Efficiency for Real-World Applications

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HPC lab

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Myself

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(November 2015 - October 2018)

Thesis defended on 08/03/2019

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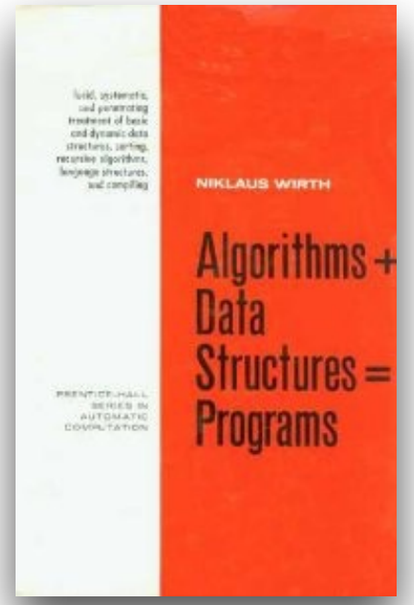
Research

1 Data Structures

how quickly a program does its work - **faster** work



2 Algorithms

how much work is required by a program - **less** work

“A good programmer cares about data structures and their relationships.”

Linus Torvalds

3 Data Compression

What is Efficiency?

Space efficiency means storing the data in **compressed** format.

Time efficiency?

You can use the theory.
Time efficiency means **“low” asymptotic complexity**.

You can (also) run **experiments**.
Time efficiency means:

- cache-friendliness
- few data dependencies
- predictable branches
- super scalar execution

Yet, no textbook can teach you this.

Goal

Design time/space efficient algorithms and data structures with:
- appealing theoretical guarantees;
- a significant impact in practice, i.e.,
  applications to problems at an industrial scale.

Inverted indexes

Google YAHOO! bing

Databases

IBM Dropbox ORACLE

RDF indexing

ontotext

E-Commerce

ebay amazon

Geo-spatial data

Graph-compression

facebook

LinkedIn

Some Problems

Inverted Indexing	TOIS 2017, WSDM 2019, TKDE 2019, CSUR 2020, DCC 2021 https://github.com/jermp/2i_bench
Language Modeling	SIGIR 2017, TOIS 2019 https://github.com/jermp/tongrams
RDF Triples Indexing	TKDE 2020 https://github.com/jermp/rdf_indexes
Query Auto-Completion	SIGIR 2020 https://github.com/jermp/autocomplete
Prefix-Sums	SPE 2020 https://github.com/jermp/psds
Rank/Select Over Bitmaps	INFOSYS 2021 https://github.com/jermp/mutable_rank_select

Inverted Indexing

You have a large collection of Web pages, like several millions.
Given *k* words, how to find all Web pages
where these words occur?

Build an inverted index data structure.

On Gov2 (~5 billion integers):

- Use PEF (SIGIR 2014) for **3.12 bits/int** and **3 ms/query**
- Use Slicing (DCC 2021) for **4.31 bits/int** and **1 ms/query**

Language Modeling

amazon alexa

Google Translate

You have a large collection of q-grams, like 11 billions.
How, given a q-gram, return its context probability
as fast as possible?

Build a compressed trie data structure.

On GoogleBooksV2 (~11 billion q-grams):

- Use EF-Trie (SIGIR 2017, TOIS 2019) for **1.31 bytes/q-gram** and **2 µs/query**
- KenLM (best alternative) is much larger with scalability problems

RDF Triples Indexing

You have a large collection of RDF triples (S,P,O), like 350 millions.
Given a wildcard query like (? ? O) or (? P ?),
how to return all matching triples?

