



[Weinbergsquelle, Hohenwarthe]

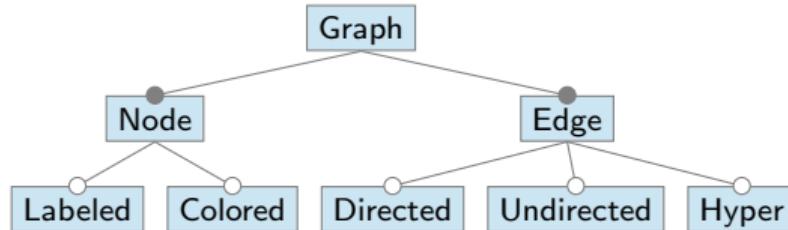
How Easy is SAT-Based Analysis of a Feature Model?

VaMoS 2024 — February 7–9 — Bern, Switzerland

Elias Kuiter¹, Tobias Heß², Chico Sundermann², Sebastian Krieter², Thomas Thüm², Gunter Saake¹

University of Magdeburg¹, Ulm², Germany

Recap: Product-Line and Feature-Model Analysis



$\neg(Directed \wedge Undirected)$

$Hyper \rightarrow Undirected$

$Directed \nleftrightarrow (Undirected \wedge Hyper)$

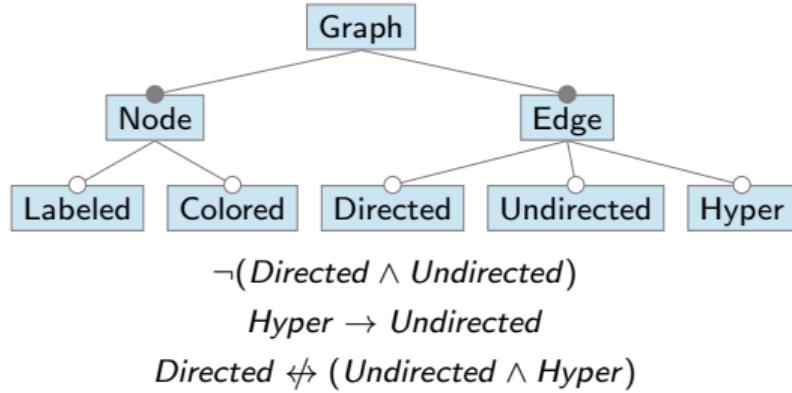
node.cpp

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class Node {  
    #ifdef LABELED  
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Product-Line Analyses ...

[ref]

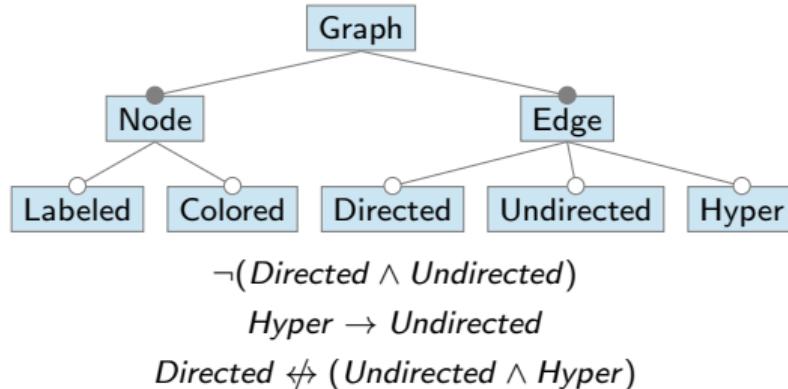
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Product-Line Analyses ...

[ref]

Which product(s) ...

