# VERIFICATION OPTIMIZATION THROUGH GLOBAL COMMON SUBEXPRESSION ELIMINATION

Menezes, R. S., Tihanyi, N. Jain, R., Levin, A., de Freitas, R. Cordeiro, L.

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- https://github.com/esbmc/esbmc

# HOW IT WORKS

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```
1 struct my_ptr {
2   int64_t size : 8;
3   int64_t addr : 56;
4 };
```

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```
 1 int foo() {
 2   struct my_ptr ptr;
 3   if(*) {
 4       ptr.addr = malloc(120);
 5       ptr.size = 120;
 6     }
 7   else {
 8     ptr.addr = malloc(150);
 9     ptr.size = 150;
10   }
11   int64_t my_addr = *((int64_t*)&ptr);
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13   ...
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- We can accelerate it and other operations by applying compiler optimizations.

# EXAMPLE

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1 void write(table *tbl, unsigned EntryIndex) {
2   tbl->Map[EntryIndex].Auxiliary.Flags &= 1;
3   tbl->Map[EntryIndex].Wc++;
4   tbl->Map[EntryIndex].V = 42;
5 }
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- Invoking the `write` function over 1000 entries results in a 160s symbolic execution and memory exhaustion at solving (after 10min).

# EXAMPLE

```
1 void write(table *tbl, unsigned EntryIndex) {
2   entry *pEntry = &(tbl->Map[EntryIndex]);
3   pEntry->Auxiliary.Flags &= 1;
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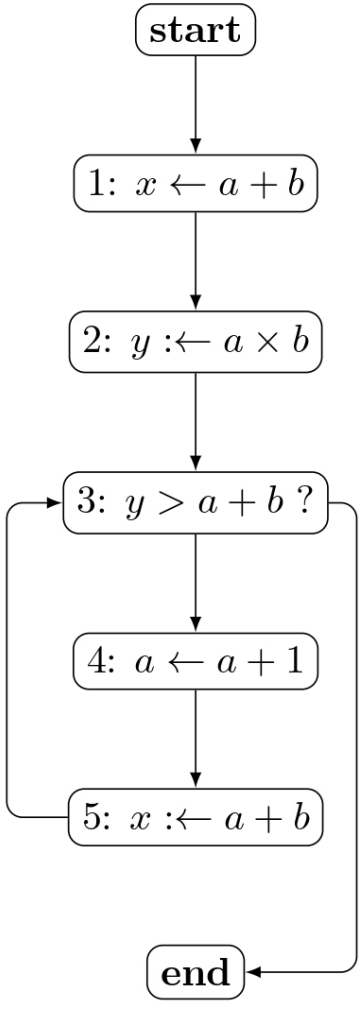
- By constructing an alias the analysis now takes less than 1s.

# AVAILABLE EXPRESSIONS




**Domain:** $\{a + b, a \times b, a + 1\}$

| Vertex | Gen(v) | Kill(v) |
|---|---|---|
| 1 | $\{a + b\}$ | $\emptyset$ |
| 2 | $\{a \times b\}$ | $\emptyset$ |
| 3 | $\{a + b\}$ | $\emptyset$ |
| 4 | $\emptyset$ | $\{a+b, a \times b, a+1\}$ |
| 5 | $\{a + b\}$ | $\emptyset$ |

$$\texttt{In}(v) = \begin{cases} \mathbf{I}, \texttt{v} = \texttt{start} \\ \sqcap_{x \in \texttt{pred}(v)} \texttt{Out}(x) \end{cases}$$

