Data Integrity

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Speaker notes

No notes on this slide.

Data Integrity?

Speaker notes

- What is that?
- How do you identify if a file is *intact*?
- How do you identify duplicates?

What is “Fixity” information?

Speaker notes

Fixity information is metadata that can be used to check/verify that binary data has not (been) changed. This can be used to make sure that files were copied properly from A-to-B, or retrieved bit-exactly the way they were stored, etc.

Fixity information is directly linked to so called “hashcodes”.

Hashcodes

raw.txt

“This is a raw text file.”

```
MD5 = b3a243d2443037a783c8799fe2c4926a
```

Speaker notes

Hashcode = A fixed size number that’s like a fingerprint for data.

A “hash” or “hashcode” is the result of a mathematical algorithm that produces something like a fingerprint number for the input data provided. With the intention for any source not to map to an identical number. That would be called a “hash collision”: 2 different sources mapping to the same hash value/number.

To keep the numbers short(er), they are usually written in hexadecimal (0..9, A..F).

The above example is the hashcode for the string “This is a raw text file.”

Hashcodes

raw.txt

“This is a raw text file.□”

`MD5 = 7096384353da7d8cb59b1395e63d1250`

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Even though only a simple space character was added to the string from before, the resulting MD5 hashcode is completely different than before. That’s good!

This allows to quickly and securely identify even the smallest deviation in the source data. Even a small change like a single character - or even a binary bit. This way, a mismatching hashcode will tell you if your data is either exactly the way it was - or if anything has changed.

Hashcodes

raw.txt

“this is a raw text file.”

`MD5 = a94a15d1b72bbfee7997bf237cf0347e`

Speaker notes

Now, the case of the first letter “T” was changed to “t”: Different character = different hashcode. Again: Good! :)

Hashcodes

raw-text.txt

“this is a raw text file.”

`MD5 = a94a15d1b72bbfee7997bf237cf0347e`

Speaker notes

Now, the filename - not the content - was changed. This has no effect on the hashcode, as the hash only depicts the content. The filename is outside, on the filesystem level. The hashcode does not include the name of a file.

Different algorithms

- CRC
- MD5
- SHA .. 1 .. 2 .. 256 .. SHA512
- XXHASH
- WTF?

Speaker notes

There are different hashing algorithms with different properties (pros/cons).

In a nutshell:

- Shorter hash = faster(*)
  but higher collision chance
  = less secure
- Longer hash = slower(*)
  but lower collision chance
  = more secure

For data integrity verification, short hashes are perfectly fine.

Since hashing algorithms are also used for security purposes (digital signatures), MD5 was said to be “broken”. This is only true for security/signature purposes. It is still perfectly valid for checking data integrity.

“xxHash” is relatively new, and is the only “Non-cryptographic hash function” in the above list, designed for speed and not security. It is becoming more common for fixity checks in A/V production, but yet it’s still rather the exception.

Hashcodes are fixed-length numbers that are generated in a way that if even a single bit in the source data changes, that number will be completely different. They are often written in hexadecimal, therefore including the characters 0-9 and A-F.

If you have a hashcode for a set of data, it can be used to verify the bit-exact integrity of that data, by calculating the same-algorithm hashcode again and comparing them. If they’re identical, the data is intact. If two distinct sets of data have the same hash, it’s called a “hash collision. Hash algorithms are designed particularly to keep the chance for collision as low as possible.

Anyways: hashcodes are a must for safe data transfer and integrity checks.

In case someone has heard that MD5 is broken, fear not: For plain checking of file transfer or stored data integrity, MD5 is sufficient. It was cryptographically “broken” - which is relevant for security, but not for data integrity checking.

Important: Hashcodes are not sufficient for proving authenticity! In case you need to deal with important originals/documents and you need to make sure they’re originals and not forged, etc. please check out this:

- Digital Signatures
- Blockchain

Digital signatures are good, but could be signed with a date in the past (backdating).

