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IDLab
INTERNET & DATA LAB

imec

FACULTY OF ENGINEERING
AND ARCHITECTURE

AUTOMATIC (RE)CONFIGURATION OF RSP ENGINES

Mathias De Brouwer

Stream Reasoning Workshop 2019 in Linköping, Sweden – 17 April 2019

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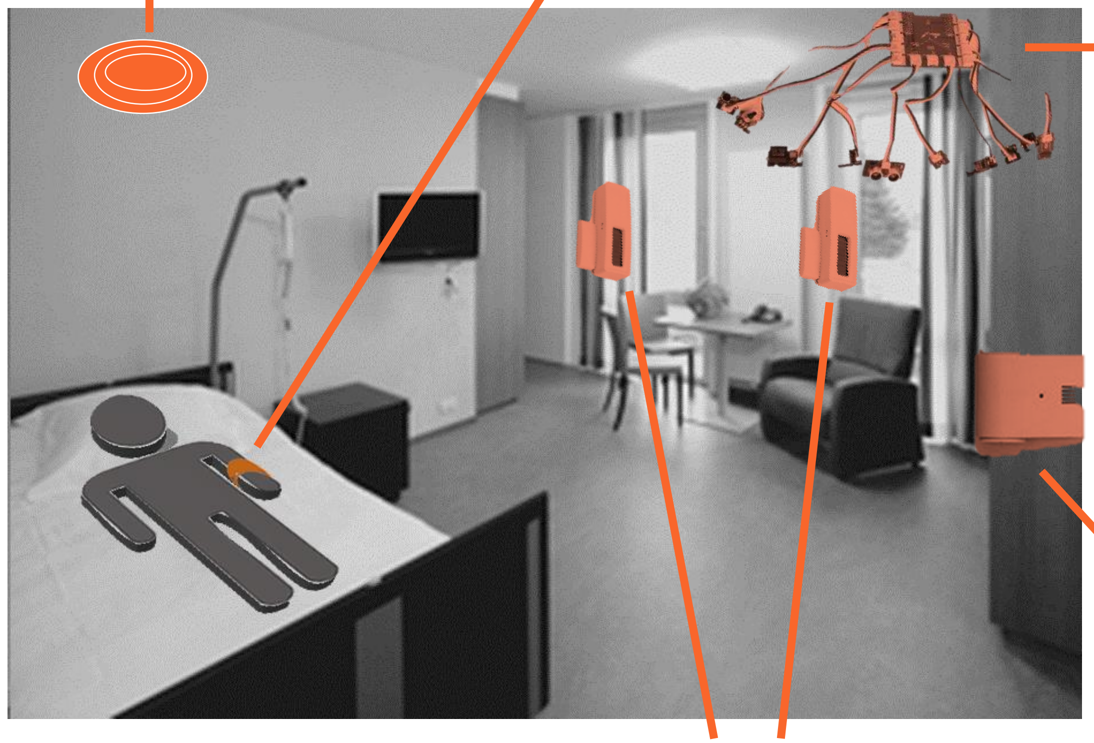
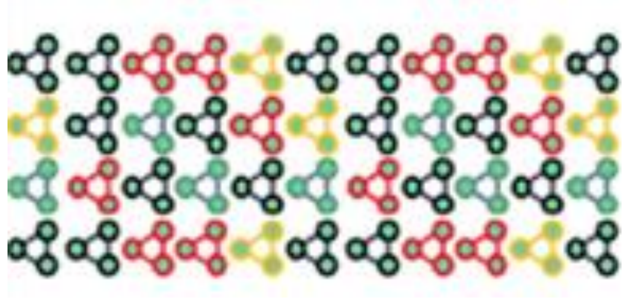
EXAMPLE USE CASE – PATIENT BOB

Motion sensor

Wearable



Sound sensor A0
Light sensor A1
Temperature sensor A2
…



Localization

Door/window sensor

Query 1: generate alarm if value measured by sensor A1 is > 250

RSP engine

Diagnosis Bob: epilepsy attack

Epilepsy patients are sensitive to light
Threshold: light should not go > 250 lumen

