Formal Methods Group ETH Zürich

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Vision

Formal method tools are used like **compilers:**

In the context of (formal)

1. verification.
2. synthesis.
3. analysis.

Overview

1. Model Checking, SAT, and QBF.
2. Translation of liveness into safety.
3. High-level data races.
4. Replaying of multi-threaded executions.
5. Equivalence checking of SDL vs C.

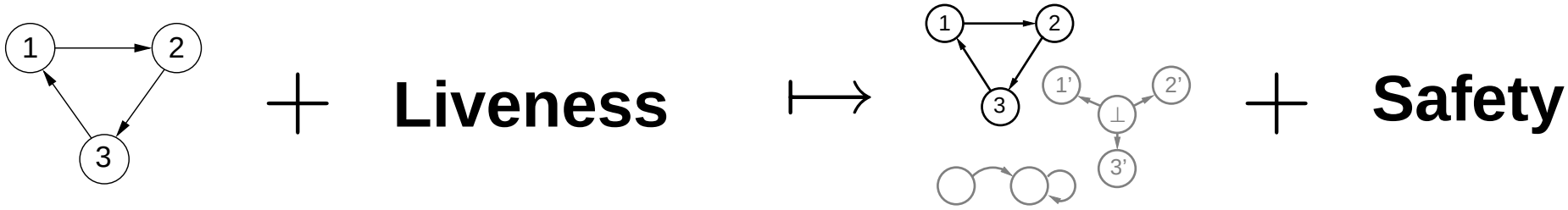
Model Checking

- BDD based mu-calculus model checker mu-cke
  - Efficient implementation.
  - Input language with C++ syntax for specifying model and properties.
- Performance study of BDD based model checking
- Bounded Model Checking
  - Leverages power of SAT solvers for model checking purposes.
  - Wide industrial acceptance.

SAT and QBF

- SAT (propositional satisfiability solvers)
  - **Continuing** increase in reasoning power.
  - Instances with million of variables can often be handled.
  - Dedicated heuristics for bounded model checking possible.
- Solvers for QBF (quantified boolean formula), e.g., $\forall x \exists y \left[(\bar{x} \vee y) \wedge (x \vee \bar{y})\right]$
  - Start to become practical ...
  - ... although more practical research necessary (efficient implementations).
  - Potentially allow to make bounded model checking complete.
- Applications of QBF and SAT in other domains (e.g., SW checking).

Translating Liveness into Safety: Finite State Systems

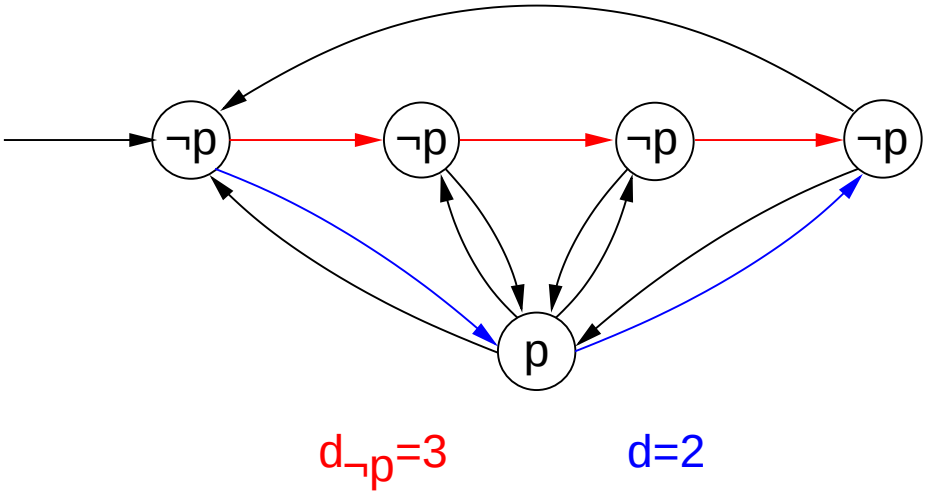


If the number of states is finite:

1. A system with a liveness property can be transformed into a system with an equivalent safety property.

2. The transformed system can be model-checked **efficiently**.

Translating Liveness into Safety: Predicated Radius/Diameter

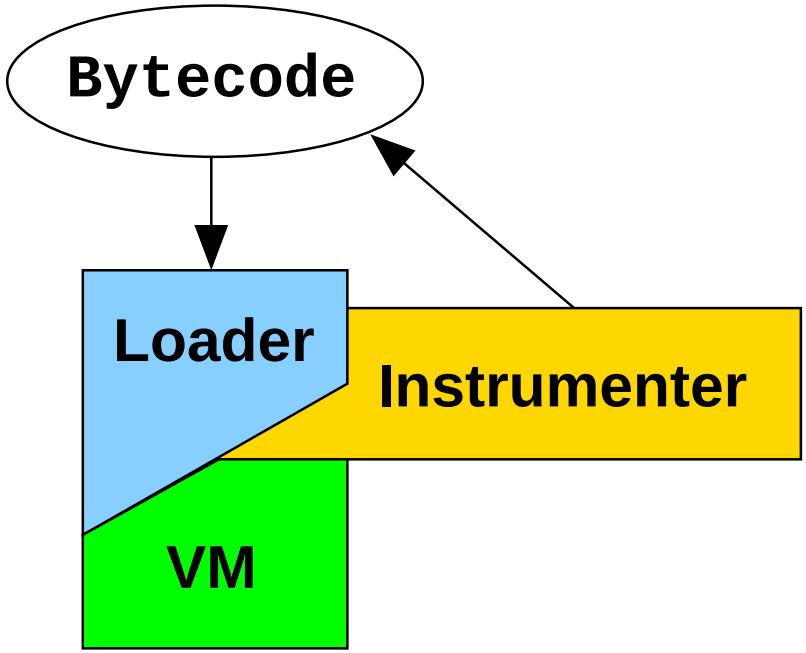


Bounds stated at FMICS'02 require further restrictions:

- Search for counterexample traverses paths where $\neg p$ holds.
- Notion of predicated radius and diameter.
- Leads to tight bound for bounded model checking of $\mathbf{F}p$.

