JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

CIIS

DICOM in Dart (DCMiD)

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Stated Topic and Goal

Determine the feasibility of using binary DICOM for building browser based medical imaging applications

Method:

- Design and implement a DICOM editor that reads and writes binary DICOM and displays it using HTML5, CSS3 and the Dart programming language.
- Test performance by reading, displaying and writing DICOM studies in binary format.
- Goal: Read and display imaging studies in less than 3 seconds.

Relevance/Importance

- DICOM is the standard by which medical imaging information is transmitted, stored, and displayed for use by healthcare providers and their healthcare organizations.
- Nearly all healthcare systems use the DICOM standard in their medical equipment and information systems.
- The DICOM Standard does not specify any application implementation details.

Zero-footprint Client

- It is crucial that information systems be created that allow end users to access and edit DICOM data in a fast, secure, and intuitive manner.
- Zero Clients have many advantages over downloaded software applications:
  - HIPAA covered patient data is not stored on the end point device.
    - Data cache can be encrypted.
  - Applications can be maintained and upgraded without the need for access control on the end point device.
  - Improved security
  - Lower cost (management, implementation, security).

- Class based and object oriented programming language for creating web applications.
- Dart programs compile to JavaScript (dart2js) or native in Chromium.
- Native Dart code is much faster than JavaScript and dart2js during benchmarking.[1]
- Development overhead can be simpler
  - Dart has classes, first class procedures, and optional static typing.

