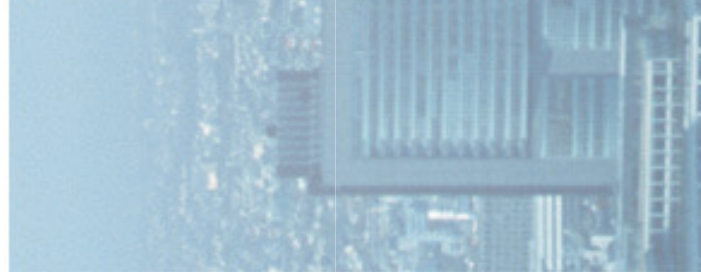


ACCELERATE  
DEVELOPMENT

IMPROVE  
SERVICE

OPTIMISE  
SALES



[www.ontoprise.de](http://www.ontoprise.de)

## *How Ontologies and Rules Help to Advance Automobile Development*

**RuleML 2007  
Juergen Angele,  
ontoprise GmbH**

# know how to use Know-how!

Ontoprise is a leading semantic software company.  
Our goal is to make a company's know-how visible and reusable

**Founded:**

1999

**Team:**

approx. 50 Employees

**Headquarter:**

Karlsruhe

**Market:**

9 out of the 20 largest German companies are our customers

Strategic Partner for Oracle and Software AG

## Karlsruhe: Location for Semantic Technologies



## Field of Applications for ontoprise Technology



„If I knew that we have already implemented this component from this vendor somewhere else, I had calculated differently.“

Support users in quickly finding information

**SemanticMiner®**



„With this error message, I always exchange the complete PC. Is there another way?“

Reuse the know-how of your engineers

**SemanticGuide®**



„While I am still busy collecting all the information from all systems most of the customers already ran out of patience“

Single View on Multiple Sources

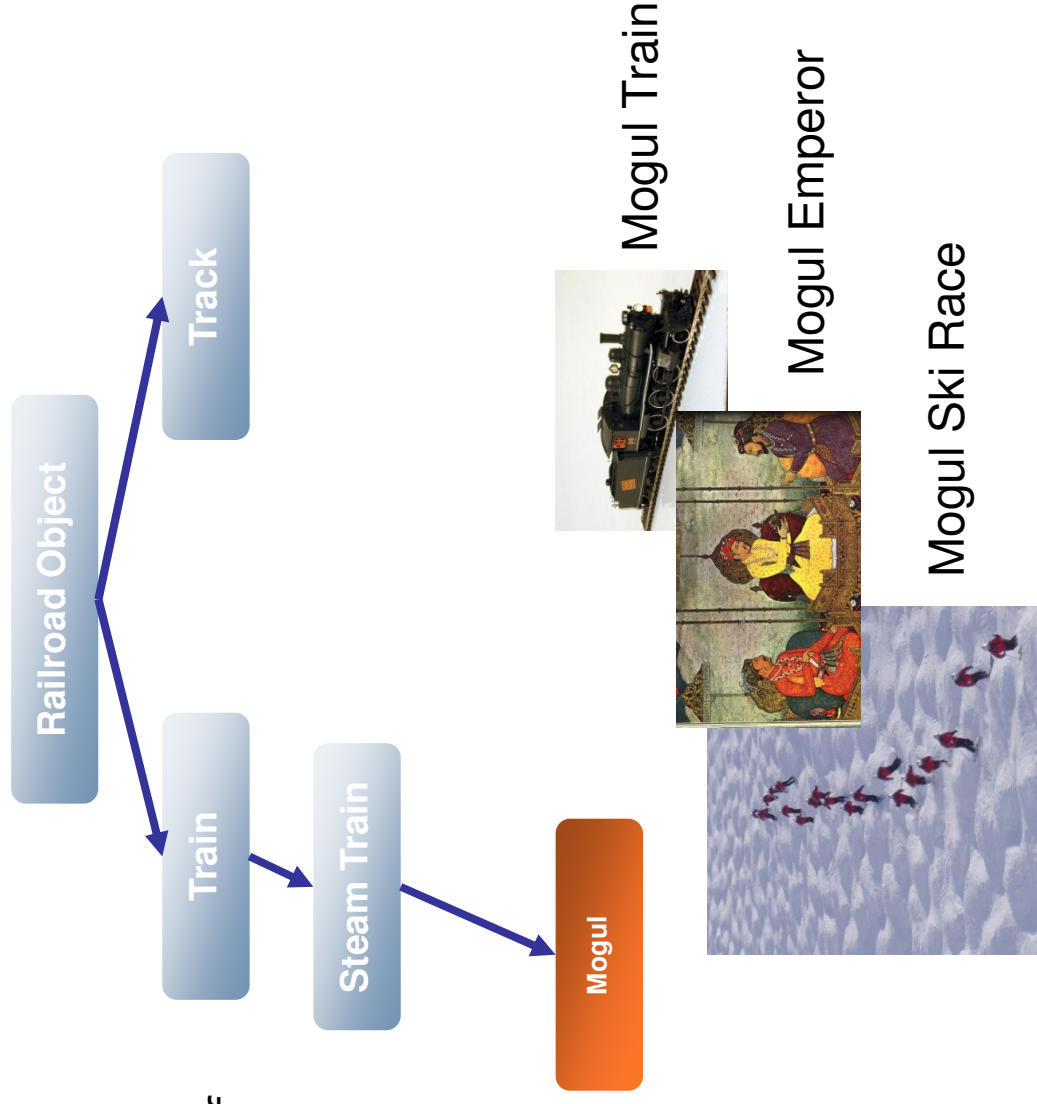
**SemanticIntegrator®**



# Semantics = All About Meaning

**Ontology**  
 „An Ontology is a **shared** conceptualization of a domain [Tom Gruber].“

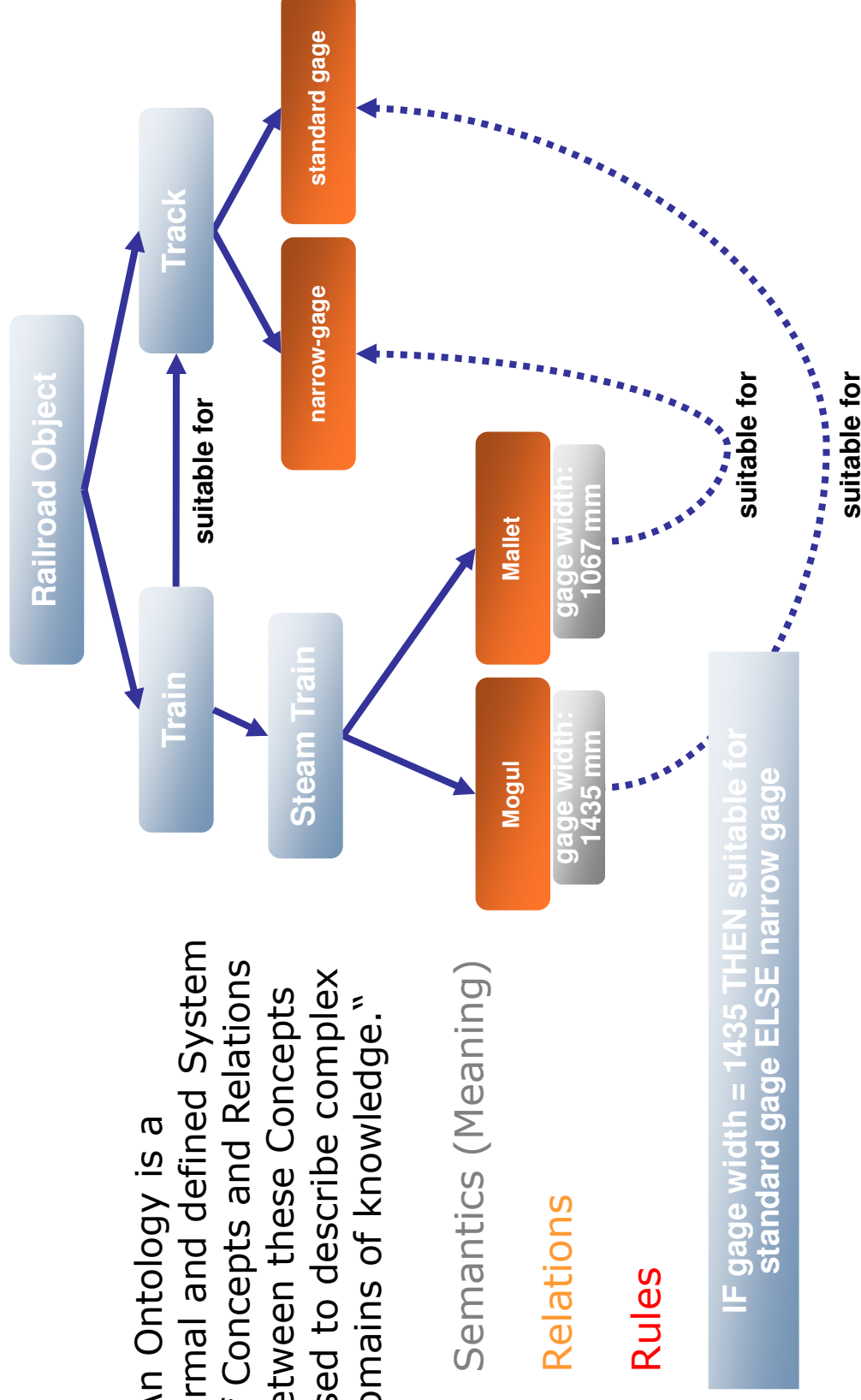
- social semantics (meaning)



