
ULTRA

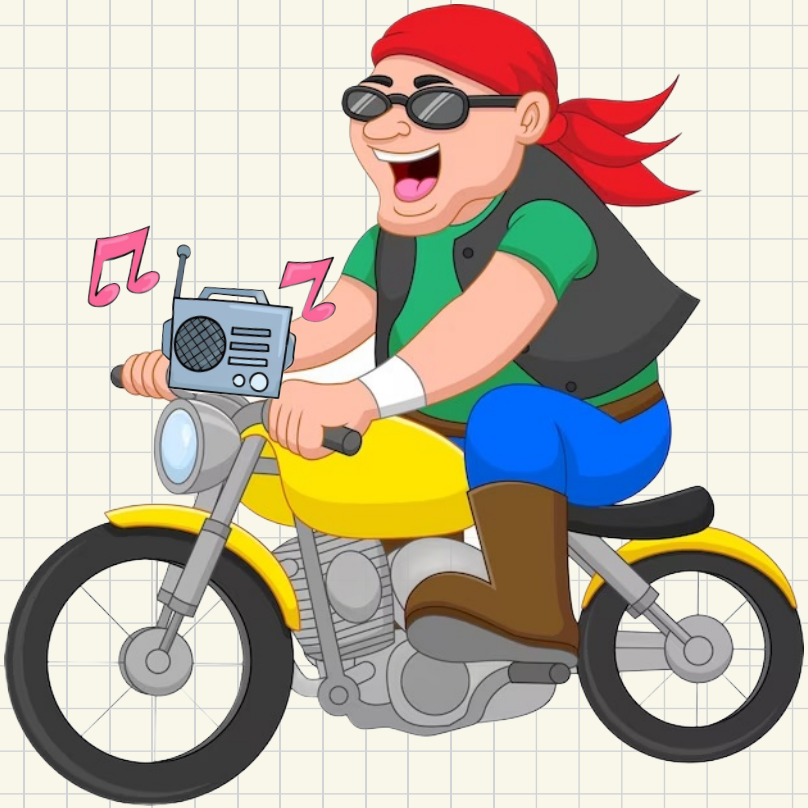
Foundation model

for

Knowledge graphs completion

based on

Graph Neural Networks



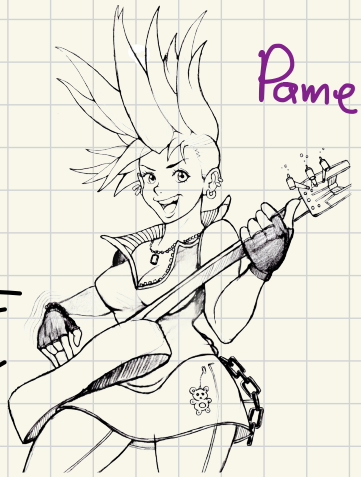
Metallica

Nirvana

Linkin Park

Patrick

Pamela



Metallica

Nirvana

Linkin Park

Gorillaz

Jenifer

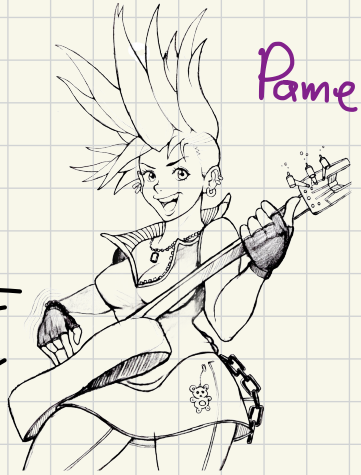
Eminem

2pac

Jordan

Patrick

Pamela



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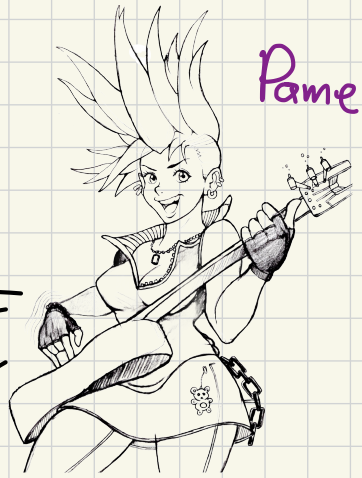

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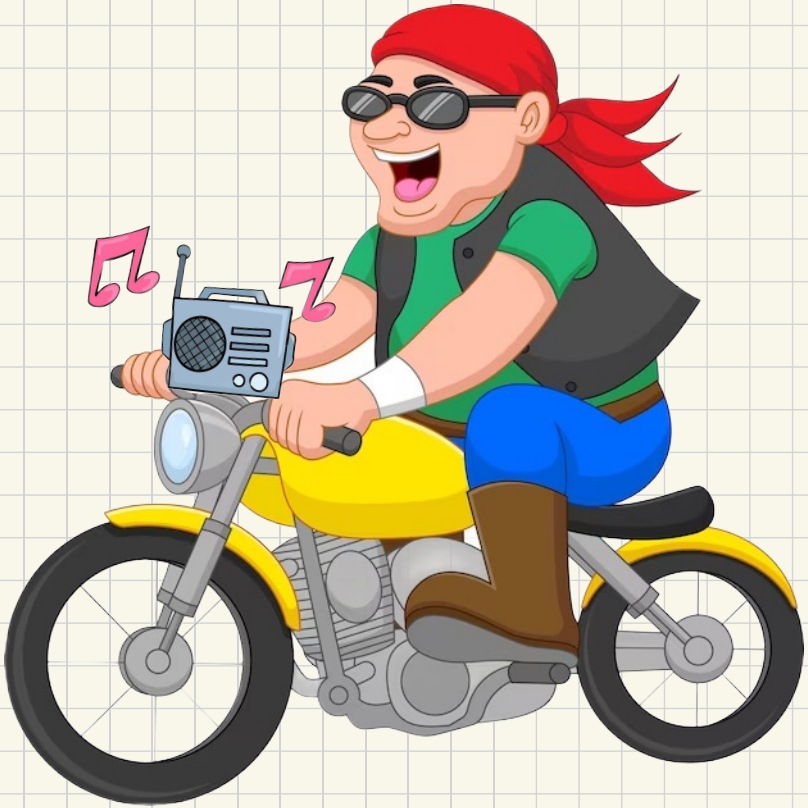

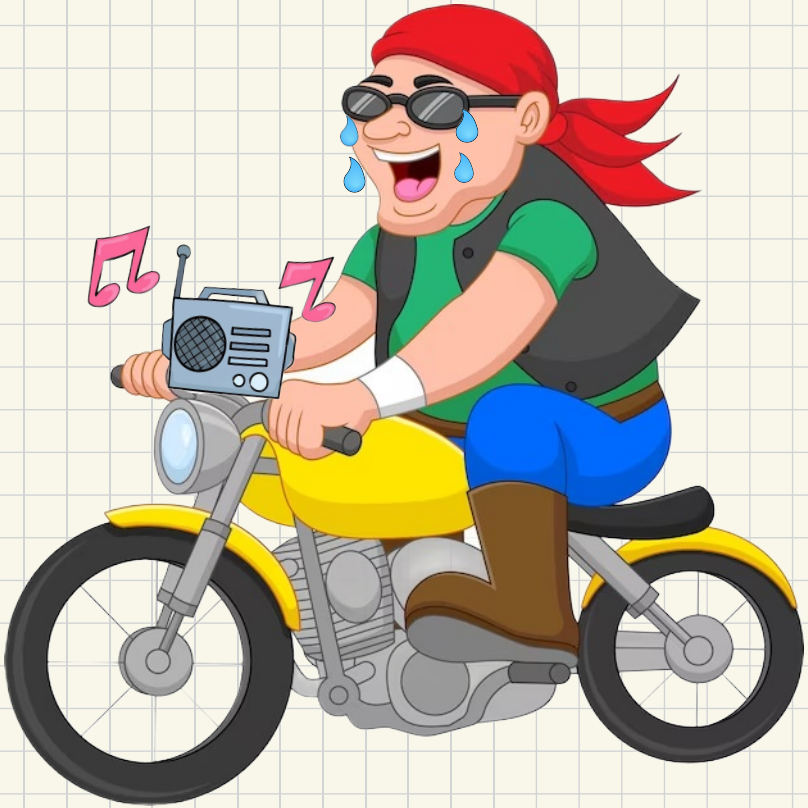

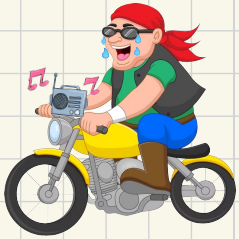

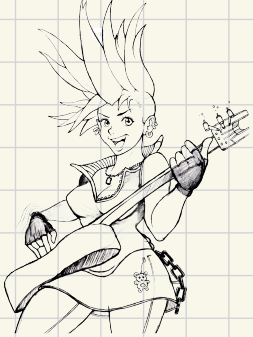

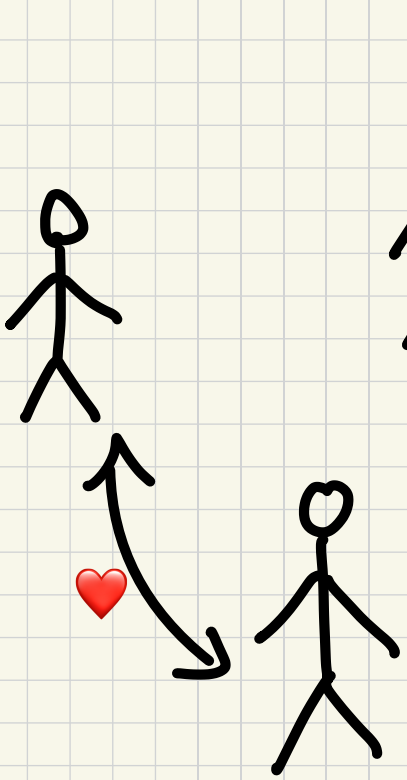

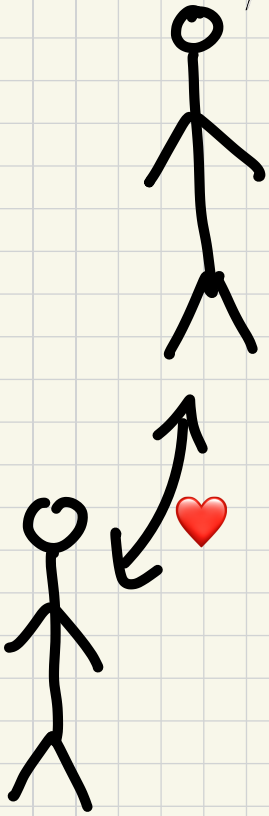

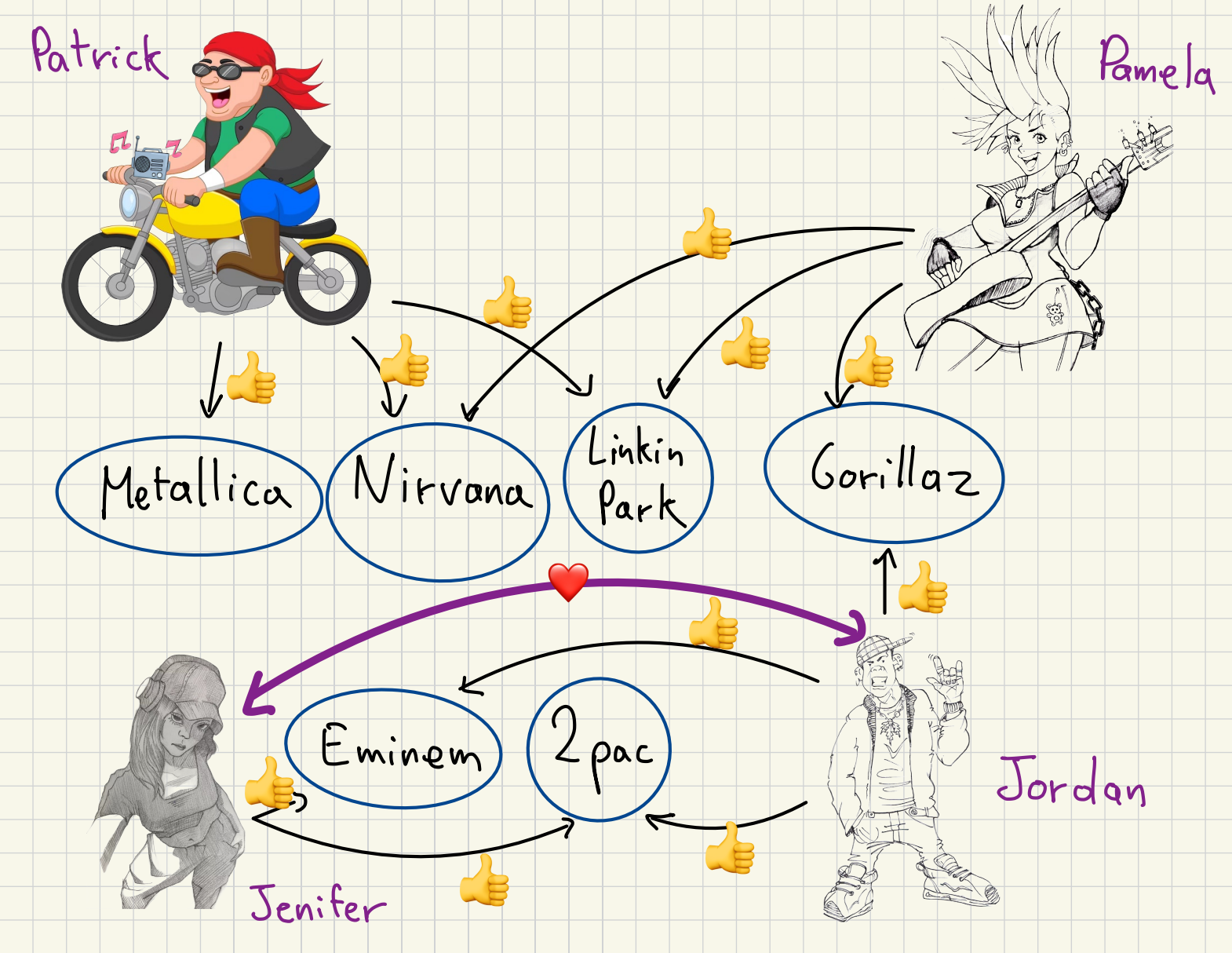
Patrick
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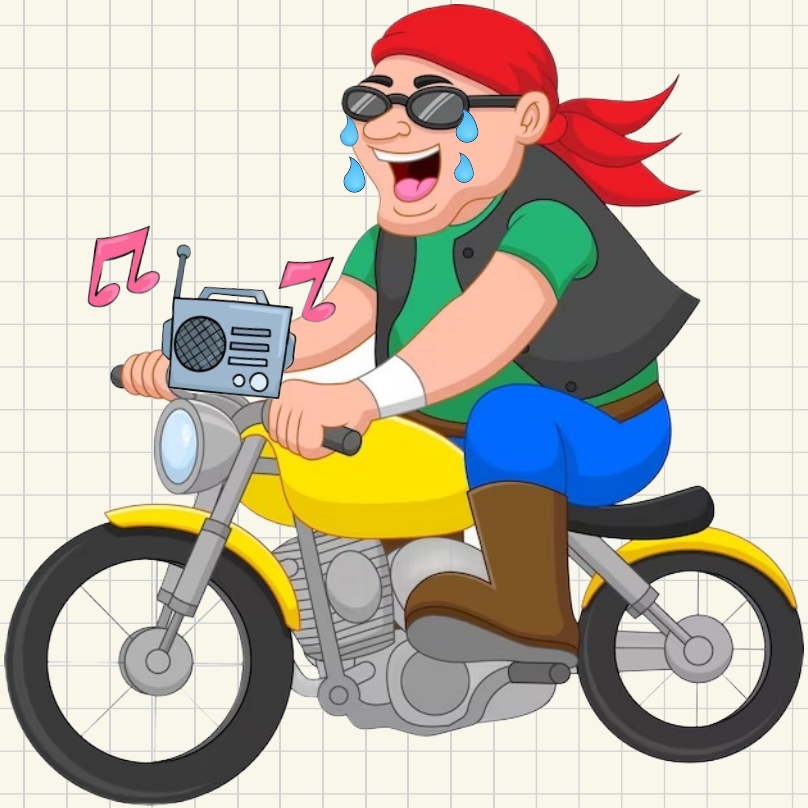
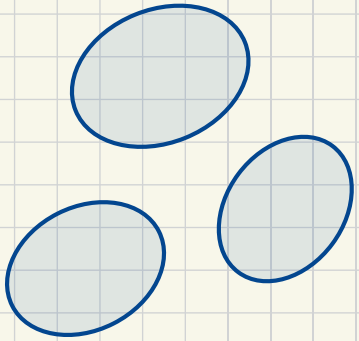


