

CC7220-1

LA WEB DE DATOS

PRIMAVERA 2021

LECTURE 2: RDF MODEL AND SYNTAX

Aidan Hogan
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THE “SEMANTIC WEB”



SEMANTIC WEB: DATA, LOGIC, QUERY

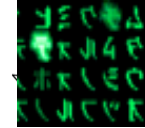
DATA:

Ireland



(Ireland,partOf,Europe)
(Ireland,isA,Country)
(Ireland,capital,Dublin)

Dublin



(Ireland,capital,Dublin)
(Dublin,population,1000000)

LOGIC: $((b, \text{capital}, a) \rightarrow (a, \text{partOf}, b))$
 $((a, \text{partOf}, b), (b, \text{partOf}, c) \rightarrow (a, \text{partOf}, c))$

QUERY: $((x, \text{partOf}, y)?)$

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



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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SEMANTIC WEB: DATA

DATA:

Ireland



(Ireland,partOf,Europe)
(Ireland,isA,Country)
(Ireland,capital,Dublin)

Dublin



(Ireland,capital,Dublin)
(Dublin,population,1000000)

LOGIC: $(b, \text{capital}, a) \rightarrow (a, \text{partOf}, b)$
 $(a, \text{partOf}, b), (b, \text{partOf}, c) \rightarrow (a, \text{partOf}, c)$

QUERY: $(x, \text{partOf}, y)?$

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

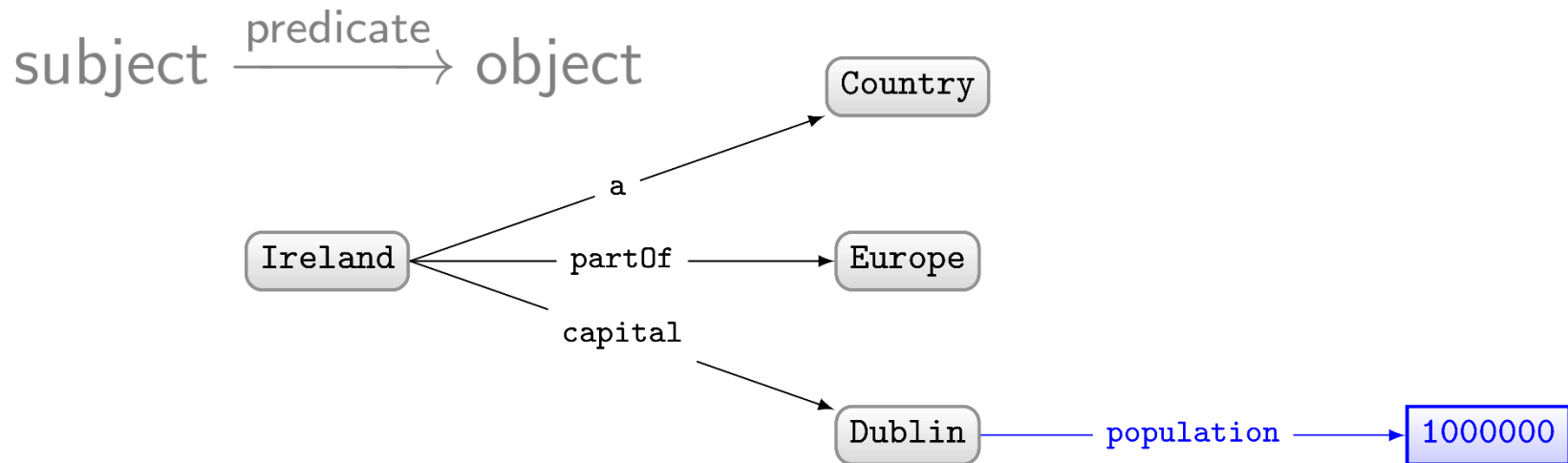
<i>subject</i>	<i>predicate</i>	<i>object</i>
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin

CONCATENATE TO “INTEGRATE” NEW DATA

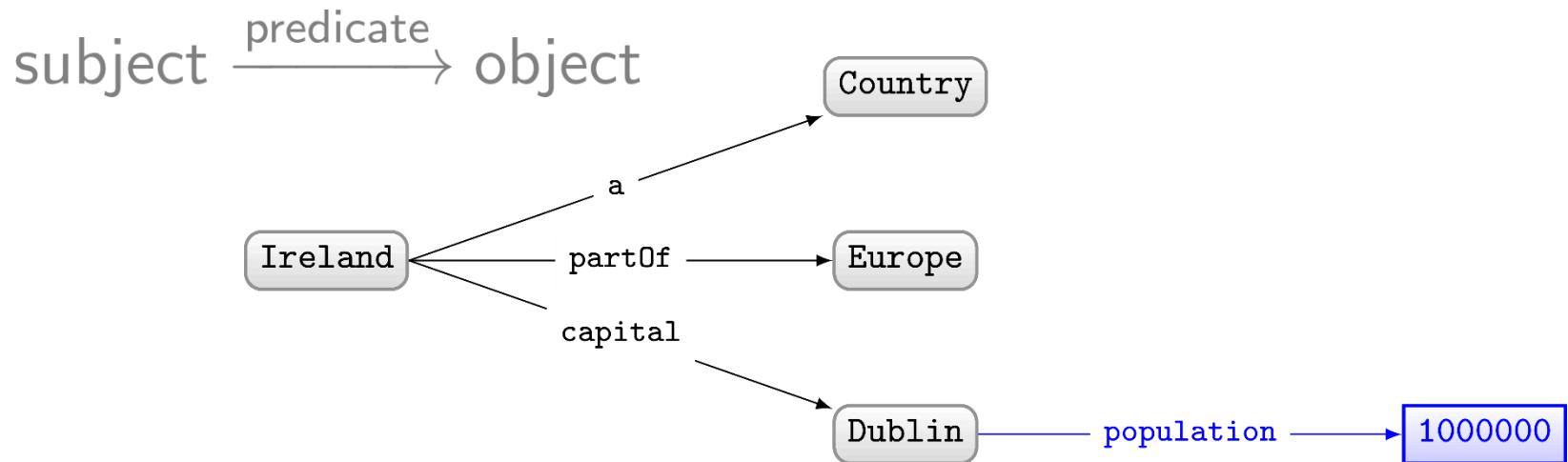
<i>subject</i>	<i>predicate</i>	<i>object</i>
Ireland Ireland Ireland	partOf a capital	Europe Country Dublin
Dublin	population	1,000,000

RDF OFTEN DRAWN AS A (DIRECTED, LABELLED) GRAPH

<i>subject</i>	<i>predicate</i>	<i>object</i>
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000



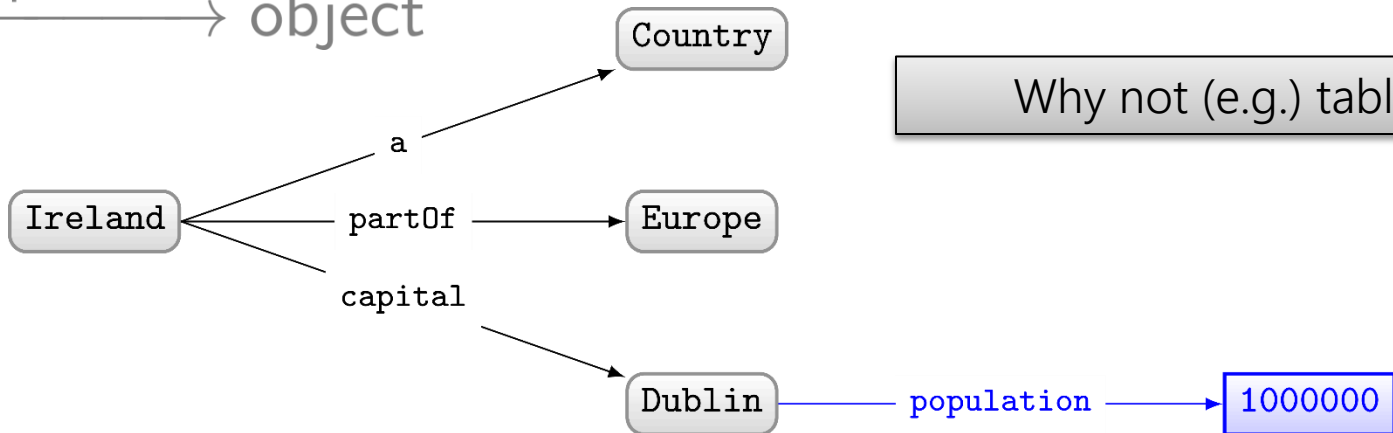
SET OF TRIPLES THUS CALLED AN “RDF GRAPH”



BUT WHY GRAPHS?

<i>subject</i>	<i>predicate</i>	<i>object</i>
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000

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



Why not (e.g.) tables?

GRAPHS ARE FLEXIBLE

RELATIONAL DATABASES ...



RELATIONAL DATABASES ...

Debit

<u>account</u>	<u>comment</u>	<u>date</u>	<u>time</u>	<u>amount</u>	<u>total</u>	<u>id</u>
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

<u>account</u>	<u>comment</u>	<u>date</u>	<u>time</u>	<u>amount</u>	<u>total</u>	<u>id</u>
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

<u>number</u>	<u>rut</u>	<u>type</u>	<u>total_clp</u>	<u>total_usd</u>
7873698669	32.000.273-K	Current	225000	344,94

Client

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

Exchange

<u>c1</u>	<u>c2</u>	<u>value</u>
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	
<u>name</u>	dist
Mercury	
Venus	
Earth	1.00
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	

PLANETS / RELATIONAL DATA

Planet	
<u>name</u>	dist
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	49.31

PLANETS / RELATIONAL DATA

Planet		
<u>name</u>	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							
<u>name</u>	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							
<u>name</u>	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								
<u>name</u>	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							
<u>name</u>	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	
<u>name</u>	planet
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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			
<u>name</u>	planet	discoverer	year
Ganymedes	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	⊥	⊥
Oberon	Uranus	William Herschel	1787
Charon	Pluto	⊥	1978
...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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
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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

Moon	
<u>name</u>	<u>planet</u>
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	<u>discoverer</u>
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	<u>year</u>
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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
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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	
<u>name</u>	planet
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Terra
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA

Planet							
<u>name</u>	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	
<u>name</u>	P.name
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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
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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	
<u>name</u>	P.name
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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

DwarfPlanet							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon	
<u>name</u>	P.name
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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

DwarfPlanet							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon	
<u>name</u>	P.name
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
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Jupiter	5.20	10.97	22.9	0.414	11.862	152	true
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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							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon	
<u>name</u>	parent
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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

DwarfPlanet							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.063	6.39	248.000	44	false

Moon	
<u>name</u>	parent
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / RELATIONAL DATA



Planet							
<u>name</u>	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

Dwarf Planet							
<u>name</u>	dist	radius	grav	days	years	temp	ring
Pluto	49.31	0.19	0.005	0.39	248.000	44	false

Moon	
<u>name</u>	parent
Ganimesdes	Jupiter
Calisto	Jupiter
Europa	Jupiter
Io	Jupiter
Titan	Saturn
Triton	Neptune
Luna	Earth
Oberon	Uranus
Charon	Pluto
...	...

MoonDiscoverer	
<u>name</u>	discoverer
Ganimesdes	Galileo Galilei
Calisto	Galileo Galilei
Europa	Galileo Galilei
Io	Galileo Galilei
Titan	Christiaan Huygens
Triton	William Lassell
Oberon	William Herschel
...	...

MoonDiscYear	
<u>name</u>	year
Ganimesdes	1610
Calisto	1610
Europa	1610
Io	1610
Titan	1655
Triton	1846
Oberon	1787
Charon	1978
...	...

