Report on improvements in the HDF5/Blosc2 integration

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LEAPS INNOV Meeting -- Kraków, Poland
April 8th 2024

Agenda

Plugins for **JPEG2000**

Support for **Blosc2 Ndim in HDF5**

Btune: Predicting the **best codecs and filters**

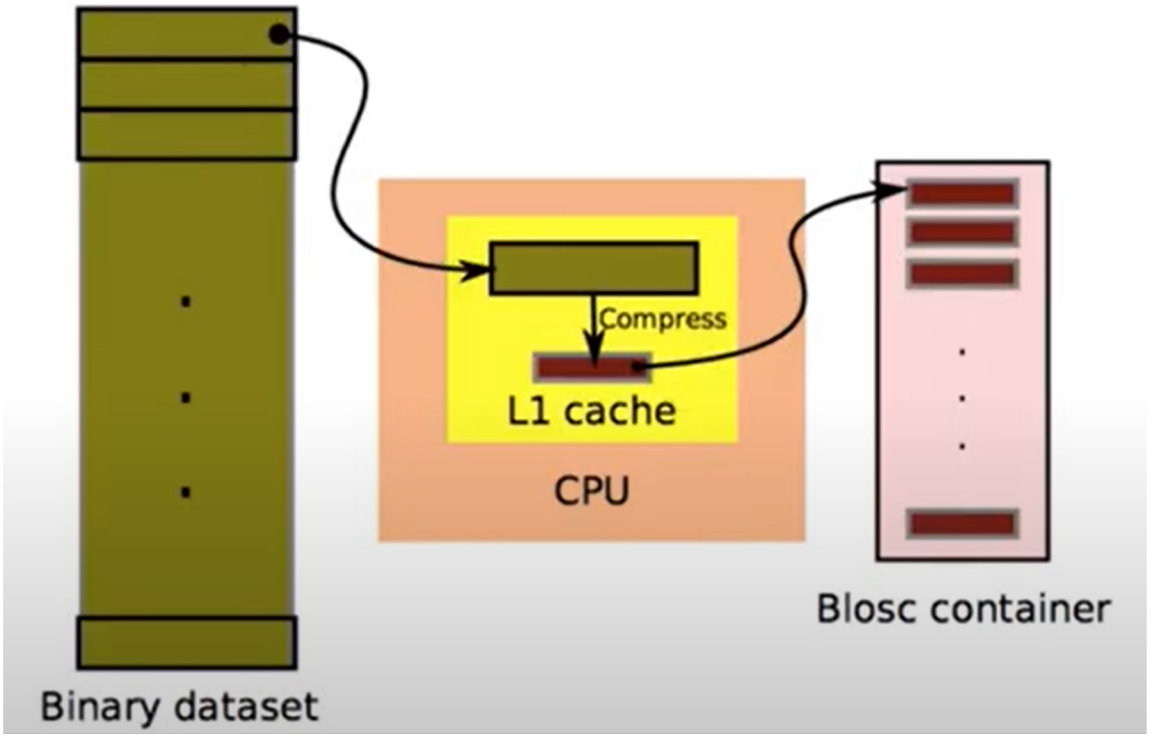
Handling **sparse datasets** with Blosc2

Caterva2: On-demand access to local/remote Blosc2/HDF5 data repositories

Intro

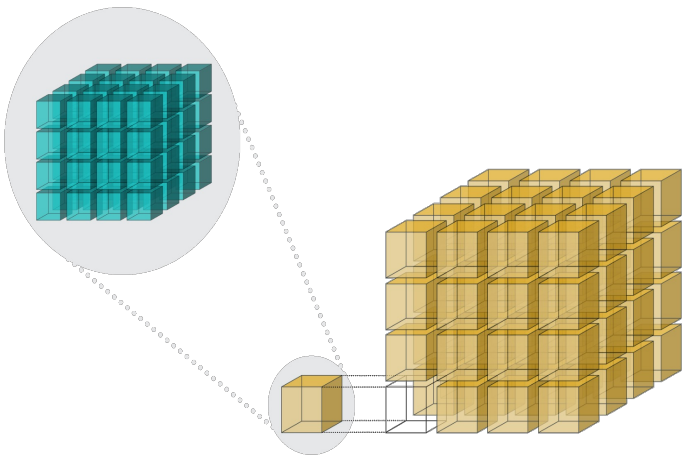
What is Blosc?

- A collection of codecs and filters for compressing binary data
- Goal: sending data from memory to CPU (and back) faster than *memcpy()*.
- Combining chunking and blocking: divide and conquer.



What is Blosc2?

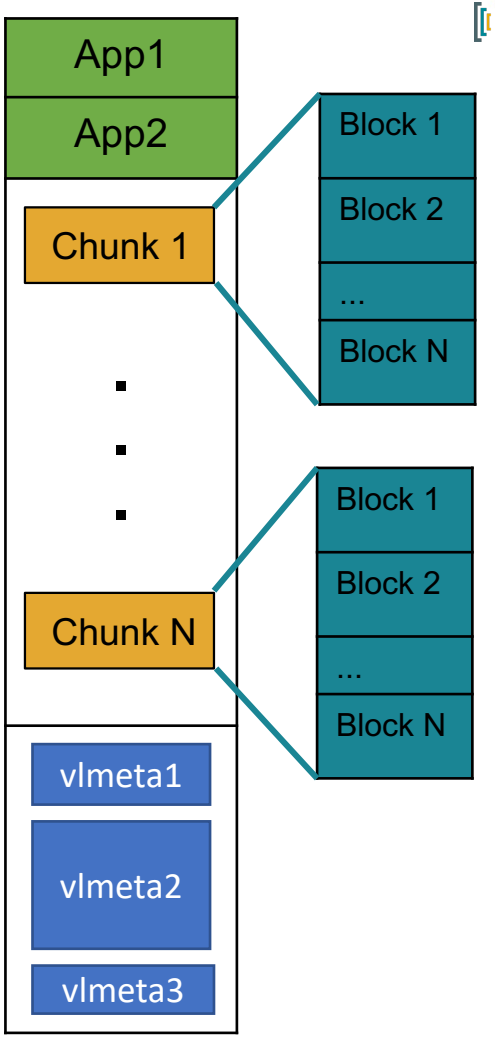
- ✓ Adds 63-bit containers.
- ✓ Metalayers for adding info for apps and users.
- ✓ Multidimensional blocks and chunks.



Header:
Fixed Length
Metalayers

Data:
Super-Chunk

Trailer:
Var Length
Metalayers
(up to 2 GB)



Who is ironArray SLU?

