Standards and the Technology for Image Exchange

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Image Exchange

- Who?
- What?
- Why?
- When?
- How?

Image Exchange – Who

- Performer
- Interpreting radiologist
- Referring provider
- Provider to whom referred
- Patient
- Payer
- Auditor
- Accreditor
- Teacher or student
- Researcher
- Registry (cancer, dose)
- …

Image Exchange – What

- "Diagnostic" images
  - "***Complete*** set of images of ***diagnostic quality***" (AMA resolution)
- "Review" images
  - implies that somewhat lesser quality or subset adequate for some purpose and has advantage (smaller/faster)
- Key images
  - implies that someone has selected them
- Annotations
  - e.g., measurements, again implies author
- Images in-line in report
  - selected, rendered

Image Exchange – Why

- "View"
  - look at images in on-line tool +/- some interactivity
- "Download"
  - to load into some other tool (e.g., viewing, planning, PACS)
  - to transmit/mail/carry to someone else (e.g., specialist)
- "Transmit"
  - have it "sent" (electronically) to someone else
  - may send copy or link
- "Interpret"
  - "view" but with quality/tools needed for primary read

Image Exchange – When

- Primary interpretation
  - radiologist
  - non-radiologist
- Clinical care requiring image review beyond report
  - elucidate report (clarity, visualization, trust, …)
  - no report (not done yet, missing)
  - ignore report
  - diagnosticians require “diagnostic” quality images
- Remote access
  - working from home/beach/ski-slope/pub (“teleradiology 1.0”)
  - outsider/nighthawk/load balancing (“teleradiology 2.0”)
- Sharing beyond local enterprise
  - return to local care (GP)
  - referral
  - clinical trial submission

Image Exchange – How

- Local PACS
  - accessible by all local providers
  - can allow remote access (limited scalability)
  - can import outside priors (CD, network)
  - can be integrated with EHR (hyperlink to images from record/report)
- External ("Central") PACS/Archive/Repository
  - everything locally acquired gets sent centrally ("Canadian model")
  - accessible by everyone (local or outside)
  - contains all priors
  - ? more effort to integrate with EHR
  - can support VDT +/- common "universal viewer" (? reporting – "cloud PACS")
  - corrections need propagation
  - who pays?
- External Registry
  - everything remains local, but its existence is registered centrally
  - local contain is remotely accessible

How - Monolithic

- "There can be only one"

How - Monolithic

- One vendor for ***everything***
  - means no/less need for standards
- Reality: multiple modalities and modality vendors
  - DICOM standard for modality -> PACS/Archive/…
  - standard payload, standard protocol, standard workflow services
- If single central "cloud" PACS/Archive/…
  - and viewer(s) from same vendor … no (viewer) standard needed
  - specialized workstations … still need DICOM
- The "one" could even be "part of" the EHR
  - rather than "integrated with" (VA VISTA Imaging)
- Essentially expanding the size of the single "enterprise"
  - to regional/national level
- Politically/financially untenable in some jurisdictions

How - Distributed

- Multiple vendors
  - greater need for standards at the “edges” (system/vendor boundaries)
  - DICOM standard payload for all (radiology/cardiology) images
  - need a standard protocol too (beyond modalities)?
- Images in two or more different places
  - greater need for standards
- Share by transmission between PACS/archives
  - consistent (corrections standards)
  - complete
  - inter-changeable, -operable, -functional (e.g., store, view, analyze)
- Different “viewers” connected to different PACS/archives
  - performance ****
  - quality (software and display hardware)
  - capability (features sufficient for intended use)

How – Distributed Scalability

- 1990's PACS – centralized vs. distributed architecture
  - hotly debated
  - +/- local (workstation, room, floor, site) cache
  - affected performance, reliability, network infrastructure
- 2010's PACS/Image Sharing
  - similar issues, similar solutions (local cache, pre-fetching)
  - different scale (mergers, cross-enterprise sharing)
  - different parameters (storage and bandwidth costs)
  - different incentives (HIPAA offsite archive, MU)
  - mobile, wireless (cellular & Wi-Fi)
  - growth of Internet standards/conventions to leverage

