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shaping tomorrow with you

Erasure Code with Shingled Local Parity Groups for Efficient Recovery from Multiple Disk Failures

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Contents

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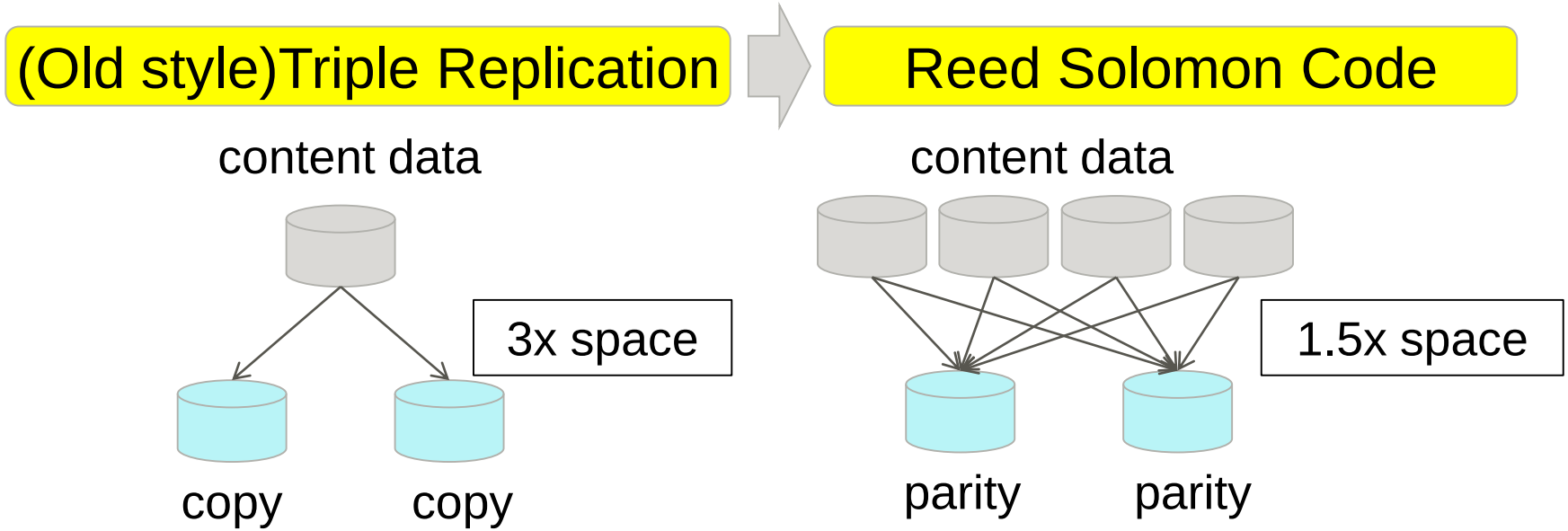
1. Backgrounds and Our Proposal

Backgrounds (1)

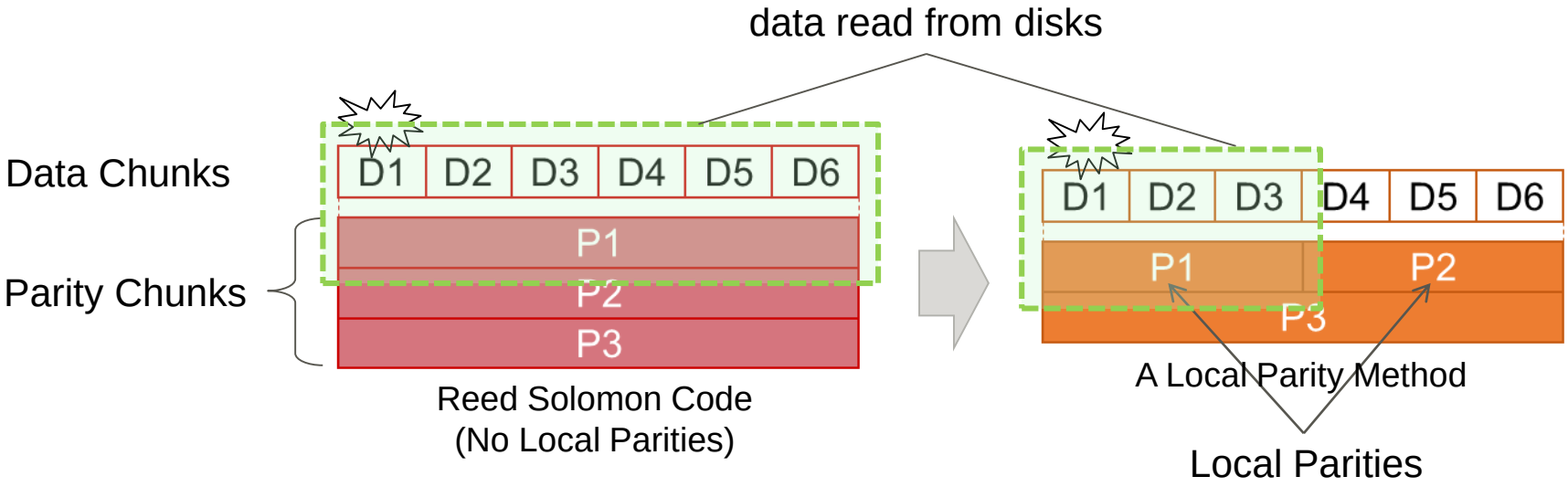
- Erasure codes for content data
  - Content data for ICT services is ever-growing
  - Demand for higher space efficiency and durability
  - Reed Solomon code (de facto erasure code) improves both



However, Reed Solomon code is not so recovery-efficient

Backgrounds (2)

- Local parity improves recovery efficiency
  - Data recovery should be as efficient as possible
    - in order to avoid multiple disk failures and data loss
  - Reed Solomon code is improved by local parity methods
    - data read from disks is reduced during recovery



However, multiple disk failures is out of consideration

Our Goal

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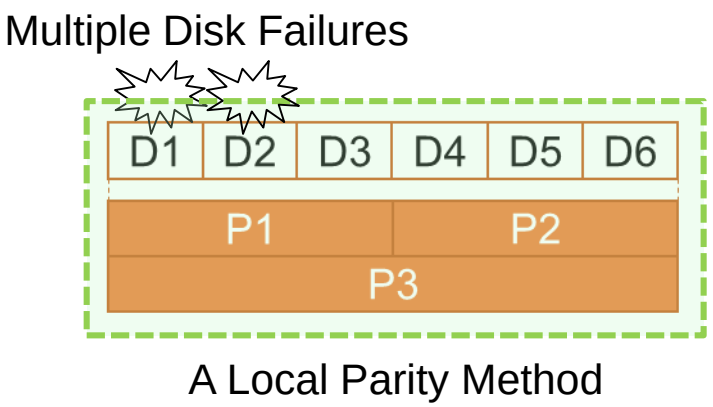
- Local parity method for multiple disk failures
  - Existing methods are optimized for single disk failure
    - e.g. Microsoft MS-LRC, Facebook Xorbas
  - However, Its recovery overhead is large in case of multiple disk failures
    - because they have a chance to use global parities for recovery