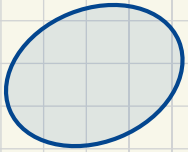
3 Graphs



Train

⇒

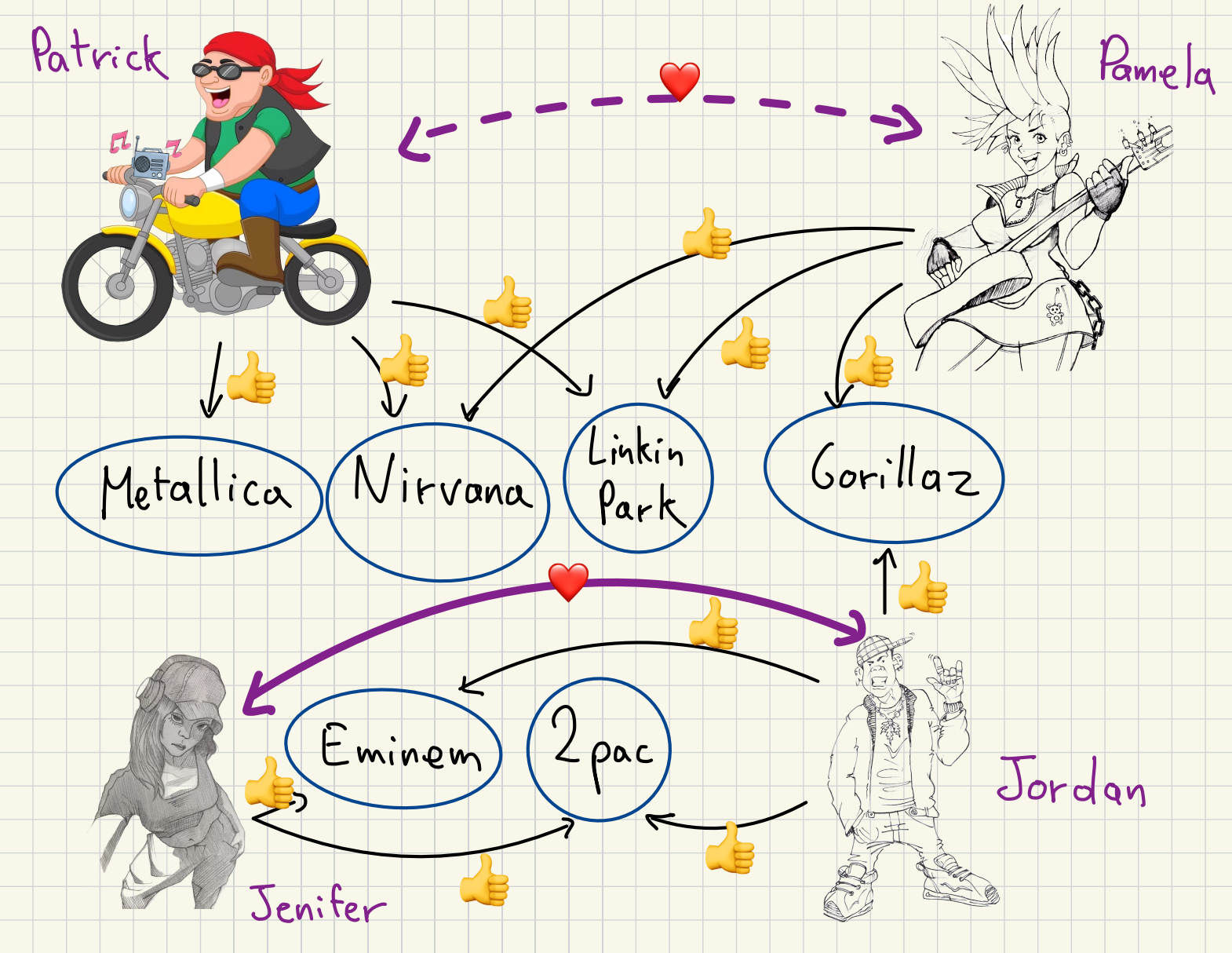
New Graph



⇒

⇒ Performance

✓ Good!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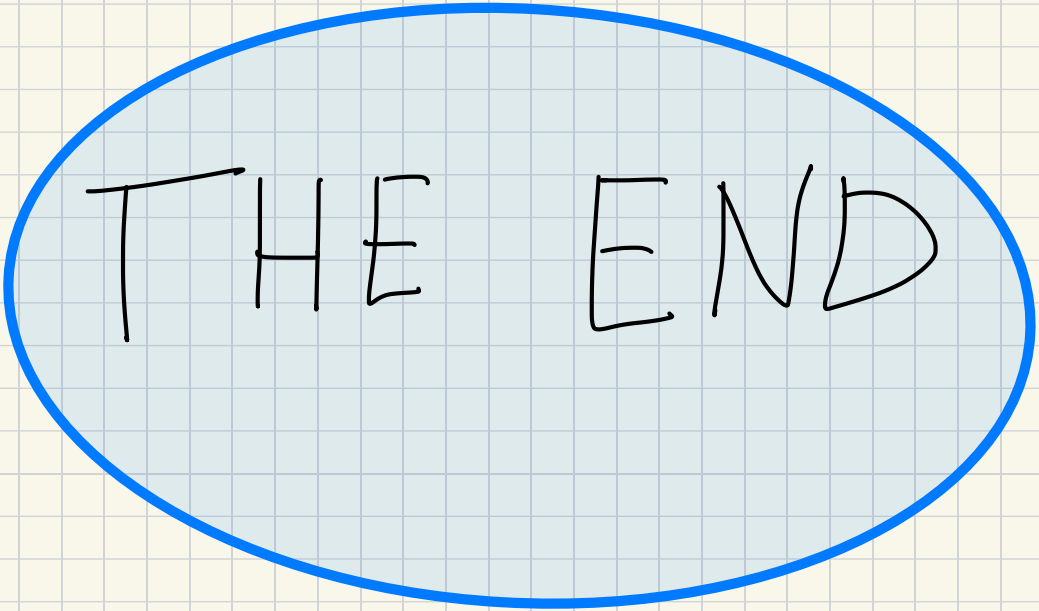
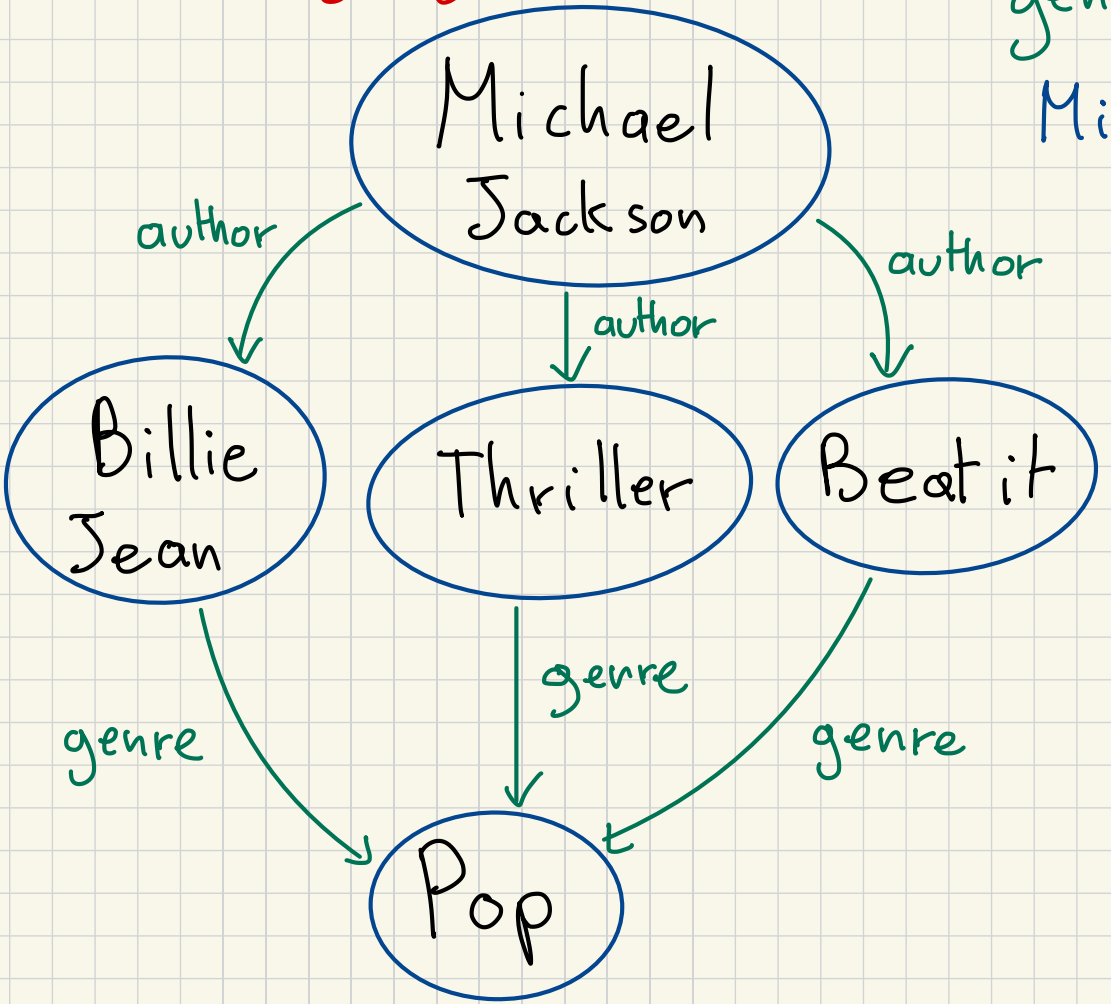

THE END

1- Knowledge graphs completion

genre of Michael Jackson?



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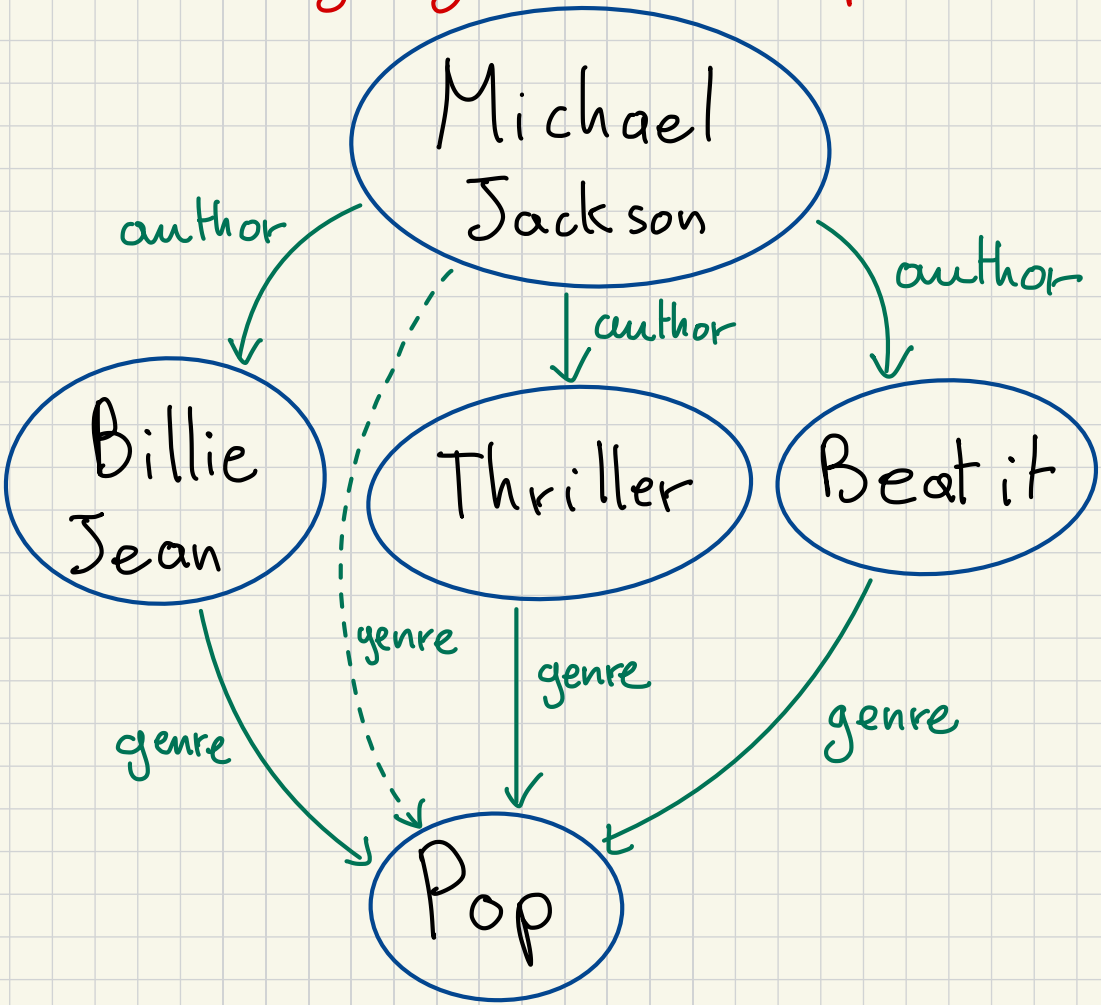

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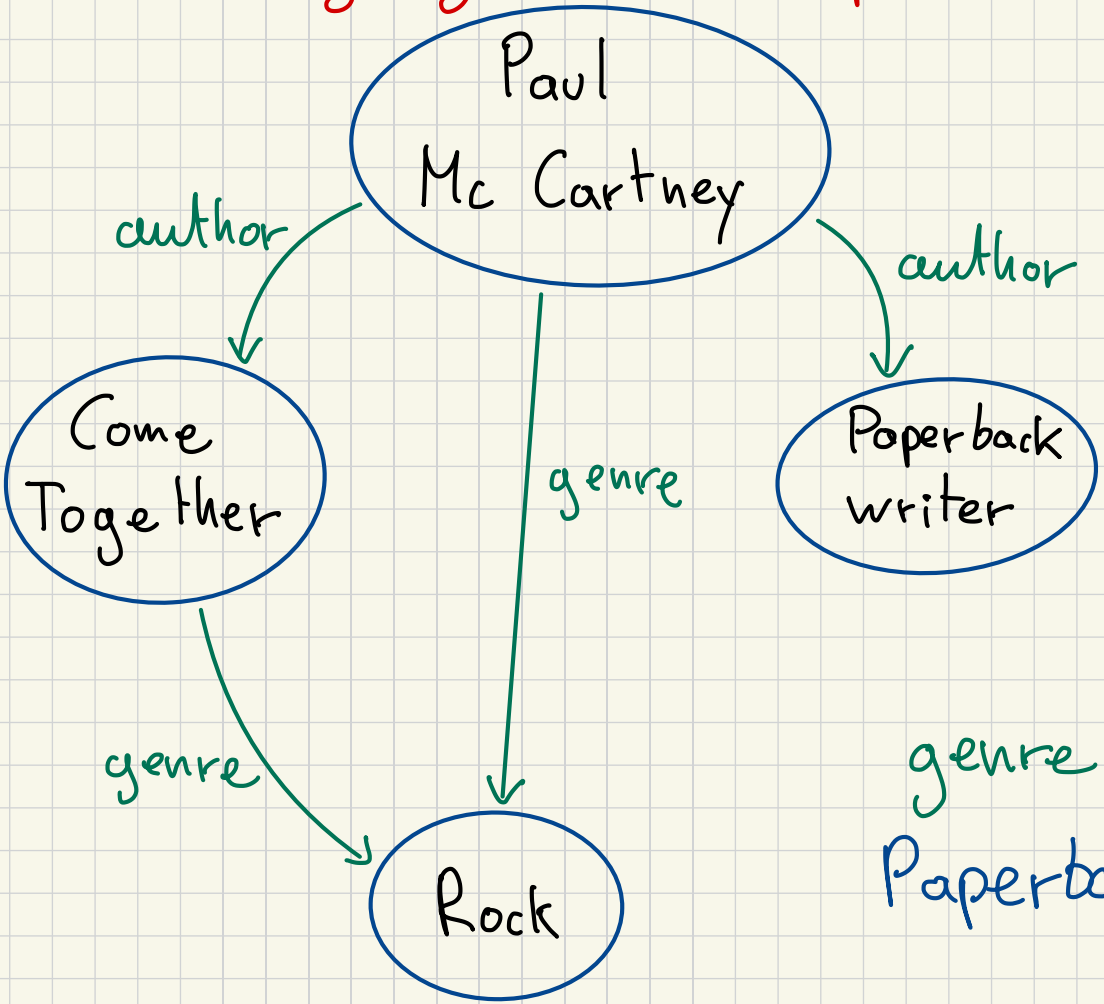
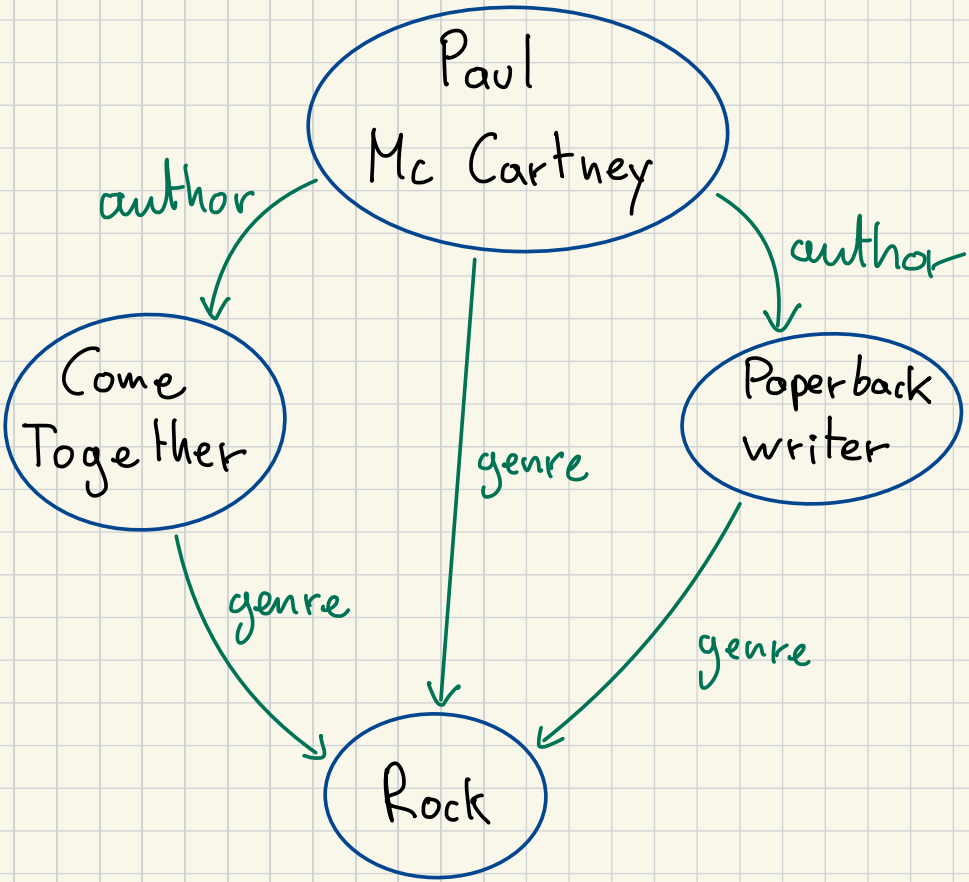


genre of
Paperback writer?

