Relation Extraction, Neural Network, and Matrix Factorization

Presenter: Haw-Shiuan Chang

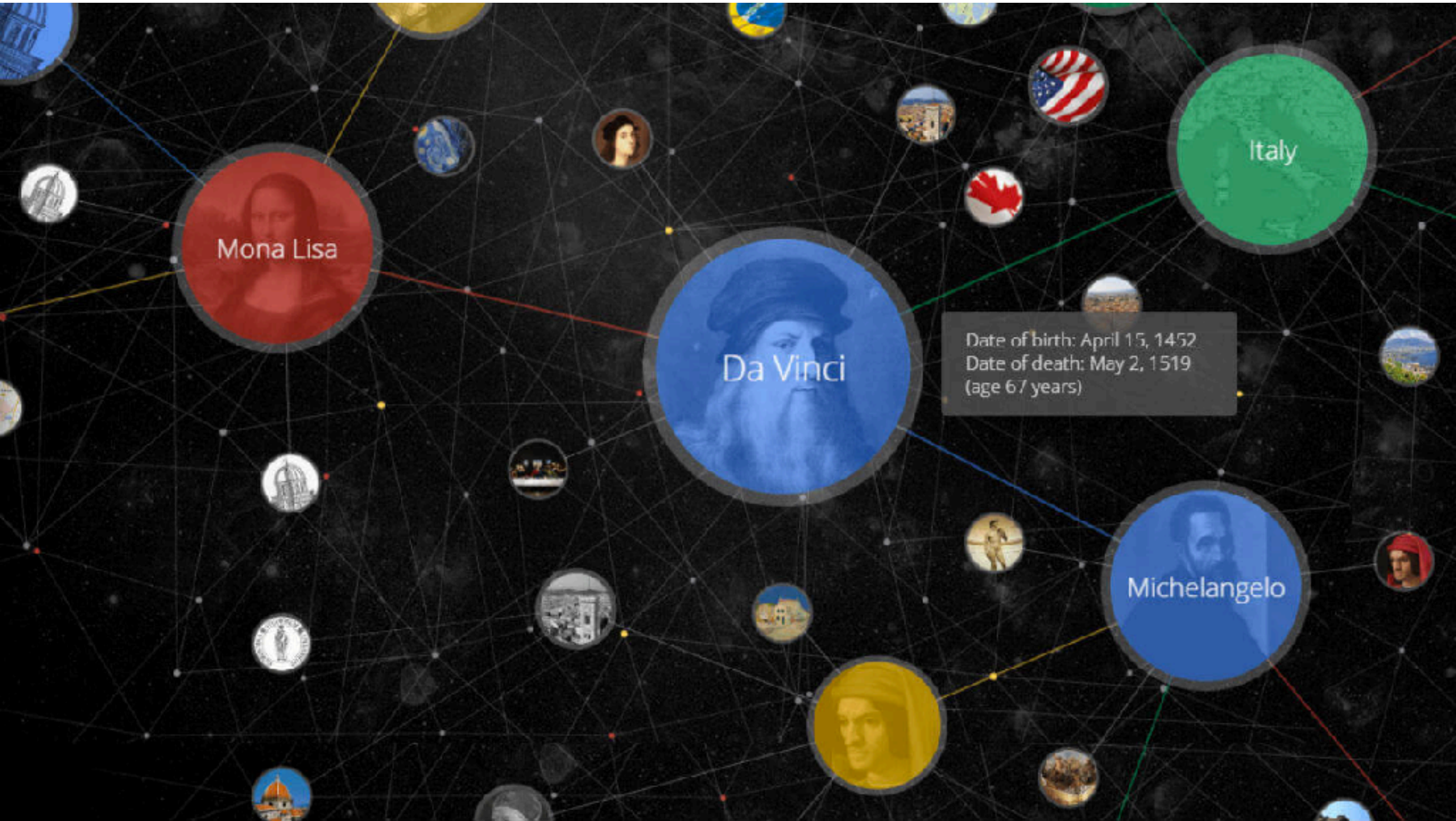
UMass CS585 guest lecture on 2016 Nov. 17

UMassAmherst IESL

Most slides prepared by Patrick Verga

Relation Extraction

Knowledge Graph



Entities

- Common Types
  - NIL
  - Person
  - Organization
  - Location
    - country
    - state
    - city
  - Numbers/Date

- You can have different ontology
  - more fine-grain types
  - Common nouns (common sense)
- Classifiers is called “Named Entities Recognizer” (NER)
- Features
  - POS tagging
  - Lexicon dictionary (gazetteer)
  - word embedding or topic models

Relations

Brendan, birthplace, USA

↑

- Brendan born in USA ⟶ Relation Extraction
- Brendan traveled to Pittsburgh ⟶ Event Extraction
- Brendan likes Amherst ⟶ Sentiment Extraction
- Brendan thinks midterm is hard ⟶ Belief Extraction

January 15, 2000

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Gates moved his family into their 55,000-square-foot, $54 million house on the shore of Lake Washington, just outside Seattle.

Edges =
{
spouse,
located in,
lives in
founded
}

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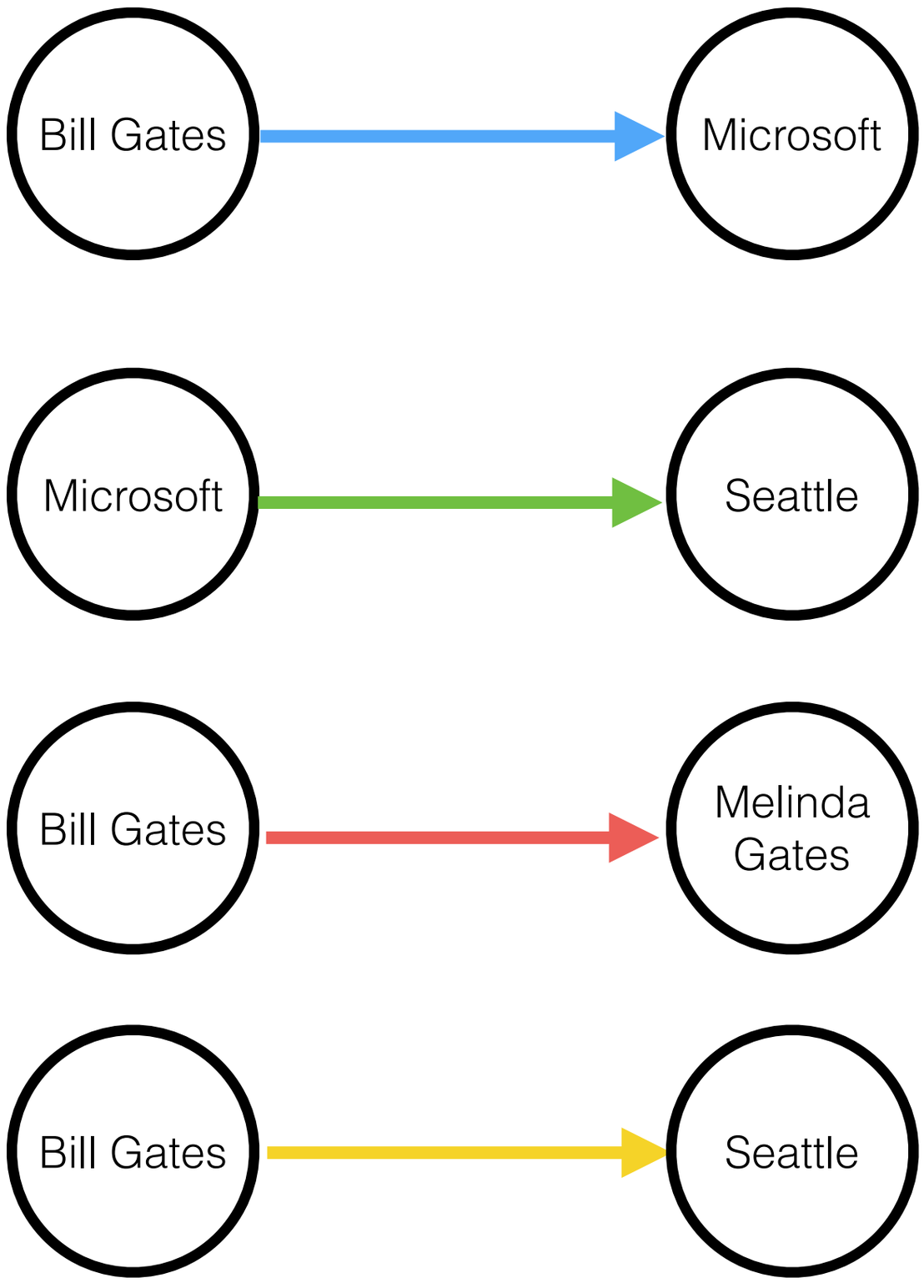

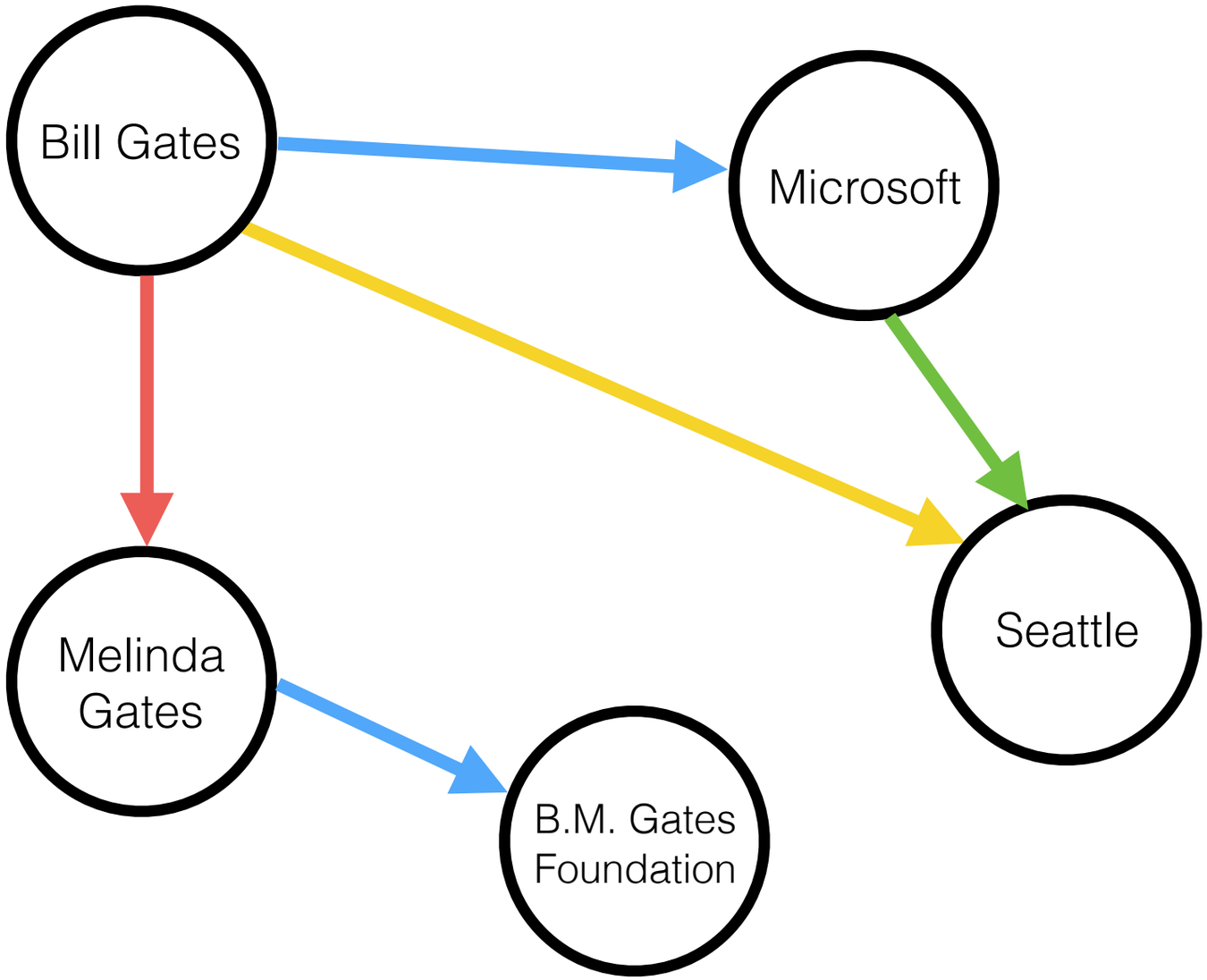

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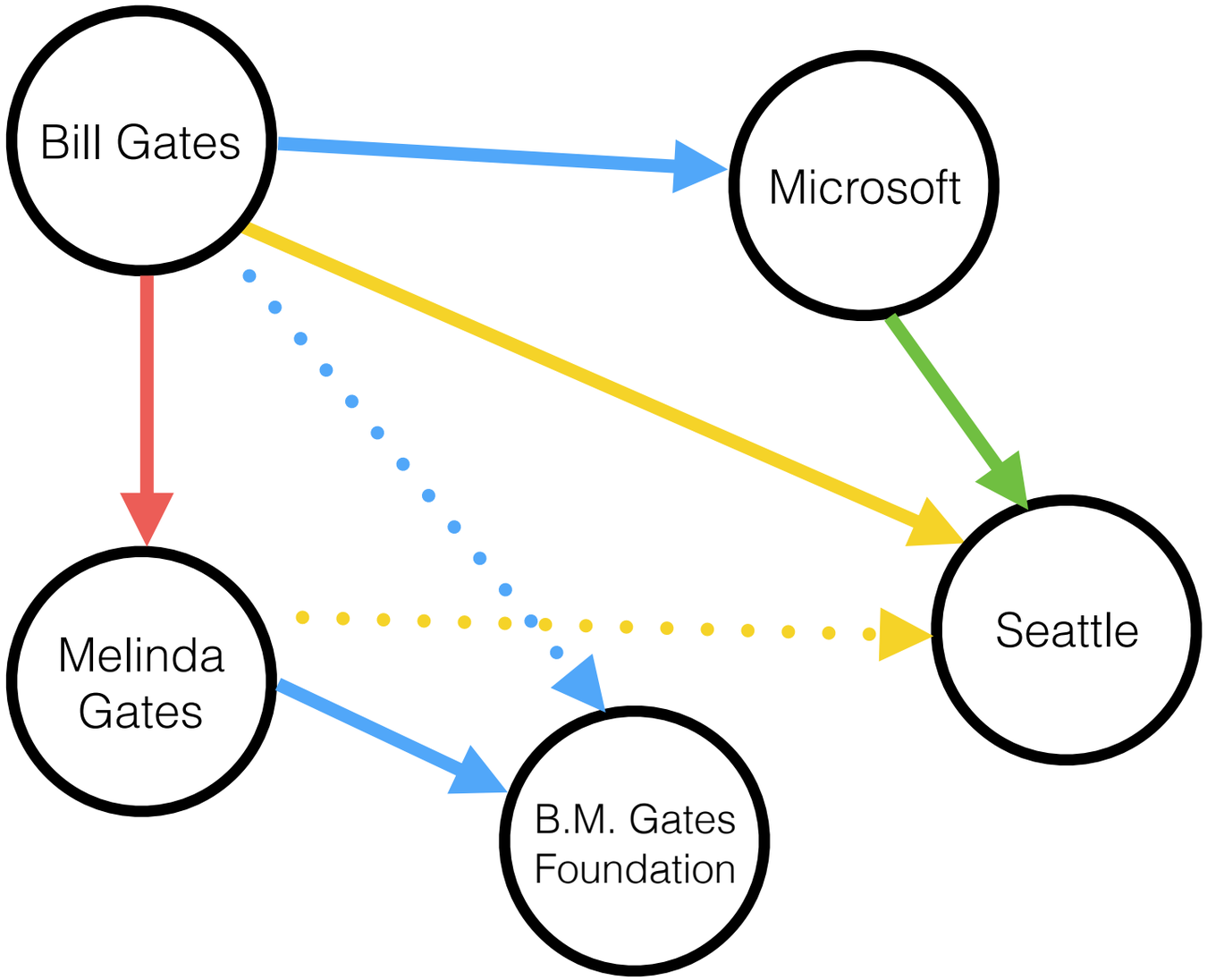

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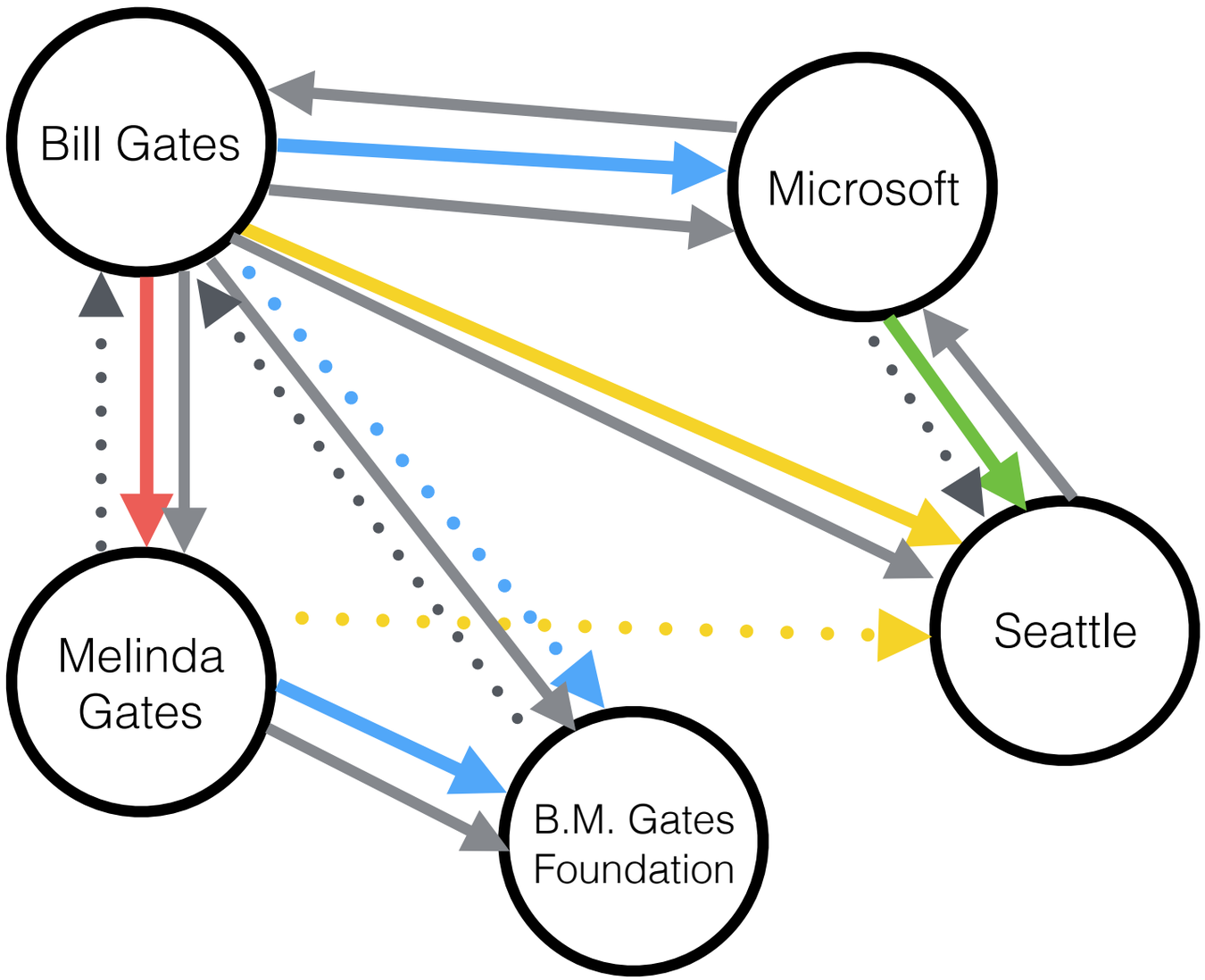


Edges =
{
spouse,
located in,
lives in,
founded
} is married to,
became the CEO of,
is headquartered in,
helped to start,
resides in the city of,
....
....
}

Research Questions

- How to extract relations?
  - Relation Extraction
- How to perform reasoning on relations?
  - Knowledge Base Completion
- What can be qualified as a relation?
  - Schema/Ontology Definition

Challenges in Relation Extraction

- The problem could be very general
  - Many different relations
  - Many ways to expressing one relation in different context
- Hard to get annotated data
  - Hard to get training data
  - Hard to evaluate the results completely
  - Unlabeled data: Missing positive or False?

