

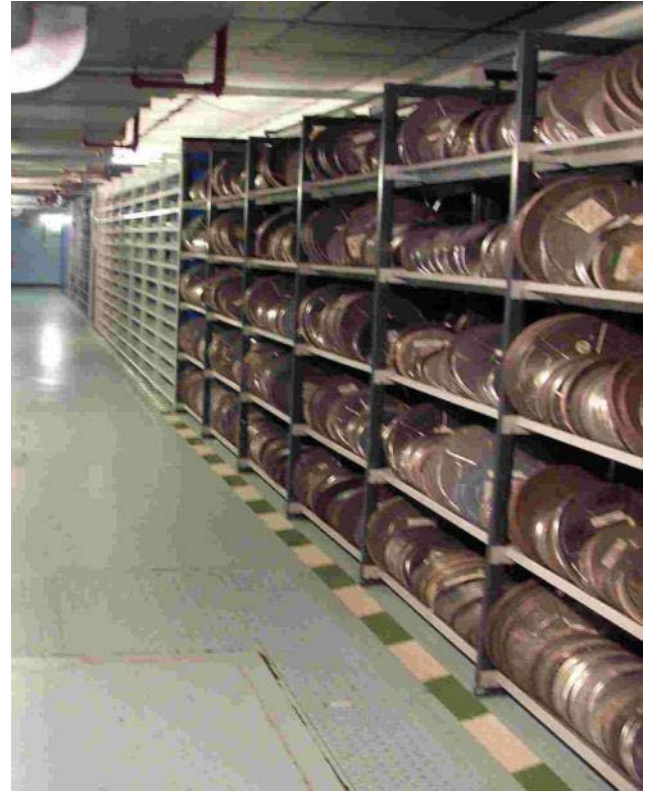
Requirements for digital preservation storage

BBC Research and Development
John Zubrzycki

What does a media archive need to do?

BBC Archives

- AV archive recently moved to new purpose-built premises in Perivale, west London
 - 100 km of shelves
 - 650k hours video
 - 350k hours audio
 - 1.5M titles in “grams library”
 - 400k “pronunciations”
 - 2M stills; ¼ online
 - 3M items sheet music*
 - BBC business documents*
- (* Documents at Caversham archive)



- A working media library:
 - Preservation for heritage is important, but
 - Preservation for future re-use is the real value of the archive
- 95% Internal use by BBC
- Established workflow based on tapes and film
- Browse or broadcast quality tapes can be supplied to programme-makers in 24 hours
- Infax database available to BBC staff to find content
- LonClass classification system for powerful relational search
- Experienced Media Managers can help programme makers find suitable content

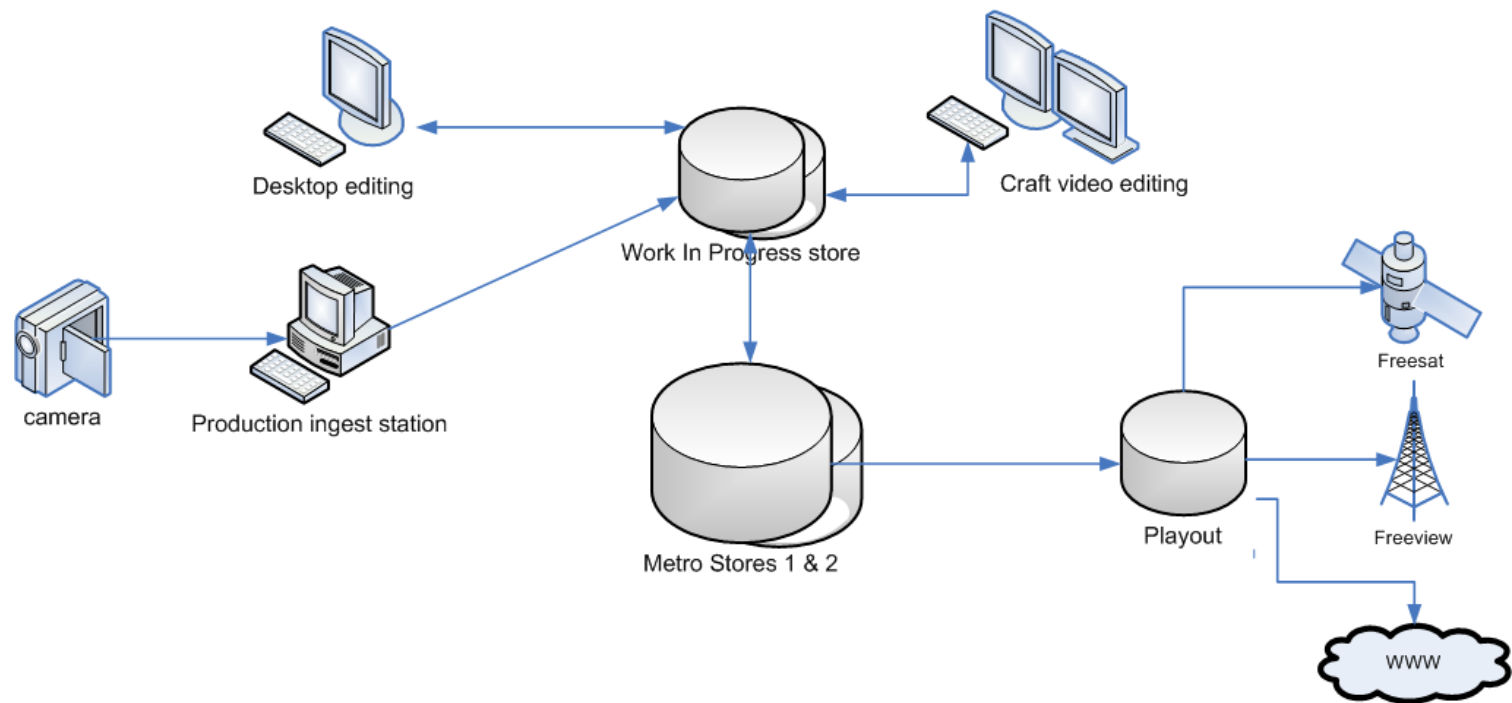
An archive for tapeless production

| Tapeless digital production

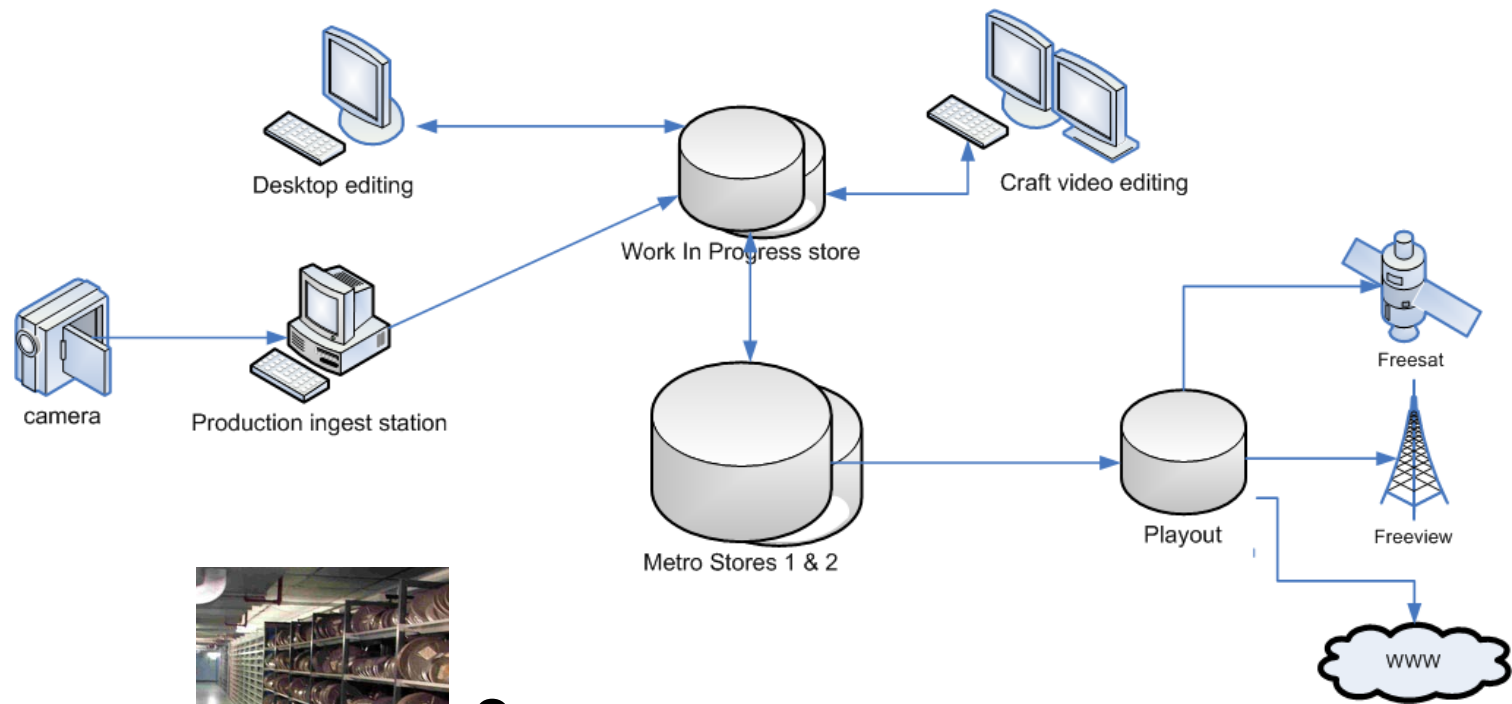
- BBC Digital Media Initiative project developed the Fabric desktop production system:
 - Ingest from camera solid state memory card faster than real-time
 - Addition of metadata about the production only once
 - Automatic inclusion of metadata from cameras etc.
 - Programme-makers rough-cut edits at desktop via browser
 - Working with browse quality proxies to reduce network load
 - Access to archive browse store from desktop



