

Knowledge Graphs creation

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 imec.be- IDLab.technology

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 @natadimou

do you remember ...

how Google results were in 1999?



Searched the web for **Microsoft**.

Category: [Computers > Multimedia > MPEG > Audio > News and Media](#)

News: [Microsoft Donates \\$100 Million for Kids Tech Program](#) (Excite Reuters - 12/4/2000)
[Microsoft To Donate \\$100M to Clubs](#) (Excite AP - 12/4/2000)
[Internet Daily Asia: Microsoft eyes v-commerce deal with Sumitomo NEC](#) (CBS MarketWatch - 12/4/2000)

[Welcome to Microsoft's Homepage \(Microsoft^{RM}\)](#)

... NET, **Microsoft**.NET: News and resources for developers, IT pros, and business. E-commerce,

Winning clicks: Find out why Guinness World Records is switching to a ...

Description: Official homepage of **Microsoft** Corporation

Category: [Computers > Companies > ... > Consumer Software > Microsoft Corporation](#)

[www.microsoft.com/](#) - 22k - [Cached](#) - [Similar pages](#) - [New!](#) [Stock quotes: MSFT](#)

[Microsoft - Information on Terms of Use](#)

"I gen true comment "RSACI North America Server" by "inet@microsoft.com

" on "1997.06.30T14:48-0500" r (n 0 s 0 v 0 1 0))"> ...

[www.microsoft.com/info/copyright.htm](#) - 20k - [Cached](#) - [Similar pages](#)

[[More results from www.microsoft.com](#)]

[Microsoft Press: Computers books and interactive products on ...](#)

... that uses an XML document's data. Complete Coverage of SQL Server Essentials **Microsoft**

SQL Server 2000 Administrator's Companion THE daily operations guide to ...

Description: **Microsoft** Press provides comprehensive learning tools to help users of all levels get the most from...

Category: [Computers > Education > Commercial Services > Training Companies](#)

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[MSDN Online](#)

... Exchange 2000 Unveiled, Exchange 2000 Unveiled **Microsoft** released Exchange 2000 at

the **Microsoft** Exchange Conference. Get more information on the latest version ...

Description: Provides articles, whitepapers, interviews, and sample code for software developers using **Microsoft**...

Category: [Computers > Companies > ... > Developer Tools > Microsoft Corporation](#)

[msdn.microsoft.com/](#) - 55k - [Cached](#) - [Similar pages](#)

[Microsoft .NET on MSDN](#)

... Updated: October 18, 2000. **Microsoft**.NET is designed to make the Internet a true

distributed computing platform, providing a framework that allows computers ...

Description: A listing of **Microsoft**.NET articles on MSDN.

Category: [Computers > Programming > Component Frameworks > NET](#)

[msdn.microsoft.com/net/](#) - 31k - [Cached](#) - [Similar pages](#)

[[More results from msdn.microsoft.com](#)]

[Microsoft Windows Update](#)

... that does not support Frames or ActiveX technology. To learn more about browsers

that do support these technologies, please visit the **Microsoft** Web site. ...

[windowsupdate.microsoft.com/](#) - 3k - [Cached](#) - [Similar pages](#)

1999

... how are the
same results
presented
nowadays?



microsoft



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Shop the Latest Microsoft Products Including Surface, Office, Xbox, & More! View Deals. Track Your Order. Find A Store. Highlights: Free Shipping Available, Team Of Experts Available, Easy Returns Available.

Microsoft - Official Home Page

<https://www.microsoft.com/>

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Results from microsoft.com



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Visual Studio 2019 Launch Event

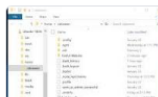
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GOJO Industries hopes to influence and improve hand hygiene with the help of the cloud and #IoT: [mstf.social/FR5YBk](#) via @Forbes

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This week on #MicrosoftUnboxed @sonia_data and @colleenobrien share stories that show how #MixedReality can transform the way we work. Tune in every Thursday at 9AM PT

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2019

Microsoft Corporation

Technology company



[microsoft.com](https://www.microsoft.com)

Microsoft Corporation is an American multinational technology company with headquarters in Redmond, Washington. It develops, manufactures, licenses, supports and sells computer software, consumer electronics, personal computers, and related services. [Wikipedia](#)

CEO: Satya Nadella (Feb 4, 2014-)

Headquarters: Redmond, Washington, United States

Founded: April 4, 1975, Albuquerque, New Mexico, United States

Stock price: MSFT (NASDAQ) 108,22 US\$ +1,32 (+1,23%)
15 Feb, 16:00 GMT-5 - Disclaimer

Founders: Bill Gates, Paul Allen

Subsidiaries: Yammer, Skype Communications S.a r.l., Mojang, [MORE](#)

Did you know: Microsoft is the world's sixth-largest information technology company by revenue. [wikipedia.org](#)

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People also search for

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IBM



Sony Corporation



Amazon...



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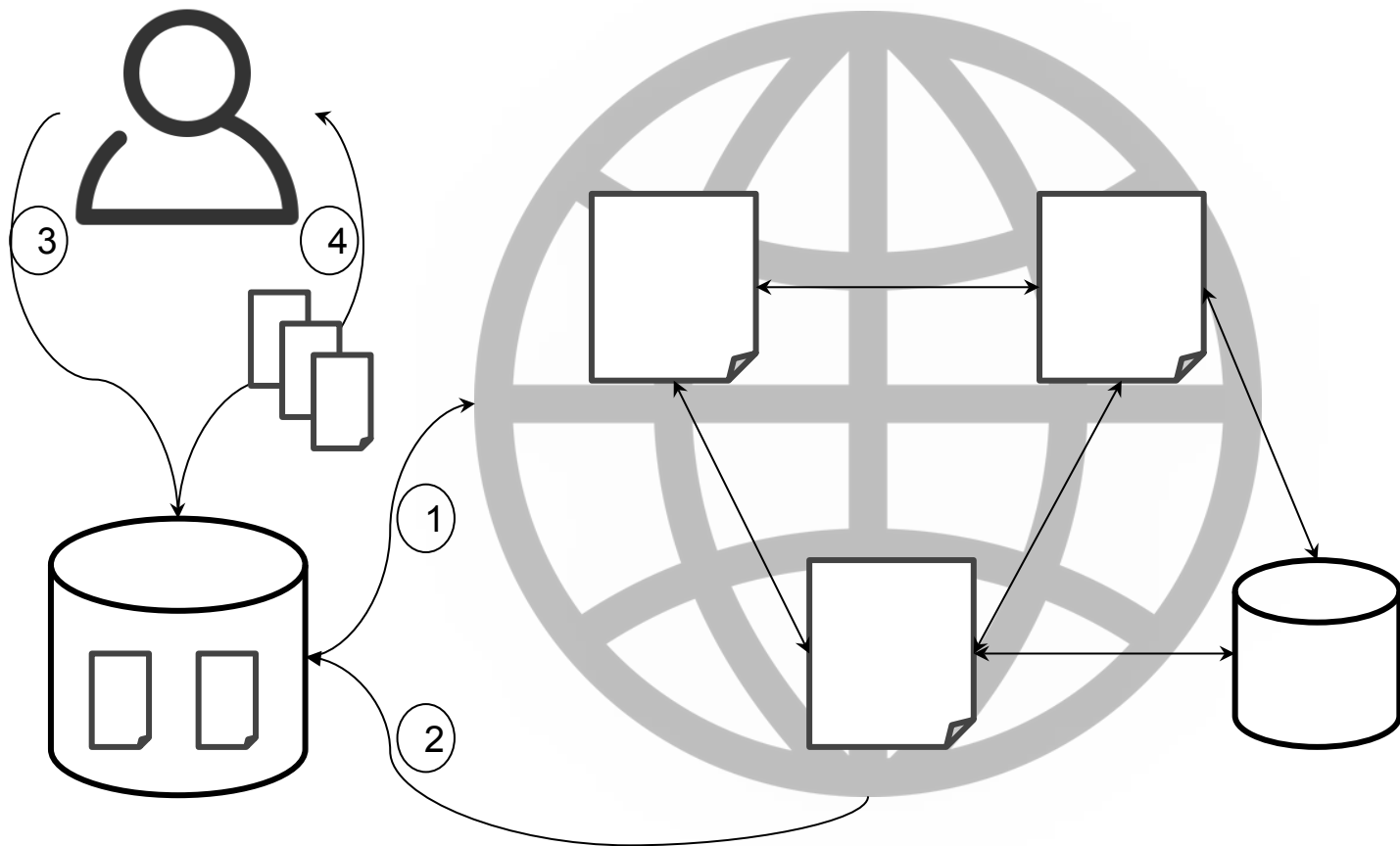
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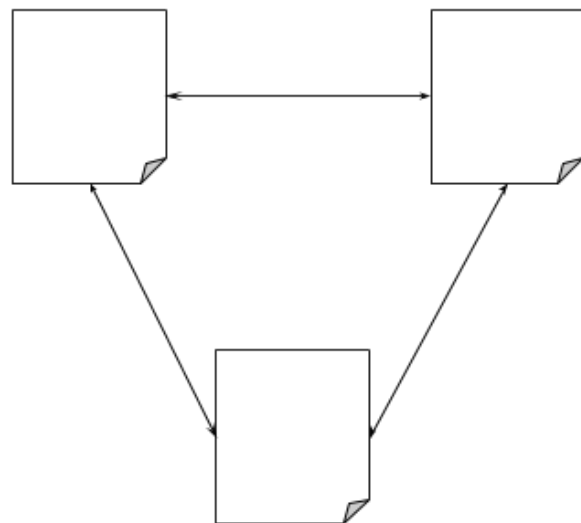
... what has changed
the past 20 years?

