Evaluating OWL 2 Reasoners in the context of Clinical Decision Support in Lung Cancer Treatment Selection

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Outline

Background

Lung Cancer Treatment

- Lung cancer is responsible of the 21% of cancer-related deaths.
- There are (substantial and unjustified) variations in treatment decisions between cancer centres.
- Clinical guidelines (CGs) reduce variability in clinical practice.
- Originally CGs are unstructured and free-text documents, and often not readily accessible at the point of decision making.

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Clinical decision support (CDS) systems can...

- facilitate the access to clinical guidelines.
- computerise CGs using structured logical languages.
- match guidelines rules against a patient record to infer the appropiate treatment.

Examples

- PROforma. Fox et al. (1997)
- EON. Musen et al. (1996)
- GLIF3. Want et al. (2004)
- SAGE. Tu et al. (2007)
- **LUNG CANCER ASSISTANT**. Berkan Sesen et al. (2012)

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Lung Cancer Assistant (LCA)

- An **ontology-based** system which provides guideline rule-based decision support for lung cancer treatment.
- LCA exploits the English Lung Cancer Dataset (**LUCADA**)

LUCADA ontology

- LUCADA has been built using the OWL 2 language.
- Represents the semantic layer of the LCA:
  - Captures the **domain** in the LUCADA dataset.
  - Encodes the **clinical guidelines**.
  - Represents **patient data**.

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LUCADA Ontology

Example of guideline rule

- Eligibility criteria are encoded as equivalence axioms.
- *"Consider radiotherapy for Stage I, II, III patients with good performance status"*

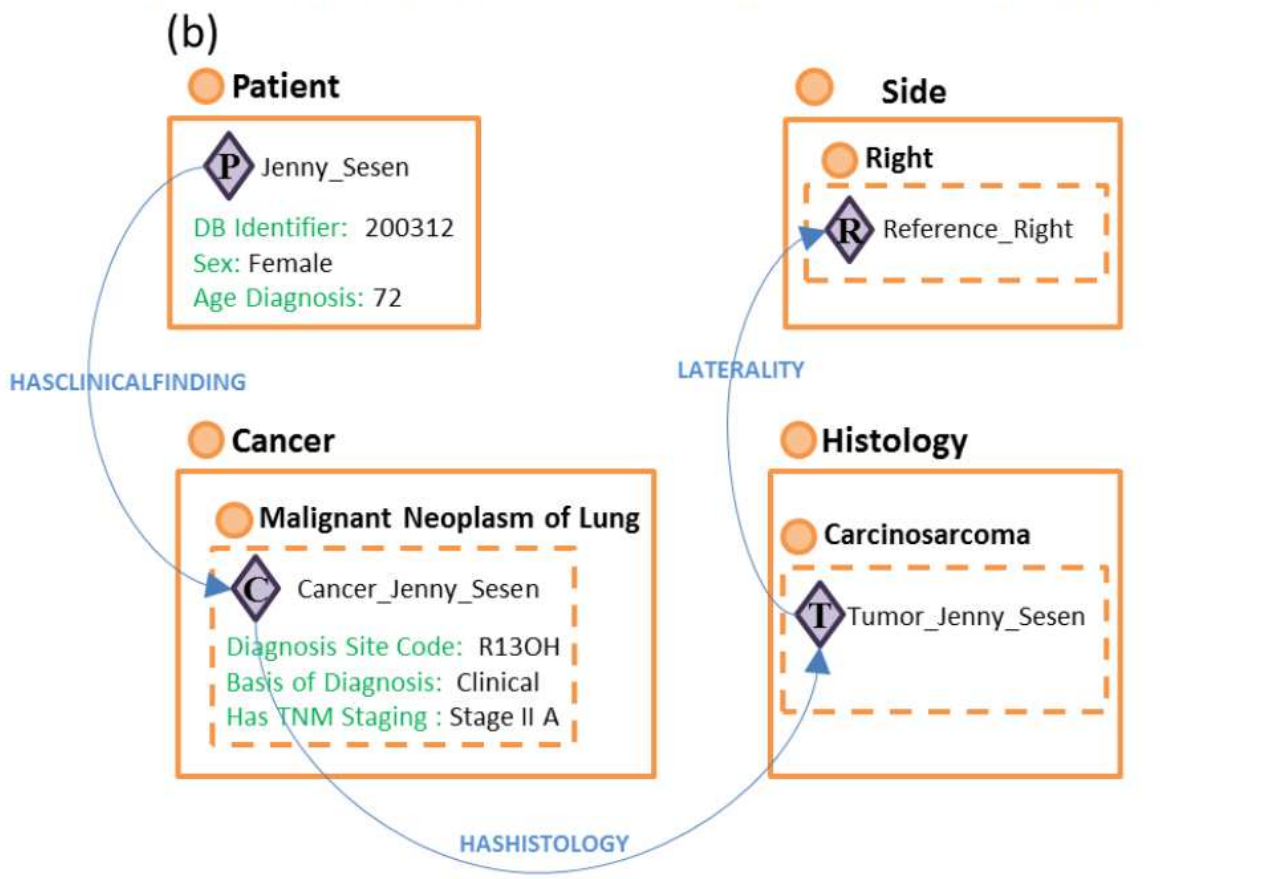
$$\begin{aligned}\mathsf{RT\_GR} \equiv\ & \mathsf{GoodPerformancePatient} \sqcap \exists \mathsf{hasClinicalFinding}. \\ & (\mathsf{NeoplasticDisease} \sqcap \\ & \exists \mathsf{hasPreHistology}.\mathsf{NonsmallCellCarcinoma} \sqcap \\ & \exists \mathsf{hasPreTNMStaging}.\mathit{string} \sqcap \\ & \forall \mathsf{hasPreTNMStaging}.\{\mathit{I}, \mathit{II}, \mathit{III}\})\end{aligned}$$

