Graph Convolutions over Constituent Trees for Syntax-Aware Semantic Role Labeling

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Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence

Investors appeal to the CEO not to limit their access to sales data

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover predicates

V

Investors appeal to the CEO not to limit their access to sales data

V

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover predicates
  - Identify arguments and label them with their semantic roles

ARG0 V

Investors appeal to the CEO not to limit their access to sales data

V

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover predicates
  - Identify arguments and label them with their semantic roles

ARG0 V ARG1

Investors appeal to the CEO not to limit their access to sales data

V

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover predicates
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ARG0 V ARG1 ARG2

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Semantic Role Labeling

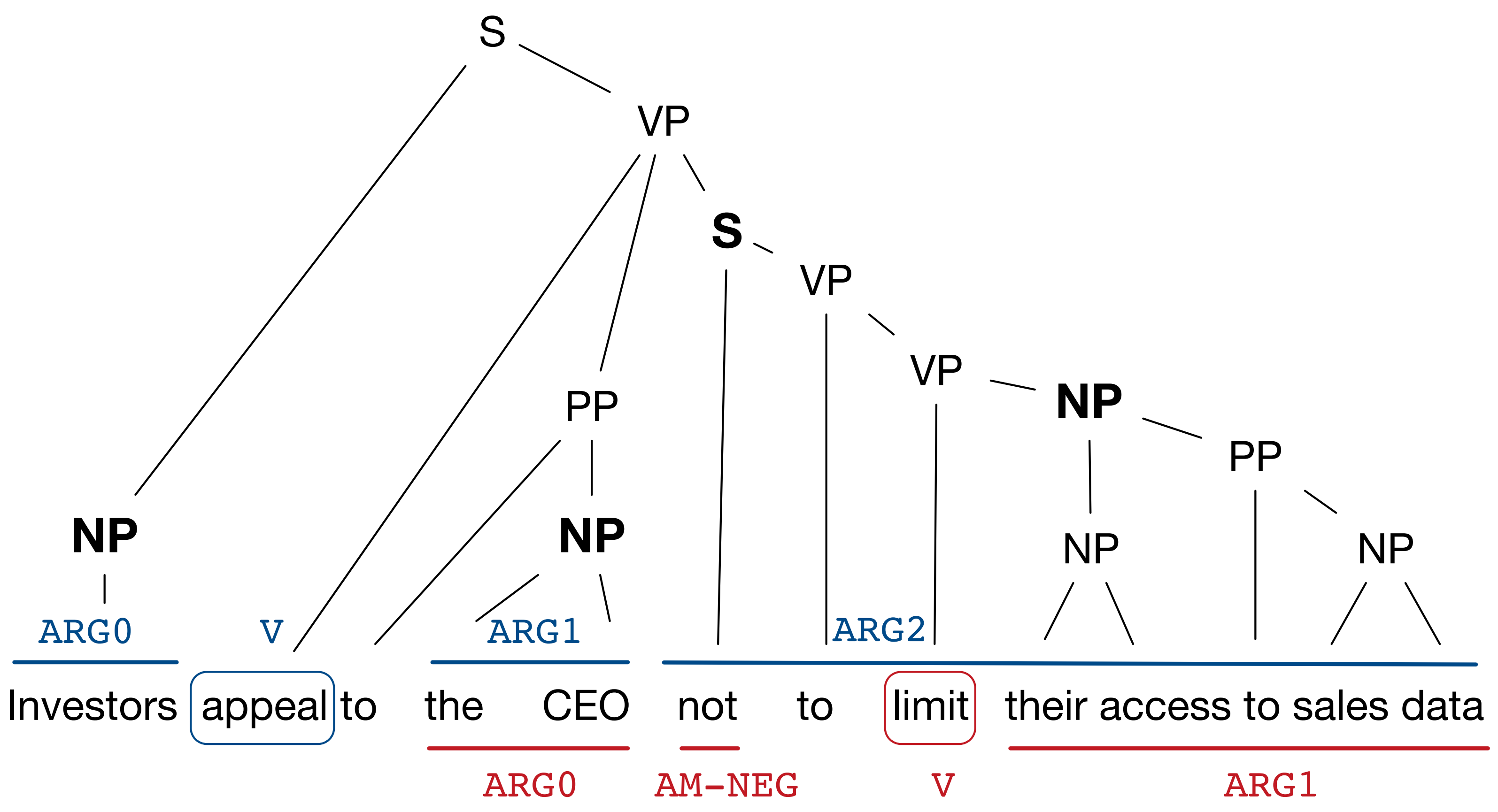
- Predicting the predicate-argument structure of a sentence
  - Discover predicates
  - Identify arguments and label them with their semantic roles

ARG0 V ARG1 ARG2

Investors appeal to the CEO not to limit their access to sales data

ARG0 AM-NEG V ARG1

Motivation- Importance of syntax in SRL



Previous work

- Converted into dependency trees and encoded with self-attention:
  - Strubell et al. (2018)
- Constituency syntax extracted using heuristics:
  - He et al. (2019)
  - Wang et al. (2019)
- Syntax-agnostic models:
  - He et al. (2017)
  - Tan et al. (2018)
  - Ouchi et al. (2018)

Contributions

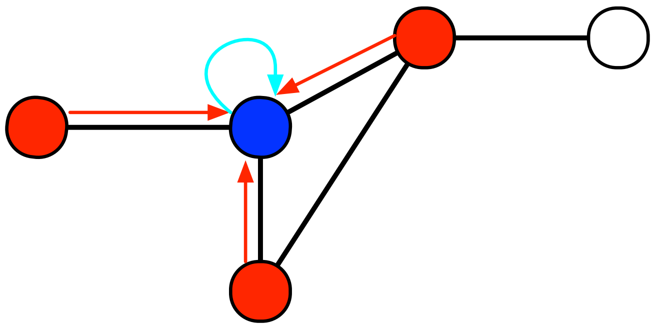
- Span Graph Convolutional Networks (SpanGCN)
- Encode constituent structure:
  - efficiently (in a single pass)
  - at the level of words representation (compatible with seq2seq)
  - general and applicable to other span-based structures
- Syntax remains beneficial for SRL

Graph Convolutions over Constituent Trees

- **Graph Convolutional Networks**
- SpanGCN
- Semantic Role Labeling Model
- Experiments
- Conclusions

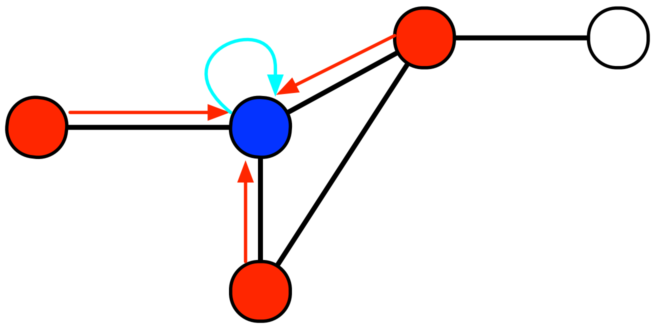
[Kipf and Welling, 2016]

Graph Convolutional Networks



[Kipf and Welling, 2016]

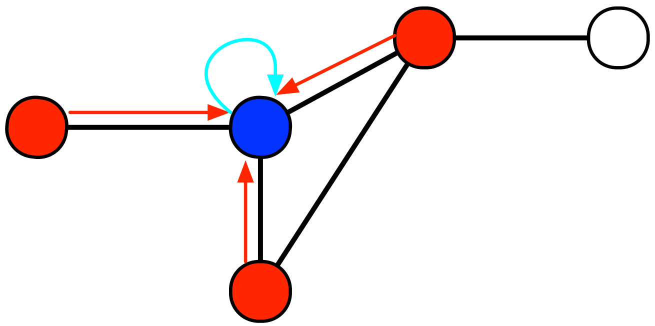
Graph Convolutional Networks



$$h_i = ReLU\left(W_0 h_i + \sum_{j \in \mathcal{N}(v)} W_1 h_j\right)$$

[Kipf and Welling, 2016]

Graph Convolutional Networks



$$h_i = ReLU\left(W_0 h_i + \sum_{j \in \mathcal{N}(v)} W_1 h_j\right)$$

combination

messages

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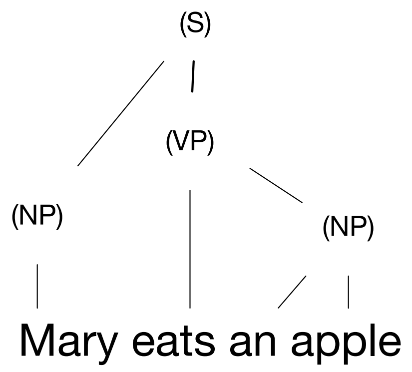
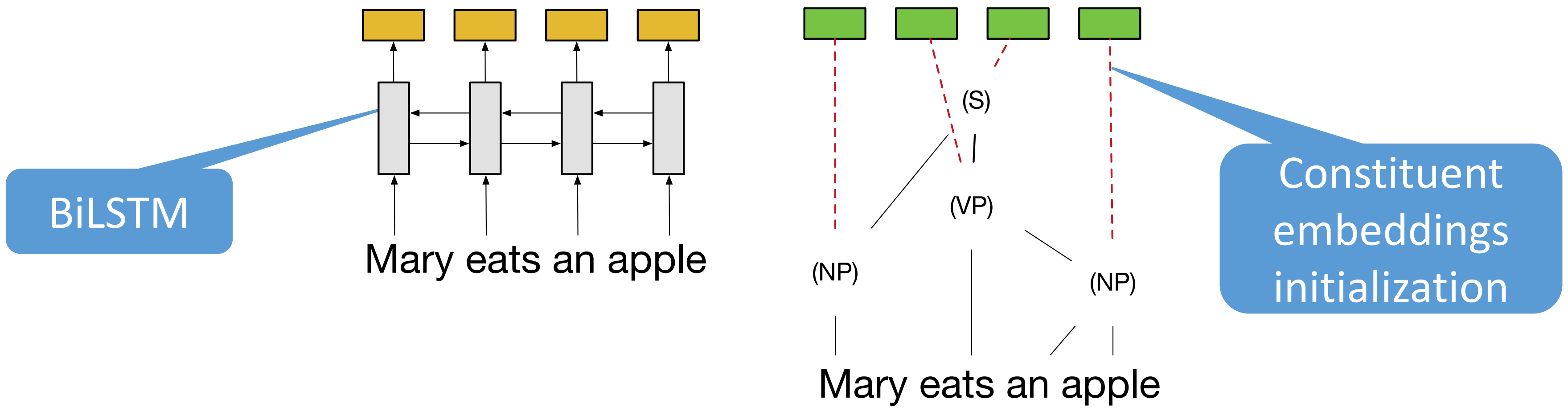
Example

