REMEDI: Robust and Efficient Machine Translation in a Distributed Infrastructure

Bi-Annual Report: Month 6

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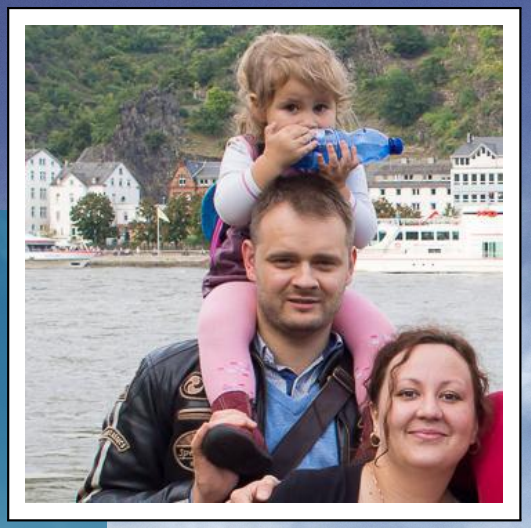
Bios

- About:
  - 35 years old
  - Russian
  - Married
  - Mathematician (Bsc, Msc)
  - PhD in Theoretical Computer Science
  - 15 Years work experience (7 researcher)



Project/Delivery: Month 6

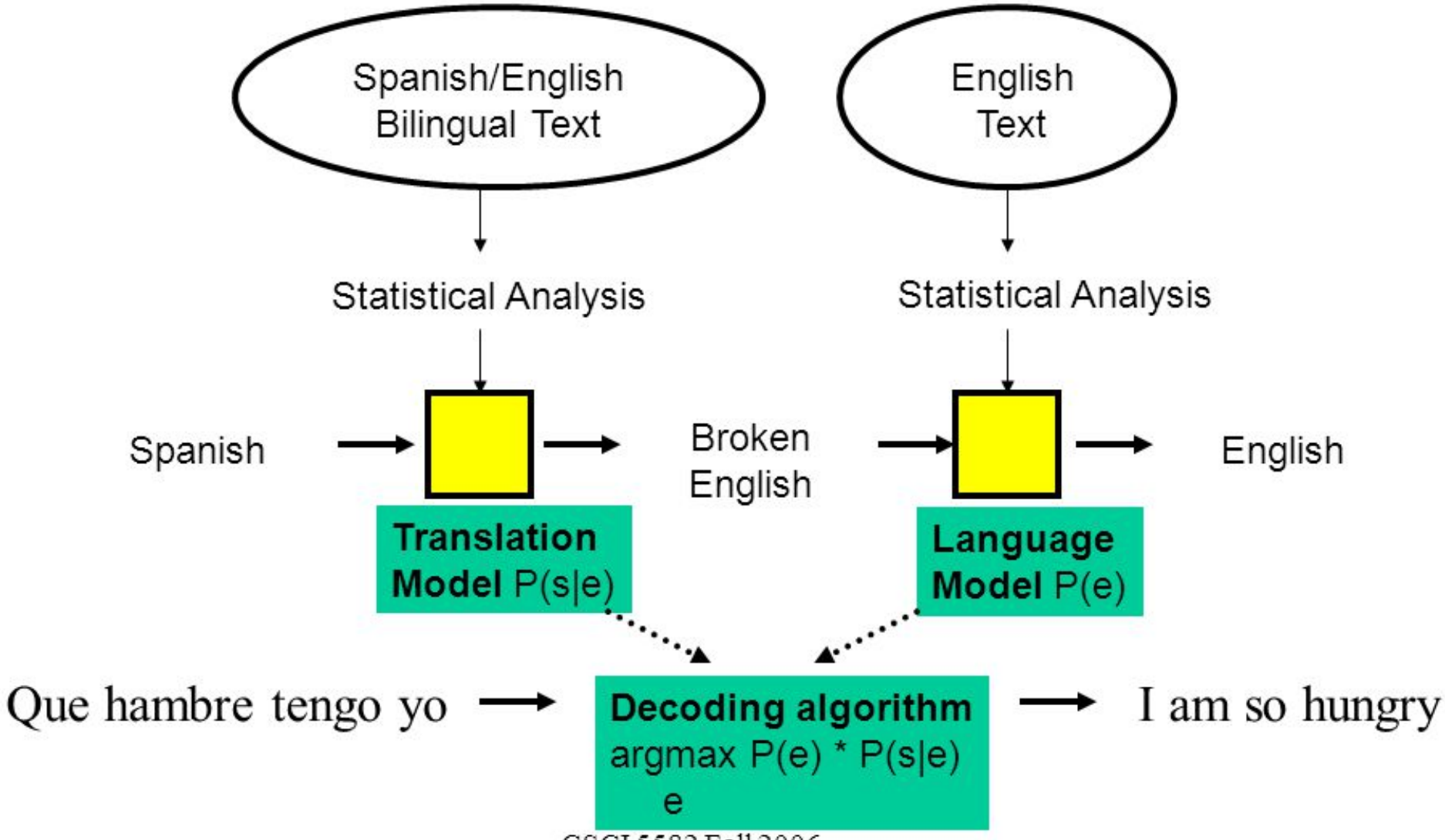
Address speed, scalability and robustness

via

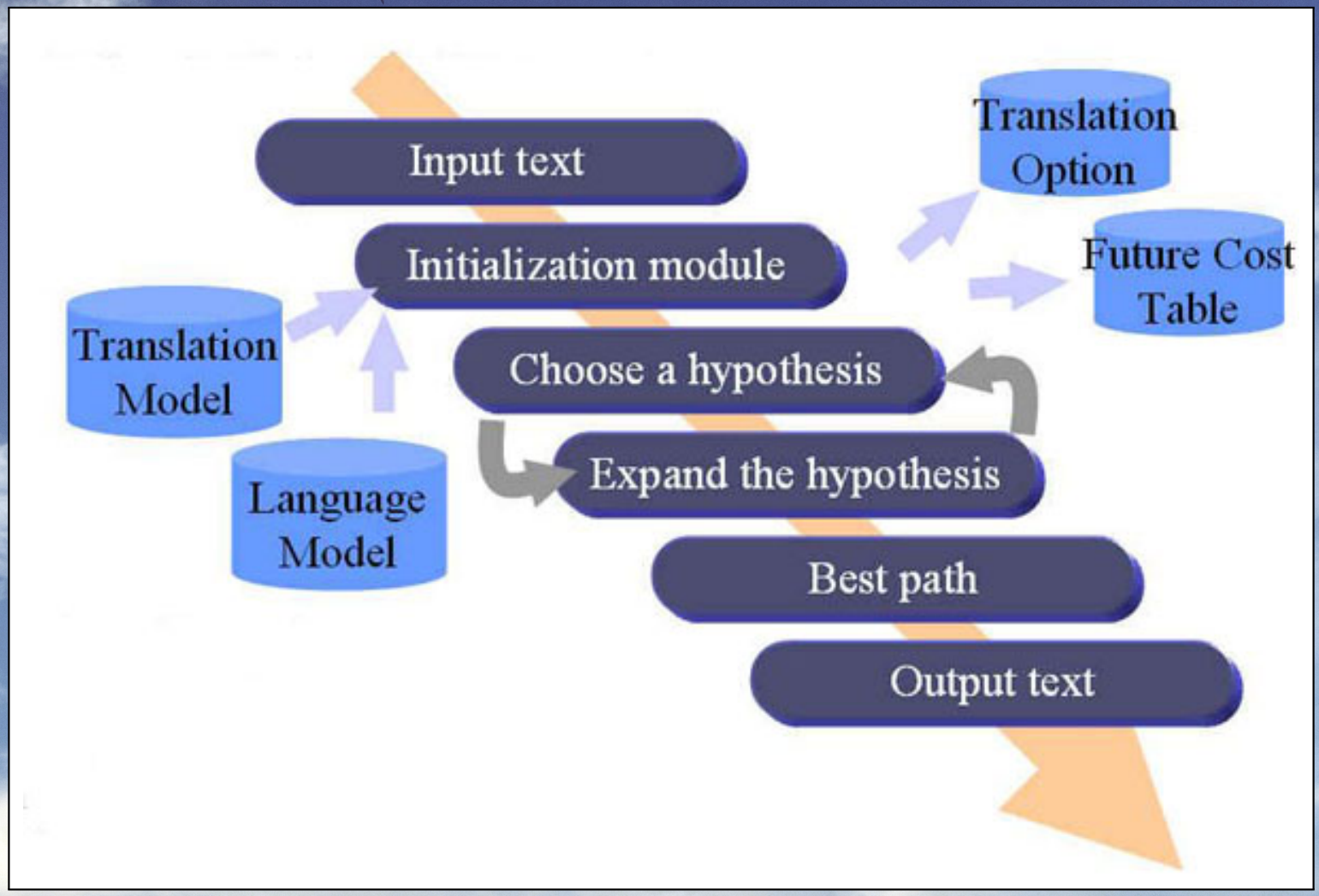
Complete re-development of the existing SMT infrastructure:

1. Implementation of language models;
2. Multi-threading with large shared data;

Statistical MT Systems



SMT: Multiple computationally intensive steps.