Electronic Health Record of patients

Medical domain knowledge

Hospital lay-out

Care staff

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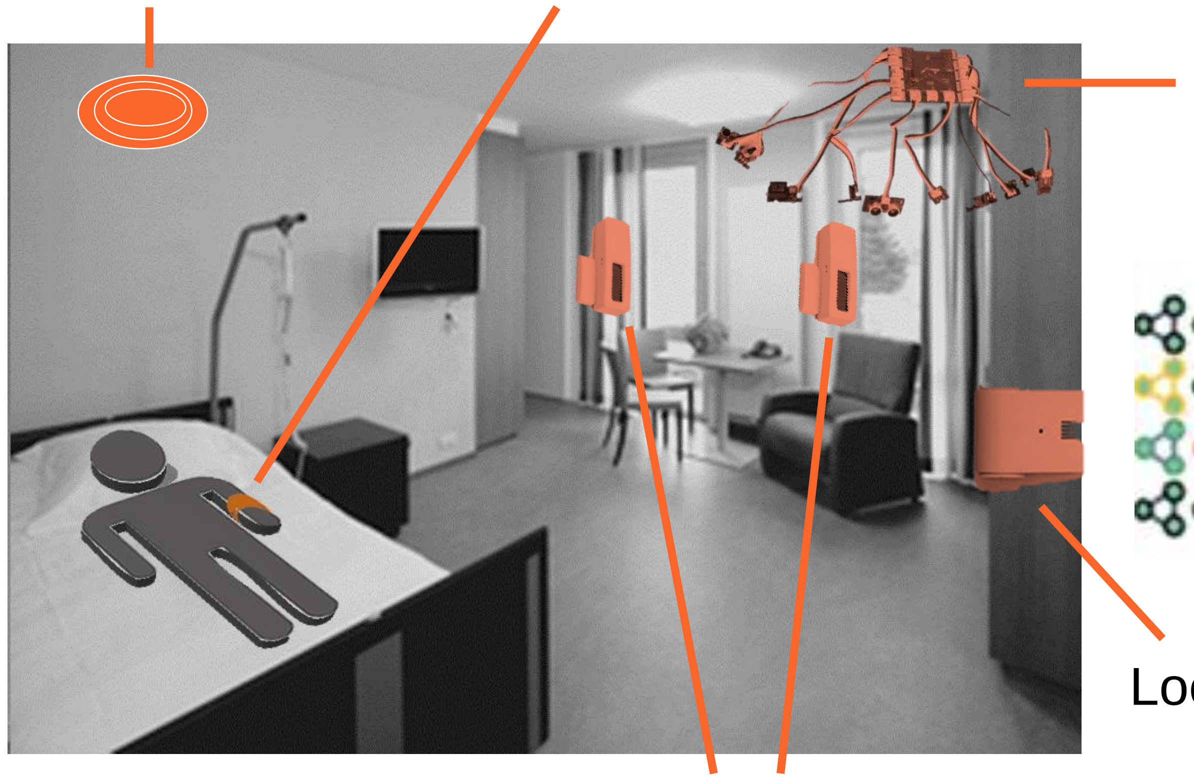
EXAMPLE USE CASE – PATIENT BOB

Motion sensor

Wearable



Sound sensor A0
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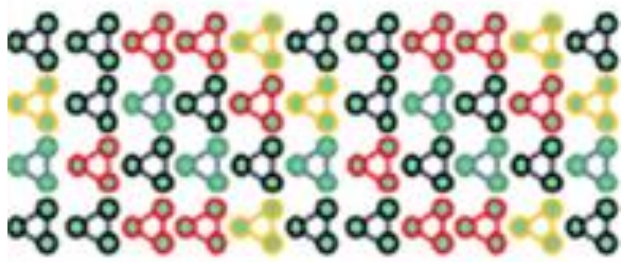

