



# Many-Core Compiler Fuzzing

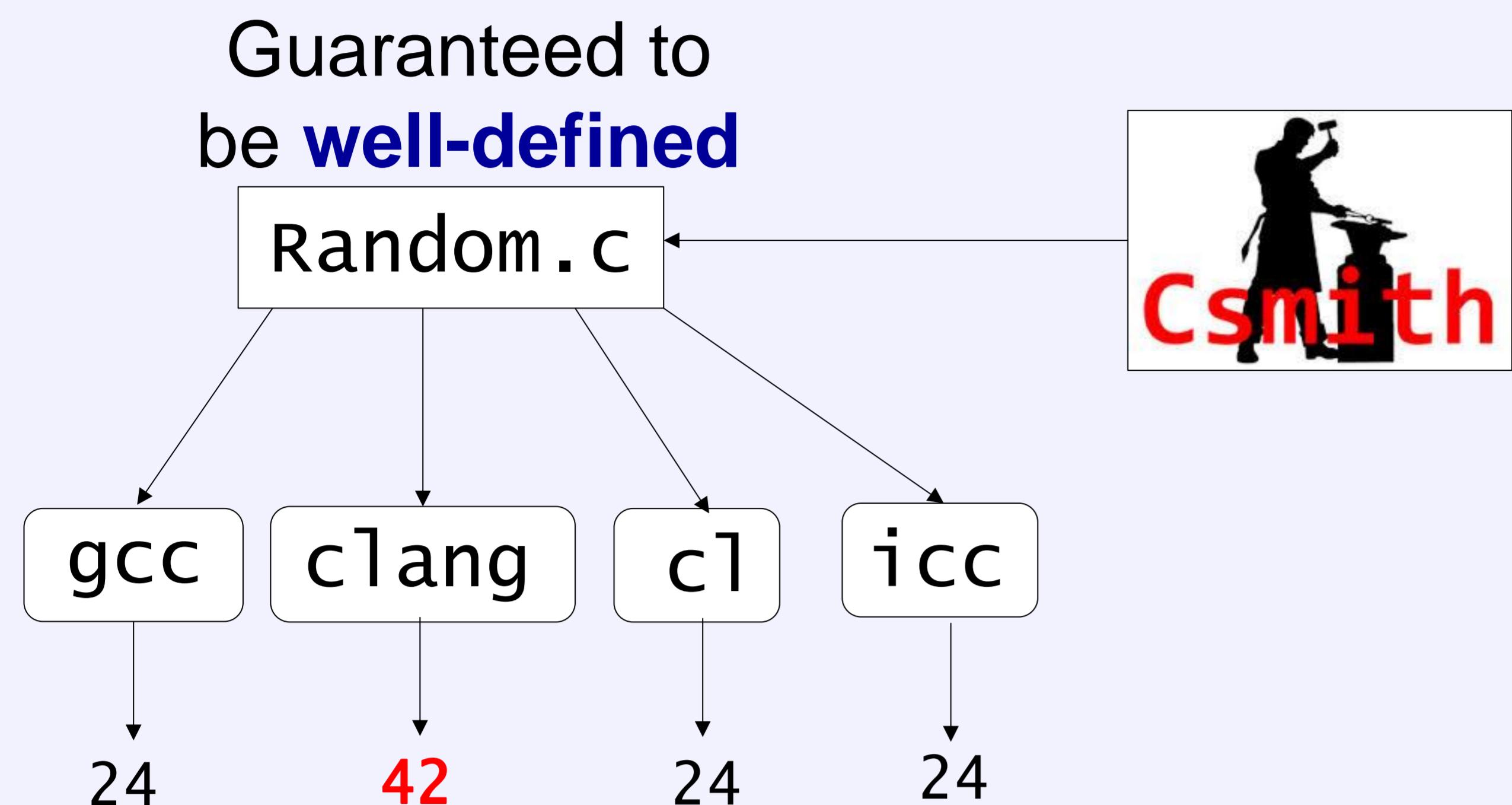
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**Research aim:** validate effectiveness of existing compiler testing methods...

