There is a real world with real structure. The program of mind has been trained on vast interaction with this world and so contains code that reflects the structure of the world and knows how to exploit it. This code contains representations of real objects in the world and represents the interactions of real objects.

You exploit the structure of the world to make decisions and take actions. Where you draw the line on categories, what constitutes a single object or a single class of objects for you, is determined by the program of your mind, which does the classification. This classification is not random but reflects a compact description of the world, and in particular a description useful for exploiting the structure of the world.

– Eric B. Baum [2004]

Knowledge Graphs and Ontologies

- Is there a flexible way to represent relations?
- How can knowledge/data bases be made to interoperate?

Choosing Individuals and Relations

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prop(*Individual*, *Property*, *Value*) is the only relation needed:
called individual-property-value representation
or triple representation

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- *prop*(*aifca*, *book*, *true*), where *book* is a Boolean property. "*book*" is the characteristic function of the class.

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When you only have one relation, *prop*, it can be omitted without loss of information.

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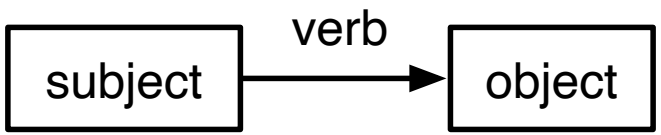

Triples are universal representations of relations

All relations can be represented in terms of triples:

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$prop(subject, verb, object)$ is the only relation needed: $\langle subject, verb, object \rangle$ triples, semantic network, entity relationship model, knowledge graphs, concept maps, ...

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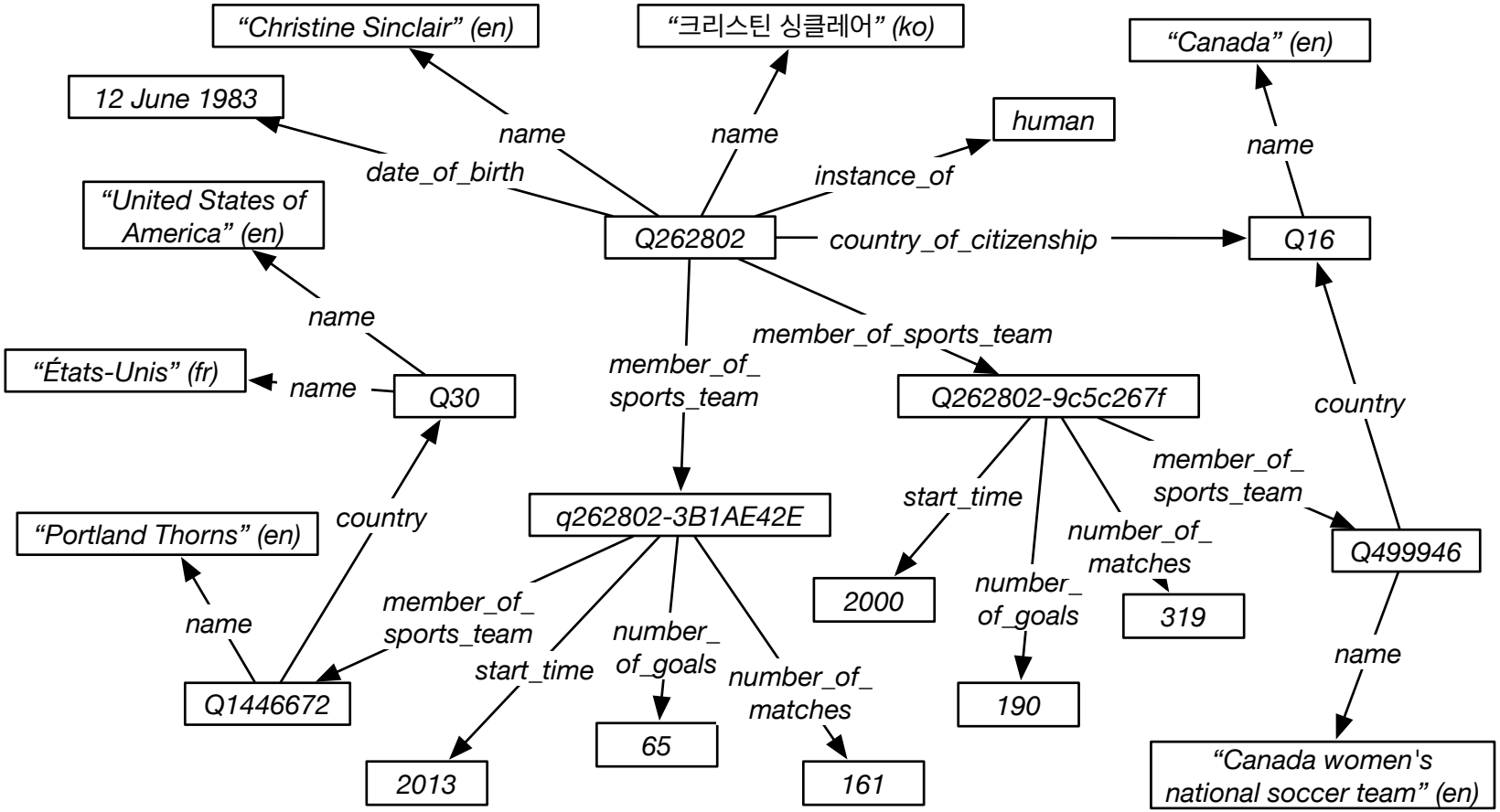
- "Christine Sinclair is a citizen of Canada": *`/entity/Q262802`* *`/prop/direct/P27`* *`/entity/Q16`*

  but all starting with `http://www.wikidata.org`

Part of the Wikidata Knowledge Graph



Accessing Wikidata using Prolog

`https://artint.info/3e/resources/ch16/sem_web.pl`

Clicker Question

In the query

```
?- rdf('http://www.wikidata.org/entity/Q34086',
       'http://www.wikidata.org/prop/direct/P25',M),
   rdf(M,'http://schema.org/name',MN).
```

the reason to use the constant `'http://schema.org/name'` is:

A to make it look complicated and impressive

B it has a standard meaning and everyone who uses that constant means the same thing

C because schema.org is sponsored by Google, Microsoft, Yahoo and Yandex, and they will be impressed if we use schema.org

D it is part of the semantic web, which is the future of the Internet

E there is no reason to use such a complicated constant when a simple one would do just as well.

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What is not a reason to use the constant `'http://www.wikidata.org/entity/Q34086'` instead of using his name `'Justin Bieber'`

A the constant denotes the person, not the name

B it has a standard meaning and everyone who uses that constant means the same thing

C there may be multiple people called 'Justin Bieber' and the constant denotes a particular one

D the constant is easier for people to find and remember

E these are all reasons

Some Wikidata Individuals

- Taylor Swift's albums in chronological order
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- However, Air Canada does not fly from New York to Los Angeles.
  The information about flights is lost!

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- OWL the Web Ontology Language, defines some primitive properties that can be used to define terminology. (Doesn't define a syntax).

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How many indexes are needed so all such queries can be implemented efficiently?

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- Google's Knowledge Graph, contains 500 billion facts on 5 billion entities.

  `https://blog.google/products/search/about-knowledge-graph-and-knowledge-panels/`

  Much of the data is from marked-up web pages; see `http://schema.org/`.

Clicker Question

What is not a reason for using triples as a representation for relations:

A They can be indexed efficiently, whereas arbitrary relations may require too many indexes or are restricted to index on given keys

B Extra arguments to the relation can be added simply

C They allow for more flexible queries

D These are all reasons