CC7220-1
La Web de Datos
Primavera 2018

Lecture 2: RDF Model and Syntax

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The "Semantic Web"

* More or less

Semantic Web: Data → Rules → Query → Output*

Data:

Rules:

"$(b$,capital,$a)$ → $(a$,partOf,$b)$"

"$(a$,partOf,$b)$, $(b$,partOf,$c)$ → $(a$,partOf,$c)$"

Query: "$(x$,partOf,$y)$?"

Output: $\{(x \mapsto \text{Ireland}, y \mapsto \text{Europe}),$
$(x \mapsto \text{Dublin}, y \mapsto \text{Ireland}),$
$(x \mapsto \text{Dublin}, y \mapsto \text{Europe})\}$

RDF:
Resource Description Framework

RDF (1.1): A Web Standard

W3C Recommendation

RDF 1.1 Concepts and Abstract Syntax

W3C Recommendation 25 February 2014

This version:
http://www.w3.org/TR/2014/REC-rdf11-concepts-20140225/
Latest published version:
http://www.w3.org/TR/rdf11-concepts/
Previous version:
http://www.w3.org/TR/2014/PR-rdf11-concepts-20140109/
Previous Recommendation:
http://www.w3.org/TR/rdf-concepts
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Jeremy J. Carroll
Brian McBride

Semantic Web: Data → Rules → Query → Output

Data:

Rules:

"$(b$,capital,$a)$ → $(a$,partOf,$b)$"

"$(a$,partOf,$b)$, $(b$,partOf,$c)$ → $(a$,partOf,$c)$"

Query:

"$(x$,partOf,$y)$?"

Output:

$\{(x \mapsto \text{Ireland}, y \mapsto \text{Europe}),$
$(x \mapsto \text{Dublin}, y \mapsto \text{Ireland}),$
$(x \mapsto \text{Dublin}, y \mapsto \text{Europe})\}$

Semantic Web: Data

Data:

RDF is based on triples:

(Ireland,capital,Dublin)

(*subject*,*predicate*,*object*)

Modelling the world with triples

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin

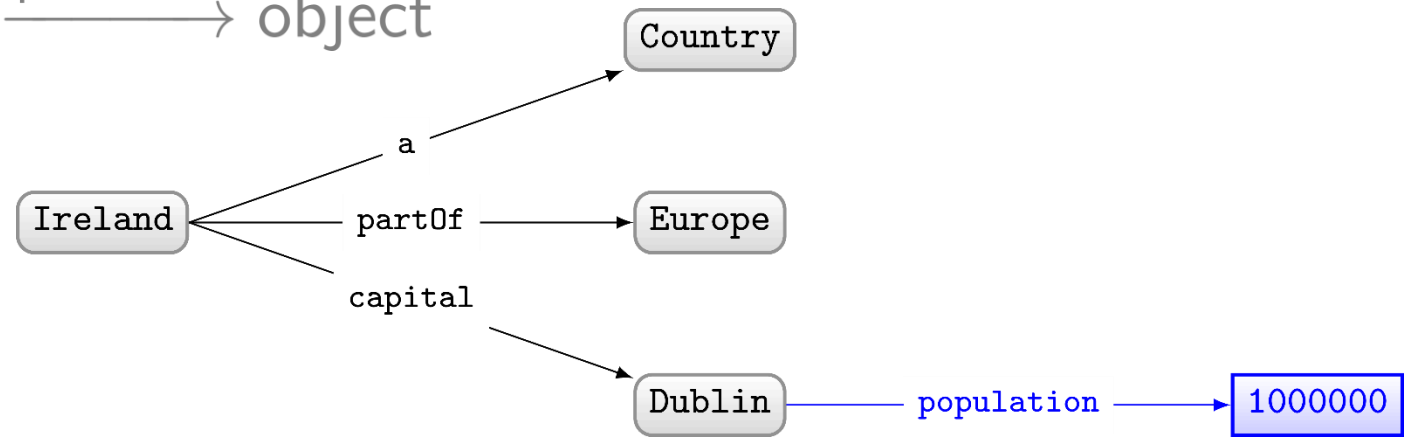
Concatenate to "integrate" new data

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

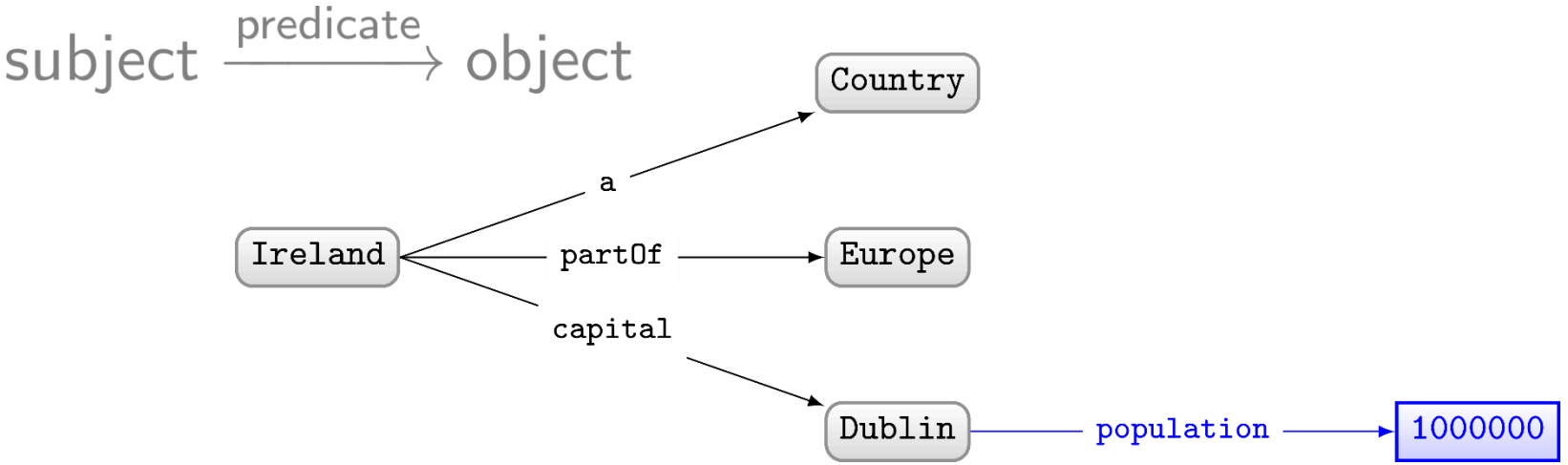
RDF often drawn as a (directed, labelled) graph

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

subject $\xrightarrow{\text{predicate}}$ object



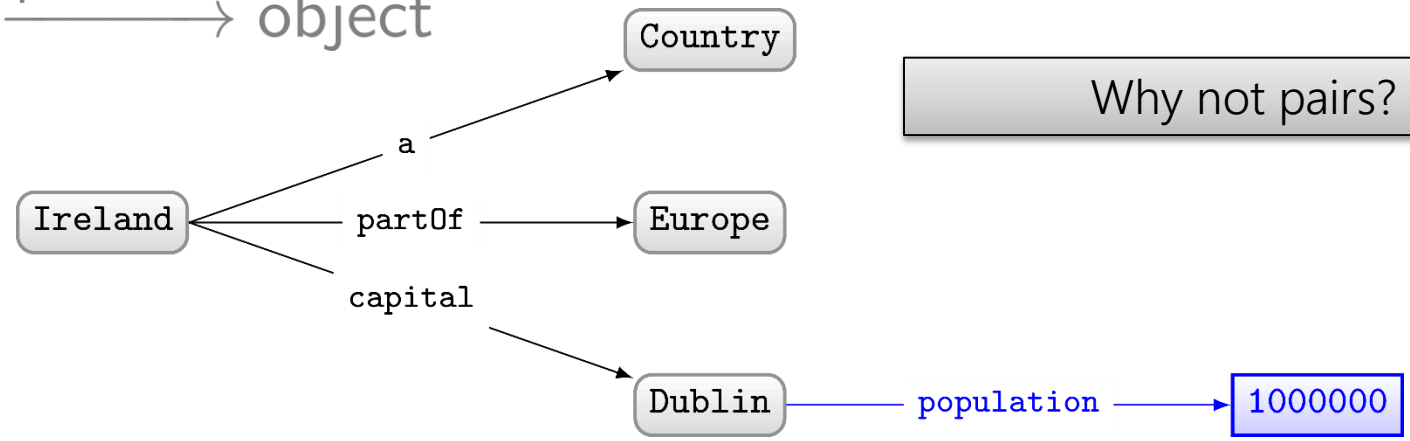
Set of triples thus called an "RDF Graph"



But why triples?

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

subject $\xrightarrow{\text{predicate}}$ object

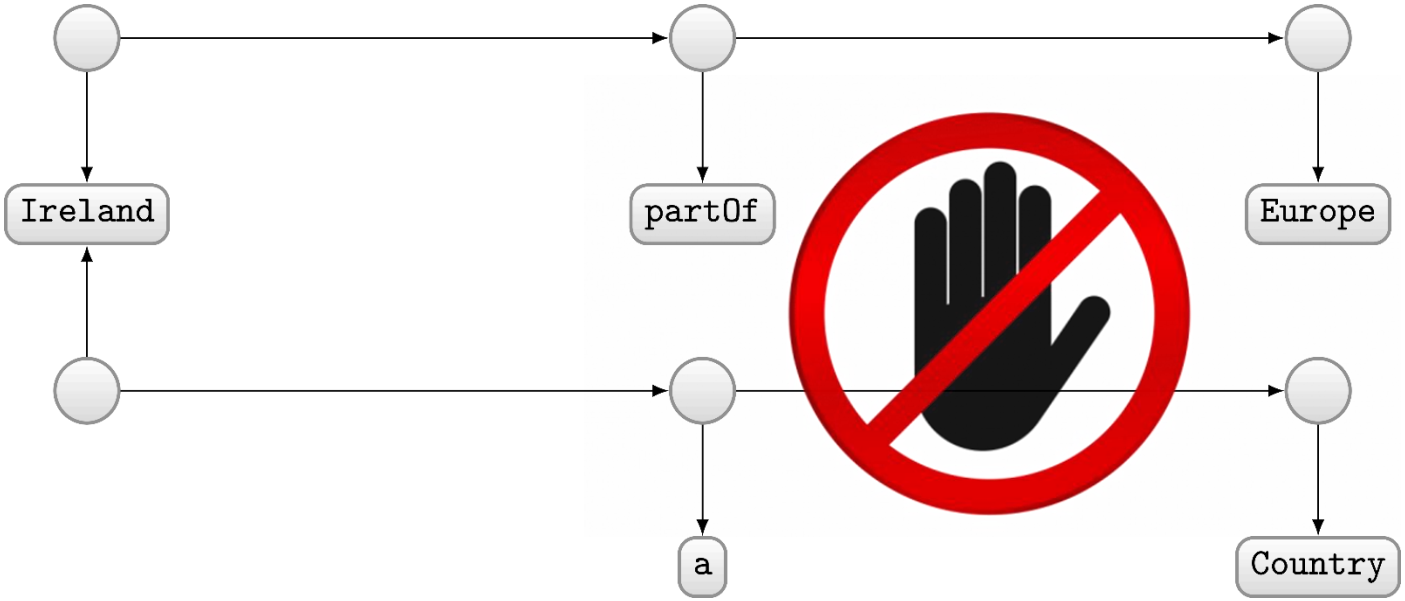


Why not pairs?

Modelling with pairs (directed unlabelled graph)?

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country

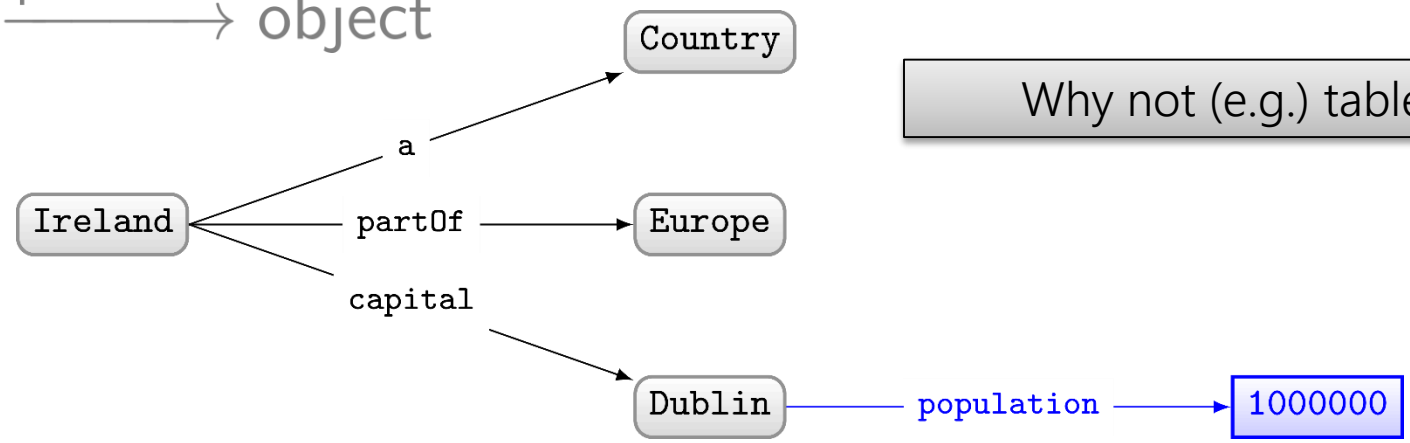
Modelled as pairs?



But why graphs?

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

subject —predicate→ object



Why not (e.g.) tables?

Graphs are flexible

Relational Databases ...

Relational Databases ...

Debit

account	comment	date	time	amount	total	id
7873698669	Initial deposit	2020-21-01	20:02:02	300000	300000	TRCXGU8JSHD
7873698669	C0°0°L Designs	2020-02-06	09:15:33	50000	325000	TRCCIA2J8A0

Credit

account	comment	date	time	amount	total	id
7873698669	Electricity	2020-02-02	20:00:01	8200	291800	TRCJASJDA9A
7873698669	Heat	2020-02-02	20:00:02	600	291200	TRC81KAQWAS
7873698669	Moviestar	2020-02-02	20:00:03	16200	275000	TRCK8J7JA8D
7873698669	ATM	2020-02-08	16:05:02	100000	225000	TRCPM8A45AD

Account

number	rut	type	total_clp	total_usd
7873698669	32.000.273-K	Current	225000	344,94

Client

rut	name	phone	address
32.000.273-K	Kelvin	+56976698463	Campo de Hielo Sur, Depto 273

Exchange

c1	c2	value
CLP	USD	0,0001533
USD	CLP	652,2750000

Planets / Relational Data

Planets / Relational Data

Planet
name
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto

Planets / Relational Data

Planet	
name	**dist**
Mercury	
Venus	
Earth	1.00
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	

Planets / Relational Data

Planet

name	**dist**
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	49.31

Planets / Relational Data

Planet

name	**dist**	**radius**
Mercury	0.39	0.38
Venus	0.72	
Earth	1.00	1.00
Mars	1.52	0.53
Jupiter		10.97
Saturn	9.54	
Uranus	19.19	3.98
Neptune		
Pluto	49.31	

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
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Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring	moon
Mercury	0.39	0.38	2.8	58.646	0.241	440	false	⊥
Venus	0.72	0.95	8.9	-243.019	0.615	730	false	⊥
Earth	1.00	1.00	9.8	0.997	1.000	288	false	Luna
Mars	1.52	0.53	3.7	1.026	1.880	186	false	Phobos, Deimos
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true	Callisto, Ganymede, ...
Saturn	9.54	9.14	9.1	0.444	29.447	134	true	Titan, Rhea, ...
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true	Oberon, Titania, ...
Neptune	30.07	3.86	11.0	0.671	164.791	53	true	Triton, ...
Pluto	49.31	0.19	0.063	6.39	248.000	44	false	Charon

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	planet
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	planet	discoverer	year
Ganimedes	Jupiter	Galileo Galilei	1610
Calisto	Jupiter	Galileo Galilei	1610
Europa	Jupiter	Galileo Galilei	1610
Io	Jupiter	Galileo Galilei	1610
Titan	Saturn	Christiaan Huygens	1655
Triton	Neptune	William Lassell	1846
Luna	Terra	$\perp$	$\perp$
Oberon	Uranus	William Herschel	1787
Charon	Pluto	$\perp$	1978
...	...	...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
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Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	planet
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
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Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	planet
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	P.name
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	P.name
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
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Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true

DwarfPlanet

name	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	P.name
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
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Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true

DwarfPlanet

name	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	P.name
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
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...	...

Planets / Relational Data

Planet

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Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true

DwarfPlanet

name	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	parent
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
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Planets / Relational Data

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Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true

DwarfPlanet

name	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon

name	parent
Ganimedes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer

name	discoverer
Ganimedes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear

name	year
Ganimedes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Planets / Relational Data

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false
Earth	1.00	1.00	9.8	0.997	1.000	288	false
Mars	1.52	0.53	3.7	1.026	1.880	186	false
Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
Saturn	9.54	9.14	9.1	0.444	29.447	134	true
Uranus	19.19	3.98	7.8	-0.719	84.017	76	true
Neptune	30.07	3.86	11.0	0.671	164.791	53	true

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DwarfPlanet

name	dist	radius	grav	days	years	temp	ring
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Moon

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Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

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MoonDiscYear

name	year
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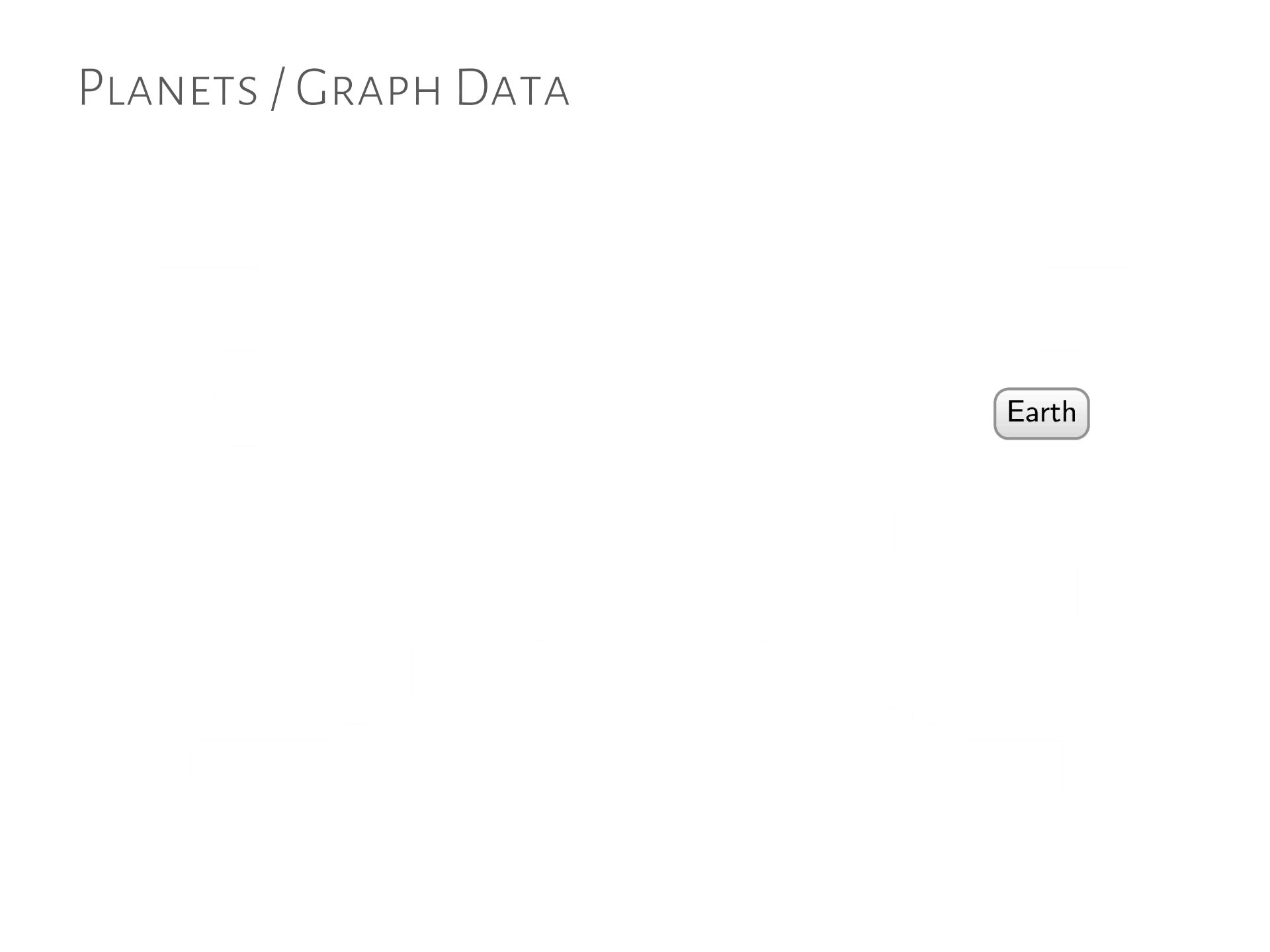
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