- We are the developers of PyTables, numexpr and Blosc ecosystems
- Team of experts empowering you to harness the full potential of compression for big data: we are here to help!

ironArray

https://ironarray.io

Plugins for JPEG 2000

Introducing grok and OpenHTJ2K dynamic plugins

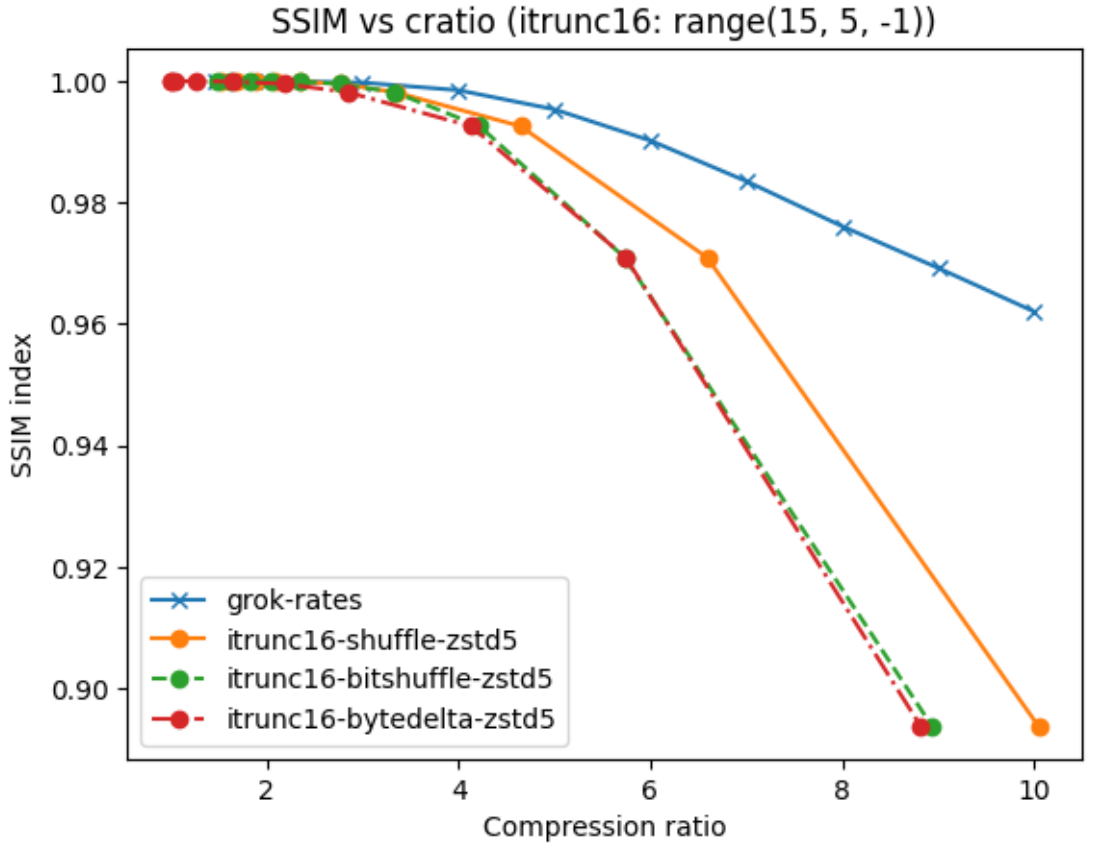
- OpenHTJ2K, an open source HTJ2K implementation by Osamu Watanabe.
- Grok, another free implementation for HTJ2K by Grok Image Compression Inc.
- Packed and distributed as Python wheels:
  - `$ pip install blosc2-openhtj2k`
  - `$ pip install blosc2-grok`

Grok supports 16-bit gray images, while OpenHTJ2K is only 12-bit

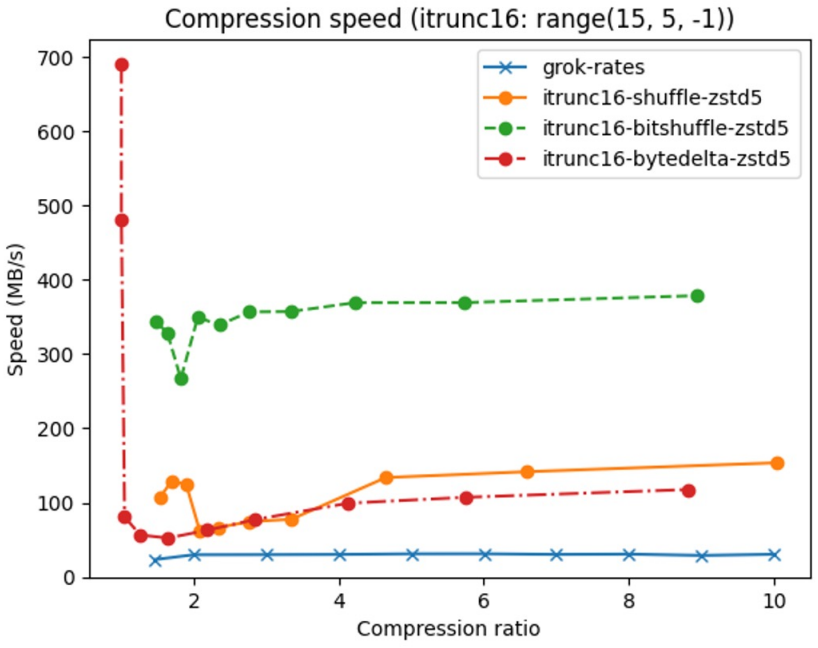
Lossy compression with grok and itrunc+zstd

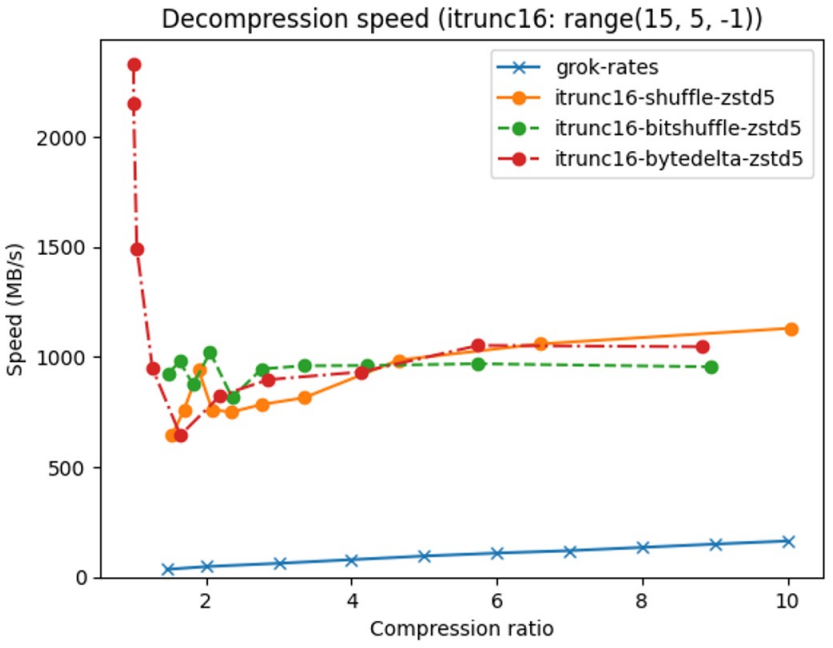
- JPEG 2000 can achieve much better quality for the same compression ratio.
- For low compression ratios, itrunc can provide similar quality.

