Code and Named Entity Recognition in StackOverflow




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THE OHIO STATE UNIVERSITY

StackOverflow Entity Recognition

BRAT

I am trying to do a search query on the SoundCloud API. (Library)

Using their JavaScript (Language) SDK, (Application) the following works:

NEW NER CORPUS

15,372 Sentences
Manually Annotated
20 Entity Types

StackOverflow Entity Recognition

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extracts the software entities with **79.1%** $\mathbf{F_1}$

StackOverflow Entity Recognition

1st

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NEW NER MODEL

21.6 F_1↑

StackOverflow Entity Recognition

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NEW NER MODEL

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BERTOverflow
Pre-trained on 152M Sentences

StackOverflow NER

Code Retrieval

NL Query:

Using mysql find the sorted list of 200 most popular links with date earlier than 2014/02/25

Code Snippet

```
SELECT url FROM links WHERE date =
    ( SELECT date FROM links WHERE
    date < "2014/02/25" ORDER BY date
    DESC LIMIT 1)
ORDER BY date DESC, clicks DESC LIMIT 200
```

[Yao et al., 2019]
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StackOverflow NER

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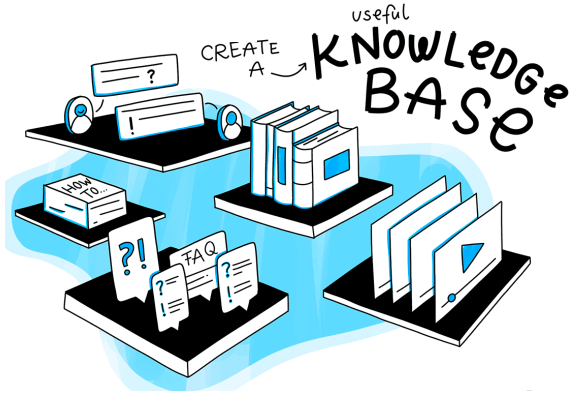
KB Creation



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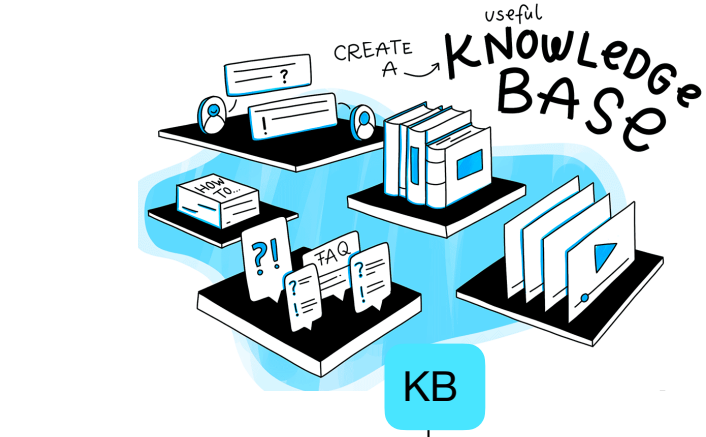

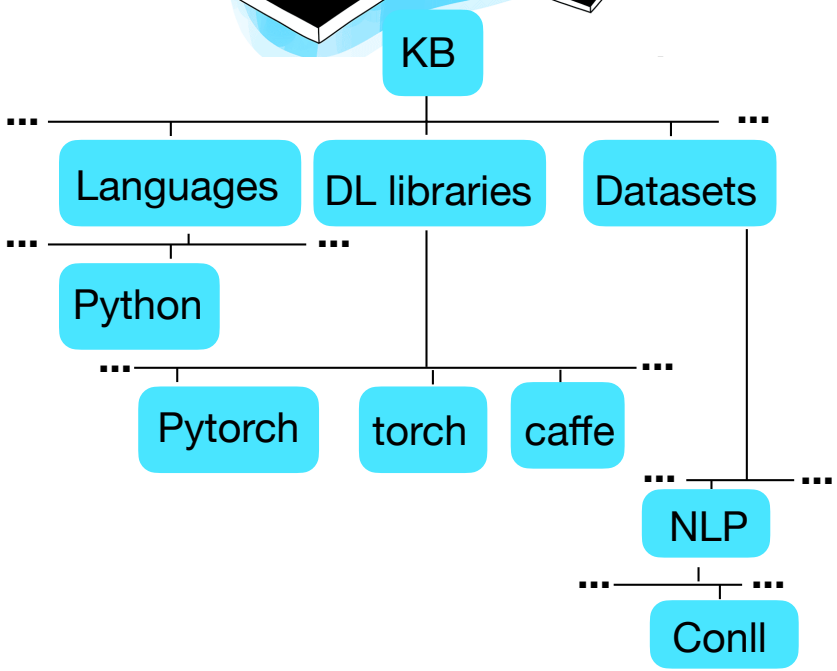

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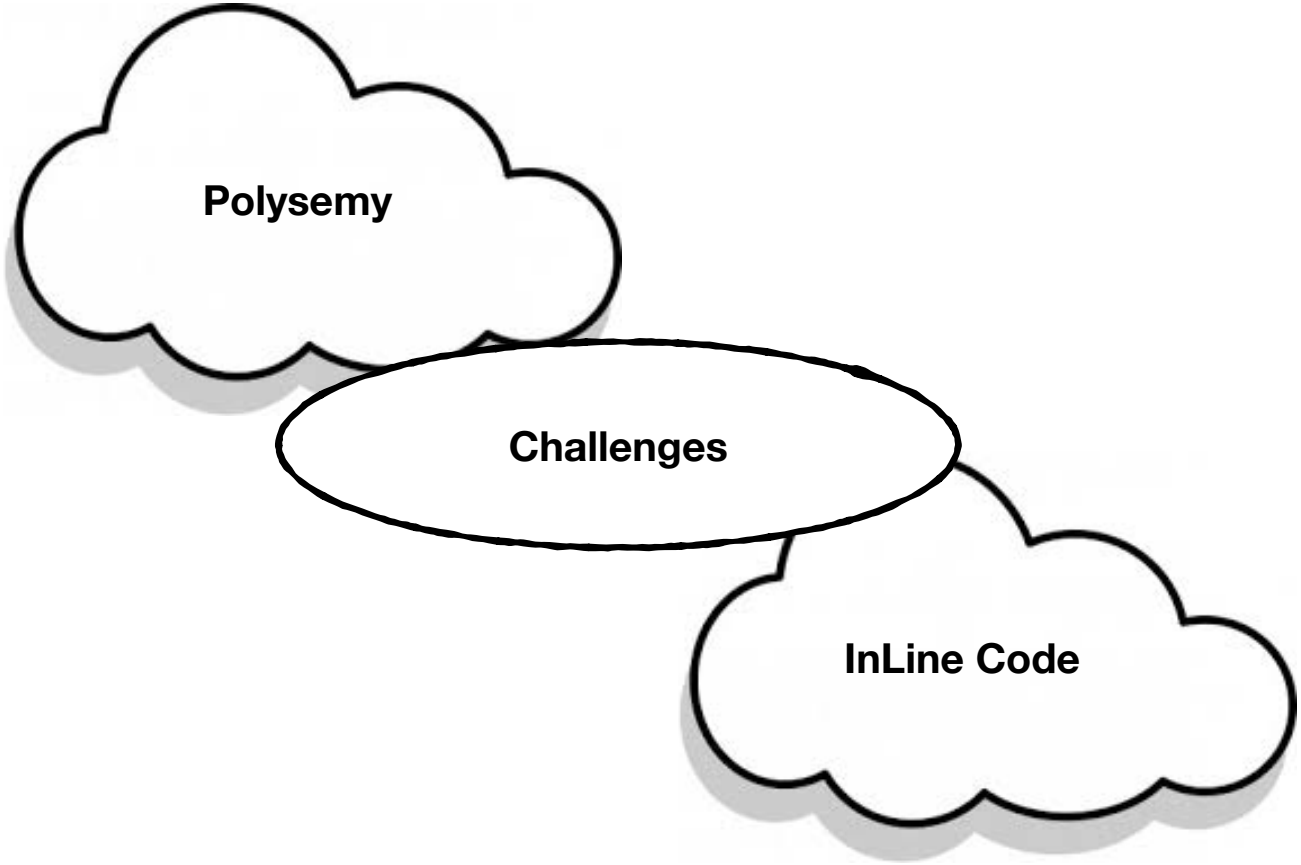
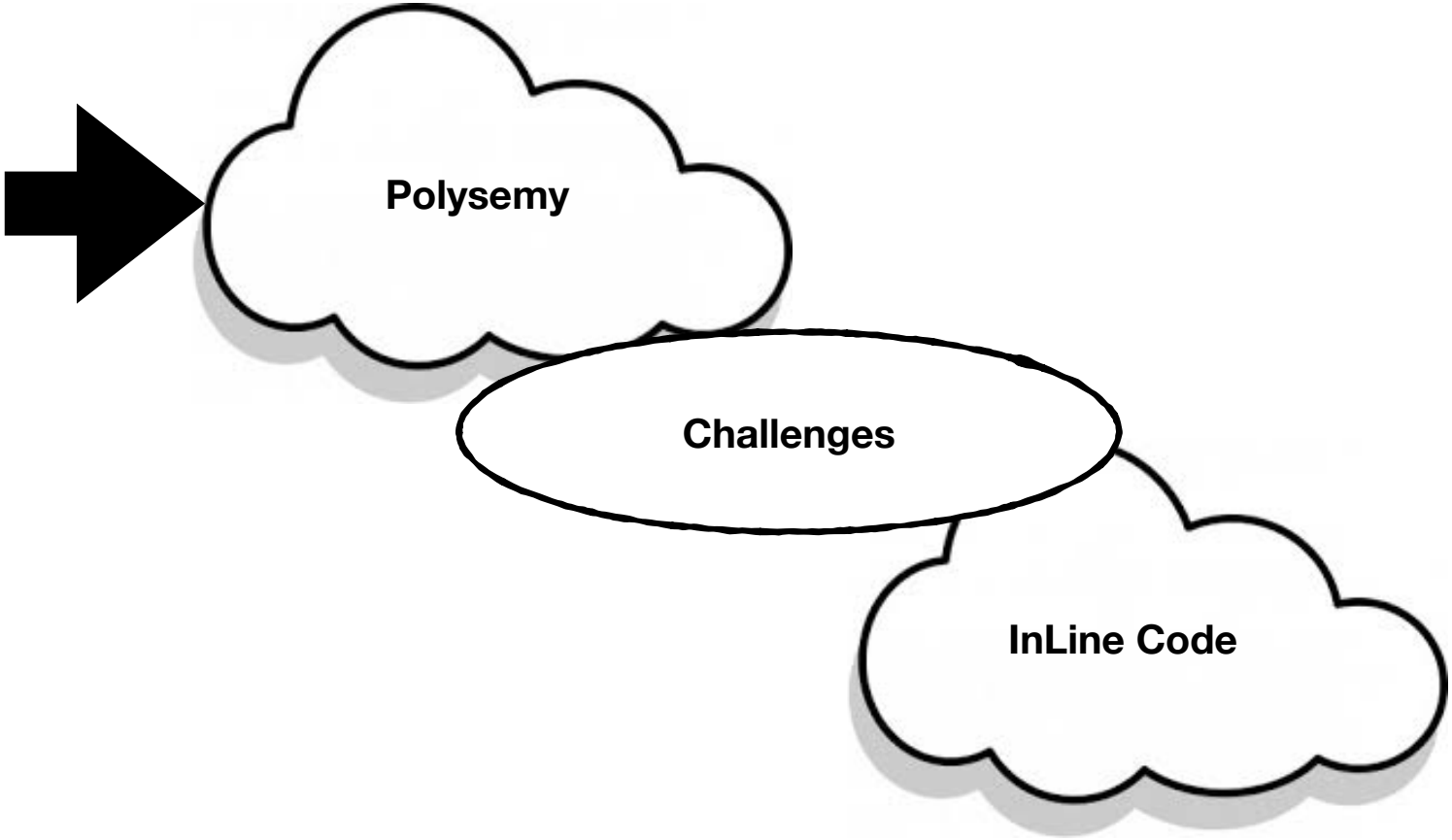
StackOverflow Entity Recognition



StackOverflow Entity Recognition



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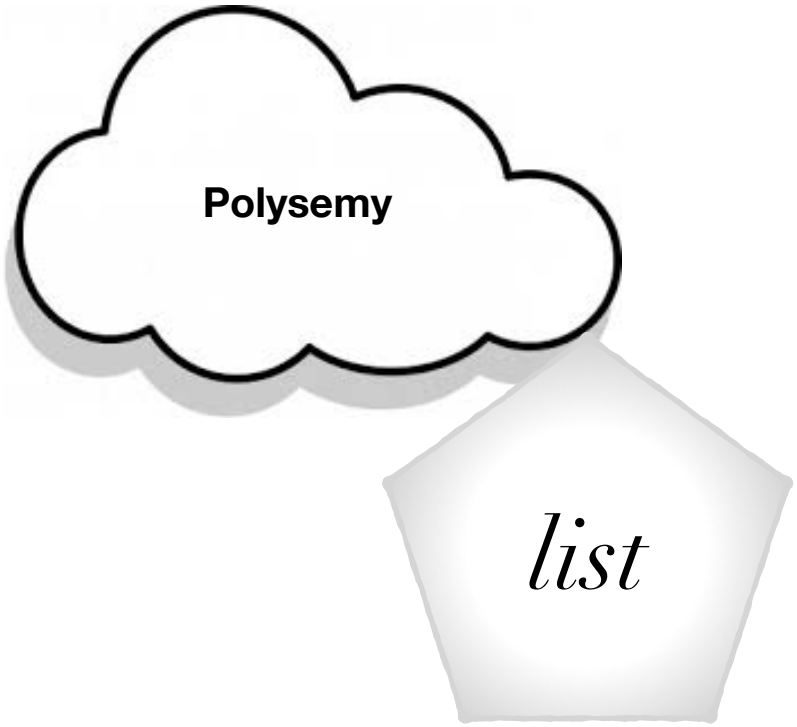

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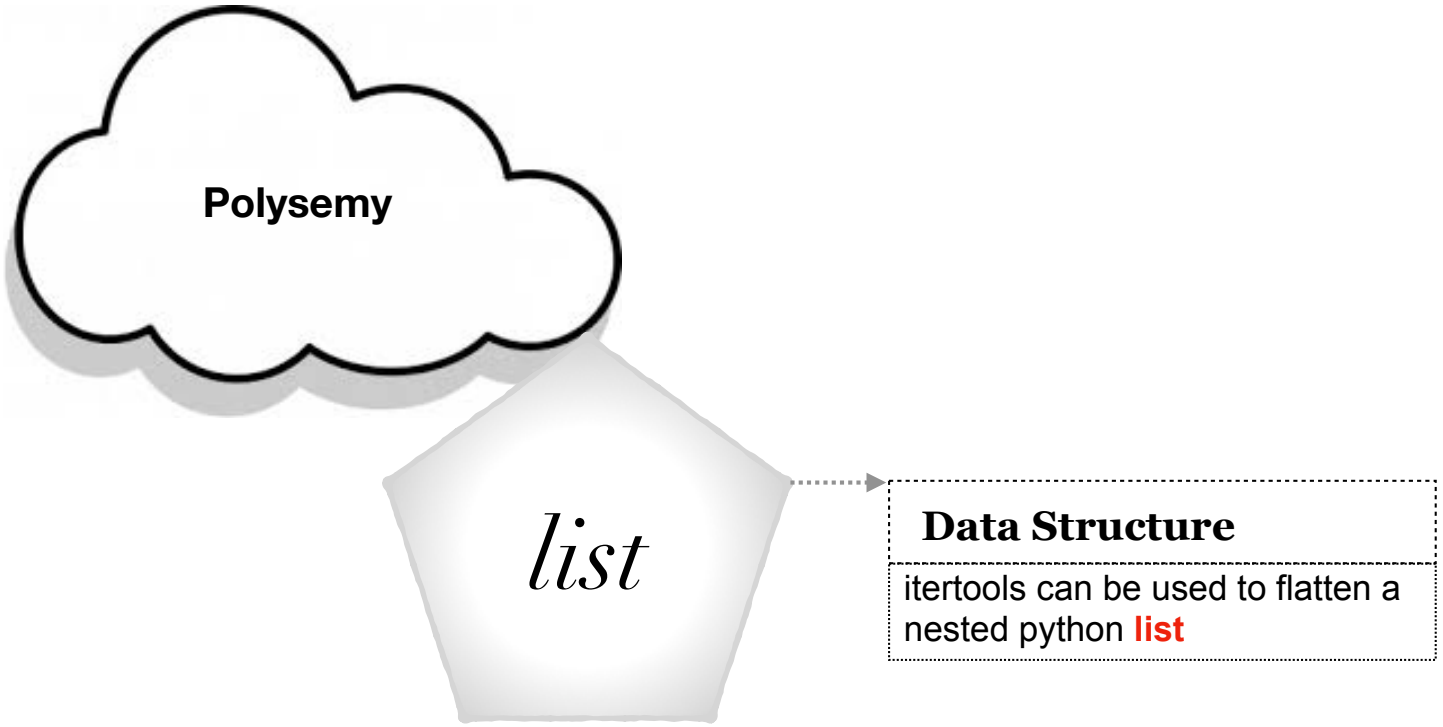
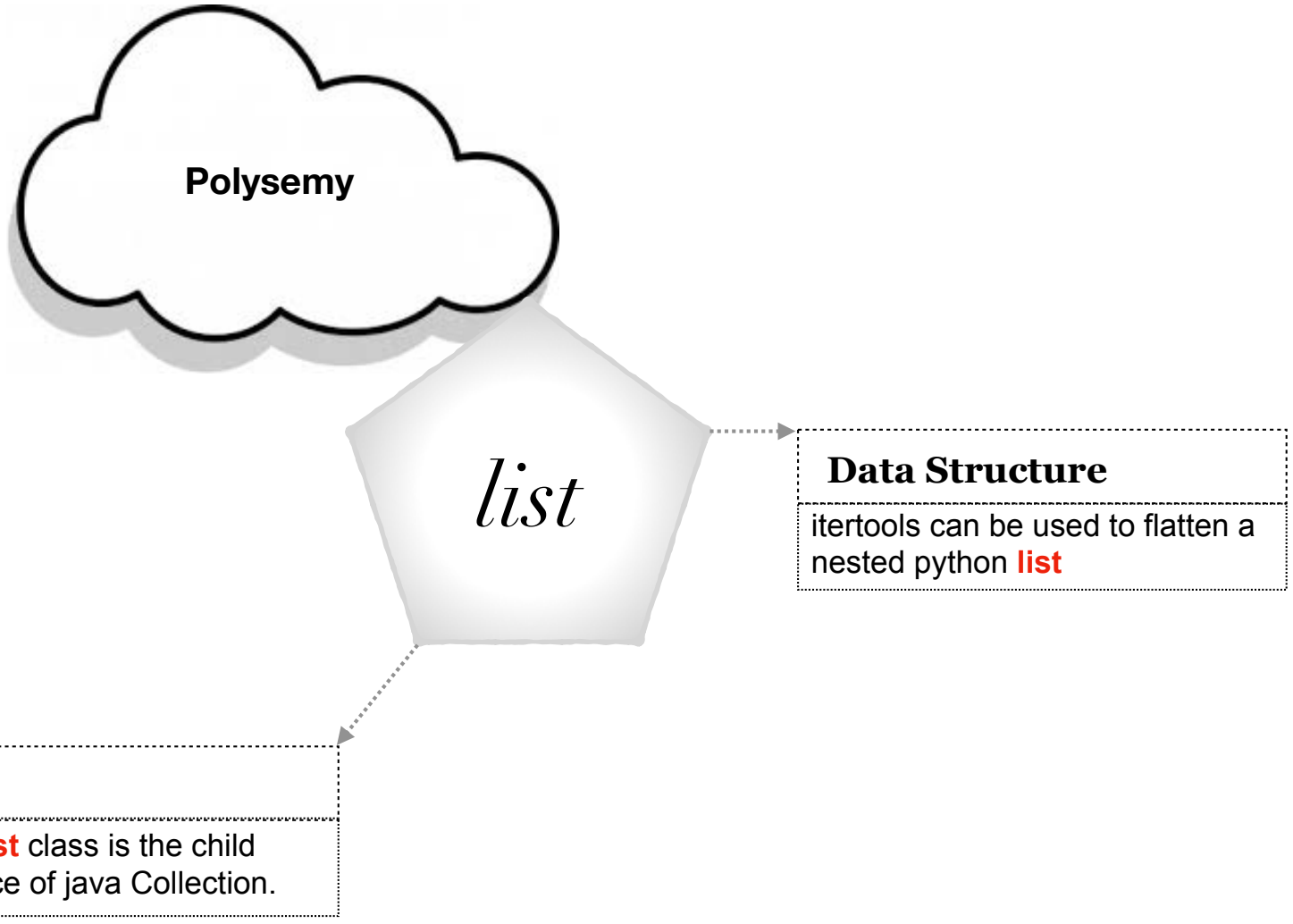


