How Many Copies Is Enough?

MIT Digital Document Preservation Simulation
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Problem to Solve

- You have a large, valuable, digital document collection
  - How many copies do you need to keep it safe?
  - On what quality level of servers?
  - How often should you audit the servers?
    - Do they still have all the docs?
- Not much hard data on which to base policy decisions
- We are trying to provide some data, admittedly hypothetical

Assumptions

- Everything costs $
  - Storing multiple copies
  - Higher quality services to store your docs
    - Data generally not available about "quality"
  - Bandwidth for auditing
- Our goal: provide data you can use to set policies

Our Basic Data, to Extrapolate

- Not keyed to any specific problems
- Many hints on how to extrapolate from our data to your situations
  - Number of docs, doc sizes, storage shelf sizes
  - Server failure rates
  - Audit strategies
- Very preliminary results

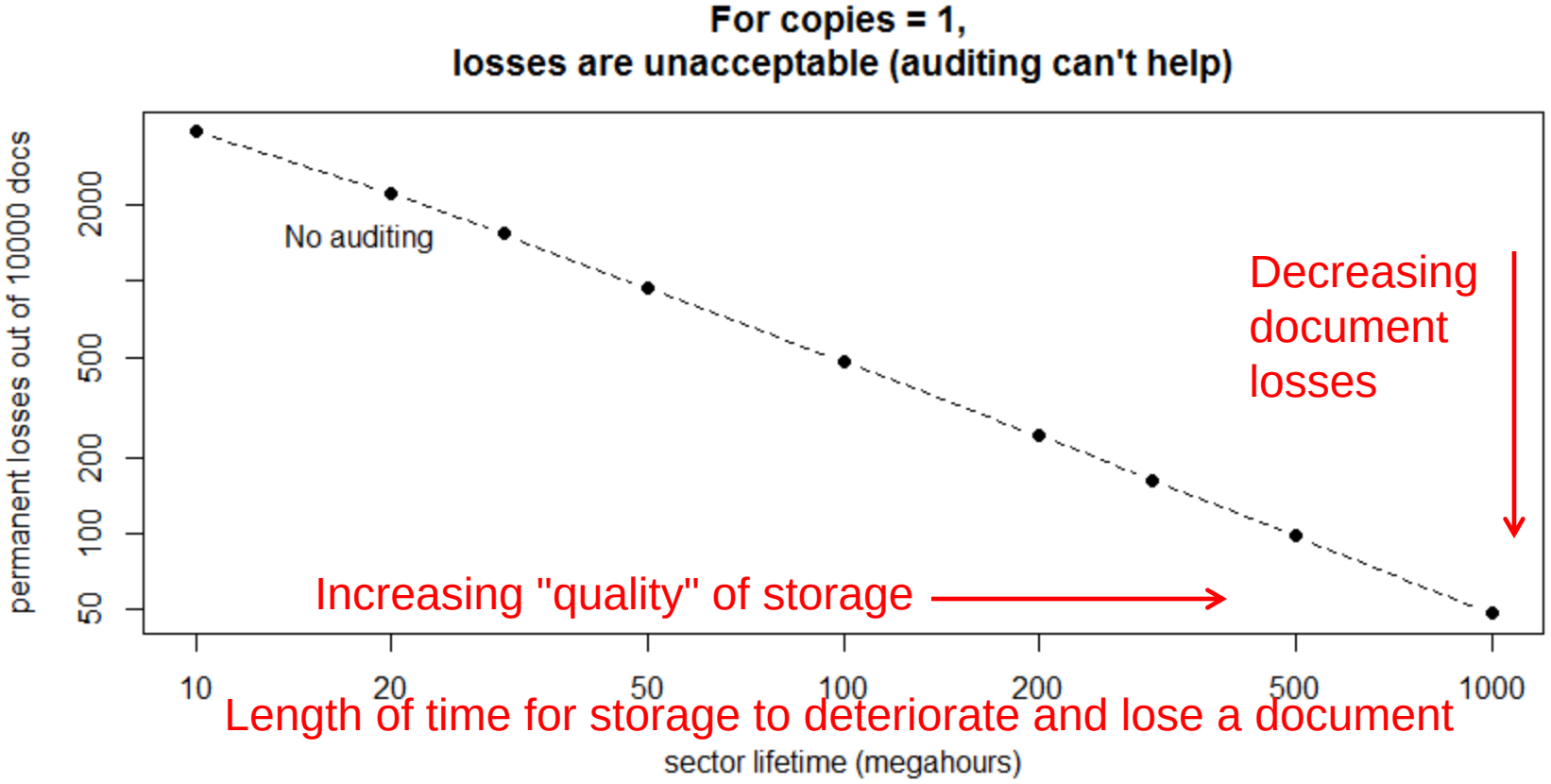
Two Type of Failures

- Common: A copy of a document dies on a particular server
- Less common: A server dies, losing all the documents it contains
  - "Institutional failure:" fire, flood, war, economic downturn, etc.
- All failures are silent (to the client = library)
- Auditing is *essential*