Challenges in Relation Extraction

- Different ways of defining what is correct
  - Correct in reality, correct in author's belief, probably correct?
- Error propagation at different stages
  - Entity detection: F1 0.8~0.9
  - Entity Linking: F1 0.5~0.6
  - Relation Extraction: F1 0.2~0.3

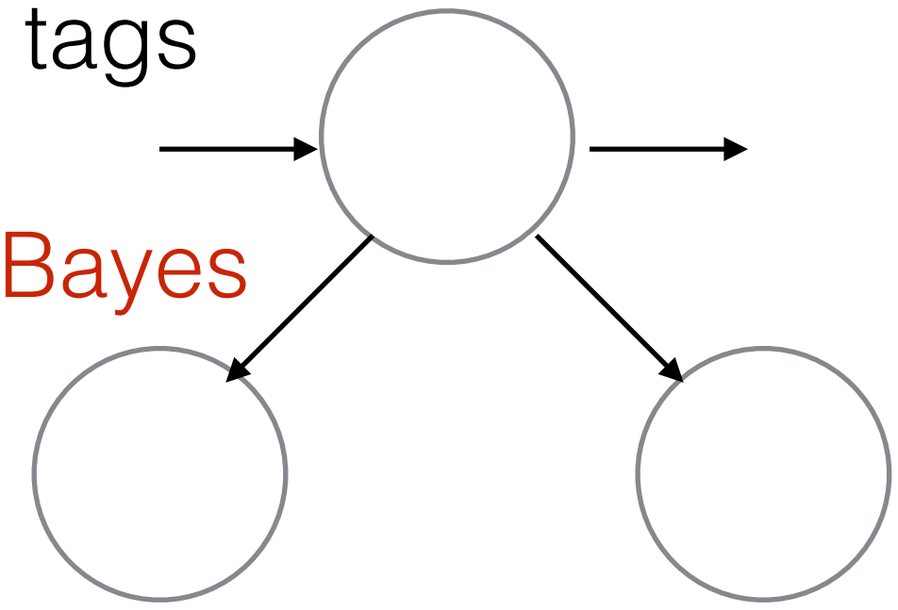
Neural Networks

Or any other tags

Noun

Adj

Naive Bayes



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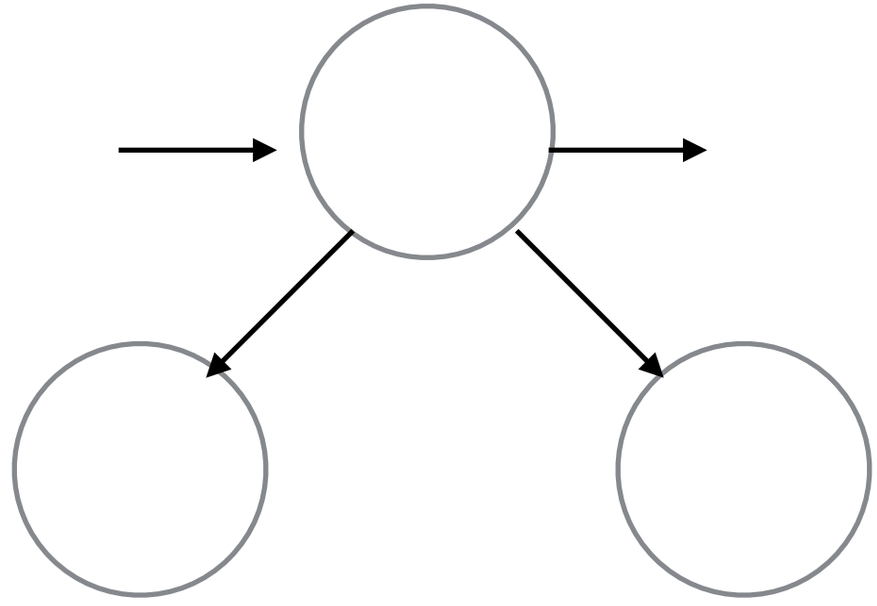
HMM



chairs

end with s

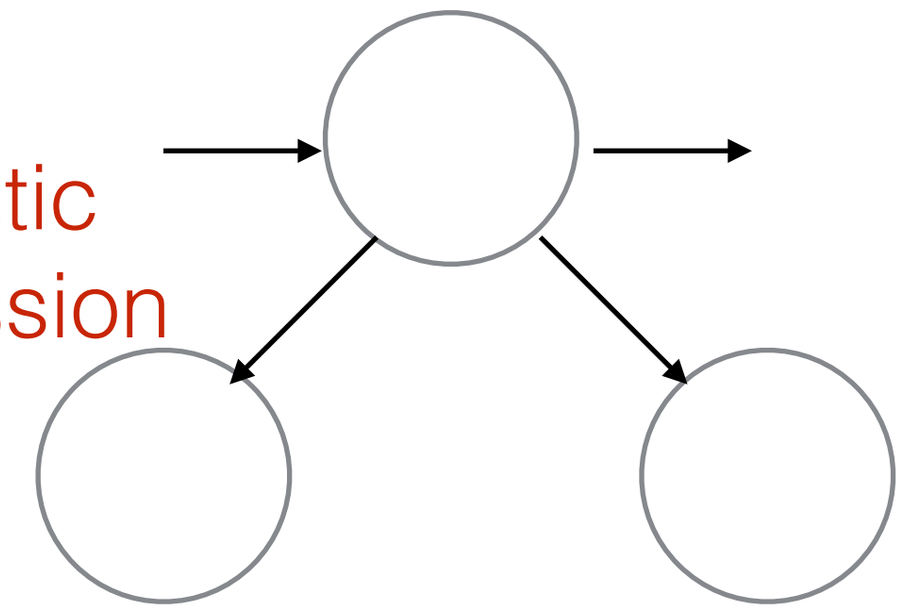
comfortable

end with s

Noun

Adj

Logistic Regression



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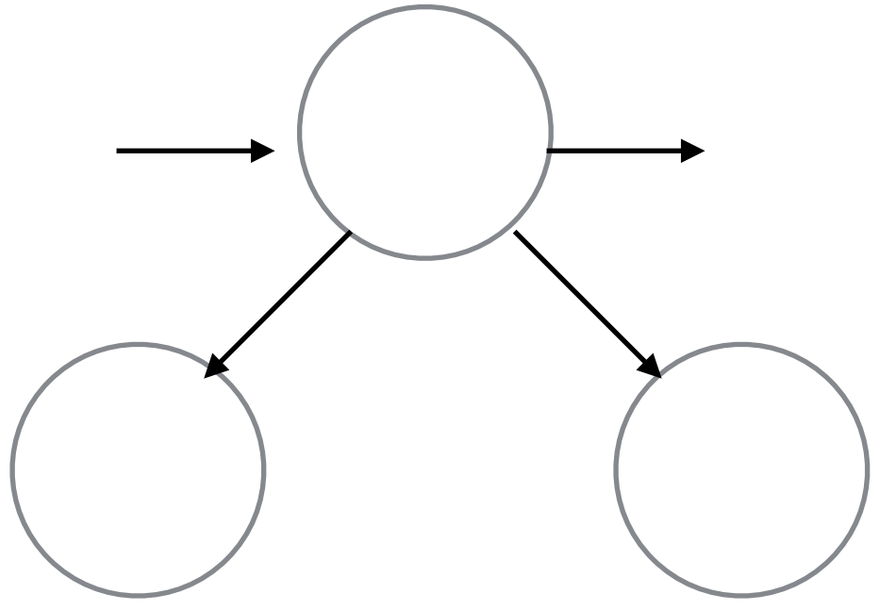
CRF



chairs

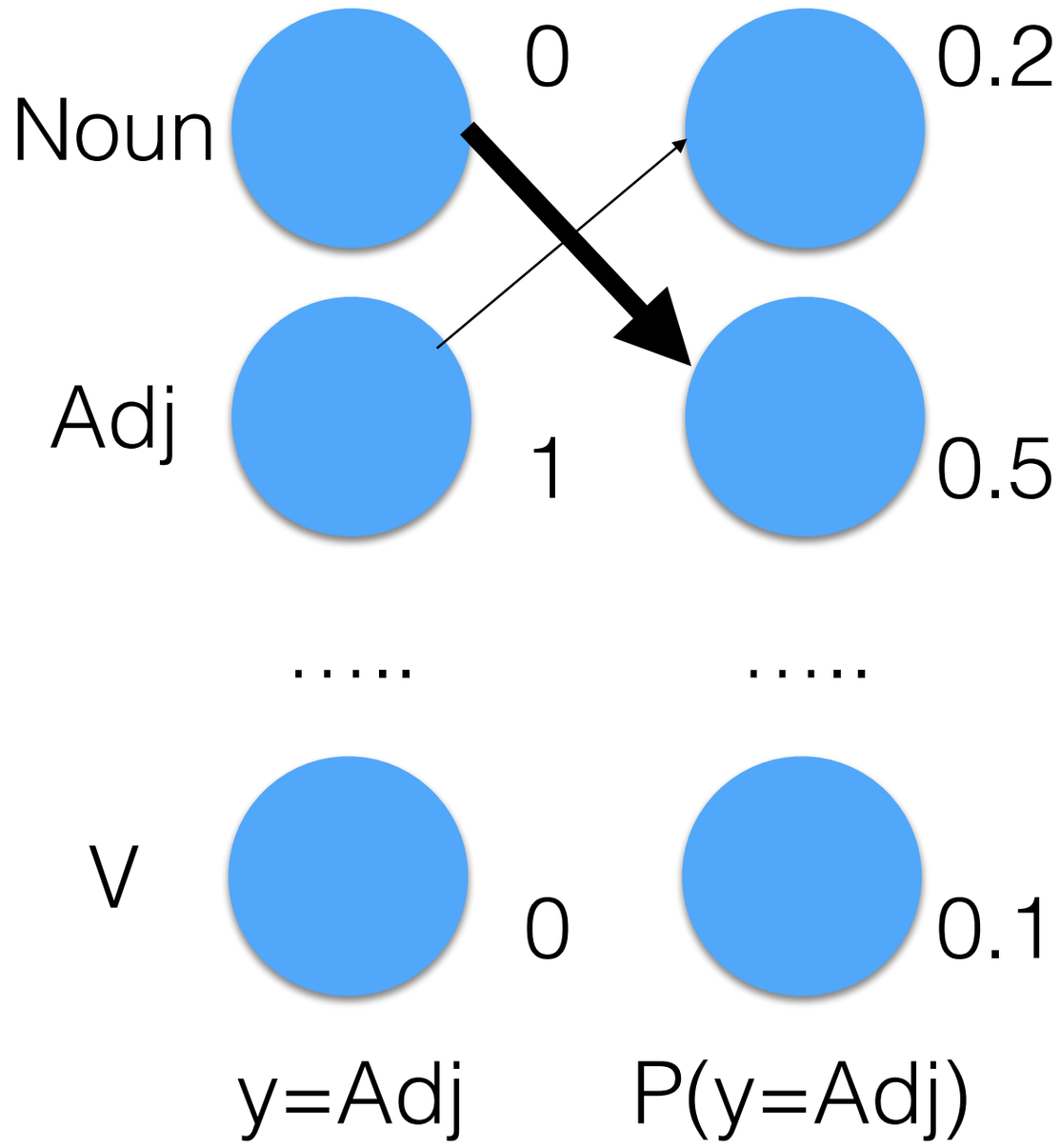
end with s

comfortable

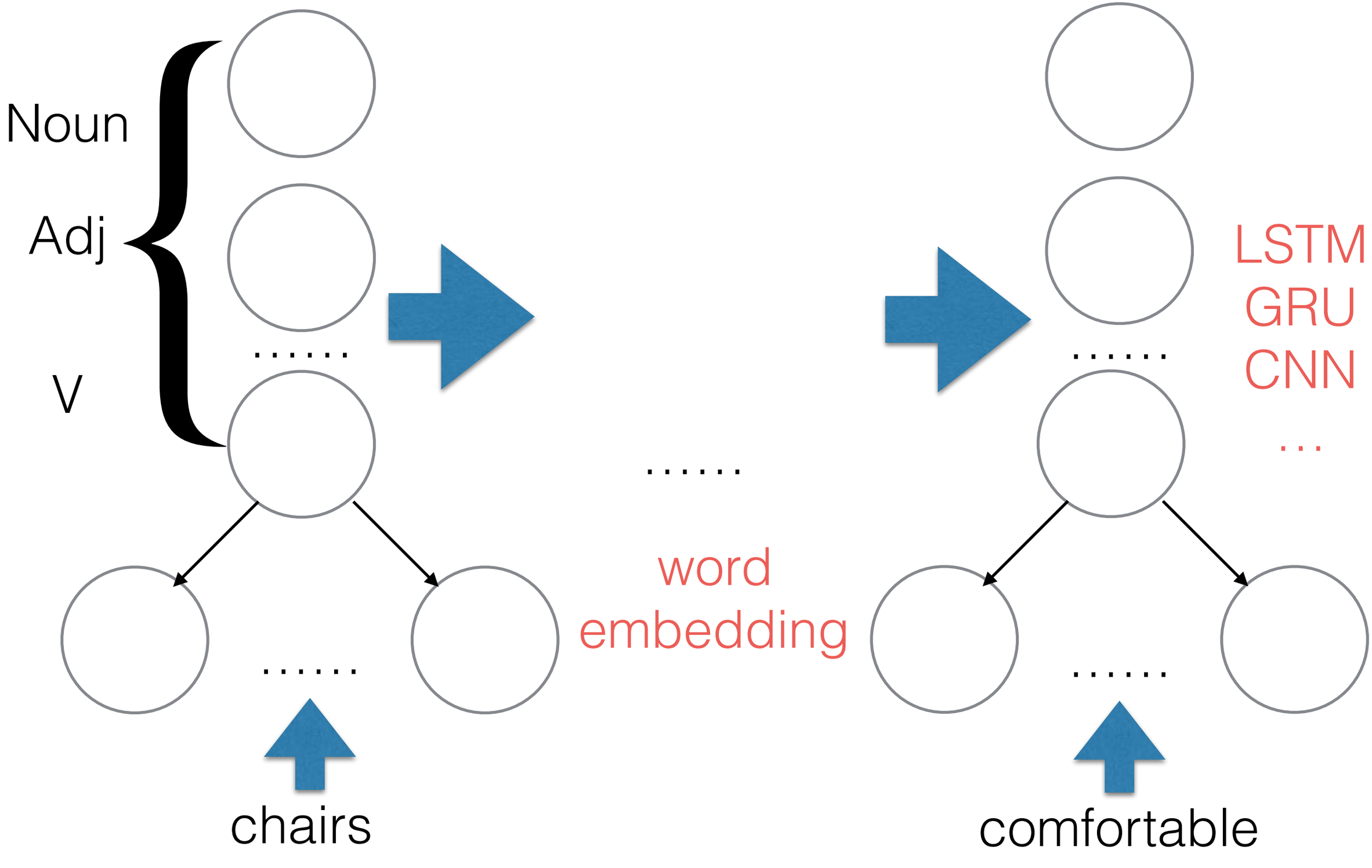
end with s

Discrete Model

- Input/output:
  - sequence/sequence
- The feature is discrete
  - f(x): [0, …, 1, 0, …]
  - x: […, chairs, …]
- The state is discrete

