Baskin Engineering
UC SANTA CRUZ

Erasure Coding & Read/Write Separation in Flash Storage

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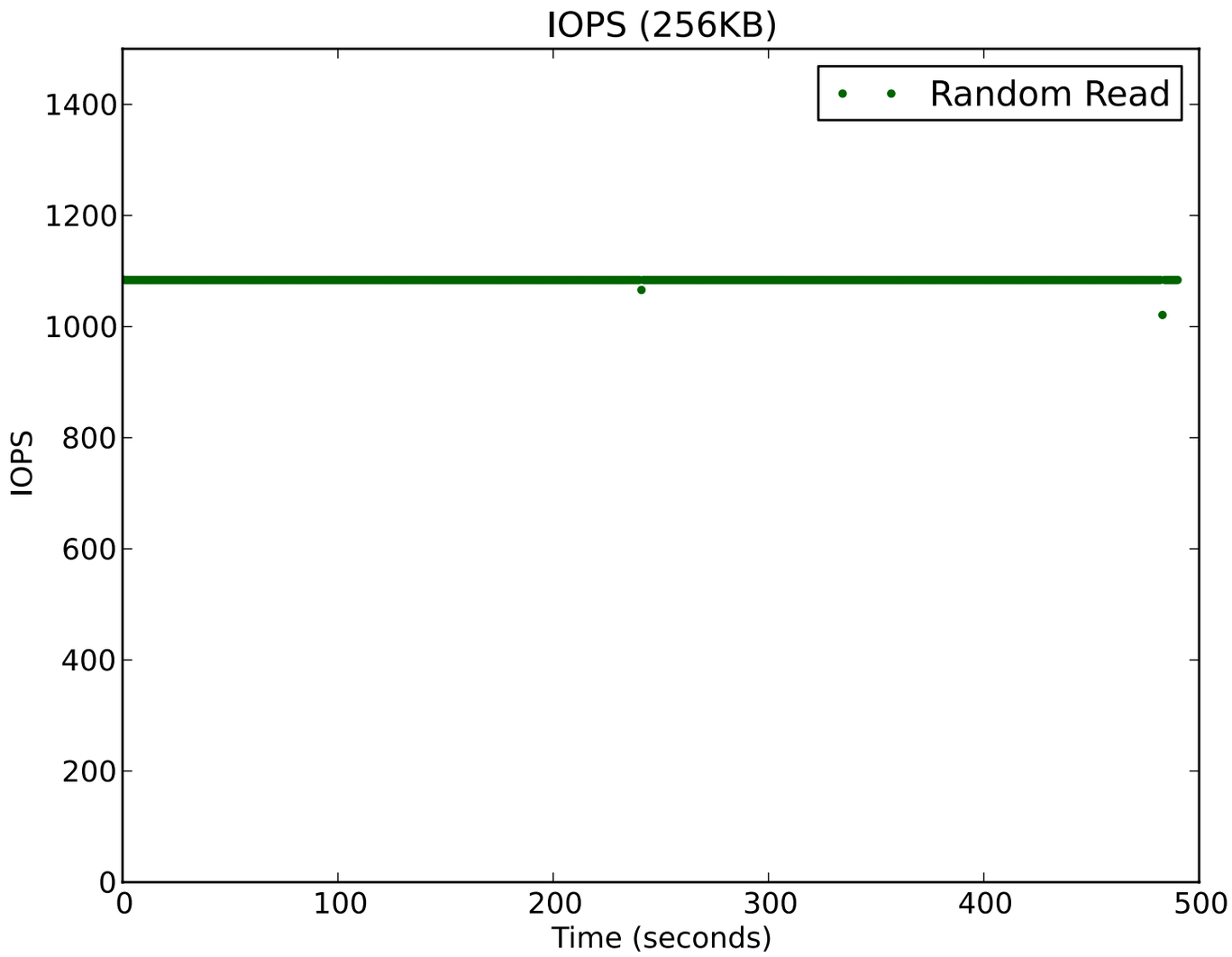
INFLOW'14

Outline

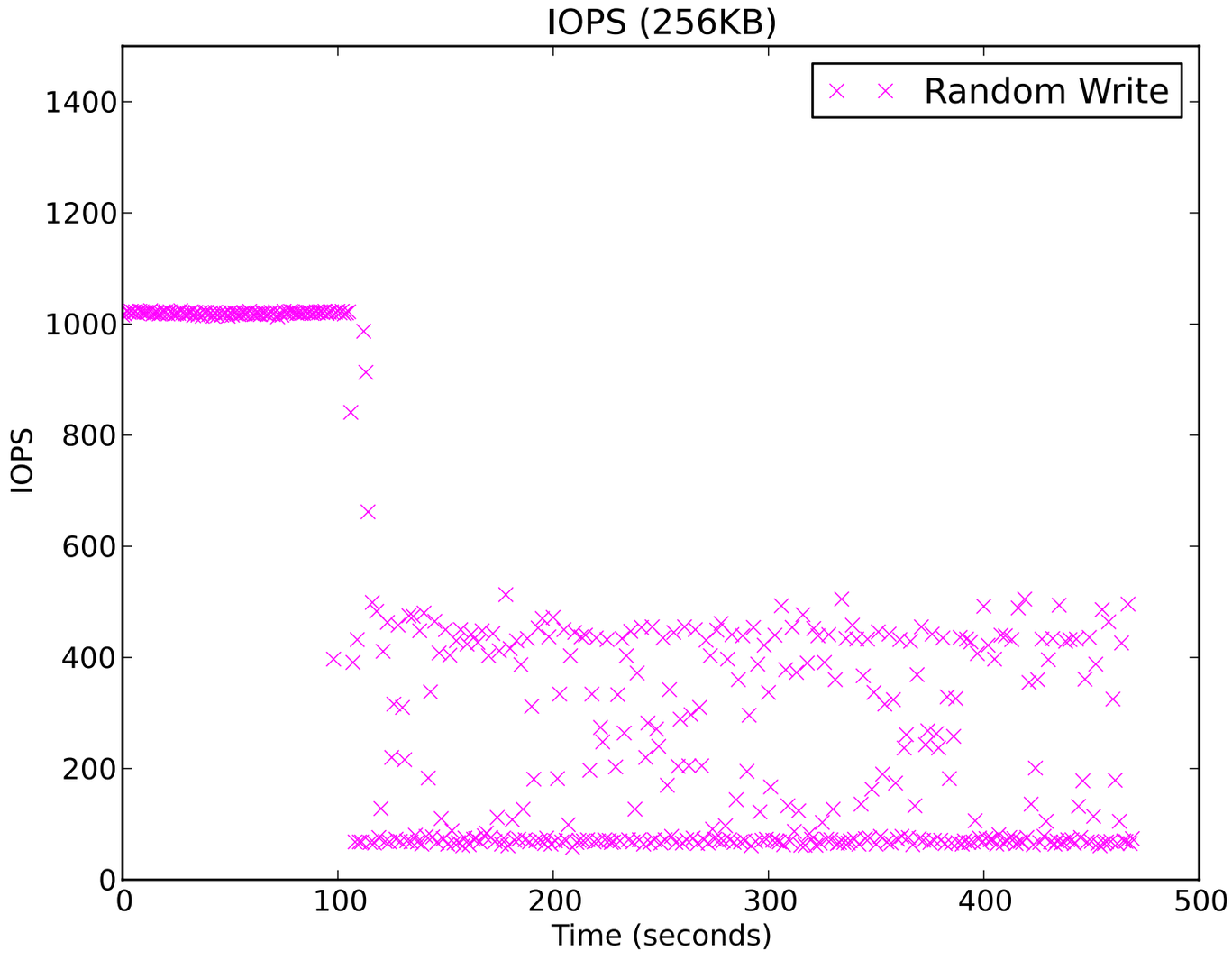
- Background
  - Performance (un)predictability in SSDs
  - Making SSD storage predictable with Rails
- Erasure Coding and Rails
  - Coding performance
  - Throughput and scaling
  - Evaluation
- Conclusion

