

# Row-less Universal Schema

Patrick Verga and Andrew McCallum

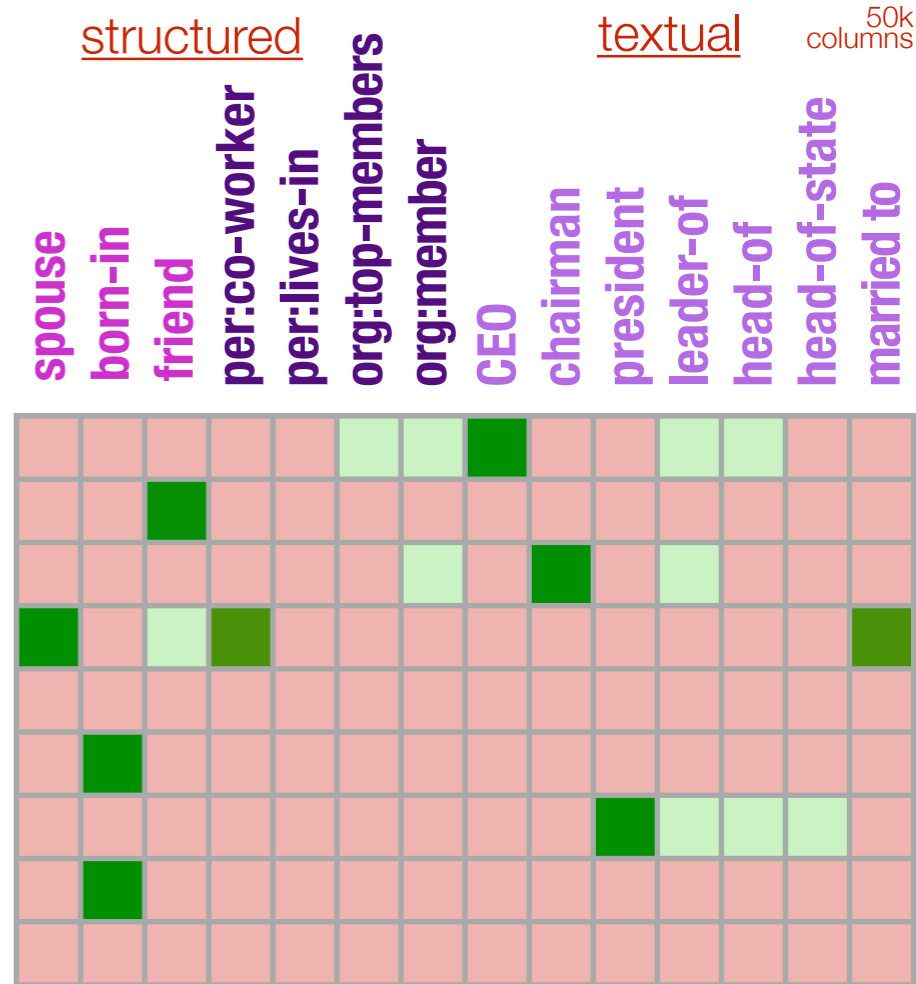
UMassAmherst

January 15, 2000

Tech pioneer **Bill Gates** stepped down today as chief executive officer of **Microsoft**, the **Seattle**-headquartered software giant. His long-time friend, **Steve Balmer**, will take over as CEO of **Microsoft**. **Gates** will now focus on the charitable foundation he runs with **his** wife **Melinda French Gates**. **Bill** and **Melinda** were married in a ceremony in **Hawaii**, rather than her hometown of **Dallas**. **Gates** moved his family into their 55,000-square-foot, \$54 million house on the shore of Lake Washington, just outside **Seattle**.

Steve, Microsoft  
Bill, Steve  
Bill, Microsoft  
Melinda, Bill  
Microsoft, Seattle  
Melinda, Dallas  
Obama, US  
Obama, Hawaii  
Bill, Seattle

