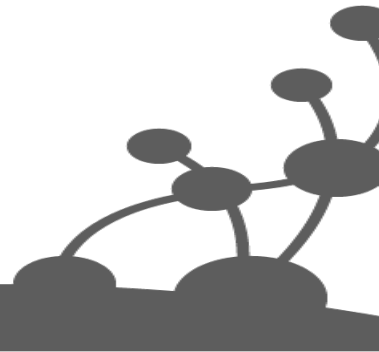
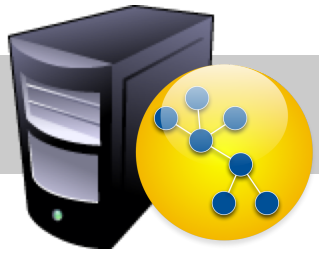
Test-Driven Data Modeling With Graphs

Twitter: @ianSrobinson

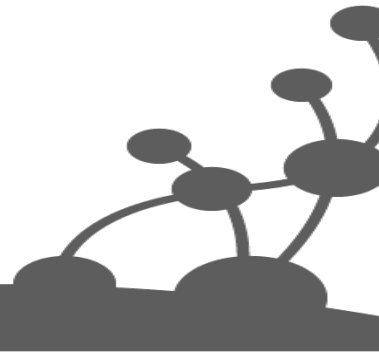
#neo4j



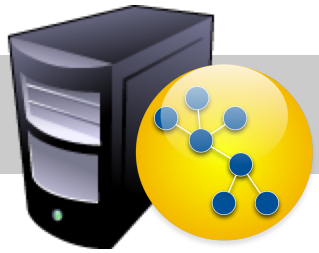
Outline



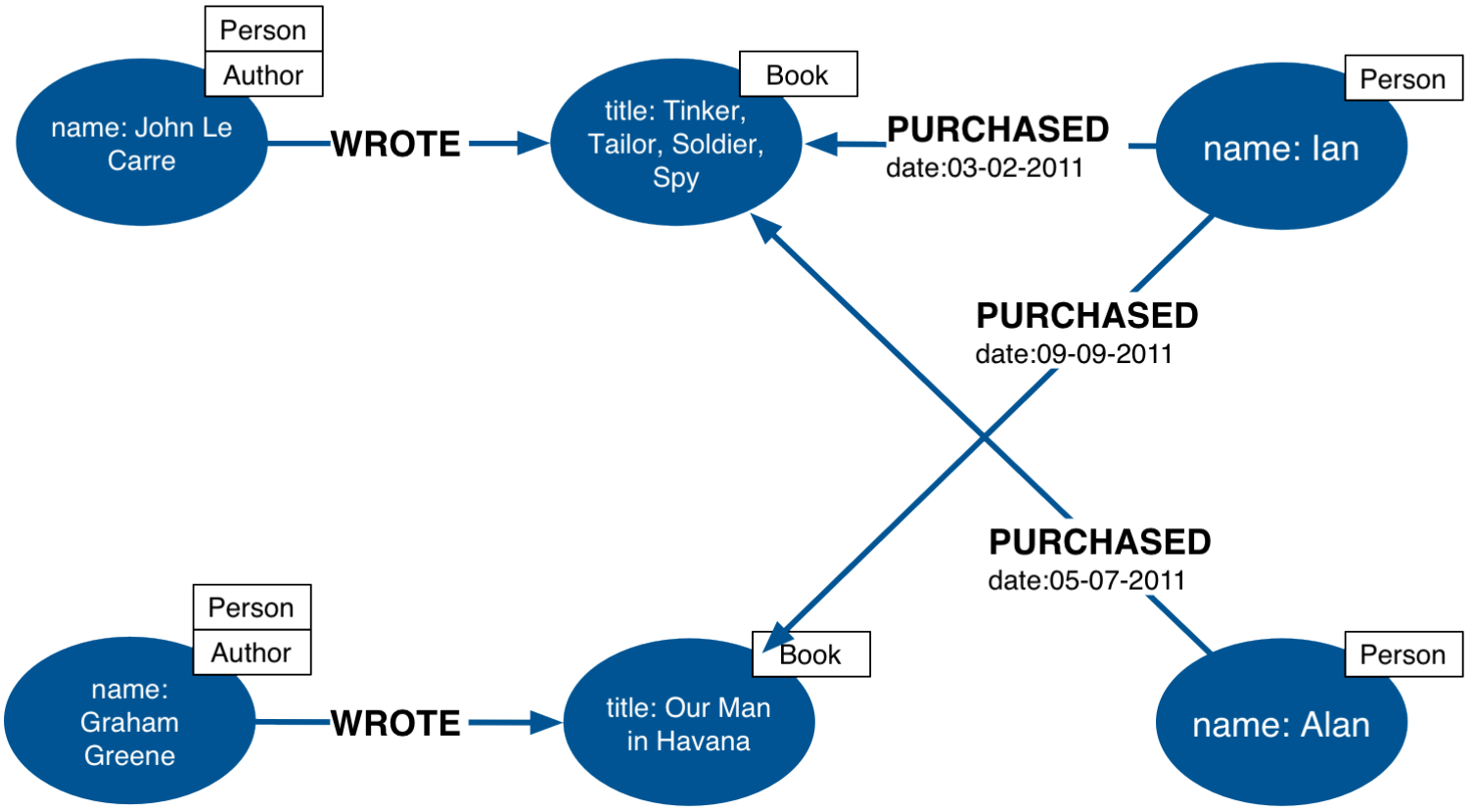
- Data modeling with graphs
- Neo4j application architecture options
- Testing your data model



Graph data modeling

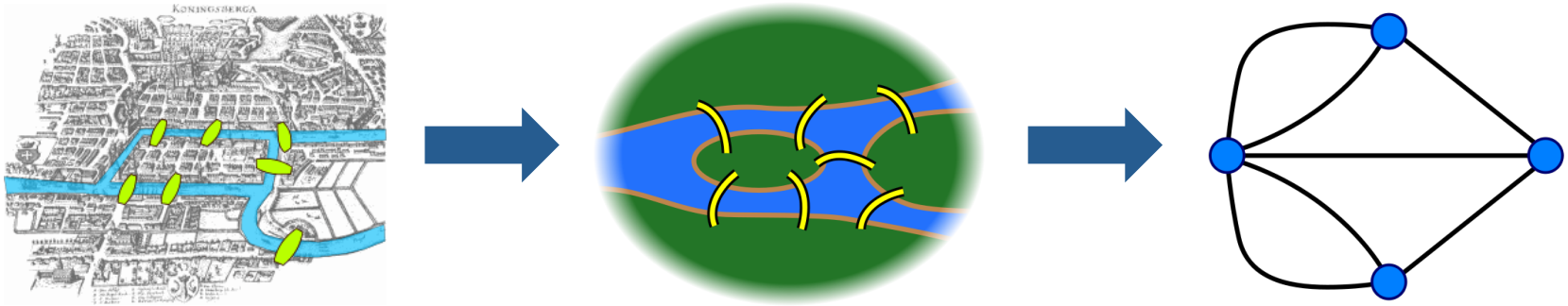


Labeled Property Graph



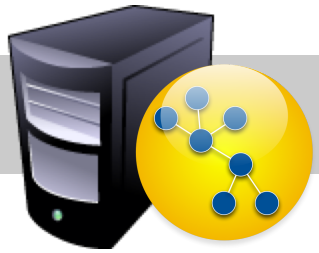
Models

Purposeful abstraction of a domain designed to satisfy particular application/end-user goals



Images: en.wikipedia.org

Example Application



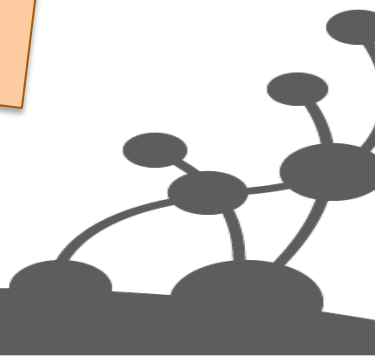
- Knowledge management
  - People, companies, skills
  - Cross organizational
- Find my professional social network
  - Exchange knowledge
  - Interest groups
  - Help
  - Staff projects

Application/End-User Goals

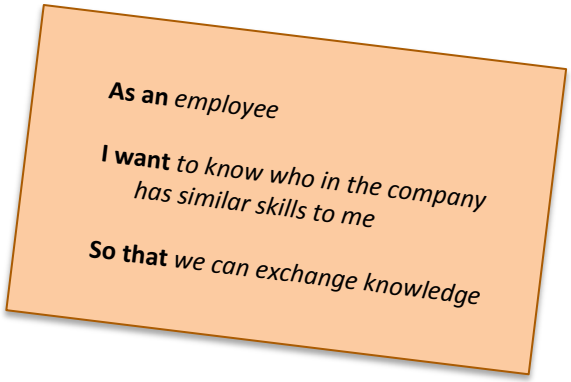
As an *employee*

I want *to know who in the company has similar skills to me*

So that *we can exchange knowledge*



Questions To Ask of the Domain



Which people, who work for the same company as me, have similar skills to me?

Identify Entities

Which people, who work for the same company as me, have similar skills to me?

