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Variability Management

or

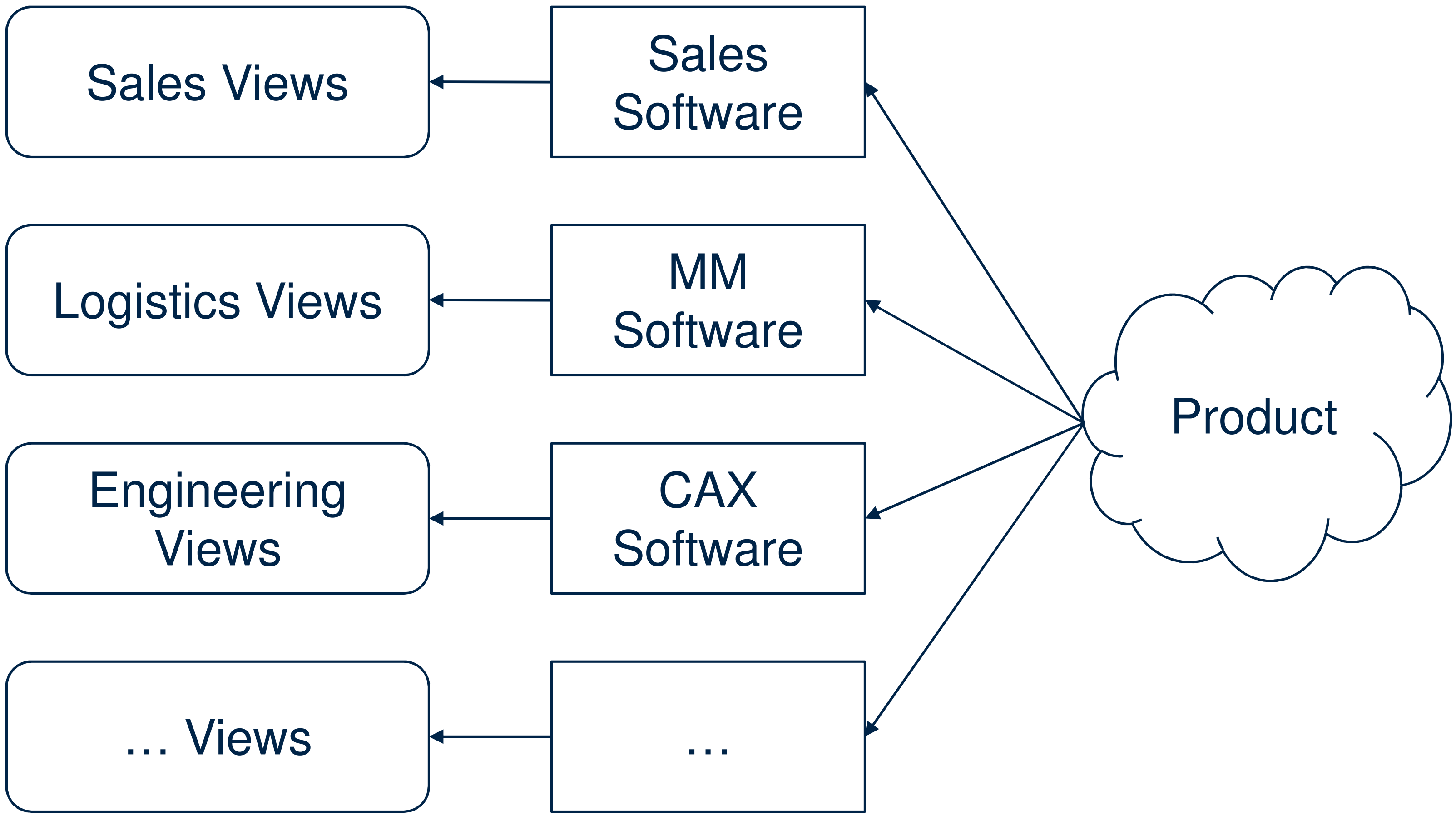
How to construct a new car in 5 min

or

How to make your specification run

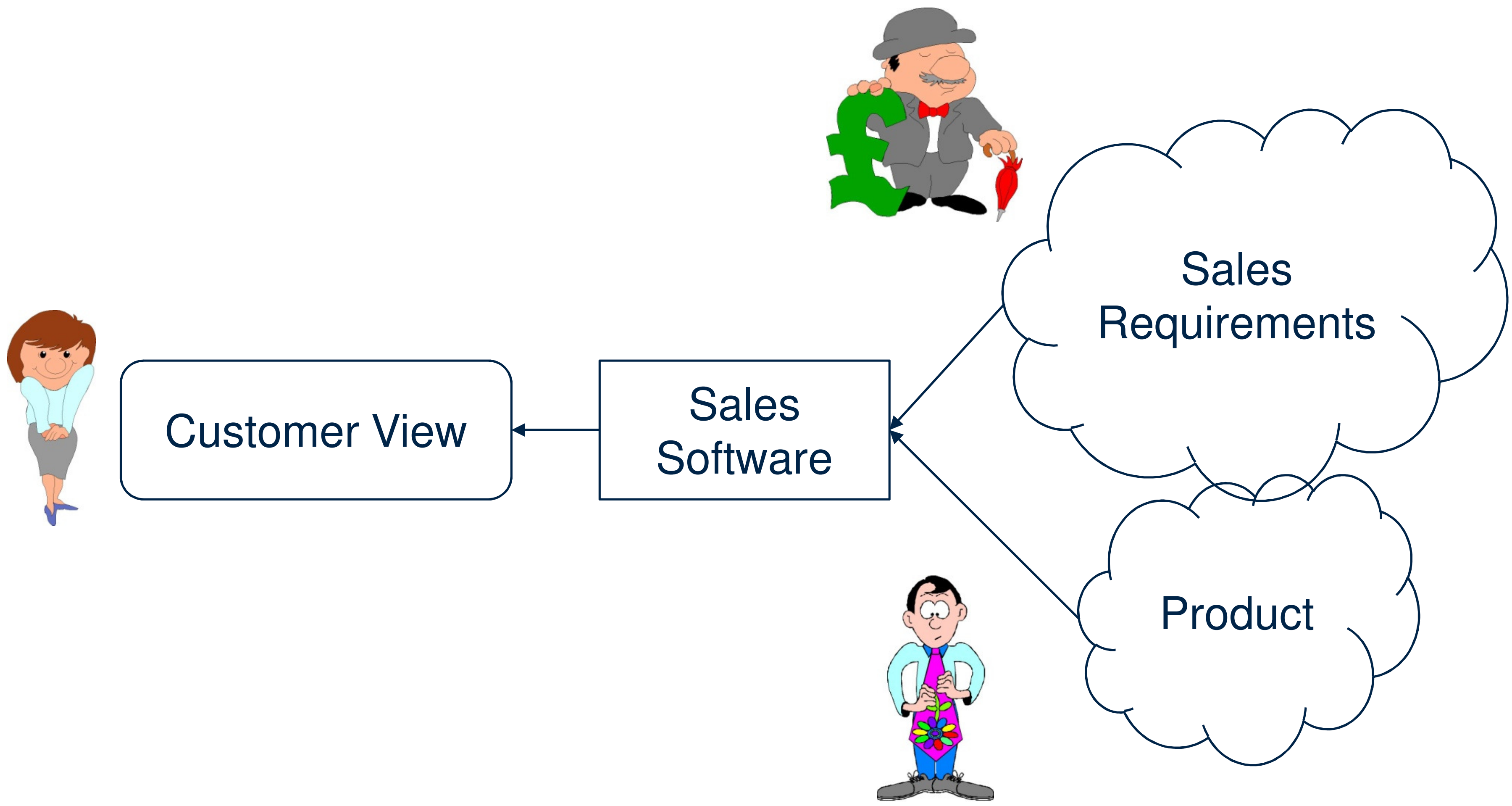
Prof. Dr. Christoph Weidenbach

Today’s Architecture



Application **Application + DB** **Paper, People**

Sales Software Development



(Dis)Advantages

Disadvantages

- changes to the product means changes to the software
- verification of the software not affordable
- architecture is not flexible
- no consistency between product and software
- no queries beyond single views

