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Manchester University Transactions for Scala

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Teraflux & Scala

- Teraflux: Exploiting Data Parallelism for 1000 Core Processors
  - Programming Models, Transactional Memory, Memory Models, Chip Design, Fault Tolerance, ...
  - European Commission’s FP7 funded
  - Using Scala as a basis for high productivity language

- Scala
  - Combination of Object Oriented and Functional Programming Models
  - Compiles to JVM Byte-Code

Why MUTS

Existing Scala STMs do not allow transactions to be added to code without restructuring the code.

We want:

- No difference between transaction syntax and other language constructs
- No restrictions on transaction granularity
- Works with legacy code
- Maintainability

MUTS Syntax

- ```
  atomic {
      body
  }
  ```
- ```
  atomic(test) {
      body
  }
  ```

Transaction that **does not** retry on failure

- ```
  atomic {
      body
  } retry;
  ```
- ```
  atomic(test) {
      body
  } retry;
  ```

Transaction that **does** retry on failure

- ```
  atomic {
      body
  } orElse {
      elseBody
  }
  ```
- ```
  atomic(test) {
      body
  } orElse {
      elseBody
  }
  ```

Transaction that runs alternative code on failure

Implementing MUTS

43 Possible locations within the compiler to add or augment passes to implement transactions

- Two phases
  - Modifications to the parser
  - Java Agent to instrument the Byte-Code
- Both of these work with well defined interfaces
  - Scala
  - JVM Byte-Code

Parser Modifications

- Add new keywords
- When an atomic section is detected:
  - Add the control logic using **existing** tree constructs
  - **Encase the transactional code with an try/catch**
    - Handle exceptions thrown by the body
    - **Mark the code that is transactional**
    - Allow transactions to abort
  - Create a context to store the transaction meta-data
  - Copy method variables so that active updates can be used on them by the body

Parser Modifications

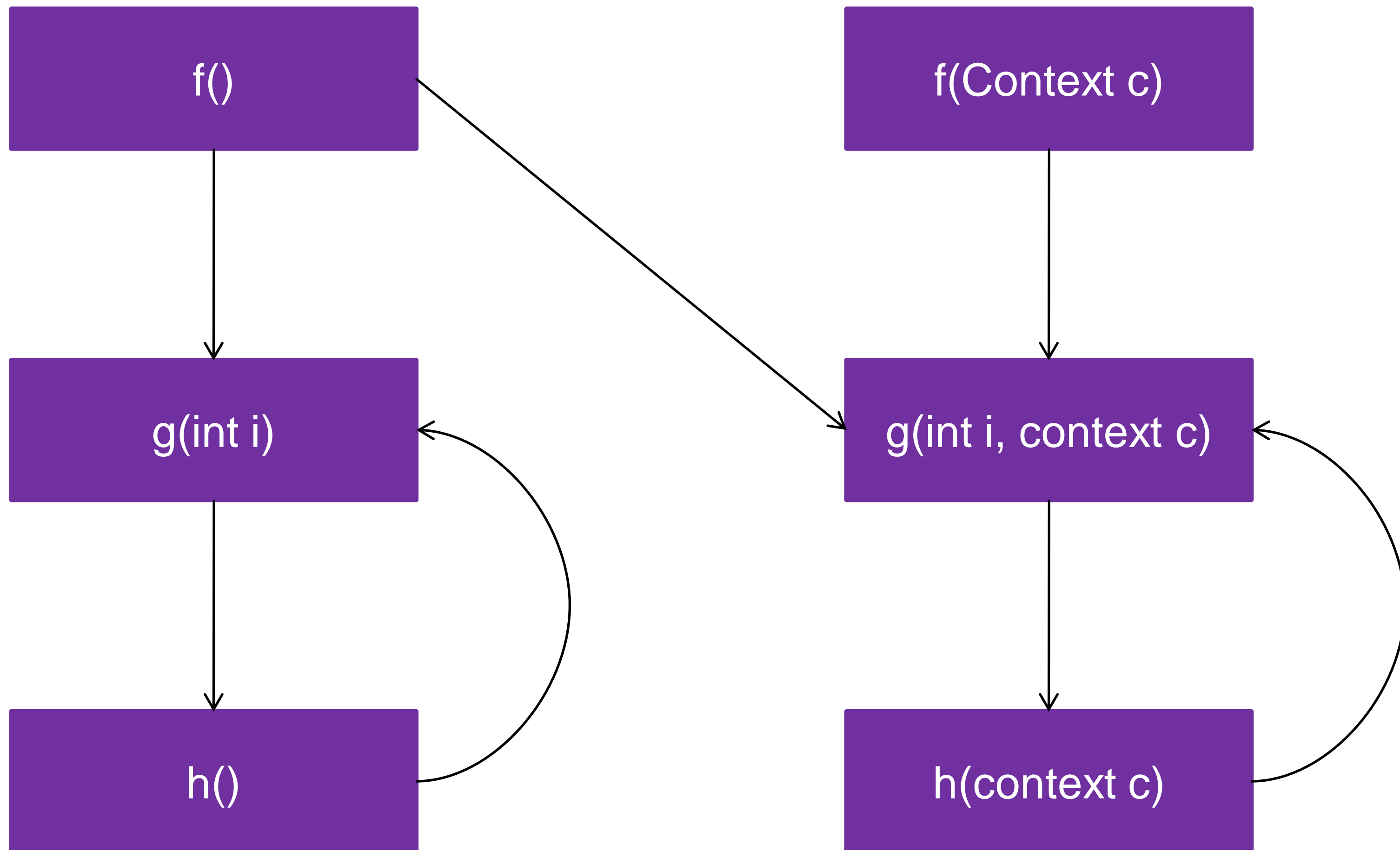
```
var committed$TM = false
Var context$TM = null
do{
  context$TM = TM.beginTransaction()
  atomic {
  try {
    Body
  } retry;
    committed$TM = TM.commit(context$TM)
  } catch {
    case e:TransactionArea => ()
    case e:TransactionException => context$TM.rollback()
    case e:Exception => {
      committed$TM = TM.commit(context$TM)
      if (committed$TM) throw e
    }
  }
} while(!committed$TM)
```