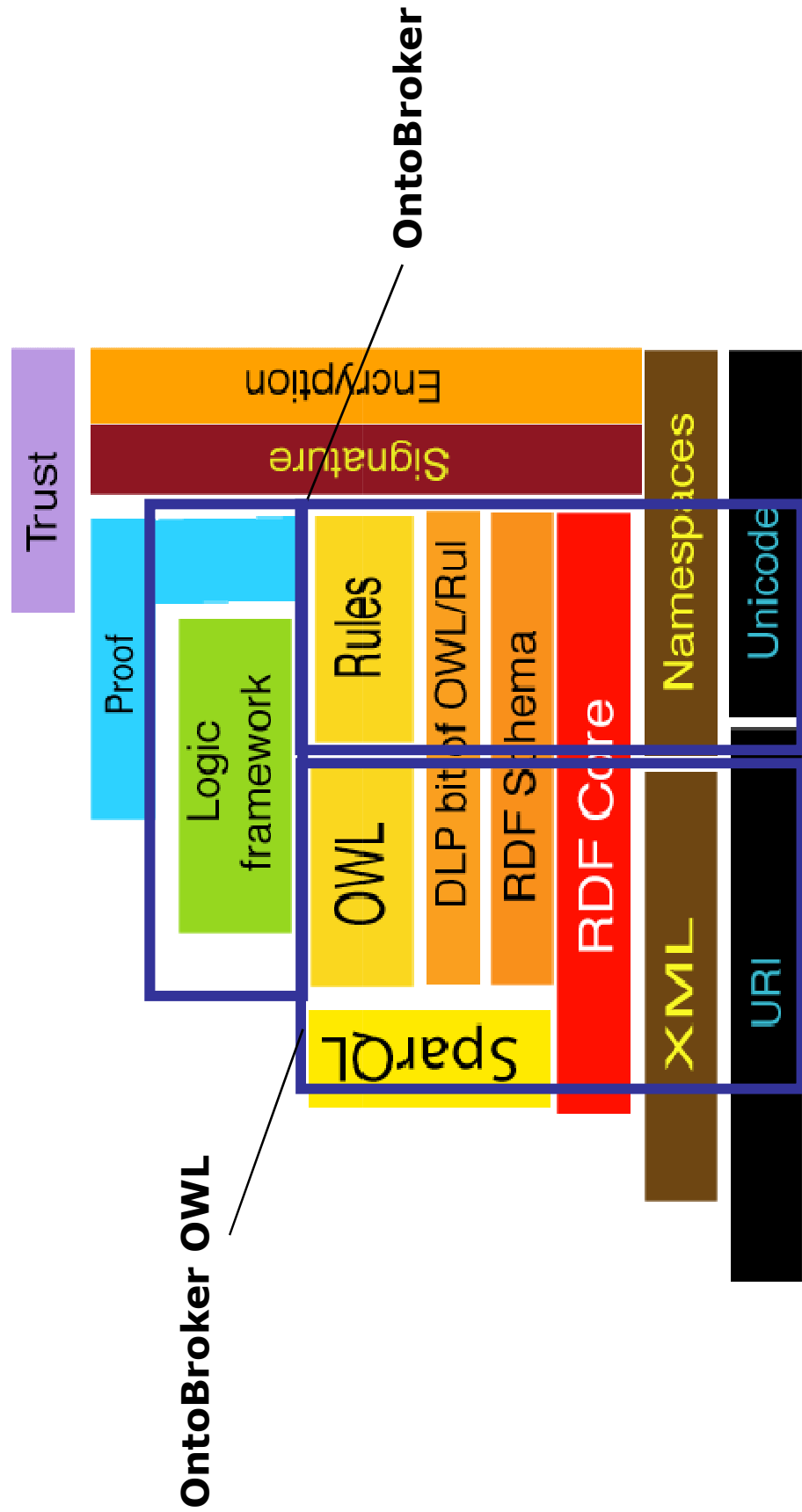
# Parts of an Ontology

**Ontology**  
„An Ontology is a formal and defined System of Concepts and Relations between these Concepts used to describe complex domains of knowledge.“

- Semantics (Meaning)
- Relations
- Rules



IF gage width = 1435 THEN suitable for standard gage ELSE narrow gage



Tim Berners-Lee, ISWC November 2005, [http://www.w3.org/2005/Talks/1110-iswc-tbl/#\(12\)](http://www.w3.org/2005/Talks/1110-iswc-tbl/#(12))



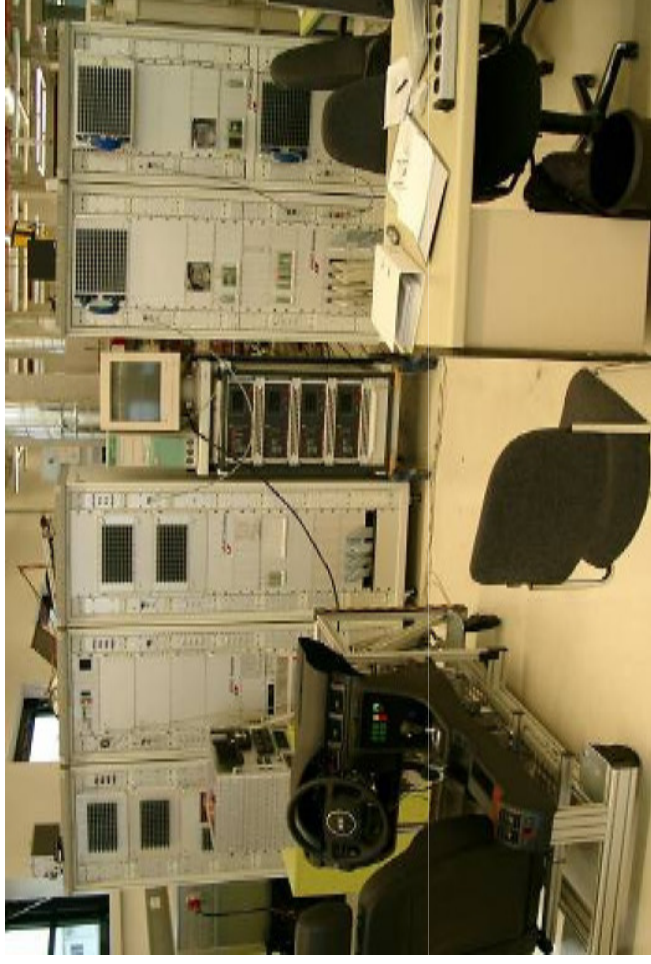
# Automatic Analysis of Control Units for Audi