A Local Parity Method

Our goal is a method efficiently handling multiple disk failures

Our Proposal Method (SHEC)

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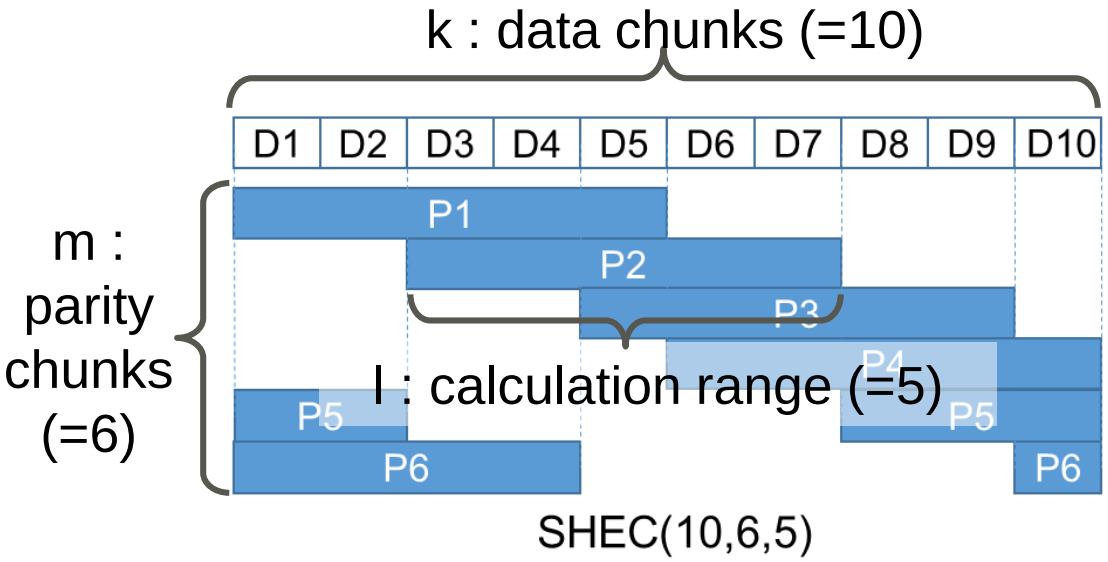
- SHEC (= Shingled Erasure Code)
  - An erasure code only with local parity groups
    - to improve recovery efficiency in case of multiple disk failures
  - The calculation ranges of local parities are shifted and partly overlap with each other (like the shingles on a roof)
    - to keep enough durability



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2. SHEC's Theoretical Analysis

Erasure Code's Properties

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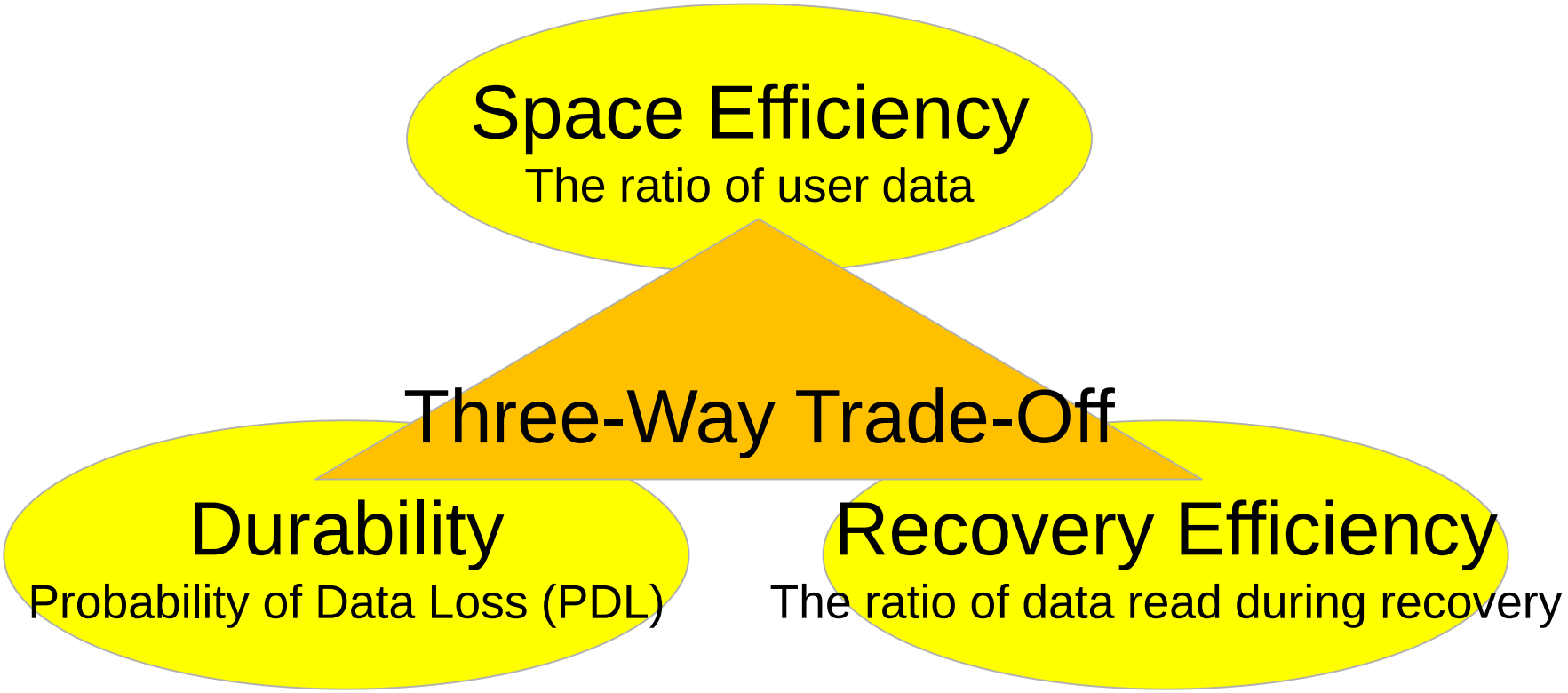
- We picked three erasure code's properties for SHEC's theoretical analysis



