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# The Model-Based Car Lifecycle
# A Challenge to Automated Reasoning

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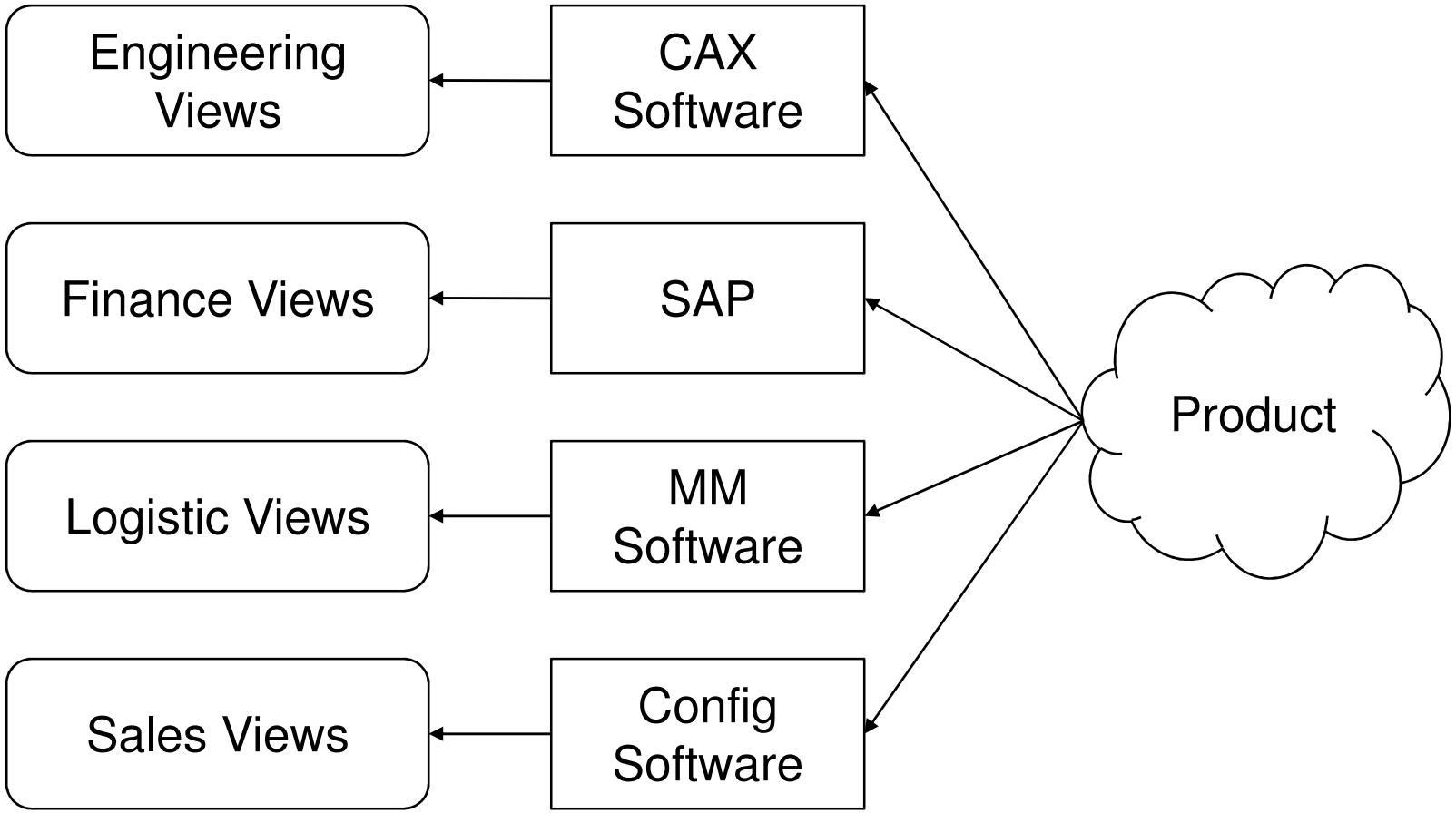
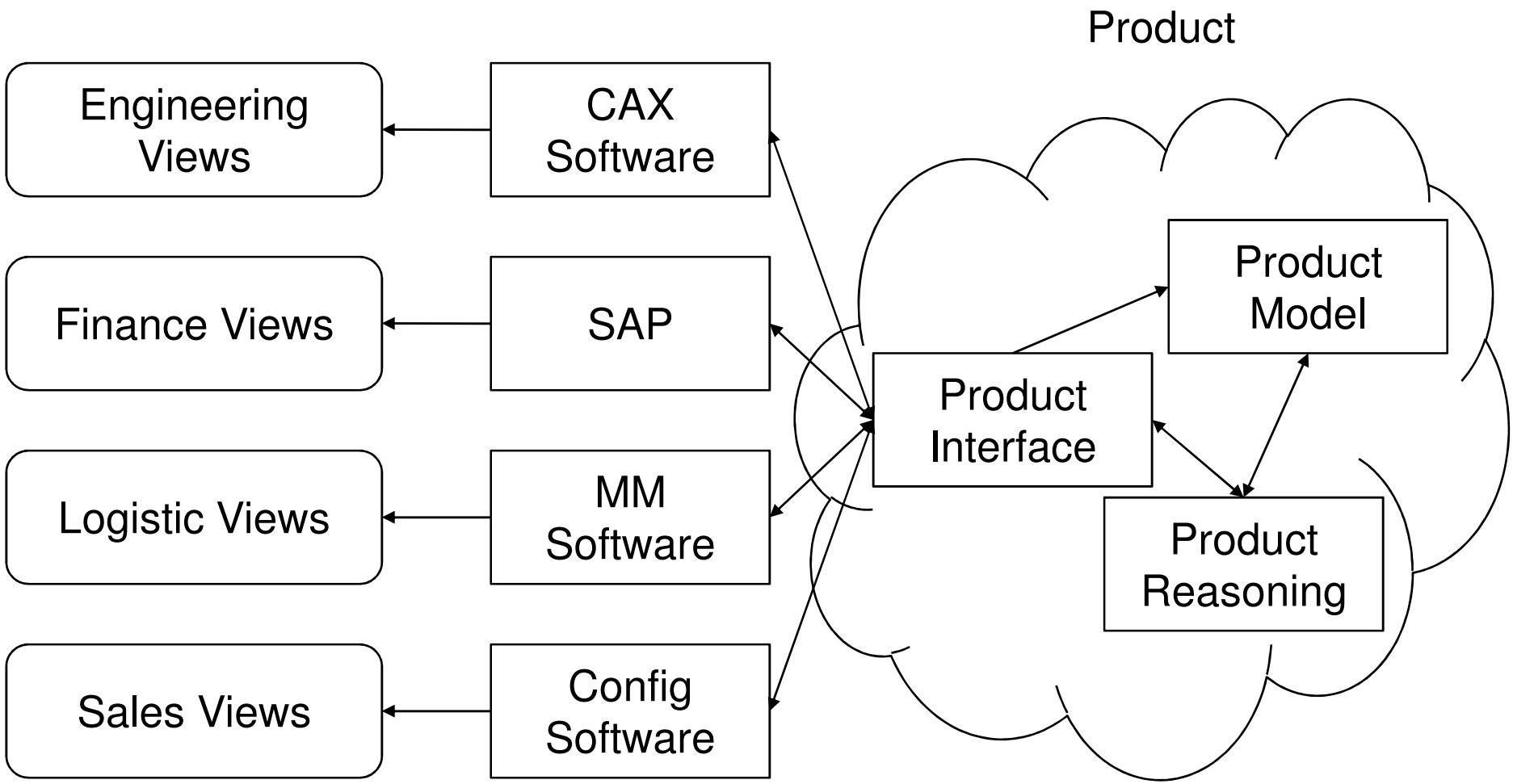
# Today's Car Lifecycle Business