## Challenges

- Majority of innovations is in electronical equipment
- Increasing complexity in development and integration
- shorter development cycles
- increasing quality measures

## Goals

- Introduction of efficient testing methods to reduce manual work
- Manage complexity
- Increase transparency



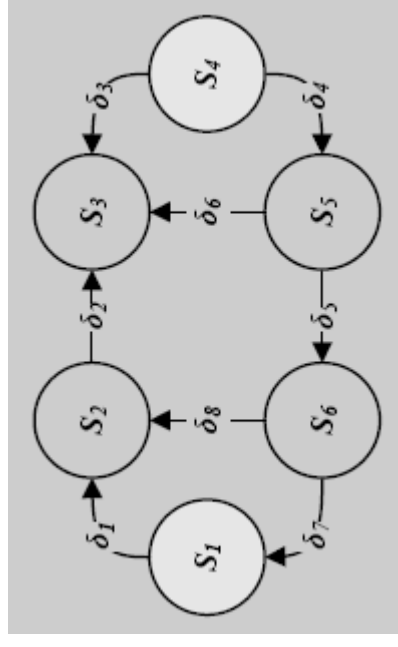
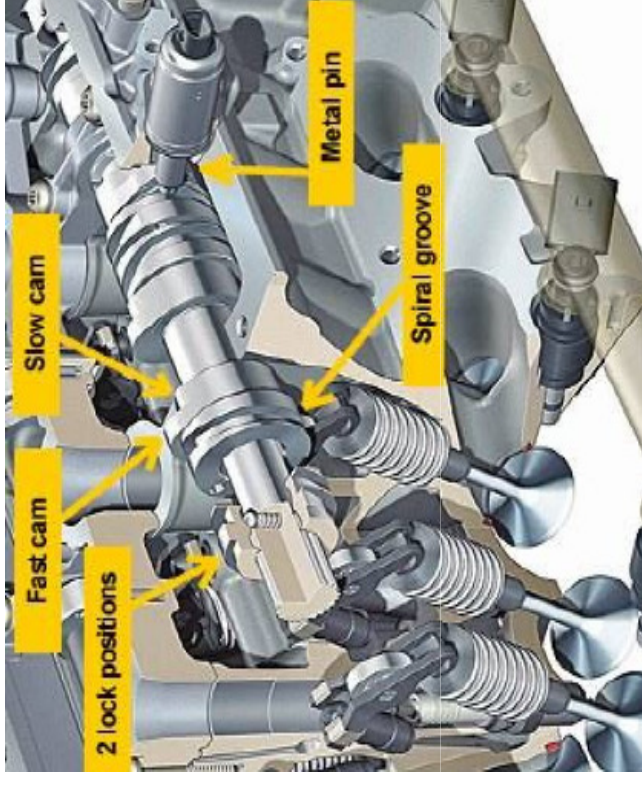
## Solution

- Extraction of rules from requirement specification and functional frames
- Collection of expert knowledge from engineers in free text
- Carve out of logic by means of an ontology
- Automatic validation of test results by means of specifications



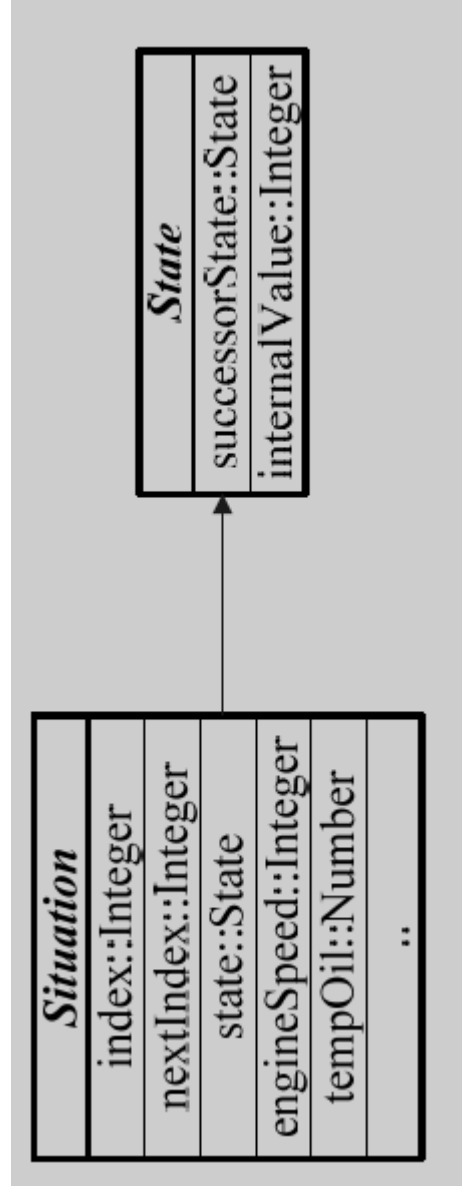
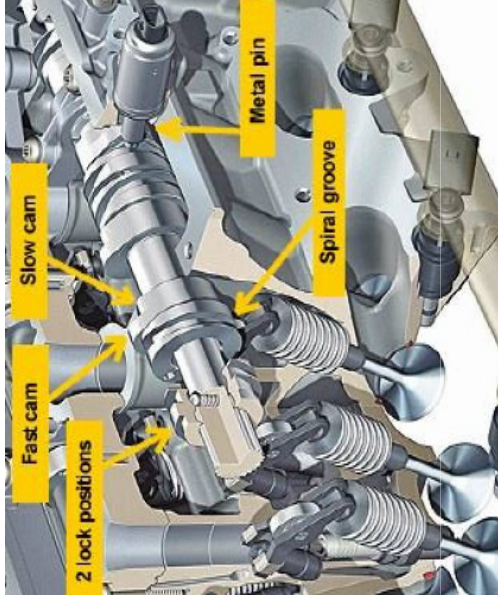
## Use Case

- Audi Valvelift System (AVS)
- 2 different Cam Contours for small and large Valve Lift
- Increases Engine Efficiency (more Power, lower Fuel Consumption)
- Controlled by Engine ManagementSystem
  - Deterministic Finite Automaton
  - $S_1$ ,  $S_4$  - small, large Valve Lift
  - Transition Functions

