Adaptively Compressing IoT Data on the Resource-constrained Edge

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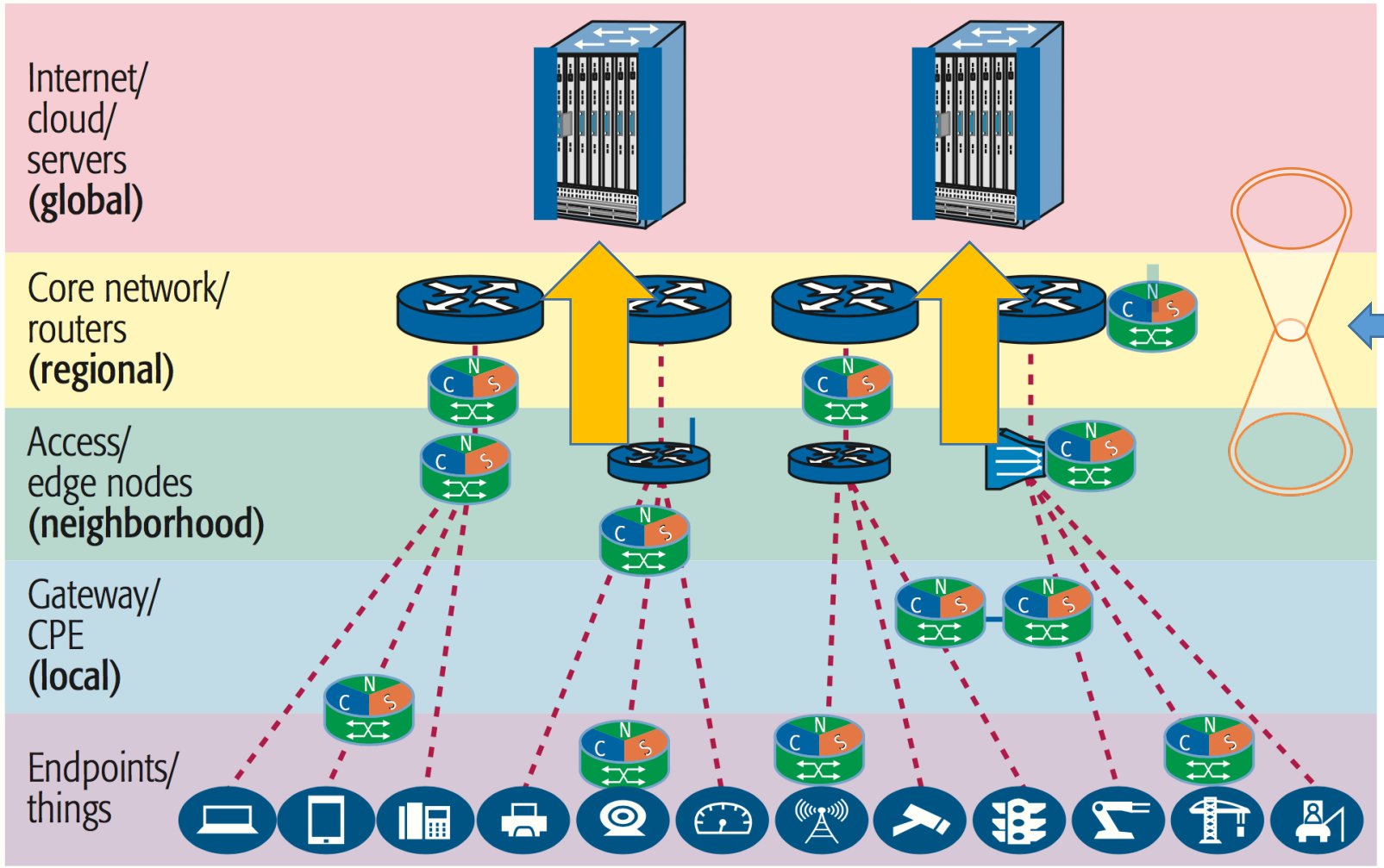
Overview

- Background
- ZipMate Adaptive Compression Design
- Preliminary Evaluation
- Conclusion and Future Work

