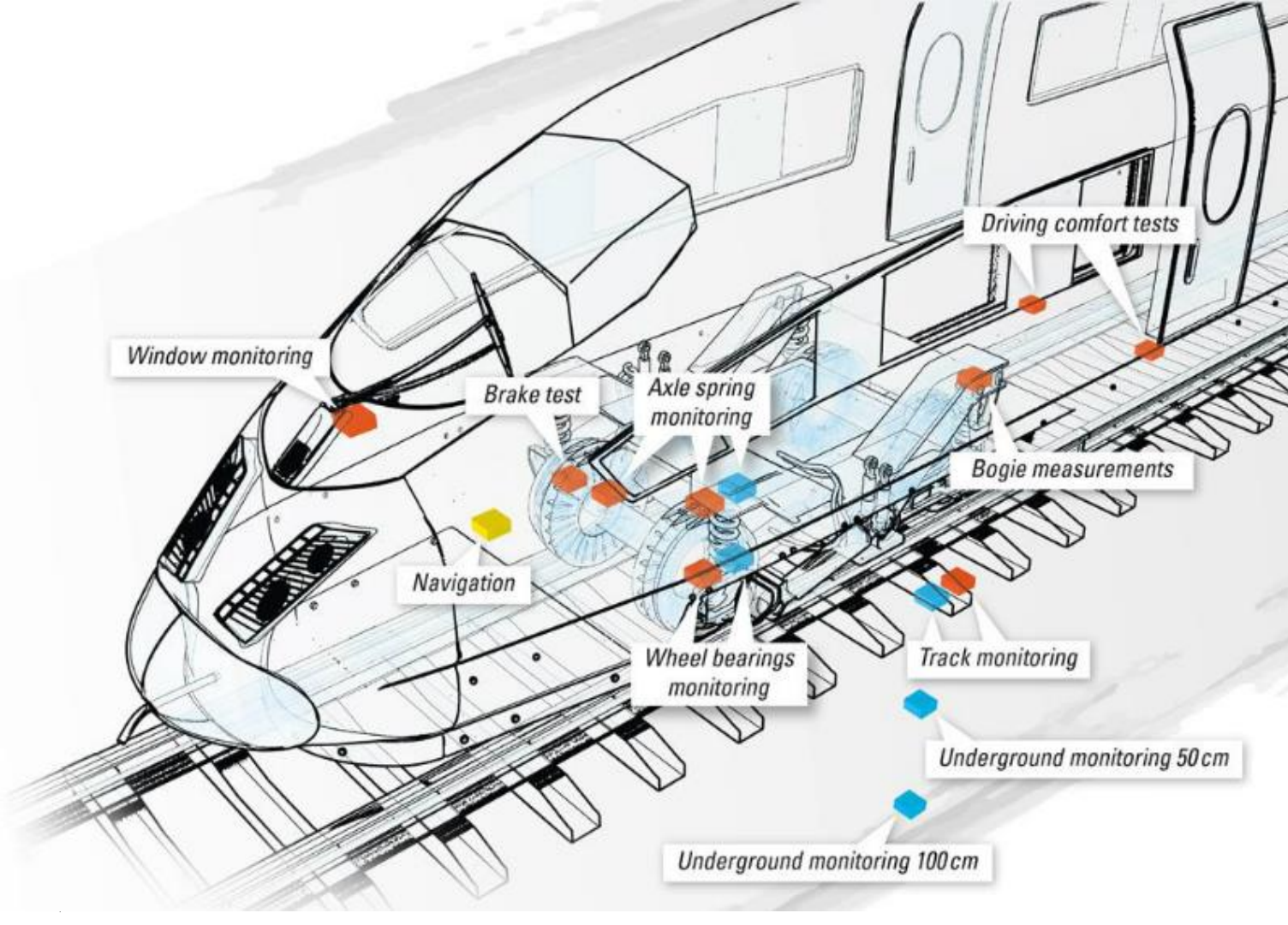
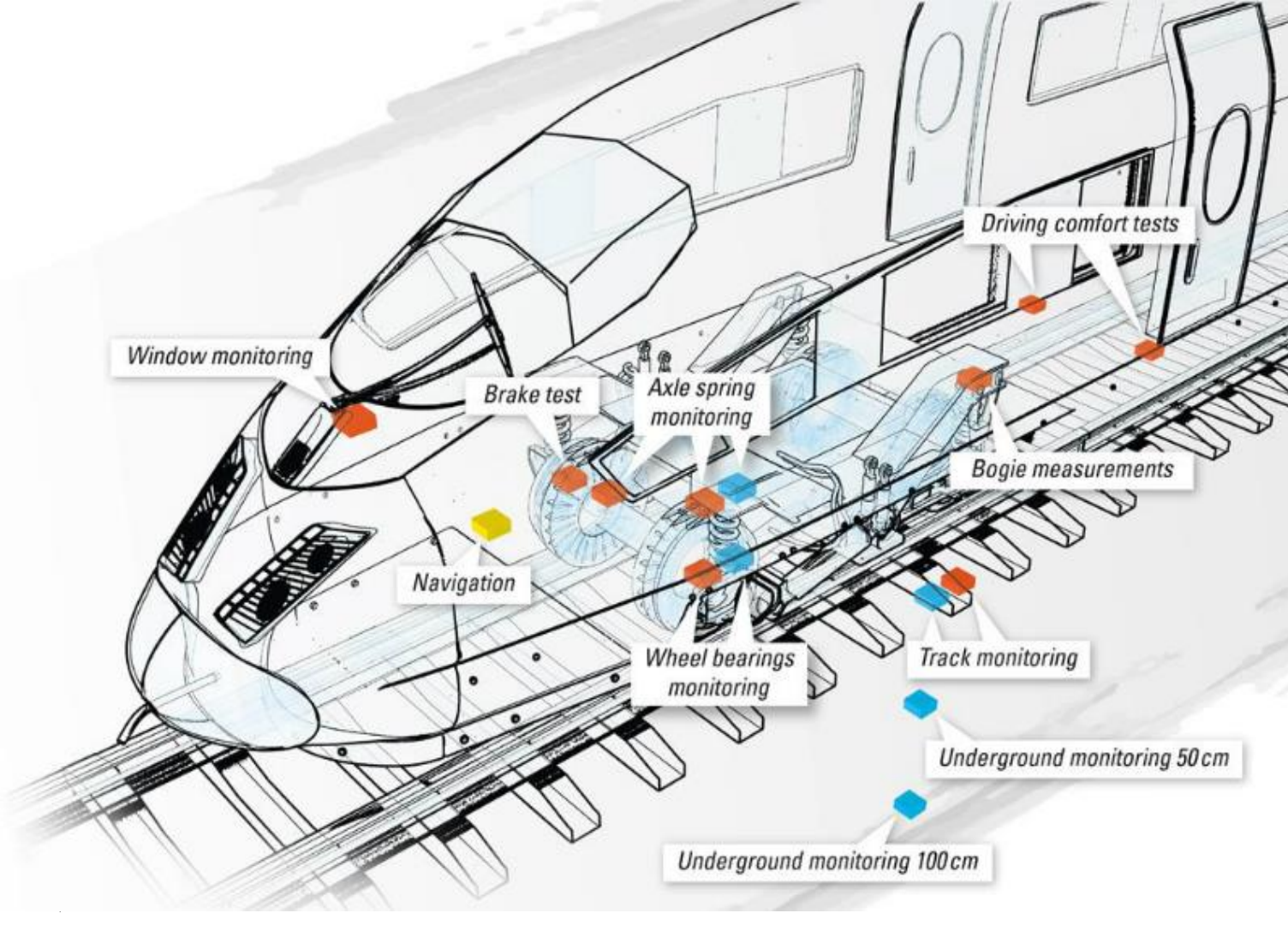
TOWARDS ADAPTIVE ANOMALY DETECTION AND ROOT CAUSE ANALYSIS BY AUTOMATED EXTRACTION OF KNOWLEDGE FROM RISK ANALYSES

