Handling Massive N-Gram Datasets Efficiently

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Fast **access** to individual n-grams?

How to **estimate** the probability of occurrence of the n-grams under a given probability model?

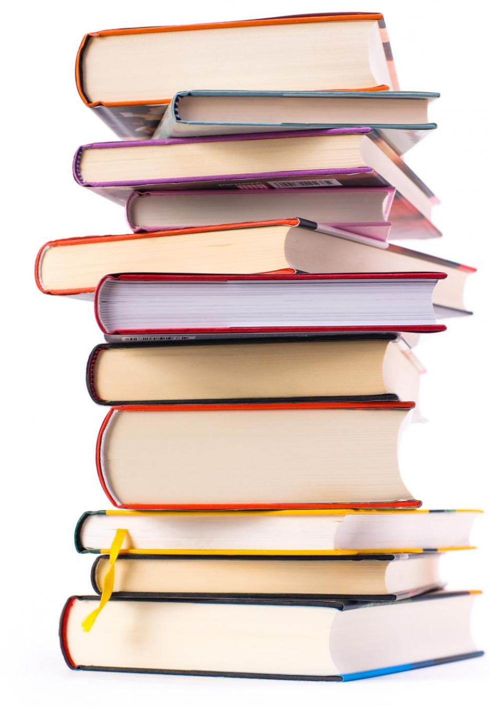
N-Grams Applications

- auto-completion in search engines
- spelling correction
- similarity search
- identification of text reuse and plagiarism
- automatic speech recognition
- machine translation
- and many others….

Many results and softwares available

- **CSTLM** [Shareghi et al., TACL 2016]
- **KenLM** [Heafield, WMT 2011]
- **BerkeleyLM** [Pauls and Klein, ACL 2011]
- **ExpGram** [Watanabe et al., IJCNLP 2009]
- **IRSTLM** [Federico et al., ACL 2008]
- **RandLM** [Talbot and Osborne, ACL 2007]
- **SRILM** [Stolcke, INTERSPEECH 2002]

Numbers are big



Google Books

~6% of the books ever published

n	number of n-grams
1	24,359,473
2	667,284,771
3	7,397,041,901
4	1,644,807,896
5	1,415,355,596

More than 11 billions of n-grams!

Indexing: Context-based Remapped Trie

(1) Store all distinct words in a hash table (the vocabulary)
mapping words to integer ids.
(2) Represent the (mapped) integer n-grams with a *trie* data structure.

The number of distinct words appearing after a given context is small.

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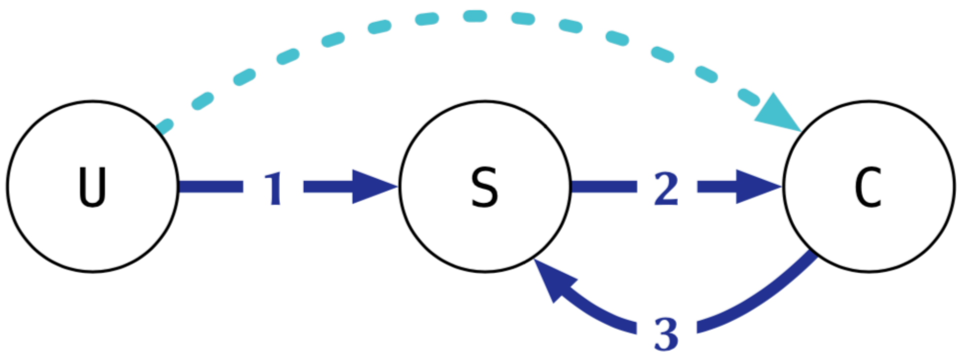
As fast as the fastest competitor, but up to **65%** smaller.

Even smaller than the most space-efficient competitors and up to **5X** faster.

Estimation: 1-Sort Algorithm for Kneser-Ney

To compute the modified *Kneser-Ney* probabilities of the n-grams, the fastest algorithm in the literature uses **3 sorting steps** in external memory [Heafield et al., ACL 2013].



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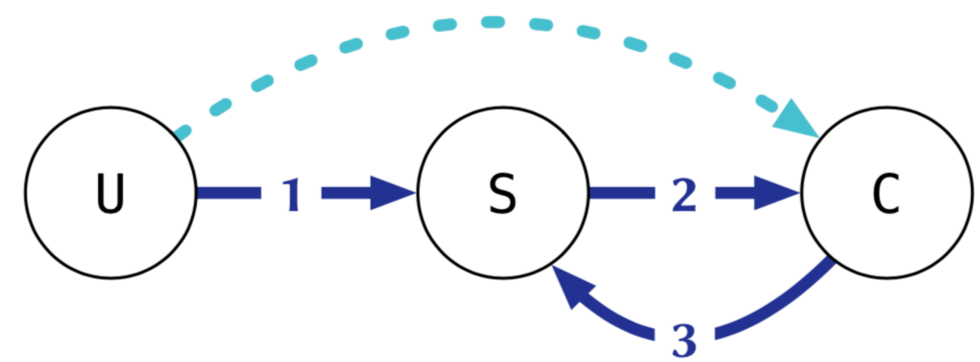

Idea: compute statistics directly over the *context*-sorted n-grams, using space only proportional to the vocabulary.

3-Sort → **1-Sort**

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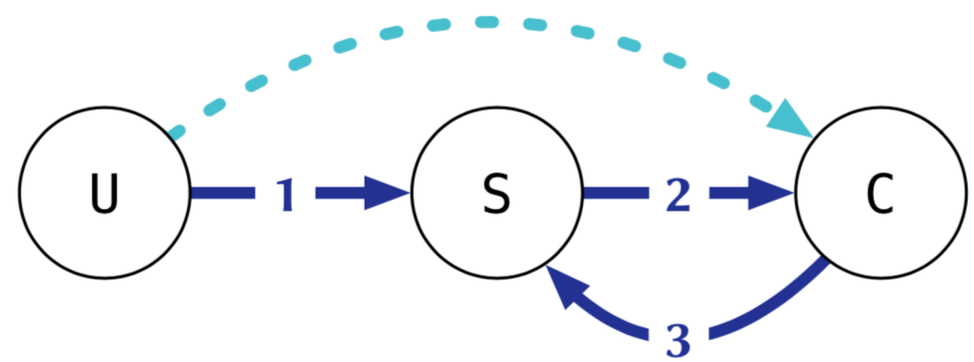

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Estimation runs 4.5X faster with billions of strings.

Tongrams — Tons of N-Grams

C++

https://github.com/jermp/tongrams

https://github.com/jermp/tongrams_estimation

Thanks for your attention!