Realizing Implicit Computational Complexity

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mwp-analysis

$\downarrow$

$$\begin{bmatrix} m & p & 0 \\ 0 & m & 0 \\ 0 & 0 & m \end{bmatrix}$$

1. **Input program**: simple, imperative
2. **mwp-Calculus**: inference rules
3. **Matrix**: assigned to commands by the inference rules
4. **Typed flows**: represent variable dependencies in matrix

Neil Jones and Lars Kristiansen. *"A Flow Calculus of mwp-Bounds for Complexity Analysis"*. ACM Trans. Comput. Logic (2009).

mwp-analysis

If derivation succeeds, guarantees that the values computed by an imperative program will be bounded by polynomials in the program's inputs.

Neil Jones and Lars Kristiansen. *"A Flow Calculus of mwp-Bounds for Complexity Analysis"*. ACM Trans. Comput. Logic (2009).

mwp-Analysis: Example

Program

```
loop X3 {
   X2 = X1 + X2;
}
```

$\rightarrow$

Analysis result

	X1	X2	X3
X1	m	p	0
X2	0	m	0
X3	0	p	m

The many properties of *mwp*-analysis

- Multi-variate result
- Language-agnostic, expressive syntax
- Compositional method
- Termination and loop conditions have no impact
- Nondeterministic inference rules
- Derivability problem is NP-complete
- Pen & paper analysis

There were several open questions

- **Powerfulness** – what is the size of the class programs that can be analyzed?
- **Richness** – can it be extended to analyze more commands?
- **Practicality** – can it be used to analyze real-world programs?
- **Utility** – what else can be done with this analysis?

The extended and improved *mwp*-analysis

We defined an *extended* and *improved mwp*-analysis and created a practical implementation.

The extended and improved *mwp*-analysis – highlights

1. Improved by defining **deterministic inference rules**: analysis always completes and can internally handle failure.
2. Extended the syntax richness with support for **function calls**, including recursion.
3. Gained efficiency by **separating computation** into 2 phases: determining if a bound exists and computing its value.
4. Our **tool implementation,** `pymwp`, supports complexity analysis on a subset of C syntax.

Realizing Implicit Computation Complexity

We know ICC offers powerful analysis tools, that can be extended in richness, and made practical.

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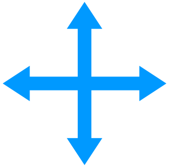
. . . but wait, there is more!

Many other directions are being explored

performance optimization

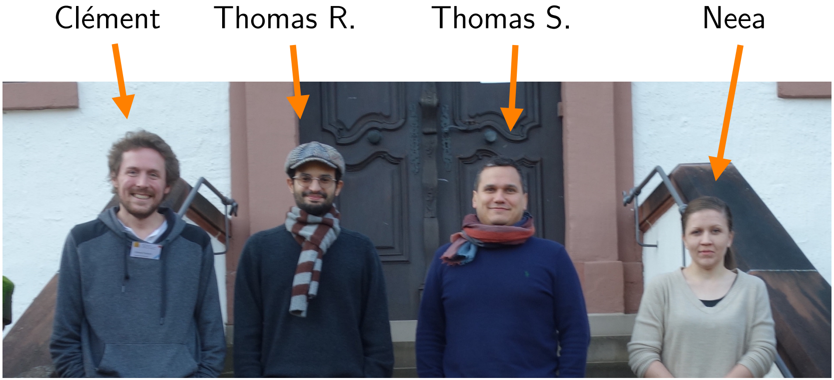
compiler integrations



formal verification

other kinds of ICC analyses

Come talk to us @ TYPES 2022!



Our source code – `pymwp` and more:

`https://github.com/statycc`