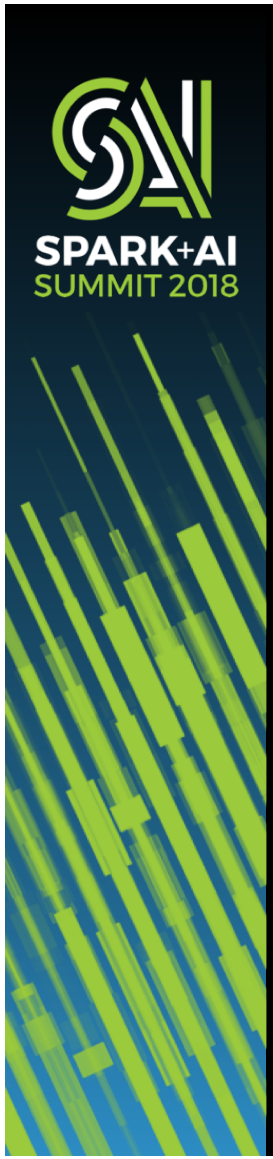

Best Practice of Compression Codecs in Spark

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About me

- Big data software engineer from Intel.
- Focus on Spark performance profiling and optimization for Intel Architecture.

Outlines

- Compression Needs & Motivations
- Data Compression Pipelines in Spark
- Experiment Compression Codecs Intros
- Intel® Codec Accelerator Architecture Overview
- Takeaways
- Future Works

