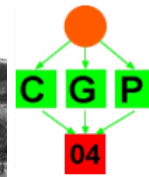# A Description Logics Approach to Clinical Guidelines and Protocols

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International Joint Meeting

EuroMISE 2004

C G P

04

Formalization of CGP

- Up until now:
  CGPs are treated as **plans**: actions, states, transition functions. Methodologies from the AI Planning & OR Scheduling community

- New Approach:
  Formal Ontology methodology can be used to represent (at least, selected) aspects of CGPs in order to support consistency, fusion, and modulariziation of CGPs

Our Proposal

- Ontological analysis of CGPs
  - Introduce basic categories
  - Classification of domain entities
  - Axiomatize foundational relations
  - Study interrelations between domain entities
- Choose a logic framework for the formalization of the ontology
  - Representation: Description Logics (FOL subset)
  - Reasoning: Powerful Taxonomic Classifiers (e.g., FaCT, RACER)

Fundamental Distinctions

Continuants	vs.	Occurrents

Physical Objects, Substances, Organisms, Body Parts

Processes, Events, Actions, Courses of Diseases, Treatment Episodes

Individuals	vs.	Classes

my left Hand, Paul's Diabetes, Appendectomy of Patient #230997

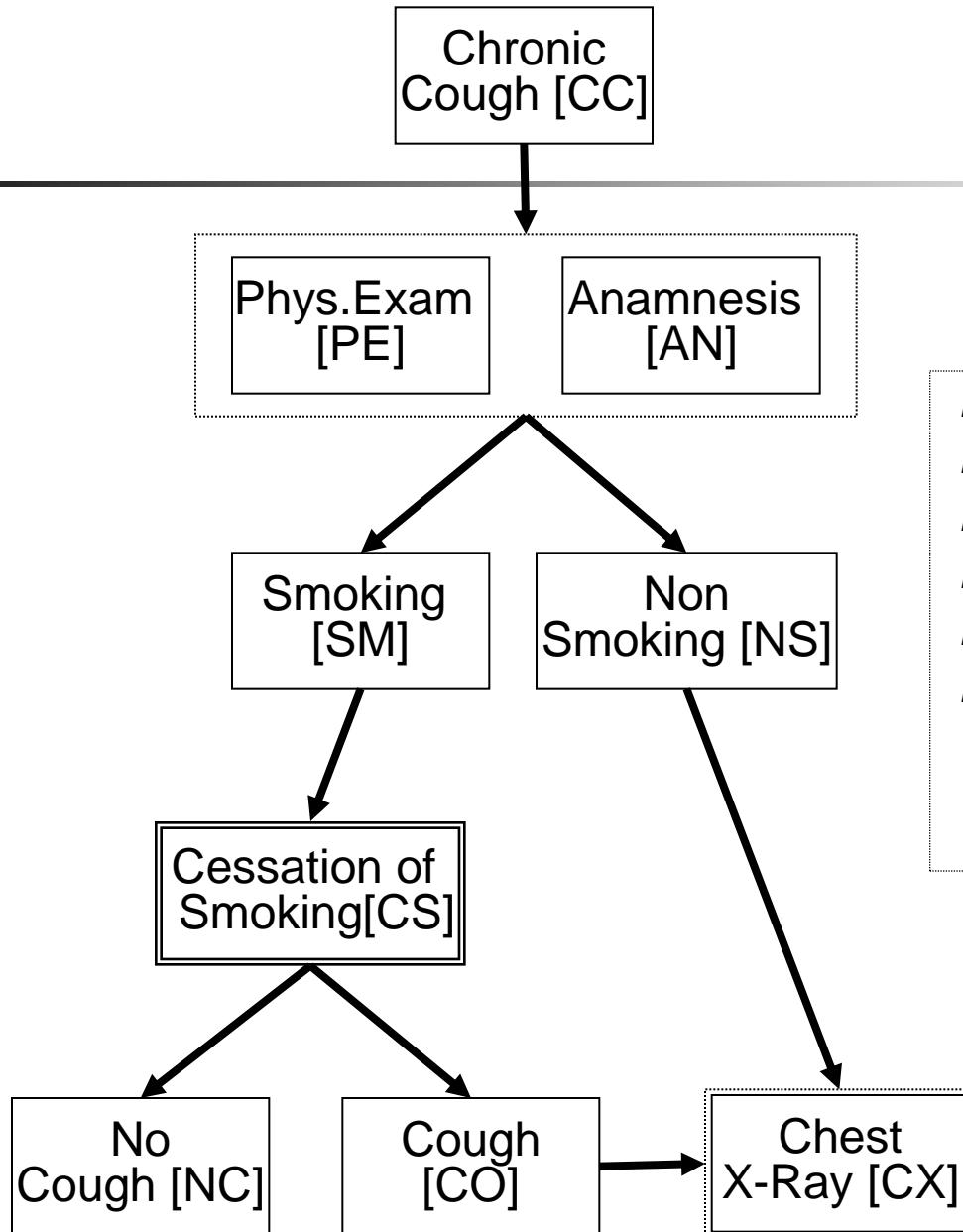*Hand, Diabetes, Appendectomy*

How do CGPs fit into this framework ?