PLANETS / GRAPH DATA



PLANETS / GRAPH DATA



PLANETS / GRAPH DATA



Earth

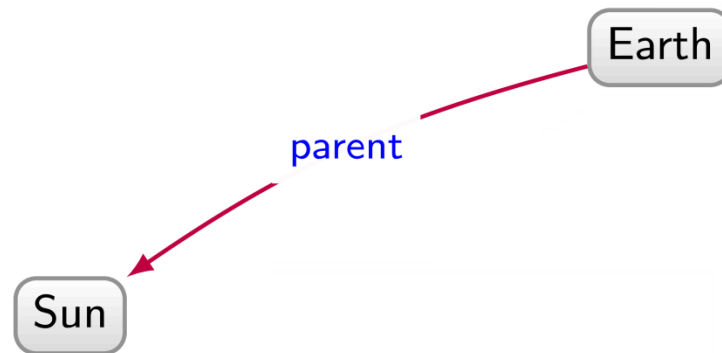
PLANETS / GRAPH DATA



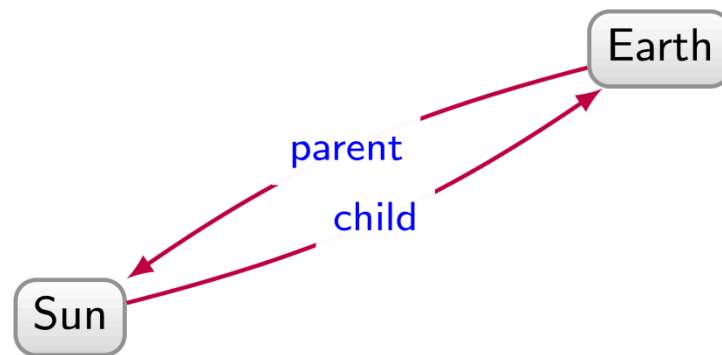
PLANETS / GRAPH DATA



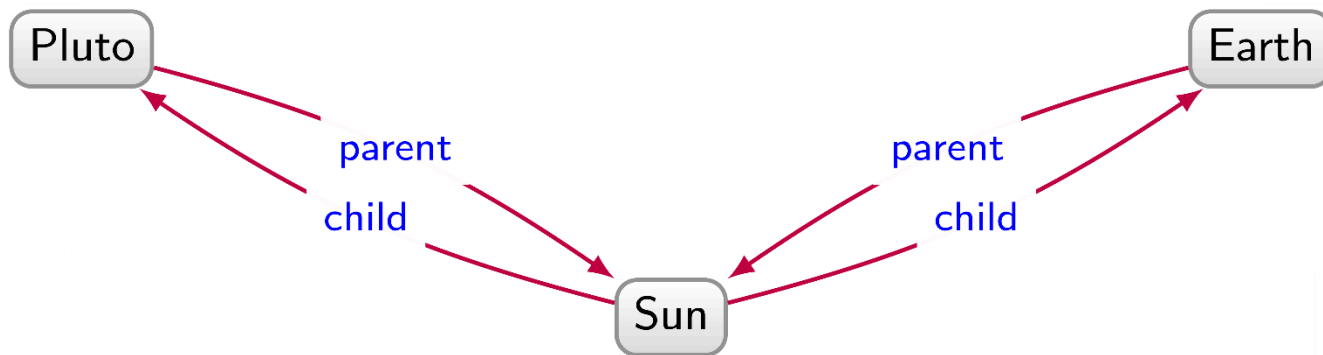
PLANETS / GRAPH DATA



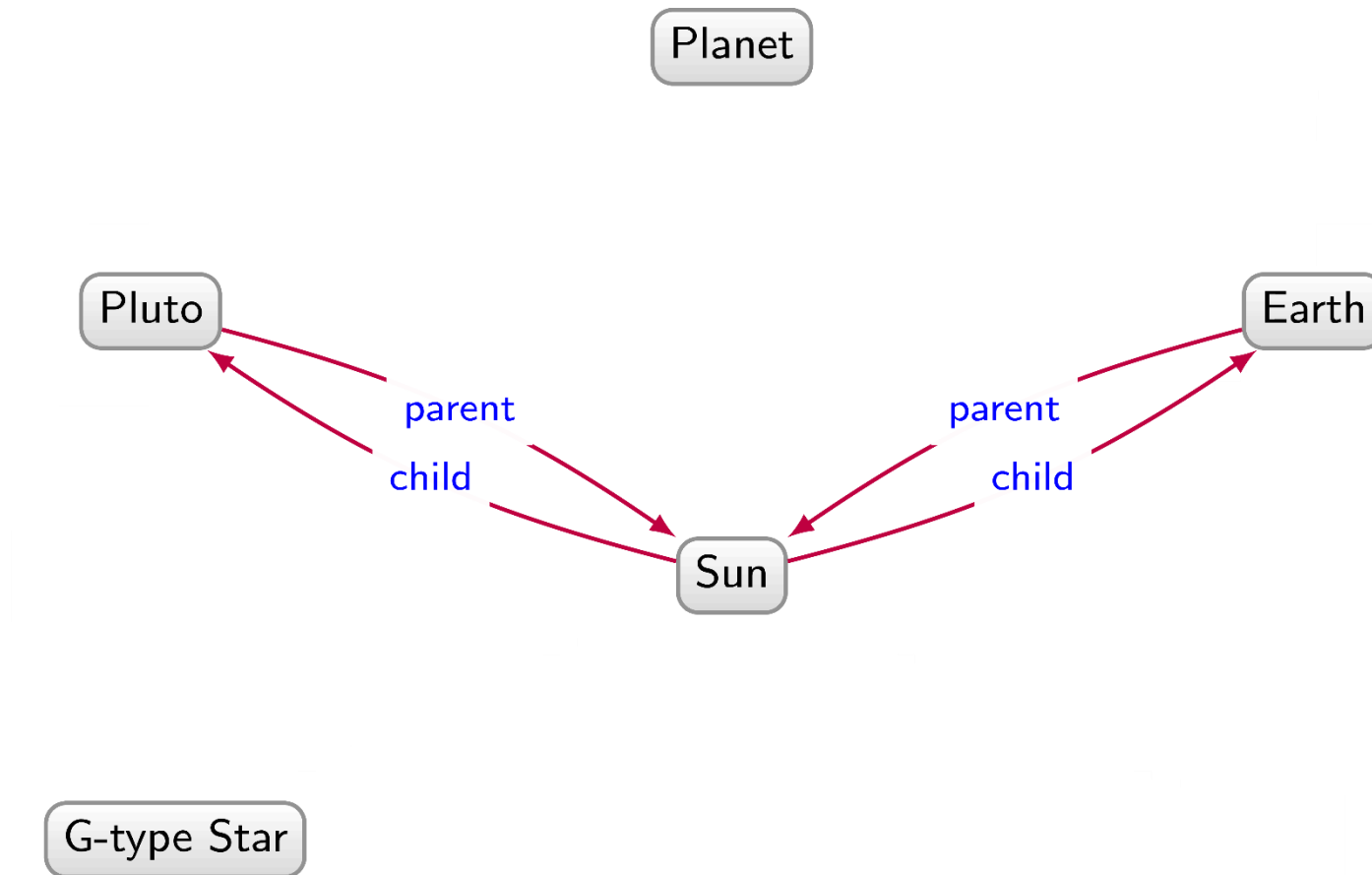
PLANETS / GRAPH DATA



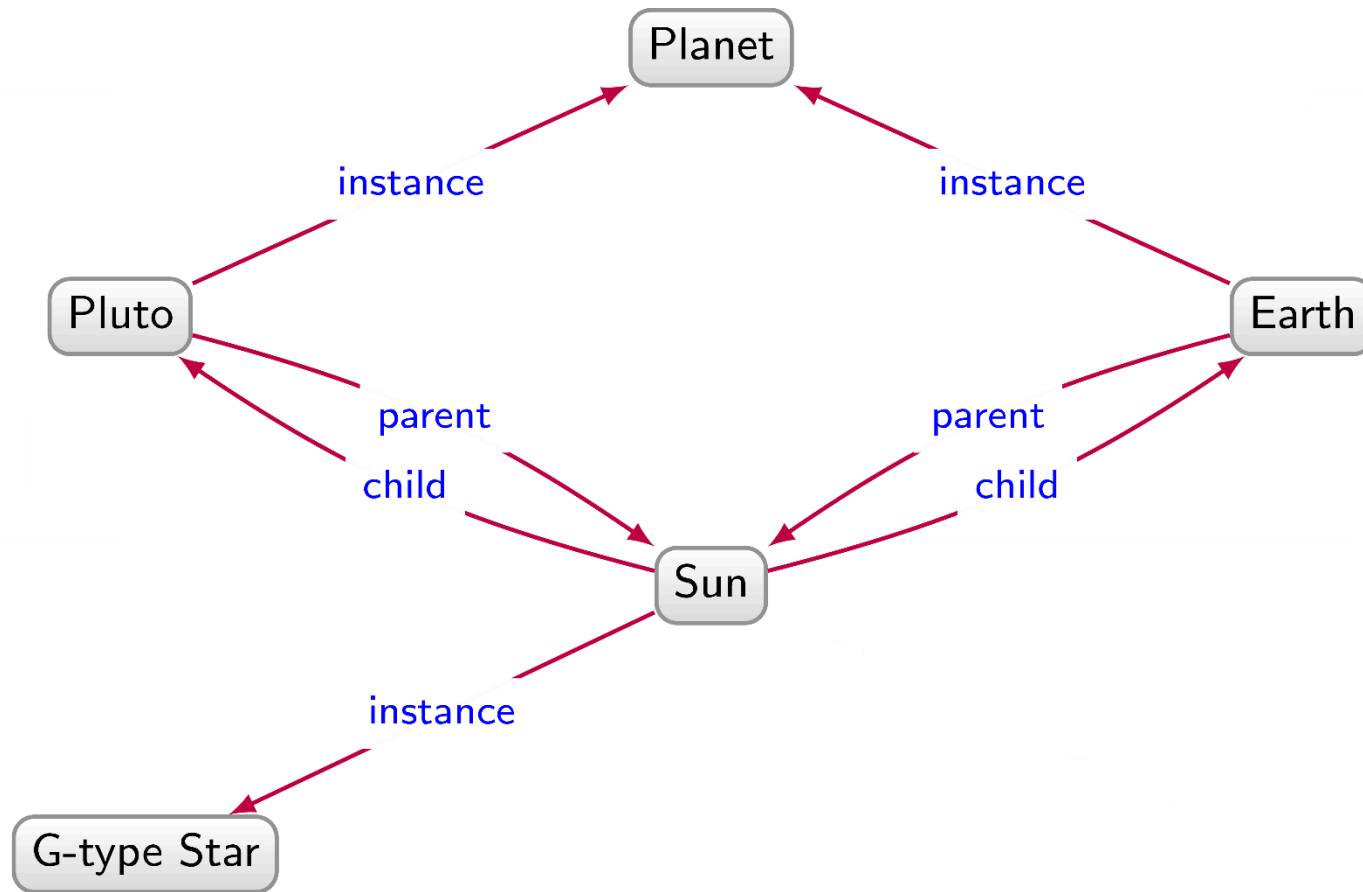
PLANETS / GRAPH DATA



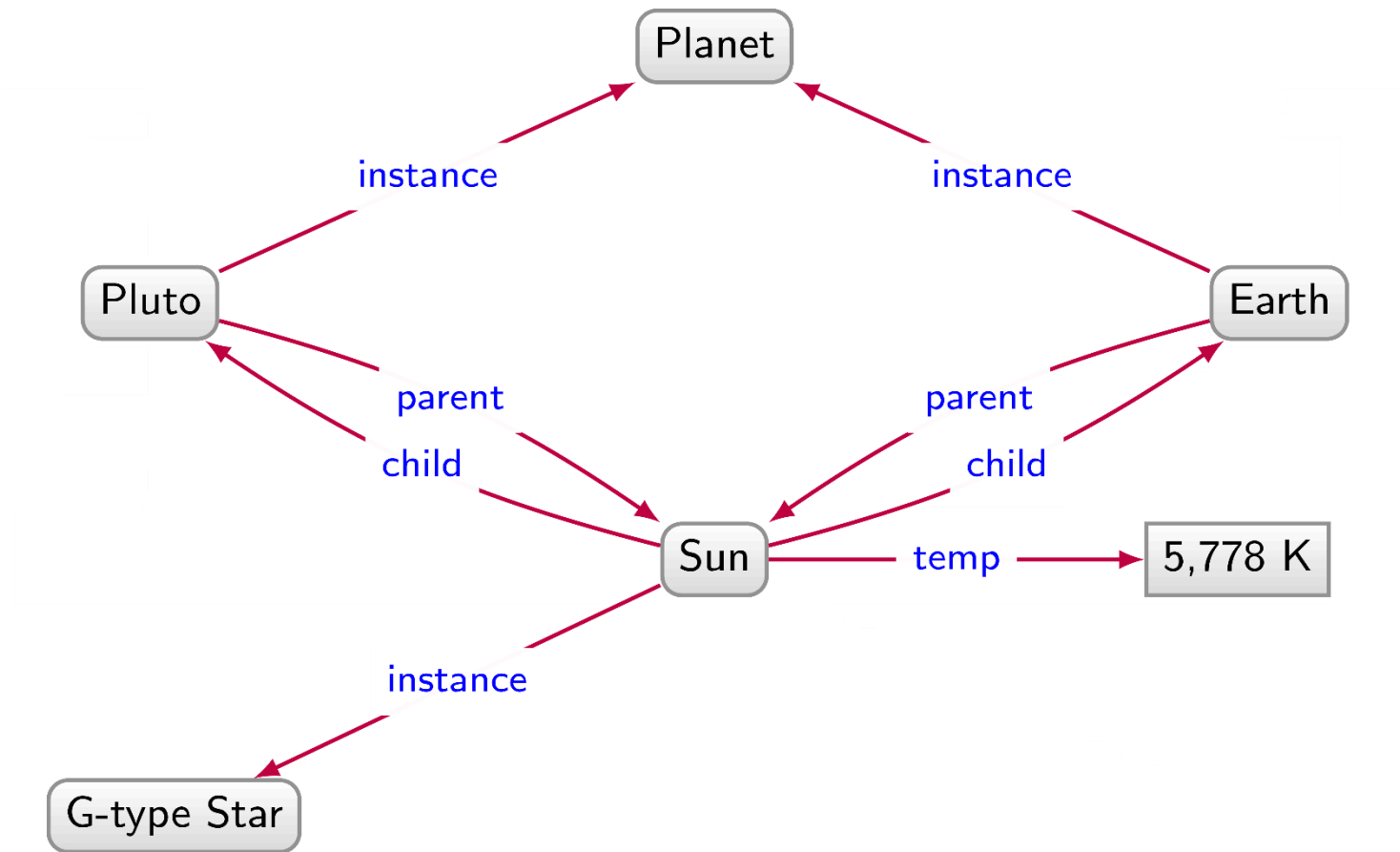
PLANETS / GRAPH DATA



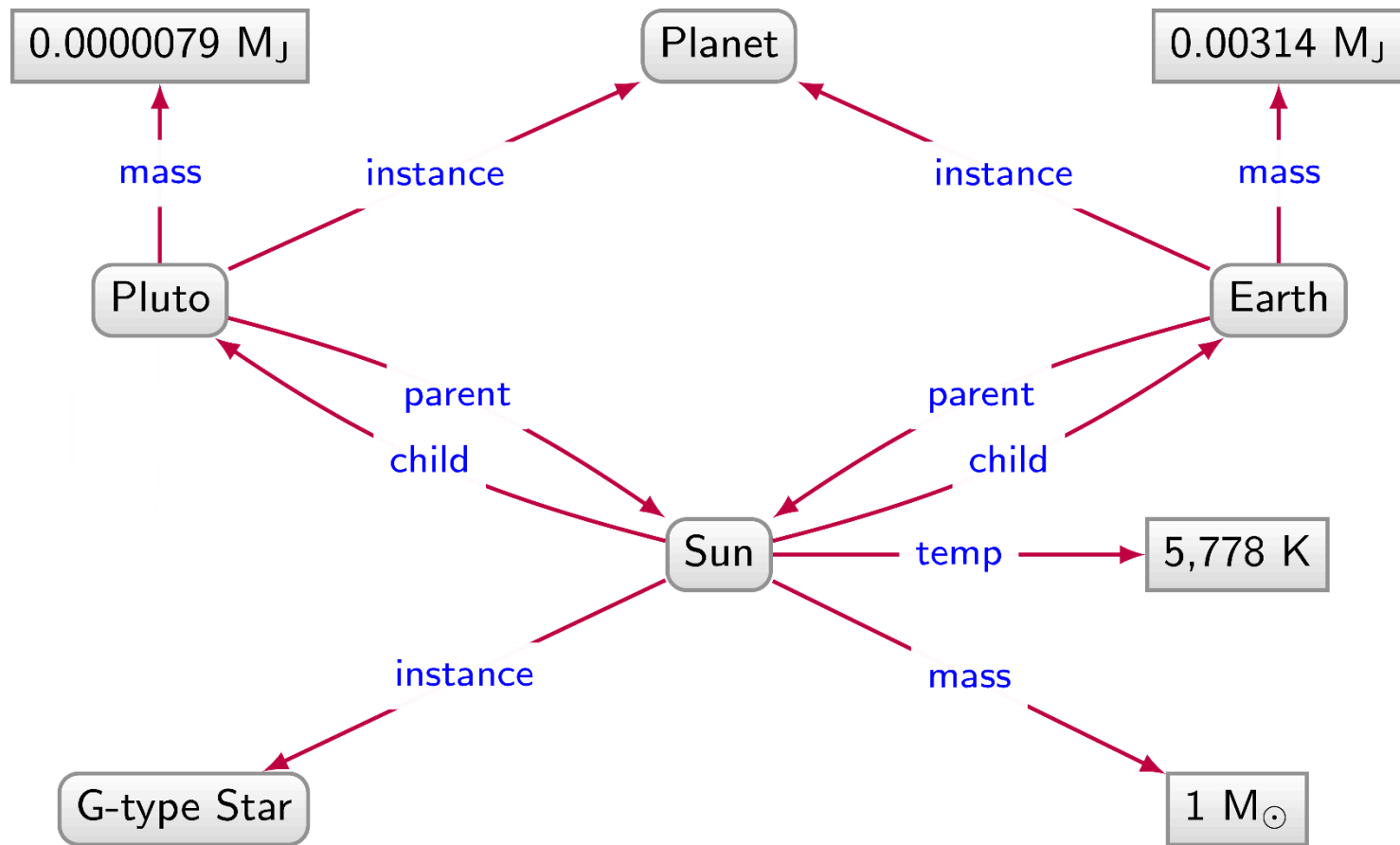
PLANETS / GRAPH DATA



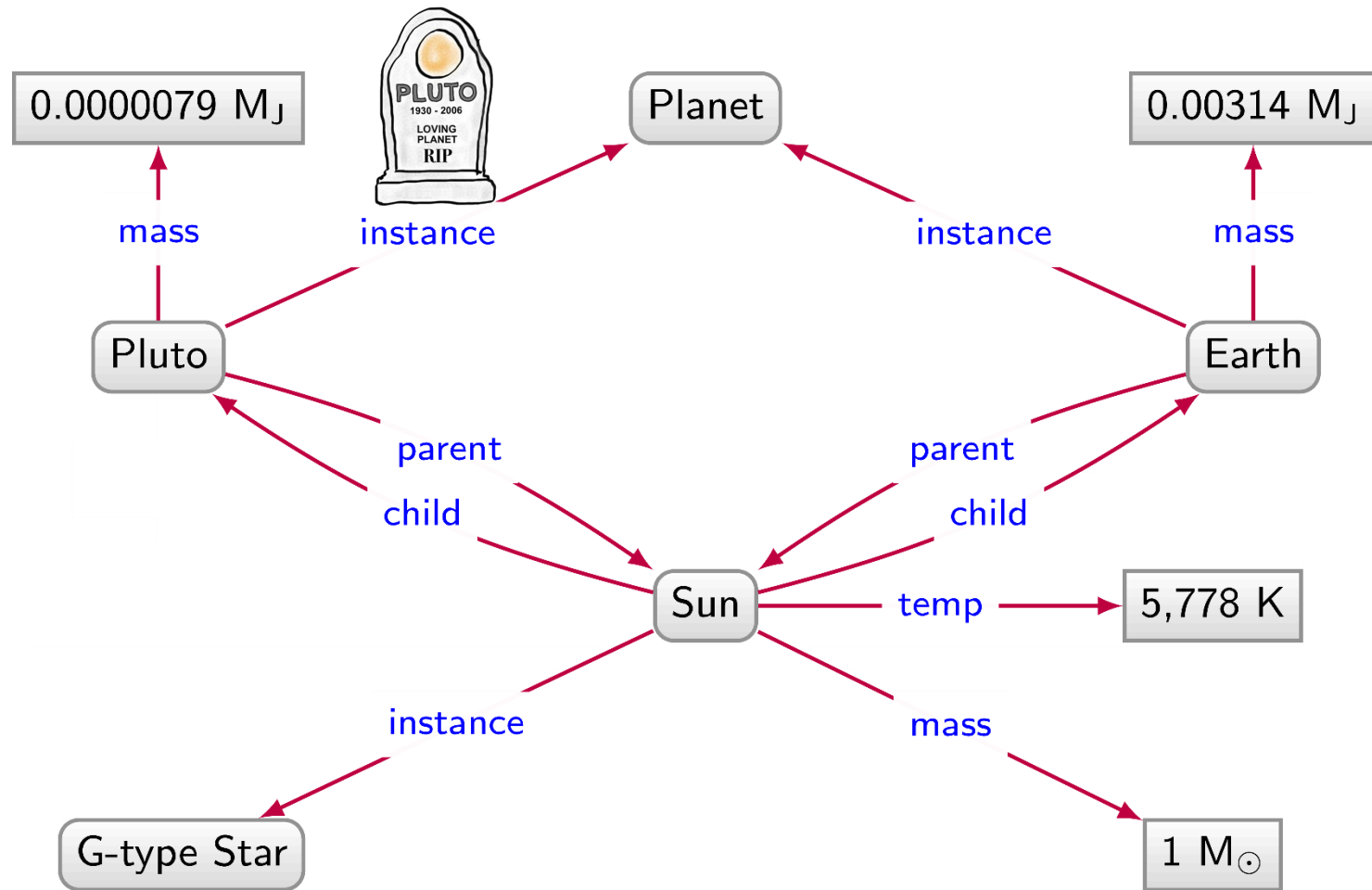
PLANETS / GRAPH DATA



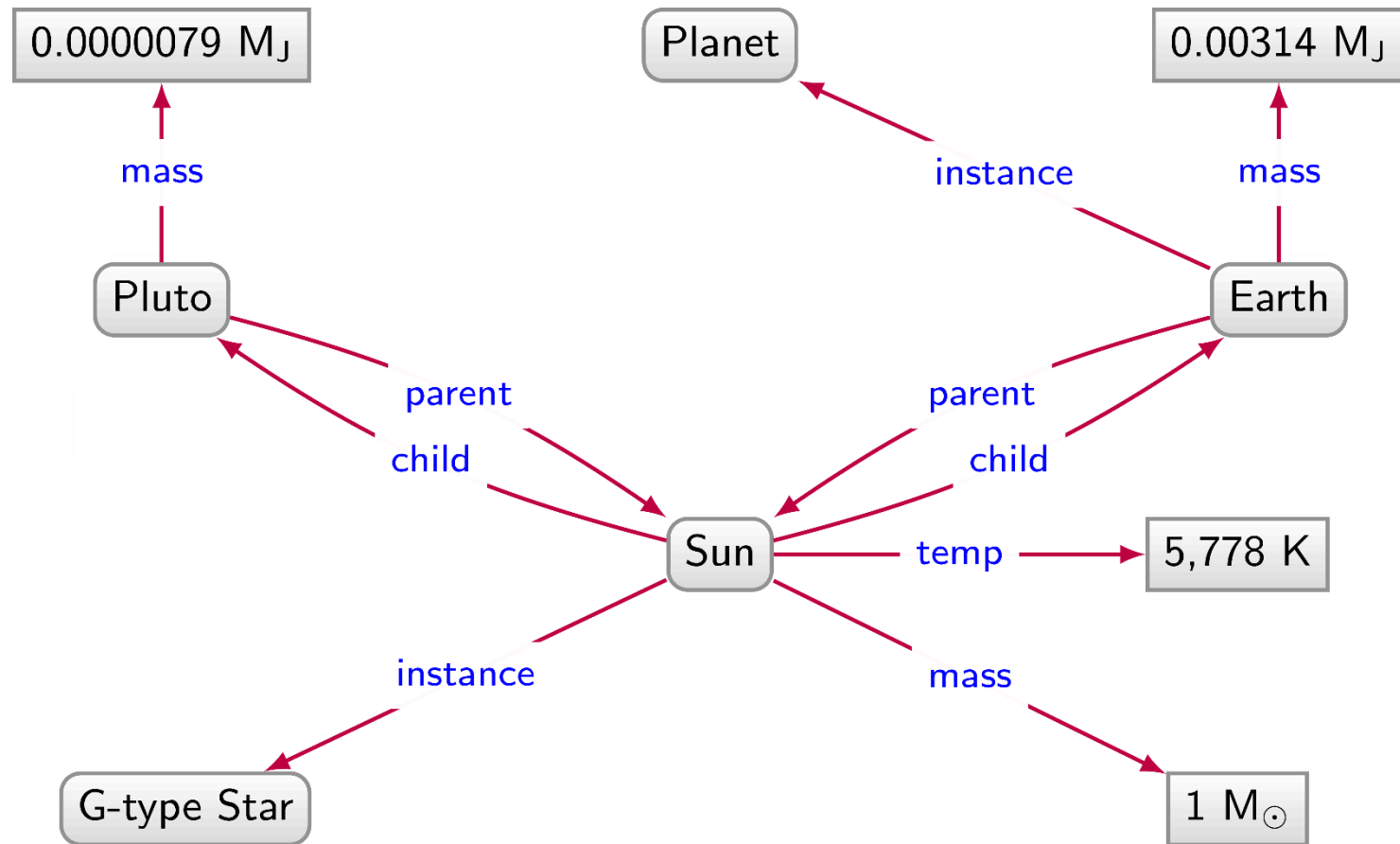
PLANETS / GRAPH DATA



