DBRIDGE: A PROGRAM REWRITE TOOL FOR SET-ORIENTED QUERY EXECUTION

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The Problem

- Applications often invoke
- Database queries/Web Service requests
  - repeatedly (with different parameters)
  - synchronously (blocking on every request)
- Naive iterative execution of such queries is **inefficient**
  - No sharing of work (eg. Disk IO)
  - Network round-trip delays

The problem is **not** within the database engine!

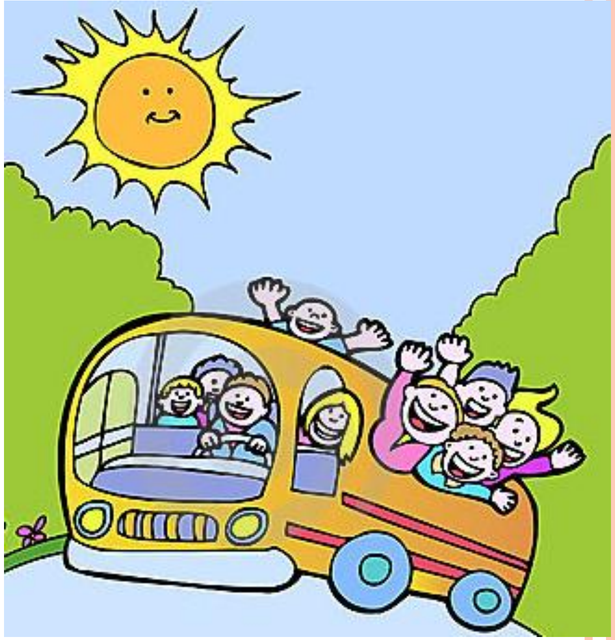
The problem is **the way queries are invoked** from the application!!

Query optimization:
time to think out of the box

Our Work 1: Batching

Rewriting Procedures for Batched Bindings
Guravannavar et. al. VLDB 2008

- Repeated invocation of a query **automatically** replaced by a single invocation of its batched form.



- Enables use of efficient set-oriented query execution plans
- Sharing of work (eg. Disk IO) etc.
- Avoids network round-trip delays

Approach

- Transform imperative programs using equivalence rules
- Rewrite queries using decorrelation, APPLY operator etc.

Our Work 2: Asynchronous query submission

Program Transformation for Asynchronous Query Submission

Chavan et al., ICDE 2011 Research track – 8; April 13th, 14:30-16:00

- Repeated synchronous invocation of queries **automatically** replaced by asynchronous submission.
- Application can perform other work while query executes

- Sharing of work (eg. Disk IO) on the database engine
- Reduces impact of network round-trip delays
- Extends and generalizes equivalence rules from our VLDB 2008 paper on batching

DBridge: Bridging the divide

- A tool that implements these ideas on Java programs that use JDBC
  - Set-oriented query execution
  - Asynchronous Query submission
- Two components:
  - **The DBridge API**
    - Handles query rewriting and plumbing
  - **The DBridge Transformer**
    - Rewrites programs to optimize database access
- Significant performance gains on real world applications

The DBridge API

- Java API which extends the JDBC interface, and can wrap any JDBC driver
- Can be used with:
  - Manual writing/rewriting
  - Automatic rewriting (by DBridge transformer)
- Same API for both batching and asynchronous submission
- Abstracts the details of
  - Parameter batching and query rewrite
  - Thread scheduling and management

The DBridge API

```
stmt = con.prepareStatement(
        "SELECT count(partkey) " +
         "FROM part " +
         "WHERE p_category=?");

while(!categoryList.isEmpty()) {
        category = categoryList.next();
        stmt.setInt(1, category);
        ResultSet rs = stmt.executeQuery();
        rs.next();
        int count = rs.getInt(”count");
        sum += count;
        print(category + ”: ” + count);
}
```

