



TECHNISCHE
UNIVERSITÄT
DARMSTADT



UKP Lab
Darmstadt, Germany

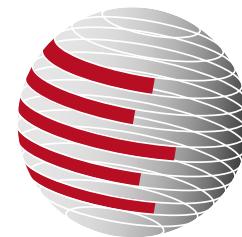
Encoding Knowledge with Graph Neural Networks



Daniil Sorokin

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<https://daniilsorokin.github.io>



UKP

Imperial College London

January 24, 2019

Me

Bachelor in Applied
Linguistics
at St. Petersburg State
University, Russia
2011

Master in Computational
Linguistics
at University of Tübingen,
Germany, 2014

PhD in NLP
at the **UKP Lab**,
Darmstadt University of
Technology, Germany,
since 2015,
<http://ukp.tu-darmstadt.de>

Research intern at
Factmata, London
November 2018 -
January 2019,
<https://factmata.com>

Knowledge Base Question Answering

What is Princess Leia's home planet?

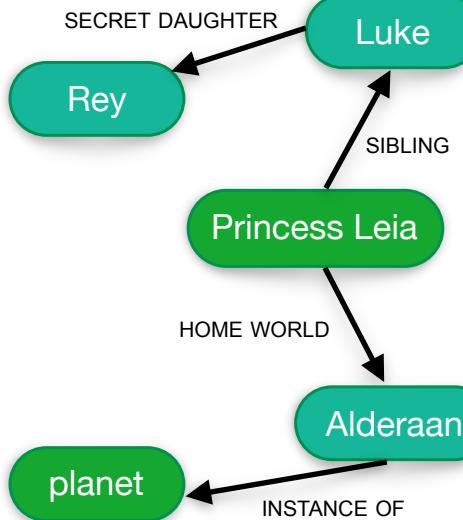
Entity Linking

Princess Leia planet

Semantic interpretation

?

Knowledge Base



Answer

Alderaan

Knowledge Base

Knowledge Base

Princess Leia

English Not logged in Talk Contributions Create account Log in

Item Discussion Read View history Search Wikidata

Princess Leia (Q51797)

character in Star Wars

Leia Organa | Princess Leia Organa of Alderaan | General Organa | Princess Leah

[edit](#)

[In more languages](#) [Configure](#)

Language	Label	Description	Also known as
English	Princess Leia	character in Star Wars	Leia Organa Princess Leia Organa of Alderaan General Organa Princess Leah
French	Leia Organa	personnage de Star Wars	Princesse Leia
German	Leia Organa	Figur in Star Wars	Prinzessin Leia Prinzessin Leia Organa
Scots	Princess Leia	No description defined	

All entered languages

Statements

home world	Alderaan	edit
	▼ 0 references	+ add reference
	Naboo	edit
	from fictional universe	Star Wars expanded to other media
	▼ 0 references	+ add reference
		+ add value

Knowledge Base Question Answering

What is Princess Leia's home planet?

Entity Linking

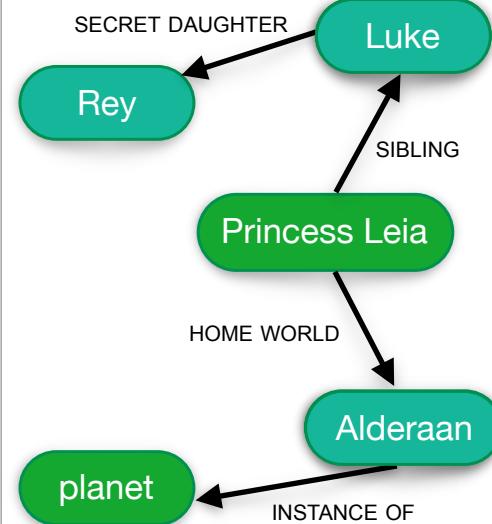
Princess Leia planet

Semantic interpretation

?



Knowledge Base



Answer

Alderaan

Knowledge Base Question Answering

What is Princess Leia's home planet?

Entity Linking

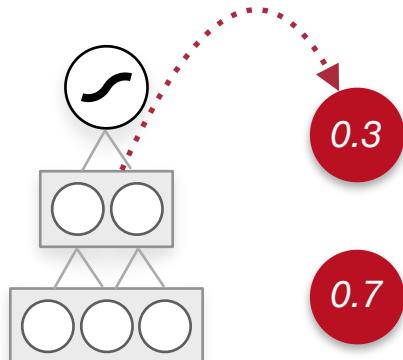
Princess Leia

planet

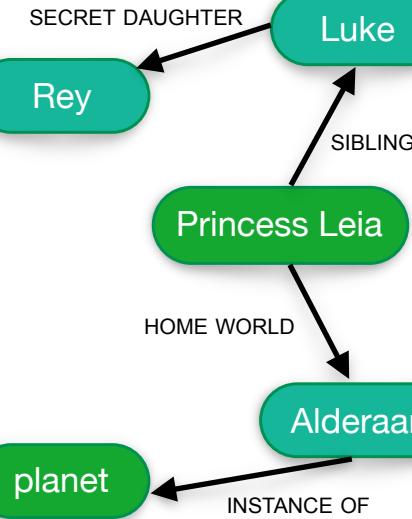
Semantic interpretation

Luke

Alderaan



Knowledge Base



Answer

Alderaan

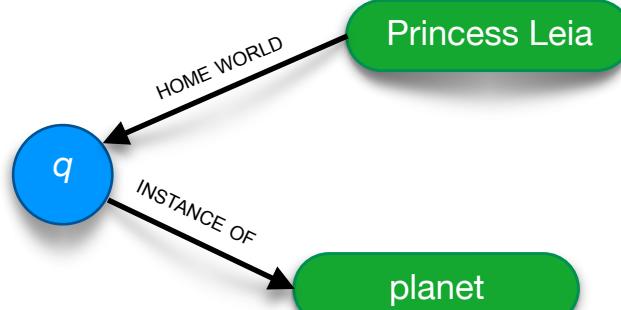
Knowledge Base Question Answering

What is Princess Leia's home planet?

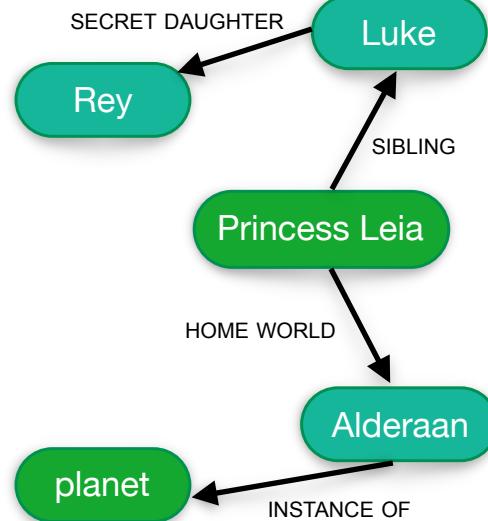
Entity Linking

Princess Leia planet

Semantic interpretation
Structured representation



Knowledge Base



Answer

Alderaan

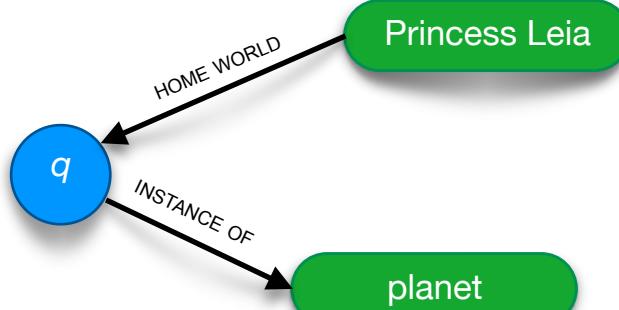
Knowledge Base Question Answering

What is Princess Leia's home planet?

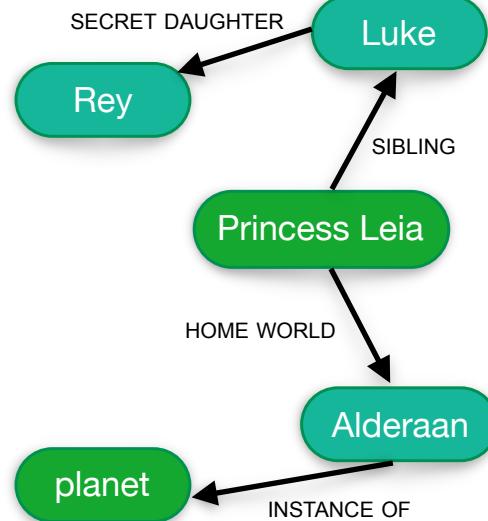
Entity Linking

Princess Leia planet

Semantic interpretation
Structured representation



Knowledge Base



Answer

Alderaan

Knowledge Base Question Answering

What is Princess Leia's home planet?

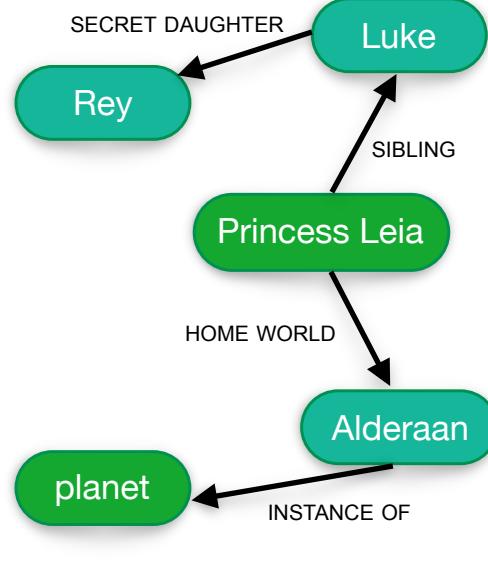
Entity Linking

Princess Leia planet

Semantic interpretation
SPARQL query

```
SELECT DISTINCT ?q WHERE {
  GRAPH <statements> {
    Princess Leia p:homeworld ?q.
    ?q rdf:type planet
  }
}
```

Knowledge Base



Answer

Alderaan

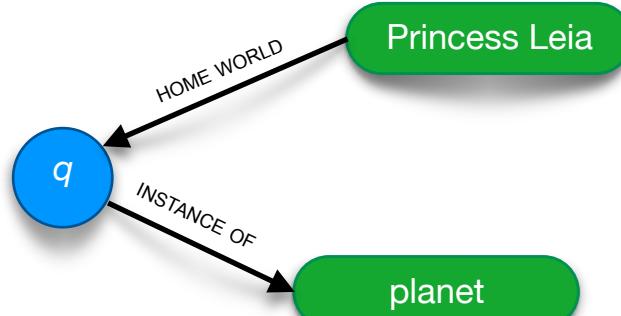
Knowledge Base Question Answering

What is Princess Leia's home planet?

