



TECHNISCHE
UNIVERSITÄT
DARMSTADT



UKP Lab
Darmstadt, Germany

Encoding Knowledge with Graph Neural Networks



Daniil Sorokin

@daniilmagpie 🙌

<https://daniilsorokin.github.io>



UKP

Imperial College London
January 24, 2019

Me

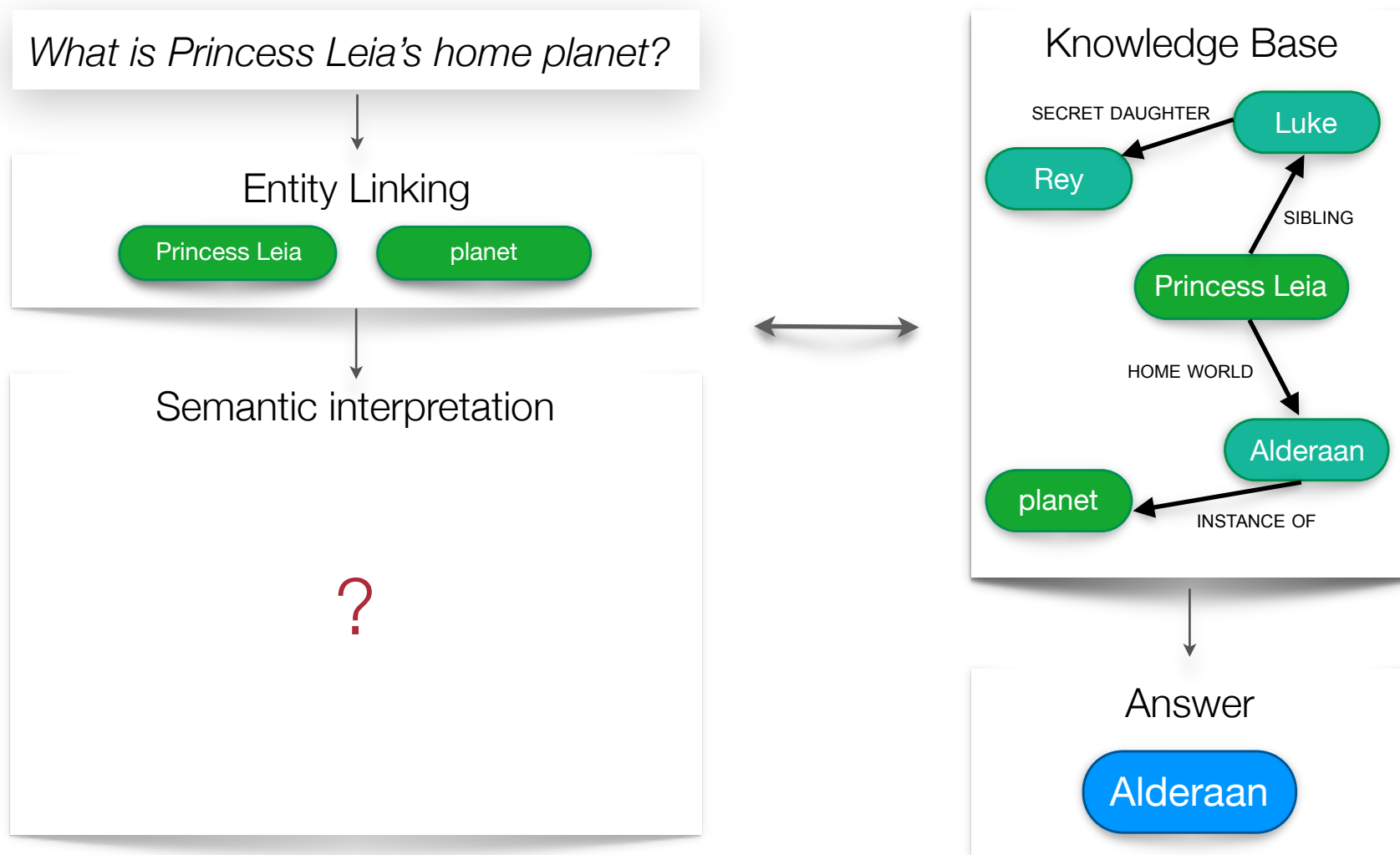
Bachelor in Applied
Linguistics
at St. Petersburg State
University, Russia
2011

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



Knowledge Base

Knowledge Base

Princess Leia English Not logged in [Talk](#) [Contributions](#) [Create account](#) [Log in](#)



WIKIDATA

Item Discussion Read View history

Princess Leia (Q51797)

character in Star Wars [edit](#)



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

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

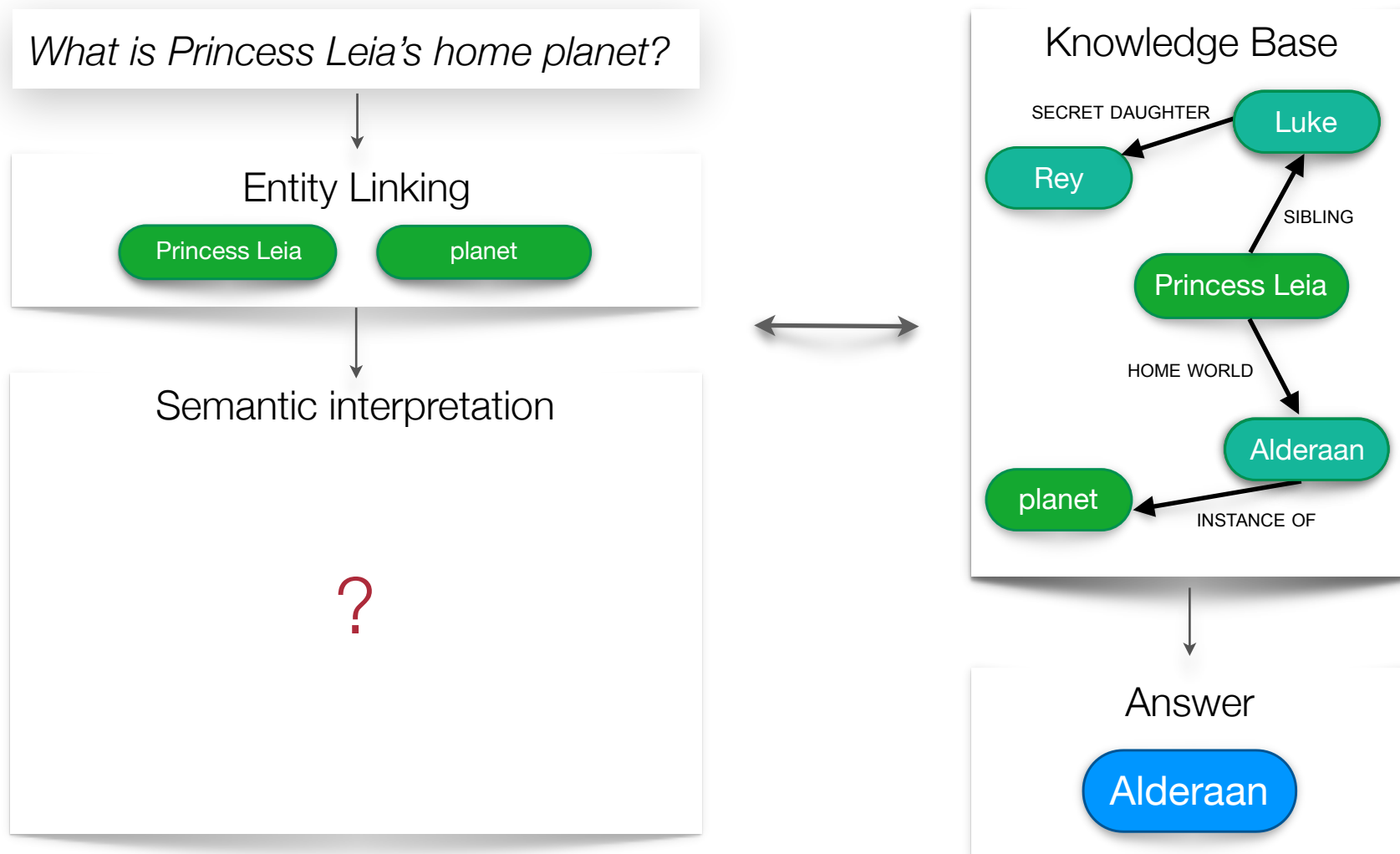
Language	Label	Description	Also known as
English	Princess Leia	character in Star Wars	Leia Organa Princess Leia Organa of Alde... General Organa Princess Leah
French	Leia Organa	personnage de Star Wars	Princesse Leia
German	Leia Organa	Figur in Star Wars	Prinzessin Leia Prinzessin Leia Organa
Scots	Princess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

[All entered languages](#)

