



Conversational Passage Ranking by Reasoning over Word Networks

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SAMPLE CONVERSATION

Turn 1: What **flowering plants** work for **cold climates**?

Turn 2: Which of them **survive frost**?

Turn 3: How much **cold** can **pansies tolerate**?

Turn 4: What's the **UK hardiness rating**?

.....



<https://commons.wikimedia.org/w/index.php?curid=1954190>

Method Overview

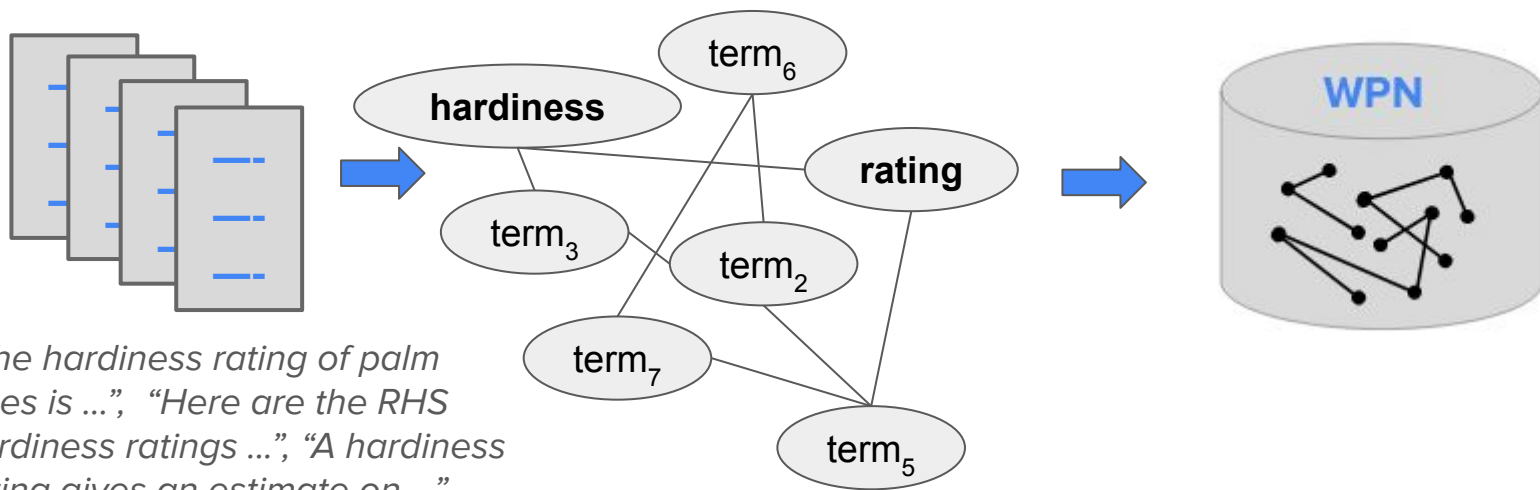
- ★ CROWN is an **unsupervised** method for passage ranking
- ★ Pseudo-relevant passages obtained with any standard retrieval system (e.g. Indri) using an **expanded conversational query**
- ★ CROWN models passage relevance as combination of **similarity** and **coherence**
- ★ Creates **Word Proximity Network** (WPN) from large corpus as backbone for passage scoring

Method Overview

- ★ The WPN stores **co-occurrences** of words, **within a context window**, as measured by Normalized Pointwise Mutual Information (NPMI)
- ★ Similarity between query and passage terms measured in terms of **embedding vectors (node weights)**
- ★ Coherence measured using proximities of **significant pairs** of passage terms (**edge weights**)

Word Proximity Network

- ★ Estimate term relationships from a large corpus
- ★ Store term co-occurrence in WPN
- ★ Graph as a very flexible structure with extension possibilities



“The hardiness rating of palm trees is ...”, “Here are the RHS hardiness ratings ...”, “A hardiness rating gives an estimate on ...”

Step 1: Query Expansion

SAMPLE CONVERSATION

Turn 1: What **flowering plants** work for **cold climates**?

...

Turn T-2: ...

Turn T-1: How much **cold** can **pansies tolerate**?

Turn T: What's the **UK hardiness rating**?

Step 1: Query Expansion

SAMPLE CONVERSATION

Turn 1: What **flowering plants** work for **cold climates**?

...

Turn T-2: ...

Turn T-1: How much **cold** can **pansies tolerate**?

Turn T: What's the **UK hardiness rating**?

Conversational Query:

combine (w_1^* (flowering plants cold climates)

Turn 1

...

w_{T-1}^* (pansies tolerate)

Turn T-1

w_T^* (UK hardiness rating))

Turn T

Step 2: Candidate passage retrieval

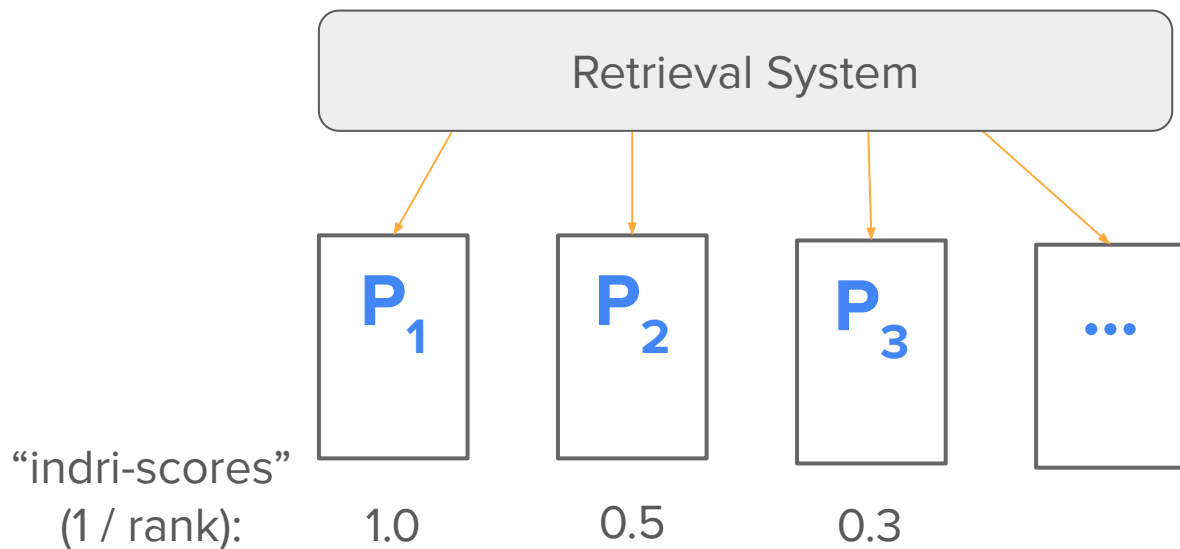
Issue conversational query to standard retrieval system (e.g. Indri)



Retrieval System

Step 2: Candidate passage retrieval

Issue conversational query to standard retrieval system (e.g. Indri)



Step 3: Modeling Similarity

Conversational Query:

w_1^* (flowering plants cold climates) w_{T-1}^* (pansies tolerate) w_T^* (UK hardiness rating)

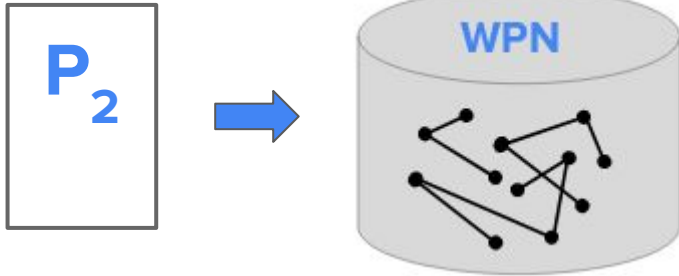
Candidate Passage:

P2: “Winter pansies have a UK hardiness rating of H5. In cold climate, pansies can ...”

