What is this thing called Linked Data?

Part II - Hands-on session

Manuel Atencia, Jérôme David and Philippe Genoud

DocEng 2015, September 8, Lausanne, Switzerland

Hands-on session

- Part I: From an Excel data file to linked open data
  - you will learn how to
    - create "cool" URIs
    - describe things with RDF
    - make links to other datasets
  - we will use the OpenRefine tool + RDF extension
- Part II: Querying linked data with SPARQL
  - you will learn how to make queries with SPARQL
  - we will use Apache Jena - ARQ command line applications

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Part I: 14:00 – 15:30
Coffee break: 15:30 – 16:00
Part II: 16:00 – 17:30

Hands-on session

Introduction
Case study: **Artemis Bookstore**

- Artemis owns a bookstore. She has heard of the Linked Data technologies, but she is not fully convinced of the benefits of using these technologies.
- Artemis has provided you with a sample of her data in an Excel file: `artemisBookstoreData.xlsx`

- Let's convince Artemis to join Linked Open Data!

Artemis Bookstore

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Hands-on session (I)

Artemis' bookstore data

- Let's have a look at `artemisBookstoreData.xlsx`
- There are two kinds of data: authors and books

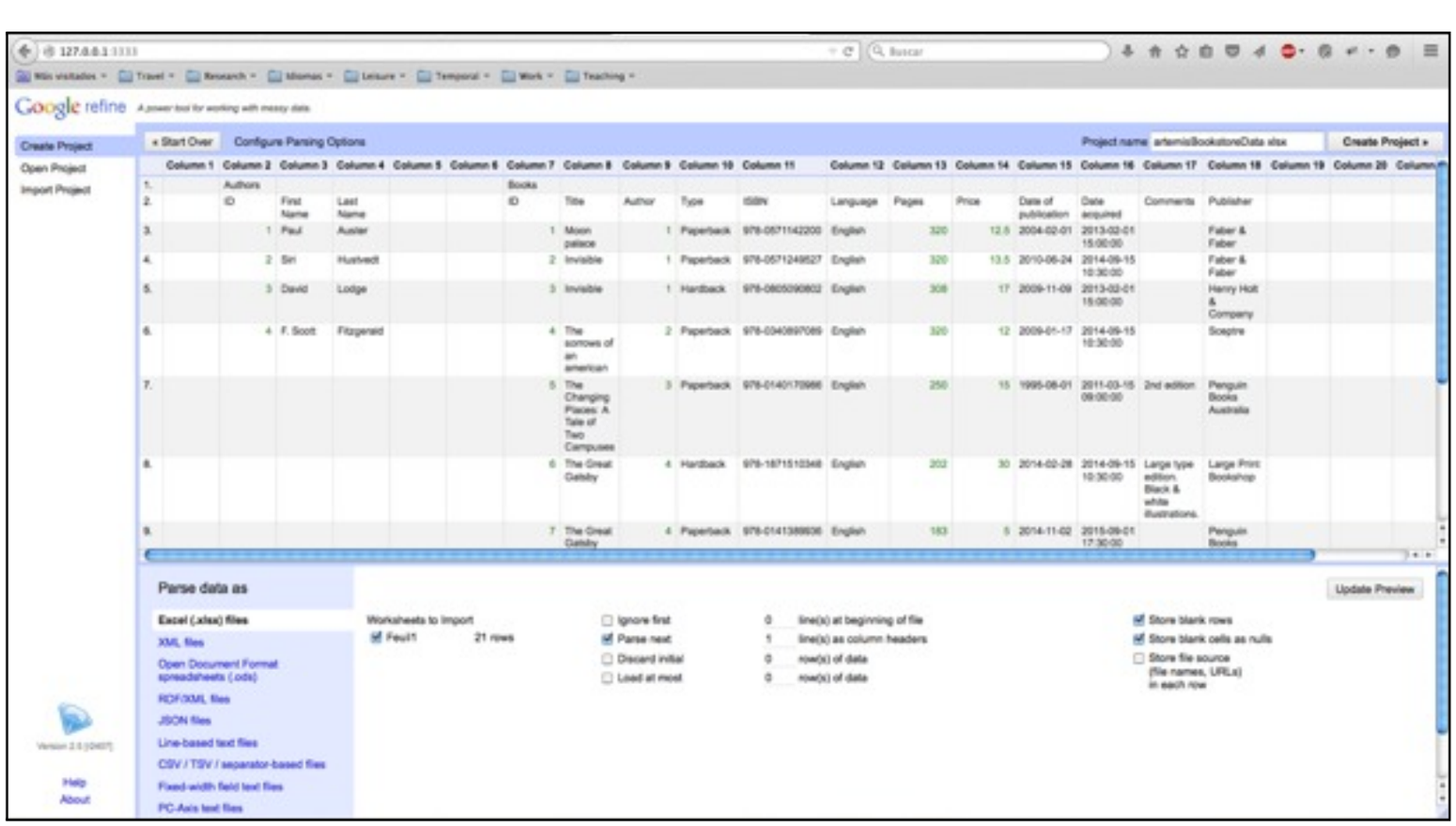
Authors		
ID	First Name	Last Name
1	Paul	Auster
2	Siri	Hustvedt
3	David	Lodge
4	F. Scott	Fitzgerald

Authors have an ID, a first name and a second name. Books have an ID, a title, author(s), a type, an ISBN, a language, pages, a price, a date of publication, a date of acquirement, comments and a publisher

Books											
ID	Title	Author	Type	ISBN	Language	Pages	Price	Date of publication	Date acquired	Comments	Publisher
1	Moon palace	1	Paperback	571142200	English	320	12.5	2004-02-01	2013-02-01 15:00:00		Faber & Faber
2	Invisible	1	Paperback	571249527	English	320	13.5	2010-06-24	2014-09-15 10:30:00		Faber & Faber
3	Invisible	1	Hardback	805090802	English	308	17	2009-11-09	2013-02-01 15:00:00		Henry Holt & Company
4	The sorrows of an american	2	Paperback	340897089	English	320	12	2009-01-17	2014-09-15 10:30:00		Sceptre
5	The Changing Places: A Tale	3	Paperback	140170986	English	250	15	1995-08-01	2011-03-15 09:00:00	2nd edition	Penguin Books Australia
6	The Great Gatsby	4	Hardback	1871510348	English	202	30	2014-02-28	2014-09-15 10:30:00	Large type e	Large Print Bookshop
7	The Great Gatsby	4	Paperback	141389936	English	183	5	2014-11-02	2015-09-01 17:30:00		Penguin Books
8	The Great Gatsby	4	Hardback	1857150193	English	176	15	1991-09-26	2011-03-15 09:00:00		Everyman's library

Hands-on session (I)

- Our goal is to convert Artemis' raw data into linked open data and for this we will use OpenRefine tool and its RDF extension developed by DERI
- Open OpenRefine and create a new project by uploading `artemisBookstoreData.xlsx`

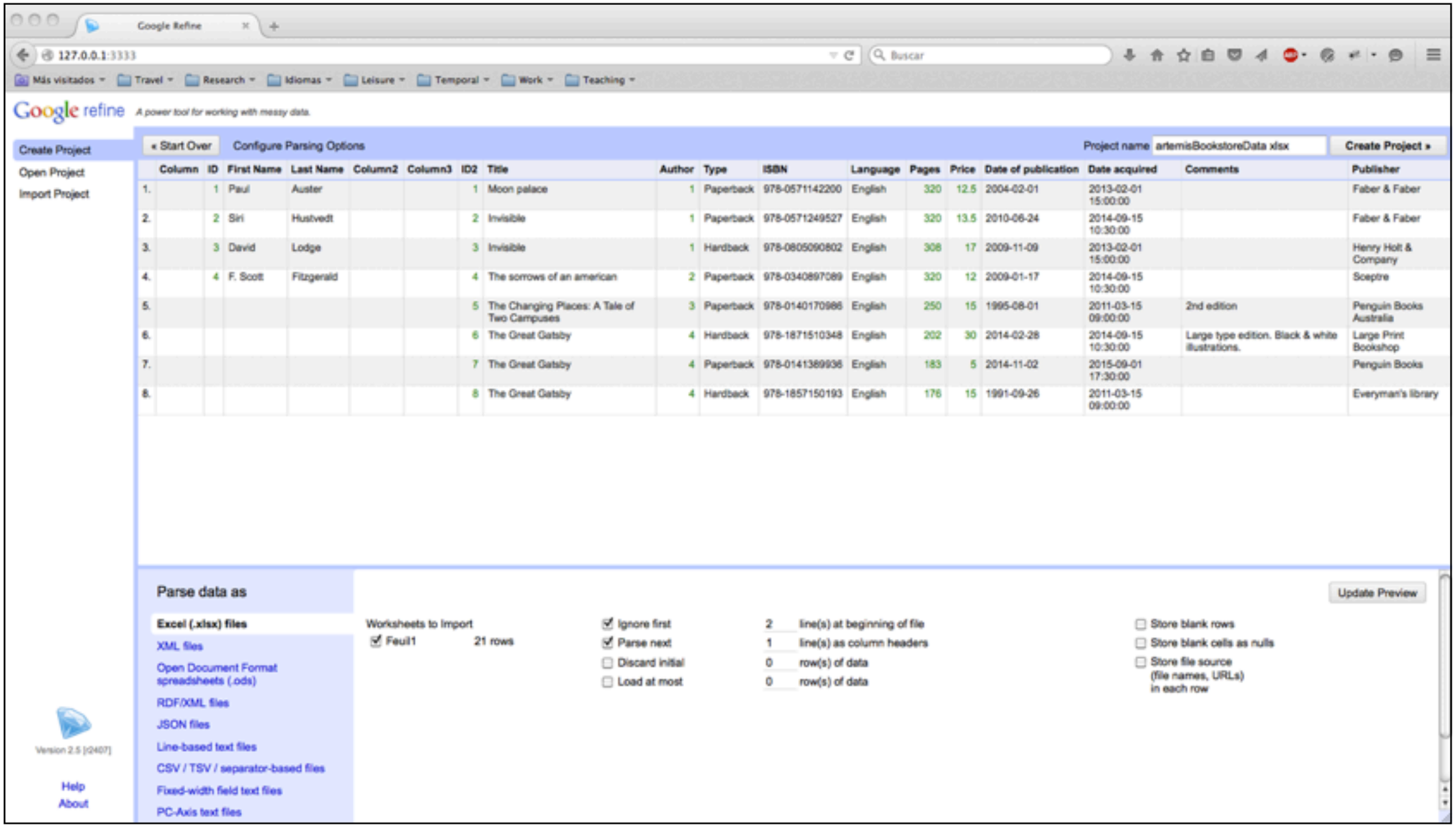


you can download OpenRefine at http://openrefine.org/download.html

Hands-on session (I)

OpenRefine
Preprocessing data

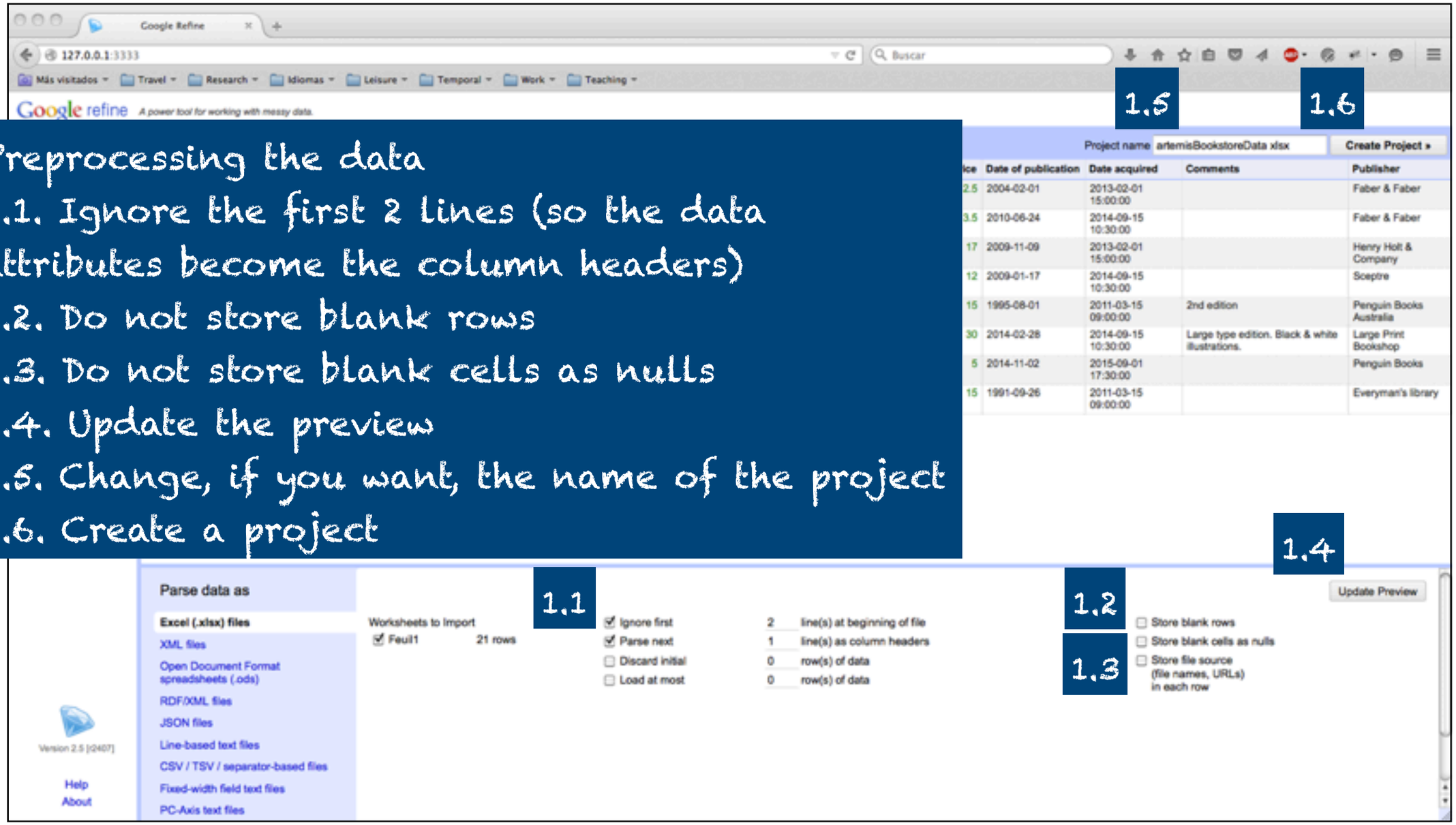
- Let's start by doing some preprocessing of the data



Hands-on session (I)

- Let's start by doing some preprocessing of the data

1. Preprocessing the data
   1.1. Ignore the first 2 lines (so the data attributes become the column headers)
   1.2. Do not store blank rows
   1.3. Do not store blank cells as nulls
   1.4. Update the preview
   1.5. Change, if you want, the name of the project
   1.6. Create a project



Hands-on session (I)

OpenRefine
Preprocessing data

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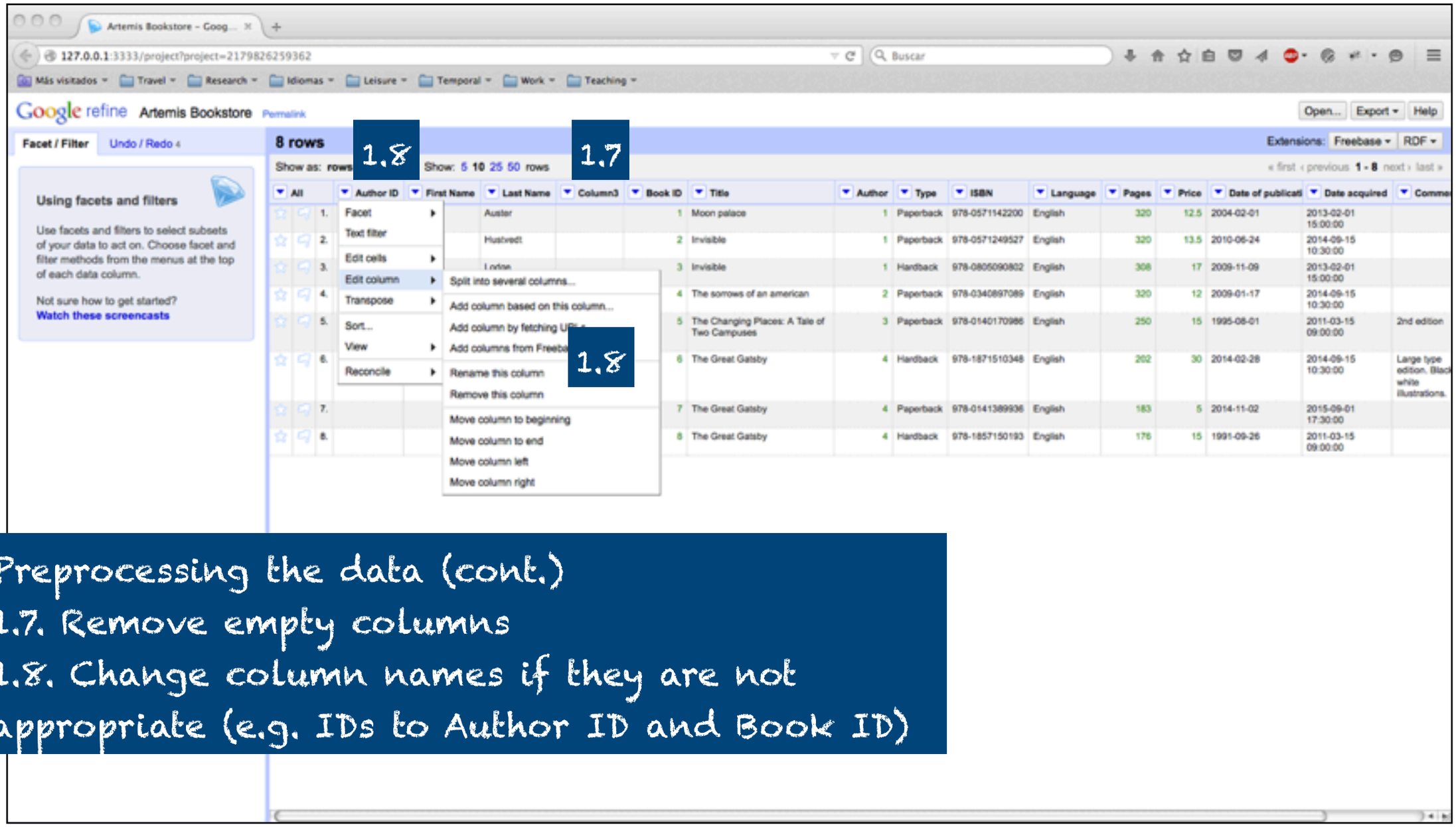

1. Preprocessing the data (cont.)
   1.7. Remove empty columns
   1.8. Change column names if they are not appropriate (e.g. IDs to Author ID and Book ID)

Hands-on session (I)

Hands-on session (I)

- Now, let's create RDF data!

Hands-on session (I)

- Now, let's create RDF data!
- But before, let's recall the Linked Data principles:

1. Use URIs as names for things.
2. Use HTTP URIs, so that people can look up those names.
3. When someone looks up a URI, provide useful information using the standards (RDF, SPARQL).
4. Include links to other URIs, so that they can discover more things.

