Tackling healthcare workflows with behavioural models and natural language processing: a proposal

Maurizio Atzori[1], Ivan Lanese[2], Ugo de'Liguoro[3], Emilio Tuosto[4], and Andrea Vandin[5]

[1] Dept. of Mathematics and Computer Science, University of Cagliari (Italy)
[2] Dept. of Computer Science, University of Turin (Italy)
[3] Focus Team, University of Bologna/INRIA (Italy)
[4] Gran Sasso Science Institute (Italy)
[5] Sant'Anna School of Advanced Studies, Pisa (Italy)

Tackling healthcare workflows with behavioural models and natural language processing: a proposal

Maurizio Atzori[1], Ivan Lanese[2], Ugo de'Liguoro[3], Emilio Tuosto[4], and Andrea Vandin[5]

[1] Dept. of Mathematics and Computer Science, University of Cagliari (Italy)
[2] Dept. of Computer Science, University of Turin (Italy)
[3] Focus Team, University of Bologna/INRIA (Italy)
[4] Gran Sasso Science Institute (Italy)
[5] Sant'Anna School of Advanced Studies, Pisa (Italy)

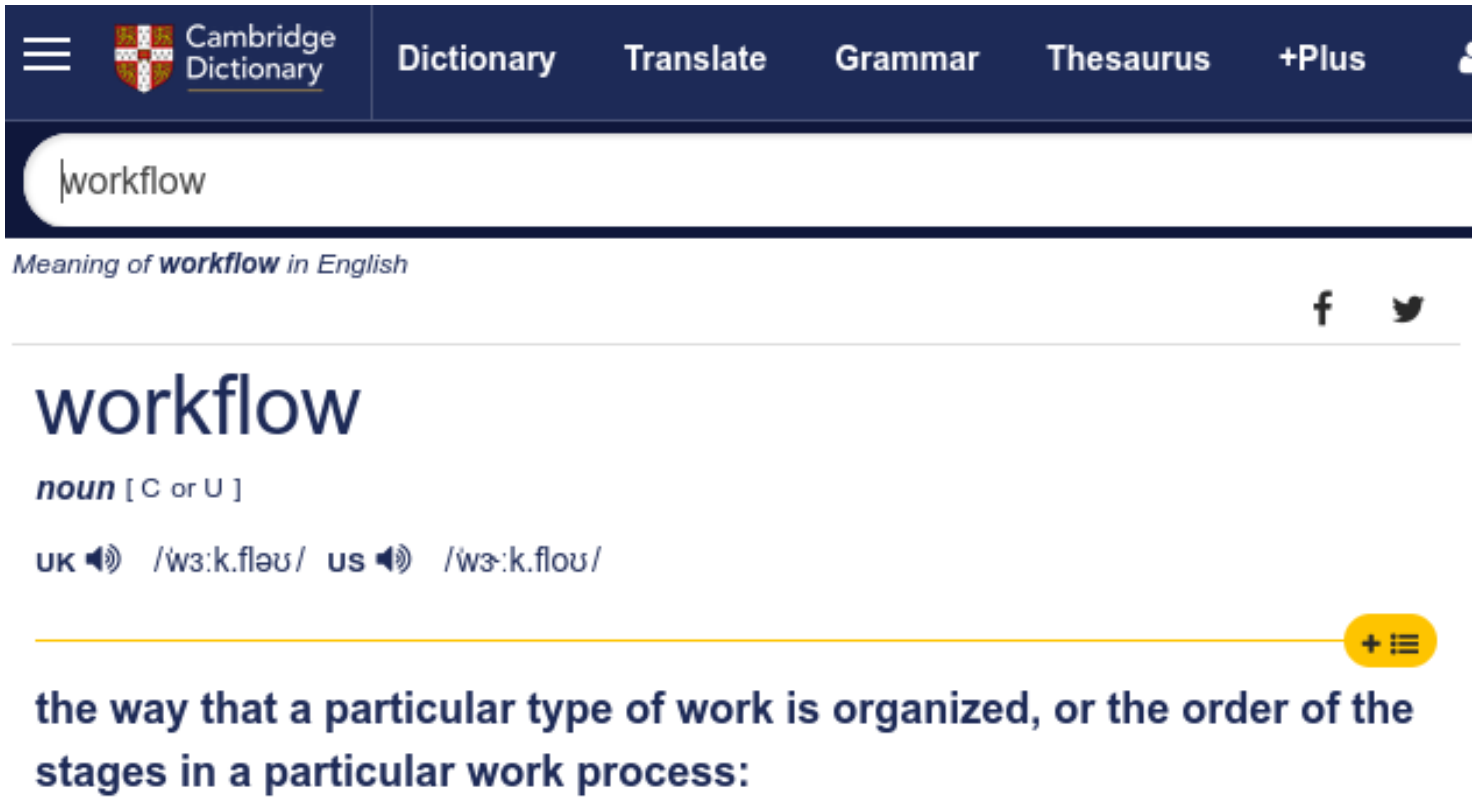
Workflows = beh. models + NLP

Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

... problems, rather than solutions;
