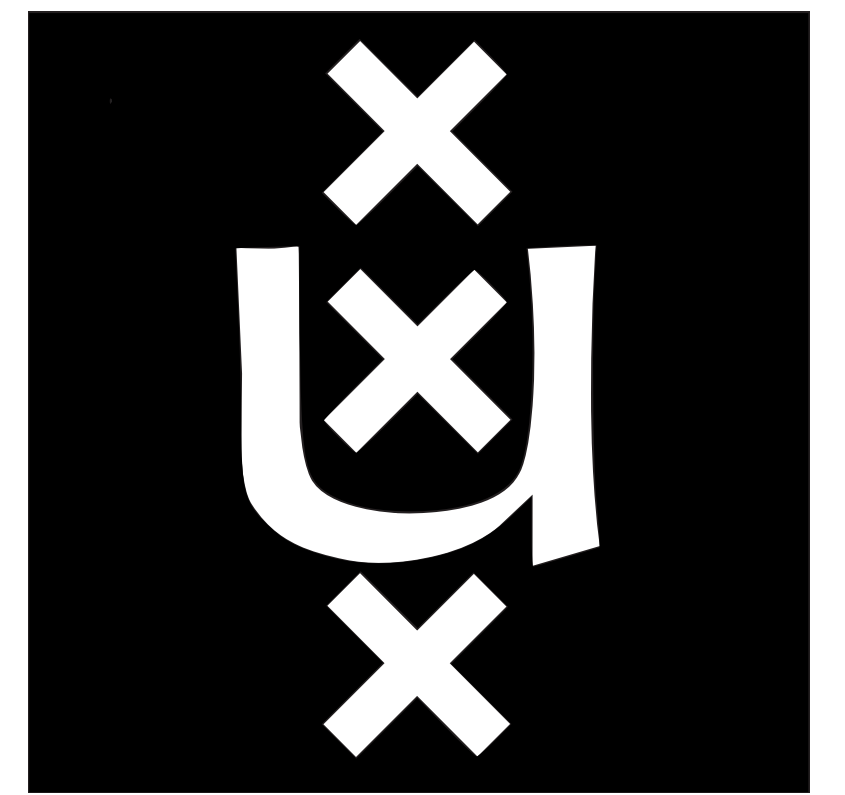




Exploiting Semantics in Neural Machine Translation with Graph Convolutional Networks

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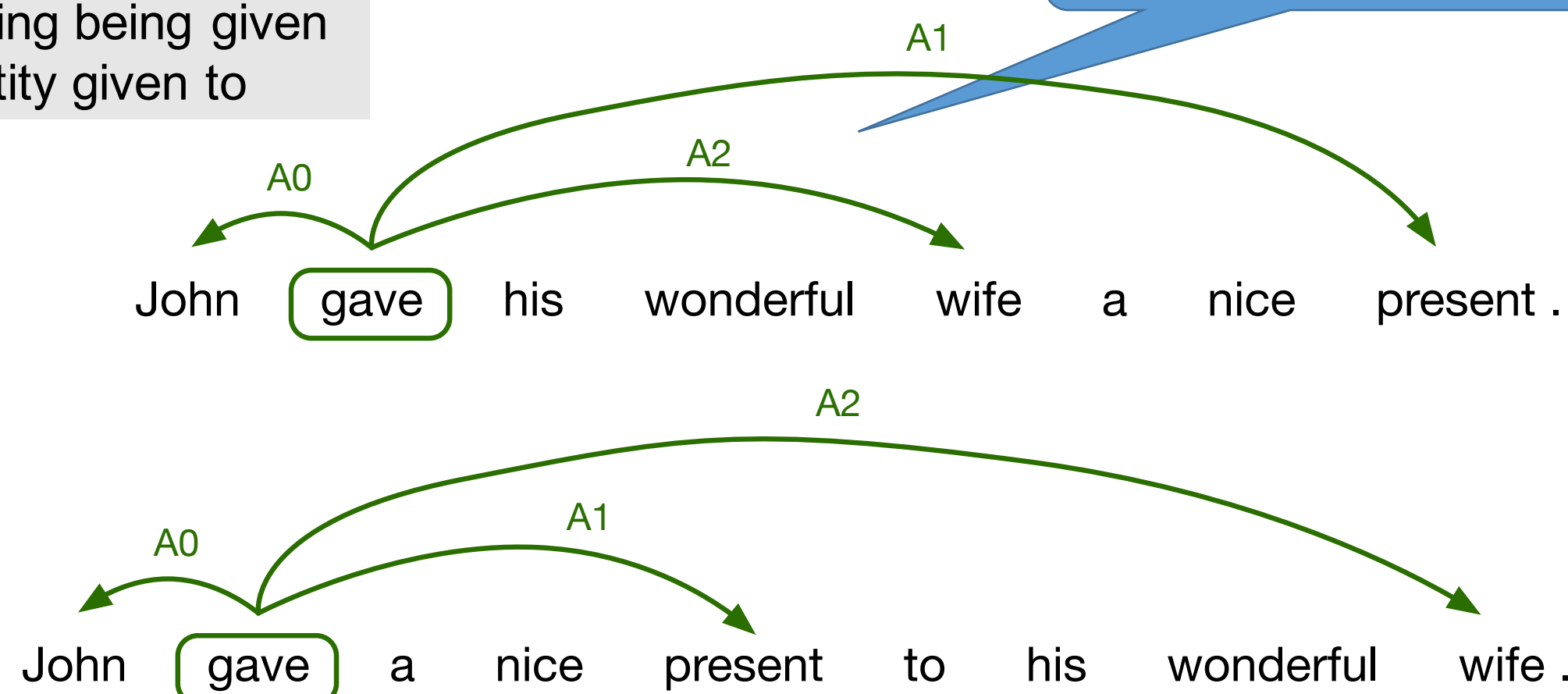
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- We use graph convolutional networks (GCNs) to inject semantic structures into a neural machine translation.
- The semantic-aware model outperforms the linguistic-agnostic one (EN-DE WMT16).
- Syntax and semantics are complementary.