LUCADA Ontology

Example of patient

- Each patient is encoded with $\sim$ 25 individual axioms.

DB Identifier	Name	Sex	Age	Primary Diagnosis	TNM Staging	Histology	Tumour Laterality
200312	Jenny_Sesen	F	72	Malignnant Neoplasm of Lung	II A	Carcinosarcoma	Right



LUCADA Ontology

Integration with SNOMED CT

- SNOMED is the reference ontology in the National Health Service (NHS).
- To facilitate interoperability we have integrated LUCADA with SNOMED.
- We have used LogMap matching system to
  - identify the classes in SNOMED related to LUCADA.
  - extract a lung cancer-specific module of SNOMED CT.

LUCADA Ontology

Summary of LUCADA and LUCADA-SNOMED metrics

Metric \ Ontology	LUCADA-SNOMED	LUCADA
DL Expressivity	$\mathcal{ALCHIF}(\mathcal{D})$	$\mathcal{ALCHI}(\mathcal{D})$
# Classes	1553	376
# Object properties	63	37
# Data Properties	63	63
# Equiv. class axioms	1050	40
# Subclass of axioms	999	386
# Prop. domain axioms	97	97
# Prop. range axioms	30	30

Outline

Evaluation

Evaluation settings

- Windows 7 64-bit desktop computer,
- 15 GiB of RAM, and
- Intel Xeon 2.27 GHz CPU.
- Results have been calculated as average of at least 10 repetitions of the experiment.

