

# THETA: Various Approaches for Concurrent Program Verification (Competition Contribution)

*Csanád Telbisz, Levente Bajczi, Dániel Szekeres,  
András Vörös*



**Critical Systems  
Research Group**

# Original Theta Approach

# Original Theta Approach

- **CEGAR**: counterexample-guided abstraction refinement
  - Different **abstract domains**, **refinement** strategies

# Original Theta Approach

- **CEGAR**: counterexample-guided abstraction refinement
  - Different **abstract domains**, **refinement** strategies
- Concurrency:
  - **Abstraction-aware Partial Order Reduction** (POR)
  - **On-the-fly cone-of-influence** (COI)

# Original Theta Approach

- **CEGAR**: counterexample-guided abstraction refinement
  - Different **abstract domains**, **refinement** strategies
- Concurrency:
  - **Abstraction-aware Partial Order Reduction** (POR)
  - **On-the-fly cone-of-influence** (COI)
- Interprocedural verification
  - **Stack abstraction**

# Original Theta Approach

- **CEGAR**: counterexample-guided abstraction refinement
  - Different **abstract domains**, **refinement** strategies
- Concurrency:
  - **Abstraction-aware Partial Order Reduction** (POR)
  - **On-the-fly cone-of-influence** (COI)
- Interprocedural verification
  - **Stack abstraction**

See SPIN Thursday  
afternoon session

# New approach

# New approach

- Bounded Model Checking (BMC) for handling concurrency



# New approach

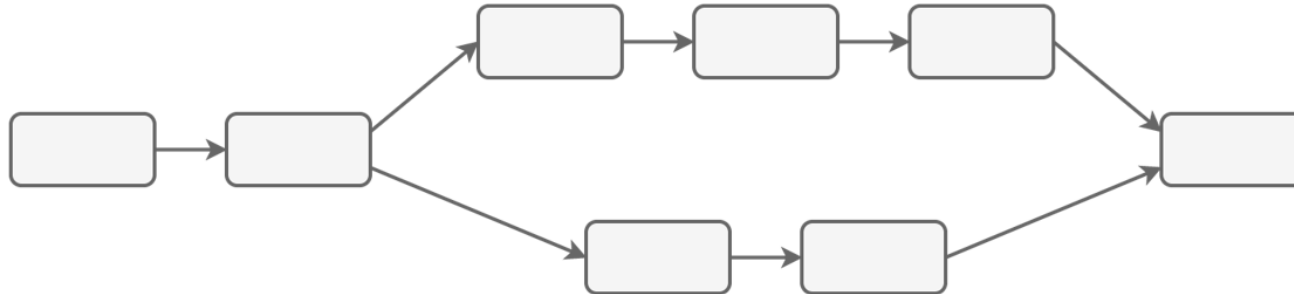
- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)

# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Key idea:
  - Build a **happens-before relation**  
(program order + dataflow + axioms)

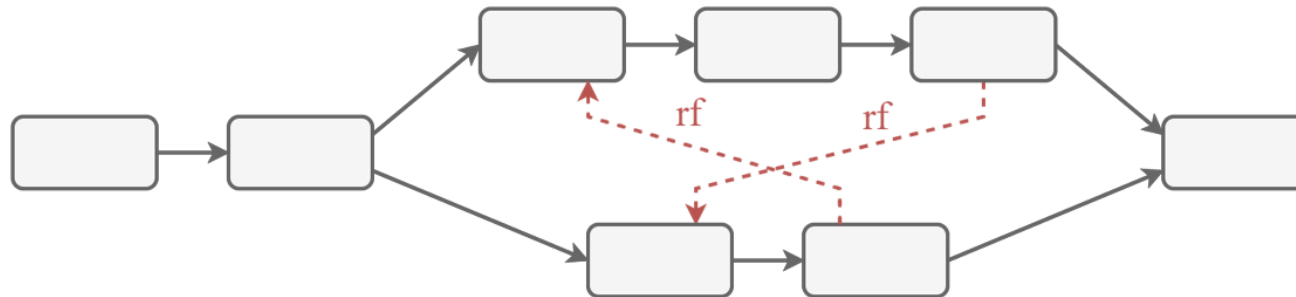
# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Key idea:
  - Build a **happens-before relation**  
(program order + dataflow + axioms)