If this is a concern, you may consider blockchain mechanisms: Blockchain cipher became popular for digital currency (like Bitcoin), but it can also be used to proof data authenticity and avoid backdating.

AFAIK there are currently no systems that implement this productively yet, but some have already researched into prototyping blockchain use for storage.

Hashcode Examples

- CRC =
  4294967295
- MD5 =
  `d41d8cd98f00b204e9800998ecf8427e`
- SHA256 =
  `e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855`
- xxHash =
  `e4c191d091bd8853`

Speaker notes

Algorithms in order of complexity/size: > CRC —— MD5 —— SHA256 —— SHA512

Speed matters when it comes to calculating hashes for several hundreds of TB or PB of data.

Execution speed depends on the actual implementation of the algorithm. Even if a simpler algorithm may be faster in theory, it may not make a difference if the implementation isn't speed-optimized. However, speeding up hashing becomes more and more interesting e.g. for transfer of digital cinema files, because validating these data amounts may currently be a bottleneck.

Different hashcodes algorithms/implementations may have significantly different runtimes. When dealing with large quantities of data, this may matter.

MD5 is the most popular one around: Well known and widely supported by different applications/systems, etc.

Anyone transferring lots of uncompressed film? You may want to look at xxHash. It's designed for speed.

When?

Generate fixity information as early as possible in a file's lifecycle.

Speaker notes

No notes on this slide.

Different levels

- Filesystem
- File (=data)
- Content (=payload)
  - per stream
  - per frame / group of samples