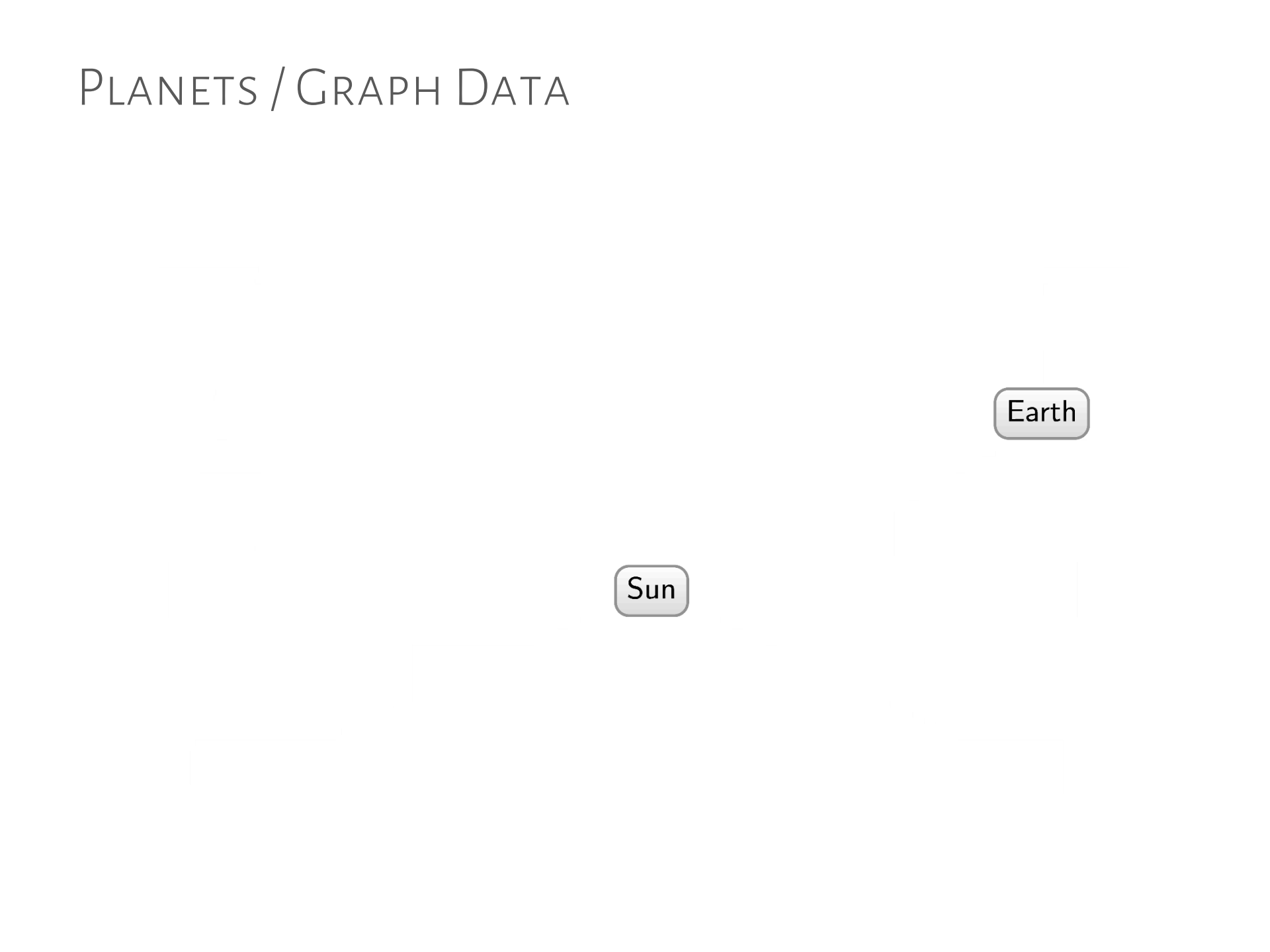
Planets / Graph Data

Planets / Graph Data

Planets / Graph Data

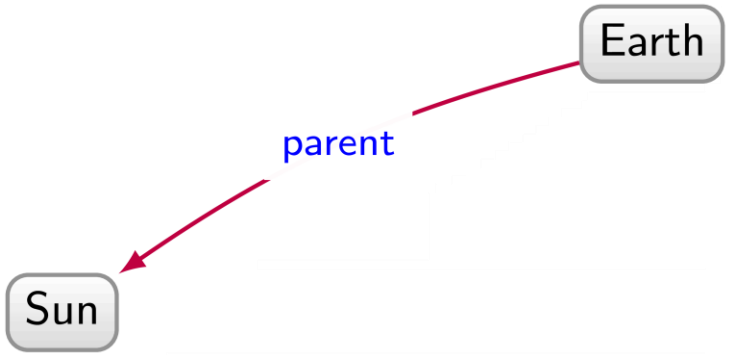


Planets / Graph Data

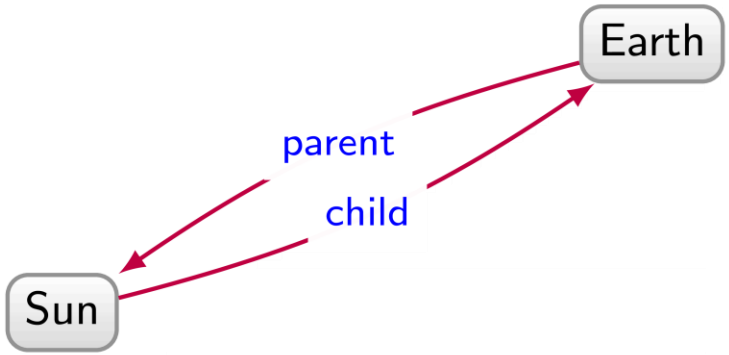


Planets / Graph Data

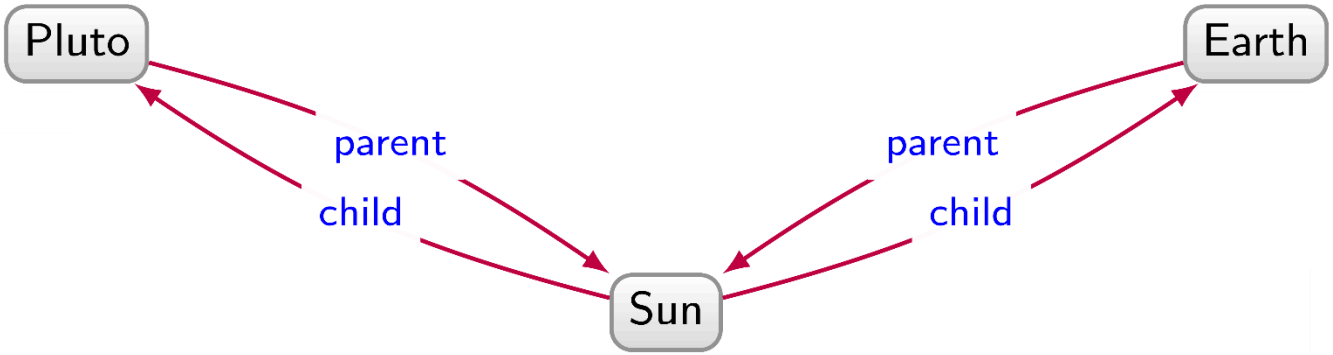
Planets / Graph Data



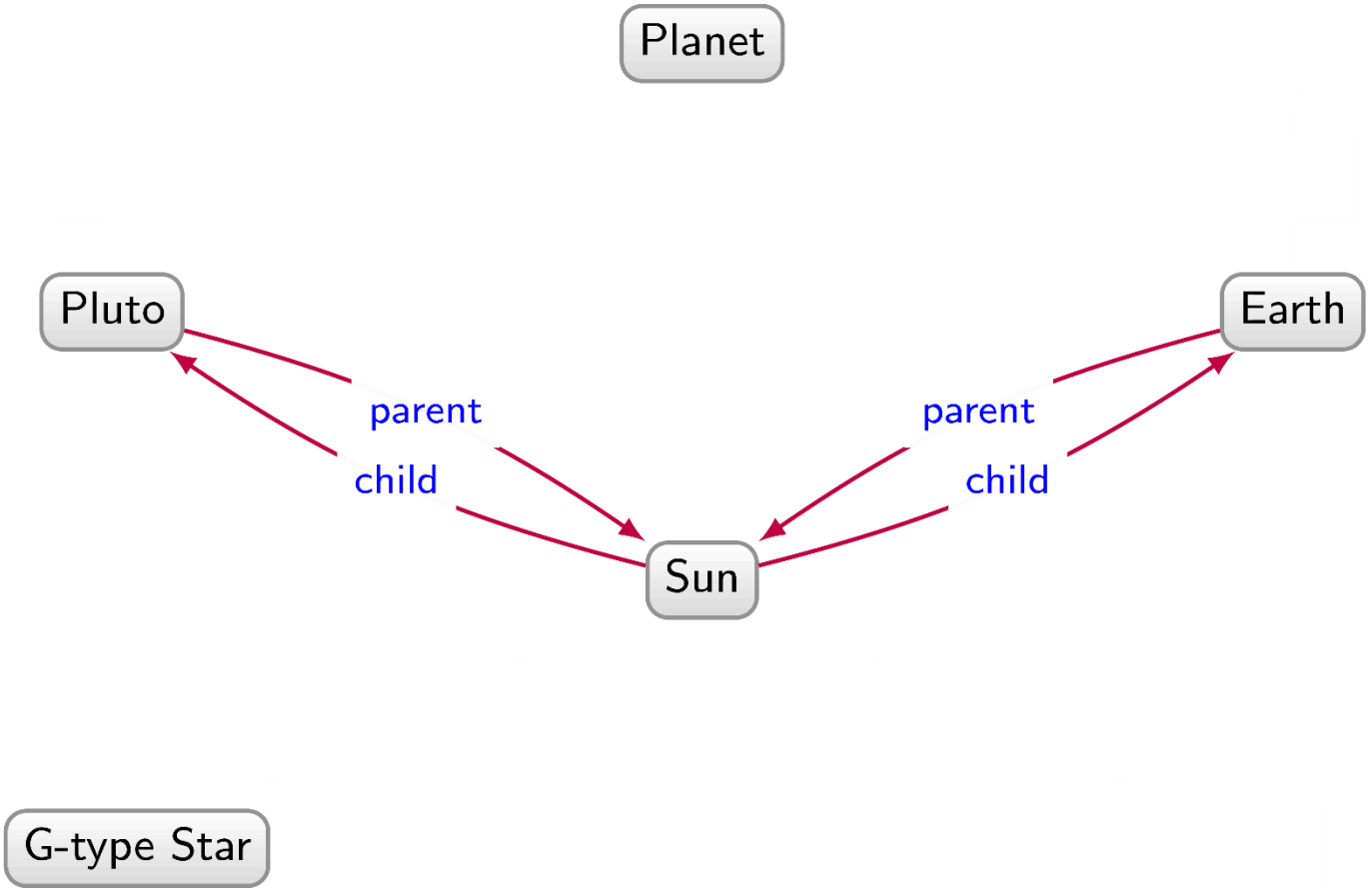
Planets / Graph Data



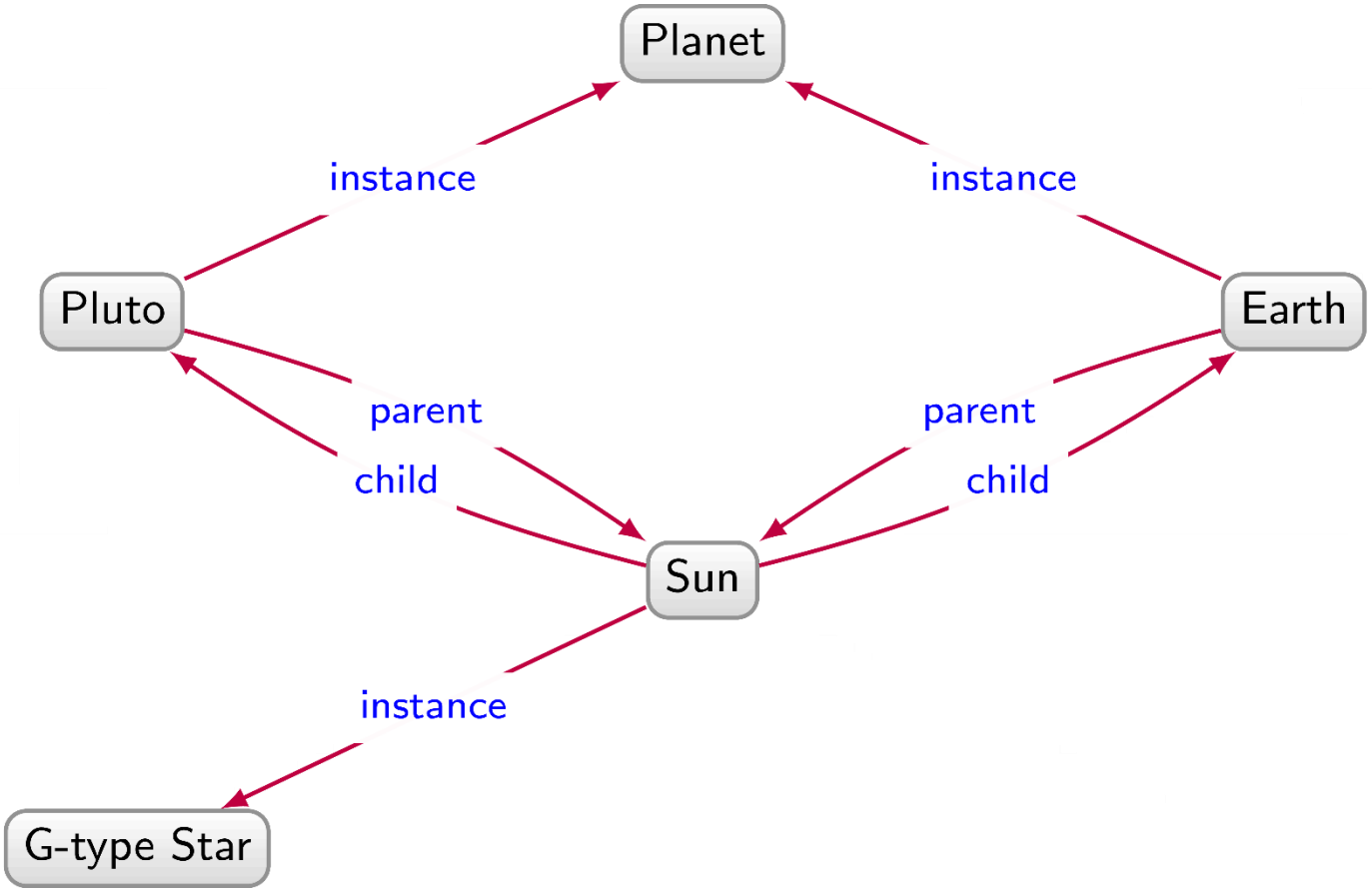
Planets / Graph Data



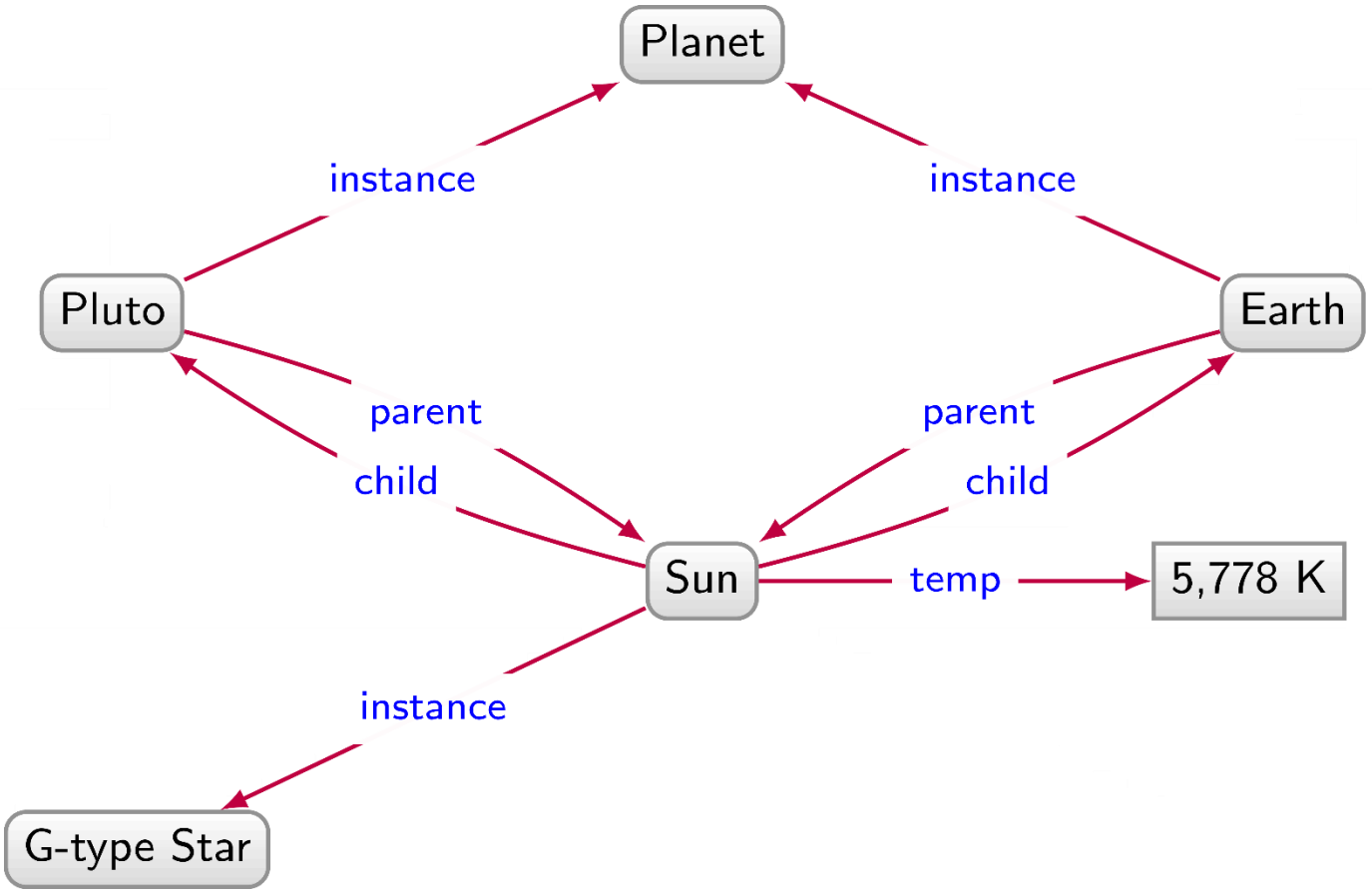
Planets / Graph Data



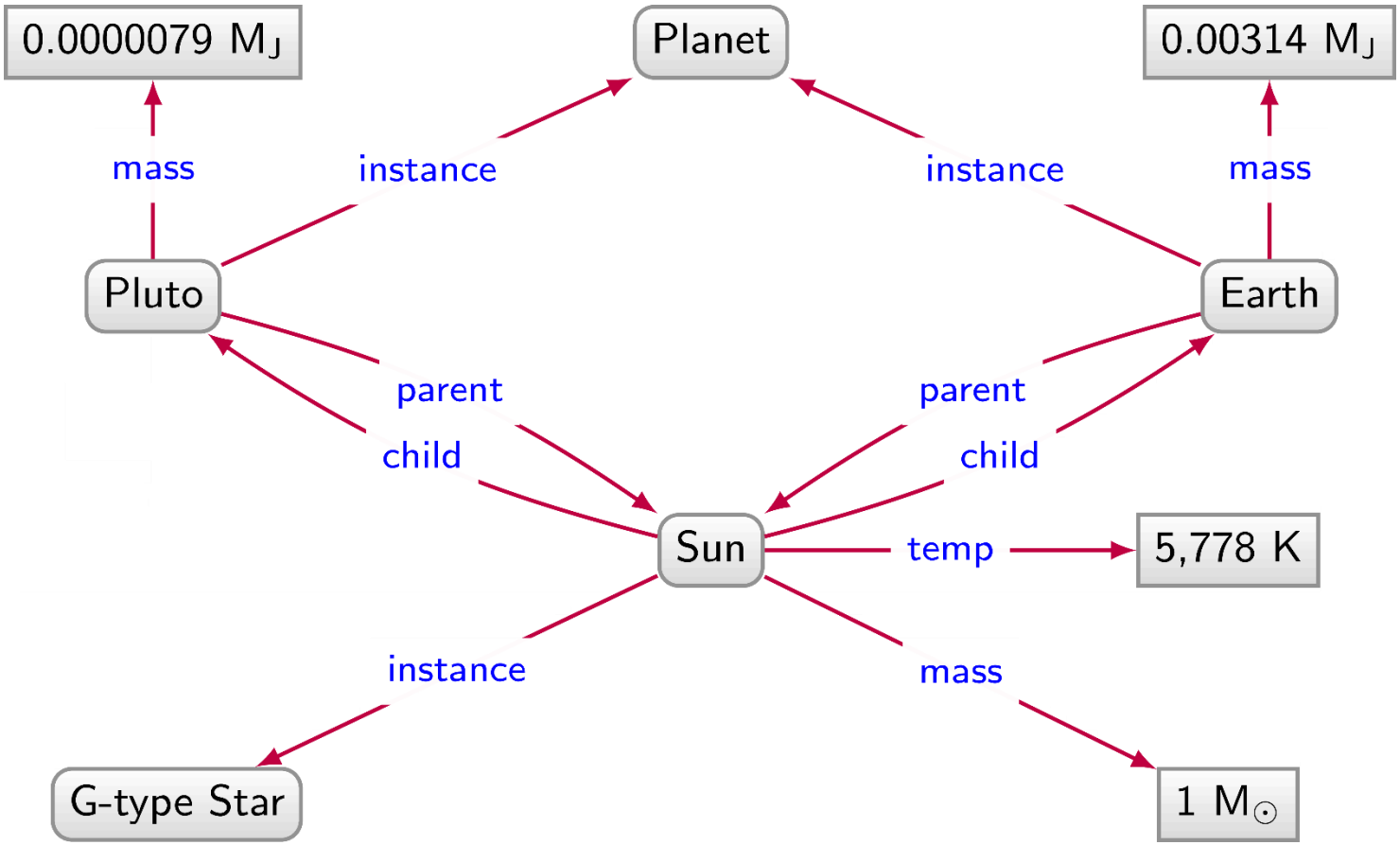
Planets / Graph Data



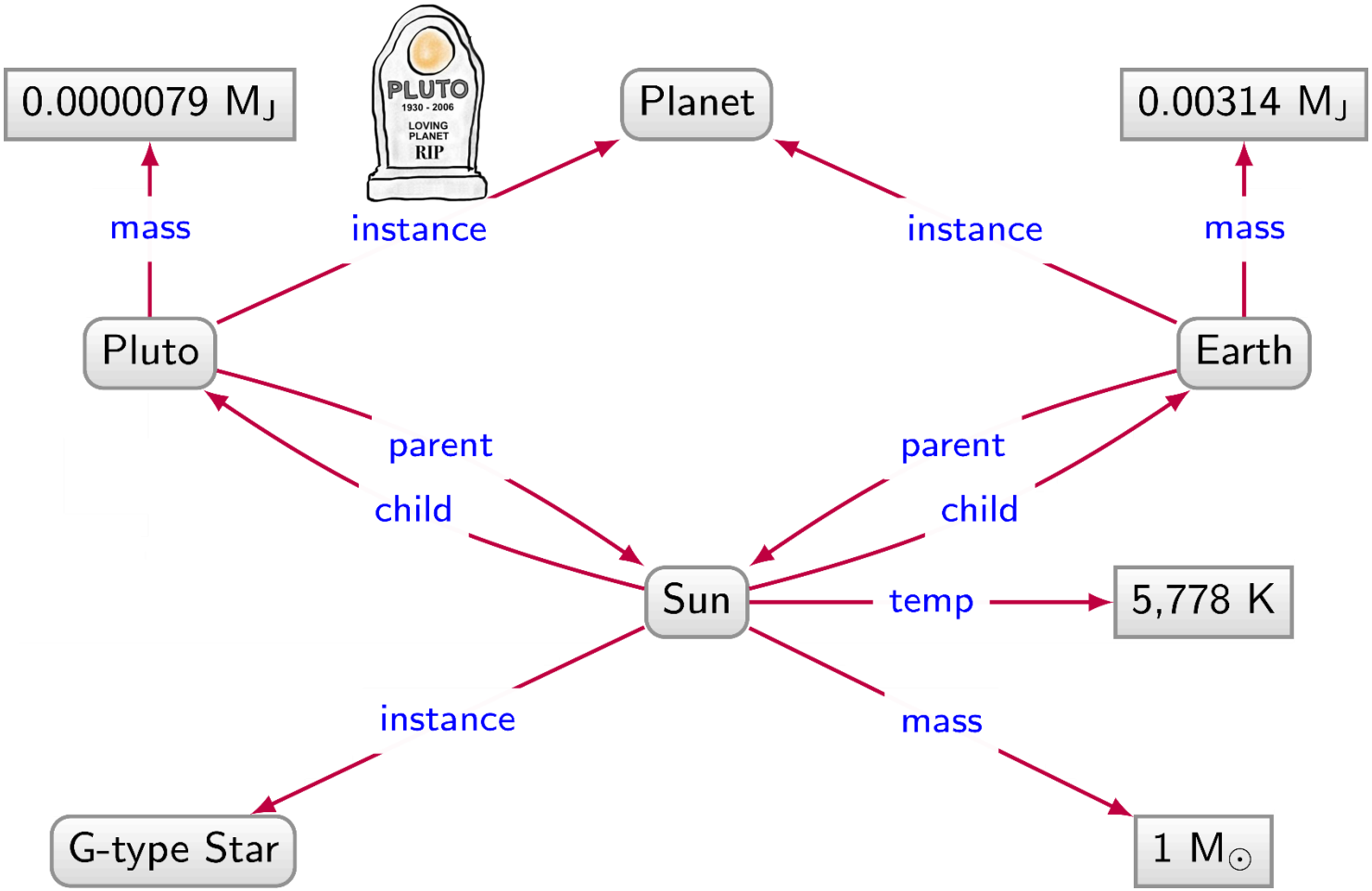
Planets / Graph Data



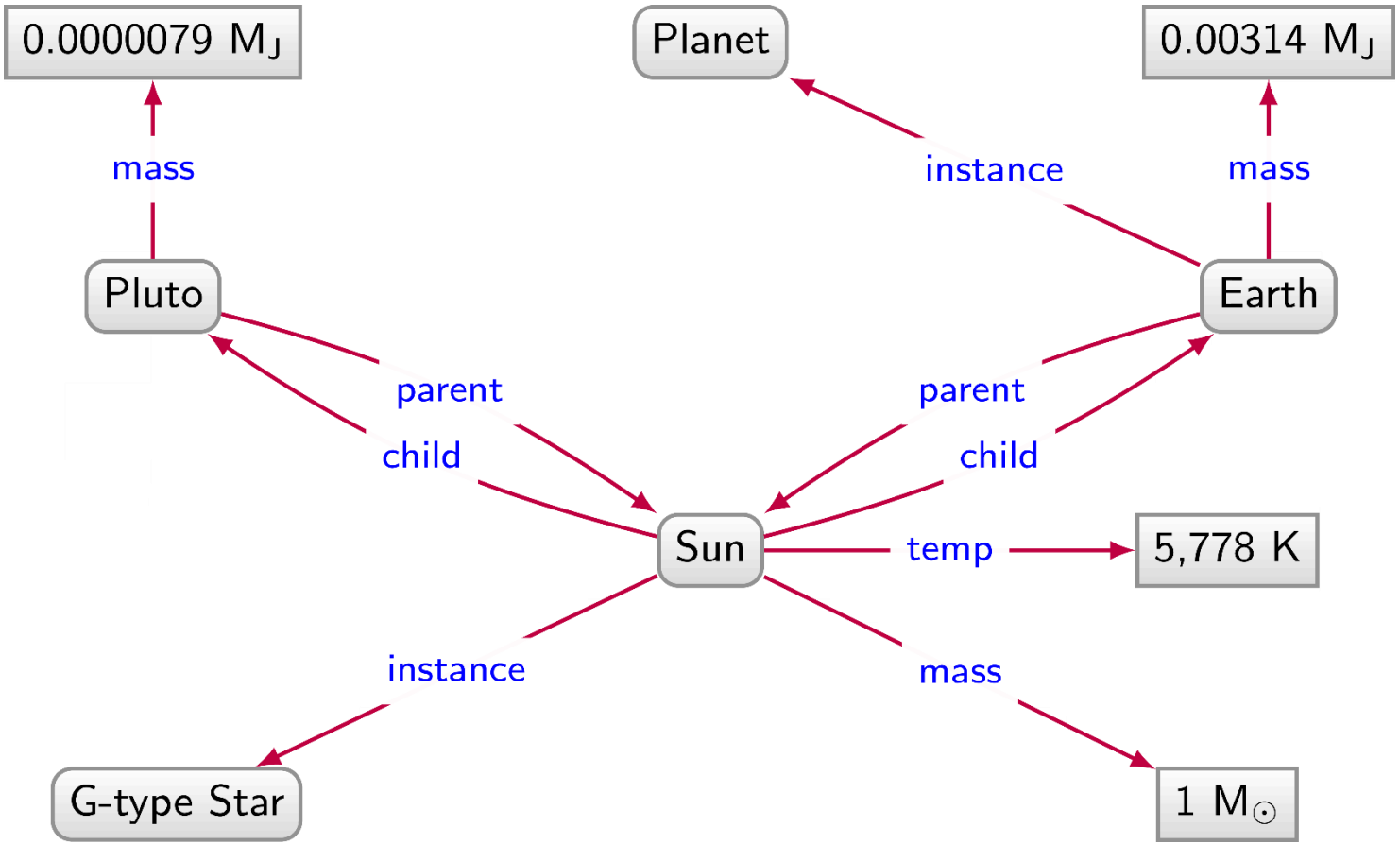
Planets / Graph Data



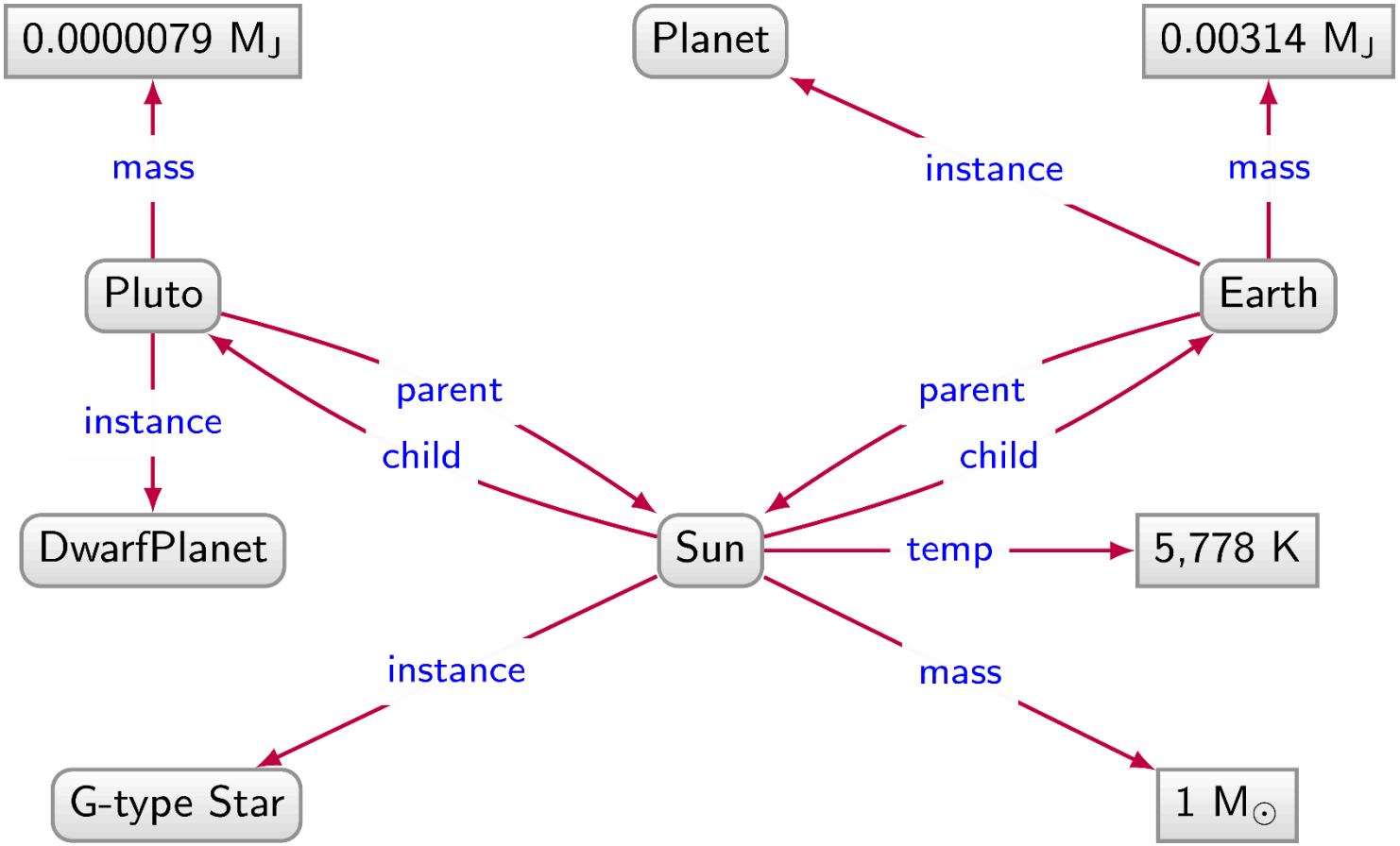
Planets / Graph Data



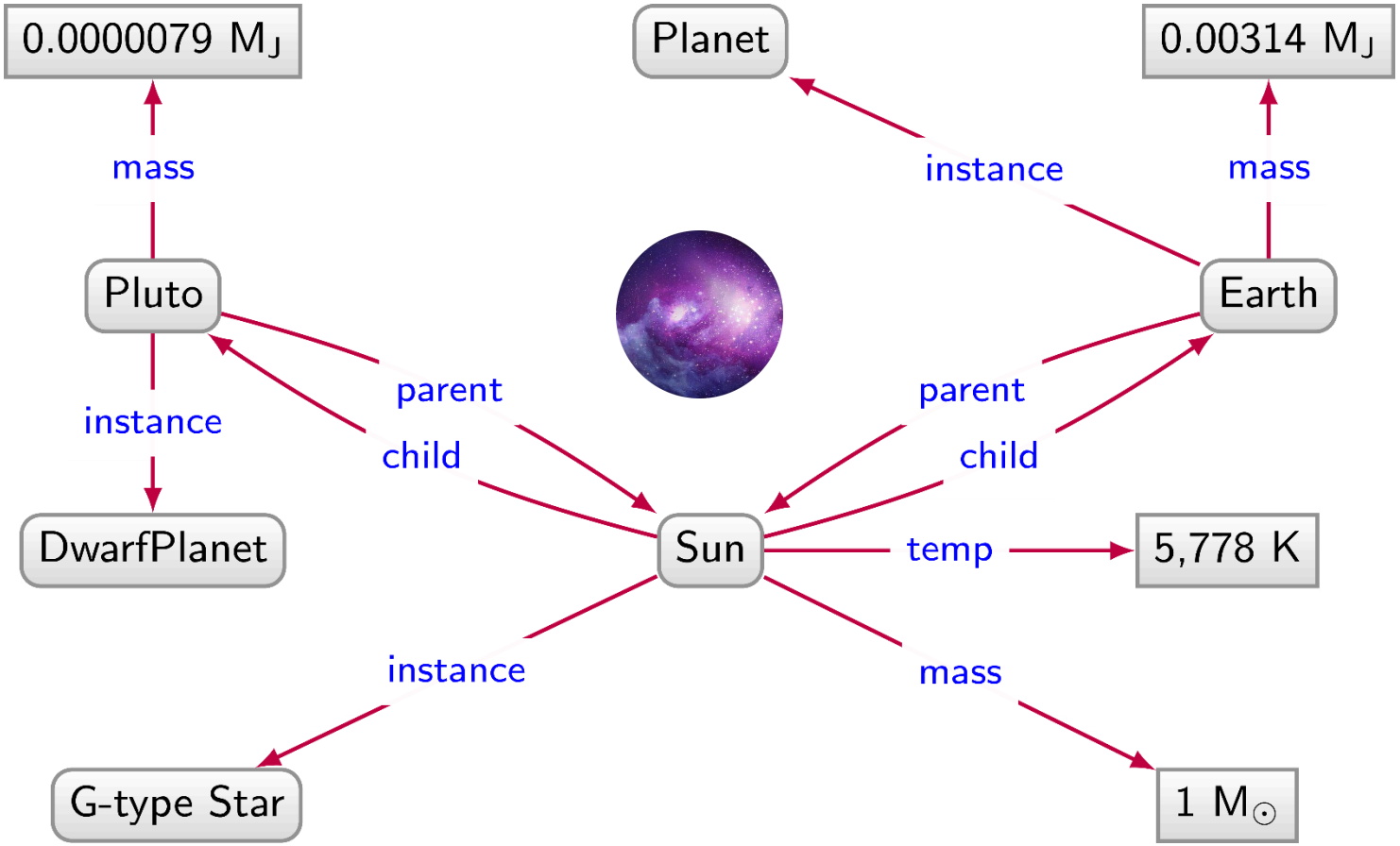
Planets / Graph Data



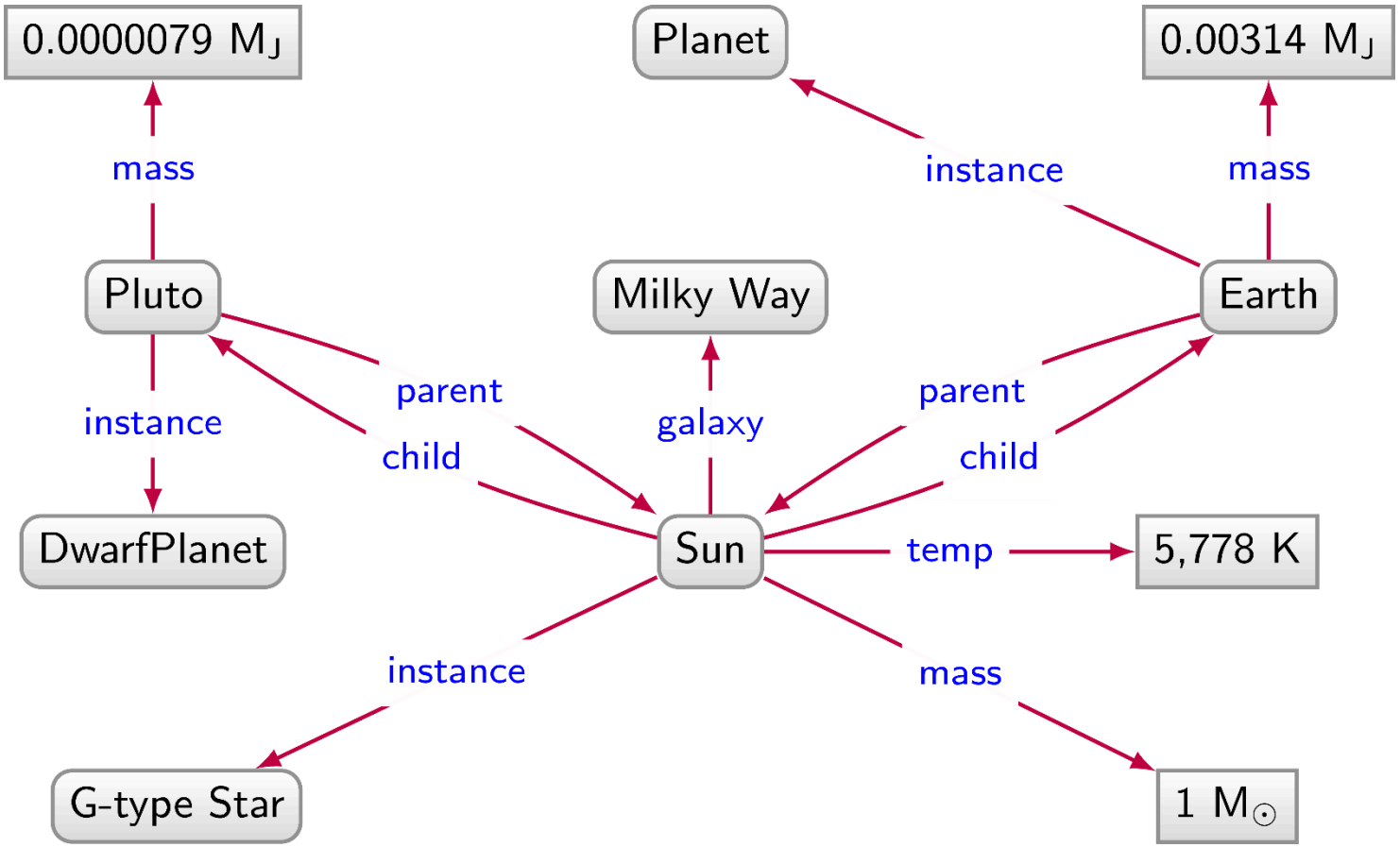
Planets / Graph Data



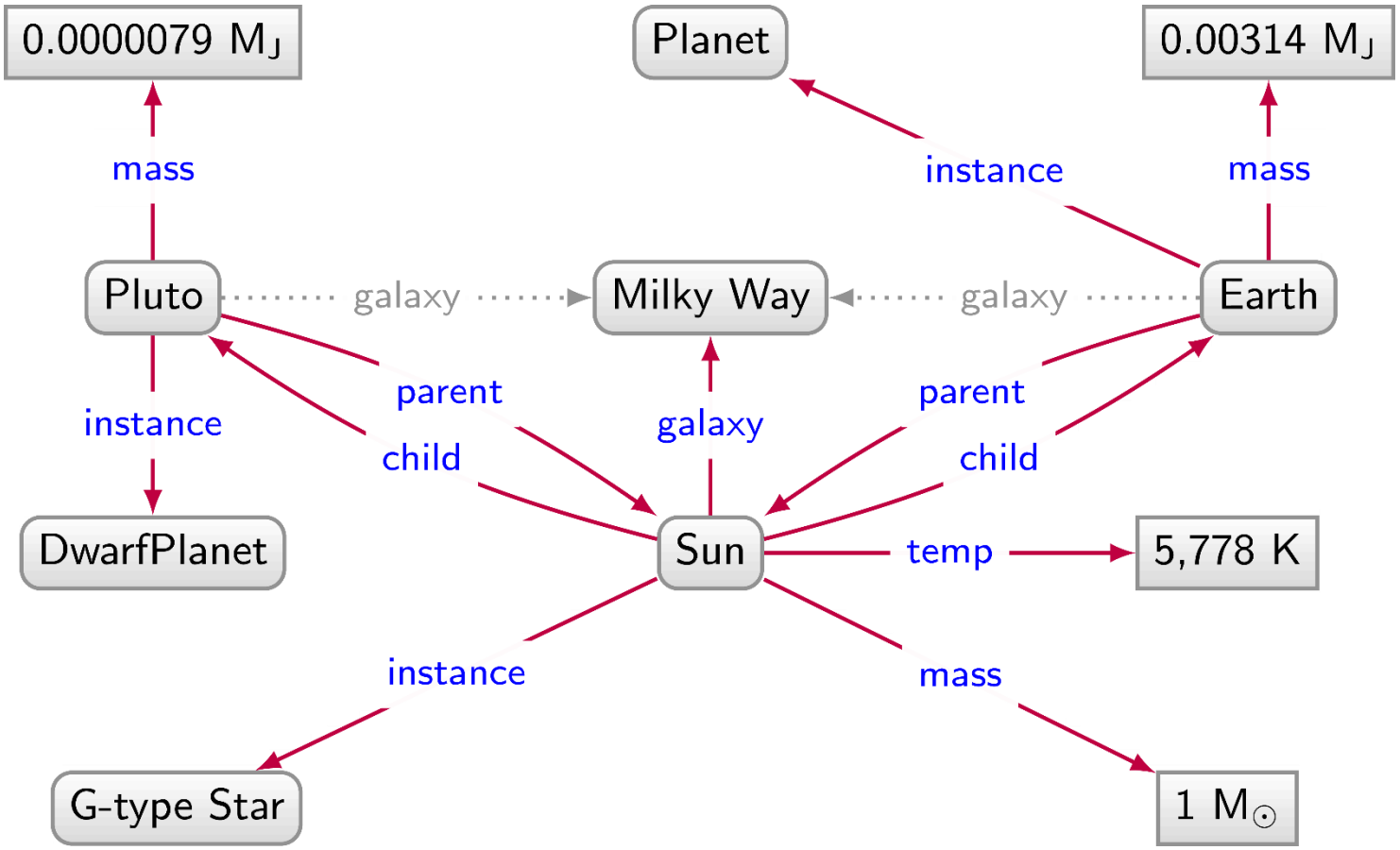