Semantic Role Labeling

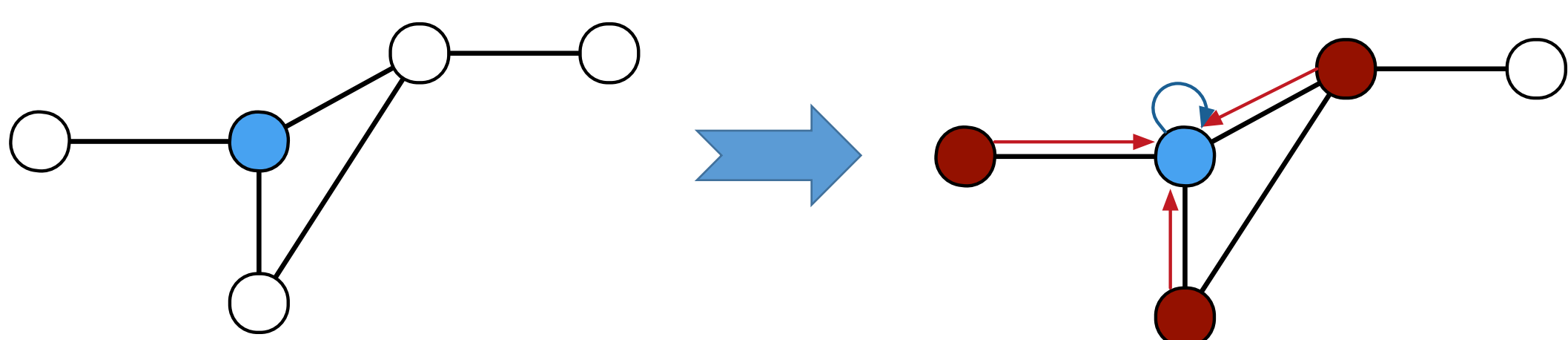
- A0: the giver
- A1: the thing being given
- A2: an entity given to



- Predicate-argument structures define an abstraction which helps to generalize over different surface realizations of the same underlying "meaning".
- We explicitly encode semantic role labeling (SRL) graphs using GCNs.