Web of Documents

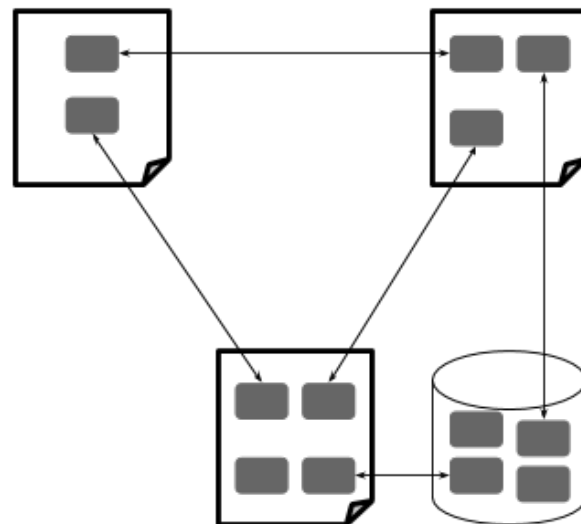




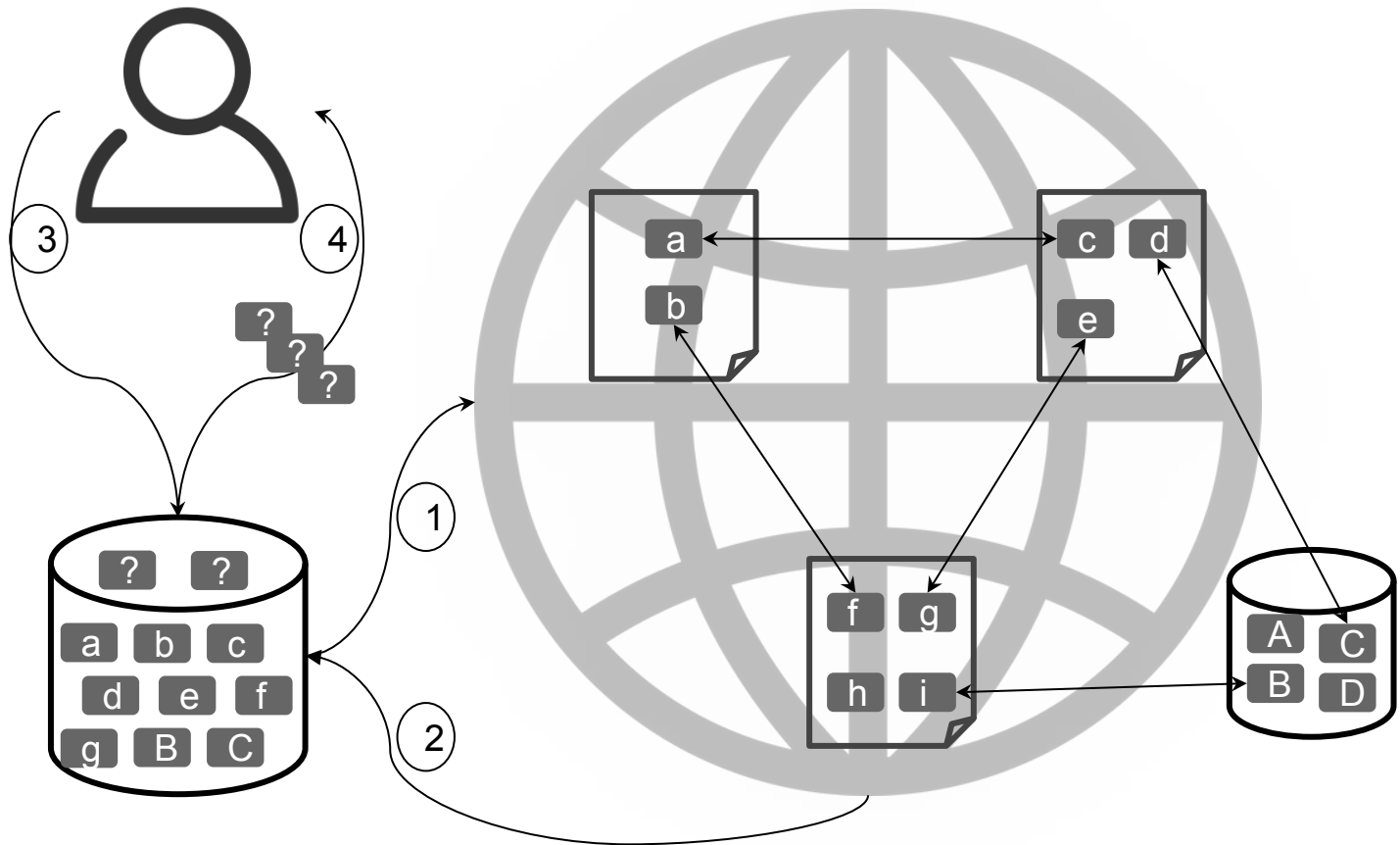
Web of Documents



Web of Data



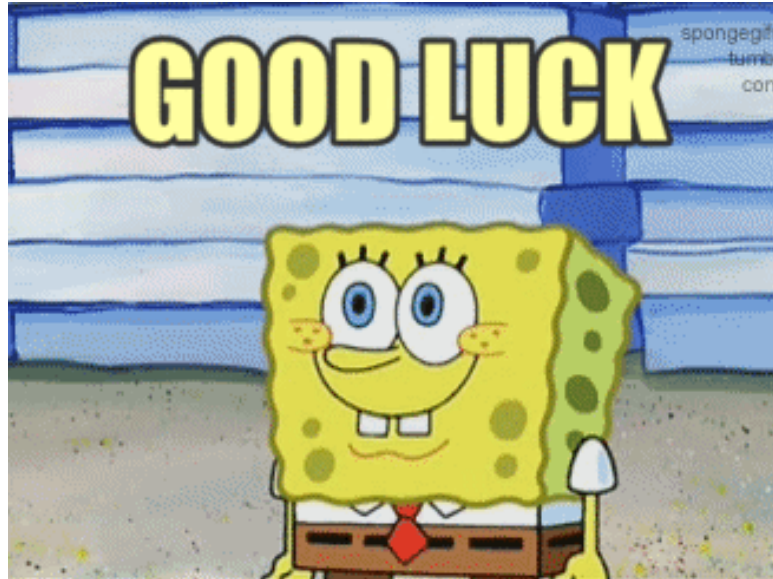
Web of Data





Knowledge Graphs

Knowledge Graph describes
entities and their interrelations
by means of a graph



where are these Knowledge Graphs coming from?