Advantages

- it works

What Cannot be Answered

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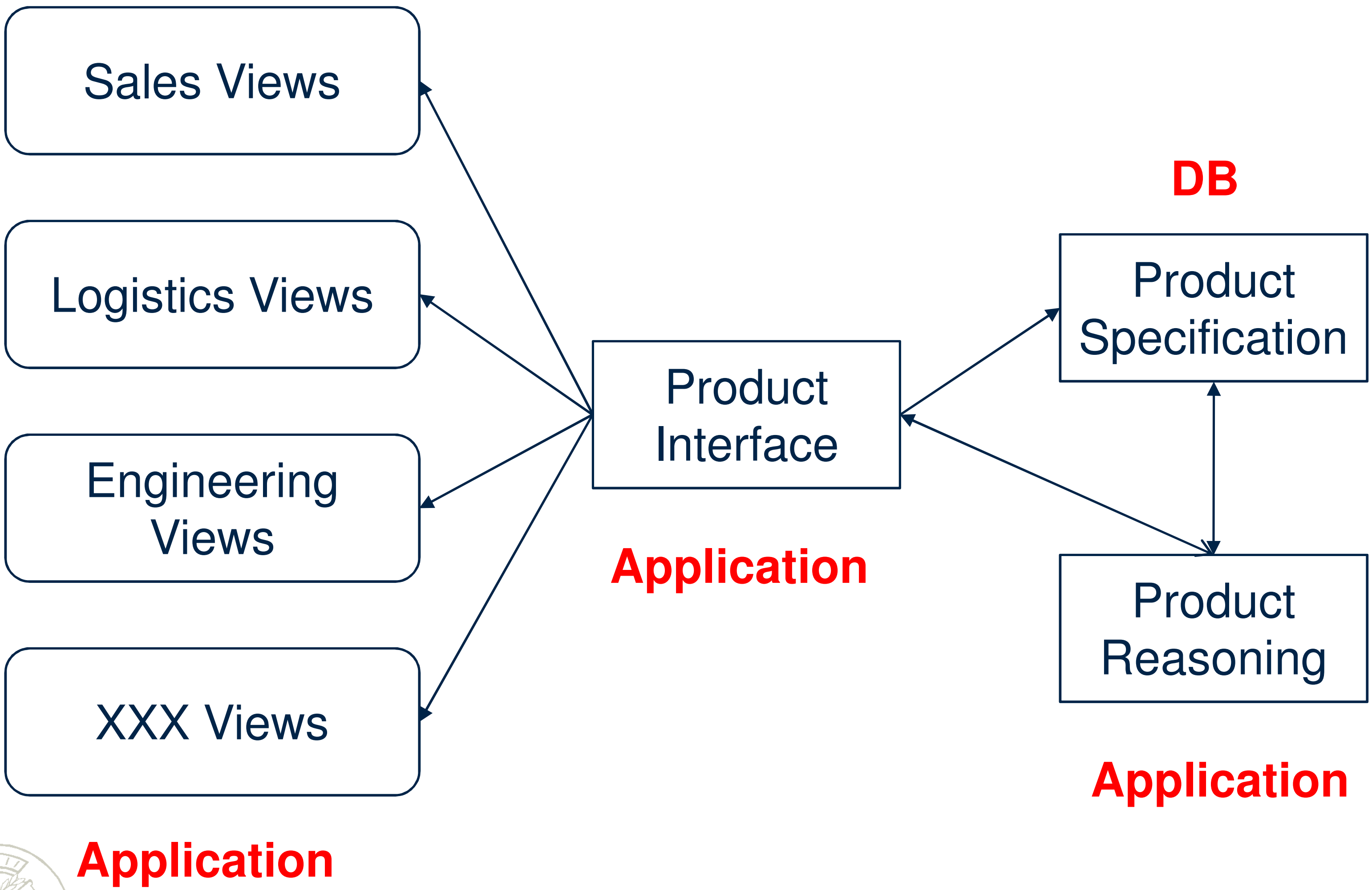
- Can we build a car with weight less than x?
- Is there a reasonable substitution for part x?
- Can we produce car x without supplier y?
- Which parts of our portfolio are not used anymore?
- How long does it need to build a new car with properties x?
- Is it profitable to get rid of part x?
- What is the most profitable car we could build?
- How much does it cost to produce a real sports car?
- …