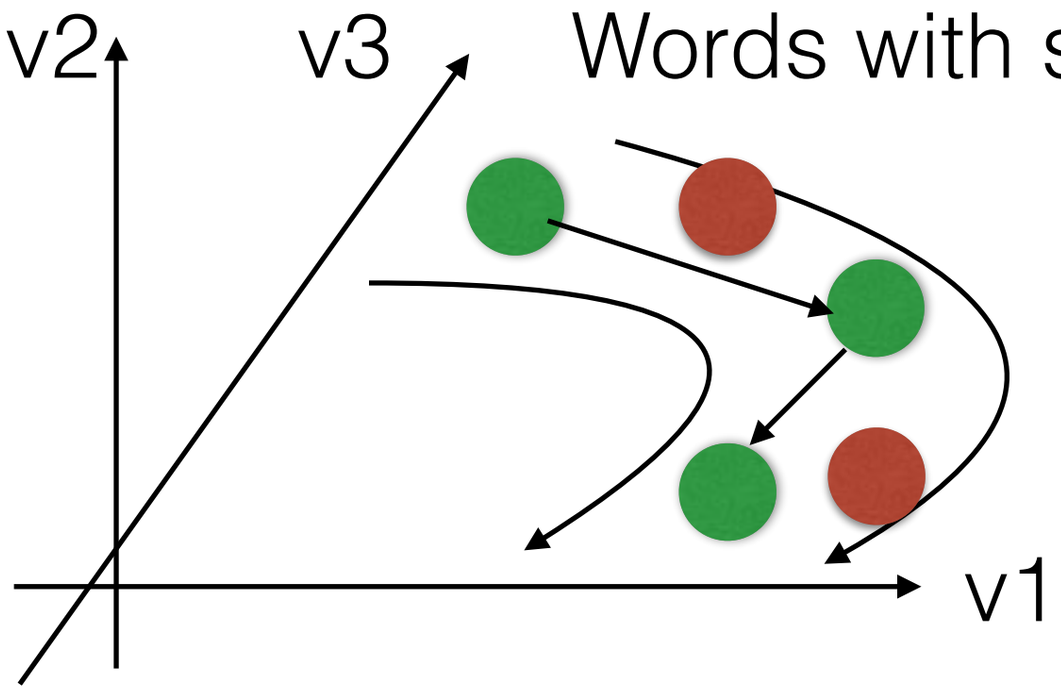


Neural Networks

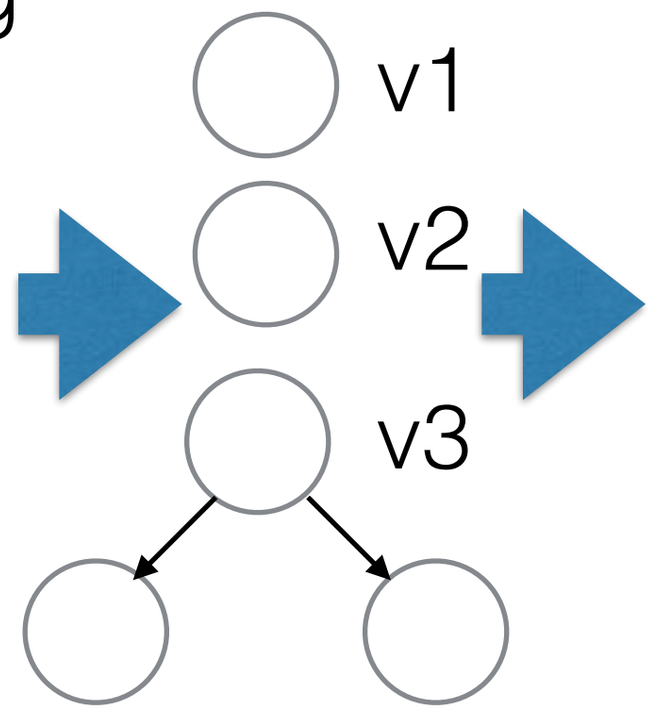


Continuous State Transition

- We can extend the size of the state to model longer dependency



Words with similar meaning



Traverse the state space similarly

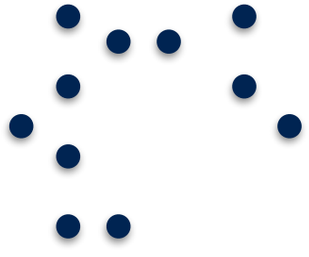
Applications of Sequence Learning

- Tags
  - POS tag
  - Dependency tags
  - Entity types
  - Event types
  - Words
  - Other language
  - …
- Applications
  - POS tagging
  - Dependency parsing
  - Entity detection
  - Event detection
  - Language modeling
  - Translation
  - …

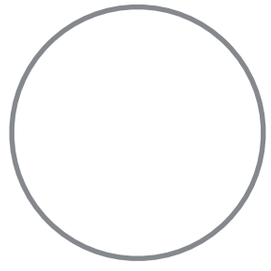
How Discriminative you want?

- Model flexibility:
  - HMM<CRF<LSTM
- Number of parameters:
  - HMM<CRF<LSTM
- Performance (give sufficient data):
  - HMM<CRF<LSTM
- Interpretability:
  - HMM>CRF>LSTM
- Optimization easiness
  - HMM>CRF>LSTM
- Robustness against Overfitting
  - HMM>CRF>LSTM

Constraints and Problems



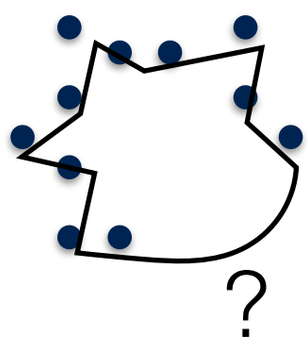
Prior knowledge
of the problem



Training Data
External Resources

Model
Feature Engineering

Prediction



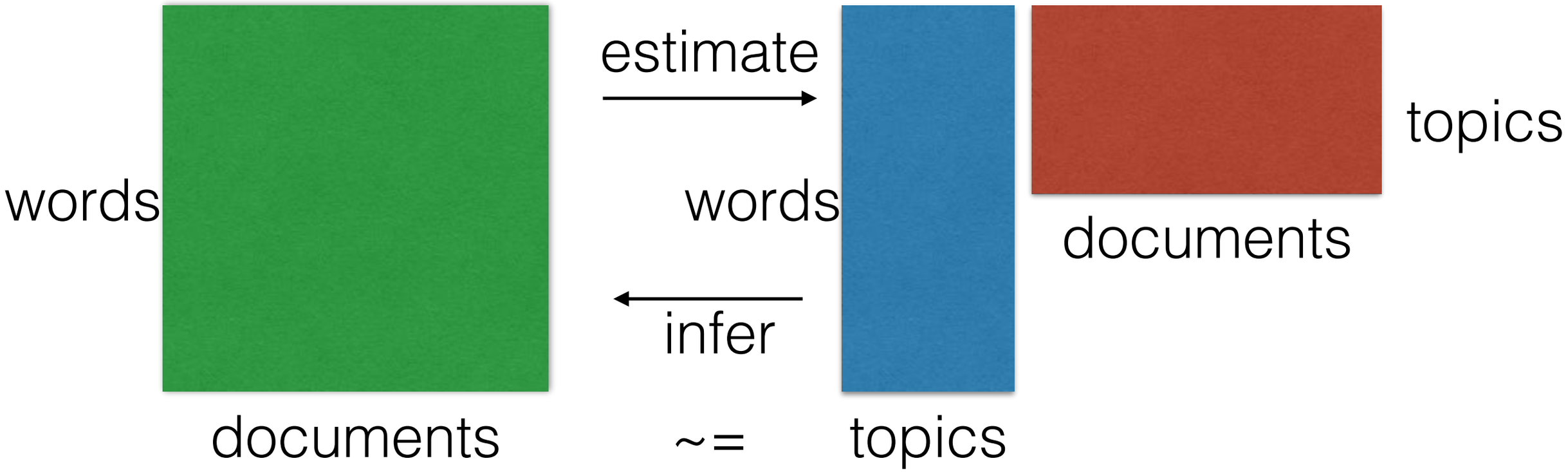
?

Trying many models?
Getting more data?
Describing precisely?

Matrix Factorization

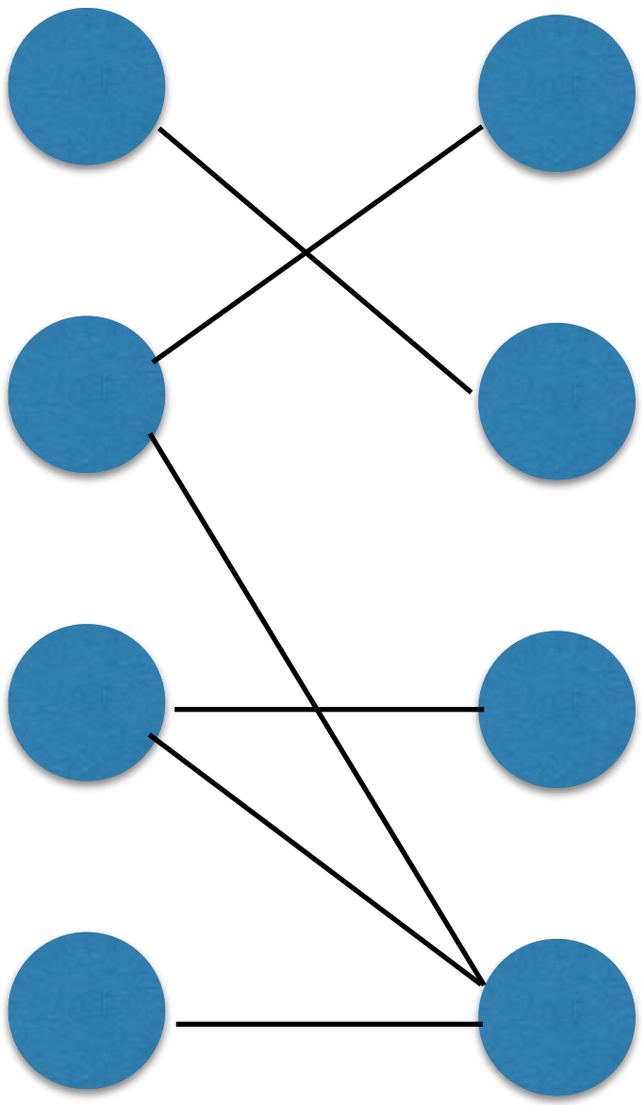
Interpretations of Word Embedding

Unsupervised learning



- Word similarity
  - documents -> short context, semantic -> syntax
- Document similarity
- Topic modeling (LSA)

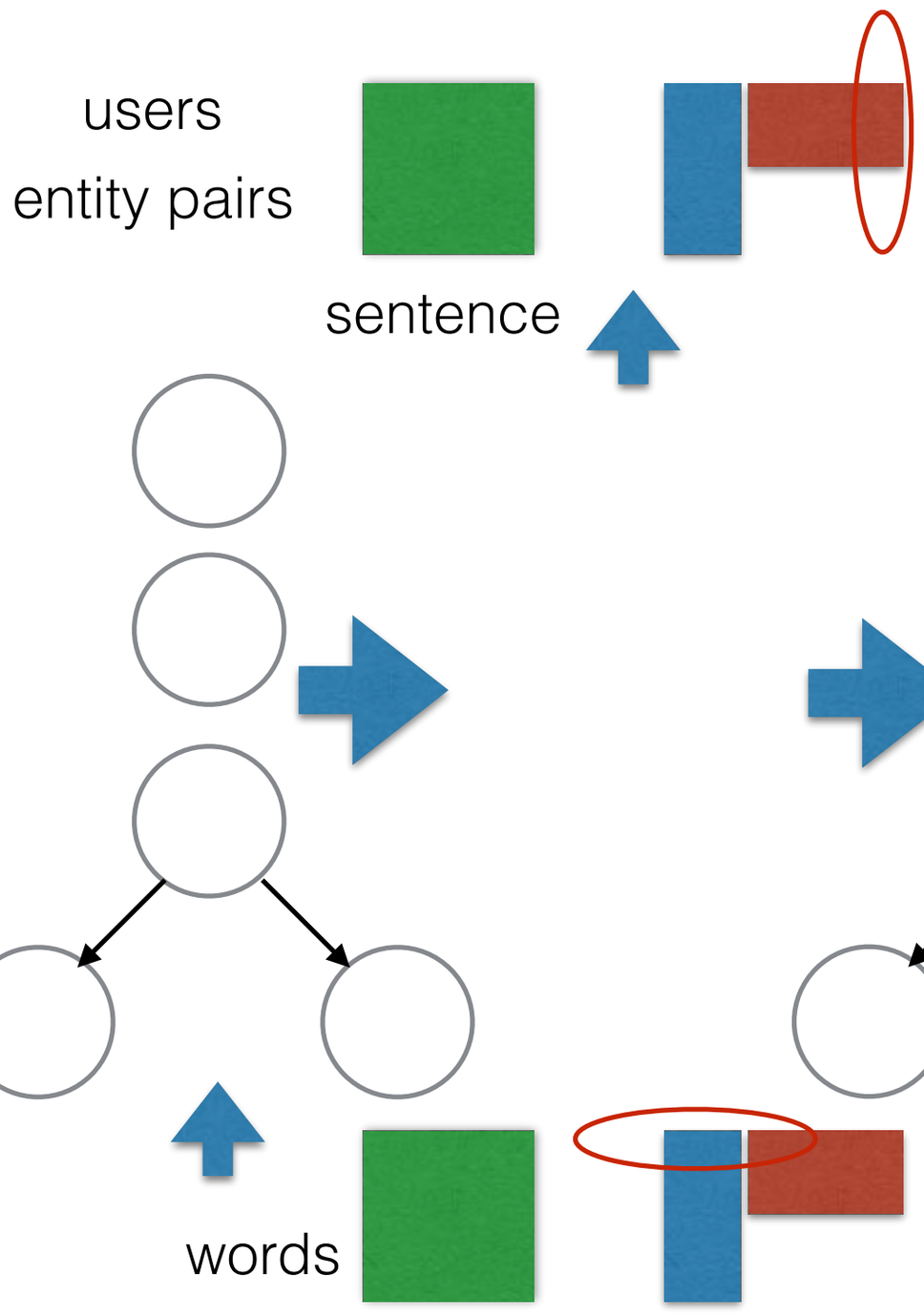
Structure on Interactions

words		near word (context)
words		documents
key words		documents
users		documents
entities		near entities
entity pairs		relations

Applications

words	word embedding	near word (context)
words	topic modeling	documents
key words	summarization	documents
users	recommendation	documents
entities	coreference	near entities
entity pairs	relation extraction	relations