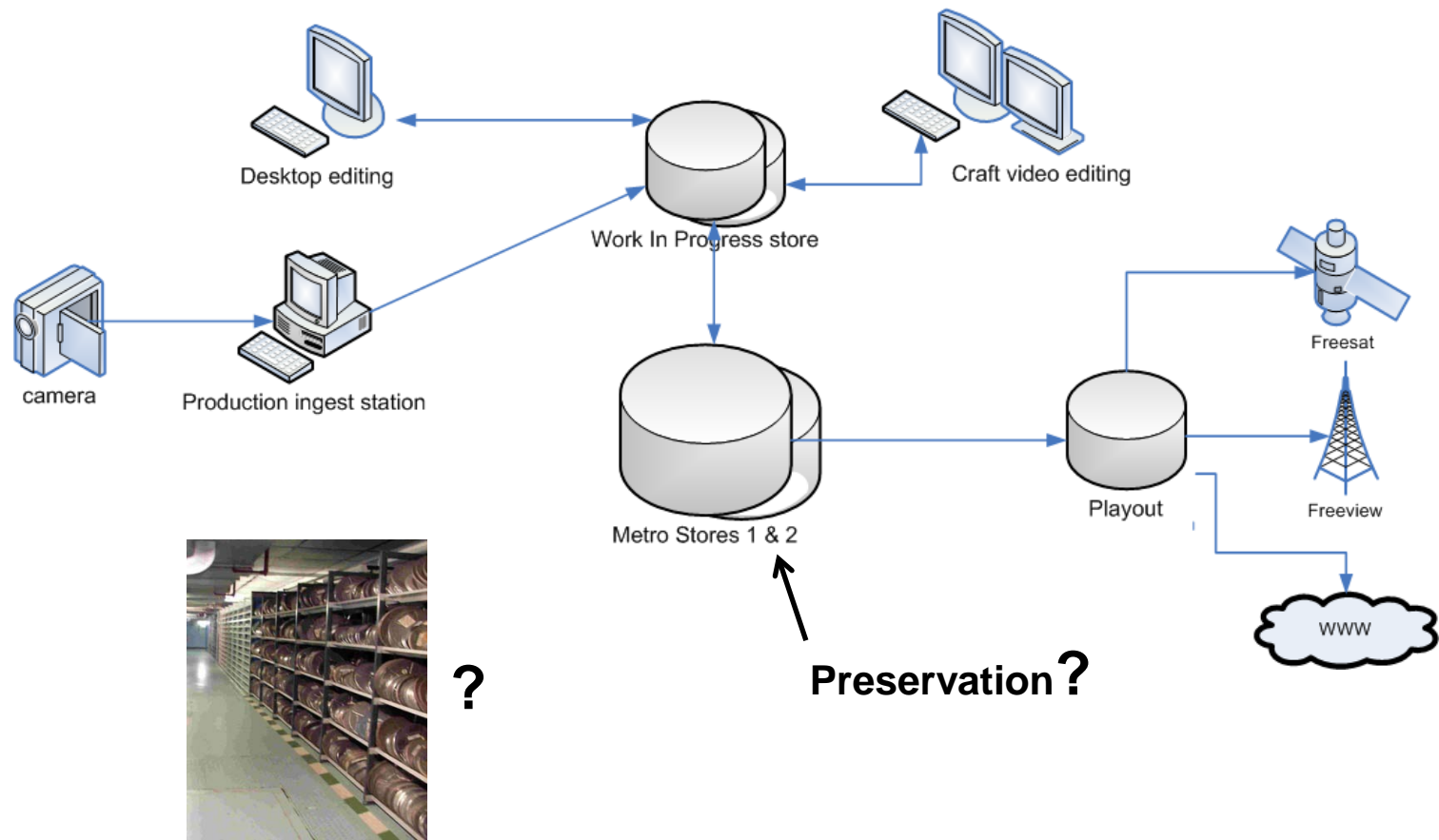
Tapeless digital production



Tapeless digital production



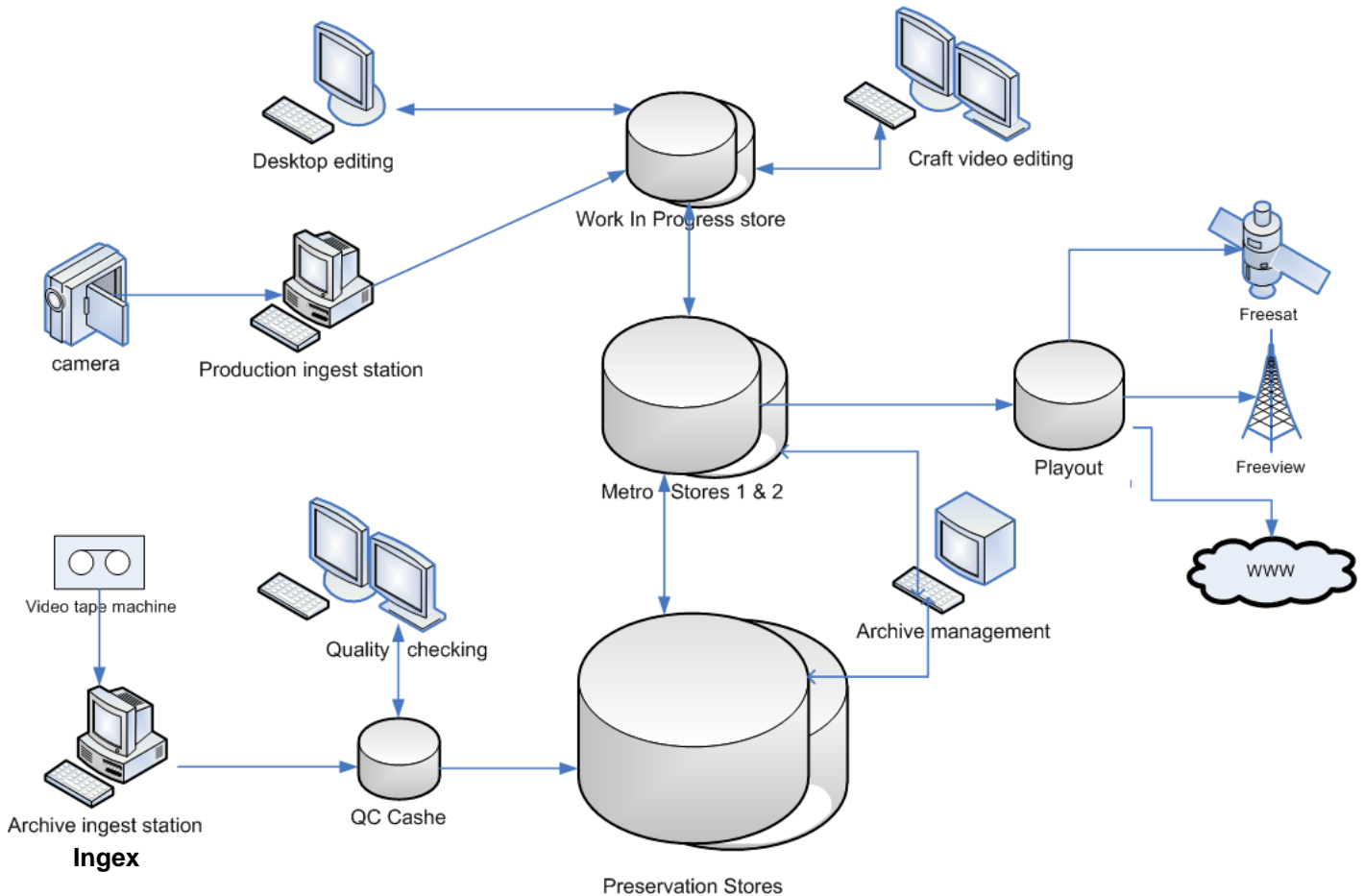
Tapeless digital production



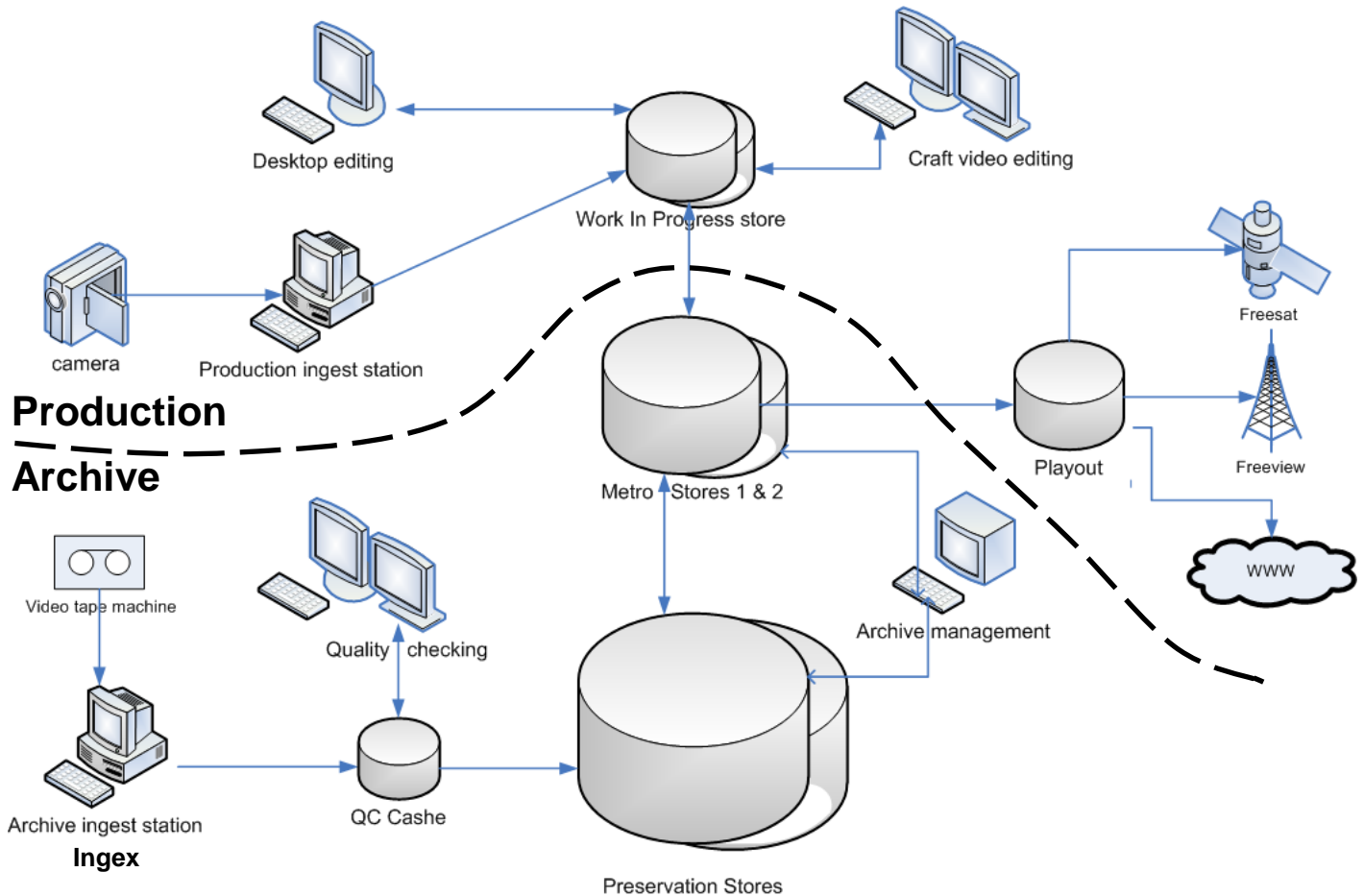
| Digitising BBC Archives

- D3 digital videotape was used from the early 1990's:
 - Migrated 2" analogue videotape to D3
 - But D3 is not file-based
- D3 preservation project migrating D3 to digital files:
 - IngeX archive – digitisation (developed by BBC R&D)
 - PAL transform decoder (developed by BBC R&D)
 - 200 hrs / week
 - Stored as uncompressed files (72 GB/hr) in an MXF wrapper
 - LTO-3 and LTO-4 data tape
 - 1 PetaByte / yr
 - MPEG-2 browse files at 3 Mbit/s
 - Expanding to other tape formats (Digibeta and HD)

