OAK RIDGE National Laboratory

File Level Erasure Coding in Lustre

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Outline

- Current Progress
- Introduction to Erasure Coding
- Erasure Coding in Lustre's Progressive File Layout (PFL)
- Using File Level Erasure Coding in Lustre
- Limitations and Possible Pitfalls in Initial Version

Current Progress

- Original patches are ~1-2 years old and written by Bobi Jam
  - LU-10911, LU-12186, LU-12187, LU-12188, LU-12189, LU-12668, LU-12669
- I have
  - Inspected these patches
  - Ported to master (a few months ago)
    - f55fdfff5dede69e6674999fb02c1add513704f0
  - Fixed a few bugs
    - EC code errors, logic errors, NULL deref, etc.
  - Tested regression (sanity.sh)
- Currently developing tests and fixing bugs as they're discovered
- Targeting 2.15 release (~80% complete)

File Level Replication in Lustre

- Problem
  - I'm putting my file into Lustre and I don't want it to be lost.
- Solution
  - I'll put multiple copies of my file in Lustre.
- Downside
  - Multiple copies are expensive.
    - 100% overhead per copy

File Level Erasure Coding in Lustre

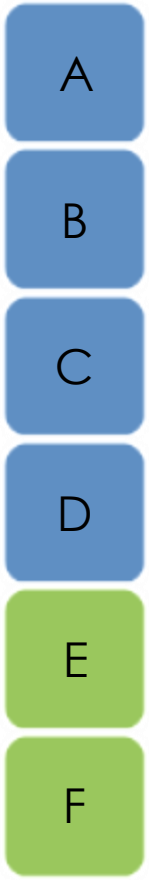
- Problem
  - I'm putting my file into Lustre and I don't want it to be lost.
- Solution
  - I'll store some coding data for my file in Lustre.
- Coding calculations take time but generally requires far less space.

Reed-Solomon Codes

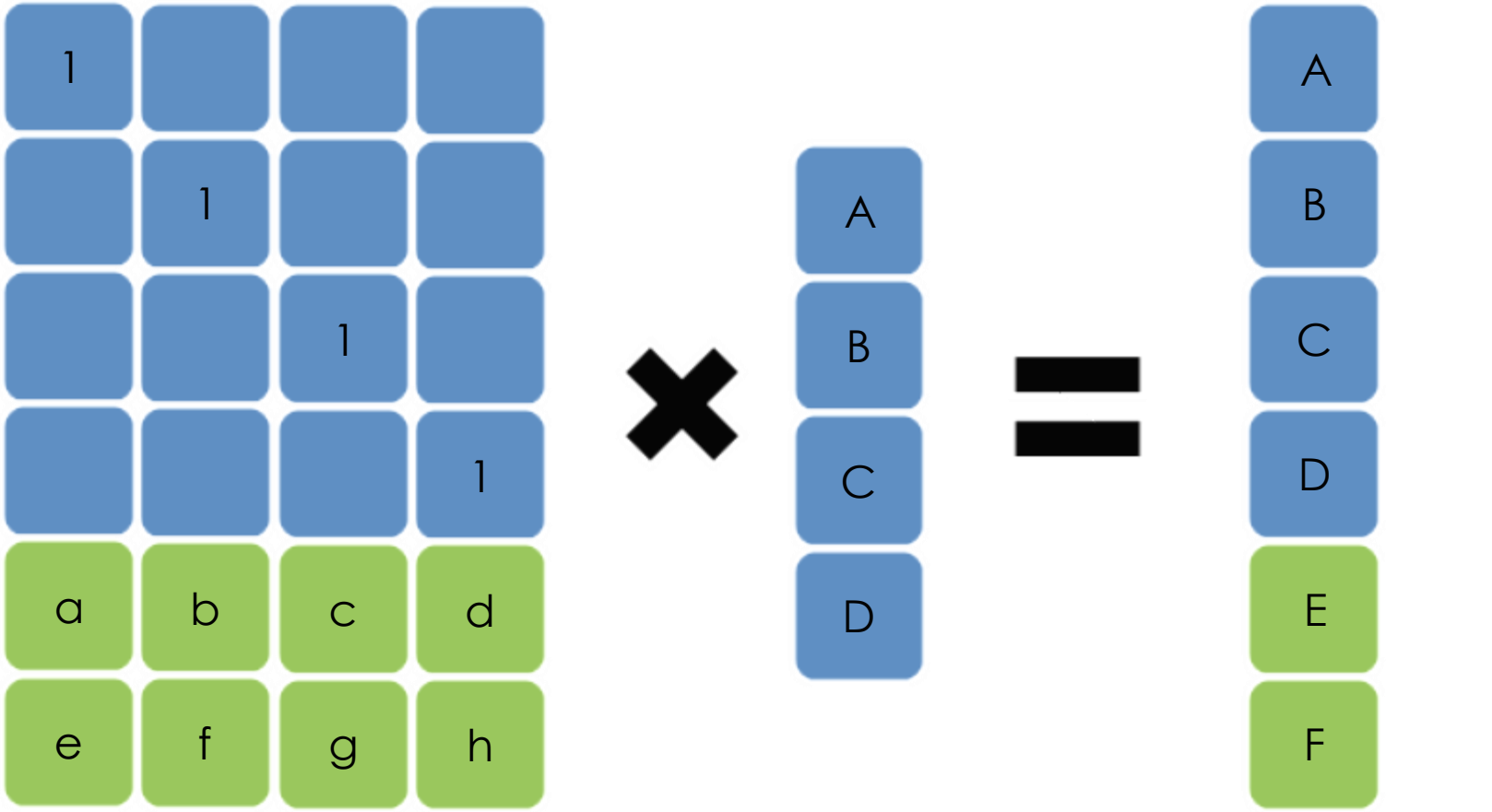
- K = Number of data blocks per stripe
- M = Number of code blocks per stripe
- Data blocks and code blocks are the same size
- Basically, one can pick any K + M
- For any K + M stripe, one can recover all K data blocks from any K blocks