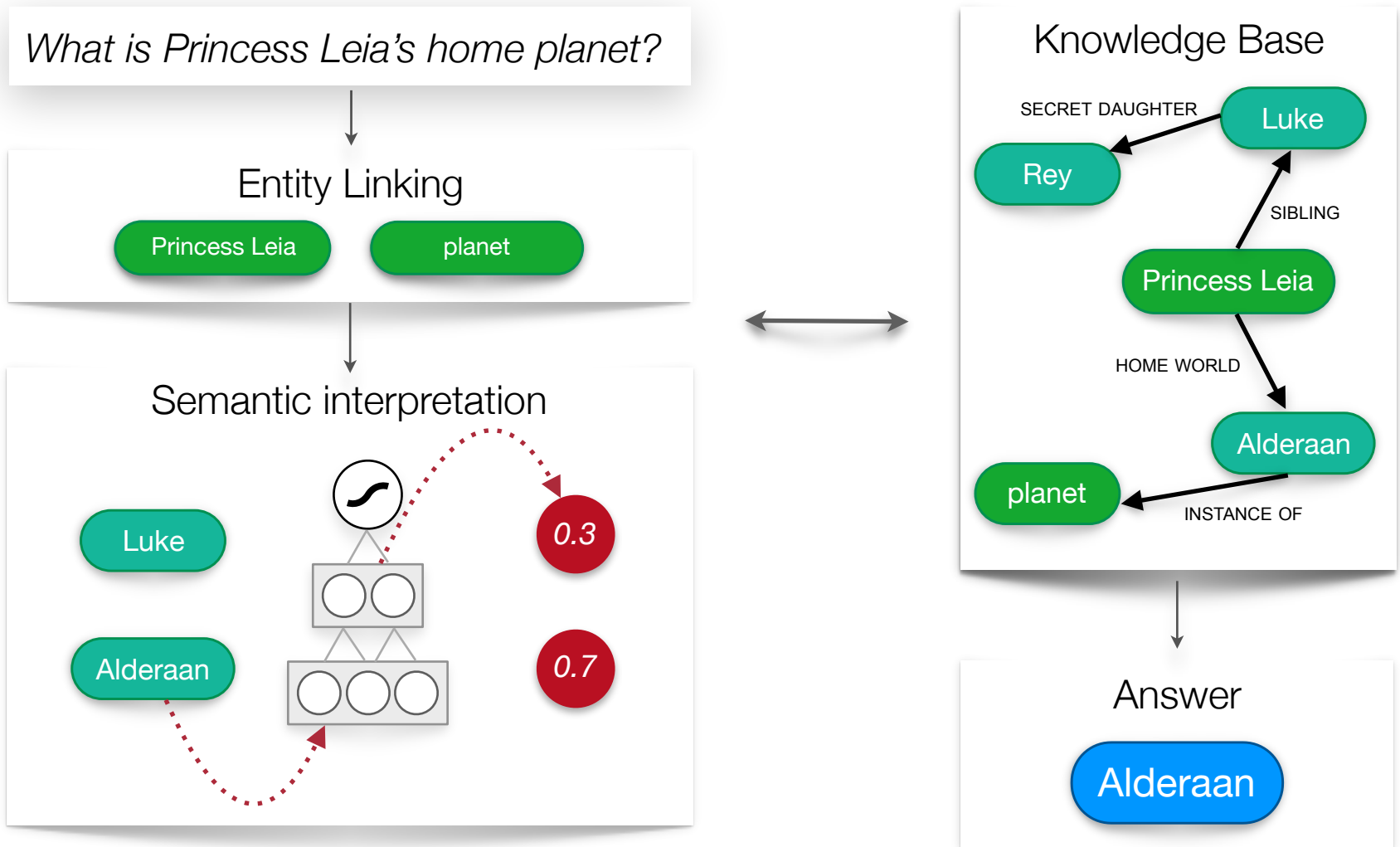
Statements

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

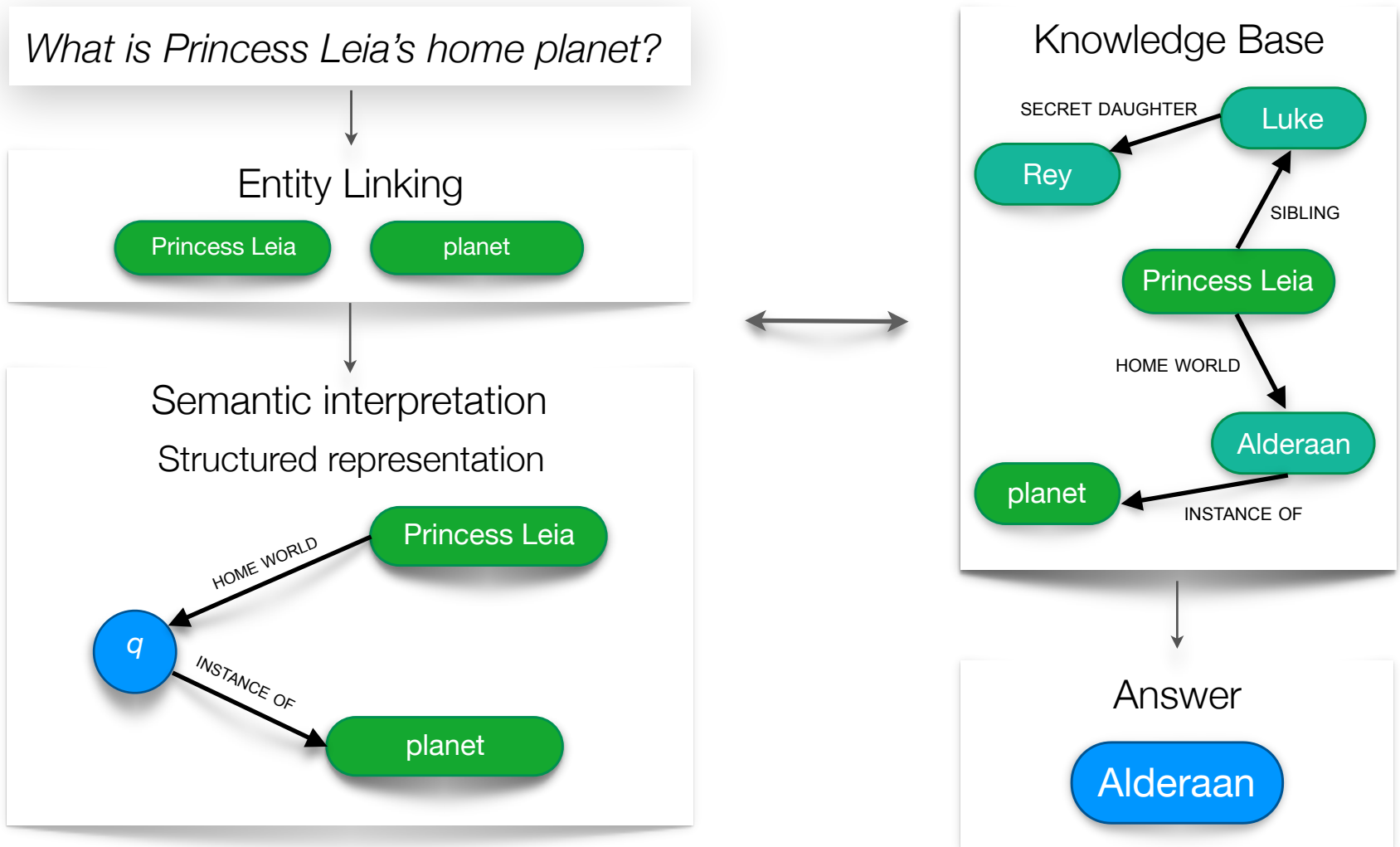
Knowledge Base Question Answering



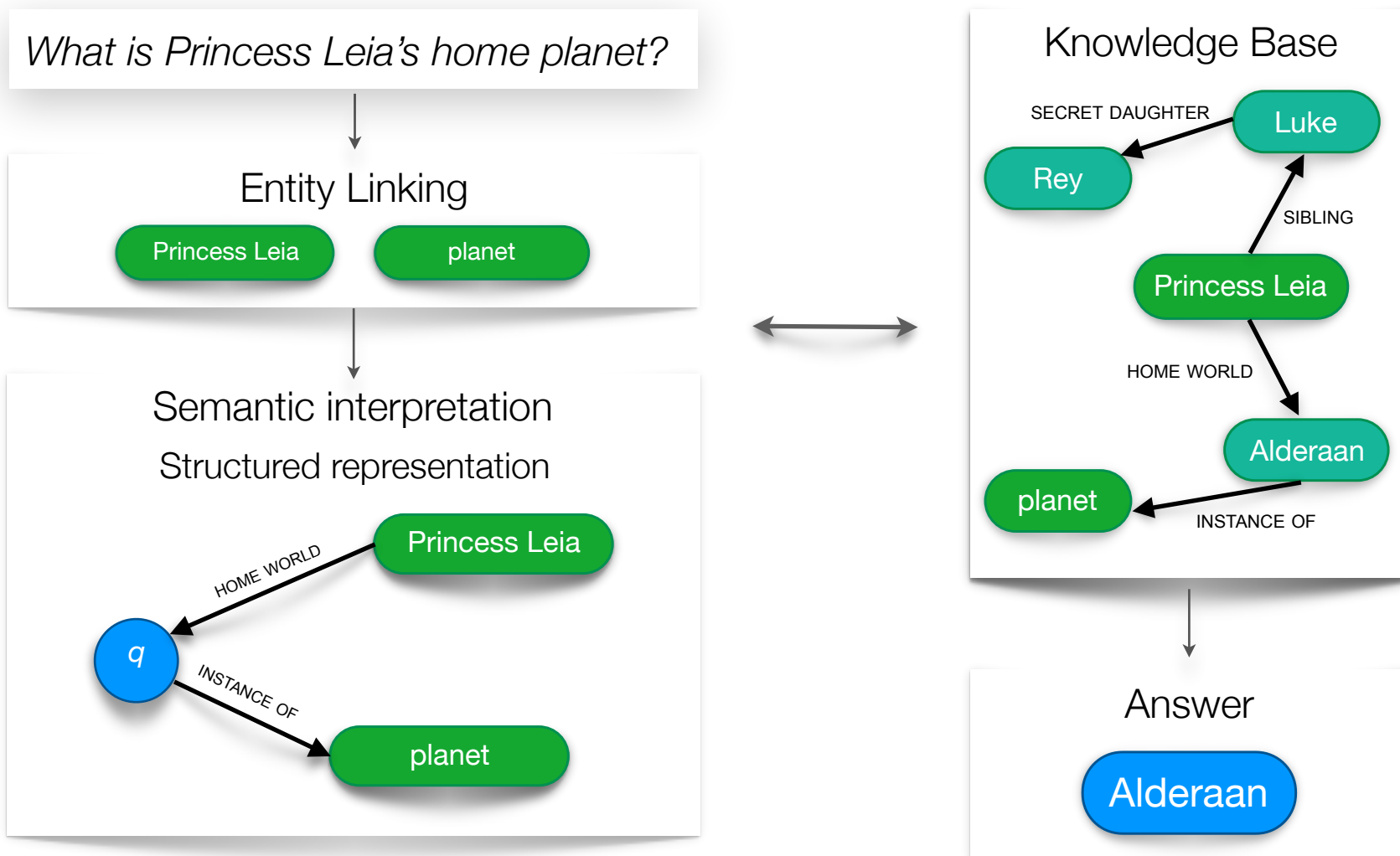
Knowledge Base Question Answering



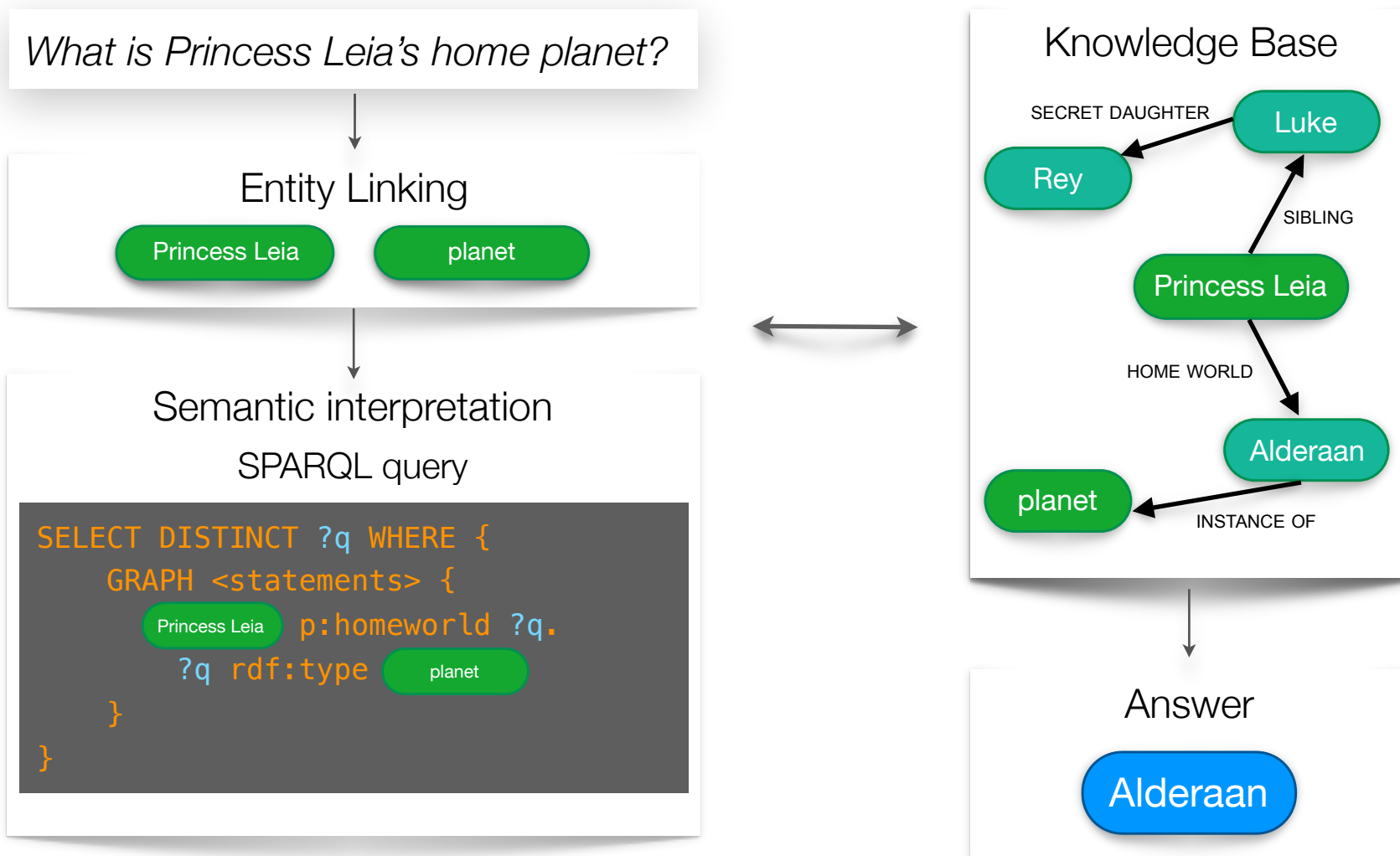
Knowledge Base Question Answering



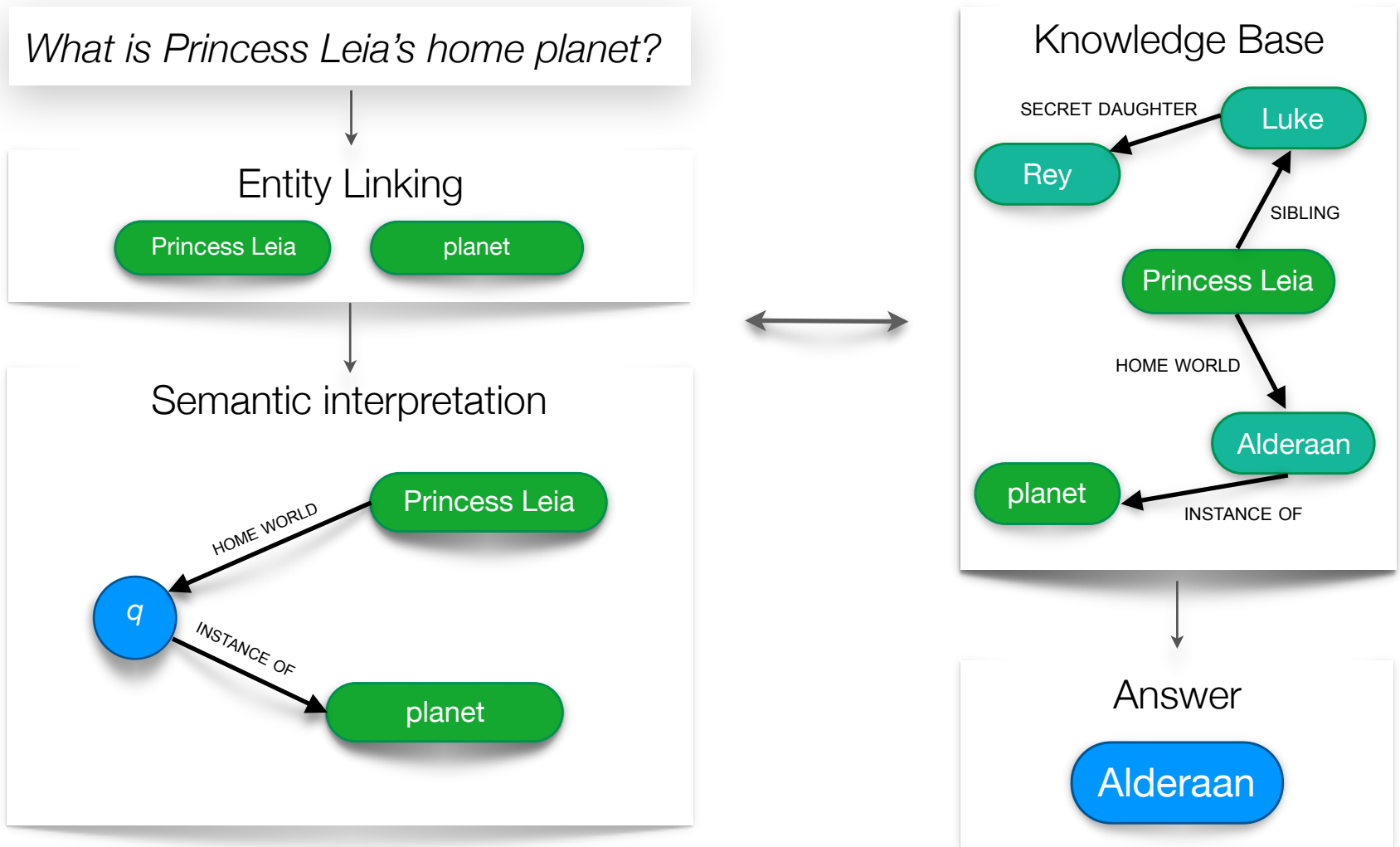
Knowledge Base Question Answering



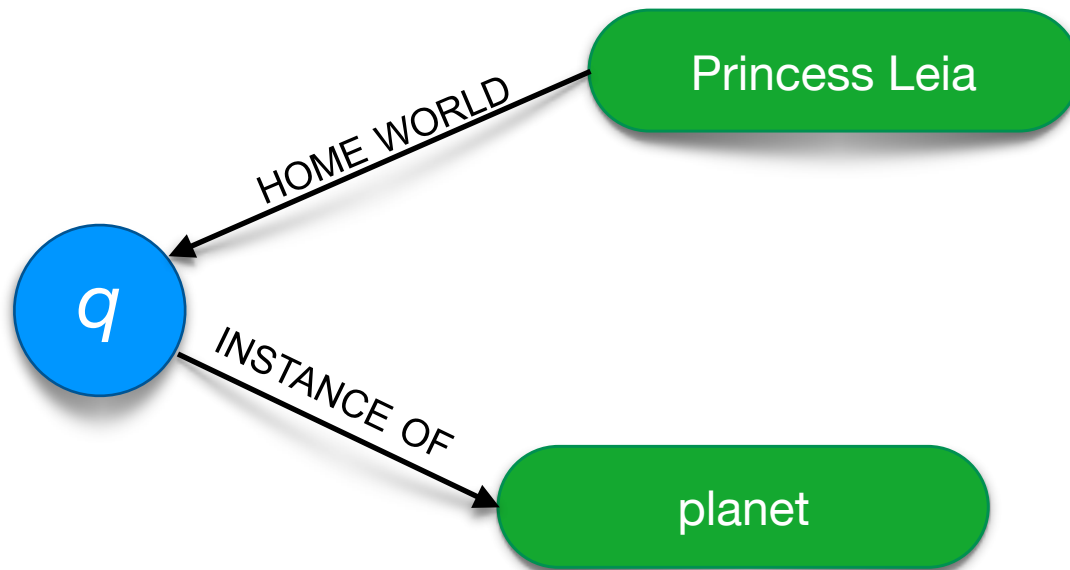
Knowledge Base Question Answering



Knowledge Base Question Answering



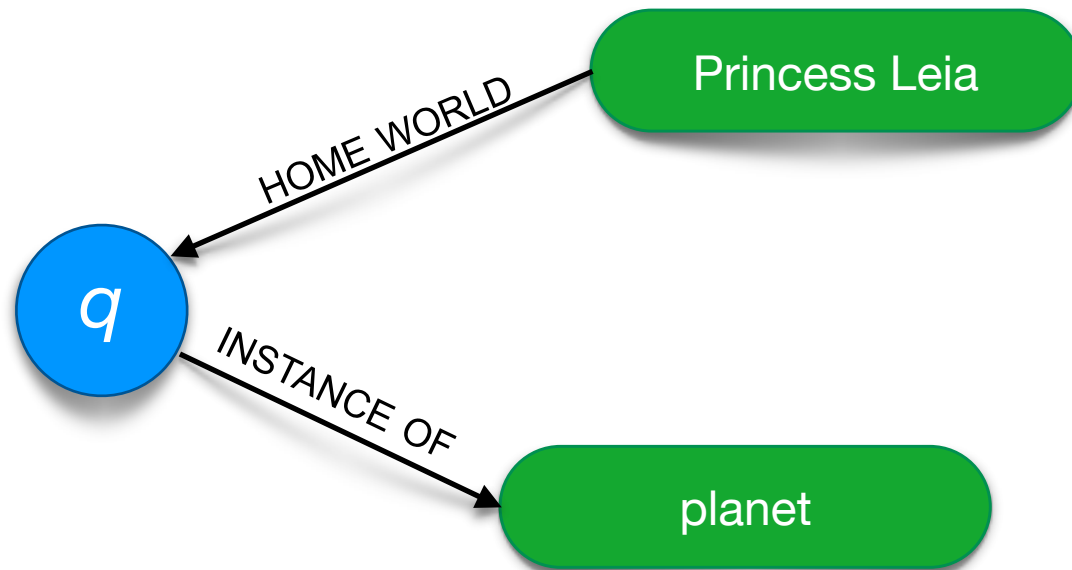
Structured Representation Approach



What is Princess Leia's home planet?

