Natural Language Processing

Lecture 4.2

The arc-standard algorithm

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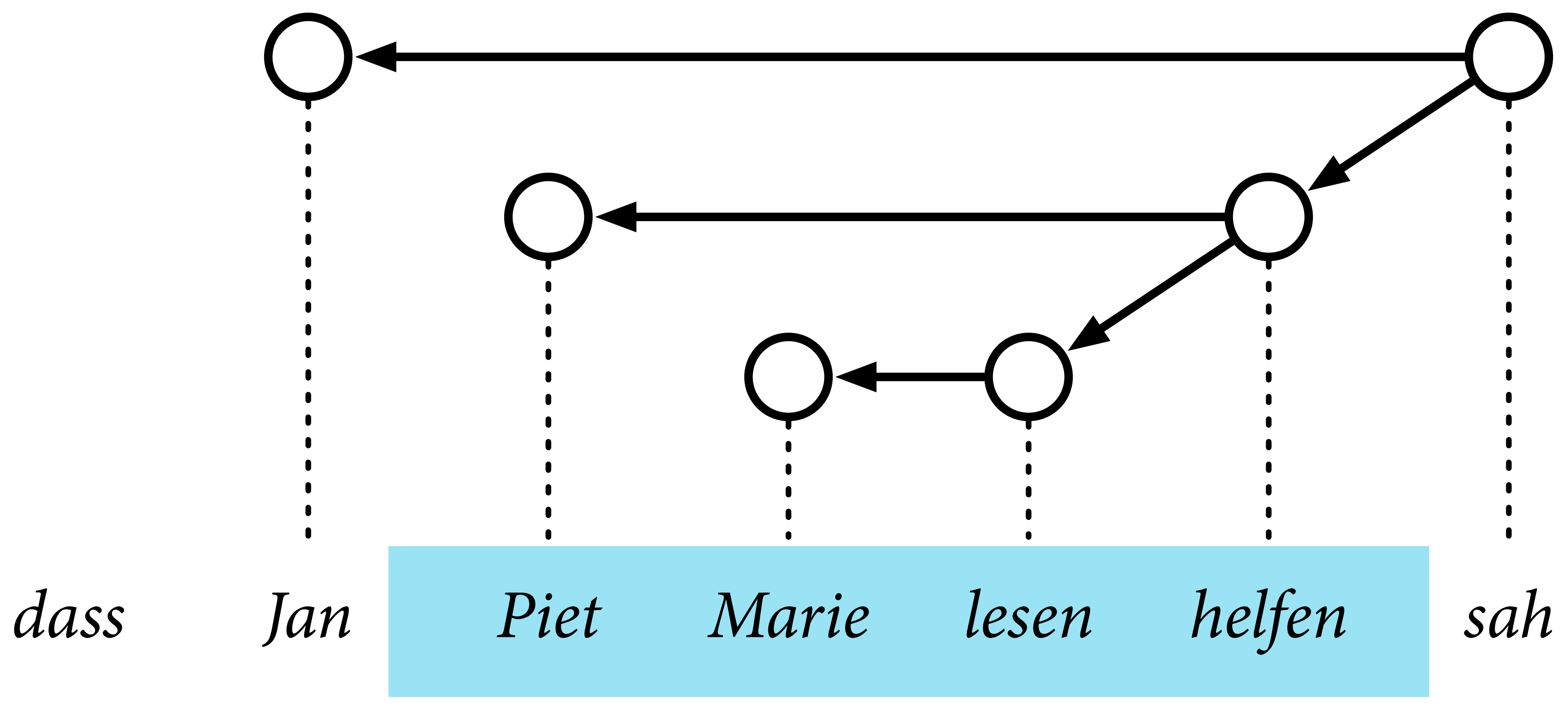
The arc-standard algorithm

- The **arc-standard algorithm** is an algorithm for transition-based dependency parsing.
- It can be viewed as a generalisation of the shift–reduce algorithm for parsing context-free grammars.

  two types of ‘reduce’ actions
- The arc-standard algorithm can only predict projective dependency trees.

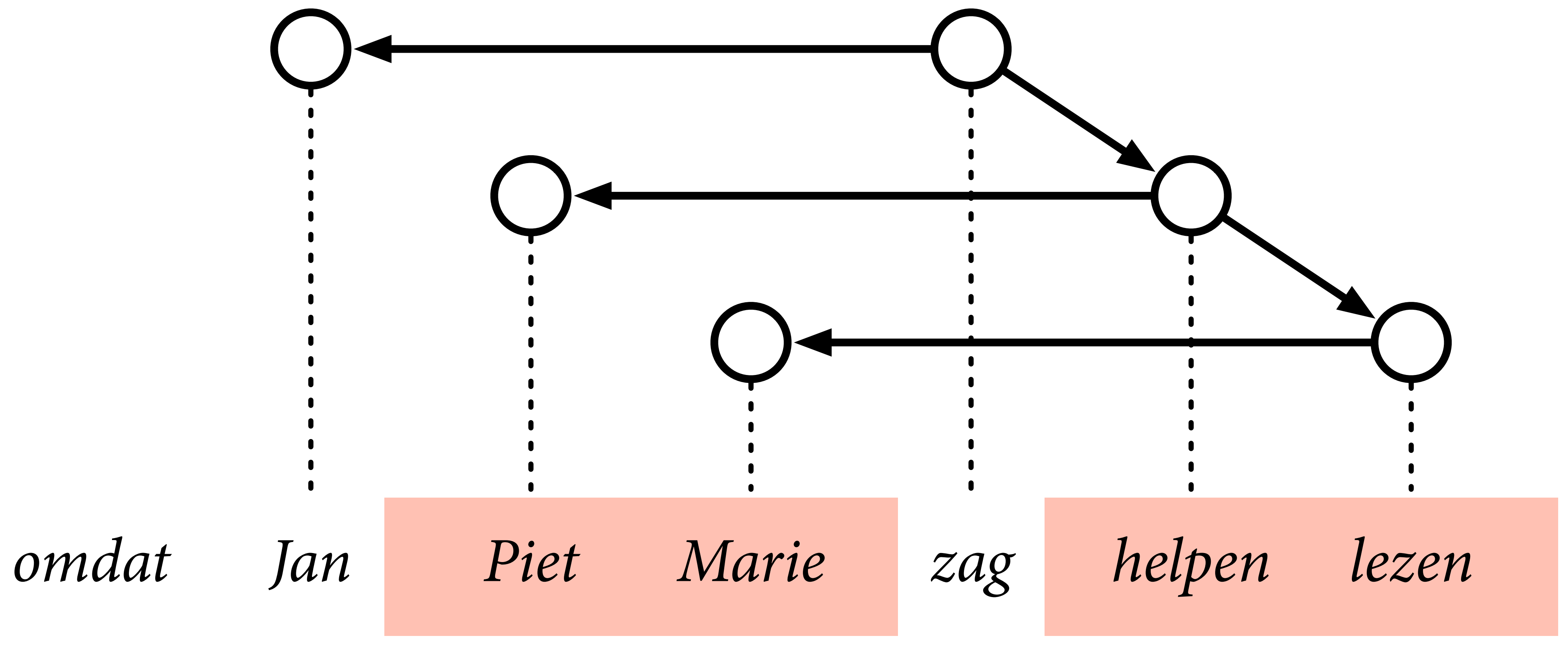
  Algorithms for non-projective trees exist, see e.g. Nivre (2009).

