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Computational Logic Exercises
Module III – The Logic of Entities (LOE)

Vincenzo Maltese

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Define a LOE model from natural language

Define a domain D and a model M for the following text in natural language.

The Eiffel Tower is located in the city of Paris. The Eiffel Tower is a place that has been visited by Alice and Bill.

ANSWER:

D = <E, C, P>;

E = {Alice, Bill, The Eiffel Tower, Paris} C = {place, city} P = {locatedIn, visited}

M = {place(The Eiffel Tower), city(Paris), locatedIn(The Eiffel Tower, Paris), visited(Alice, The Eiffel Tower), visited(Bill, The Eiffel Tower)}

NOTE: there are some implicit concepts that are not represented, e.g. the fact that Alice and Bill are persons; in this example all properties are Object Properties.

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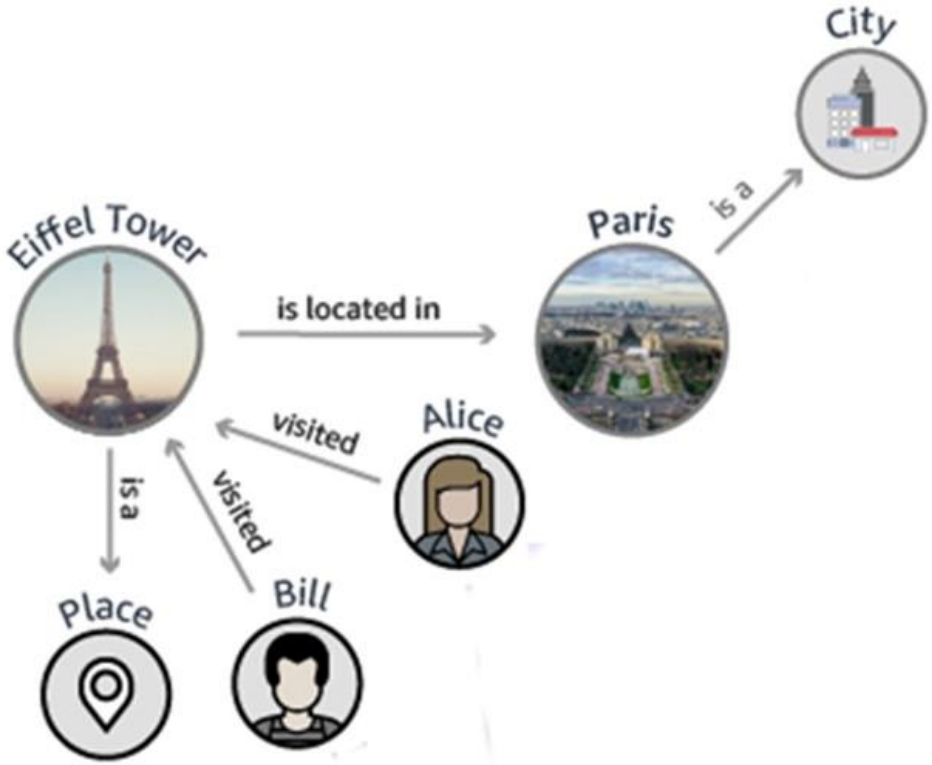
Design a knowledge graph from a model

Design a knowledge graph for the previous model



https://aws.amazon.com/neptune/knowledge-graphs-on-aws/

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Define a theory from natural language (I)

Given the following text in natural language, design a corresponding knowledge graph and then both a theory and an interpretation function in LOE.

The Mona Lisa was created by Leonardo da Vinci.
“La Joconde a Washington” is about The Mona Lisa.
Bob is a person born on 14 July 1990.
Bob is a friend of Alice and is interested in The Mona Lisa.

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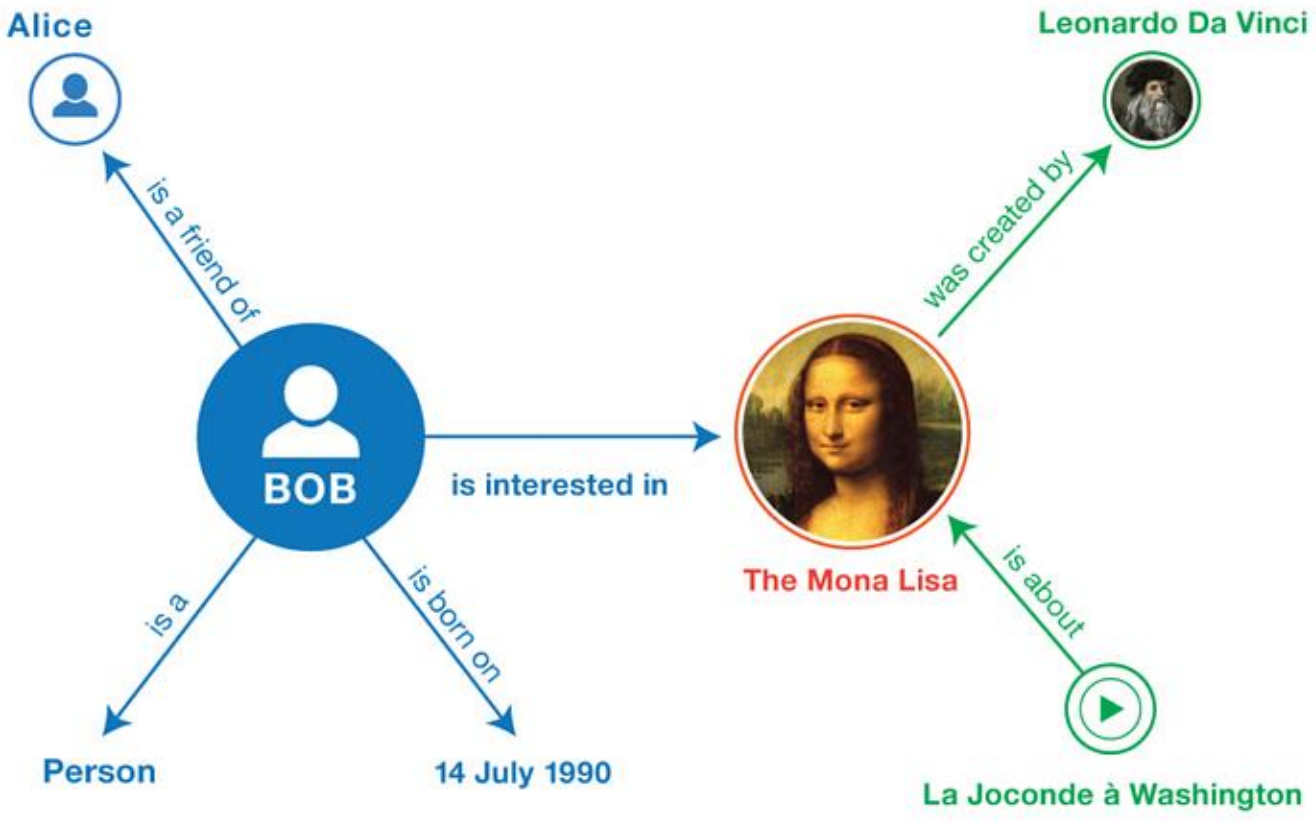
Define a theory from natural language (II)