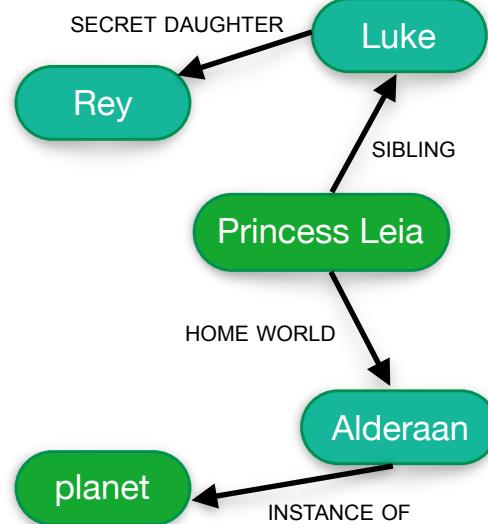
Entity Linking

Princess Leia planet

Semantic interpretation



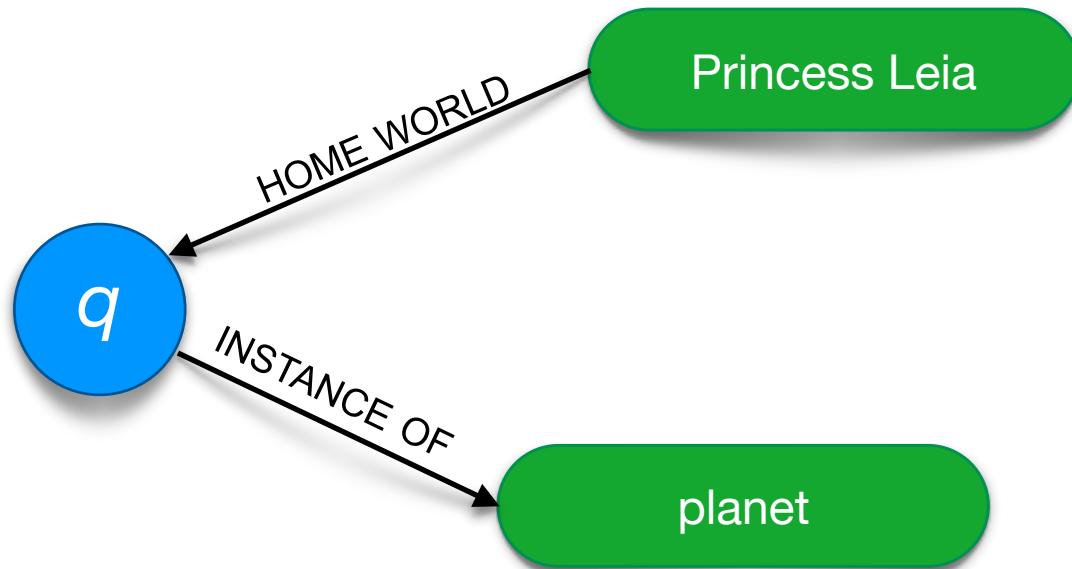
Knowledge Base



Answer

Alderaan

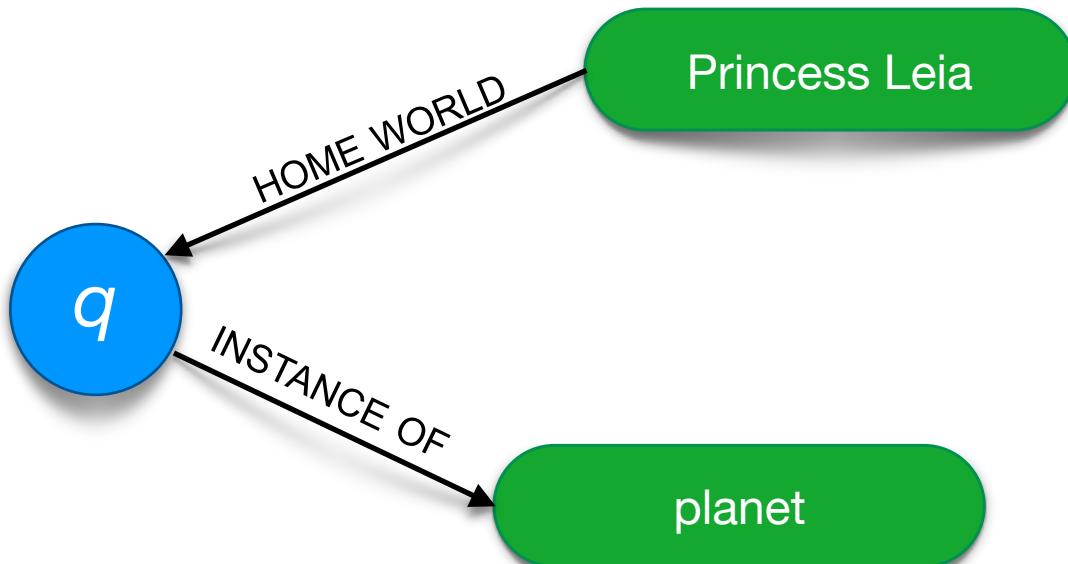
Structured Representation Approach



What is Princess Leia's home planet?

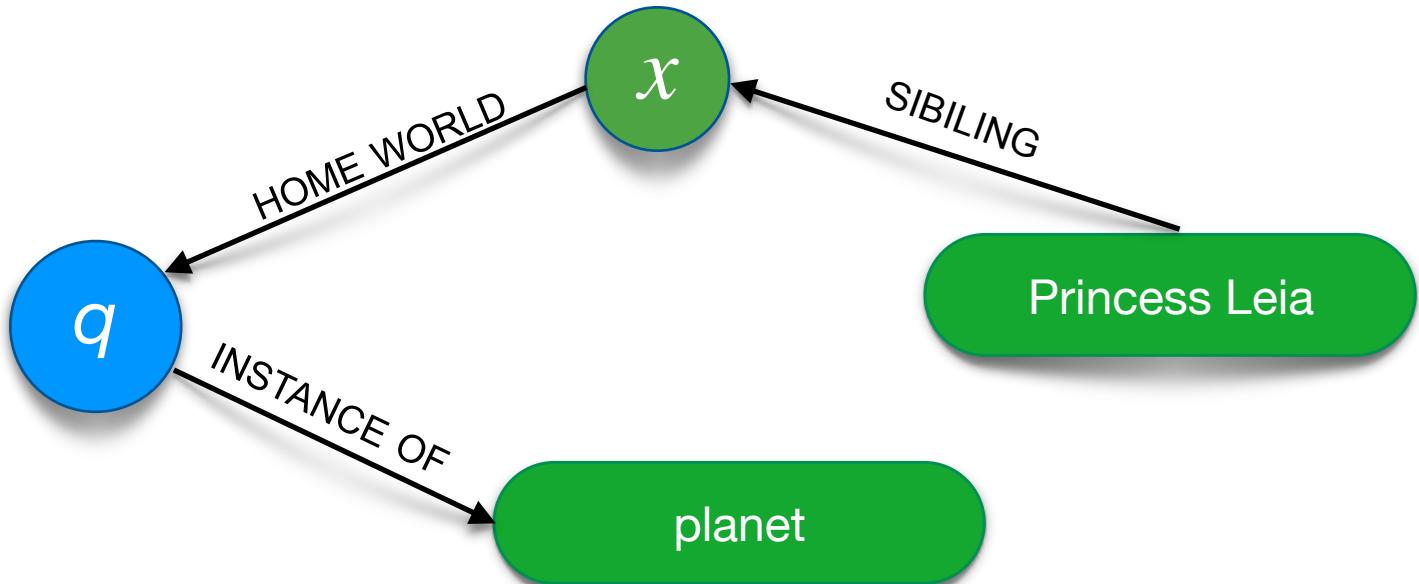
Possible Semantic Graphs

Yih et al. (2015)



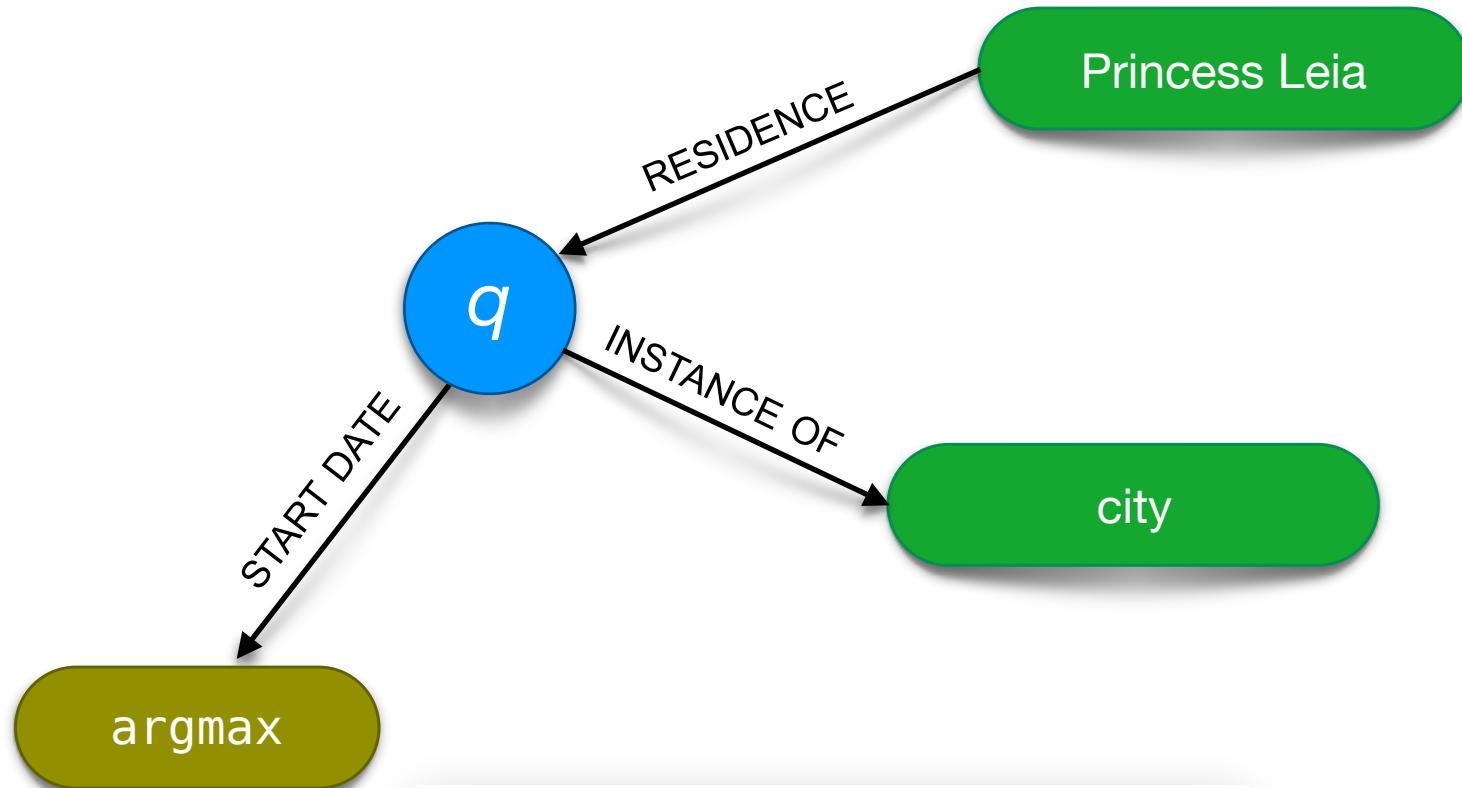
What is Princess Leia's home planet?

Possible Semantic Graphs

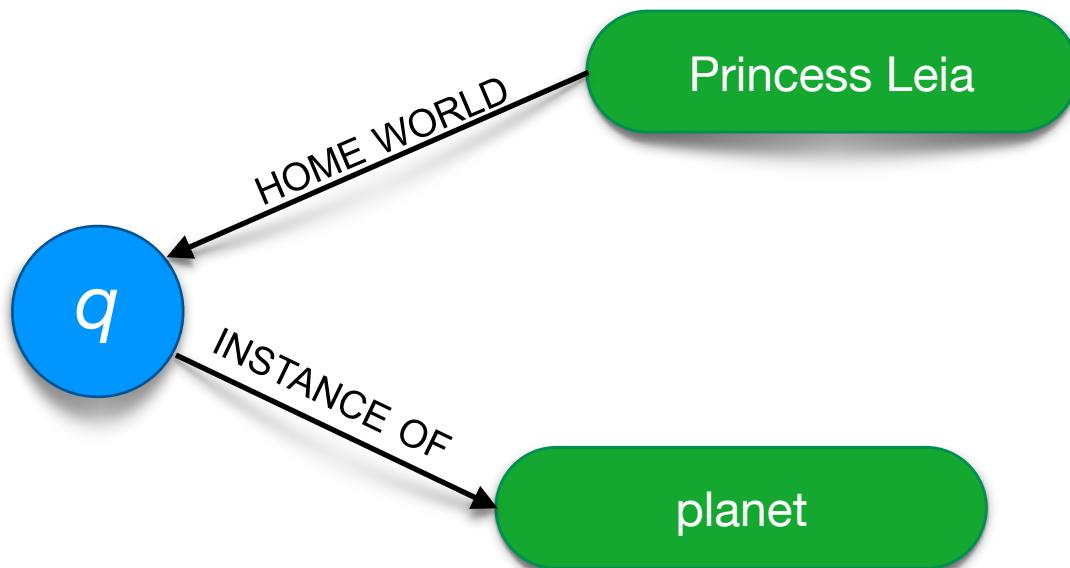


What is the home planet of Princess Leia's family?

Possible Semantic Graphs

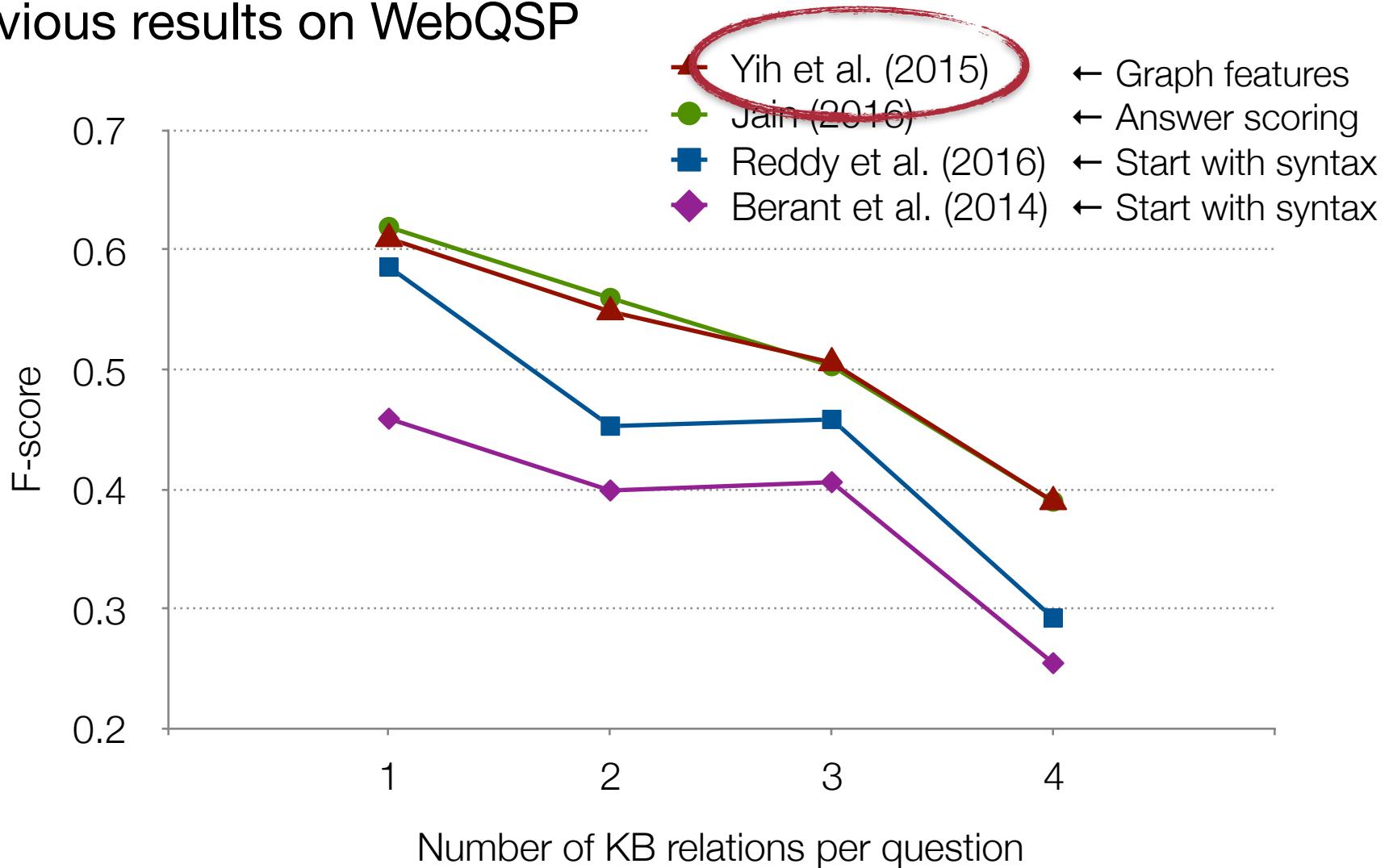


Possible Semantic Graphs



Representation structure is a graph
and we model it as such

Previous results on WebQSP



 Freebase™

Previous approaches do not integrate
the structure of the representation into
the model