Reed-Solomon Codes (Example 4 + 2)

K = 4
M = 2

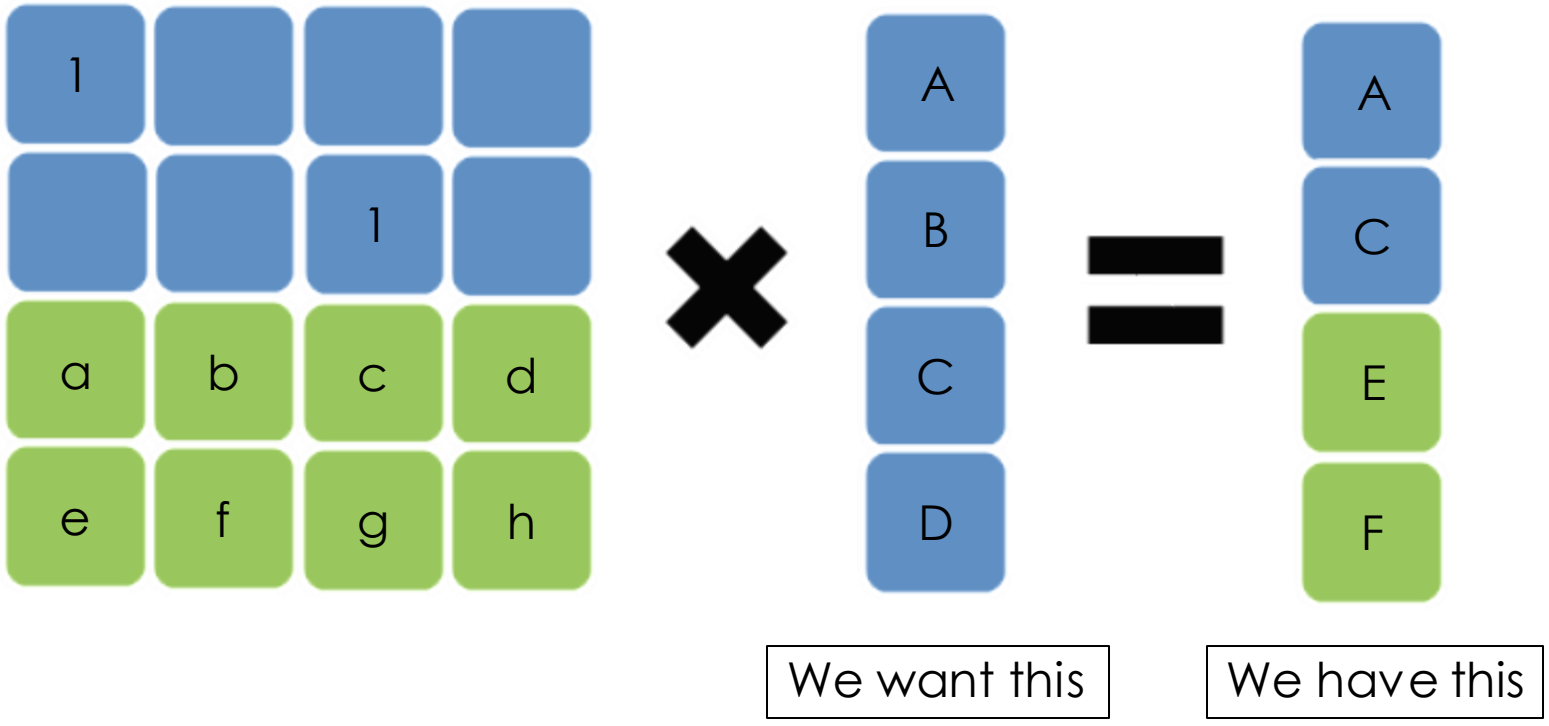


Reed-Solomon Codes (Example 4 + 2)



Reed-Solomon Codes (Example 4 + 2)

