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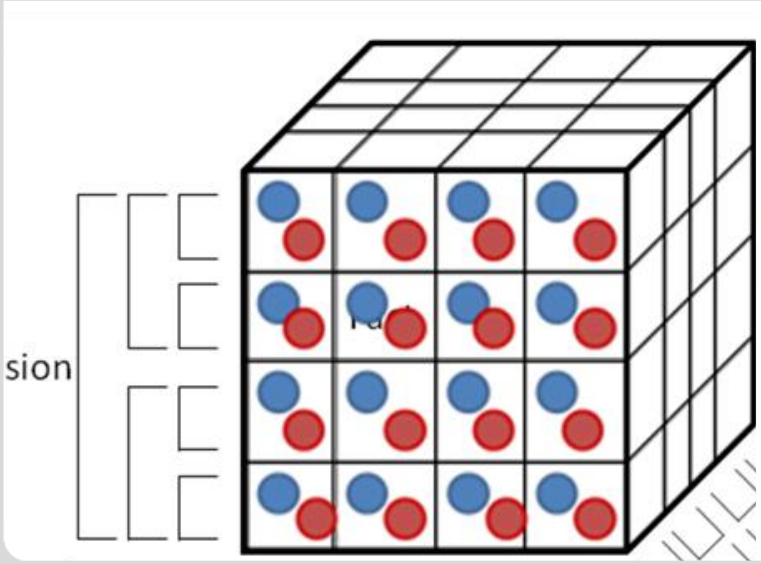
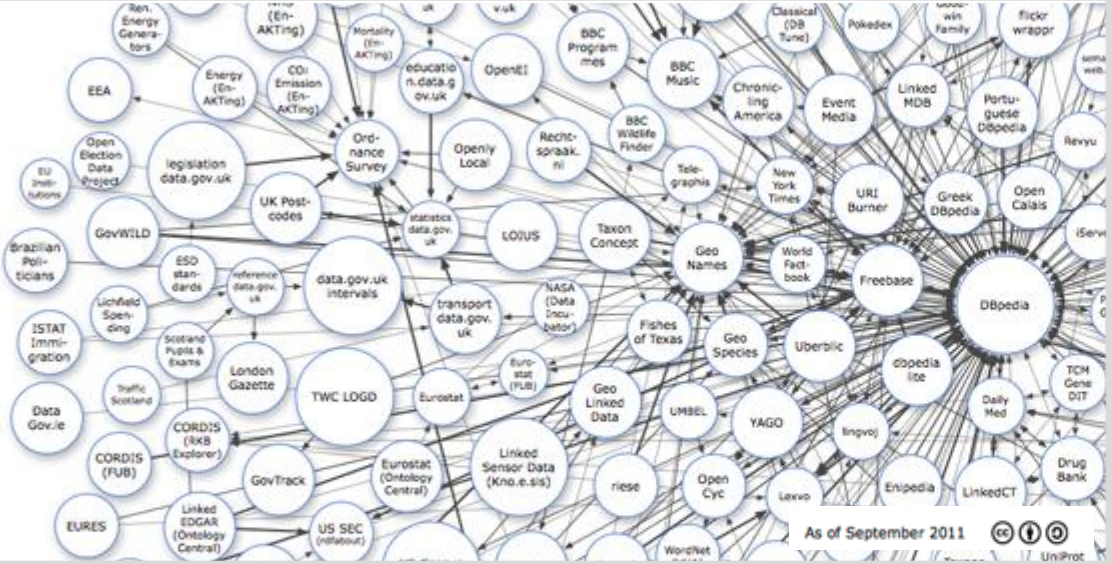
Querying the Global Cube: Integration of Multidimensional Datasets from the Web

Benedikt Kämpgen, Steffen Stadtmüller, Andreas Harth

EKAW 2014

Institute of Applied Informatics and Formal Description Methods (AIFB)