looking for feedback

A ubiquitous concept



Essentially a workflow is a description of some procedural knowledge used to

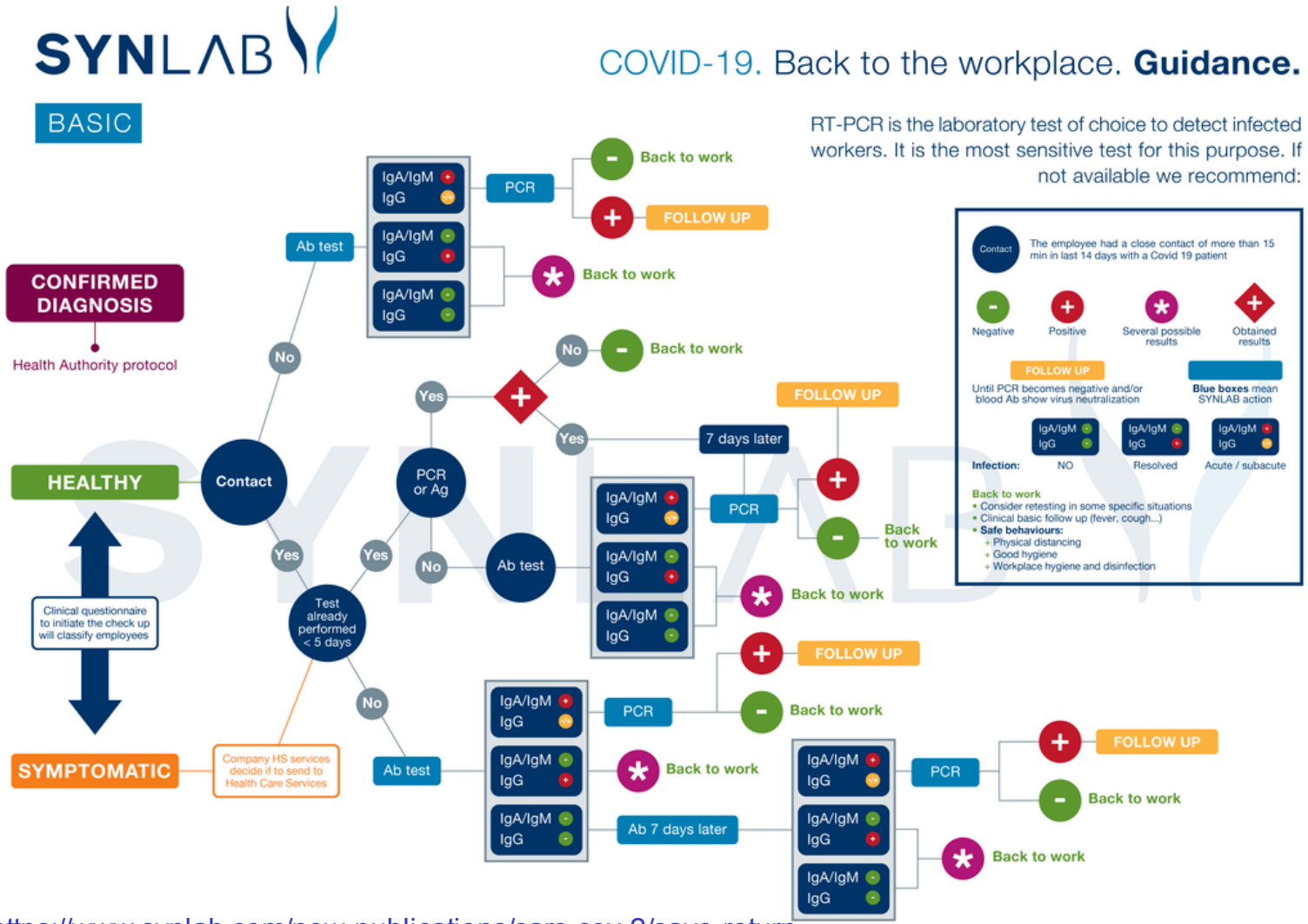
- design, organise, coordinate
- communicate
- monitor
- measure effectiveness

of some procedures, policies, protocols, ...

Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Just a (bunch of) diagrams ?



https://www.synlab.com/new-publications/sars-cov-2/save-return

- many workflow users
  - stakeholders
    - policy makers, experts...
  - actors
    - humans, institutions, sw, ...
- resource management
- distributed choices
- no standard / precision
  - ambiguity
  - no machine processable artefact

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Workflows in ICT/CS (aka business processes)

Industry

- standard practices
  - ✓ tools
  - ✗ lack of precision
  - ✗ minimal support to resource management

Academia

behavioural models

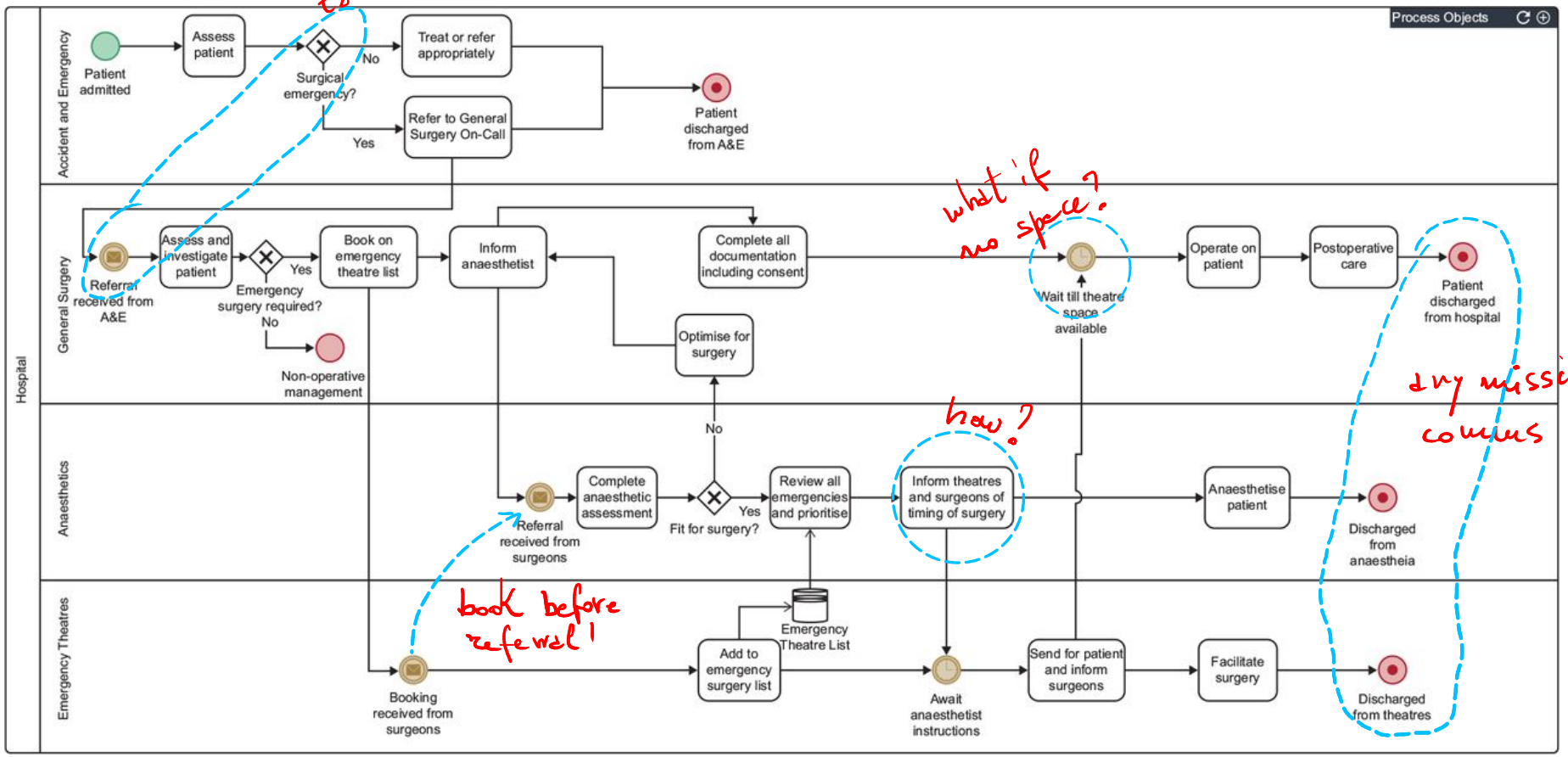
- precision ✓
- prototype tools ✓
- lack of intelligibility ✗

Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Example

what are these to clinical staff?