StackOverflow Entity Recognition



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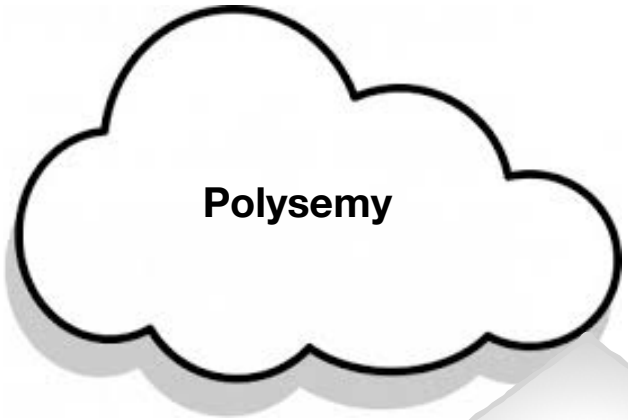


list

Data Structure

itertools can be used to flatten a nested python **list**

Class

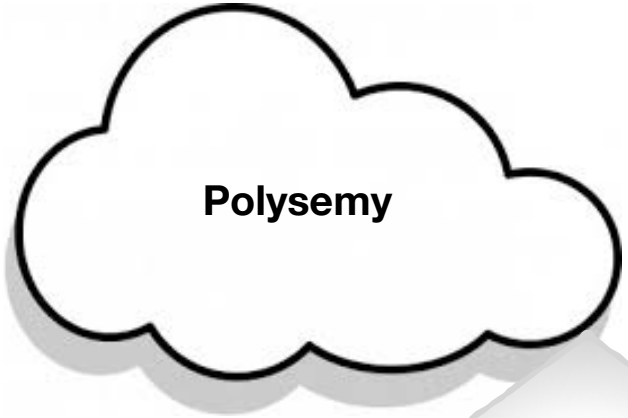
The **List** class is the child interface of java Collection.

Variable

I want to iterate through the following **list**

```
ArrayList<String> list=new ArrayList<String>();
                list.add("http://www.google.com");
                list.add("http://www.stackoverflow.com");
                  exchange.getOut().setHeader("endpoints",list);
```

StackOverflow Entity Recognition



list

Non Entity

Here is a **list** of most useful ajax frameworks

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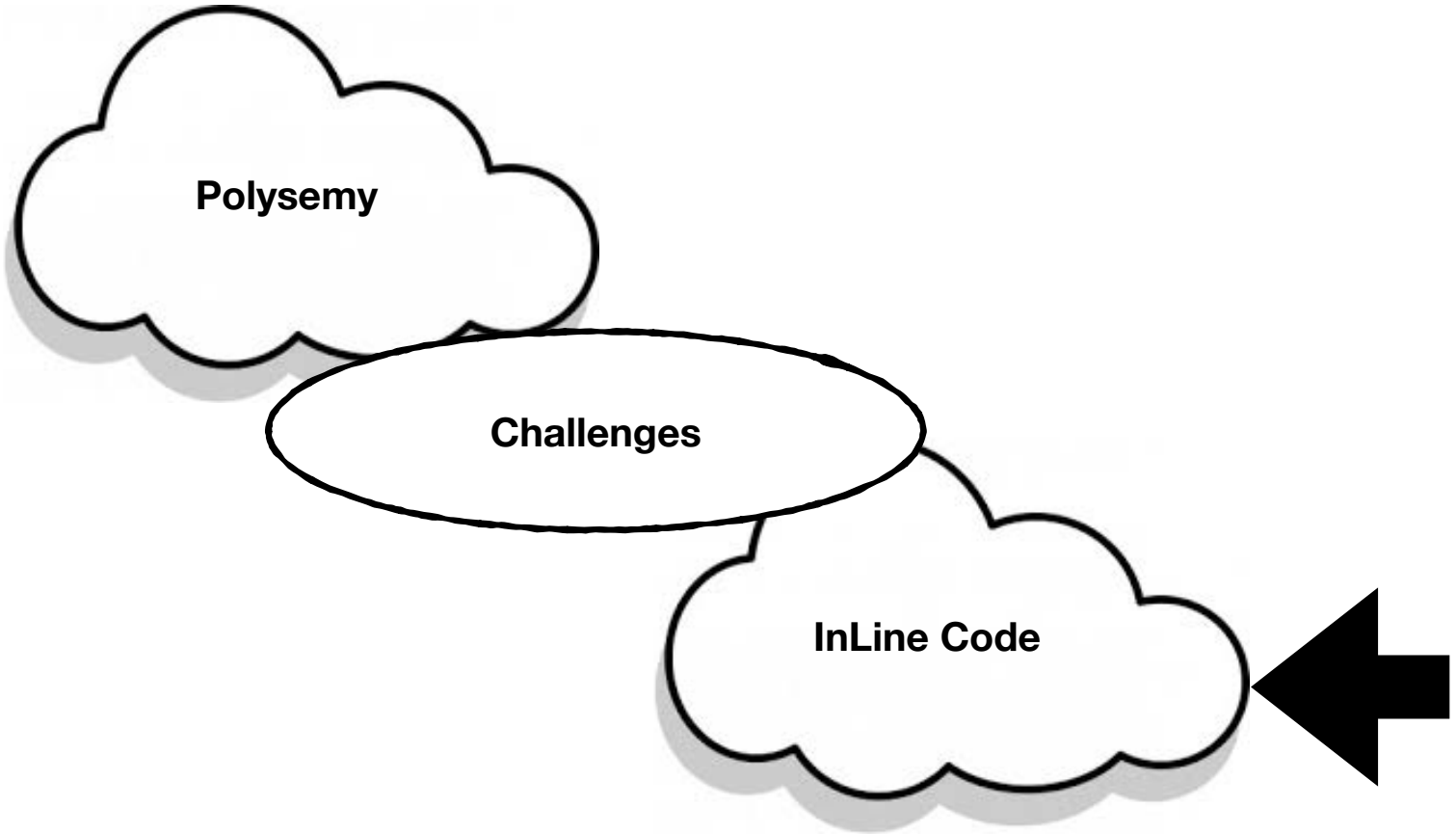

StackOverflow Entity Recognition

check if key is numeric by `is_numeric($key)` function

StackOverflow Entity Recognition

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StackOverflow Entity Recognition

980 Unique Function Names in **15k sentences**

check if key is numeric by is_numeric($key) function

StackOverflow Entity Recognition

980 Unique Function Names in **15k sentences**

Before adding element to array, check if key is numeric by is_numeric($key) function.
If it return false, then, covert key to integer using typecasting, (int)$key.

Now, the array will have numeric keys only and can be ordered.

share improve this answer follow

answered Oct 23 '15 at 9:16

300 ● 1 ● 5

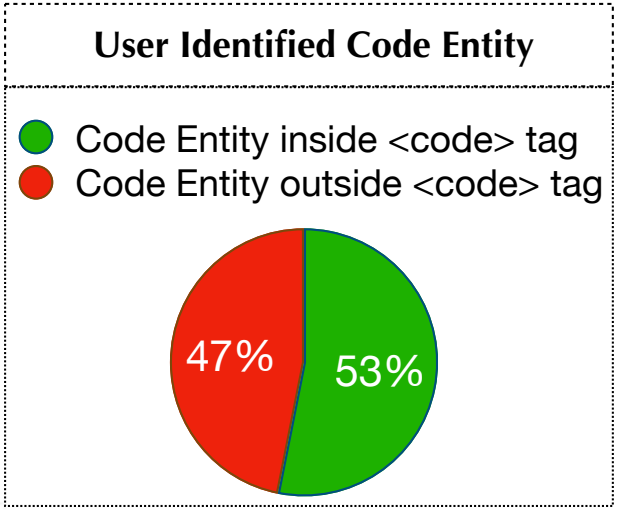
InLine Code

check if key is numeric by is_numeric($key) function

StackOverflow Entity Recognition

980 Unique Function Names in **15k sentences**

User Identified Code Entity



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Contribution #1: Construct **new data** for Software Entities

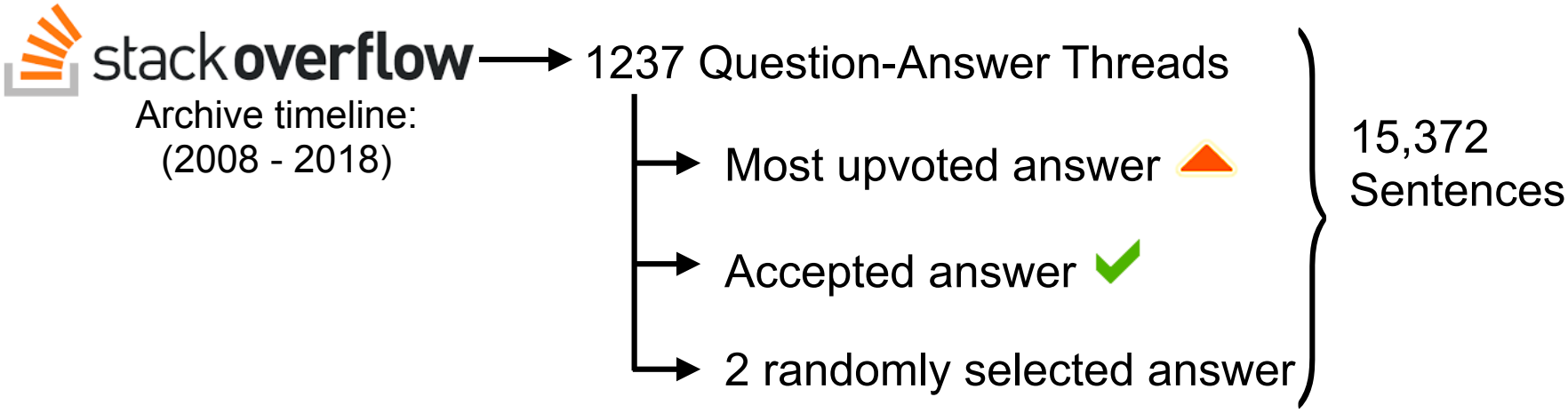
Contribution #2: Propose a **new model** for Software Entities

Contribution #1: Construct **new data** for Software Entities

- Manually annotated sentence with **20 types of entities**
- **15k** StackOverflow sentence

Contribution #2: Propose a **new model** for Software Entities

Annotated StackOverflow Corpus



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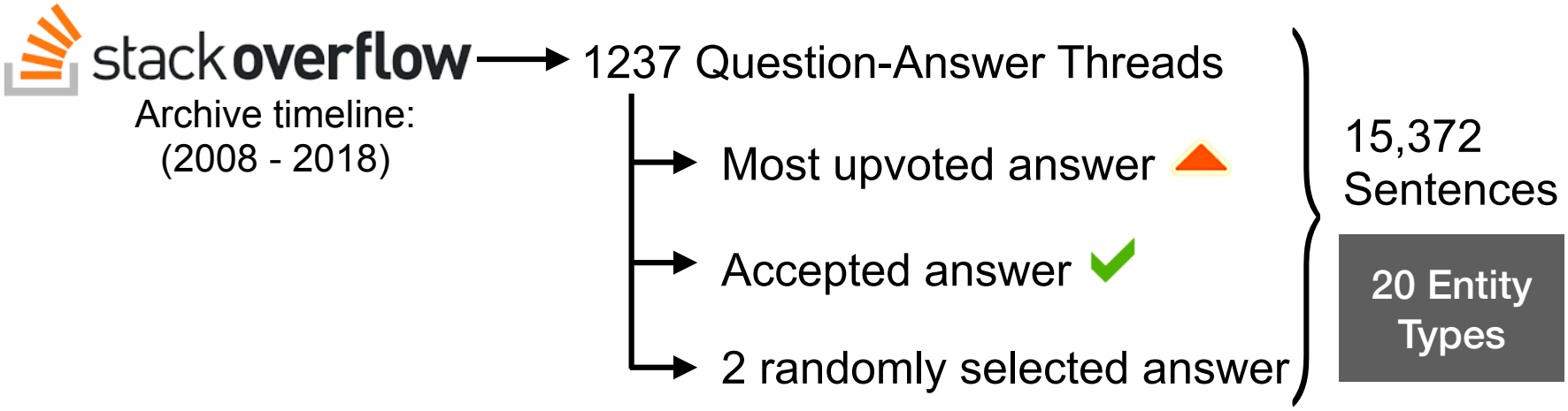
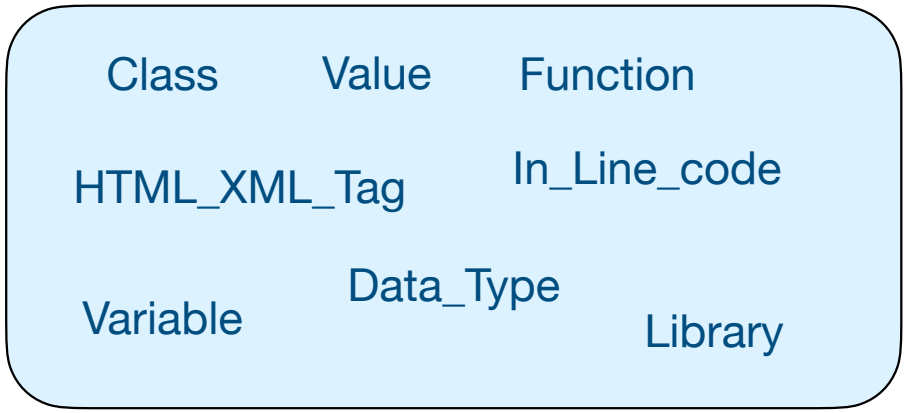
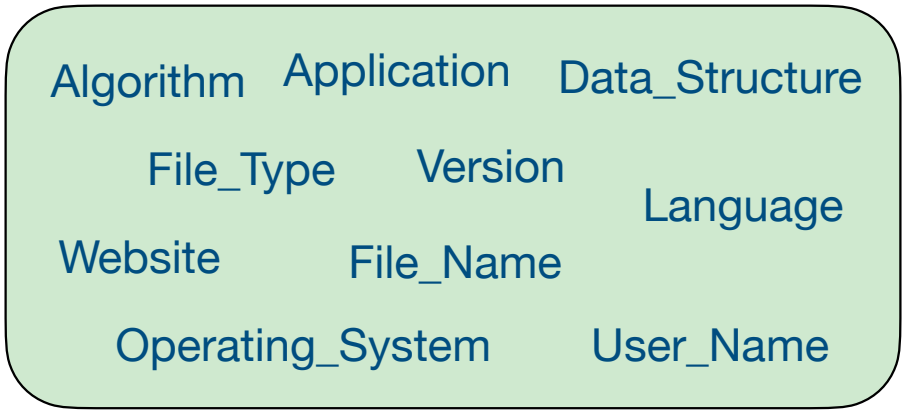


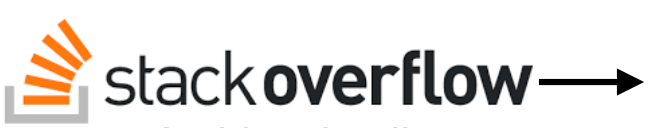


Code Entity Types



Natural Language Entity

Annotated StackOverflow Corpus



Archive timeline:
(2008 - 2018)

→ 1237 Question-Answer Threads

- Most upvoted answer
- Accepted answer
- 2 randomly selected answer

15,372 Sentences

20 Entity Types

Code Entity Types

Class, Value, Function, HTML_XML_Tag, In_Line_code, Variable, Data_Type, Library

Natural Language Entity

Algorithm, Application, Data_Structure, File_Type, Version, Language, Website, File_Name, Operating_System, User_Name

Annotated StackOverflow Corpus

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15,372 Sentences

20 Entity Types

1 Answer_to_Question_ID: 27926052
2 Question_URL: https://stackoverflow.com/questions/27926052/

4 You can now add customised selector(please refer 'IQUIView+IQKeyboardToolbar.h') for previous/next/done to get notify.
(Library_Class: 'IQUIView+IQKeyboardToolbar.h'; File_Name: 'IQUIView+IQKeyboardToolbar.h'; Value: previous/next/done)

5 Note that custom selector doesn't affect the native functionality of previous/next/done, it's just used for callback purpose only.
(Value: previous/next/done)

6 For detail documentation please refer 'IQUIView+IQKeyboardToolbar.h', for 'how to use?'
(Library_Class: 'IQUIView+IQKeyboardToolbar.h'; File_Name: 'IQUIView+IQKeyboardToolbar.h')

7 please refer 'TextFieldViewController.m'.
(File_Name: 'TextFieldViewController.m')

[annotators]

[**40%** double annotated]
[**62%** agreemnet]

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```

(Library_Class, File_Name, Value, Value, Library_Class, File_Name, File_Name)

[annotators]

[40% double annotated]
[62% agreemnet]

[adjudicator]

- Resolves disagreement in double annotated data
- Ensures the sanity of single annotated data

Contribution #1: Construct **new data** for Software Entities

- Manually annotated sentence with **20 types of entities**
  - **15k** StackOverflow sentence

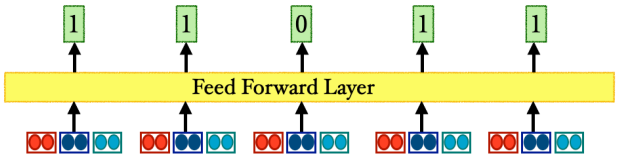
Contribution #2: Proposed a **new model** for Software Entities