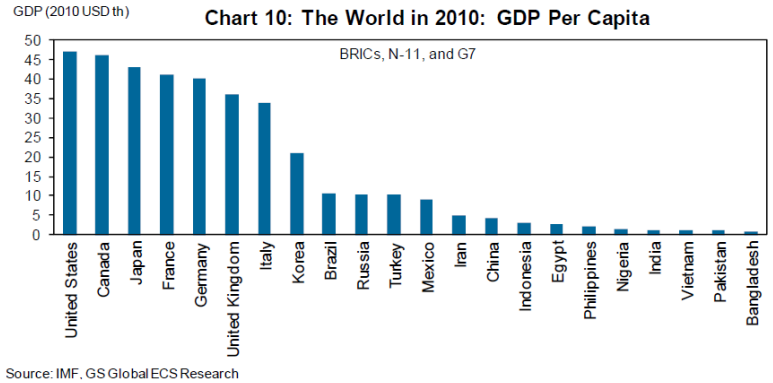


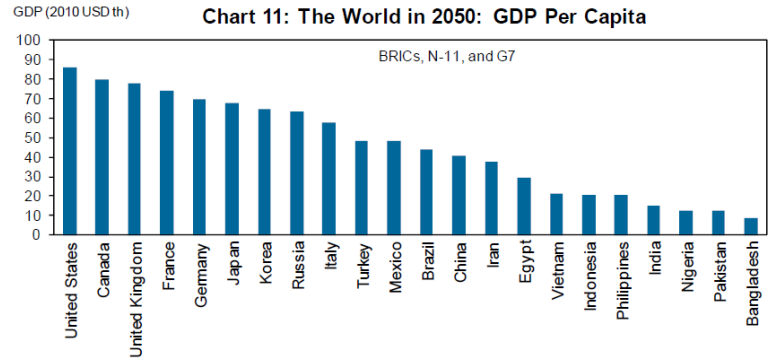


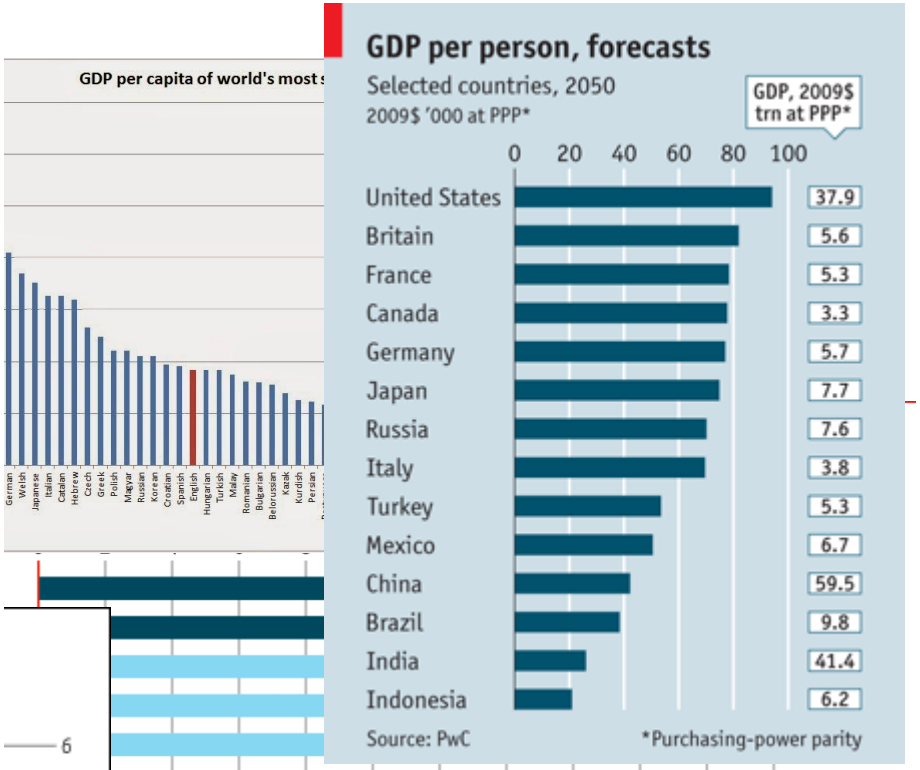
G8 Open Data Charter

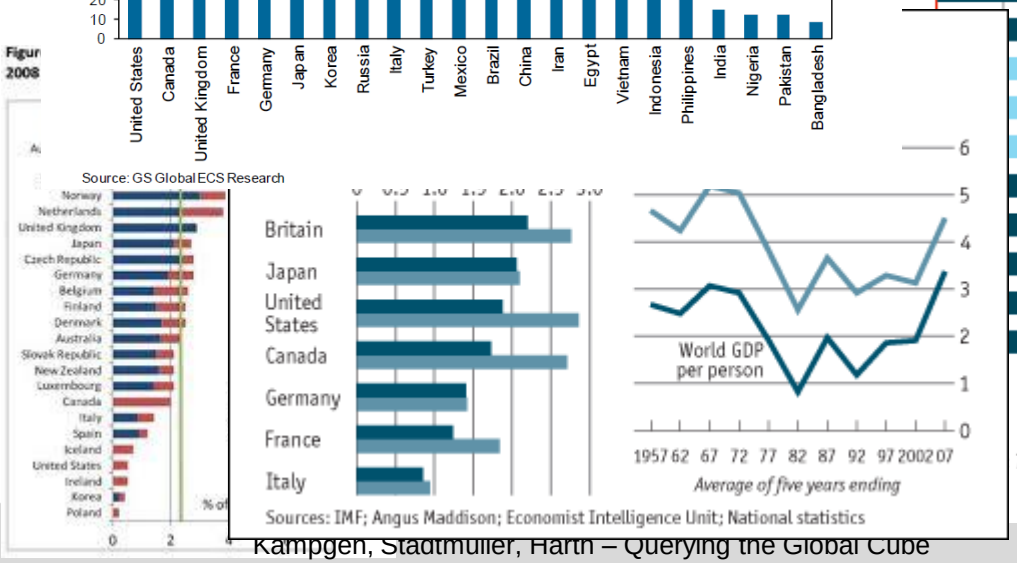
http://www.telegraph.co.uk/news/worldnews/g8/10128266/G8-Open-Data-Charter-why-it-matters.html

GDP Per Capita









Requirements – GDP Per Capita Example

- Answered by datasets from the Web
- Confirmed by as many sources as possible

Problem:
Query in Terms of the Global Cube

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Data Structure:

Geo	Unit	Date	Indicna	Sex	...	Value
de, uk, ...	eur, eur_hab, ...	2001, ...	b1g, ngdp,...	f, m,...	...	**Decimal**

Query:

Geo	Unit	Date	Indicna	Sex	...	Value
uk	eur_hab	2010	ngdph	ALL	ALL	**?**

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Problem:
Query in Terms of the Global Cube

Data Structure:

Geo	Unit	Date	Indicna	Sex	...	Value
de, uk, ...	mio_eur, eur_hab, ...	2001, ...	b1g, d21_m_d31, ngdp,...	f, m, t,...	...	**Decimal**

Data:

?