Dataset:
http://www.silx.org/pub/leaps-innov/tomography/lung_raw_2000-2100.h5



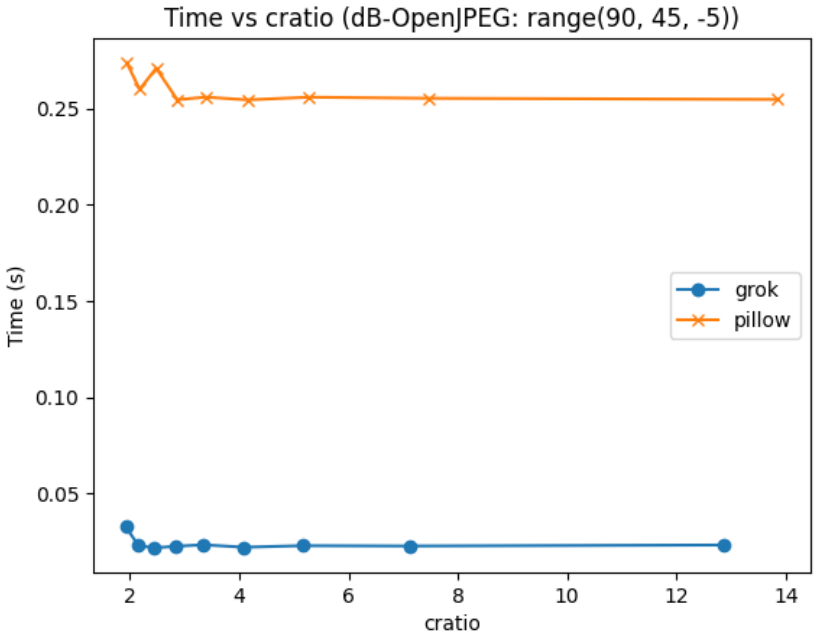
Lossy compression with grok and itrunc+zstd





Speed-wise, itrunc+bitshuffle+zstd is very competitive

JPEG 2000 in grok is still very fast!



Same order of cratio than OpenJPEG, but 10x faster

New: Ability to link with C/C++ Apps

- We recently added the possibility to use the blosc2-grok plugin with C/C++ applications.
- You can **tweak almost all the params** that grok allows: https://github.com/Blosc/blosc2_grok?tab=readme-ov-file
- This allows JPEG 2000 to be used in scenarios where C/C++ is the main language (e.g. acquisition devices).
- See example using HDF5 + Blosc2 + grok at:

https://github.com/Blosc/leaps-examples/tree/main/c-compression

Future Work

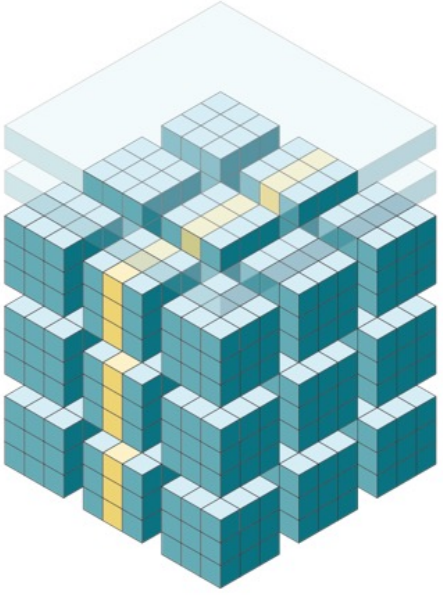
- Webassembly
    - JPEG 2000 has a lot of potential to be sent to a browser and be decompressed in-place (much less data to send).
    - **Blosc2 (+ plugins) in the browser** (see demo on Caterva2 later)

- Better **interaction with hdf5plugin** for setting different parameters (cratio, dB...). For now, this is possible via HDF5 direct chunking.

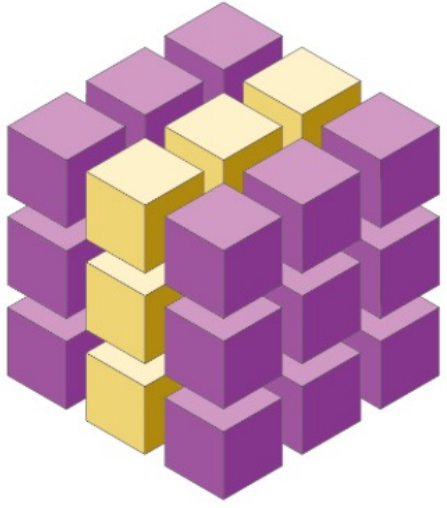
Support for Blosc2 NDim in h5py / HDF5

Leveraging the second partition in Blosc2 NDim

Much more selective and hence, faster queries!