Mary eats an apple

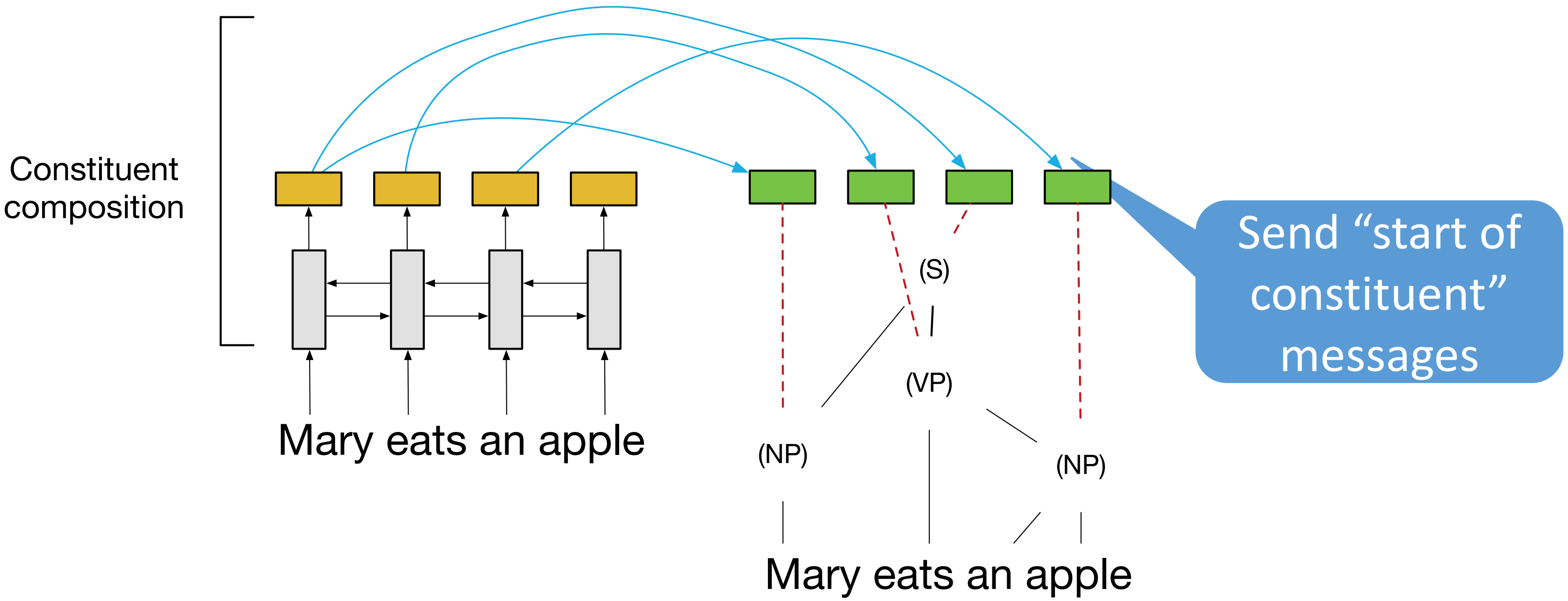


Example



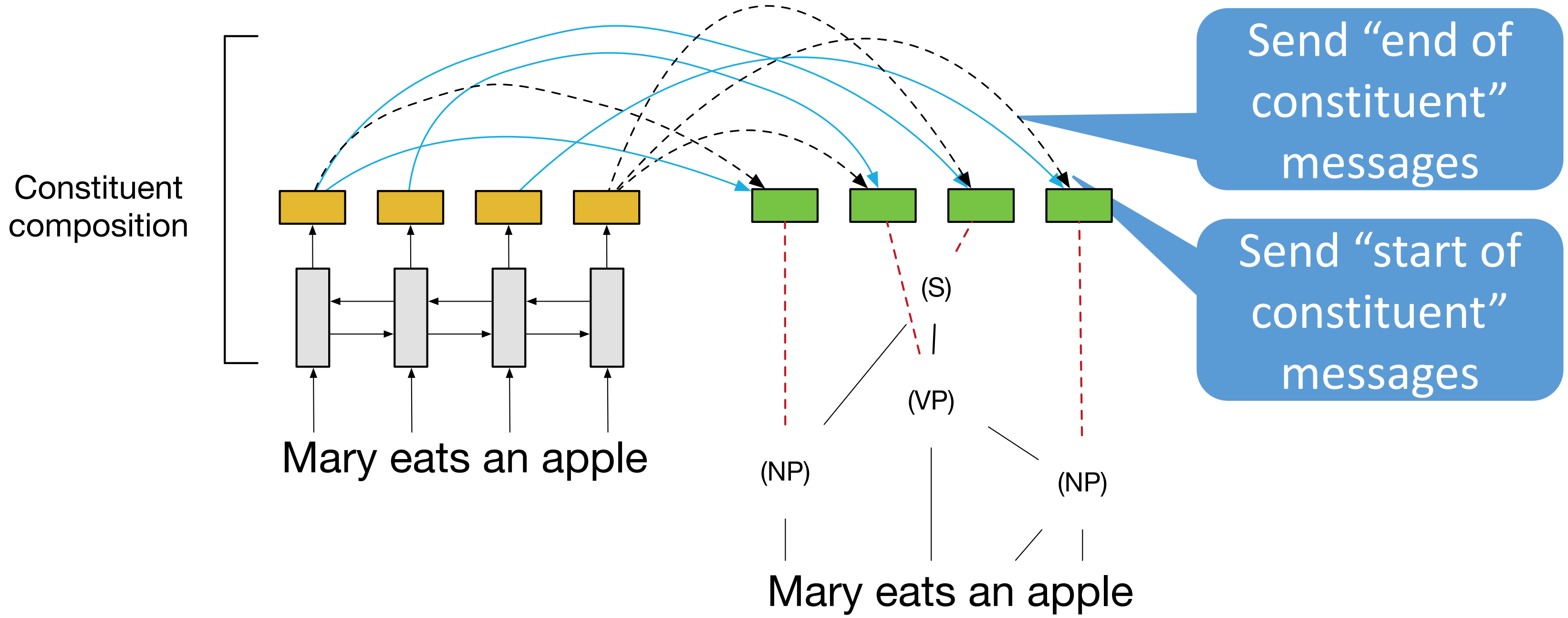
BiLSTM
Mary eats an apple
(S)
(VP)
(NP)
(NP)
Mary eats an apple
Constituent embeddings initialization

Example



Constituent composition
Mary eats an apple
(S)
(VP)
(NP)
(NP)
Mary eats an apple
Send "start of constituent" messages

Example



Constituent composition
Mary eats an apple
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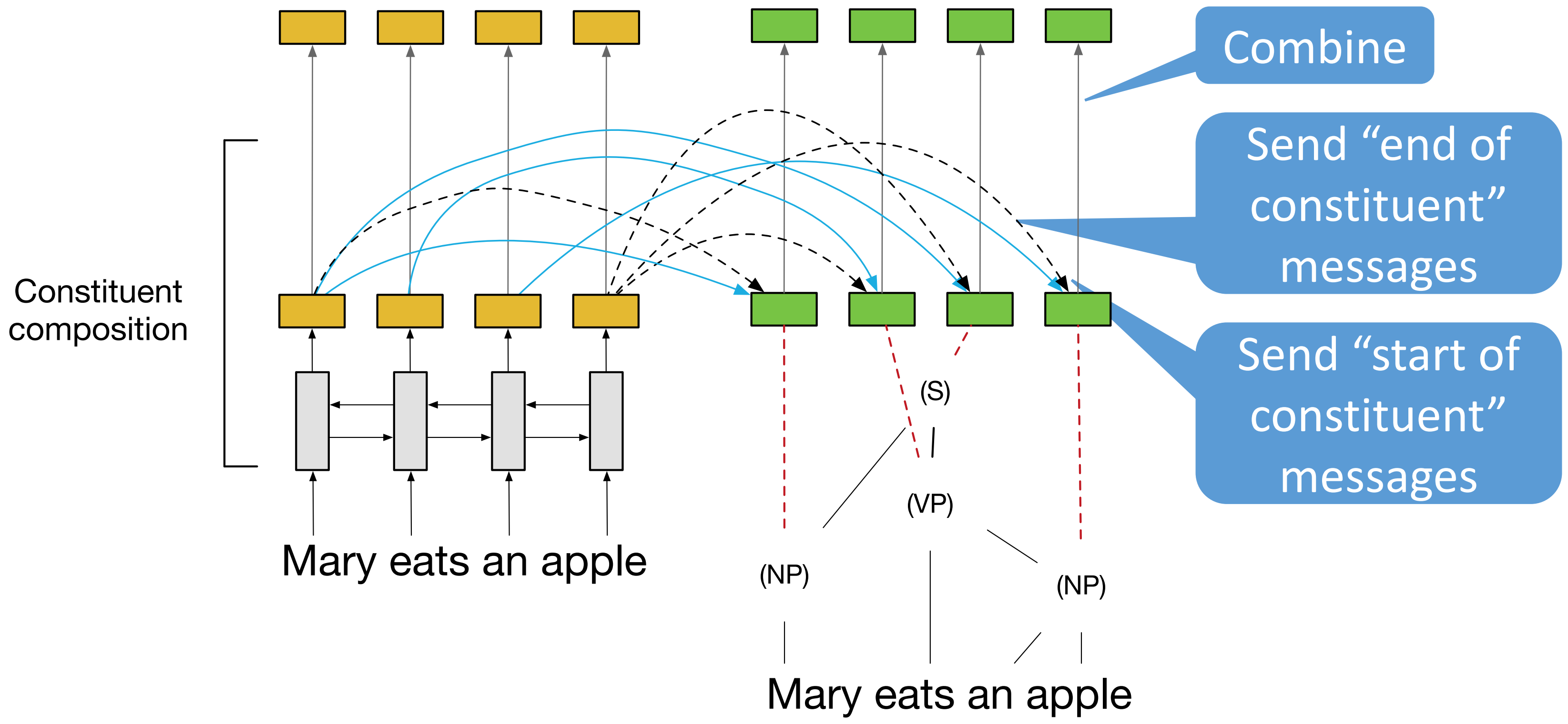
Mary eats an apple
Send "end of constituent" messages
Send "start of constituent" messages