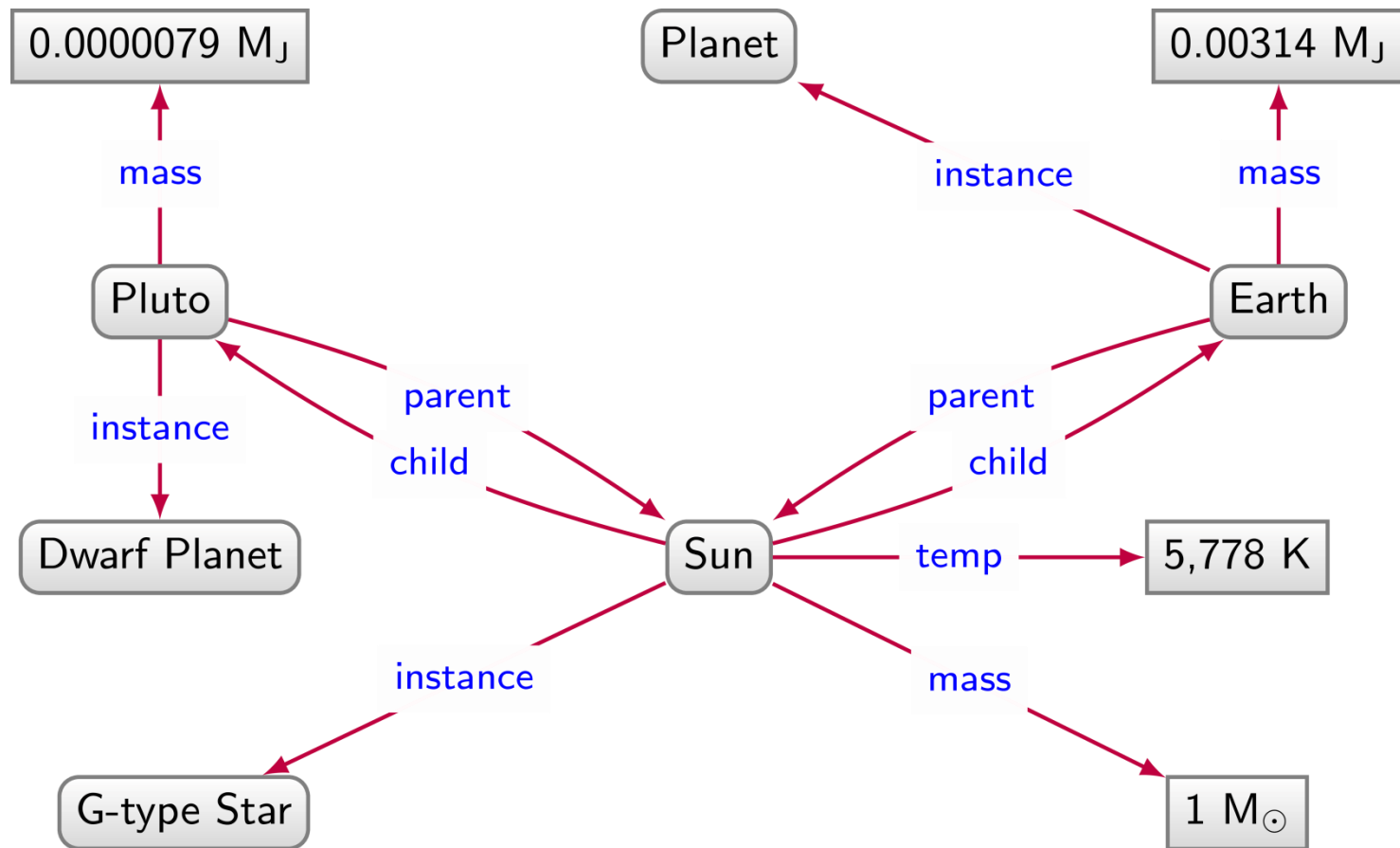
PLANETS / GRAPH DATA



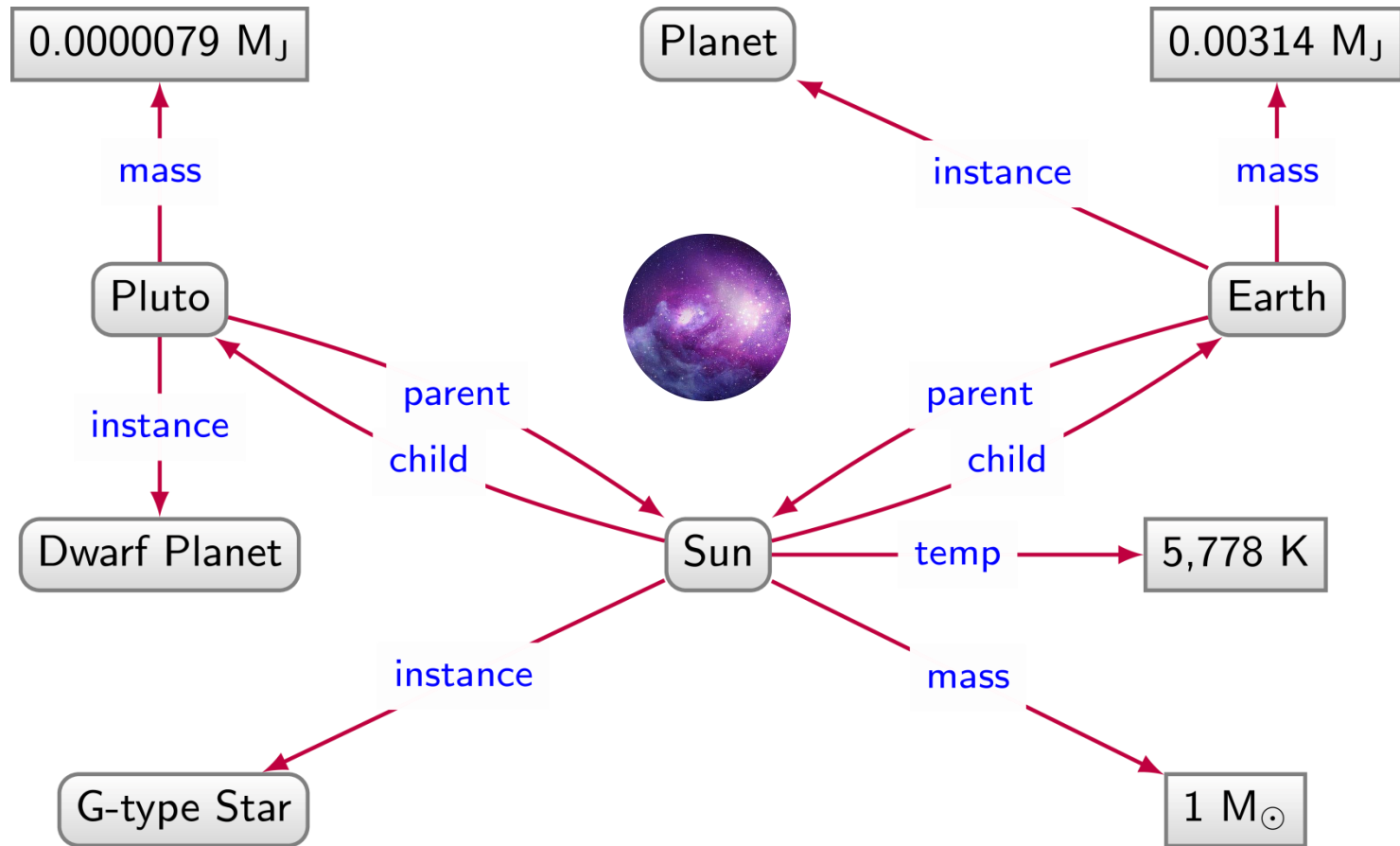
PLANETS / GRAPH DATA



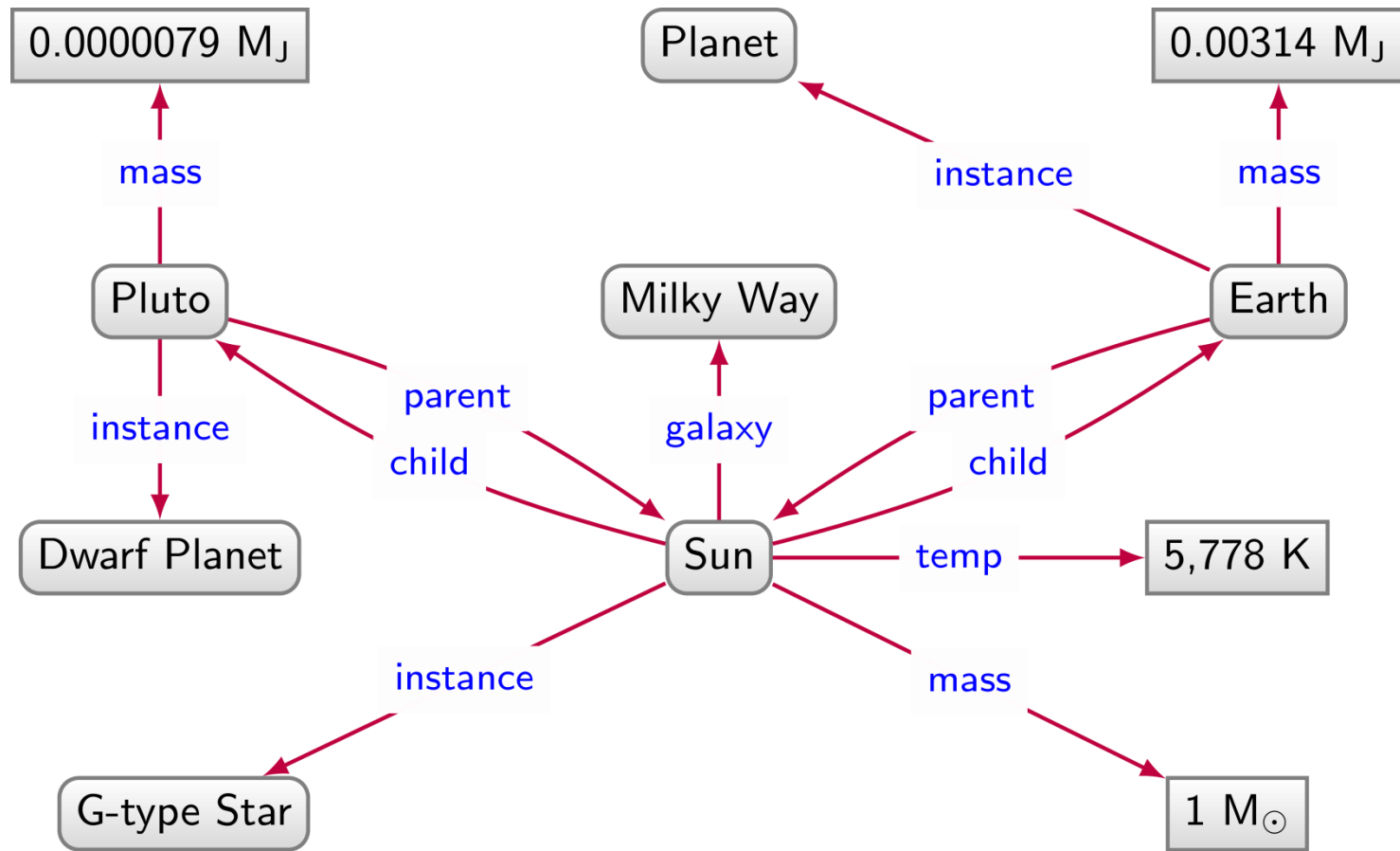
PLANETS / GRAPH DATA



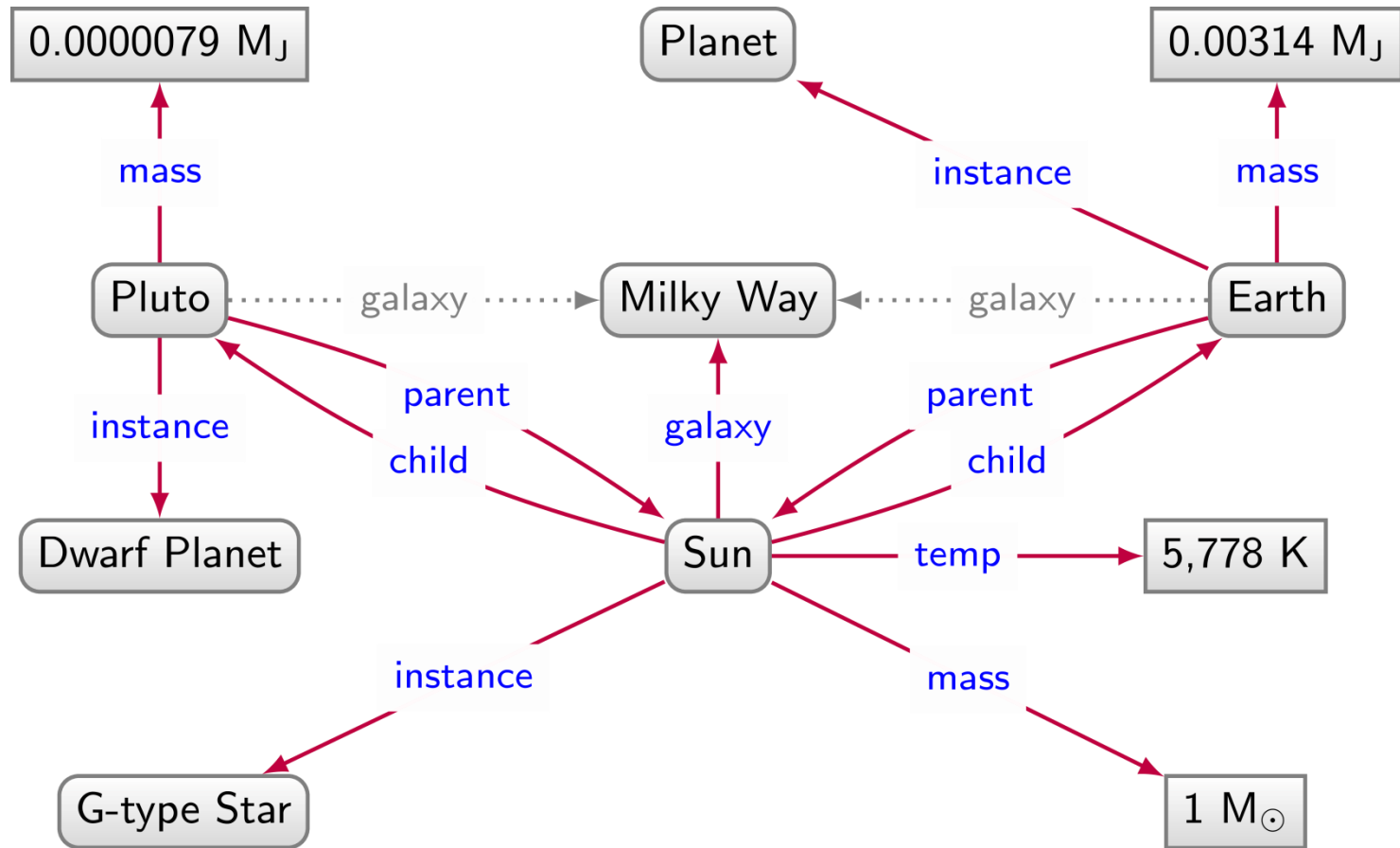
PLANETS / GRAPH DATA



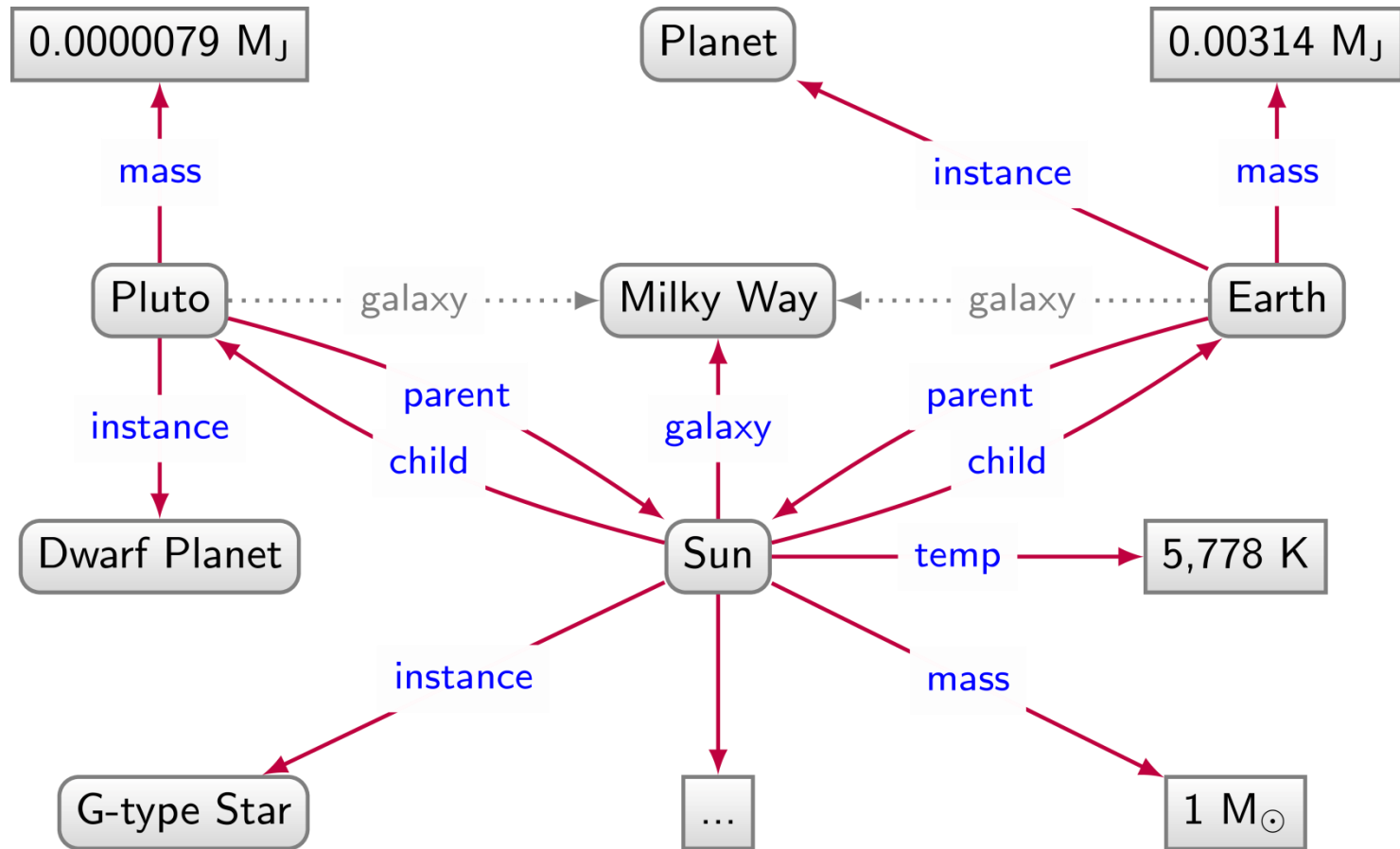
PLANETS / GRAPH DATA



PLANETS / GRAPH DATA



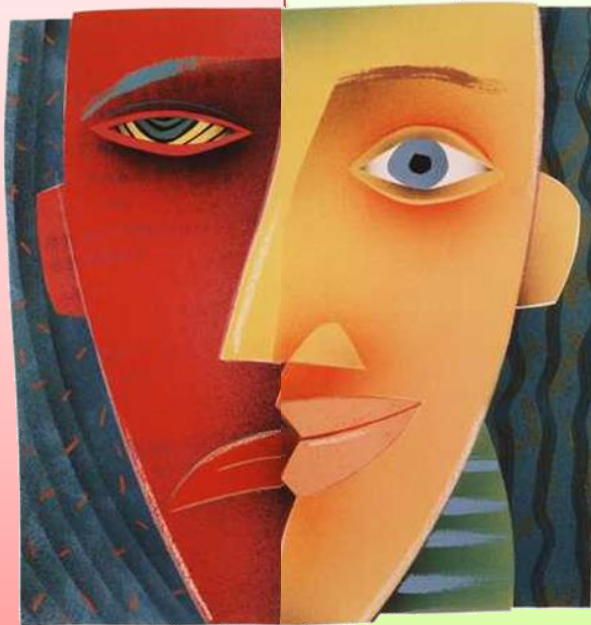
PLANETS / GRAPH DATA



RELATIONAL DATA: PROS AND CONS

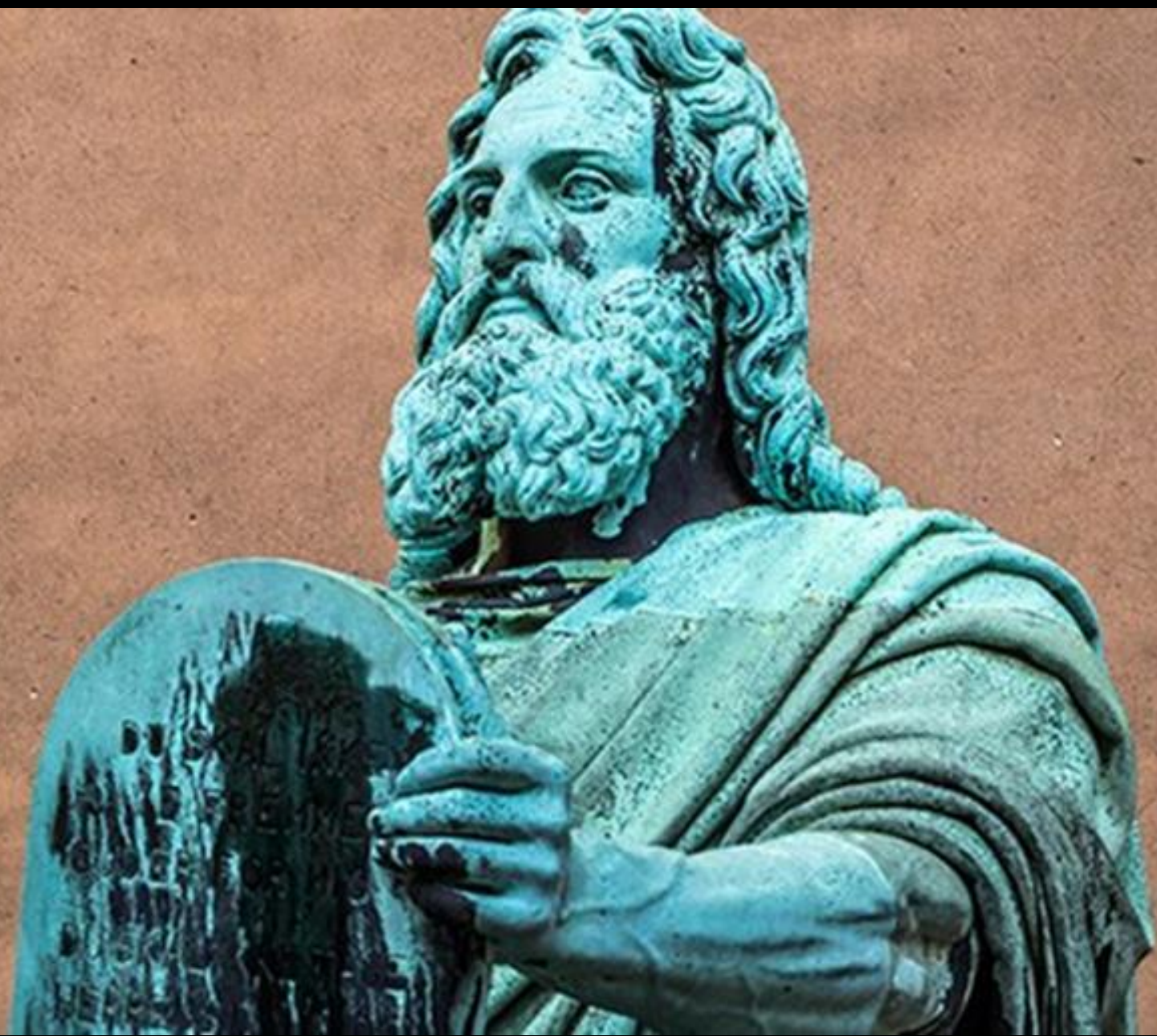
Planet							
<u>name</u>	<u>dist</u>	<u>radius</u>	<u>grav</u>	<u>days</u>	<u>years</u>	<u>temp</u>	<u>ring</u>
Mercury	0.39	0.38	2.8	58.646	0.241	440	false
Venus	0.72	0.95	8.9	-243.019	0.615	730	false

