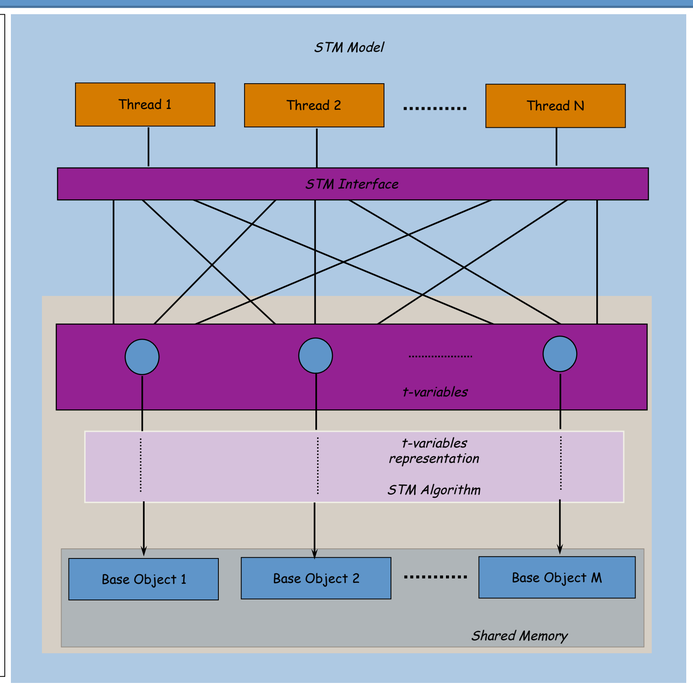
TransForm
Theoretical Foundations of Transactional Memory

http://www.ics.forth.gr/carv/transform/

Motivation

TRANSACTIONAL MEMORY (TM)

- Arguably, a new parallel programming paradigm considered by many researchers promising.
- A lot of work is being devoted to the implementation of TM systems, in hardware or in software.
- Yet, a sound theoretical framework to reason about the TM abstraction needs to be devised:
  - understand properly TM systems,
  - be able to assess and improve them.



THEORY CHALLENGES for TM

- Provisioning of a common framework/interface for TM (and concurrent) computing.
- Deep understanding and precise formulation of the correct semantics of TM systems.
- Exploration of valuable complexity measures and performance metrics.
- Formalization of abstractions for the major problems that are encountered when designing TM systems.
- Design of new TM implementations.
- Discovery of TM limitations, lower bounds, impossibility results.

TransForm: Research Directions & Progress

RESEARCH DIRECTIONS

WP1: Common framework/Interface. Derive a common framework for the design and analysis of TM algorithms and express state-of-the-art algorithms under the derived framework.

WP2: Safety. Discover subtleties encountered when defining correctness in TM and derive appropriate consistency conditions to capture these subtleties. Can consistency be traded for performance or liveness? How?

WP3: Liveness. Design of mechanisms to transform systems with weak liveness guarantees to others with stronger guarantees; identification of conditions under which transactions may be aborted and exploration of the power of algorithms that ensure them.

WP4: Complexity Measures & Performance Metrics. Derive appropriate time and space metrics, as well as complexity measures that can express and measure contention; design contention-wise TM implementations.

WP5: Locks versus Non-Blocking Synchronization. Formalize performance properties and limitations of blocking and non-blocking TM.

WP6: Limitations. Can existing lower bounds be beaten by trading safety or liveness? Derive new lower bounds and impossibility results for TM.

CURRENT PROGRESS

➢ 12 Early Stage Researchers (ESR) have been recruited in TransForm: 3 at EPFL, 4 at ICS-FORTH, 2 at Technion, 1 at TUB, 2 at UR1

EPFL:
- Metrics for predicting the scalability of concurrent algorithms.
- Formal definitions and reasoning about liveness properties.
- Trading safety to overcome existing lower bounds in TM (with FORTH).

FORTH
- Derivation of a common framework.
- Techniques for boosting performance of state-of-the-art STMs.
- Trading safety to overcome existing lower bounds in TM (with EPFL).
- Understanding safety for TM (with UR1 and Technion).

Technion
- Transactional schedulers for known and unknown workloads.
- Equivalence of transactional consistency definitions.

TUB
- Study of liveness conditions.
- Understanding the power of different synchronization techniques.
- Safety properties of deferred-update semantics (with Technion).

UR1
- Design of shared data structures for speculative executions.
- Design of a TM algorithm that implements strong isolation.
- Understanding safety for TM (with FORTH and Technion).

Innovation, Impact & Dissemination

INNOVATION & IMPACT

1. Reduction of the big complexity of concurrent programming by providing formalization that makes it possible to:
   - check the correctness of current TM implementations,
   - capture the details of their performance,
   - discover TM inherent limitations and establish optimality results,
   - determine whether TM design tradeoffs are indeed fundamental or simply artefacts of certain environments.
2. Improvement of Career Prospects of several Early Stage Researchers
3. Establishment of a long-term network of experts in concurrent computing

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DISSEMINATION

1. TransForm Initial Training School, Rennes, February 2011
2. TransForm/Euro-TM Workshop on the Theory of Transactional Memory, Rome, September 2011
3. TransForm Track on Microsoft Research Cambridge PhD Summer School, UK, July 2012.
4. TransForm/Euro-TM Workshop on the Theory of Transactional Memory, Portugal, July 2012
5. TransForm Summer School on Research Directions in Distributed Computing, Crete Island, June 2013 (upcoming)
6. TransForm/Euro-TM Workshop on the Theory of Transactional Memory, Israel, September 2013 (upcoming)
7. Interactive web site where external researchers can provide feedback. E-mailing List: Transform@lists.net.t-labs.tu-berlin.de

TransForm is a Marie Curie Initial Training Network funded by the E.C. under the 7th Framework program (contract number 238639).