Suppose we lost data blocks B and D

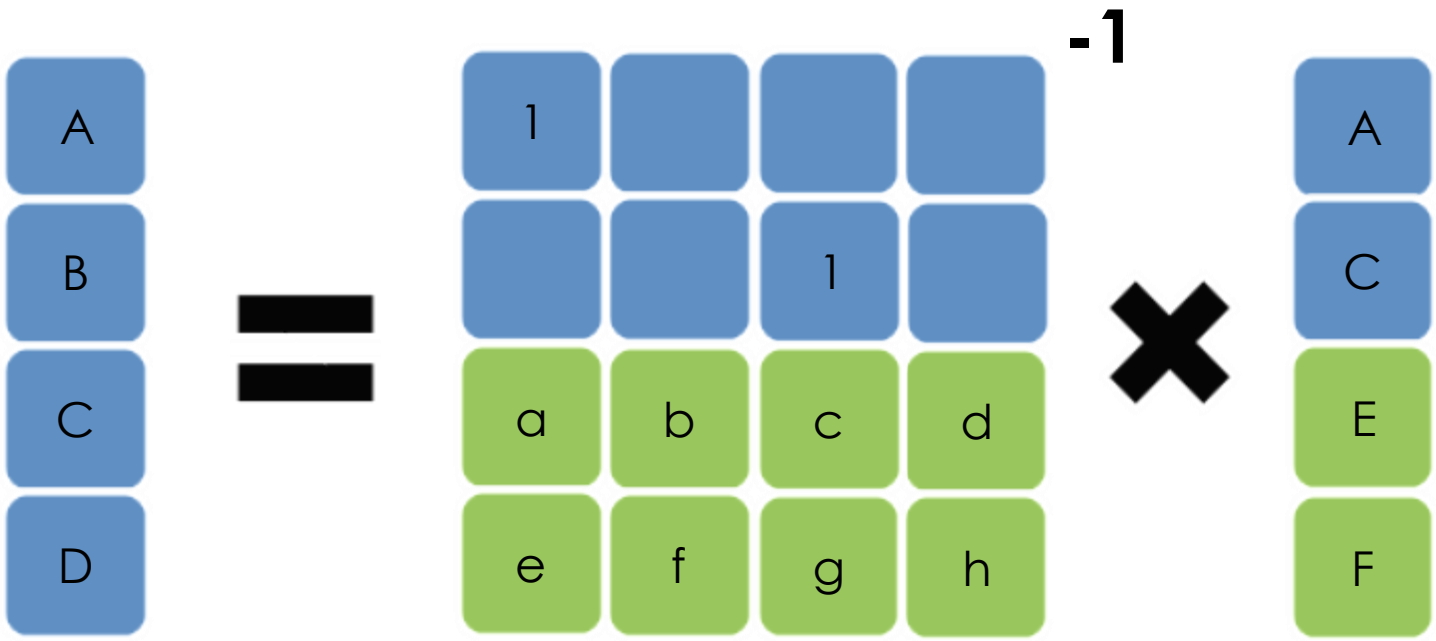


We want this

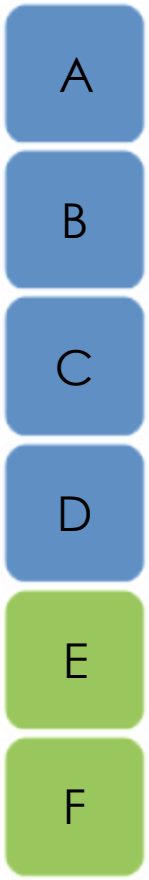
We have this

Reed-Solomon Codes (Example 4 + 2)