Projective dependency trees



Every subtree corresponds to a contiguous sequence of words.

Non-projective dependency trees



The sequence of words in a subtree may contain ‘gaps’.

Transition-based dependency parsing

- The parser starts in the **initial configuration**.

  empty dependency tree

- It then calls a classifier, which predicts the **transition** that the parser should make to move to a next configuration.

  extend the partial dependency tree

- This process is repeated until the parser reaches a **terminal configuration**.

  complete dependency tree

Configurations

A parser configuration consists of three parts:

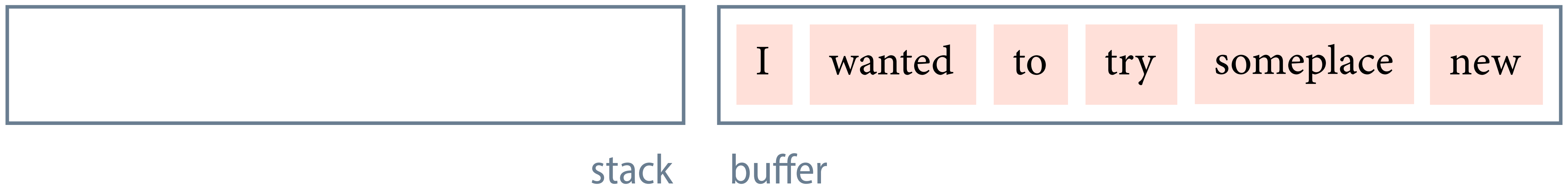
- A **buffer**, which contains those words in the sentence that still need to be processed. Initially, the buffer contains all words.
- A **stack**, which contains those words in the sentence that are currently being processed. Initially, the stack is empty.
- A **partial dependency tree**. Initially, this tree contains all the words of the sentence, but no dependency arcs.

Transitions

- The **shift transition (SH)** removes the frontmost word from the buffer and pushes it to the top of the stack.
- The **left-arc transition (LA)** creates a dependency from the topmost word on the stack to the second-topmost word, and pops the second-topmost word.
- The **right-arc transition (RA)** creates a dependency from the second-topmost word on the stack to the topmost word, and pops the topmost word.

