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DICOM-compatible compression of WSI and diagnostic evaluation

R. Zwönitzer, H. Hofmann, A. Roessner , T. Kalinski

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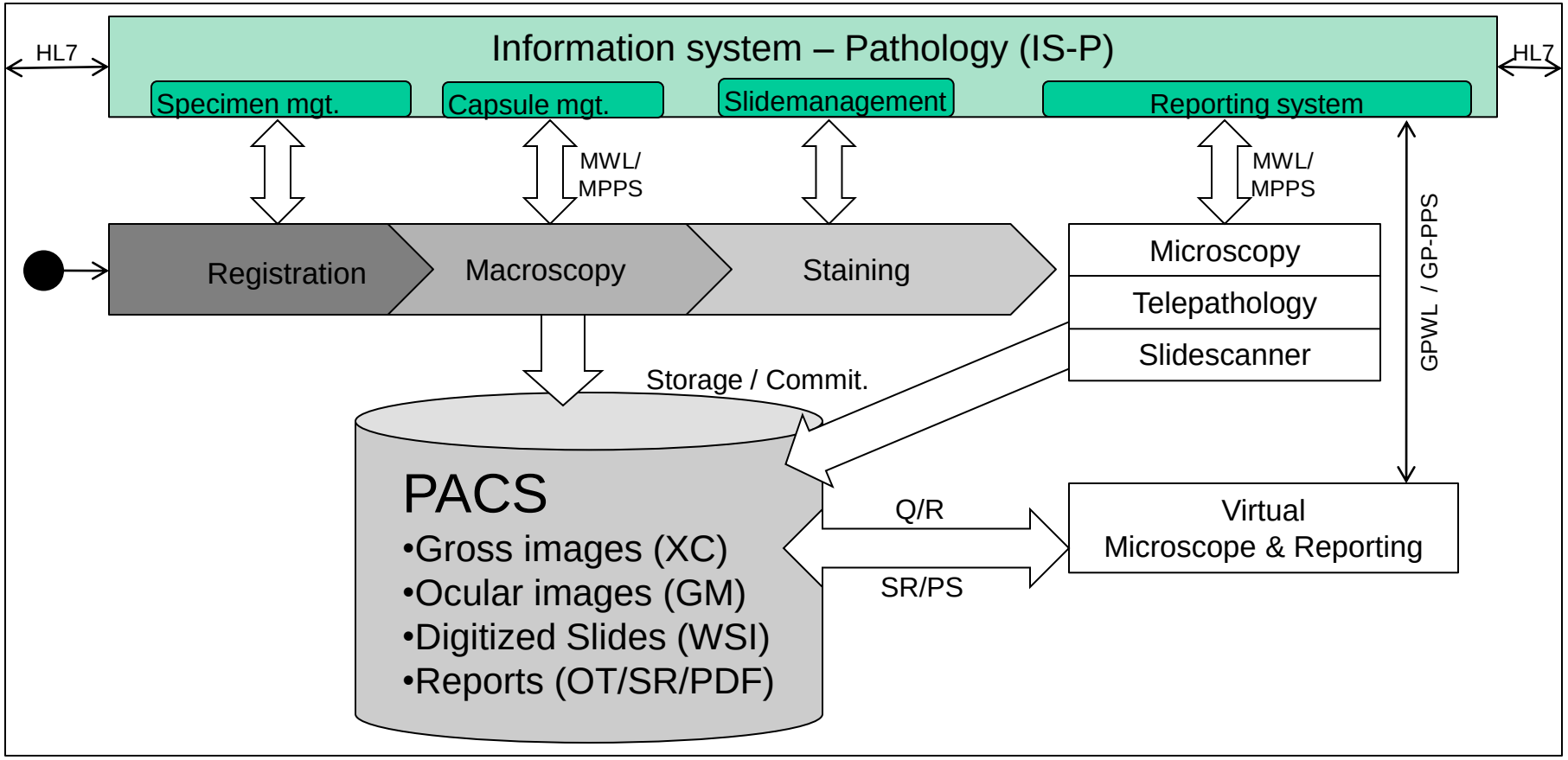
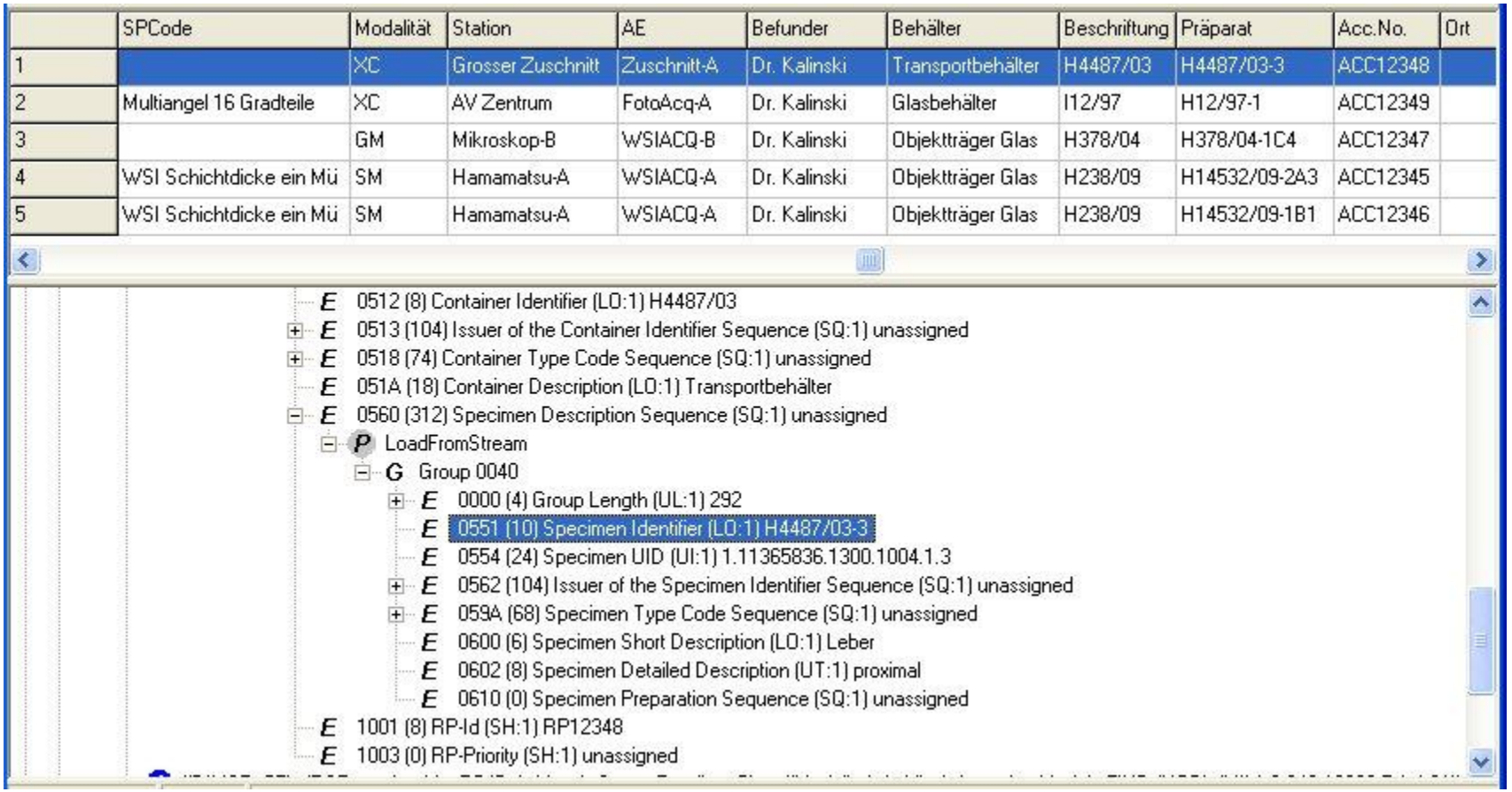
Overview Digital Pathology (DP)



