Databases and Software Engineering

Hochschule Harz
Harz University of Applied Sciences

MENSCH | TECHNIK
ORGANISATION | PLANUNG

PCLocator: A Tool Suite to Automatically Identify Configurations for Code Locations

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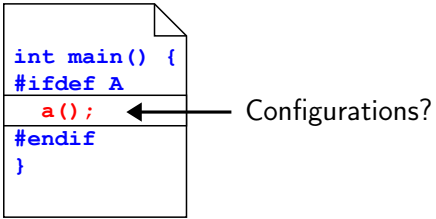
Challenge

The Challenge

Given a specific **program location** in the source code,



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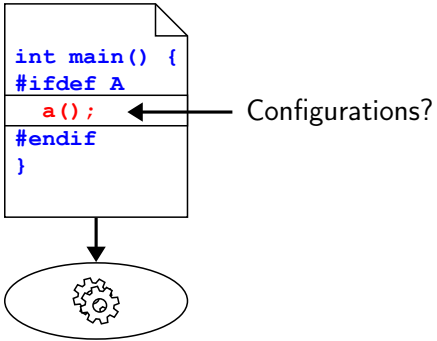

Challenge

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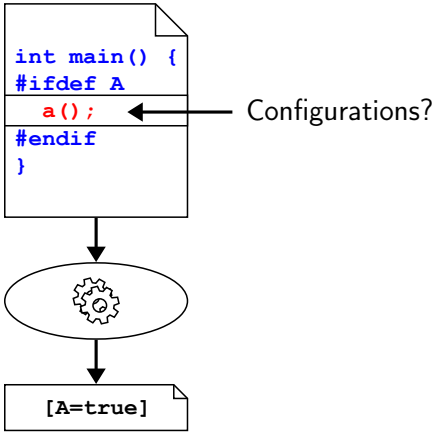
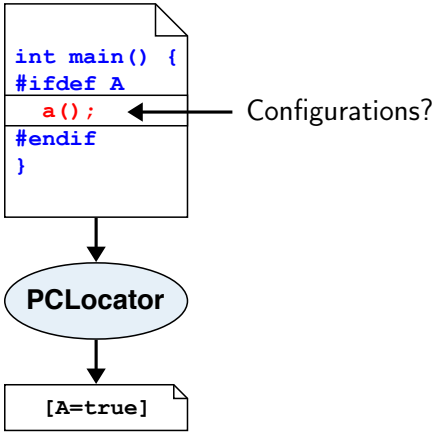
Given a specific **program location** in the source code, can you apply automatic analysis techniques to find **concrete configurations** that include the program location in question?



Challenge

Presence Condition Locator Tool Suite

- Static analysis of C code
- Uses existing tools
- Analyzes preprocessor and build system usage
- Open source, simple usage
- freely available on GitHub



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Under which conditions is a program location included?

Source Code Annotations

- For fine-grained variability
- C preprocessor directives (`#ifdef`)
- Results in propositional formulas (*presence conditions*)

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/* Autodetects gzip/bzip2 formats. fd may
     be in the middle of the file! */
#if ENABLE_FEATURE_SEAMLESS_LZMA \
 || ENABLE_FEATURE_SEAMLESS_BZ2 \
 || ENABLE_FEATURE_SEAMLESS_GZ \
 /* || ENABLE_FEATURE_SEAMLESS_Z */
    extern void setup_unzip_on_fd(int fd);
#else
#define setup_unzip_on_fd(...) ((void)0)
#endif
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lib-y:=
lib-$(CONFIG_ARP)         += arp.o interface.o
lib-$(CONFIG_ARPING)      += arping.o
lib-$(CONFIG_BRCTL)       += brctl.o
lib-$(CONFIG_DNSD)        += dnsd.o
lib-$(CONFIG_ETHER_WAKE)  += ether-wake.o
lib-$(CONFIG_FAKEIDENTD)  += isrv_identd.o isrv.o
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lib-$(CONFIG_FTPGET)      += ftpgetput.o
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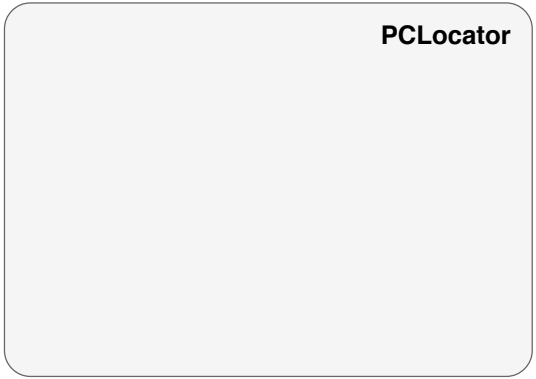

