

# Structured reporting system

Paweł Paczuski  
`p.paczuski@stud.elka.pw.edu.pl`

06.04.2018

# Outline

## Introduction

- Problems of modern medicine
- Standards
- Typical workflow of a radiologist

## Design and implementation of Structured reporting system

- Radiological report as a tree
- Technological stack
- User interface

## Validation

## Plans for the future

# Areas of interest of modern medicine

- increasing variety of diagnostic techniques and procedures
- unsatisfiable demand for medical services
- bureaucracy
- huge volumes of data to process and store. **Healthcare Informatics**

# Healthcare Informatics vs Computer Science

<b>Computer Science</b>	<b>Healthcare Informatics</b>
general field	information engineering applied to the health care
data structures, algorithms	flow of information
ways of persistently storing data	ways of presenting data at proper time to proper person

# Healthcare standards

- medical nomenclature SNOMED CT, LOINC
- exchange protocols and formats HL7, DICOM

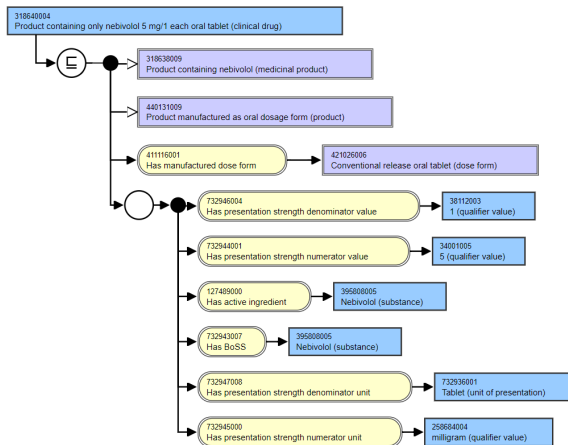


Figure: Drug product example in SNOMED CT

**examreport.txt**

Patient: 1086 Angles: 4.0 D: 3.0 mm  
RA: 03:155 L3-L5 Series ID: 3  
RLO/LRO: 100%  
Thickness: 3.00 mm collimator: 60.00 mm

EXAMENT:  
IDNM: 047M  
DOB: 01/19/1995  
FILE #112845  
REFERRING CLINIC: MRI ABDOMEN WITH CONTRAST  
DATE:  
TIME: 11/17/2011

Surgical phase (series 15 Image 35) may reflect a renal compromise. Stable mild hydronephrosis is again noted in the left kidney. No mass is identified in the kidneys. No masses seen along the right ureter.

Postoperative changes are seen from a distal pancreatectomy and cholecystectomy following previous Whipple procedure. There is dilatation of the pancreatic duct in the body and tail (series 6 Image 23) No recurrent mass is seen in the pancreas or anastomosis.

There is mild prominence of the biliary ducts in the left hepatic lobe (series 7 Image 20). No filling defect is seen within common duct.  
Spleen and adrenal glands are unremarkable. No free fluid or lymphadenopathy seen.  
No bowel obstruction is identified. Anterior abdominal hernia is again noted entrapping small bowel without evidence of strangulation (series 7 Image 35).  
There is marked S-shaped scoliosis of the thoracolumbar spine. No net anterior wall lesions are identified.

IMPRESSIONS: Interval development of marked hydroureteris/hydronephrosis in the right kidney. No discrete stone or mass is visualized portions of the right ureter. Recurrent CT scan of the abdomen and pelvis with and without contrast for further evaluation:

- 1. Stable mild polycysticitis in the left kidney.
- 2. Postoperative change from previous Whipple procedure. No recurrent mass in the pancreas or anastomosis.
- 3. Mild prominence of the biliary ducts in the left hepatic lobe.
- 4. Nephroptosis or metastatic long lesions.
- 5. Anterior abdominal wall hernia contains small bowel without evidence of strangulation or obstruction.
- 7. Marked S-shaped scoliosis of the thoracolumbar spine. [National Radiologist]

Phase Name : Scan Width: 80 cm L3-L5, C4T-18 300

Exam: 1086 Angles: 4.0 D: 3.0 mm  
RA: 03:155 L3-L5 Series ID: 3  
RLO/LRO: 100%  
Thickness: 3.00 mm collimator: 60.00 mm

Area: 18.00 cm x 18.02 cm = 3.43 cm² 12.5 ml  
Mean: 18.00 HU Area: 17.97 HU Std: 200 Std: 60  
Min: 15.00 HU Max: 192.00 HU