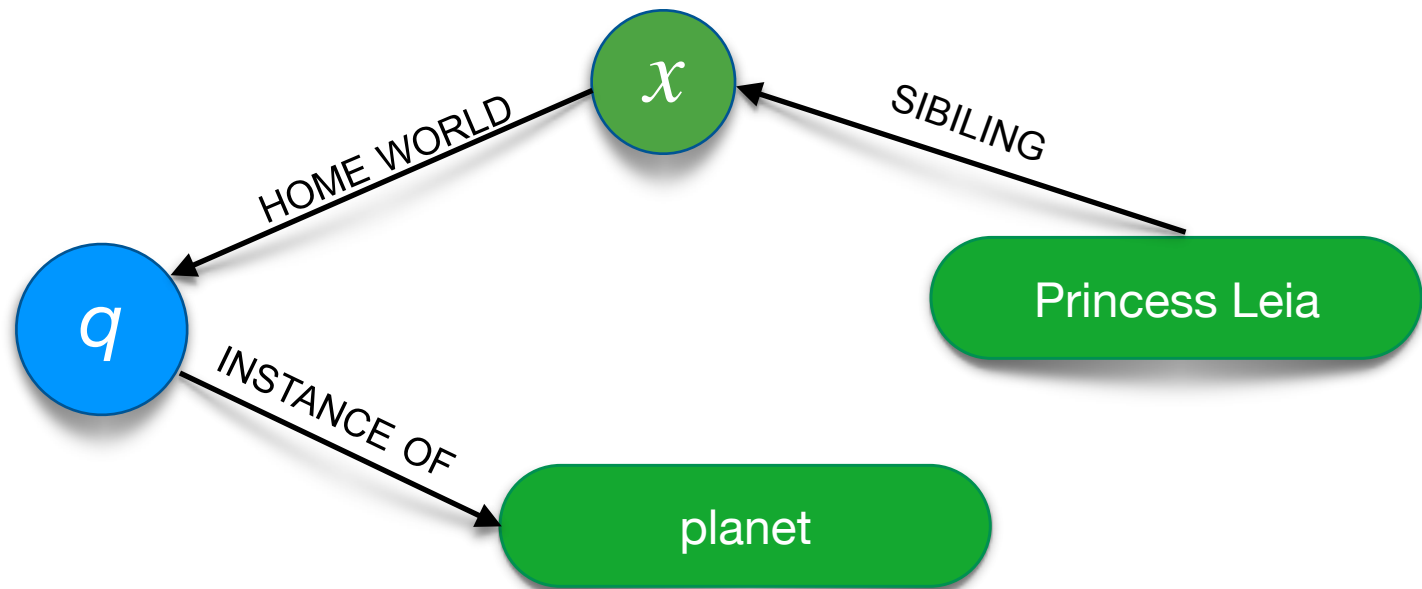
Possible Semantic Graphs

Yih et al. (2015)



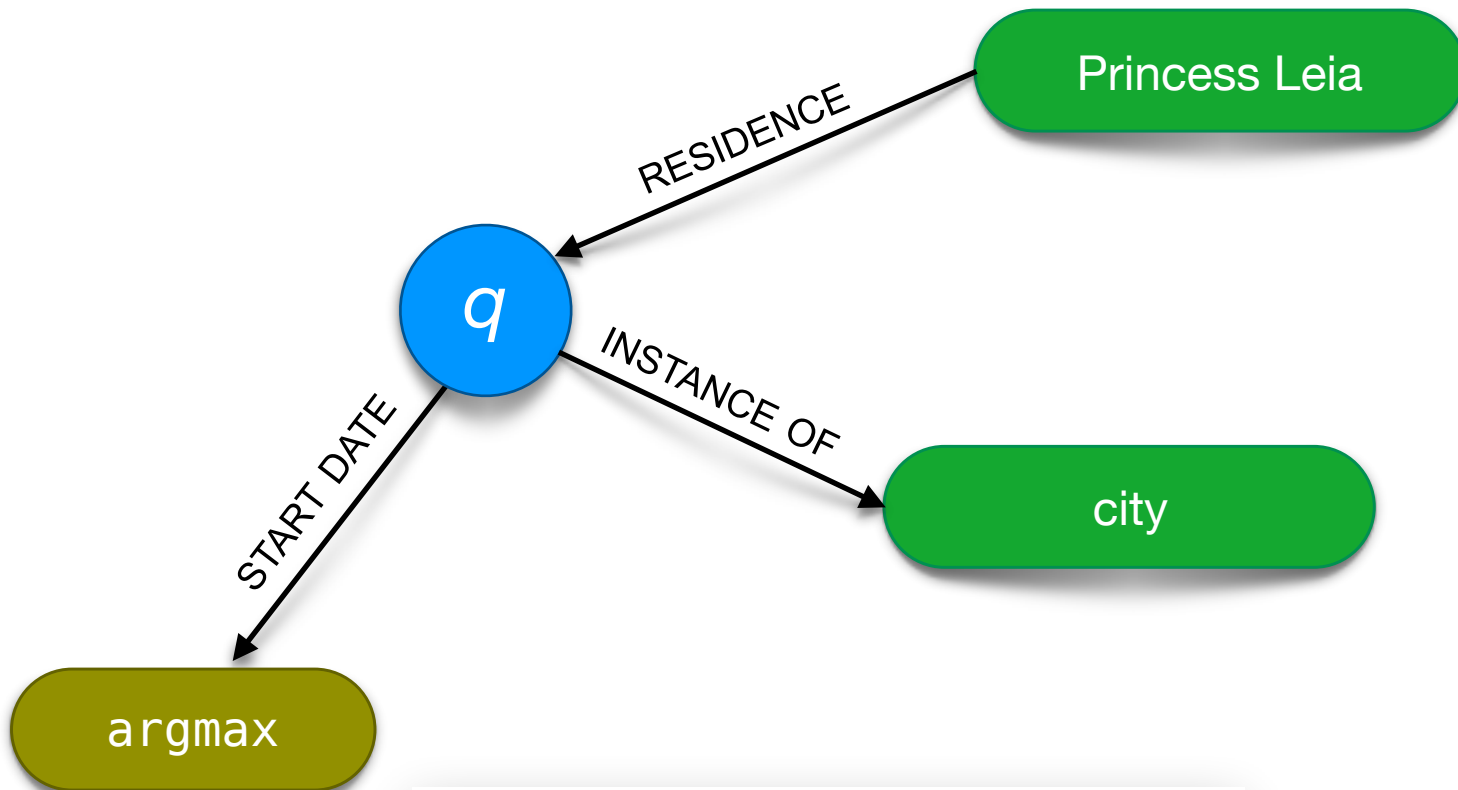
What is Princess Leia's home planet?

Possible Semantic Graphs



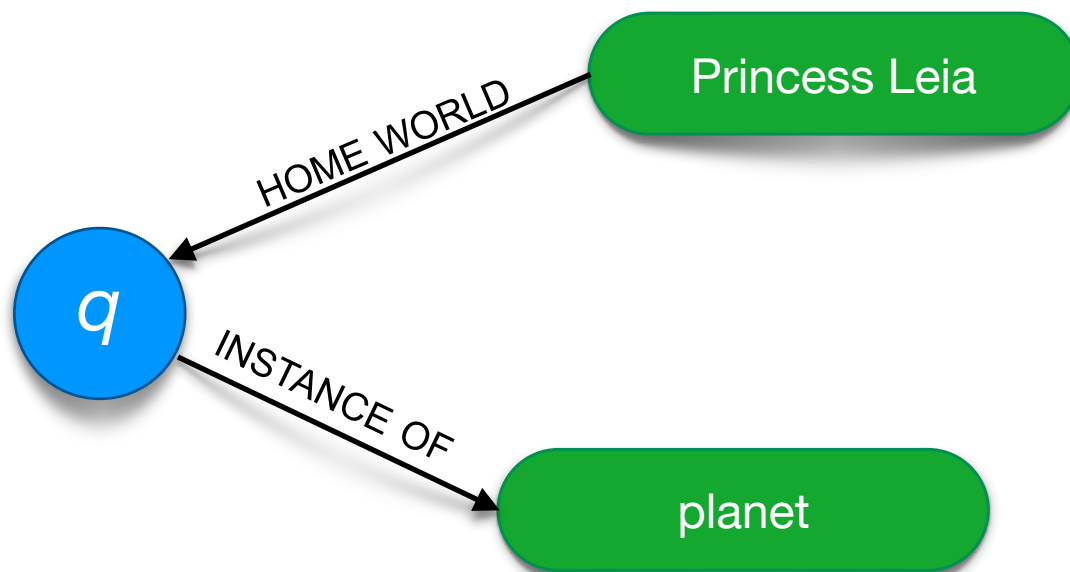
What is the home planet of Princess Leia's family?

Possible Semantic Graphs



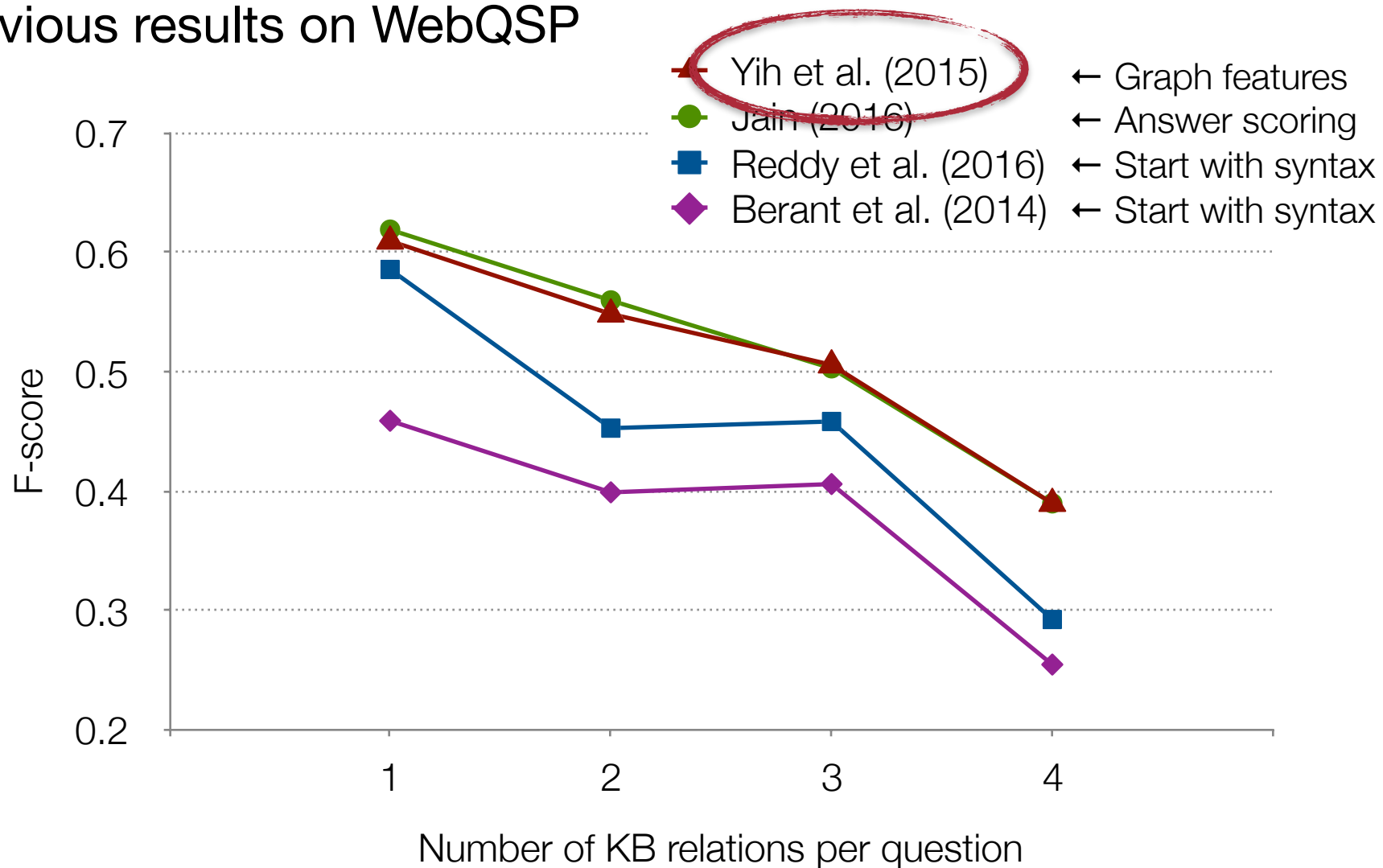
Where was Princess Leia's first home?