Matrix Factorization plus Neural Networks



Sentence Embedding

LSTM

GRU
CNN

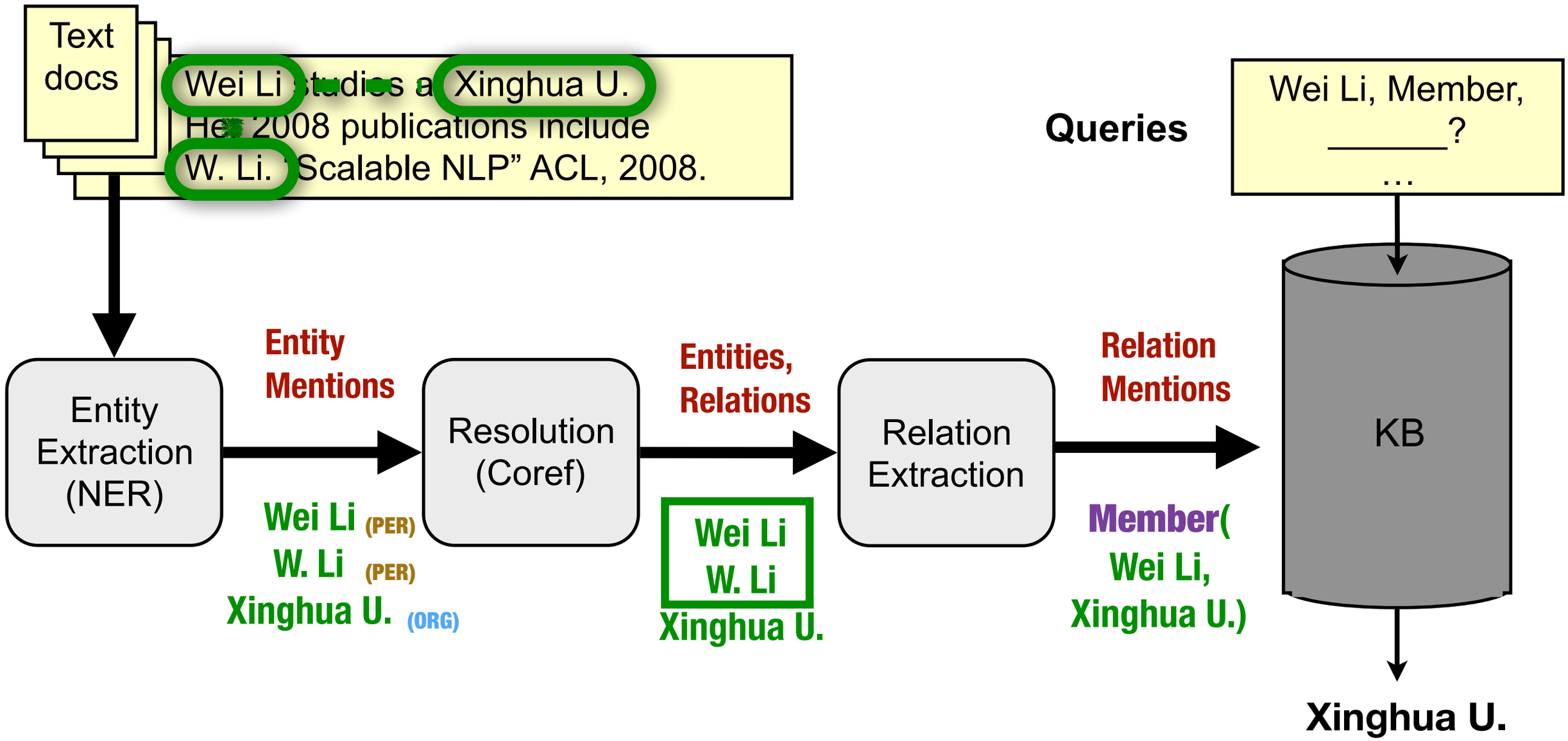
word embedd

An example

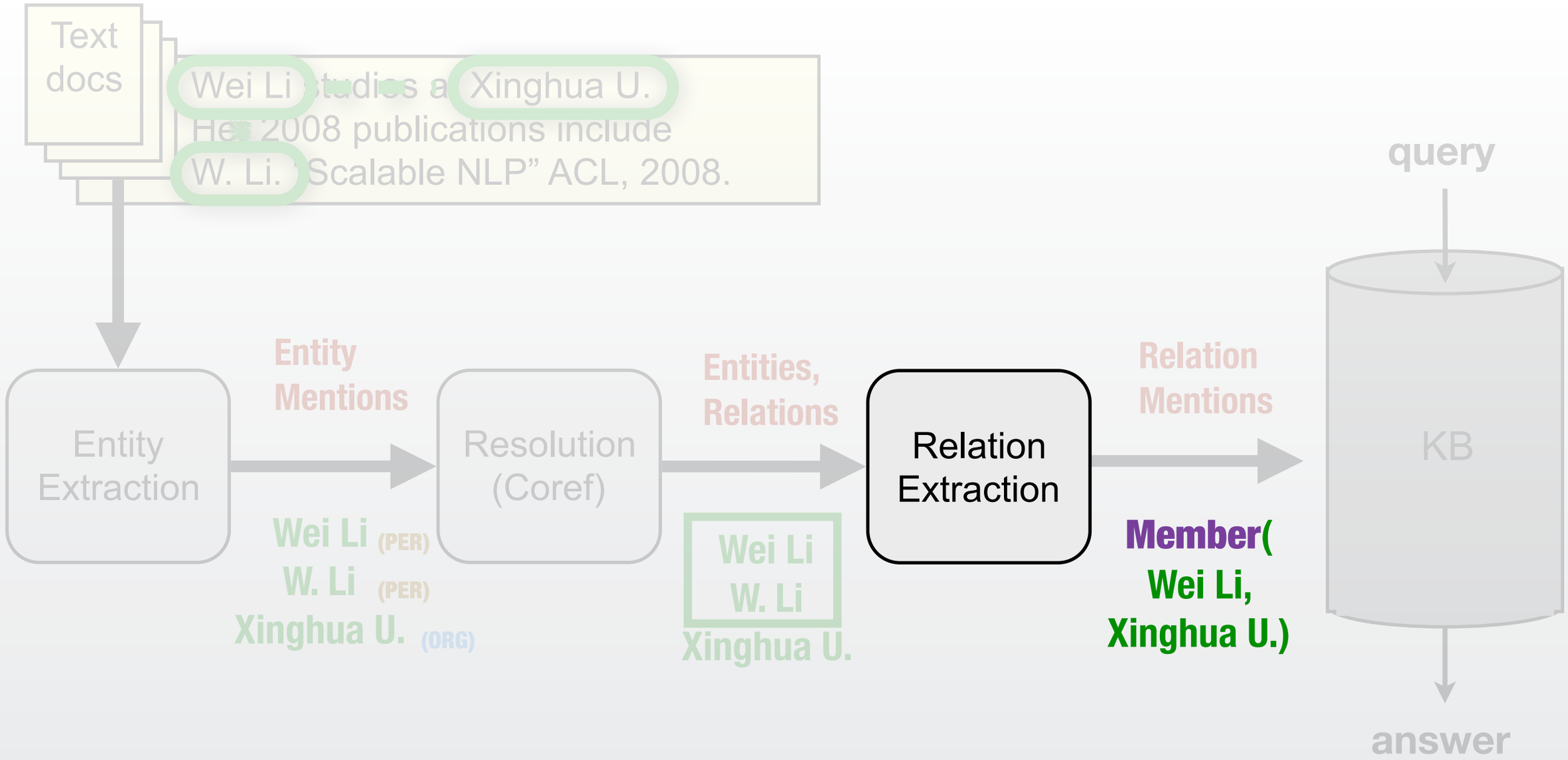
Universal Schema

- How to extract relations?
  - Neural Network (LSTM)
- How to perform reasoning on relations?
  - Matrix Factorization
- What can be qualified as a relation?
  - Everything could be a schema

Knowledge Base (KB) Construction



Relation Extraction



Compositional Universal Schema

Verga, P., Belanger, D., Strubell, E., Roth, B., and McCallum, A. (2016). Multilingual relation extraction using compositional universal schema. In Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL).

Universal Schema

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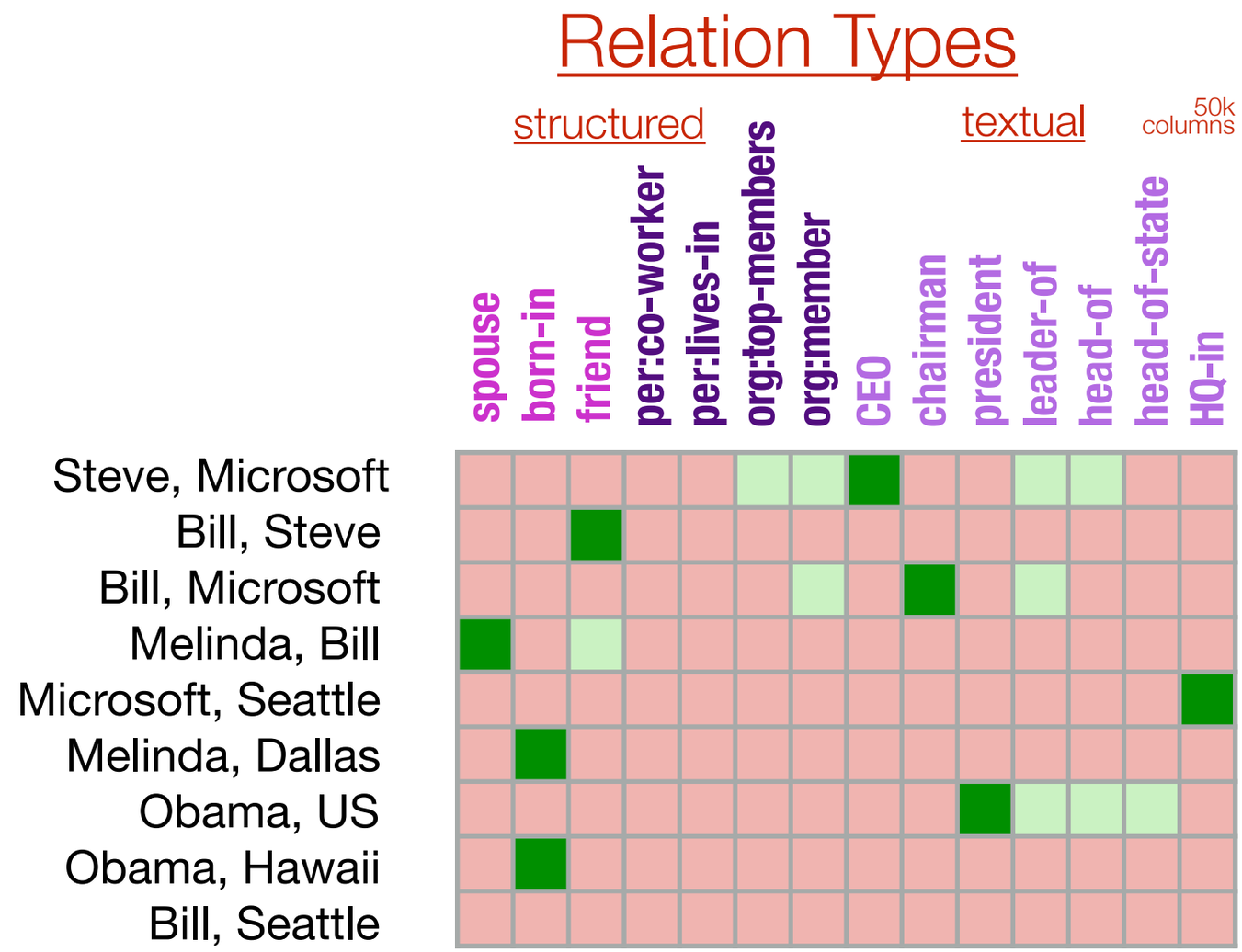

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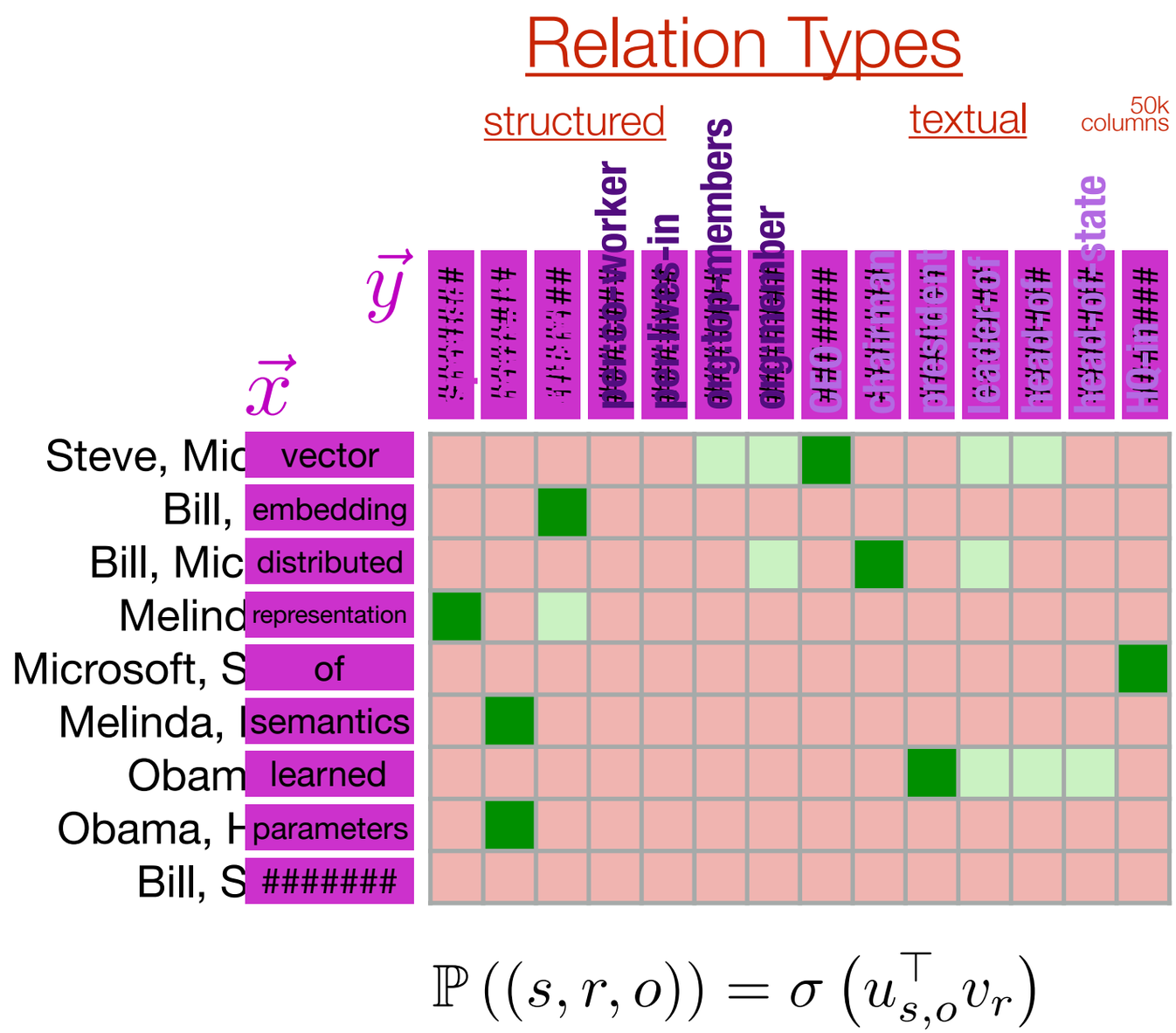

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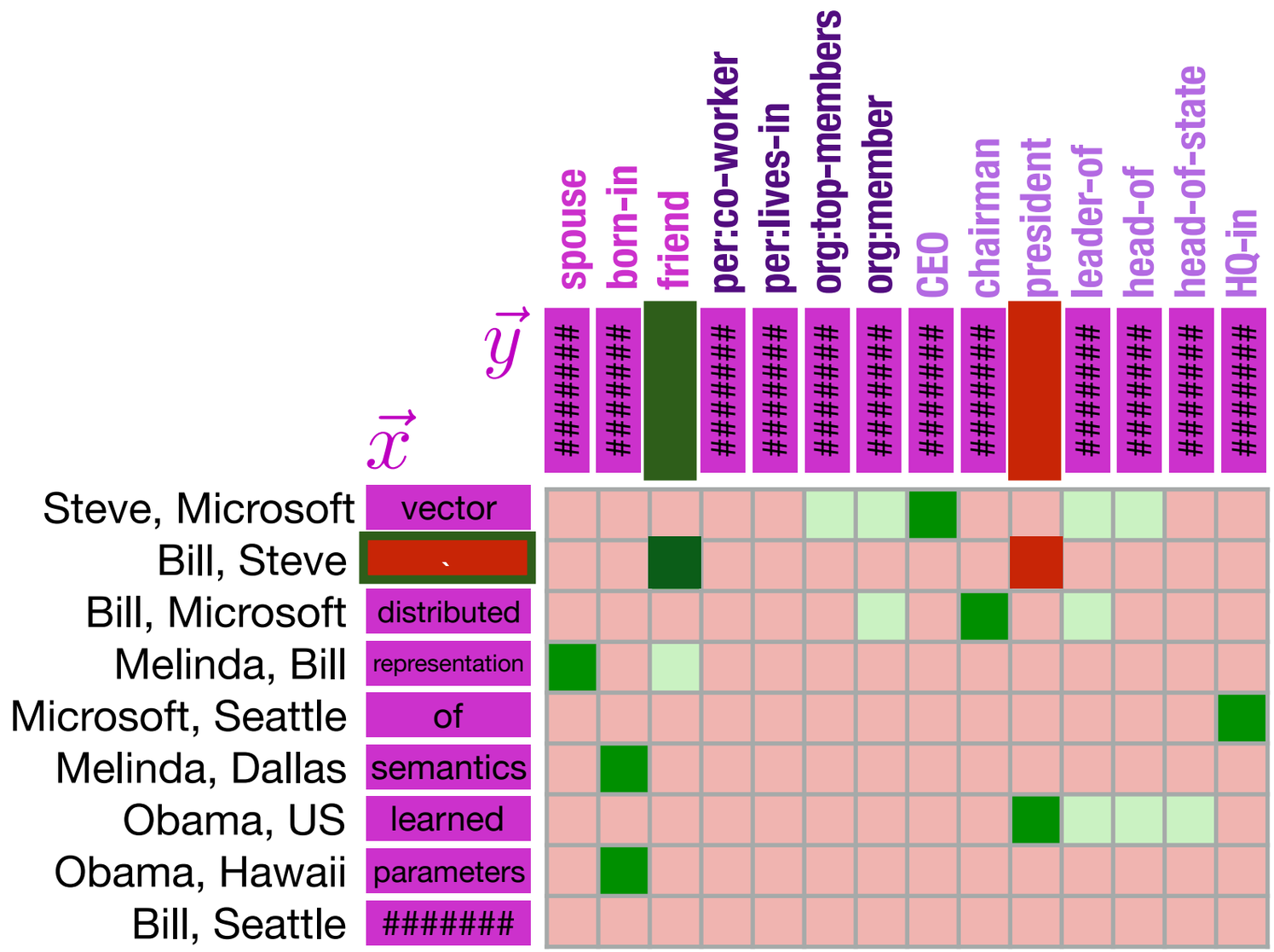
Bayesian Personalized Ranking (BPR)

$$u^T_{s,o} v_r > u^T_{s,o} v_r$$



$$\mathbb{P}\left((s,r,o)\right) = \sigma\left(u^\top_{s,o} v_r\right)$$

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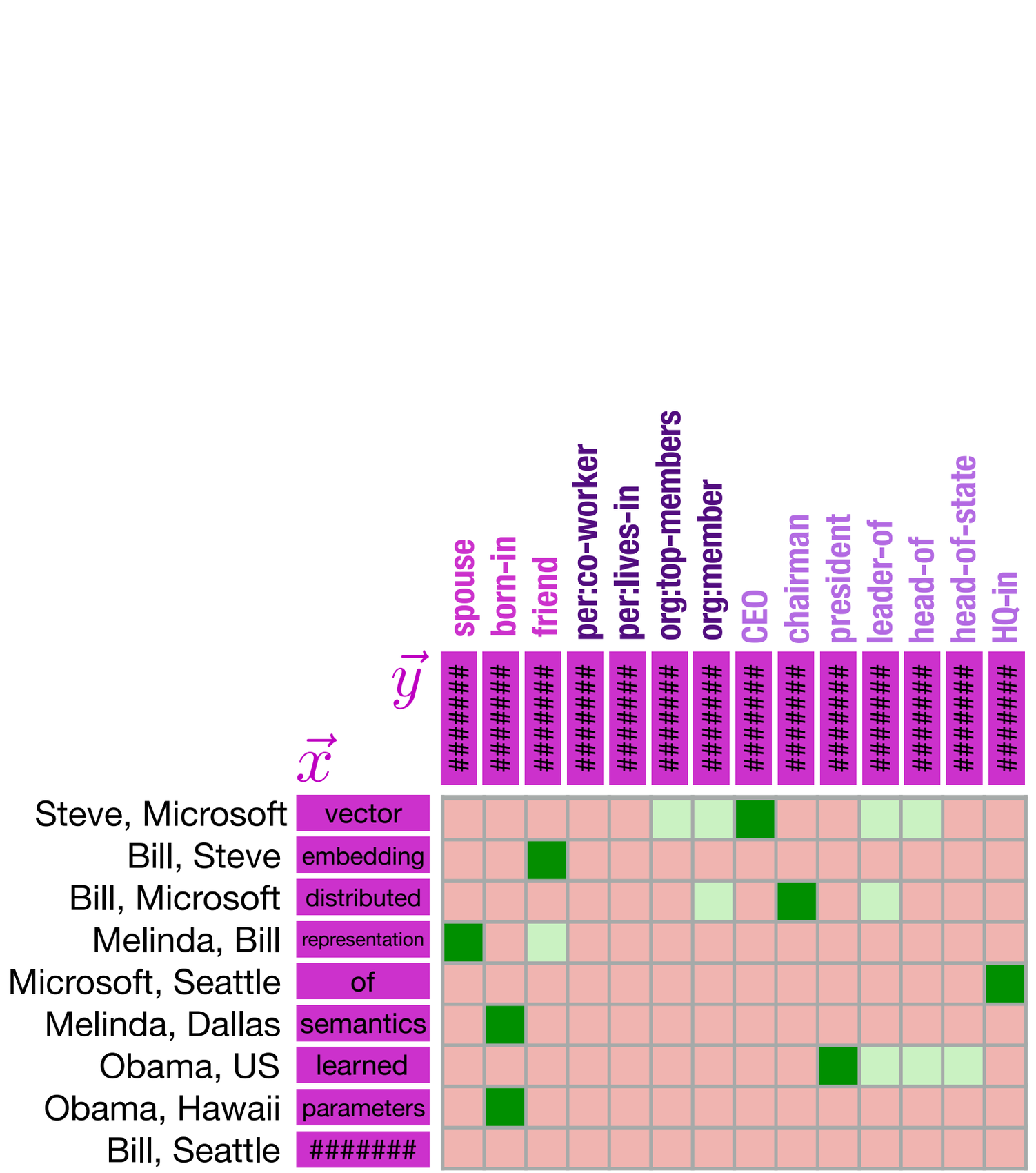