Step 3: Modeling Similarity

Conversational Query:

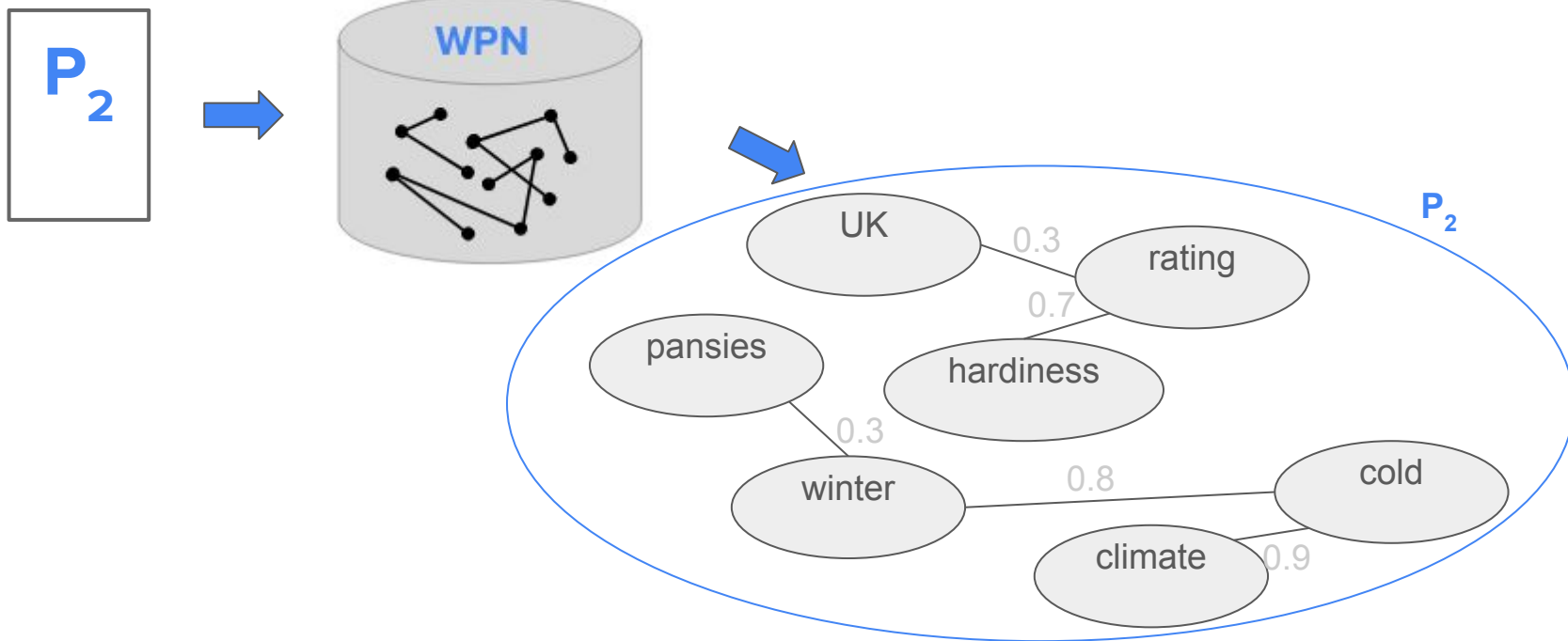
w_1^* (flowering plants cold climates) w_{T-1}^* (pansies tolerate) w_T^* (UK hardiness rating)



Step 3: Modeling Similarity

Conversational Query:

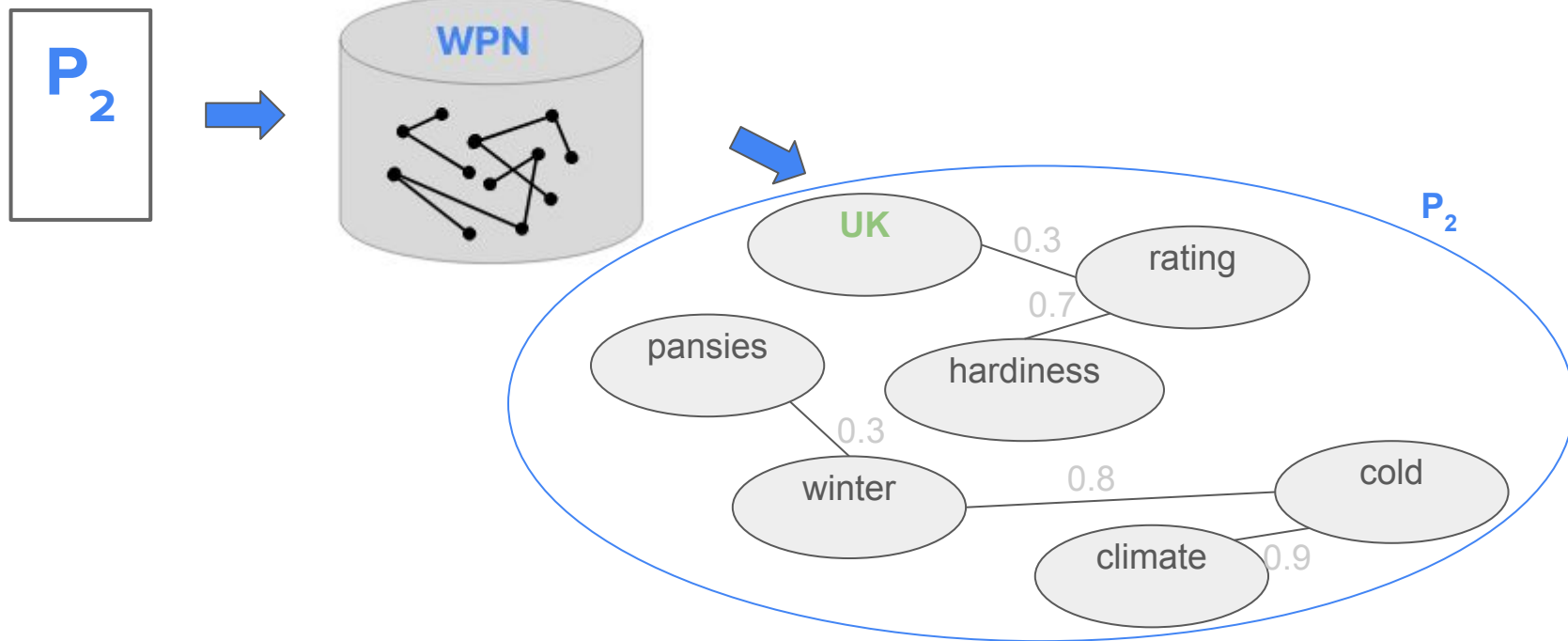
w_1^* (flowering plants cold climates) w_{T-1}^* (pansies tolerate) w_T^* (UK hardiness rating)



Step 3: Modeling Similarity

Conversational Query:

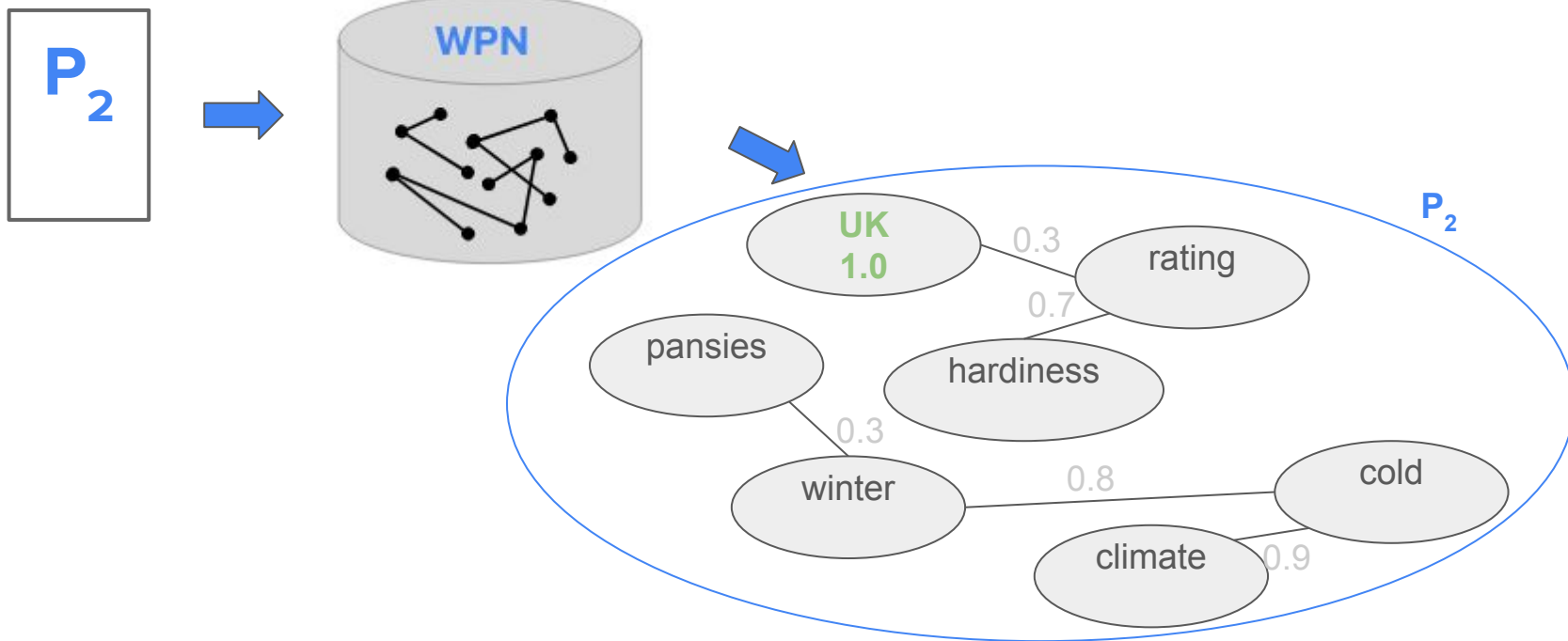
w_1^* (flowering plants cold climates) w_{T-1}^* (pansies tolerate) w_T^* (**UK** hardiness rating)



Step 3: Modeling Similarity

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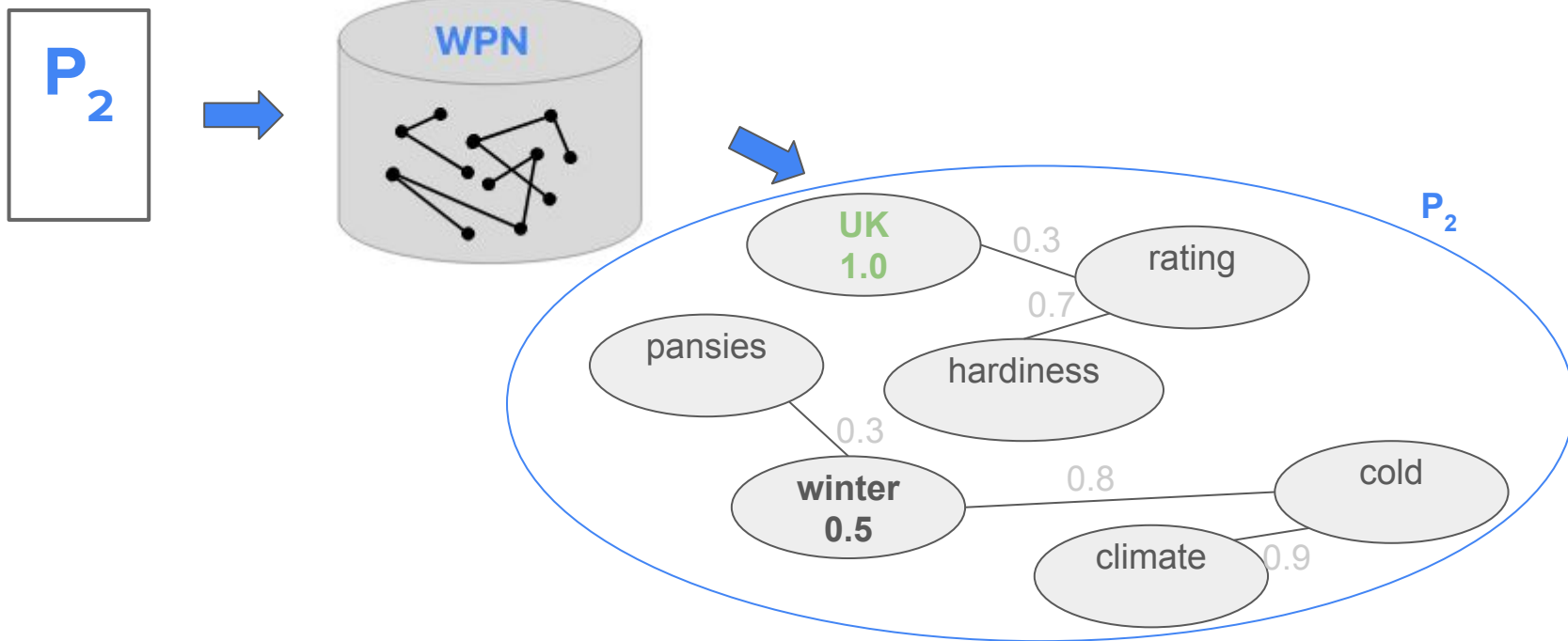
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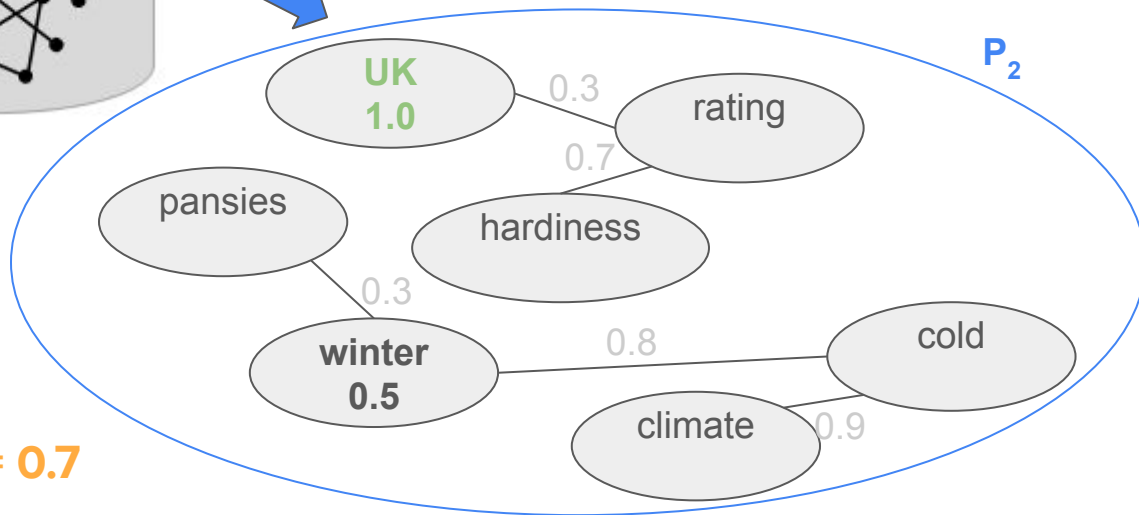
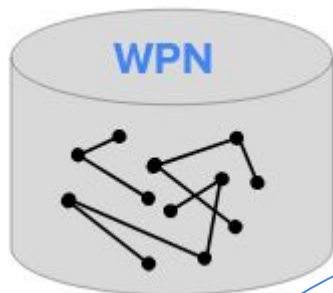