Guidelines and Occurrents

- Proposal: A Guideline G can be mapped to a set of classes of occurrents:
$$E = \{E_1, E_2, ..., E_n\}$$

- The elements of E correspond to all allowed paths through a Guideline G

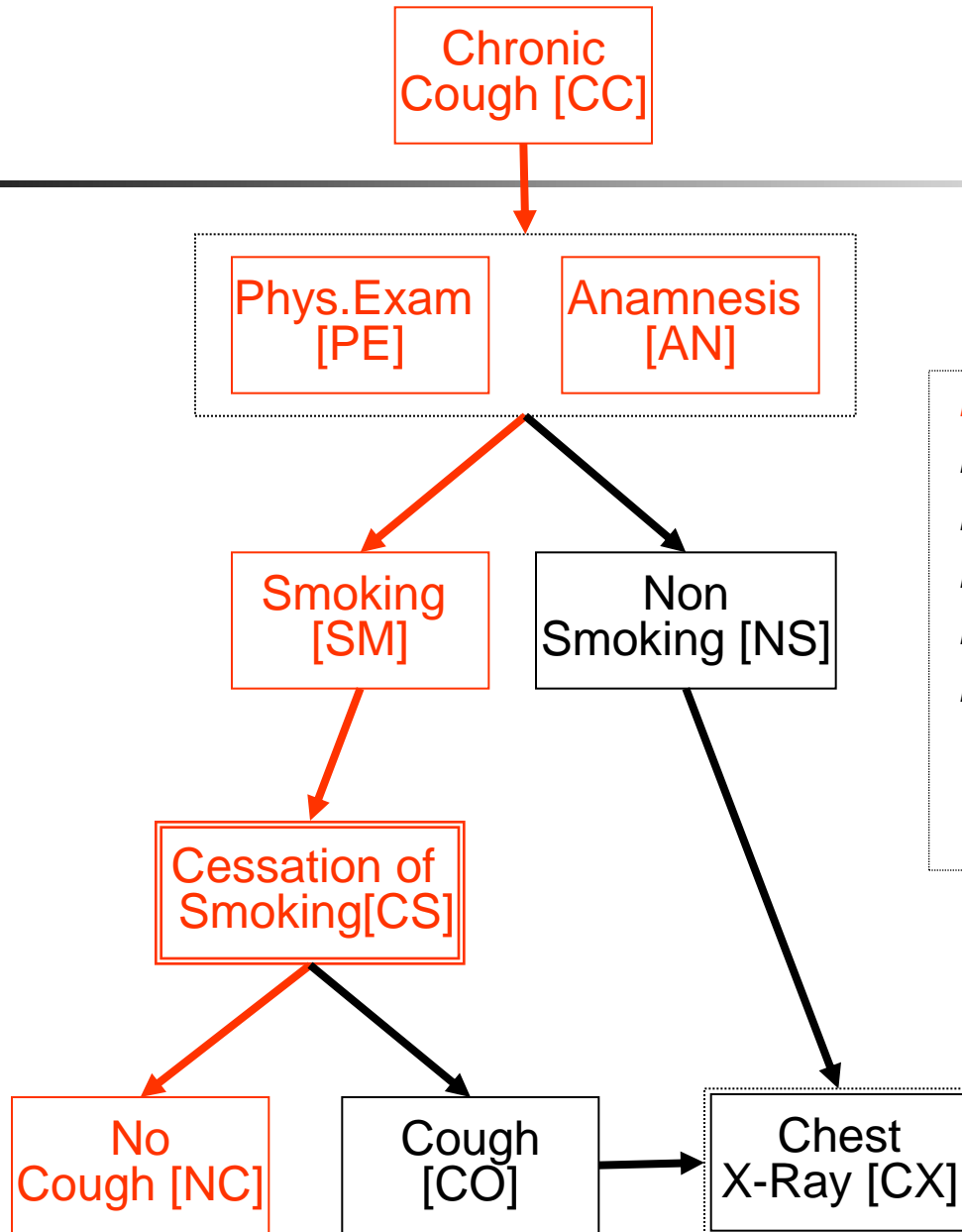- Each element of E represents - as a conceptual abstraction – a class of individual clinical occurrents

Simplified Chronic Cough Guideline

Chronic Cough [CC]

Phys.Exam [PE]   Anamnesis [AN]

Smoking [SM]   Non Smoking [NS]

Cessation of Smoking[CS]