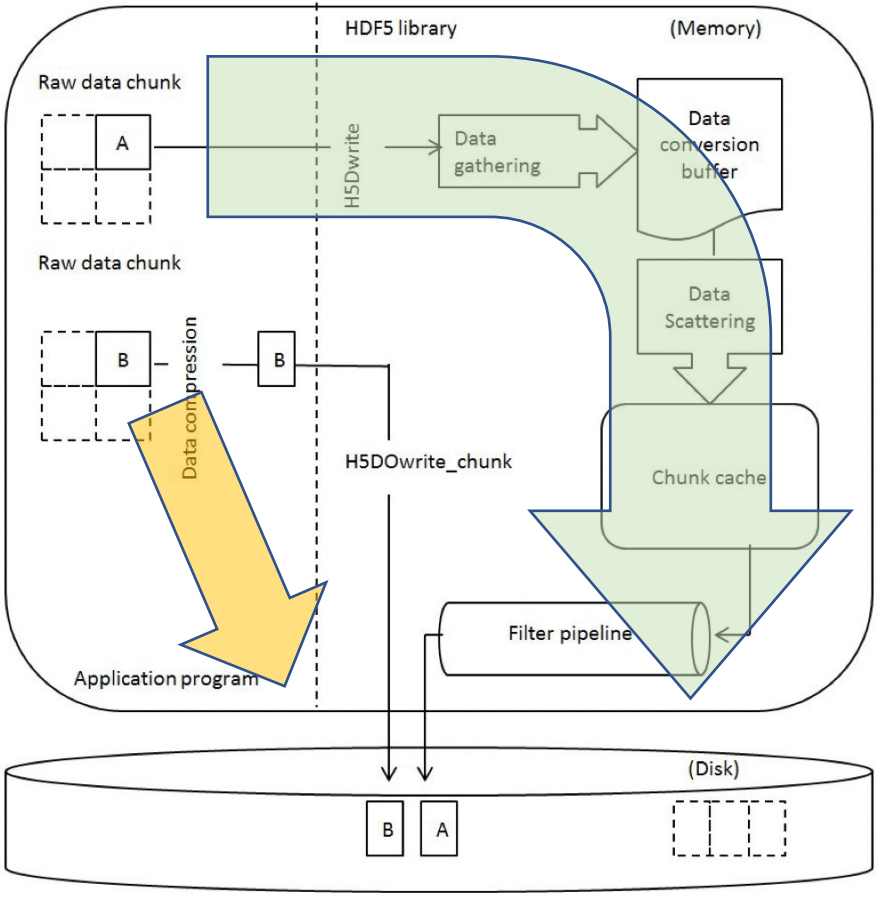
Blosc2 NDim



HDF5 / Zarr / others

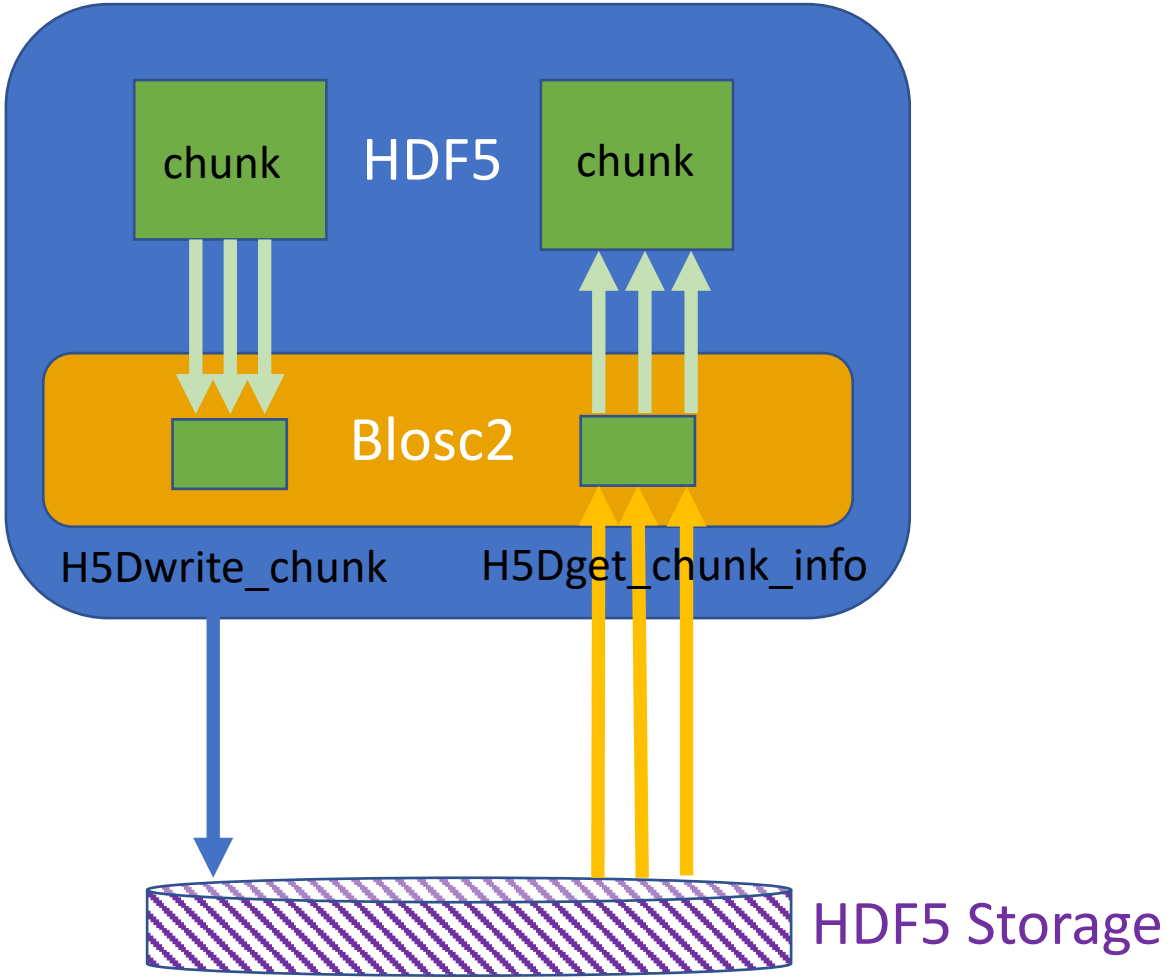
Bypassing the HDF5 pipeline: Direct Chunking

- HDF5 pipeline implementation is powerful but known to be slow.
- This can be bypassed using direct chunking in HDF5. **Integrated in new b2h5py**.
- New version of Blosc2 plugin for HDF5. It has been **integrated in hdf5plugin**.



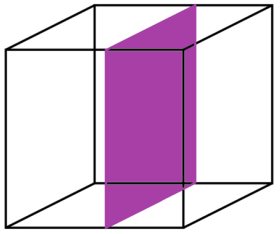
b2h5py: Use Blosc2 Inside Direct Chunking

- All compression and decompression executed in parallel via Blosc2!
- Blosc2 can do parallel I/O for reads
- Blosc2 can do chunk reads with enhanced selectivity from disk
- Data can still be read with hdf5plugin and h5py.

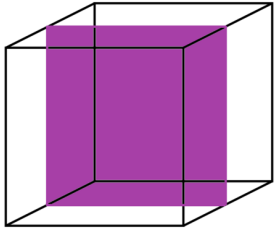


https://github.com/Blosc/b2h5py

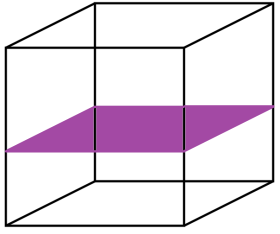
HDF5 pipeline vs direct chunking: Reading orthogonal slices with b2h5py



