Assessing the Efficiency of Suffix Stripping Approaches for Portuguese Stemming

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Problem

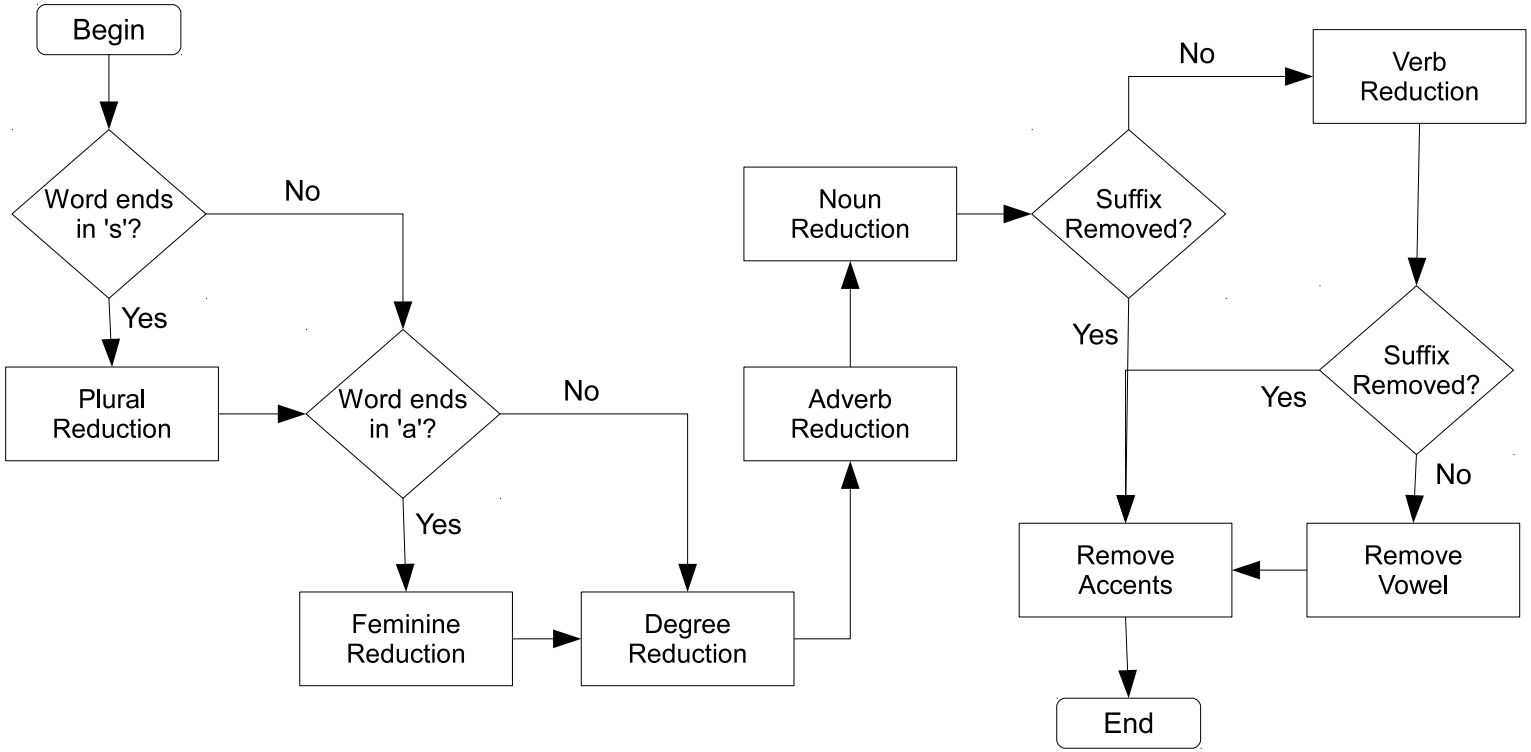
Perform Portuguese Stemming Efficiently

- State-of-the-Art Algorithm $\rightarrow$ RSLP
- RSLP $\rightarrow$ Suffix stripping by processing a list of rules
- Time complexity $\rightarrow O(WR)$
  - $W \rightarrow$ Number of characters to compare (all characters of the word in the worst case)
  - $R \rightarrow$ Number of suffix rules to process
- Objective $\rightarrow$ Improve processing time by reducing R

Stemming Strategies

1. Table Lookup → Lookup of a word in a table to retrieve the stem. Simple, but strongly dependent on the language vocabulary
2. N-grams → Word clustering procedure to identify bigrams and trigrams in text
3. Successor Variaty → Morpheme boundaries recognition within the language organization to produce the stem
4. Affix Removal → Word affixes removal or replacement, following well defined affix rules for a language

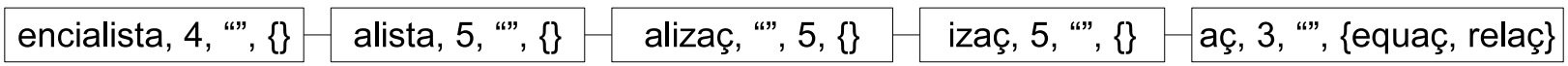
Suffix Stripping Strategy



The List-Based Approach (LBA)

For each step (type of reduction), process a single list of suffix rules to iteratively reduce the word or not