Future's Architecture



(Dis)Advantages

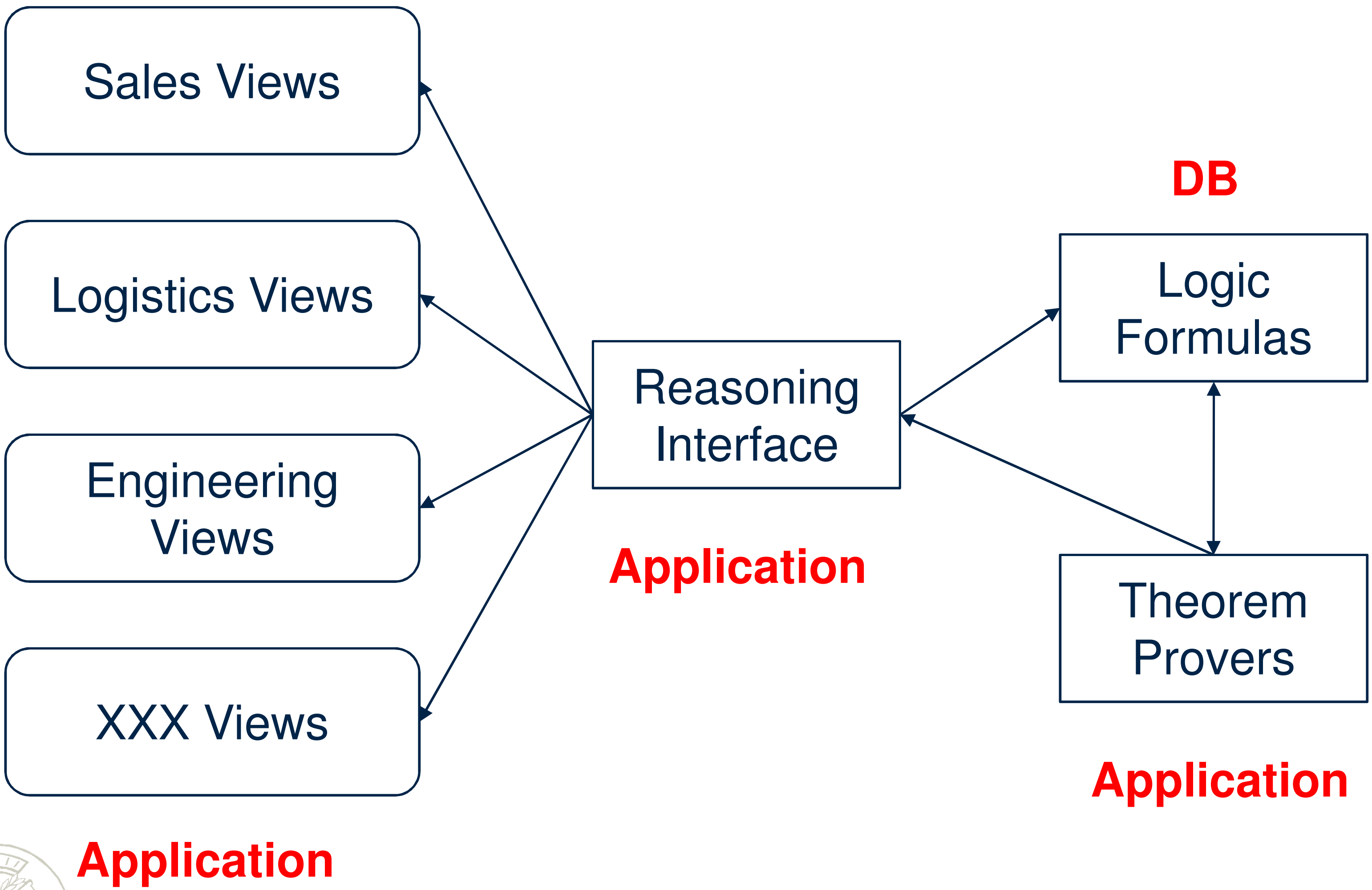
Advantages

- changes to the product automatically adjust software
- verification of the software for free
- architecture is highly flexible
- proven consistency between product and software
- support for overall product queries