The properties satisfy a three-way trade-off relationship

SHEC's Recovery Efficiency

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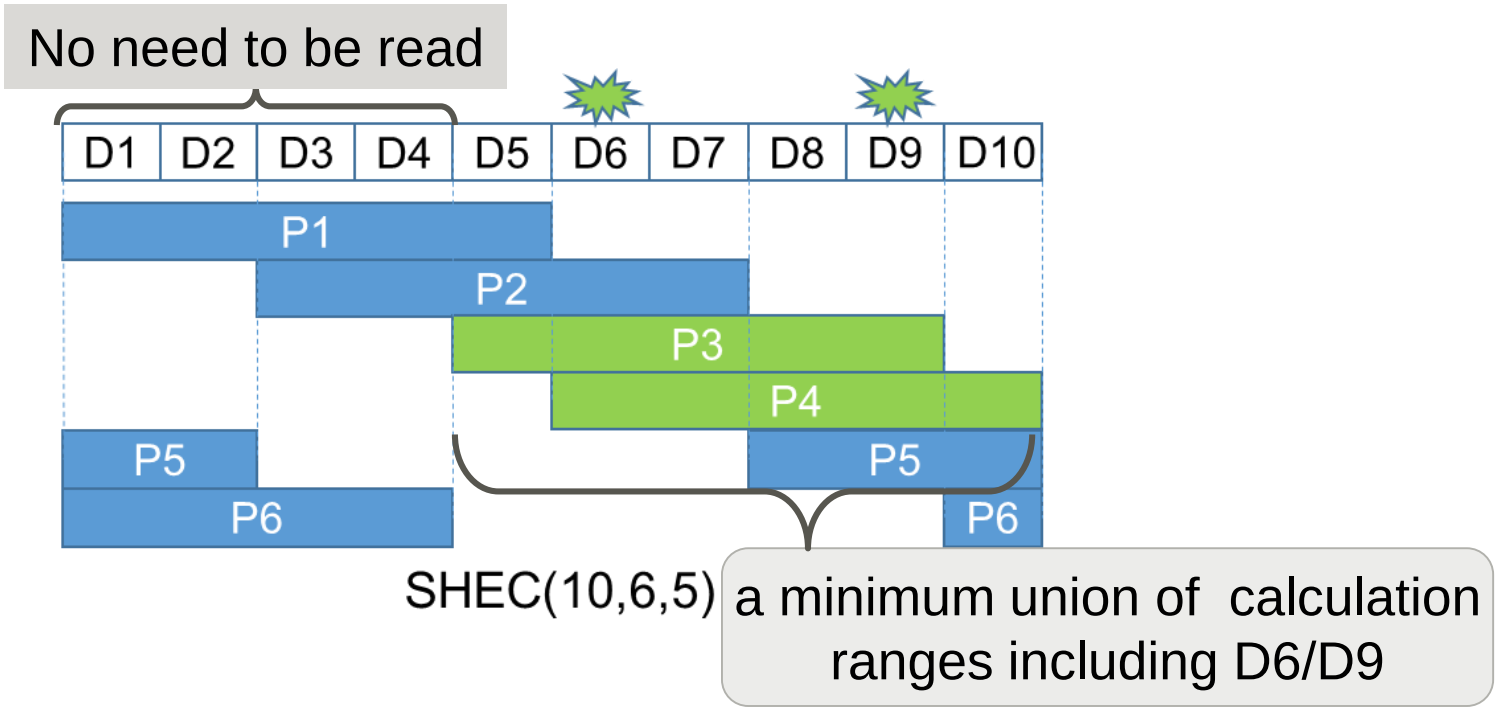
- High Recovery Efficiency from Multiple Disk Failures
  - The amount of data read from disks is minimized
    - (e.g.) When D6/D9 break out, SHEC will select P3/P4 for recovery