$$Rule(suffix, remainingsize, replacement, exceptions)$$

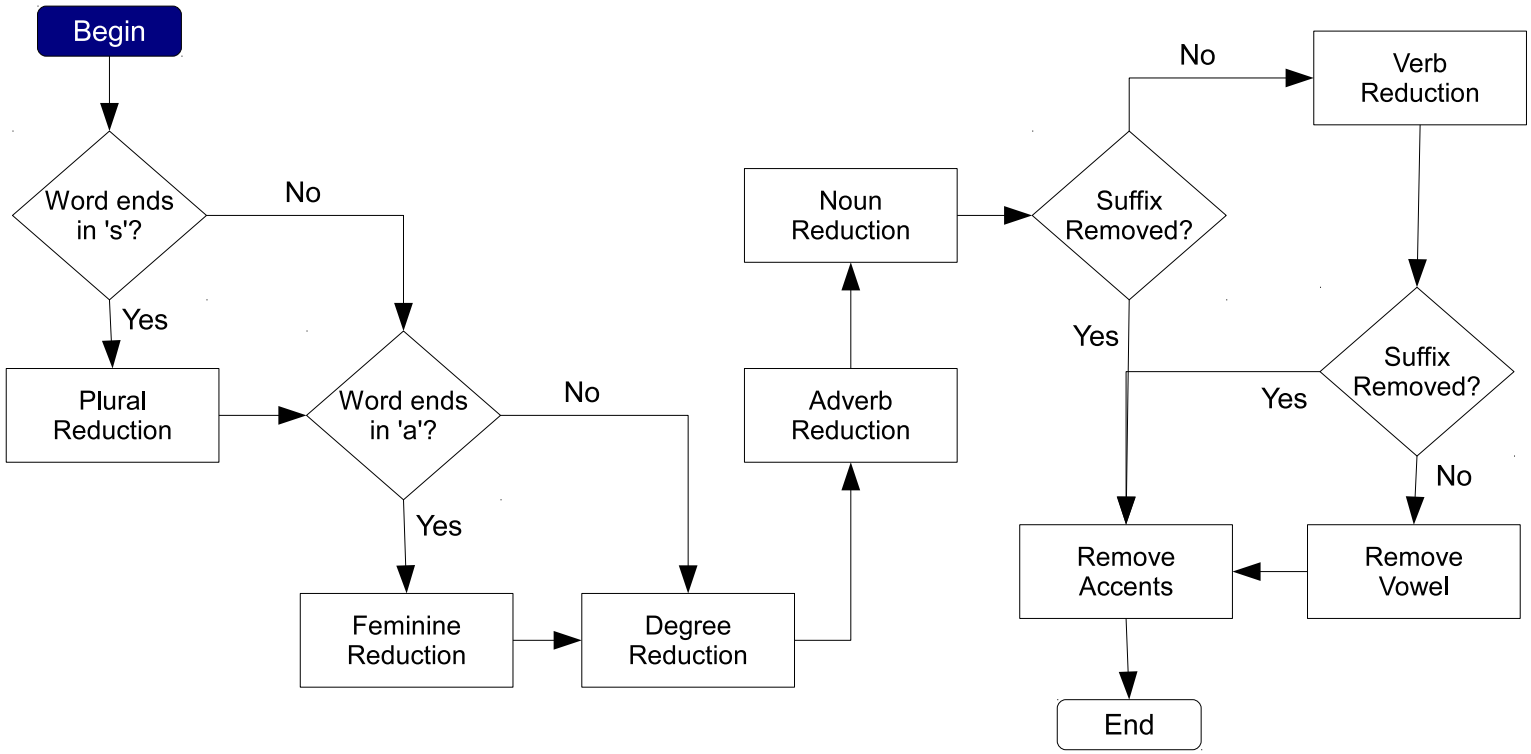


- Worst case → All suffix rules are processed in each step

Plural	Feminine	Degree	Adverb	Noun	Verb
11	15	18	1	61	89

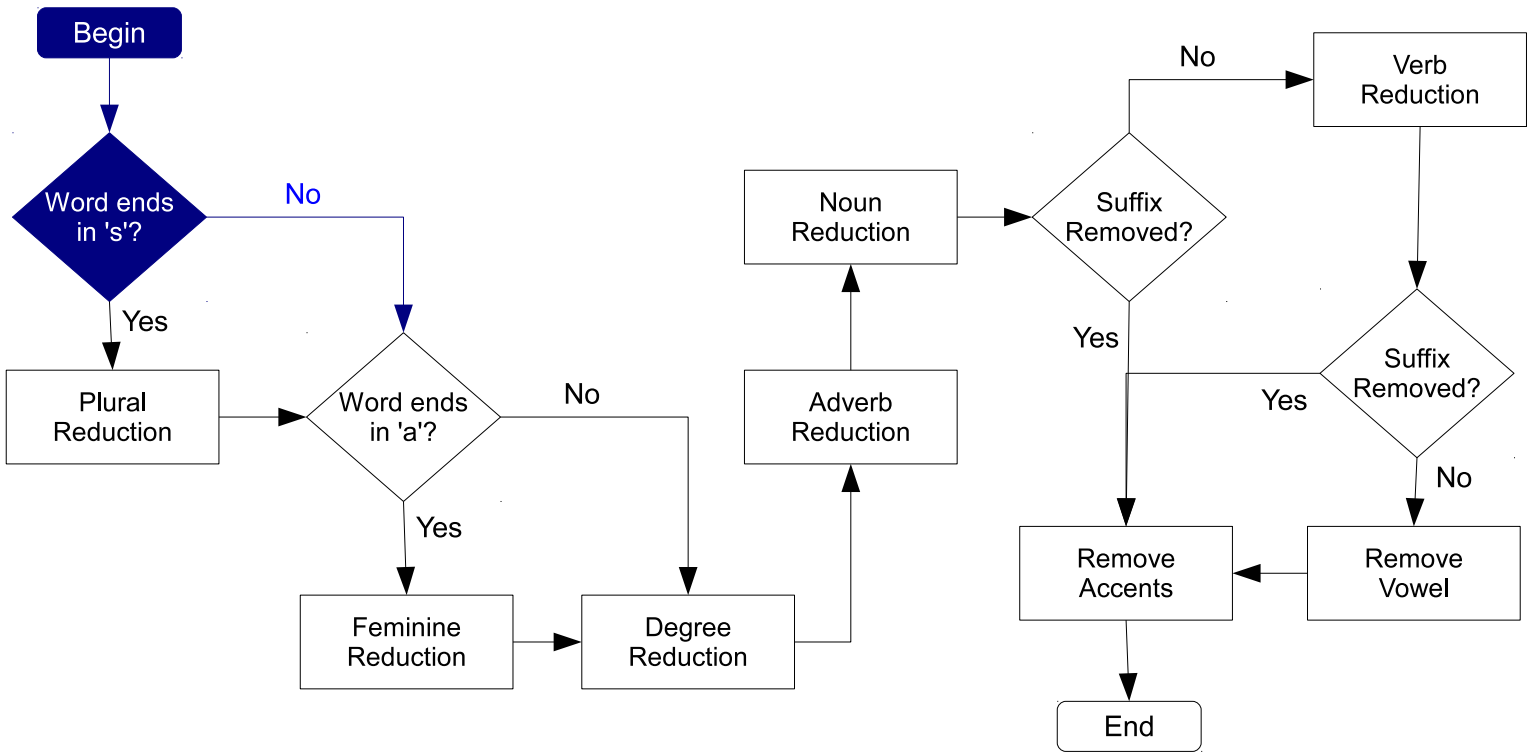
LBA Example

- subutilização (underutilization)



