

# Standardization efforts of digital pathology in Europe

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**Abstract.** *Background:* EURO-TELEPATH is a European COST Action IC0604. It started in 2007 and will end in November 2011. Its main objectives are evaluating and validating the common technological framework and communication standards required to access, transmit, and manage digital medical records by pathologists and other medical specialties in a networked environment.

*Business modelling:* Working Group 1, “Business Modelling in Pathology,” has designed main pathology processes – Frozen Study, Formalin Fixed Specimen Study, Telepathology, Cytology, and Autopsy – using Business Process Modelling Notation (BPMN).

*Informatics standards in pathology:* Working Group 2 has been dedicated to promoting the application of informatics standards in pathology, collaborating with Integrating Healthcare Enterprise (IHE), Digital Imaging and Communications in Medicine (DICOM), Health Level Seven (HL7), and other standardization bodies.

*Conclusions:* Health terminology standardization research has become a topic of great interest. Future research work should focus on standardizing automatic image analysis and tissue microarrays imaging.

**Keywords:** Digital pathology, digital slide, business modelling, DICOM, HL7, IHE, SNOMED CT

## 1. Background

EURO-TELEPATH stands for “Telepathology Network in Europe,” a European COST Action IC0604 (<http://www.conganat.org/eurotelepath/>). It was started in 2007 and will end in November 2011. COST (Cooperation in Science and Technology) fosters collaboration among European research groups working in an adequate technological framework for the management of multimedia electronic healthcare records, in informatics applied to anatomic pathology, and, most importantly, in IT standards applied to digital medical images [3]. It promotes cooperation among scientists and researchers across Europe

and is supported by the European Union Research and Technological Development (EU RTD) Framework Programme. COST Action IC0604 belongs to the domain of Information and Communication Technologies (ICT).

## 2. Digital pathology

The concept of digital pathology includes the use of multiple digital images (gross studies, microscopic, and, molecular pathology images), including whole slide microscopic digital images that are integrated with pathology information systems, enterprise image repositories, and electronic health records. The main challenges in digital pathology include educational, technological, and complexity of health information systems.

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The main objectives of EURO-TELEPATH are evaluating and validating the common technological framework and communication standards required to access, transmit, and manage digital medical records by pathologists and other medical specialties in a networked environment.

Research directions in EURO-TELEPATH focus on the following.

- Automation procedures in pathology (the best technology available).
- Scanning solutions for pathology microscopic slides.
- Technological solutions for compression and storage problems with large image files.
- Virtual slide standard viewer specifications that enable efficient reviewing of pathology images.
- International standards like Digital Imaging and Communications in Medicine (DICOM), Health Level Seven (HL7) and Systematized Nomenclature of Medicine-Clinical Terms (SNOMED CT), European Committee for Standardization (CEN), and Integrating the Healthcare Enterprise (IHE) initiative.
- Model for pathology and other hospital information systems.
- A European-scope telepathology network.
- Collection of interesting and typical samples and clinico-pathological sessions

To achieve these objectives, research was structured under four working groups. Working Group (WG) 1, called “Business Modelling in Pathology,” developed a consensus study of existing workflows in pathol-

ogy departments. The main activity of WG 2, called “Informatics Standards in Pathology,” involved active participation in covered standards, bodies, and initiatives. WG 3, “Images: Analysis, Processing, Retrieval, and Management,” included studies of the image analysis models in pathology (methods, systems, and tools). WG 4, “Technology and Automation in Pathology,” worked on the analysis of microscope brands and scanning solutions [5].

This paper describes the main work performed by WG1 and WG2 as related to IT standards in digital pathology.

### 3. Business modelling in pathology

WG1 performed a comparison study between different notations in business modelling (Business Process Modelling Notation – BPMN, Event Process Chain – EPC and Unified Modelling Language – UML Activity Diagram). The study concluded that BPMN was the modelling notation that was clearer and more easily understandable to pathologists (Fig. 1). EPC was harder for pathologists to read and understand. This might be due to the fact that EPC is not as popular as BPMN and UML AD; therefore, pathologists are not as familiar with the concept of event-driven processes.