1- Knowledge graphs completion



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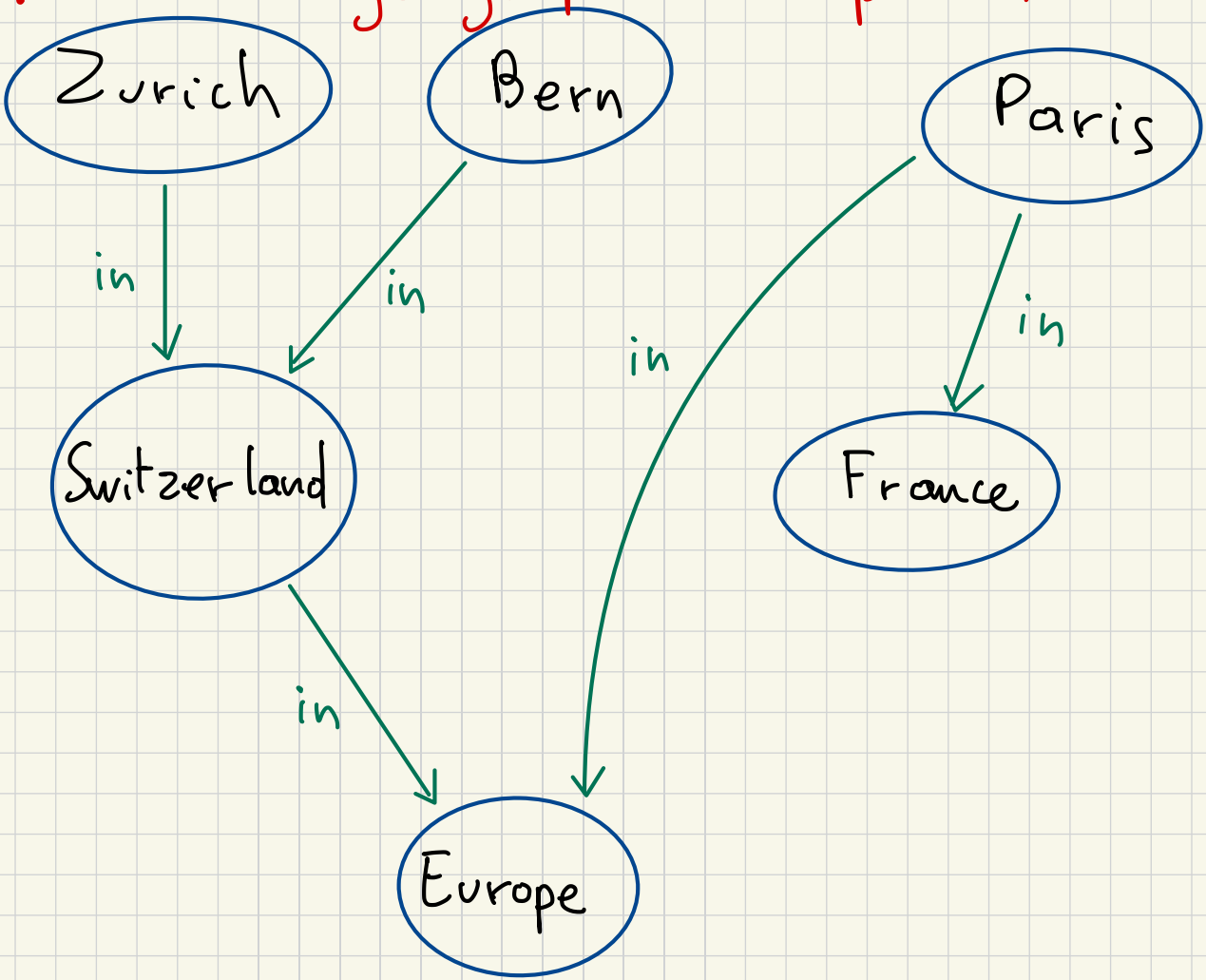

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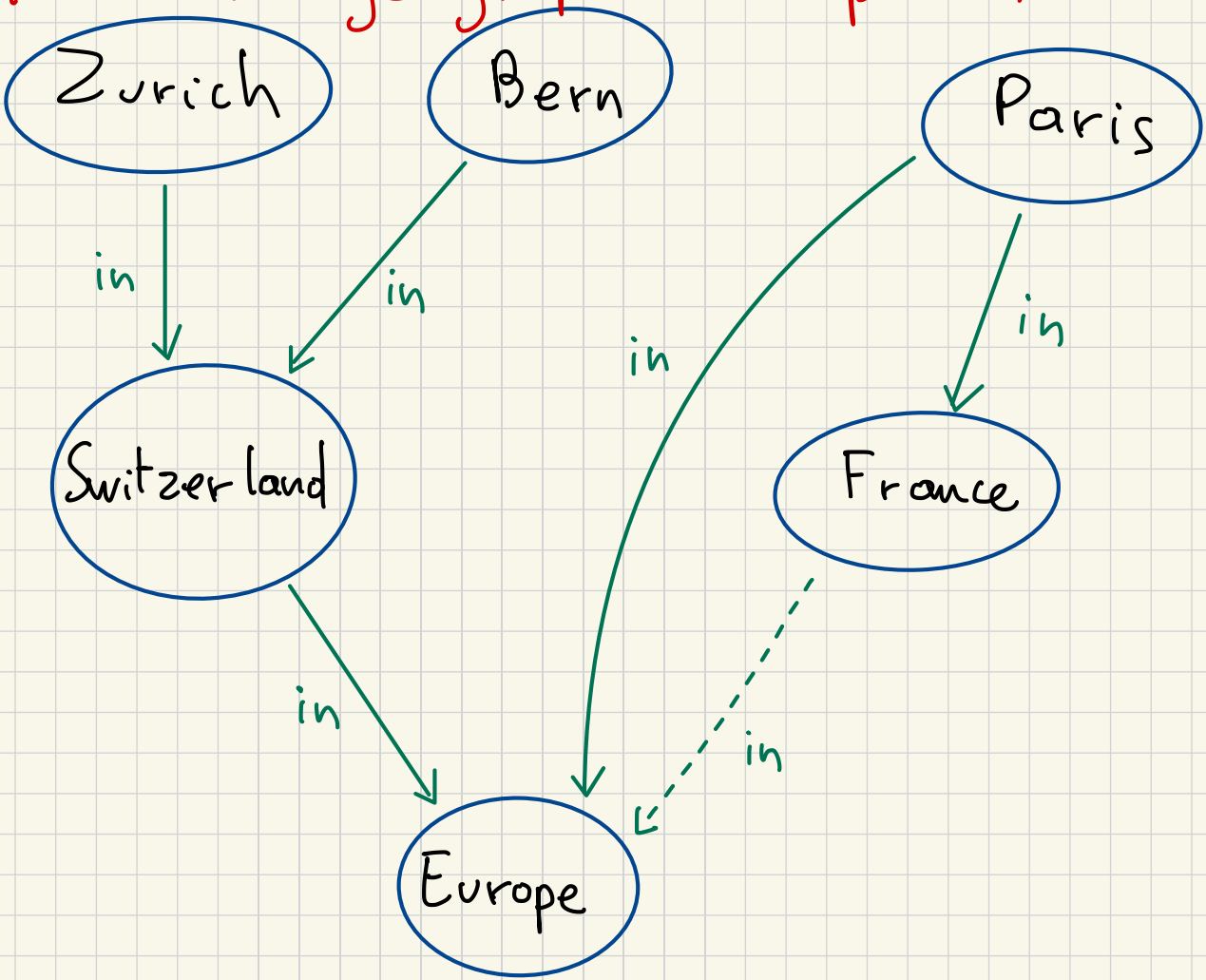

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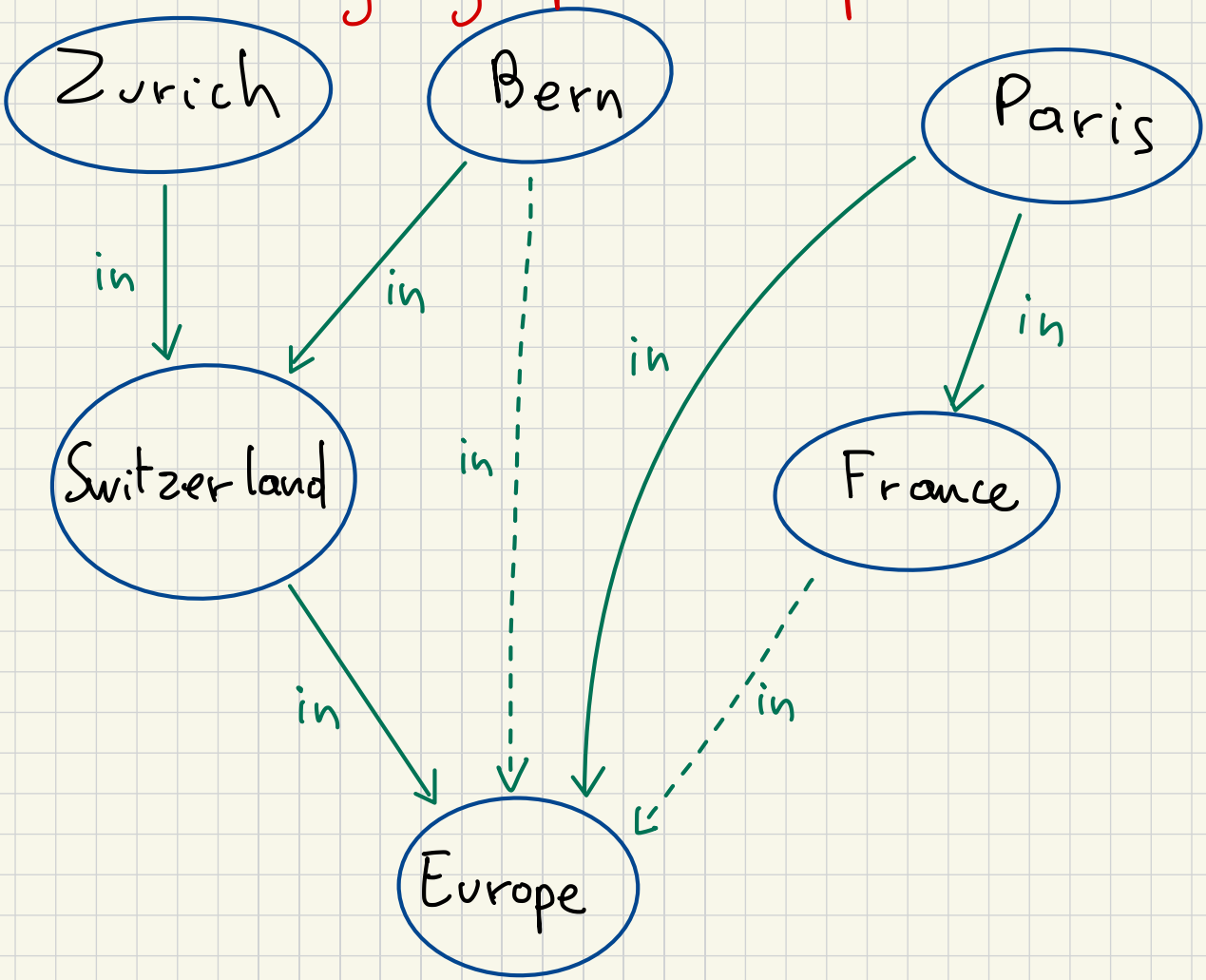

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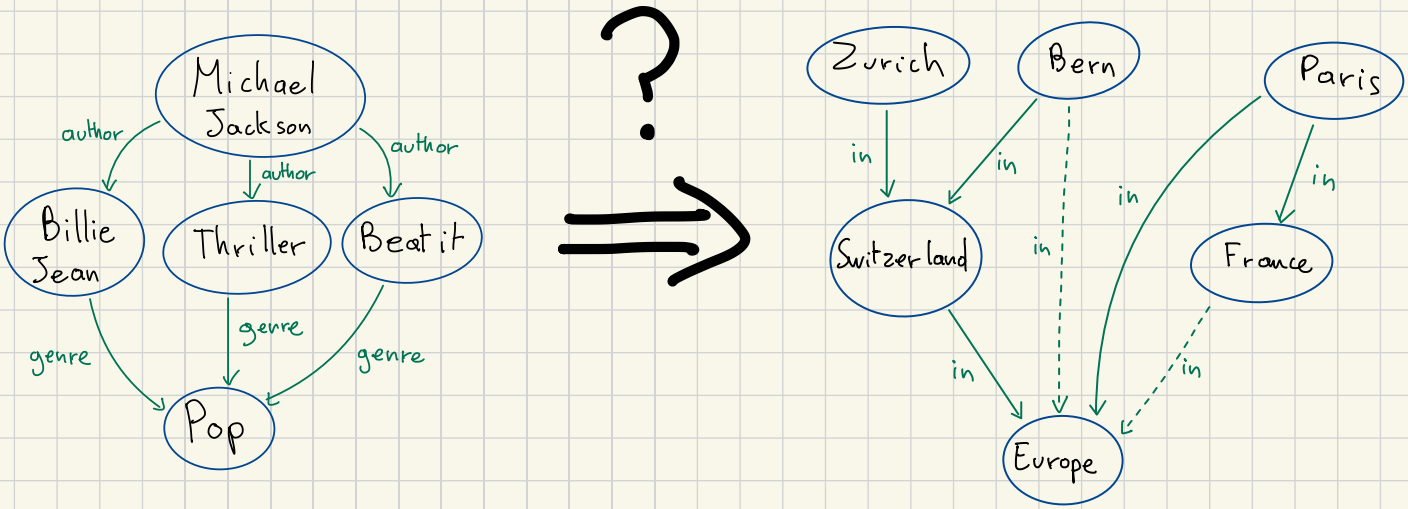

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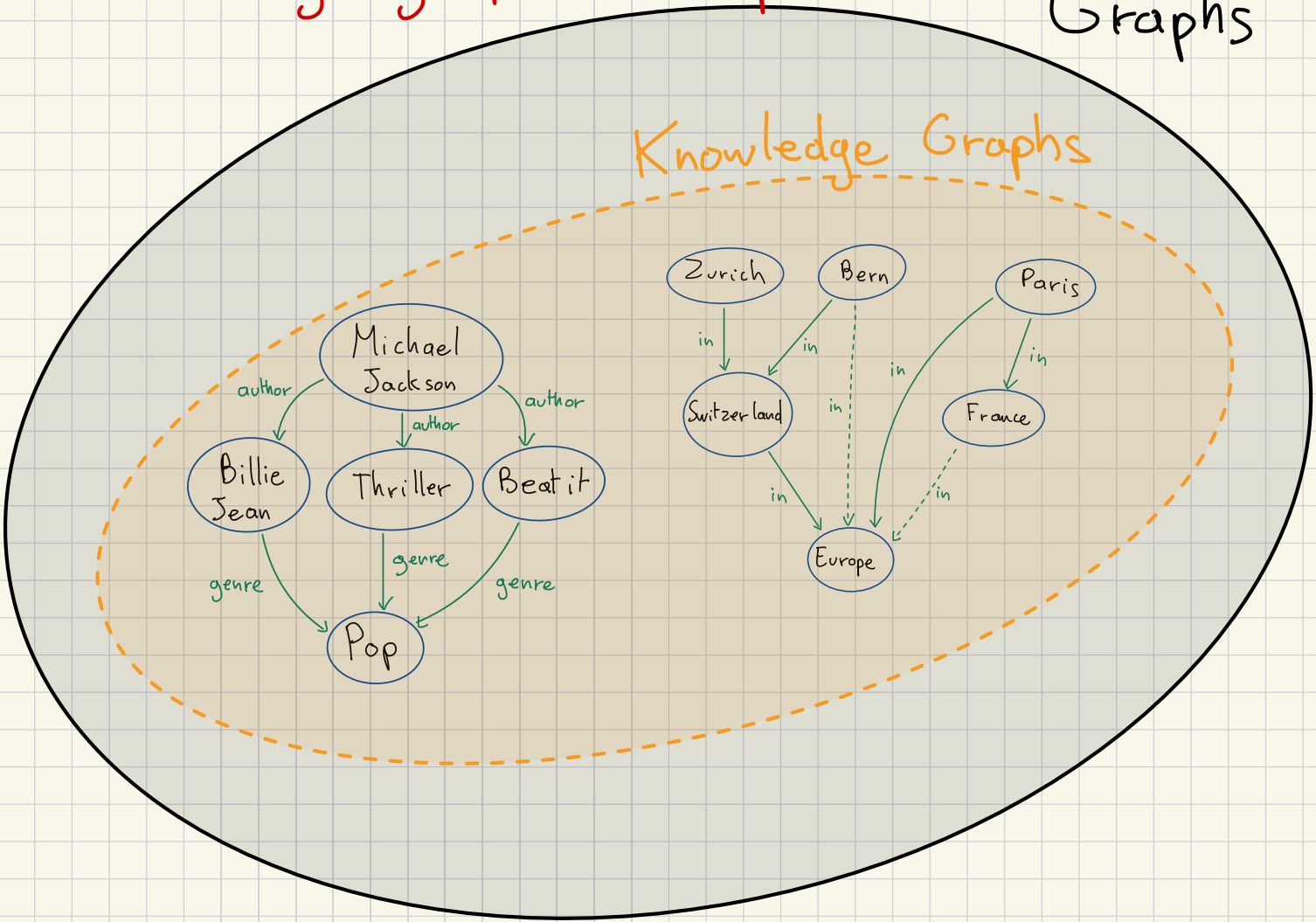

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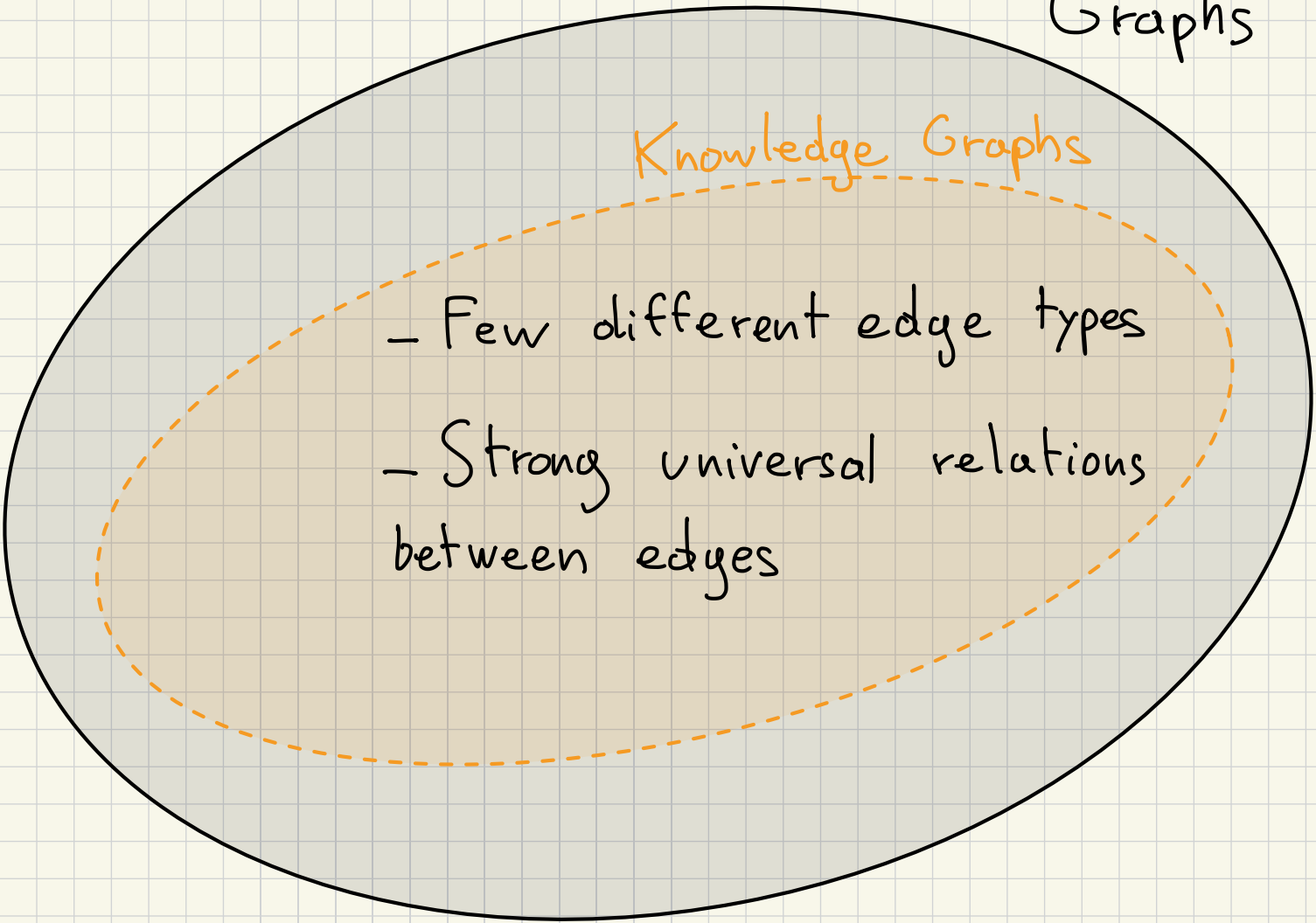

