



Cutting Edge T-Wise Sampling with ddnnife

Bachelor Thesis by Lars Licha, Supervised by Chico Sundermann, Sebastian Krieter | April 10, FOSD'24, Eindhoven, The Netherlands

T-Wise Sampling

Goal:

- Representative list of configurations
- Include all valid feature combinations of size t

Usage:

- Testing, analyzing, profiling, evaluation, ...

T-Wise Sampling

Goal:

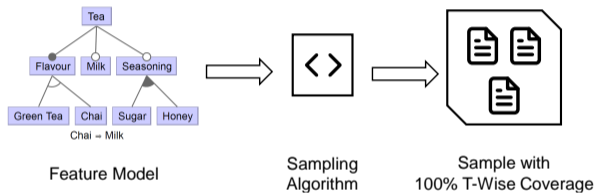
- Representative list of configurations
- Include all valid feature combinations of size t

Usage:

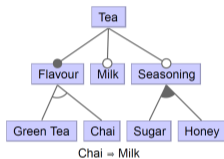
- Testing, analyzing, profiling, evaluation, ...

Implementation:

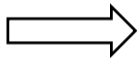
- Typically SAT-based



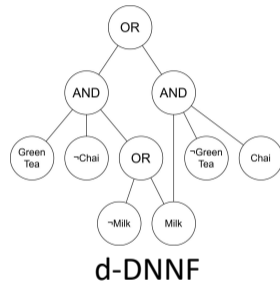
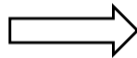
Knowledge Compilation with d-DNNFs



Feature Model



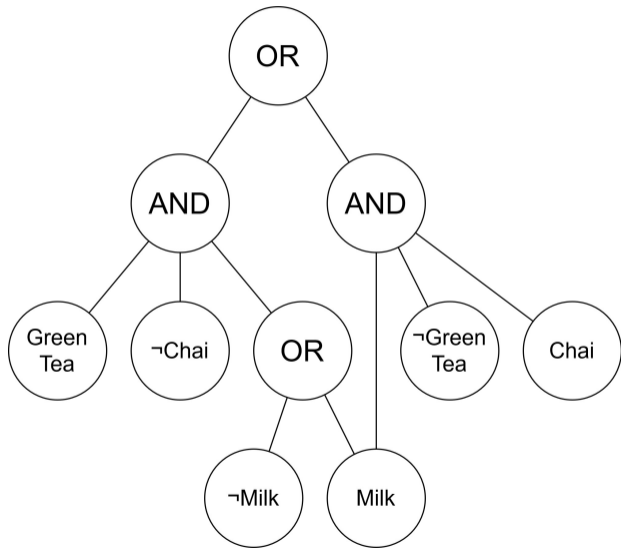
Knowledge Compiler



d-DNNF

Knowledge Compilation with d-DNNFs

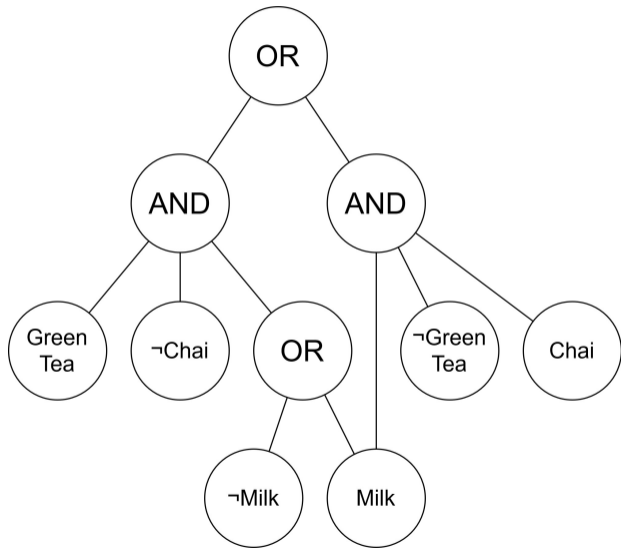
deterministic **D**ecomposable **N**egation
Normal Form