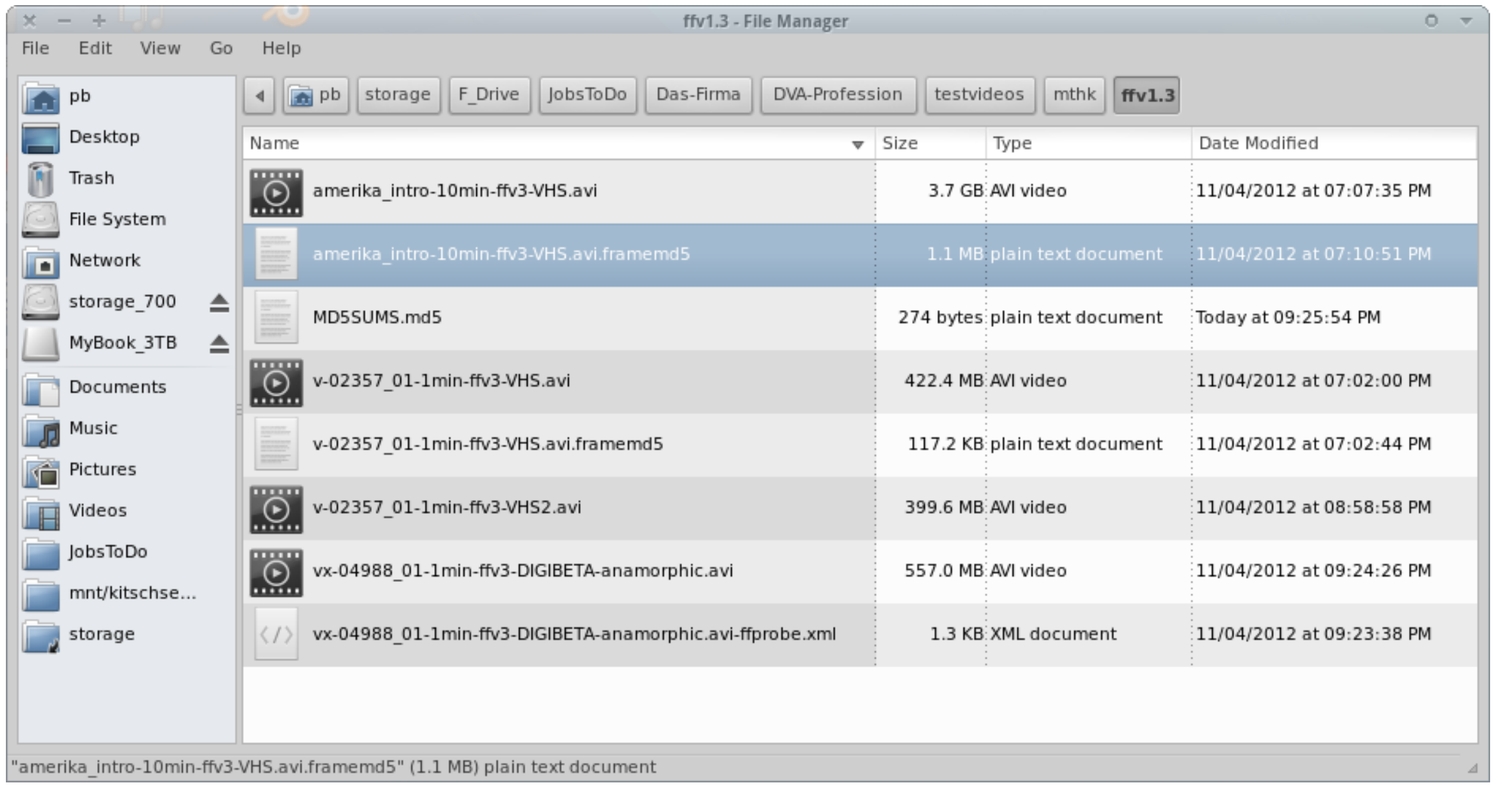
Speaker notes

No notes on this slide.

Level 1

```
Linux / MacOS
$ ls -la > dirlist.txt
```

```
Windows:
C:\> dir /s /a > dirlist.txt
```



Speaker notes

By default, date/time format may not be sufficient/suitable for preservation and/or exchange. Therefore make sure that date/time are displayed in a formaat tht is exactly interpretable.

GNU/Linux systems offer the ability to format it in ISO8601, which is great:

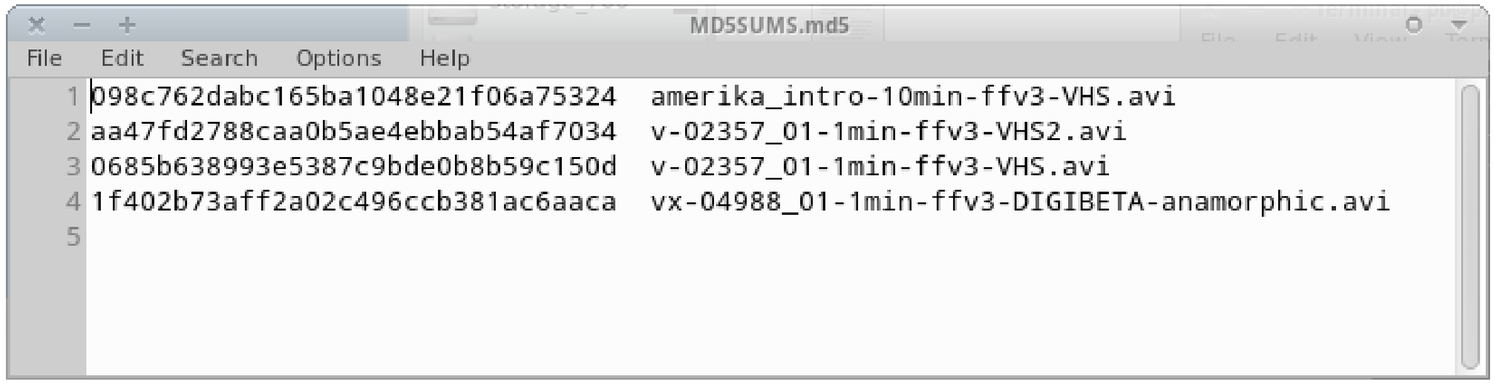
```
$ ls -la --time-style=full-iso
```

Nice trick: If you want to transfer files from A-to-B, and want to make sure that its timestamps are preserved, you can pack it in a ZIP file: If the application allows it, disable compression (or use TAR).