Possible Semantic Graphs



Representation structure is a graph
and we model it as such

Previous results on WebQSP



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

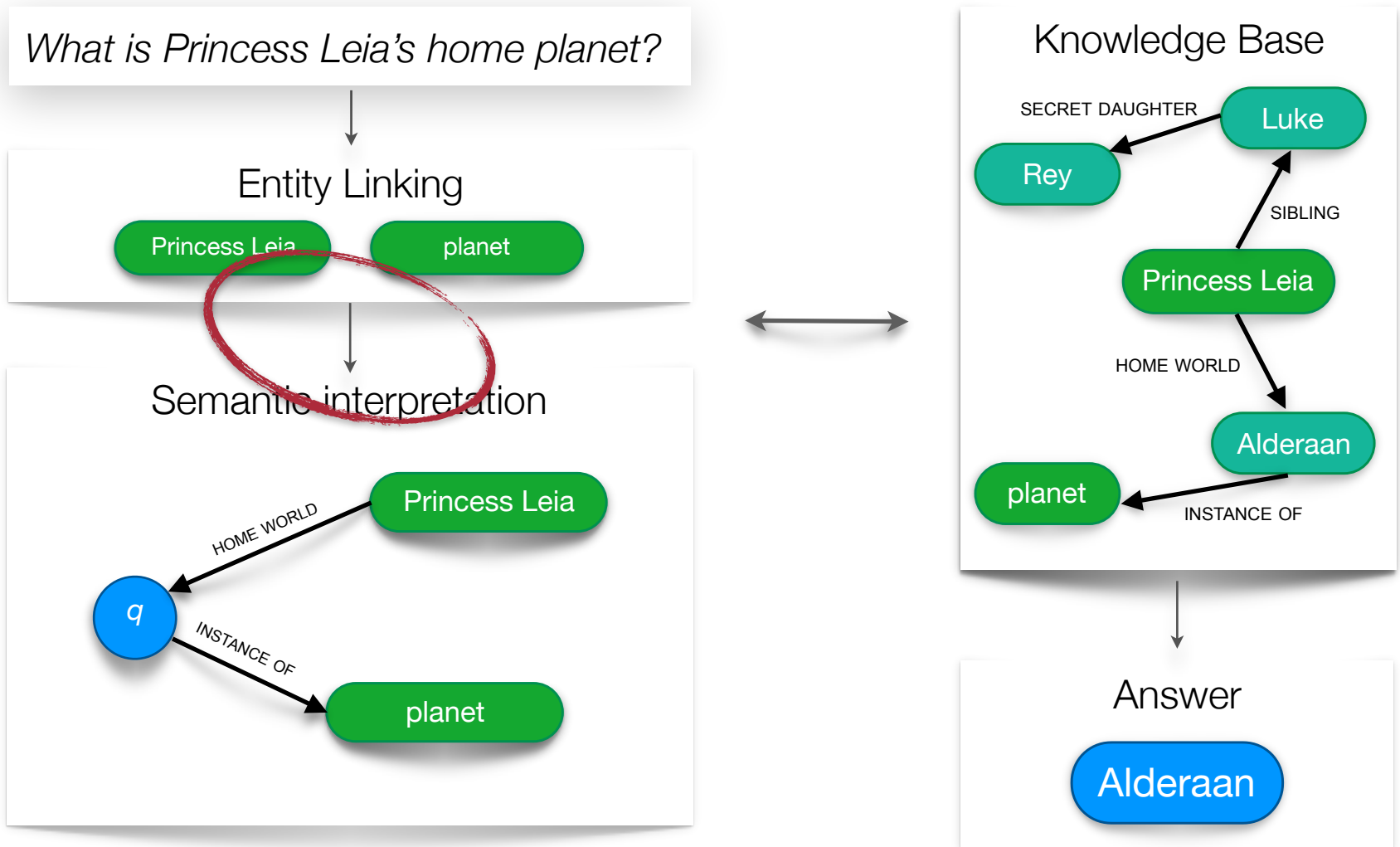
- Kipf and Welling (2017) – document classification
- Marcheggiani and Titov (2017) – encode syntax dependencies for SRL
- Schlichtkrull et al. (2018) – KB embeddings

2. Gated Graph Neural Networks

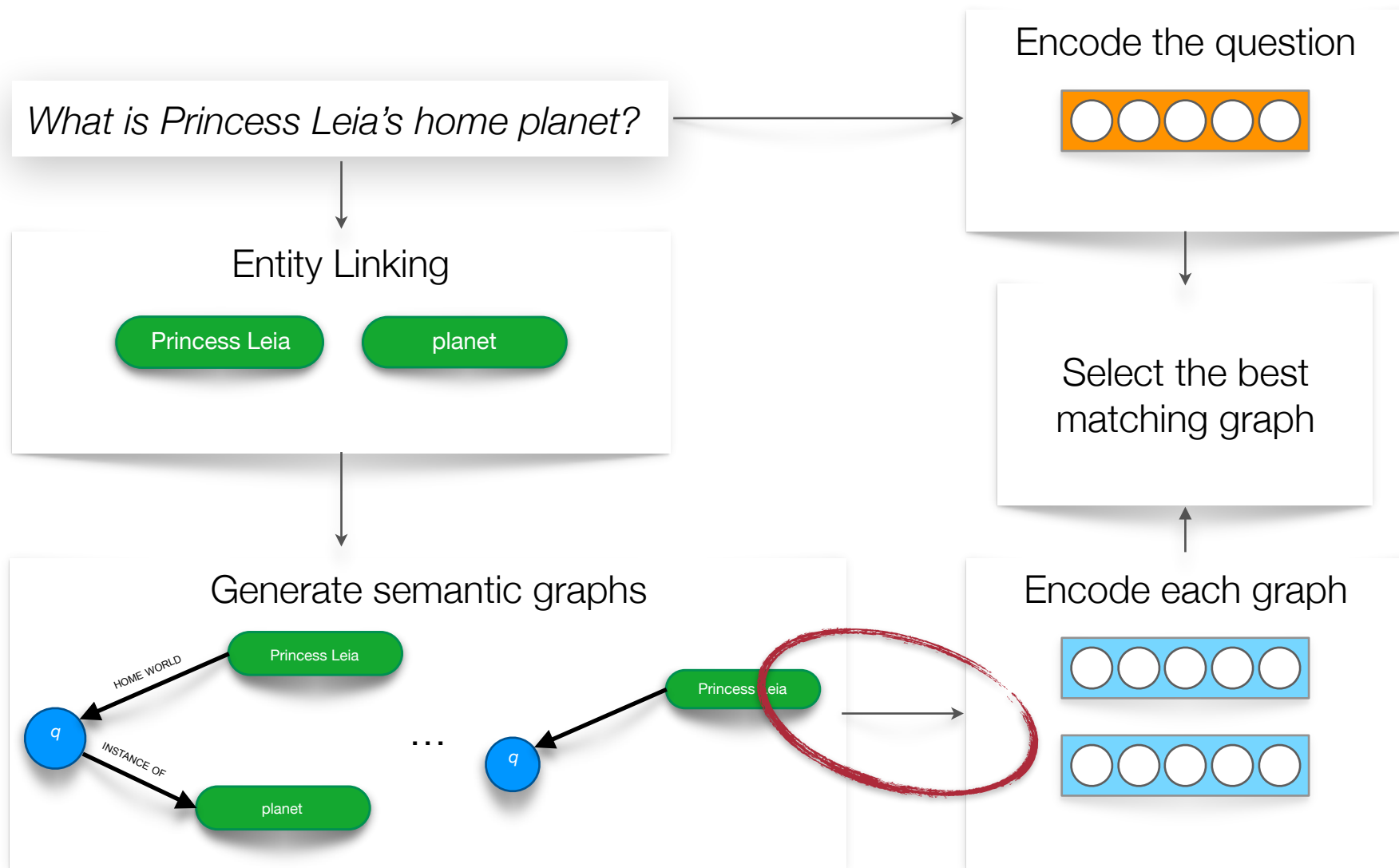
- Scarselli et al. (2009) – Graph Neural Networks
- Li et al. (2016) – Gated variant
- Chen et al. (2018) – Structured Dialogue Policy
- Sun et al. (2018) – QA with Fusion of Knowledge Bases and Text

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

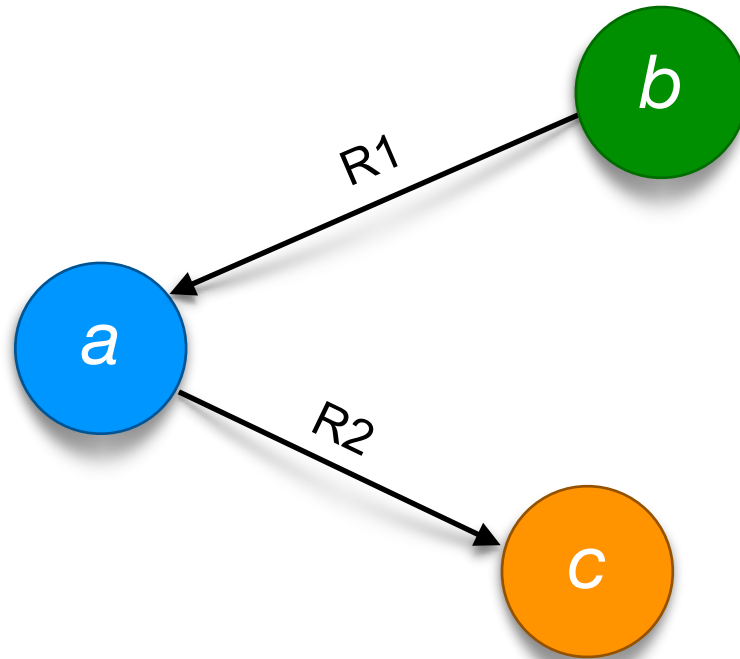
Knowledge Base Question Answering



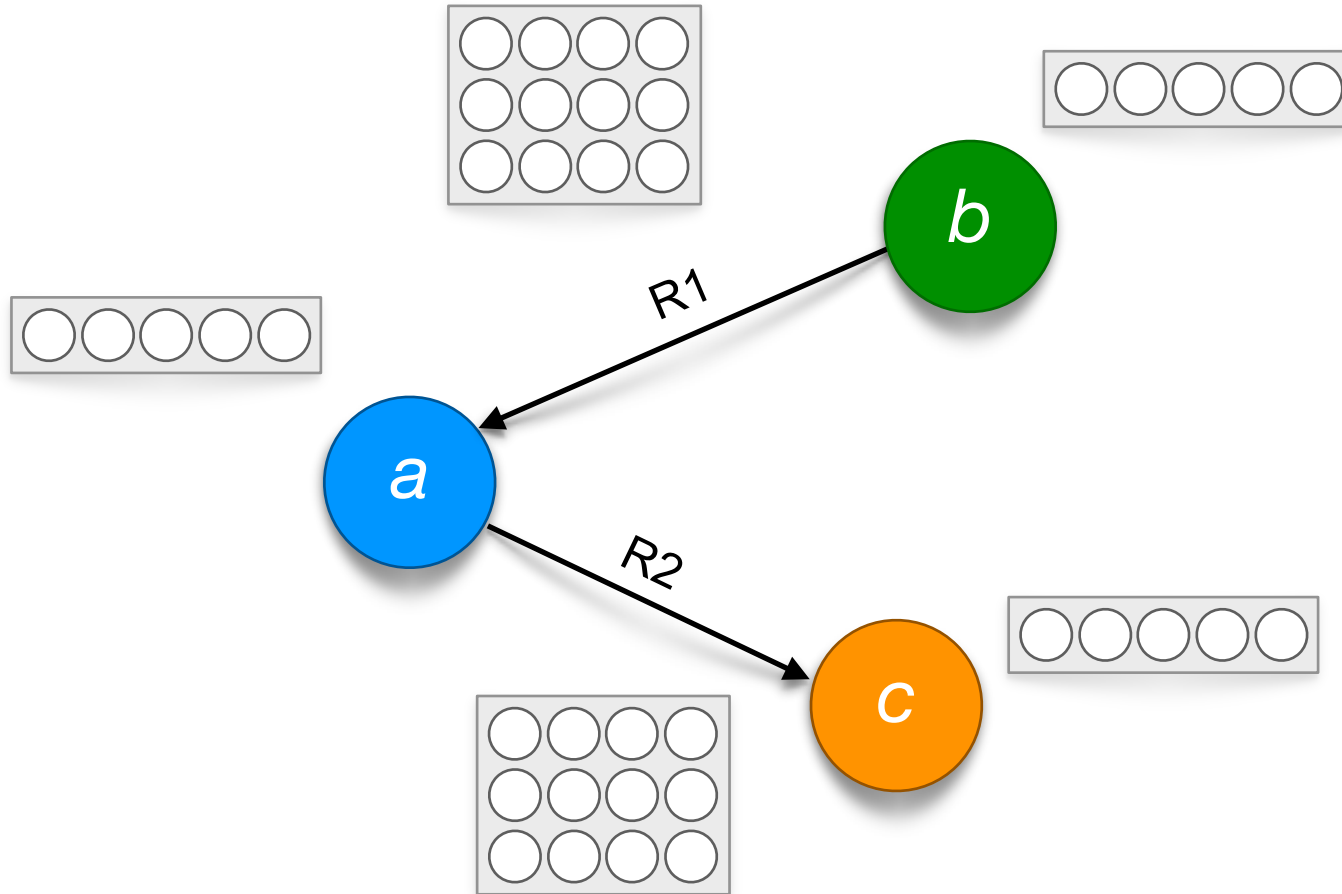
Representation Learning



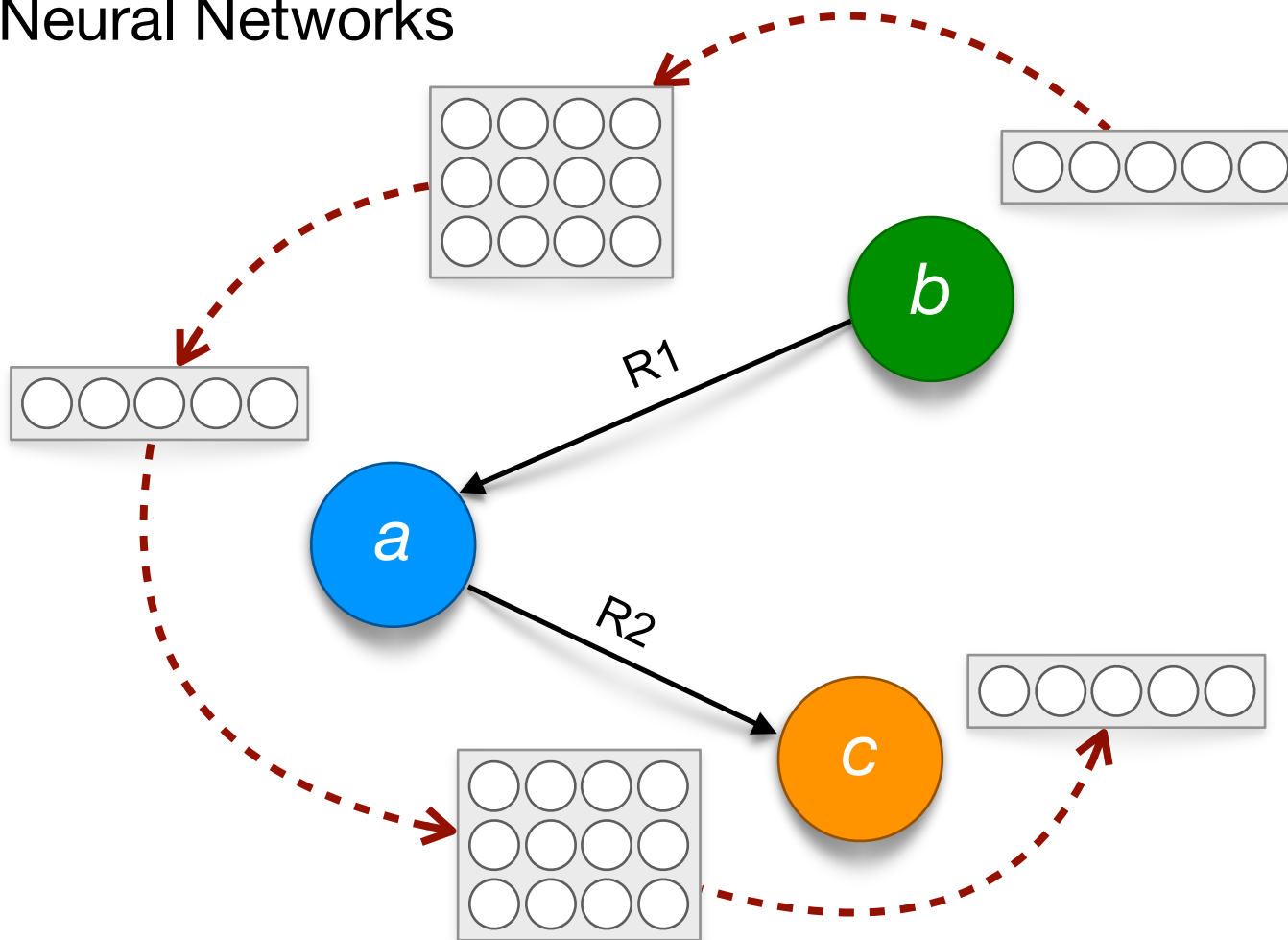
Graph Neural Networks – Scarselli et al. (2009)