- Attentive NER tagger
  - combined with in-domain contextual representation

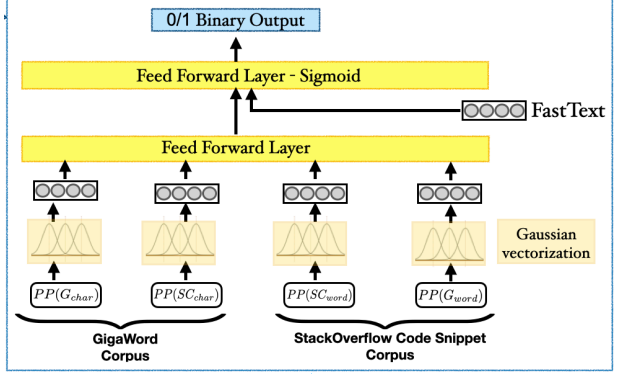
SoftNER

Contextual Word Representation

Entity Segmenter



Code Recognizer



Polysemy

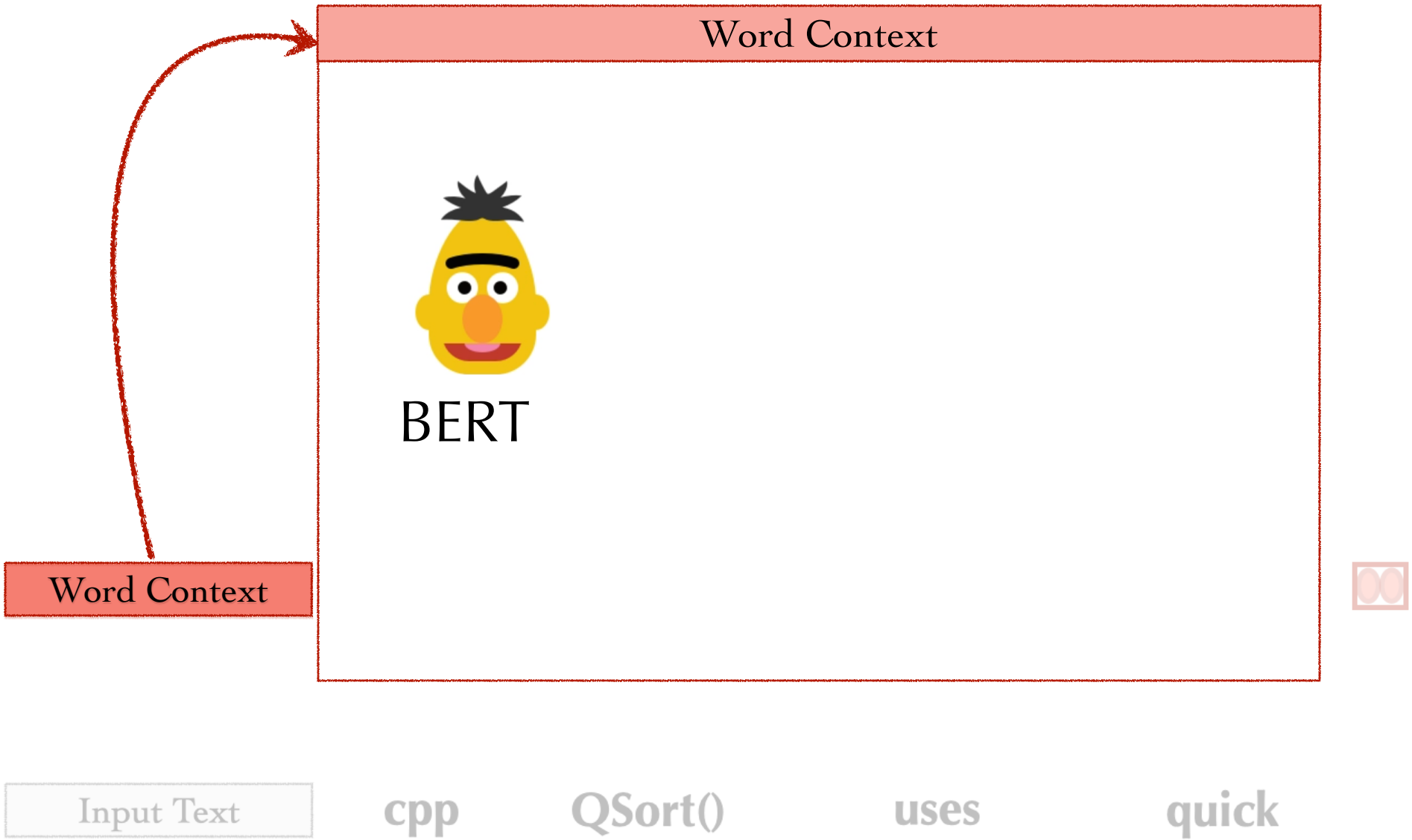
Challenges

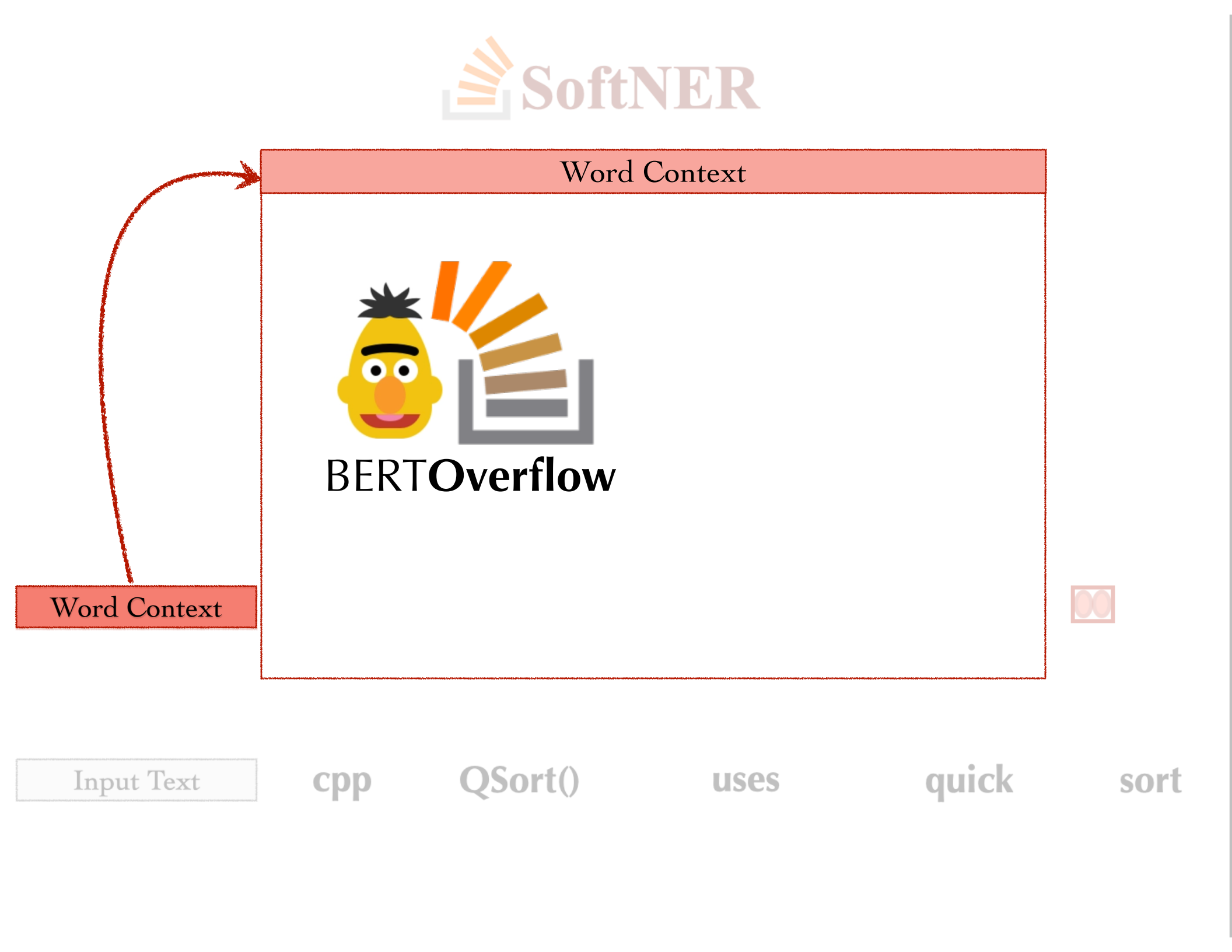
InLine Code

Input Text

cpp **QSort()** **uses** **quick** **sort**

SoftNER


SoftNER
Word Context
BERT
Word Context
Input Text
cpp
QSort()
uses
quick
sort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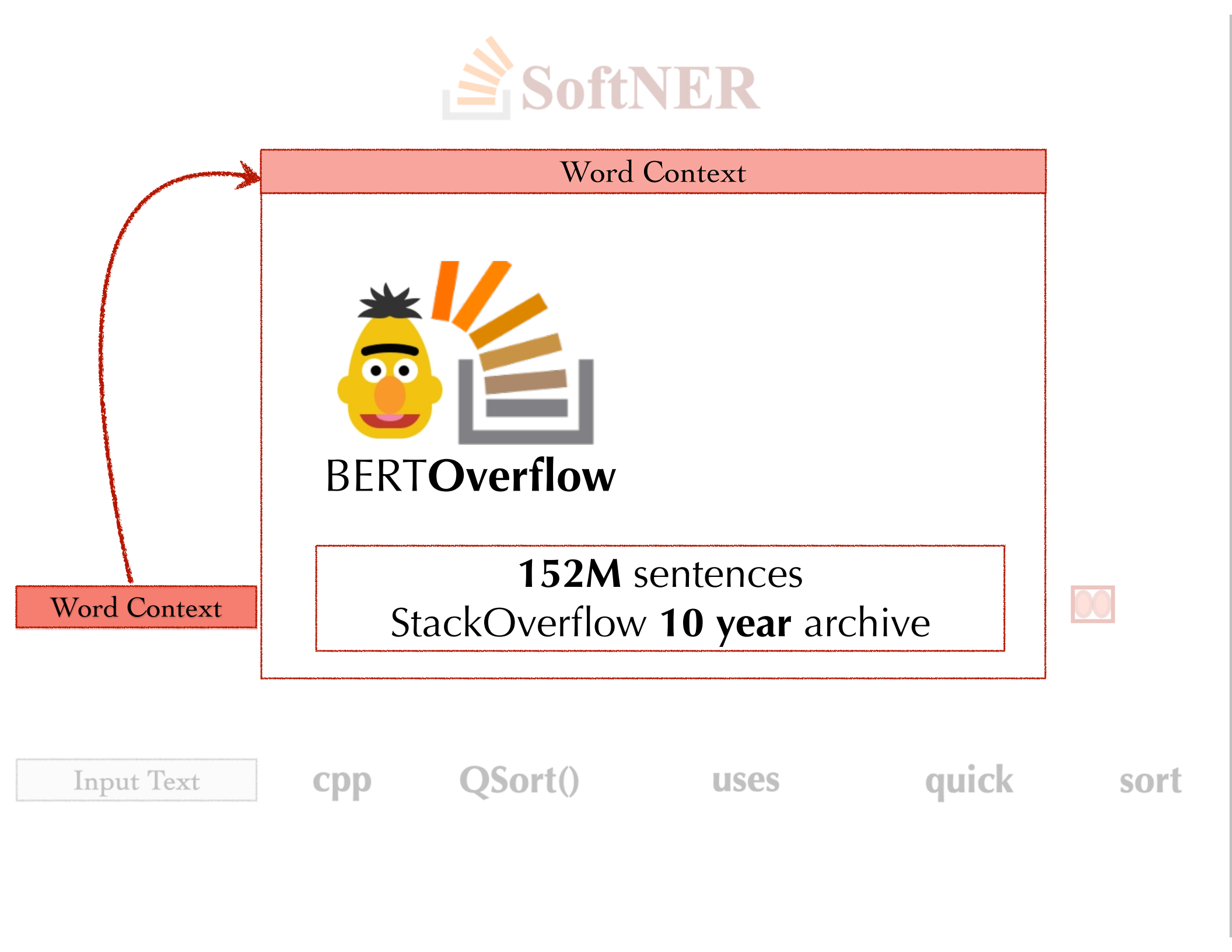
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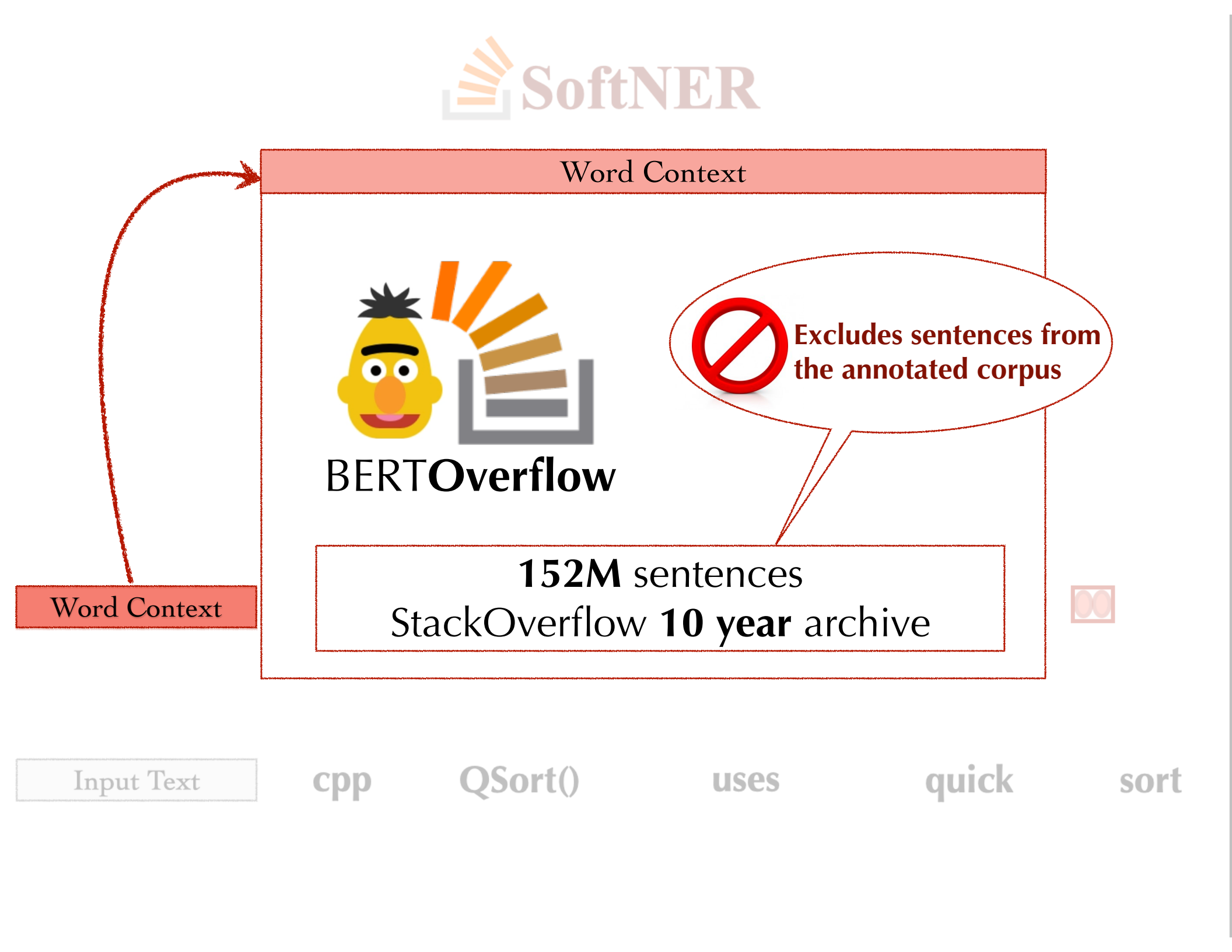
SoftNER
Word Context
BERTOverflow
Excludes sentences from the annotated corpus
152M sentences
StackOverflow 10 year archive
Word Context
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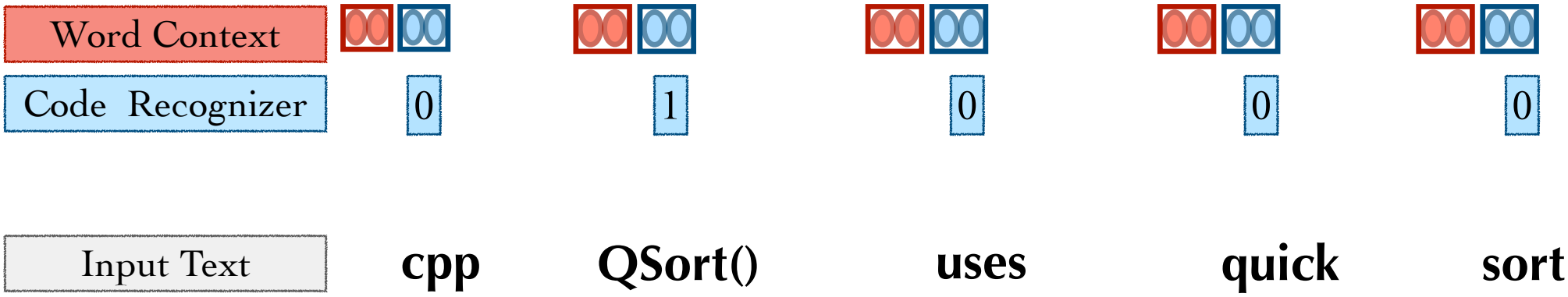
SoftNER


