FIXITY & DATA INTEGRITY

DATA INTEGRITY

DATA INTEGRITY

PRESERVATION CONSIDERATIONS

- Data that can be **rendered**
- Data that is **properly formed** and can be **validated**

DATA DEGRADATION

HOW DO FILES LOSE INTEGRITY?

DATA DEGRADATION

HOW DO FILES LOSE INTEGRITY?

Storage: hardware issues

- Physical damage, improper orientation, magnets, dust particles, mold, disasters

Storage: software issues

- "bit rot", "flipped" bits, small electronic charge, solar flares, radiation

DATA DEGRADATION

HOW DO FILES LOSE INTEGRITY?

Transfer/Retrieval

- **Transfer** from one operating system or file system to another, transfer across network protocols
- **Metadata loss**: example – Linux has no "Creation Date" (usually "**file system**" metadata)

Mismanagement

- **Permissions issues** (read/write allowed), human error

DATA PROTECTION

VERIFICATION

DATA PROTECTION

VERIFICATION

- Material proof or evidence that data is unchanged
- Material proof or evidence that data is well-formed and should be renderable
    - Example: Developer writes code for standard file formats that are irregular

DATA PROTECTION

VERIFICATION

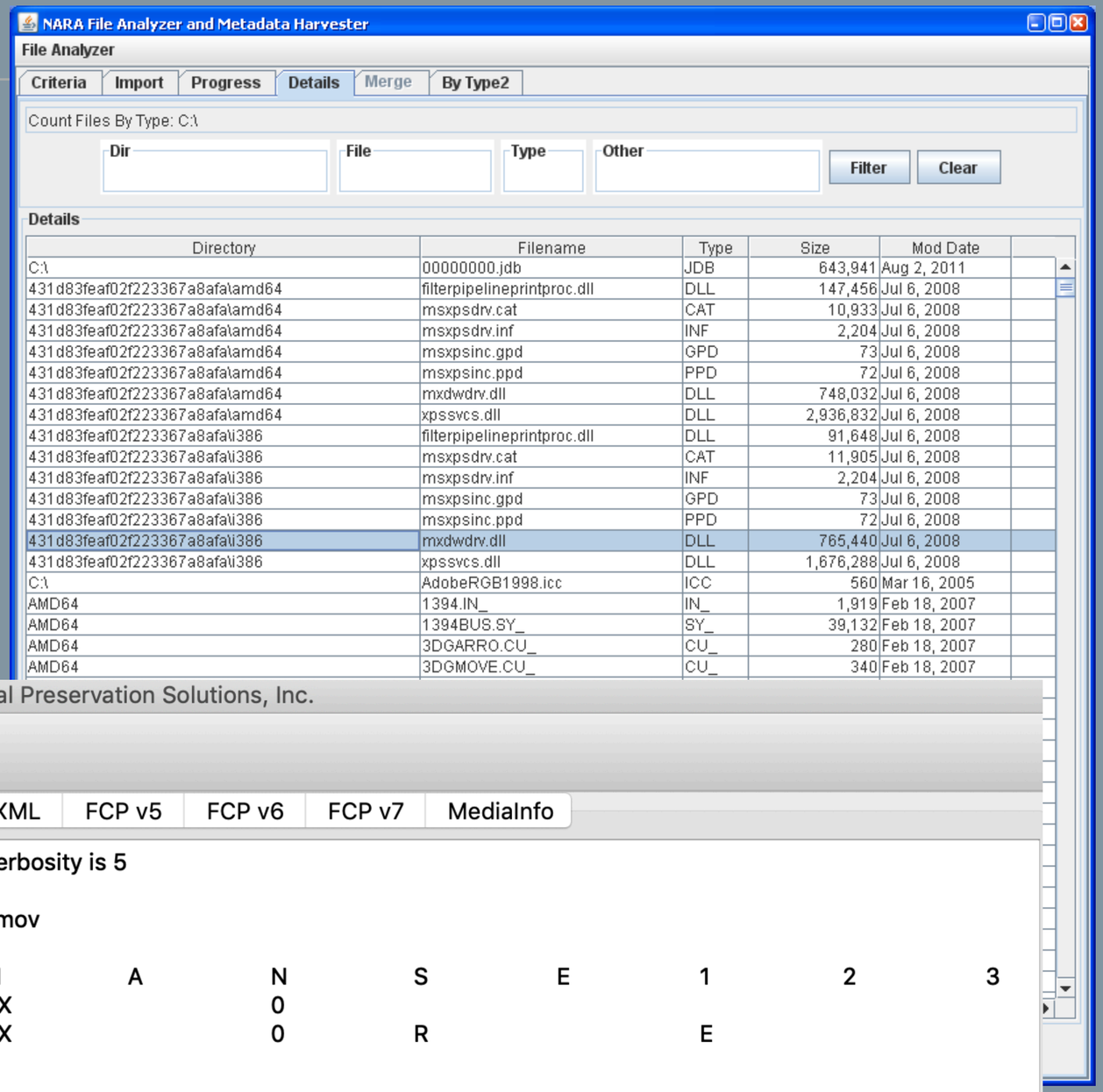
Verify that data is well-formed using...

