Toward Understanding Life-Long Performance of a Sonexion File System

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Agenda

- Introduction of concepts
- Experiment to reduce I/O variation
- Test method and results
- Summary

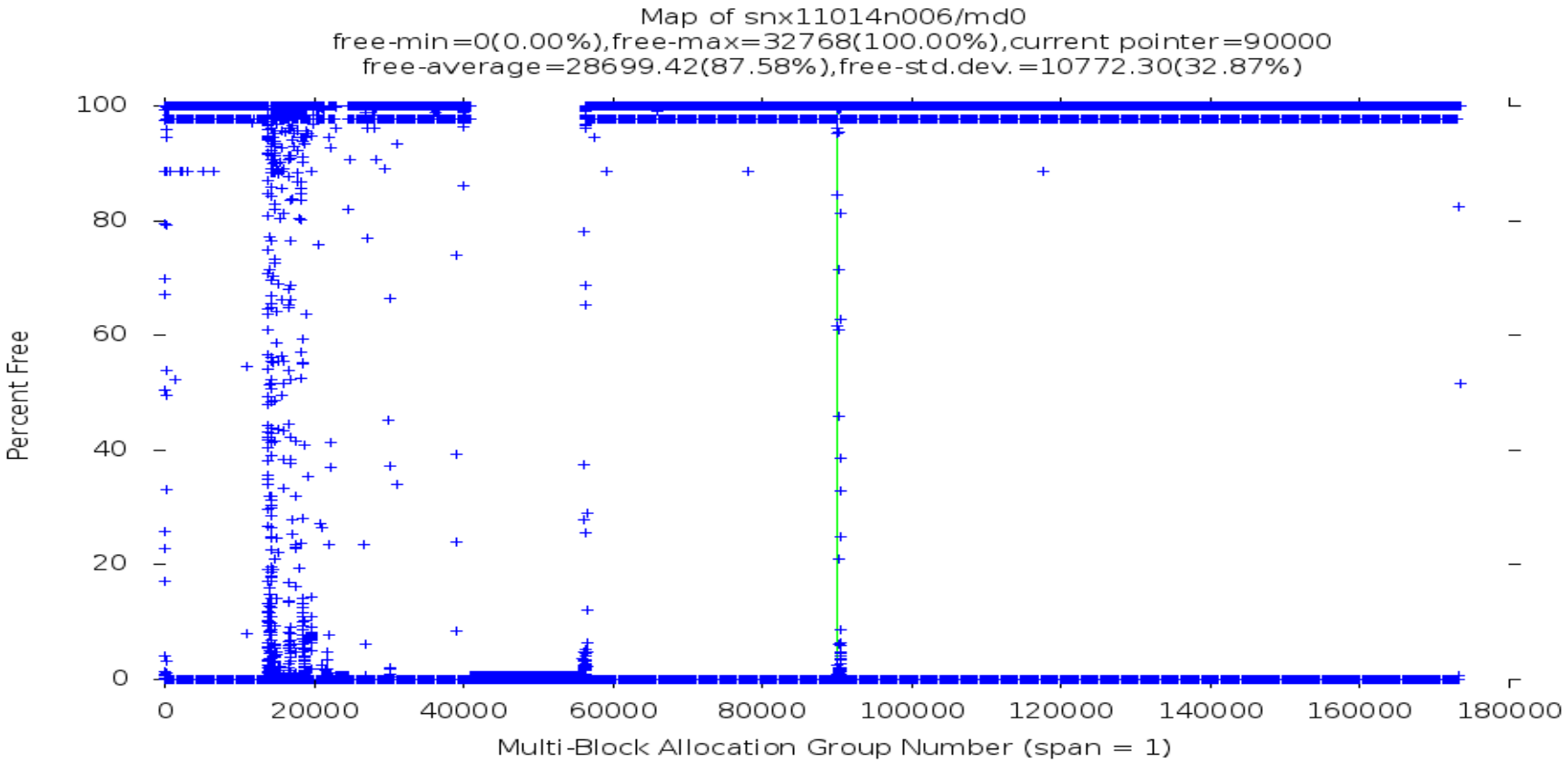
Sources of I/O Performance Variation Over Time

- **Software updates**
  - Lustre client and servers, I/O libraries
- **Transient hardware issues**
  - IB cables, degraded connections
  - Failing disks, bad sectors, RAID rebuilds
- **Disk position and fragmentation**
  - Can it be controlled?
  - Focus of this presentation

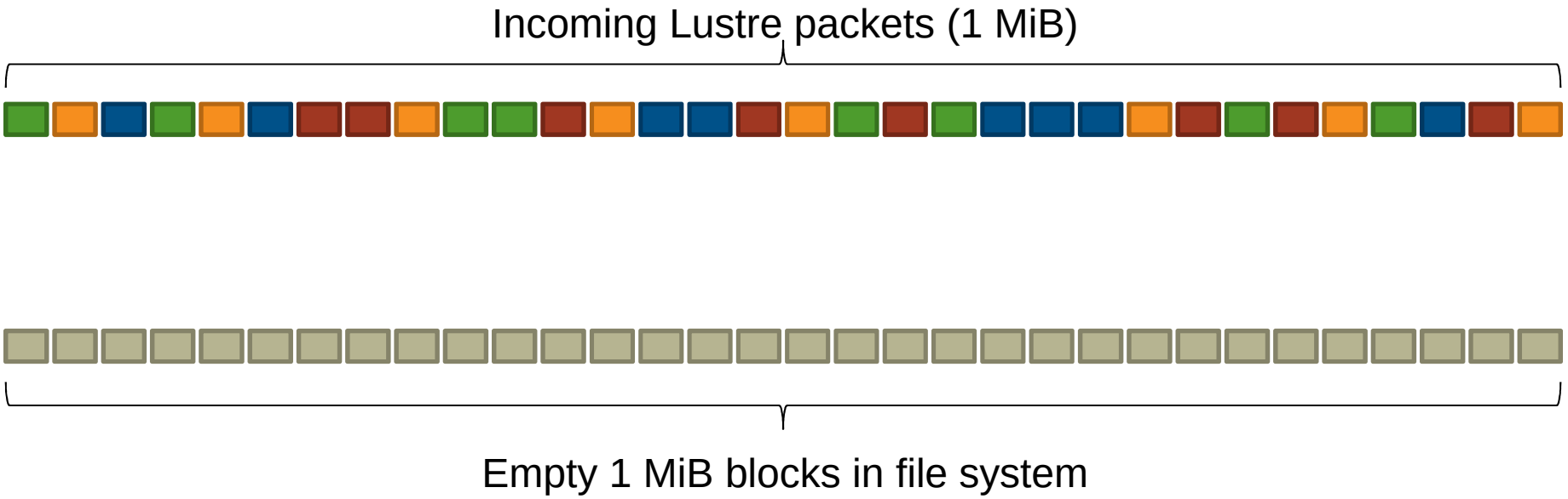
Lustre File System Terms

- **Cray Sonexion 1600 file system**
  - 1 SSU contains 2 servers with 4 OSTs each
- **Files in /proc/fs/ldiskfs/<device>**
  - mb_groups - bitmap of free space
  - mb_last_group - current allocation pointer
  - prealloc_table - disk space allocation size
- **Each multi-block allocation group is 128 MiB**
  - 32768 (4096 byte) disk blocks
  - Over 160k groups in a 23 TB OST (3 TB disks)