Volume: 10.873 cm³ @ 3.00 cm slice  
Mean HU: 4.0 HU Min: 1.00 HU Max: 4.177 HU SD: 177.84 HU  
Min: 11.00 HU Max: 10.00 HU  
Slice: 10.00 HU @ 3.00 cm  
HU Coefficient: 0.014 of Phase: 105.113 HU Scale: 4.000 Slice: 108 HU

18.00 cm x 17.97 cm  
Made in Canada

◀ ◻ ▶ ◀ ◻ ▶ ◀ ≡ ▶ ◀ ≡ ▶ ≡

# Areas of optimization

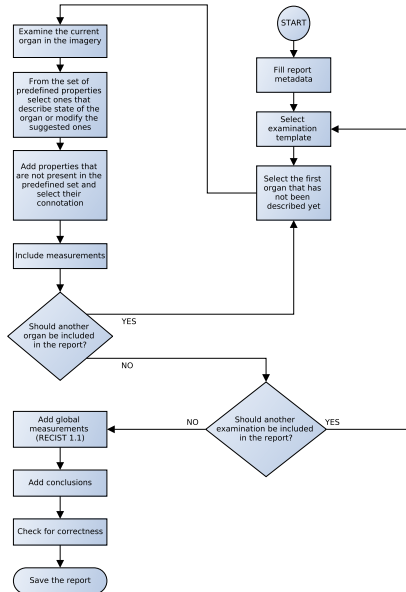
What can be improved:

- radiologists are **very BAD** at typing on keyboard
- speech recognition has problems with capturing medical language
- reporting quality

How:

- typing on keyboard replaced by checking boxes with predefined phrases
- reports represented as trees that have relations between causes and effects
- workflow organized around set of checklists and **templates**

# Modified workflow





# Reporting ontology

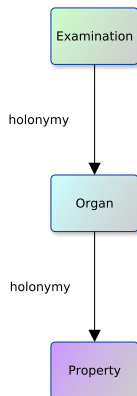
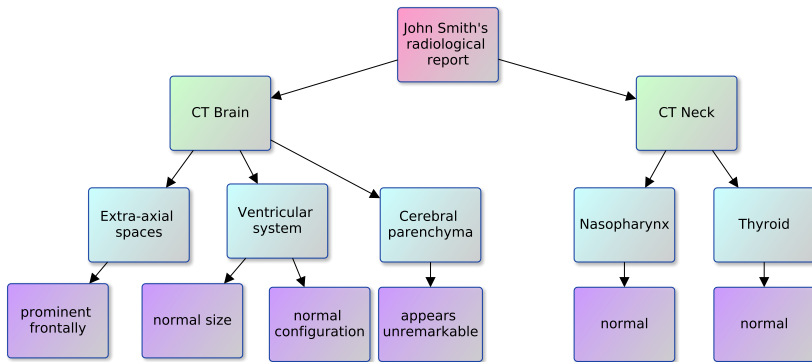


Figure: Types of entities and relations between them

# Radiological report as a tree



# Textual representation

## John Smith

date: 02.04.2005

### CT Brain

**Extra-axial spaces:** prominent frontally.

**Ventricular system:** normal size; normal configuration.

**Cerebral parenchyma:** appears unremarkable.

### CT Neck

**Nasopharynx:** normal.

**Thyroid:** normal.

# Technological stack

- backend
  - C#
  - ASP.NET
  - MS SQL
- frontend (hybrid approach)
  - AngularJS, ES5

# Report metadata

Report metadata.

Report title

Report title ...

Report name is **OBLIGATORY**

Findings: ...

ICD-10

Clinical data ...

Compared with: ...

OK

# Report editor interface

Click on an examination that should be included in the report. In one report many examinations can be included.

## Search examination

Show exams only from selected category:

Applied filter:

 CT Brain


0/12

 CT Pelvis

0/12

 CT Abdomen

0/12

 CT Cervical Spine

0/12

 CT Neck

0/12

 CT Chest

0/12

# Organ list

## Select an organ

**Organs**

Liver ✓ N	Bile ducts N	Gallbladder N	Pancreas ✓ N
Spleen ✓ N	Adrenals ✓ N	Kidneys ✓ N	Bowel ✓ N
Mesenteric lymph nodes N	Peritoneum ✓ N	Vessels N	Retroperitoneum ✓ N
Abdominal wall ✓ N	Bones ✓ N		

## Properties

Examination name

CT Pelvis

☐ Contrast agent was used

Preview

Preview:

CT Brain  
Extra-axial spaces: Normal  
Intracranial hemorrhage: None  
Basal cisterns: Normal

CT Pelvis  
Reproductive organs: No pelvic free fluid  
Ureters: Normal  
Bladder: Normal  
Bowel: Normal caliber  
Peritoneum: No ascites or free fluid  
Bones: Normal

Properties:

Vessels

OK

Select properties which will be included in the report. You can change the default text of any property.