ANSWER



Theory T

wasCreatedBy(TheMonaLisa, LeonardoDaVinci)

isAbout(LaJocondeAWashington, TheMonaLisa)

Person(Bob)

friendOf(Bob, Alice)

isBornOn(Bob,"14 July 1990")

interestedIn(Bob, TheMonaLisa)

NOTE: isBornIn is a Data Property, while the other properties are Object Properties.

https://towardsdatascience.com/a-guide-to-the-knowledge-graphs-bfb5c40272f1

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Define a theory from natural language (III)

Theory T

wasCreatedBy(TheMonaLisa, LeonardoDaVinci)

isAbout(LaJocondeAWashington, TheMonaLisa)

Person(Bob)

friendOf(Bob, Alice)

isBornOn(Bob,”14 July 1990”)

interestedIn(Bob, TheMonaLisa)

Interpretation function I

I(Bob) = Bob White

I(Alice) = Alice Black

I(LeonardoDaVinci) = Leonardo Da Vinci

I(TheMonaLisa) = The Mona Lisa

…

I(Person) = {Bob White}

I(wasCreatedBy) = {(The Mona Lisa, Leonardo Da Vinci)}

I(isAbout) = {(La Joconde a Washington, The Mona Lisa)}

…

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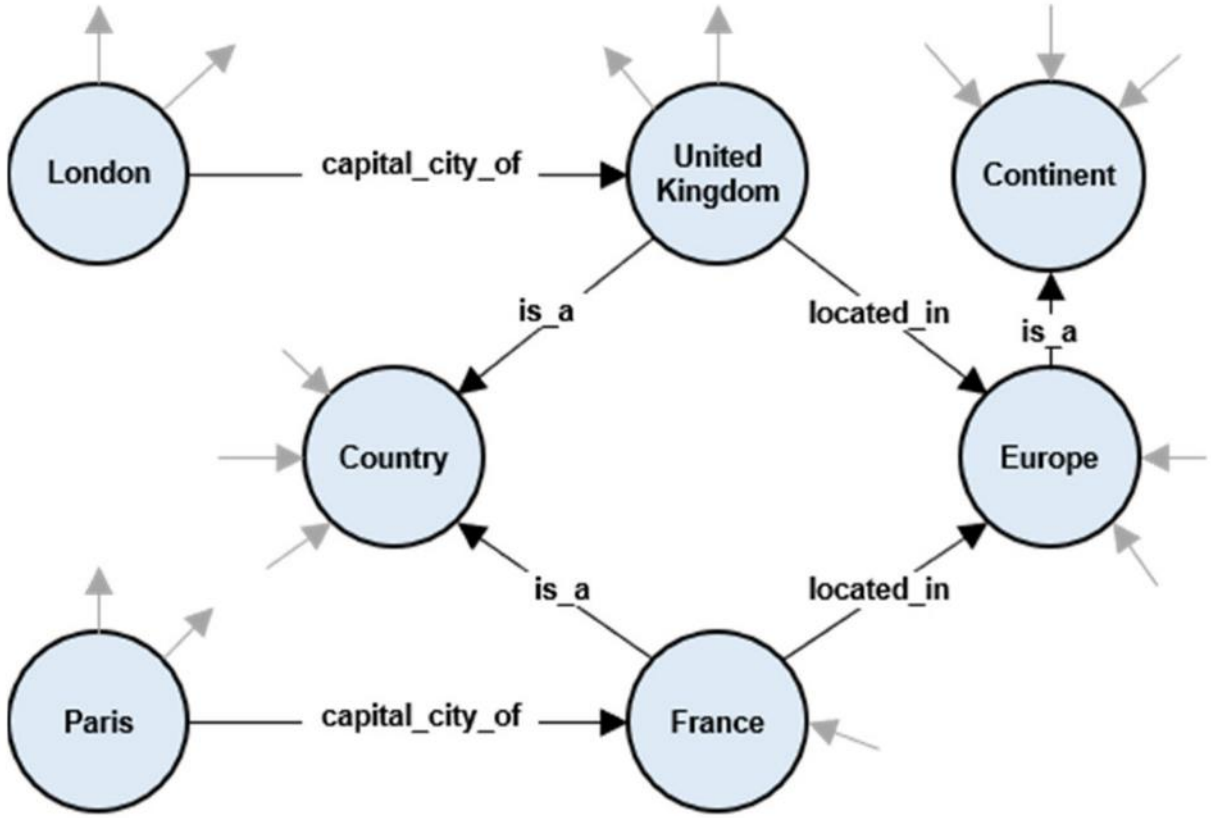
Design a knowledge graph from a triple store (informal model)

