

Commonsense for Generative Multi-Hop Question Answering Tasks

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Yicheng Wang*

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- Reading Comprehension Task (Lisa)
- Reading Comprehension Baseline (Yicheng)
- Commonsense Extraction (Lisa)
- Commonsense Model Integration (Yicheng)
- Results on NarrativeQA & WikiHop (Yicheng)

Reading Comprehension Task

Question

“What is the connection between Esther and Lady Dedlock?”



Context

"Sir Leicester Dedlock and his **wife** Lady Honoria live on his estate at Chesney Wold.."

"..Unknown to Sir Leicester, Lady Dedlock had a **lover** .. before she married and had a **daughter** with him.."

"..Lady Dedlock believes her daughter is dead. The daughter, Esther, is in fact alive.."

multi-hop reasoning



Answers

“Mother and daughter.”
“Mother and illegitimate child.”



- Motivation
 - Answer spans: 44.05%
 - Outside knowledge required: 42%
- Challenges
 - Intricate event timelines
 - “*Who leads Mickey back to boxing **after** the HBO documentary is released?*”
 - Large number of characters
 - “*Why did **Sophia** go to Russia with **Alexei**, instead of **John**?*”
 - Complex structure
 - “***Why** did Mickey have reservations about his fight in Atlantic City?*”

Baseline Multi-Hop Pointer-Generator



- Success on Multi-Hop Reasoning QA datasets require a model to have:

Baseline Multi-Hop Pointer-Generator



- Success on Multi-Hop Reasoning QA datasets require a model to have:
 - Strong NLU capabilities

Baseline Multi-Hop Pointer-Generator



- Success on Multi-Hop Reasoning QA datasets require a model to have:
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Baseline Multi-Hop Pointer-Generator



- Success on Multi-Hop Reasoning QA datasets require a model to have:
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 - Tools to process long/interconnected context

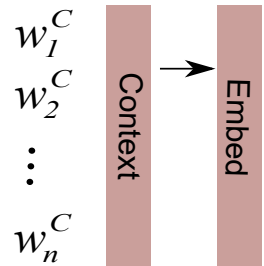
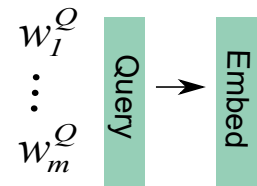
Baseline Multi-Hop Pointer-Generator



- Success on Multi-Hop Reasoning QA datasets require a model to have:
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 - Tools to process long/interconnected context
 - Strong generative modelling capabilities (rare words)

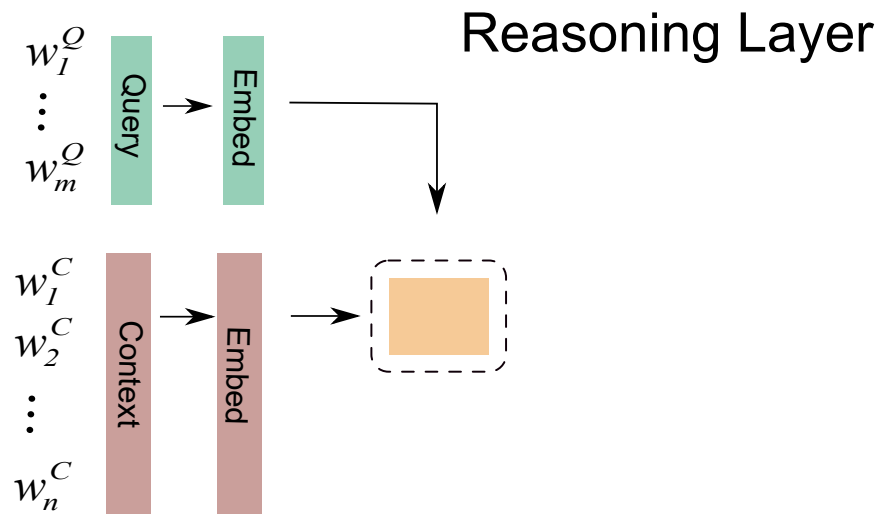
Baseline Multi-Hop Pointer-Generator

Embedding Layer



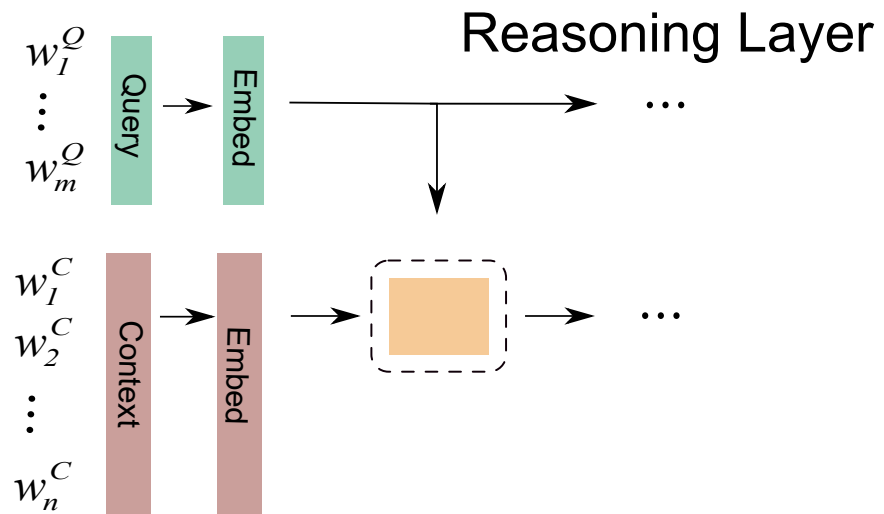
Baseline Multi-Hop Pointer-Generator

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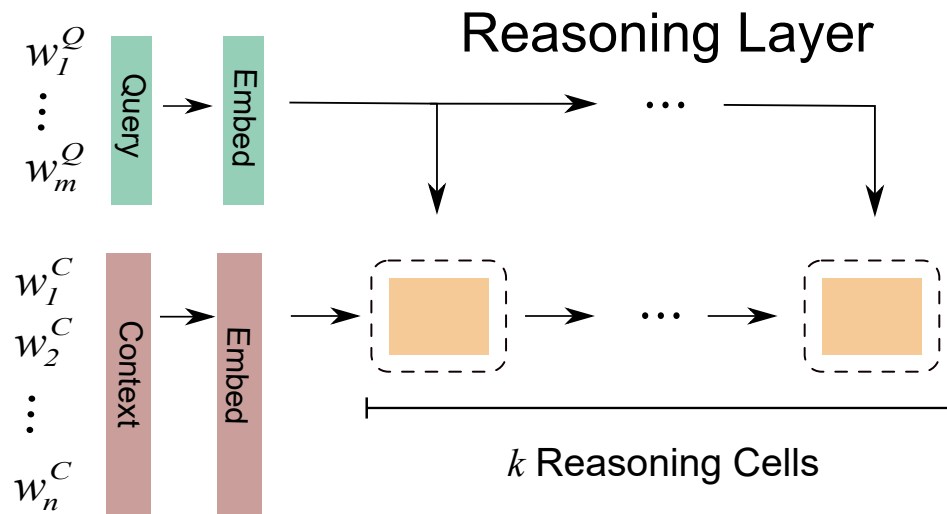
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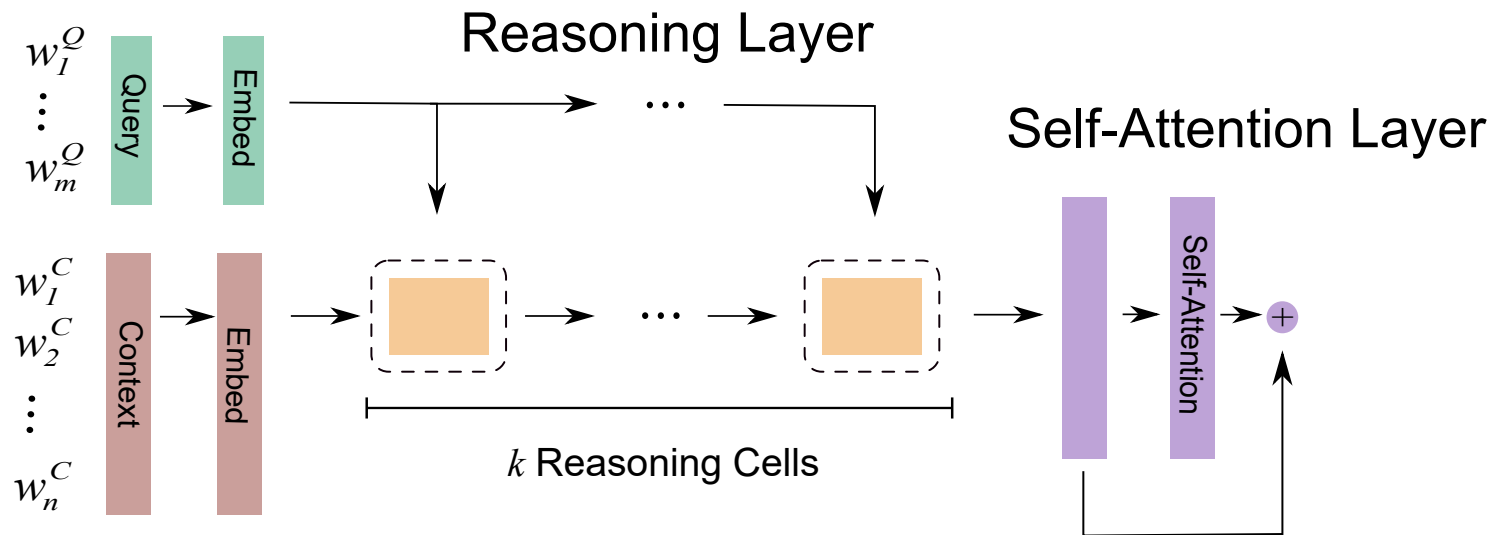
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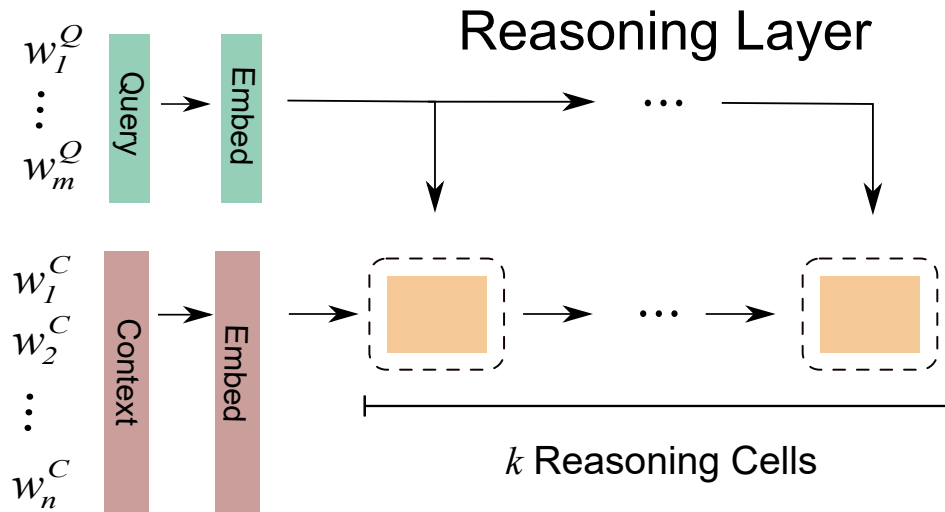
Baseline Multi-Hop Pointer-Generator

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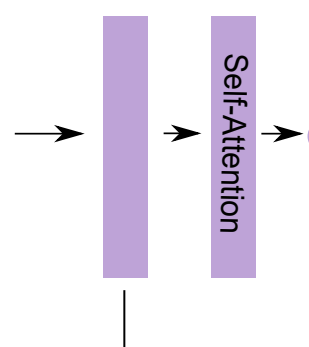


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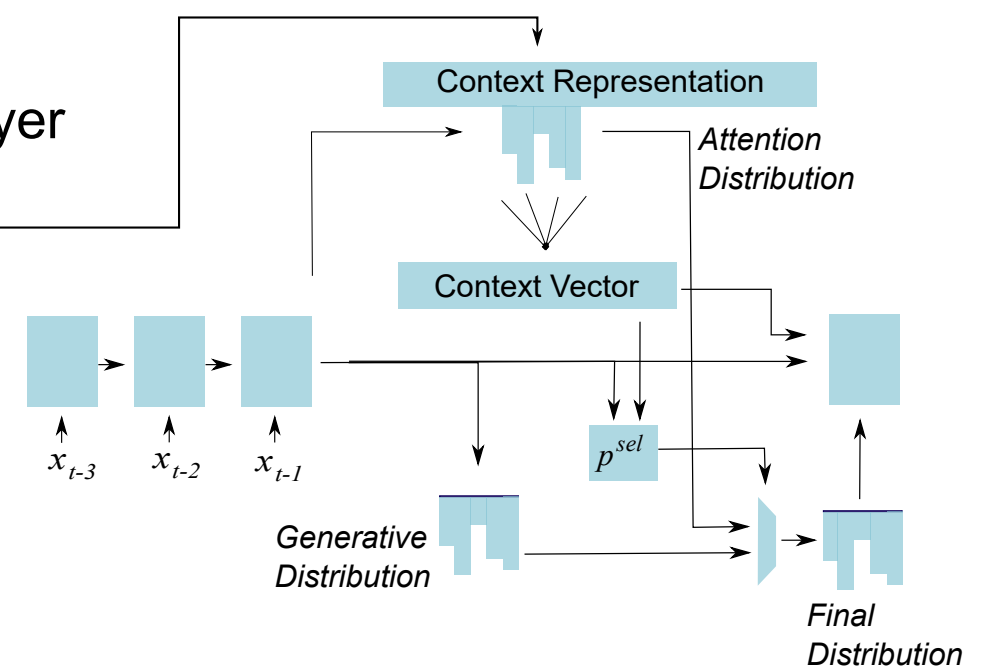
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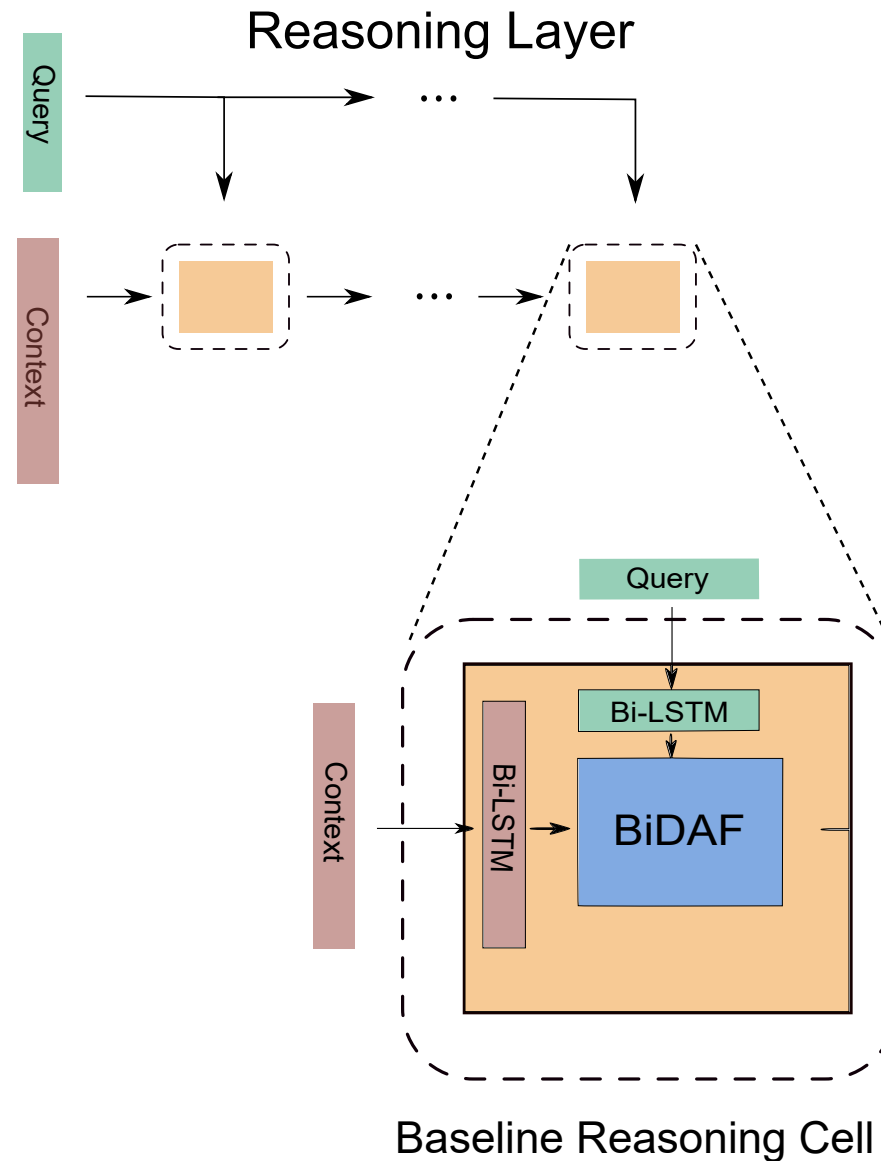
Self-Attention Layer