BRAM STEENWINCKEL

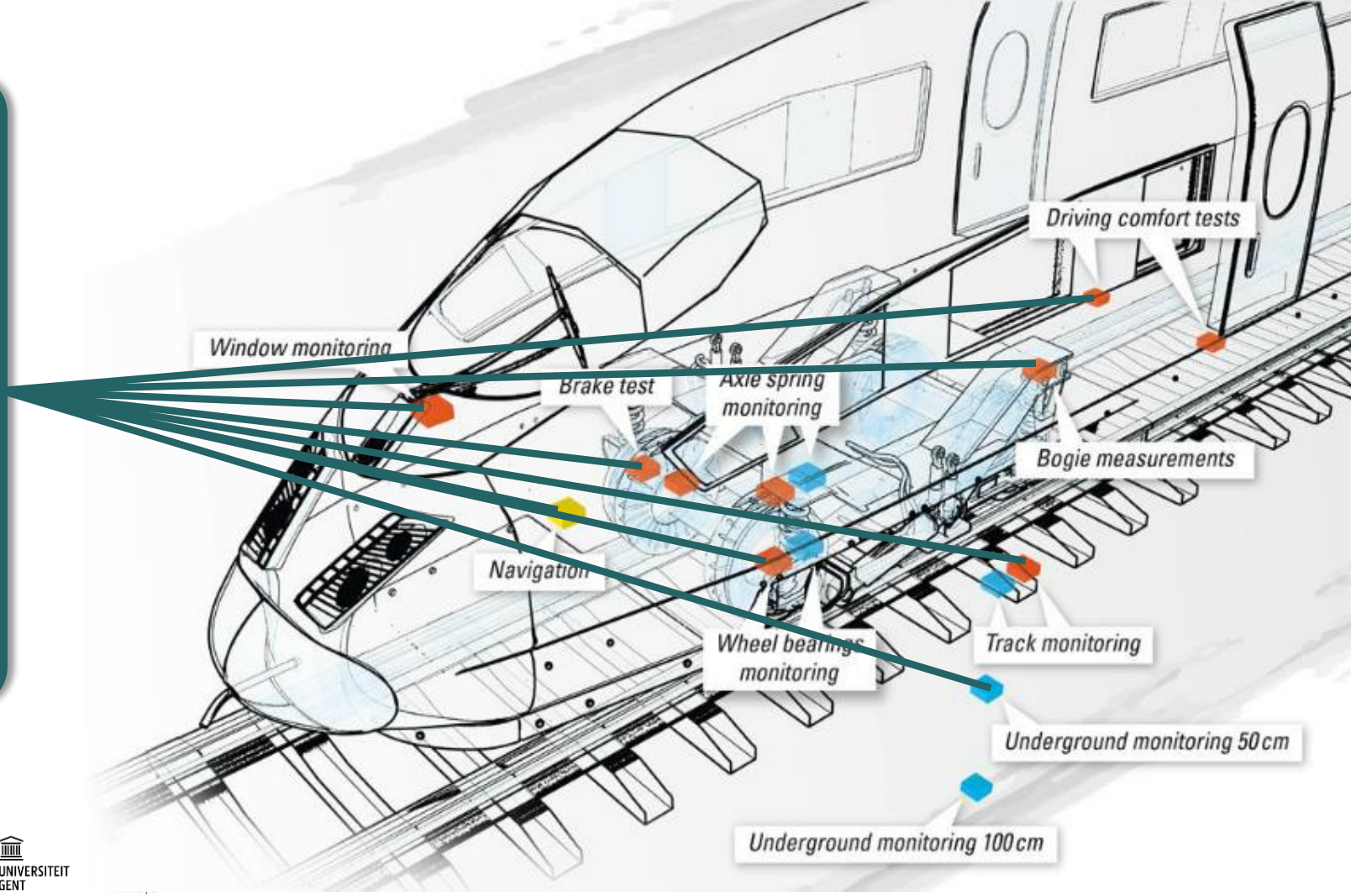
RISK
LOW
MEDIUM
HIGH
VERY HIGH
EXTREME


Driving comfort tests
Window monitoring
Brake test
Axle spring monitoring
Bogie measurements
Navigation
Wheel bearings monitoring
Track monitoring
Underground monitoring 50 cm
Underground monitoring 100 cm

Passenger comfort level



Passenger comfort level



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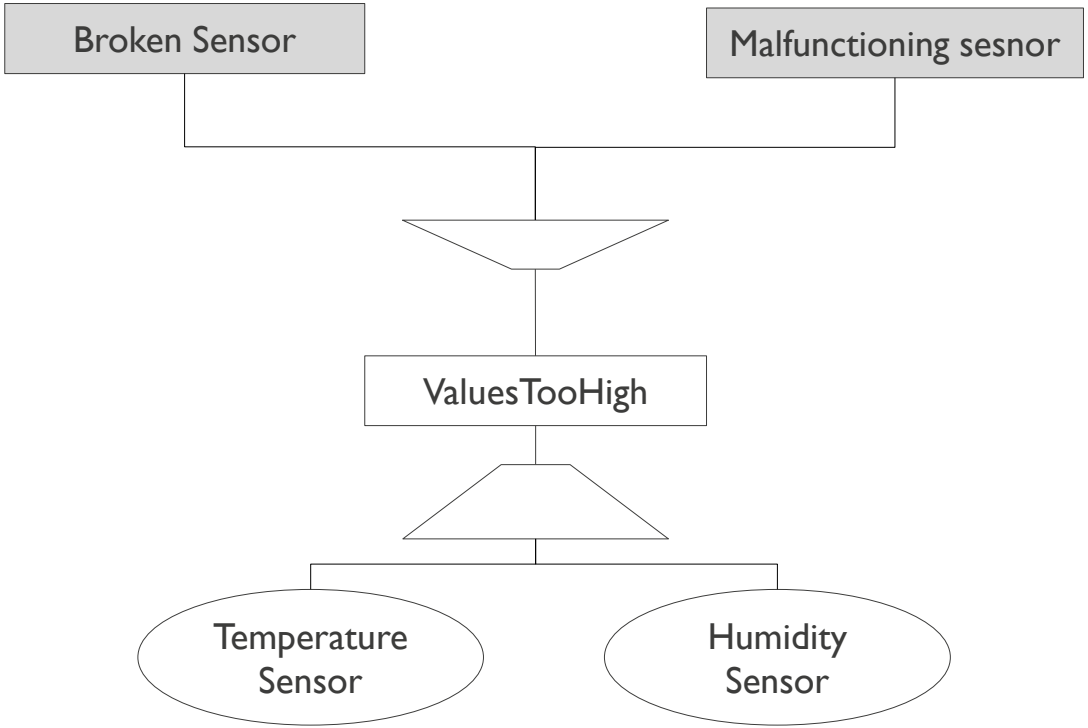
DOMAIN SPECIFIC KNOWLEDGE DEFINES THE BEHAVIOURS

FAILURE MODE AND EFFECT ANALYSIS (FMEA)