Step 3: Modeling Similarity

Conversational Query:

w_1^* (flowering plants **cold** climates) w_{T-1}^* (pansies tolerate) w_T^* (**UK** hardiness rating)

P_2

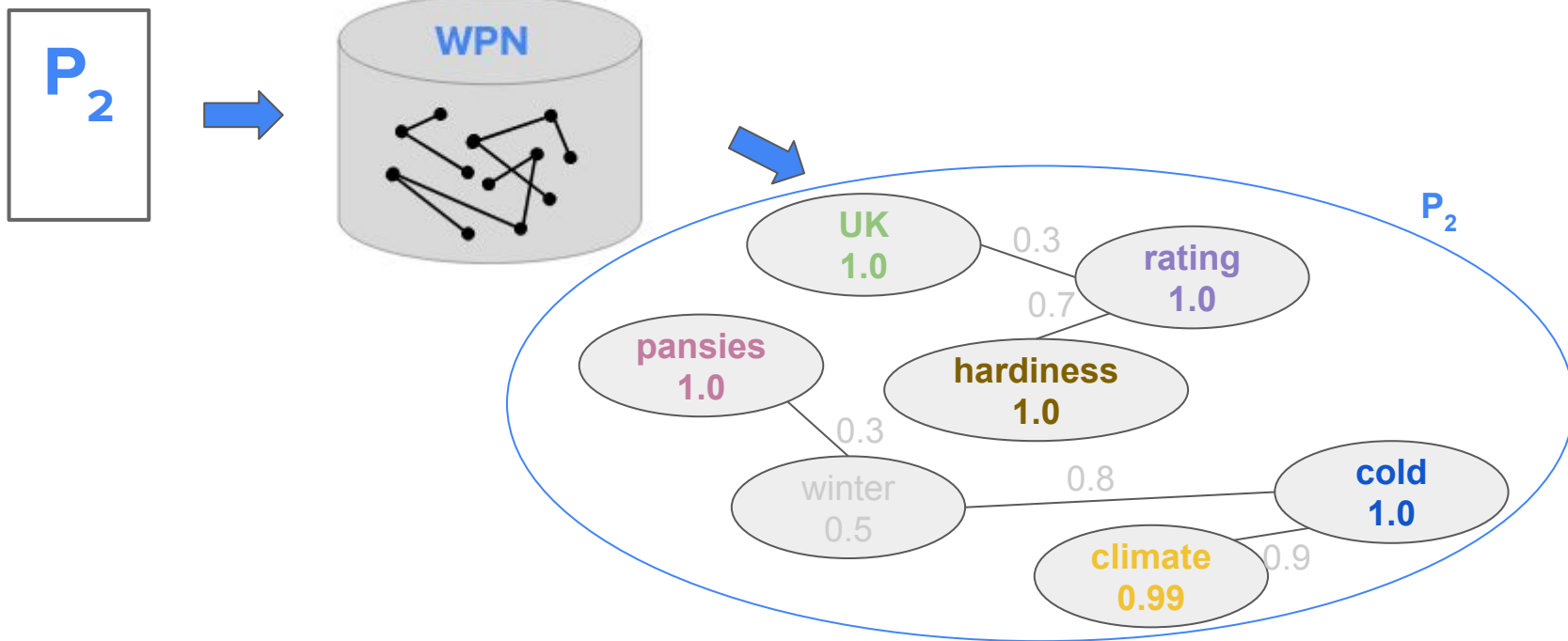


threshold:
node-weight ≥ 0.7

Step 3: Modeling Similarity

Conversational Query:

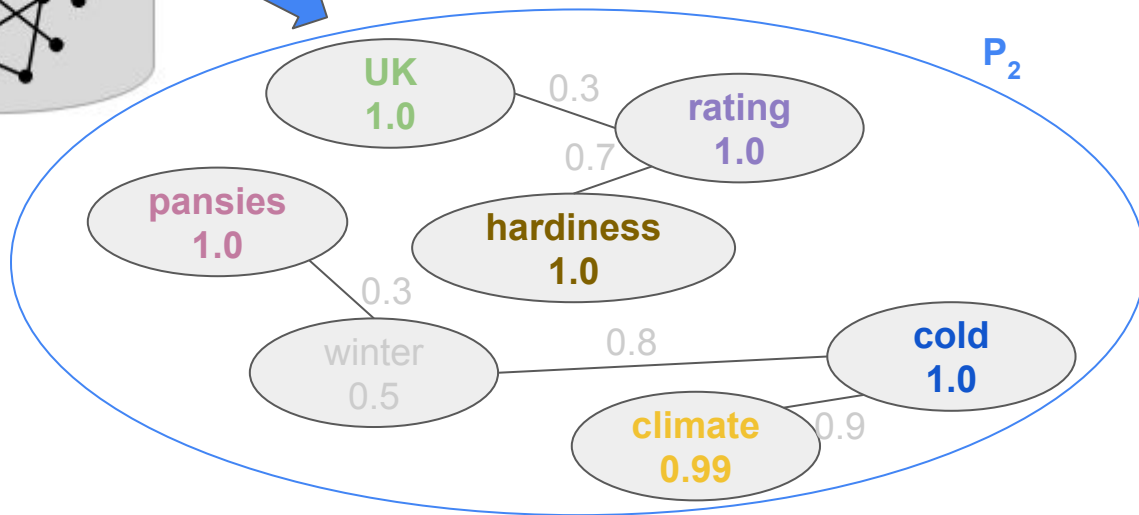
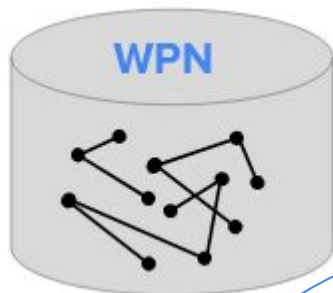
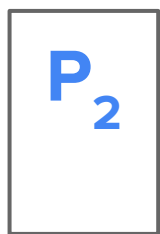
w_1^* (flowering plants **cold climates**) w_{T-1}^* (**pansies** tolerate) w_T^* (**UK hardiness rating**)



