IBM T. J. Watson Research Center

IBM STM Interface and X10 Extensions

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Outline

- **STM Runtime Interface**
- **X10 Extensions**
- **Obstacles to a Single TM Standard**

STM Runtime Interface

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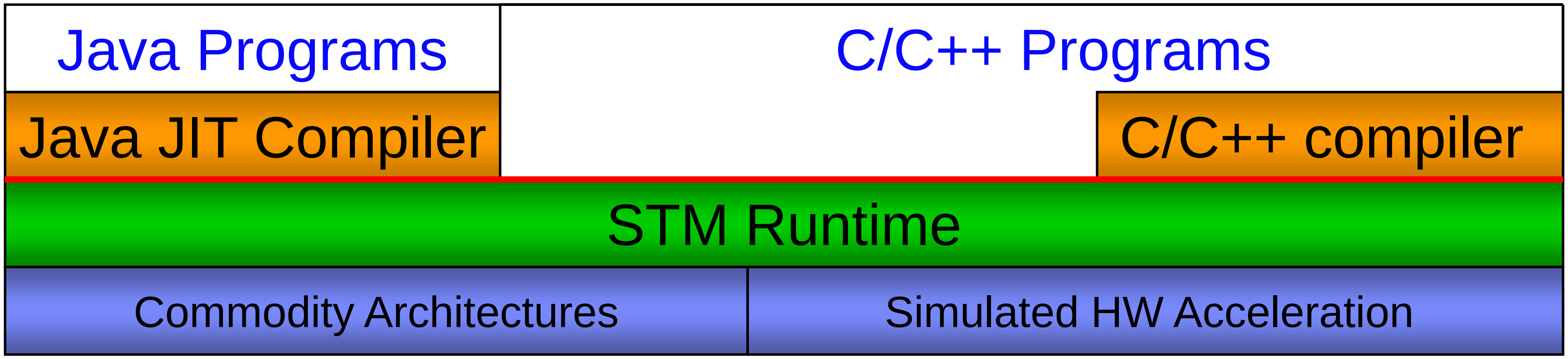
IBM Common STM Runtime



- **Implemented as a C library**
- **A version released to open source (June 2008)**
- **STM runtime supports:**
  - A Java JIT compiler STM implementation
  - C/C++ STM compilers
  - Binary of IBM STM XL compiler released in May 2008
- **Runs on:**
  - Commodity platforms: AIX/Linux PPC/X86
  - Hardware acceleration models

STM Interface – Per-Thread STM Descriptors

```
void * stm_thr_init();
```

- **Creates a new per-thread STM descriptor**
- **Returns a pointer to per-thread STM descriptor**

```
void * stm_desc();
```

- **Returns a pointer to per-thread STM descriptor of the current thread**

```
void stm_thr_retire(void * mydesc);
```

- **Retire the current thread’s descriptor**

STM Interface – Transaction Begin and End

```
int stm_begin(void * buf,void * mydesc,char * fname,int line);
```

- **Arguments:**
  - ***buf***: pointer to a buffer for use by longjmp on abort
  - ***mydesc***: pointer to per-thread transactional descriptor
  - ***fname***: string representing the filename where the code of the transaction occurs, e.g., __FILE__
    - Used for per-static-transaction statistics
  - ***line***: integer representing the line number where the code of the transaction starts, e.g., __LINE__
- **Returns an integer representing encountered state:**
    - INACTIVE (started outermost transaction)
    - ACTIVE (nested)
    - ABORTED (nested)
    - NON_SPECULATIVE (nested)

```
int stm_end(void * mydesc);
```

- **Returns a Boolean value representing outcome:**
  - SUCCESS
  - FAILURE

STM Interface – Transaction Status and Validation

```
int in_transaction(void * mydesc);
```

- **Returns a Boolean value indicating whether the current thread is running inside a transaction or not**

```
int stm_validate(void * mydesc);
```

- **Returns a Boolean result indicating whether the current transaction’s read set is valid or not**

STM Interface – Non-Speculative Mode

```
int become_inevitable(void * mydesc);
```

- **Try to get into inevitable (non-speculative) mode**
- **If successful, then this transaction is guaranteed not to be aborted**
- **The transaction may execute non-speculative actions with irrevocable effects**
- **Returns Boolean value indicating whether the transaction was able or not to enter the non-speculative mode**

STM Interface – Abort if Speculative

```
int stm_abort(void *mydesc);
```

- **Aborts the current transaction if running speculatively**
- **Returns integer value representing status before abort**
  - INACTIVE
  - ACTIVE
  - ABORTED
  - NON_SPECULATIVE
- **Note:**
  - The transaction is not aborted if it is running in non-speculative mode

STM Interface – Transactional Reads

```
void * stm_read_ptr(void * volatile * addr,void * mydesc);
float stm_read_float(float volatile * addr,void * mydesc);
... <other basic data types>
unsigned long stm_read_ulong(unsigned long volatile * addr,void * mydesc);
unsigned long long stm_read_ull(unsigned long long volatile * addr,
   void * mydesc);
```

