Storage and Services: Planning and managing cost, quality and risk

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An archive provides services:

- Ingest, access
- Safe storage
- Formats
- Metadata
- Rights

- They all cost money
- They all take time
- Never enough of either!
Services have location and responsibility
Is currently being set up. Different technology used. For all data, also applications.

RAID Mirror (Linux-based)
Services need planning and managing

• Service Level Agreements (SLA)
  – What the service does

• Quality of Service (QoS)
  – How well it does it

• If you can’t **measure** it then you can’t **manage** it
  – Throughput
  – Quality
  – Cost
  – Risk
Planning and managing includes compromises

- Volume
- Quality
- Deadline
- Budget

- Digitisation workflows
  - Cost, throughput, quality
  - E.g. QC v.s. automation

- Storage strategies
  - Cost, risk of loss
  - E.g. copies v.s. cost

- Online access services
  - Cost, QoS, Users
  - E.g. KPI v.s. customers
Storage SLA Terms

- Availability
- Integrity / Safety
  - How to measure?
- Ingestion time
  - Indexing, generating access copies
- Search time
- Delivery time
  - From request to start of delivery
- Bandwidth

- Subscription fee
- Charge for data
  - On disc
  - Ingest
  - Access
- Charge for CPU
- Charge per user
- Maximum storage size
- Maximum number of users
Availability

I need the service to be available almost all the time

Can you be more specific?

I need the access service available 99.9% of the time

Is that measured over a day, month or year?

The access service must be available 99.9% of the time each month

That’s 43 minutes of downtime each month – what if that’s all in one go one afternoon?

When can maintenance be done on the service?

Do you want different uptimes for day and night?

When is “daytime” for an international operation?
Access Time

I want a good response time for delivery

- For every delivery, or on average?

The average delivery time must be less than 5 minutes

- Average over what period?

The average delivery time each month should be less than 5 minutes

What about the network connection - doesn’t that affect it?

Files must be ready for download in less than 5 minutes (on average, per month)

What about big files? Won’t they take longer?

Files must be ready for download in less than the size of the file in GB + 15 minutes, on average, per month.
I want everything returned in perfect condition all the time.

That’s hard: at least three copies and an active management system.

OK, maybe I can lose a bit, but not too much.

How much risk are you willing to take?

Are we talking about losing files, parts of files or a few individual “bits”?

Or, are you talking about programmes, scenes, shots, frames...?

What about a certain number of programme-minutes at risk per year?

Is losing 1%-3% of the archive over 20 years acceptable?

Maybe, but what’s the chance that I could lose more than that?

OK, let’s run a model to look at the options.
**Storage**

- Is not 100% safe
- Becomes obsolete quickly
- Total cost is high, but falls quickly
- Fast access and safety don’t always go together

<table>
<thead>
<tr>
<th>Medium</th>
<th>Storage Density bits/cm²</th>
<th>Life, years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone</td>
<td>10</td>
<td>10000</td>
</tr>
<tr>
<td>Paper</td>
<td>$10^4$</td>
<td>1000</td>
</tr>
<tr>
<td>Film</td>
<td>$10^7$</td>
<td>100</td>
</tr>
<tr>
<td>Disc</td>
<td>$10^{10}$</td>
<td>10</td>
</tr>
</tbody>
</table>
Many storage choices

• **Longer lived** storage technology
  – E.g. Printing bits to film

• **More reliable** storage technology
  – E.g. data tape instead of HDD on shelves

• Make **more copies**
  – E.g. off site deep archiving

• Encode to **make content more resilient**
  – E.g. Graceful behaviour if a few bits and bytes are corrupted

• **Conceal errors**
  – E.g. Interpolation of corrupted frames or blocks

• **Check often and fix quickly**
  – E.g. ‘scrubbing’ of HDD servers
Comparing ‘cost of risk of loss’

- Diversity (copies) keeps things safe
- Active management of data integrity
- Migration to address obsolescence
- All activities have a cost, especially access
## Cost, safety and access: Simple comparison of IT storage