Query:

Geo	Unit	Date	Indicna	Sex	...	Value
uk	eur_hab	2010	ngdph	ALL	ALL	**?**

Institute of Applied Informatics and Formal Description Methods (AIFB)

Outline

- Global Cube Definition
- Reducing Heterogeneity in Global Cube
- Analysis of Size of Global Cube

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- **Global Cube Definition**
- Reducing Heterogeneity in Global Cube
- Analysis of Size of Global Cube

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Real-World Dataset
Eurostat GDP Components (readable)

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Data Structure:

Geo	Unit	Date	Indicna	Value
de, uk, ...	mio_eur	2001, ...	b1g, d21_m_d31, ...	**Decimal**

Data:

Geo	Unit	Date	Indicna	Value
uk	mio_eur	2010	b1g	**1,547,984.5**
...	...	...	...	**...**

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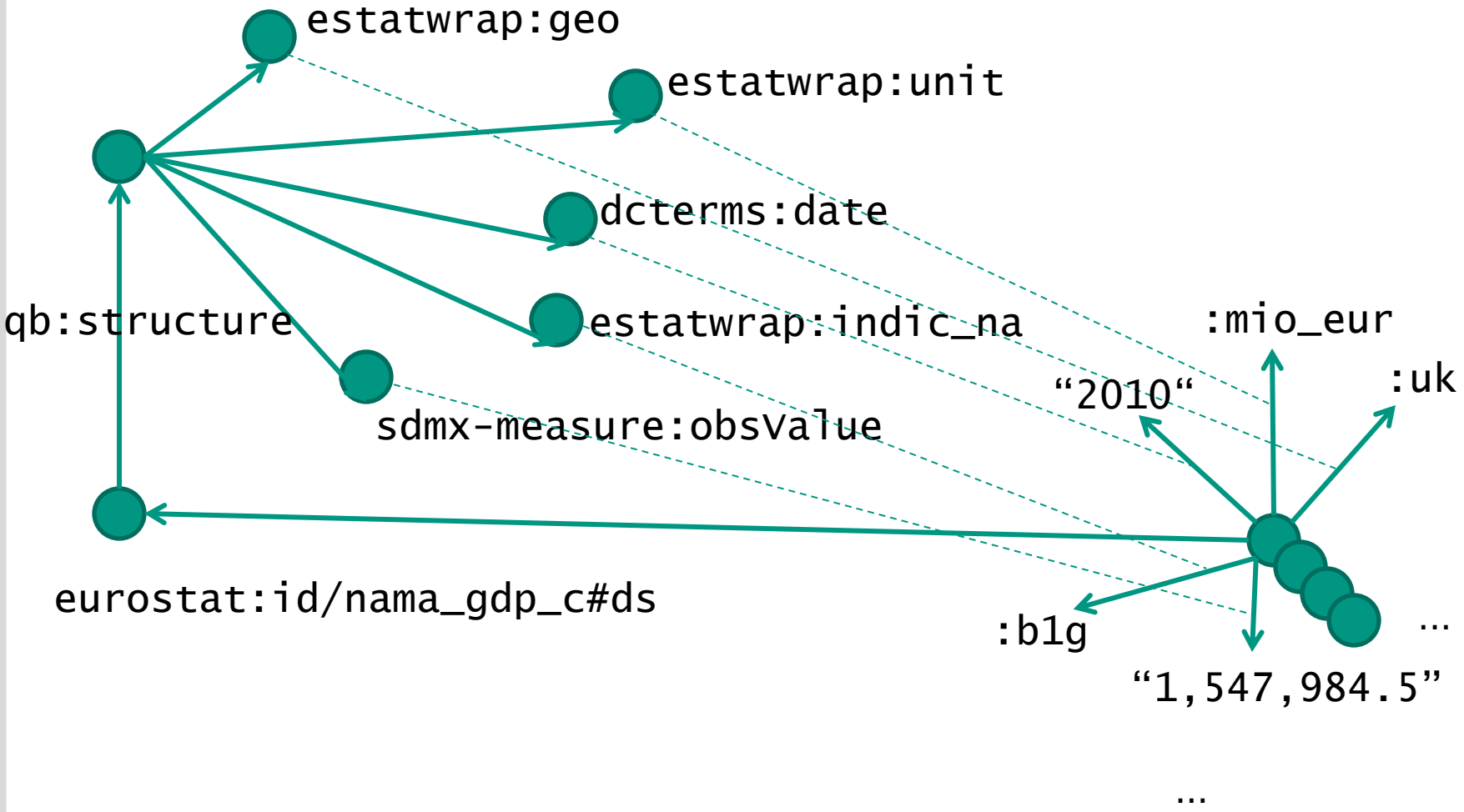
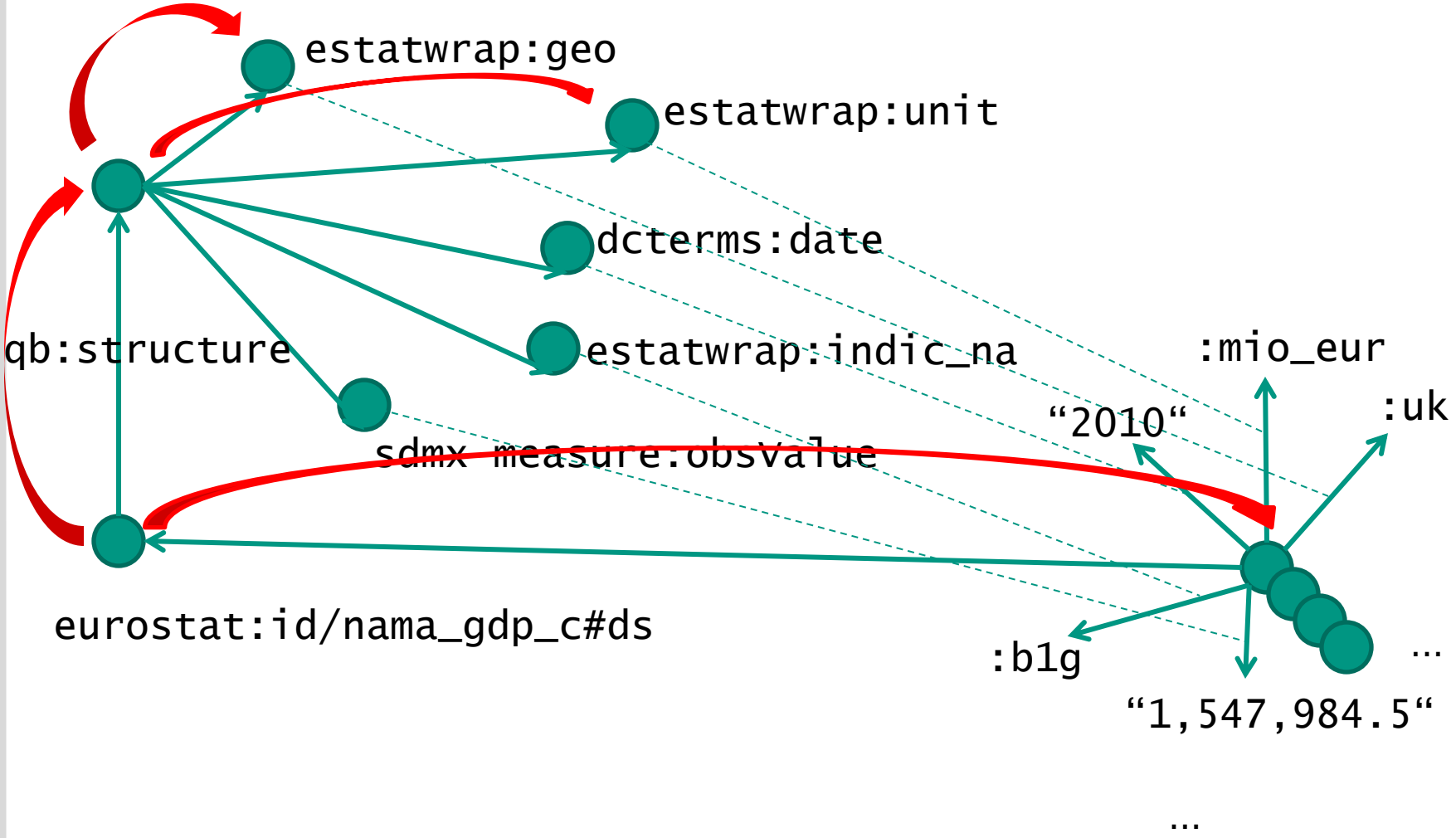
Real-World Dataset
Eurostat GDP Components (Linked Data)