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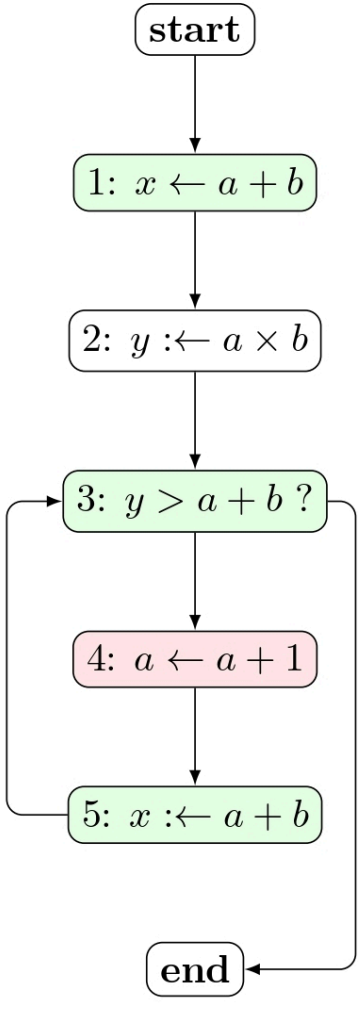


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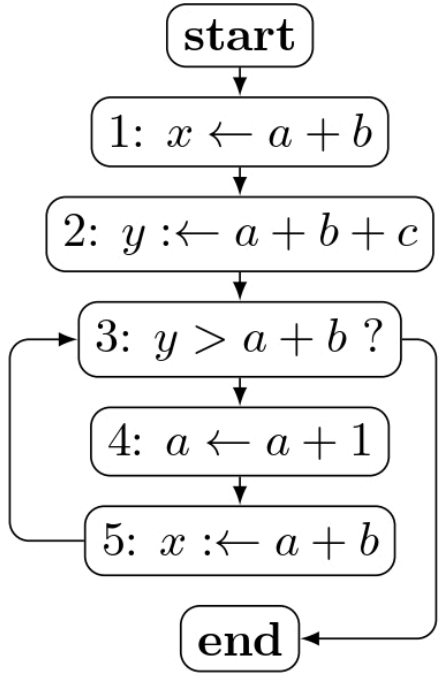
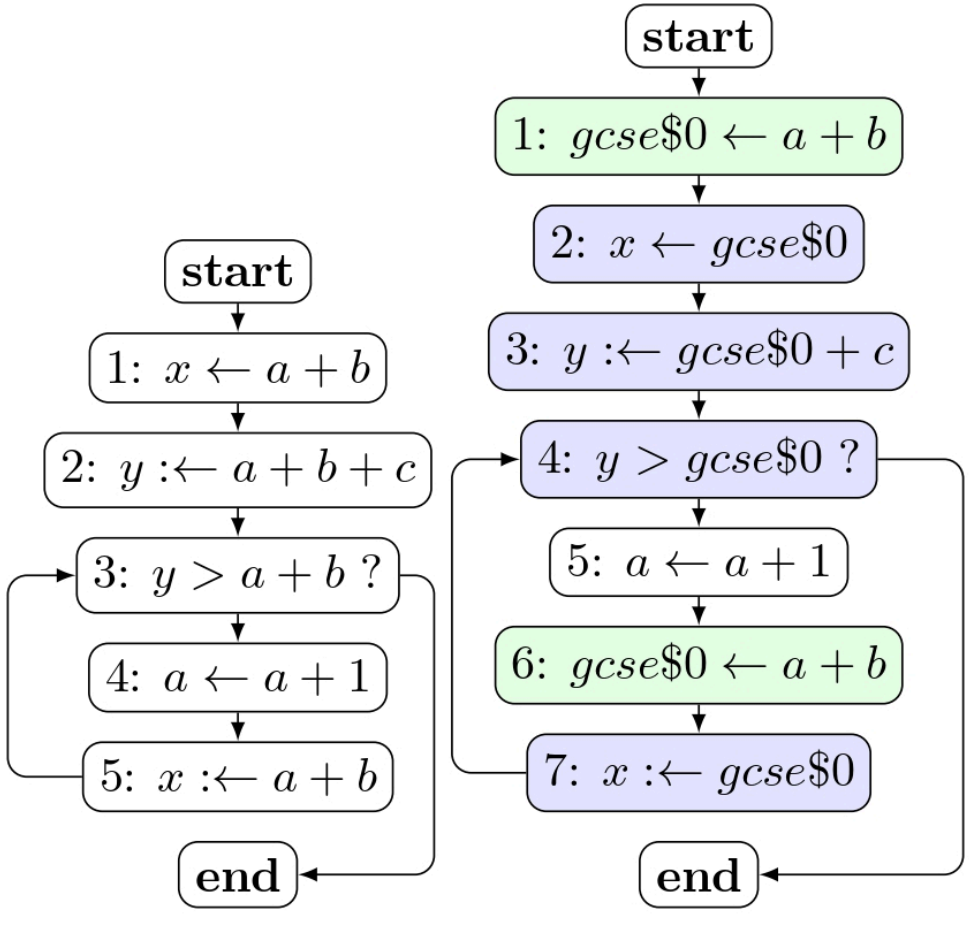
# GCSE