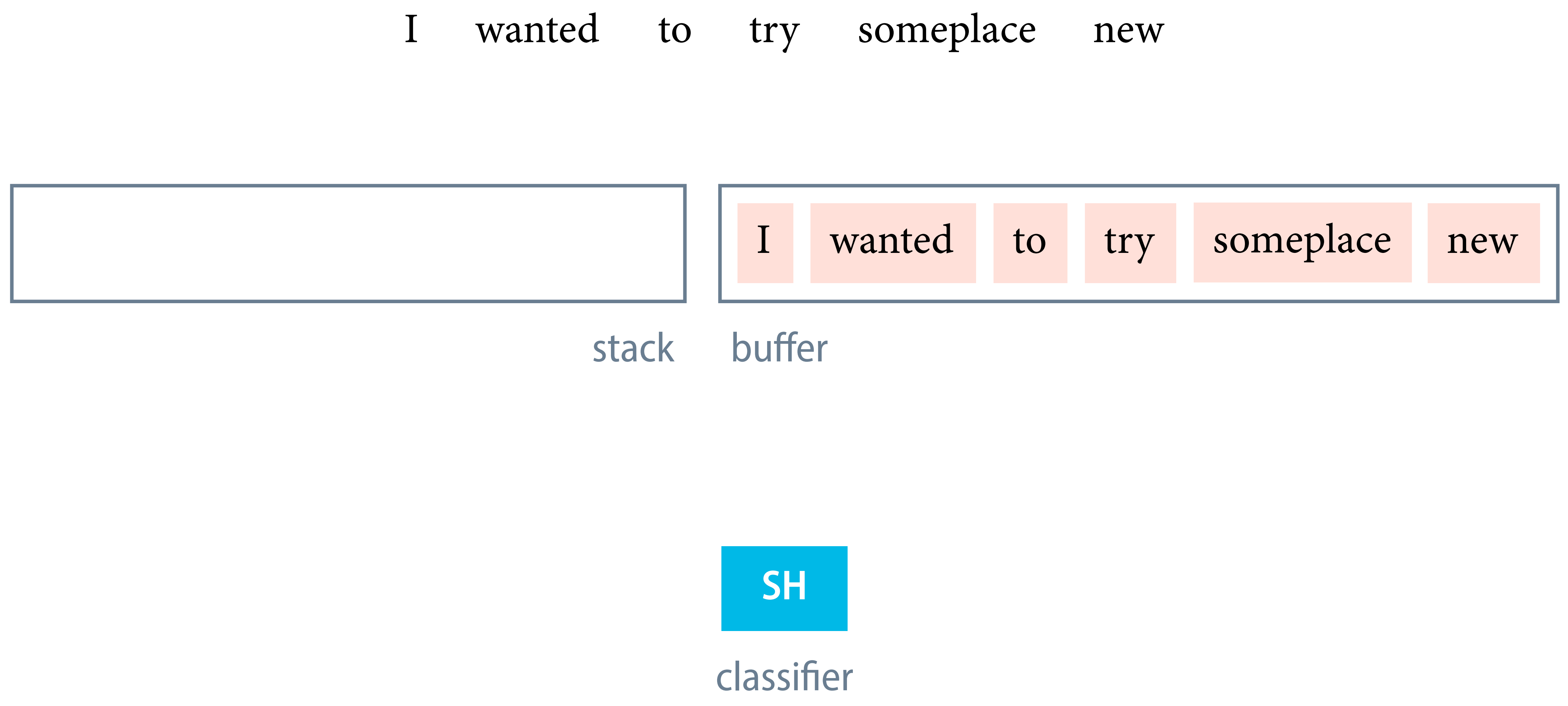
Example run

I wanted to try someplace new

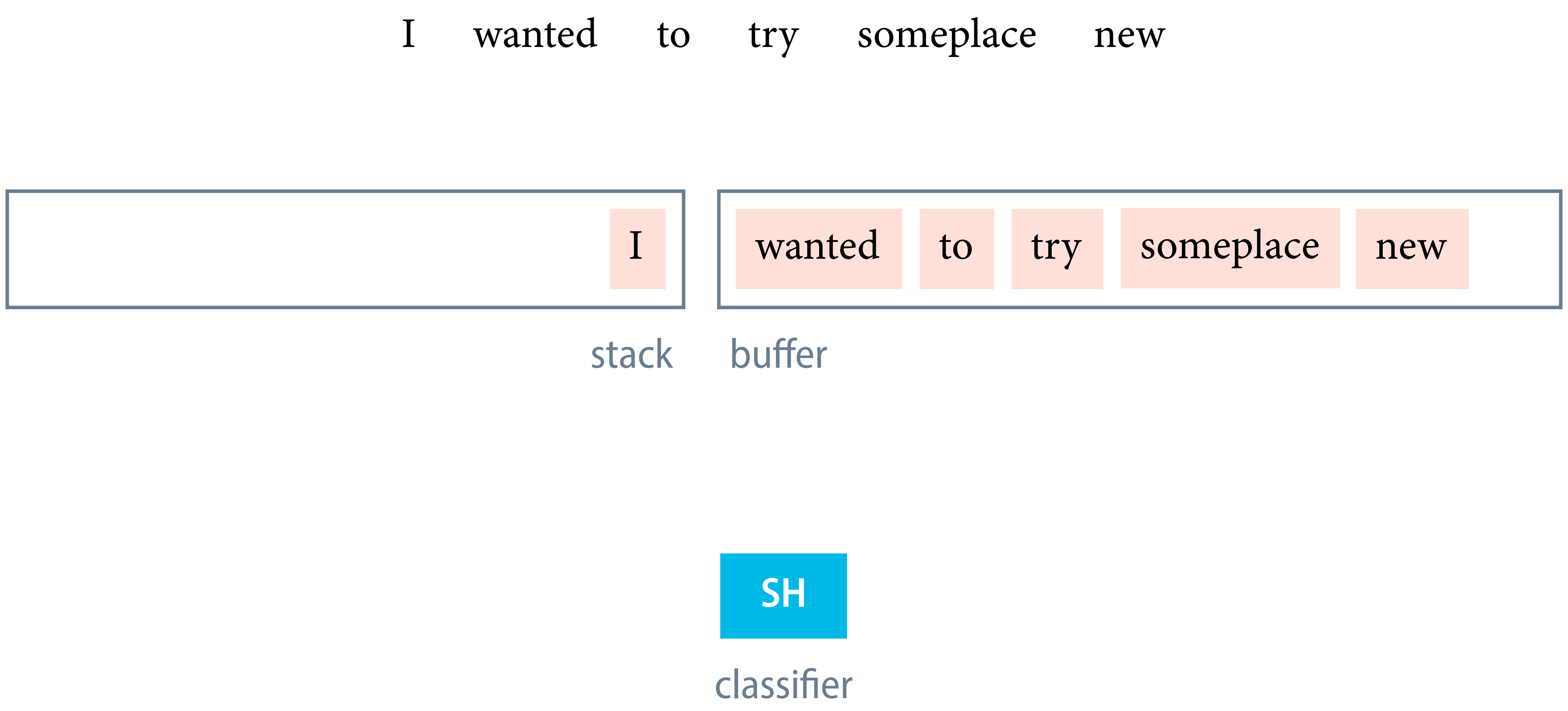


(initial configuration)

Example run


I wanted to try someplace new
I
wanted
to
try
someplace
new
stack
buffer
SH
classifier

Example run


I wanted to try someplace new
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stack
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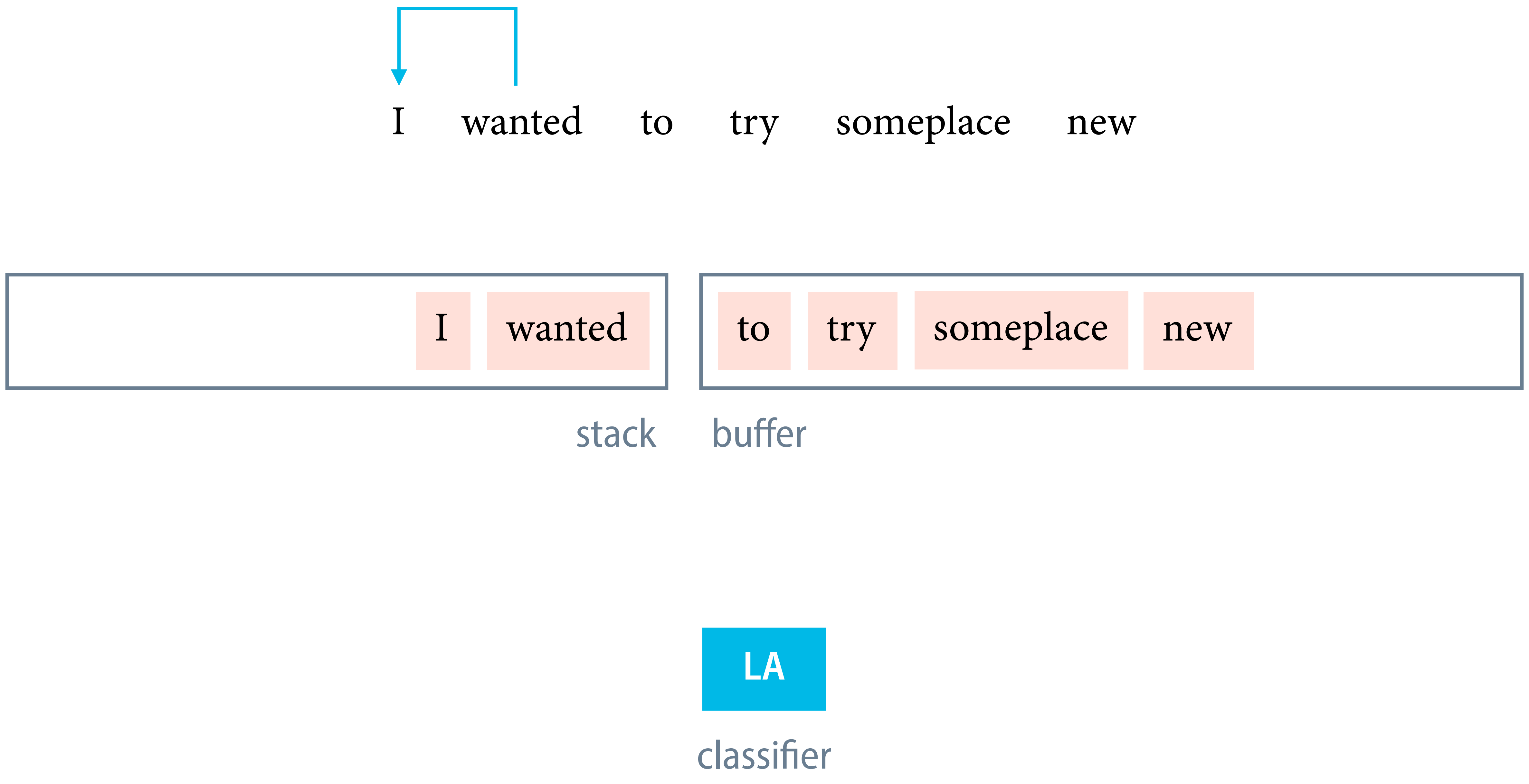
SH
classifier

