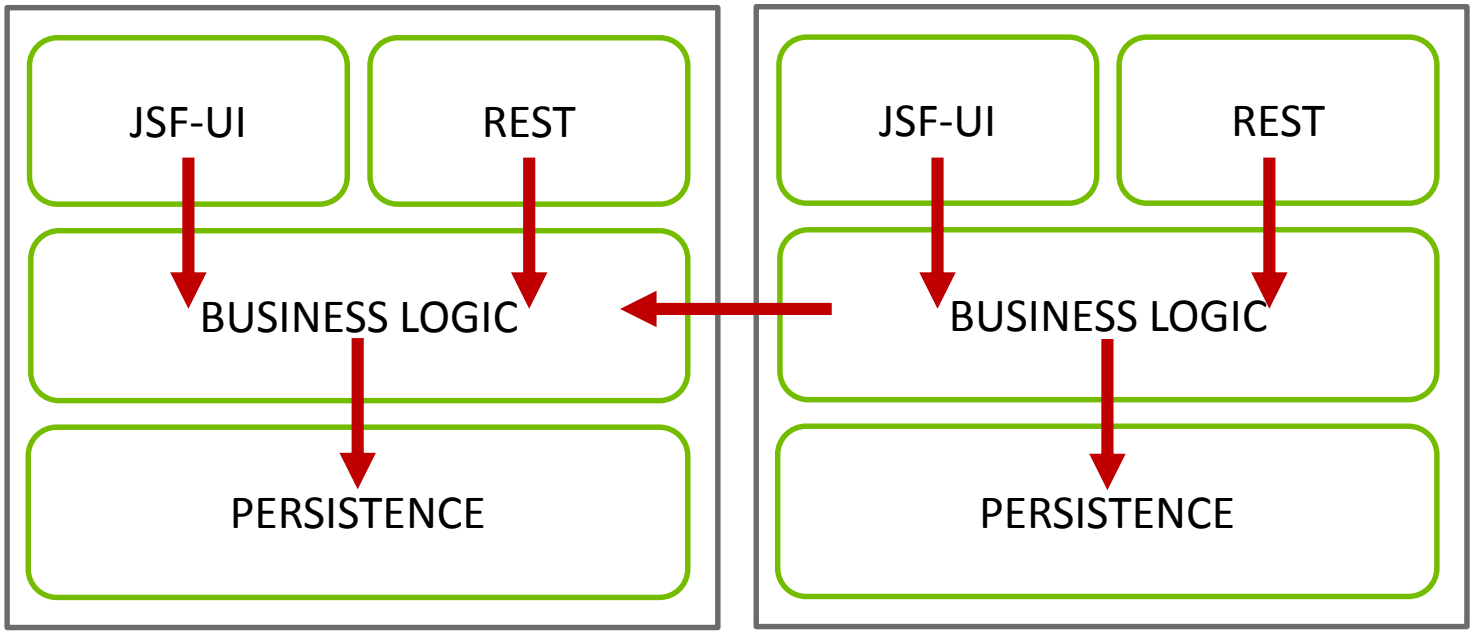
- Sketch of an architecture
  - Technical layering



- Sketch of an architecture
  - Defined dependencies between technical layers



- Sketch of an architecture
  - Defined dependencies of business modules & technical layers