Digital Simulation Programs

- Input = error rates, numbers of copies, auditing rate, etc.
- Output = number of documents permanently lost over the life of the test
- Failure events happen at random intervals
  - Audits are regularly scheduled
- The programs are "open source," will be freely available for others to use, test, verify
  - "It's just computer time."

One Copy? All Losses Are Permanent Losses



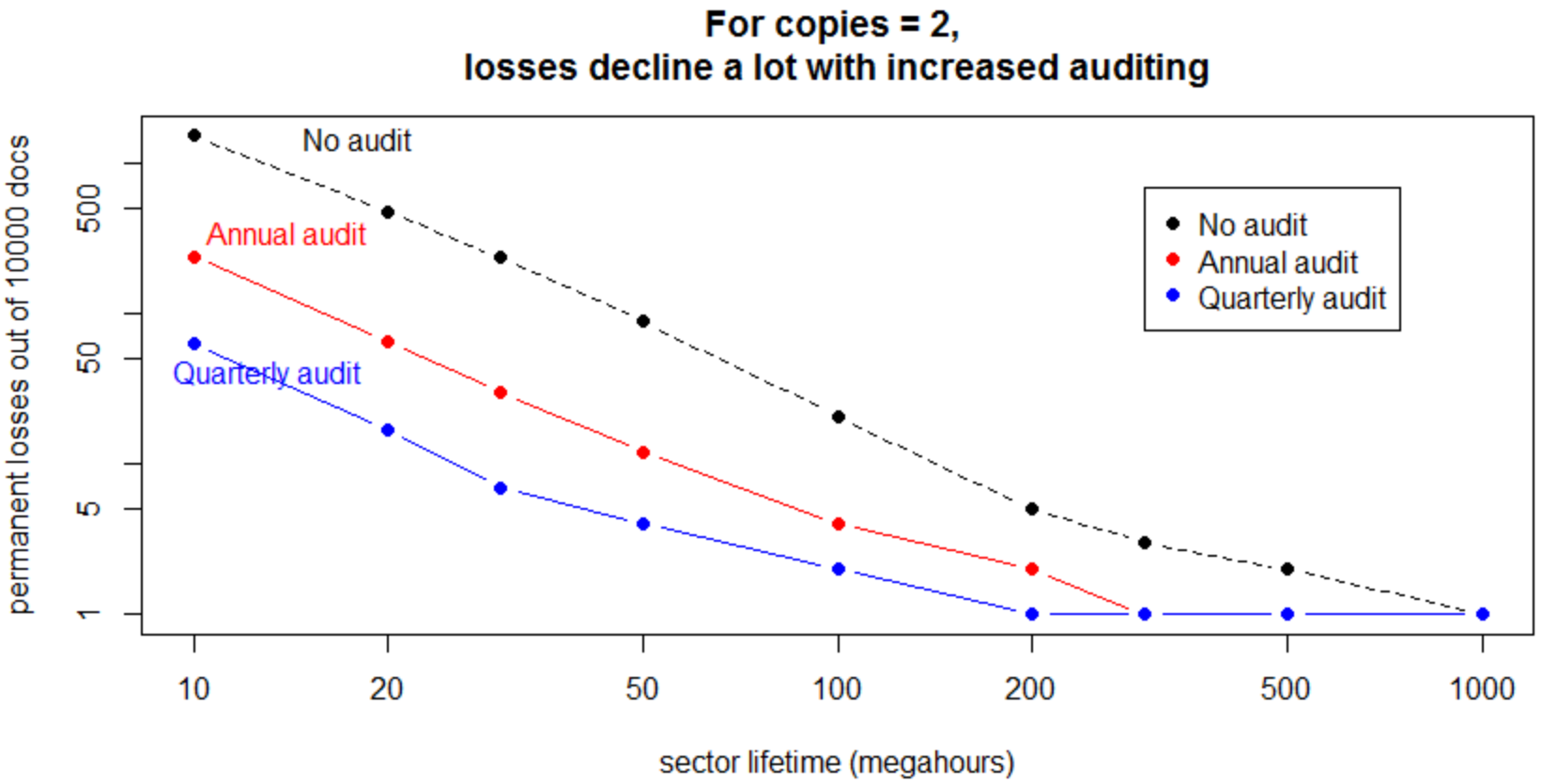
(Not much is known about the reliability of real storage services)