Modeling the knowledge base graph and other graphs

1. Graph Convolutional Networks

- Kipf and Welling (2017) – document classification
- Marcheggiani and Titov (2017) – encode syntax dependencies for SRL
- Schlichtkrull et al. (2018) – KB embeddings

2. Gated Graph Neural Networks

- Scarselli et al. (2009) – Graph Neural Networks
- Li et al. (2016) – Gated variant
- Chen et al. (2018) – Structured Dialogue Policy
- Sun et al. (2018) – QA with Fusion of Knowledge Bases and Text

3. Battaglia et al. (2018) – Relational inductive biases, deep learning, and graph networks

Knowledge Base Question Answering

What is Princess Leia's home planet?

Entity Linking

Princess Leia

planet

Semantic interpretation

q

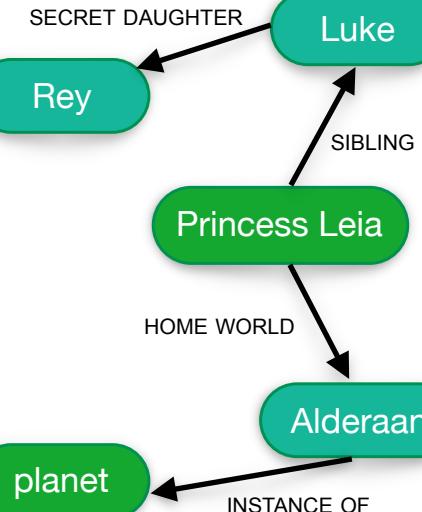
Princess Leia

planet

HOME WORLD

INSTANCE OF

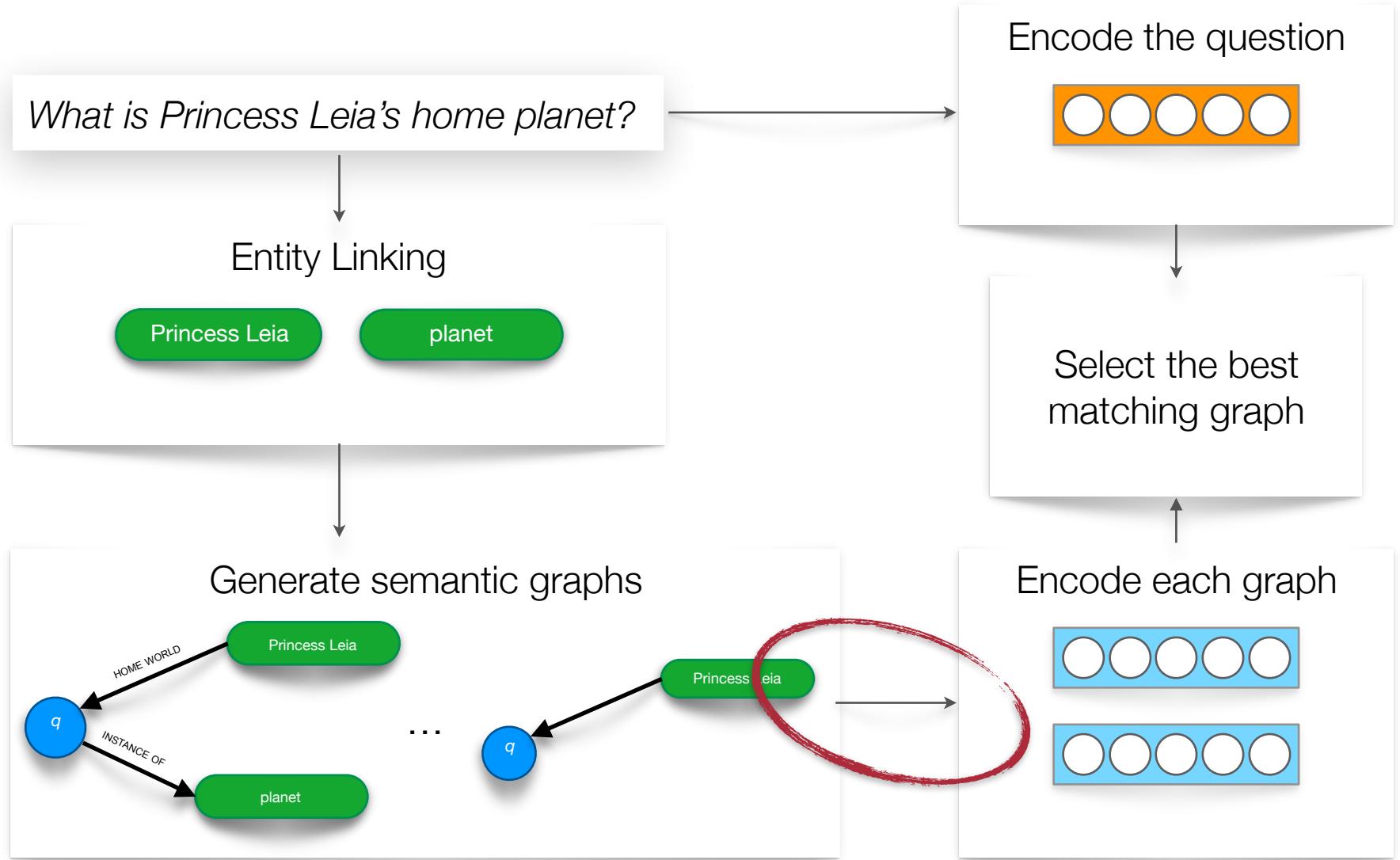
Knowledge Base



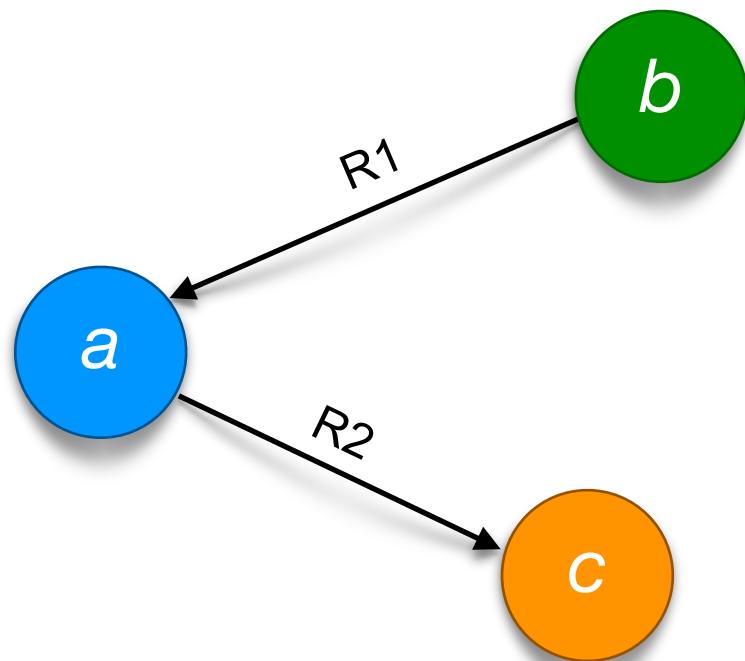
Answer

Alderaan

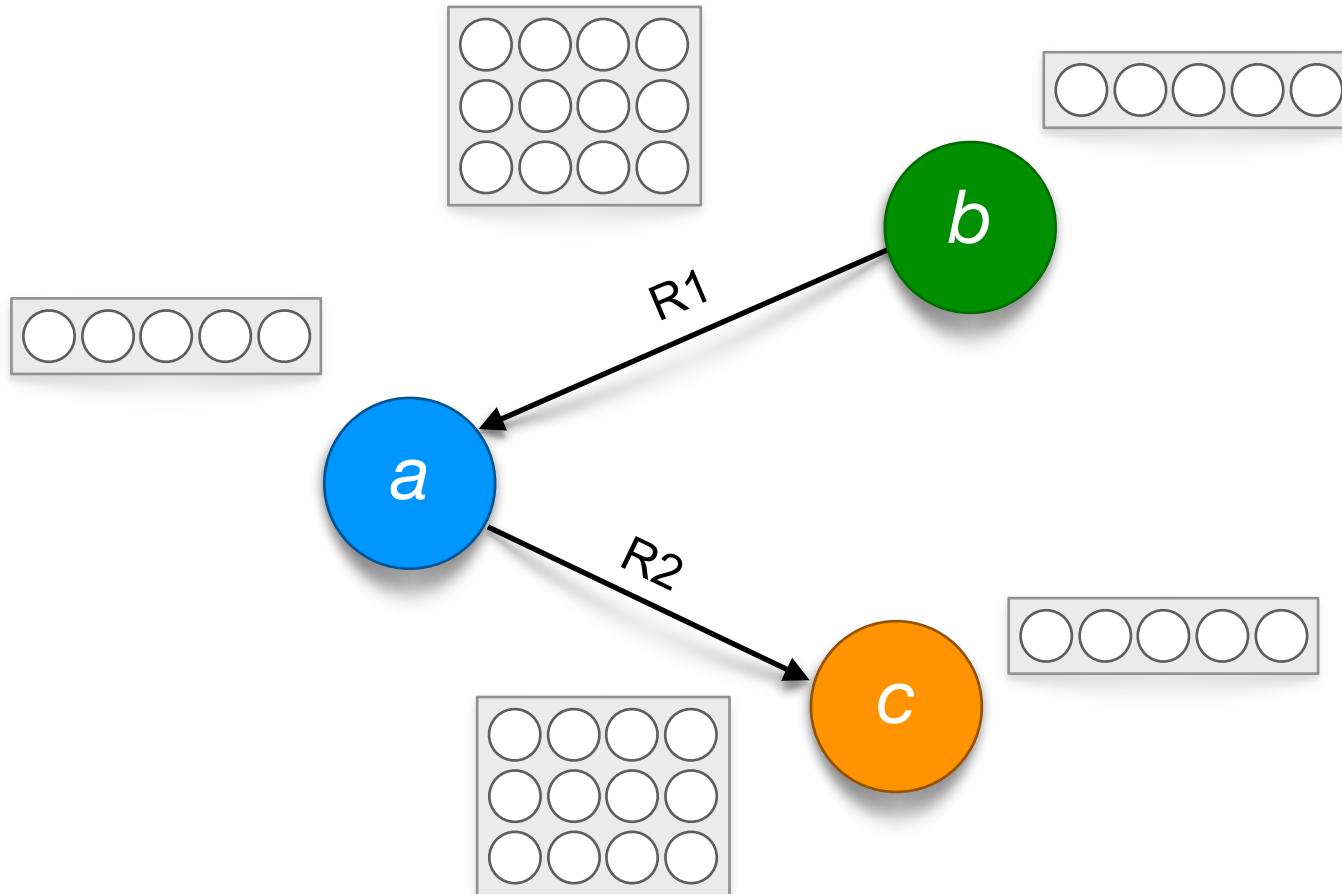
Representation Learning



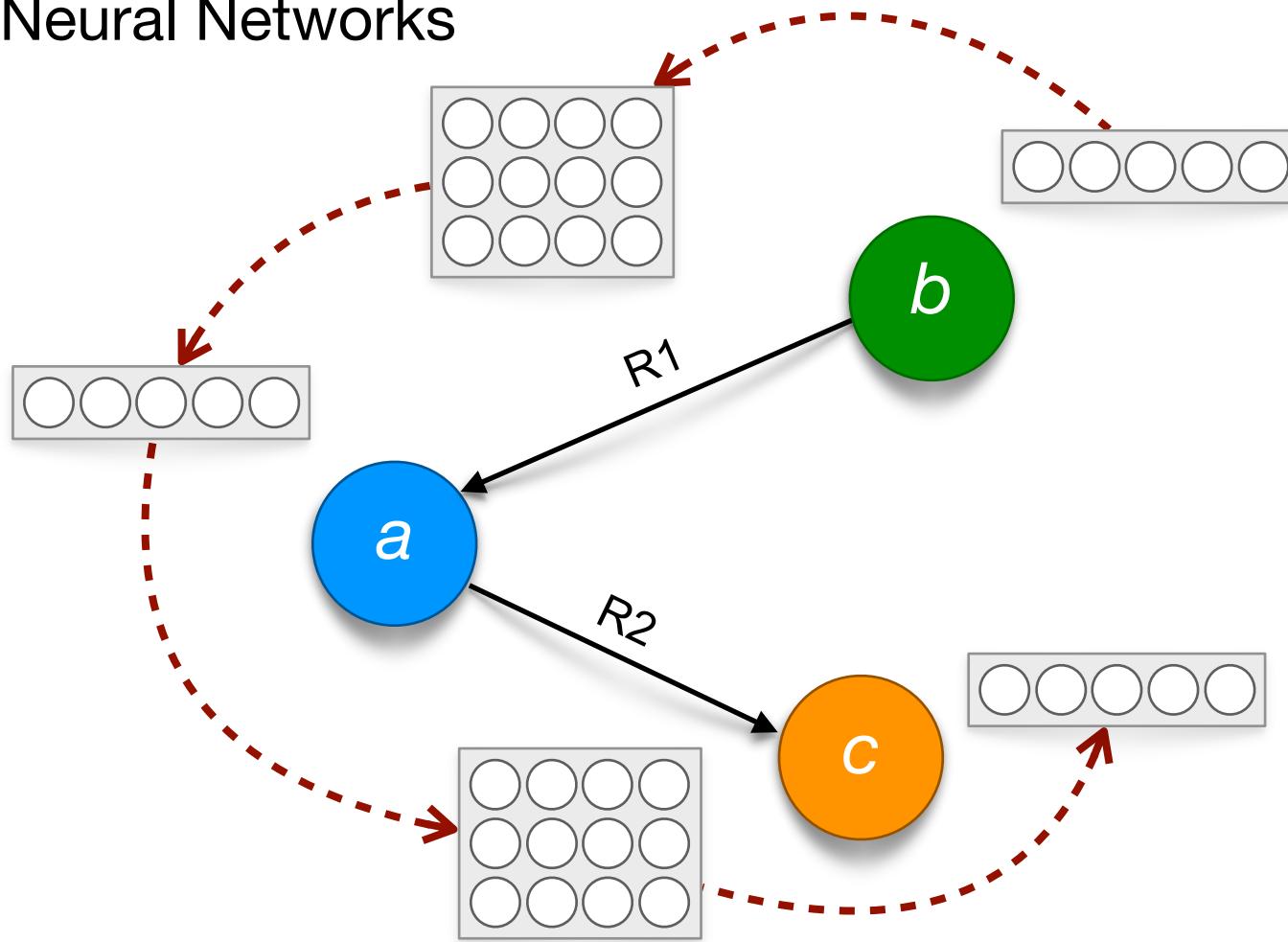
Graph Neural Networks – Scarselli et al. (2009)