Language model: Computes phrase probabilities

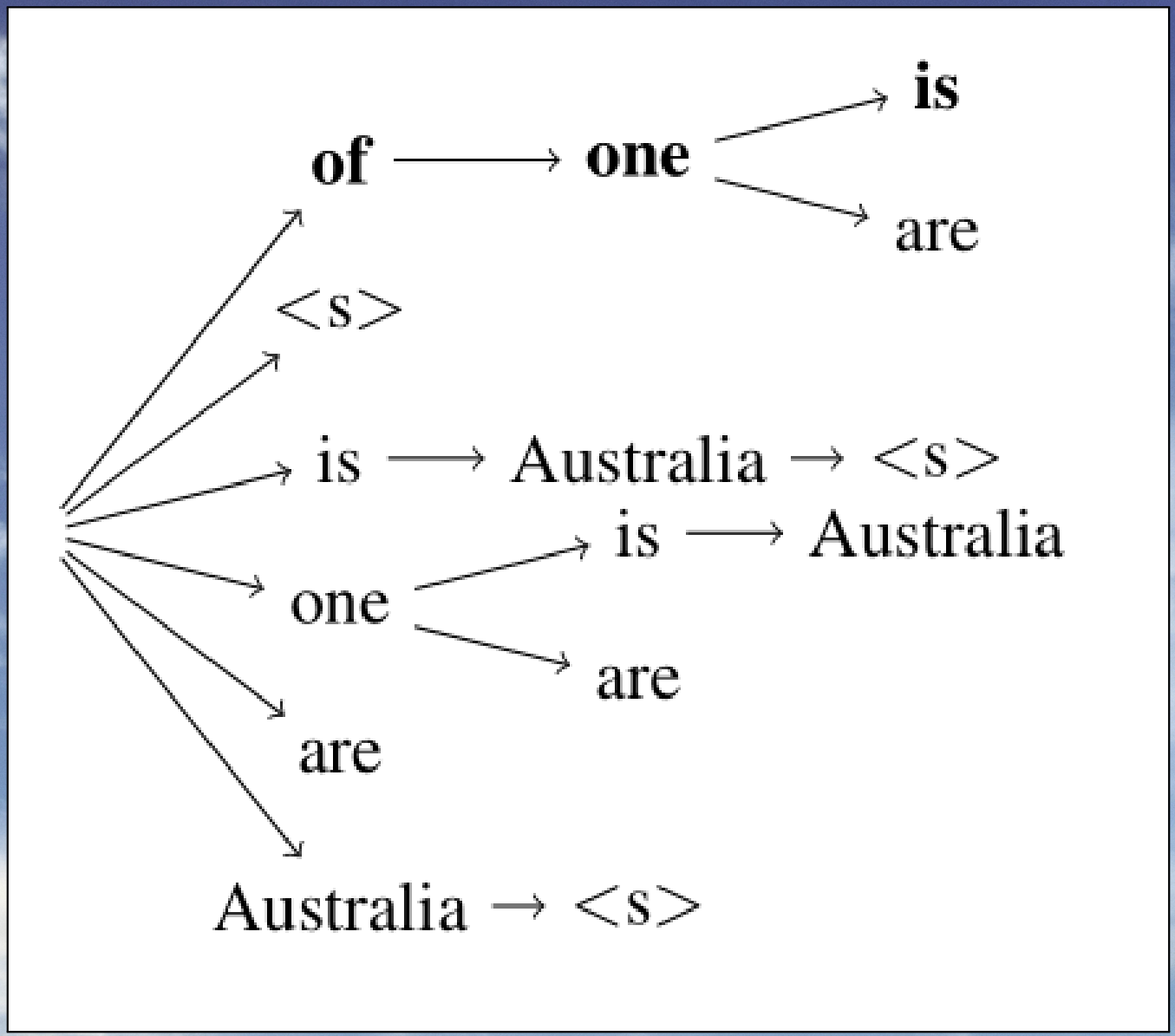
N-gram Model

- An n-gram is a sequence of n words
  - unigrams(n=1):"is","a","sequence",etc.
  - bigrams(n=2): ["is","a"], ["a","sequence"],etc.
  - trigrams(n=3): ["is","a","sequence"],["a","sequence","of"],etc.
- n-gram models estimate the conditional from n-grams counts

$$p(w_t \mid w_{t-(n-1)}, \ldots, w_{t-1}) = \frac{\text{count}(w_{t-(n-1)}, \ldots, w_{t-1}, w_t)}{\text{count}(w_{t-(n-1)}, \ldots, w_{t-1}, \cdot)}$$

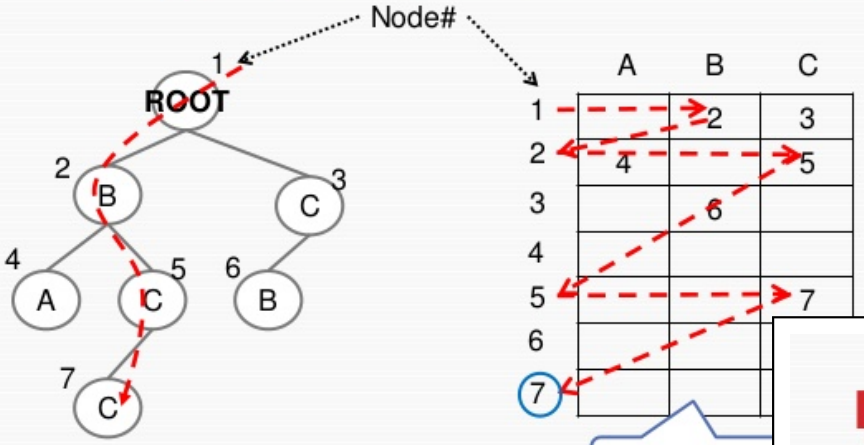
- the counts are obtained from a training corpus (a data set of word text)

Language model: Is stored in a form of a Trie



Tries: Different versions have different properties

2D Array Implementation of a Trie



Simple and fast but consumes a lot of me

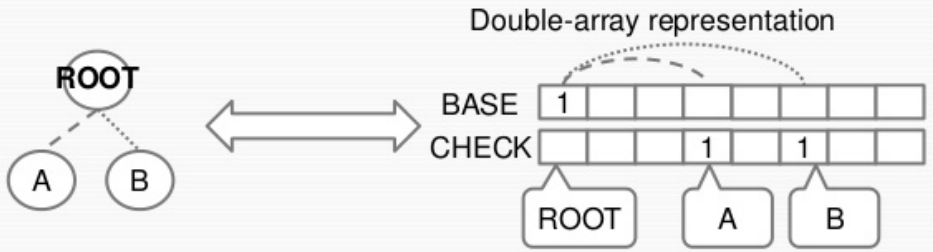
Double-Array Structures (Aoe, 1989)

What is a double-array structure?

A **fast** and **compact** representation of a trie

Abstract image

A trie is represented by two arrays (BASE and CHECK)



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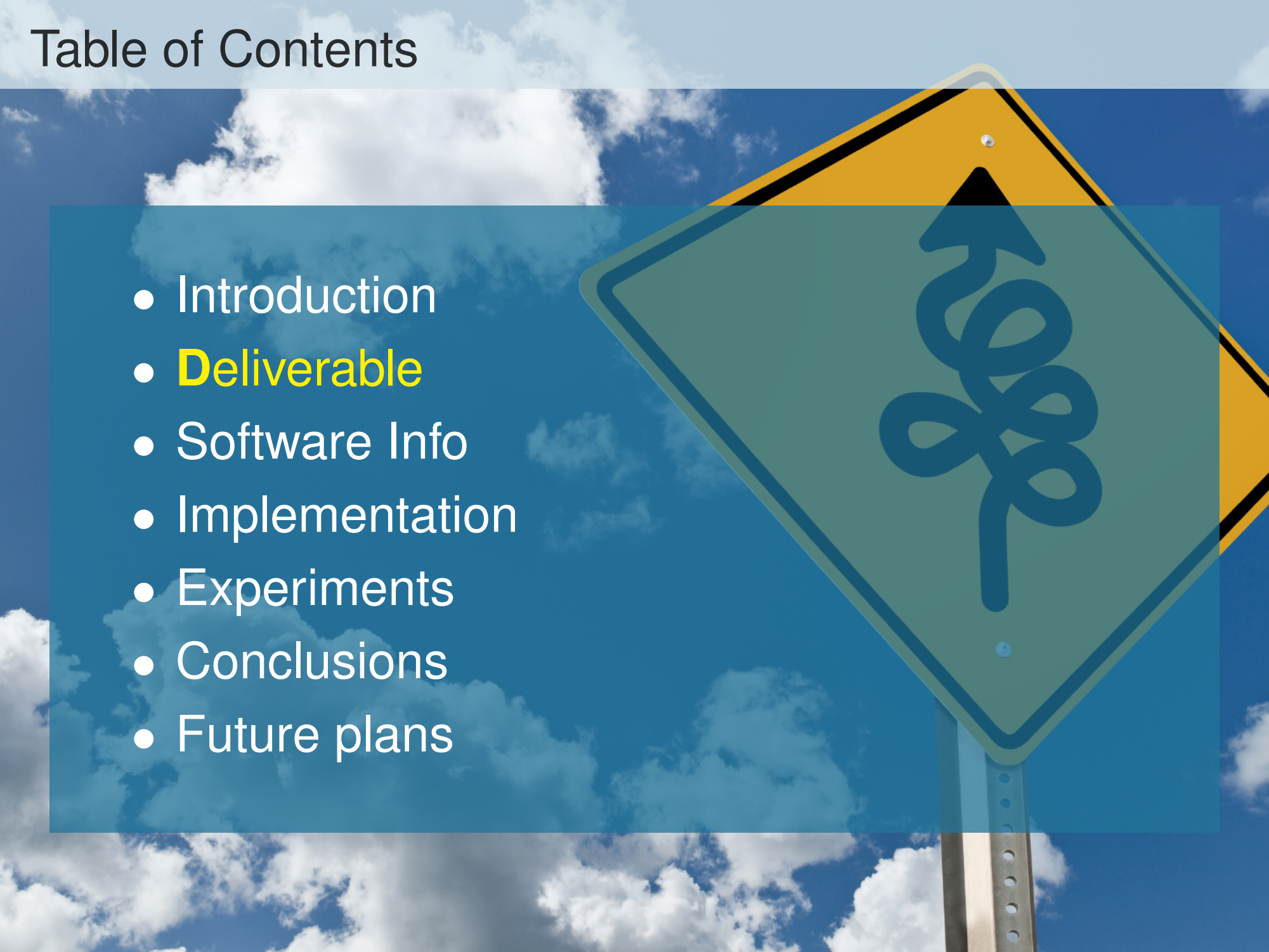

Deliverable: Software, Report, Example models

- REMEDI/month-6/
  - **software/**
    - doc/
    - inc/
    - src/
    - nbproject/
    - doxygen/
  - **report/**
  - **data/**

GitHub project:

`https://github.com/ivan-zapreev/Back-Off-Language-Model-SMT`

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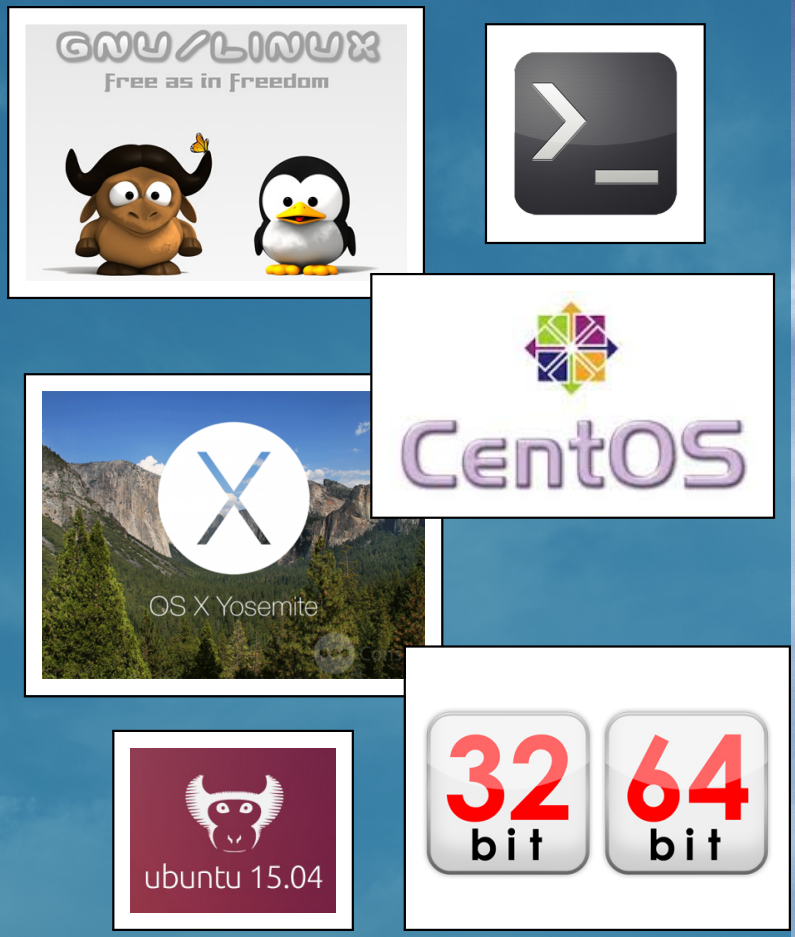
Software Info: Type, License, Platforms, Architectures

- Type:
  - Command line tool.
- License:
  - Gnu Public License v2.0
- Platforms:
  - CentOS 6.6
  - Ubuntu 15.04
  - Mac OS Yosemite 10.10
- Architectures:
  - 64-bit - full
  - 32-bit - partial