SSD Performance Unpredictability

Reads are perfect

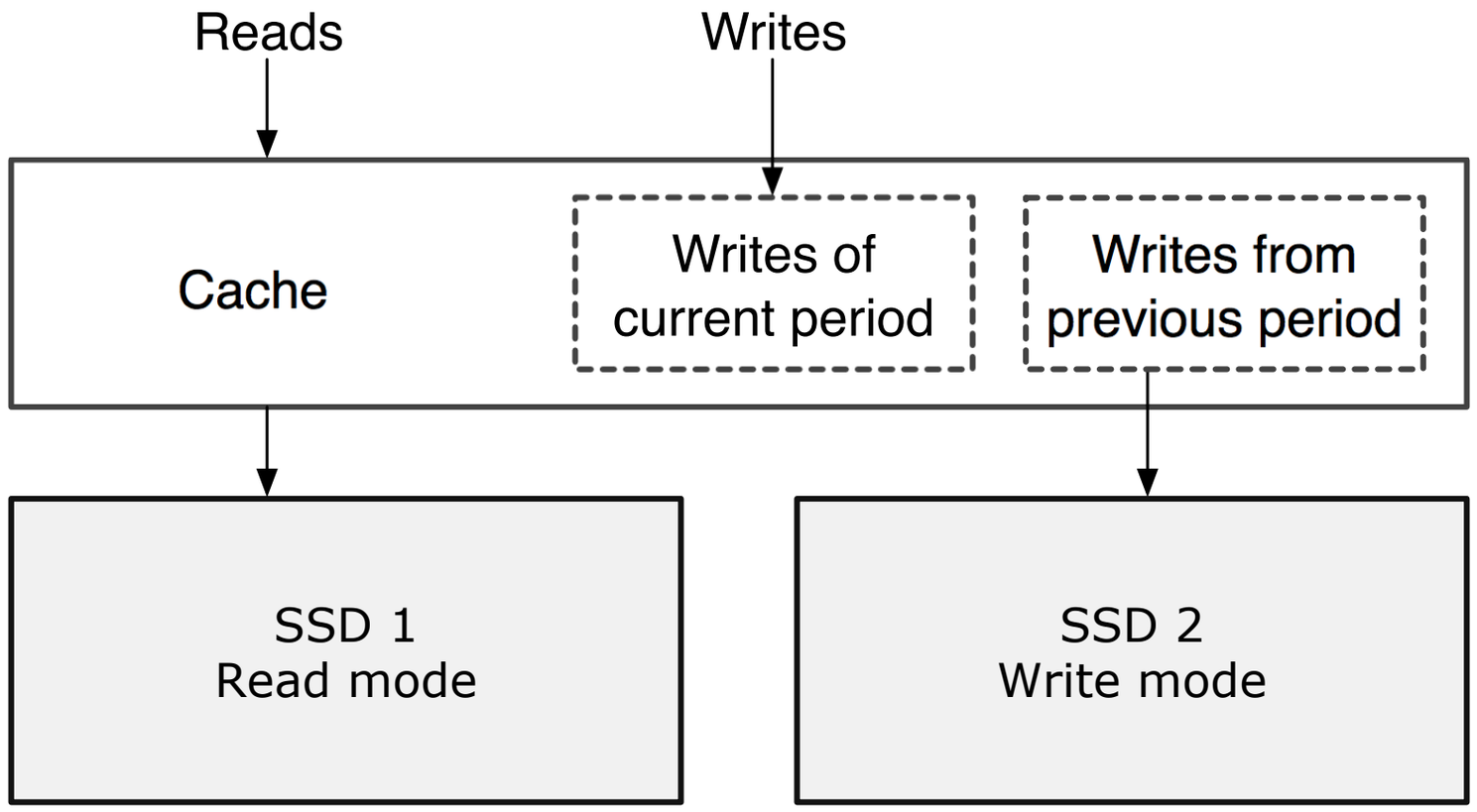


Writes are unpredictable



Physical read/write separation with Rails

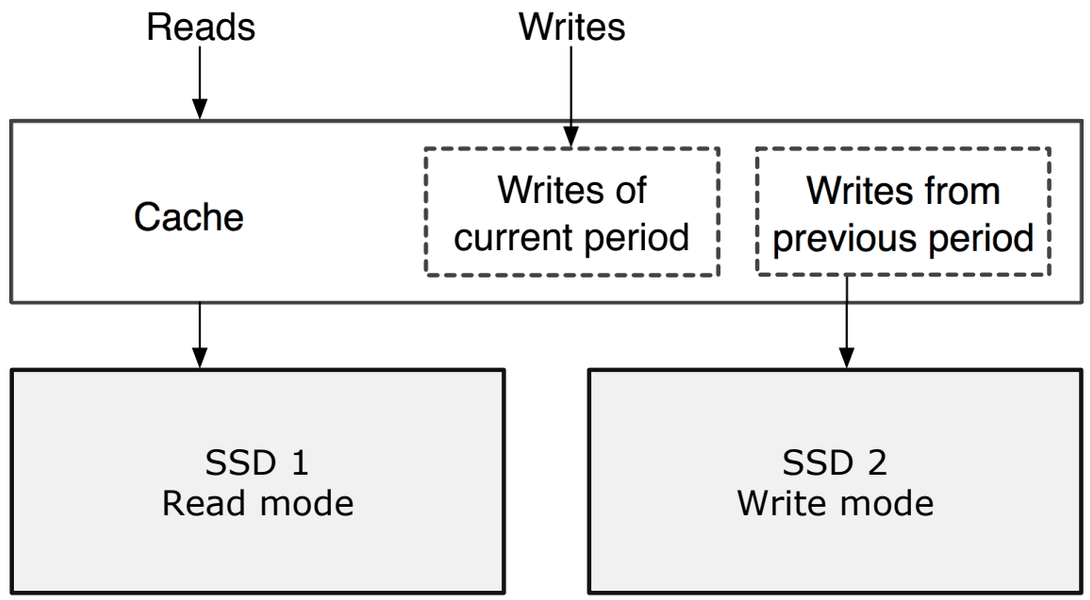
Basic 2 drive design



Drives stay in sync (periodically)