Recovery efficiency is one of the biggest features of SHEC

Comparison with Other Methods

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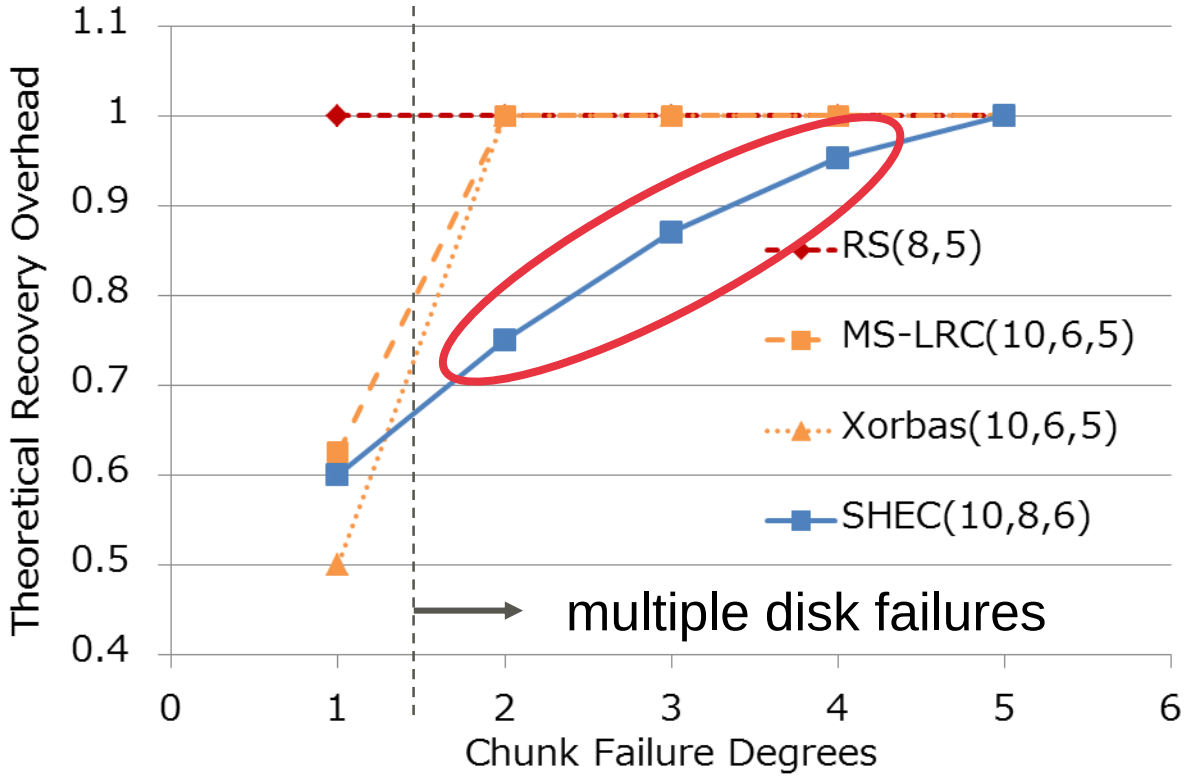
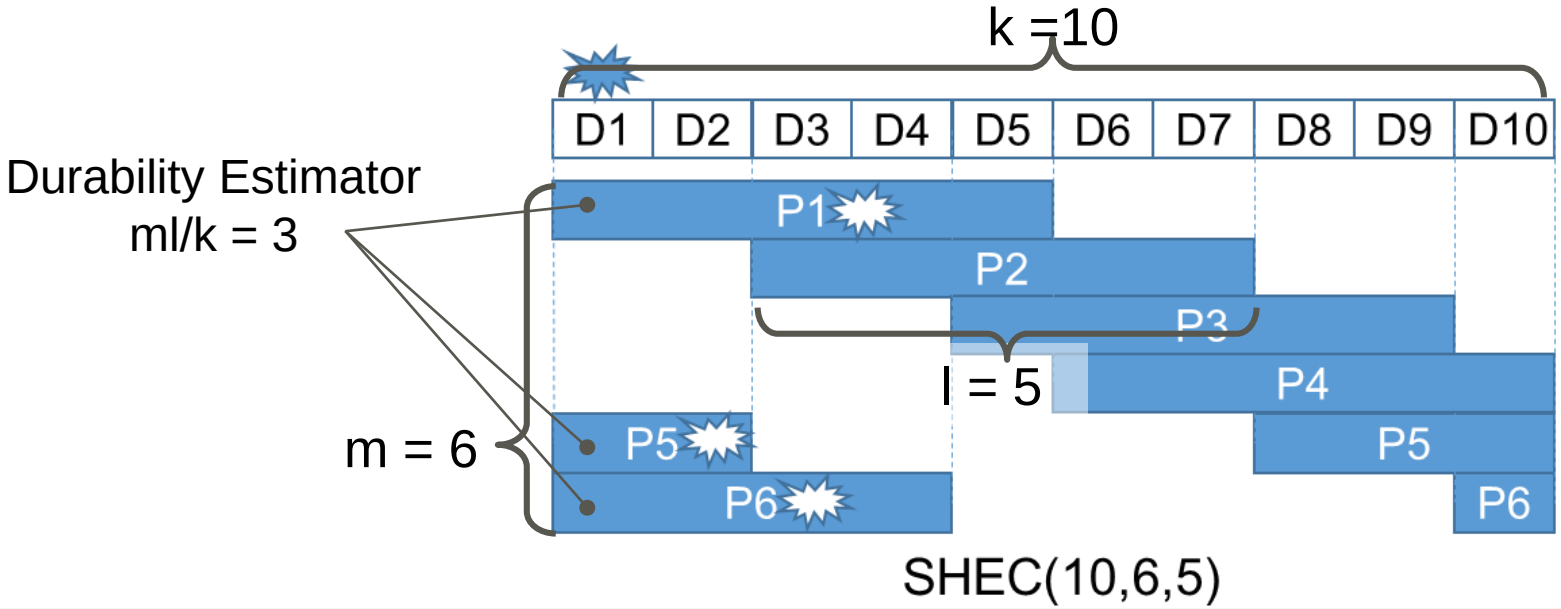
- SHEC is expected to recover more efficiently than the other methods in case of multiple disk failures
  - Other methods : Reed Solomon, MS-LRC and Xorbas



