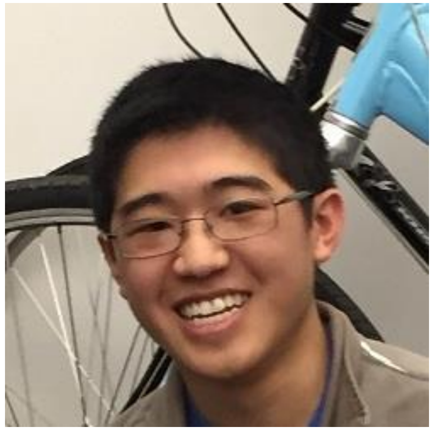
# Incremental Neural Coreference Resolution in Constant Memory

Patrick Xia, João Sedoc, Benjamin Van Durme



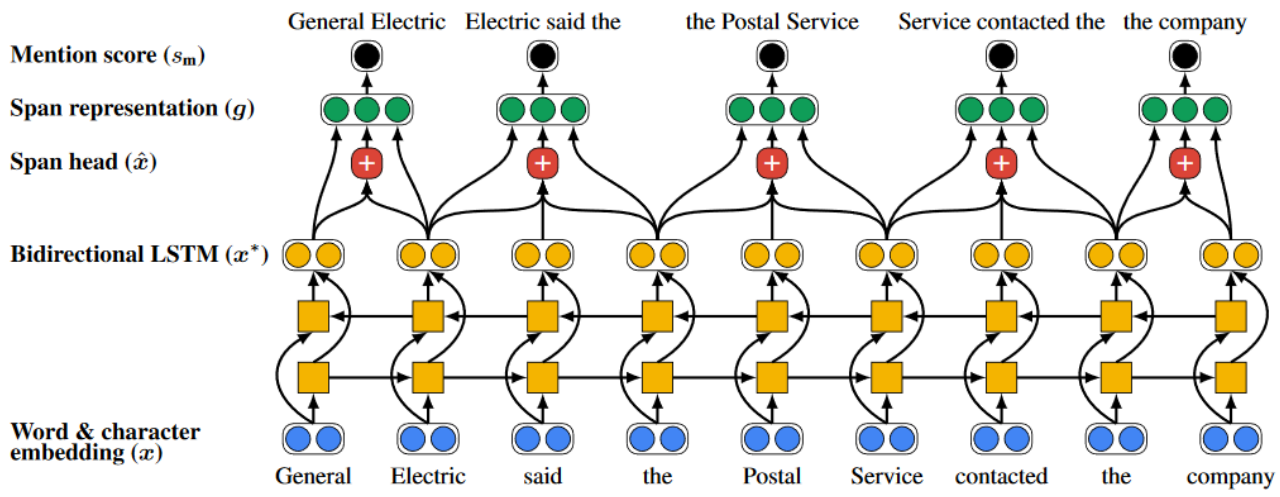
Johns Hopkins University
NYU
Center for Language and Speech Processing

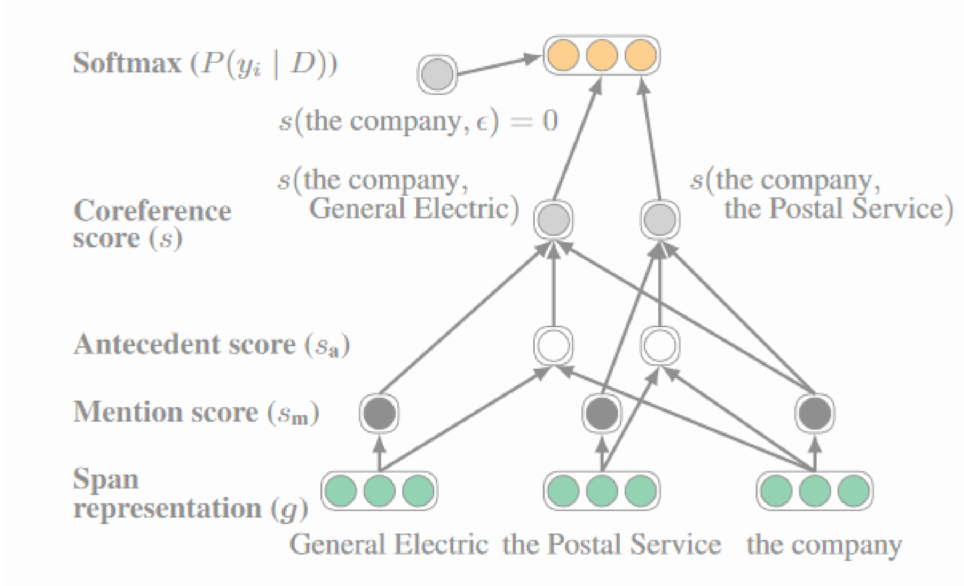
# Outline

1. Background and Motivation
2. Algorithm and Model
3. Experiments and Results

# Background

- Span Detection → Mention Pair Scoring (Lee et al., 2017)