Graph Convolutional Networks

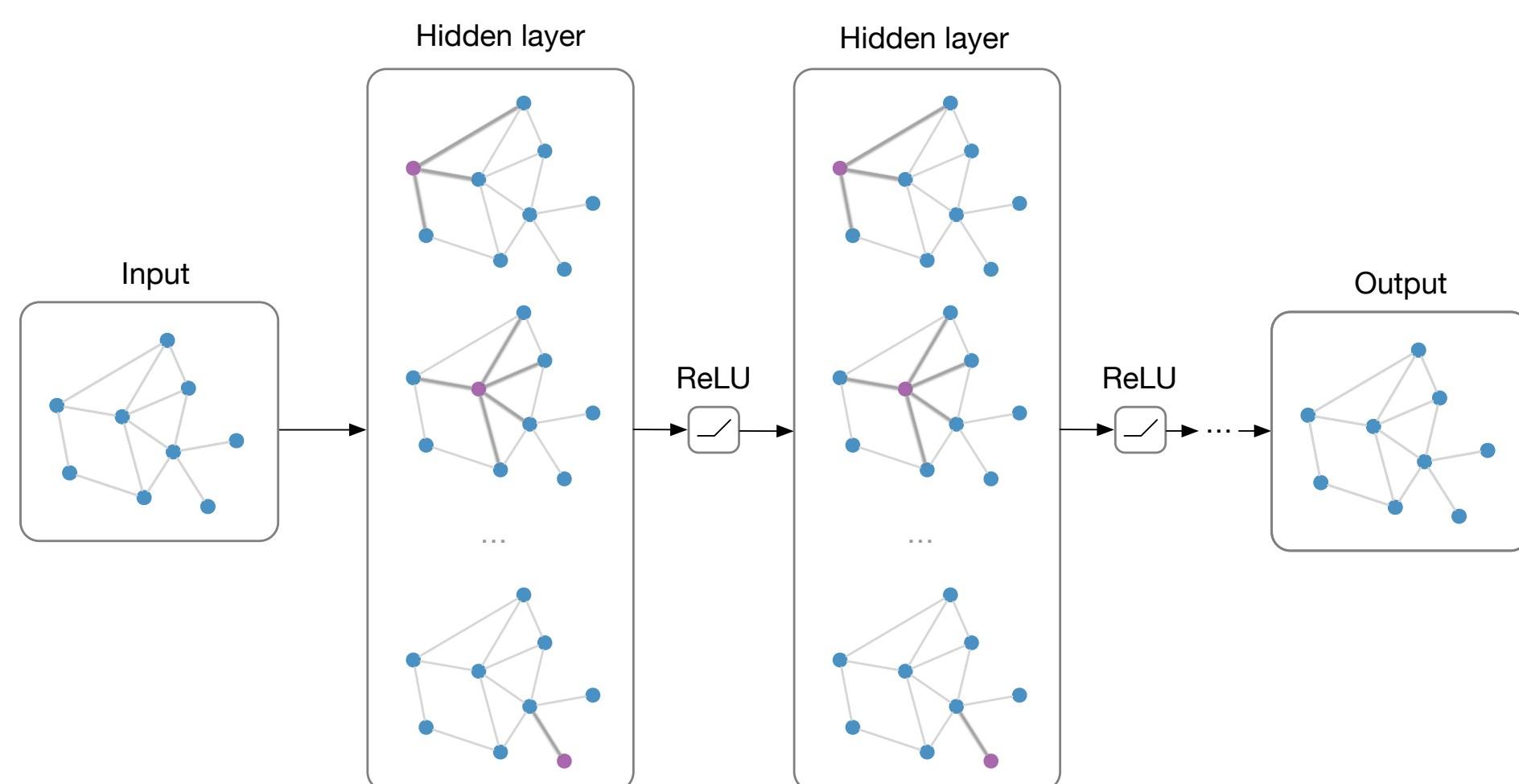
[Kipf and Welling, ICLR 2016]



- Nodes are represented as vectors
- Messages are summed up following the graph structure
- Same W for every edge but self loop

$$\mathbf{h}_i^{(l+1)} = \sigma(\mathbf{W}_0^{(l)} \mathbf{h}_i^{(l)} + \sum_{j \in \mathcal{N}_i} \mathbf{W}_1^{(l)} \mathbf{h}_j^{(l)})$$

Self loop Node neighborhood



Semantic GCN

Marcheggiani and Titov (2017)
 Bastings et al. (2017)

- GCNs are used to encode syntactic dependencies for SRL and NMT.
- SRL graphs have directed and labeled edges.
- Message passed through **different edges** have **different meaning**.
- Parameterize each message according to syntactic label and edge direction.

