



DICOM – there can
be only one standard
for Digital Imaging
and Communications
in Medicine

PRESIMAL Workshop at
Solstrand, 2022

“DICOM ensures that all computer systems in
clinics, medical imaging centers, and hospitals will
work together and distribute the digital medical
images correctly, across countries, modalities, and
clinics.”

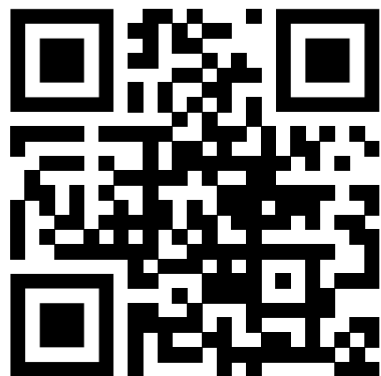
Experiment

<https://haukebartsch.github.io/dicom-meta-data-viewer/>

App



Data



tinyurl.com/yu2raks9

About

Review a zip file with DICOM inside to make sure we forward the right information.
This page will not transfer any files to our server.

Looking for test data?

```
git clone https://github.com/ImagingInformatics/hackathon-dataset.git
```

```
cd hackathon-dataset
```

```
git submodule update --init --recursive
```

Afterwards zip this folder or sub-folders and upload at "Browse File".

Contact

Hauke Bartsch

DICOM is complete

[git source code](#)



This page only accepts zip folders and parses them for DICOM files. It is safe to use this application on sensitive data as no part of your zip-files will be uploaded to any server. If this application is used on a hosted system, that system might track who or how often this service is used. All data stays on your system and computations are done in your web-browser.

[Browse File](#) hackathon-images.zip

Summary

Number of files: 3,666/7,706

Number of series: 37

#files: 34 SeriesNumber: Modality:	TCGA-17-Z058, Sun Mar 30 1986 Topogram 1.0 T20s #files: 2 SeriesNumber: 1 Modality: CT	TCGA-17-Z058, Sat May 31 1986 #files: 1 SeriesNumber: 000002 Modality: CT	TCGA-17-Z058, Tue Apr 22 1986 Abd.CT 5.0 B30s #files: 127 SeriesNumber: 2 Modality: CT
TCGA-BA-4077, Tue May 14 1996 CT 5.0 B40s #files: 26 SeriesNumber: 2 Modality: CT	TCGA-50-5072, Wed Apr 19 2000 WB_2D AC #files: 267 SeriesNumber: 5 Modality: PT	TCGA-50-5072, Fri Feb 11 2000 WB_2D NAC #files: 267 SeriesNumber: 6 Modality: PT	TCGA-50-5072, Wed Apr 19 2000 WB_2D NAC #files: 267 SeriesNumber: 6 Modality: PT
TCGA-BA-4077, Sun Apr 28 1996	TCGA-17-Z058, Tue Apr 22 1986	TCGA-BA-4077, Tue May 14 1996	TCGA-BA-4077, Tue May 14 1996

Details

hackathon-images.zip (loaded in 3309ms)