## Relation Types



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## Entity Types

structured

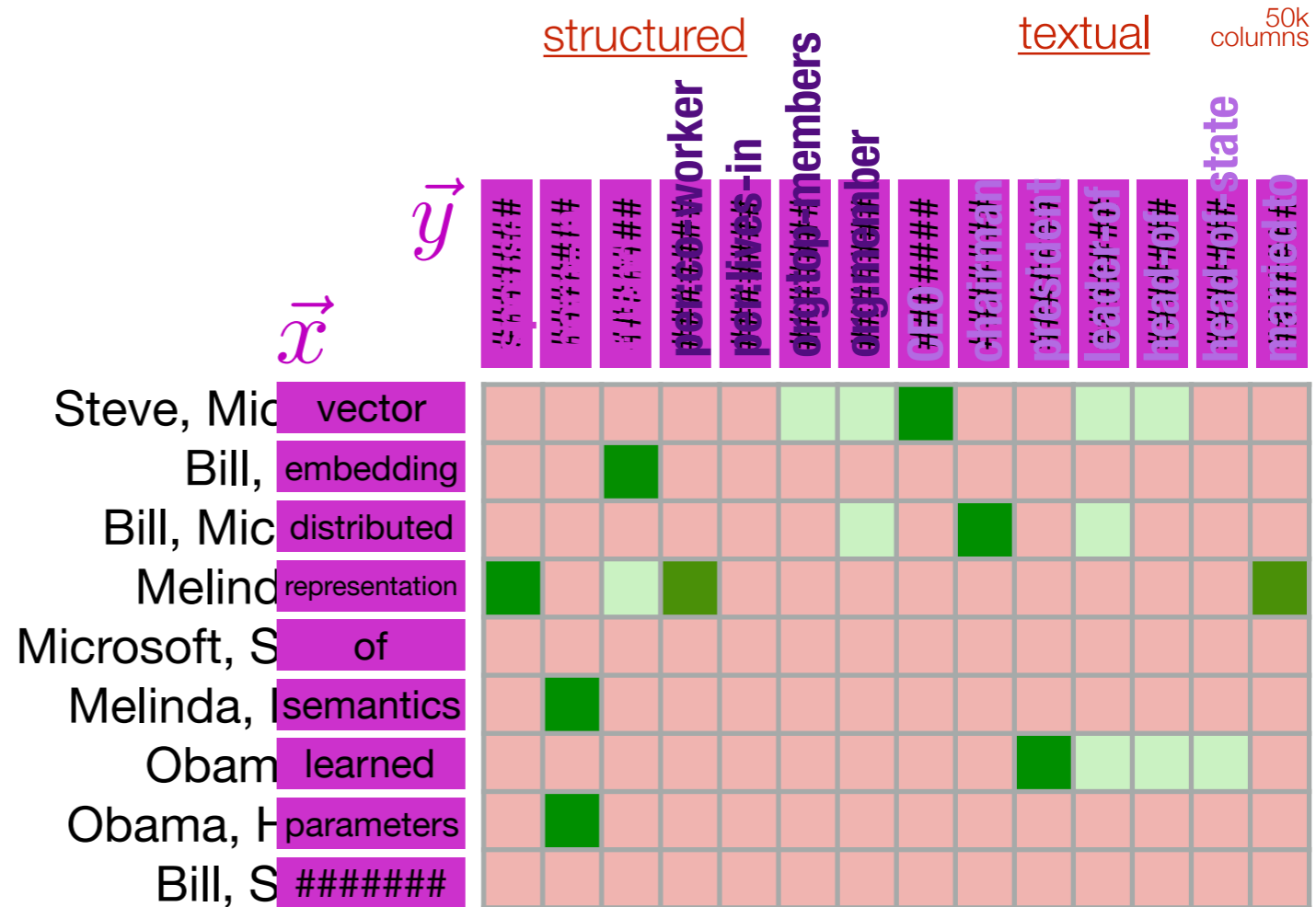
textual

	person	location	organization	per:worker	per:scientist	loc:city	org:non-profit	country	providence	chairman	president	athlete	politician	head-of-state
Steve	dark green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Bill	dark green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Microsoft	light green	light green	dark green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Melinda	dark green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Seattle	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Dallas	light green	dark green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
Obama	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	dark green	light green	dark green	light green
Hawaii	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green	light green
USA	light green	light green	dark green	light green	light green	light green	light green	dark green	light green	light green	light green	light green	light green	light green

January 15, 2000

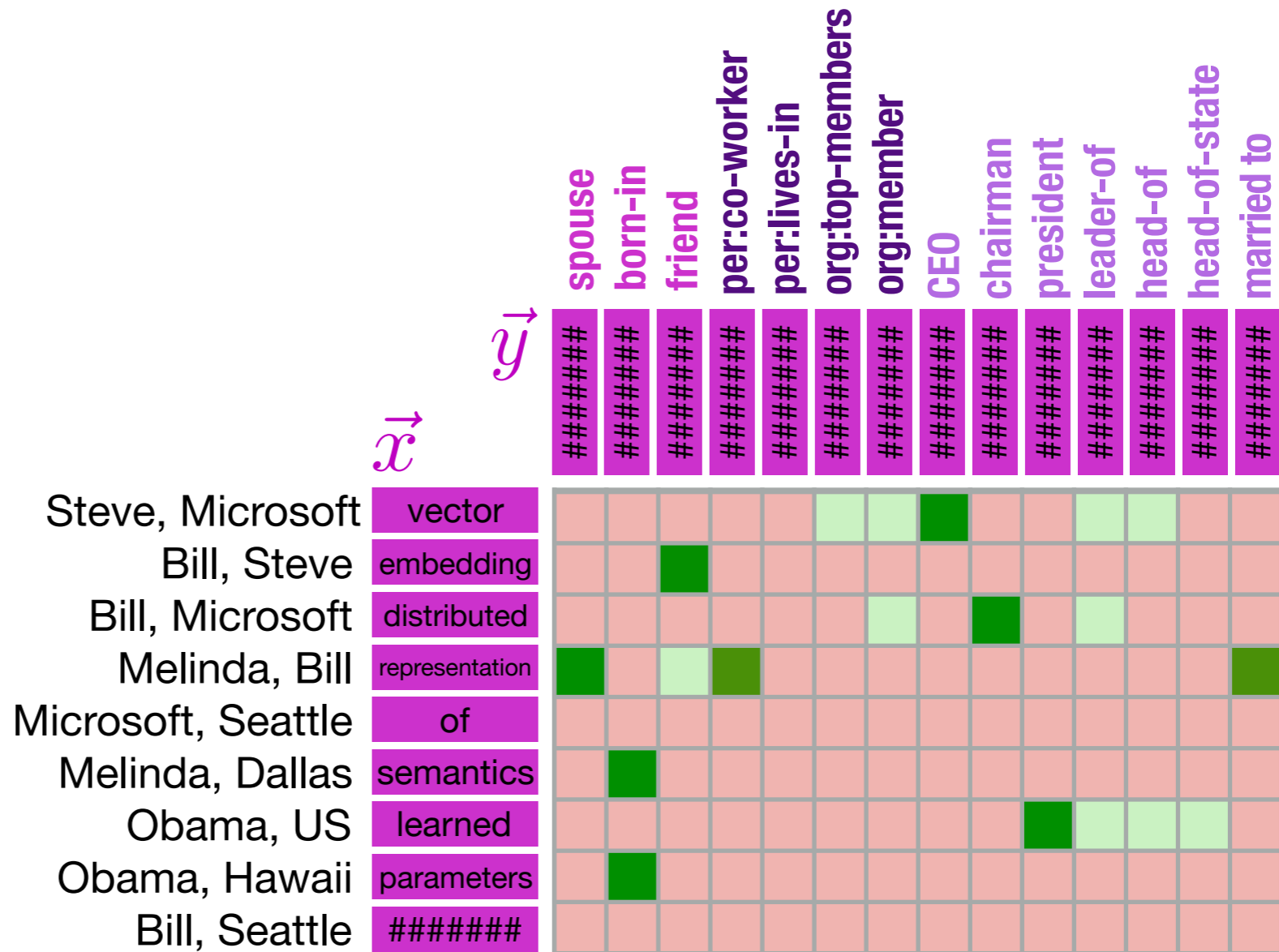
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## Relation Types