	Head	Relation	Tail
1	London	capital_city_of	United Kingdom
2	United Kingdom	is_a	Country
3	United Kingdom	located_in	Europe
4	Europe	is_a	Continent
5	Paris	capital_city_of	France
6	France	is_a	Country
7	France	located_in	Europe



https://www.mdpi.com/2071-1050/14/19/12299

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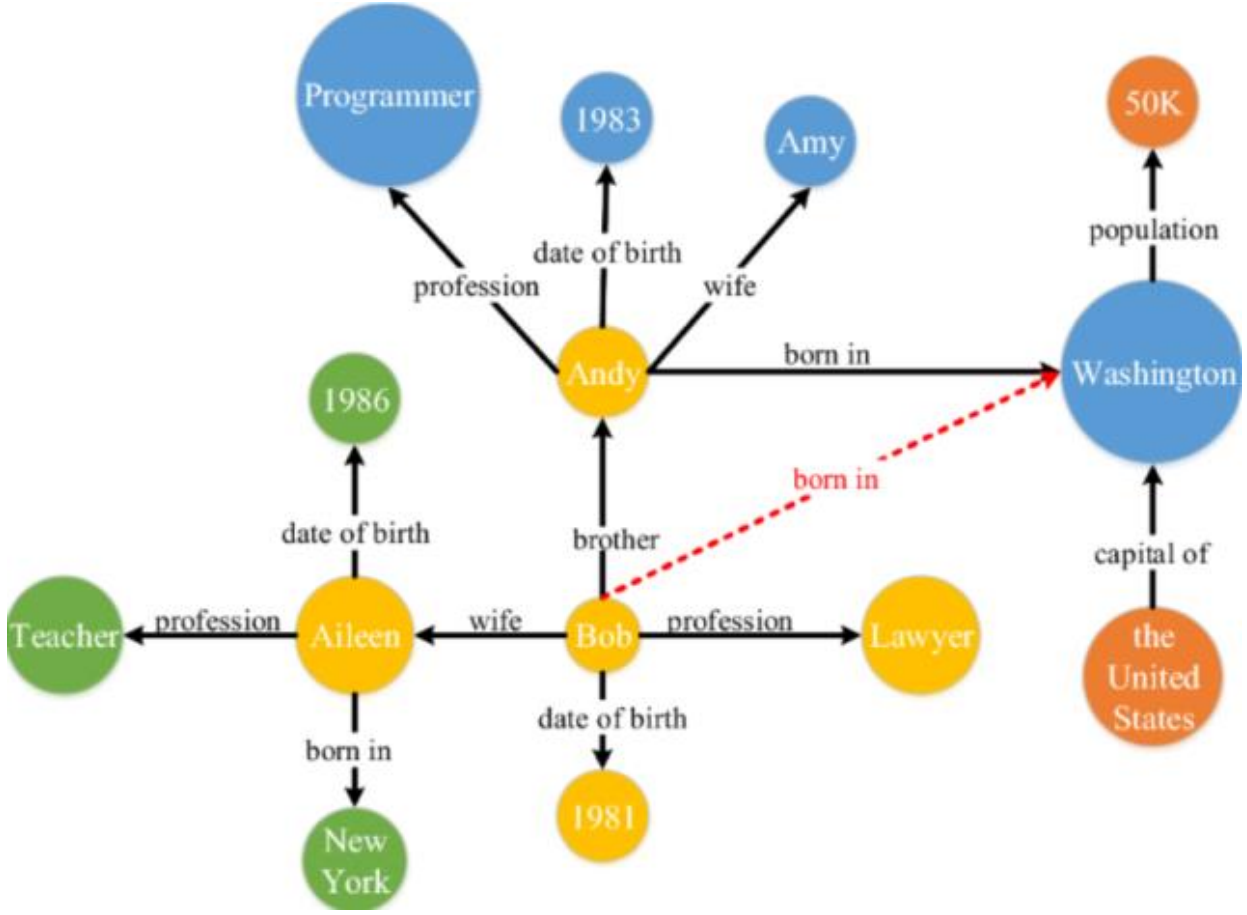
Define a theory from a knowledge graph

Given the following knowledge graph, define a theory for it.



THEORY T

profession(Andy, programmer)

dateOfBirth(Andy, 1983)

wife(Andy, Amy)

bornIn(Andy, Washington)

brotherOf(Bob, Andy)

…

https://vitalflux.com/knowledge-graph-concepts-machine-learning-examples/

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Define a model from a LOE theory

Given a theory, define a linguistic model for it

THEORY T

profession(A, P)

dateOfBirth(A, Y)

wife(A, C)

bornIn(A, W)

brotherOf(B, A)

MODEL M

Andy is born on 1993 in Washington. He is married with Carol and currently employed as programmer. He has a brother called Bob.

M as a set of facts in natural language

Andy is born on 1993.

Andy is born in Washington.

Andy is married with Carol.

The profession of Andy is the programmer.

Andy's brother is called Bob.

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Define an entailment relation

Define an entailment relation ⊨ between M and all formulas w in T

ANSWER: Remind that M ⊨ w if and only if I(w) ∈ M for every w ∈ T. Therefore, we need to come up with the I.

I(A) = Andy

I(B) = Bob

I(C) = Carol

I(W) = Washington

I(Y) = 1983

I(P) = programmer

I(profession) = {(I(A), I(P)}

I(dateOfBirth) = {(I(A), I(Y)}

I(wife) = {(I(A), I(C)}

I(bornIn) = {(I(A), I(W)}

I(brotherOf) = {(I(B), I(A)}

NOTE: in this case, the KG only includes entities and properties;
i.e. the KG does not contain concepts to be interpreted

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Decide weather M is a model for the theory T (model checking)

THEORY T

profession(A, P)

dateOfBirth(A, Y)

wife(A, C)

bornIn(A, W)

brotherOf(B, A)

Model M

Andy is born on 1929.

