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Semantic variant management

… and the automotive industry's cry for help

September 2019
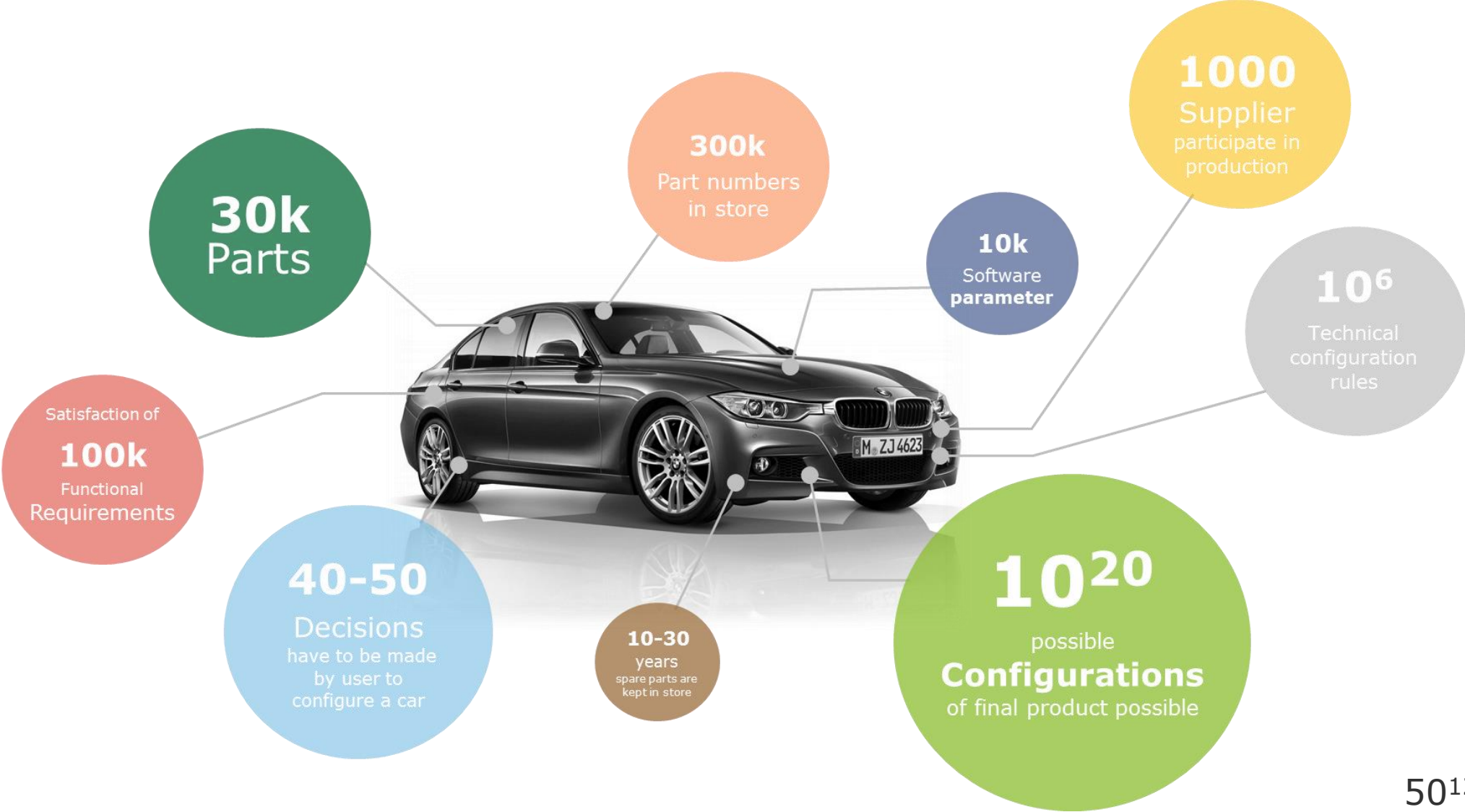
95% dark stuff

5% normal stuff

Semantic variant management | Situation
Mass individualization makes automotive manufacturers face immense data complexity.