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

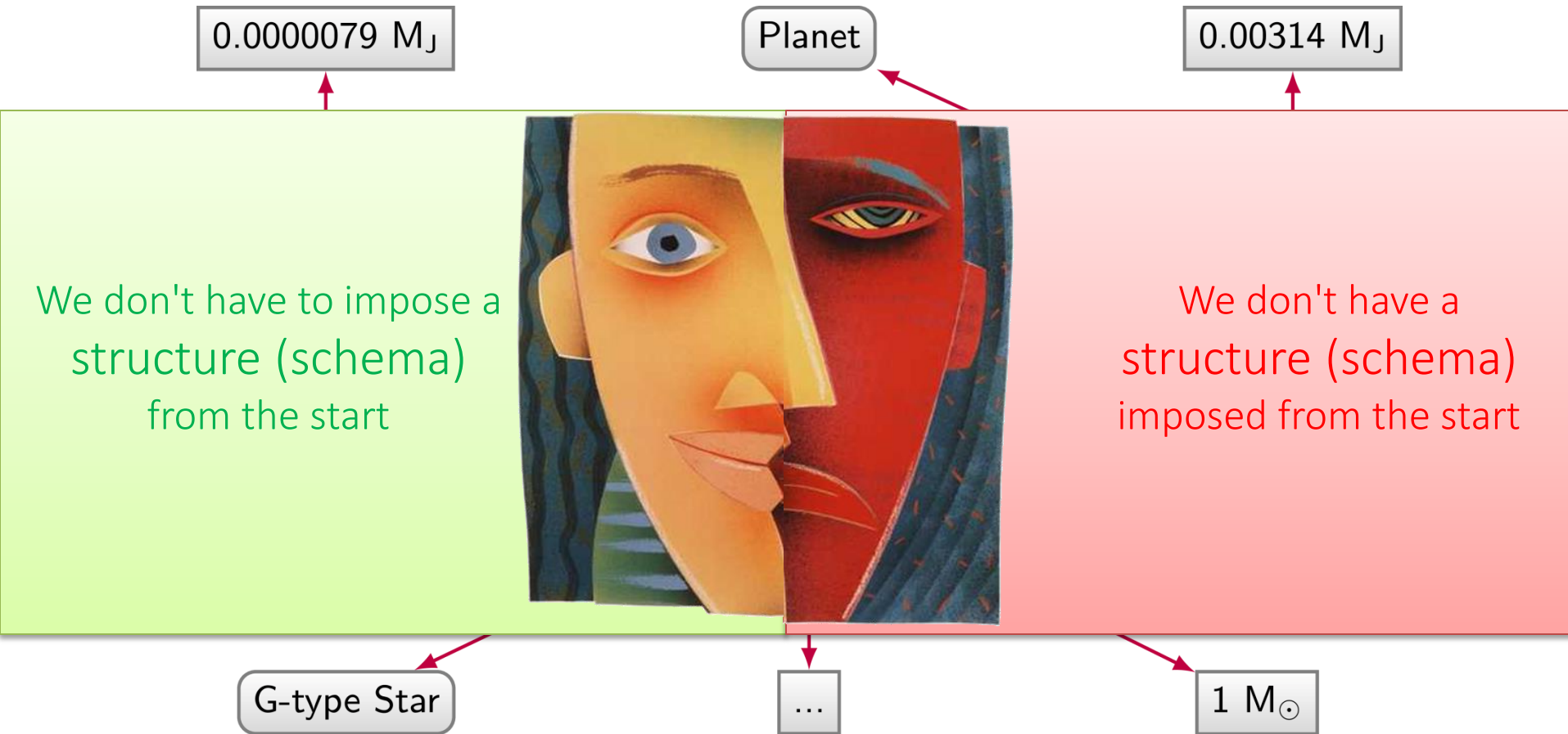


We have a
structure (schema)
imposed from the start

Europa	Jupiter	Europa	Galileo Galilei	Europa	1610
Io	Jupiter	Io	Galileo Galilei	Io	1610
Titan	Saturn	Titan	Christiaan Huygens	Titan	1655
Triton	Neptune	Triton	William Lassell	Triton	1846
Luna	Earth	Oberon	William Herschel	Oberon	1787
Oberon	Uranus	Charon	1978
Charon	Pluto		
...	...				



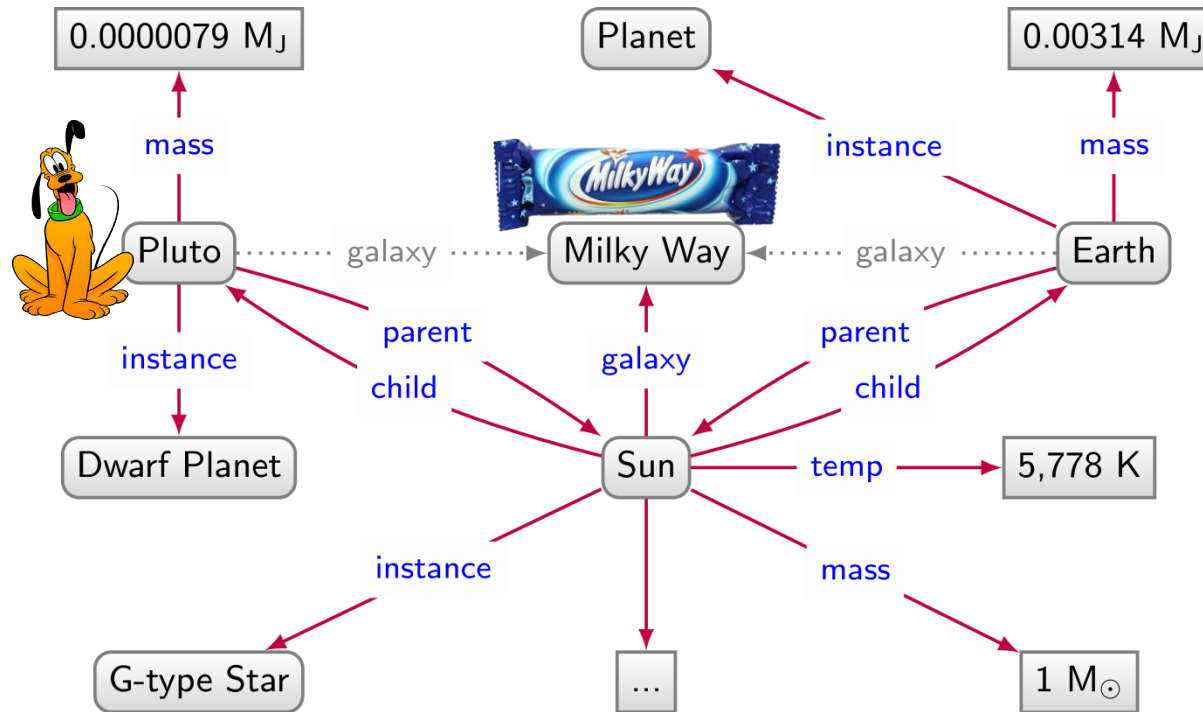
GRAPH DATA: PROS AND CONS



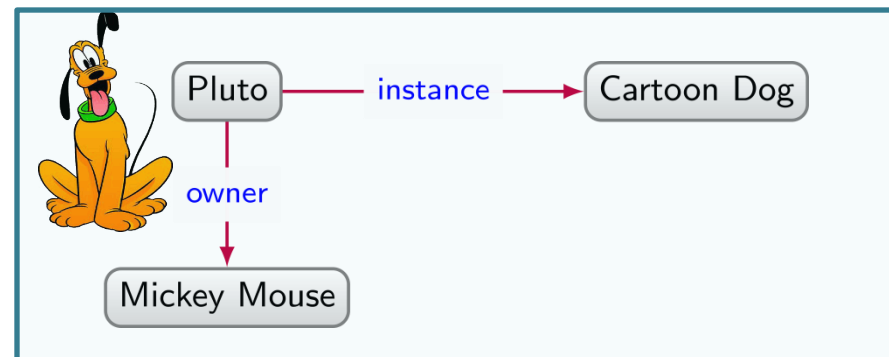
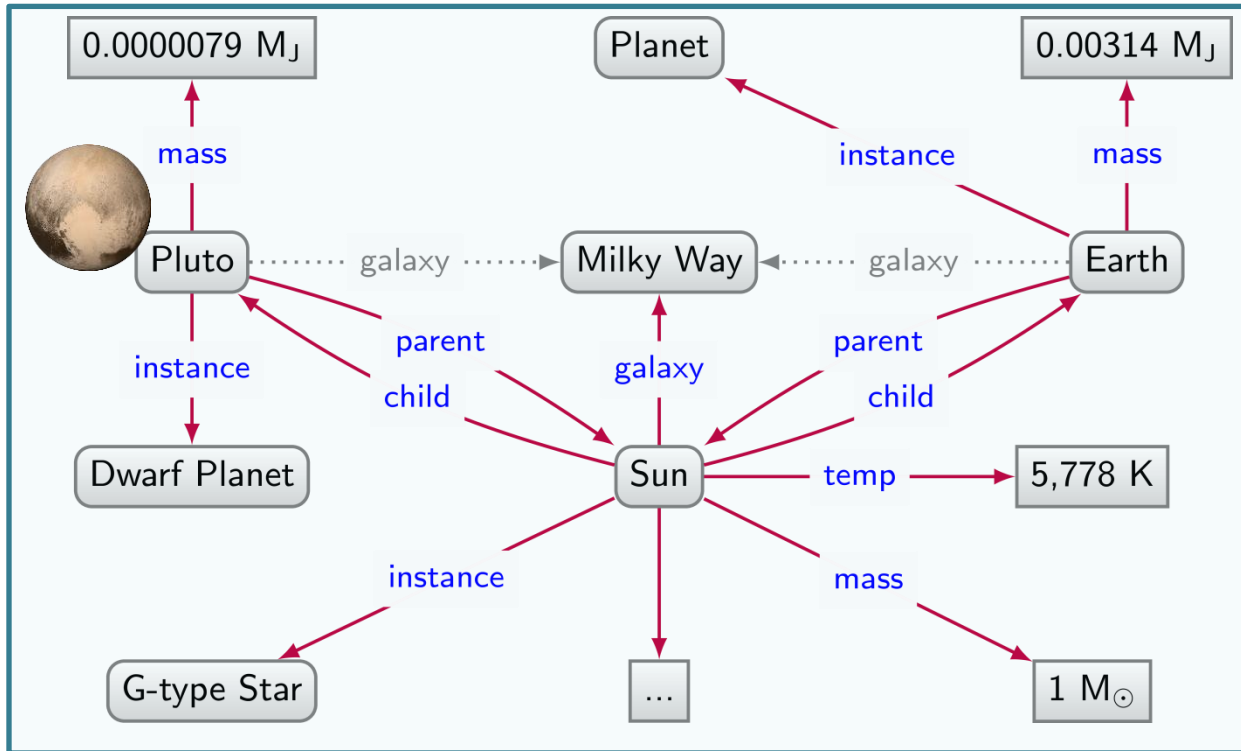


NAMING THINGS

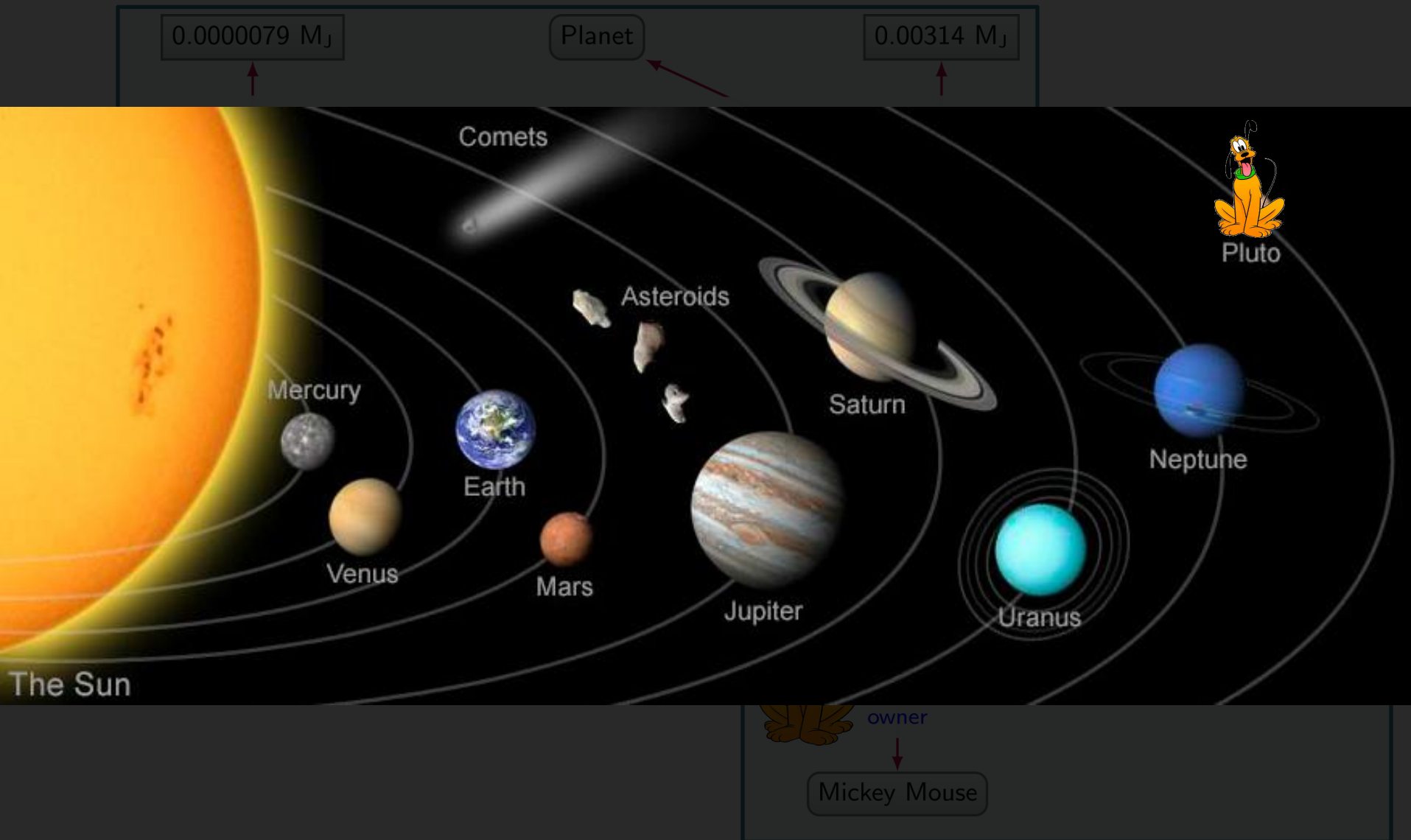
NAMING THINGS: STRINGS NOT ENOUGH



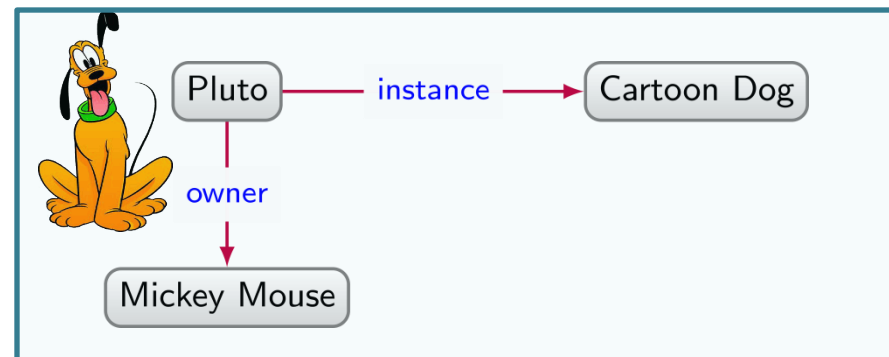
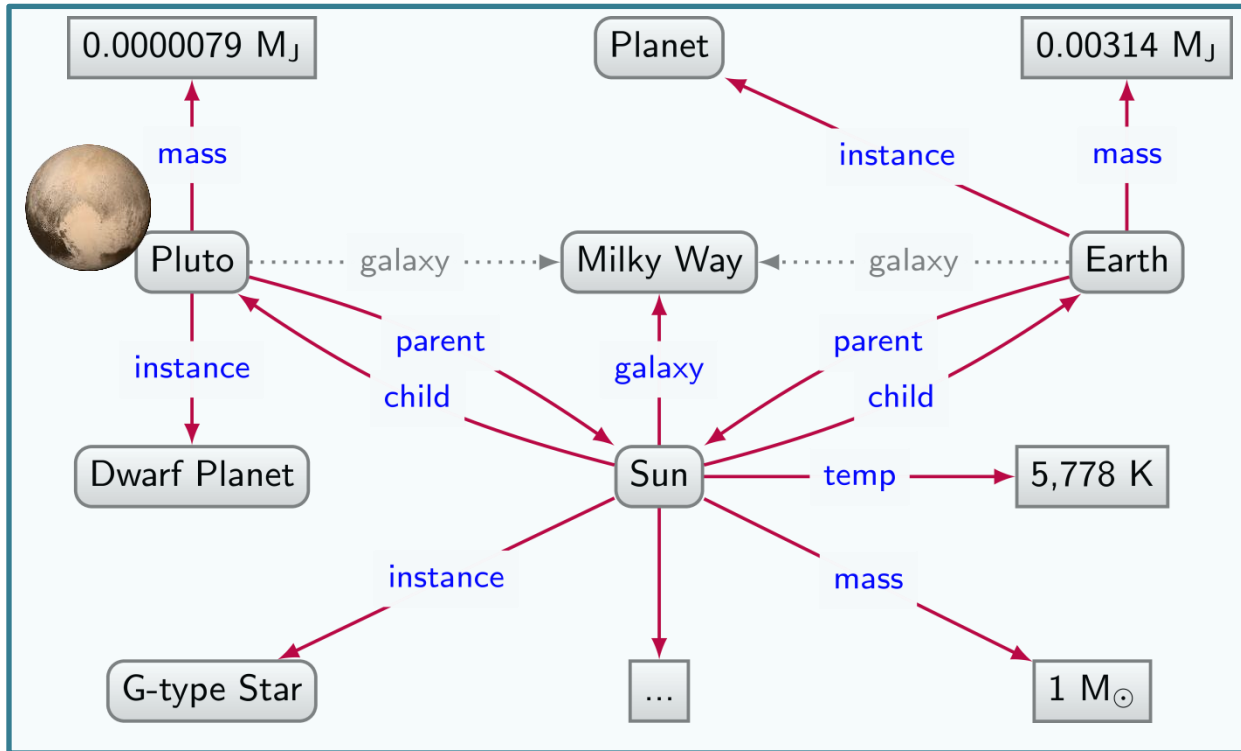
NAMING THINGS: STRINGS NOT ENOUGH