Before

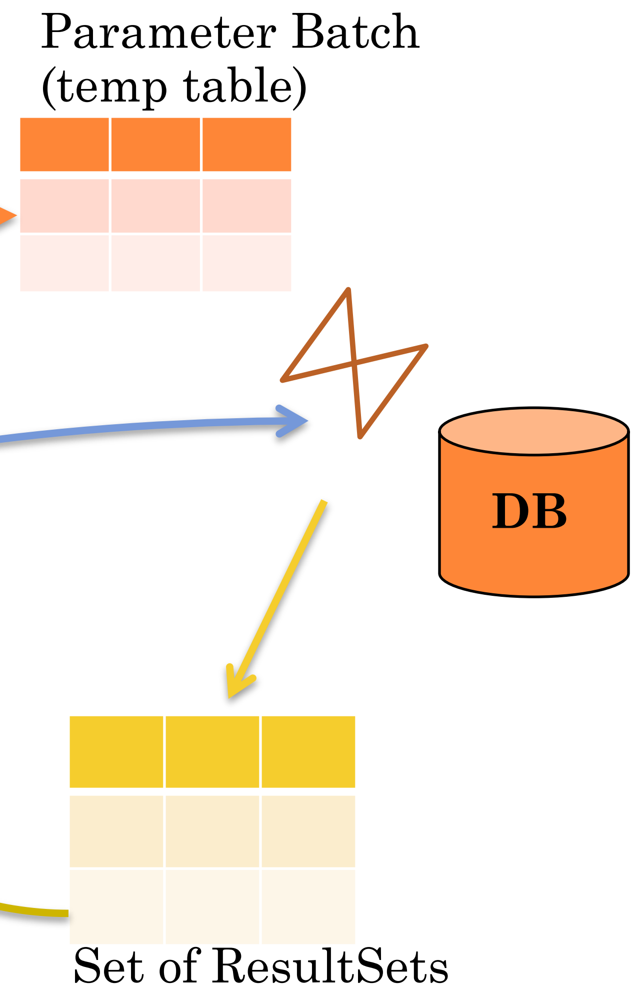
```
stmt = con.dbridgePrepareStatement(
            "SELECT count(partkey) " +
            "FROM part " +
            "WHERE p_category=?");
LoopContextTable lct = new LCT();
while(!categoryList.isEmpty()) {
        LoopContext ctx=lct.createContext();
        category = categoryList.next();
        stmt.setInt(1, category);
        ctx.setInt(”category”, category);
        stmt.addBatch(ctx);
}
stmt.executeBatch();

for (LoopContext ctx : lct) {
        category = ctx.getInt(”category”);
        ResultSet rs = stmt.getResultSet(ctx);
        rs.next();
        int count = rs.getInt(”count");
        sum += count;
        print(category + ”: ” + count);
}
```