Evaluation

Evaluated Reasoners

- HermiT 1.3.7, Pellet 2.3.0 and FaCT++ 1.6.2

Experiments

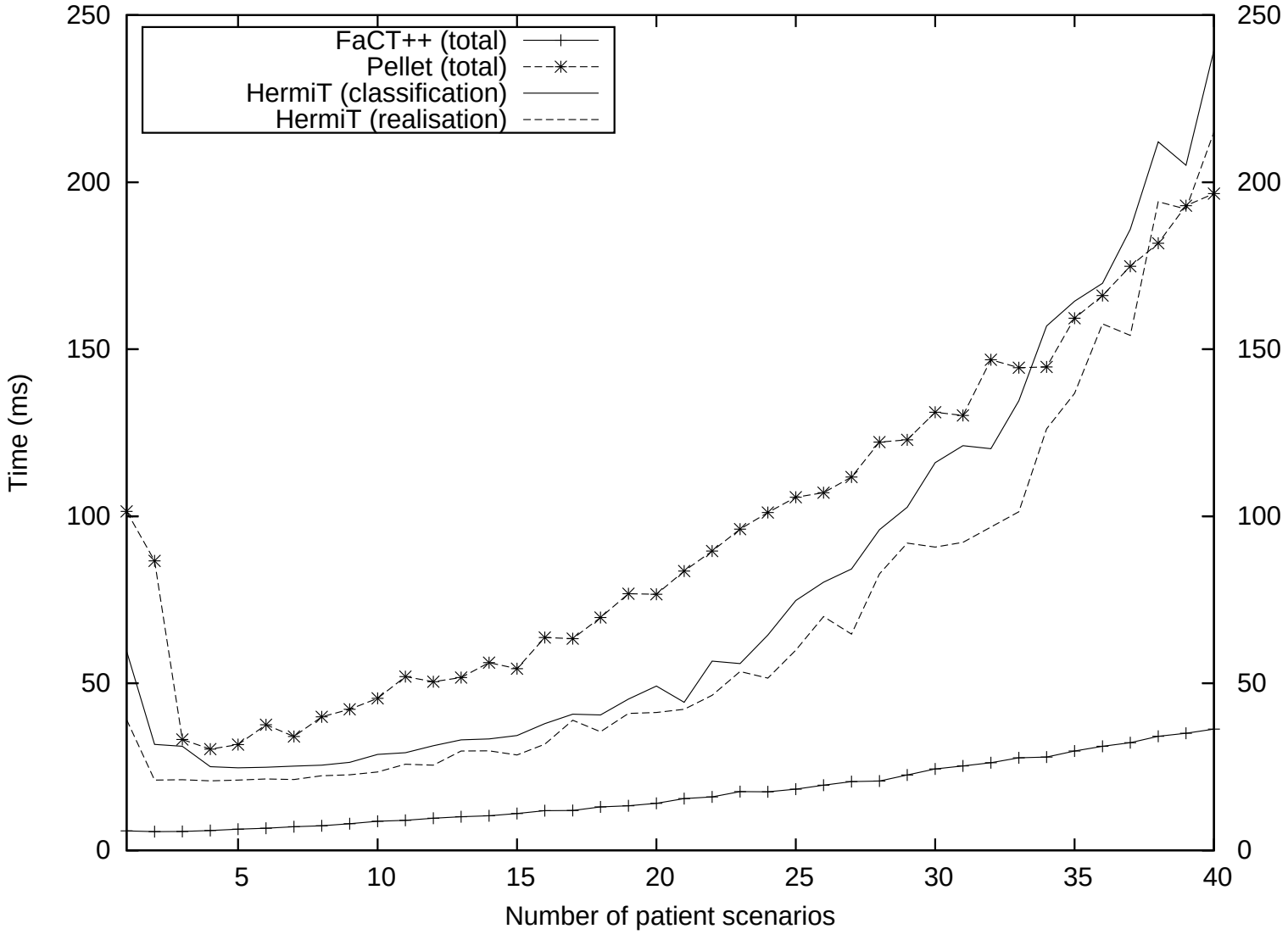
- Increasing the TBox with guideline rules or patient scenarios.
- Increasing the ABox with patient records.