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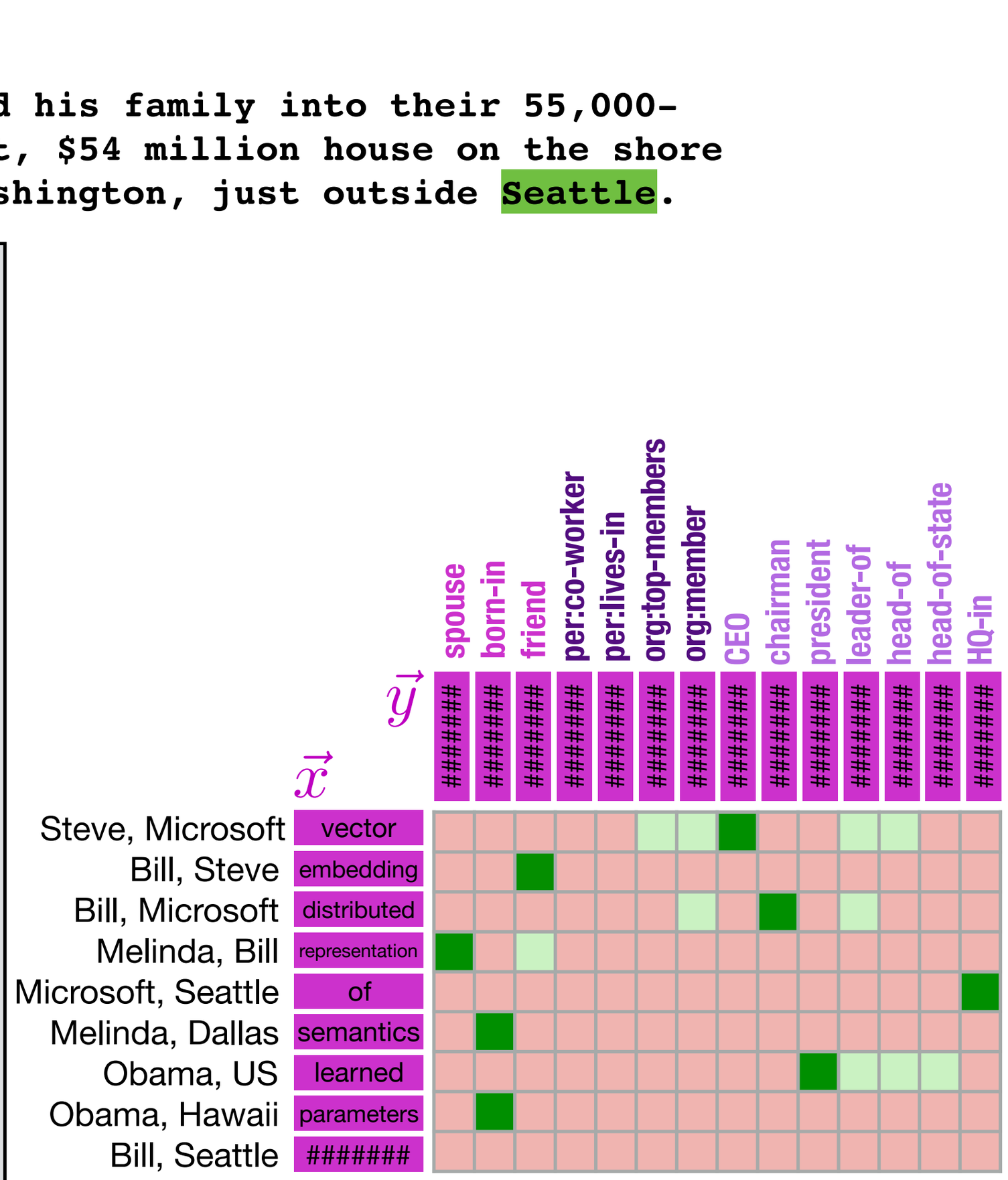

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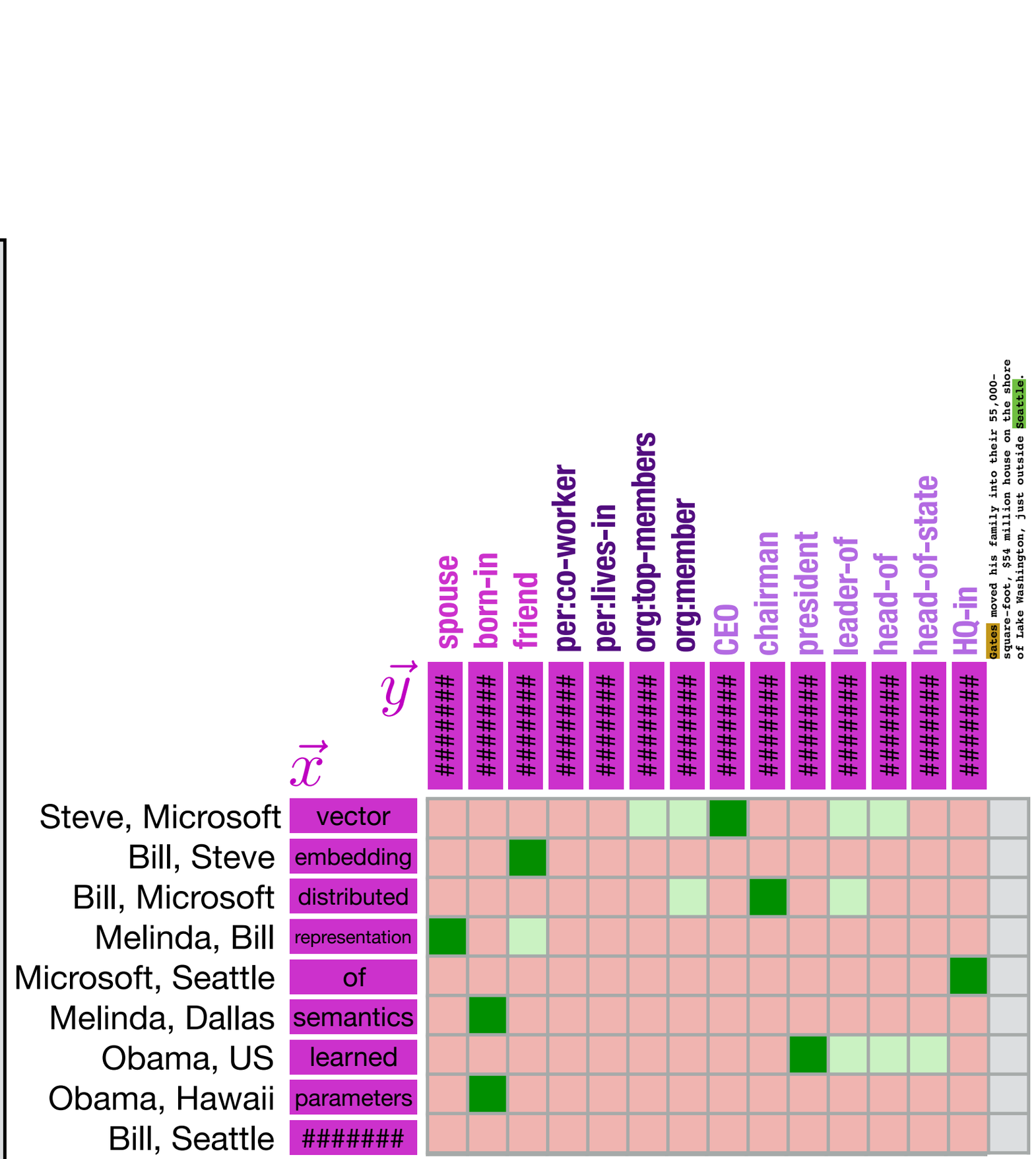

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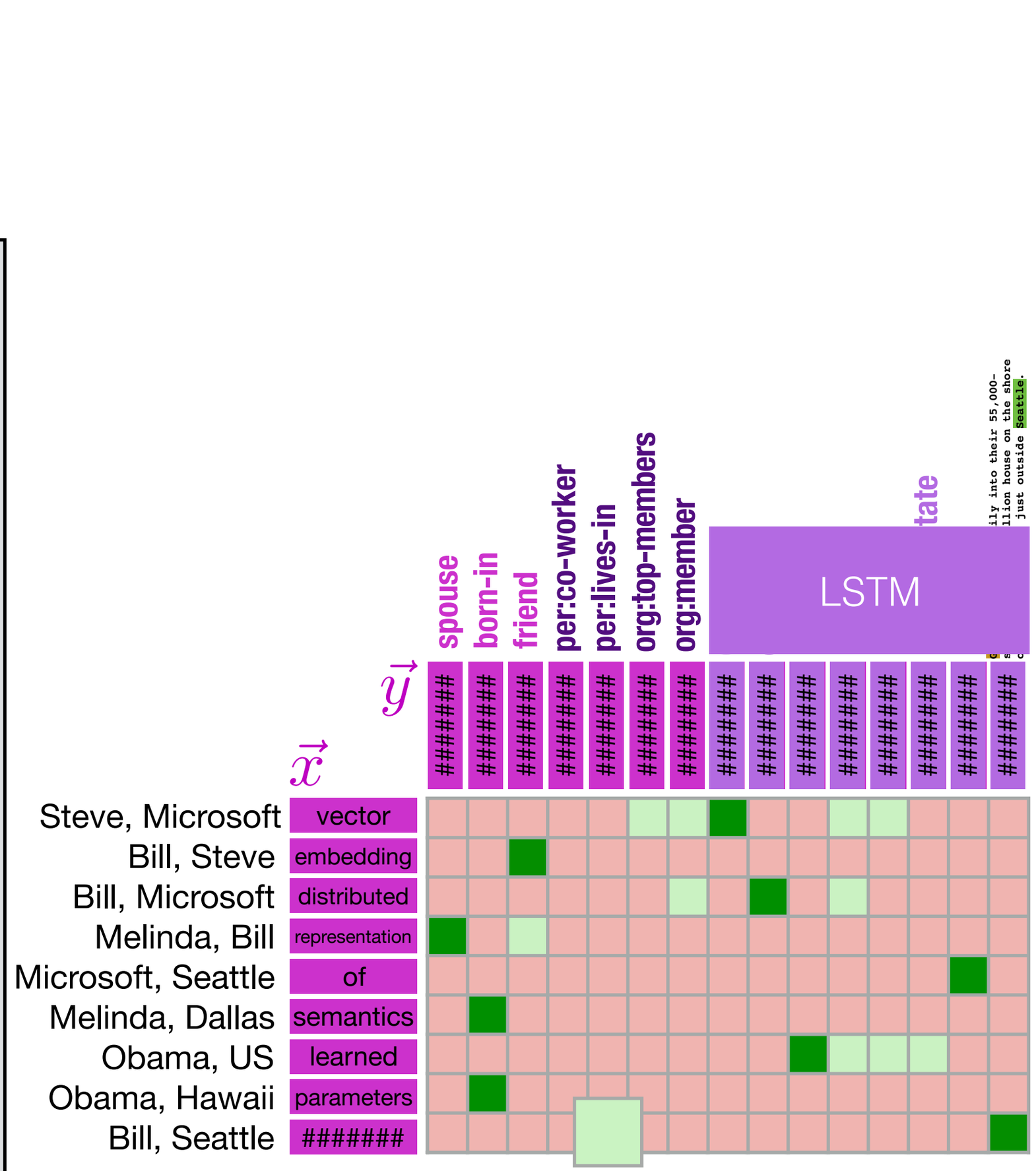
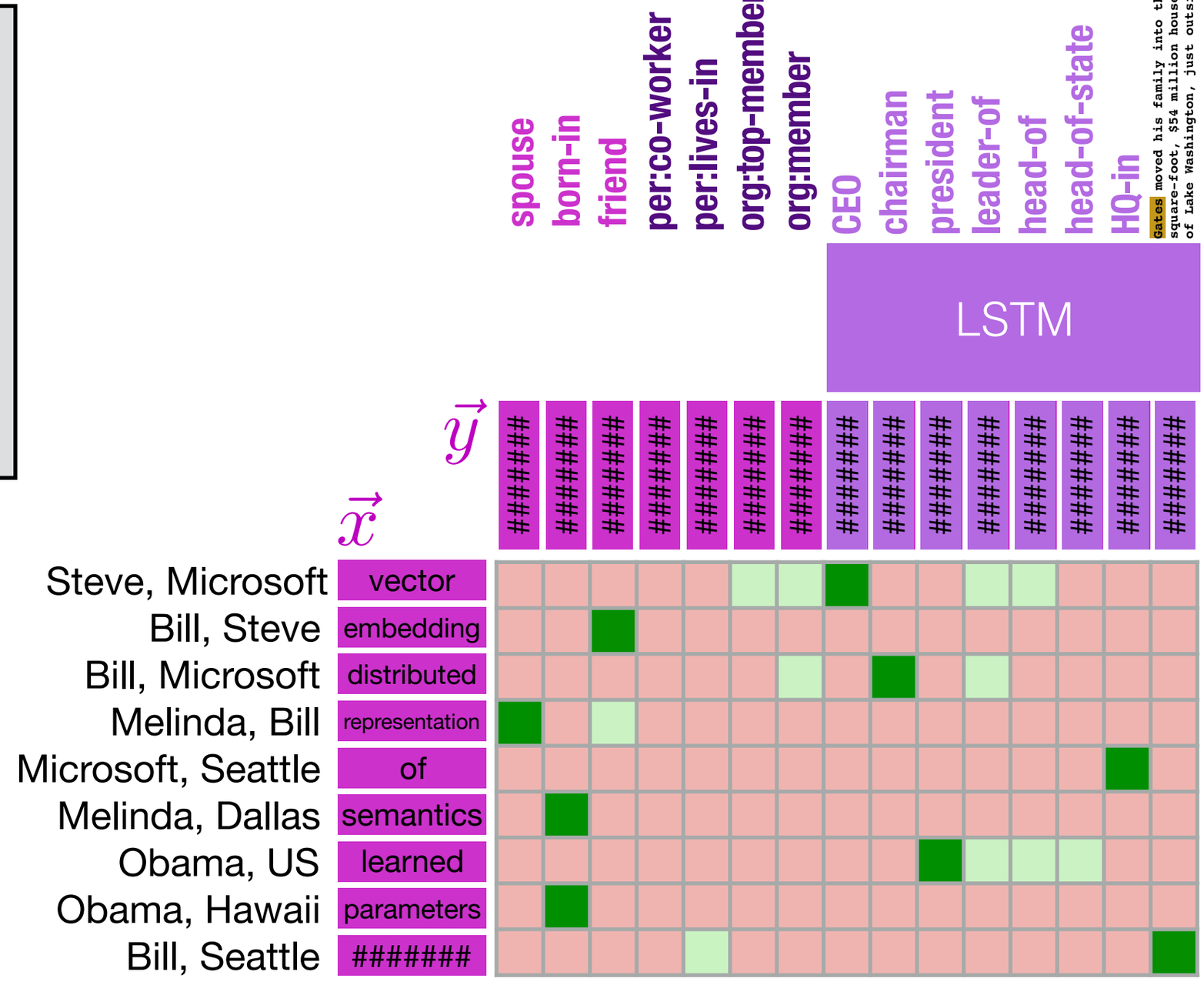


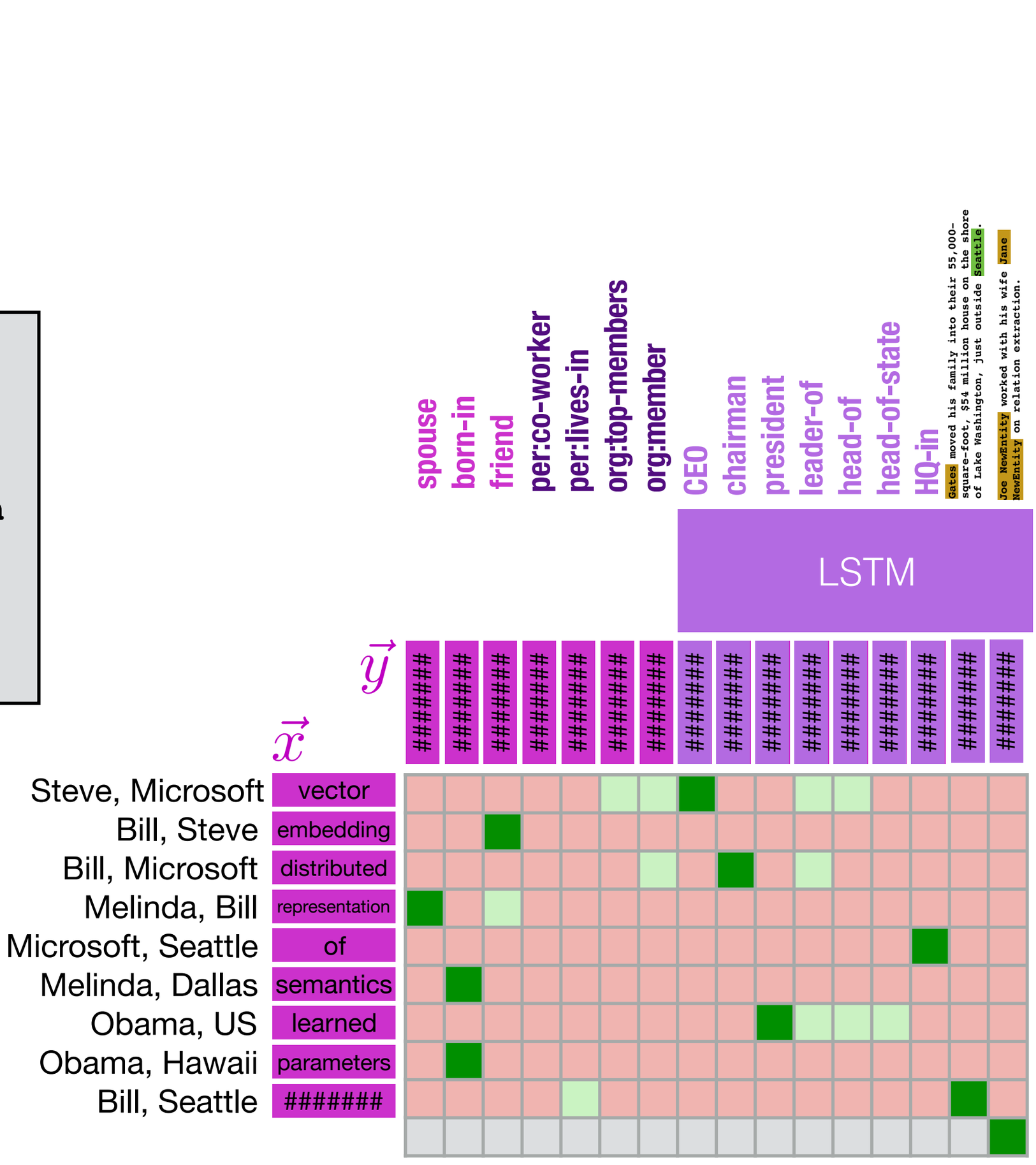
query: **spouse**

Joe NewEntity worked with his wife **Jane NewEntity** on relation extraction.



query: **spouse**

Joe NewEntity worked with his wife **Jane NewEntity** on relation extraction.