Decoding Layer



Baseline Reasoning Cell



Baseline Ablations

Model	BLEU-1 (Δ)	BLEU-4(Δ)	METEOR(Δ)	ROUGE-L(Δ)	CiDER(Δ)
Baseline	42.3 (-)	18.9 (-)	18.3 (-)	44.9 (-)	151.6 (-)
Single-Hop Baseline	32.5 (-9.8)	11.7 (-7.2)	12.9 (-5.4)	32.4 (-12.5)	95.7 (-55.9)
Without ELMo	32.8 (-9.5)	12.7 (-6.2)	13.6 (-4.7)	33.7 (-11.2)	103.1 (-48.5)
Without Self-Attn	37.0 (-5.3)	16.4 (-2.5)	15.6 (-2.7)	38.6 (-6.3)	125.6 (-26.0)

Commonsense Requirements



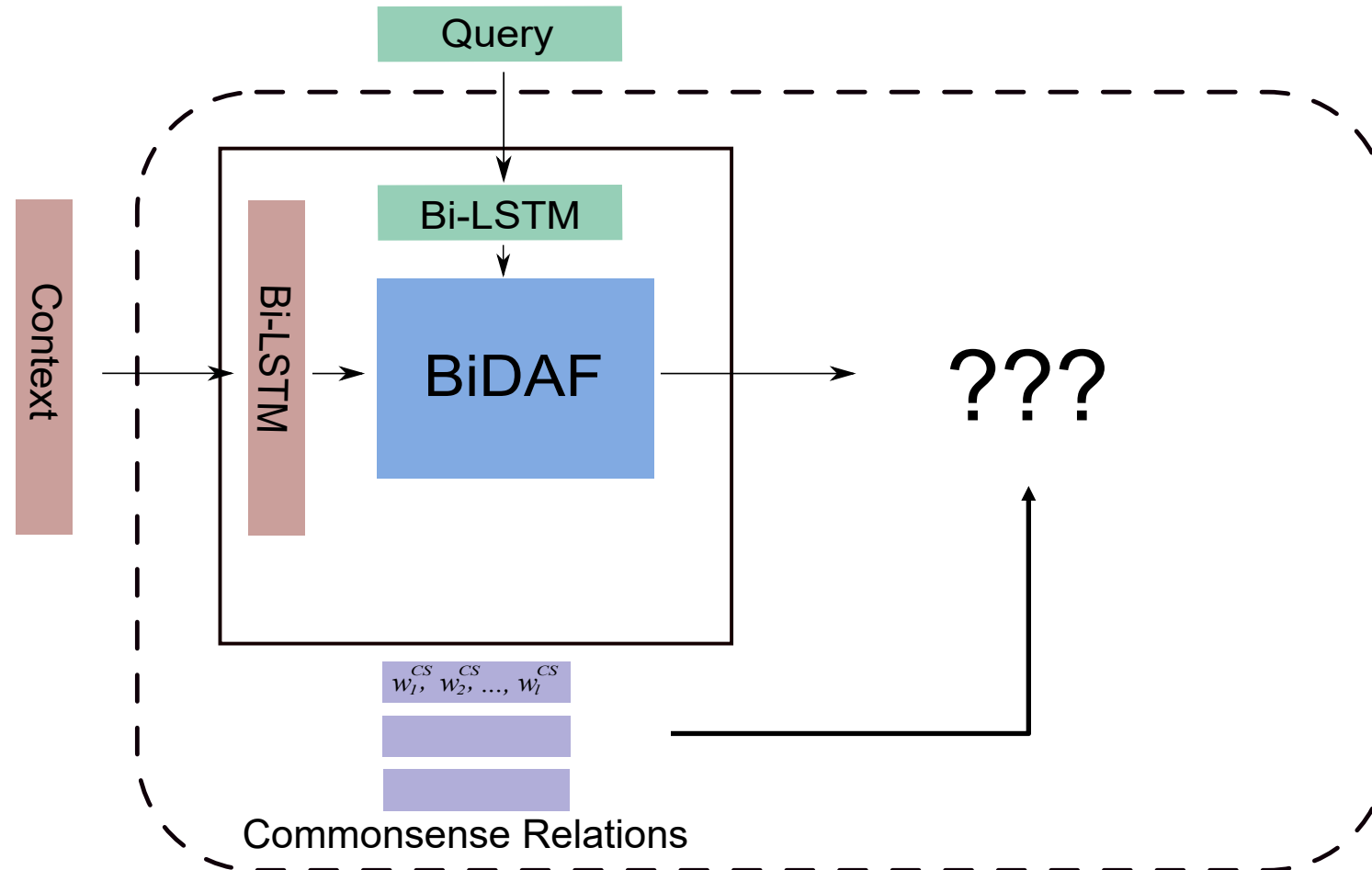
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 - Strong NLU capabilities
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Commonsense Requirements



- Success on Multi-Hop Reasoning QA datasets require a model to have:
 - Strong NLU capabilities
 - Ability to extract disjoint pieces of information
 - Tools to process long/interconnected context
 - Strong generative modelling capabilities (rare words)
 - Reason with implicit relations not mentioned in the context

Commonsense Addition



Types of Commonsense

- Taxonomic

What **physical disorders** do Paul and Charmian have in common?

Paula, like Charmian, is subject to **insomnia**, and Paula, like Charmian, is **unable to bear children.**

Insomnia and the inability to have kids

Types of Commonsense

- Taxonomic

What **physical disorders** do Paul and Charmian have in common?

Paula, like Charmian, is subject to **insomnia**, and Paula, like Charmian, is **unable to bear children**.

Insomnia and the inability to have kids

- Cause/Effect

What **position does Anne take** at Summerside School?

Having recently **received an offer** to be the principal of the Summerside School in the fall, Anne is keeping herself occupied.

Principal

Types of Commonsense

- Taxonomic

What **physical disorders** do Paul and Charmian have in common?

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Insomnia and the inability to have kids

- Cause/Effect

What **position does Anne take** at Summerside School?

Having recently **received an offer** to be the principal of the Summerside School in the fall, Anne is keeping herself occupied.

Principal

- Colloquialisms

Why did Jack take the job?

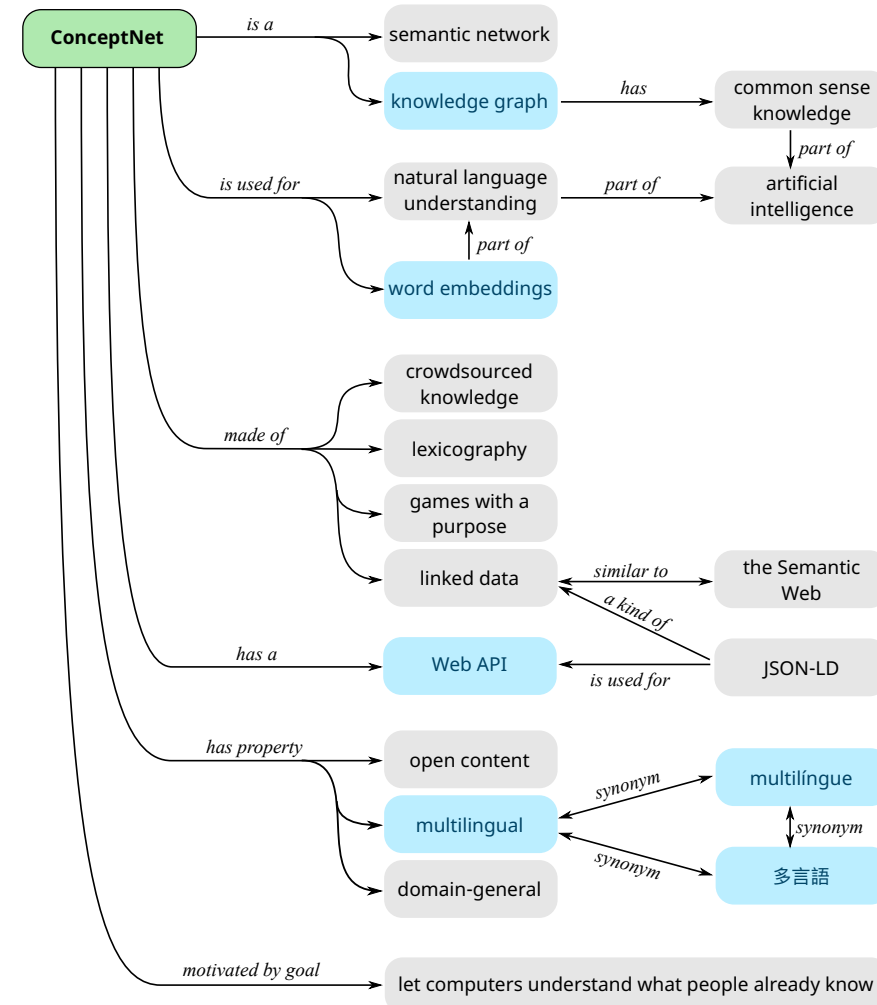
To make ends meet and against better judgement, he takes a job as a croupier.

Jack took the job **to pay for necessities**.

ConceptNet

[Speer and Havasi, 2012]

- A knowledge graph of semantic relations between concepts
- Has **28 million edges**
- Each edge represents one of 37 types of semantic relationship, e.g., UsedFor, FormOf, CapableOf, etc.



Commonsense Extraction

[Speer and Havasi, 2012]

Question

“What is the connection between Esther and Lady Dedlock?”

Context

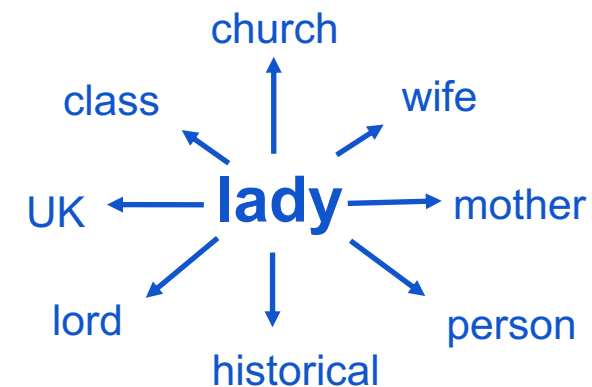
“Sir Leicester Dedlock and his **wife Lady** Honoria live on his estate at Chesney Wold..”

“..Unknown to Sir Leicester, Lady Dedlock had a **lover** .. before she married and had a **daughter** with him..”

“..**Lady Dedlock** believes her **daughter** is dead. The **daughter, Esther**, is in fact alive..”

“..Esther sees Lady Dedlock at **church** and talks with her later at Chesney Wold though neither woman recognizes **their** connection..”

ConceptNet



multi-hop reasoning

lady → mother → daughter → child

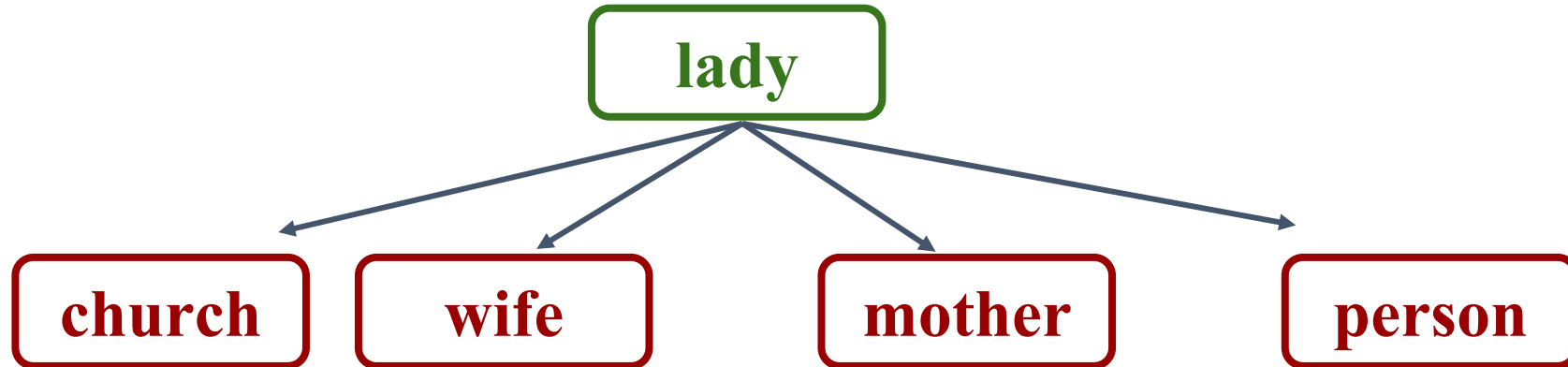
Answers

“Mother and daughter.”
“Mother and illegitimate child.”