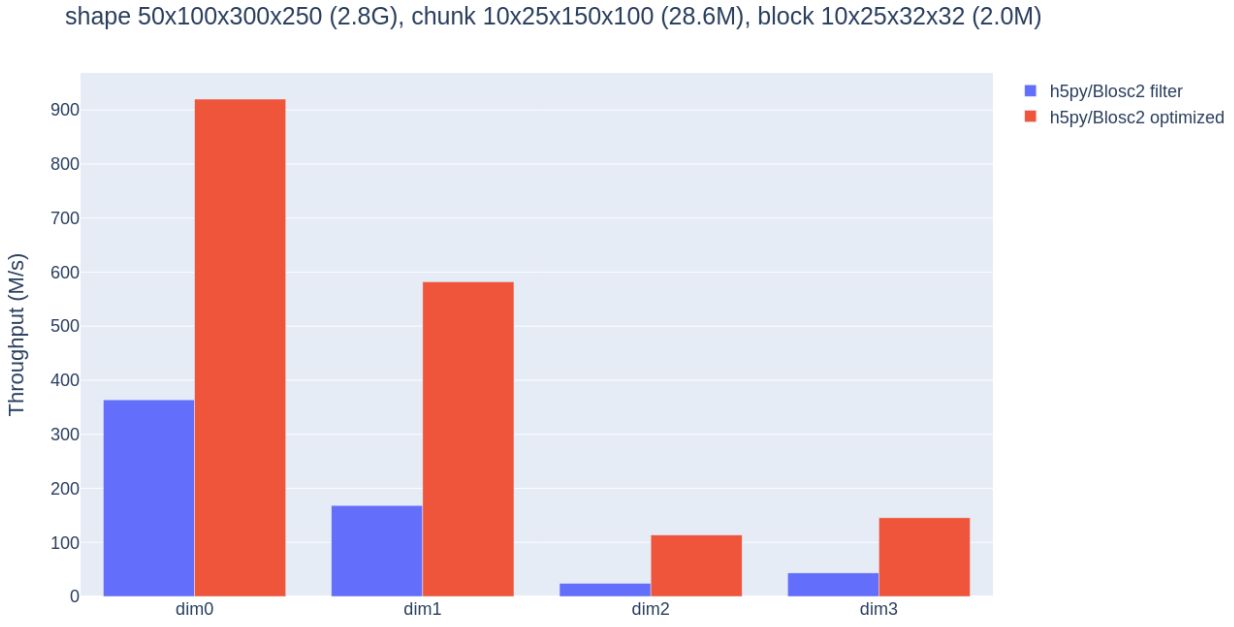
constant dim0



constant dim1



constant dim2



Faster slicing due to higher data selectivity in double partitioning

Btune: automatic selection of the best codecs / filters

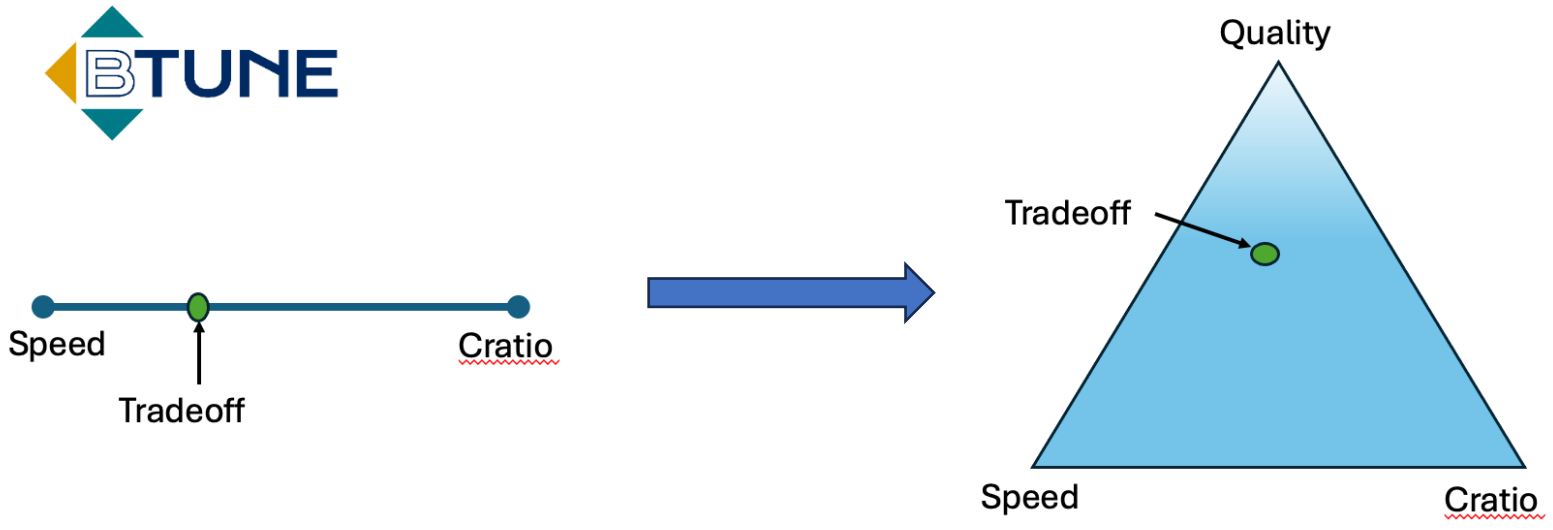
Allowing selection of Btune params programmatically

```
kwargs = {
    "tradeoff": 0.3,
    "perf_mode": blosc2_btune.PerformanceMode.DECOMP,
    "models_dir": f"{base_dir}/models/"}
blosc2_btune.set_params_defaults(**kwargs)
```

With that, and after a training, Btune predicts the best parameters **per chunk**

https://btune.blosc.org

New Lossy Mode in Btune



Lossless compression

Lossy compression

Works by combining neural networks and heuristics

Example of Prediction of Lossy Codecs

Example with tradeoff `(cratio=0.7, speed=0.2, quality=0.1)`

```
(btune_arm64) martaiborra@MacBook-Air examples % BTUNE_TRADEOFF="(0.7, 0.2, 0.1)" BTUNE_TRACE=1 python quality_mode.py
Performing compression using Btune
-=-=-=
```

Challenges for Btune

- It does not have a good (and fast) estimator for the image quality

  (This is why we are using heuristics here)

- There is **great potential on finding image quality estimator**

  Nice (and quite challenging) project for the future

Handling sparse data

Compressing sparse data with Blosc2

Blosc2 has many provisions for compressing sparse data:

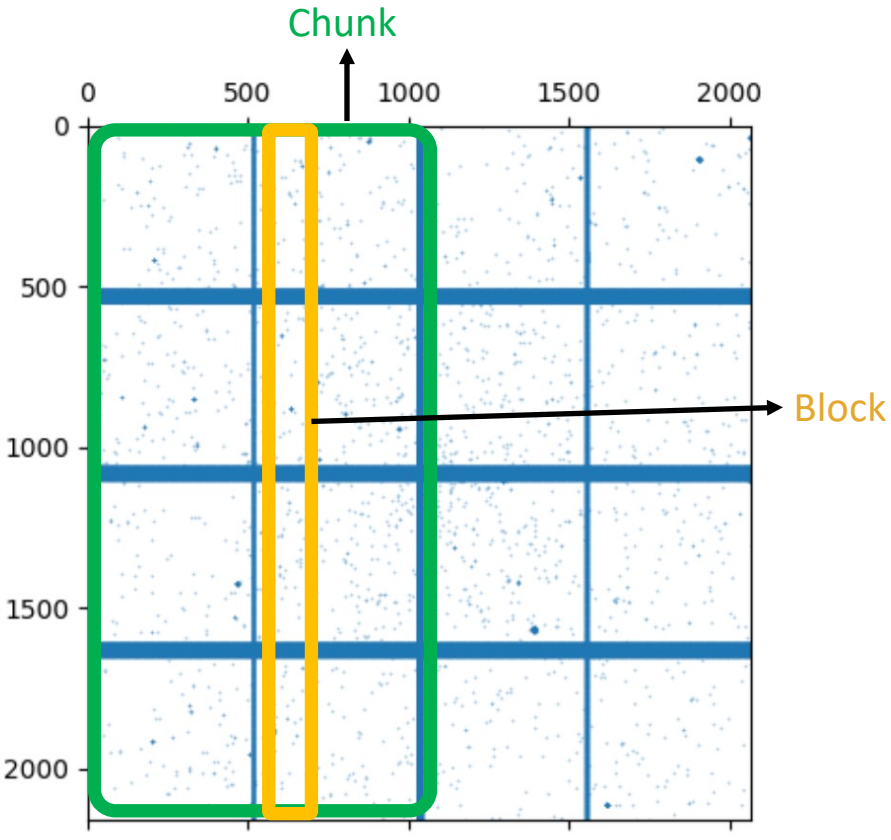
- Blocks of zeros can be represented by just 4 bytes
- Chunks of zeros can be represented by just 8 bytes
- Sequence of several chunks of zeros can be represented with 8 bytes.