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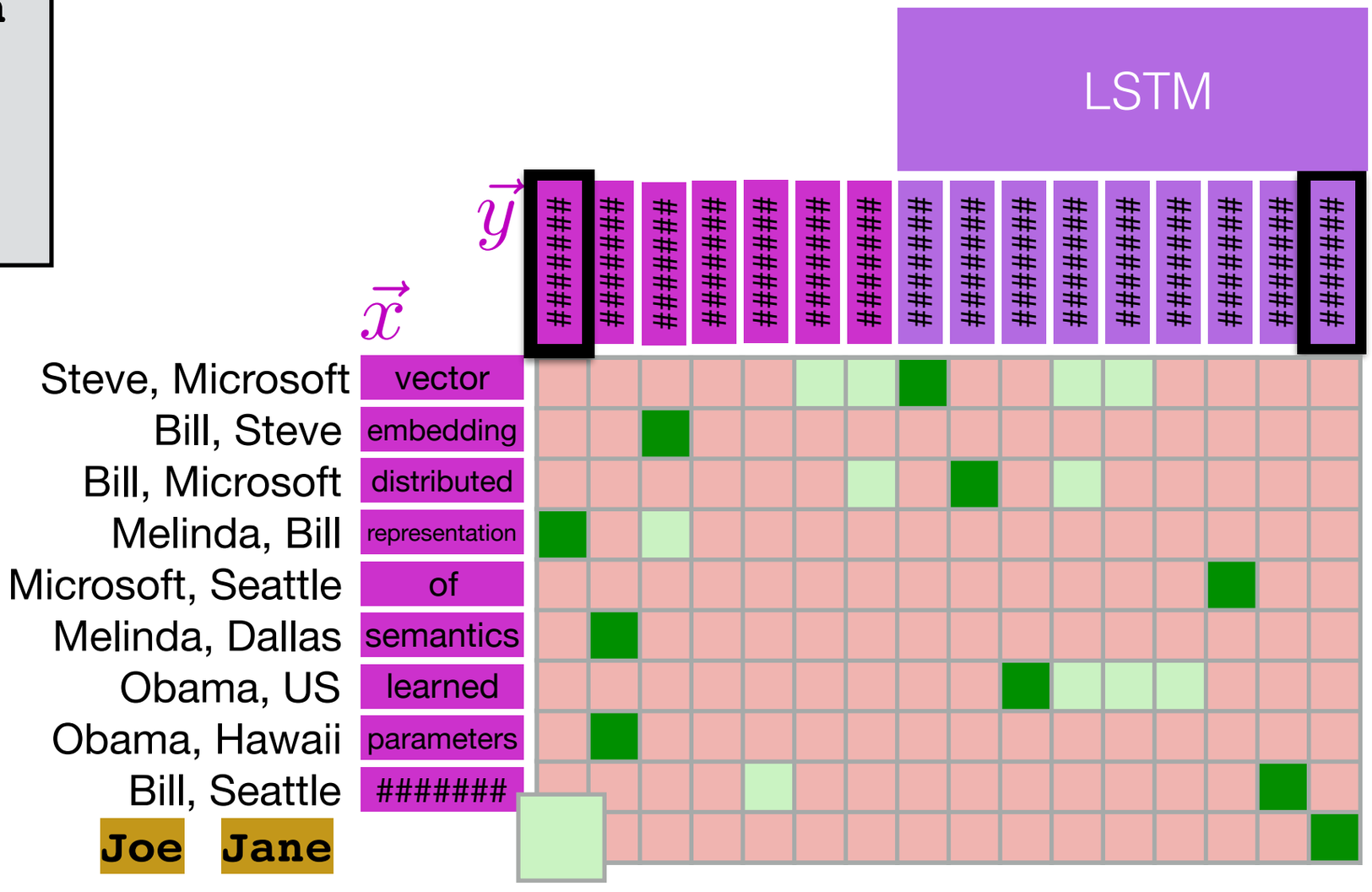
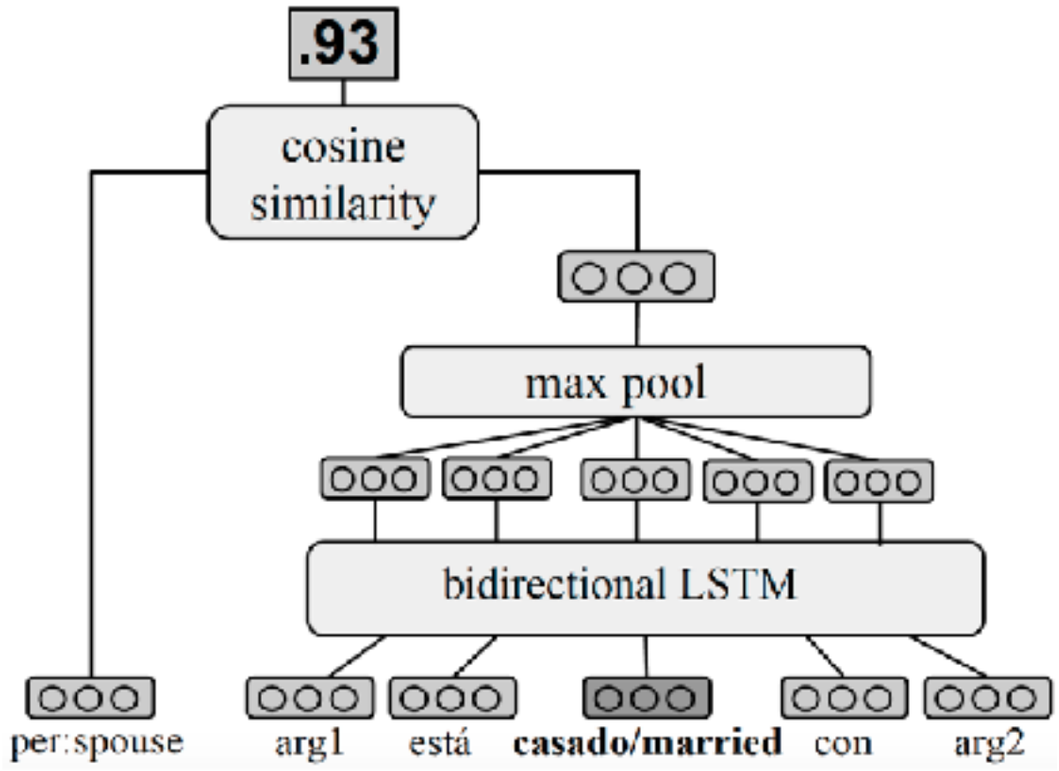
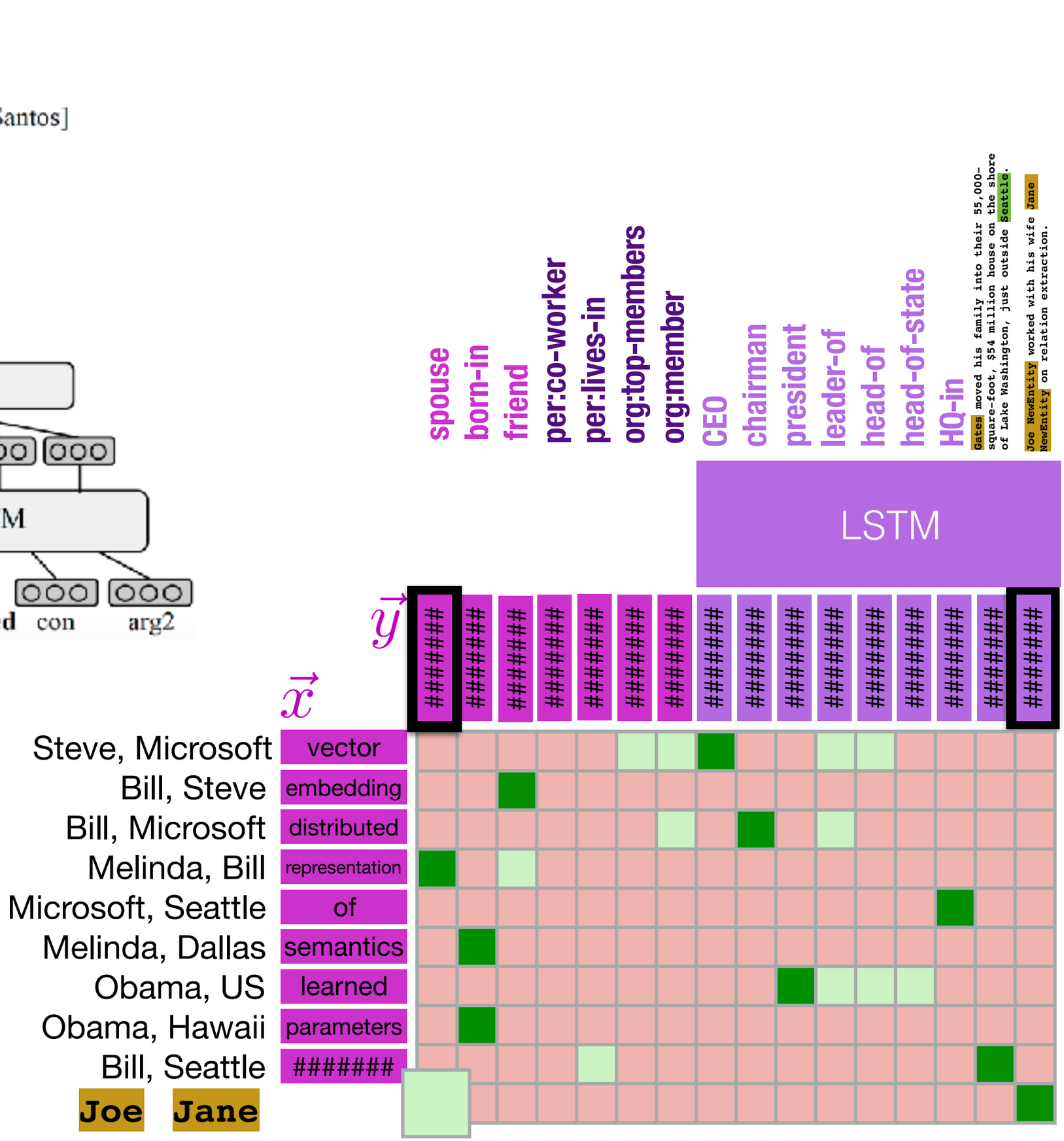


Input :
[per:spouse]
[María Múnera está casado con Juan M Santos]





Conclusions

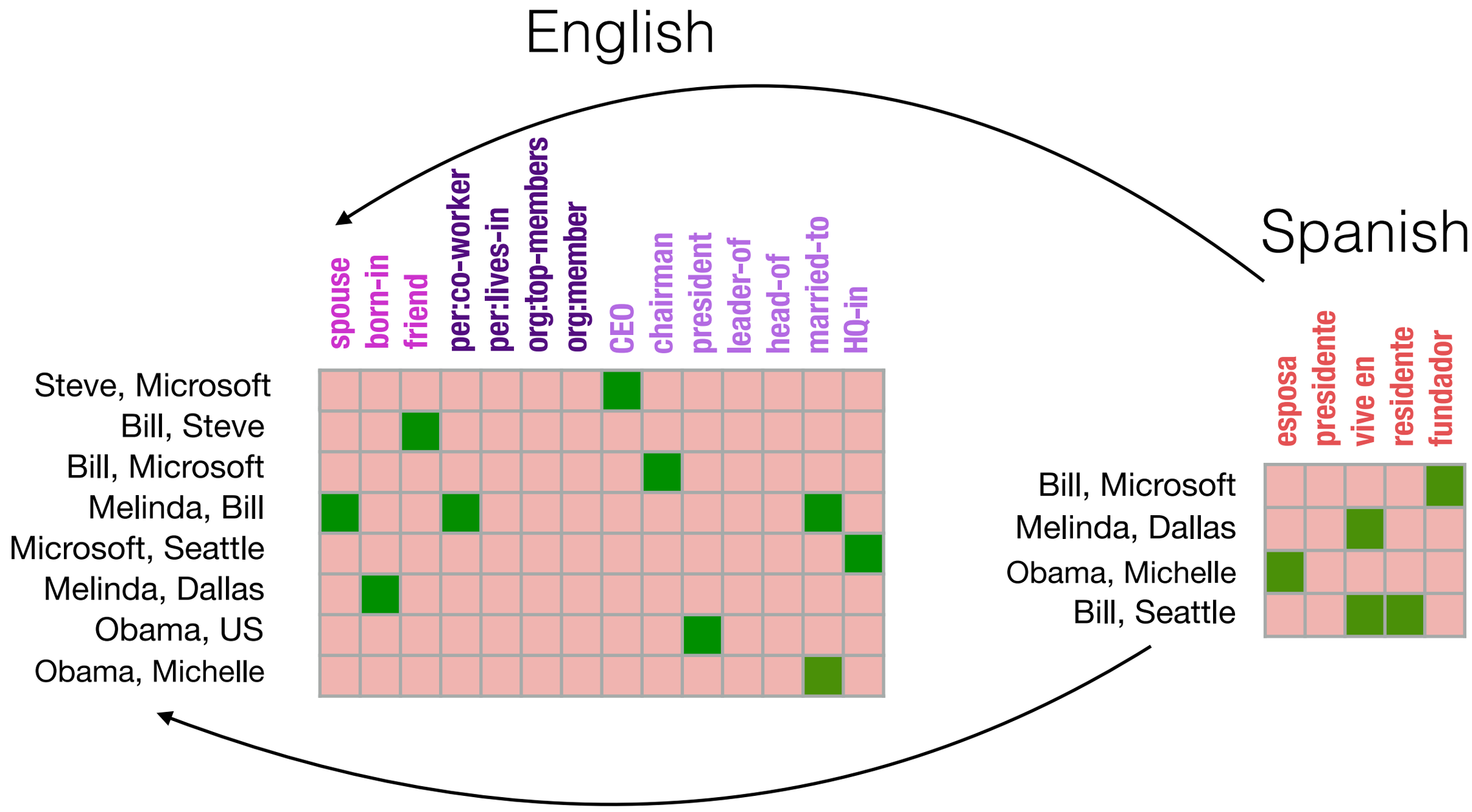
- Relation extraction is one step further toward bridging the gap between text and knowledge
- Neural networks are powerful, but data is usually the bottleneck in relation extraction
- Matrix factorization can alleviate the requirements of large amount of annotations
- Universal Schema is an example of combining complex methods to solve complex problem