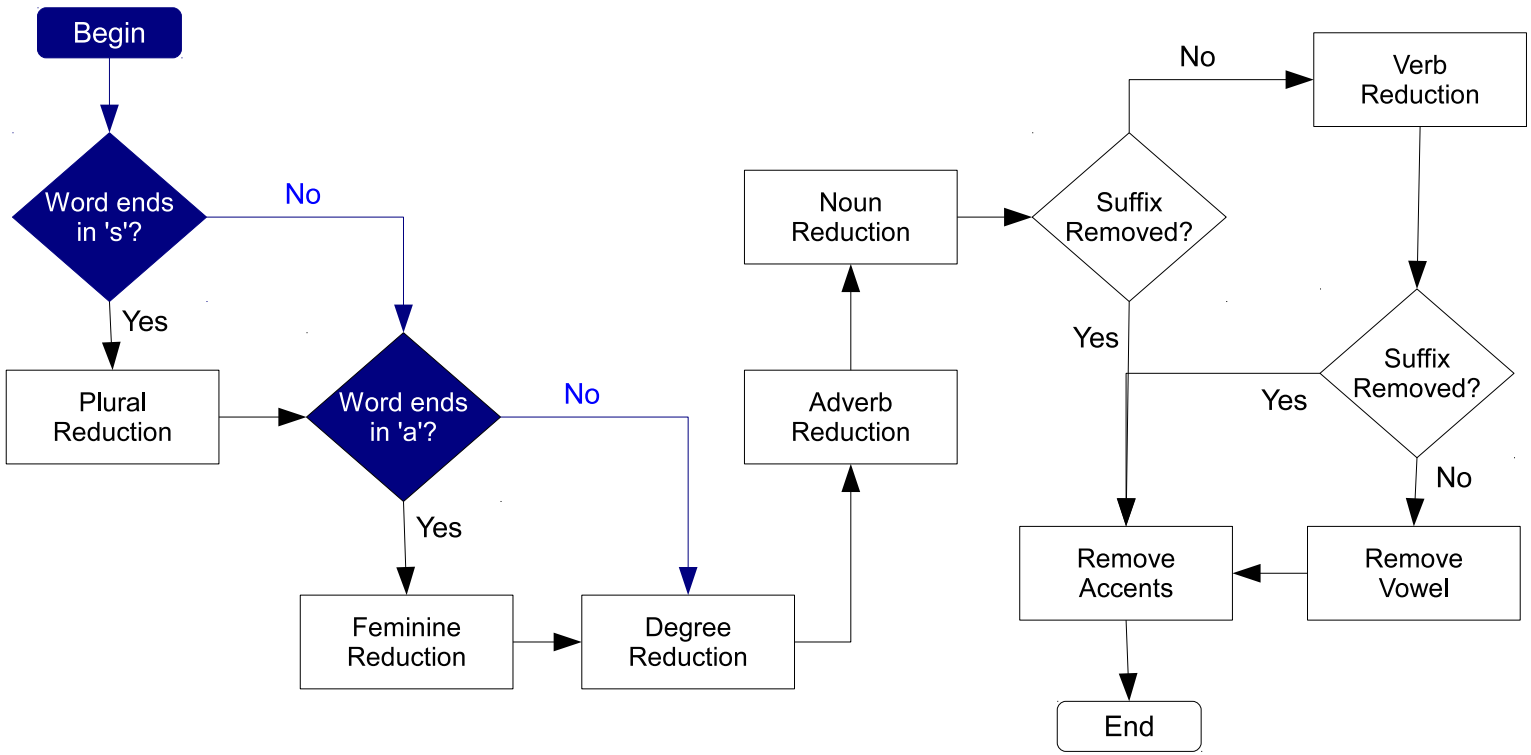
LBA Example

- subutilizaçã**o**



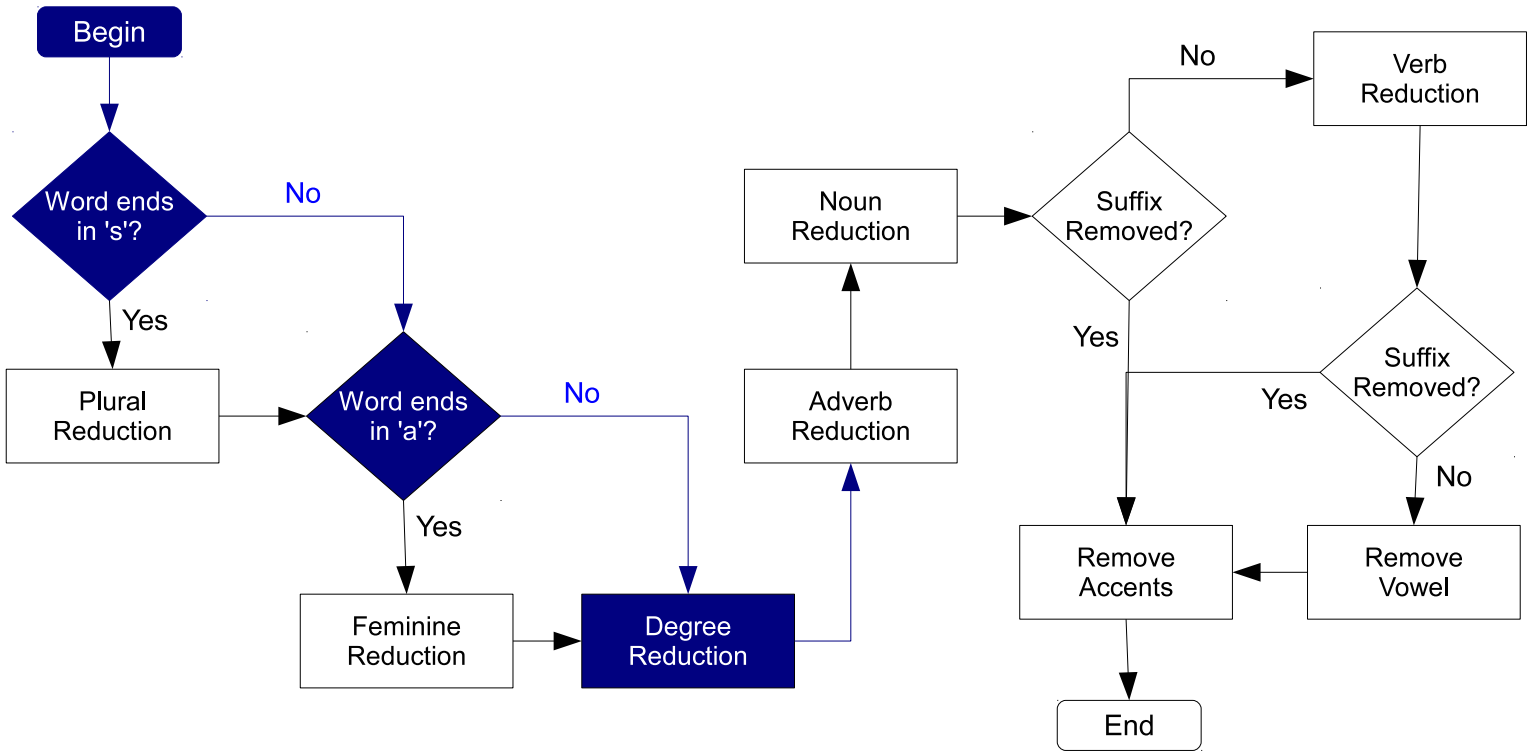
LBA Example

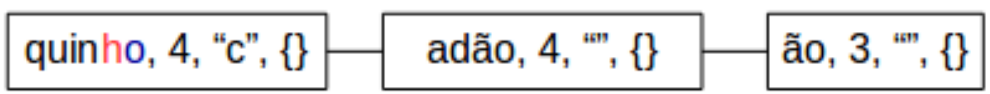
- subutilizaçã**o**



LBA Example

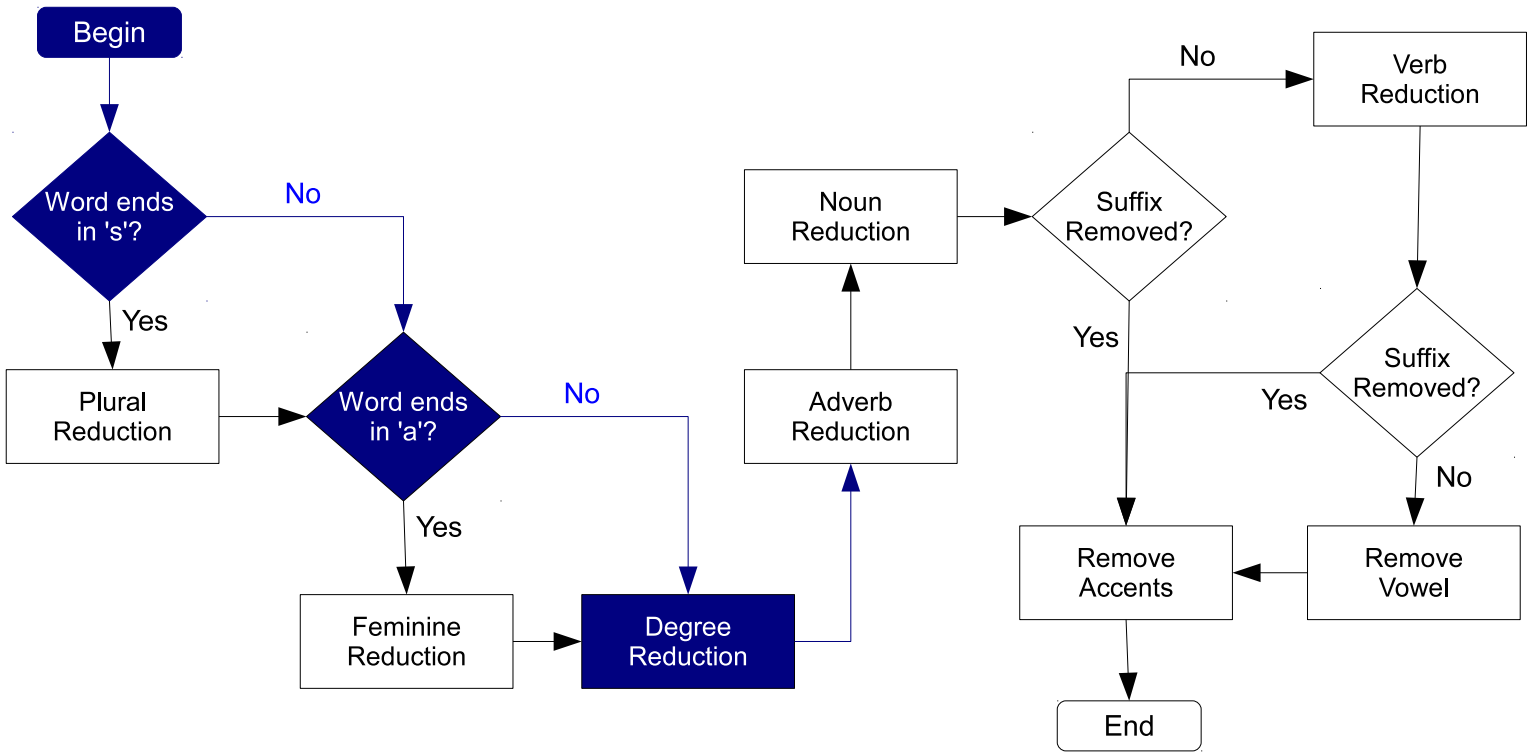
- subutilização

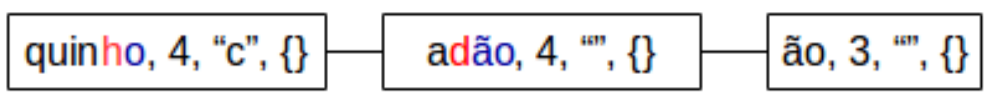




LBA Example

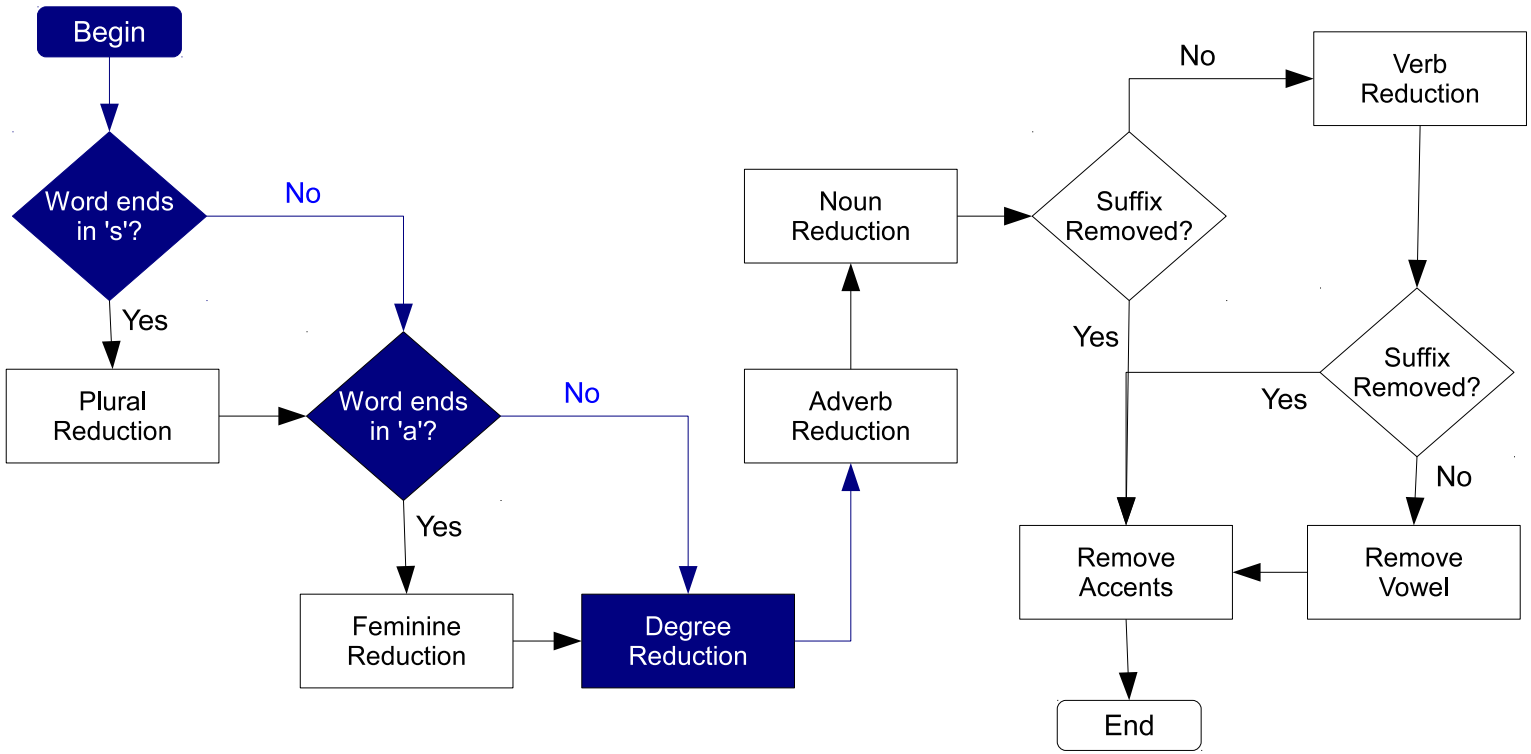