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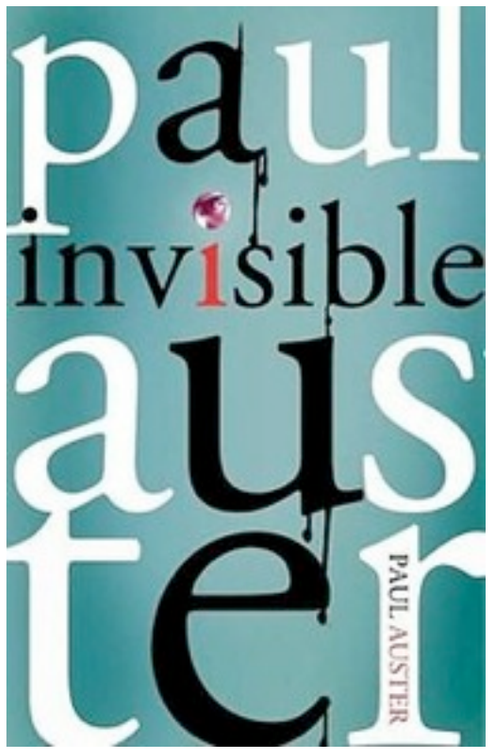
Hands-on session (I)

- Let's consider the paperback book "Invisible" written by Paul Auster. Can you find a cool URI for this resource?



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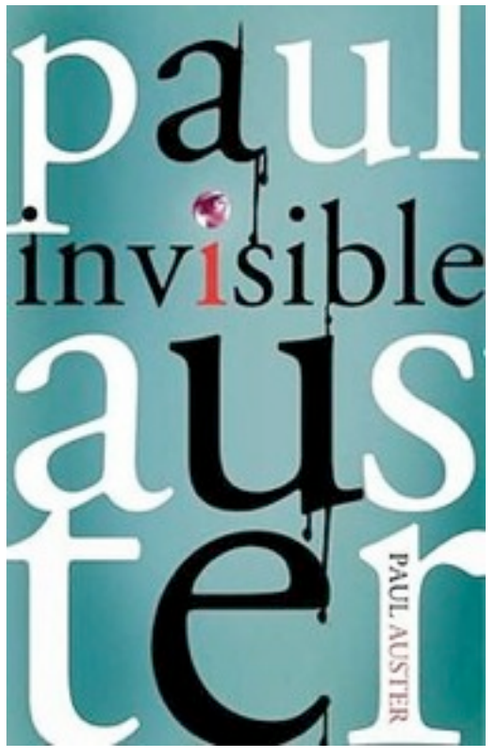

REMEMBER!
web document ≠ web resource
Actually, you should find
- A URI for the real object itself.
- A URI for the related information resource that describes the real-world object and has an HTML representation.
- A URI for a related information resource that describes the real-world object and has an RDF/XML representation.

Hands-on session (I)

Creating RDF data
Cool URIs

Hands-on session (I)

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    http://www.amazon.com/Invisible-Paul-Auster/dp/0312429827

Hands-on session (I)

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  - uncool URIs

    keep out of namespaces you do not control

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http://artemisbookstore.com:8080/book.php?title=Invisible&author=Paul-Auster&format=rdf

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abstract away from implementation details

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    use ISBN better than Book_ID (internal)

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    http://artemisbookstore.com/**data**/book/0571249527

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    more info at http://www.w3.org/TR/cooluris/

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    http://**page.**artemisbookstore.com/book/0571249527

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Creating RDF data
Describing things with RDF

Hands-on session (I)

Creating RDF data
Describing things with RDF

- Which kind of information should we include in the description of the book "Invisible" written by Paul Auster?

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Creating RDF data
Describing things with RDF

- Which kind of information should we include in the description of the book "Invisible" written by Paul Auster?
  - triples that describe the resource with literals (e.g. title)

Hands-on session (I)

Creating RDF data
Describing things with RDF

- Which kind of information should we include in the description of the book "Invisible" written by Paul Auster?
  - triples that describe the resource with literals (e.g. title)
  - triples that describe the resource by linking *to* other resources, or *incoming links* (e.g. author)

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  - triples describing related resources (e.g. the name of the resource's creator)

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  - triples describing related resources (e.g. the name of the resource's creator)
  - triples describing the description itself (e.g. licensing terms)

Hands-on session (I)

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Describing things with RDF

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  - triples describing related resources (e.g. the name of the resource's creator)
  - triples describing the description itself (e.g. licensing terms)
  - triples about the broader dataset of which this description is a part

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Describing things with RDF

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  - triples that des
    resources, or *o*
  - triples describi
    resource's crea
  - triples describi
  - triples about th
    a part

and, for writing this description, you can use:
- terms from existing vocabularies
  - Dublin Core (e.g. dcterms:title)
  - FOAF (e.g. foaf:name)
  - ...
- your own defined terms
- RDFS (rdfs:comment and rdfs:label for annotations), OWL (owl:sameAs for links)

Hands-on session (I)

Reusing Existing Terms
FOAF vocabulary

- The FOAF ("Friend of a Friend") vocabulary can be used for describing persons, their activities and their relations to other people and objects.
- FOAF = RDF + Social Web
- namespace:

  foaf: <http://xmlns.com/foaf/0.1>

Hands-on session (I)

Reusing Existing Terms
FOAF vocabulary

- An example:

```
@base <http://exmo.inrialpes.fr/about> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

<#jdavid>
  a foaf:Person ;
  foaf:name "Jérôme David"@fr ;
  foaf:nick "JD" ;
  foaf:mbox <mailto:jerome.david@inria.fr> ;
  foaf:homepage "http://exmo.inrialpes.fr/~jdavid/" ;
  foaf:depiction <http://exmo.inrialpes.fr/jdavid_img_small.jpg> ;
  foaf:knows <http://exmo.inrialpes.fr/about#matencia> ,
             <http://www.imag.fr/id/pgenoud> ,
             [ a foaf:Person ;
               foaf:name "Ewan David" ;
               foaf:age "5" ] .
```

Hands-on session (I)

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<#jdavid>
  a foaf:Person ;
  foaf:name "Jérôme David"@fr ;
  foaf:nick "JD" ;
  foaf:mbox <mailto:jerome.david@inria.fr> ;
  foaf:homepage "http://exmo.inrialpes.fr/~jdavid/" ;
  foaf:depiction <http://exmo.inrialpes.fr/jdavid_img_small.jpg> ;
  foaf:knows <http://exmo.inrialpes.fr/about#matencia> ,
             <http://www.imag.fr/id/pgenoud> ,
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```

Hands-on session (I)

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- An example:

```
@base <http://exmo.inrialpes.fr/abo
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@prefix rdfs: <http://www.w3.org/20
@prefix foaf: <http://xmlns.com/foa

<#jdavid>
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  foaf:mbox <mailto:jerome.david@inria.fr> ;
  foaf:homepage "http://exmo.inrialpes.fr/~jdavid/" ;
  foaf:depiction <http://exmo.inrialpes.fr/jdavid_img_small.jpg> ;
  foaf:knows <http://exmo.inrialpes.fr/about#matencia> ,
             <http://www.imag.fr/id/pgenoud> ,
             [ a foaf:Person ;
               foaf:name "Ewan David" ;
               foaf:age "5" ] .
```

jdavid is a person, with the name of "Jérôme David" and the nickname of "JD", who has an email address of "jerome.david@inria.fr". His homepage is... He is depicted in the image... He knows... He also knows a person whose name is "Ewan David" and who is 5 years old.

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  foaf:name "Jérôme David"@fr ;
  foaf:nick "JD" ;
  foaf:mbox <mailto:jerome.david@inria.fr> ;
  foaf:homepage "http://exmo.inrialpes.fr/~jdavid/" ;
  foaf:depiction <http://exmo.inrialpes.fr/jdavid_img_small.jpg> ;
  foaf:knows <http://exmo.inrialpes.fr/about#matencia> ,
```

jdavid is a person, with the name of "Jérôme David" and the nickname of "JD", who has an email address of "jerome.david@inria.fr". His homepage is... He is depicted in the image... He knows... He also knows a person whose name is "Ewan David" and who is 5 years old.

Property: foaf:knows

knows - A person known by this person (indicating some level of reciprocated interaction between the parties).
Status: stable
Domain: having this property implies being a Person
Range: every value of this property is a Person

The knows property relates a Person to another Person that he or she knows.

from http://xmlns.com/foaf/spec/#term_knows

Hands-on session (I)

Reusing Existing Terms
The Dublin Core Schema

- The Dublin Core Schema is a vocabulary of terms that can be used to describe web resources (videos, images, web pages) and physical resources (books, publications, CDs).
- Dublin Core Metadata Initiative (DCMI)
- two namespaces:
  - Dublin Core Metadata Set version 1.1

    dc: <http://purl.org/elements/1.1/>
  - DCMI Metadata Terms

    dcterms: <http://purl.org/dc/terms/>

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- An example:

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix ex: <http://www.example.org/> .

ex:myPaper a dcterms:BibliographicResource ;
           dcterms:title "What is this thing called Linked Data?" ;
           dcterms:creator ex:matencia, ex:jdavid , ex:pgenoud ;
           dcterms:subject "Linked Data", "Semantic Web" ;
           dcterms:issued "2015" ;
           dcterms:publisher "ACM Digital Library" ;
           dcterms:bibliographicCitation "Proceedings of the " .

ex:matencia a foaf:Person ;
            foaf:familyName "Atencia" ;
            foaf:givenName "Manuel" .

...
```

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           dcterms:creator ex:matencia, ex:jdavid , ex:pgenoud ;