Knowledge Graph creation

KG creation history

languages for KG creation

R2RML and RML

data transformations

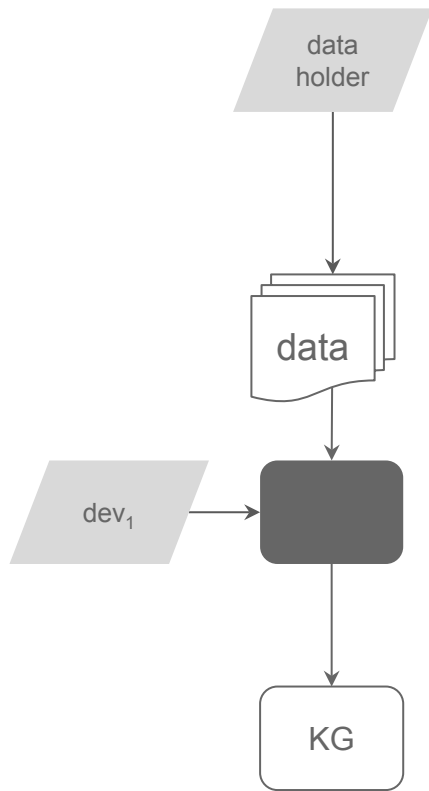
Knowledge Graph creation

KG creation history

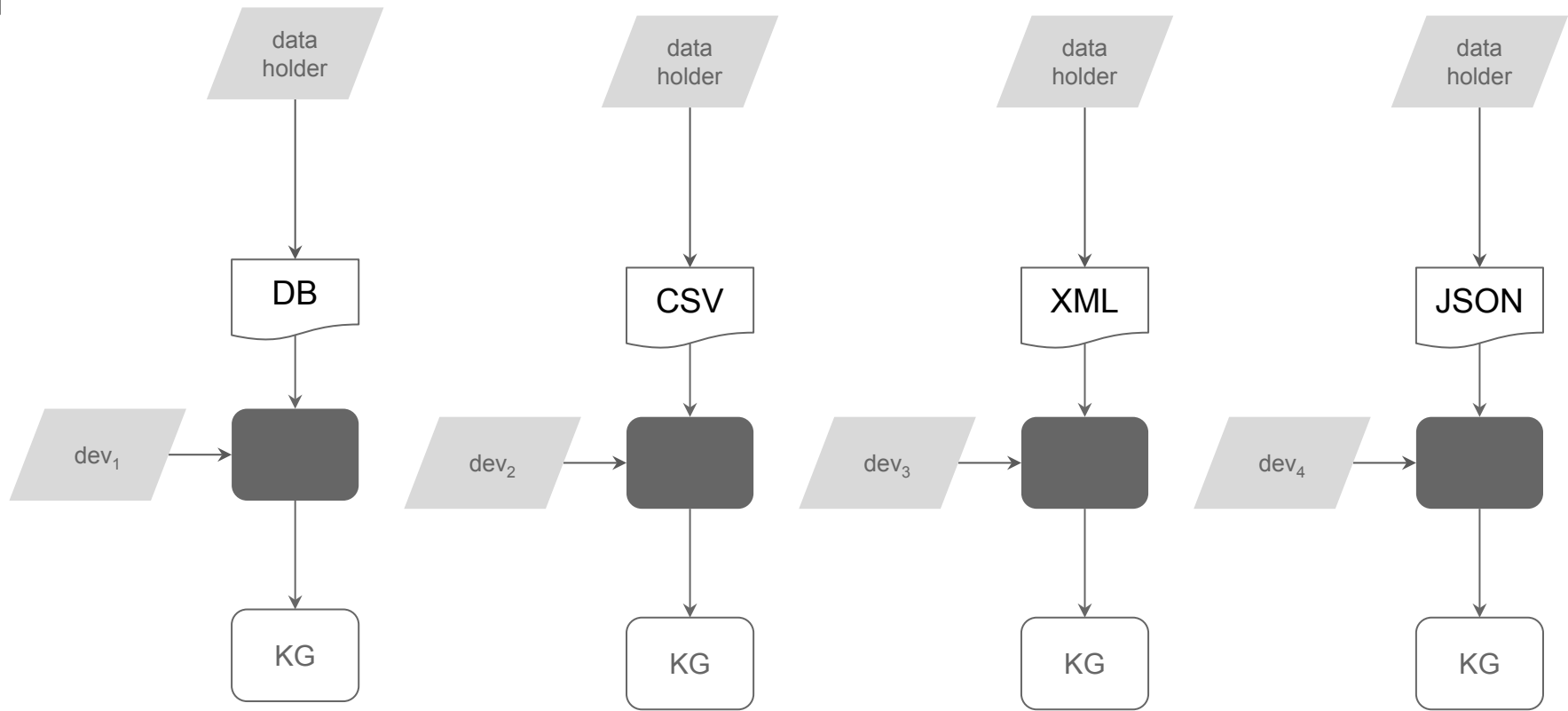
languages for KG creation

R2RML and RML

data transformations

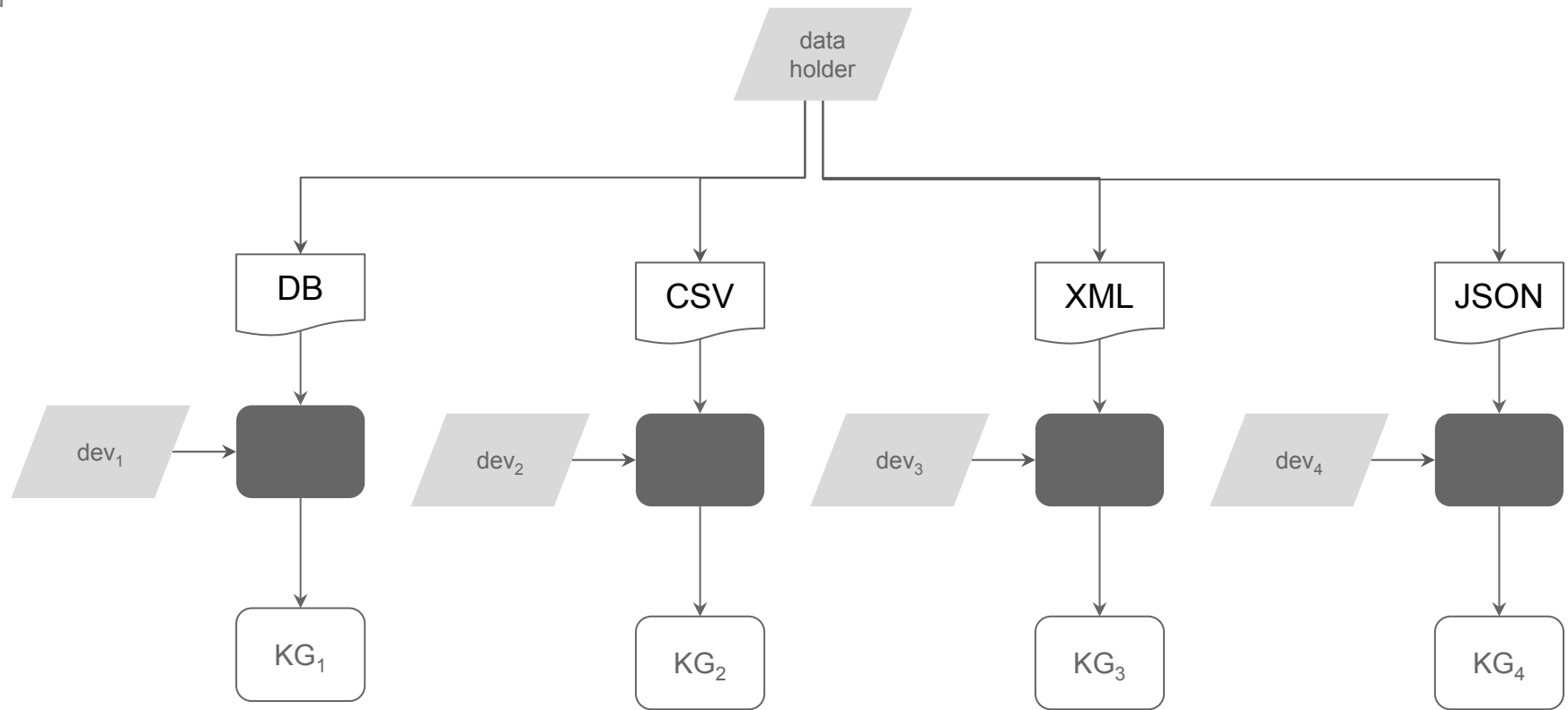


custom dedicated script for a data owner's data
(-) new development cycle every time a modification is needed