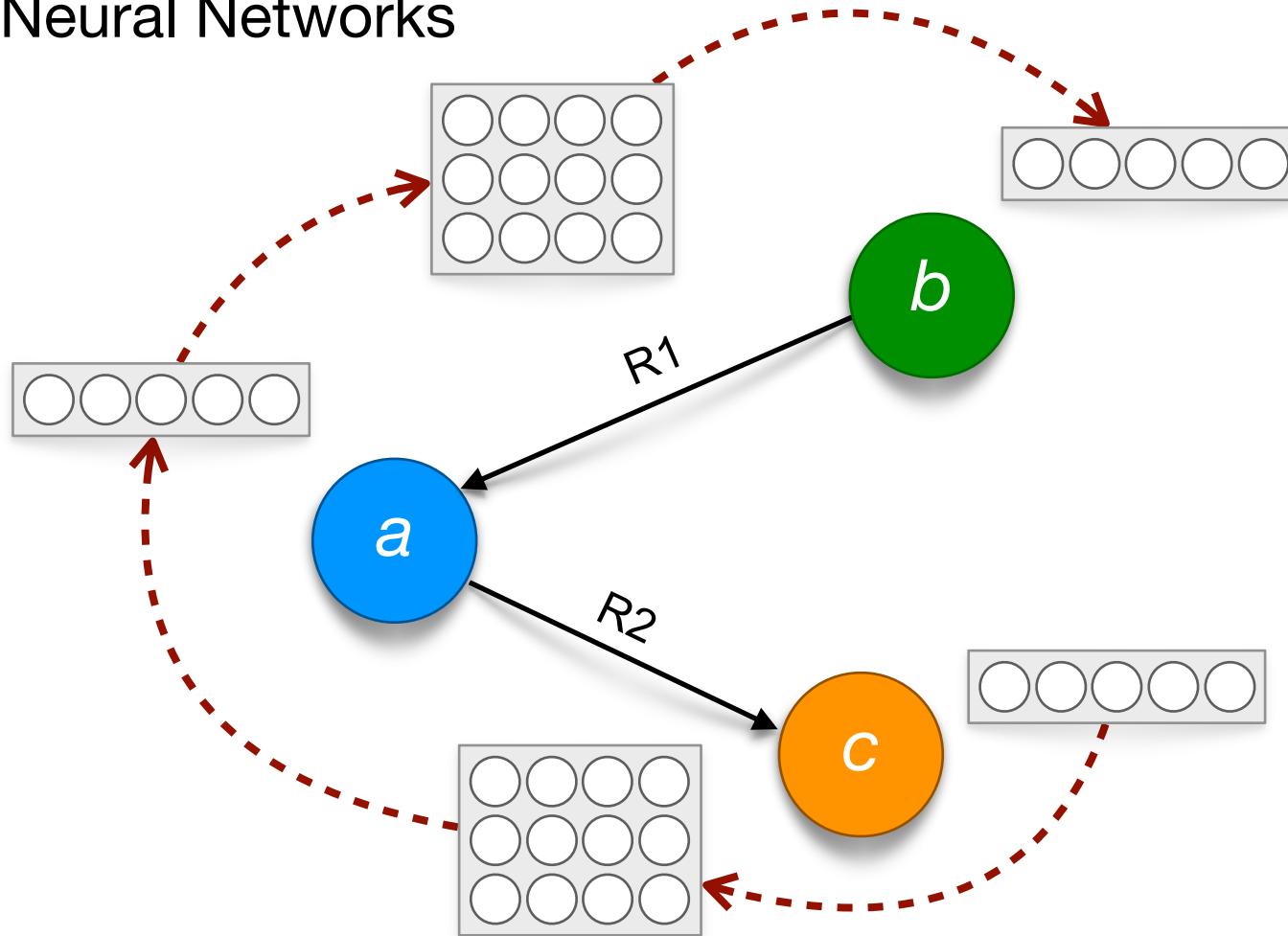
Graph Neural Networks



Graph Neural Networks

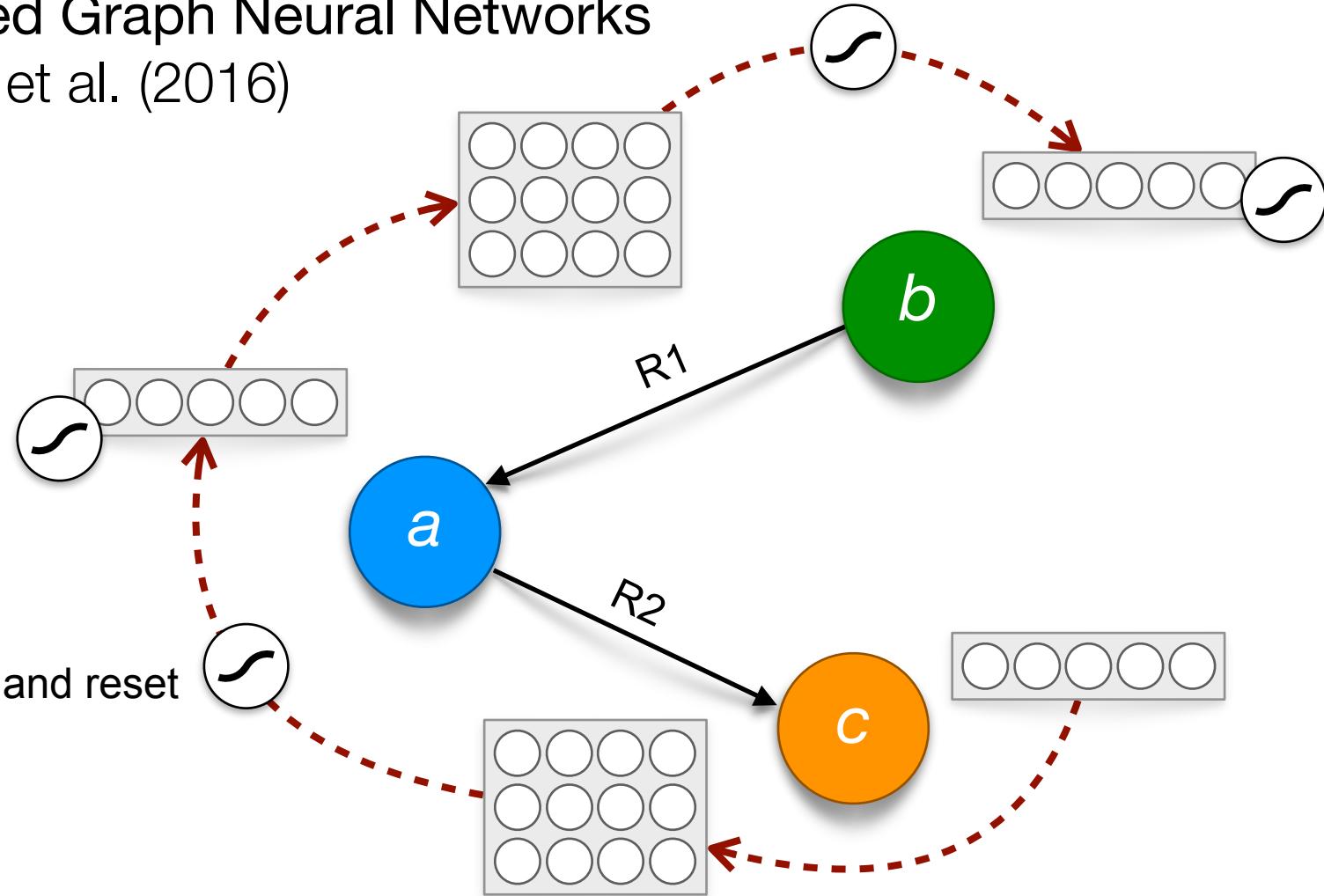


Graph Neural Networks

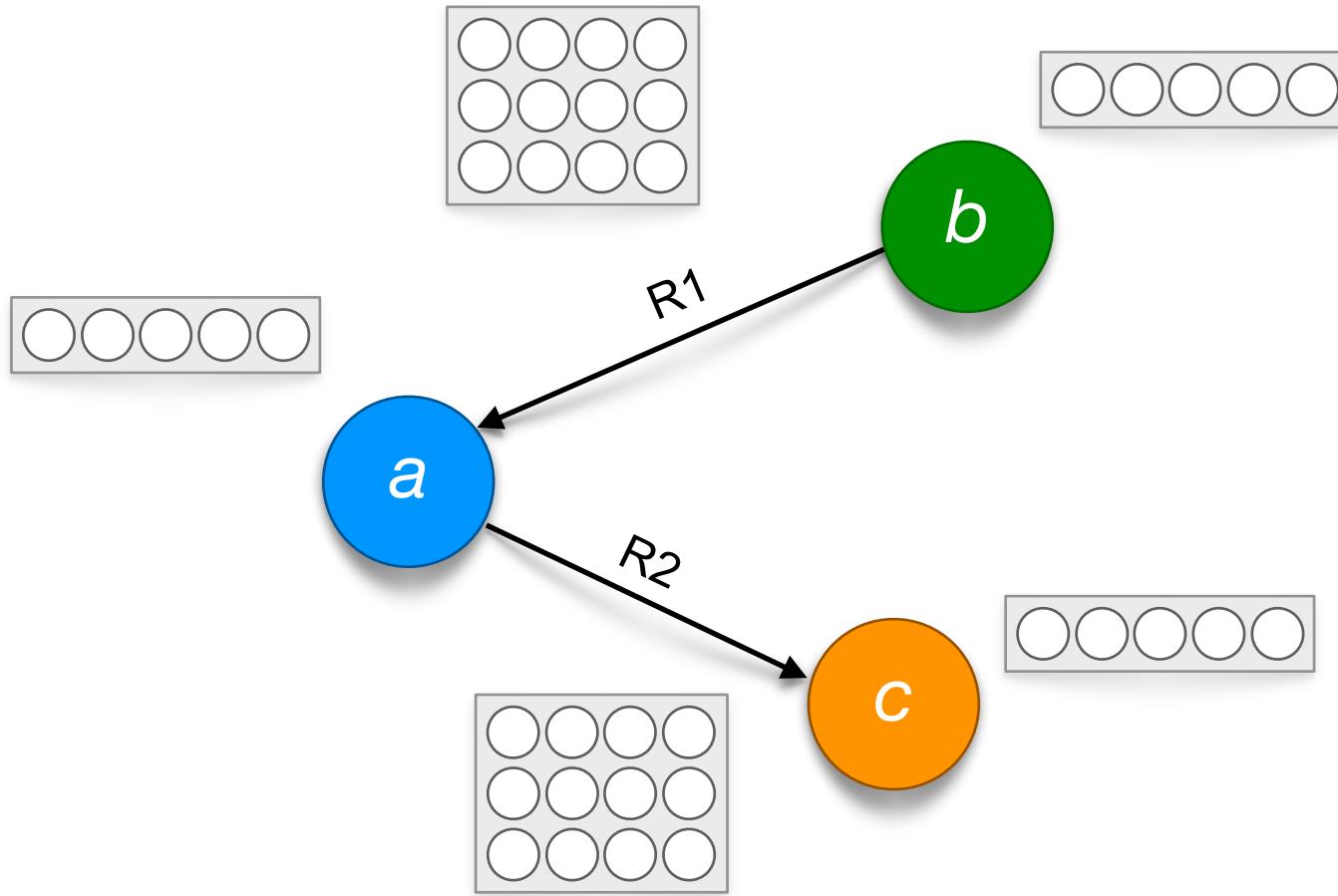


Gated Graph Neural Networks

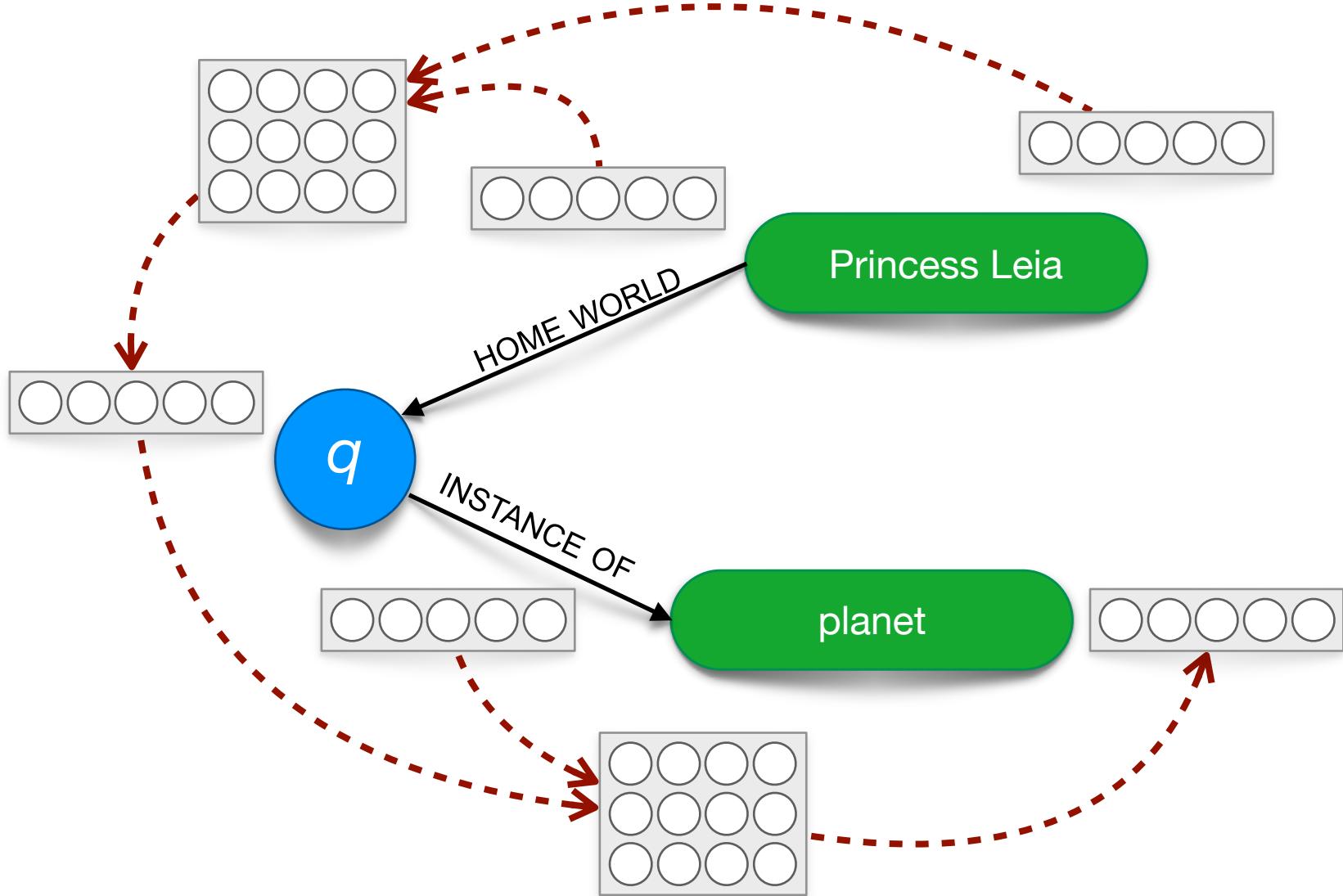
– Li et al. (2016)