Planets / Graph Data



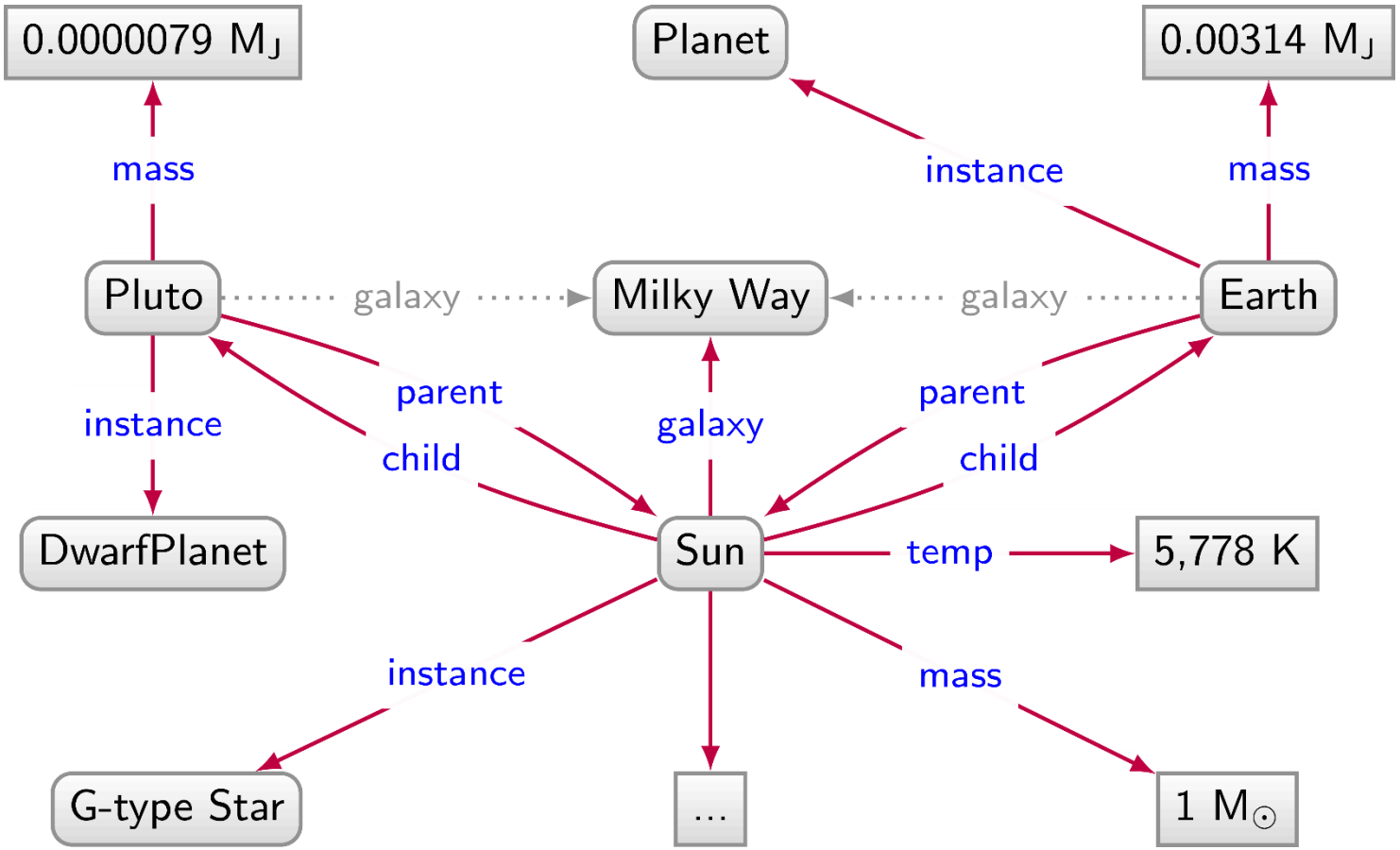
Planets / Graph Data



Planets / Graph Data



Planets / Graph Data

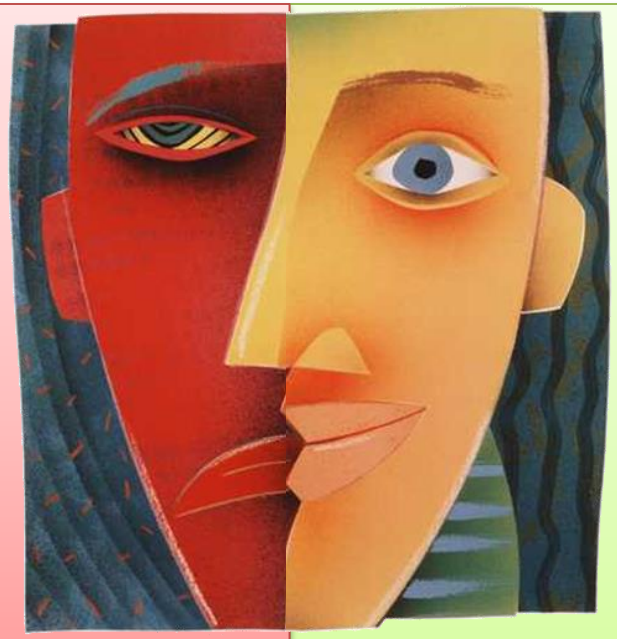


Relational data: Pros and Cons

Planet

name	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false

We have to impose a
structure (schema)
from the start



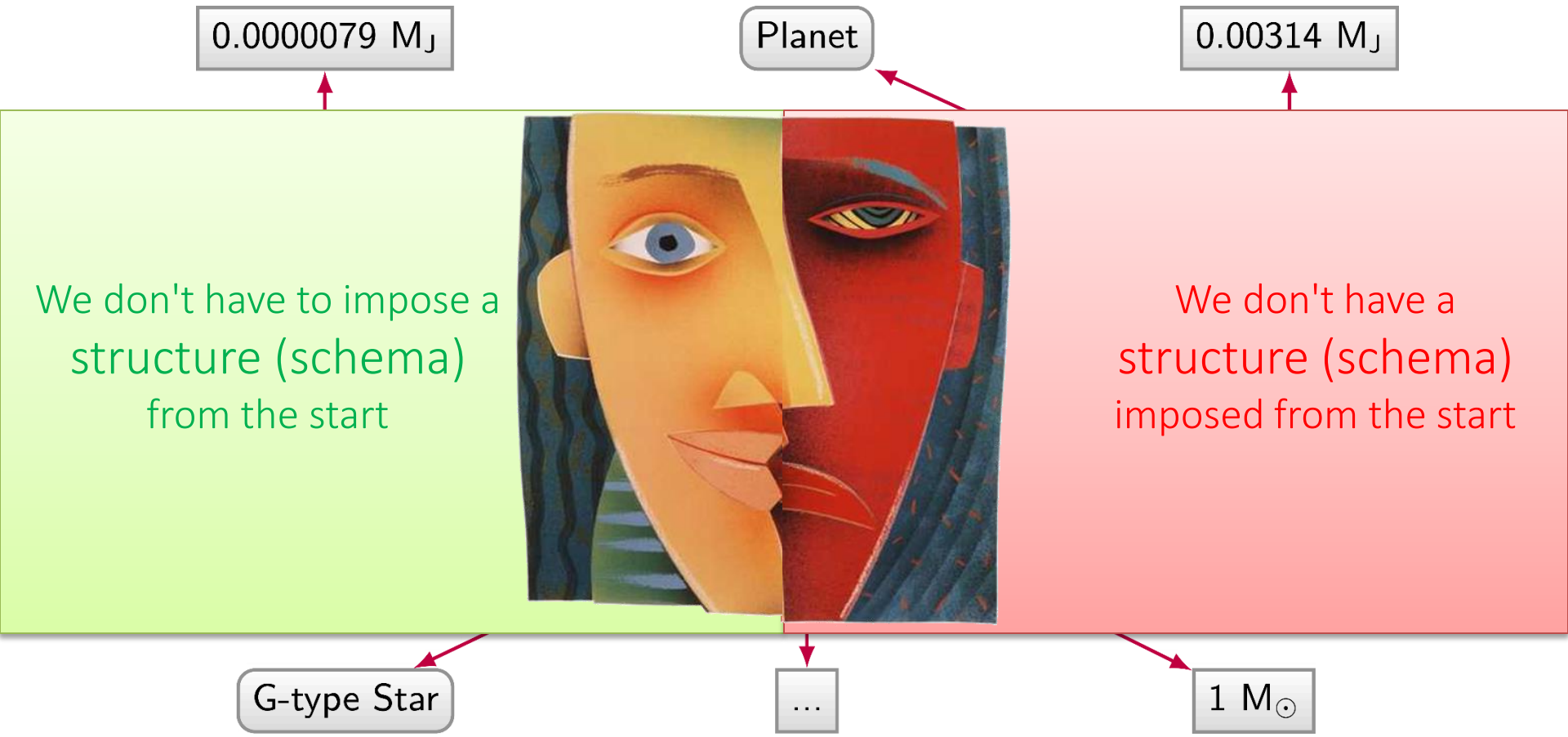
We have a
structure (schema)
imposed from the start

Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

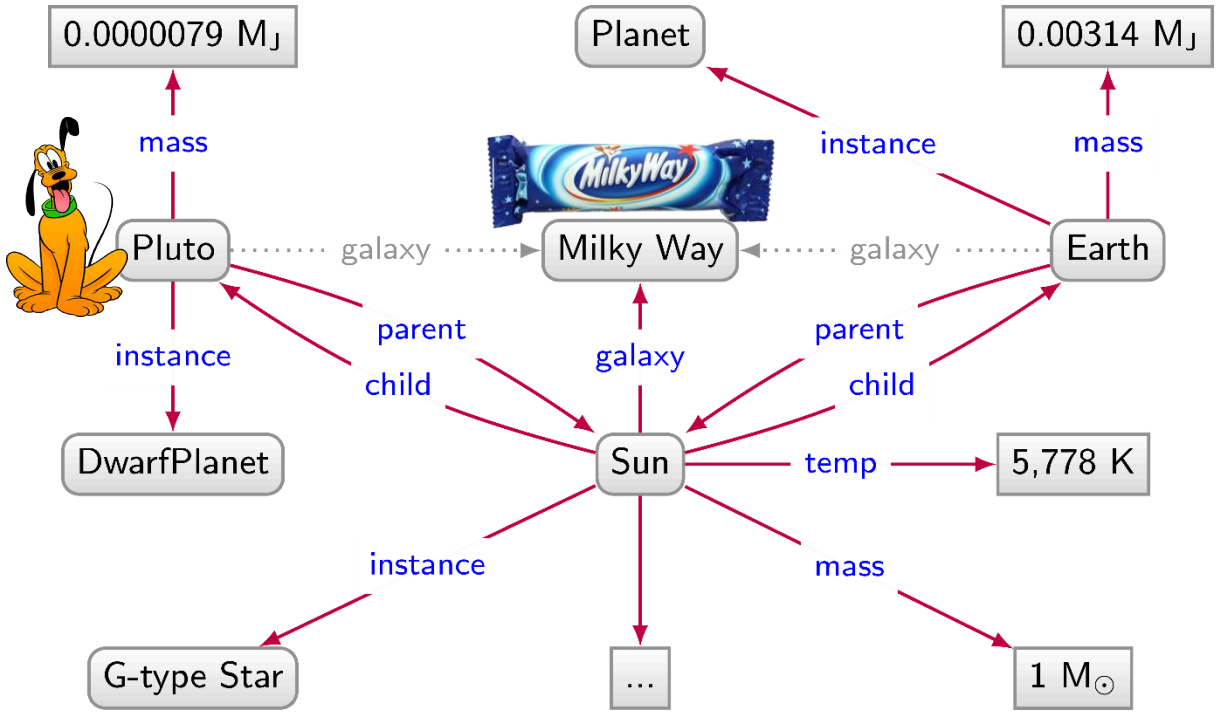
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

Graph Data: Pros and Cons

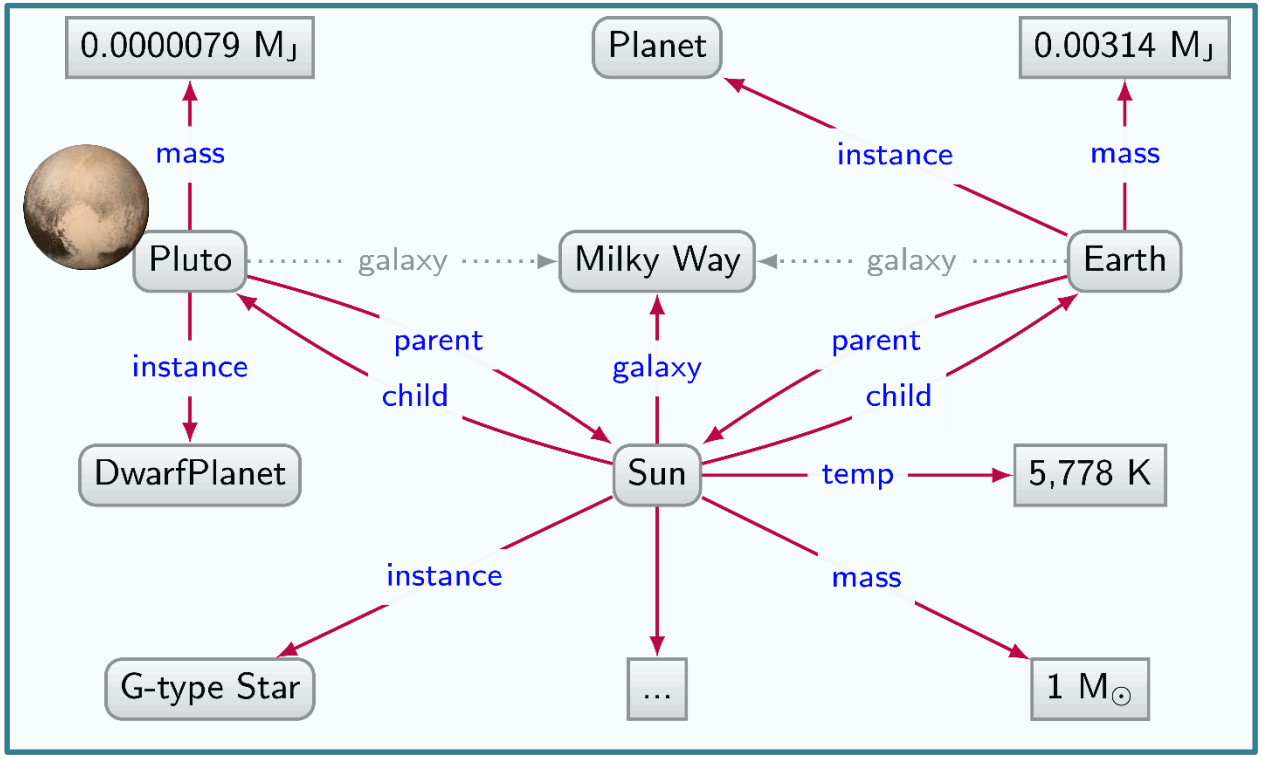


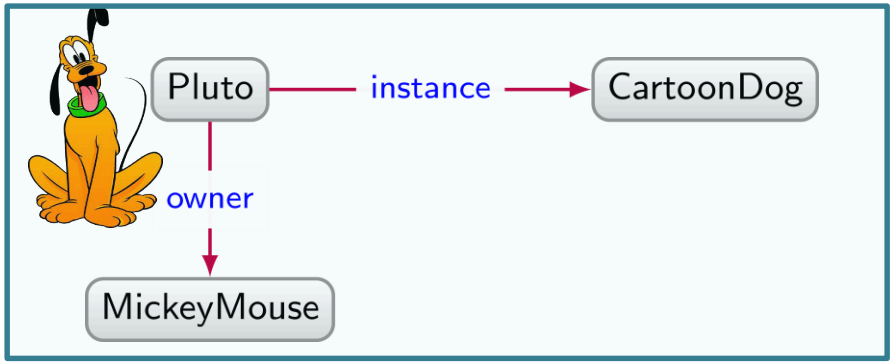
Naming things

Naming things: Strings not enough

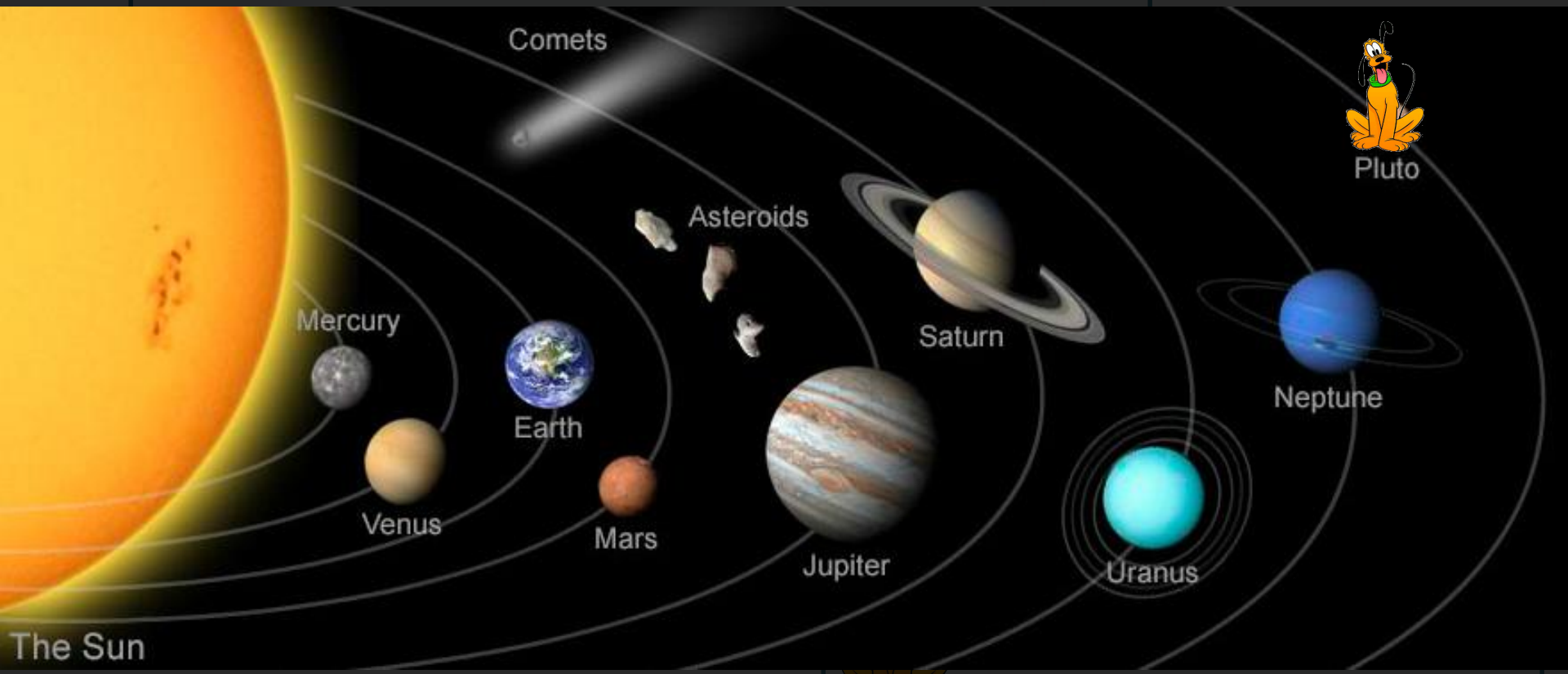


Naming things: Strings not enough

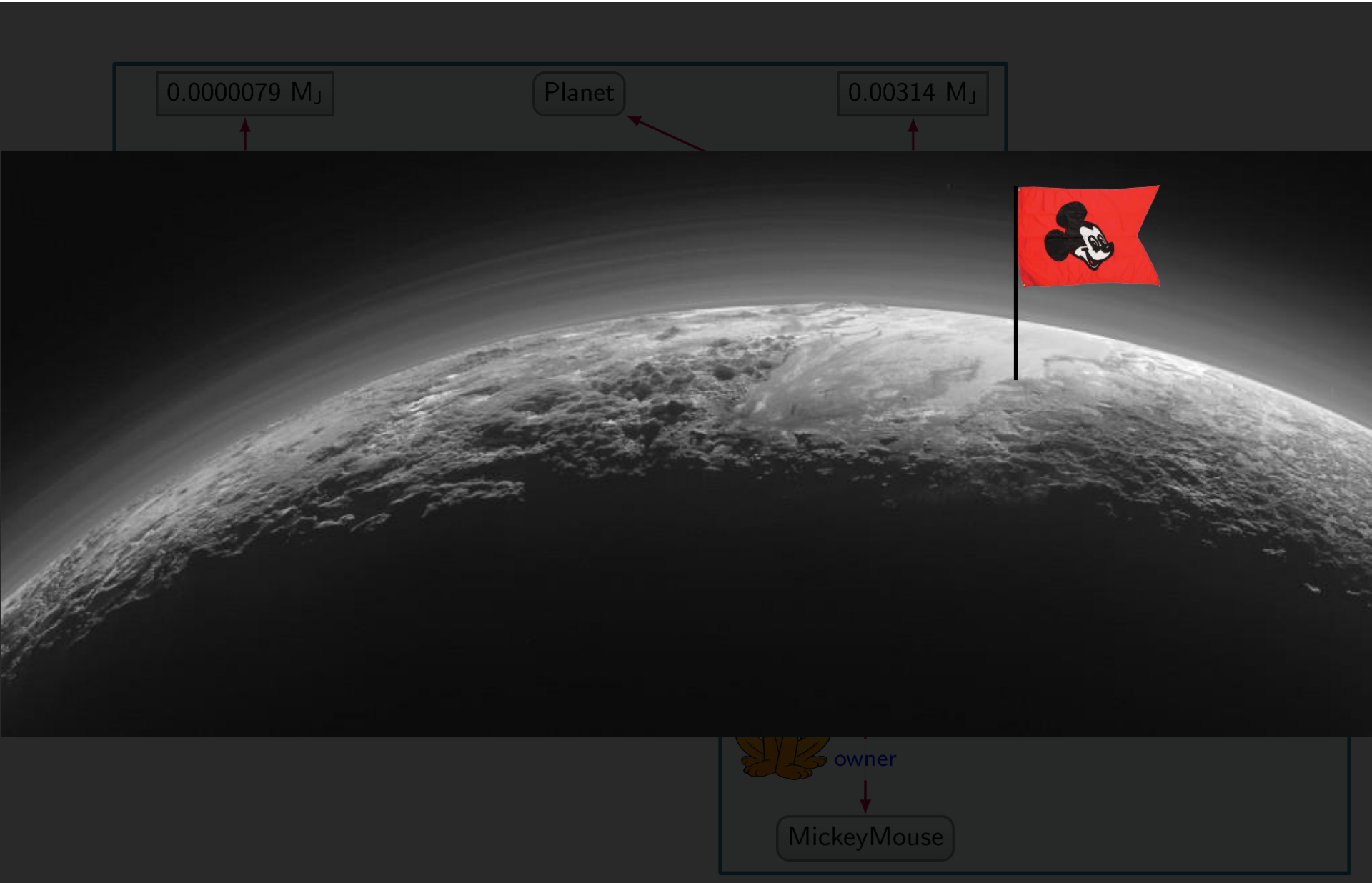




Naming things: Strings not enough