30k Parts

300k Part numbers in store

1000 Supplier participate in production

10k Software **parameter**

10^6 Technical configuration rules

Satisfaction of **100k** Functional Requirements

40-50 Decisions have to be made by user to configure a car

10-30 years spare parts are kept in store

10^{20} possible **Configurations** of final product possible

$50^{12} \approx 10^{20}$

Semantic variant management | Situation
Configuration knowledge management is one of the most complex areas in PDM.

Example: Car seats

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Car seat complexity

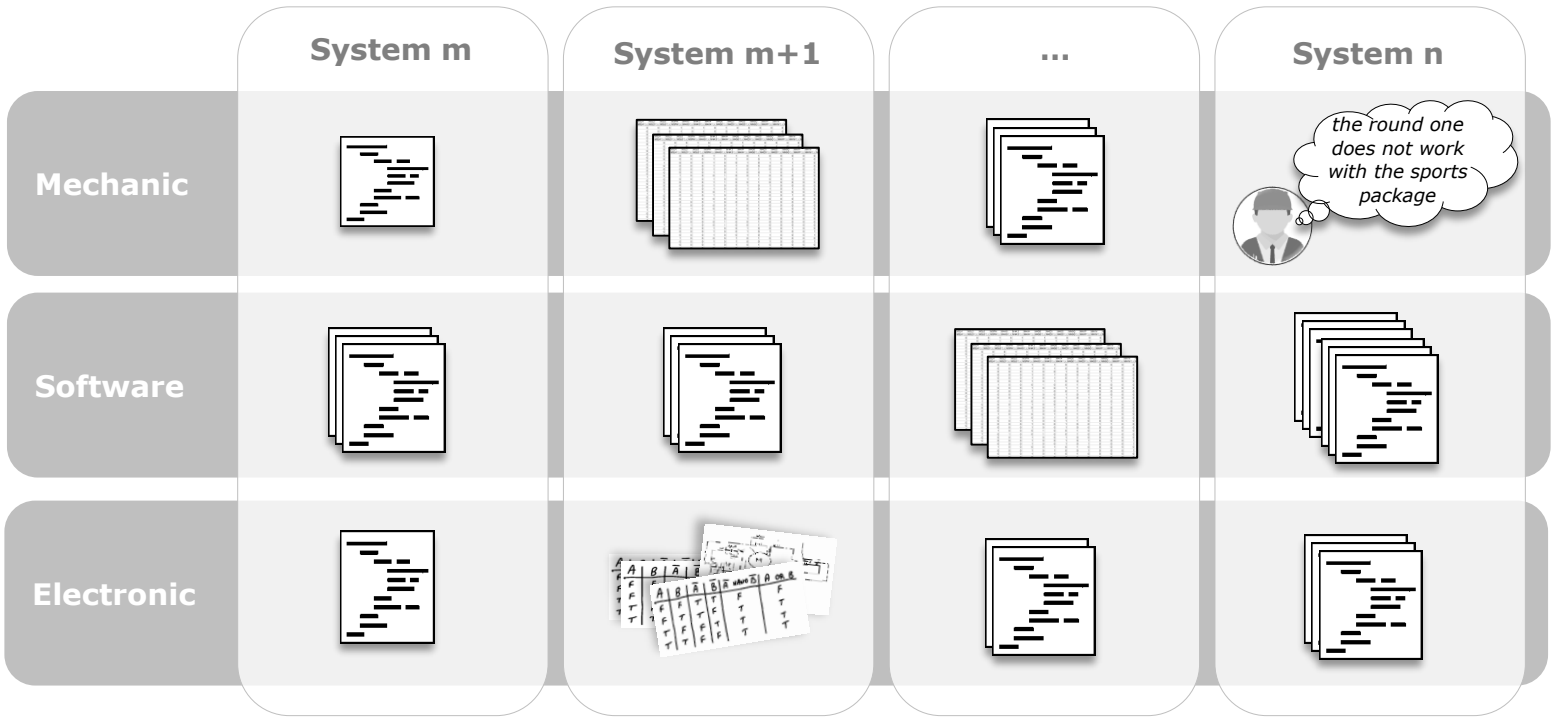|	
👆	50 customer feature decisions
⚙️	10 thousand configuration rules
🔗	6.5 millions seat variants
📢	1 feature affects 90% of the cars components
💰	10% complexity cost (CapEx, direct / R&D cost)

Semantic variant management | Complication

Inconsistent rule sets lead to high financial distress due to consideration of not existing configurations across the entire value chain.