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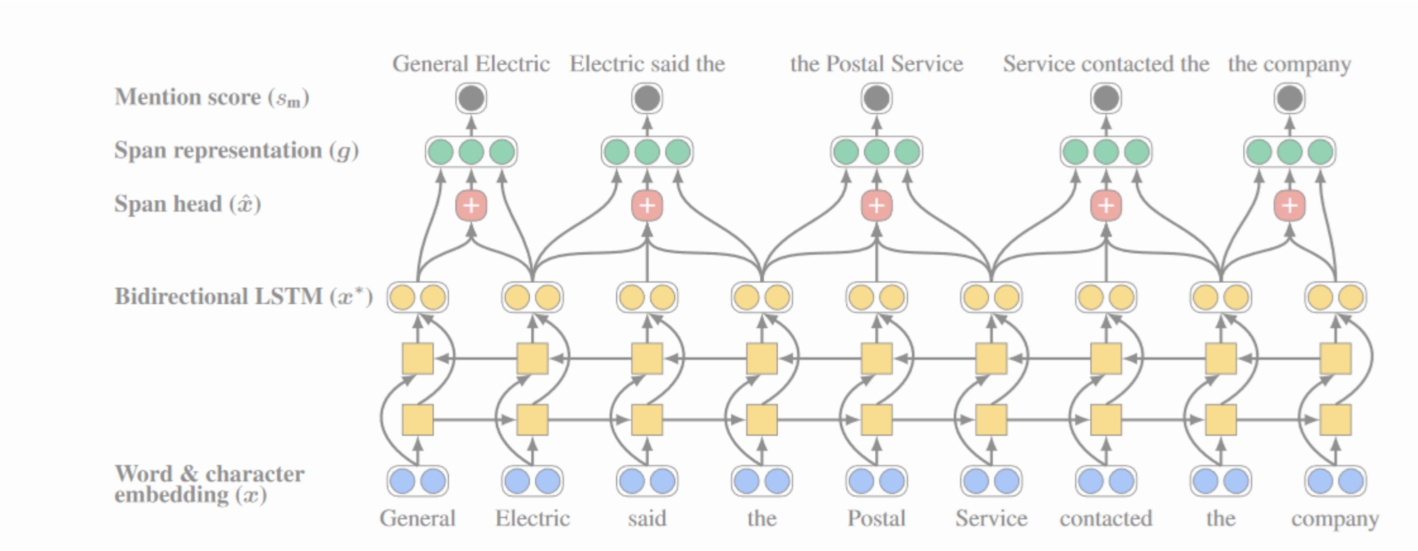
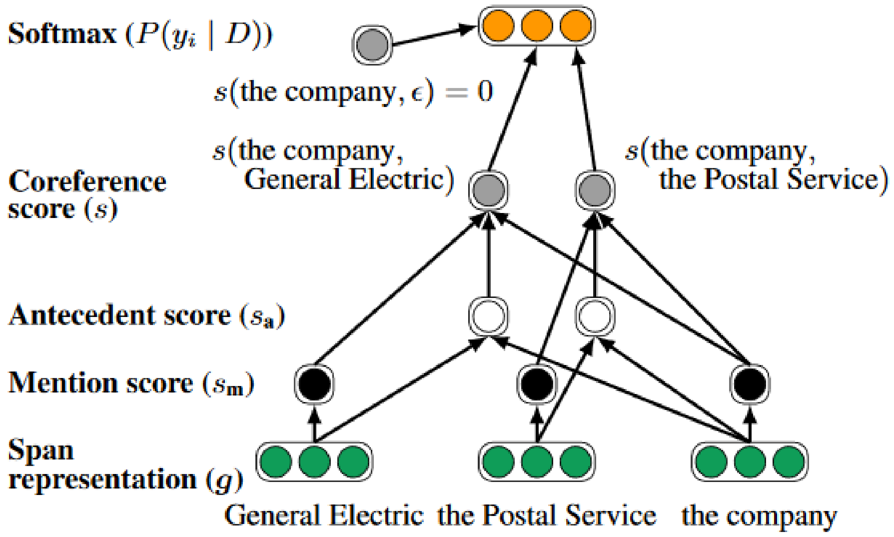


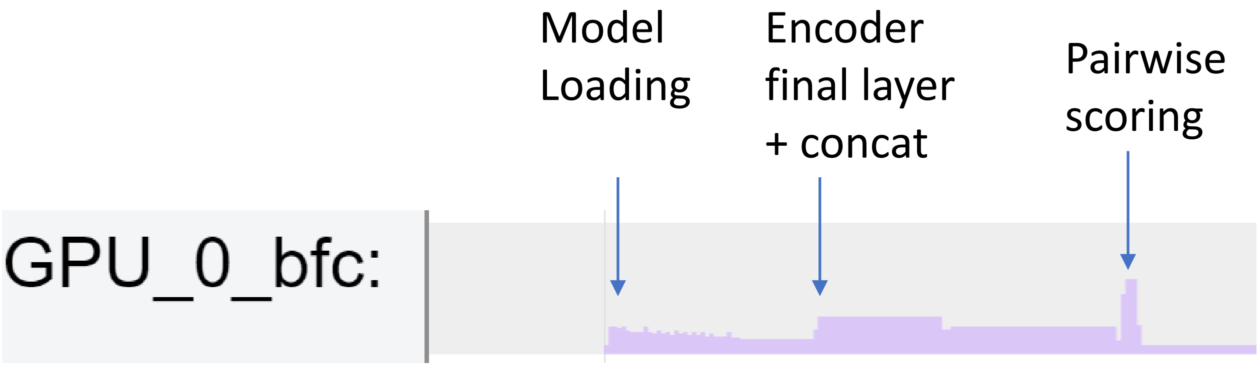
# Extensions

- Higher-order resolution: re-score against cluster average (Lee et al., 2018)
- ELMo/BERT/SpanBERT: Fine-tune pretrained encoders (Joshi et al., 2019)
- “Machine reading comprehension” scorer (Wu et al., 2020)

# Motivation

- For long documents (roughly >3000 tokens), GPUs run out of memory
  - The encoder is not always the bottleneck

- Some documents (books) exceed 100K tokens




Memory Profile for a long document with model by Joshi et al., 2019

# Some solutions…

- Some fixes:
  - Sparse Transformer
  - Sequential pairwise scoring
- … but they do not resolve:
  - Span ranking is linear in document size
  - All spans are needed in decoding
  - Even sparse Transformers need $\Omega$(document size)

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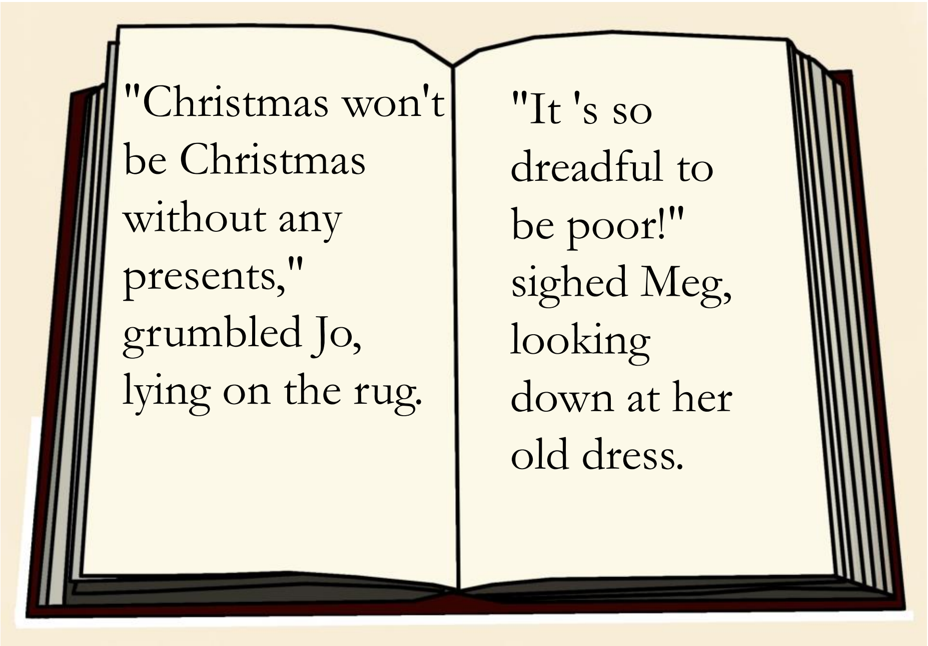
# Approach