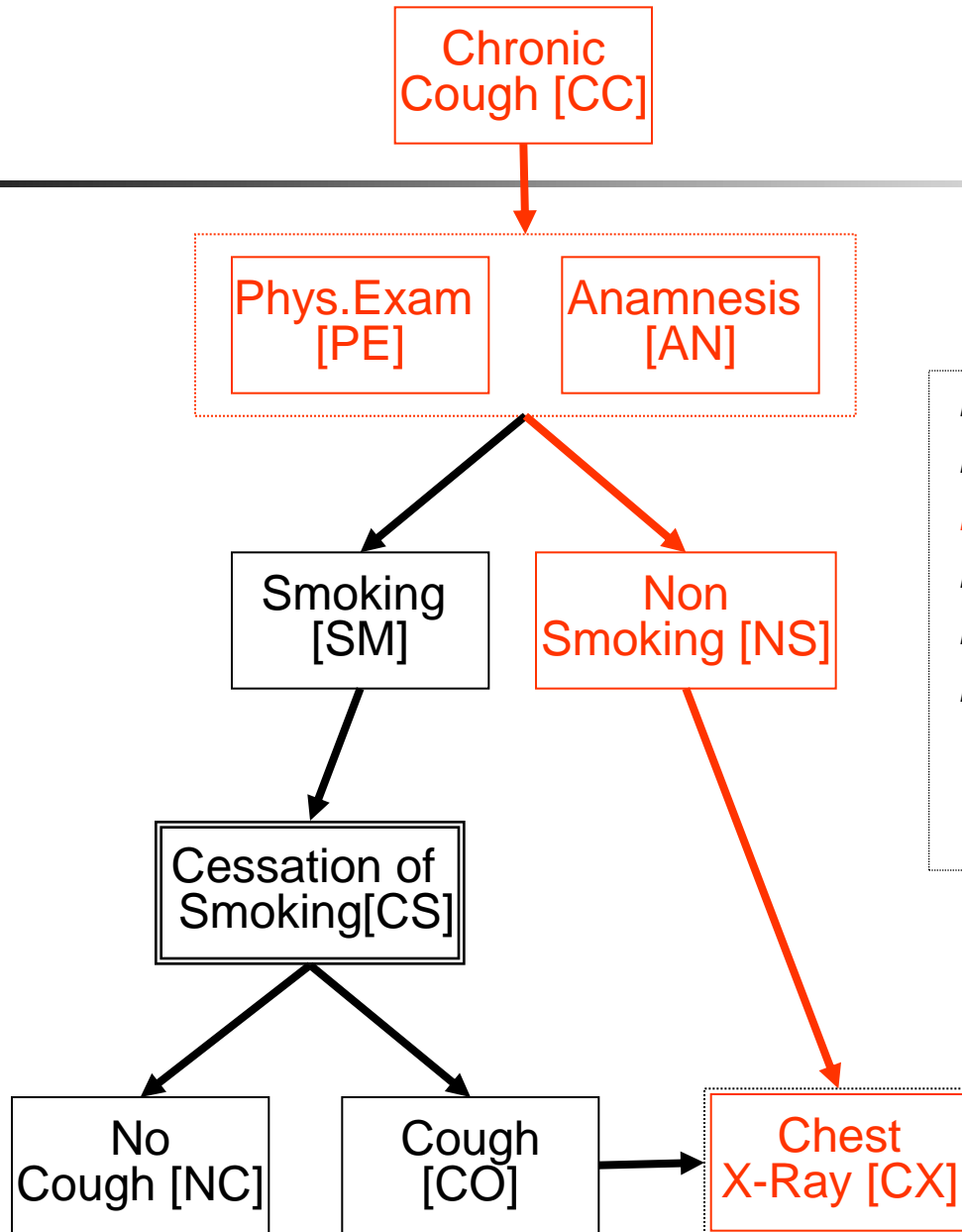No Cough [NC]   Cough [CO]   Chest X-Ray [CX]

E1 = (CC, AN, PE, SM, CS, NC)
E2 = (CC, AN, PE, SM, CS, CO, CX)
E3 = (CC, AN, PE, NS, CX)
E4 = (CC, PE, AN, SM, CS, NC)
E5 = (CC, PE, AN, SM, CS, CO, CX)
E6 = (CC, PE, AN, NS, CX)

Temporal sequence of clinical occurrents

Simplified Chronic Cough Guideline

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Clinical occurrence

Temporal sequence of clinical occurrents

# Simplified Chronic Cough Guideline

Chronic Cough [CC]

Phys.Exam [PE]   Anamnesis [AN]

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Temporal sequence of clinical occurences
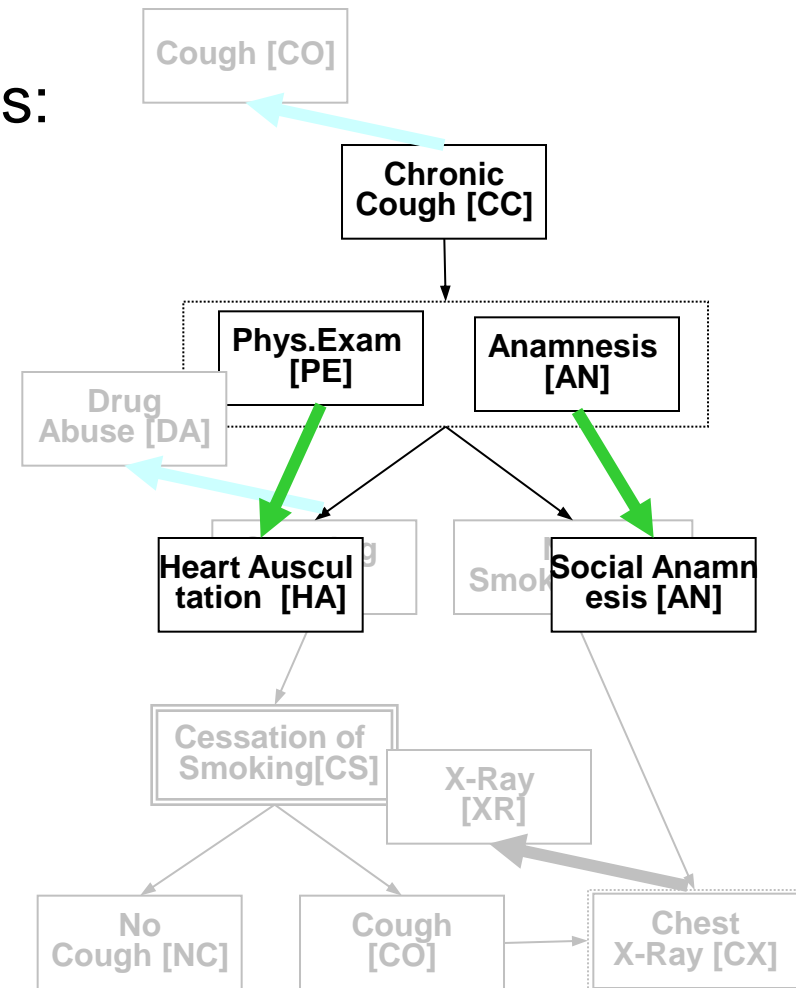
Basic Relations