Knowledge Compilation with d-DNNFs

deterministic Decomposable Negation Normal Form

- *Leaf nodes* are literals
- *AND children* share no variables
- *OR children* share no valid assignments

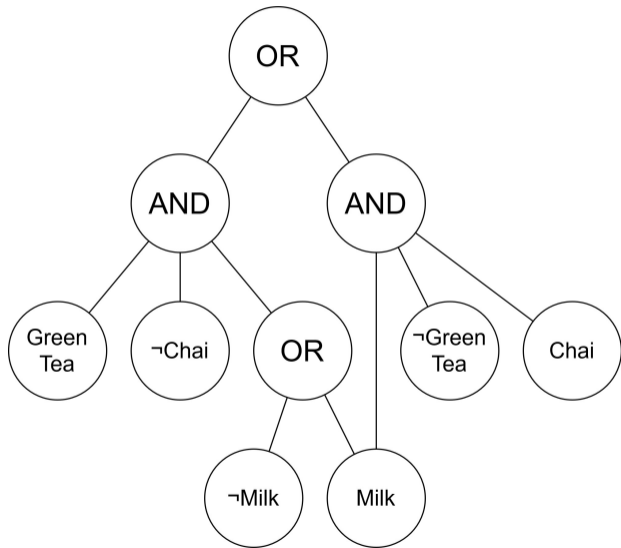


Knowledge Compilation with d-DNNFs

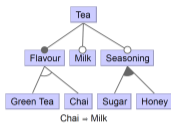
deterministic **D**ecomposable **N**egation
Normal Form

- *Leaf nodes* are literals
- *AND children* share no variables
- *OR children* share no valid assignments

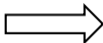
⇒ **SAT** and **#SAT** can be computed efficiently



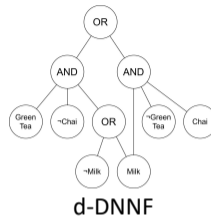
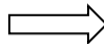
T-Wise Sampling with d-DNNF



Feature Model

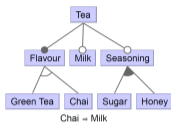


Knowledge
Compiler

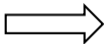


d-DNNF

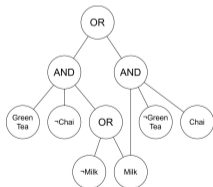
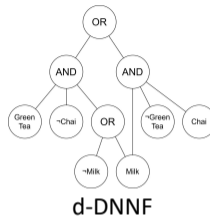
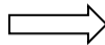
T-Wise Sampling with d-DNNF



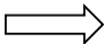
Feature Model



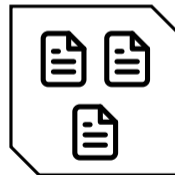
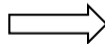
Knowledge
Compiler