## Random Differential Testing

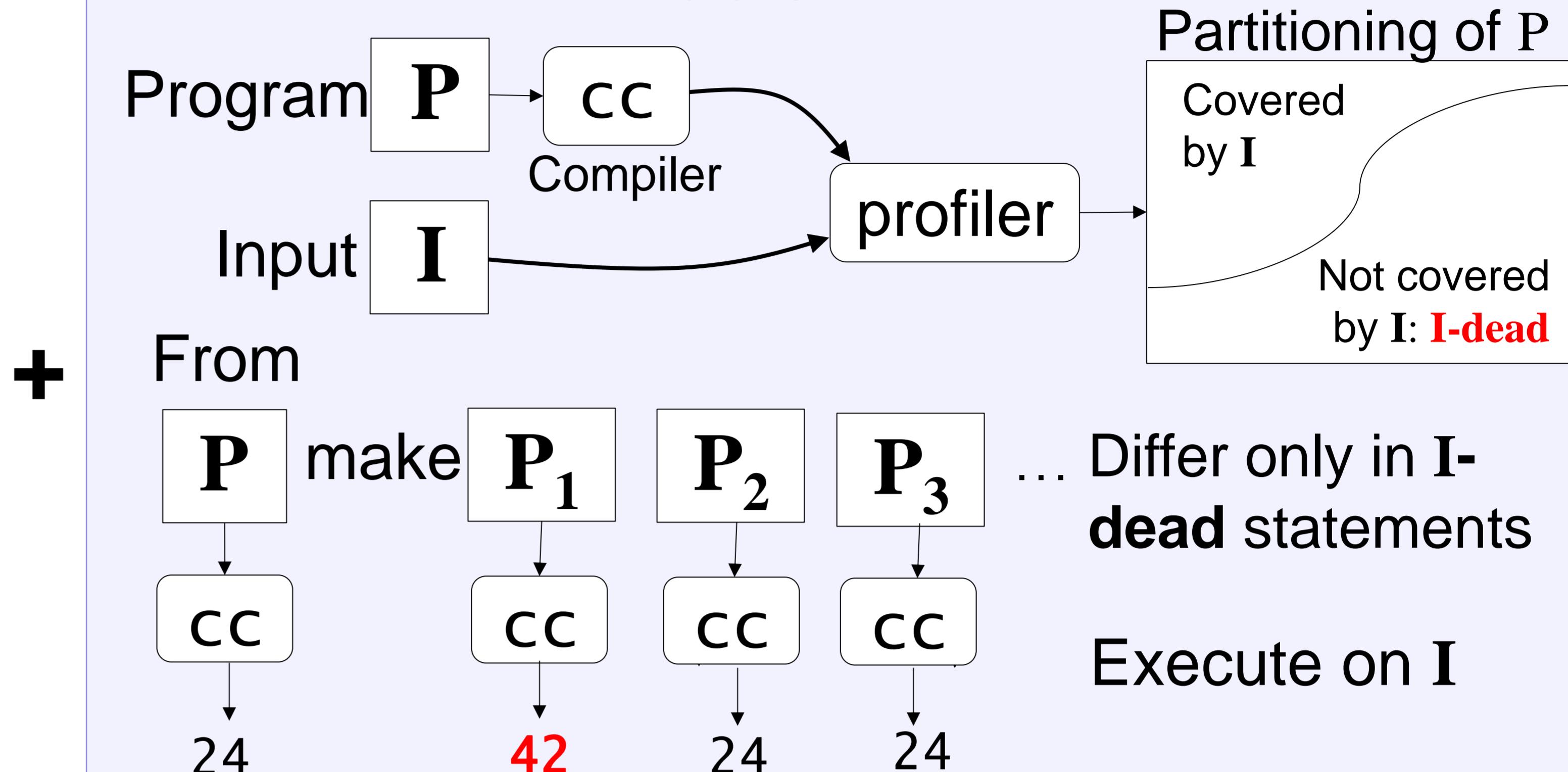
Yang et al. PLDI'11



Cross-check **multiple compilers** on random programs. **Mismatches** indicate **bugs**.

## Equivalence Modulo Inputs Testing

Le et al. PLDI'14



Cross-check **single compiler** using EMI variants. **Mismatches** indicate **bugs**.

...in a many-core domain: **OpenCL**. Our innovations include:

## Generating Random Kernels

Our CLsmith tool generates **concurrent-yet-deterministic** OpenCL kernels

**Vector mode:** exercises **vector operations**

```
uint4 v = clamp(a, b.xyyy, clz(c));
```

**Barrier mode:** orchestrates **race-free** shared memory communication via **barriers**

**Atomic mode:** exercises **read-modify-write** operations in a deterministic way

```
if(atomic_inc(c) == 42) {  
    // Thread-insensitive code  
}
```

Which thread enters: **non-deterministic**

Effect of section: **deterministic**

## Dead-By-Construction Injection

Equip kernel with extra Boolean parameter, **DEAD**  
Inject code conditional on **DEAD**

```
kernel void BFS(bool DEAD, global int *q1, ...){  
    if(get_local_id(0) == 0)  
        *local_q_tail = 0;  
    barrier();  
    if( tid<no_of_nodes)  
    {  
        int pid = q1[tid];  
  
        g_color[pid] = BLACK;  
        int cur_cost = g_cost[pid];  
        struct Node cur_node = g_graph_nodes[pid];  
        for(int i=cur_node.x; i<cur_node.y + cur_node.x; i++)  
    }  
    if(DEAD) {  
        // ARBITRARY code  
    }  
}
```

At runtime, set **DEAD** to **false**

Injected code is **dead by construction**

Enables **EMI testing** without the need to detect I-dead code

Tested 21 OpenCL (device, compiler) combinations; major vendors + open source



Results show that RDT and EMI are **effective** in this domain

More than 50 distinct bugs found, many now **fixed** by vendors

**Test programs and full results:** [multicore.doc.ic.ac.uk/tools/CLsmith](http://multicore.doc.ic.ac.uk/tools/CLsmith)

Thanks to support from:

