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► **To cite this version:**

Alexandre Bonlarron, Aurelie Calabrese, Pierre Kornprobst, Jean-Charles Régis. Intertwining NLP and CP-AI-OR Reasoning for Constrained Text Generation. Journée Natural Language Argumentation – GDR TAL – GDR RADIA, Nov 2023, Sophia Antipolis (06), France. . hal-04296814

**HAL Id: hal-04296814**

**<https://hal.science/hal-04296814v1>**

Submitted on 21 Nov 2023

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# Intertwining NLP and CP-AI-OR Reasoning for Constrained Text Generation

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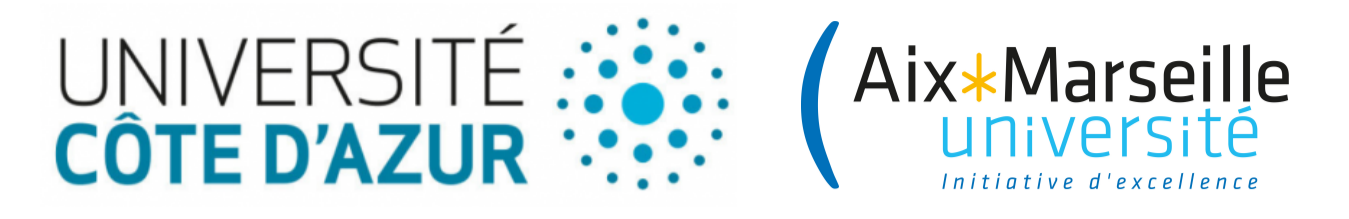
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IJCAI/2023 MACAO



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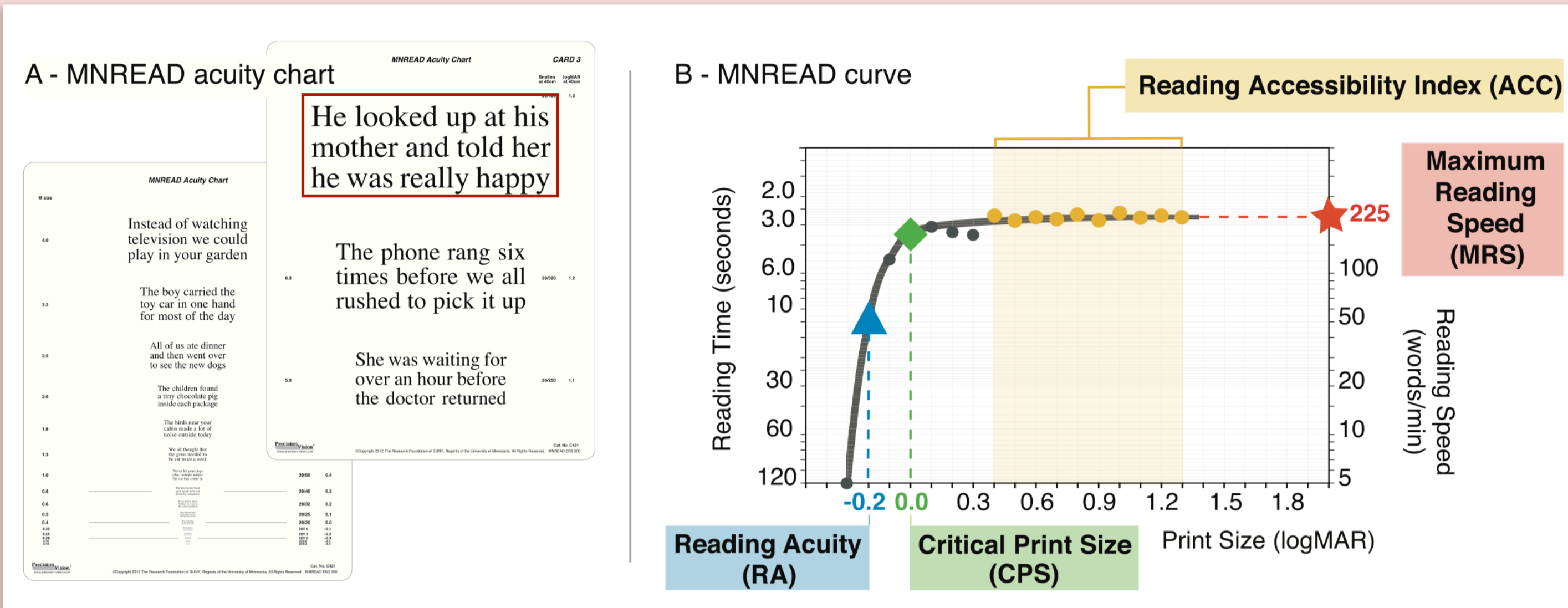


## General Idea

**Beam Search** fails to generate constrained text when the solutions space is **strongly constrained** (e.g., length, display). When constraints are defined on the **whole text**. Our **CP-based** approach solves it.