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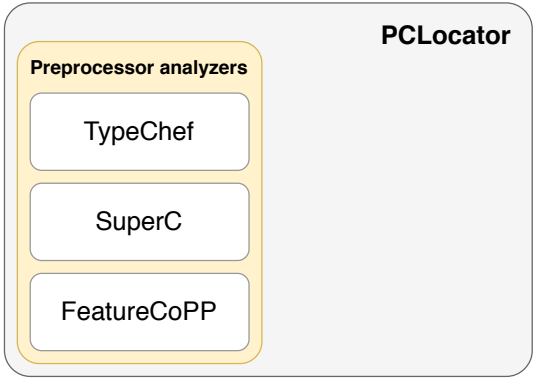

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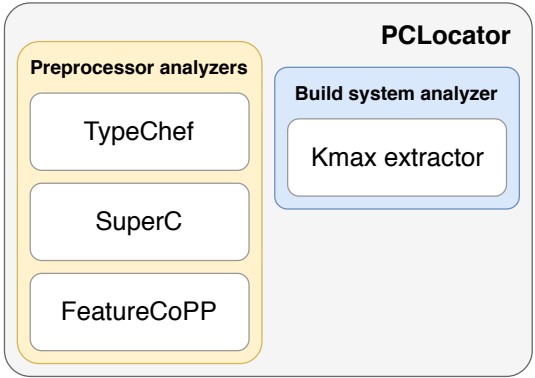

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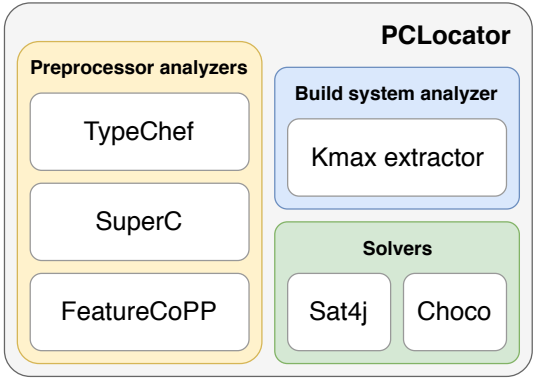

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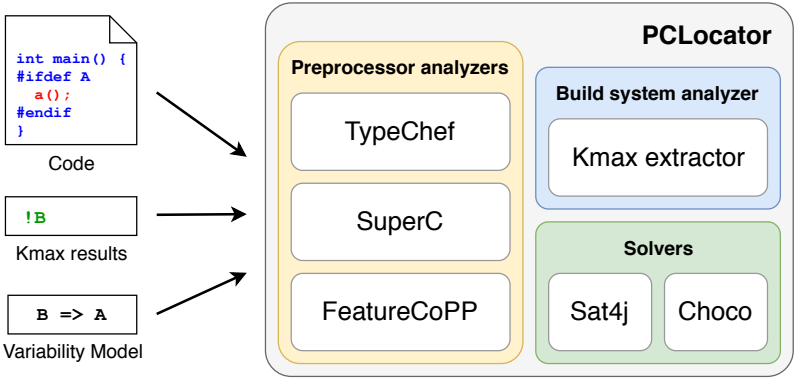
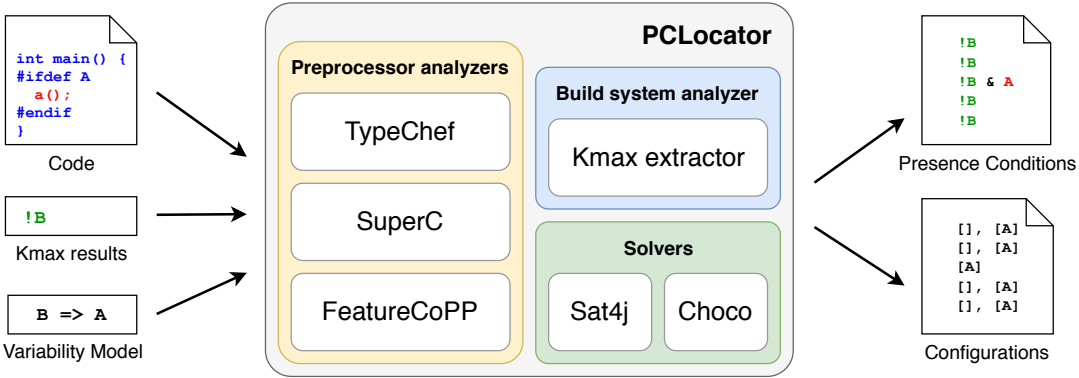