Andy is born in New York City.

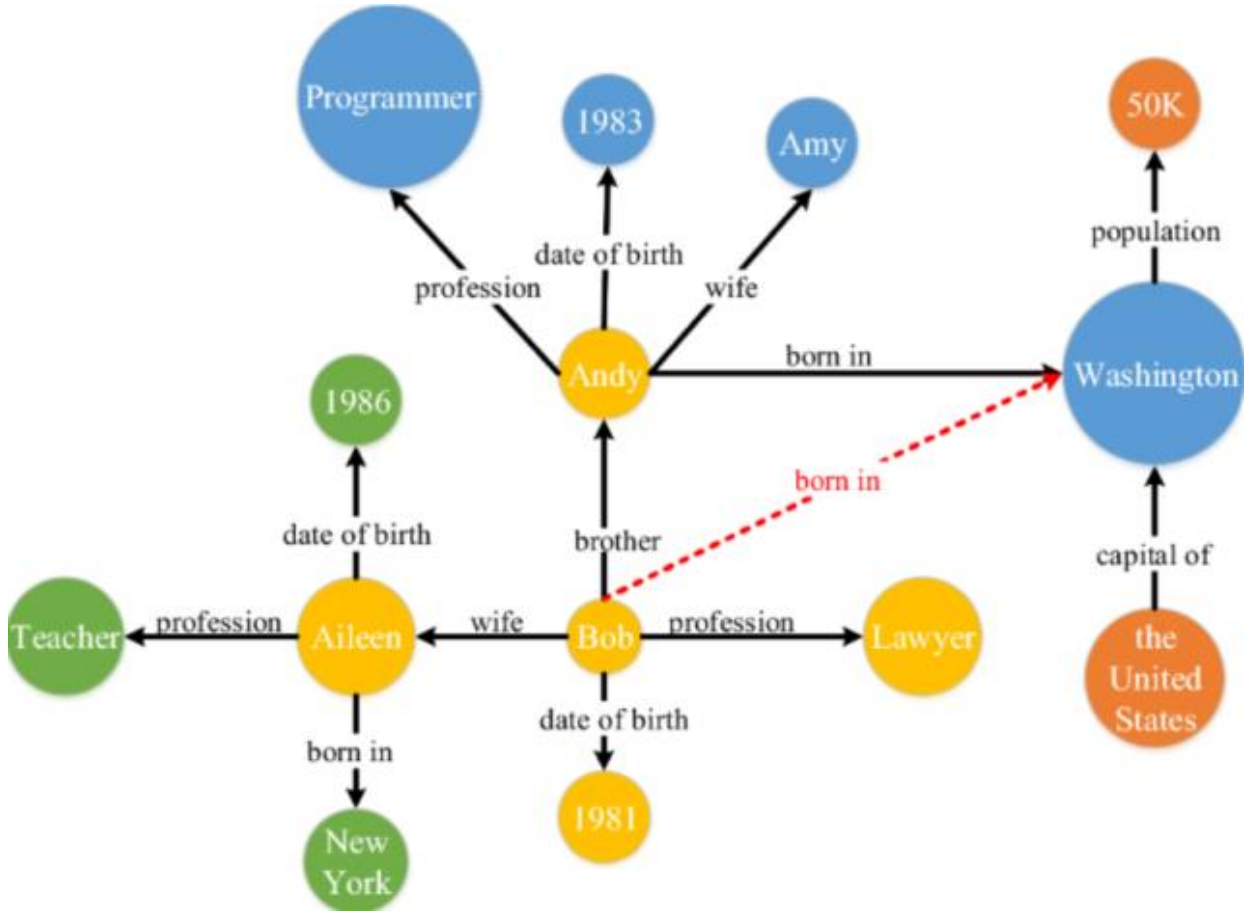
Andy is married with Carol.

The profession of Andy is the programmer.

Andy's brothers are called Bob and Ralph.

ANSWER: yes, despite T is not complete w.r.t. M

Query answering on a knowledge graph (model checking)



Answering a query q on the basis of a knowledge graph KG is basically model checking: KG ⊨ q