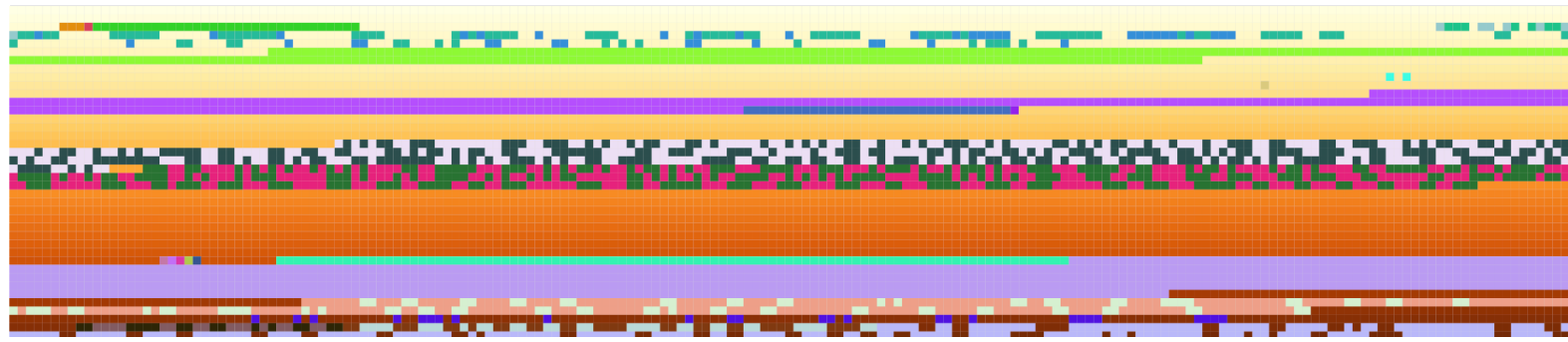


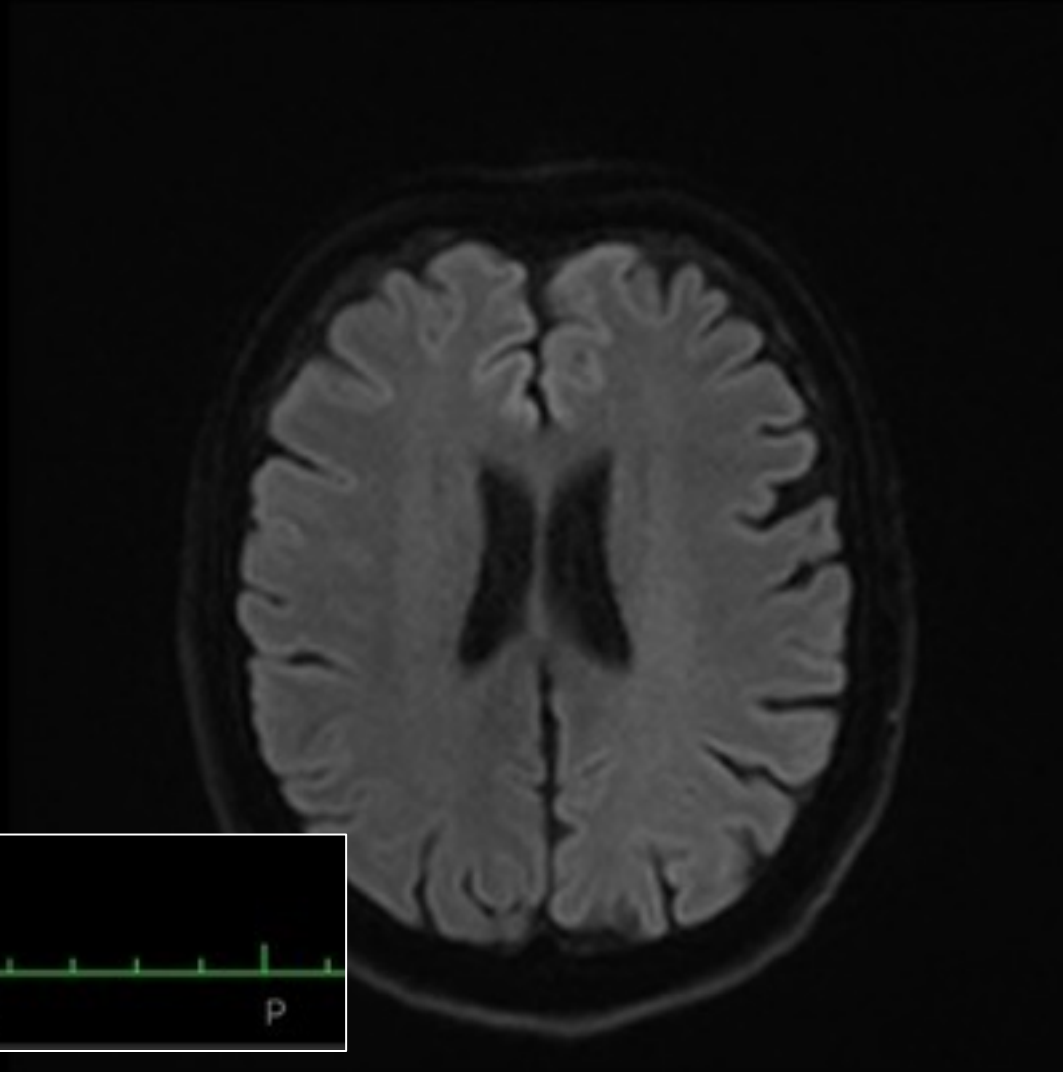
Image size: 160 x 160
View size: 1304 x 1278
WL: 406 WW: 851
X: 0 px Y: 0 px Value: 44.00