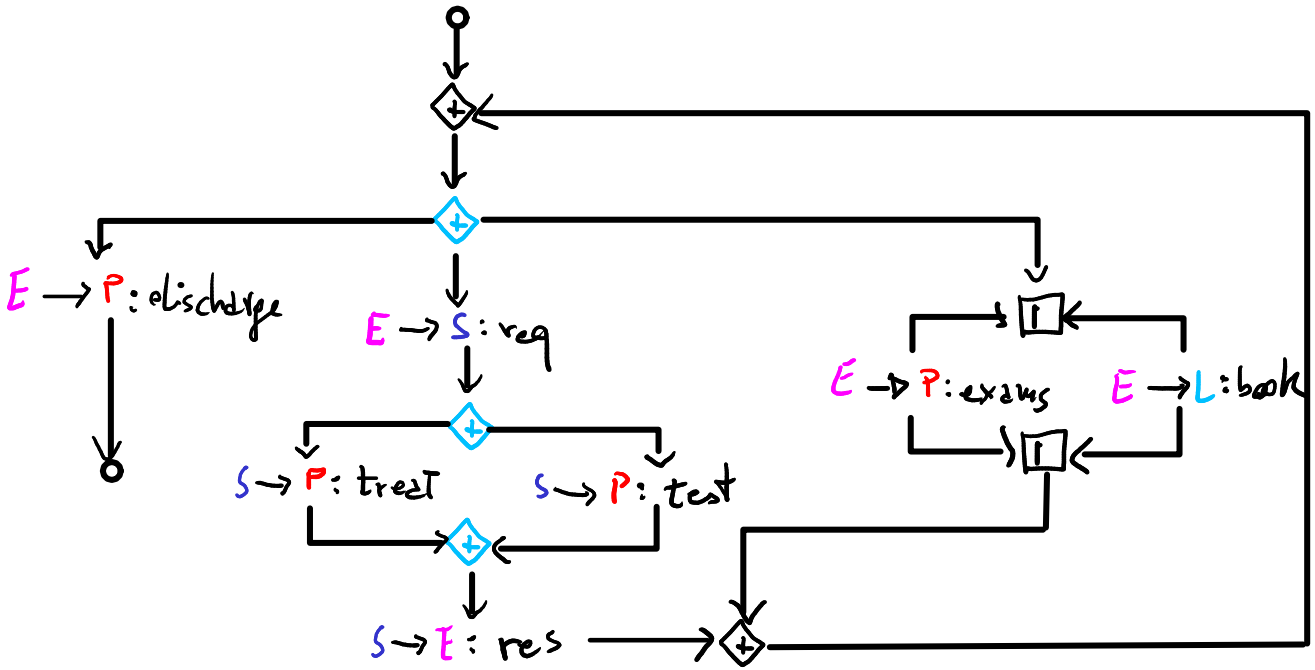


Chandrabalan, Shanmugham: Automating clinical pathways using executable business process model and notation
Int. J. of Innovation in Health Informatics. 24(3), 2017

Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

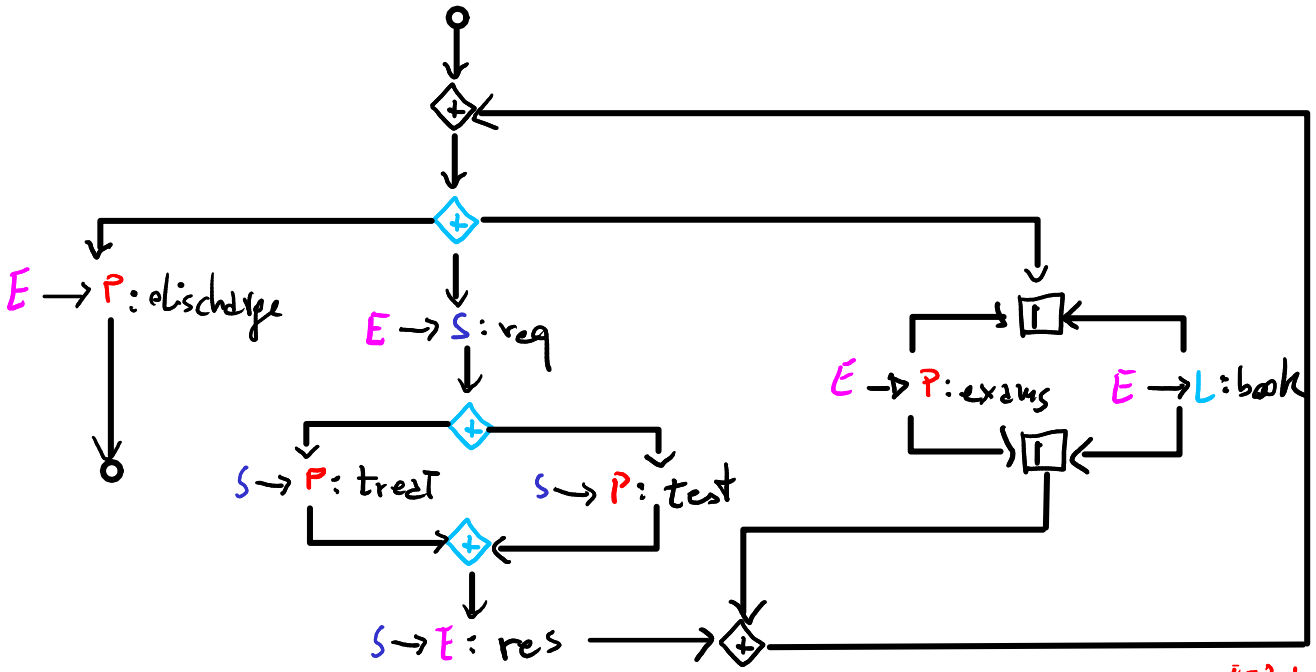
Behavioural models as type

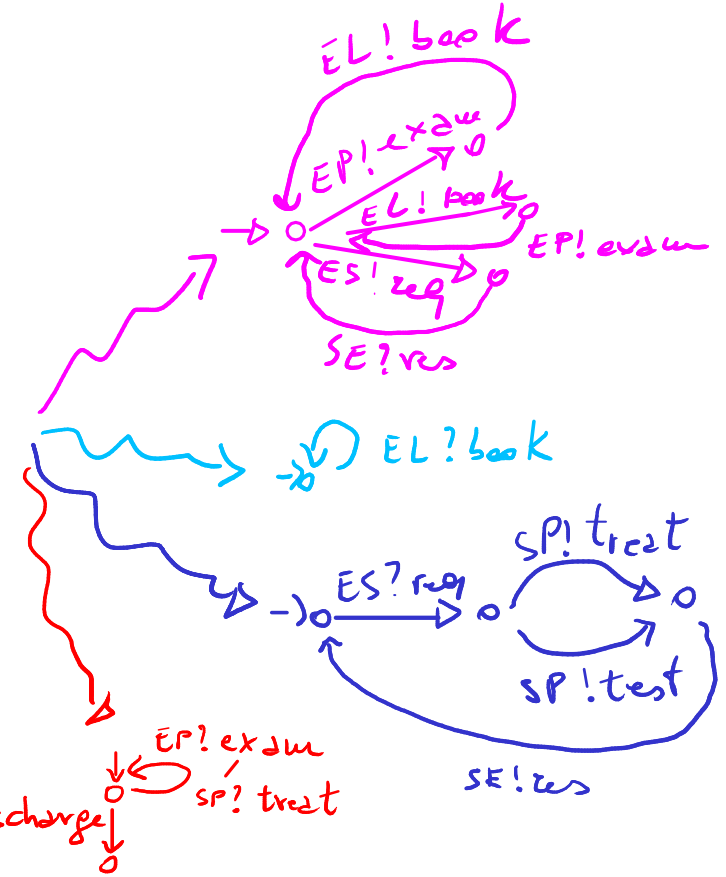


Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Behavioural models as type

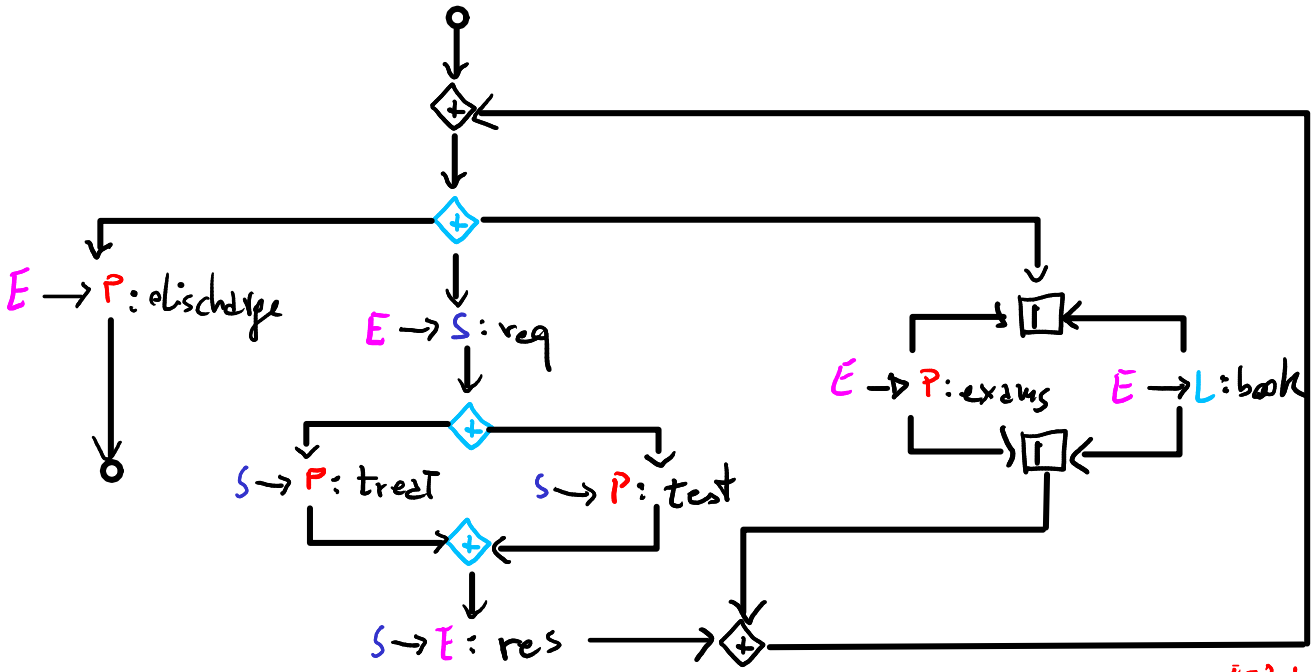


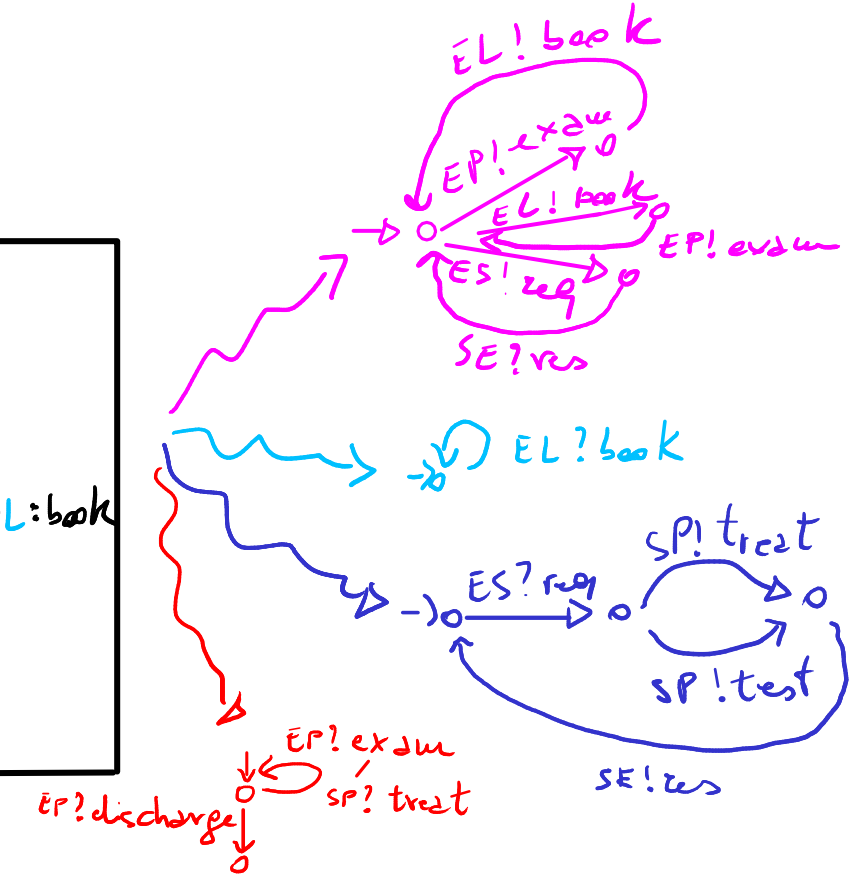


Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Behavioural models as type



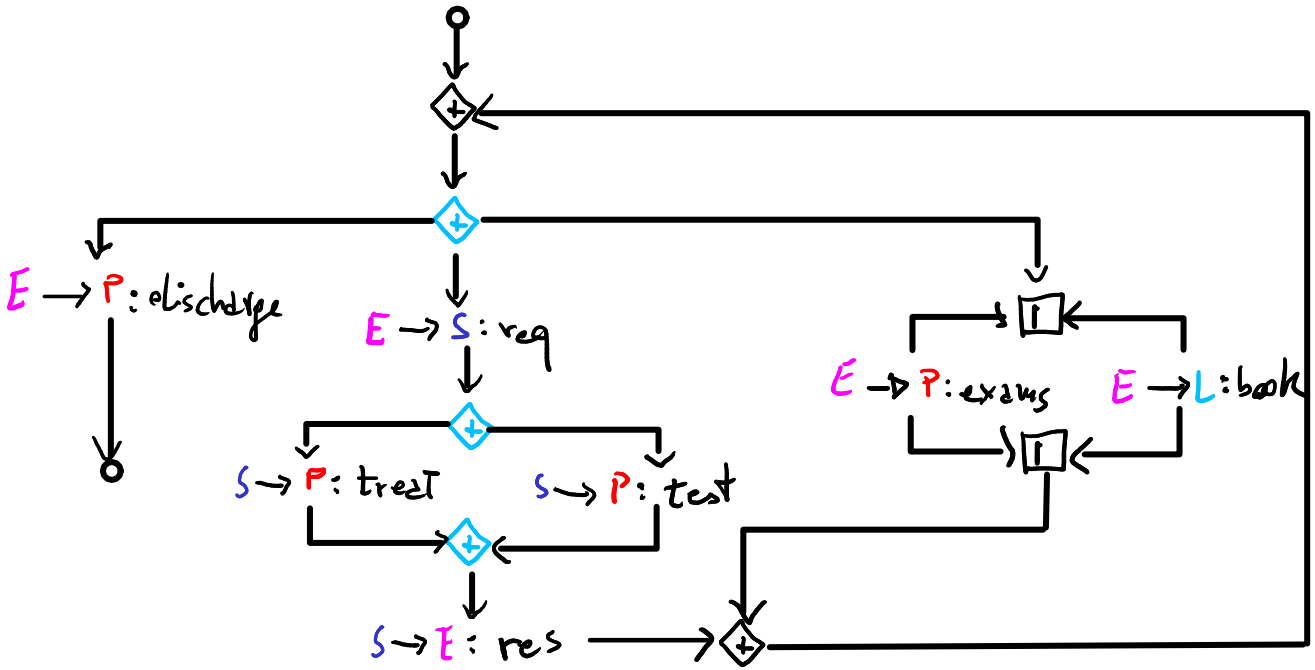


- ✓ formal basic syntax/semantics
- ✓ several decidable properties
- ✗ tradeoff between control-resources
- ✓✗ operational & denotational semantics

tools for "typing"
- compliance
- realisability
- soundness/liveness
- ...

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Natural language