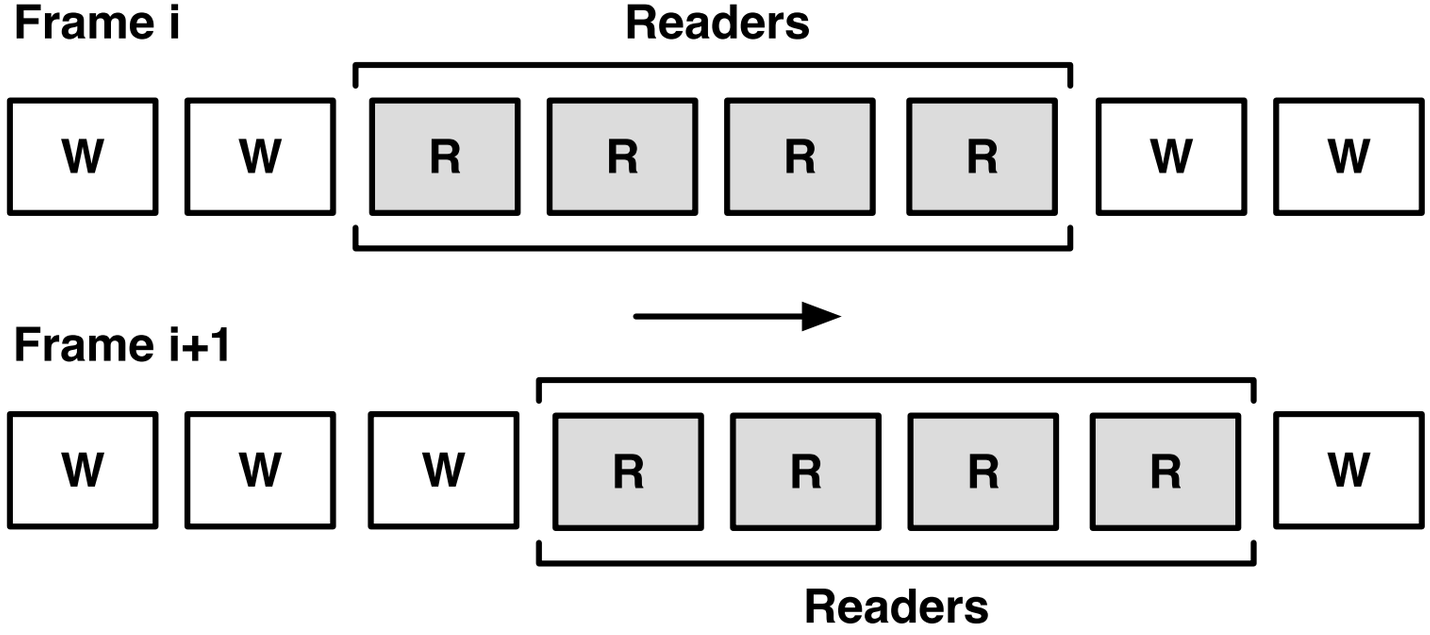
Design properties

- Consistency
- Heterogeneity
- Power failure
- Twice the cost?



Cache + SSD 1 = Cache + SSD 2

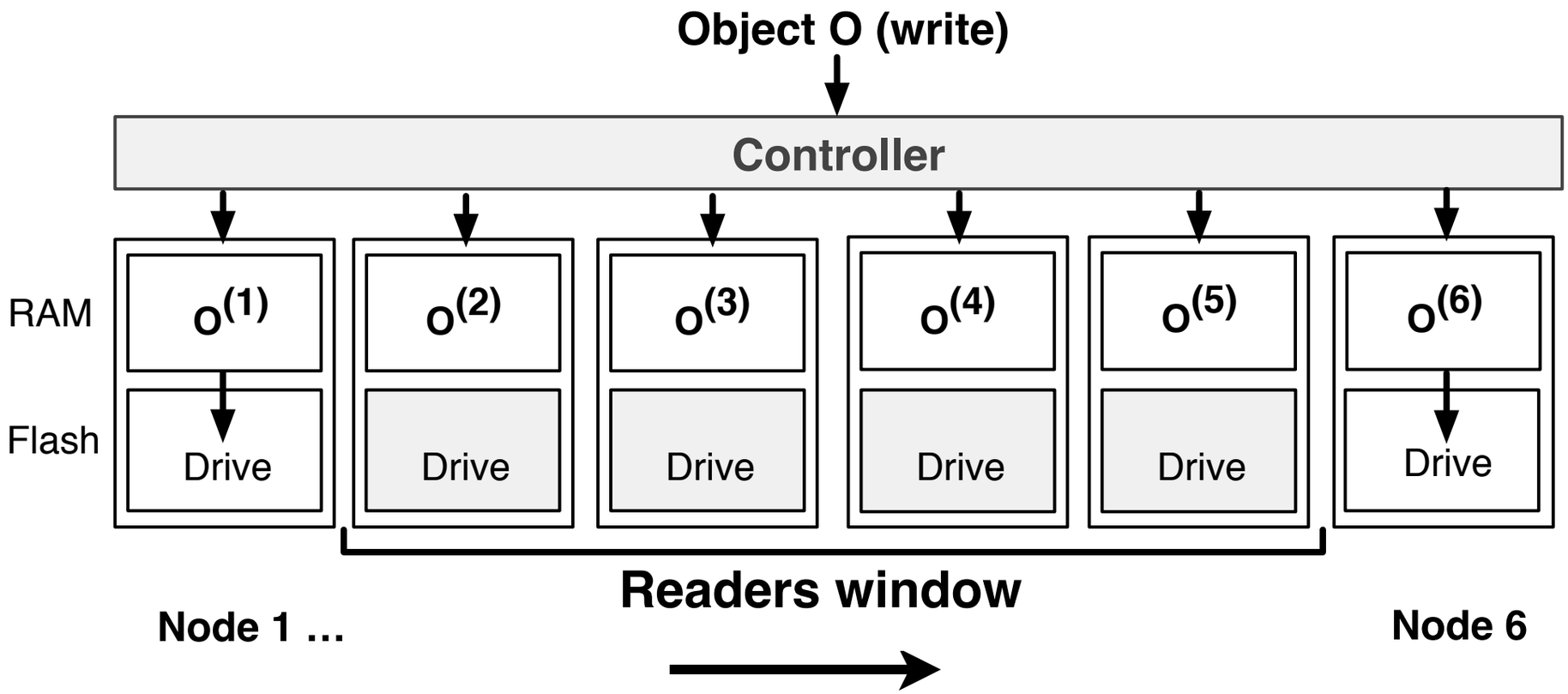
Design generalization



Large storage arrays and distributed storage already employ redundancy (replication or erasure coding)