Architecture



Example

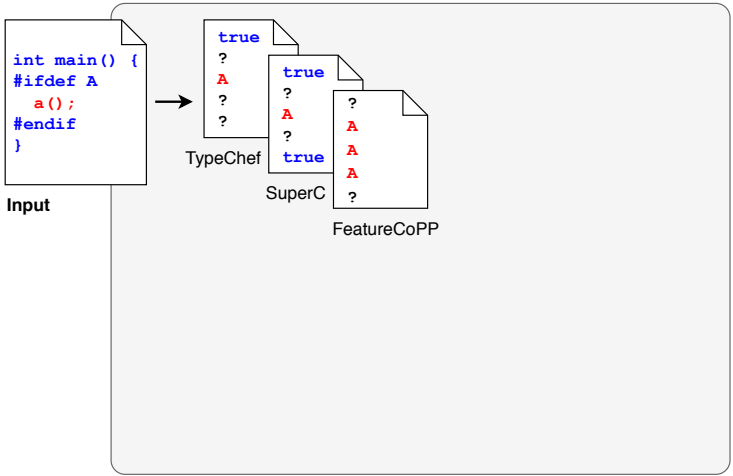
```
int main() {
#ifdef A
  a();
#endif
}
```

Input

Example

Parsing the File

- Parse the file using TypeChef, SuperC and FeatureCoPP
- There are differences between the analyzers



Example

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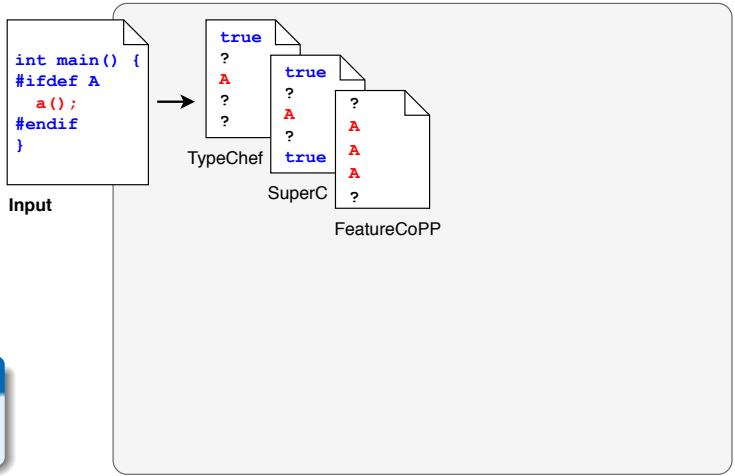
Conditional Token Stream

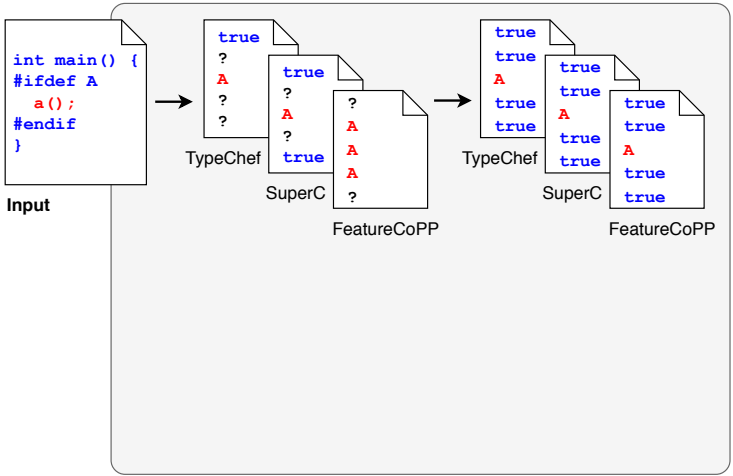
$\texttt{int}_{true}\ \texttt{main}_{true}\ \texttt{a()}_{A}$