Person

Company

Skill

Identify Relationships Between Entities

Which people, who work for the same company as me, have similar skills to me?

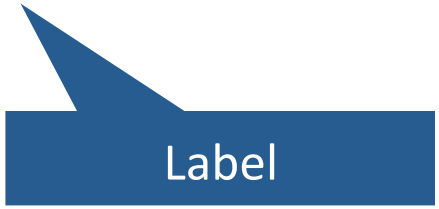
Person WORKS_FOR Company

Person HAS_SKILL Skill

Convert to Cypher Paths

Person WORKS_FOR Company

Person HAS_SKILL Skill

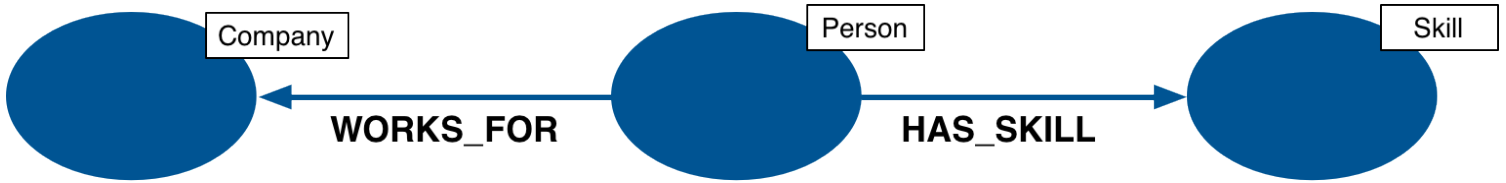


```
(:Person)-[:WORKS_FOR]->(:Company),
(:Person)-[:HAS_SKILL]->(:Skill)
```

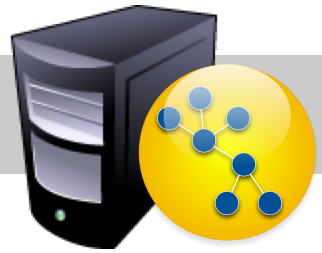
Consolidate Paths

```
(:Person)-[:WORKS_FOR]->(:Company),
(:Person)-[:HAS_SKILL]->(:Skill)
```

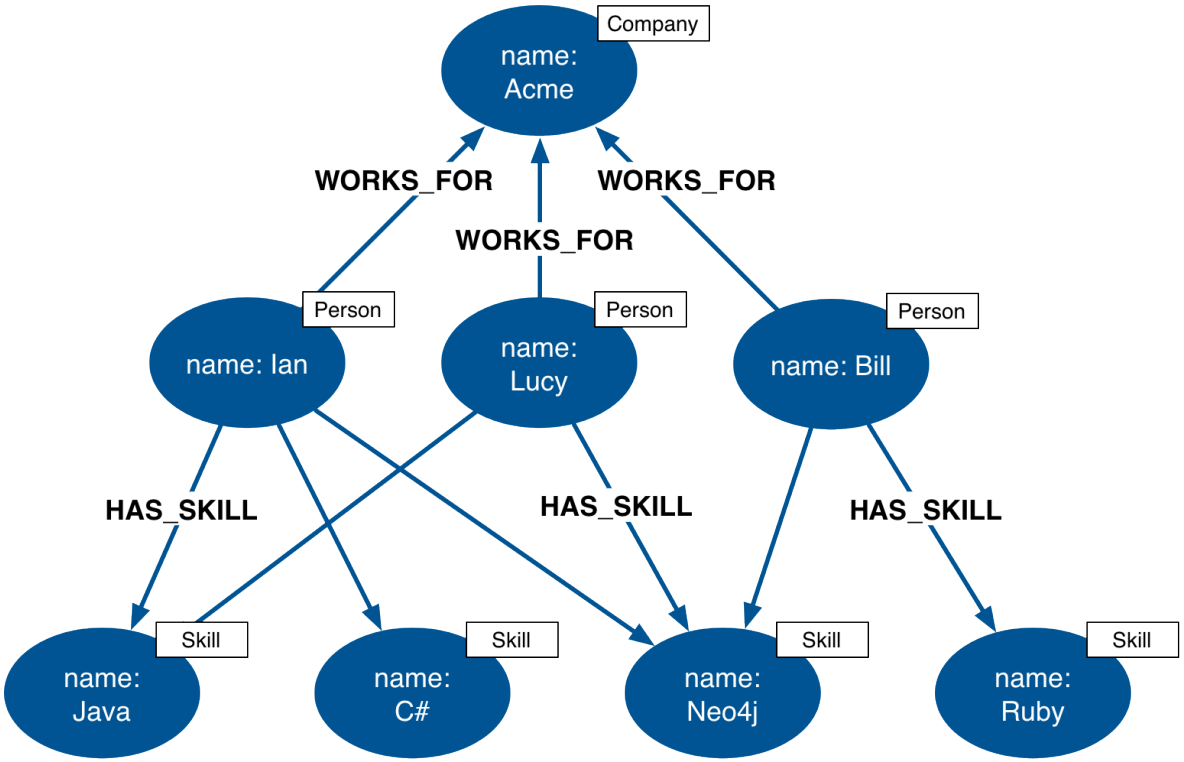
```
(:Company)<-[:WORKS_FOR]-(:Person)-[:HAS_SKILL]->(:Skill)
```



Candidate Data Model

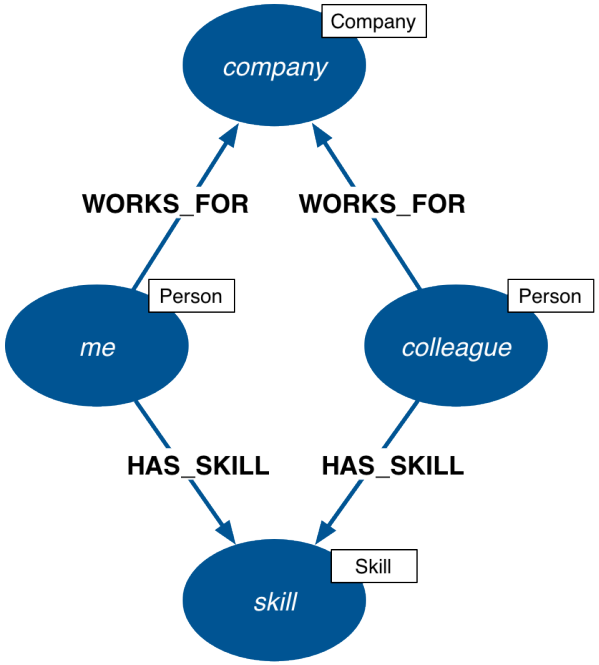


```
(:Company)<-[:WORKS_FOR]-(:Person)-[:HAS_SKILL]->(:Skill)
```

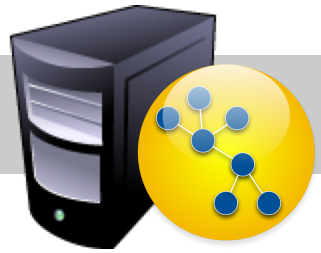


Express Question as Graph Pattern

Which people, who work for the same company as me, have similar skills to me?

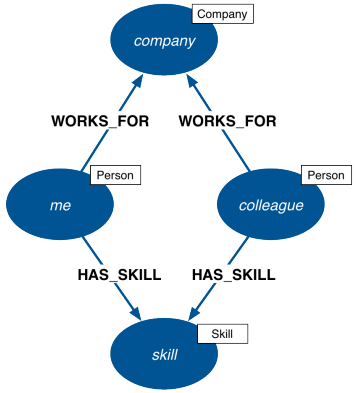


Cypher Query



Which people, who work for the same company as me, have similar skills to me?

```
MATCH (company)<-[:WORKS_FOR]-(me:Person)-[:HAS_SKILL]->(skill),
      (company)<-[:WORKS_FOR]-(colleague)-[:HAS_SKILL]->(skill)
WHERE  me.name = {name}
RETURN colleague.name AS name,
       count(skill) AS score,
       collect(skill.name) AS skills
ORDER BY score DESC
```



Graph Pattern

Which people, who work for the same company as me, have similar skills to me?

```
MATCH (company)<-[:WORKS_FOR]-(me:Person)-[:HAS_SKILL]->(skill),
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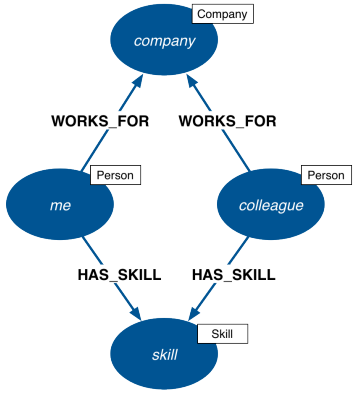
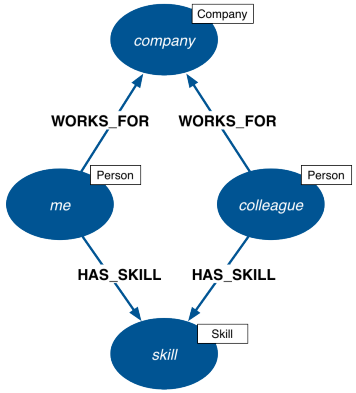


Anchor Pattern in Graph

Which people, who work for the same company as me, have similar skills to me?