## Context

### Case study: the MNREAD test



A psychophysical test based on standardised sentences, available in 19 languages

- Assessing the **reading speed** is crucial for evaluating patients with visual impairments
- The need for a collection of **standardized** sentences respecting grammar, lexicon, size, or display rules
- Limitation: **few sentences** available due to the rules being too restrictive (**only 38 MNREAD sentences in French...**)
- Problem: How can we **generate** sentences that comply with several rules?

## Methods

### Principle (n-gram)

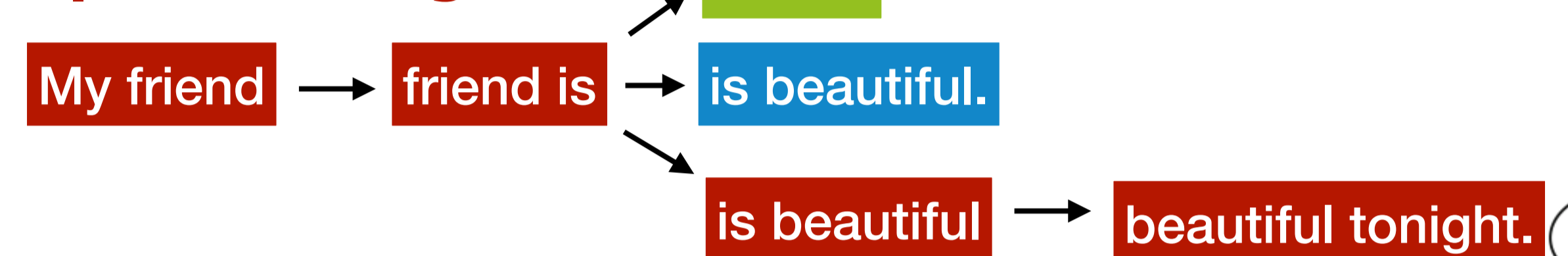
#### Step 1: Corpus

He is angry.  
 My friend is sad.  
 She is beautiful tonight.

#### Step 2: set of 2-grams

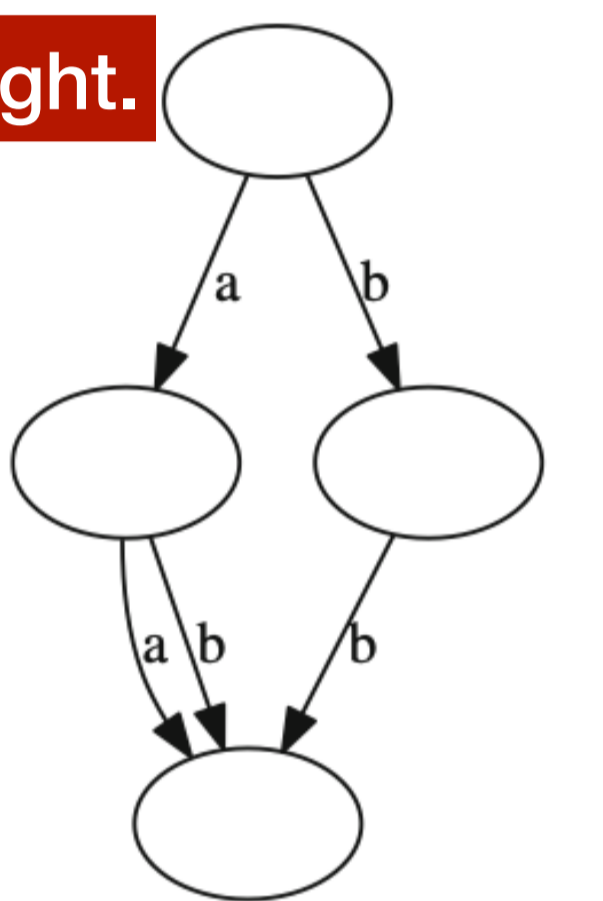
Is beautiful friend is Is beautiful He is  
 My friend She is beautiful tonight Is sad.

#### Step 3: chaining



### MDD Paradigm (Constraint Programming)

- Data structures for calculating and storing the solutions to a problem in a compressed form using an acyclic directed graph.
- Advantage: powerful modelling tool, computing solutions set without a search.