Component	Function	Failure Mode	Failure Effect	Failure Cause	Control Method	Containement Action
Passenger Comfort unit	Detects the level of comfort	False warning	Indicating an impossible comfort level	Broken sensor	None	None
Temperature Sensor	Measures the temperature of the wheels	Values too high	Broken sensor	Degredation of the sensor	None	Replace sensor
			Malfunctioning sesnor	Rapid temperature changes	None	Calibrate sensor
Humidity sensor	Measures the outside humitidity	Values too high	Broken sensor	Degredation of the sensor	None	Replace sensor
			Malfunctioning sesnor	Rapid temperature changes	None	Calibrate sensor

DOMAIN SPECIFIC KNOWLEDGE DEFINES THE BEHAVIOURS

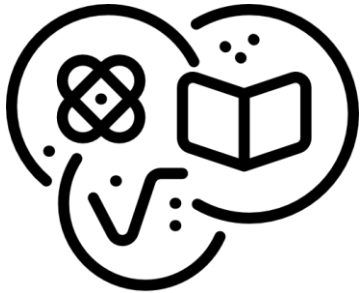
FAULT TREE ANALYSIS (FTA)



PROBLEM…

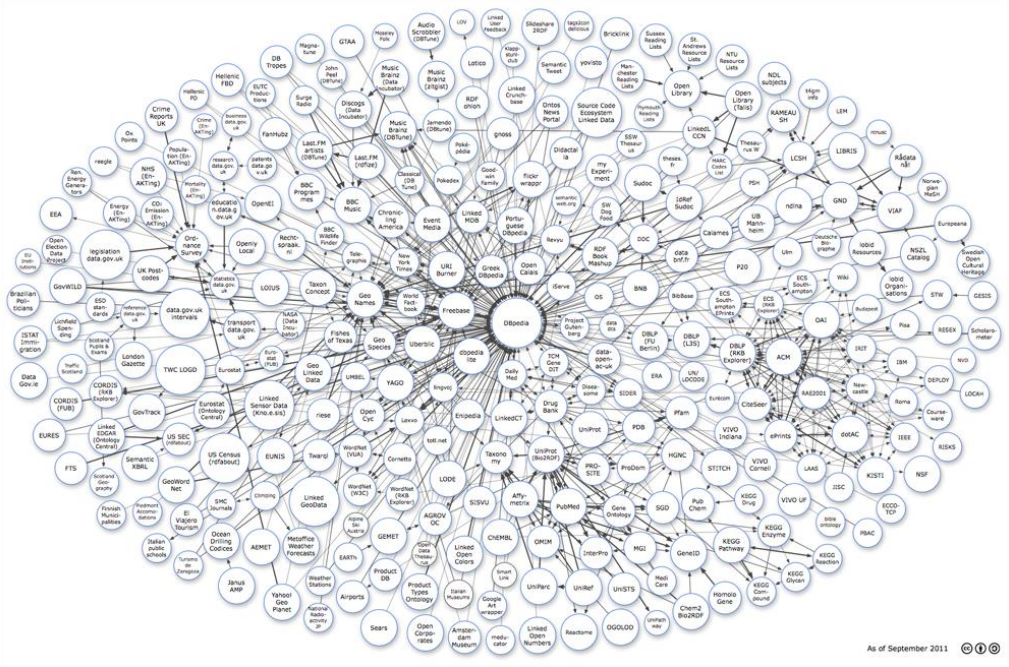
Two common risk analysis procedures: FMEA & FTA

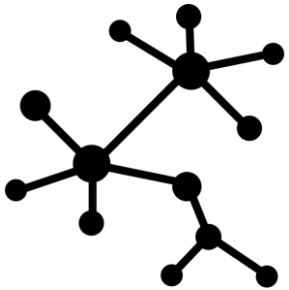
- Experts with different view on the system
- Ambiguities
- Inconsistencies



SOLUTION

Ontology design



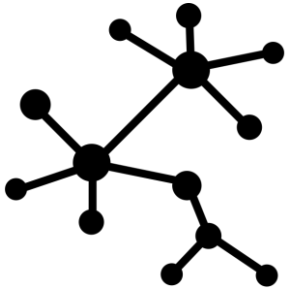


PROBLEM...

Domain expert != Ontology expert

SOLUTION

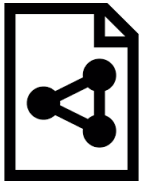
Knowledge



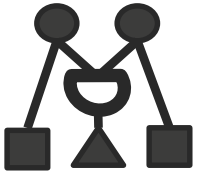
Ontology + Rules

SOLUTION

FMEA tables



Domain ontology



FTA tree

Semantic rules

FMEA MAPPING APPROACH

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FMEA MAPPING APPROACH

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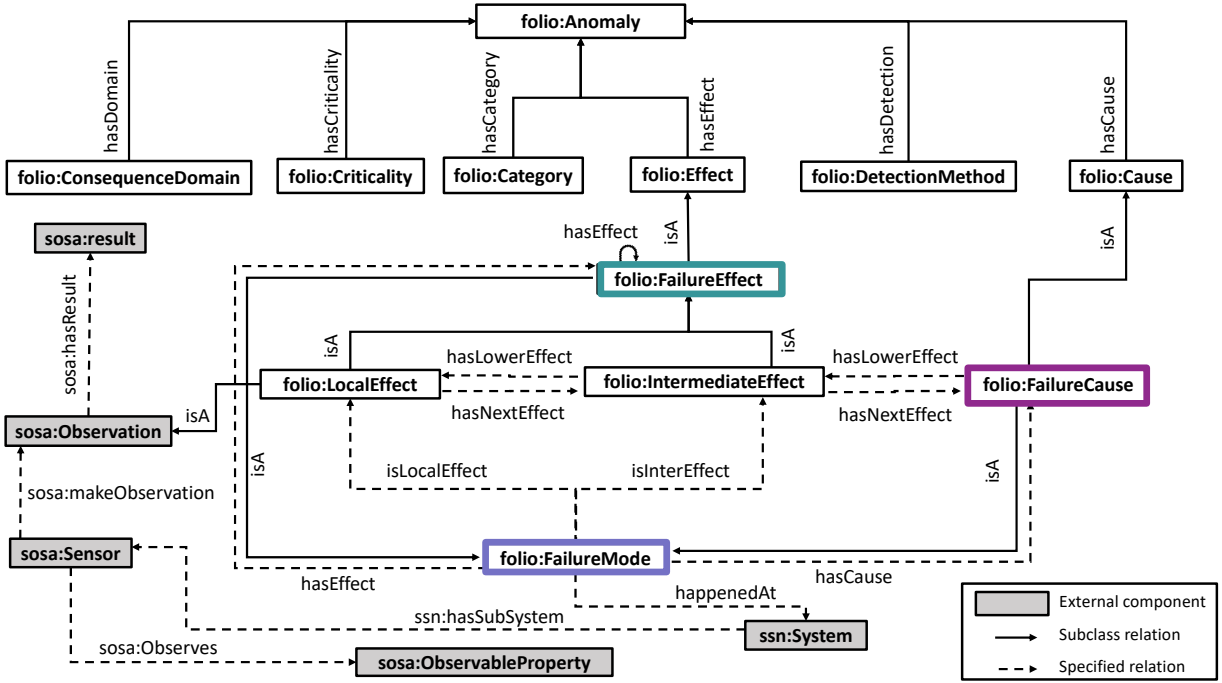
FMEA MAPPING APPROACH

FOLIO ONTOLOGY

Component	Function	Failure Mode	Failure Effect	Failure Cause	Control Method	Containement Action