SHEC's Durability

- Durability Estimator (=ml/k)
  - Indicates the number up to how many disks can be failed
  - Therefore, ml/k+1 disk failures can cause data loss
    - (e.g.) SHEC(10,6,5)'s durability estimator is three. Therefore, four failures of D1/P1/P5/P6 cause data loss because D1 cannot be recovered from the remaining chunks



Property Map of Reed Solomon code

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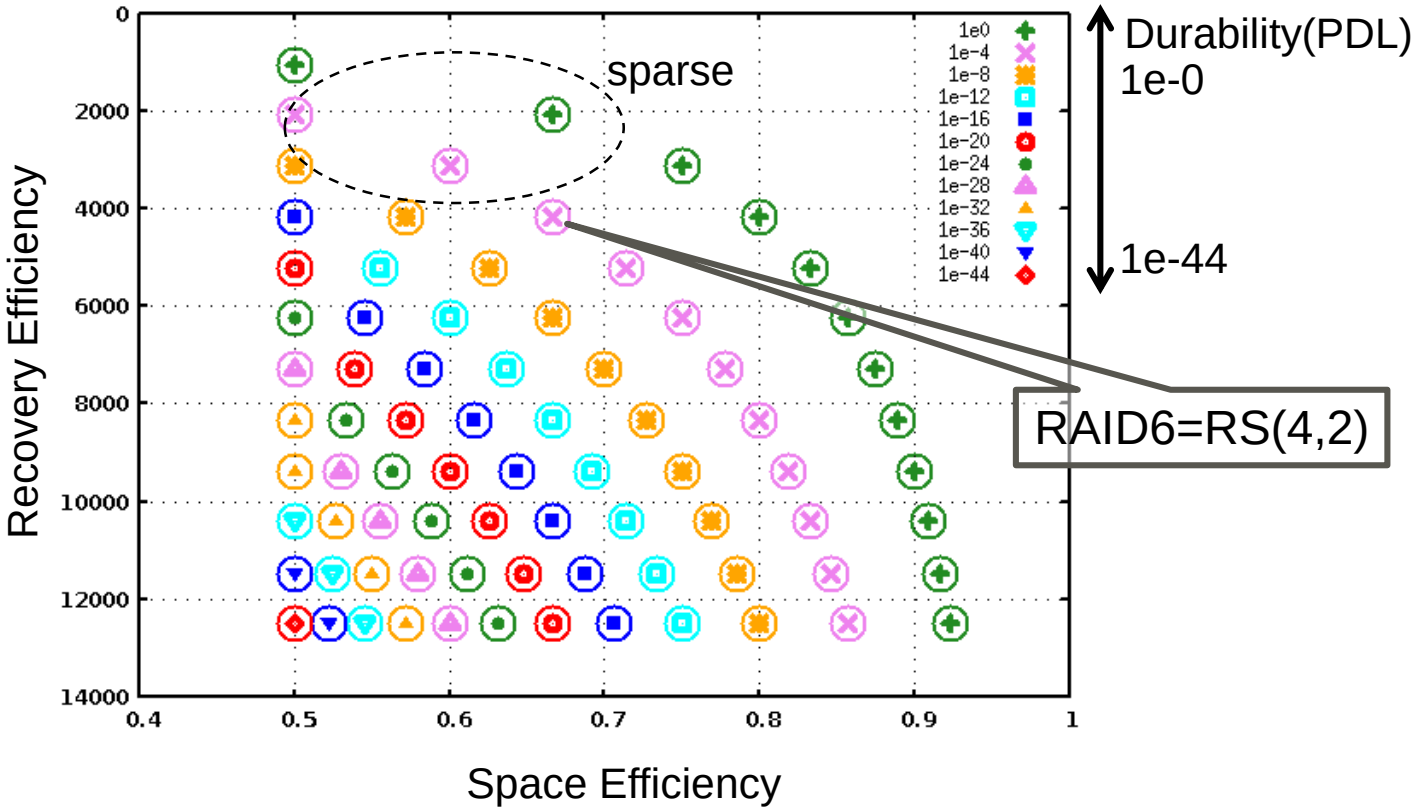
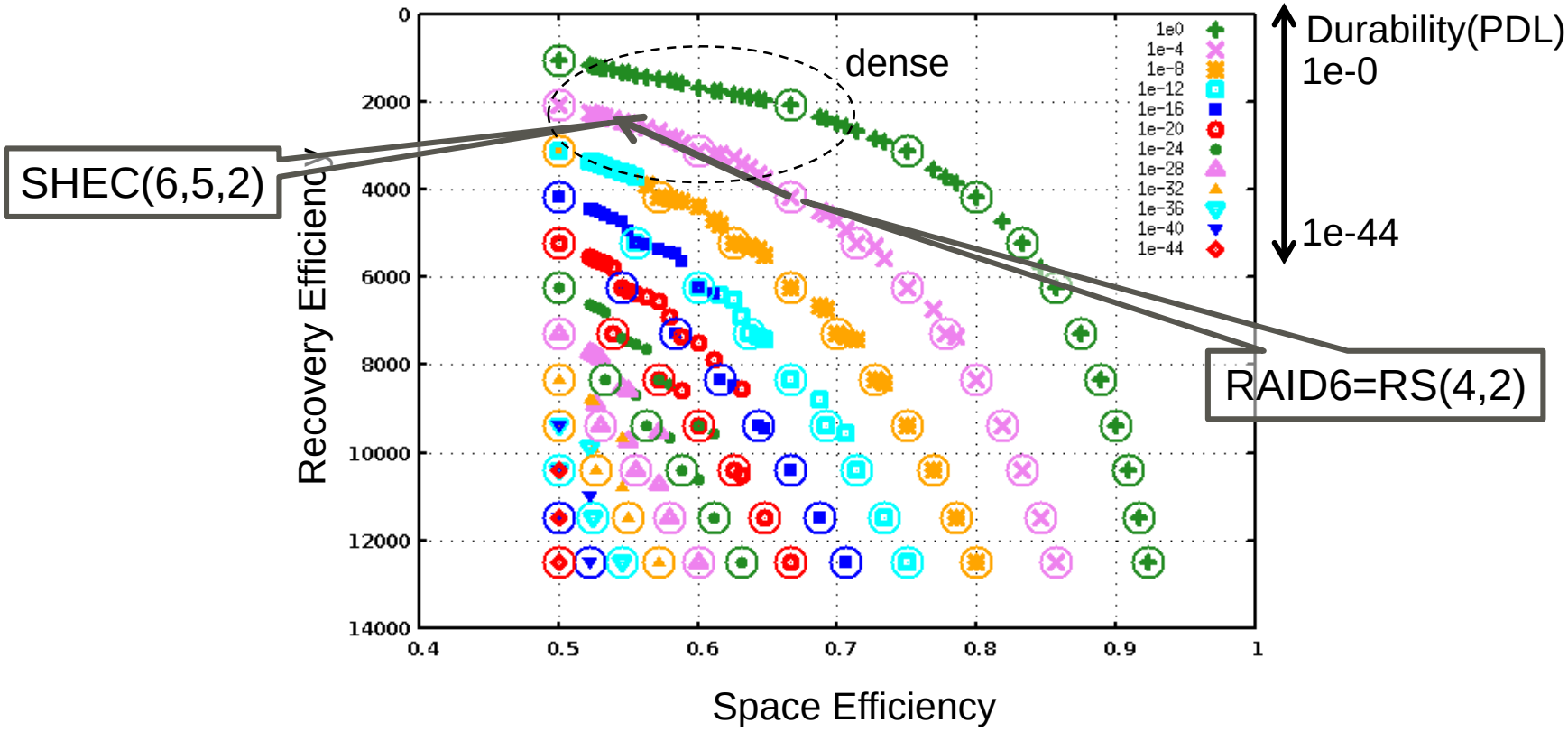
- Upper area becomes sparse
  - Reed Solomon code has few recovery-efficient layouts



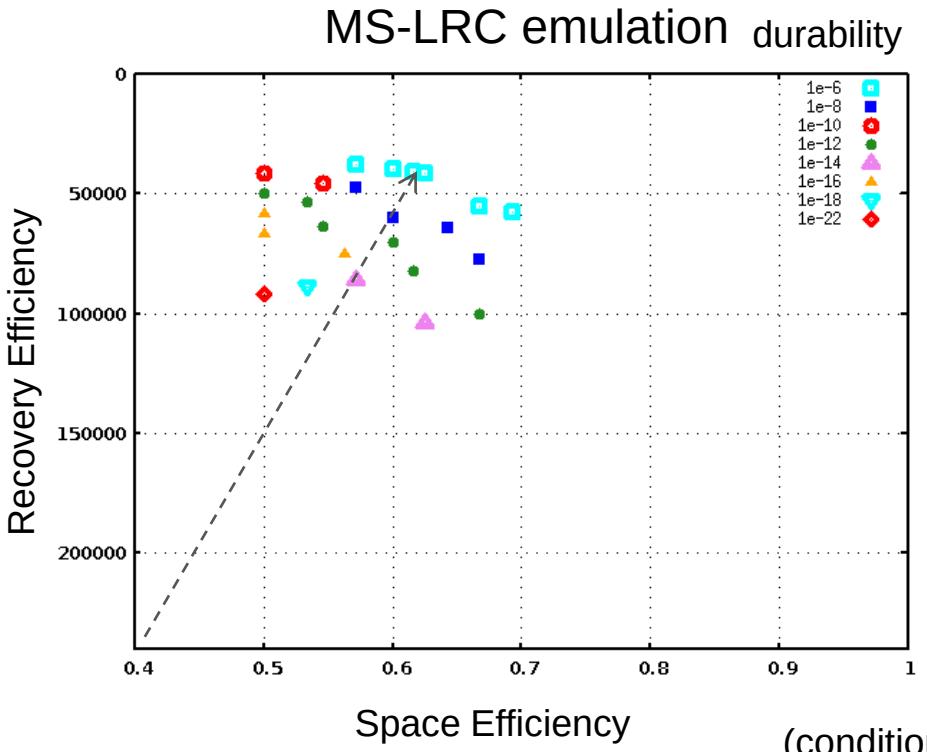
Property Map of SHEC

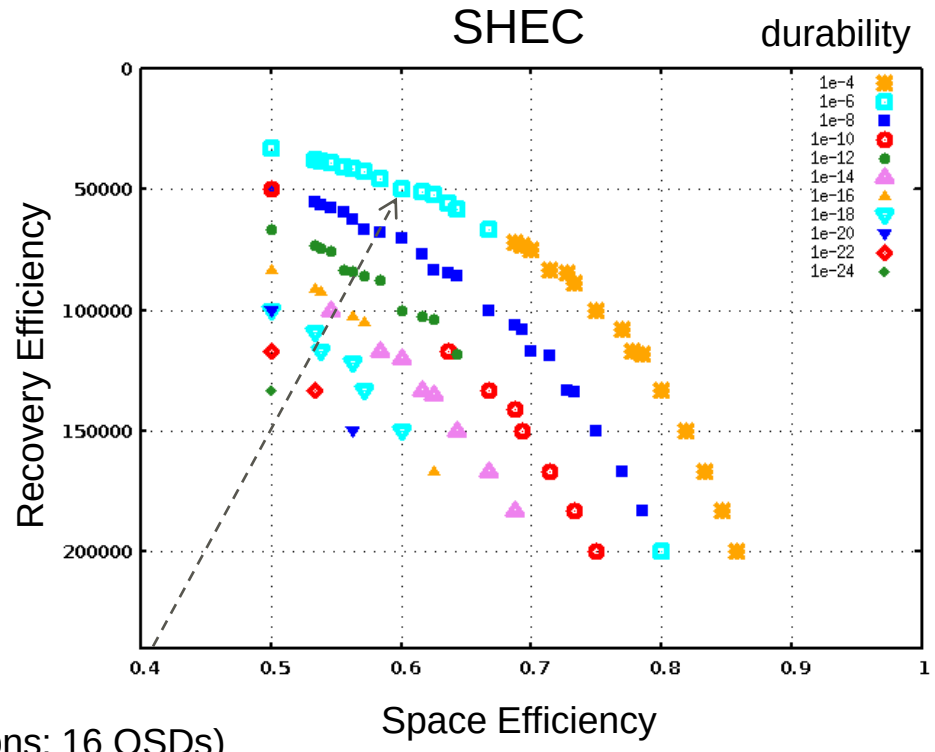
- Upper area is filled with SHEC-specific layouts
  - SHEC provides many recovery-efficient layouts
  - SHEC is more adjustable than Reed Solomon code



Comparison with MS-LRC (1)

- Single disk failure case
  - MS-LRC is plotted farther from the origin (= superior)
  - SHEC is plotted in a broader area (= more flexible)

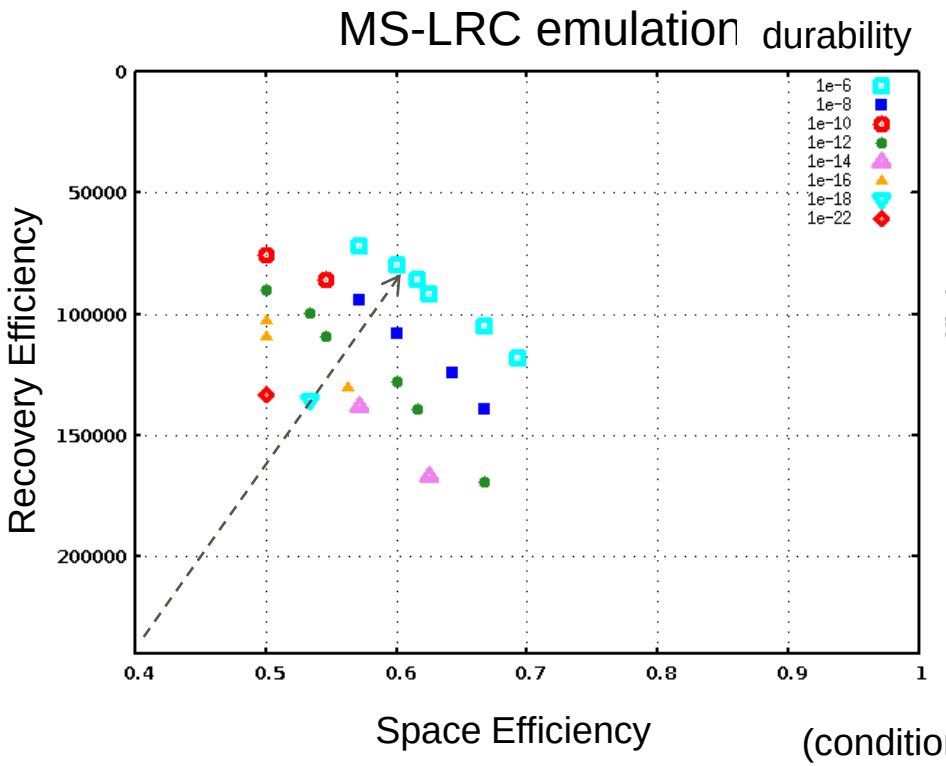


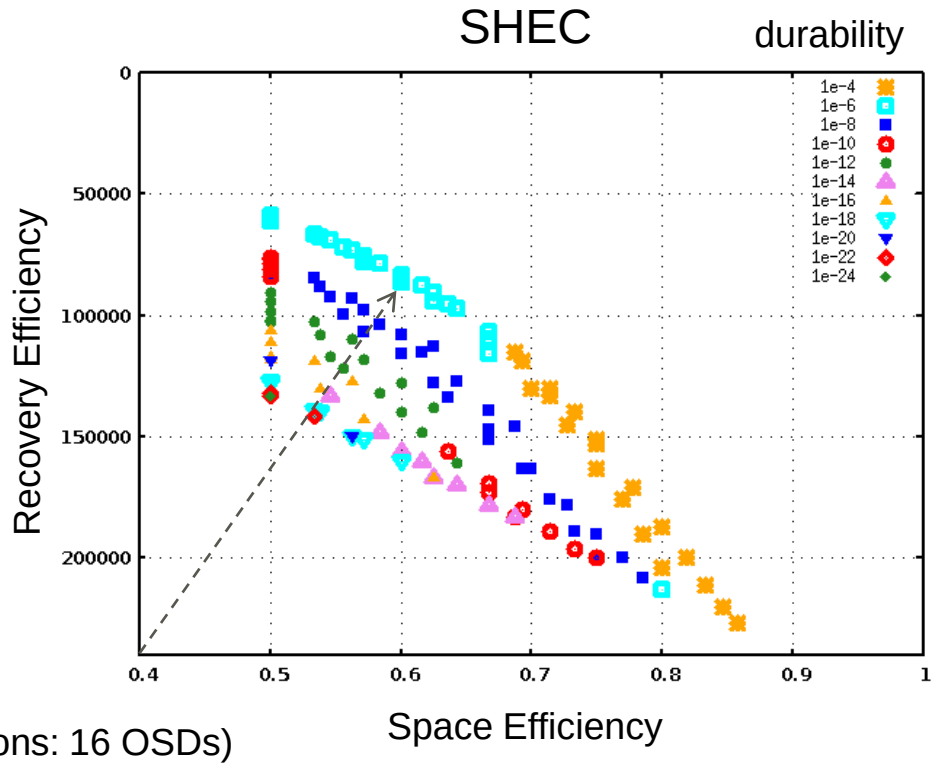


(conditions: 16 OSDs)

