Copysets : Reducing the Frequency of Data Loss in Cloud Storage

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Source:

2013 USENIX Annual Technical Conference
(Awarded Best Student Paper)

[1] www.usenix.org/conference/atc13/technical-sessions/presentation/cidon

Outline

Random Replication

Widely used in data center storage systems to prevent data loss.

- Hadoop Distributed File System (HDFS)
- RAMCloud *(https://ramcloud.stanford.edu)*
- Google File System (GFS)
- Windows Azure

However, large-scale correlated failures such as cluster power outages handled poorly by random replication.[1][2][3][4]
This stresses the availability of the system.

[1] R. J. Chansler. Data Availability and Durability with the Hadoop Distributed File System.

[2] J. Dean. Evolution and future directions of large-scale storage and computation systems at Google.

[3] D. Ford et al. Availability in globally distributed storage systems.

[4] K. Shvachko et al. The hadoop distributed file system.

Copysets Replication

- Split node into copysets
- Replicas of single chunk can only be stored on one copyset.
- Data loss events occur only when all the nodes of some copyset fail simultaneously.
- Decrease the probability of data loss under power outages.

Outline

Probability of data loss

- N : # nodes in the system
- R : # replicas of each chunk

$$\frac{\#copyset}{\binom{N}{R}}$$

Example :

