Watch out for that hole! Proper and improper implementations of DICOM
Including “Top 10 common mistakes in DICOM”, and how to avoid them

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Introduction

• DICOM is all about interoperability
• Not everyone follows the rules, but you have to work with them!
  – Saying “it’s his fault” rarely helps the customer
  – The larger the other supplier, the more true this is
• So, you need to:
  – Make sure that what you produce is as accurate as possible
  – Accept “bad data” and “bad behaviour” as much as safely possible
• This talk is about how to make you a solution rather than a problem in the DICOM world
What commonly goes wrong?

- Simple “Mistakes”
  - Misunderstanding the standard
  - Coding mistakes - “bugs”
- Efficiency disasters
- Deliberate incompatibilities/abuses
  - “special features”
  - Vendor lock-in
- Errors and ambiguities in the standard itself
Top 10 common mistakes in DICOM

• **Formatting**
  – Basic Low level rules
  – Implicit VR in UN sequences
  – Meta header issues

• **Content**
  – Images with missing/incorrect Character Set
  – Beware that DICOM can be inconsistent
  – Mixing up mandatory/optional
  – Dodgy icons

• **Behaviour**
  – Misunderstanding C-MOVE
  – End of association ≠ end of study
  – Printing is simplistic but difficult
Formatting Basics

• Defined mainly in Parts 5 & 10 of DICOM

• These are the smallest and easiest to read parts of DICOM – every DICOM developer should read them in full

• The easiest errors to identify by simple validators, but people still leave them in production code.
• **Basic Low level rules**
  – Filenames must conform to CS rules, with upper case, space, _ and digits only
  – Leading 0s are not permitted in UIDs

• **Sequences labelled “UN” must be Implicit VR**
  – Whatever the surrounding transfer syntax

• **Meta header issues**
  – 0002 group is NOT part of the dataset on the wire
  – Must have a length, to know when to change transfer syntax!
Content Basics

• Defined mainly in Part 3 of DICOM
  – Defined via “modules”
  – Different for every SOP class
  – Varying optionalities

• Can be identified by good validators, but harder than formatting issues, as some relate to “real world” conditions
Content Examples

• **Missing/incorrect Character Set**
  – If no 0008,0005 then you ONLY have ASCII!

• **DICOM can be “unusual”**
  – Rows & Columns are specified as Y\X
  – But 3D coordinates are X\Y\Z

• **Confusion between mandatory & optional elements**
  – Easy to “forget” mandatory elements, but easy to check for them being missing with validators
  – Harder to check for reliance on missing optional ones
Dodgy Icons
An error class all on its own!

- Least useful part of DICOM
- Causes most grief
- Rules:
  - Always allowed to be uncompressed
  - If outer transfer syntax is compressed, then they may also be compressed, with **same** transfer syntax
  - Need full DICOM fragment encoding
  - May **not** appear in private sequences
• Defined mainly in Part 4 of DICOM
  – Defined as “Services”
  – Often with “options”
• Require simulators for proper testing
• Even then, there is a huge range of received behaviours to cope with:
  – Good
  – Bad
  – “unusual”
 Behaviour Examples (1)

• What does the end of an association “mean”
  – Unless printing, it means **nothing**
  – It never means “end of study”

• Printing is simplistic but difficult
  – Monochrome & Colour are different processes
  – Meta SOP Classes are not always understood
  – DICOM printers are “dumb”
    • No windowing
    • No presentation states etc.
Misunderstanding C-MOVE
- It is NOT the same as C-GET – always needs a reverse path
  - Set up in database
  - Killed by DHCP, firewalls or NAT
- Notifications
  - Interim notifications are optional
  - Completion notification is mandatory and must not be sent early
Efficiency disasters (how to make it go slowly!)

- Unnecessary compression & decompression, especially JPEG 2000
- Bad database design – e.g.
  - on the fly counting of images
  - Reading the images themselves for C-FIND
- Multiple single associations
- 6 second reverse DNS lookup on every association!
Common “Abuses”

- Anything from previous list of common errors
  - If known about, and not fixed
- Anything from previous list of efficiency disasters
  - If known about, and not fixed
- Typical examples of “Pseudo-DICOM”:
  - Hiding vital information (such as video) in private elements
  - Badly formatted data, only readable by one company’s viewers
  - Sequencing errors – e.g. sending C-MOVE complete message “all sent OK”, before even trying!
Problems in DICOM itself

- DICOM is not perfect!
- If YOU find that something is ambiguous, then other may do so as well
- In the first instance – ASK:
  - [http://groups.google.com/group/comp.protocols.dicom/](http://groups.google.com/group/comp.protocols.dicom/)
  - we’re all friendly – honest!
  - If it turns out that clarification is needed, then get involved in writing a correction proposal (CP) – they are a vital part of DICOM development!
- Longer term – get involved, see:
  - [http://dicomconference.org/contact/participation-in-dicom-activities/](http://dicomconference.org/contact/participation-in-dicom-activities/)
  - We were all new to this once upon a time!
Summary

• Getting DICOM “right” is not easy, but please try!
• Accept that others may send you “rubbish” – consider carefully how to cope with it.
• Try to avoid “fitting in” by following other people’s mistakes unless absolutely unavoidable
• Help and clarification are always available from friendly experts
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Thank you for your attention!