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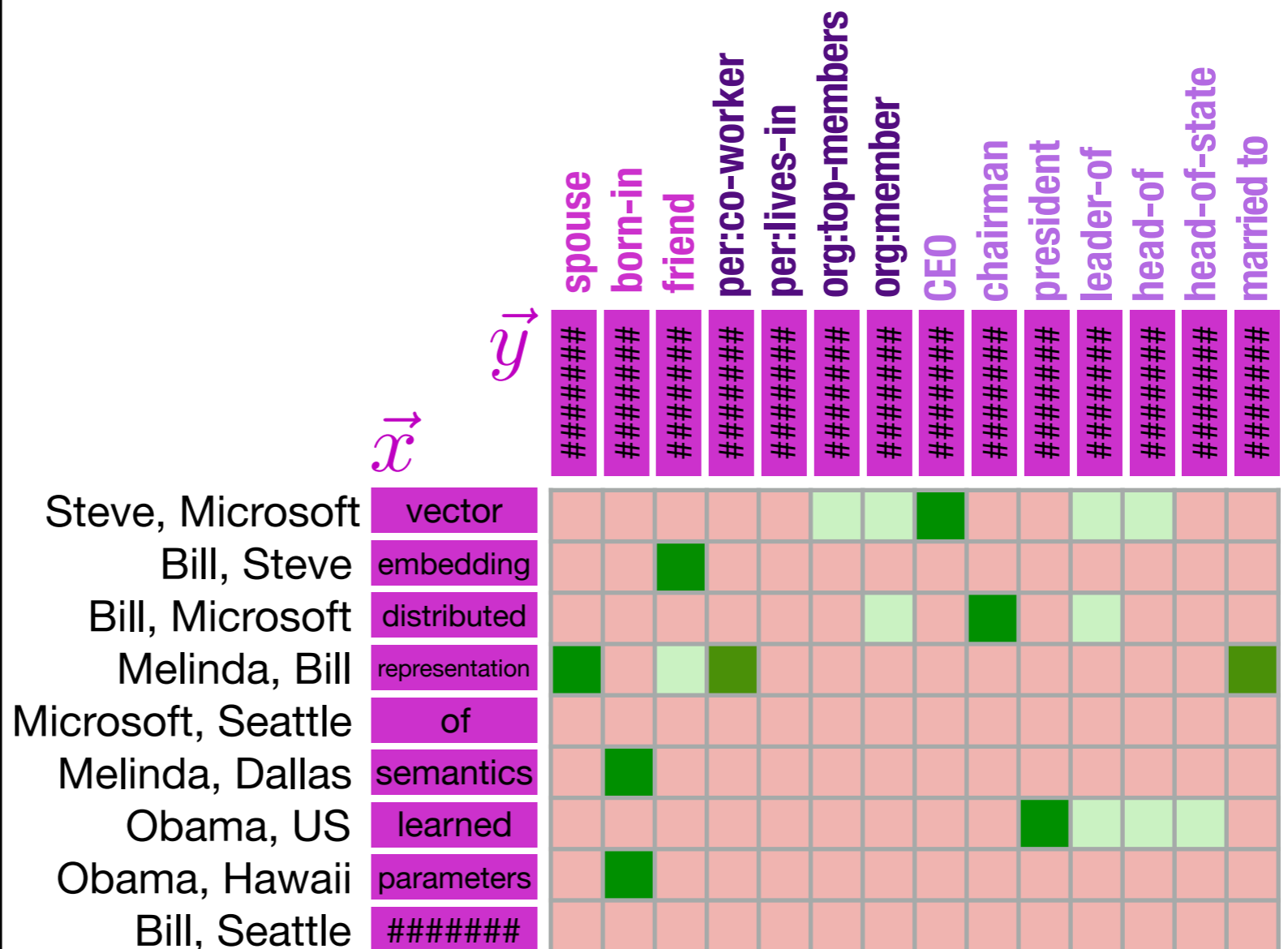
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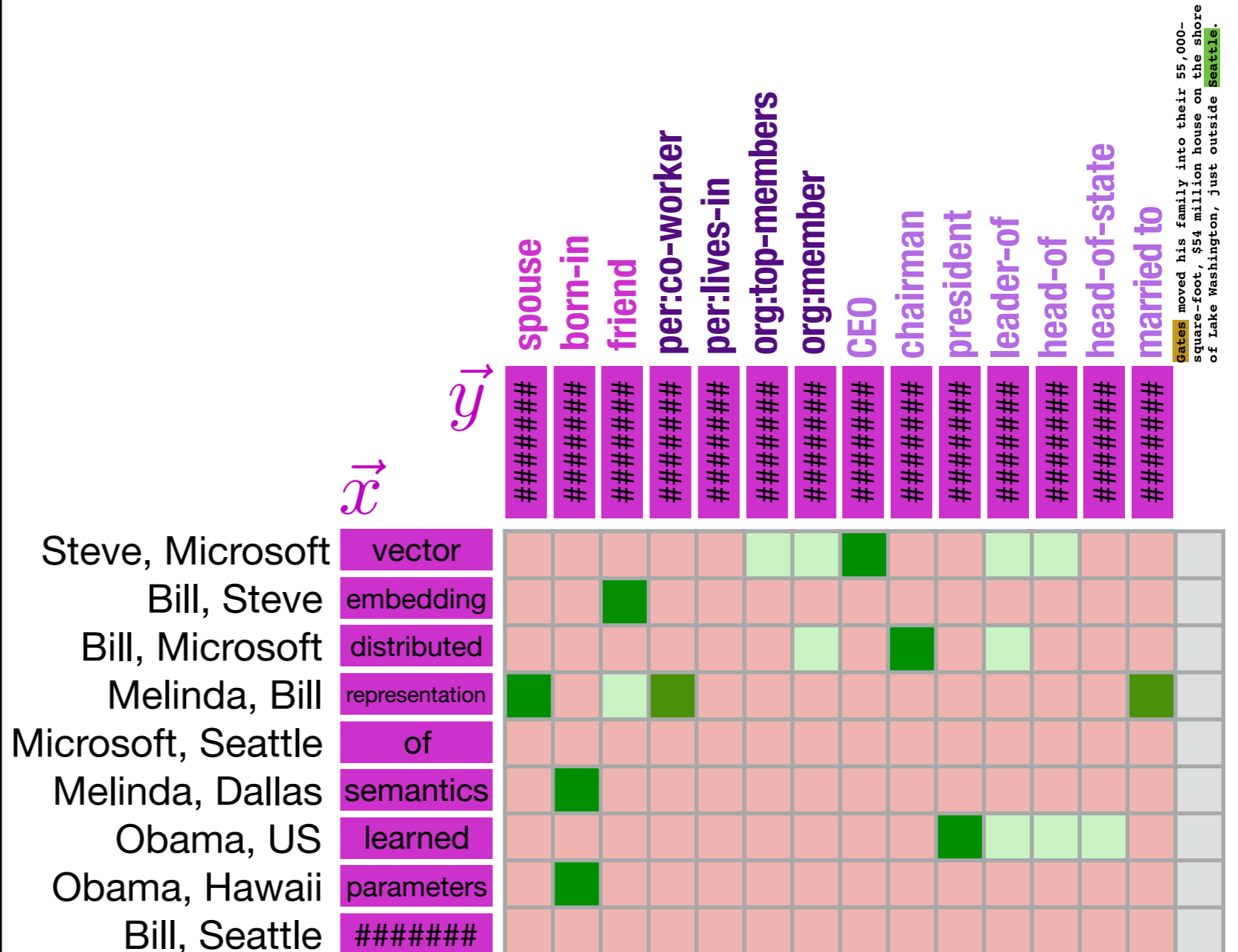
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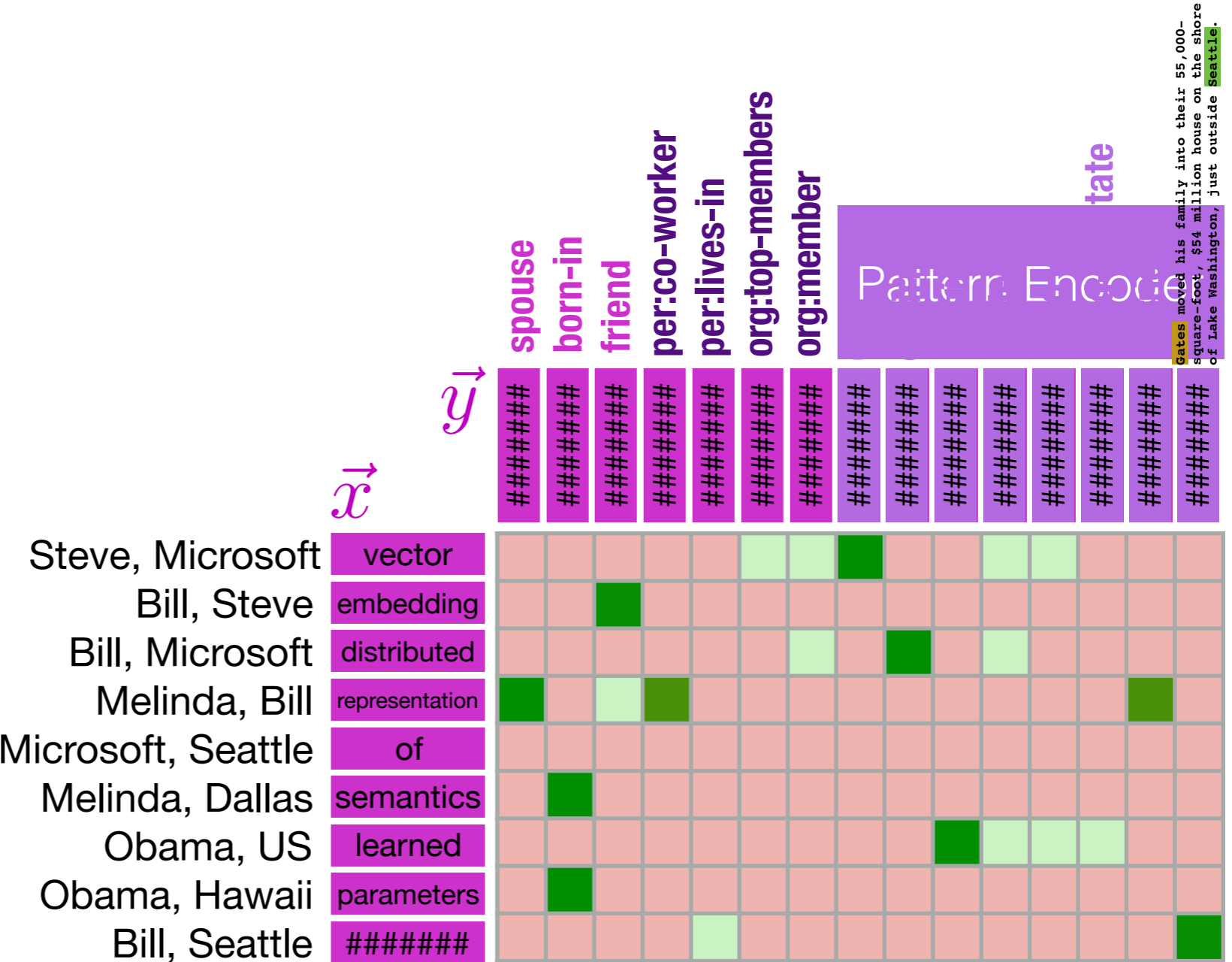
