Transactifying Applications Using an Open Compiler Framework

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Joint work with

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MICS

Problem

- How many real users does your STM have?
- Can real users easily try out your STM?

- Lack of users is a major problem
  - Lack of workloads
  - No education of users, no feedback from them

- Not just technical reasons (slow STM), also:
  - Availability, ease-of-use, lock-in?, costs, …

Our contributions

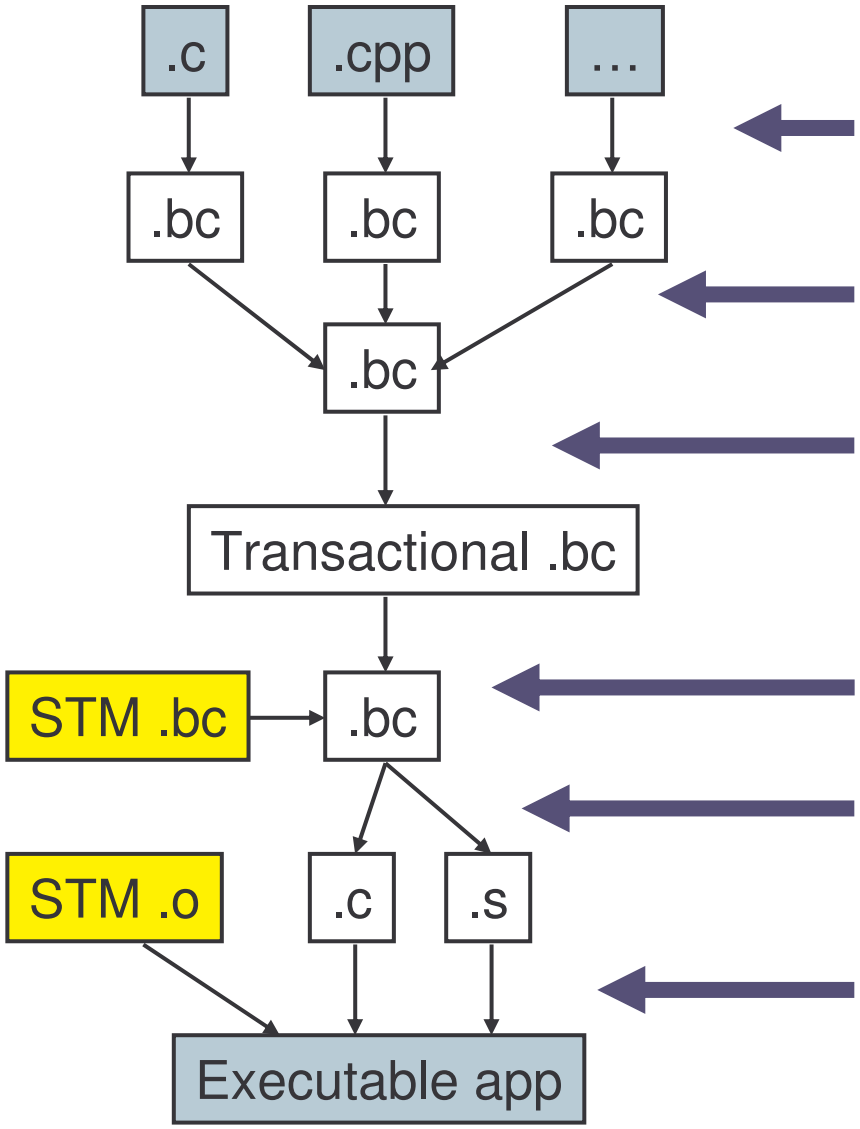
- **Tanger**
  - Open source compiler support
  - Application code with transaction boundary declarations is transformed to real transactional code that uses an STM
  - Uses LLVM's compiler framework
- **Tarifa**
  - Transforms declared transactions in IA32 assembler code to transactional asm code
  - More detail: ask me (later)
- License: GPL

What Tanger does

- Application code uses minimal declaration API:
  - begin, commit, init/shutdown function calls
  - Language syntax not changed, tools continue to work

- Tanger transforms code to use word-based STM API:
  - Find transactional code (bounded by begin/commit)
  - Redirect to STM functions (begin, commit, malloc, …)
  - Memory accesses to STM load/store
  - Redirect calls to transactional versions of functions

Usage (build cycle)



`llvm-gcc` (LLVM frontend):
- compile to intermediate representation (IR) (.bc = bitcode)

`llvm-ld` (LLVM linker/optimizer):
- link and optimize (potentially whole-program)

Tanger (compiler pass)
- **transform/create transactional code**

`llvm-ld`:
- link in STM, optimize

`llc` (LLVM backend):
- create target architecture asm or C code

`gcc`:
- compile and link with remaining binary objects or libraries

Why LLVM?

- LLVM (Low Level Virtual Machine):
  - Good intermediate representation (IR) for code (see next slide)
  - Very modular compiler
  - Link-time optimizations
  - JIT compilation support
  - Generates native code (e.g., x86, PowerPC, ARM, …) and C code (gcc)

- Alternatives:
  - Source to source translation: Easier? Optimizations?
  - gcc: Easier?

LLVM Intermediate Representation (IR)

- Sufficiently low-level (few dependencies), but still platform-independent and light-weight
- Can express C/C++ programs (important applications!)
- On-disk (.bc) and human-readable representations
- API for modifying IR is good and quick to learn
- IR uses types from source code (e.g., C structs)
- SSA
- Memory accesses are explicit (load/store)
- Stack contents in virtual registers unless accessed via pointers (fewer load/stores transformed!)

Current performance (tinySTM, single thread)

RBTree (STAMP)	Throughput	# calls in executable	
		Load	Store
Manual, gcc	11		
Manual, llvm-gcc	9.4	156	81
Tanger	8.8	127	77
Global lock, llvm	19		

Linked list	Throughput	# calls in executable	
		Load	Store
Manual, gcc	1.8		
Manual, llvm-gcc	1.3	16	3
Tanger	1.3	10	6

Things we'd like to build/have

- Our goals for Tanger: An STM environment:
  - Easy to use, practical: attract users!
  - Not just a research prototype
  - But allow plugging in research prototypes
- Compiler-based optimizations
- More features / subsystems:
  - Privatization, external actions, …
- STM support code (tracing, statistics, …)
- If you have ideas/plans, please talk to me

Benefits for users

- Decreases initial hurdles significantly
  - Minimal instrumentation overhead (parallelization, begin/commit, external actions)
  - Only have to select an STM
  - Performance is likely to get better, not worse

- Can get TM experience earlier
- Can follow research progress more easily

Benefits for research community

- User feedback: usability, workloads, …
- Smaller time-to-benchmark
- Environment for evaluation of your STM
- Comparing STMs gets easier (e.g., TL2 with tinySTM)
- Reference implementations for
  - Language integration proposals
  - Compiler support
- Benchmark writers could target Tanger instead of STM

Download Tanger, tinySTM, Tarifa at

http://tinystm.org