Step 3: Modeling Similarity

Conversational Query:

w_1^* (flowering plants **cold climates**) w_{T-1}^* (**pansies** tolerate) w_T^* (**UK hardiness rating**)



node-score(P_2) =

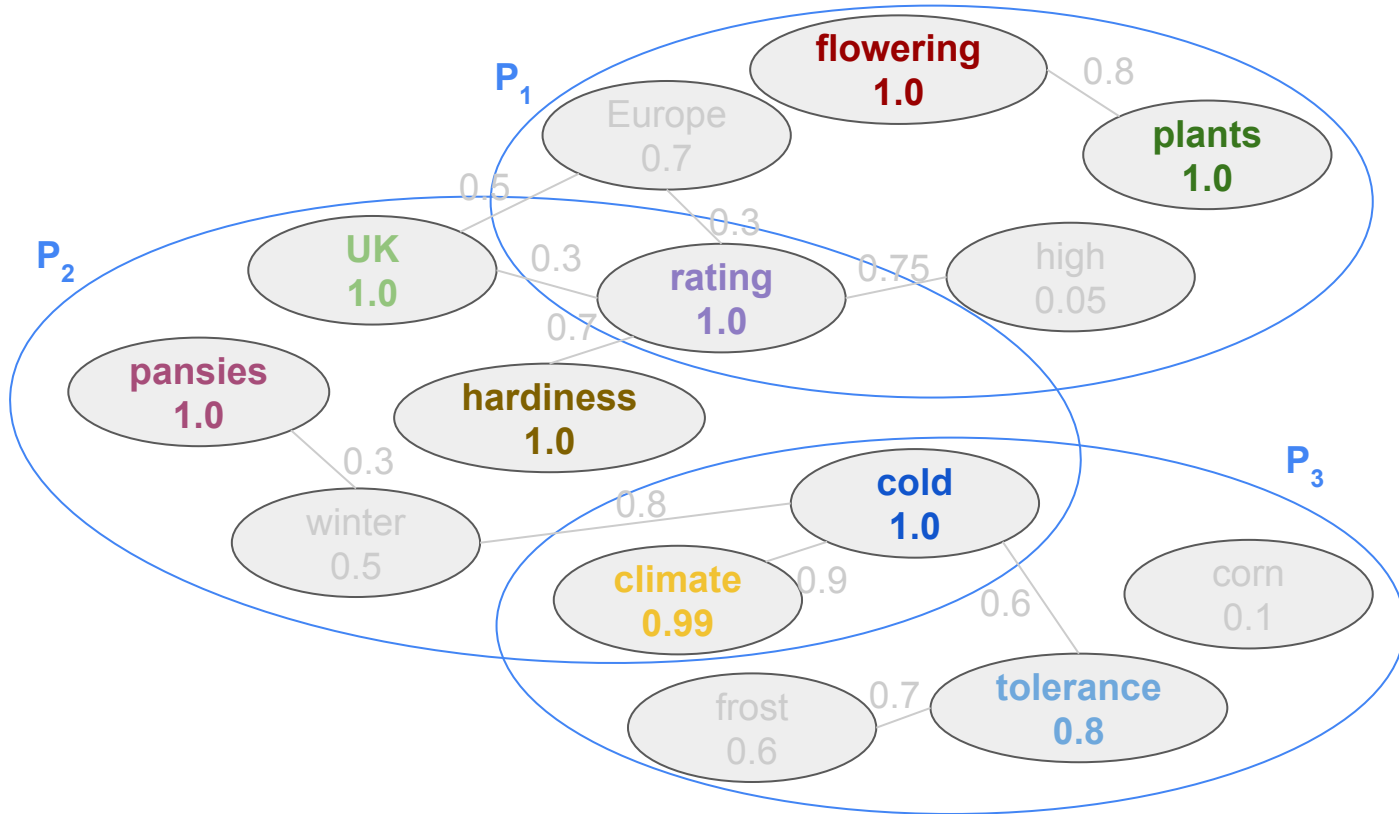
$$w_1^* (0.99 + 1.0) +$$

$$w_2^* 1.0 +$$

$$w_3^* (1.0 + 1.0 + 1.0)$$

Step 3: Modeling Similarity

w_1^* (**flowering plants cold climates**) w_{T-1}^* (**pansies tolerate**) w_T^* (**UK hardiness rating**)



Step 4: Modeling Coherence

P2: “Winter pansies have a UK hardiness rating of H5. In cold climate, pansies can ...”

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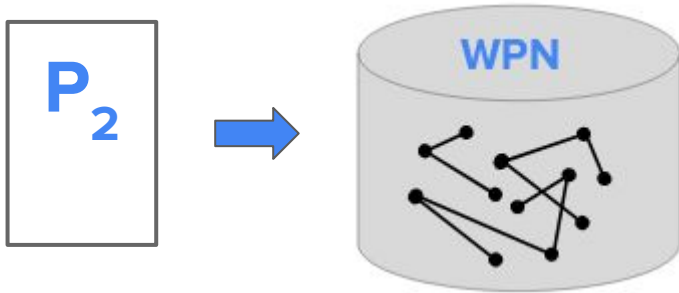
Step 4: Modeling Coherence

P2: “**Winter** **pansies** have a **UK hardiness rating** of H5. In cold climate, pansies can ...”

Pairs within context window 3:

(winter, pansies), (pansies, UK), (pansies, hardiness), (pansies, rating),
(winter, UK), (UK hardiness), (UK rating), (hardiness, rating), (UK, H5),
(hardiness, H5), (rating, H5), (H5, cold), (H5, climate), (H5, pansies), (cold,
climate), (cold, pansies), (climate, pansies)