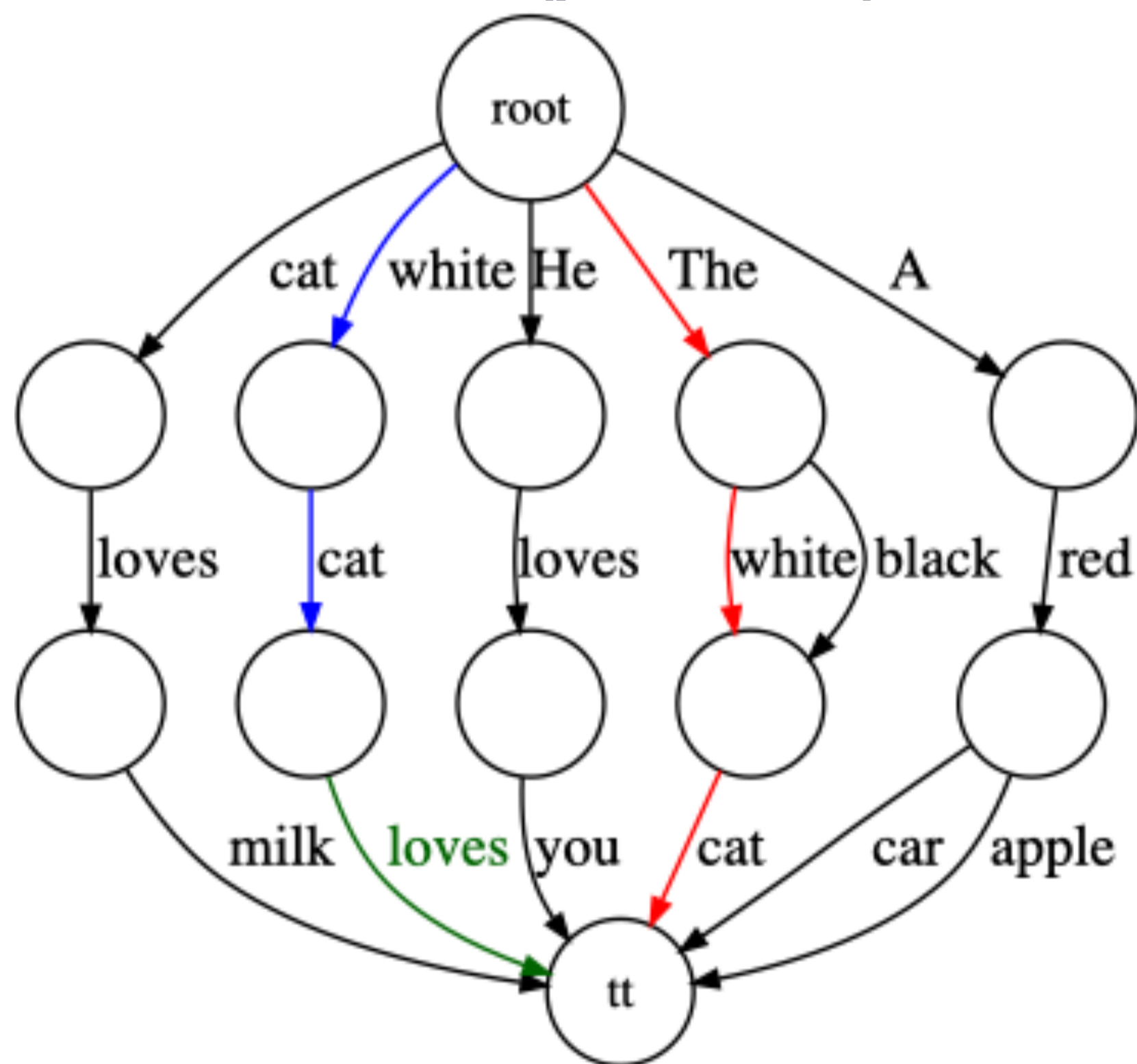


Large Language Model (LLM) can be used to score generated sentences. This score is viewed as a quality measurement of the generated sentences.