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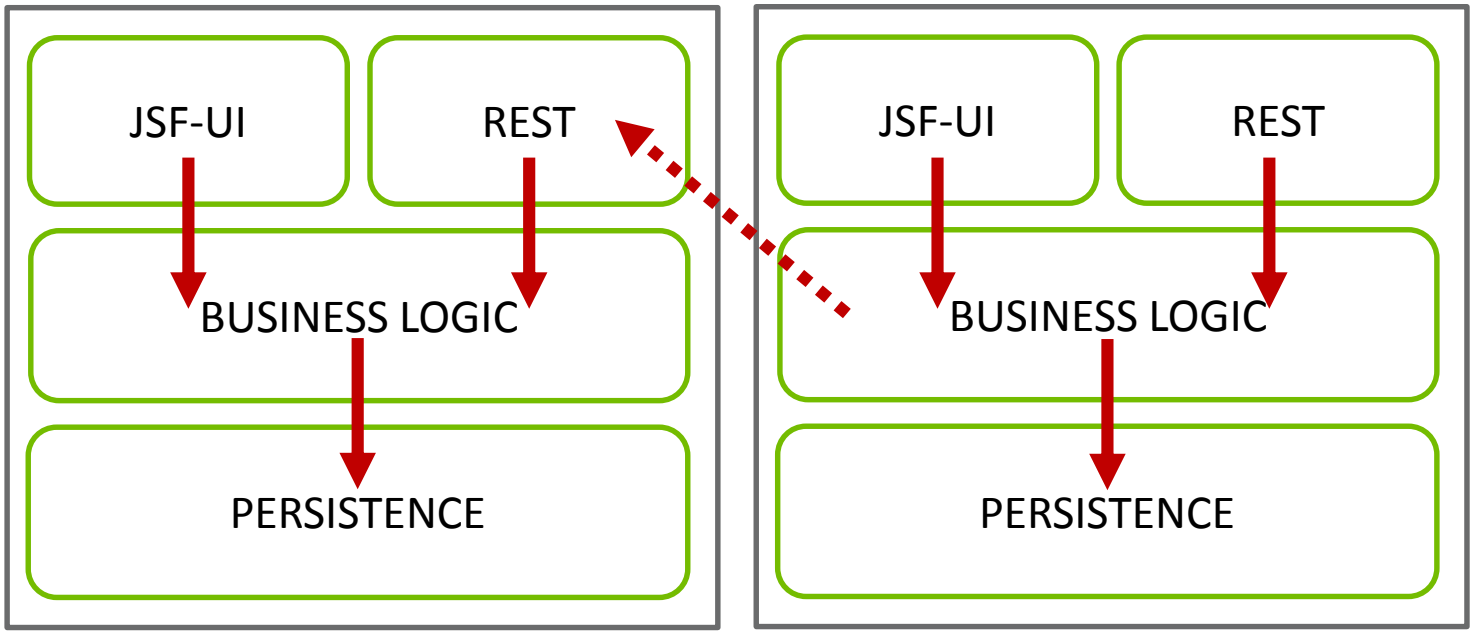
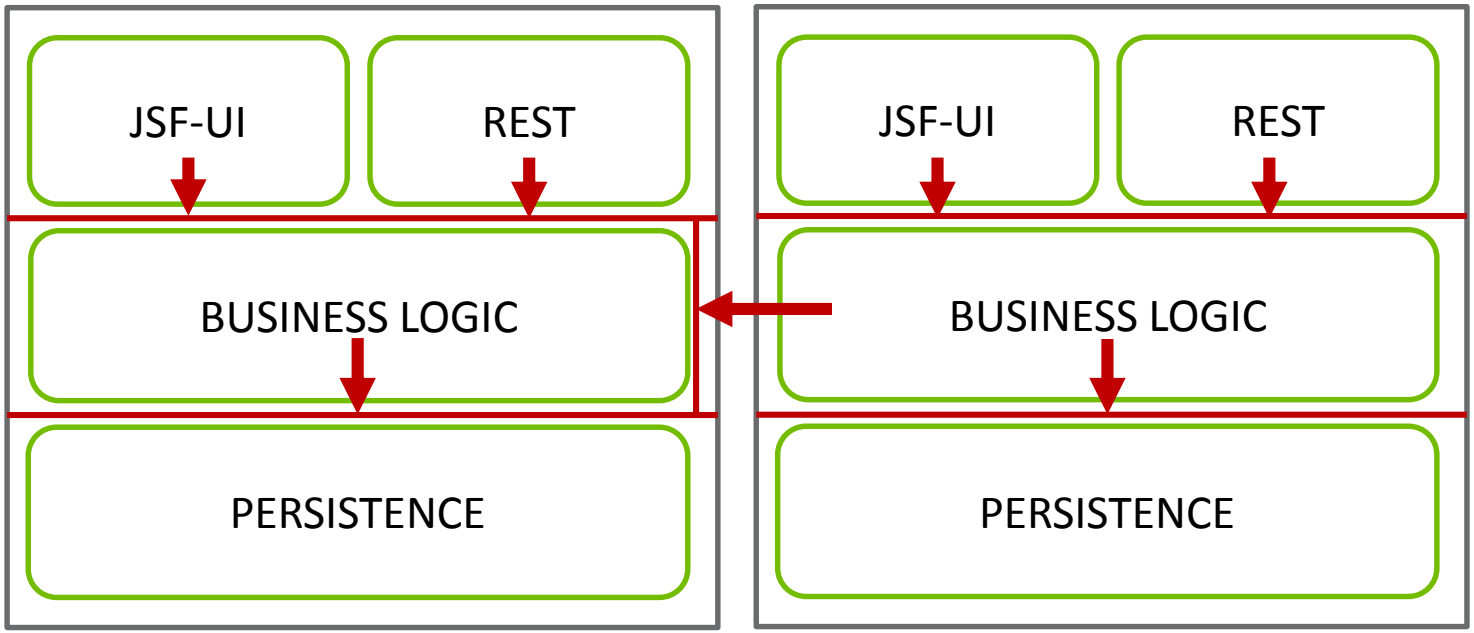
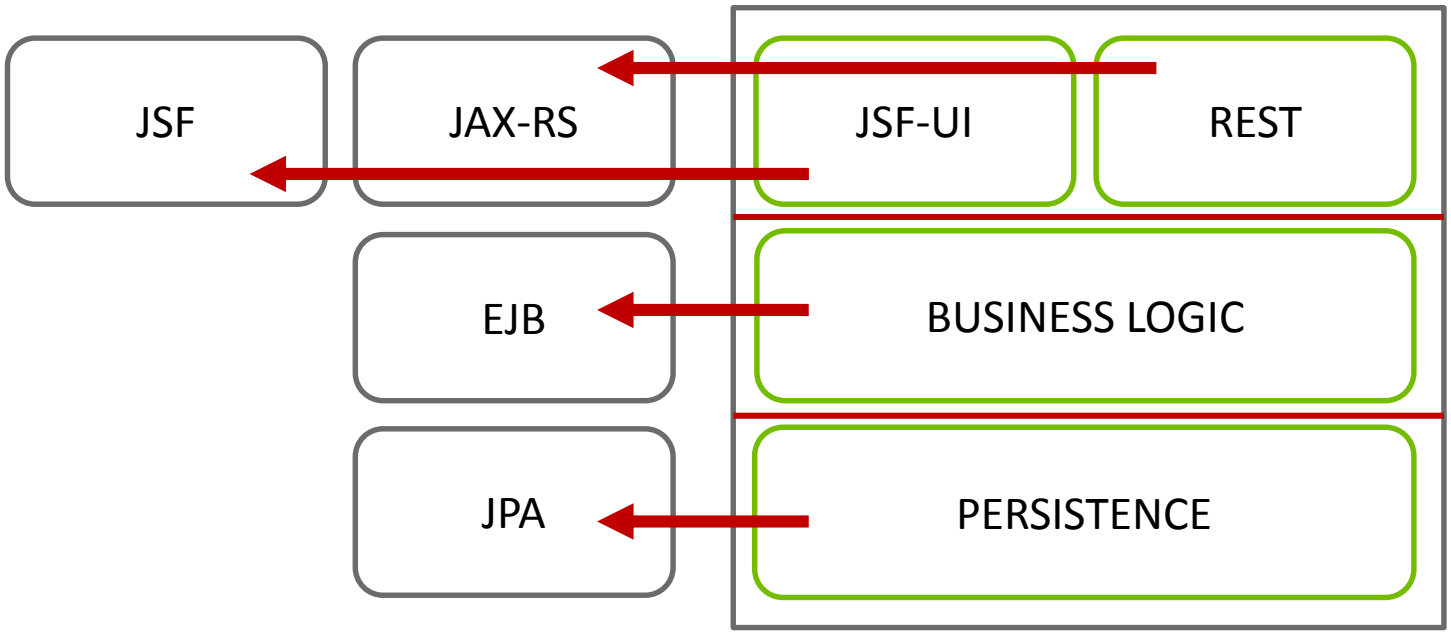


- Sketch of an architecture
  - Decoupling of technical layers (APIs, Interfaces)



- Sketch of an architecture
  - Limitation of the visibility of external dependencies per layer



- Translation of architecture rules into the project structure
  - Java language element: Package

- Translation of architecture rules into the project structure
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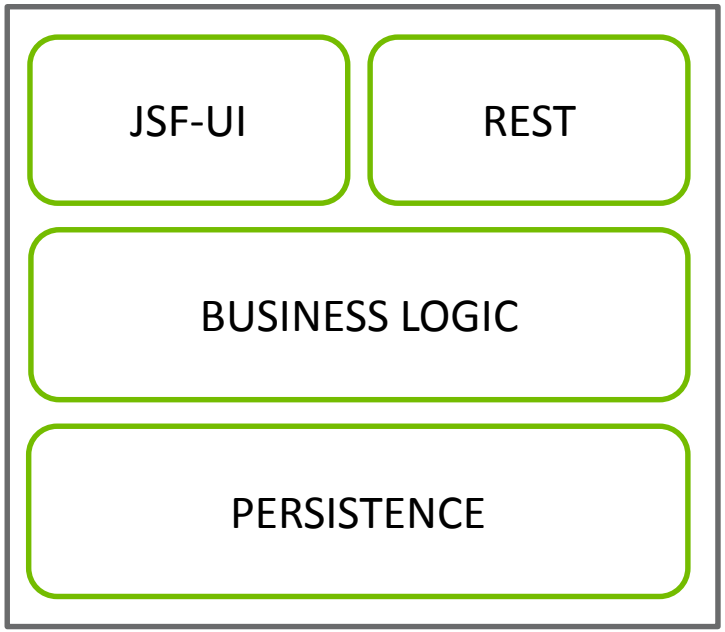
  - Definition of business modules on „top level“

- Translation of architecture rules into the project structure
  - Java language element: Package
  - Technical layers
    - …shop.cart.ui
    - …shop.cart.rest
    - …shop.cart.logic
    - …shop.cart.persistence