After

DBRIDGE API – SET ORIENTED EXECUTION

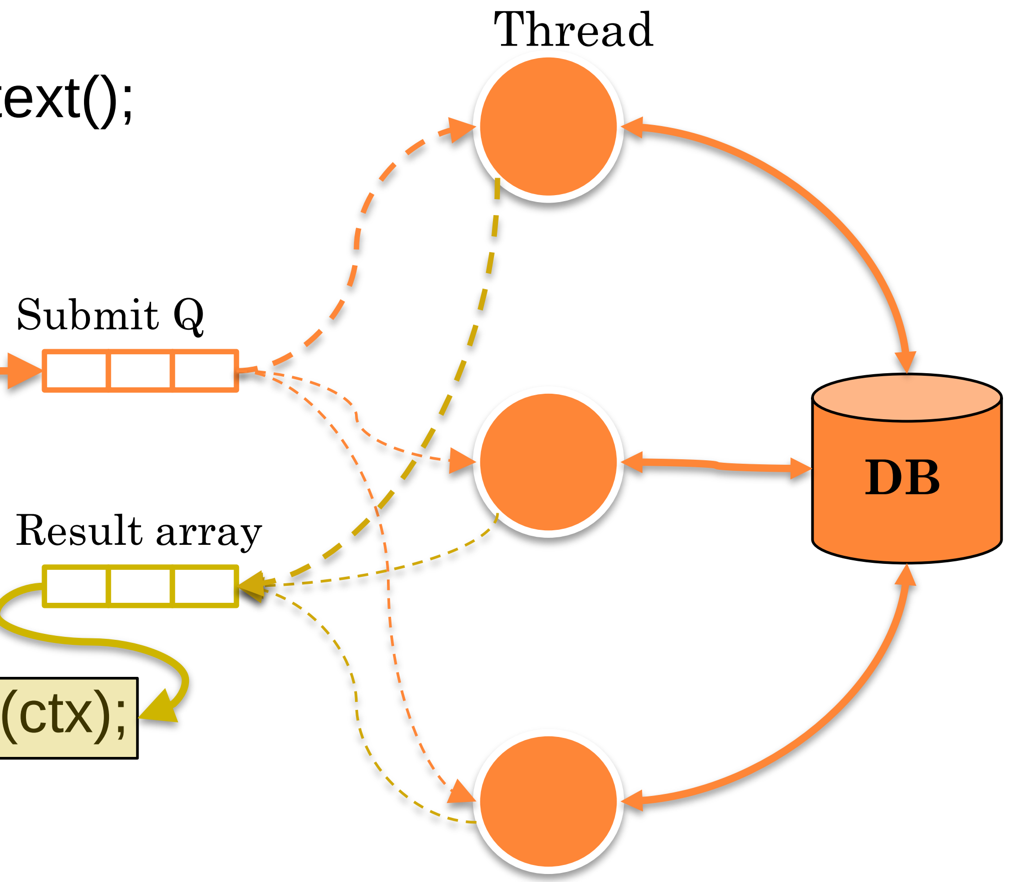
```
LoopContextTable lct = new LoopContextTable();
while(!categoryList.isEmpty()){
     LoopContext ctx = lct.createContext();
    category = categoryList.next();
    stmt.setInt(1, category);
    ctx.setInt(”category”, category);
    stmt.addBatch(ctx);
}
stmt.executeBatch();
for (LoopContext ctx : lct) {
     category = ctx.getInt(”category”);
     ResultSet rs = stmt.getResultSet(ctx);
     rs.next();
     int count = rs.getInt(”count");
     sum += count;
     print(category + ”: ” + count);
}
```



- addBatch(ctx) – insert tuple to parameter batch
- executeBatch() – execute set-oriented form of query
- getResultSet(ctx) – retrieve results corresponding to the context

DBridge API – Asynchronous submission

```
LoopContextTable lct = new LoopContextTable();
while(!categoryList.isEmpty()){
     LoopContext ctx = lct.createContext();
    category = categoryList.next();
    stmt.setInt(1, category);
    ctx.setInt(”category”, category);
     stmt.addBatch(ctx);
}
stmt.executeBatch();
for (LoopContext ctx : lct) {
     category = ctx.getInt(”category”);
     ResultSet rs = stmt.getResultSet(ctx);
     rs.next();
     int count = rs.getInt(”count");
     sum += count;
     print(category + ”: ” + count);
}
```