Properties

Mark organ as healthy

Check all properties with good connotation

☒

Atherosclerotic changes

Bad

Add a property

OK

In order to copy the report, it has to be confirmed

Select an organ

Organs

Mark all organs as healthy

Check all properties with good connotation in all organs

Search organs

Reproductive organs

N

Ureters

N

Bladder

N

Bowel

N

Peritoneum

N

Vessels

N

Bones

N

Add new organ

OK



# Connotations

<input checked="" type="checkbox"/>	Normal	Good	⋮
<input checked="" type="checkbox"/>	In pathological condition	Bad	⋮
<input checked="" type="checkbox"/>	Property with a neutral connotation	NA	⋮

## def. RECIST 1.1

- response evaluation criteria in solid tumours
- calculates changes in sizes of solid tumors
- results based on several factors: change, nodes, selection of measurements

# Parsing values for RECIST 1.1



33mm[22mm]

Bad

**Recist**  
current: **33mm**  
previous: **22mm**

# Configuring RECIST 1.1

Select which measurements should be included in RECIST 1.1 calculation

## CT Chest

Lungs and large airways

Text:

3mm[4mm]

Extracted values:

3, [4]



Include



Node

Text:

1mm[3mm]

Extracted values:

1, [3]



Include



Node

Calculate RECIST 1.1

Sum of previous measurements: 7

Sum of current measurements: 4

Difference (absolute): -3

Difference (relatively): -42.857%

Status: Complete response

# Generated report

## Report

Title: "John Smith"

Date Created:  
2018-4-4 16:14

CT Brain  
Extra-axial spaces: Normal .  
Intracranial hemorrhage: None .  
Basal cisterns: Normal .

CT Pelvis  
Reproductive organs: No pelvic masses .  
Ureters: Normal .  
Bladder: Normal .  
Bowel: Normal caliber .  
Peritoneum: No ascites or free air; no fluid collection .  
Vessels: Atherosclerotic changes .  
Bones: Normal .

CT Chest  
Lungs and large airways: 3mm[4mm] ; 1mm[3mm] .

Conclusions: Further observation recommended

Sum of previous measurements: 7  
Sum of current measurements: 4  
Difference (absolute): -3  
Difference (relatively): -42.857%  
Status: Complete response

 Pdf

 Email

 Edit

 List of reports

# Template editor

Create own templates which are tailored to your needs

Filter examinations using category:

CT

Current filter:

New examination



CT Chest



CT Neck



CT Cervical Spine



CT Abdomen



CT Pelvis



CT Brain

Add an organ

#### Chosen organs



Lungs and large airways 1 Properties

0.0



Pleura 1 Properties

0.0



Heart and pericardium 1 Properties

0.0



Mediastinum and hila 1 Properties

0.0



Chest wall and lower neck 1 Properties

0.0



Vessels 1 Properties

0.0



Bones 1 Properties

0.0

# Validation

Places where the software was used:

- Several independent teleradiologists
- Small hospital in Wieliszew
- Large network of clinics in Łódź

Conclusions:

- Tens of thousands reports generated
- Reports generated 3 times faster



# Plans for the future

- develop independent commercial version of the software based on some ideas from this system
- support for more general ontologies
- conform to standards, integrations with existing RIS systems

# Q&A

# Bibliography

-  <https://www.bls.gov/ooh/healthcare/physicians-and-surgeons.htm>, accessed 08.10.2017 13:30
-  M. Recht, N. Bryan, Artificial Intelligence: Threat or Boon to Radiologists? N1 - doi: 10.1016/j.jacr.2017.07.007
-  T. Benson, Principles of health interoperability HL7 and SNOMED.
-  D. A. Clunie, DICOM Structured Reporting
-  <http://www.hl7.org/Special/committees/structure/index.cfm>
-  <https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/language-specification/lexical-structure>
-  S. Hanenberg, S. Kleinschmager, R. Robbes, É. Tanter, A. Stefik, An empirical study on the impact of static typing on software maintainability