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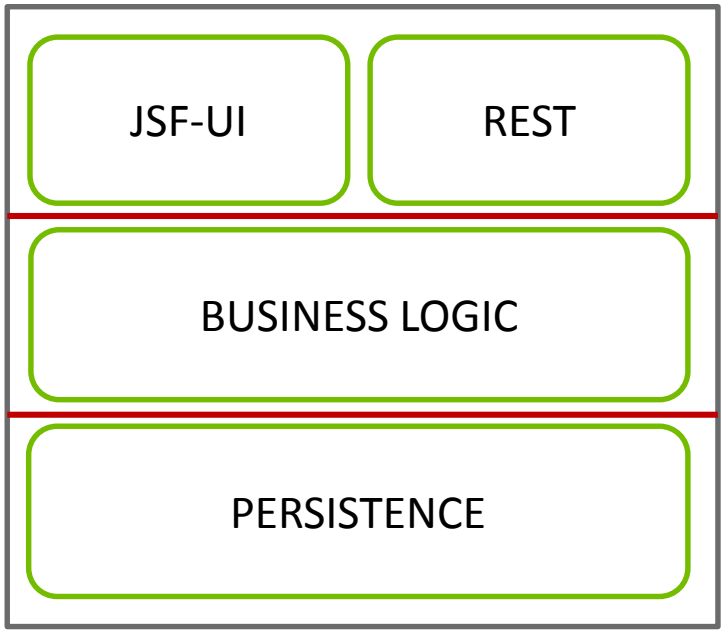
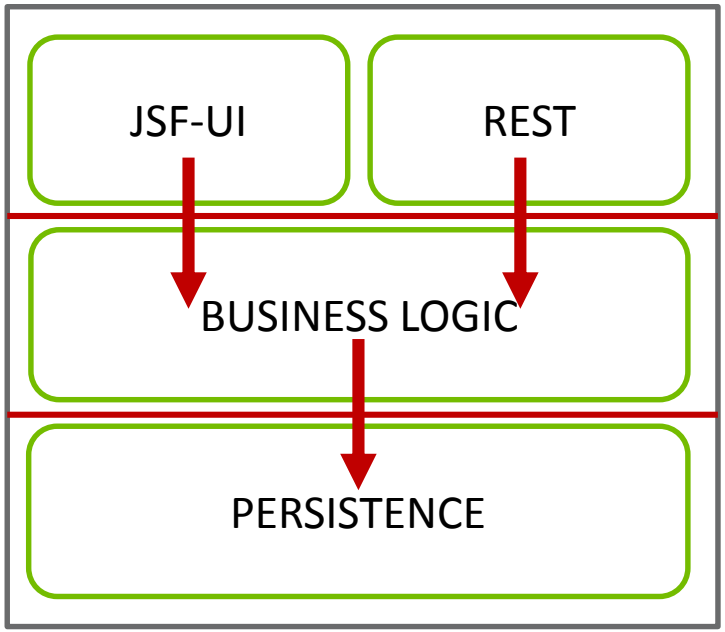
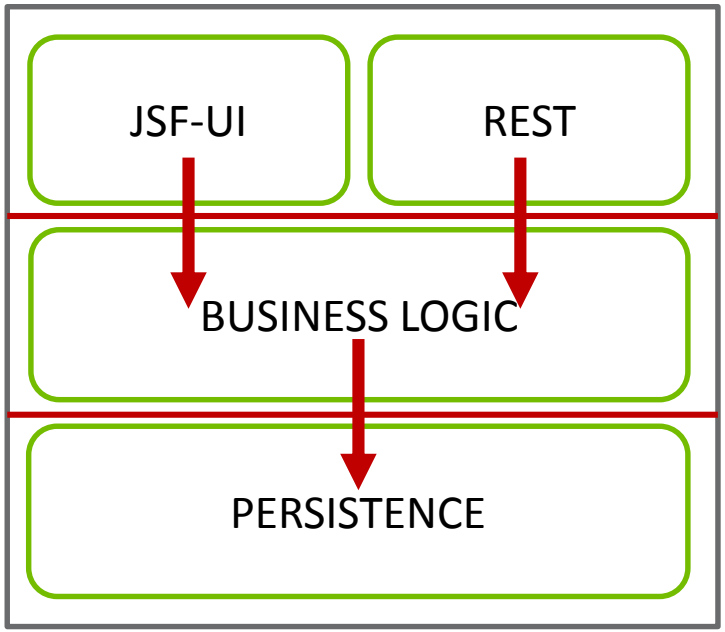


- Translation of architecture rules into the project structure
  - Definition/restriction of allowed dependencies?
  - Not (yet) supported by Java
  - Solution: using dependency managment of the build system, e.g. Maven



- Translation of architecture rules into the project structure
  - Definition of dependencies using the build system…
    - Lots of small modules
    - Lack of control (changes of build descriptors)
    - Unwanted transitive dependencies
    - No feedback to the developers, i.e. „You can‘t do that because…“



- Conventions, e.g. definition of naming rules, e.g.
  - Package names
    - api, spi, impl
  - Suffixes for JPA elements
    - *Entity, *Key
  - Suffixes for EJBs
    - *Bean, *MDB
- But how does all this work in practice?

- „Erosion“ starts at the first day of development!
  - Constantly increasing number of violations of conventions and constraints
  - Even with a one-man developer team…
- Common causes
  - Fast growing complexity of applications
  - Increasing amount and complexity of conventions and constraints
  - Project documentation is never up-to-date
  - Different skill level of developers
  - Different types of developers
  - Time pressure („Hacks“)
  - Broken windows

Exploration And Verification Of Java Applications

Using A Graph Database

Verification Of Conventions And Constraints

Validation Of Conventions And Constraints

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- Approach consisting of 3 steps

Validation Of Conventions And Constraints

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  - 1. Scan
    - Parsing of the application and storing as raw data in a database

Validation Of Conventions And Constraints

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- Approach consisting of 3 steps
  - 1. Scan
    - Parsing of the application and storing as raw data in a database
  - 2. Enhancement of raw data by CONCEPT queries
    - Labeling of nodes
      - Architectural concepts (e.g. modules, layers)
      - Design concepts (e.g. API vs. implementation)
      - Technical concepts (JPA Entities, EJBs, tests, etc.)
    - Adding relationships
      - class and package dependencies

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    - Adding relationships
      - class and package dependencies
  - 3. Execution of CONSTRAINT queries
    - Queries to detect violated rules (conventations and constraints)
      - API classes which depend on implementation classes
      - Message Driven Beans not having the name suffix MDB