Adding preservation archive to digital production



Adding preservation archive to digital production

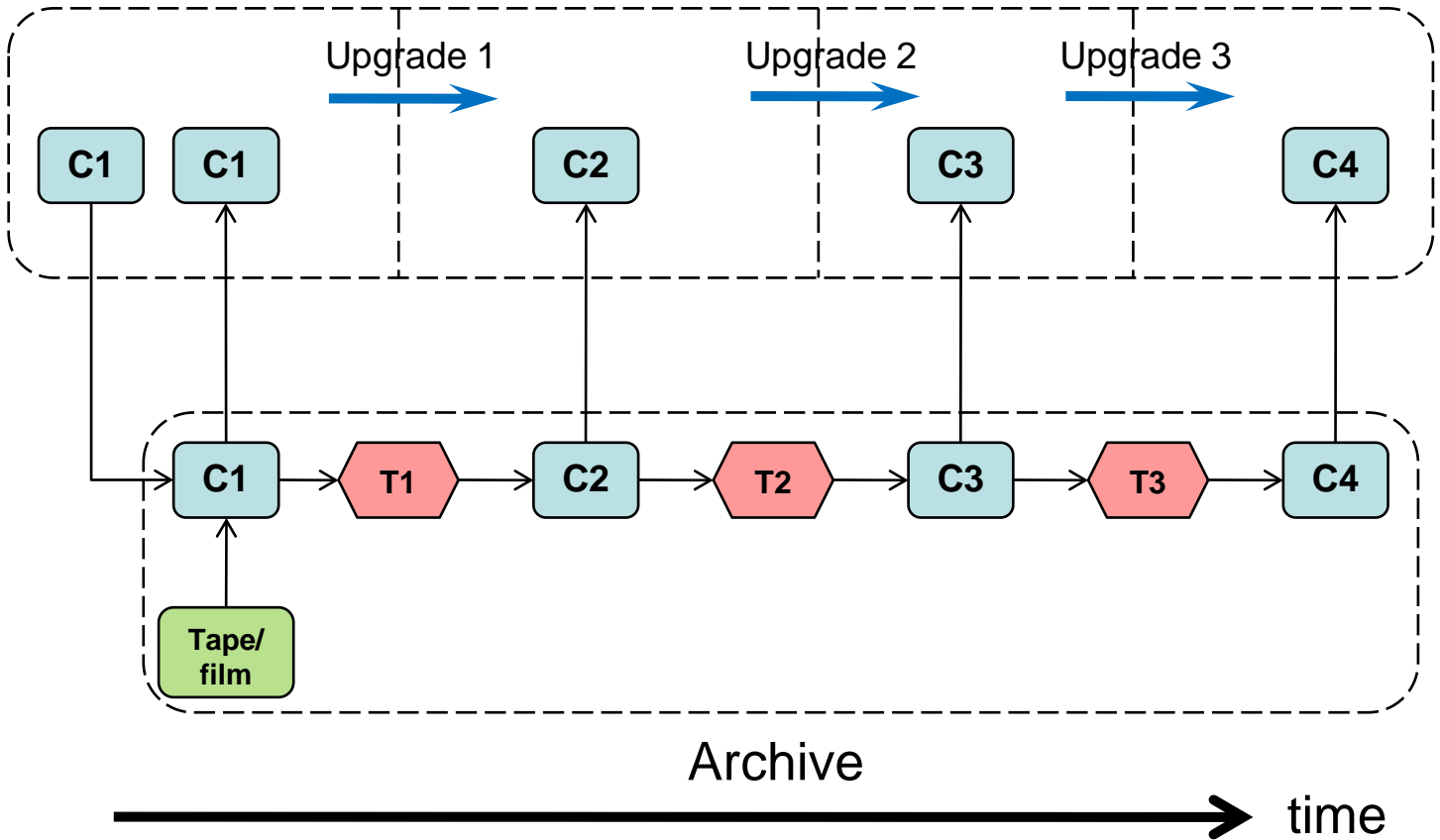


Relationship between production and archive

Production



Traditional archive migration – not recommended for digital Production



