Large-scale compression of software source code

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Why data compression?

It provides rich dividends:

- Space saving, of course!
  - … and thus, reduced storage and transmission costs
- Energy saving: less servers involved
- Speed: not so obvious!
  - better exploitation of the memory hierarchy
  - reduced burning out of sectors in SSD disks
  - no need to decompress the whole data, in some approaches

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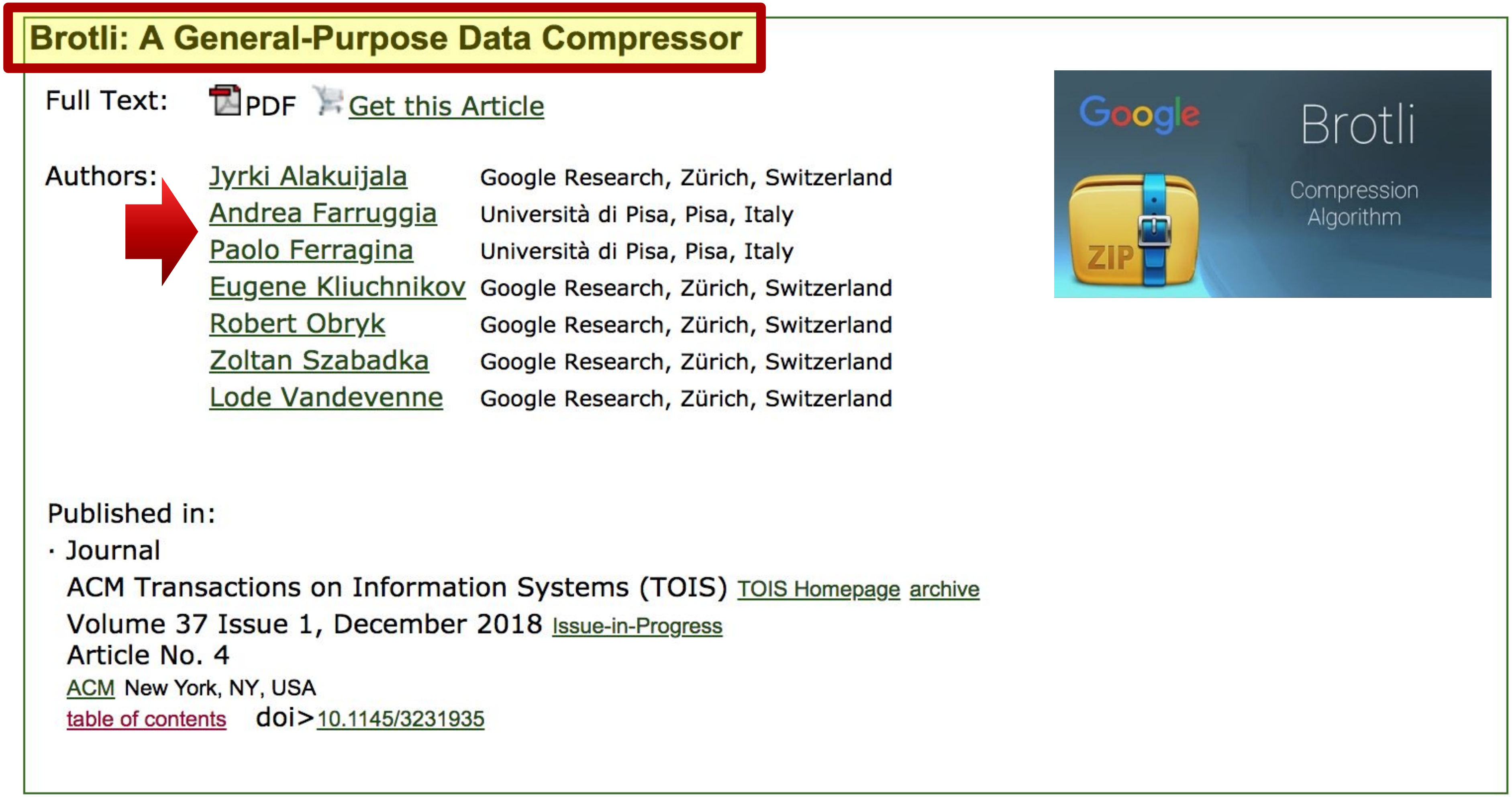
The edition of 2016