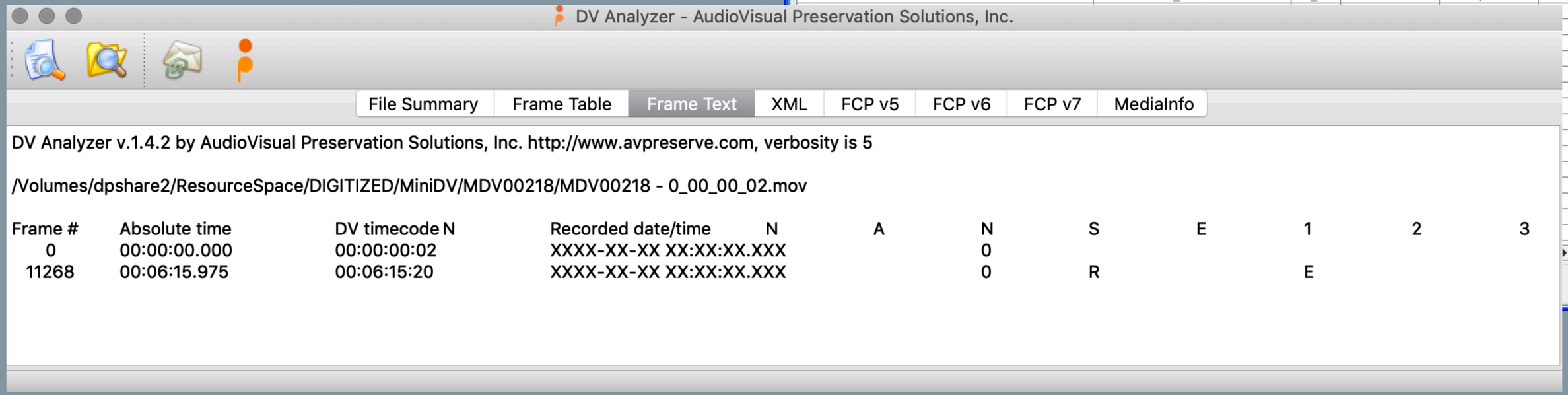
DATA PROTECTION

VERIFICATION

Verify that data is well-formed using...