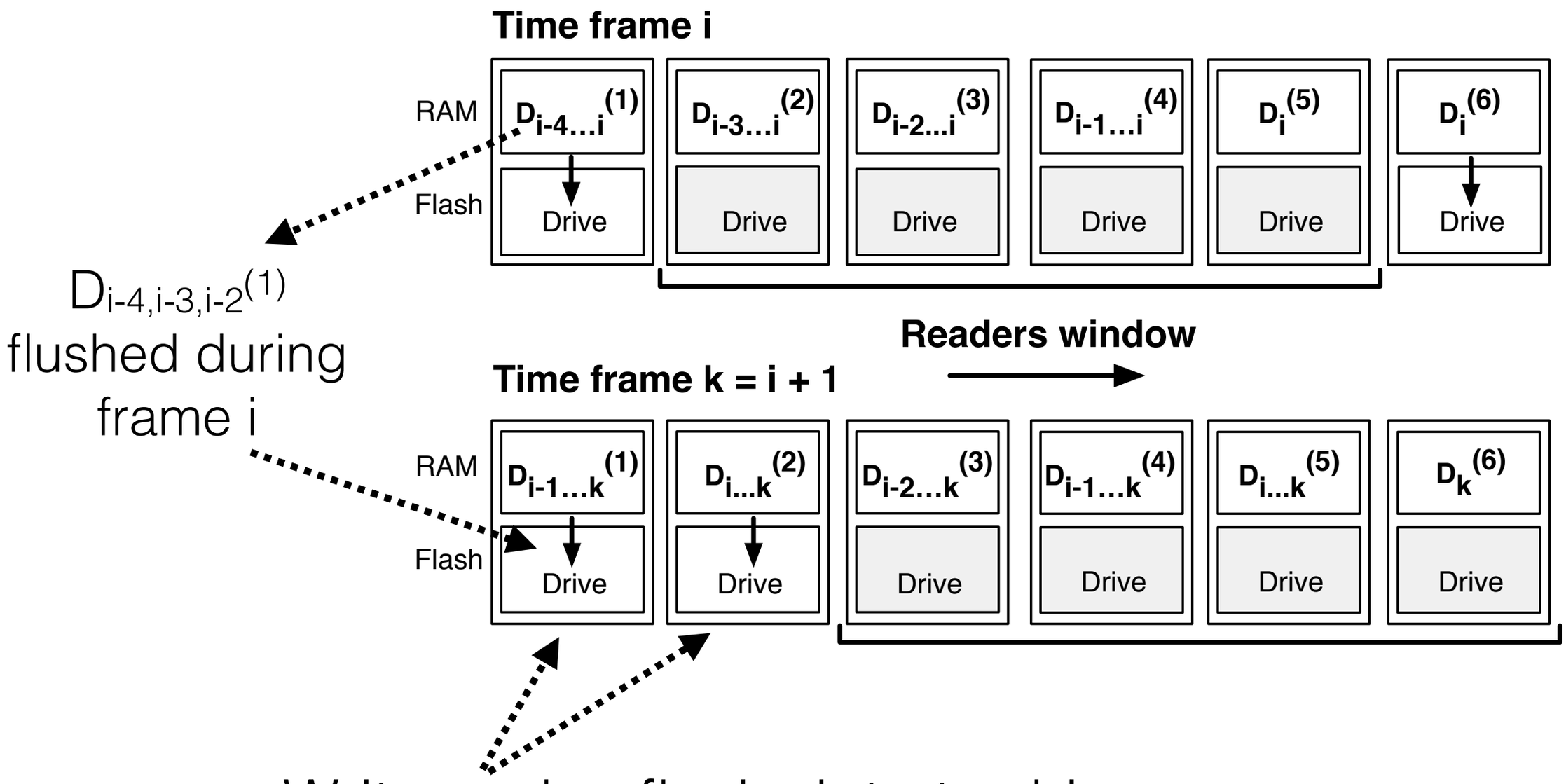
An object is spread among nodes

depending on the redundancy



Reading nodes accumulate writes in RAM

Flushing writes



Rails & Erasure Coding

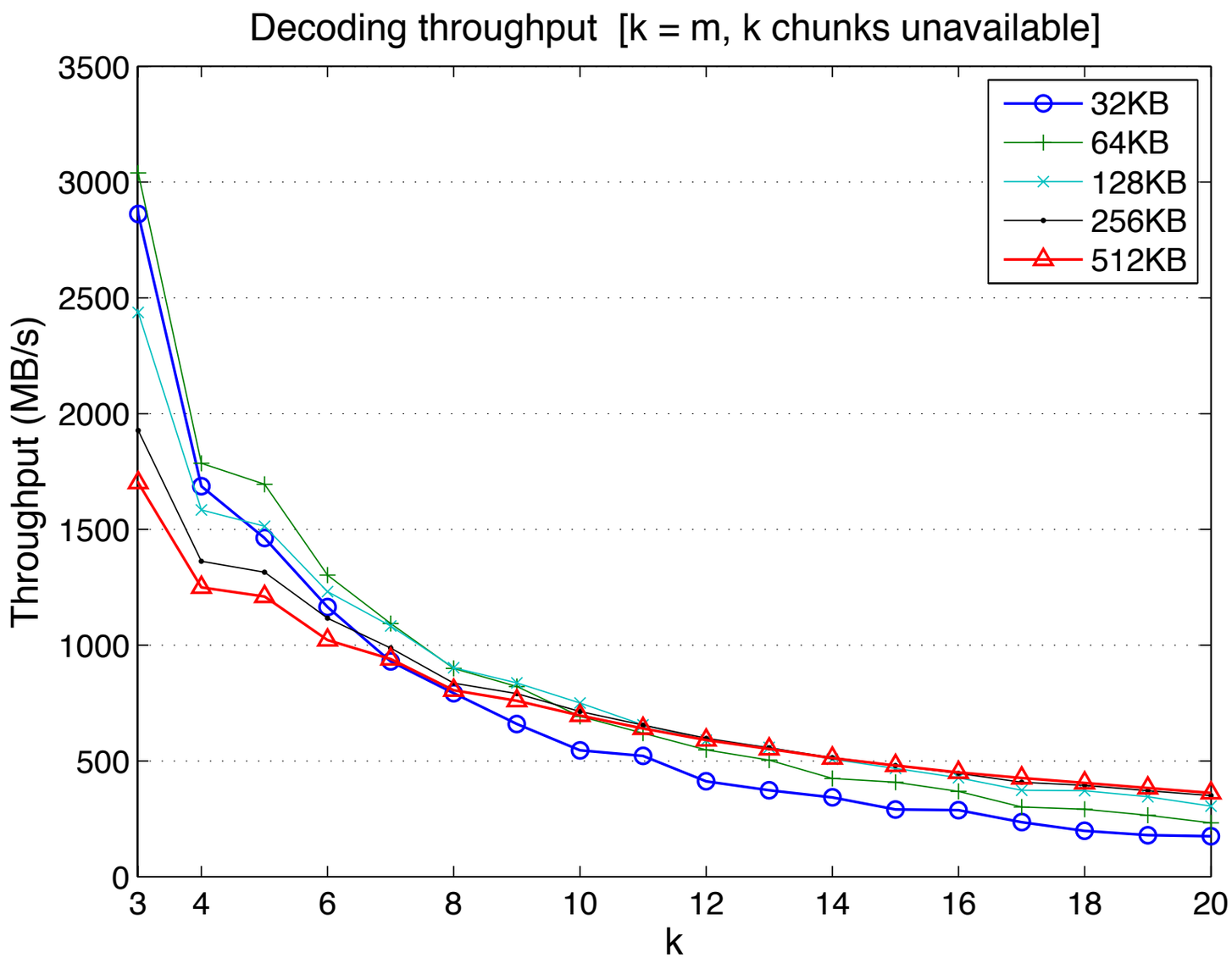
Rails & erasure coding

- Avoid storage space overhead of replication
- Perform reads through reconstruction (decoding)
  - Utilizes current set of drives dedicated to reading
  - Pay in computational cost
- Scale by constructing redundancy groups
  - Computational cost scalable
  - Maintain read/write separation