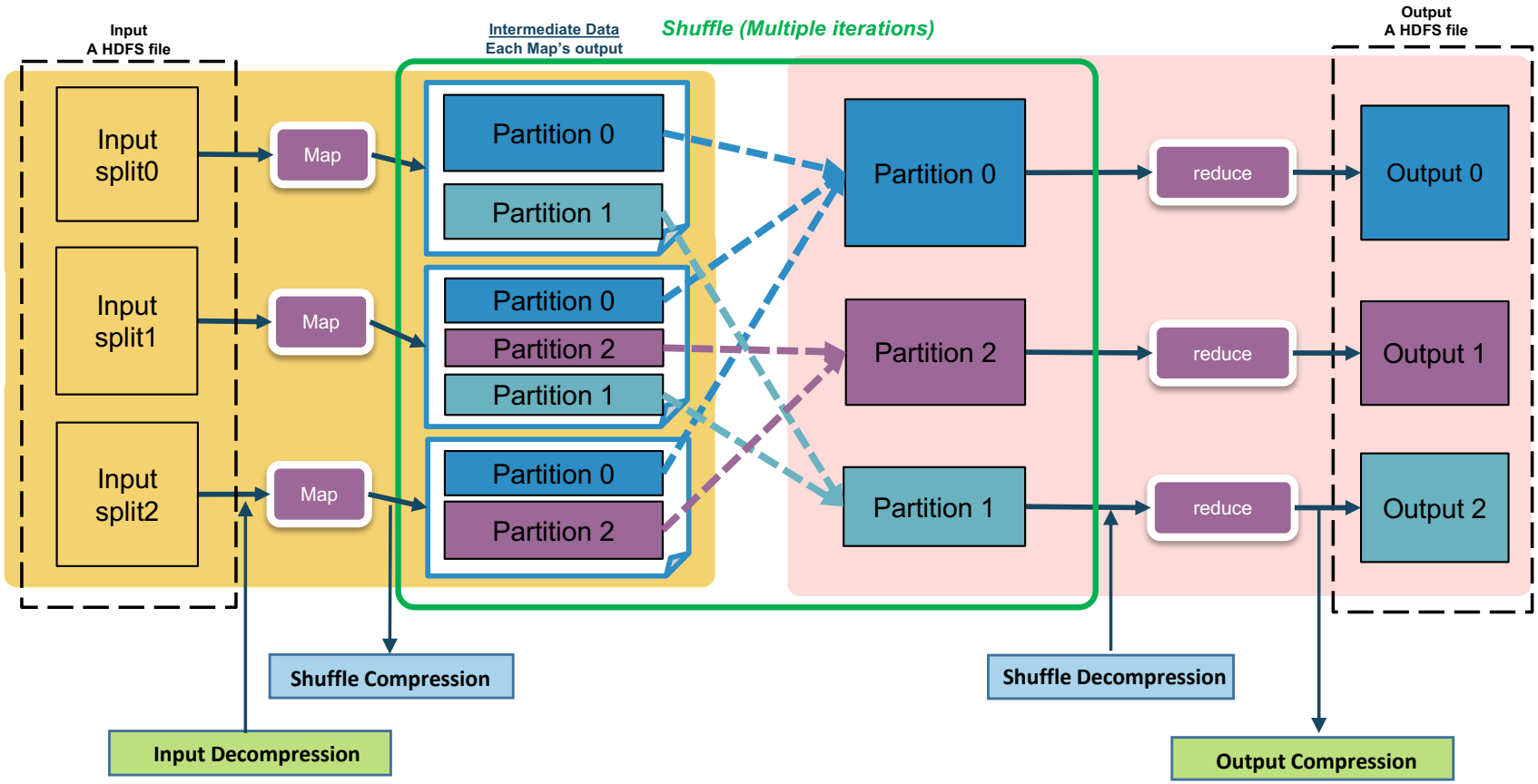
Compression Needs

- **Compression Needs**
  - Reduce data volume and save storage space.
  - **Speed up the disk I/O operations** and **data transfer** across network, optimize workload performance.
- **Trade-off**
  - Computation overhead for high compression ratio codecs.

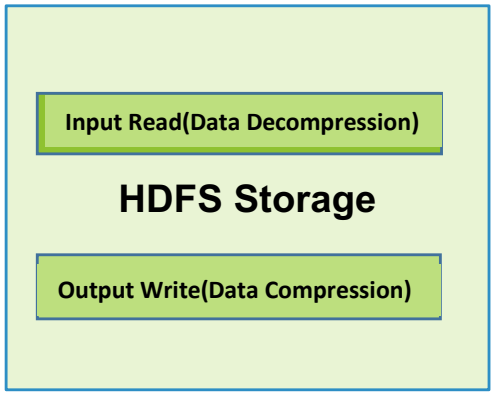
Motivations

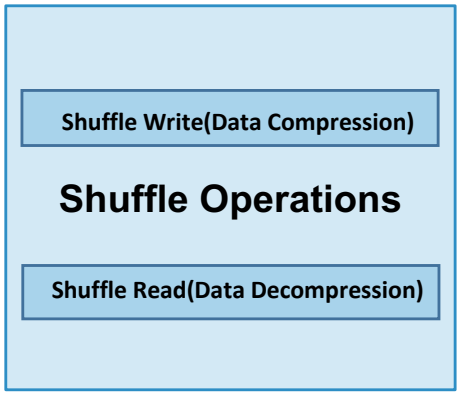
- Understanding popular compression codecs in Spark.
- Take advantage of **Intel® optimized libraries** or **accelerate hardware** for data compression/decompression.

Data Compression Pipeline in Spark



Data Compression Pipeline in Spark - I/O Characteristics





- HDFS Storage
  - Generally sequence read/write
  - Generally one time read/write
- Shuffle Operations
  - Random read/write
  - Multiple times read/write