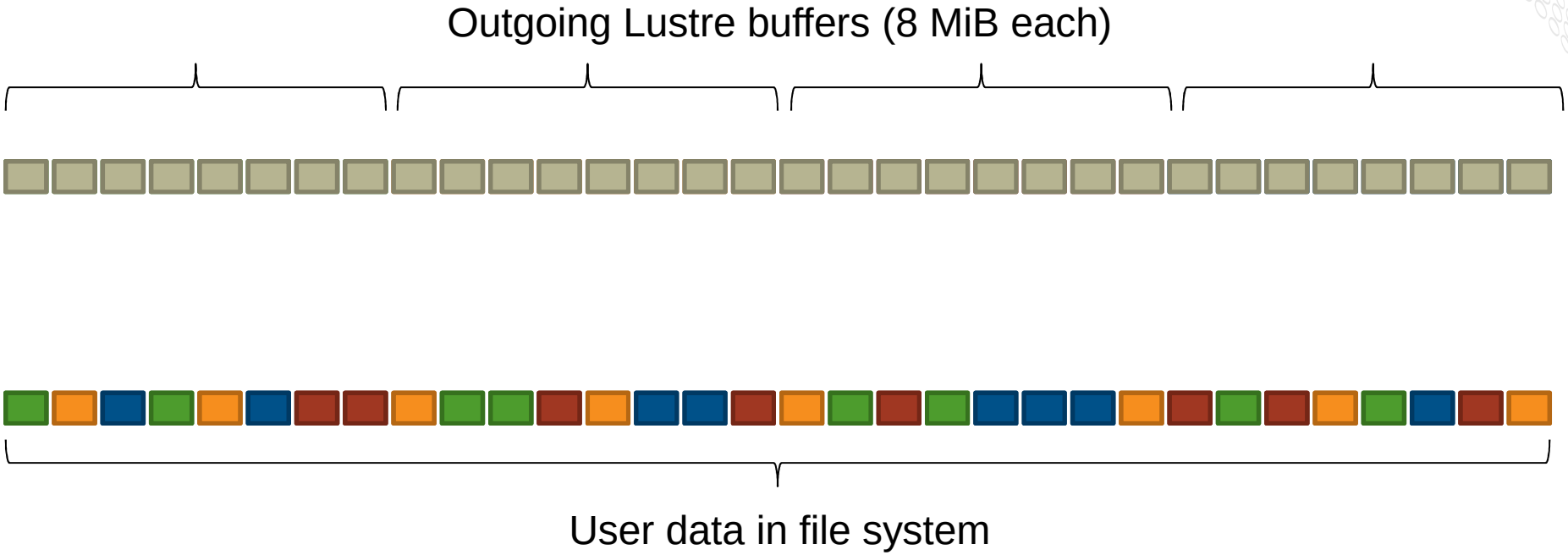
Allocation Bitmap of an OST



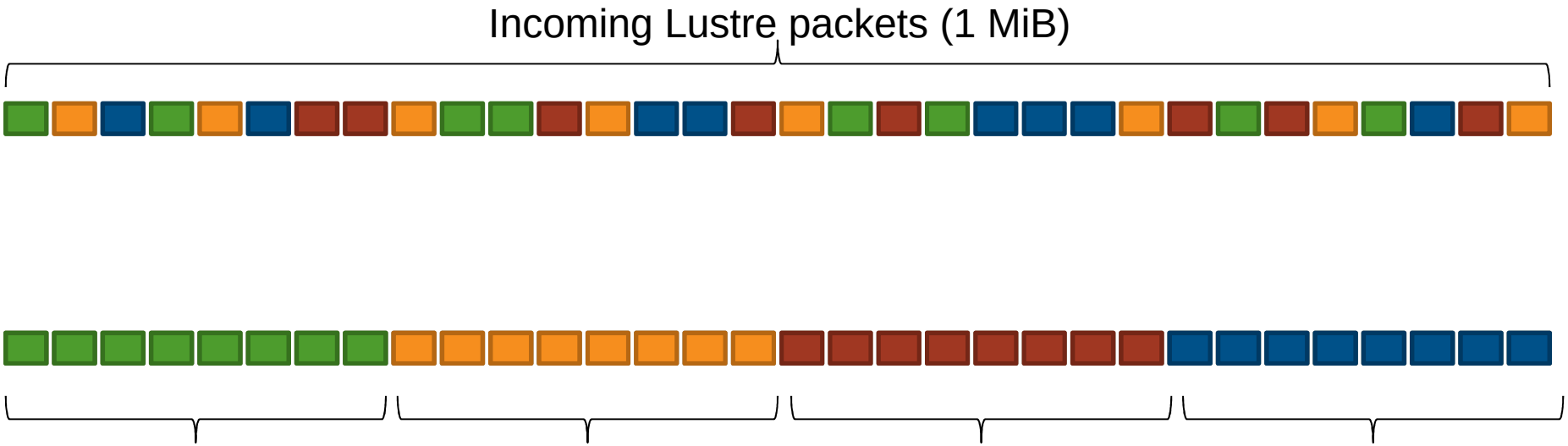
1M OST pre-allocation
4 files, 8M per file, write



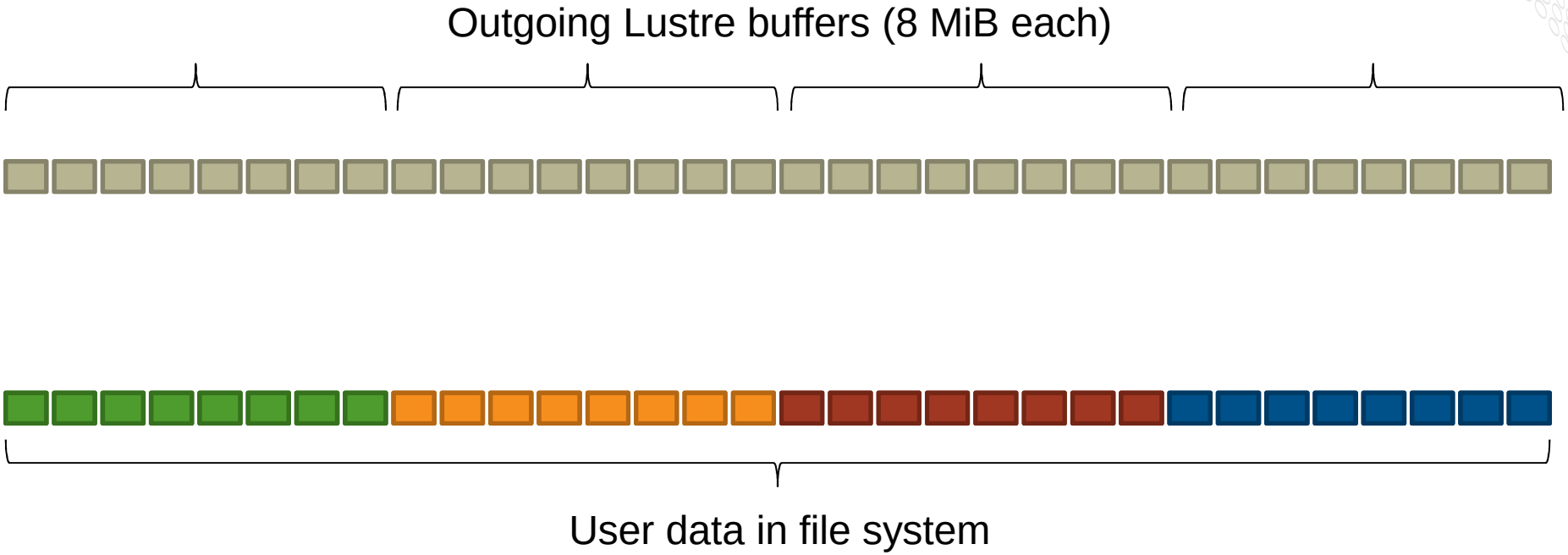
1M OST pre-allocation
4 files, 8M per file, read