Brotli: A General-Purpose Data Compressor

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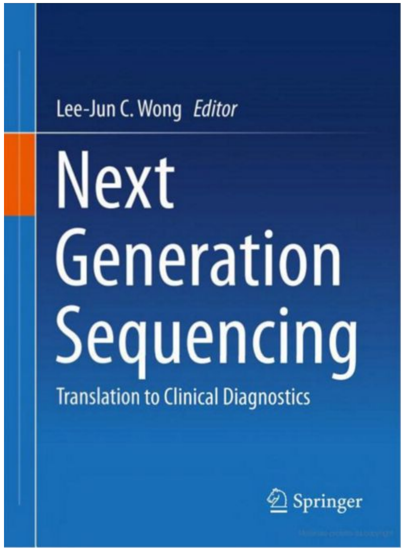
Searching Compressed Data

FM-index

We were the first in 2000 to show how to search *compressed* data, without decompressing all of them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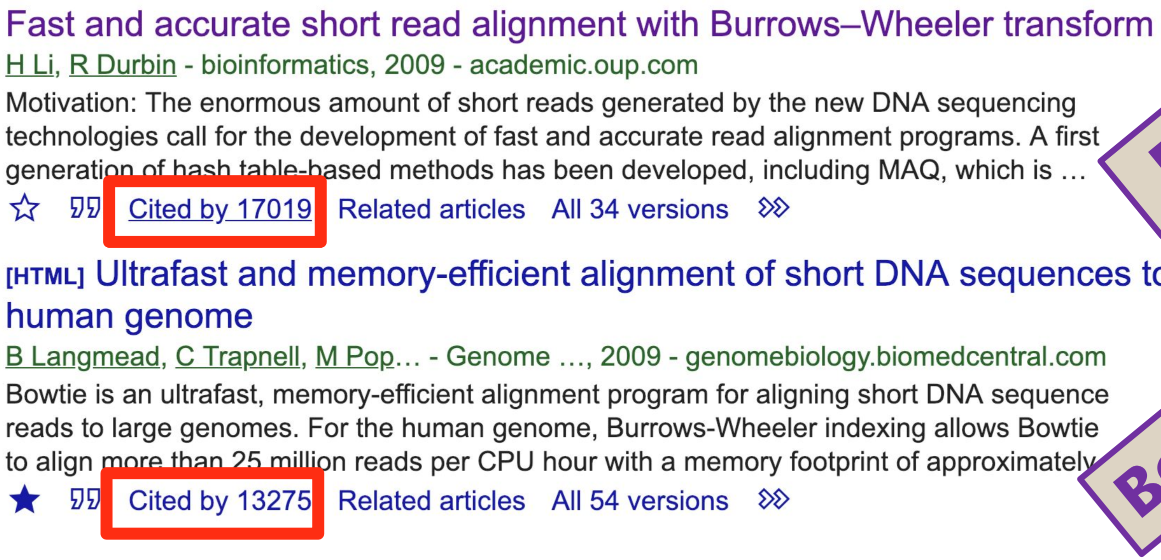
Fast and accurate short read alignment with Burrows–Wheeler transform

H Li, R Durbin - bioinformatics, 2009 - academic.oup.com

Motivation: The enormous amount of short reads generated by the new DNA sequencing technologies call for the development of fast and accurate read alignment programs. A first generation of hash table-based methods has been developed, including MAQ, which is …

☆ 99 Cited by 17019 Related articles All 34 versions »

[HTML] Ultrafast and memory-efficient alignment of short DNA sequences to the human genome

B Langmead, C Trapnell, M Pop… - Genome …, 2009 - genomebiology.biomedcentral.com

Bowtie is an ultrafast, memory-efficient alignment program for aligning short DNA sequence reads to large genomes. For the human genome, Burrows-Wheeler indexing allows Bowtie to align more than 25 million reads per CPU hour with a memory footprint of approximately …