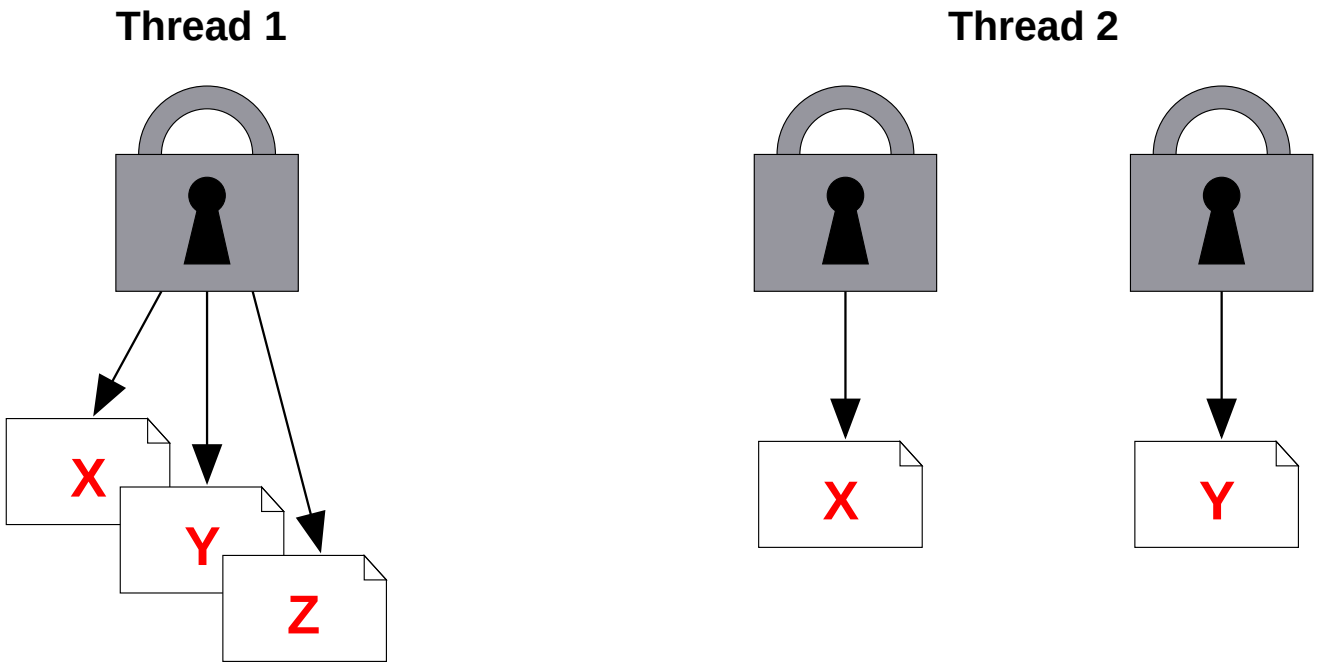
JNuke: Our own Java Virtual Machine

Platform for static and dynamic analysis



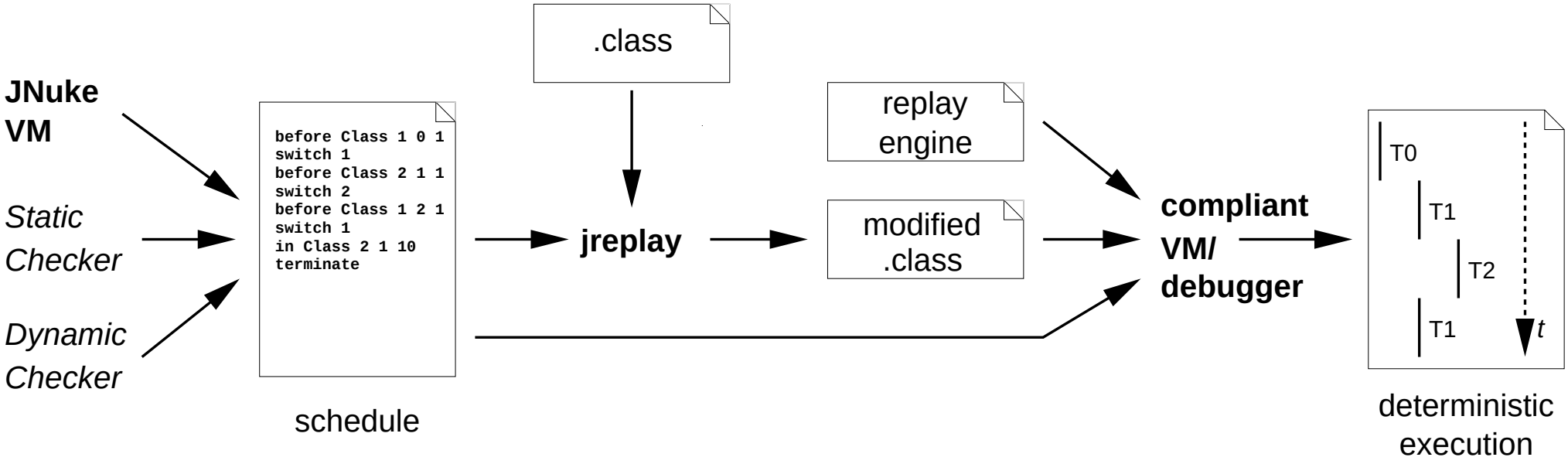
- Java VM written in C.
- API for run-time analysis.
- Small state representation.
- Rollback (undo) operations.
- “Exhaustive” scheduling possible (Rivet).
- Instrumentation: reproducing counterexamples.

JNuke: High-level data race analysis



- Both accesses are protected by a common lock (Eraser).
- Different atomicity assumptions by the two threads.
- New source of potential errors, found by **view consistency**.

