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pymwp: A Static Analyzer Determining Polynomial Growth Bounds

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```
void main(int X1, int X2, int x3)
{
    while(X1 < 10){
        X1 = X2 + X3;
    }
    // X1'  X2'  X3'
}
```

For input variables of an imperative program:

Does there exist a polynomially bounded data-flow relation between variables' **initial** values and **final** values?

That is, $\forall n$, is $X_n \rightsquigarrow X'_n$ polynomially bounded?



```
void main(int X1, int X2, int x3)
{
    while(X1 < 10){
        X1 = X2 + X3;
    }

    // X1'   X2'   X3'

}
```

Yes. Here is a bound:

$$X1' \leq \max(X1, X2+X3)$$

$$\wedge X2' \leq X2$$

$$\wedge X3' \leq X3$$

mwp-flow analysis¹

Calculus for resource analysis of imperative programs.

```
while(X1 < 10)
  X1 = X2 + X3
```

0 – no dependency

m – maximal (of linear)

w – weak polynomial

p – polynomial

¹Neil D. Jones and Lars Kristiansen. “A flow calculus of mwp-bounds for complexity analysis”. In: ACM Trans. Comput. Log. 10.4 (Aug. 2009), 28:1–28:41. doi: [10.1145/1555746.1555752](https://doi.org/10.1145/1555746.1555752).

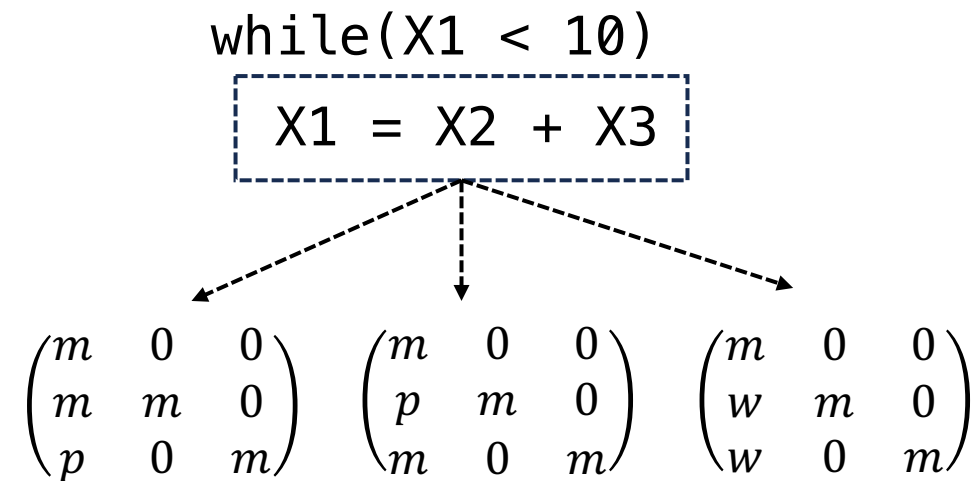
mwp-flow analysis¹

Many nice properties

- Sound syntactic calculus
- Compositional ...

Challenges

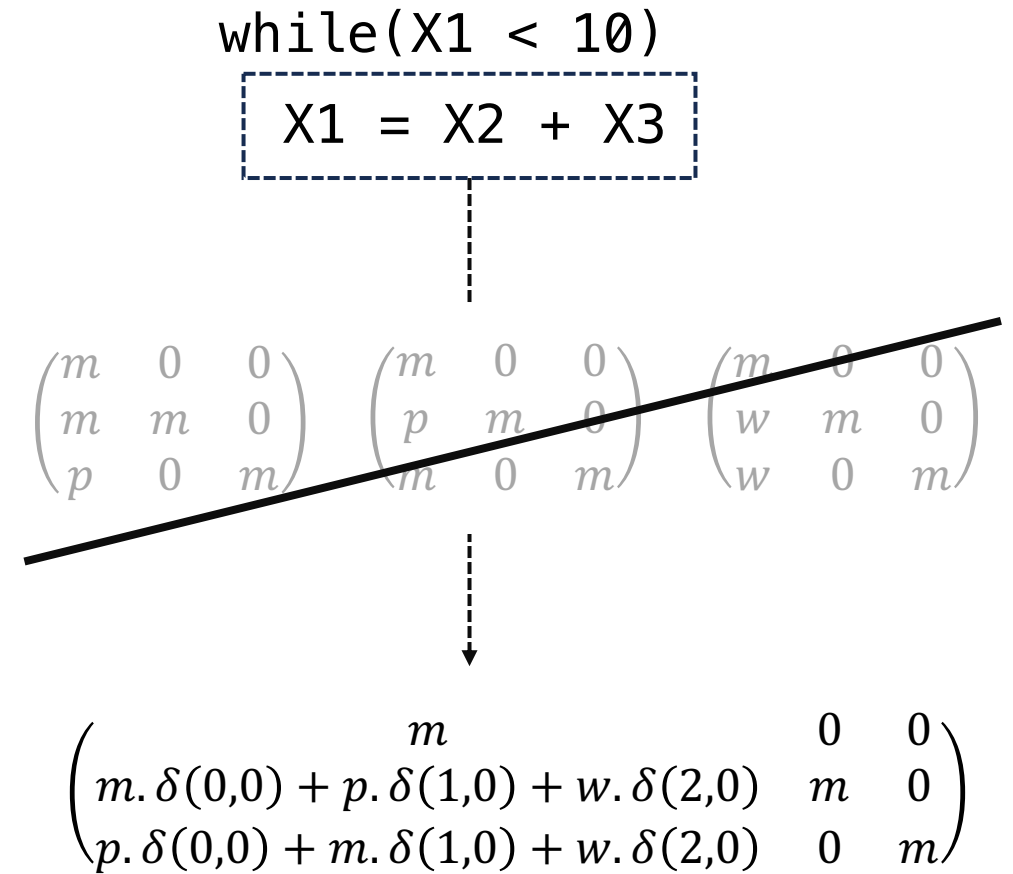
- Non-determinism
- Derivation failure



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Automating mwp

Handling non-determinism



Automating mwp

Handling derivation failure

0 – no dependency

m – maximal (of linear)

w – weak polynomial

p – polynomial

∞ – non-polynomial (failure)