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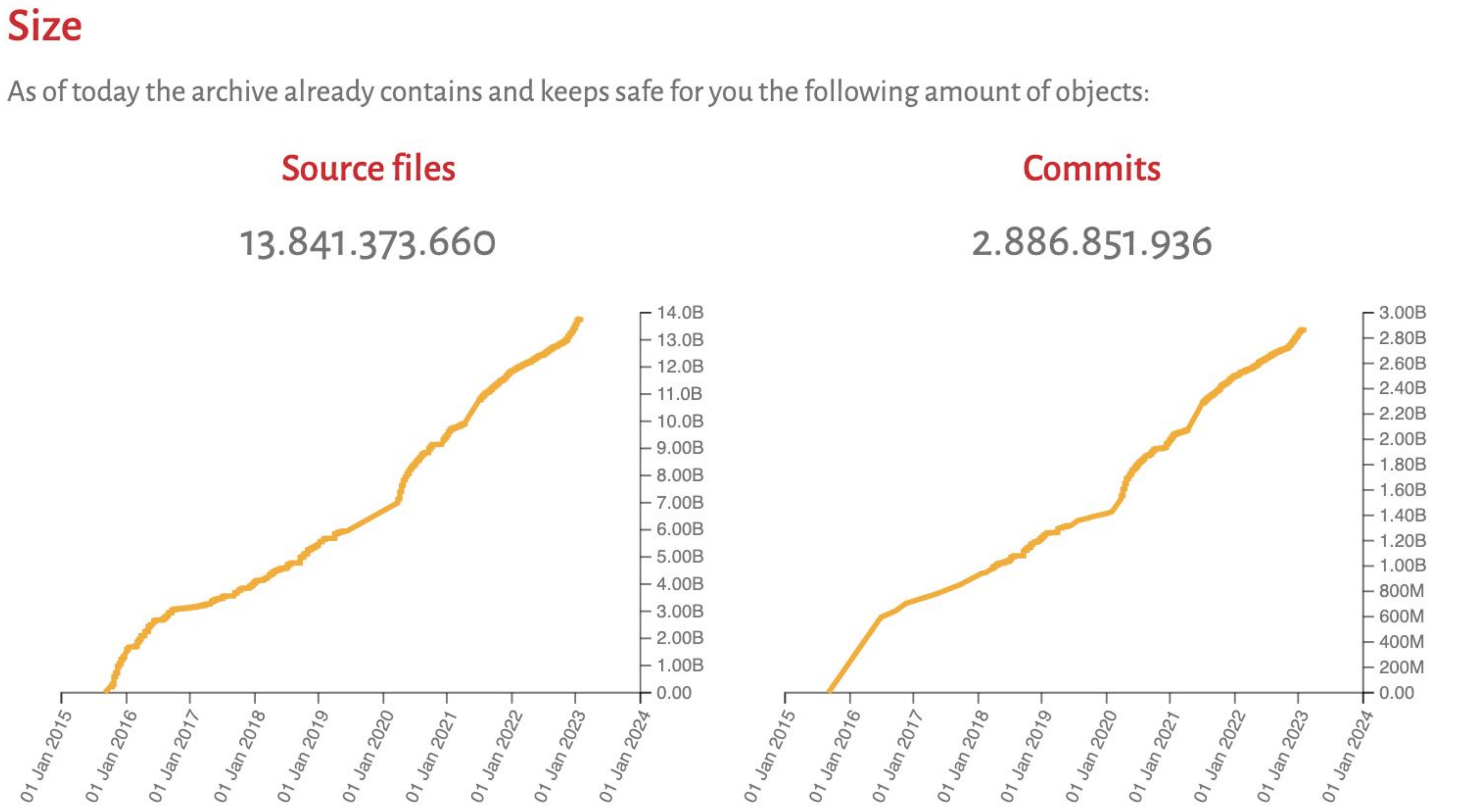
BWA

BowTie

The Software Heritage...



Size

As of today the archive already contains and keeps safe for you the following amount of objects:

Source files

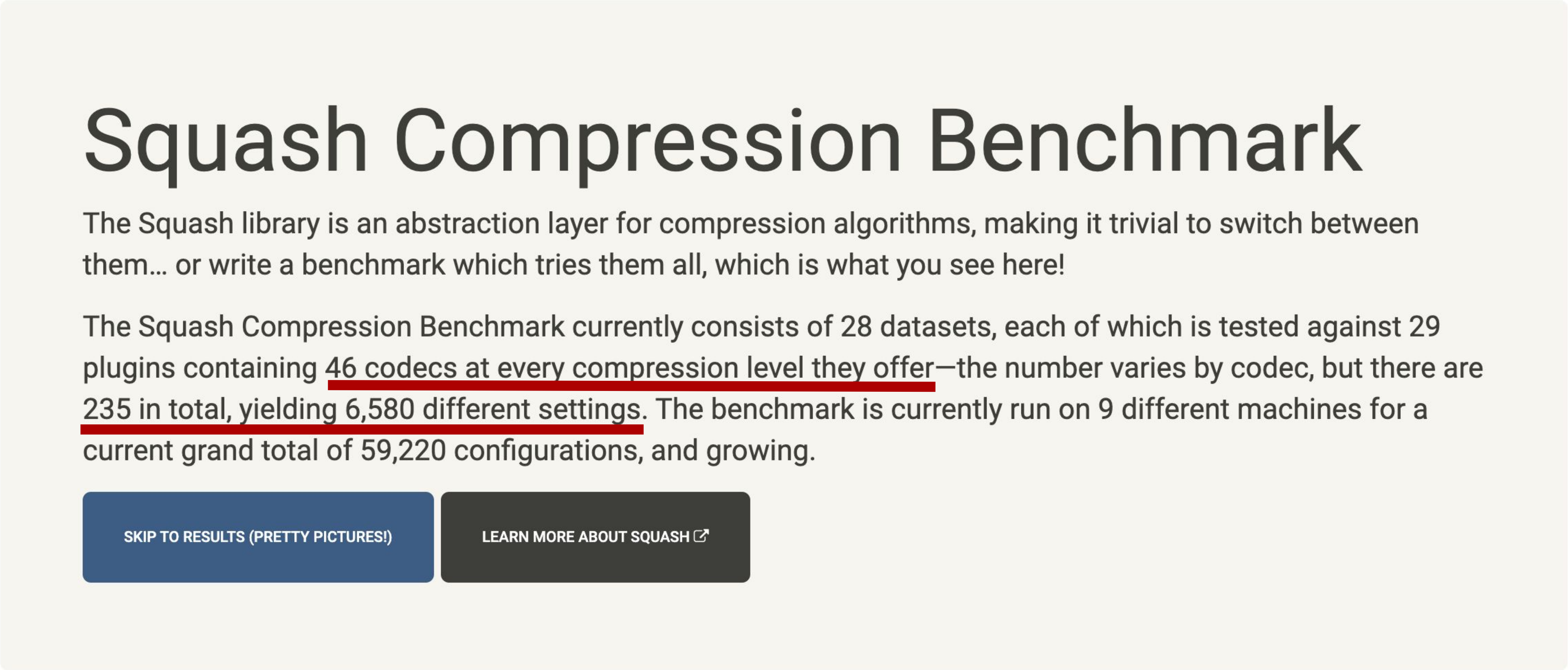
13.841.373.660

Commits

2.886.851.936

Raw space (files) is about 1 PetaByte (10^{15} bytes)

How to approach the problem?



Squash Compression Benchmark

The Squash library is an abstraction layer for compression algorithms, making it trivial to switch between them… or write a benchmark which tries them all, which is what you see here!

The Squash Compression Benchmark currently consists of 28 datasets, each of which is tested against 29 plugins containing 46 codecs at every compression level they offer—the number varies by codec, but there are 235 in total, yielding 6,580 different settings. The benchmark is currently run on 9 different machines for a current grand total of 59,220 configurations, and growing.

Three main families of compressors

[1977] Lempel-Ziv parsing and its derivatives

- The classic approach, made famous by **gzip**
- A revamped interest around it: 7z, zstd, brotli, lzfse, …

[1994] Burrows-Wheeler Transform and its derivatives

- Better entropy-bounds than gzip-like compressors (□ **bzip**)
- But building a ***big*** BWT is costly and complicated…

[2000] Compressed (self-)indexes: offer space/decompress trade-offs

- **FM-index**, CSA, LZ-trie,… [Ferragina-Manzini, J.ACM '05]
  - In the compressed space, they include text + (full-text) index
  - Query/Decompression time is theoretically optimal

New compressors are based on sophisticated ML models, but slow.