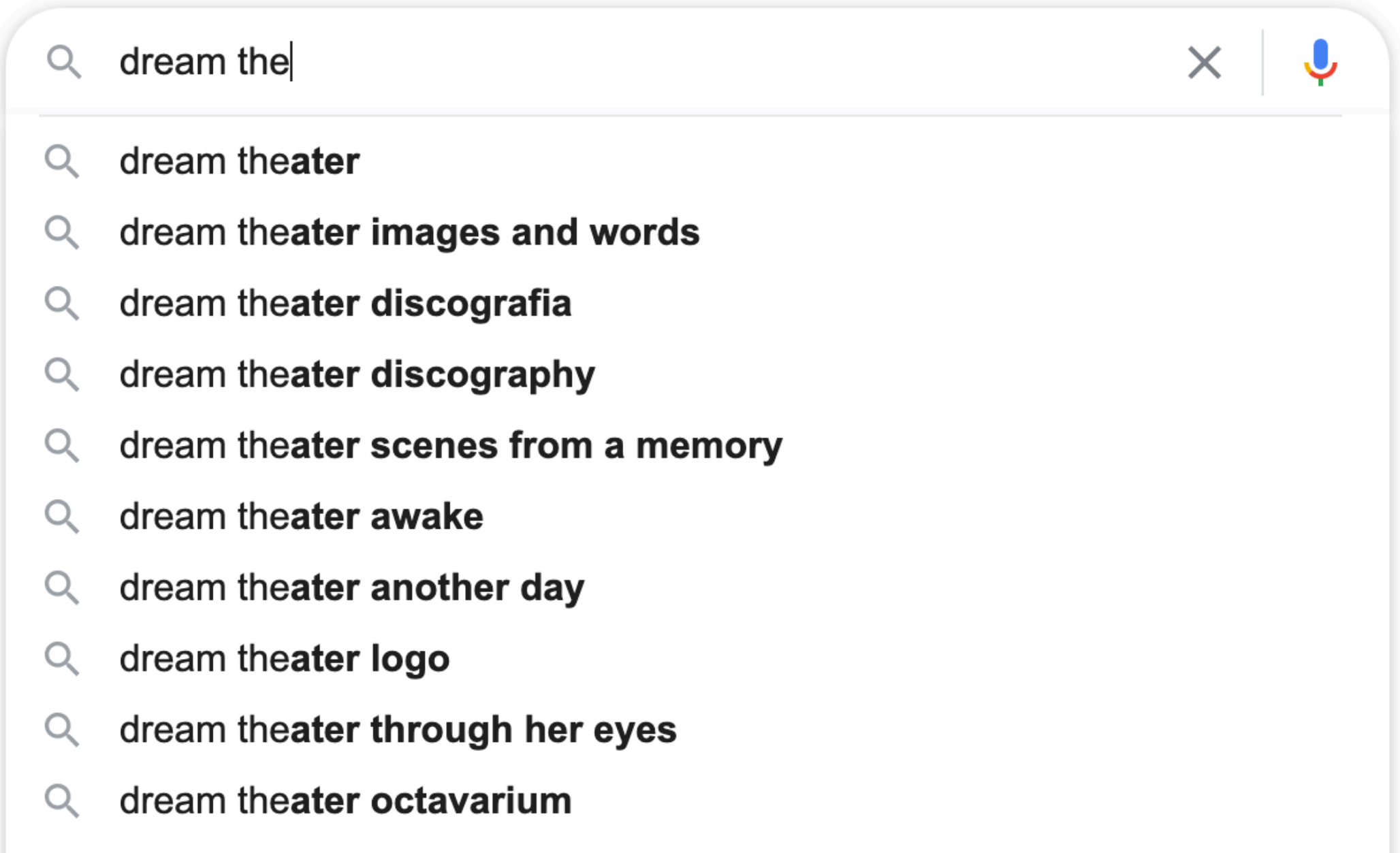
Build a compressed trie data structure.