Taxonomic Order (*is-a*)

relates classes of specific occurrences to classes of general ones:

$$is\text{-}a(CX, XR) \rightarrow_{def} \forall x: CX(x) \rightarrow XR(x)$$
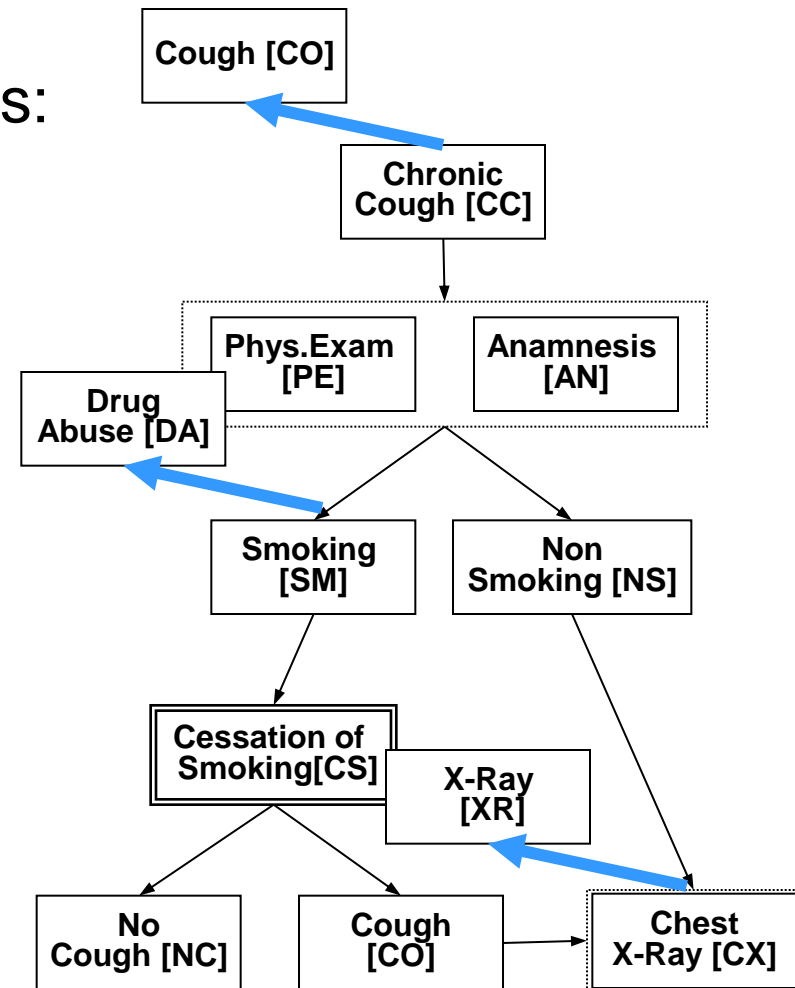
Basic Relations

Taxonomic Order (*is-a*)

relates classes of specific occurrences to classes of general ones:

$$\text{is-a}(CX, XR) \rightarrow_{def} \forall x: CX(x) \rightarrow XR(x)$$

## Mereologic Order (has-part)

relates classes of occurrences to classes of sub-occurrences

$$\forall x: PE(x) \rightarrow \exists y: HA(y) \wedge \text{has-part}(x,y)$$

Cough [CO]

Chronic Cough [CC]

Phys.Exam [PE]

Anamnesis [AN]

Drug Abuse [DA]

Heart Auscultation [HA]

Smok

Social Anamnesis [AN]

Cessation of Smoking[CS]

X-Ray [XR]

No Cough [NC]

Cough [CO]

Chest X-Ray [CX]

Basic Relations

Taxonomic Order *(is-a)*
relates classes of specific occurrences to classes of general ones:
$is\text{-}a(CX, XR) \rightarrow_{def} \forall x: CX(x) \rightarrow XR(x)$

Mereologic Order *(has-part)*
relates classes of occurrences classes of sub-occurrences
$\forall x: PE(x) \rightarrow \exists y: HA(y) \land has\text{-}part(x,y)$