ex:matencia

...
```

Term Name: creator	
URI:	http://purl.org/dc/terms/creator
Label:	Creator
Definition:	An entity primarily responsible for making the resource.
Comment:	Examples of a Creator include a person, an organization, or a service.
Type of Term:	Property
Refines:	http://purl.org/dc/elements/1.1/creator
Refines:	http://purl.org/dc/terms/contributor
Has Range:	http://purl.org/dc/terms/Agent
Version:	http://dublincore.org/usage/terms/history/#creatorT-002
EquivalentProperty:	http://xmlns.com/foaf/0.1/maker

from http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=terms#creator

Hands-on session (I)

- Which properties/classes could we use for describing Artemis' bookstore data?

Hands-on session (I)

Creating RDF data
Reusing existing terms

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foaf vocabulary 

Classes: | Agent | Document | Group | Image | LabelProperty | OnlineAccount | OnlineChatAccount | OnlineEcommerceAccount | OnlineGamingAccount | Organization | Person | PersonalProfileDocument | Project |

Properties: | account | accountName | accountServiceHomepage | age | aimChatID | based_near | birthday | currentProject | depiction | depicts | dnaChecksum | familyName | family_name | firstName | focus | fundedBy | geekcode | gender | givenName | givenname | holdsAccount | homepage | icqChatID | img | interest | isPrimaryTopicOf | jabberID | knows | lastName | logo | made | maker | mbox | mbox_sha1sum | member | membershipClass | msnChatID | myersBriggs | name | nick | openid | page | pastProject | phone | plan | primaryTopic | publications | schoolHomepage | sha1 | skypeID | status | surname | theme | thumbnail | tipjar | title | topic | topic_interest | weblog | workInfoHomepage | workplaceHomepage | yahooChatID |

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Classes	Agent , AgentClass , BibliographicResource , FileFormat , Frequency , Jurisdiction , LicenseDocument , LinguisticSystem , Location , LocationPeriodOrJurisdiction , MediaType , MediaTypeOrExtent , MethodOfAccrual , MethodOfInstruction , PeriodOfTime , PhysicalMedium , PhysicalResource , Policy , ProvenanceStatement , RightsStatement , SizeOrDuration , Standard

Hands-on session (I)

Creating RDF data
Reusing existing terms

- Which properties/classes could we use for describing Artemis' bookstore data?

Author ID	First Name	Last Name	Book ID	Title	Author	Type	ISBN
1	Paul	Auster	1	Moon palace	1	Paperback	571142200
2	Siri	Hustvedt	2	Invisible	1	Paperback	571249527

Language	Pages	Price	Date of publicati	Date acquired	Comments	Publisher
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well... not so optimal

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Hands-on session (I)

Creating RDF data
User-defined vocabularies

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Hands-on session (I)

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your own vocabulary/ontology

http://artemisBookstore.com/ontology#author
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use hash URIs for small datasets (e.g. ontologies)

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rdfs

rdfs:comment

your own vocabulary/ontology

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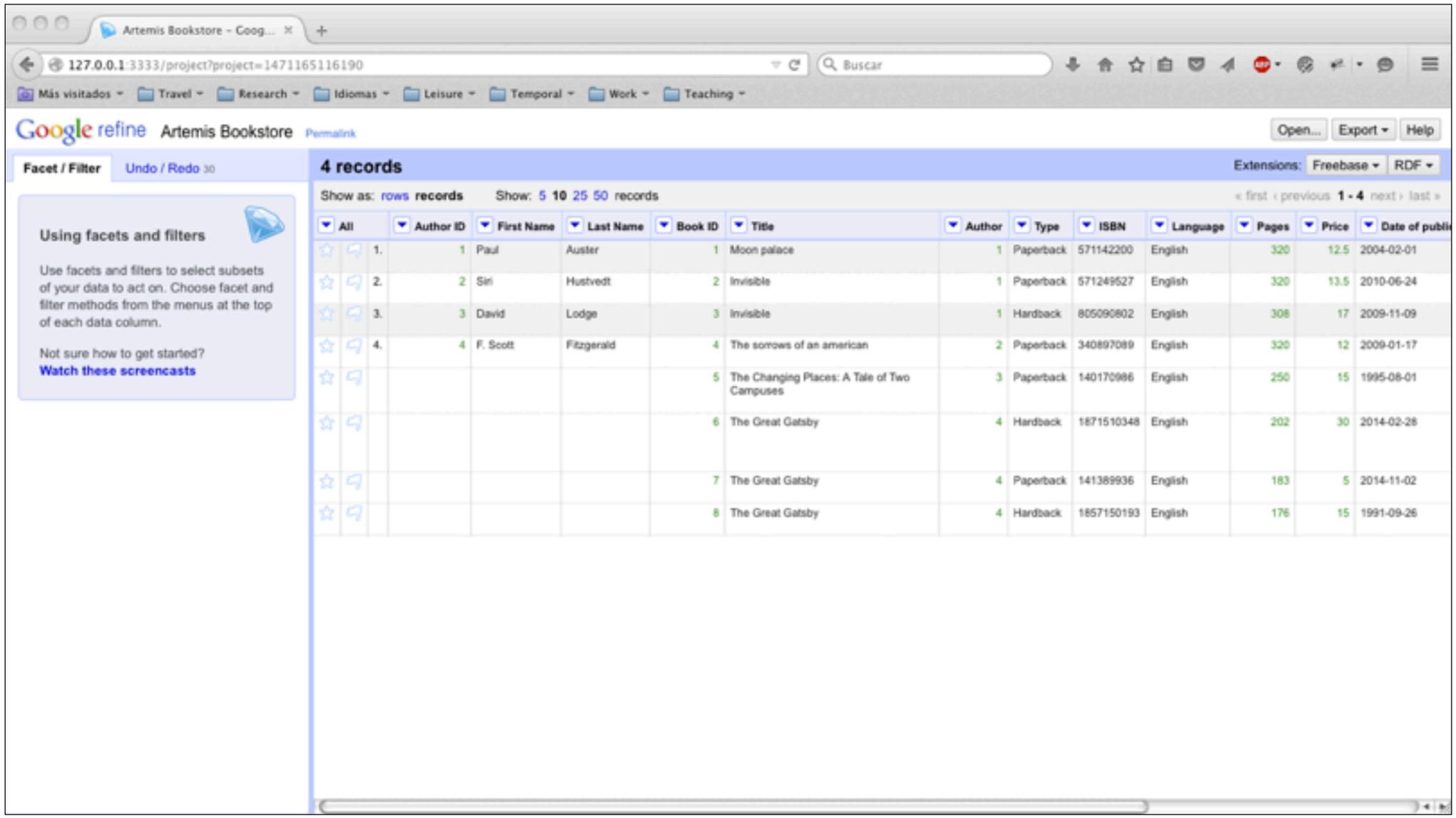
use hash URIs for small datasets (e.g. ontologies)

protégé **out of scope**

Hands-on session (I)

OpenRefine
RDF extension

- Let's create RDF data with OpenRefine + RDF extension (developed at DERI)



All		Author ID	First Name	Last Name	Book ID	Title	Author	Type	ISBN	Language	Pages	Price	Date of publi
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3.	3	David	Lodge	3	Invisible	1	Hardback	805090802	English	308	17	2009-11-09
4.	4	F. Scott	Fitzgerald	4	The sorrows of an american	2	Paperback	340897089	English	320	12	2009-01-17
				5	The Changing Places: A Tale of Two Campuses	3	Paperback	140170986	English	250	15	1995-08-01
				6	The Great Gatsby	4	Hardback	1871510348	English	202	30	2014-02-28
				7	The Great Gatsby	4	Paperback	141389936	English	183	5	2014-11-02
				8	The Great Gatsby	4	Hardback	1857150193	English	176	15	1991-09-26

you can download OpenRefine RDF extension at http://refine.deri.ie/

Hands-on session (I)

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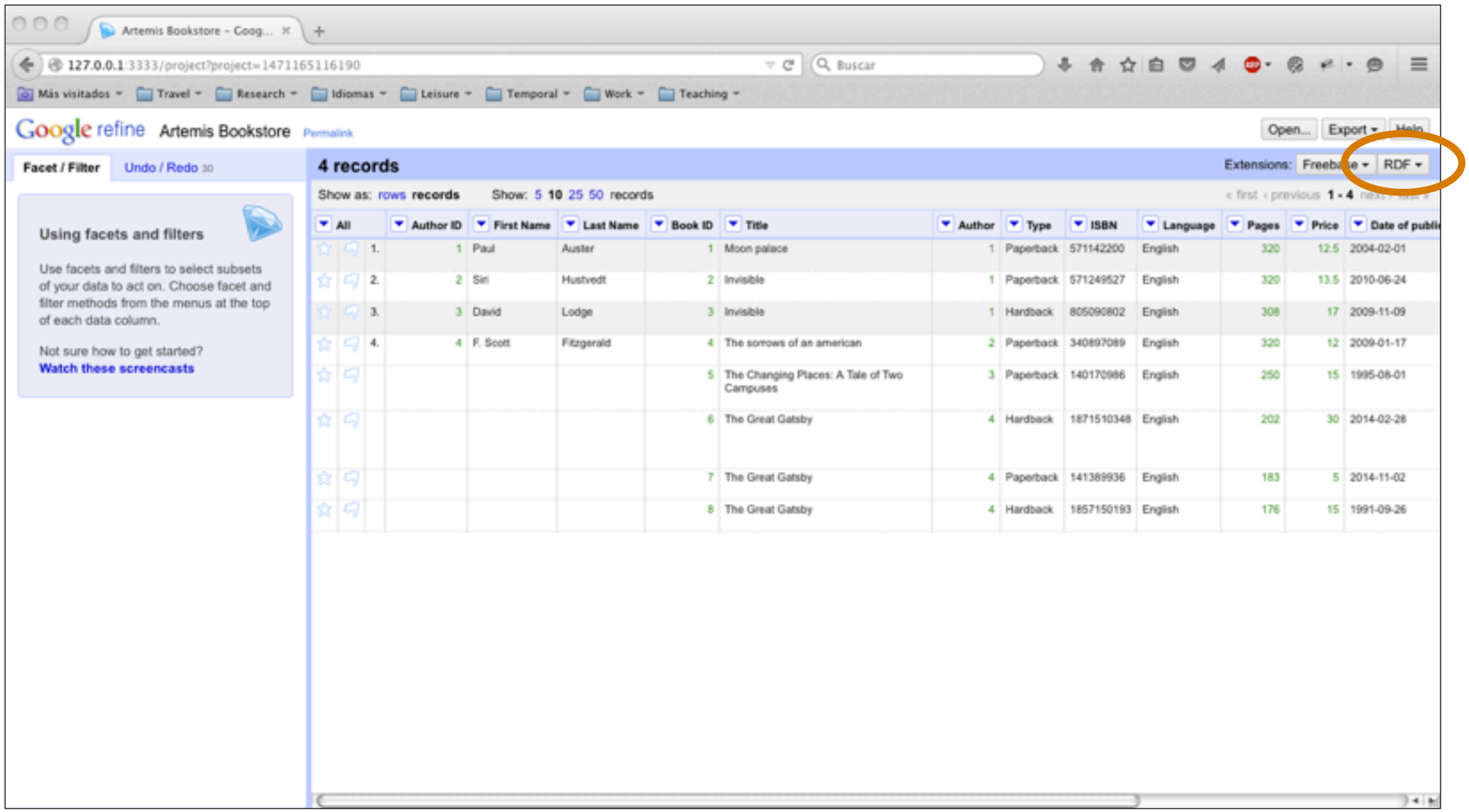

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Hands-on session (I)

- Let's create RDF data!

Hands-on session (I)

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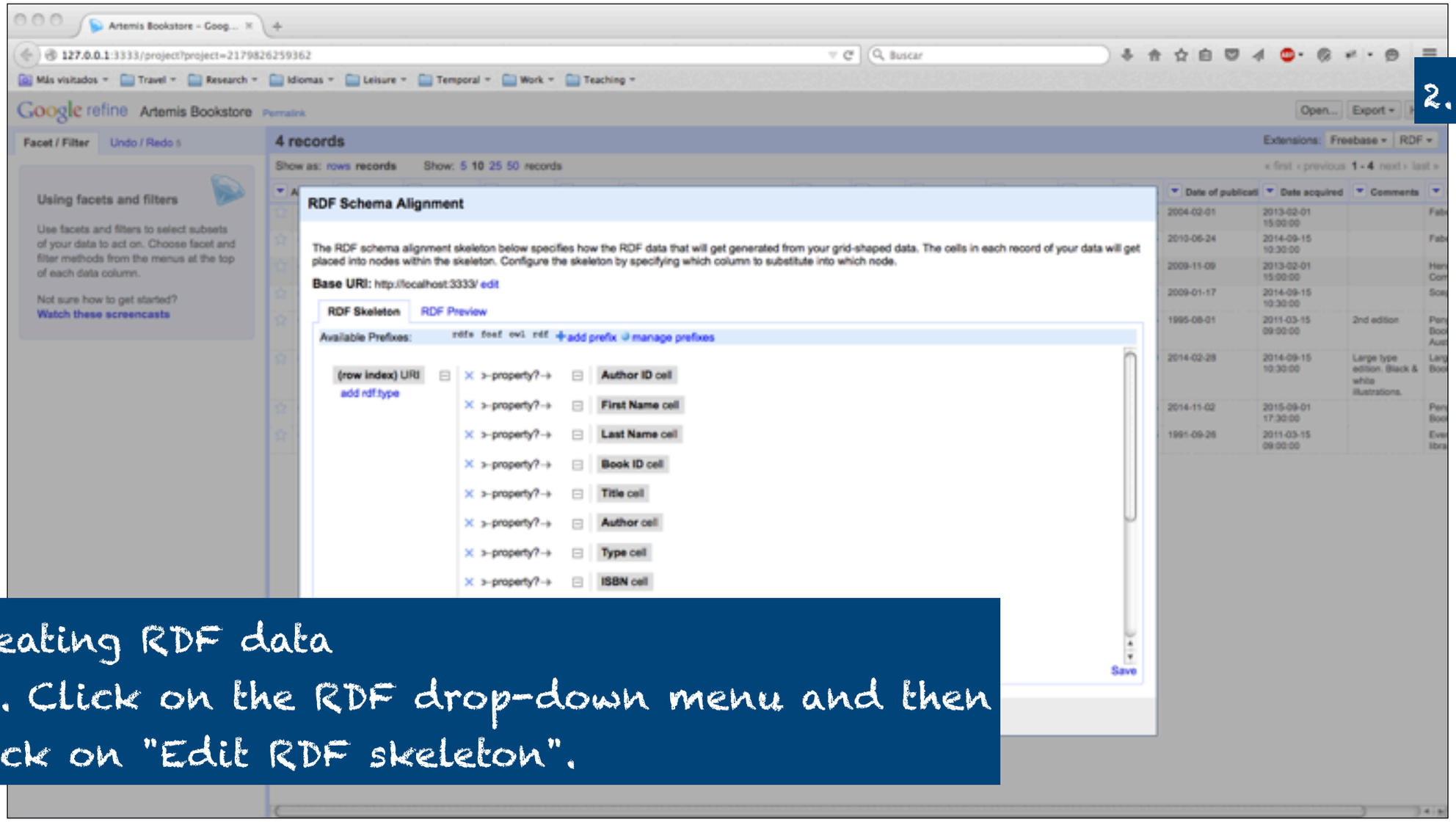
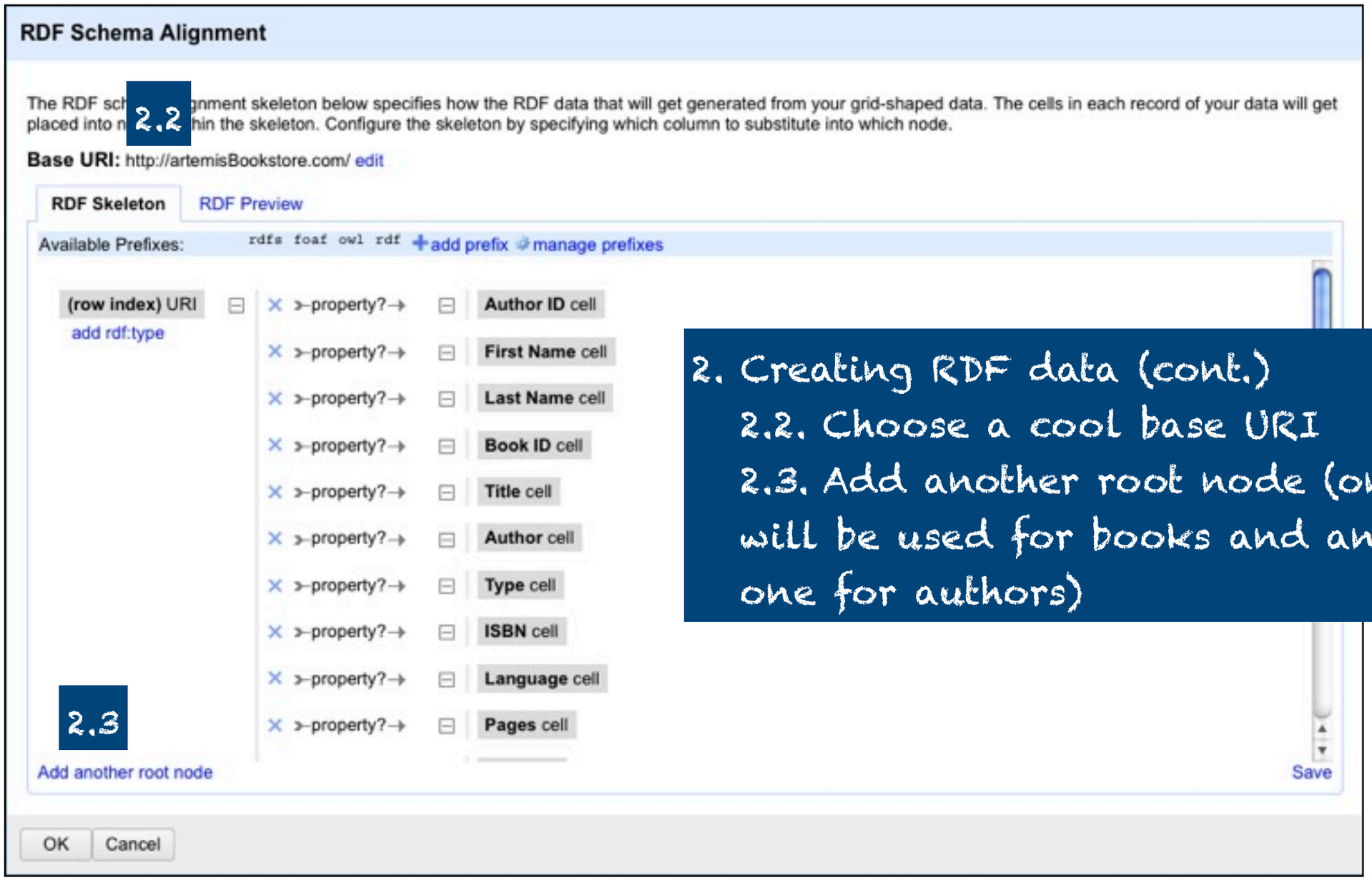


2. Creating RDF data
   2.1. Click on the RDF drop-down menu and then click on "Edit RDF skeleton".

Hands-on session (I)

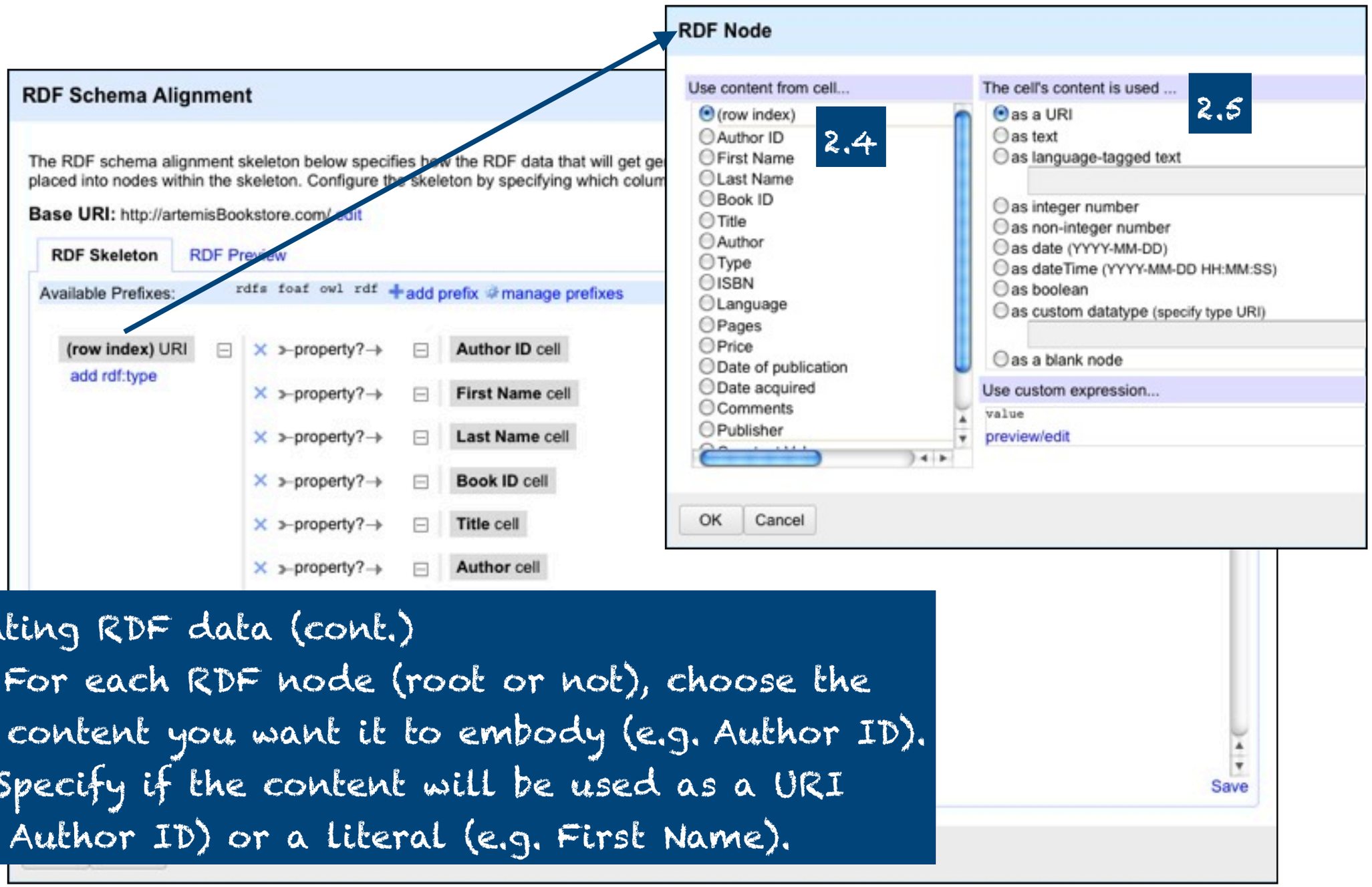
- Let's create RDF data!



2. Creating RDF data (cont.)
   2.2. Choose a cool base URI
   2.3. Add another root node (one will be used for books and another one for authors)

Hands-on session (I)

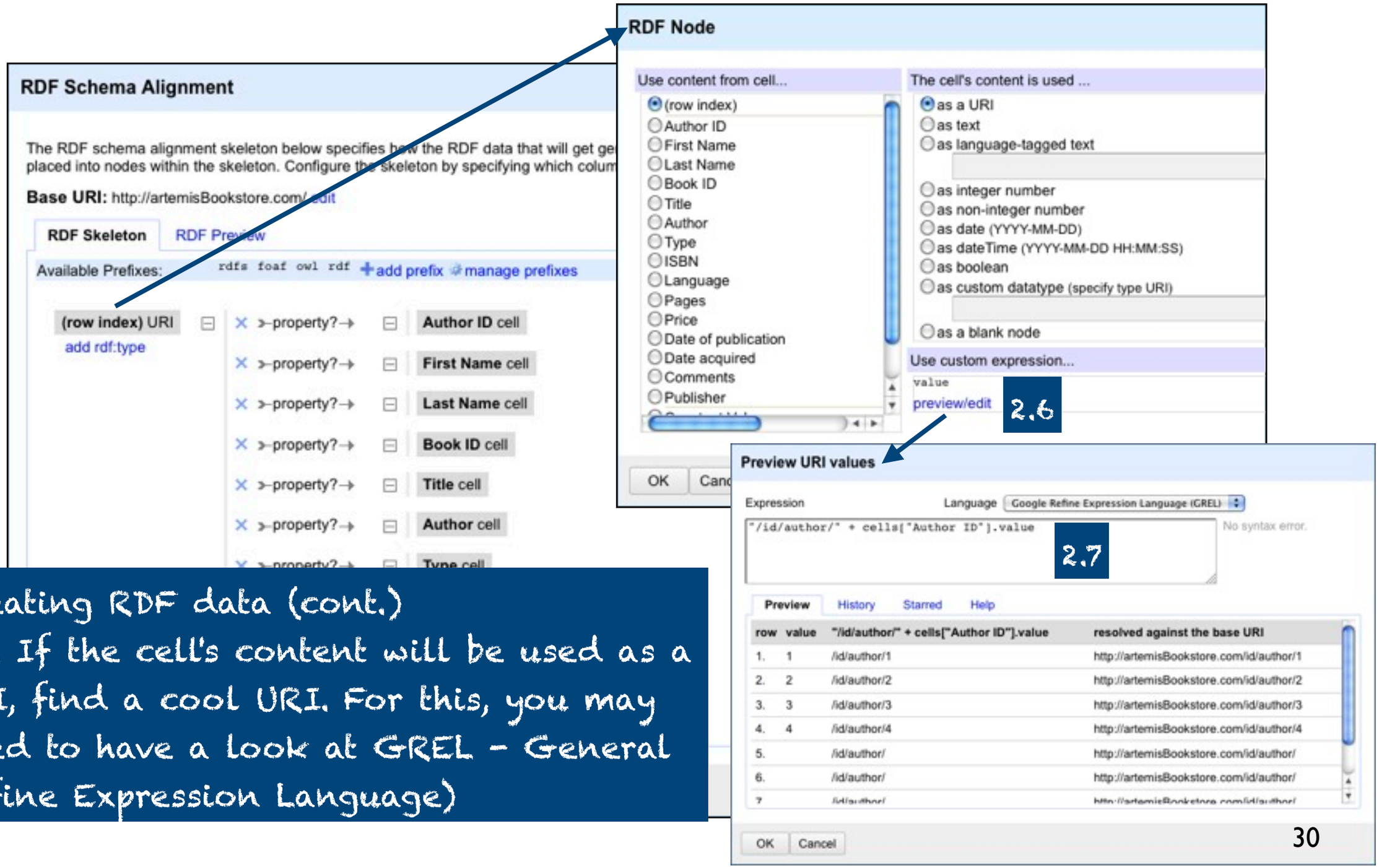
- Let's create RDF data!



2. Creating RDF data (cont.)
   2.4. For each RDF node (root or not), choose the cell content you want it to embody (e.g. Author ID).
   2.5. Specify if the content will be used as a URI (e.g. Author ID) or a literal (e.g. First Name).

Hands-on session (I)

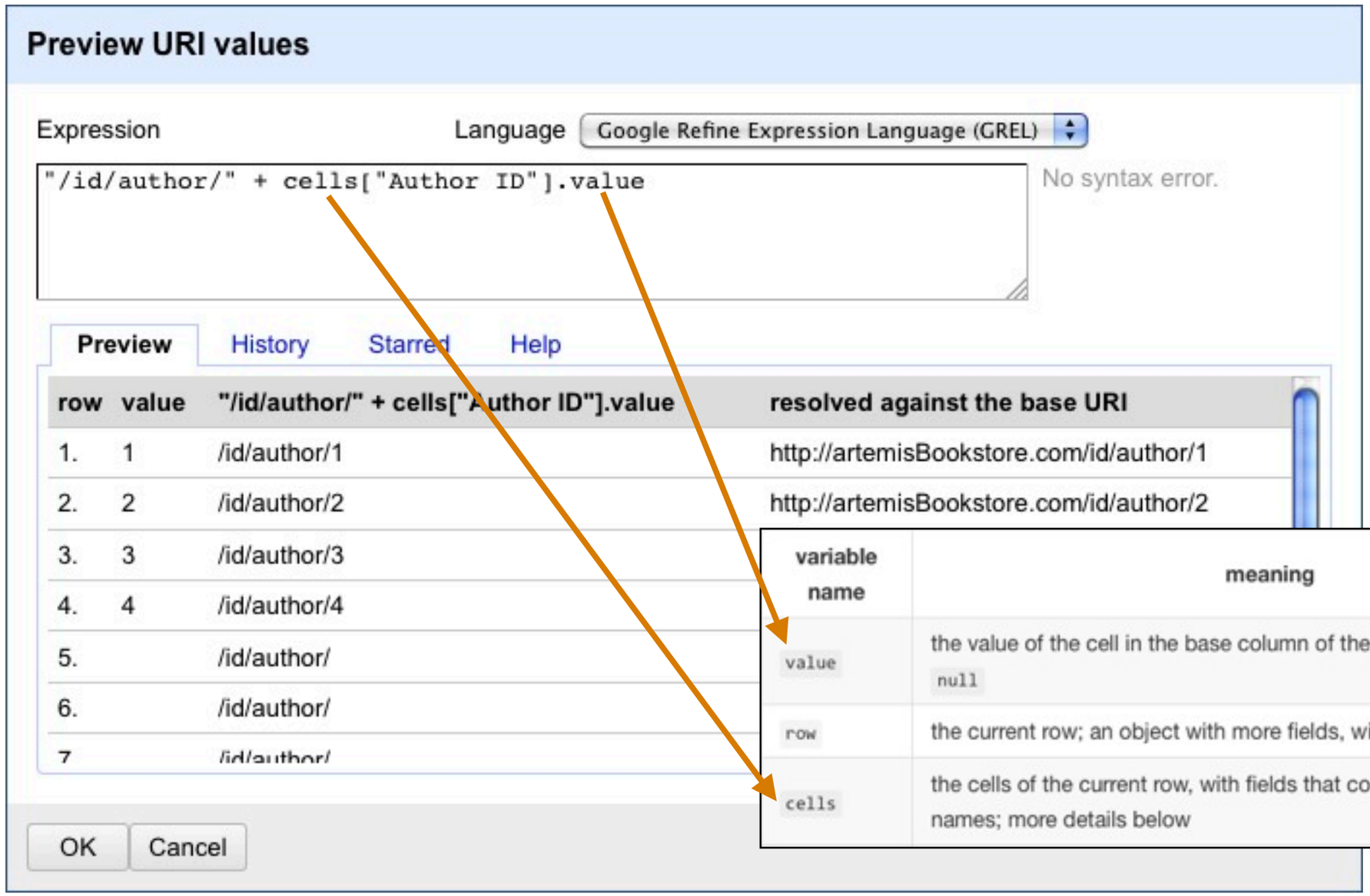
- Let's create RDF data!



2. Creating RDF data (cont.)
   2.6. If the cell's content will be used as a URI, find a cool URI. For this, you may need to have a look at GREL - General Refine Expression Language)

Hands-on session (I)

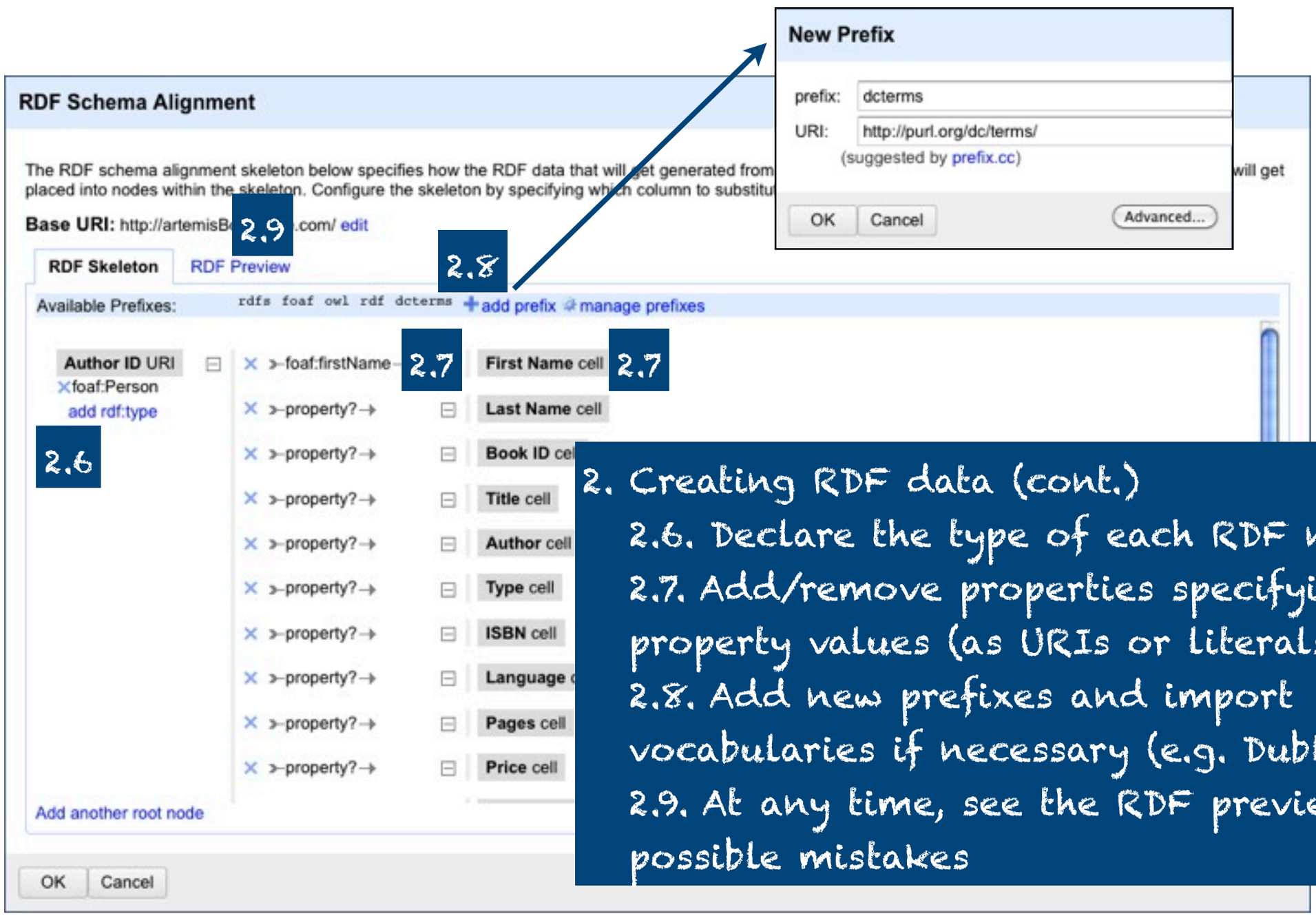
- General Refine Expression Language (GREL)



more info at https://github.com/OpenRefine/OpenRefine/wiki/Variables
https://github.com/OpenRefine/OpenRefine/wiki/General-Refine-Expression-Language

Hands-on session (I)

- Let's create RDF data!



Hands-on session (I)

- You should end up with something like this:

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix abo: <http://artemisBookstore.com/ontology#> .
@prefix dcterms: <http://purl.org/dc/terms/> .


<http://artemisBookstore.com/id/author/1> a foaf:Person ;
        foaf:firstName "Paul" ;
        foaf:lastName "Auster" .

<http://artemisBookstore.com/id/book/571142200> a dcterms:BibliographicResource ;
        dcterms:title "Moon palace" ;
        abo:author <http://artemisBookstore.com/id/author/1> ;
        abo:bookType "Paperback" ;
        abo:isbn "571142200" ;
        abo:language "English" ;
        abo:pages "320"^^<http://www.w3.org/2001/XMLSchema#int> ;
        abo:price "12.5"^^<http://www.w3.org/2001/XMLSchema#double> ;
        abo:datePublication "2004-02-01" ;
        abo:dateAcquired "2013-02-01 15:00:00" ;
        dcterms:publisher "Faber & Faber" .

<http://artemisBookstore.com/id/author/2> a foaf:Person ;
        foaf:firstName "Siri" ;
        foaf:lastName "Hustvedt" .
```