$$h_v^{(k+1)} = \text{ReLU} \left(\sum_{u \in \mathcal{N}(v)} W_{L(u,v)}^{(k)} h_u^{(k)} + b_{L(u,v)}^{(k)} \right)$$

Self loop is included Returns label and direction indices

Edge-wise gates

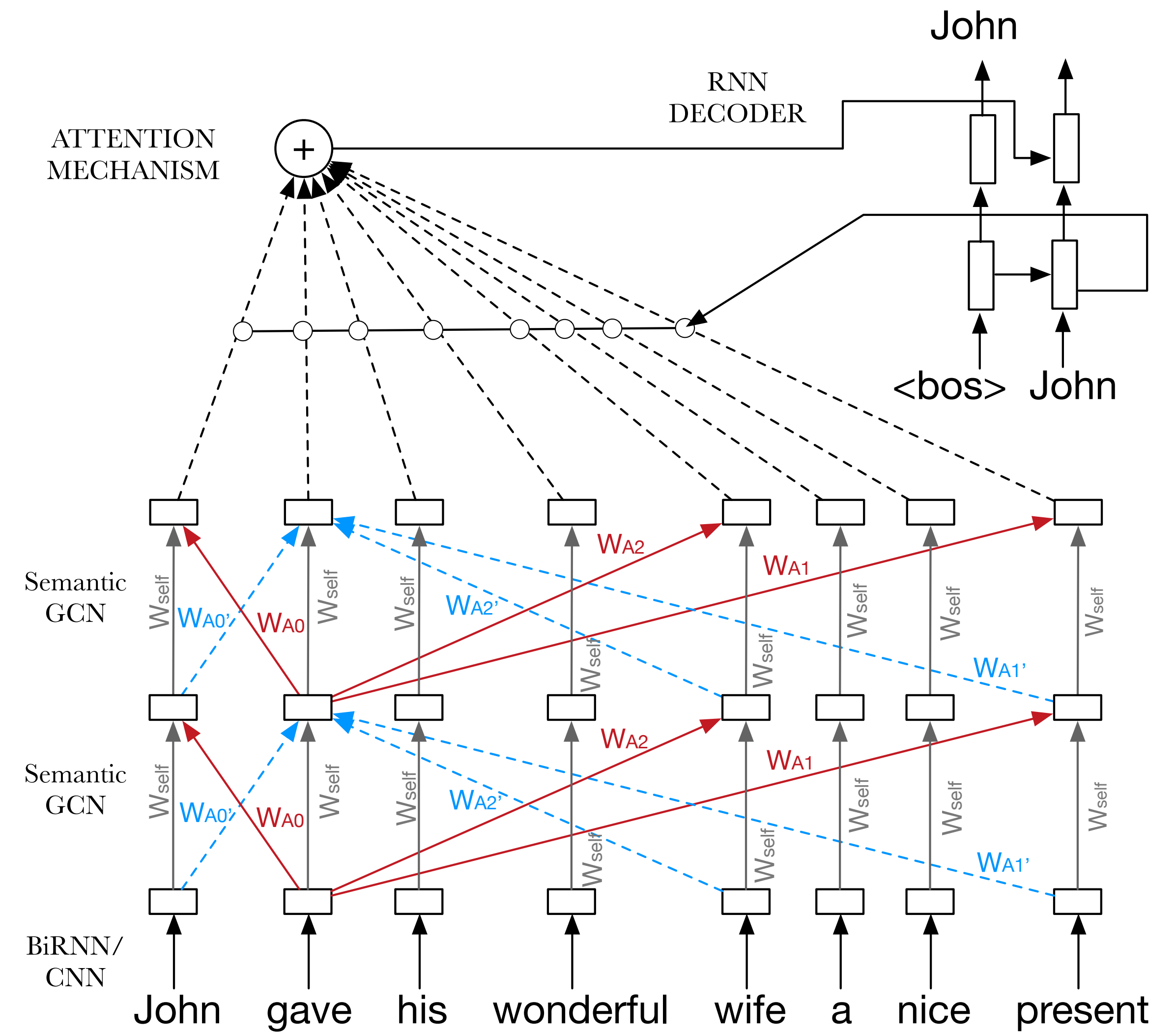
- Not all edges are equally important
- Gates decide the importance of each edge based on edge labels and node representations

$$g_{u,v}^{(k)} = \sigma \left(h_u^{(k)} \cdot \hat{v}_{L(u,v)}^{(k)} + \hat{b}_{L(u,v)}^{(k)} \right)$$