Experiment Compression Codecs Intros

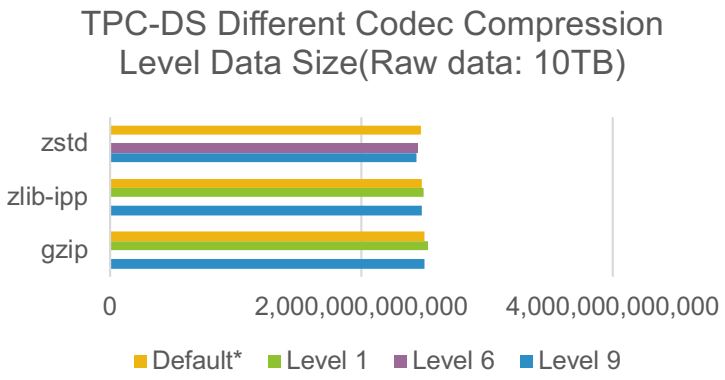
Codecs	Supported levels	Default level	Degree of Compression	Compression speed	CPU Usage	Comments
ISA-L(igzip)	(0~1)	1	Medium	Medium	Medium~High	Based on Intel® ISA-L ver 2.0.19 optimization
Zlib-ipp	(1~9)	Best balance(near to 6)	High	Slow	High	Based on Intel® IPP library optimization
Zlib/gzip	(1~9)	Best balance(near to 6)	High	Slow	High	Open source codec
zstd	1~22	3	High	Medium	Medium~High	Open source codec
Lz4-ipp	N/A	N/A	Medium	Fast	Low	Based on Intel® IPP library optimization
Lz4	Lz4 fast Lz4 hc	Lz4 fast	Low Medium	Fast Low	Low Medium	Open source codec
snappy	N/A	N/A	Low	Fast	Low	Open source codec

High compression ratio codecs

High throughput codecs

Intel® ISA-L reference: https://software.intel.com/en-us/storage/ISA-L ; Intel® IPP reference: https://software.intel.com/en-us/intel-ipp