Naming things: Strings not enough



Naming things in RDF: IRIs

Need unambiguous symbols/identifiers

- Since we're on the Web … use Web identifiers

- URL: Uniform Resource Location
  - The location of a resource on the Web
  - `http://ex.org/Dubl%C3%ADn.html`

- URI: Uniform Resource Identifier (RDF 1.0)
  - Need not be a location, can also be a name
  - `http://ex.org/Dubl%C3%ADn`

- IRI: Internationalised Resource Identifier (RDF 1.1)
  - A URI that allows Unicode characters
  - `http://ex.org/Dublín`

We will use IRIs with prefixes

- `http://ex.org/Dublín` ↔ `ex:Dublín`
  - "`ex:`" denotes a prefix for `http://ex.org/`
  - "`Dublín`" is the local name

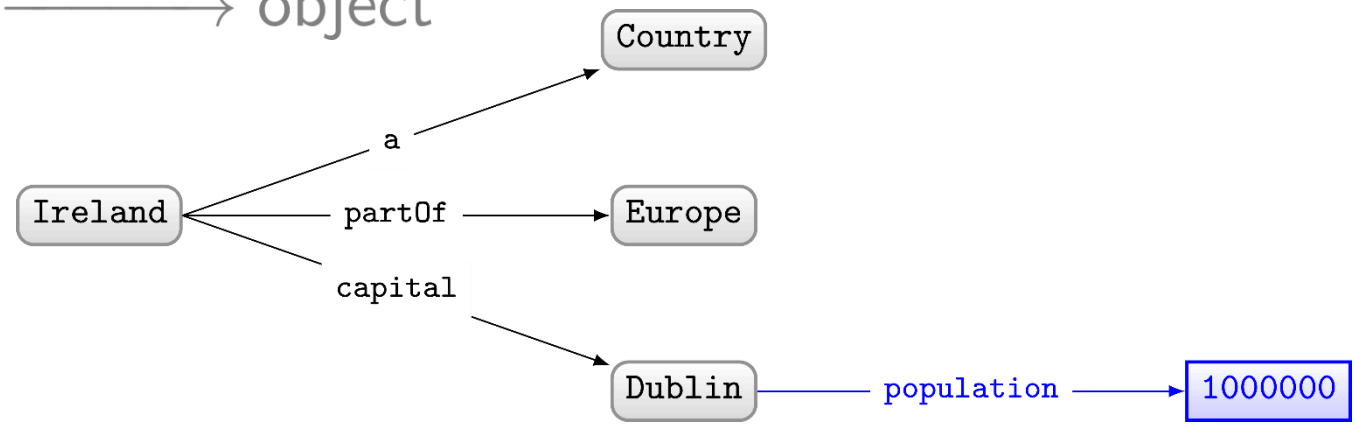
Frequently used prefixes

Prefix	Value
rdf:	http://www.w3.org/1999/02/22-rdf-syntax-ns#
xsd:	http://www.w3.org/2001/XMLSchema#
rdfs:	http://www.w3.org/2000/01/rdf-schema#
owl:	http://www.w3.org/2002/07/owl#

From strings ...

