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Verification of Industry Code : Challenges

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Overview

- Focus of talk
  - Scalability problems in industry code
  - Ideas we are exploring
- Formal verification @ TRDDC
  - Apply academic ideas to address quality related problems
    - Experiments and tools
  - Adapt as required
    - Scale up
    - Specific solutions
- Based on experiences with embedded software

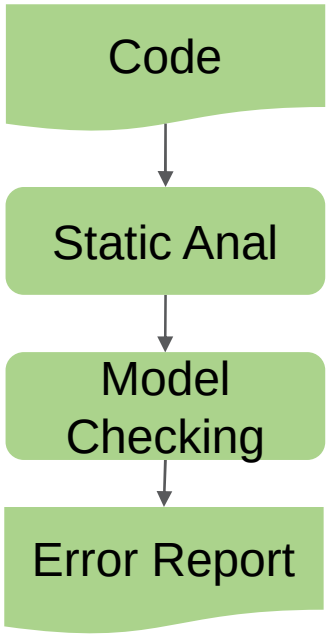
Context

- Finding bugs early in software
- Model based development
  - Matlab Simulink
  - Statecharts
  - Code
    - Generated and hand written
- Analysis and Testing
  - Most bugs can be found

Experience

Code Analysis

- Standard + other properties
  - Zero division
  - Correct use of semaphores
- Dataflow analysis + model checking
  - Variable ranges from static analysis
- Precision is the key challenge
  - Model checking does not scale up



Code Characteristics

Application	Size	Key Characteristics	FPS(ZD)
Infotainment	2MLOC (1 task)	Large, large arrays(512), loops(unknown bounds)	77
Smart card component	7K	Loops with large bounds and unknown bounds	55
Several	Upto 36K	-	0

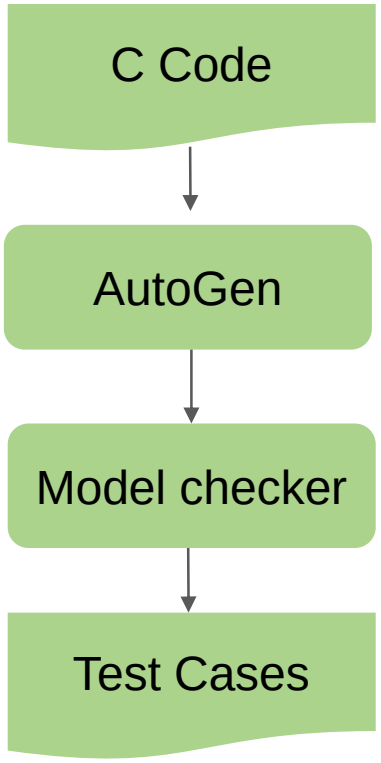
```
j = nondet() * 2;

for ( ; j < 512; j += 2)
        assert( j + 1 < 512);
```

```
t = nondet_long();
while((t / sec_366) > 0)
{
    if( y % 4)   t -= sec_365;
     else t -= sec_366;
    y++ ;
}
…
assert (m < 12 );
```

Test Generation

- Code coverage
  - Modified Decision Condition Coverage
- Very similar to property checking
  - Most states will be reachable
  - High coverage needed
  - False positives not an issue
- Scaling up is the key challenge



Code Characteristics

- Driver assist + odometer cluster
- Generated code
- Recursive code
- Nested loops
- Counters + floating operations

```
while ( j++ <= 31 && !l)
    for (i = 0; i <= 31; i++)
            if (*)
                f(a[i]);
                l = i;

 while c(a[l],  a[l + 1] )
    l++;
```

```
while ( *)
    recursion
    <counters>++;
    assert (counter < k );
```