Validation Of Conventions And Constraints

- Concept query: Labeling JPA entities

```
@Entity
public class Person { …
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Validation Of Conventions And Constraints

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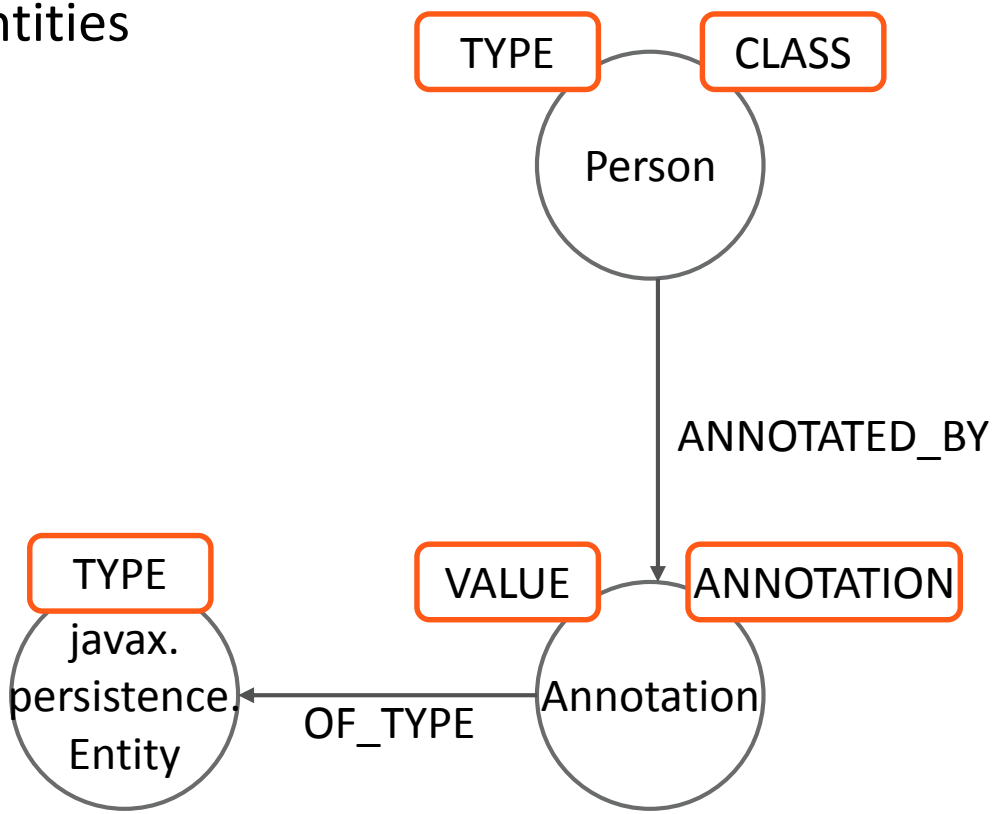

Validation Of Conventions And Constraints

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  (e:CLASS)-[:ANNOTATED_BY]->(a),
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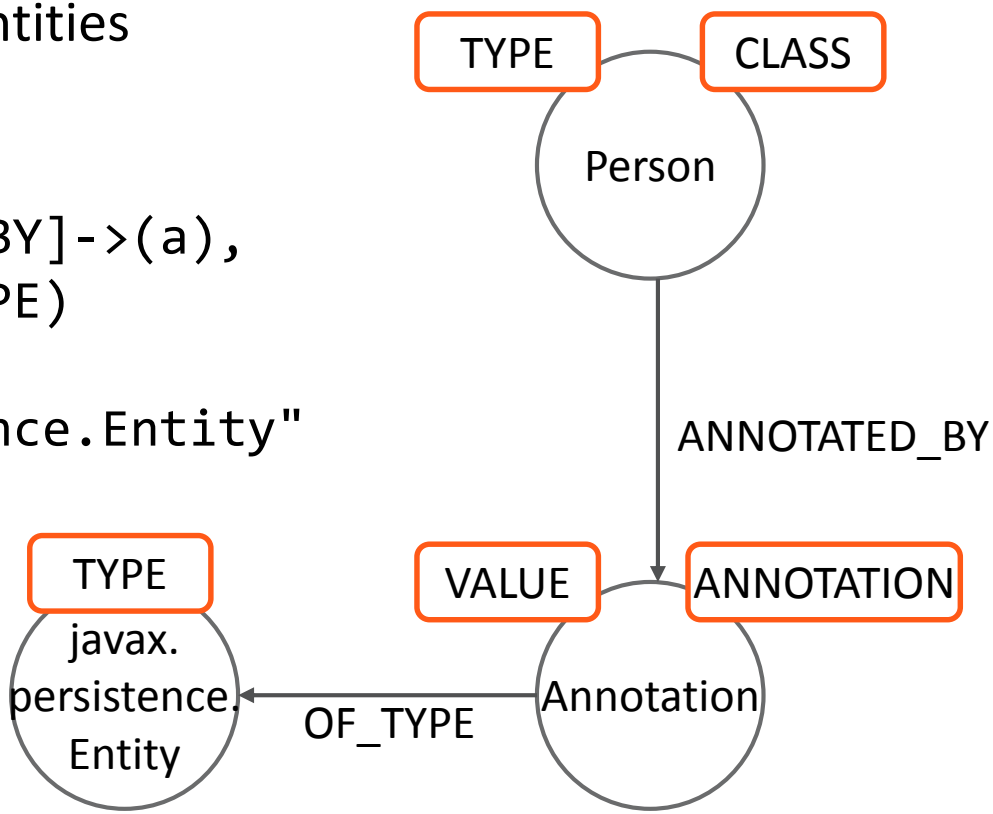
WHERE
  at.FQN="javax.persistence.Entity"
SET
  e:JPA:ENTITY
RETURN
  e.FQN as EntityName
```



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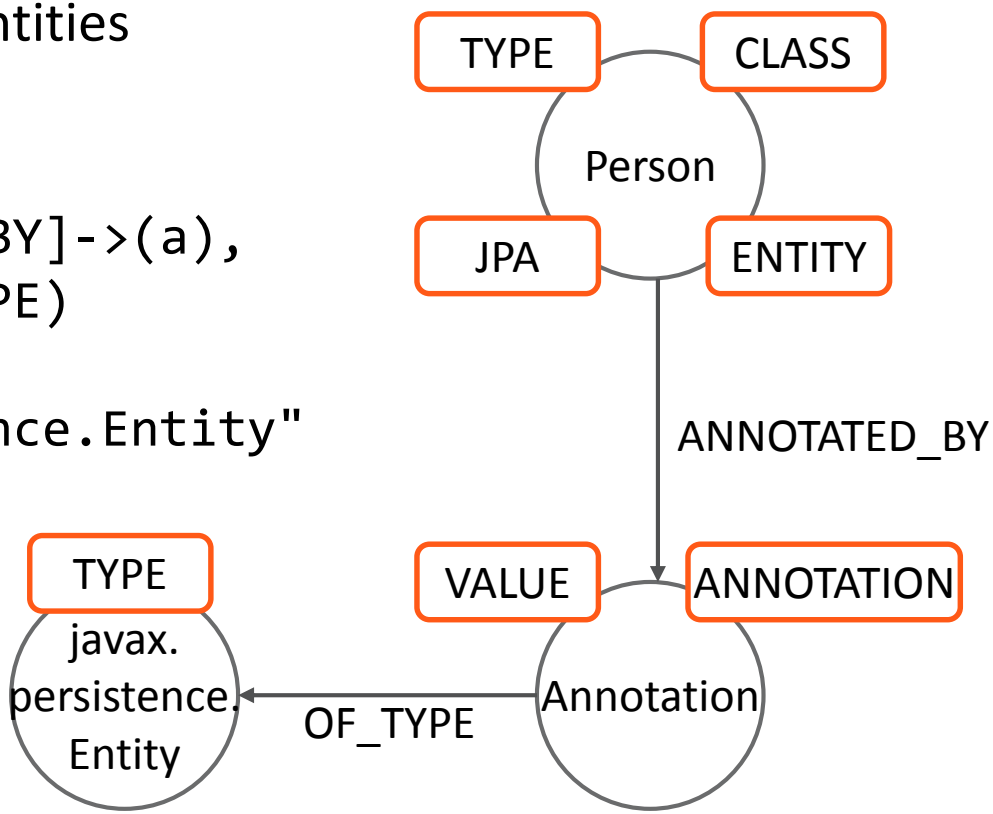