Example

Refining the Results

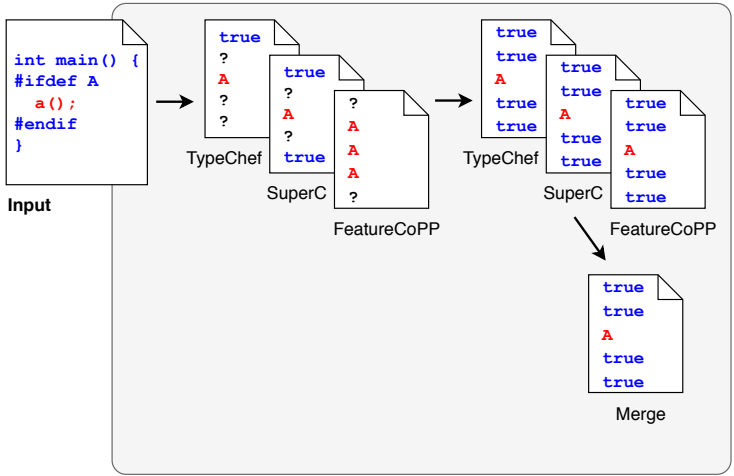
- Deduce missing presence conditions from surrounding lines



Example

Merging the Results

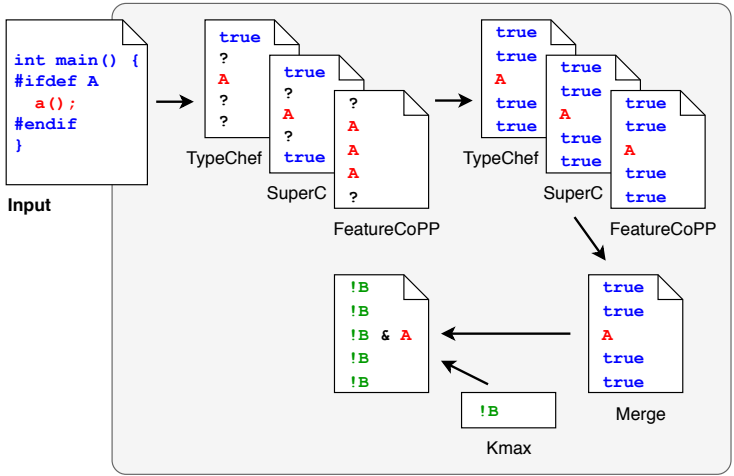
- Choose the "best" presence condition
- TypeChef, SuperC » FeatureCoPP
- Specializations are preferable



Example

Build System analysis

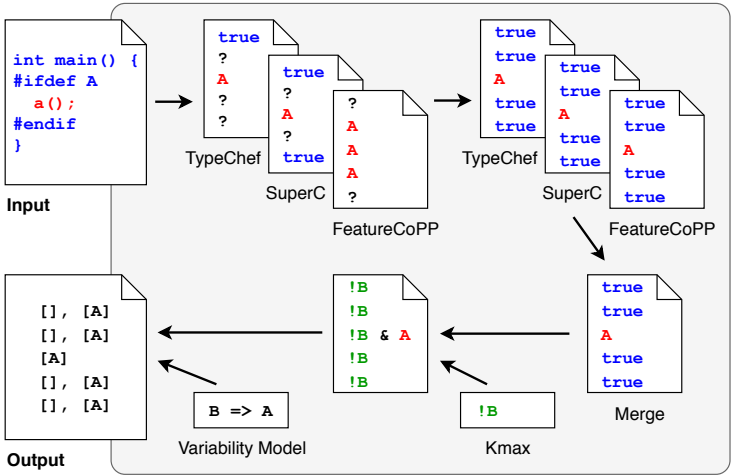
- Consider Kmax results in *Kbuild* projects
- Combine Kmax + Merge presence conditions



Example

Configuration Space

- Call a solver to obtain configurations
- Repeat for more configurations
- Requires a variability model