- ... has the most **lines of code**? [ref]

- ... is the **fastest** or **smallest**? [ref, ref]

- ... have type or **logic errors**? [ref, ref]

- ... have unsafe **data flows**? [ref]

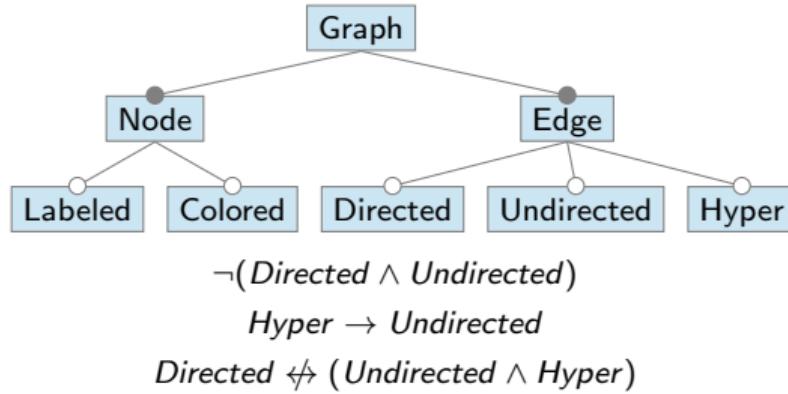
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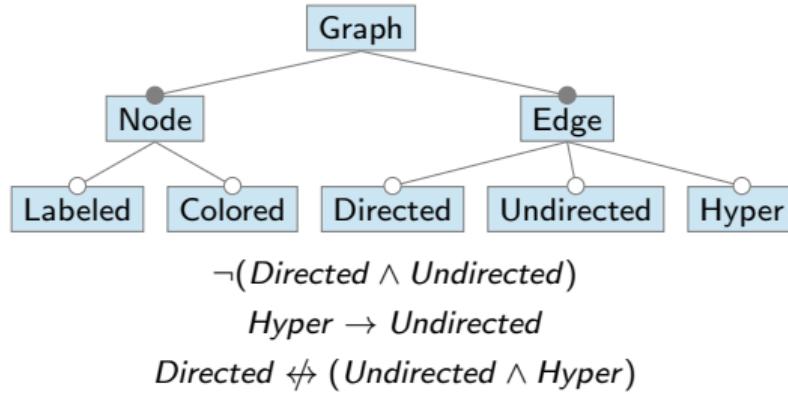
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... Often Rely on Feature-Model Analyses ...

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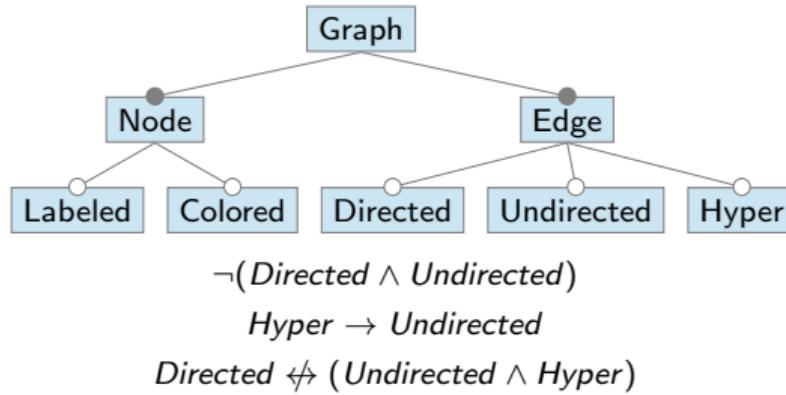
- Which features are **core/dead**? [\[ref\]](#)

- A sample covering all **t-wise interactions**? [\[ref\]](#)

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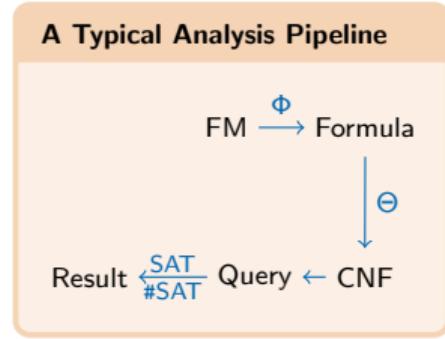
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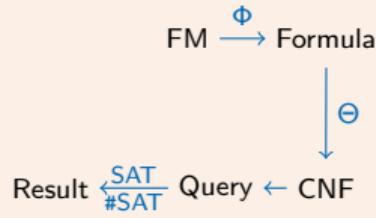
... which often rely on **SAT solving** (et al.)!