```
MATCH (company)<-[:WORKS_FOR]-(me:Person)-[:HAS_SKILL]->(skill),
      (company)<-[:WORKS_FOR]-(colleague)-[:HAS_SKILL]->(skill)
WHERE  me.name = {name}
RETURN colleague.name AS name,
       count(skill) AS score,
       collect(skill.name) AS skills
ORDER BY score DE
```

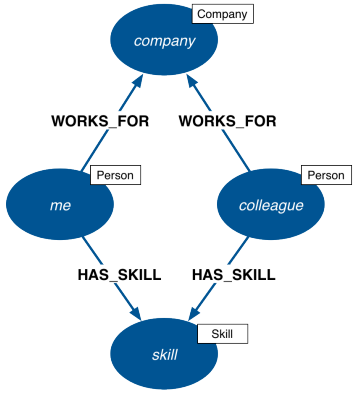
Search nodes labeled 'Person', matching on 'name' property



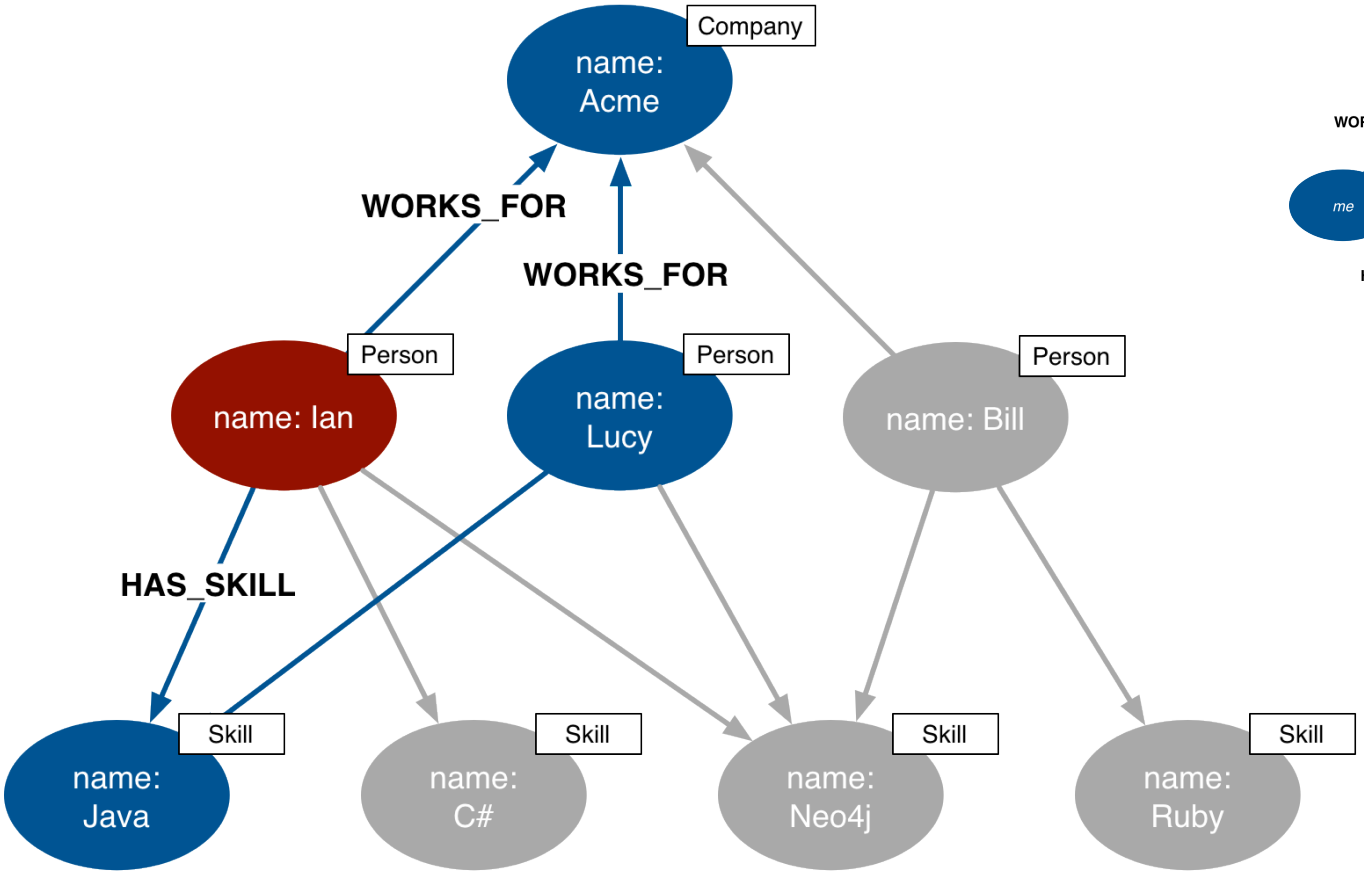
Create Projection of Results

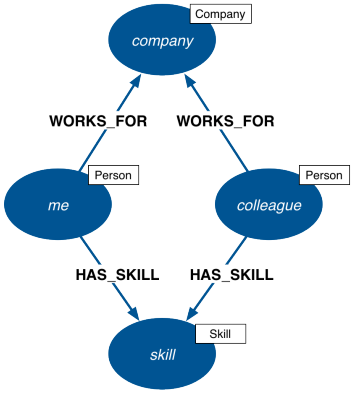
Which people, who work for the same company as me, have similar skills to me?