- subutilização

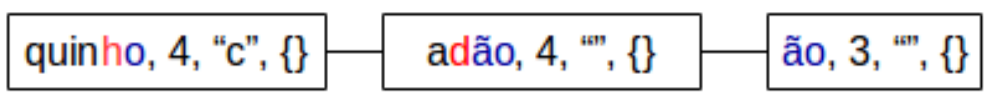




LBA Example

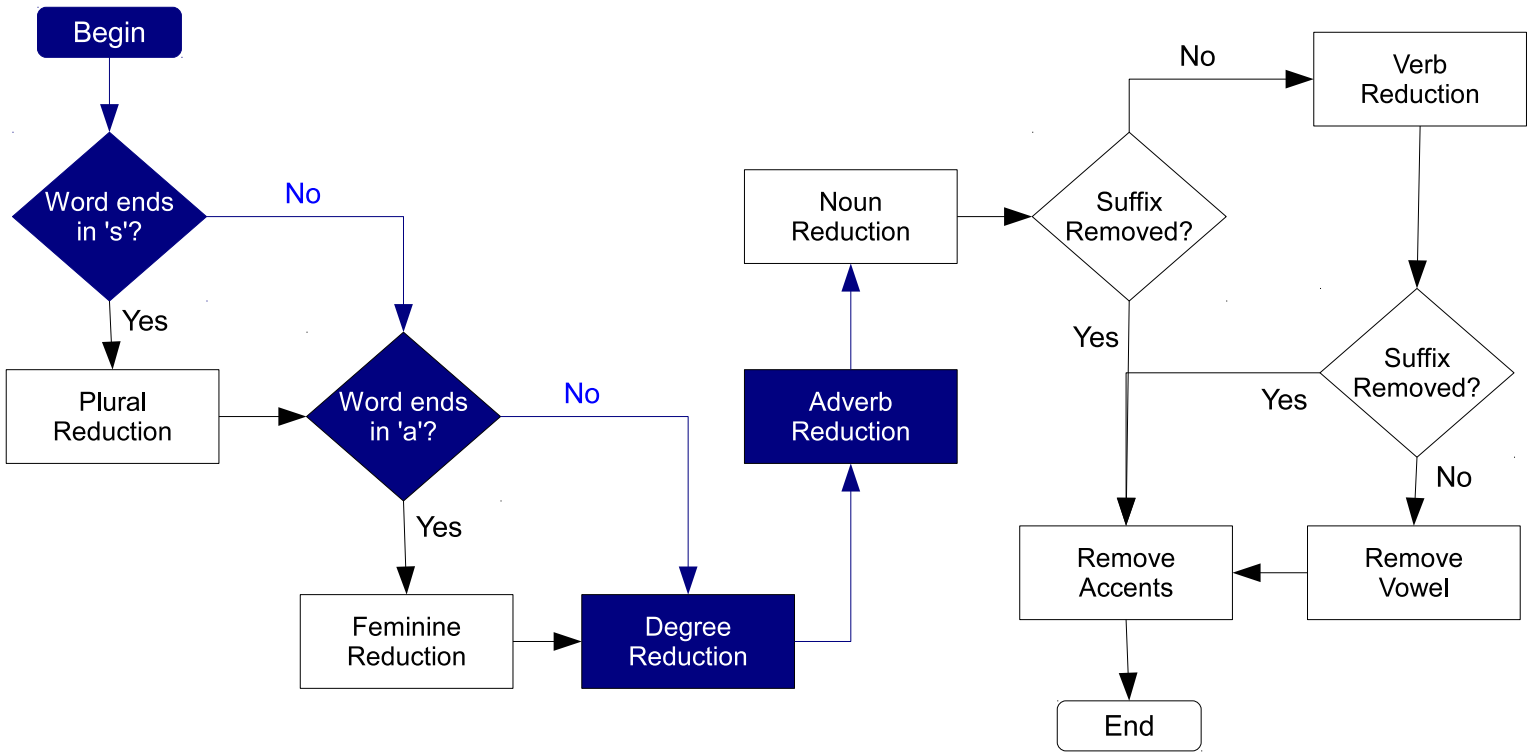
- subutilização → subutilizaç





LBA Example

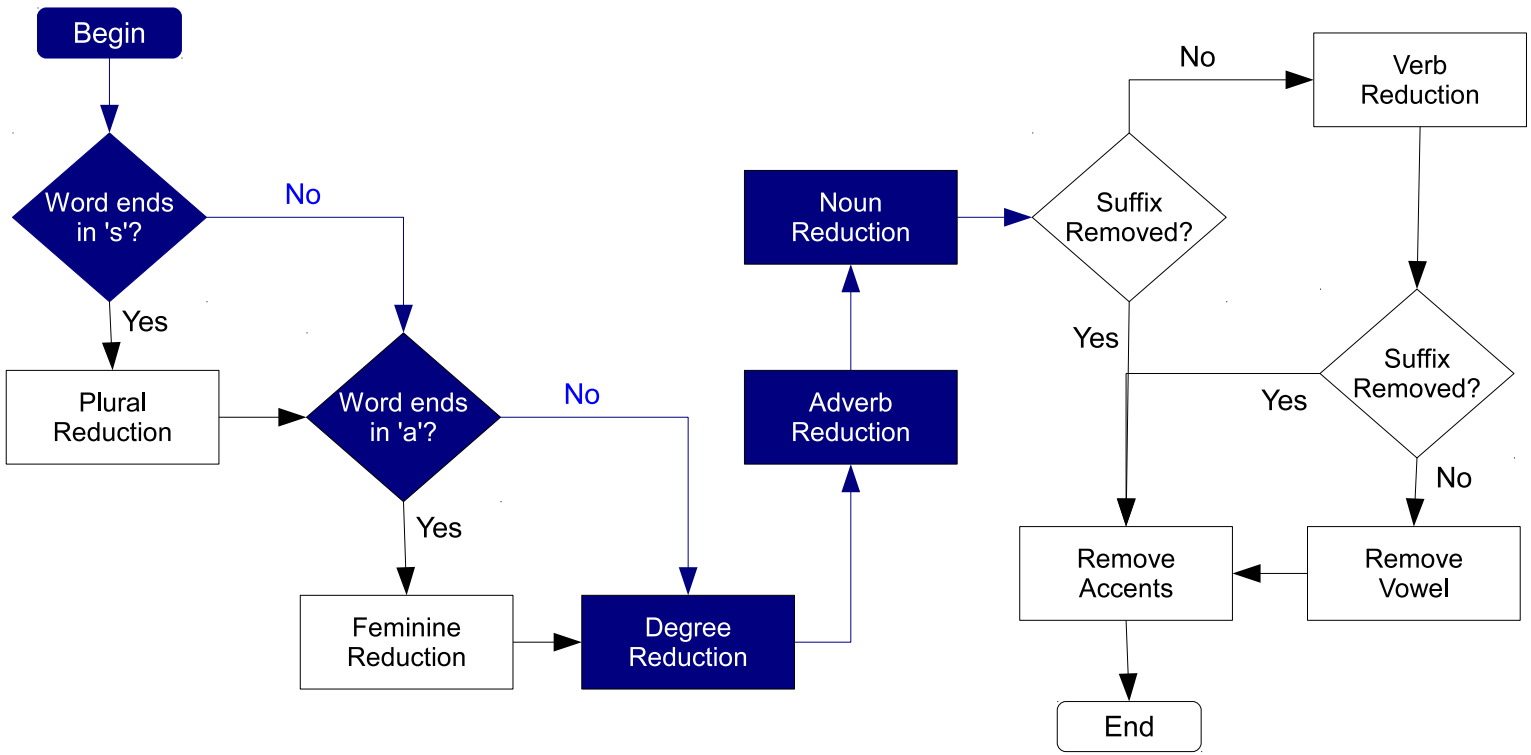
- subutilizaç



mente, 4, "", {}

LBA Example

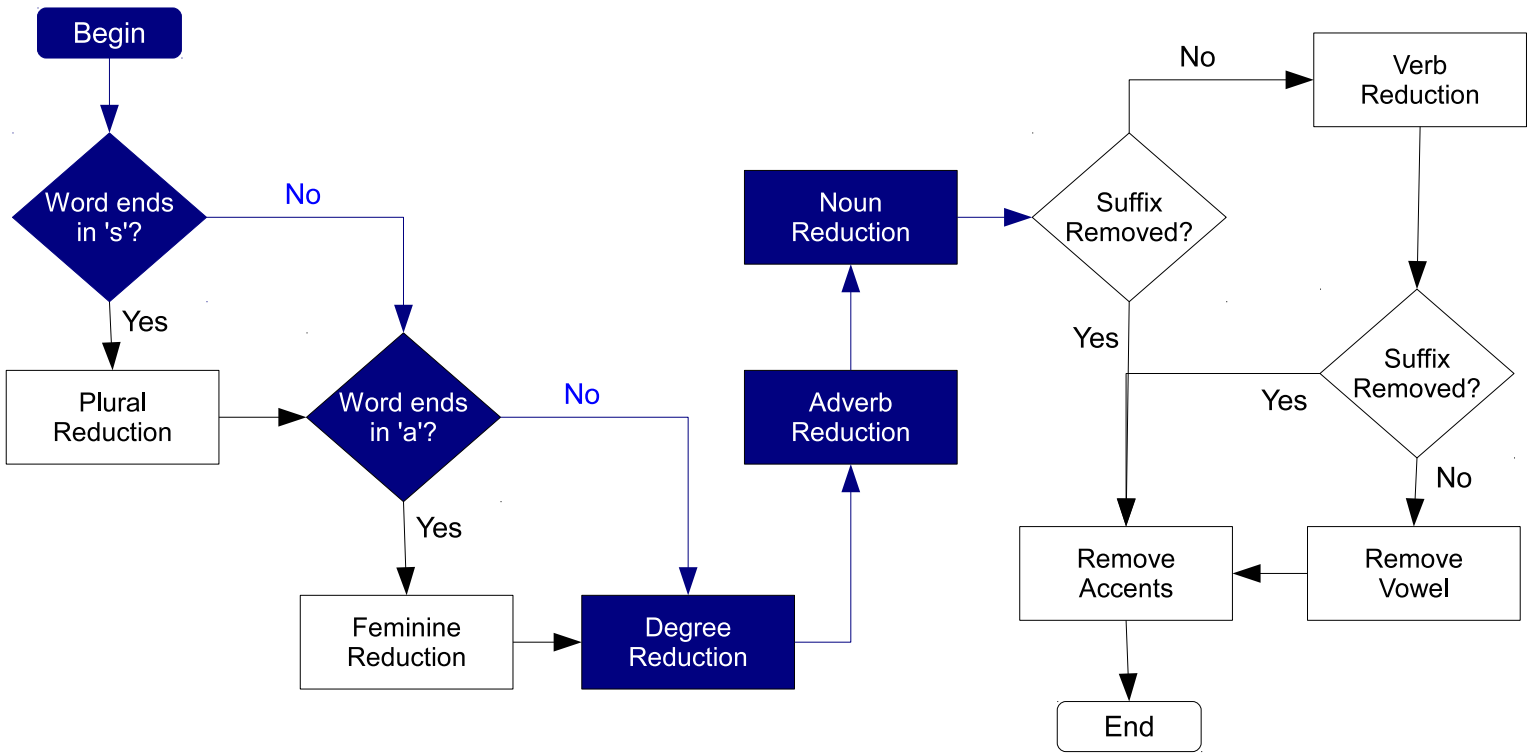
- subutilizaç