Example run


I
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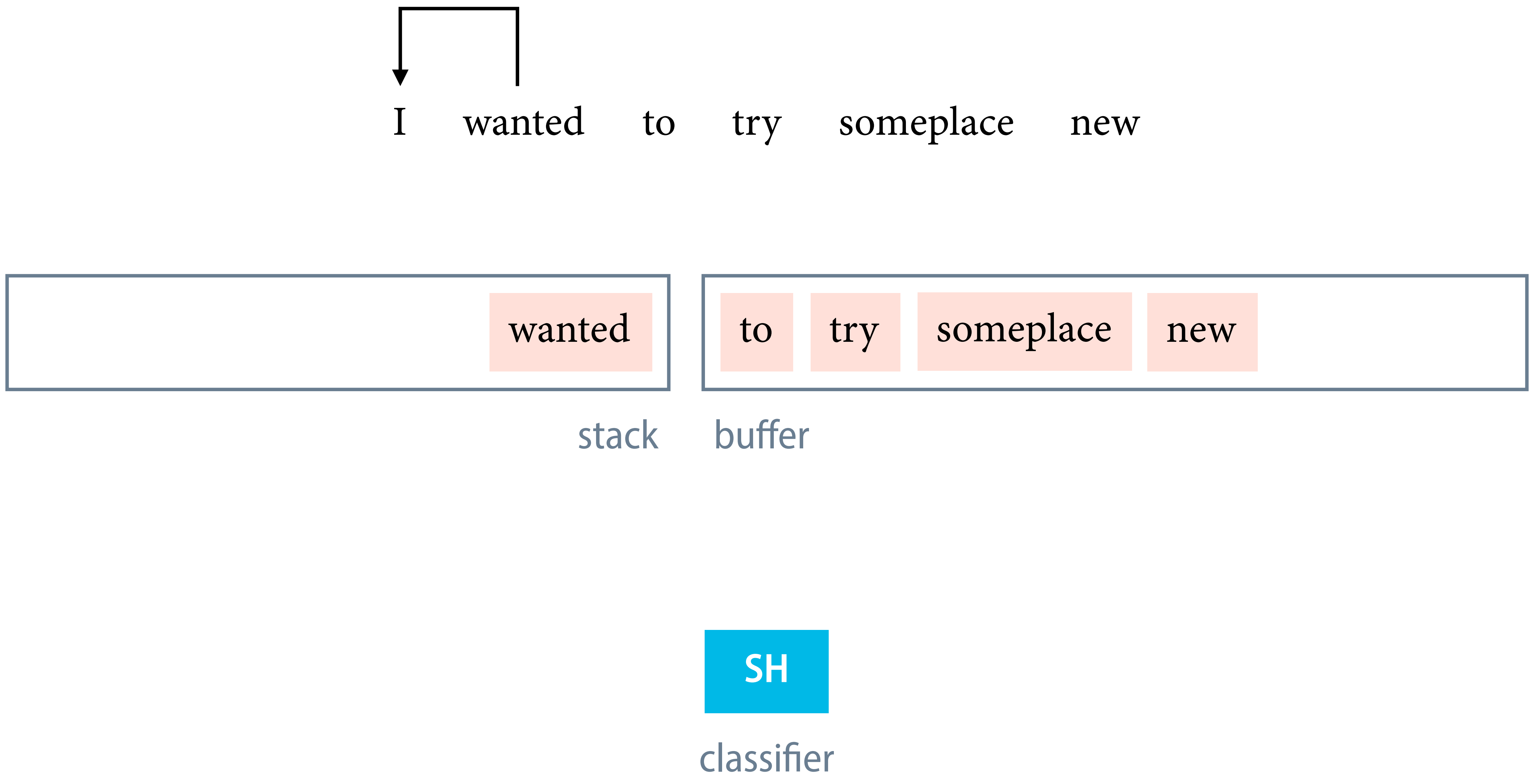
stack
buffer
LA
classifier

Example run



I
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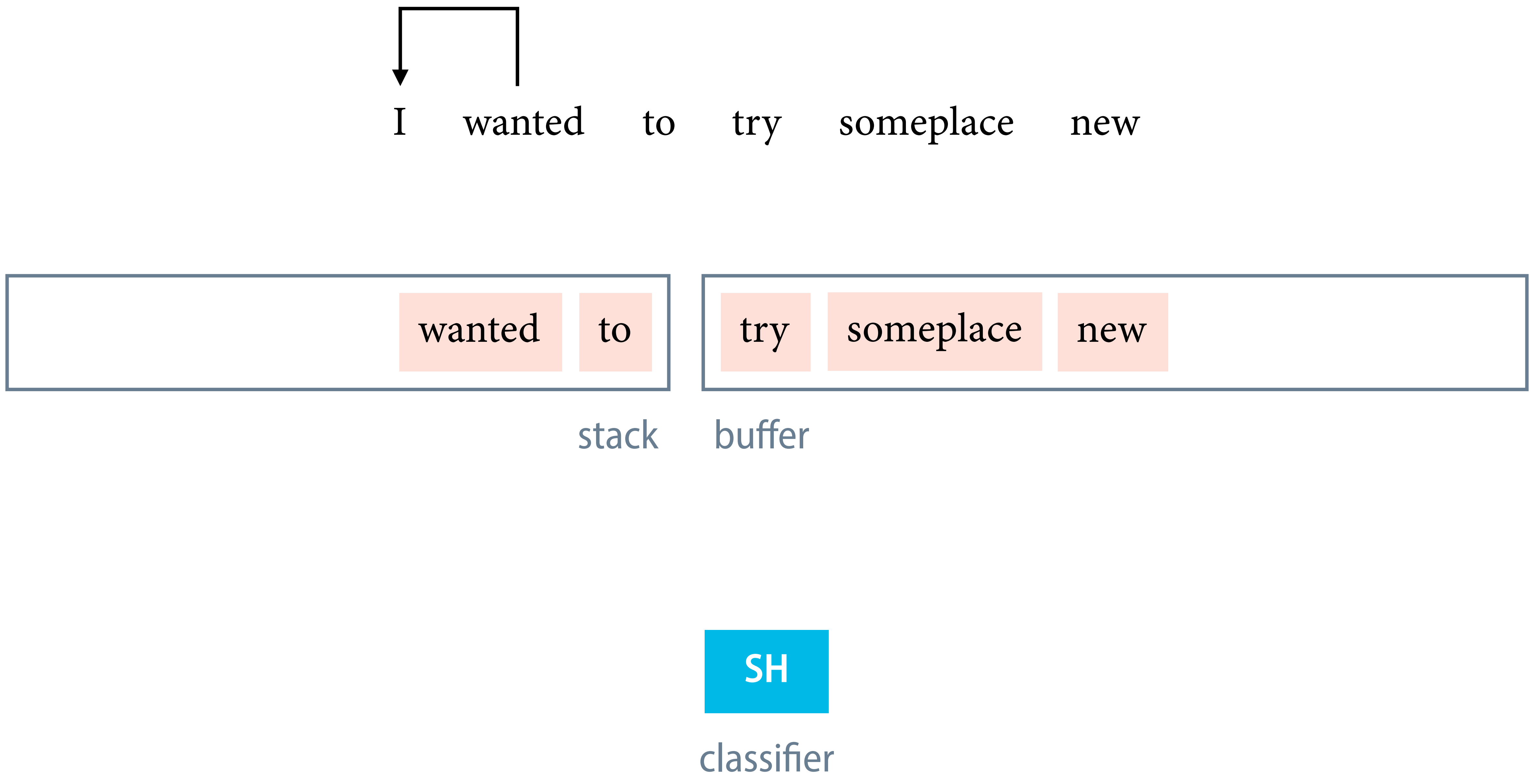
stack
buffer
SH
classifier