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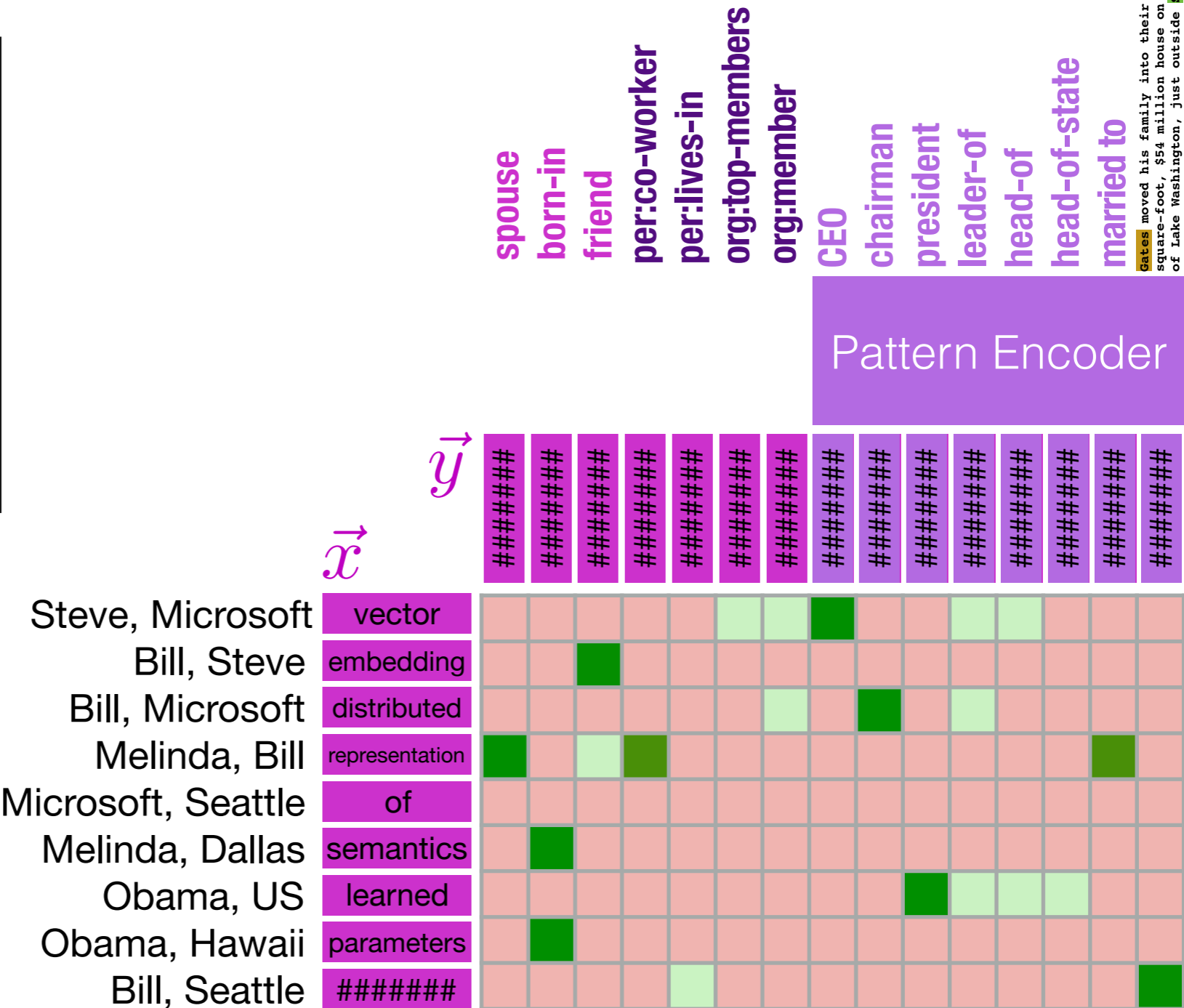
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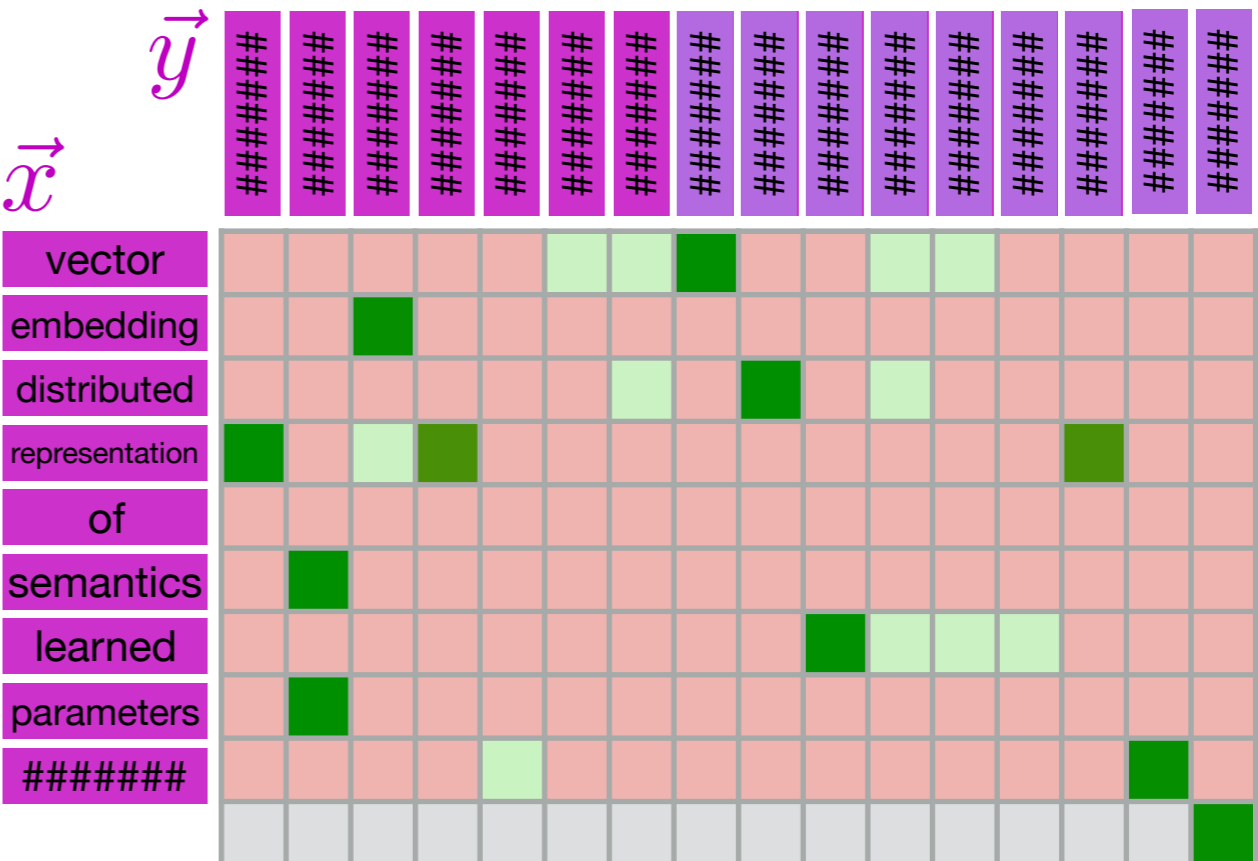
Joe NewEntity worked with his wife Jane NewEntity on relation extraction.