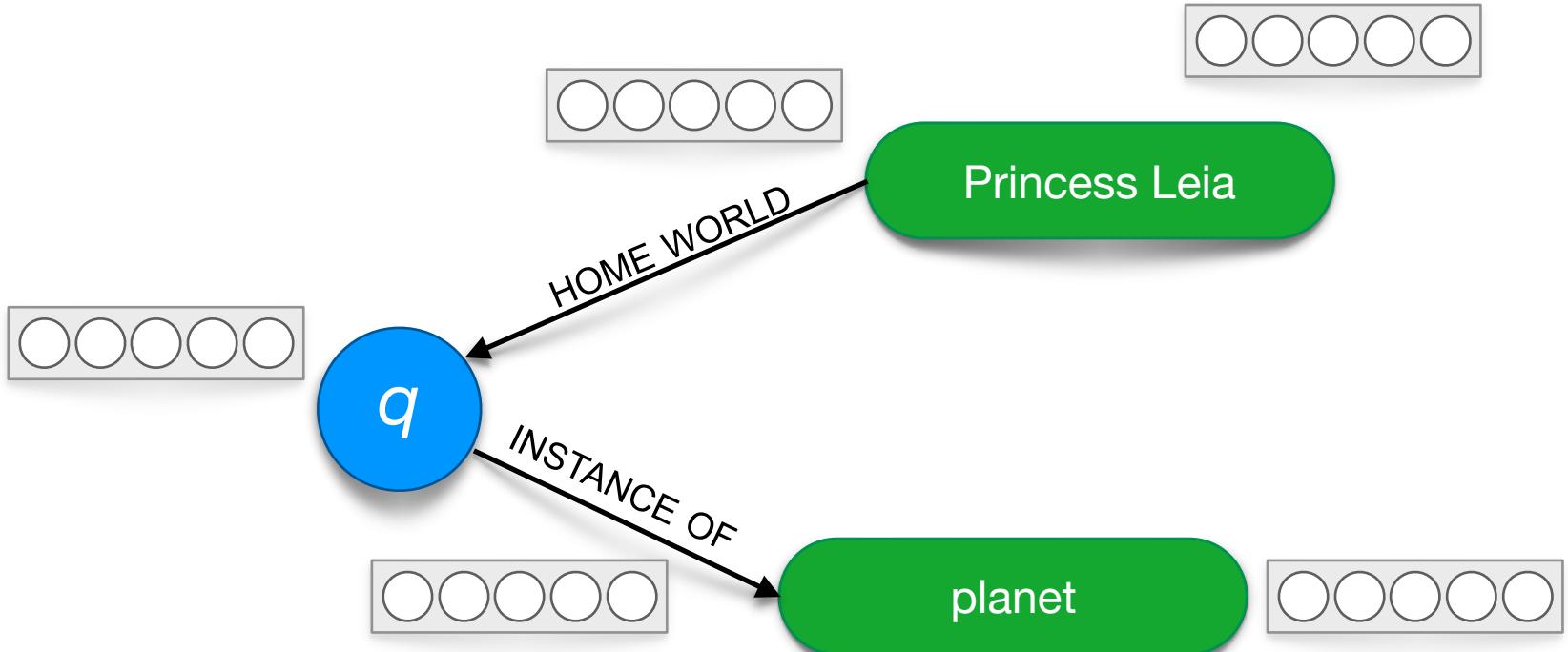
Gated Graph Neural Networks



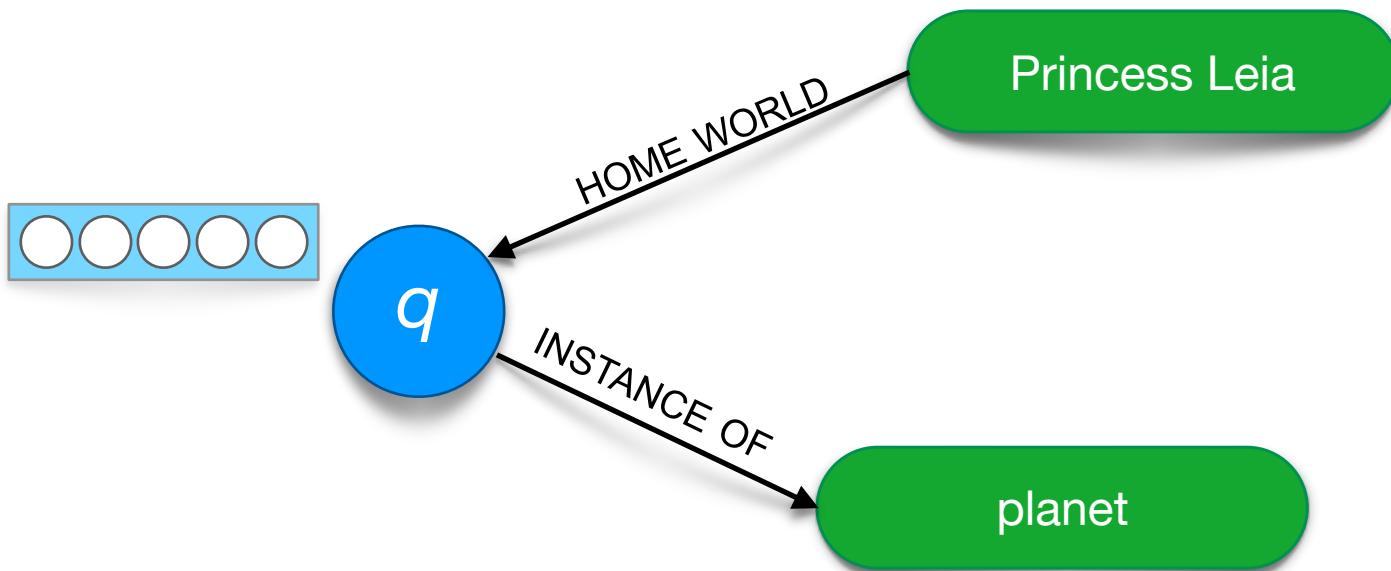
Gated Graph Neural Networks with Labels



Graph Encoding

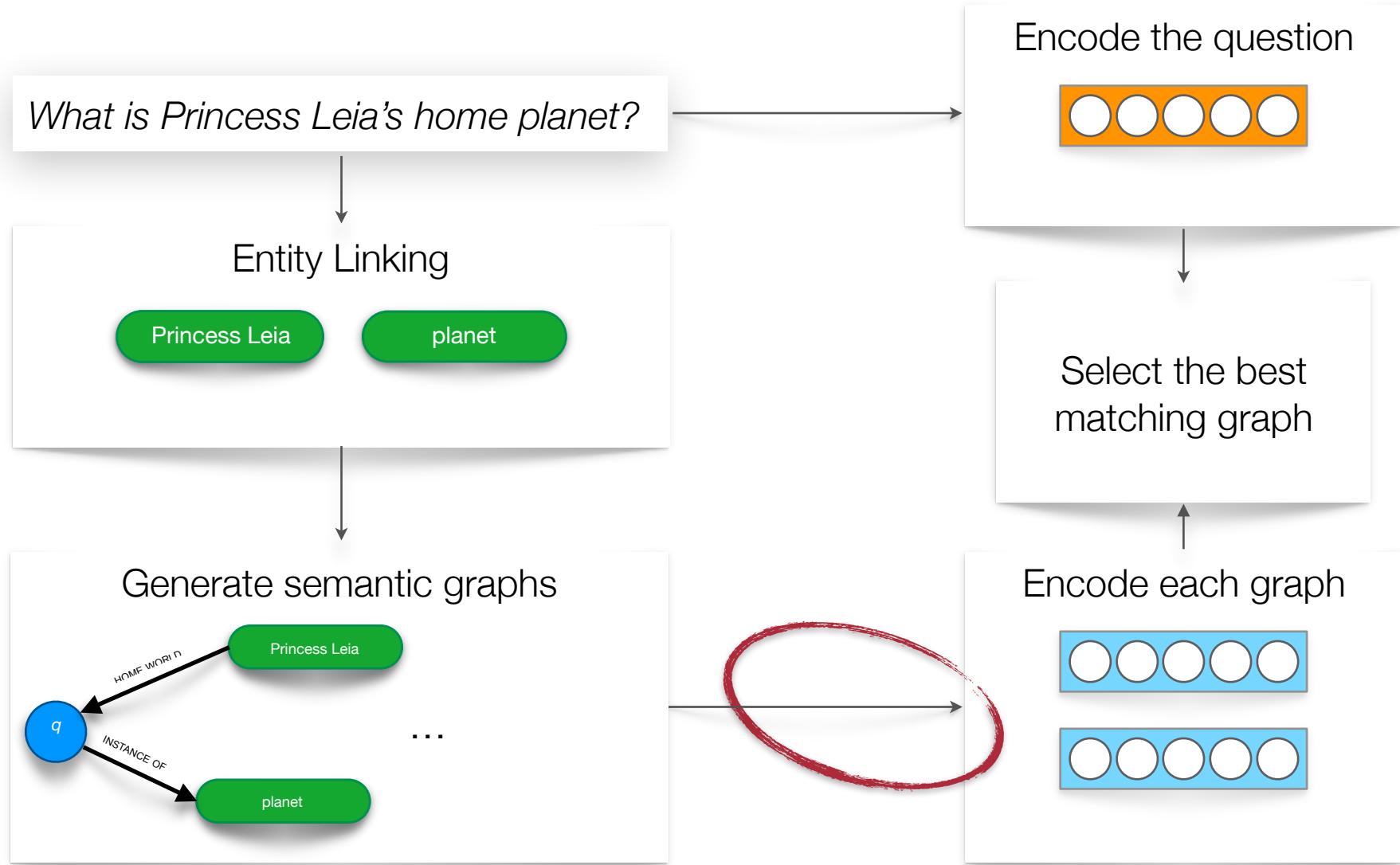


Graph Encoding

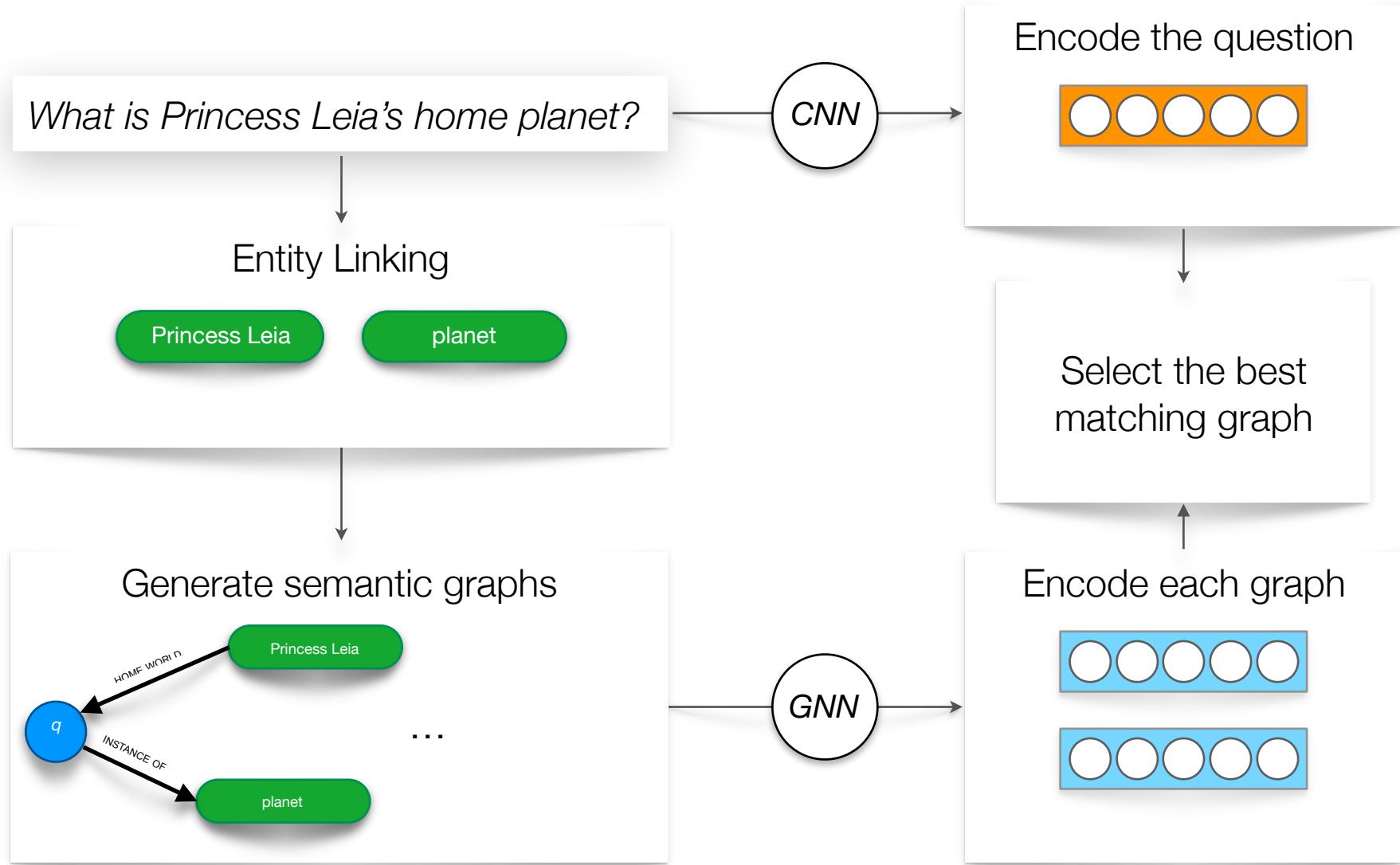