Good News & Bad News

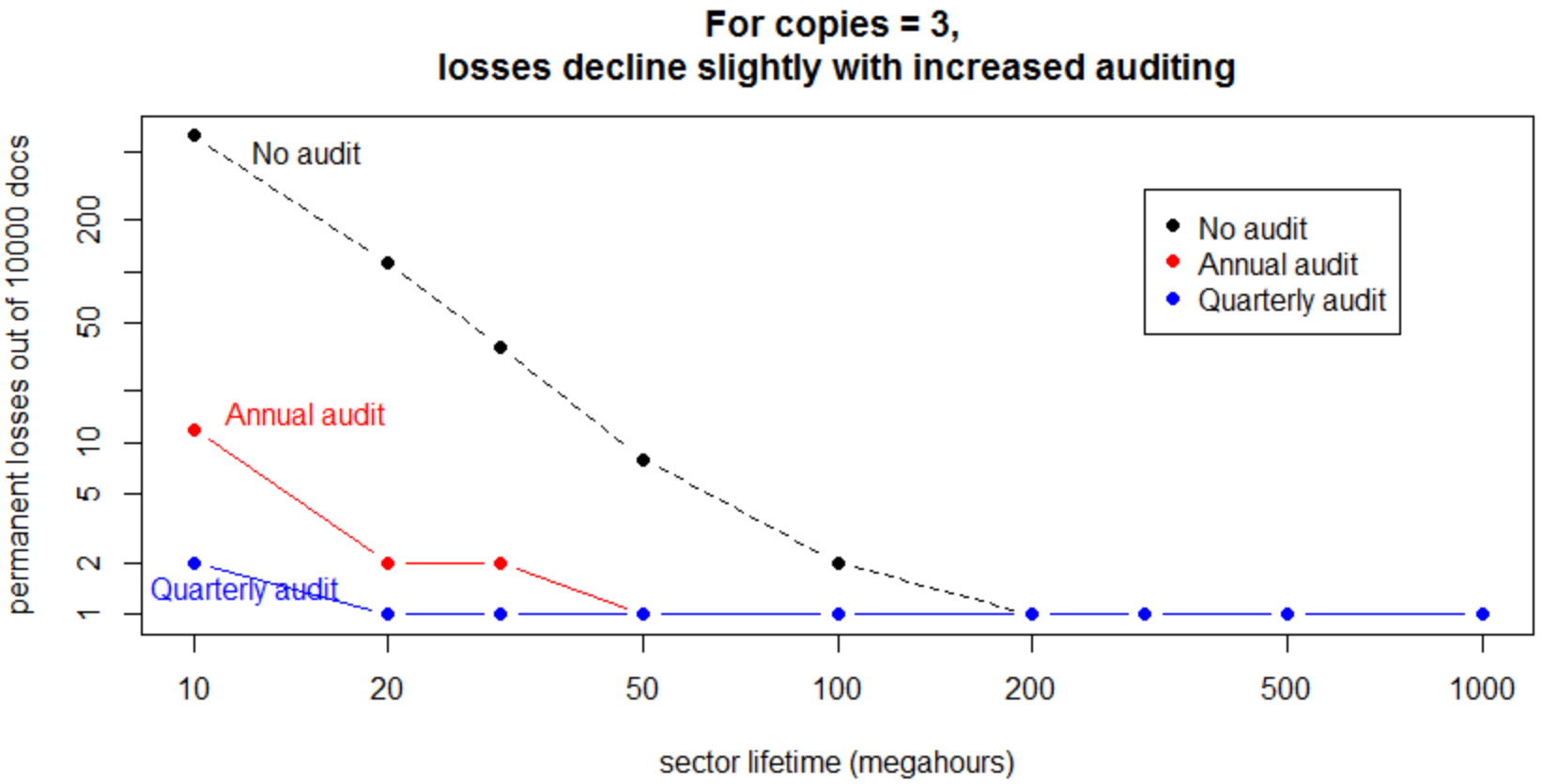
- Bad news: if anyone really understands the "quality" of modern storage, he/she is not talking
- Good news: we *think* that modern storage methods, like those used in cloud storage, are very reliable, high quality

- Strategy: Structure your storage to protect your collection from variations in reliability