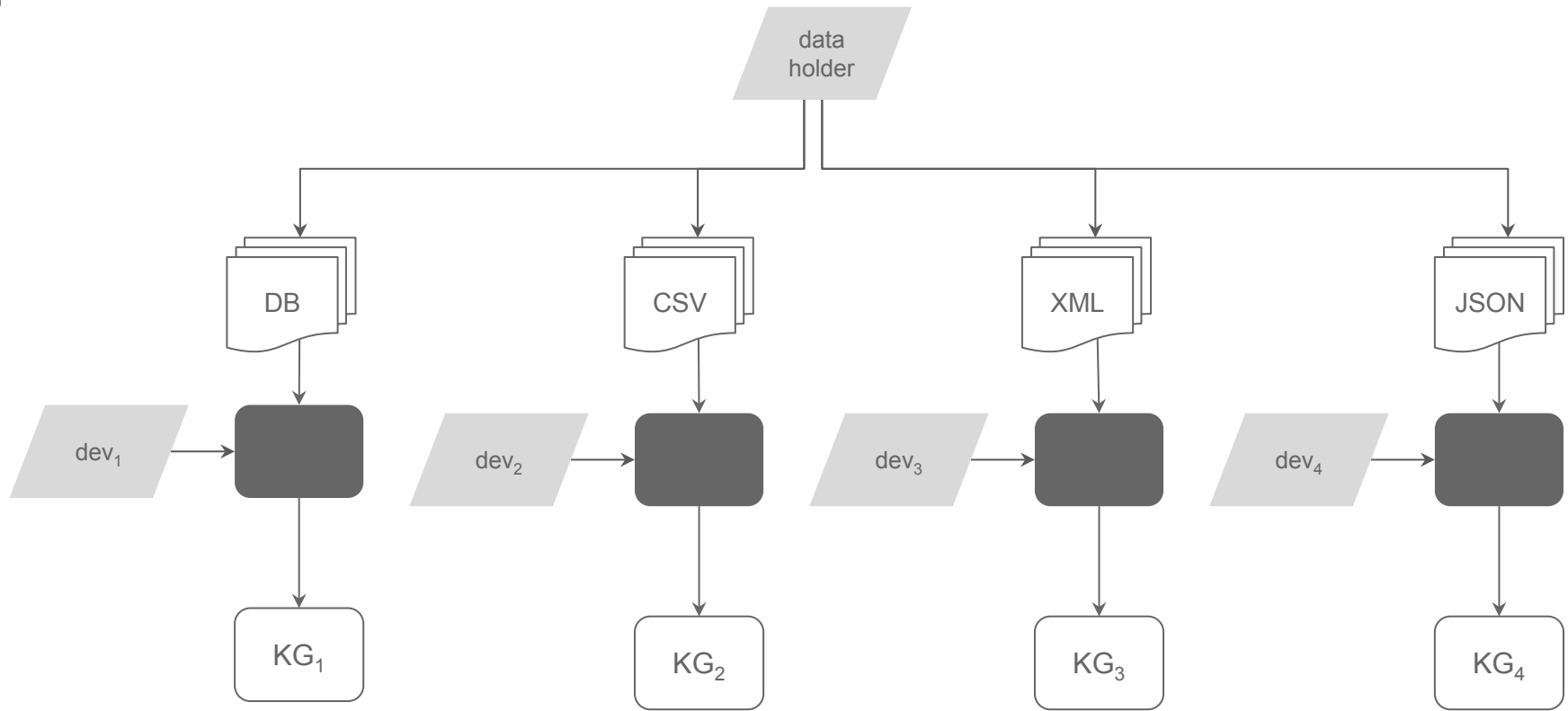
dedicated tool for certain format

(+) great solution if a data owner has data only in a certain format



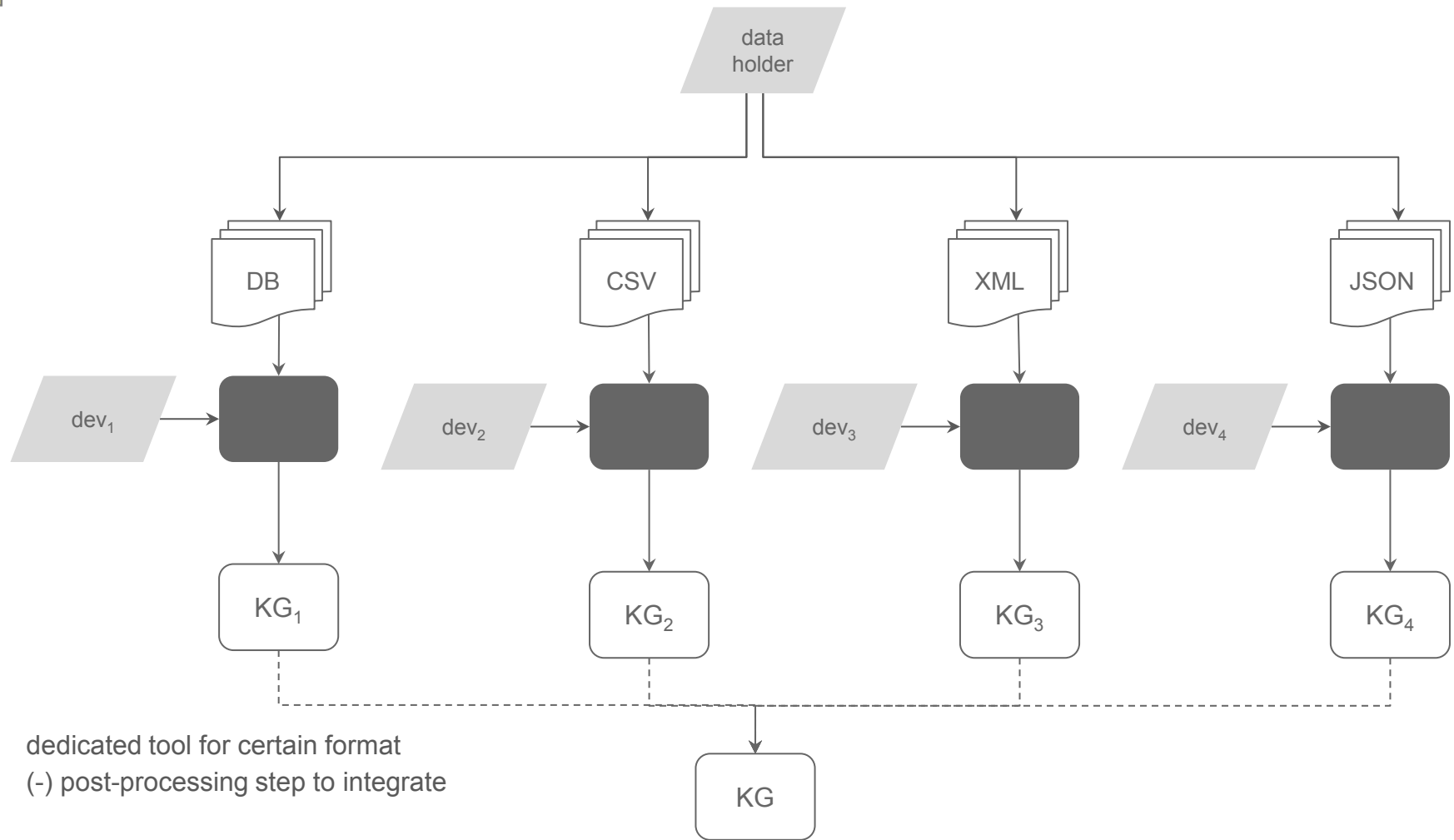
dedicated tool for certain format

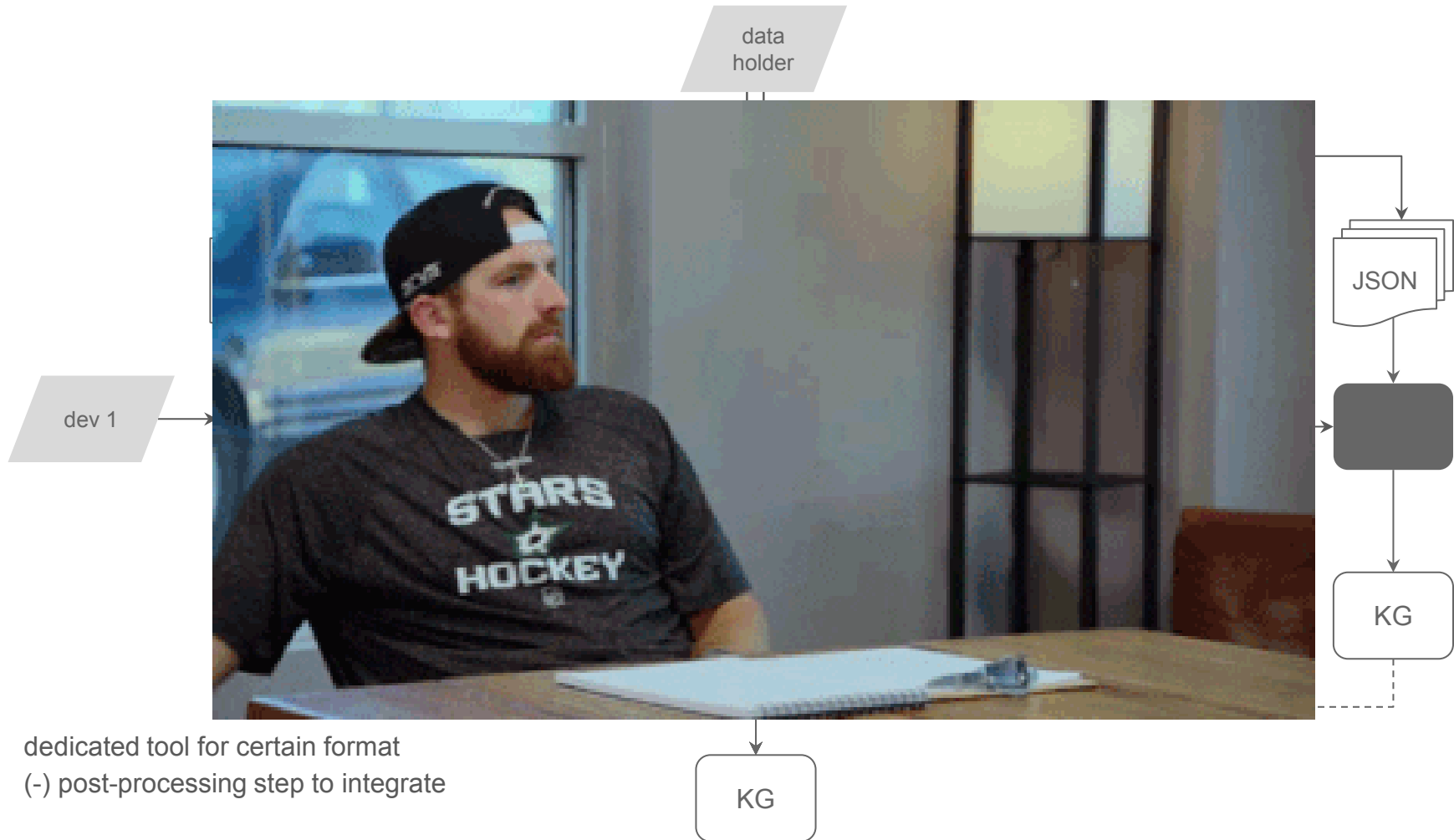
(-) learn and maintain multiple tools if a data owner has data in different formats



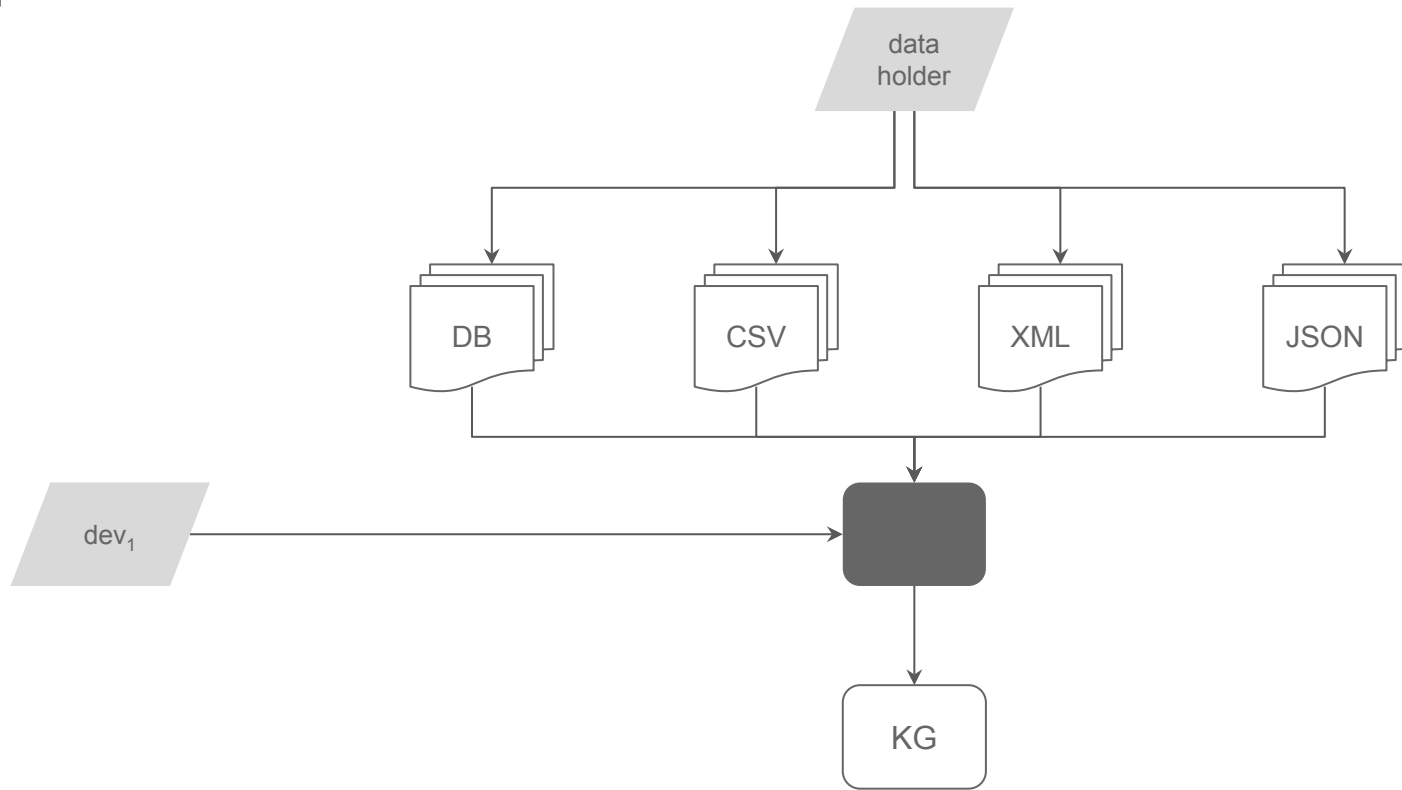
dedicated tool for certain format

(-) learn and maintain multiple tools if a data owner has data in different formats