Word Context
Code Recognizer
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Input Text
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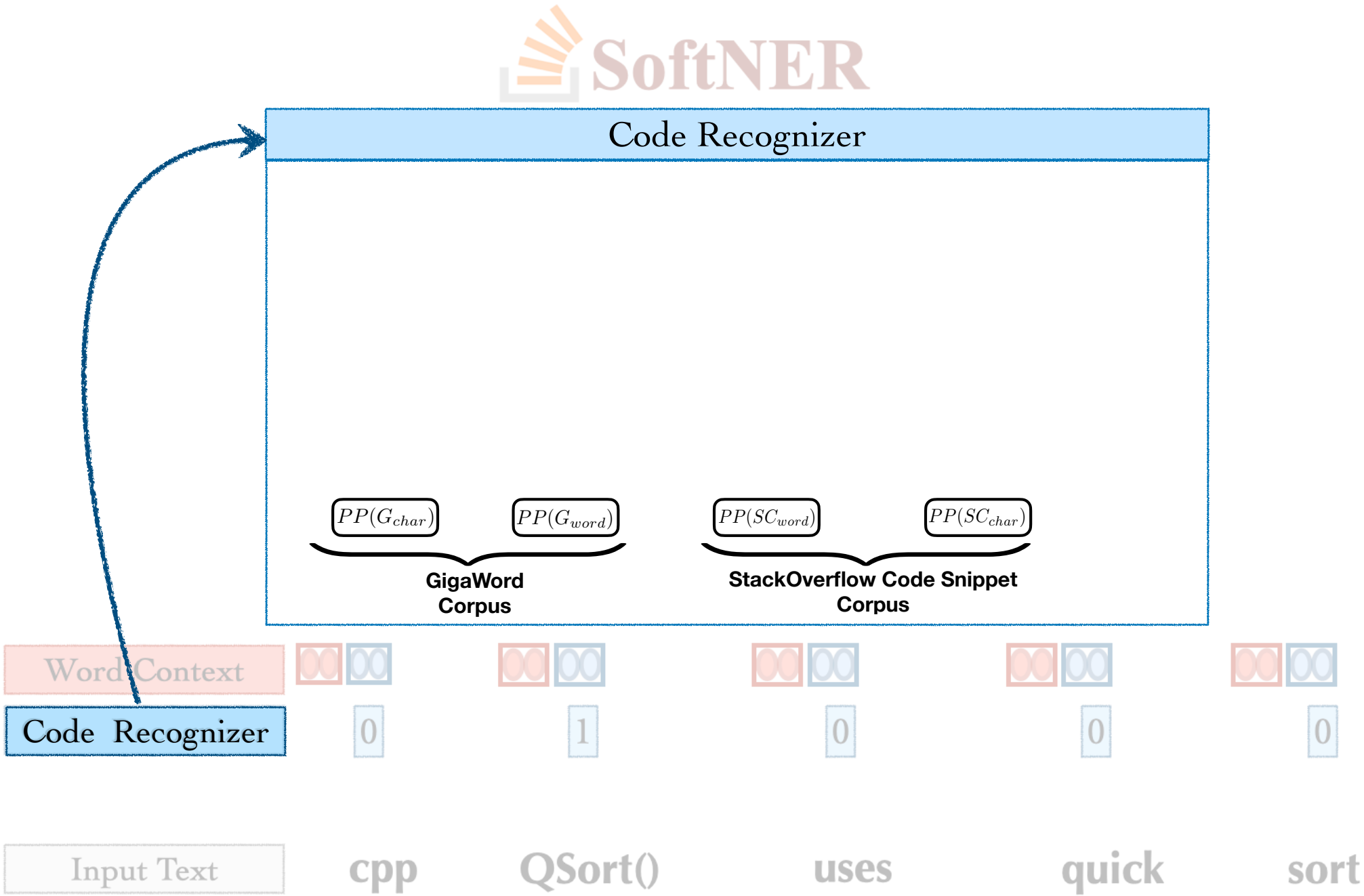
SoftNER
Code Recognizer
$PP(G_{char})$
$PP(G_{word})$
$PP(SC_{word})$
$PP(SC_{char})$
GigaWord Corpus
StackOverflow Code Snippet Corpus
Word Context
Code Recognizer
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Input Text
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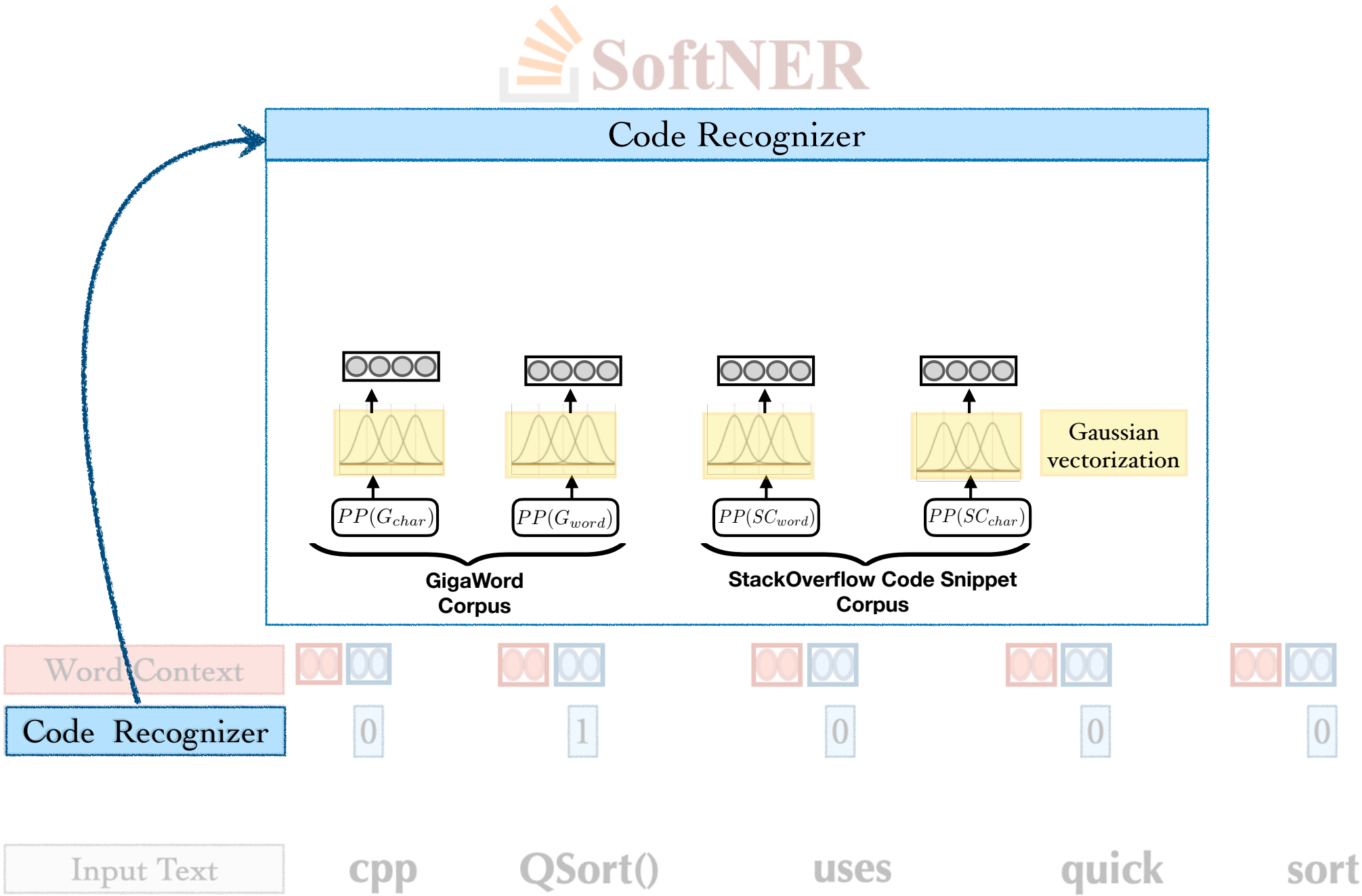
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Word Context
Code Recognizer
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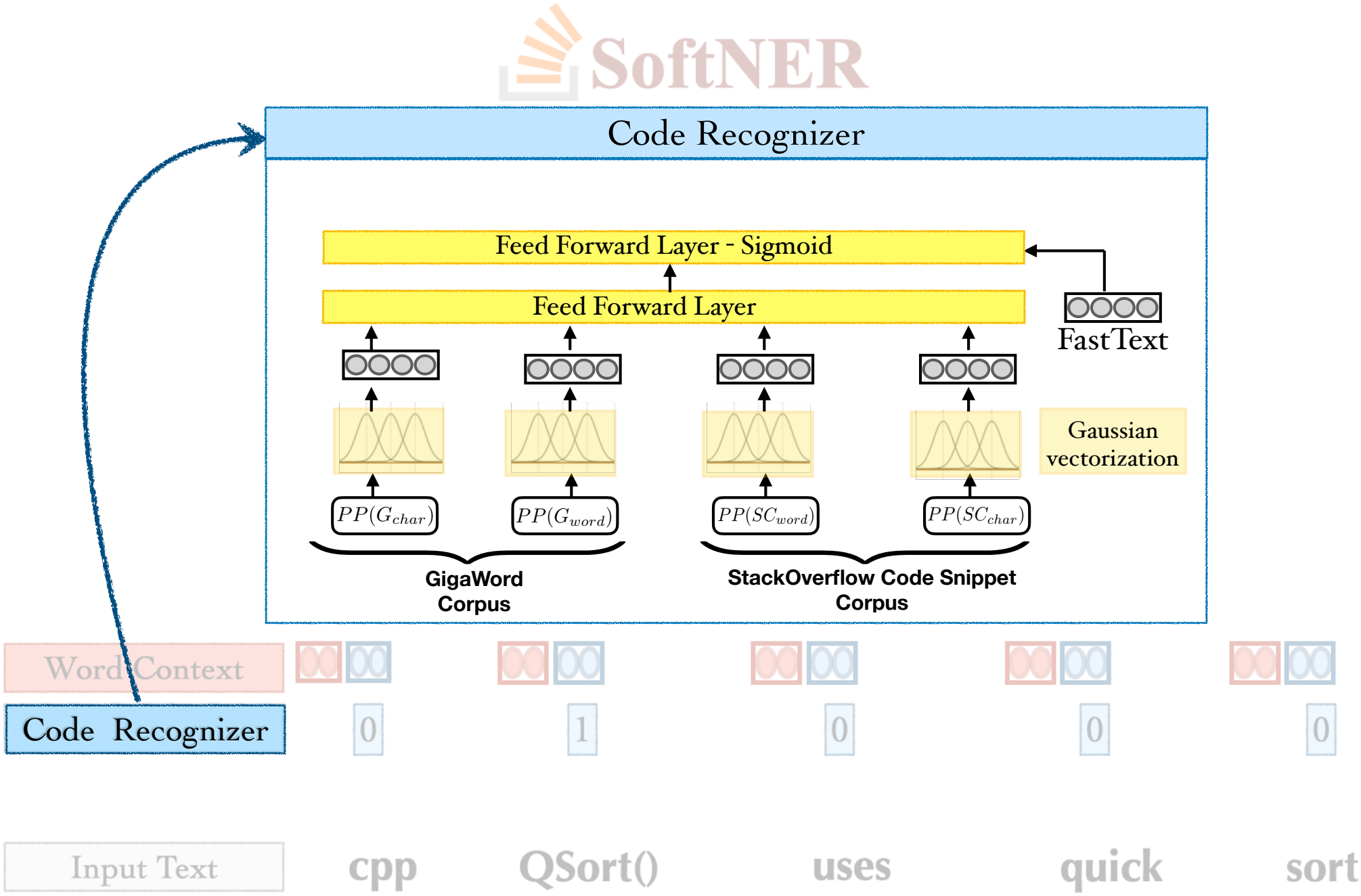
SoftNER
Code Recognizer
Feed Forward Layer - Sigmoid
Feed Forward Layer
FastText
Gaussian vectorization
$PP(G_{char})$
$PP(G_{word})$
$PP(SC_{word})$
$PP(SC_{char})$
GigaWord Corpus
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Word Context
Code Recognizer
0
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Input Text
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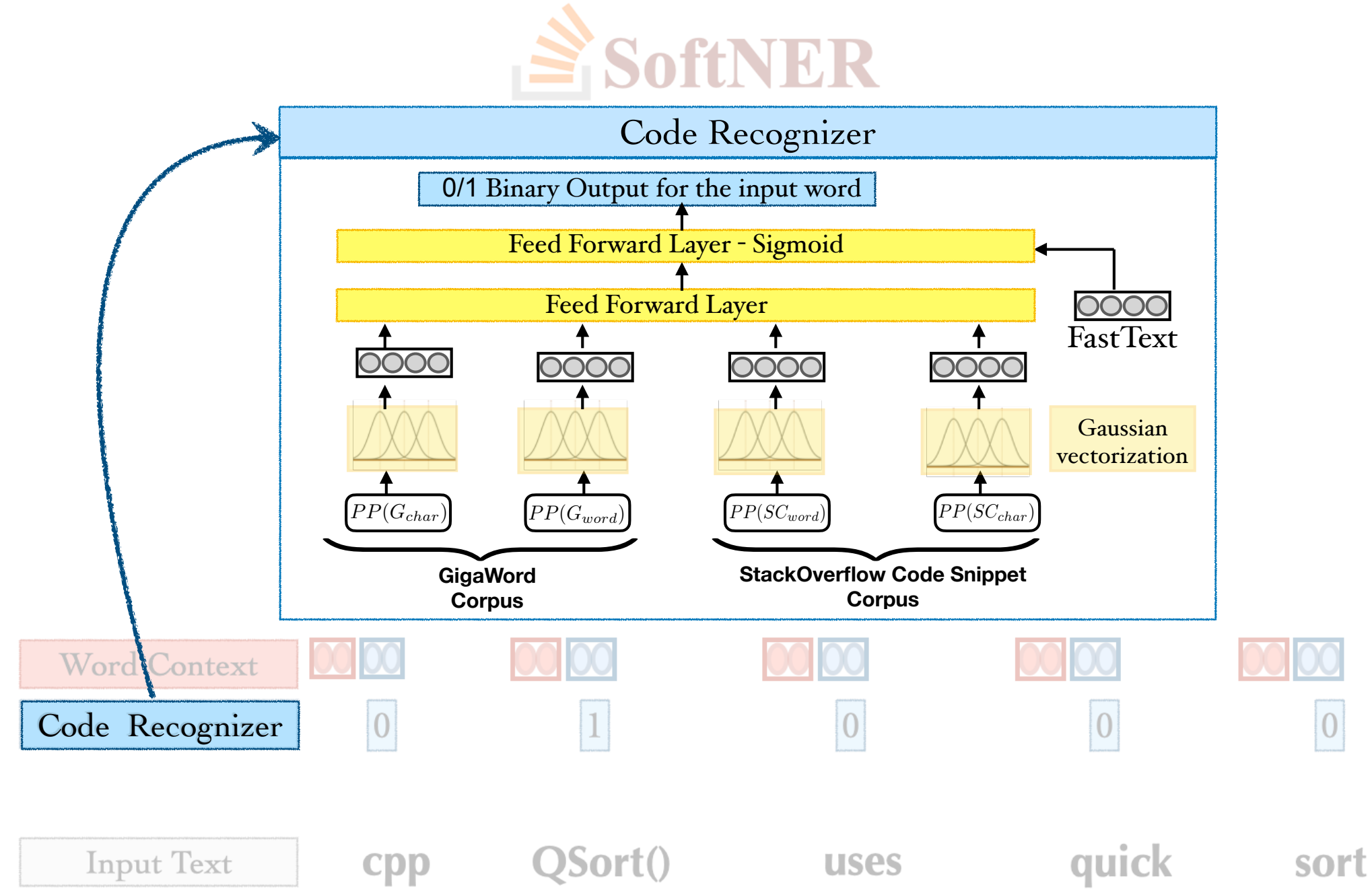
SoftNER
Code Recognizer
0/1 Binary Output for the input word
Feed Forward Layer - Sigmoid
Feed Forward Layer
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Word Context
Code Recognizer
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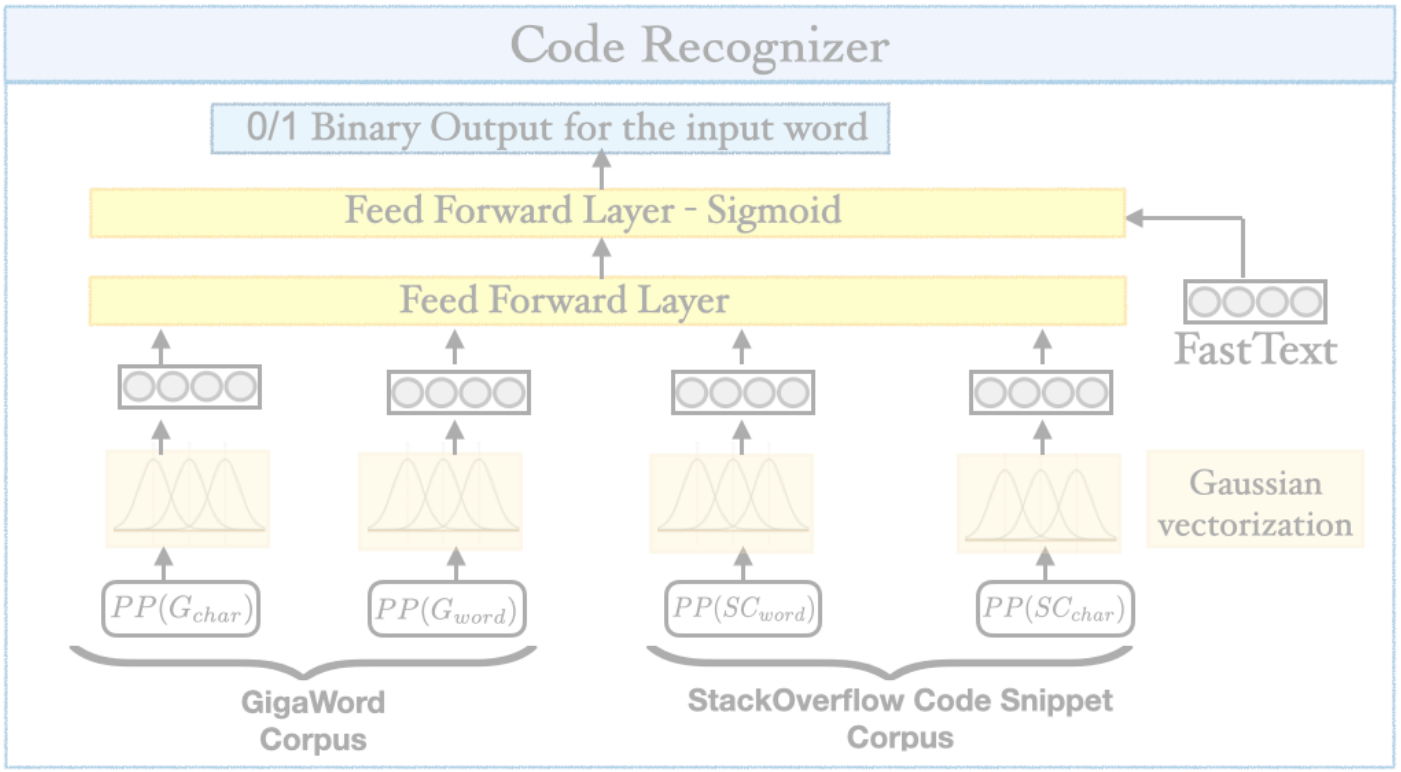
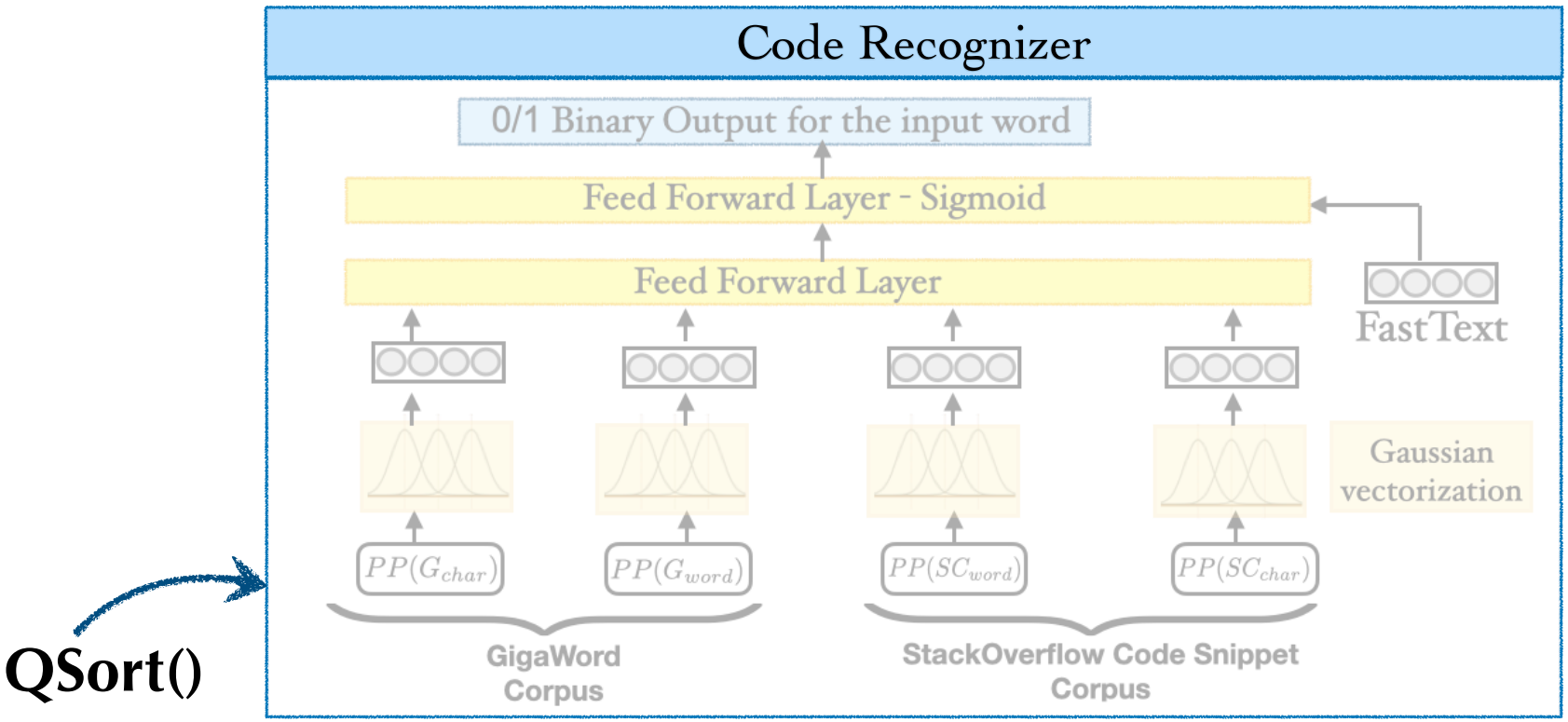