Linked Data URIs serving RDF, e.g., eurostat:id/nama_gdp_c#ds = http://estatwrap.ontologycentral.com/id/nama_gdp_c#ds

Real-World Dataset
Eurostat GDP Components (Linked Data)



Linked Data URIs serving RDF, e.g., eurostat:id/nama_gdp_c#ds = http://estatwrap.ontologycentral.com/id/nama_gdp_c#ds

Global Cube Definition: GDP Per Capita Example

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Data Structures:

Cube\Dimension	Geo	Unit	Date	Indicna	Sex	Age	Value
gdp-components	de, uk, ...	mio_eur, ...	2001, ...	b1g, d21_m_d31	-	-	**Decimal**
population	de, uk, ...	-	2001, ...	-	f, m, t	y18,..., total	**Decimal**
gdp-per-capita	de, uk, ...	eur_hab, ...	2001, ...	ngdph	-	-	**Decimal**
...	...	...	...	...	...	...	**...**

Global Cube Definition: GDP Per Capita Example

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Data Structures:

Cube\Dimension	Geo	Unit	Date	Indicna	Sex	Age	Value
gdp-components	de, uk, ...	mio_eur, ...	2001, ...	b1g, d21_m_d31	-	-	**Decimal**
population	de, uk, ...	-	2001, ...	-	f, m, t	y18,..., total	**Decimal**
gdp-per-capita	de, uk, ...	eur_hab, ...	2001, ...	ngdph	-	-	**Decimal**
...	...	...	...	...	...	...	**...**

- Example Data Sources
  - Eurostat as Linked Data (>5,000 datasets) http://eurostat.linked-statistics.org/
  - The World Bank as Linked Data (>8,000 datasets) http://worldbank.270a.info/
  - U.S. SEC as Linked Data (>1,000 datasets) http://edgarwrap.ontologycentral.com/
  - OECD as Linked Data (>100 datasets) http://oecd.270a.info/
  - ...

Global Cube Definition: GDP Per Capita Example

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gdp-components	de, uk, ...	mio_eur, ...	2001, ...	b1g, d21_m_d31	-	-	Decimal
population	de, uk, ...	-	2001, ...	-	f, m, t	y18,..., total	Decimal
gdp-per-capita	de, uk, ...	eur_hab, ...	2001, ...	ngdph	-	-	Decimal

Data:

Cube\Dimension	Geo	Unit	Date	Indicna	Sex	Age	Value
gdp-components	uk	mio_eur	2010	b1g	-	-	1547984
...	...	...	...	...	-	-	...
population	uk	-	2010	-	t	total	62510197
...	...	-	...	-	...	...	...
gdp-per-capita	uk	eur_hab	2010	ngdph	-	-	27800
...	...	...	...	...	-	-	

Global Cube Definition: GDP Per Capita Example

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Data Structures:

Geo	Unit	Date	Indicna	Sex	Age	Value
de, uk, ...	mio_eur, eur_hab, ...	2001, ...	b1g, d21_m_d31, ngdph	f, m, t	y18,..., total	**Decimal**

Data:

Cube\Dimension	Geo	Unit	Date	Indicna	Sex	Age	Value
gdp-components	uk	mio_eur	2010	b1g	-	-	1547984
...	...	...	...	...	-	-	...
population	uk	-	2010	-	t	total	62510197
...	...	-	...	-	...	...	...
gdp-per-capita	uk	eur_hab	2010	ngdph	-	-	27800
...	...	...	...	...	-	-	