Scalar gate Sigmoid function

$$\text{Resulting update: } h_v^{(k+1)} = \text{ReLU} \left(\sum_{u \in \mathcal{N}(v)} g_{u,v}^{(k)} (W_{L(u,v)}^{(k)} h_u^{(k)} + b_{L(u,v)}^{(k)}) \right)$$

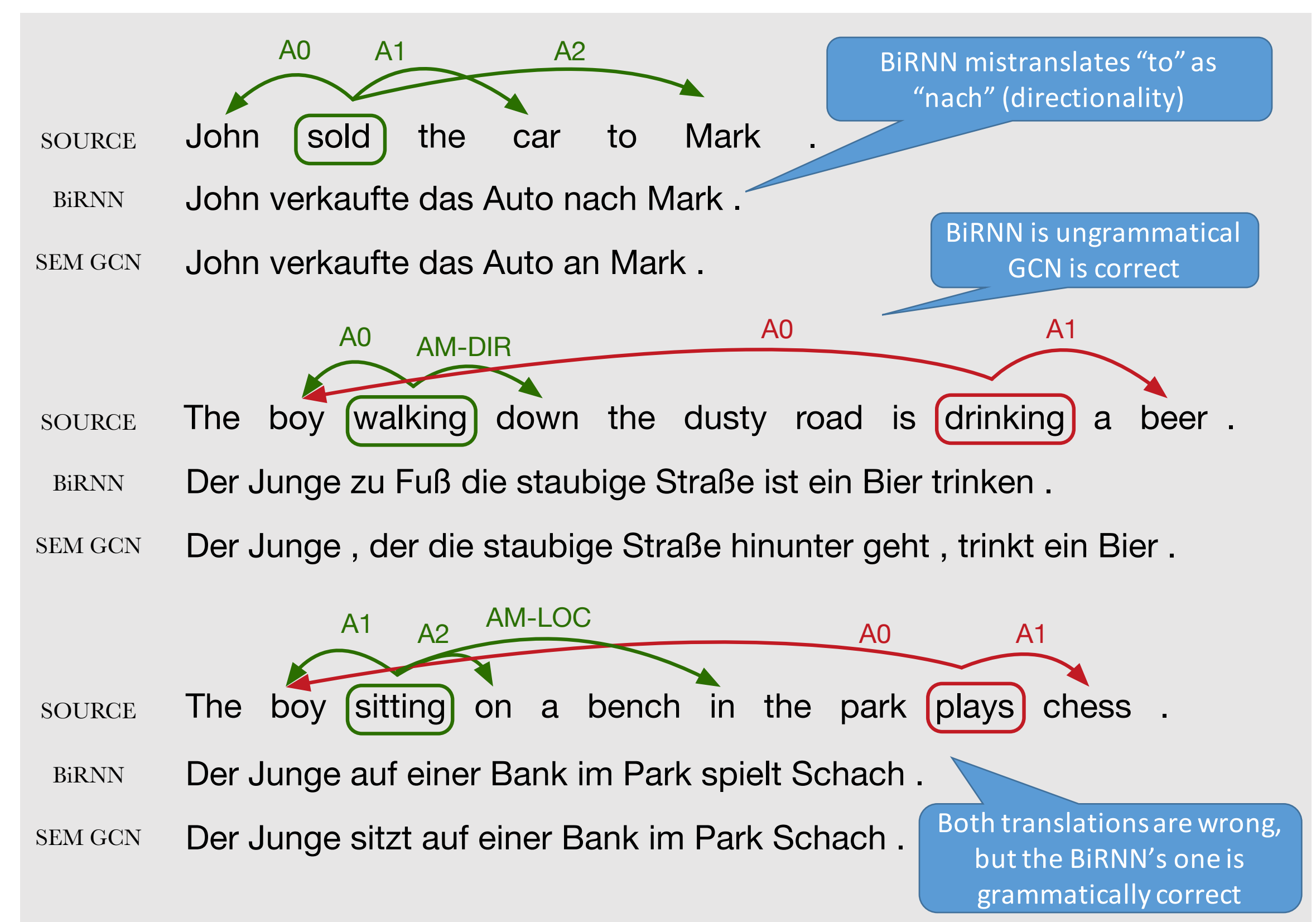
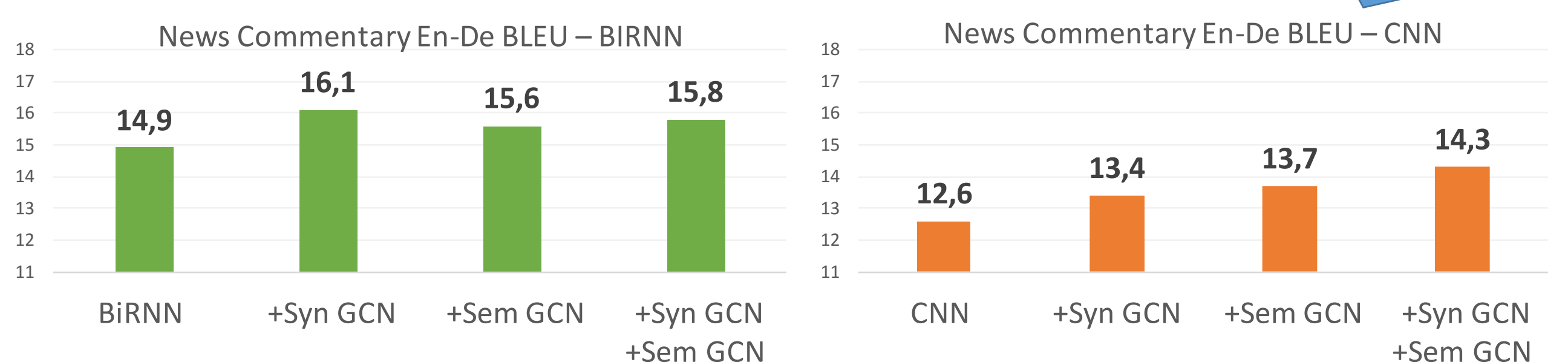