Example



Constituent composition
Mary eats an apple
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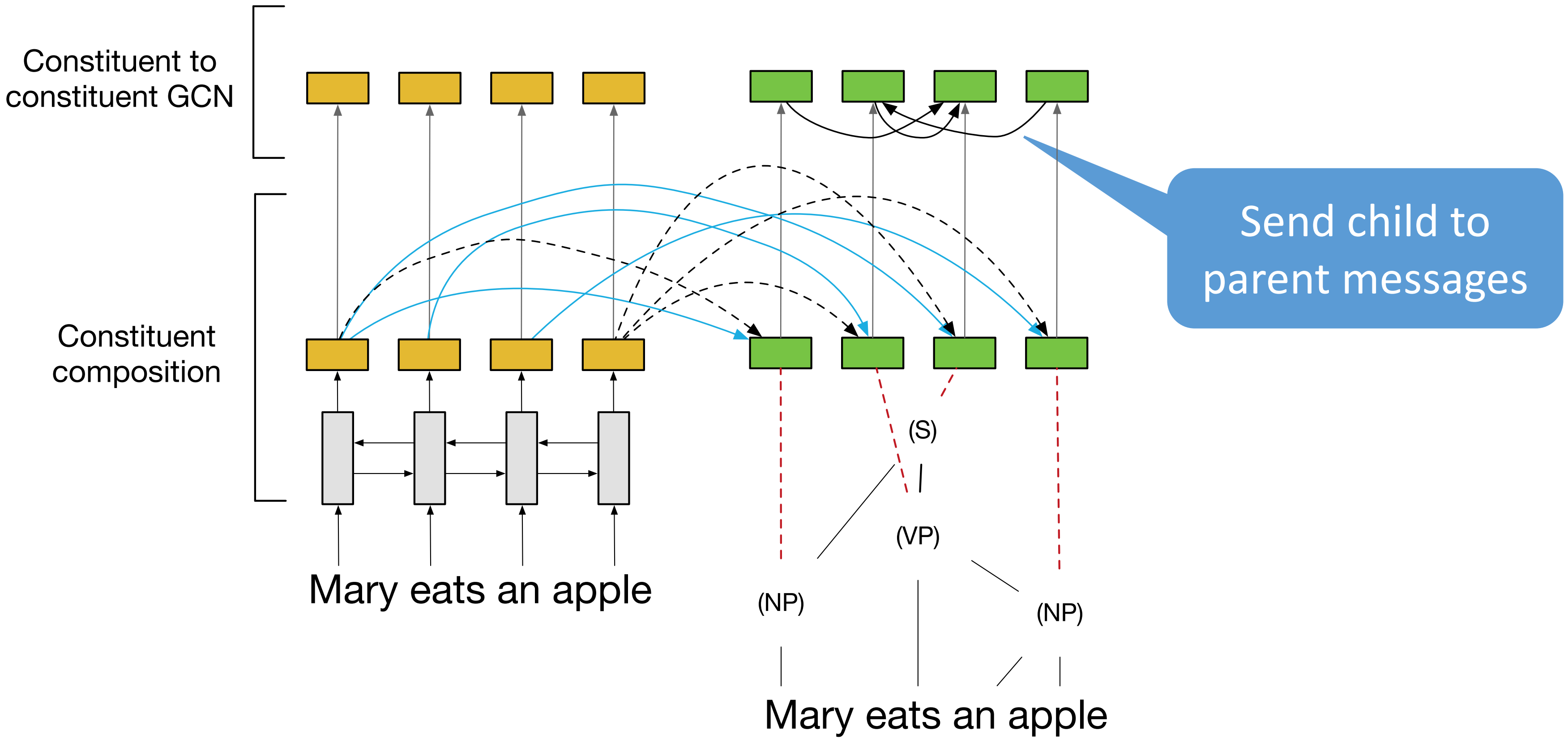
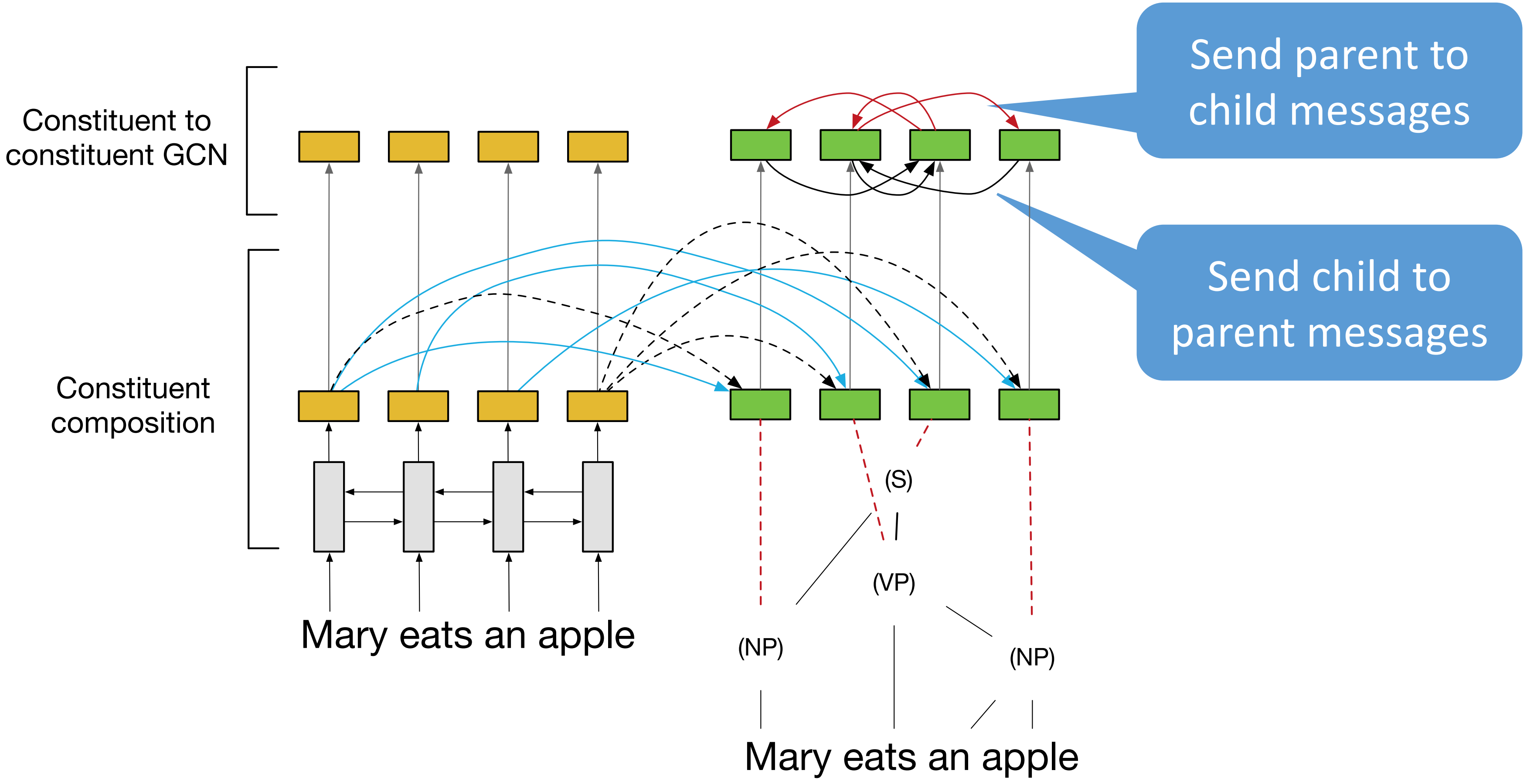
Combine
Send "end of constituent" messages
Send "start of constituent" messages

Example



Constituent to
constituent GCN
Constituent
composition
Mary eats an apple
(S)
(VP)
(NP)
(NP)
Mary eats an apple
Send child to
parent messages

Example



Constituent to constituent GCN
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Mary eats an apple
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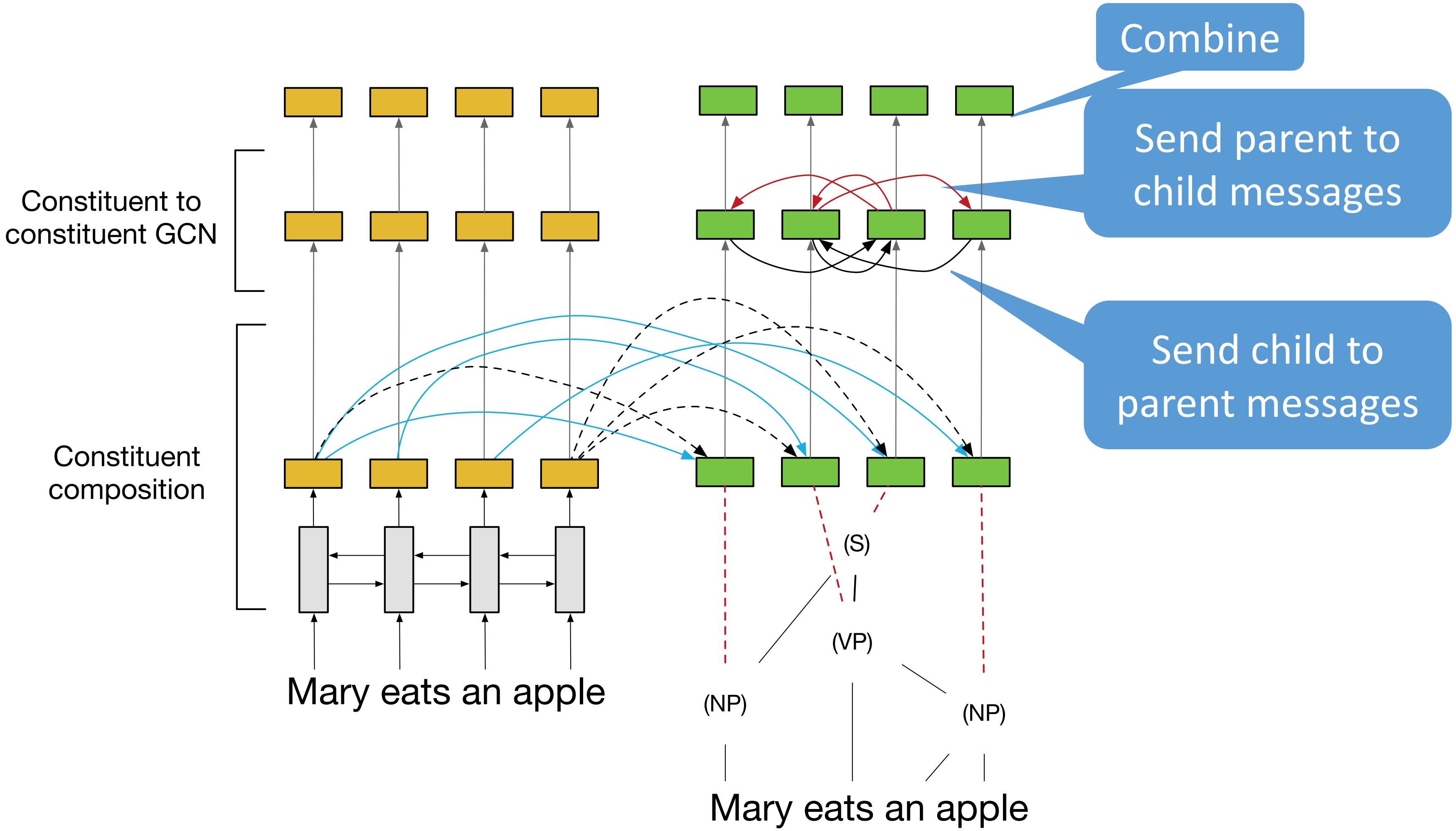
Mary eats an apple
Send parent to child messages
Send child to parent messages

Example


Combine
Send parent to child messages
Send child to parent messages
Constituent to constituent GCN
Constituent composition
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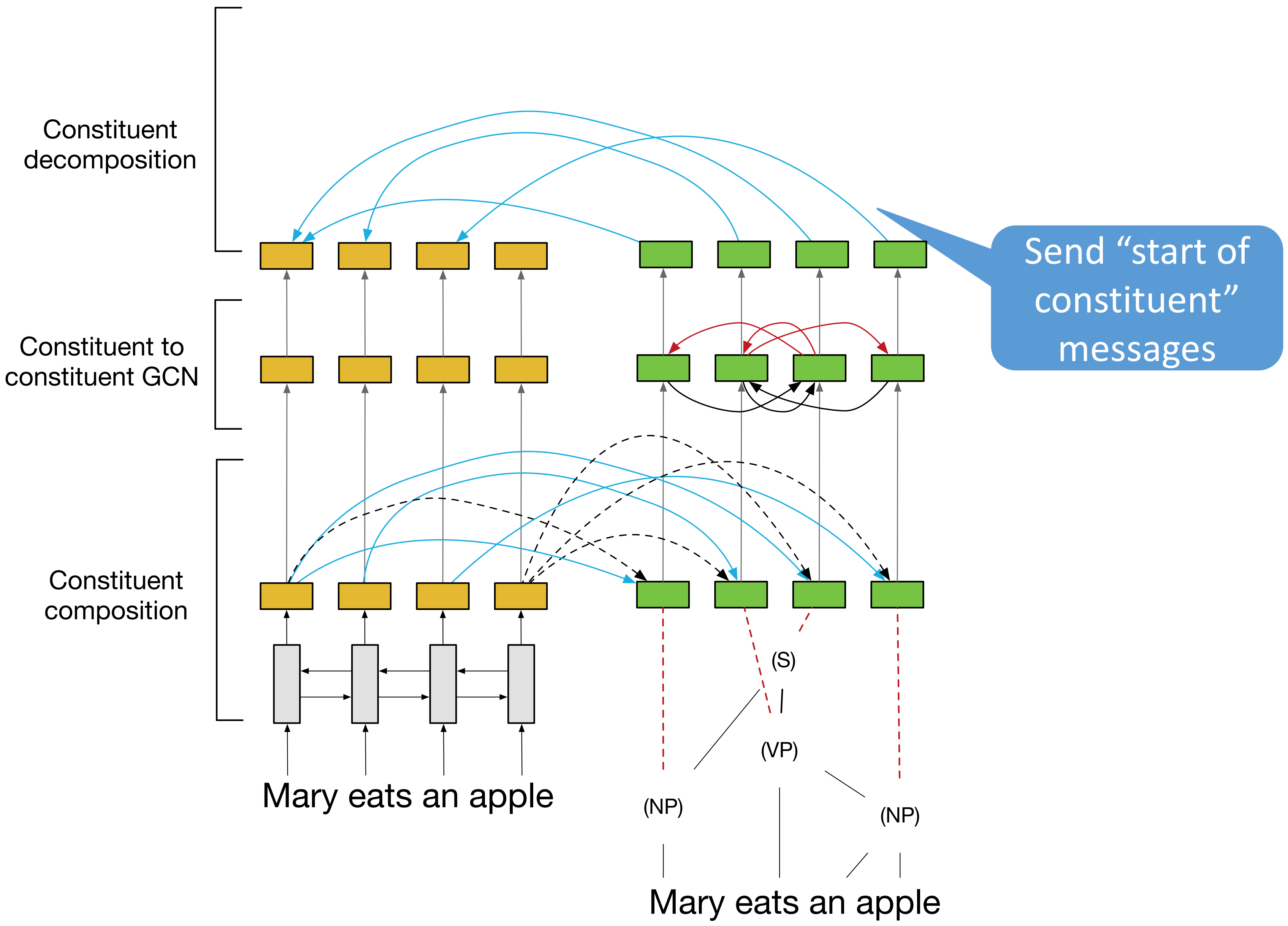

