

# Long-term View of the Reliability of Archival Storage Systems

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## First Step Towards a Reliability-aware Storage System Manager

### The Problem

Storage systems evolve over time. No company would use only a single storage system to store its business data, instead, people use storage systems from many vendors and these systems tend to change over time.

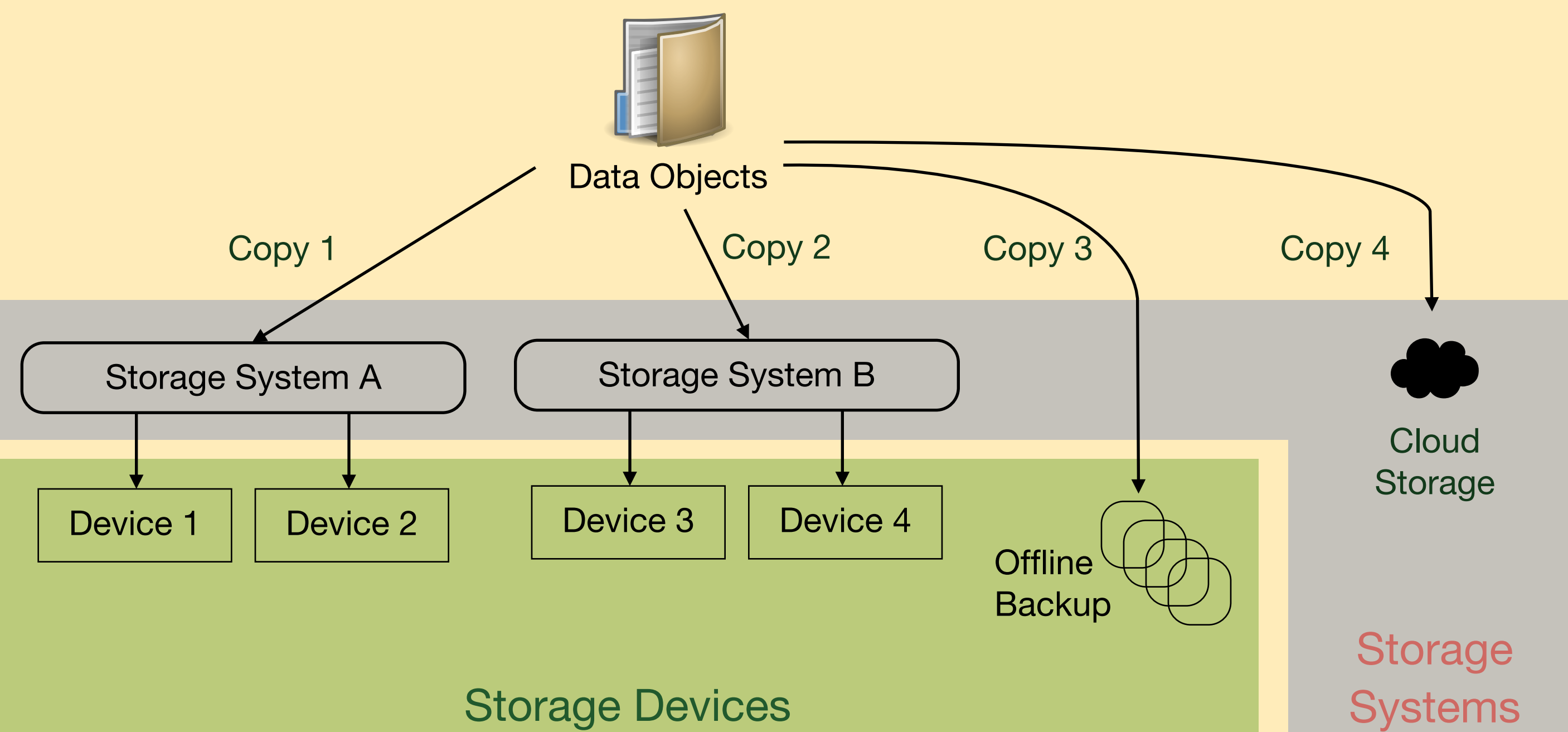


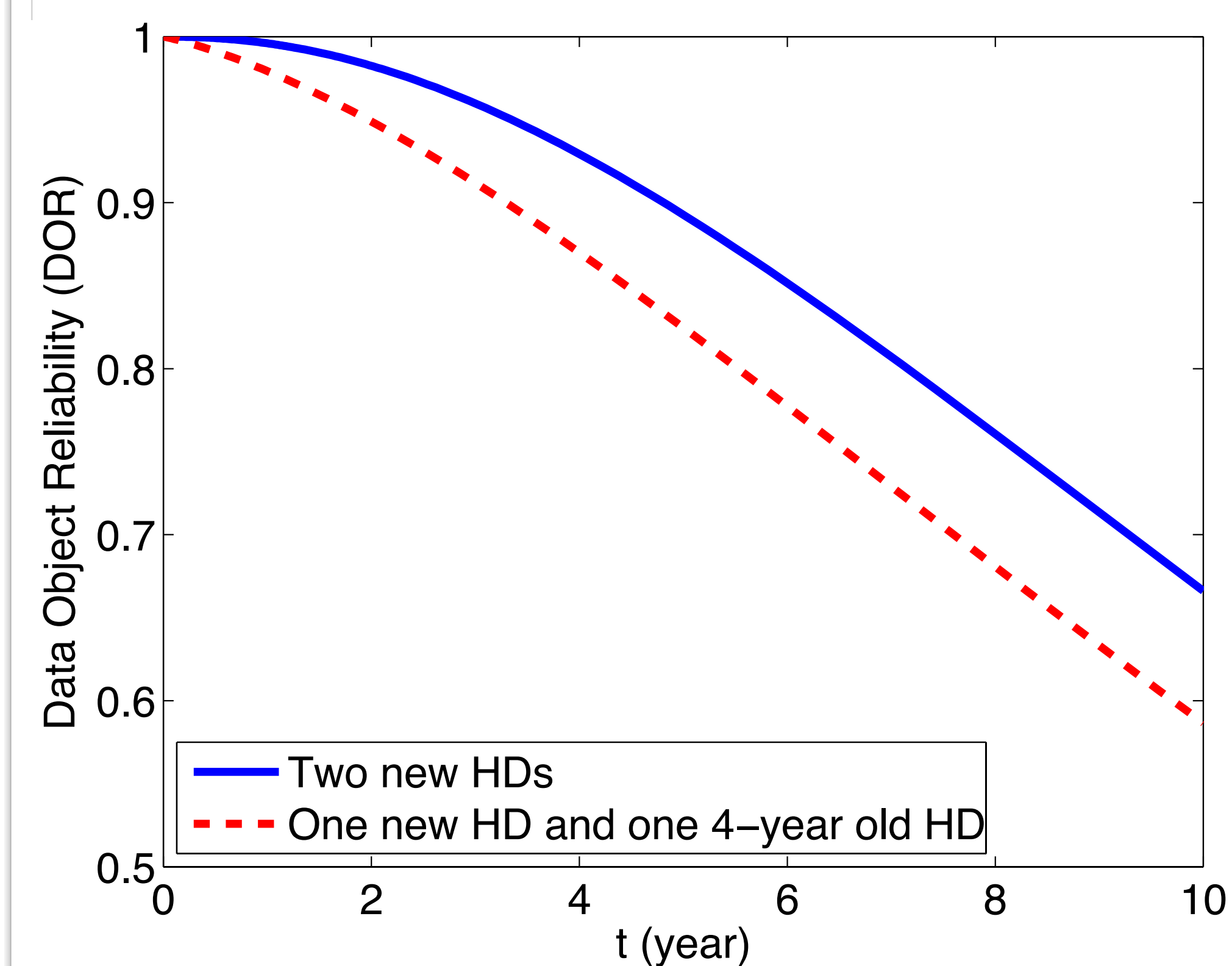
Figure 1 A Modern Storage Solution

**Do you know the reliability of your data in this always changing storage solution?**

### Three Tenets of This Research

- The idea in this poster is based on these three key observations:
  - Reliability of Data  $\neq$  Reliability of Storage System
  - Devices and systems **age** and their reliabilities decline, which is a very important factor for the reliability of archival storage systems
  - Some **large scale events** can affect several or all storage systems simultaneously

### Aging of Devices Affects Data Object's Reliability (DOR)



Reliability of data stored on a mirrored two-HD system. You can see how the reliability changes if one of these two HDs is a 4-year old one. (Both tests use the same Weibull distribution and empirical parameters)

Definition of DOR: the probability that a data object will survive during a specified period of time under stated conditions.