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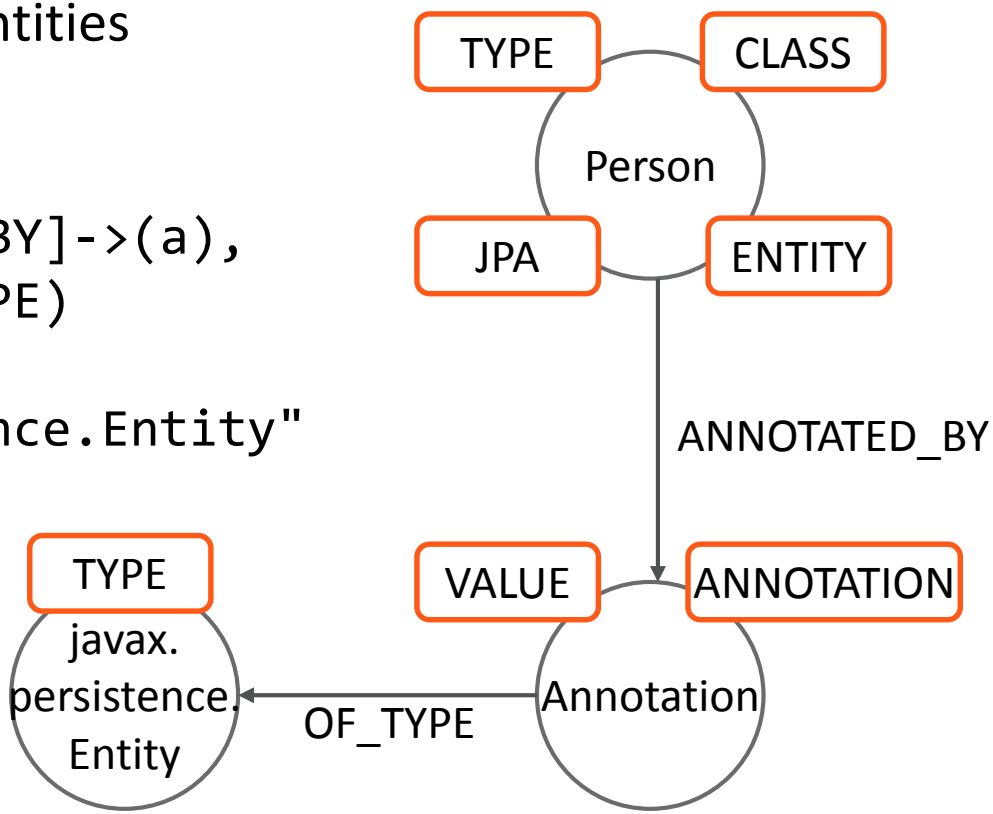

- A concept is **applicable** if its query returns a result

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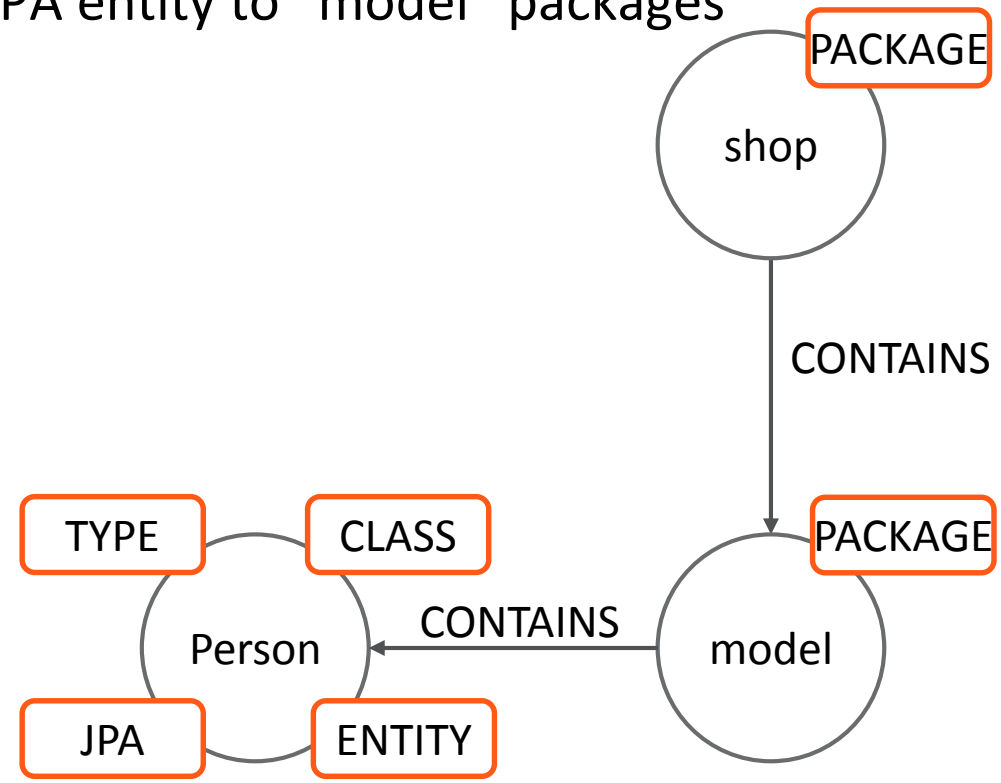

Validation Of Conventions And Constraints

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- Constraint query: Restrict JPA entity to “model” packages

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MATCH
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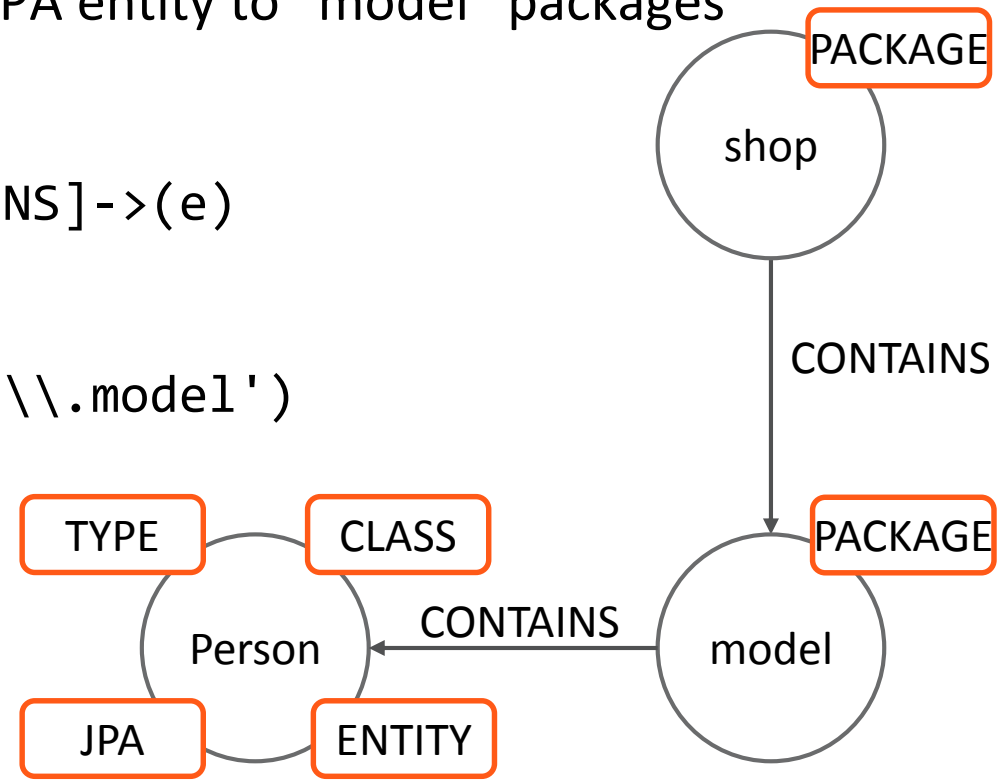