| Codec concatenation



Coded



1st recode



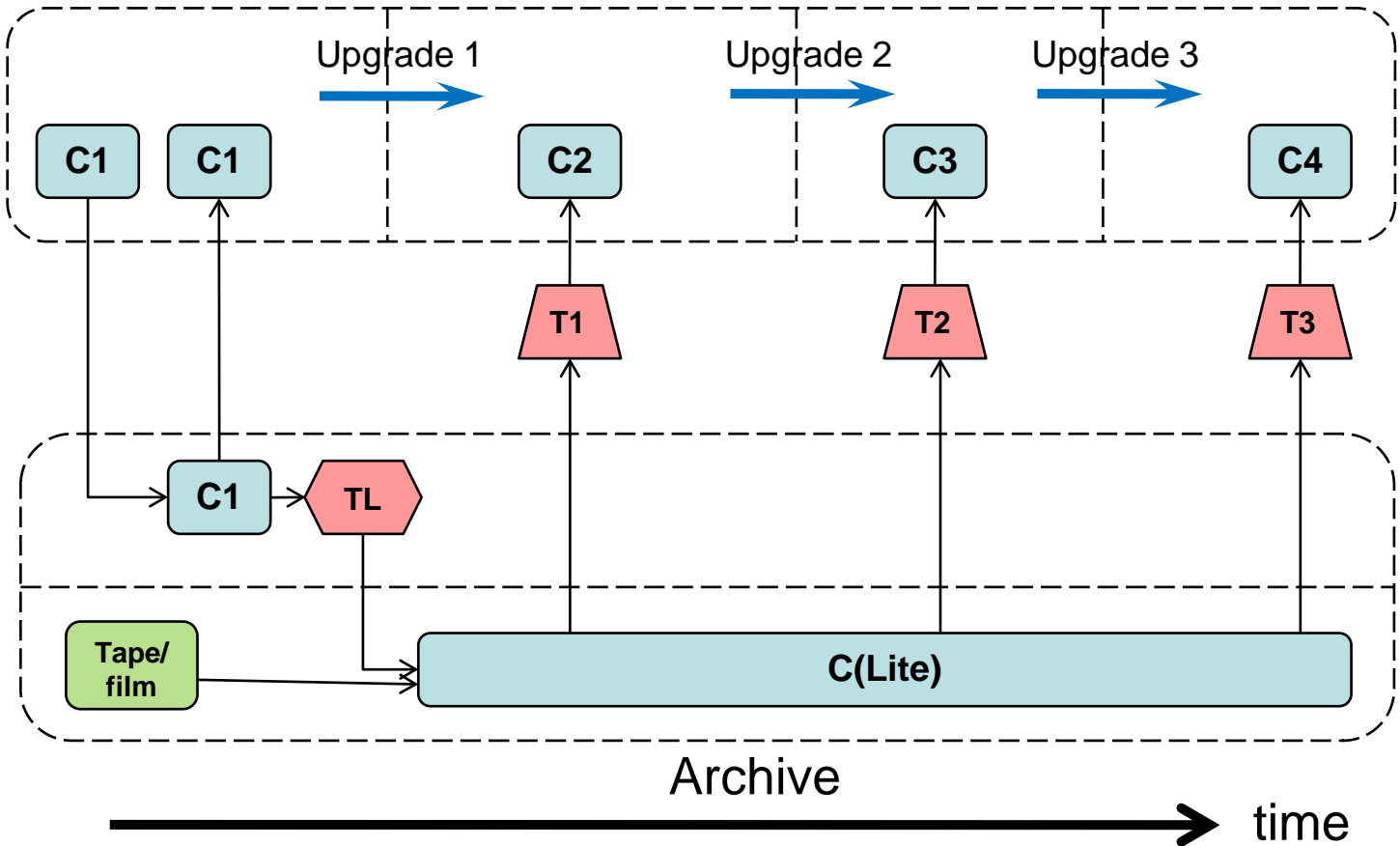
2nd recode



3rd recode

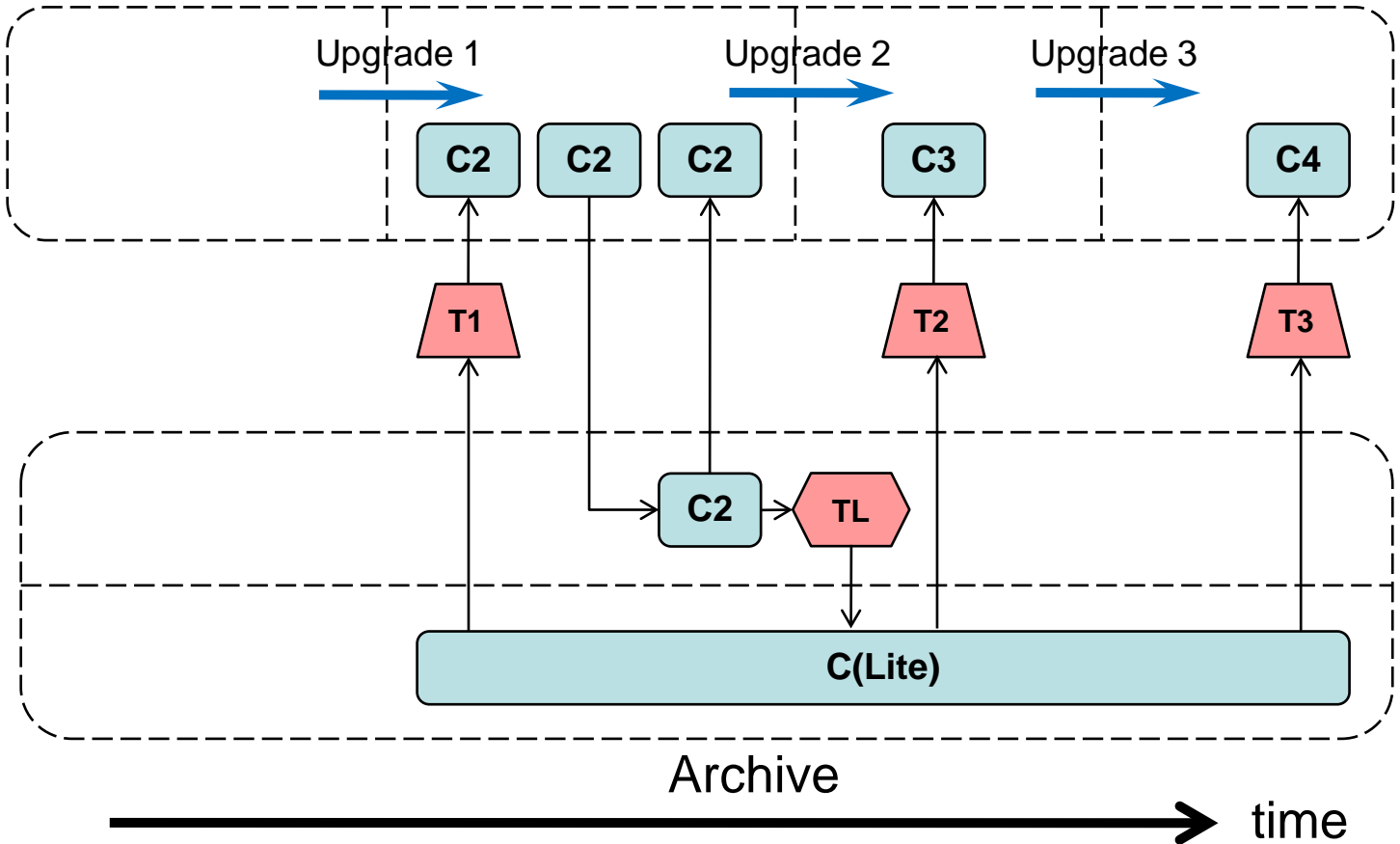
Archive migration – recommended for digital

Production

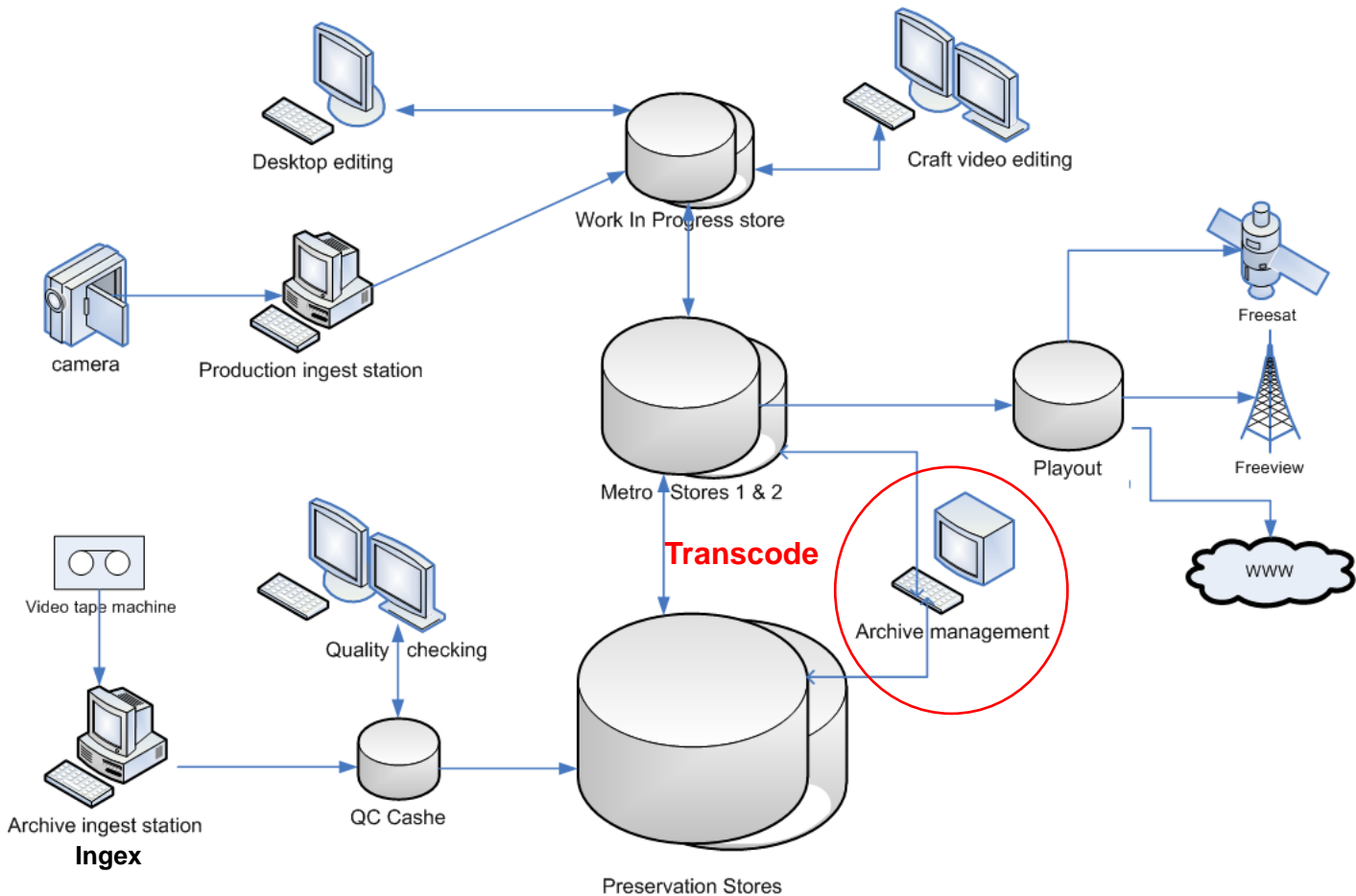


Archive migration – recommended (phase 2)