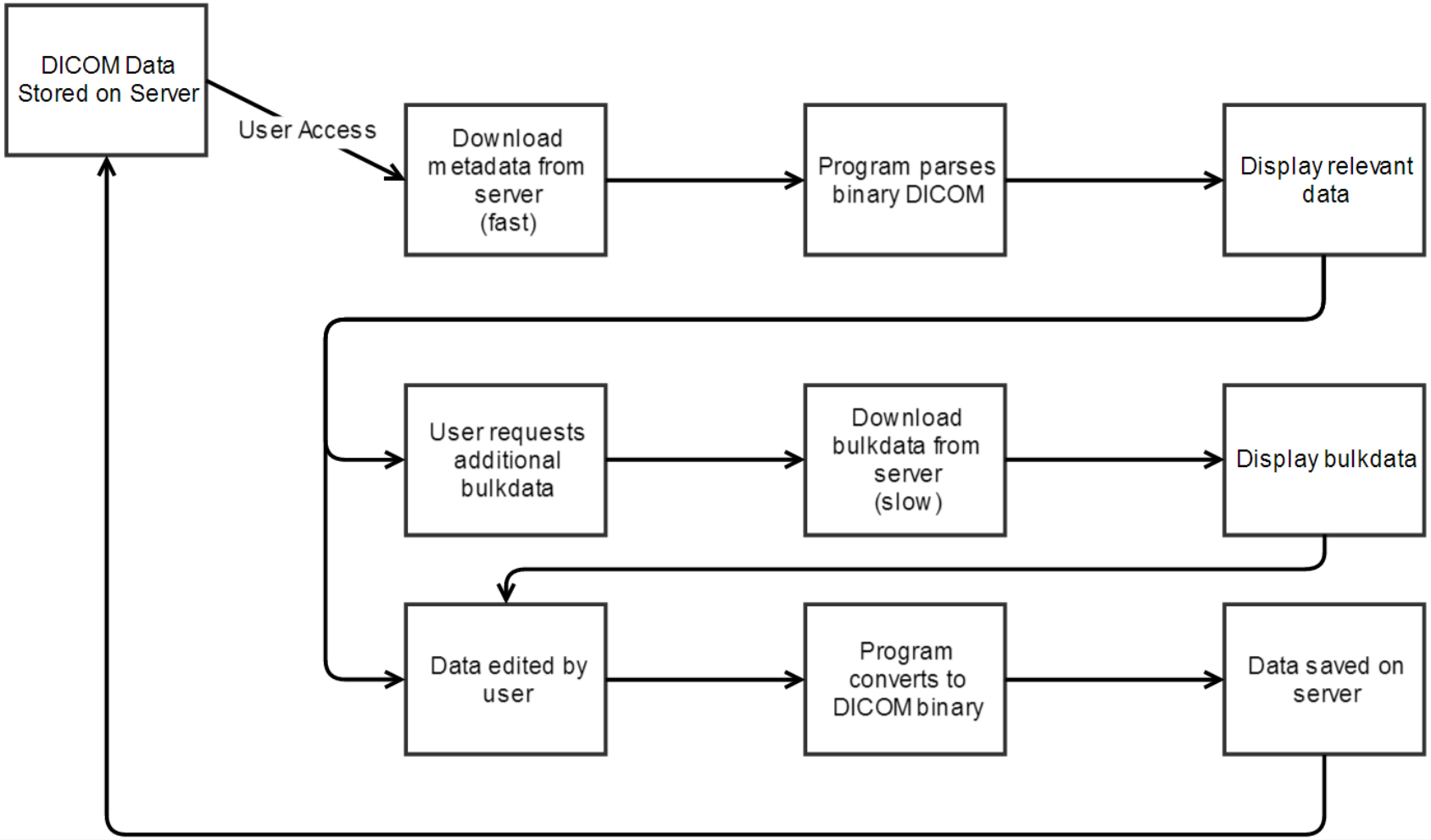
Google

[1] DeltaBlue, FluidMotion, Richards, Tracer Benchmarks (https://www.dartlang.org/performance/)

Technical Summary and Approach

- Learn the DICOM standard to understand how medical imaging data is stored.
- Design a data structure for DICOM studies.
- Create a project plan including packages and classes for our viewer/editor.
- Learn the Dart syntax and translate our plan into code.
  - Develop unit tests for each class
- Iteratively optimize code.

Block Diagram



Data Structures: Top Level

Information Model

- PatientStudies
- Patient
- Study
- Series
- Instance
- Frame

Data Types

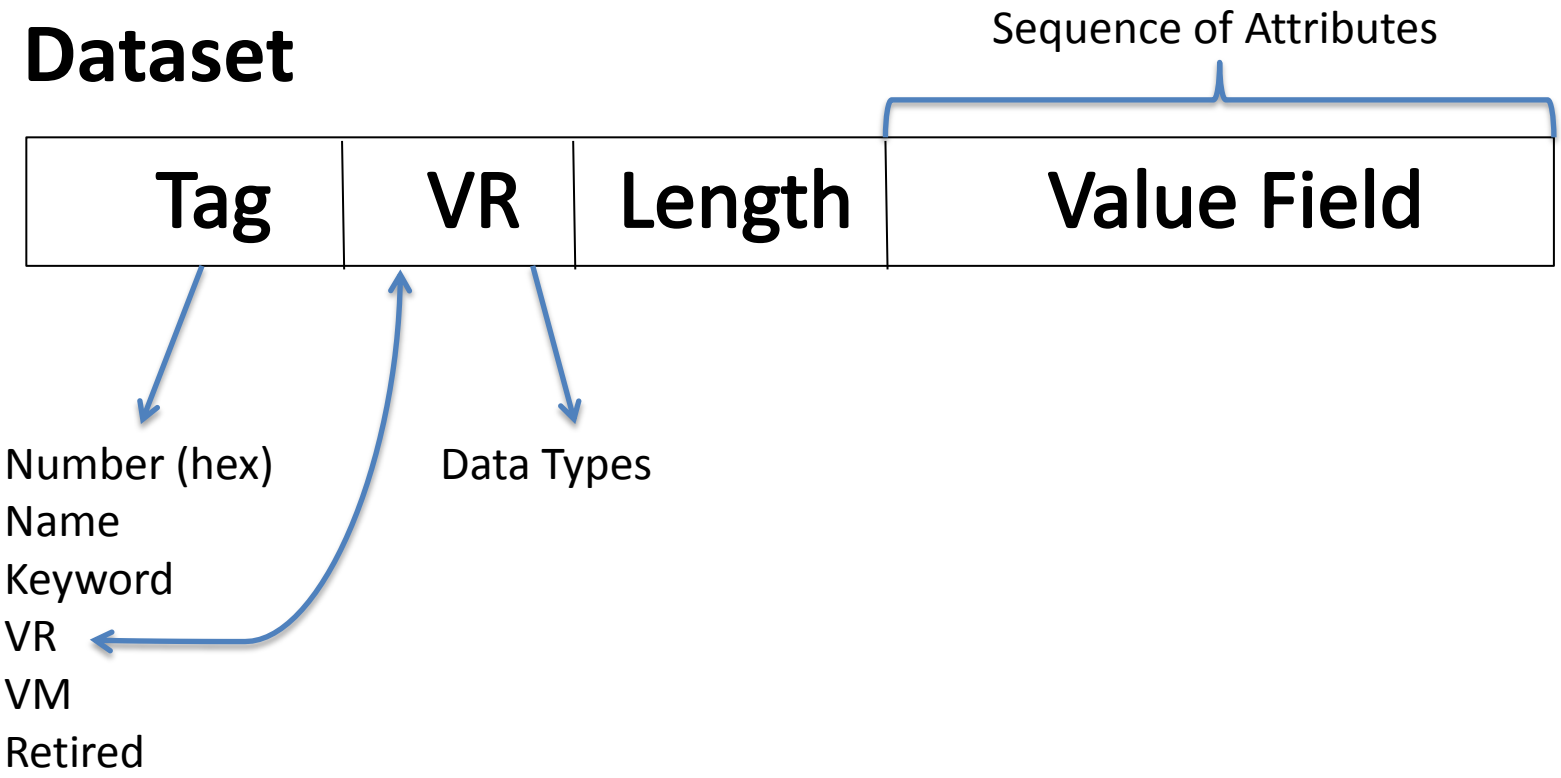
- Dataset
- Sequence
- Attribute
- aType (attribute type)
- VR (Value Representation)
- ValueType
- VM (Value Multiplicity)