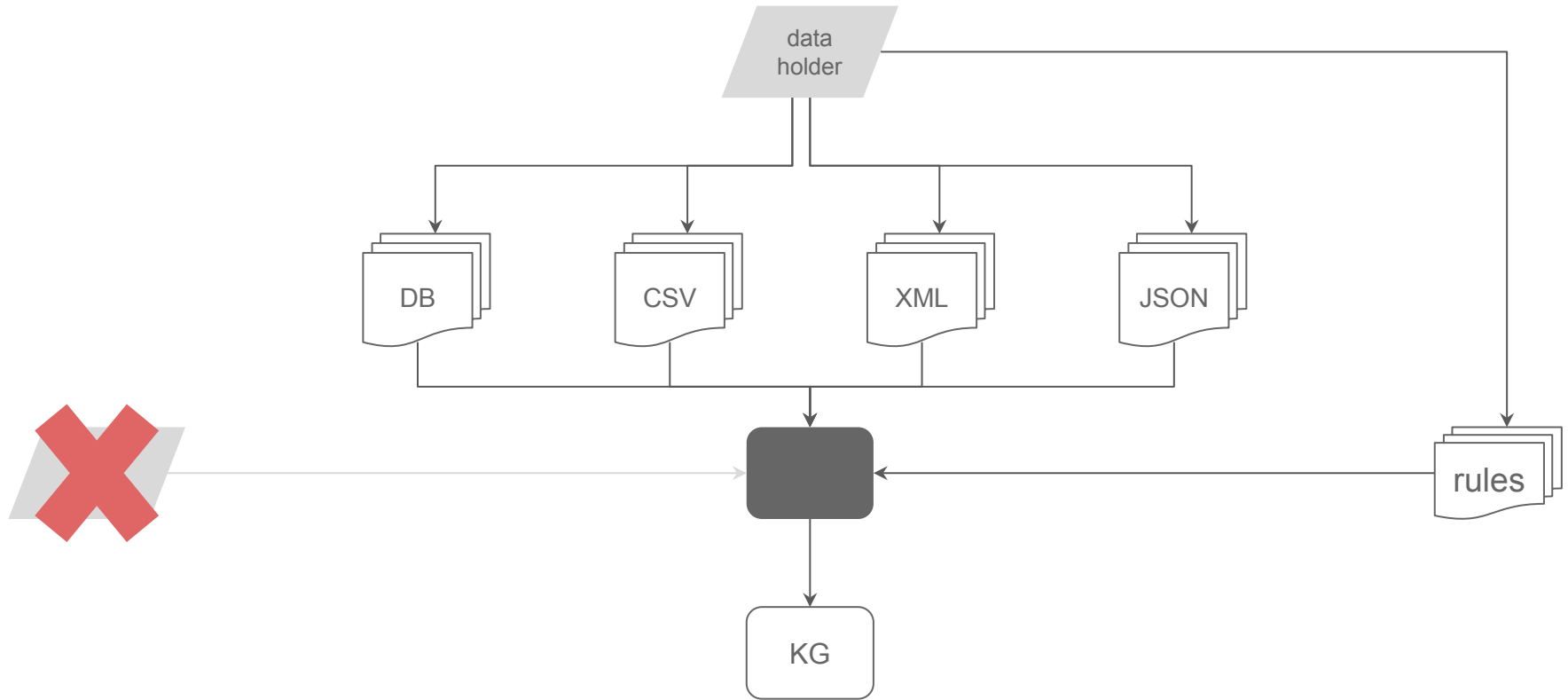


dedicated tool for certain format
(-) post-processing step to integrate



a tool for all data formats

(+) learn and maintain a single tool



a tool for all data formats

(+) learn and maintain a single tool

(+) configure the rules that define how a KG is generated

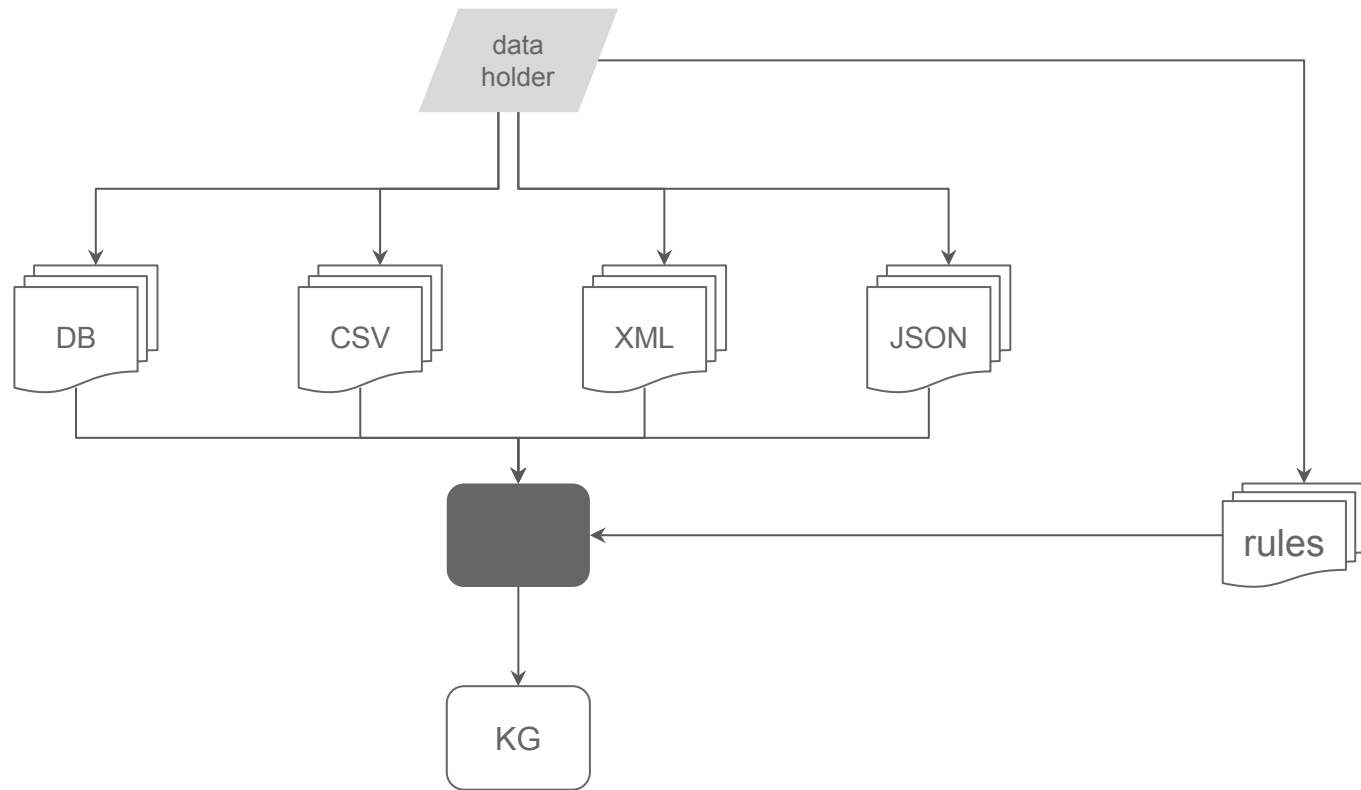
Knowledge Graph creation

KG creation history

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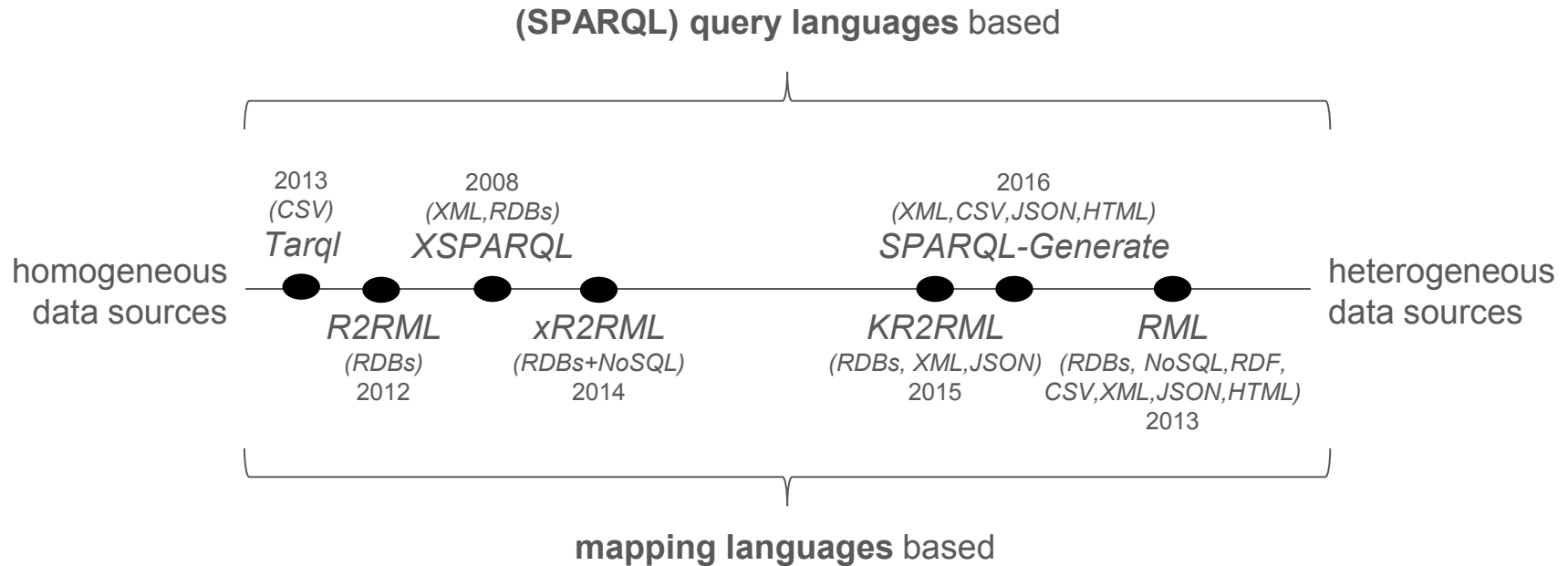


rules based on:

dedicated mapping

languages

adjusted query languages





homogeneous
data sources

R2RML
(RDBs)

xR2RML
(RDBs+NoSQL)

KR2RML
(RDBs, XML, JSON)

RML
(RDBs, NoSQL, RDF,
CSV, XML, JSON, HTML)

heterogeneous
data sources



mapping languages based



homogeneous
data sources

R2RML
(RDBs)

xR2RML
(RDBs+NoSQL)

KR2RML
(RDBs, XML, JSON)

RML
(RDBs, NoSQL, RDF,
CSV, XML, JSON, HTML)

heterogeneous
data sources

DB2triples (<https://github.com/antidot/db2triples>)

XSPARQL (<http://xsparql.sourceforge.net/>)

Morph (<https://github.com/oeg-upm/morph-rdb>)

R2RML Parser (<https://github.com/nkons/r2rml-parser>)

(<https://github.com/RMLio/rmlmapper-java>) RMLMapper

(<https://github.com/semantifyit/RocketRML>) RocketRML

(<https://github.com/RMLio/RMLStreamer>) RMLStreamer

(<https://github.com/carmil/carmil>) CARML

(<https://github.com/SDM-TIB/SDM-RDFizer>) SDM-RDFizer

Choose yourself the best tool for your needs!