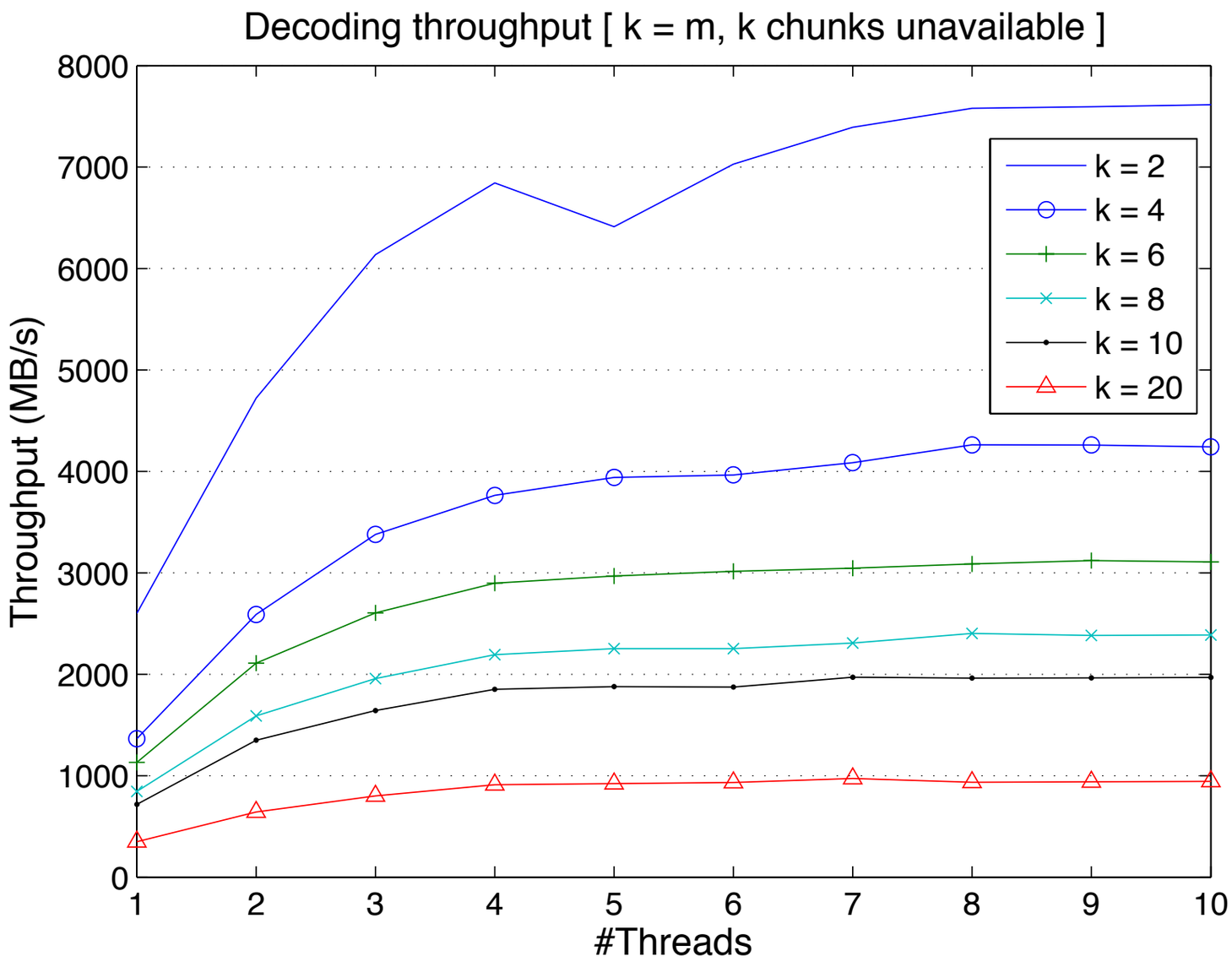
Erasure coding

- Write object of size 100MB
- Obfuscate (encode) to 120MB
- Split into 12 chunks of 10MB each
- Distribute across 12 drives
- Any 10 drives/chunks may be used to read the original object