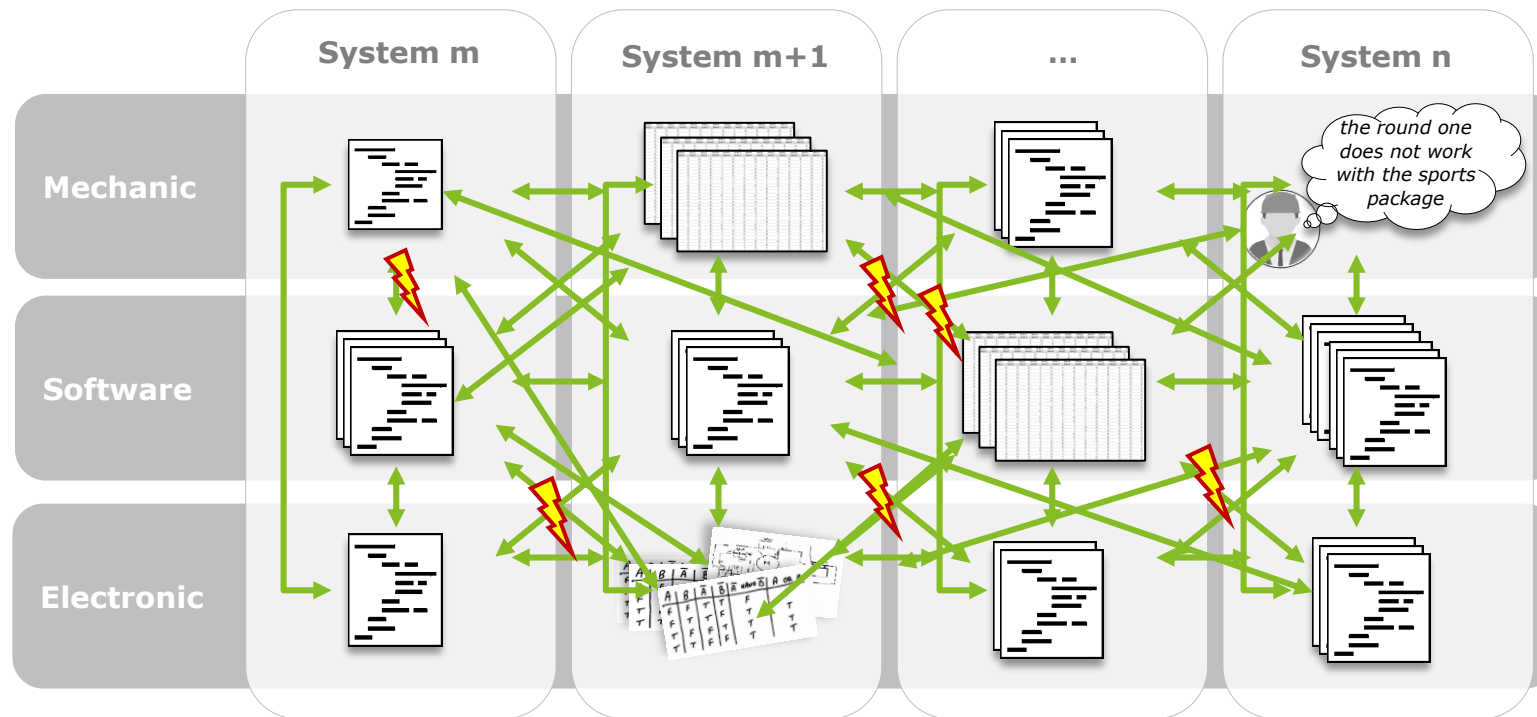## Representation of configuration knowledge