lady

Question concept

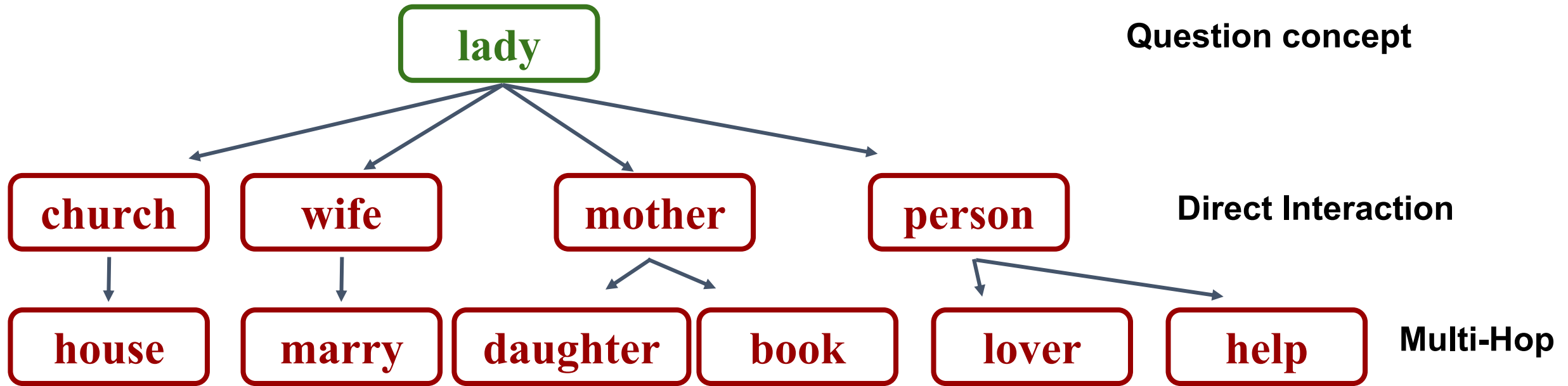
Tree Construction



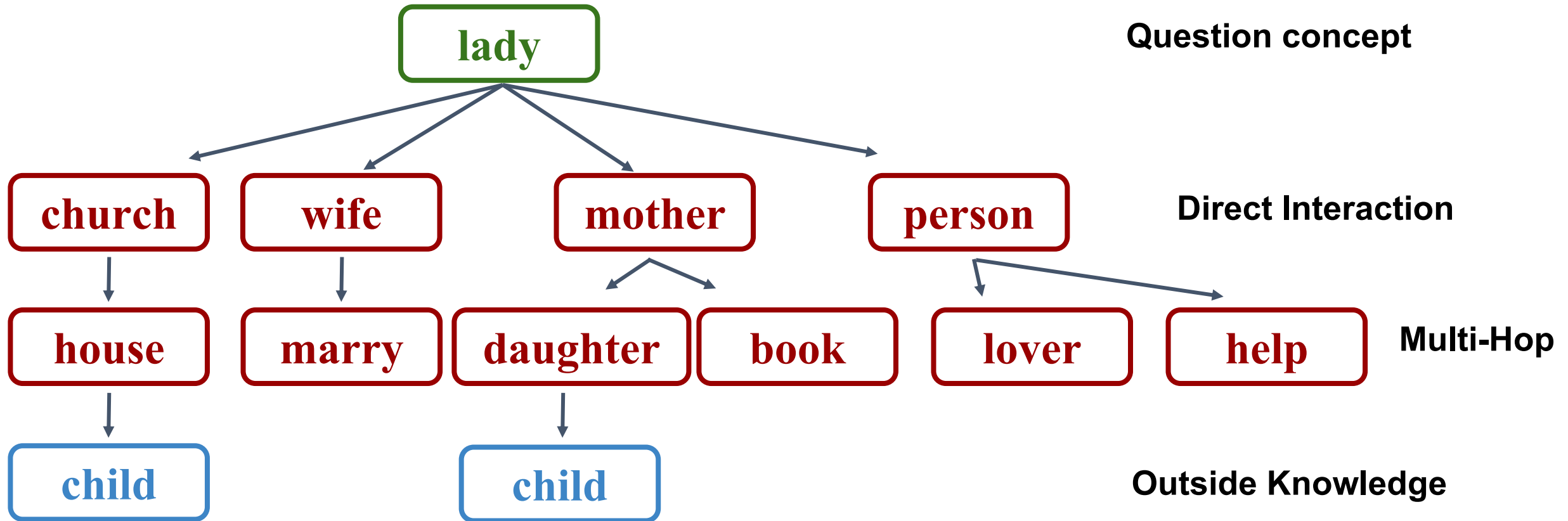
Question concept

Direct Interaction

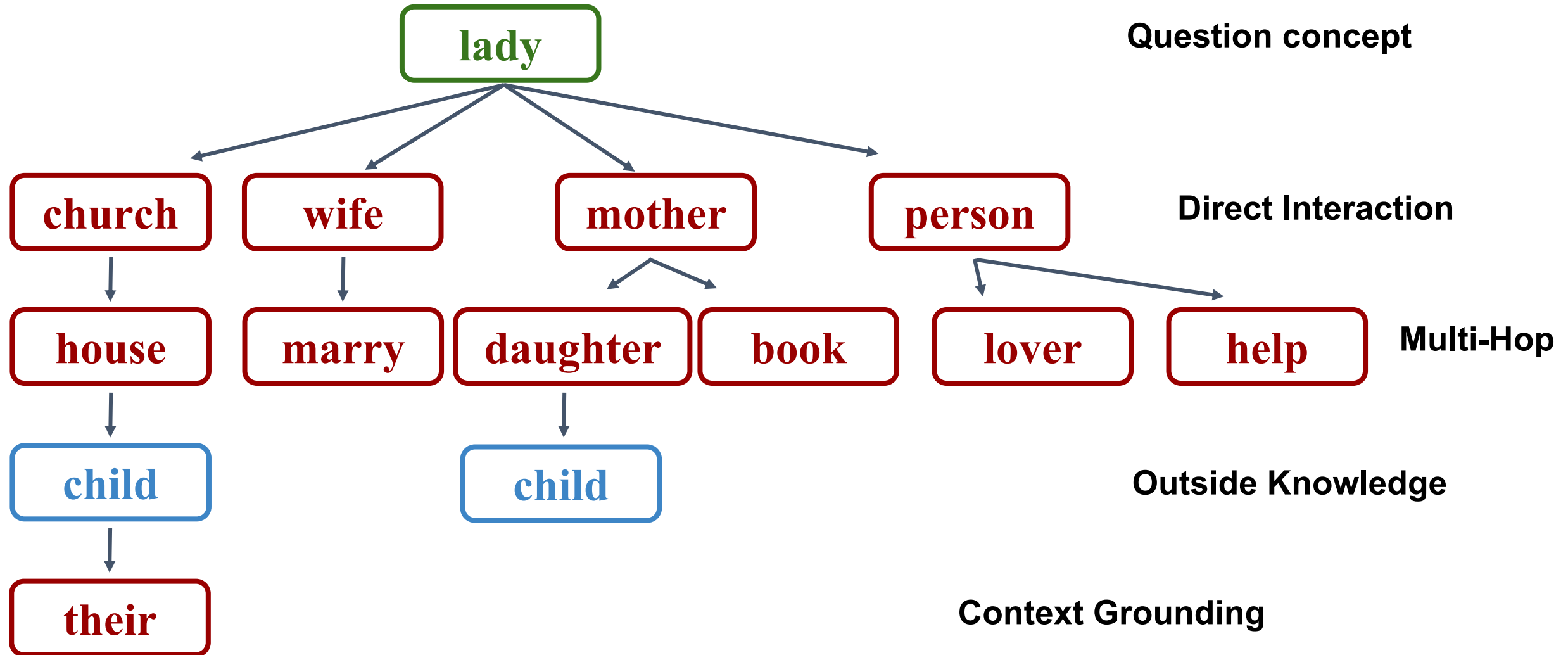
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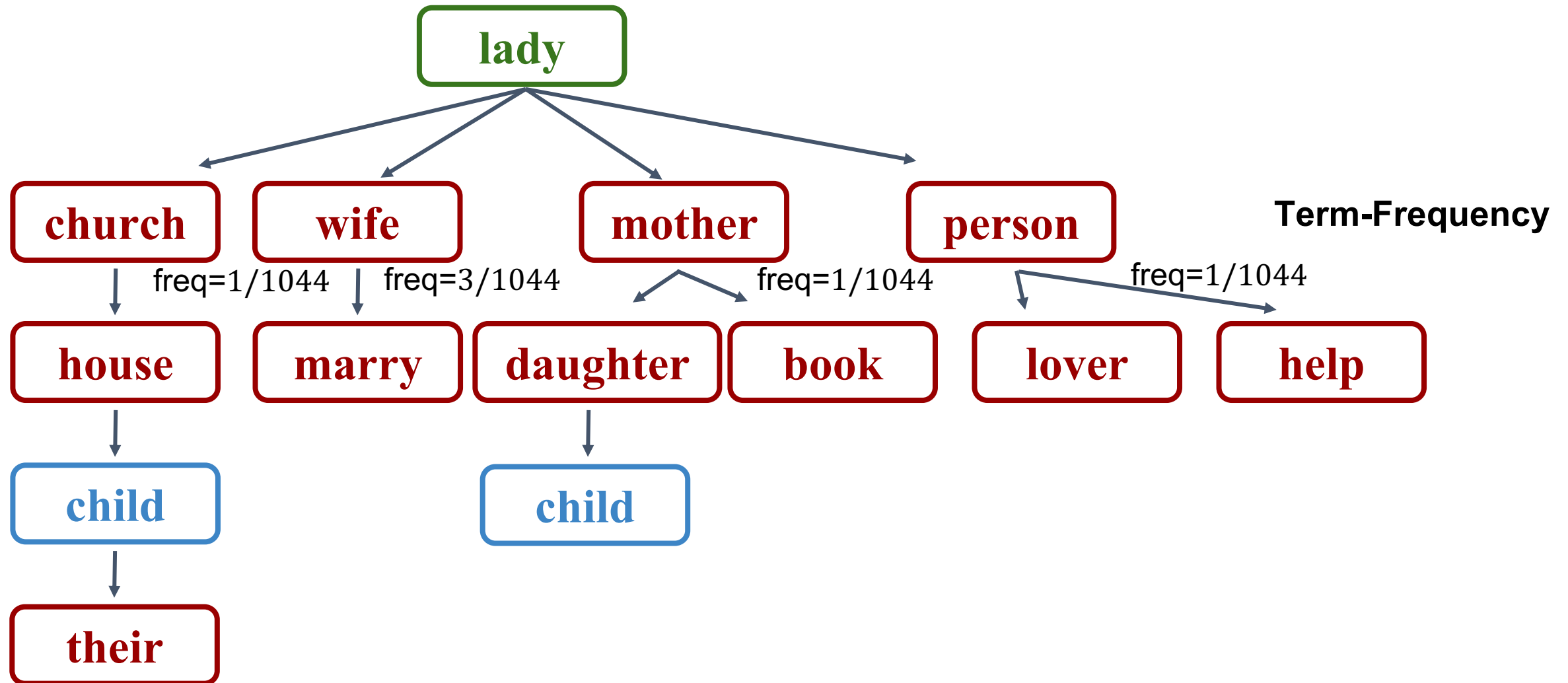
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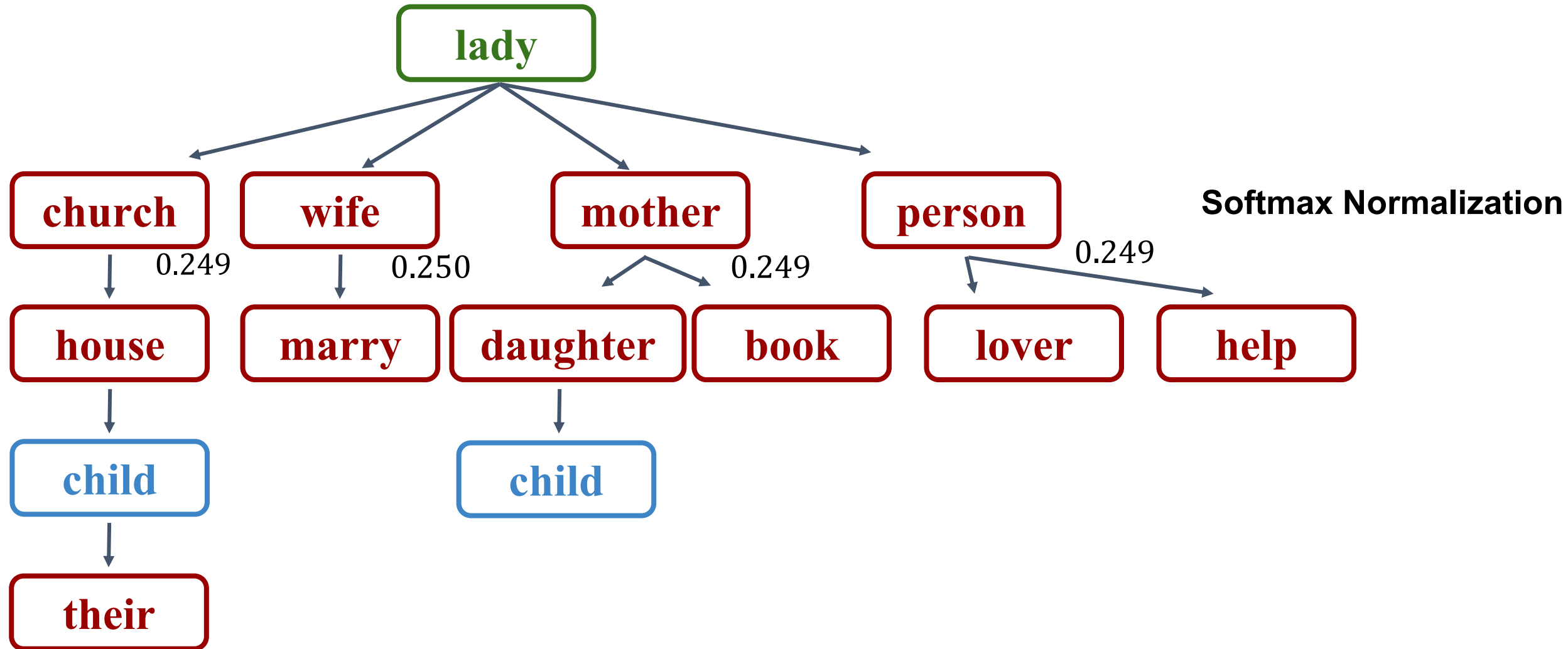
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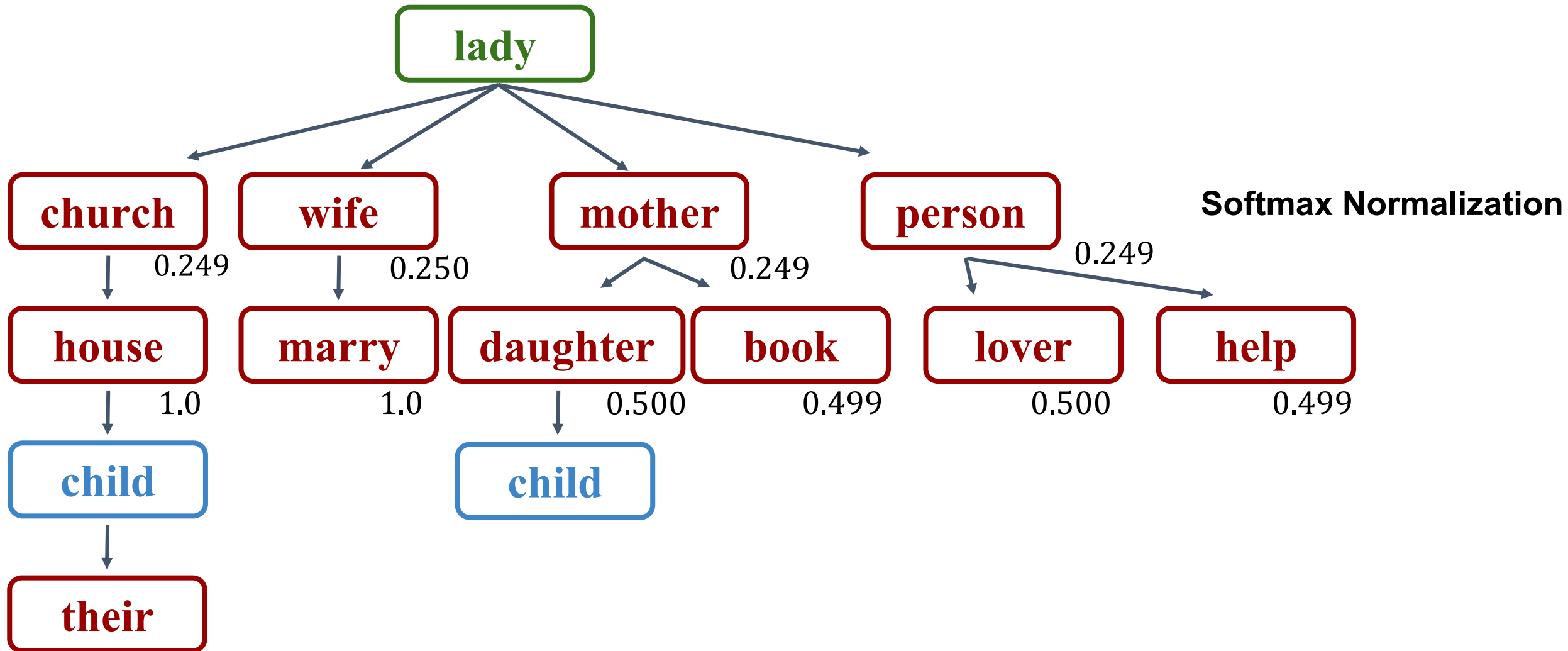
Initial Node Scoring