Byte-Code Rewrite

Modifying the Deuce Java Agent

- Add Duplicate Methods
- Detect atomic sections of methods
  - Detect the location of the context
  - Instrument field accesses
  - Augment method calls
  - Remove the marker exception

Byte-Code Rewrite



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Protecting Against Code Reordering

```
try {
  System.out.println("This is the start of the test");

  try{ foo(); }
  catch(IOException e) { System.out.println("IO exception"); }
  catch(NullPointerException e) { System.out.println("Null Pointer
                                                        Exception");
   }

  System.out.println("This is the end of the test");
}
catch(Exception e) {  System.out.println("The final Exception"); }
```

Exception table:

```
   from    to  target type
     8     11     14   Class java/io/IOException
     8     11     26   Class java/lang/NullPointerException
     0     43     46   Class java/lang/Exception
```

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What Have We Gained?

User:

- Native Constructs
- No change of syntax
- No restrictions on the granularity of transactions
- No restrictions on the use of legacy code
- Interoperable with Java

Implementer:

- Working against well defined interfaces
- Native constructs with minimal changes to the compiler

Conclusions

- MUTS is a much more intuitive and flexible STM for users
- Interoperable with Java
- Implemented with minimal changes to the parser, and no other changes to the compiler
- Exception handler overcomes code reordering
- This 2-phase approach can be applied to implementing other native constructs
- Part of a suite of Scala STMs at Manchester

Produced as part of the Teraflux Project http://www.teraflux.eu

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Other TM Research at Manchester

- Applications: Transactional Parallel Routing
  - Lee-TM (aka labyrinth in STAMP) [1][2]
- TM Contention Managers [3]
- Control of Optimistic Execution [4]
- Scheduling of Transactions [5, 6]
- Hardware TM [6, 7, 8]
- Distributed TM [9, 10]

http://apt.cs.manchester.ac.uk/projects/TM

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Selected References

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