$\{1, 2, 3\}, \{4, 5, 6\}, \{7, 8, 9\}$

N = 9
R = 3

copysets = 3

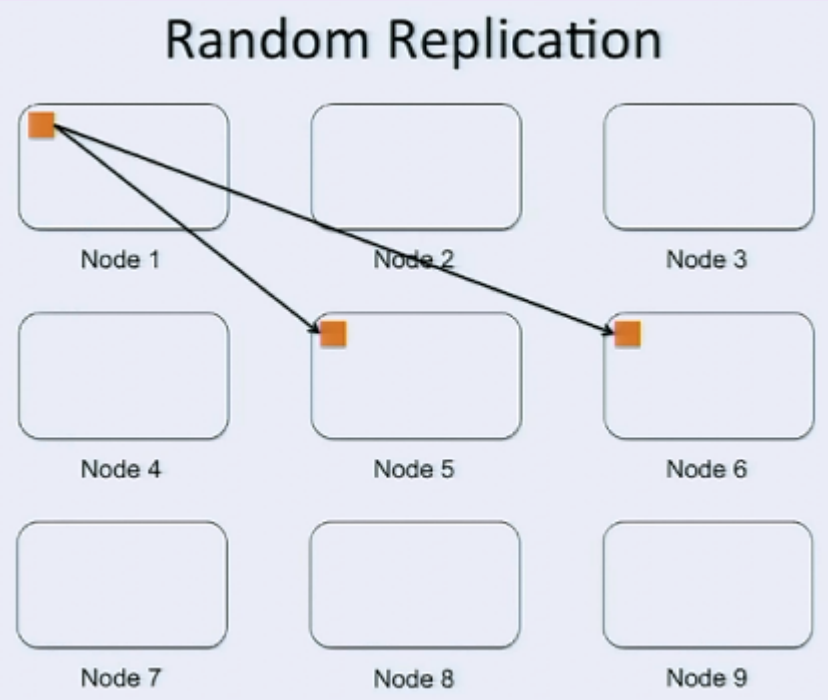


Figure : 1

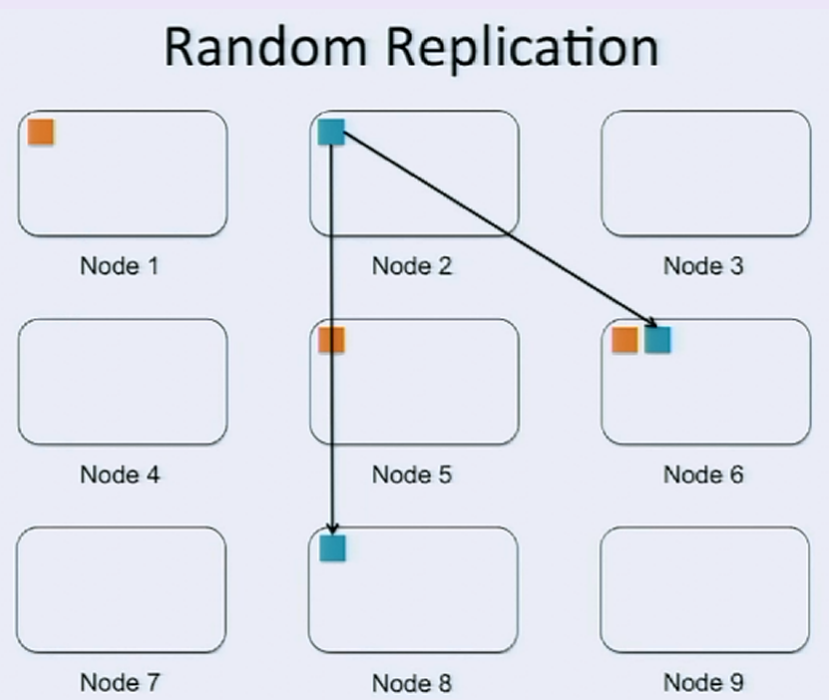
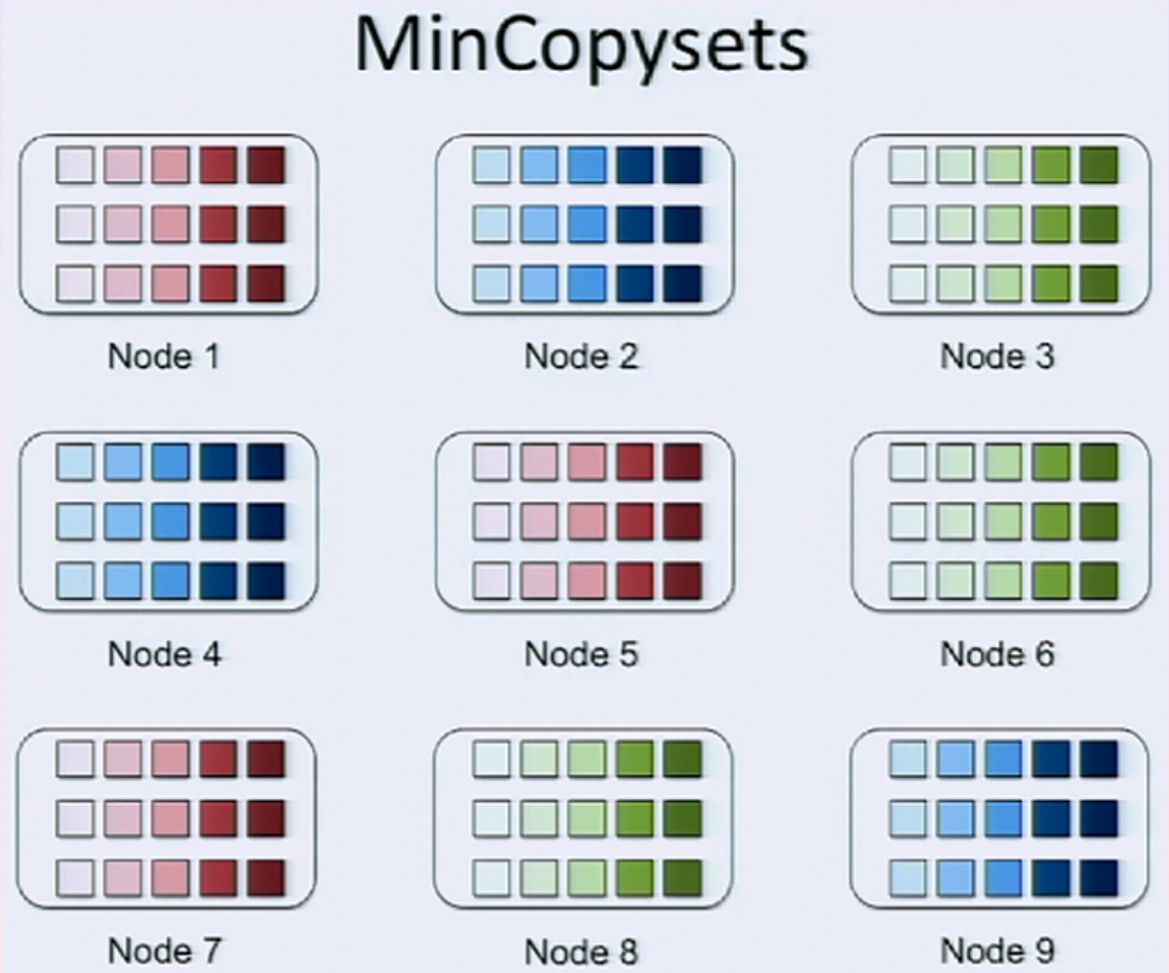