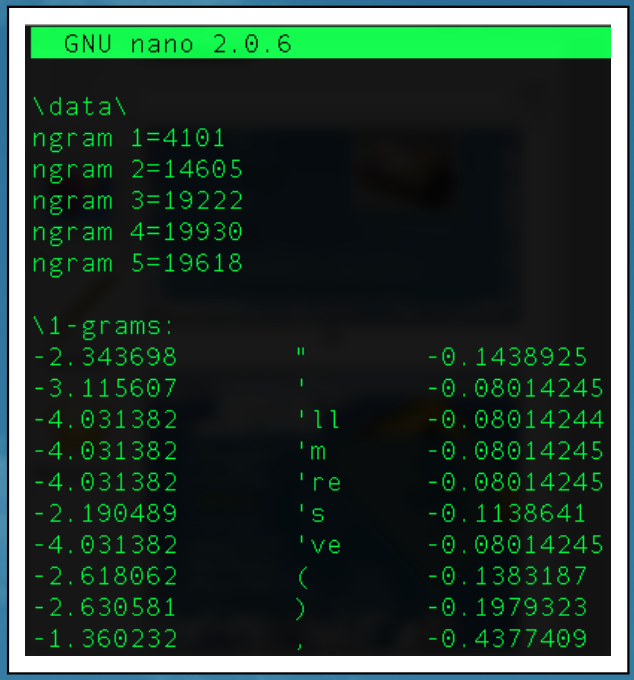


Software Info: Language, Project, Documentation, Testing

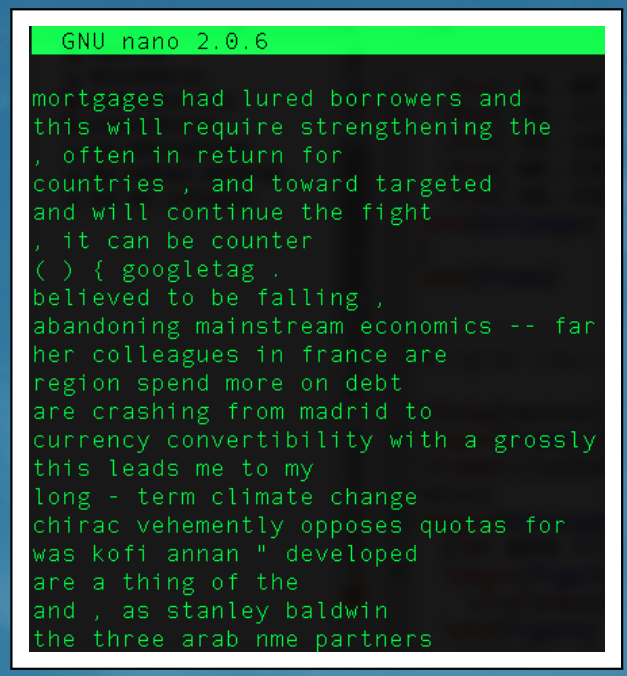
- Language:
  - C++ 11
- Project:
  - Netbeans 8.0.2
  - Makefiles
- Documentation:
  - Doxygen
- Profiling:
  - Valgrind

Software Info: Inputs and Outputs

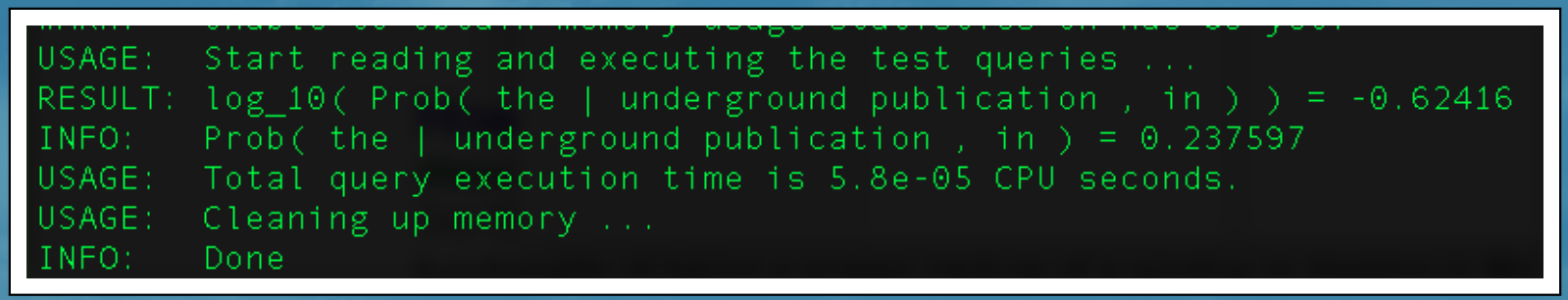
ARPA file:



Queries file:



Result:



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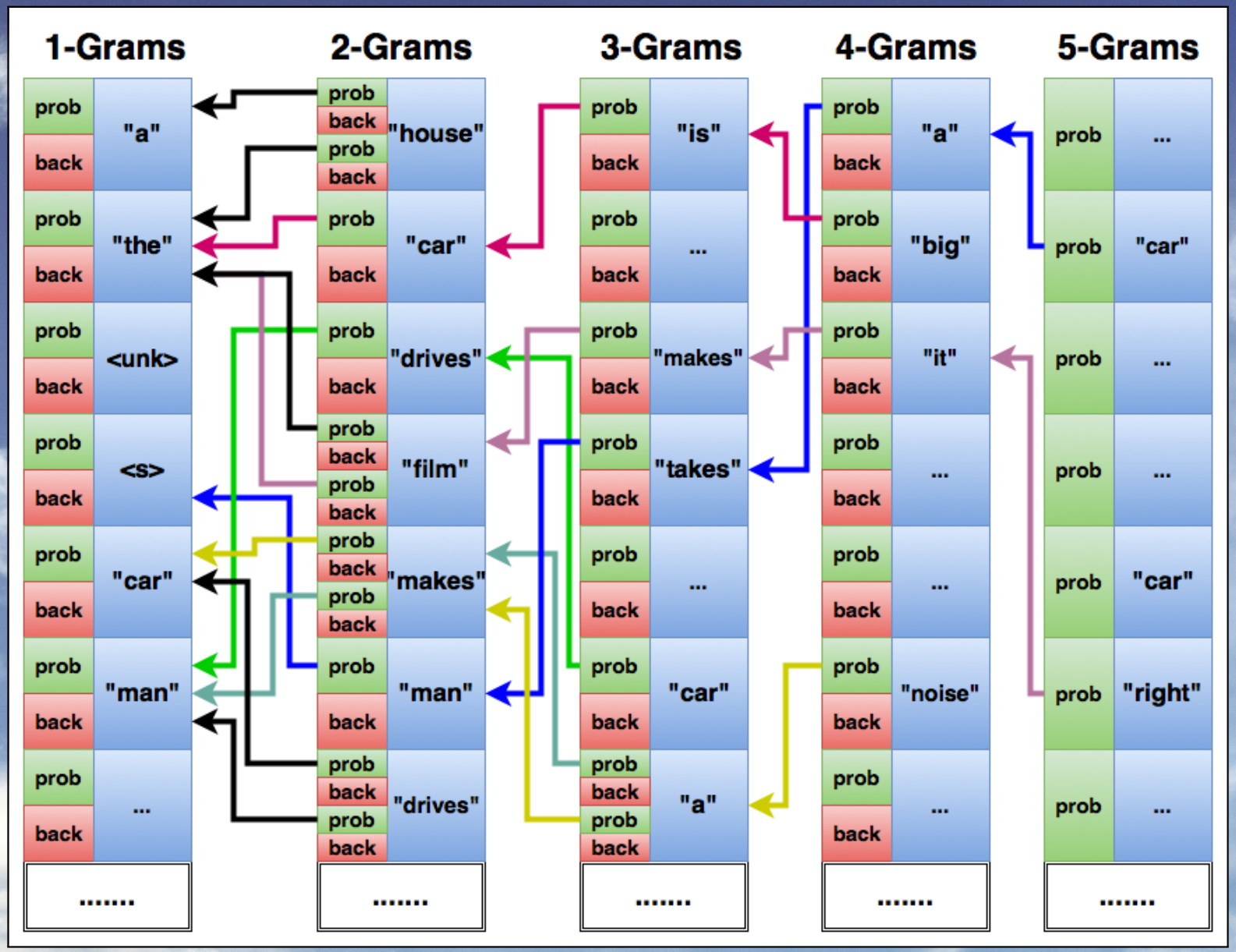
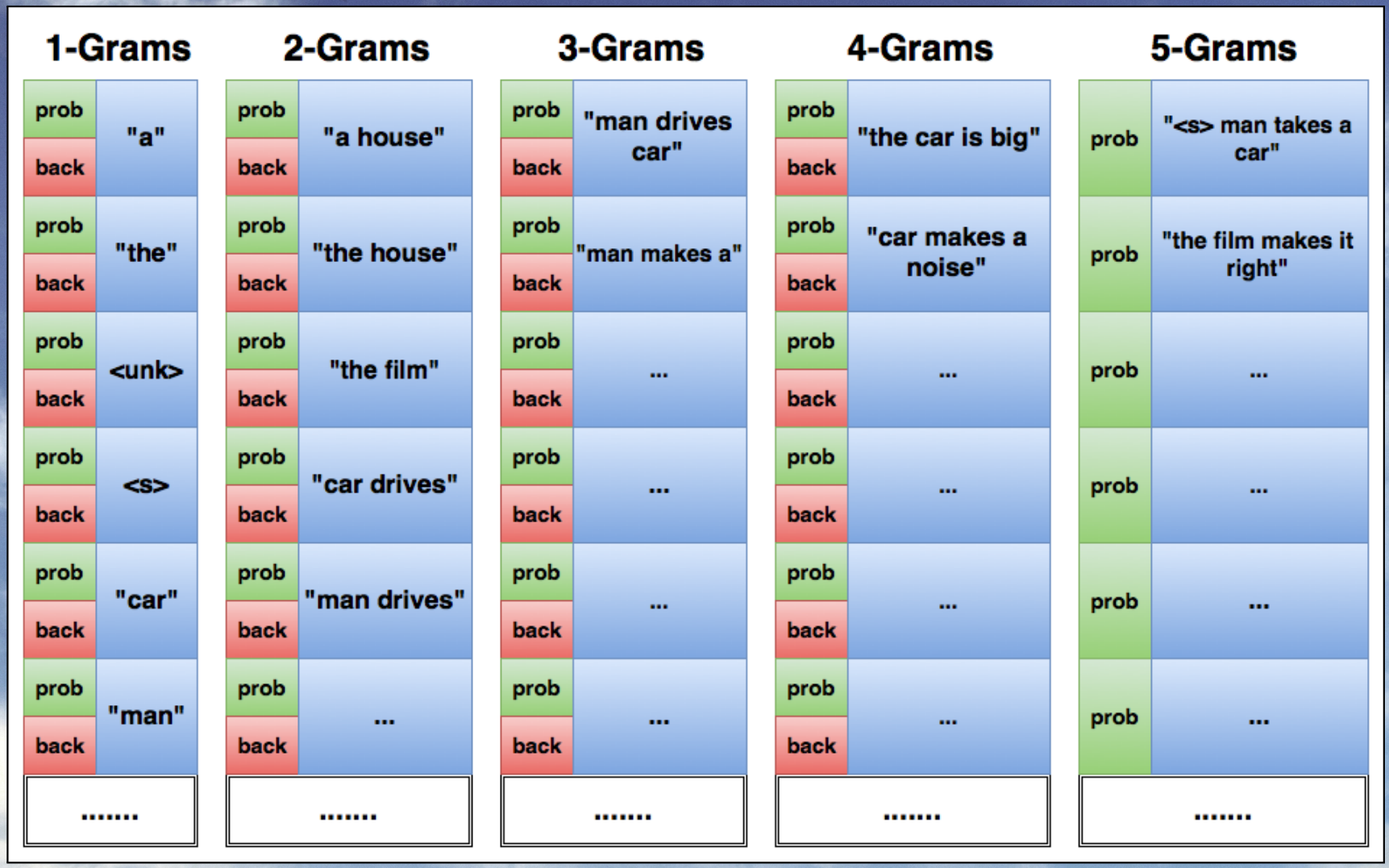
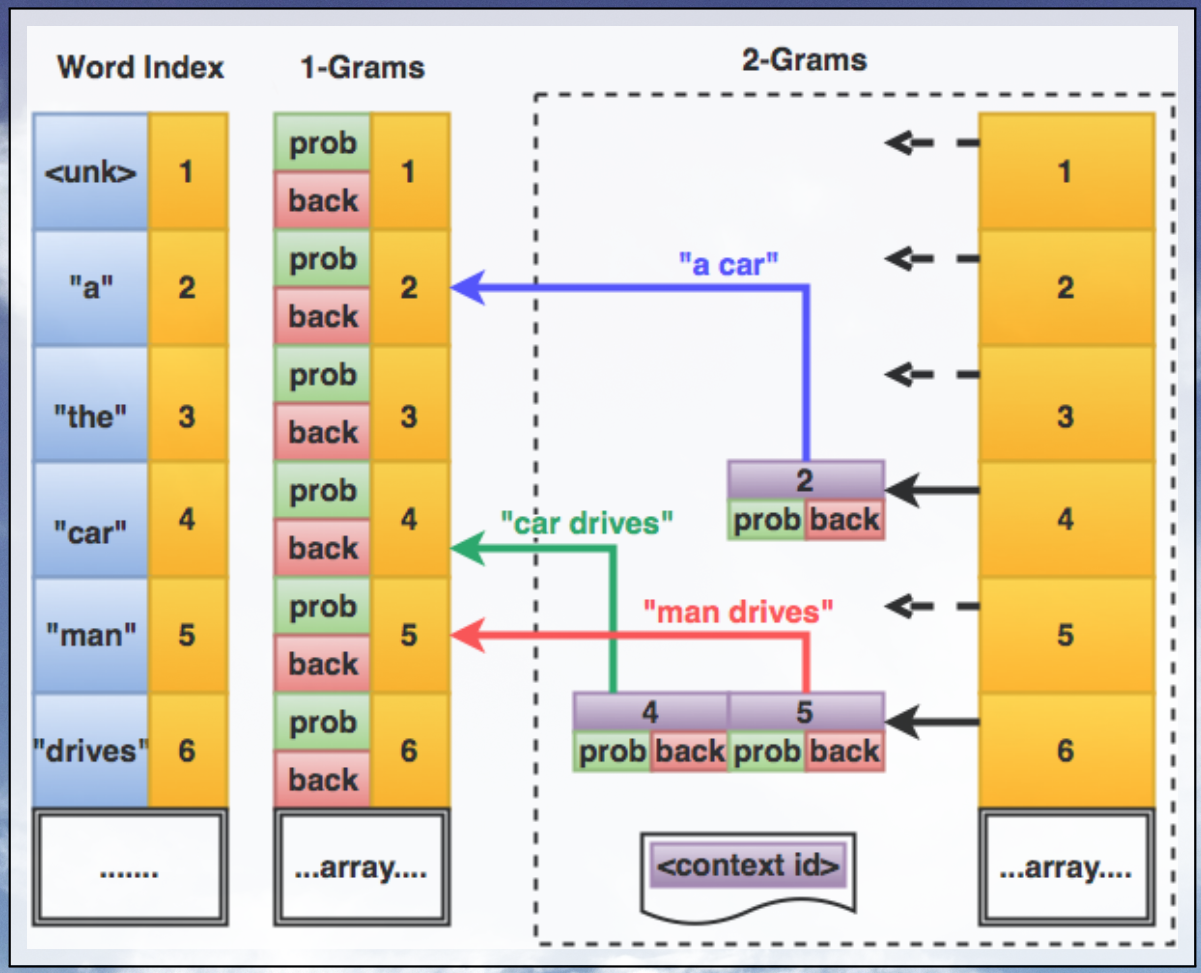
Trie types: Layered, spread *n*-grams