Big Data Concerns in IoT Environments

- IDC Predicts
  - By 2025
  - 41.6 billion connected IoT devices or things
  - Generating more than 79 zettabytes (ZB) of data
- NSF Data Storage Research Report Identifies
  - IoT brings an explosion of data collection, storage, and processing demands
  - It is important to identify and reduce IoT data in a timely fashion
  - It is important to balance among storage, preprocessing, and communication between IoT devices and cloud

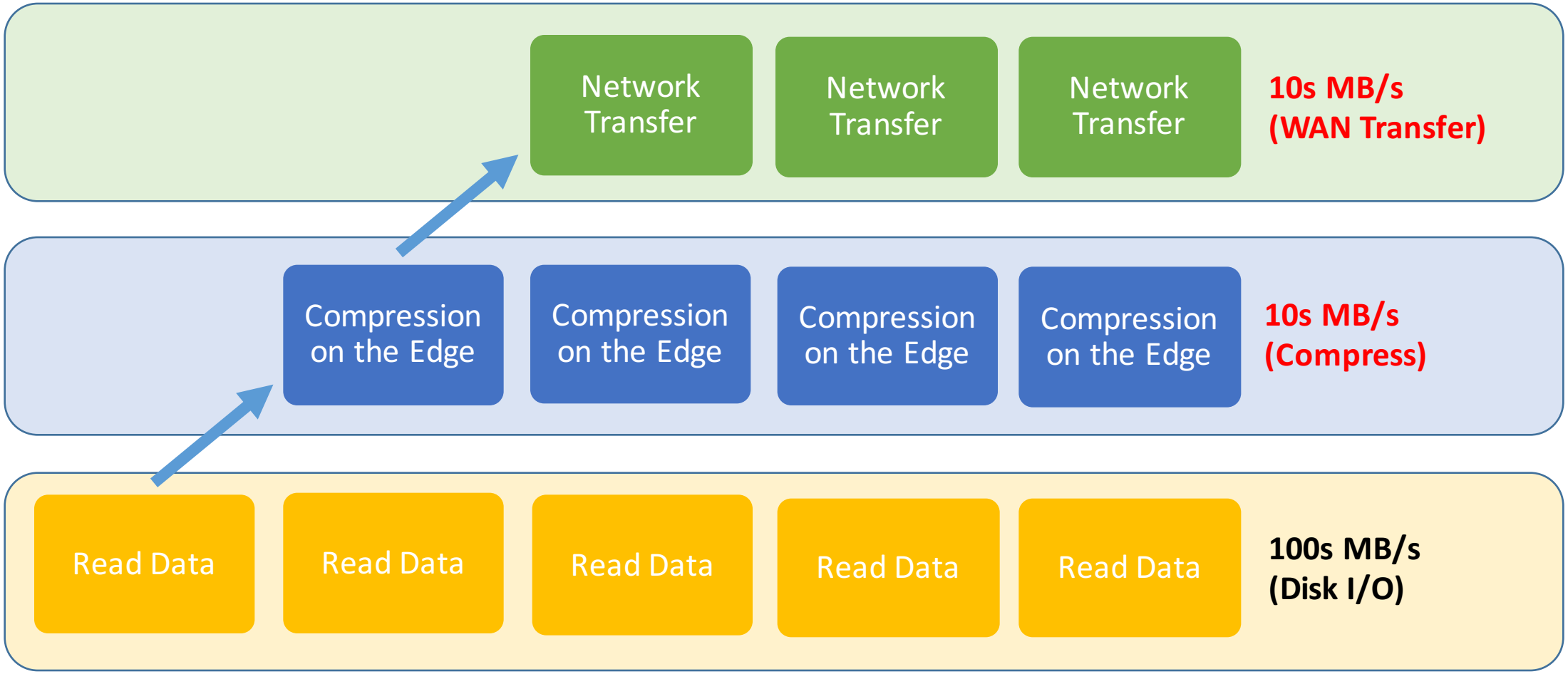
Application Scenario: Edge-Cloud Data Transfer