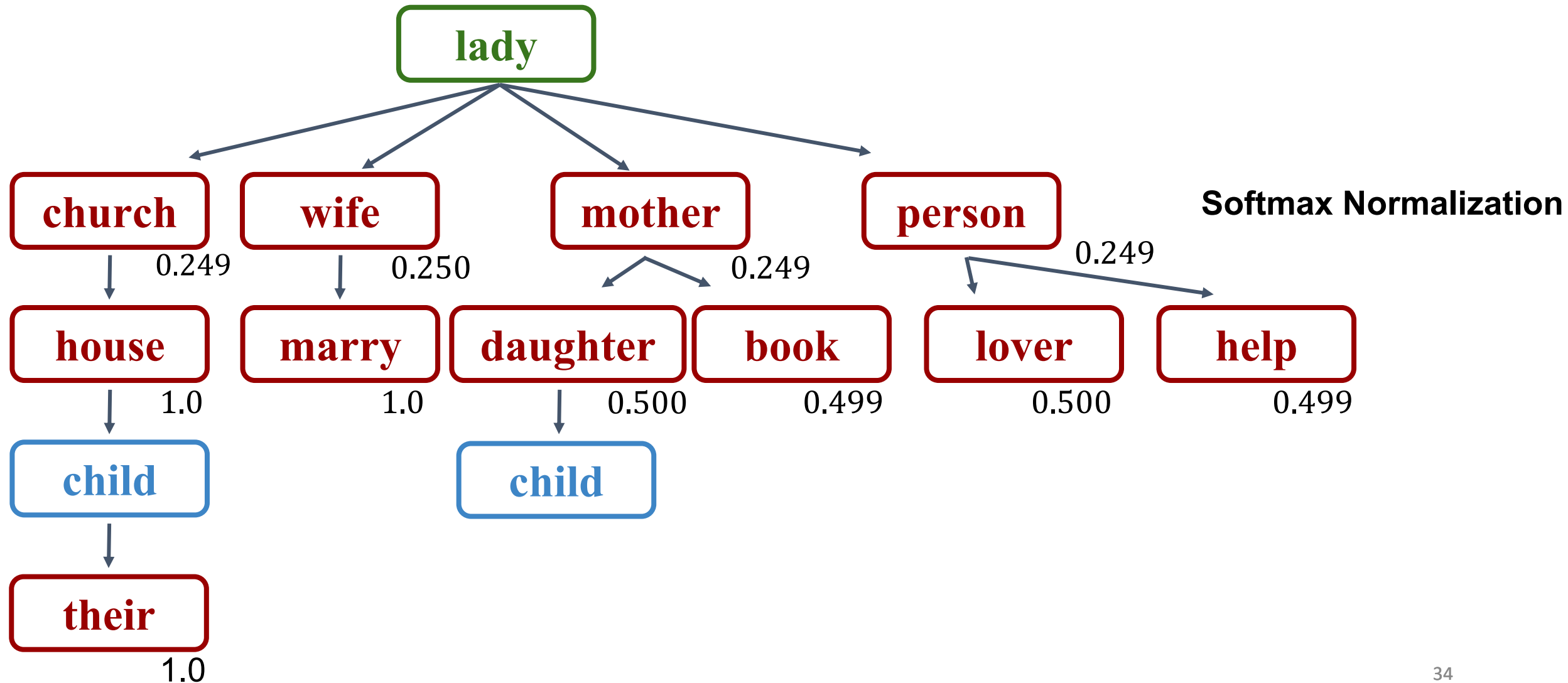
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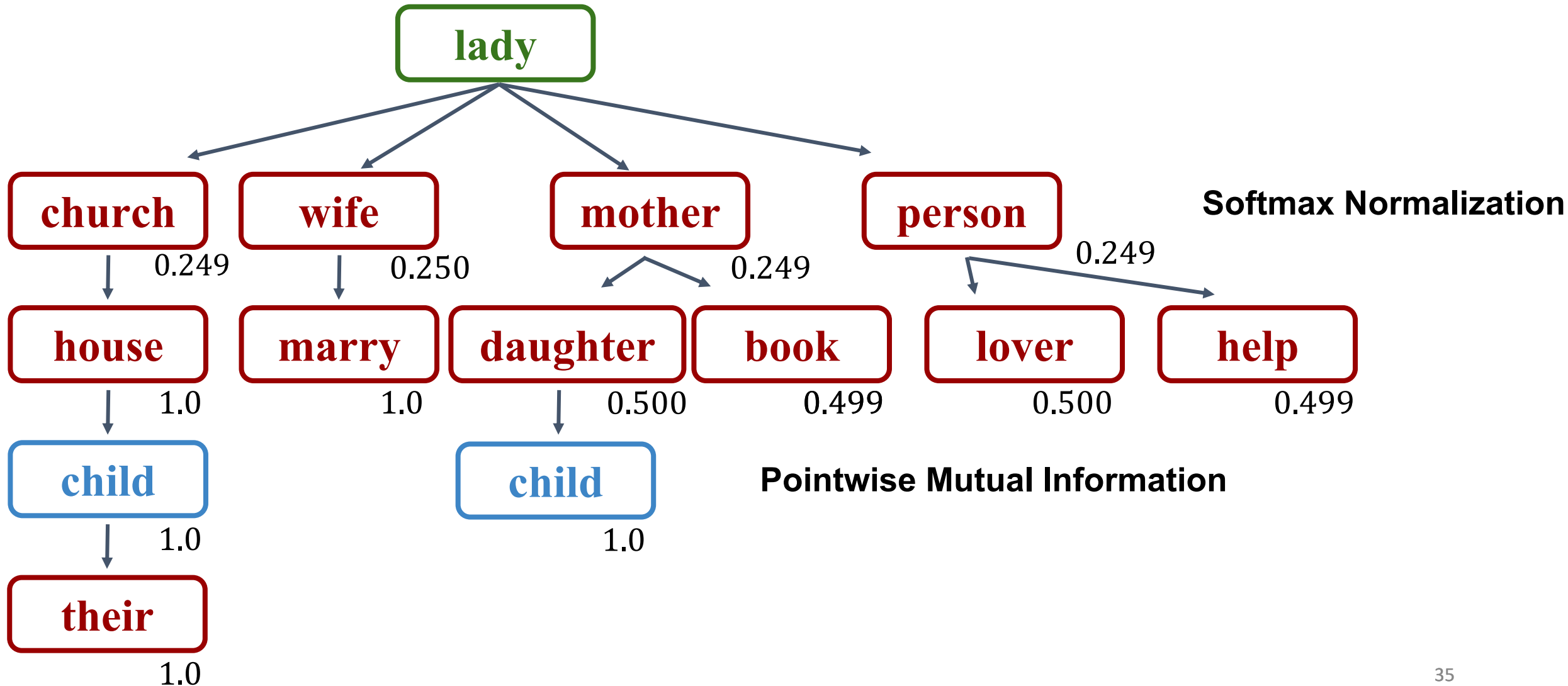
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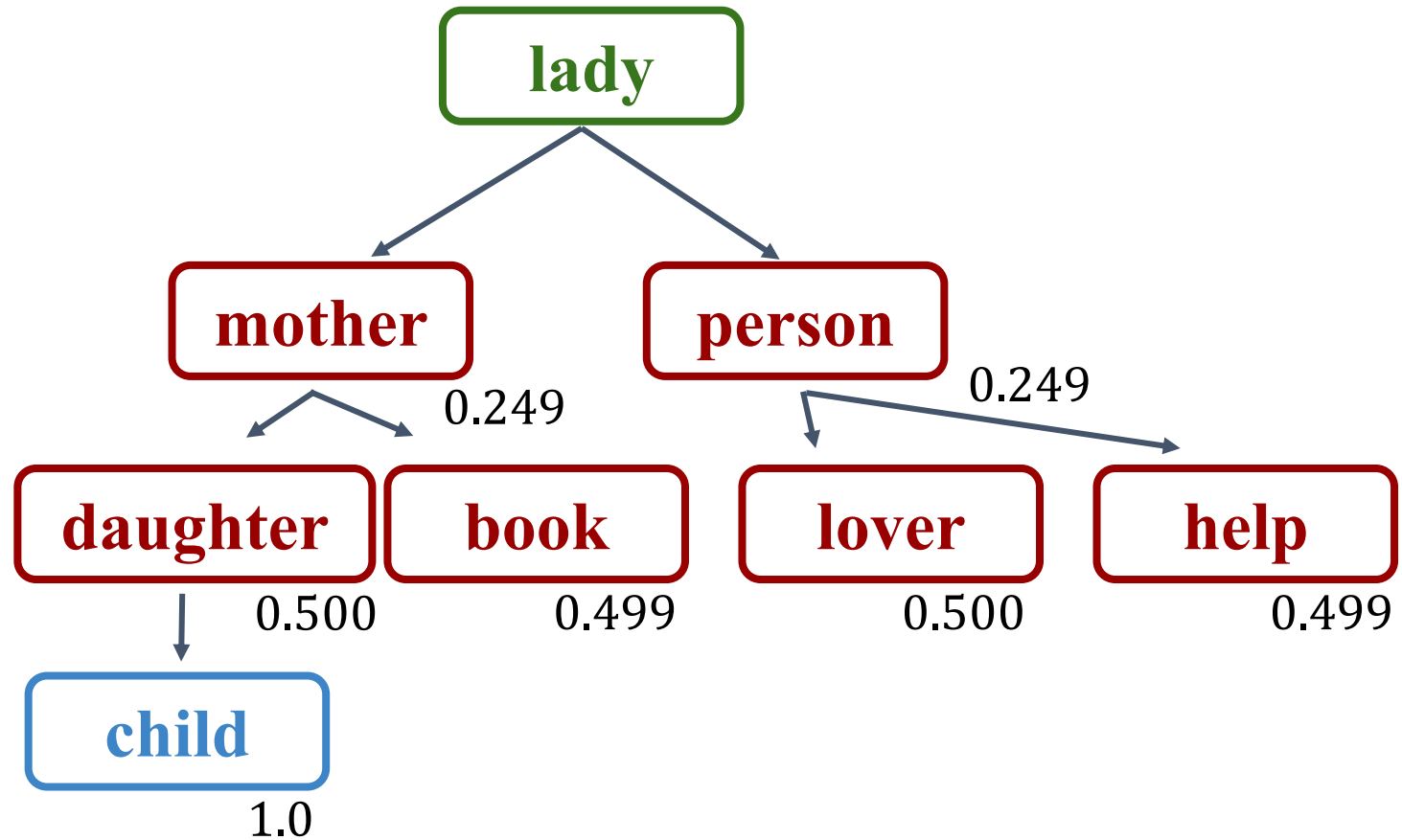
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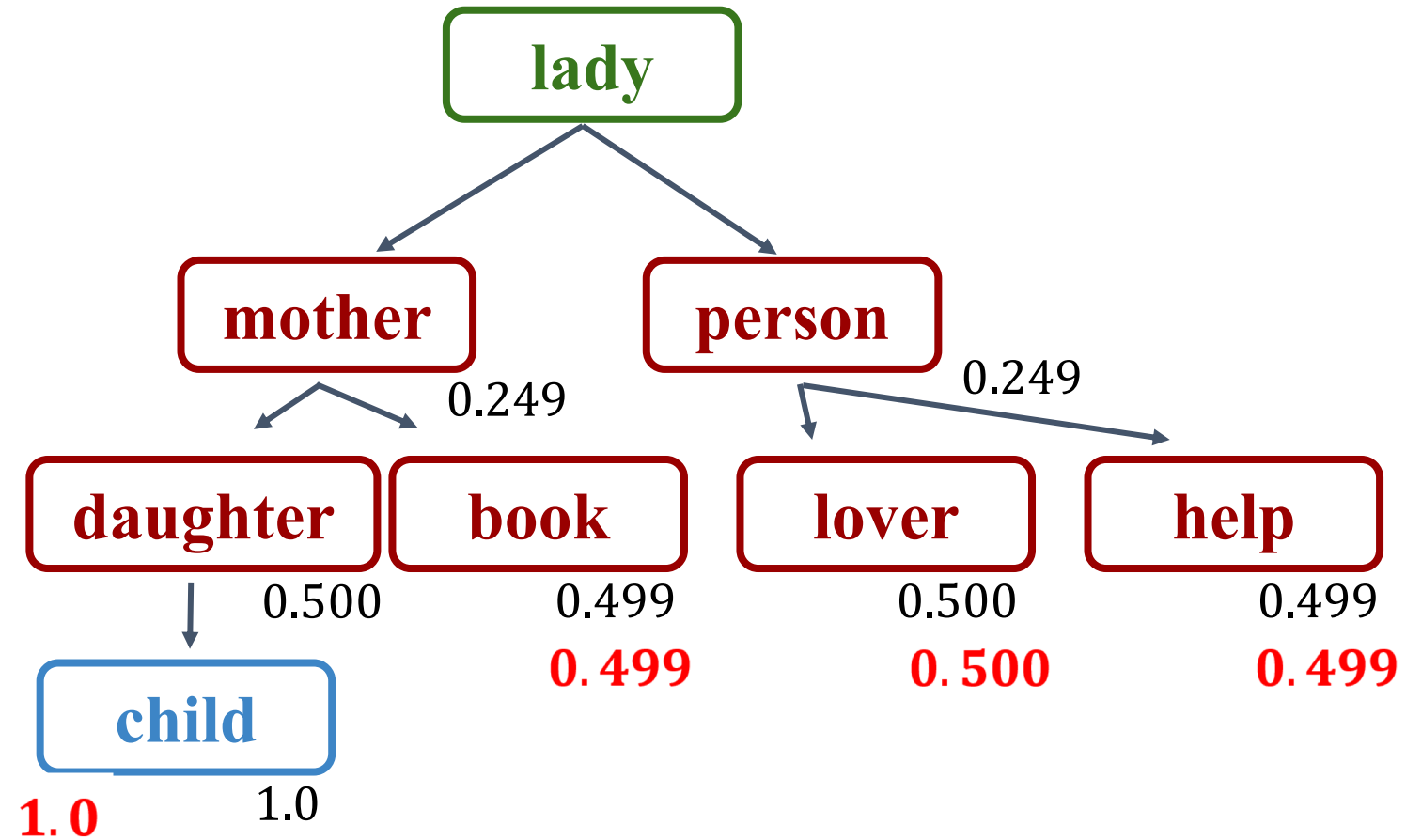
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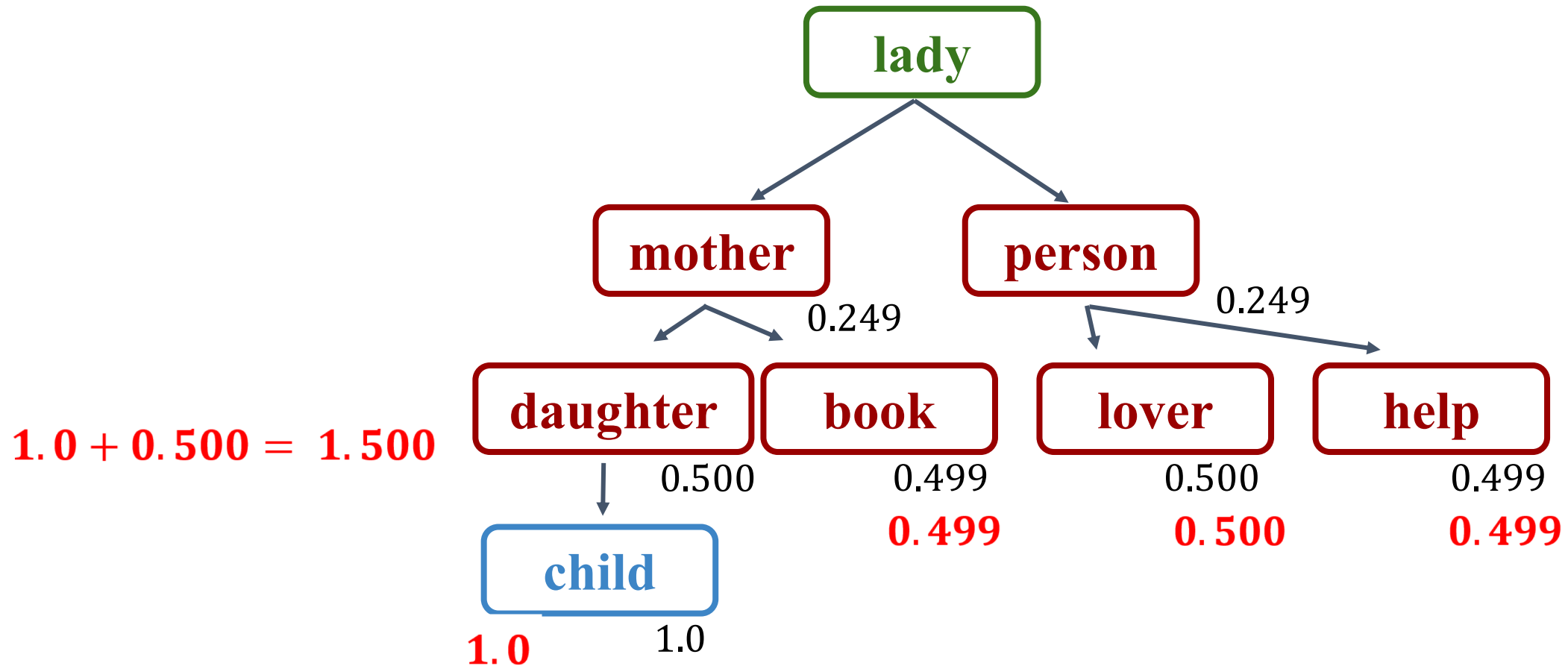
Cumulative Node Scoring



