SCFENCE: Automatic Inference of Memory Order Parameters to Obtain SC Behaviors under C/C++11

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Abstract

1. Introduction

2. Motivating Example

3. Technical

3.1 Inference Rules

Previous work takes advantage of model-checking approach to check whether a specific C/C++11 trace is sequentially consistent. By estabishing edges (*sb*, *rf* and *sc* by implication rules) between atomic operations, it judges whether the trace is SC by whether there exists a cycle in that graph.

Under the C/C++11 memory model, inferring the ordering parameters to obtain SC behaviors is essentially a searching problem. In the absence of consume operations, memory order parameters for atomic operations can be only one of the following: *memory_order_relaxed*, *memory_order_release*, *memory_order_acquire*, *memory_order_acq_rel* and *memory_order_seq_cst*. By enumerating all possible memory order parameters, we can guarantee that we can find out all the possible inference of parameters that ensure SC behaviors for a specific test case. However, this naive approach obviously leads to an exponential searching space.

Consider we start from the case where all memory order parameters are *memory_order_relaxed*. Whenever the model-checking approach finds out a cycle in a specific execution, we have to infer some stronger memory orders to eliminate the cycle. In order to guarantee completeness, we propose a search-based approach combined with patterns to reduce searching space. In Figure 1 , we show a number of common patterns that can exist in cycles. We explain what the weakest orders we should impose on operations to eliminate the corresponding cycle as the following.

Synchronization: This pattern considers

Circular reads-from:

Peterson lock:

Release sequence:

Independent reads & independent writes:

Figure 2 shows the core searching algorithm for all possible parameters.

4. Evaluation

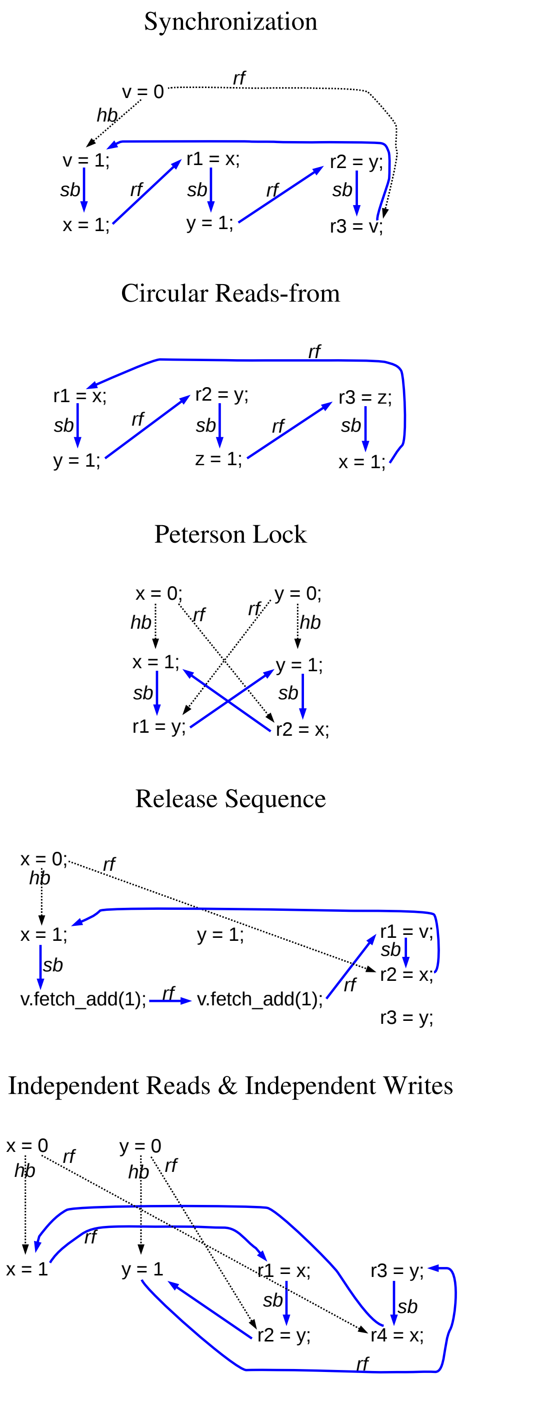
5. Related Work

SC [1]

6. Conclusion

References

[1] L. Lamport. How to make a multiprocessor computer that correctly executes multiprocess programs. *IEEE Transactions on Computers*, 28(9):690–691, Sept. 1979.



Synchronization

Circular Reads-from

Peterson Lock

Release Sequence

Independent Reads & Independent Writes

Figure 1. Cycle Patterns for Non-SC Behaviors

```
function INFERPARAMS
    candidates := {}
    candidate $c1$ := replace all wildcards with *relaxed*
    candidates += $c1$
    results := {}
    while candidates is not empty do
        Candidate $c$ := candidates.pop()
        Model-check with $c$ and yield a cycle $l$
        if $l$ == NULL then
            results += $c$
        else
            STRENGTHENPARAM($l$, $c$, candidates)
        end if
    end while
    return results
end function
procedure STRENGTHENPARAM(cycle, candidate, candidates)
    if $\exists$ a pattern $p$ in $c$ then
        Candidate new := strengthen $c$ by pattern $p$
        candidates += new
    else
        for all wildcard $w$ in $c$ do
            if $w$ can be strengthened then
                Candidate new := strengthen $w$ in $c$
                candidates += new
            end if
        end for
    end if
end procedure
```

Figure 2. Algorithm for Searching All Possible Parameters