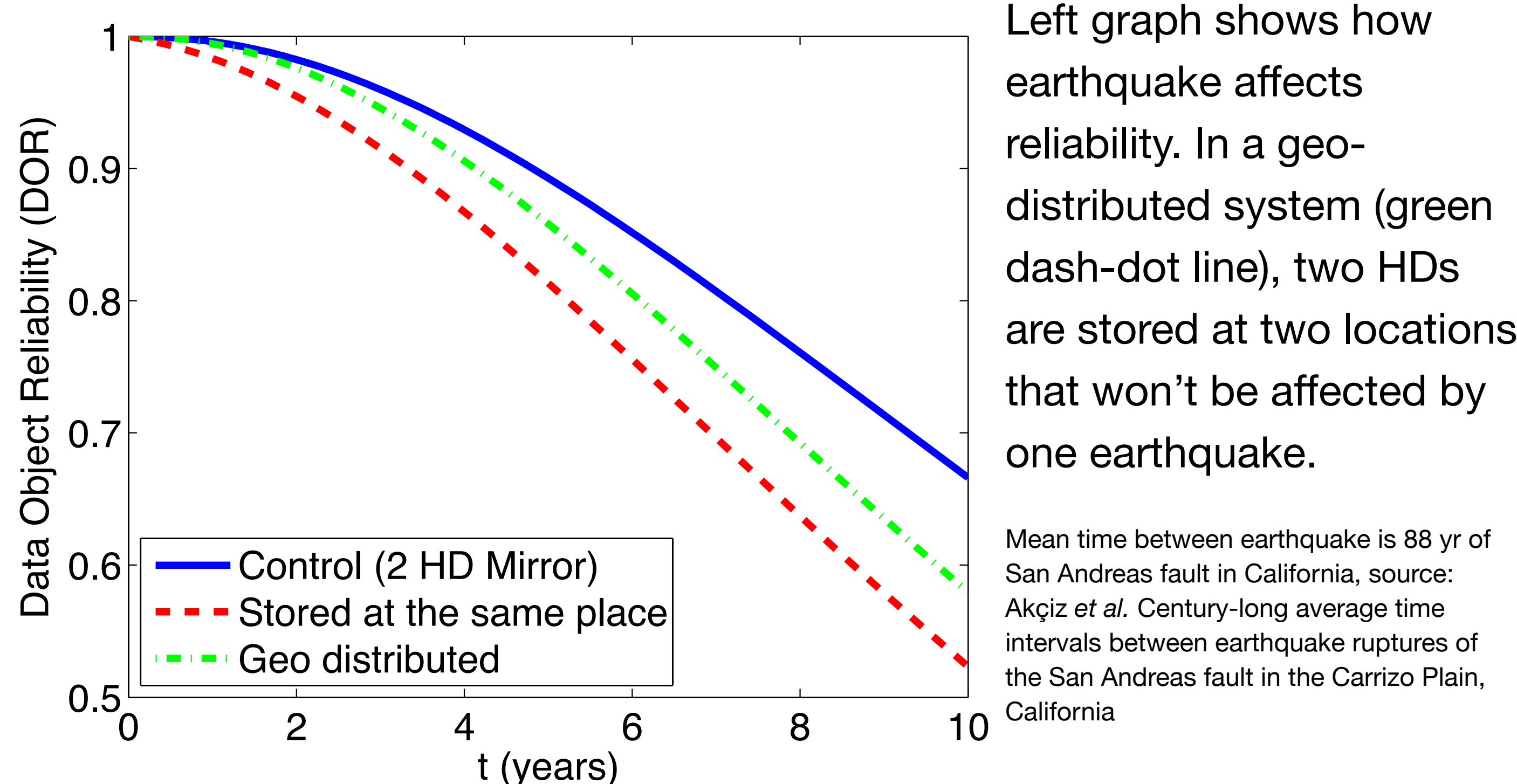
### S.M.A.R.T. Event's Affect on Reliability

Pinheiro *et al.* [1] presented the correlation between some SMART events and the failure of hard drives. For example, the group of drives with "Scan Error" is ten times more likely to fail than the group with no error. This effect is shown in Figure 3 at the right.

[1] Eduardo Pinheiro, Wolf-Dietrich Weber, Luiz André Barroso, Failure Trends in a Large Disk Drive Population

### Modeling Large Scale Events

Large events such as earthquake can affect more than one systems at the same time. We assume one earthquake can destroy all storage systems.



Left graph shows how earthquake affects reliability. In a geo-distributed system (green dash-dot line), two HDs are stored at two locations that won't be affected by one earthquake.