```
MATCH (company)<-[:WORKS_FOR]-(me:Person)-[:HAS_SKILL]->(skill),
      (company)<-[:WORKS_FOR]-(colleague)-[:HAS_SKILL]->(skill)
WHERE  me.name = {name}
RETURN colleague.name AS name,
       count(skill) AS score,
       collect(skill.name) AS skills
ORDER BY score DESC
```

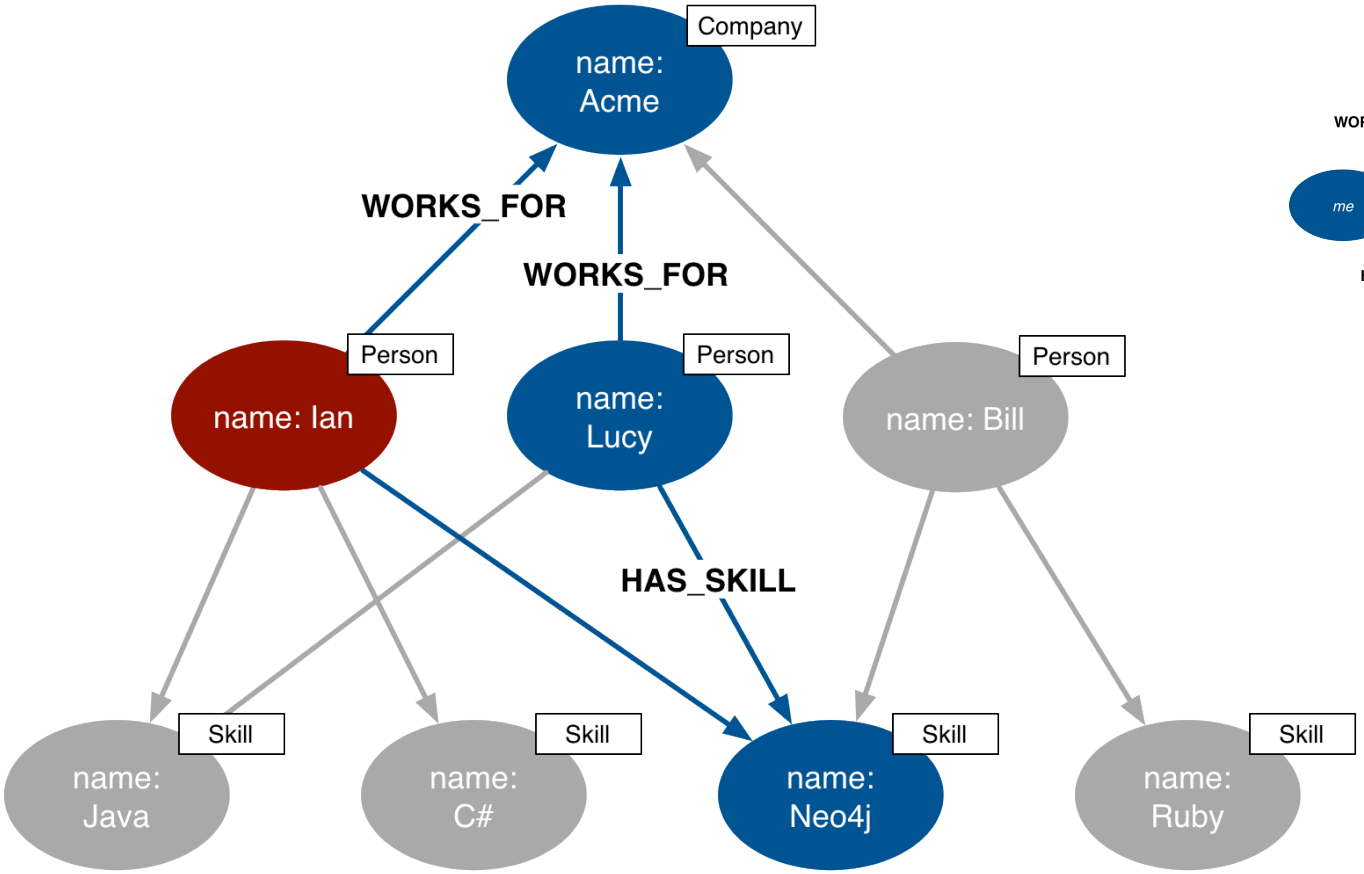


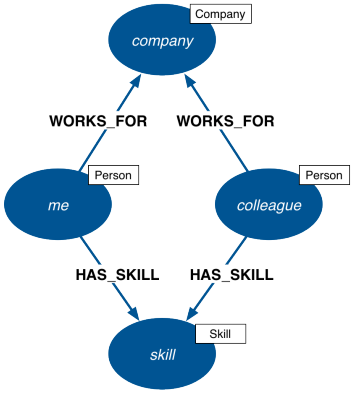
First Match


Company
name: Acme
WORKS_FOR
WORKS_FOR
Person
name: Ian
Person
name: Lucy
Person
name: Bill
HAS_SKILL
Skill
name: Java
Skill
name: C#
Skill
name: Neo4j
Skill
name: Ruby

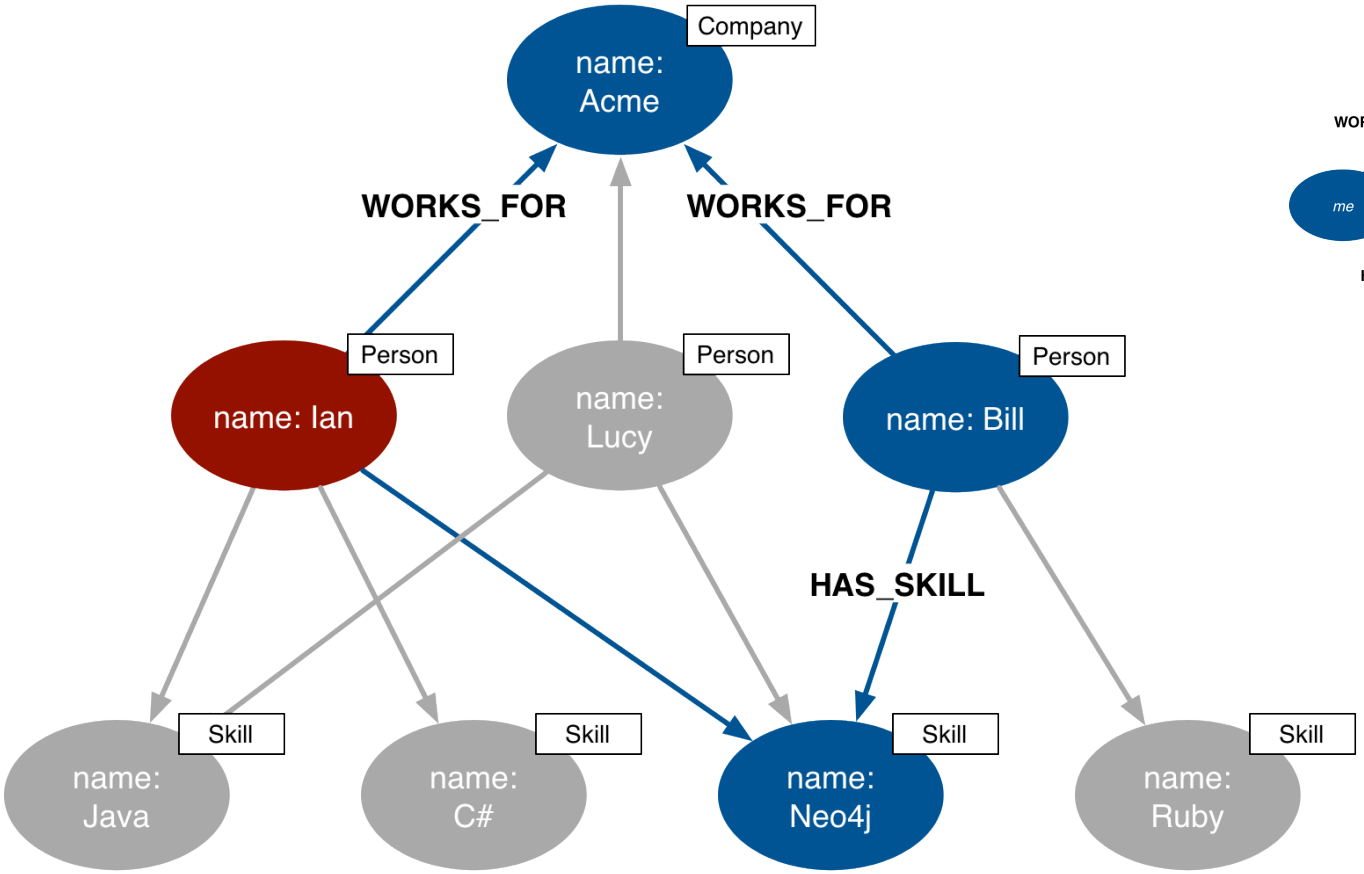

Company
company
WORKS_FOR
WORKS_FOR
Person
me
Person
colleague
HAS_SKILL
HAS_SKILL
Skill
skill

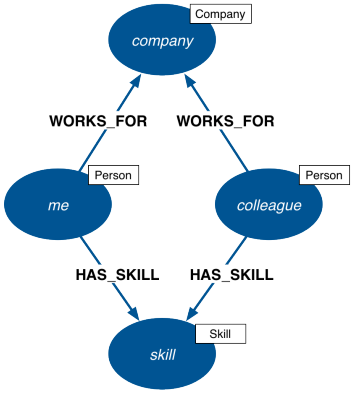
Second Match





Third Match


Company
name: Acme
WORKS_FOR
WORKS_FOR
Person
name: Ian
Person
name: Lucy
Person
name: Bill
HAS_SKILL
Skill
name: Java
Skill
name: C#
Skill
name: Neo4j
Skill
name: Ruby


Company
company
WORKS_FOR
WORKS_FOR
Person
me
Person
colleague
HAS_SKILL
HAS_SKILL
Skill
skill

Running the Query

```
+-----------------------------------+
| name    | score | skills          |
+-----------------------------------+
| "Lucy" | 2     | ["Java","Neo4j"] |
| "Bill" | 1     | ["Neo4j"]        |
+-----------------------------------+
2 rows
```

From User Story to Model and Query

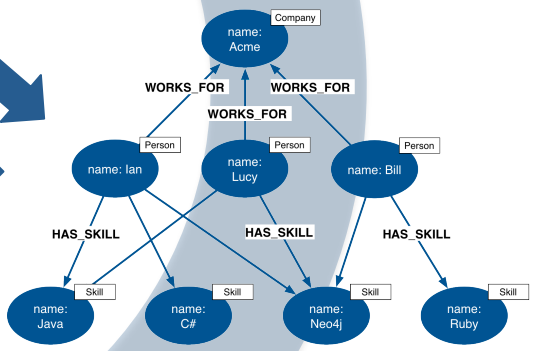
As an *employee*

I want *to know who in the company has similar skills to me*

So that *we can exchange knowledge*

```
MATCH (company)<-[:WORKS_FOR]-(me:Person)-[:HAS_SKILL]->(skill),
      (company)<-[:WORKS_FOR]-(colleague)-[:HAS_SKILL]->(skill)
WHERE  me.name = {name}
RETURN colleague.name AS name,
       count(skill) AS score,
       collect(skill.name) AS skills
ORDER BY score DESC
```

Which people, who work for the same company as me, have similar skills to me?

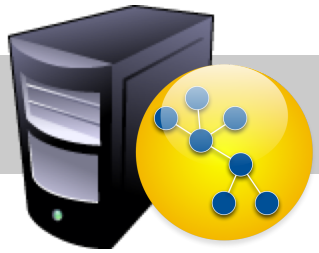


Person WORKS_FOR Company

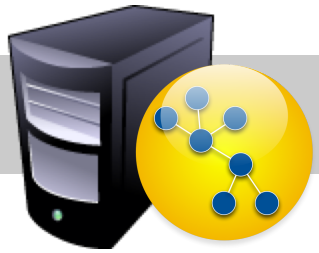
Person HAS_SKILL Skill