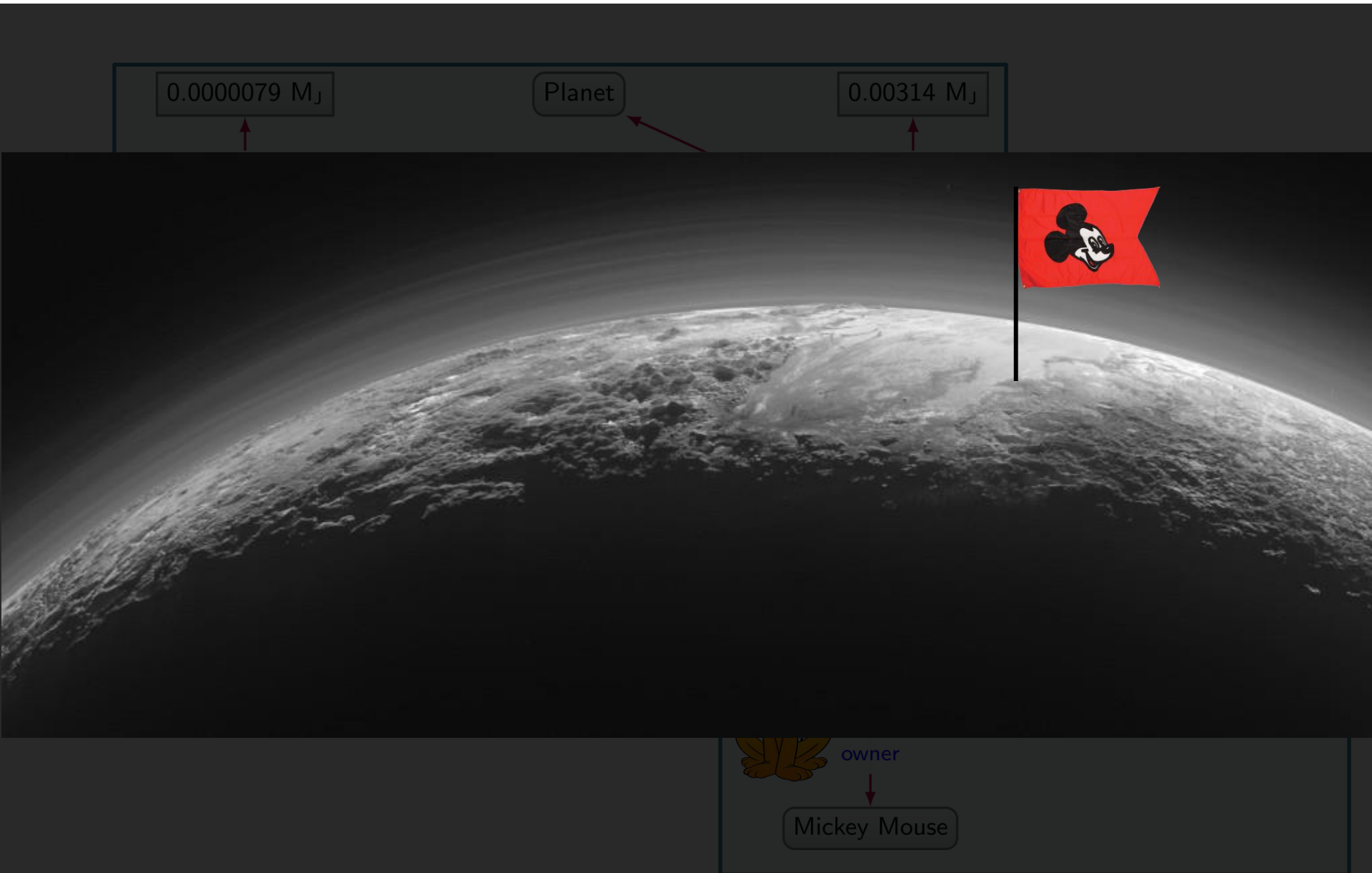
NAMING THINGS: STRINGS NOT ENOUGH



NAMING THINGS: STRINGS NOT ENOUGH



NAMING THINGS: 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`

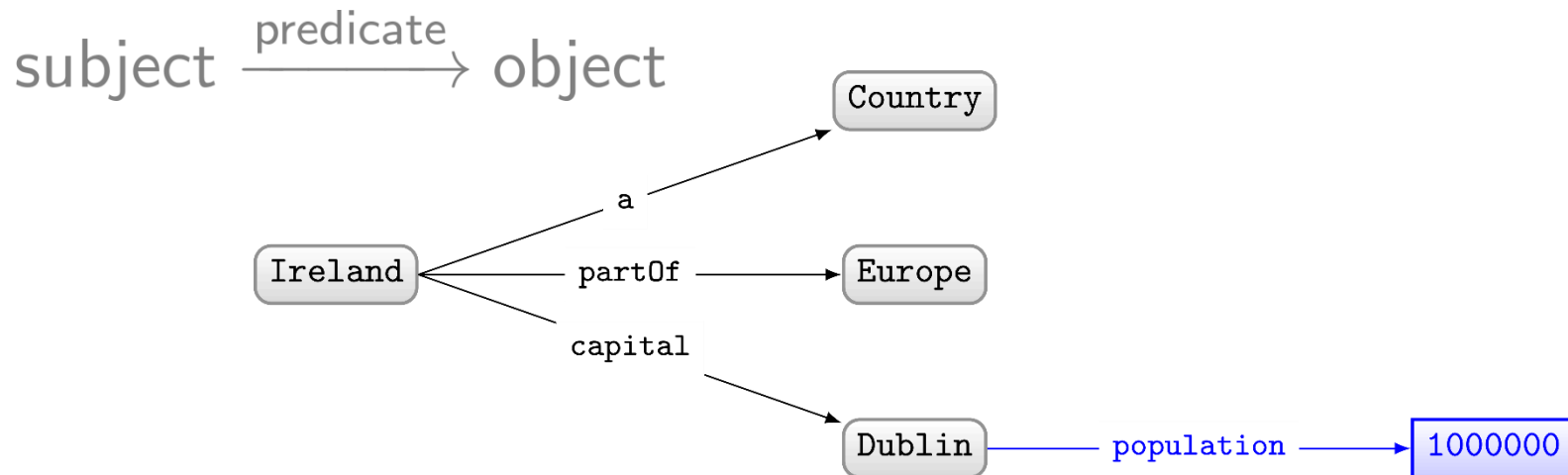
WE WILL USE IRIS WITH PREFIXES

- `http://ex.org/Dublin` ↔ `ex:Dublin`
 - “`ex:`” denotes a prefix for `http://ex.org/`
 - “`Dublin`” is the local name
- Frequently used prefixes:

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

FROM STRINGS ...

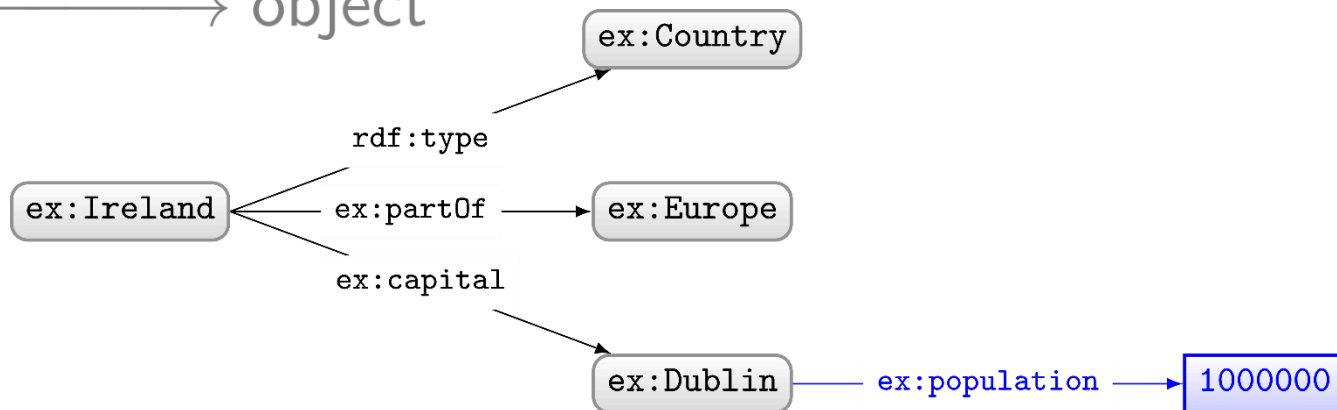
<i>subject</i>	<i>predicate</i>	<i>object</i>
Ireland	partOf	Europe
Ireland	a	Country
Ireland	capital	Dublin
Dublin	population	1,000,000



... TO IRIs ...

<i>subject</i>	<i>predicate</i>	<i>object</i>
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

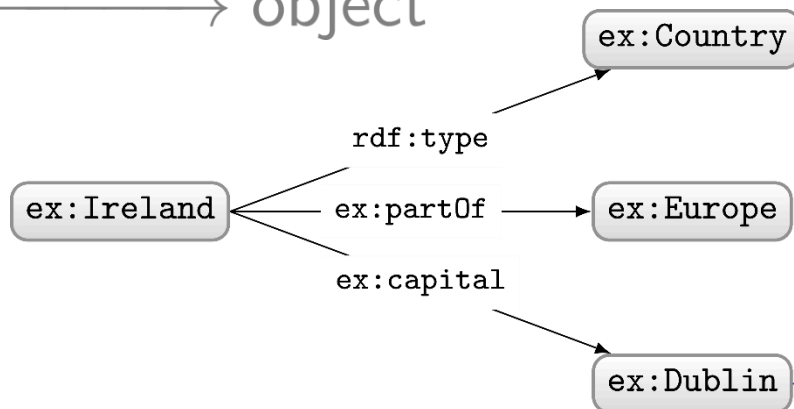


NAMING THINGS IN RDF: LITERALS

WHAT ABOUT NUMBERS?

<i>subject</i>	<i>predicate</i>	<i>object</i>
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



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

RDF ALLOWS “LITERALS” IN OBJECT POSITION

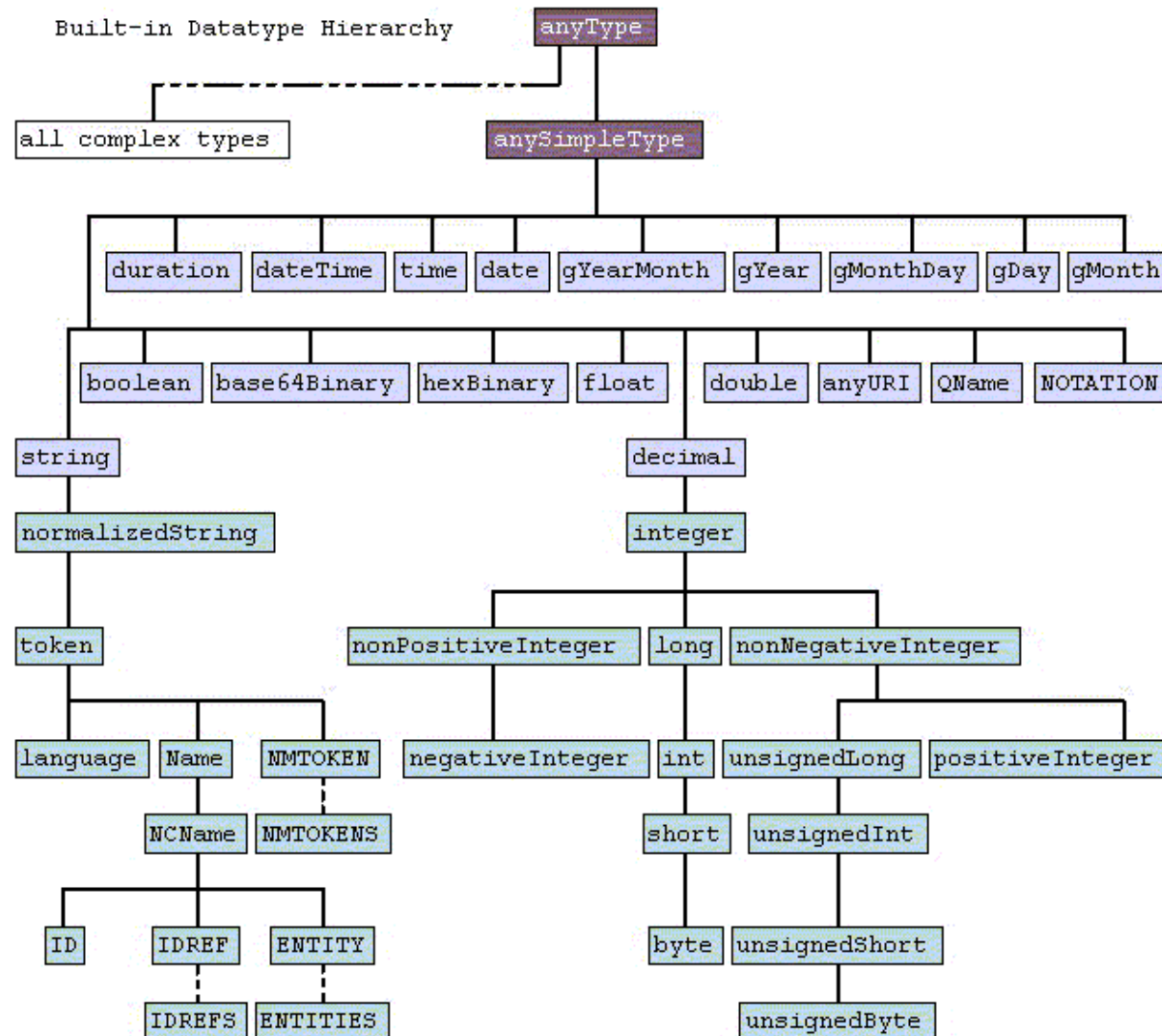
- Literals are for datatype values, like strings, numbers, booleans, dates, times
- Only allowed in object position

<i>subject</i>	<i>predicate</i>	<i>object</i>	
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

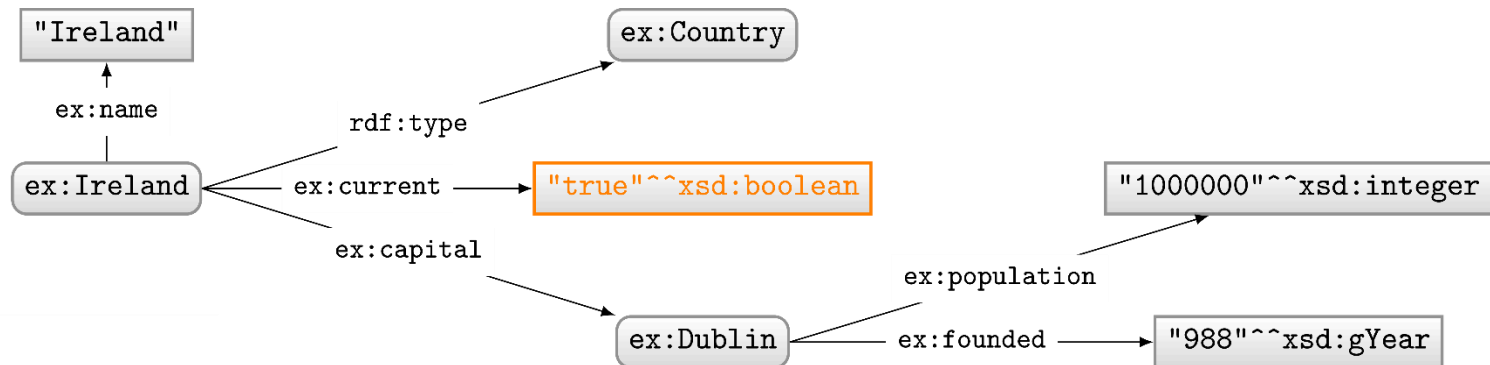
- "[lexical-string]"^^[datatype-IRI]
 - "200"^^xsd:int
 - "2014-12-13"^^xsd:date
 - "true"^^xsd:boolean
 - "this is a string"^^xsd:string
- If the datatype is omitted, it's a string
 - "this is a string"
 - "200" is a string, not a number!

MANY DATATYPES BORROWED FROM XML SCHEMA



BOOLEAN DATATYPE

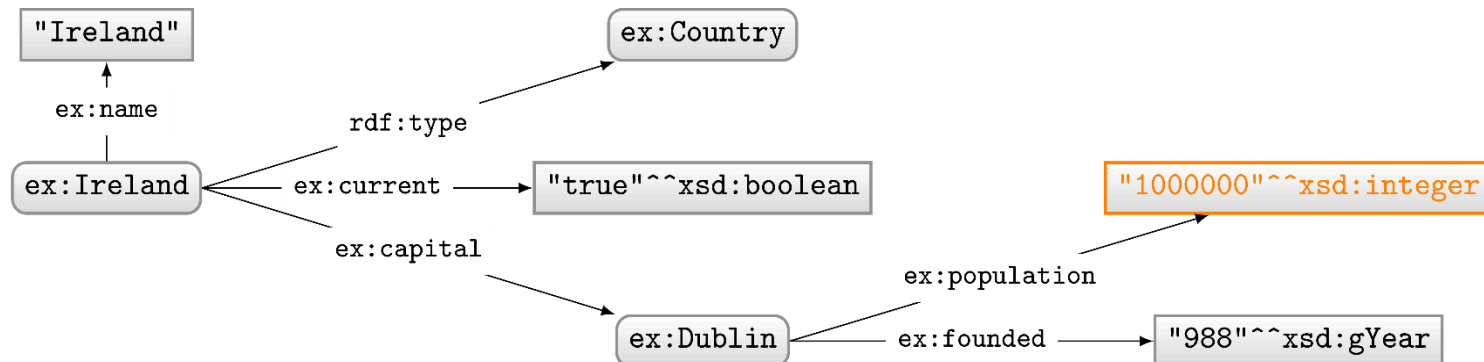
BOOLEAN		
xsd:boolean	"true", "false", "1", "0"	Case sensitive



NUMERIC DATATYPES

NUMERIC

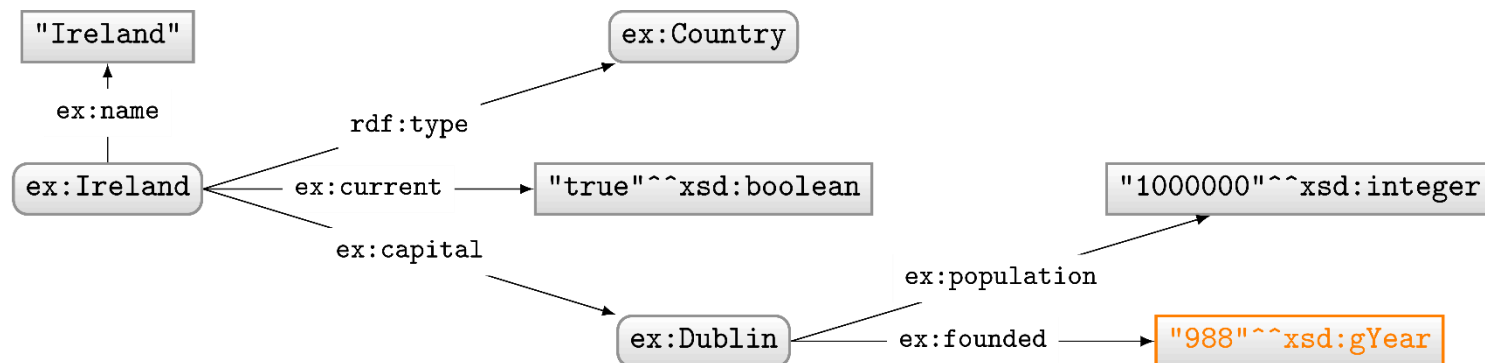
xsd:decimal	"-2.320"	Any precision
└ xsd:integer	"-3"	Any precision, $x \in \mathbb{Z}$
└└ xsd:long	"-9223372036854775808"	$-2^{63} \leq x < 2^{63}$
└└└ xsd:int	"+2147483647"	$-2^{31} \leq x < 2^{31}$
└└└└ xsd:short	"-32768"	$-2^{15} \leq x < 2^{15}$
└└└└└ xsd:byte	"127"	$-2^7 \leq x < 2^7$
└ xsd:nonNegativeInteger	"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

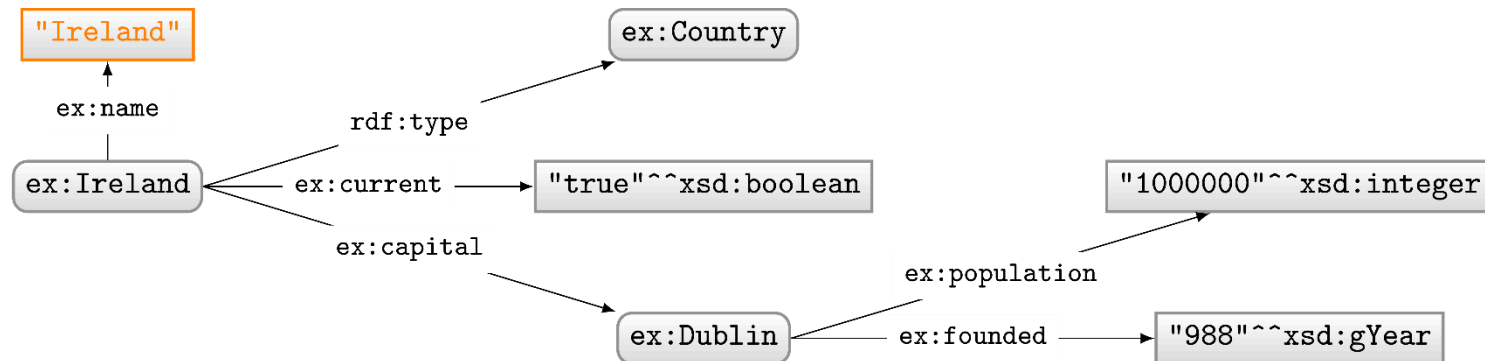
xsd:time	"05:04:12", "05:04:12Z", "05:04:12.00-10:00"	Z indicates +00:00 timezone
xsd:date	"2012-02-29", "2012-12-31+04:00"	Timezone optional
xsd:dateTime	"2012-12-31T00:01:02.034"	Timezone optional
└ xsd:dateTimeStamp	"2012-12-31T00:01:02+04:00"	Timezone required
xsd:duration	"P6Y9M15DT25H61M4.2S", "P6Y4.2S"	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

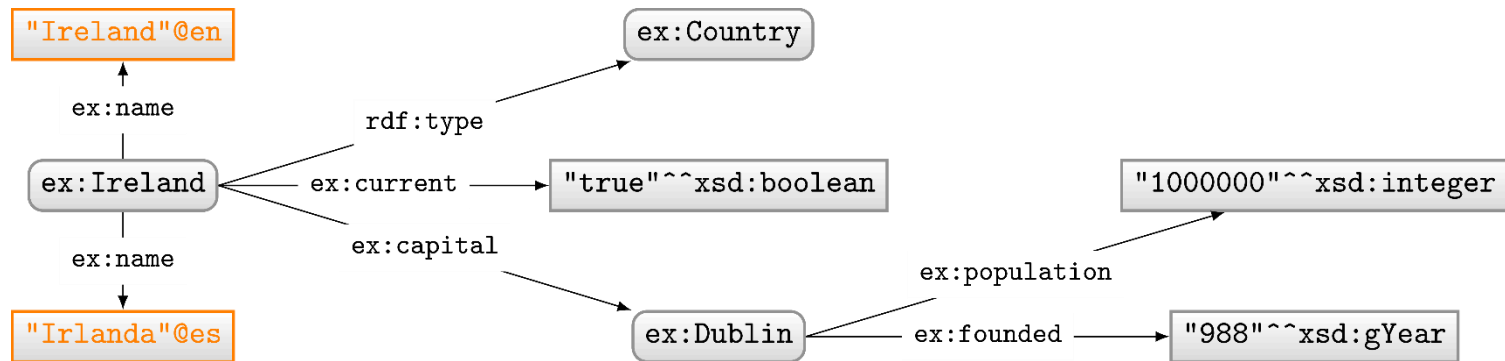
TEXT

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
└ xsd:name	"ns:some_name"	XML names
└ xsd:NCName	"some_name"	XML names: no colons
└ xsd:NMTOKEN	"1some_name"	XML names: 1 st char relaxed
xsd:base64Binary	"QS5ILiBuZWVkcYBhIHNTb2t1Lg=="	Base-64 encoded strings
xsd:hexBinary	"2e2e2e20616e6420616c6366f686f6c2e"	Hexadecimal strings
xsd:anyURI	"http://example.com/",	Full IRI strings
rdf:HTML	"<div class="display">some data</div>"	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