QSort()

Word Context					
Code Recognizer	0	1	0	0	0
Input Text	cpp	QSort()	uses	quick	sort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StackOverflow Code Snippet Corpus
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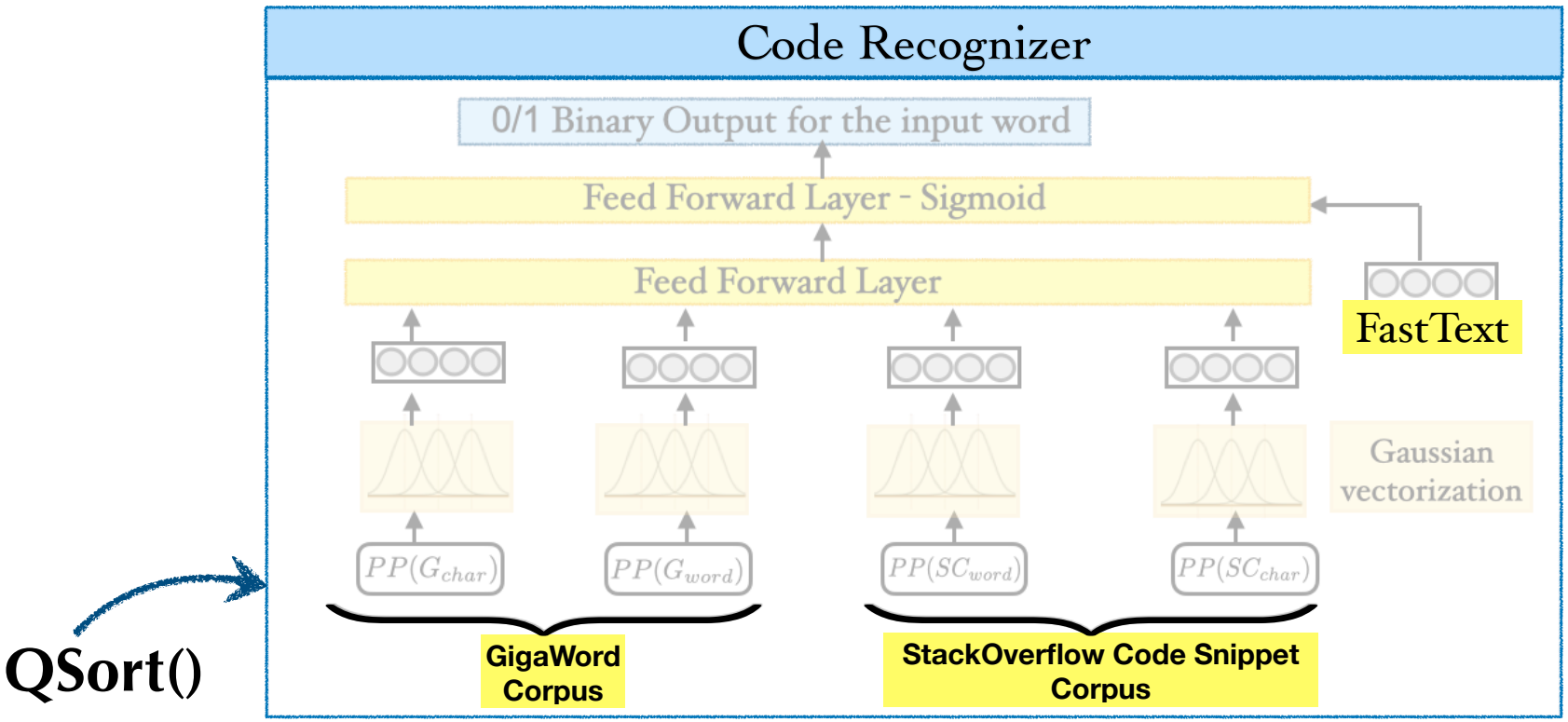
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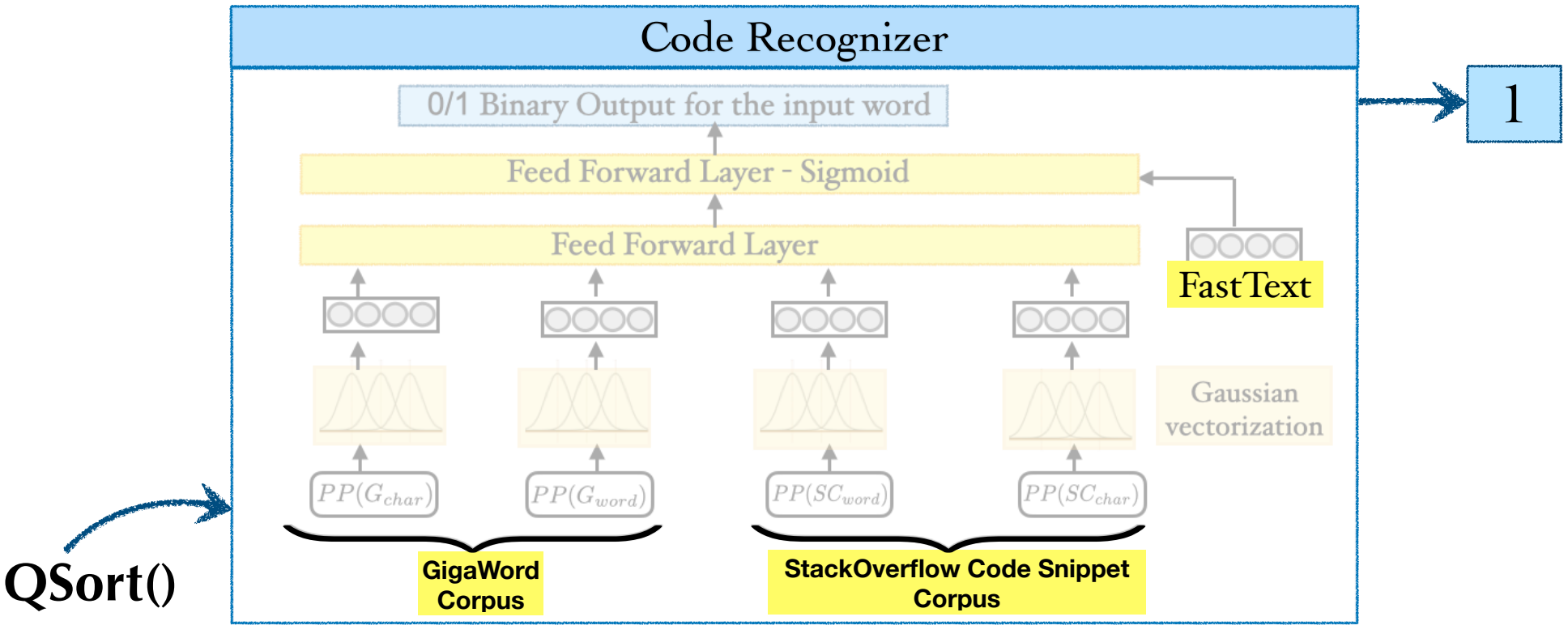
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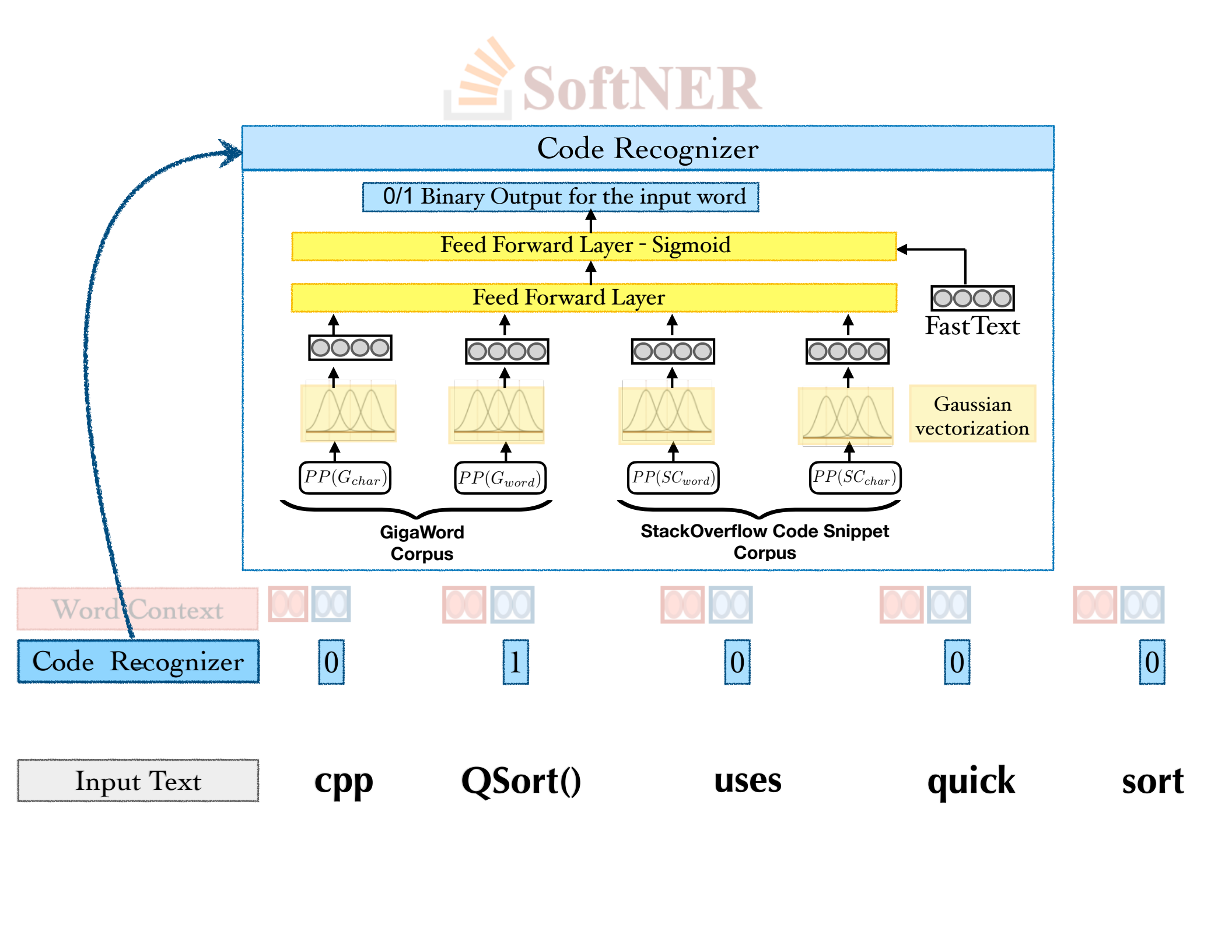
$PP(G_{char})$
$PP(G_{word})$
$PP(SC_{word})$
$PP(SC_{char})$
GigaWord Corpus
StackOverflow Code Snippet Corpus
QSort()
1


SoftNER
Code Recognizer
0/1 Binary Output for the input word
Feed Forward Layer - Sigmoid
Feed Forward Layer
FastText
Gaussian vectorization
$PP(G_{char})$
$PP(G_{word})$
$PP(SC_{word})$
$PP(SC_{char})$
GigaWord Corpus
StackOverflow Code Snippet Corpus
Word Context
Code Recognizer
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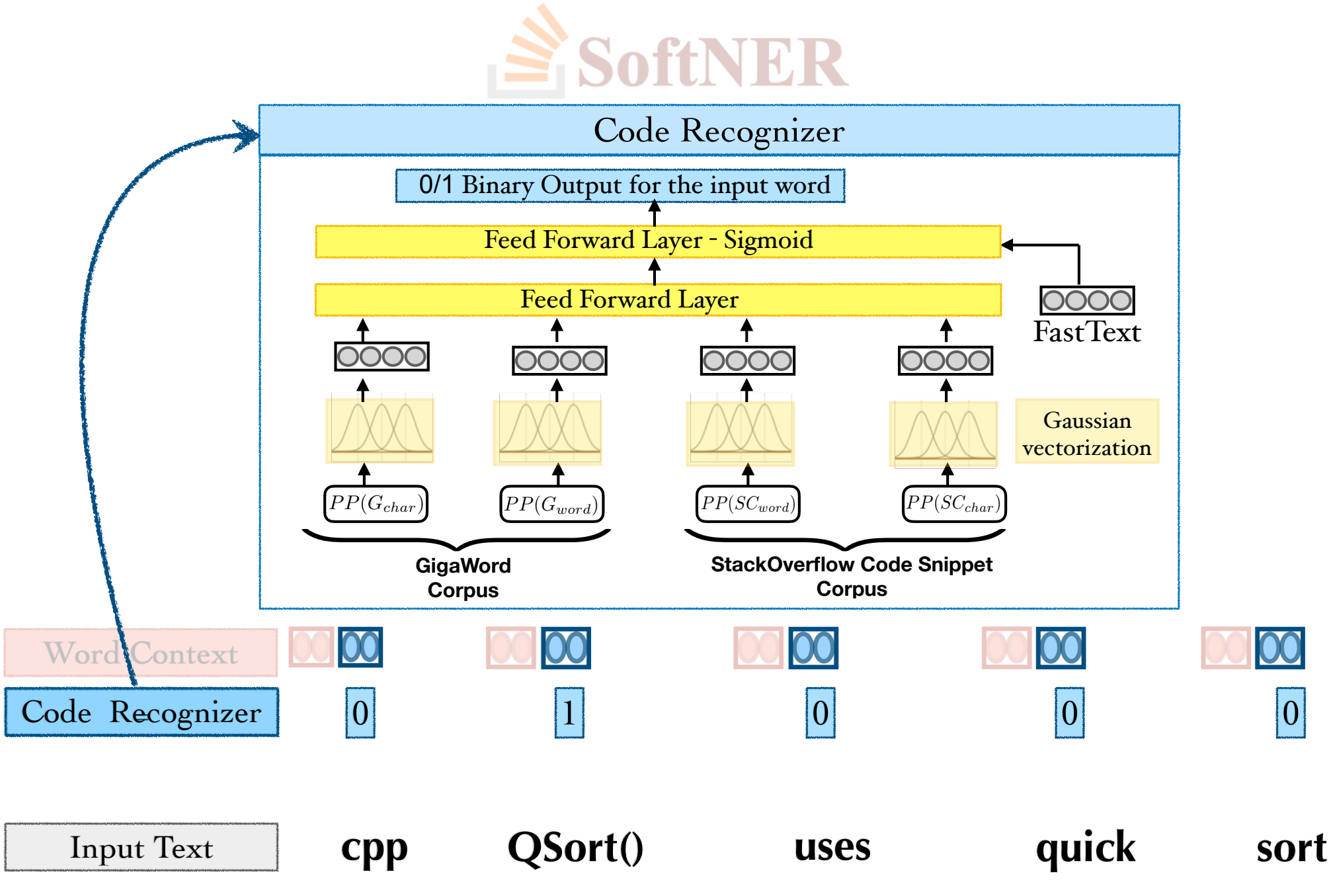
Input Text
cpp
QSort()
uses
quick
sort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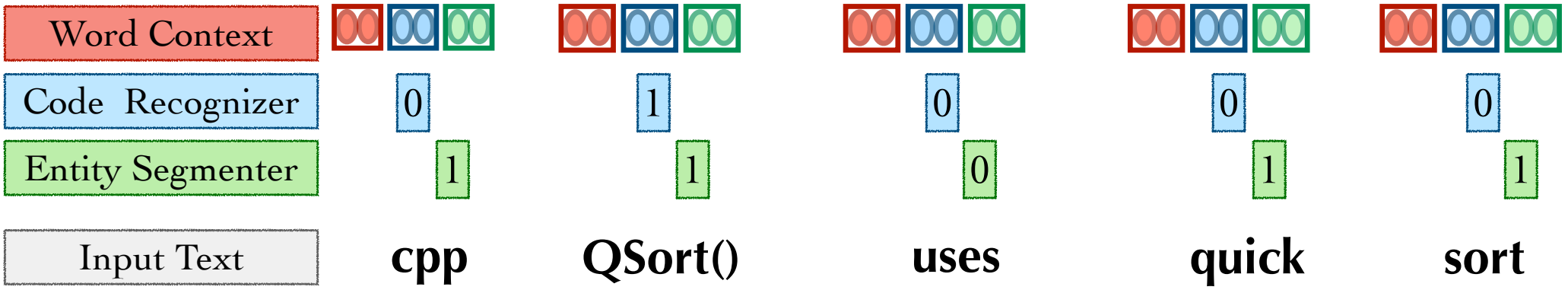
Word Context
Code Recognizer
Entity Segmenter
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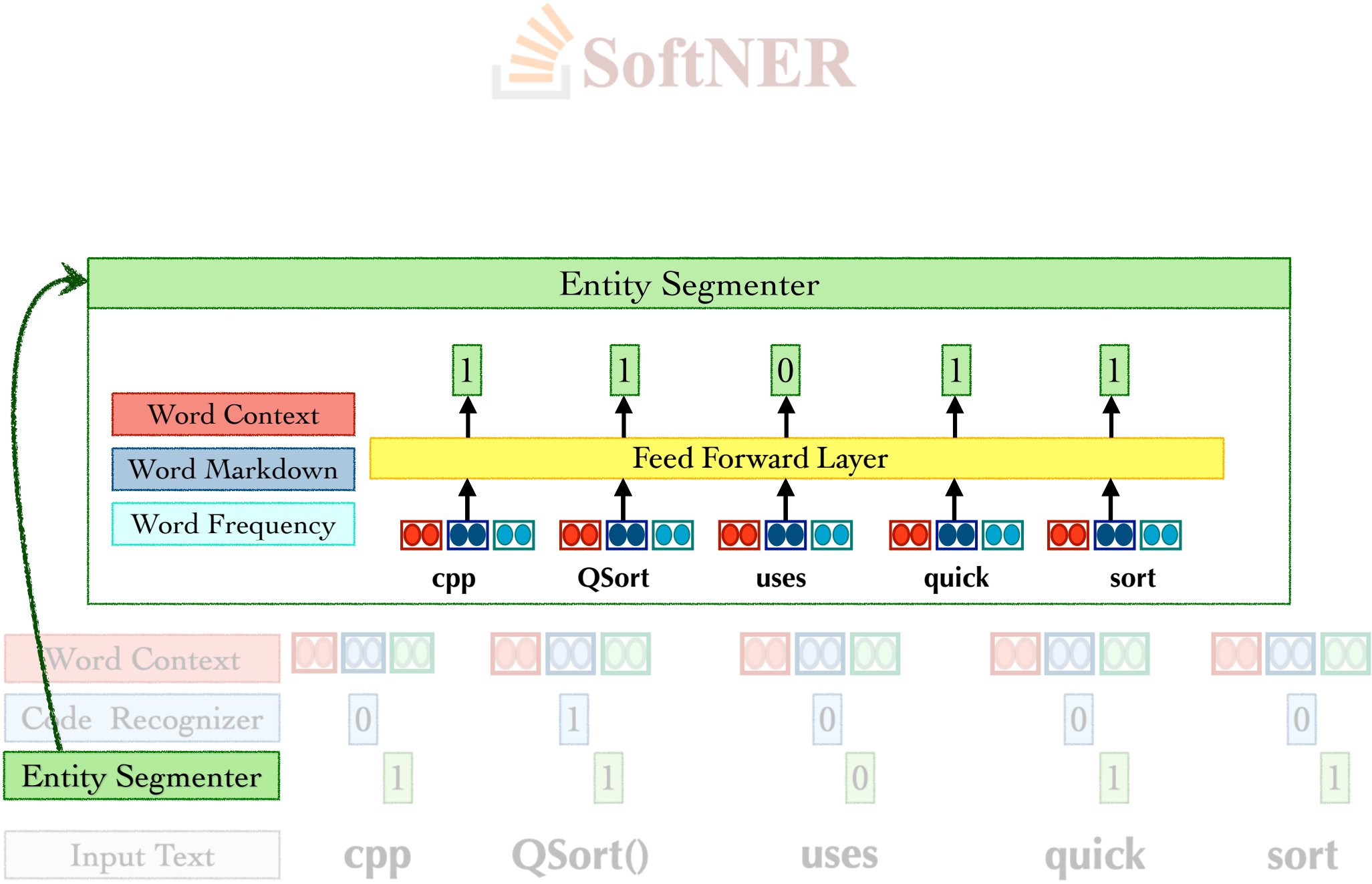
SoftNER
Entity Segmenter
Word Context
Word Markdown
Word Frequency
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QSort
uses
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sort
Word Context
Code Recognizer
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QSort()
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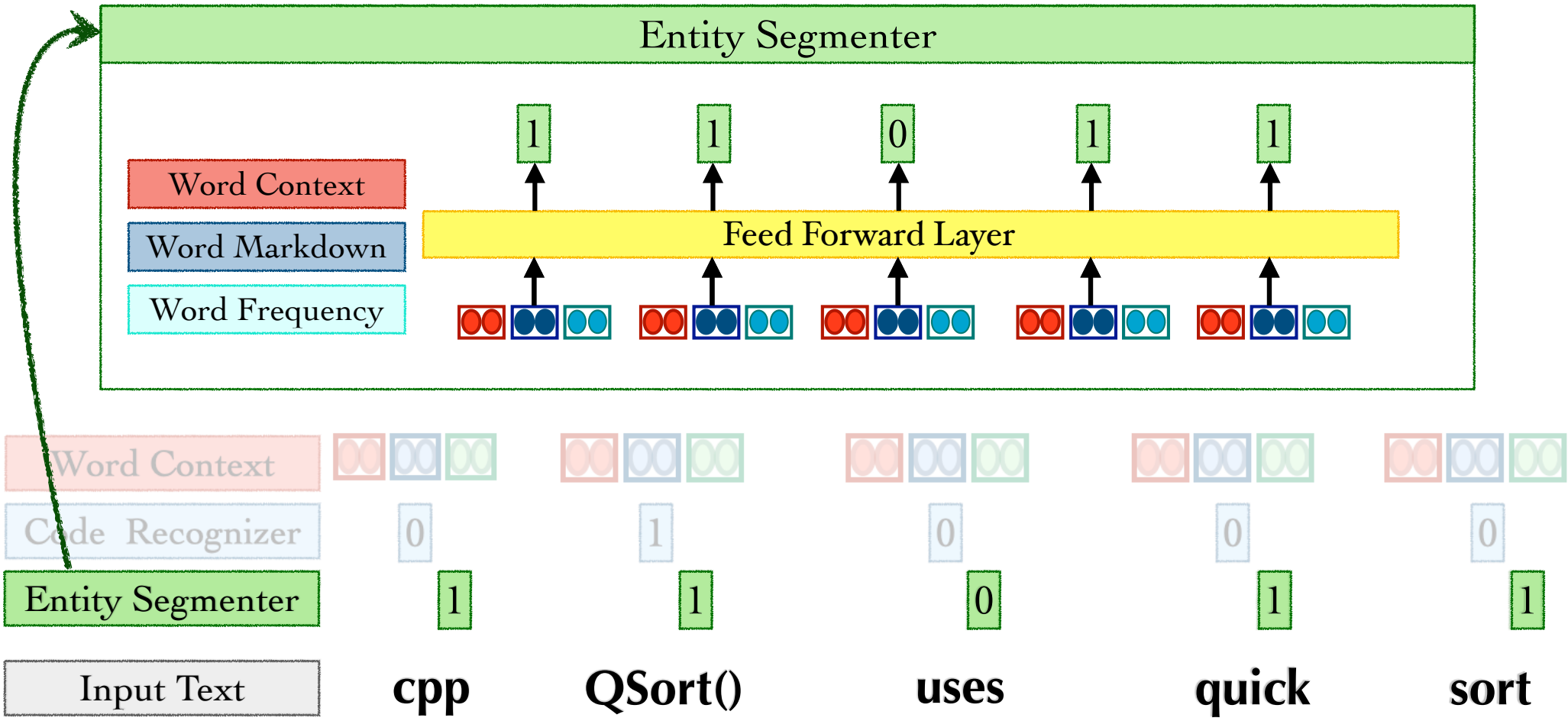
sort


