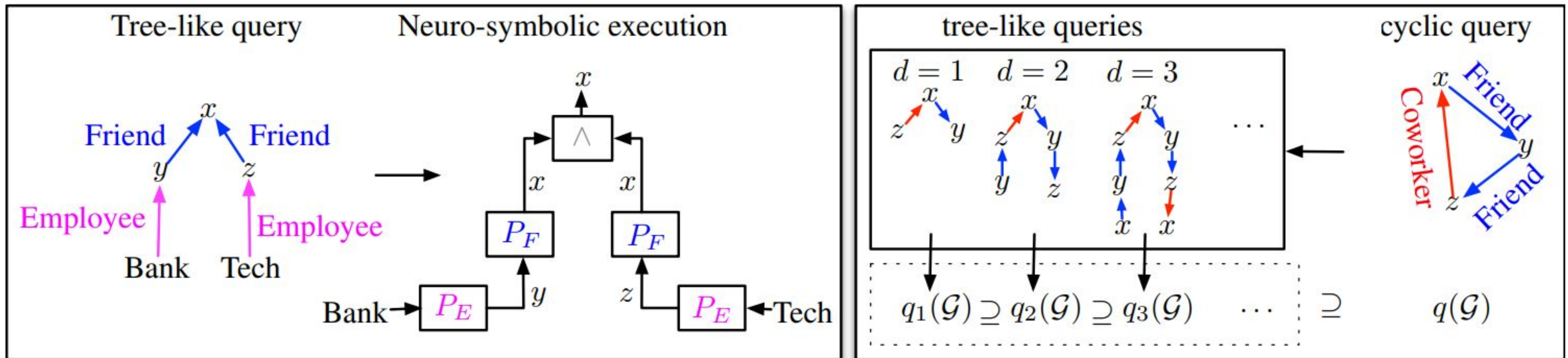


UnRavL: A Neuro-Symbolic Framework for Answering Graph Pattern Queries in Knowledge Graphs

Tamara Cucumides, Daniel Daza, Pablo Barceló, Michael Cochez, Floris Geerts, Juan Reutter, Miguel Romero

UnRavL: complex query answering via approximations

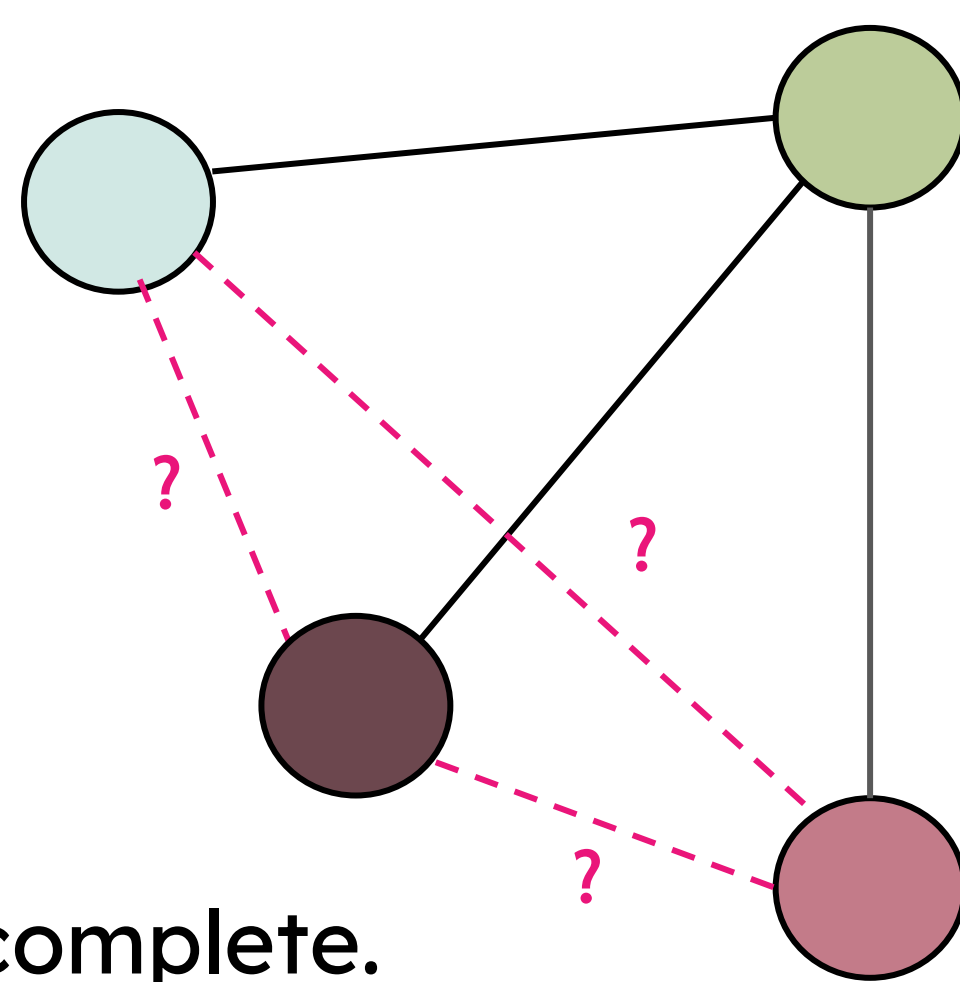
We propose a neuro-symbolic framework that includes an approximation scheme for complex queries



Querying incomplete knowledge graphs

Which nodes are connected to ?