- Limited-memory incremental algorithm for coreference resolution (Webster and Curran, 2014)
  - Similar to shift-reduce algorithms

- Neural components + **explicit** entity representations

Entity List

Document

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Create an empty Entity List, $E$
**for** segment $\in$ Document **do**
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  **for** $m \in M$ **do**
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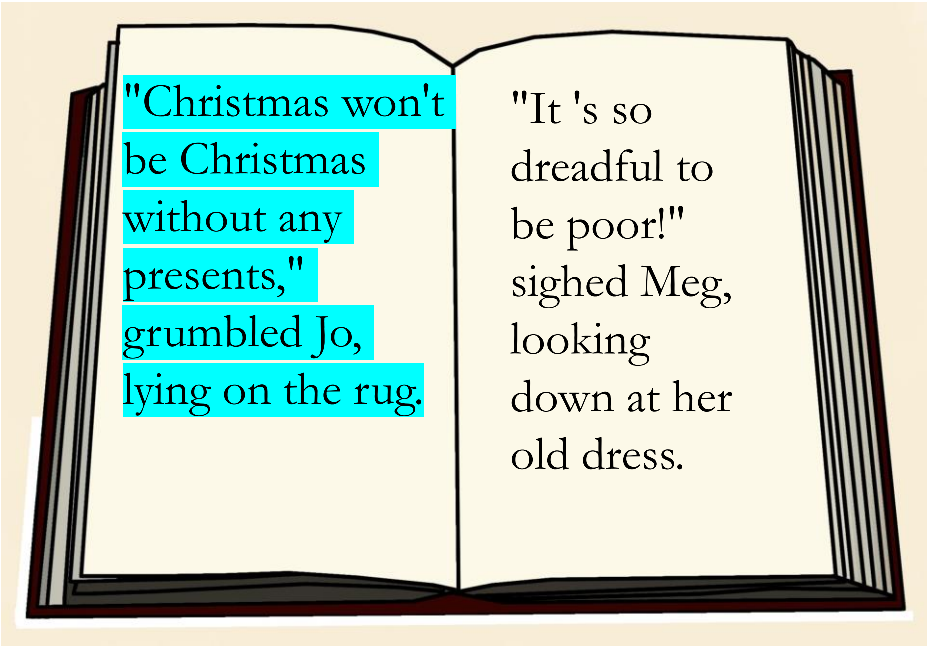


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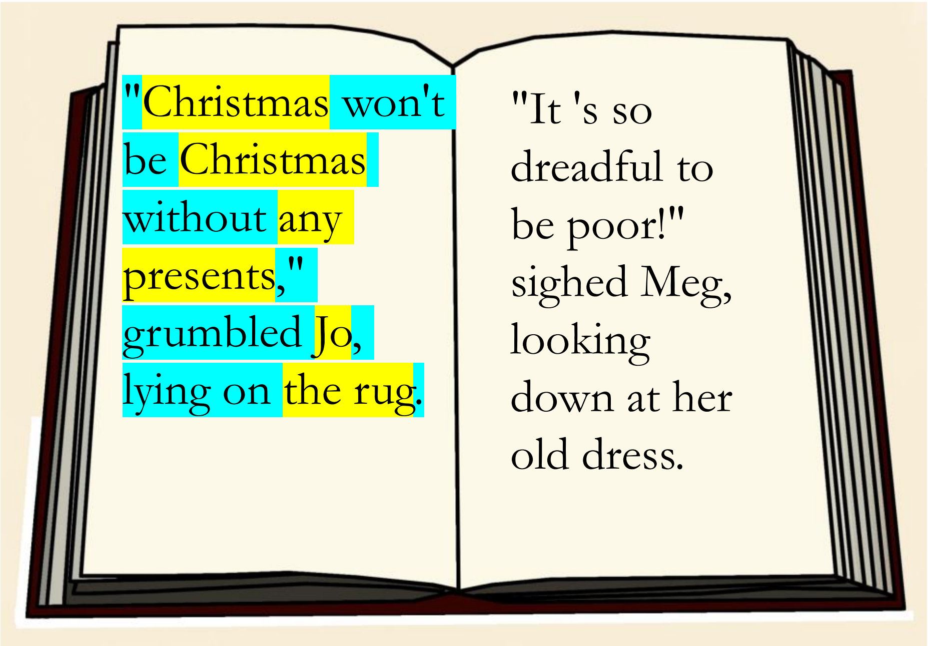


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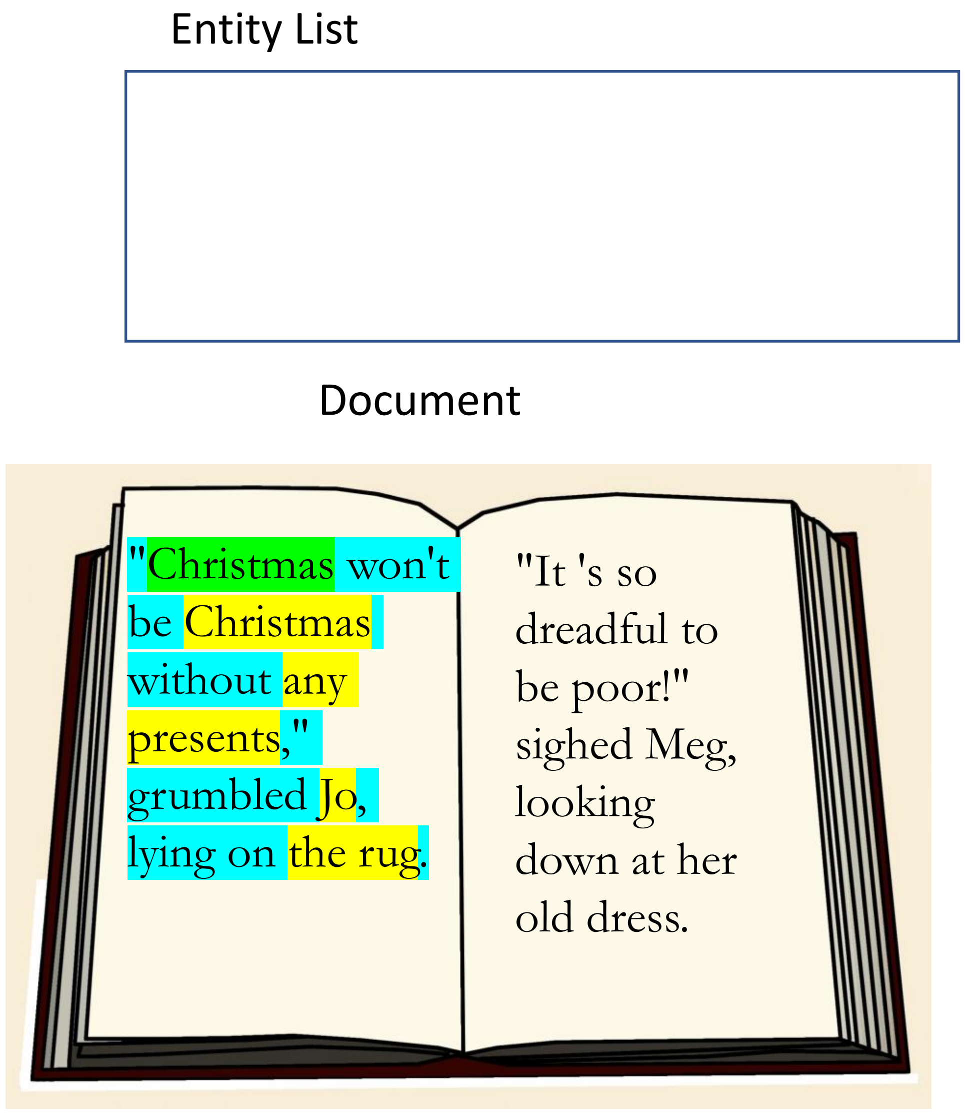