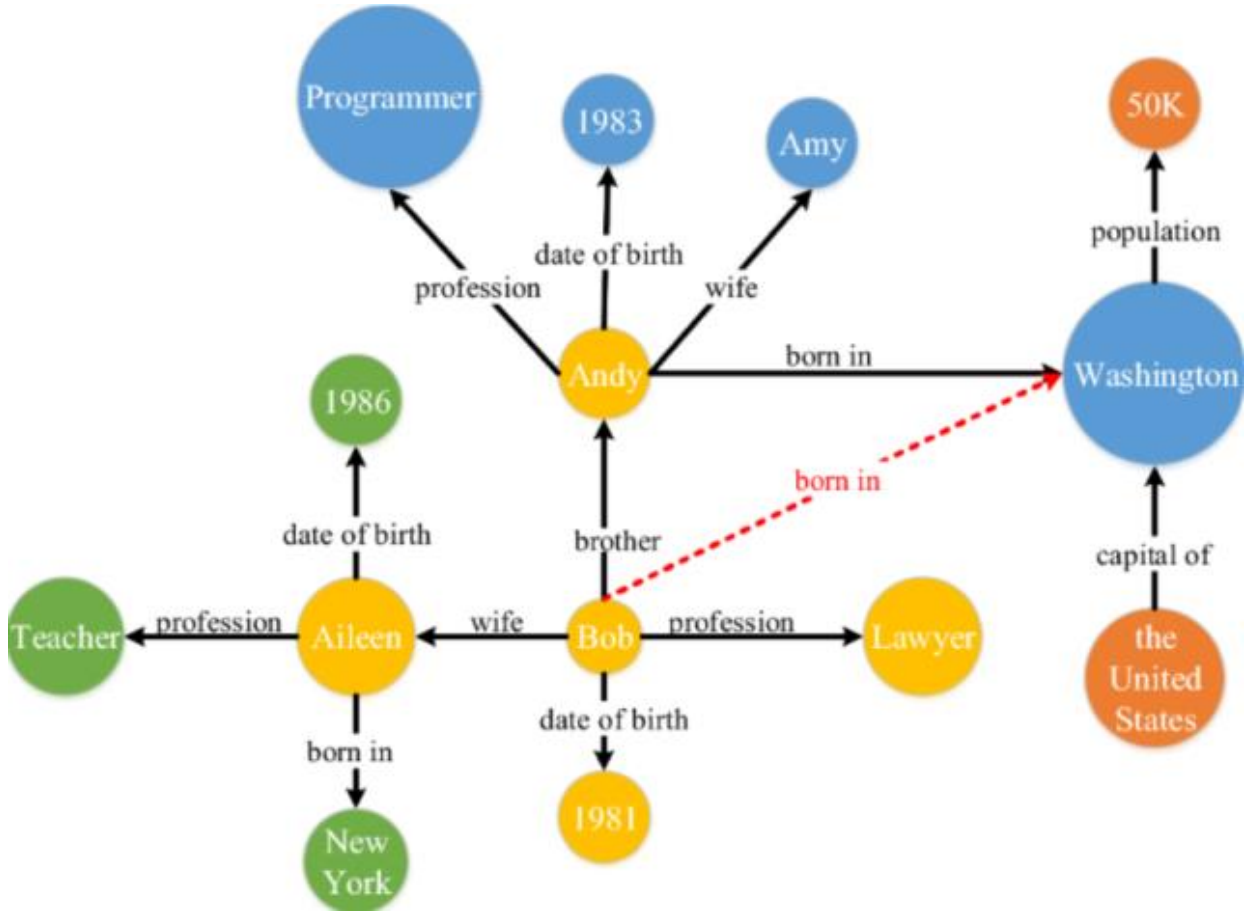
For instance:

KG ⊨ bornin(Andy, Washington)

KG ⊨ profession(Bob, Lawyer)

KG ⊭ wife(Andy, Aileen)

Finding entities on a knowledge graph (instance retrieval)