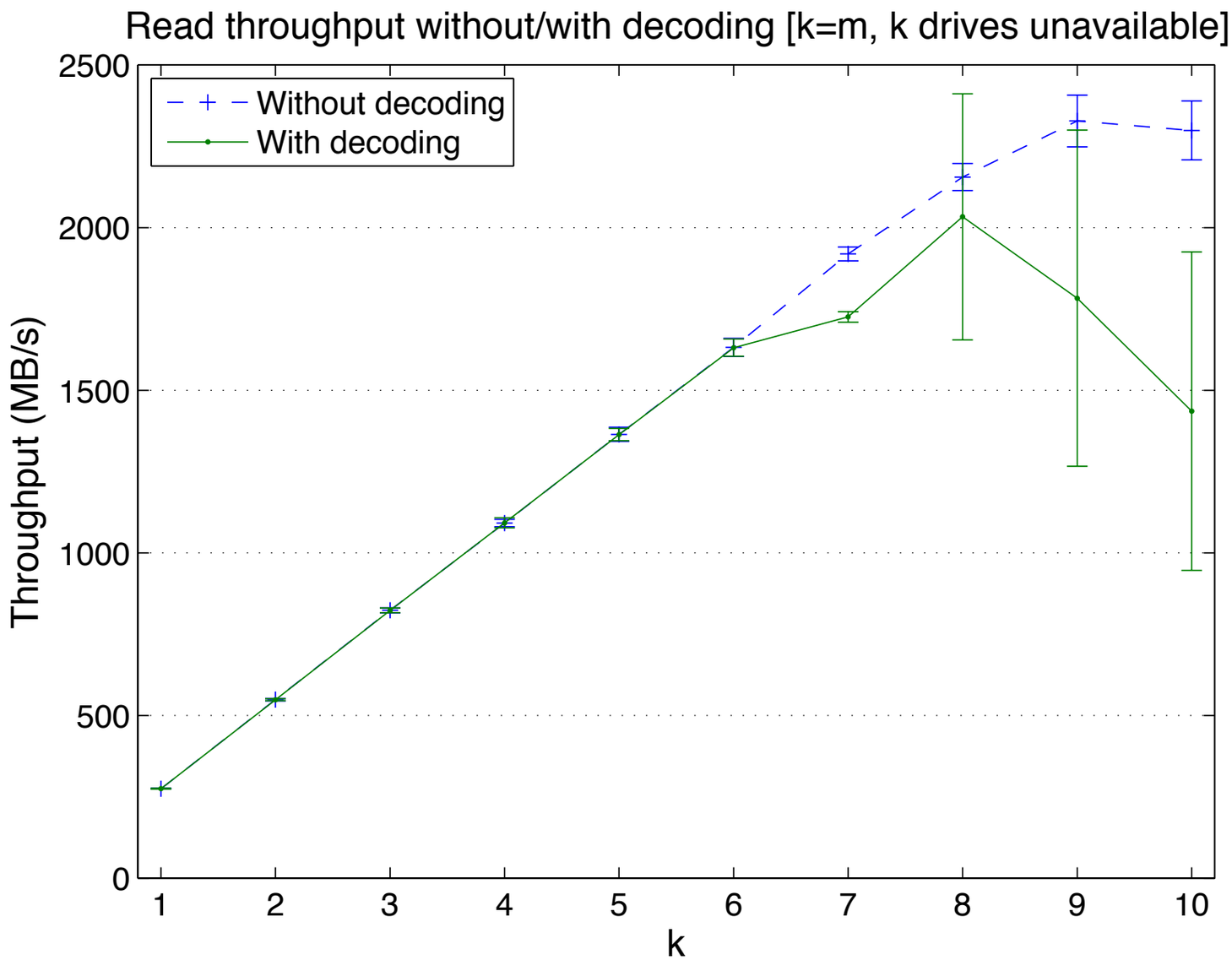
Decoding throughput



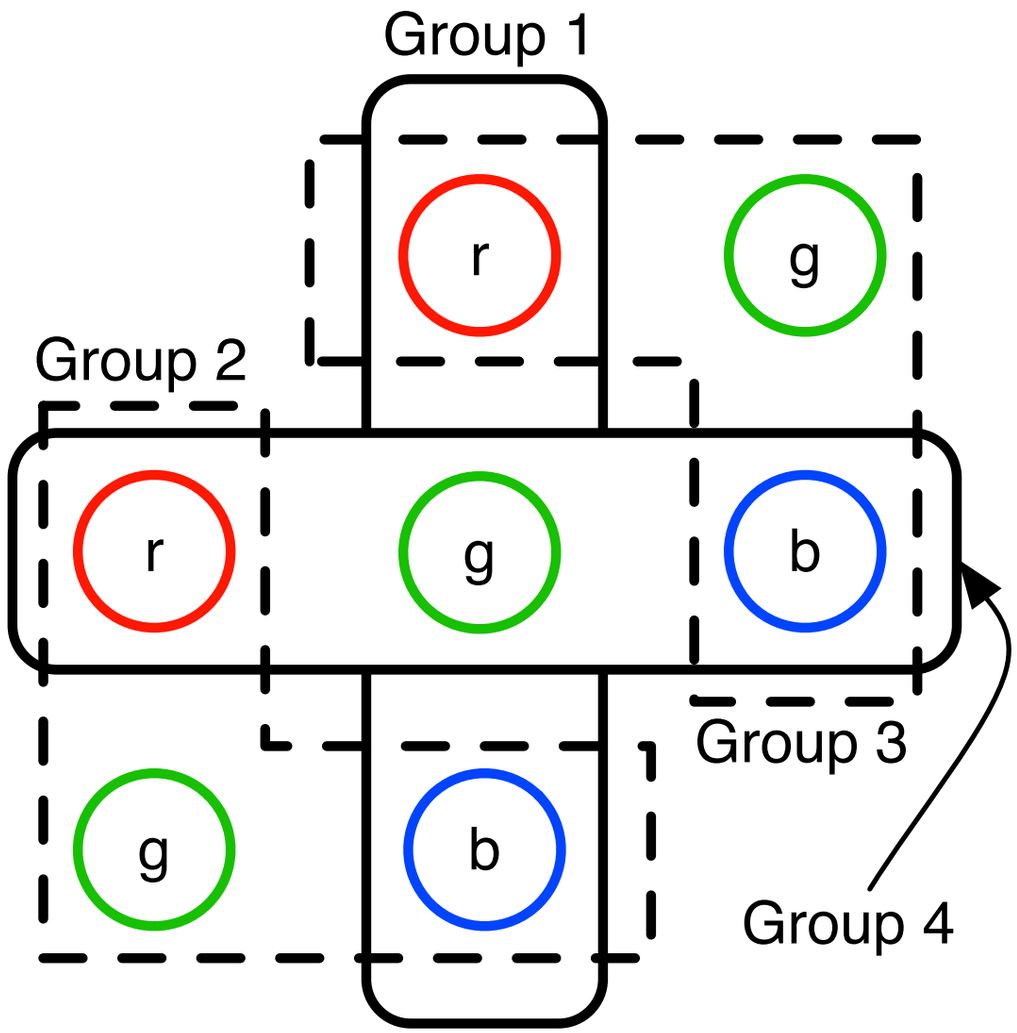
Throughput in #threads



Read throughput

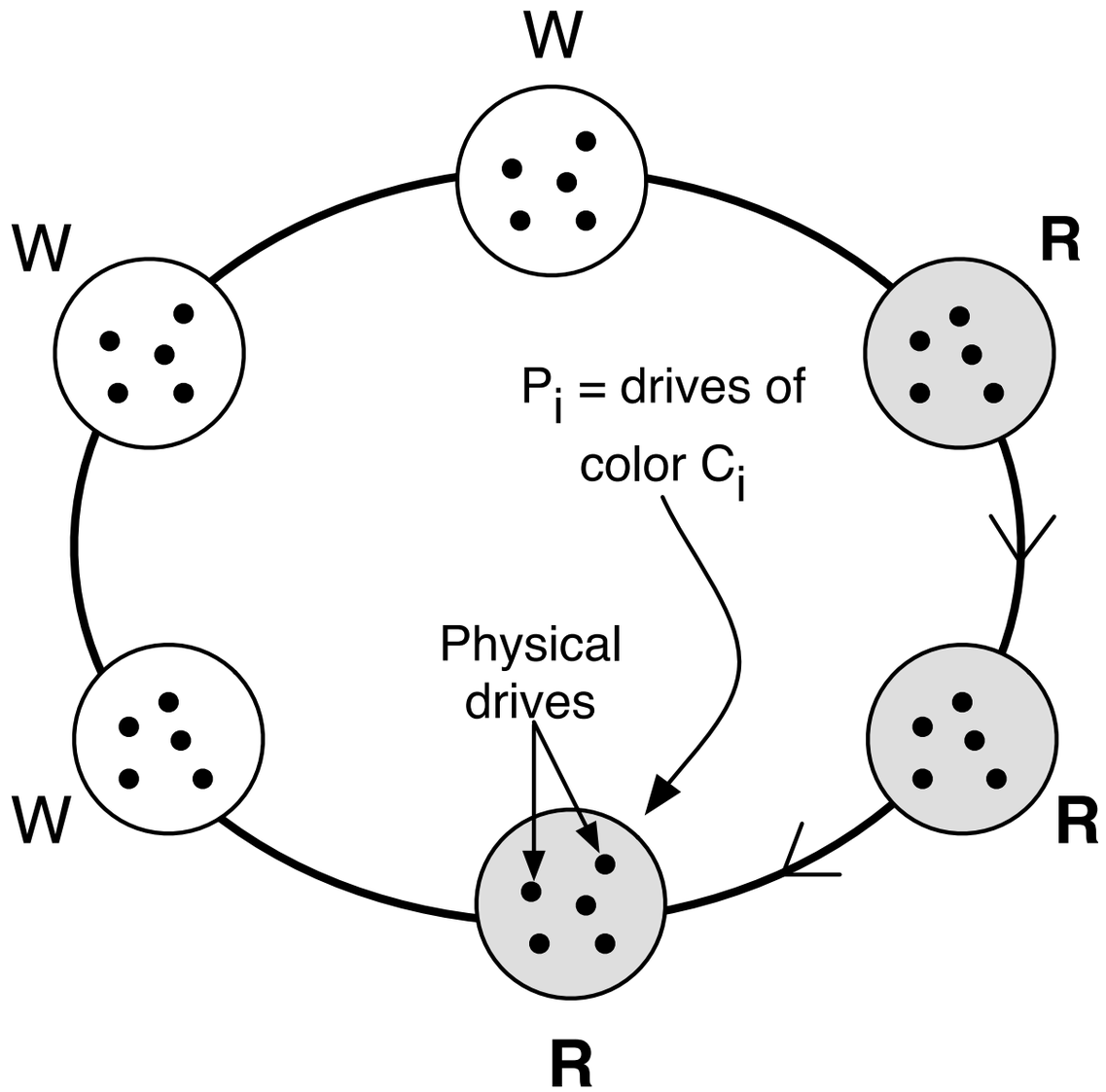


Redundancy groups with R/W separation

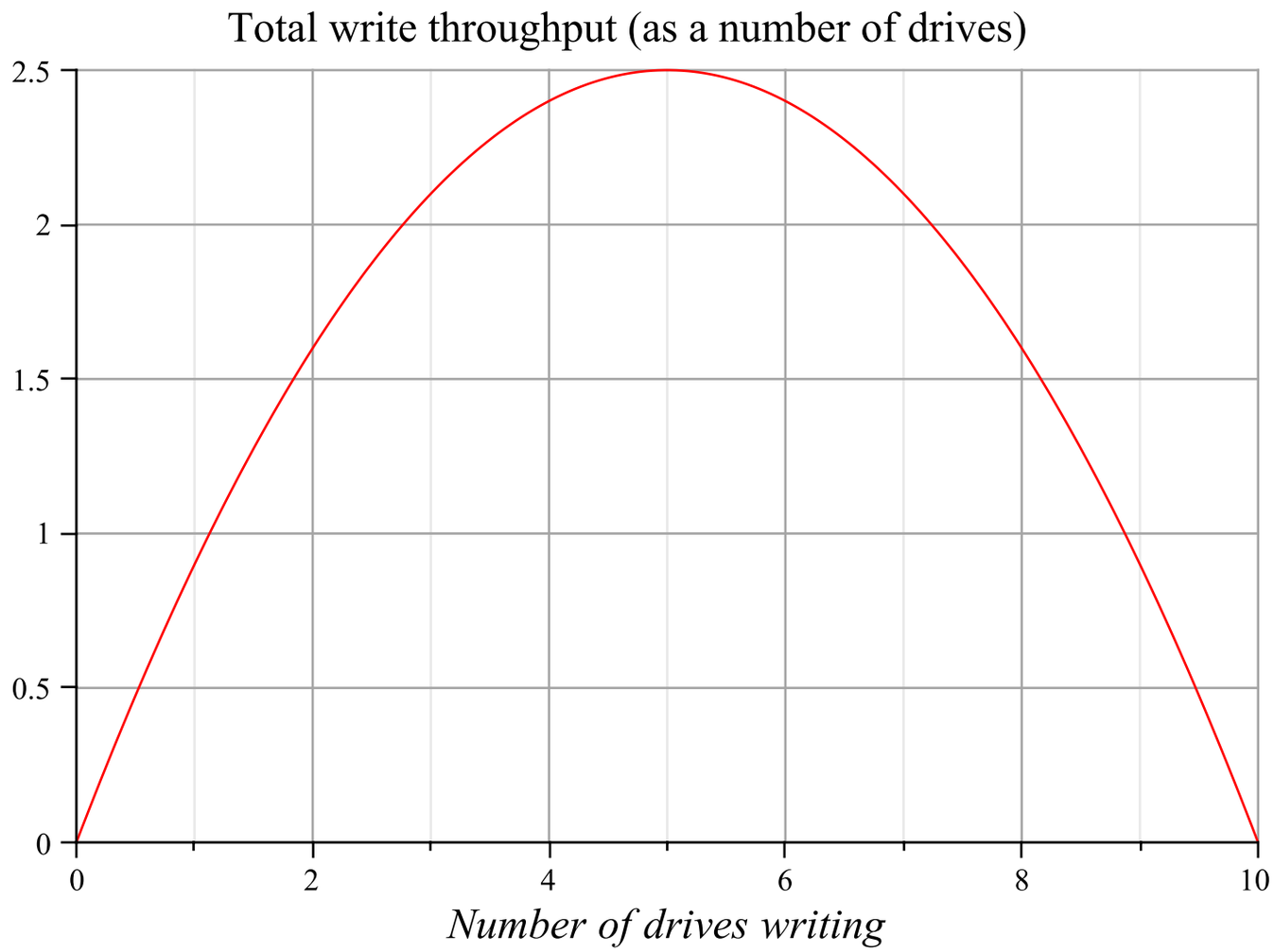


Hypergraph with four overlapping hyperedges (redundancy groups), each containing three vertices (drives)