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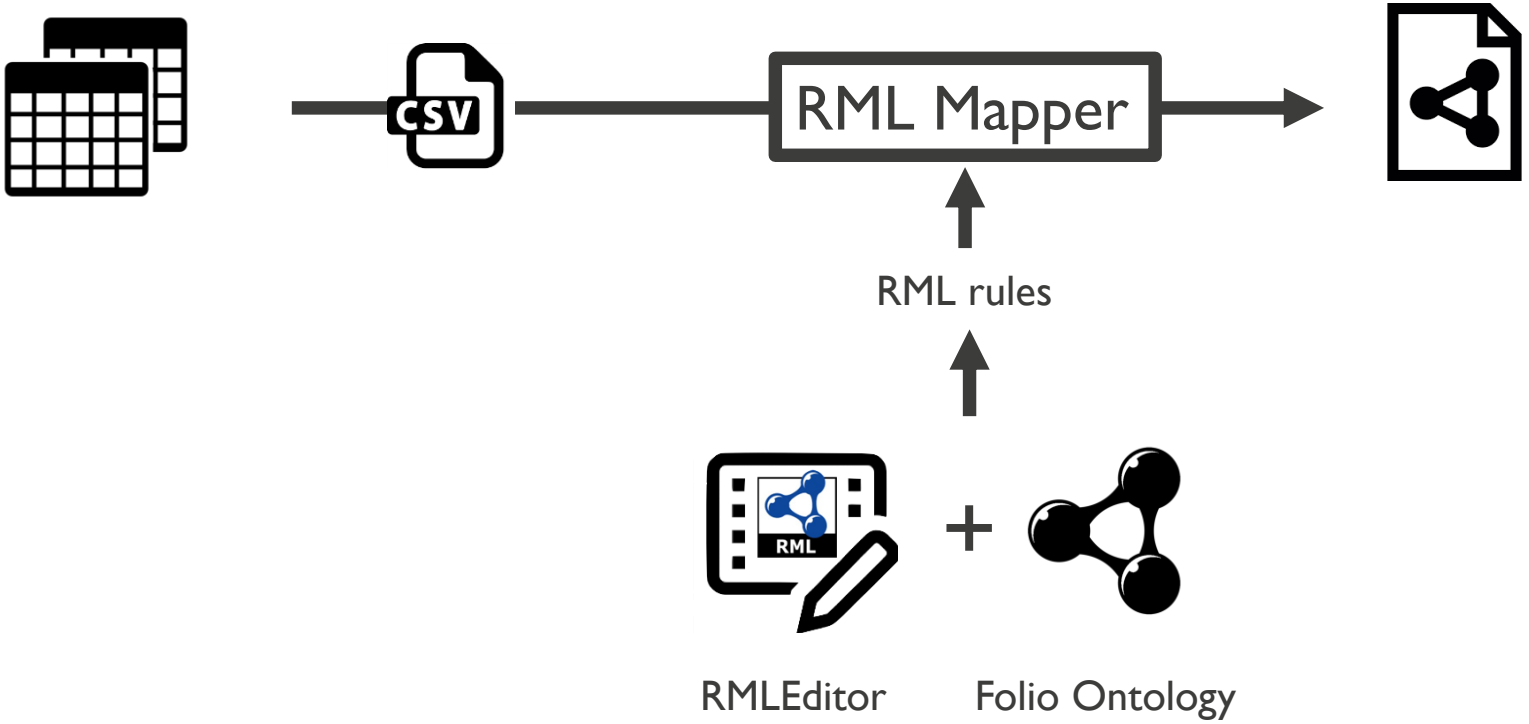
FMEA MAPPING APPROACH



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FMEA MAPPING APPROACH

EXAMPLE:

Component	Function	Failure Mode	Failure Effect	Failure Cause	Control Method	Containement Action
Temperature Sensor	Measures the temperature of the wheels	Values too high	Broken sensor	Degredation of the sensor	None	Replace sensor

New Concepts

- ValuesTooHigh is a folio:FailureMode
- BrokenSensor is a folio:FailureEffect
- DegredationOfTheSensor is a folio:FailureCause

FMEA MAPPING APPROACH

UPDATABILITY OF APPROACH?

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- What if expert adds aditional failure information?

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			Malfunctioning sesnor	Rapid temperature changes	None	Calibrate sensor
		Values stay the same	Malfunctioning sensor	Frozen sensor	None	None
Humidity sensor	Measures the outside humitidity	Values too high	Broken sensor	Degredation of the sensor	None	Replace sensor

FMEA MAPPING APPROACH

UPDATABILITY OF APPROACH?

- What if extra information from the FMEA template becomes important?

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UPDATABILITY OF APPROACH?

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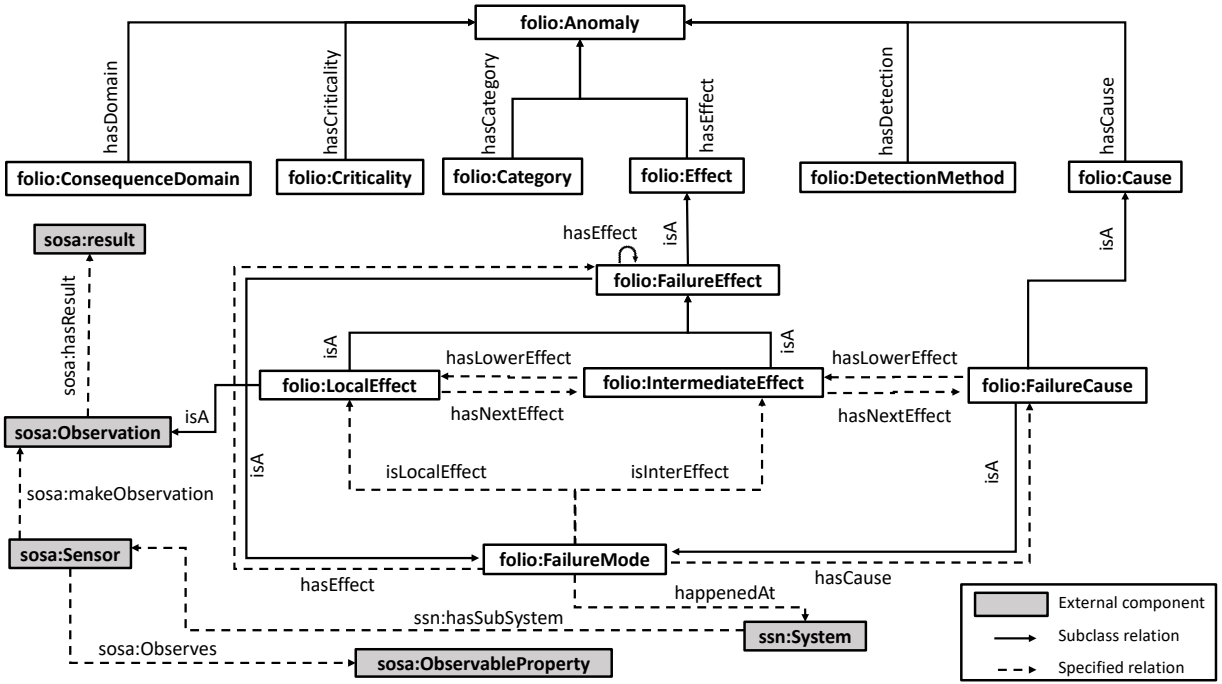
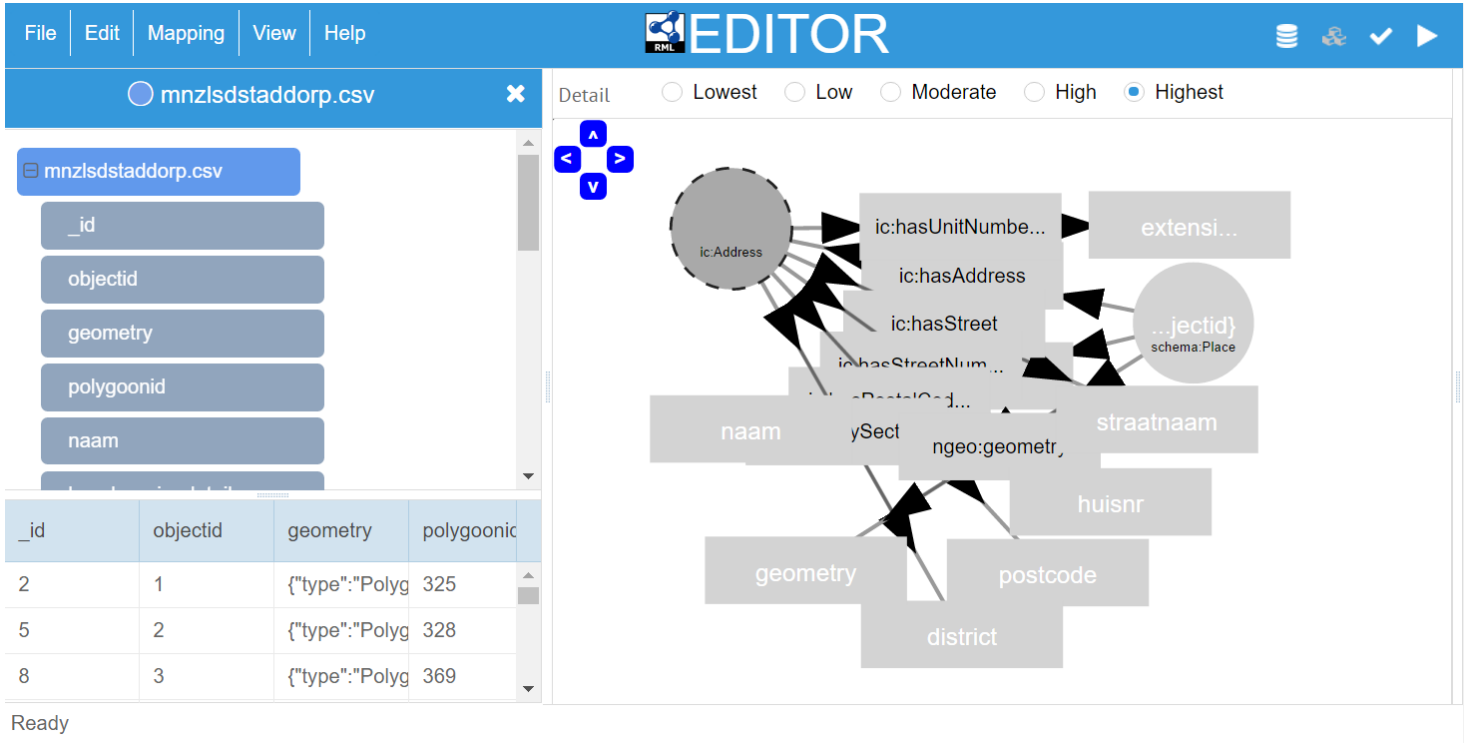
Component	Function	Failure Mode	Failure Effect	Failure Cause	Control Method	Containement Action	Criticality