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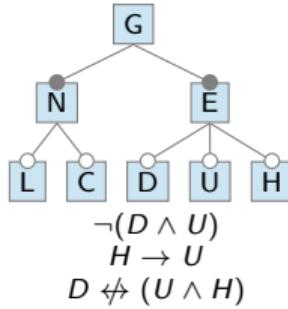


Recap: Product-Line and Feature-Model Analysis

A Typical Analysis Pipeline

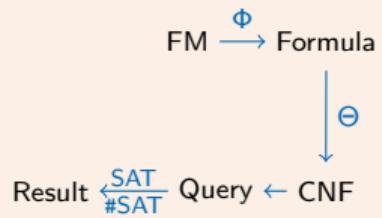


A Feature Model FM

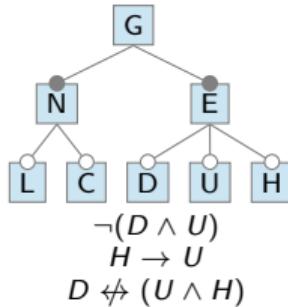


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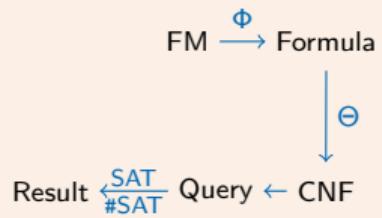


As a Formula $\Phi(FM)$

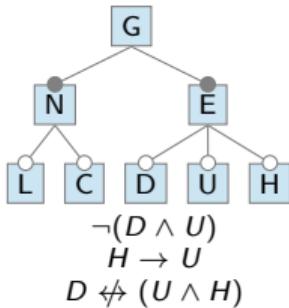
$$\begin{aligned} & G \\ & \wedge (N \leftrightarrow G) \wedge (E \leftrightarrow G) \\ & \wedge ((L \vee C) \rightarrow N) \\ & \wedge ((D \vee U \vee H) \rightarrow E) \\ & \wedge \neg(D \wedge U) \wedge (H \rightarrow U) \\ & \wedge (D \nleftrightarrow (U \wedge H)) \end{aligned}$$

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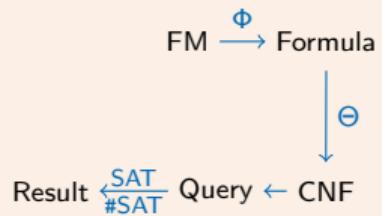
$\downarrow \Theta$

As a CNF $\Theta(\Phi(FM))$

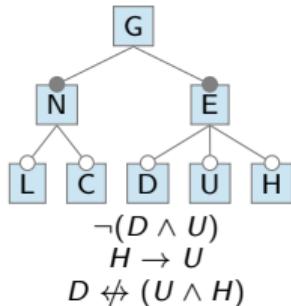
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Core Features

$$\{G, N, E\}$$

←

Core Feature F ?