A

Bicam00001 BICAM00001 (- , -)
Renate Nevro
resolve_3scan_trace_tra_160_p2
2

Image size: 160 x 160
View size: 1304 x 1278
WL: 406 WW: 851
X: 0 px Y: 0 px Value: 44.00

R



L

Zoom: 596% Angle: 0
Im: 66/84
Uncompressed
Thickness: 4.00 mm Location: 41.33 mm

Zoom: 596% Angle: 0
Im: 66/84
Uncompressed

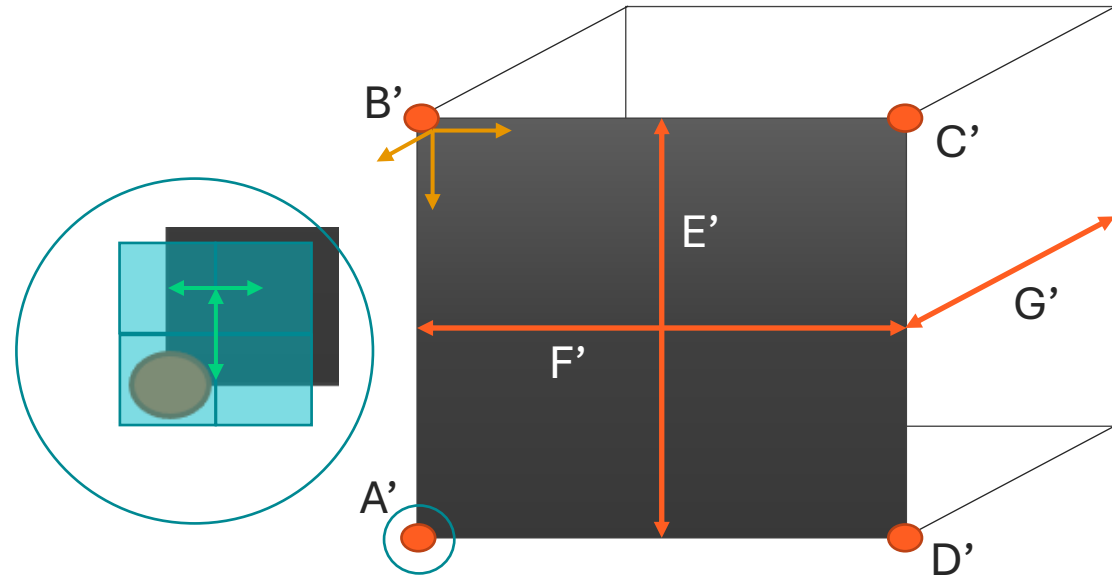
Thickness: 4.00 mm Location: 41.33 mm

P

TE: 54 TR: 3700
FS: 3
1/5/19, 12:51:09 PM
Made In Horos

TE: 54 TR: 3700
FS: 3
1/5/19, 12:51:09 PM
Made In Horos

How do we describe things in space?



We need conventions on how to store data for 2D and 3D:

bounding-box + matrix size + encoding per value + number of values per pixel

Tricky corner cases!

What about rotations?

What could possibly go wrong?

Interfile

```
#define MDC_INTF_MAXKEYCHARS 256
char keystr[MDC_INTF_MAXKEYCHARS];
/* the data type */
#define MDC_INTF_STATIC 1
#define MDC_INTF_DYNAMIC 2
#define MDC_INTF_GATED 3
#define MDC_INTF_TOMOGRAPH 4
#define MDC_INTF_CURVE 5
#define MDC_INTF_ROI 6
/* the process status */
#define MDC_INTF_ACQUIRED 1
#define MDC_INTF_RECONSTRUCTED 2
/* gated spect nesting outer level */
#define MDC_INTF_NESTING_SPECT 1
#define MDC_INTF_NESTING_GATED 2
typedef struct MdcInterFile_t {
    int data_type, process_status, pixel_type, gspect_nesting;
    Uint32 width, height, images_per_dimension, time_slots;
    Uint32 data_offset, data_blocks, imagesize, number_images;
    Uint32 energy_windows, frame_groups, time_windows, detector_heads;
    float pixel_xsize, pixel_ysize, slice_thickness, centre_centre_separation;
    float study_duration, image_duration, image_pause, group_pause, ext_rot;
    Int8 patient_rot, patient_orient, slice_orient;
    double version;
} MDC_INTERFILE;
```