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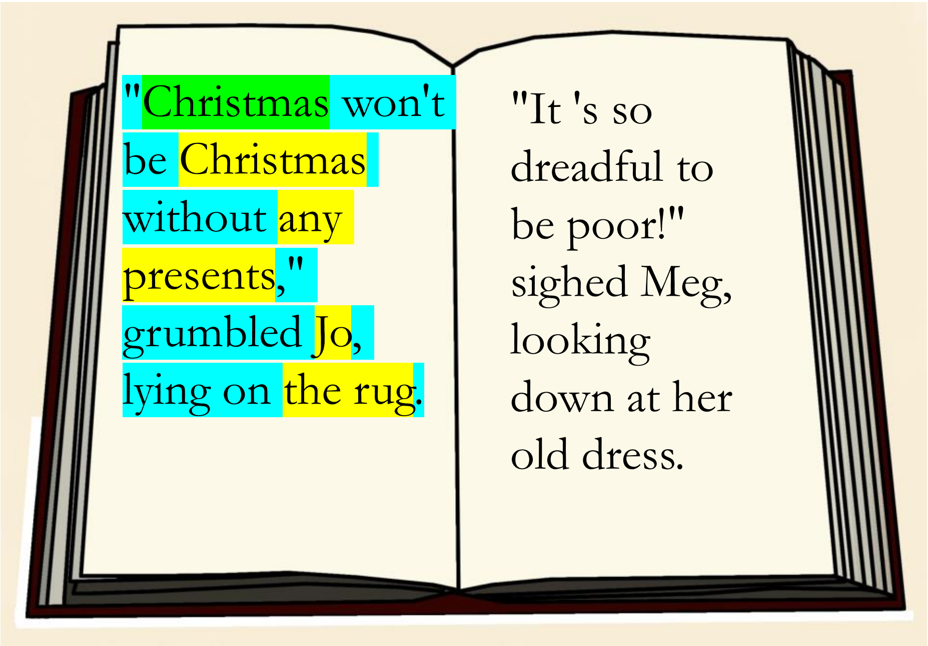
Entity List

{Christmas}

Document

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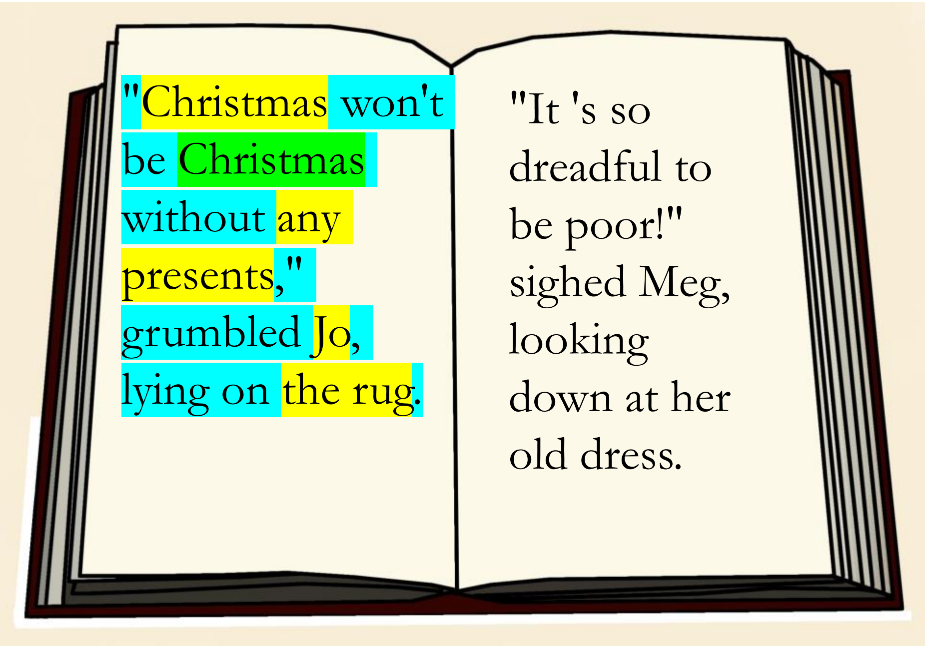


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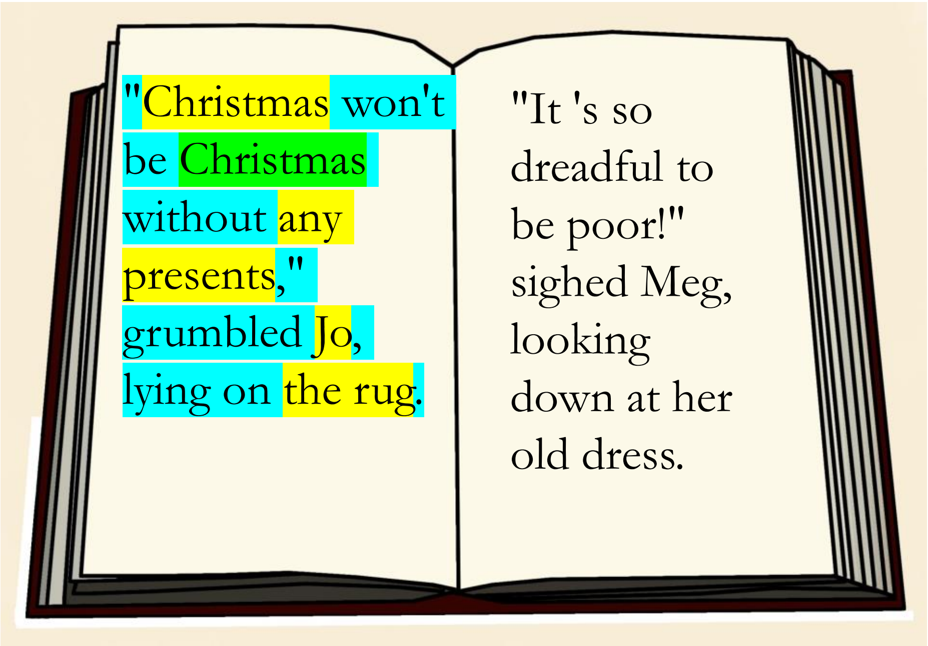