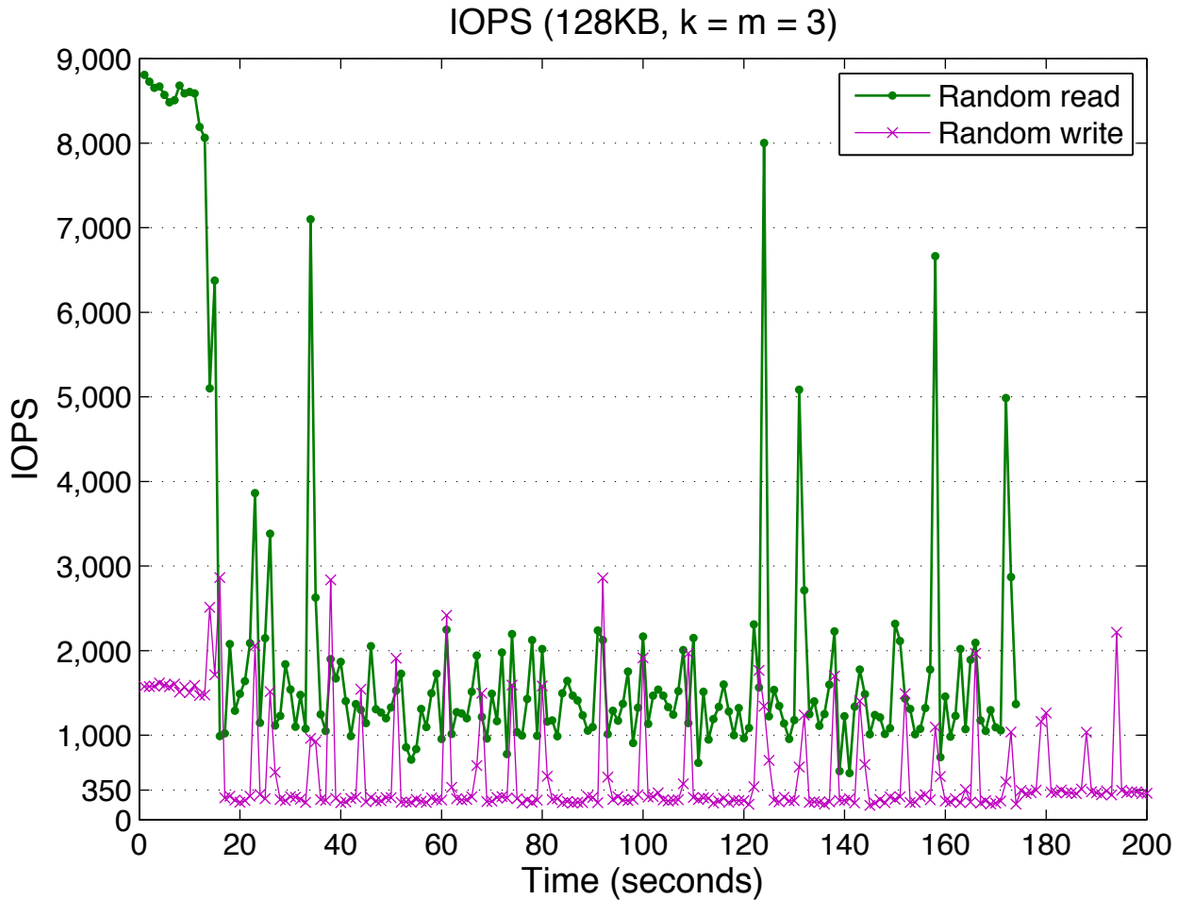
Generating redundancy groups for R/W separation



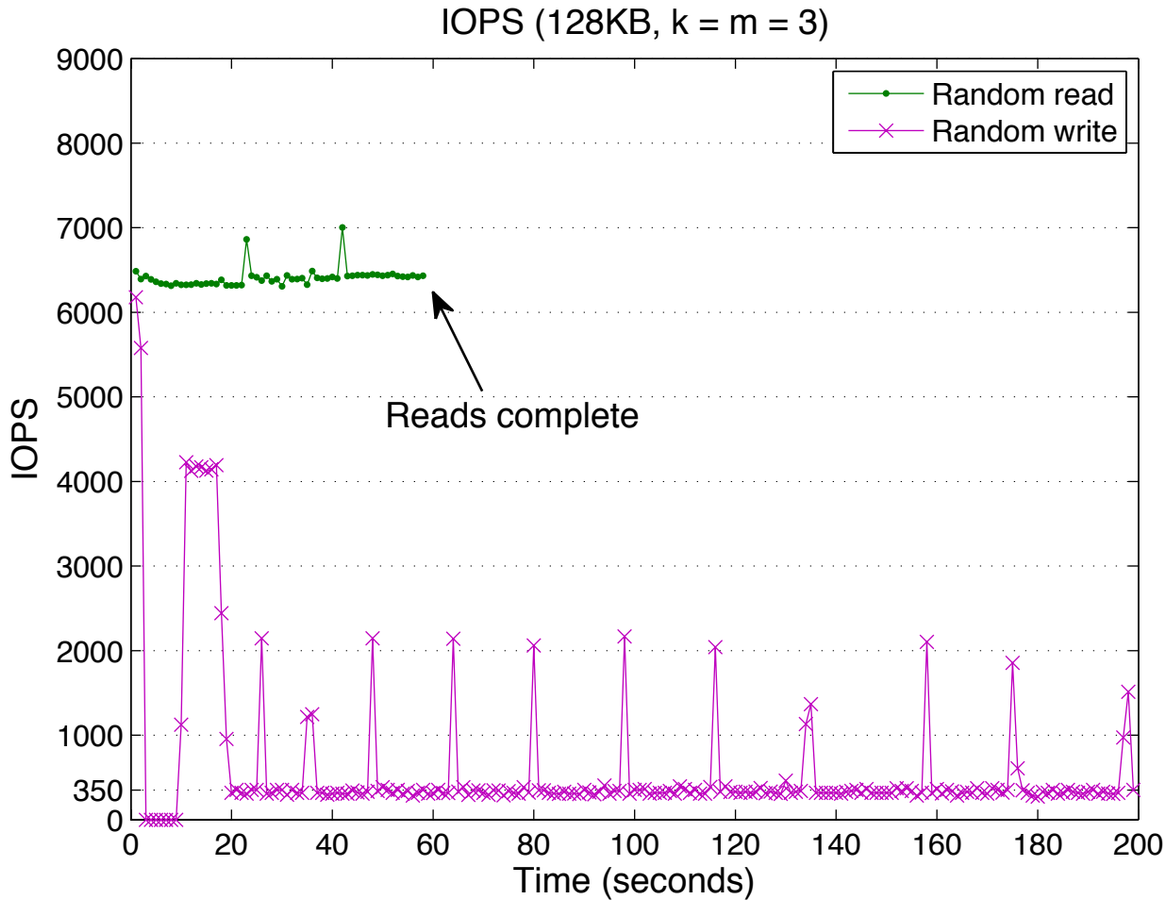
Write throughput bound



Performance of eRails (erasure coding, 6 drives)