An audit panel may want to check

a) □◇ P discharged

b) □ S requested → ◇ E gets results

but they would phrase them as

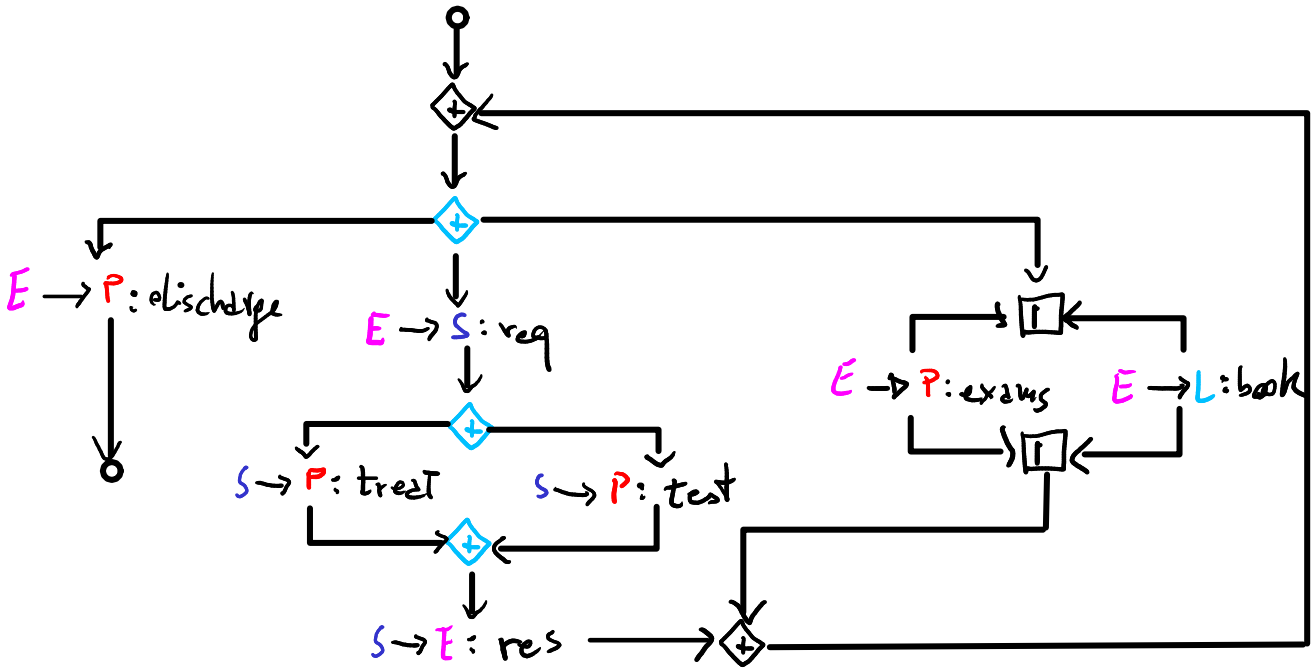
a') my patient will be discharged

b') the results of a specialist's examinations are sent to the emergency department

Can we "translate" (a) and (b) into (a') and (b')... and viceversa?

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Natural language



generation

reads

the emergency department
a. discharges patients immediately
(if their conditions are good), or
until the conditions of the patient are good,
b. requests for a specialist, or else
c. informs the patient about the exams
to do and books the lab