Evaluation

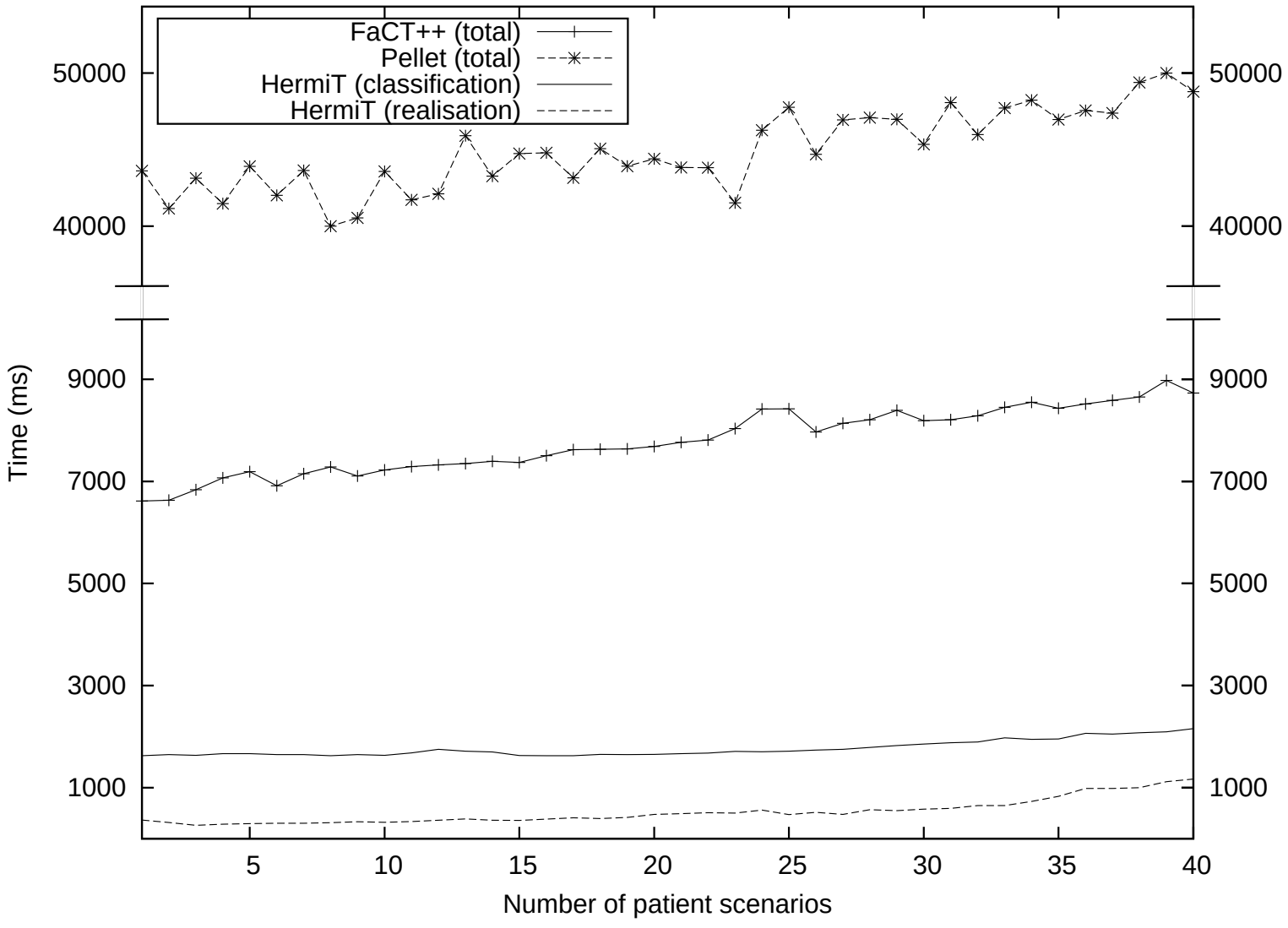
Experiment 1: Increasing the TBox with guideline rules

- 1 to 40 patient scenarios or guideline rules.
- With LUCADA and LUCADA-SNOMED with 1 patient.
- Recorded times for classification and realisation.