JNuke: Replay of Multi-Threaded Executions

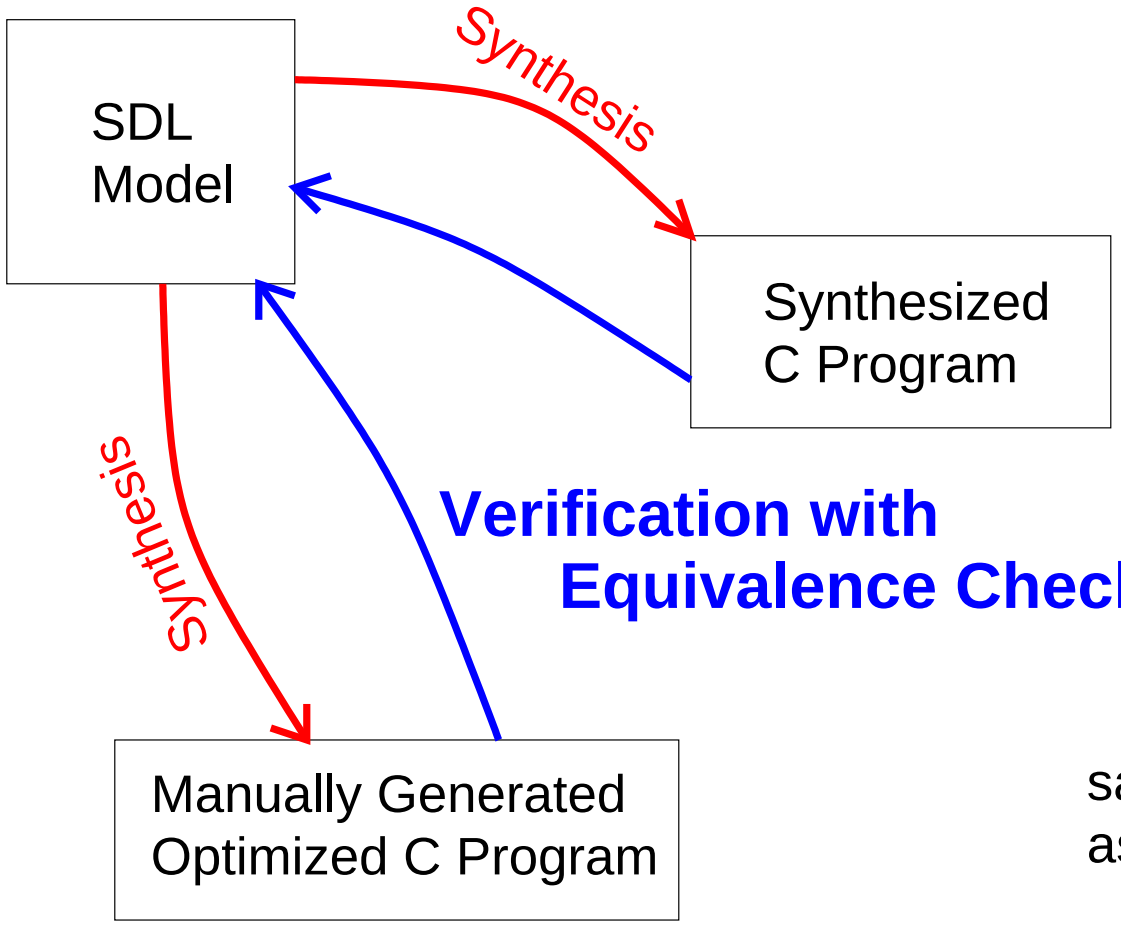


- Enables replay of thread schedules independently of specific VM.
  → Off-the-shelf debuggers.

- Schedule format not tailored to JNuke VM.
  → Usable by other tools.

Equivalence Checking SDL vs C

SDL as modelling language in telecommunication applications
(or more general for embedded SW)



same motivation
as in HW equivalence checking

Establishing formal methods

Short-term:

Scalability, light-weight process.

Long-term:

Formal loop: Formal methods on all levels.