- JHOVE
- DROID
- DVAnalyzer
- BWF Metaedit
- NARA File Analyzer
- XML Validator





WHOLE-FILE CONSISTENCY

FIXITY

FIXITY

BASIC METHODS

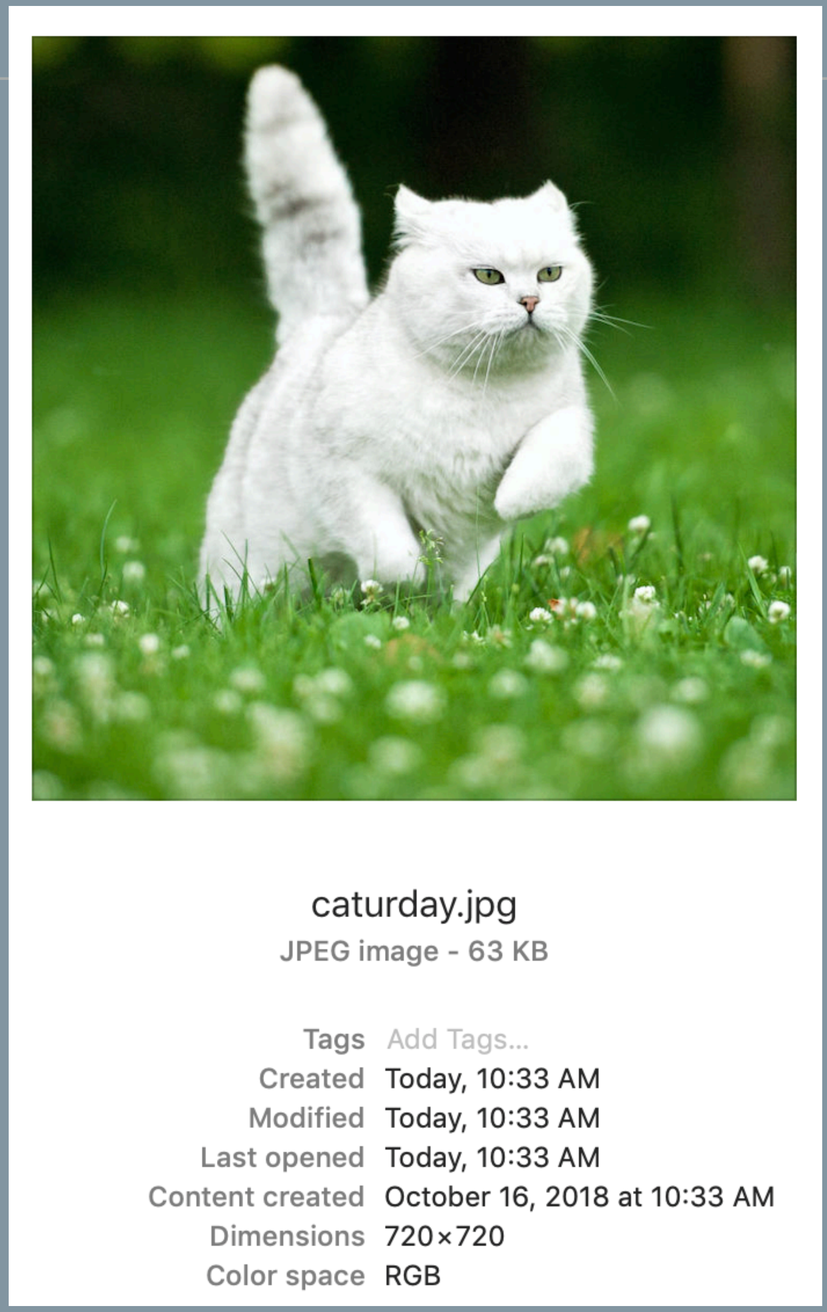
Manual checks of **file metadata** such as...

FIXITY

BASIC METHODS

Manual checks of **file metadata** such as...

- File name
- File size
- Creation date
- Modified date
- Duration (time-based media)



FIXITY

ADVANCED METHODS

FIXITY

ADVANCED METHODS - CRYPTOGRAPHIC HASH

FIXITY

ADVANCED METHODS - CRYPTOGRAPHIC HASH

checksum

hash

digest

fixity check

digital signature

hashcode

FIXITY

ADVANCED METHODS - CRYPTOGRAPHIC HASH

checksum

hash

digest

fixity check

digital signature

hashcode

Mathematical function itself = "**hash**"

Operation used for fixity = "**checksum**"

FIXITY

WHAT IS A CHECKSUM? - CRYPTOGRAPHIC HASH

FIXITY

WHAT IS A CHECKSUM? - CRYPTOGRAPHIC HASH

- Algorithm analysis of file produces a **string**

FIXITY

WHAT IS A CHECKSUM? - CRYPTOGRAPHIC HASH

- Algorithm analysis of file produces a **string**

f49c2e9f08490c055cddba6d3b049f94

FIXITY

WHAT IS A CHECKSUM? - CRYPTOGRAPHIC HASH

- Algorithm analysis of file produces a **string**

f49c2e9f08490c055cddba6d3b049f94

- **MD5**: 128-bits consolidated into a 32-character hexadecimal (4 bits per character)

FIXITY

WHAT IS A CHECKSUM? - CRYPTOGRAPHIC HASH

- Algorithm analysis of file produces a **string**

f49c2e9f08490c055cddba6d3b049f94

1882e58c22a2c132b7b9763d24ae9bffe68d00ab

- **MD5**: 128-bits consolidated into a 32-character hexadecimal (4 bits per character)
- **SHA-1**: 160-bits consolidated into a 40-character hexadecimal (4 bits per character)

ALGORITHMS

MD5

ALGORITHMS

MD5

Message Digest Algorithm 5

- Written in 1991 to replace... MD4
- 32-character hexadecimal string
- Used in cryptography and data integrity
  - Considered "**cryptographically broken**"
- Current usage: data integrity for file download and transfer
  - Example: Download of Android applications, Microsoft updates