Trie types: Generic, independent *n*-grams

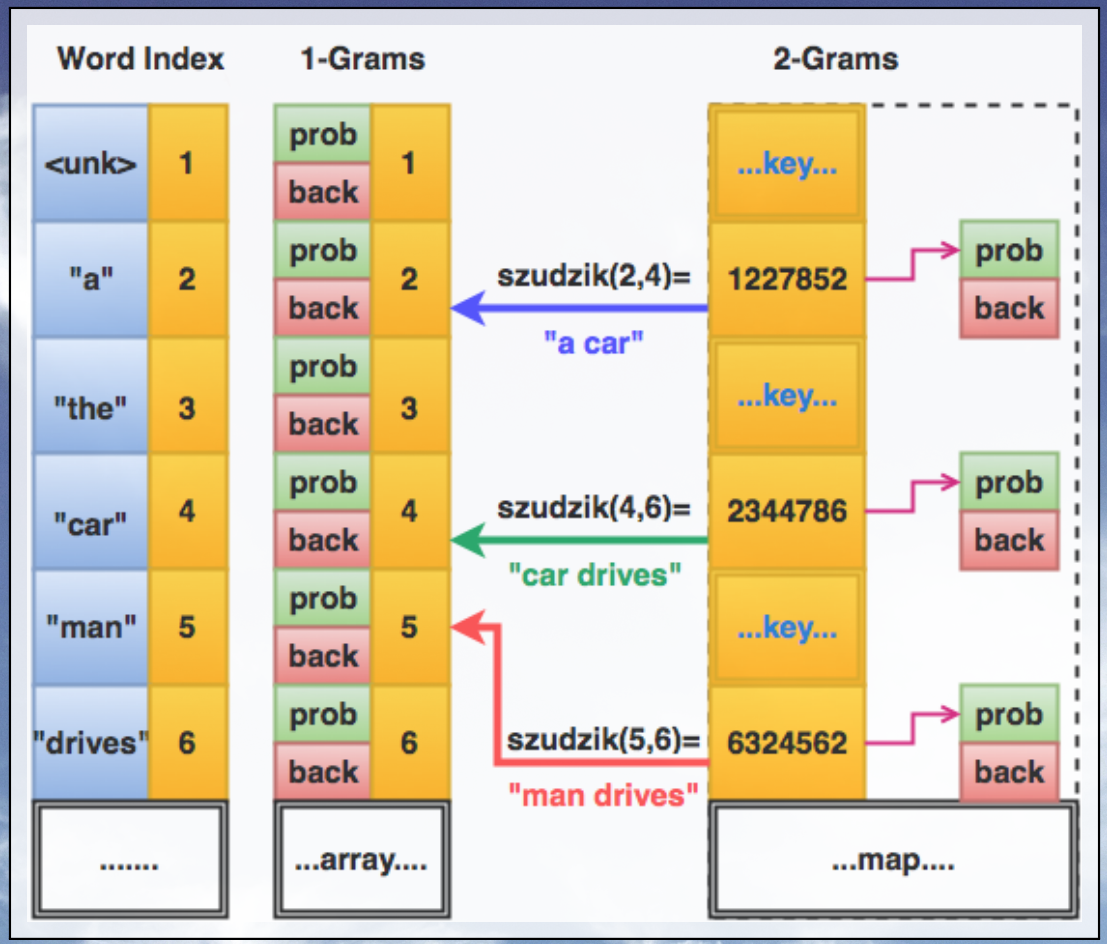


Layered: Word to Context Array (w2ca)



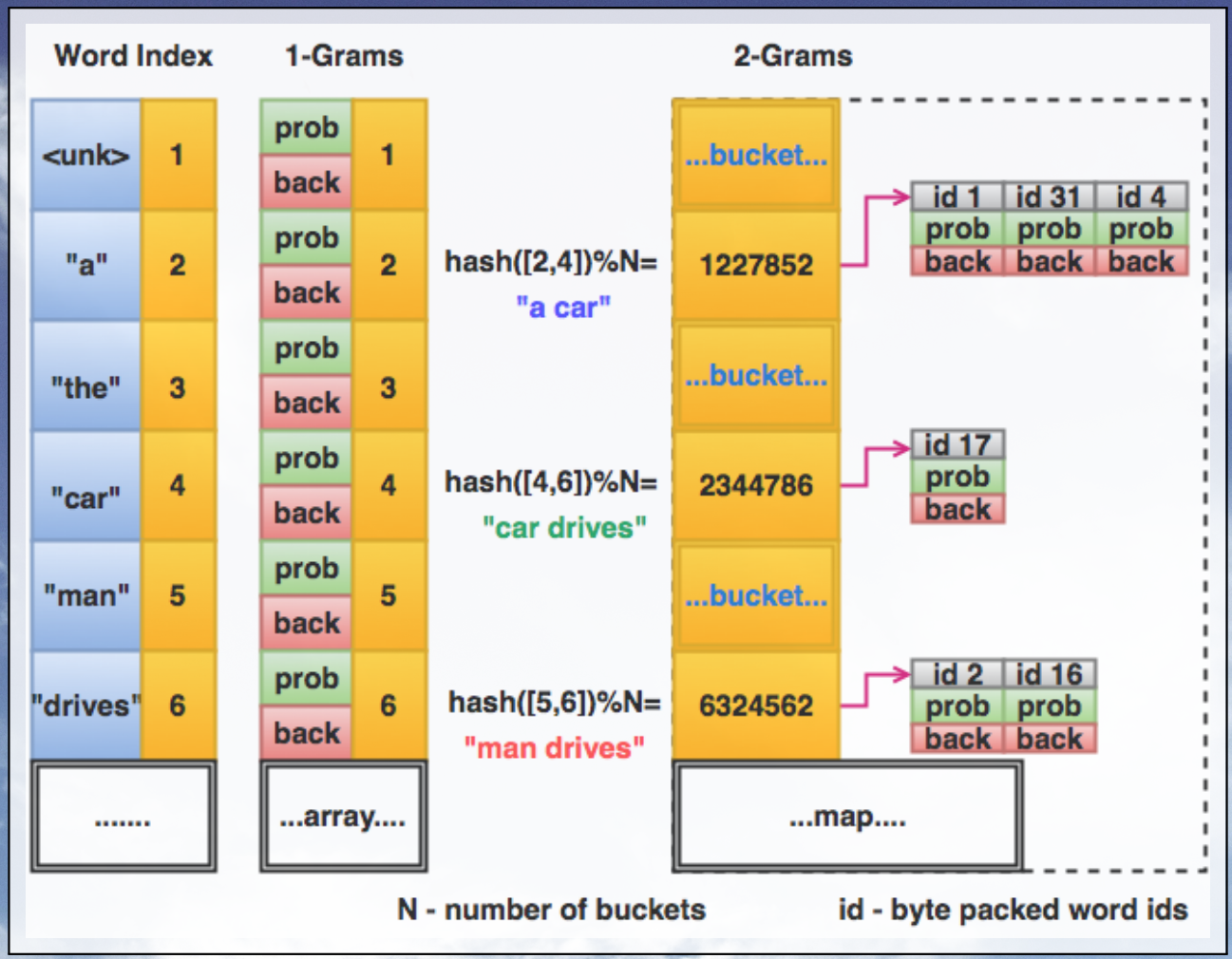
Indexed by word id; Natural Context id; Ordered arrays;
Memory efficient; Binary search;