- **Arguments:**
  - ***addr***: pointer to the variable being read
- **Returns the value of the variable being read from the point of view of the current transaction**

STM Interface – Transactional Writes

```
void stm_write_ptr(void * volatile * addr, void * val,void * mydesc);
void stm_write_float(float volatile * addr, float val,void * mydesc);
... <other basic data types>
void stm_write_ulong(unsigned long volatile * addr, unsigned long val,
   void * mydesc);
void stm_write_ull(unsigned long long volatile * addr,
   unsigned long long val, void * mydesc);
```

- **Arguments:**
  - ***addr***: pointer to the variable to be written
  - ***val***: value to be written

STM Interface – Memory Allocation

- **Only memory allocations inside transactions need to call special STM functions**

```
void * stm_malloc(size_t sz,void * mydesc);
void * stm_calloc(size_t ne,size_t sz,void * mydesc);
void stm_free(void * ptr,void * mydesc);
```

- **Arguments and return values:**
  - Same as standard malloc/calloc/free

STM Interface – Writes to Local Variables

- **Local variables initialized outside the transactions need to be checkpointed for rollback on abort, before being written inside a transaction**

```
void stm_checkpoint(char * addr, int size,void * mydesc);
```

- **Arguments:**
  - ***addr***: pointer to local variable
  - ***size***: size of local variable

```
int found = 0; ...
stm_begin(...); ...
found = 1; ...
stm_end();
if (found) ...
```

pre-transaction value needs to be restored on abort

STM Interface – Handling Address-Taken Stack Variables

- **If addresses of local variables are passed as arguments to function calls, the STM may end up treating these variables as shared**
- **STM needs to handle accesses to these variables consistently as local**

```
void stm_stack_range(void * addr, int size, void *mydesc);
```

- **Arguments:**
  - ***addr***: beginning of range
  - ***size***: size of range

```
stm_begin(...); ...
int var = a; ...
foo(&var); ...
stm_end();
```

```
Void foo(int * ptr) {
  *ptr = b;
}
```

Treated as local variable

Must be treated as local for consistency

STM Interface – Collecting Statistics

```
void stm_stats_out();
```

- **Saves a snapshot of STM stats**
- **Inherent transactional stats**
- **Implementation-specific stats**
- **Stats per static transaction**

```
  65536      READ_WRITE_COMMITS
  69528      READ_SET_VALIDATIONS
      0      READ_ENCOUNTER_RETRIES
      0      SIGNAL_RETRIES
      0      WRITE_ACQUIRE_RETRIES
      0      READ_VALIDATION_RETRIES
 525712      WRITE_BARRIERS
  13419      NUM_SILENT_WRITES
      0      SILENT_WRITES_BECAME_READS
      0      WRITE_BARRIERS_OUTSIDE_TXNS
 131010      WRITE_BARRIERS_FOR_STACK
   9730      DUPLICATE_WRITES
      0      DUPLICATE_WRITE_CONFLICT_SET
10726816     READ_BARRIERS
      0      READ_BARRIERS_OUTSIDE_TXNS
      0      READ_BARRIERS_FOR_STACK
4225604      DUPLICATE_READS
6874933      DUPLICATE_READ_CONFLICT_SET
      0      USEFUL_DUP_READ_CHECKS
      0      USELESS_DUP_READ_CHECKS
 934007      BLOOM_FILTER_CHECKS
 102826      BLOOM_FILTER_MATCHES
  88121      READ_AFTER_WRITE_MATCHES
10638695     READ_LIST_SIZES
 384972      WRITE_LIST_SIZES
6501212      READ_SET_SIZES
 384972      WRITE_SET_SIZES
    653      READ_LIST_MAX_SIZE
    230      WRITE_LIST_MAX_SIZE
    272      READ_SET_MAX_SIZE
    230      WRITE_SET_MAX_SIZE
      1      MAX_NESTING
  99.20      AVG_READ_SET_SIZE
   5.87      AVG_WRITE_SET_SIZE
 162.33      AVG_READ_LIST_SIZE
   5.87      AVG_WRITE_LIST_SIZE
      0      TOTAL_RETRIES
   0.00      AVG_RETRIES_PER_TXN
   0.00      AVG_CHECKPOINTING_CALLS_PER_TXN
  39.39      PCT_DUPLICATE_READS
  64.09      PCT_DUPLICATE_READ_CONFLICT_SET
   1.85      PCT_DUPLICATE_WRITES
   2.55      PCT_SILENT_WRITES
```

STM Interface – Sub-Operations

- **Interface for uncommon sub-operations, in order to enable inlining of common sub-operations**

```
void stm_read_bloom_match(void * addr, int size, void * mydesc);
void expand_reads(void * mydesc);
void stm_cleanup_aborted(void * mydesc);
...
```

- **Interface to fences and validation checks, in order to enable aggregation of fences and validation checks**

```
void stm_read_orec_check(void * addr, void * mydesc);
void stm_read_orec_mem_fence();
void stm_read_from_mem(void * addr, int size, void * mydesc);
...
```

X10 Extensions

X10 Atomic Constructs

- **`atomic:`**
  - Unconditional atomic block

```
atomic {
   S;
}
```

- **`when:`**
  - Conditional atomic block
  - Atomically guarantees that the condition *c* holds and executes the atomic section *S*.