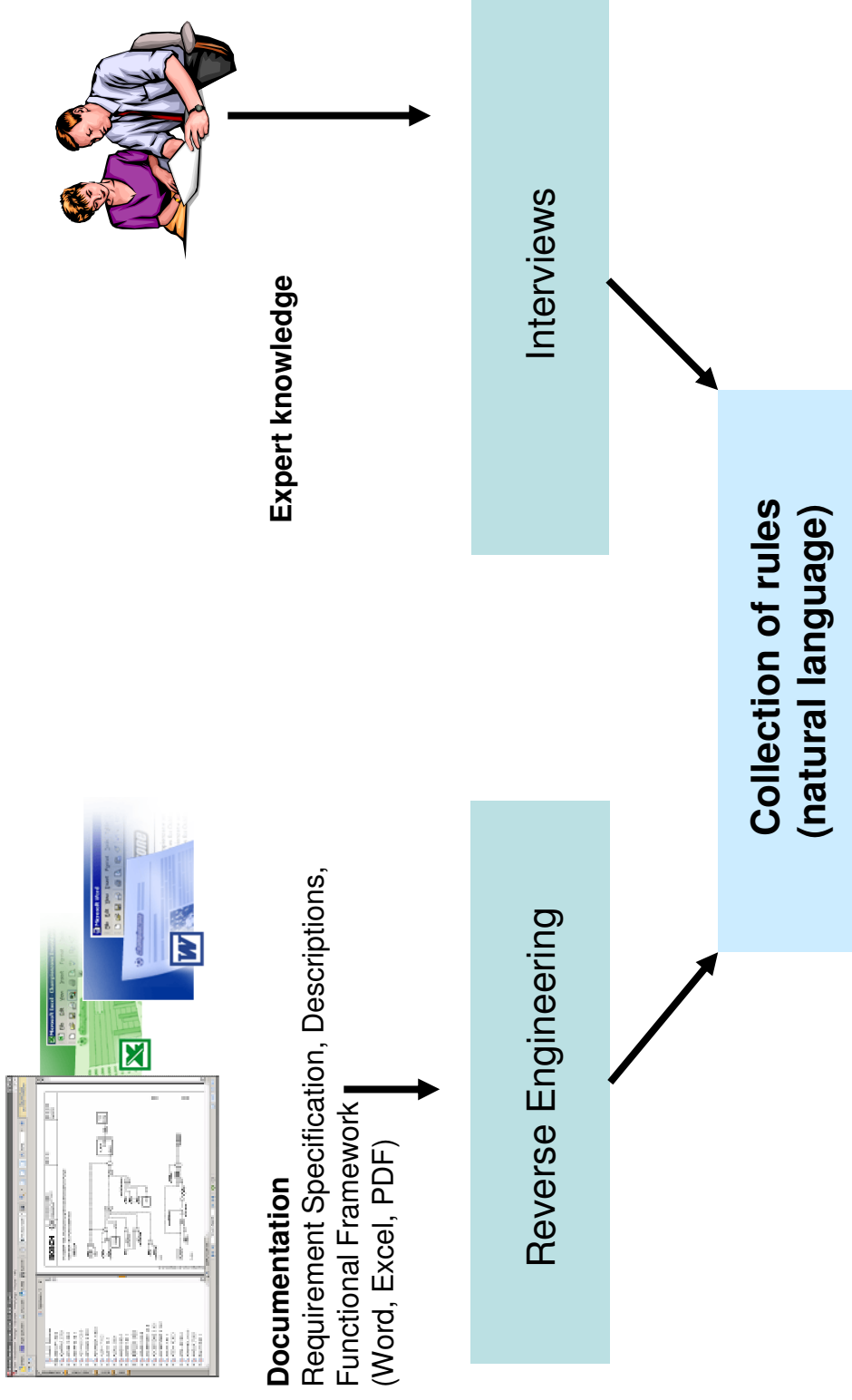


## Use Case

- Observable Variables during HiL Tests
- Snapshots at different Times
- Ontology Reflects Data Structure recorded during HiL Tests
- Introduces Terms as known to Experts (e.g., engineSpeed)