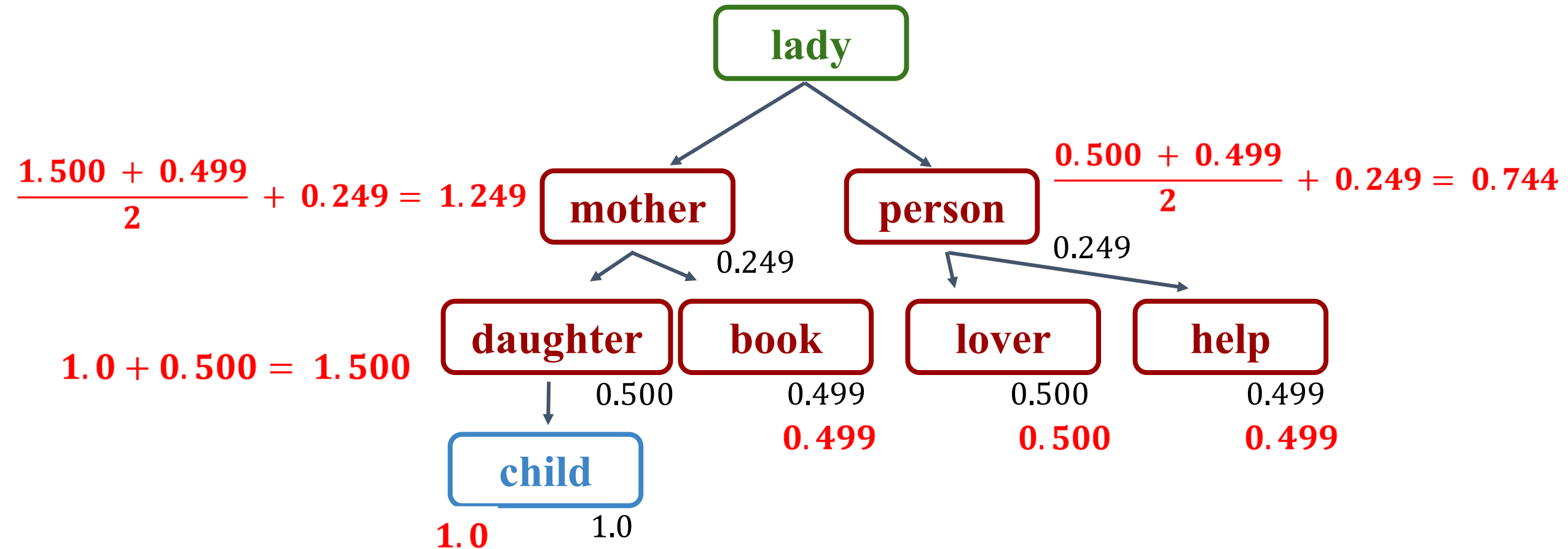
Cumulative Node Scoring



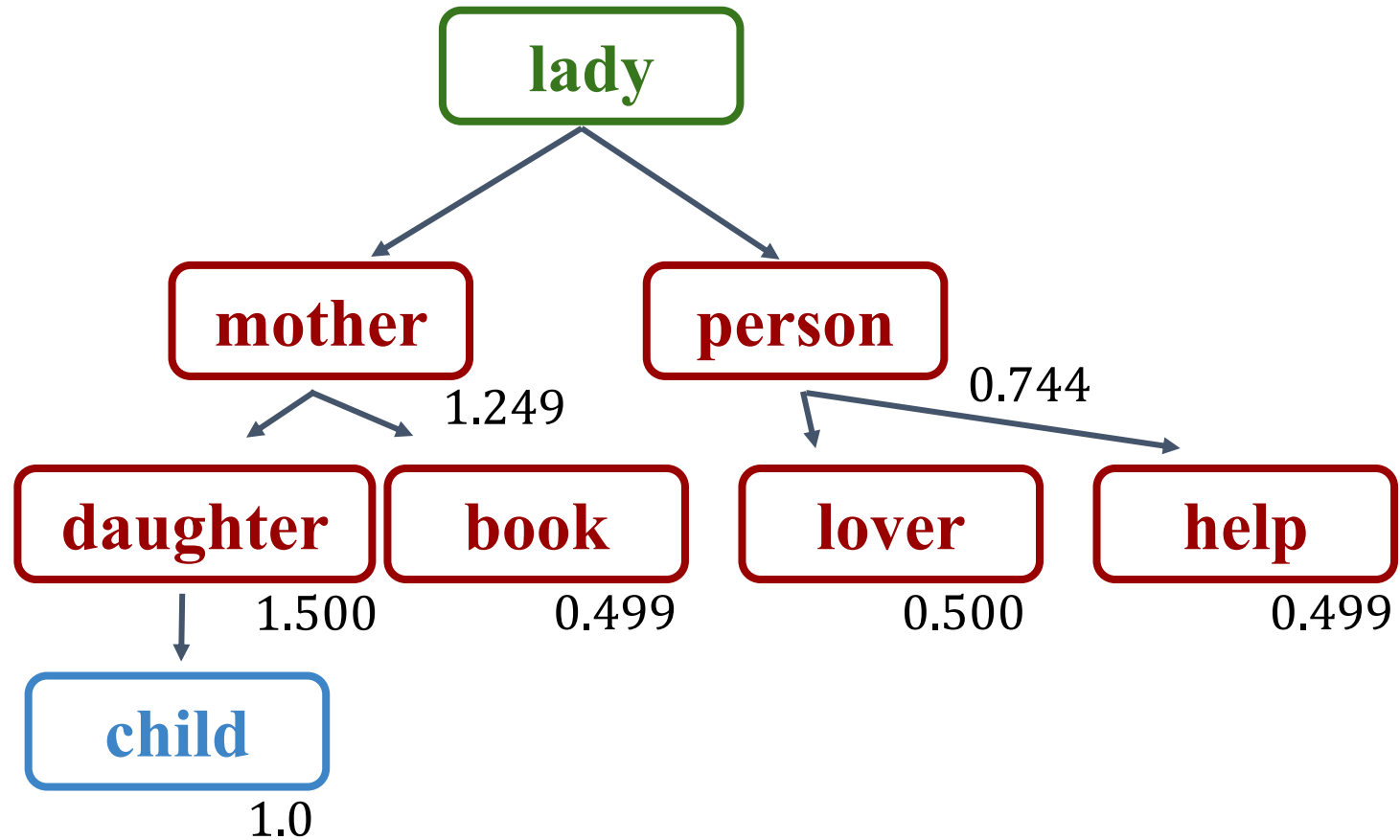
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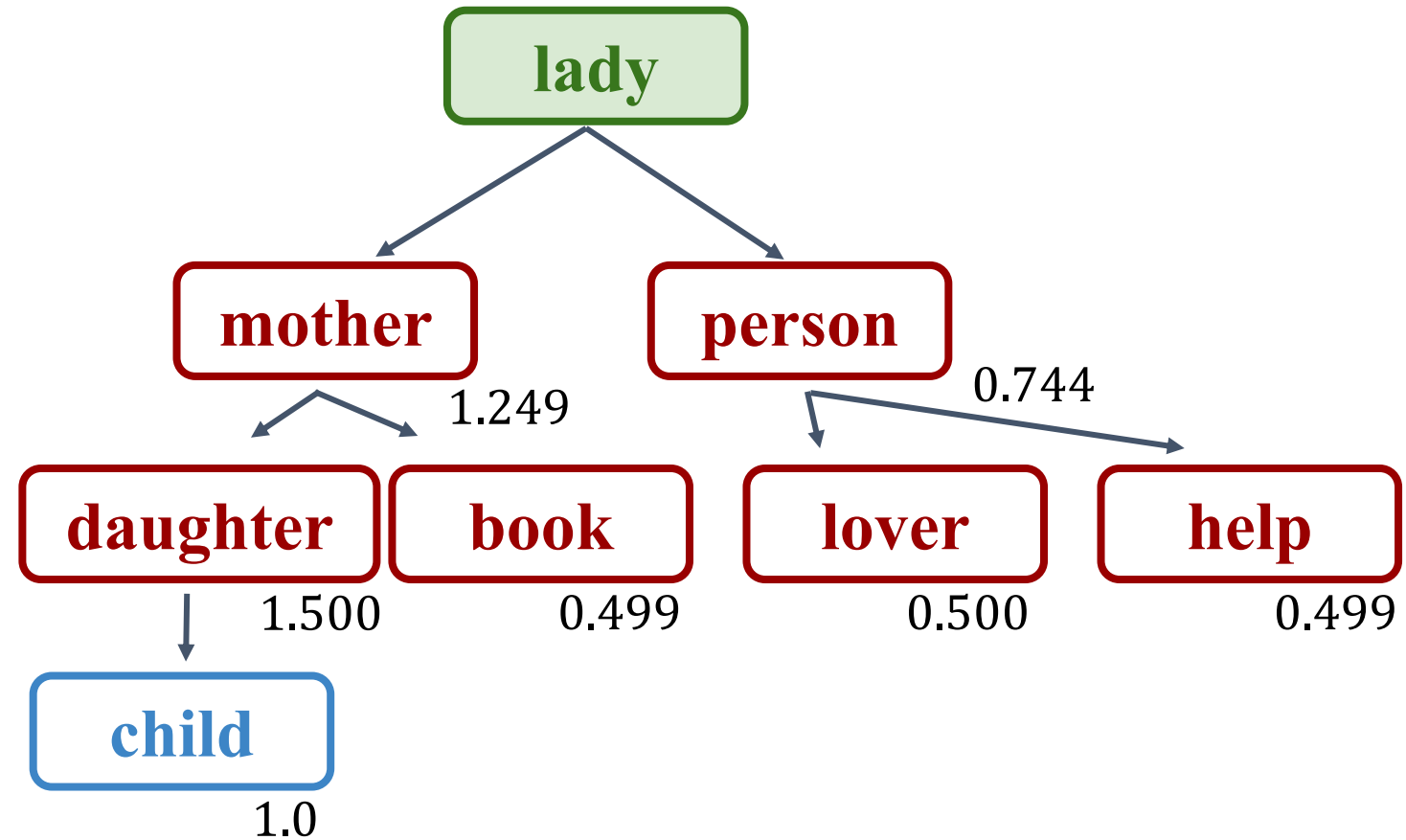
Cumulative Node Scoring



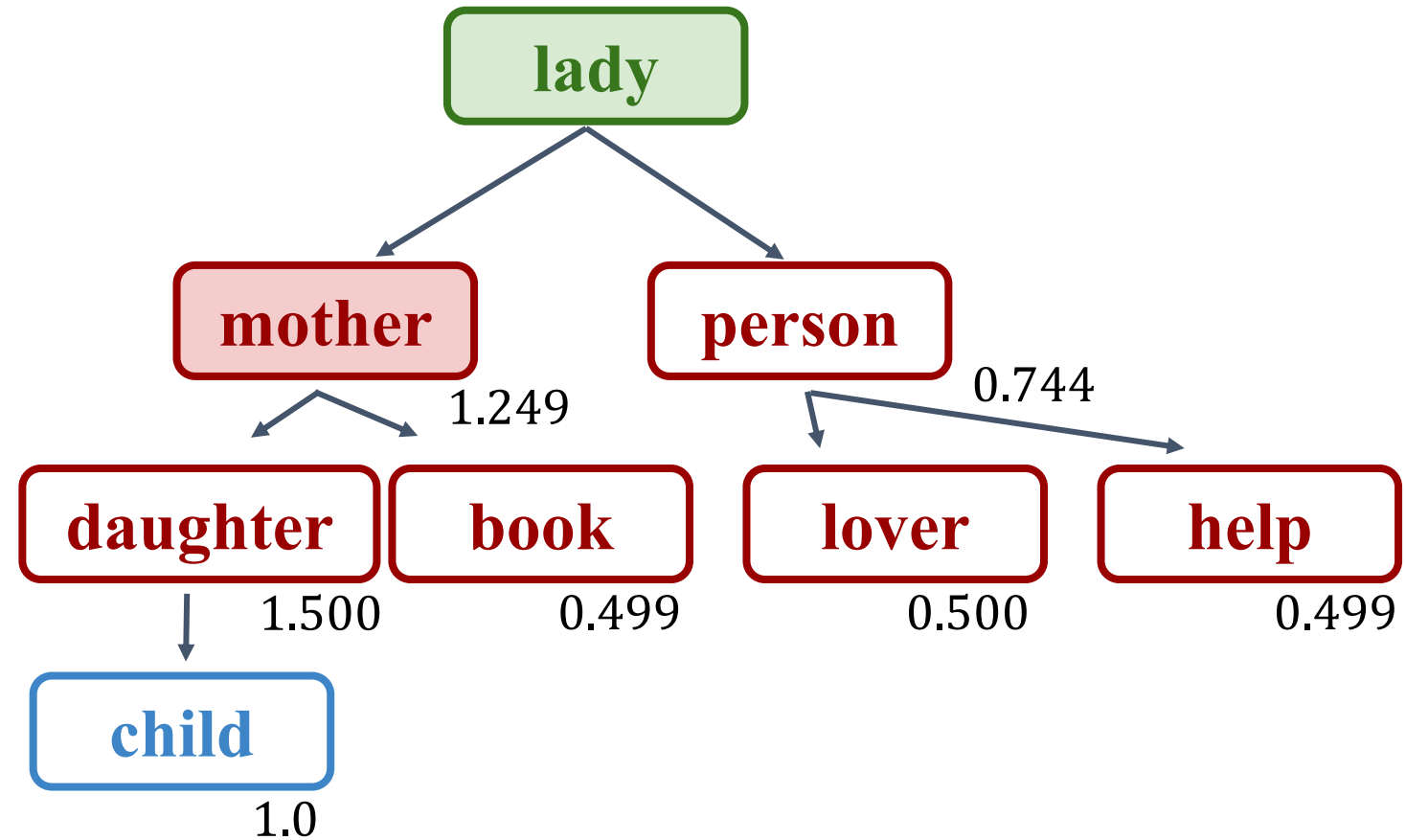
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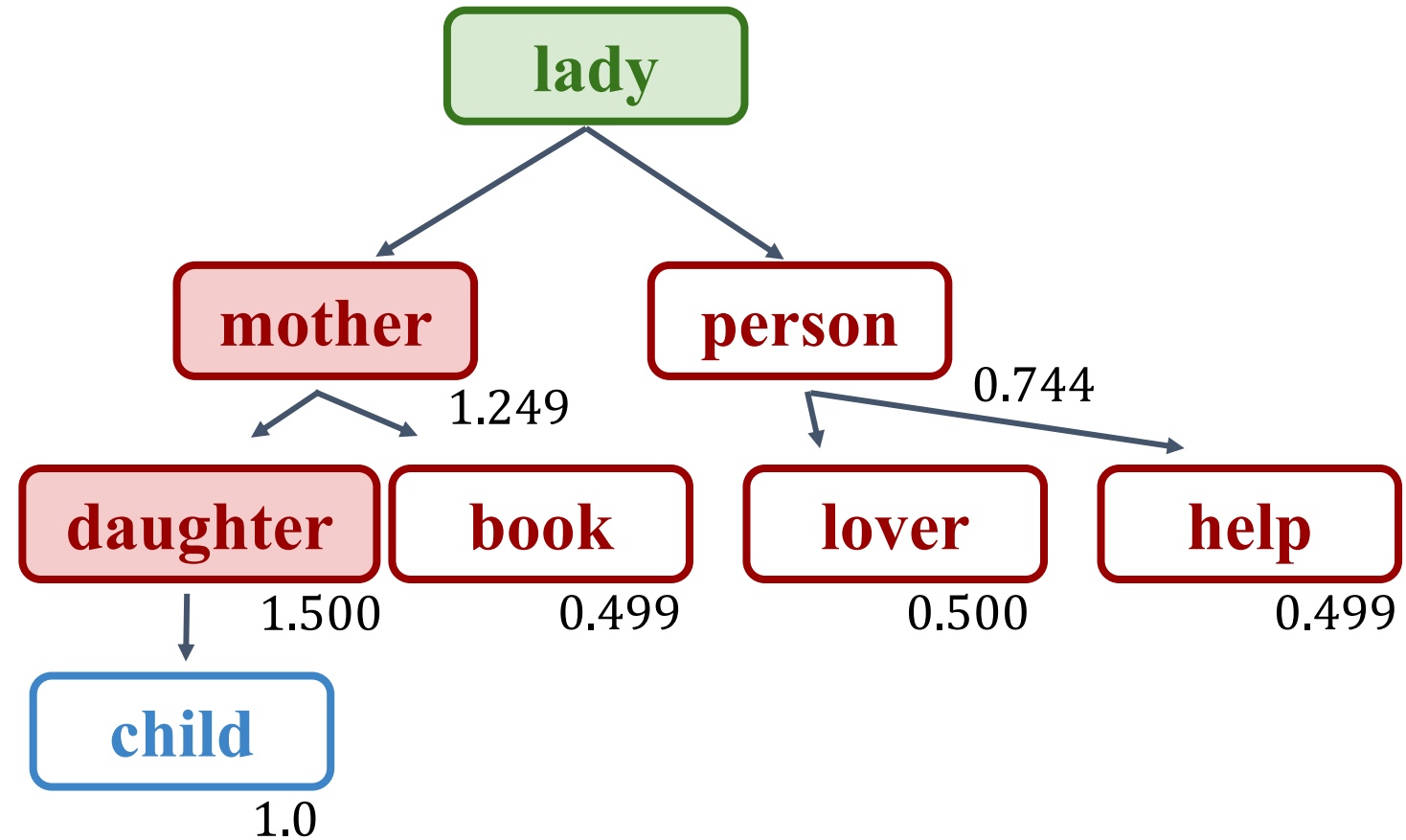
Path Selection