Complication

- Non compliant rules sets in different systems and functional areas (mechanics, electronics, software)
- Satisfiability check for completeness, consistency and redundancy not/partly possible
- Huge resources waste at simulation, verification and homologation of not existent configurations
- Errors and waste in production due to e.g. wrong software parameter for a configuration
- Inefficiencies in storage management due to lack of transparency in required parts

Semantic variant management | Complication

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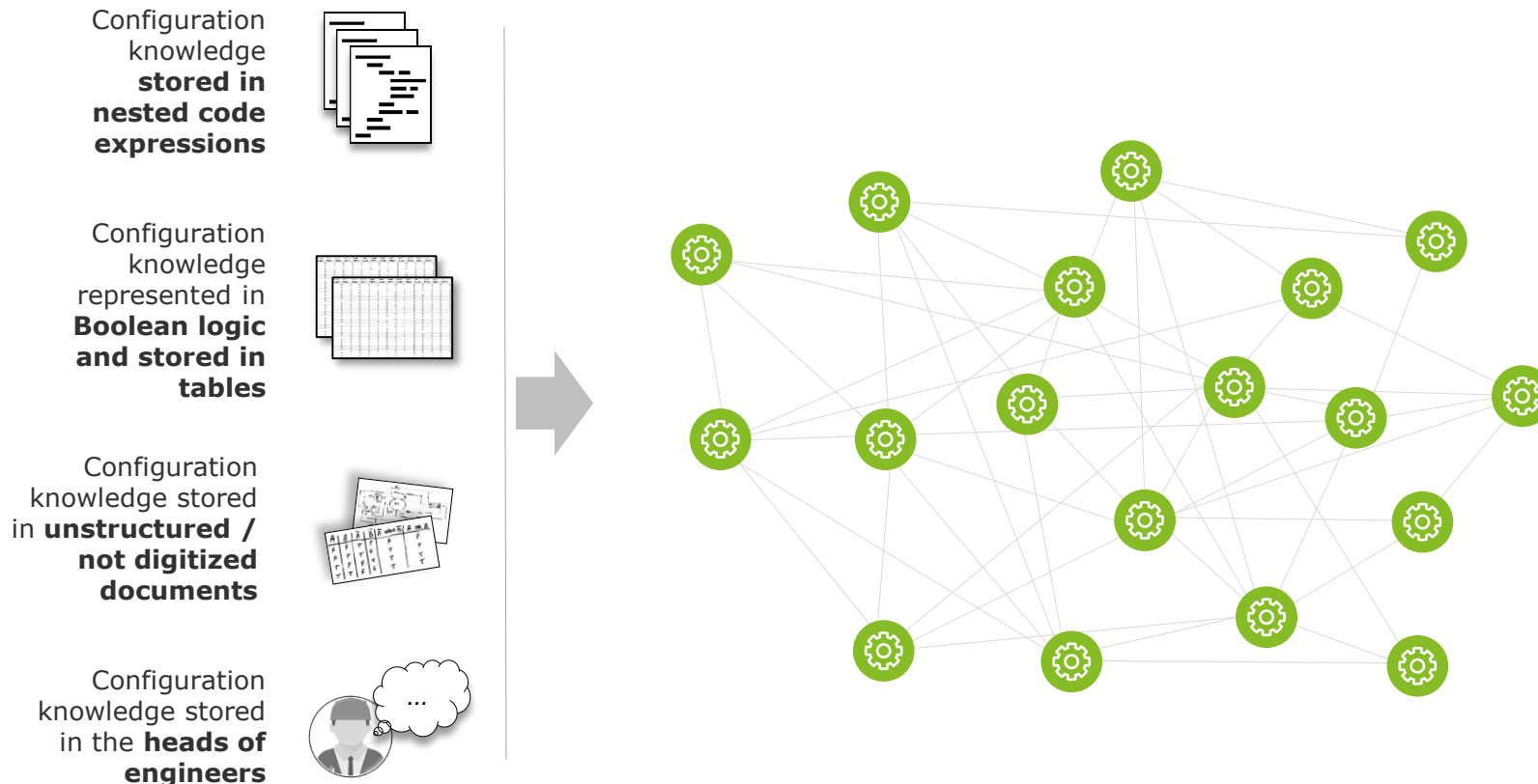## Representation of configuration knowledge

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Semantic variant management | Solution

Representation of rules as objects with semantic context incl. effectivities, versions and dependencies allows rule satisfiability analysis.