1. Future save integration in clinical infrastructure through DICOM
2. Organization of documents within a scalable information model (IM)
3. Query and retrieve out of this IM → Image distribution

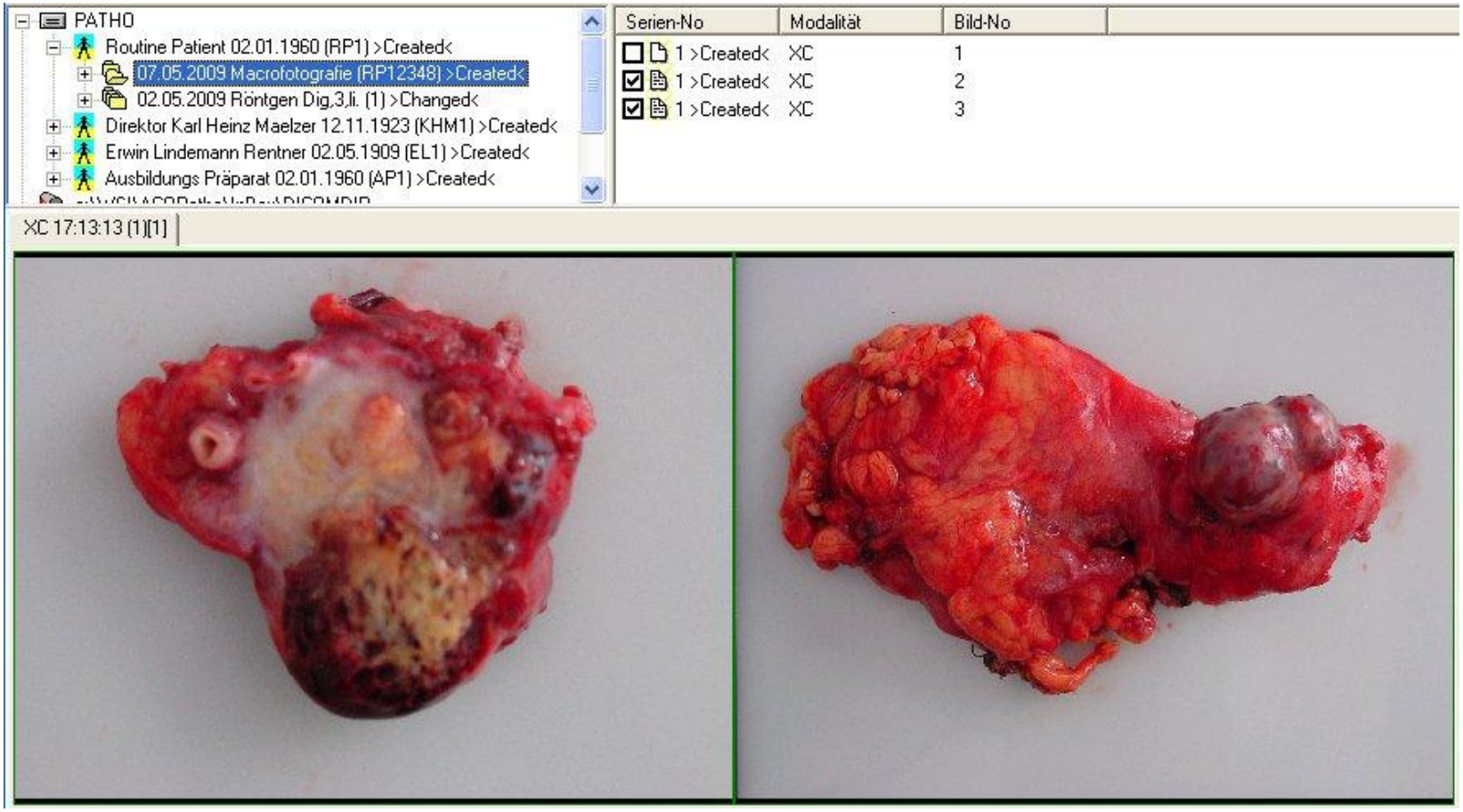
Modality Worklist (MWL) – Specimen Identification

	SPCode	Modalität	Station	AE	Befunder	Behälter	Beschriftung	Präparat	Acc.No.	Ort
1		XC	Grosser Zuschnitt	Zuschnitt-A	Dr. Kalinski	Transportbehälter	H4487/03	H4487/03-3	ACC12348	
2	Multiangel 16 Gradteile	XC	AV Zentrum	FotoAcq-A	Dr. Kalinski	Glasbehälter	I12/97	H12/97-1	ACC12349	
3		GM	Mikroskop-B	WSIACQ-B	Dr. Kalinski	Objektträger Glas	H378/04	H378/04-1C4	ACC12347	
4	WSI Schichtdicke ein Mü	SM	Hamamatsu-A	WSIACQ-A	Dr. Kalinski	Objektträger Glas	H238/09	H14532/09-2A3	ACC12345	
5	WSI Schichtdicke ein Mü	SM	Hamamatsu-A	WSIACQ-A	Dr. Kalinski	Objektträger Glas	H238/09	H14532/09-1B1	ACC12346	