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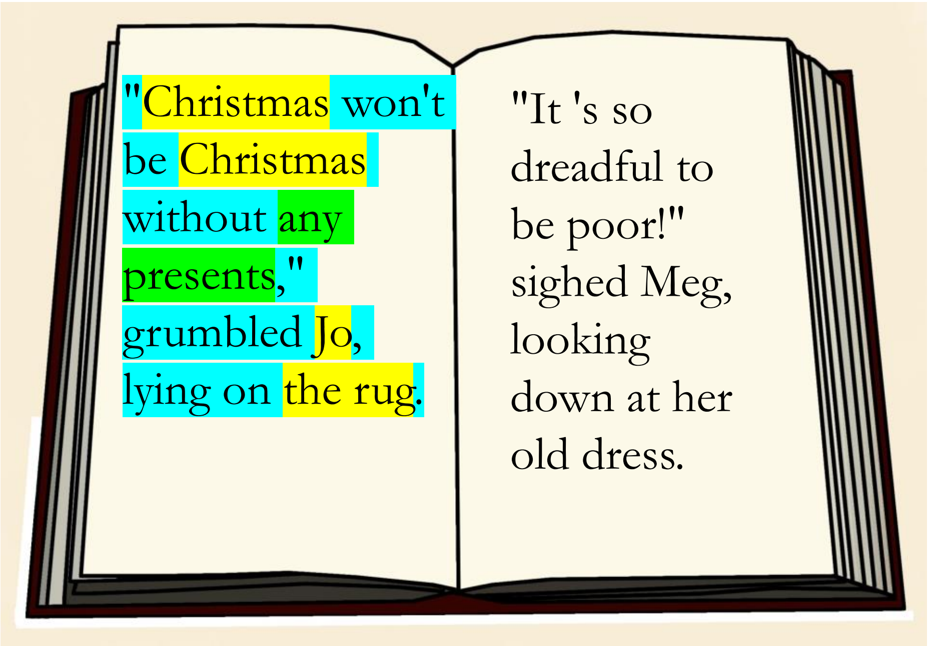


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Entity List

{Christmas, Christmas},
{any presents}

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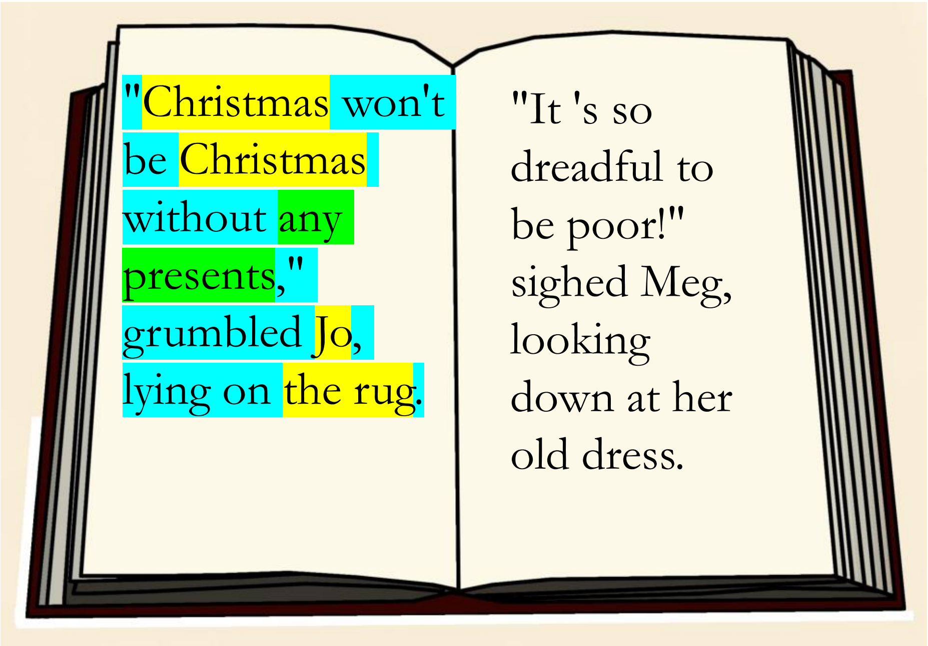


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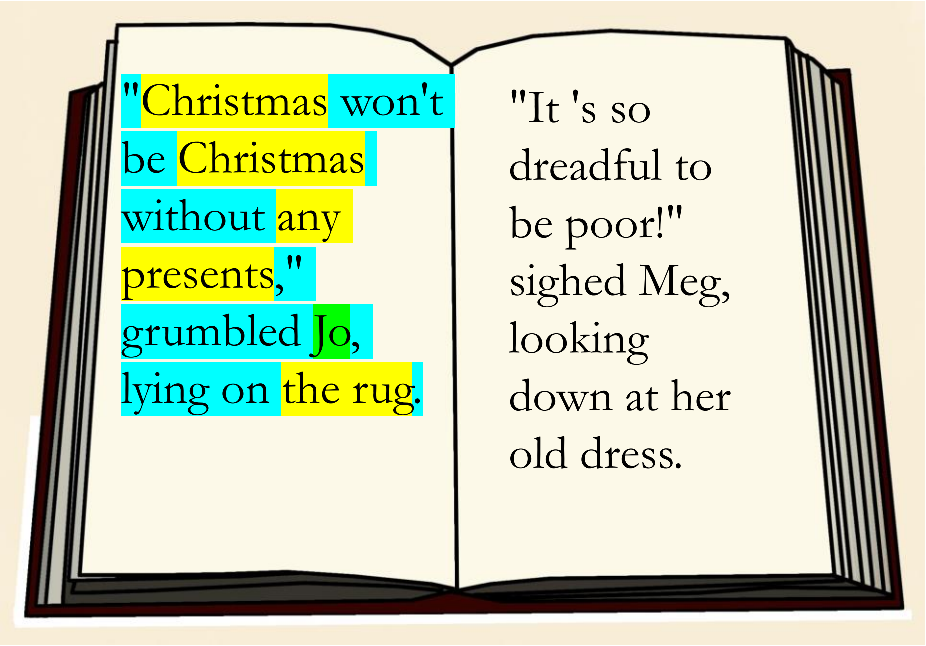