The Graph Neural Network models all aspects of the semantic graph representation

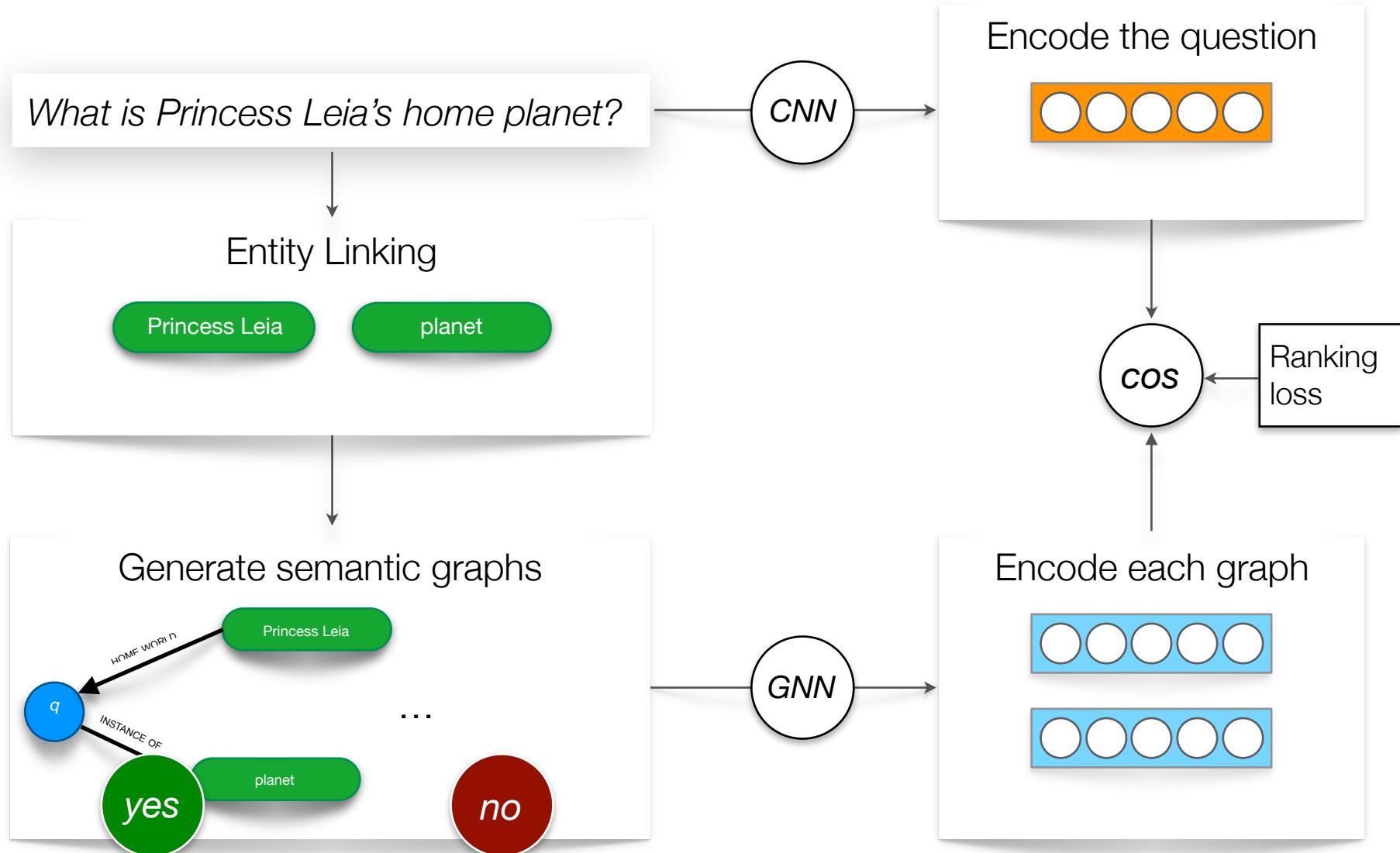
Question Answering Pipeline – Representation Learning



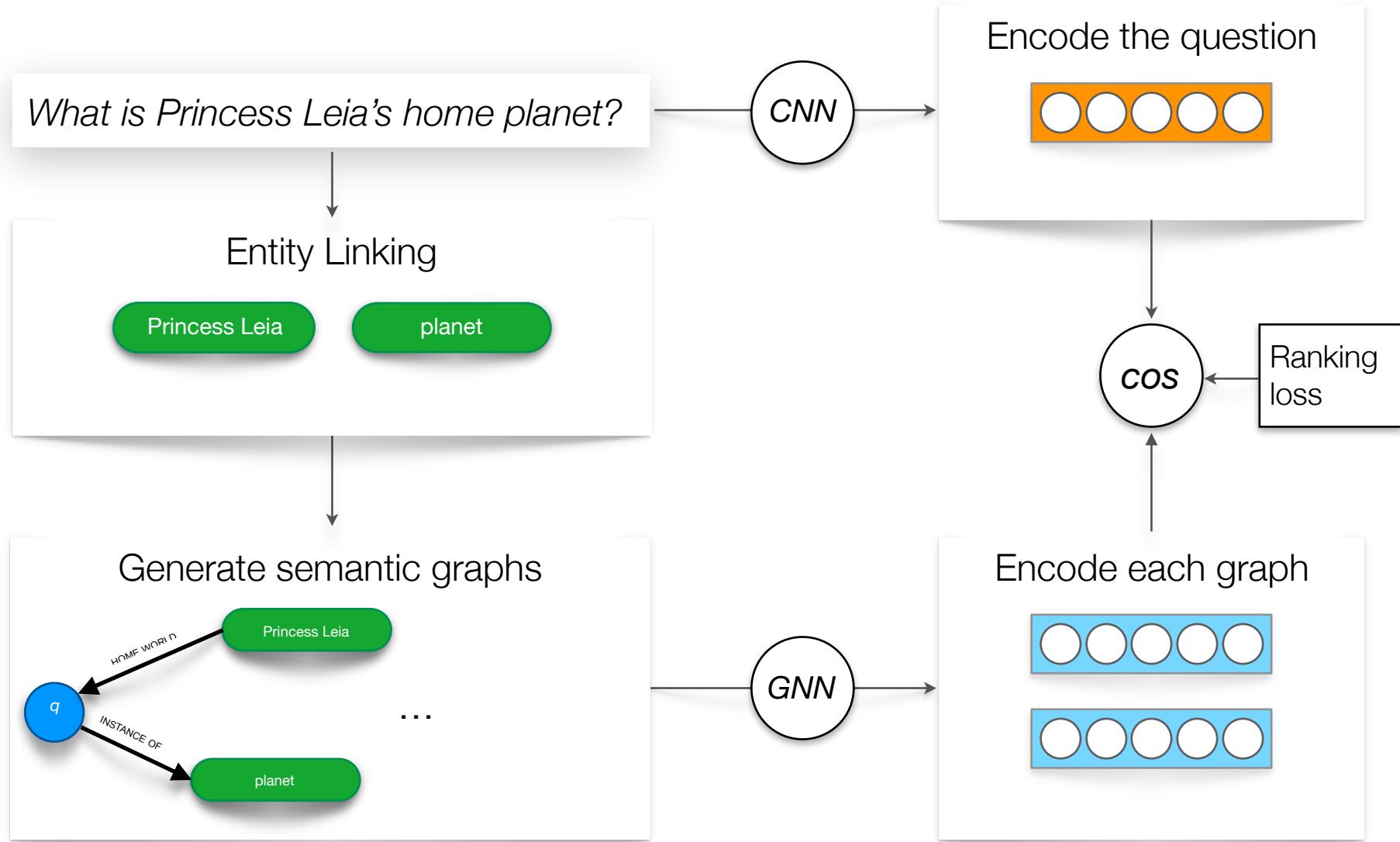
Question Answering Pipeline – Representation Learning