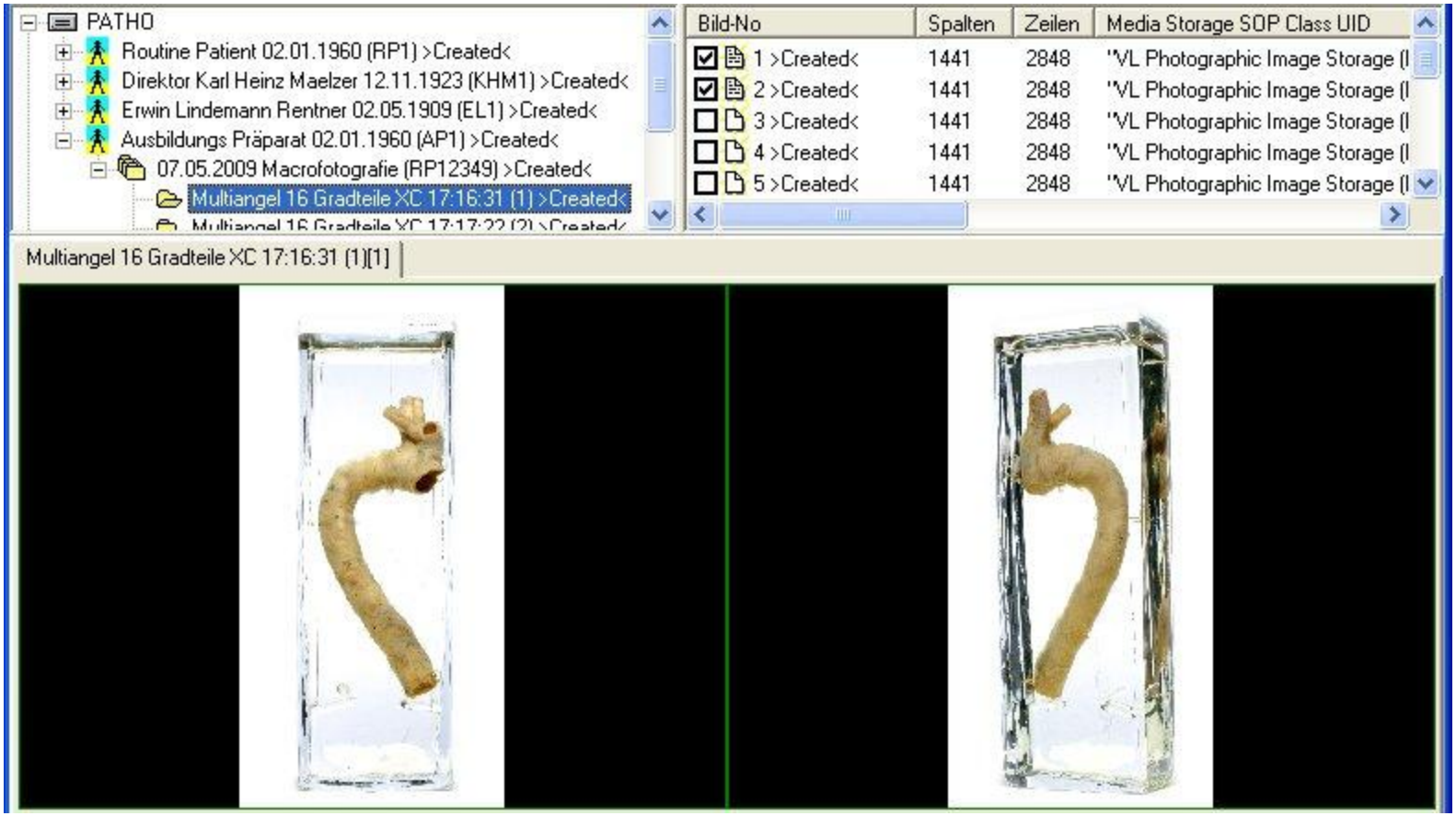
- Specimen information and workflow communication according to DICOM requires extensions from Supplement 122.

Macroscopic Images (Clinic)



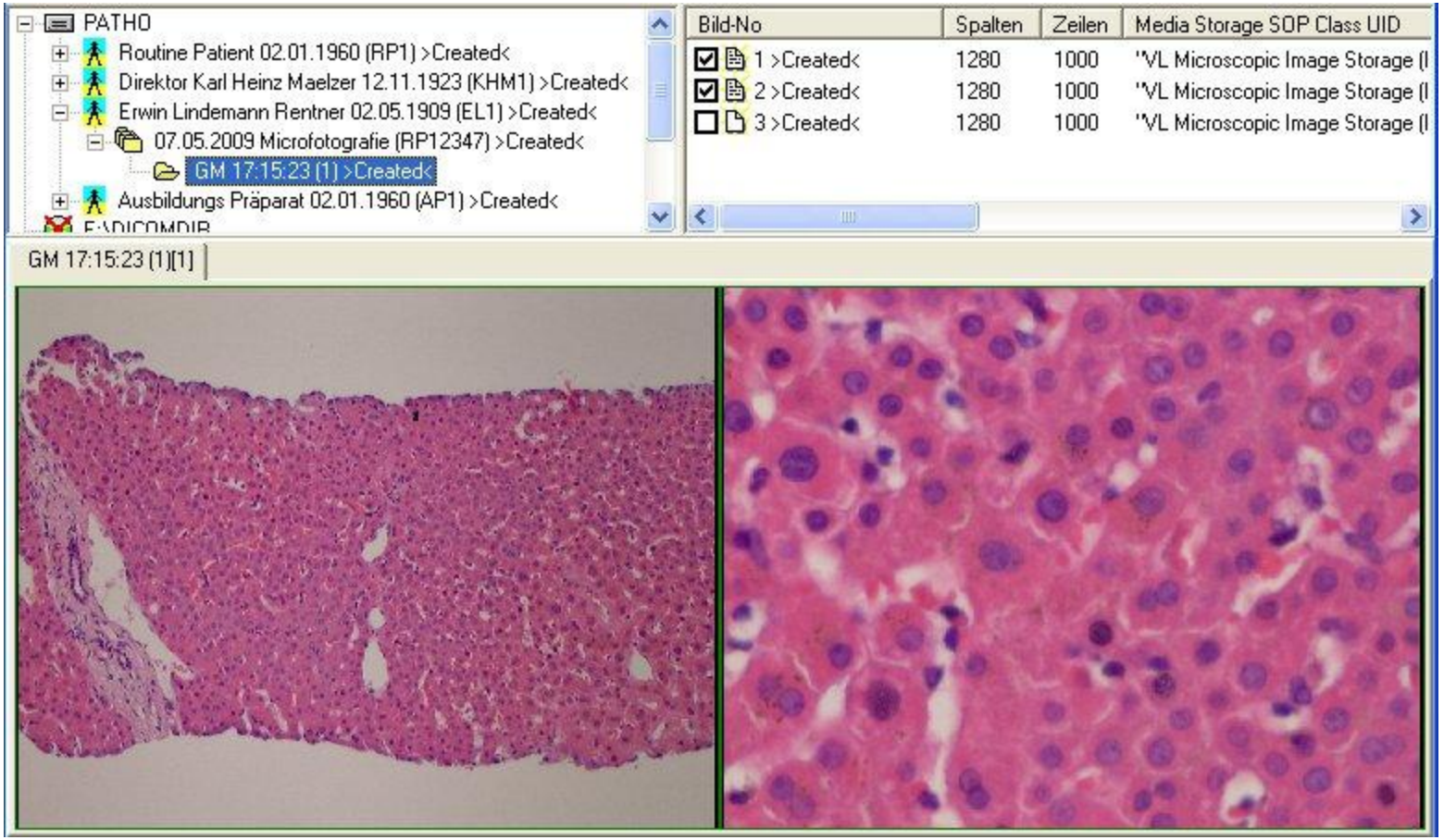
- DICOM Class Visible Light Photographic is sufficient
- Specimen ids required → Supplement 122