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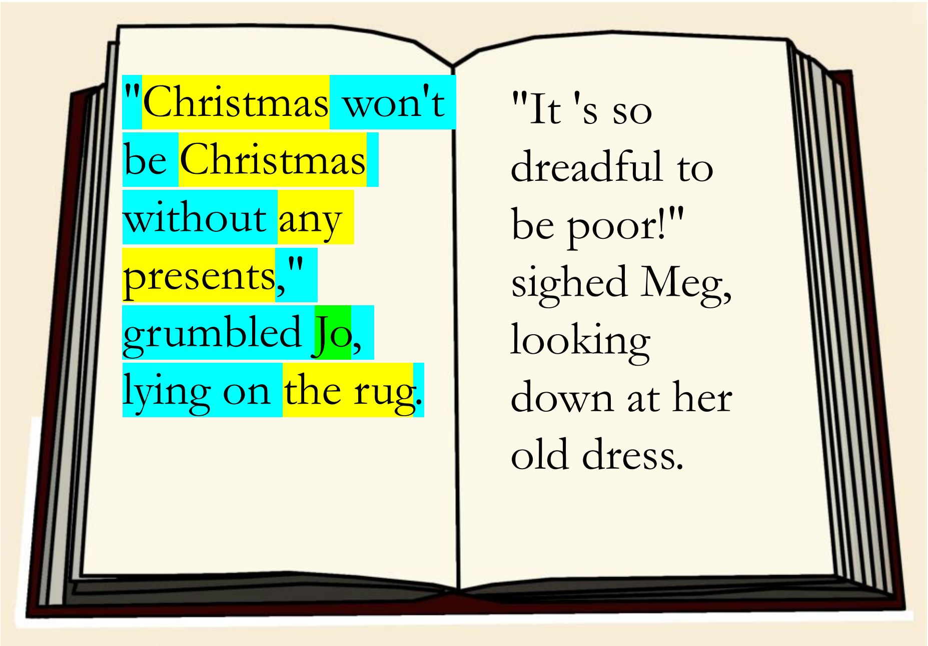
Entity List

{Christmas, Christmas},
{any presents},
{Jo}

Document

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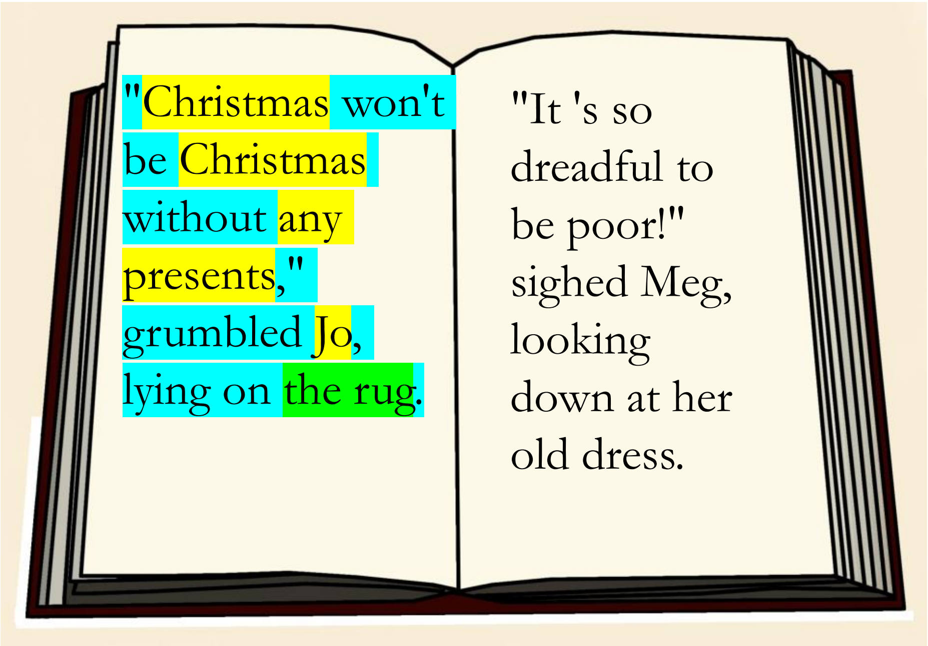


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Entity List

{Christmas, Christmas},
{any presents},
{Jo},
{the rug}

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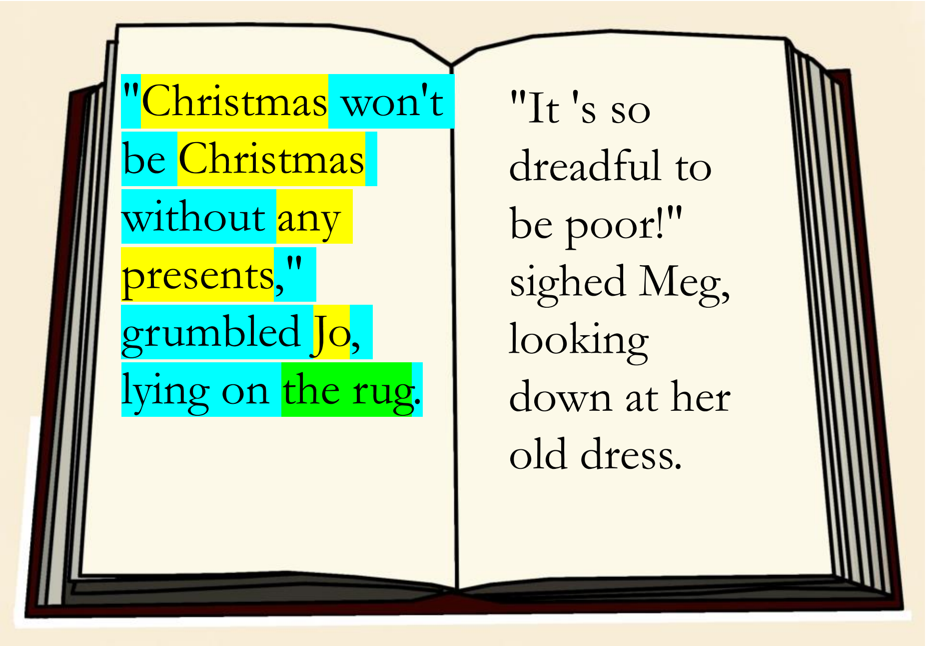