FMEA MAPPING APPROACH

RMLEDITOR



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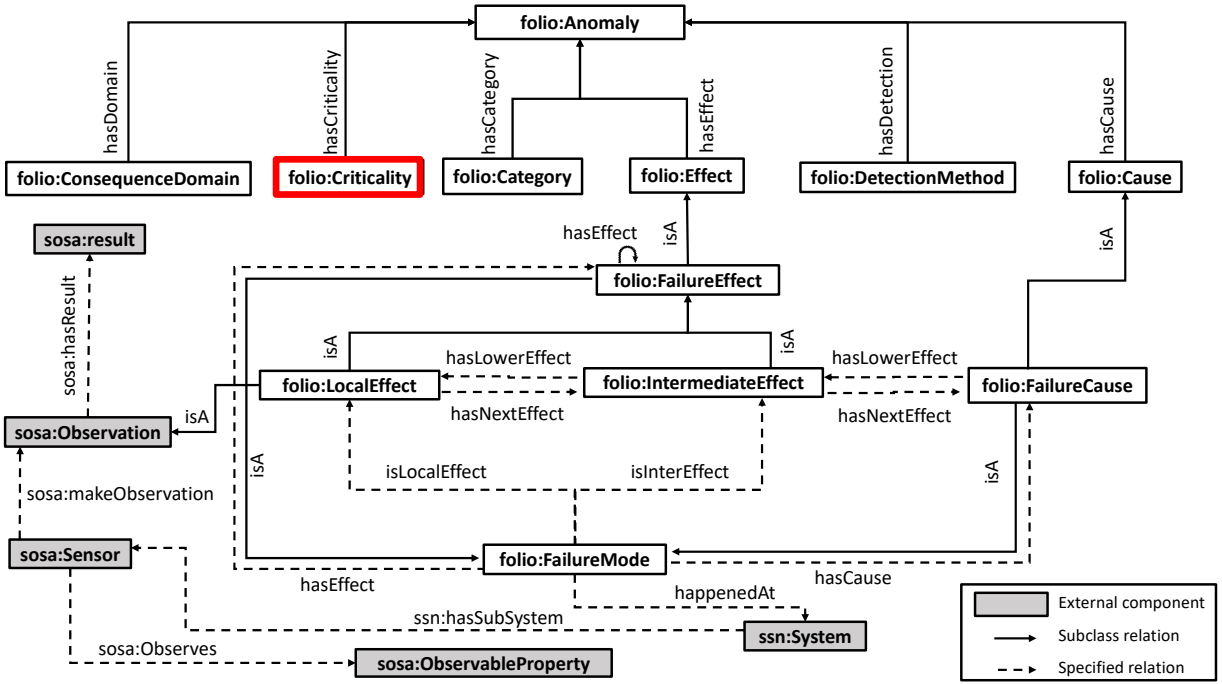
FMEA MAPPING APPROACH

UPDATABILITY OF APPROACH?

- What if extra information from the FMEA template becomes important?

Component	Function	Failure Mode	Failure Effect	Failure Cause	Control Method	Containement Action	Criticality



FTA MAPPING APPROACH

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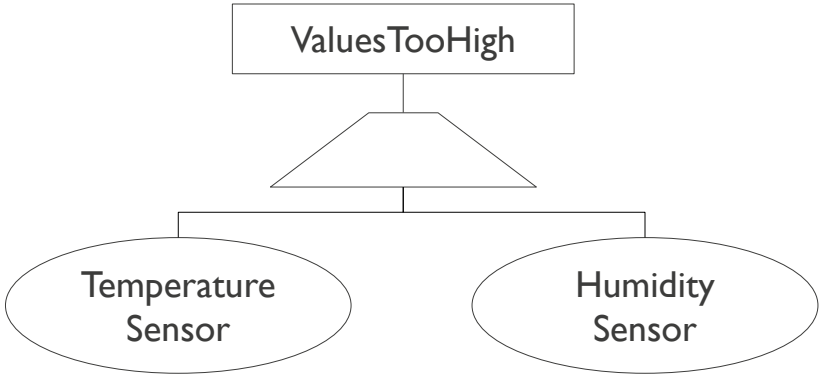
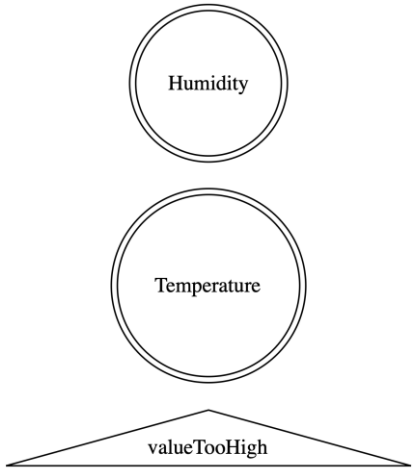
RULE GENERATION