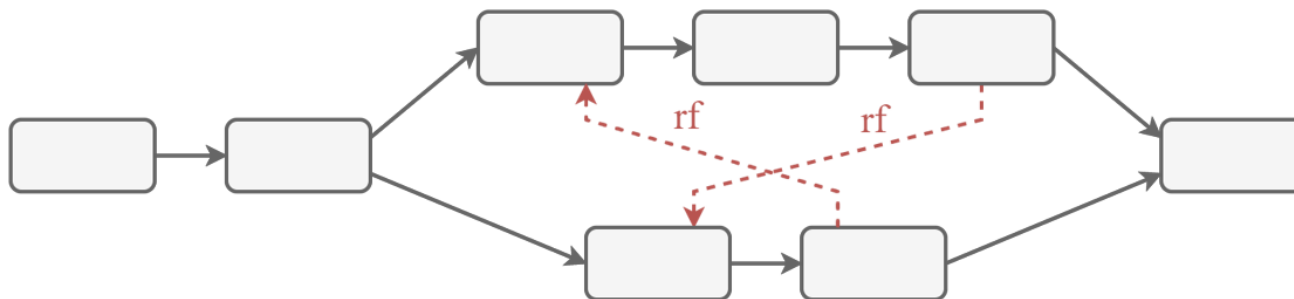
# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Key idea:
  - Build a **happens-before relation** (program order + dataflow + axioms)



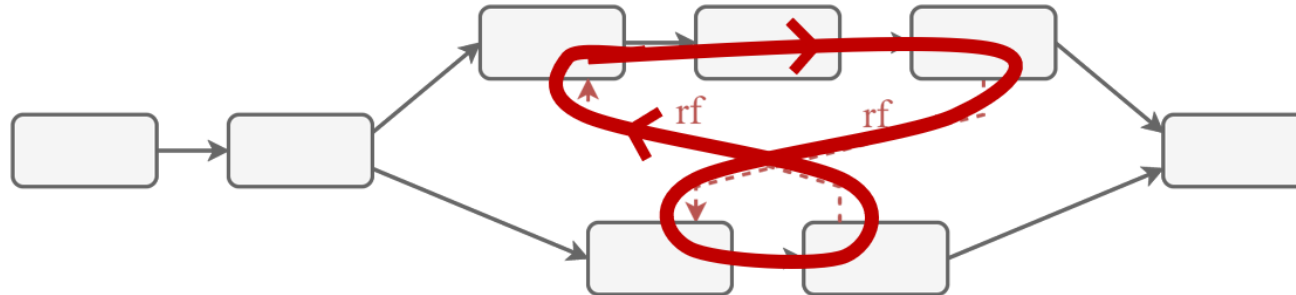
# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Key idea:
  - Build a **happens-before relation**  
(program order + dataflow + axioms)
  - **Avoid cycles**  
(exclude cycles/backtrack in the search space)



# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Key idea:
  - Build a **happens-before relation**  
(program order + dataflow + axioms)
  - **Avoid cycles**  
(exclude cycles/backtrack in the search space)



# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)

# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Different **decision procedures**:
  - **Refinement**-based: detect cycles on **full models** provided by an SMT solver
  - **Propagator**-based: detect cycles **on-the-fly** in a **custom SMT theory** (Z3 user propagator interface via JavaSMT)



# New approach

- Bounded Model Checking (BMC) for handling concurrency
- Reasoning with **partial orders** (happens-before relation)
- Different **decision procedures**:
  - **Refinement**-based: detect cycles on **full models** provided by an SMT solver
  - **Propagator**-based: detect cycles **on-the-fly** in a **custom SMT theory** (Z3 user propagator interface via JavaSMT)
- **Automatic cycle avoidance**: find&exclude cycles before starting the search space exploration

# Portfolio & Results

# Portfolio & Results

- Base strategy:
  - **BMC first**
  - If no (reliable) result: **fallback on abstraction-based methods**

# Portfolio & Results

- Base strategy:
  - **BMC first**
  - If no (reliable) result: **fallback on abstraction-based methods**
- Solved tasks by Theta in concurrency compared to last year:  
(on common tasks)