```
(:Company)<-[:WORKS_FOR]-(:Person)-[:HAS_SKILL]->(:Skill)
```

Testing

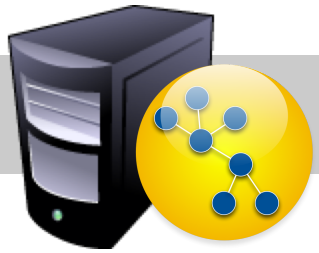


Why Test?



- Ensure model is fit for queries
  - Rapid feedback
- Ensure correctness of queries
- Document your understanding of your domain
  - Including corner cases and exceptions
- Provide a regression test suite
  - Allows you to change and evolve model and queries

Method



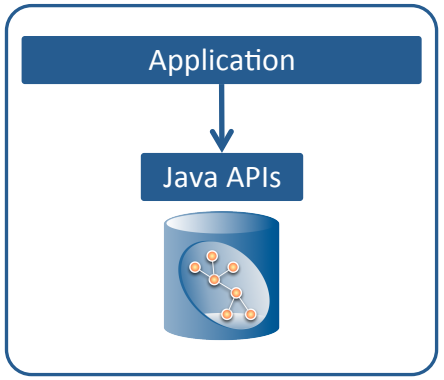
- Develop queries, or classes that encapsulate queries, using *unit tests*
- Use *small, well-understood* datasets in each test
  - Create data in test setup
  - Test dataset expresses your understanding of (part of) the domain
- Inject *in-memory graph database* (or Cypher engine) into object under test
- The exact strategy you use depends on your application architecture…

Application Architectures

- Embedded
- Server
- Server with Extensions

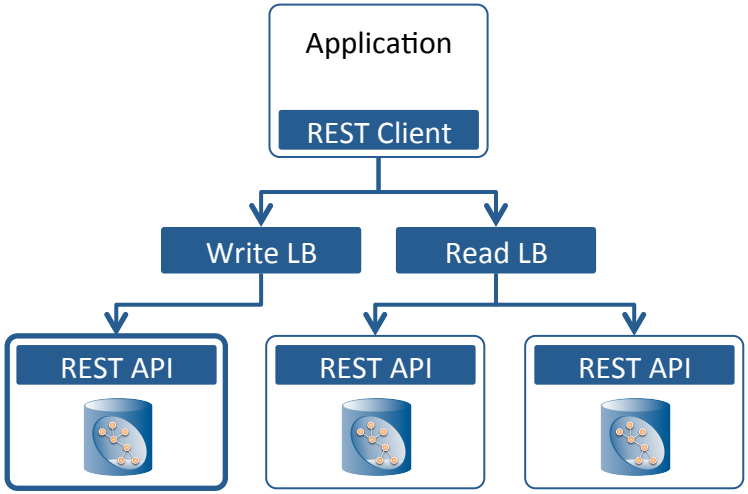
Application Architectures

- Embedded
  - Host in Java process
  - Access to Java APIs
- Server
- Server with Extensions



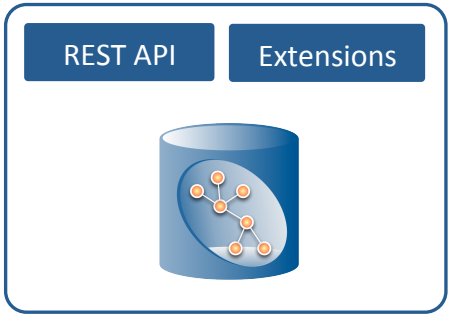
Application Architectures

- Embedded
- Server
  - HTTP/JSON interface
  - Server wraps embedded instance
- Server with Extensions

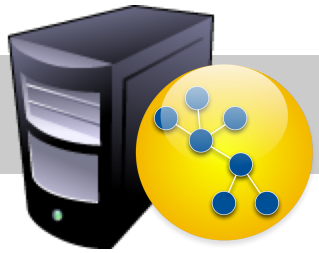


Application Architectures

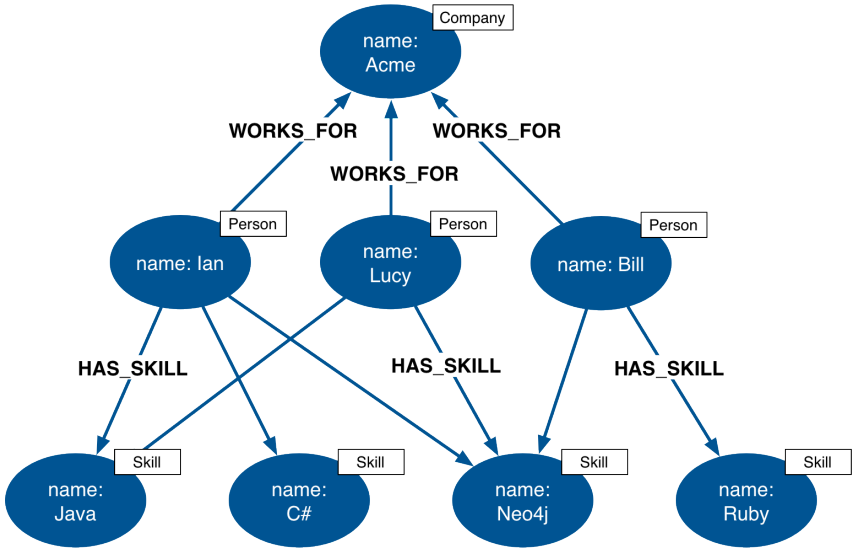
- Embedded
- Server
- Server with Extensions
  - Execute complex logic on server
  - Control HTTP request/response format



Embedded Example



- Company social network
- Find colleagues with similar skills
- Encapsulate query in a `ColleagueFinder`



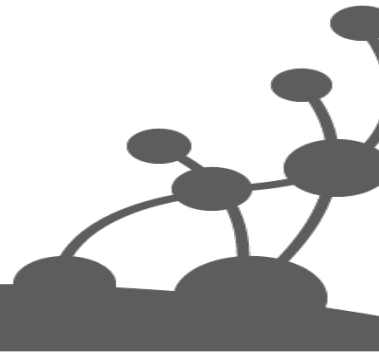
Unit Test Fixture

```
public class ColleagueFinderTest {

  private GraphDatabaseService db;
  private ColleagueFinder finder;

  @Before
  public void init() {
    db = new TestGraphDatabaseFactory().newImpermanentDatabase();
    ExampleGraph.populate( db );
    finder = new ColleagueFinder( new ExecutionEngine( db ) );
  }

  @After
  public void shutdown() {
    db.shutdown();
  }
}
```



Create Database

```
public class ColleagueFinderTest {

  private GraphDatabaseService db;
  private ColleagueFinder finder;

  @Before
  public void init() {
    db = new TestGraphDatabaseFactory().newImpermanentDatabase();
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  @After
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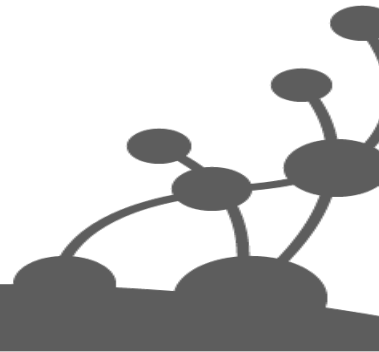


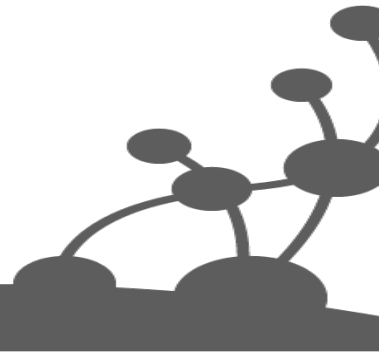
Populate Graph

```
public class ColleagueFinderTest {

  private GraphDatabaseService db;
  private ColleagueFinder finder;

  @Before
  public void init() {
    db = new TestGraphDatabaseFactory().newImpermanentDatabase();
    ExampleGraph.populate( db );
    finder = new ColleagueFinder( new ExecutionEngine( db ) );
  }

  @After
  public void shutdown() {
    db.shutdown();
  }
}
```



Create Object Under Test

```
public class ColleagueFinderTest {

  private GraphDatabaseService db;
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  @Before
  public void init() {
    db = new TestGraphDatabaseFactory().newImpermanentDatabase();
    ExampleGraph.populate( db );
    finder = new ColleagueFinder( new ExecutionEngine( db ) );
  }

  @After
  public void shutdown() {
    db.shutdown();
  }
}
```
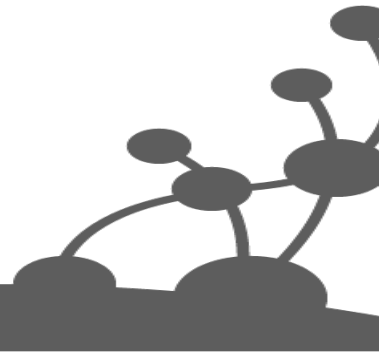

Inject ExecutionEngine



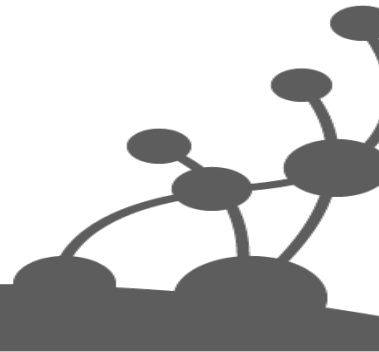
ImpermanentGraphDatabase

- In-memory
- For testing only, not production!

```
<dependency>
  <groupId>org.neo4j</groupId>
  <artifactId>neo4j-kernel</artifactId>
  <version>${project.version}</version>
  <type>test-jar</type>
  <scope>test</scope>
</dependency>
```