encialista, 4, “”, {} — alista, 5, “”, {} — alizaç, “”, 5, {} — izaç, 5, “”, {} — aç, 3, “”, {equaç, relaç}

LBA Example

- subutilizaç



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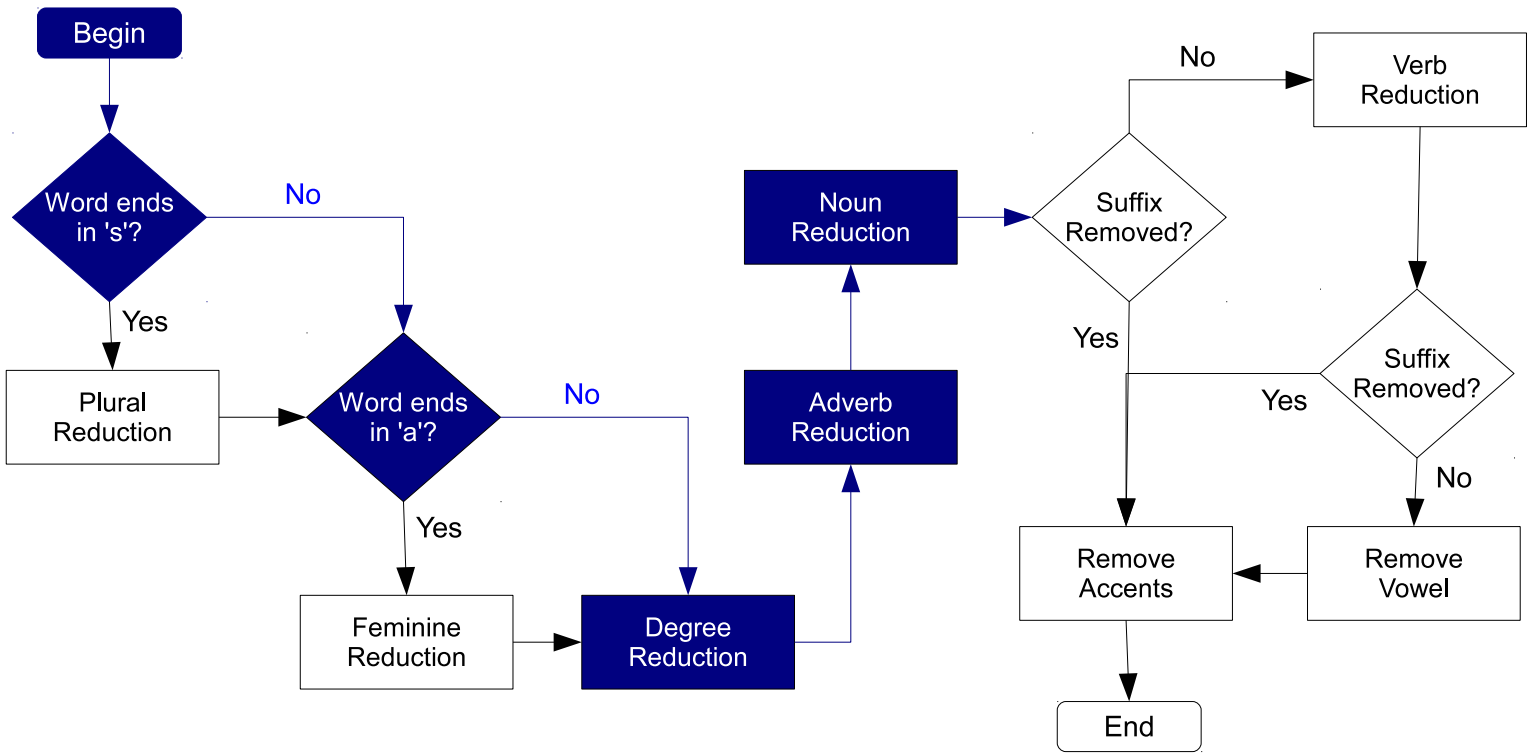
LBA Example

- subutilizaç



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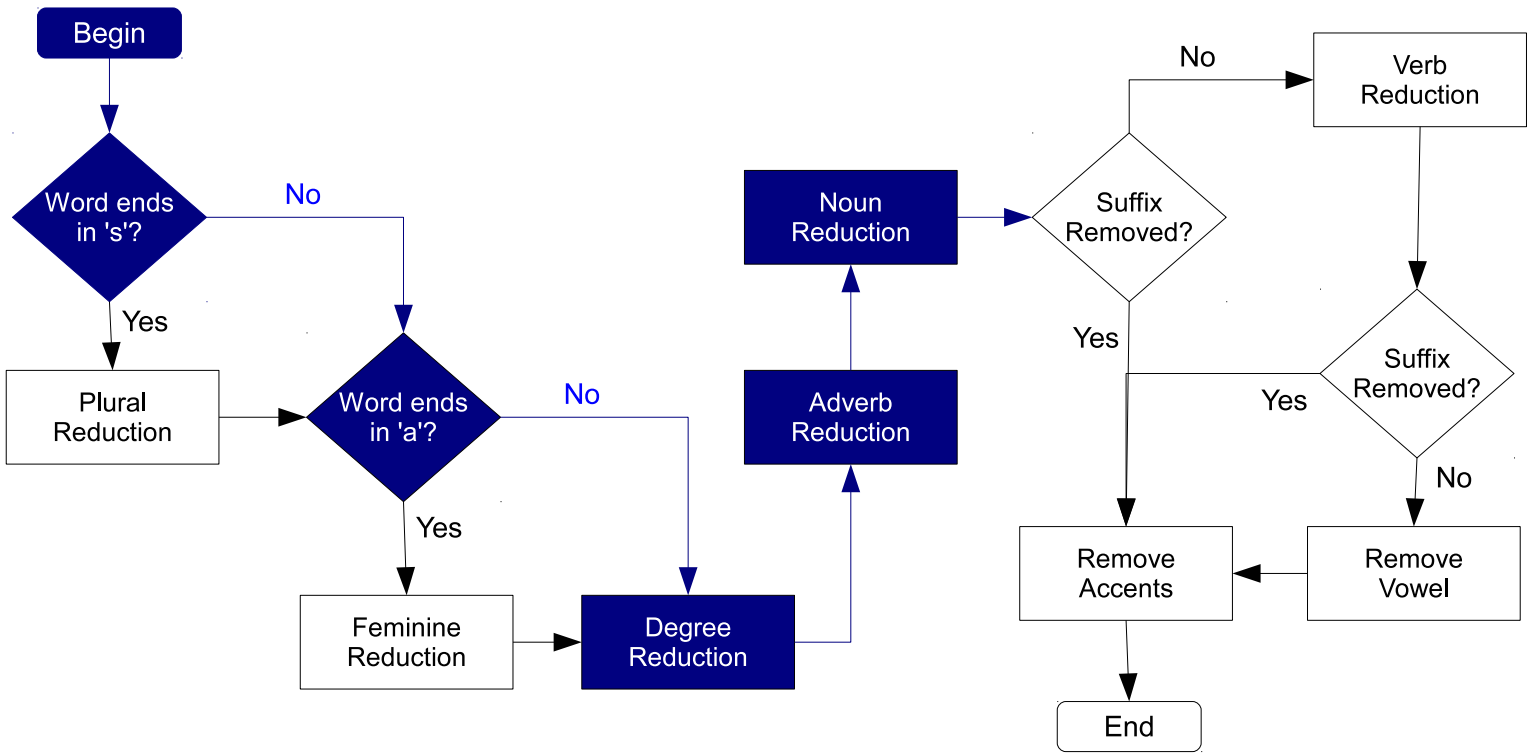
LBA Example