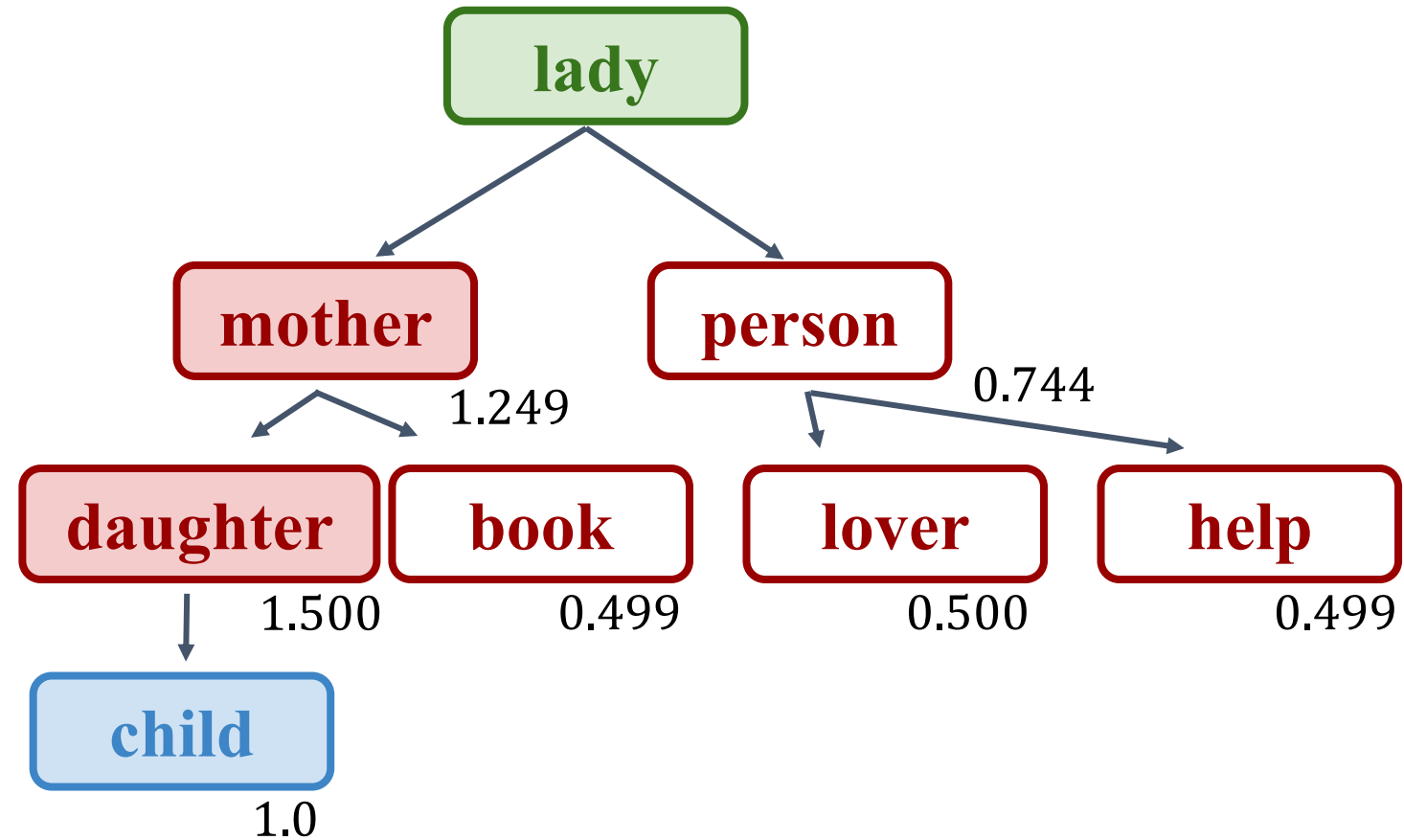
Path Selection



Path Selection



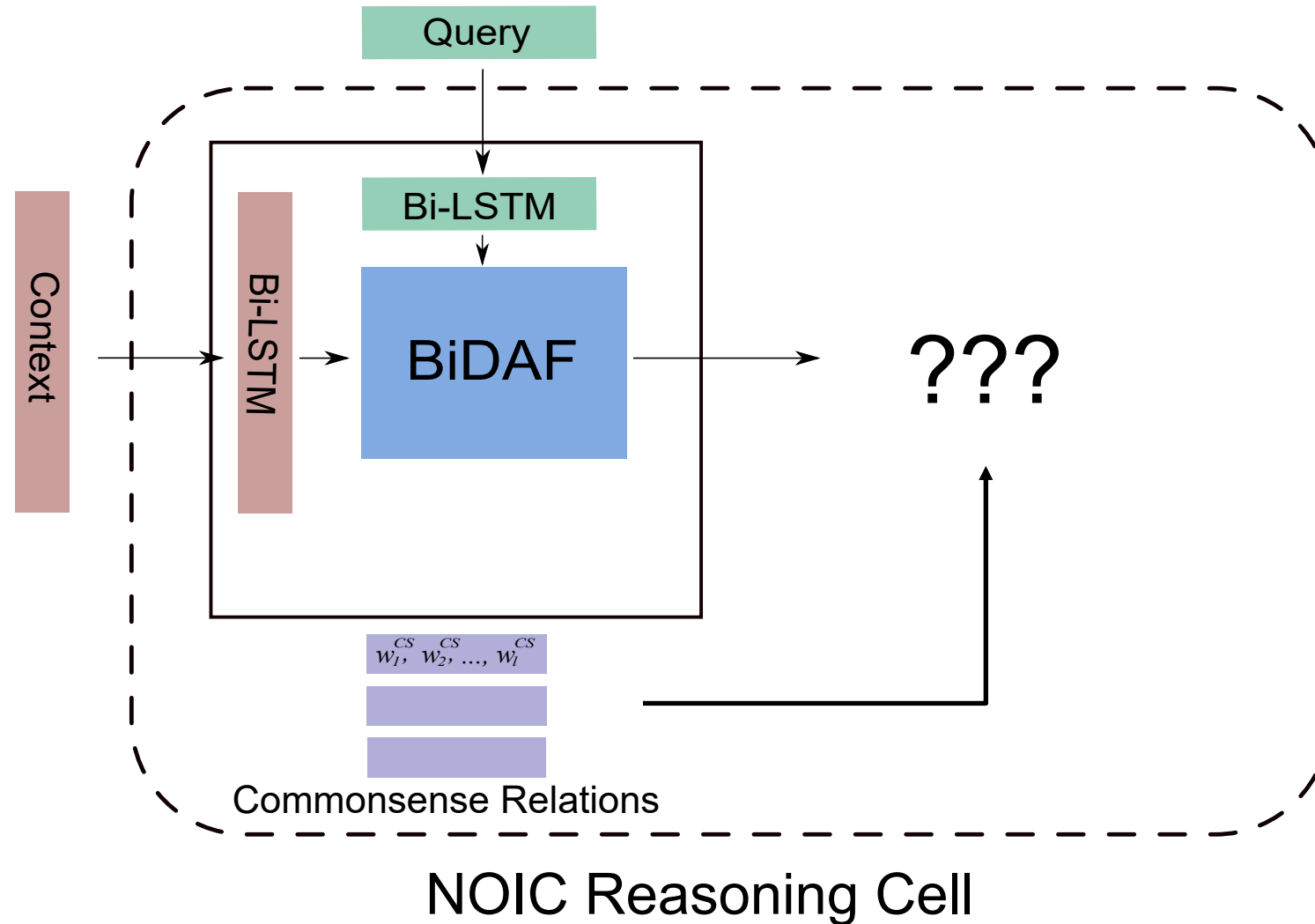
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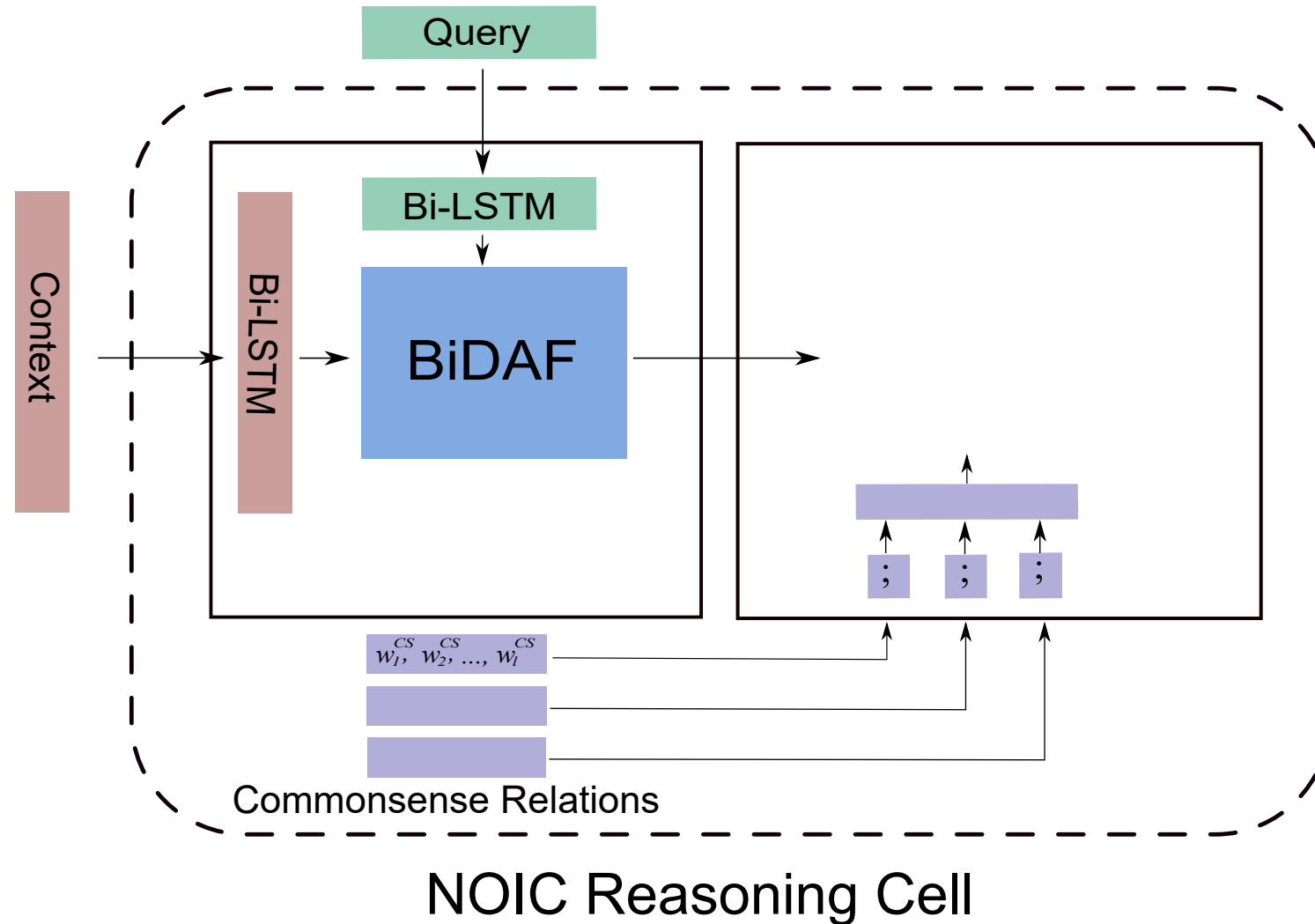