ALGORITHMS

SHA-1

1882e58c22a2c132b7b9763d24ae9bffe68d00ab

ALGORITHMS

SHA-1

Secure Hash Algorithm 1

- Designed by **NSA** (US National Security Agency) in 1995
- 40-character hexadecimal string
- Used in cryptography and data integrity
  - Considered **cryptographically questionable**
- Online transactions will be encrypted under SHA-2, SHA-3 starting in 2017
- Current usage: data integrity for file download and transfer
  - Example: GIT repository "consistency check"

ALGORITHMS

OTHER CRYPTOGRAPHIC ALGORITHMS & HASH FUNCTIONS

ALGORITHMS

OTHER CRYPTOGRAPHIC ALGORITHMS & HASH FUNCTIONS

- BLAKE
- Tiger
- Whirlpool
- GOST
- HAVAL
- SHA-2, SHA-3

CHECKSUM SCRIPTING

CHECKSUM SCRIPTING

```
md5 /Path-to-file/$filename.xml
```

CHECKSUM SCRIPTING

md5 /Path-to-file/$filename.xml

f49c2e9f08490c055cddba6d3b049f94

CHECKSUM SCRIPTING

md5 /Path-to-file/$filename.xml

f49c2e9f08490c055cddba6d3b049f94

openssl sha1 /Path-to-file/$filename.xml

CHECKSUM SCRIPTING

md5 /Path-to-file/$filename.xml

f49c2e9f08490c055cddba6d3b049f94

openssl sha1 /Path-to-file/$filename.xml

1882e58c22a2c132b7b9763d24ae9bffe68d00ab

CHECKSUM SCRIPTING

LOOP SCRIPT!

CHECKSUM SCRIPTING

LOOP SCRIPT!

create-md5.sh

```
1  #!/bin/sh
2
3  for f in *.*; do
4  md5 "$f" > "${f%.*}.txt"; done
5
```

CHECKSUMS FOR

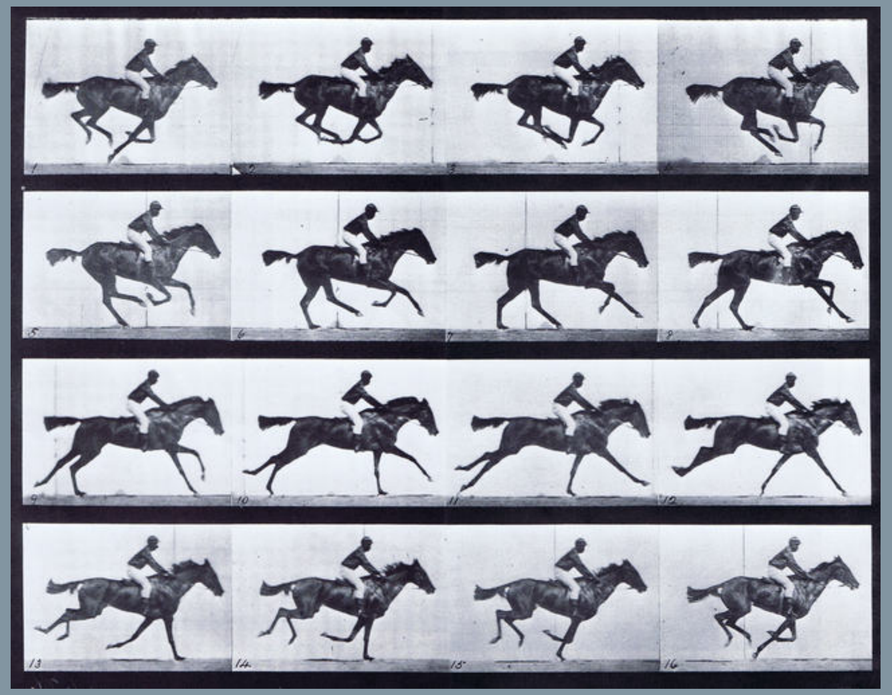
AUDIOVISUAL MEDIA

DAVE RICE

CHECKSUMS FOR AUDIOVISUAL MEDIA

DAVE RICE

CHECKSUMS FOR AUDIOVISUAL MEDIA



- Thesis: Whole-file checksums for AV files are incomplete
- **Scale**: Fixity for large files that contain **complex data** should be analyzed on a **more granular level**
- Failures for whole-file checksums for audiovisual data objects cannot pinpoint **specific errors**
- Files may appear to play back (render, decode) perfectly to viewer

CHECKSUMS FOR AUDIOVISUAL MEDIA

ERROR CONCEALMENT

CHECKSUMS FOR AUDIOVISUAL MEDIA

ERROR CONCEALMENT

- Video formats are designed to **conceal errors**
  - **Examples**: MPEG-2, MP3, DV formats (DVCam, miniDV, HDV)
- Built-in technology hides discrepancies from viewer during playback