This wraps a layer around the files, so that their timestamps are now stored as tech-MD inside the archive file.

Level 2

```
Linux / MacOS
$ md5sum *.* > MD5SUMS.md5
```



Speaker notes

Hashcode manifests are simple plain text files where each line represents a file and its hash. This is also called fixity information.

There are different tools to generate/validate hashcode manifests.

The most basic one is “md5sum”, which is available by default on *nix systems. For example:

- Single file:
  `$ md5sum my_file.txt > my_file.txt.md5`
- Multiple files:
  `$ md5sum *.mkv > MD5SUMS.md5`

Level 3: Content (Streams)

```
$ ffmpeg -i input_file -map 0 \
-f streamhash -hash md5 -hide_banner - -v quiet
```

Output:

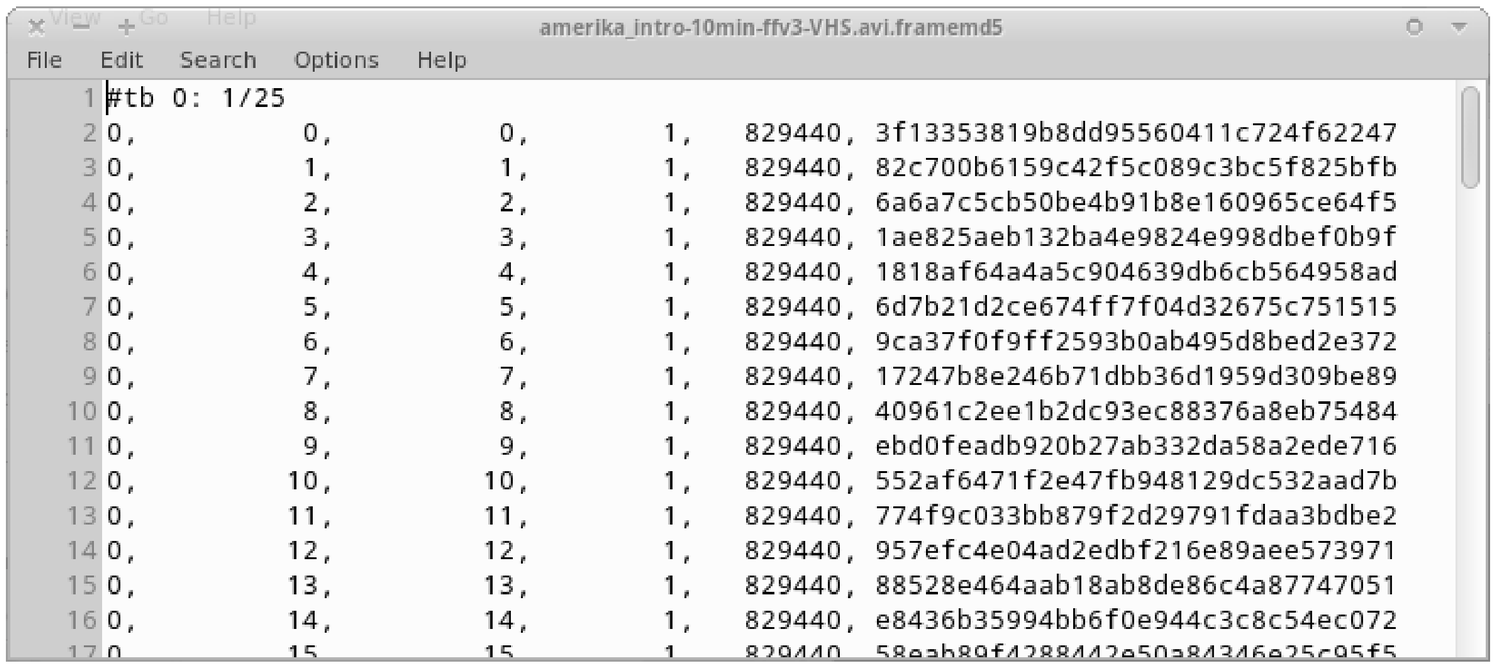
```
0,v,MD5=3f874757d9c1a2bc8adacb070f1a2e60
1,a,MD5=484a92455b87cc48d6d9cad5dd93435c
2,a,MD5=fdb680635a4cc3dd8419c96387760031
```