Production



Managing the access and preservation stores



Storage size / video coding trade-off

BBC digital storage estimates (uncompressed)

- Digitisation / Migration from video tape:
 - 1500 video items / 800 hours/week = 80 TB per week
 - For 16 years to digitise whole archive
 - 65 PetaBytes
- New content:
 - 300 hours/week = 30 TB per week
 - moving to 120 TB/week with move to HD
 - 100 PetaBytes (in 16 years time)
- Total storage needed in 2026:
 - 165 PetaBytes (one copy only) (Data tape cost £5.8M)
 - 330 PetaBytes (two copies) (£11.6M)

**Storage estimates for
Preservation Stores:
Metro Stores will also
require storage**

Compression debate

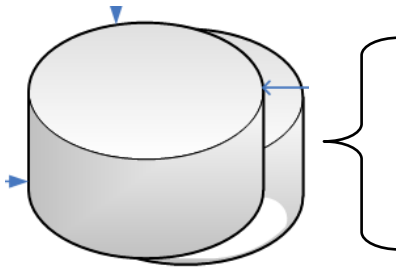
- Video and audio coding reduces storage size and cost
- Each compression technique adds its own type of impairments:
 - Including loss and distortion of picture and sound content
 - Future consumer displays could unmask impairments
- Coding concatenation builds up impairments:
 - Particularly if compression types are mixed
 - ‘Last Straw’ effect result in sudden appearance of impairments
- Compressed content can be more fragile in the presence of errors
- Long-term sustainability of the decoders
 - Will decoders still work on new operating systems?
 - Is emulation a safe way to run decoders?.
 - Best chance for ongoing support is if all archives use same codecs
- Audio the debate is over:
 - Cost effective to operate Uncompressed (48 kHz sampling)

| Gold, Silver, Bronze quality standards for content

- **Gold:**
 - Preservation standard with long-term viability
 - Digitised archive videotape and film
 - Highest value new content; e.g. cinema style co-productions
 - Production copies transcoded from Gold to current production standards
- **Silver:**
 - Everyday content
 - Coded to current production standard:
 - Broadcast quality, but perhaps not long-term viable
 - Transcoded to 'gold' standard if selected for preservation
- **Bronze:**
 - Non-broadcast content
 - E.g. user generated content
 - Not kept beyond economic life of codec
 - Unless of historical value
 - Content of worth likely inserted into completed programmes

Compression in the Archive: Summary

File World

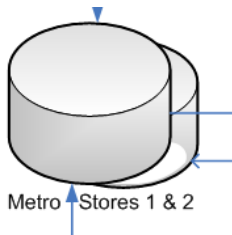


Preservation Stores



Uncompressed
or CLite

Gold



Metro Stores 1 & 2



Production
codec

Silver



Mobile phone
codec etc



Web video
codec

Bronze

Tape World



Archive Master



Loan tape



Consumer tape
(UGC etc)



Viewing tape

Uncompressed capacities of video and film formats

Format	Bit rate	File size
SD (8 – 10 bit)	165 - 207 Mbit/s	75 - 93 GByte/hr
HD	1 Gbit/s	466 GByte/hr
2k film (444 16 bit)	2.5 Gbit/s	1.1 TByte/hr
4k TV (12 bit)	5.8 Gbit/s	2.6 TByte/hr
4k film (444 16 bit)	7.7 Gbit/s	3.5 TByte/hr
SHV (DG* – YUV)	24 – 40 Gbit/s	11 – 18 TByte/hr
SHV** (120 fps)	80 Gbit/s	36 TByte/hr

(** SHV – Super Hi-Vision)

(* DG – Double Green format)

I Compressed or uncompressed in the archive?

- Advances in technology tend to produce more data:
 - E.g. higher bit-depth
- Archive content must still look good on future TV systems
- Performance of production or delivery codecs is not good enough for archives:
 - Particularly for preserving HDTV
- Video and audio bit accuracy is not required:
 - Not banking data
 - Should be visually lossless
- Compressed content might not be decodable in the future
- Funding is rarely sufficient to store uncompressed

Requirements for an archive (Lite) Gold standard codec

Gold

- Higher quality than codecs used in production
 - Lossless option for highest value content
- Real-time or faster coding and decoding
- Long-term viable:
 - Simple coding algorithm:
 - Easy to recompile for future computer systems
 - Described in internationally recognised standards
 - Non-restrictive licensing
- Wide adoption by the media archive industry

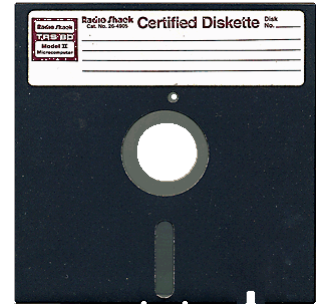
Requirements for archiving compressed content

- Accept borne digital content in the file format given
- Store and supply content in same format
- When the production format changes, convert content to lightly compressed, lossless compressed or uncompressed.
 - Transcode to new production format to supply when requested
- Ensure that decoders can still be run when upgrading the storage management system h/w or s/w.
 - If problems found, then convert content to uncompressed
- Do not re-code content more than necessary
- Critically view content on a good quality large display to check for visible impairments, but wary that some may still remain hidden
- A/V archives need to agree a set of archive quality light compression codecs for both SD and HD for when uncompressed is not practical

Storage reliability

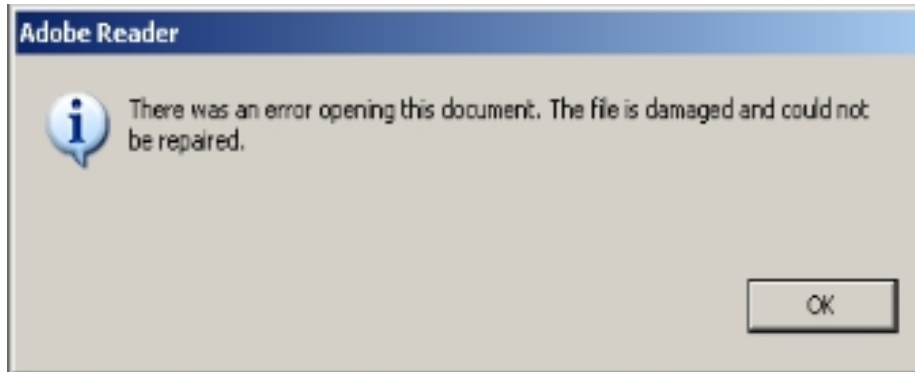
| Long-term digital storage

- “We’ve digitised all our content – it’s safe”
 - “I just need a place to store the floppy disks”
- Digital technology is evolving fast creating obsolescence in only a few years!
- Long-term storage systems:
 - Holographic storage
 - Digital film
 - LTO data tape
 - ...
- Can long-term storage be trusted?
 - It is dangerous to store and forget!



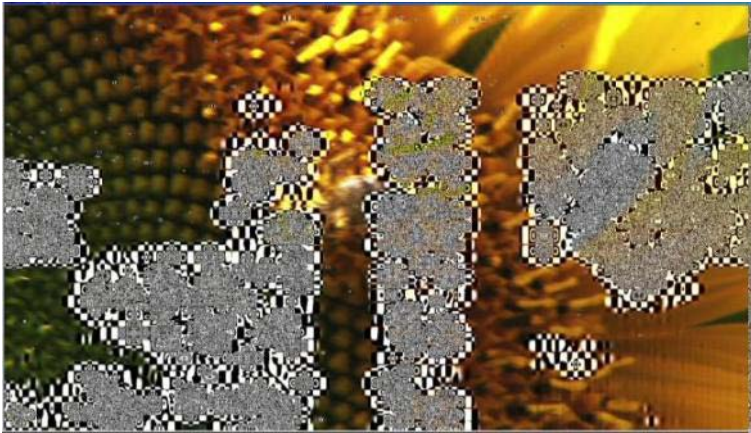
Storage corruption

- “Help! I got this message when I tried to open the file”