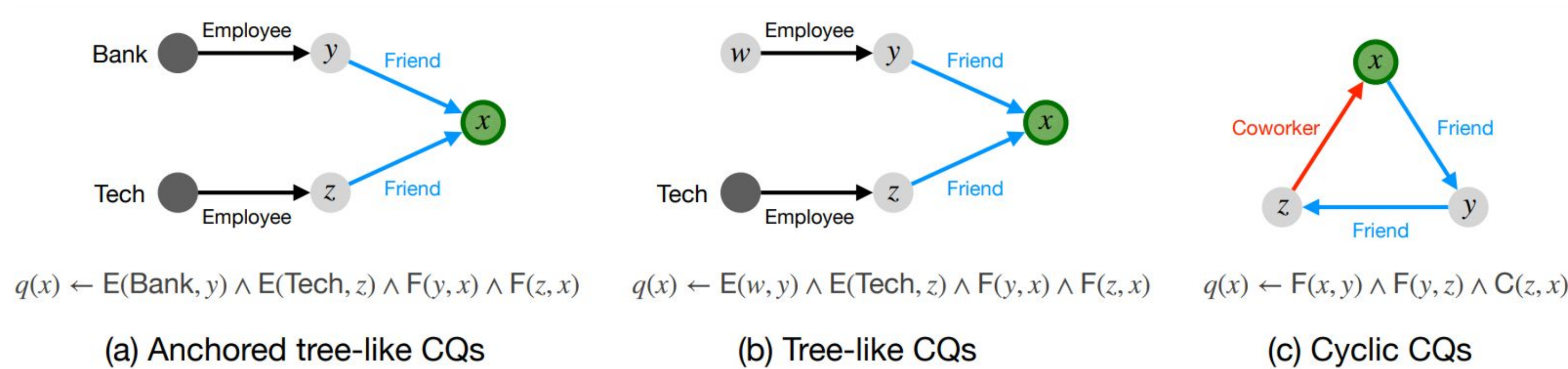
- Node is connected to
- what about and ?



... most knowledge graphs are incomplete. How can we appropriately query the graph if we have missing information?

Limitations of (most) existing models

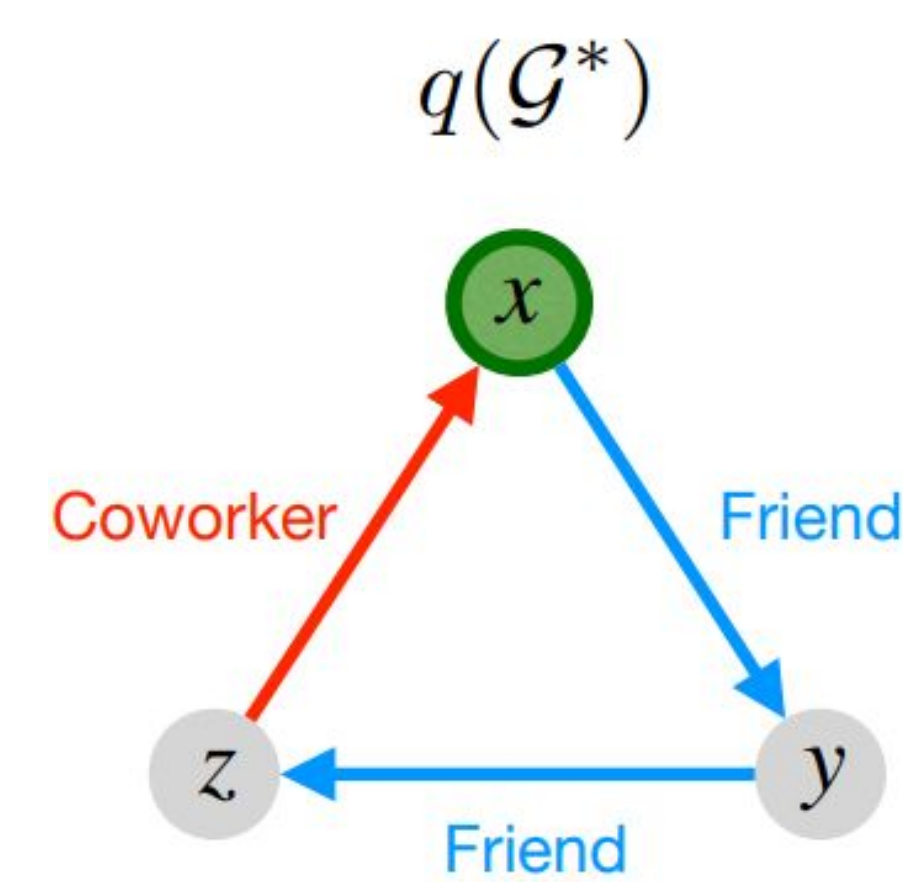
Most existing models can only deal with tree-like queries



While expressive, tree-like queries cannot capture information such as triangles, or cycles.