Something to be careful…

We are talking about compressing a:

✓ **collection of files** of **different types.**

We have to apply a different compression scheme:

PPC: Permute + Partition + Compress

and study it in two experimental scenarios

- **BackUp** for the streaming access to compressed data
- **Random access** to single compressed files

Two main issues to deal with:

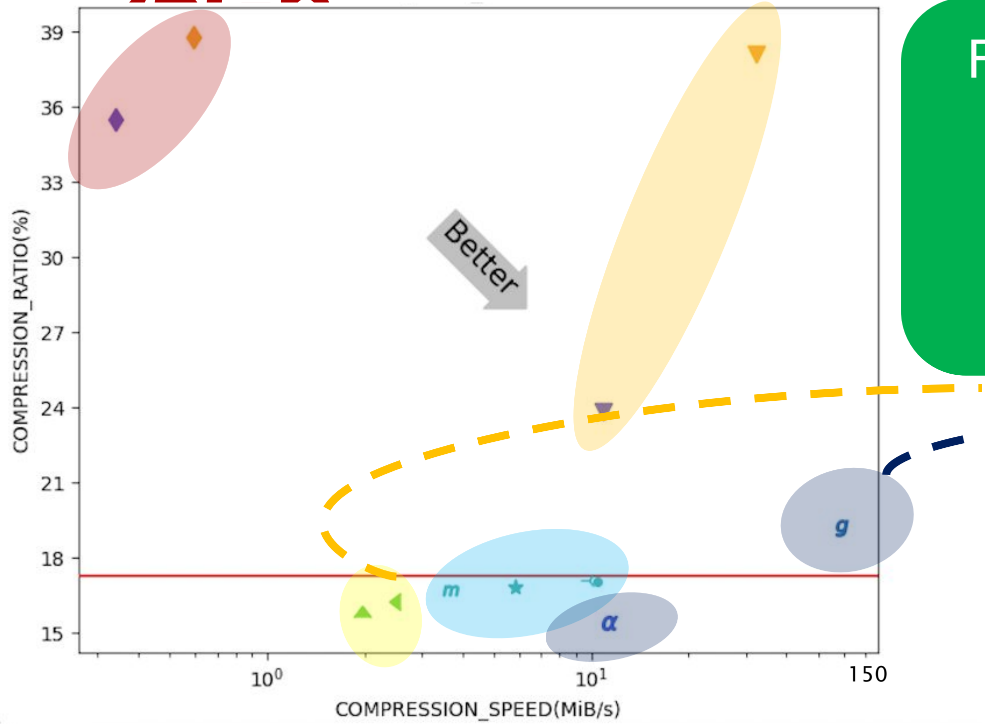
- Permuting based on which information ? filename, path, file type, content,…
- Partitioning based on which block size ? BackUp/Random access, compressor,..

Our experimental framework

The C and Python repositories in Github with **most *stars*,** each consisting of about 25 Gb.

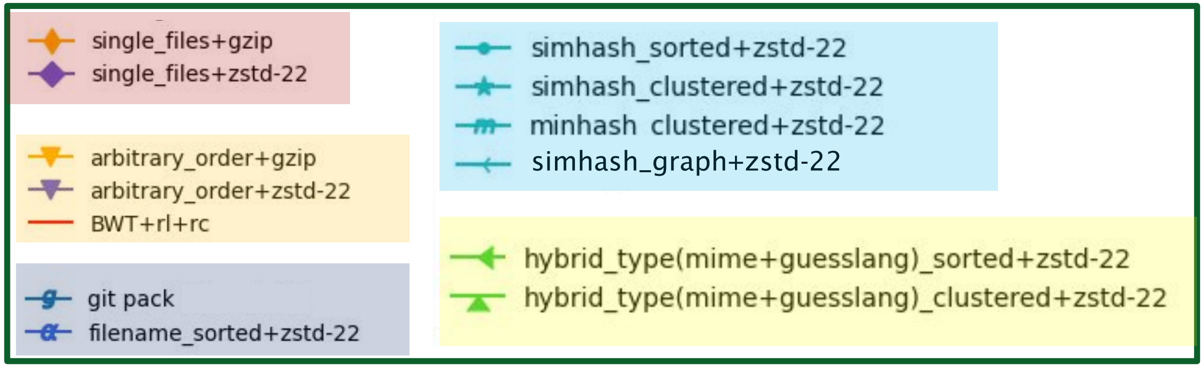
redis
NGINX
Brot
li
ZStandar
d
K Keras
A deep learning library
curl://
Google AI
NLP BERT
PyTorch
scikit
learn

BackUp scenario: Python files ≅ 25Gb



For random access, even with 4 MB blocks, HYBRID is very robust by loosing only about 1% in compression ratio wrt Backup scenario