Speaker notes

No notes on this slide.

Level 4: Image / Samples

```
$ ffmpeg -i my_video.mkv -an \
-f framemd5 my_video-video.framemd5
```



Speaker notes

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Some Tools

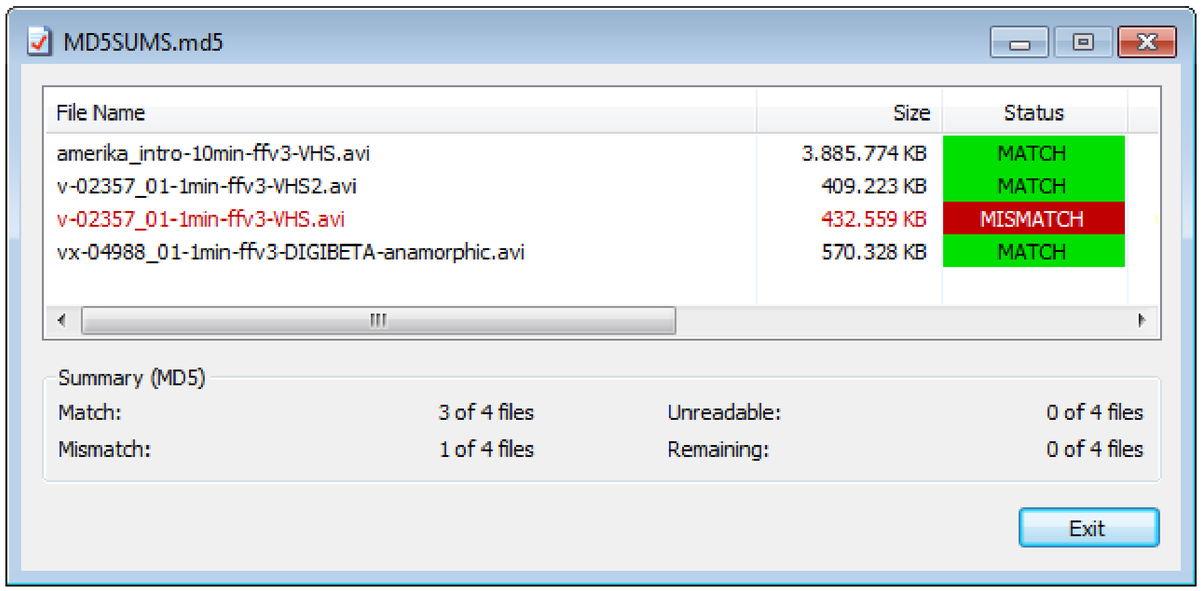
Speaker notes

No notes on this slide.

HashCheck

GUI to handle hashcodes (Windows only).

Website: code.kliu.org/hashcheck



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LoC BagIt “Bags”

“Bags have built-in inventory checking, to help ensure that content transferred intact.”

- Intro at ‘digitalpreservation.gov’
- Same on Youtube

Speaker notes

No notes on this slide.