d-DNNF



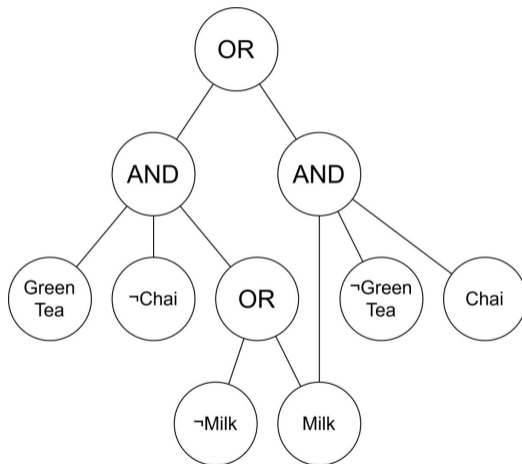
Sampling
Algorithm



Sample with
100% T-Wise Coverage

General Idea

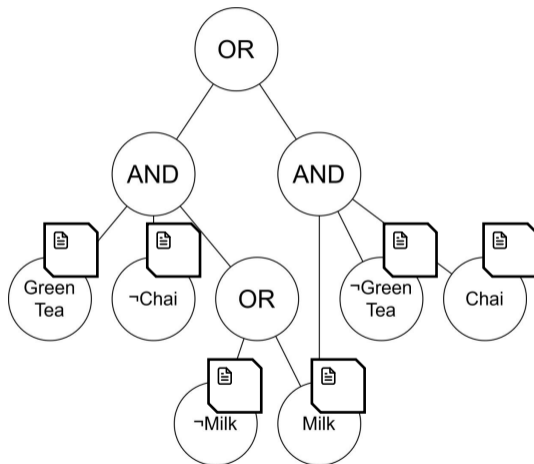
Use bottom-up approach



General Idea

Use bottom-up approach

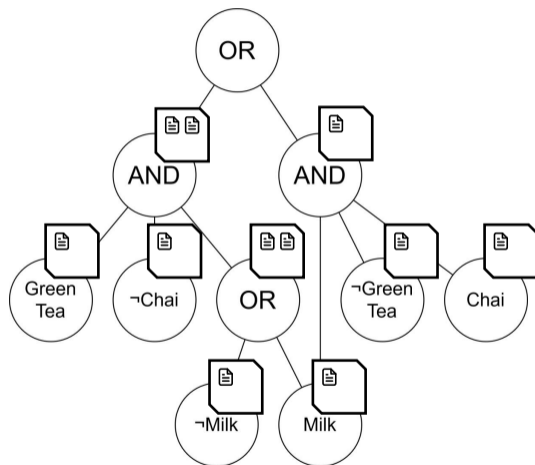
1. Create partial samples at leaf nodes



General Idea

Use bottom-up approach

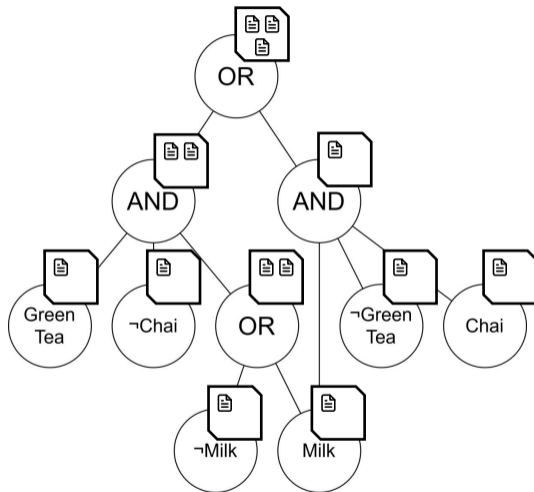
1. Create partial samples at leaf nodes
2. Merge partial samples at parent nodes
3. Extend partial sample for each parent node



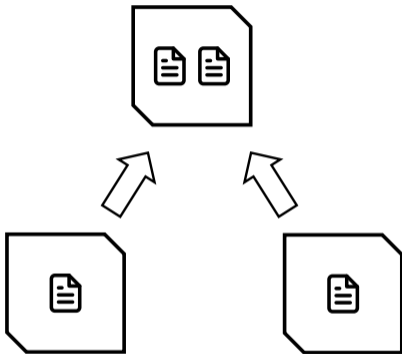
General Idea

Use bottom-up approach

1. Create partial samples at leaf nodes
2. Merge partial samples at parent nodes
3. Extend partial sample for each parent node
4. Repeat 2–3 until root node yields complete t-wise sample



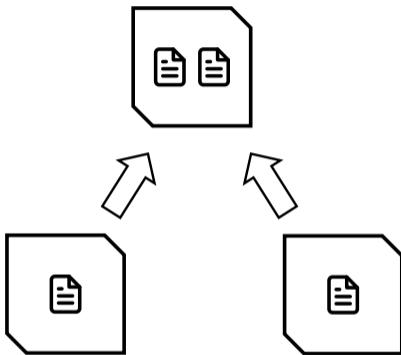
Merging Samples at OR Nodes



Merge:

1. Build union of samples of children

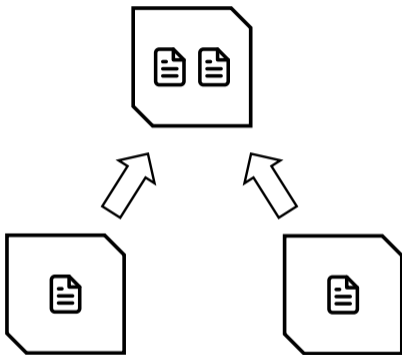
Merging Samples at OR Nodes



Merge:

1. Build union of samples of children
2. Remove redundant configurations
 - Uses greedy approach
 - Sort configurations with a heuristic
 - Add configurations to union sample one by one, ignoring configurations that cover no new tuples

Merging Samples at OR Nodes



Merge:

1. Build union of samples of children
2. Remove redundant configurations
 - Uses greedy approach
 - Sort configurations with a heuristic
 - Add configurations to union sample one by one, ignoring configurations that cover no new tuples

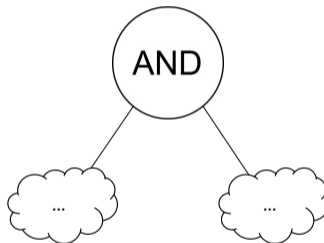
Possible optimizations:

- Better utilization of OR-node property possible?
- Use non-local optimization (Consider nodes higher up in the d-DNNF graph)?

Merging Samples at AND Node

Merge:

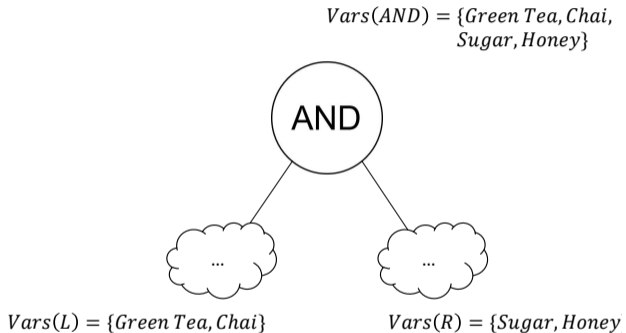
1. Combine configurations in partial samples



Merging Samples at AND Node

Merge:

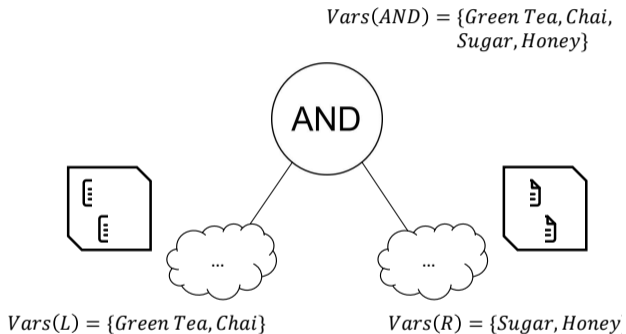
1. Combine configurations in partial samples



Merging Samples at AND Node

Merge:

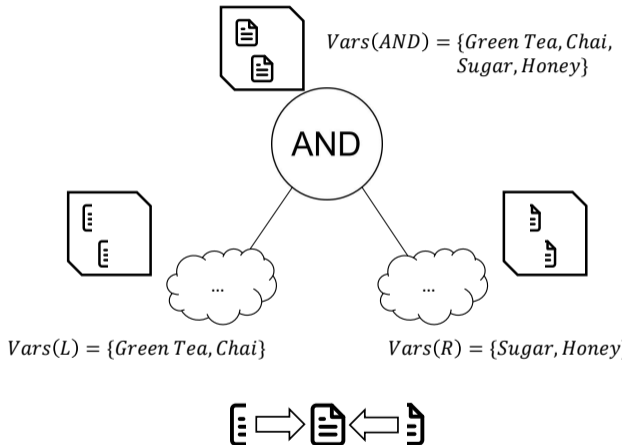
1. Combine configurations in partial samples



Merging Samples at AND Node

Merge:

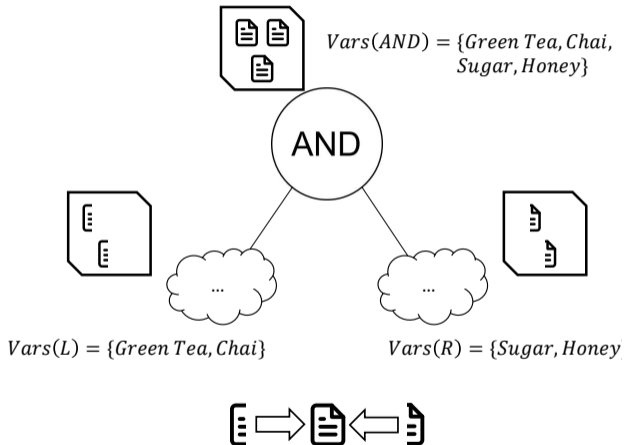
1. Combine configurations in partial samples



Merging Samples at AND Node

Merge:

1. Combine configurations in partial samples
2. Create new configurations for missing tuples



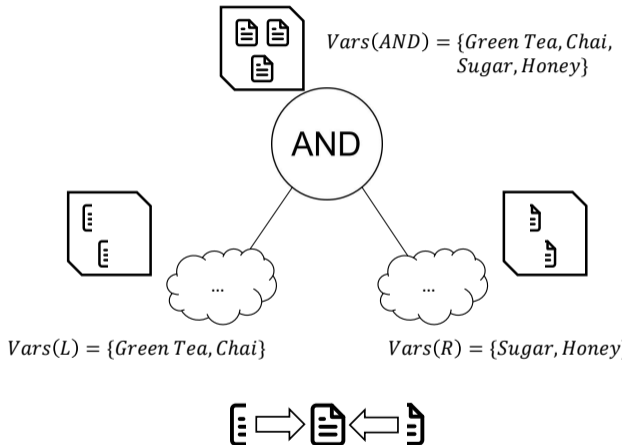
Merging Samples at AND Node

Merge:

1. Combine configurations in partial samples
2. Create new configurations for missing tuples

Possible optimizations:

- Better matching strategy?
- Better strategy for finding new tuples?



Comparison to SAT-Based Sampling

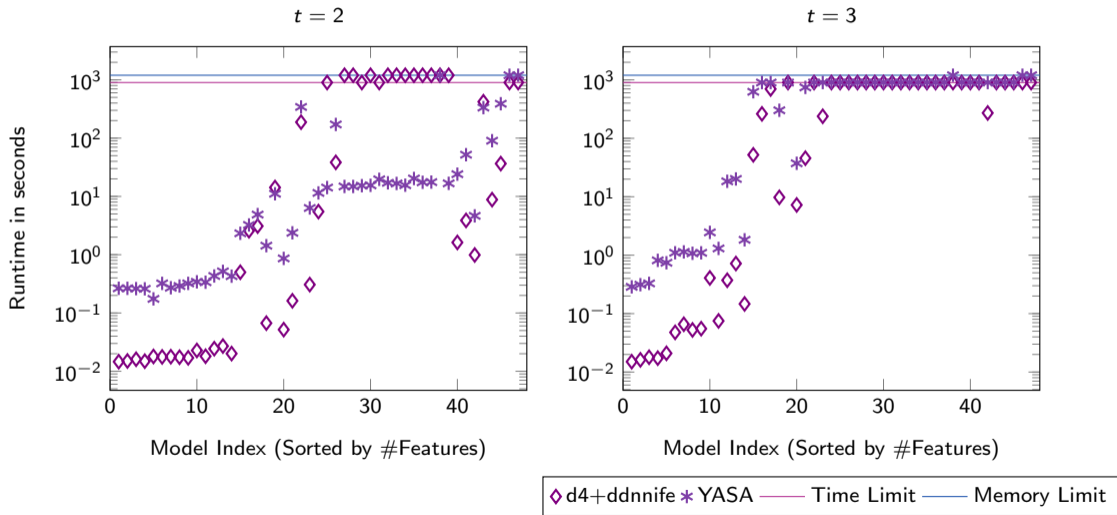
Sampling with $t \in \{2, 3\}$, comparing