8M OST pre-allocation
4 files, 8M per file, write



8M OST pre-allocation
4 files, 8M per file, read



Hypothesis

Using larger values of OST pre-allocation will:

- **Create more contiguous space when files are created**
- **Leave behind fewer, bigger, holes when files are remove**
- **Increase read rates due to more contiguous space**
- **Decrease write rates due to seeking**
- **The increase seen in read rates will be larger than the decrease in write rates, providing better balance for large-block sequential I/O**

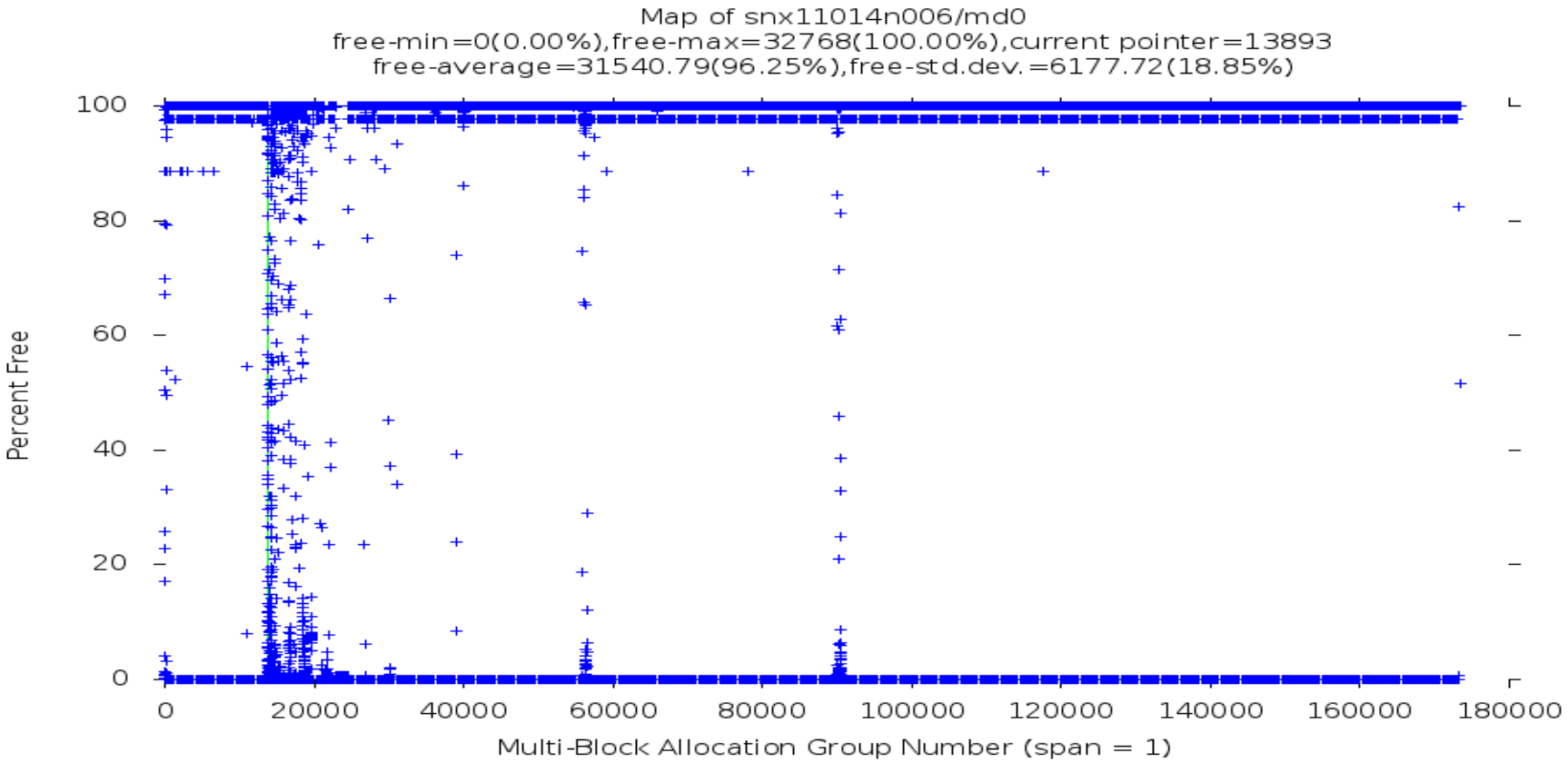
Testing Scenario

- Set 4 SSUs to 4 different OST pre-allocation sizes
- Choose a clean section of each OST
- Run optimal write and optimal read IOR jobs in each SSU to determine base rates at 100% free
- Simultaneously write 20 files on each OST so that data from all 20 files is intermingled
- Show distribution of contiguous space in each SSU

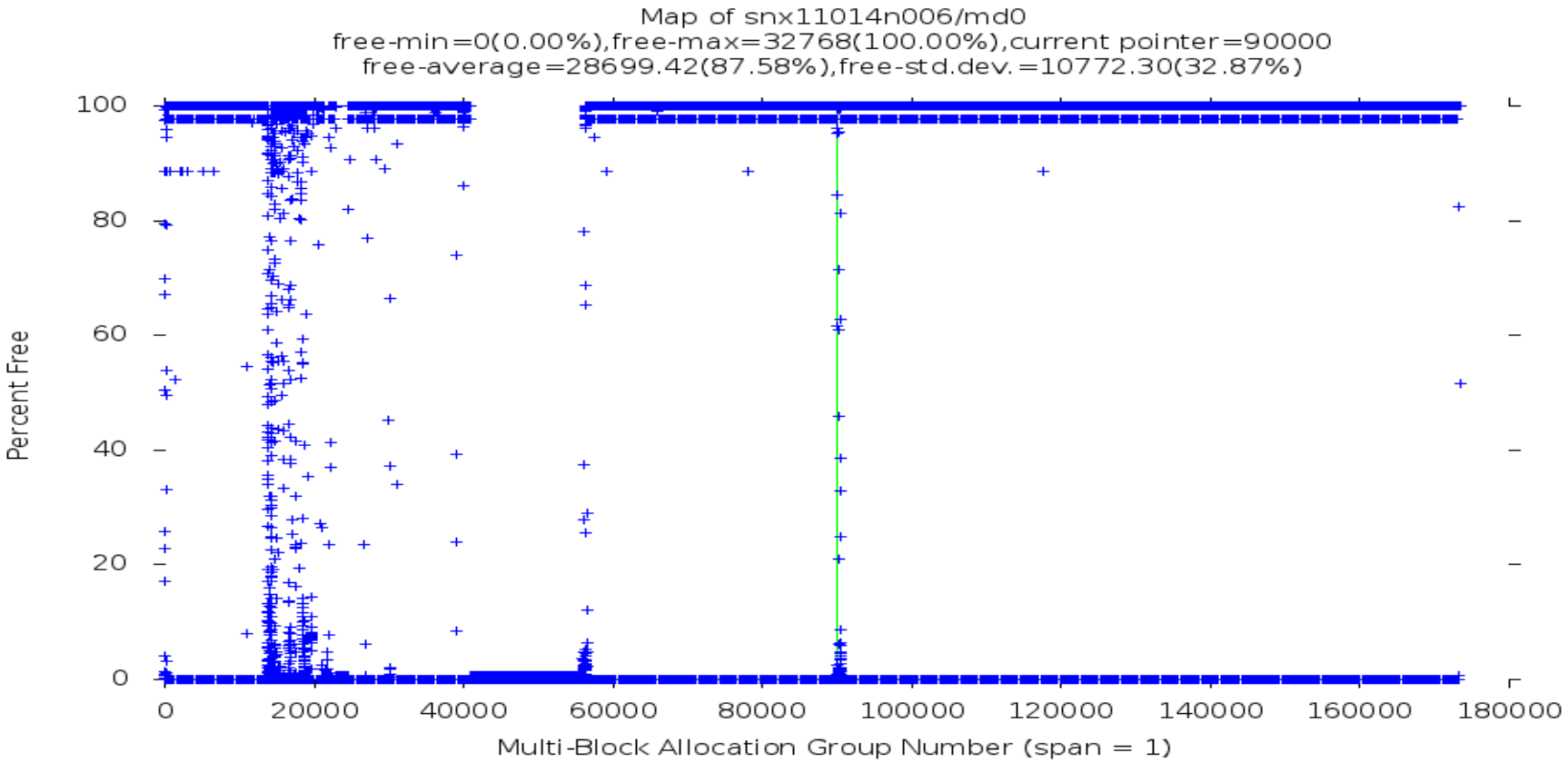
Testing Scenario (continued)