Macroscopic Images (Teaching & Learning)



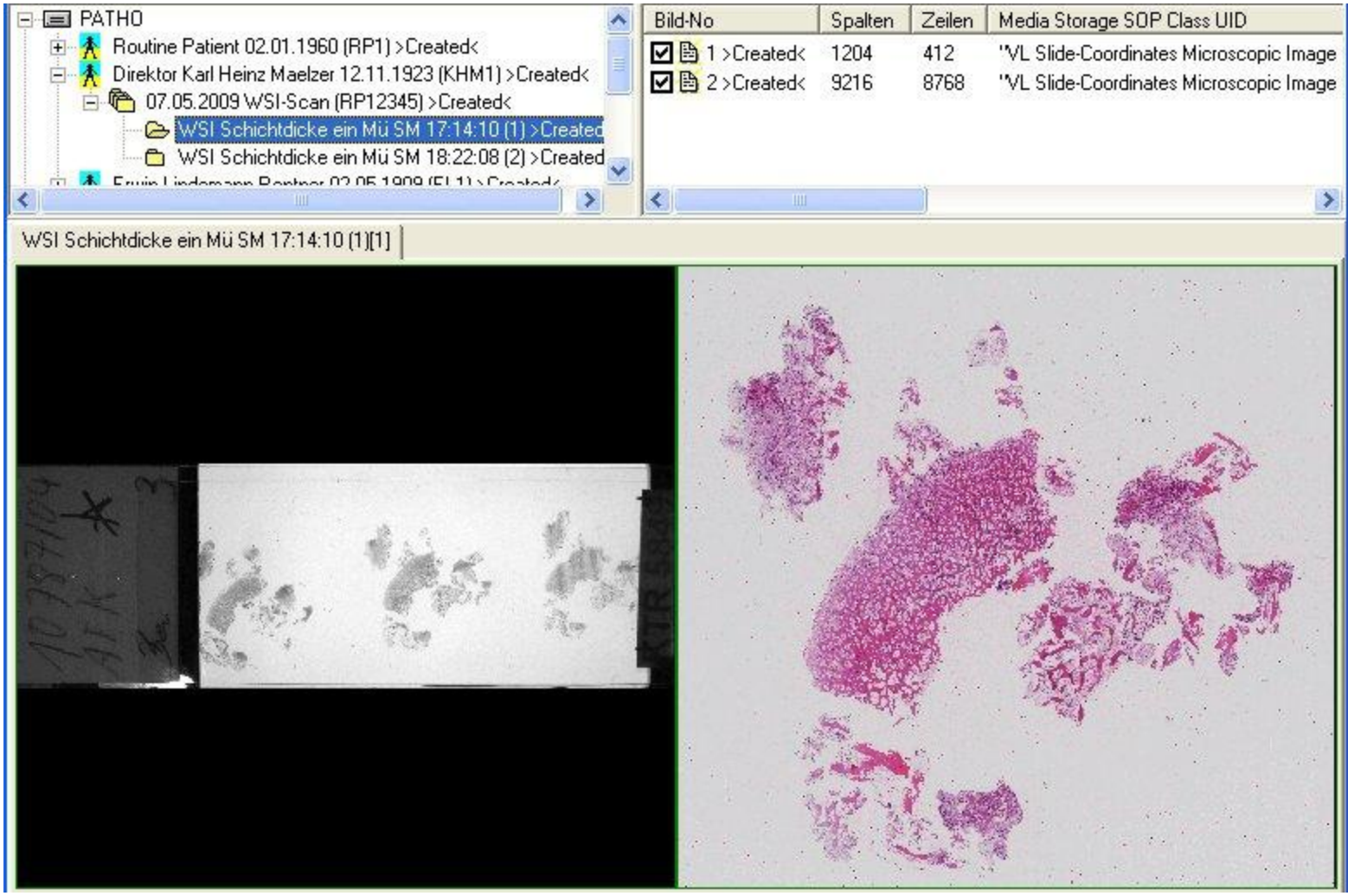
- DICOM Class Visible Light Photographic is not sufficient.
- Multi frame module needed