Layered: Context to Data Map (c2dm)



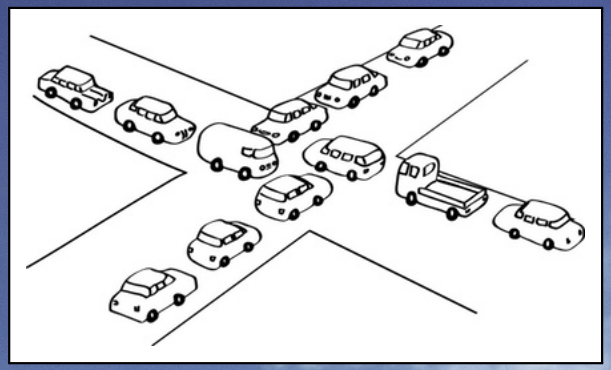
N-gram id via 2D plane enumeration; Unordered hash map; Memory efficient; Constant average time look up;

Generic: Gram to Data Map (g2dm)



Unordered hash map; *n*-gram id from word ids; Memory greedy; Potentially Constant average time look up;

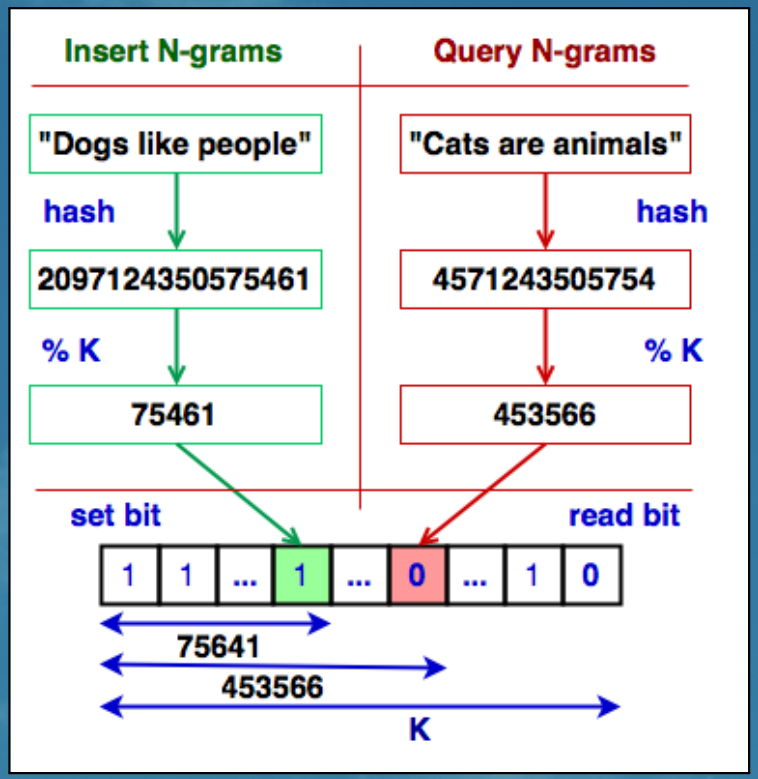
Multi-threading: Are we ready?



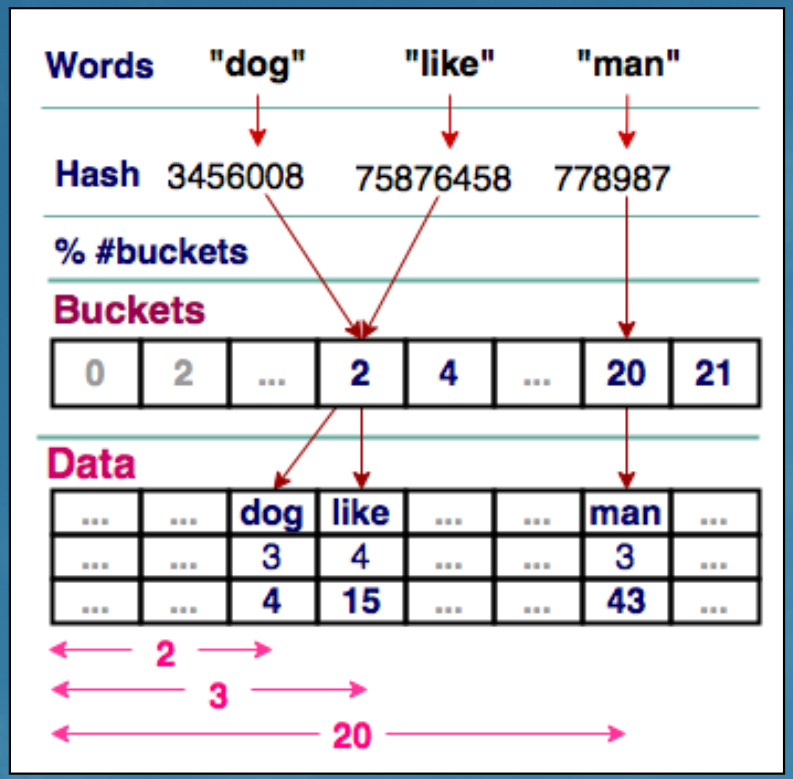
All shared resources are read only, when querying!

Implemented optimizations

- Hash Caching:



- Optimizing Index:



Plus:

- Lower index to more frequent words
- Etc.

Further details: w2ch, c2dh, c2wa, and etc

SEE THE REPORT!

YOUR next great Read?

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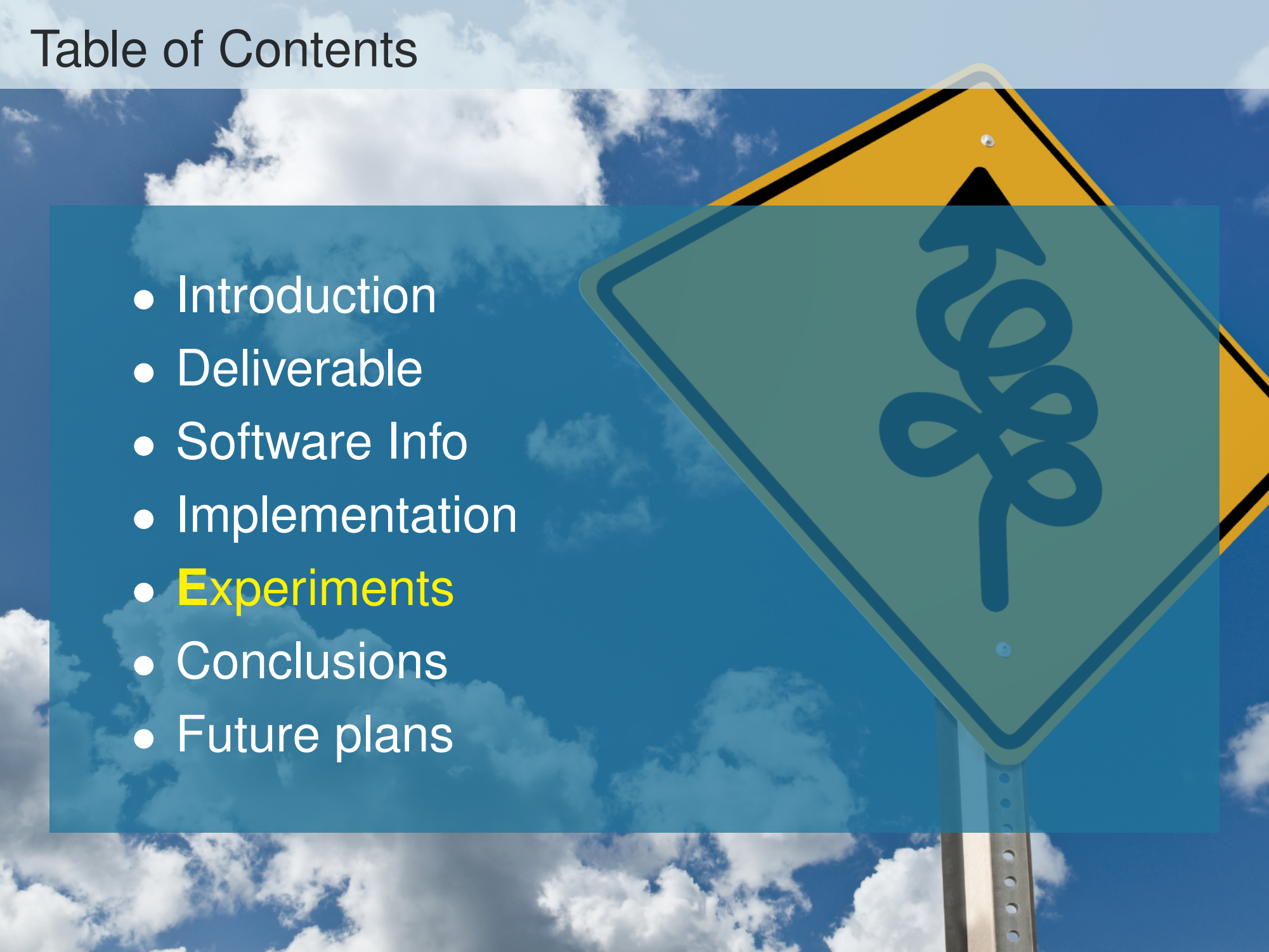
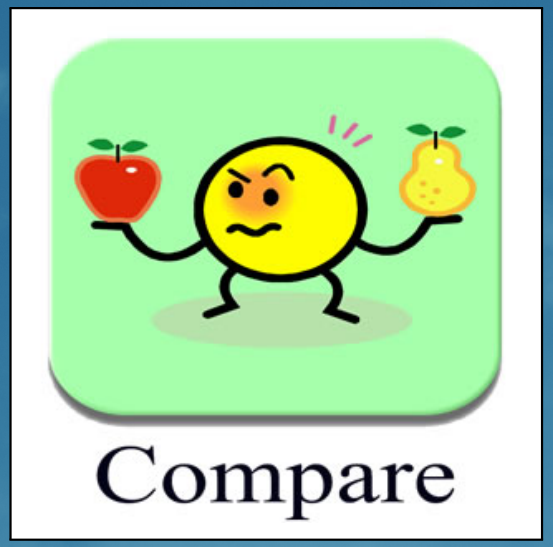


Considered tools and configurations.