Question Answering Pipeline – Representation Learning



Question Answering Pipeline – Representation Learning



Models

- STAGG (Yih et al. 2015)

Manually defined features on graphs

- Single Edge

Use the CNN encoder to encode one edge as a serialised triple

- Pooled Edges

Use the CNN encoder to encode all edges and apply max pooling

- GNN

Graph Neural Network without gates

- Gated GNN

Graph Neural Network with gates

Data set

WebQSP-WD

Based on WebQSP/WebQuestions

Contains questions and correct answers

Mapped to Wikidata

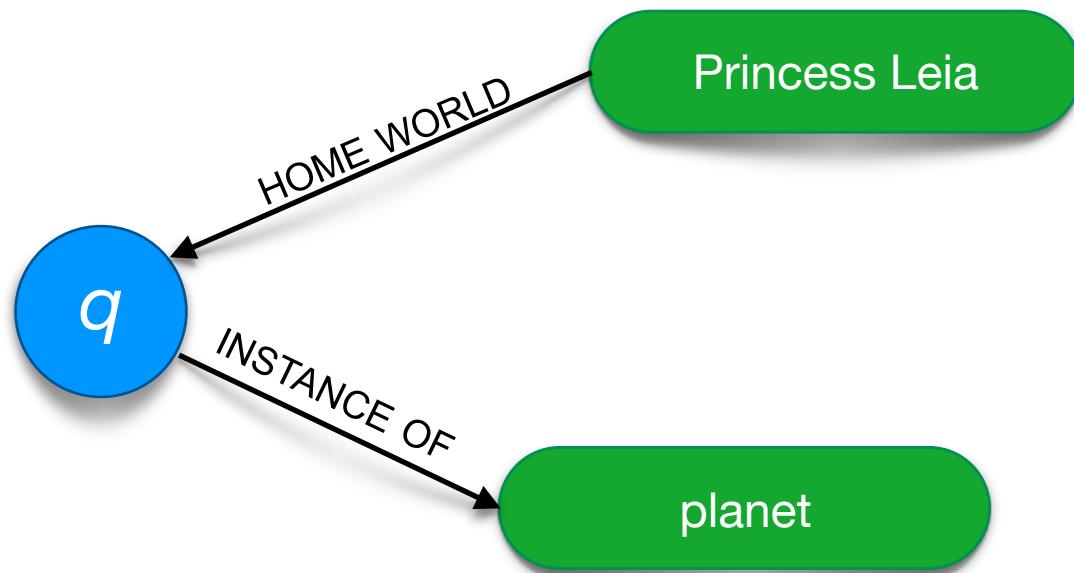
1033 test questions (293 complex)

2880 train questions (419 complex)

Evaluation

What is Princess Leia's home planet?

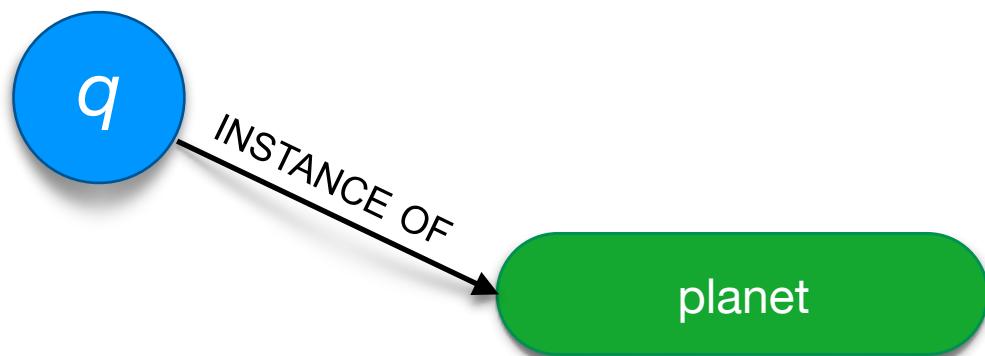
Precision	Recall	F-score
1.000	1.000	1.000



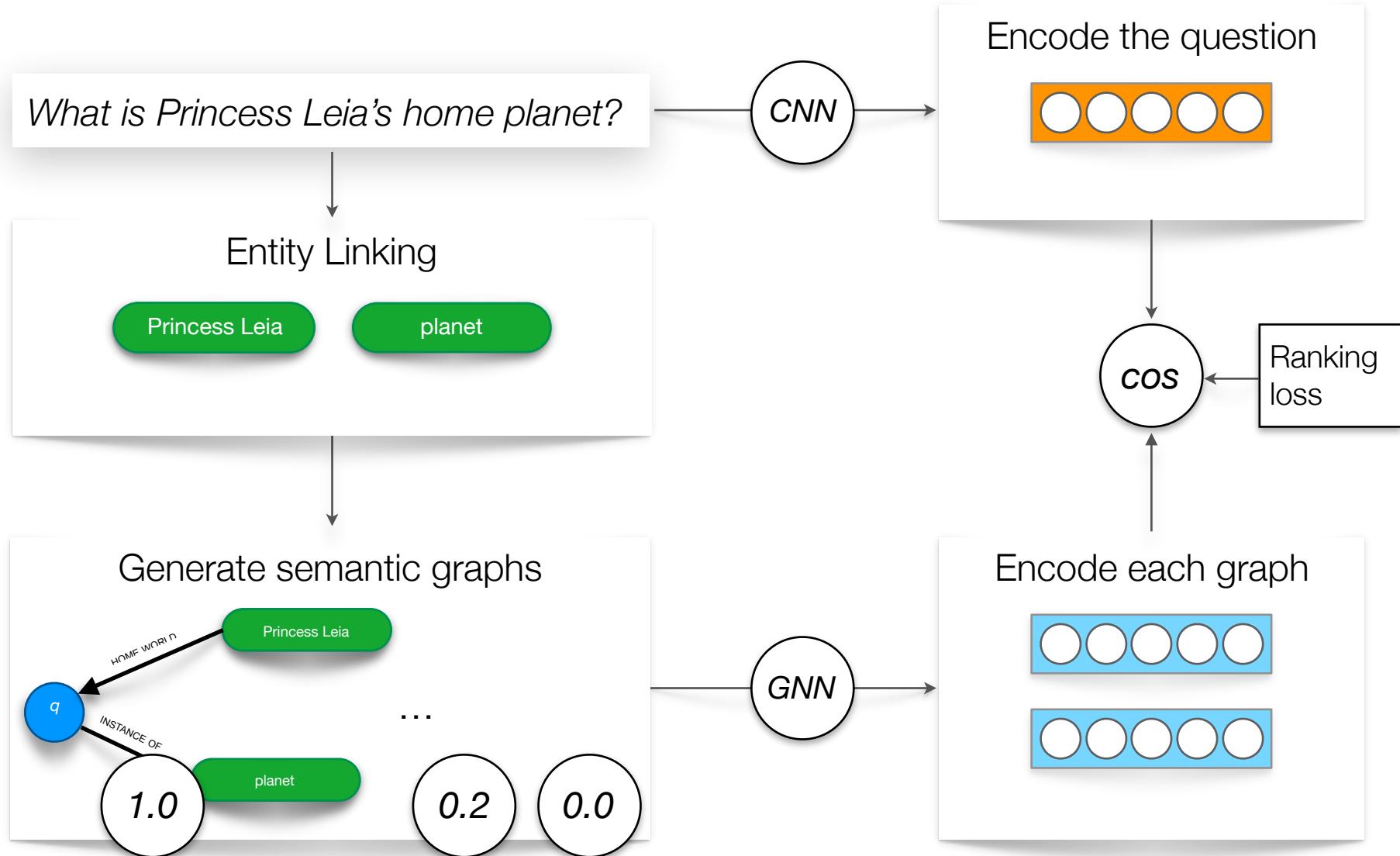
Evaluation

What is Princess Leia's home planet?

Precision	Recall	F-score
0.050	1.000	0.095



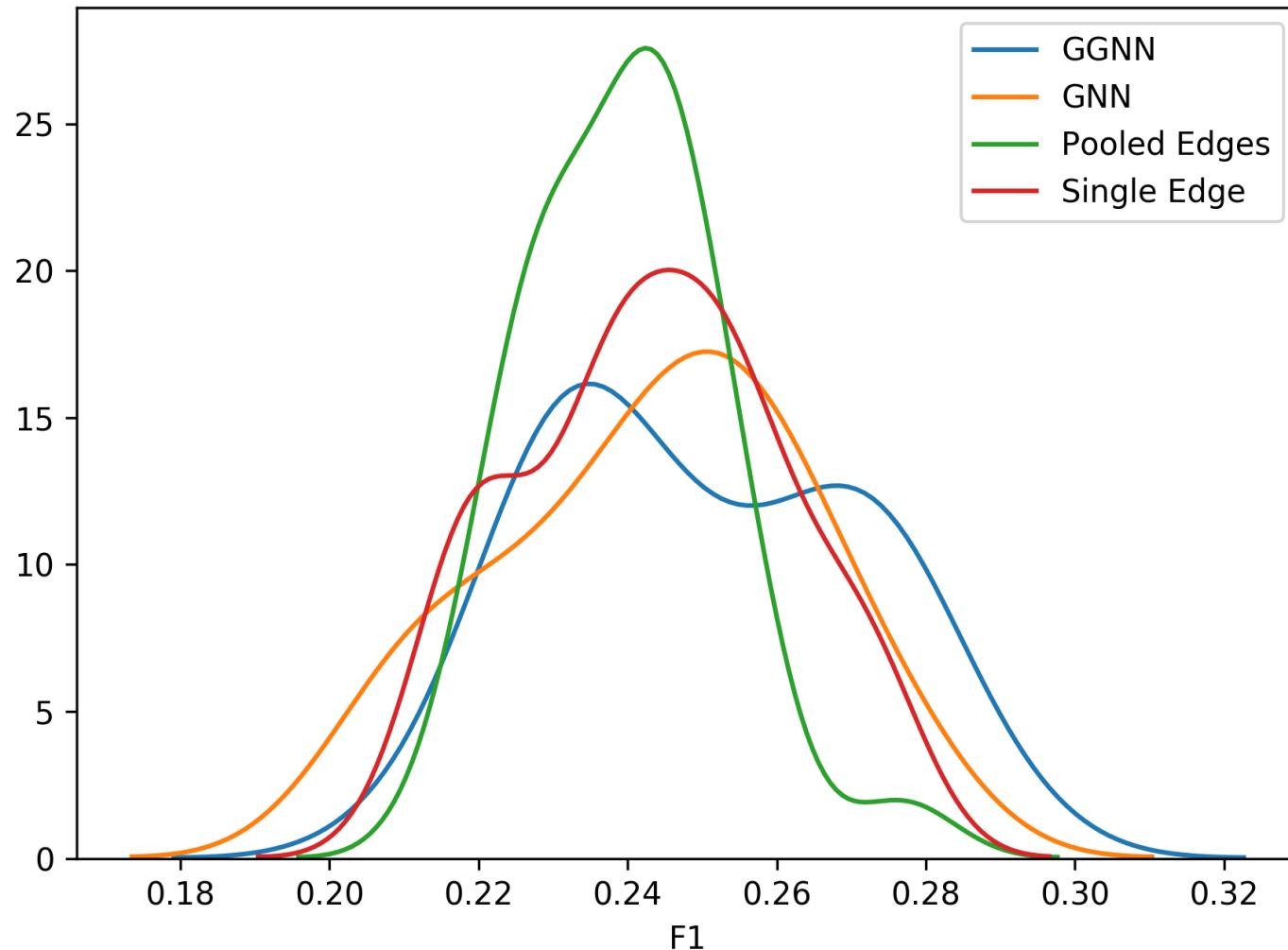
Question Answering Pipeline – Representation Learning