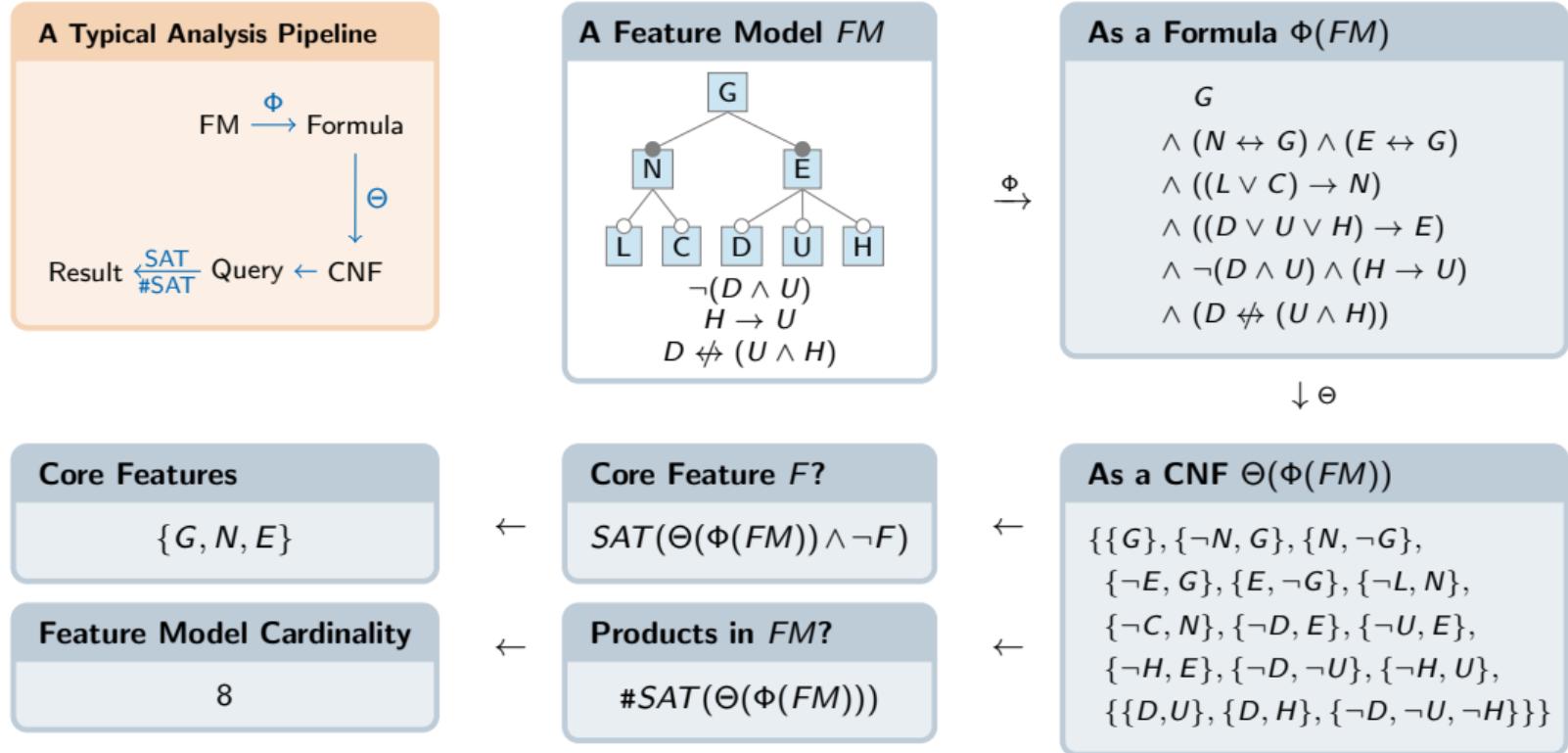
$$SAT(\Theta(\Phi(FM)) \wedge \neg F)$$

←

As a CNF $\Theta(\Phi(FM))$

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 & \{\{G\}, \{\neg N, G\}, \{N, \neg G\}, \\
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“easy”

as in

**“performs much better than expected
despite being NP-complete”**

(because no phase transition is observed on typical
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Yes, But . . .

- easy = **fast**?
 - what about **pre-solving steps**?
 - what about **repeated solver calls**?
- are **non-SAT analyses** also easy?
- are all feature models **equally** easy?

SAT-Based Analysis of Feature Models is Easy*

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*on most instances, for most purposes

How Bad is It?

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(REDACTED)

- Linux kernel
 - number of configurations **unknown** past 2007
 - family-based type checking **infeasible** [ref]
 - as is uniform random sampling, slicing, diffing, ...
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Feature-Model Meta-Analysis

the practice of **asking** and answering **questions**
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From Class-Based Meta-Analysis ...