Compression Level

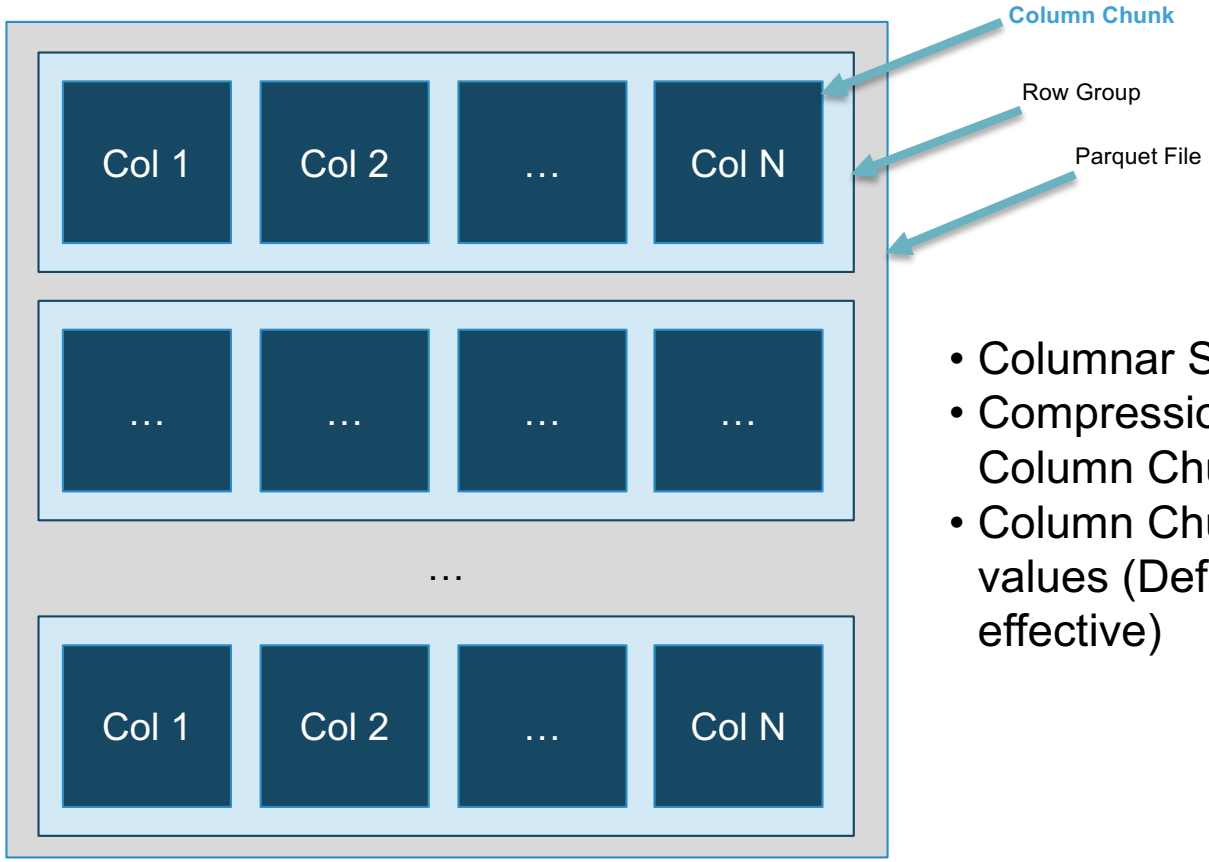


Compression codec	*Default level Data Size	Level6 Data Size	Level9 Data Size	Default Vs Level6	Default Vs Level 9
zstd	2,472,315,429,619	2,446,857,474,146	2,440,389,051,782	**1.04%**	**1.31%**

Compression codec	Level9 Data Size	Level1 Data Size	*Default level Data Size	Default Vs Level9	Level1 Vs Level9
gzip/zlib	2,500,252,836,007	2,528,269,315,543	2,502,656,222,082	**0.096%**	**1.12%**
zlib-ipp	2,482,050,449,516	2,492,687,484,854	2,482,595,509,721	**0.022%**	**0.429%**

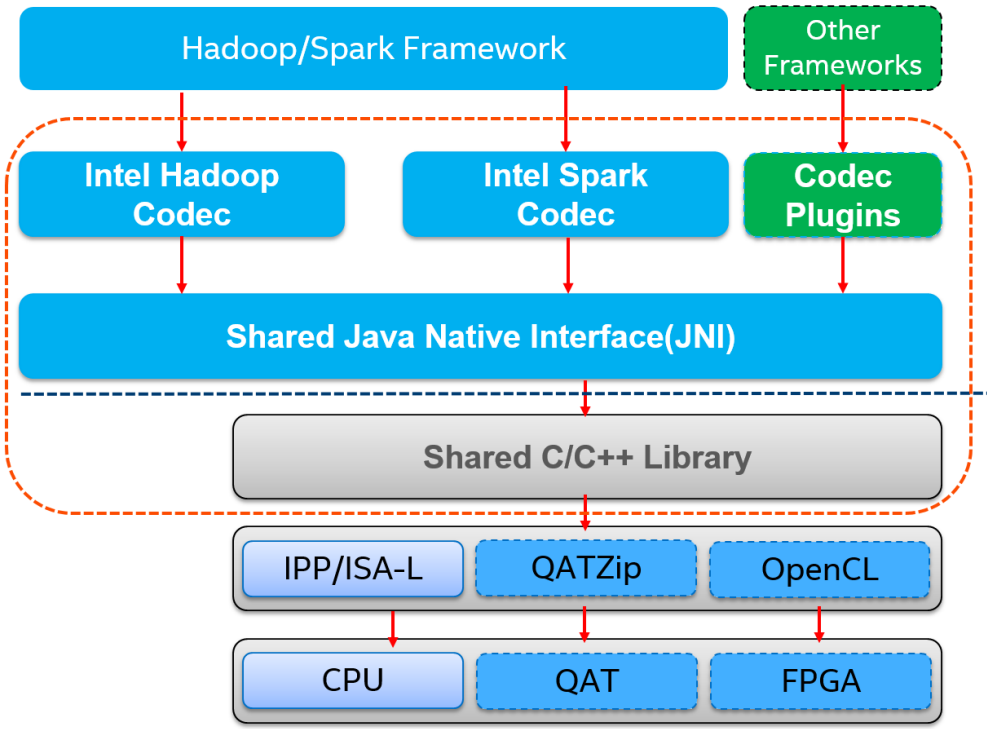
- zstd, gzip, zlib-ipp and igzip support compression level adjustment, while codec lz4 and snappy does not support.
- No big data size difference among different compression level in TPC-DS parquet format data generation test.