Temporal Order *(follows / precedes)*
relates classes of occurrences in terms of temporal succession
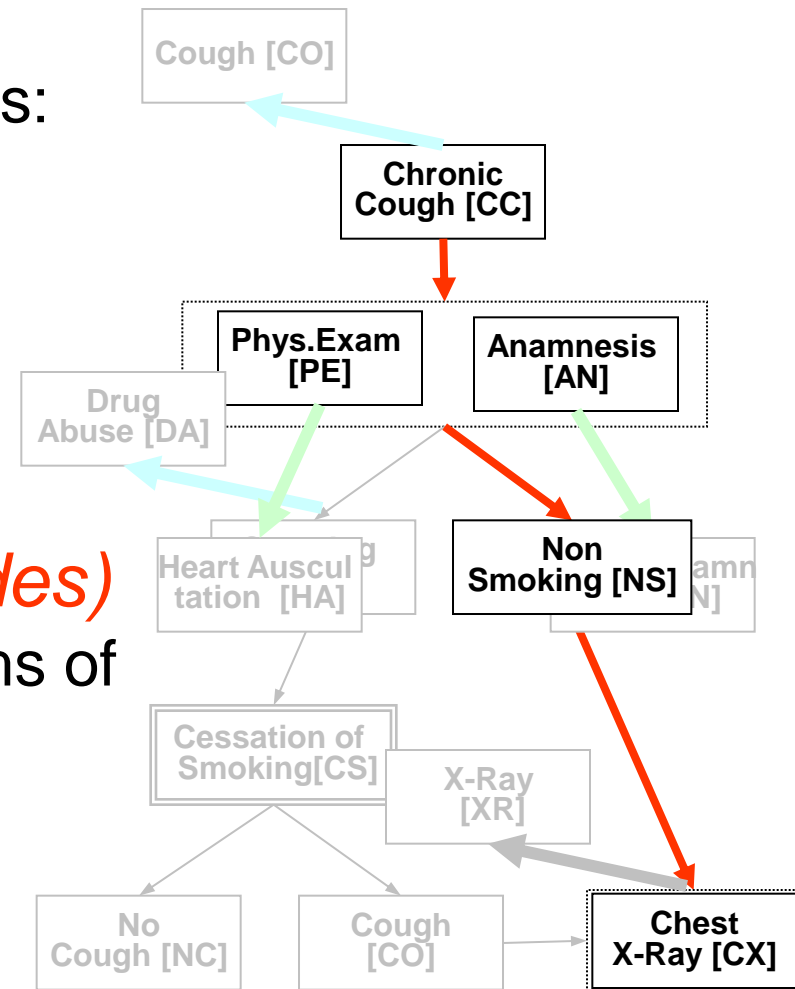
Modelling Pattern

K   L   T   S   *occurrent* concepts

transitive relations	
$\exists$ *has-part*	⟶
$\exists$ *precedes*	⟶
is-a	⟶

Modelling Pattern
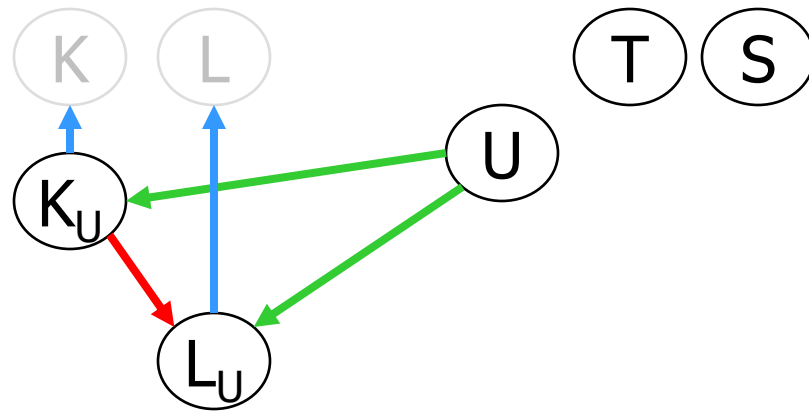
occurrent concepts
definition of U

transitive relations	
$\exists$ has-part	→ (green)
$\exists$ precedes	→ (red)
is-a	→ (blue)
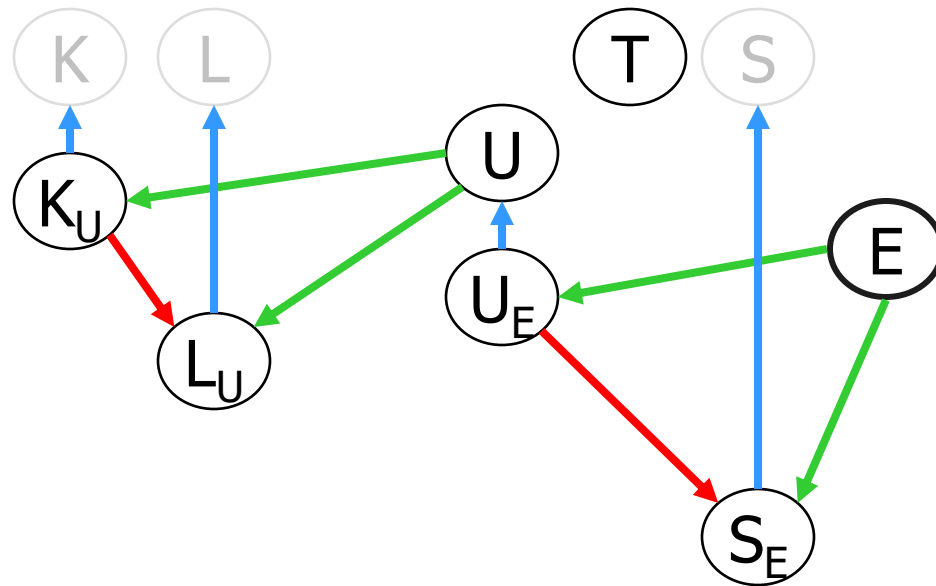
Modelling Pattern

occurrent concepts
definition of U
definition of E

K   L   T   S

U

K_U

L_U

U_E   E

S_E

transitive relations	
∃ *has-part*	⟶ (green)
∃ *precedes*	⟶ (red)
is-a	⟶ (blue)