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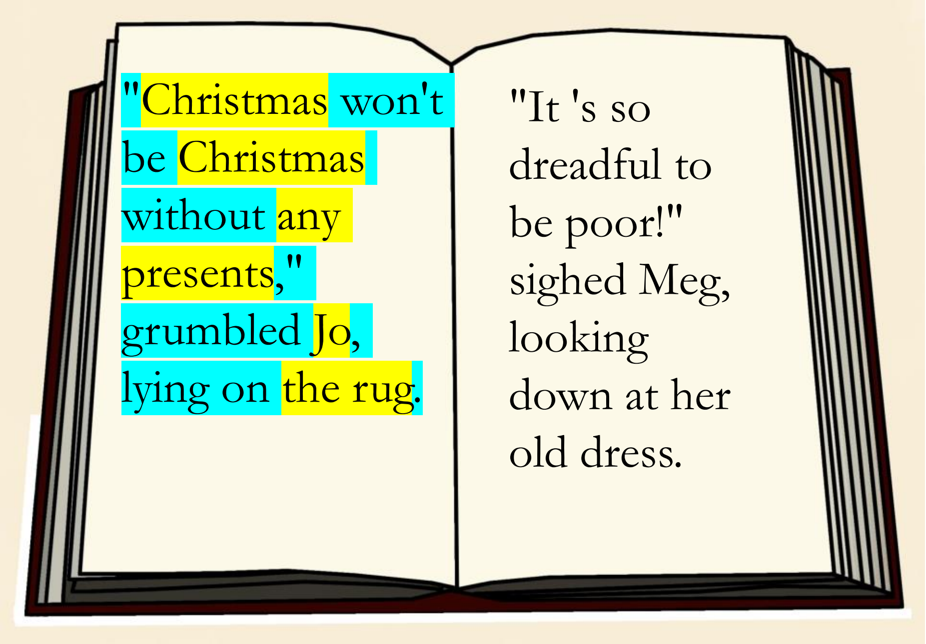


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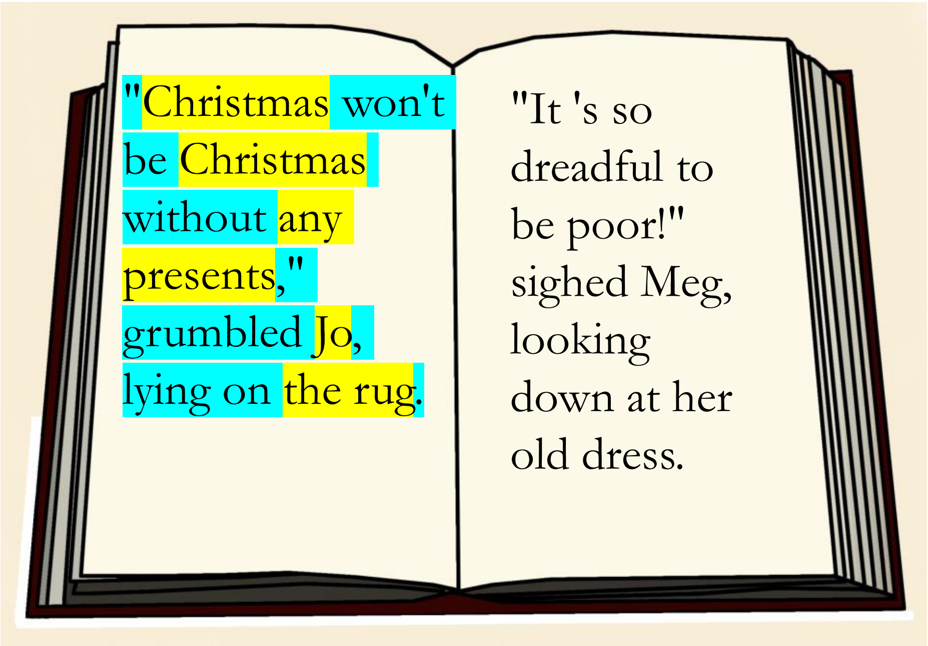


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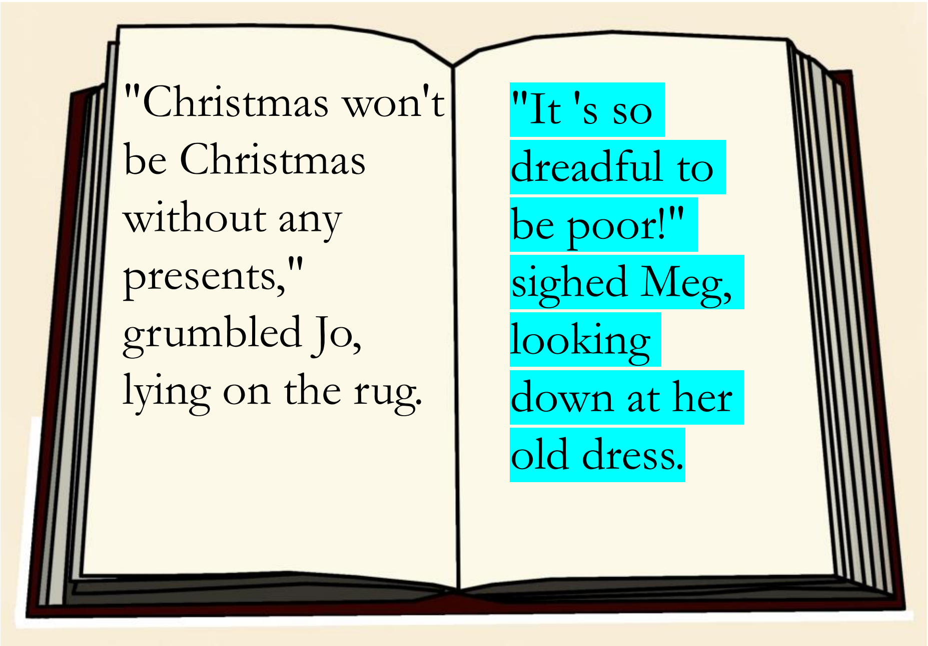


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# Implementation

- Encoder: SpanBERT
- **Spans**: top-*k* spans based on learned scorer
- **PairScore**: FFNN(m, e)
- **Update**: learned average of spans
- **Evict**: all old entities