subject	*predicate*	*object*
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

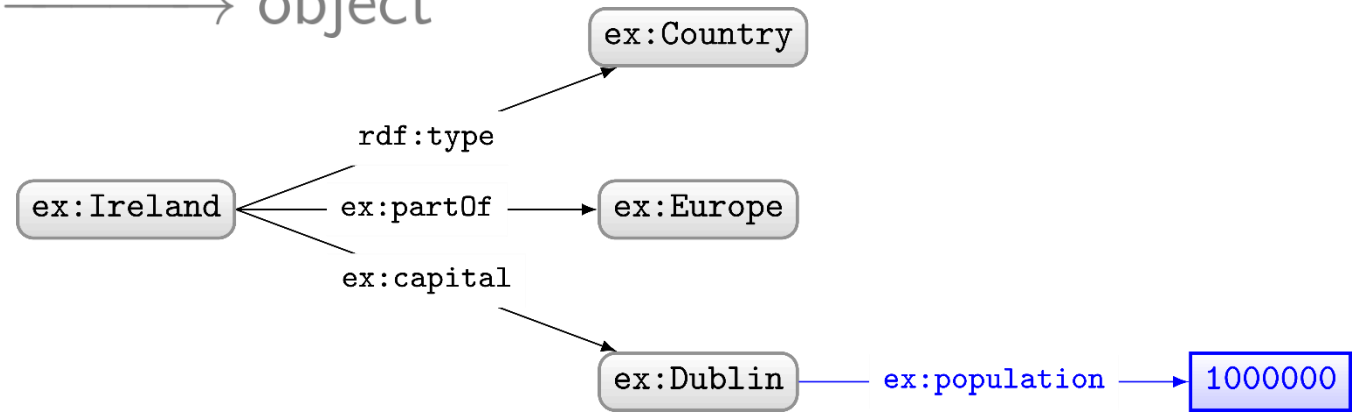
subject $\xrightarrow{\text{predicate}}$ object



… to IRIs …

subject	*predicate*	*object*
ex:Ireland	ex:partOf	ex:Europe
ex:Ireland	rdf:type	ex:Country
ex:Ireland	ex:capital	ex:Dublin
ex:Dublin	ex:population	1,000,000

subject $\xrightarrow{\text{predicate}}$ object

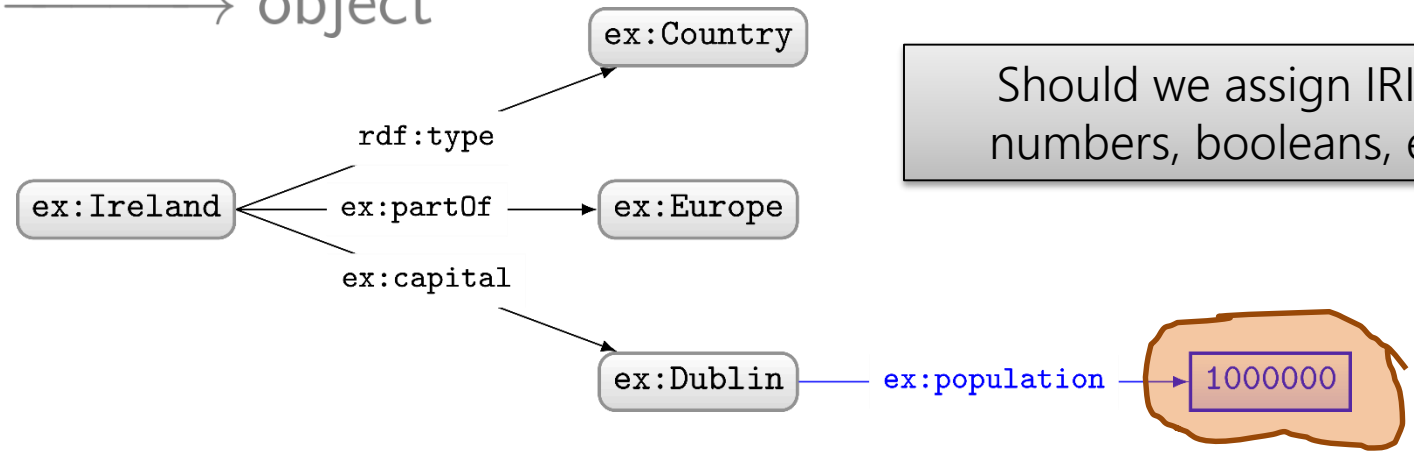


Naming things in RDF: Literals

What about numbers?

subject	*predicate*	*object*
ex:Ireland	ex:partOf	ex:Europe
ex:Ireland	rdf:type	ex:Country
ex:Ireland	ex:capital	ex:Dublin
ex:Dublin	ex:population	1,000,000

subject —predicate→ object



Should we assign IRIs to numbers, booleans, etc.?

RDF allows "literals" in object position

- Literals are for datatype values, like strings, numbers, booleans, dates, times
- Only allowed in object position

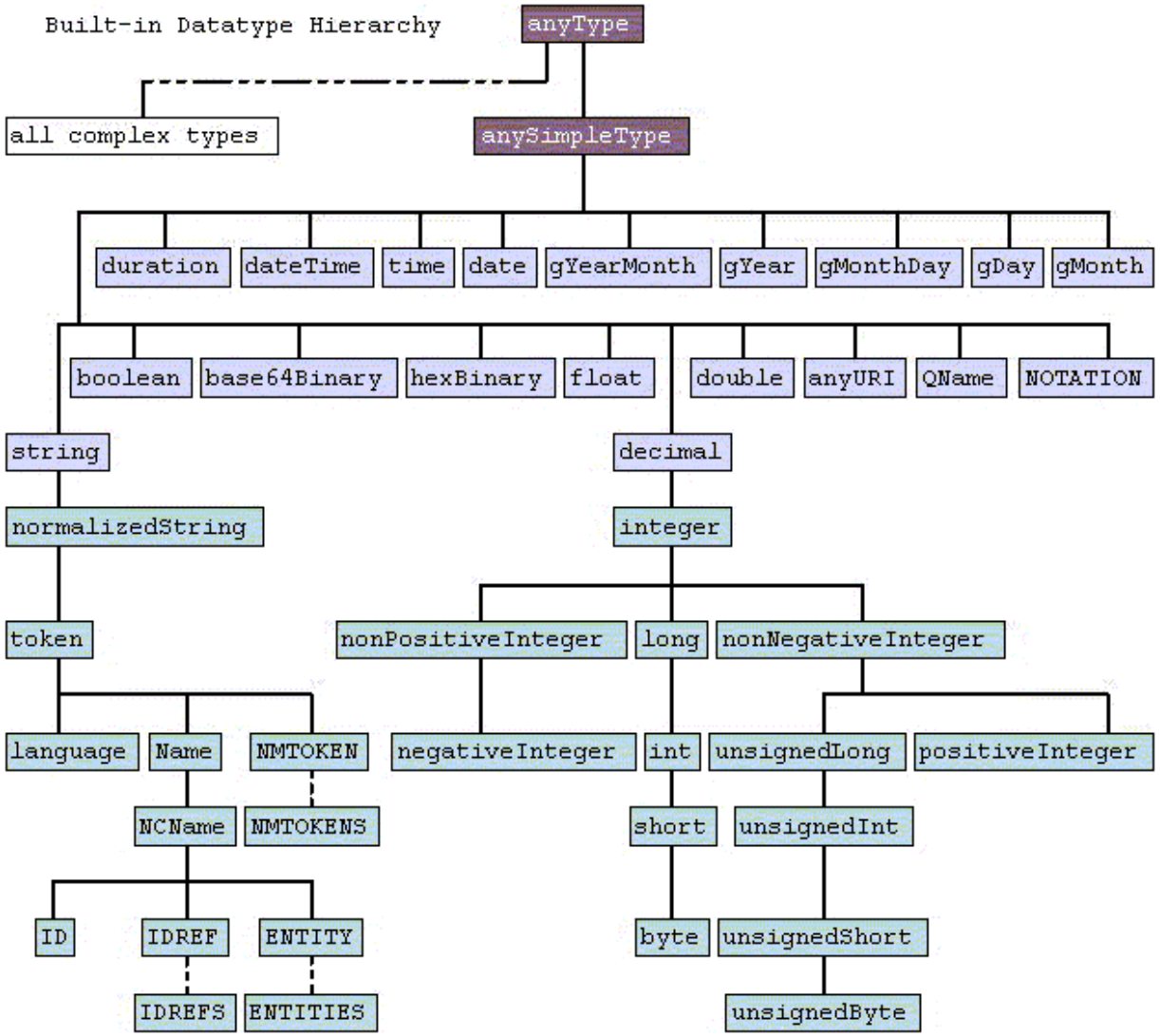
subject	*predicate*	*object*	
ex:Dublin	ex:population	1,000,000	CORRECT
1,000,000	ex:populationOf	ex:Dublin	INCORRECT
ex:Dublin	1,000,000	ex:population	INCORRECT

Datatype literals

- "[lexical-string]"^^[datatype-IRI]
  - "200"^^xsd:int
  - "2014-12-13"^^xsd:date
  - "true"^^xsd:boolean
  - "this is a string"^^xsd:string

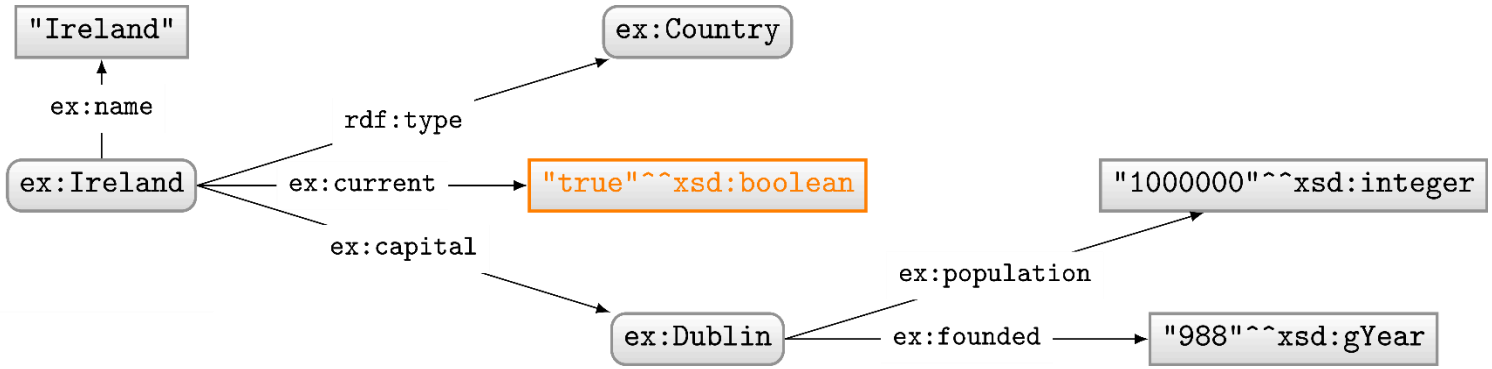
- If the datatype is omitted, it's a string
  - "this is a string"
  - "200" is a string, not a number!

Many datatypes borrowed from XML Schema



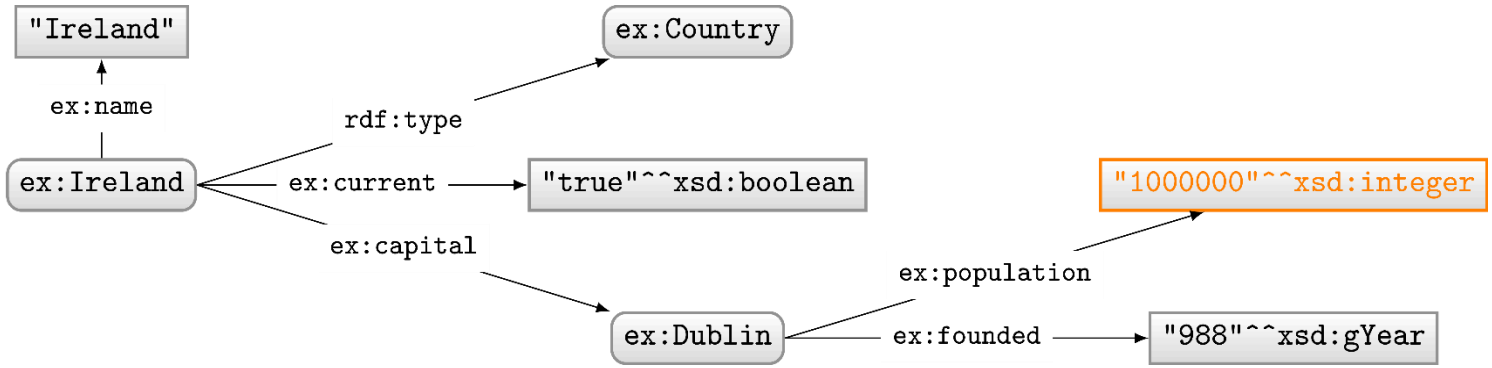
Boolean datatype

Boolean		
xsd:boolean	"true", "false", "1", "0"	Case sensitive



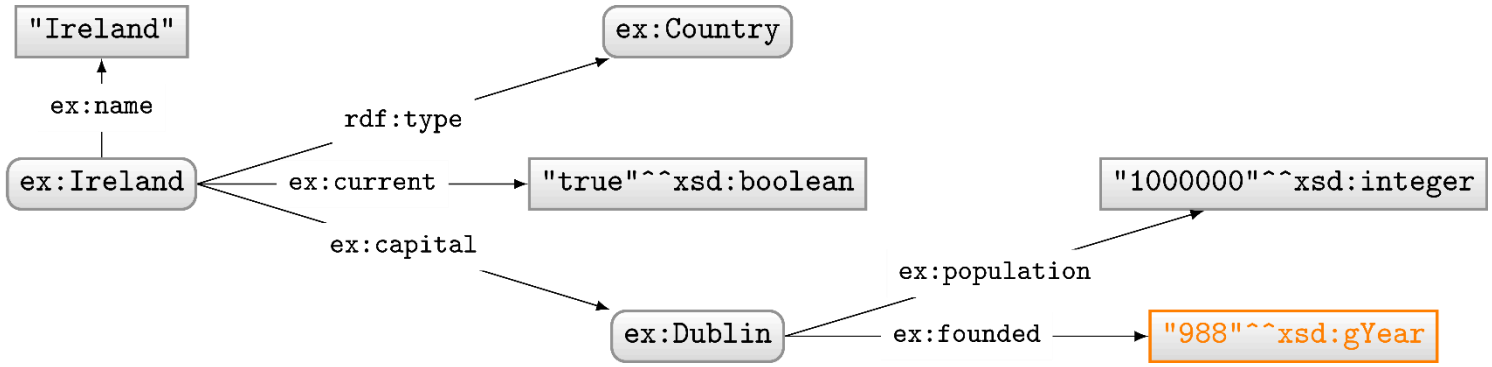
Numeric datatypes

Numeric		
xsd:decimal	"-2.320"	Any precision
└xsd:integer	"-3"	Any precision, $x \in \mathbb{Z}$
└xsd:long	"-9223372036854775808"	$-2^{63} \leq x < 2^{63}$
└xsd:int	"+2147483647"	$-2^{31} \leq x < 2^{31}$
└xsd:short	"-32768"	$-2^{15} \leq x < 2^{15}$
└xsd:byte	"127"	$-2^{7} \leq x < 2^{7}$
└xsd:nonNegativeInteger	"0"	$0 \leq x < \infty$
└xsd:positiveInteger	"3152"	$1 \leq x < \infty$
└xsd:unsignedLong	"18446744073709551615"	$0 \leq x < 2^{64}$
└xsd:unsignedInt	"+4294967295"	$0 \leq x < 2^{32}$
└xsd:unsignedShort	"65535"	$0 \leq x < 2^{16}$
└xsd:unsignedByte	"+255"	$0 \leq x < 2^{8}$
└xsd:nonPositiveInteger	"0"	$x \leq 0$
└xsd:negativeInteger	"-3152"	$x < 0$
xsd:double	"1.7e308" "-4.9E-324", "NaN", "INF", "-INF"	IEEE 64-bit floating point
xsd:float	"3.4E38", "-1.4e-45", "NaN", "INF", "-INF"	IEEE 32-bit floating point



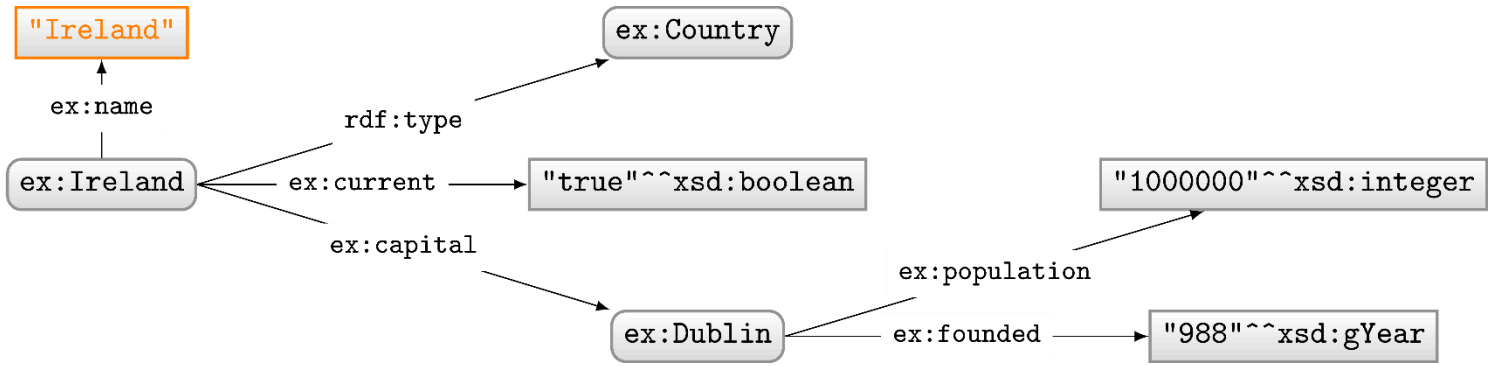
Temporal datatypes

Temporal		
xsd:time	"05:04:12", "05:04:12Z", "05:04:12.00-10:00"	Z indicates +00:00 timezone
xsd:date	"29-02-2012", "31-12-2012+04:00"	Timezone optional
xsd:dateTime	"31-12-2012T00:01:02.034"	Timezone optional
└xsd:dateTimeStamp	"31-12-2012T00:01:02+04:00"	Timezone required
xsd:duration	"P6Y9M15DT25H61M4.2S"	6 Years … 4.2 Seconds
├xsd:dayTimeDuration	"P2DT8H14S"	No month or year
└xsd:yearMonthDuration	"-P89Y13M"	No days or time
xsd:gDay	"---15", "---01-13:59"	Day recurring every month
xsd:gMonth	"--12", "--01+14:00"	Month recurring every year
xsd:gMonthDay	"--02-29", "--03-01Z"	Date recurring every year
xsd:gYear	"1985", "-0005"	A year ($-y$ indicates B.C.)
xsd:gYearMonth	"1985-05", "-0005-02"	A specific month



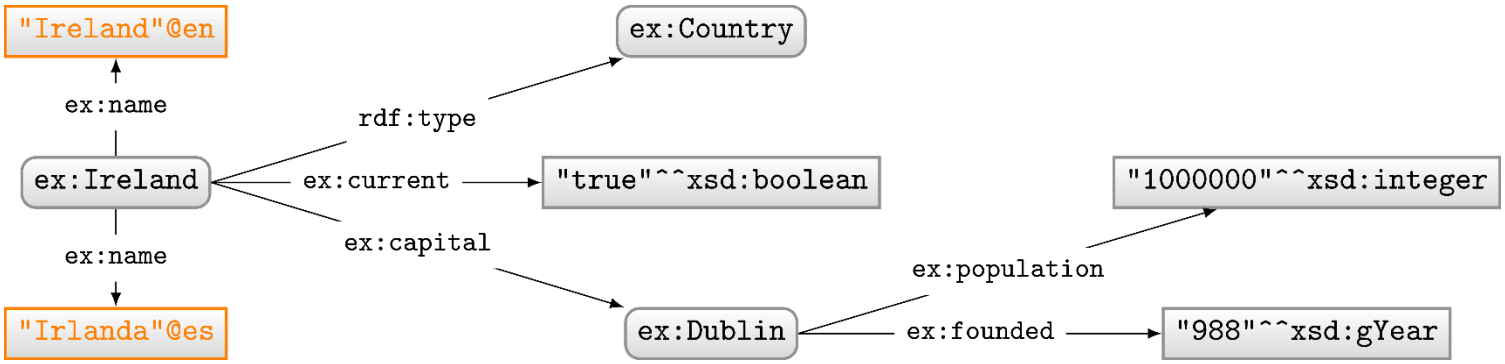
Text/string datatypes

Text		
xsd:string	" tab-> <-tab "	Most Unicode characters
└ xsd:normalizedString	" multiple-> <-spaces "	No \r, \n, \t
└ xsd:token	"one-> <-space"	No leading or double spaces
└ xsd:language	"en", "en-UK", "en-uk", "zh-yue-Hant"	Generalises BCP47 [57]
└ xsd:name	"ns:some_name"	XML names
└ xsd:NCName	"some_name"	XML names: no colons
└ xsd:NMTOKEN	"1some_name"	XML names: 1st char relaxed
xsd:base64Binary	"QS5ILiBuZWVkcyBhIHNtb2tlLg=="	Base-64 encoded strings
xsd:hexBinary	"2e2e2e20616e6420616c636f686f6c2e"	Hexadecimal strings
xsd:anyURI	"http://example.com/",	Full IRI strings
rdf:HTML	" some data "	Well-formed HTML content
rdf:XMLLiteral	"<flavours><fruit>apple</fruit></flavours>"	Well-formed XML content



Language-Tagged Strings

- Specify that a string is in a given language
  - “string”@lang-tag
- No datatype!



(Not) Naming Things in RDF: Blank Nodes

Having to name everything is hard work

"Now! ... *That* should clear up a few things around here!"