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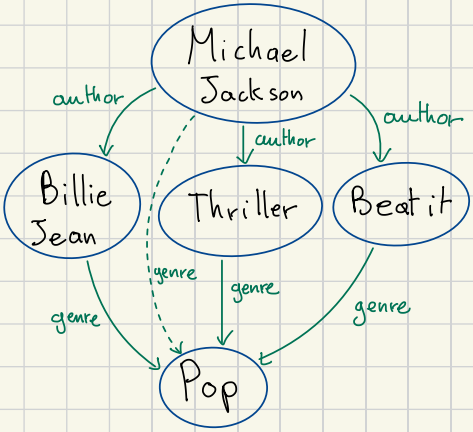
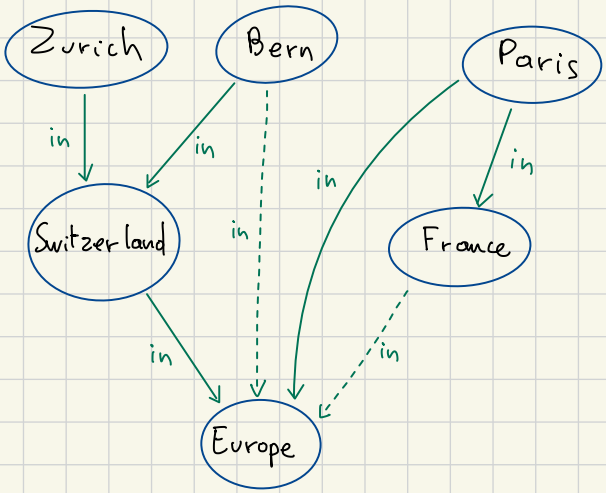
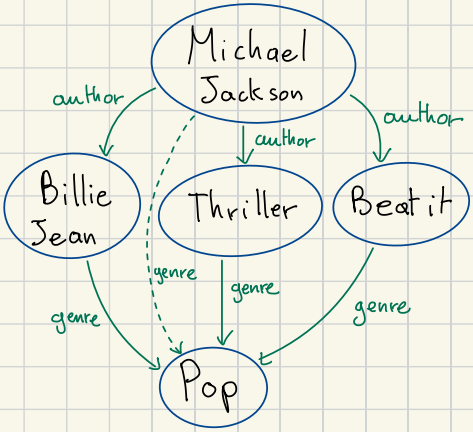


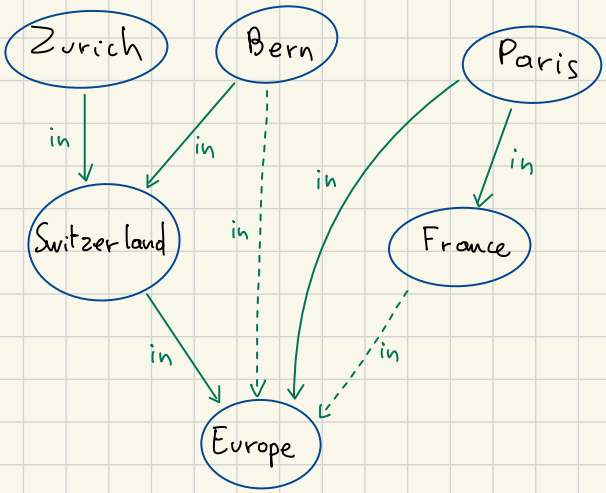
2 edge types



1 edge type

1- Knowledge graphs completion





2 edge types

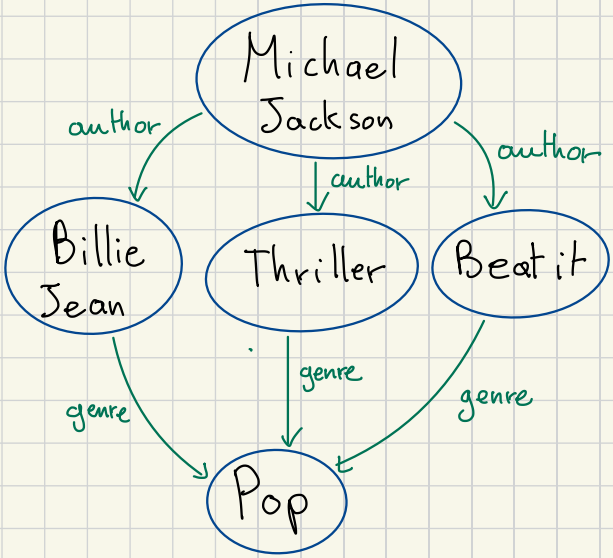
1 edge type

author + genre = genre

in + in = in

2 - Graph Neural Networks

genre of Michael Jackson ?



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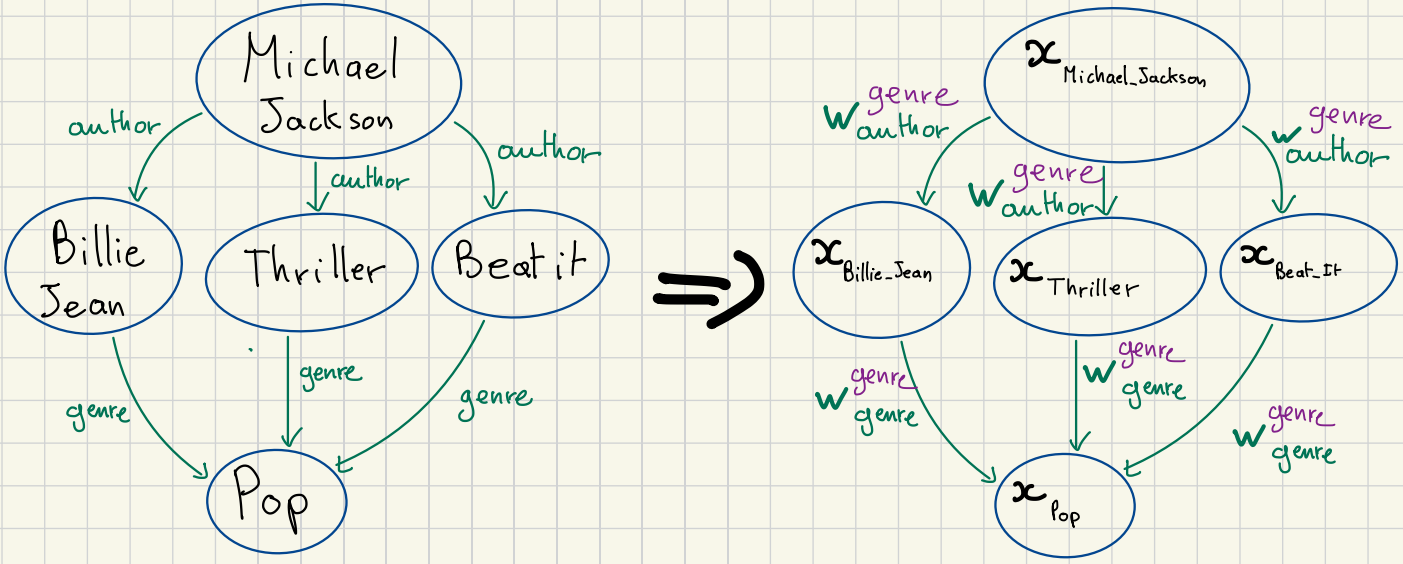

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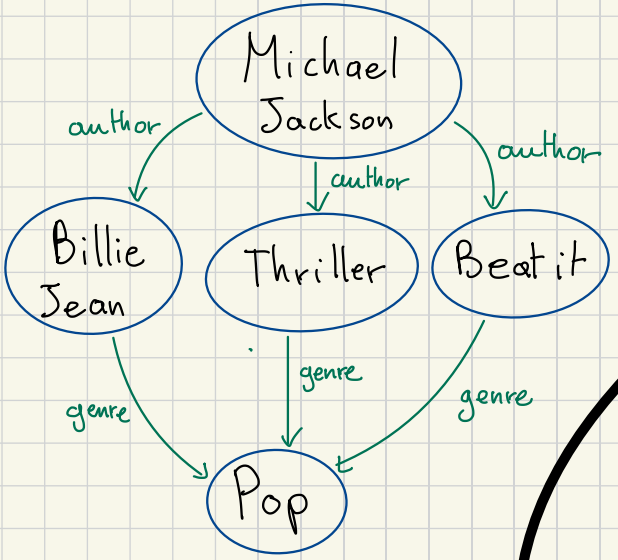
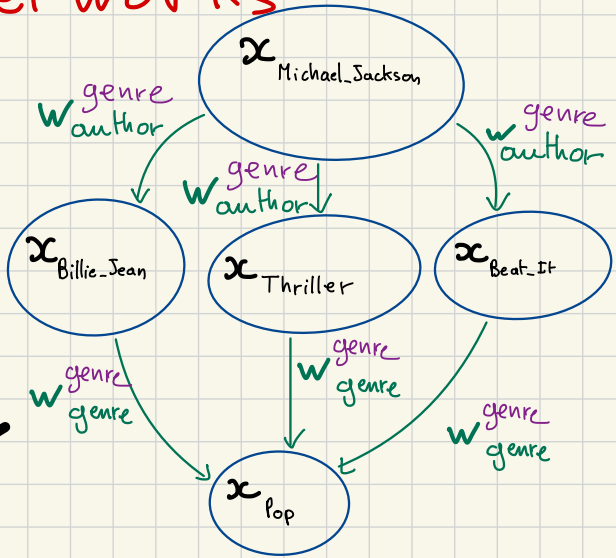




Graph layers

0.01

0.1

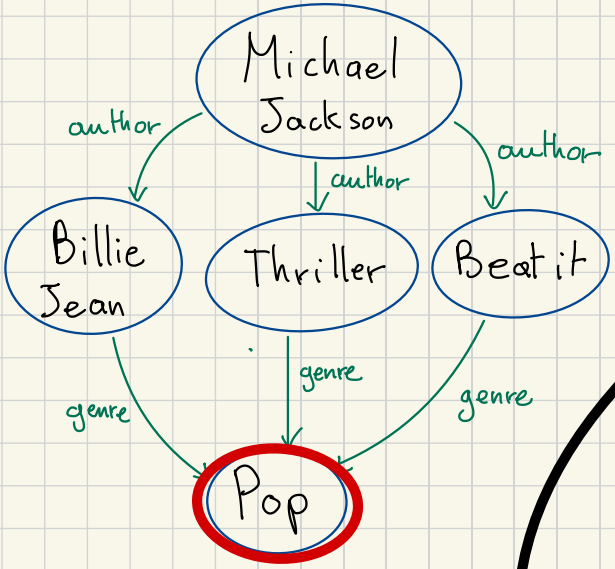
0.09

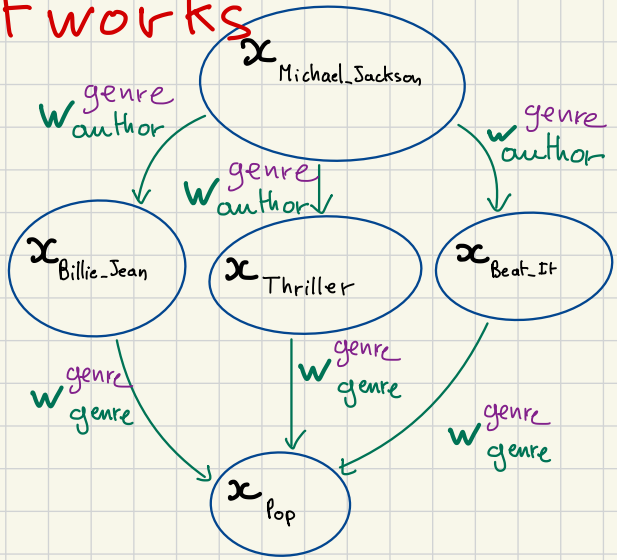
0.18

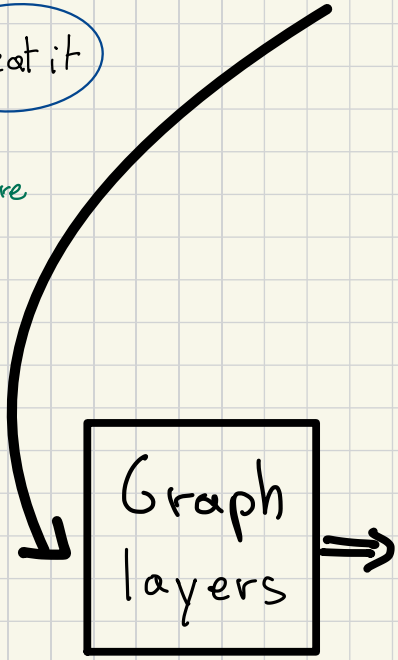
0.78

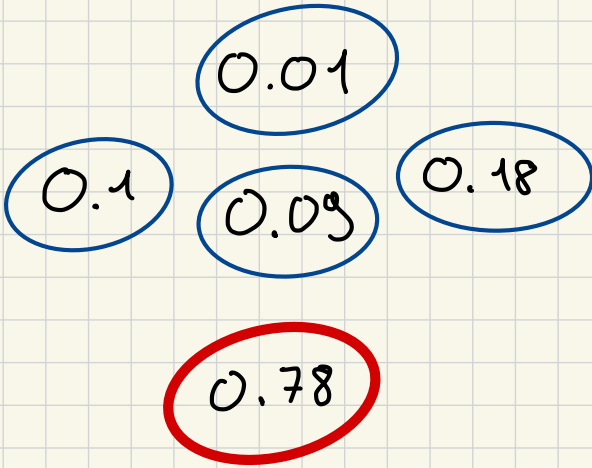
2 - Graph Neural Networks

genre of Michael Jackson ?









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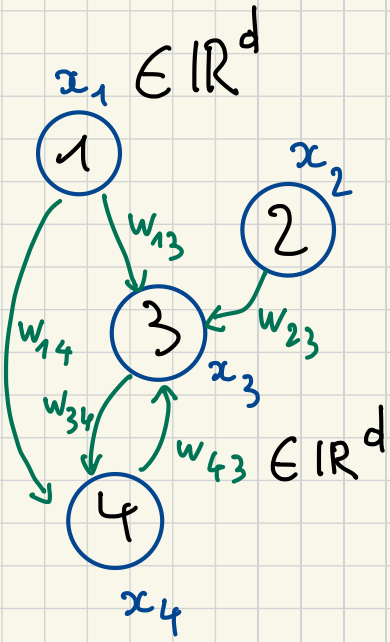

$d > 1$

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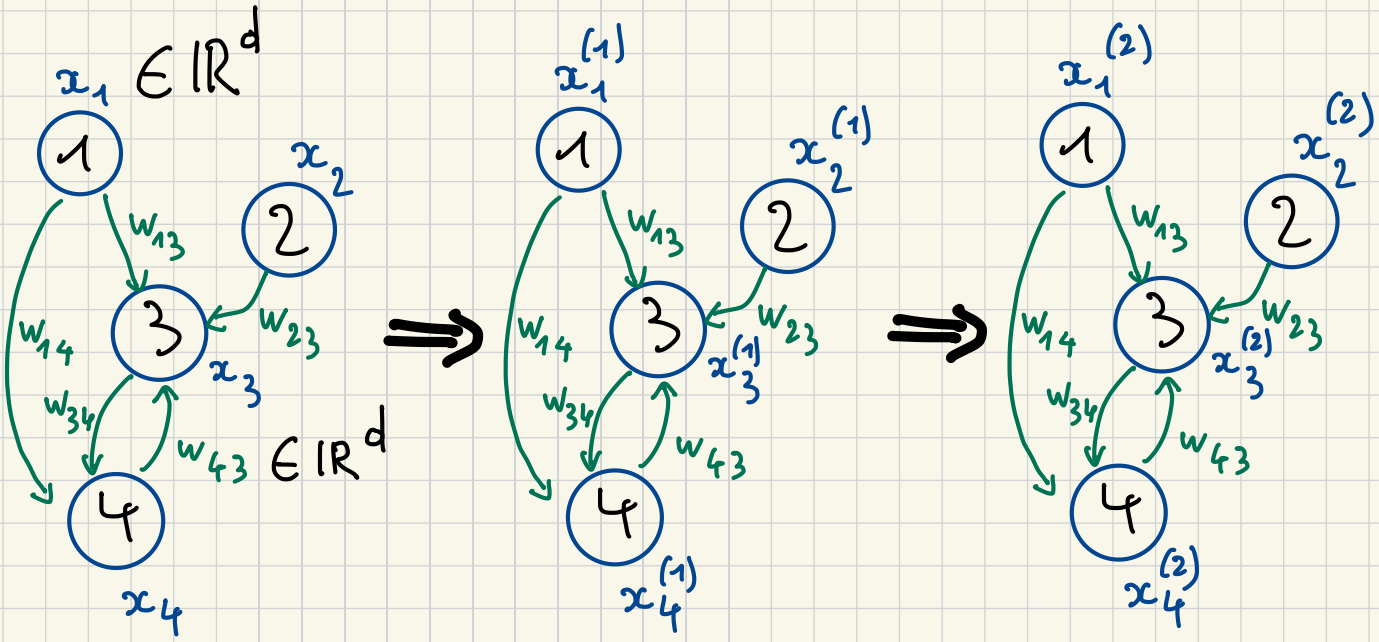