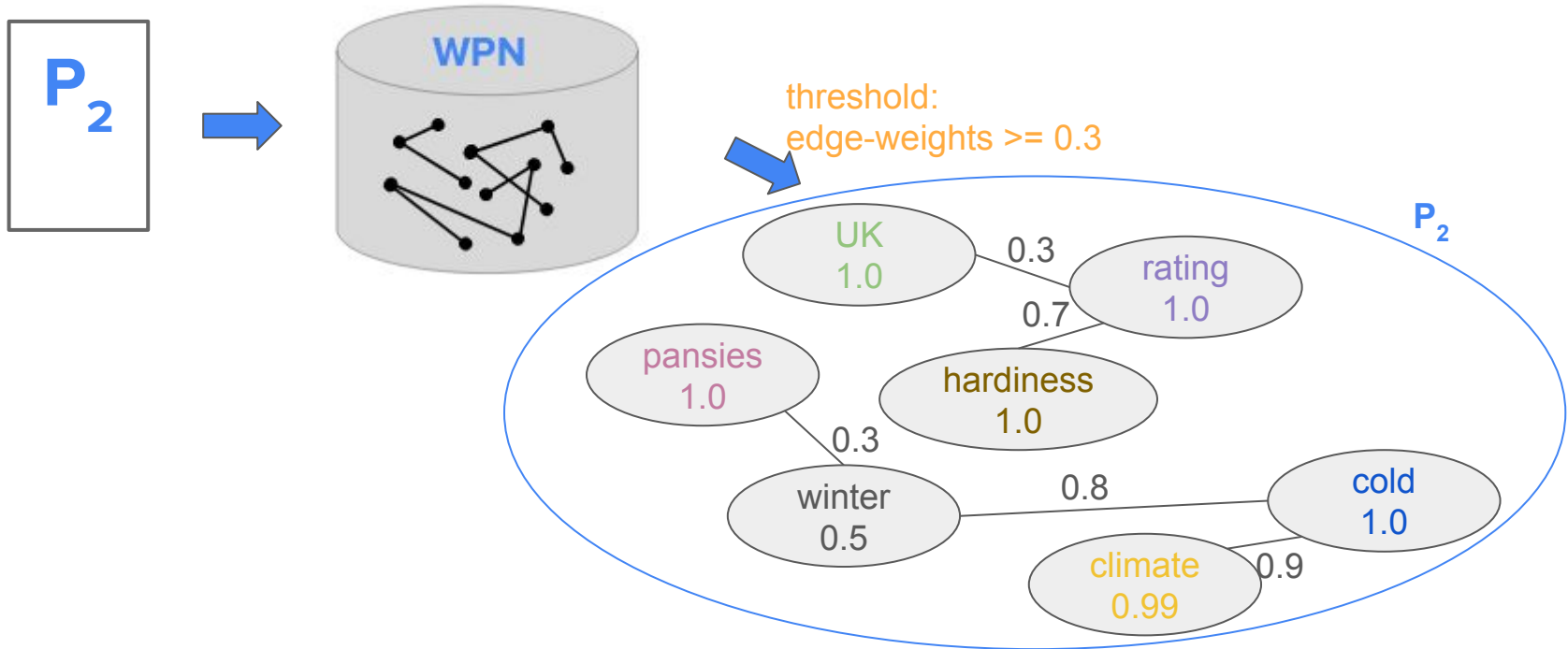
Step 4: Modeling Coherence



Step 4: Modeling Coherence

Relevant pairs:

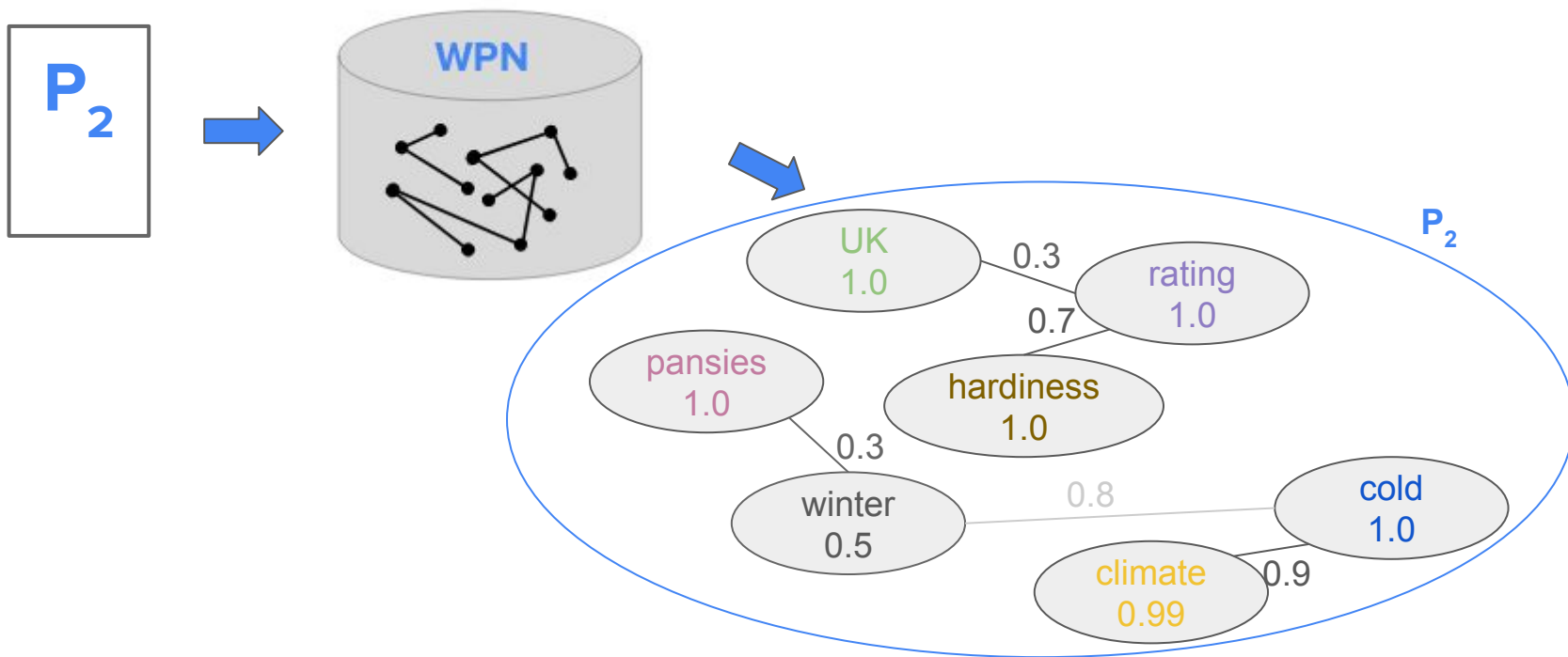
(winter, pansies), (UK rating), (hardiness, rating), (cold, climate)



Step 4: Modeling Coherence

Relevant pairs:

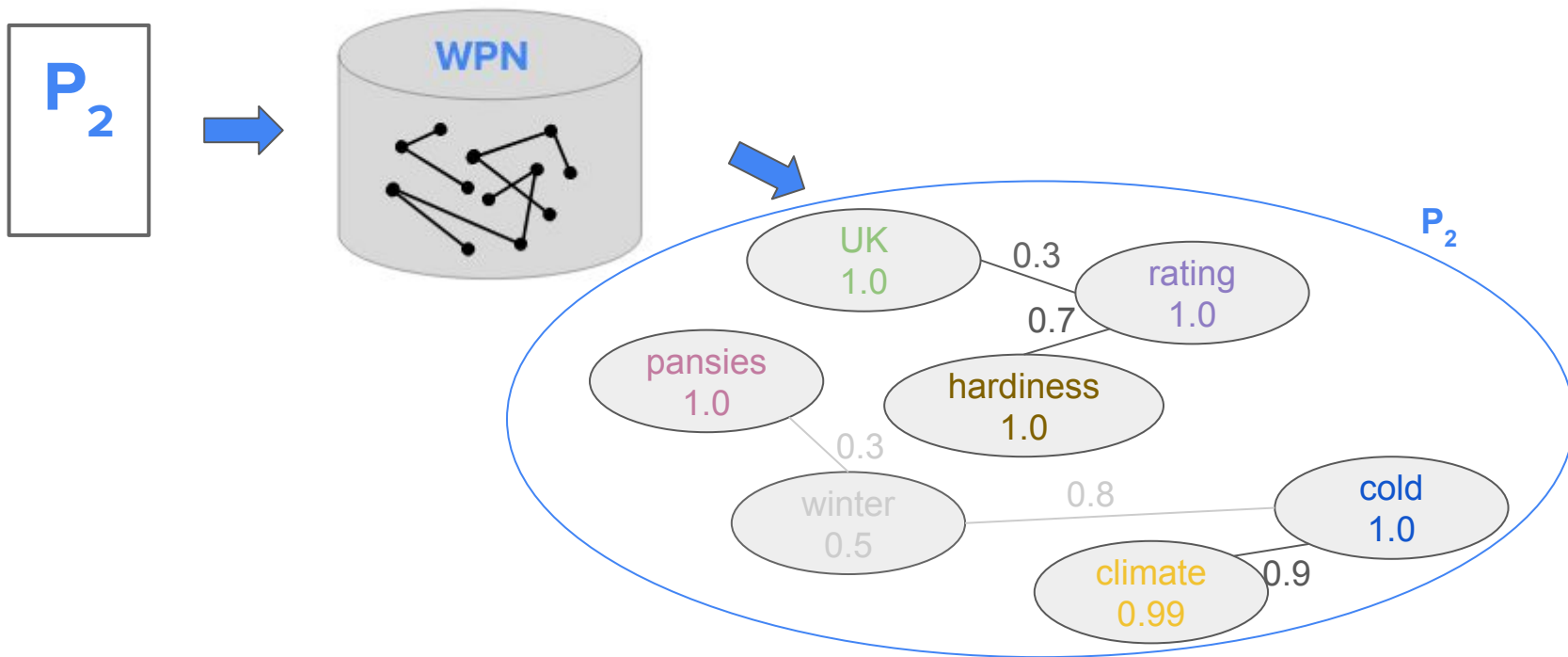
(winter, pansies), (UK rating), (hardiness, rating), (cold, climate)