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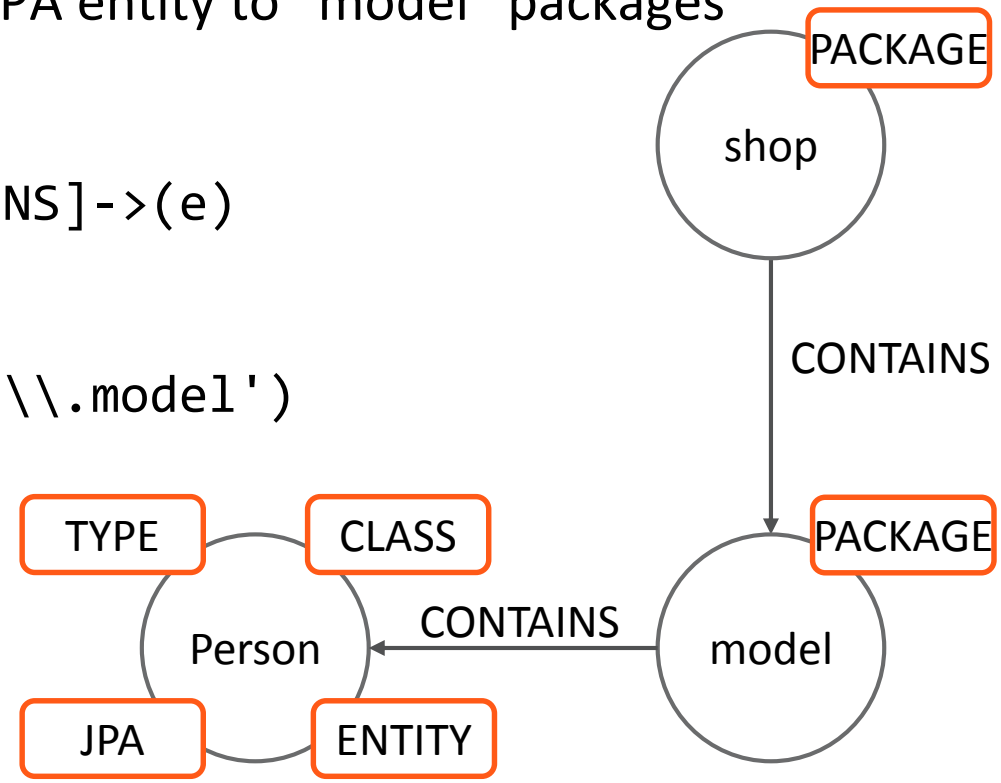

- A constraint is **violated** if its query returns a result

Validation Of Conventions And Constraints

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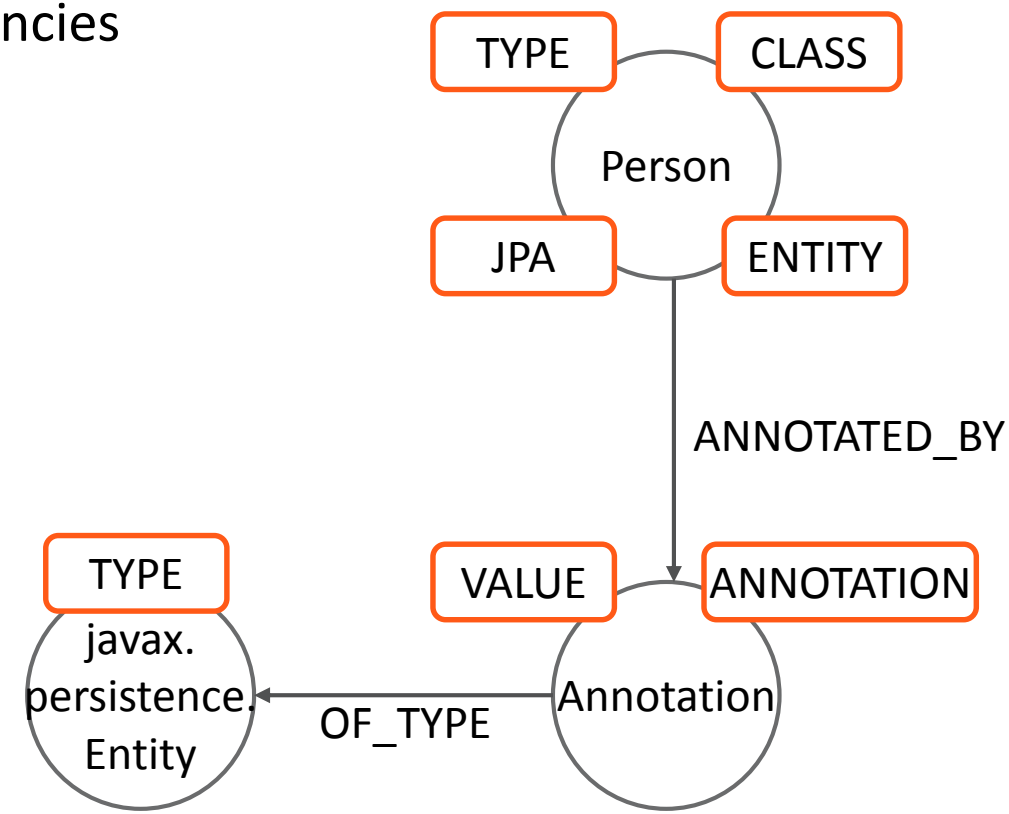
- Concept query: Type dependencies