Hands-on session (I)

Creating links to external datasets

- Now, let's create RDF data! But before

- Let's recall the Linked Data principles:

  1. Use URIs as names for things.
  2. Use HTTP URIs, so that people can look up those names.
  3. When someone looks up a URI, provide useful information using the standards (RDF, SPARQL).
  4. **Include links to other URIs, so that they can discover more things.**

Hands-on session (I)

- Data interlinking
  - Not an easy task
    - a large quantity of data
    - semantic heterogeneity
    - noisy data
  - Performed manually or (semi-)automatically
  - Key-based approaches vs similarity-based approaches
  - Data interlinking tools:
    - Silk - Link Discovery Framework
    - LiMES - Link Discovery Framework for Metric Spaces
    - Link Keys
    - OpenRefine + Reconciliation services

Hands-on session (I)

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Hands-on session (I)

OpenRefine
Reconciliation services

- Reconciliation services based on SPARQL endpoints

Hands-on session (I)

OpenRefine
Reconciliation services

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http://artemisBookstore.com/id/book/0571249527

Hands-on session (I)

OpenRefine
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Artemis Bookstore

http://artemisBookstore.com/id/book/0571249527

DBpedia

Hands-on session (I)

OpenRefine
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Artemis Bookstore

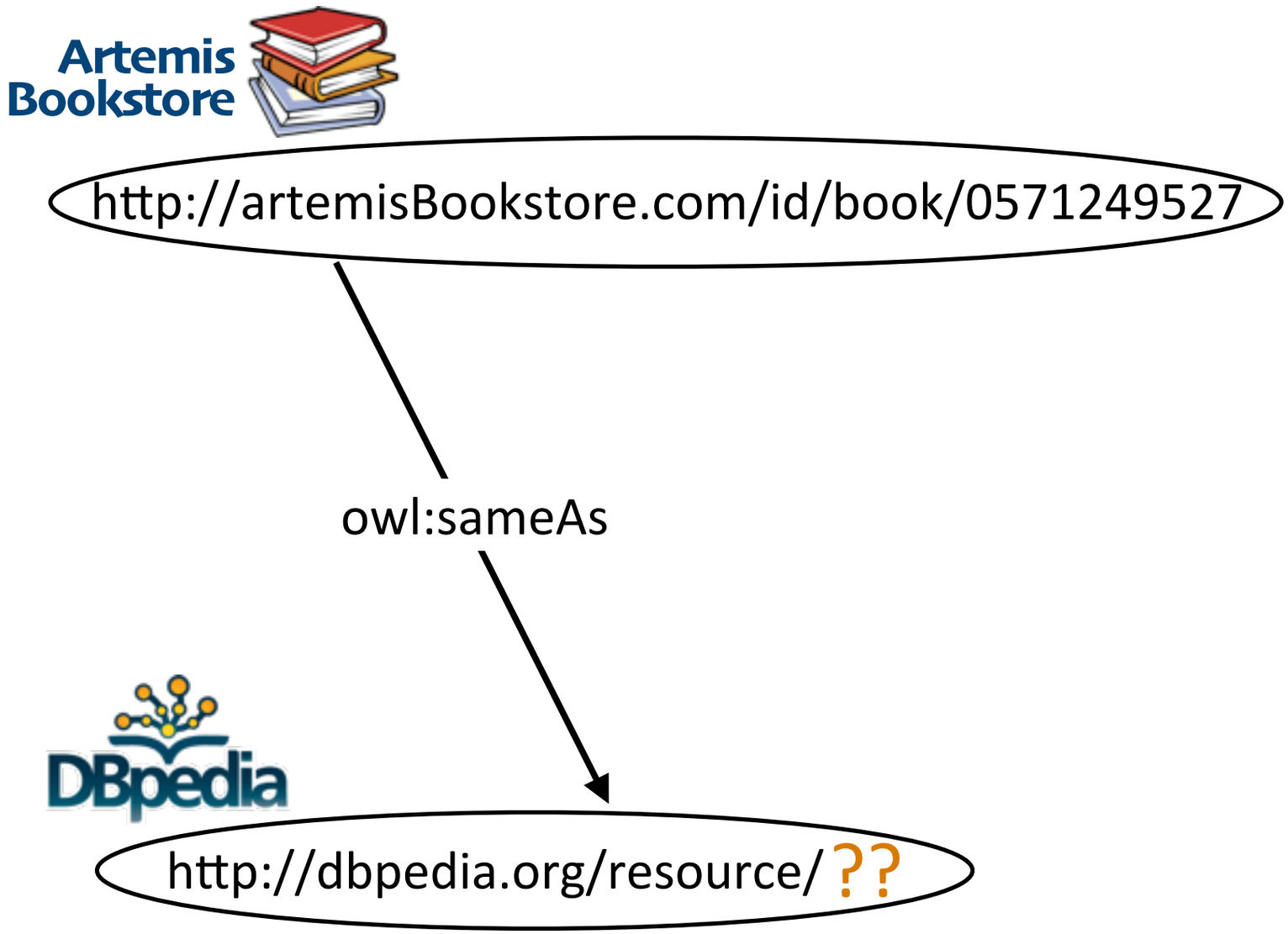
http://artemisBookstore.com/id/book/0571249527

DBpedia

http://dbpedia.org/resource/ ??

Hands-on session (I)

- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

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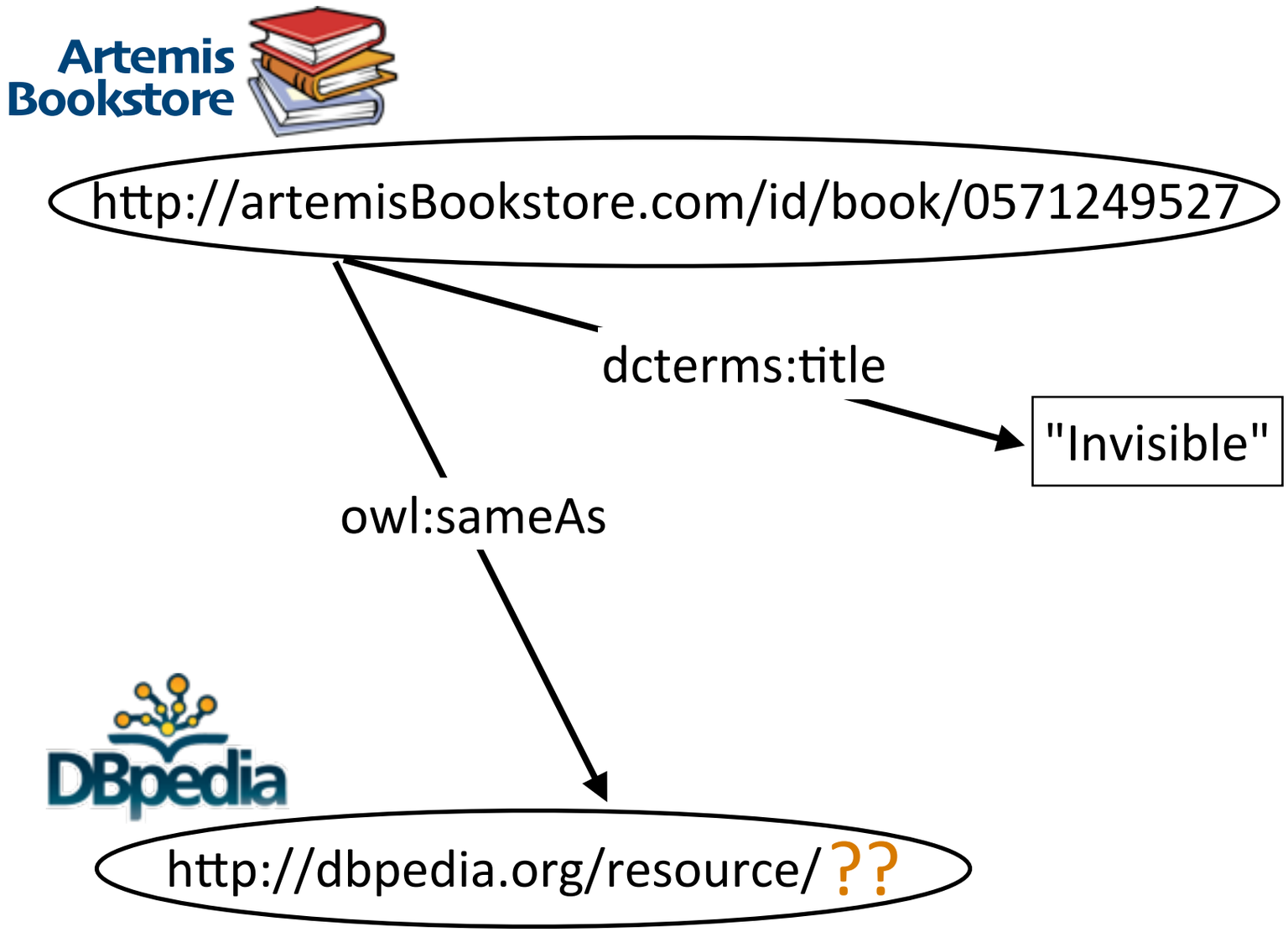

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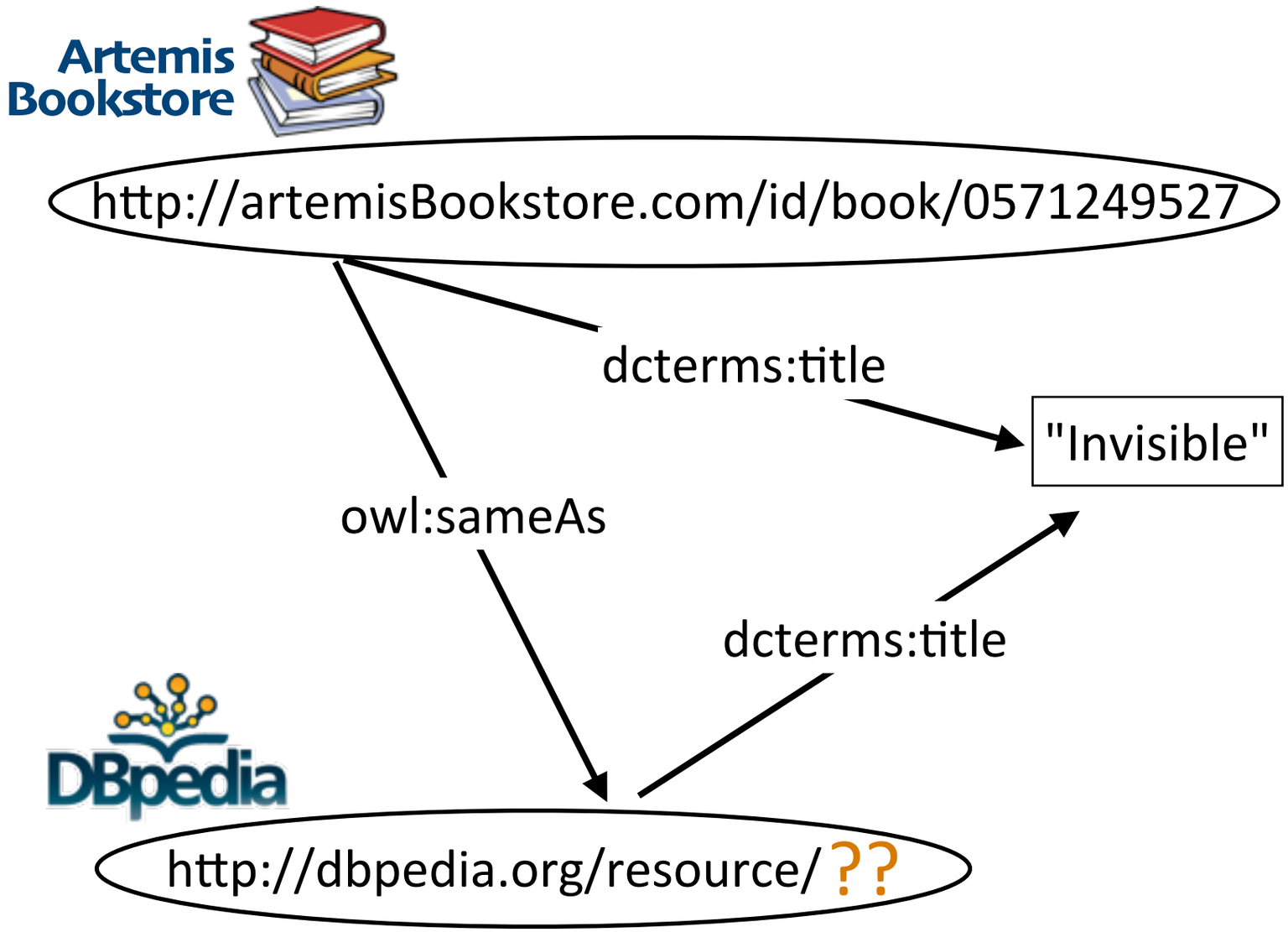