- Tools:
  - Our tool:
    - Owl release, v1.0
    - Different trie types
    - Optimizations On/Off
  - KenLM:
    - GitHub snapshot
    - Modified source code
  - SRILM:
    - v1.7.0
- Target:
  - Model MRSS
  - Query CPU times
- Config:
  - Various 5-gram model sizes
  - 10^8 of 5-gram queries



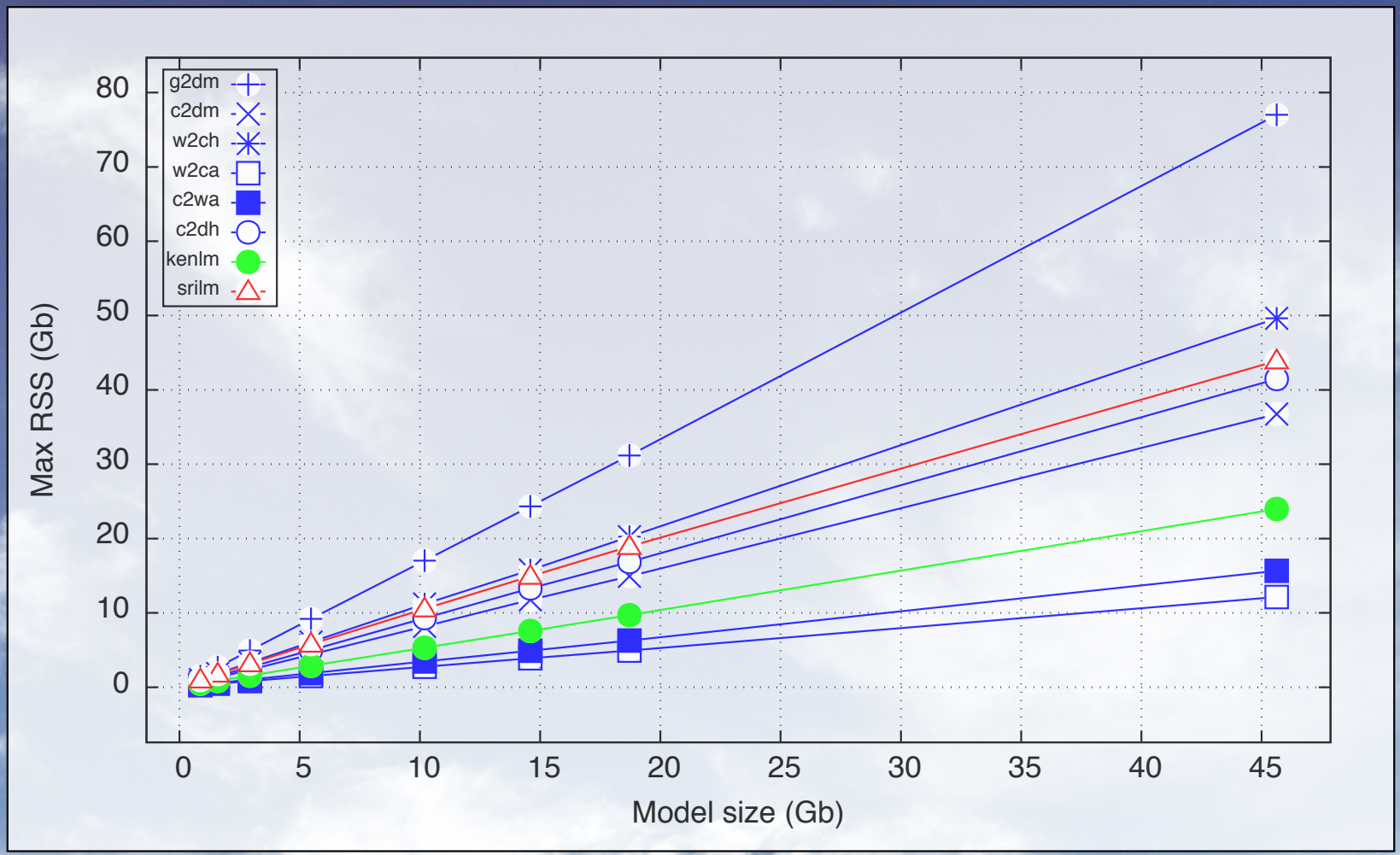
Warning: Not 100% fair!

$$Prob\,(w_5|w_1\,w_2\,w_3\,w_4)$$

vs

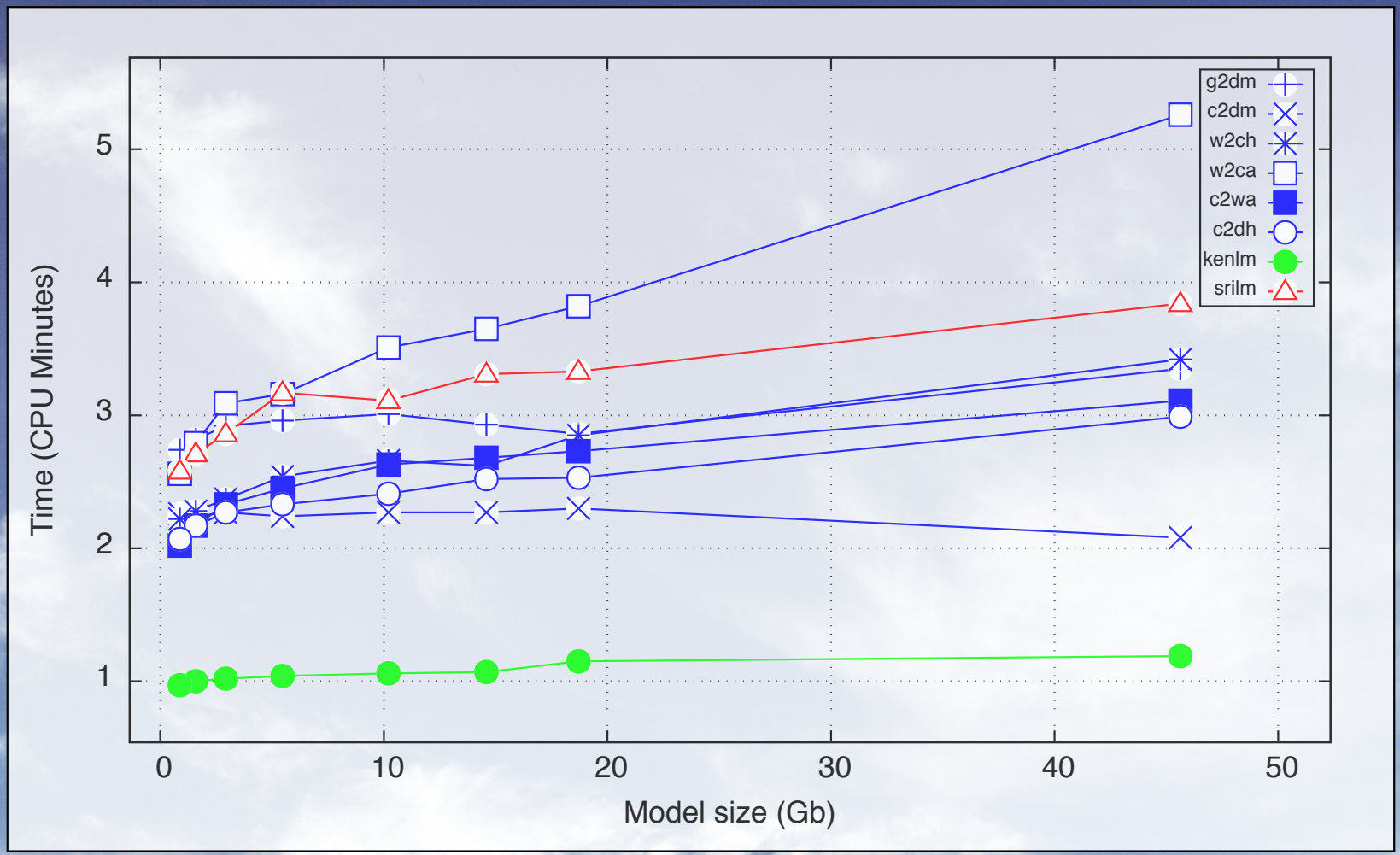
$$\sum_{i=1}^{5} Prob\,(w_i|w_1\,\ldots\,w_{i-1})$$

MRSS: Hash Caching - Off; Optimizing Index - Off



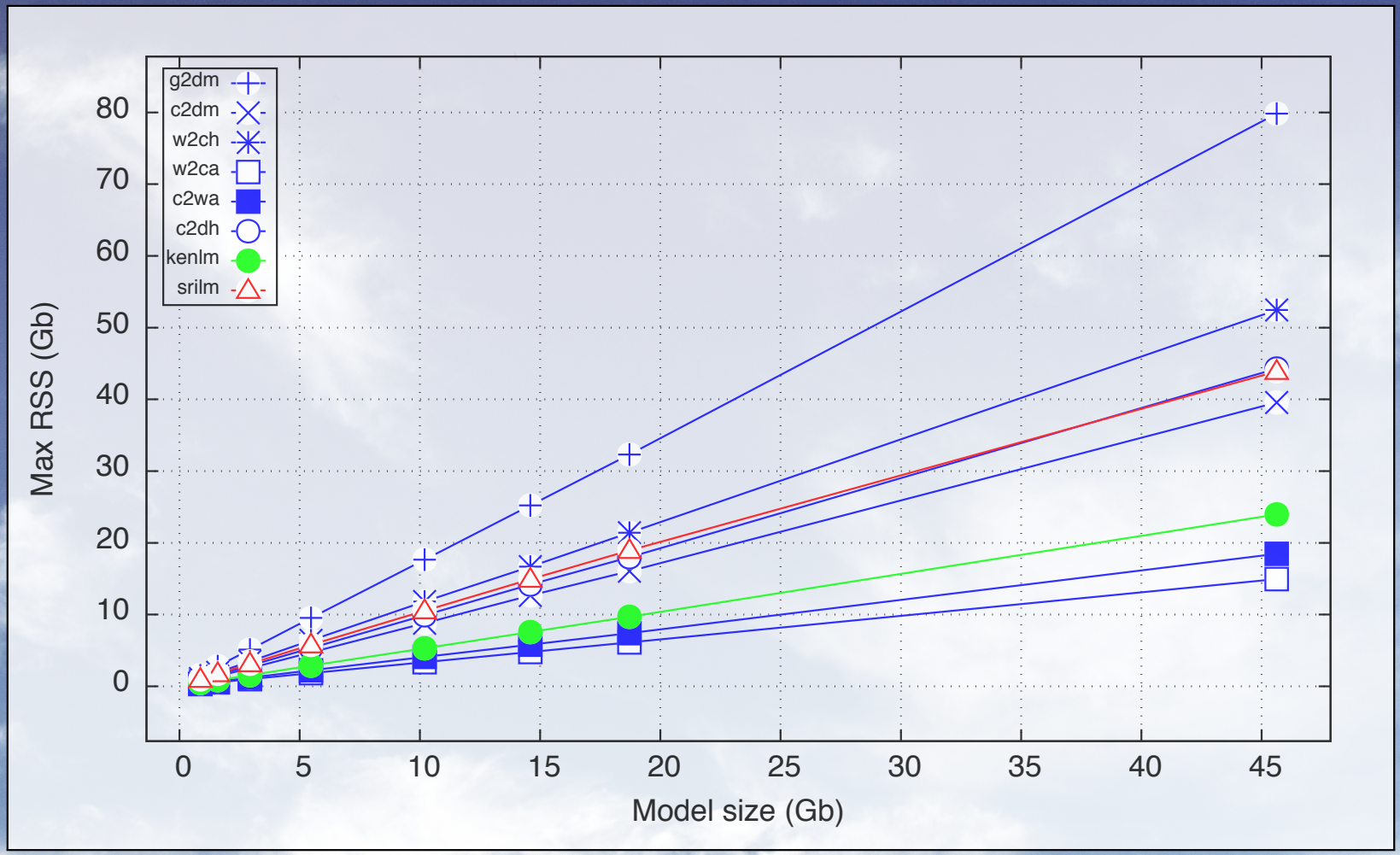
w2ca is 2 times more memory efficient than KenLM ; *c2wa* is almost as efficient ; *g2dm* is the greediest ;