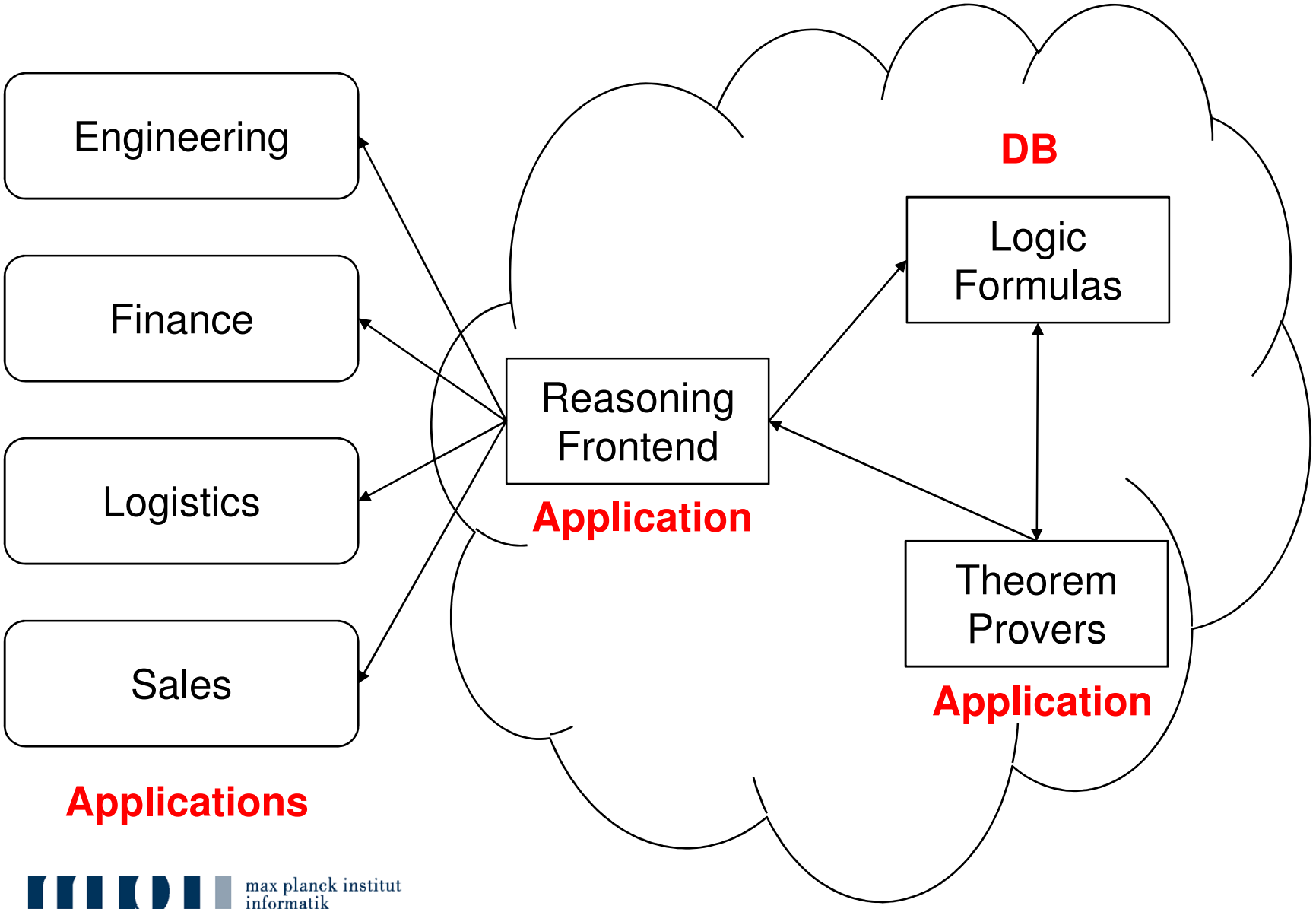


# Cloud Computing

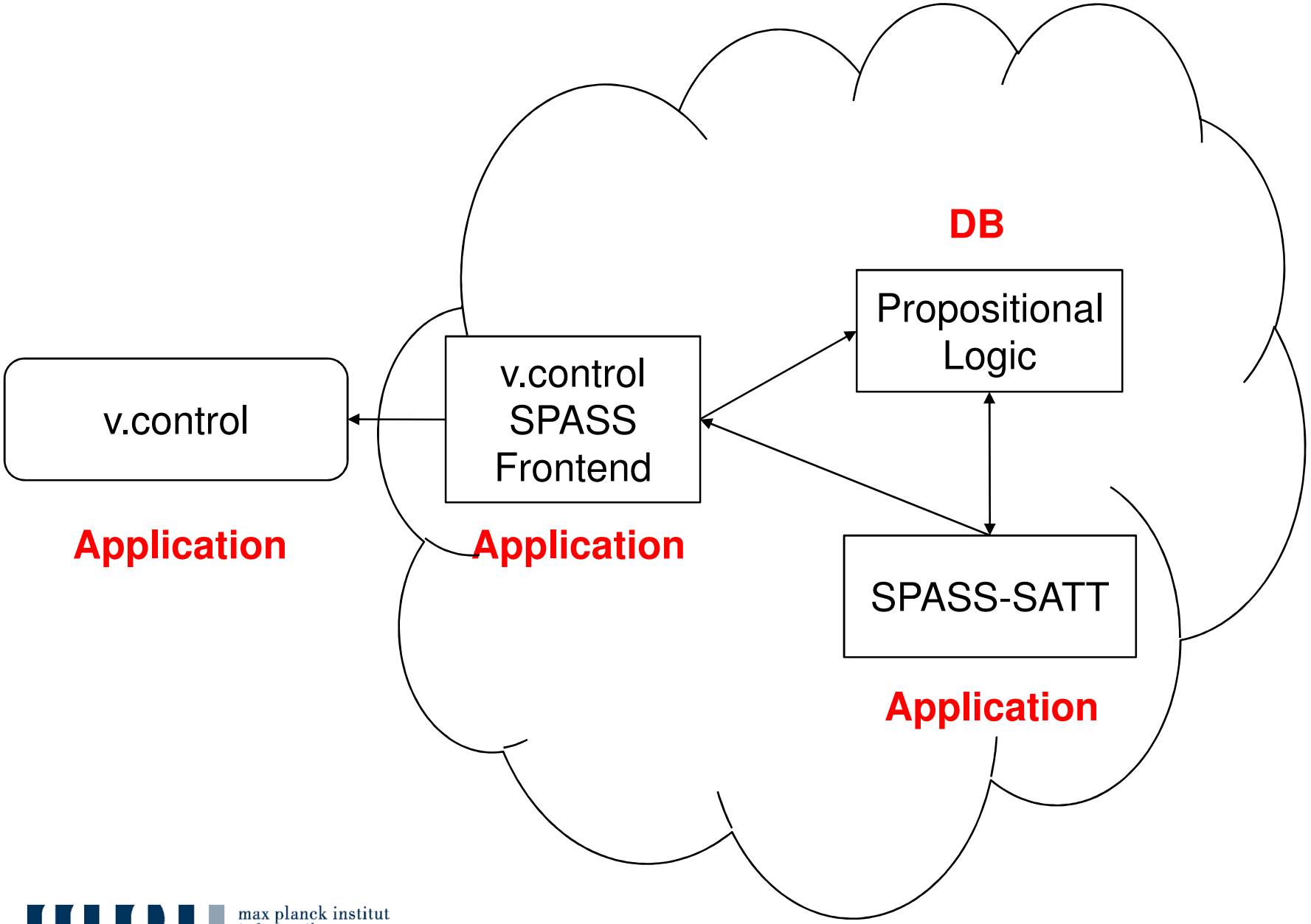



**Application** **Software + DB** **Paper + People + DB + Software**

# Cloud Deduction

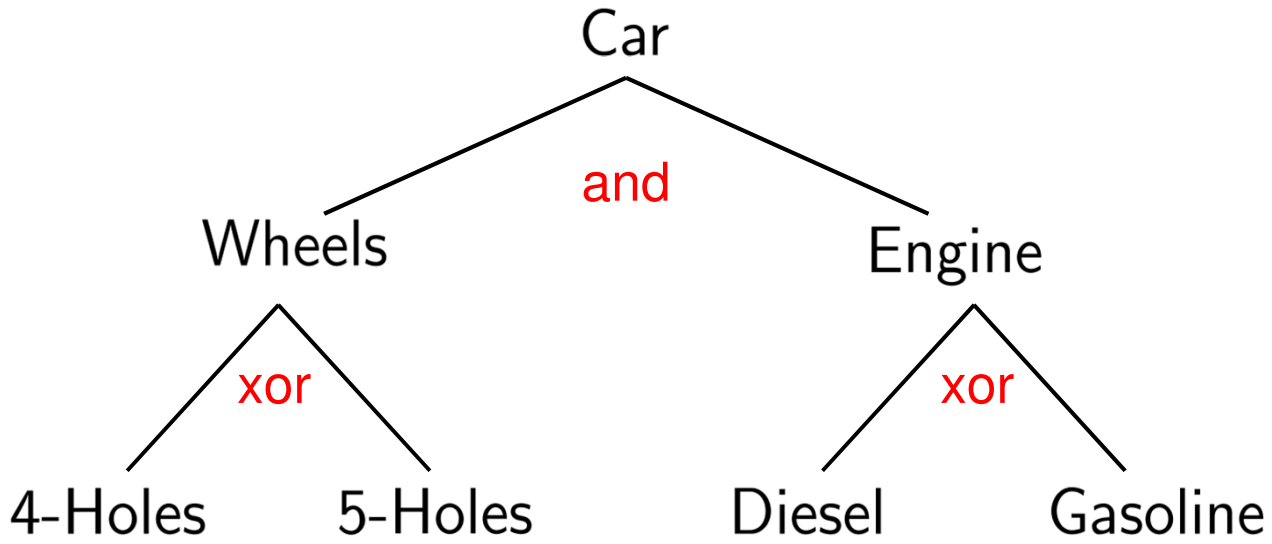


# It’s not a cloud castle



# Propositional Logic Car