Evaluation Setup

- Target systems:
  - 56 locations in the *Variability Bugs Database* (VBDb)
  - 120 random locations in the *BusyBox toolkit*

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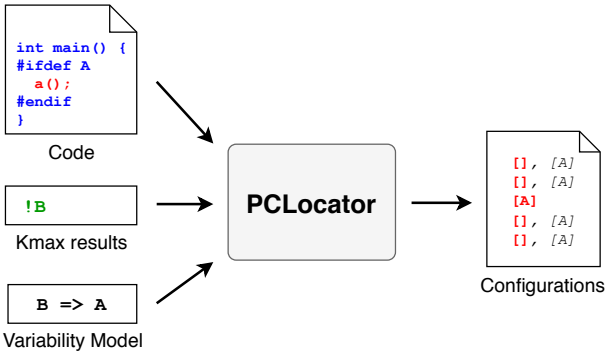
- Measured metrics:
  - Analysis time
  - Correctness

Measuring Correctness



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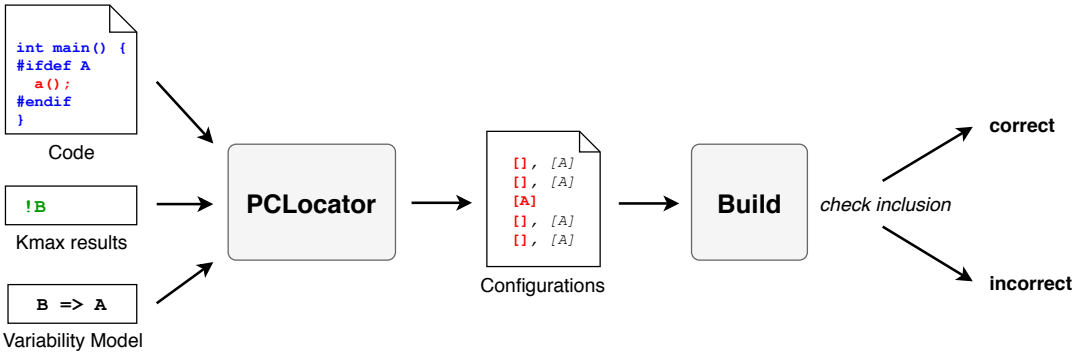
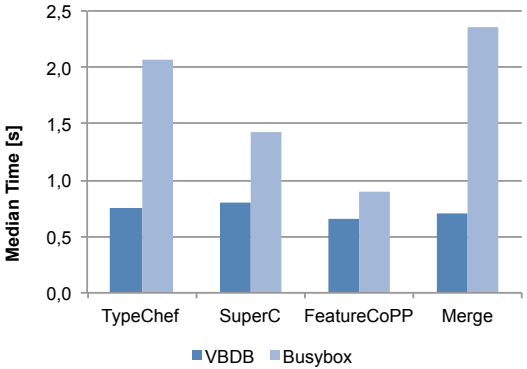
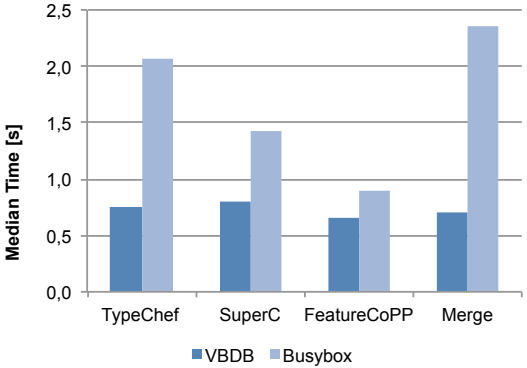


Evaluation


Median Time [s]
2,5
2,0
1,5
1,0
0,5
0,0
TypeChef
SuperC
FeatureCoPP
Merge
VBDB
Busybox