Global Cube Definition: GDP Per Capita Example

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Data Structures:

Geo	Unit	Date	Indicna	Sex	Age	Value
de, uk, ...	mio_eur, eur_hab, ...	2001, ...	b1g, d21_m_d31, ngdph	f, m, t	y18,..., total	Decimal

Data:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	mio_eur	2010	b1g	ALL	ALL	1547984
...	...	...	...	ALL	ALL	...
uk	ALL	2010	ALL	t	total	62510197
...	ALL	...	ALL	...	...	...
uk	eur_hab	2010	ngdph	ALL	ALL	27800
...	...	...	...	ALL	ALL	

Global Cube Definition: GDP Per Capita Example

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Data Structures:

Geo	Unit	Date	Indicna	Sex	Age	Value
de, uk, ...	mio_eur, eur_hab, ...	2001, ...	b1g, d21_m_d31, ngdph	f, m, t	y18,..., total	Decimal

Data:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	mio_eur	2010	b1g	ALL	ALL	1547984
...	...	...	...	ALL	ALL	...
uk	ALL	2010	ALL	t	total	62510197
...	ALL	...	ALL	...	...	...
uk	eur_hab	2010	ngdph	ALL	ALL	27800
...	...	...	...	ALL	ALL	

Related Work

- We define a unified view over datasets from the Web.
  - Ontology matching approaches are less suitable for finding relationships between multidimensional datasets [Zapilko].
- We solve heterogeneities with conversion (combination) relationships between datasets in Linked Data.
  - Conversion functions and combinations have been defined in a relational setting [Siegel, Calvanese] but not in Linked Data.
- We estimate the size of Global Cube with number of derived datasets.
  - Semantic integration systems [Bressan, Ambite] focus on fast query execution based on input-/output descriptions.

Outline

- Global Cube Definition
- Related Work
- **Reducing Heterogeneity in Global Cube**
- Analysis of Size of Global Cube

Heterogeneity Problems

Data:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	mio_eur	2010	b1g	ALL	ALL	1547984
...	...	...	...	ALL	ALL	...
uk	ALL	2010	ALL	t	total	62510197
...	ALL	...	ALL	...	...	...
uk	eur_hab	2010	ngdph	ALL	ALL	27800
...	...	...	...	ALL	ALL	

Query:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	eur_hab	2010	ngdph	ALL	ALL	?

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Heterogeneity Problems

Data:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	mio_eur	2010	b1g	ALL	ALL	1547984
...	...	...	...	ALL	ALL	...
uk	ALL	2010	ALL	t	total	62510197
...	ALL	...	ALL	...	...	...
uk	eur_hab	2010	ngdph	ALL	ALL	27800
...	...	...	...	ALL	ALL	

Query:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	eur_hab	2010	ngdph	ALL	ALL	?

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Heterogeneity Problems

Data:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	mio_eur	2010	b1g	ALL	ALL	1547984
...	...	...	...	ALL	ALL	...
uk	ALL	2010	ALL	t	total	62510197
...	ALL	...	ALL	...	...	...
uk	eur_hab	2010	ngdph	ALL	ALL	27800
...	...	...	...	ALL	ALL	

Query:

Geo	Unit	Date	Indicna	Sex	Age	Value
uk	eur_hab	2010	ngdph	ALL	ALL	?

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Solution – Complex Relationships: GDP Per Capita Example