Mean time between earthquake is 88 yr of San Andreas fault in California, source: Akçiz *et al.* Century-long average time intervals between earthquake ruptures of the San Andreas fault in the Carrizo Plain, California

### Getting System's Reliability from Devices' Reliability

- Many commercial storage systems use proprietary algorithms, which is hard to analysis
- Some algorithm's reliability can't be calculated without using simulation

BUT

They all depends on the reliability of the underlying **Storage Devices**.

We propose to use **Reliability Transition Function (RTF)** to reflect this relationship.

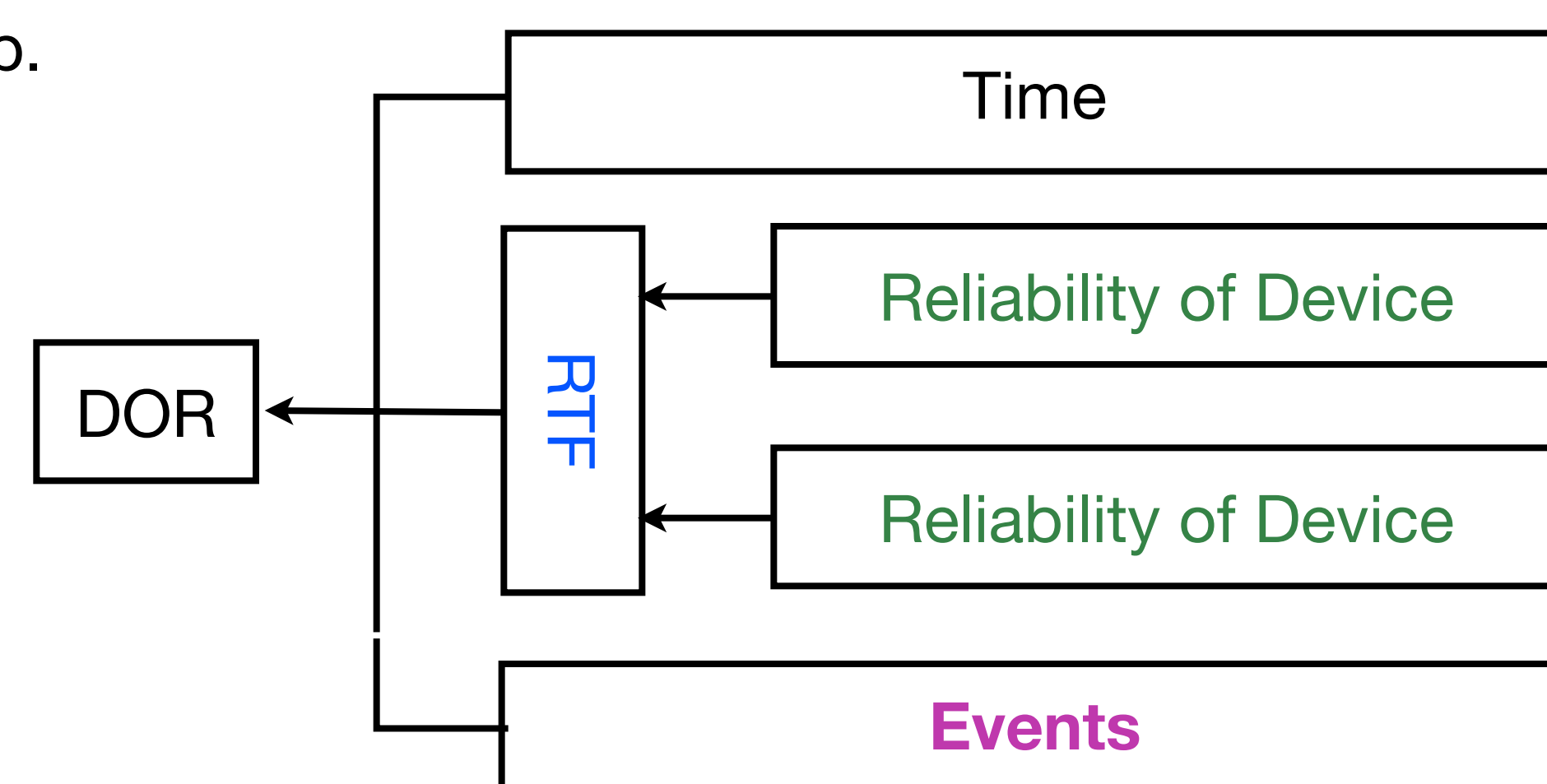


Figure 2 How the Reliability is calculated

### A Feedback System that Decides the Impact of Age of Devices and Frequency of Large Scale Events

Devices' error pattern is similar among the same vintage of devices. Therefore a failure observed from one device affects the reliability of devices from the same shipment.