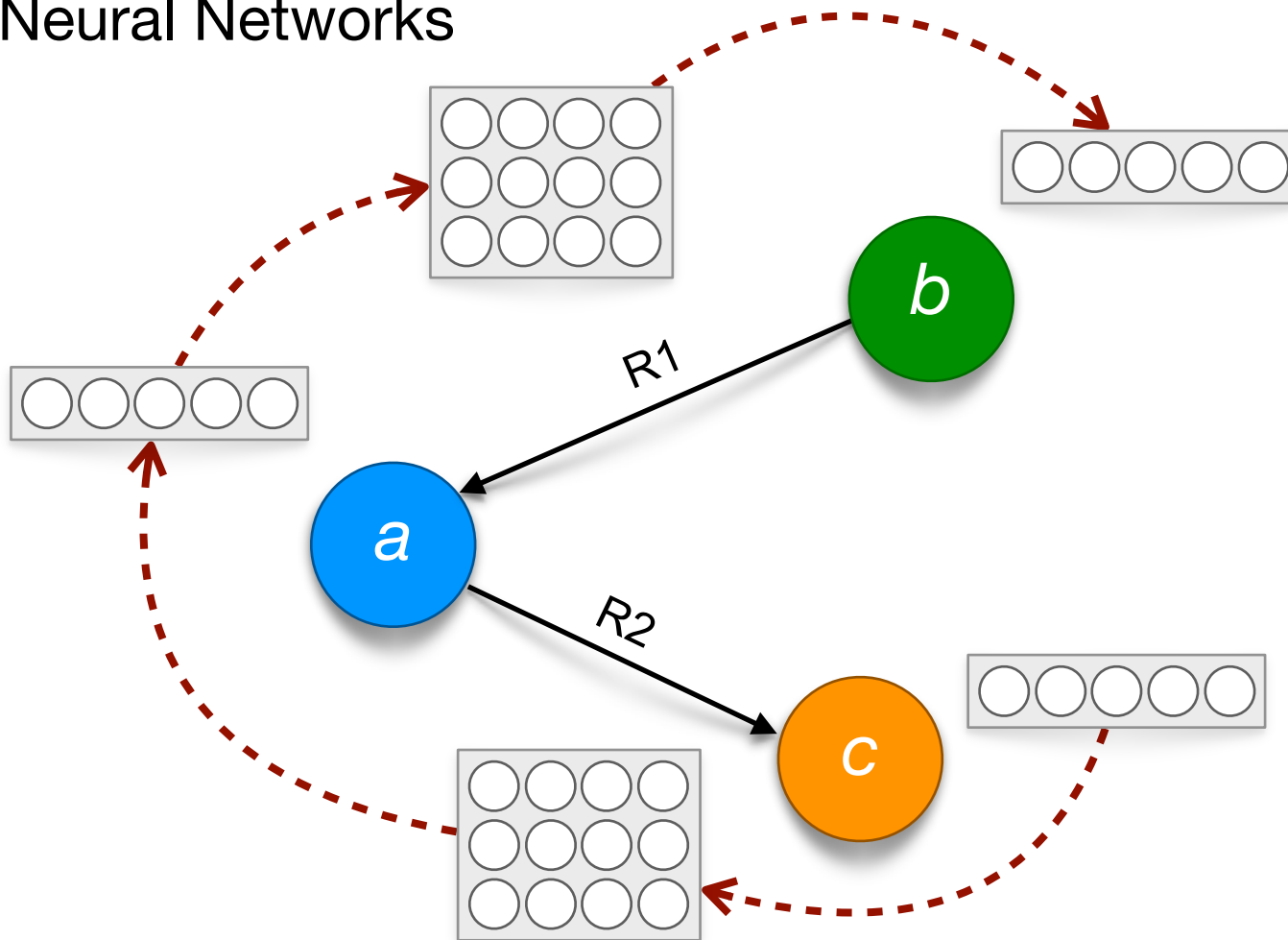
Graph Neural Networks



Graph Neural Networks

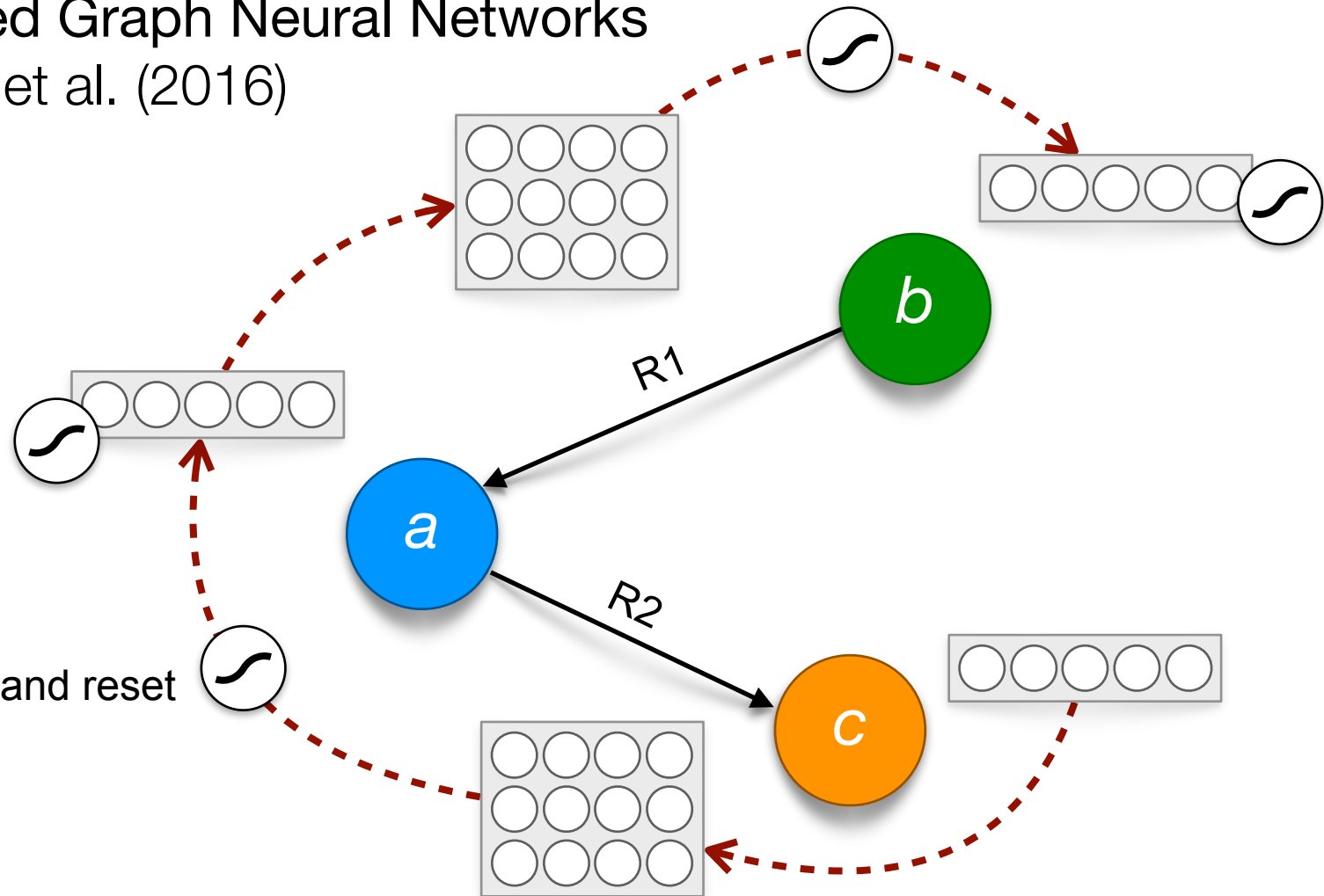


Graph Neural Networks



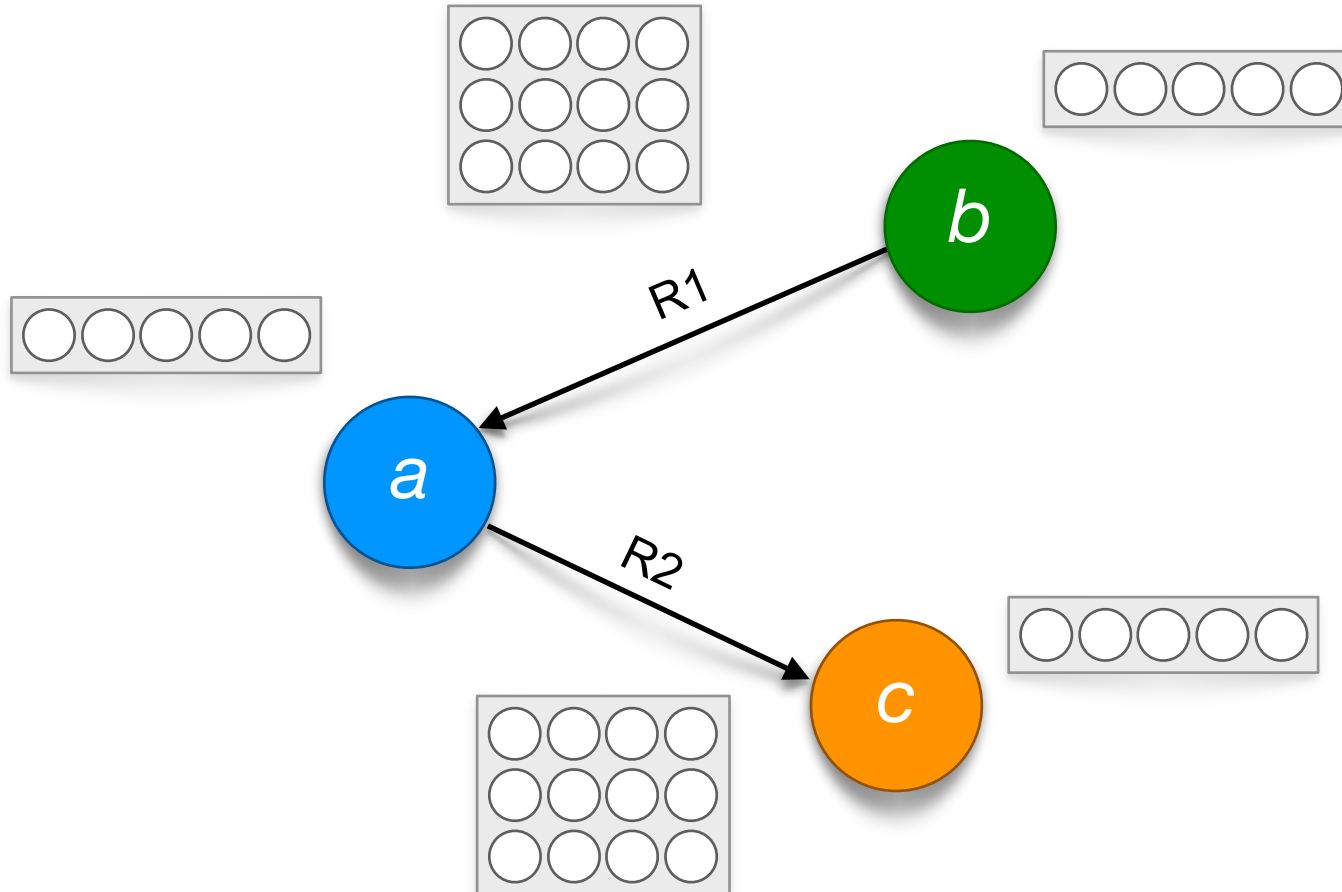
Gated Graph Neural Networks

– Li et al. (2016)