- d4 + ddnife
- YASA

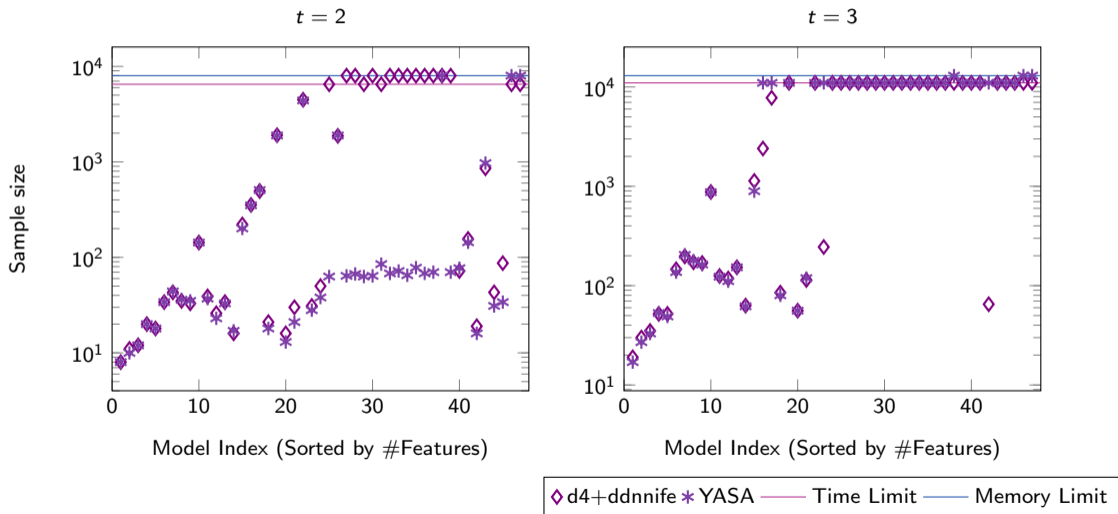
Using 47 different FMs, including

- Automotive01
- Automotive02
- BerkeleyDB
- FinancialServices
- 6 KConfig Systems
- 3 Models from CDL
- 34 Models from Smarch evaluation

Comparison to SAT-Based Sampling (Sampling Time)

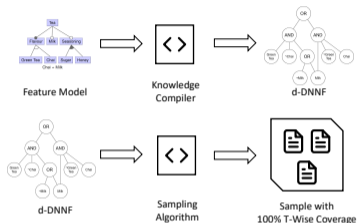


Comparison to SAT-Based Sampling (Sample Size)



Conclusion

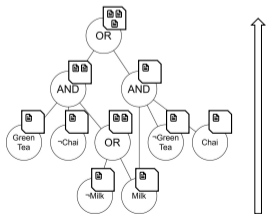
T-Wise Sampling with d-DNNF



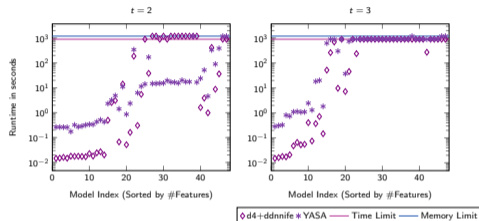
General Idea

Use bottom-up approach

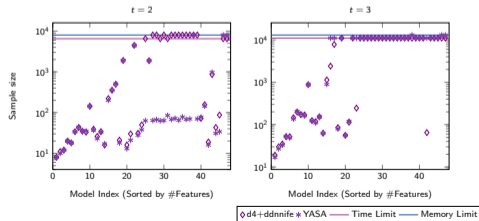
1. Create partial samples at leaf nodes
2. Merge partial samples at parent nodes
3. Extend partial sample for each parent node
4. Repeat 2-3 until root node yields complete t-wise sample



Comparison to SAT-Based Sampling (Sampling Time)



Comparison to SAT-Based Sampling (Sample Size)





1st ReVolution Workshop @ SPLC 2024

- Paper submission: **June 04**
- Paper notification: **June 28**
- Final Version: **July 10**

- Short (≤ 4) and Full Papers (≤ 8 pages)
- Position Paper
- Industrial Challenges and Lessons Learned
- Informal Tool Demos



Sebastian Krieter



Sandra Greiner



Wesley Assuncao



Roberto Herrejon



#re_volution24

<https://sites.google.com/view/re-volution2024/home>