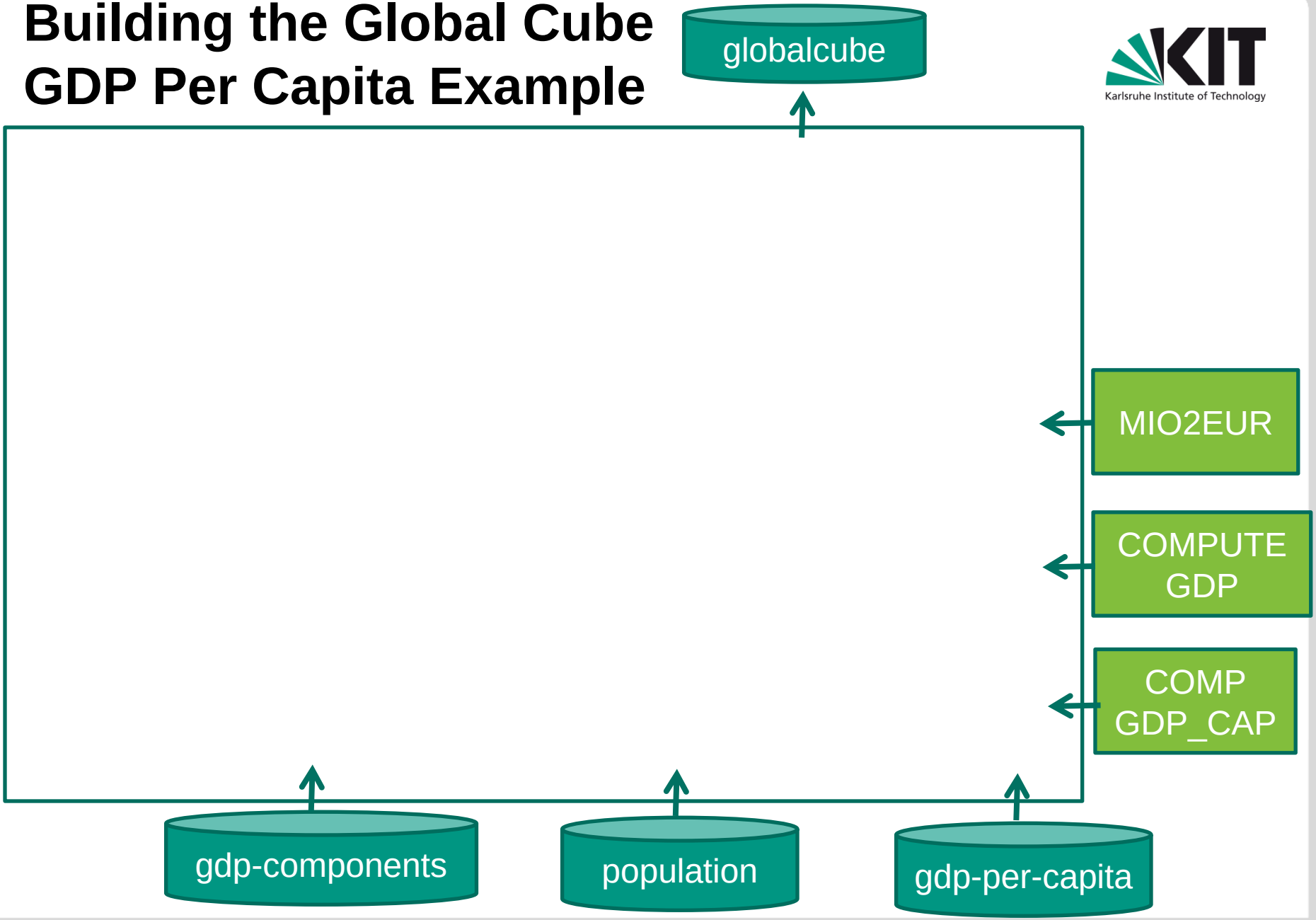
Conversion (and Merging) Relationships

MIO2EUR

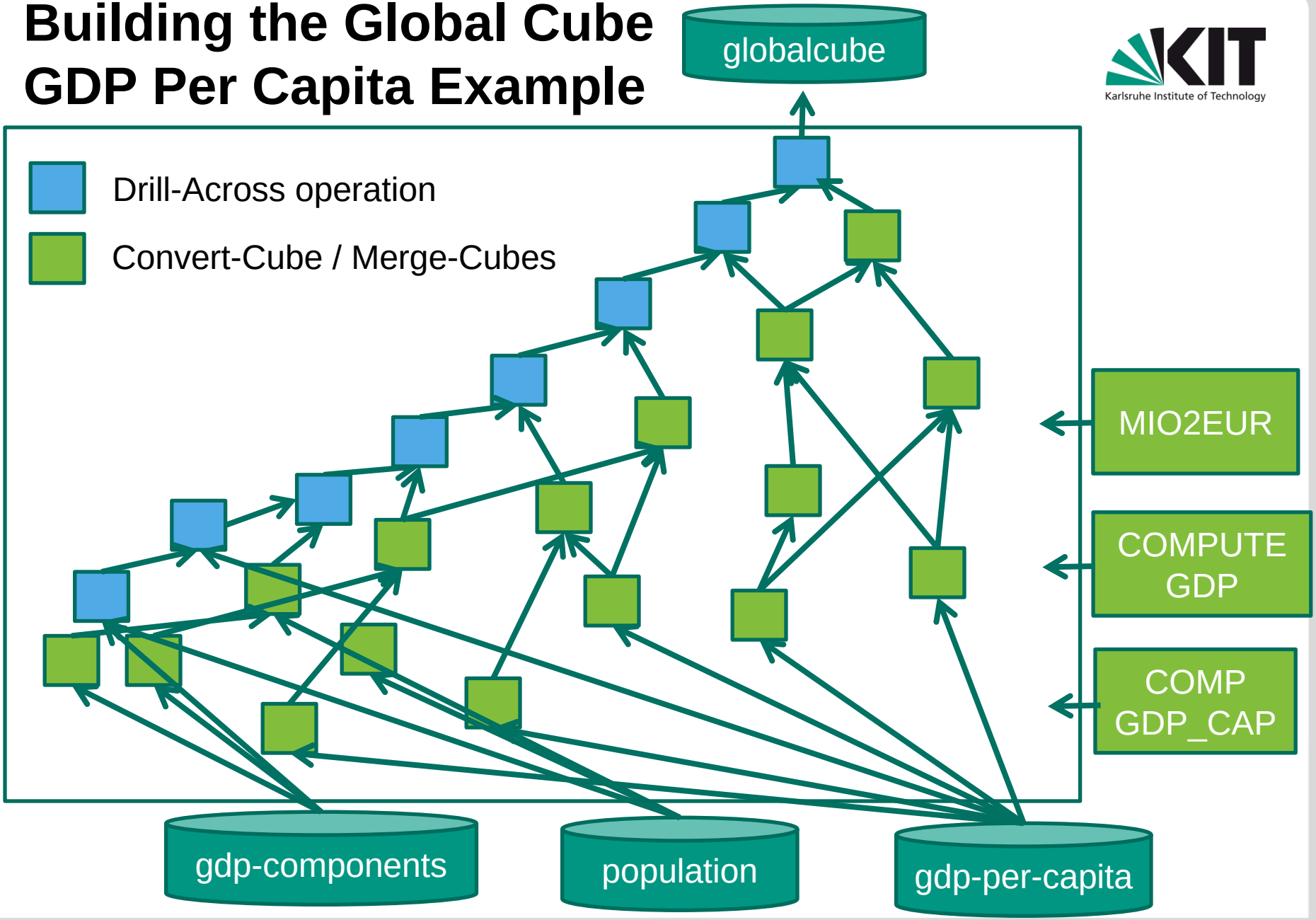
Unit	Value
mio_eur	value
eur	1,000,000 * value

Relationships can be implemented as Convert-Cube (Merge-Cubes) operation using Datalog (and SPARQL)