Constituent decomposition
Constituent to constituent GCN
Constituent composition
Mary eats an apple
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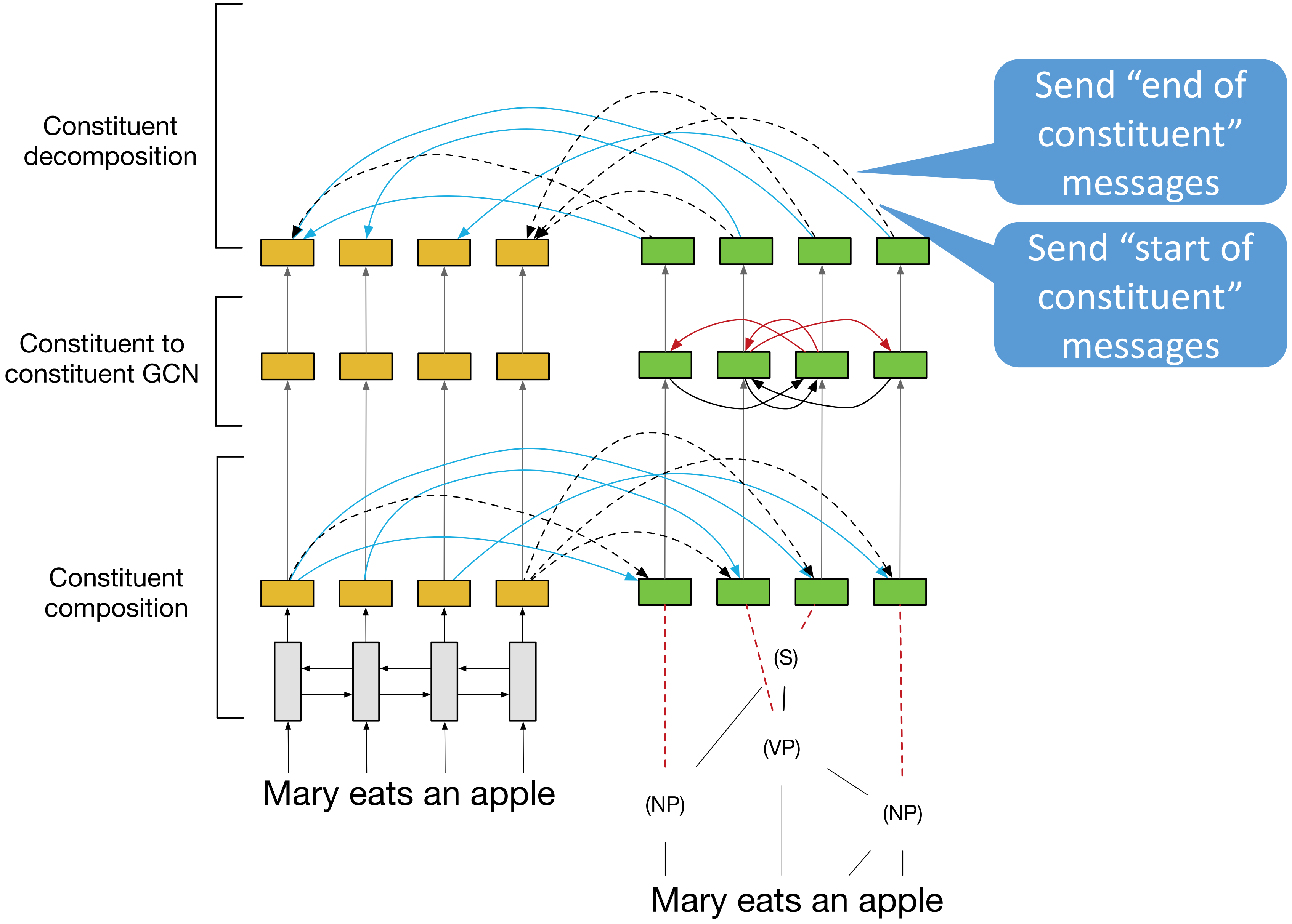
(NP)
Mary eats an apple
Send "start of constituent" messages

Example



Constituent decomposition
Constituent to constituent GCN
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Send “end of constituent” messages
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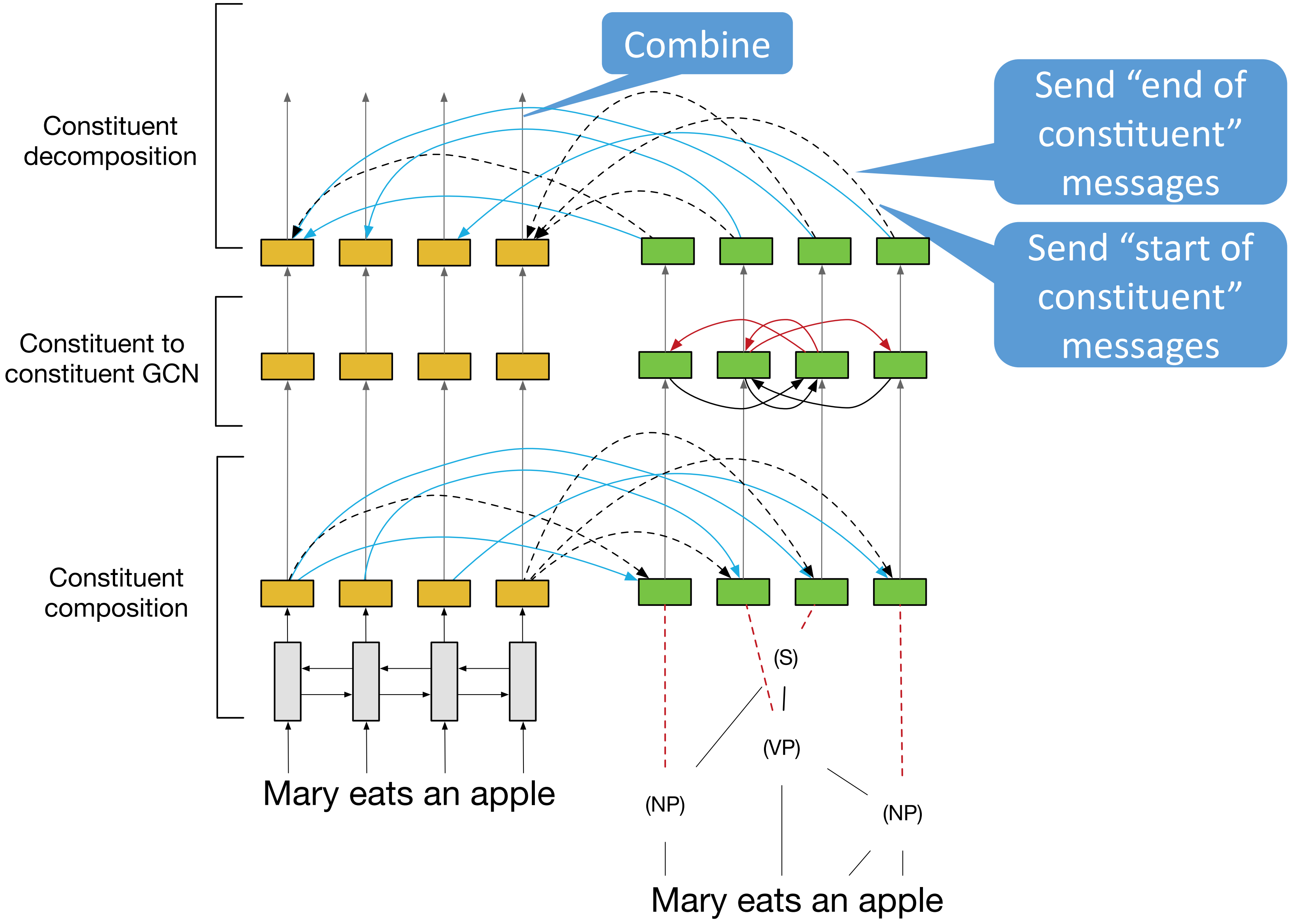

Combine
Send "end of constituent" messages
Send "start of constituent" messages
Constituent decomposition
Constituent to constituent GCN
Constituent composition
Mary eats an apple
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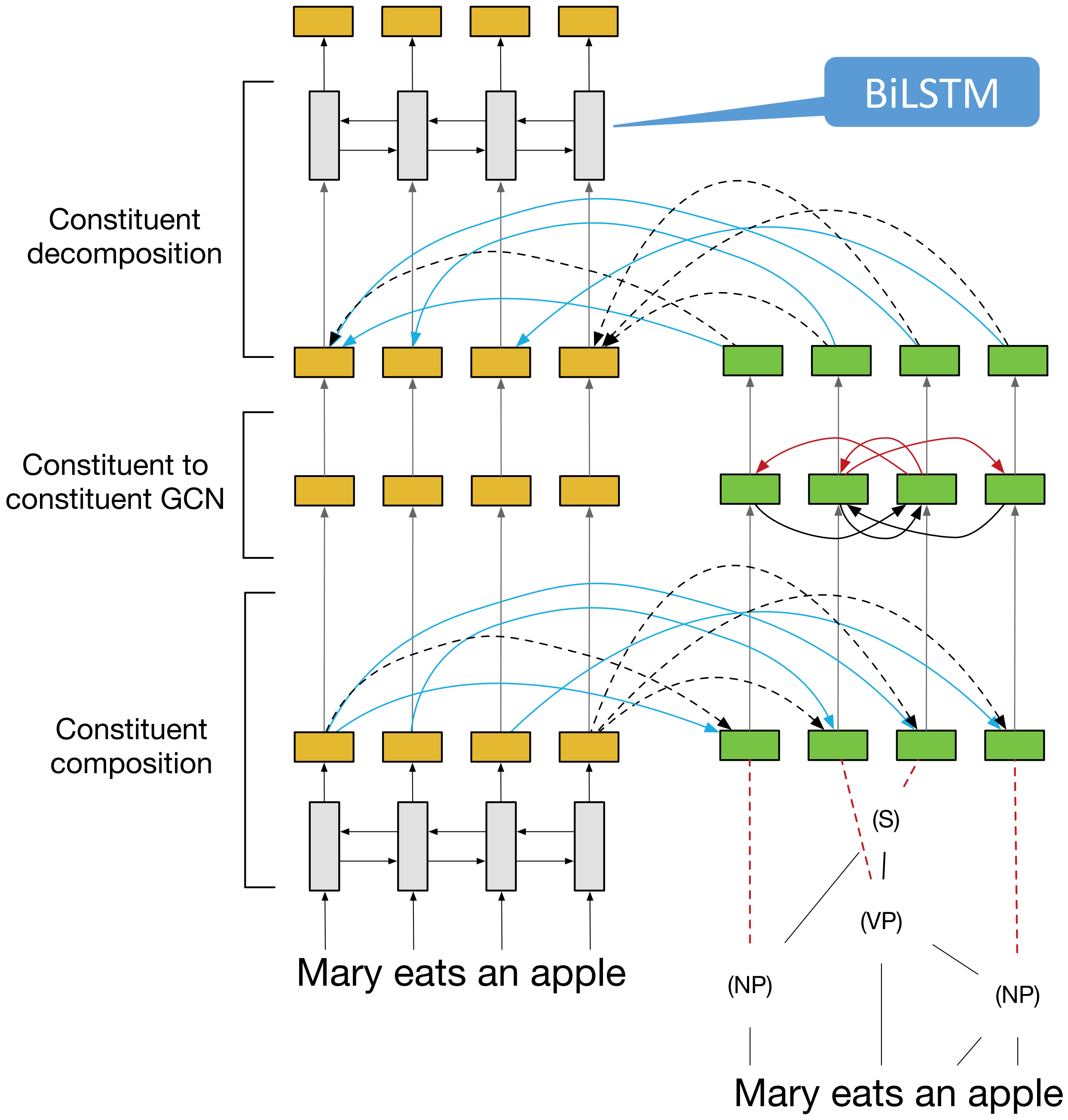
BiLSTM
Constituent decomposition
Constituent to constituent GCN
Constituent composition
Mary eats an apple
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SpanGCN Update