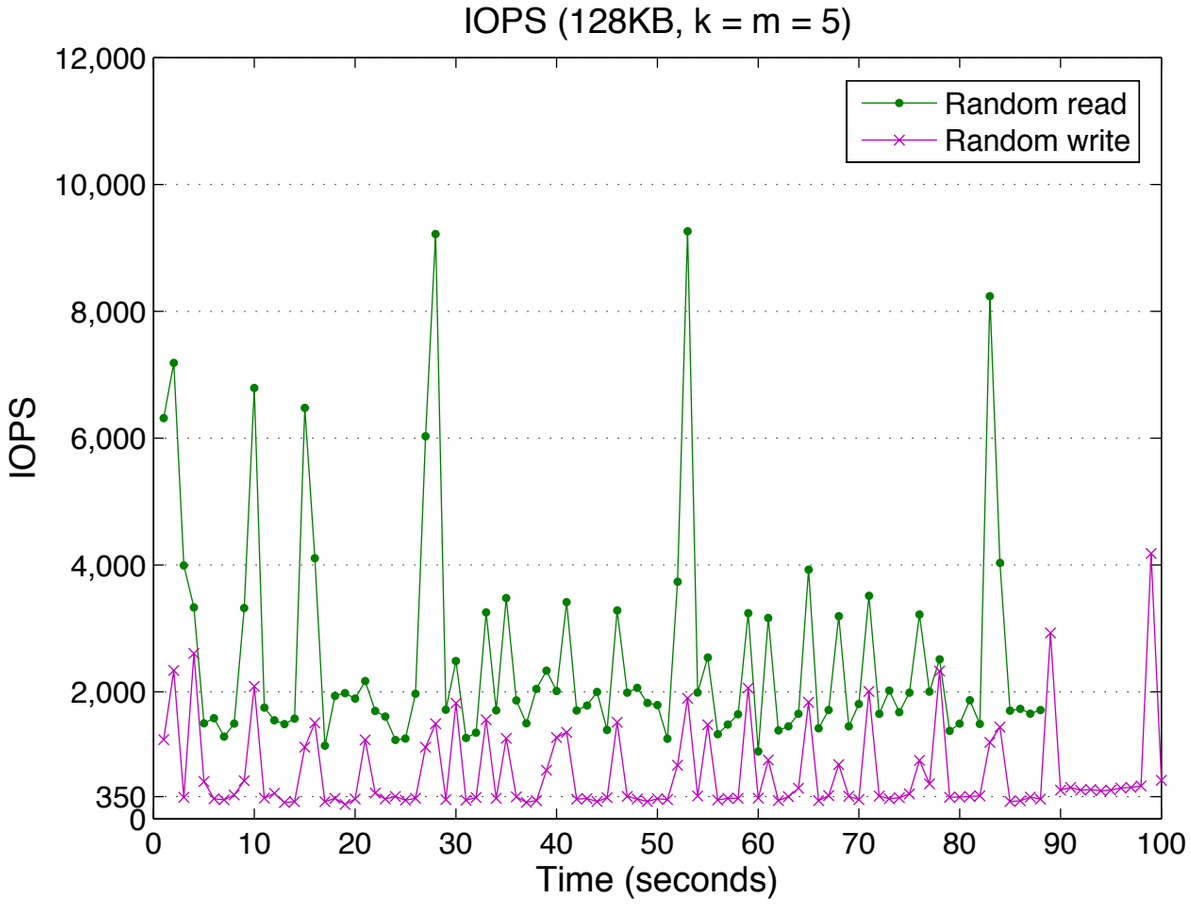


Without eRails

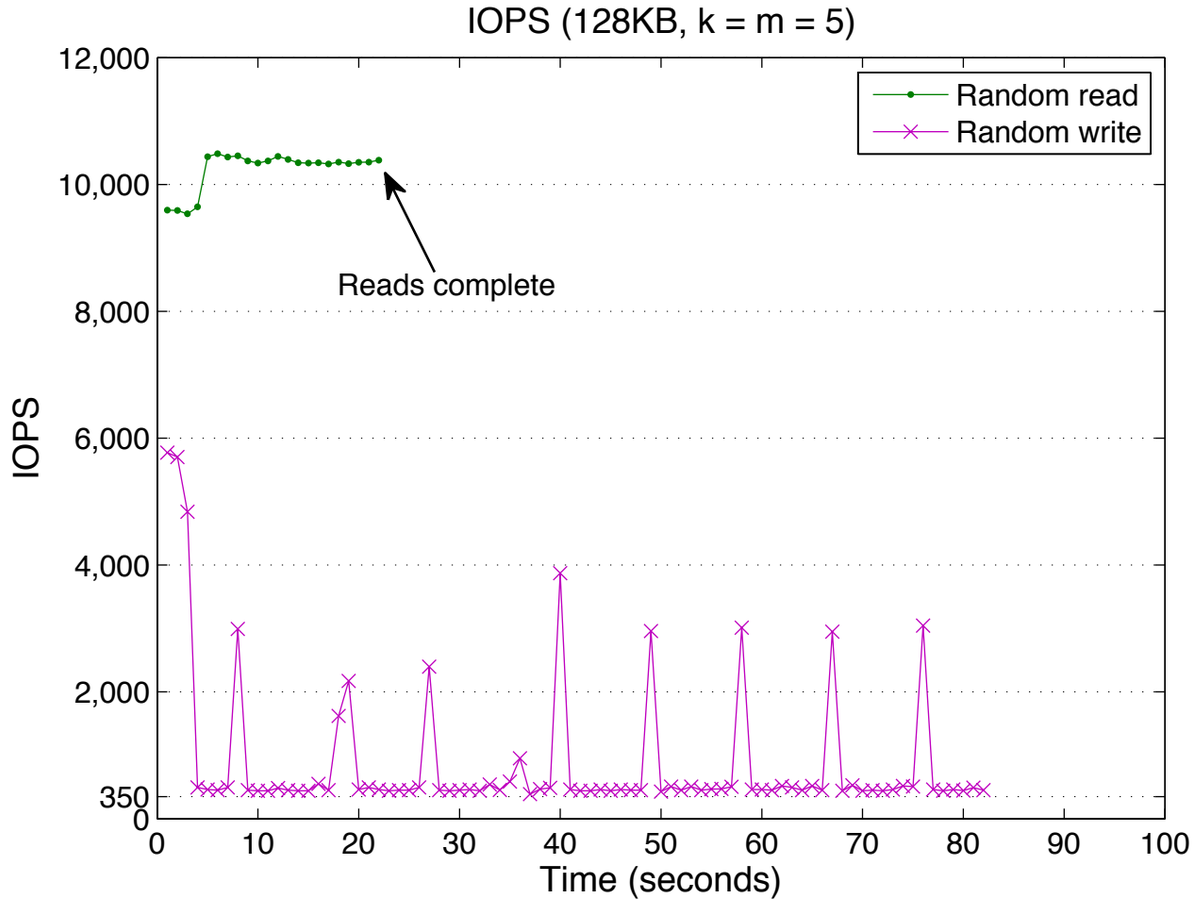


With eRails

Performance of eRails (erasure coding,10 drives)



Without eRails



With eRails

Summary

- Erasure coding
  - Space-efficient redundancy method for Rails
- Computational cost
  - Increase to the array size
  - After certain #drives (e.g., more than 10) throughput decreases
- Achieve scaling
  - Generate overlapping redundancy groups
  - Leads to proportional increase of computational cost