Experiment 1 (increasing TBox) with LUCADA



Experiment 1 (increasing TBox) with LUCADA-SNOMED

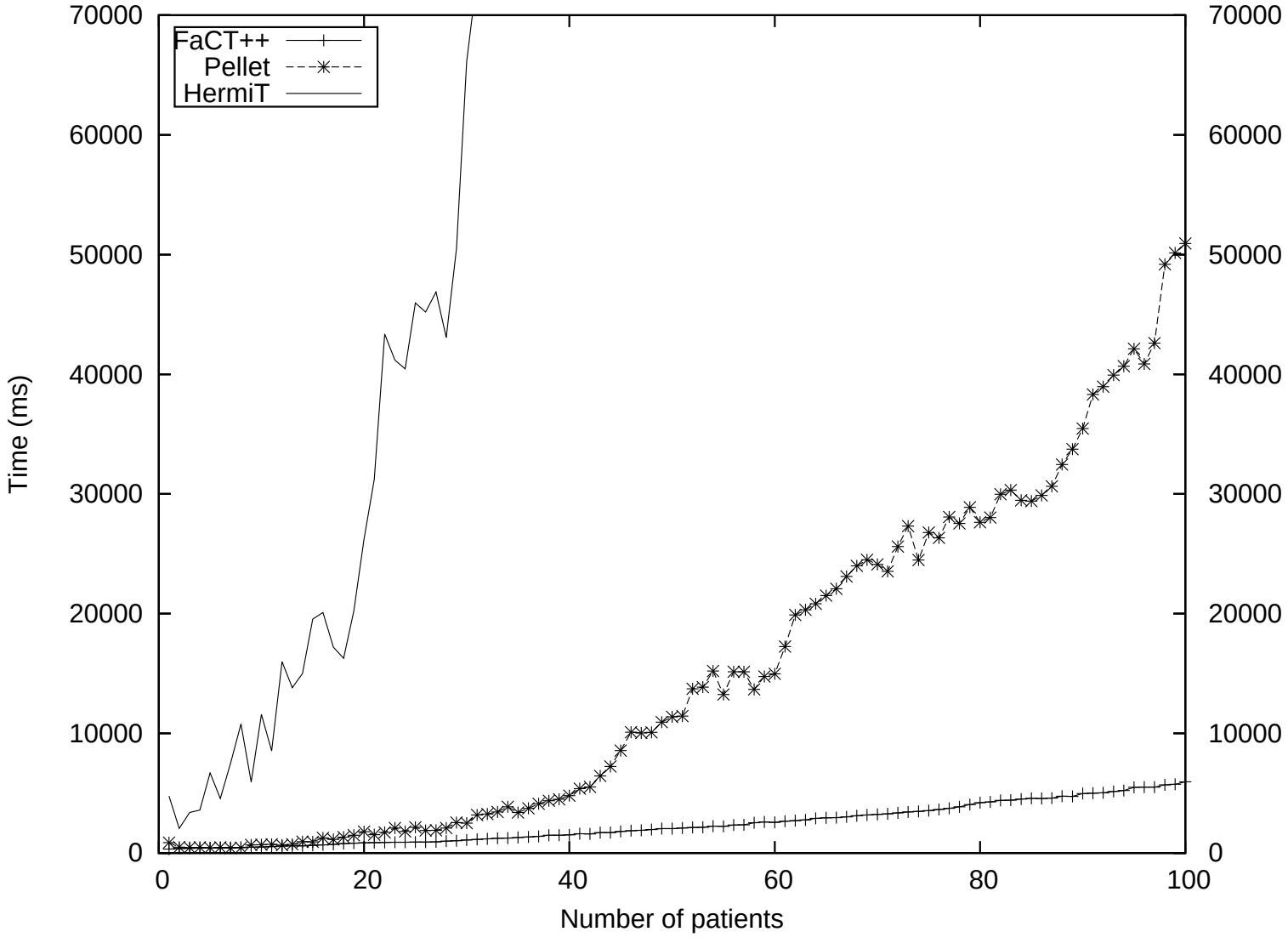


Evaluation

Experiment 2: Increasing the ABox with patient records

- 1 to 100 patient records.
- Experiment with LUCADA with 40 patient scenarios.
- Recorded times for realisation of all patients.

Experiment 2 (increasing ABox) with LUCADA



Conclusions from the LCA experiments

- **FaCT++ is currently the best choice for LCA.**
- HermiT provides the fastest TBox reasoning for LUCADA-SNOMED CT.
- HermiT does not scale for ABOX reasoning with LUCADA.
- Pellet performs well in classifying the LUCADA.
- Pellet struggles with the LUCADA-SNOMED CT ontology.

Questions?

- Lung Cancer Assistant (LCA):
  `http://lca.eng.ox.ac.uk/LungCancerSmartGWT/`
- LCA's main contact:
  Berkan Sesen (berkan.sesen@eng.ox.ac.uk)
- Tests and LUCADA-SNOMED integration:
  Ernesto Jimenez Ruiz (ernesto.jimenez.ruiz@gmail.com)

Thank you for your attention

Acknowledgements

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