Microscopic Ocular Images

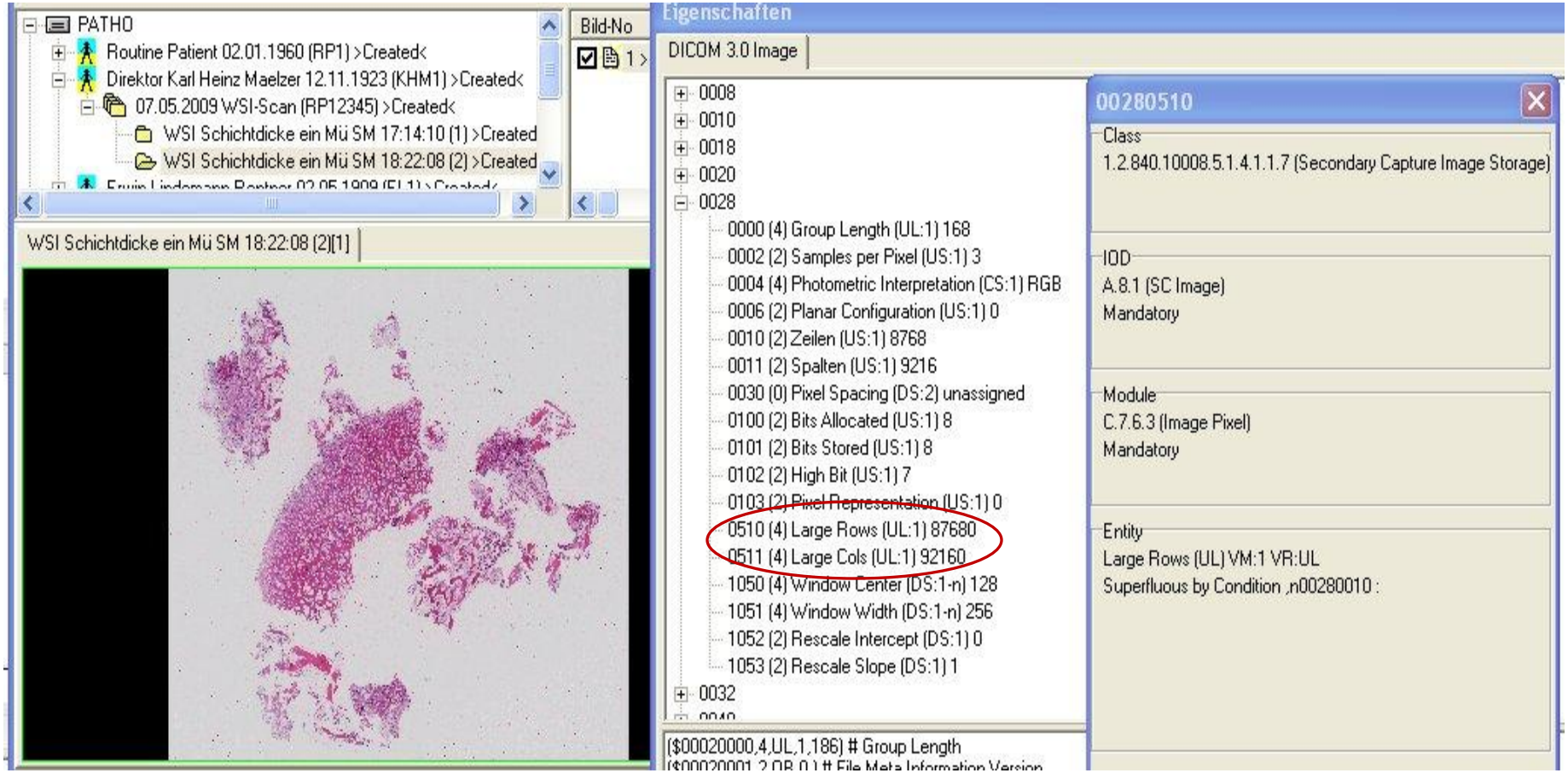


- DICOM Class Visible Light Microscopic is sufficient
- Single images in series

Whole Slide Images (WSI)

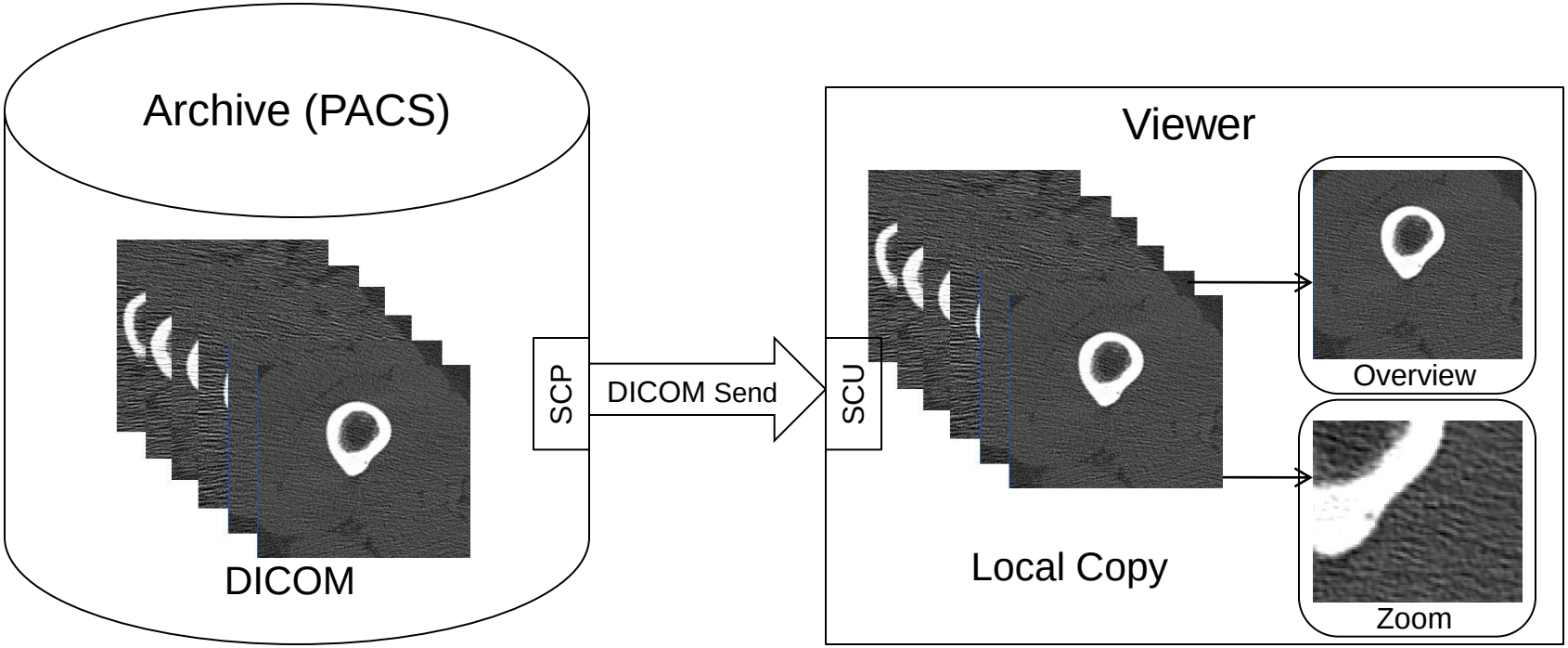


Whole Slide Images (WSI)



- DICOM Class Visible Light Slide Coordinates is not sufficient
- Multi frame module and Large-Dimension-Tags needed

Radiologic Image Distribution - DICOM (store and forward)