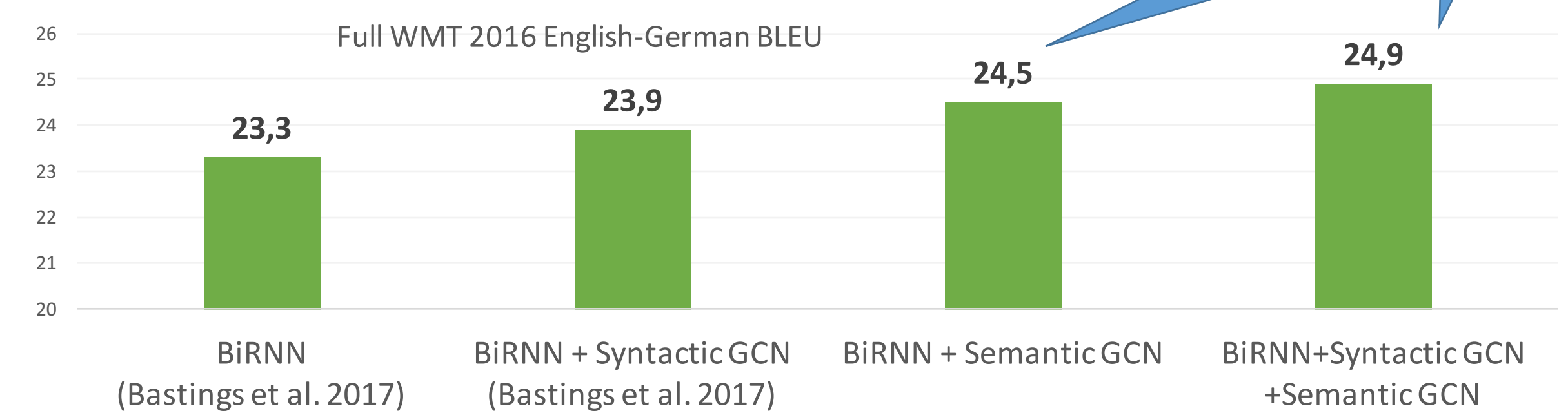
GCN Encoder-Decoder Model



Experiments

Data:

- Full WMT16 En-De (~4.5 million sentences)
- News Commentary En-De (~226.000 sentence pairs)



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