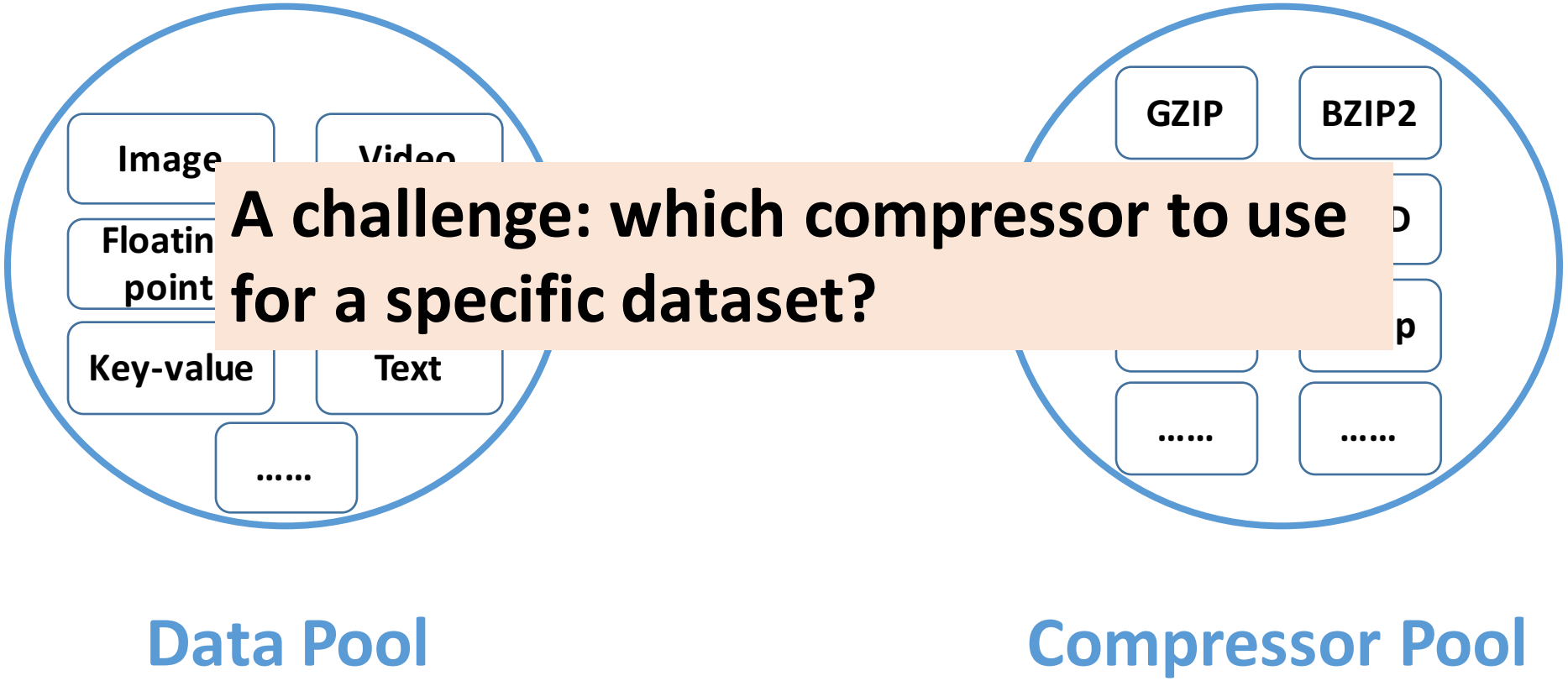
Wide-area network bottleneck

Source: Charles C. Byers, Architectural Imperatives for Fog Computing, IEEE Communications Magazine, August 2017

Compression-based Data Transfer



A Challenge of Compression-based Data Transfer: Compressor Selection



ZipMate Application Scenarios

- **Scenario 1: Computation offloading**
  - To accelerate the data transfer so that analysis of IoT data in cloud can be launched as soon as possible

Accelerate data analysis

- **Scenario 2: Storage offloading**
  - To reduce data volume as much as possible, maximizing cloud storage cost savings.

Minimize cloud storage costs

Optimal Compressor Selection

A simplified model for Scenario 1 :

Data transfer throughput (in uncompressed size) =

min (*Compression Throughput*, *Network Bandwidth* * *Compression Ratio*)

In Scenario 1: The optimal compressor is the one that can deliver maximal data transfer throughput.