Transformation of configuration rules to a Knowledge Graph

Configuration knowledge **stored in nested code expressions**

Configuration knowledge represented in **Boolean logic and stored in tables**

Configuration knowledge stored in **unstructured / not digitized documents**

Configuration knowledge stored in the **heads of engineers**
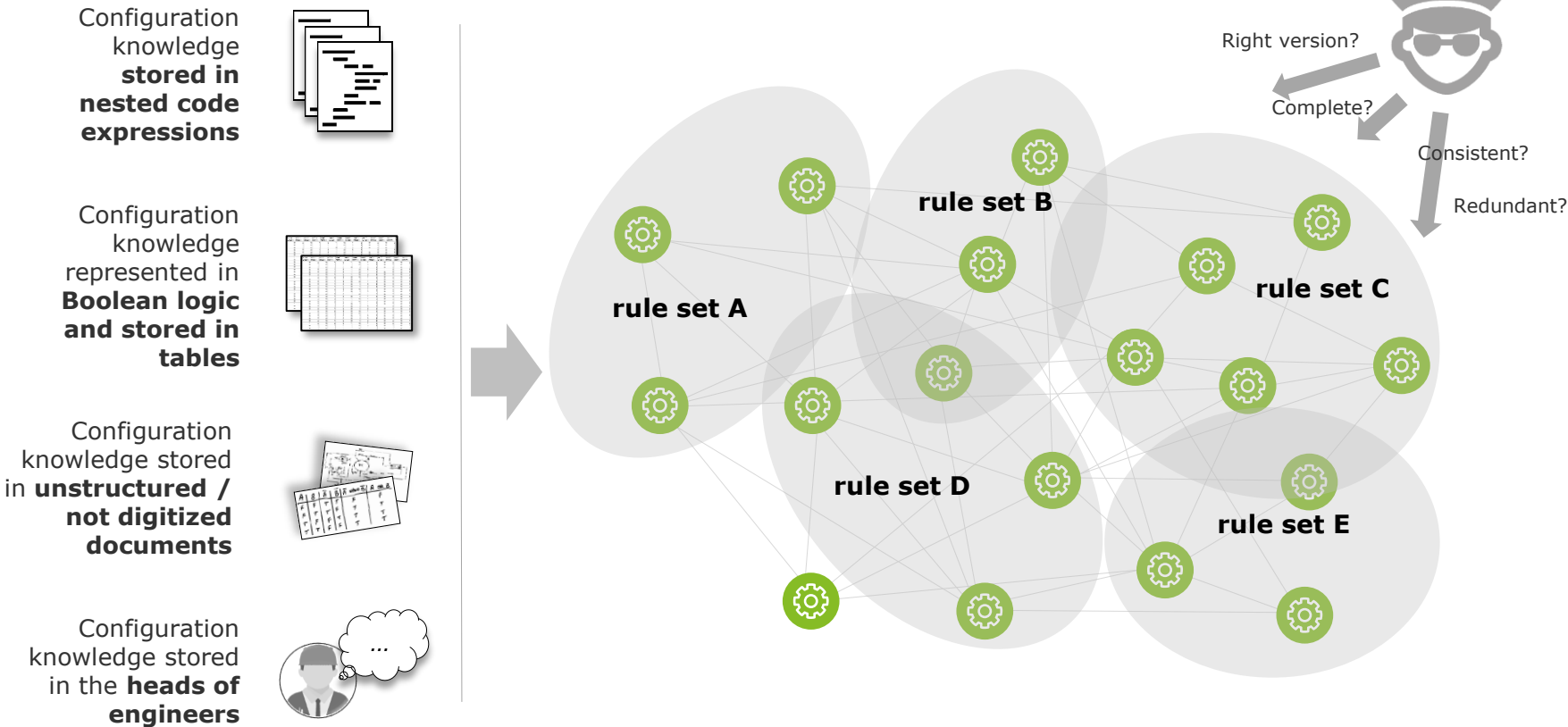

Solution

- Integrated representation of rules, configuration parameters and their manifestations

- Rule engine can perform satisfiability checks of rule set within milliseconds

- Graphical representation and navigation in Browser

- Navigation and backtracking configuration logic

- Recommendation engine to resolve consistency conflicts

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...

meta rules

Right version?