<i>subject</i>	<i>predicate</i>	<i>object</i>	
ex:Ireland	ex:capital	<code>_:b1</code>	✓ CORRECT
<code>_:b2</code>	ex:capital	ex:Dublin	✓ CORRECT
ex:Ireland	<code>_:b3</code>	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

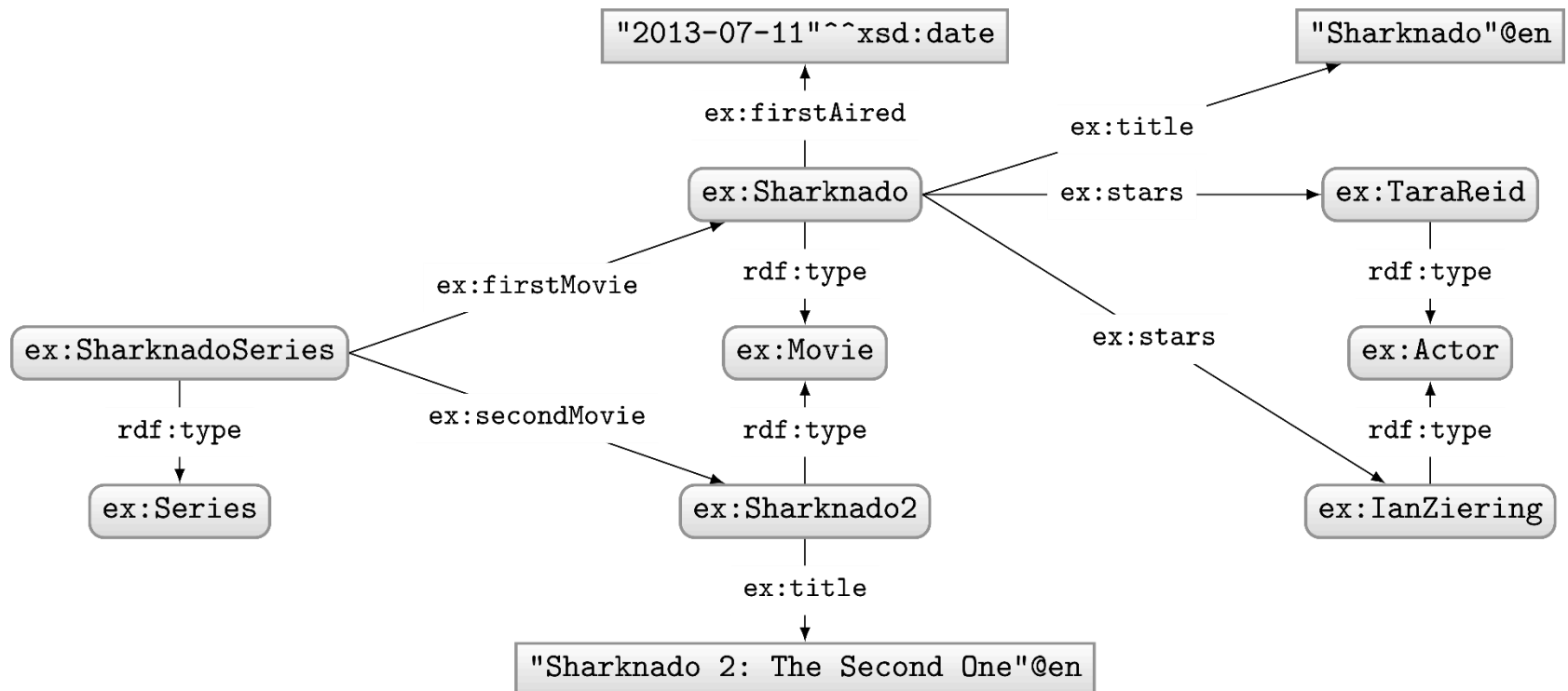
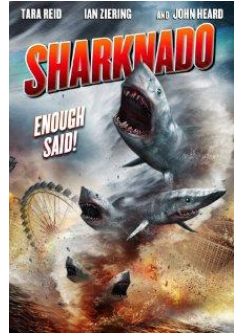
<i>subject</i>	<i>predicate</i>	<i>object</i>
[IRI, Blank Node]	[IRI]	[IRI, Blank Node, Literal]

MODELLING DATA IN RDF

LET'S MODEL SOMETHING IN RDF ...

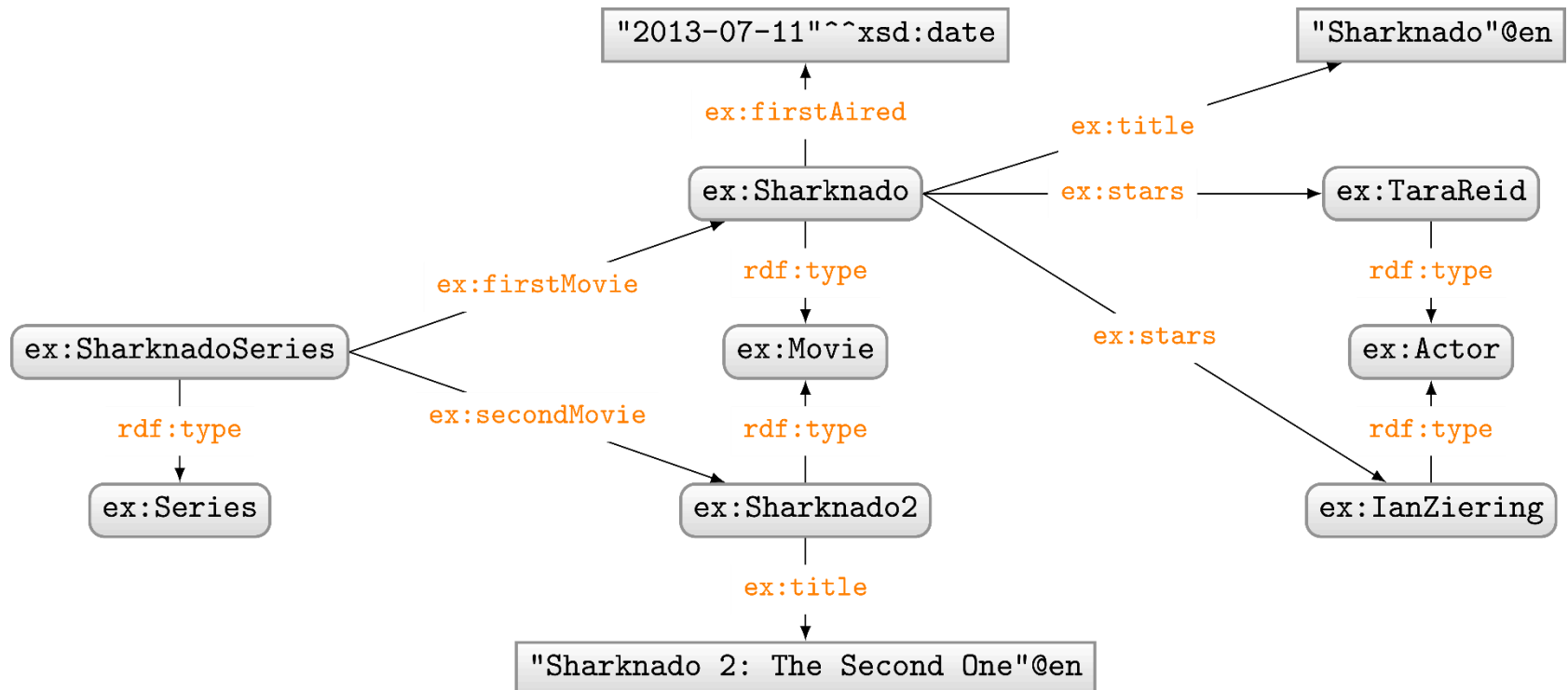
Model the following in RDF:

"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 another called 'Sharknado 2: The Second One'."



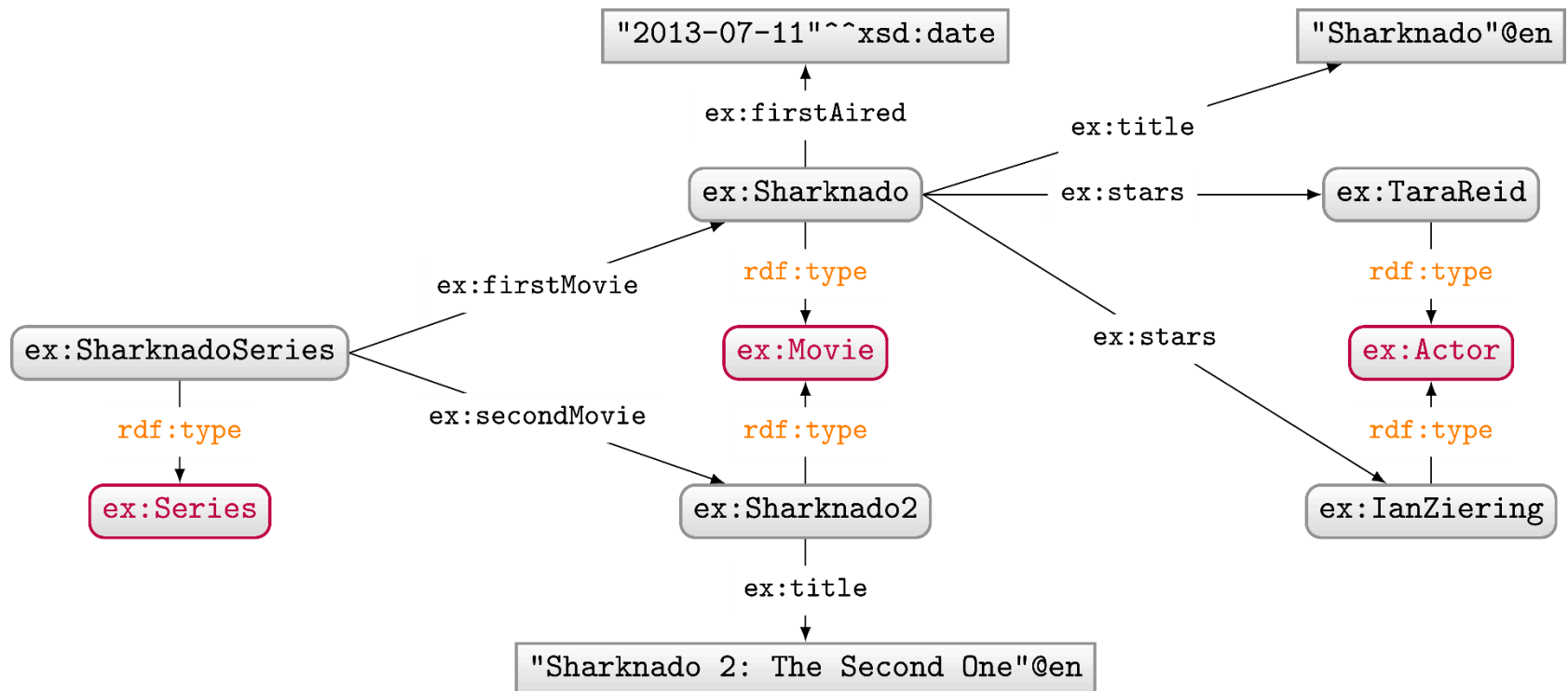
RDF PROPERTIES

- 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 property `rdf:type` to type a resource



MODELLING IN RDF NOT ALWAYS SO SIMPLE

Model the following in RDF:

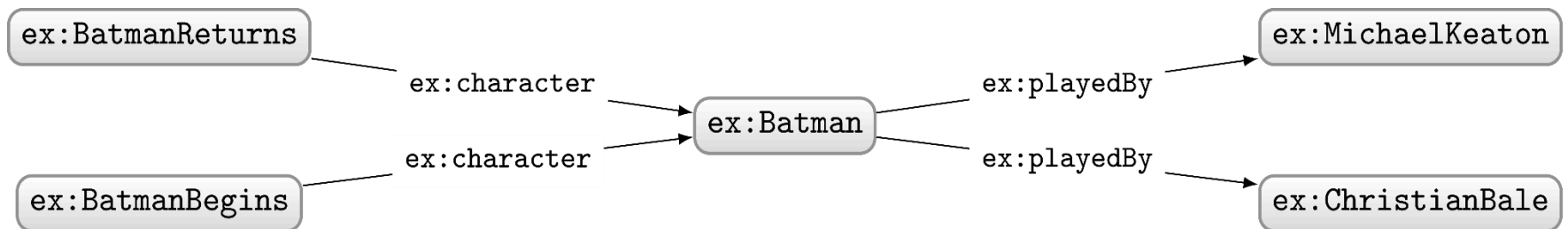
"'Batman Returns' stars Michael Keaton in the role of 'Batman'."

ex:BatmanReturns — ex:character —> ex:Batman — ex:playedBy —> ex:MichaelKeaton

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'."

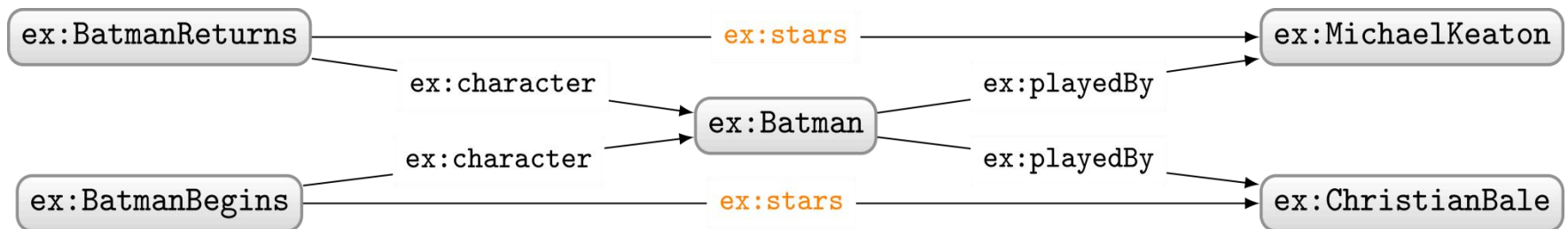


Problem?

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'."

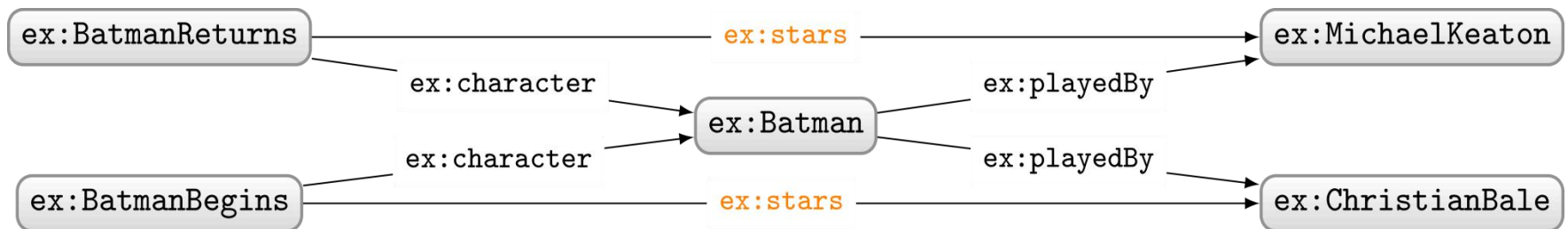


Problem?

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:

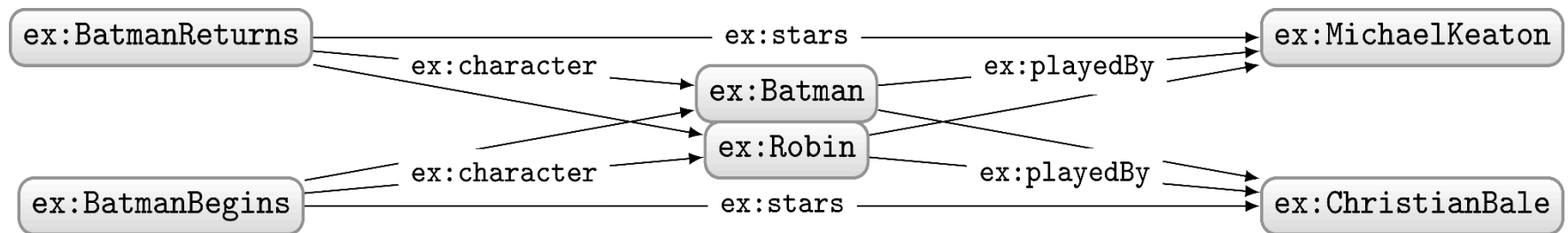
"'Batman Returns' stars Michael Keaton in the role of 'Batman'."

"'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 😊

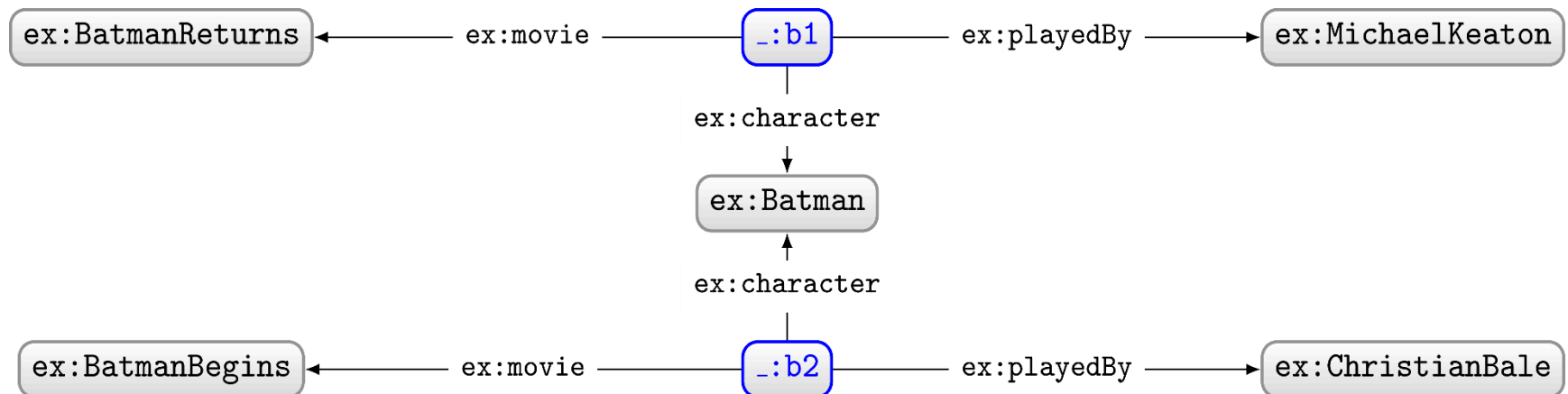


Who played which character in which movie?

MODELLING N-ARY RELATIONS

Model the following in RDF:

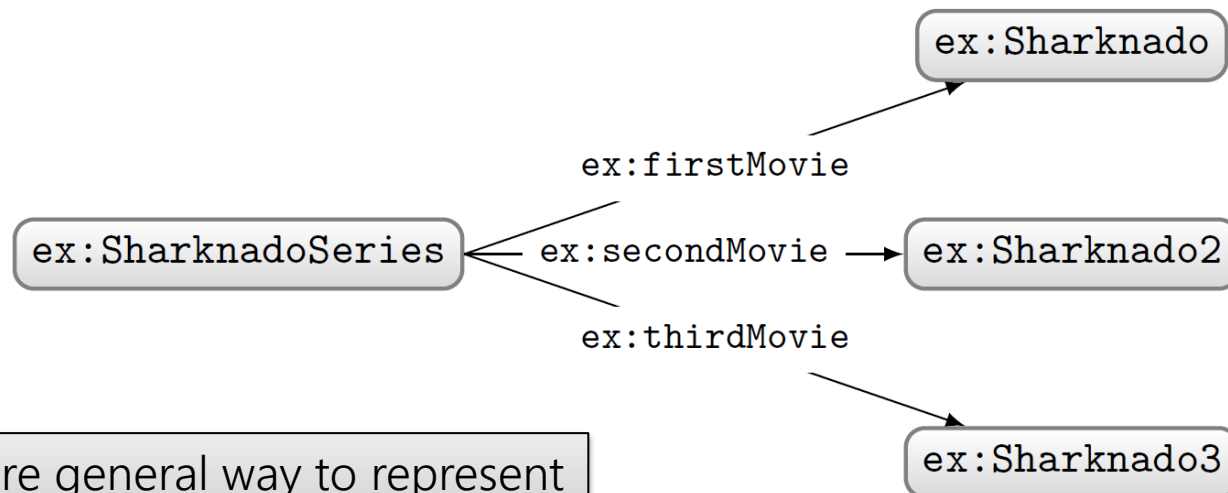
"'Batman Returns' stars Michael Keaton in the role of 'Batman'."
"'Batman Begins' stars Christian Bale in the role of 'Batman'."