Compression in Parquet Format



- Columnar Storage (For Column Pruning)
- Compression / Decompression for each Column Chunk
- Column Chunk has same data type even same values (Default Compression Level is usually effective)

Intel® Codec Accelerator Architecture(1/2)



JAVA Application:
TeraSort, WordCount, PageRank etc.

Extend class from Hadoop and Spark CompressionCodec, configurable, implements compression codec interfaces of Hadoop/Spark And extend class from Hadoop Compressor, Decompressor, implements interface of Hadoop

Forward Hadoop/Spark Compress/decompress request from JAVA to under layer C/C++

Codec Adapter Layer, Self adaption to codec according to configuration from JAVA

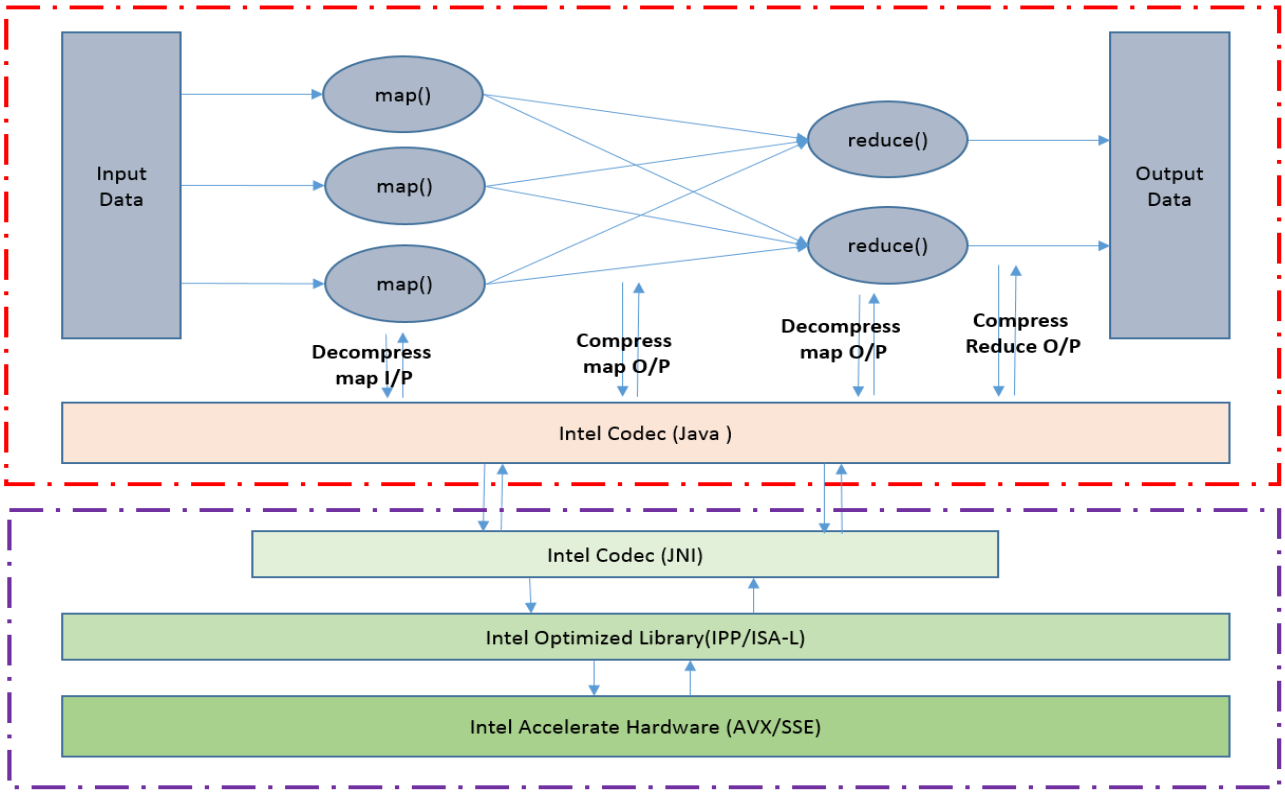
Intel Optimized Accelerate Library Using AVX-512, QAT, FPGA