### Wrap Up

This graph shows how the data's reliability changes in one simulation.

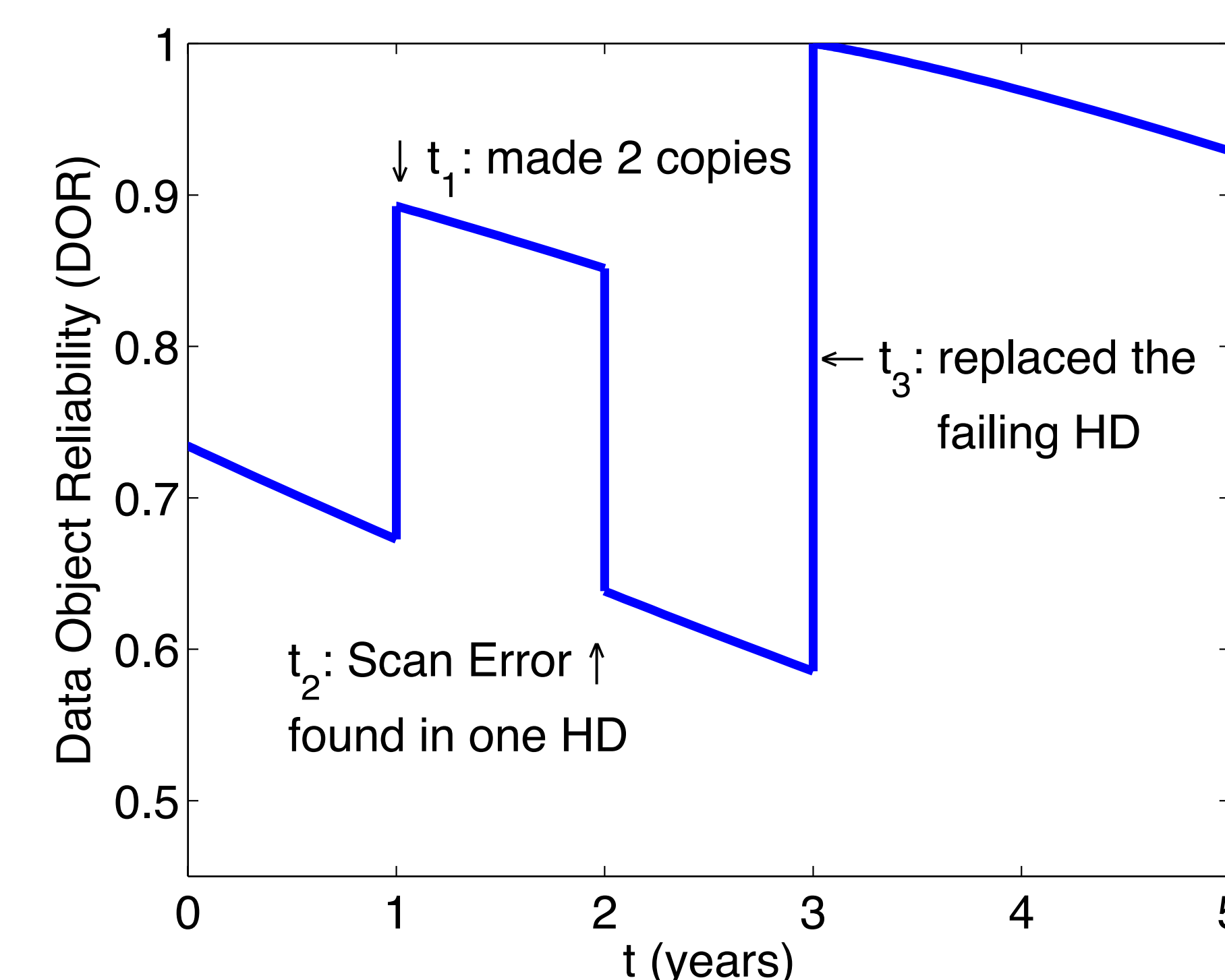


Figure 3: DOR of a changing system

A data object was generated at time 0, and stored in one HD. The beginning reliability was not 1 because the HD was old.