Modelling Pattern

occurrent concepts
definition of U
definition of E
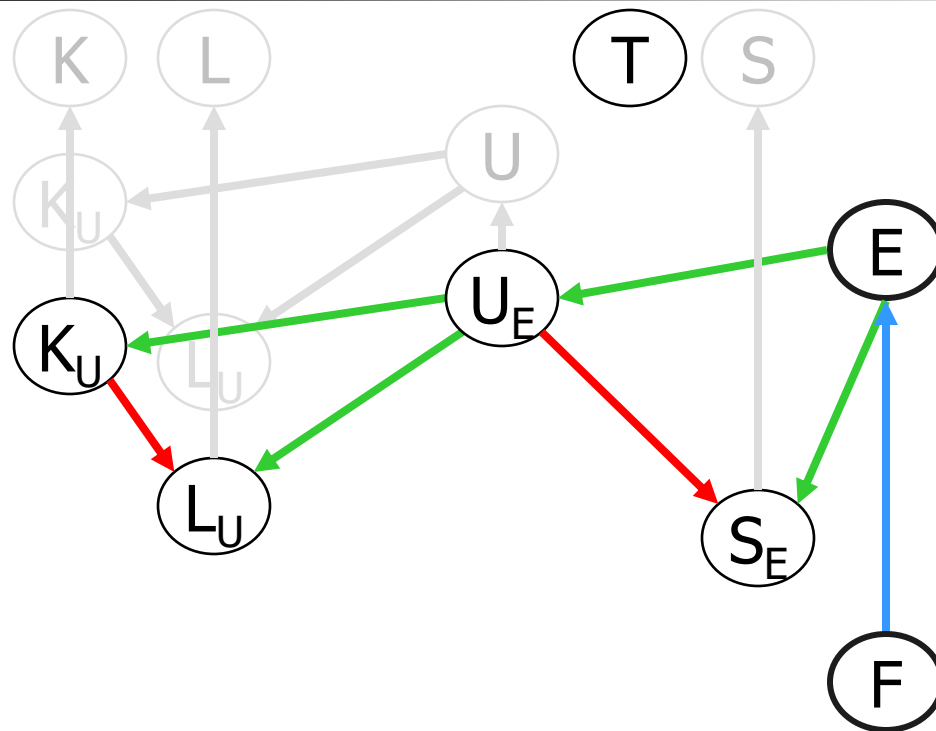U_E inherits properties of U

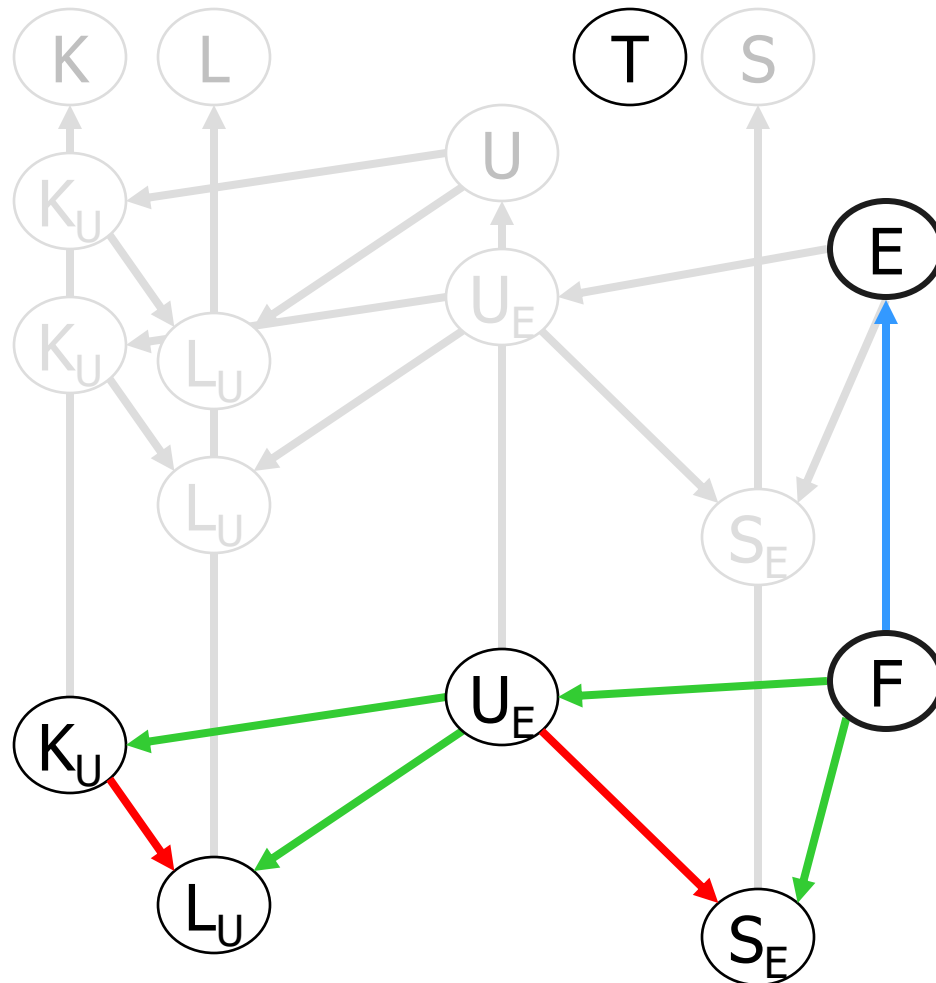| transitive relations	
$\exists$ *has-part*	⟶ (green)
$\exists$ *precedes*	⟶ (red)
is-a	⟶ (blue)

Modelling Pattern

occurrent concepts
definition of U
definition of E
U_E inherits properties of U
definition of F as a subconcept of E