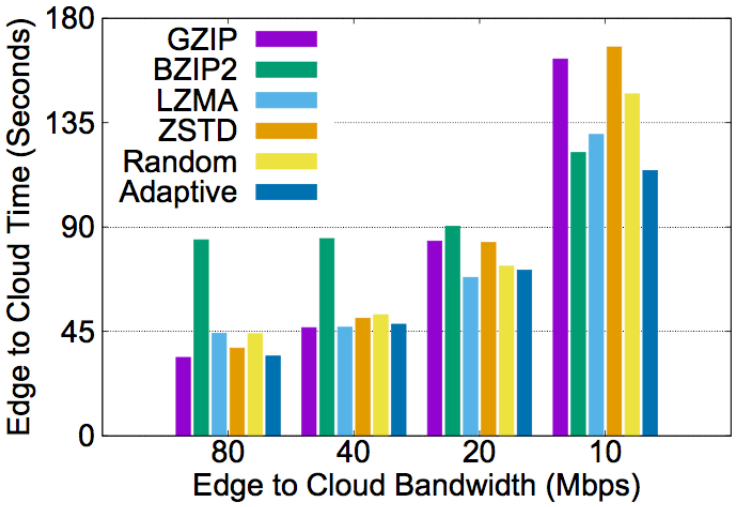
In Scenario 2: The optimal compressor is simply the one that can achieve maximal compression ratio.

Predicting the compression ratios of a dataset with different compressors is the key.

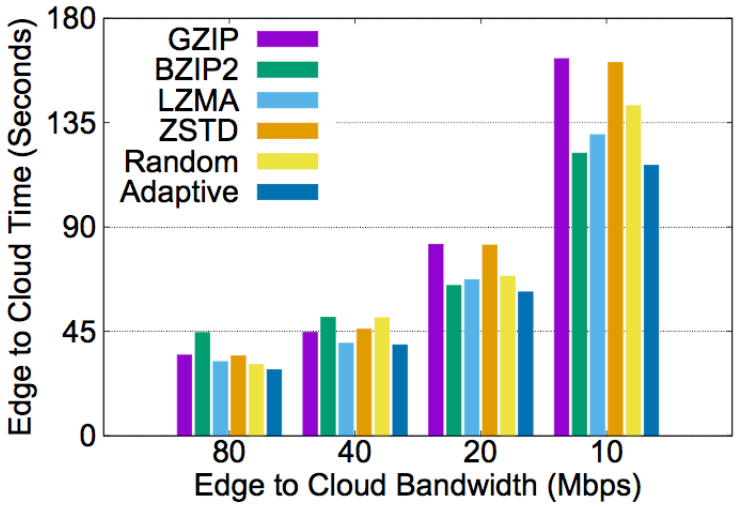
IoT Datasets for Evaluation

Data	IoT Domain / Scenario / Device	Format/Type
1	Energy/Appliance Power/ Meter [25]	CSV/Integer
2	Health Care/ Cancer/ DCE-MRI [15]	DCM/Image
3	Space Science/Exoplanet/Satellite [6]	TIFF/Image
4	Petro Science / Oil Well / Meter [28]	CSV/Float
5	Agriculture / Soil / Sensor [26]	CSV/Float
6	Biology / Cell / Simulator [22]	TIFF/Image
7	Climate / Weather / Thermometer [1]	CSV/Float
8	Smart City / User Study / Phone [3]	JSON/K-V
9	Earth / Ocean / Sensor [4]	CSV/Float