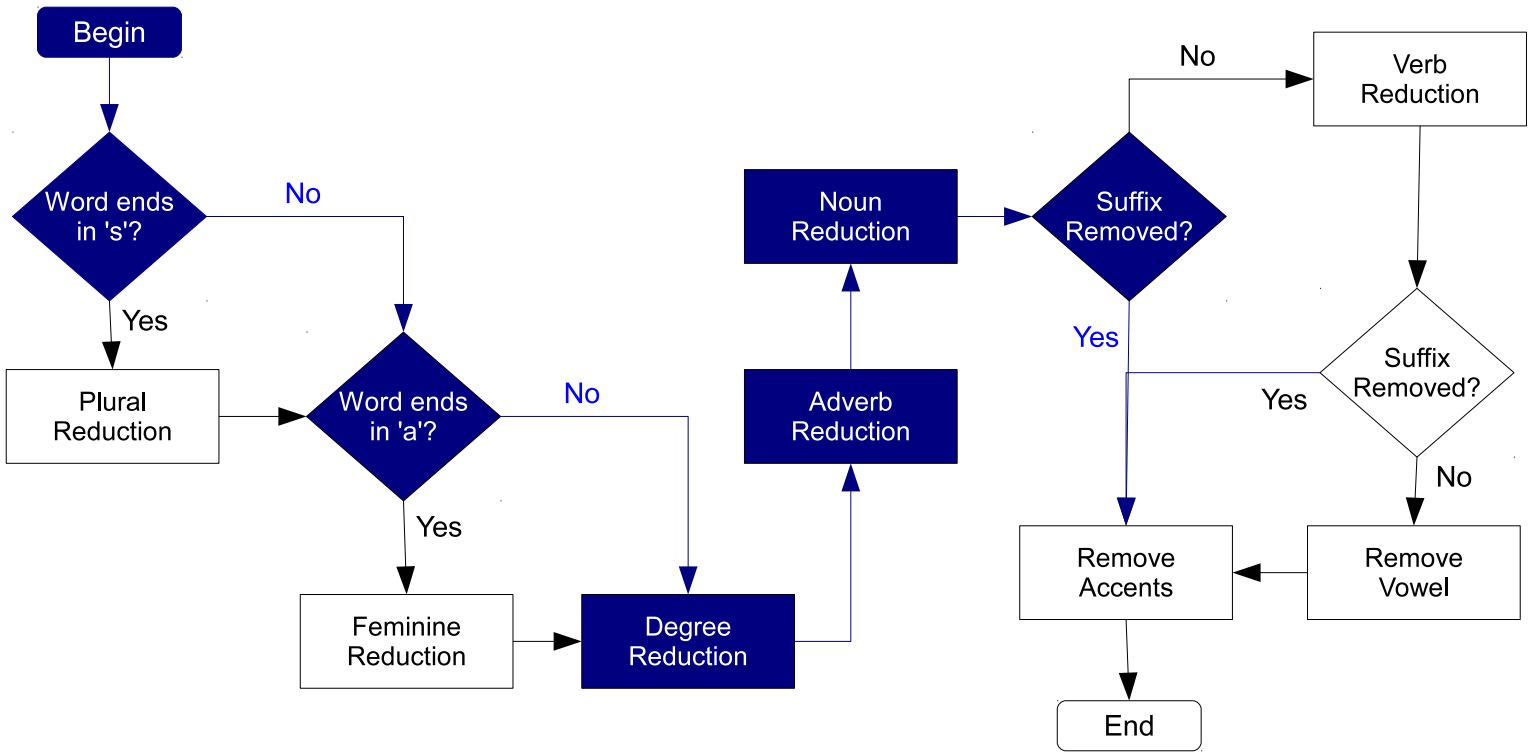
- subutil**izaç** → subutil



encialista, 4, “”, {} — alista, 5, “”, {} — alizaç, “”, 5, {} — izaç, 5, “”, {} — aç, 3, “”, {equaç, relaç}