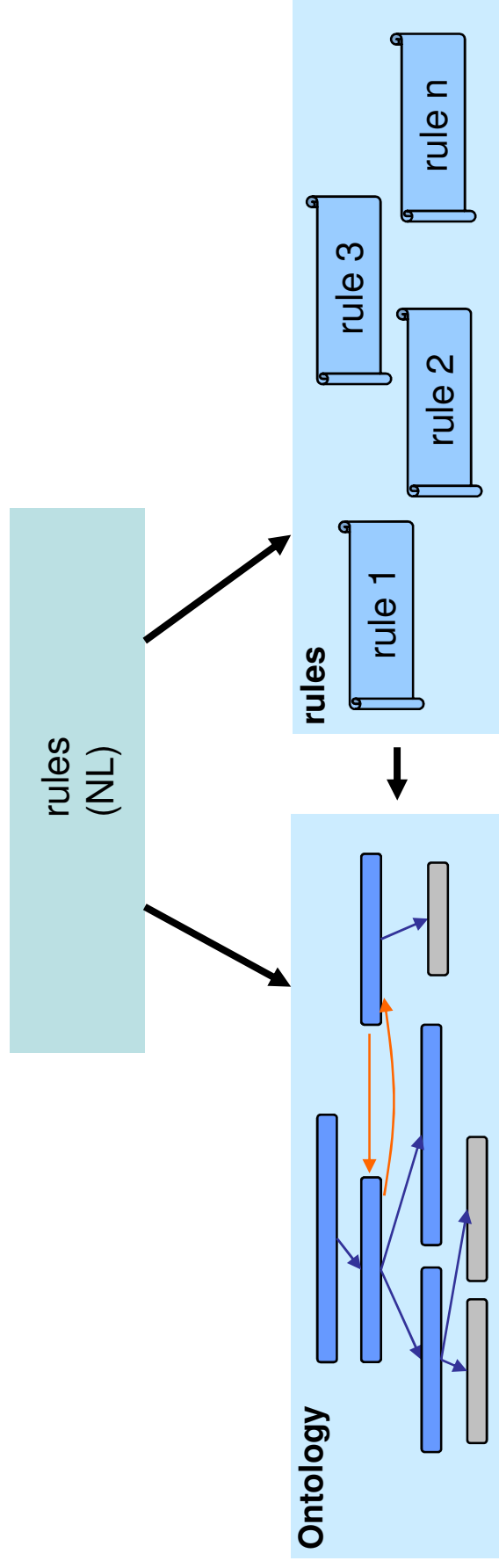


# Collection of rules





# Ontology- and rule development

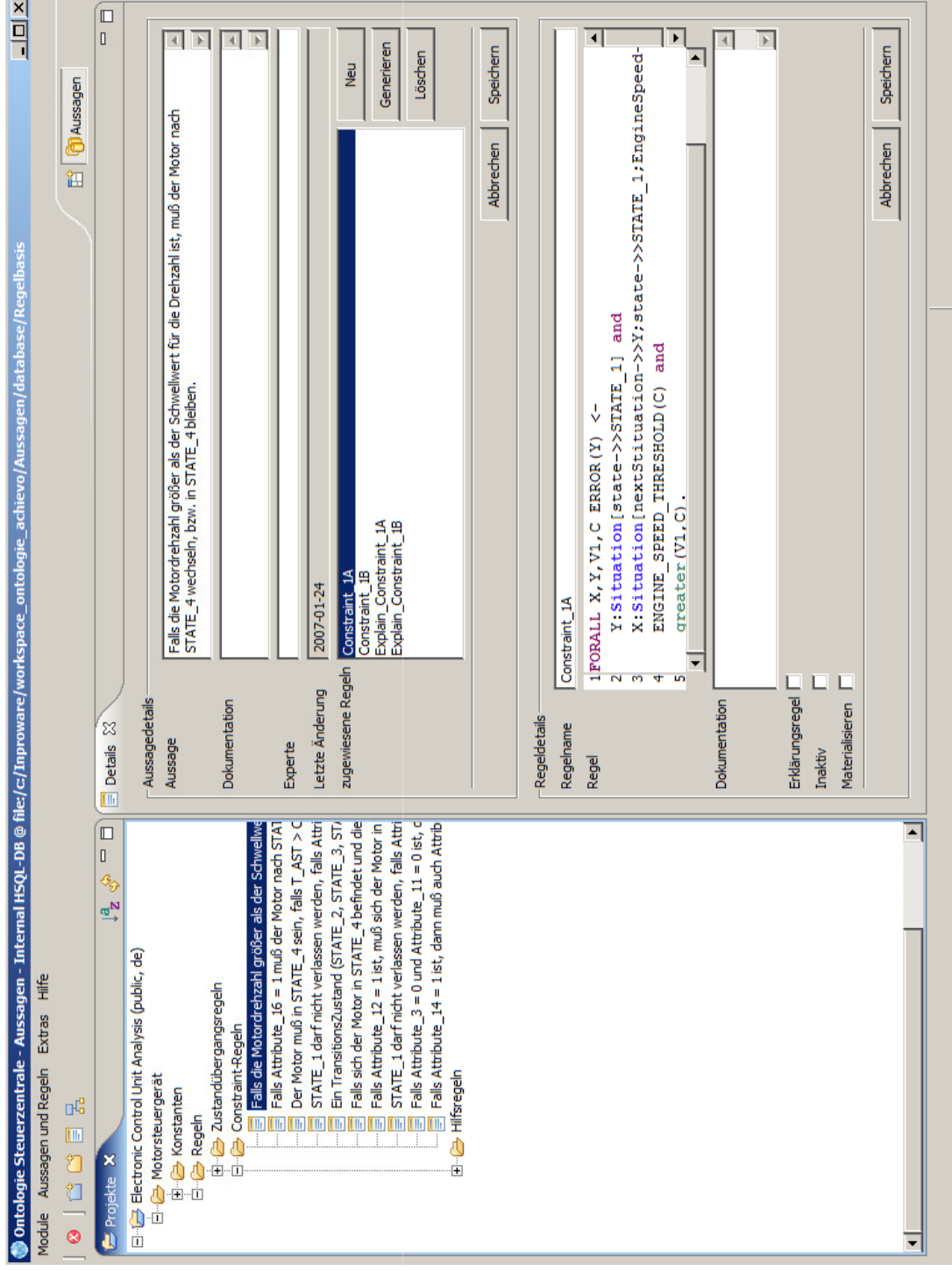


## advantages:

- Set of rules is extendable in an incremental way
- Rules are not hidden in program code.
- Rules are automatically explainable.



# Collecting rules



The screenshot displays the ontoprise software interface, which is used for managing knowledge bases. The main window is titled "Ontologie Steuerzentrale - Aussagen - Internal HSQL-DB @ file:/c:/Inproware/workspace\_ontologie\_achievo/Aussagen/database/Regelbasis".

The interface is divided into several panes:

- Left Pane (Project Explorer):** Shows a tree structure of the project "Electronic Control Unit Analysis (public, de)". It includes folders for "Motorsteuergerät", "Konstanten", "Regeln", "Zustandsübergangsregeln", "Constraint-Regeln", and "Hilfsregeln".
- Top Pane (Details):** Displays details for the selected rule "Constraint\_1A". It includes fields for "Aussage" (Statement), "Dokumentation" (Documentation), "Experte" (Expert), "Letzte Änderung" (Last Change), and "zugewiesene Regeln" (Assigned Rules). The "Aussage" field contains the text: "Falls die Motordrehzahl größer als der Schwellwert für die Drehzahl ist, muß der Motor nach STATE\_4 wechseln, bzw. in STATE\_4 bleiben." The "Letzte Änderung" field shows the date "2007-01-24".
- Bottom Pane (Rule Editor):** Displays the rule definition for "Constraint\_1A". The rule is defined as:
 

```

1 FORALL X, Y, V1, C ERROR(Y) <-
2   Y: Situation[state->>STATE_1] and
3   X: Situation[nextSituation->>Y, state->>STATE_1; EngineSpeed-
4     ENGINE_SPEED_THRESHOLD(C) and
5     greater(V1, C) .
      
```

The interface also includes buttons for "Abbrechen" (Cancel), "Speichern" (Save), "Neu" (New), "Generieren" (Generate), and "Löschen" (Delete).

# Ontology- and rule development

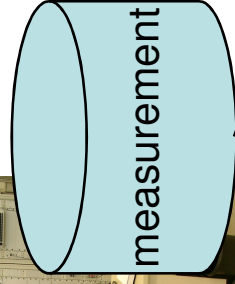
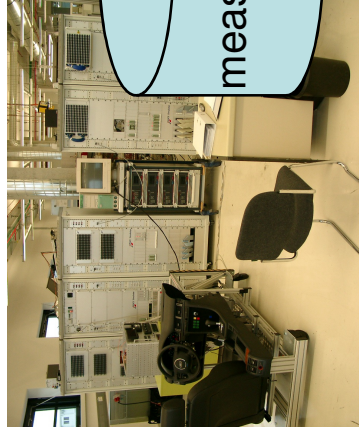
ECU Specification: *„If the engine speed is greater than 4000, the valve lift system must switch to S4 if it is in S1.“*

**?S[nextState->S4] <-  
?S:Situation[state->S1, engineSpeed->?V] and  
?V > 4000.**

Experts: *„At idle speed the small valve lift must be used.“*

**ERROR(?S) <-  
?S:Situation[state->S4, idle->1].**

# Testing measurements



Ontology and rules

OntoBroker

Analysis result

# Analyzing data

Ontologie Steuerzentrale - Steuergeraete Analyse  
Module Extras Hilfe

Simulationsergebnis

Index	time	EngineSpeed	state	Attribute ...	TCO	TOIL	T AST	MAF	Attribute 3	Attribute 6	Attribute ...	Att
1	8.923034414	5000	3	2	90	90	137.3	35.53125	1	1	0	0
2	8.931841668	2517	3	2	90	90	137.4	35.53125	1	1	0	0
3	8.941808559	2517	3	2	90	90	137.4	35.53125	1	1	0	0
4	8.95095039	2517	4	2	90	90	137.4	67.09375	1	1	0	0
5	8.96242129	2516	5	2	90	90	137.4	93.96875	1	1	0	0
6	8.971859184	2515	5	2	90	90	137.4	154.71875	1	1	0	0
7	8.981926043	2515	5	2	90	90	137.4	233.6875	1	1	0	0
8	8.993232515	2514	5	2	90	90	137.4	268.21875	1	1	0	0
9	9.002239703	2515	5	2	90	90	137.4	379.09375	1	1	0	0
10	9.011716745	2514	5	2	90	90	137.4	379.09375	1	1	0	0
11	9.021643646	2516	5	2	90	90	137.4	379.09375	1	1	0	0
12	9.03419968	2526	5	2	90	90	137.4	379.09375	1	1	0	0
13	9.042377171	2542	5	2	90	90	137.4	379.09375	1	1	0	0
14	9.052334061	2550	5	2	90	90	137.4	379.09375	1	1	0	0
15	9.062021036	2550	5	2	90	90	137.4	379.09375	1	1	0	0
16	9.073157556	2531	5	2	90	90	137.4	379.09375	1	1	0	0
17	9.081714883	2514	5	2	90	90	137.4	379.09375	1	1	0	0
18	9.091681768	2500	5	2	90	90	137.4	379.09375	1	1	0	0
19	9.102038532	2487	5	2	90	90	137.4	379.09375	1	1	0	0
20	9.113115069	2455	5	2	90	90	137.4	379.09375	1	1	0	0
21	9.12022285	2438	5	2	90	90	137.4	379.09375	1	1	0	0
22	9.131899197	2421	5	2	90	90	137.4	379.09375	1	1	0	0
23	9.141966049	2404	5	2	90	90	137.4	379.09375	1	1	0	0
24	9.153242523	2371	5	2	90	90	137.4	379.09375	1	1	0	0
25	9.163106437	2343	5	2	90	90	137.4	379.09375	1	1	0	0

Abbrechen Details >>

Statusinformationen  
Starte Simulation...  
Analyse Messdaten

Nächster Fehler... Erkläre Fehler... Konfiguration... Lade Simulationsdaten... Start Simulation...

Erklärung Zusammenfassung Beweisbaum

Keine Fehler gefunden...



