

# Deterministic Parsing

## *Basic idea*

Derive a single syntactic representation (dependency graph) through a deterministic sequence of elementary parsing actions

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Derive a single syntactic representation (dependency graph) through a deterministic sequence of elementary parsing actions

## Configurations

A parser configuration is a triple  $c = (S, B, A)$ , where

- $S$  : a stack  $[\dots, w_i]_S$  of partially processed words,
- $B$  : a buffer  $[w_j, \dots]_B$  of remaining input words,
- $A$  : a set of labeled arcs  $(w_i, d, w_j)$ .

### Stack

[sent, her, a]<sub>S</sub>

### Buffer

[letter, .]<sub>B</sub>

### Arcs

He  $\xleftarrow{\text{SBJ}}$  sent

# Transition System

*A transition system for dependency parsing is a quadruple  $S = (C, T, c_s, C_t)$ , where*

- $C$  is a set of configurations,
- $T$  is a set of transitions, such that  $t : C \rightarrow C$ ,
- $c_s$  is an initialization function
- $C_t \subseteq C$  is a set of terminal configurations.

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A transition sequence for a sentence  $x$  is a set of configurations

$C_{0,m} = (c_o, c_1, \dots, c_m)$  such that  
 $c_o = c_s(x)$ ,  $c_m \in C_t$ ,  $c_i = t(c_{i-1})$  for some  $t \in T$

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**Initialization:**  $([\ ]_S, [w_1, \dots, w_n]_B, \{\})$

**Termination:**  $(S, [\ ]_B, A)$

# Transitions for Arc-Eager Parsing

$$\text{Left-Arc}(d) \frac{([\dots, w_i]_S, [w_j, \dots]_B, A)}{([\dots]_S, [w_j, \dots]_B, A \cup \{(w_j, d, w_i)\})} \neg\text{HEAD}(w_i)$$

$$\text{Right-Arc}(d) \frac{([\dots, w_i]_S, [w_j, \dots]_B, A)}{([\dots, w_i, w_j]_S, [\dots]_B, A \cup \{(w_i, d, w_j)\})}$$

$$\text{Reduce} \frac{([\dots, w_i]_S, B, A)}{([\dots]_S, B, A)} \text{HEAD}(w_i)$$

$$\text{Shift} \frac{([\dots]_S, [w_i, \dots]_B, A)}{([\dots, w_i]_S, [\dots]_B, A)}$$

## Parse Example

### Transitions:

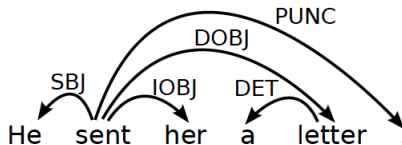
**Stack**

[ ]<sub>S</sub>

**Buffer**

[He, sent, her, a, letter, .]<sub>B</sub>

**Arcs**



## Parse Example

**Transitions:** SH

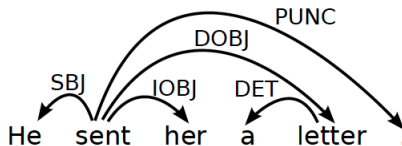
**Stack**

[He]<sub>S</sub>

**Buffer**

[sent, her, a, letter, .]<sub>B</sub>

**Arcs**





## Parse Example

**Transitions:** SH-LA

**Stack**

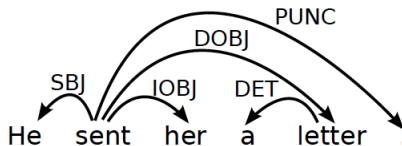
[ ]<sub>S</sub>

**Buffer**

[sent, her, a, letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent



## Parse Example

**Transitions:** SH-LA-SH

**Stack**

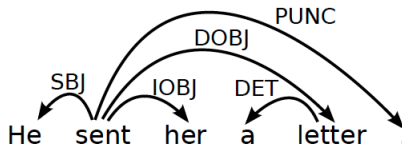
[sent]<sub>S</sub>

**Buffer**

[her, a, letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent



## Parse Example

**Transitions:** SH-LA-SH-RA

**Stack**

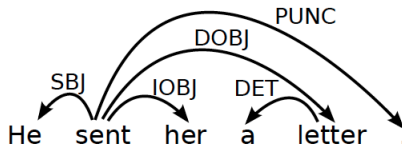
[sent, her]<sub>S</sub>

**Buffer**

[a, letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her



## Parse Example

**Transitions:** SH-LA-SH-RA-SH

**Stack**

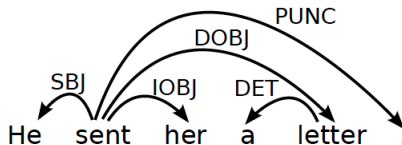
[sent, her, a]<sub>S</sub>

**Buffer**

[letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her



## Parse Example

**Transitions:** SH-LA-SH-RA-SH-LA

**Stack**

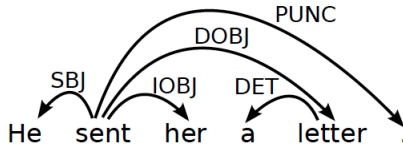
[sent, her]<sub>S</sub>

**Buffer**

[letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her  
a  $\xleftarrow{\text{DET}}$  letter



## Parse Example

**Transitions:** SH-LA-SH-RA-SH-LA-RE

**Stack**

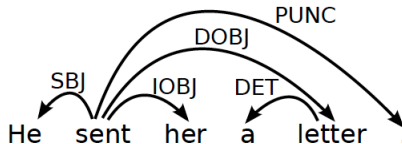
[sent]<sub>S</sub>

**Buffer**

[letter, .]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her  
a  $\xleftarrow{\text{DET}}$  letter



## Parse Example

**Transitions:** SH-LA-SH-RA-SH-LA-RE-RA

**Stack**

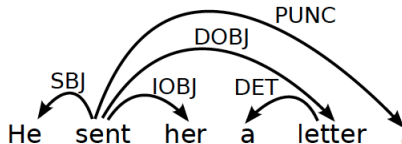
[sent, letter]<sub>S</sub>

**Buffer**

[.]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her  
a  $\xleftarrow{\text{DET}}$  letter  
sent  $\xrightarrow{\text{DOBJ}}$  letter



## Parse Example

**Transitions:** SH-LA-SH-RA-SH-LA-RE-RA-RE

**Stack**

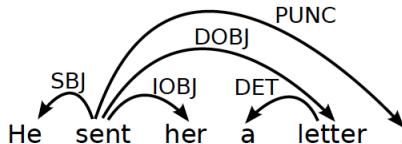
[sent]<sub>S</sub>

**Buffer**

[.]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her  
a  $\xleftarrow{\text{DET}}$  letter  
sent  $\xrightarrow{\text{DOBJ}}$  letter





## Parse Example

**Transitions:** SH-LA-SH-RA-SH-LA-RE-RA-RE-RA

**Stack**

[sent, .]<sub>S</sub>

**Buffer**

[ ]<sub>B</sub>

**Arcs**

He  $\xleftarrow{\text{SBJ}}$  sent  
sent  $\xrightarrow{\text{IOBJ}}$  her  
a  $\xleftarrow{\text{DET}}$  letter  
sent  $\xrightarrow{\text{DOBJ}}$  letter  
sent  $\xrightarrow{\text{PUNC}}$  .