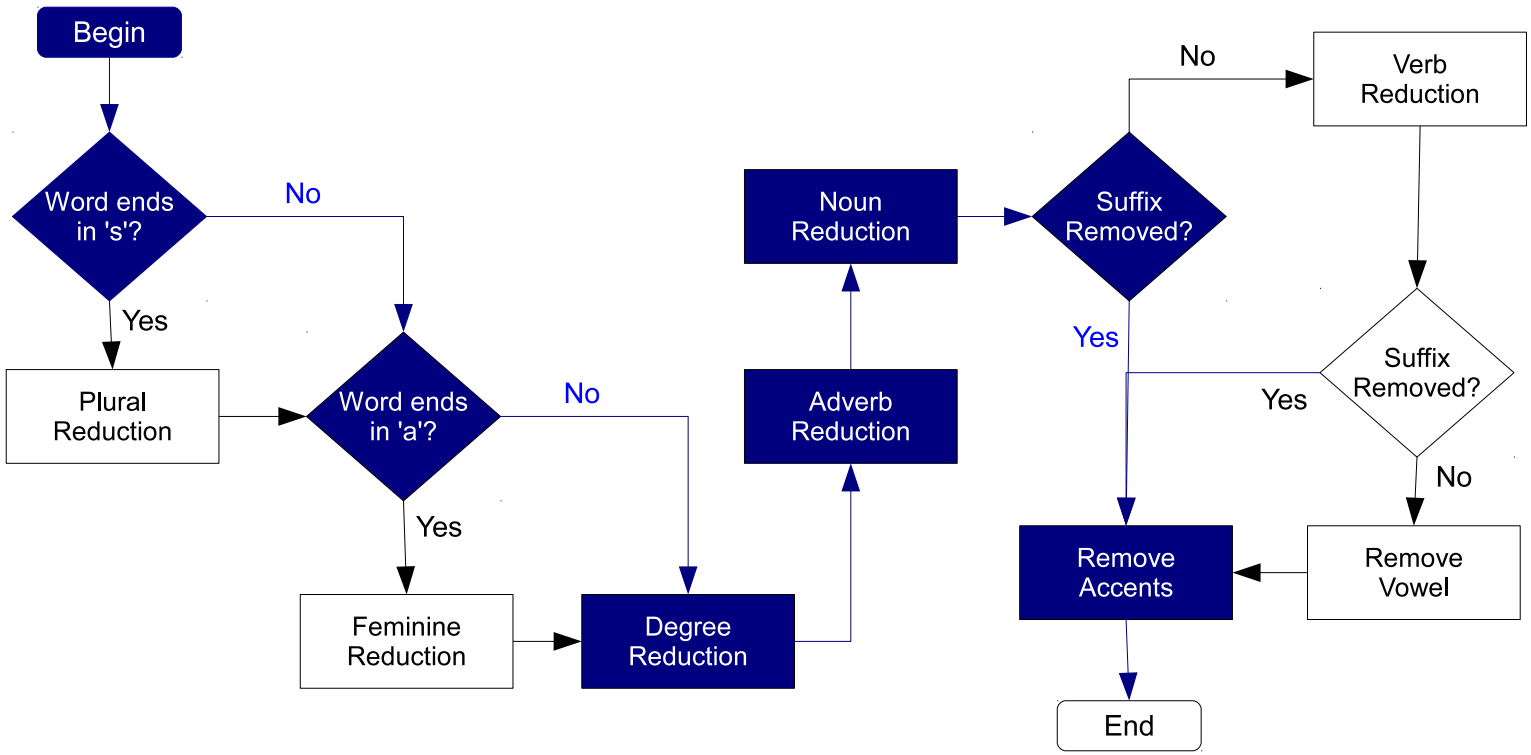
LBA Example

- subutil



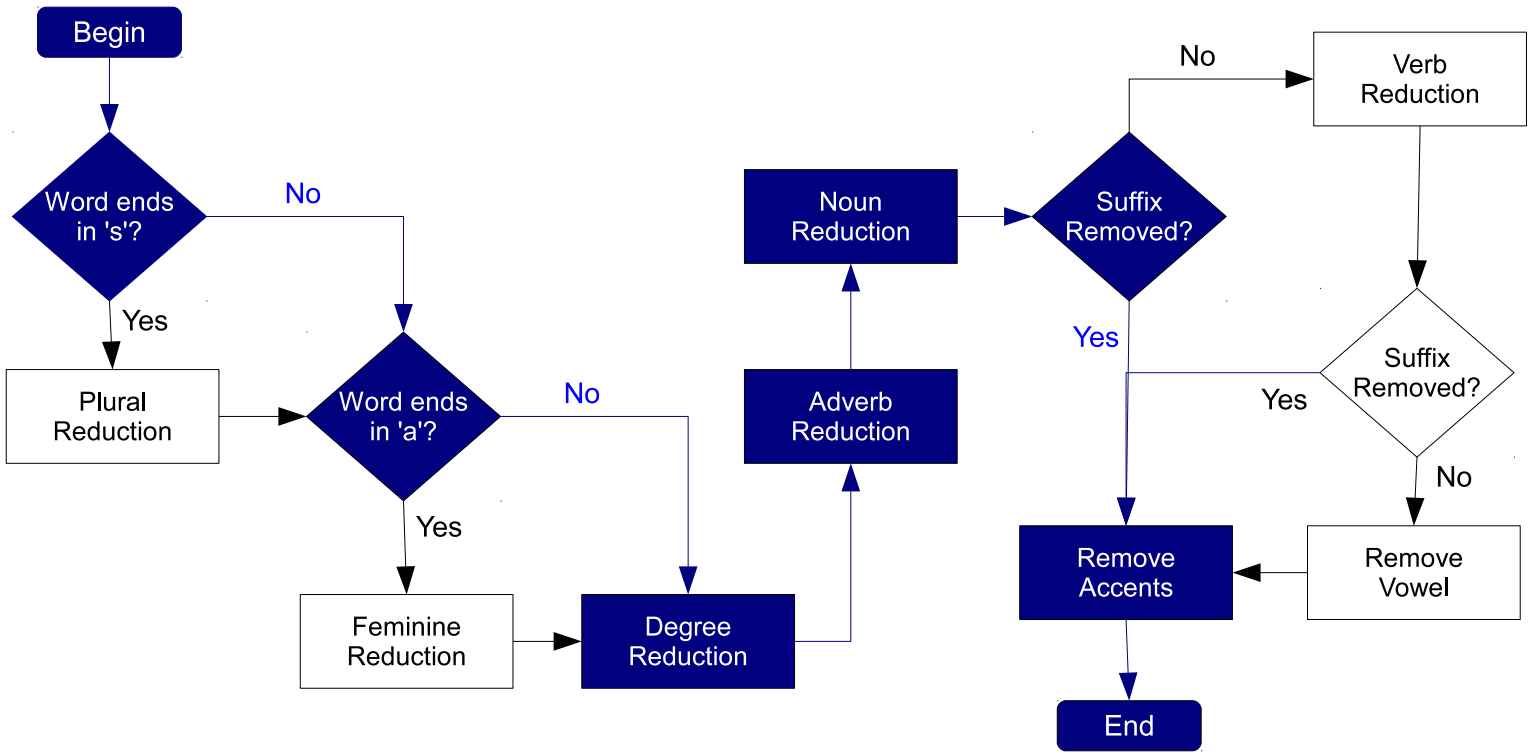
LBA Example

- subutil



LBA Example

- subutil



Many "inappropriated" suffix rules must be checked

The Hash-Based Approach (HBA)

For each step (type of reduction), a hash table breaks the single list of suffix rules into smaller lists

- Worst case → Hash entry pointing to the longest list of suffix rules

Plural	Feminine	Degree	Adverb	Noun	Verb
11	15	18	1	24	25

HBA Example

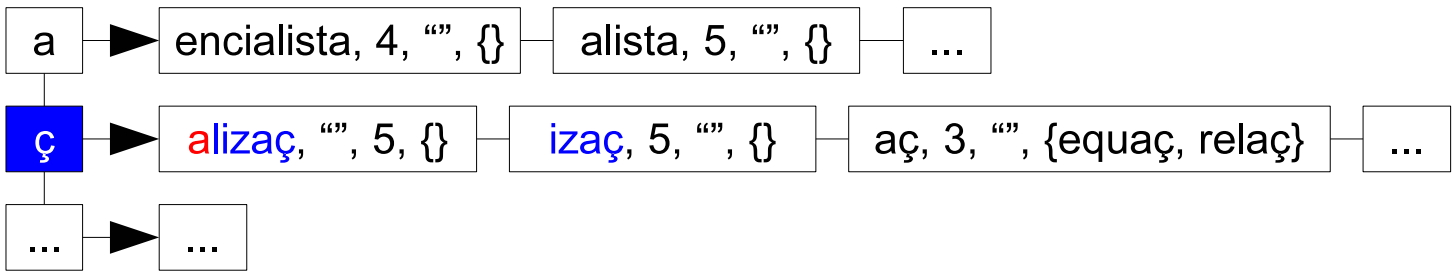
- subutilizaç

HBA Example

- subutilizaç

HBA Example

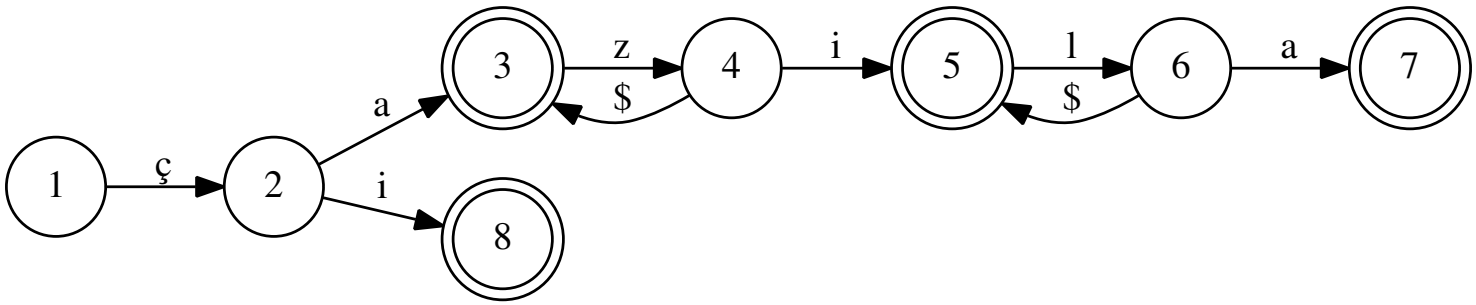
- subutil**izaç**



Less than LBA, but still many “inappropriated” suffix rules must be checked

The Automata-Based Approach (ABA)

For each step (type of reduction), a deterministic finite automata (DFA) reduces the number of character comparisons to the minimum, processing only the appropriate suffix rules