# Found errors

Ontologie Steuerzentrale - Steuergeraete Analyse  
Module Extras Hilfe

Simulationsergebnis

Index	time	EngineSpeed	state	Attribute ...	TCO	TOIL	T AST	MAF	Attribute 3	Attribute 6	Attribute ...	Att
1	8.923034414	5000	3	2	90	90	137.3	35.53125	1	1	0	0
2	8.931841663	2517	3	2	90	90	137.4	35.53125	1	1	0	0
3	8.941808559	2517	3	2	90	90	137.4	35.53125	1	1	0	0
4	8.953095039	2517	4	2	90	90	137.4	67.09375	1	1	0	0
5	8.962422129	2516	5	2	90	90	137.4	93.96875	1	1	0	0
6	8.971859184	2515	5	2	90	90	137.4	154.71875	1	1	0	0
7	8.981926043	2515	5	2	90	90	137.4	233.6875	1	1	0	0
8	8.993232515	2514	5	2	90	90	137.4	268.21875	1	1	0	0
9	9.002239703	2515	5	2	90	90	137.4	379.09375	1	1	0	0
10	9.011716745	2514	5	2	90	90	137.4	368.5625	1	1	0	0
11	9.021643646	2516	5	2	90	90	137.4	273.03125	1	1	0	0
12	9.033419968	2526	5	2	90	90	137.4	273.03125	1	1	0	0
13	9.042377171	2542	5	2	90	90	137.4	273.03125	1	1	0	0
14	9.052334061	2550	5	2	90	90	137.4	273.03125	1	1	0	0
15	9.062021036	2550	5	2	90	90	137.4	273.03125	1	1	0	0
16	9.073157556	2531	5	2	90	90	137.4	273.03125	1	1	0	0
17	9.081714883	2514	5	2	90	90	137.4	273.03125	1	1	0	0
18	9.091681768	2500	5	2	90	90	137.4	273.03125	1	1	0	0
19	9.102038532	2487	5	2	90	90	137.4	273.03125	1	1	0	0
20	9.113115069	2455	5	2	90	90	137.4	273.03125	1	1	0	0
21	9.12022285	2438	5	2	90	90	137.5	103.09375	1	1	0	0
22	9.131899197	2421	5	2	90	90	137.6	100.8125	1	1	0	0
23	9.141966049	2404	5	2	90	90	137.6	98.8125	1	1	0	0
24	9.153242523	2371	5	2	90	90	137.6	94.84375	1	1	0	0
25	9.163106437	2343	5	2	90	90	137.6	93.76125	1	1	0	0

Anzahl der gefundenen Fehler: 1

Ergebnis

OK

Nächster Fehler... Erkläre Fehler... Konfiguration... Lade Simulationsdaten... Start Simulation...

Beweisbaum

Zusammenfassung

Anzahl der aufgetretenen Fehler: 1

# Explaining inferences

**Ontologie Steuerzentrale - Steuergeraete Analyse**  
Module Extras Hilfe

Simulationsdaten X Simulationsergebnis

Index	time	EngineSpeed	state	Attribute ...	TCO	TOIL	T AST	MAF	Attribute 3	Attribute 6	Attribute ...	Att
1	8.923034414	5000	3	2	90	90	137.3	35.53125	1	1	0	0
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3	8.941808559	2517	3	2	90	90	137.4	35.53125	1	1	0	0
4	8.953095039	2517	4	2	90	90	137.4	67.09375	1	1	0	0
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10	9.011716745	2514	5	2	90	90	137.4	368.5625	1	1	0	0
11	9.021643646	2516	5	2	90	90	137.4	273.03125	1	1	0	0
12	9.033419668	2526	5	2	90	90	137.5	135.90625	1	1	0	0
13	9.042377171	2542	5	2	90	90	137.5	133.96875	1	1	0	0

Nächster Fehler... Erkläre Fehler...

?? Erklärung Zusammenfassung

\*Constraint-Verletzung: in Situation S2 liegt immer STATE\_4 vor und die...  
Situationsübergang erfolgen müssen.\*

Anzahl der aufgetretenen Fehler: 1

In situation s2 still state 4 holds. In the situation before state 4 hold as well. The rotary speed was larger than the threshold. Therefore a state transition should have happened.

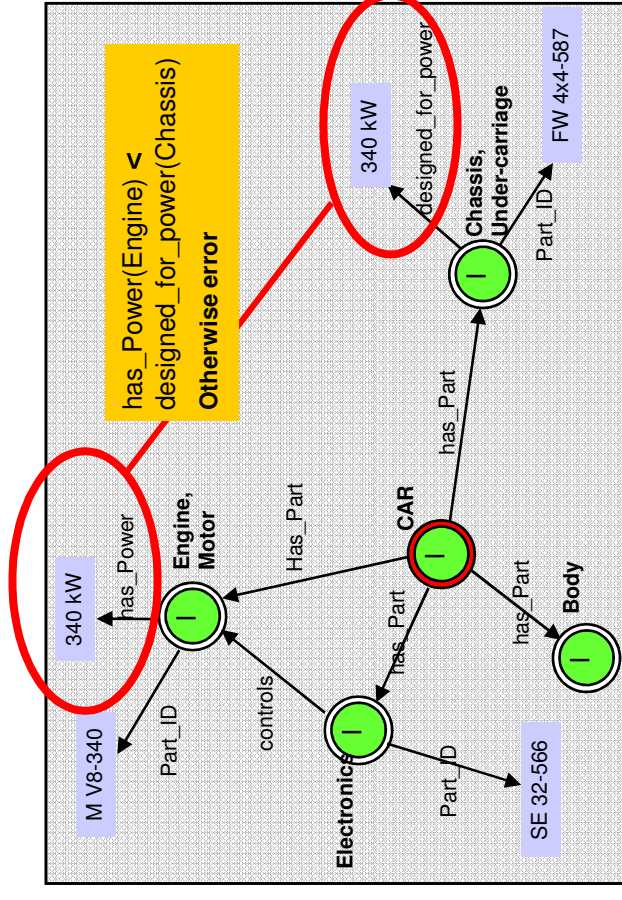
# Ontology-based Testcar Configurator at Audi

## Functionality

- Support of internal order processing for building and rebuilding testcars (AVx)
- Integrate cross department dependencies into AVx
- The knowledge about functional, geometrical and processual dependencies is spread over many engineers

## Goal

- Reduce time for testcar lifecycle and therefore for the whole development cycle
- Utilize expertise of engineers to improve testcar process
- prevent time-lags in testcar process

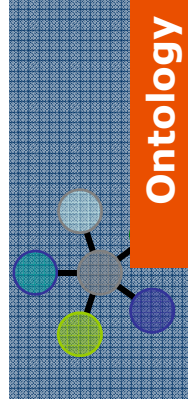


Sample Ontology (Source ontoprise)

„There is no other technology to both describe this level of complexity and being flexible enough to adapt to changes. ontoprise's technology enables us to describe and make executable our complex domain in a flexible and maintainable manner.“