CHECKSUMS FOR AUDIOVISUAL MEDIA

ERROR CONCEALMENT - HOW IT WORKS

CHECKSUMS FOR AUDIOVISUAL MEDIA

ERROR CONCEALMENT - HOW IT WORKS

MPEG-2, MP3, DV formats (DVCam, miniDV, HDV)

CHECKSUMS FOR AUDIOVISUAL MEDIA

ERROR CONCEALMENT - HOW IT WORKS

MPEG-2, MP3, DV formats (DVCam, miniDV, HDV)

- **Checksums** produced during the **encoding** process for each **data packet**
- Each packet contains data that makes up the **audio and video stream**
- Checksums are (usually) stored in the file's **header**
- During the **decoding** process (**playback** via application), packets with bad checksums are skipped
- Decoding application plays packet on either side of bad section

FRAME-LEVEL CHECKSUMS

FRAME-LEVEL CHECKSUMS

FORMATS WITHOUT ERROR CONCEALMENT

FRAME-LEVEL CHECKSUMS

FORMATS WITHOUT ERROR CONCEALMENT

ffmpeg's framemd5 produces frame-level checksums for **ALL** AV formats
This allows a digital repository to...

FRAME-LEVEL CHECKSUMS

FORMATS WITHOUT ERROR CONCEALMENT

ffmpeg's framemd5 produces frame-level checksums for **ALL** AV formats
This allows a digital repository to...

- Locate the **exact frame** that yielded error
- Reuse of original checksums after migration to **lossless formats** (new container)
- Checksum for AV content remains unchanged even when **metadata** changes

BATCH FIXITY CHECKS

MINI-GUIDE

CREATING CHECKSUMS

1

CREATING CHECKSUMS

1

Designate a package

CREATING CHECKSUMS

1

Designate a package

- OAIS package or similar
- SIP: Recently acquired submission or source data
- AIP: Group of data objects prepared for archiving
- BagIt "Bag"
- Preparation for long-term storage (LTO, cloud, or other)

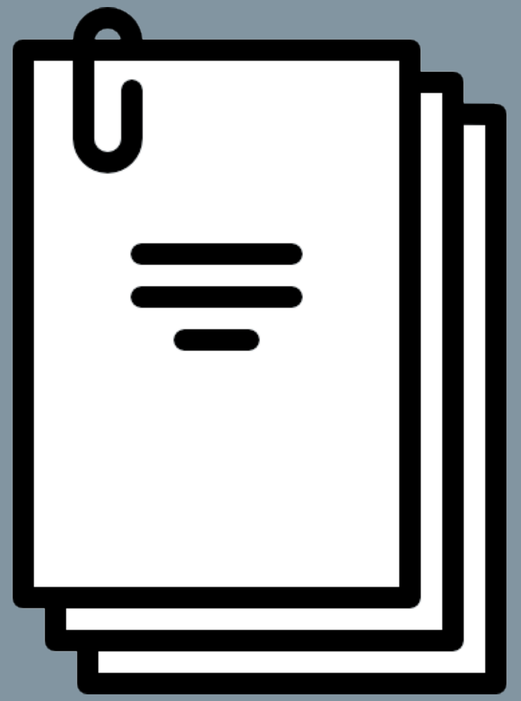
CREATING CHECKSUMS

2

CREATING CHECKSUMS

2

Create checksums contained in a log file or manifest

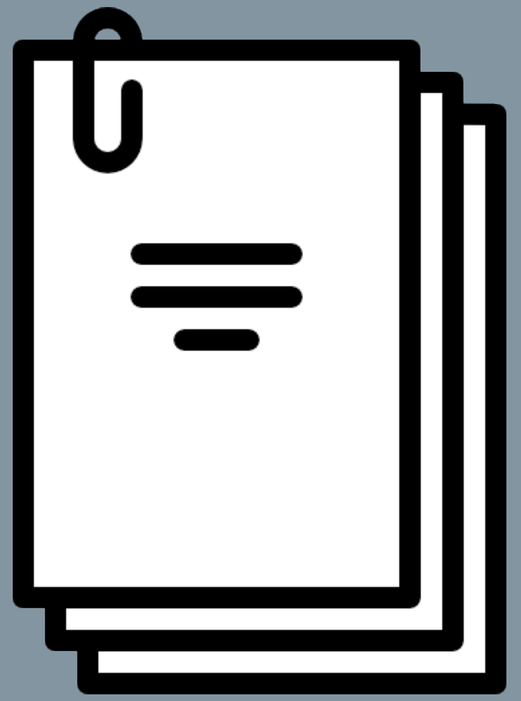


CREATING CHECKSUMS

2

Create checksums contained in a log file or manifest

- Manifest is probably a text file
- Programs for **batch** checksums: **md5deep**, **hashdeep**
- Algorithms: MD5 and/or SHA-1 (most likely)
- Manifest contains either **one or two strings** per file



