

Symbolic Loop Bound Analysis

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Loop Bound Problem

"What is the maximum possible number of cycle iterations?"

Usage:

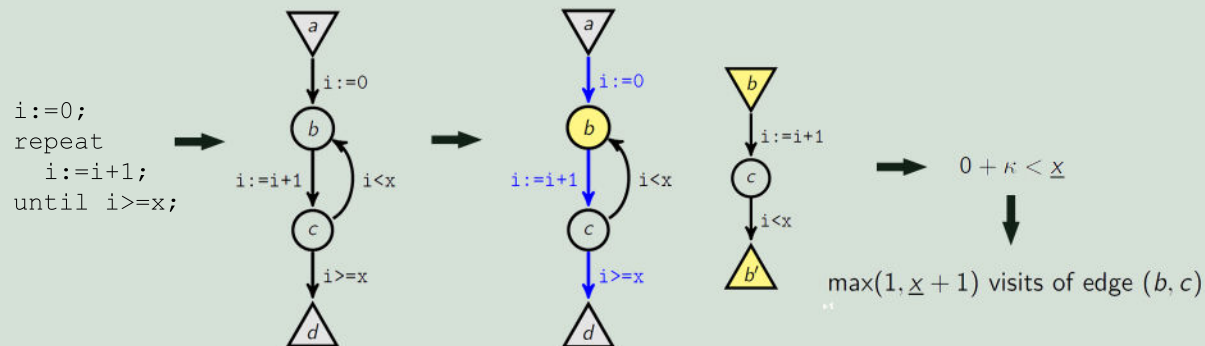
- worst case execution time analysis (real-time systems)
- memory consumption analysis
- model checking, etc.

Formal Problem

Find an upper bound (preferably tight) on the number of visits of a given code location during a single execution.

Symbolic Bound: The bounds are given as functions over the input variable symbols.

Basic Principles of the Solution



- flowgraph representation of programs
- program runs divided into classes according to their "backbones" (acyclic paths from the start to the exit node)
- backbones are executed with symbolic variable values
- flowgraph induced by a loop represents one loop iteration
- induced flowgraphs are treated as new standalone programs
- path counters represent number of iterations along their corresponding loop paths
- the number of visits of a certain edge is derived from equations using the path counters

Results

We introduced a novel approach for loop bound analysis.

Our method was implemented in a prototype tool Loperman.

We evaluated Loperman on 199 benchmarks from the literature and compared it against four other state-of-the-art tools.

Our tool was the 3rd (out of 5) in the number of successfully analysed programs, but it inferred more precise bounds than all the other tools in many cases.

Loperman is the only tool (as far as we know), which gives the precise result for Bubble Sort.

| | Correct Bound | Failed | Time-out | Incorrect Bound |
|-----------|---------------|--------|----------|-----------------|
| Looperman | 104 | 95 | 8 | 0 |
| Loopus | 163 | 36 | 0 | 0 |
| KoAT | 140 | 57 | 22 | 2 |
| PUBS | 85 | 85 | 1 | 29 |
| Rank | 26 | 171 | 0 | 2 |