.hdr

.img

Error prone



Difficult to add new things



```

short qform_code ;      /*!< NIFTI_XFORM_ code.      */ /*-- all ANALYZE 7.5 ---*/
short sform_code ;      /*!< NIFTI_XFORM_ code.      */ /*  fields below here  */
                          /*  are replaced        */

float quatern_b ;        /*!< Quaternion b param.    */
float quatern_c ;        /*!< Quaternion c param.    */
float quatern_d ;        /*!< Quaternion d param.    */
float qoffset_x ;        /*!< Quaternion x shift.    */
float qoffset_y ;        /*!< Quaternion y shift.    */
float qoffset_z ;        /*!< Quaternion z shift.    */

float srow_x[4] ;        /*!< 1st row affine transform. */
float srow_y[4] ;        /*!< 2nd row affine transform. */
float srow_z[4] ;        /*!< 3rd row affine transform. */

char intent_name[16]; /*!< 'name' or meaning of data. */

char magic[4] ;          /*!< MUST be "ni1\0" or "n+1\0". */

} ;                      /**** 348 bytes total ****/

```

NIFTI header (Mayo/SPM Analyze format + orientation information)

DICOM[®] is a Standard for communication of medical imaging information.

History of DICOM 1980 -

<https://www.dicomstandard.org/history>

History

DICOM[®] is a **Standard** for communication of **medical imaging** information. Selected highlights of its history are shown below:

1980

In the beginning... it was very difficult for anyone other than manufacturers of **computed tomography (CT)** or **magnetic resonance imaging (MRI)** devices to decode the images that the machines generated, or to print them.

1983

The **American College of Radiology (ACR)** and the **National Electrical Manufacturers Association (NEMA)** joined forces and formed a Standards committee to meet the combined needs of radiologists, physicists and equipment vendors.

How is data stored in DICOM?

1 Patient Level:

Patient's Name
Patient ID
Patient's Sex
Patient's Birth Date
Specific Character Set

2 Study Level:

Study Instance UID
Study Date
Study Time
Referring Physician's Name
Study ID
Accession Number

3 Series Level:

Series Instance UID
Series Number
Manufacturer

Attributes



(0010,0010)	PN	[SIIM^Andy]	#	10, 1	PatientName
(0010,0020)	LO	[TCGA-50-5072]	#	12, 1	PatientID
(tag)		(value (value)		(length)	(number of values)
		representation)			

(group) (element, hexadecimal, 0000...FFFF)

(tag) (0018,0051) - Patient Position relative to the imaging equipment space : “FFS” – Feet first - Supine (Face up)

(0020,0032) – Image Position (Patient): "-142.7265625\ -302.7265625\ -270.5"

(0020,0037) – Image Orientation (Patient): "1\0\0\0\1\0"
(rows) (columns)

(0020,1041) – Slice Location: "270.5"

(0028,0030) – Pixel Spacing: “0.703125, 0.703125”



More details:

<https://dicom.innolitics.com/ciods/ct-image/general-series>

Create a DICOM file

```
hauke@Haukes-MacBook-Pro-4 DICOM % ls -laghtr
total 0
drwxr-xr-x  2 wheel   64B Sep 14 07:26 .
drwxr-xr-x  5 wheel  160B Sep 14 07:26 ..
hauke@Haukes-MacBook-Pro-4 DICOM % touch empty.dump
hauke@Haukes-MacBook-Pro-4 DICOM % dump2dcm empty.dump one.dcm
W: output transfer syntax unknown, assuming --write-xfer-little
hauke@Haukes-MacBook-Pro-4 DICOM % dcmfstest one.dcm
yes: one.dcm
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump one.dcm

# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 194 # 4, 1 FileMetaInfo
(0002,0001) OB 00\01 # 2, 1 FileMetaInfo
(0002,0002) UI [1.2.276.0.7230010.3.1.0.1] # 26, 1 MediaStorage
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.74507.1663133221.580797] # 50, 1 M
(0002,0010) UI =LittleEndianExplicit # 20, 1 TransferSynt
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 Implementati
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 Implementati

# Dicom-Data-Set
# Used TransferSyntax: Little Endian Explicit
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump one.dcm > step1.dump
hauke@Haukes-MacBook-Pro-4 DICOM % vim step1.dump
hauke@Haukes-MacBook-Pro-4 DICOM % dump2dcm step1.dump two.dcm
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump two.dcm

# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 194 # 4, 1 FileMetaInformationGroupLength
(0002,0001) OB 00\01 # 2, 1 FileMetaInformationVersion
(0002,0002) UI [1.2.276.0.7230010.3.1.0.1] # 26, 1 MediaStorageSOPClassUID
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.74507.1663133221.580797] # 50, 1 MediaStorageSOPInstanceUID
(0002,0010) UI =LittleEndianExplicit # 20, 1 TransferSyntaxUID
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 ImplementationClassUID
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 ImplementationVersionName

# Dicom-Data-Set
# Used TransferSyntax: Little Endian Explicit
(0010,0010) PN [WORKSHOP01] # 10, 1 PatientName
(0010,0020) LO [WORKSHOP01] # 10, 1 PatientID
hauke@Haukes-MacBook-Pro-4 DICOM %
```