CREATING CHECKSUMS

3

CREATING CHECKSUMS

3

Set up an audit schedule

CREATING CHECKSUMS

3

Set up an audit schedule

- Check files agains the manifest at regular intervals through the year
- Can be performed **manually** or via **automation**
  - Some **DAMS** produce checksums according to schedule
  - Create a **CRON** job to perform scheduled audits

CREATING CHECKSUMS

4

CREATING CHECKSUMS

4

Run fixity checks after lifecycle events, such as...

CREATING CHECKSUMS

4

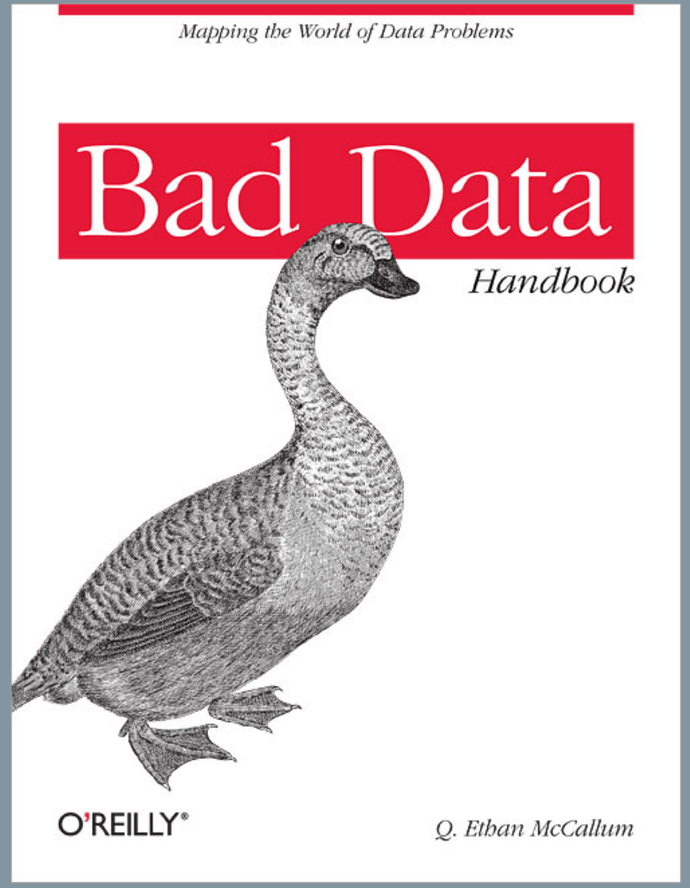
Run fixity checks after lifecycle events, such as...

- A disaster event (power outage, flood, fires, etc.)
- Data is transferred to a brand new server (every 4 years)
- Data is transferred to a new backup location (LTO, etc.)
- Data is compromised (hack, mismanagement, backups recovered)

WHY SO MANY CHECKSUMS?

WHY SO MANY CHECKSUMS?

1. To determine whether data has **changed**
2. **Uncover issues** in repository workflow, infrastructure or hardware
3. To **prove consistency** within the repository: show that data has definitively not changed or that storage and archival workflows are working properly



WHY NOT JUST RUN CHECKSUM ALL THE TIME?

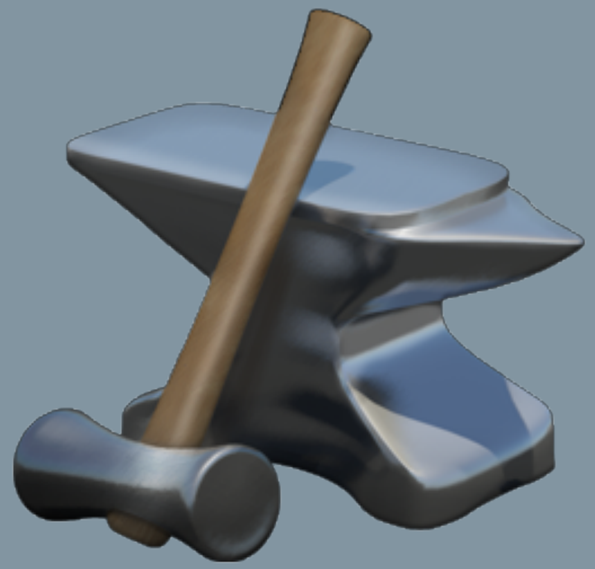
WHY NOT JUST RUN CHECKSUM ALL THE TIME?