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

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

Steve, Microsoft  
 Bill, Steve  
 Bill, Microsoft  
 Melinda, Bill  
 Microsoft, Seattle  
 Melinda, Dallas  
 Obama, US  
 Obama, Hawaii  
 Bill, Seattle

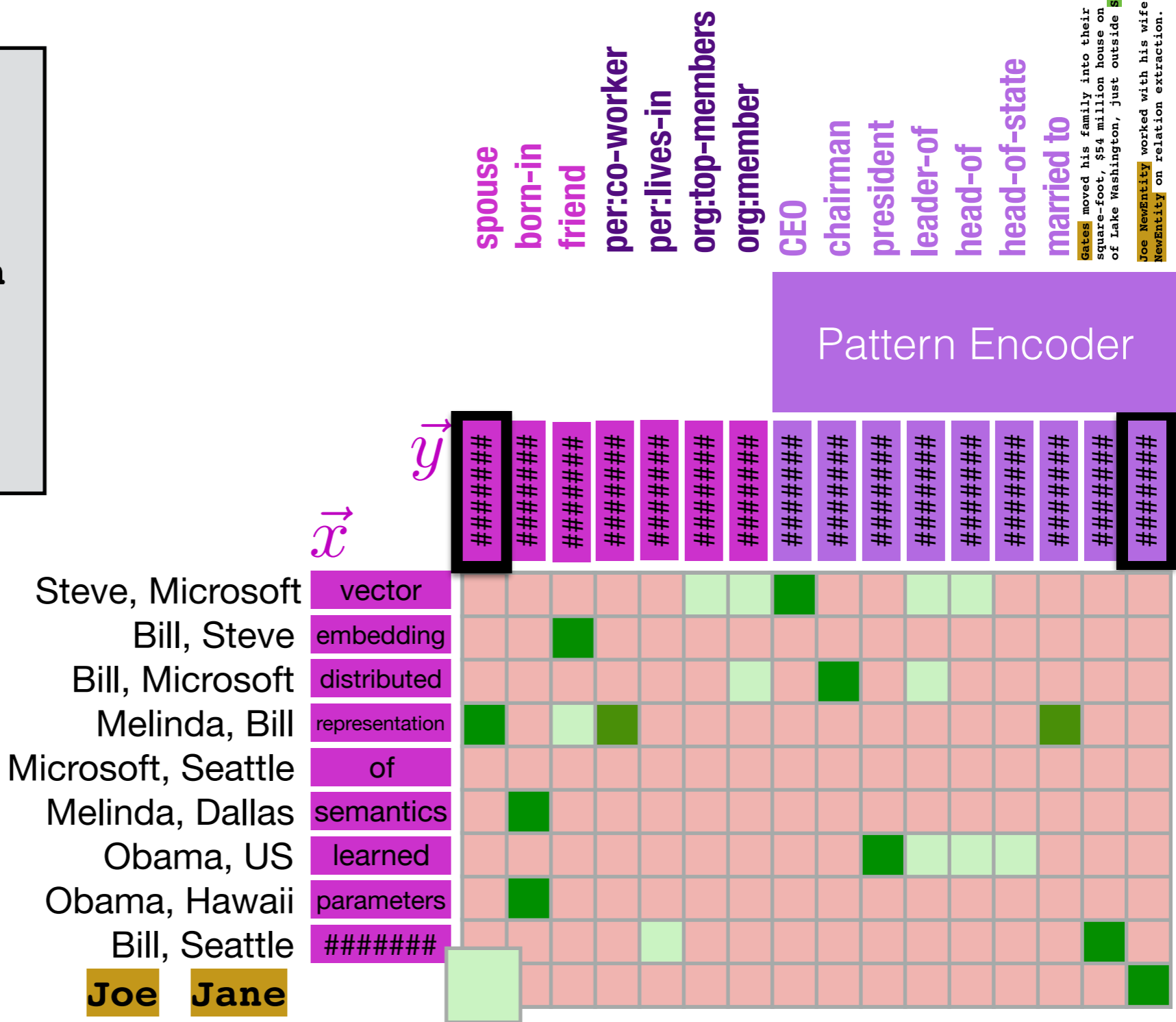


Pattern Encoder

Gates moved his family into their 55,000-square-foot, \$4 million house on the shore of Lake Washington, just outside Seattle.  
 Joe NewEntity worked with his wife Jane NewEntity on relation extraction.