Complete?

Consistent?

Redundant?

rule set B

rule set A

rule set C

rule set D

rule set E

Solution

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Semantic variant management | Solution
Simple example

Dependency matrix

TOP Motor	Sports Package	Stainless Steel	SPOILER
0	0	0	-
1	0	0	Variant A
0	1	0	Variant B
0	0	1	Variant C
1	1	0	Variant A
1	0	1	Variant C
0	1	1	Variant C
1	1	1	Variant C

Code

```
if (
    top = 0 && sports = 0 && steel = 1 ||
    top = 1 && sports = 0 && steel = 1 ||
    top = 0 && sports = 1 && steel = 1 ||
    top = 1 && sports = 1 && steel = 1 || ){

            spoiler = "variant a"

}

else if (
    top = 0 && sports = 0 && steel = 0 ||
    top = 1 && sports = 0 && steel = 0 ||
    top = 1 && sports = 1 && steel = 1 ||( {

            spoiler = "variant b"
}

else if (
    top = 0 && sports = 1 && steel = 0 || ( {

            spoiler = "variant c"
}
```

Graph

TOP, Basis, Sport, Comfort, Stainless, Aluminum

A — 2 restriction = 2 combinations

B — 3 restrictions = 1 combination

C — 1 restriction = 4 combinations

Conflict detection and recommendation to resolve conflict

recommendation: add missing configuration rule

Graph extract containing all nodes related to configuration conflict

Configuration Rule Knowledge Graph for **frontend** – contains all dependencies related to frontend
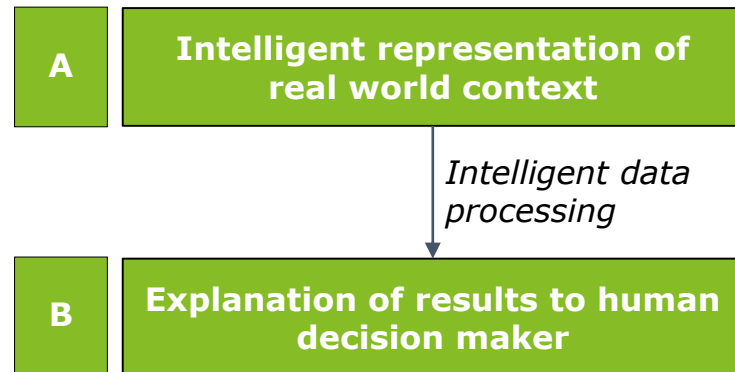
AllegroGraph

Semantic variant management | Outlook
Knowledge based variant management enable software dependency management, supply chain risk analysis and portfolio evaluation.