Example run


I
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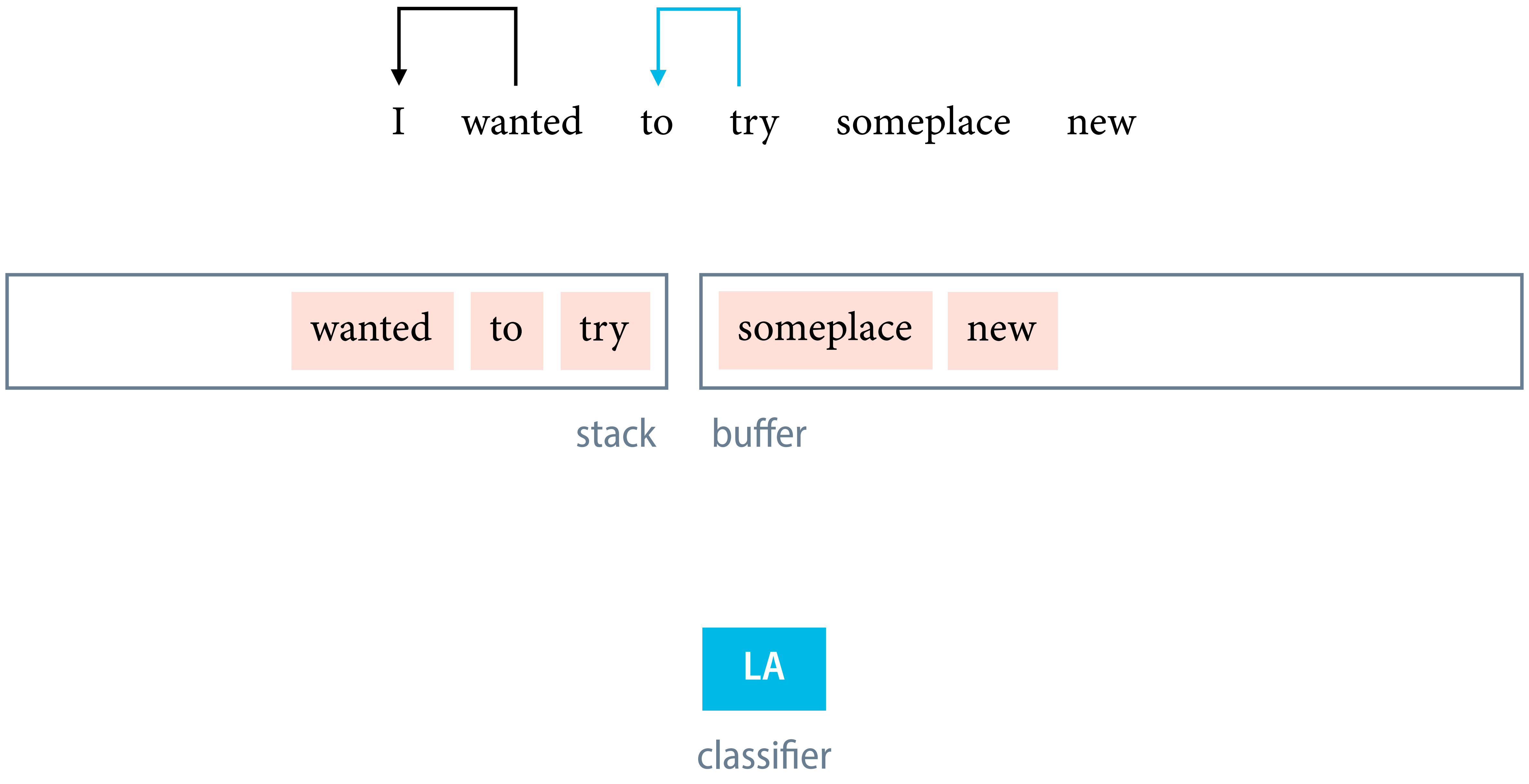
SH
classifier

Example run


I
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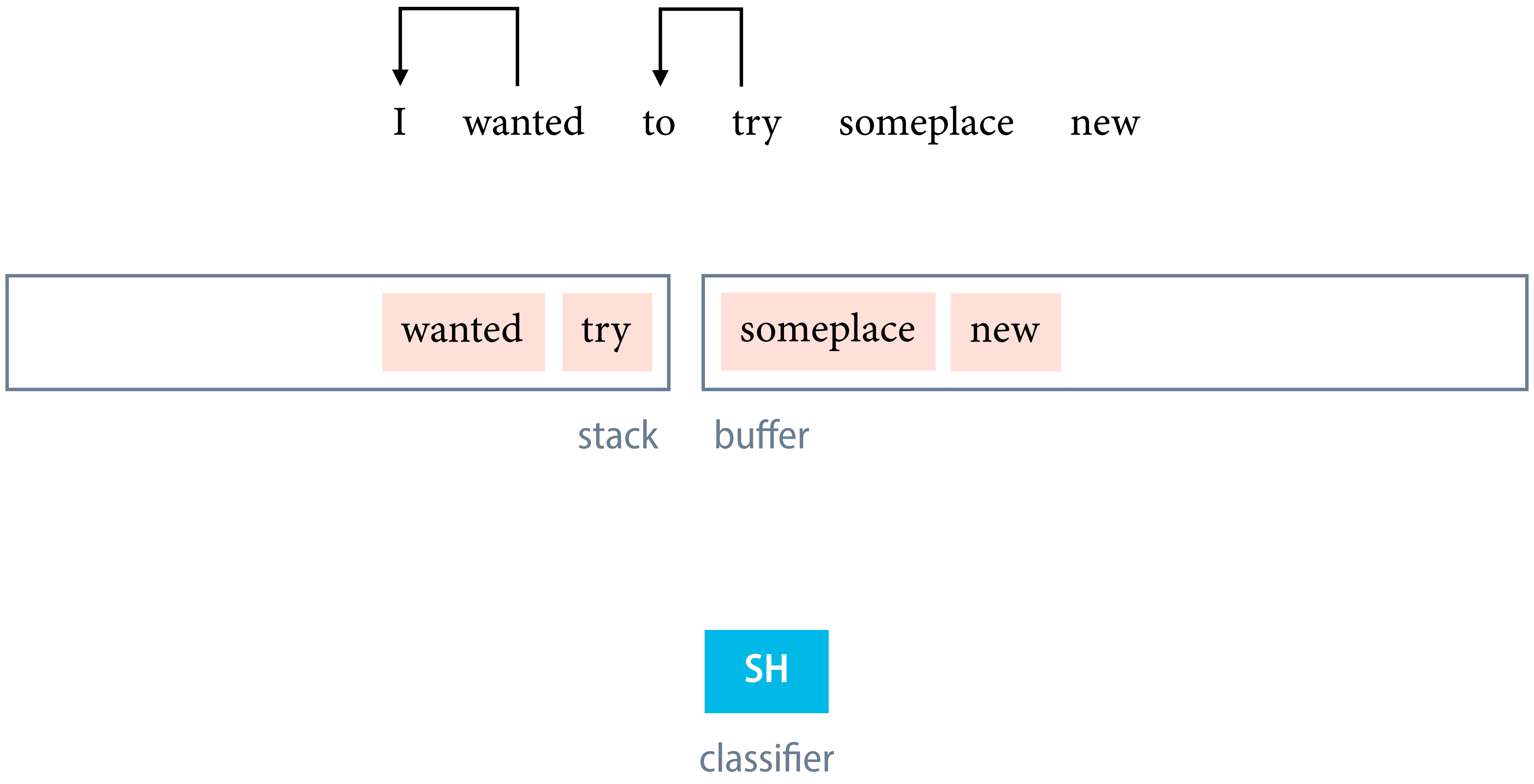
LA
classifier