How – Standards

- 1990's DICOM
  - standard modality-specific image payloads ("files")
  - specialized protocol and services (store, q/r, work list)
  - retrieval (as opposed to sending) across firewalls awkward
  - fast if implementations optimized but many are not
  - non-trivial learning curve (arcane terminology)
- 2010's DICOM (and IHE XDS-I)
  - same payload (model), but alternate XML, JSON headers
  - same protocols/services, but alternate HTTP URL, SOAP and RESTful methods (WADO-URI, -WS, -RS, STOW, QIDO)
  - metadata access without retrieving entire objects
  - "server-side" rendered images (windowed, sub-region, scaled), e.g., encoded as 8 bit JPEG, GIF, PNG, etc.
  - more accessible to generic "web" developers

How – Standards Proliferation

- *"The nice thing about standards is that you have so many to choose from"* – Andrew Tanenbaum
- Are we creating a mess?
  - chasing buzzword compliance
  - religious wars over SOAP vs. REST, so put both in DICOM
  - more charitably, different advantages (security, cache)
- E.g., viewer talking to (another vendor's) server:
  - traditional DICOM protocol (thick client OK, JavaScript not)
  - XDS-I RAD-69 retrieval of DICOM (JS SOAP pain)
  - WADO-URI of DICOM or JPEG (JS OK, but which slices?)
  - WADO-WS of DICOM (JS SOAP pain, XML metadata)
  - WADO-RS of DICOM (JS URL + JSON metadata, sweet)

How – Standards Performance

- DICOM is "slow" (not necessarily)
  - perception problem, implementations not optimized
  - need more than just "faster" protocol
  - fast access to the right information at the right time
  - e.g., don't require downloading of the entire uncompressed study before showing first or key image
  - which images/frames, what resolution, etc.?
- Client needs information to know what to ask for
  - access to (organized, consistent) metadata
- Server needs to provide it quickly
  - bulk data in (optimal) encoding/order requested

How – Standards Performance

- Avoid "impedance mismatch"
  - in design expectations of client and server
  - e.g., optimal sequence of operations (what to request in what order for variety of use cases)
  - one cause of "bad reputation" for mixed vendor viewer/ archive performance
  - implementers may prefer proprietary rather than standard choices because they have control over both ends and the middle
  - mitigate with good off-the-shelf tools (e.g., how many developers write their own web server from scratch, rather than use Apache, etc.)

How – Performance

- Match expectations with architecture/resources
  - "A" is for "Absent" rather than "Archived" (Rego/Kennedy)
  - no "standard" interface can compensate for images on slow media rather than spinning/close by
  - decoupling archive from viewer and moving offsite requires adequate bandwidth (esp., for lossless)
  - "tiered" life cycle management with priors on slow media without prefetching -> unsatisfying performance
  - ***perceptible*** delay -> user avoidance (2 seconds is ***not*** good enough)
  - retention period based "purging" may discard the one prior study that's really needed (and compromises teaching, research, etc.); besides, if you are growing …

How – Which Standards

- Which (DICOM) standards for what?
  - image encoding – DICOM PS3.10 (including other 'ology)
  - modality -> PACS – DICOM PS3.4/PS3.7/PS3.8 protocol
  - image store/query/retrieve inside site – DICOM protocol
  - remote access – XDS-I.b, DICOM PS3.19 WADO-URI, WADO-WS or WADO-RS (+/- STOW send, QIDO query)
  - key images – DICOM Key Object Selection (IHE KIN)
  - annotations – DICOM Presentation States (IHE CPI)
  - corrections and life cycle management – IHE Image Object Change Management (IOCM)
  - EHR integration (link) – absolute URL or IHE Invoke Image Display (IID) parameterized URL
  - viewer functionality – IHE Basic Image Review (BIR)

Recommendations for Image Sharing

Health IT Standards Committee
A Public Advisory Body on Health Information Technology to the National Coordinator for Health IT