Automatic zero detection:

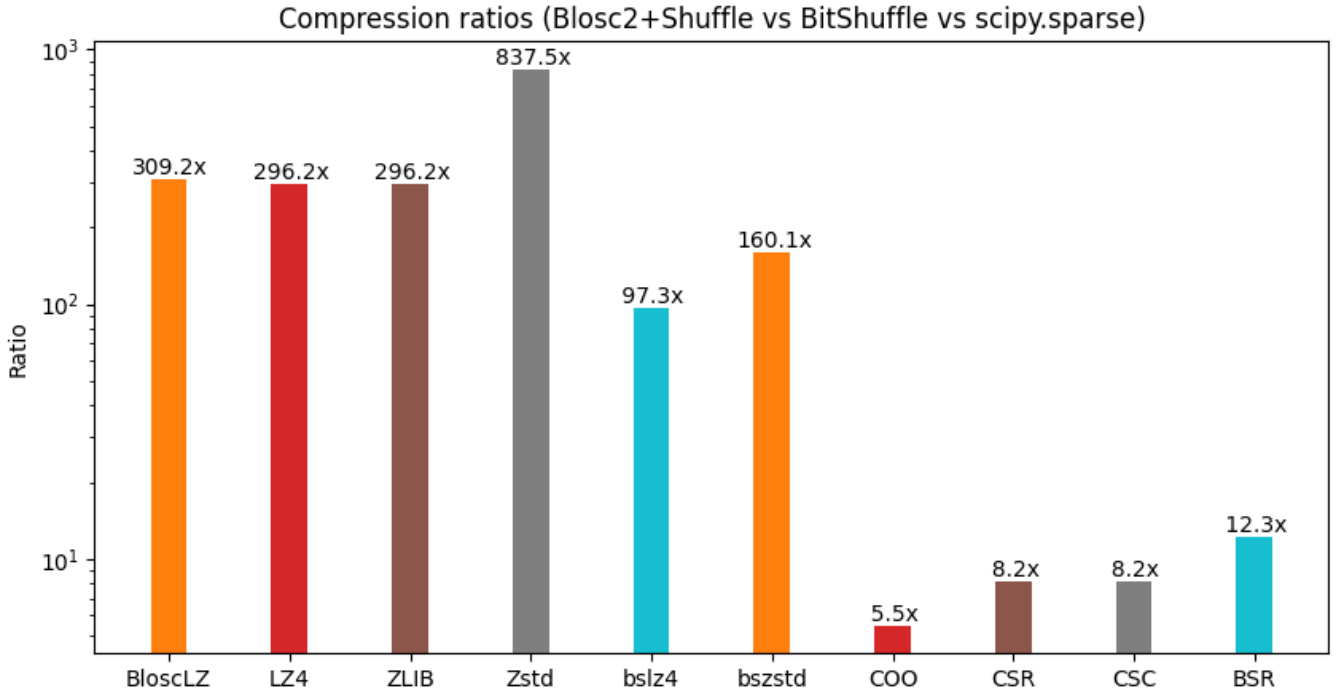
- Such runs (blocks or chunks) of zeros can be detected automatically, but you can provide chunks of zeros explicitely too.

Example: X-ray tomography

- A sample image. A tomography can be formed by 1000's of them.
- When compressing, it is important to be able to specify different partitions: this can make a **huge difference** in compression ratio, or speed.
- Blosc2 allows to do that in two-level, multidimensional partitions.



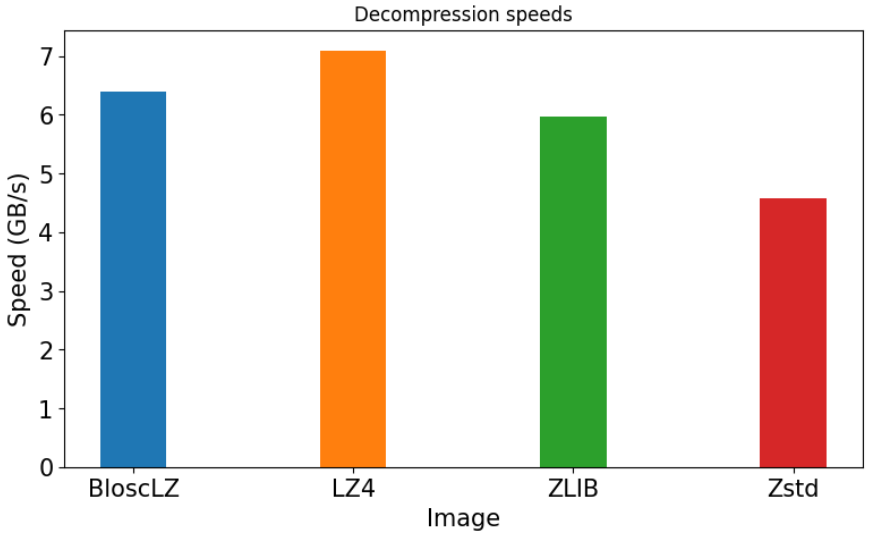
Example: X-ray tomography



Blosc2+Shuffle+Zstd shines with this sparse dataset

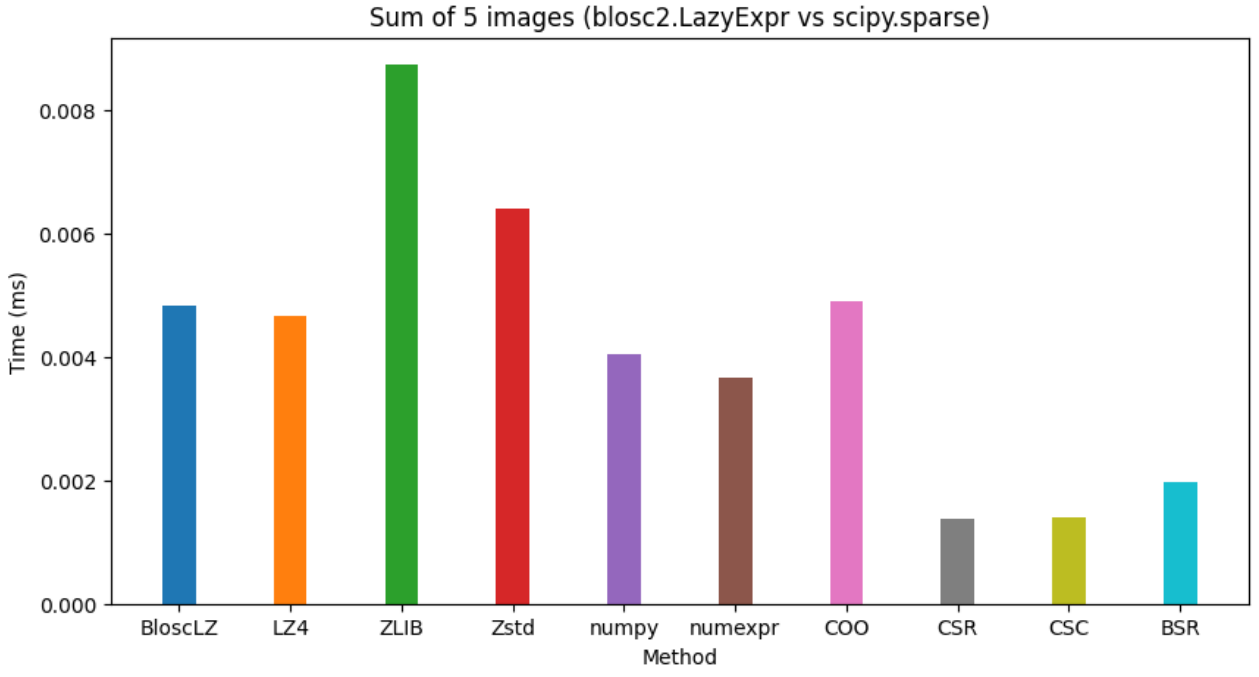
https://github.com/Blosc/leaps-examples/tree/main/sparse