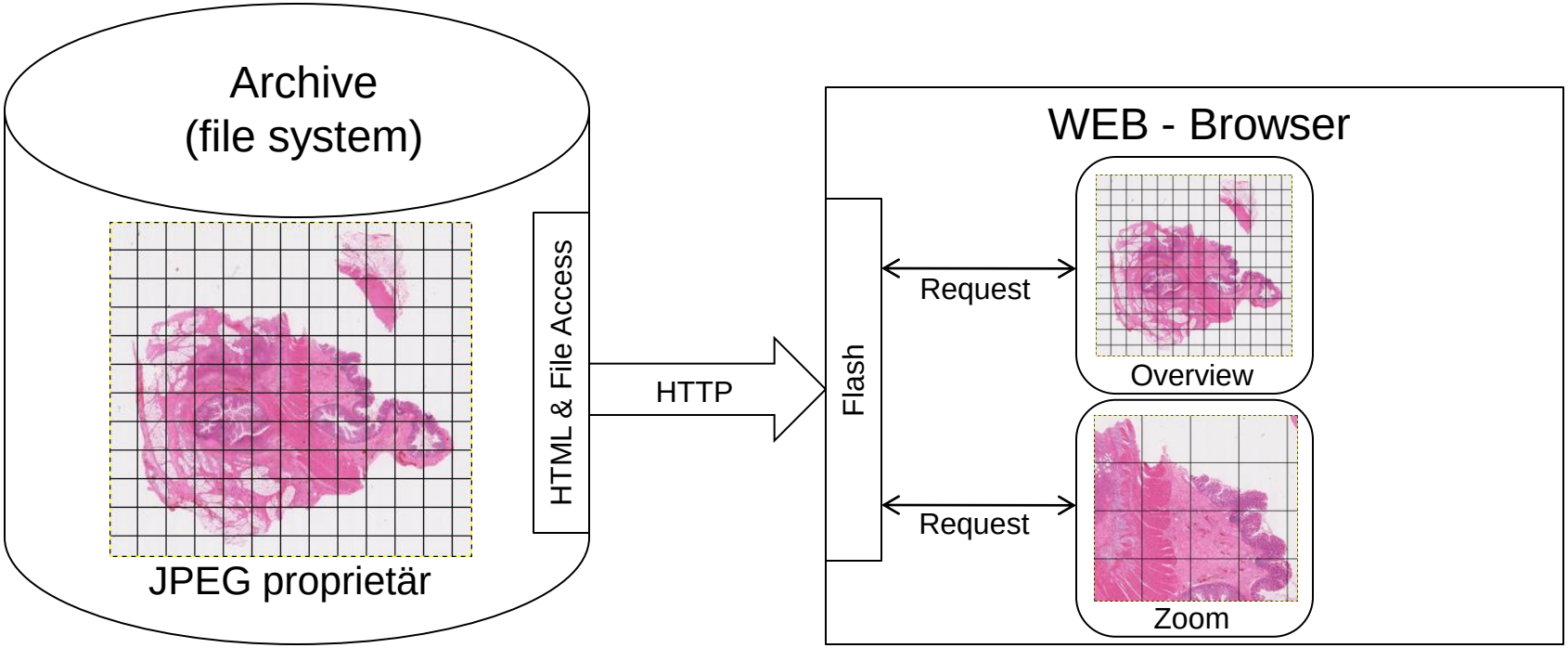


- Display after complete transport only

→ Store and forward is not sufficient for very large WSI images

→ Integration of JPIP in DICOM solves this problem by streaming

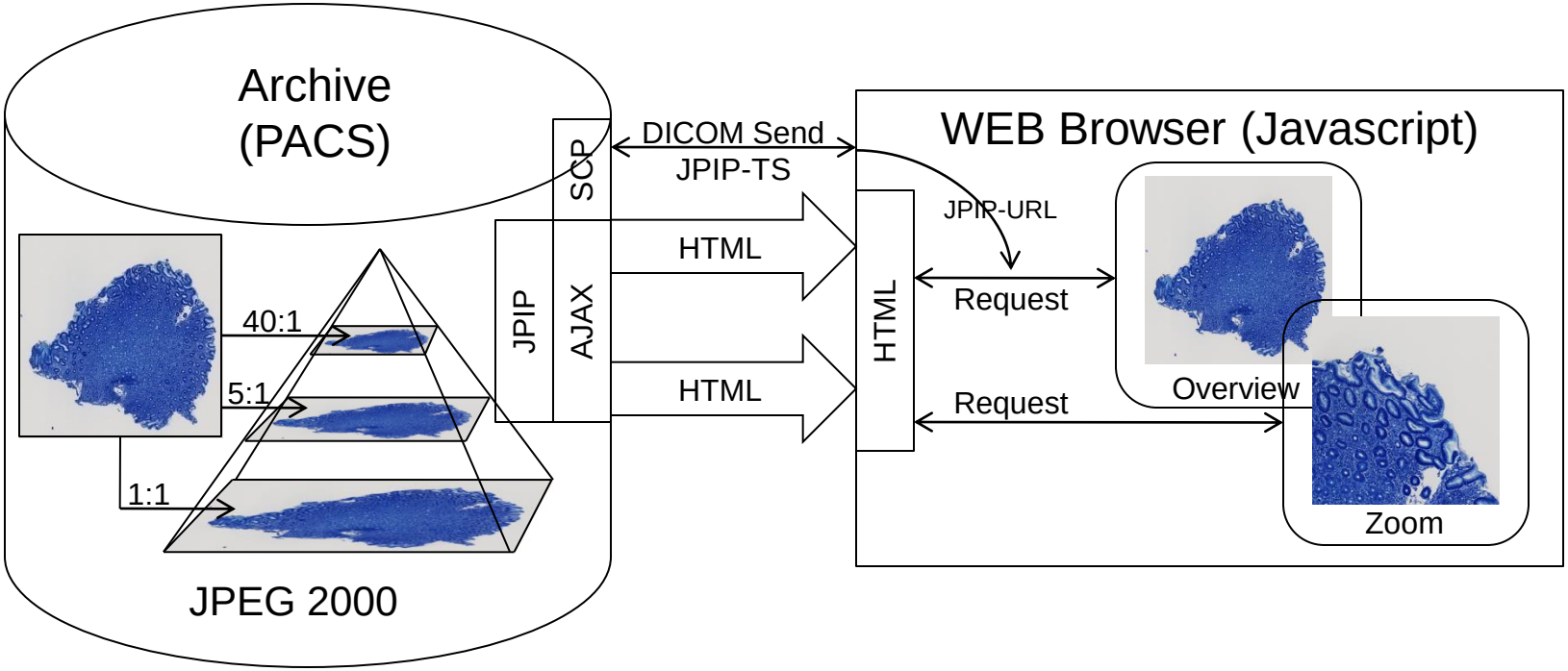
Image Distribution „Fractioning“ (e.g. silverZoom , Zoomify)



- Image fractioning results in higher resource loads
- Problems possible by active parts in browser (e.g. Flash)
- Non-standard format und protocol, no integration in DICOM

→ Not sufficient for future save archiving huge amount of data

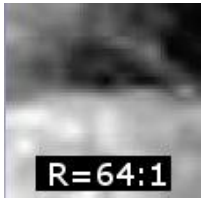
Image Distribution - JPEG2000 / JPIP (AJAX)



- Image calculation on demand on server.
- Access to JPEG2000 images through JPIP or directly.
- Parallel usage for intra- and internet possible, one format only.

→ Sufficient for intranet and internet but elaboration on server.

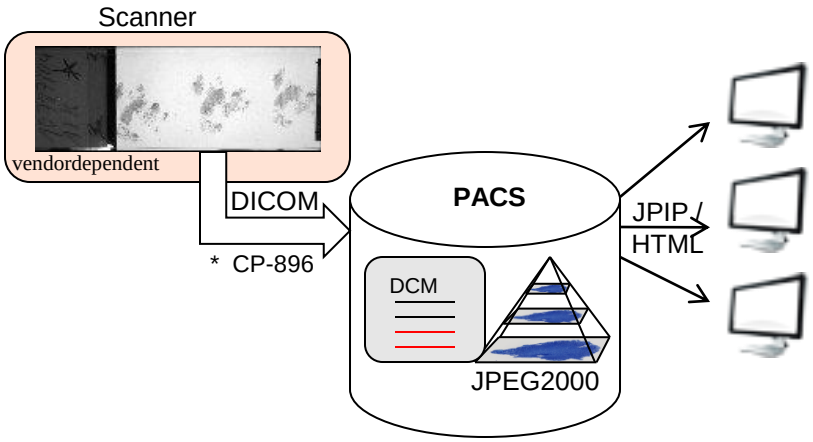
Technical Requirements Image Compression