Lifecycle Model - SAT

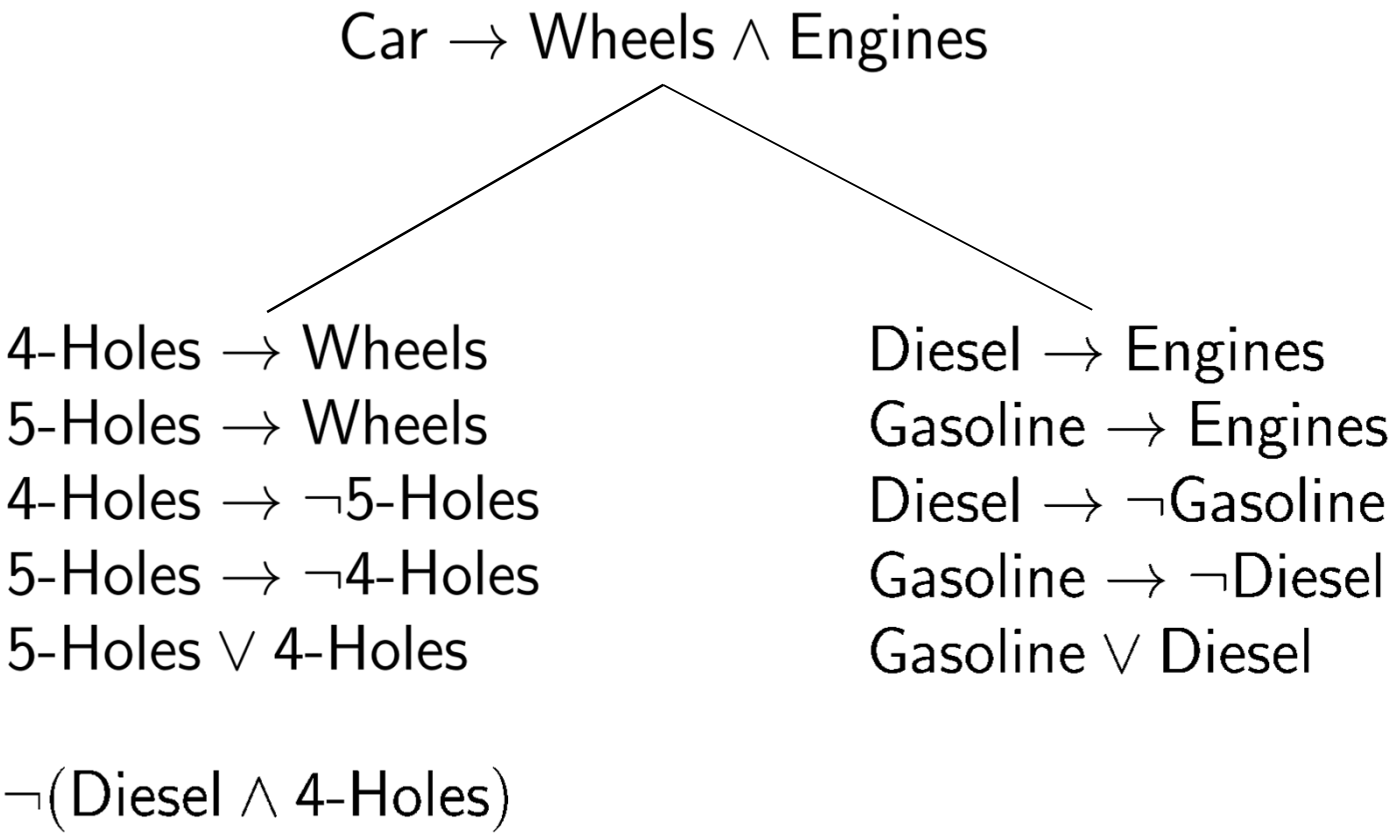
- represent a car as its part assembly
- represent variants
- represent constraints