Comparison with MS-LRC (2)

- Double disk failures case
  - Both are plotted at the same distance from the origin
  - SHEC is plotted in a broader area (=more flexible)





(conditions: 16 OSDs)

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3. SHEC's Experimental Evaluation

SHEC's Implementation on Ceph

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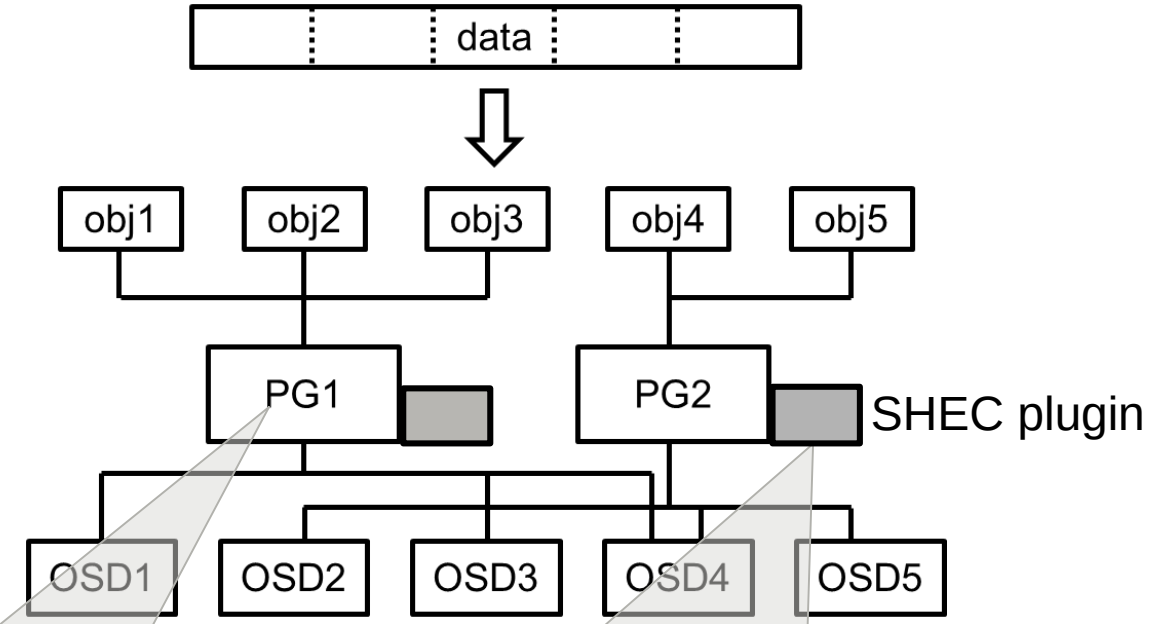
- SHEC is implemented as an erasure code plugin of Ceph, an open source scalable object storage



4MB objects are split into data/parity chunks, distributed over OSDs

encode/decode logic is separated from main part of Ceph Storage

Experiment of Recovery Efficiency

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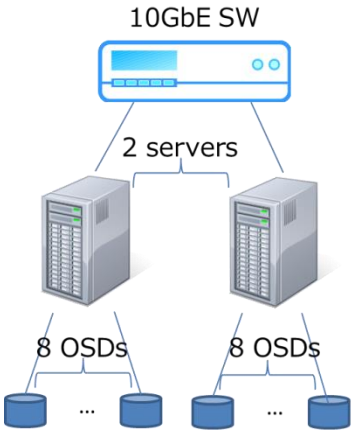
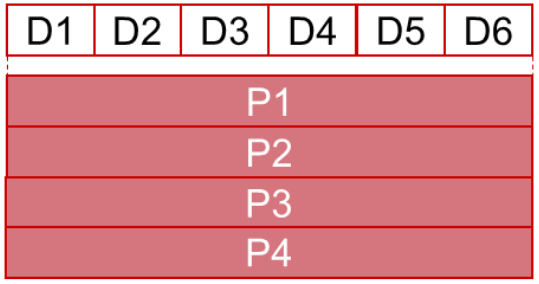
- Experiment Abstract
  - Test items : Recovery completion time / Resource profiles
  - Failure degree : Double disk failures
  - Comparison : Reed Solomon RS(6,4) / SHEC(6,4,3)

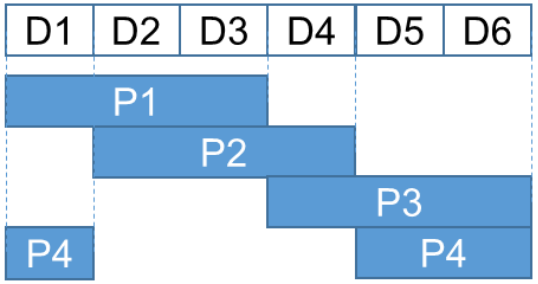


Machine	Fujitsu RX300 S7 (x2)
CPU	Xeon 300GHz (8 core)
Memory	32GB
HDD	300GB SAS (x8)
Network	10GbE NIC
OS	Ubuntu 14.04
Kernel	3.13.0-24
Ceph	v0.80.1 (Firefly)

Hardware and Software Setup



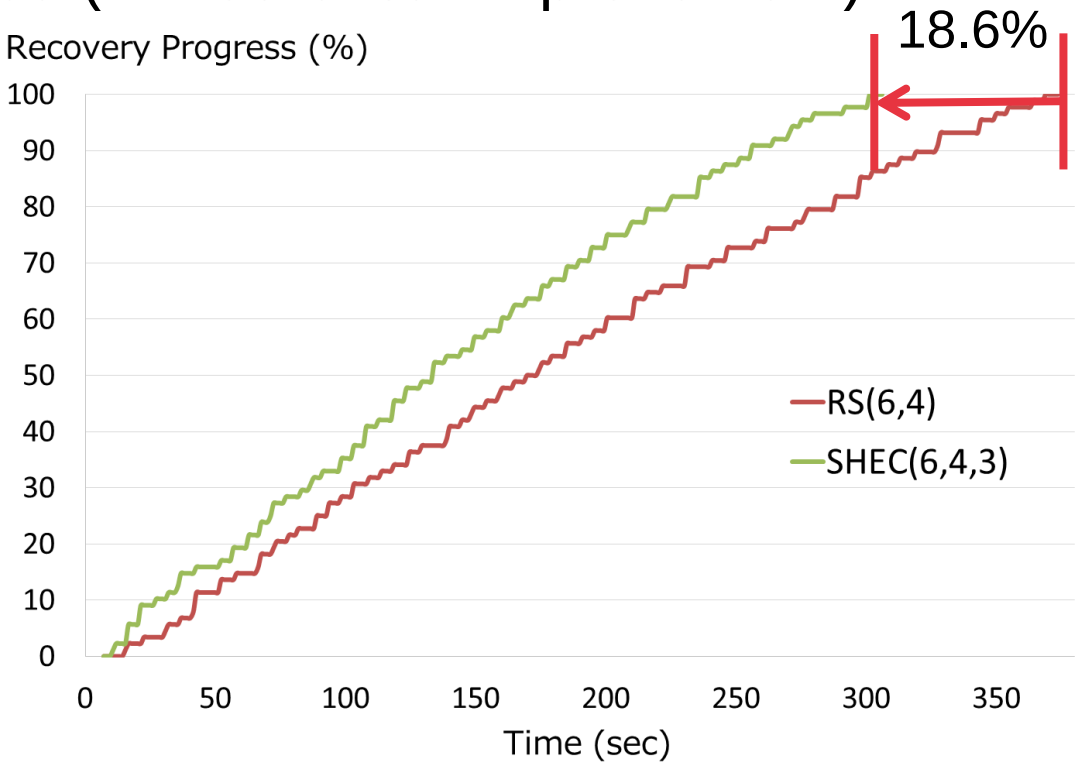
RS(6,4)