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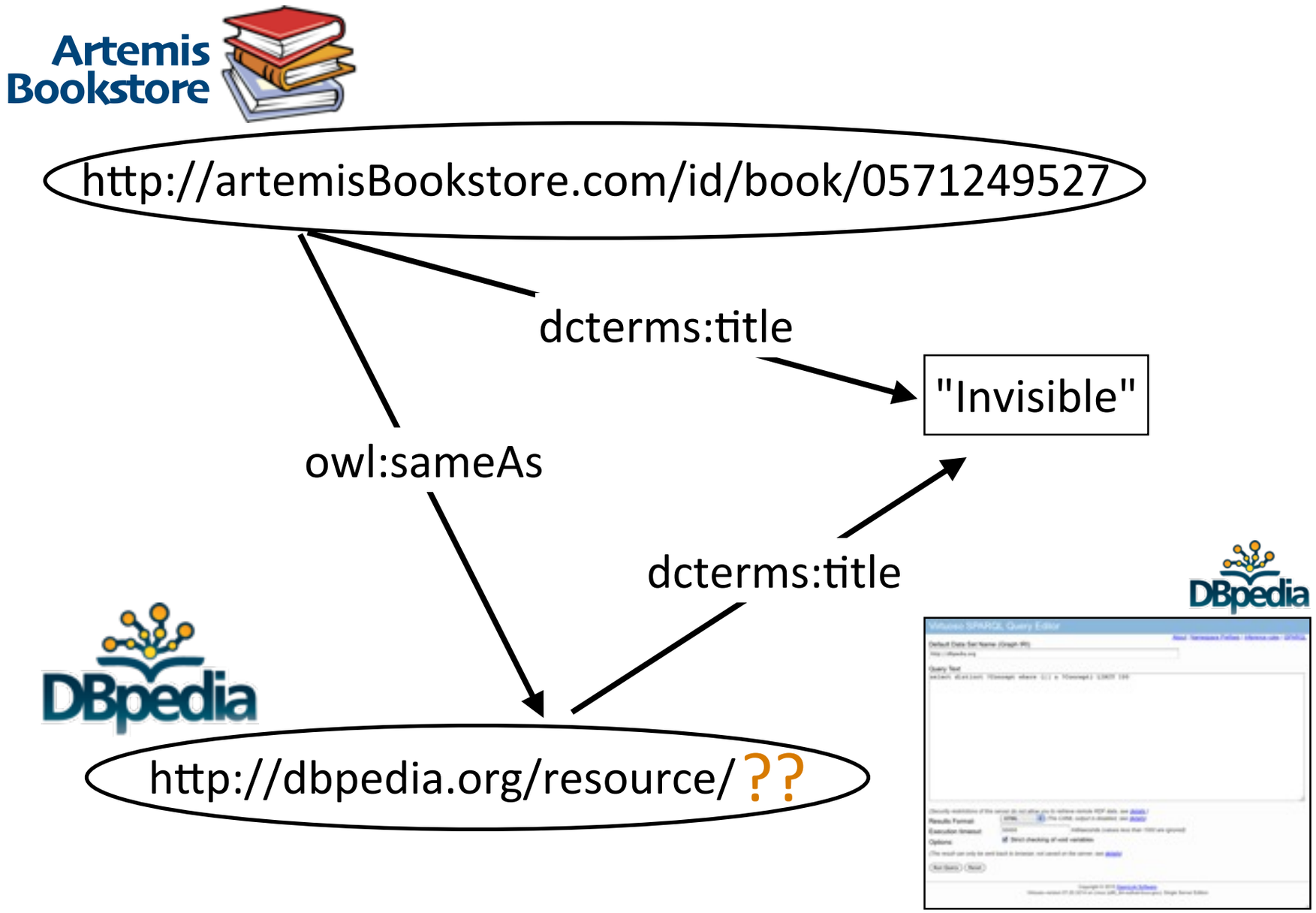

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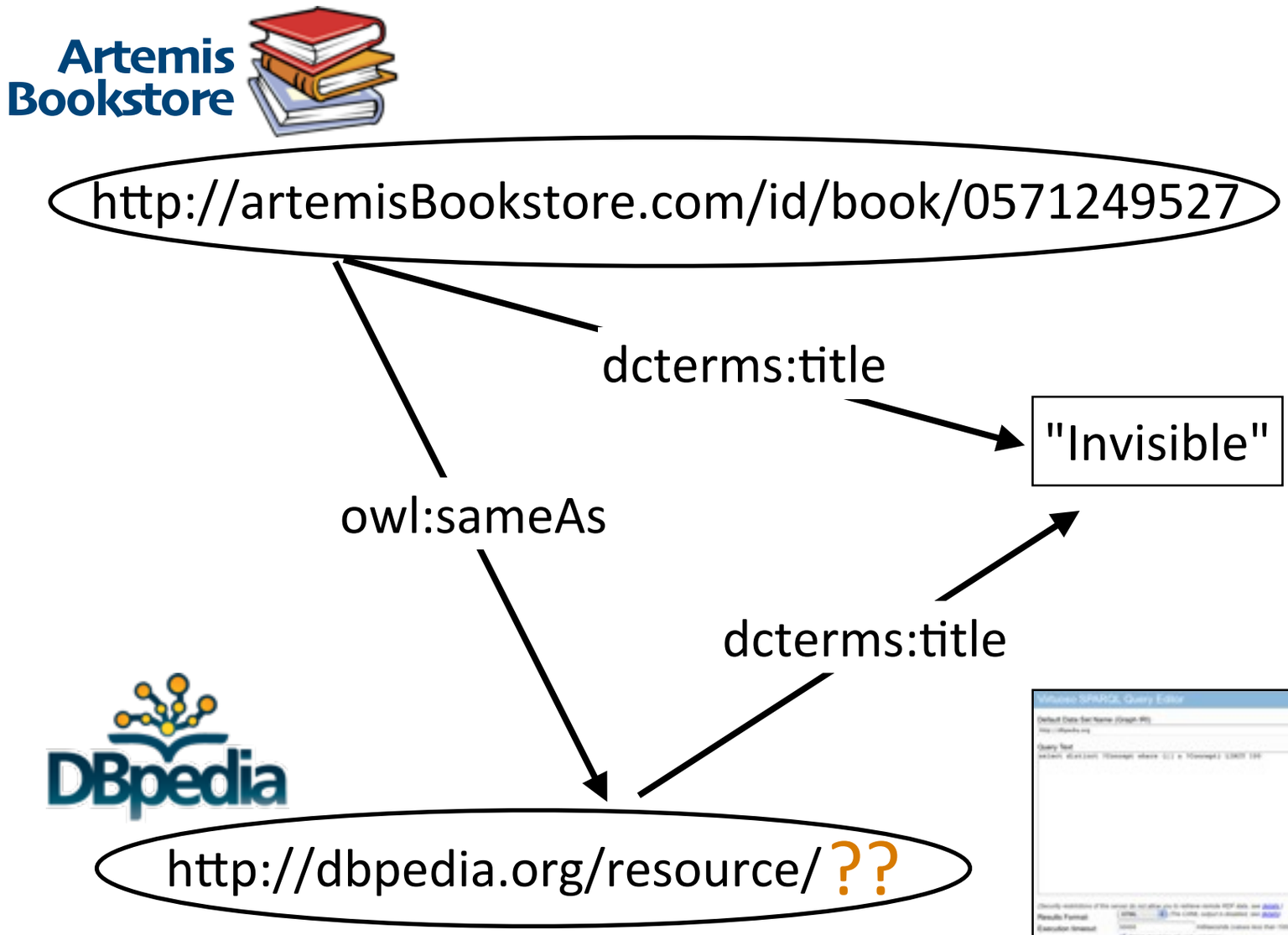
- Reconciliation services based on SPARQL endpoints

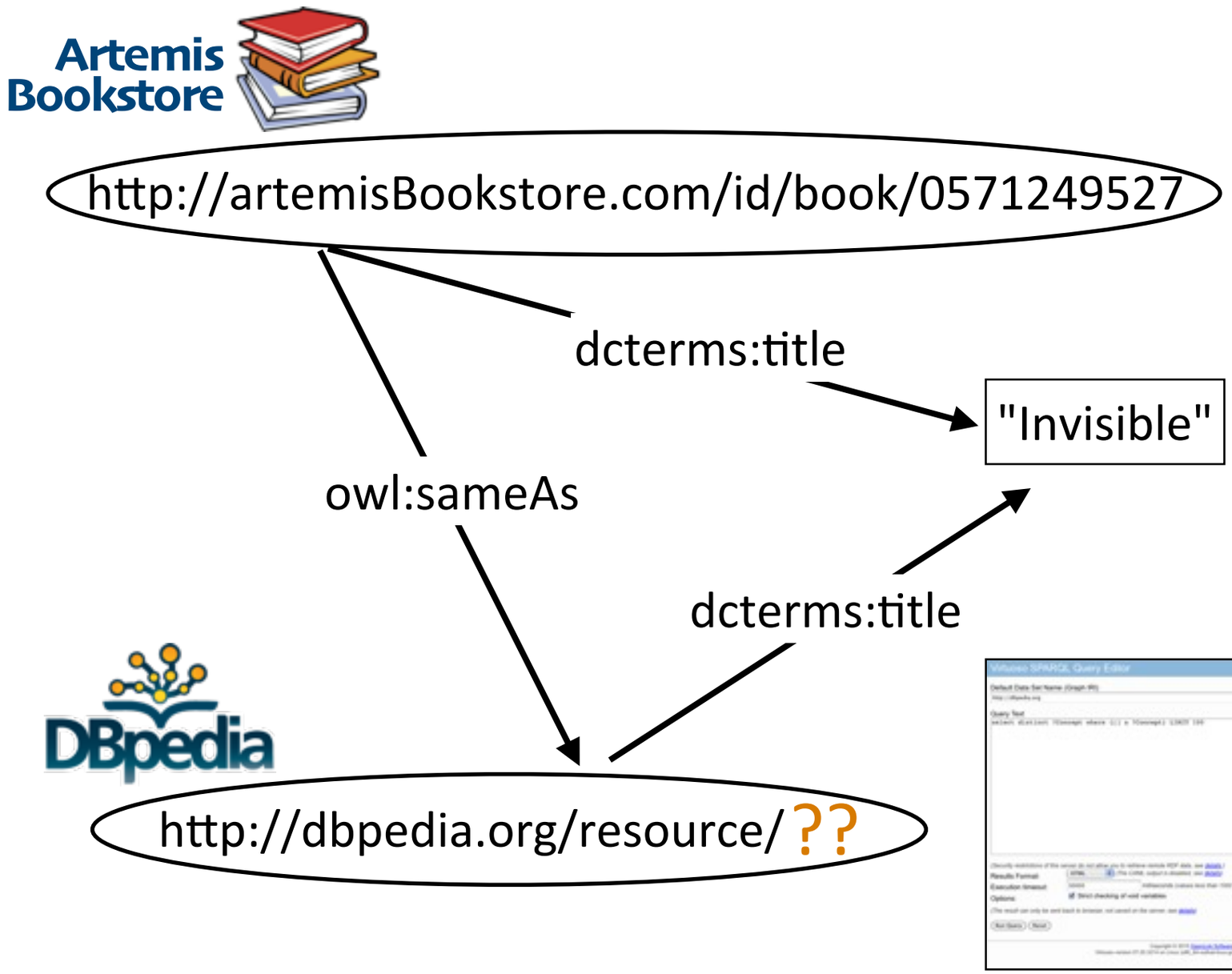


find DBpedia resources having "Invisible" as a value for the property dcterms:title

Hands-on session (I)

OpenRefine
Reconciliation services

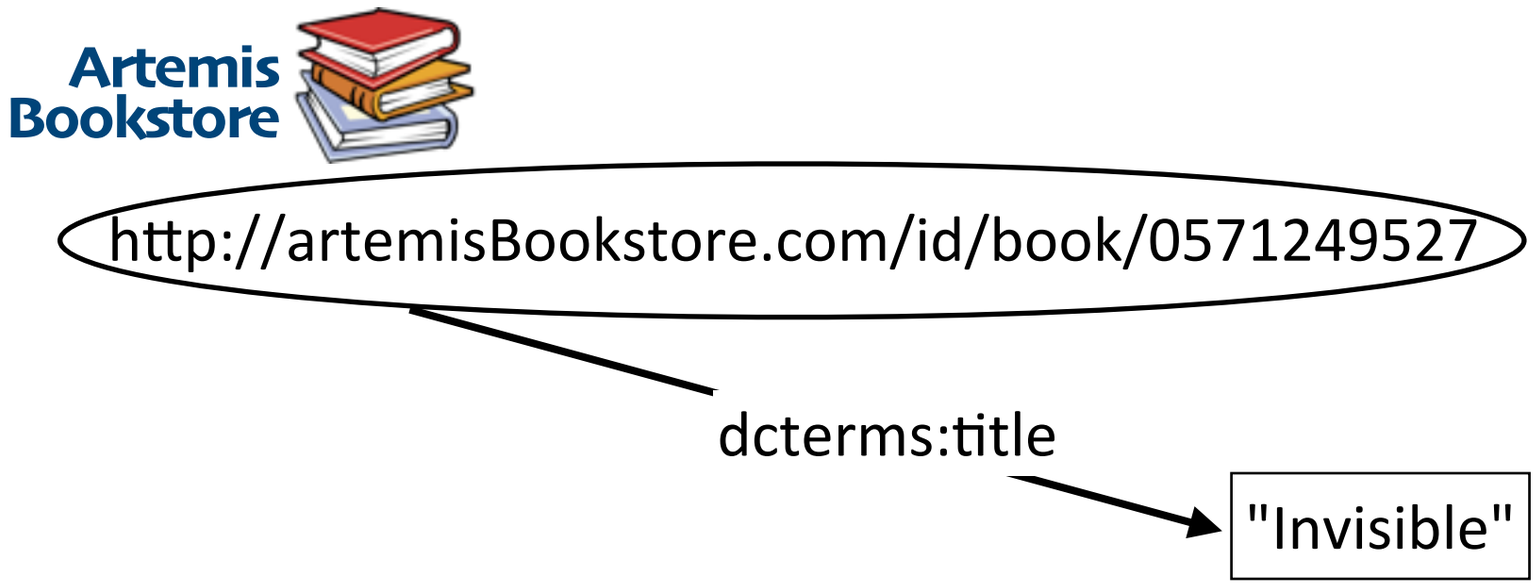
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

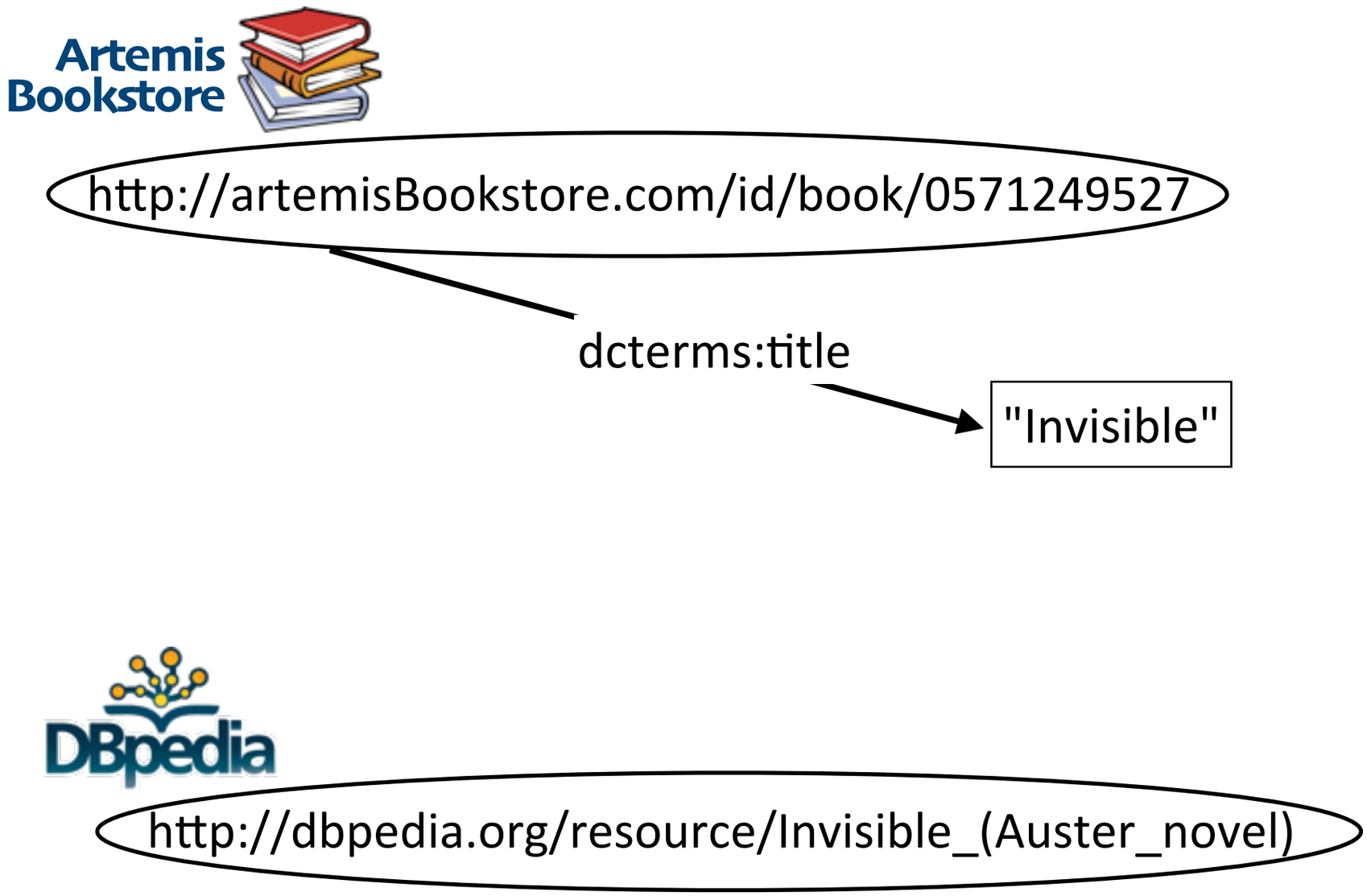
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

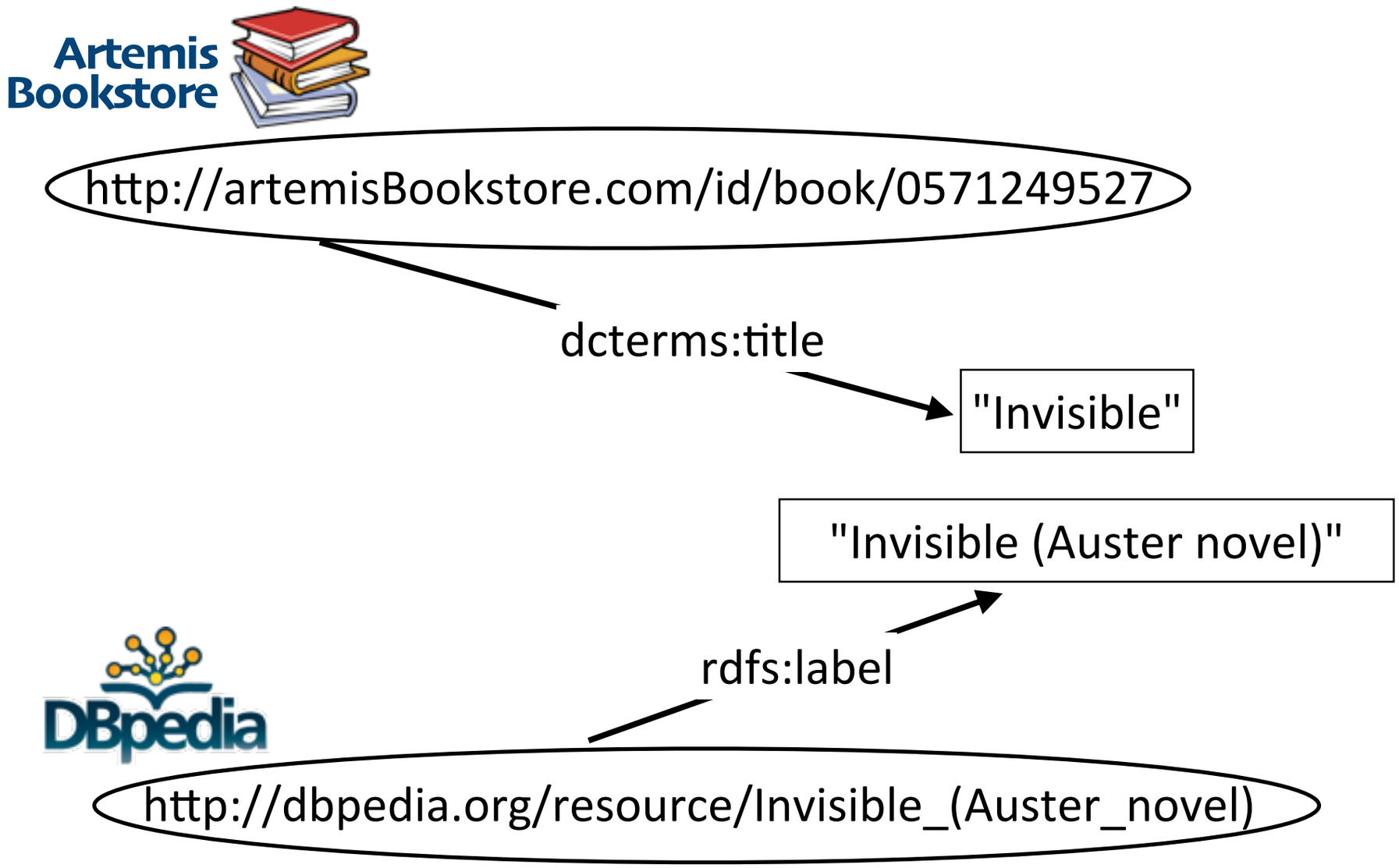
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