For this reason, RDF gives blank nodes

- Syntax: `_:blankNode`
- Represents existence of something
  - Often used to avoid giving an IRI (e.g., shortcuts)
- Can only appear in subject or object position

subject	*predicate*	*object*	
ex:Ireland	ex:capital	_:b1	CORRECT
_:b2	ex:capital	ex:Dublin	CORRECT
ex:Ireland	_:b3	ex:Dublin	INCORRECT

- (More later)

RDF Terms: summary

A Summary of RDF Terms

1. IRIs (Internationalised Resource Identifiers)
   – Used to name generic things
2. Literals
   – Used to refer to datatype values
   – Strings may have a language tag
3. Blank Nodes
   – Used to avoid naming things
   – A little mysterious right now

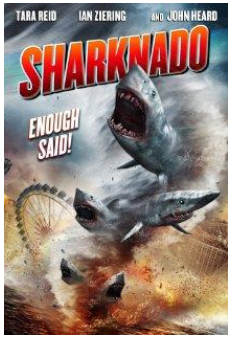
subject	*predicate*	*object*
[IRI, Blank Node]	[IRI]	[IRI, Blank Node, Literal]

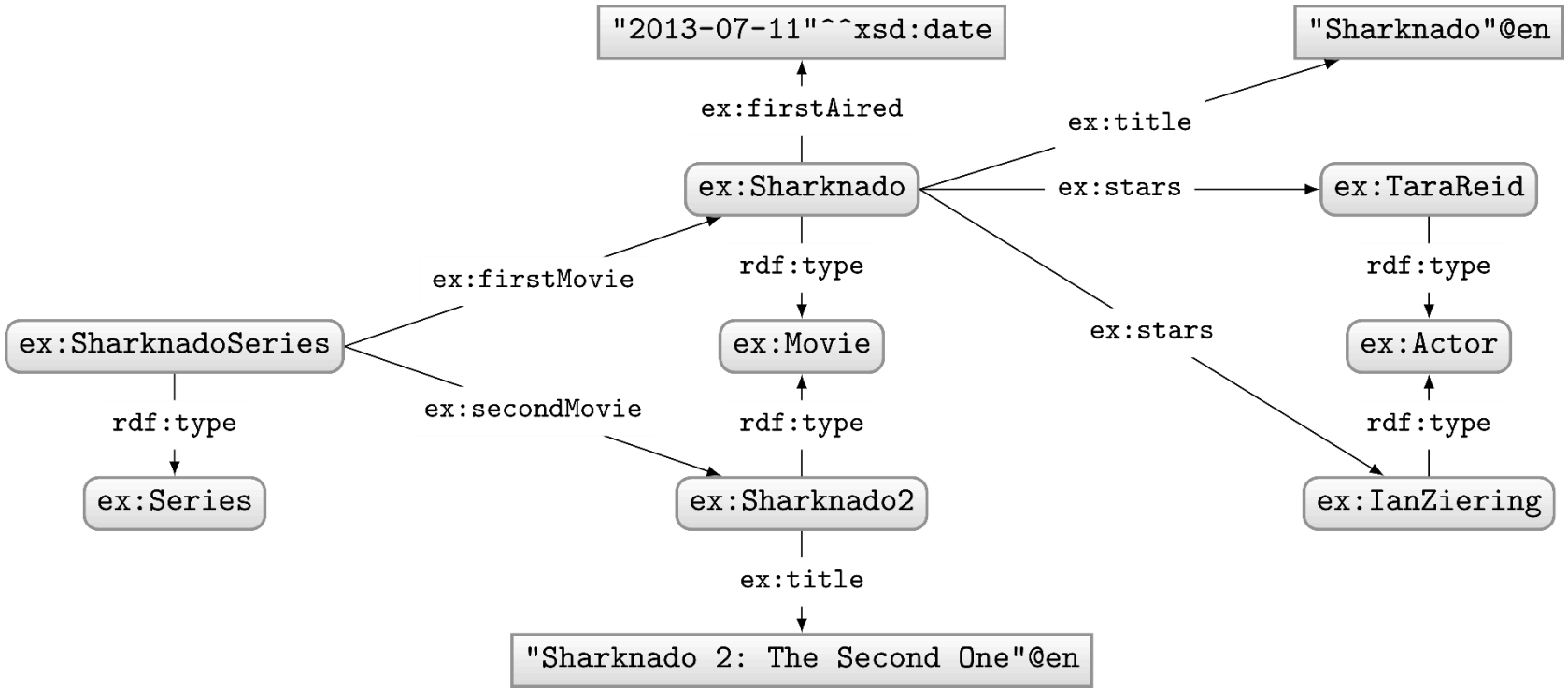
Modelling data in RDF

Let's model something in RDF ...

Model the following in RDF:

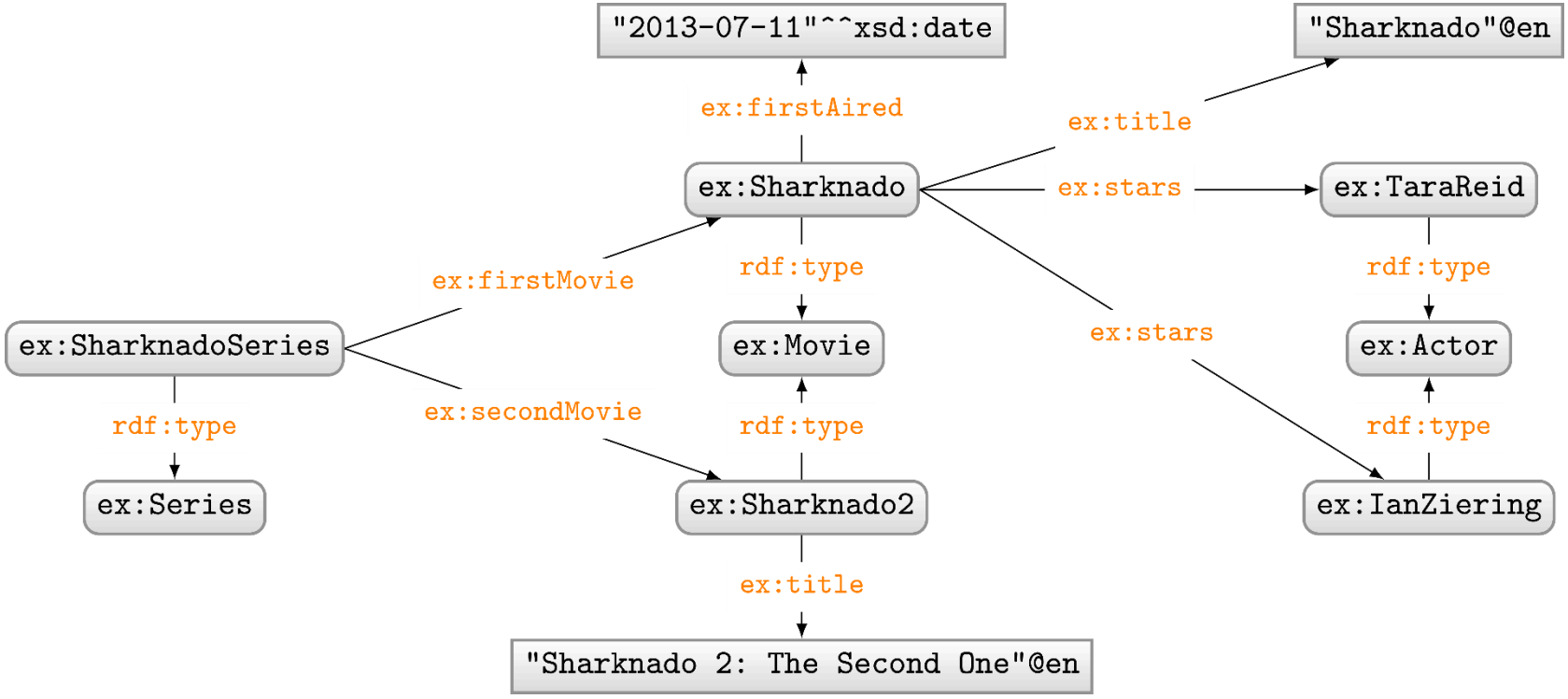
"Sharknado is the first movie of the Sharknado series. It first aired on July 11, 2013. The movie stars Tara Reid and Ian Ziering. The movie was followed by 'Sharknado 2: The Second One'."





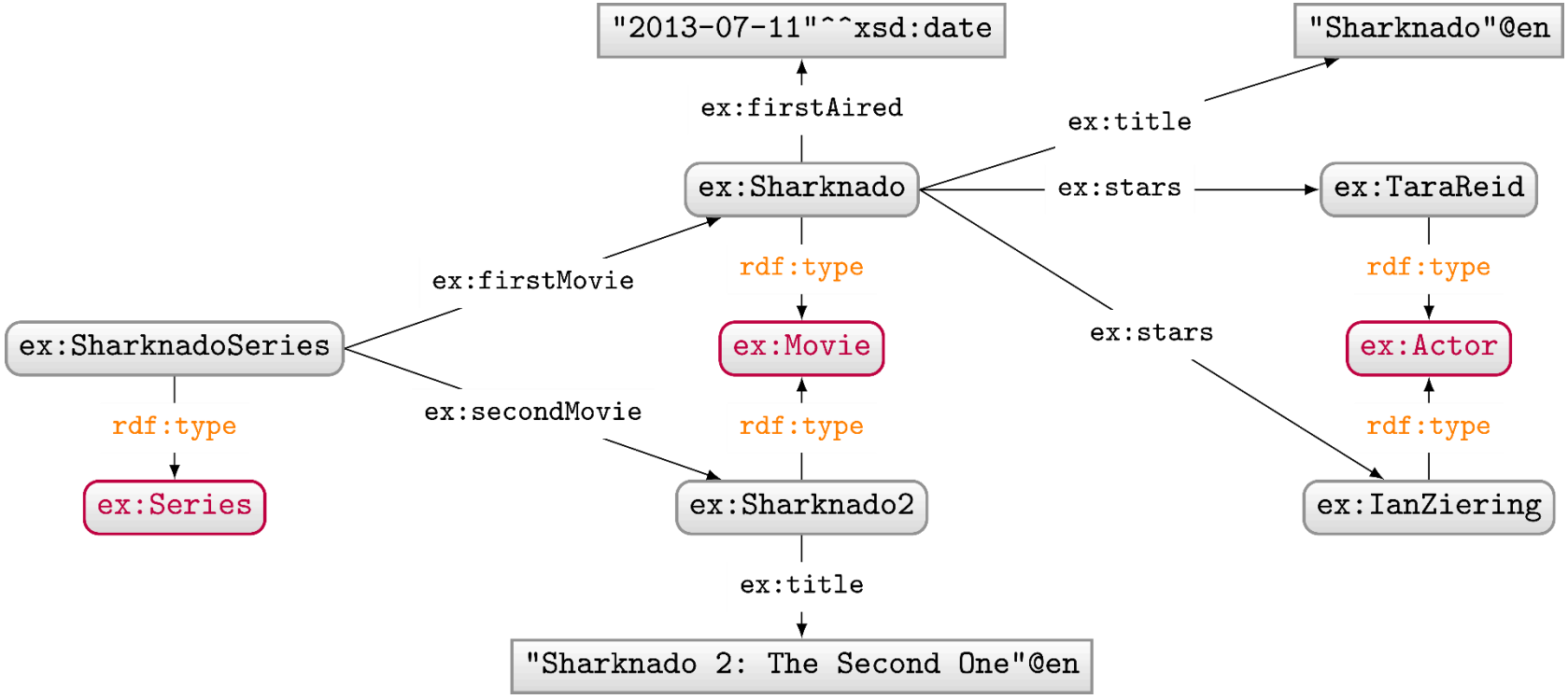
RDF Properties

- RDF Terms used as predicate
  - `rdf:type`, `ex:firstMovie`, `ex:stars`, …



RDF Classes

- Used to conceptually group resources
  - `ex:Movie`, `ex:Actor`, `ex:Series`, etc.
  - Uses predicate `rdf:type` to type a resource



Modelling in RDF not always so simple

Model the following in RDF:

"Sharknado stars Tara Reid in the role of 'April Wexler'."

Modelling in RDF not always so simple

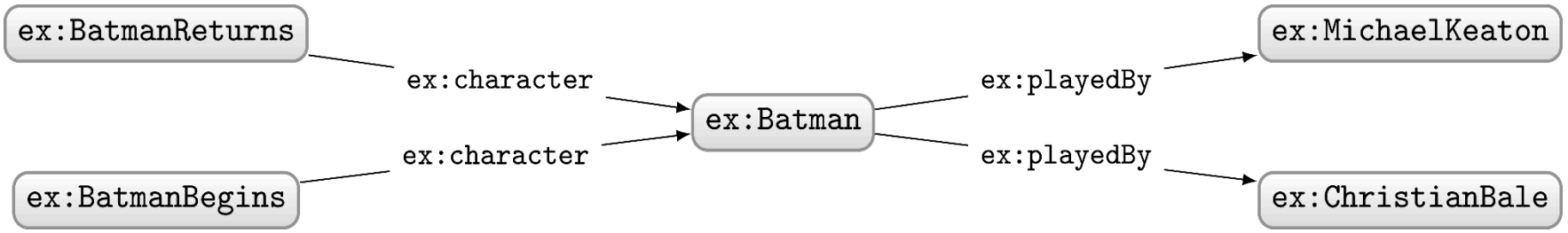
Model the following in RDF:

"'Batman Returns' stars Michael Keaton in the role of 'Batman'."

Modelling in RDF not always so simple

Model the following in RDF:

"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."

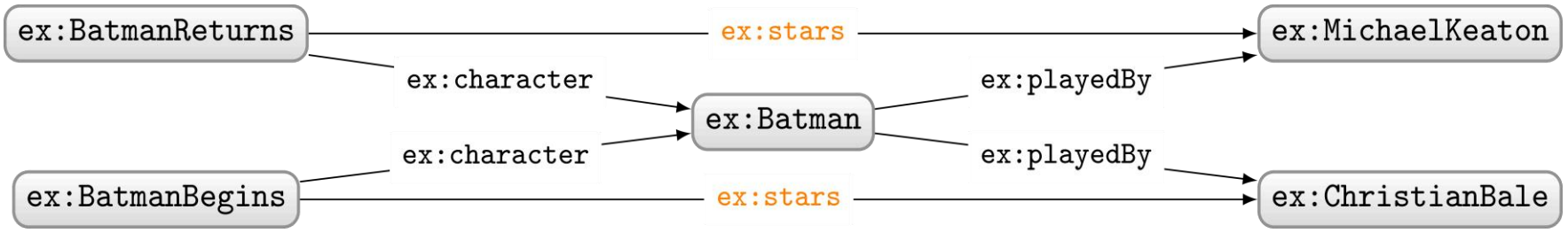


Problem?

Modelling in RDF not always so simple

Model the following in RDF:

"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."

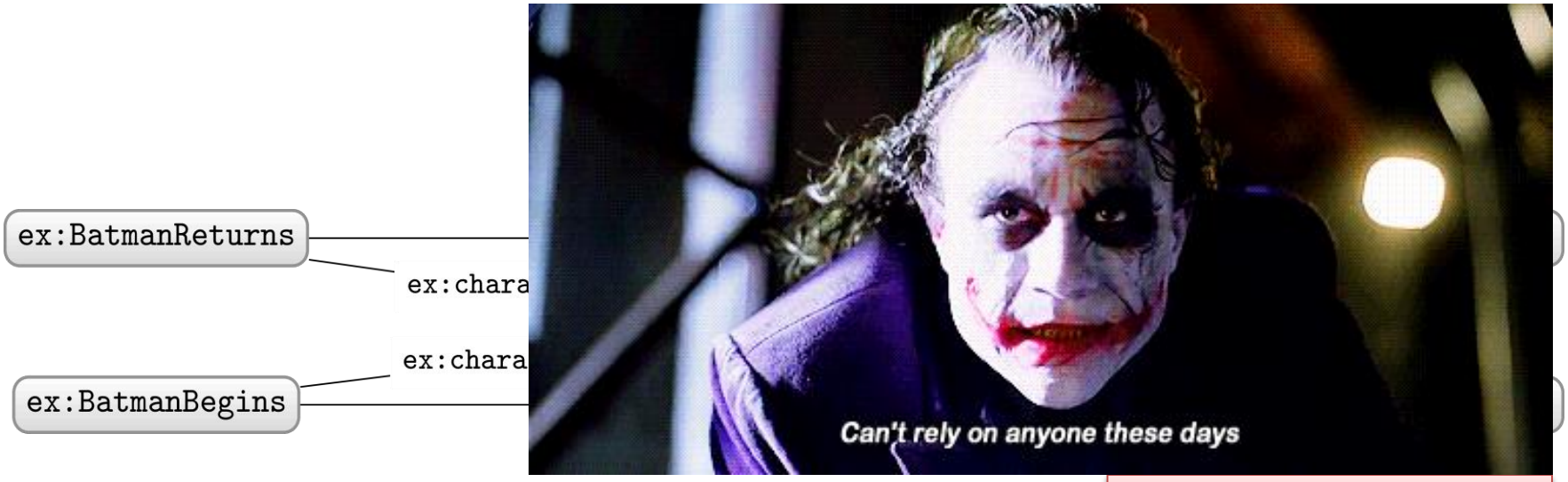


Problem?

Modelling in RDF not always so simple

Model the following in RDF:

"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."



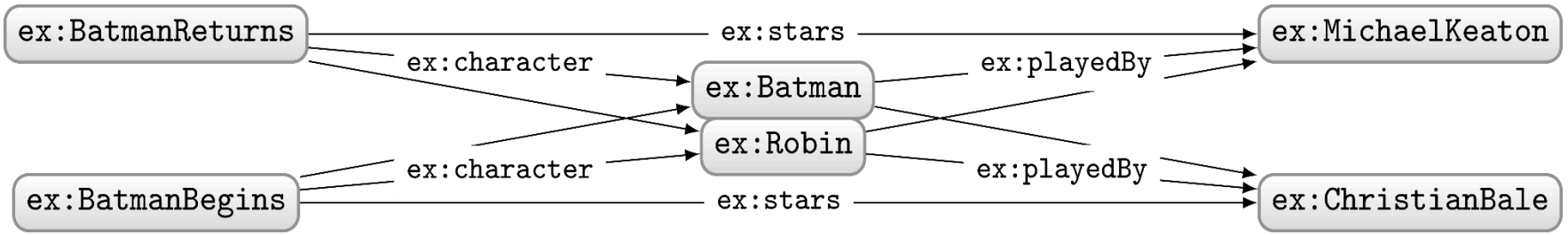
Problem?

Modelling in RDF not always so simple

Model the following in RDF:

"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."
"'Batman Returns' stars Christian Bale in the role of 'Robin'."*
"'Batman Begins' stars Michael Keaton in the role of 'Robin'."*

* hypothetical ☺

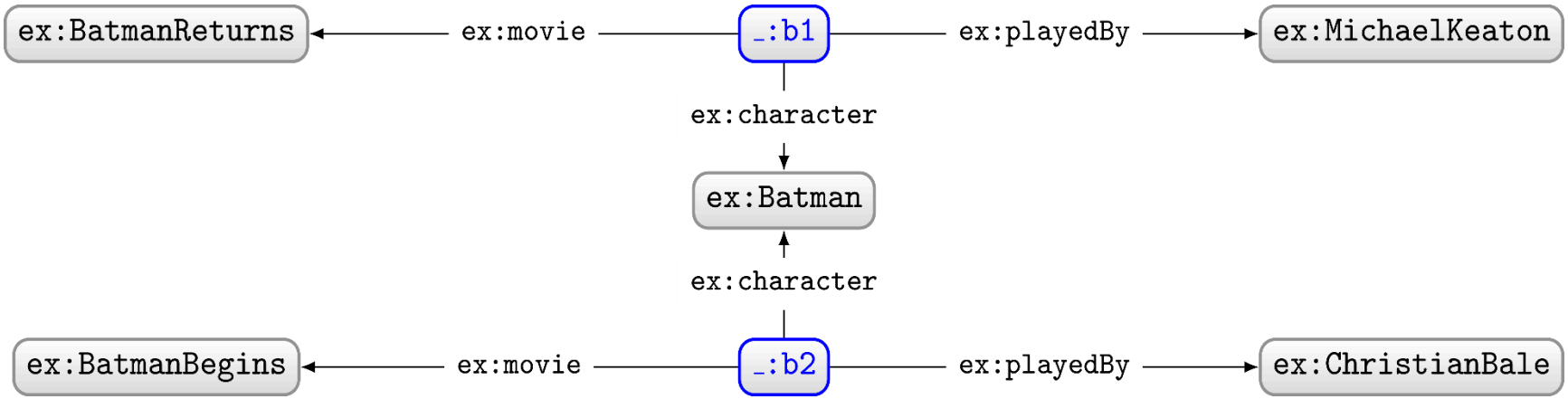


Who played which character in which movie?

Modelling n-Ary Relations

Model the following in RDF:

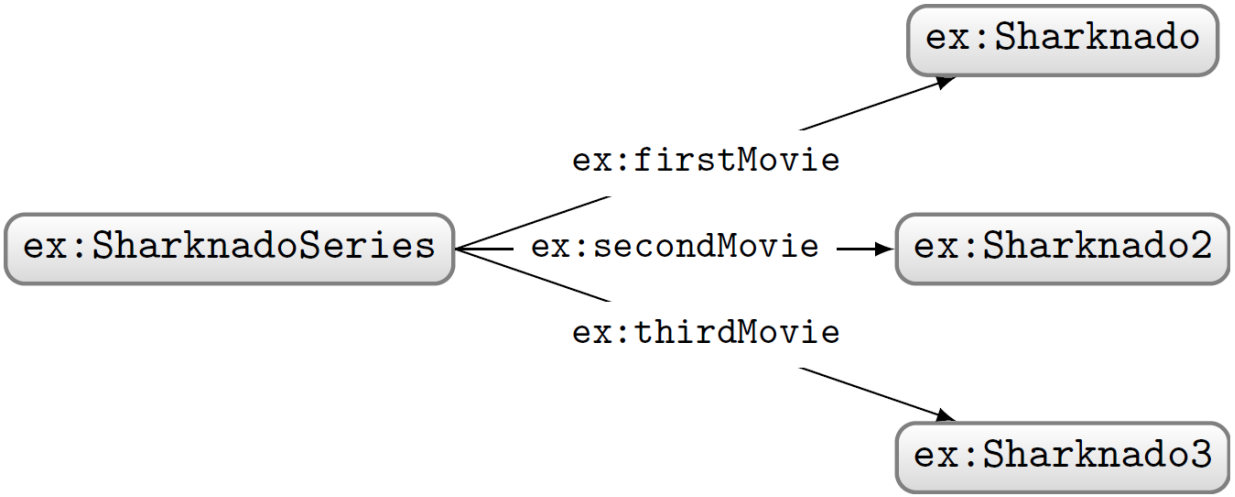
"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."



Modelling in RDF not always so simple

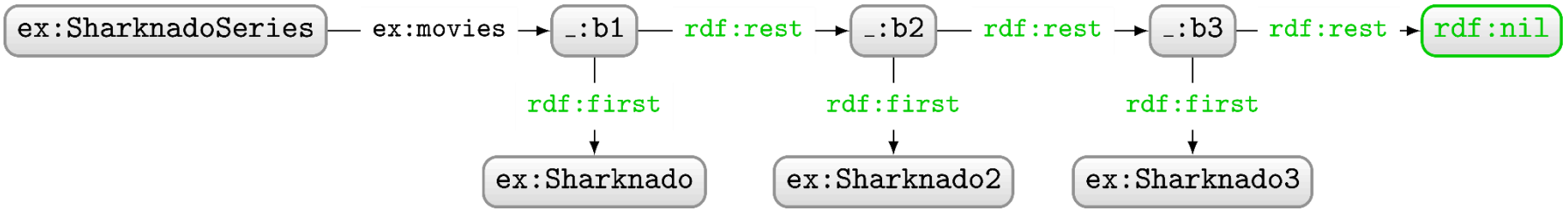
Model the following in RDF:

"The first movie in the Sharknado series is 'Sharknado'.
The second movie is 'Sharknado 2: The Second One'.
The third movie is 'Sharknado 3: Oh Hell No!'."