Example: X-ray tomography



Blosc2+Shuffle+LZ4 shows good balanced speed (~1000 fps)

Computing with sparse data



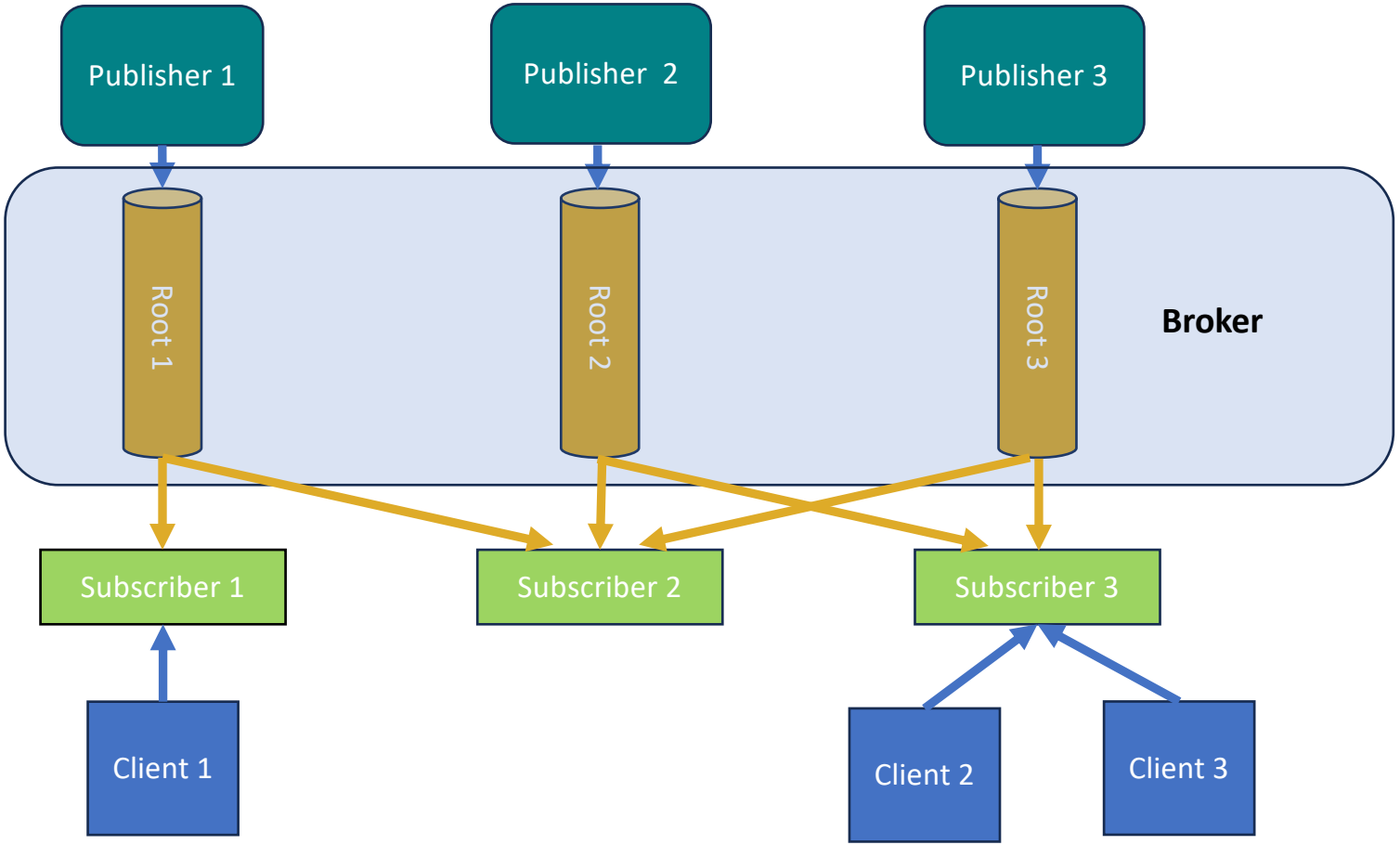
New LazyExpr computation engine in Blosc2:
summing at 1000 fps