**Critical success factors** to support highly complex decision making are:

A	**Intelligent representation of real world context**

Intelligent data processing

B	**Explanation of results to human decision maker**

Traditional AI trained to solve complex problems can't explain its results to a human - **semantic technologies are designed to fit both requirements.**
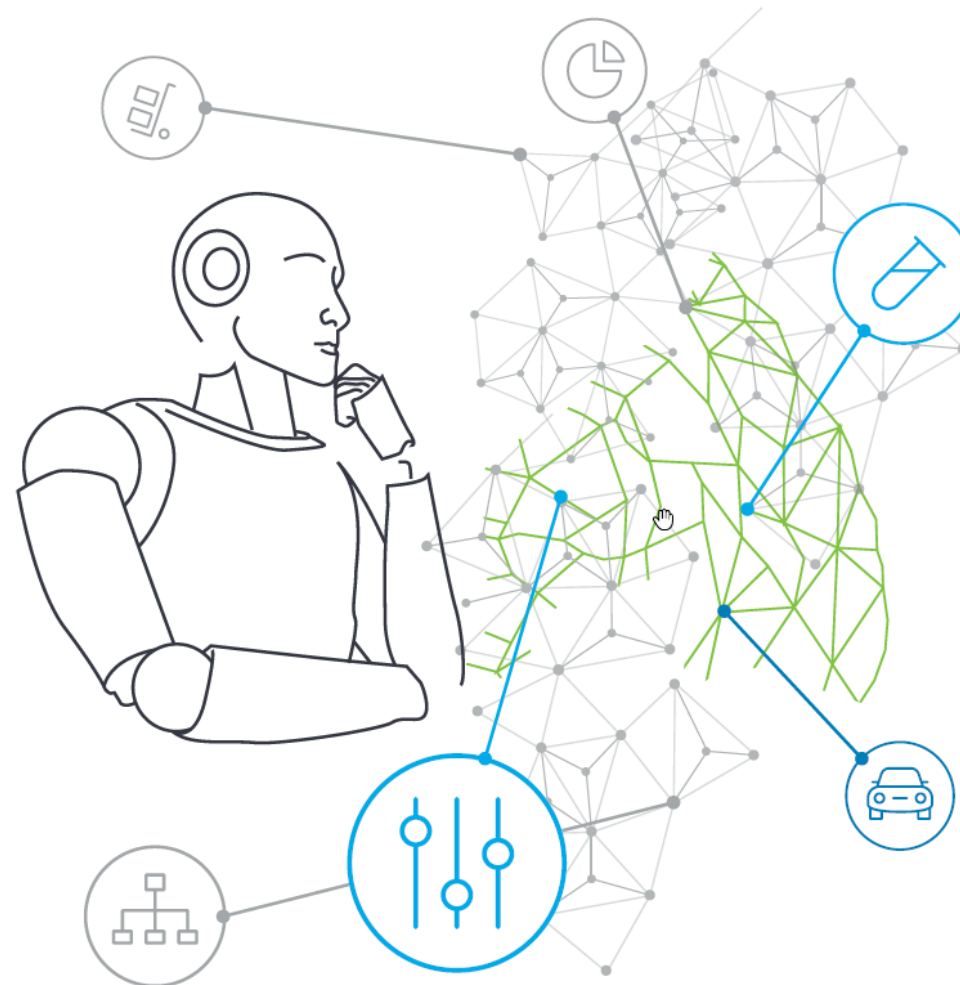
Business Transformation with Knowledge Graphs

Deloitte supports its customers all around development, evaluation and implementation of semantic technologies within enterprise ecosystems.

Strategy & Operations
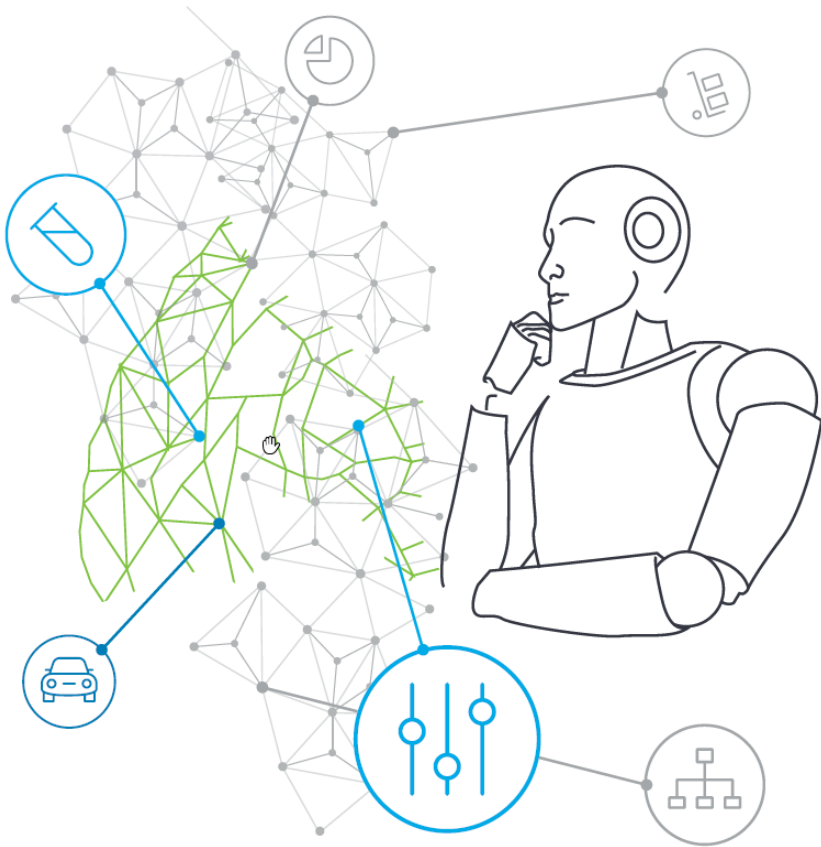
- $ DEVELOPMENT OF NEW BUSINESS MODEL
- PRODUCT AND SERVICE PORTFOLIO ROADMAP
- BUSINESS TRANSFORMATION