Current Ideas being Explored

Loop Abstraction

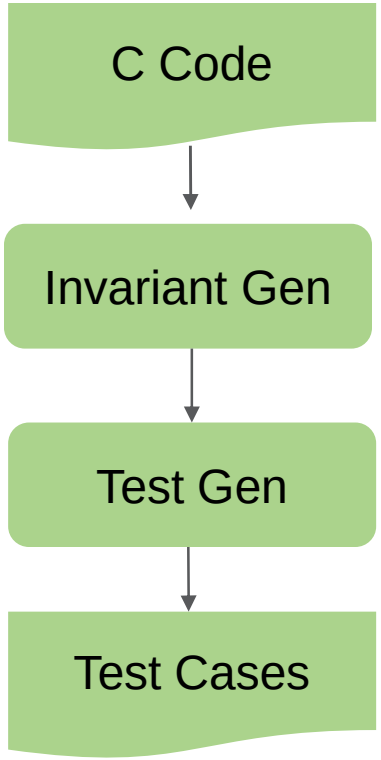
- Replace loops by small bounded loops
- One execution of body
  - Each distinct path
  - Distinct output variable
- Recurrence relations
  - Linear
- Naïve refinement

```
while (*)
        o_n = f(<io>);
```

```
for ( i in 1..n )
        k = *;
        <io> = */recur(k);
        o_n = f(<io>);
```

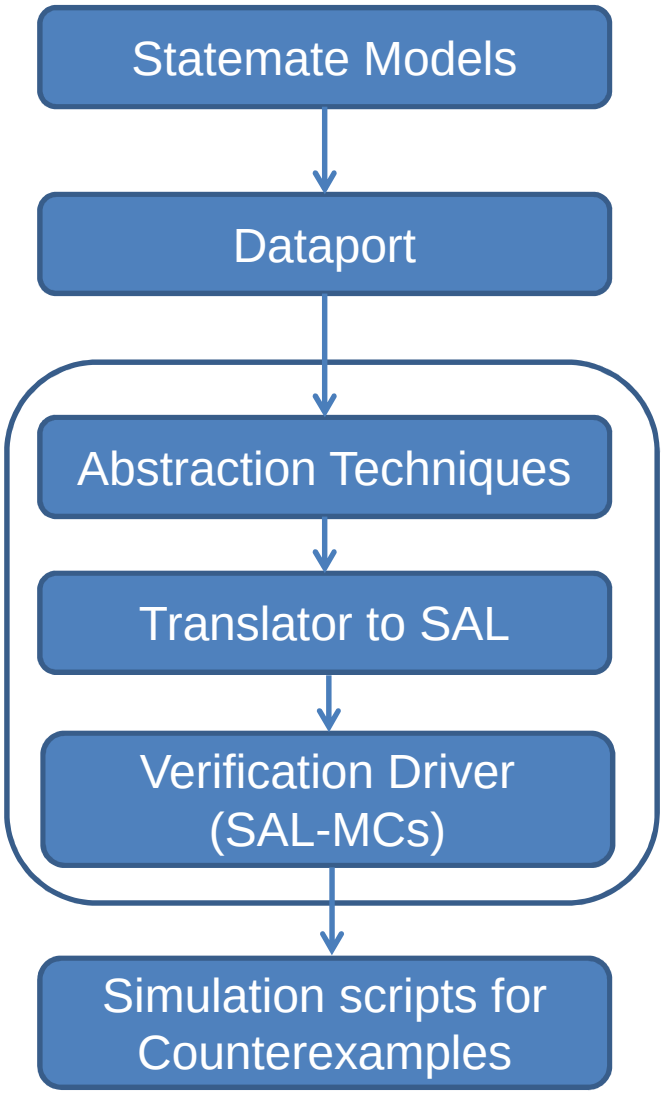
Guessing Invariants : Daikon

- Generate random traces
- Guess invariants
  - Daikon
  - Template based
- Replace complex code by invariants
- Works well in practice



Statecharts Analysis

- Size
  - Per statechart
    - ~ 5 states, ~ 6-7 transitions
    - Translates to ~200 lines of C code
  - ~ 500 statecharts, composed in parallel
- Real valued clock variables, ~ 1-2 per statechart
- Very long paths to reach some states
  - A fourth of the states did not reach in depth 50
- loops in each statechart



Summary

- Success
  - Scales up well to several thousand lines
  - Found several bugs
    - Production code
    - Medical, smart card, auto …
- Limitations
  - Scalability
    - ECUs of millions of lines of code
    - Financial software much bigger
  - Distributed systems
    - Multiple ECUs
- Need order of magnitude scale up
  - Compositional, heuristics