Main pathology processes – Frozen Study, Formalin Fixed Specimen Study, Telepathology, Cytology, and Autopsy – are now complete [6]. Further work will be needed to modify the processes according to the feedback we have received from pathologists. These results can be beneficial for improving the organization of

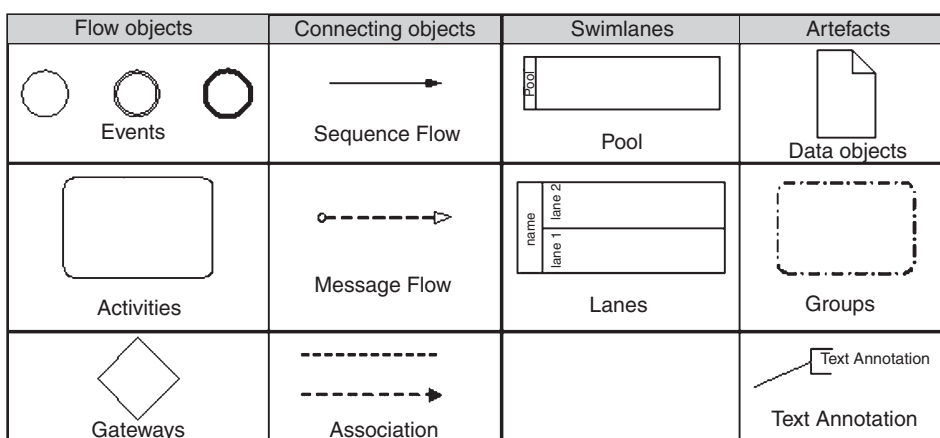


Fig. 1. BPMN diagram elements.

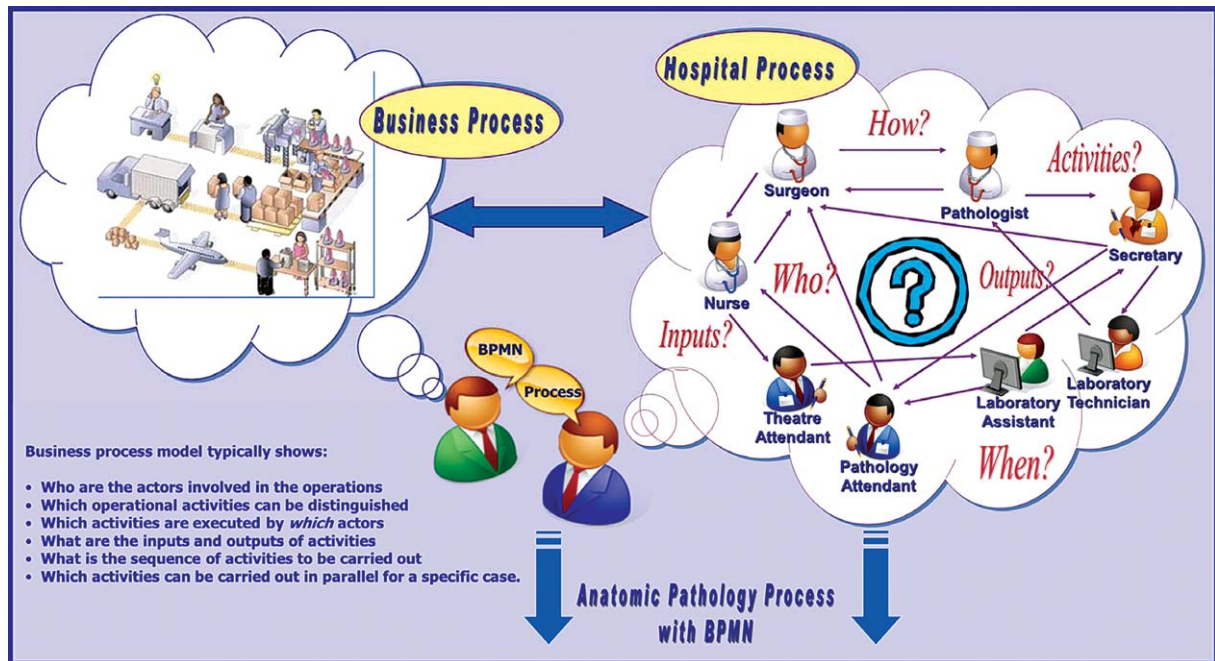


Fig. 2. Hospital processes can also be represented using a business process modelling notation.

digitizing centres, since they can be used to create models and protocols that enable telepathology international network websites for teleconsultation services. In the near future, this work also can be applied to the documentation of pathology processes described in many standardization documents (DICOM, HL7, and IHE).

Hospital processes typically are complex (Fig. 2), and business process modelling can be used to define the actors, activities, inputs, and outputs and to determine how such activities can be carried out in parallel in certain circumstances.

The process followed by WG1 consisted of six steps: Informal process description, formal process description, analysis of process model, verification of process model, process trace, and process simulation.

Figure 3 shows BPMN representation of the first steps in specimen processing in surgical pathology, including digitalization steps.