Entity Segmenter
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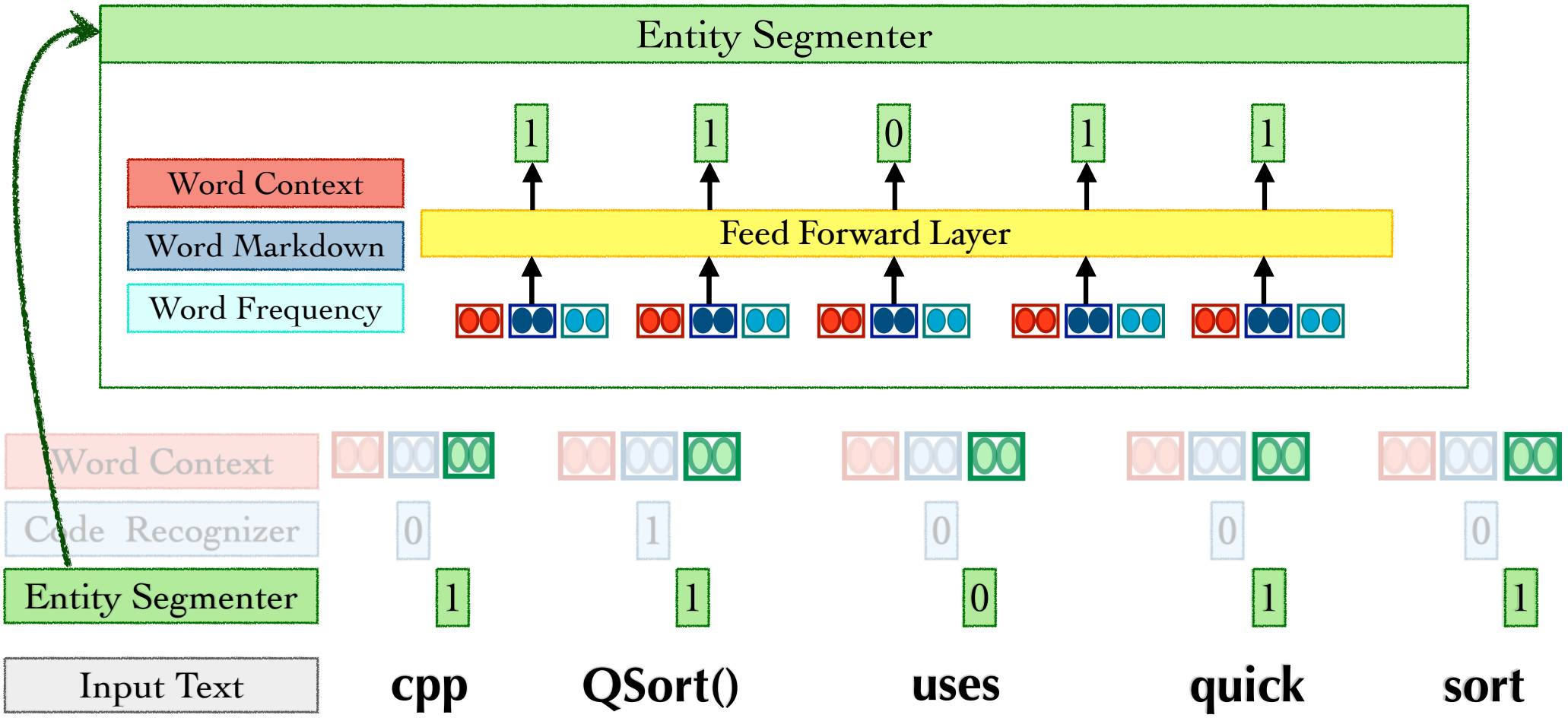
Entity Segmenter
Word Context
Word Markdown
Word Frequency
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Feed Forward Layer
Word Context
Code Recognizer
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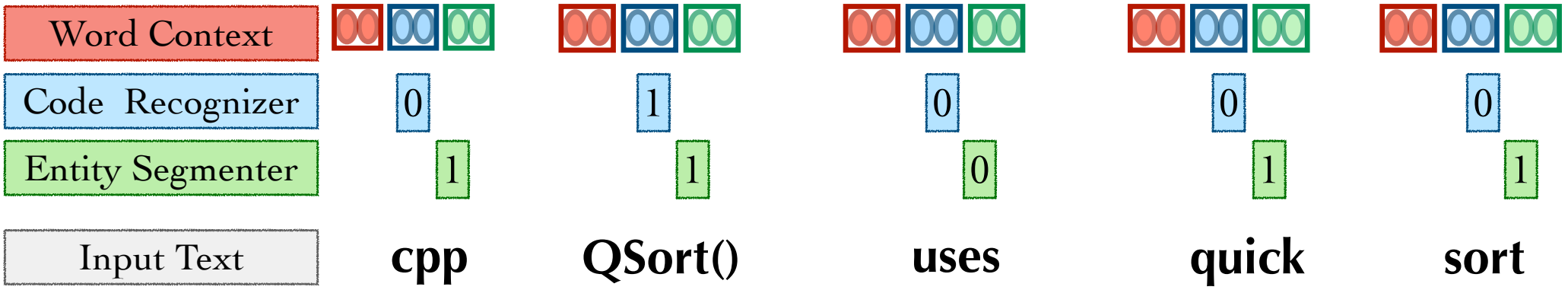
SoftNER


Word Context
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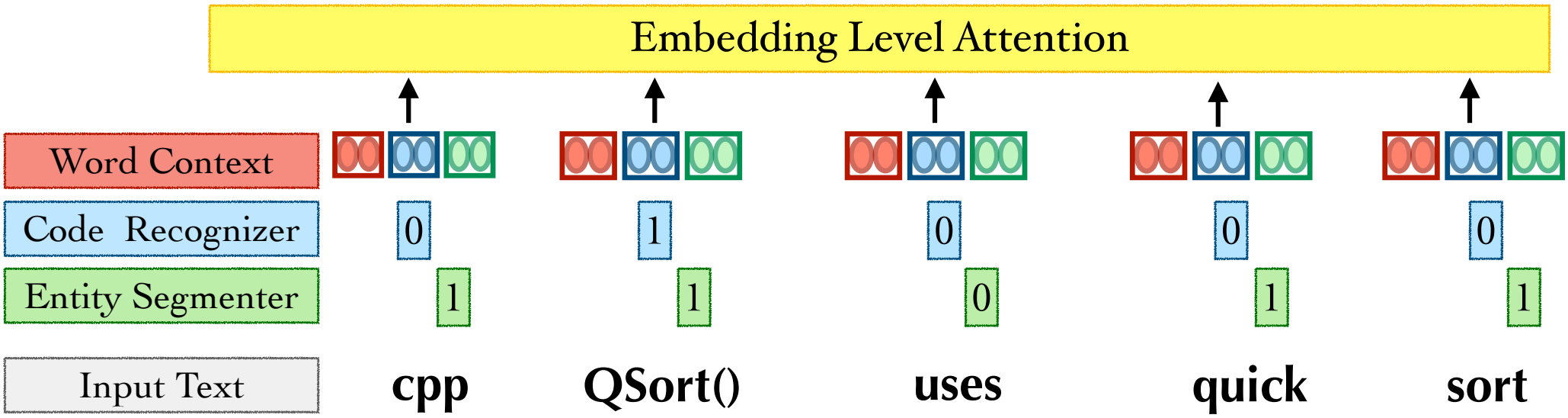
SoftNER


Embedding Level Attention
Word Context
Code Recognizer
Entity Segmenter
Input Text
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cpp
QSort()
uses
quick
sort