SHEC(6,4,3)

Recovery Completion Time

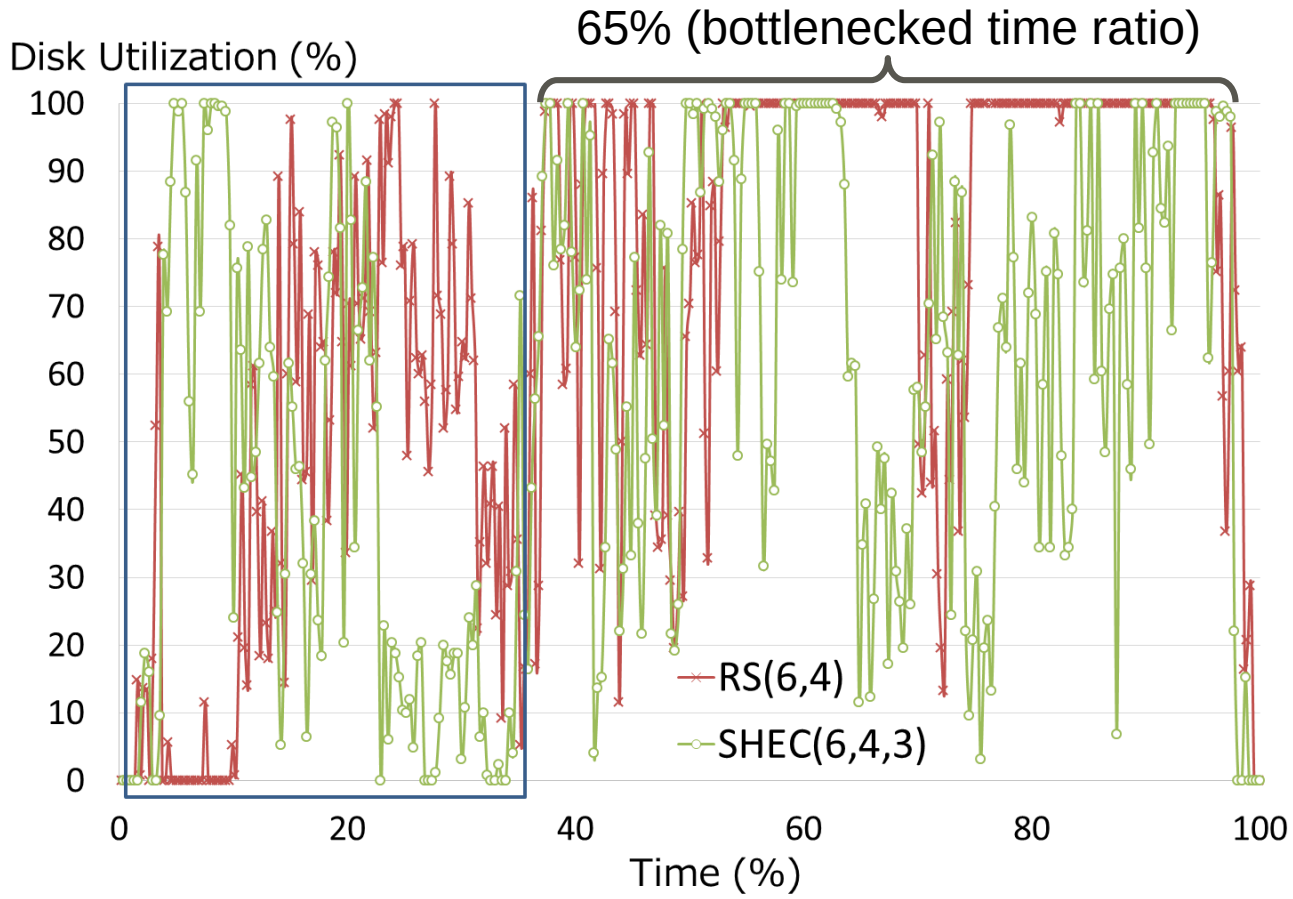
- SHEC's recovery completion time was 18.6% faster
  - OTOH, total amount of data read from disks was 26% decreased (= theoretical improvement)



Why were not these figures the same?

The Reason (= Disk utilization)

- Disks were only partly (65%) bottlenecked



There is 35% room for recovery time improvement

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4. Summary

Summary

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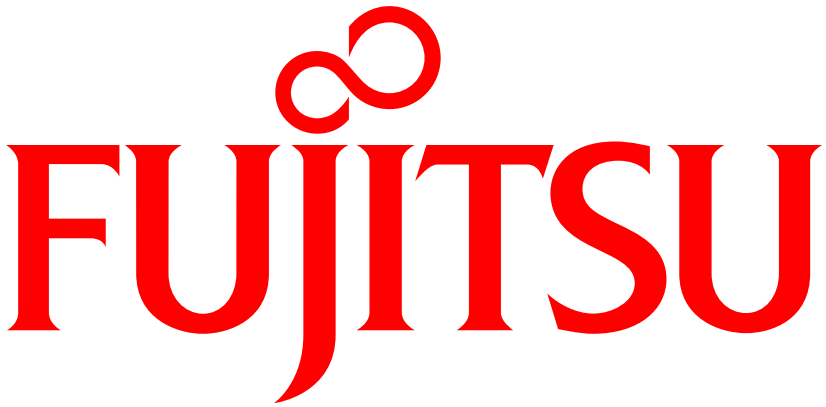
1. We proposed Shingled Erasure Code (SHEC)
   - SHEC is recovery-efficient especially in case of multiple disk failures
2. We found SHEC is more adjustable than Reed Solomon code
   - because SHEC provides many recovery-efficient layouts including Reed Solomon codes
3. We confirmed SHEC's recovery efficiency in an experiment
   - SHEC's recovery time was 18.6% faster than Reed Solomon code in case of double disk failures



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