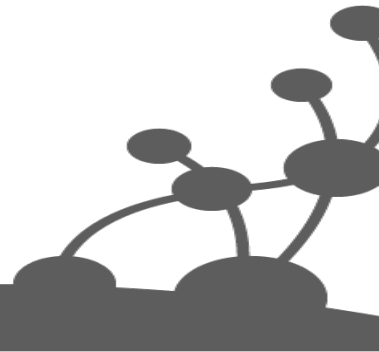
Create Sample Data

```
public static void populate( GraphDatabaseService db ) {

  ExecutionEngine engine = new ExecutionEngine( db );

  String cypher =
    "CREATE ian:Person VALUES {name:'Ian'},\n" +
    "       bill:Person VALUES {name:'Bill'},\n" +
    "       lucy:Person VALUES {name:'Lucy'},\n" +
    "       acme:Company VALUES {name:'Acme'},\n" +

      // Cypher continues...

    "       (bill)-[:HAS_SKILL]->(neo4j),\n" +
    "       (bill)-[:HAS_SKILL]->(ruby),\n" +
    "       (lucy)-[:HAS_SKILL]->(java),\n" +
    "       (lucy)-[:HAS_SKILL]->(neo4j)";

  engine.execute( cypher );
}
```



Unit Test

```
@Test
public void shouldFindColleaguesWithSimilarSkills() throws Exception {

  // when
  Iterator<Map<String, Object>> results = finder.findColleaguesFor( "Ian" );

  // then
  assertEquals( "Lucy", results.next().get( "name" ) );
  assertEquals( "Bill", results.next().get( "name" ) );

  assertFalse( results.hasNext() );
}
```

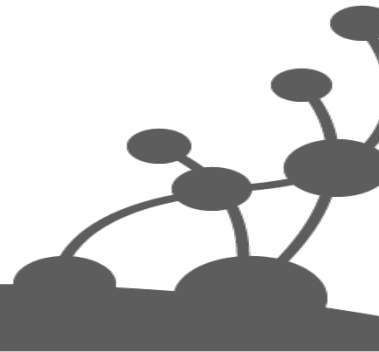


Execute Object Under Test

```
@Test
public void shouldFindColleaguesWithSimilarSkills() throws Exception {

  // when
  Iterator<Map<String, Object>> results = finder.findColleaguesFor( "Ian" );

  // then
  assertEquals( "Lucy", results.next().get( "name" ) );
  assertEquals( "Bill", results.next().get( "name" ) );

  assertFalse( results.hasNext() );
}
```

Assert Results

```
@Test
public void shouldFindColleaguesWithSimilarSkills() throws Exception {

  // when
  Iterator<Map<String, Object>> results = finder.findColleaguesFor( "Ian" );

  // then
  assertEquals( "Lucy", results.next().get( "name" ) );
  assertEquals( "Bill", results.next().get( "name" ) );

  assertFalse( results.hasNext() );
}
```

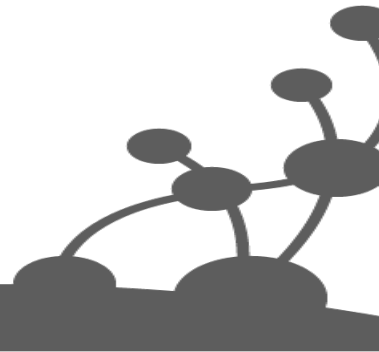


Ensure No More Results

```
@Test
public void shouldFindColleaguesWithSimilarSkills() throws Exception {

  // when
  Iterator<Map<String, Object>> results = finder.findColleaguesFor( "Ian" );

  // then
  assertEquals( "Lucy", results.next().get( "name" ) );
  assertEquals( "Bill", results.next().get( "name" ) );

  assertFalse( results.hasNext() );
}
```

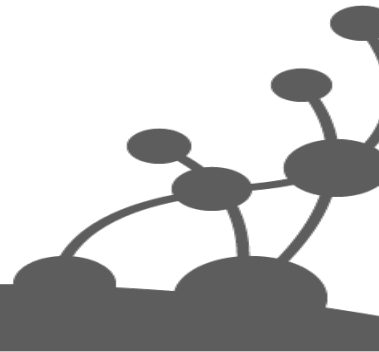
ColleagueFinder

```
public class ColleagueFinder {

  private final ExecutionEngine executionEngine;

  public ColleagueFinder( ExecutionEngine executionEngine ) {
      this.executionEngine = executionEngine;
  }

  public Iterator<Map<String, Object>> findColleaguesFor( String name ) {
      ...
  }
}
```



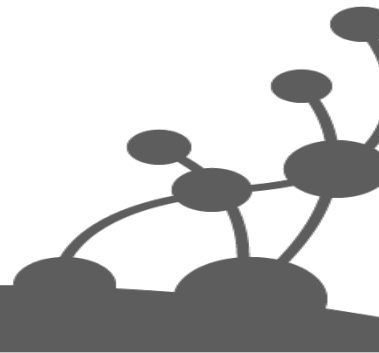
Inject ExecutionEngine

```
public class ColleagueFinder {

  private final ExecutionEngine executionEngine;

  public ColleagueFinder( ExecutionEngine executionEngine ) {
      this.executionEngine = executionEngine;
  }

  public Iterator<Map<String, Object>> findColleaguesFor( String name ) {
      ...
  }
}
```



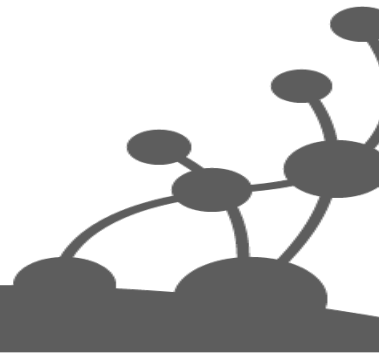
findColleaguesFor() Method

```
public Iterator<Map<String, Object>> findColleaguesFor( String name ) {

  String cypher =
    "MATCH (me:Person)-[:WORKS_FOR]->(company),\n" +
    "      (me)-[:HAS_SKILL]->(skill),\n" +
    "      (colleague)-[:WORKS_FOR]->(company),\n" +
    "      (colleague)-[:HAS_SKILL]->(skill)\n" +
    "WHERE  me.name = {name}\n" +
    "RETURN colleague.name AS name,\n" +
    "       count(skill) AS score,\n" +
    "       collect(skill.name) AS skills\n" +
    "ORDER BY score DESC";

  Map<String, Object> params = new HashMap<String, Object>();
  params.put( "name", name );

  return executionEngine.execute( cypher, params ).iterator();
}
```



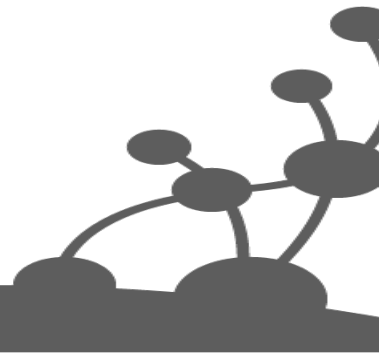
Cypher Query

```
public Iterator<Map<String, Object>> findColleaguesFor( String name ) {

  String cypher =
    "MATCH (me:Person)-[:WORKS_FOR]->(company),\n" +
    "      (me)-[:HAS_SKILL]->(skill),\n" +
    "      (colleague)-[:WORKS_FOR]->(company),\n" +
    "      (colleague)-[:HAS_SKILL]->(skill)\n" +
    "WHERE  me.name = {name}\n" +
    "RETURN colleague.name AS name,\n" +
    "       count(skill) AS score,\n" +
    "       collect(skill.name) AS skills\n" +
    "ORDER BY score DESC";

  Map<String, Object> params = new HashMap<String, Object>();
  params.put( "name", name );

  return executionEngine.execute( cypher, params ).iterator();
}
```



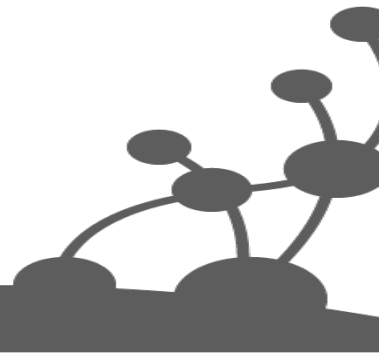
Parameterized Query

```
public Iterator<Map<String, Object>> findColleaguesFor( String name ) {

  String cypher =
    "MATCH (me:Person)-[:WORKS_FOR]->(company),\n" +
    "      (me)-[:HAS_SKILL]->(skill),\n" +
    "      (colleague)-[:WORKS_FOR]->(company),\n" +
    "      (colleague)-[:HAS_SKILL]->(skill)\n" +
    "WHERE  me.name = {name}\n" +
    "RETURN colleague.name AS name,\n" +
    "       count(skill) AS score,\n" +
    "       collect(skill.name) AS skills\n" +
    "ORDER BY score DESC";

  Map<String, Object> params = new HashMap<String, Object>();
  params.put( "name", name );

  return executionEngine.execute( cypher, params ).iterator();
}
```