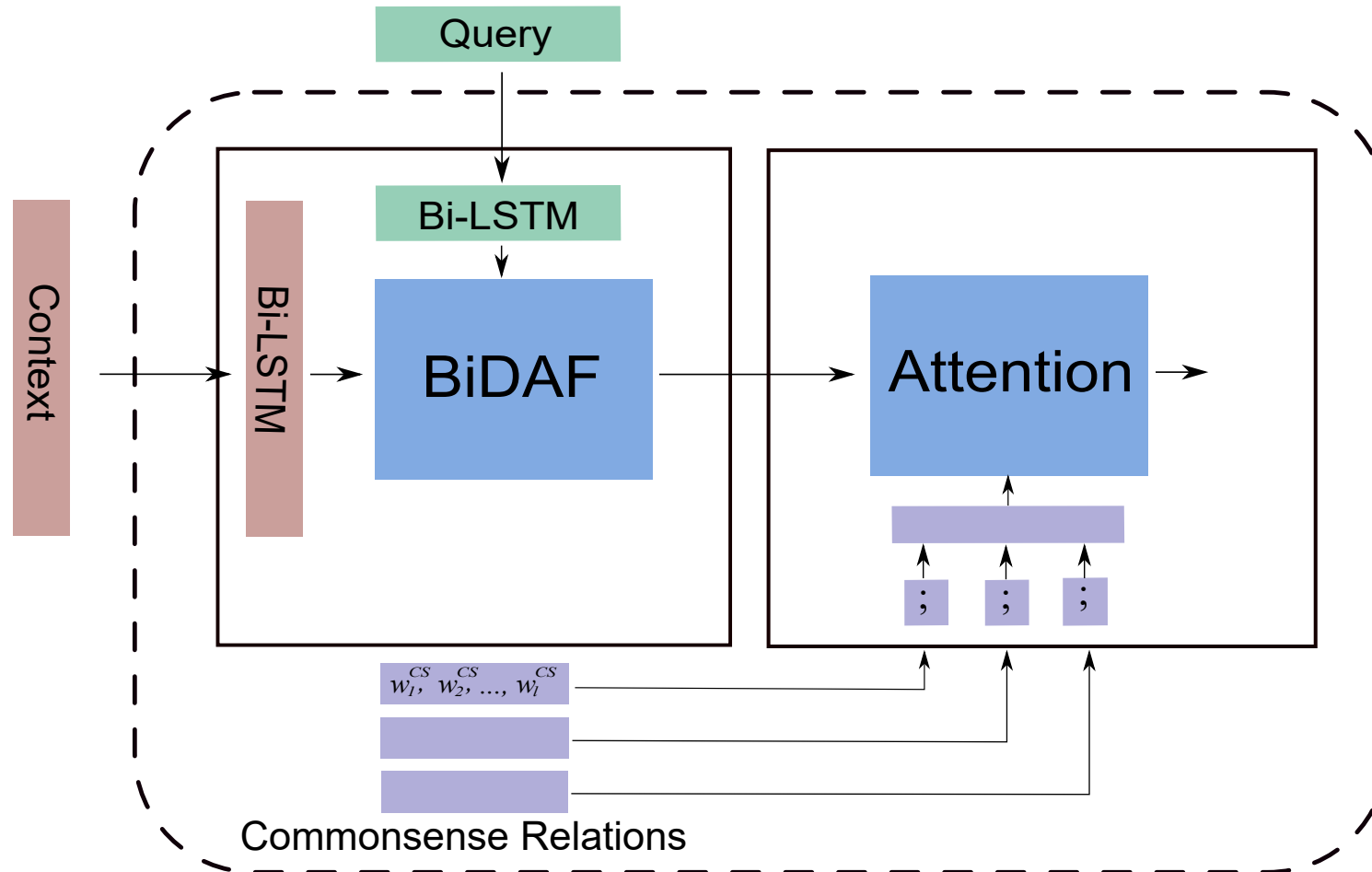
Commonsense Incorporation



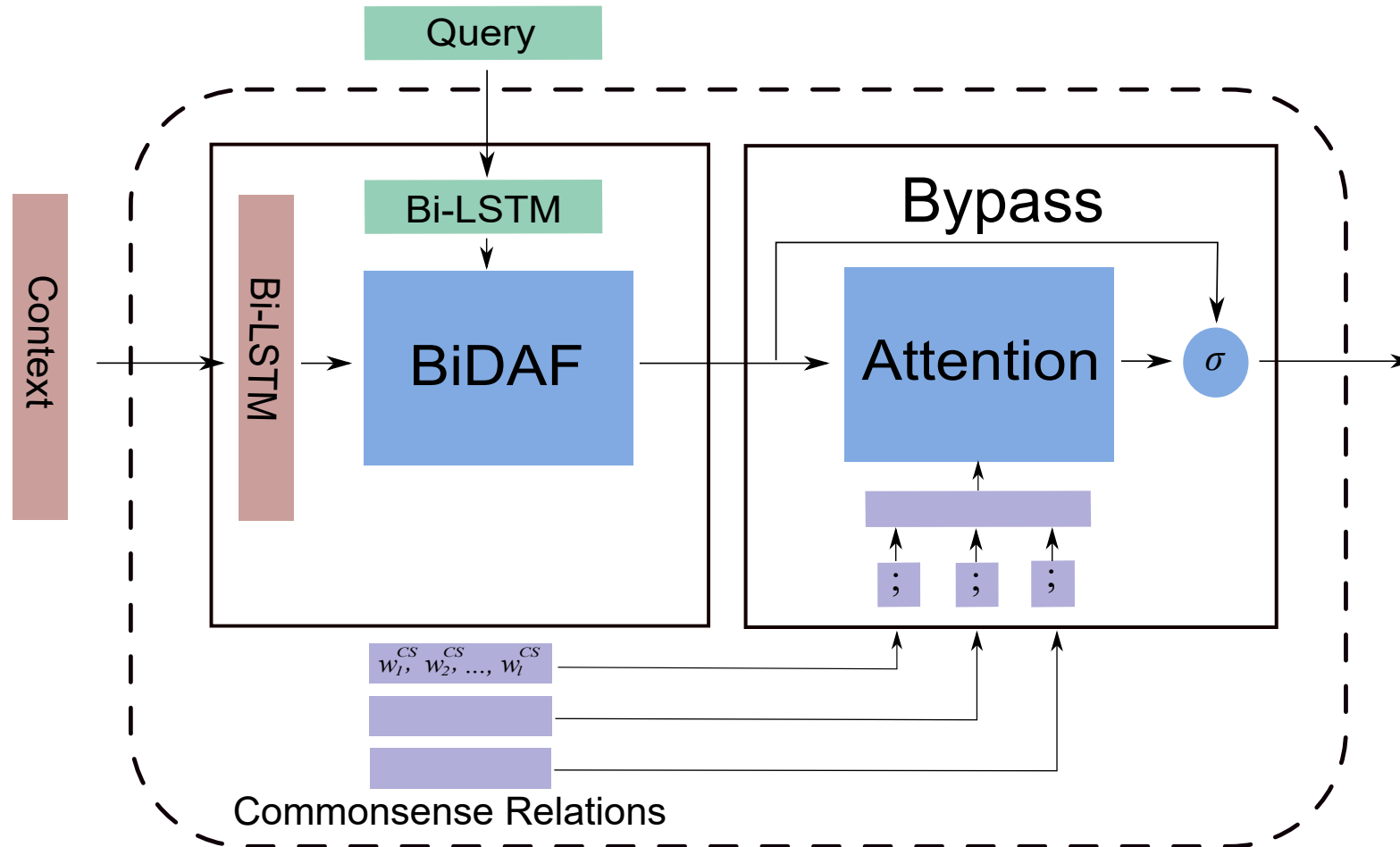
- Effective incorporation of commonsense information requires:
 - Multihop, selective commonsense incorporation
 - The ability to ignore ‘noisy’ unnecessary commonsense
- This fits in with our modular baseline design
- **Necessary and Optional Information Cell (NOIC)** incorporates optional commonsense information via a gated-attention layer





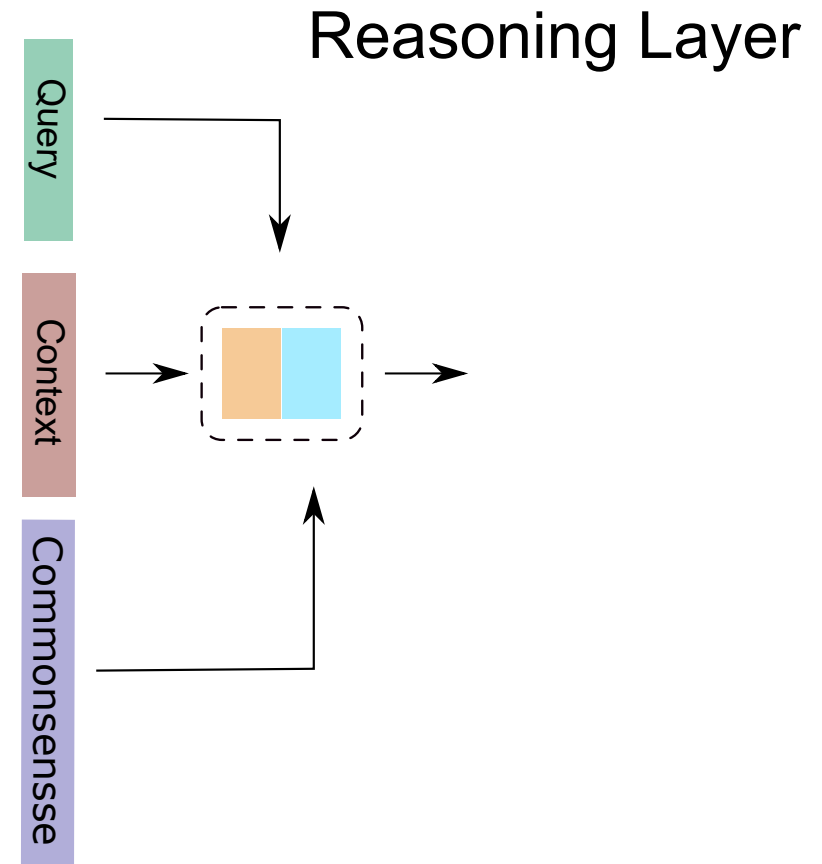
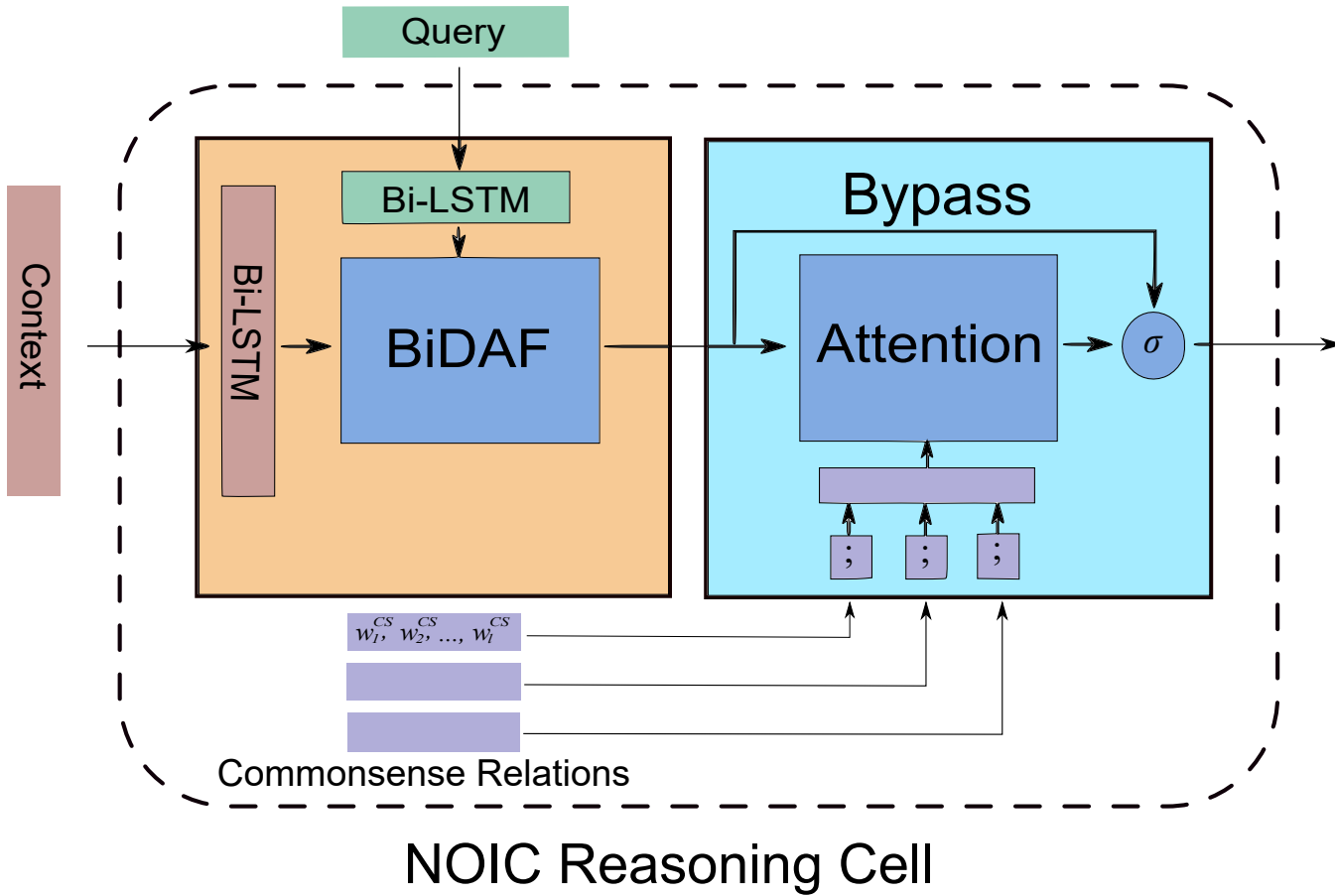


NOIC Reasoning Cell

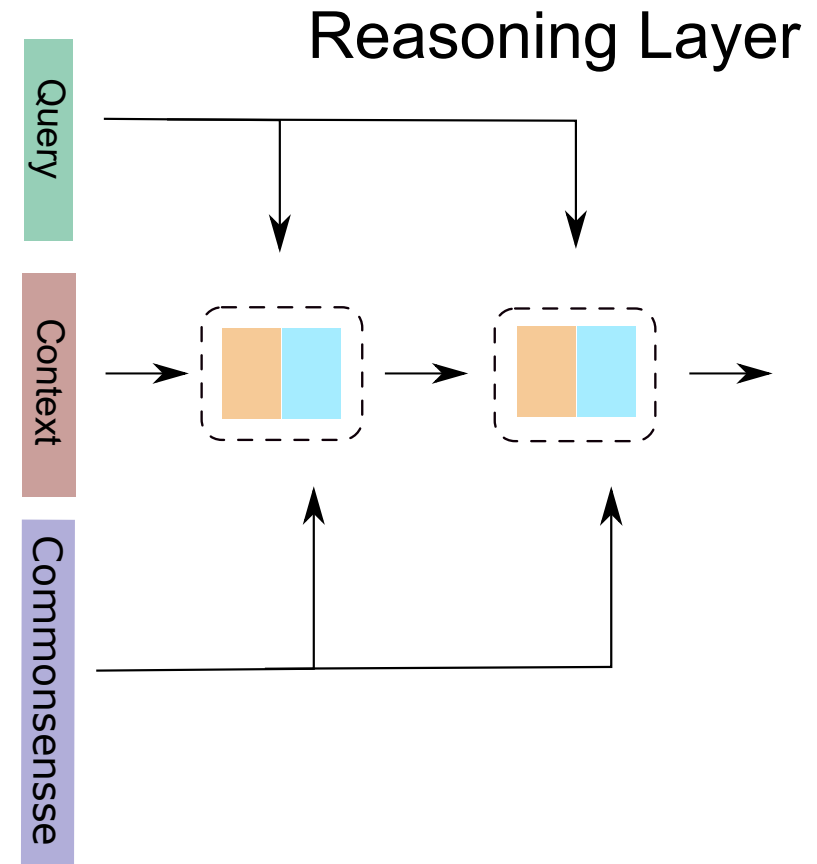
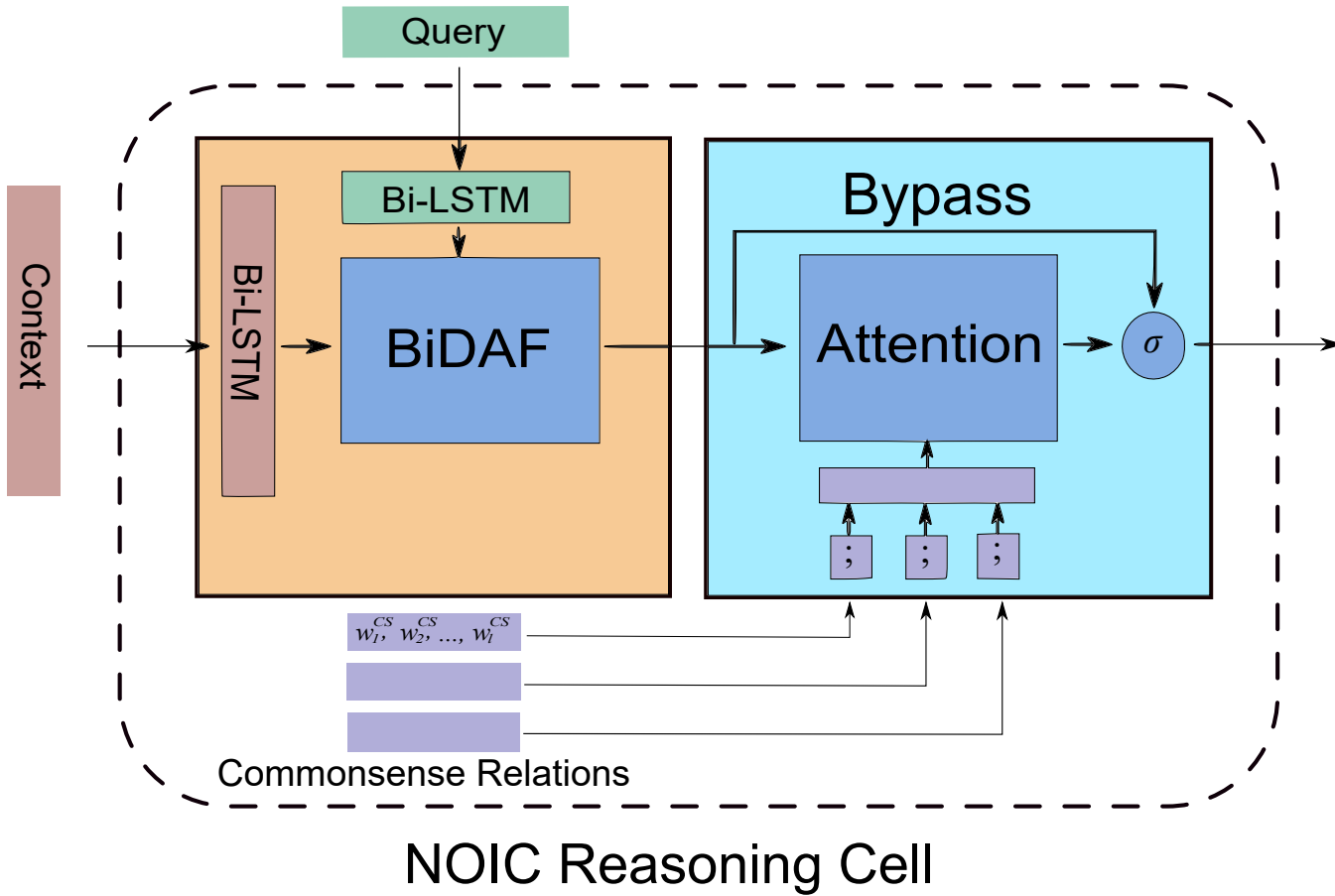