UID - Magic numbers

(unique for our universe, de-centralized)

1.3.6.1.4.1.45037.5.2.1.6279.6001.31413861641106194805 *Shall not exceed 64 characters.*

Organization root: 1.3.6.1.4.1.45037 (whodunit)

Descriptive suffix: 5.2.1

Unique suffix: 6279.6001.314138616411061948052843767346

Get an organization ID if you generate your own DICOM files:

<http://www.oid-info.com/get/1.3.6.1.4.1.45037>

SOPInstanceUID, SeriesInstanceUID, StudyInstanceUID, Frame of Reference UID

*unique for image
(Service Object Pair)*

*Series are slices of a
volume or time series
or single image*

*Study is collection of
series done in the
same imaging session*

*All series in a study that share
this will spatially relate to each
other – participant did not
reposition.*

```
[hauke@Haukes-MacBook-Pro-4 DICOM % img2dcm --series-from two.dcm image.jpg three.dcm  
[hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump three.dcm
```

```
# Dicom-File-Format
```

```
# Dicom-Meta-Information-Header
```

```
# Used TransferSyntax: Little Endian Explicit
```

```
(0002,0000) UL 196 # 4, 1 FileMetaInformationGroupLength  
(0002,0001) OB 00\01 # 2, 1 FileMetaInformationVersion  
(0002,0002) UI =SecondaryCaptureImageStorage # 26, 1 MediaStorageSOPClassUID  
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.15096.1663134574.193501] # 50, 1 MediaStorageSOPInstanceUID  
(0002,0010) UI =JPEGFullProgression:Non-hierarchical:Process10+12 # 22, 1 TransferSyntaxUID  
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 ImplementationClassUID  
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 ImplementationVersionName
```

```
# Dicom-Data-Set
```

```
# Used TransferSyntax: JPEG Full Progression, Non-hierarchical, Process 10+12
```

```
(0008,0005) CS [ISO_IR 100] # 10, 1 SpecificCharacterSet  
(0008,0016) UI =SecondaryCaptureImageStorage # 26, 1 SOPClassUID  
(0008,0018) UI [1.2.276.0.7230010.3.1.4.0.15096.1663134574.193501] # 50, 1 SOPInstanceUID  
(0008,0020) DA (no value available) # 0, 0 StudyDate  
(0008,0030) TM (no value available) # 0, 0 StudyTime  
(0008,0050) SH (no value available) # 0, 0 AccessionNumber  
(0008,0064) CS [WSD] # 4, 1 ConversionType  
(0008,0070) LO (no value available) # 0, 0 Manufacturer  
(0008,0090) PN (no value available) # 0, 0 ReferringPhysicianName  
(0010,0010) PN [WORKSHOP01] # 10, 1 PatientName  
(0010,0020) LO [WORKSHOP01] # 10, 1 PatientID  
(0010,0030) DA (no value available) # 0, 0 PatientBirthDate  
(0010,0040) CS (no value available) # 0, 0 PatientSex  
(0020,000d) UI [1.3.6.1.4.1.45037.5.2.1.123456789] # 34, 1 StudyInstanceUID  
(0020,000e) UI [1.3.6.1.4.1.45037.5.2.1.987655444] # 34, 1 SeriesInstanceUID  
(0020,0010) SH (no value available) # 0, 0 StudyID  
(0020,0011) IS (no value available) # 0, 0 SeriesNumber  
(0020,0013) IS (no value available) # 0, 0 InstanceNumber  
(0020,0020) CS (no value available) # 0, 0 PatientOrientation  
(0028,0002) US 1 # 2, 1 SamplesPerPixel  
(0028,0004) CS [MONOCHROME2] # 12, 1 PhotometricInterpretation  
(0028,0010) US 10 # 2, 1 Rows  
(0028,0011) US 10 # 2, 1 Columns  
(0028,0100) US 8 # 2, 1 BitsAllocated  
(0028,0101) US 8 # 2, 1 BitsStored  
(0028,0102) US 7 # 2, 1 HighBit  
(0028,0103) US 0 # 2, 1 PixelRepresentation  
(0028,2110) CS [01] # 2, 1 LossyImageCompression  
(0028,2114) CS [ISO_10918_1] # 12, 1 LossyImageCompressionMethod  
(7ffe0,0010) OB (PixelSequence #=2) # u/l, 1 PixelData  
  (fffe,e000) pi (no value available) # 0, 1 Item  
  (fffe,e000) pi ff\d8\xff\db\00\43\00\03\02\02\03\02\02\03\03\03\03\04\03\03\04\05... # 326, 1 Item  
(fffe,e0dd) na (SequenceDelimitationItem) # 0, 0 SequenceDelimitationItem  
hauke@Haukes-MacBook-Pro-4 DICOM %
```