Localization

Door/window sensor

Query 1: generate alarm if value measured by sensor A1 is > ~~250~~ 170

Query 2: generate alarm if value measured by sensor A0 is > 30

RSP engine

Diagnosis Bob: concussion

Concussion patients are sensitive to light & sound
Thresholds: light should not go > 170 lumen, sound should not go > 30 decibels

Electronic Health Record of patients

Medical domain knowledge

Hospital lay-out

Care staff

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GENERAL ISSUE vs. GOAL

(Changed) context

~~Queries need to be **manually** (re)configured~~

By performing reasoning on changed context instead of on the real-time data streams

Queries of interest are **automatically** derived & (re)configured

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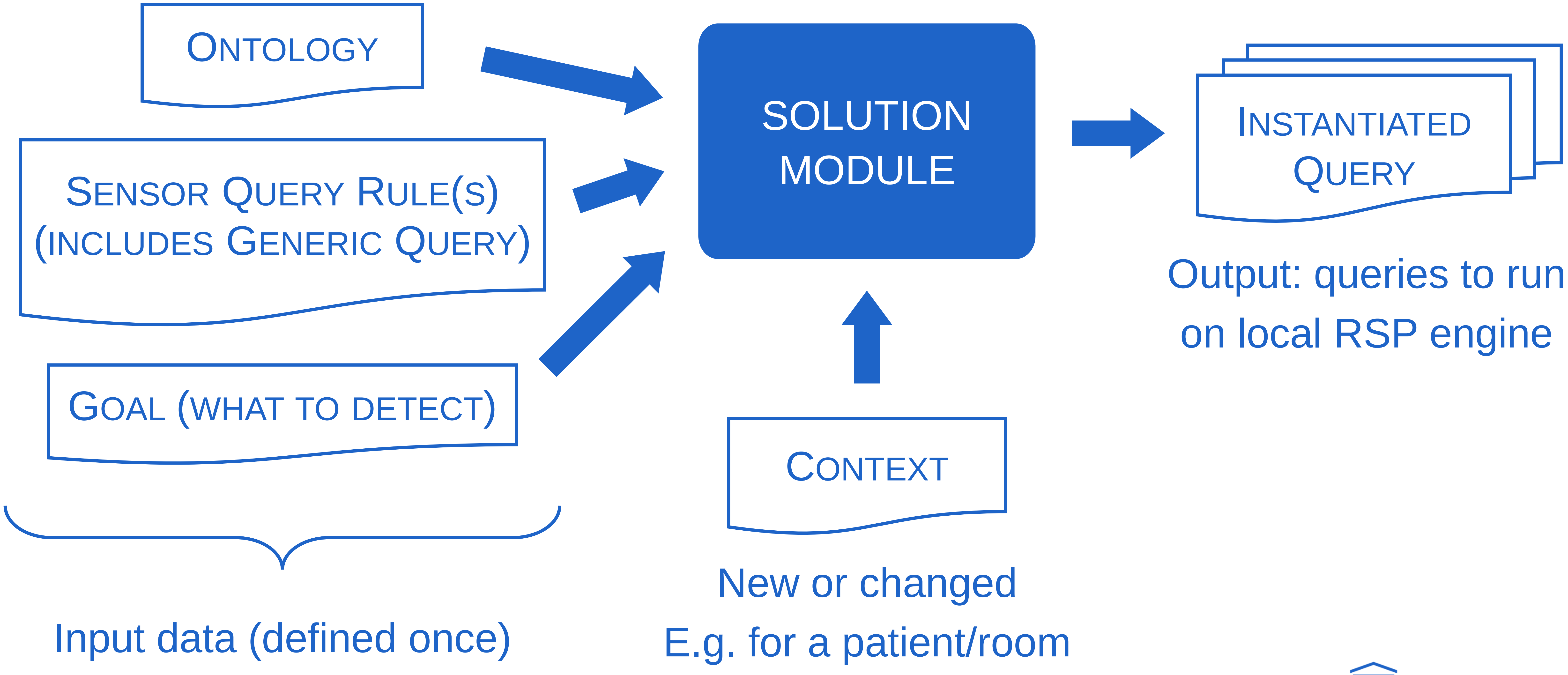
OUR SOLUTION: PROCESS