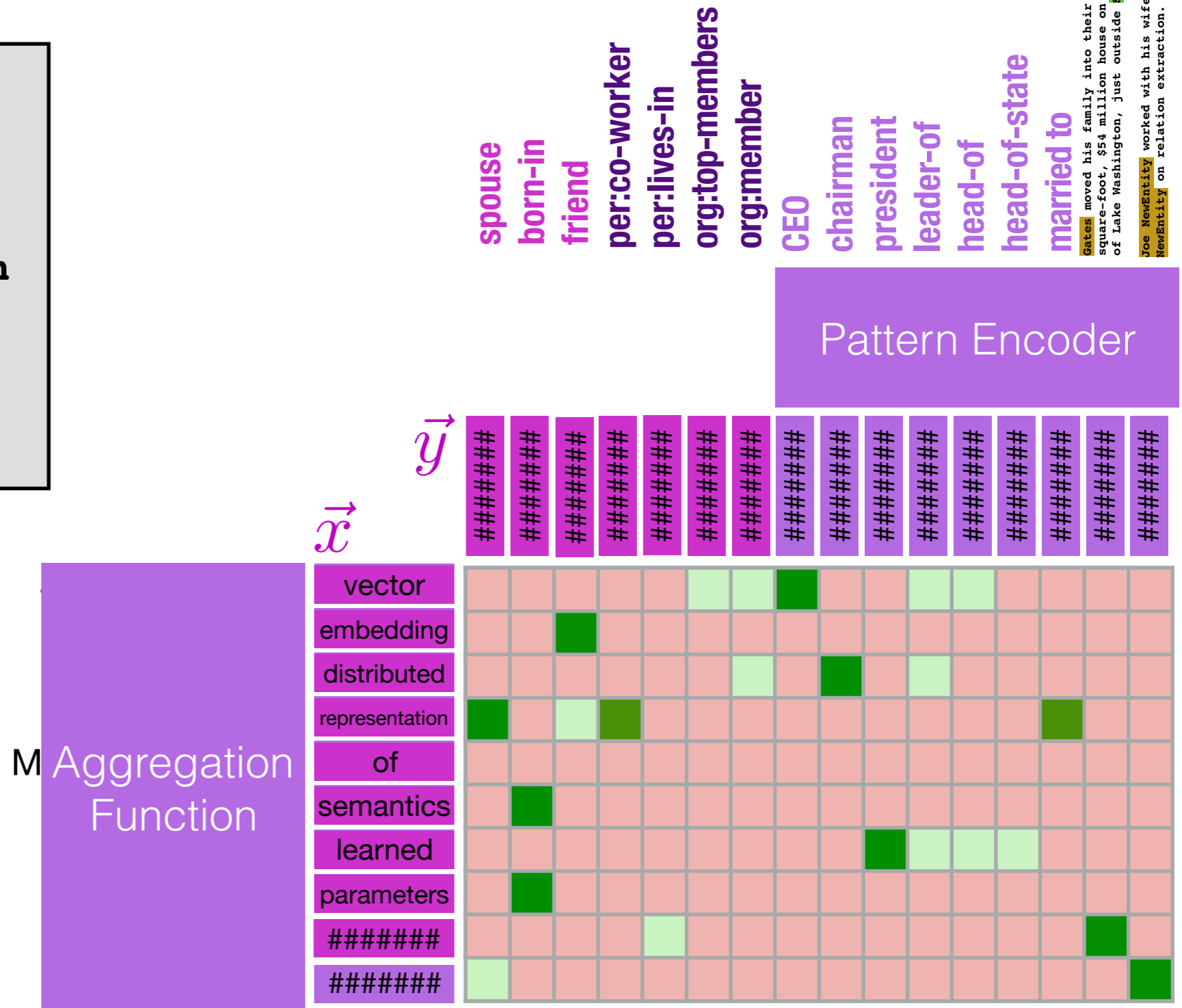
query: **spouse**

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



query: **spouse**

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

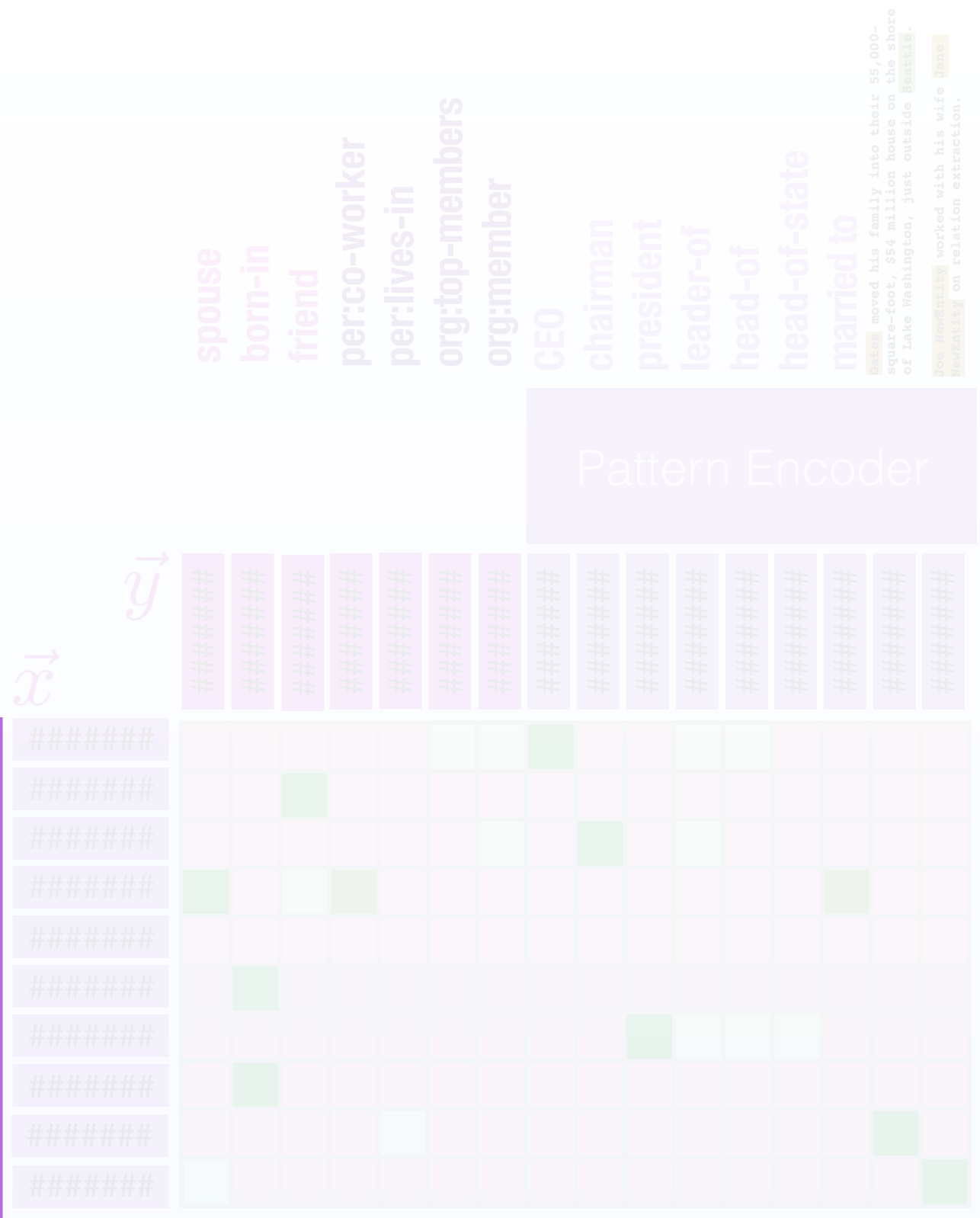


query: **spouse**

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

- Steve, Microsoft
- Bill, Steve
- Bill, Microsoft
- Melinda, Bill
- Microsoft, Seattle
- Melinda, Dallas
- Obama, US
- Obama, Hawaii
- Bill, Seattle
- Joe**
- Jane**

Aggregation Function



# Query Independent

query: **spouse**

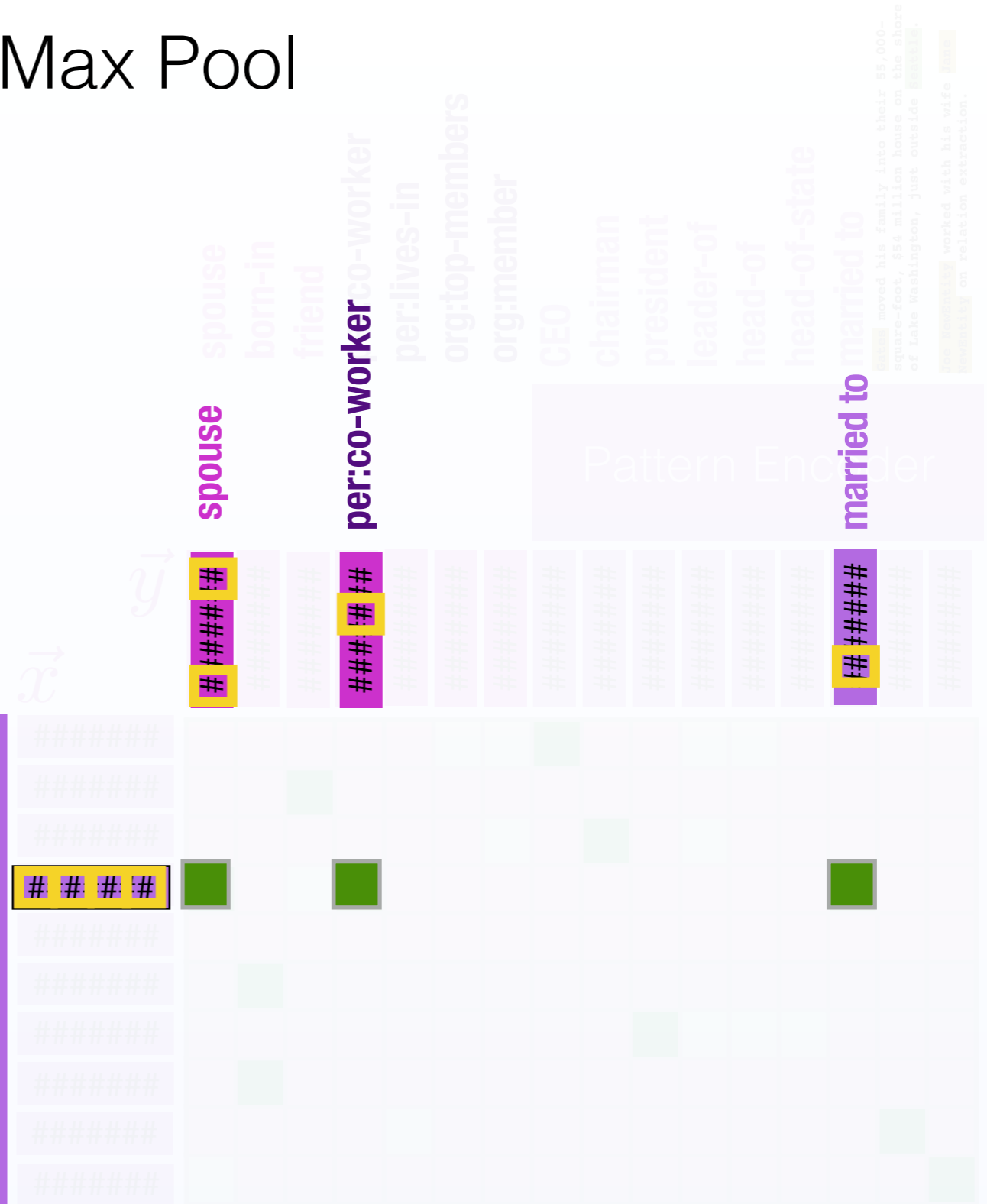
1. Mean Pool

2. Max Pool

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

Steve, Microsoft  
 Bill, Steve  
 Bill, Microsoft  
**Melinda, Bill**  
 Microsoft, Seattle  
 Melinda, Dallas  
 Obama, US  
 Obama, Hawaii  
 Bill, Seattle  
**Joe Jane**

Aggregation Function



# Query Dependent

## 1. Max Column

query: **co-founder** #####

-0.1

5.0

0.02

spouse

per:co-worker

married to

Pattern Encoder

Steve, Microsoft  
Bill, Steve  
Bill, Microsoft  
Melinda, Bill  
Microsoft, Seattle  
Melinda, Dallas  
Obama, US  
Obama, Hawaii  
Bill, Seattle  
Joe Jane

Aggregation Function

$\vec{x}$

$\vec{y}$

#####

#####

#####



# Query Dependent

1. Max Column

2. Attention

query: **co-founder** #####

-0.1

5.0

0.02

spouse

per:co-worker

married to

Pattern Encoder

Steve, Microsoft  
Bill, Steve  
Bill, Microsoft  
Melinda, Bill  
Microsoft, Seattle  
Melinda, Dallas  
Obama, US  
Obama, Hawaii  
Bill, Seattle  
Joe Jane