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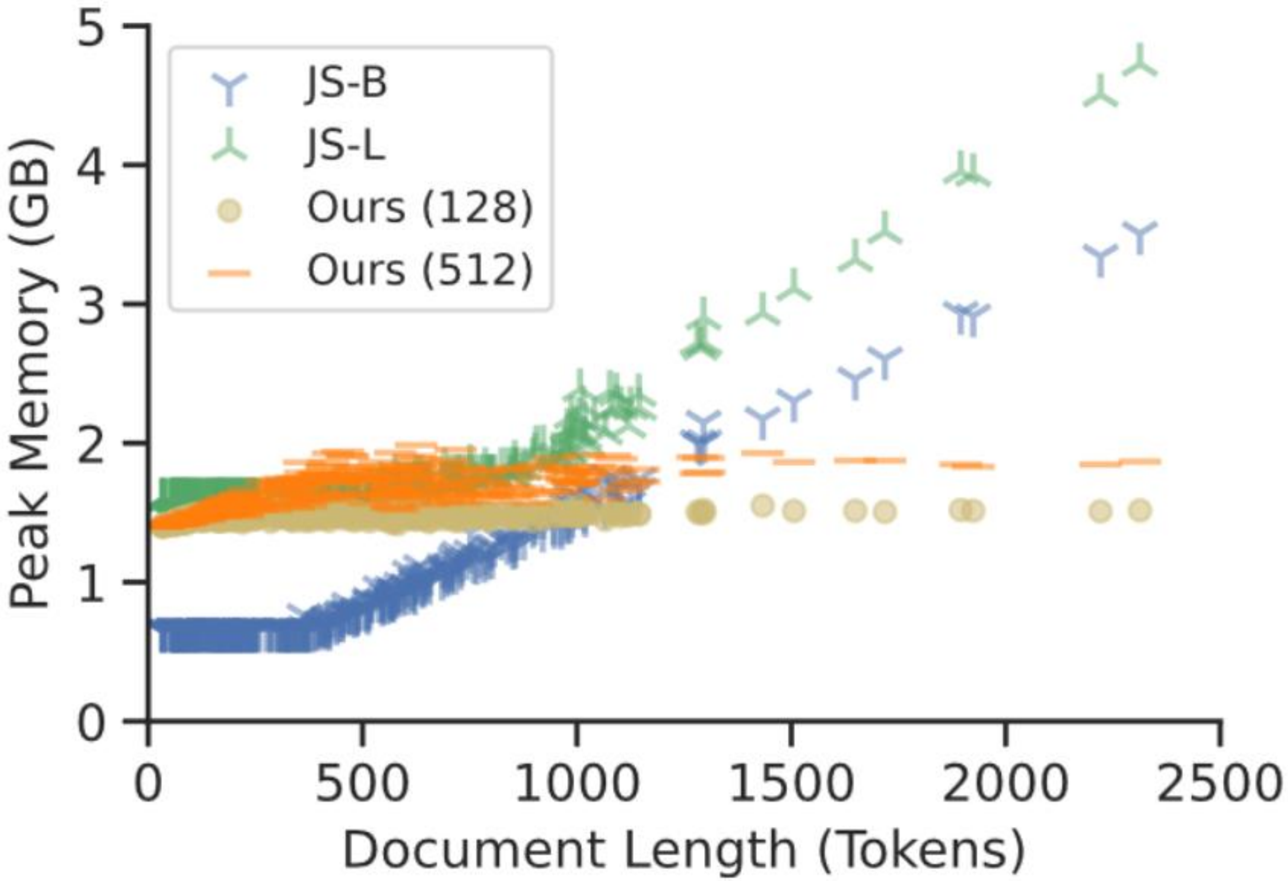
# Experiments

- OntoNotes 5.0 (English)
- Evaluated with average F1 (MUC, $B^3$, and $CEAF_{\phi 4}$)
- Goal: compare performance between incremental algorithm vs. full-document model

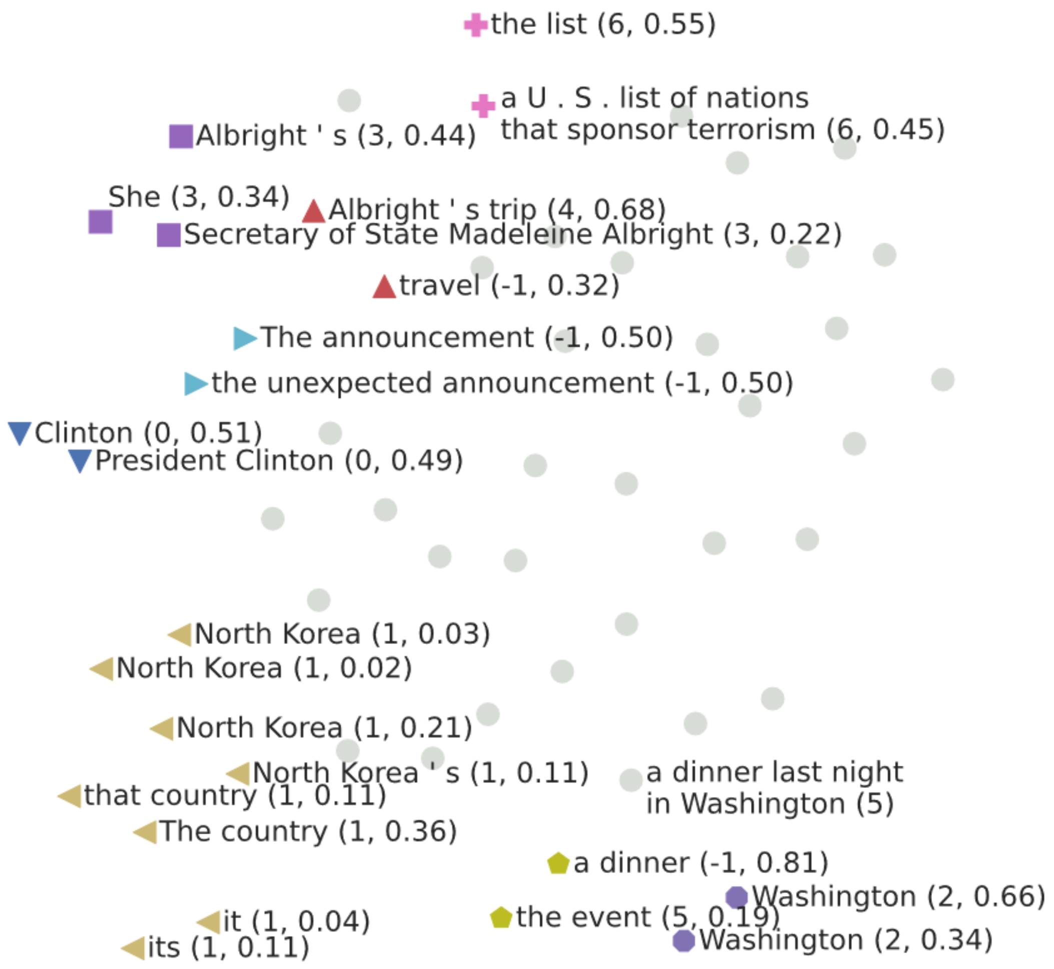
# Results

- 79.6 F1 → 79.4 F1
  - Virtually no loss in performance
- Constant space implementation at inference (2GB) and training (<10GB)
- Our algorithm has O(1) space complexity
  - A fixed-sized set of entities kept across time



# Entity Analysis

- Coreference is well-suited for (online) clustering: coreferent mentions are close in embedding space



# Conclusions

- Constant memory algorithm + model for coreference resolution
- Can be applied to future SOTA models
- Detailed analysis of document and segment lengths in paper!
- Thanks!

Code and models at
github.com/pitrack/incremental-coref