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EXAMPLE – OVERVIEW OF INPUTS

Reasoner goal: look for a Fault

```
{?x a :Fault.} => {?x a :Fault.}.
```

Ontology – relevant definitions (Manchester syntax) & individuals:

```
:LightIntensityAboveThresholdFault ≡ (:hasSymptom some :LightIntensityAboveThresholdSymptom)
                                     and ...
:LightIntensityAboveThresholdFault ⊆ :Fault

:Concussion a :Diagnosis; :hasMedicalSymptom :ConcussionSensitivenessToLight .
:ConcussionSensitivenessToLight :hasThreshold :ConcussionLightThreshold .
:ConcussionLightThreshold :hasDataValue "170"^^xsd:float ;
                          :isThresholdOnProperty [ a :LightIntensity ] .
```

Context – part about Bob and his room:

```
:Bob a :Person ; :hasRole [ a :PatientRole ] ; :hasLocation :R101 ; :hasDiagnosis :Concussion .

:40-a5-ef-05-a4-a6-A0 a :SoundSensor ; :hasLocation :R101 .
:40-a5-ef-05-a4-a6-A1 a :LightSensor ; :hasLocation :R101 .
:40-a5-ef-05-a4-a6-A2 a :TemperatureSensor ; :hasLocation :R101 .
...
```

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WHAT IS THIS SENSOR QUERY RULE ?

```
{
    ?p :hasRole [ a :PatientRole ] ;
       :hasLocation ?l ;
       :hasDiagnosis [ :hasMedicalSymptom [ :hasThreshold [
           :hasDataValue ?t ; :isThresholdOnProperty [ a ?prop ]
       ] ] ] .

    ?s a :Sensor ; :observes [ a ?prop ] ; :hasLocation ?l .
} => {
    _:x a :Query ;
        :queryPattern { _:o a sosa:Observation ; :madeBySensor ?s ;
                                :hasResult [ :hasDataValue _:v ] . } ;
        :valueThreshold ?t .

    _:oo a :observation ; :madeBySensor ?s ;
         :hasResult [ :hasDataValue _:v ] ;
         :hasSymptom [ a :ThresholdSymptom ; :forProperty [ a ?prop ] ] .
} .
```

Representation of generic query

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MAGIC BEHIND SOLUTION MODULE

Proof-of-Concept: N_3Logic & EYE reasoner

Reasoner inputs:

- Ontology + sensor query rule + context
- Rules (OWL-RL & existential rules supported by N_3 not in OWL-RL)

Reasoner goal: look for a Fault

```
{?x a :Fault.} => {?x a :Fault.}.
```

➔ EYE reasoner produces a proof with the goal as the last applied rule

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WHAT IS THIS SENSOR QUERY RULE ?

```
{
    ?p :hasRole [ a :PatientRole ] ;
       :hasLocation ?l ;
       :hasDiagnosis [ :hasMedicalSymptom [ :hasThreshold [
           :hasDataValue ?t ; :isThresholdOnProperty [ a ?prop ]
       ] ] ] .

    ?s a :Sensor ; :observes [ a ?prop ] ; :hasLocation ?l .
} => {
    _:x a :Query ;
        :queryPattern { _:o a sosa:Observation ; :madeBySensor ?s ;
                                :hasResult [ :hasDataValue _:v ] . } ;
        :valueThreshold ?t .

    _:oo a :observation ; :madeBySensor ?s ;
         :hasResult [ :hasDataValue _:v ] ;
         :hasSymptom [ a :ThresholdSymptom ; :forProperty [ a ?prop ] ] .
} .
```

Representation of generic query

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HOW ARE THE QUERIES DERIVED ?