$$h_v = ReLU(\sum_{u \in \mathcal{N}(v)} U_{T_c(u,v)} h_u + b_{T_f(u,v)})$$

SpanGCN Update

Marcheggiani and Titov, (2017)
Schlichtkrull et al. (2018)

Messages

$$h_v = ReLU(\sum_{u \in \mathcal{N}(v)} \boxed{U_{T_c(u,v)} h_u + b_{T_f(u,v)}})$$

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Messages

$$h_v = ReLU(\sum_{u \in \mathcal{N}(v)} \boxed{U_{T_c(u,v)} h_u + b_{T_f(u,v)}})$$

Coarse edge labels

Fine edge labels

SpanGCN Update

$$h_v = ReLU\left(\sum_{u \in \mathcal{N}(v)} \overbrace{\boxed{U_{\underbrace{T_c(u,v)}_{\text{Coarse edge labels}}} h_u + b_{\underbrace{T_f(u,v)}_{\text{Fine edge labels}}}}}^{\text{Messages}}\right)$$

- Composition and Decomposition
  - $T_c(u,v)$ distinguishes between start or end token
  - $T_f(u,v)$ specifies syntactic labels of the constituent

SpanGCN Update

$$h_v = ReLU\Big(\sum_{u\in\mathcal{N}(v)} \overbrace{\boxed{U_{\underbrace{T_c(u,v)}_{\text{Coarse edge labels}}} h_u + b_{\underbrace{T_f(u,v)}_{\text{Fine edge labels}}}}}^{\text{Messages}}\Big)$$

- Composition and Decomposition
  - $T_c(u,v)$ distinguishes between start or end token
  - $T_f(u,v)$ specifies syntactic labels of the constituent
- Constituent GCN
  - $T_c(u,v)$ specifies message directions (parent to child and vice-versa)
  - $T_f(u,v)$ specifies syntactic labels

Graph Convolutions over Constituent Trees

- Graph Convolutional Networks
- SpanGCN
- **Semantic Role Labeling Model**
- Experiments
- Conclusions

SRL Model

Pennington et al., (2014)
Peters et al. (2018)
Liu et al., (2019)

- Frozen word representation (Glove, ELMo, RoBERTa)
  - with predicate embeddings
- SpanGCN
- Conditional Random Field
  - Minimize negative conditional log likelihood

Baseline: BiLSTM in place of SpanGCN

Graph Convolutions over Constituent Trees

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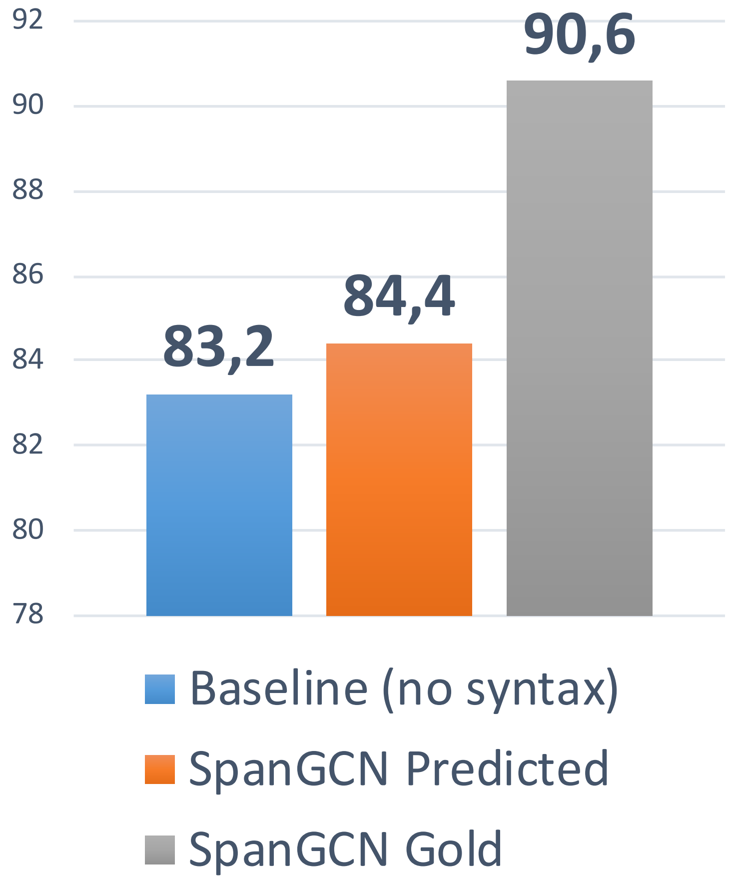
Experiments

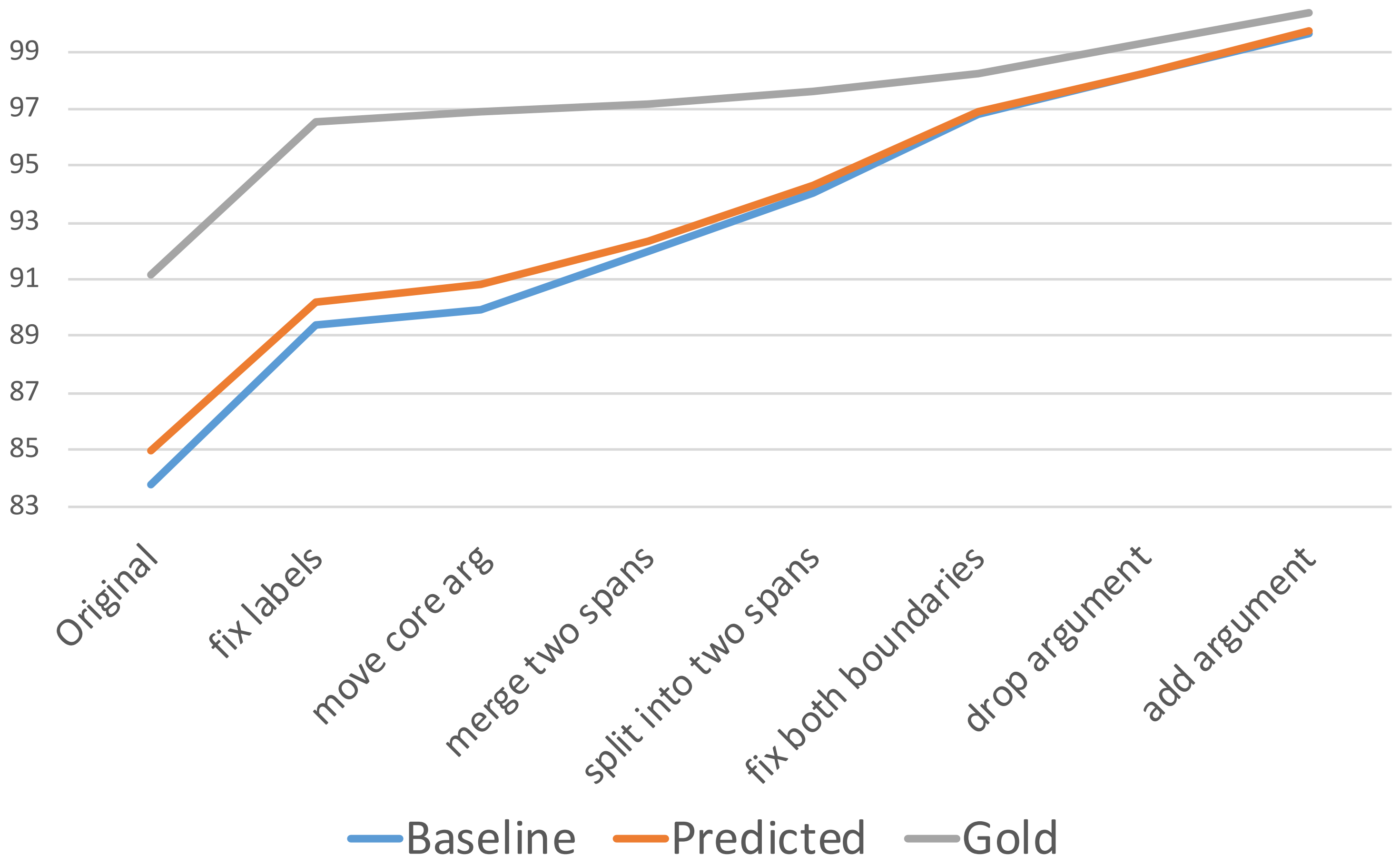
- Data
  - PropBank (CoNLL 2005)
  - FrameNet 1.5
- Gold predicates are given
- Syntactic parser of Kitaev and Klein, (2018)
- F1 score as metric
- Hyperparameters are tuned on Dev set of CoNLL 2005

PropBank
Palmer et al., (2005)
Carreras and Màrquez, (2005)

FrameNet
Baker et al., (1998)

Predicted vs. Gold Syntax (Dev CoNLL 2005)