Underlying Technology

- SEMANTIC TECHNOLOGIES INCUBATION
- 360° ENTERPRISE ONTOLOGY DEVELOPMENT
- KNOWLEDGE GRAPH MATURITY ASSESSMENT
- DATA INTEGRATION & GOVERNANCE
- DATA ANALYTICS AND MACHINE LEARNING
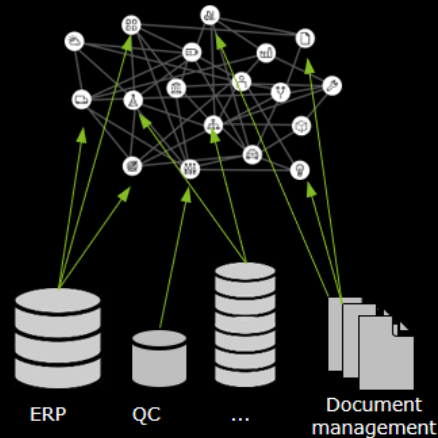- ARCHITECTURE DESIGN

SPDM | Project overview
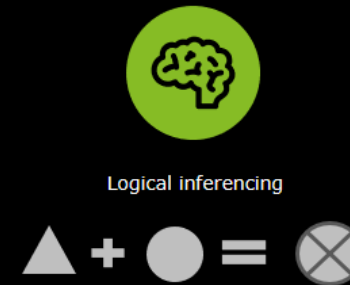## Creating knowledge out of unstructured data for enabling AI based solutions

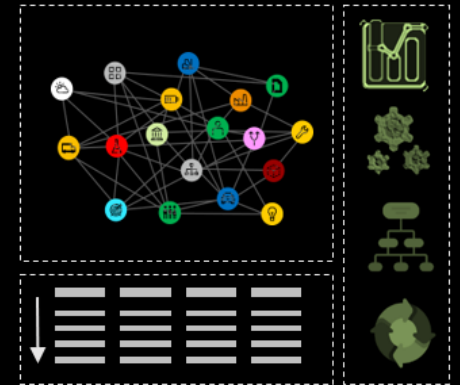### The Case

1 Creation of metalevel ontology graph

2 Assignment of enterprise data to metalevel ontology

ERP   QC   ...   Document management

3 Implementation of semantic reasoner

Logical inferencing

▲ + ● = ⊗

4 Customized visualisation of data and creation of data analysis cockpit

Benefits for our Clients

- Connecting existing data and creating a single point of truth
- Inter-divisional impact analysis of product changes and decisions
- Real-time data analysis and discovery of hidden knowledge
- Usage of human-like language for querying
- Flexibility of data model and scalability of database

Our Services

- Creation of customized, graph-based metalevel ontology and implementation in a graph database
- Data transformation to graph and definition of rules for semantic reasoning
- Use case specific algorithm creation
- Customised visualisation of data and creation of data analysis cockpit

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Building an ecosystem?
Connect the dots.