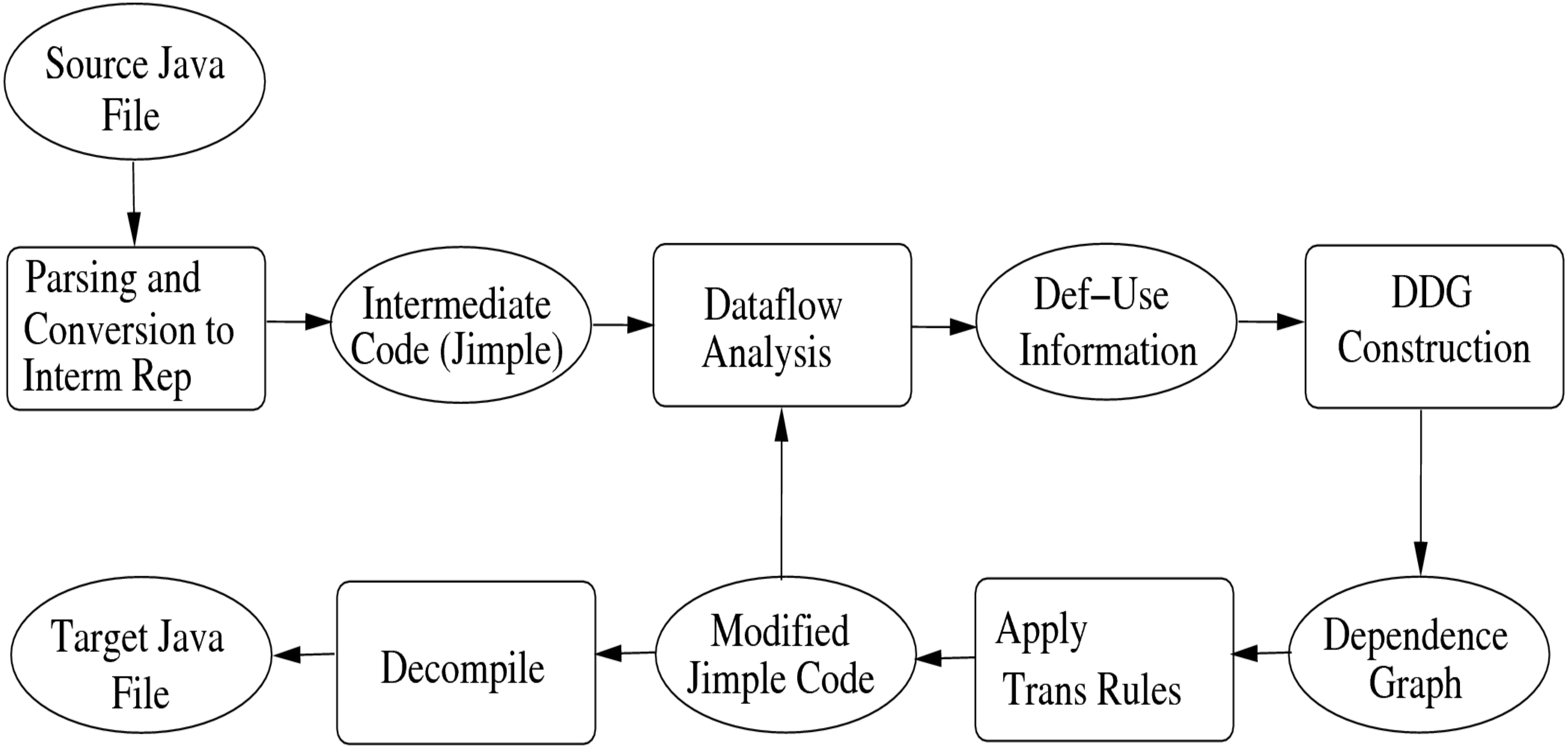


- addBatch(ctx) – submits query and returns immediately
- getResultSet(ctx) – blocking wait