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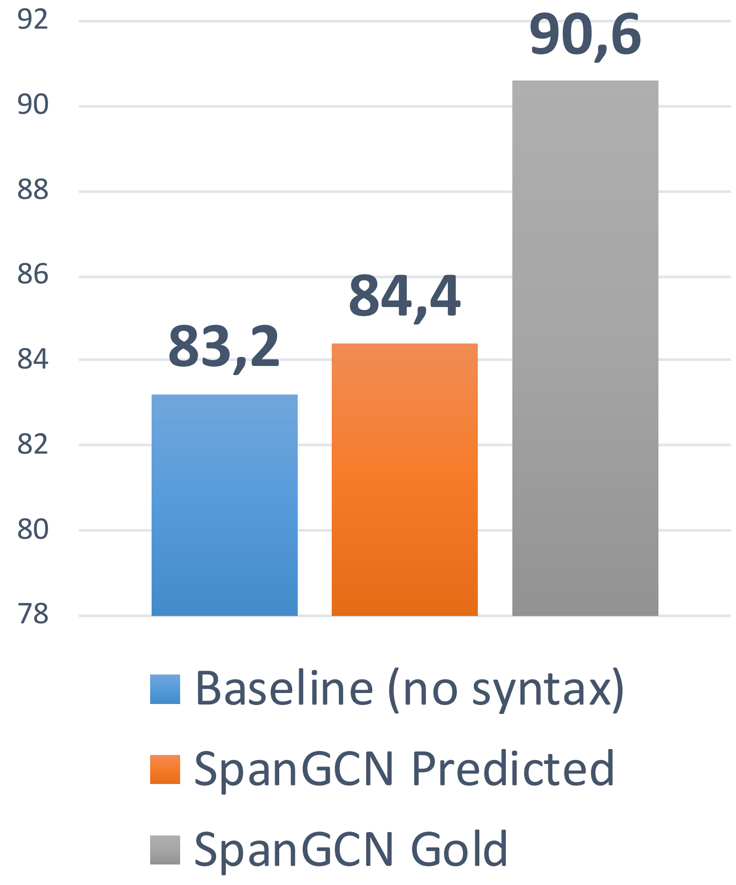
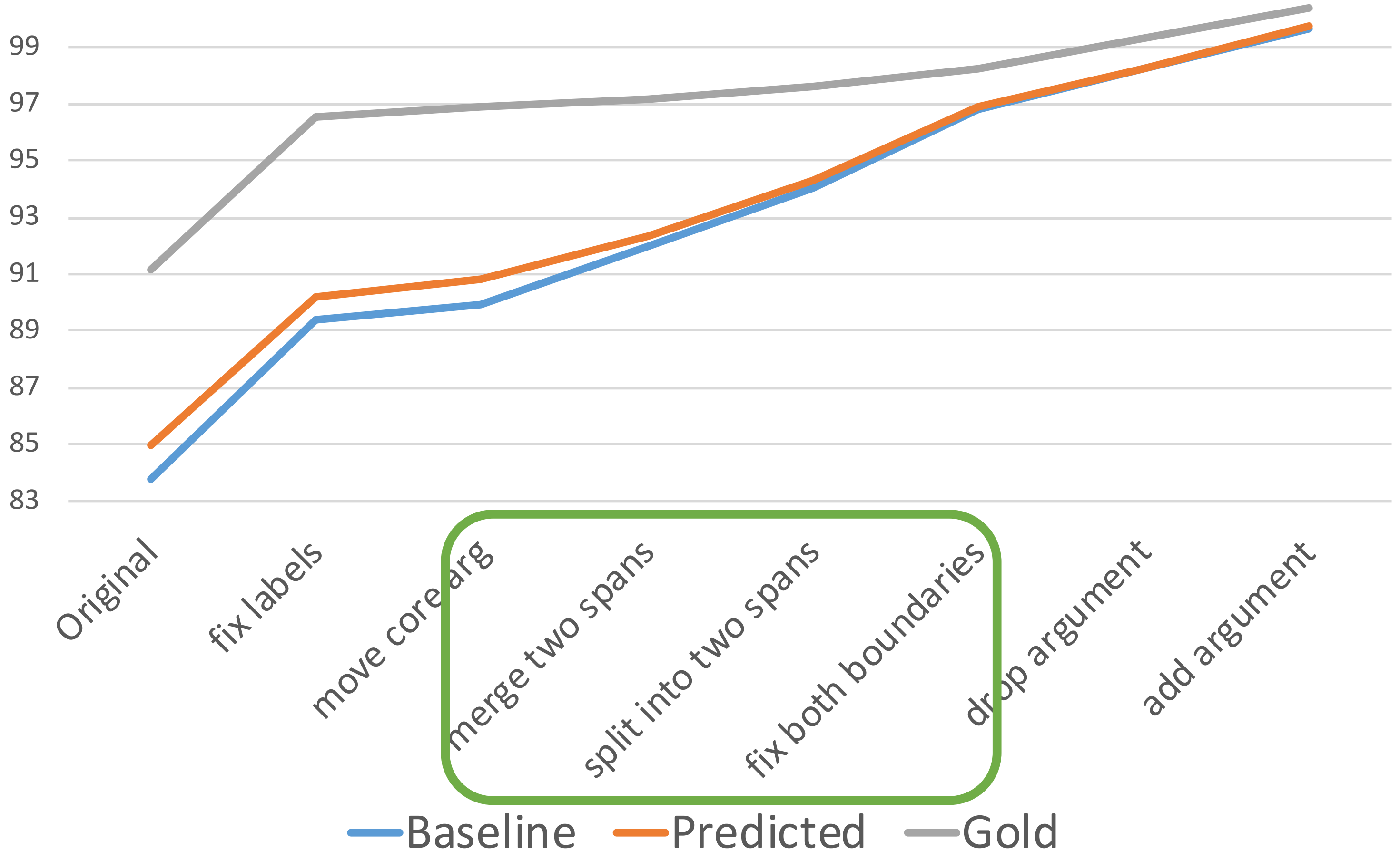
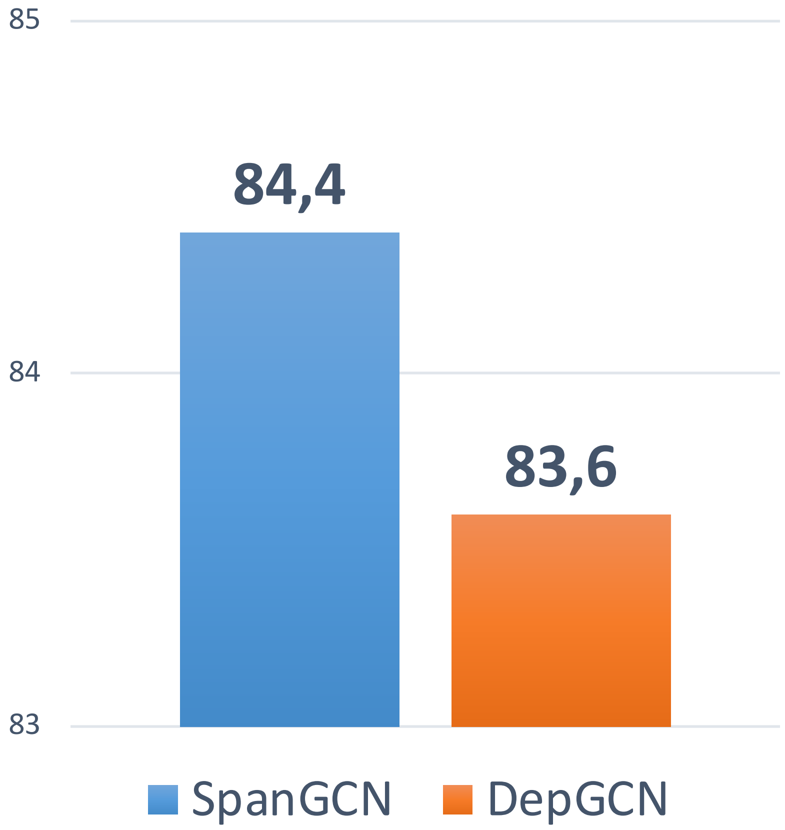
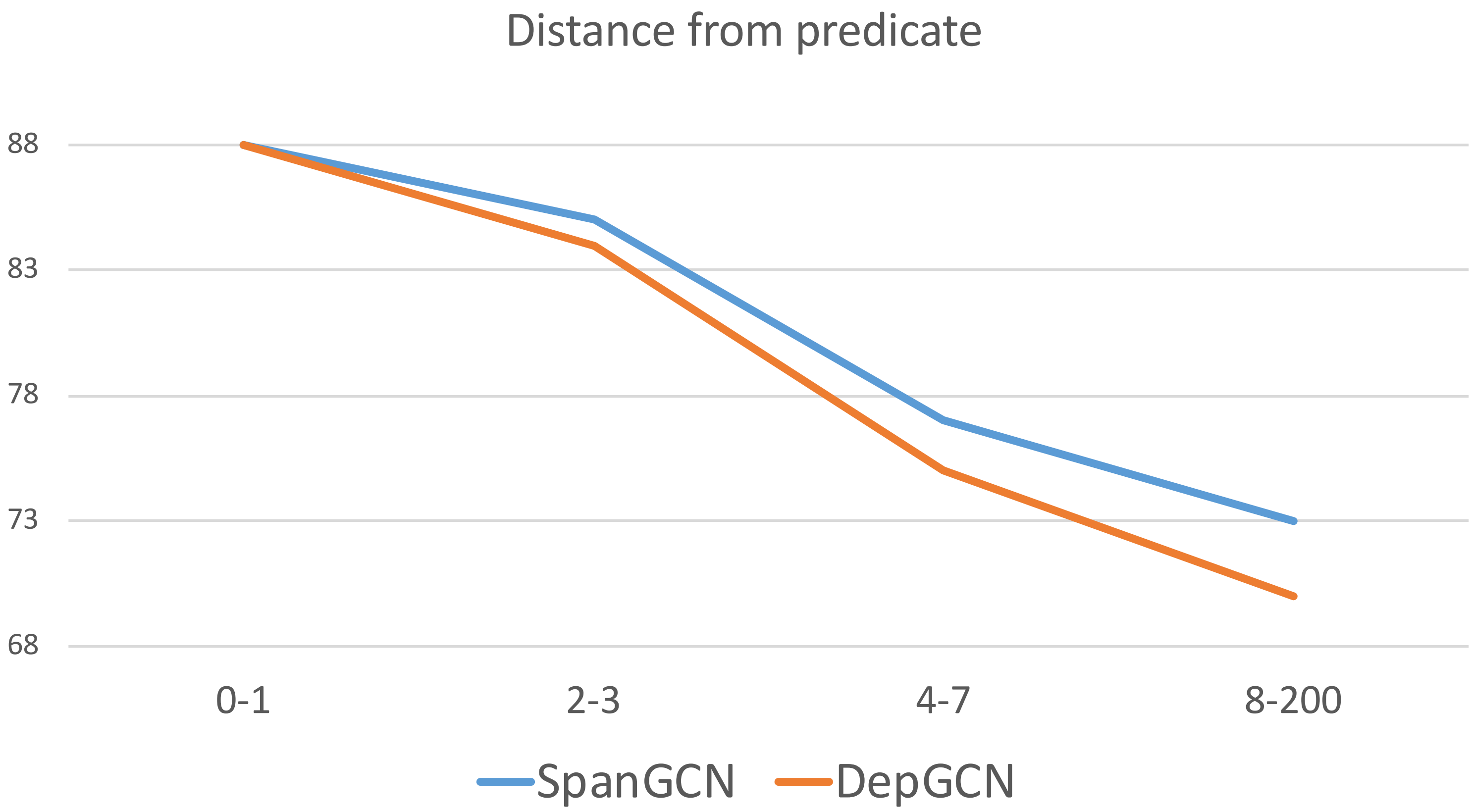




SpanGCN vs. DependencyGCN (Dev CoNLL 2005)





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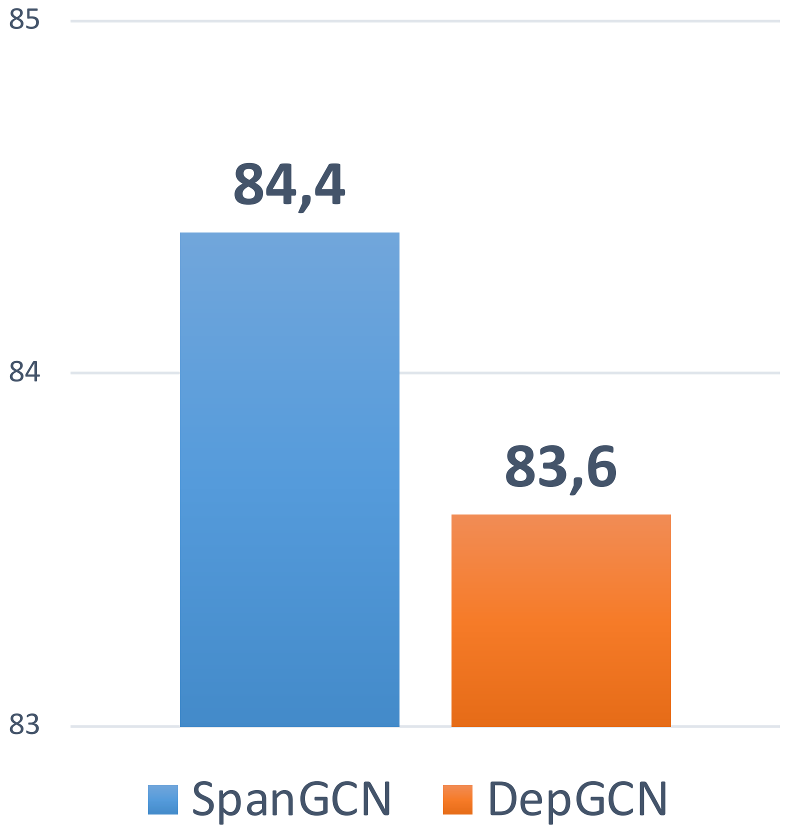
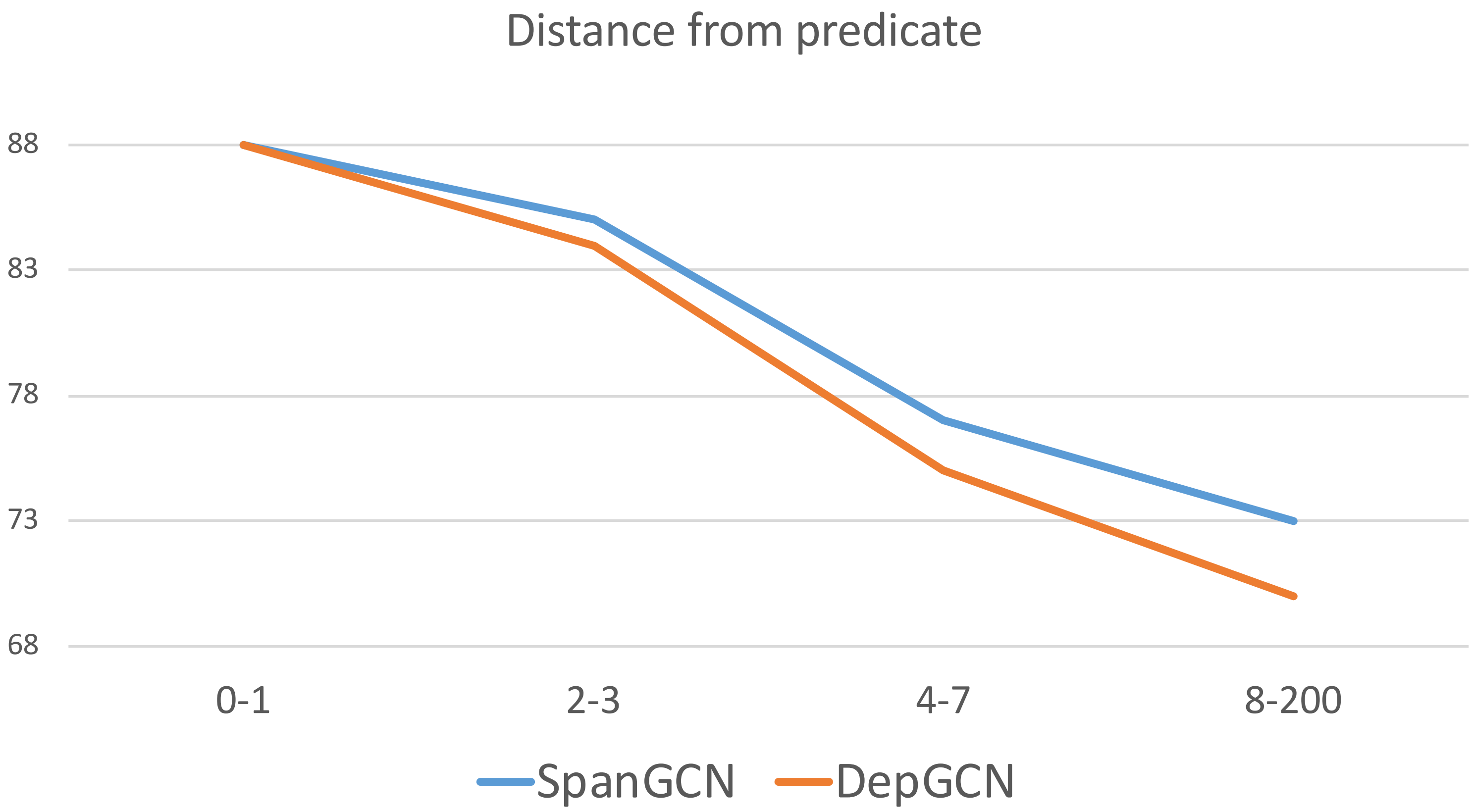
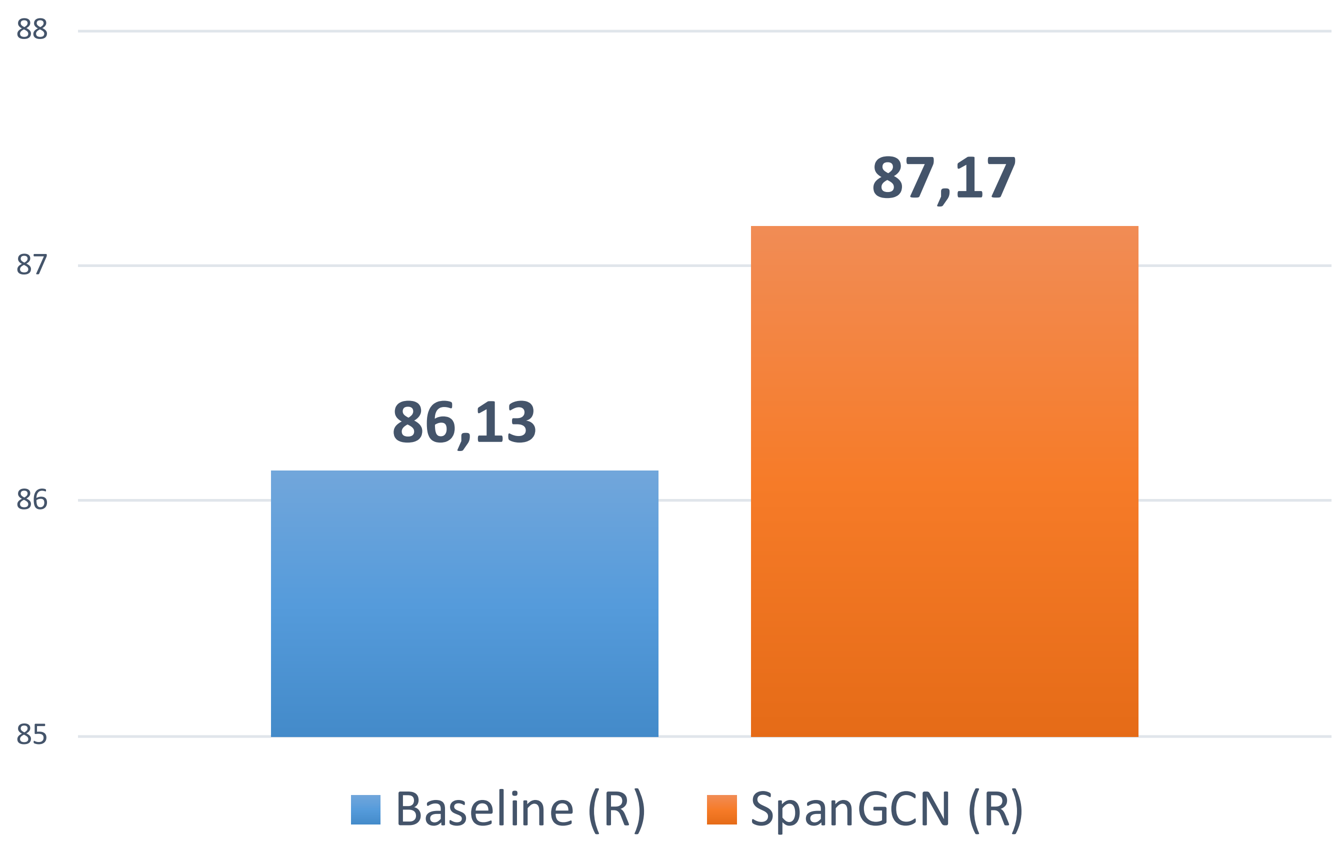




SpanGCN is more effective for distant arguments

RoBERTa + SpanGCN (Dev CoNLL 2005)