Private Tags

Tags with an odd group number. Can be used by any vendor.

(0013,0000): "6"
(0013,0010): "CTP"
(0013,1010): "TCGA-LUAD"
(0013,1013): "77779002"

Good!

https://mircwiki.rsna.org/index.php?title=MIRC_CTP



Boo Siemens! Boo!



(0029, 1008)	[CSA Image Header Type]	OB: 'IMAGE NUM 4 '
(0029, 1009)	[CSA Image Header Version]	OB: '20100114'
(0029, 1010)	[CSA Image Header Info]	OB: Array of 11560 bytes
(0029, 1018)	[CSA Series Header Type]	OB: 'MR'
(0029, 1019)	[CSA Series Header Version]	OB: '20100114'
(0029, 1020)	[CSA Series Header Info]	OB: Array of 80248 bytes

Summary

DICOM is complex because medical imaging has many components, but it is not difficult.

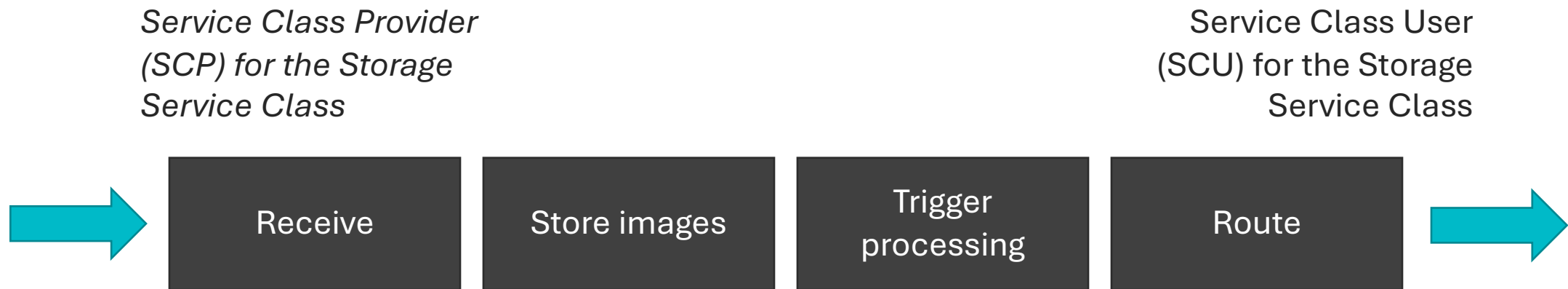
Meaning of DICOM tags:

<https://dicom.innolitics.com/ciods/rt-plan/rt-series/00080060>

|

How to build a medical workstation

Many tools are freely available – example DCMTK



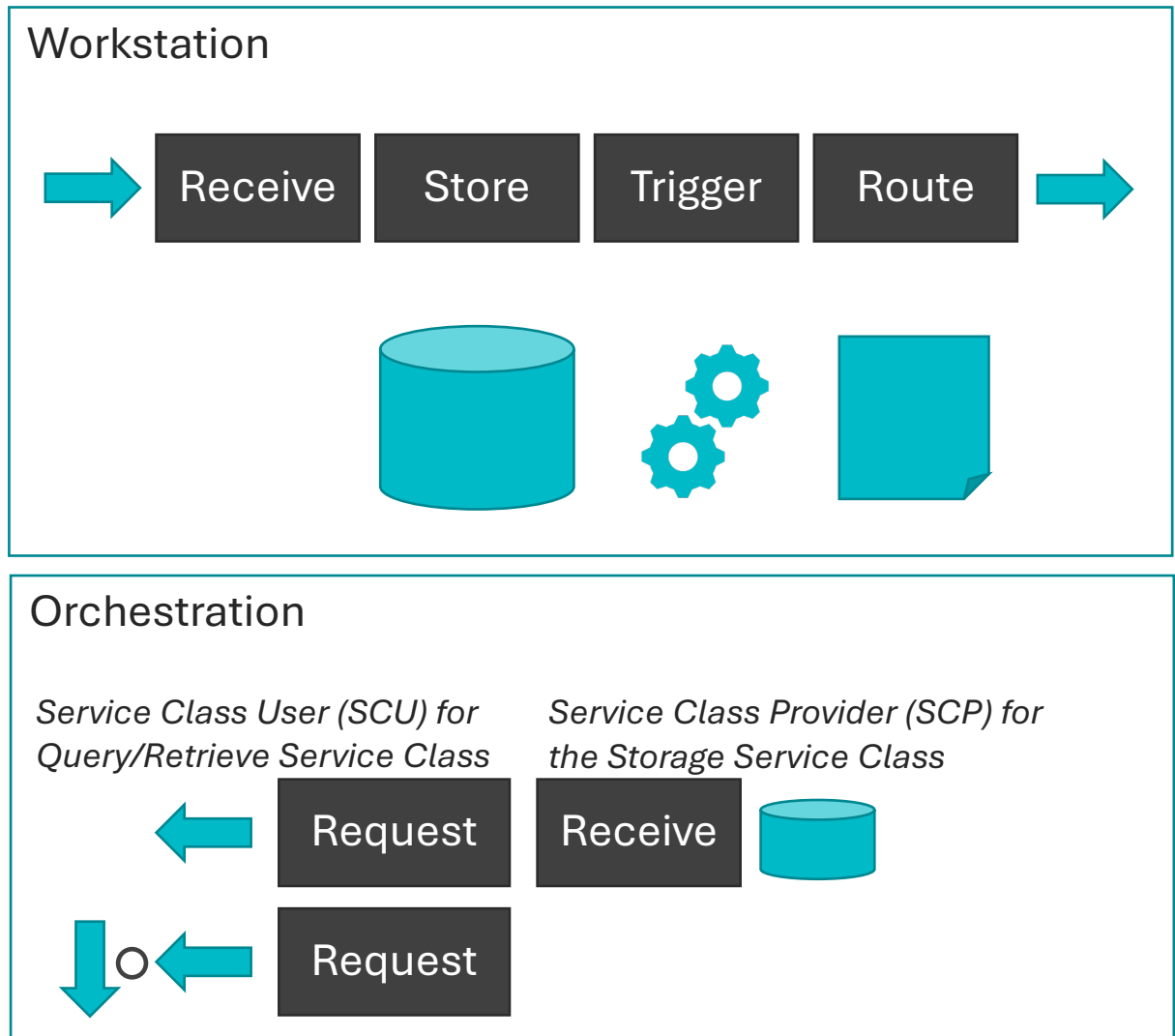
PACS

Modality

Modality

PACS

Hospital Systems



Modality

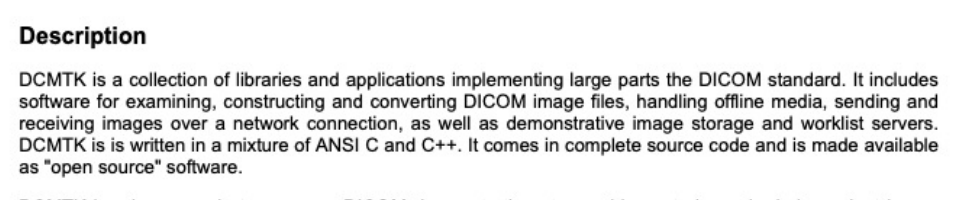
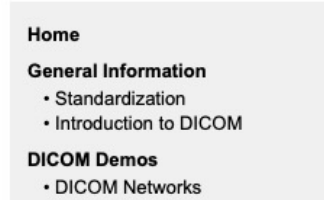
PACS