RULE GENERATION

Editor | Gui | Engine: dot | Format: svg | Show raw output

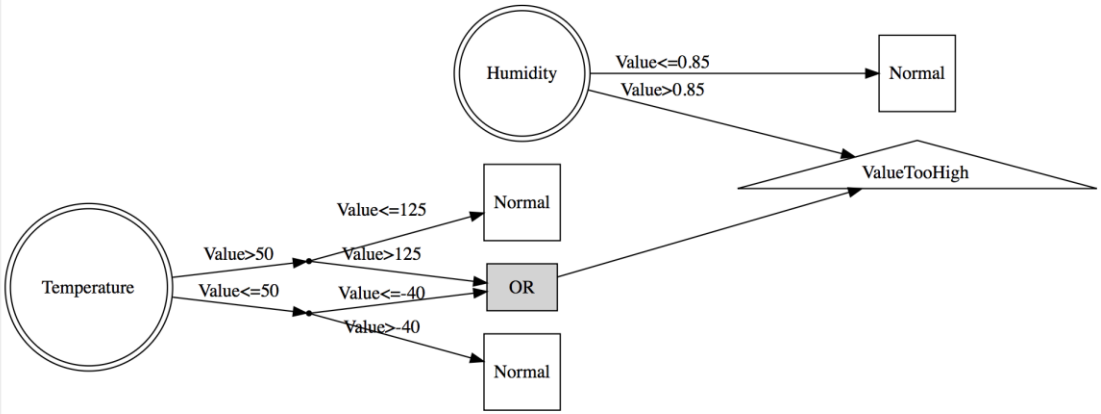
```
1  Observation(Temperature)
2  Observation(Humidity)
3  Failure(valueTooHigh)
```



RULE GENERATION

Editor | Gui | Engine: dot | Format: svg | Show raw output

```
1  Observation(Temperature)
2  Observation(Humidity)
3  Failure(ValueTooHigh)
4
5
6  Connection(Temperature, Blank_1, Value>50)
7  Connection(Blank_1, OrGate_1, Value>125)
8  Connection(Blank_1, Normal_1, Value<=125)
9  Connection(Temperature, Blank_2, Value<=50)
10 Connection(Blank_2, OrGate_1, Value<=-40)
11 Connection(OrGate_1, ValueTooHigh,)
12 Connection(Blank_2, Normal_2, Value>-40)
13
14 Connection(Humidity,ValueTooHigh, Value>0.85)
15 Connection(Humidity,Normal_3, Value<=0.85)
```



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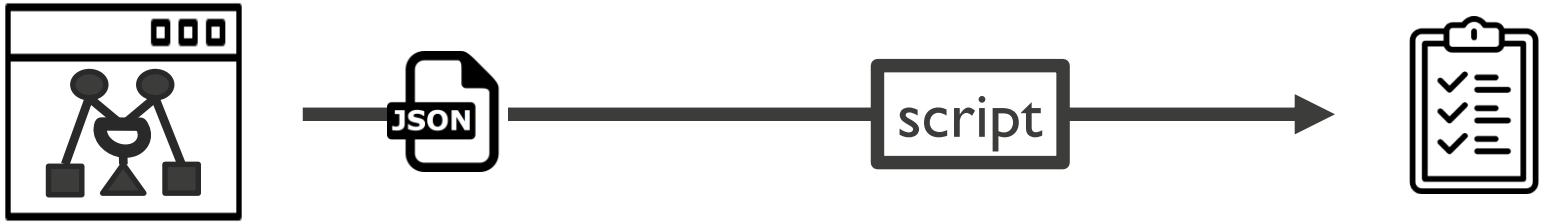
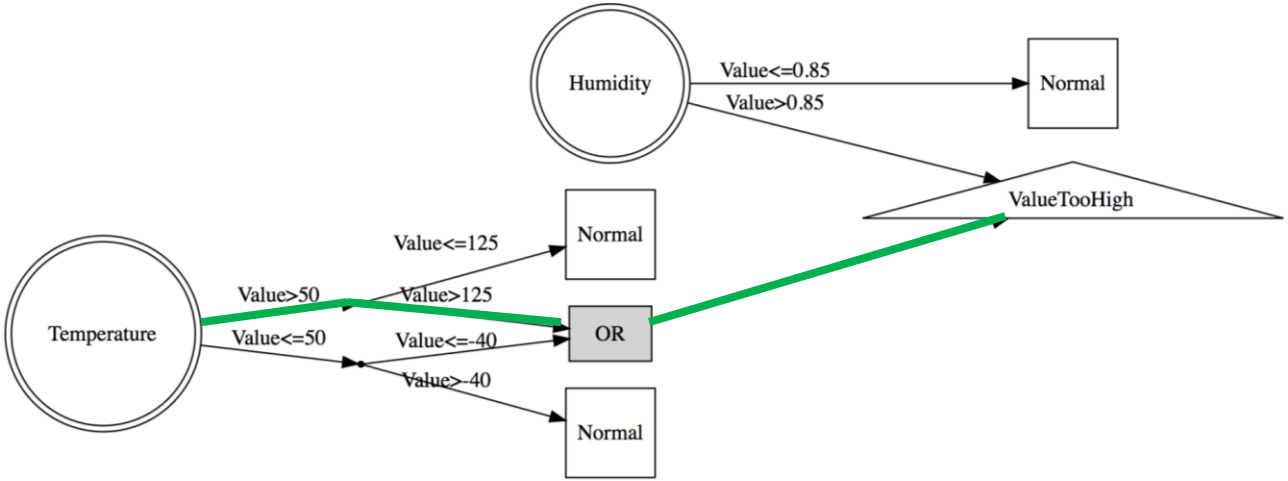
RULE GENERATION



RULE GENERATION

RESULT



- S0: System(?s, 'Comfort') ^ Sensor(?t, 'TemperatureSensor') ^ hasSubSystem(?s, ?t) ^ TemperatureObservation(?o) ^ observerdBy(?o, ?t) ^ hasResult(?o, ?result) ^ hasValue(?result, ?Value) ^ swrlb:greaterThan(?Value, 50) ^ swrlb:greaterThan(?Value, 125) => valueTooHigh(?o)

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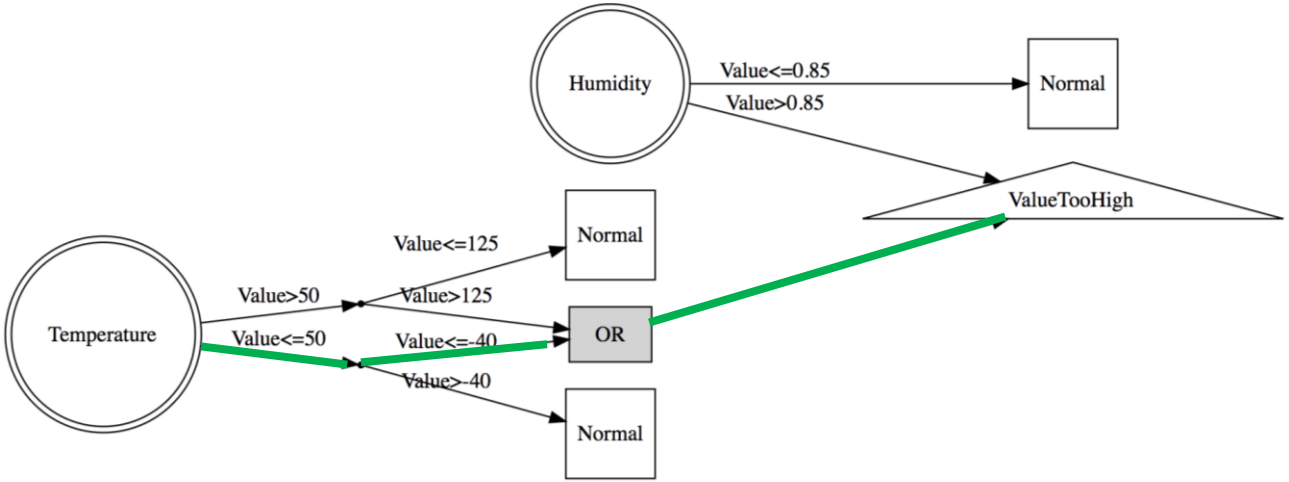
RULE GENERATION