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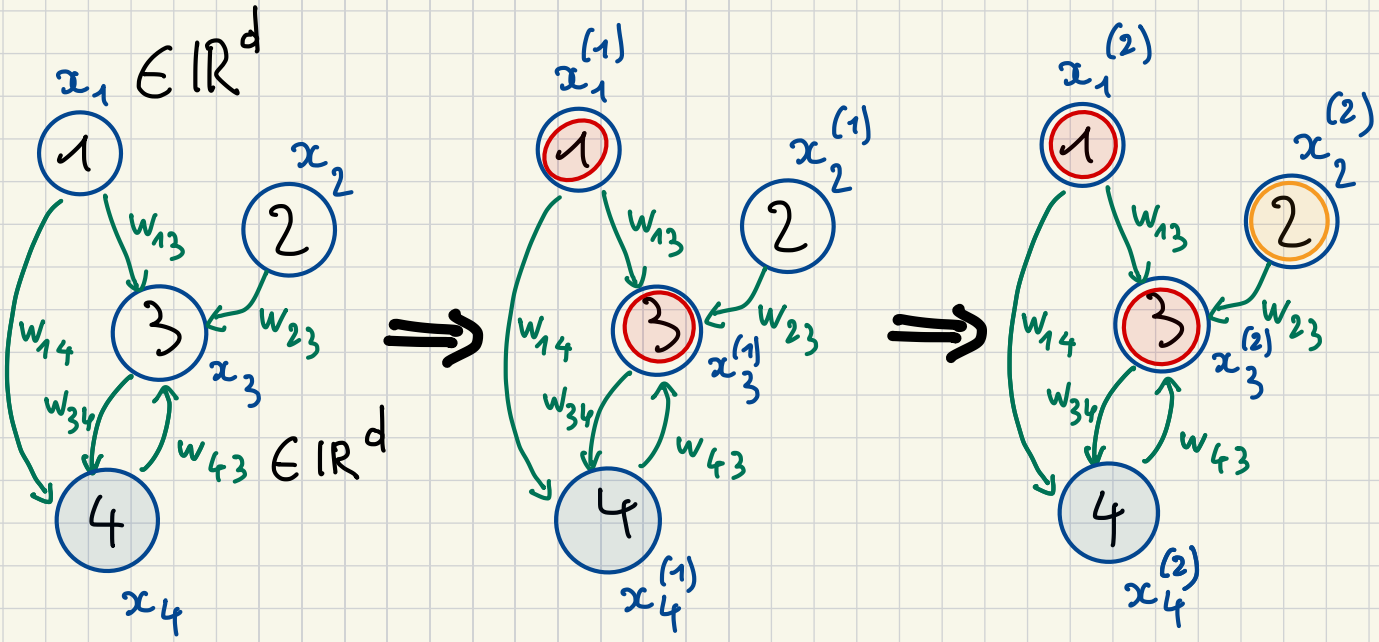
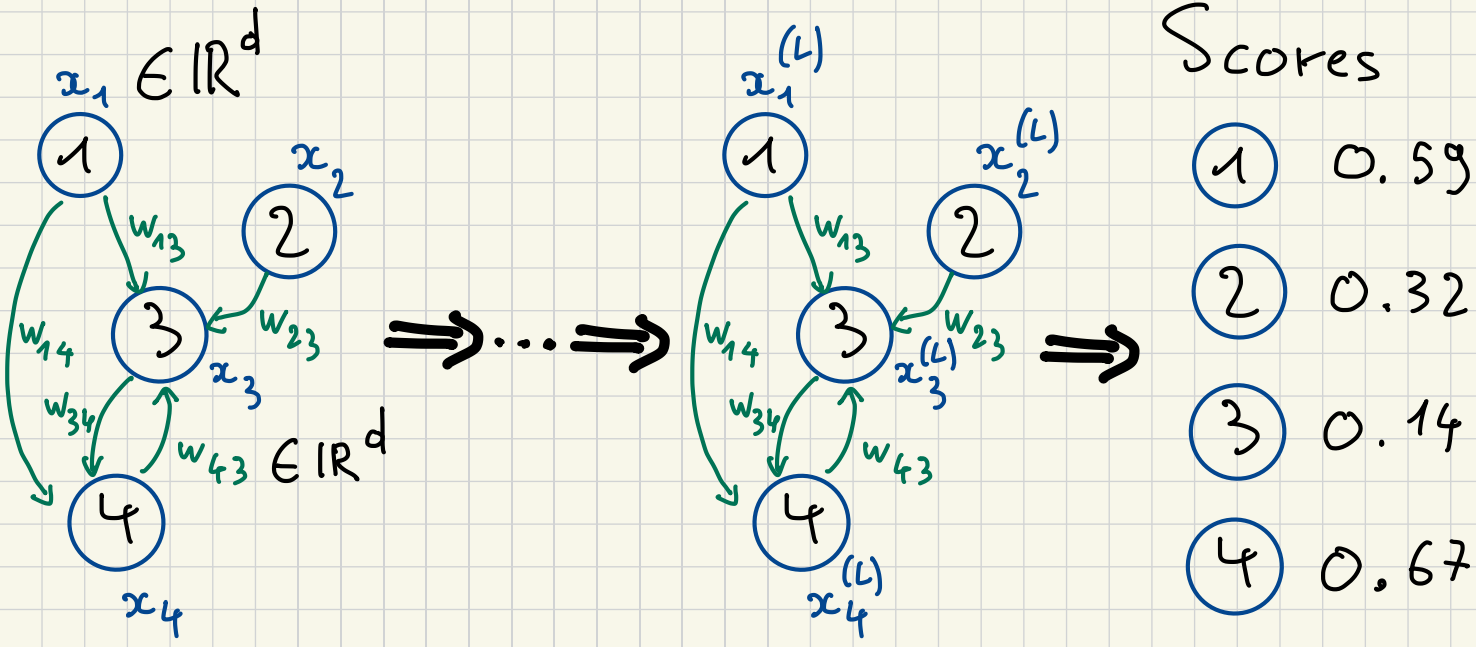


$d > 1$

$$x_4^{(t+1)} = \mathrm{ReLU}\left(\left(x_1^{(t)} w_{14} + x_3^{(t)} w_{34}\right) W^{(t)}\right)$$

2 - Graph Neural Networks



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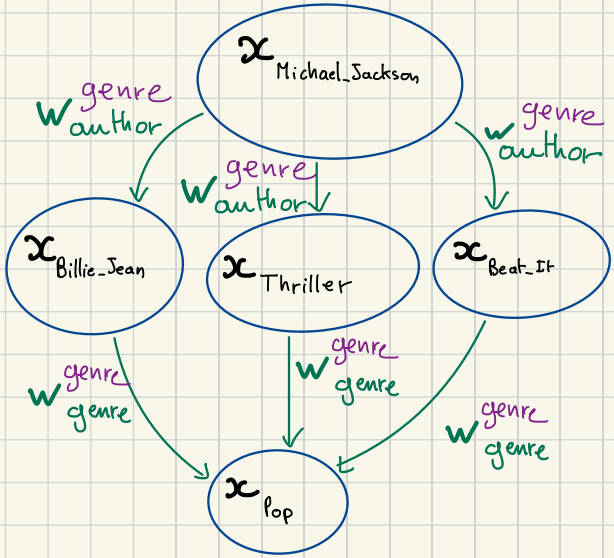
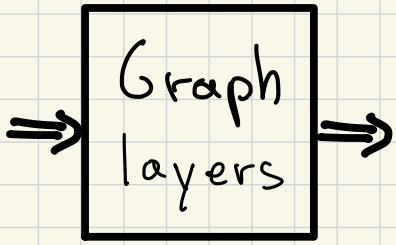


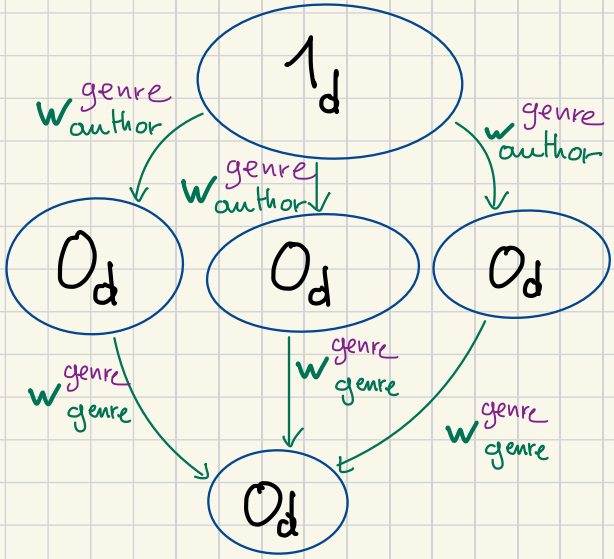


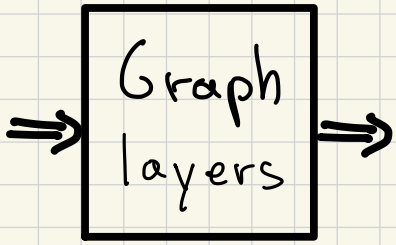
Scores

Michael Jackson	0.01
Billie Jean	0.11
Thriller	0.23
Beat it	0.05
Pop	0.76

3 - Neural Bellman-Ford Network

genre of Michael Jackson ?





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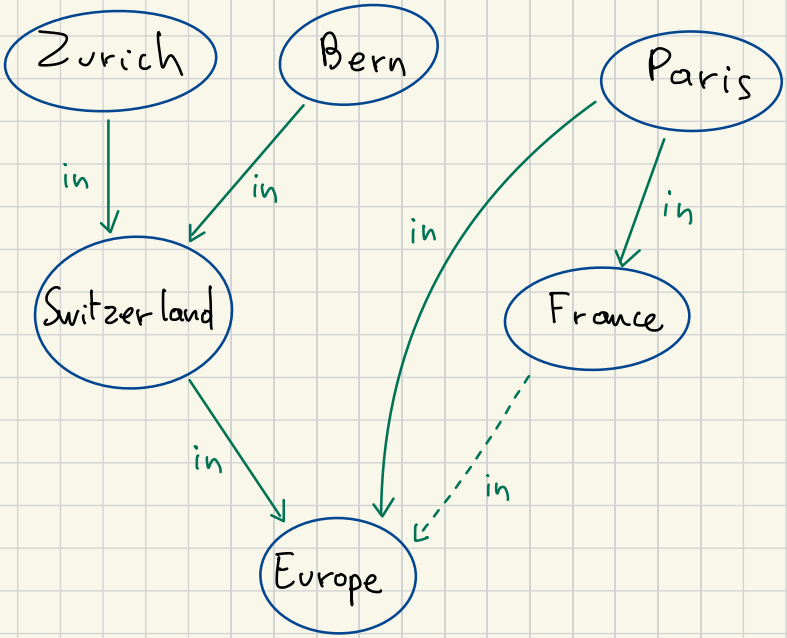
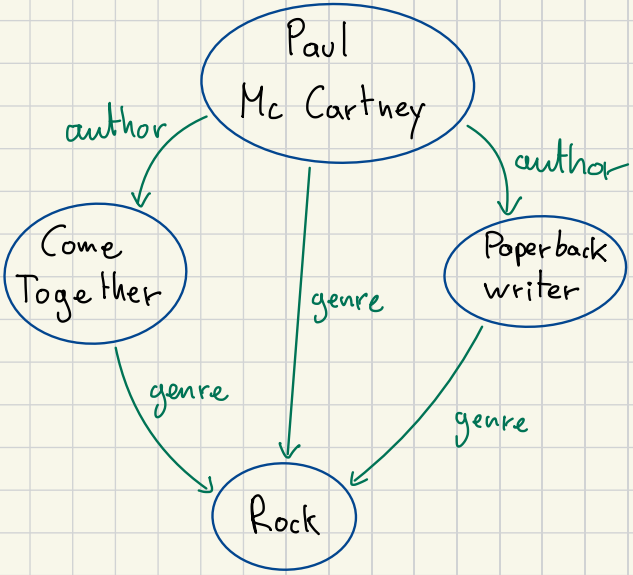


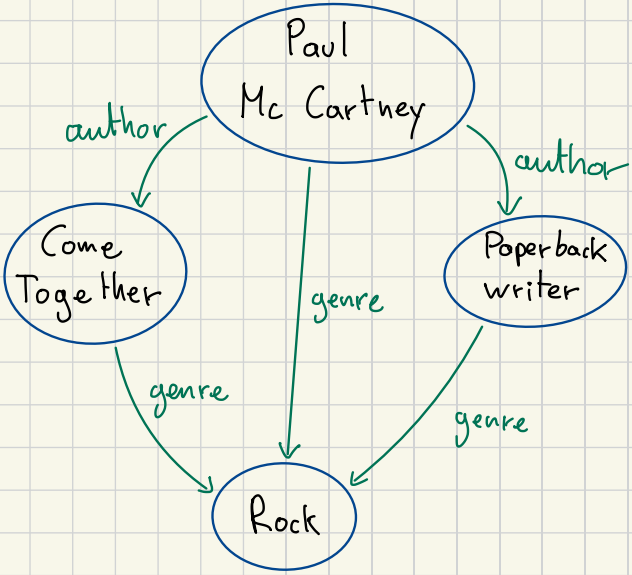
$\Longrightarrow$??

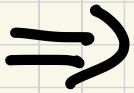
We do not know w^{in}_{in}

4 - The ULTRA method



4 - The ULTRA method





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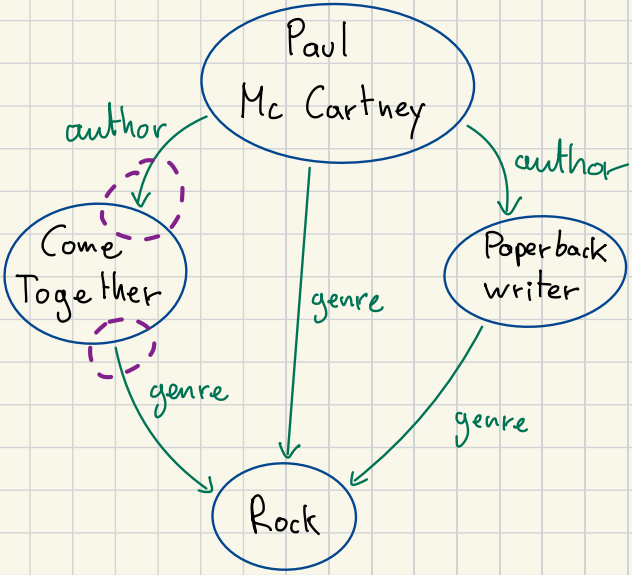

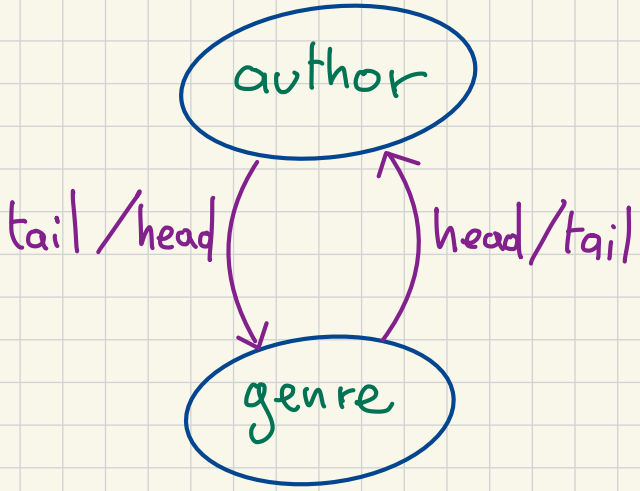

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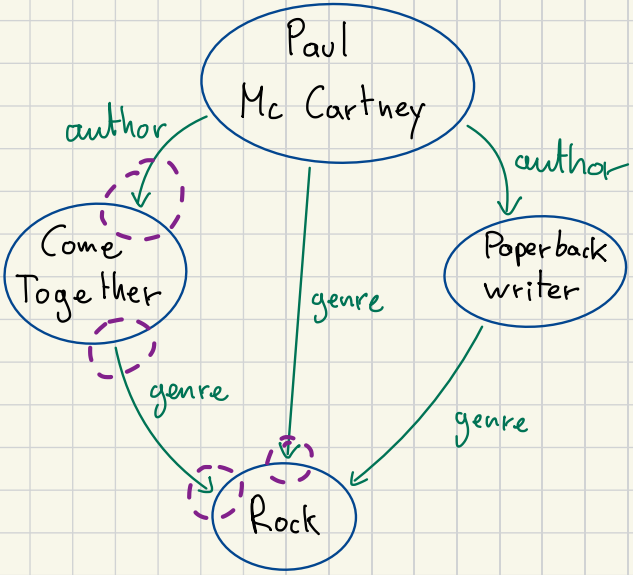

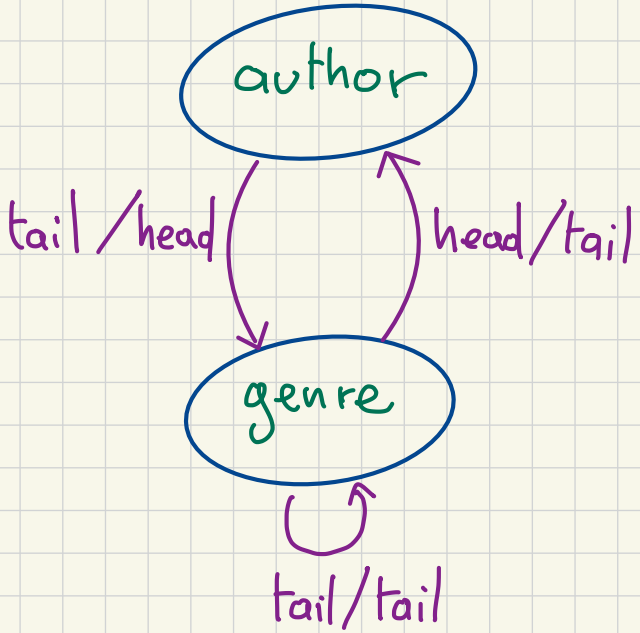

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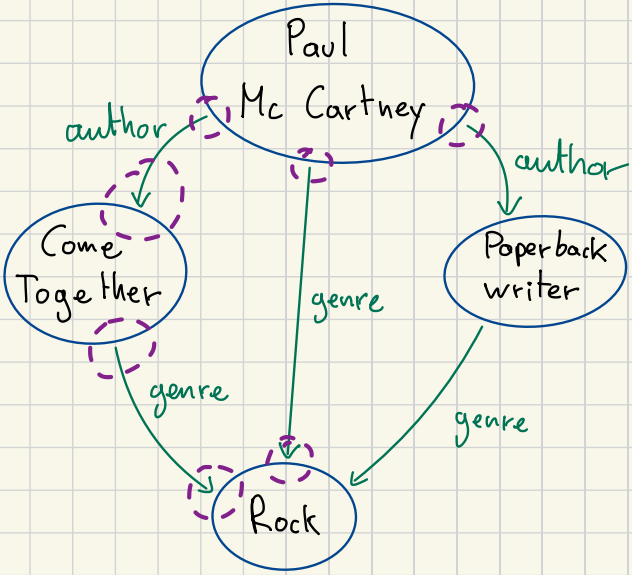