Embedding Level Attention

input embeddings

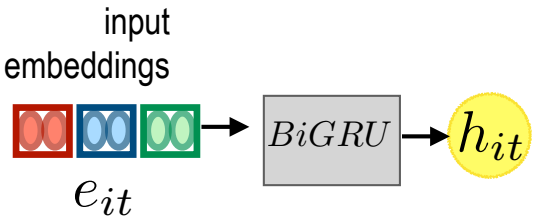
e_{it}

Entity Segmenter 1 1 0 1 1

Input Text cpp QSort() uses quick sort

SoftNER

Embedding Level Attention



Entity Segmenter

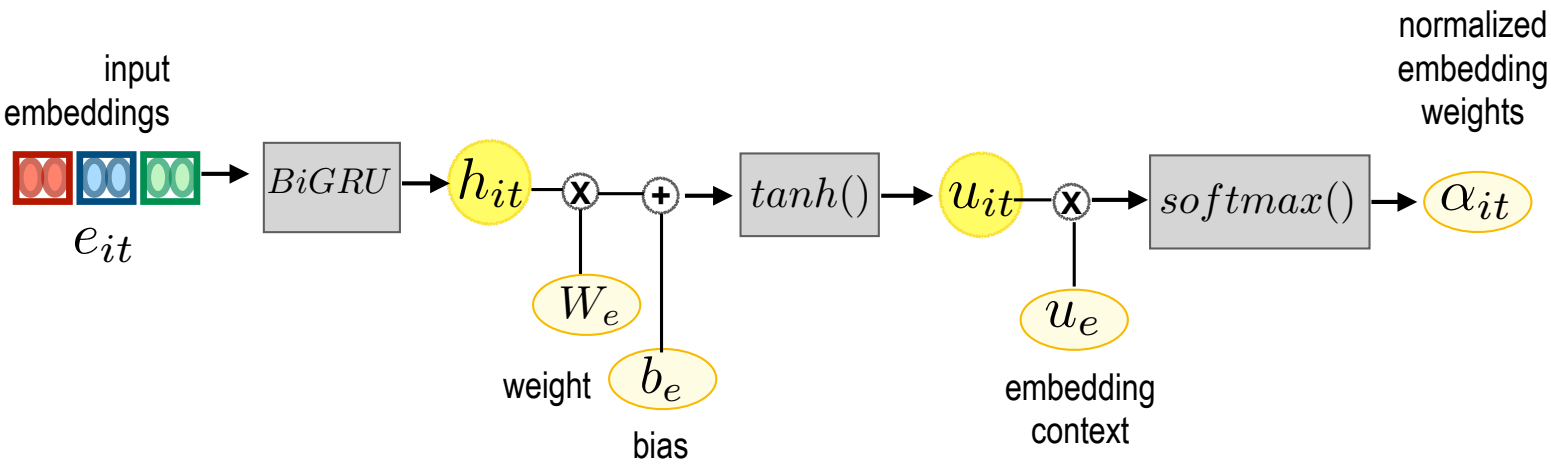
1 1 0 1 1

Input Text

cpp QSort() uses quick sort

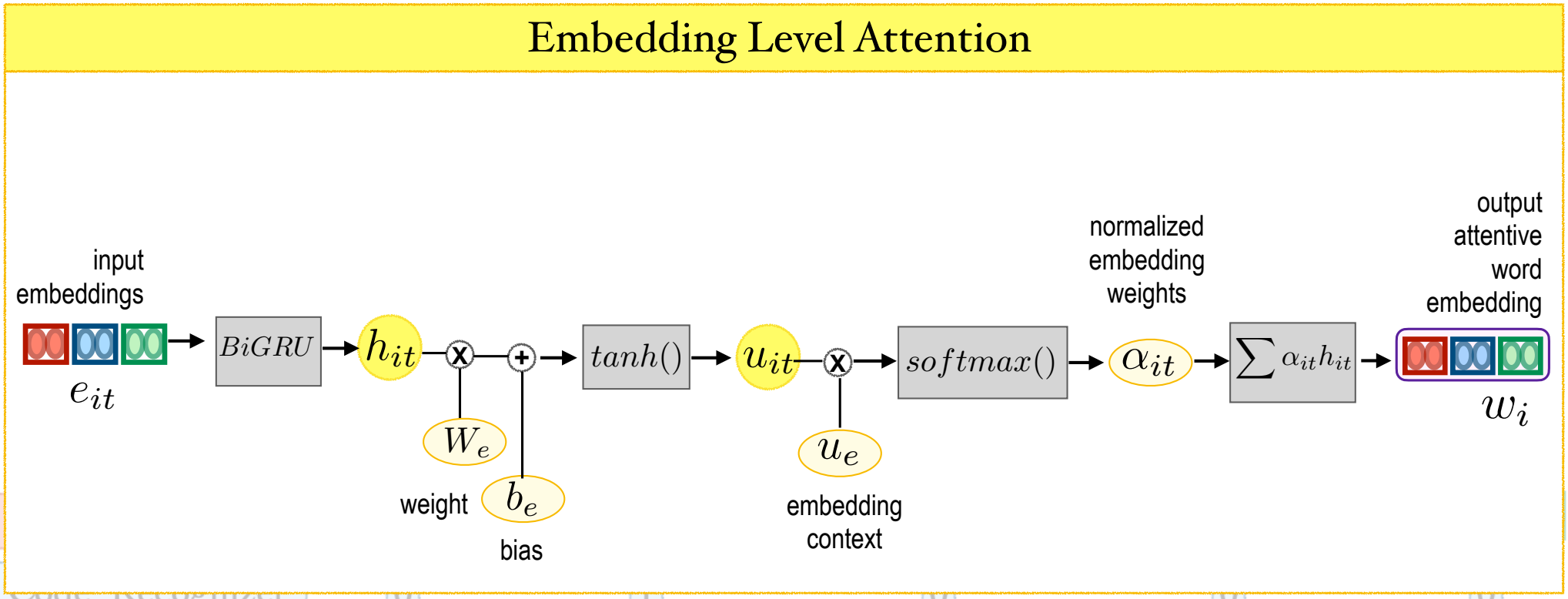
SoftNER

Embedding Level Attention

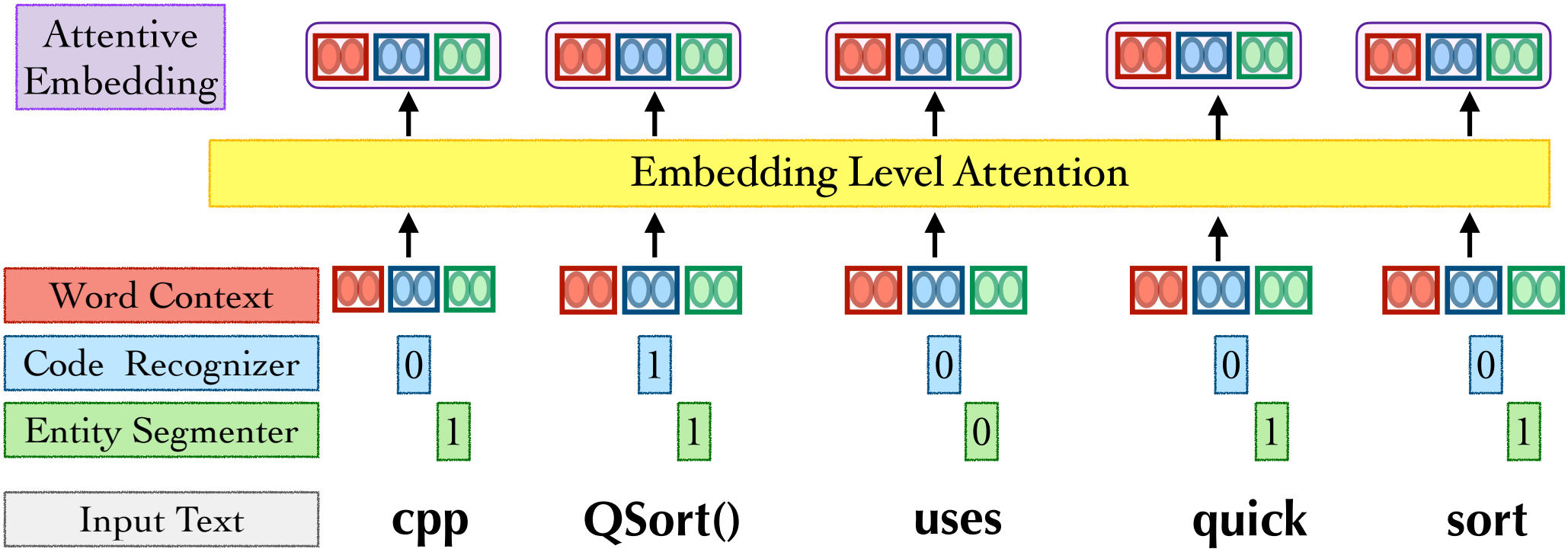


Entity Segmenter 1 1 0 1 1

Input Text cpp QSort() uses quick sort



SoftNER


Attentive Embedding
Embedding Level Attention
Word Context
Code Recognizer
Entity Segmenter
Input Text
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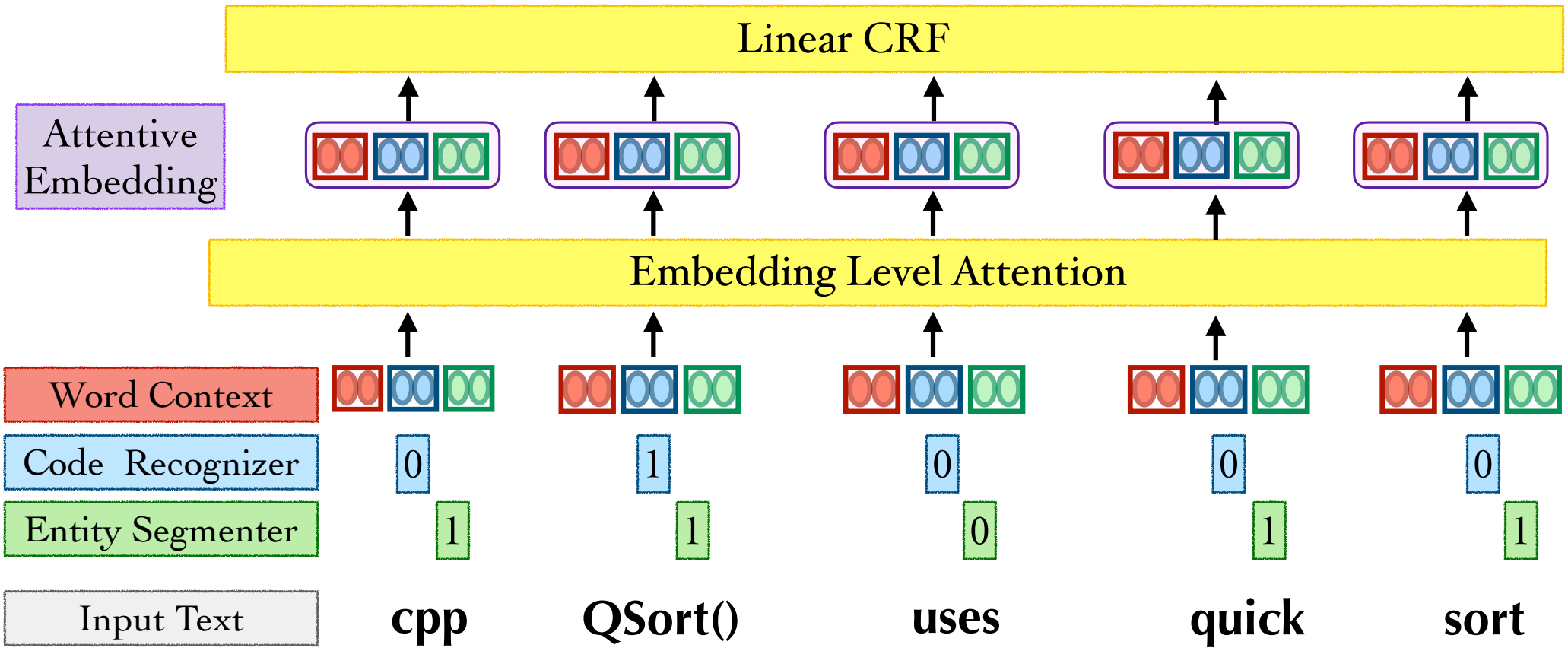
Linear CRF
Attentive Embedding
Embedding Level Attention
Word Context
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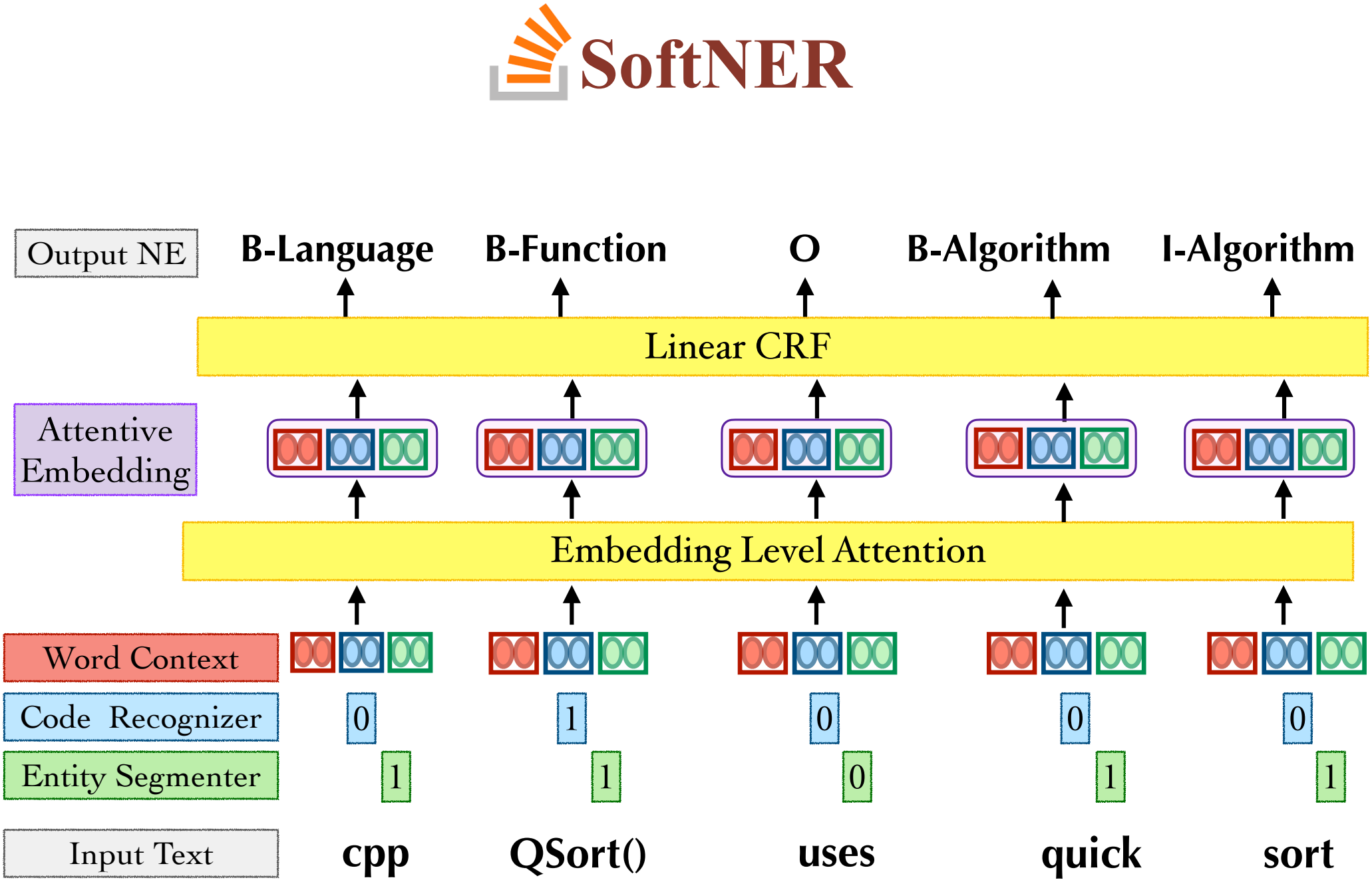
SoftNER
Output NE
B-Language
B-Function
O
B-Algorithm
I-Algorithm
Linear CRF
Attentive Embedding
Embedding Level Attention
Word Context
Code Recognizer
Entity Segmenter
Input Text
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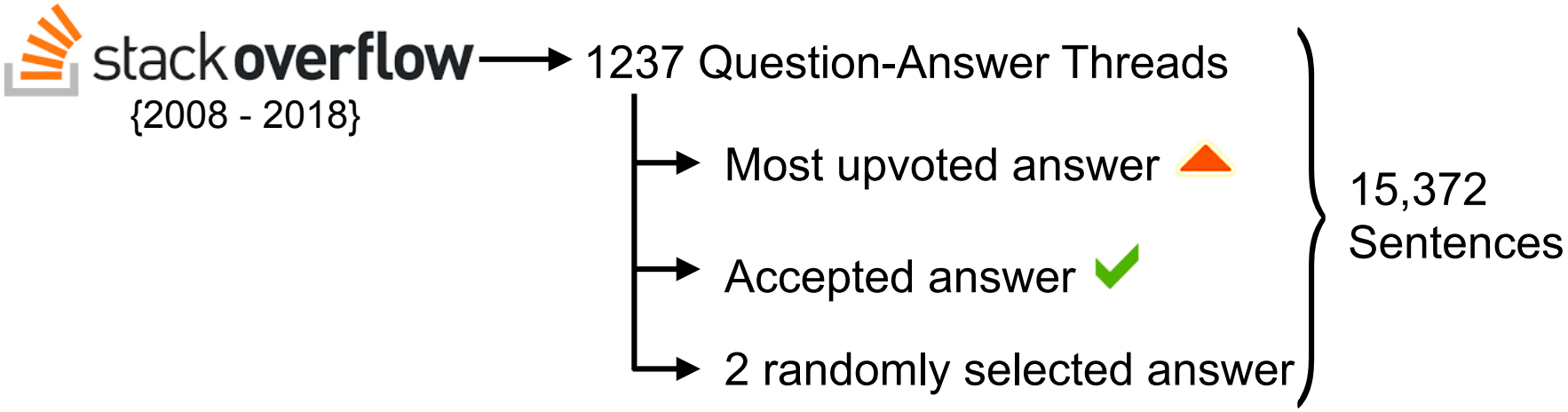
SoftNER

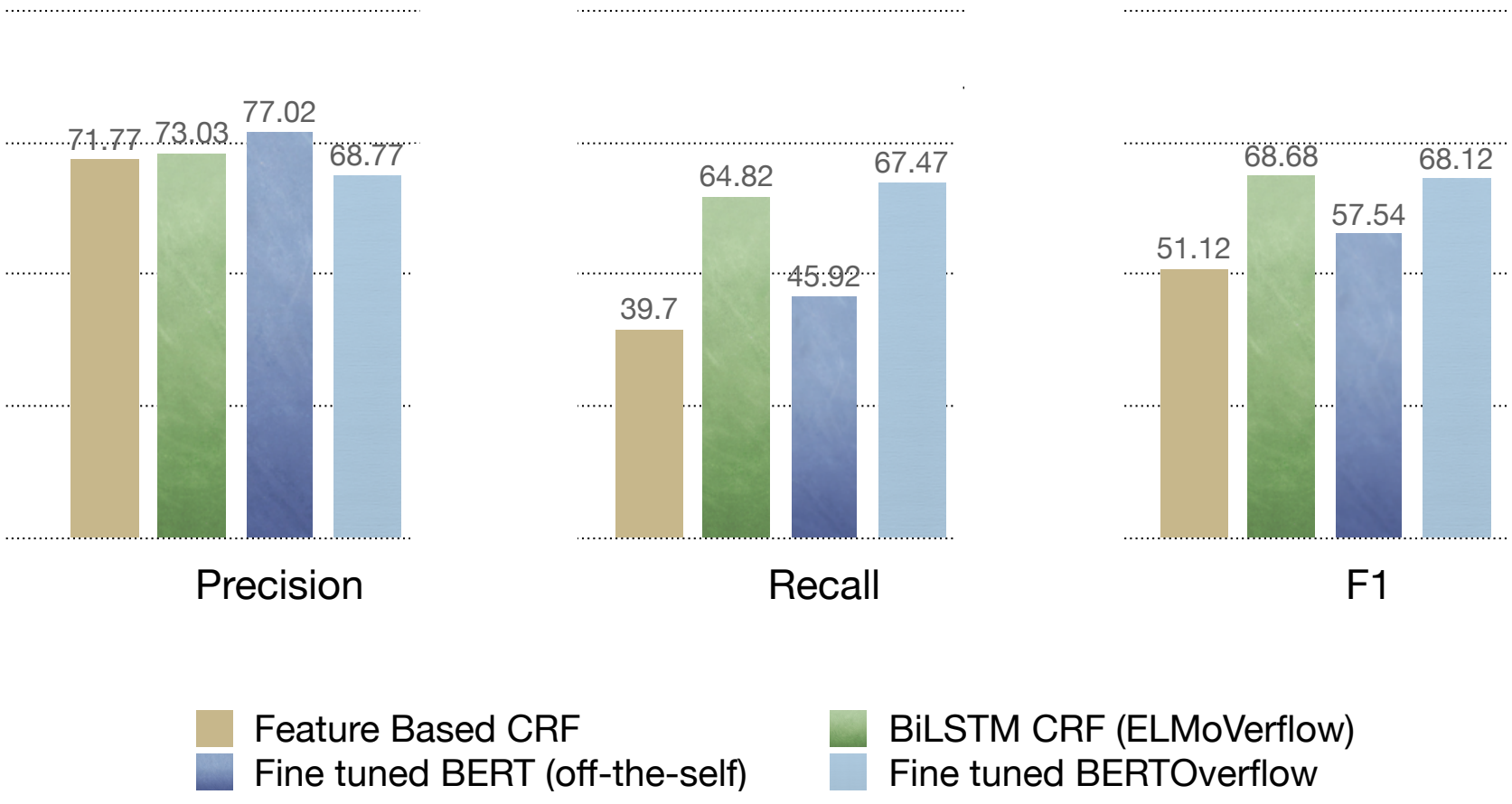
Annotated Corpus



Single annotated	**Double annotated**	
Train Set	Dev Set	Test Set
741 Question-Answers 9,315 Sentences	247 Question-Answers 2,942 Sentences	249 Question-Answers 3,115 Sentences