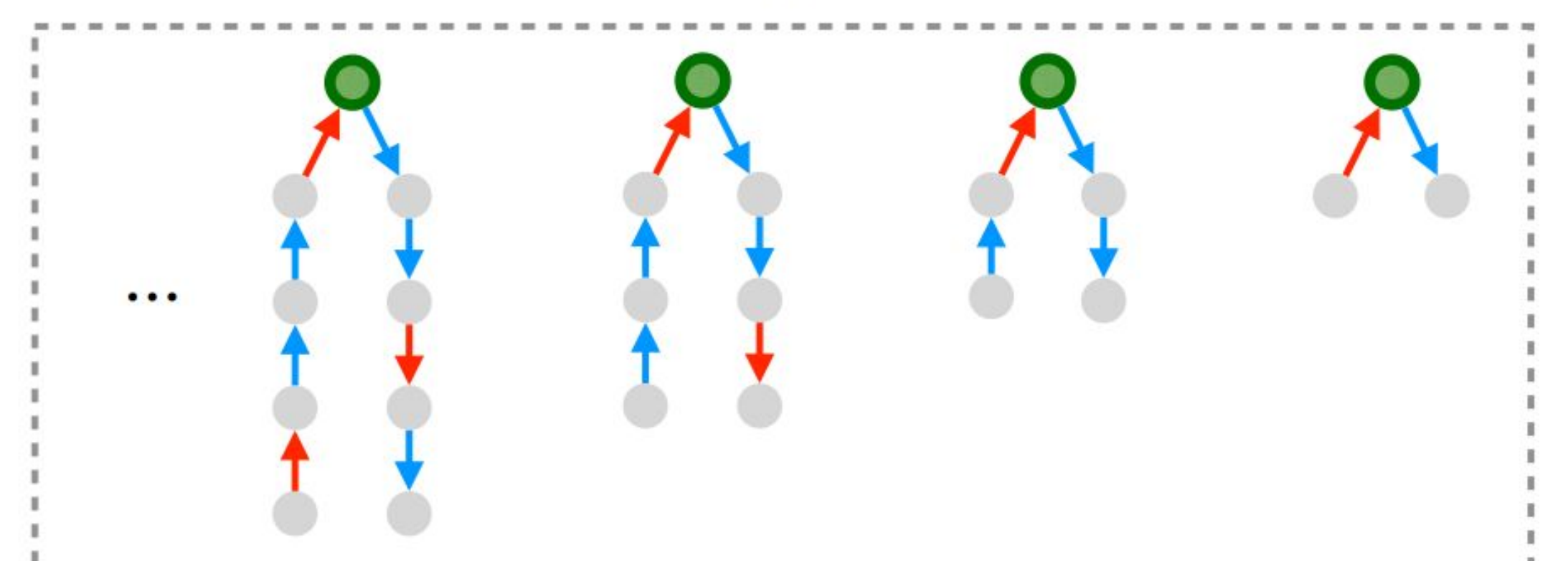
Approximations via unravelings

Cyclic CQs



Tree-like CQs

$$\dots \tilde{q}_4(\mathcal{G}^*) \subseteq \tilde{q}_3(\mathcal{G}^*) \subseteq \tilde{q}_2(\mathcal{G}^*) \subseteq \tilde{q}_1(\mathcal{G}^*)$$



The unravelings approximations are:

- **Safe:** no false negatives
- **Conservative:** if the query is tree-like, its unraveling is equivalent
- **Optimal:** the best tree-like over approximation

Experimental results

Metric	Model	FB15k237			FB15k			NELL995		
		∃1p2c	∃3c	∃4c	∃1p2c	∃3c	∃4c	∃1p2c	∃3c	∃4c
hits@1	UnRavL	0.027	0.073	0.036	0.057	0.092	0.057	0.065	0.114	0.067
	PQE	0.011	0.027	0.009	—	—	—	—	—	—
	MPQE	0.023	0.031	0.005	0.064	0.063	0.000	0.074	0.060	0.098
hits@10	UnRavL	0.151	0.292	0.187	0.227	0.305	0.372	0.286	0.419	0.257
	PQE	0.127	0.135	0.059	—	—	—	—	—	—
	MPQE	0.147	0.149	0.062	0.225	0.218	0.000	0.301	0.313	0.326
mrr	UnRavL	0.067	0.148	0.088	0.098	0.297	0.159	0.146	0.211	0.122
	PQE	0.057	0.077	0.031	—	—	—	—	—	—
	MPQE	0.069	0.072	0.025	0.120	0.116	0.000	0.150	0.142	0.180

UnRavL outperforms other neural methods on cyclic patterns, and a probabilistic query evaluation baseline



LoG paper