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- Concept query: Type dependencies

```
MATCH
  (t:TYPE)-[:ANNOTATED_BY]->(a),
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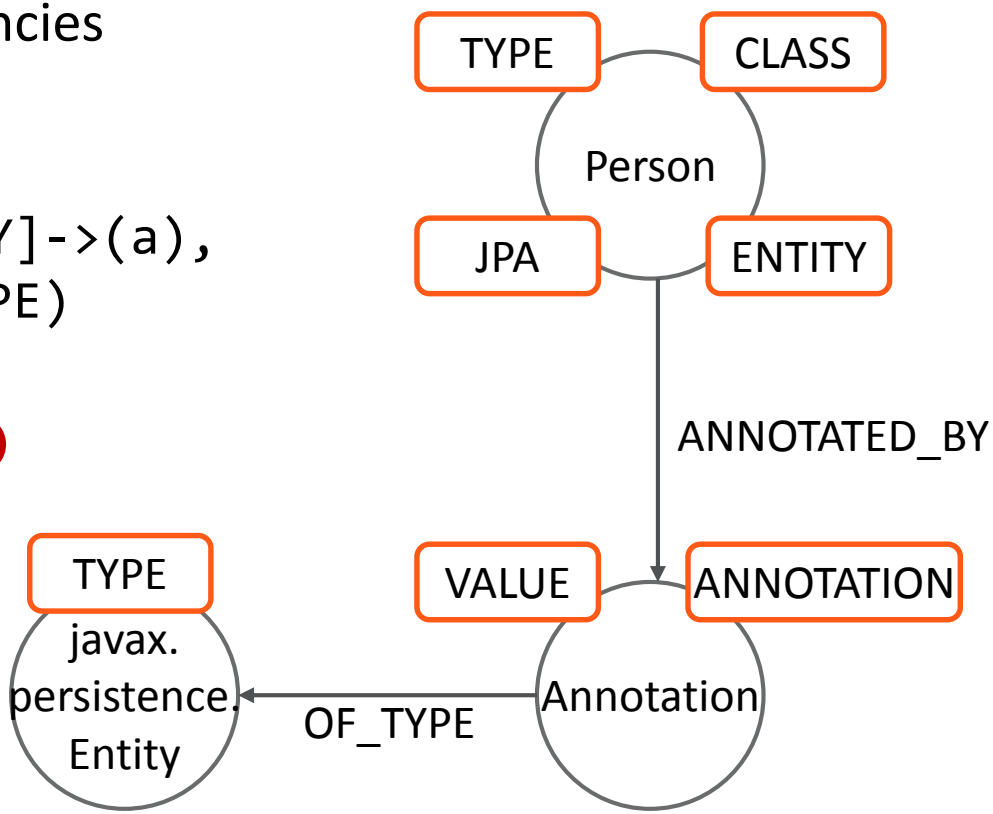
CREATE UNIQUE
  (t)-[:DEPENDS_ON]->(at)
RETURN
  count(t)
  as AnnotatedTypes
```



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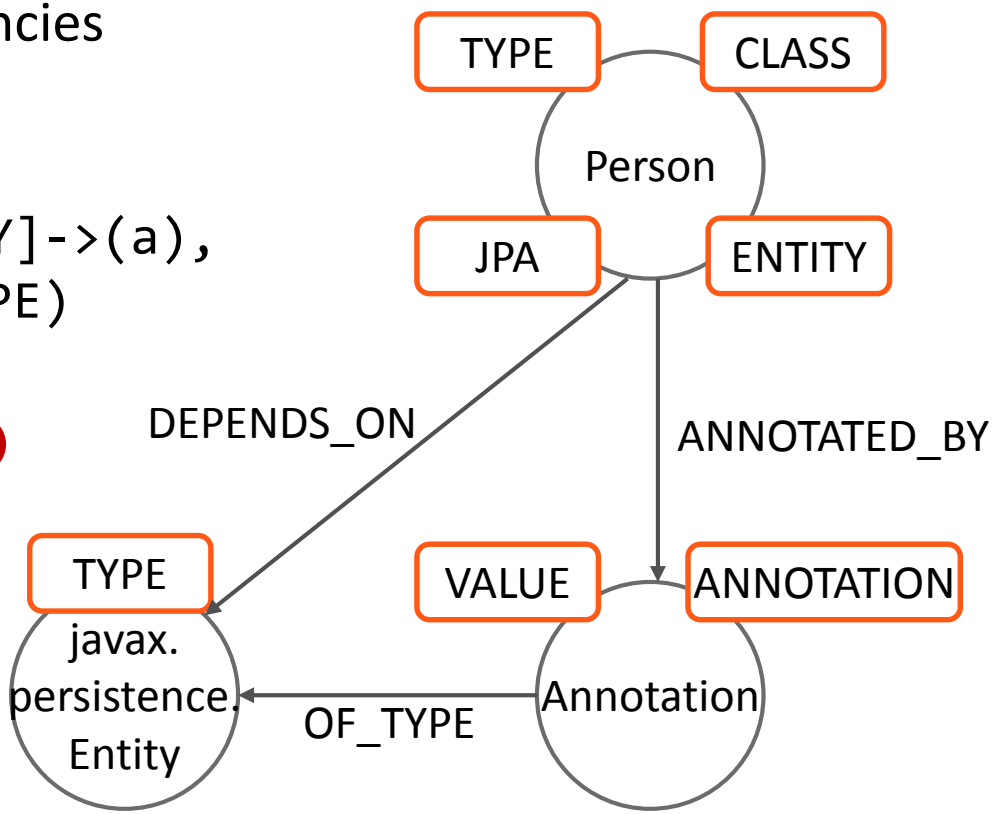

Exploration And Verification Of Java Applications
Using A Graph Database

- Homepage http://github.com/buschmais/jqassistant
- License: Apache Software License 2.0
- Milestone 1.0.0-M1
- Based on Neo4j (embedded)
- Tool for definition and validation of coding, design and architecture rules.
  - Scan of bytecode, property files, descriptors, etc.
  - Re-usable rules in XML descriptors
  - Cypher based queries
  - Reporting with comprehensive violation messages
- Integration in build process
  - Maven Plugin

- Rule definitions
  - Cypher queries specified in XML files…

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  - …in a project directory (project/jqassistant), or…

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  - …as part of plugins for re-usable rules
    - Technical concepts, e.g. JPA entities, EJBs, test classes and methods, etc.
    - Dependency concepts, e.g. class and package dependencies
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    - Technical concepts, e.g. JPA entities, EJBs, test classes and methods, etc.
    - Dependency concepts, e.g. class and package dependencies
    - Dependency constraints, e.g. cyclic package constraints
  - Rules can have dependencies on each other
    - e.g. concept package dependencies requires concept type (dependencies)
    - jQAssistant resolves correct order and executes only required rules