CPU: Hash Caching - Off; Optimizing Index - Off



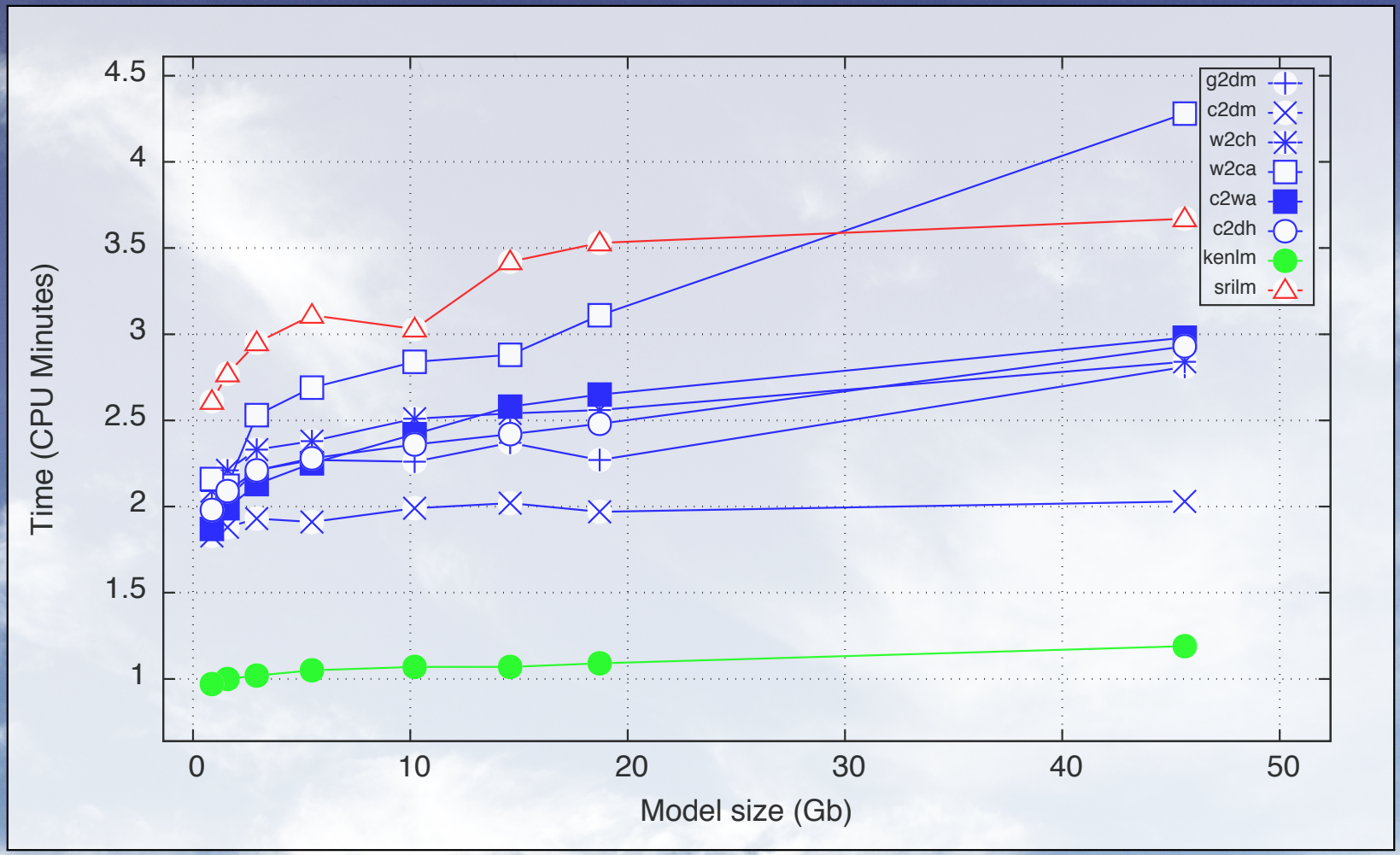
w2ca is the slowest ; *c2dm* is the fast and close to constant ;
c2wa exhibits a decent performance ;

MRSS: Hash Caching - On; Optimizing Index - Off



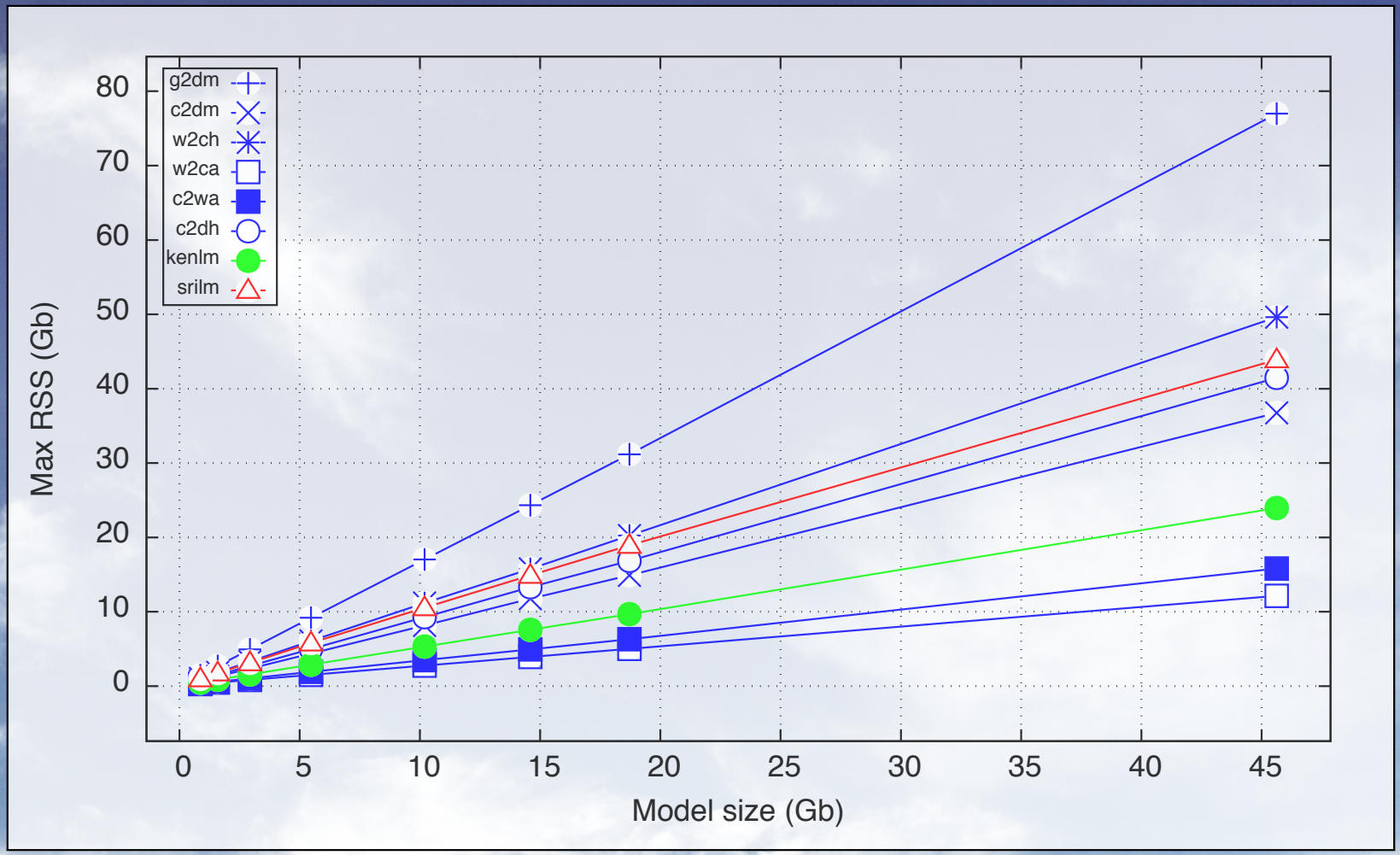
≈ 2.5% memory increase only ;

CPU: Hash Caching - On; Optimizing Index - Off



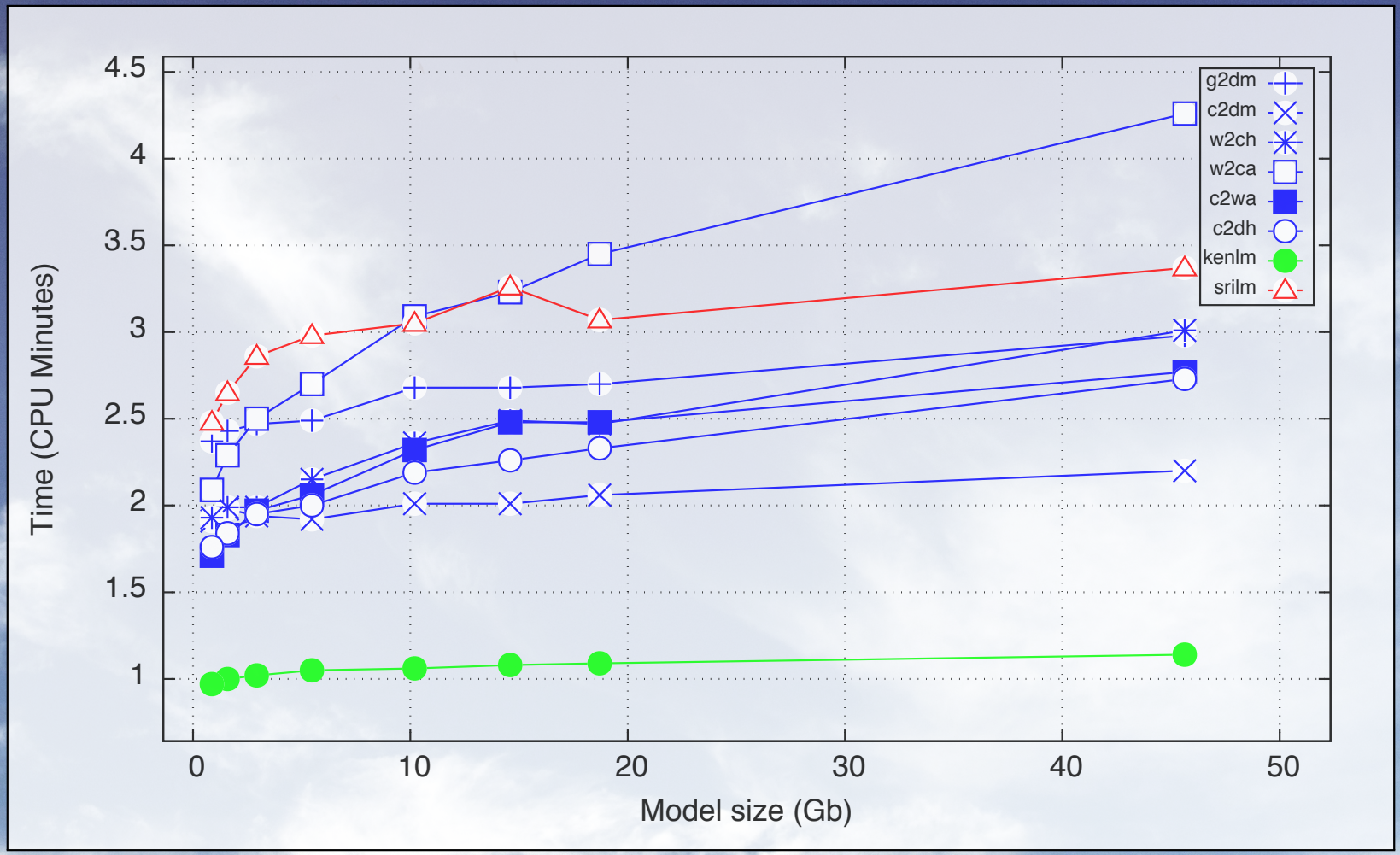
10 to 15 % performance improvement ;