Multilingual Relation Extraction

Multilingual Relation Extraction

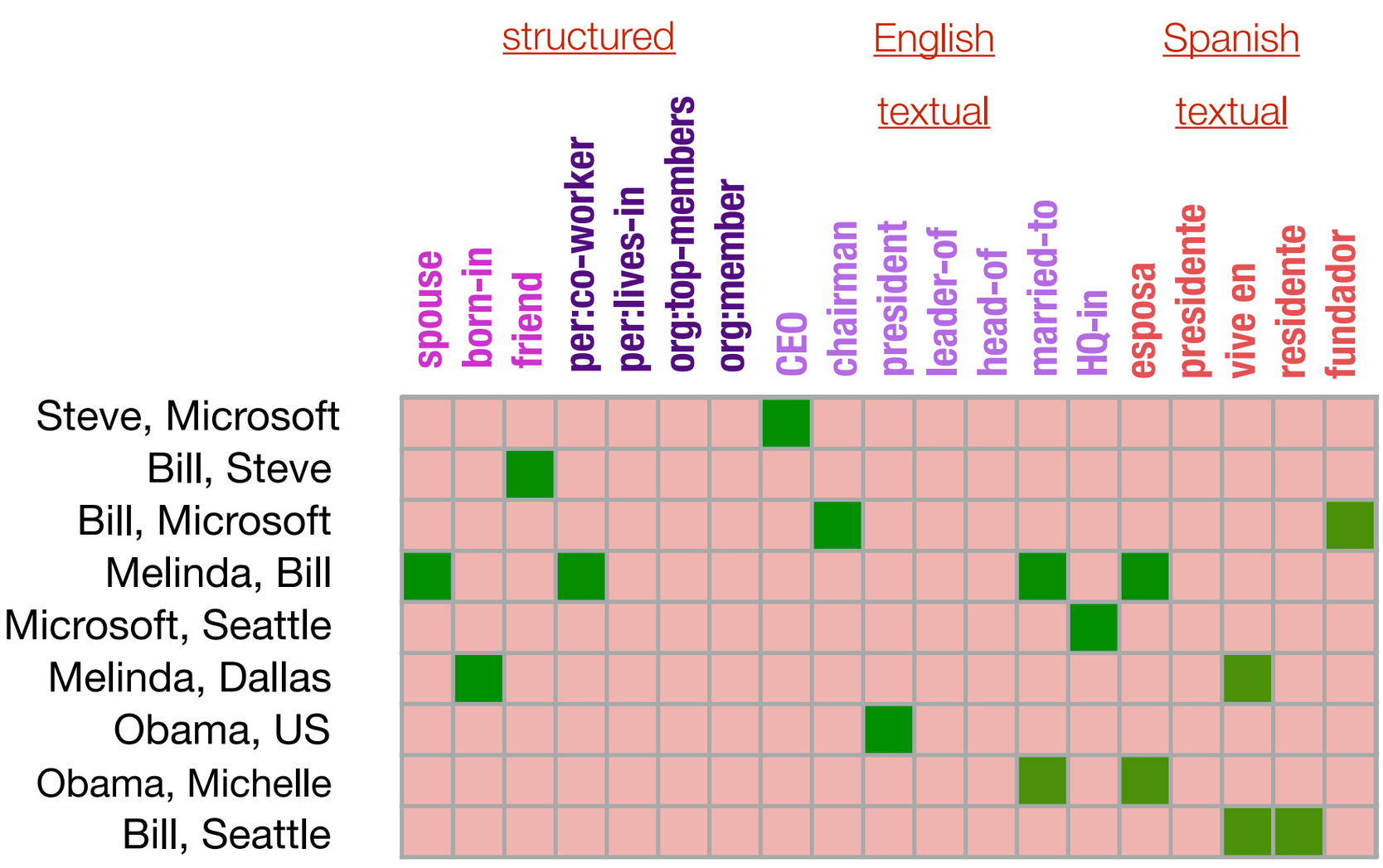
English

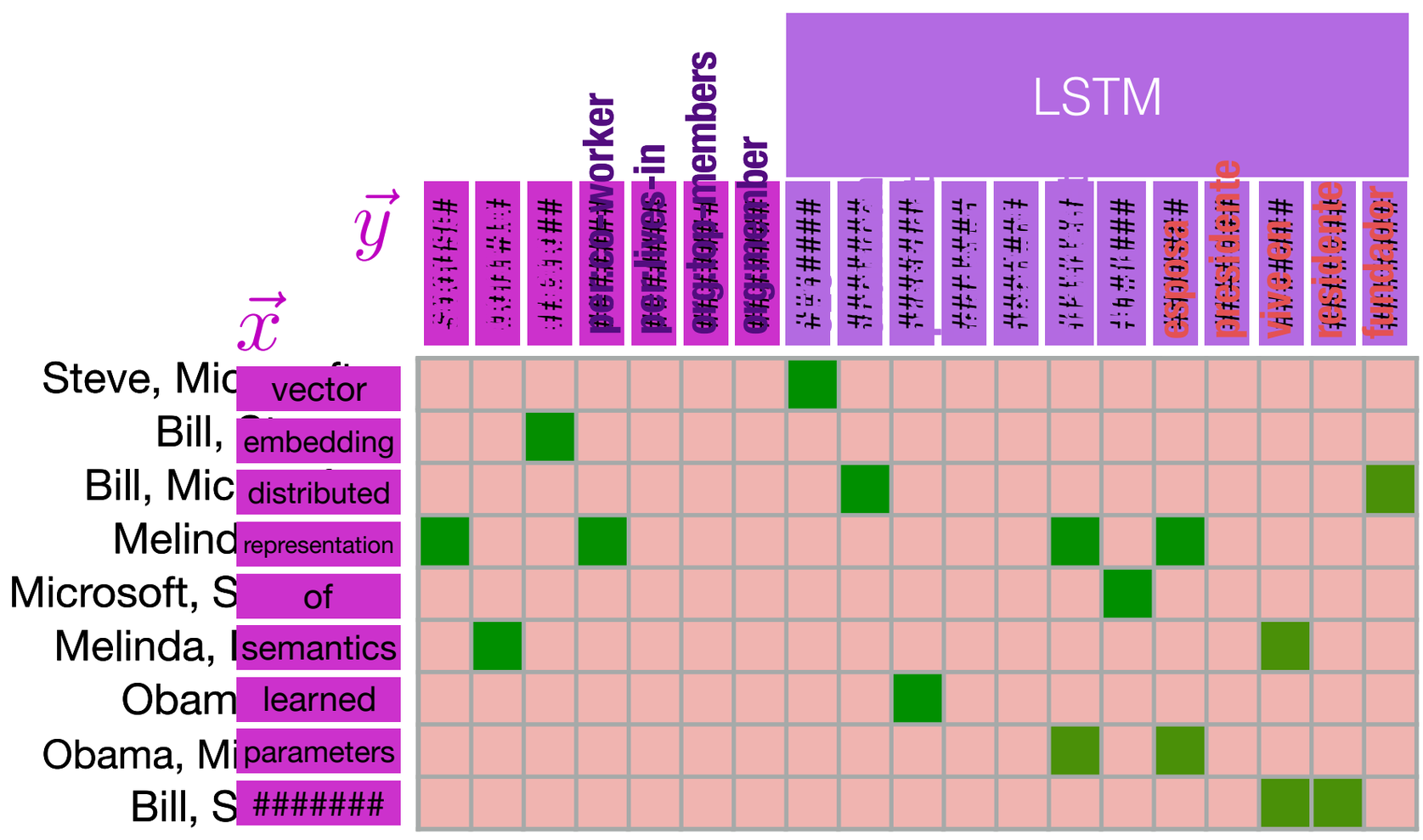
Spanish

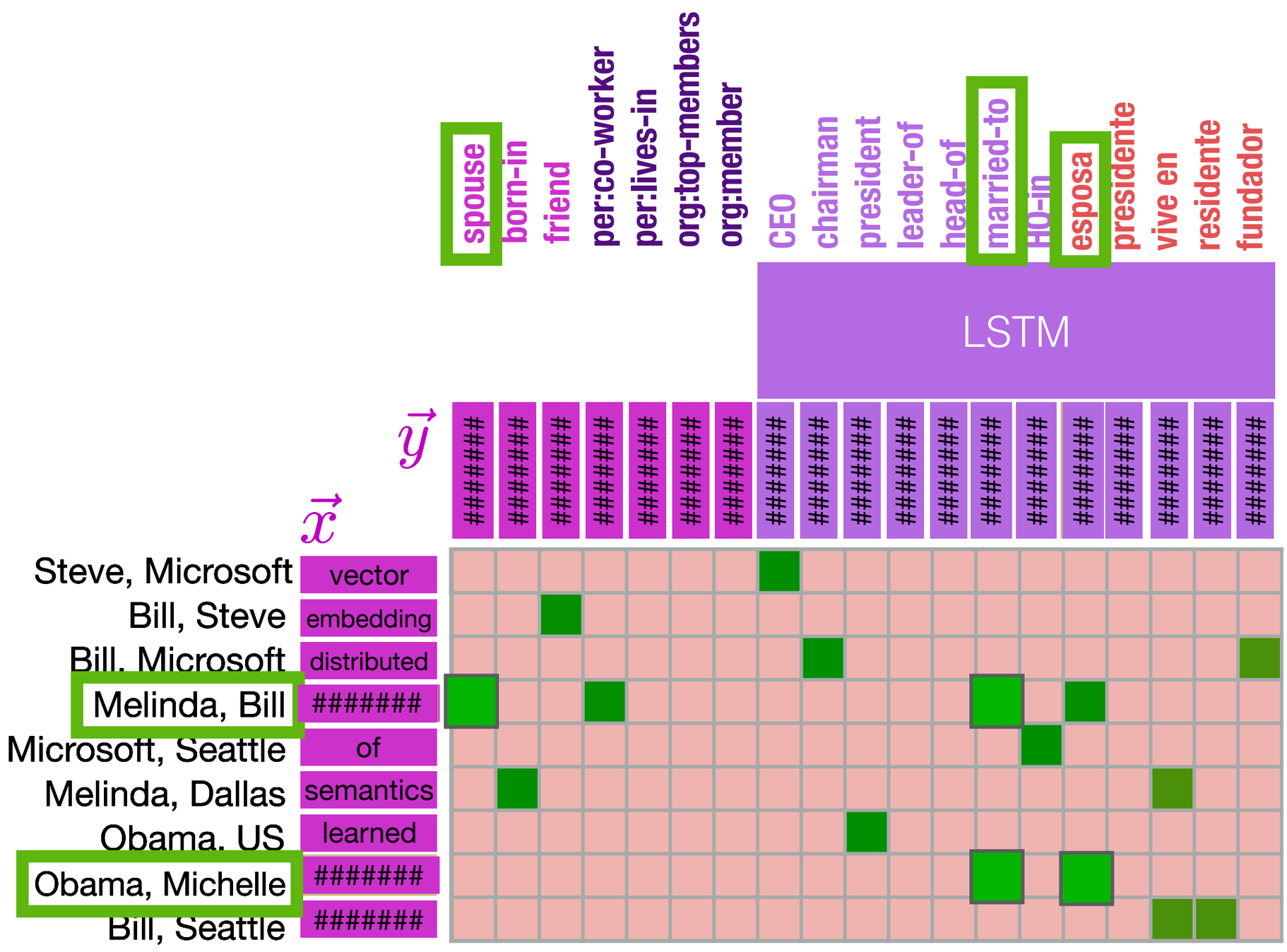


Multilingual Universal Schema

Relation Types




$\vec{y}$
$\vec{x}$
LSTM
Steve, Mic
Bill,
Bill, Mic
Melind
Microsoft, S
Melinda, I
Obam
Obama, Mi
Bill, S
vector
embedding
distributed
representation
of
semantics
learned
parameters
########
########
########
########
########
########
########
explosi#
presidente
vivien#
residente
fundador
########
########
########
########
########
########
########
worker
-in
-members
member


spouse
born-in
friend
per:co-worker
per:lives-in
org:top-members
org:member
CEO
chairman
president
leader-of
head-of
married-to
HQ-in
esposa
presidente
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fundador
LSTM
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Steve, Microsoft
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Bill, Microsoft
Melinda, Bill
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Obama, US
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vector
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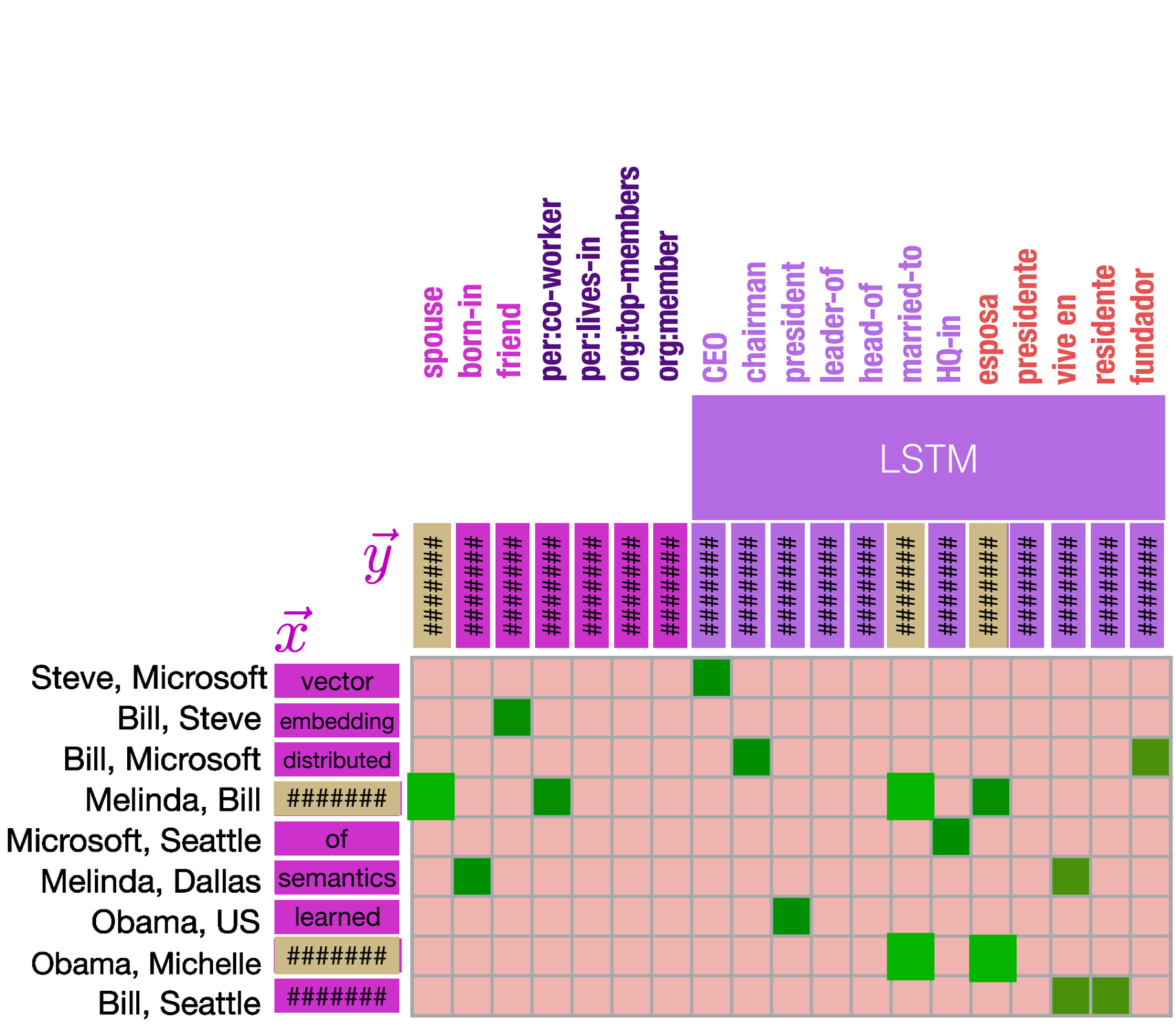
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born-in
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per:lives-in
org:top-members
org:member
CEO
chairman
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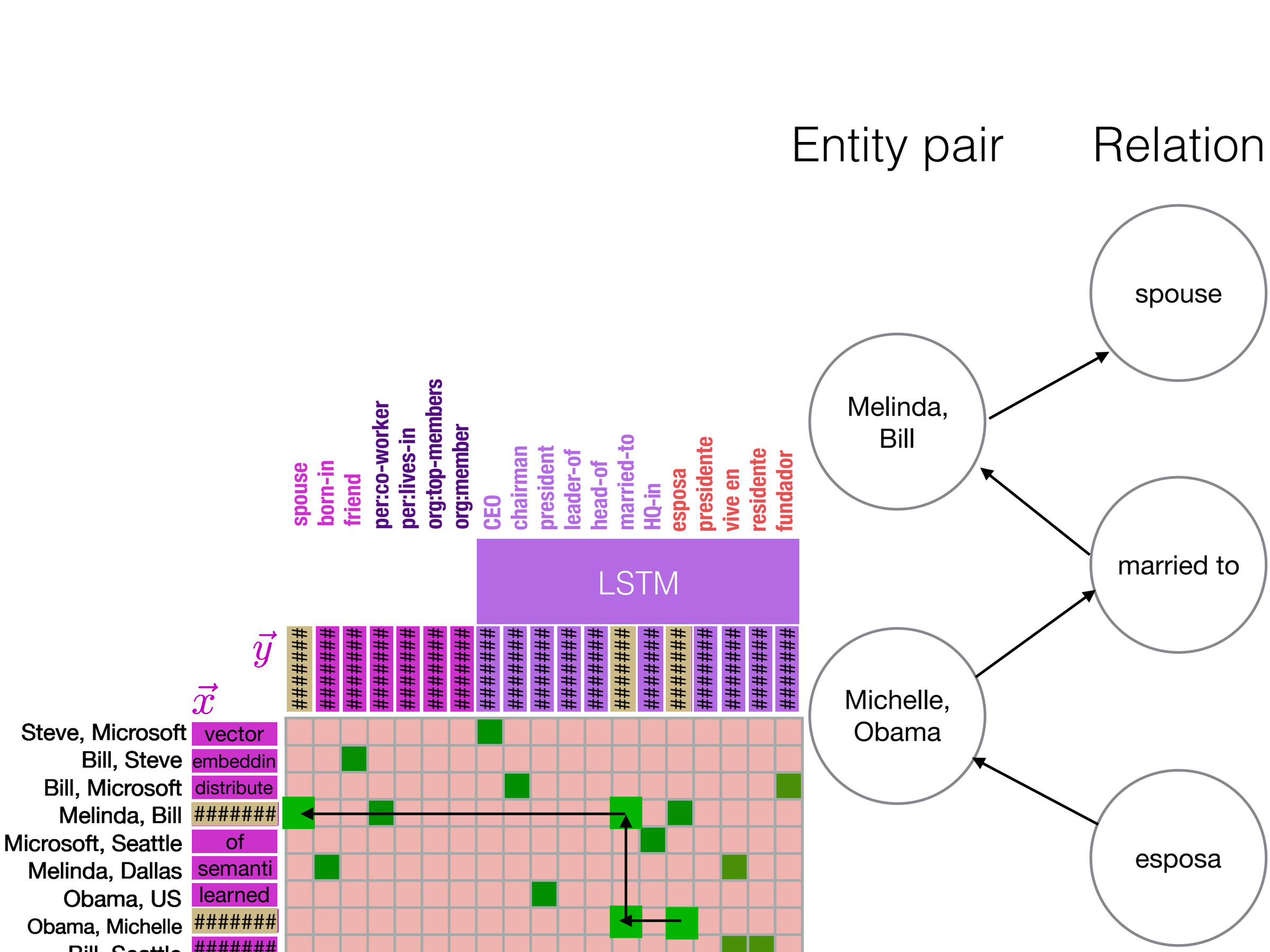
spouse
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org:top-members
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CEO
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Melinda, Bill
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Melinda, Dallas
Obama, US
Obama, Michelle
Bill, Seattle
vector
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of
semanti
learned
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#######
Entity pair
Relation
Melinda, Bill
Michelle, Obama
spouse
married to
esposa