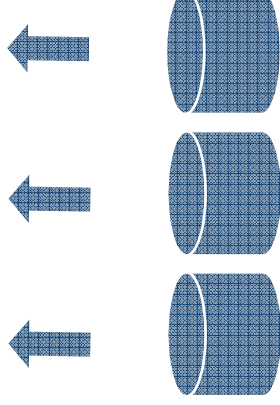


# Ontology combines rules, structures and information



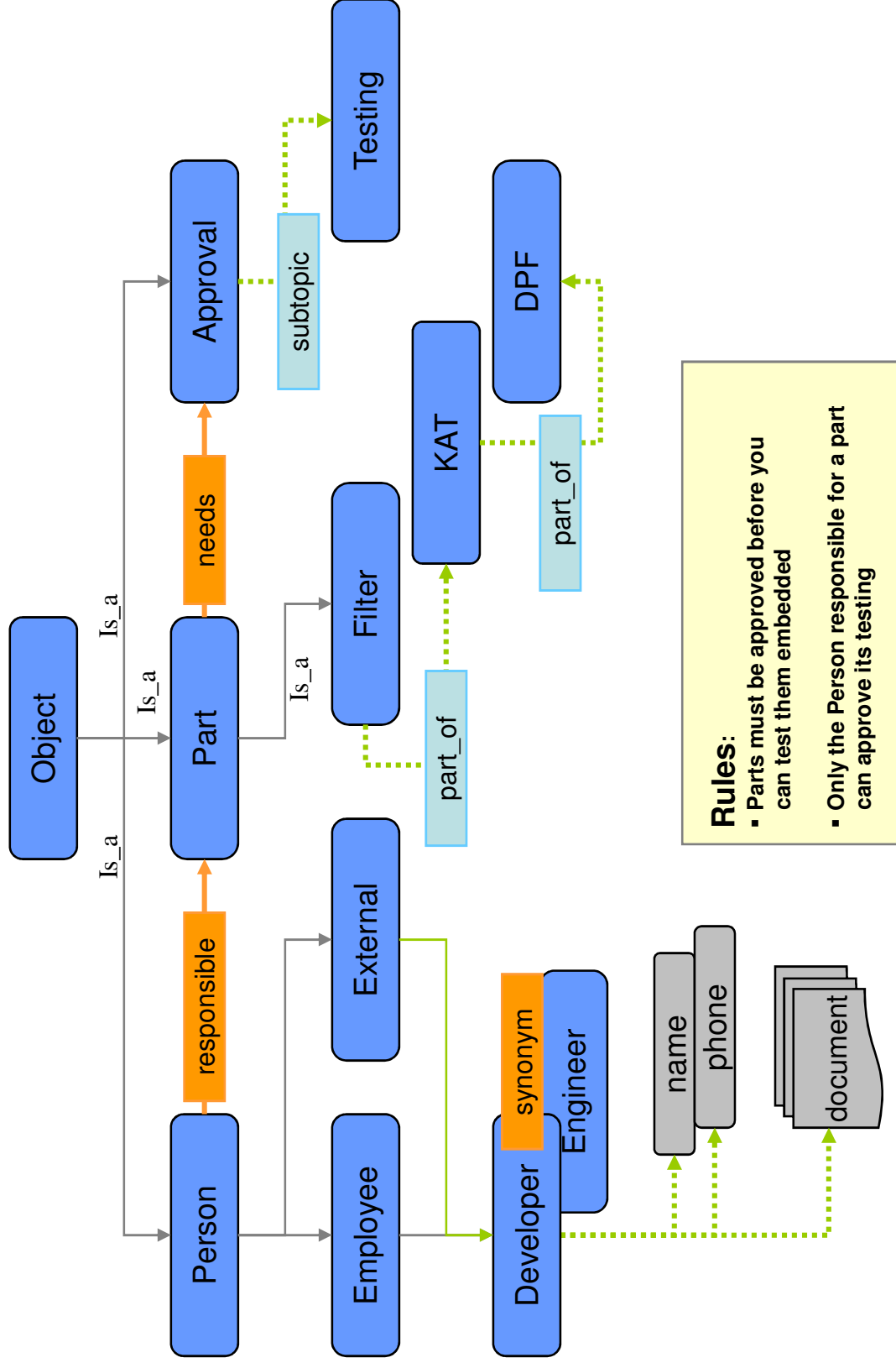
Structures  
Dependencies, rules

Mapping of existing information



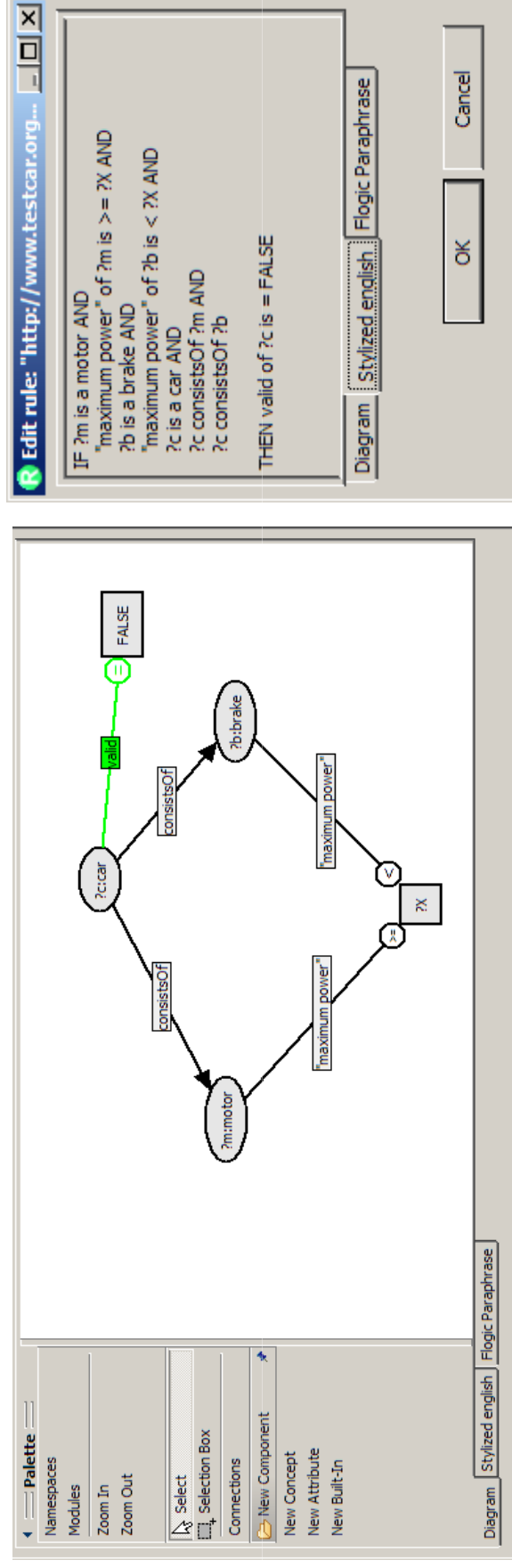


# Ontologies represent the meaning of information



# Relationships/Constraints

**Example Rule:** *The maximum power of the motor must not exceed the one of the brakes:  $P_{\text{motor}} < P_{\text{brakes}}$*



```

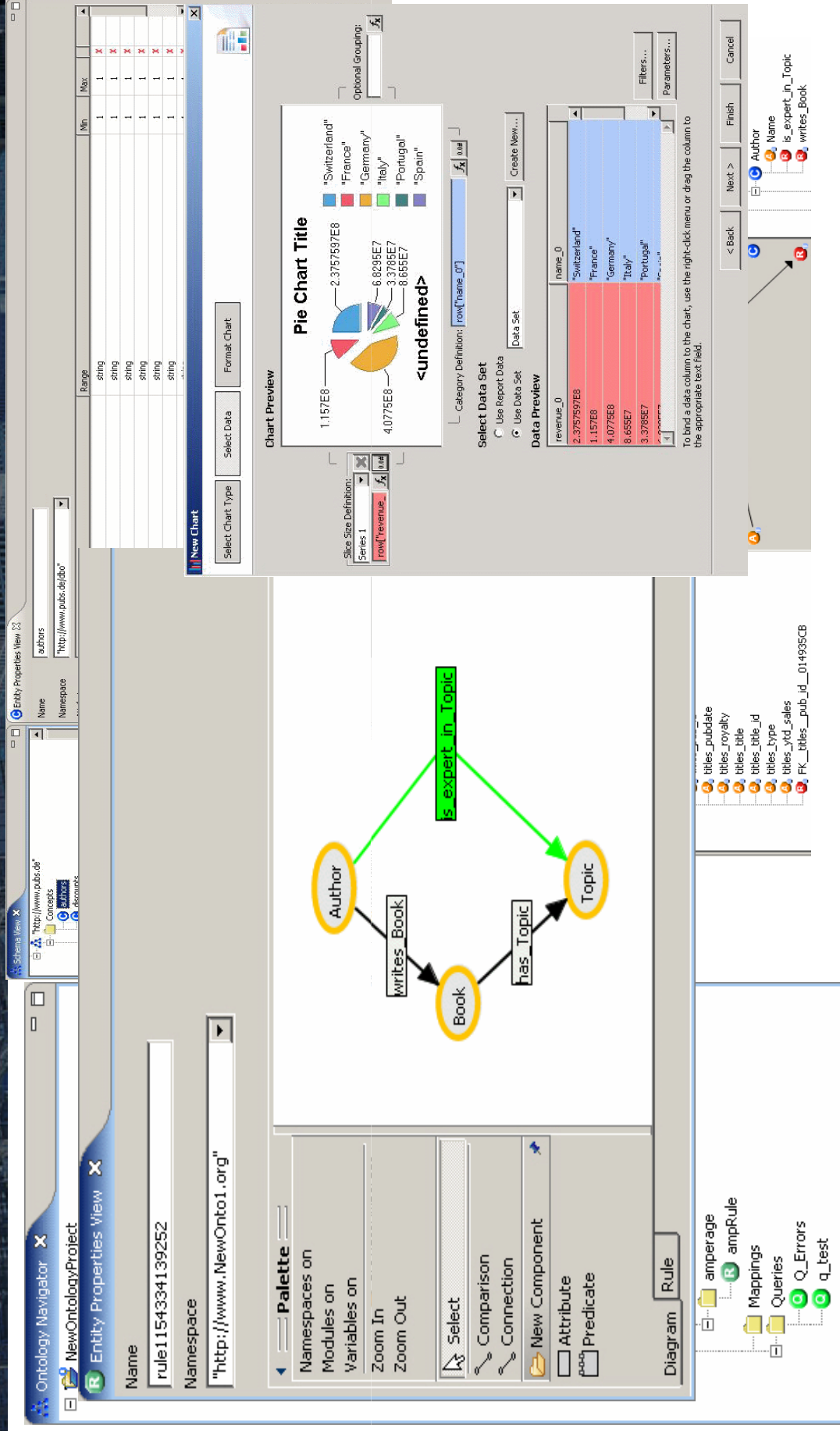
FORALL c, entity21, X, b, entity22, m
c["http://www.testcar.org/#valid->>FALSE"]@["http://www.testcar.org/#"
<-
m: "http://www.testcar.org/#motor@["http://www.testcar.org/#" AND
m["http://www.testcar.org/#maximum power->>entity21]@["http://www.testcar.org/#" AND
b: "http://www.testcar.org/#brake@["http://www.testcar.org/#" AND
b["http://www.testcar.org/#maximum power->>entity22]@["http://www.testcar.org/#" AND
c: "http://www.testcar.org/#car@["http://www.testcar.org/#" AND
c["http://www.testcar.org/#consistsOf->>m]@["http://www.testcar.org/#" AND
c["http://www.testcar.org/#consistsOf->>b]@["http://www.testcar.org/#".
  
```

# What our customer likes on Flogic

## F-Logic

- declarative (logic-based)
- clear semantics (well-founded semantics)
- powerful (rules, functions, negations)
- ontology based structuring (frame)
- schema reasoning
- simple human readable syntax
- homogenous rule and query syntax
- logical model of a domain
- modelling environment
- close integration into databases
- IT infrastructure
- handling large amounts of data
- fast engine

# OntoStudio / NEON toolkit



The screenshot displays the OntoStudio / NEON toolkit interface, which is used for creating and managing ontologies and generating visualizations.

**Ontology Editor (Left Panel):**

- Namespaces:** Includes "http://www.pubs.de" and "http://www.NewOnto1.org".
- Entity Properties View:** Shows a table of properties for the "authors" namespace.

**Diagram View (Center):**

- Classes:** Author, Book, Topic.
- Relationships:** "writes Book" (from Author to Book), "has Topic" (from Book to Topic).
- Instance:** "s\_expert\_in\_Topic" (green box) is linked to the Topic class.

**Chart Generation (Right Panel):**

- Pie Chart Title:** "Pie Chart Title".
- Category Definition:** "row['name\_0']".
- Data Set:** A table with columns "name\_0" and "revenue\_0".
- Chart Preview:** A pie chart showing the distribution of revenue by country.

name_0	revenue_0
"Switzerland"	2.3757597E8
"France"	1.157E8
"Germany"	4.0775E8
"Italy"	8.655E7
"Portugal"	3.3795E7
"Spain"	8.655E7