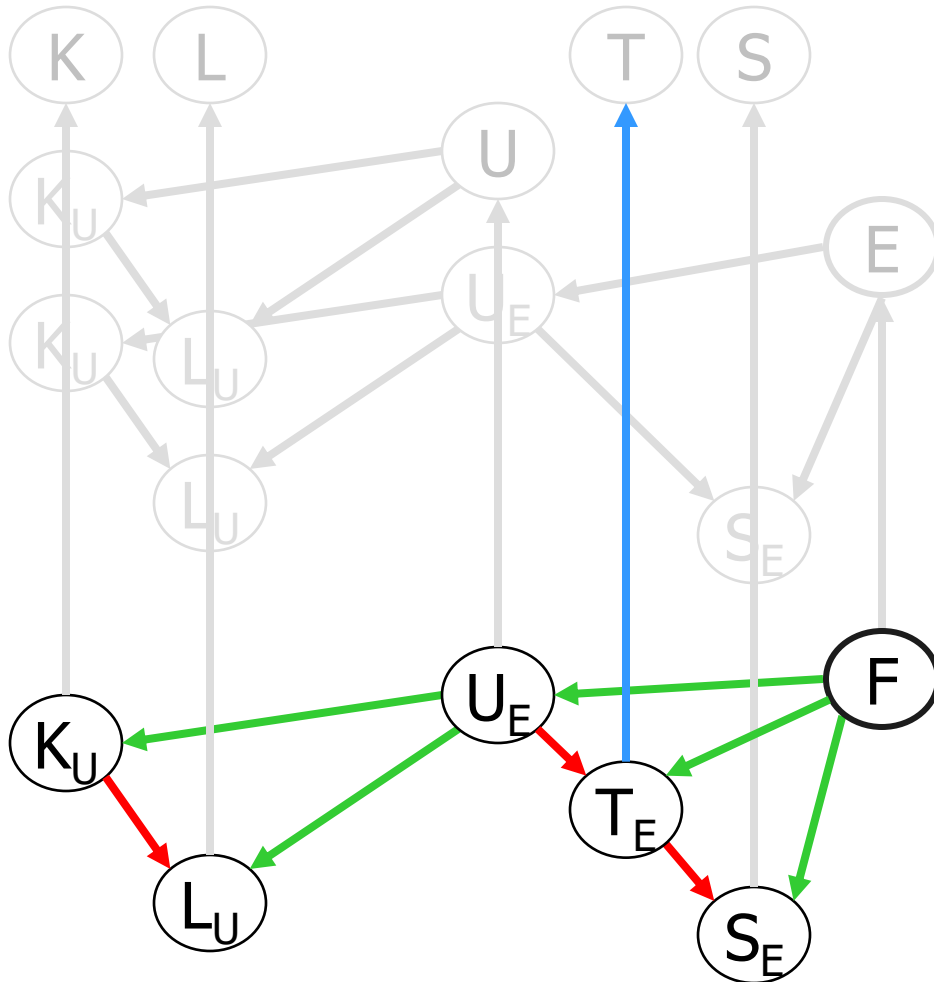| transitive relations	
∃ *has-part*	——→
∃ *precedes*	——→
is-a	——→

Modelling Pattern

occurrent concepts
definition of U
definition of E
U_E inherits properties of U
definition of F as a subconcept of E

F inherits properties of E

transitive relations

∃ *has-part*	→ (green)
∃ *precedes*	→ (red)
is-a	→ (blue)

Modelling Pattern

occurrent concepts
definition of U
definition of E
U_E inherits properties of U
definition of F as a subconcept of E
F inherits properties of E
F, additionally, has a T which occurs between U and S

transitive relations

∃ *has-part*	→ (green)
∃ *precedes*	→ (red)
is-a	→ (blue)

Modelling Pattern

occurrent concepts
definition of U
definition of E
U_E inherits properties of U
definition of F as a subconcept
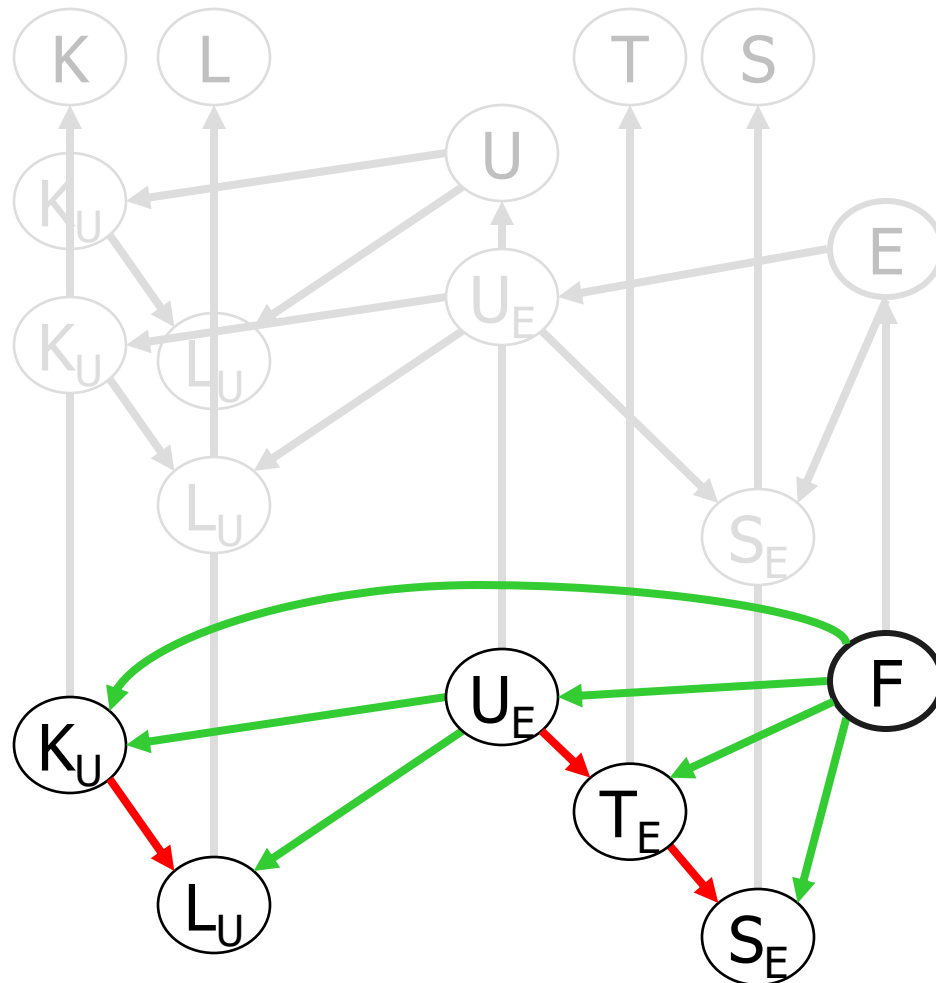of E
F inherits properties of E
F, additionally, has a T which
occurs between U and S
inferences / constraints
(formalization see paper)