```
while(X1 < 10)
  X1 = X2 + X3
```

$$\begin{pmatrix} m + \infty.\delta(0,0) + \infty.\delta(1,0) & 0 & 0 \\ \infty.\delta(0,0) + \infty.\delta(1,0) + w.\delta(2,0) & m & 0 \\ \infty.\delta(0,0) + \infty.\delta(1,0) + w.\delta(2,0) & 0 & m \end{pmatrix}$$

```
void main(int X1, int X2, int x3)
{
    while(X1 < 10){
        X1 = X2 + X3;
    }

    // X1'   X2'   X3'

}
```

We were here

$$\begin{pmatrix} m + \infty.\delta(0,0) + \infty.\delta(1,0) & 0 & 0 \\ \infty.\delta(0,0) + \infty.\delta(1,0) + w.\delta(2,0) & m & 0 \\ \infty.\delta(0,0) + \infty.\delta(1,0) + w.\delta(2,0) & 0 & m \end{pmatrix}$$

But we *actually* want

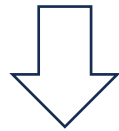
$$\begin{aligned} X1' &\leq \max(X1, X2+X3) \\ \wedge X2' &\leq X2 \quad \wedge X3' \leq X3 \end{aligned}$$

Obtaining bounds compactly and efficiently

$$\begin{pmatrix} m + \infty \cdot \delta(0,0) + \infty \cdot \delta(1,0) & 0 & 0 \\ \infty \cdot \delta(0,0) + \infty \cdot \delta(1,0) + w \cdot \delta(2,0) & m & 0 \\ \infty \cdot \delta(0,0) + \infty \cdot \delta(1,0) + w \cdot \delta(2,0) & 0 & m \end{pmatrix}$$


Find the derivation paths that lead to ∞ , then simplify.

~~$[\{\emptyset, 1, 2\}, \{0, 1, 2\}, \{0, 1, 2\}]$~~



$[\{2\}, \{0, 1, 2\}, \{0, 1, 2\}]$

Build "choice vectors".



```
void main(int X1)
{
    while(X1 < 10){
        X1 = X1 * X1;
    }
}
```

When derivation fails

Problematic flows: $X1 \rightarrow X1$

pymwp is an automatic static analyzer for C code,
to determine if inputs' value growth is polynomially-bounded.

run in terminal



```
pip install pymwp  
  
pymwp file.c [ARGS]
```

run in browser

statycc.github.io/pymwp/demo



source code + docs: **statycc/pymwp**