start
1: $x \leftarrow a + b$
2: $y :\leftarrow a + b + c$
3: $y > a + b$ ?
4: $a \leftarrow a + 1$
5: $x :\leftarrow a + b$
end

# GCSE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2: $x \leftarrow gcse\$0$
3: $y :\leftarrow gcse\$0 + c$
4: $y > gcse\$0$ ?
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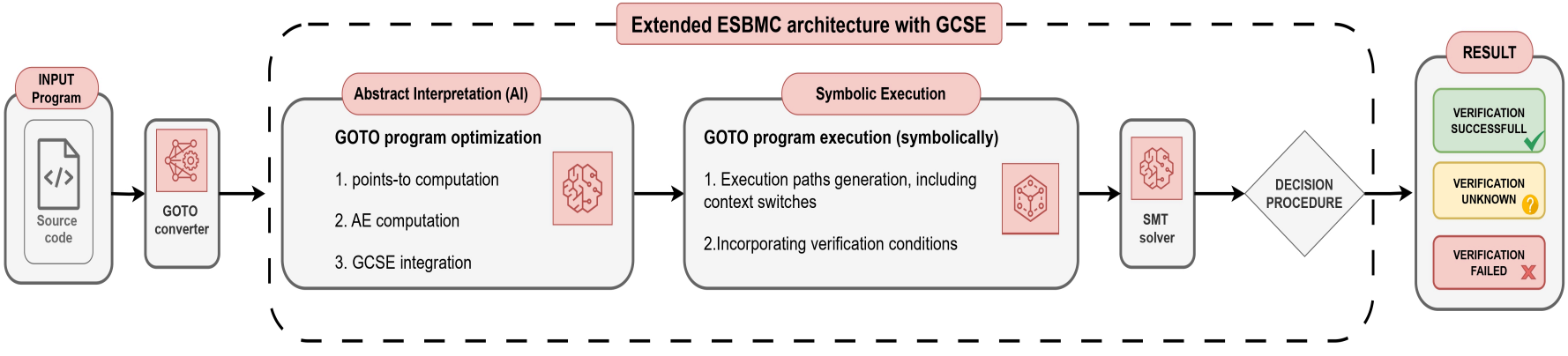
6: $gcse\$0 \leftarrow a + b$
7: $x :\leftarrow gcse\$0$
end

# VO-GCSE


Extended ESBMC architecture with GCSE
INPUT Program
Source code
GOTO converter
Abstract Interpretation (AI)
GOTO program optimization
1. points-to computation
2. AE computation
3. GCSE integration
Symbolic Execution
GOTO program execution (symbolically)
1. Execution paths generation, including context switches
2.Incorporating verification conditions
SMT solver
DECISION PROCEDURE
RESULT
VERIFICATION SUCCESSFULL
VERIFICATION UNKNOWN
VERIFICATION FAILED

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- VO-GCSE delivers significant performance improvements in verification time— up to 52%—in memory-related verification tasks.
- VO-GCSE struggles in categories such as Hardware and ECA. Mainly due to the overhead of the Abstract Interpreter.

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- Improve the points-to analysis.
- Explore other compiler techniques that can be applied to software verification (e.g., loop transformations, strength weakening).

# THANK YOU