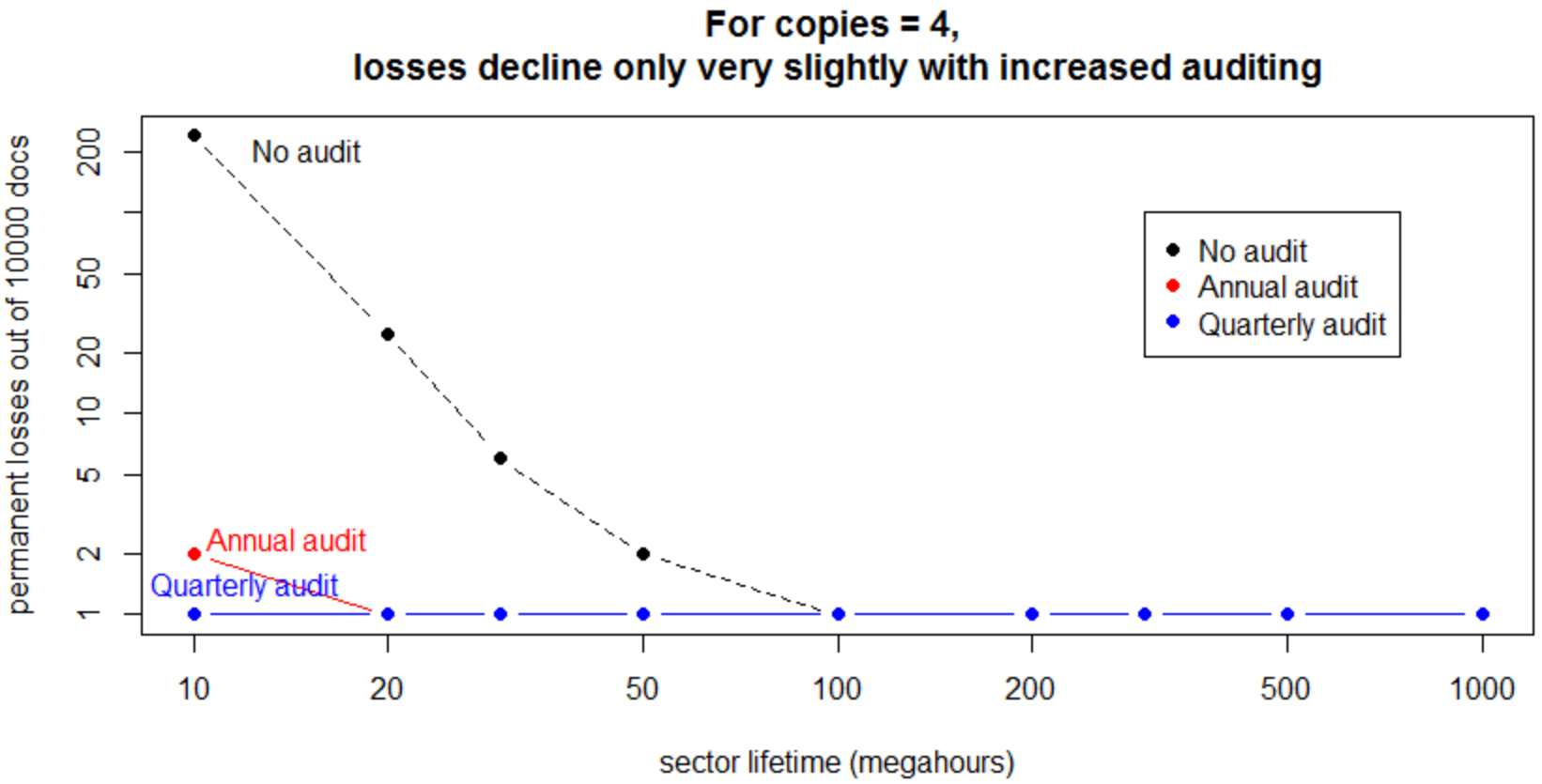
Two Copies? Definitely Not Enough



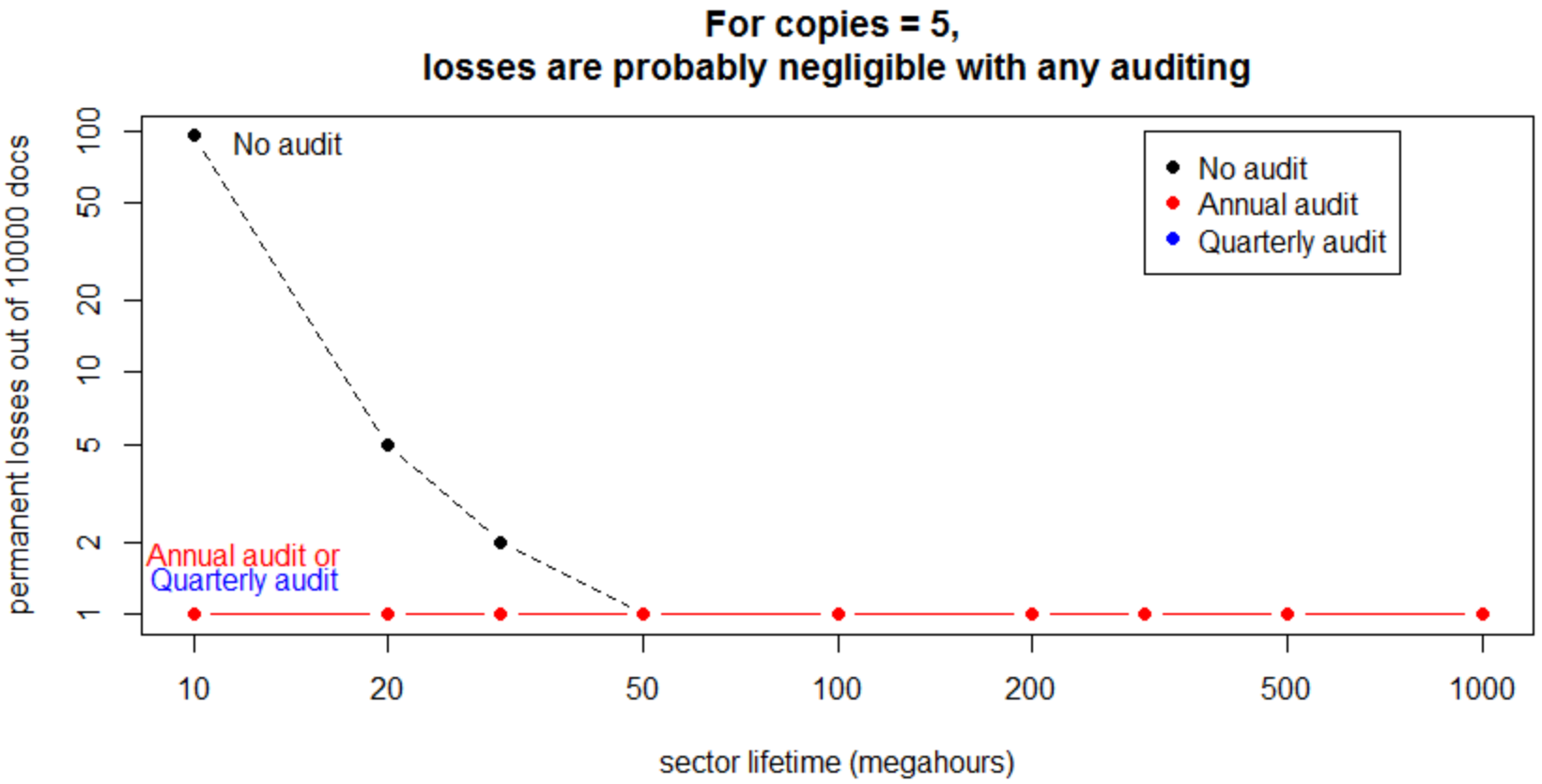
Three Copies? Marginal



Four Copies? Looks Good



Five Copies? Works



Preliminary Conclusions - 1

- More copies are better (duh!)
- Auditing is *essential* to collection health
  - Protects collection over huge range of "quality"
  - Very frequent auditing is probably overkill
  - Tricky auditing (subsets, random) is less effective
  - Auditing is expensive (in bandwidth, bytes moved, time)
    - We should work toward efficient auditing functions

Preliminary Conclusions - 2

- Institutional failures are pernicious -- but how often do they occur?
  - The problem: a silent institutional failure reduces the number of redundant copies you have stored
  - Risk is increased until you discover the problem (in auditing) and provision a new server
    - Thought you had four copies? Well, for a period of time, you actually have only three.
    - And another failure before the audit reduces copies to two
    - Failures may be correlated due to economic conditions, wars

Preliminary Conclusions - 3

- How many copies do you need to limit losses?
  - Limit permanent losses to some part of the collection?
  - Better: How many to keep likelihood of *any* permanent loss under some percentage?
    - 5 per cent, 1 per cent, 0.1 per cent?
  - For institutional failures, how many copies to keep likelihood of total loss under some percentage?

- *Q: What information do you need to manage your libraries?*

Backup

Form of the Data

- Fixed number of documents, fixed time
  - Scale to your needs
- Number of copies varies, 1 to 10
- Reliability of storage servers varies
  - Very little real data in this area
- Auditing strategies vary
- Document size varies (but doesn't matter)