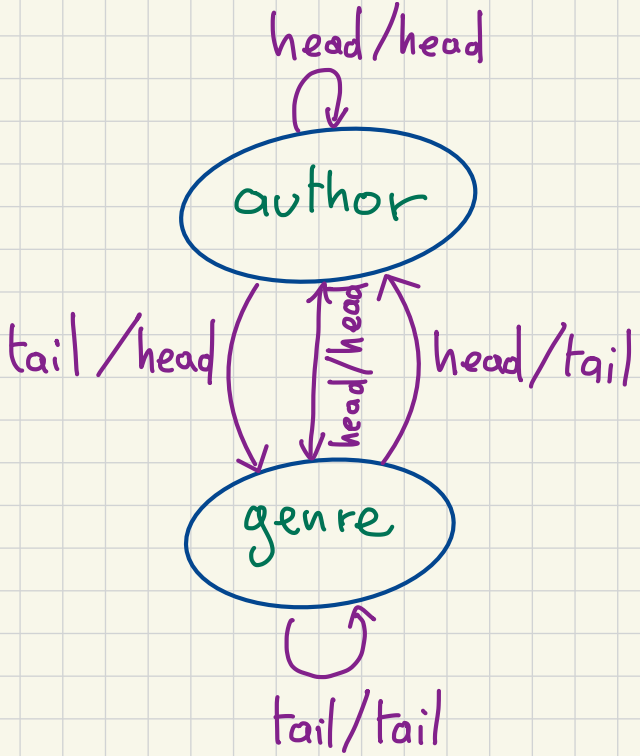

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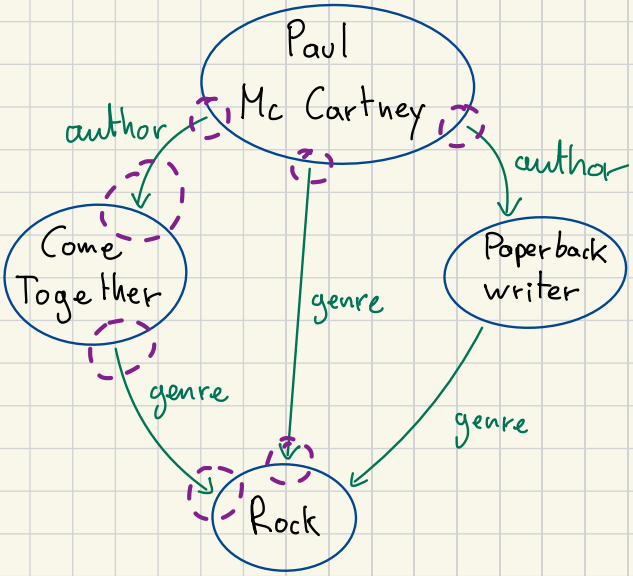
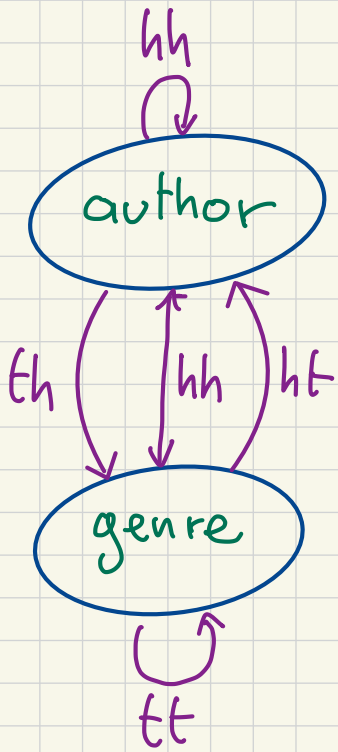
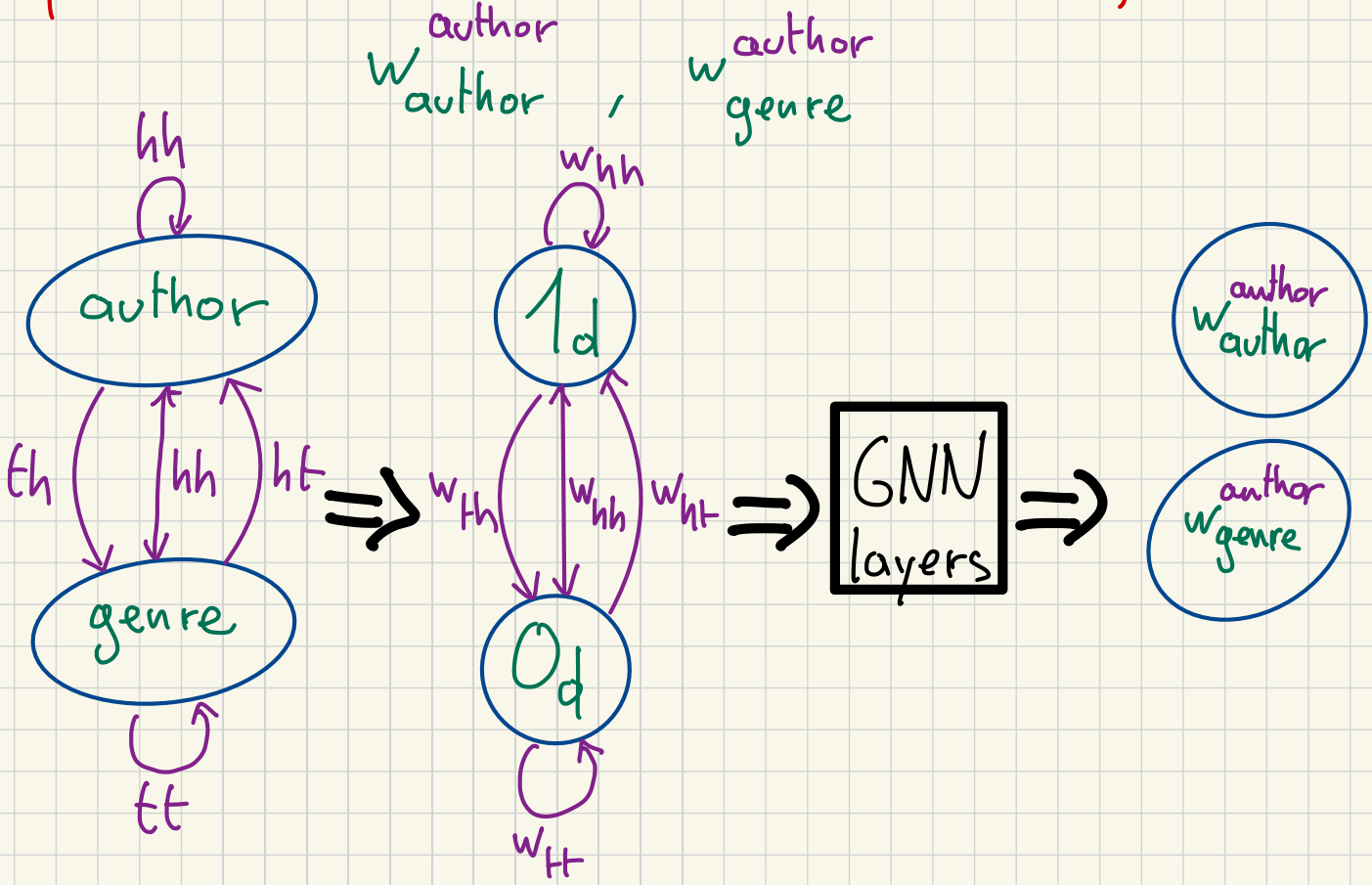
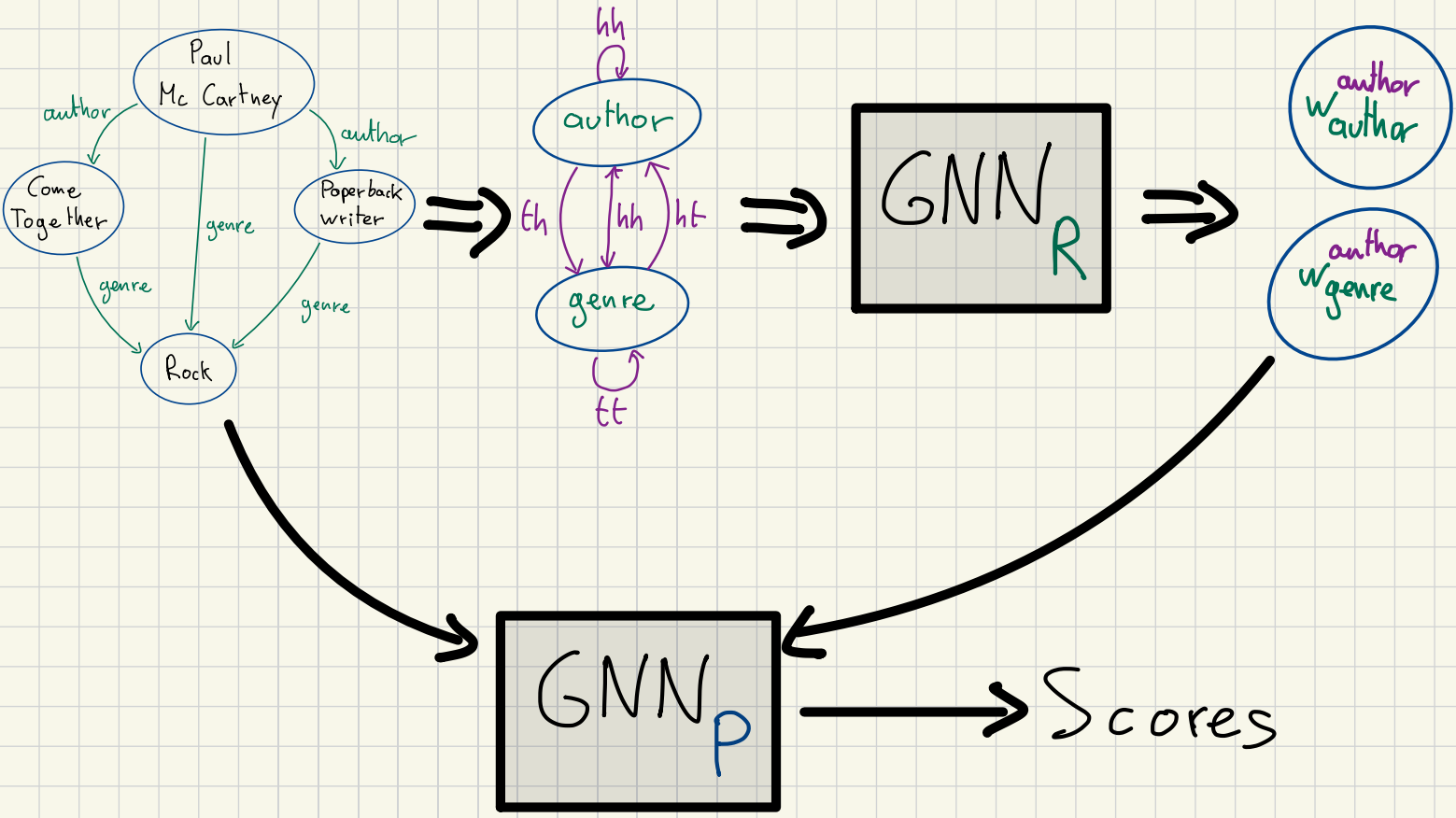