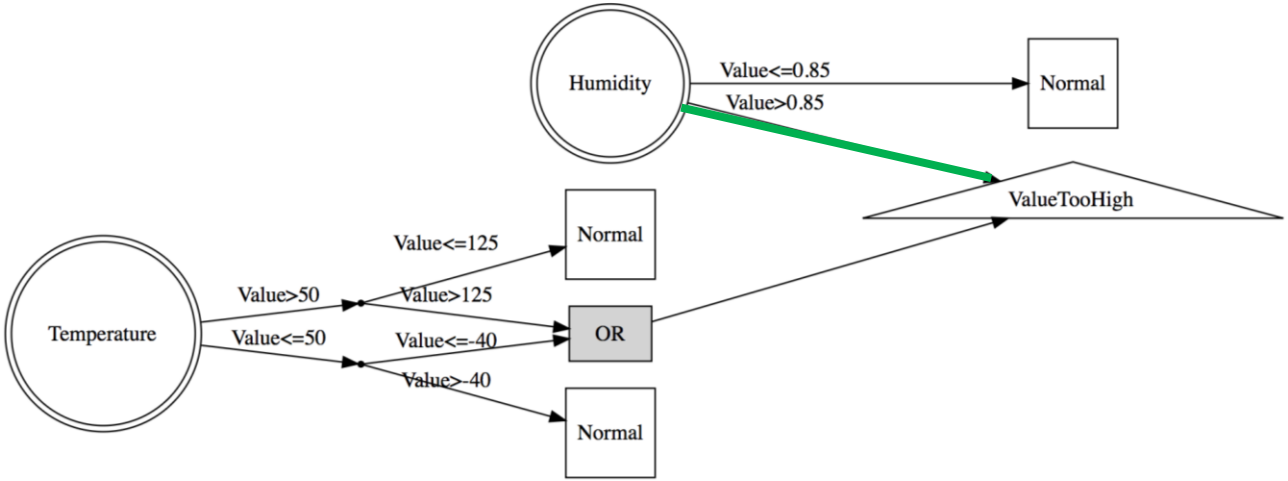
RESULT



- S1: System(?s, 'Comfort') ^ Sensor(?t, 'TemperatureSensor') ^ hasSubSystem(?s, ?t) ^ TemperatureObservation(?o) ^ observerdBy(?o, ?t) ^ hasResult(?o, ?result) ^ hasValue(?result, ?Value) ^ swrlb: lessThanOrEqual(?Value, 50) ^ swrlb:lessThan(?Value, -40) => valueTooHigh(?o)

RULE GENERATION

RESULT



- S2: System(?s, 'Comfort') ^ Sensor(?h, HumiditySensor) ^ ') ^ hasSubSystem(?s, ?h) HumidityObservation(?o) ^ observerdBy(?o, ?h) ^ hasResult(?o, ?result) ^ hasValue(?result, ?Value) ^ swrlb:greaterThan(?Value, 0.85) => valueTooHigh(?o)

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SUMMARY & CONCLUSION

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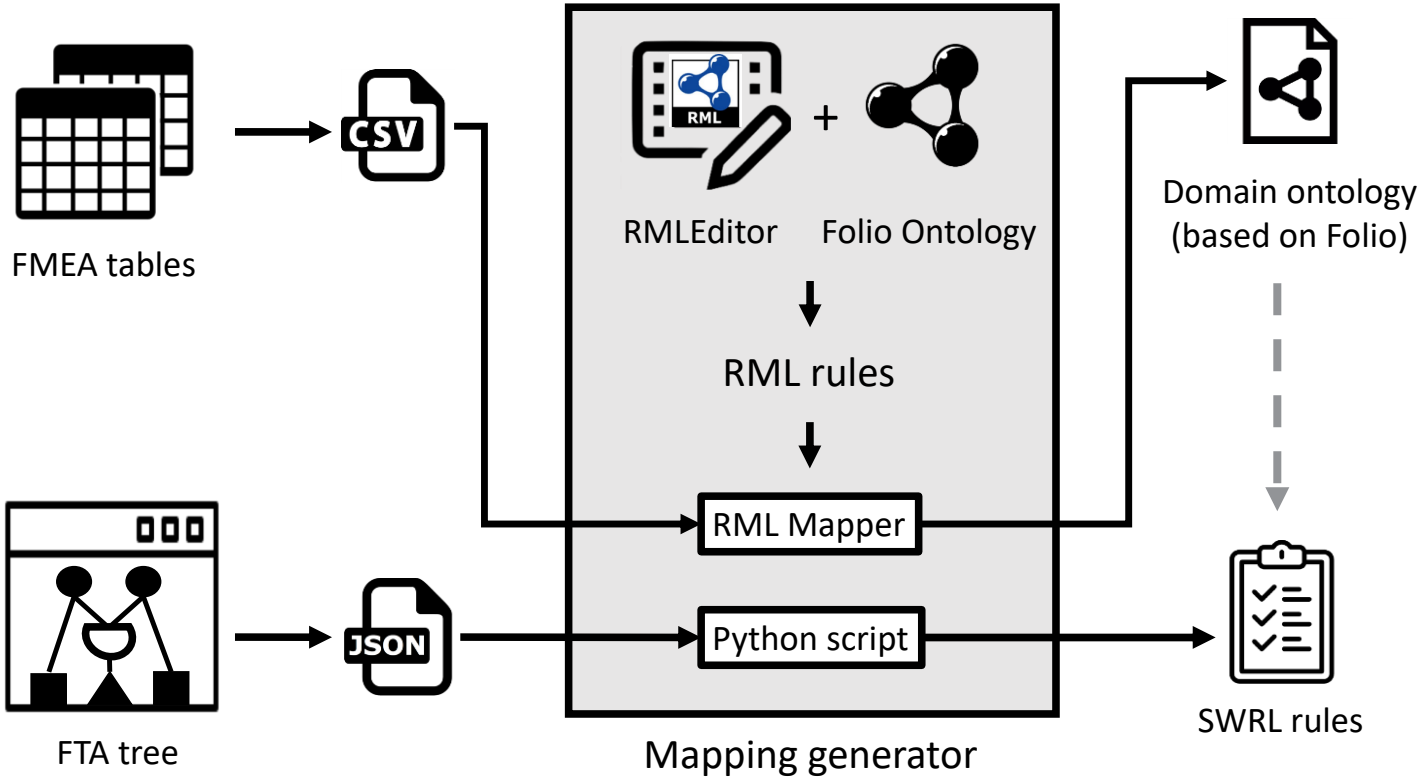
APPROACH