Data Structure: Top Level

DICOM (structured study)

- Patient
- Study
  - —Series
    - —Instance
      - —Frame

Data Structure: DICOM Internals



Tag can have a value of sequence.
Value field is an array of items and each item contains a data set.

Packages and Classes

- Study
  - Atype
  - Bulkdata
  - DataSet
  - Instance
  - PatientName
  - QC-mode
  - Sequence Series
  - Studies Study
  - TagDictionary
  - UT
  - ValueField
  - VM
  - VR
- I/O
  - BulkdataInputStream
  - BulkdataOutputStream
  - MetadataInputStream
  - MetadataOutputStream
  - ReadBulkdata
  - ReadMetadata
  - WriteBulkdata
  - WriteMetadata
- Test
  - ReadThenWriteMetadata
  - VM-Test
- Display
  - DisplayImage
  - Study
  - WorkList
- Util
  - ByteUtils
  - DateRange
  - DateUtils
  - StringUtils
  - TagUtils
  - UIDUtils
  - UUIDUtils

Deliverables

- Minimum deliverables
  - Read and display DICOM in a browser and then write it
  - Build a test program that compares input and output to validate correctness
  - Create unit tests for each class
- Expected deliverables
  - Display a work list of studies of n patients
  - Display patient as collapse/expand tree for study information model
- Maximum deliverables
  - Edit metadata
  - Display images and add overlay information
  - Encrypt and decrypt studies using AES (GCM) using an encryption framework created at Hopkins Security Institute.

Dependencies

- Access to our mentor
- Computer to write code
- Bitbucket to share code
- Dart & DICOM Reference Information
- Access to DICOM Test Data

Management Plan

- Meet twice a week to work on code as a team.
    - Mondays & Fridays at 10:00AM
- Weekly meetings with Dr. Philbin
    - Wednesdays at 9:30AM
    - Code reviews as classes and modules develop
- More meetings can be scheduled as required.

Key Dates

- **February 20:** Have project proposal finished and all of the programming planned and reviewed by Dr. Philbin
- **March 6:** Read input (parse)
- **March 20:** Write and validate output
- **April 3:** HTML5/CSS3 display metadata
- **April 17:** Edit data
- **May 1:** Display/Edit images
- **May 9:** Final Poster Presentation

Reading List

- MINT Toolkit source code and documentation (provided by Dr. Philbin)
- DICOM Standard
- Dart documentation
- Mahmoud Ismail and James Philbin, Multi-series DICOM: an Extension of DICOM That Stores a Whole Study in a Single Object. Journal of Digital Imaging, August 2013; 26(4):691-697
- **James Philbin**, Tim Culp, Tim Dawson, Jonathan Whitby. RESTful Web Services in DICOM. *The DICOM 2013 International Conference*, Bangalore, India. March 2013.
- **James Philbin**, Mahmoud Ismail. Fast, Storage Efficient De-identification of Medical Studies. *The DICOM 2013 International Conference*, Bangalore, India. March 2013.
- Mahmoud Ismail, Yu Ning, **James Philbin**. Transmission of DICOM Studies using Multi-Series DICOM Objects. *Proceedings SPIE 8674, Medical Imaging 2013: Advanced PACS-based Imaging Informatics and Therapeutic Applications*. April 8, 2013.
- Mahmoud Ismail, Yu Ning, and **James Philbin**, Separation of metadata and pixel data to speed DICOM tag morphing. *SPIE Medical Imaging 2014: PACS and Imaging Informatics: Next Generation and Innovations*, Forthcoming.