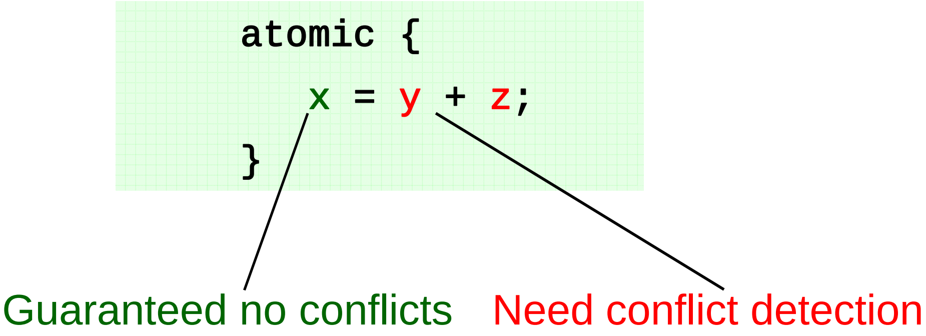
```
when(c) {
   S;
}
```

X10 Common Patterns

- **Atomic blocks with static data sets**

```
atomic {
  x = y + z;
}
```

- **Shared data accessed in atomic sections that is guaranteed to have no conflicts**



```
atomic {
  x = y + z;
}
```

Guaranteed no conflicts

Need conflict detection

Extensions to Exploit Patterns

- **Capability to specify:**
  - Shared variables that may be read, written, or read and written inside an atomic block
  - Whether the identified data set is complete or not
  - Shared variables that are guaranteed to have no conflicts

```
@fun(rd(y), wr(w), rd_wr(x), nc(z)) atomic {
   w = x + y + z;
   x = x + w;
}
```

or

```
@fun(rd(y),wr(w), rd_wr(x), complete) atomic {...}
```

STM Extensions

```
void stm_add_to_read_set(void * addr,int size, void * mydesc);
void stm_add_to_write_set(void * addr,int size, void * mydesc);
```

- **Add address range to the read set and write set of the current transaction**

```
void stm_no_conflict(void * addr,int size, void * mydesc);
```

- **Ignore subsequent transactional reads and writes to locations in the address range**

```
void stm_data_set_complete(void * mydesc);
```

- **Indicate that the specified transactional data set is complete**

Obstacles to a Single TM Standard

Variety of TM Features and Requirements

- **Allowing non-speculative actions**
  - e.g., to execute I/O, system calls
- **Non-blocking progress**
  - e.g., in real-time apps
- **Allowing user abort, abort on exception**
  - e.g., for convenience of recovery
- **Strong atomicity**
  - e.g., for simulation of complex atomic operations
- **Privatization-safety, publication-safety**
- **Open nesting, transactional boosting**
- **Allowing condition variables**

Limitations on TM Features

- **Some TM Features are contradictory**
  - Some features cannot be allowed concurrently without programming restrictions
    - E.g., Non-blocking transactions that may conflict with transactions with non-speculative actions
  - Some features have per-transaction restrictions:
    - E.g., User abort after executing non-speculative actions
- **Unused features are often costly**
  - Performance overheads
    - Strong atomicity
  - Complexity of combination with other features
    - Non-speculative actions and strong atomicity

No One TM Standard Fits All

Variety of Performance Priorities

- **Performance characteristics**
  - High/low Parallelism
  - Low/high Overheads
  - Graceful/fall-off-a-cliff degradation
- **Performance depends on TM implementation options**
  - Conflict detection policies
  - Contention management
  - Consistency granule, e.g., object/block-based, block size
- **Sharp trade-offs among performance characteristics**
  - e.g., graceful-degradation vs. low best-case overheads
- **Adaptivity is often costly**
- **Performance is a primary motivation for many TM uses**

A single omni-featured TM is likely to deliver inadequate performance

A Multi-TM Standard?

- **Allow multi-TM co-existence**

Can this be done without compromising code modularity?

and without an explosion in feature combinations?

A single TM standard will have to make careful choices that hopefully capture the most useful features of TM

Thank You

BACKUP

Constructs

- **Multiple TM instances**

```
    __tm_attribute((non_blocking)) __tm_atomic {r = x; ....};
    __tm_attribute((nonspeculative)) __tm_critical {r = y; ....}
```