Aggregation Function

$\vec{x}$

$\vec{y}$

#####

#####

#####

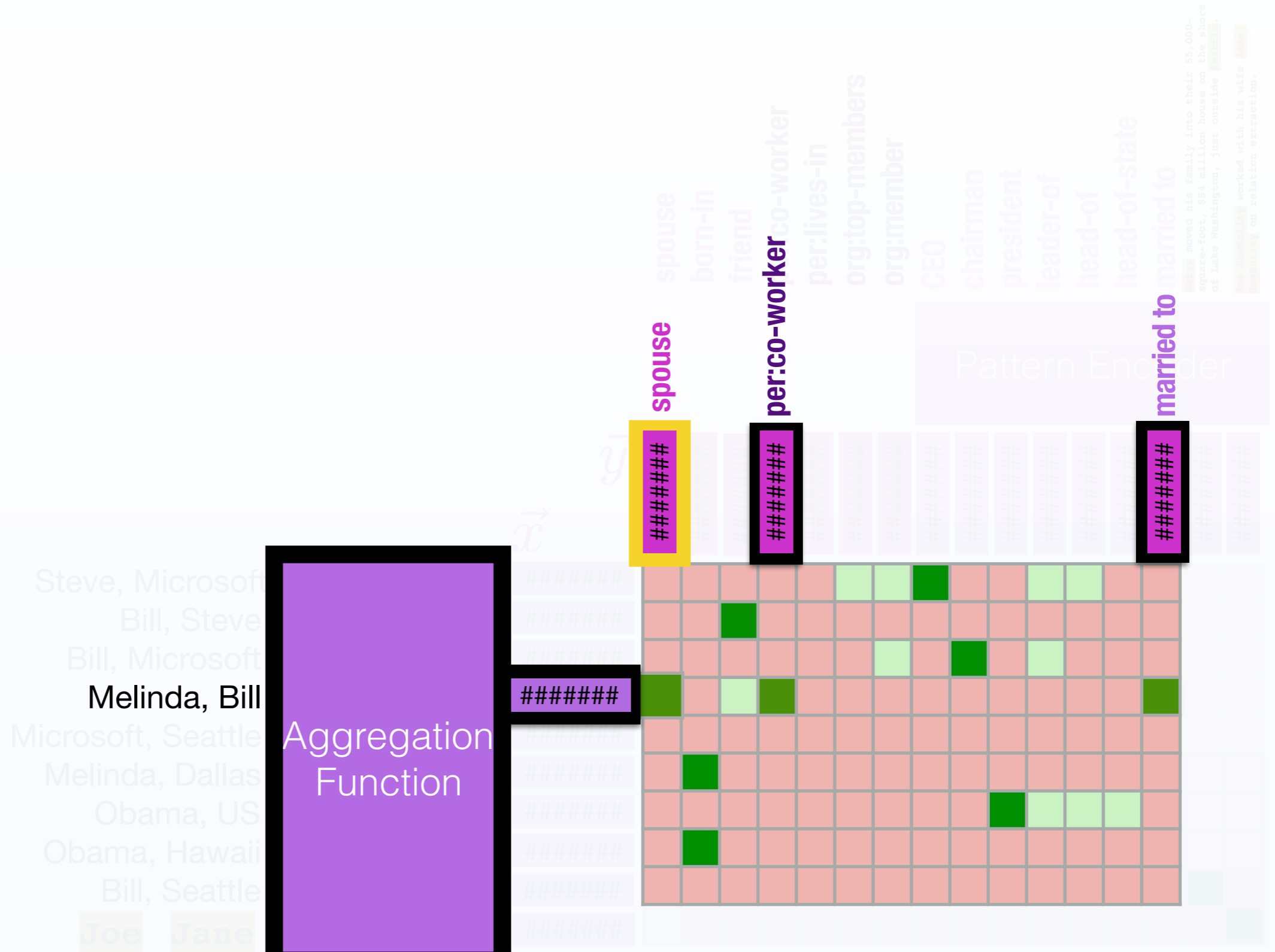
.006

.986

.008



# Training



# Entity Type Prediction

- Freebase + Clueweb
- 1.1k FB types, 5k textual types, ~140k entities
- MAP over 707 test types
  - 100 negatives randomly generated for each positive

# Example Max Columns

/baseball  
/baseball player

**/sports/pro athlete**

/sports/sports award winner /people/person  
/award/award winner /tv/tv actor

/architecture  
/engineer

**engineer**, /book/author, sir  
/projects/project focus , /people/person

/computer  
/computer scientist

**/education/academic**, /music/artist,  
/music/group member, /people/person

# Entity Type Prediction

Model	seen at train	unseen at train
	MAP	MAP
Entity Embeddings	54.8	3.1
Mean Pool	39.5	35.5
Max Pool	32.6	31.0
Attention	<b>55.7</b>	<b>54.5</b>
Max Column	<b>55.4</b>	<b>54.7</b>

# Relation Extraction

- Subset of FB15k-237
  - Freebase + Clueweb

# Relation Extraction

seen  
at train

unseen  
at train

Model	MRR	Hits@10	MRR	Hits@10
Entitiy Pair Embeddings	31.9	51.7	5.2	11.9
Mean Pool	25.9	45.9	18.1	35.8
Max Pool	29.6	49.9	20.8	40.3
Attention	31.9	51.7	29.8	49.7
Max Column	31.7	51.9	28.5	48.1

# Relation Extraction

## Rowless + Columnless

seen  
at train

unseen  
at train

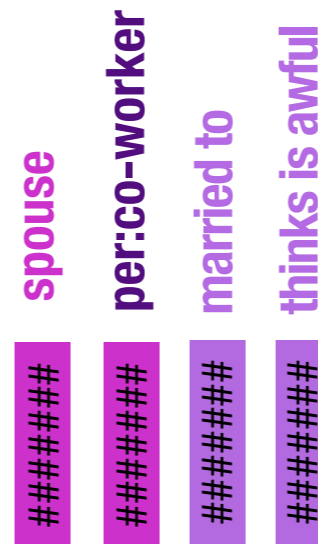
Model	MRR	Hits@10	MRR	Hits@10
Entity Embeddings	31.9	51.7	5.2	11.9
Entity Embeddings-LSTM	33.4	54.4	5.2	11.9
Attention	31.9	51.7	29.8	49.7
Attention-LSTM	30.0	53.4	27.8	51.0
Max Column	31.7	51.9	28.5	48.1
Max Column-LSTM	30.8	54.8	29.6	54.2

# Future Work

- Improvements to Attention model
- Discern between irrelevant and counter evidence

query: **hates**

Melinda, Bill





# Summary

- Row-less Universal Schema forgoes explicit row representations for aggregation over observed columns
- Performs as well as old model using fewer parameters
- Naturally extends to unseen entities
- Aggregation based on query-specific attention outperforms query-independent aggregations

**Thank you!**