Step 4: Modeling Coherence

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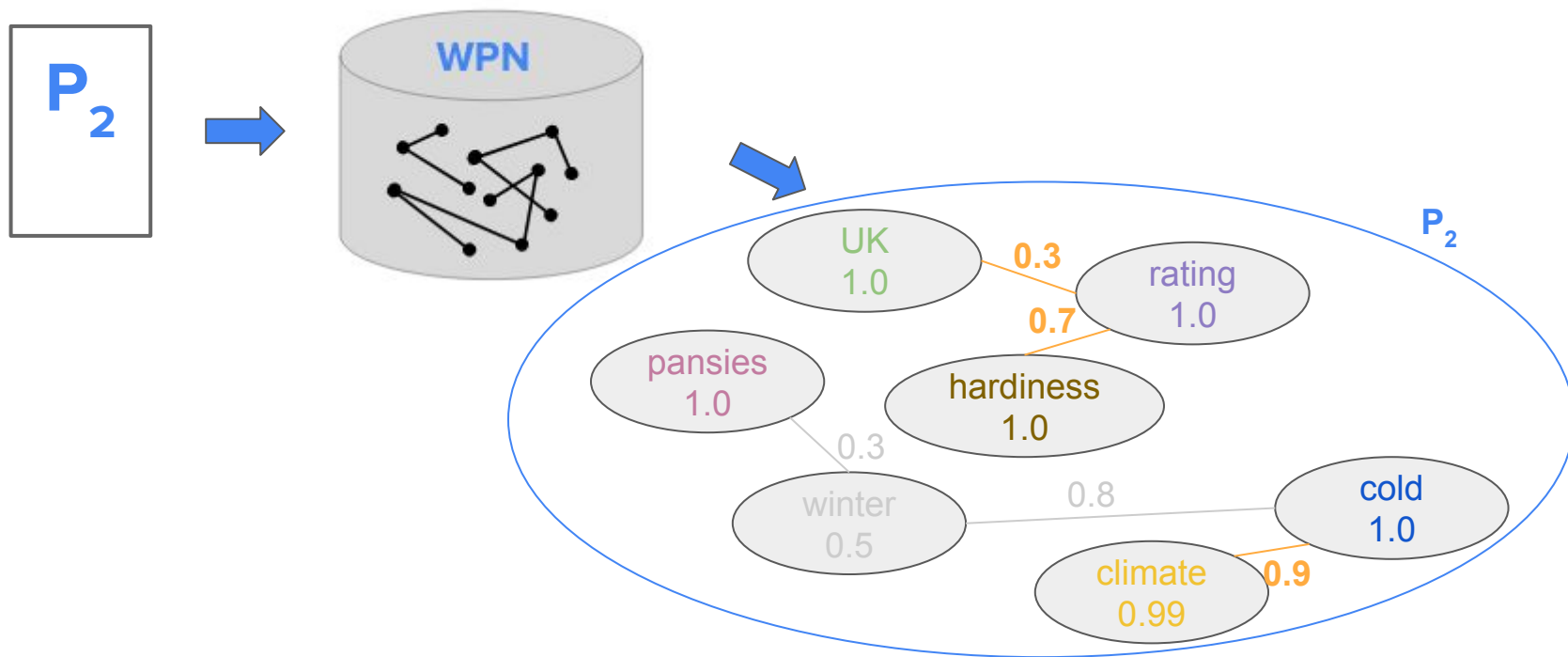
(winter, pansies), (UK rating), (hardiness, rating), (cold, climate)



Step 4: Modeling Coherence

Relevant pairs:

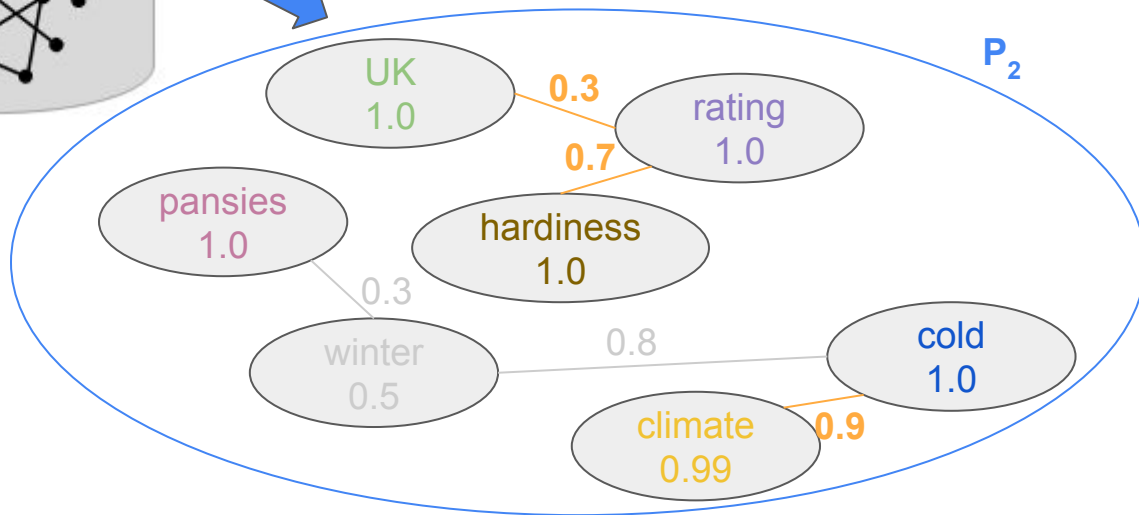
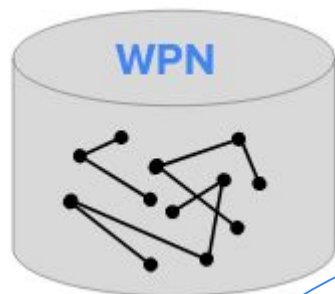
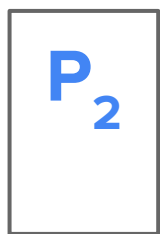
(winter, pansies), (UK rating), (hardiness, rating), (cold, climate)