KG ⊨ wife

answer: {wife(Bob, Aileen), wife(Andy, Amy)}

KG ⊨person

answer = ∅

In fact, there is no explicit representation of concepts in this KG

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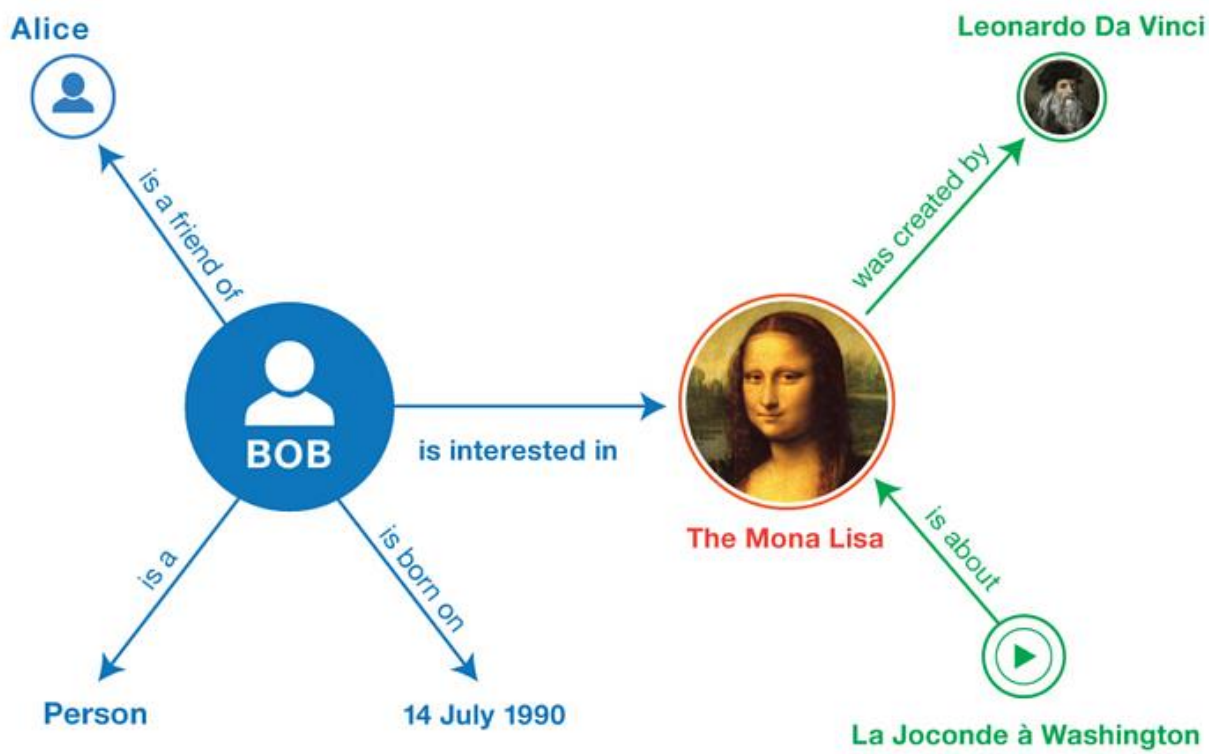
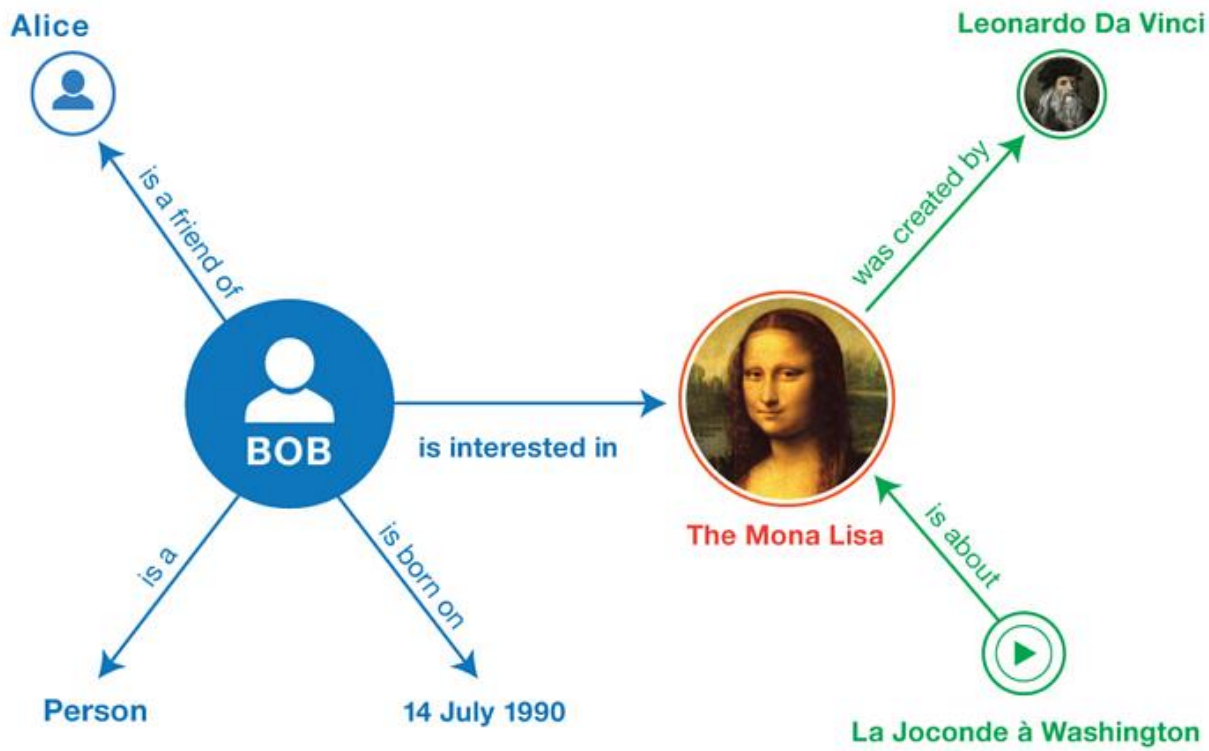
Languages to represent knowledge graphs: RDF (Turtle syntax)




```
01    BASE   <http://example.org/>
02    PREFIX foaf: <http://xmlns.com/foaf/0.1/>
03    PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
04    PREFIX schema: <http://schema.org/>
05    PREFIX dcterms: <http://purl.org/dc/terms/>
06    PREFIX wd: <http://www.wikidata.org/entity/>
07
08    <bob#me>
09        a foaf:Person ;
10        foaf:knows <alice#me> ;
11        schema:birthDate "1990-07-04"^^xsd:date ;
12        foaf:topic_interest wd:Q12418 .
13
14    wd:Q12418
15        dcterms:title "Mona Lisa" ;
16        dcterms:creator
<http://dbpedia.org/resource/Leonardo_da_Vinci> .
17
18
<http://data.europeana.eu/item/04802/243FA8618938F4117025F
17A8B813C5F9AA4D619>
19        dcterms:subject wd:Q12418 .
```