<http://rml.io/test-cases/>

<http://rml.io/implementation-report/>

Conformance test-cases for the RDF Mapping Language.

P. Heyvaert, D. Chaves-Fraga, F. Priyatna, O. Corcho,

E. Mannens, R. Verborgh, A. Dimou. KGSWC2019

Knowledge Graph creation

KG creation history

languages for KG creation

R2RML and RML

data transformations



R2RML: RDB to RDF Mapping Language

W3C Recommendation 27 September 2012

This version:

<http://www.w3.org/TR/2012/REC-r2rml-20120927/>

Latest version:

<http://www.w3.org/TR/r2rml/>

Previous version:

<http://www.w3.org/TR/2012/PR-r2rml-20120814/>

Editors:

Souripriya Das, Oracle

Seema Sundara, Oracle

Richard Cyganiak, DERI, National University of Ireland, Galway

<https://www.w3.org/TR/r2rml/>

W3C recommendation to create a
knowledge graph from a relational database



<http://RML.io>

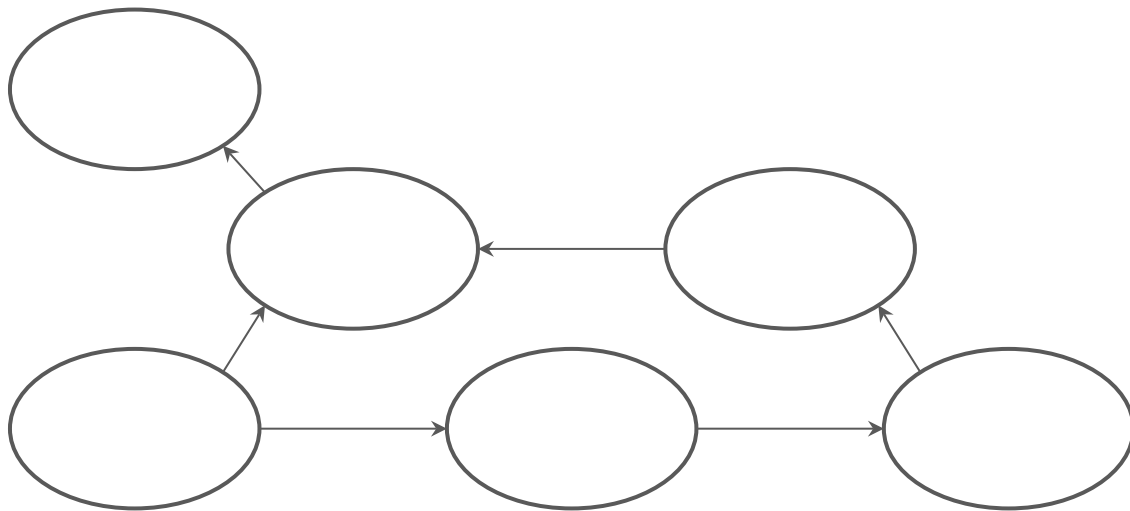
**RML: A Generic Language for Integrated RDF Mappings
of Heterogeneous Data** A. Dimou et al. LDOW 2014

language	R2RML	RML
prefix	rr	rml
URI	http://www.w3.org/ns/r2rml#	http://semweb.mmlab.be/ns/rml#
relational DBs	multiple tables one DB	multiple tables multiple DBs
access interfaces	only ODBC	multiple
other data structures	—	tabular (e.g., CSV, TSV, XLS) hierarchical (e.g., XML, JSON) pair-valued (e.g., wikitext) graphs (e.g., RDF), etc.
integration	materialisation virtualisation	materialisation virtualisation
data transformation	pre-processing	pre-processing inline processing

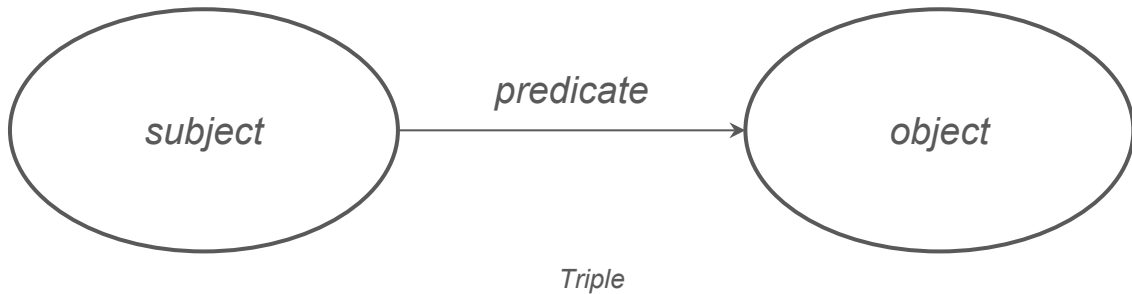


rank	name	nationality	mark	notes
1	Anzhelika Sidorova	Russia	4.95	WL,PB
2	Sandi Morris	USA	4.90	SB
3	Katerina Stefanidi	Greece	4.85	SB
4	Holly Bradshaw	UK	4.80	-
5	Alysha Newman	Canada	4.80	-
6	Angelica Bengtsson	Sweden	4.80	NR

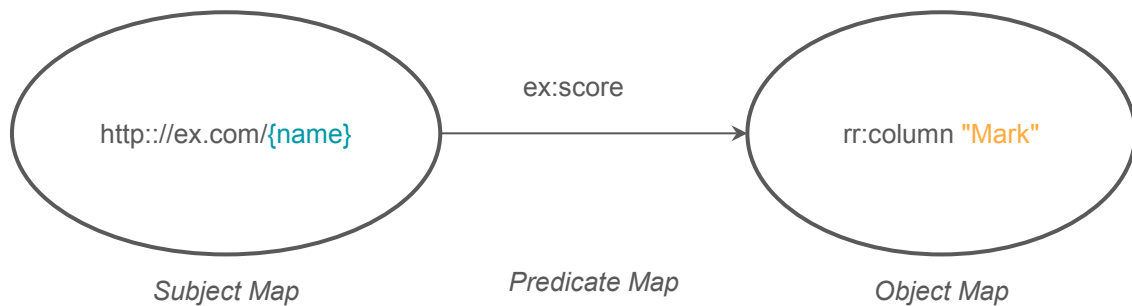
rank	name	nationality	mark	notes
1	Anzhelika Sidorova	Russia	4.95	WL,PB
2	Sandi Morris	USA	4.90	SB
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4	Holly Bradshaw	UK	4.80	-
5	Alysha Newman	Canada	4.80	-
6	Angelica Bengtsson	Sweden	4.80	NR

```

<countries>
  <country continent="Europe">
    <country_abb>GR</country_abb>
    <country_name country_language="en">Greece</country_name>
    <country_name country_language="nl">Griekenland</country_name>
  </country>
  <country continent="Europe">
    <country_abb>UK</country_abb>
    <country_name country_language="en">United Kingdom</country_name>
    <country_name country_language="nl">Verenigd Koninkrijk</country_name>
  </country>
  <country continent="America">
    <country_abb>CA</country_abb>
    <country_name country_language="en">Canada</country_name>
    <country_name country_language="nl">Canada</country_name>
  </country>
  ...
</countries>

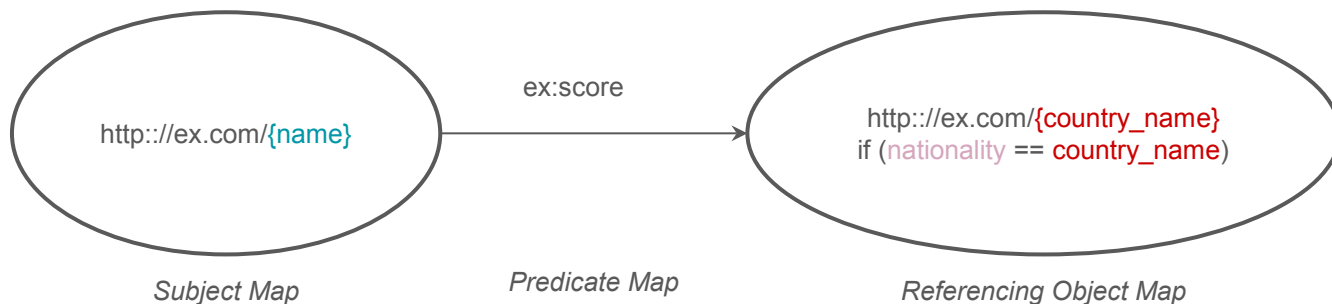
```

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<countries>
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    <country_name country_language="nl">Verenigd Koninkrijk</country_name>
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    <country_name country_language="en">Canada</country_name>
    <country_name country_language="nl">Canada</country_name>
  </country>
  ...
</countries>

```



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```

<countries>
  <country continent="Europe">
    <country_abb>GR</country_abb>
    <country_name country_language="en">Greece</country_name>
    <country_name country_language="nl">Griekenland</country_name>
  </country>
  <country continent="Europe">
    <country_abb>UK</country_abb>
    <country_name country_language="en">United Kingdom</country_name>
    <country_name country_language="nl">Verenigd Koninkrijk</country_name>
  </country>
  <country continent="America">
    <country_abb>CA</country_abb>
    <country_name country_language="en">Canada</country_name>
    <country_name country_language="nl">Canada</country_name>
  </country>
  ...
</countries>