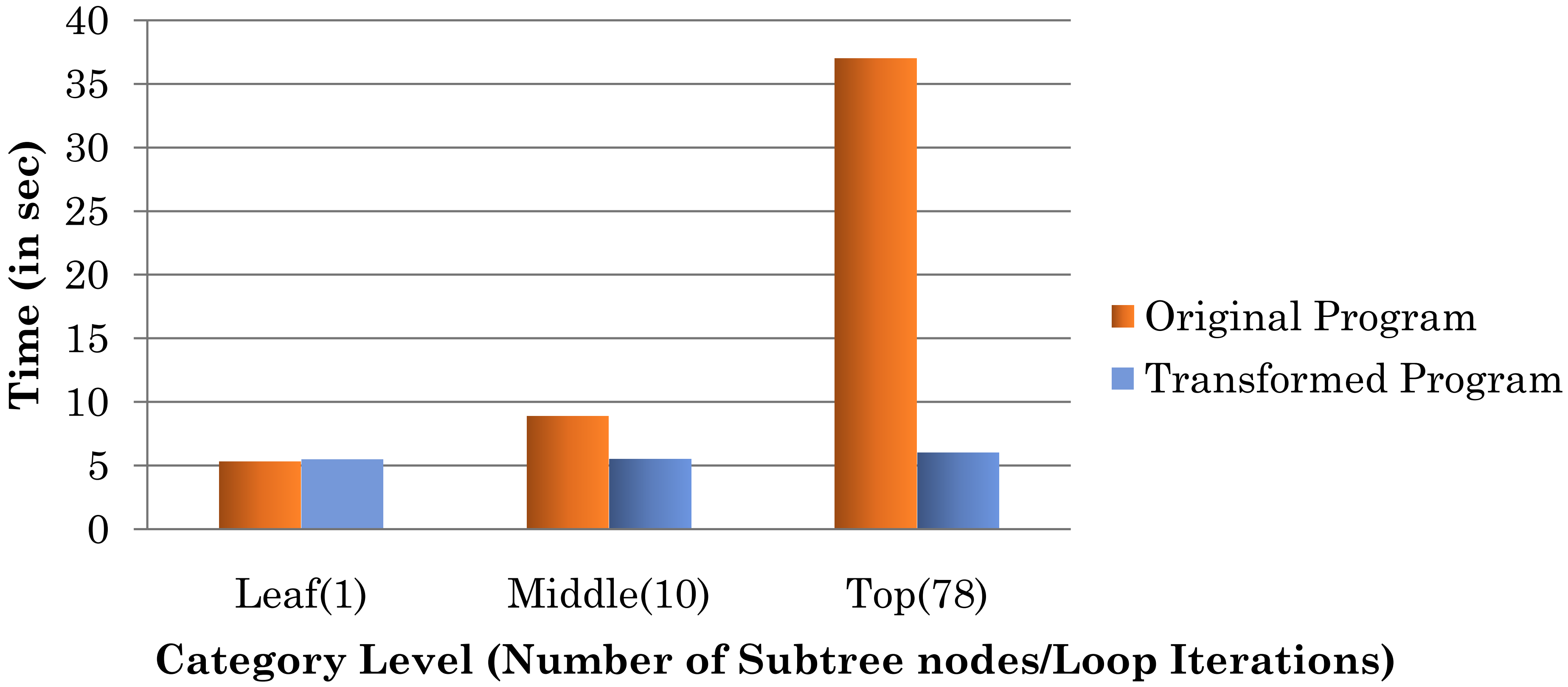
DBRIDGE - TRANSFORMER

- Java source-to-source transformation tool
- Rewrites programs to use the DBridge API
- Handles complex programs with:
  - Conditional branching (if-then-else) structures
  - Nested loops
- Performs statement reordering while preserving program equivalence
- Uses SOOT framework for static analysis and transformation (http://www.sable.mcgill.ca/soot/)