https://www.w3.org/TR/rdf11-primer/

Languages to query knowledge graphs: SPARQL



Q: Provide the name and number of persons who are friends

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name (COUNT(?friend) AS ?count)
WHERE {
    ?person foaf:name ?name .
    ?person foaf:knows ?friend .
} GROUP BY ?person ?name
```

Answer (in CSV format):

name	count
Bob	1

https://www.w3.org/TR/sparql11-overview/

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Example: schema.org

Types:

Close hierarchy / Open hierarchy

- Thing -
  - Action +
  - BioChemEntity +
  - CreativeWork +
  - Event +
  - Intangible +
  - MedicalEntity +
  - Organization +
  - Person +
  - Place +
  - Product +
  - Taxon

DataTypes:

Close hierarchy / Open hierarchy

- DataType -
  - Boolean +
  - Date
  - DateTime
  - Number +
  - Text +
  - Time

ETYPES

DTYPES

Event

A Schema.org Type

Thing > Event

Property	Expected Type
Properties from Event	
about	Thing
actor	Person
aggregateRating	AggregateRating
attendee	Organization or Person
director	Person
doorTime	DateTime or Time
duration	Duration
endDate	Date or DateTime

Object Property

Object Property

Data Property

Object Property

Object Property

Data Property

Data Property

Data Property

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Homework (I)

Answer to the following questions

1. What is the purpose of the Logic of Entities?
2. What are the key elements of the Logic of Entities?