```

Subject Map

```
<#Person_SM>.      rr:template      "http://ex.com/person/{name}" .
```

Predicate Object Map with Object Map

```
<#Mark_POM>      rr:predicate      ex:score ;
                  rr:objectMap      [ rr:column "Mark" ] .
```

Predicate Object Map with Referencing Object Map

```
<#Nationality_POM> rr:predicateMap    <#Country_PM> ;
                  rr:objectMap        <#Country_ROM> .
```

Referencing Object Map

```
<#Country_ROM>   rr:parentTriplesMap <#Country_TM> ;
                  rr:join [
                      rr:cild "nationality" ;
                      rr:parent "country_name" ] .
```

```
<#Country_TM>   rr:logicalTable [ rr:tableName "country" ];
                  rr:subjectMap   rr:template "http://ex.com/country/{country_name}" .
```



```
# Subject Map
<#Person_SM>.      rr:template      "http://ex.com/person/{name}" .

# Predicate Object Map with Object Map
<#Mark_POM>        rr:predicate      ex:score ;
                   rr:objectMap      [ rr:column "Mark" ] .

# Predicate Object Map with Referencing Object Map
<#Nationality_POM> rr:predicateMap    <#Country_PM> ;
                   rr:objectMap      <#Country_ROM> .

# Referencing Object Map
<#Country_ROM>     rr:parentTriplesMap <#Country_TM> ;
                   rr:join [
                       rr:cild "nationality" ;
                       rr:parent "country_name" ] .

<#Country_TM>      rr:logicalTable [ rr:tableName "country" ];
                   rr:subjectMap    rr:template "http://ex.com/country/{country_name}" .
```



Term Map	language	value	Term Type	RDF Type
Subject Map rr:SubjectMap	[R2]RML	rr:template	(rr:IRI) rr:BlankNode	IRI BlankNode
		rr:constant	(rr:IRI)	IRI
		rr:column	rr:IRI	IRI
	RML	rml:reference	rr:IRI rr:BlankNode	IRI BlankNode
		—	rr:BlankNode	BlankNode
Predicate Map rr:PredicateMap	[R2]RML	rr:template	(rr:IRI)	IRI
		rr:constant	(rr:IRI)	IRI
		rr:column	rr:IRI	IRI
	RML	rml:reference	rr:IRI	IRI
Object Map rr:ObjectMap	[R2]RML	rr:template	IRI rr:Literal	IRI Literal
		rr:constant	(rr:IRI) rr:Literal	IRI IRI
		rr:column	(rr:Literal) rr:IRI	Literal IRI
	RML	rml:reference	rr:IRI	IRI
			rr:BlankNode rr:Literal	BlankNode Literal
Referencing Object Map rr:RefObjectMap	[R2]RML	rr:parentTriplesMap	IRI BlankNode	IRI BlankNode
Language Map rml:LanguageMap	RML	rr:template	rr:Literal	n/a
		rr:constant	rr:Literal	n/a
		rml:reference	(rr:Literal)	n/a

R2RML Vs RML



YARRRML

```
mappings:
  country:
    sources:
      - ['data.json~jsonpath', '$.countries[*]']
    s: http://ex.com/$(abbreviation)
    po:
      - [ex:name, $(name)]
      - [ex:abbreviation, $(abbreviation)]
```

```
{  "countries": [
    {  "name": "Canada",
      "abbreviation": "CA" },
    {  "name": "Great Britain",
      "abbreviation": "GB" },
    {  "name": "Greece",
      "abbreviation": "GR" },
    {  "name": "Sweden",
      "abbreviation": "SE" },
    {  "name": "United States (USA)",
      "abbreviation": "US" } ] }
```

YARRRML = YAML + RML <https://rml.io/yarrml/>

Developer-friendly serialisations and their UIs

YARRRML = YAML + RML(Matey, <https://rml.io/yarrml/>)

Expressive RDF Mapper (XRM, <https://zazuko.com/products/expressive-rdf-mapper/>)



Everyone needs a matey, this is **YARRRML's Matey!**

See [below](#) to start editing YARRRML-documents!

Or, check the [screencast](#)!

Reload example:

People (JSON)

Advanced

Facebook

Actions:

Generate RML

Generate LD

Layout:



Input: data.json



```
1- {
2-   "persons": [
3-     {
4-       "firstname": "John",
5-       "lastname": "Doe"
6-     },
7-     {
8-       "firstname": "Jane",
9-       "lastname": "Smith"
10-    },
11-    {
12-      "firstname": "Sarah",
13-      "lastname": "Bladinck"
14-    }
15-  ]
16- }
```

Input: YARRRML

```
1- prefixes:
2-   ex: "http://example.com/"
3-
4- mappings:
5-   person:
6-     sources:
7-       - ['data.json~jsonpath', '$.persons[*]']
8-     s: http://example.com/${firstname}
9-   po:
10-     - [a, foaf:Person]
11-     - [ex:name, ${firstname}]
```

Output: Turtle/TriG

```
1
2
3
```

Declarative Rules for Linked Data Generation at your Fingertips!

P. Heyvaert, Ben De Meester, Anastasia Dimou, Ruben Verborgh et al. ESWC 2018

User-friendly UIs

RMLEditor (<https://app.rml.io/rmleditor/>)

RMLx Visual Editor (<http://pebbie.org/mashup/rml>)

Developer-friendly serialisations and their UIs

YARRRML = YAML + RML(Matey, <https://rml.io/yarrmml/>)

Expressive RDF Mapper (XRM, <https://zazuko.com/products/expressive-rdf-mapper/>)

File
Edit
Mapping
View
Help

EDITOR

FemalePoleValuters.csv

FemalePoleValuters.... +

Name
Birth
Country

Name	Birth	Country
Katerina STEFANIDI	1990-02-04	Greece
Sandi MORRIS	1992-07-08	USA
Nicole BÜCHLER	1983-12-17	Switzerland
Lisa RYZIH	1988-09-27	Germany
Angelica MOSER	1997-10-09	Switzerland
Kelsie AHBE	1991-07-06	Canada
Tina ŠUTEJ	1988-11-07	Slovenia
Alysha NEWMAN	1994-06-29	Canada
Chloe HENRY	1987-03-05	Belgium
Fanny SMETS	1986-04-21	Belgium

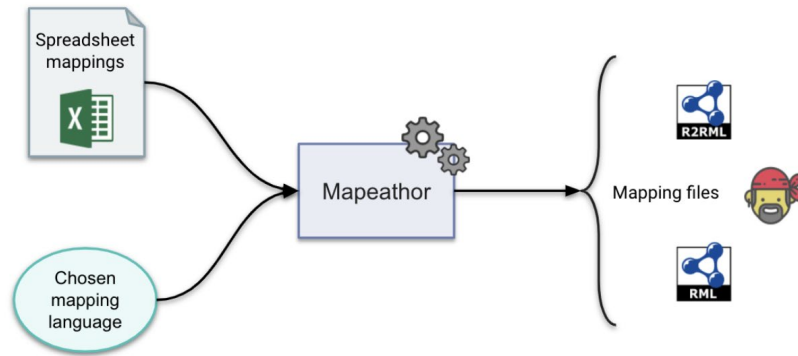
Detail
Lowest
Low
Moderate
High
Highest

```

graph TD
    A((.../{Name})
    A --> B[dbpedia-owl:country]
    A --> C[foaf:birthday]
    B --> D[Country]
    C --> E[Birth]
        
```

Subject	Predicate	Object
http://ex.com/Alysha%20NEWMAN	dbpedia-owl:country	Canada
http://ex.com/Alysha%20NEWMAN	foaf:birthday	1994-06-29
http://ex.com/Angelica%20MOSER	dbpedia-owl:country	Switzerland
http://ex.com/Angelica%20MOSER	foaf:birthday	1997-10-09
http://ex.com/Chloe%20HENRY	dbpedia-owl:country	Belgium
http://ex.com/Chloe%20HENRY	foaf:birthday	1987-03-05
http://ex.com/Fanny%20SMETS	dbpedia-owl:country	Belgium
http://ex.com/Fanny%20SMETS	foaf:birthday	1986-04-21
http://ex.com/Katerina%20STEFANIDI	dbpedia-owl:country	Greece
http://ex.com/Katerina%20STEFANIDI	foaf:birthday	1990-02-04
http://ex.com/Kelsie%20AHBE	dbpedia-owl:country	Canada
http://ex.com/Kelsie%20AHBE	foaf:birthday	1991-07-06
http://ex.com/Lisa%20RYZIH	dbpedia-owl:country	Germany
http://ex.com/Lisa%20RYZIH	foaf:birthday	1988-09-27
http://ex.com/Nicole%20BÜCHLER	dbpedia-owl:country	Switzerland
http://ex.com/Nicole%20BÜCHLER	foaf:birthday	1983-12-17
http://ex.com/Sandi%20MORRIS	dbpedia-owl:country	USA
http://ex.com/Sandi%20MORRIS	foaf:birthday	1992-07-08
http://ex.com/Tina%20ŠUTEJ	dbpedia-owl:country	Slovenia

Specification and implementation of mapping rule visualization and editing:
MapVOWL and the RMLEditor. P. Heyvaert & A. Dimou, et al. JWS 2018



Do It For You

Mapeathor (<https://github.com/oeg-upm/Mapeathor>)

User-friendly UIs

RMLEditor (<https://app.rml.io/rmleditor/>)

RMLx Visual Editor (<http://pebbie.org/mashup/rml>)

Developer-friendly serialisations and their UIs

YARRRML = YAML + RML(Matey, <https://rml.io/yarrml/>)

Expressive RDF Mapper (XRM, <https://zazuko.com/products/expressive-rdf-mapper/>)