- Rule definitions: Concept

Rule definitions: Concept

```
<jqa:jqassistant-rules xmlns:jqa="...">

  <concept id="jpa2:Entity">
    <description>Labels all types annotated with
@javax.persistence.Entity with JPA and ENTITY.</description>
    <cypher><![CDATA[
      MATCH
        (t:TYPE)-[:ANNOTATED_BY]->()-[:OF_TYPE]->(a:TYPE)
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<jqa:jqassistant-rules xmlns:jqa="...">

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    <includeConstraint
      refId="abstractness:ApiMustNotDependOnImplementation"/>
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      refId="JpaEntitiesInModelPackage"/>
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      refId="EjbLocatedInImplementationPackage"/>
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- Maven goals
  - scan
    - Scan the byte code
  - available-rules
    - List all available rules
  - effective-rules
    - List all rules which would be applied in the current configuration
  - analyze
    - Execute analysis according to the effective rules
  - report
    - Creates a report for maven sites
  - server
    - Run the embedded Neo4j server

- Plugin based and extensible
  - jQAssistant is just a framework
  - Plugins provide scanner and rules
    - Java
      - class and property file scanner
      - dependency concepts and constraints (cycles)
    - JPA2
      - persistence descriptor scanner (persistence.xml)
      - JPA entity concept
    - EJB3
      - concepts for EJB types and interfaces (local, remote)
    - JUnit4
      - Test methods and classes
      - Ignored tests

Exploration And Verification Of Java Applications
Using A Graph Database

Live Demo #2

jQAssistant – Wishlist

- Plugins
  - More scanners
  - e.g. CDI
    - Scanner for beans.xml
    - Concepts for beans, injection points and producer, interceptors, delegates, …
  - Rules, rules, rules
    - Community?

jQAssistant – Wishlist

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- Visualization
  - Heat maps
    - e.g. dependencies of packages or modules
- Tool integration
  - Gradle
  - Jenkins
  - Sonar
  - Eclipse
    - „Manual“ query execution
    - On-The-Fly scan & analysis
- More documentation
  - Cook Books

More Information

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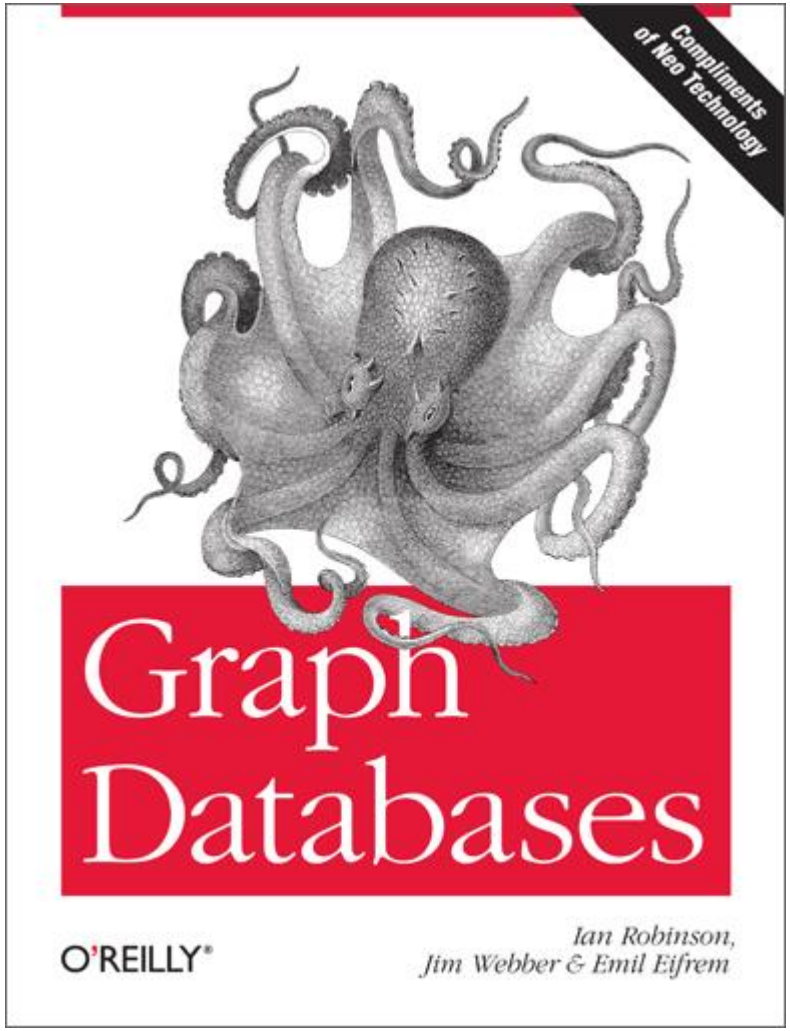
- 1 Day Workshop (03/04/2014)
  - Introduction Neo4j
  - Definining conventions and constraints for software projects
  - Integration of jQAssistant in the development process

- Neo4j
  - Tutorial (1 day workshop)
    - Data modelling, Cypher, use cases
  - Meetup
    - Community events for Neo4j users (beginners & professionals)
    - Discussion of use case scenarios, problems and solutions
    - Free pizza and beer!

More Information

- Graph Databases
  - Ian Robinson, Jim Webber, Emil Eifrem
  - O'Reilly Media
  - 1. Auflage
  - ISBN: 978-1449356262



More Information

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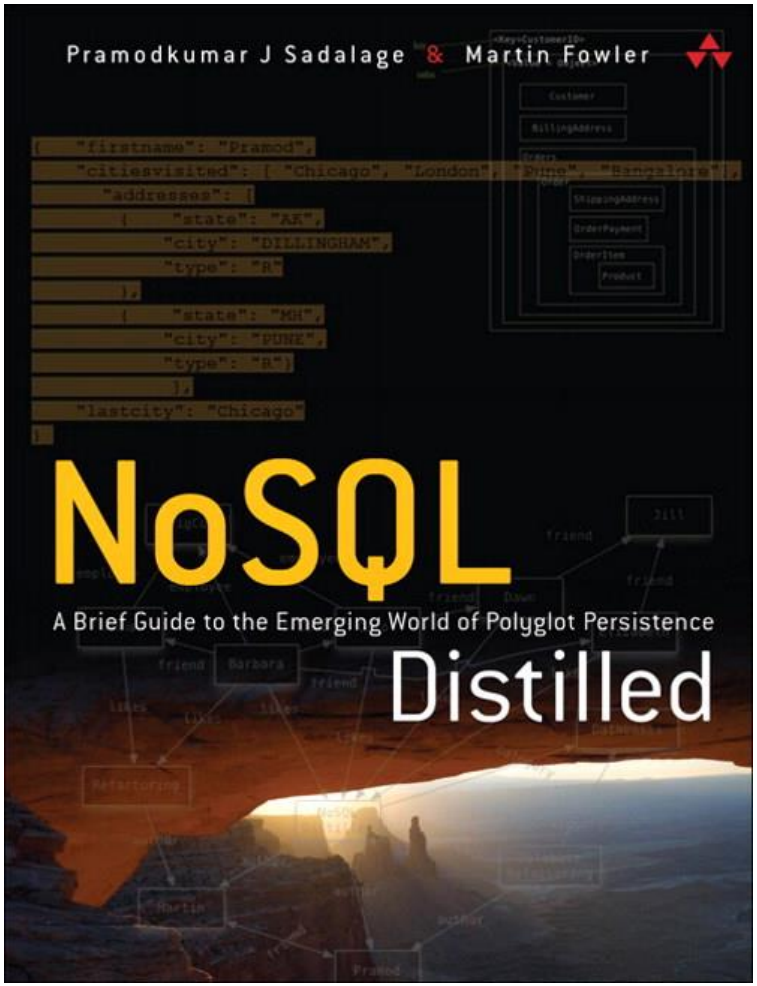
- NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence
  - Pramodkumar J. Sadalage, Martin Fowler
  - Addison-Wesley Longman
  - ISBN: 978-0321826626



More Information

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- Hypermodelling - Next Level Software Engineering with Data Warehouses

  http://accepted.hypermodelling.com/frey_magdeburg_dissertation_hypermodelling_2013.pdf

- Oliver Gierke: Ooops, where did my architecture go?

  http://www.slideshare.net/olivergierke/whoops-where-did-my-architecture-go-10414858

More Information

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- Raoul-Gabriel Urma: Expressive and Scalable Source Code Queries with Graph Databases [Paper]
  http://urma.com/pdf/oopsla13.pdf
- Pavlo Baron: Graphlr, a ANTLR storage in Neo4j
  http://github.com/pavlobaron/graphlr
- Michael Hunger: Class-Graph
  http://github.com/jexp/class-graph

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Vielen Dank! Thank you!

Questions?

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