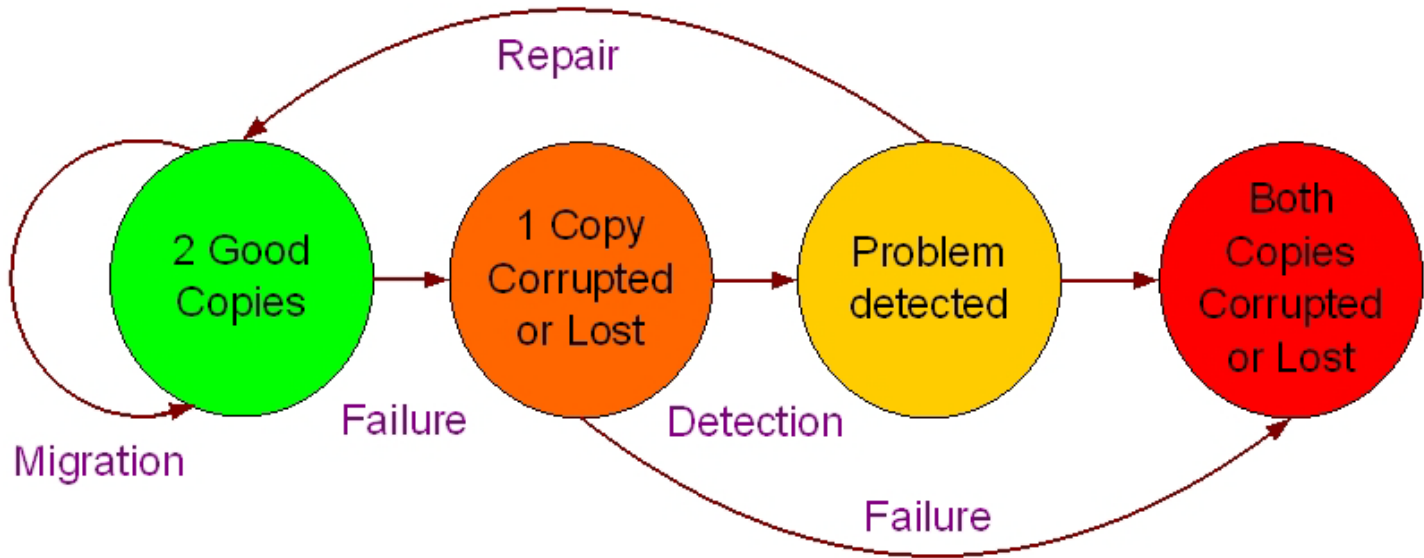


Digital storage is not perfect

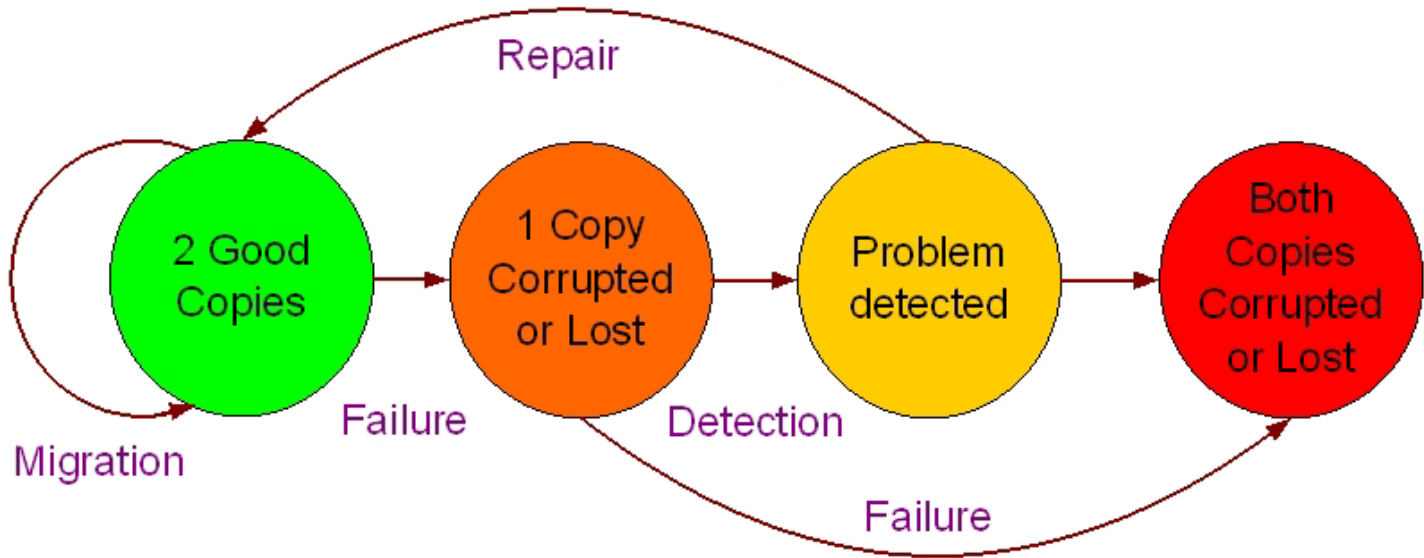
- CERN found error rate in storage of 1 in 10^7
- Equivalent to 33 Gbytes in 330 PetaBytes
- Errors highly bunched:
 - e.g. due to RAID failure
- Effect of errors on coded pictures:



Simple Preservation Model



Simple Preservation Model

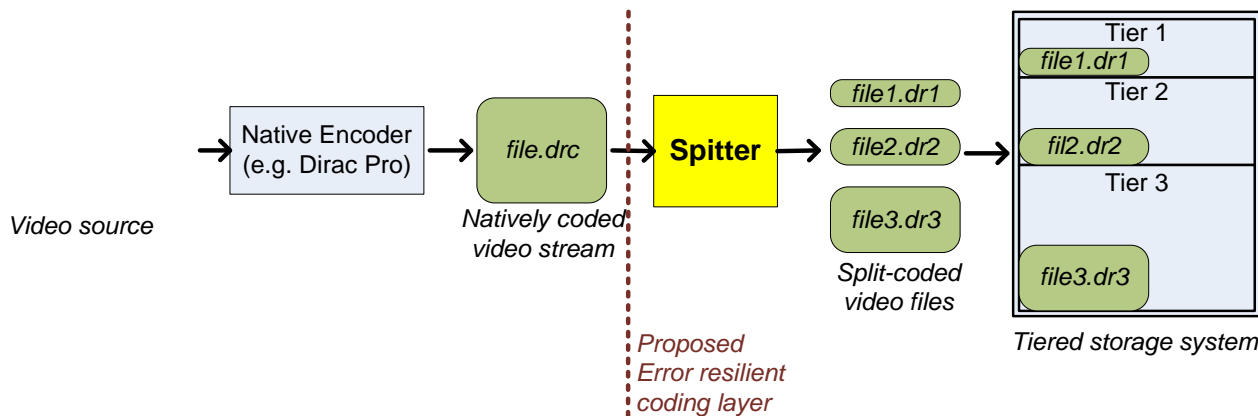


Are two copies sufficient?



Protection of compressed files

- Multiple copies of media files can require very large storage
- Avatar-m project developed codec header protection



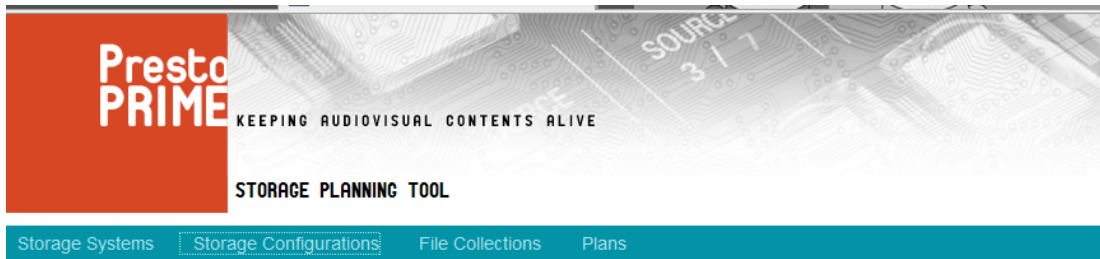
<http://www.avatar-m.org.uk>

| Storage condition monitoring requirements

- Storage management software:
 - Monitors performance and errors
 - Anticipate problems
- Monitoring is needed at all levels of the system:
 - Without overloading the operator
 - Must be obvious when problems arise
- Automatic monitoring and periodic testing:
 - Hard drives, data tapes & drives, RAID arrays, file systems
 - Fixity checks on files
 - Sub-file fixity checks if problems
 - Checks at the A/V level.

