R-Verify: Deep Checking of Embedded Code

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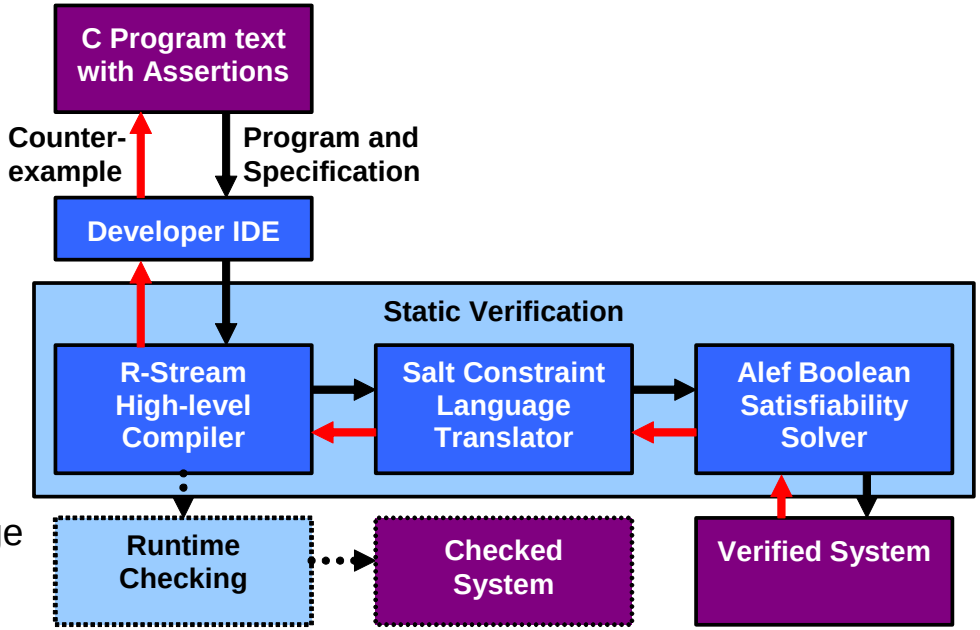
LOCKHEED MARTIN

R-Verify Design

Usable

- Simplifies software development process
  - Find bugs earlier (debugging)
  - Static identification of bug patterns (regression testing)
  - Verify entire application with components (integration testing)
- Integrates with existing workflows
- Visual counter-example presentation
- Extensible to any domain
- Verification expertise not required
  - No new language to learn
  - Properties written in source language



Powerful

- SAT based model checking technology
  - Modeling and deep semantic checking of complex systems
  - Aggressively optimized search
- Works with any programming style

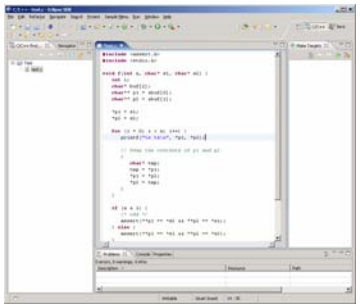
Scalable

- Uses reasonable time and space
- Applies abstraction and refinement

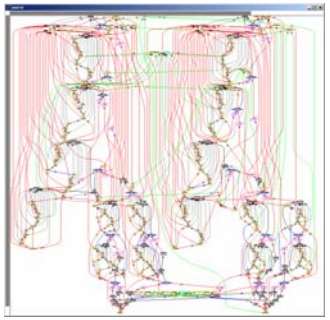
R-Verify Supports:

- **Pre- and post-condition** checking including documented **VSIPL rules**
- **Memory safety** of embedded device drivers, **interrupt handlers**, and **VSIPL "admitted" blocks**
- **Numerical precision** of arithmetic pipelines with an emphasis on **VSIPL pipeline** implementations

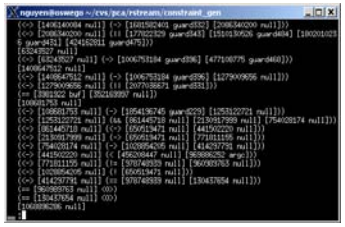
R-Verify Deep Checking Cycle



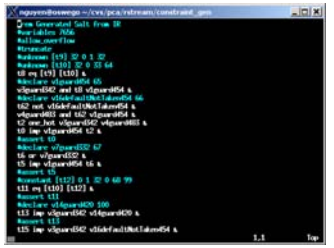
Developer IDE



R-Stream IR

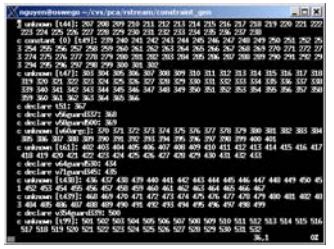


Constraint Encoding



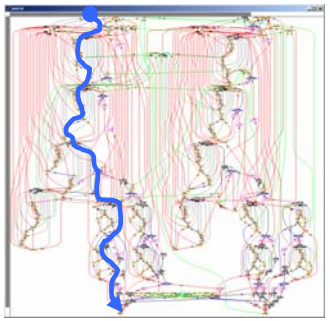
Salt

Development/Verification Cycle

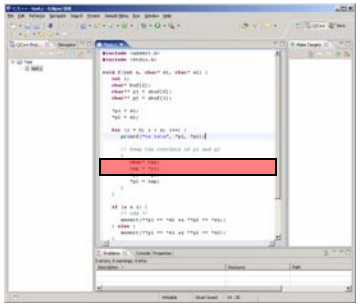


Alef Input

Alef Solution



Execution Trace



Program Error

Built on Existing Reservoir Labs Technologies

- **R-Stream 3.0**
  - Can plug into existing development environments such as Eclipse
  - Industry-standard C front end
  - Parses source code and generates intermediate representation (IR)
  - Robust toolkit of compiler algorithms
    - Infer known loop bounds
    - Unroll loops and inline entire function calls
  - Supports classical optimizations
    - Constraint propagation
    - Dead code elimination
    - Partial subexpression elimination
    - Many more
  - Integrated IR visualization and reflection tools to aid reporting
  - Rich library of useful analyses and representations
    - Points-to analysis
    - Reachability analysis
    - Program dependency graphs
    - Augmented post-dominator tree

- **Salt 1.5**
  - Constraint intermediate language
    - Easy to target
  - Optimizes constraint representations
  - Supports logical, pseudo-Boolean, fixed point arithmetic and set constraints
  - Extensible to other constraint logics

- **Alef SAT Solver**
  - Parallel satisfiability solver
  - Targets large problem sizes
  - Improved performance by exploiting data and cooperative search parallelism

By basing R-Verify on mature, robust technologies we were able to:

- ***Manage Risk***
- ***Reduce development time, cost***
- ***Focus on applications and usability rather than technology***