Currently, we are in the process of standardizing terminology using SNOMED CT for process descriptions. Procedure hierarchy in SNOMED CT can be useful in this task. For instance, the following concept: 77946005 | microscopic examination and diagnosis of previously processed surgical specimen (procedure) can be used in the pathology process description.

#### 4. Informatics standards in pathology

WG2 is dedicated to informatics standards in pathology and promoting their application in pathology departments in European institutions. The main research was conducted in the following. (1) Advances in Integrating Healthcare Enterprise (IHE) - Anatomic Pathology: Anatomic Pathology Workflow (APW) within the hospital, Anatomic Pathology Reporting to Public Health (ARPH), and Anatomic Pathology Structured Report (APSR). (2) The practical application of DICOM standard (medical image) in Pathology. (3) Image compression. (4) Semantic interoperability: PathLex and SNOMED CT in Pathology.

IHE Anatomic Pathology has proposed an Anatomic Pathology Structured Report (APSR), based in HL7 Clinical Document Architecture (CDA) [1, 2]. In this document, anatomic pathology observations (e.g., breast-specimen collection procedure) and the possible values (e.g., breast excision without wire-guided localization) have been coded using the PathLex coding system. We are collaborating with the International Health Terminology Standards Development Organisation (IHTSDO) to find an efficient mapping between PathLex and SNOMED CT and to improve the

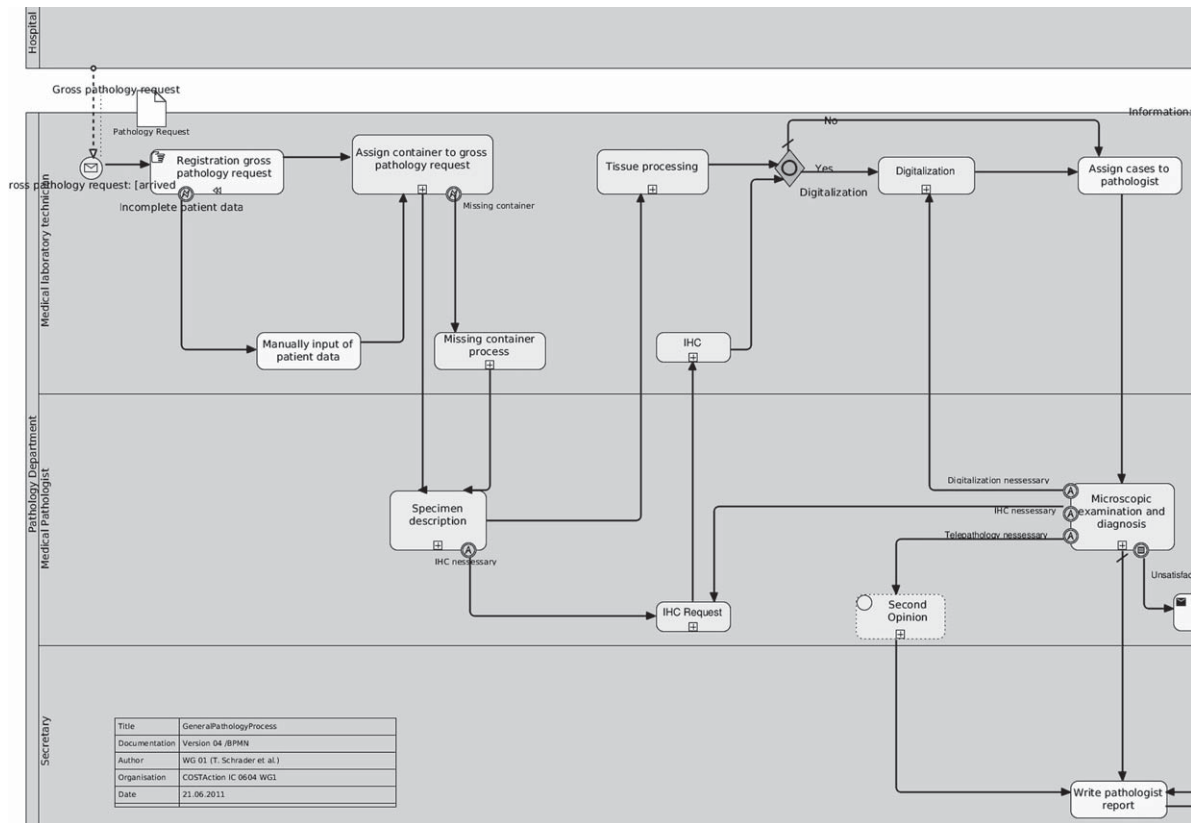


Fig. 3. BPMN in pathology workflow, starting in specimen registration.