... to Instance-Based Meta-Analysis

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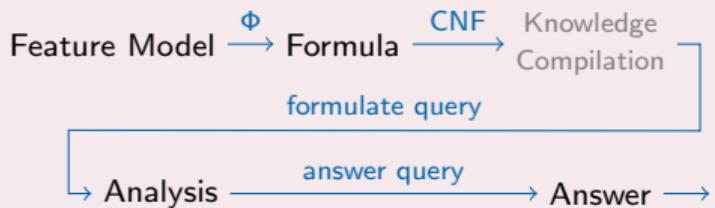
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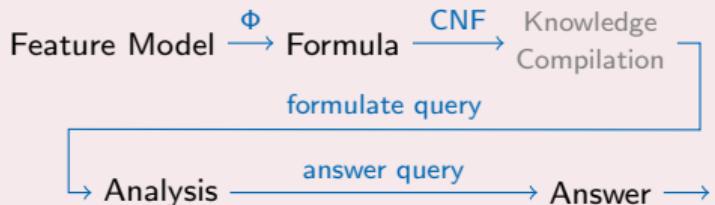
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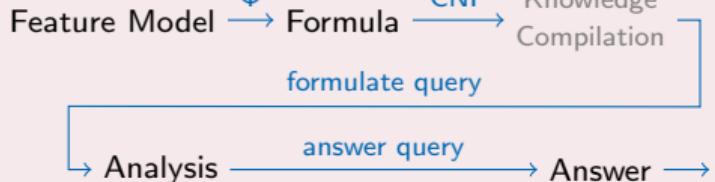
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KConfig extractor
non-Boolean variability
preprocessing



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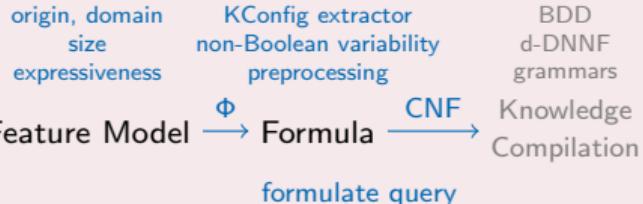
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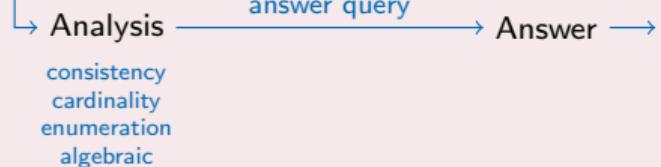
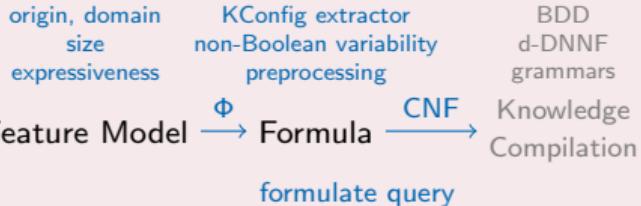
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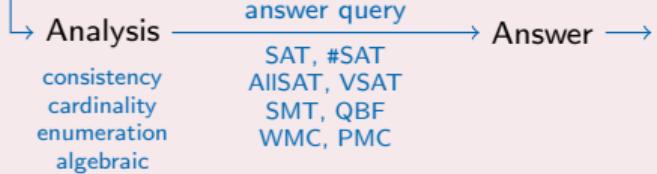
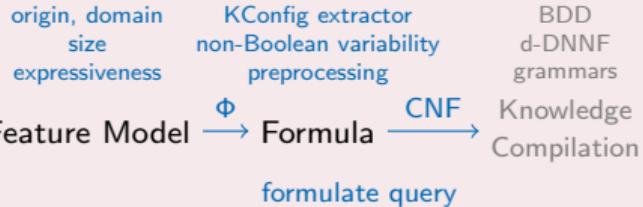
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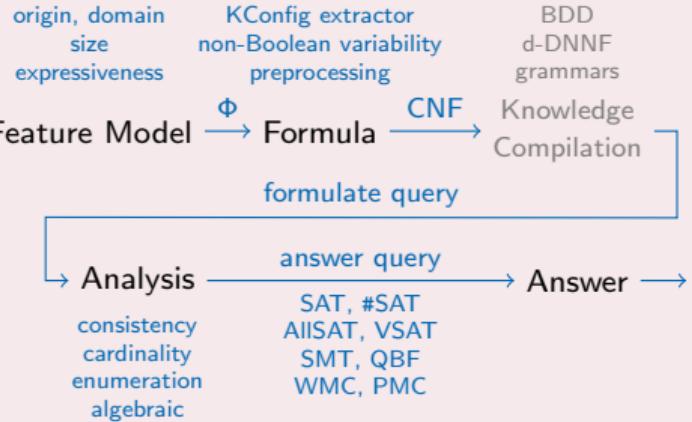
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- + **parametrization:** extractor, compiler, analysis, solver
- + **prior information:** incremental analysis, interfaces
- + **execution environment:** CPU, RAM, deep variability