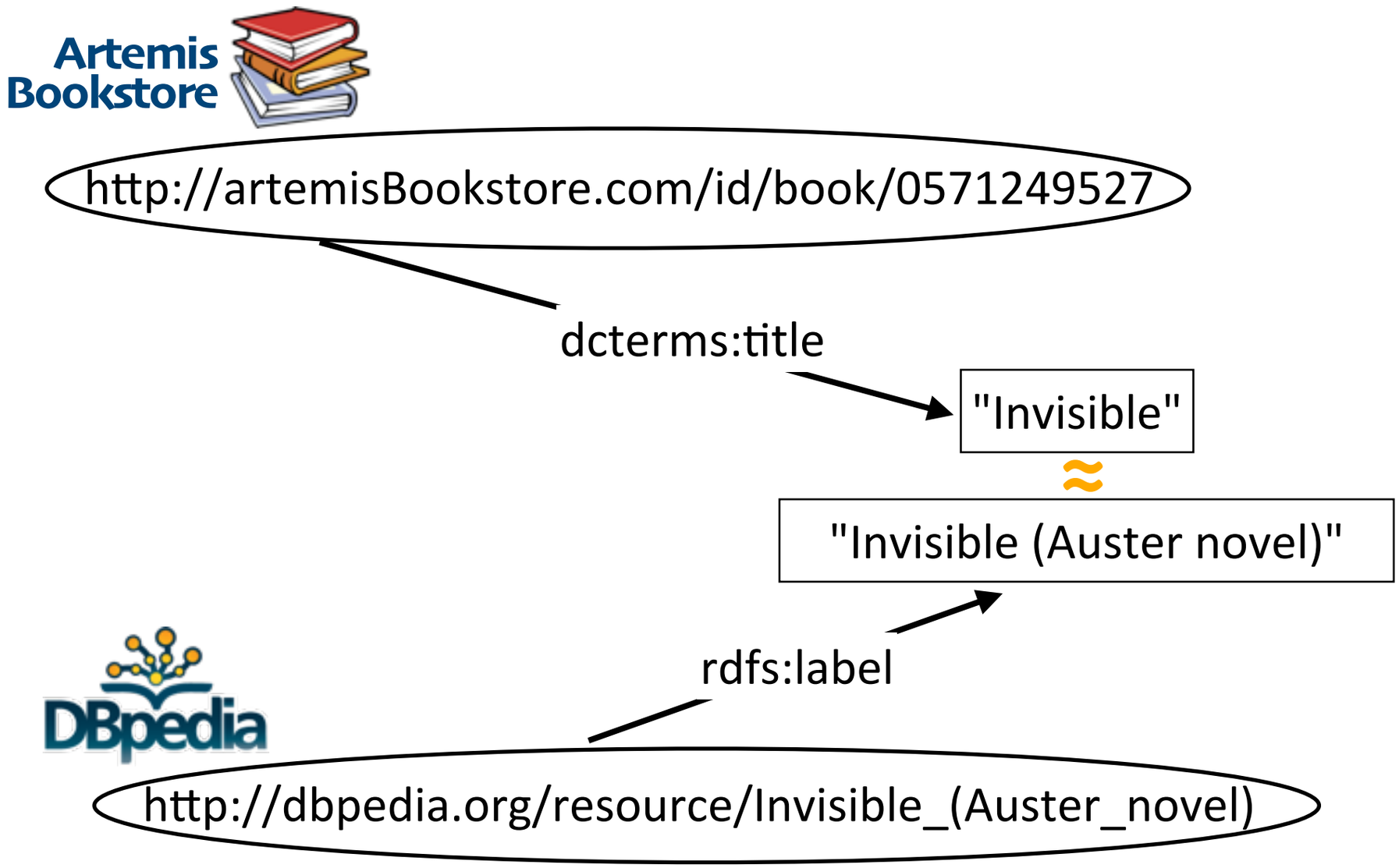
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

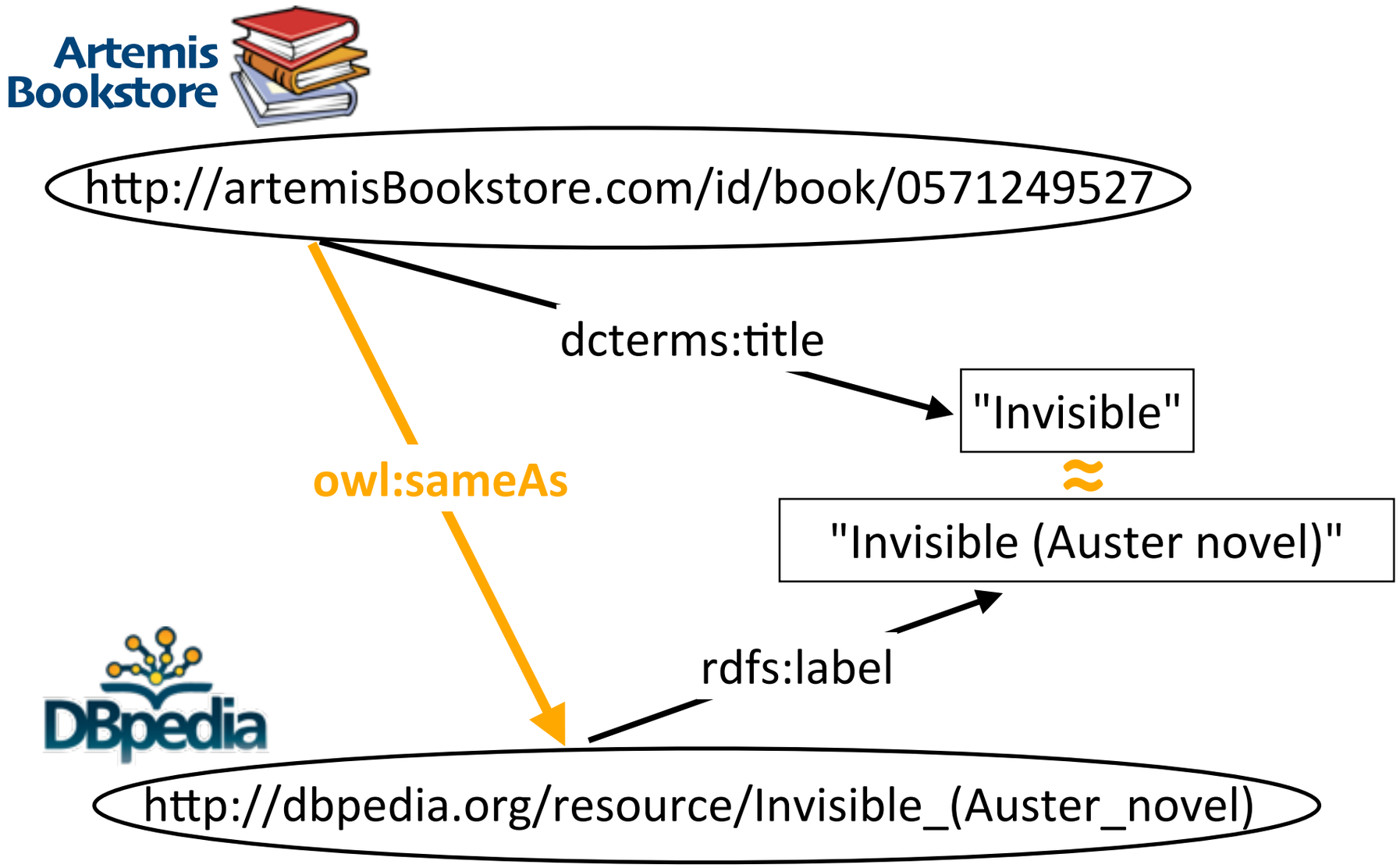
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

OpenRefine
Reconciliation services

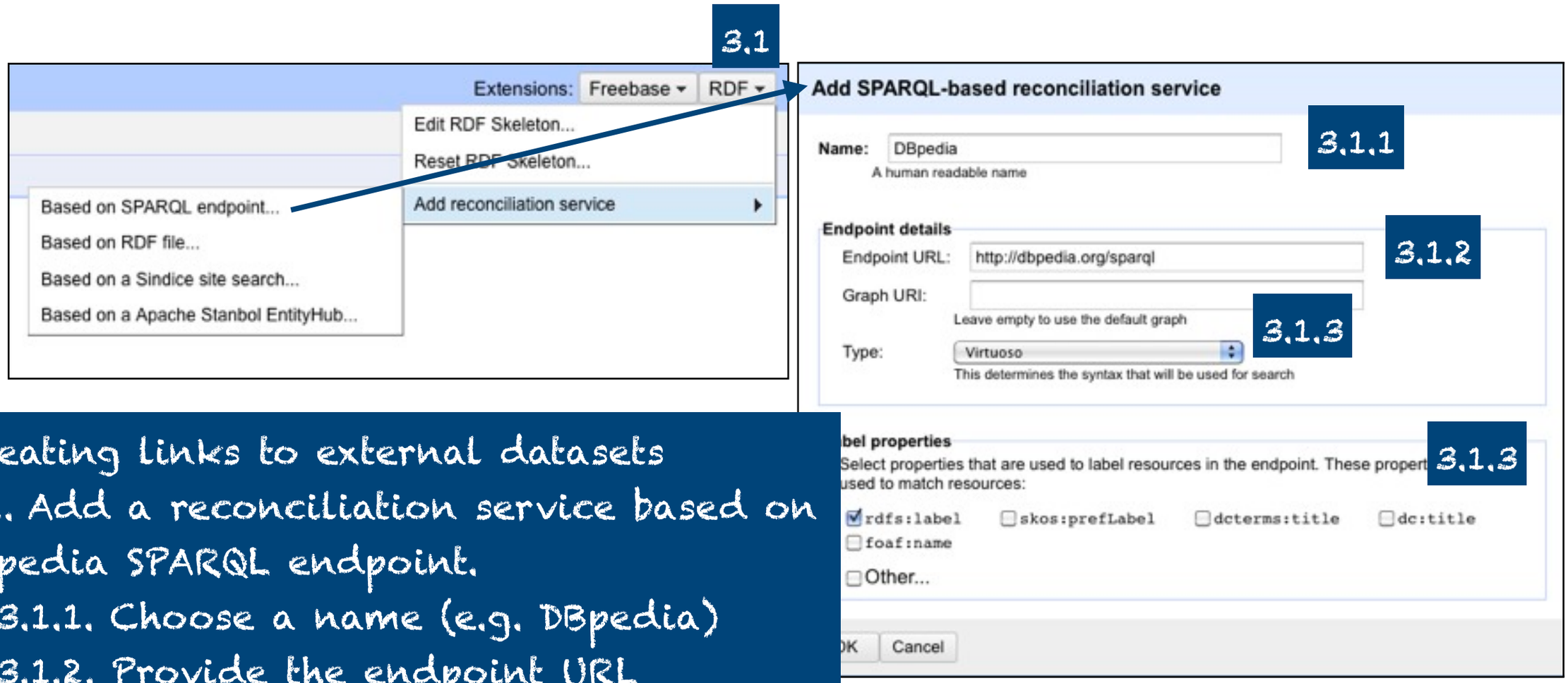
- Reconciliation services based on SPARQL endpoints



Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!

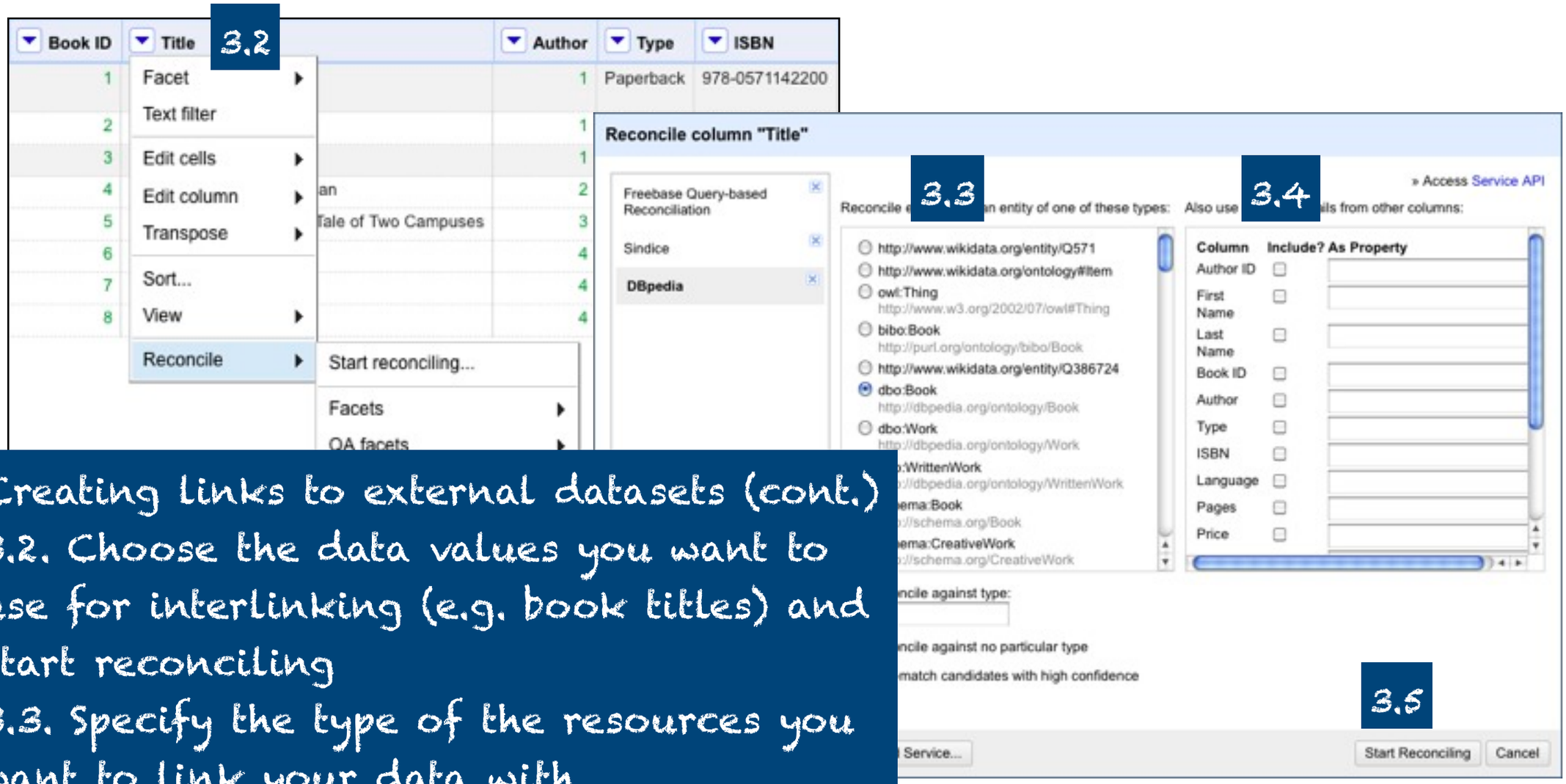


3. Creating links to external datasets
   3.1. Add a reconciliation service based on DBpedia SPARQL endpoint.
      3.1.1. Choose a name (e.g. DBpedia)
      3.1.2. Provide the endpoint URL (http://dbpedia.org/sparql)
      3.1.3. Select the type virtuoso
      3.1.4. Select the properties that will be used to match resources (e.g. rdfs:label)

Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!

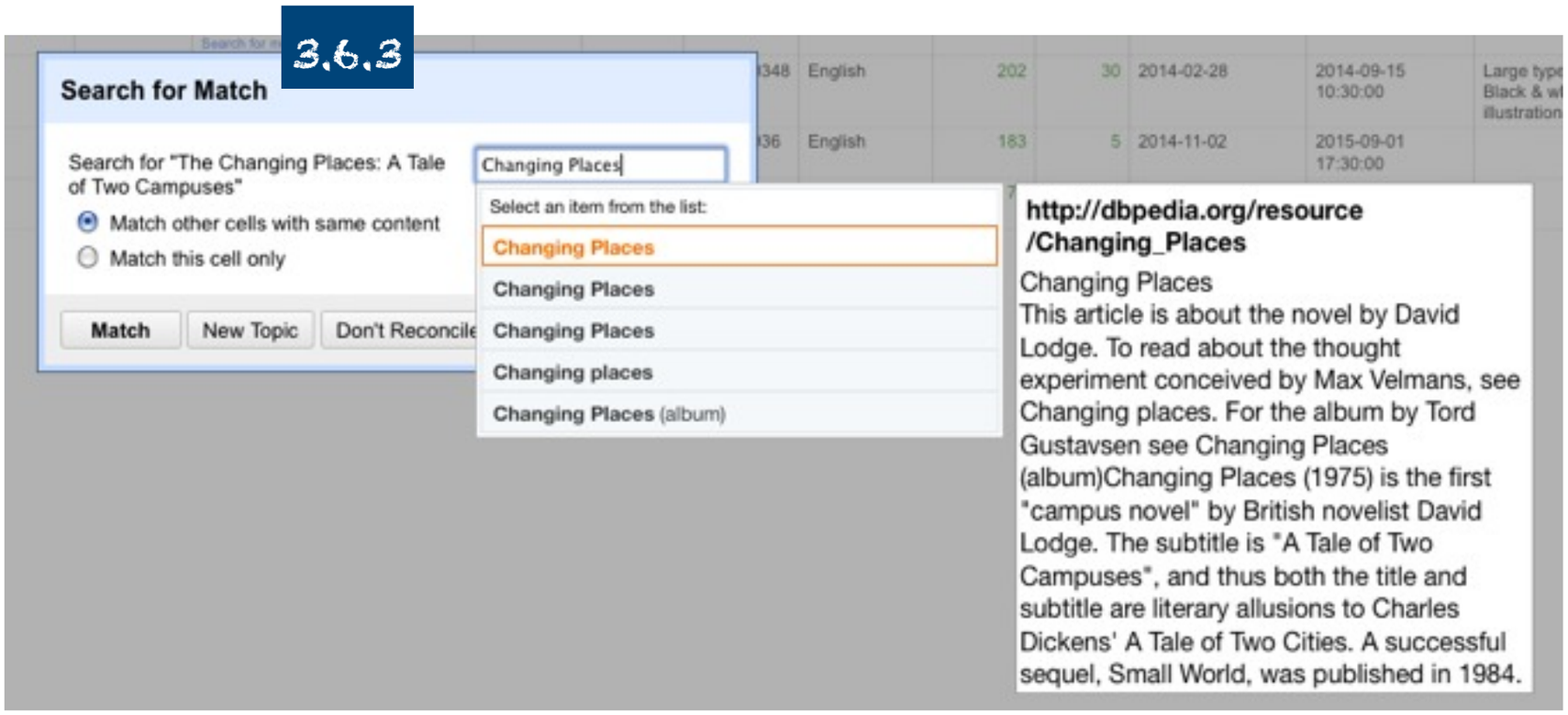


3. Creating links to external datasets (cont.)
   3.2. Choose the data values you want to use for interlinking (e.g. book titles) and start reconciling
   3.3. Specify the type of the resources you want to link your data with
   3.4. You also can select other properties. to be used for interlinking
   3.5. Start reconciling!

Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!