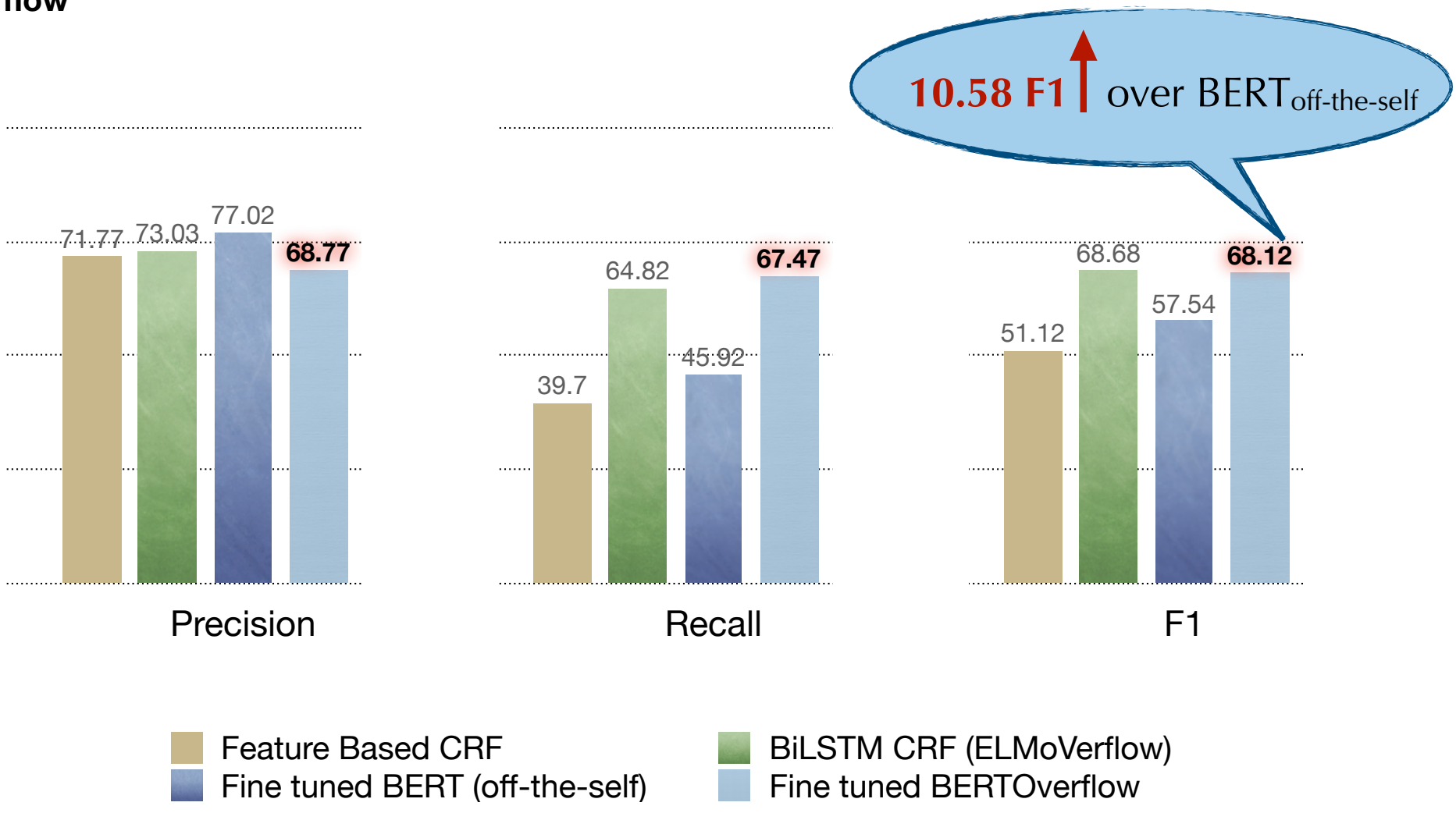
StackOverflow

Performance



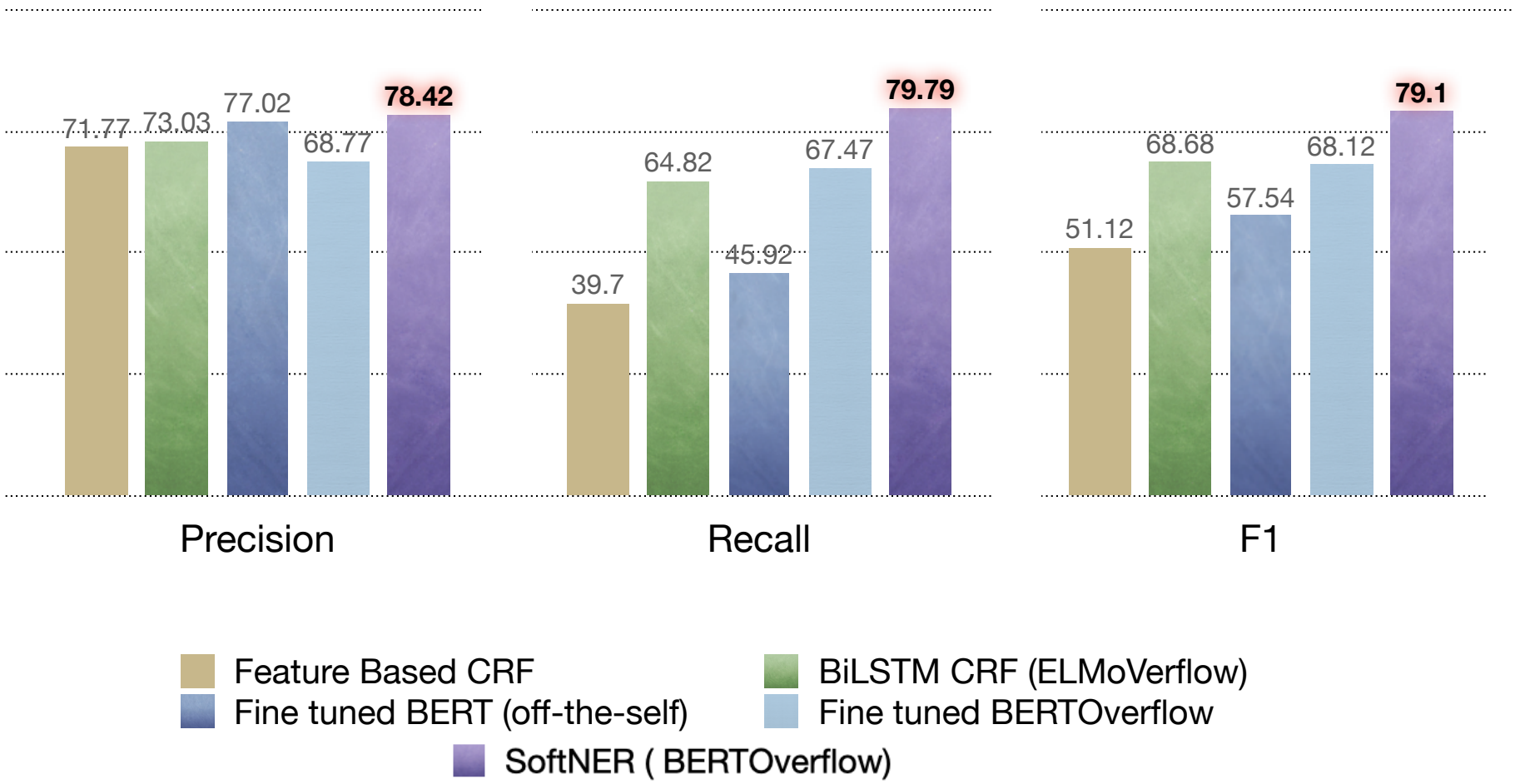
StackOverflow

Performance



StackOverflow

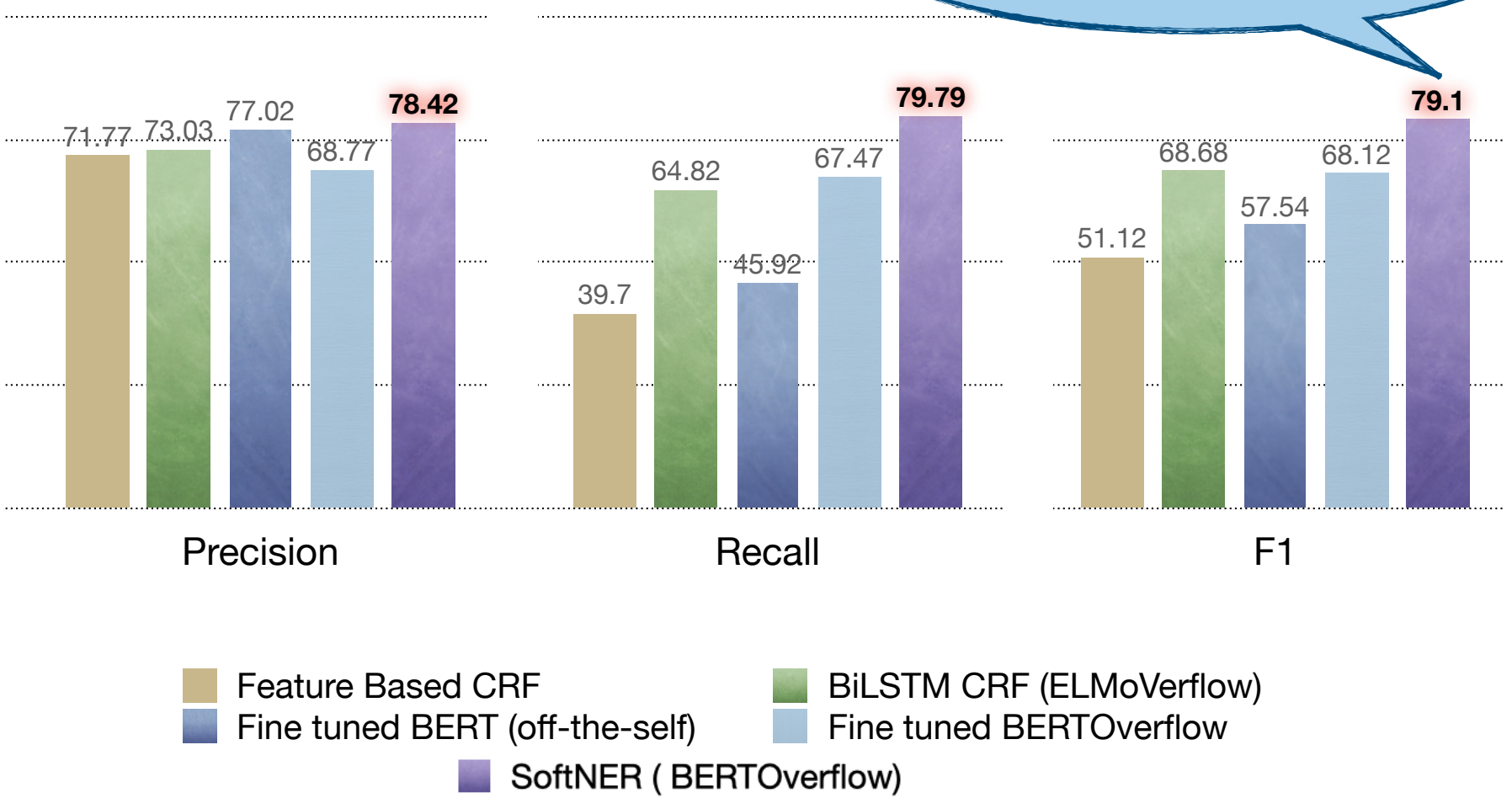
Performance



StackOverflow

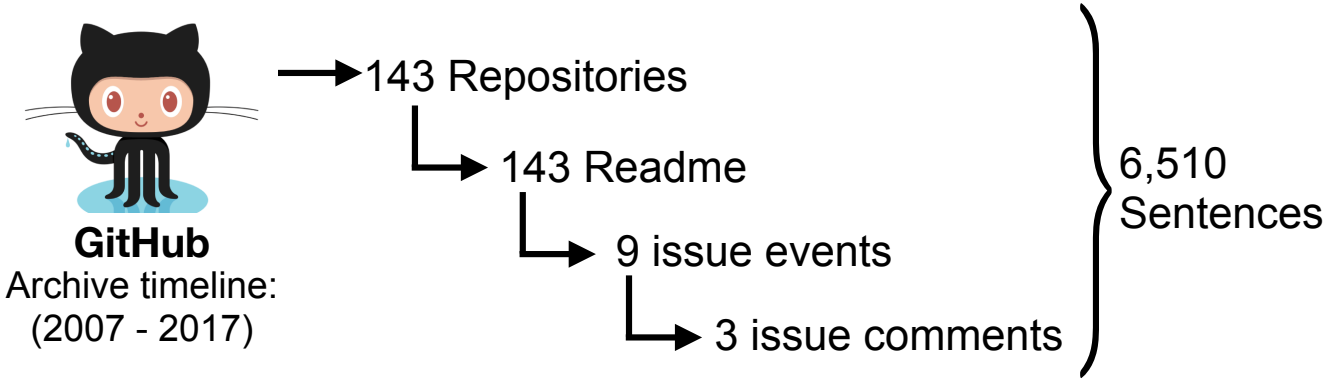
Performance

10.98 F1 over fine-tuned BERTOverflow

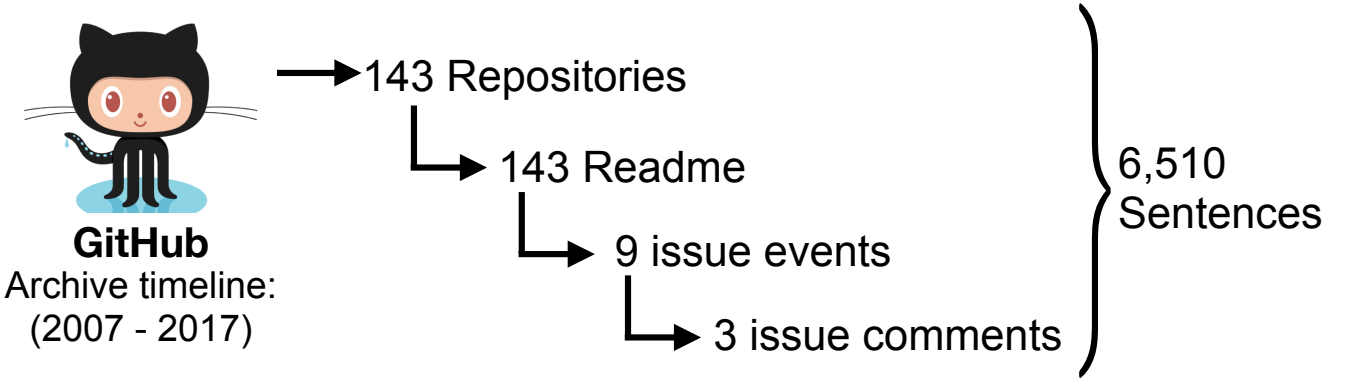


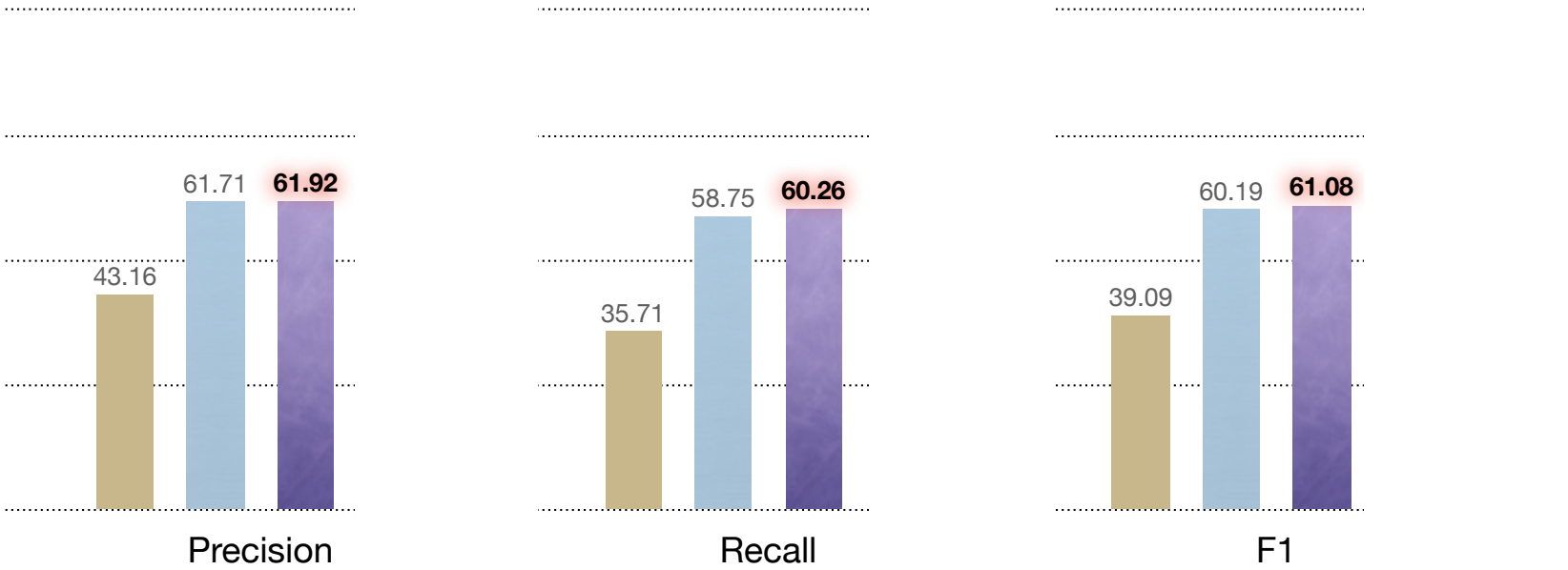
Does SoftNER work on **other social software domain** text?

Performance on GitHub Test Set



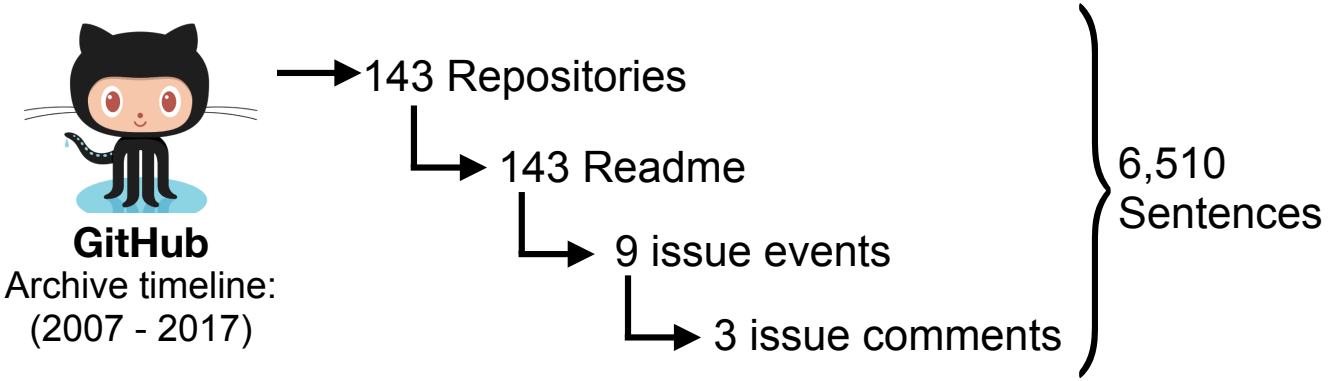
Performance on GitHub Test Set

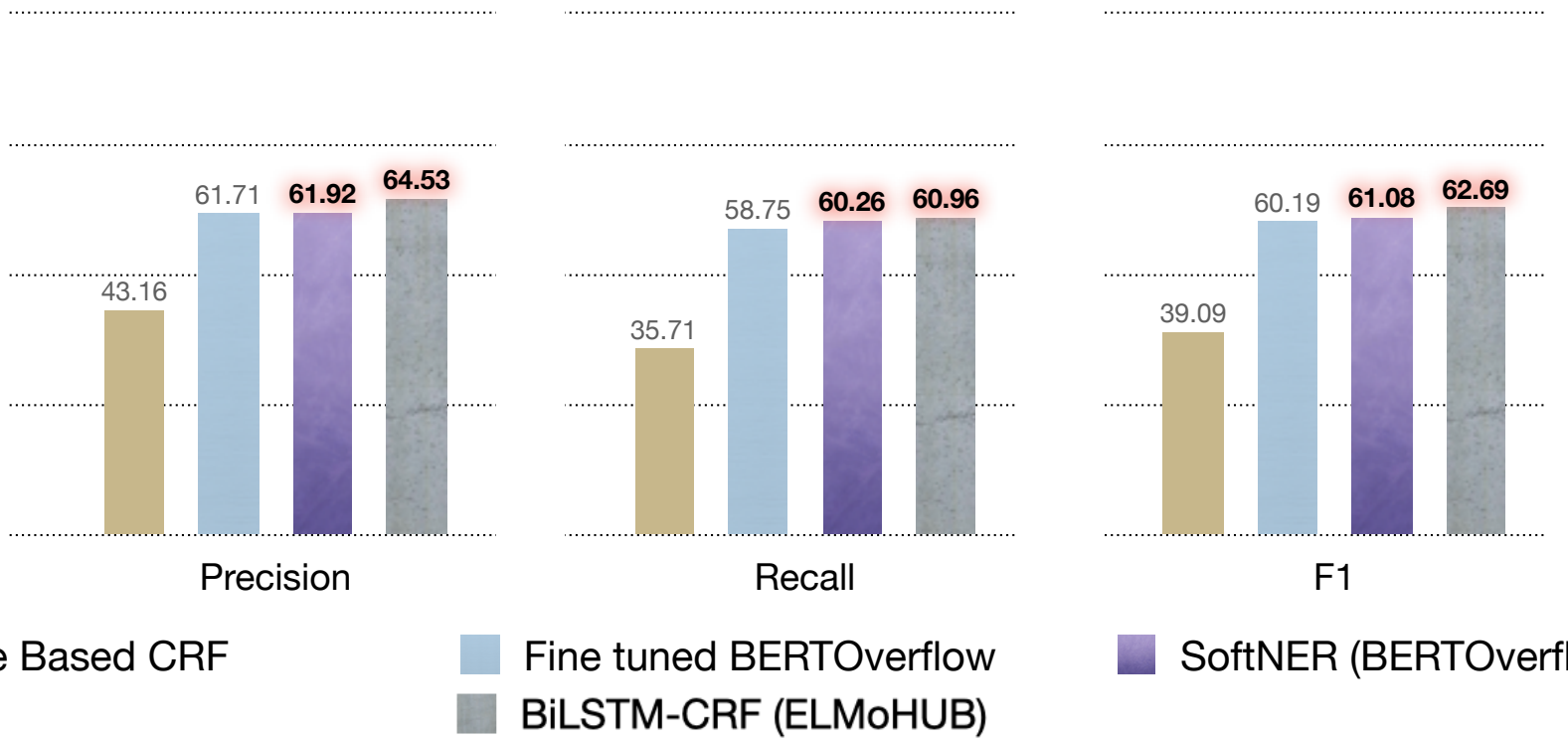




Trained on 9,315 manually annotated **StackOverflow** Sentences

Performance on GitHub Test Set





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Takeaway

Task: Fine-Grained Software Entity Extraction

- Covers **20 types** of fine-grained named entities
- Works on StackOverflow and Github Data

StackOveflow

code and data at: https://github.com/jeniyat/StackOverflowNER

GitHub

Takeaway

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New Data

- **15k** manually annotated sentences with fine grained software entities
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  - ❖ BERTOverflow, ELMoVerflow, GLoVerflow

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New Model

- Attentive NER tagger to combine the domain knowledge with contextual knowledge
  - **10.98 F1 increase** over fine tuned BERT
- Standalone code token recognizer

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Takeaway

7 July
5:00 PM UTC
8:00 PM UTC

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