Accelerate Hardware

Notes:

- QAT and ISA-L AVX512 is available on Intel® Skylake-X platform.
- Open Source codec zstd also can build with Intel® ISA-L AVX512 support to accelerate data compression/decompression.

Intel® Codec Accelerator Architecture(2/2)



User Layer

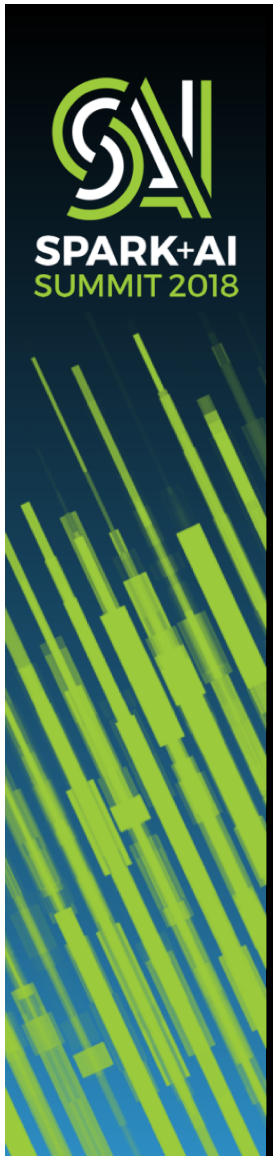
Native Layer

Takeaways

- Better to choose high compression codecs for source data* for IO intensive workload, such as zstd, zlib-ipp, zlib, igzip.
- Better to use high throughput codecs for spark shuffle compression codec, such as lz4-ipp, lz4.
- Higher compression codec reduce I/O and network pressure, but consumes CPU resource, use accelerate hardware such as QAT and FPGA can help to offload CPU resources.
- Zstd can qualify as both a reasonably strong compressor and a fast one.
- Best balance of compression codec depends on cluster characteristics and workloads.