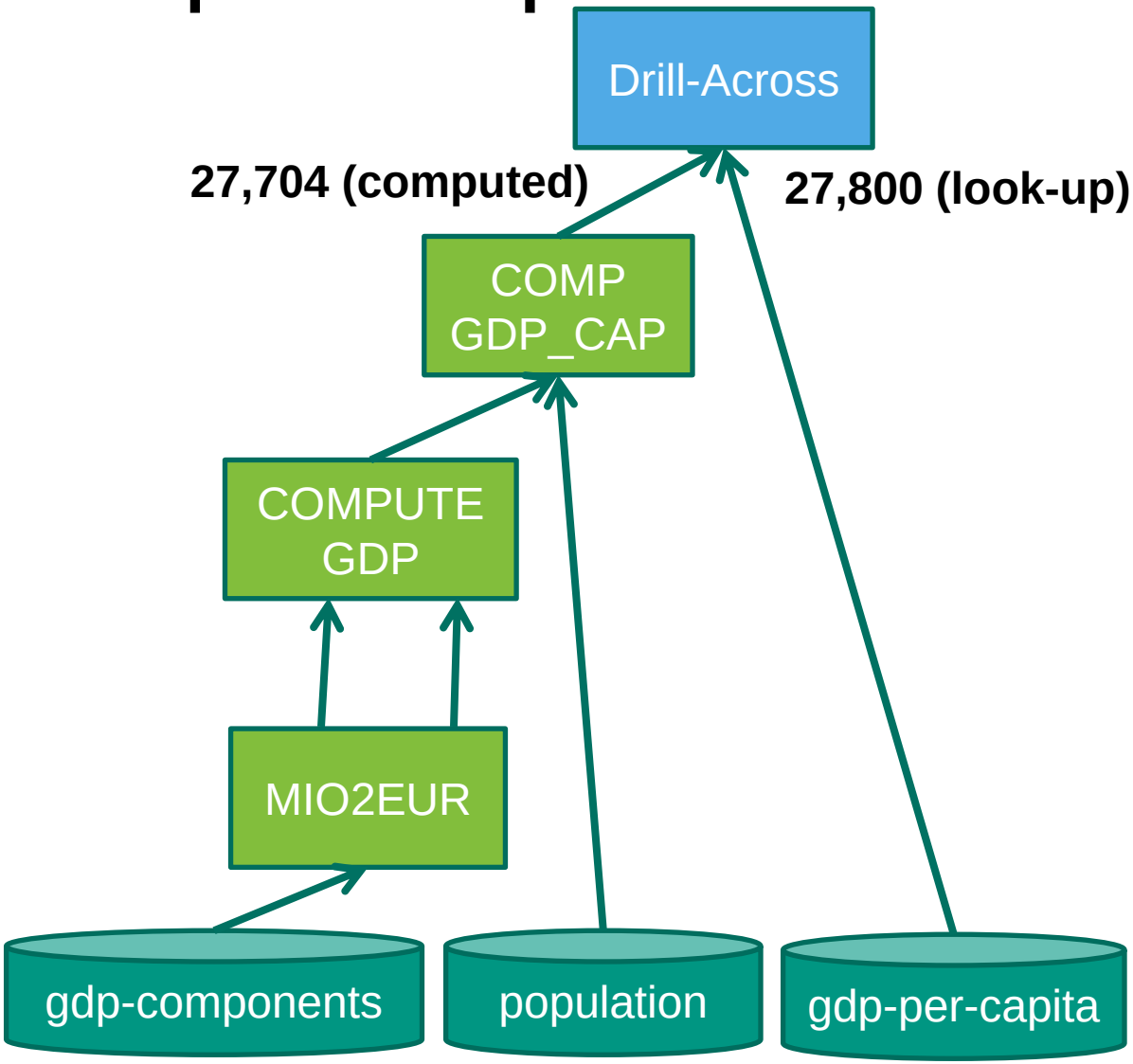
Building the Global Cube
GDP Per Capita Example



Building the Global Cube
GDP Per Capita Example



Building the Global Cube
GDP Per Capita Example



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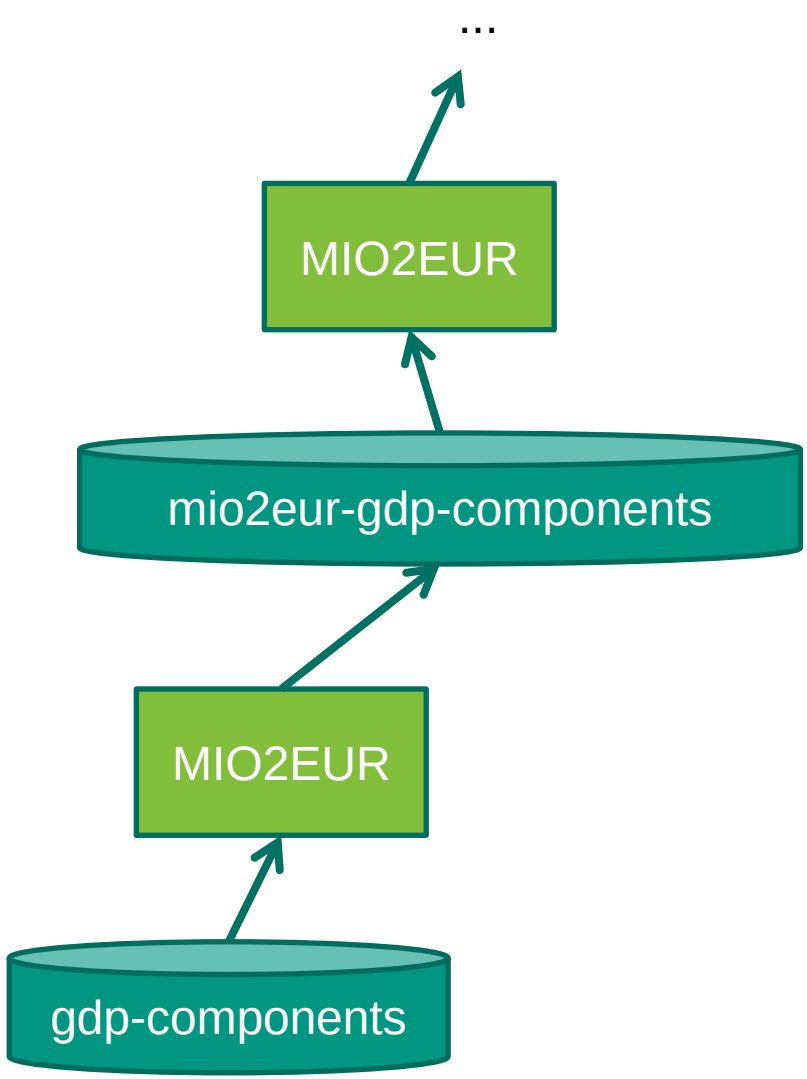
How to restrict the number of derived datasets?