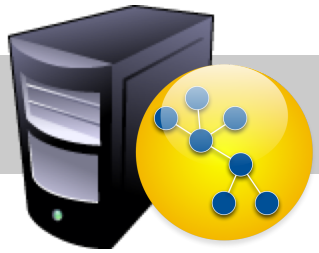


Execute Query

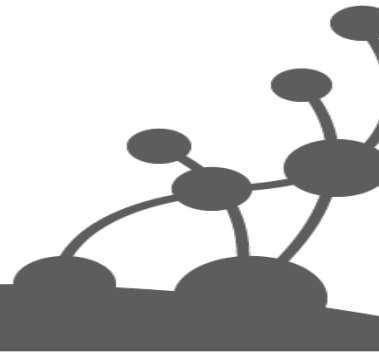
```
public Iterator<Map<String, Object>> findColleaguesFor( String name ) {

  String cypher =
    "MATCH (me:Person)-[:WORKS_FOR]->(company),\n" +
    "      (me)-[:HAS_SKILL]->(skill),\n" +
    "      (colleague)-[:WORKS_FOR]->(company),\n" +
    "      (colleague)-[:HAS_SKILL]->(skill)\n" +
    "WHERE  me.name = {name}\n" +
    "RETURN colleague.name AS name,\n" +
    "       count(skill) AS score,\n" +
    "       collect(skill.name) AS skills\n" +
    "ORDER BY score DESC";

  Map<String, Object> params = new HashMap<String, Object>();
  params.put( "name", name );

  return executionEngine.execute( cypher, params ).iterator();
}
```



Server Extension Example

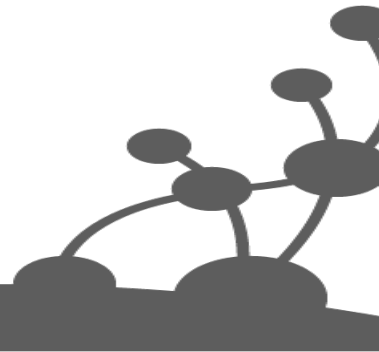


- Same data mode and query as before
- This time, we'll host `ColleagueFinder` in a server extension



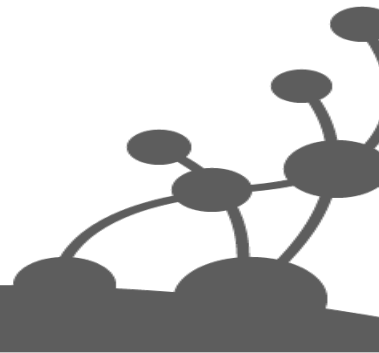
Server Extension

```
@Path("/similar-skills")
public class ColleagueFinderExtension {
  private static final ObjectMapper MAPPER = new ObjectMapper();
  private final ColleagueFinder colleagueFinder;

  public ColleagueFinderExtension( @Context CypherExecutor cypherExecutor ) {
    this.colleagueFinder = new ColleagueFinder( cypherExecutor.getExecutionEngine() );
  }

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  @Path("/{name}")
  public Response getColleagues( @PathParam("name") String name )
    throws IOException {

    String json = MAPPER
        .writeValueAsString( colleagueFinder.findColleaguesFor( name ) );
    return Response.ok().entity( json ).build();
  }
}
```



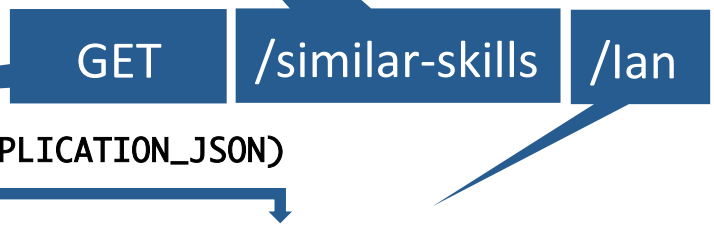
JAX-RS Annotations

```
@Path("/similar-skills")
public class ColleagueFinderExtension {
  private static final ObjectMapper MAPPER = new ObjectMapper();
  private final ColleagueFinder colleagueFinder;

  public ColleagueFinderExtension( @Context CypherExecutor cypherExecutor ) {
    this.colleagueFinder = new ColleagueFinder( cypherExecutor.getExecutionEngine() );
  }

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  @Path("/{name}")
  public Response getColleagues( @PathParam("name") String name )
    throws IOException {

    String json = MAPPER
        .writeValueAsString( colleagueFinder.findColleaguesFor( name ) );
    return Response.ok().entity( json ).build();
  }
}
```



Map HTTP Request to Object + Method

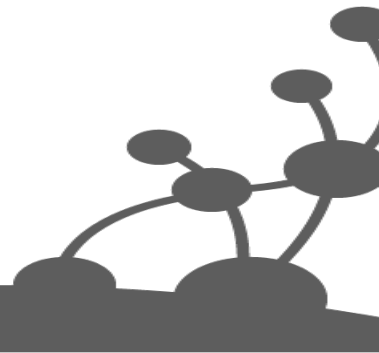
```
@Path("/similar-skills")
public class ColleagueFinderExtension {
  private static final ObjectMapper MAPPER = new ObjectMapper();
  private final ColleagueFinder colleagueFinder;

  public ColleagueFinderExtension( @Context CypherExecutor cypherExecutor ) {
    this.colleagueFinder = new ColleagueFinder( cypherExecutor.getExecutionEngine() );
  }

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  @Path("/{name}")
  public Response getColleagues( @PathParam("name") String name )
    throws IOException {

    String json = MAPPER
        .writeValueAsString( colleagueFinder.findColleaguesFor( name ) );
    return Response.ok().entity( json ).build();
  }
}
```



CypherExecutor Injected by Server

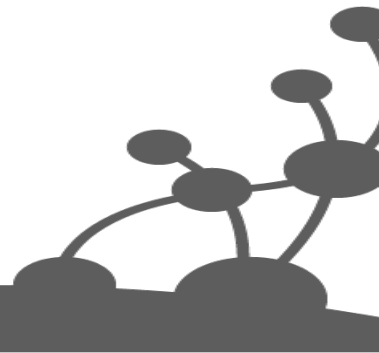
```
@Path("/similar-skills")
public class ColleagueFinderExtension {
  private static final ObjectMapper MAPPER = new ObjectMapper();
  private final ColleagueFinder colleagueFinder;

  public ColleagueFinderExtension( @Context CypherExecutor cypherExecutor ) {
    this.colleagueFinder = new ColleagueFinder( cypherExecutor.getExecutionEngine() );
  }

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  @Path("/{name}")
  public Response getColleagues( @PathParam("name") String name )
    throws IOException {

    String json = MAPPER
        .writeValueAsString( colleagueFinder.findColleaguesFor( name ) );
    return Response.ok().entity( json ).build();
  }
}
```

Ensures ExecutionEngine reused across resource instances



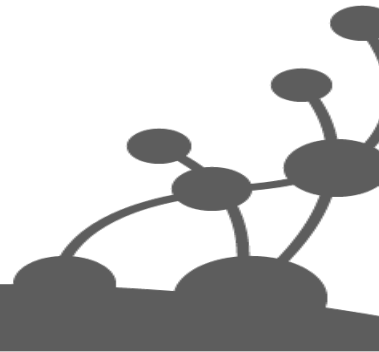
Generate and Format Response

```
@Path("/similar-skills")
public class ColleagueFinderExtension {
  private static final ObjectMapper MAPPER = new ObjectMapper();
  private final ColleagueFinder colleagueFinder;

  public ColleagueFinderExtension( @Context CypherExecutor cypherExecutor ) {
    this.colleagueFinder = new ColleagueFinder( cypherExecutor.getExecutionEngine() );
  }

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  @Path("/{name}")
  public Response getColleagues( @PathParam("name") String name )
    throws IOException {

    String json = MAPPER
        .writeValueAsString( colleagueFinder.findColleaguesFor( name ) );
    return Response.ok().entity( json ).build();
  }
}
```



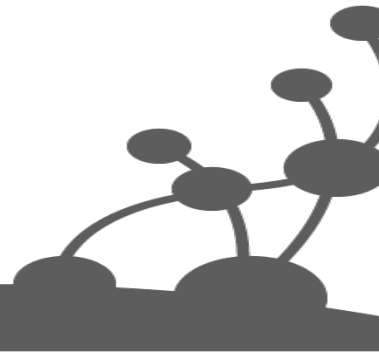
Extension Test Fixture

```
public class ColleagueFinderExtensionTest {
  private CommunityNeoServer server;

  @Before
  public void startServer() throws IOException
  {
    server = CommunityServerBuilder.server()
            .withThirdPartyJaxRsPackage(
                    "org.neo4j.good_practices", "/colleagues" )
            .build();
    server.start();

    ExampleGraph.populate( server.getDatabase().getGraph() );
  }

  @After
  public void stopServer() {
    server.stop();
  }
}
```



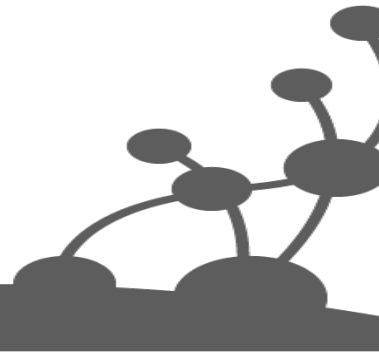
Build and Configure Server

```
public class ColleagueFinderExtensionTest {
  private CommunityNeoServer server;

  @Before
  public void startServer() throws IOException
  {
    server = CommunityServerBuilder.server()
            .withThirdPartyJaxRsPackage(
                    "org.neo4j.good_practices", "/colleagues" )
            .build();
    server.start();

    ExampleGraph.populate( server.getDatabase().getGraph() );
  }

  @After
  public void stopServer() {
    server.stop();
  }
}
```