Workstation

Workstation

DCMTK

(C++ solution for Mac, Windows, Linux)

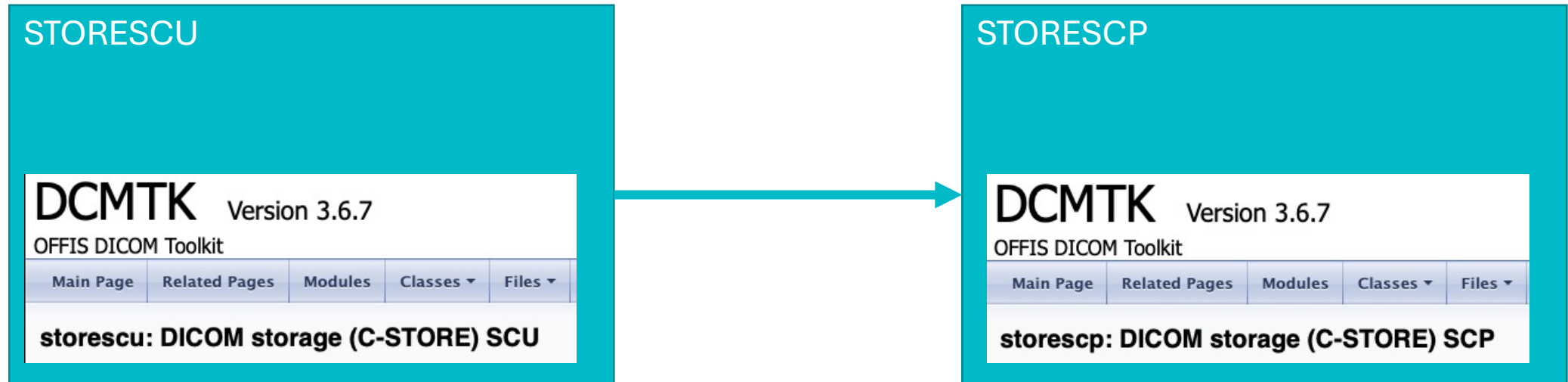


Example:

MIRC Clinical trials processor

dcm4che

<https://github.com/HaukeBartsch/data-transfer-station>



Receiver

DCMDICTPATH=/usr/local/Cellar/dcmtool/3.6.6_1/share/dcmtool/dicom.dic

```
storescp -v \
  --aetitle HAUKE \
  --exec-on-reception "myScript.sh '#a' '#c' '#r' '#p' '#f'" \
  --sort-on-study-uid scp \
  --output-directory "/tmp/dicom/" \
  11112
```

IP address

Application Entity Title
16 Characters string

Port number

Sender

cd /to/where/the/data/is/you/want/to/send

```
storescu -v -nh -aet me -aec HAUKE +r +sd localhost 11112 .
                        (AETitle)           (IP address)  (Port number)
```

Expected output at receiver:

I: Received Store Request (MsgID 2718, CT)

RECV:

W: subdirectory for study already exists: /tmp/dicom/scp_1.3.6.1.4.1.14519.5.2.1.6450.9002.583820547490466057447627106523

I: storing DICOM file: /tmp/dicom/scp_1.3.6.1.4.1.14519.5.2.1.6450.9002.583820547490466057447627106523/CT.1.3.6.1.4.1.14519.5.2.1.6450.9002.208529295915804180587759513360

We got this job: "me" "HAUKE" localhost /tmp/dicom/scp_1.3.6.1.4.1.14519.5.2.1.6450.9002.288546507090256430792536709588 CT.1.3.6.1.4.1.14519.5.2.1.6450.9002.2673086187569250

I: Received Store Request (MsgID 2719, CT)

RECV: We got this job: "me" "HAUKE" localhost /tmp/dicom/scp_1.3.6.1.4.1.14519.5.2.1.6450.9002.583820547490466057447627106523 CT.1.3.6.1.4.1.14519.5.2.1.6450.9002.2085292959

Done with DICOM? Have a look at HL7 next