Step 4: Modeling Coherence

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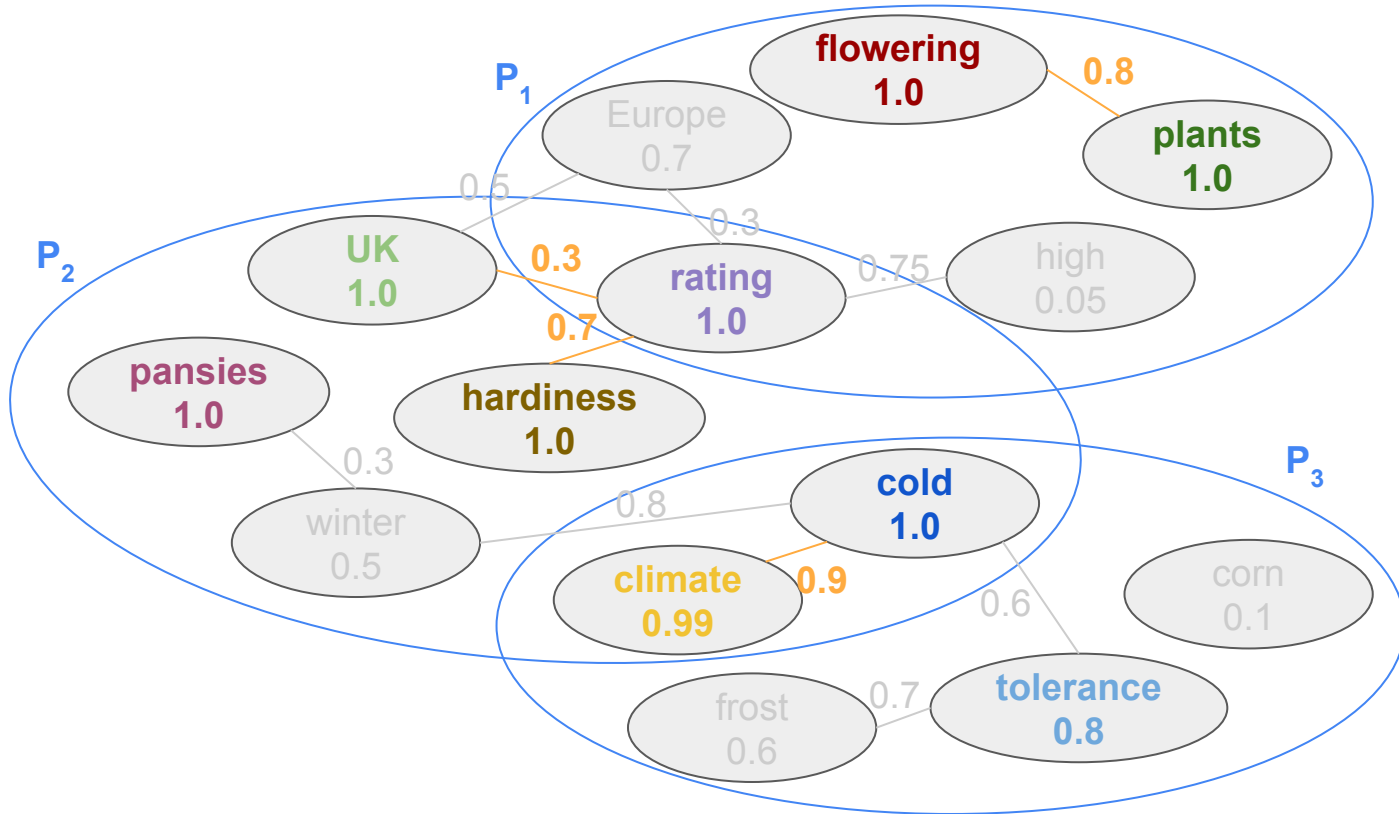
(winter, pansies), (UK rating), (hardiness, rating), (cold, climate)



$$\text{edge-score}(P_2) = 0.3 + 0.7 + 0.9$$

WPN adapted to current query

w_1^* (**flowering plants cold climates**) w_{T-1}^* (**pansies tolerate**) w_T^* (**UK hardiness rating**)



Step 5: Putting it together

$$\text{score}(P_i) = \text{indri-score}(P_i) + \text{node-score}(P_i) + \text{edge-score}(P_i)$$

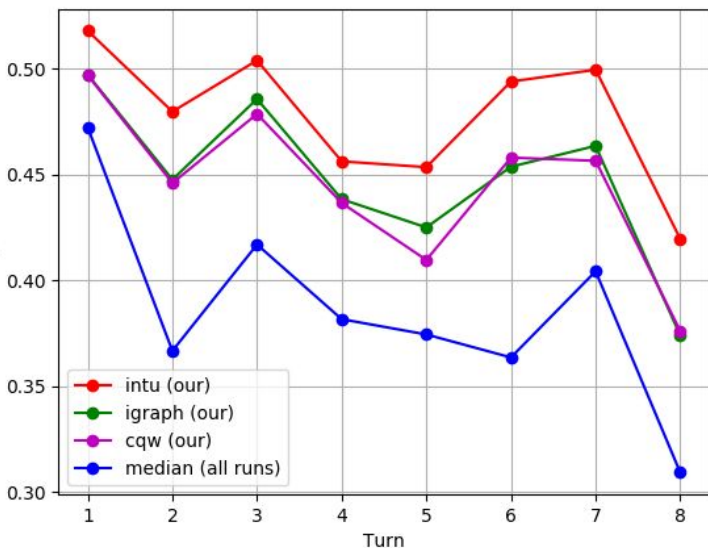
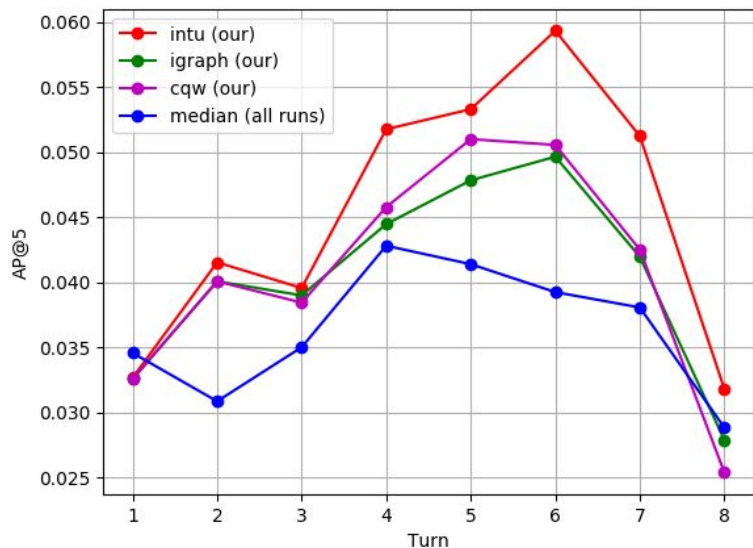
Step 5: Putting it together

$$\text{score}(P_i) = h_1 * \text{indri-score}(P_i) + h_2 * \text{node-score}(P_i) + h_3 * \text{edge-score}(P_i)$$

with hyperparameters h_1 , h_2 and h_3

Results

- ★ Submitted four runs that explored some variations of our CROWN method
- ★ Three out of four runs achieved **above median performance** over all submitted runs (**AP@5** and **nDCG@1000**)



Conclusion

- ★ CROWN is an unsupervised method for passage ranking
- ★ Word proximity network as underlying structure
- ★ Similarity as node weights and coherence as edge weights
- ★ In future work:
 - Consider term position
 - Better normalization
 - More parameter tuning