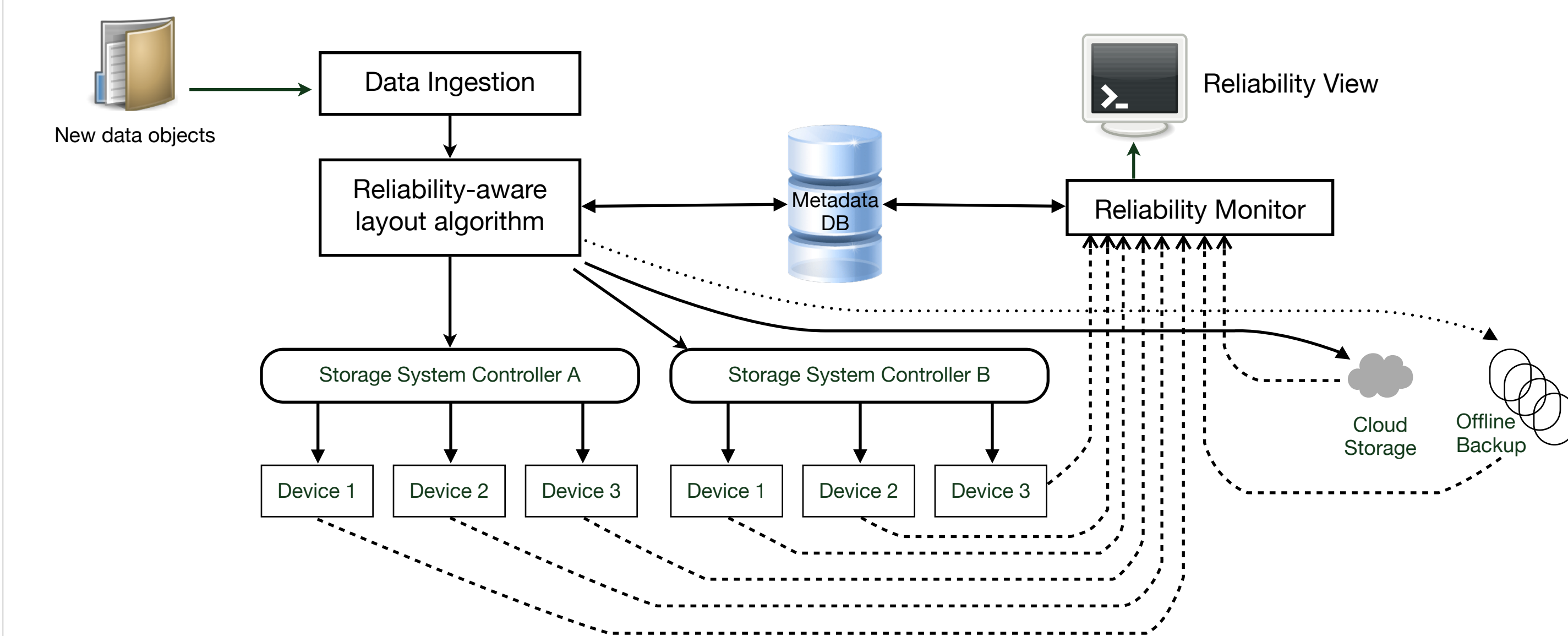
- t<sub>1</sub>: made an extra copy to another old HD
- t<sub>2</sub>: a SMART Scan Error event was observed in one HD
- t<sub>3</sub>: the failing HD was replaced by a new one

### Reliability-aware Storage Manager

Layout of data affects its reliability

- Prioritizing data objects according to their importance
- High priority objects should be stored on new systems/devices

We propose a storage solution manager that tracks events, reports the reliability of data objects and arranges layout accordingly. It can be part of a larger storage system manager, and a foundation for future works.



### Ongoing Work

- Building reliability-aware archival storage systems
- Integrate events tracking and reliability-aware data layout algorithm into Ceph<sup>[2]</sup>
- Provide future reliability prediction to help choosing between new devices
- Smart scrubbing based on event history

[2] Ceph is a distributed file system with high scalability: <http://ceph.newdream.net/>

### Conclusion

- Understanding the reliability of **data** is more important than understanding the reliability of systems or devices
- Reliability of data is always changing and must be tracked systematically
- A large amount of device information, which should be useful in understanding the storage systems is lost everyday because there is no systematic effort on gathering and processing them