NOIC Reasoning Cell

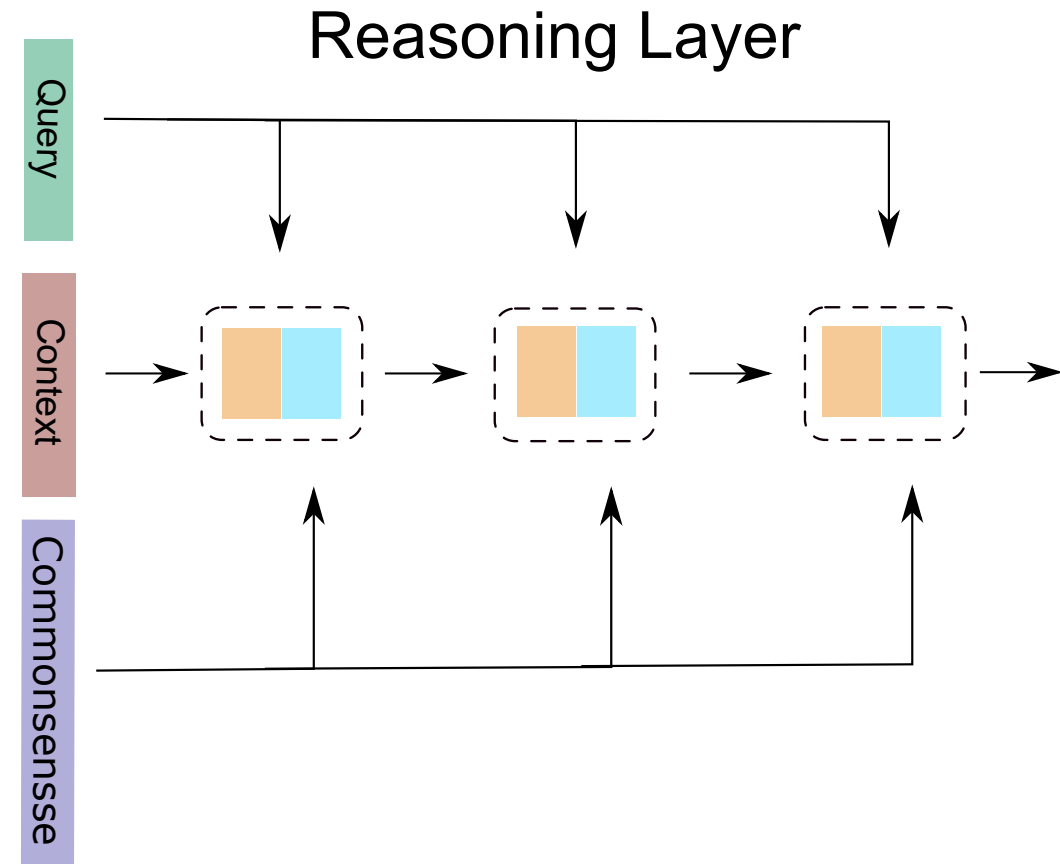
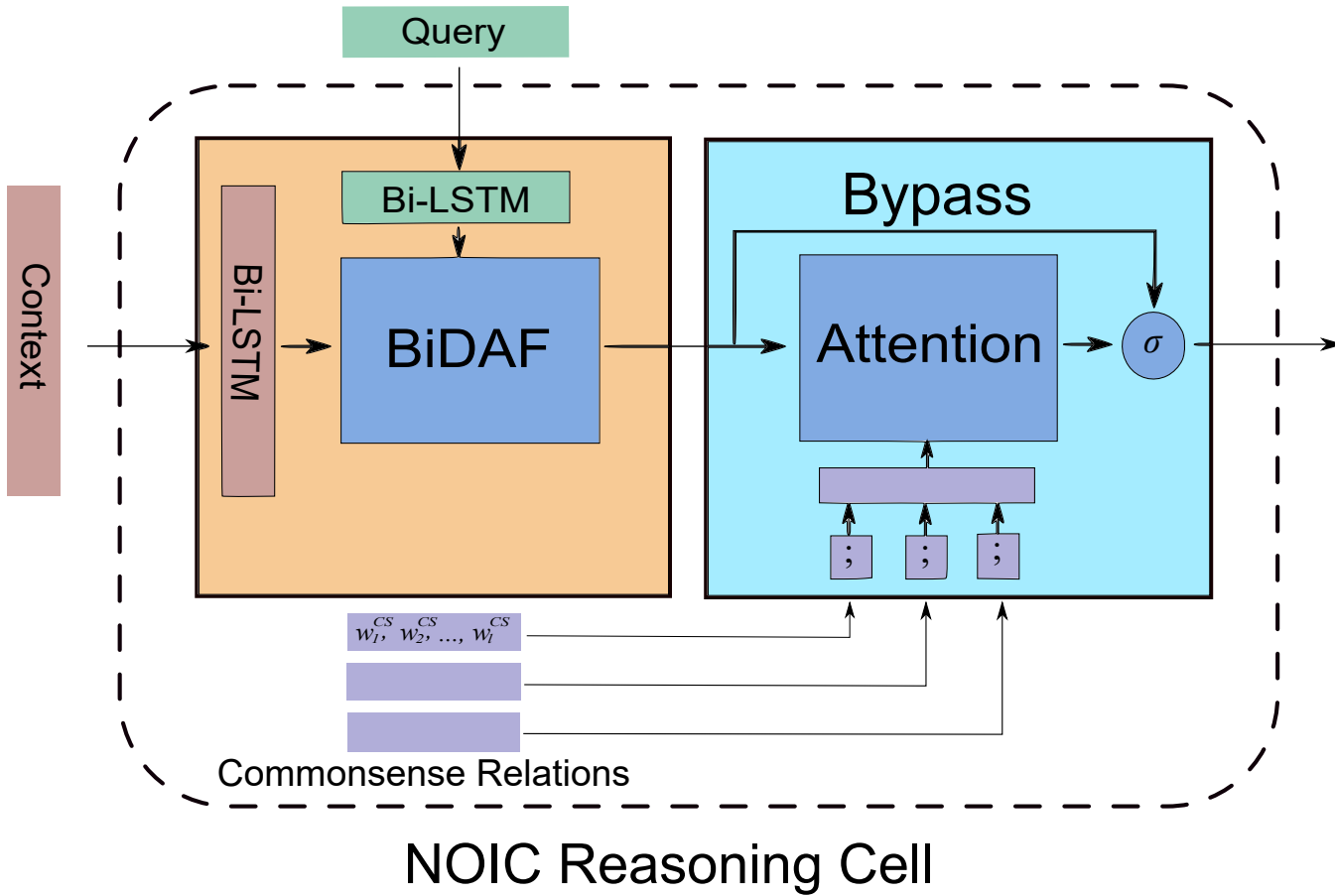
MHPGM + NOIC



MHPGM + NOIC



MHPGM + NOIC



- By visualizing the sigmoid activation value, we can visualize how much commonsense was added into each part of the context during each hop.
- Consider the question “What shore does Michael’s corpse wash up on?”

“Maurya has lost her husband, and five of her sons to the sea. As the play begins Nora and Cathleen receive word from the priest **that a body, that may be their brother Michael, has washed up on shore in Donegal**, the island farthest north of their home Island of Inishmaan. Bartley is planning to sail to Connemara to sell a horse, and ignores Maurya’s pleas to stay. He leaves gracefully. Maurya predicts that by nightfall she will have no living sons, and her daughters chide her for sending Bartley off with an ill word. Maurya goes after Bartley to bless his voyage, and Nora and Cathleen receive clothing from the drowned corpse that confirms it is their brother. Maurya returns home claiming to have seen the ghost of Michael riding behind Bartley and begins lamenting the loss of the men in her family to the sea, after which some villagers bring in the corpse of Bartley, who has fallen off his horse into the sea and drowned. This speech of Maurya’s is famous in Irish drama: (raising her head and speaking as if she did not see the people around her) They’re all gone now, and there isn’t anything more the sea can do to me... . I’ll have no call now to be up crying and praying when the wind breaks from the south, and you can hear the surf is in the east, and the surf is in the west, making a great stir with the two noises, and they hitting one on the other. I’ll have no call now to be going down and getting holy water in the dark nights after samhain, and I won’t care what way the sea is when the other women will be keening. (to Nora) give me the holy water , Nora: there’s a small sup still on the dresser .”

Visualization (Hop 1)

maurya has lost her husband , and five of her sons to the sea . as the play begins nora and cathleen receive word from the priest that a body , that may be their brother michael , has washed up on shore in donegal , the island farthest north of their home island of inishmaan . bartley is planning to sail to connemara to sell a horse , and ignores maurya s pleas to stay . he leaves gracefully . maurya predicts that by nightfall she will have no living sons , and her daughters chide her for sending bartley off with an ill word . maurya goes after bartley to bless his voyage , and nora and cathleen receive clothing from the drowned corpse that confirms it is their brother . maurya returns home claiming to have seen the ghost of michael riding behind bartley and begins lamenting the loss of the men in her family to the sea , after which some villagers bring in the corpse of bartley , who has fallen off his horse into the sea and drowned . this speech of maurya s is famous in irish drama : (raising her head and speaking as if she did not see the people around her) they re all gone now , and there is n't anything more the sea can do to me i ll have no call now to be up crying and praying when the wind breaks from the south , and you can hear the surf is in the east , and the surf is in the west , making a great stir with the two noises , and they hitting one on the other . i ll have no call now to be going down and getting holy water in the dark nights after samhain , and i wo n't care what way the sea is when the other women will be keening . (to nora) give me the holy water , nora ; there s a small sup still on the dresser .

Visualization (Hop 3)

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Corpse
related to
body

Visualization (Hop 3)

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Shore related to sea

Corpse related to body

Visualization (Hop 3)

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Shore related to sea

Corpse related to body

Shore related to sea made of water

Visualization (Hop 3)

maurya has lost her husband , and five of her sons to the sea . as the play begins nora and cathleen receive word from the priest that a body , that may be their brother michael , has washed up on shore in donegal , the island farthest north of their home island of inishmaan . bartley is planning to sail to connemara to sell a horse , and ignores maurya s pleas to stay . he leaves gracefully . maurya predicts that by nightfall she will have no living sons , and her daughters chide her for sending bartley off with an ill word . maurya goes after bartley to bless his voyage , and nora and cathleen receive clothing from the drowned corpse that confirms it is their brother . maurya returns home claiming to have seen the ghost of michael riding behind bartley and begins lamenting the loss of the men in her family to the sea , after which some villagers bring in the corpse of bartley , who has fallen off his horse into the sea and drowned . this speech of maurya s is famous in irish drama : (raising her head and speaking as if she did not see the people around her) they re all gone now , and there is n't anything more the sea can do to me . . i ll have no call now to be up crying and praying when the wind breaks from the south , and you can hear the surf is in the east , and the surf is in the west , making a great stir with the two noises , and they hitting one on the other . i ll have no call now to be going down and getting holy water in the dark nights after samhain , and i wo n't care what way the sea is when the other women will be keening . (to nora) give me the holy water , nora ; there s a small sup still on the dresser .

Shore related to sea

Corpse related to body

Up related to north

Shore related to sea made of water

Results: NarrativeQA

[Kočiský et al., 2018, Tay et al., 2018]

Model	BLEU-1	BLEU-4	METEOR	Rouge-L	CIDEr
Seq2Seq (Kočiský et al., 2018)	15.89	1.26	4.08	13.15	-
ASR (Kočiský et al., 2018)	23.20	6.39	7.77	22.26	-
BiDAF [†] (Kočiský et al., 2018)	33.72	15.53	15.38	36.30	-
BiAttn + MRU-LSTM [†] (Tay et al., 2018)	36.55	19.79	17.87	41.44	-
MHPGM	40.24	17.40	17.33	41.49	139.23
MHPGM+ NOIC	43.63	21.07	19.03	44.16	152.98

† indicates span prediction models trained on the Rouge-L retrieval oracle.

MHPGM+NOIC better	23%
MHPGM better	15%
Indistinguishable (Both-good)	41%
Indistinguishable (Both-bad)	21%

- Fleiss-Kappa between three human annotators = 0.831 (“Almost-perfect agreement” ([Landis and Koch, 1997](#)))

Results: WikiHop

[Welbl et al., 2018, Dhingra et al., 2018]

Model	Dev (%)	Test (%)
MHPGM	56.7	57.5
MHPGM+ NOIC	58.2	57.9

- Only 11% of examples need outside knowledge as opposed to 42% on NarrativeQA
- Needs more fact-based commonsense (e.g., Freebase) instead of semantics-based ones (e.g., ConceptNet)
- Future Work: Adding commonsense to new/stronger state-of-the-art 68-70% baseline for WikiHop

Results: Commonsense Ablation

Commonsense	BLEU-1	BLEU-4	METEOR	ROUGE-L	CiDER
None	42.3	18.9	18.3	44.9	151.6
NumberBatch	42.6	19.6	18.6	44.4	148.1
Random Rel.	43.3	19.3	18.6	45.2	151.2
Single Hop	42.1	19.9	18.2	44.0	148.6
Grounded Rel.	45.9	21.9	20.7	48.0	166.6

Results: Commonsense Ablation

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Random Rel.	43.3	19.3	18.6	45.2	151.2
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Results: Commonsense Extraction



	Commonsense Required	
	Yes	No
Relevant CS Extracted	34%	14%
Irrelevant CS Extracted	16%	36%

- In this work, we...
 - Proposed a strong multi-hop baseline for generative QA task
 - Used PMI/TF based filtering algorithm to effectively query large knowledge graphs for relevant subgraphs
 - Effectively incorporated commonsense paths into our multi-hop baseline via multiple hops of selectively gated attention
- In the future, we will...
 - Explore adding different types of commonsense to other domains
 - Explore the possibility of adding graph-based attention to more directly incorporate semantic networks

Thank you for listening!
Questions?

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