- **Repeat until 100% free again:**
  - Delete 1 file from each OST which releases 5% of the used space
  - Reset allocation pointer to beginning of test section on each OST
  - Run optimal write and optimal read IOR jobs
- **Record and plot results**
- **Test system**
  - Cray XE6, 12 LNET routers
    - Lustre 2.5.1 client
  - 4 SSU Sonexion 1600
    - NEO software level 1.2.1 (MDRAID)
    - 3 TB disk drives

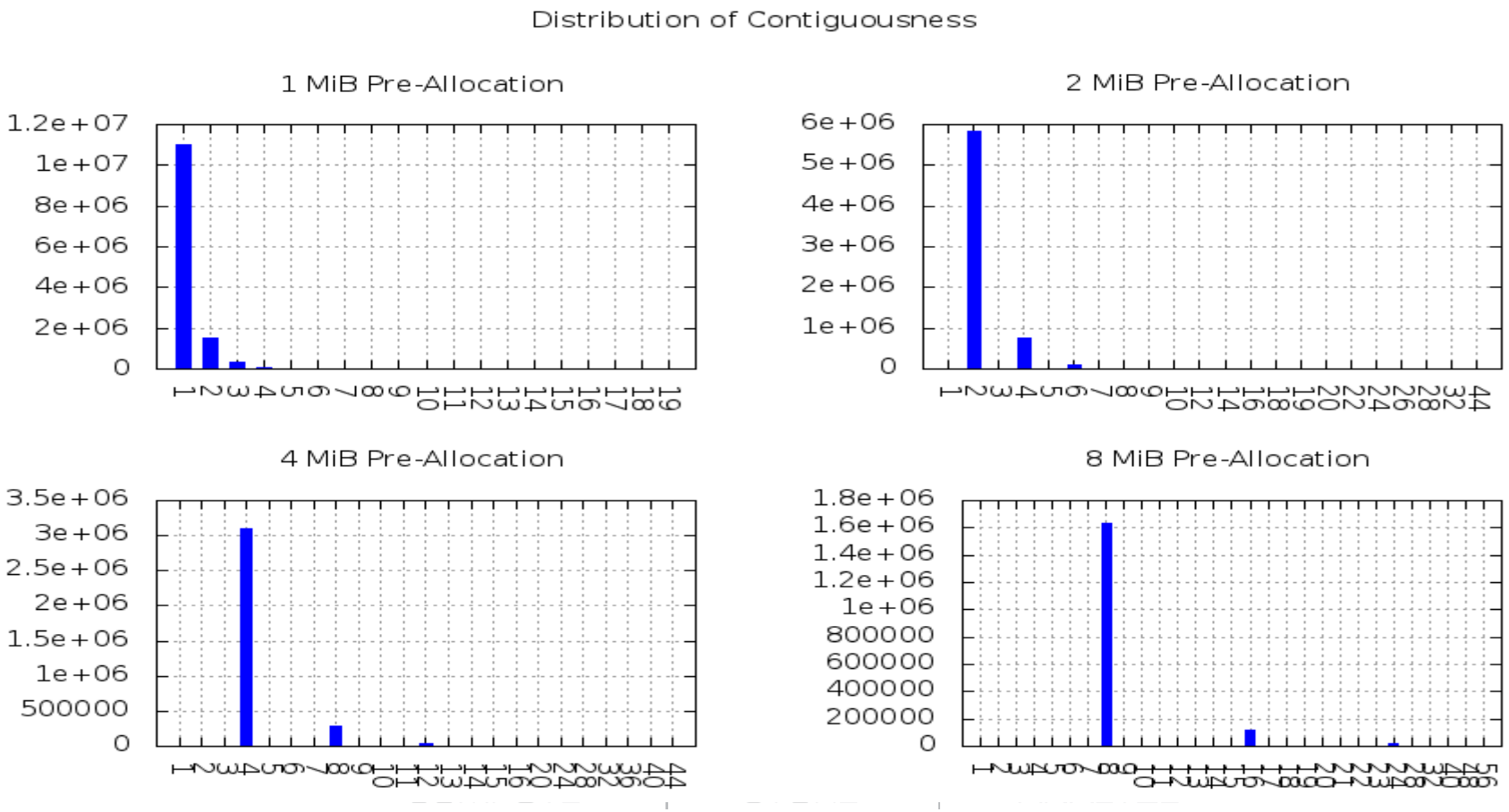
Bitmap of an OST (before)



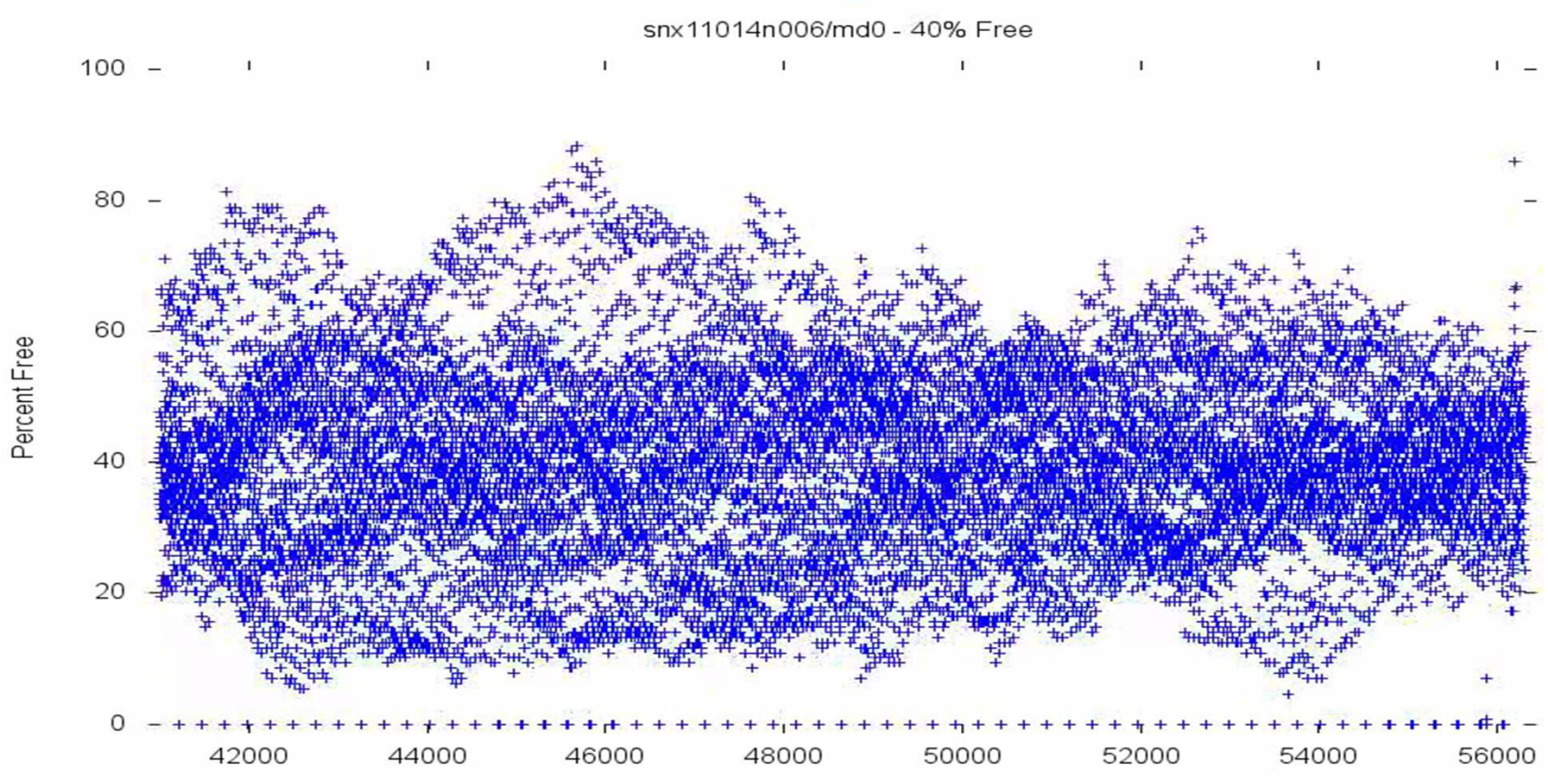
Bitmap of an OST (after)