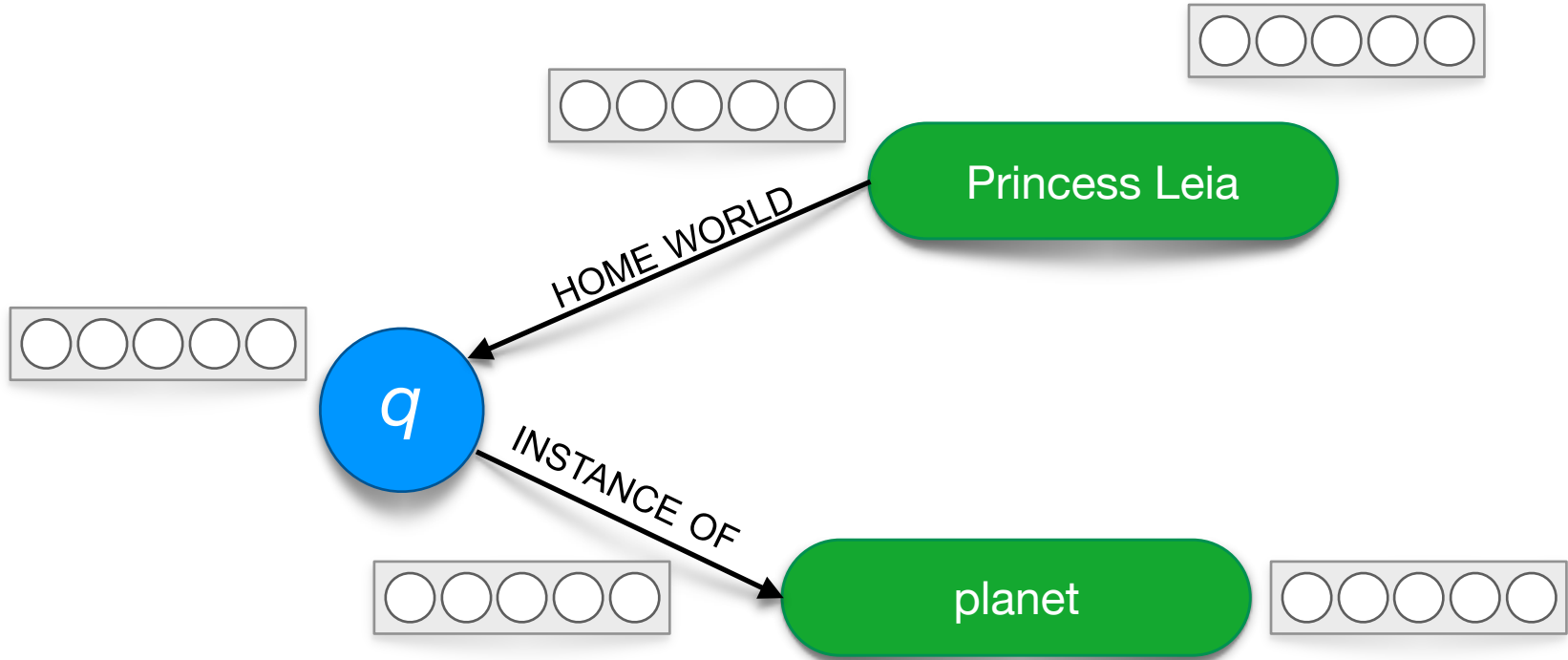


Update and reset
gates

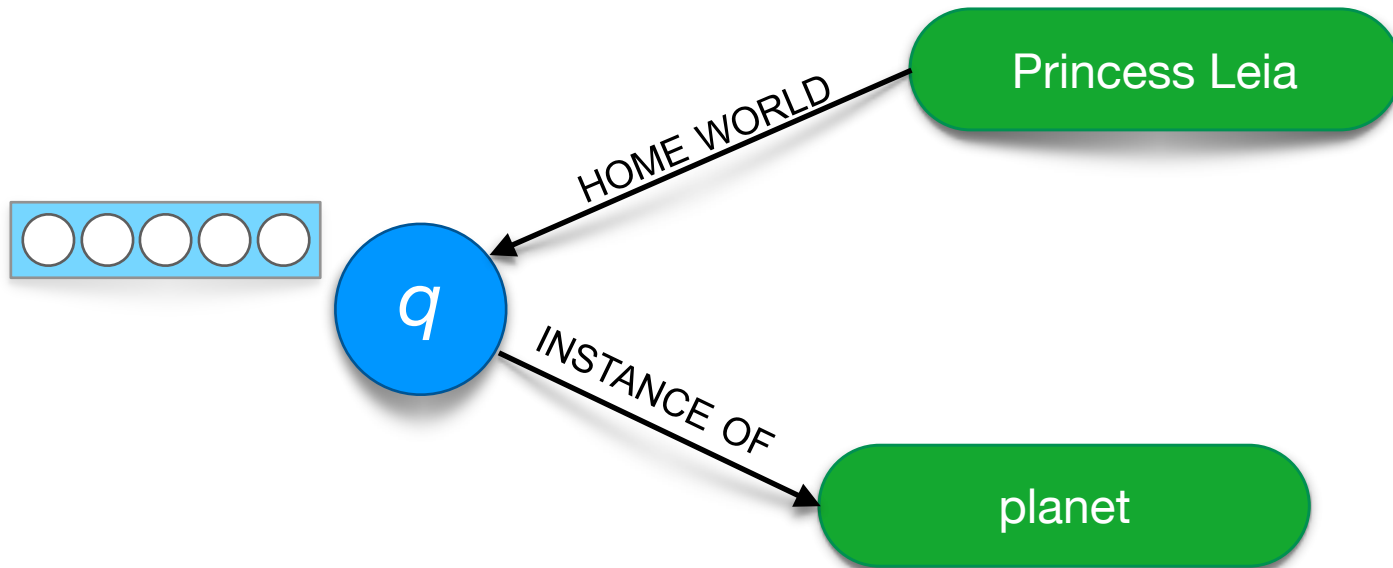
Gated Graph Neural Networks



Graph Encoding

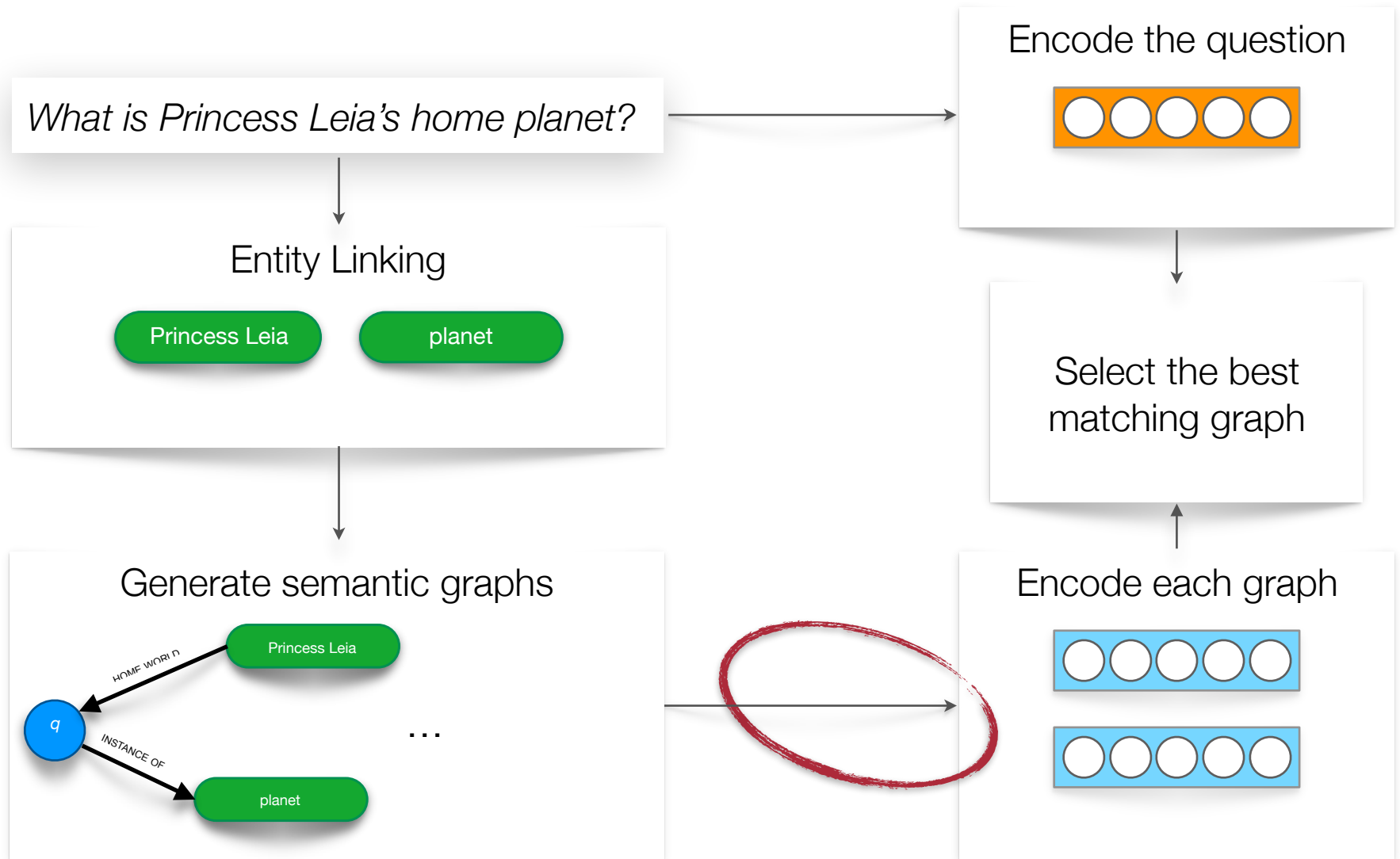


Graph Encoding

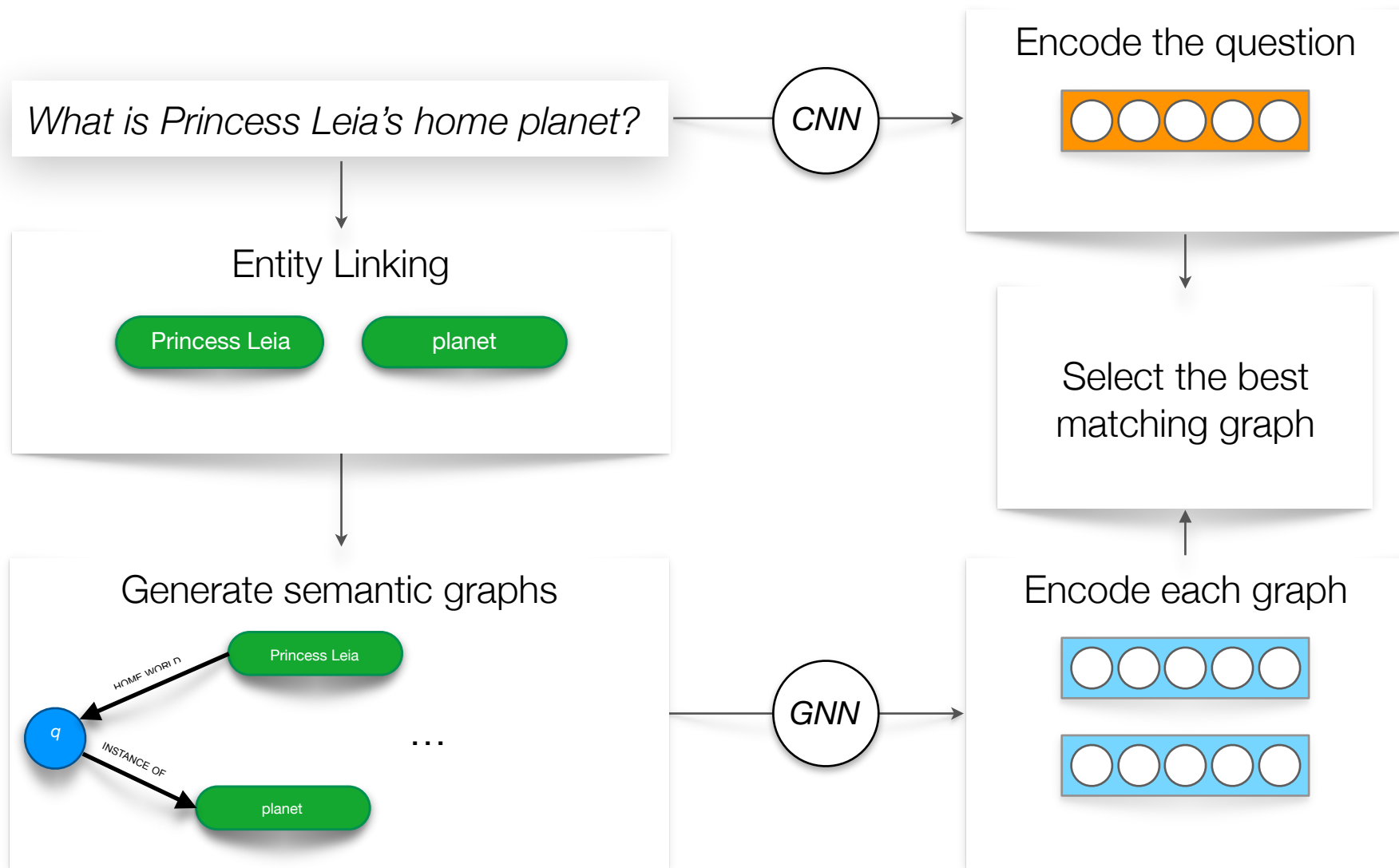


The Graph Neural Network models all aspects of the semantic graph representation

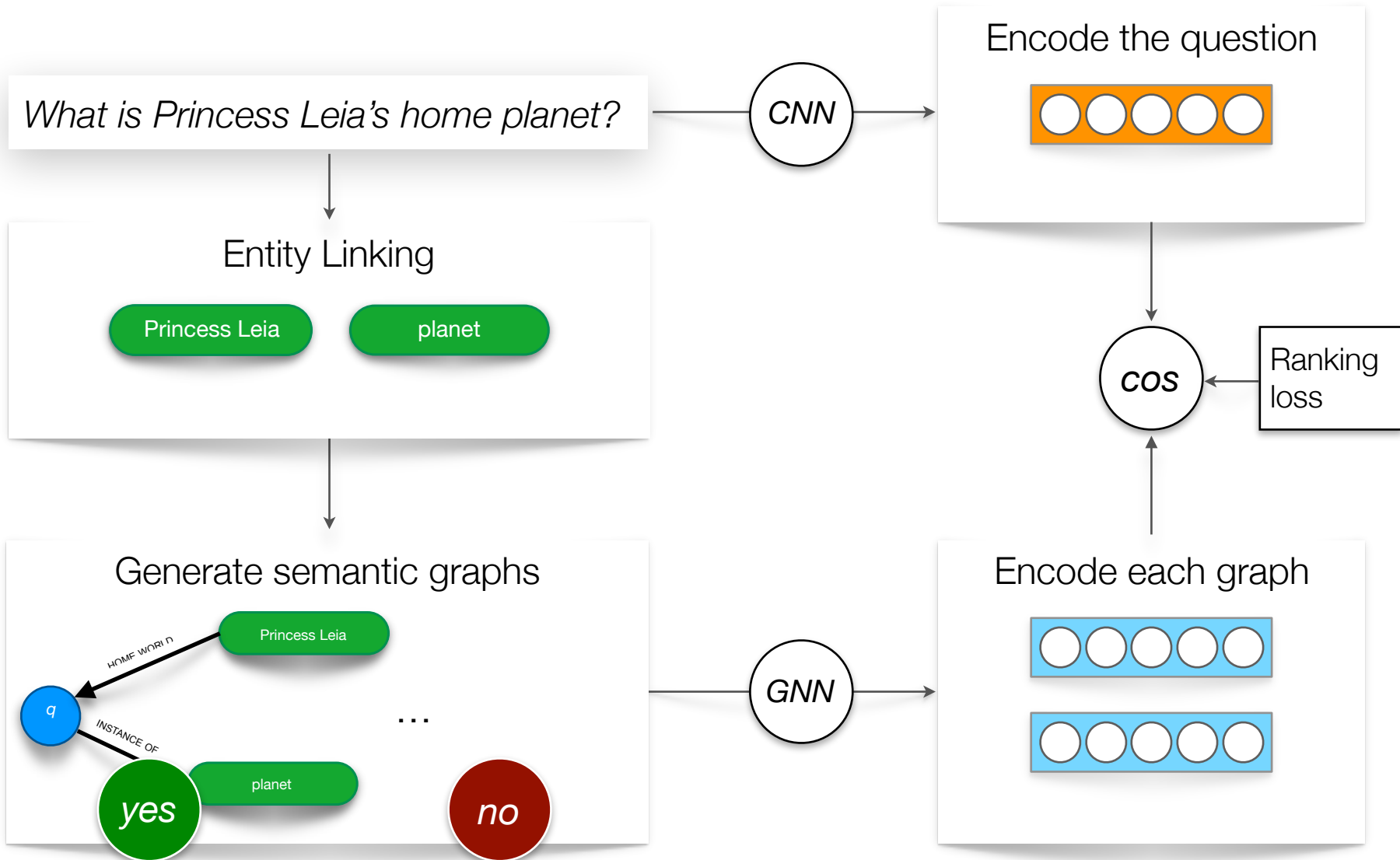
Question Answering Pipeline – Representation Learning