Figure : 2

{1, 5, 6}
{2, 6, 8}
{3, 4, 5}
...
{5, 6, 9}


MinCopysets
Node 1
Node 2
Node 3
Node 4
Node 5
Node 6
Node 7
Node 8
Node 9

{1, 5, 7}
{2, 4, 9}
{3, 6, 8}

Probability of data loss

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The Trade-off

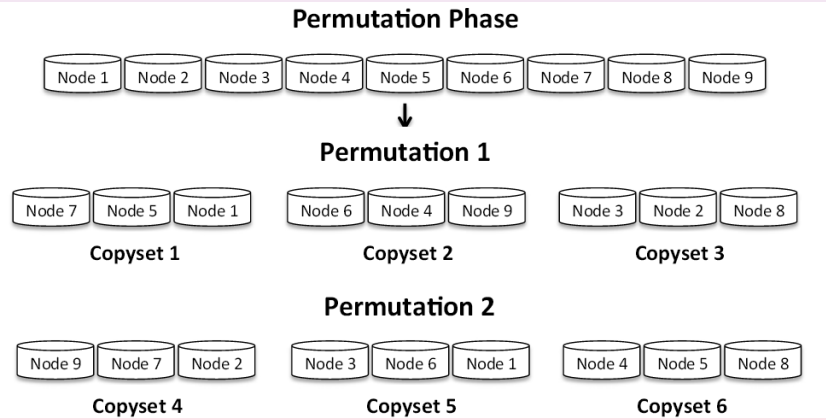
	MinCopysets	Random Replication
Mean time to Failure	625 years	1 year
Amount of Data Lost	1 TB	5.5 GB

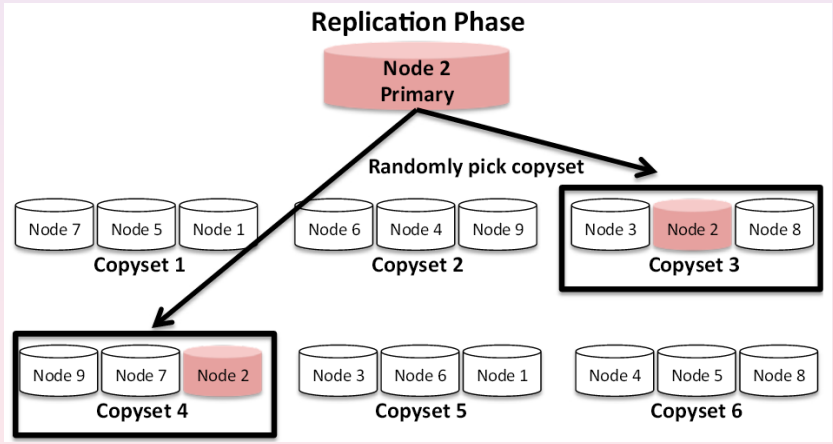
5000-node cluster

Outline

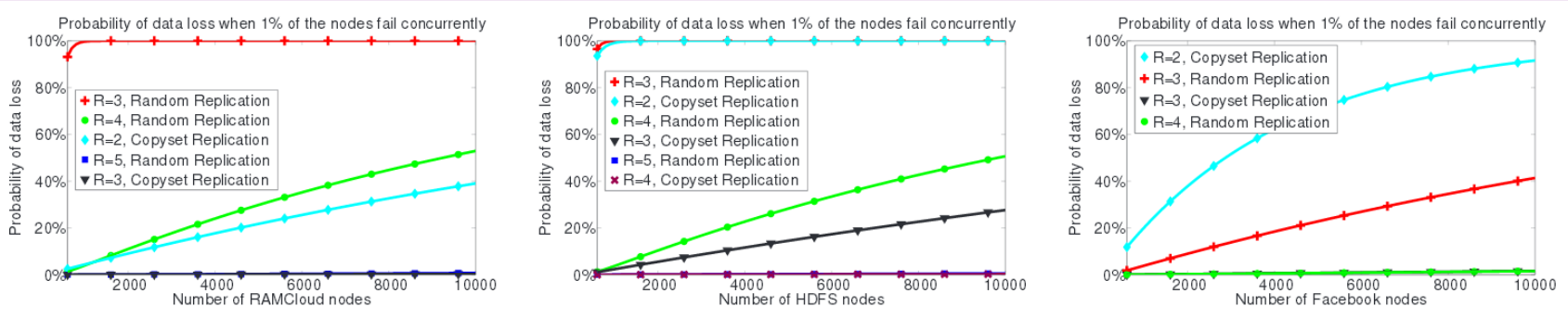
Design

- 2 phases : Permutation & Replication.
- Scatter width : # nodes that store copies for each nodes data.





Data loss probability of random replication and Copyset Replication in different systems.



Outline

Related Work

- BIBD. (Balanced Incomplete Block Designs) [Fisher, '40]
- Power downs. [Harnik et al '09, Leverich et al '10, Thereska '11]
- Multi-fabric interconnects. [Mehra, '99]

Outline

Conclusion

1. Many Storage systems randomly spray their data across a large number of nodes.
2. Serious problem with correlated failures.
3. Copyset Replication is a better way of spraying data that decreases the probability of correlated failures.

Thank You for Your Listening