Processing load

- Large-scale checksum creation can make system unusable for other processes
- Dedicated hardware is advised

Time

- Whole-file checksums for 1TB of data takes hours
- Frame-level checksums for 1TB of data takes... many more hours

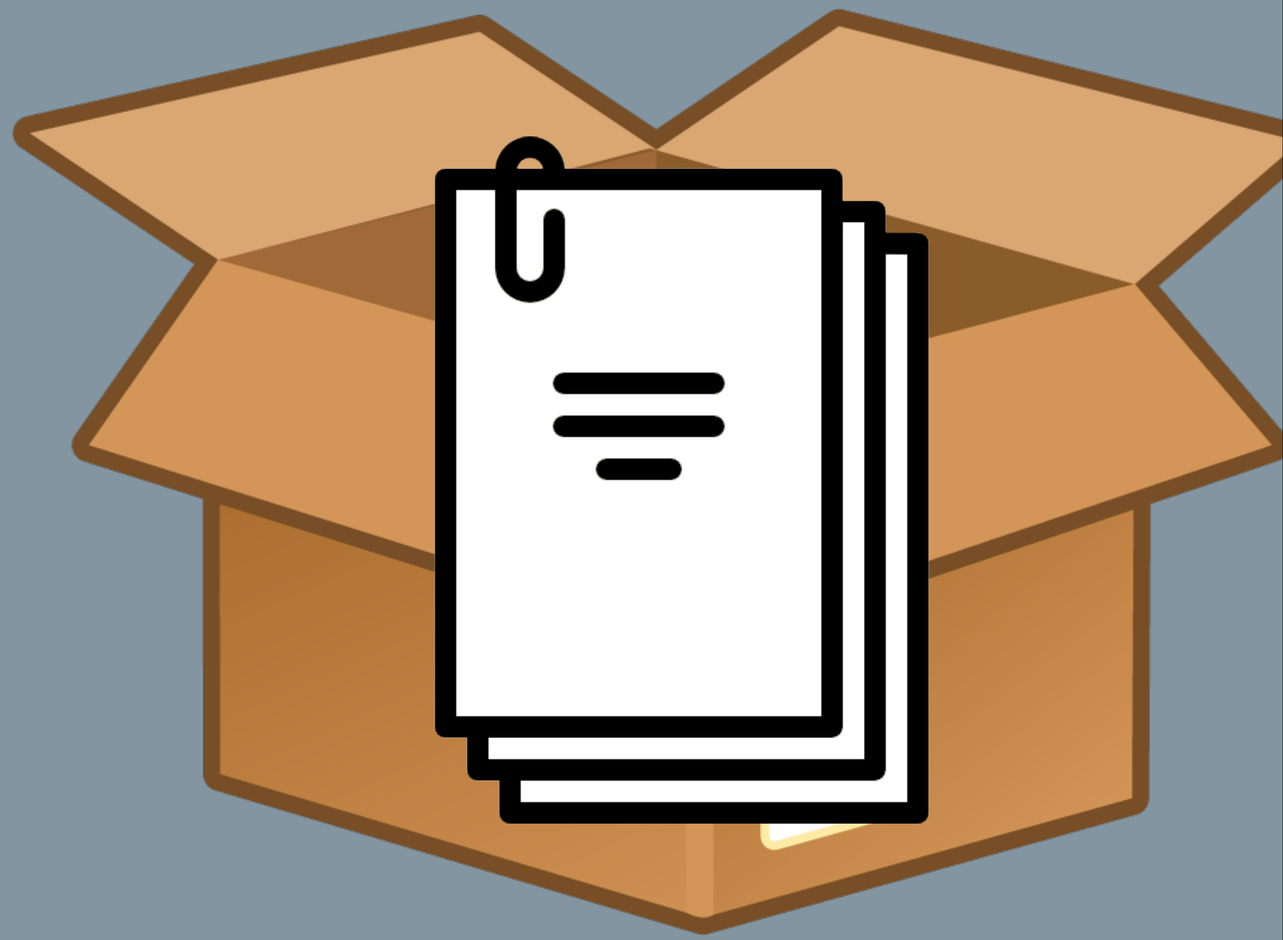


PROPRIETARY SYSTEM CHECKSUMS

PROPRIETARY SYSTEM CHECKSUMS

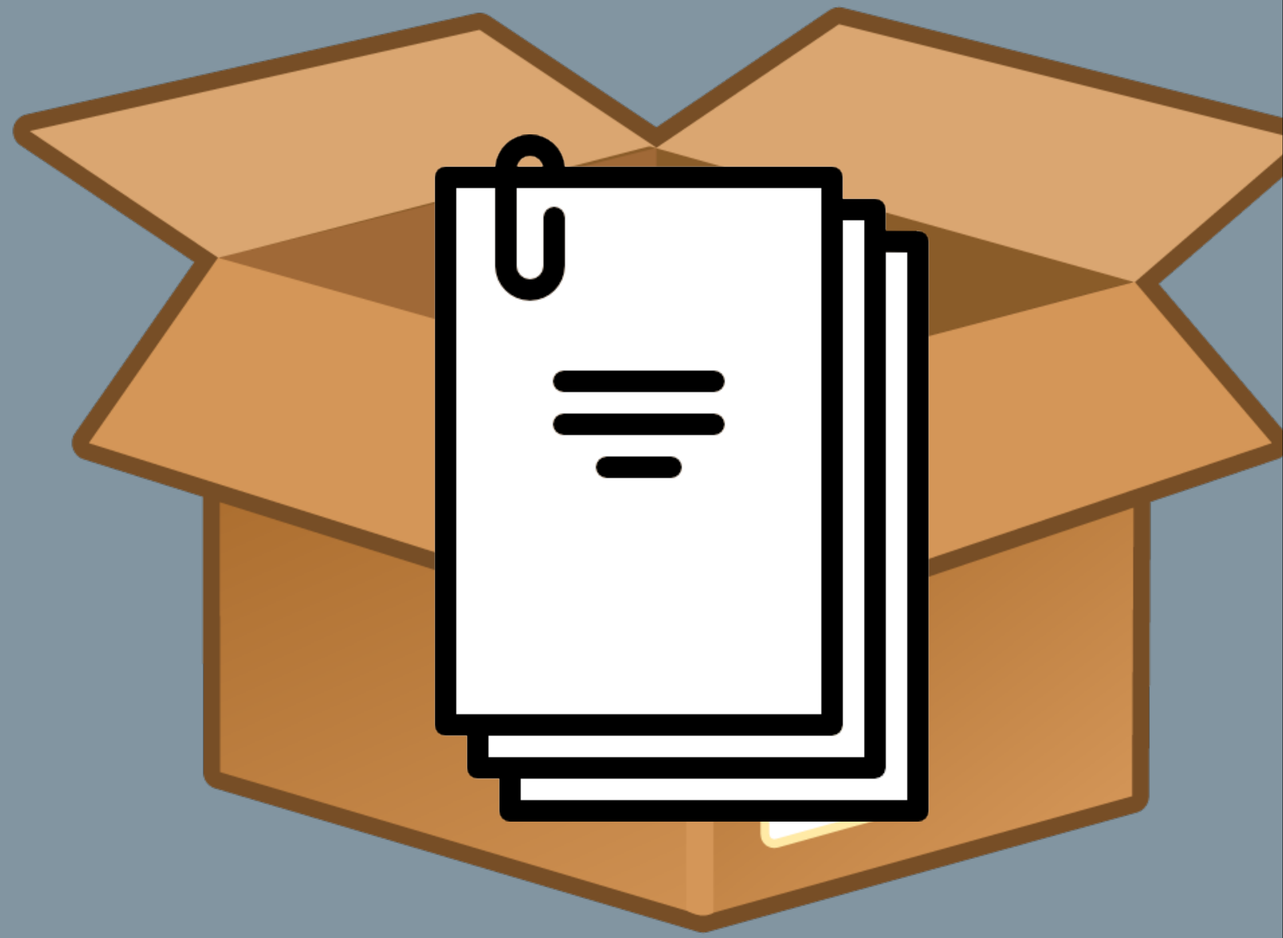
- Some products produced by vendors make their own checksums
  - LTO software vendors
  - Cloud storage vendors
  - DP application & DAMS vendors
- Learn the points in the workflow when fixity checks are performed
- Try to secure access to actual hashes (algorithm strings)

MANIFEST STORAGE



MANIFEST STORAGE

- Text or log files (created manually or with automation)
- Within your DAM or catalog
- Database created to manage fixity checks
- Proprietary software products
- Log "sidecar" files stored alongside digital objects
- Within file metadata itself



THE

END.