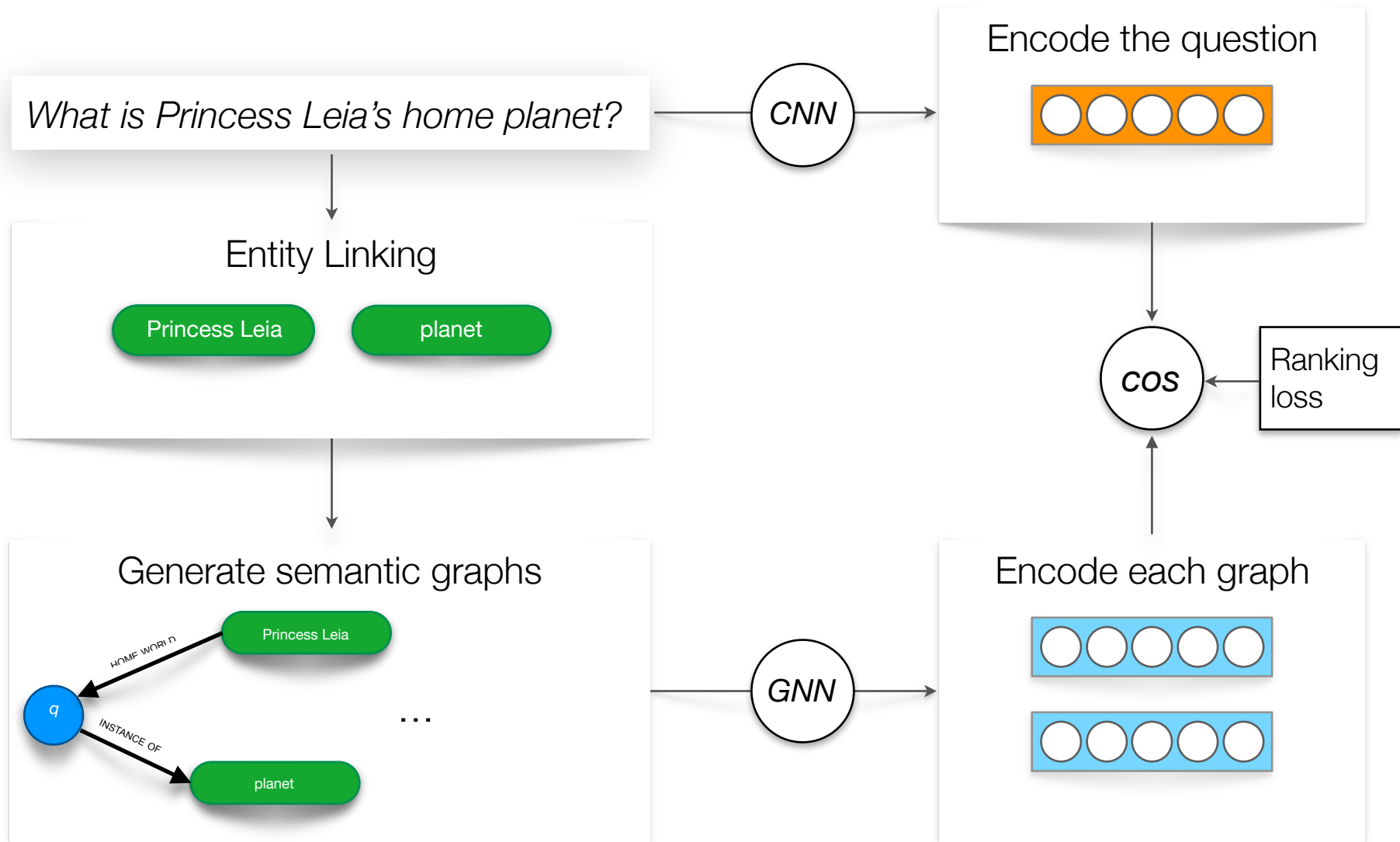
Question Answering Pipeline – Representation Learning



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 without 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

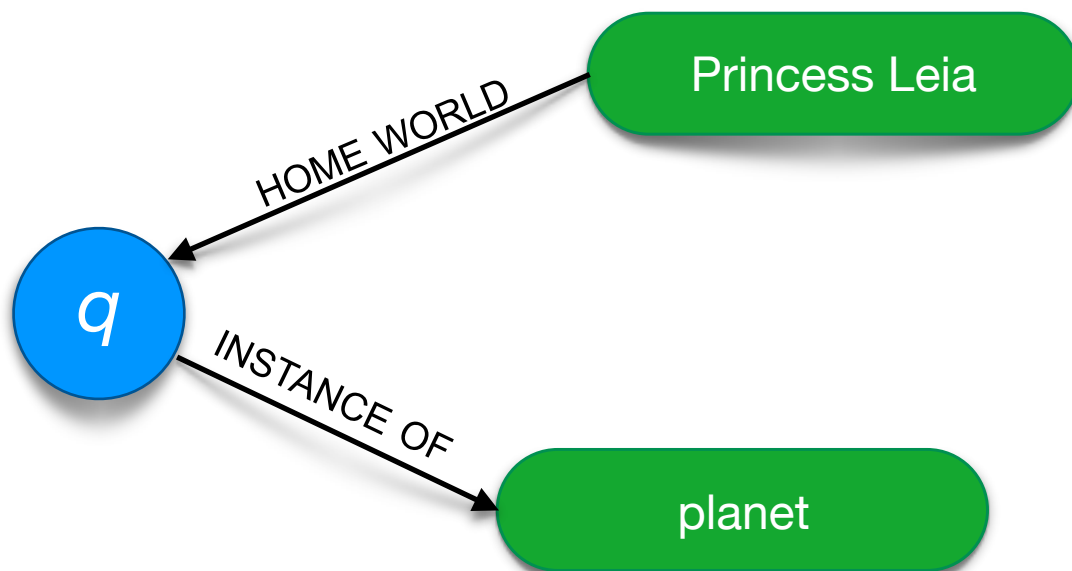
Recall

F-score

1.000

1.000

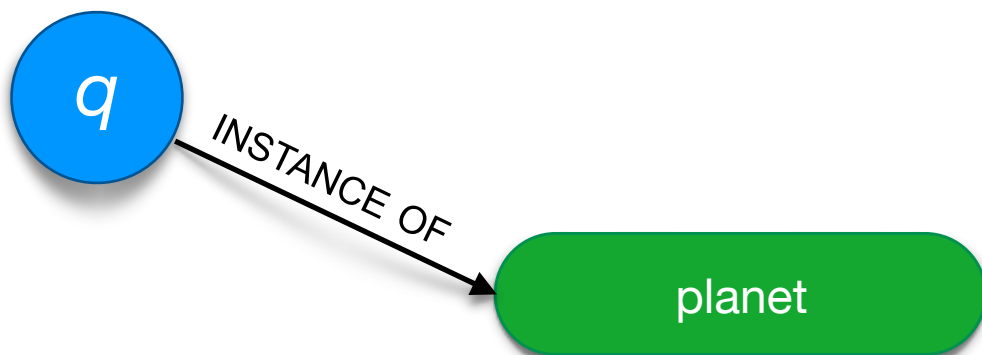
1.000



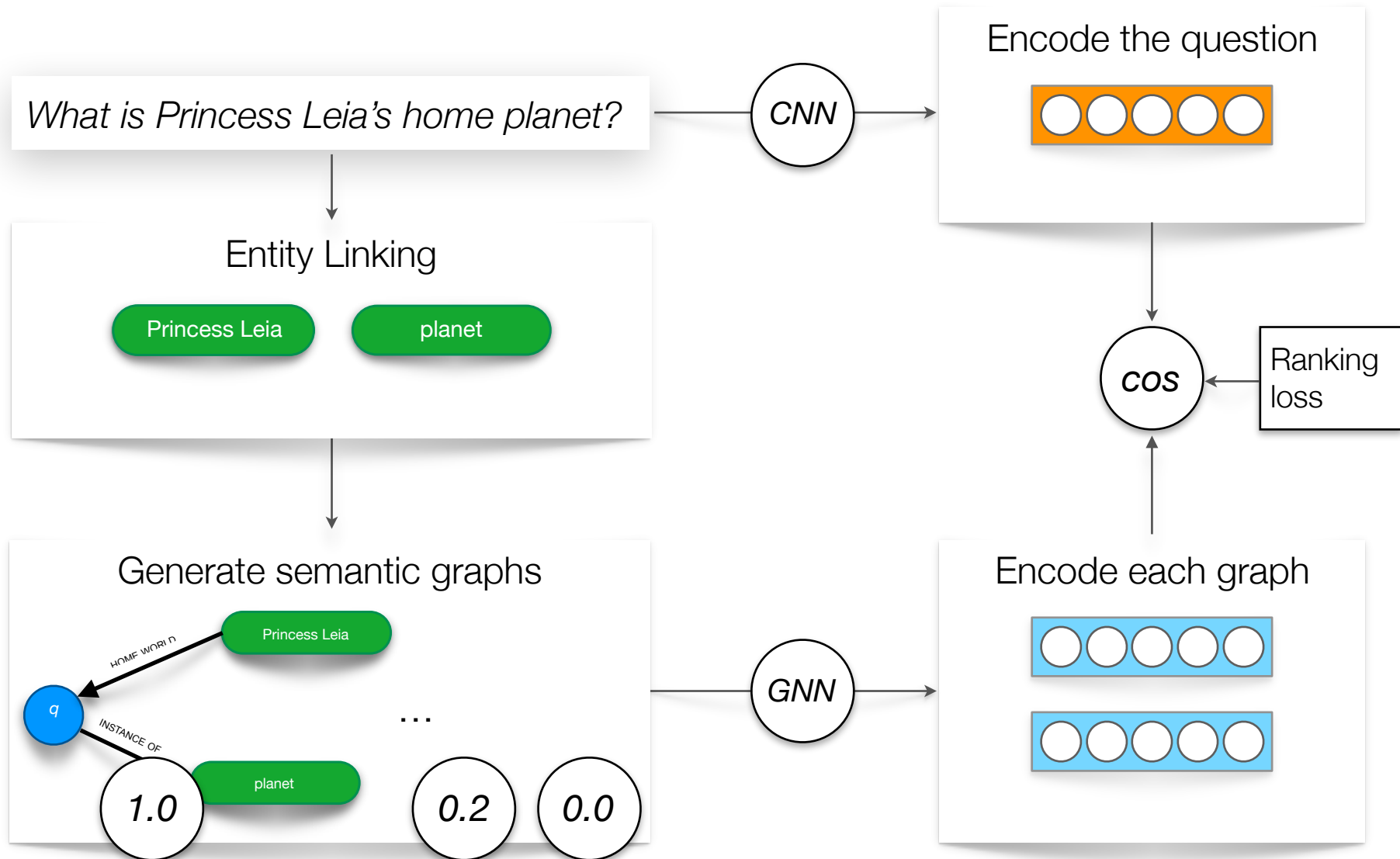
Evaluation

What is Princess Leia's home planet?

Precision	Recall	F-score
0.050	1.000	0.095



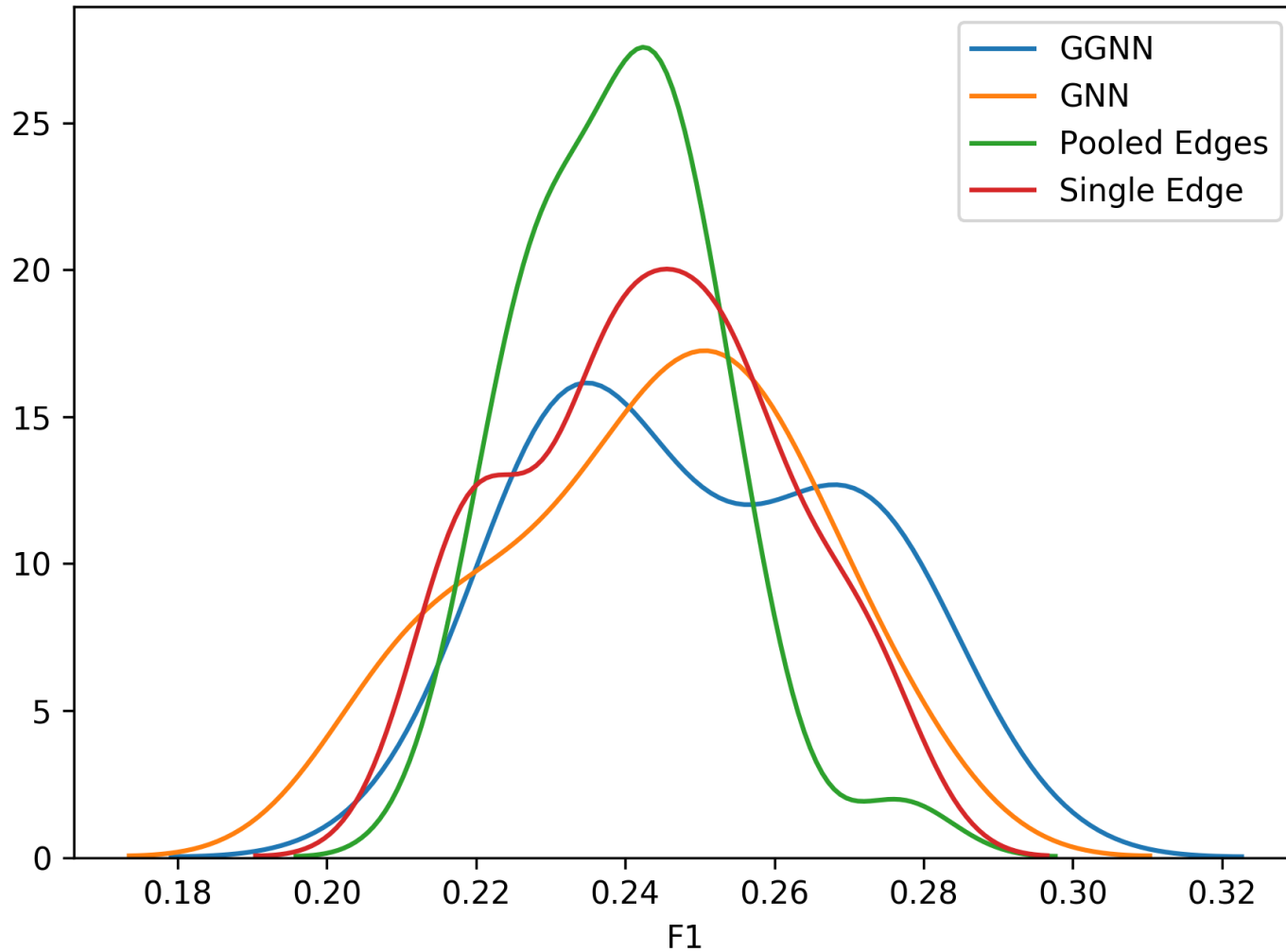
Question Answering Pipeline – Representation Learning