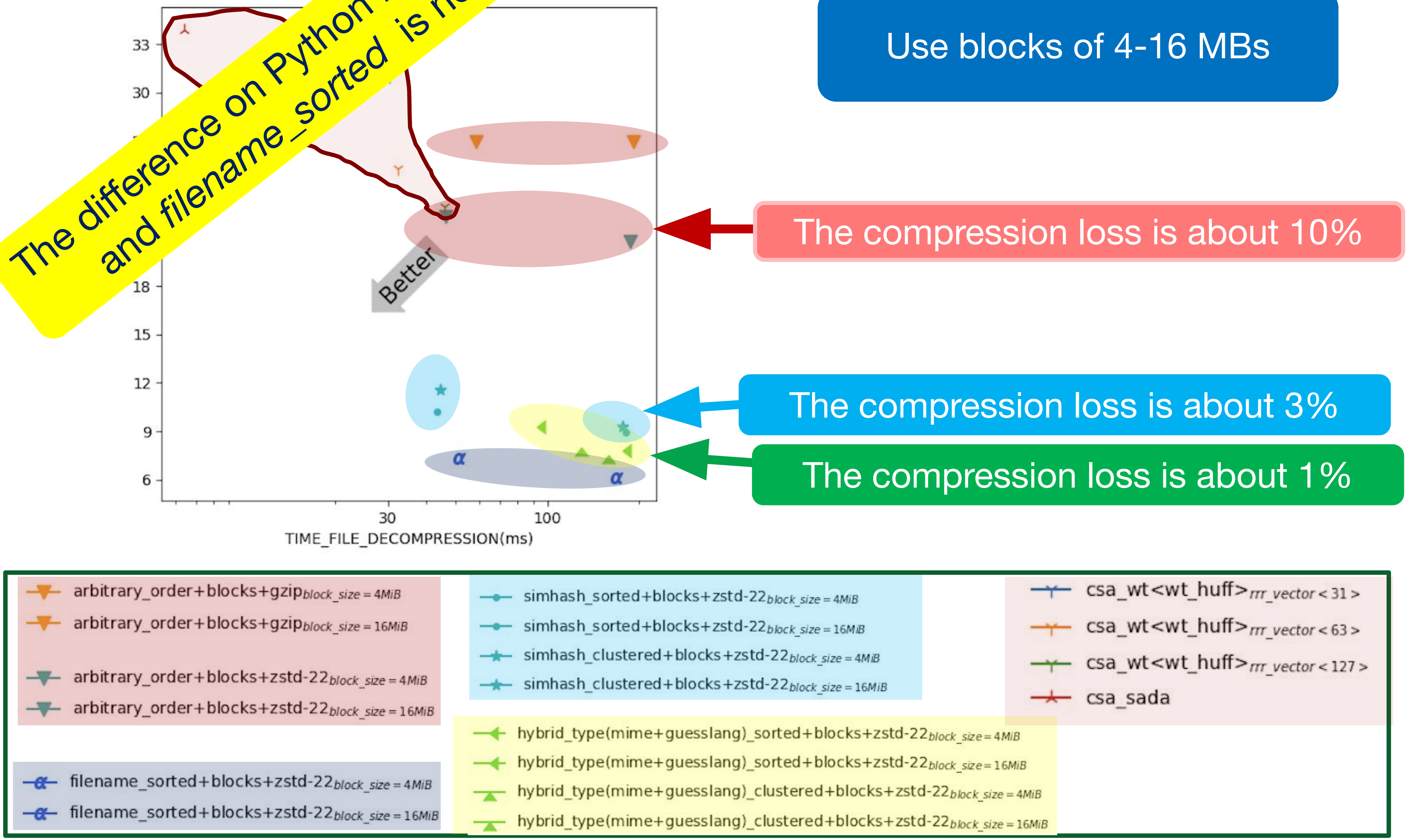
On C files we get about 6% vs 27% compr. ratio of gzip



Random access: C files ≅ 25Gb

The difference on Python between hybrid and filename_sorted is negligible

Use blocks of 4-16 MBs



The compression loss is about 10%

The compression loss is about 3%

The compression loss is about 1%

The moral...

We compared **Data-aware-PPC** versus **Context-aware** approaches (à la GitPack), achieving the following results:

- Our features subsume the "context" at a larger decompression speed than GitPack
- They are robust with respect to block size
- zstd is a good compressor: large window at 100MB/sec speed

Next, we aim at:

- Investigating other orderings and partitionings
- C++ coding & HPC is needed because a single machine would take about 3 months of computation (≅ 200 Tb space at about 4k euro).

It’s time to try it on the whole SH