## Results

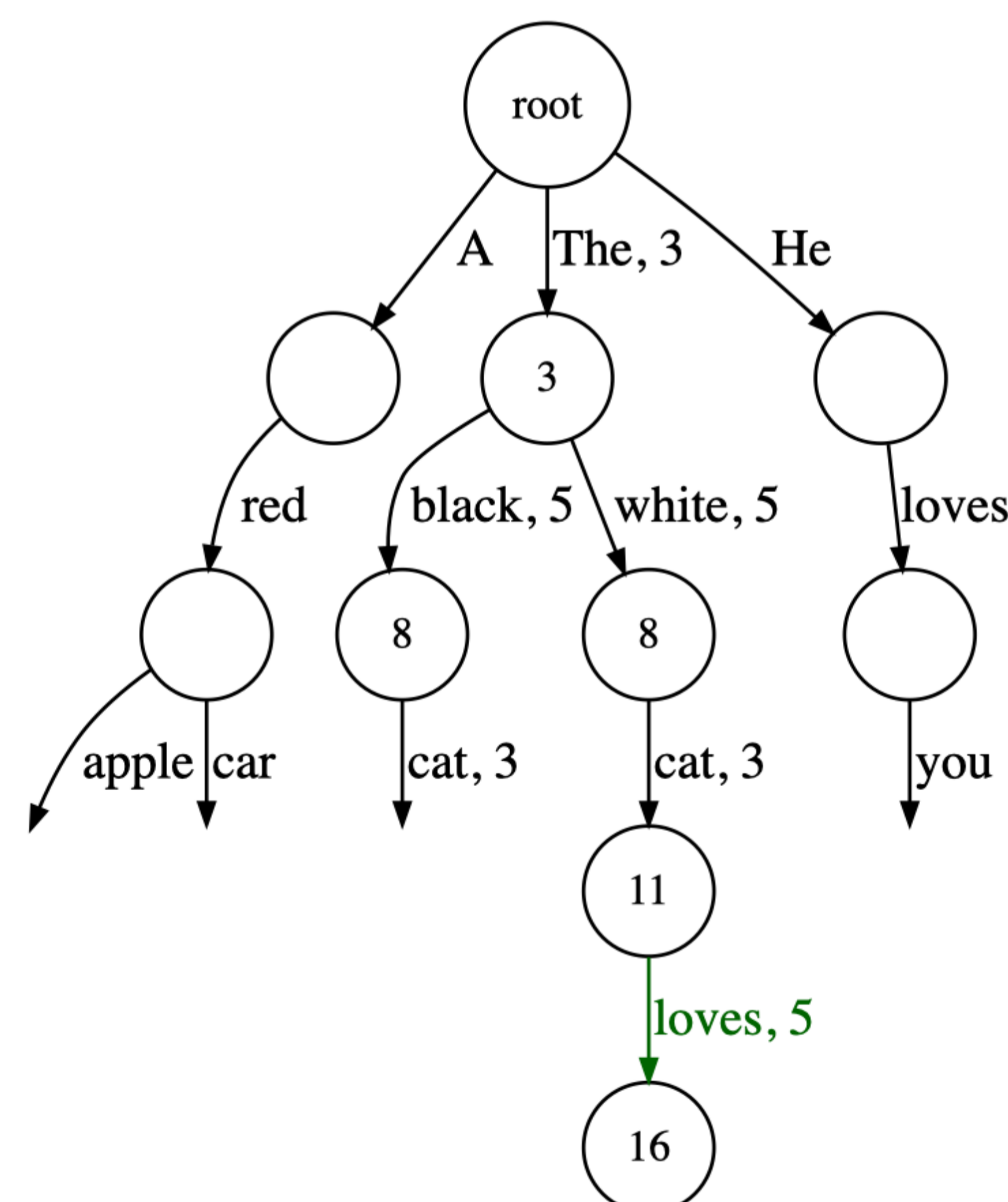
From MNREAD rules to Sentences Generation in 3 steps

### 1 - MDD as a Trie (prefix tree)



➔ What is the successor of **The white cat** ?

### 2 - MDD top-down compilation



### 3 - Sentences scoring with LLM

$$P(X_1 \dots X_n) = \prod_{i=1}^n P(X_i | X_1 \dots X_{i-1})$$

$$PPL(X_1 \dots X_n) = \sqrt[n]{\frac{1}{P(X_1 \dots X_n)}}$$

$$PPL(X_1 \dots X_n) = \sqrt[n]{\frac{1}{\prod_{i=1}^n P(X_i | X_1 \dots X_{i-1})}}$$

- 'Perplexity' is derived from Shannon's Entropy.
- It quantifies the uncertainty of a model with respect to a sample
- The lower, the better; range is [1 ; + inf]