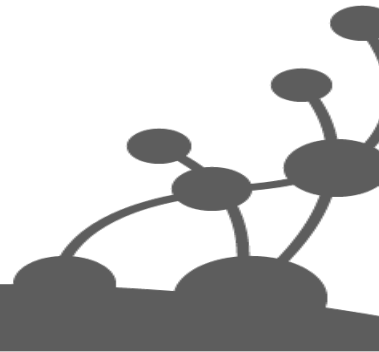
Start Server

```
public class ColleagueFinderExtensionTest {
  private CommunityNeoServer server;

  @Before
  public void startServer() throws IOException
  {
    server = CommunityServerBuilder.server()
            .withThirdPartyJaxRsPackage(
                    "org.neo4j.good_practices", "/colleagues" )
            .build();
    server.start();

    ExampleGraph.populate( server.getDatabase().getGraph() );
  }

  @After
  public void stopServer() {
    server.stop();
  }
}
```



Populate Database

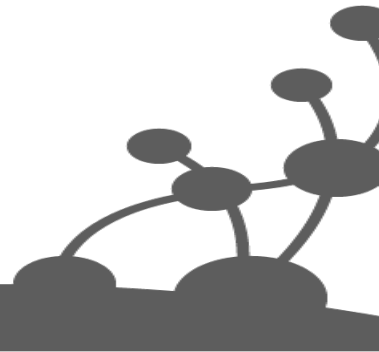
```
public class ColleagueFinderExtensionTest {
  private CommunityNeoServer server;

  @Before
  public void startServer() throws IOException
  {
    server = CommunityServerBuilder.server()
            .withThirdPartyJaxRsPackage(
                    "org.neo4j.good_practices", "/colleagues" )
            .build();
    server.start();

    ExampleGraph.populate( server.getDatabase().getGraph() );
  }

  @After
  public void stopServer() {
    server.stop();
  }
}
```



CommunityServerBuilder

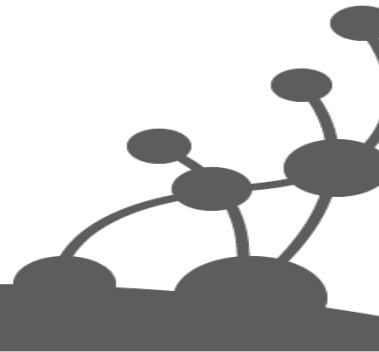
- Programmatic configuration

```
<dependency>
  <groupId>org.neo4j.app</groupId>
  <artifactId>neo4j-server</artifactId>
  <version>${project.version}</version>
  <type>test-jar</type>
</dependency>
```



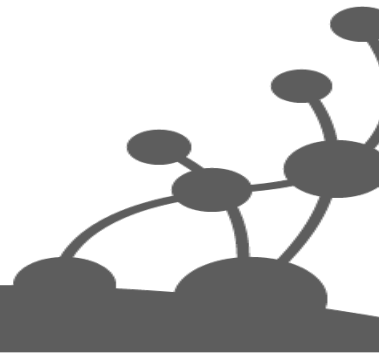
Testing Extension Using HTTP Client

```
@Test
public void shouldReturnColleaguesWithSimilarSkills() throws Exception {

  Client client = Client.create( new DefaultClientConfig() );

  WebResource resource = client
        .resource( "http://localhost:7474/colleagues/similar-skills/Ian" );

  ClientResponse response = resource
        .accept( MediaType.APPLICATION_JSON )
        .get( ClientResponse.class );

  List<Map<String, Object>> results = new ObjectMapper()
        .readValue(response.getEntity( String.class ), List.class );

  // Assertions

  ...
```



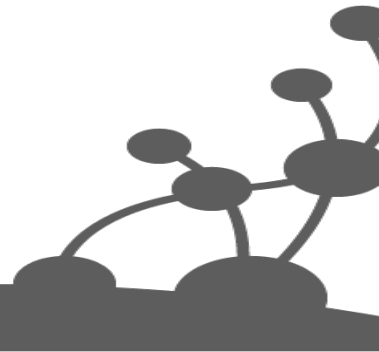
Create HTTP Client

```
@Test
public void shouldReturnColleaguesWithSimilarSkills() throws Exception {

  Client client = Client.create( new DefaultClientConfig() );

  WebResource resource = client
        .resource( "http://localhost:7474/colleagues/similar-skills/Ian" );

  ClientResponse response = resource
        .accept( MediaType.APPLICATION_JSON )
        .get( ClientResponse.class );

  List<Map<String, Object>> results = new ObjectMapper()
        .readValue(response.getEntity( String.class ), List.class );

  // Assertions

  ...
```



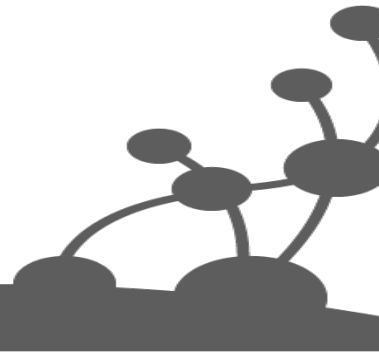
Issue Request

```
@Test
public void shouldReturnColleaguesWithSimilarSkills() throws Exception {

  Client client = Client.create( new DefaultClientConfig() );

  WebResource resource = client
        .resource( "http://localhost:7474/colleagues/similar-skills/Ian" );

  ClientResponse response = resource
        .accept( MediaType.APPLICATION_JSON )
        .get( ClientResponse.class );

  List<Map<String, Object>> results = new ObjectMapper()
        .readValue(response.getEntity( String.class ), List.class );

  // Assertions

  ...
```



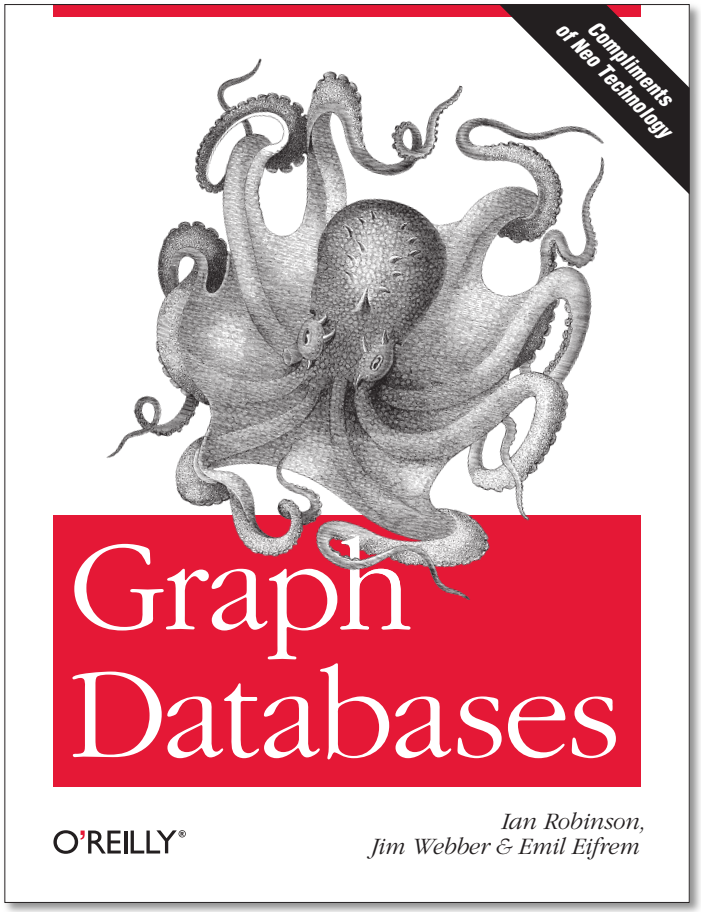
Parse Response

```
@Test
public void shouldReturnColleaguesWithSimilarSkills() throws Exception {

  Client client = Client.create( new DefaultClientConfig() );

  WebResource resource = client
        .resource( "http://localhost:7474/colleagues/similar-skills/Ian" );

  ClientResponse response = resource
        .accept( MediaType.APPLICATION_JSON )
        .get( ClientResponse.class );

  List<Map<String, Object>> results = new ObjectMapper()
        .readValue(response.getEntity( String.class ), List.class );

  // Assertions

  ...
```



Assert Results

```
  ...

  assertEquals( 200, response.getStatus() );
  assertEquals( MediaType.APPLICATION_JSON,
                response.getHeaders().get( "Content-Type" ).get( 0 ) );

  assertEquals( "Lucy", results.get( 0 ).get( "name" ) );
  assertThat( (Iterable<String>) results.get( 0 ).get( "skills" ),
              hasItems( "Java", "Neo4j" ) );
}
```



Thank you

Twitter: @ianSrobinson
#neo4j

github.com/iansrobinson/neo4j-good-practices