<table>
<thead>
<tr>
<th></th>
<th>Data tape on shelves</th>
<th>HDD in servers</th>
<th>Storage as a Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Cost</strong></td>
<td><strong>Low</strong> <em>(media, shelves, climate control)</em></td>
<td><strong>High</strong> <em>(servers, power, cooling, maintenance)</em></td>
<td><strong>High</strong> <em>(fully managed service)</em></td>
</tr>
<tr>
<td><strong>Access Cost</strong></td>
<td><strong>High</strong> <em>(people retrieve and load media)</em></td>
<td><strong>Low</strong> <em>(internal network, automated)</em></td>
<td><strong>High</strong> <em>(bandwidth, charges for i/o)</em></td>
</tr>
<tr>
<td><strong>Latent Failures</strong></td>
<td><strong>Low</strong> <em>(data tape is reliable)</em></td>
<td><strong>Med</strong> <em>(‘bit rot’)</em></td>
<td><strong>Low</strong> <em>(replication and monitoring)</em></td>
</tr>
<tr>
<td><strong>Access Failures</strong></td>
<td><strong>Medium</strong> <em>(drives eat tapes)</em></td>
<td><strong>Low/Medium</strong> <em>(depends on system)</em></td>
<td><strong>Low</strong> <em>(automated checks)</em></td>
</tr>
</tbody>
</table>
Two tools that might help

• Long term planning
  – 25 years
  – High level choices
  – Estimates of total cost and loss
  – Narrow down the options

• Short to medium term simulation
  – Simulates actual events
  – Corruption, loss, catastrophes
  – Ingest, access, ‘active preservation’
  – Impact of limited resources
# Storage Systems

Found 5 storage systems. Add...

<table>
<thead>
<tr>
<th>Storage System</th>
<th>Access Costs</th>
<th>Storage Costs</th>
<th>Corruption Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD in servers</td>
<td></td>
<td>€0.1 per GB</td>
<td></td>
</tr>
<tr>
<td>Migration required every 4 years.</td>
<td></td>
<td>€1 per GB</td>
<td></td>
</tr>
<tr>
<td>Running Costs</td>
<td>Access:</td>
<td>Storage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€0.1 per GB</td>
<td>€1 per GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 in 500 files</td>
<td>1 in 750 files</td>
<td></td>
</tr>
<tr>
<td>HDD on shelves</td>
<td></td>
<td>€0.25 per GB</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>€0.1 per GB</td>
<td></td>
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<td>Running Costs</td>
<td>Access:</td>
<td>Storage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€1 per GB</td>
<td>€0.25 per GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 in 100 files</td>
<td>1 in 500 files</td>
<td></td>
</tr>
<tr>
<td>Data tape in a robot</td>
<td></td>
<td>€0.2 per GB</td>
<td></td>
</tr>
<tr>
<td>Migration required every 6 years.</td>
<td></td>
<td>€0.4 per GB</td>
<td></td>
</tr>
<tr>
<td>Running Costs</td>
<td>Access:</td>
<td>Storage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€0.2 per GB</td>
<td>€0.4 per GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 in 1x10^4 files</td>
<td>1 in 1x10^5 files</td>
<td></td>
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<td></td>
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<td>€0.1 per GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 in 1x10^4 files</td>
<td>1 in 1x10^5 files</td>
<td></td>
</tr>
<tr>
<td>mystorage</td>
<td></td>
<td>€1 per GB</td>
<td></td>
</tr>
<tr>
<td>Migration required every 5 years.</td>
<td></td>
<td>€1 per GB</td>
<td></td>
</tr>
<tr>
<td>Running Costs</td>
<td>Access:</td>
<td>Storage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€1 per GB</td>
<td>€1 per GB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 in 10 files</td>
<td>1 in 10 files</td>
<td></td>
</tr>
</tbody>
</table>
Long term cost
Simulating retention and access

- Resources are often limited
  - People, servers, bandwidth
  - Contention and priorities
- Capacity planning, Disaster simulation, Training
Data Service Management

Online service

Monitoring

User and resource management

Automatic Control

Decision Support

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What have we built?

Online service

MServe serving your needs

127.0.0.1

jobs data storage

Number of Jobs: 84  Number of Files: 84  Largest File: 907.9 KB
Average File Size: 396.2 KB  Disk Space Used: 32.5 MB

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What have we built?

Monitors:
- Availability
- Data ingest and access
- Disc space
- Errors in files
- Delivery time

Manages:
- Bandwidth
Predict Future Trends

If we change nothing:
• Will I lose any data next year?
• How many assets will be at risk?
• What will the running costs be?

If we store another copy:
• How much will storage costs increase?
• How much safer will it be?
Optimising the System

Given the current state:
• How often should I be scrubbing the data?
• How many copies should I keep?
• How much resource should I dedicate to access?
... whilst keeping the data safe and the cost within budget.
More information

• D2.1.1 Preservation Strategies
• D2.1.2 Preservation Modelling Tools
• D2.2.1 Processes for preservation and access
• D2.3.1 SOA for AV storage
• D3.2.1 Threats from mass storage
• D6.3.1 Financial models and cost calculation
• D7.1.4 Annual AV preservation report(s)

All available from the PrestoCentre
Try out the tools

http://prestoprime.it-innovation.soton.ac.uk