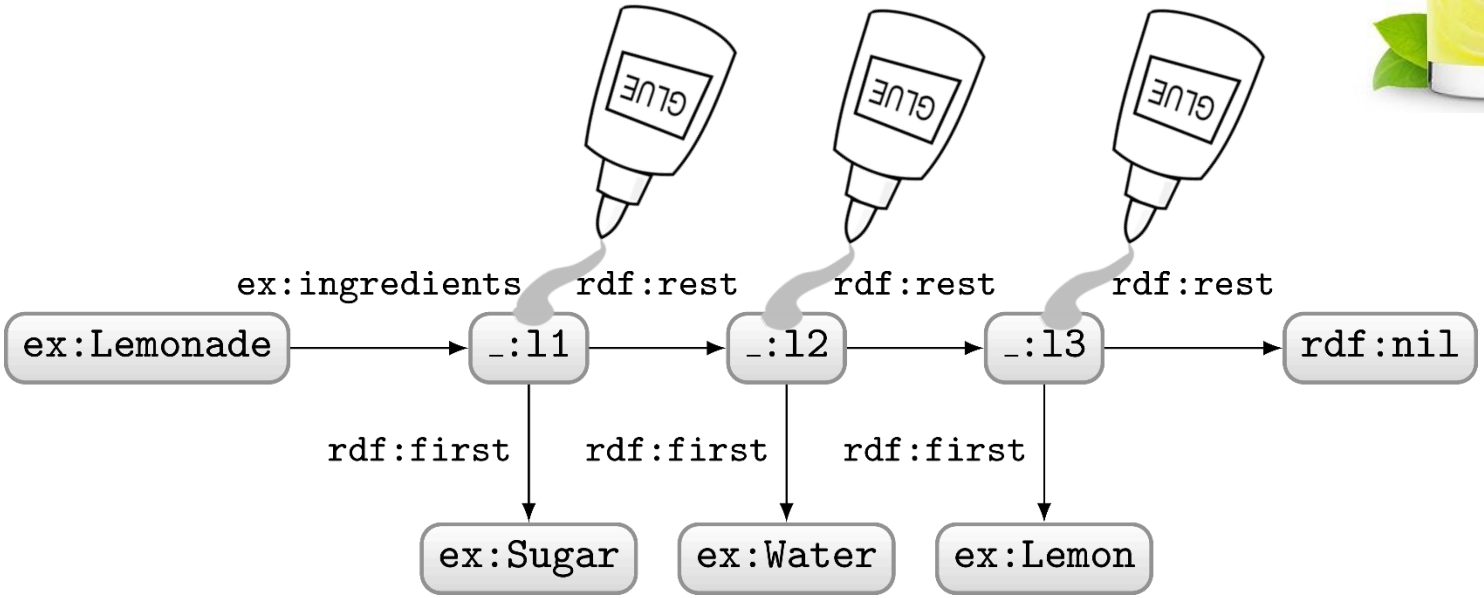
RDF Collections: Model Ordered Lists

- Standard way to model linked lists in RDF
  - Use `rdf:rest` to link to rest of list
  - Use `rdf:first` to link to current member
  - Use `rdf:nil` to end the list



RDF Collections: Generic Modelling

- Not just for Sharknado series



Another modelling example: From Tables to RDF

Course data as an RDF graph?

How might we model these relational data as as RDF graph?

professors.csv

ID	Name	Course
...		
24.482.054-9	Aidan Hogan	CC3201
24.482.054-9	Aidan Hogan	CC5212
24.482.054-9	Aidan Hogan	CC6202
...		

students.csv

ID	Name	Course
...		
10.323.634-4	Pia García	CC3201
12.323.792-8	Juan Ramírez	CC6202
12.323.792-8	Juan Ramírez	CC5212
...		

tas.csv

ID	Name	Course
...		
12.412.412-4	Sebastián Ferrada	CC3201
12.412.412-4	Sebastián Ferrada	CC5208
13.123.024-9	Daniel Hernández	CC6202
...		

courses.csv

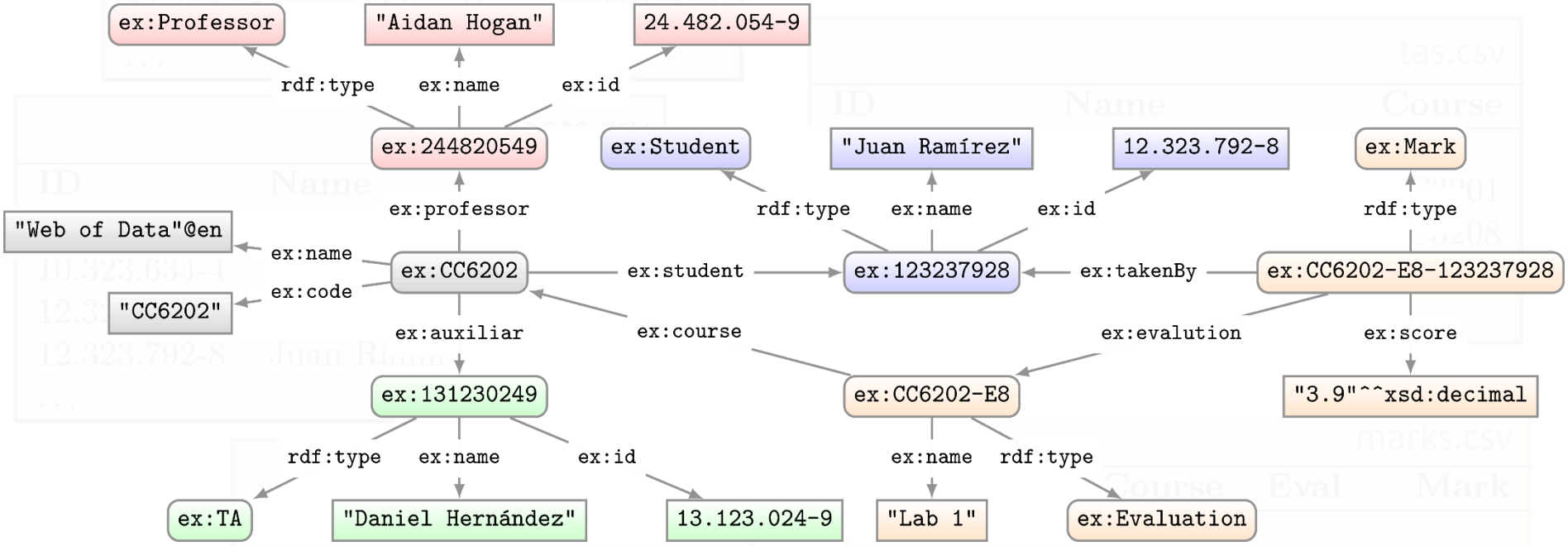
Code	Name
...	
CC3201	Databases
CC5212	Big Data Processing
...	

marks.csv

ID	Course	Eval	Mark
...			
10.323.634-4	CC3201	Lab1	6.0
10.323.634-4	CC3201	Lab2	4.5
12.323.792-8	CC6202	Exam1	3.9
...			

Course data as an RDF graph?

How might we model these relational data as as RDF graph?



... for example

RDF Syntaxes: Writing RDF down

N-Triples

- Line delimited format
- No shortcuts

ex1:Jen	rdf:type	ex1:Person
ex1:Jen	rdf:type	ex1:Female
ex1:Jen	rdfs:label	"Jen"@en
ex1:Jen	ex1:allergy	ex1:Citrus
ex1:Jen	ex1:location	_:loc
_:loc	ex1:lat	"53.3"^^xsd:decimal
_:loc	ex1:long	-9.0^^xsd:decimal

```
<http://ex1.org/#Jen> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://ex1.org/#Person> .
<http://ex1.org/#Jen> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://ex1.org/#Female> .
<http://ex1.org/#Jen> <http://www.w3.org/2000/01/rdf-schema#label> "Jen"@en .
<http://ex1.org/#Jen> <http://ex1.org/#allergy> <http://ex1.org/#Citrus> .
<http://ex1.org/#Jen> <http://ex1.org/#location> _:loc .
_:loc <http://ex1.org/#lat> "53.3" <http://www.w3.org/2001/XMLSchema#decimal> .
_:loc <http://ex1.org/#long> -9.0 <http://www.w3.org/2001/XMLSchema#decimal> .
```

RDF/XML

- Legacy format
- Just horrible

ex1:Jen	rdf:type	ex1:Person
ex1:Jen	rdf:type	ex1:Female
ex1:Jen	rdfs:label	"Jen"@en
ex1:Jen	ex1:allergy	ex1:Citrus
ex1:Jen	ex1:location	_:loc
_:loc	ex1:lat	"53.3"^^xsd:decimal
_:loc	ex1:long	-9.0^^xsd:decimal

```
<?xml version="1.0"?>
<!DOCTYPE img [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#"> ]>
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:ex1="http://example1.org/#">
 <ex1:Person rdf:about="http://example1.org/#Jen">
  <rdf:type rdf:resource="http://example1.org/#Female" />
  <rdfs:label xml:lang="en">Jen</rdfs:label>
  <ex1:allergy rdf:resource="http://example1.org/#Citrus" />
  <ex1:location>
   <rdf:Description>
    <ex1:lat rdf:datatype="&xsd;decimal">53.3</ex1:lat>
    <ex1:long rdf:datatype="&xsd;decimal">-9.0</ex1:long>
   </rdf:Description>
  </ex1:location>
 </ex1:Person>
</rdf:RDF>
```

RDFa

- Embed RDF into HTML
- Not so intuitive

```
<!DOCTYPE html>
<html>
 <head>
  <meta charset="utf-8" />
  <title>Recipe for Coffee Parfait</title>
  <base href="http://example.org/" />
 </head>
 <body vocab="http://example.org/#" lang="en"
       prefix="rdfs: http://www.w3.org/2000/01/rdf-schema#">
  <div typeof="Recipe" resource="#CoffeeParfait">
   <h1 property="rdfs:label">Coffee Parfait</h1>
   <p>Time: <span property="minutes" datatype="xsd:integer" content="25">25 mins</span></p>
   <h2>Ingredients:</h2>
   <ul rel="ingredient">
    <li about="#EggYolk" property="rdfs:label">Egg Yolk</li>
    <li about="#Sugar" property="rdfs:label">Sugar</li>
    <li about="#Cream" property="rdfs:label">Cream</li>
    <li about="#Coffee" property="rdfs:label">Coffee</li>
   </ul>
  </div>
 </body>
</html>
```

JSON-LD

- Embed RDF into HTML
- Not completely RDF

```
{
 "@context": {
  "xsd": "http://www.w3.org/2001/XMLSchema#",
  "@base": "http://example.com/",
  "@vocab": "http://example.com/#",
  "label": "http://www.w3.org/2000/01/rdf-schema#label",
  "minutes": {
   "@id": "minutes",
   "@type": "xsd:integer"
  },
  "@language": "en"
 },
 "@id": "#CoffeeParfait",
 "@type": "Recipe",
 "label": "Coffee Parfait",
 "minutes": "25",
 "ingredient": [
  { "@id": "#EggYolk", "label": "Egg Yolk"},
  { "@id": "#Sugar", "label": "Sugar"},
  { "@id": "#Cream", "label": "Cream"},
  { "@id": "#Coffee", "label": "Coffee"}
 ]
}
```

Turtle

- Readable format

ex1:Jen	rdf:type	ex1:Person
ex1:Jen	rdf:type	ex1:Female
ex1:Jen	rdfs:label	"Jen"@en
ex1:Jen	ex1:allergy	ex1:Citrus
ex1:Jen	ex1:location	_:loc
_:loc	ex1:lat	"53.3"^^xsd:decimal
_:loc	ex1:long	-9.0^^xsd:decimal

```
@base <http://ex1.org/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix ex1: <http://ex1.org/#> .
<#Jen> a <http://ex1.org/#Person> , ex1:Female ;
  rdfs:label "Jen"@en ; <#allergy> <#Citrus> ;
  ex1:location [ ex1:lat 53.3 ; ex1:long -9.0 ] .
```

Relative URIs

Prefixes

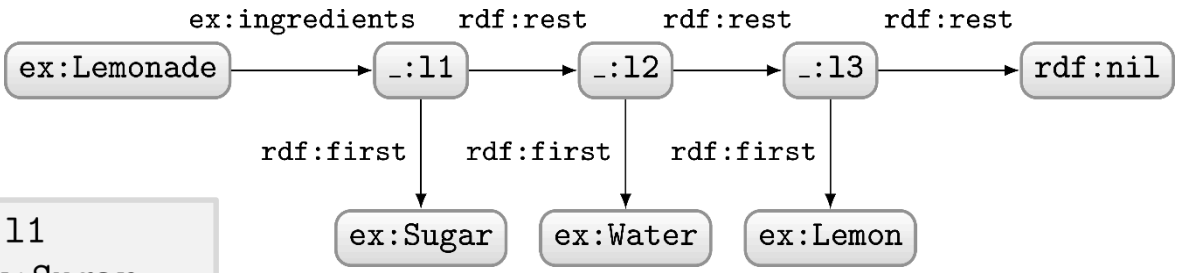
Repeat S (‘;’) SP (‘,’)

rdf:type

Datatype shortcuts

Blank node shortcuts

Turtle: Collections Shortcut



ex:Lemonade	ex:ingredients	_:l1
_:l1	rdf:first	ex:Sugar
_:l1	rdf:rest	_:l2
_:l2	rdf:first	ex:Water
_:l2	rdf:rest	_:l3
_:l3	rdf:first	ex:Lemon
_:l3	rdf:rest	rdf:nil

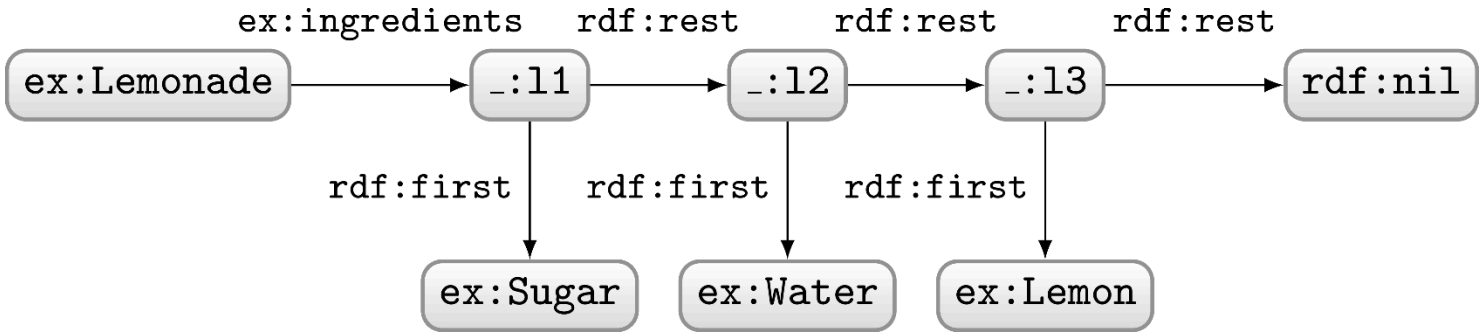
Only possible with blank nodes!

```
@base <http://example.org/#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
  <Lemonade> <ingredients> [
   rdf:first <Sugar> ; rdf:rest [
     rdf:first <Water> ; rdf:rest [
       rdf:first <Lemon> ; rdf:rest rdf:nil
     ]
   ] .
```

```
@base <http://example.org/#> .
  <Lemonade> <ingredients> ( <Sugar> <Water> <Lemon> ) .
```

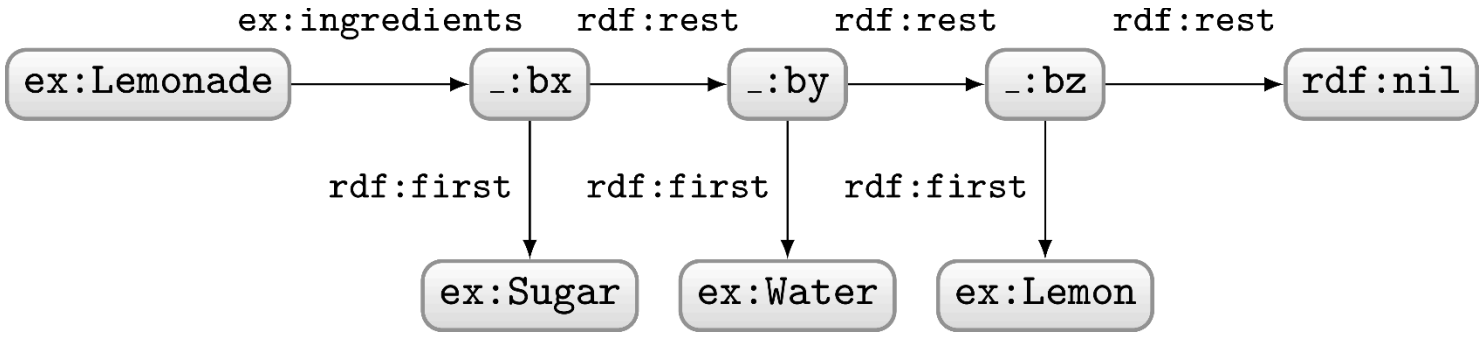
Blank nodes add complexity

Blank nodes names aren't important ...

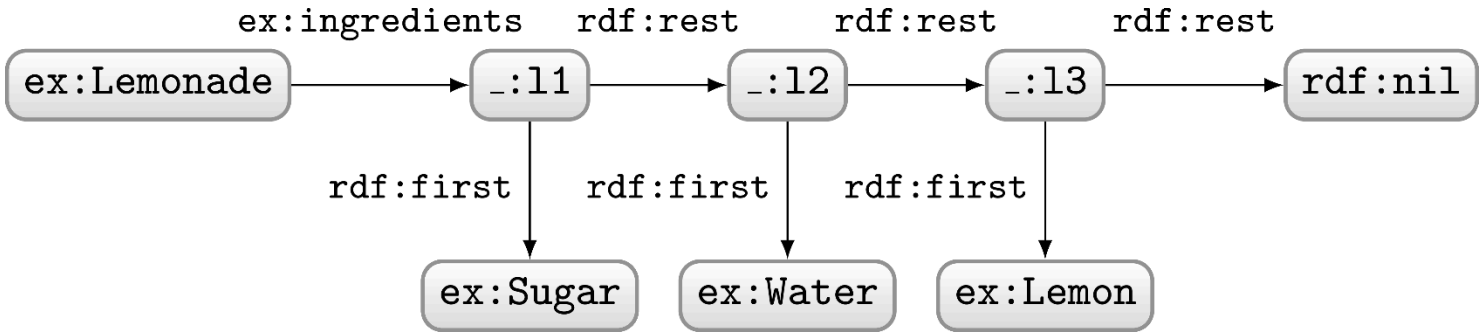


≃

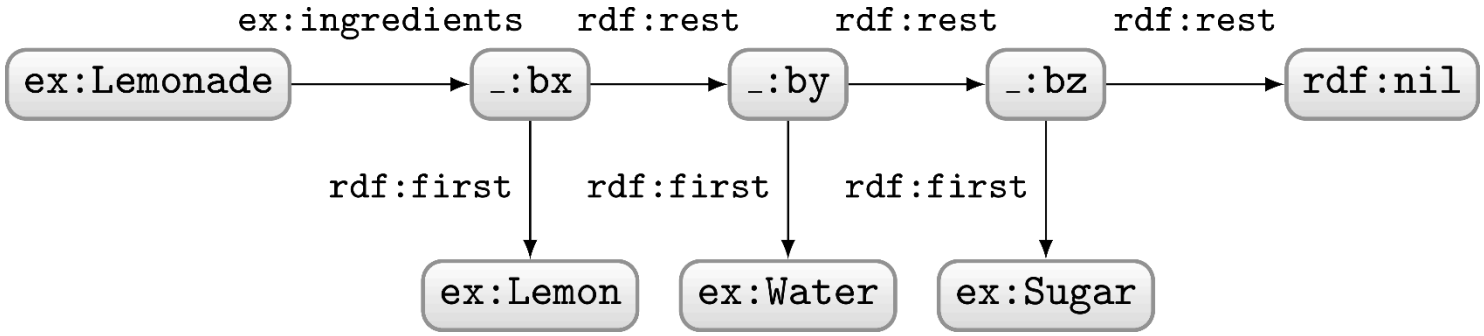
(Isomorphic)



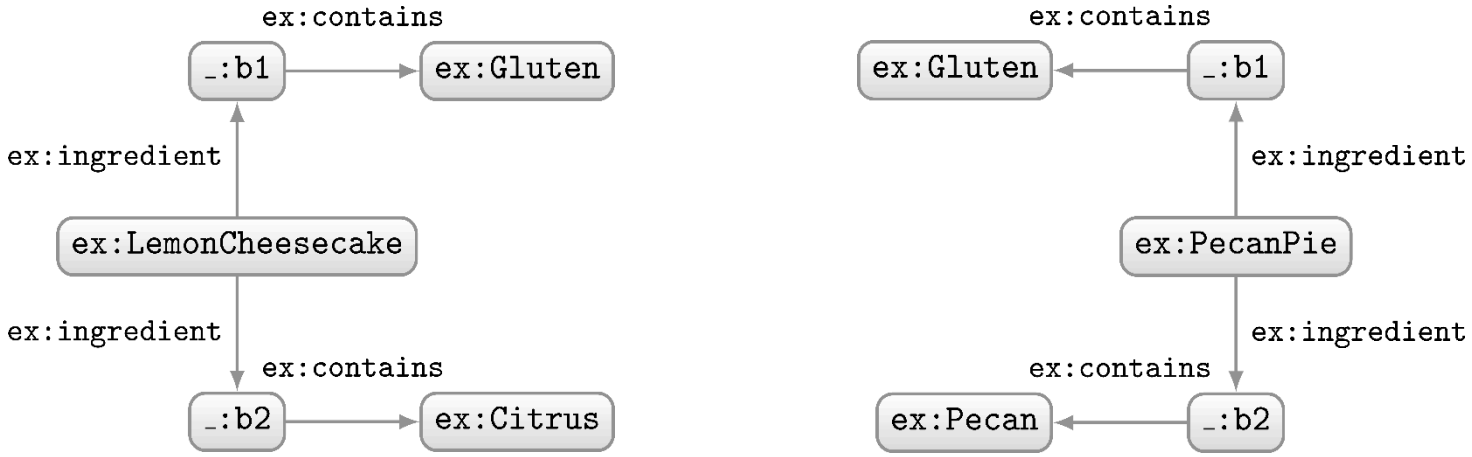
Blank nodes names aren't important ...



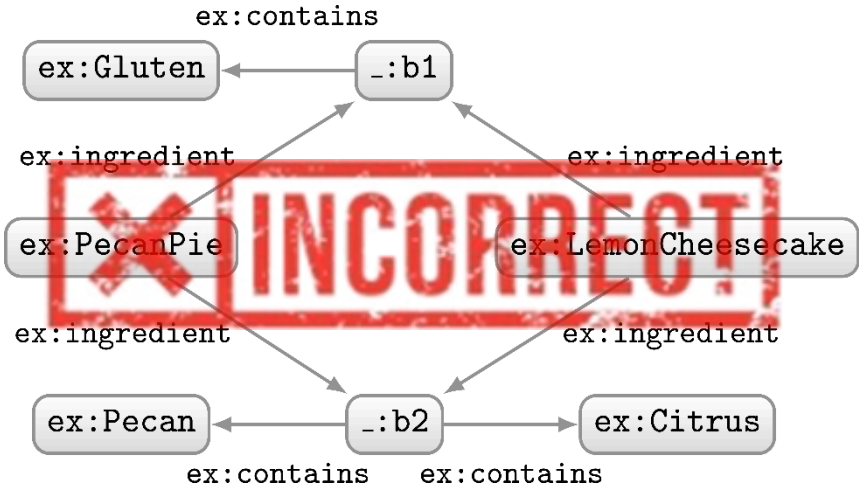
(Not Isomorphic!)