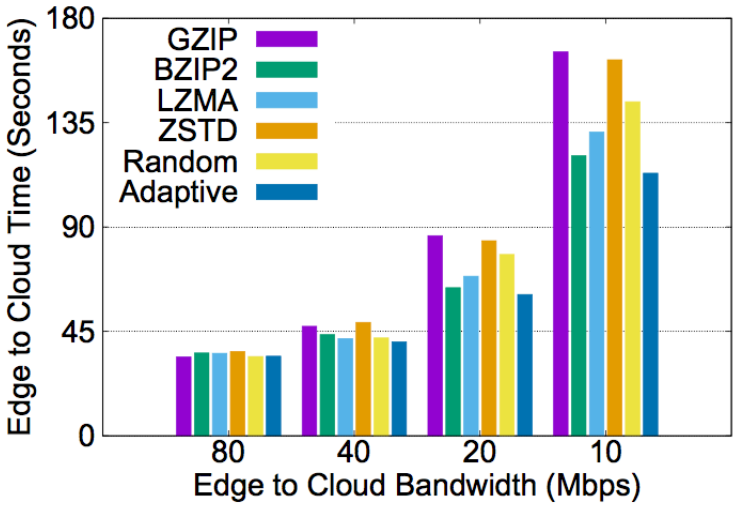
Preliminary Evaluation for Scenario 1 (Target Shortest Edge to Cloud Transfer Time)



(a) 1 Core



(b) 2 Cores



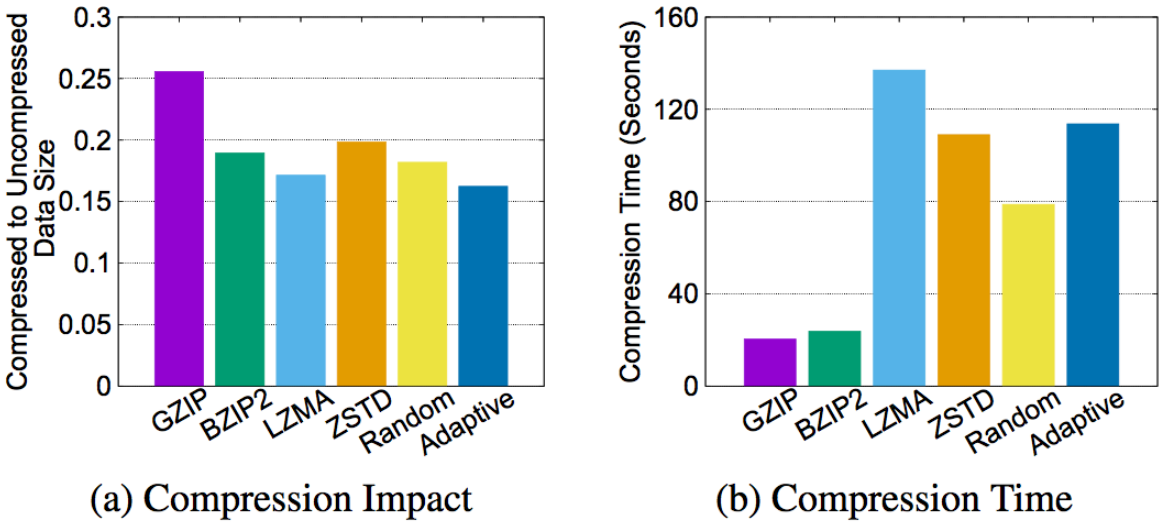
(c) 4 Cores

Observation 1: Network bandwidth and computing power both have obvious impact on data transfer time, but the bandwidth dominates the impact.

Observation 2: There is no single compressor which performs best in all or even most cases.

Observation 3: The resource-aware adaptive compressor selection scheme consistently outperforms unitary or random solutions in achieving the shortest edge-to-cloud transfer time.

Preliminary Evaluation for Scenario 2 (Target Highest Compression Ratio)



(a) Compression Impact (b) Compression Time

Same as Observation 2 in Scenario 1: There is no single compressor which performs best in all or even most cases.

Similar to Observation 3 in Scenario 1: The resource-aware adaptive compressor selection scheme consistently outperforms unitary or random solutions in achieving the highest compression ratio.

Conclusion

- For a dataset, different compressors show different performance.
- In resource limitation conditions, data transfer is limited by various runtime resource bottlenecks including available CPU resources and WAN bandwidth.
- Resource-aware adaptive compressor selection can considerably accelerate edge to cloud data transfer or improve data compression ratio.

Future Work

- To build and enhance compression ratio prediction models for various compressors.
- To run representative edge analytics workloads to measure the performance degradation of other edge applications caused by compression.
- To investigate the security challenges in IoT, edge, and cloud environments to enforce proper data security policies in our middleware.

Thanks & Questions