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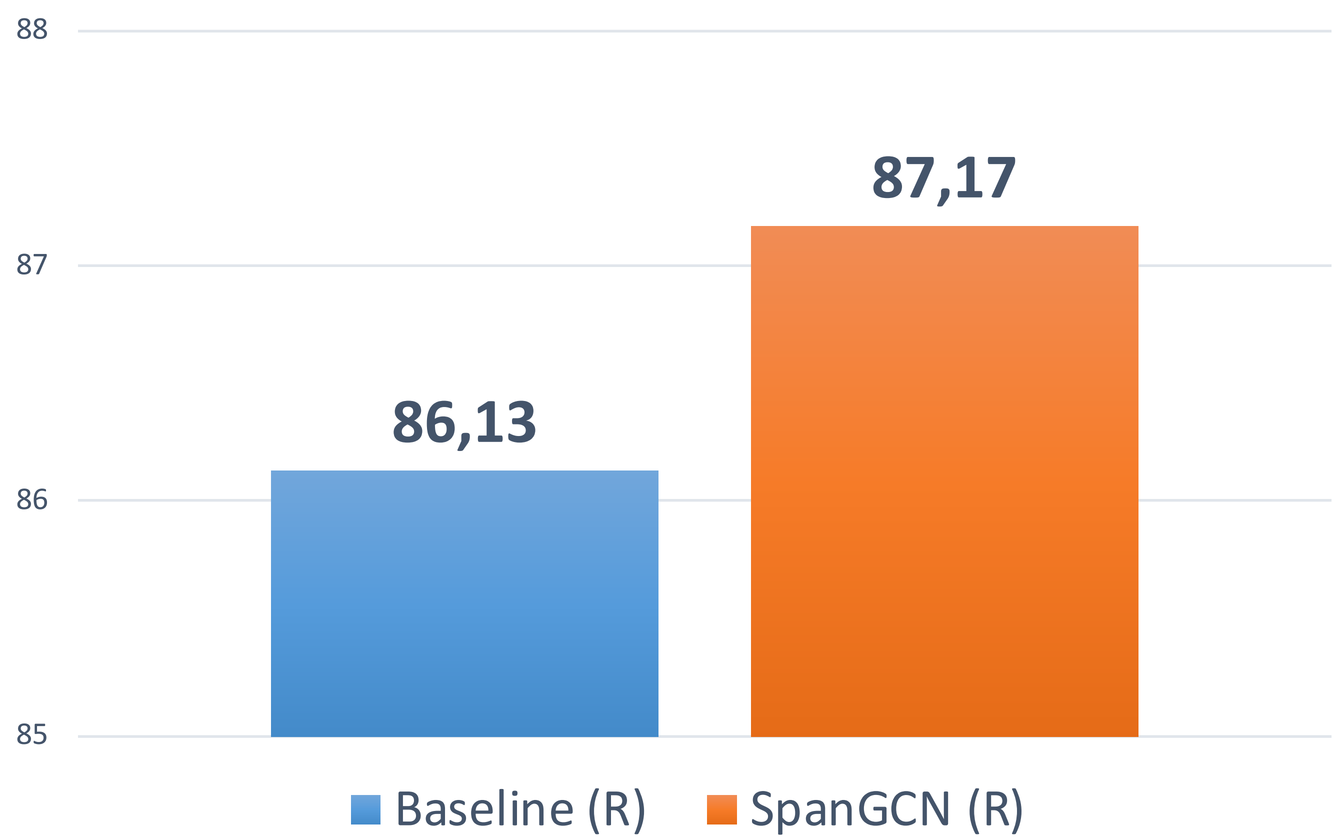
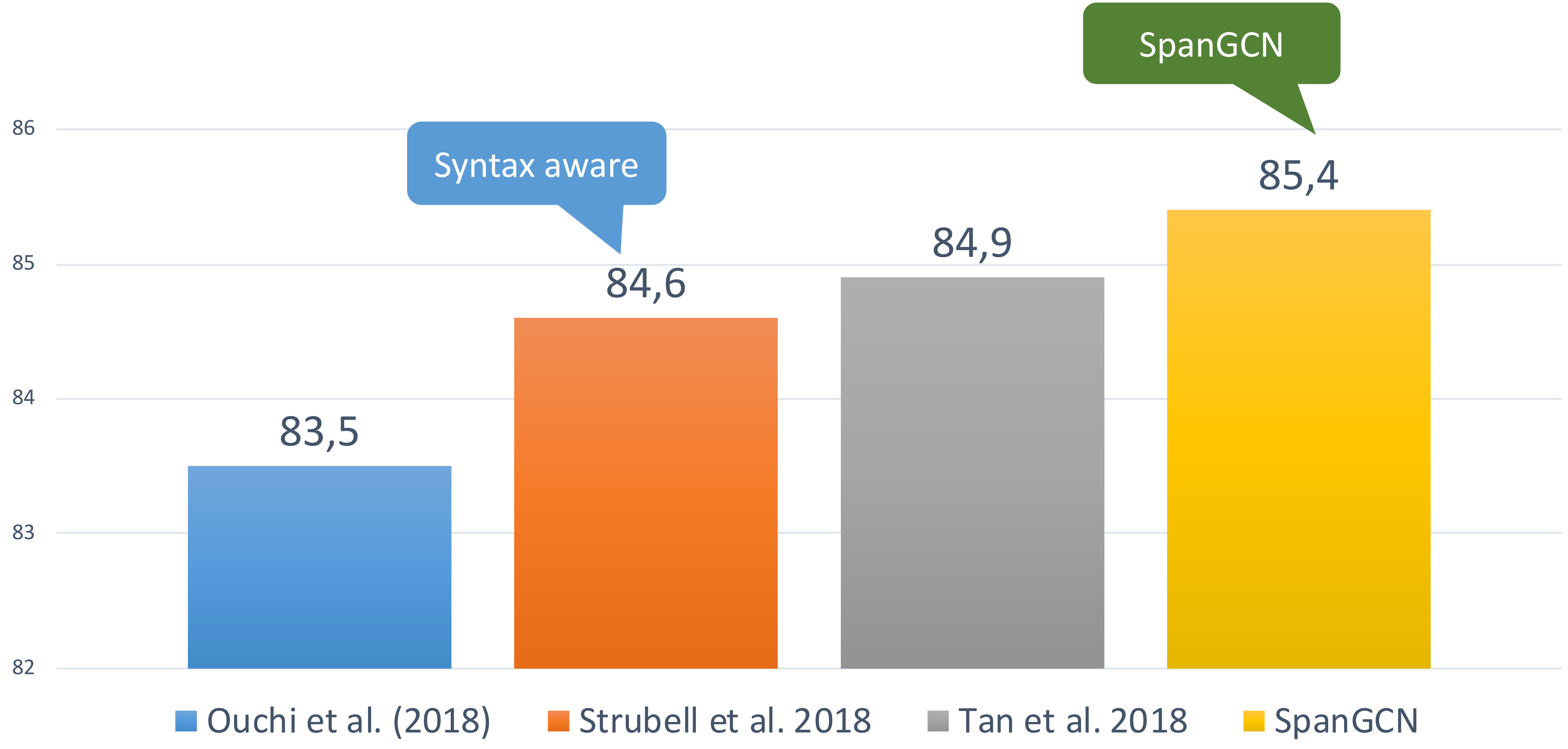
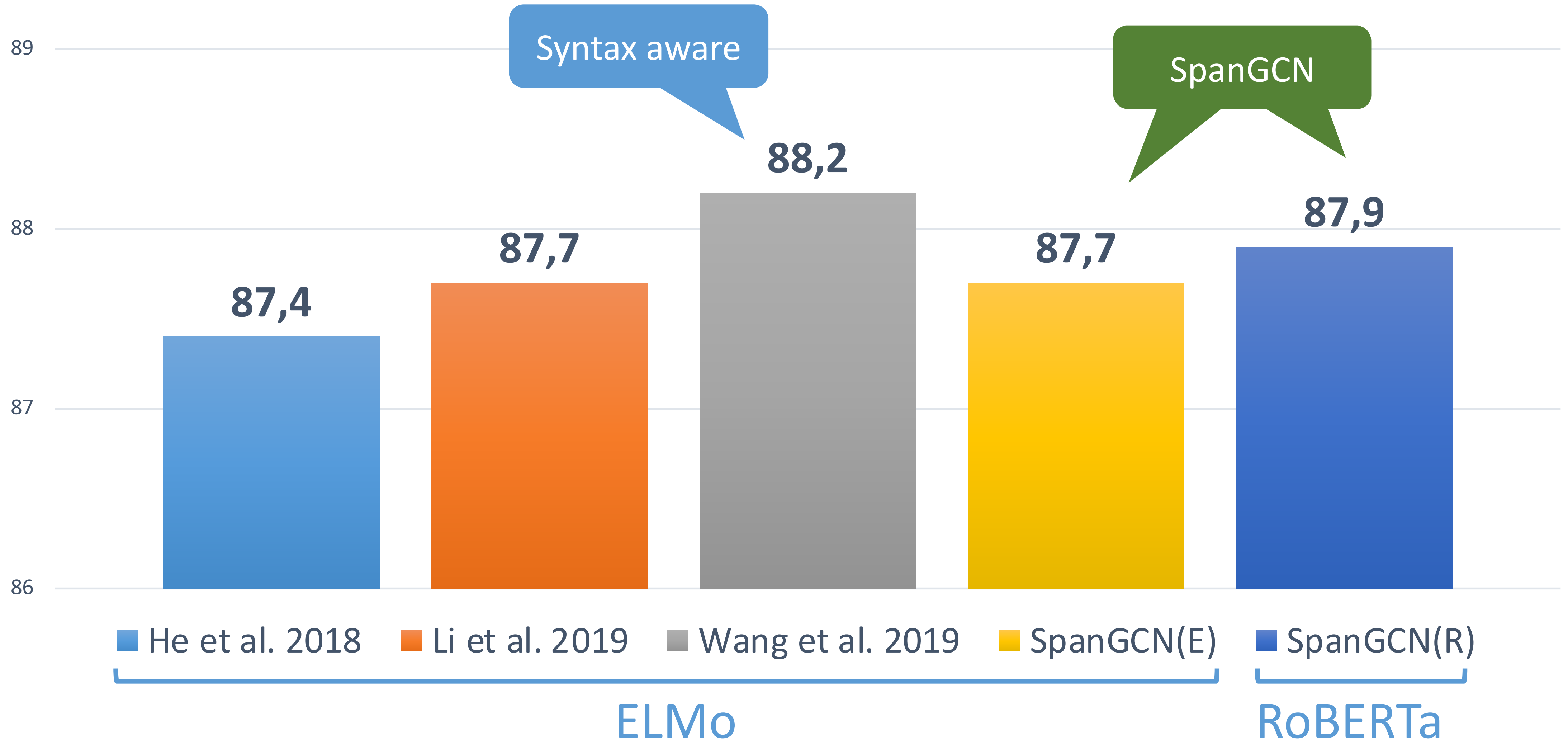


Syntax is still useful with powerful encoders

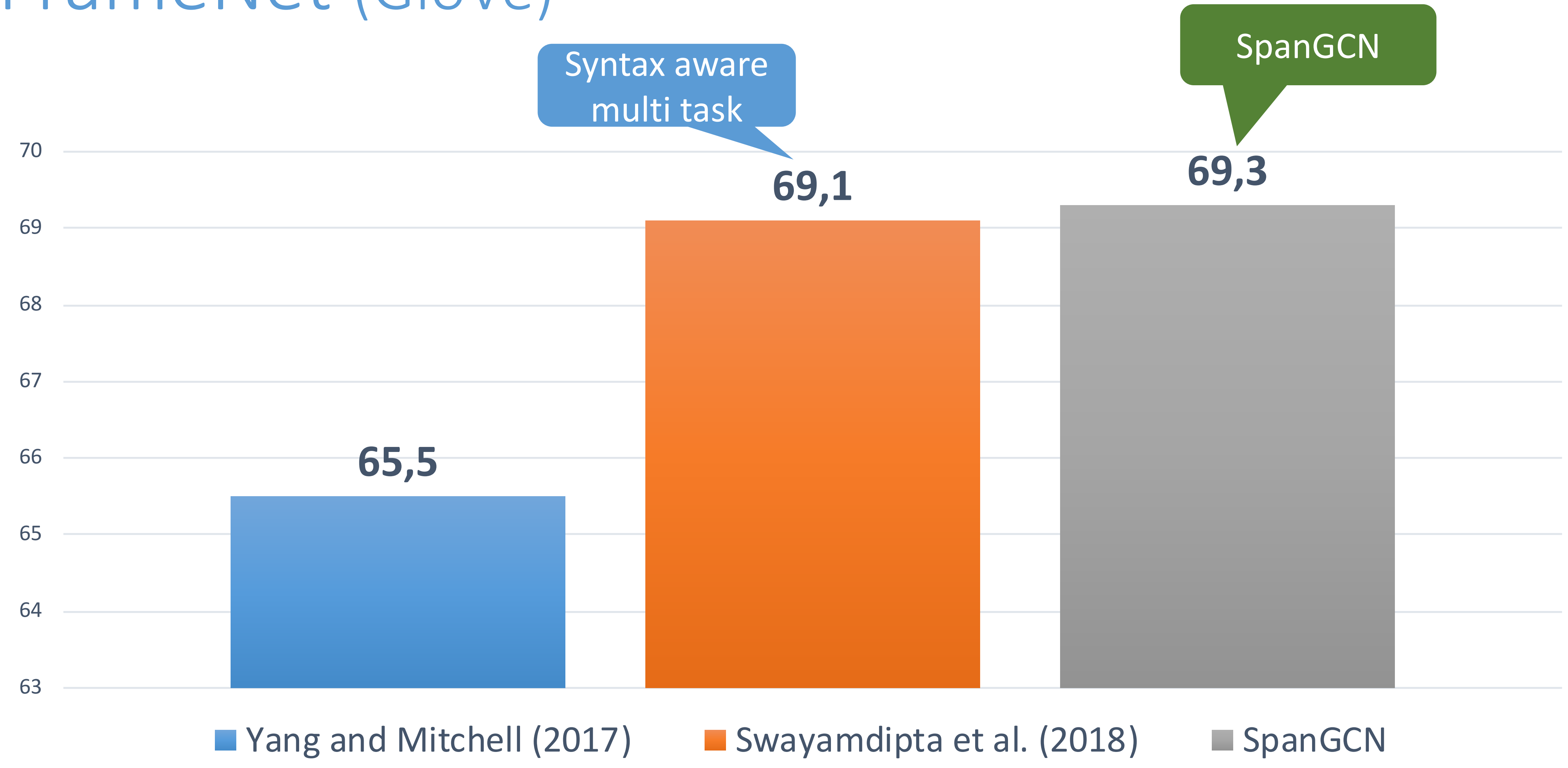
CoNLL 2005 – WSJ (GloVe)



CoNLL 2005 – WSJ (ELMo-RoBERTa)



FrameNet (GloVe)



Conclusions

- GCN-based architecture for encoding constituent structure
  - co-reference, semantic structures, entity graphs, discourse, etc.
- Obtained competitive results on SRL
  - PropBank and FrameNet

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