Storage planning tool

- PrestoPRIME has a storage planning tool:
 - Shows costs versus benefits of storage options
 - Shows results of periodic scrubbing (file checking)



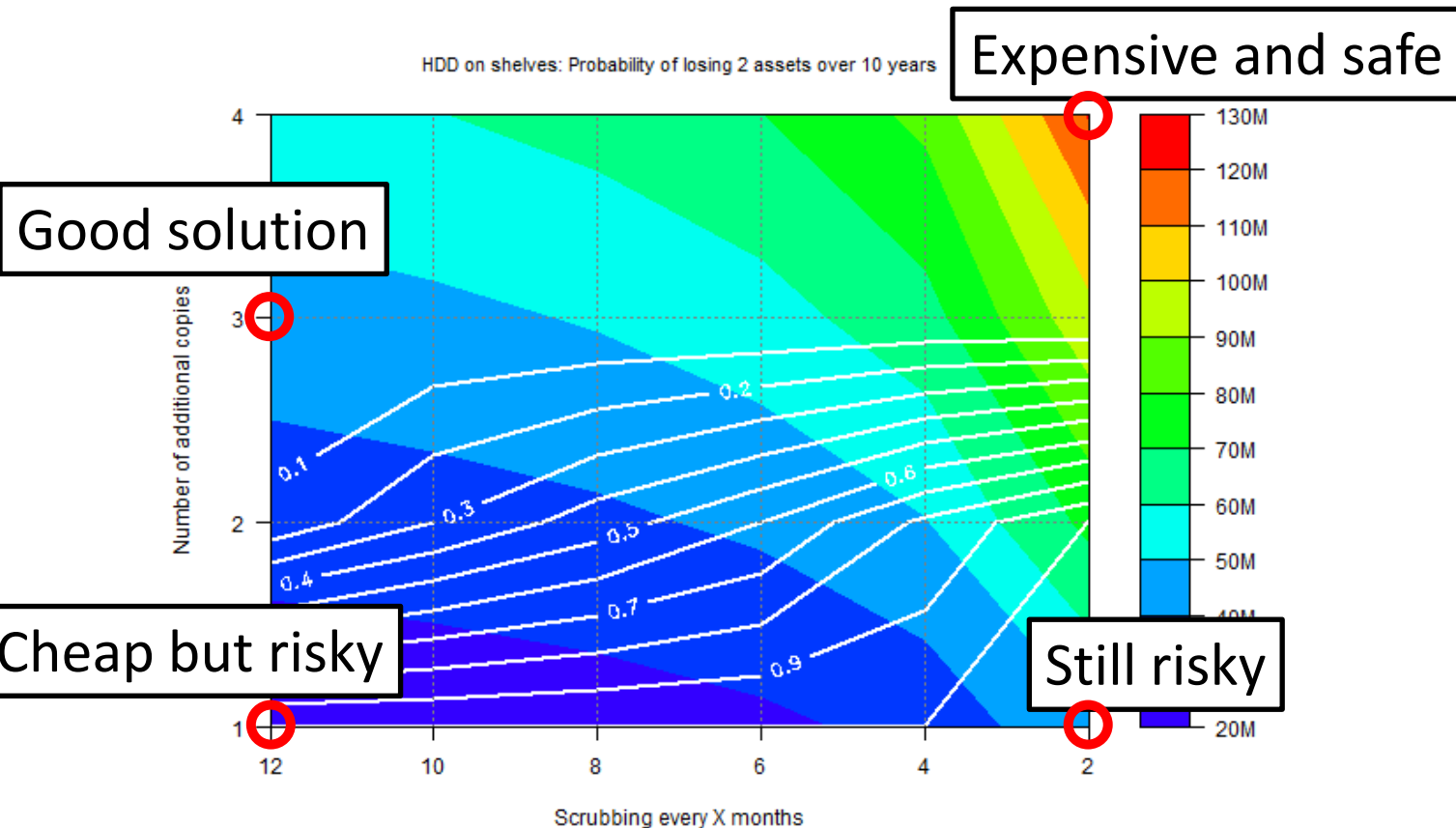
RichardBBC | [logout](#)

Storage Systems

Found 4 storage systems. [Add...](#)

HDD in servers read-only Migration required every 4 years. Running Costs Access: €0.1 per GB Storage: €1 per GB per year Corruption Rates Access: avg. 1 in 500 files Latent: avg. 1 in 750 files per year	HDD on shelves read-only Migration required every 4 years. Running Costs Access: €1 per GB Storage: €0.25 per GB per year Corruption Rates Access: avg. 1 in 100 files Latent: avg. 1 in 500 files per year	Data tapes in a robot read-only Migration required every 6 years. Running Costs Access: €0.2 per GB Storage: €0.4 per GB per year Corruption Rates Access: avg. 1 in 1×10^4 files Latent: avg. 1 in 1×10^5 files per year
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Risk of loss vs. Cost



Storage SLAs requirements

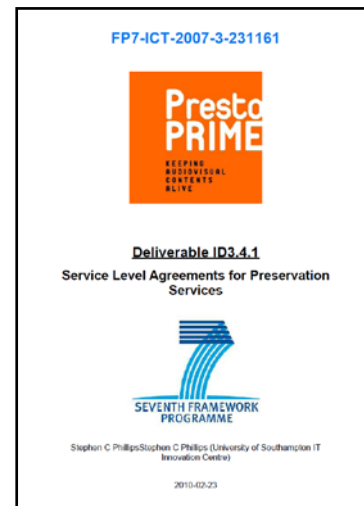
- Service Level Agreements (SLAs) :
 - Set-out the expected performance of the archive as a whole
 - Define the performance of storage services used by the archive.

- Storage services criteria important to Archive

- Not just in terms of technical IT parameters

- SLAs could cover:

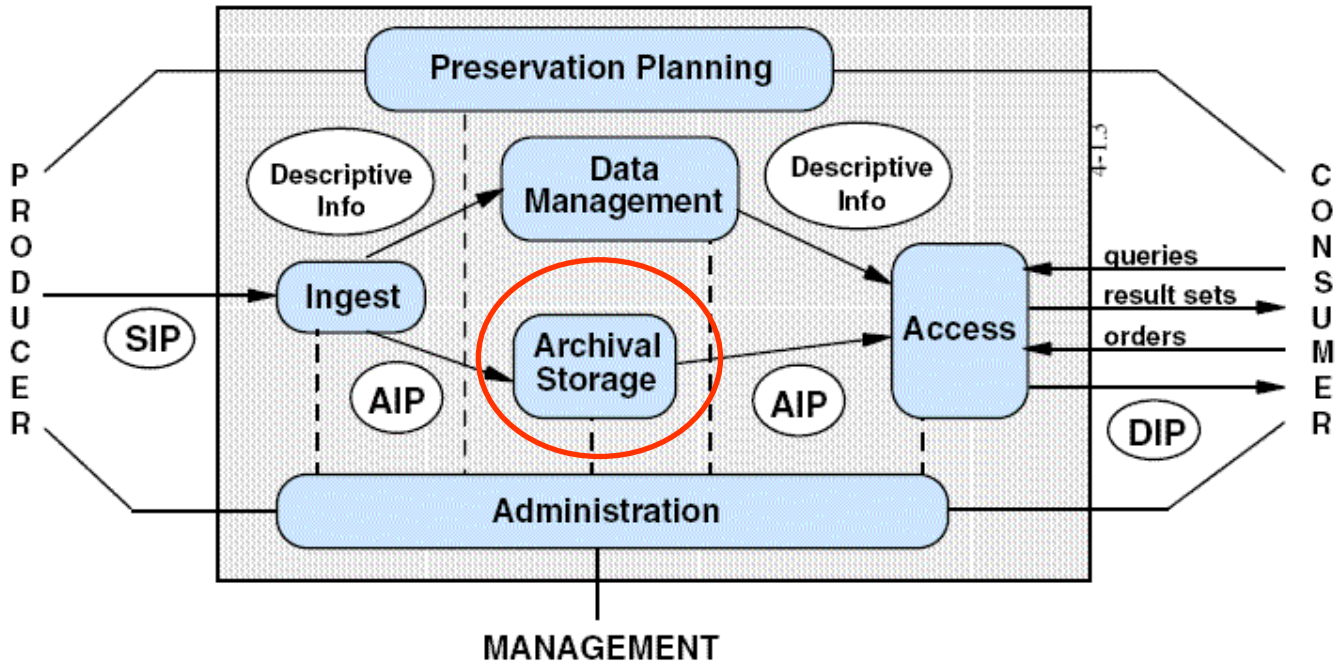
- Data Availability, Data Safety, Delivery Times, etc



- PrestoPRIME guidelines on SLAs for A/V preservation and
- Tools for monitoring performance against the SLAs

An Archive is more than just storage

OAIS – Open Archival Information System



- Archival Storage is only a part of a full OAIS Digital Repository
 - Preservation system must integrate with the storage system
 - Need clear division of responsibilities between the two systems:
 - e.g. which system will perform the file fixity checks?
 - OAIS model more applicable to Preservation Stores than Metro stores
- Several storage systems of various types may connect to the preservation system
- The Archive is about AV content + other content + metadata: these come together as packages