MODELLING IN RDF NOT ALWAYS SO SIMPLE

Model the following in RDF:

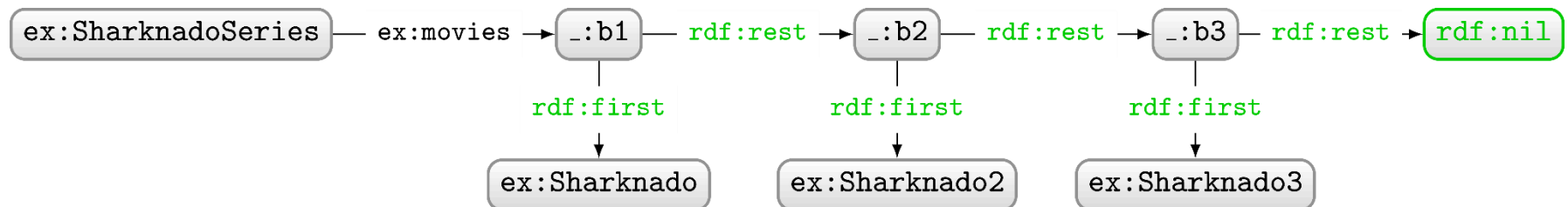
"The first movie in the Sharknado series is 'Sharknado'.
The second movie is 'Sharknado 2: The Second One'.
The third movie is 'Sharknado 3: Oh Hell No!'."



More general way to represent
lists as a graph?

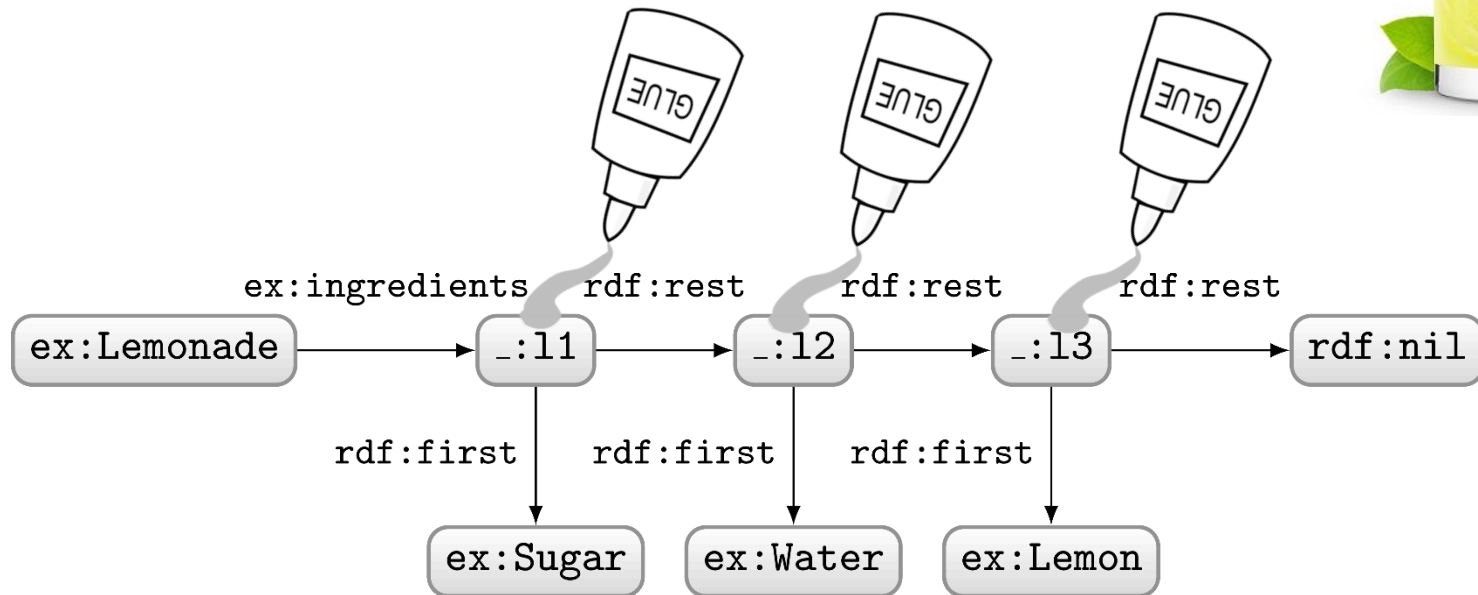
RDF COLLECTIONS: MODEL ORDERED LISTS

- 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

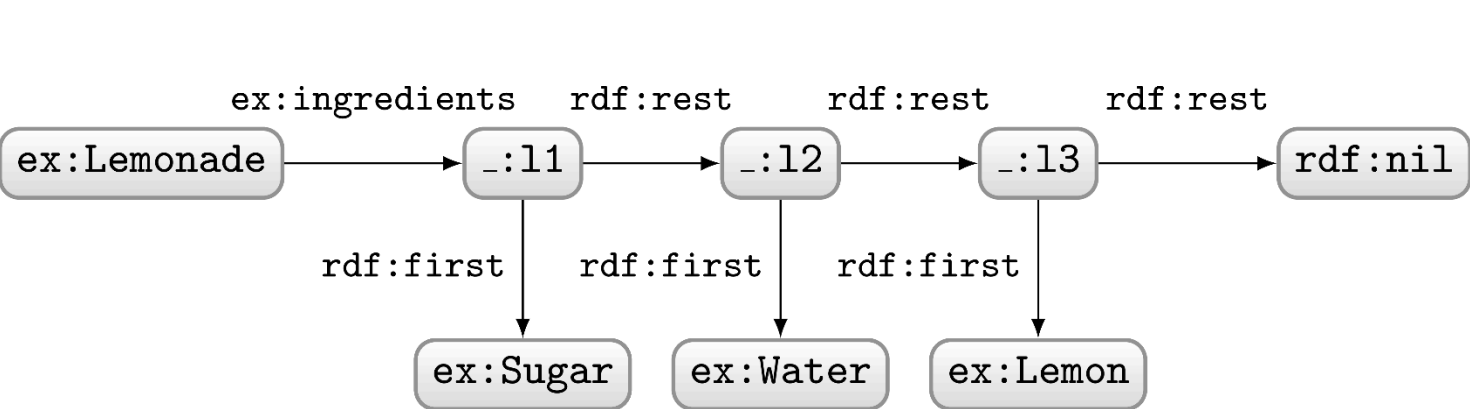


RDF COLLECTIONS: GENERIC MODELLING

- Not just for Sharknado series



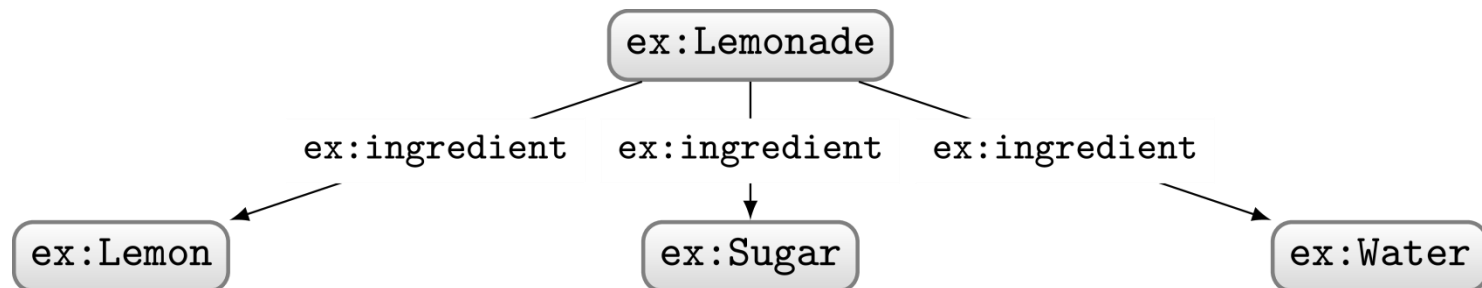
RDF COLLECTIONS: GENERIC MODELLING



Which modelling is better?

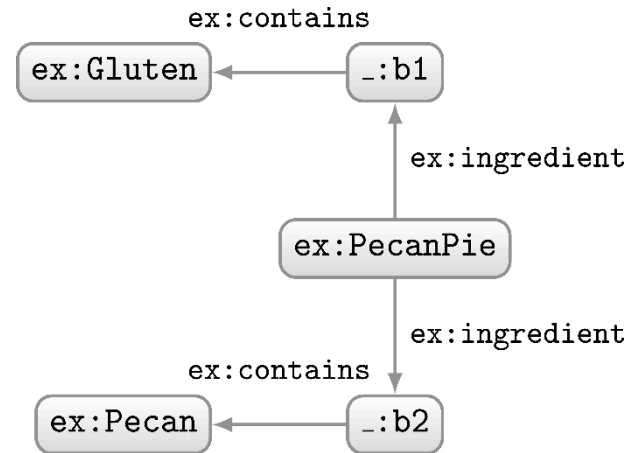
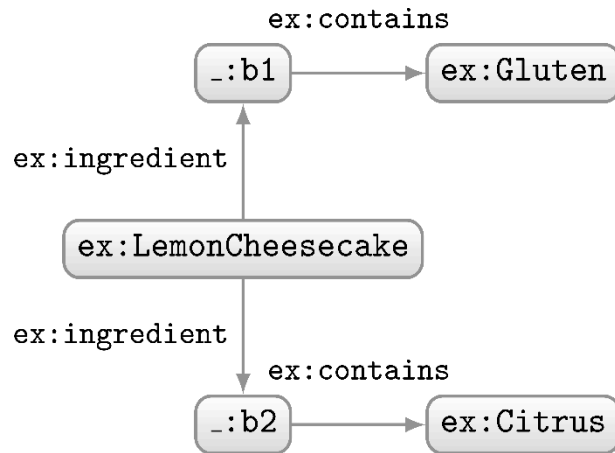
If the order of ingredients matters, the collection above is needed.*
Otherwise, the graph below is much simpler (and better).

* Sometimes collections are used for unordered elements to indicate a closed set, but this is not something recommended in general.

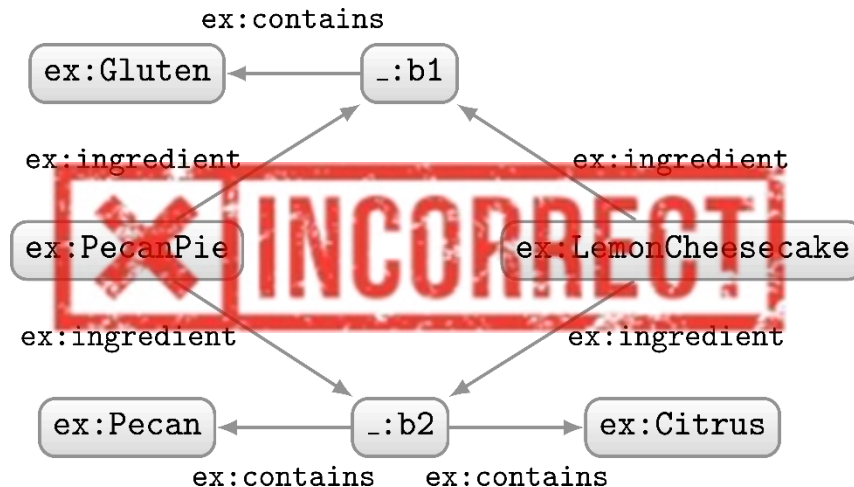


BLANK NODES ADD COMPLEXITY

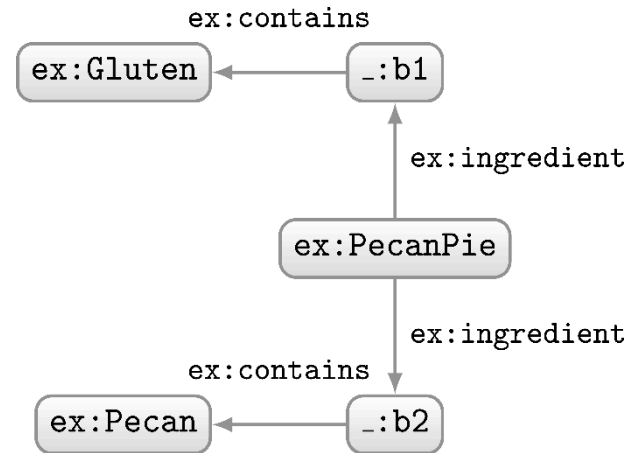
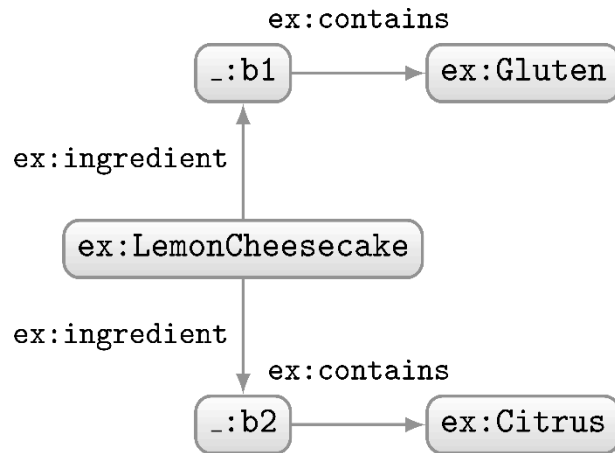
BLANK NODES ARE LOCAL IDENTIFIERS



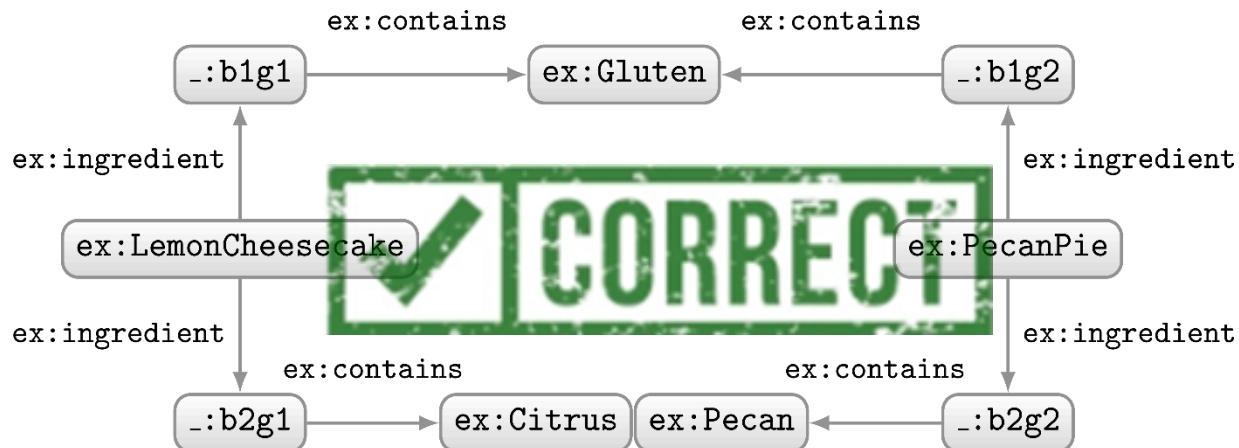
How should we combine these two RDF graphs?



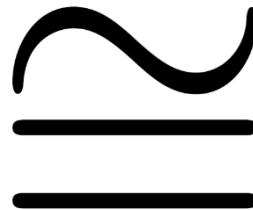
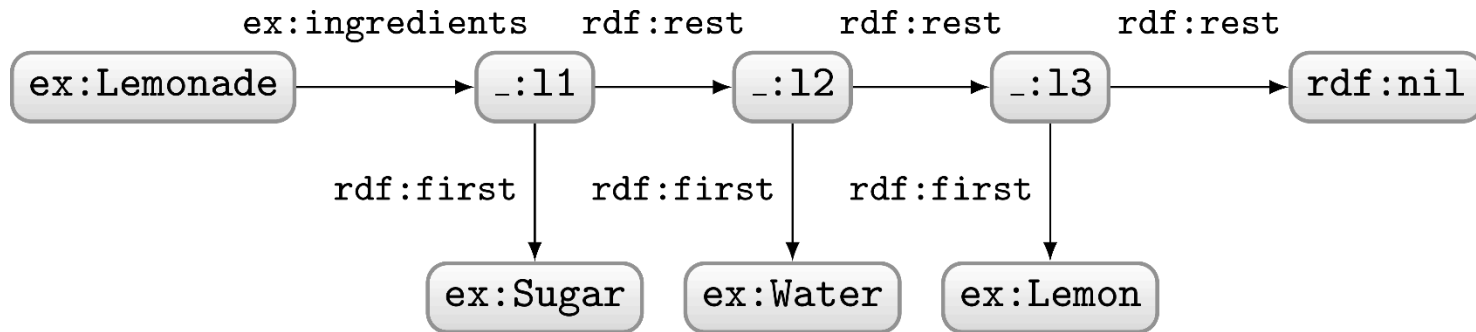
BLANK NODES ARE LOCAL IDENTIFIERS



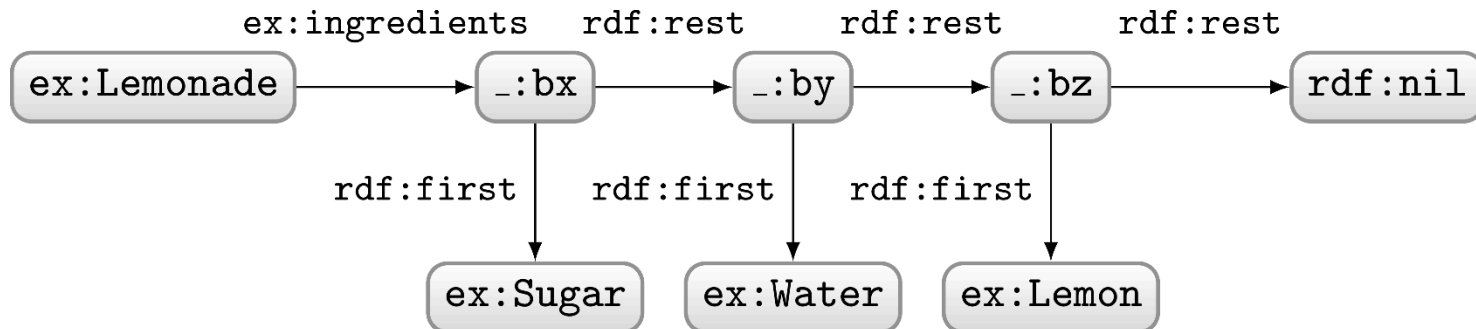
How should we combine these two RDF graphs?



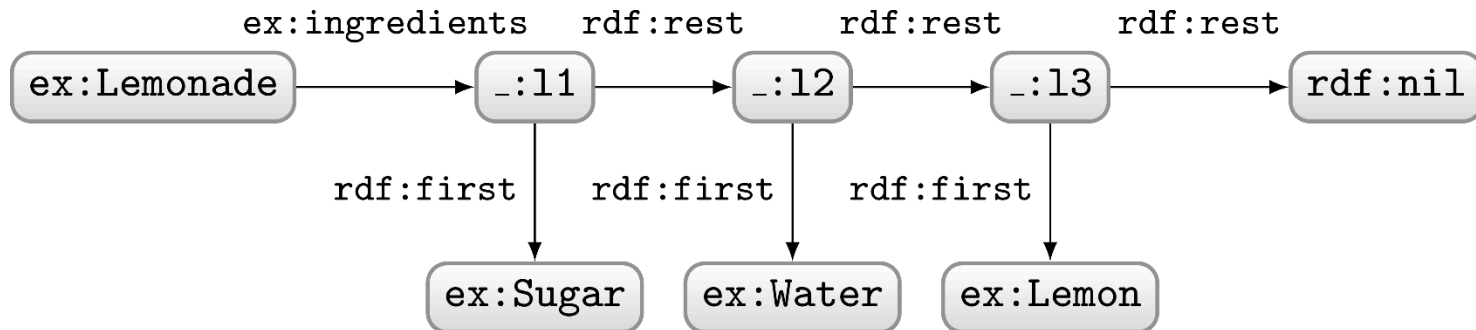
BLANK NODE NAMES AREN'T IMPORTANT ...