Diesel Engine and 4-Hole Wheels can't go together.

In general: restricted group cardinalities, *n* out of *m*.

# Propositional Logic Formulas




Every model of the above formulas “is a car”.

# Product Reasoning

- consistency
- number of models (products)
- consequence closure
- usage of parts
- accounting
- ….

**Challenge: scale to about 60k propositional variables**
**state of the art about 6k variables**



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# Centrifugal Mass Classes – Wheel Force

Diesel Engine and 4-Hole Wheels can't go together.

a little bit more realistic model

$$F = m \cdot a \qquad \begin{array}{rl} m & \text{car mass} \\ a & \text{car acceleration} \end{array}$$

$$F = m \cdot a$$
$$1 \leq F < 1000 \rightarrow \text{cmc}_1$$
$$1000 \leq F < 2000 \rightarrow \text{cmc}_2$$
$$2000 \leq F \rightarrow \text{cmc}_3$$
$$\neg((\text{cmc}_2 \vee \text{cmc}_3) \wedge \text{4-Holes})$$

Move from SAT to SMT.



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# Need for Speed

$$v_{\max} \approx \sqrt[3]{\frac{\mathrm{hp} \cdot \alpha}{\frac{\rho_{\mathrm{Air}}}{2} \cdot c_W \cdot A}}$$

| | |
|---|---|
| $\mathrm{hp}$ | power of the car engine |
| $\alpha$ | about 100 car parameters |
| $c_W$ | car air drag coefficient |
| $A$ | car face projection surface |

## Further product reasoning:

- Data Aggregation: car with $v_{\max} > 200 \ \wedge \ m < 1200$
- Optimization: what is the fastest/cheapest car?

# First-Order Logic Car Lifecycle Model - FMT

Comes with additional constraints:

- Strategic:

  for all parts of type “x” there are at least two different suppliers
- Marketing:

  the fastest car must not have a Diesel engine
- Manufacturing Engineering:

  no rectangular car body cut outs
- Regulations:

  car turn light between 20 and 70 above ground



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**Thanks for your attention**

$$\mathrm{SAT} \subseteq \mathrm{SMT} \subseteq \mathrm{FMT}$$



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