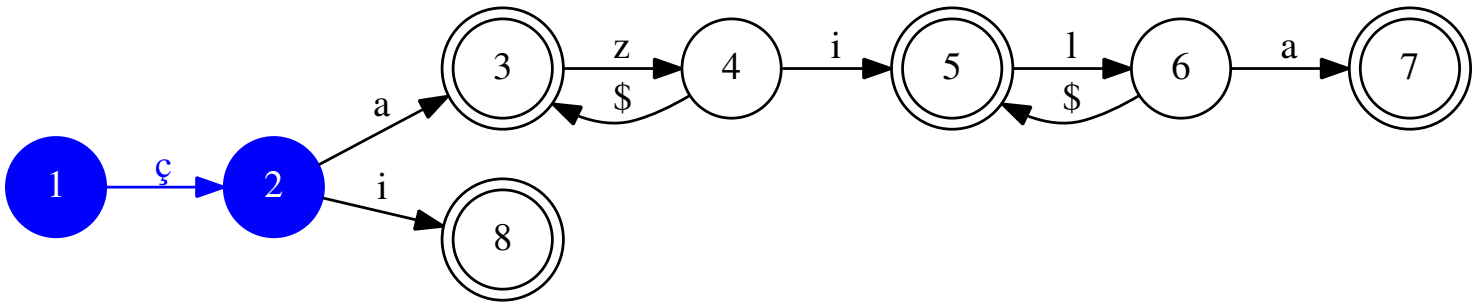


- Worst case → Checking the biggest path of the DFA

Plural	Feminine	Degree	Adverb	Noun	Verb
3	2	3	1	3	4

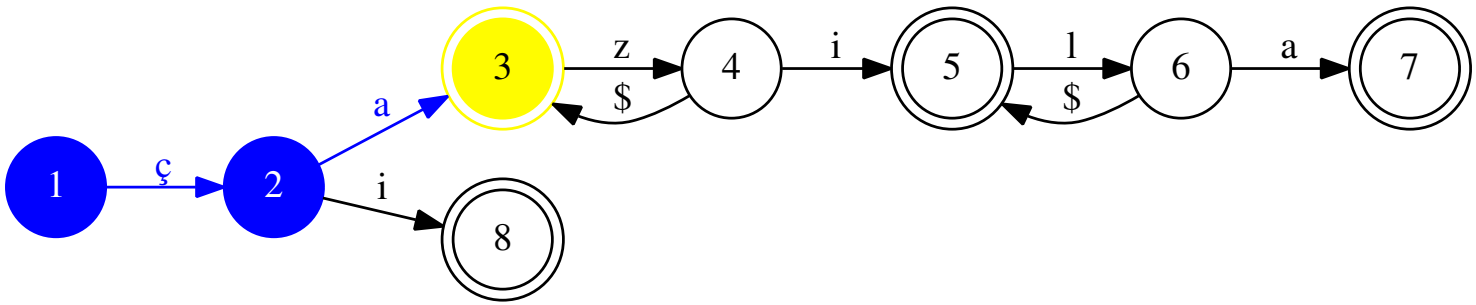
ABA Example

- subutilizaç



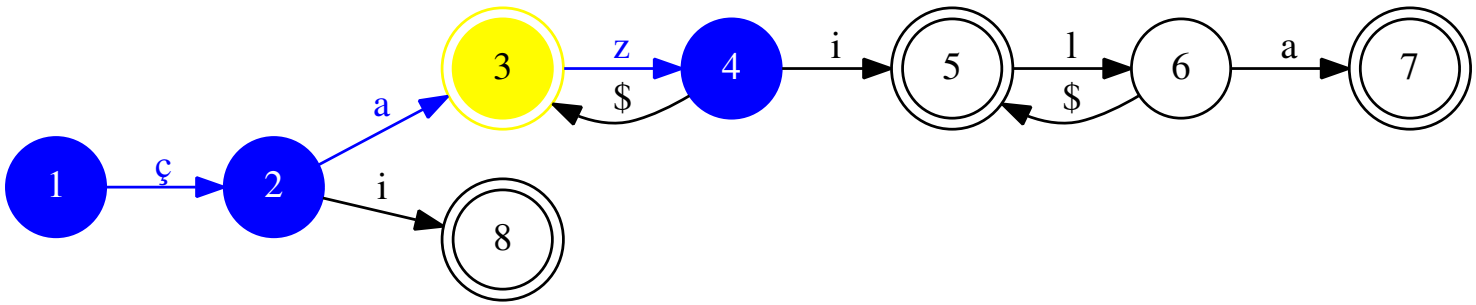
ABA Example

- subutiliz**aç**



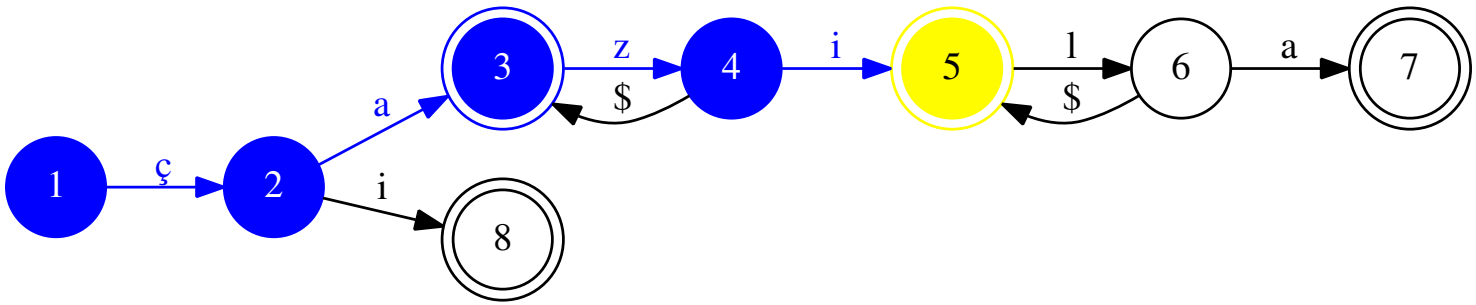
ABA Example

- subutili**zaç**



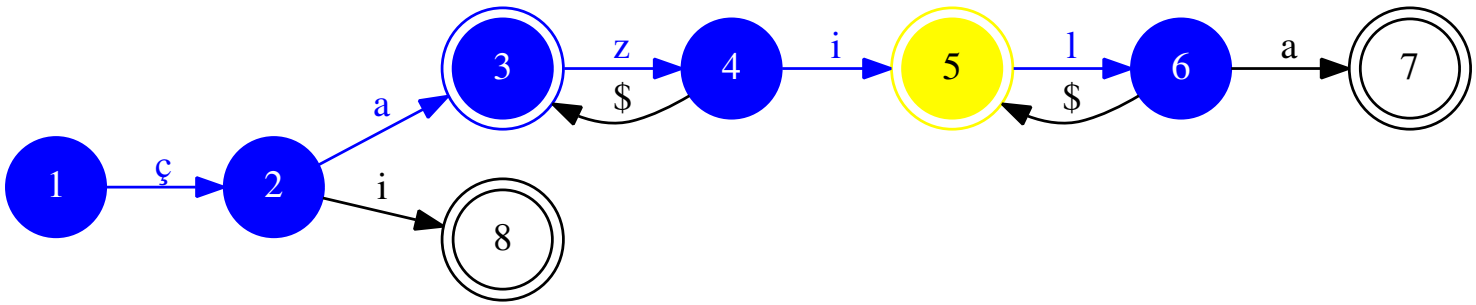
ABA Example

- subutil**izaç**



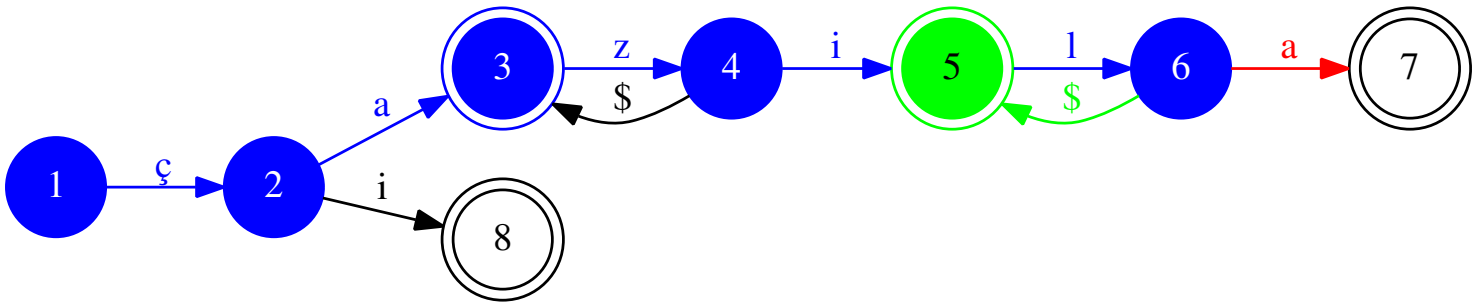
ABA Example

- subutil**izaç**



ABA Example

- subutilizaç



A small number of character comparisons and suffix rules must be performed and checked

Experiments

- Research Questions:
  - Performance by Step → How the LBA, HBA and ABA perform in each step of suffix stripping?
  - Overall Performance → How efficient (in time) are they?
- Datasets:
  - RSLP → 198 Portuguese words (one for each suffix rule in each step)
  - WBR99 → 206 millions Portuguese words extracted from approximately 6 millions Web pages crawled from the Brazilian Web (.br domain), and distributed into 6 collections.

Experiments: Setup

- Evaluation metric → Stemming time, i.e., the average elapsed time in microseconds (μs) for stemming a word, ignoring the time to load the suffix rules and hash entries in memory
- Environment → Single computer running Linux kernel version 3.16, 64-bit Intel Core i3 2.13 GHz processor, 3 GB of main memory, and 1 SATA II disk of 320 GB
- Implementation → C++
- Results → Two-tailed paired t-test at $p < 0.01$ level

Experiments: Performance by Step

Stemming time (μs) by reduction step on the RSLP dataset

Reduction Step	LBA	HBA	ABA
Noun	2.20733	1.07529 (51.28%) ▼	**0.46008 (79.15%) ▼▼**
Verb	3.63152	1.54178 (57.54%) ▼	**0.68953 (81.01%) ▼▼**
Plural	**0.16546**	**0.16546 (00.00%) •**	0.21505 (-29.97%) ▲▲
Feminine	0.28770	0.28770 (00.00%) •	**0.20967 (27.12%) ▼▼**
Degree	0.22786	0.22786 (00.00%) •	**0.18010 (19.64%) ▼▼**

Experiments: Overall Performance

Stemming time (μs) on WBR99 collections

Collection	LBA	HBA	ABA
AmostRA-NILC	1.37346	0.57674 (58.00%) ▼	**0.20779 (84.87%) ▼▼**
CETEMPúblico	0.03657	0.01338 (63.41%) ▼	**0.00504 (86.21%) ▼▼**
Museu da Pessoa	0.23419	0.09632 (58.87%) ▼	**0.03729 (84.07%) ▼▼**
ReLi	0.75644	0.31680 (58.11%) ▼	**0.12272 (83.77%) ▼▼**
Tycho Brahe	0.53799	0.19651 (63.47%) ▼	**0.07759 (85.57%) ▼▼**
Vercial	0.18901	0.06561 (65.28%) ▼	**0.02555 (86.48%) ▼▼**
All	0.52128	0.21090 (59.54%) ▼	**0.07933 (84.78%) ▼▼**

Contributions

- ABA → Simple and effective approach for Portuguese stemming
- Adaptable to work with different languages, such as English and Spanish
- Outperforms the baseline with gains of up to 86.48% in stemming time

Thank You

Questions?

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"Science is a way of thinking...
much more than it is a body of knowledge."
Carl Sagan