4 - The ULTRA method

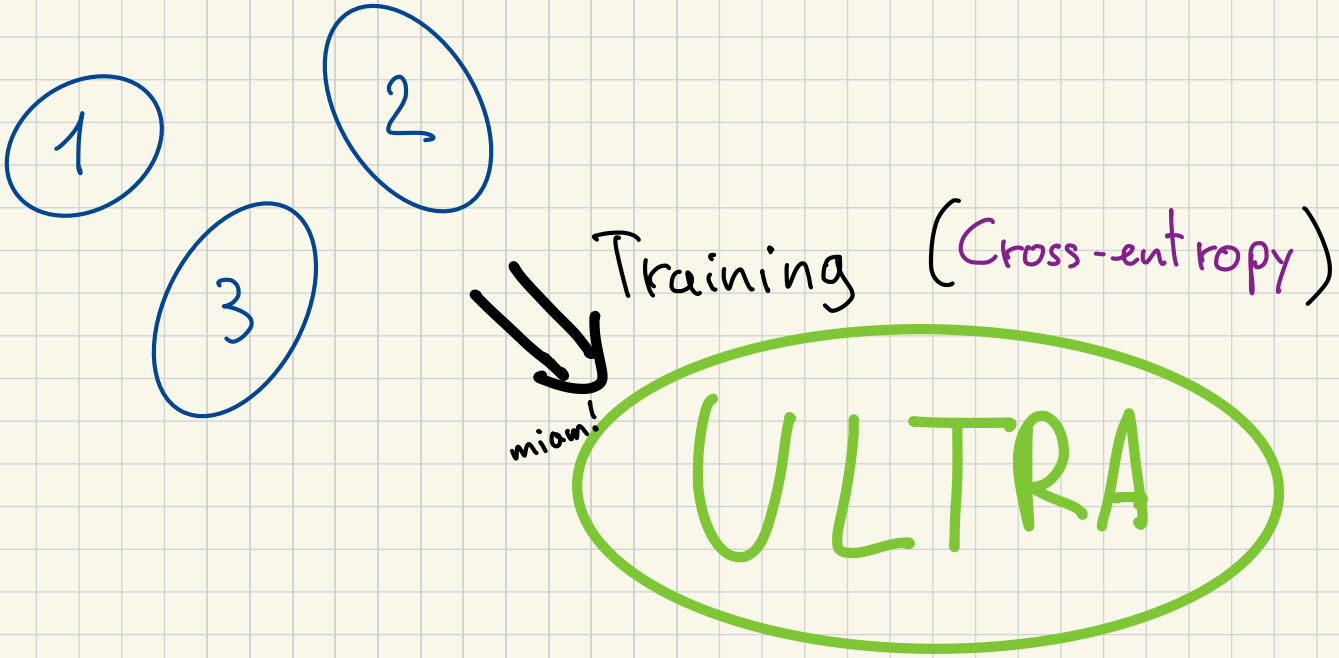


4 - The ULTRA method

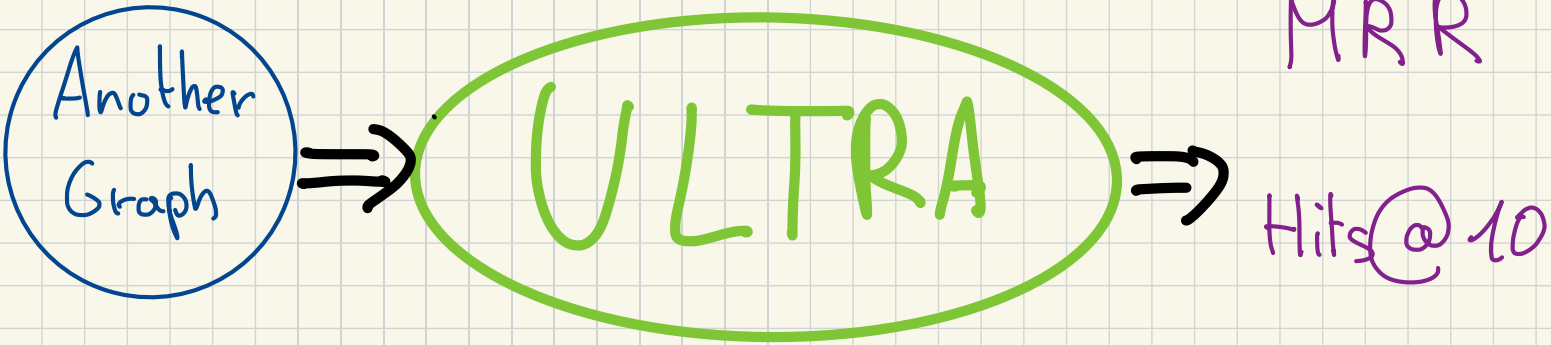


5 - Results

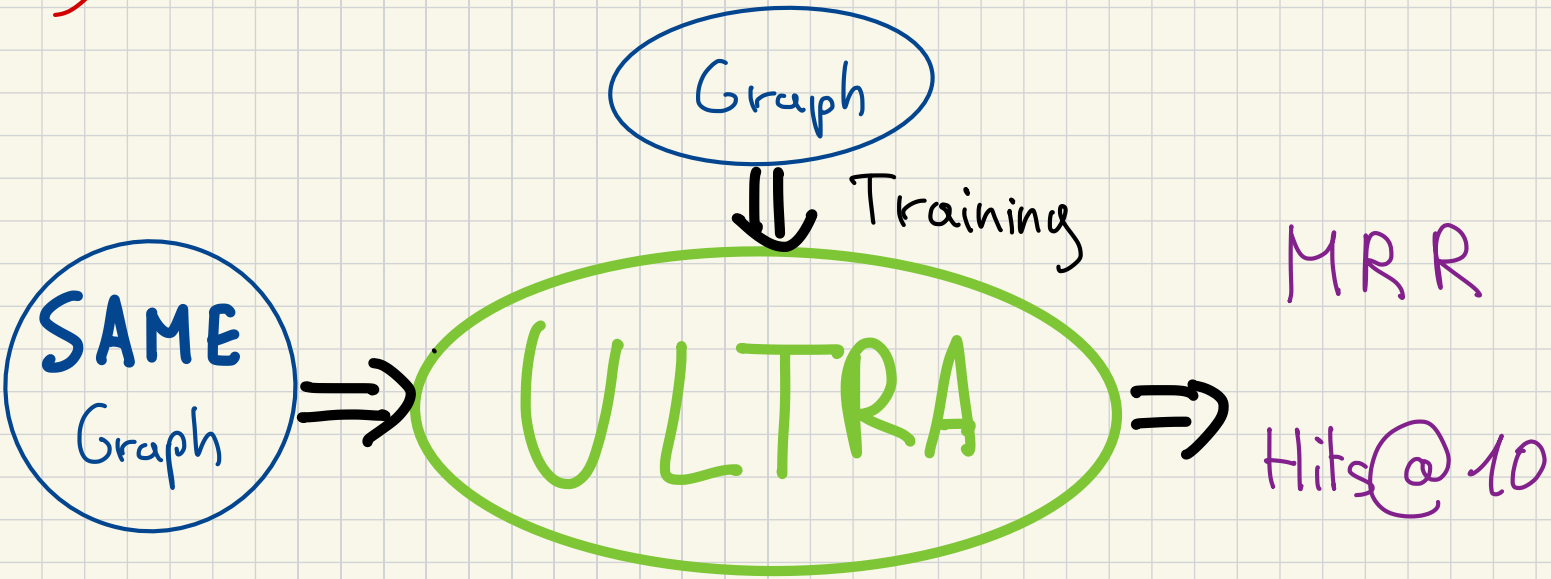
3 Graphs



5 - Results

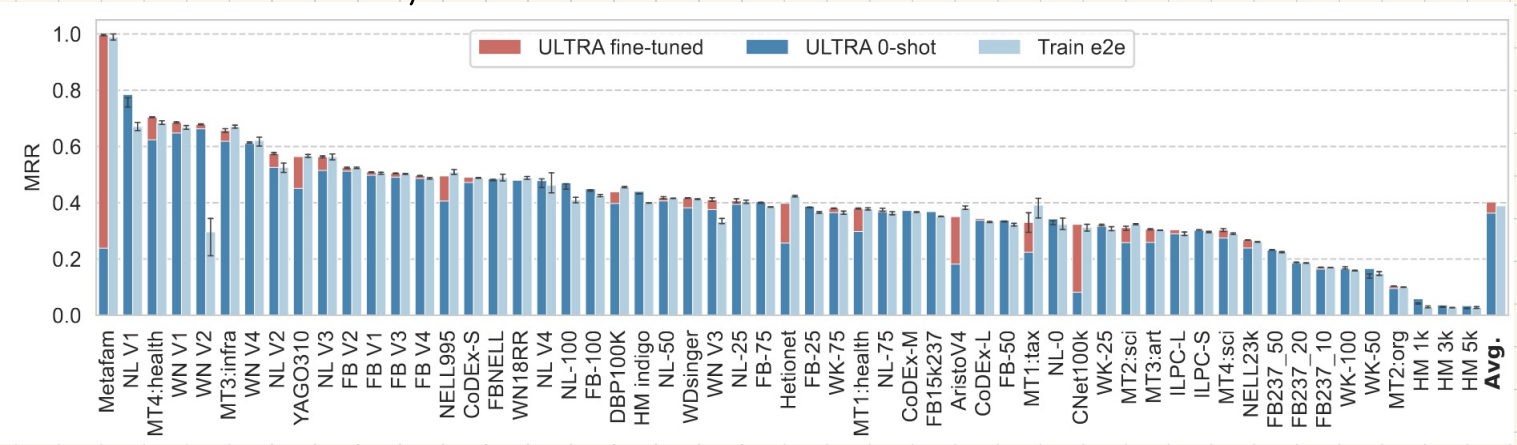


5 - Results

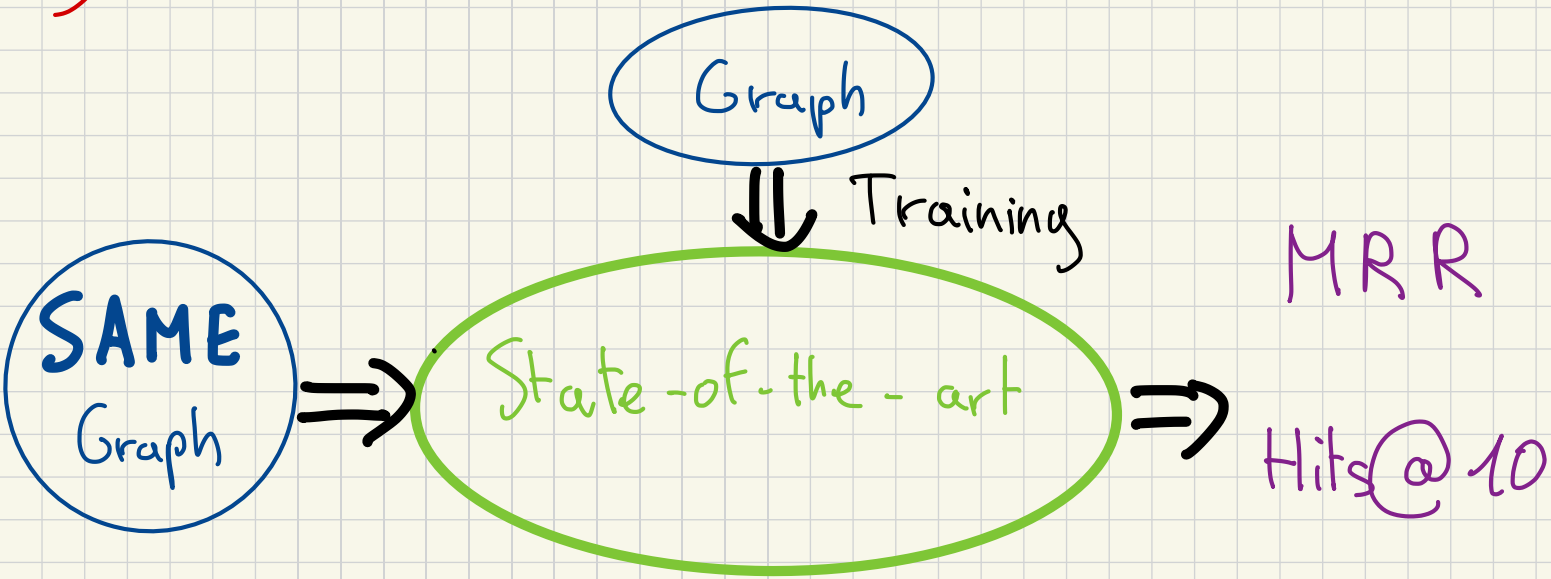


5 - Results

(more is better)

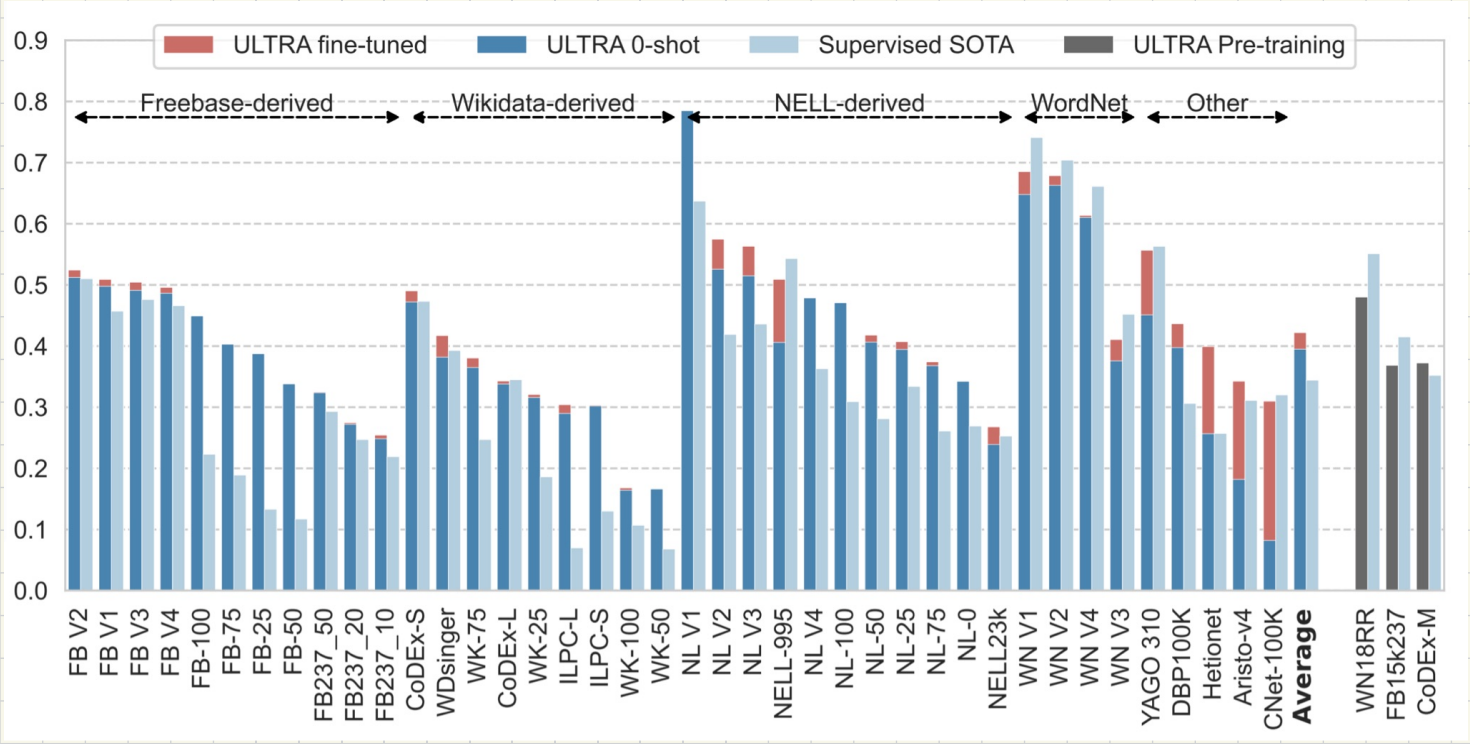


5 - Results

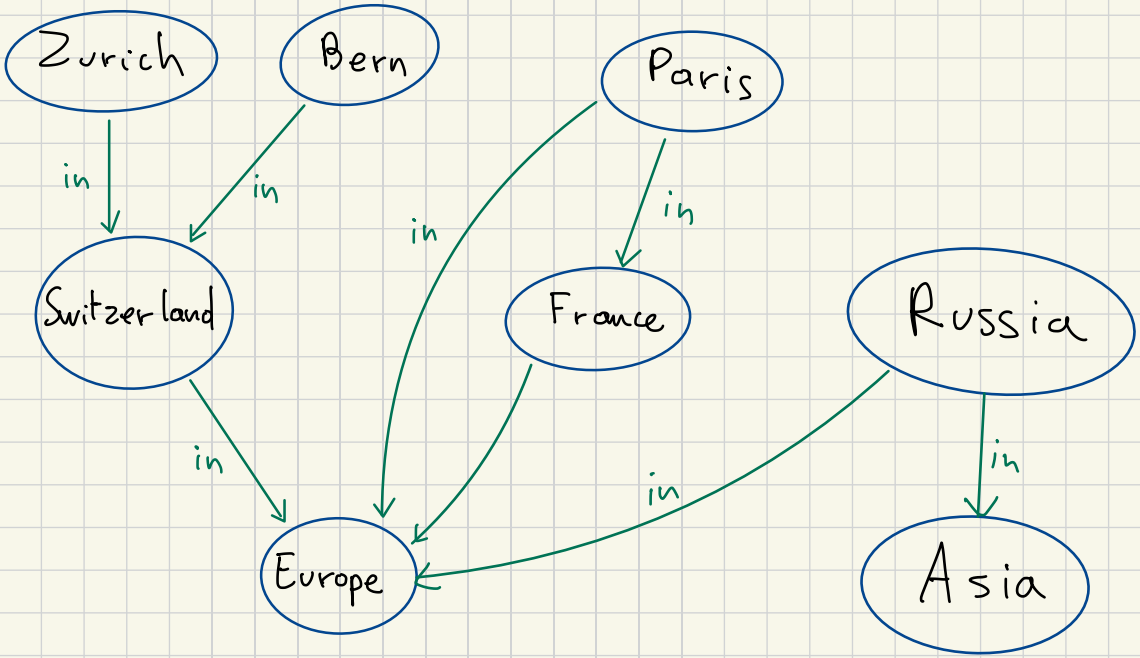


5 - Results

(more is better)

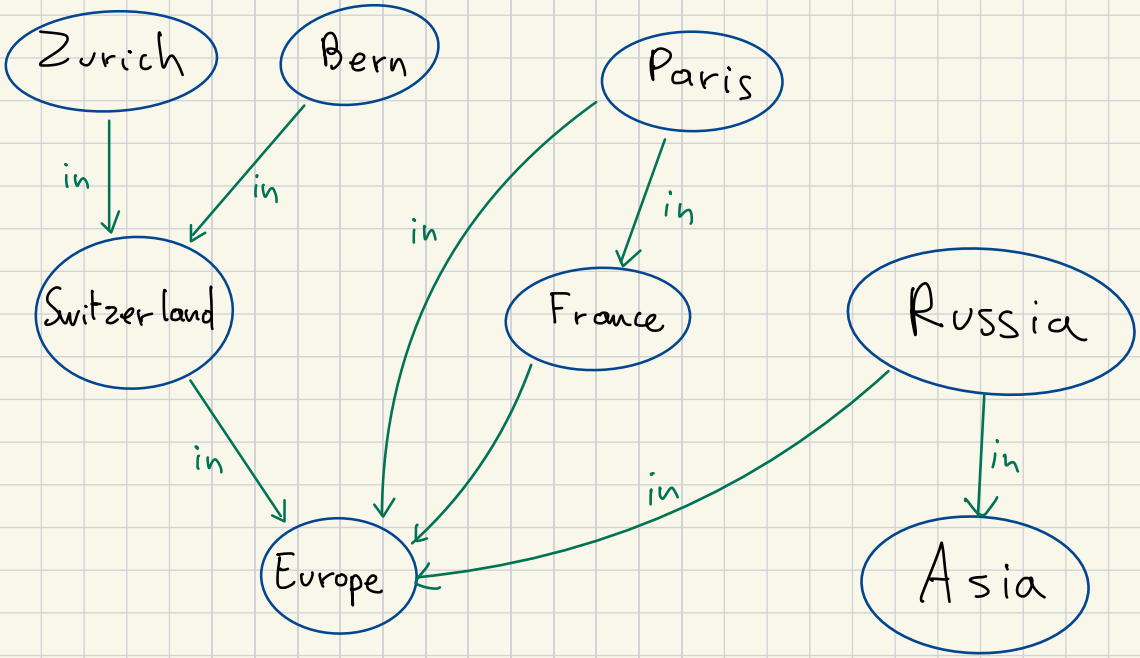


6 - ULTRA Query



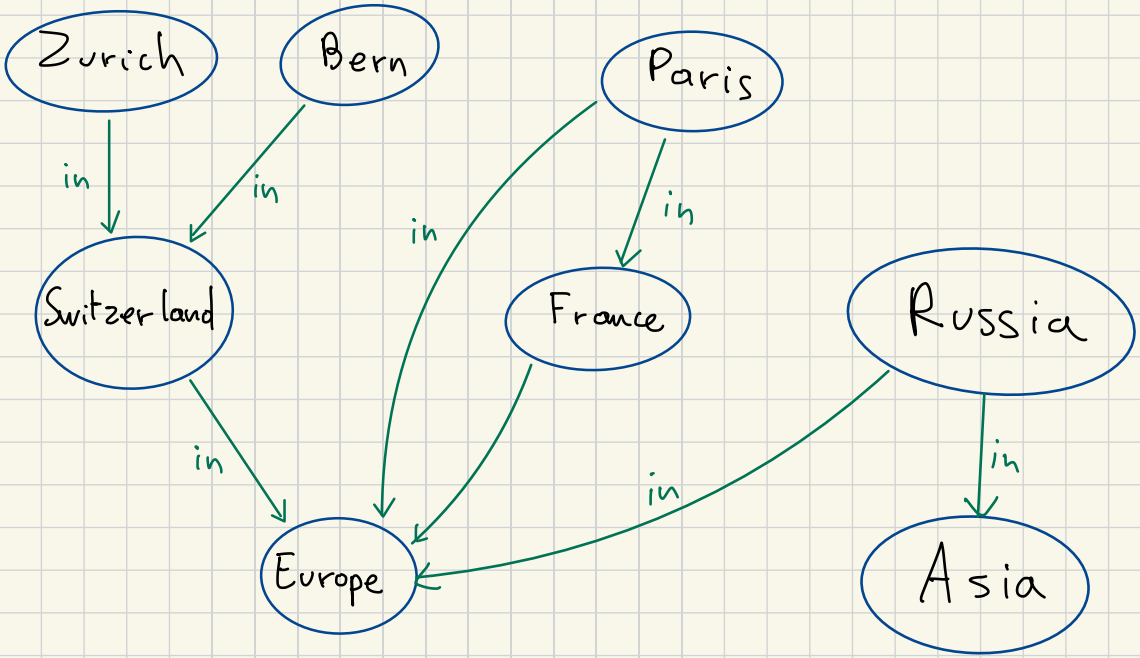
Bern is in?

6 - ULTRA Query



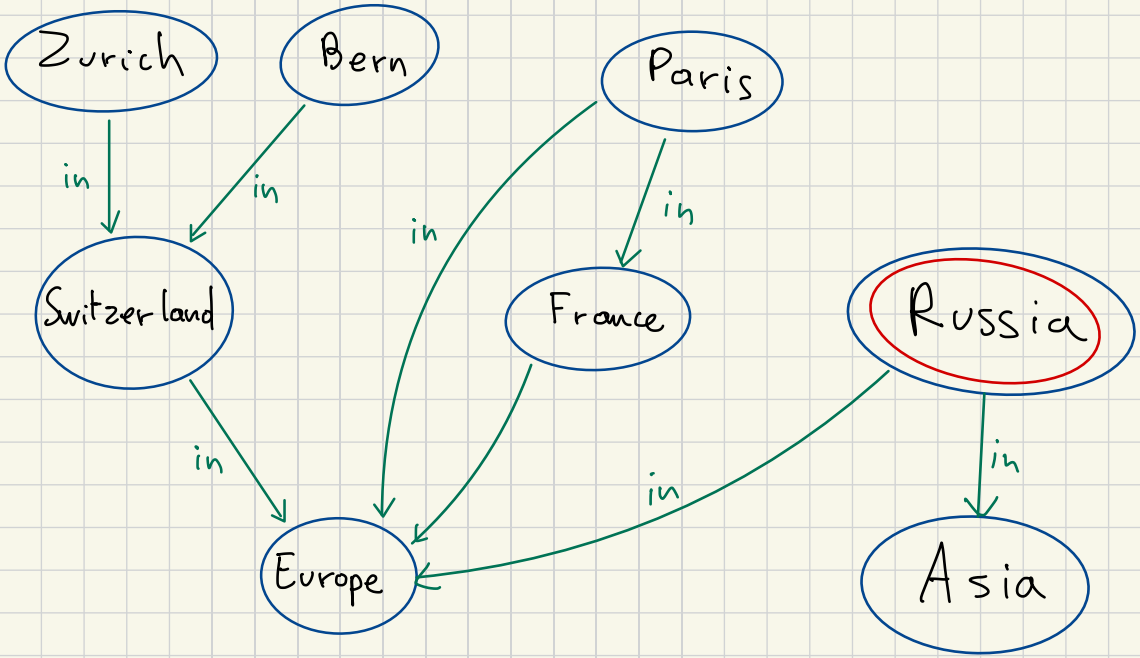
?U : in(Bern, U)

6 - ULTRA Query



$$?U : in(U, Europe) \wedge in(U, Asia)$$

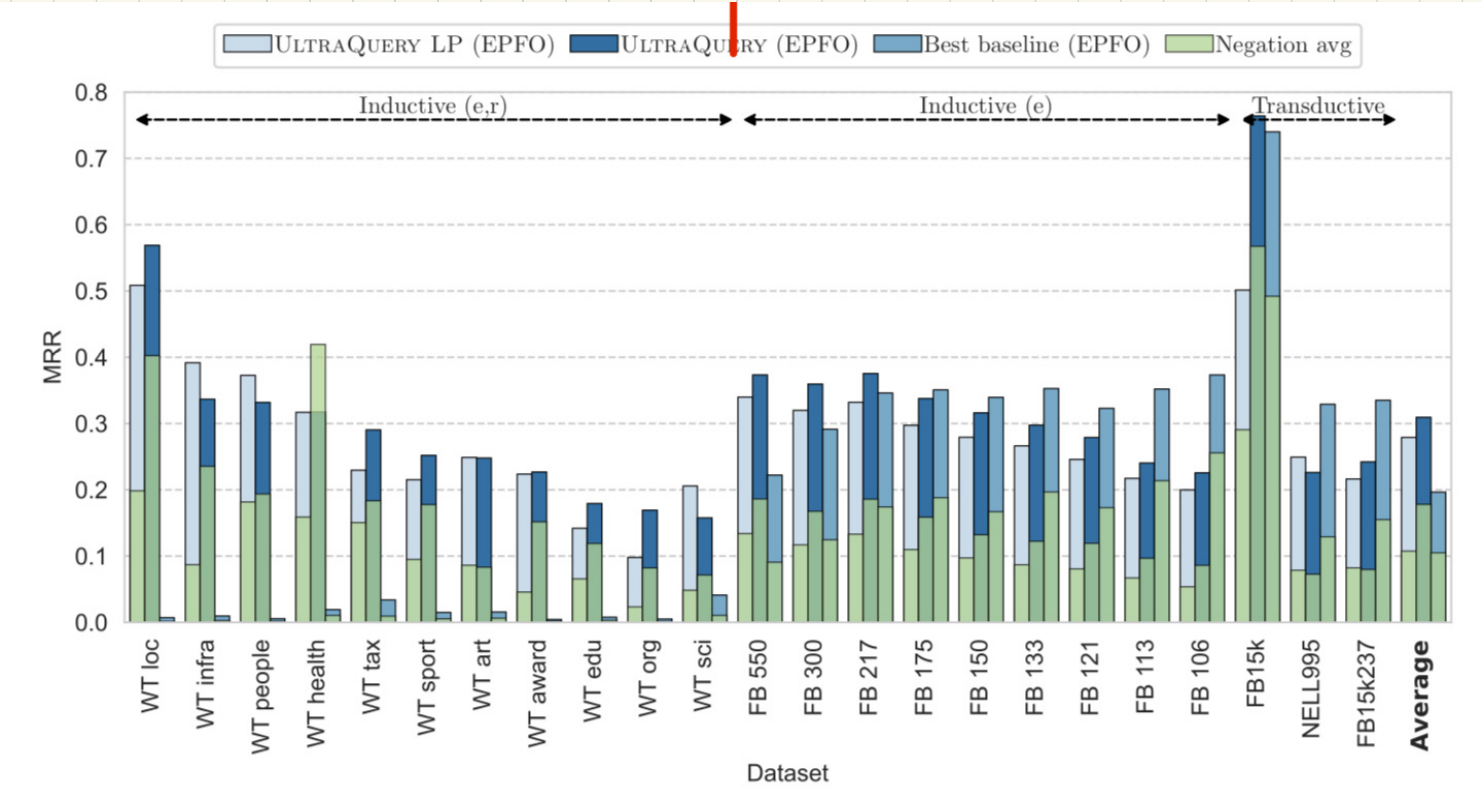
6 - ULTRA Query



$$?U : in(U, Europe) \wedge in(U, Asia)$$

6 - ULTRA Query

(more is better)