Work for the future

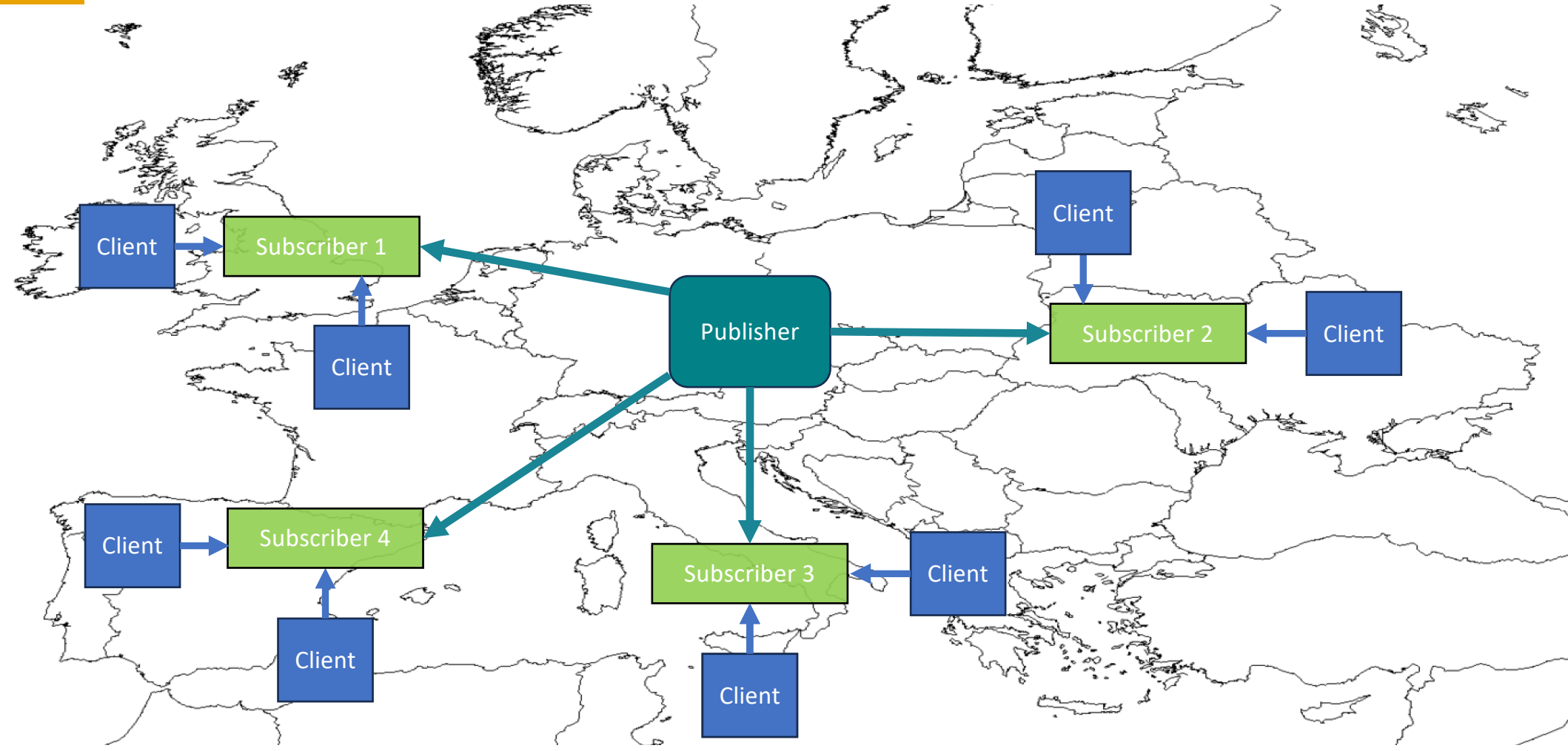
- It should be nice to **skip computations on blocks/chunks that are full of zeros**
- Add **linear algebra** computations to blosc2.NDArray instances
- Other functionality (FFTs)?

Caterva2: On-demand access to local/remote Blosc2/HDF5 datasets

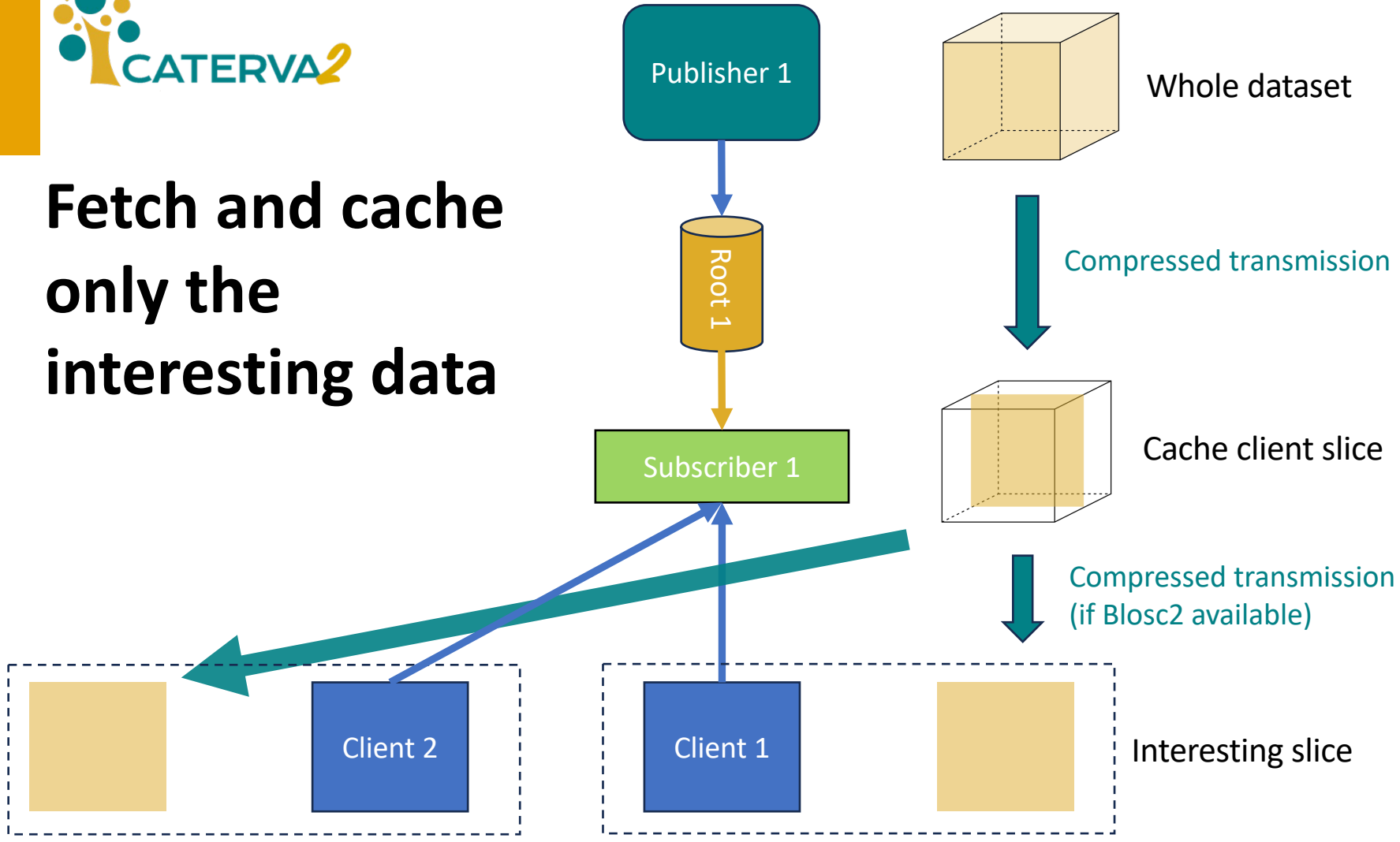
PubSub Data Flow



Putting data closer to the user



Fetch and cache only the interesting data



Demo time

- Go to demo.caterva2.net and try the interface by yourself.
- The demo box is a cheap 8 GB RAM, 64 GB disk and 4 cores, running Ubuntu 22.04 and in aarch64.
- Provider is hetzner.com in Nuremberg, Germany (so near to Krakow).

Work for the future

- Integrate LLM in the search box
- More plugins (on demand; suggestions?)
- Increase stability
- Make cache eviction more fine grained (now all the dataset is thrown away when it changes in the publisher)

Conclusion

Progress made in integrating Blosc2 with HDF5

The Blosc2 development team has recently implemented:

- **Plugins for High Throughput JPEG 2000**
- Implemented **native support for Blosc2 NDim in HDF5**, bypassing the HDF5 pipeline
- **Btune, has got support for lossy compression** when predicting the best Blosc2 parameters
- **Caterva2, making Blosc2/HDF5 data generally available with easy and efficiency.**

Blosc2: a highly efficient and flexible tool for
compressing your data, your way

Koniec and thanks! Questions?

contact@ironarray.io

We make compression better