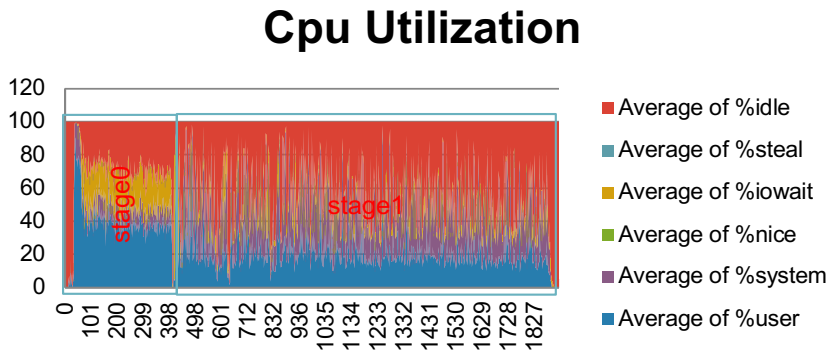
Future Plan

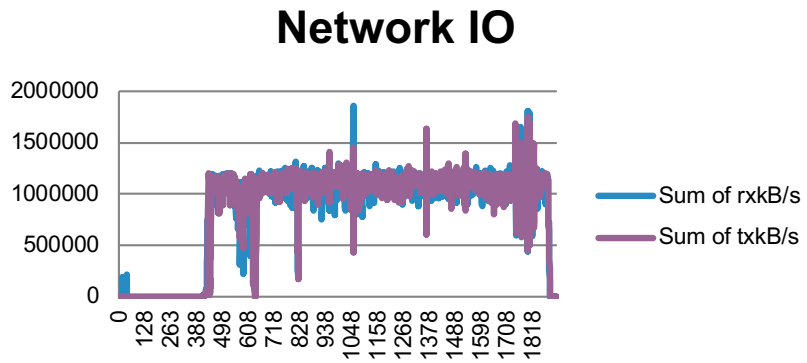
- Open source Intel® Codec Accelerator project and make it as well supported library.
- Add codec compatibility support.
- Integrate with more IA optimized codecs along with the acceleration library releases under different platform.
- Introduce more big data frameworks (Cassandra / HBase etc.)
- Besides compression / decompression, we will support more types of codec like the encryption / decryption etc.
- Keep release new version along with new Intel® Platform release or new acceleration libraries released.



Thanks!

HiBench Sort Workload bottleneck – No data compression

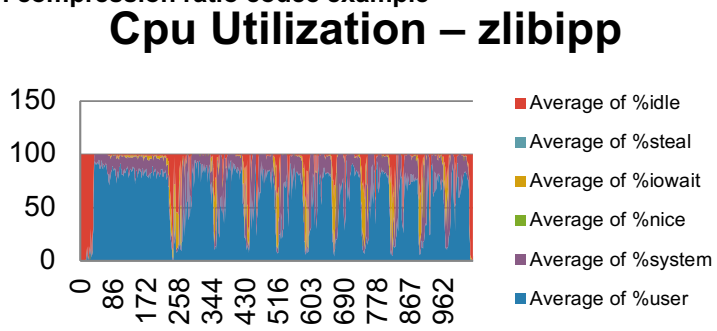




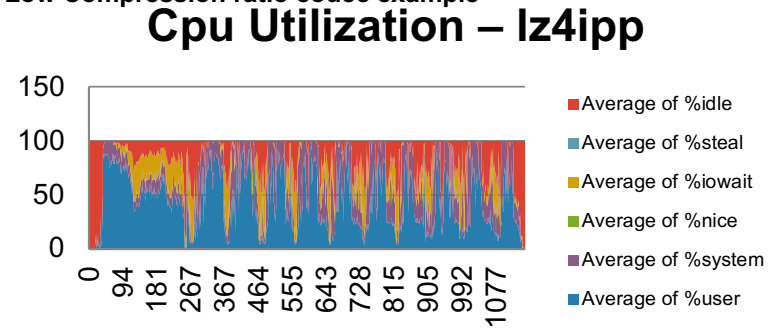
- No compression data has big data size, mapping data make the IO disk as bottleneck in stage0
- No compression data cause big pressure in shuffle stage(Stage1). 10Gb(~1.2GB) network as bottleneck in experiment environment. While CPU still has much idle resource.

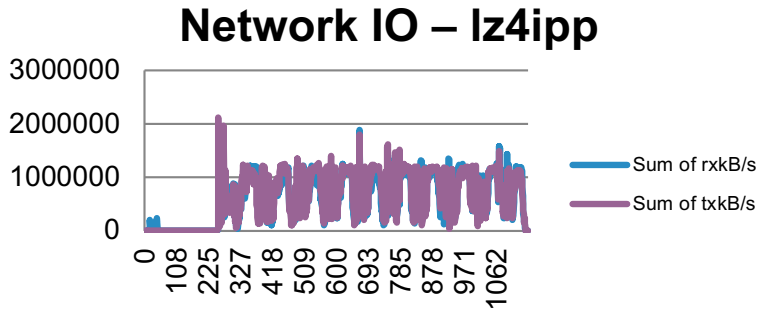
HiBench Sort Workload Resource Utilization Examples

High compression ratio codec example



Low Compression ratio codec example





- CPU as bottleneck on High compression ratio codecs (like zstd, zlibipp and igzip)
- Codec lz4, lz4ipp and snappy has lower compression ratio, large size of data read/write caused the disk as the bottleneck in stage0 and large shuffle data caused network as bottleneck in stage1