Instantiated relevant queries appear in this proof

↓

Can be extracted with additional reasoning step

```
<#lemma32> a r:Inference;
  r:gives {
    _:sk_11 a ns4:Query.
    _:sk_11 ns4:queryPattern {_:sk_12 a sosa:Observation.
     _:sk_12 sosa:madeBySensor
       <http://occs.intec.ugent.be/ontology/entity#40-a5-ef-05-a4-a6-A1>.
     _:sk_12 sosa:hasResult _:sk_13.
     _:sk_13 a SSNiot:QuantityObservationValue.
     _:sk_13 DUL:hasDataValue _:sk_14}.
    _:sk_11 ns4:valueThreshold "170.0"^^xsd:float.
    _:sk_15 a sosa:Observation.
    _:sk_15 sosa:madeBySensor
      <http://occs.intec.ugent.be/ontology/entity#40-a5-ef-05-a4-a6-A1>.
    _:sk_15 sosa:hasResult _:sk_16.
    _:sk_16 a SSNiot:QuantityObservationValue.
    _:sk_16 DUL:hasDataValue _:sk_17.
    _:sk_15 SSNiot:hasSymptom _:sk_18.
    _:sk_18 a SSNiot:ThresholdSymptom.
    _:sk_18 ssn:forProperty _:sk_19.
    _:sk_19 a SSNiot:LightIntensity.
  };
  r:evidence (
    <#lemma46>
    ...
    <#lemma57>
  );
  r:rule <#lemma58>.
```

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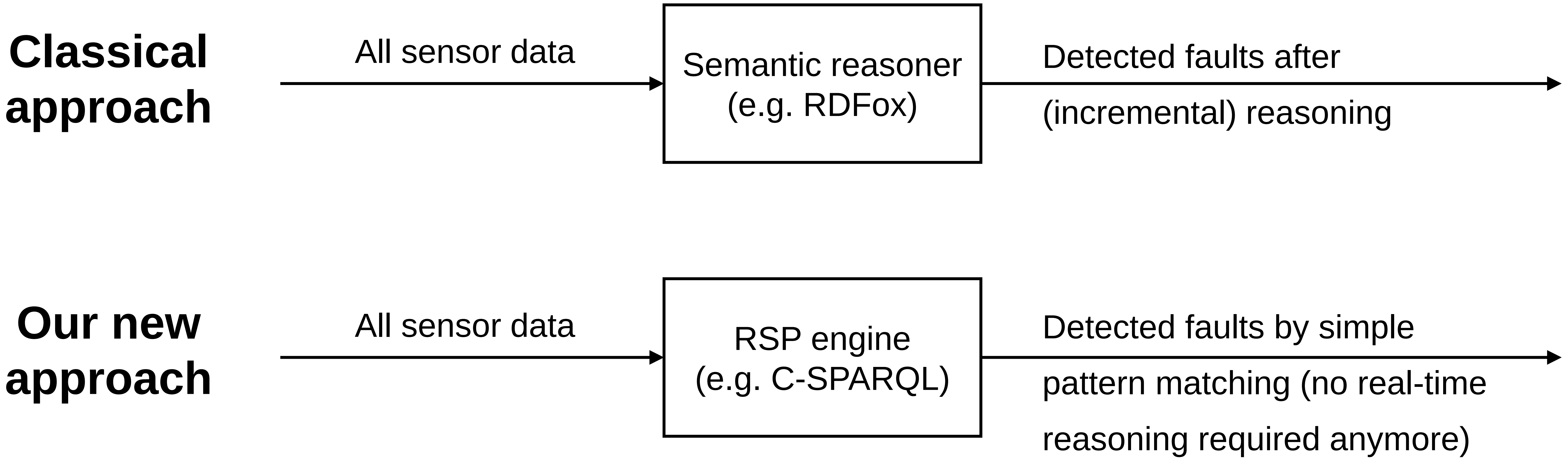
COMPARISON WITH REASONING APPROACH

What is the real-time data flow?



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FUTURE STEPS IN THIS RESEARCH

- Building a first Proof-of-Concept on an extended version of the presented use case
- Introducing SHACL for the query representation
- Solving the challenges related to retrieving an RSP engine ready query from the proof
- Evaluation: comparison with real-time reasoning approach (RDFox?)

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