	JPEG2000	JPEG
• Integration in DICOM	yes	yes
• Image quality (over all lossy)	1	3
• Efficiency	3	1
→ Effort for coding and decoding		
• Data organization und flexibility	1	5
→ Growing amounts, all sizes and kinds of images		
• Autonomy	2	4
→ Future save		
• Scalable with use case	1	4
→ Supports image distribution with progressive requests		
• Only one Algorithm (lossy and lossless)	1	5
→ Format supports all criteria	yes	no

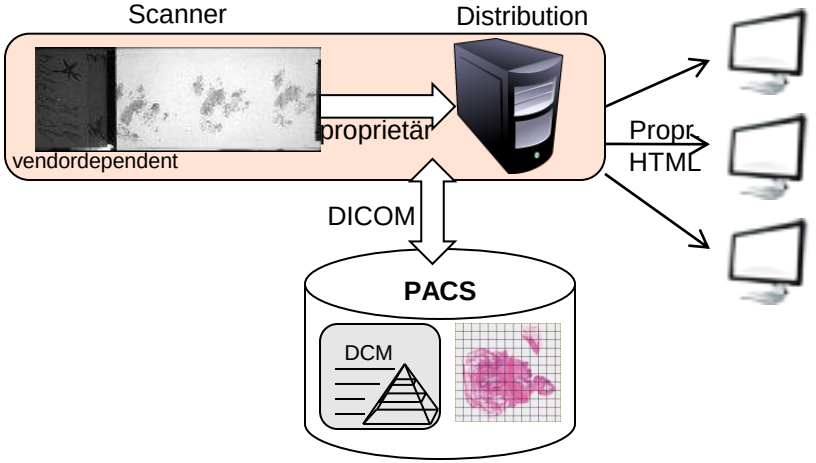
Current WSI Approaches

„Large Dimensions“



- New tags for large dimensions or extended negotiation (*)
- DICOM Header & JPEG2000
- Image distribution out of archive
- Vendor independent
- Synergies with other image classes

Supplement 145

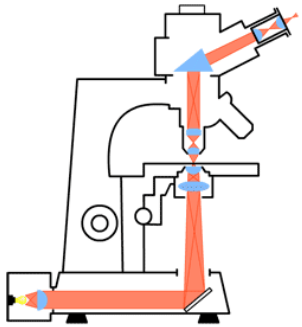


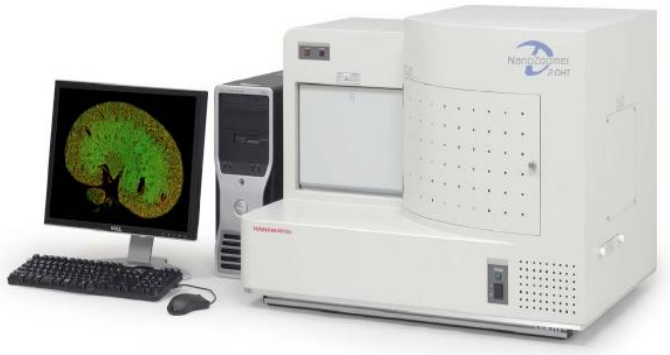
- Fractions instead of huge images
- DICOM Header contains progressive information
- Extra distribution needed
- Dependency on propr. distribution
- No synergy effects

Summary so far …

- DICOM is usable for Digital Pathology
  - → Supplement 122 functional
  - → Worklist and MPPS are sufficient
  - → Existing image classes with multi frame applicable
  - → JPEG2000 integration for lossy encoding and streaming
- JPEG2000
  - → Image distribution for all image types and transports with JPIP / AJAX
  - → Efficiency depends on optimization
- DICOM WSI
  - → Supplement 145 introduces image fractioning
  - → Large dimensions anticipated, even optional
  - → Usability of old archives for WSI image distribution doubtful
- Diagnostic Evaluation
  - → Lossy compression up to 75:1 applicable to biopsy images
  - → Other image contents to be evaluated

Can we trust virtual microscopy in diagnostic pathology?





Essential functions of conventional microscopes:

- Magnification
- Focusing
- Polarizing

Scanner conditions (as provided):

- Uncompressed raw data
- Resolution (0,23 µm/pixel)
- Multiplane images

→ Comparative investigations on the diagnostic accuracy using conventional microscopy or virtual microscopy with different qualities

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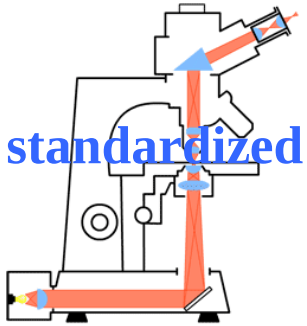

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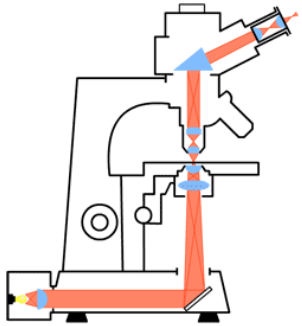
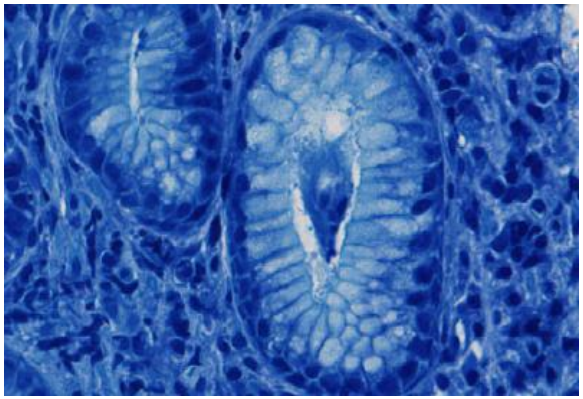
→ Comparative investigations on the diagnostic accuracy using conventional microscopy or virtual microscopy with different qualities

To begin with... Helicobacter gastritis.



Updated Sydney-classification:

- Comparable grading of Helicobacter gastritis:
  - very coarse criteria:
    - intestinal metaplasia (Grades 0,1,2,3)
    - atrophy (Grades 0,1,2,3) [not applicable in our studies]
  - coarse criteria:
    - chronic inflammation (Grades 0,1,2,3)
    - activity of inflammation (Grades 0,1,2,3)
  - fine criteria:
    - Helicobacter colonization (Grades 0,1,2,3)



Do we need focusing for the correct diagnosis?