### General observation

- n of n-grams ↗
- Quality of sentences ↗
- Number of sentences ↘

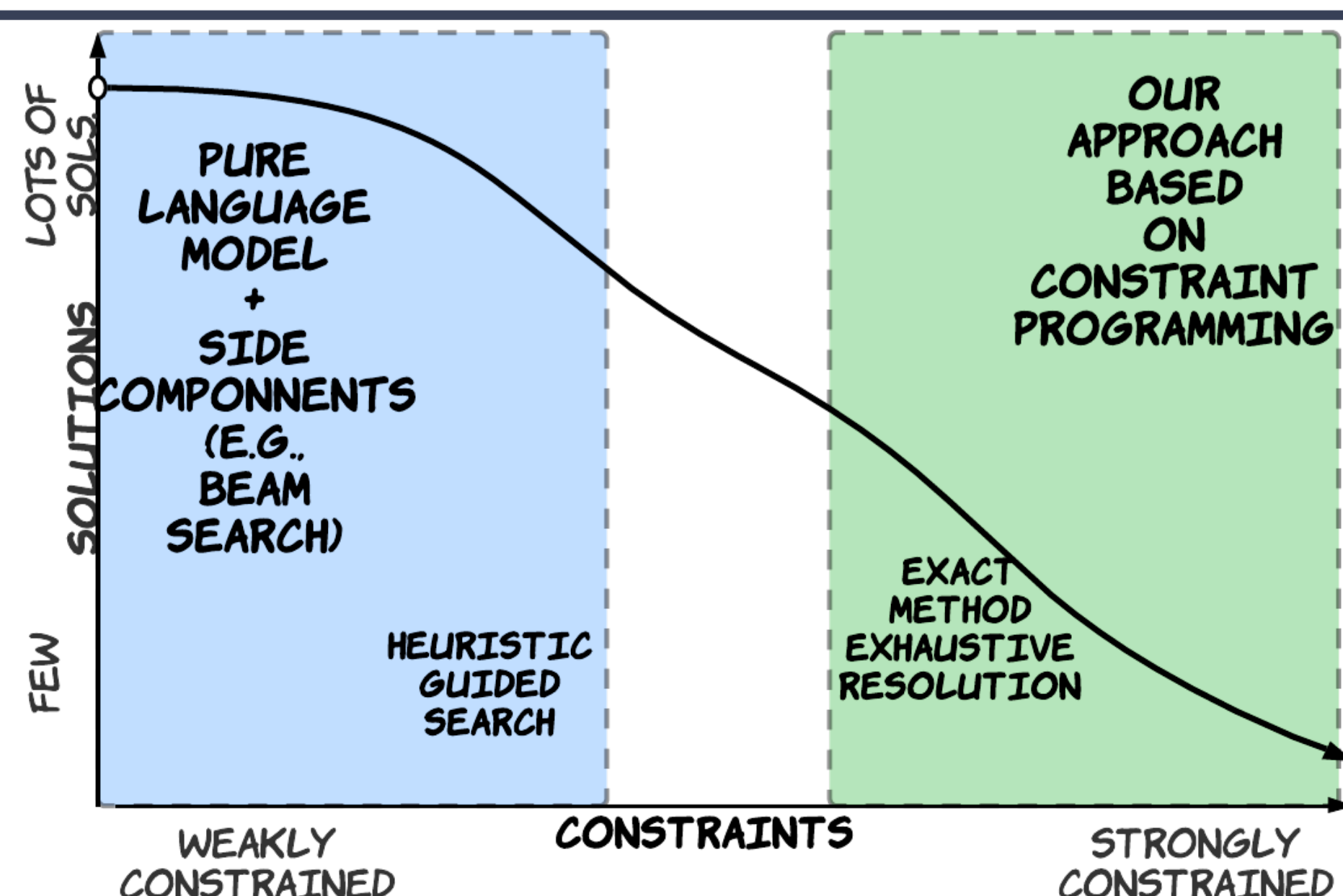
### MNREAD sentence generation

	FR	EN	RAM	Time	Number of sentences
FR	443	75	3GB	72s	7028
EN	75	<<1GB	3s	204	

### Examples of sentences

Quality	Quality: Good	Quality: Average	Quality: Poor
PPL	PPL = 12	PPL = 160	PPL = 224

## CP-ML



## Conclusion

- Promising method: more suitable than generic methods (e.g. GPT, Bert) for **managing constraints** and more **flexible** than the ad-hoc method of Mansfield et al.
- Advantages: **modularity** (easy to add and/or to remove rules), **constraints taken into account at the generation stage**, can be applied to **other languages**
- Perspectives: Bridging CP and ML

For more details, read the paper →