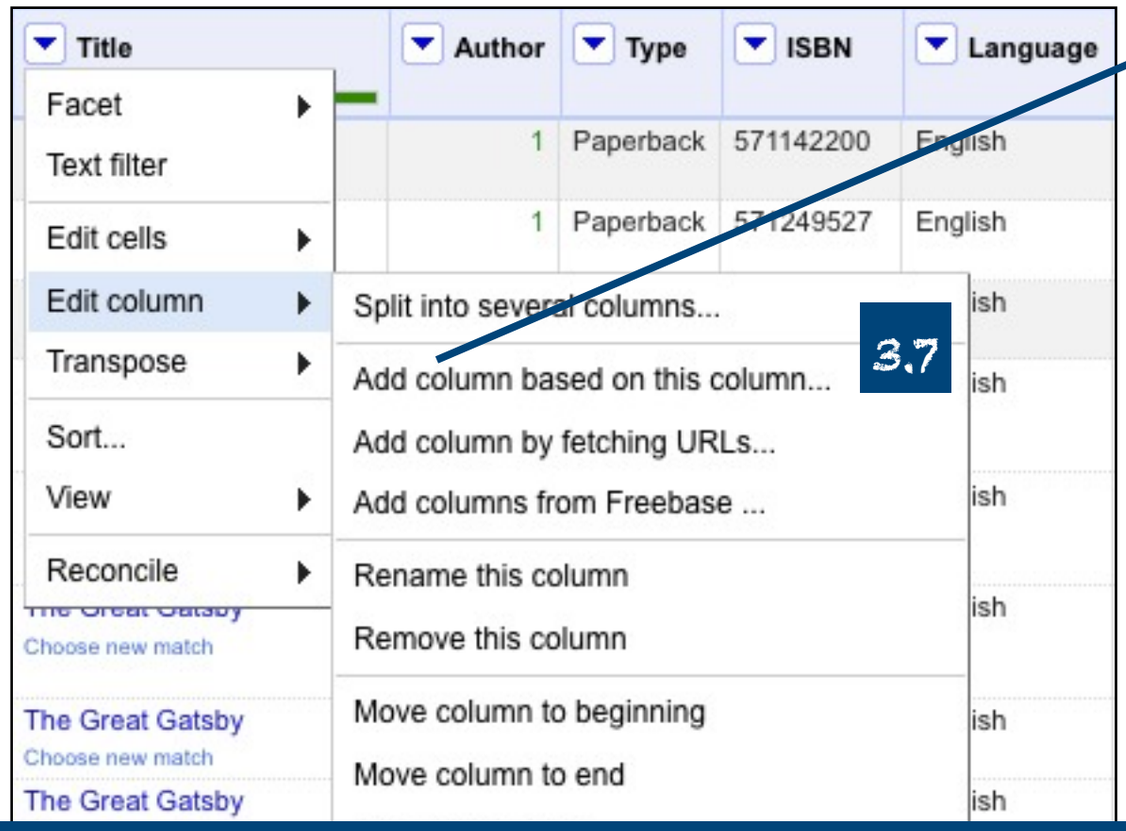


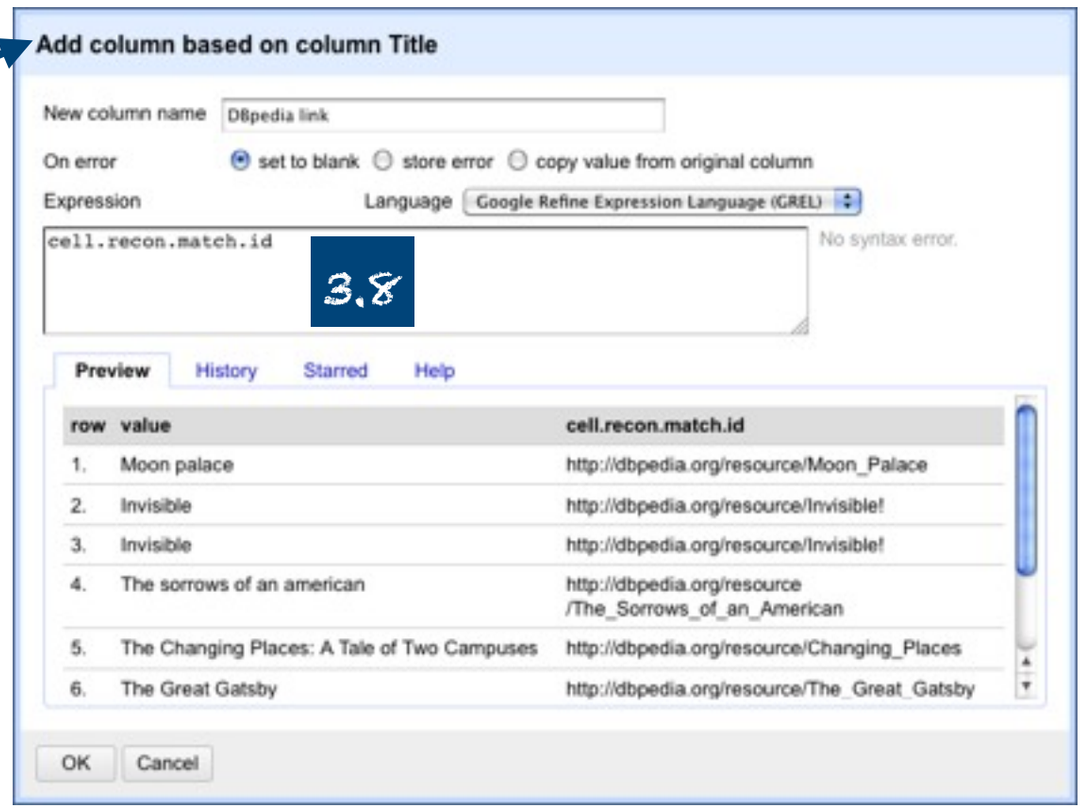
3. Creating links to external datasets (cont.)
   3.6. Once the reconciliation process is finished
      3.6.1. Some links will be correctly found, but
      3.6.2. You may need to validate other links, and
      3.6.3. You may need to find links manually

Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!



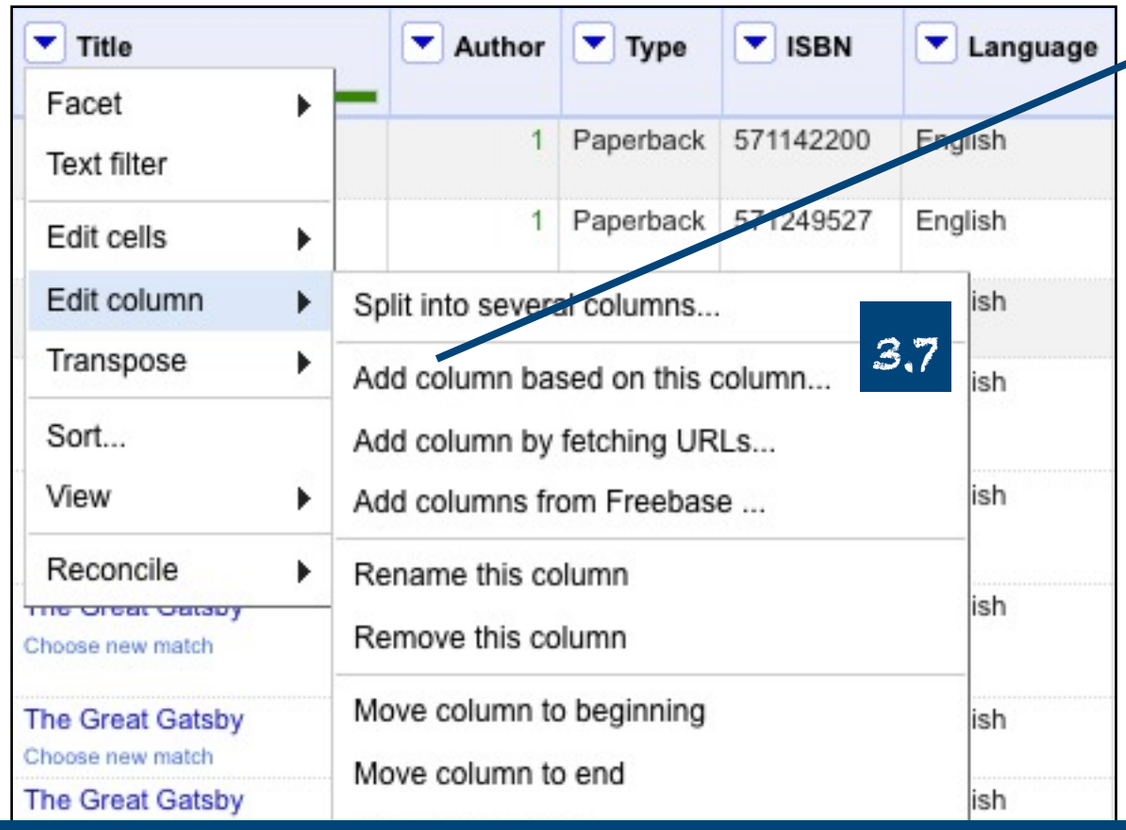


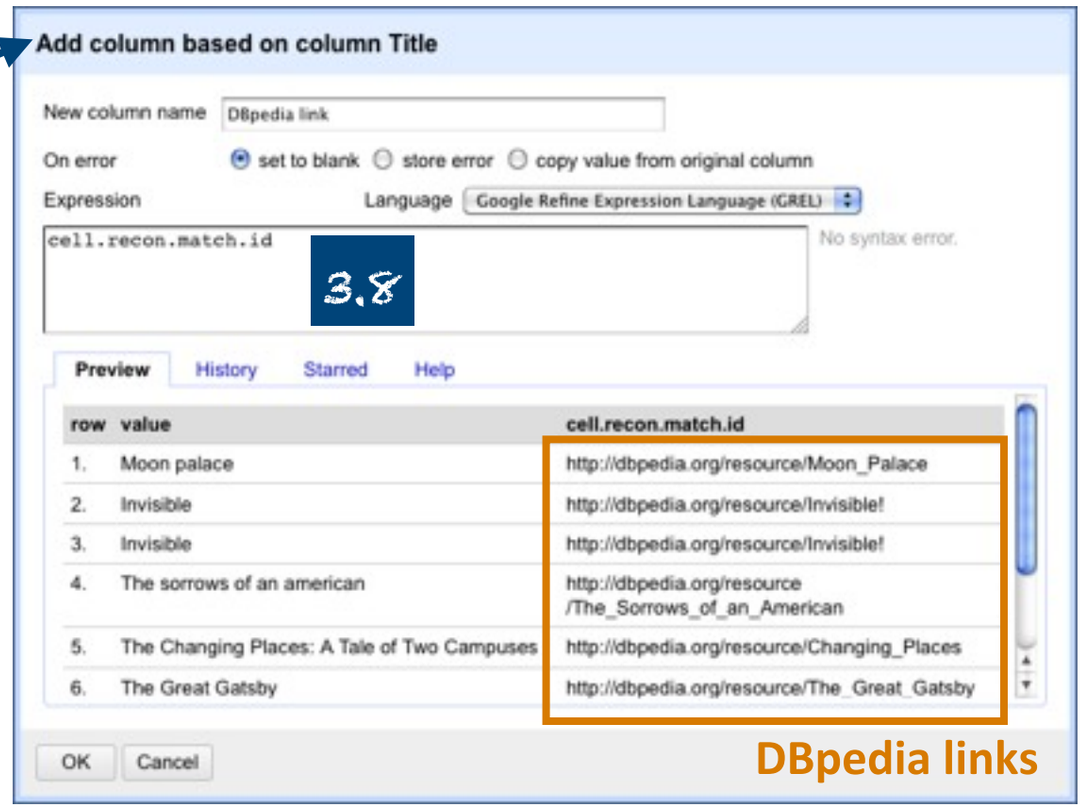
3. Creating links to external datasets (cont.)
   3.7. Add a new column based on the column used for interlinking.
   3.8. Retrieve the links found using GREL.

Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!





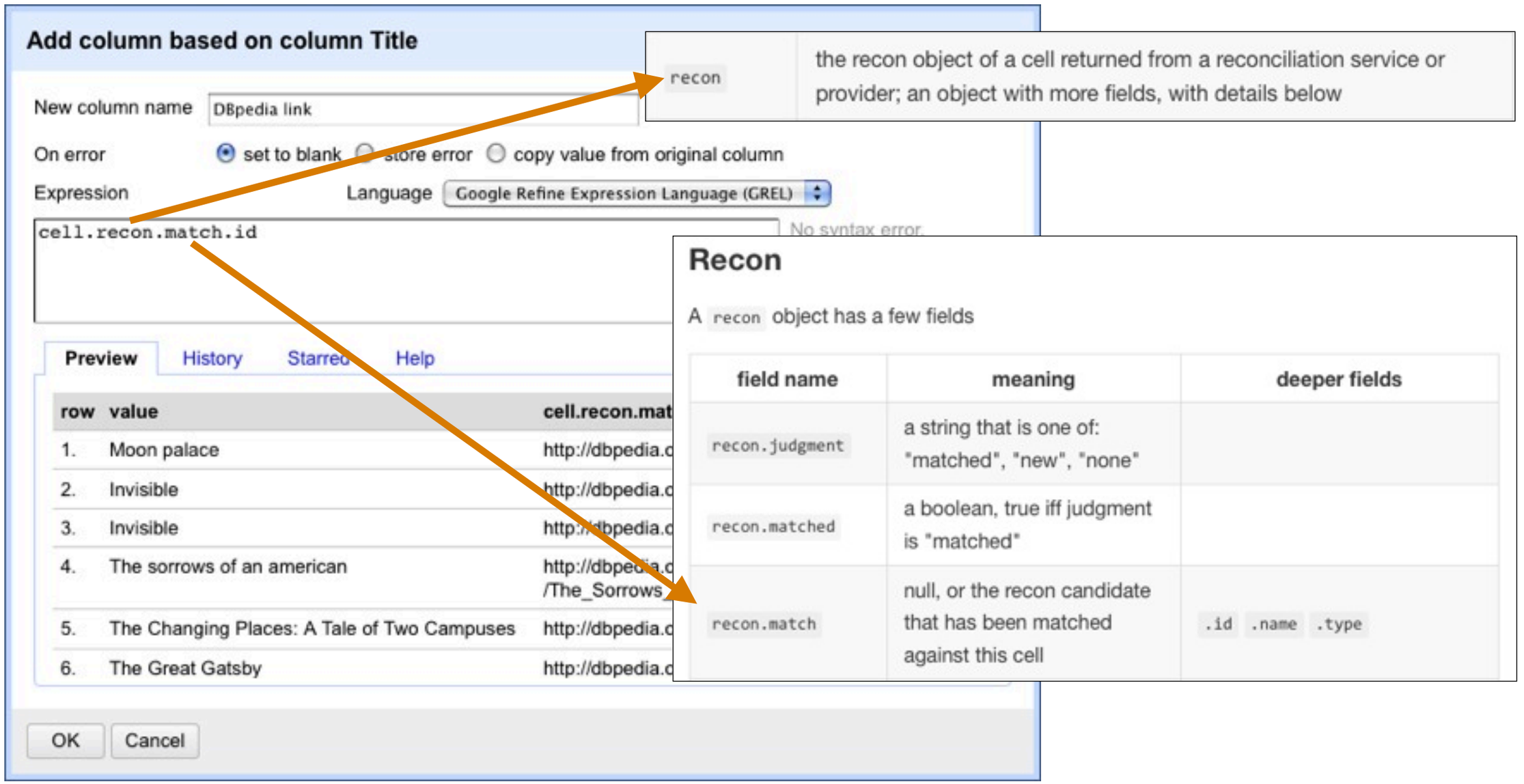
DBpedia links

3. Creating links to external datasets (cont.)
   3.7. Add a new column based on the column used for interlinking.
   3.8. Retrieve the links found using GREL.

Hands-on session (I)

OpenRefine
GREL

- General Refine Expression Language (GREL)



more info at https://github.com/OpenRefine/OpenRefine/wiki/Variables
https://github.com/OpenRefine/OpenRefine/wiki/General-Refine-Expression-Language

Hands-on session (I)

Creating links to external datasets

- Let's create links to DBpedia!

Last Name	Author's DBpedia link	Book ID	Title	Book's DBpedia link
Auster, Paul Choose new match	http://dbpedia.org /resource/Auster,_Paul	1	Moon Palace Choose new match	http://dbpedia.org/resource /Moon_Palace
Siri Hustvedt Choose new match	http://dbpedia.org /resource/Siri_Hustvedt			
David Lodge Choose new match	http://dbpedia.org /resource/David_Lodge			
F. Scott Fitzgerald Choose new match	http://dbpedia.org /resource /F._Scott_Fitzgerald			

RDF Schema Alignment

The RDF schema alignment skeleton below specifies how the RDF data that will get generated from your grid-shaped data. The cells in each record of your data will get placed into nodes within the skeleton. Configure the skeleton by specifying which column to substitute into which node.

Base URI: http://artemisBookstore.com/ edit

RDF Skeleton | RDF Preview

Available Prefixes: rdfs foaf owl rdf abo dcterms add prefix manage prefixes

Author ID URI
×foaf:Person
add rdf:type

3.9

×–foaf:firstName→ **First Name cell**

×–foaf:lastName→ **Last Name cell**

×–owl:sameAs→ **Author's DBpedia link** URI
add rdf:type

add property

Book ID URI
×dcterms:BibliographicResource
add rdf:type

×–dcterms:title→ **Title cell**

×–abo:author→ **Author** URI
add rdf:type

×–abo:bookType→ **Type cell**

ISBN cell

Save

3. Creating links to external datasets (cont.)
   3.9. Now you can update the RDF skeleton with the DBpedia links using owl:sameAs.

Hands-on session (I)

Creating links to external datasets

- You should end up with something like this

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix abo: <http://artemisBookstore.com/ontology#> .
@prefix dcterms: <http://purl.org/dc/terms/> .


<http://artemisBookstore.com/id/author/1> a foaf:Person ;
        foaf:firstName "Paul" ;
        foaf:lastName "Auster" ;
        owl:sameAs <http://dbpedia.org/resource/Auster,_Paul> .

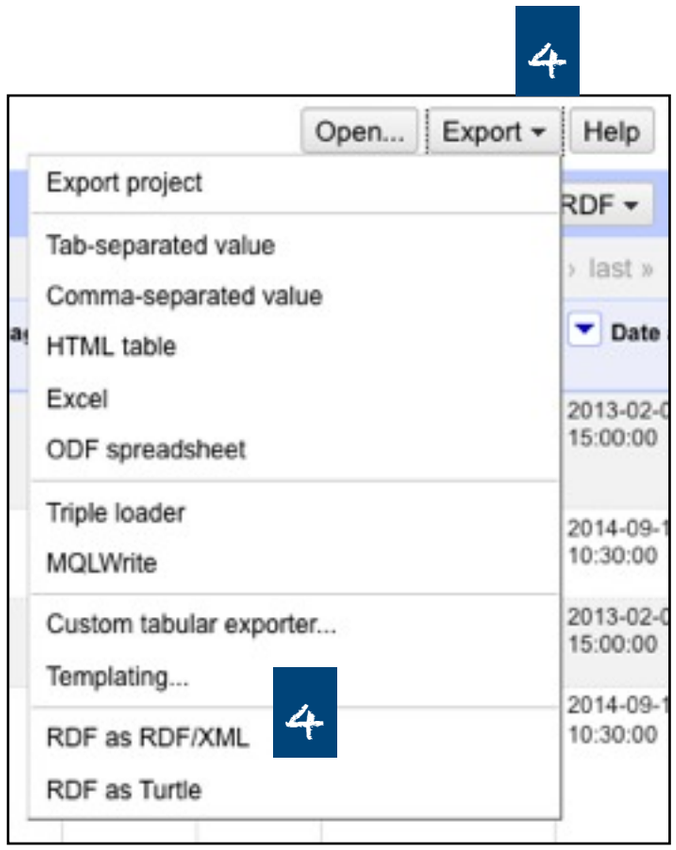
<http://artemisBookstore.com/id/book/571142200> a dcterms:BibliographicResource ;
        dcterms:title "Moon palace" ;
        abo:author <http://artemisBookstore.com/id/author/1> ;
        abo:bookType "Paperback" ;
        abo:isbn "571142200" ;
        abo:language "English" ;
        abo:pages "320"^^<http://www.w3.org/2001/XMLSchema#int> ;
        abo:price "12.5"^^<http://www.w3.org/2001/XMLSchema#double> ;
        abo:datePublication "2004-02-01" ;
        abo:dateAcquired "2013-02-01 15:00:00" ;
        dcterms:publisher "Faber & Faber" ;
        owl:sameAs <http://dbpedia.org/resource/Moon_Palace> .