Example run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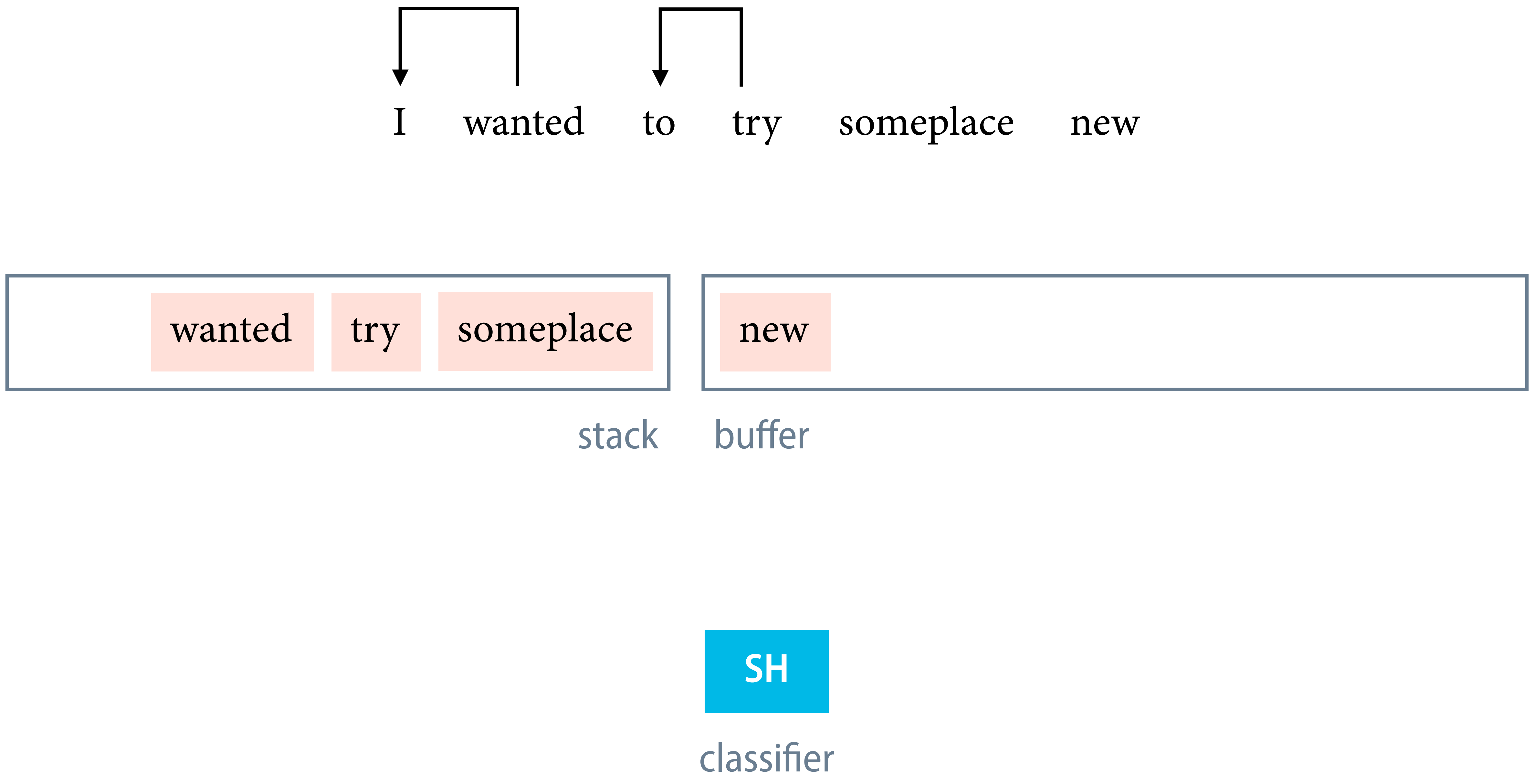
new
stack
buffer
SH
classifier

Example run


I
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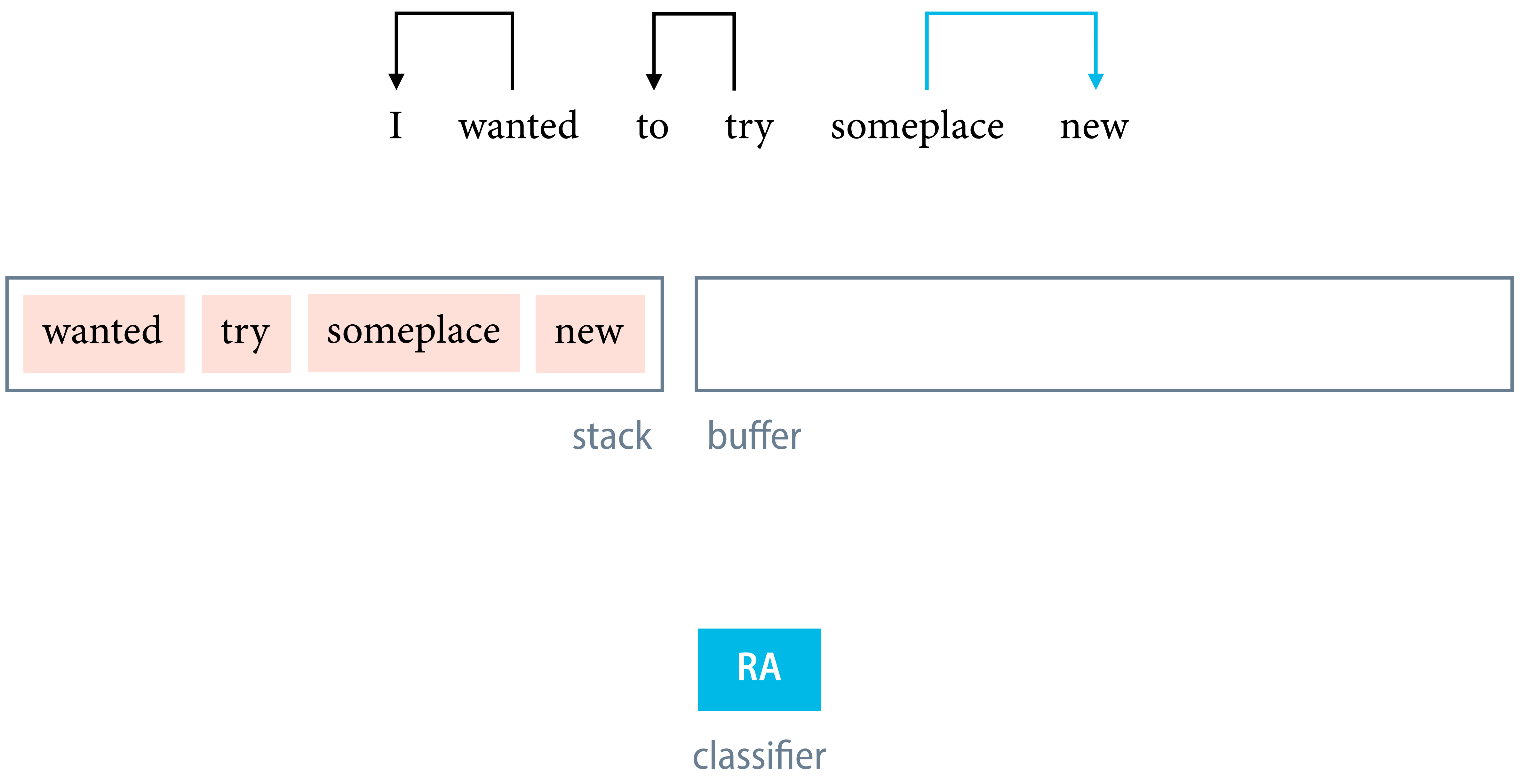
SH
classifier