On DBpedia (~350 millions of triples):

- Use HDT (W3 standard) for **77 bits/triple**
- Use 2T/3T (TKDE 2020) for **54 bits/triple** but **3-5X** faster queries on average

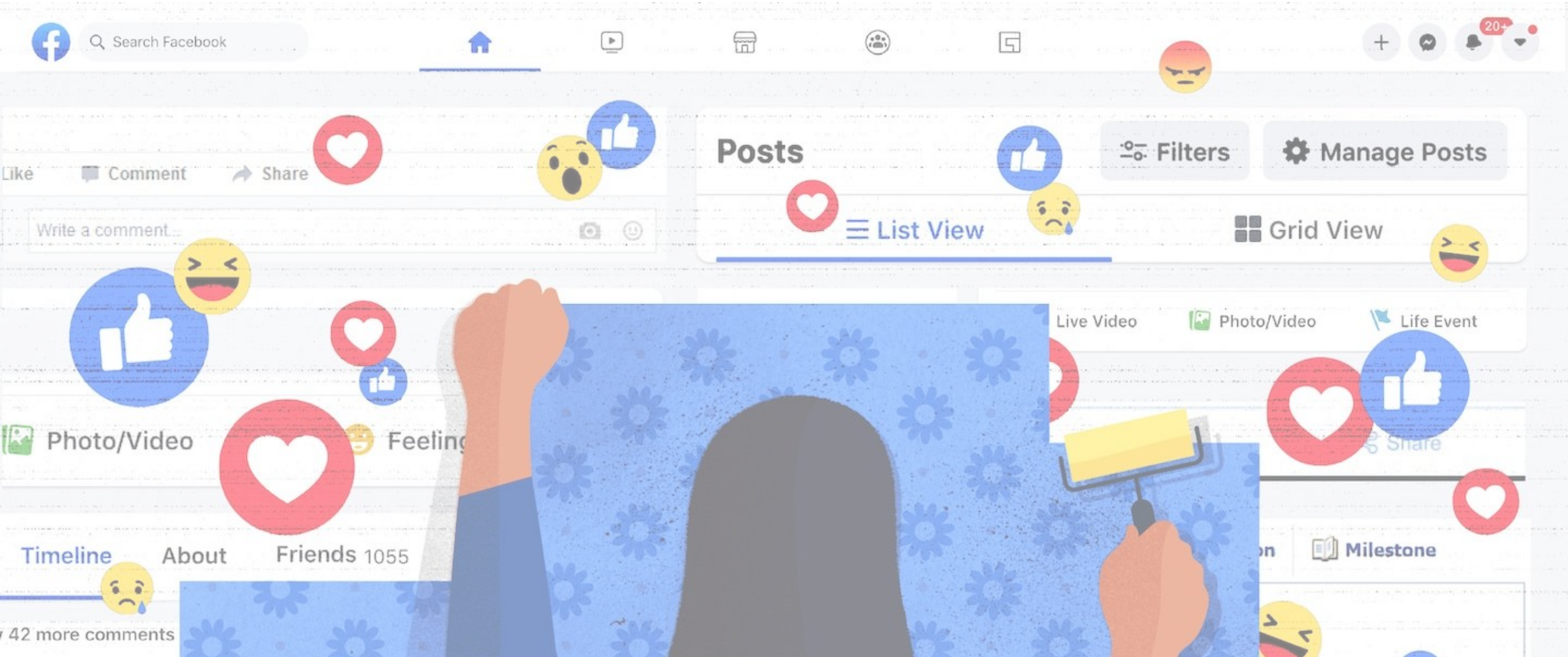
Query Auto-Completion

Given a collection S of scored strings and a partially completed user query Q,
how to find the top-*k* strings that “match” Q in S?



Puzzle

You work at Facebook. Your task is to find which users didn't ever create a post with an emoji. You have the list of users (2 billions), which you can scan several times, and a huge list of posts (user and text), which you can scan only once.
Also, you have one computer, with 1 GB of RAM. Can you do it? How?



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Minimal Perfect Hashing

Take-home messages

- **Efficiency to deliver better services by using less resources. Impact is far-reaching and implies substantial economic gains.**

- **Compression is mandatory if your data are “big”.**

- **Experiments are primary: design driven by numbers.**

Drop me a line if you are interested in this stuff!

Thanks for your attention!

Any questions?