**Chart Preview Data:**

- Switzerland: 2.3757597E8
- France: 1.157E8
- Germany: 4.0775E8
- Italy: 8.655E7
- Portugal: 3.3795E7
- Spain: 8.655E7

**Entity Properties View (Table):**

Property	Range	Min	Max
string	string	1	1
string	string	1	1
string	string	1	1
string	string	1	1
string	string	1	1
string	string	1	1



# OntoStudio / NEON toolkit



The screenshot displays the OntoStudio / NEON toolkit interface, which is used for developing and debugging rules. The main window is divided into several panes:

- Rule Graph:** A central pane showing a directed graph of rules. Nodes are labeled with IDs (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100) and edges represent dependencies or logical flow. Labels include "Q\_Errors", "wrongAmperage\_INTERNAL\_1", "configurationContainment", "componentContainment", "subsetRelationShip1", "subsetRelationShip2", "subclassTransitivity1", and "subclassTransitivity2".
- Rule Body View:** A pane on the right showing the body of a selected rule. It includes a "HEAD" section with the text "7aConfiguration has property 'http://www.ontoprise.de/OntoStudio2.0Demo#' hasCom" and a "BODY" section with several conditions:
  - ☒ body/literal
  - ☒ 7aConfiguration is instance of "http://www.ontoprise.de/OntoStudio2.0Demo#" "http://www.ontoprise.de/OntoStudio2.0Demo#"
  - ☒ 7aConfiguration has property "http://www.ontoprise.de/OntoStudio2.0Demo#" "http://www.ontoprise.de/OntoStudio2.0Demo#"
  - ☒ 7aComponent is instance of "http://www.ontoprise.de/OntoStudio2.0Demo#" "http://www.ontoprise.de/OntoStudio2.0Demo#"
  - ☒ 7aComponent has property "http://www.ontoprise.de/OntoStudio2.0Demo#" "http://www.ontoprise.de/OntoStudio2.0Demo#"
- Reference Explorer:** A pane on the right showing a list of references, including "configurationContainment".
- Result View:** A pane at the bottom showing the results of a query. It includes a "Tuples" section with a table of results and a "Data model: RAM" section.

# What our customer dislikes on Flogic

## F-Logic

- it is not a standard !

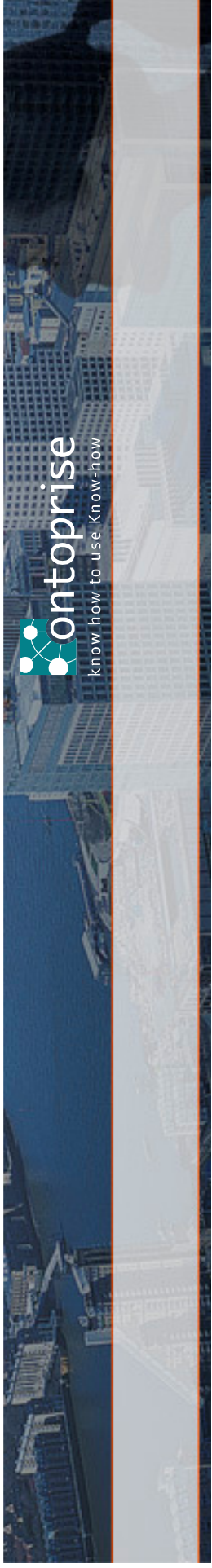
# Conclusion

## Ontologies and Rules ...

- increase the transparency
  - by carving out logics from applications and data
  - because all results are explained in natural language
- make complexity manageable
  - because informal and distributed knowledge is formalized and therefore made machine processable
  - because knowledge can be structured and re-used
- help to build flexible systems that can adapt to changes quickly

**but we need a standard!**





# Thank you!

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