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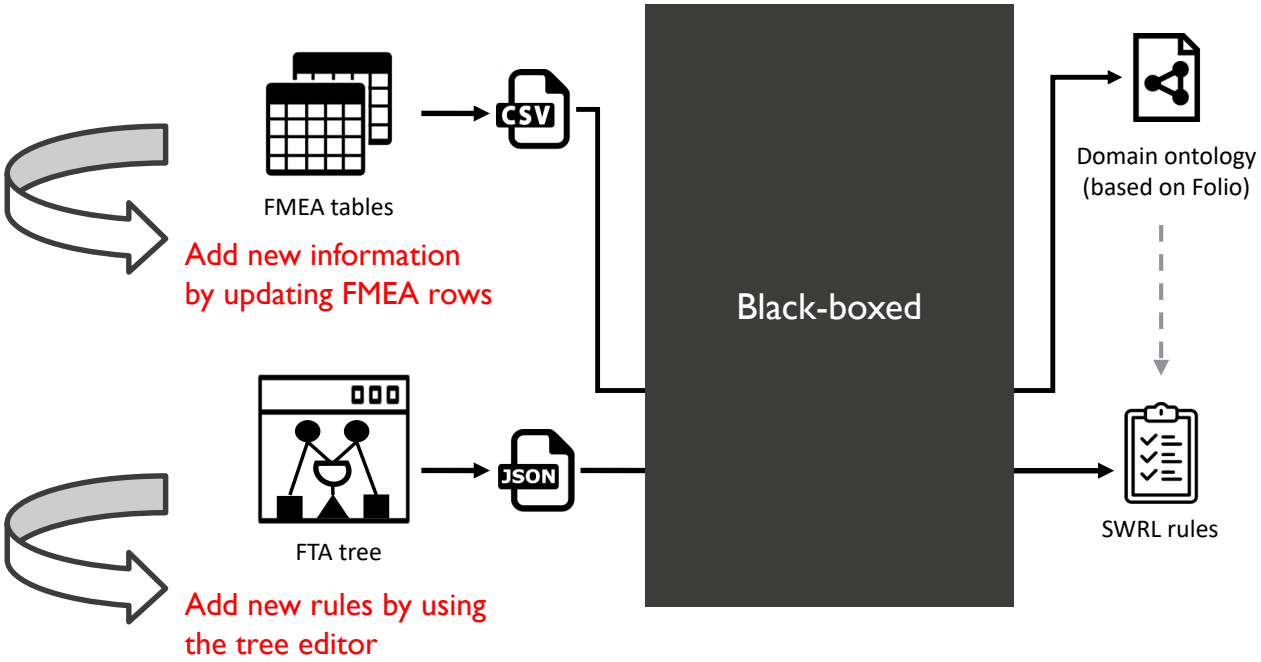
APPROACH

DOMAIN EXPERT RESPONSABILITY



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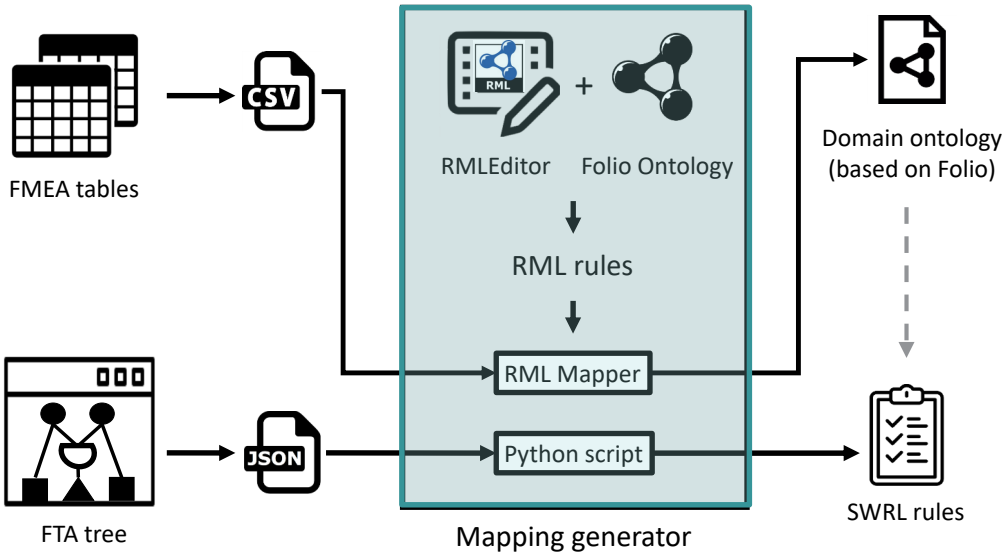
APPROACH

ONTOLOGY EXPERT RESPONSABILITY



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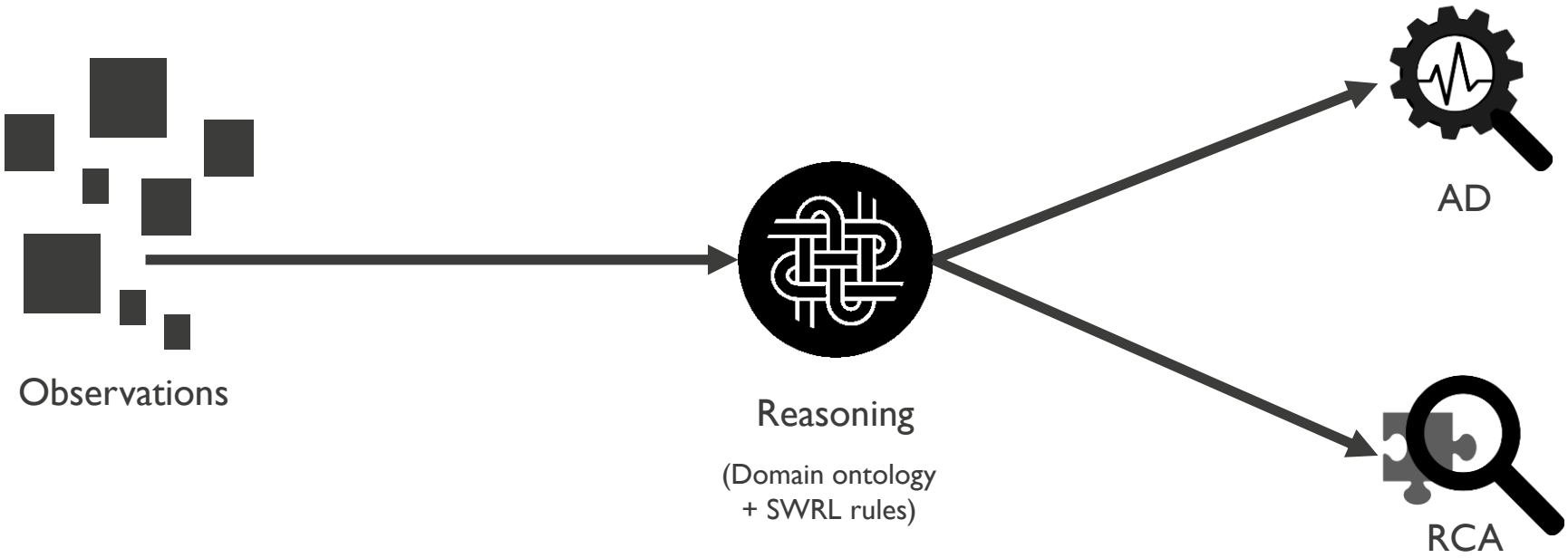
RESULT



FUTURE WORK

- Use risk analysis to provide semantic AD and RCA
- Rules from expert information reasoning

- Broader scope than current FMEA and FTA analysis

THANK YOU FOR LISTENING

- Interested?

The whole approach will be demonstrated using a ventilation use case on 11 October!
Visit demo D03

- Contact:

Bram.Steenwinckel@ugent.be

- Folio ontology + Code:

https://github.com/IBCNServices/Folio-Ontology

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