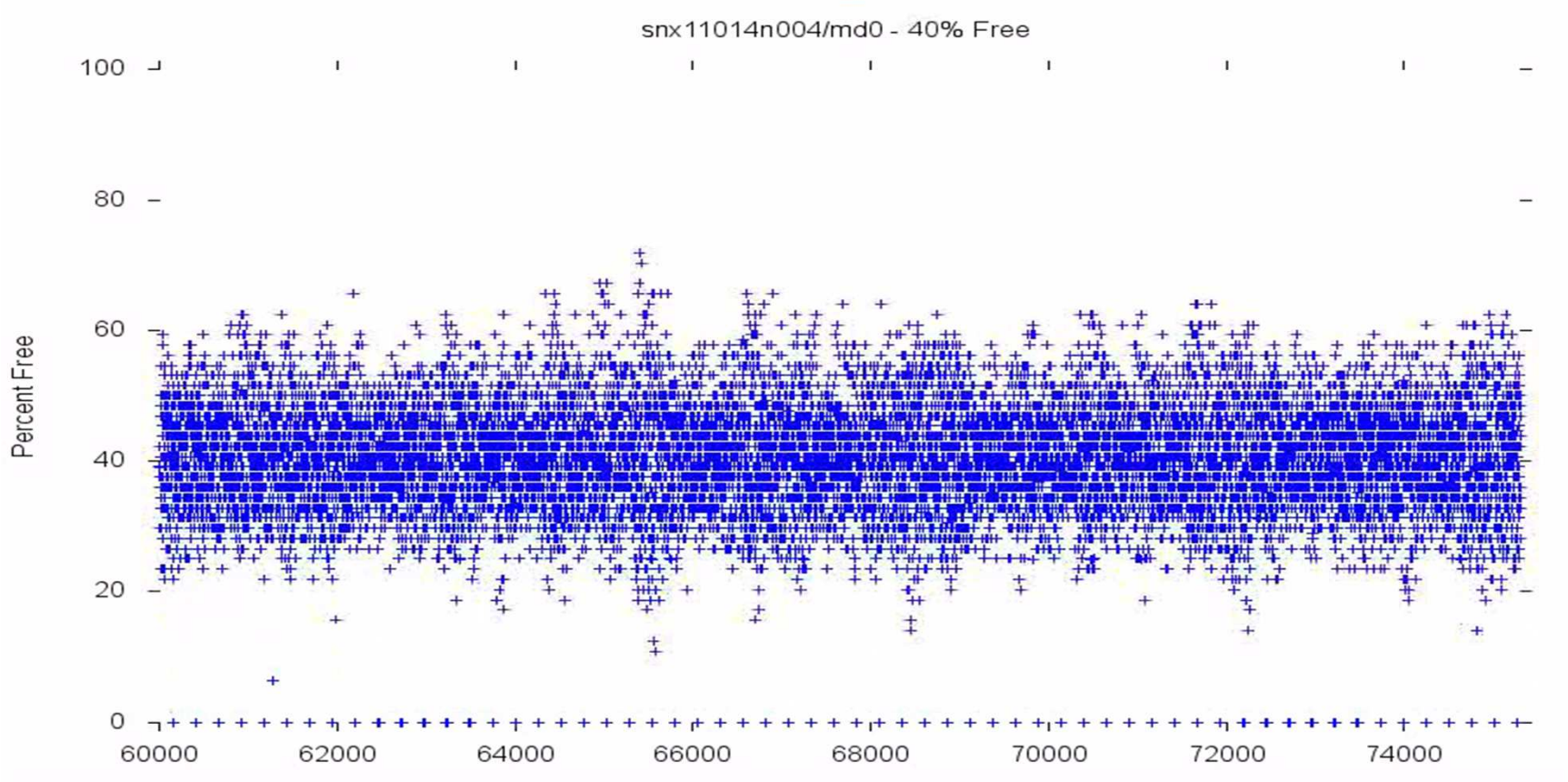
Histograms of extent sizes of IOR files



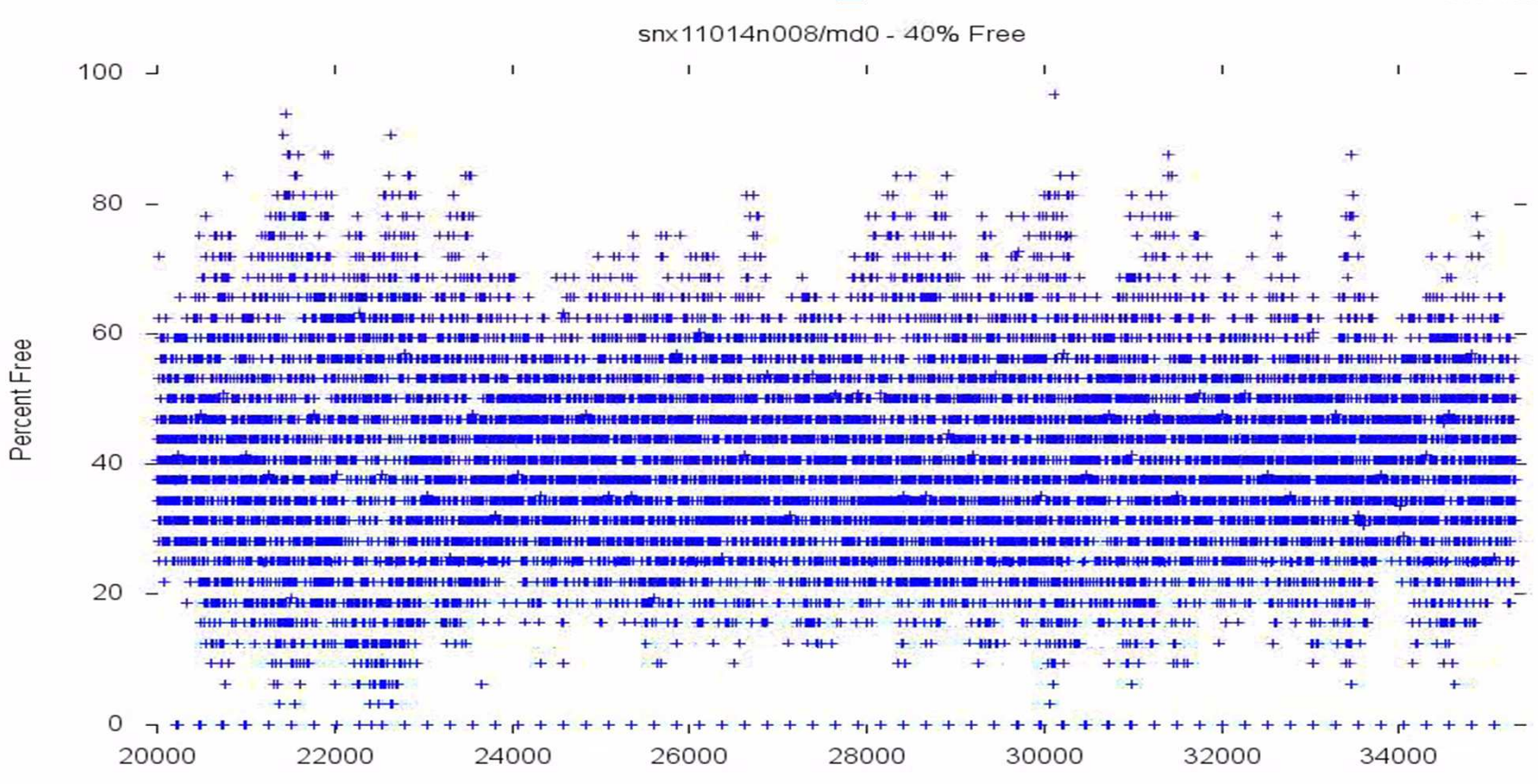
1 MiB OST Pre-allocation Fragmentation



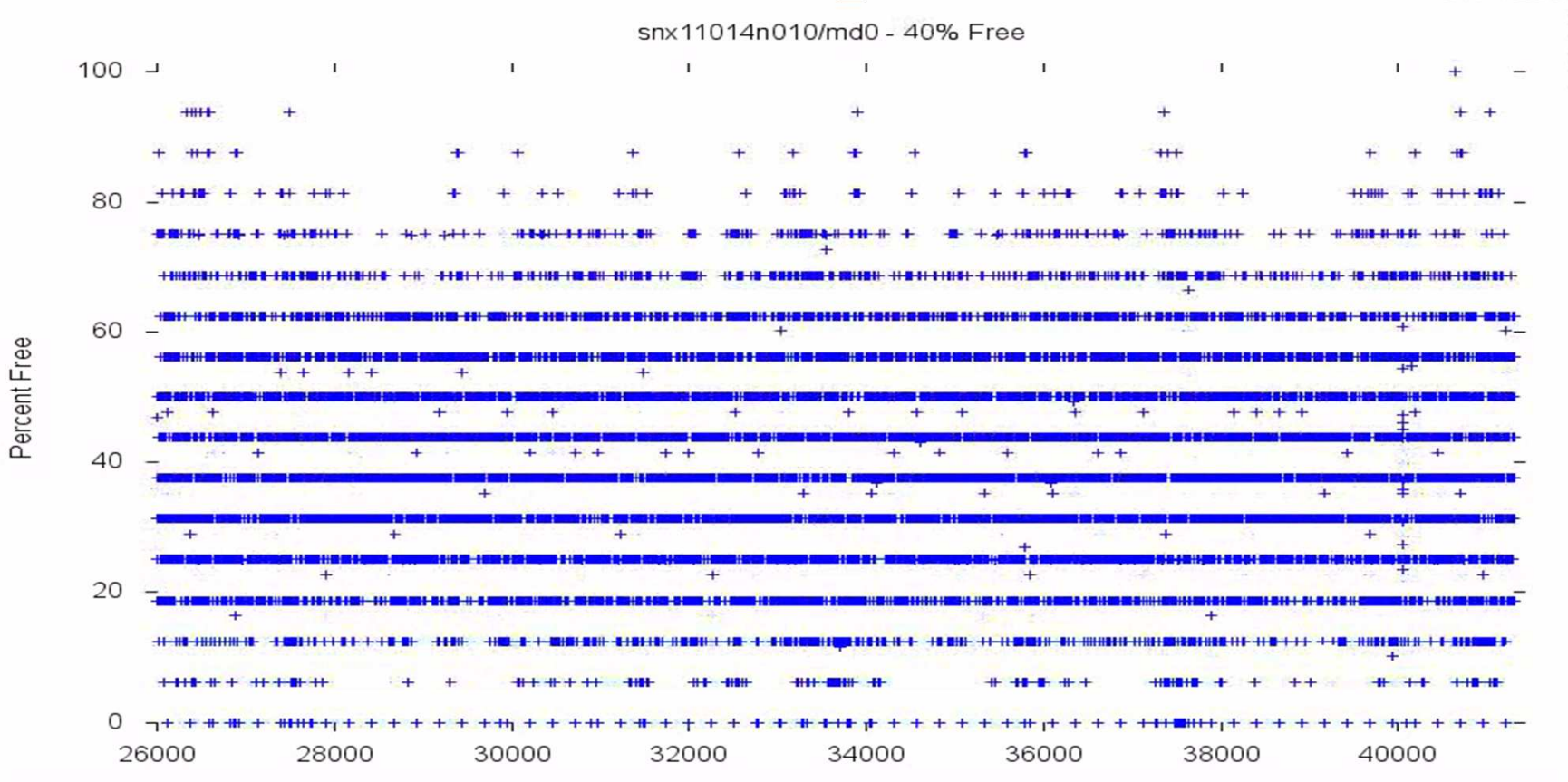
2 MiB OST Pre-allocation Fragmentation

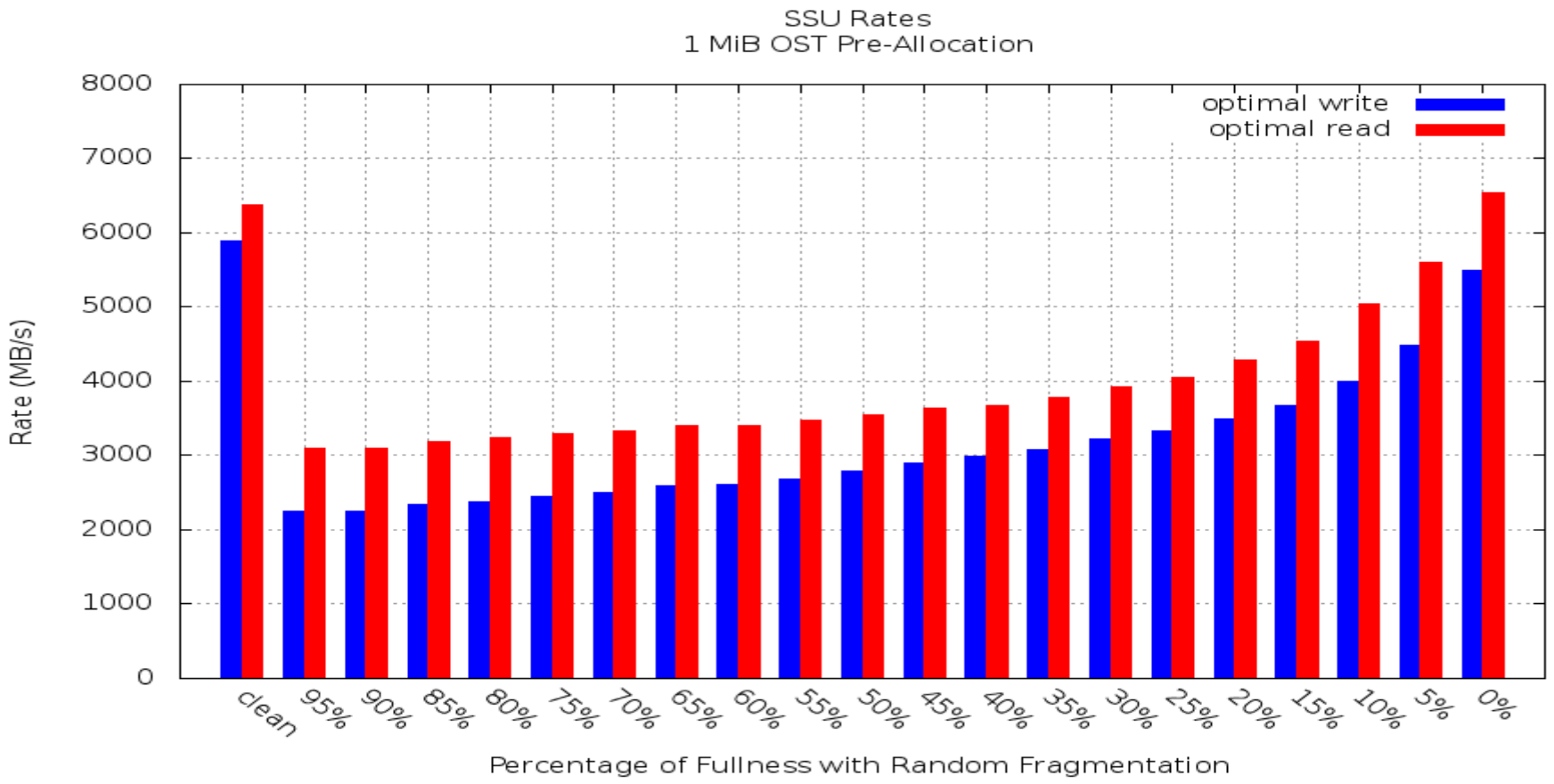


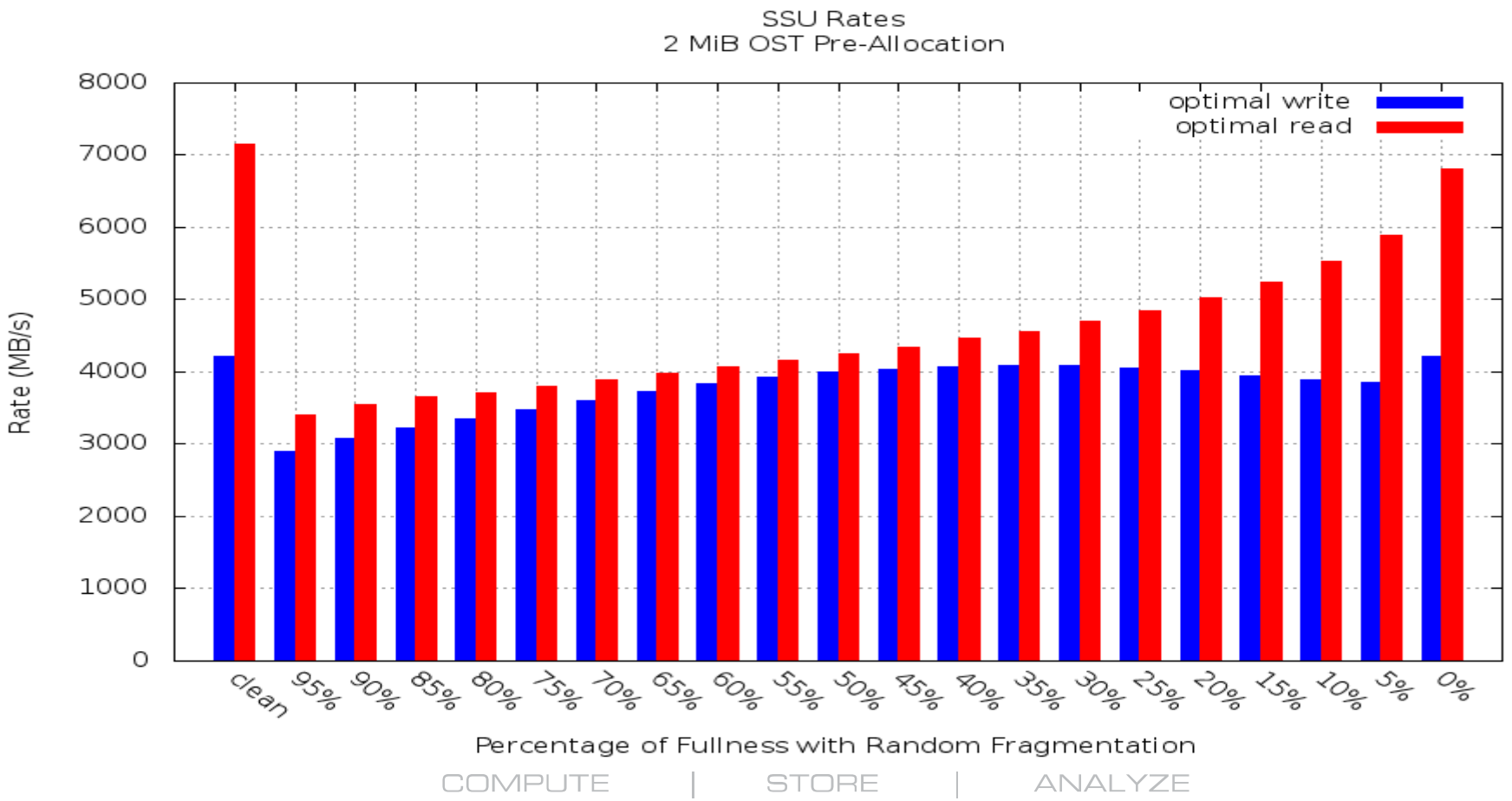