<http://artemisBookstore.com/id/author/2> a foaf:Person ;
        foaf:firstName "Siri" ;
        foaf:lastName "Hustvedt" ;
        owl:sameAs <http://dbpedia.org/resource/Siri_Hustvedt> .
```

Hands-on session (I)

Artemis' RDF data

- Artemis' data is now available in RDF. Well done!



4. You can export Artemis' RDF data as RDF/XML or Turtle.

Hands-on session

- Part I: From an Excel data file to linked open data
  - you will learn how to
    - create "cool" URIs
    - describe things with RDF
    - make links to other datasets
  - we will use the OpenRefine + RDF extension
- Part II: Querying linked data with SPARQL
  - you will learn how to make queries with SPARQL
  - we will use Apache Jena - ARQ command line applications

Hands-on session (II)

Querying Linked Data with SPARQL

- Now that her data is written in RDF, Artemis can benefit from the Linked Data technologies.
- She has a great idea: for next Valentine's day, she will offer a special discount for pairs of books written by married couples who are living writers, like Paul Auster and Siri Hustvedt, two of her favourite writers.
- Although "being married with" or "being alive" is not information Artemis can find in her local data, she could find it in the Linked Open Data cloud. Let's see how.
- We will start by running some SPARQL queries at DBpedia SPARQL endpoint, and then we will query local and remote data with Apache Jena - ARQ.

Hands-on session (II)

- Which are the properties of Paul Auster in DBpedia?

Hands-on session (II)

Querying Linked Data with SPARQL

- Which are the properties of Paul Auster in DBpedia?

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop ?obj .
}
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Which are the properties of Paul Auster in DBpedia?

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop ?obj .
}
```

prop
http://www.w3.org/1999/02/22-rdf-syntax-ns#type
http://www.w3.org/2002/07/owl#sameAs
http://www.w3.org/2000/01/rdf-schema#label
http://www.w3.org/2000/01/rdf-schema#comment
http://xmlns.com/foaf/0.1/name
http://dbpedia.org/property/name
http://xmlns.com/foaf/0.1/depiction
http://purl.org/dc/elements/1.1/description
http://xmlns.com/foaf/0.1/givenName

and more...

Hands-on session (II)

- We also can order the results.

Hands-on session (II)

- We also can order the results.

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop ?obj .
}
ORDER BY ?prop
```

Hands-on session (II)

- We also can order the results.

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop ?obj .
}
ORDER BY ?prop
```

prop
http://dbpedia.org/ontology/abstract
http://dbpedia.org/ontology/activeYearsStartYear
http://dbpedia.org/ontology/alias
http://dbpedia.org/ontology/birthDate
http://dbpedia.org/ontology/birthName
http://dbpedia.org/ontology/birthPlace
http://dbpedia.org/ontology/birthYear
http://dbpedia.org/ontology/genre
http://dbpedia.org/ontology/influenced
http://dbpedia.org/ontology/influencedBy

and more...

Hands-on session (II)

- We also can order the results.

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop ?obj .
}
ORDER BY ?prop
```

prop
http://dbpedia.org/ontology/abstract
http://dbpedia.org/ontology/activeYearsStartYear
http://dbpedia.org/ontology/alias
http://dbpedia.org/ontology/birthDate
http://dbpedia.org/ontology/birthName
http://dbpedia.org/ontology/birthPlace
http://dbpedia.org/ontology/birthYear
http://dbpedia.org/ontology/genre
http://dbpedia.org/ontology/influenced
http://dbpedia.org/ontology/influencedBy

and more...

Uhmm... so DBpedia knows
when and where Paul Auster was born

Hands-on session (II)

- When and where was Paul Auster born?

Hands-on session (II)

Querying Linked Data with SPARQL

- When and where was Paul Auster born?

```
PREFIX dbo: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?date ?place
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> dbo:birthDate ?date ;
    dbo:birthPlace ?place .
}
```

Hands-on session (II)

- When and where was Paul Auster born?

```
PREFIX dbo: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?date ?place
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> dbo:birthDate ?date ;
    dbo:birthPlace ?place .
}
```

date	place
1947-02-03	http://dbpedia.org/resource/Newark,_New_Jersey
1947-02-03	http://dbpedia.org/resource/New_Jersey

Hands-on session (II)

- Is Paul Auster dead?

Hands-on session (II)

- Is Paul Auster dead?

```
PREFIX dbo: <http://dbpedia.org/ontology/>

ASK {
  <http://dbpedia.org/resource/Paul_Auster> dbo:deathDate ?date .
}
```

Hands-on session (II)

- Is Paul Auster dead?

```
PREFIX dbo: <http://dbpedia.org/ontology/>

ASK {
  <http://dbpedia.org/resource/Paul_Auster> dbo:deathDate ?date .
}
```

false

Hands-on session (II)

- Which are the classes Paul Auster is an instance of?

Hands-on session (II)

- Which are the classes Paul Auster is an instance of?

```
SELECT DISTINCT ?class
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> a ?class .
}
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Which are the classes Paul Auster is an instance of?

```
SELECT DISTINCT ?class
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> a ?class .
}
```

class
http://www.w3.org/2002/07/owl#Thing
http://xmlns.com/foaf/0.1/Person
http://dbpedia.org/ontology/Person
http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#Agent
http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#NaturalPerson
http://www.wikidata.org/entity/Q215627
http://www.wikidata.org/entity/Q36180
http://www.wikidata.org/entity/Q483501
http://www.wikidata.org/entity/Q5
http://dbpedia.org/ontology/Agent
http://dbpedia.org/ontology/Artist
http://dbpedia.org/ontology/Writer

and more...

Hands-on session (II)

Querying Linked Data with SPARQL

- Which are the classes Paul Auster is an instance of?

```
SELECT DISTINCT ?class
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> a ?class .
}
```

class
http://www.w3.org/2002/07/owl#Thing
http://xmlns.com/foaf/0.1/Person
http://dbpedia.org/ontology/Person
http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#Agent
http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#NaturalPerson
http://www.wikidata.org/entity/Q215627
http://www.wikidata.org/entity/Q36180
http://www.wikidata.org/entity/Q483501
http://www.wikidata.org/entity/Q5
http://dbpedia.org/ontology/Agent
http://dbpedia.org/ontology/Artist
http://dbpedia.org/ontology/Writer

and more...

OK, so Paul Auster is a Writer
(an instance of the class dbo:Writer)

Hands-on session (II)

- Which are the relations (if there is any) between Paul Auster and Siri Hustvedt?

Hands-on session (II)

- Which are the relations (if there is any) between Paul Auster and Siri Hustvedt?

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop
    <http://dbpedia.org/resource/Siri_Hustvedt> .
}
```

Hands-on session (II)

- Which are the relations (if there is any) between Paul Auster and Siri Hustvedt?

```
SELECT DISTINCT ?prop
WHERE {
  <http://dbpedia.org/resource/Paul_Auster> ?prop
    <http://dbpedia.org/resource/Siri_Hustvedt> .
}
```

prop
http://dbpedia.org/ontology/spouse
http://dbpedia.org/property/spouse

Hands-on session (II)

- Let's find married couples who are writers.

Hands-on session (II)

- Let's find married couples who are writers.

```
PREFIX dbo: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?w1 ?w2
WHERE {
  ?w1 a dbo:Writer ;
      dbo:spouse ?w2 .
  ?w2 a dbo:Writer .
}
ORDER BY ?w1
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Let's find married couples who are writers.

w1	w2
http://dbpedia.org/resource/A._E._van_Vogt	http://dbpedia.org/resource/Edna_Mayne_Hull
http://dbpedia.org/resource/Aaron_Elkins	http://dbpedia.org/resource/Charlotte_Elkins
http://dbpedia.org/resource/Akiko_Yosano	http://dbpedia.org/resource/Tekkan_Yosano
http://dbpedia.org/resource/Alan_Sillitoe	http://dbpedia.org/resource/Ruth_Fainlight
http://dbpedia.org/resource/Alissa_York	http://dbpedia.org/resource/Clive_Holden
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Fleur_Adcock
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Meg_Campbell
http://dbpedia.org/resource/Andrew_Grant_(writer)	http://dbpedia.org/resource/Tasha_Alexander
http://dbpedia.org/resource/Andrew_Sarris	http://dbpedia.org/resource/Molly_Haskell
http://dbpedia.org/resource/Anita_Lobel	http://dbpedia.org/resource/Arnold_Lobel
http://dbpedia.org/resource/Ann-Marie_MacDonald	http://dbpedia.org/resource/Alisa_Palmer
http://dbpedia.org/resource/Anne_Fine	http://dbpedia.org/resource/Kit_Fine
http://dbpedia.org/resource/Anne_Henderson	http://dbpedia.org/resource/Gerard_Henderson
http://dbpedia.org/resource/Anne_Rice	http://dbpedia.org/resource/Stan_Rice
http://dbpedia.org/resource/Anne_Strieber	http://dbpedia.org/resource/Whitley_Strieber
http://dbpedia.org/resource/Anne_Wagner	http://dbpedia.org/resource/T._J._Clark_(art_historian)
http://dbpedia.org/resource/Annie_Hall_Cudlip	http://dbpedia.org/resource/Pender_Hodge_Cudlip
http://dbpedia.org/resource/Antonia_Fraser	http://dbpedia.org/resource/Harold_Pinter
http://dbpedia.org/resource/Antony_Beevor	http://dbpedia.org/resource/Artemis_Cooper
http://dbpedia.org/resource/Arnold_Lobel	http://dbpedia.org/resource/Anita_Lobel

and more...

Hands-on session (II)

Querying Linked Data with SPARQL

- Let's find married couples who are writers.

w1	w2
http://dbpedia.org/resource/A._E._van_Vogt	http://dbpedia.org/resource/Edna_Mayne_Hull
http://dbpedia.org/resource/Aaron_Elkins	http://dbpedia.org/resource/Charlotte_Elkins
http://dbpedia.org/resource/Akiko_Yosano	http://dbpedia.org/resource/Tekkan_Yosano
http://dbpedia.org/resource/Alan_Sillitoe	http://dbpedia.org/resource/Ruth_Fainlight
http://dbpedia.org/resource/Alissa_York	http://dbpedia.org/resource/Clive_Holden
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Fleur_Adcock
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Meg_Campbell
http://dbpedia.org/resource/Andrew_Grant_(writer)	http://dbpedia.org/resource/Tasha_Alexander
http://dbpedia.org/resource/Andrew_Sarris	http://dbpedia.org/resource/Molly_Haskell
http://dbpedia.org/resource/Anita_Lobel	http://dbpedia.org/resource/Arnold_Lobel
http://dbpedia.org/resource/Ann-Marie_MacDonald	http://dbpedia.org/resource/Alisa_Palmer
http://dbpedia.org/resource/Anne_Fine	http://dbpedia.org/resource/Kit_Fine
http://dbpedia.org/resource/Anne_Henderson	http://dbpedia.org/resource/Gerard_Henderson
http://dbpedia.org/resource/Anne_Rice	http://dbpedia.org/resource/Stan_Rice
http://dbpedia.org/resource/Anne_Strieber	http://dbpedia.org/resource/Whitley_Strieber
http://dbpedia.org/resource/Anne_Wagner	http://dbpedia.org/resource/T._J._Clark_(art_historian)
http://dbpedia.org/resource/Annie_Hall_Cudlip	http://dbpedia.org/resource/Pender_Hodge_Cudlip
http://dbpedia.org/resource/Antonia_Fraser	http://dbpedia.org/resource/Harold_Pinter
http://dbpedia.org/resource/Antony_Beevor	http://dbpedia.org/resource/Artemis_Cooper
http://dbpedia.org/resource/Arnold_Lobel	http://dbpedia.org/resource/Anita_Lobel

they are duplicated!

and more...

Hands-on session (II)

- Let's remove duplicates.

Hands-on session (II)

- Let's remove duplicates.

```
PREFIX dbo: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?w1 ?w2
WHERE {
  ?w1 a dbo:Writer ;
      dbo:spouse ?w2 .
  ?w2 a dbo:Writer .
  FILTER ( str(?w1) <= str(?w2) )
}

ORDER BY ?w1
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Let's remove duplicates.

w1	w2
http://dbpedia.org/resource/A._E._van_Vogt	http://dbpedia.org/resource/Edna_Mayne_Hull
http://dbpedia.org/resource/Aaron_Elkins	http://dbpedia.org/resource/Charlotte_Elkins
http://dbpedia.org/resource/Akiko_Yosano	http://dbpedia.org/resource/Tekkan_Yosano
http://dbpedia.org/resource/Alan_Sillitoe	http://dbpedia.org/resource/Ruth_Fainlight
http://dbpedia.org/resource/Alissa_York	http://dbpedia.org/resource/Clive_Holden
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Fleur_Adcock
http://dbpedia.org/resource/Alistair_Campbell_(poet)	http://dbpedia.org/resource/Meg_Campbell
http://dbpedia.org/resource/Andrew_Grant_(writer)	http://dbpedia.org/resource/Tasha_Alexander
http://dbpedia.org/resource/Andrew_Sarris	http://dbpedia.org/resource/Molly_Haskell
http://dbpedia.org/resource/Anita_Lobel	http://dbpedia.org/resource/Arnold_Lobel
http://dbpedia.org/resource/Anne_Fine	http://dbpedia.org/resource/Kit_Fine
http://dbpedia.org/resource/Anne_Henderson	http://dbpedia.org/resource/Gerard_Henderson
http://dbpedia.org/resource/Anne_Rice	http://dbpedia.org/resource/Stan_Rice
http://dbpedia.org/resource/Anne_Strieber	http://dbpedia.org/resource/Whitley_Strieber
http://dbpedia.org/resource/Anne_Wagner	http://dbpedia.org/resource/T._J._Clark_(art_historian)
http://dbpedia.org/resource/Annie_Hall_Cudlip	http://dbpedia.org/resource/Pender_Hodge_Cudlip
http://dbpedia.org/resource/Antonia_Fraser	http://dbpedia.org/resource/Harold_Pinter
http://dbpedia.org/resource/Antony_Beevor	http://dbpedia.org/resource/Artemis_Cooper
http://dbpedia.org/resource/Arthur_F._H._Mills	http://dbpedia.org/resource/Lady_Dorothy_Mills

and more...

Hands-on session (II)

- Now, let's find married couples who are living writers.

Hands-on session (II)

- Now, let's find married couples who are living writers.

```
PREFIX dbo: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?w1 ?w2
WHERE {
  ?w1 a dbo:Writer ;
      dbo:spouse ?w2 .
  ?w2 a dbo:Writer .
  FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
           NOT EXISTS {?w2 dbo:deathDate ?date2} &&
           str(?w1) <= str(?w2) )
}

ORDER BY ?w1
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Now, let's find married couples who are living writers.

w1	w2
http://dbpedia.org/resource/Aaron_Elkins	http://dbpedia.org/resource/Charlotte_Elkins
http://dbpedia.org/resource/Alissa_York	http://dbpedia.org/resource/Clive_Holden
http://dbpedia.org/resource/Andrew_Grant_(writer)	http://dbpedia.org/resource/Tasha_Alexander
http://dbpedia.org/resource/Anne_Fine	http://dbpedia.org/resource/Kit_Fine
http://dbpedia.org/resource/Anne_Henderson	http://dbpedia.org/resource/Gerard_Henderson
http://dbpedia.org/resource/Anne_Strieber	http://dbpedia.org/resource/Whitley_Strieber
http://dbpedia.org/resource/Anne_Wagner	http://dbpedia.org/resource/T._J._Clark_(art_historian)
http://dbpedia.org/resource/Antony_Beevor	http://dbpedia.org/resource/Artemis_Cooper
http://dbpedia.org/resource/Ayelet_Waldman	http://dbpedia.org/resource/Michael_Chabon
http://dbpedia.org/resource/B._M._Suhara	http://dbpedia.org/resource/M._M._Basheer
http://dbpedia.org/resource/Barb_Hendee	http://dbpedia.org/resource/J._C._Hendee
http://dbpedia.org/resource/Beth_Gylys	http://dbpedia.org/resource/Thomas_Forsthoefel
http://dbpedia.org/resource/Betsy_Lewin	http://dbpedia.org/resource/Ted_Lewin
http://dbpedia.org/resource/Bill_Pronzini	http://dbpedia.org/resource/Marcia_Muller
http://dbpedia.org/resource/Birgit_Zotz	http://dbpedia.org/resource/Volker_Zotz
http://dbpedia.org/resource/Boaz_Keysar	http://dbpedia.org/resource/Linda_E._Ginzel
http://dbpedia.org/resource/Brenda_Webster	http://dbpedia.org/resource/Ira_M._Lapidus
http://dbpedia.org/resource/Brian_Lindstrom	http://dbpedia.org/resource/Cheryl_Strayed
http://dbpedia.org/resource/Carol_Gorman	http://dbpedia.org/resource/Edward_Gorman
http://dbpedia.org/resource/Carol_Weston	http://dbpedia.org/resource/Rob_Ackerman

and more...

Hands-on session (II)

- Jena is a free and open source Java framework for building Semantic Web and Linked Data applications.
- an apache project: http://jena.apache.org/index.html
- Jena APIs:
  - RDF: RDF API, ARQ (SPARQL)
  - Triple Store: TDB, Fuseki
  - OWL: Ontology API, Inference API
- ARQ Command Line Applications
  - arq --data=mydataset.nt --query=myquery.rq
  - arq --data=mydataset.nt --query=myquery.rq --results=xml

more info at https://jena.apache.org/documentation/query/cmds.html

Hands-on session (II)

Querying Linked Data with SPARQL

- Finally, let's find in Artemis' bookstore data pairs of books written by married couples who are living writers.

```
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX abo: <http://artemisBookstore.com/ontology#>

SELECT DISTINCT ?v1 ?b1 ?v2 ?b2
WHERE {
  ?b1 abo:author ?v1 .
  ?b2 abo:author ?v2 .
  ?v1 owl:sameAs ?w1 .
  ?v2 owl:sameAs ?w2 .
  SERVICE <http://dbpedia.org/sparql> {
    SELECT DISTINCT ?w1 ?w2
    WHERE {
      ?w1 a dbo:Writer ;
          dbo:spouse ?w2 .
      ?w2 a dbo:Writer .
      FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
               NOT EXISTS {?w2 dbo:deathDate ?date2} )
    }
  }
}
ORDER BY ?v1 ?v2
```

Hands-on session (II)

Querying Linked Data with SPARQL

- Finally, let's find in Artemis' bookstore data pairs of books written by married couples who are living writers.

```
PREFIX foaf: <http://xmlns.com/foaf/0.1>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX abo: <http://artemisBookstore.com/ontology#>

SELECT DISTINCT ?fn1 ?ln1 ?t1 ?fn2 ?ln2 ?t2
WHERE {
  ?b1 dcterms:title ?t1 ; abo:author ?v1 .
  ?b2 dcterms:title ?t2 ; abo:author ?v2 .
  ?v1 foaf:firstName ?fn1 ; foaf:lastName ?ln1 ; owl:sameAs ?w1 .
  ?v2 foaf:firstName ?fn2 ; foaf:lastName ?ln2 ; owl:sameAs ?w2 .
  SERVICE <http://dbpedia.org/sparql> {
    SELECT DISTINCT ?w1 ?w2
    WHERE {
      ?w1 a dbo:Writer ;
          dbo:spouse ?w2 .
      ?w2 a dbo:Writer .
      FILTER ( NOT EXISTS {?w1 dbo:deathDate ?date1} &&
               NOT EXISTS {?w2 dbo:deathDate ?date2} )
    }
  }
}
ORDER BY ?ln1 ?ln2
```