Am J Clin Pathol 2008;130:259-264

Virtual 3D Microscopy Using Multiplane Whole Slide Images in Diagnostic Pathology

Thomas Kalinski, MD,[1] Ralf Zwönitzer,[2] Saadettin Sel, MD,[1] Matthias Evert, MD,[1,3] Thomas Guenther, MD,[1] Harald Hofmann,[4] Johannes Bernarding, MD,[2] and Albert Roessner, MD[1]

<u>Comparative Study No.1:</u>

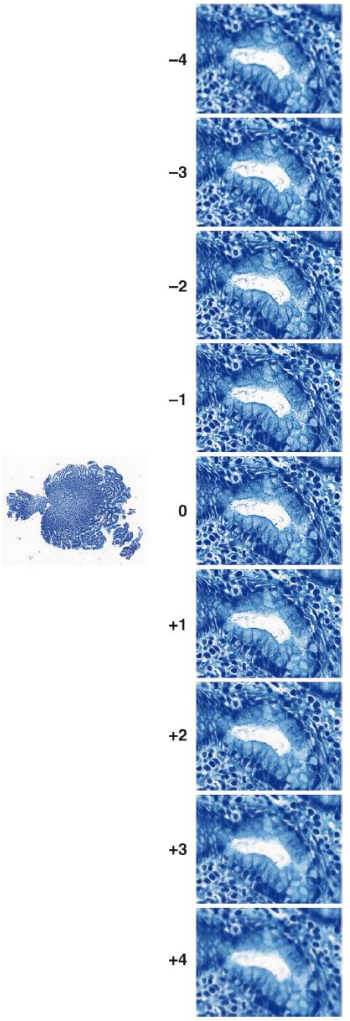
- 144 gastric biospies with/without Helicobacter gastritis
- 3 consultant pathologists:
  - conventional microscopy versus:
  - 1. virtual 2D microscopy (single focus plane)
  - 2. virtual 3D microscopy (5 focus planes)
  - 3. virtual 3D mircoscopy (9 focus planes)
- Standard format: JPEG2000; Compression: 20:1

<u>Results:</u>

→ Virtual 3D microscopy with 9 focus planes is required for the correct diagnosis of ‚fine' criteria such as Helicobacter colonization

[specificity/sensitivity: ≥0.95; kappa: 0.9]

→ Virtual 2D microscopy is sufficient for ‚coarse' criteria

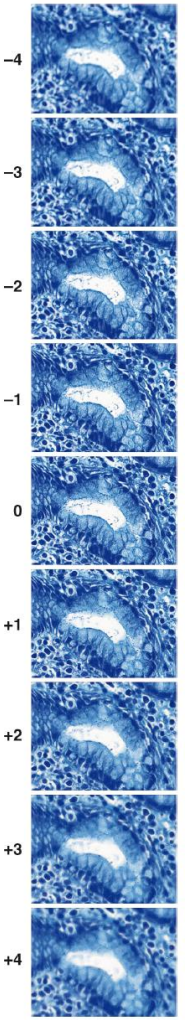


Compression in virtual 3D microscopy -- where is the limit?

Human Pathology (2009) 40, 998–1005

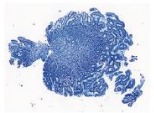
Lossy compression in diagnostic virtual 3-dimensional microscopy—where is the limit?

Thomas Kalinski MD[a,*], Ralf Zwönitzer[b], Florian Grabellus MD[c], Sien-Yi Sheu MD[c], Saadettin Sel MD[a], Harald Hofmann[d], Johannes Bernarding MD[b], Albert Roessner MD[a]



Comparative Study No.2:

- 46 gastric biospies with/without Helicobacter gastritis
- 3 consultant pathologists:
  - conventional microscopy versus:
  - 1. virtual 3D microscopy (9 focus planes); Compression 20:1 (no visible artifacts)
  - 2. virtual 3D microscopy (9 focus planes); Compression 40:1
  - 3. virtual 3D microscopy (9 focus planes); Compression 50:1 (little artifacts)
  - 4. virtual 3D microscopy (9 focus planes); Compression 75:1
  - 5. virtual 3D microscopy (9 focus planes); Compression 200:1 (clearly visible artifacts)



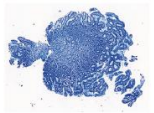
Results:

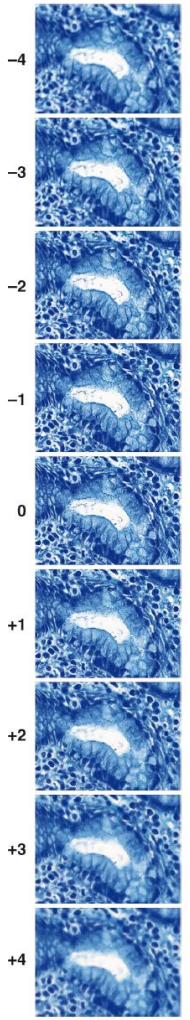
→ Even high compression rates with clearly visible artifacts have little influence on the diagnostic accuracy in Helicobacter gastritis!

Can we really do without uncompressed virtual slide?

Comparative Study No.3:

- 46 gastric biospies with/without Helicobacter gastritis
- 3 consultant pathologists:
  - conventional microscopy versus:
  - 1. virtual 3D microscopy (9 focus planes); Compression 1:1 (no compression)
  - 2. virtual 3D microscopy (9 focus planes); Compression 5:1
  - 3. virtual 3D microscopy (9 focus planes); Compression 10:1
  - 4. virtual 3D microscopy (9 focus planes); Compression 20:1





Results:

→ Uncompressed or nearly uncompressed slides do not enhance the diagnostic accuracy!

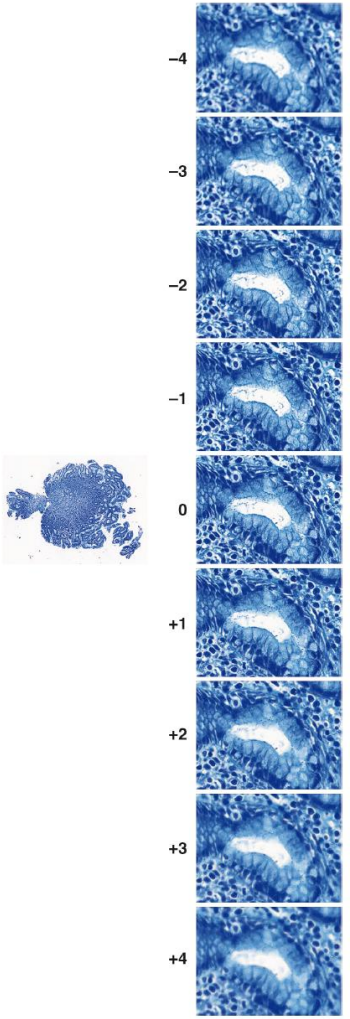
What are the remaining questions?

Next comparative studies on lossy compression:

- Where is the limit in diagnostic virtual (2D/3D) microscopy regarding diverse diagnoses?

→ Where is the limit in *image analysis*?

→ Towards a definition of the minimum image quality required in diagnostic virtual microscopy.



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Thank you very much

for your attention.