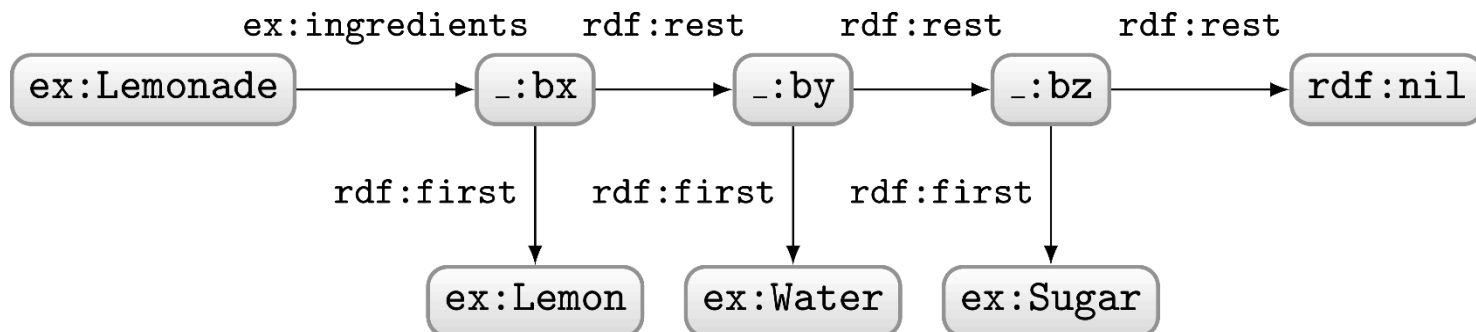
(Isomorphic)



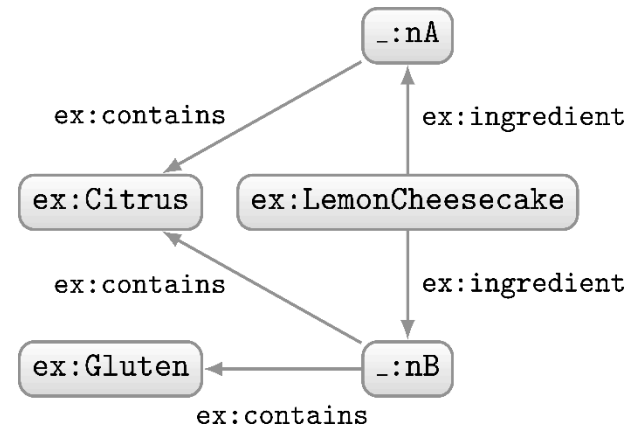
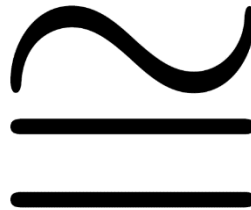
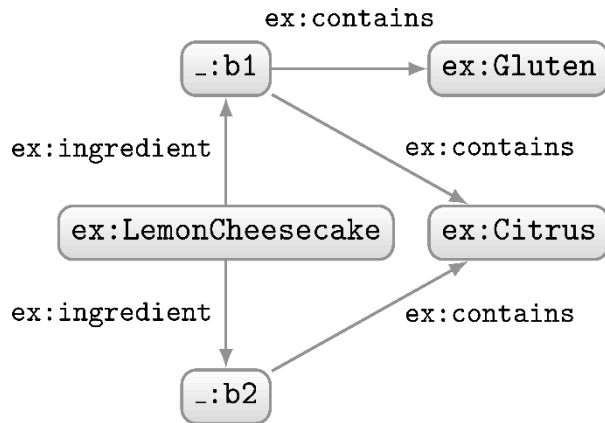
BLANK NODE NAMES AREN'T IMPORTANT ...



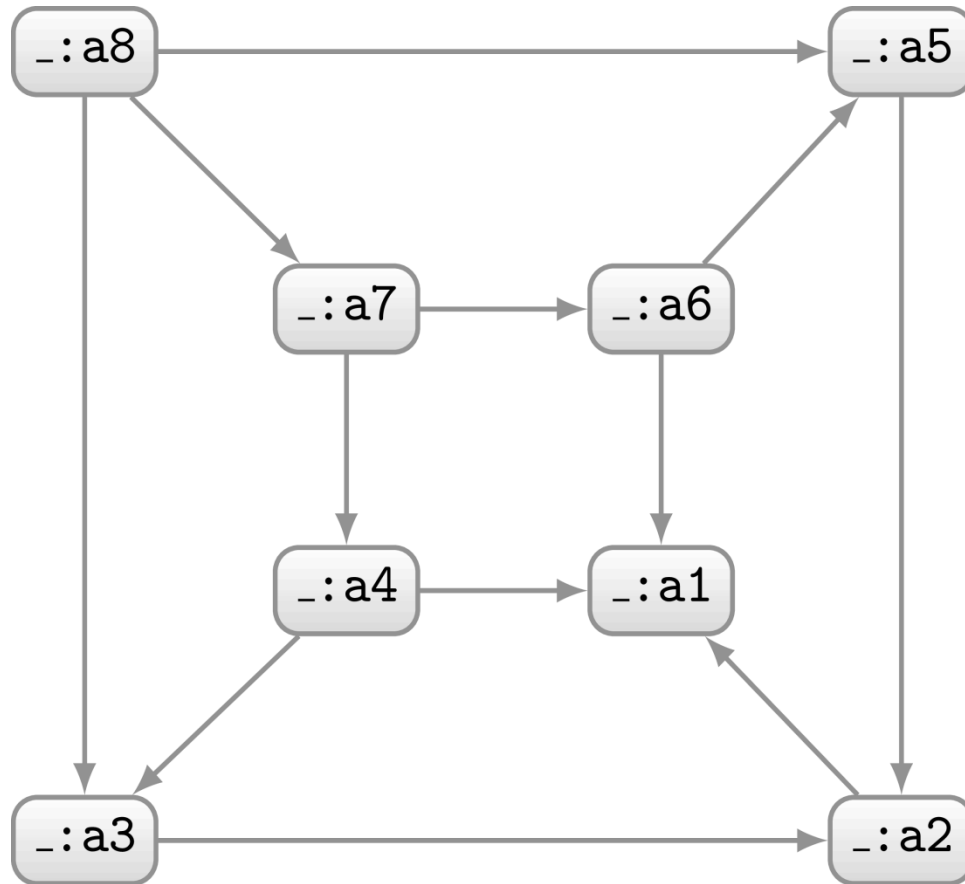
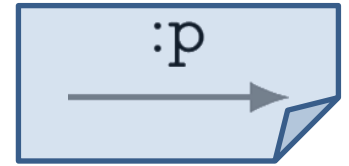
(Not Isomorphic!)



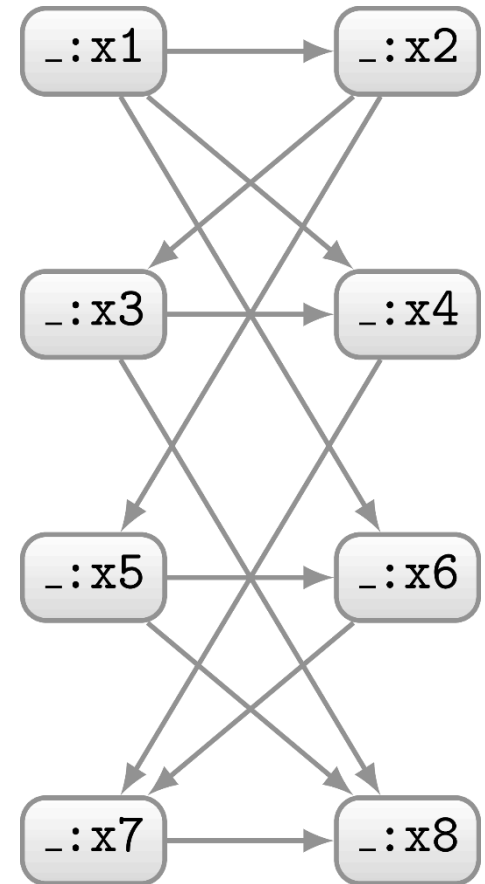
ARE TWO RDF GRAPHS THE “SAME”?



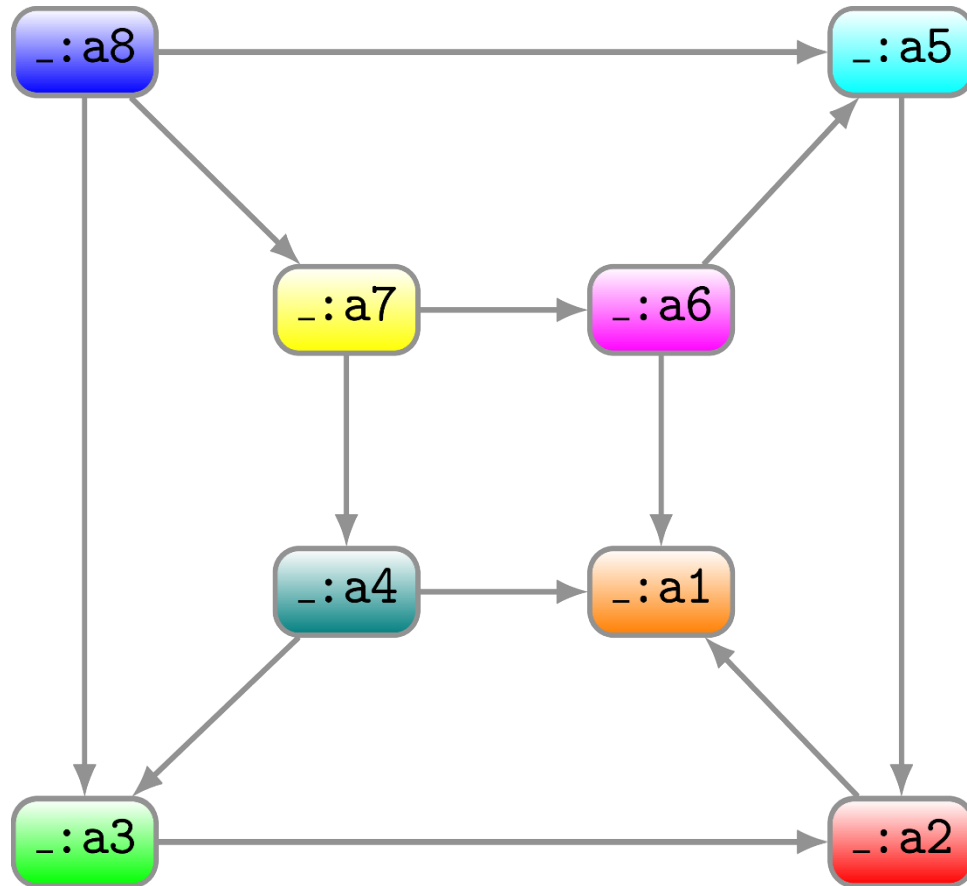
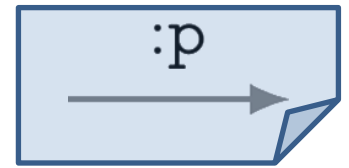
ARE TWO RDF GRAPHS THE “SAME”?



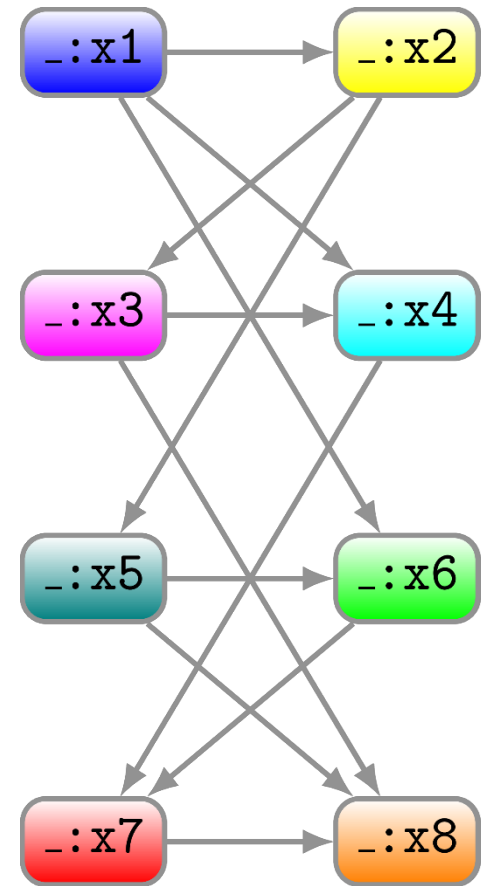
\cong



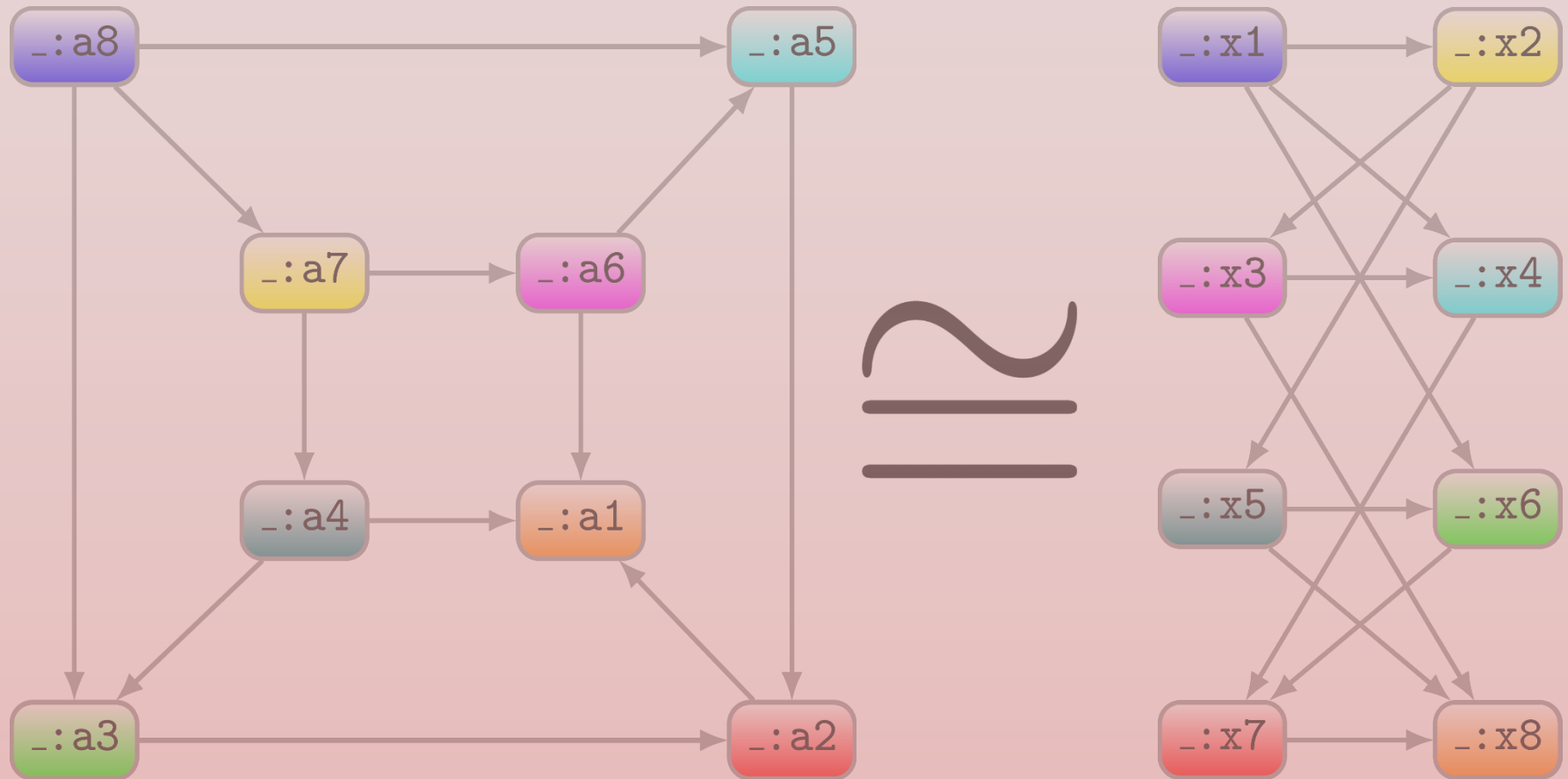
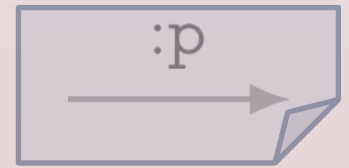
ARE TWO RDF GRAPHS THE “SAME”?



\approx



ARE TWO RDF GRAPHS THE “SAME”?



Hard problem: GI-COMplete

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
- Difficult to read

```
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

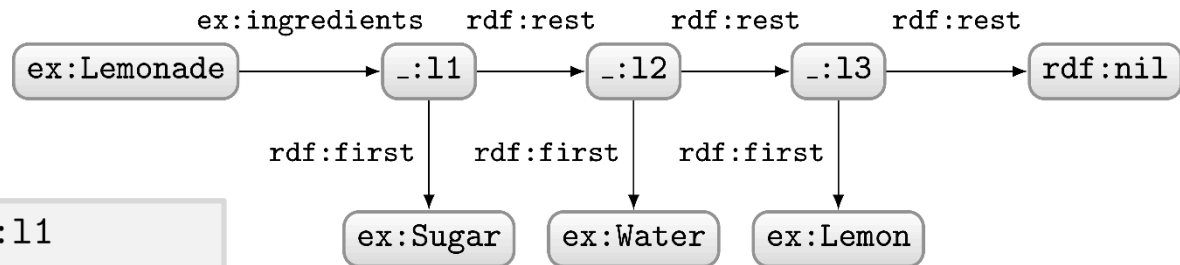
Repeat S (‘;’) SP (‘,’)

`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> ) .
```



RDF ...

SEMANTIC WEB: DATA

DATA:

Ireland

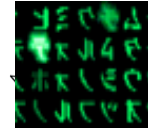


(Ireland,partOf,Europe)

(Ireland,isA,Country.)

(Ireland,capital,Dublin)

Dublin



(Ireland,capital,Dublin)

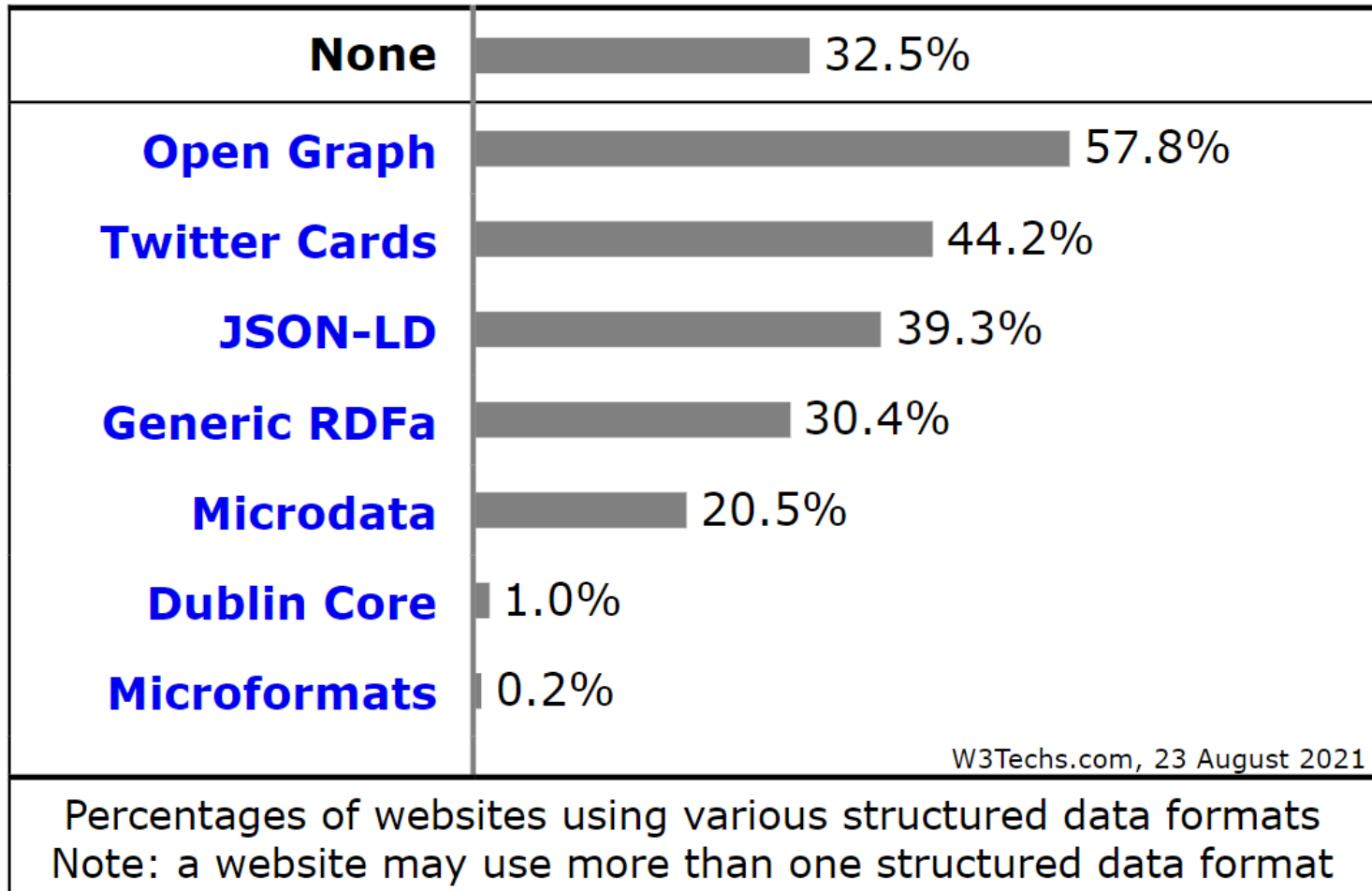
(Dublin,population,1000000)

RDF is based on triples:

(Ireland,capital,Dublin)

(*subject,predicate,object*)

BROADLY ADOPTED



QUESTIONS?