the results of a specialist's examinations are sent to the emergency department

interpretation

parses as → □ S requested → ◇ E gets results

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

A proposal

We advocate a model-driven approach combining

formal behavioural model & natural language processing

to foster

tool-supported static analysis of resource-aware workflows

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

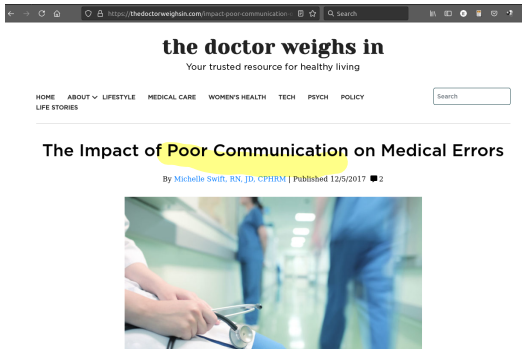
Goals

Accessibility

WUs must understand workflows

WUs do not share a common language

most WUs do not understand formal languages



Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Goals

Accessibility

WUs must understand workflows

WUs do not share a common language

most WUs do not understand formal languages

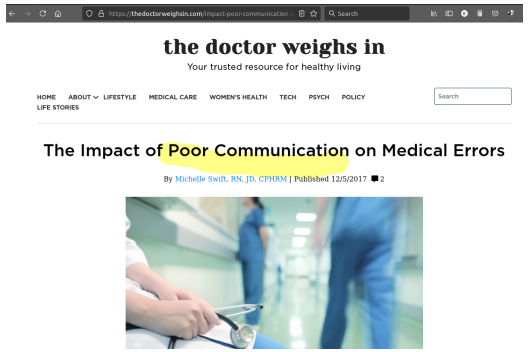
Realisability

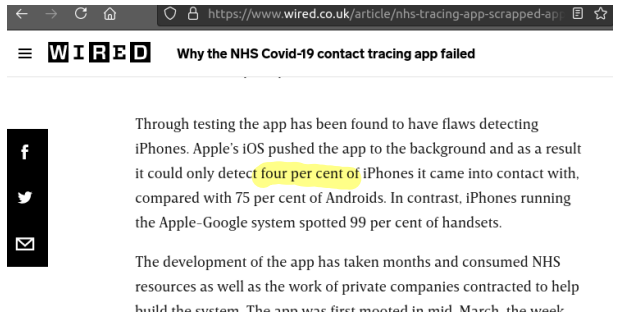
WUs are heterogeneous

Often the execution context is implicit

lack of internal consistency

Composition may break properties





Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

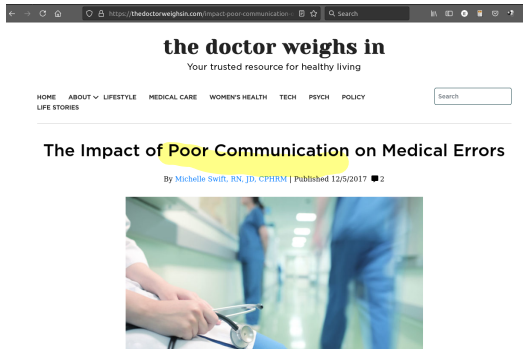
Goals

Accessibility

WUs must understand workflows

WUs do not share a common language

most WUs do not understand formal languages



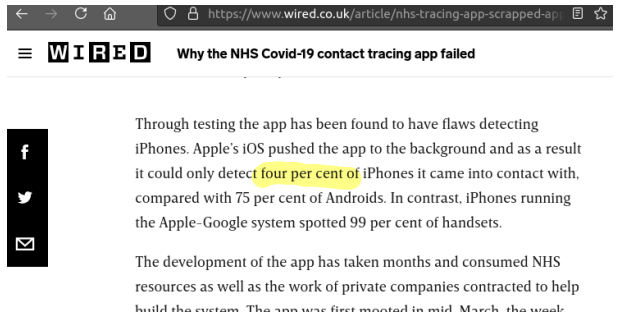
Realisability

WUs are heterogeneous

Often the execution context is implicit

lack of internal consistency

Composition may break properties



Compliance

Regulatory specs are hard to deal with

Regulatory specs may impose quantitative requirements

Simulations/monitoring are not enough

- our proposal

Harnessing workflows

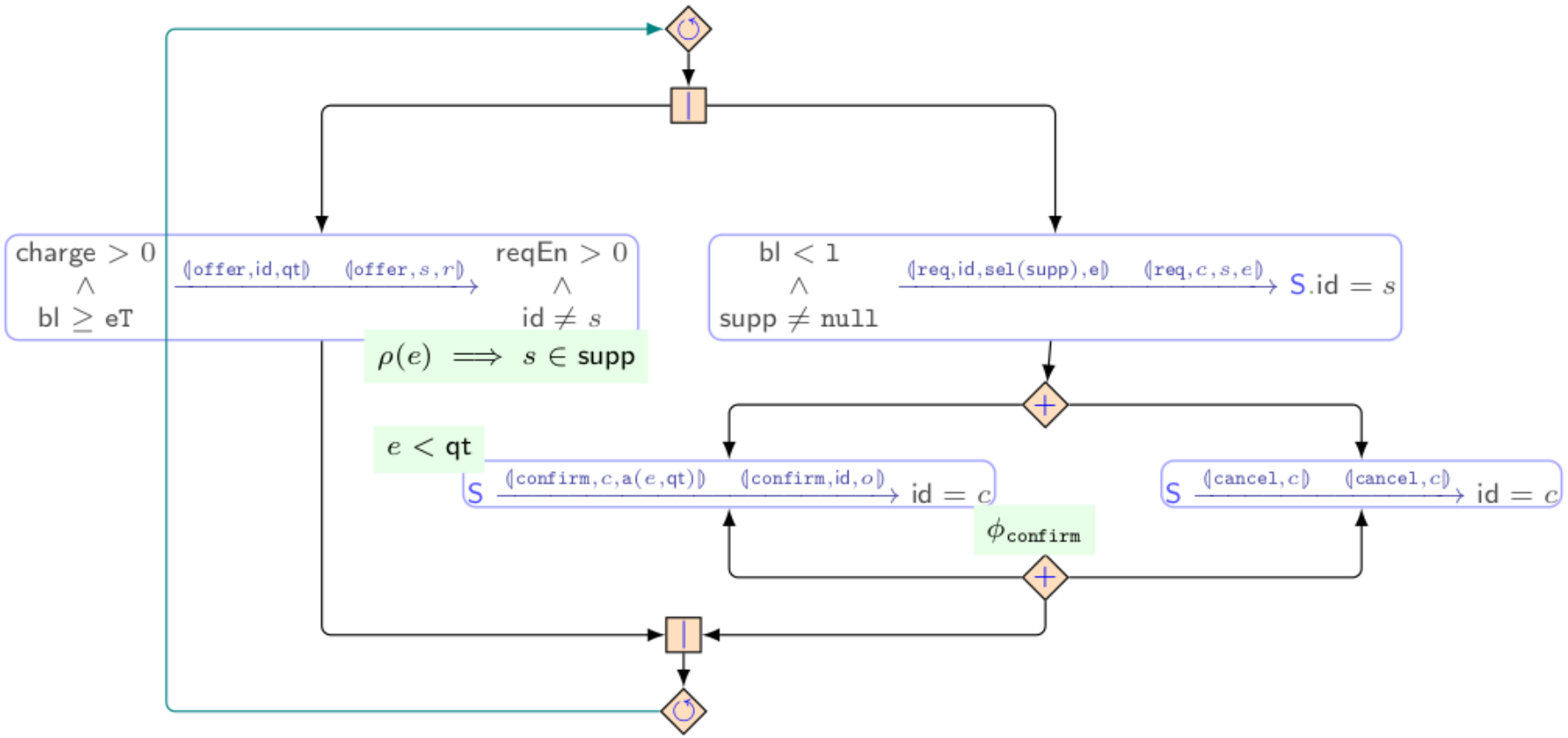
- Developing a theory of resource-aware workflows
- Defining DSL, algorithms, and tools to
  - specify workflows and their properties
  - refine workflows
  - statically analyse workflows