SNOMED CT content in the morphologically abnormal structure hierarchy.

For whole slide images, the DICOM supplement 145 has defined a messaging standard to handle tiled images (sub-region access) and multiple images at varying resolutions. It is important to remember that the DICOM supplement 145 did not establish a common standard file format for storing whole-slide imaging for pathology. Instead, it established a standard for the exchange of WSI information between systems, for the purpose of storing, retrieving, displaying, or analyzing such images [4, 7].

WG2 performed a study on 2,500 diagnosis codes frequently used in a general hospital pathology department to migrate legacy (mainly SNOMED II) codes to SNOMED CT concepts. The study found that a combination of two or more SNOMED CT concepts (postcoordination) was needed in 19% of the cases (3 conceptID needed only rarely). This meant that we could fully represent 81% of pathology diagnosis

with one single (precoordinated) concept. However, we found that only 44% of the diagnoses could be encoded using SNOMED CT abnormal body structure (morphology) hierarchy, while 48% of the diagnoses were found in the clinical findings (disorders) hierarchy. An additional 10% of the codes could only be correctly represented using SNOMED CT qualifiers, normal anatomic structures, procedures, physical object, substance, and organism concepts. In conclusions, SNOMED CT needs some changes in content and structure to be efficiently integrated in pathology information systems.

An image compression research discussion was held in collaboration with the JPEG committee. The importance of this topic can be understood if we remember that, in a medium-sized hospital, about 50 TB/year compressed images are needed only for pathology images. An efficient compression method is needed for very large medical images that can be used with standard image viewers using standards formats like

DICOM. Furthermore, JPEG compression has to be avoided for certain image analysis applications. This discussion concluded that JPEG 2000 image compression seems to be a most efficient image compression standard, but it has not become widely implemented. The JPEG committee is working on the development of a new compression method, JPEG XR, which is aimed mainly at those digital photography applications in which JPEG 2000 penetration has been limited due to complexity reasons. They are also interested in evaluating Advanced Image Coding (AIC) in medical images.

## 5. Conclusions

Some challenges we had to face during the four years of collaborative research works were the lack of experience in DICOM Supplement 145 (whole slide images) and the predominance of JPEG2000 based implementations. IHE Anatomic Pathology technical framework has been validated in clinical practice.

We noticed that terminology standardization research became a topic of high interest, after a pathology image standard (DICOM Supp. 145) was achieved in 2010. Also, image scanning technology seems to be evolving slower than expected in an effective combination of speed and image quality.

We have implemented a distributed pathology digital slides European database.

Future COST Actions and research work should focus on standardizing automatic image analysis and tissue microarrays imaging.

## References

- [1] C. Daniel, F. Macary, M.G. Rojo, J. Klossa, A. Laurinavičius, B.A. Beckwith and V. Della Mea, Recent advances in standards for collaborative digital anatomic pathology, *Diagnostic Pathology* **6**(Suppl 1) (2011), S17.
- [2] C. Daniel, M.G. Rojo, J. Klossa, V. Della Mea, D. Booker, B.A. Beckwith and T. Schrader, Standardizing the use of whole slide images in digital pathology, *Computerized Medical Imaging and Graphics* **35** (2011), 496–505.
- [3] M. Garcia Rojo, V. Punys, J. Slodkowska, T. Schrader, C. Daniel and B. Blobel, Digital pathology in Europe: Coordinating patient care and research efforts, *Studies in Health Technology and Informatics* **150** (2009), 997–1001.
- [4] L. Pantanowitz, P.N. Valenstein, A.J. Evans, K.J. Kaplan, J.D. Pfeifer, D.C. Wilbur, L.C. Collins and T.J. Colgan, Review of the current state of whole slide imaging in pathology, *Journal of Pathology Informatics* **2** (2011), 36.
- [5] M.G. Rojo, A.M. Castro and L. Gonçalves, COST Action “EuroTelepath”: Digital pathology integration in electronic health record, including primary care centres, *Diagnostic Pathology* **6**(Suppl 1) (2011), S6.
- [6] T. Schrader, B. Beckwith, M.G. Rojo, J. Gilbertson and C. Daniel, Anatomic pathology workflow. IHE: Modeling based on current developments in HL7 and DICOM, *Pathology* **29**(Suppl 2) (2008), 308–313.
- [7] R. Singh, L. Chubb, L. Pantanowitz and A. Parwani, Standardization in digital pathology: Supplement 145 of the DICOM standards, *Journal of Pathology Informatics* **2** (2011), 23.