Example run


I
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wanted
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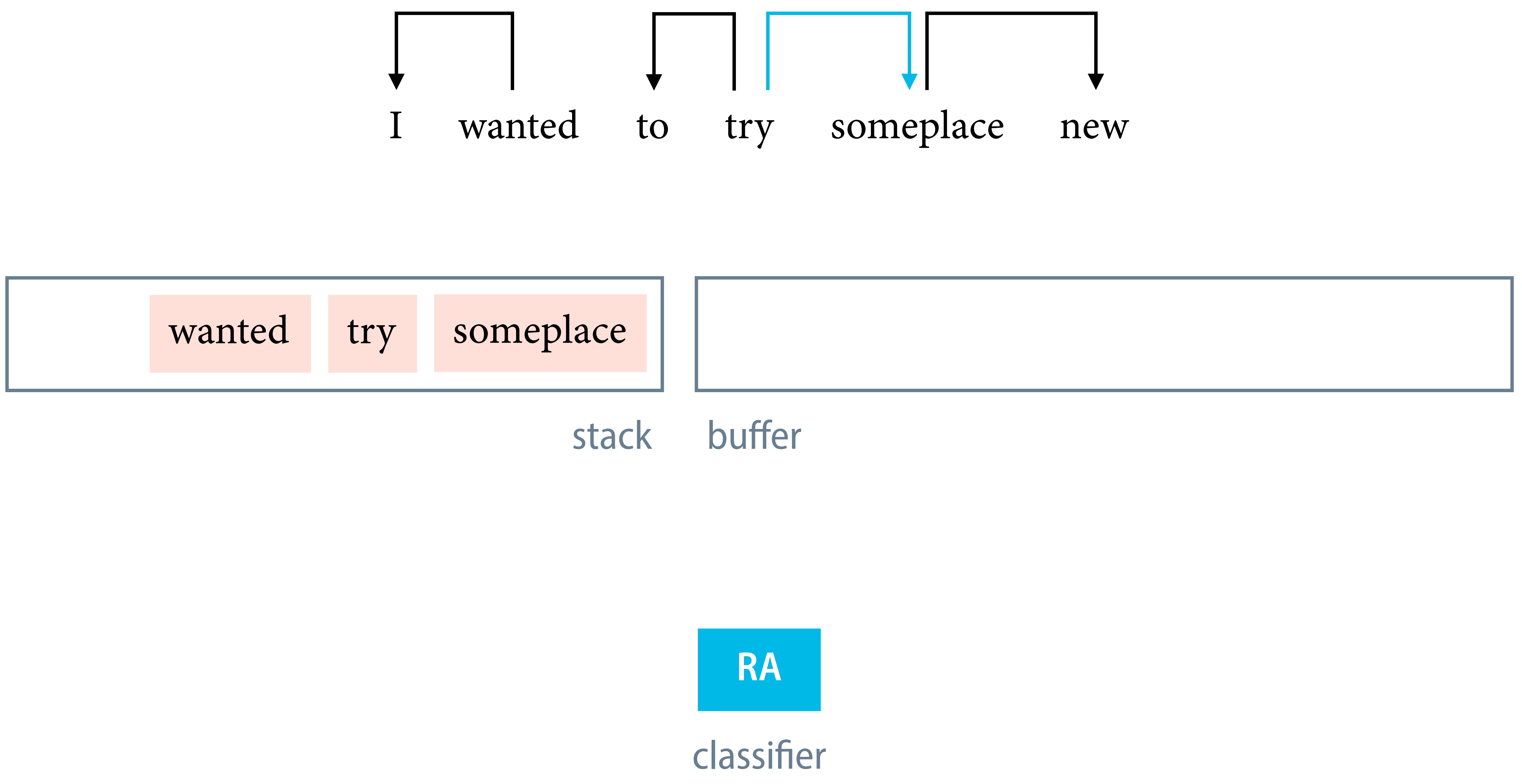
new
stack
buffer
RA
classifier

Example run


I
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to
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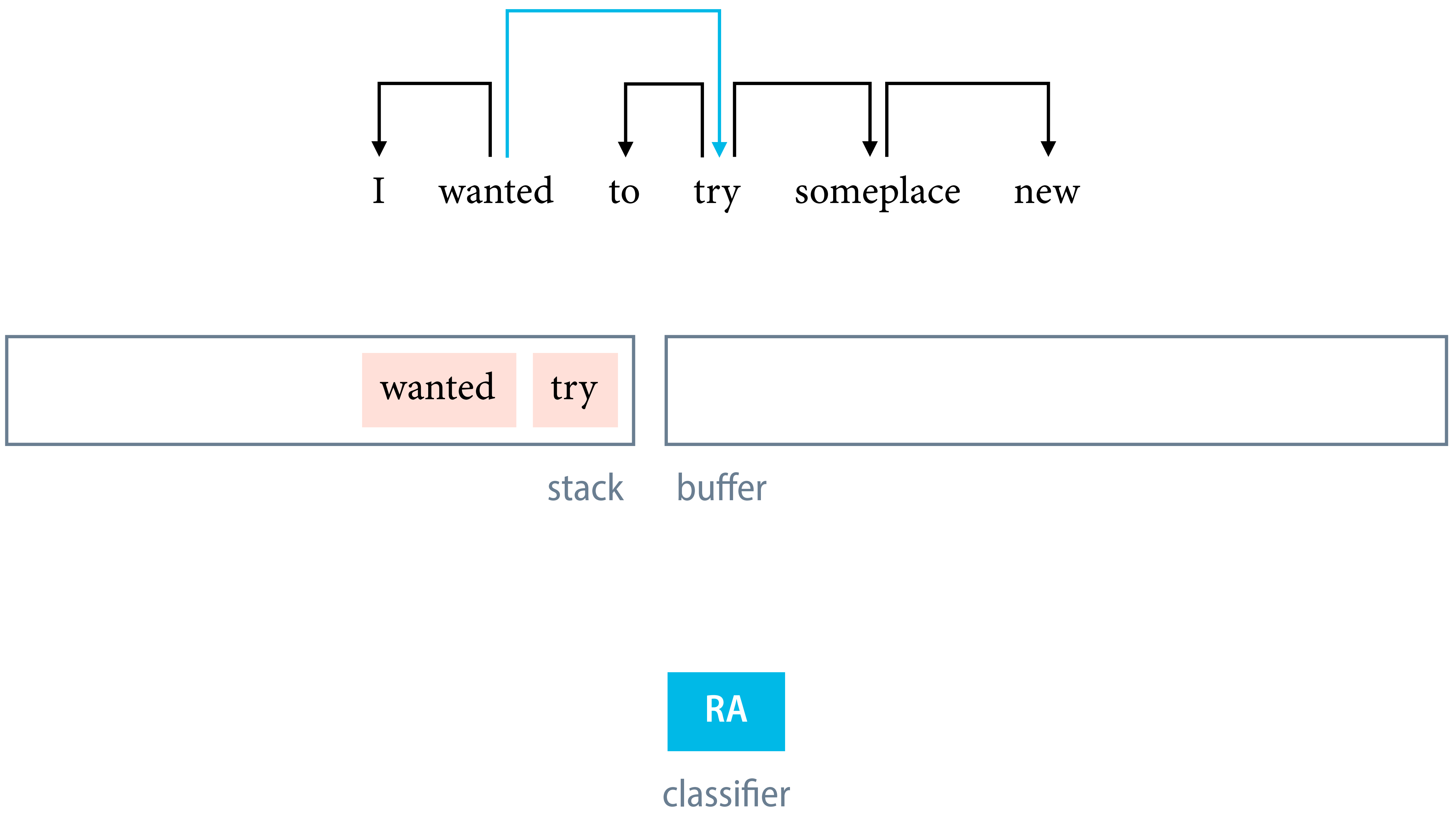
someplace
stack
buffer
RA
classifier

