MiniCrypt: Reconciling Encryption and Compression in Big Data Stores

Wenting Zheng, Frank Li, Rachit Agarwal, Raluca Ada Popa, Ion Stoica

Problem

More and more **sensitive** data outsourced to third parties, who may be ***untrustworthy***

Applications need data stores that provide
- Functionality
- Data confidentiality
- Performance

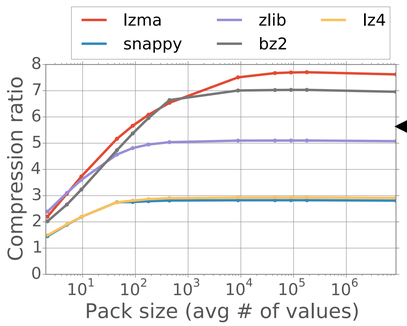
Encryption → data confidentiality
Compression → better performance because more data fits in memory

MiniCrypt

***First* system to combine compression and encryption**

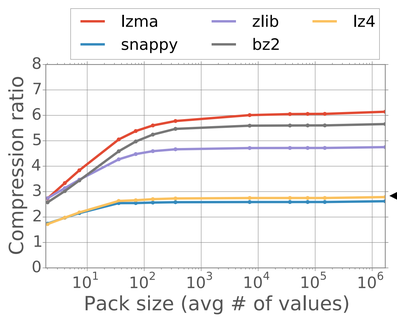
Designed a KV store interface that provides functionality, data confidentiality, and performance

Key idea: transform key value pairs by combining small number of records into *packs*, then compress and encrypt



Compression experiment on Conviva data (columnar data)

Empirical insight: can achieve near optimal compression on real datasets using *small packs*



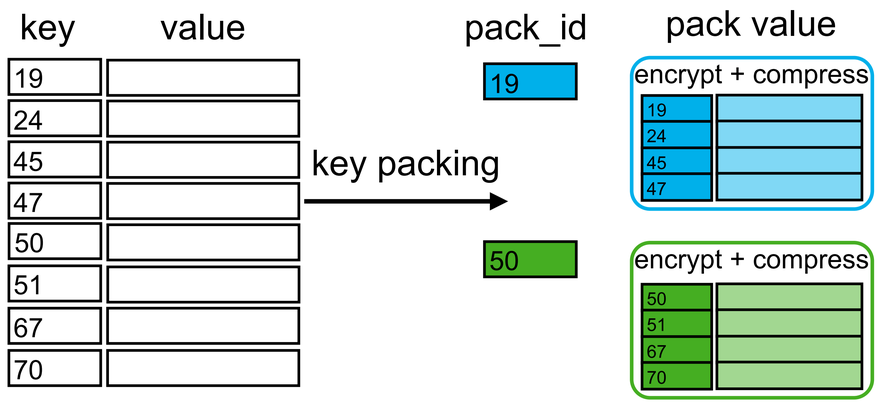
Compression experiment on genomics data

System Design

MiniCrypt is a system that enables compression and encryption, and works with existing unmodified KV stores!

An existing key value store should satisfy 2 requirements
1. Single record atomic update (UPDATE-IF)
2. Maintains sorted index on primary key

Data sorted by primary key and transformed into *packs*



Data operations

get(*key*) Select the pack with the highest pack ID from all pack IDs that are at most *key*
range(*low*, *high*) Range query + one extra read
put(*key*, *value*) Each put = get + put

Writes in MiniCrypt

Naively implementing blind writes will cause *overwrites* if there are writes to different keys within the same pack

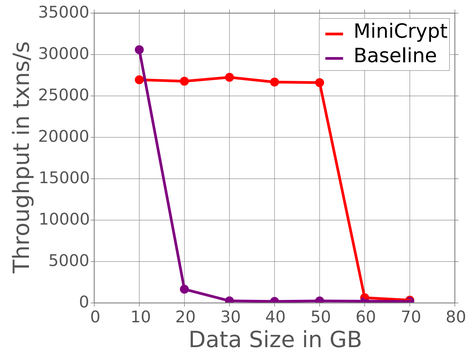
Generic mode:
- used in any write situation
- uses atomic update mechanism for each put

Append mode:
- used when data is immutable and not overwritten, and keys are increasing e.g. time-series data
- uses epoch-based logs to store new inserts; background processes merge these inserts

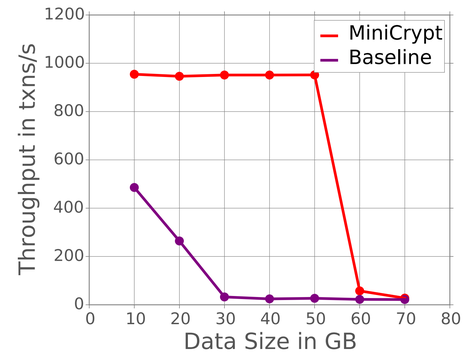
Performance

Implementation: evaluation done using Cassandra on read-only workload; we use zlib and AES encryption

MiniCrypt provides up to 100x performance gain



100% single record read YCSB workload, compared with a client that encrypts single records



100% range queries YCSB workload (1000 records)

Future Work

- Develop more sophisticated heuristics for determining how many keys reside in a pack
- Find ways to add aggregate functionalities