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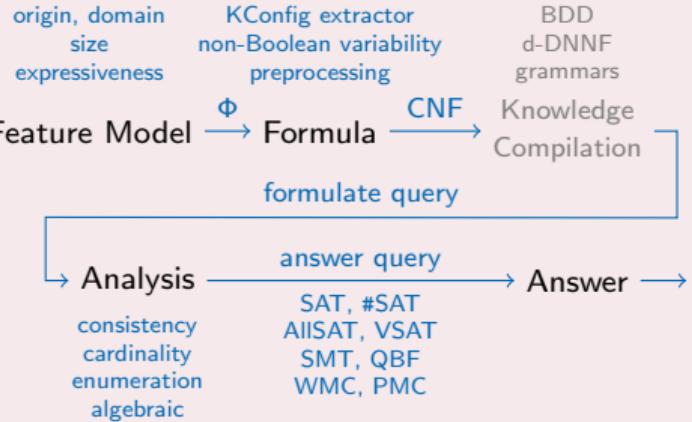
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for practical analysis tasks, there are many **analysis plans**

Answering Meta-Analysis Questions

Feature-Model Meta-Analysis

the practice of asking and **answering** questions
about feature-model analyses

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Surrogate Metrics for Avoiding the Computation

Choosing Criteria & an Algorithm

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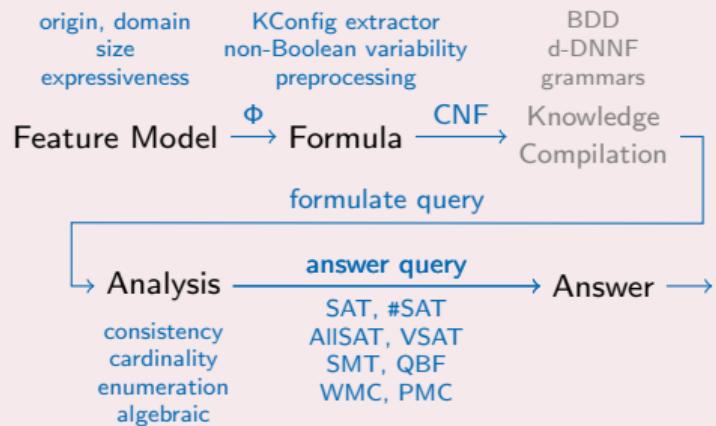
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- long-term goal: a **meta-analyzer** that finds the best analysis plan for a given analysis task (cf. portfolio solving, relational query optimization)
- tool support: FeatJAR (FeatureIDE 4.0), torte, clausy, KeYPI, PCLocator, Course on SPLs, ...

Conclusion

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Influence Factors for Feature-Model Analysis



Your opinion?

Does feature-model complexity matter for your work?
Are you doing meta-analysis?
How would you answer a meta-analysis question?



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