Knowledge Graph creation

KG creation history

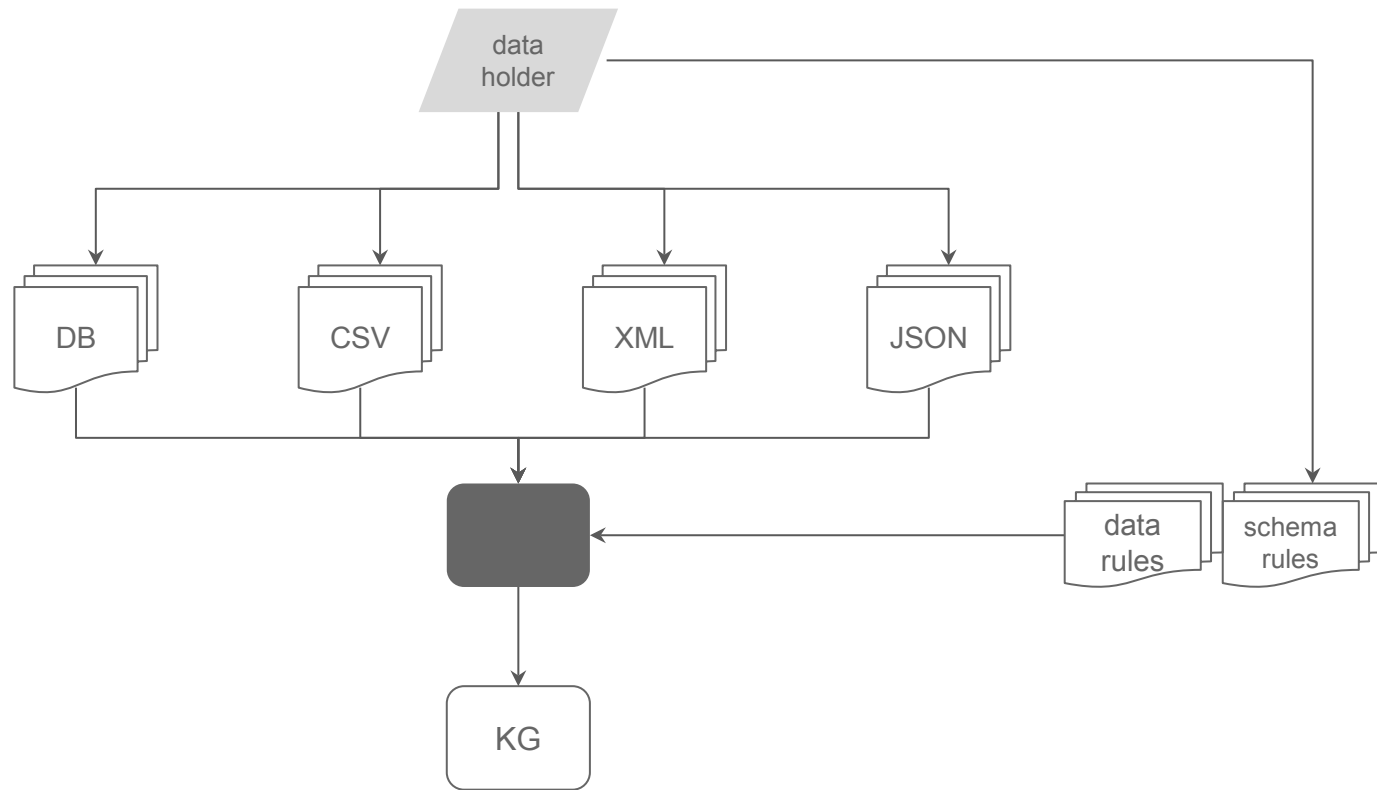
languages for KG creation

R2RML and RML

data transformations

7th June 2020
07/09/2020
09/07/2020 → 2019-09-05^^xsd:date
2019/09/07
June 7th, 2020

what if the data needs to be changed/processed?



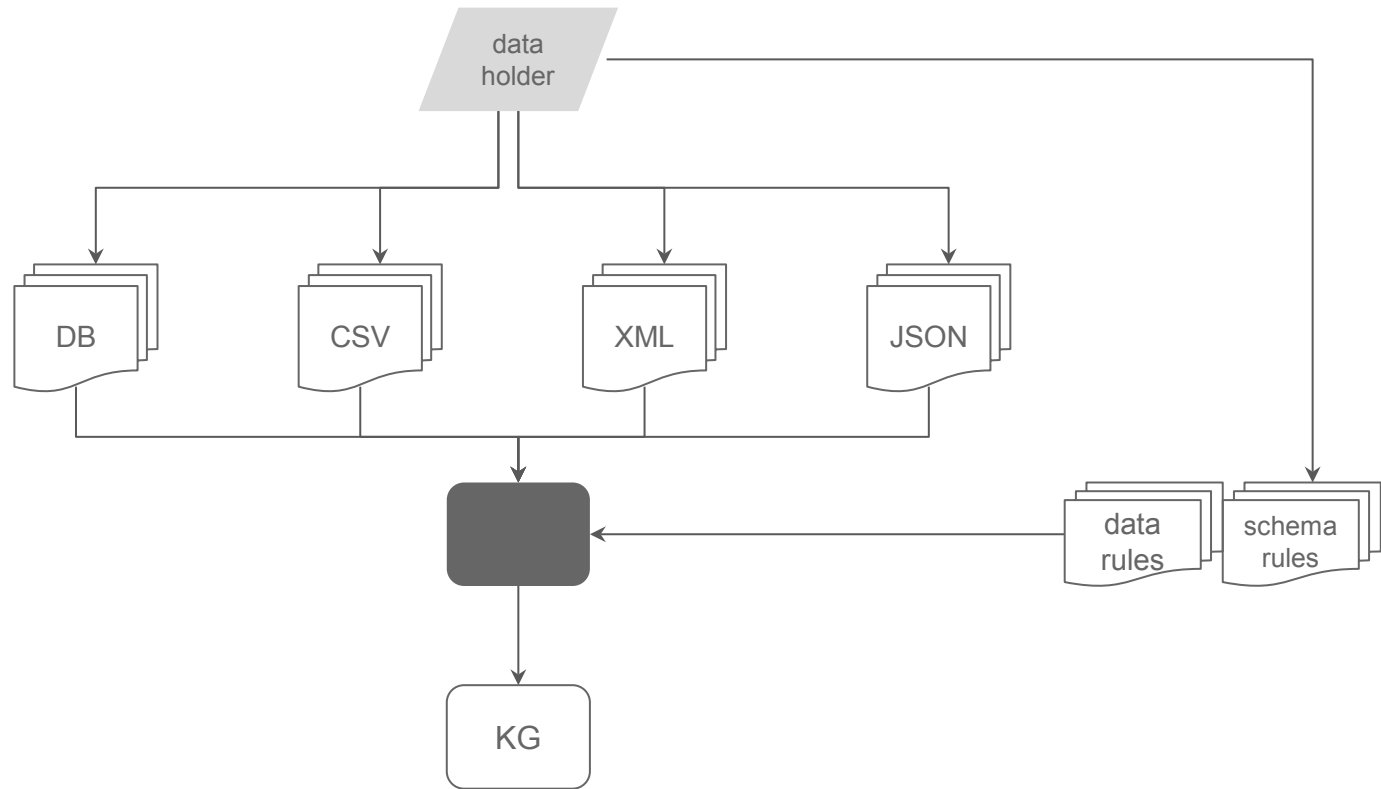
rules based on:

schema transformation

languages

data transformation

languages



FunUL FunUL: a method to incorporate functions into uplift mapping languages

A. Crotti Junior, C. Debruyne, R. Brennan, & D. O'Sullivan. iiWAS 2016

<http://FnO.io> An Ontology to Semantically Declare & Describe Functions

B. De Meester, A. Dimou, R. Verborgh, E. Mannens & R. Van De Walle. ESWC P&D 2016



```
@prefix rrf: <http://kdeg.scss.tcd.ie/ns/rrf#> .

<#SplitTransformation> a rrf:Function ;
    rrf:functionName "splitTransformation" ;
    rrf:functionBody
        """function split(value, separator) {
            str = value.split(separator).trim();
            return str; "" ; } "" ; .

<#FemalePoleVault> rr:predicateObjectMap [
    rr:predicate ex:record;
    rr:objectMap [
        rrf:functionCall [
            rrf:function <#SplitTransformation> ;
            rrf:parameterBindings (
                [ rml:reference "notes" ]
                [ rml:reference "," ] ); ]; ];
```

```
grel:string_split a fno:Function;
    fno:name "split";
    dcterms:description "split";
    fno:expects (grel:string_s grel:string_sep);
    fno:returns (grel:output_array).

<#FemalePoleVault> rr:predicateObjectMap [
    rr:predicate ex:record;
    rr:objectMap [
        fnml:functionValue [
            rr:predicateObjectMap [
                rr:predicate fno:executes ;
                rr:objectMap [ rr:constant grel:string_split ] ] ;
            rr:predicateObjectMap [
                rr:predicate grel:string_s ;
                rr:objectMap [ rml:reference "notes" ] ] ;
            rr:predicateObjectMap [
                rr:predicate grel:string_sep ;
                rr:objectMap [ rr:constant "," ] ] ] ] .
```



[Home](#) / Knowledge Graph...

KNOWLEDGE GRAPH CONSTRUCTION COMMUNITY GROUP

The overall goal of this community group is to support its participants into developing better methods for Knowledge Graphs construction. The Community Group will (i) study current Knowledge Graph construction methods and implementations, (ii) identify the corresponding requirements and issues that hinder broader Knowledge Graph construction, (iii) discuss use cases, (iv) formulate guidelines, best practices and test cases for Knowledge Graph construction, (v) develop methods, resources and tools for evaluating Knowledge Graphs construction, and in general (vi) continue the development of the W3C-recommended R2RML language beyond relational databases. The proposed Community Group could be instrumental to advance research, increase the level of education and awareness and enable learning and participation with respect to Knowledge Graph construction.

Knowledge Graph Construction Community Group

<https://www.w3.org/community/kg-construct/>



Dr Anastasia
Dimou



Dr Pieter
Heyvaert



Dr Ben
De Meester



Sven
Lieber



Gerald
Haesendonck



Dylan
Van Assche



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RML.io team

<https://www.w3.org/community/kg-construct/>

High Quality Knowledge Graphs construction to enable Intelligent Agents

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