4 MiB OST Pre-allocation Fragmentation

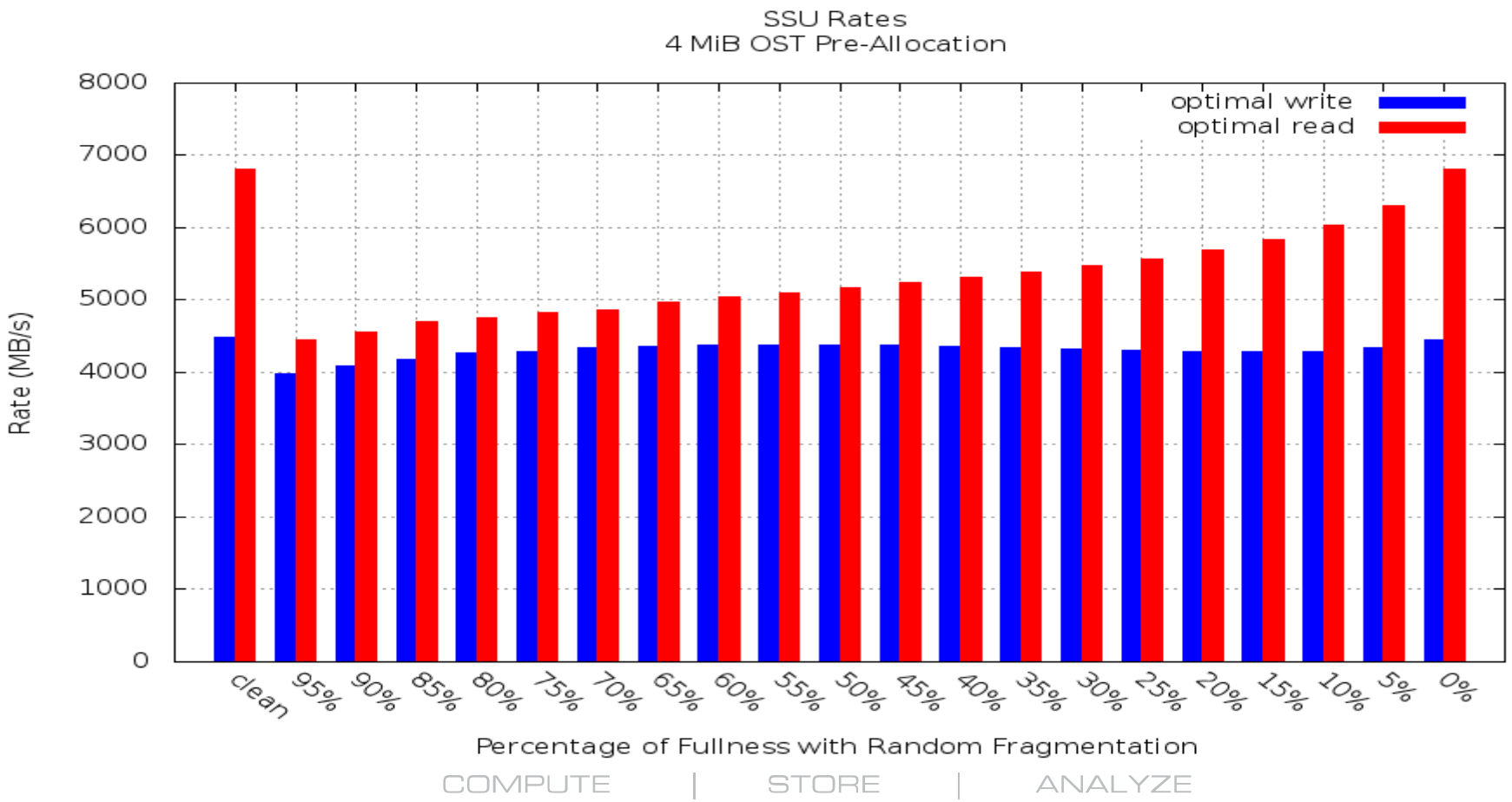


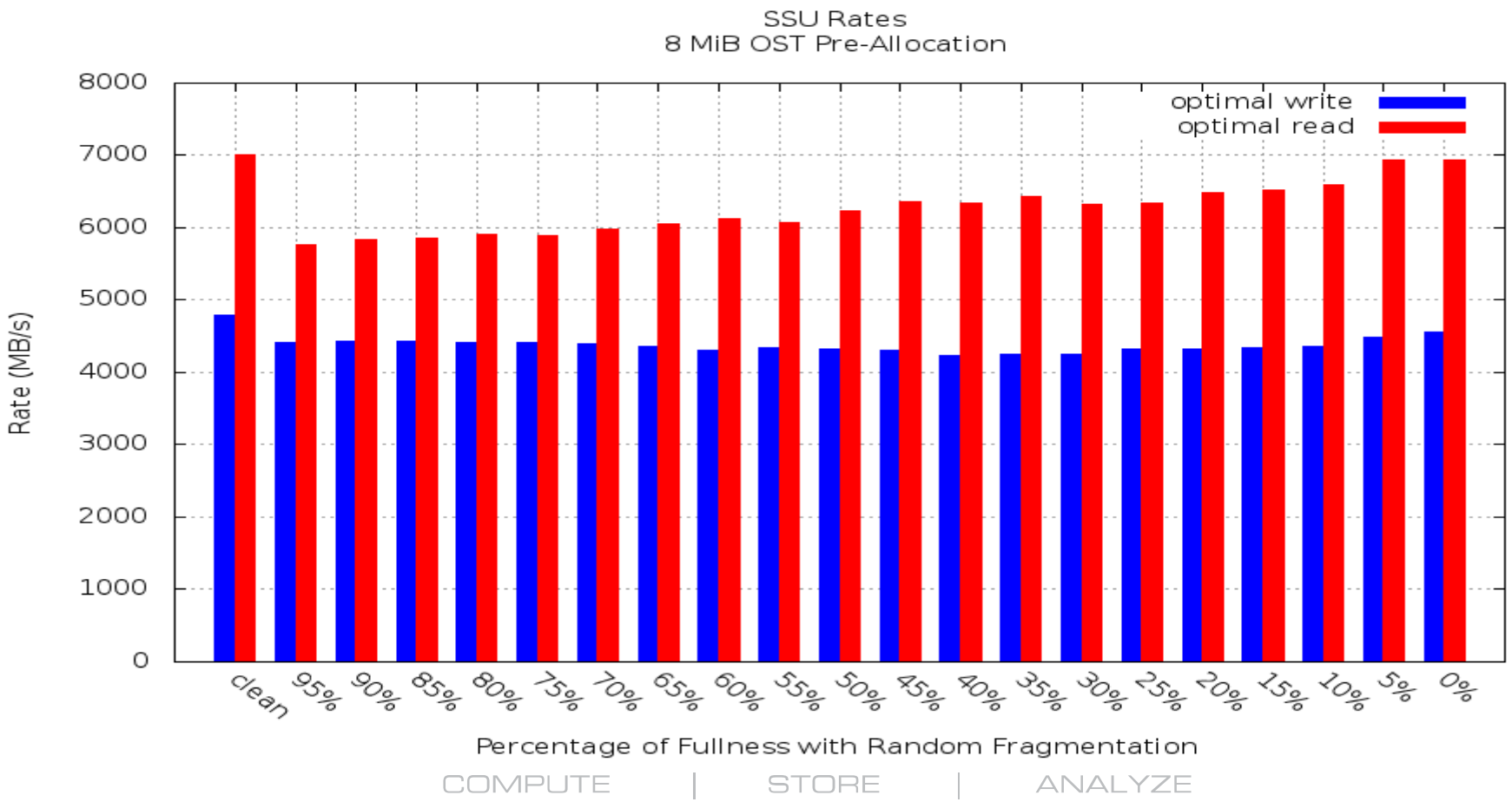
8 MiB OST Pre-allocation Fragmentation











Summary

- **The performance variation due to fragmentation is biggest for 1 MiB OST pre-allocation.**
  - This is the default for Sonexion 1600.
- **Using 8 MiB OST pre-allocation, no matter what level of fragmentation:**
  - The optimal write rate is at least 89% of a clean file system
  - The optimal read rate is at least 82% of a clean file system
  - Optimal write rates are always above 4 GB/s/SSU
  - Optimal read rates are always above 5 GB/s/SSU

Checking Settings on OSS Nodes

- **cat /proc/fs/ldiskfs/md*/prealloc_table**
  - 32 64 128 # default prealloc
  - 128 256 512 # prealloc of 2 MiB
  - 256 512 1024 # prealloc of 4 MiB
  - 256 512 1024 2048 # prealloc of 8 MiB
- **cat /proc/fs/ldiskfs/md*/mb_last_group**
  - Which of the multi-block allocation groups was last used
  - Example: 8000 means about 1 TB from start of OST

Thank You

- Questions ?