MRSS: Hash Caching - Off; Optimizing Index - On



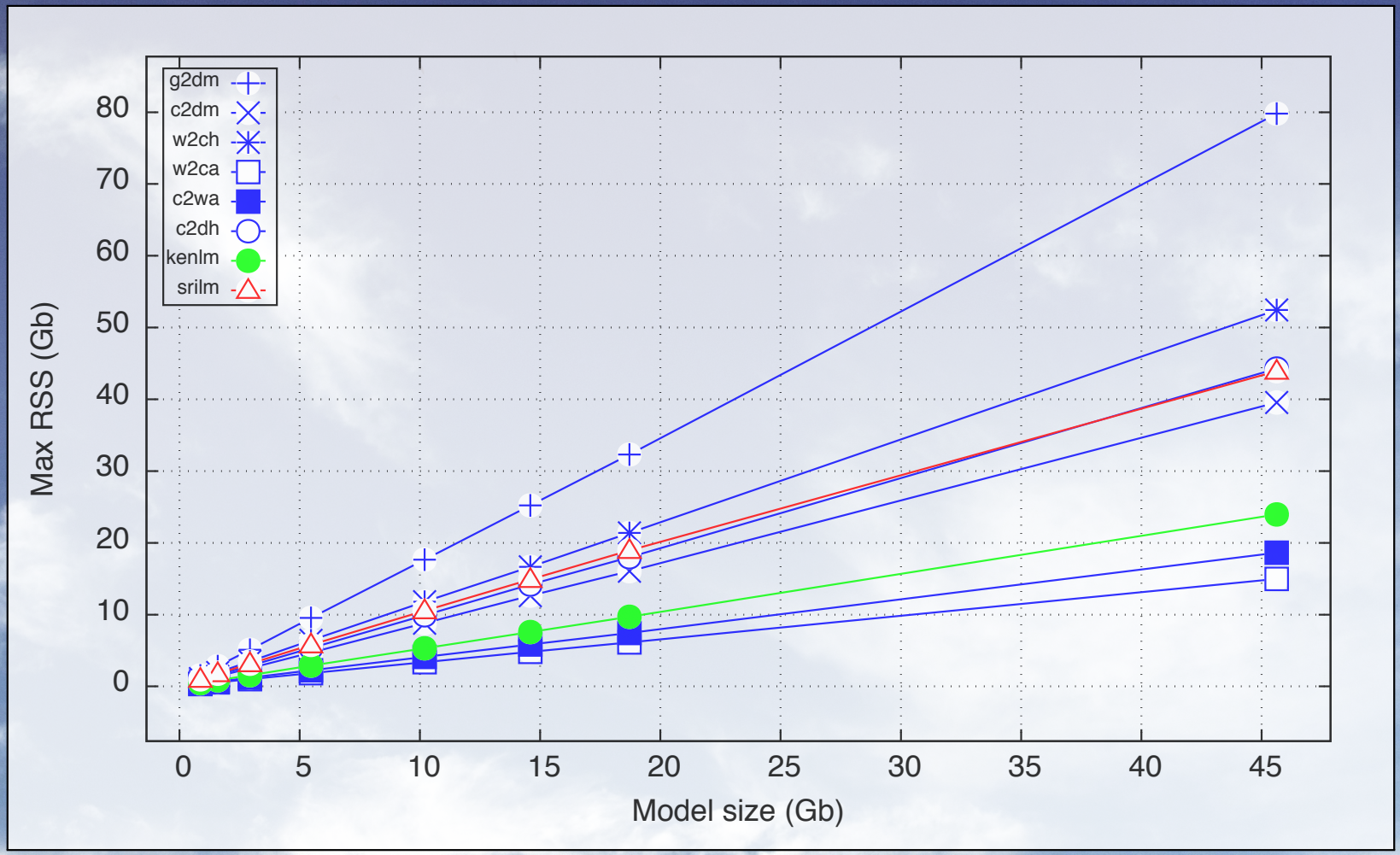
zero memory penalties ;

CPU: Hash Caching - Off; Optimizing Index - On



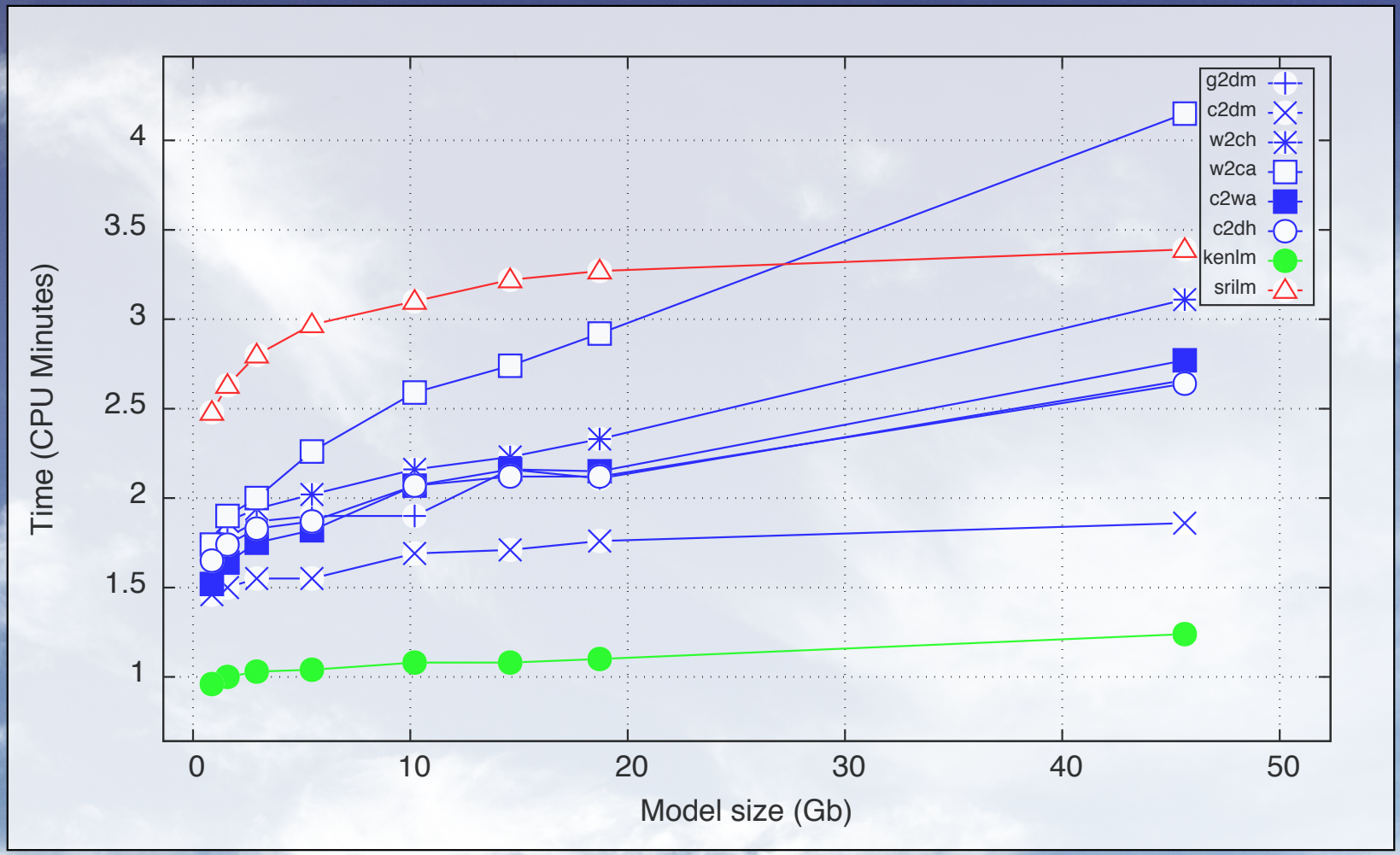
up to 10 % performance improvement ;

MRSS: Hash Caching - On; Optimizing Index - On



cumulative ≈ 2.5% memory increase ;

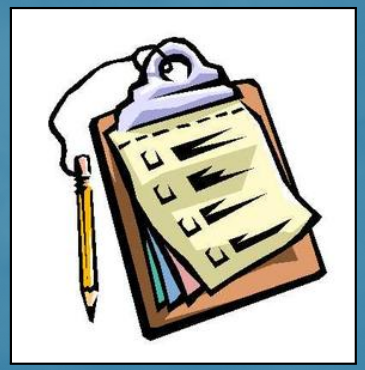
CPU: Hash Caching - On; Optimizing Index - On



cumulative 20 to 25 % performance improvement ;

Experiments: Summary

- Bitmap hashing:
  - 10 to 15% of performance improvement
  - $\approx$ 2.5% extra memory.
- Optimizing word index:
  - up to 10% of performance improvement
  - no extra memory.
- Using layered tries:
  - Small MRSS values
  - Low CPU times
- KenLM (Generic tries):
  - Moderate memory consumption
  - Very fast queries
  - Uses words and (*n*-gram) hashes as unique identifiers!



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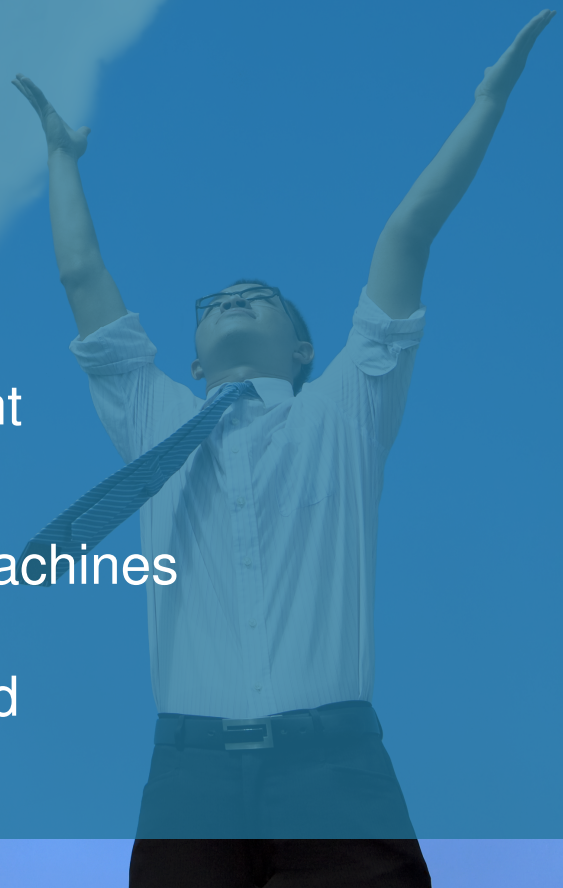
Conclusions



- Developed 6 trie variants
  - Thread-ready
  - Easily extendable
  - Valgrind profiled
- Compared to SRILM and KenLM
  - KenLM is fast but risky
- Layered tries:
  - Up to 70% memory reduction
  - Up to 2 times slower
  - Up to 25% optimization improvement
- Guidelines:
  - *c2wa* and *w2ca* - for low memory machines
  - *c2dm* and *c2dh* - for fast querying
  - *w2ch* and *g2dm* - are to be improved

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- Introduction
- Deliverable
- Software Info
- Implementation
- Experiments
- Conclusions
- **F**uture plans

Future plans: Remaining modifications

1. Introduce parallel querying.
   - Multi-threading within a trie instance.
2. Extend with the KenLM-type trie.
   - Be as good as the competitors!
3. Compute cumulative probabilities.
   - Fair comparison with competitors!

Future plans: Second stage

1. Model data structures
   - Translation
   - Reordering
2. Algorithms
   - Decoder search
   - Pruning strategies

Discussion

Thank you all!