per:spouse
per:born-in
per:friend
per:co-worker
per:lives-in
org:top-members
org:member
CEO
chairman
president
leader-of
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married-to
HQ-in
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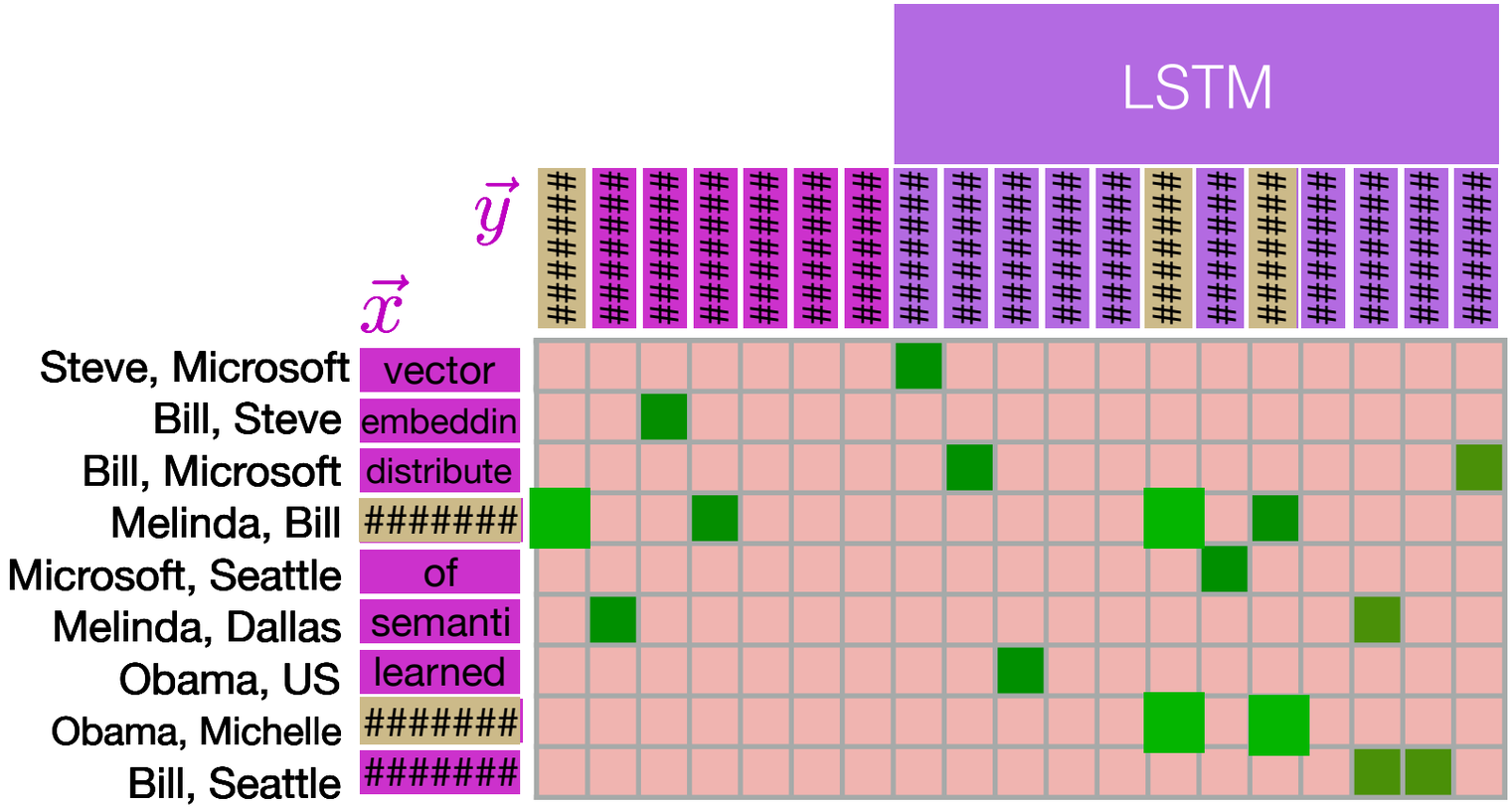
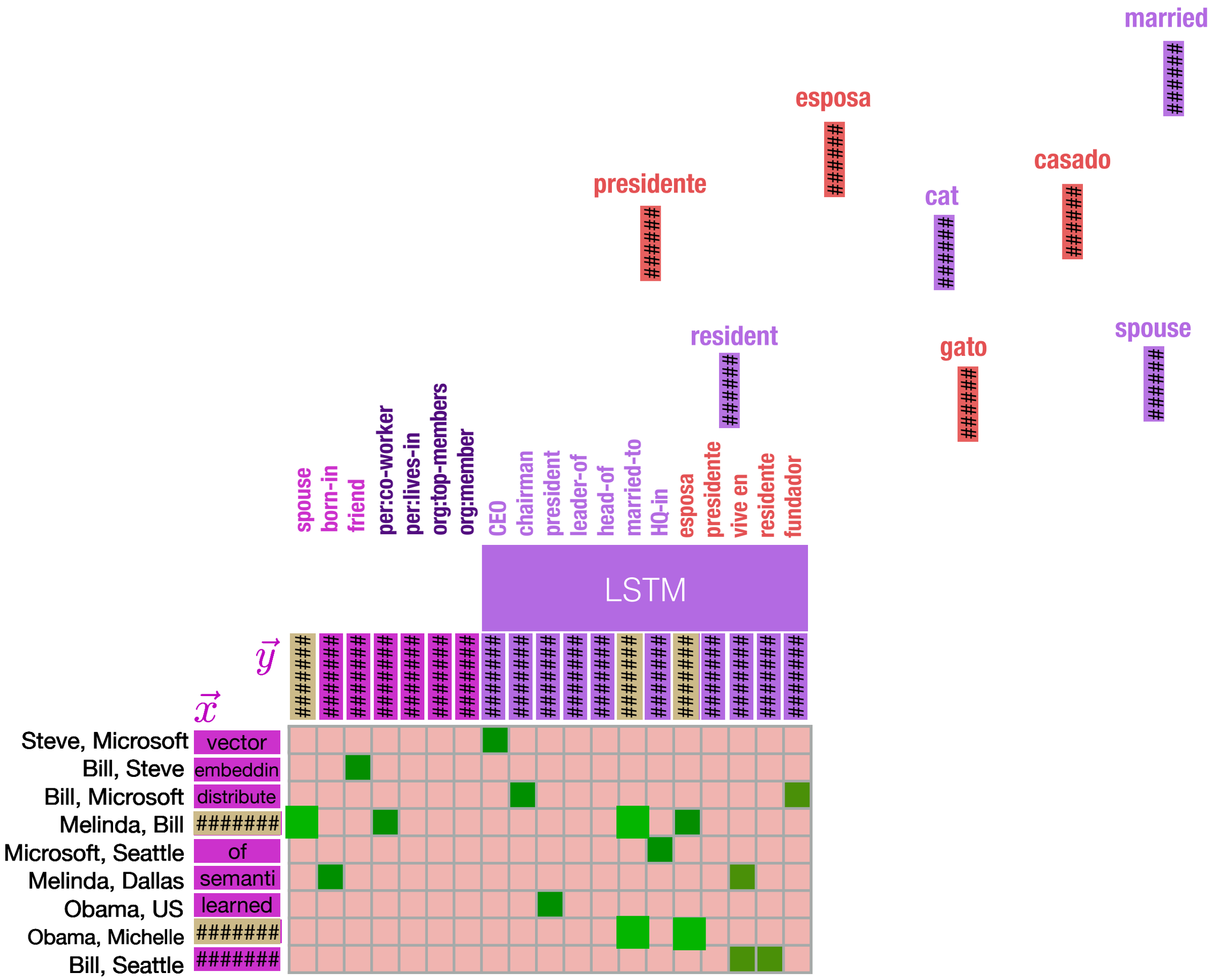
fundador




spouse
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org:top-members
org:member
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Microsoft, Seattle
Melinda, Dallas
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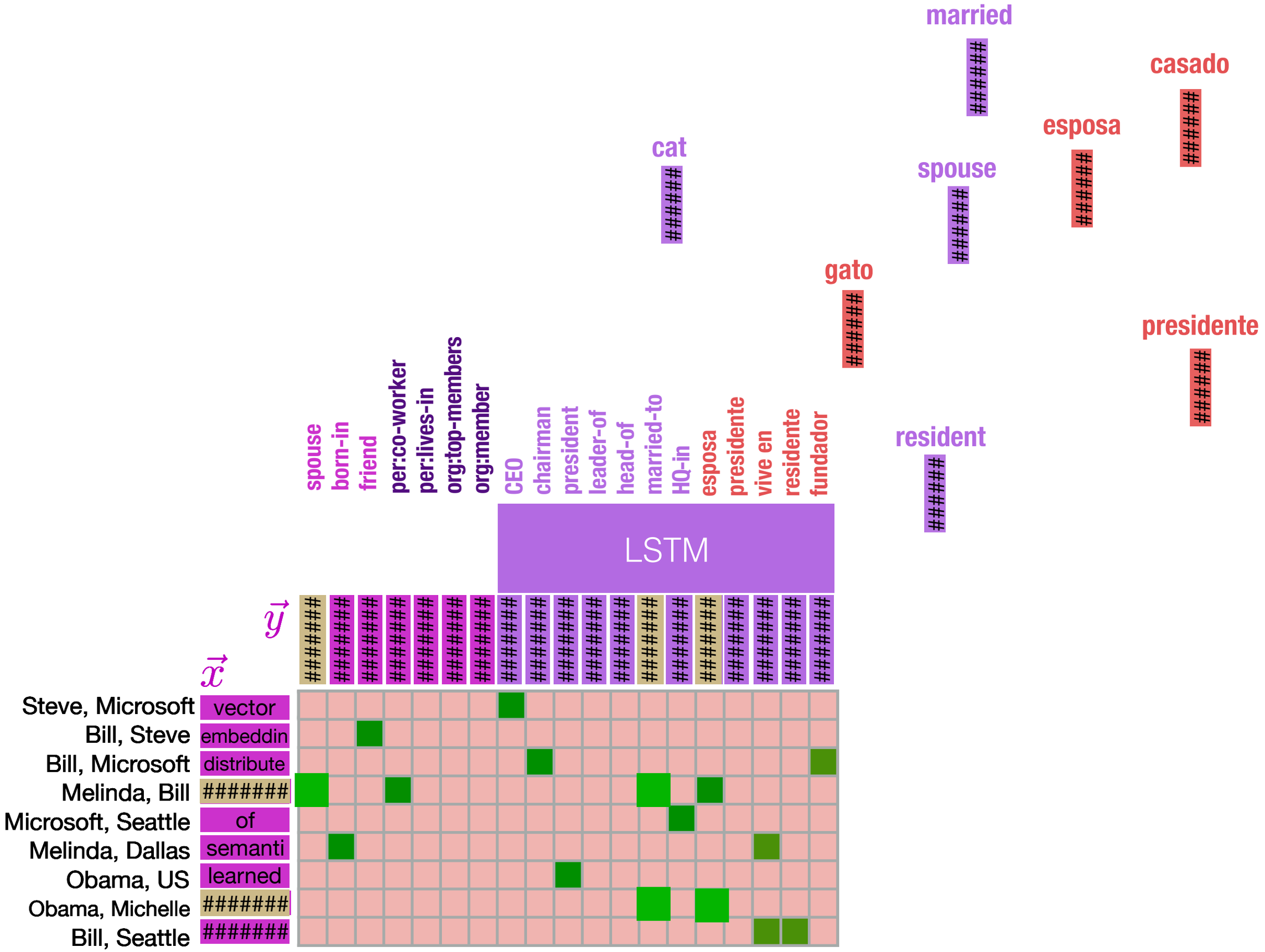
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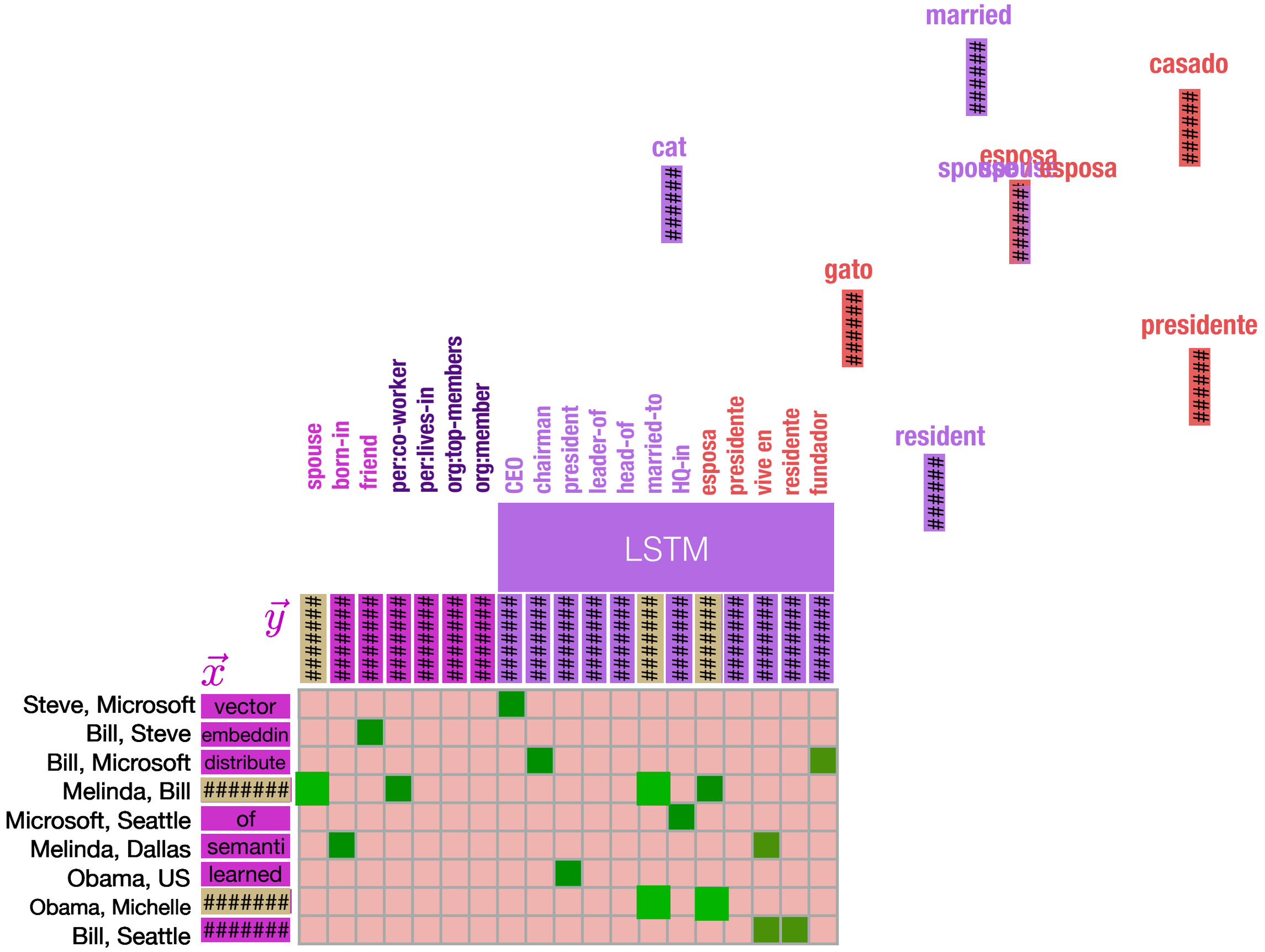
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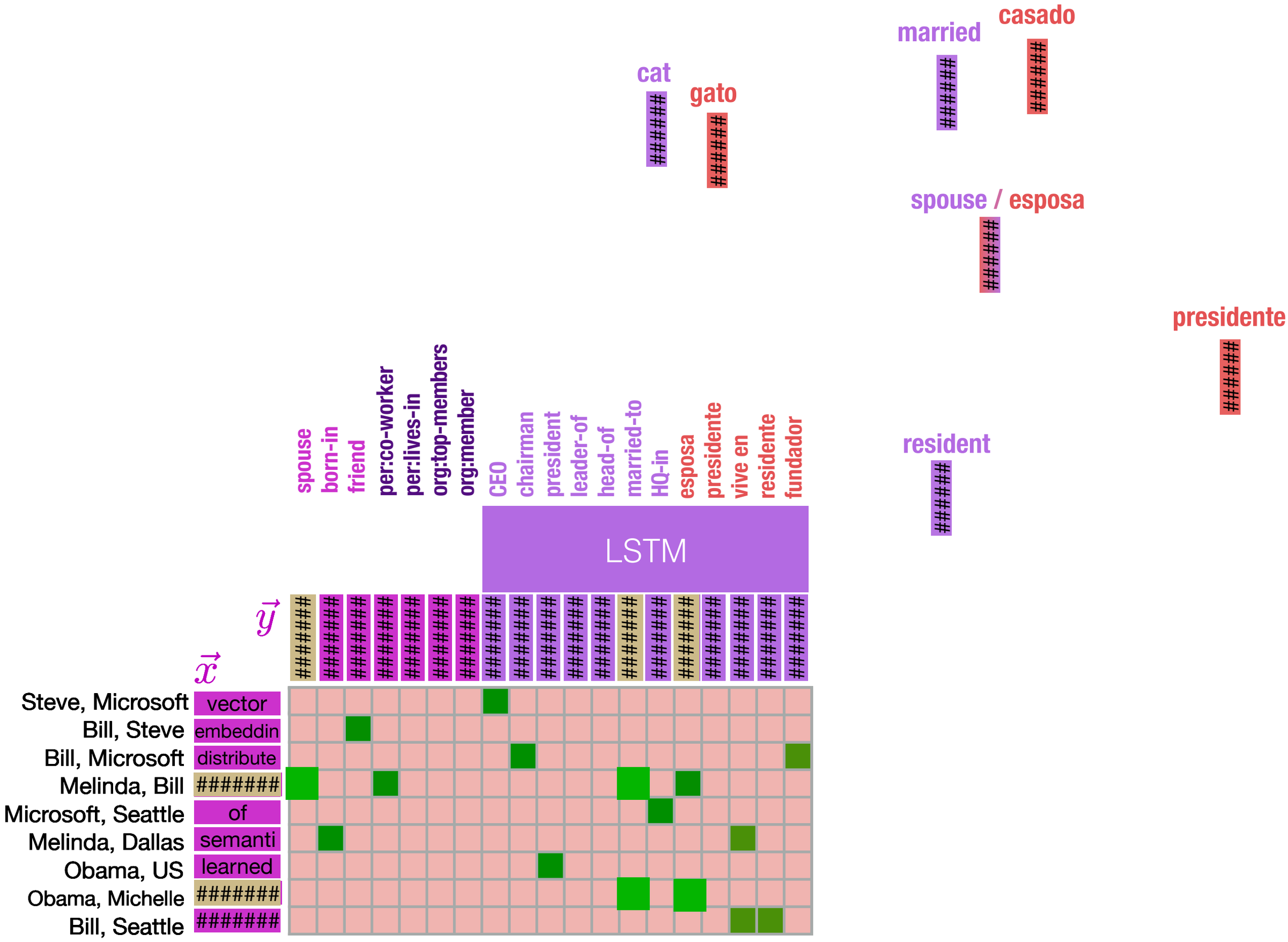
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per:co-worker
per:lives-in
org:top-members
org:member
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