3. What is the difference between an object property and a data property in an Entity Graph?
4. What is the form of facts in a domain of the Logic of Entities?
5. What is the form of assertions in a language of the Logic of Entities?
6. What is the form of a theory in the Logic of Entities?
7. What is the form of an interpretation function in the Logic of Entities?
8. What is entailment in the Logic of Entities?
9. What are the reasoning problems in the Logic of Entities?
10. Do we have negative facts in the Logic of Entities?

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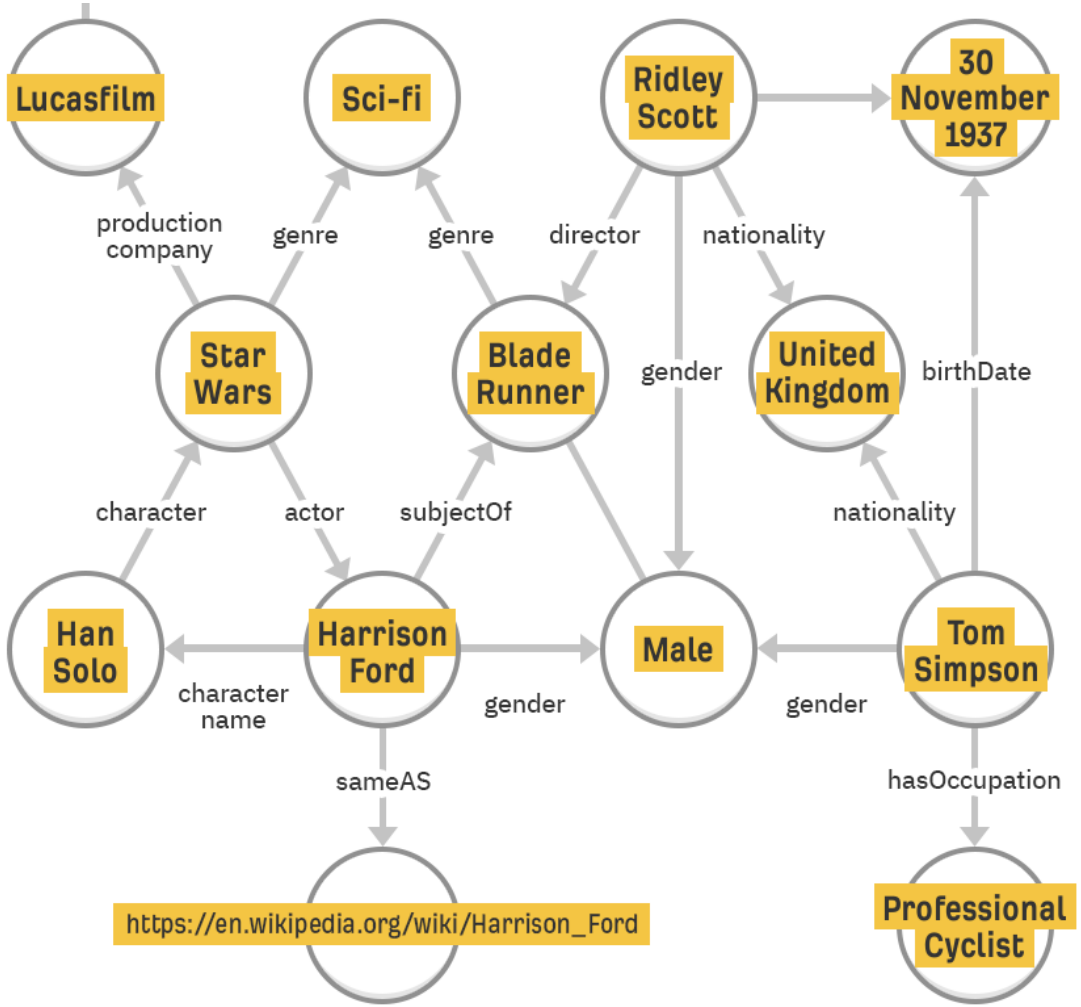
Homework (II)



https://ahrefs.com/blog/google-knowledge-graph/

Define a theory and an interpretation function for the knowledge graph.

Provide some examples of queries, as formulas in the logic of entities.

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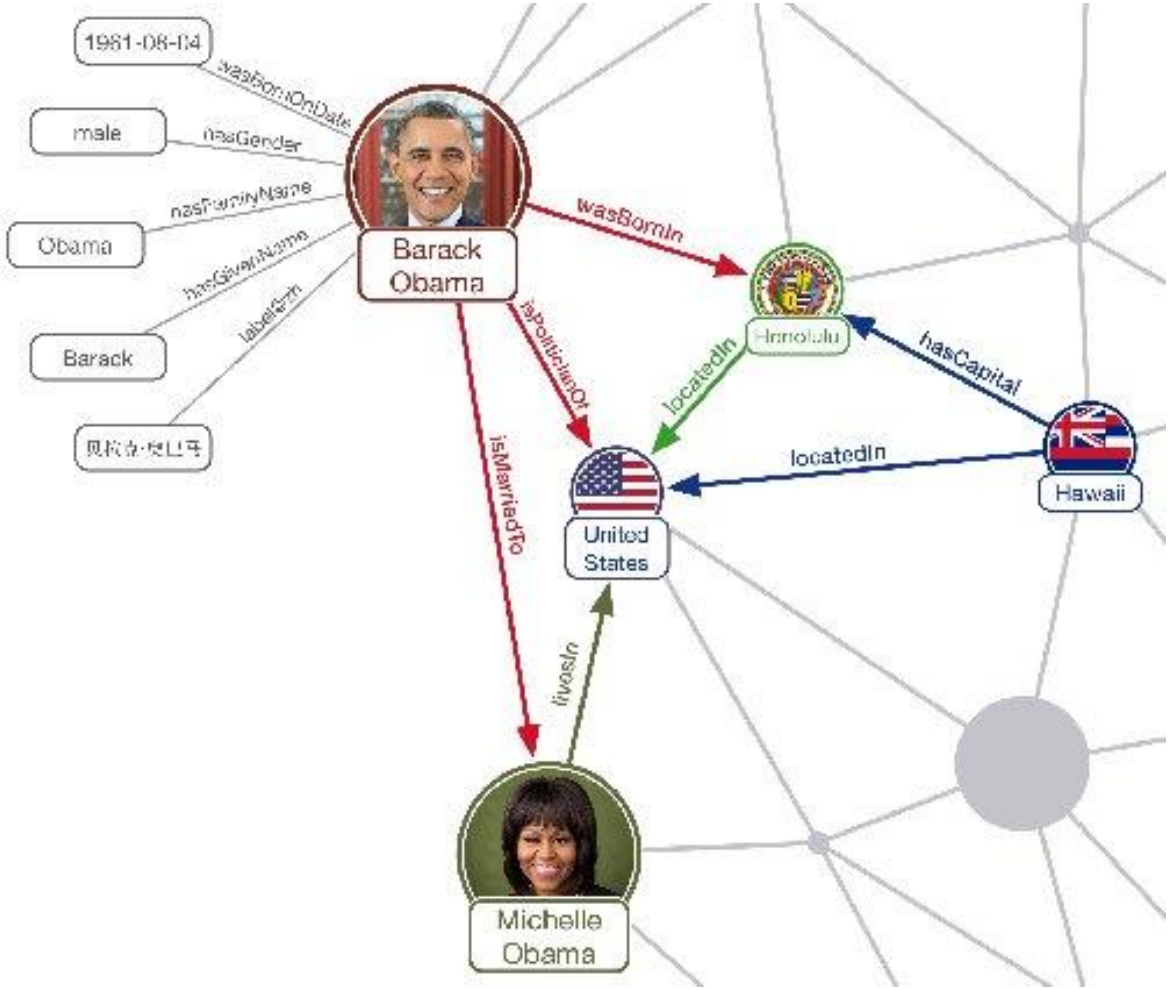
Homework (III)



Define a theory and an interpretation function for the knowledge graph.

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https://www.researchgate.net/publication/330701046_Fake_News_Detection_via_NLP_is_Vulnerable_to_Adversarial_Attacks/figures?lo=1

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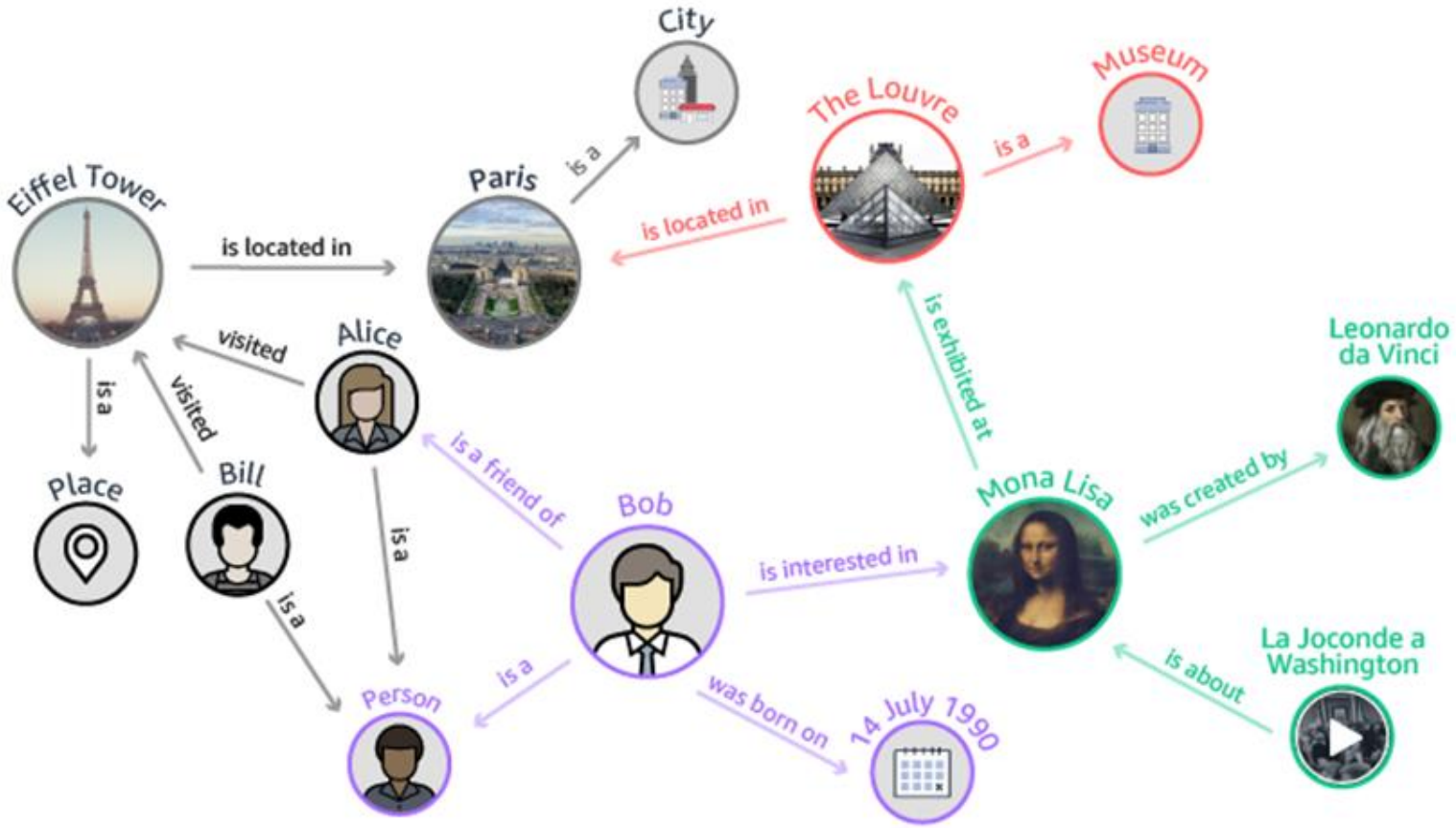
Homework (IV)



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https://aws.amazon.com/neptune/knowledge-graphs-on-aws/