Evaluation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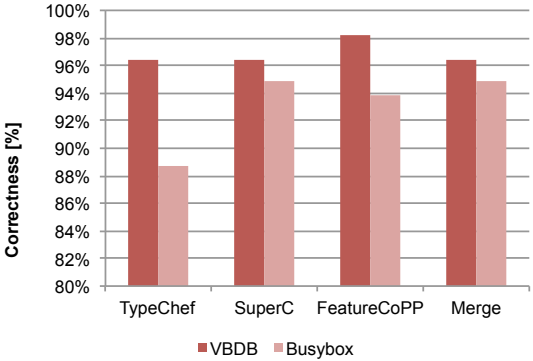
Correctness [%]
100%
98%
96%
94%
92%
90%
88%
86%
84%
82%
80%
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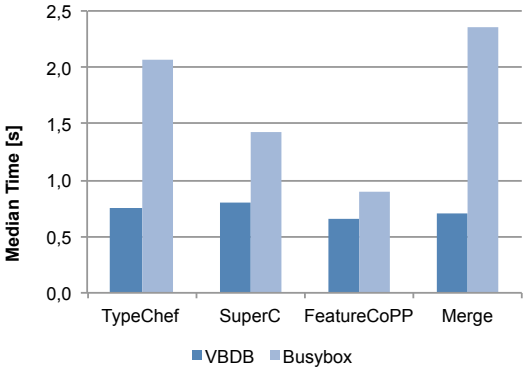
Evaluation


2,5
2,0
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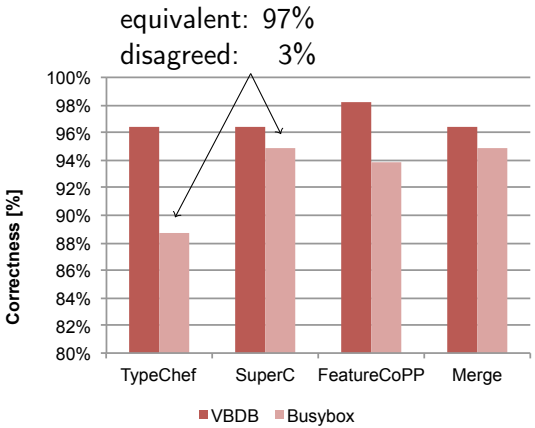
equivalent: 97%
disagreed: 3%
100%
98%
96%
94%
92%
90%
88%
86%
84%
82%
80%
Correctness [%]
TypeChef
SuperC
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Merge
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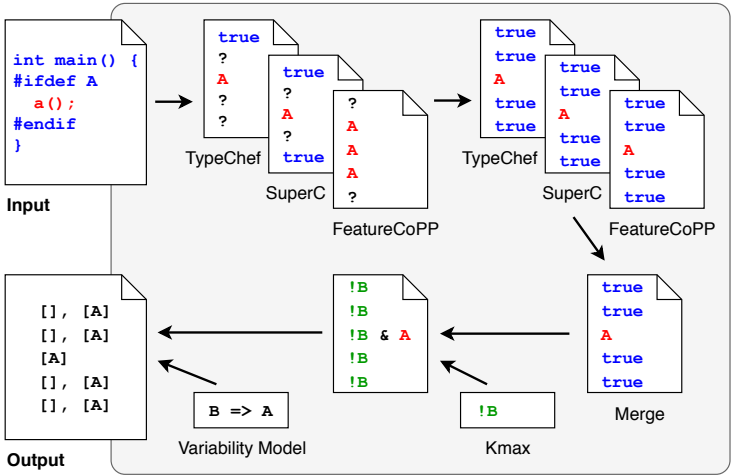
Busybox

Conclusion

PCLocator Tool Suite

- Obtains Configurations for Code Locations
- Quite accurate results in reasonable time
- freely available: **github.com/ekuiter/PCLocator**



Evaluation Results

VBDb: 56 given locations				
	Merge	**TypeChef**	**SuperC**	**FeatureCoPP**
Time (s)	40.01	42.53	44.62	36.52
Median	0.71	0.76	0.80	0.66
Min	0.62	0.63	0.25	0.10
Max	0.83	0.87	0.90	0.77
Correctness	96%	96%	96%	98%
Precision	96%	98%	96%	98%
Recall	100%	98%	100%	100%

Evaluation Results

BusyBox: 120 random locations				
	Merge	**TypeChef**	**SuperC**	**FeatureCoPP**
Time (s)	277.95	244.60	173.12	110.46
Median	2.35	2.07	1.43	0.90
Min	1.28	1.26	1.00	0.78
Max	3.37	2.81	2.11	1.25
Correctness	95%	89%	95%	94%
Precision	95%	96%	95%	94%
Recall	100%	93%	100%	100%