Left multiply both sides by the inverse encoding matrix

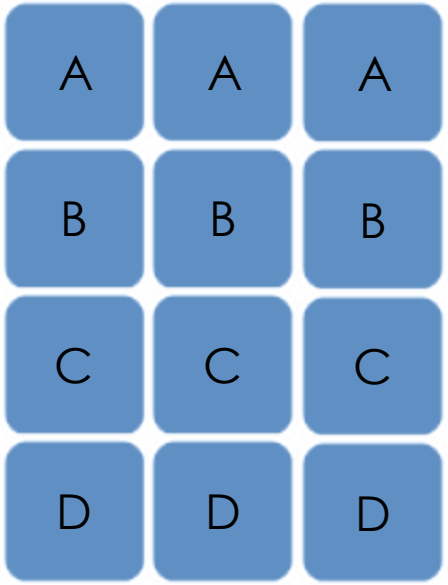


Space Savings



RS 4+2

VS



Triple Replication

Applying Erasure Coding to Lustre PFL


```
lfs setstripe -E 4M -c 1 -E eof -c 4 -E eof -L erasure_code -ec_data_count 4 -ec_parity_count 2
```

Component 0

Component 1

Component 2

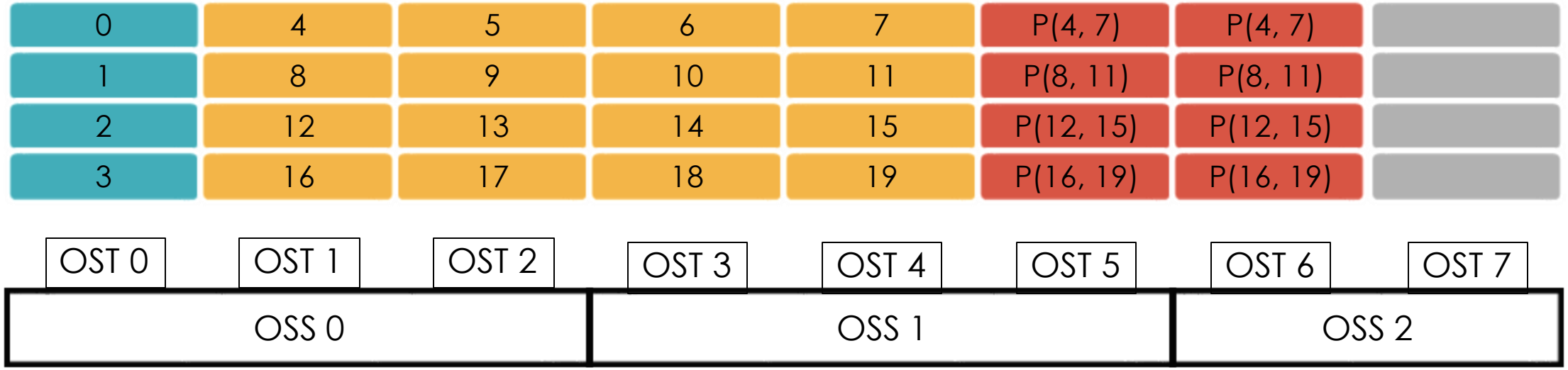
Using File Level Erasure Coding in Lustre

- `lfs setstripe -E eof -c 4 -E eof -L erasure_code -ec_data_count 4 -ec_parity_count 2 file`
- Write to the file
- `lfs mirror resync file`
- When reading the file, if there is a failure that is recoverable, reads succeed as normal
- If file is modified, must resync

Limitations/Concerns in Initial Version

- No automatic data replacement
- No automatic updating of parity
- Slow encoding/decoding
- May need to be careful with data placement

Data Placement




```
lfs setstripe -E 4M -c 1 -E eof -c 4 -E eof -L erasure_code -ec_data_count 4 -ec_parity_count 2
```

Component 0

Component 1

Component 2

Acknowledgments

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