Our guiding principle:

to deliver intelligible statically checked workflows

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

theory



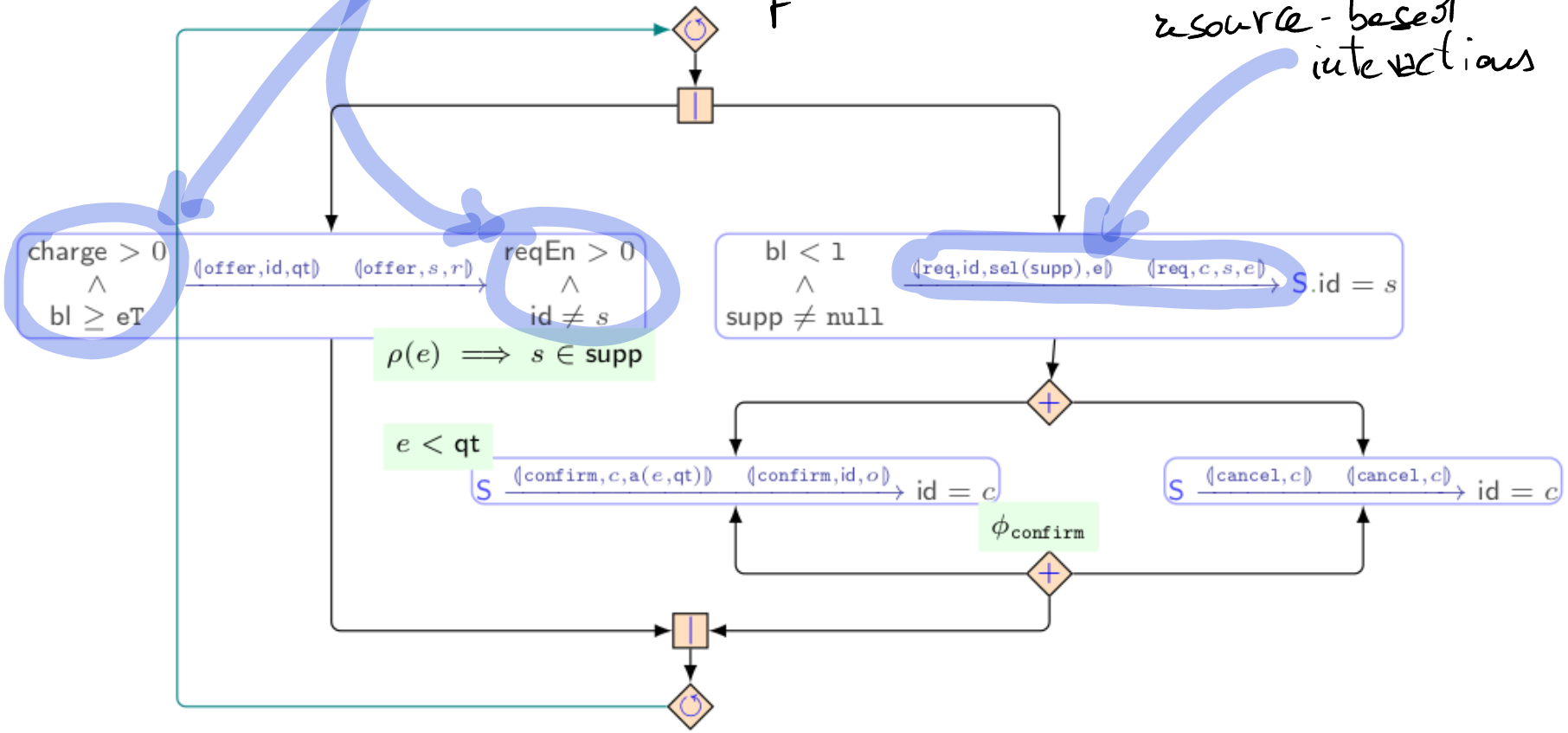
Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