Bagger

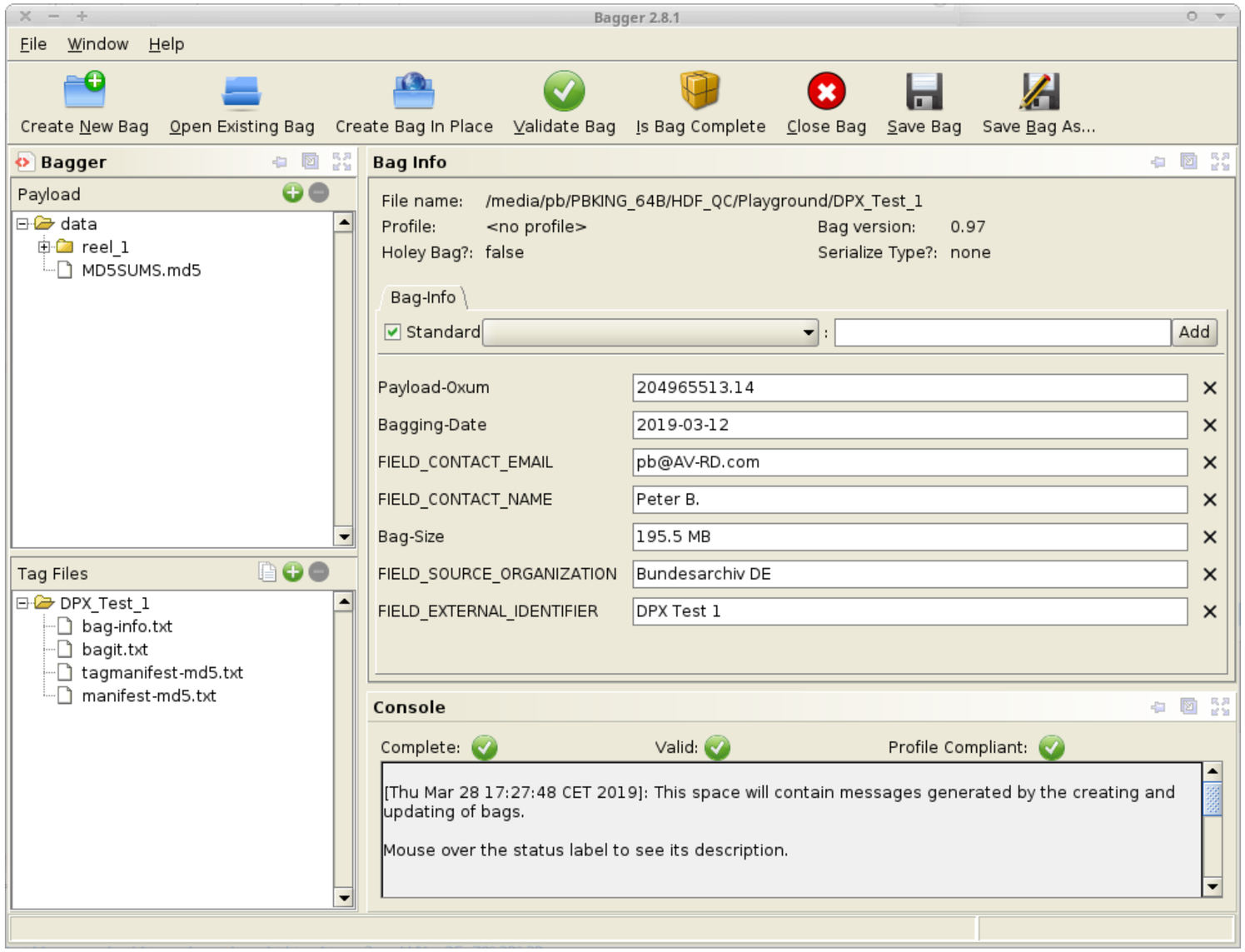
A GUI for handling BagIt bags.

- Website: github.com/LibraryOfCongress/bagger
- Cross platform release (Java)
- Open Source License

Speaker notes

No notes on this slide.

Bagger



Speaker notes

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Hashcode use: When?

- Ingest into preservation environment
- Periodically in storage/backup
- During transfers or access
- Deduplification

Speaker notes

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Comments?

Questions?

Speaker notes

No notes on this slide.