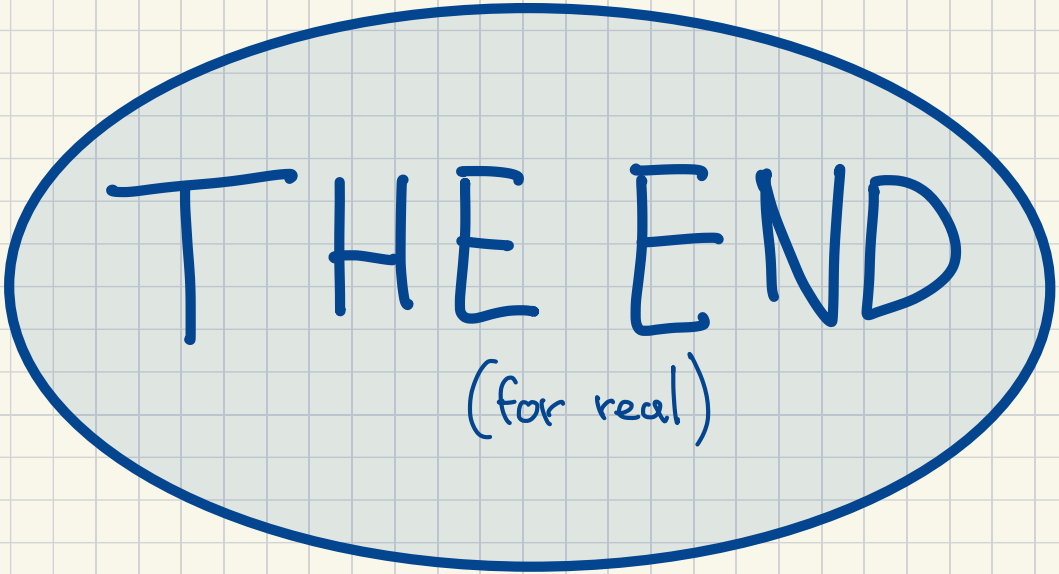


Critics

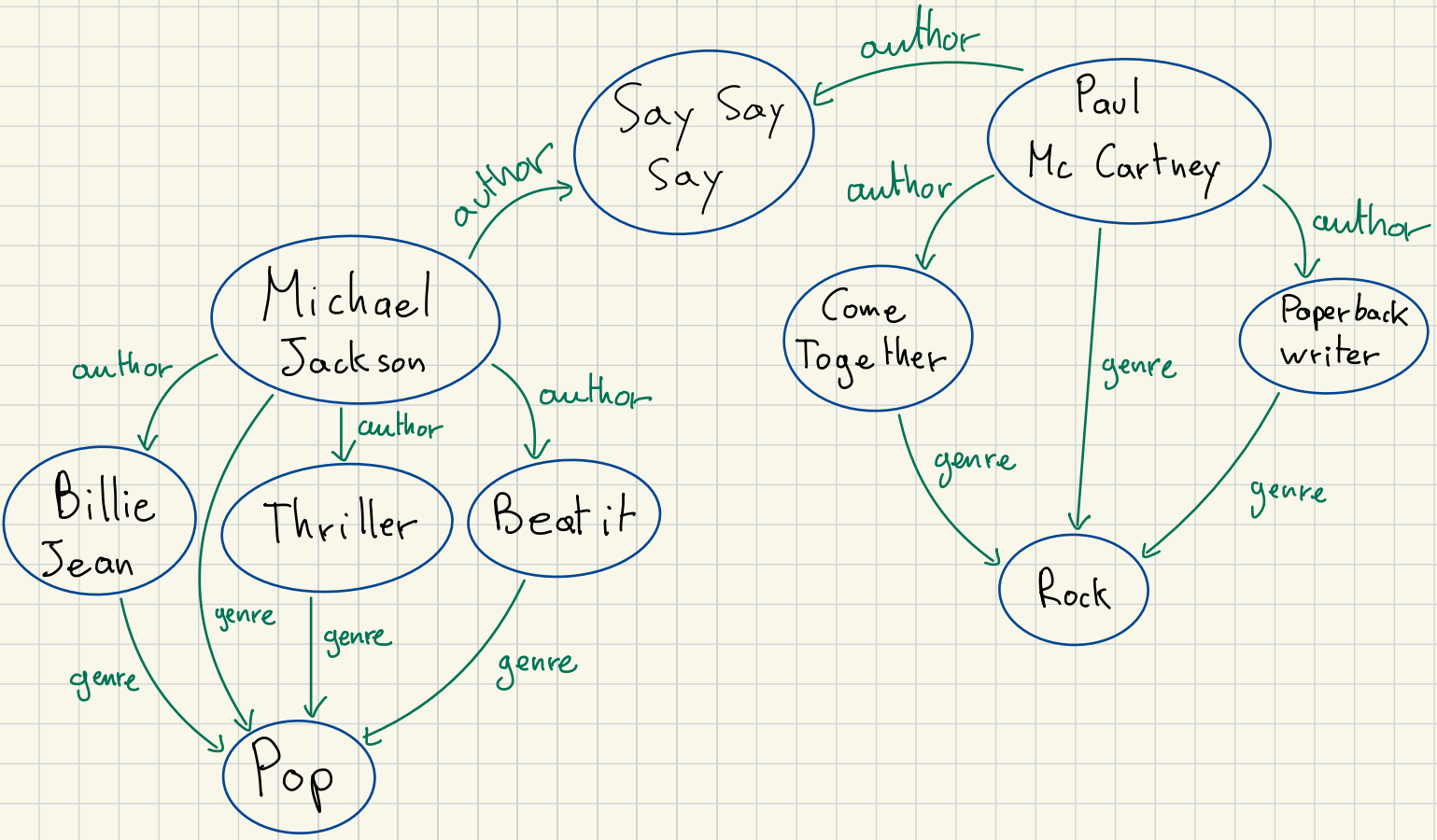
- class of knowledge graphs very restrictive
- The introduction of tt, hh, th and ht barely changes the performances
- performances still low
- potential ameliorations are pure conjectures
- terrible pedagogy

What to take home?

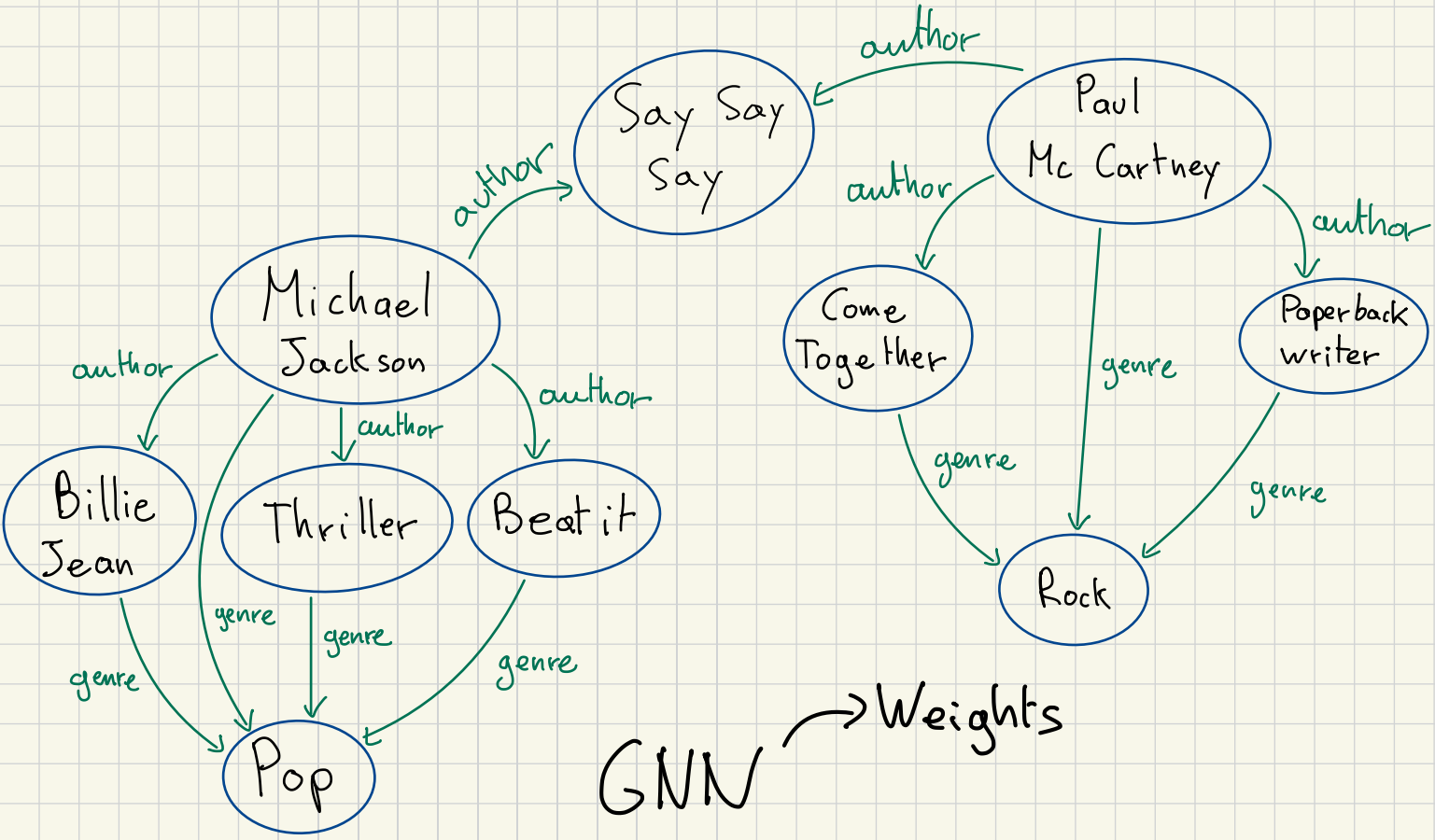
- the class of Knowledge Graphs displays invariant structural properties
- we can train a GNN to learn these properties, yielding a sort of foundation model for the knowledge graphs


THE END
(for real)

2 - Previous method



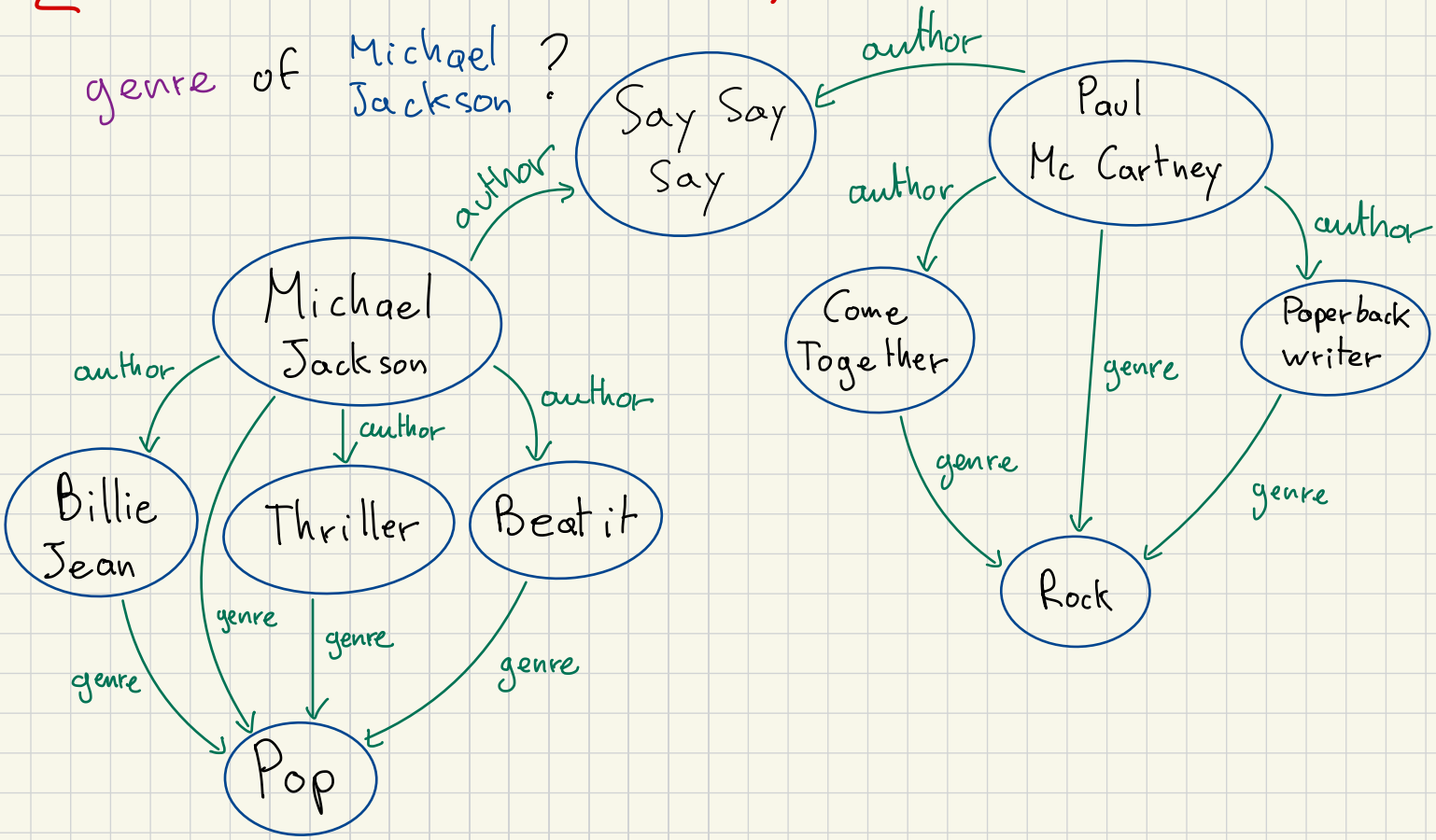
2 - Previous method



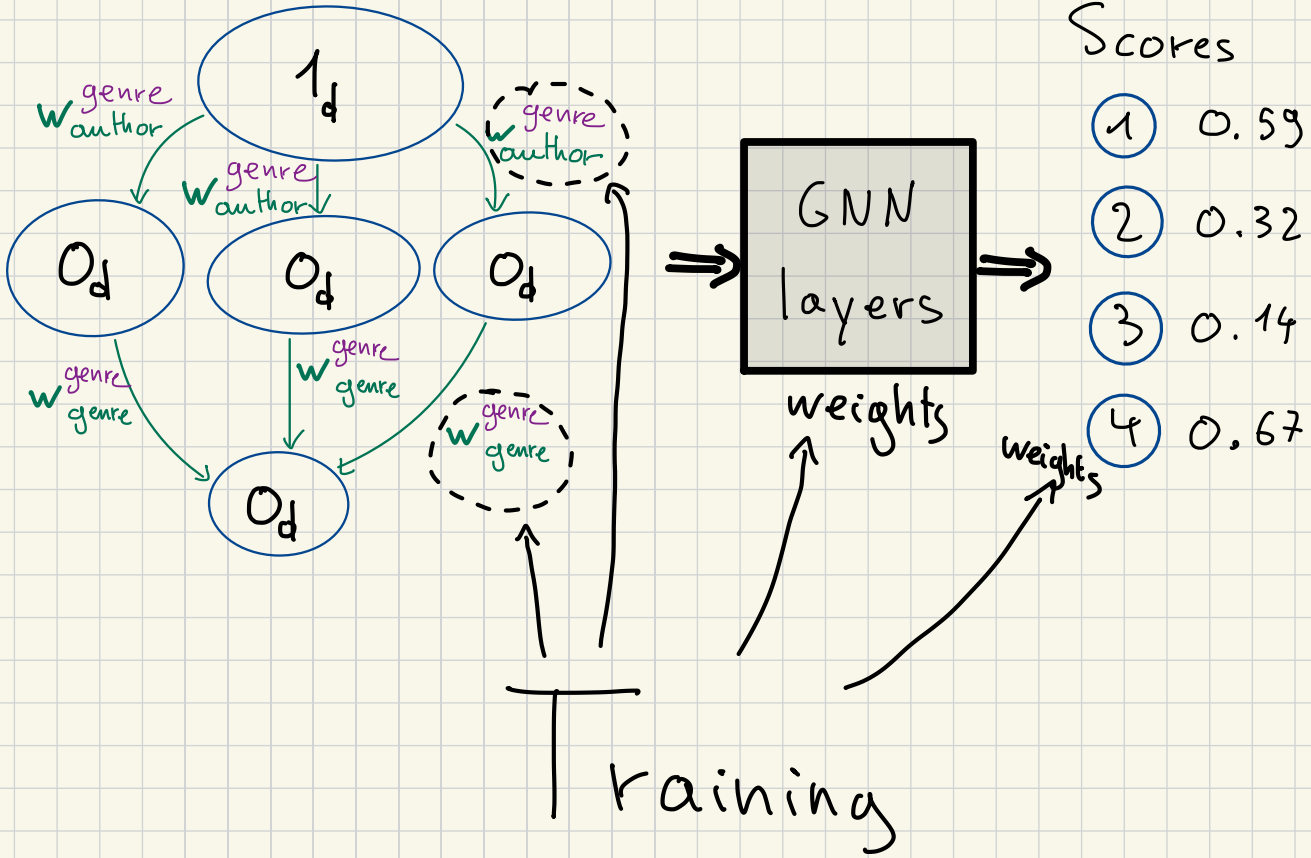
GNN → Weights

2 - Previous method

genre of Michael Jackson ?



2 - Previous method



2 - Previous method

GNN → Weights

GNN → Embeddings

W^{genre}_{genre} W^{author}_{genre} W^{genre}_{author} W^{author}_{author}