theory

attribute-based specification of WU

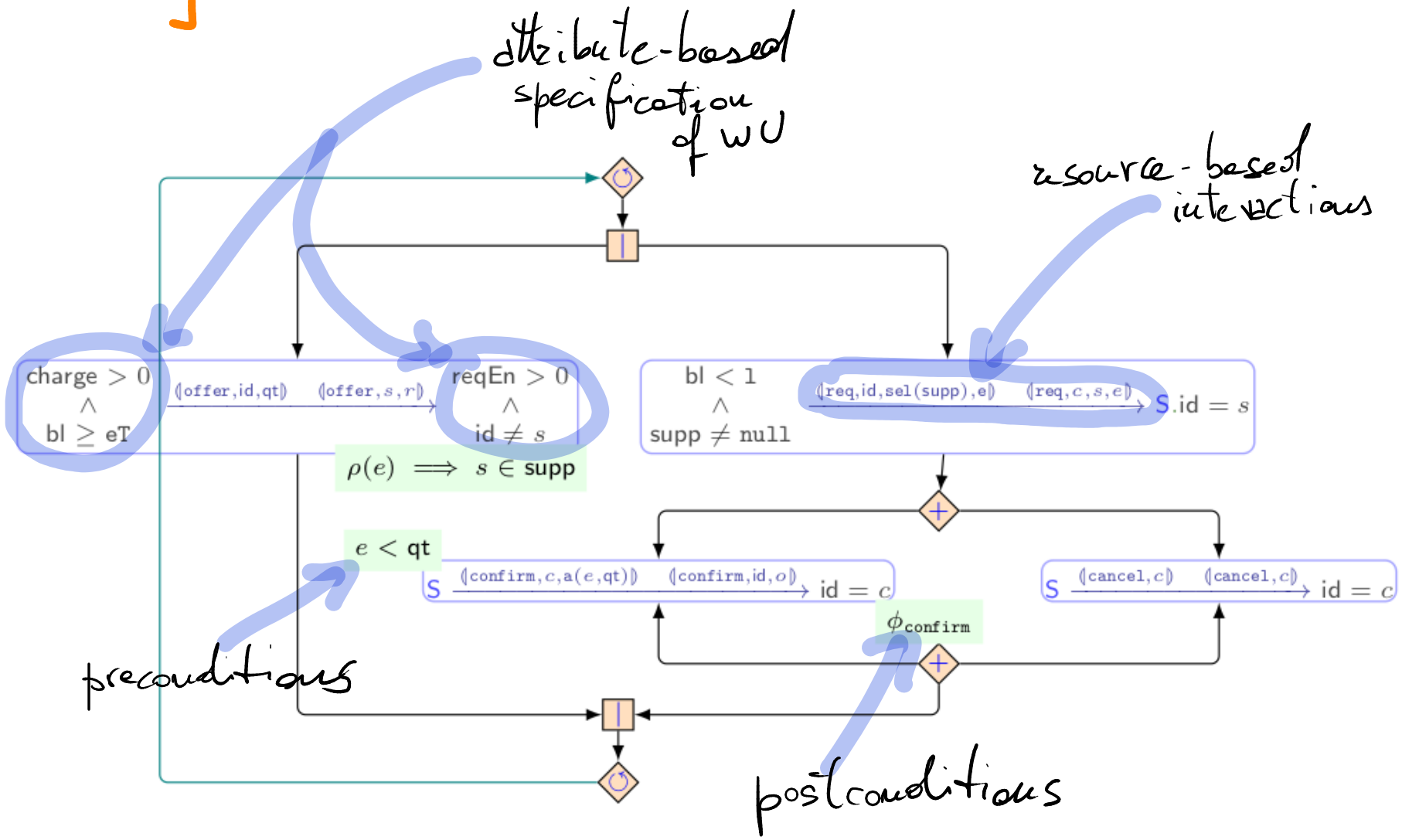
resource-based interactions



Outline of the talk

- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

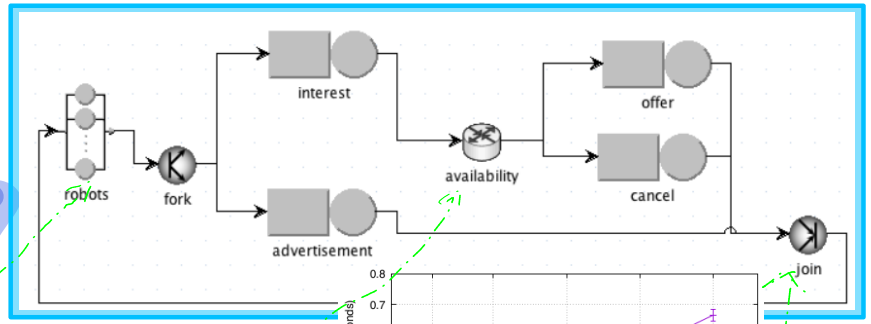
theory

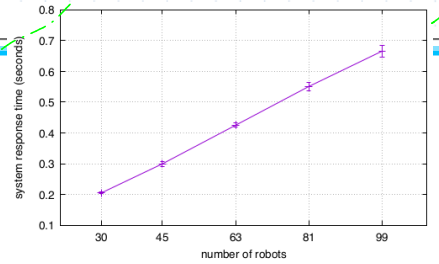


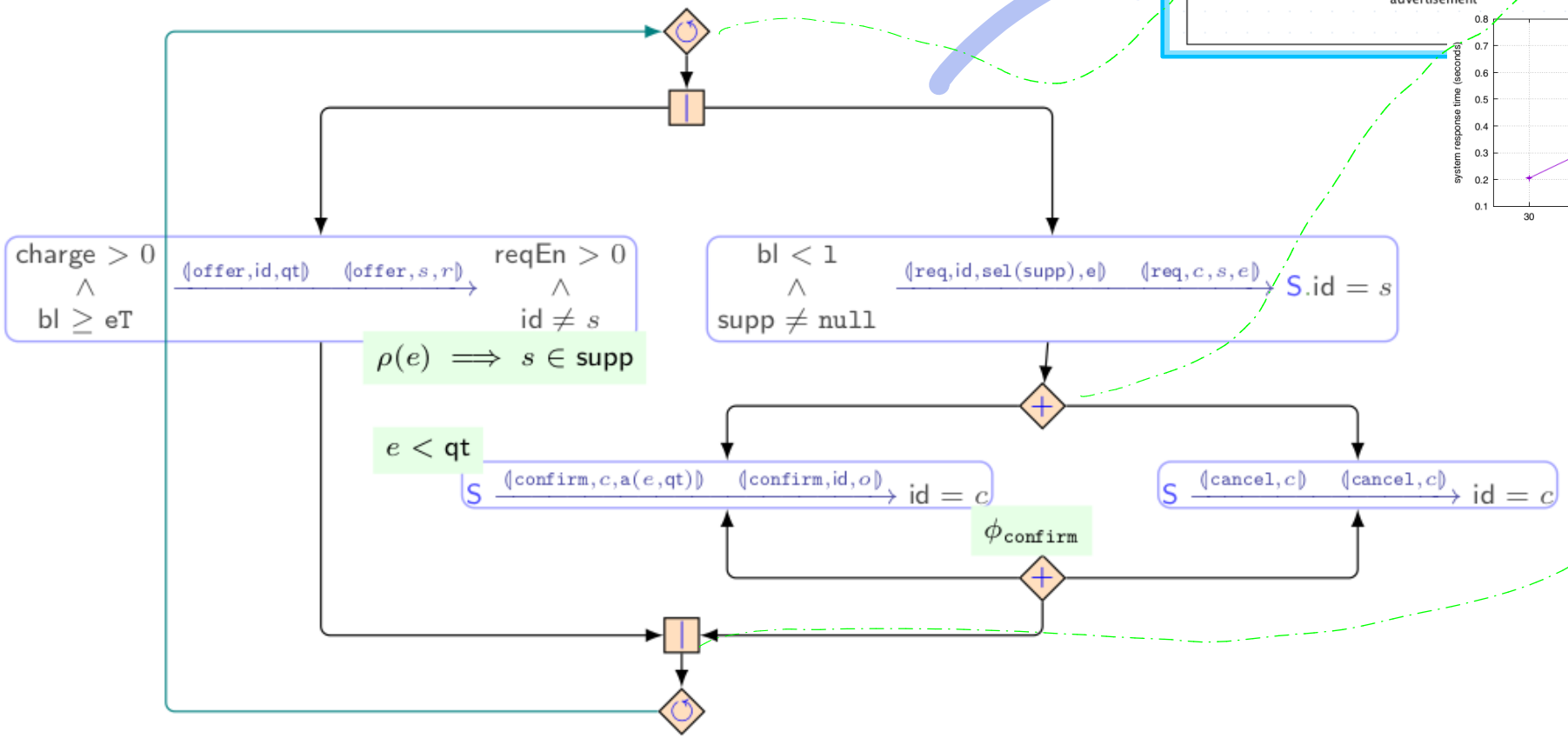
Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

theory

QN model automatically derivable







Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Languages, algorithms, and tools

- Behavioral typing to statically enforce properties
- WU-friendly DSL to capture { causal- & resource-dependencies; relevant (non-)functional properties }
- "interfaces" with industrial standards { natural language; machine processable } ... BPMN, DCR solutions, KNIME, MAPs
- Tools: besides the industrial platforms

```
(Ris)QFLan # DSLs for quantitative analysis
ChorGram   # tool-chain for multiparty session types
AIOCJ      # choreographic programming language
OKGraph    # unsupervised language understanding
...        # ...
```

Outline of the talk
- workflows (in healthcare)
- what are behavioral models
- natural language processing
- our proposal

Thank you!