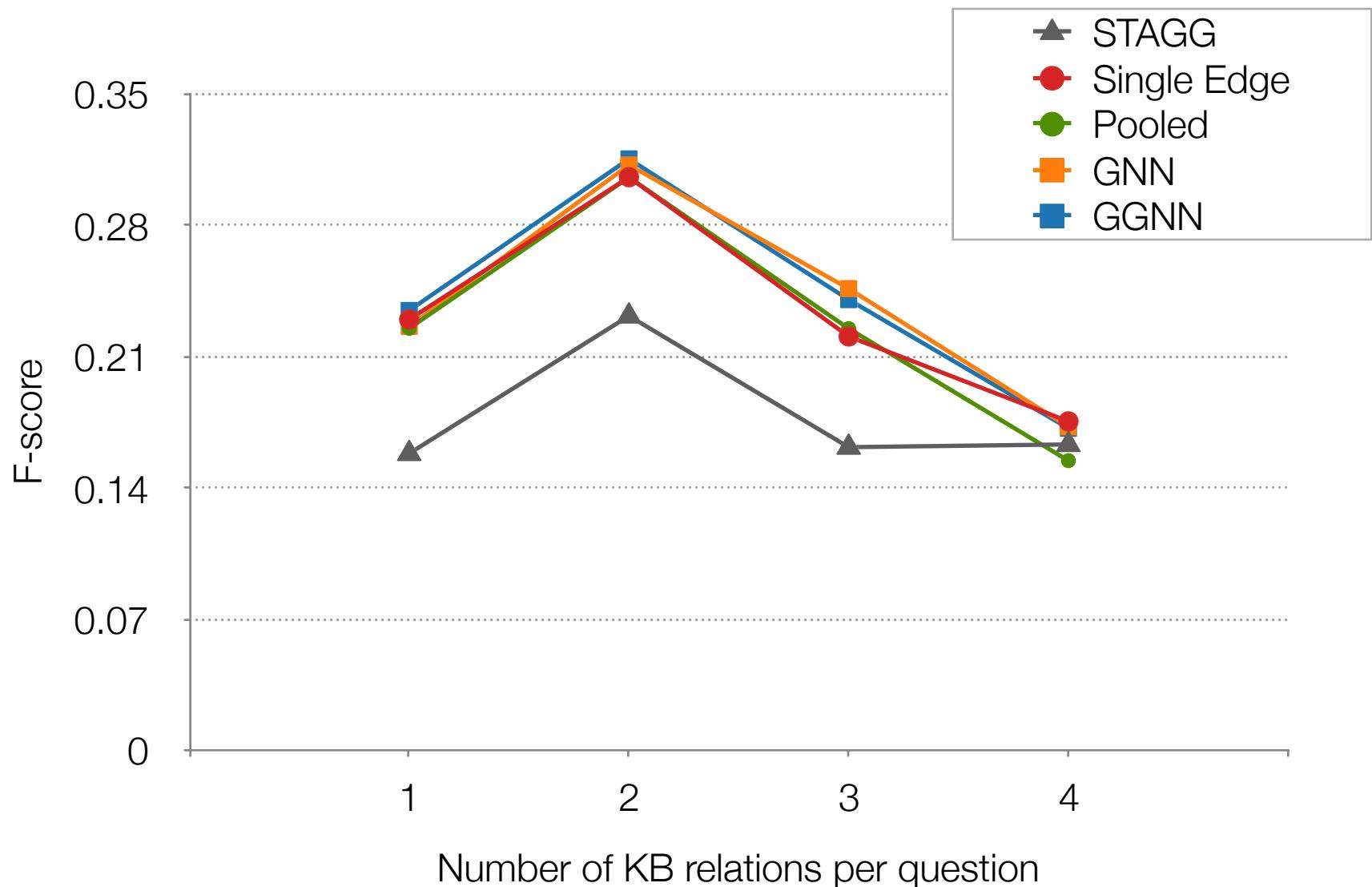


WebQSP-WD

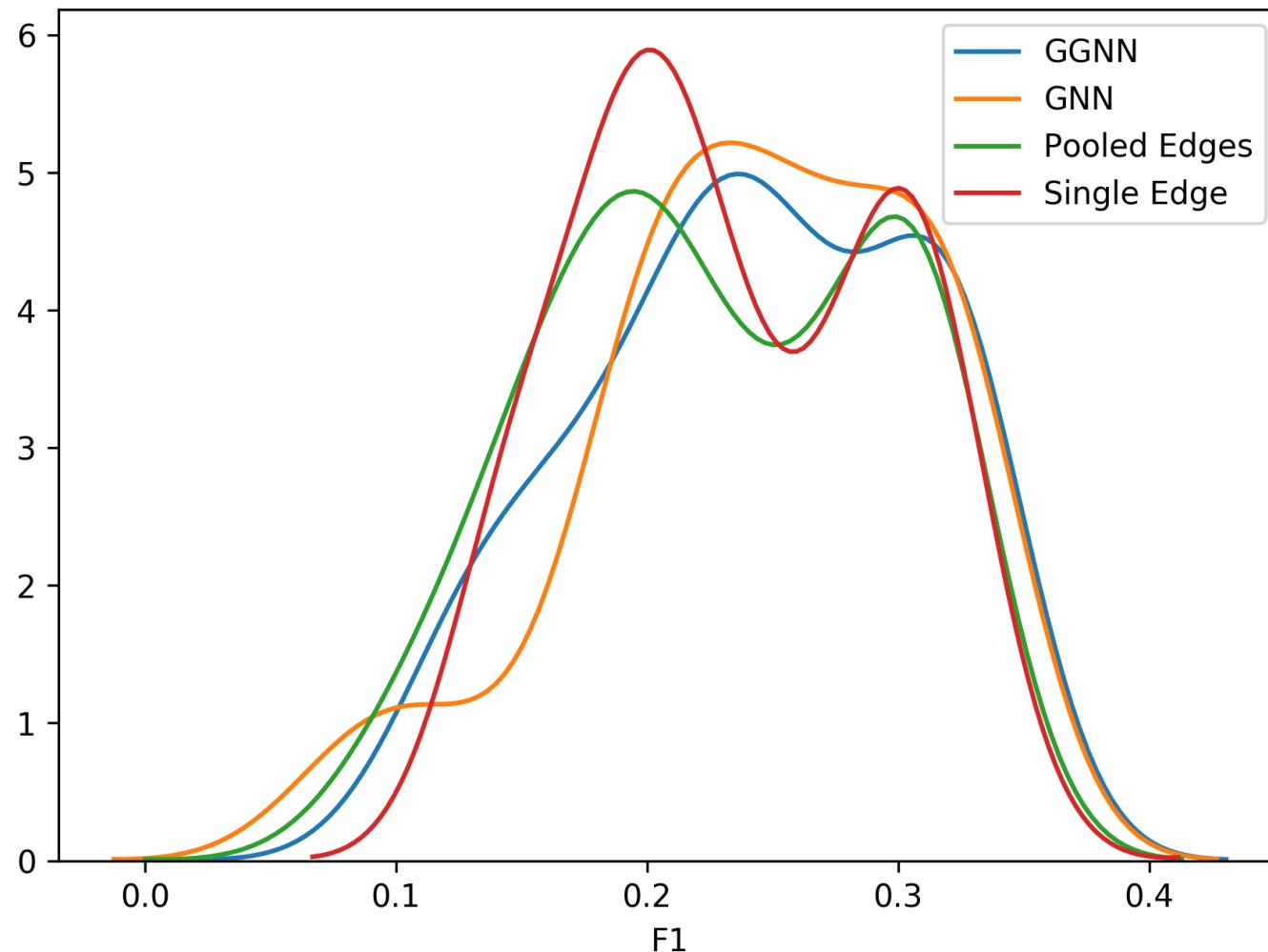
	Precision	Recall	F-score
STAGG	0.173	0.214	0.167
Single Edge	0.250	0.307	0.243
Pooled Edges	0.245	0.302	0.240
GNN	0.253	0.293	0.243
GGNN	0.259	0.305	0.250

WebQSP-WD

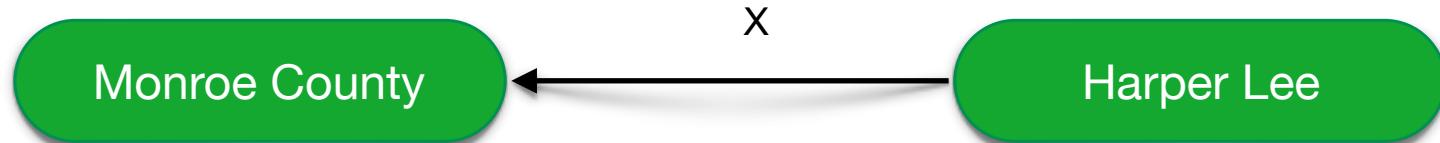




WebQSP-WD complex questions

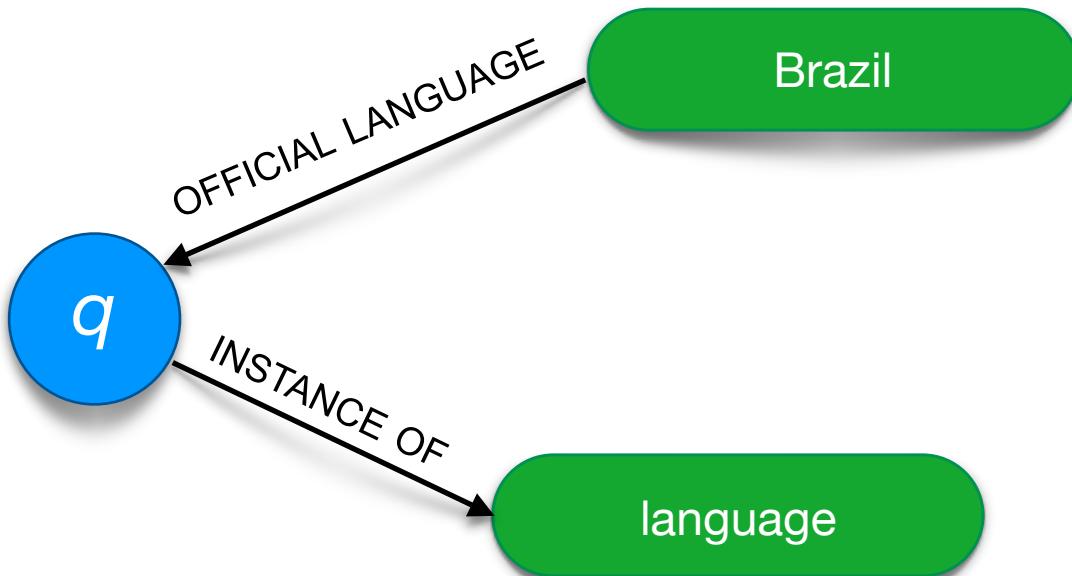


Example output



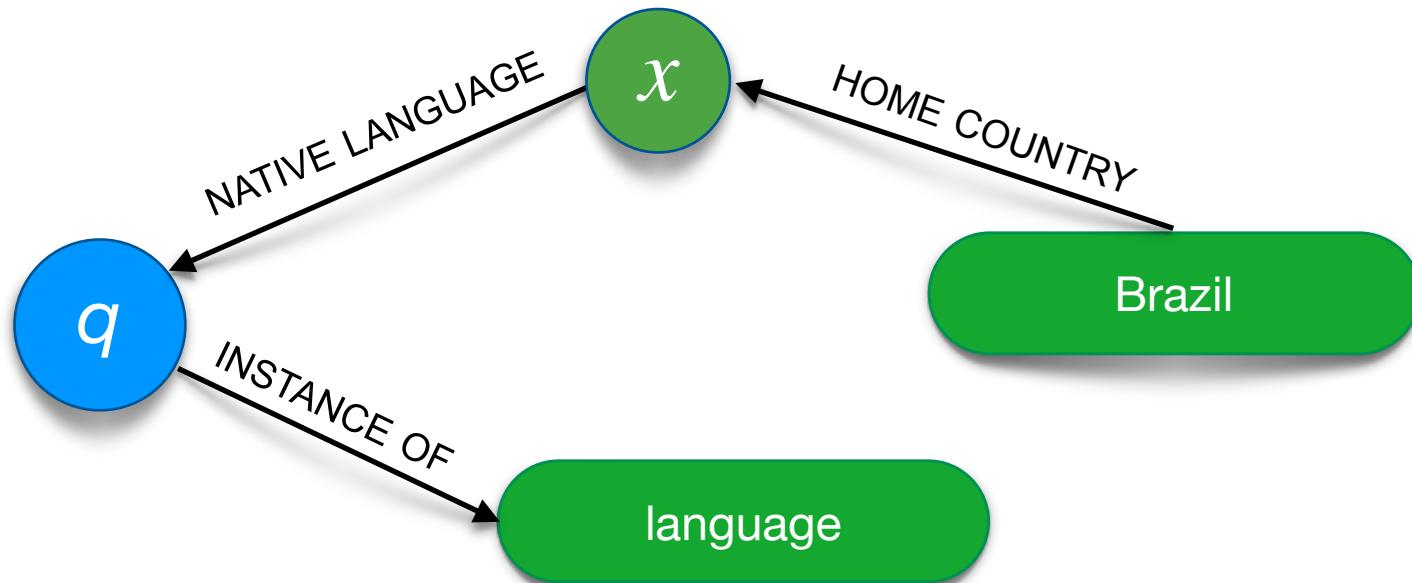
Where did Harper Lee attend high school?

Example output Pooled



What language do people speak in Brazil?

Example output GGNN



What language do people speak in Brazil?

Limitations

1. The small training set limits the more complex Graph NNs architecture
2. Small test set
3. WebQSP contains a lot of data set errors and is not entirely covered by Wikidata (around 30% of errors)
4. Few Wikidata data sets for a meaningful comparison
5. Entity linking is a bottle neck (10% of errors)

Modelling the semantic structure
with **GraphNNs** improves
the representation learning
for knowledge base graphs

Demo and code <https://github.com/UKPLab/coling2018-graph-neural-networks-question-answering>

Knowledge base question answering

Your question

Who played Luke Skywalker in Star Wars?

Answer

Follow up?

- <https://daniilsorokin.github.io> ← slides
- sorokin@ukp.informatik.tu-darmstadt.de
- [@daniilmagpie](https://twitter.com/daniilmagpie)
- COLING'18 Paper: <http://aclweb.org/anthology/C18-1280>