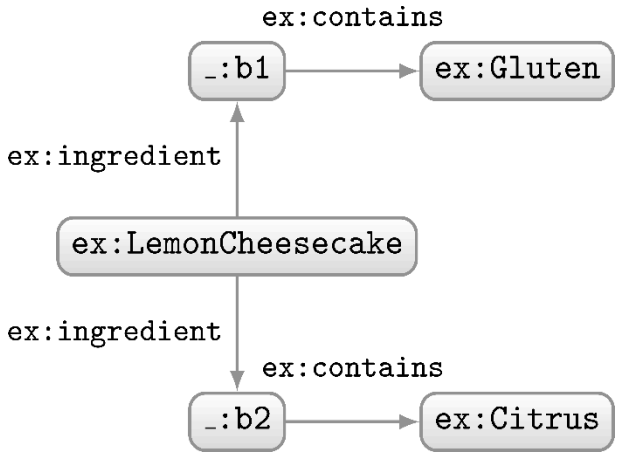
Blank nodes are local identifiers

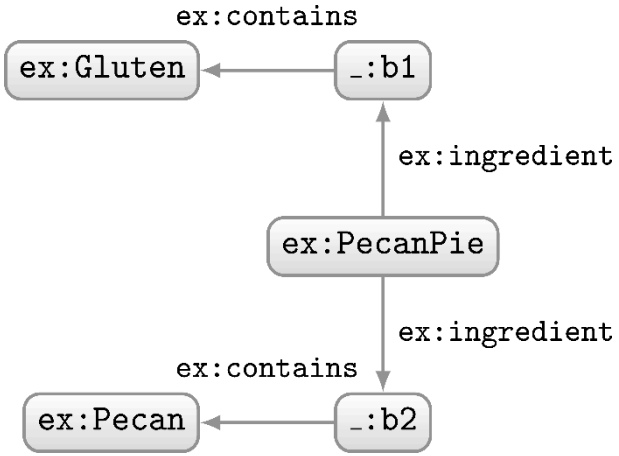


How should we combine these two RDF graphs?

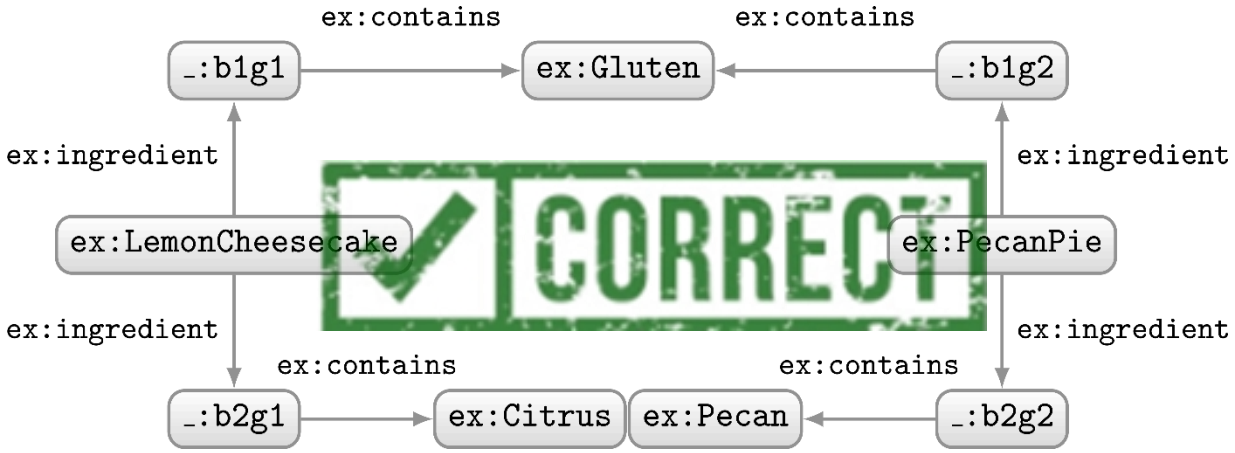


Blank nodes are local identifiers

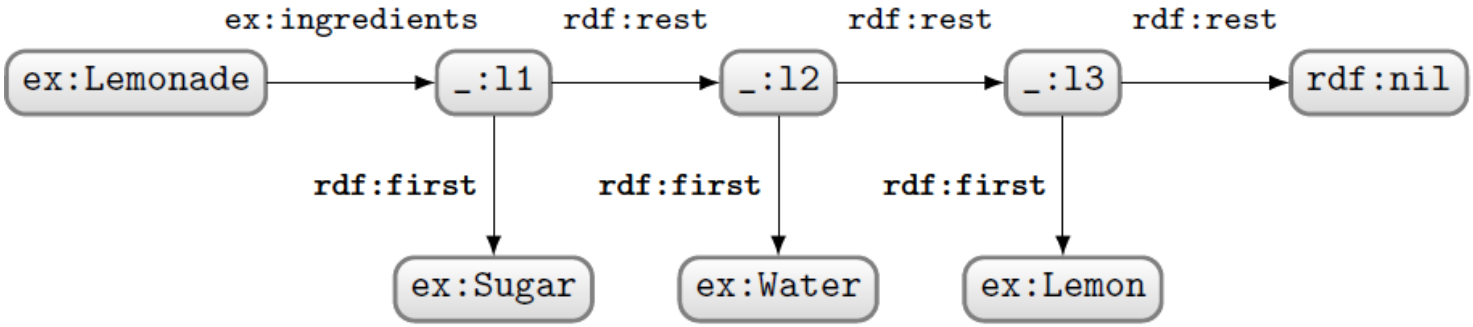


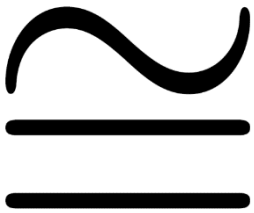


How should we combine these two RDF graphs?

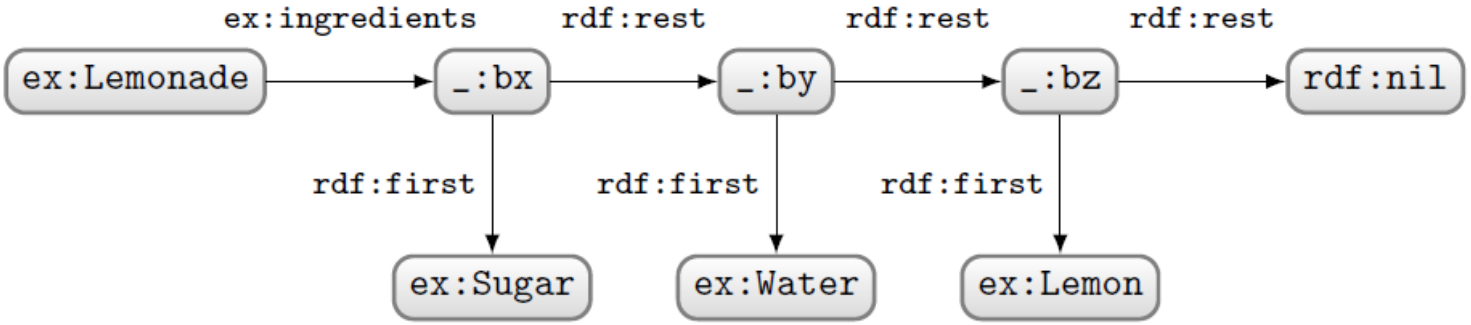


Are two RDF graphs the "same"?

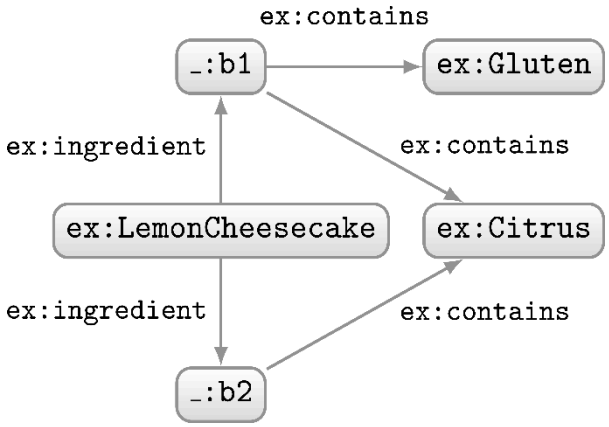


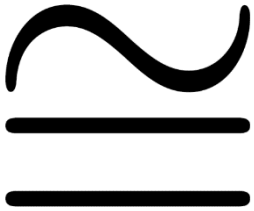


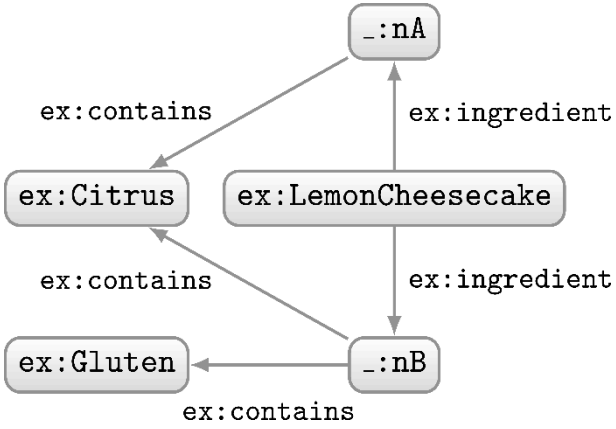
(Isomorphic)



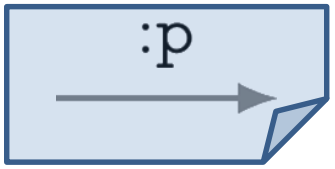
Are two RDF graphs the "same"?

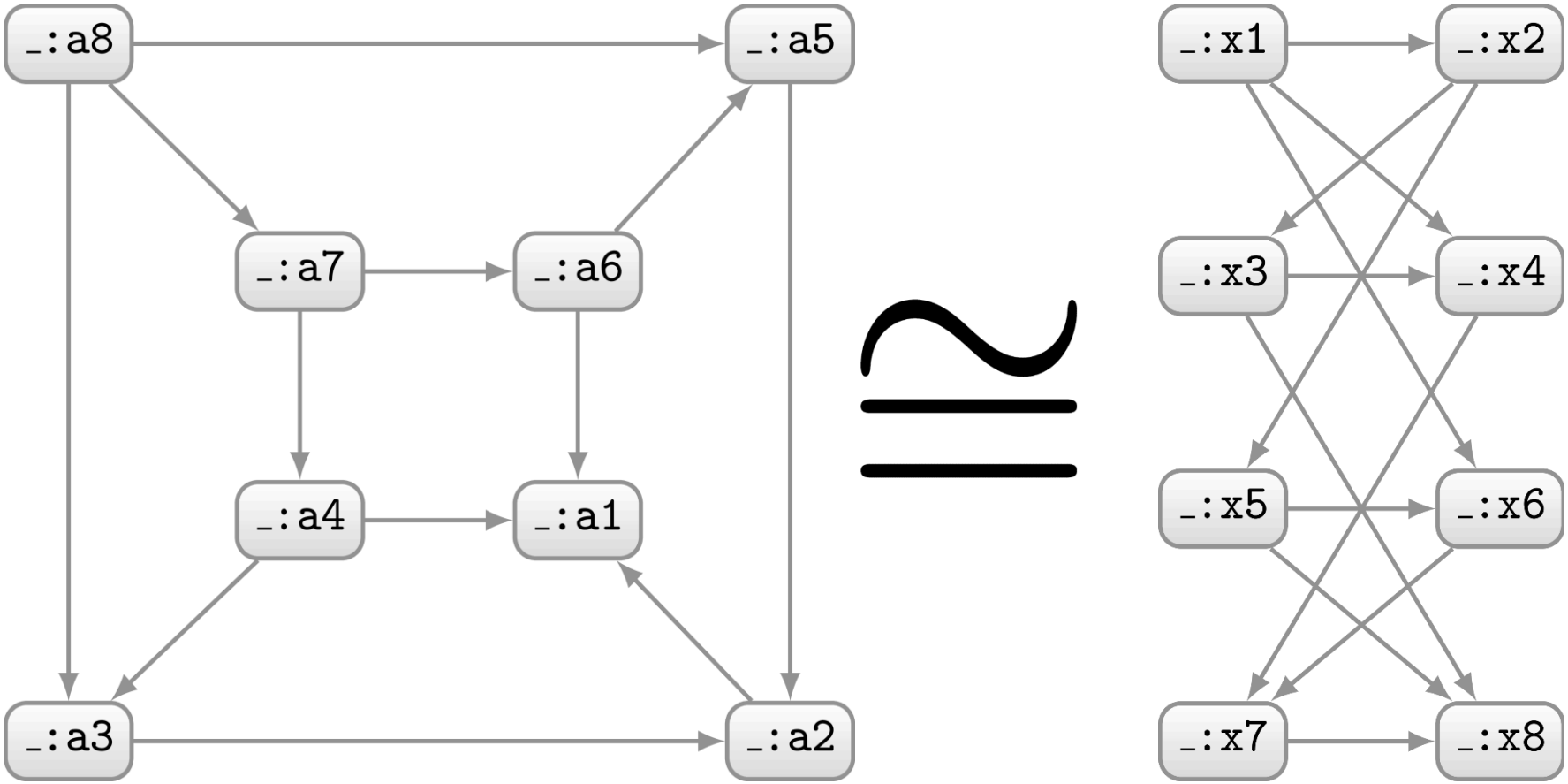




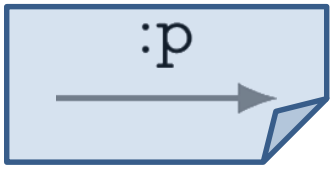


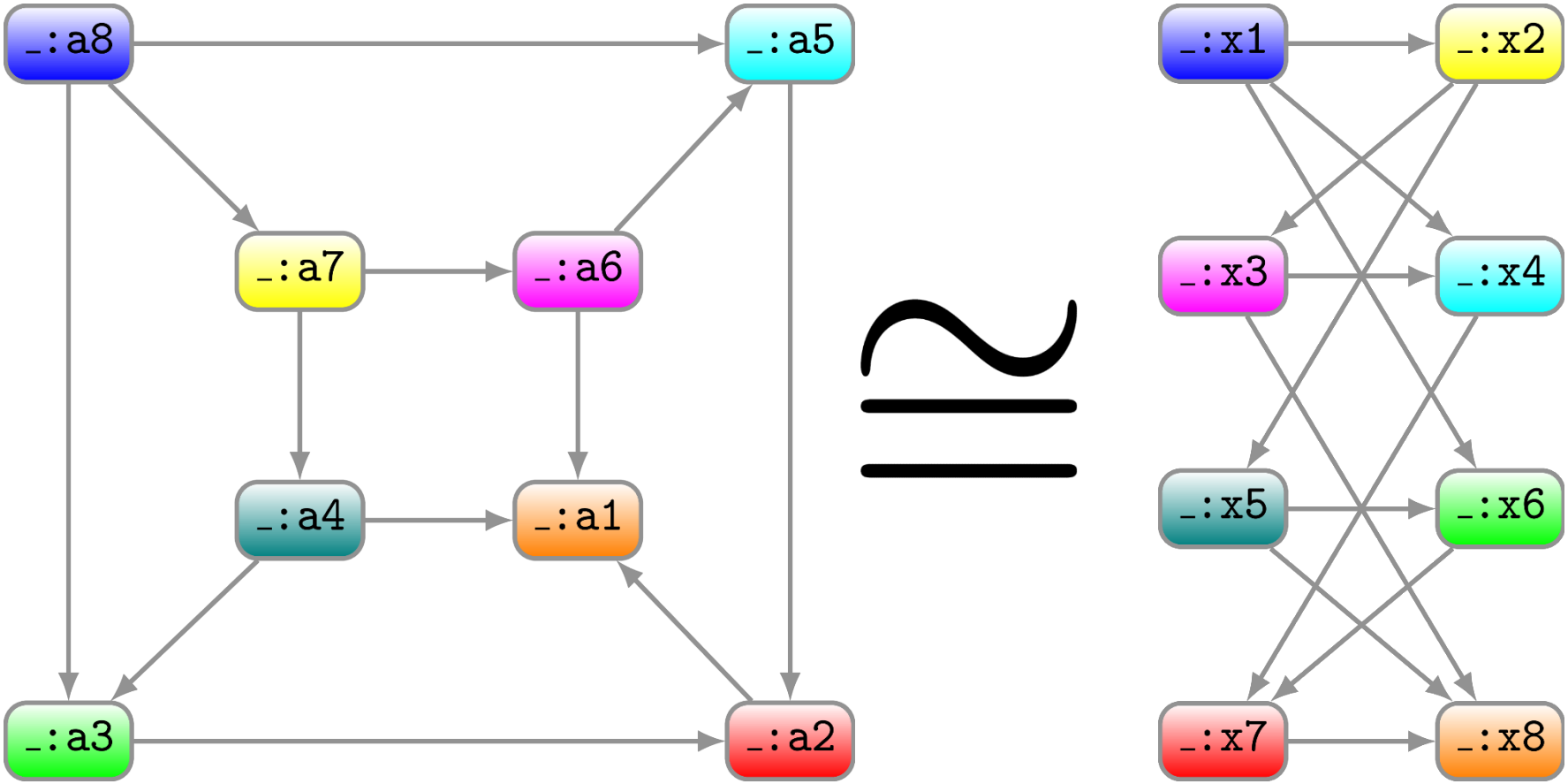
Are two RDF graphs the "same"?



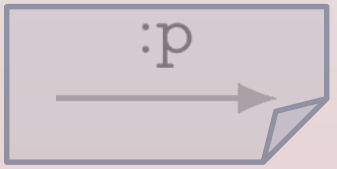


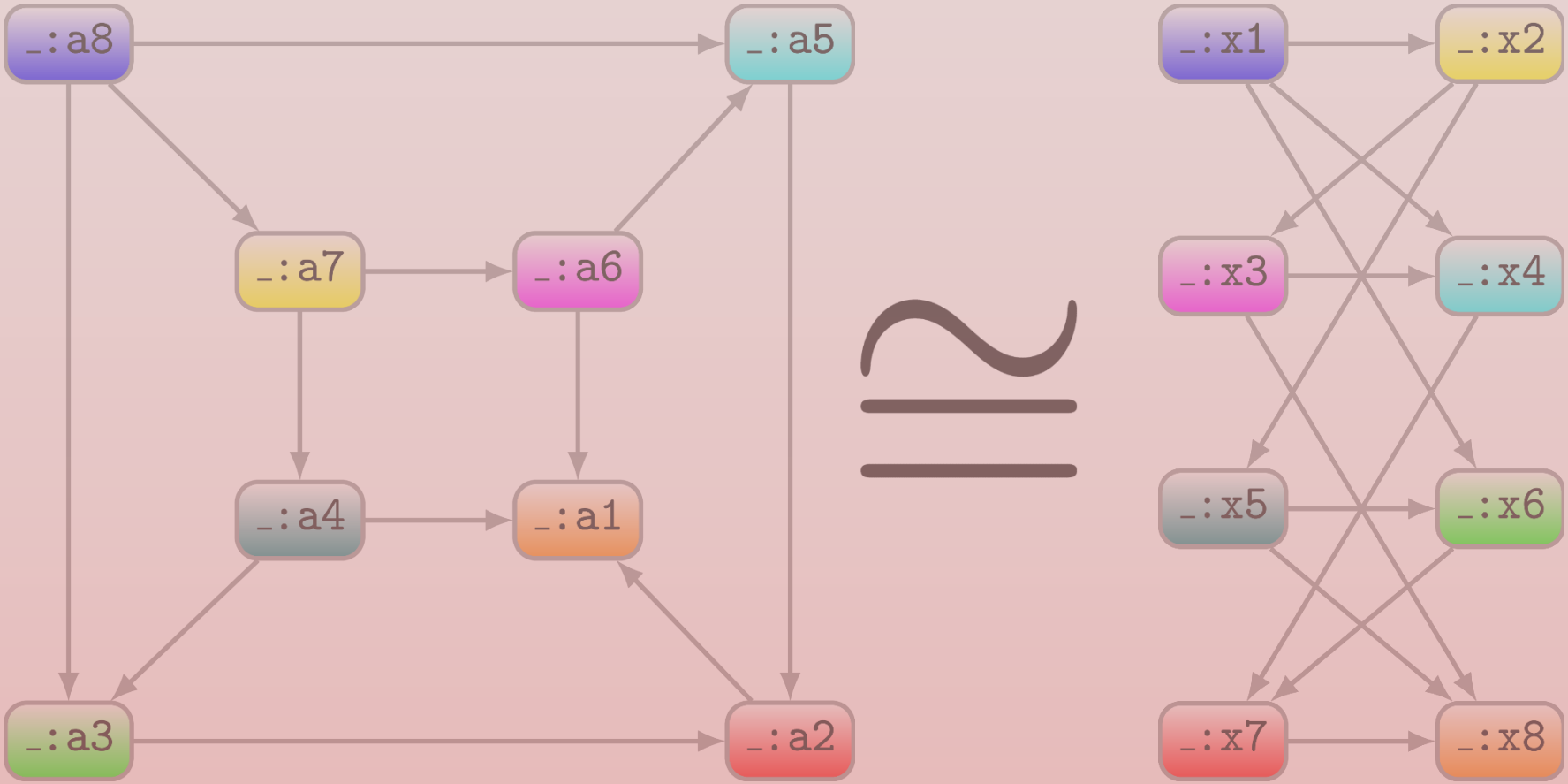
Are two RDF graphs the "same"?





Are two RDF graphs the "same"?





Hard problem: GI-complete

Recap

Semantic Web: Data

Data:

RDF is based on triples:

(Ireland,capital,Dublin)

(*subject*,*predicate*,*object*)

RDF = Resource Description Framework

- Structure data on the Web!

- RDF based on triples:
  - subject, predicate, object
  - A set of triples is called an RDF graph

- Three types of RDF terms:
  - IRIs (any position)
  - Literals (object only; can have datatype or language)
  - Blank nodes (subject or object)

RDF = Resource Description Framework

- Modelling in RDF:
  - Describing resources
  - Classes and properties form core of model
  - Try to break up higher-arity relations
  - Collections: standard way to model order/lists

- Syntaxes:
  - N-Triples: simple, line-delimited format
  - RDF/XML: legacy format, horrible
  - RDFa: embed RDF into HTML pages
  - JSON-LD: embed RDF into JSON
  - Turtle: designed to be human friendly

RDF = Resource Description Framework

- Two operations on RDF graphs:
  - Merging: keep blank nodes in source graphs from clashing
  - Are they the "same" modulo blank node labels: isomorphism check!

Questions?