Modelling Pattern

occurrent concepts
definition of U
definition of E
U_E inherits properties of U
definition of F as a subconcept
of E
F inherits properties of E
F, additionally, has a T which
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inferences / constraints
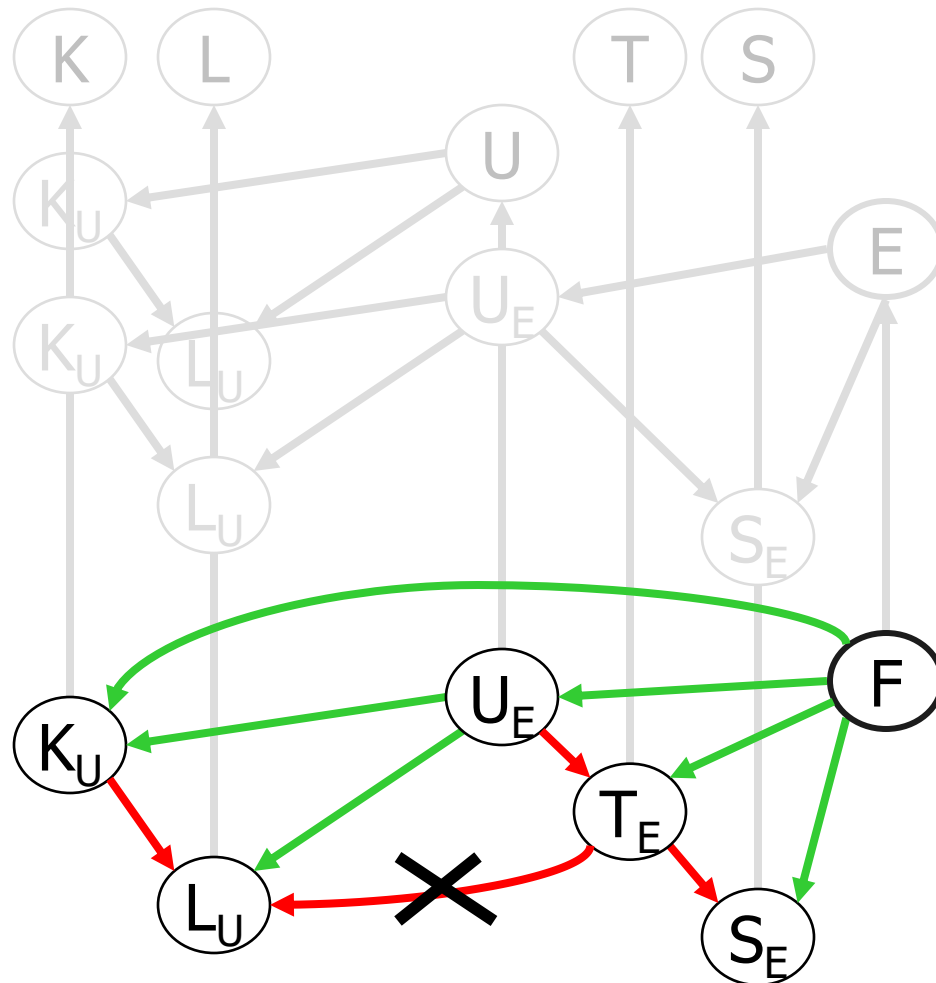(formalization see paper)

transitive relations

$\exists$ *has-part*	→ (green)
$\exists$ *precedes*	→ (red)
is-a	→ (blue)

Benefits

- Description Logics implementations allow taxonomic classification and instance recognition.
  - Checking of logical integrity in the management, cooperative development and fusion of CGPs
  - Detecting redundancies and inconsistencies, e.g., conflicting orders when applying several CGPs simultaneously to one clinical case
  - Auditing of concrete instances (cases) from the Electronic Patient Record in terms of cross-checking against applicable CGPs (quality assurance, epicritic assessment)

Discussion

- First sketch of ongoing research
- Based on Description Logics $\mathcal{ALCN}$
- Up until now, not all (temporal) inferencing capabilities are supported
- Needs to be validated under real conditions
- Recommended for further investigation
  - Tool: OilED Knowledge editor (oiled.man.ac.uk) with built-in FaCT classifier
  - Theory: Baader et al (eds.) The Description Logics Handbook