Example run


I
wanted
to
try
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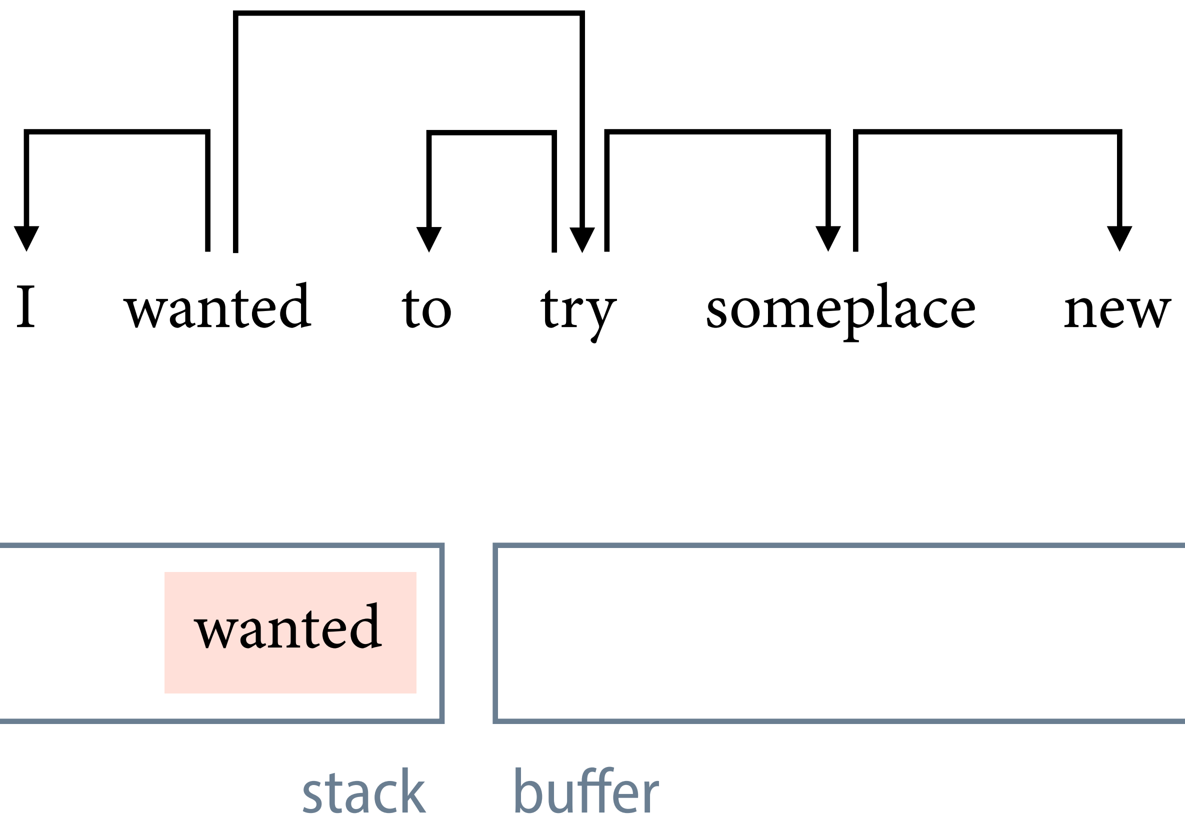
wanted
try
stack
buffer
RA
classifier

Example run



(terminal configuration)

Valid transitions

Valid transitions

- SH is valid if the buffer contains at least one word.
- LA and RA are valid if the stack contains at least two words.

Valid transition sequences

are transition sequences in which all transitions are valid

Soundness and completeness

- **Soundness**

  Every valid transition sequence that starts in the initial configuration and ends in some terminal configuration builds some projective dependency tree.

- **Completeness**

  Every projective dependency tree can be built by some valid transition sequence that starts in the initial configuration and ends in some terminal configuration.

Non-uniqueness and runtime

- **Non-uniqueness**

  One and the same projective dependency tree can in general be built by several valid transition sequences.

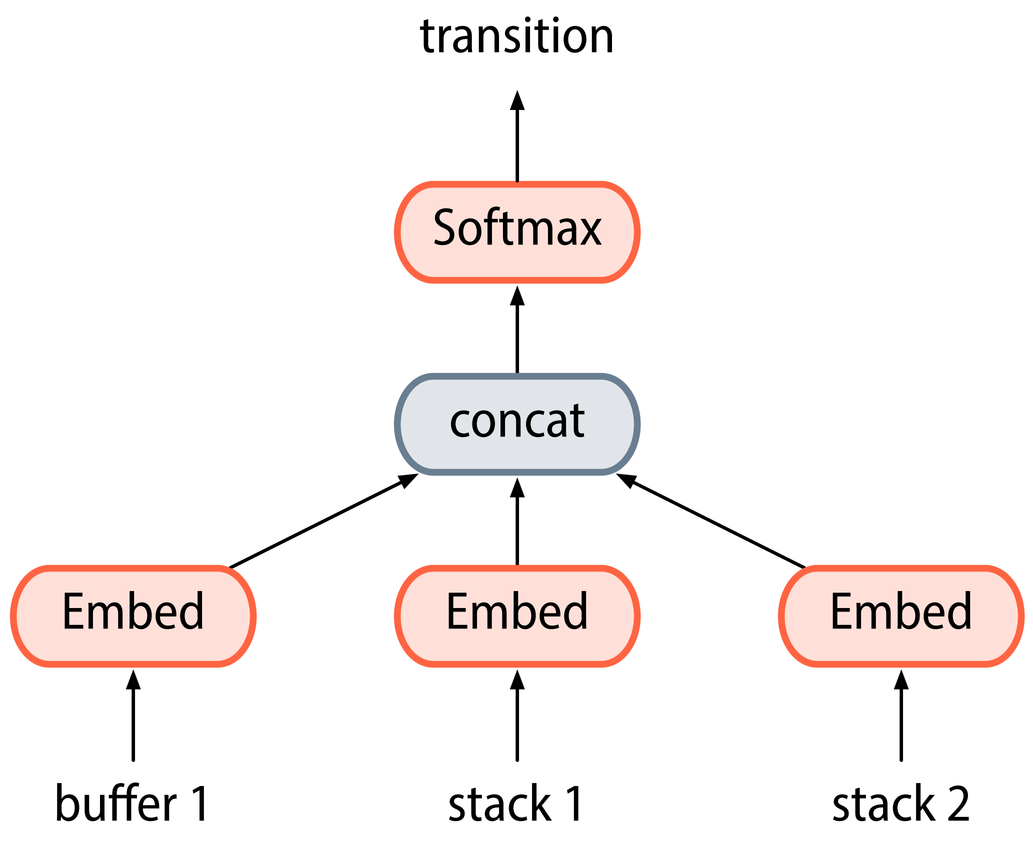
- **Runtime**

  The number of transitions that the arc-standard algorithm takes to build a tree for a sentence with n words is $2n - 1$.

Features used with the arc-standard algorithm

Features for the classifier can be defined over

- the words in the buffer
- the words on the stack
- the partial dependency tree



Chen and Manning (2014)

Static training oracle

- Choose LA if this would create an arc from the gold-standard tree, and if all arcs from the second-topmost word on the stack have already been assigned by the parser.
- Choose RA if this would create an arc from the gold-standard tree, and if all arcs from the topmost word on the stack have already been assigned by the parser.
- Otherwise, choose SH.

  must always be valid, unless the tree is non-projective