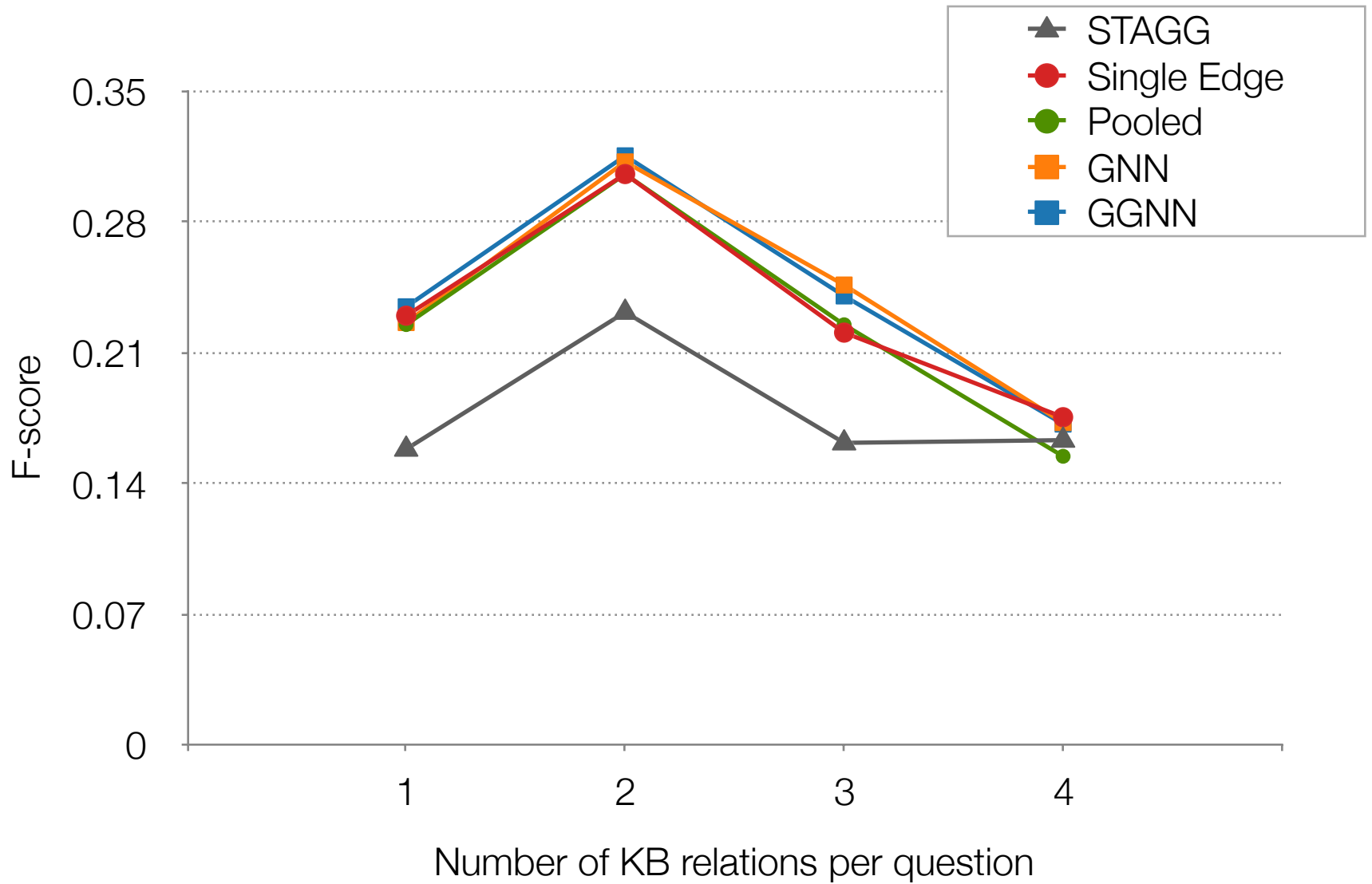


WebQSP-WD

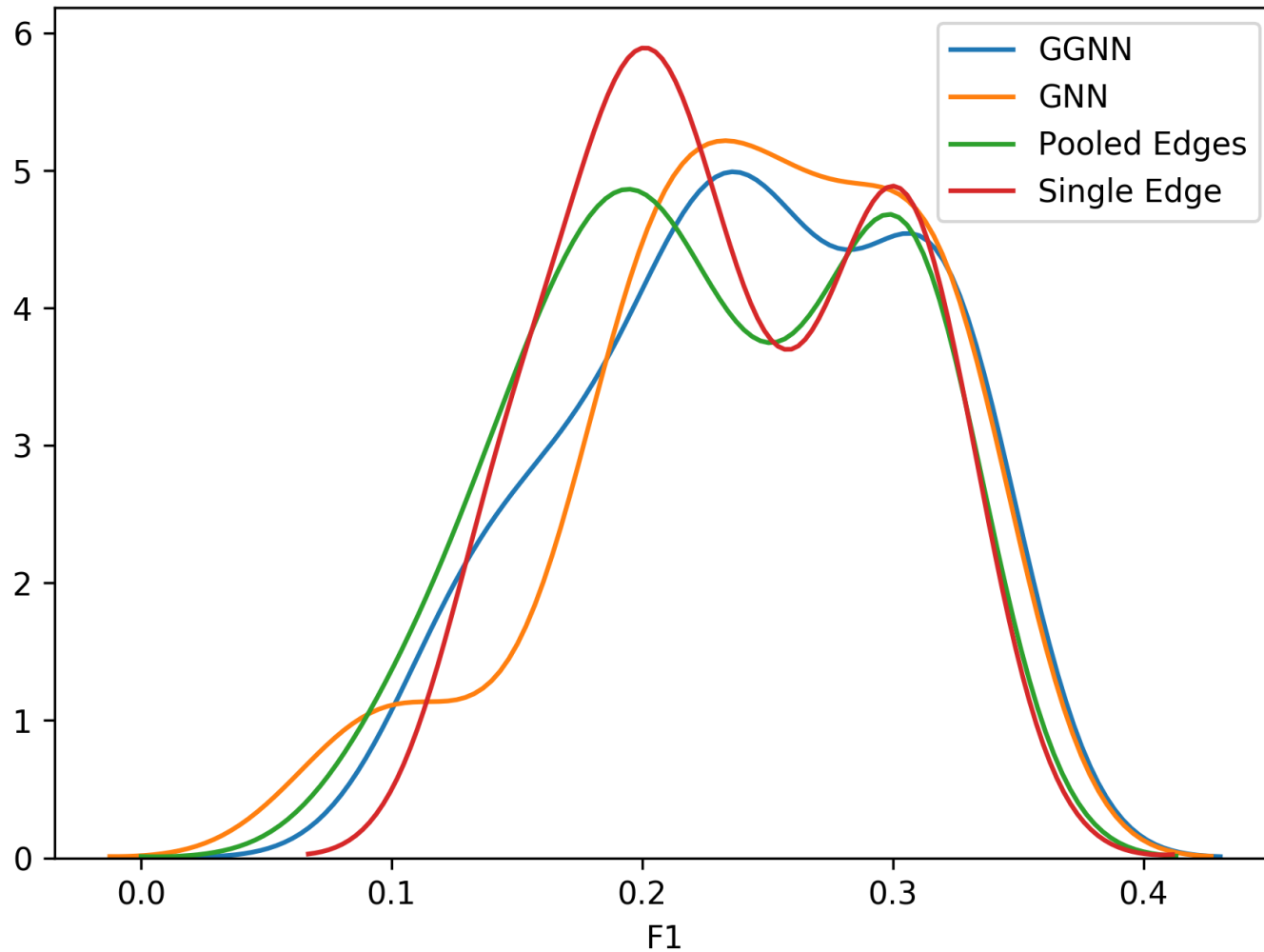
	Precision	Recall	F-score
STAGG	0.173	0.214	0.167
Single Edge	0.250	0.307	0.243
Pooled Edges	0.245	0.302	0.240
GNN	0.253	0.293	0.243
GGNN	0.259	0.305	0.250

WebQSP-WD

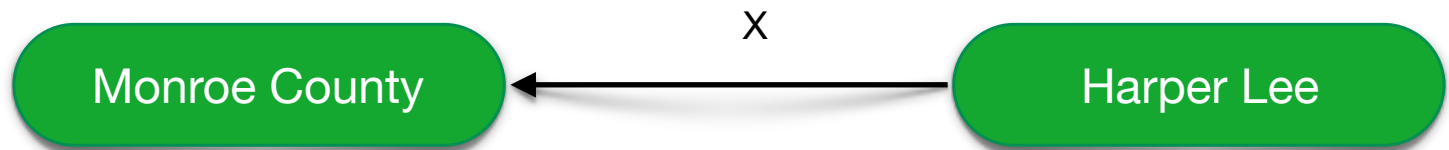




WebQSP-WD complex questions

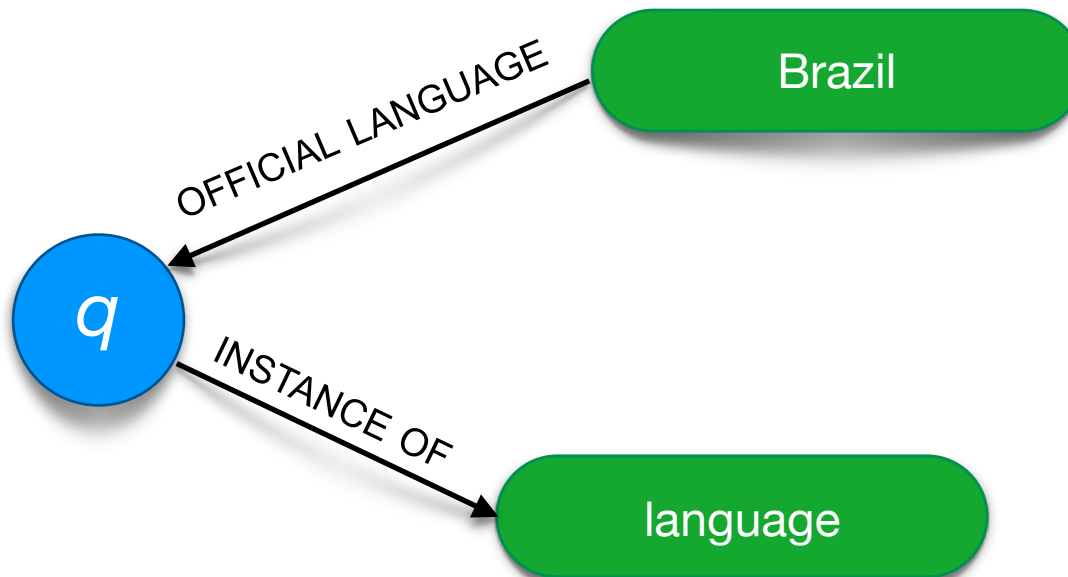


Example output



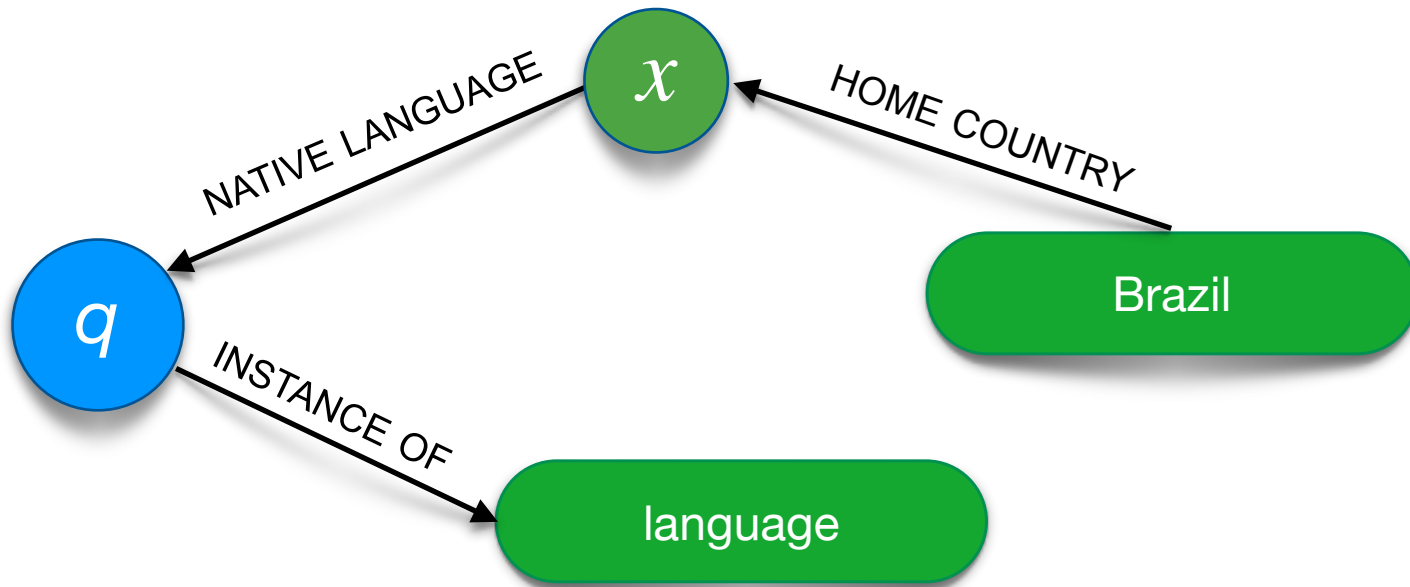
Where did Harper Lee attend high school?

Example output Pooled



What language do people speak in Brazil?

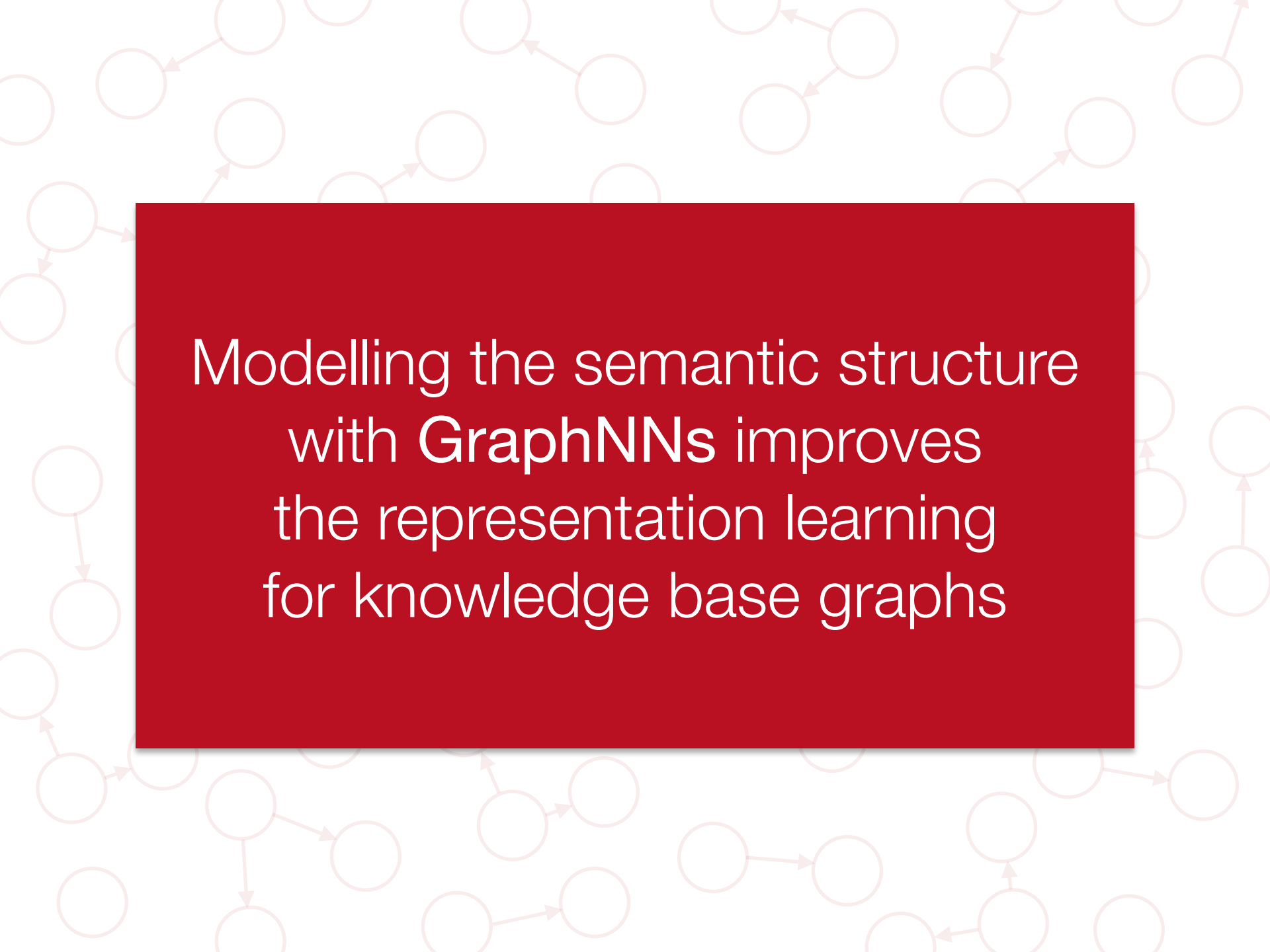
Example output GGNN



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)

The background of the slide features a repeating pattern of a graph structure. It consists of light-colored circles (nodes) connected by thin lines (edges) with small arrowheads pointing in various directions, creating a network-like appearance.

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