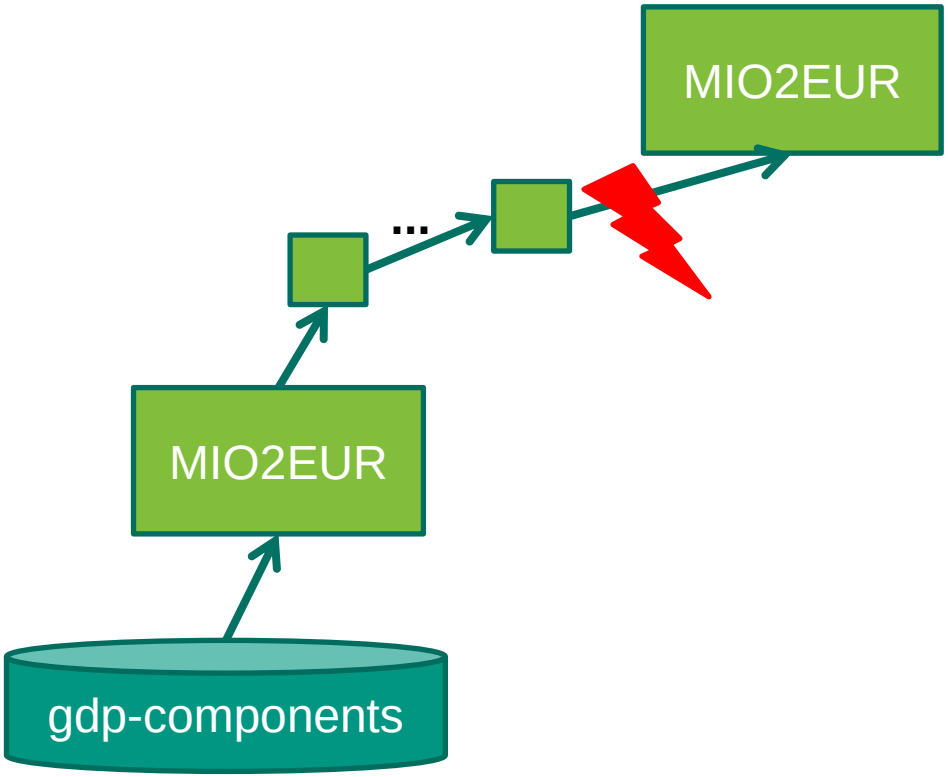
1) No restrictions

Unlimited



How to restrict the possible number of conversion and merging operations? (2)

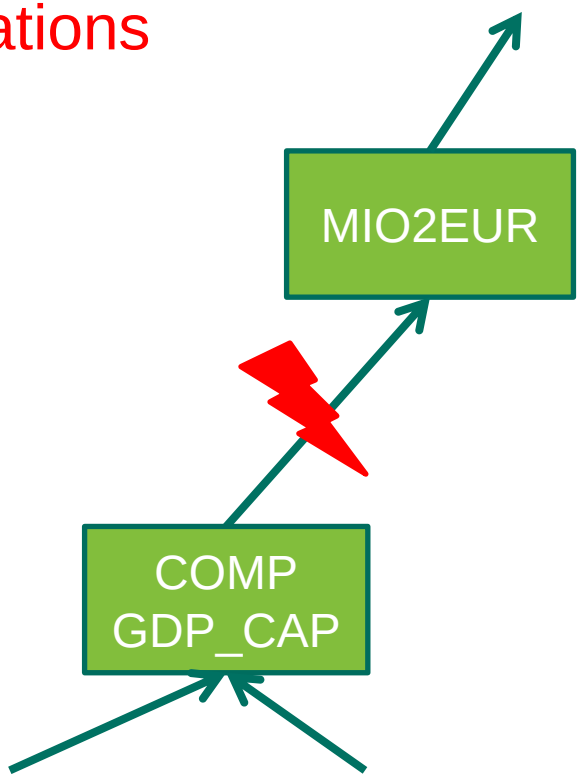
2) No repeated applications / cycles



Estimated 3,017,172 derived datasets

How to restrict the possible number of conversion and merging operations? (3)

3) Only matching dimension-member combinations



Estimated 54 derived datasets

Conclusions

- Interesting numeric datasets in **Linked Data**
  - **Global Cube** as a unified view over all datasets
  - Reducing heterogeneity with **conversion (merging) relationships**

- Reliable statistical indicators from the Web if
  - we can find relationships „in the wild“
  - we can materialise the Global Cube
  - we find out why Open Government Data sources...

A different topic...

27,704 (computed)

27,800 (look-up)

eurostat

Thanks!

27,704 (computed)

27,800 (look-up)

eurostat

References

- Ambite, J. L., & Kapoor, D. (2007). Automatically Composing Data Workflows with Relational Descriptions and Shim Services. In ISWC.
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