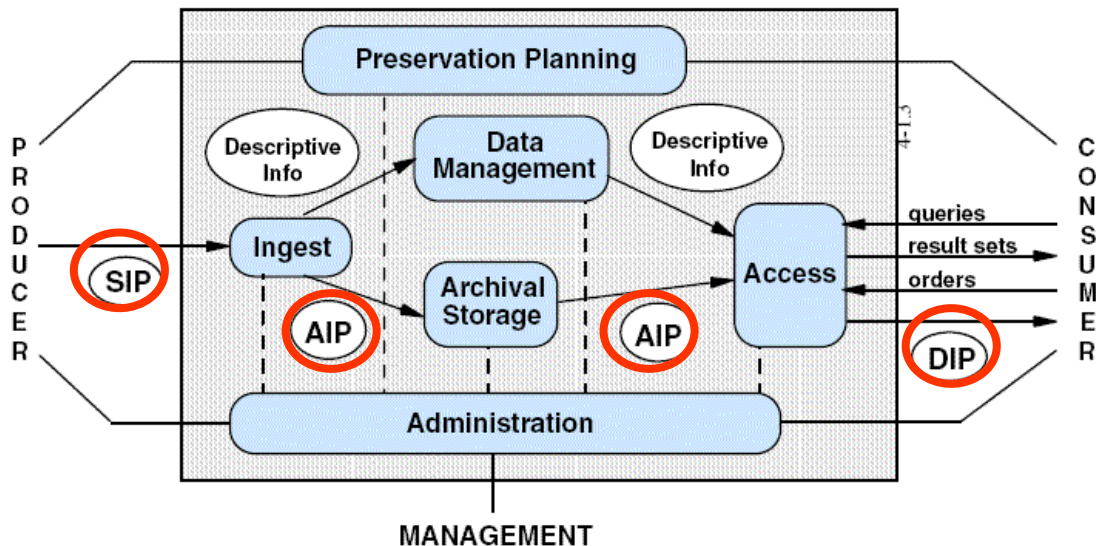
Content packages for archives

| Wrappers

- Video and audio content needs to be put in a wrapper along with essential metadata to keep it all together
- Two popular wrappers:
 - MXF
 - Quicktime
- BBC chosen MXF
- MXF variants:
 - OP Atom (for production)
 - OP 1a (for archive)

Packages

- Contain several content (MXF) files, e.g. different takes or versions
- Also can contain other files, e.g. scripts, subtitles, GPS data, etc
- Fulfil role of Information Packages in OAIS



- More work needed by archives to agree packages and uses: may need different packages for exchange (SIP/DIP) and for archiving (AIP)

| Package types

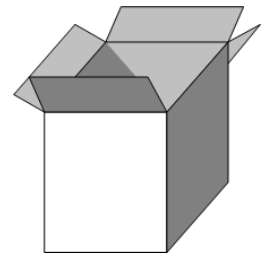
- Monolithic (e.g. MPEG-A PA-AF, AXF):
 - All content and metadata files combined into a single file, e.g. ZIP
 - Requires appropriate software to read or write package
- Folder Based (e.g. NHK DPP, BagIt):
 - Content and metadata files 'loosely' bound by standard folders
 - Only need to understand manifest to check integrity
- Index file only (e.g. METS XML):
 - Lists the content files and metadata but does not bind them all together
 - Must understand METS format to check package integrity
 - Files can be scattered across physical storage

What are the requirements for archival packages?

- OAIS principles require that content and all metadata is sealed away in an unchanging package
- Working archives have media, browse, metadata and catalogue files stored on various systems
- Copying these files to a preservation package securely stored provides for disaster recovery
- Working archive needs to update files in the package, e.g:
 - Update rights information if contracts renegotiated
 - Update tagging metadata if better auto-tagging developed
 - Add new versions of a programme if updated
 - ...

| Open Package requirement

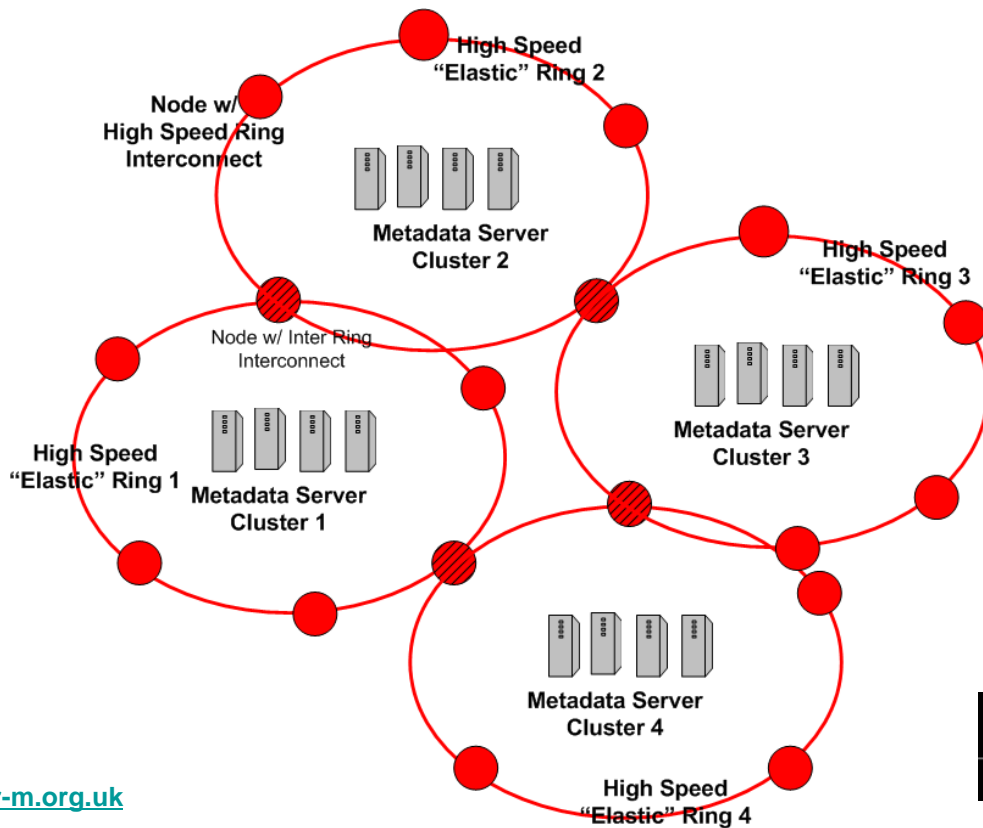
- Open Package for Archival Storage (as AIP):
 - ‘Complete’ packages on a storage medium e.g. an LTO tape
 - Package created with space sufficient for predicted storage
 - Files added or modified in package as they become available
 - Metadata likely to be updated
 - Needs a way to lock some critical files?
 - Is folder based package the best option?
 - All files ‘loosely’ bound together
 - No need for specialist software to read the contents
 - Data-tape now has LTFS for LTO-5+
 - Human and machine-readable index files
 - At some future date the package could be closed:
 - No further updates
 - Packaged placed in ‘true’ repository



Further storage considerations for archives

AV Storage

- Large storage systems need **scalable** high throughput networks to avoid congestion



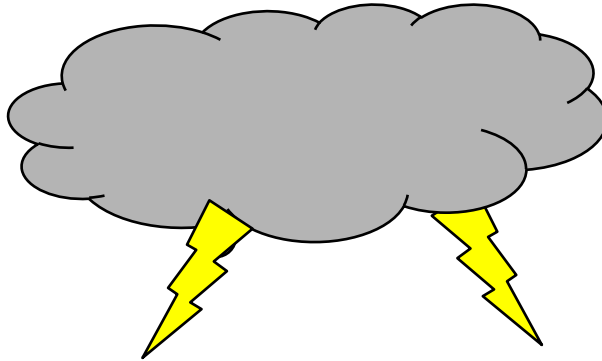
<http://www.avatar-m.org.uk>

| Storage performance requirements

- **Requires suitable network connections to both:**
 - Production systems
 - Content processing services (e.g. for transcoding)
- **Performance must be specified to cope with both:**
 - User demand for Archive content
 - Archive background tasks (e.g. content migration)
- **Define realistic performance tests on the complete system:**
 - Lots of media and other files (1000's of files at least)
 - Variety of file sizes
 - from 1 kB XML files to 1TB uncompressed HD files
 - Realistic workflows:
 - file transfers, editing-type operations, etc

| Cloud storage

- Most Cloud services rely on Trust
- Cloud rarely provides realistic compensation for loss
- Few providers allow the user Independent Verification
- Internal Cloud could provide useful savings
- External Cloud needs carefully written Service Level Agreement
- High network capacity needed for transfer of large media files



Further storage requirements for archives

- **An exit strategy is essential**
 - Able to migrate to new storage technology or supplier
- **Provenance information is important**
 - Keep a record of all the processes undergone by a file etc
- **Must support partial restore of content files**
 - Possible to retrieve only the clip of interest from the storage
- **The storage solution must be scalable**
- **Use diverse storage technologies**
 - Each copy on a different storage technology / supplier
- **Keep the storage simple**
 - Possible for other systems to directly access the files using standard (ideally open) interfaces
 - Guards against system failure and allows independent audit
- **Know physically where the files are**
 - Know which physical disks / data tapes files are stored on

Archive storage requirements conclusion

| Archive system key requirement is for permanence

- Archives need to operate for very many years:
 - Over time media storage systems will become:
 - Unreliable, Obsolete and Difficult / Expensive to maintain, and
 - Very large (Peta-Exabyte size)
- Migration strategy needs to be built in to archive operations
- Storage needs to be designed for disaster recovery:
 - Files kept in physically logical places in the system(s)
 - Storage management databases open and well-documented
 - Storage tapes, disks, etc. removable and readable externally
- Open interfaces and open standards needed:
 - Not practical to replace whole archive at once
 - Archives will have various generations of storage and networks
 - Need to purchase systems or services from multiple vendors:
 - Need interoperability

- PrestoPrime project is developing techniques for digital A/V archiving:
 - <http://www.prestoprime.org/>
- PrestoCentre new source of digital A/V archive information:
 - <http://www.prestocentre.eu/>



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