	TIER 1 Exchange of Text-Based Reports	TIER 2 Exchange of Non-Radiology/ Cardiology Images	TIER 3 Exchange of Radiology/ Cardiology Images - Full Study	TIER 4 Exchange of Radiology/ Cardiology Images- Key Images
CONTENT	Plain text +/- structured headings, scanned/ rendered document	"Clinical Capture" images with or without metadata	Complete set of images of diagnostic quality	IHE Key Image Note (KIN) and images referenced therein
ENCODING	PDF, HL7 2.x OBX segment content, CDA L1, or CDA L2 + CCDA DIR template	Without metadata: JPEG, PNG, DNG, PDF, H.264; with metadata: DICOM	DICOM (object appropriate to modality)	
VOCABULARY	LOINC to describe study/procedure, LOINC for structured headings	LOINC to describe study/ procedure (in DICOM header/XDS metadata)	LOINC to describe study/ procedure	LOINC to describe study/ procedure, DICOM DCID 7010 for titles
PUSH	HL7 V2 ORU/MDM MLLP over VPN/TLS, DIRECT SMTP or XDR preferred	DIRECT SMTP or XDR, DICOM DIMSE/ULP or STOW over VPN/TLS, IHE XDR-I	DICOM DIMSE/ULP or STOW over VPN/TLS, IHE XDR-I	DICOM DIMSE/ULP or STOW over VPN/TLS, IHE XDR-I
PULL	IHE XDS	IHE XDS-I, DICOM WADO-URI or WADO-RS over VPN/ TLS	IHE XDS-I, DICOM WADO-URI or WADO-RS over VPN/TLS	IHE XDS-I, DICOM WADO-URI or WADO-RS over VPN/TLS
VIEW			IHE IID, else pull (WADO-URI+/- XDS-I for rendered JPEGs when sufficient)	IHE IID, else pull (WADO-URI +/-XDS-I for rendered JPEGs when sufficient

How – Which Standards

- Which (underlying IT) standards for what?
  - TCP/IP for local and Internet (all DICOM, old and new)
  - HTTP for web-based applications with URL-based image (+/- report) links
  - TLS security under HTTP (or DICOM PS3.8) (HTTPS)
  - user authentication ? OAUTH ? SAML (IHE IUA and XUA)
  - for small sizes, email (SMTP) (defined in DICOM, also NHIN DIRECT)
  - could use FTP but rarely in clinical production

How – Browser Standards

- Depends entirely on viewer technology & paradigm
- Zero footprint
  - No helper apps, plugins, applets, Flash or SilverLight
  - Not even any JavaScript ????
- Absolute zero – HTML pre-5, frames, tables, images
- Almost zero – JavaScript +/- HTML5 Canvas
- Pretending to be zero – Flash (etc.) dependency
- Not zero at all – just fine for many deployments
  - thick client spawned by browser (or EHR application)
  - especially platform-specific mobile "app"
- "Web-based" PACS & "remote" viewers since 1990s

Other 'ologies

- Radiology and cardiology
  - although report is the end product, images required
  - well-defined workflow (ordered, scheduled)
- Other 'ologies
  - dermatology, endoscopy, medical photography …
  - ad hoc workflow
    - +/- ordered, scheduled or incidental part of the activity (clinic visit)
  - some metadata in camera/phone JPEG EXIF (date, time)
  - need to "attach" patient demographics (ID, name)
  - convert to DICOM ("encapsulate" still-frame or movie)
  - record metadata separately (migration problem)
  - new IHE Web Image Capture (WIC) uses DICOM STOW

Final Thoughts

- *"Change is inevitable. Change is constant."* Benjamin Disraeli
- Applies to
  - modalities (new, e.g., breast tomosynthesis)
  - use cases (e.g.,EHR, teleradiology)
  - technology (network, mobile vs. CD sneaker-net)
  - standards like DICOM
- *"The model is the message"* Dean Bidgood paraphrasing Marshall McLuhan
  - underlying (DICOM) information model transcends the protocol (DICOM DIMSE, HTTP URI, SOAP, REST) or encoding (binary, XML, JSON)

What You Need

- An image sharing solution that
  - is scalable to all referral sources and destinations
  - provides patient access
  - supports view, download and transmit (VDT) with diagnostic quality
  - supports viewing for primary interpretation (tools like 3D, fusion, measure)
  - is easily and well integrated with the local and remote users' EHRs +/- workflow engines +/- voice reporting systems (likely different vendors)
  - adapts quickly and cheaply to new modalities (like DBT)
  - handles other "'ologies" (preferably as DICOM with metadata)
  - is responsive for current and prior viewing (imperceptible delay)
  - uses DICOM, IHE and IT standards to the extent necessary to satisfy any multi-vendor components selected, and to integrate with advanced applications (like RT planning), and is adaptable to new standards
  - satisfies long term archival, disaster recovery and migration requirements
  - complies with IT infrastructure imperatives (single sign on, zero footprint, etc.)
  - may or may not involve complete replacement of existing PACS infrastructure

There is no need for PACS, only Image Sharing.

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+/- archiving, workflow