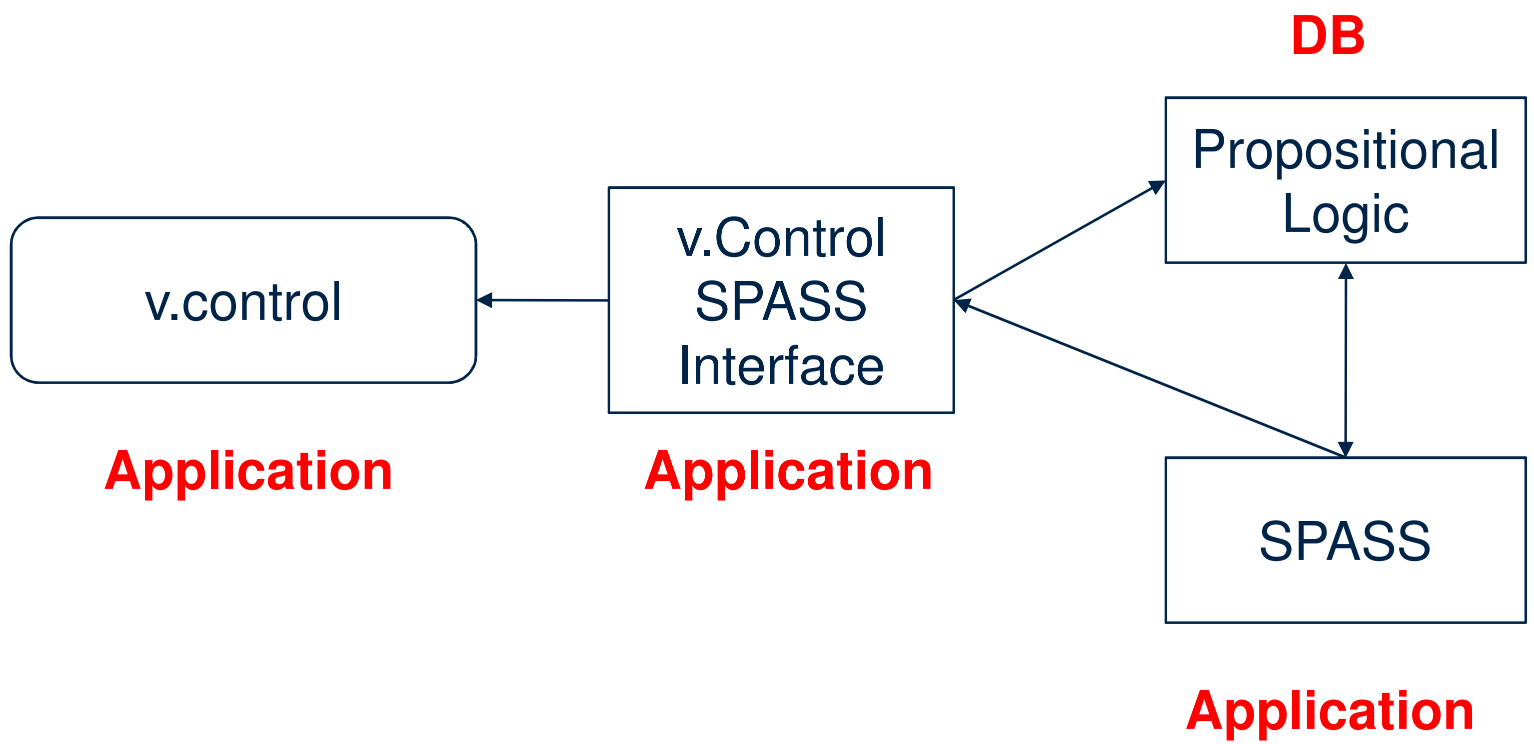
Disadvantages

- it does not work **yet**

Scientific View



Concrete Example



Propositional Logic

- Language: propositional variables can be true (1) or false (0)
- Connectives: $\Rightarrow$ implication, $\neg$ negation, $\vee$ disjunction, $\wedge$ conjunction
- Clause: disjunction of variables or their negations (literal)
- Validity: a formula is valid iff it is true for all possible assignments
- Assignment: setting all propositional variables 1 or 0, can also be expressed by showing the true literals
- we write $M \models C$ if the clause C is true by assignment M
- SAT: propositional satisfiability, find an assignment such that for a set of clauses all clauses are valid in the assignment

Unit Propagation

UProp(N,M)
  while (there is a clause $C' \lor L \in N$ such that
      $M \models \neg C'$ and $L \notin M$ and $\neg L \notin M$)
    $M := M \cup \{L\}$;
  return M;

UProp($\{\neg A \lor \neg B \lor C, \quad \neg A \lor B, \quad \neg C, \quad D, \quad A\}$,$\emptyset$)

$\rightarrow M = \emptyset$
$\rightarrow M = \{\neg C\}$
$\rightarrow M = \{\neg C, D\}$
$\rightarrow M = \{\neg C, D, A\}$
$\rightarrow M = \{\neg C, D, A, B\}$

DPLL Procedure

DPLL(N,M)
    if for all $C \in N$ we have $M \models C$ return true;
    if there is some $C \in N$ with $M \models \neg C$ return false;
    select a variable P occuring in N but not in M;
    if (DPLL(N, UProp(N, $M \cup \{P\}$))) then
        return true;
    else
        return DPLL(N, UProp(N, $M \cup \{\neg P\}$));

$\neg A \vee \neg B \vee C$
$\neg A \vee B$
$\neg C$
$A \vee D$

DPLL(N, $\emptyset$)

DPLL(N, UProp(N,$\{A\}$))	DPLL(N, UProp(N,$\{\neg A\}$))
DPLL(N, $\{A, B, \neg C\}$)	DPLL(N, $\{\neg A, D, \neg C\}$)

DPLL is sound and complete and terminating for SAT.

Propositional Logic Formulas

$$\text{Corsa} \Rightarrow \text{Wheels} \wedge \text{Engines}$$

$$\text{4-Holes} \Rightarrow \text{Wheels}$$
$$\text{5-Holes} \Rightarrow \text{Wheels}$$
$$\text{4-Holes} \Rightarrow \neg\text{5-Holes}$$
$$\text{5-Holes} \Rightarrow \neg\text{4-Holes}$$

$$\text{Diesel} \Rightarrow \text{Engines}$$
$$\text{Gasoline} \Rightarrow \text{Engines}$$
$$\text{Diesel} \Rightarrow \neg\text{Gasoline}$$
$$\text{Gasoline} \Rightarrow \neg\text{Diesel}$$

$$\text{Diesel} \Rightarrow \neg\text{4-Holes}$$

Reasoning: $\text{Corsa} \rightarrow \text{Wheels, Engines}$

$\text{4-Holes} \rightarrow \neg\text{5-Holes}, \neg\text{Diesel}, \text{Gasoline}$

$\text{Gasoline} \rightarrow \neg\text{Diesel}$

Challenge: Scalability

- before 2009: approx. 1500 nodes
- in 2009: v.control + SPASS approx. 3000 nodes
- in x years: for a reasonable product approx. 60000 nodes

Thank you for your attention