DBridge - Transformer

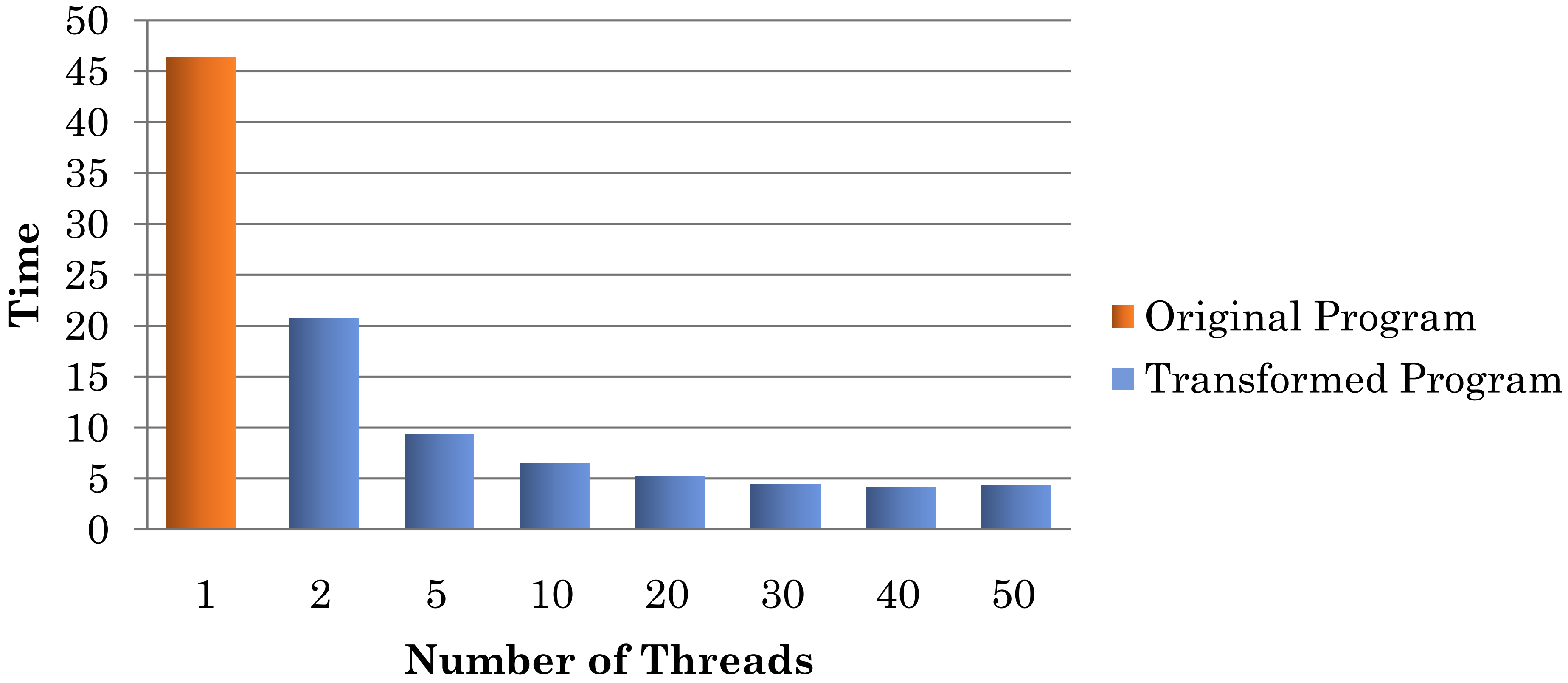


BATCHING: PERFORMANCE IMPACT



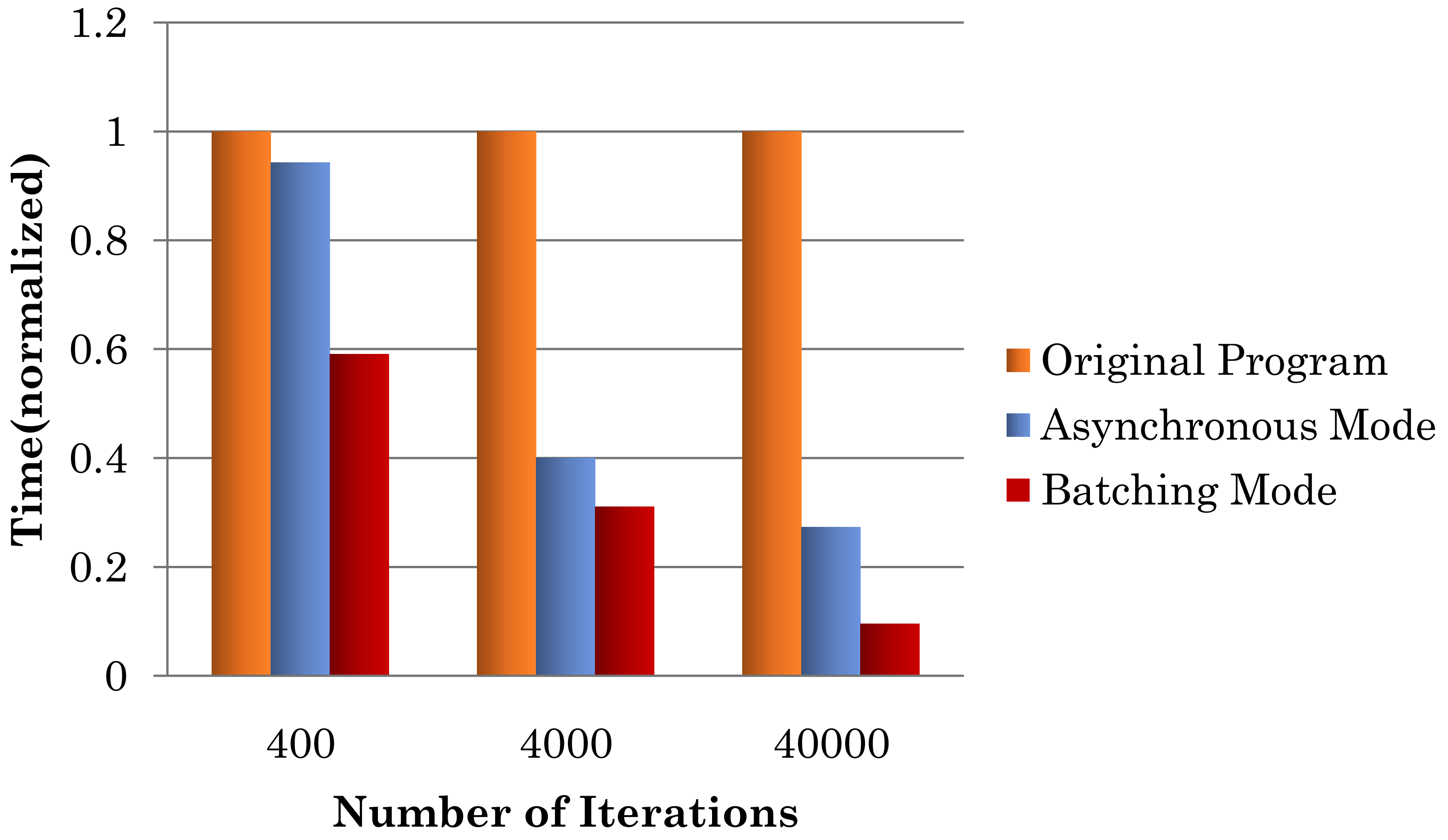
- Category hiearchy traversal (real world example)
- For small no. of iterations, no change observed
- At large no. of iterations, factor of 8 improvement

Asynchronous submission: Performance Impact



- Auction system benchmark application
- For small no. (4-40) iterations, transformed program slower
- At 400-40000 iterations, factor of 4-8 improvement
- Similar for warm and cold cache

Comparison: Batching vs. Asynchronous submission



- Auction system benchmark application
- Asynchronous execution with 10 threads

Conclusions and Ongoing Work

- Significant performance benefits possible by using batching and/or asynchronous execution for
  - Repeated database access from applications
  - Repeated access to Web services
- DBridge: batching and asynchronous execution made easy
  - API + automated Java program transformation
- Questions? Contact us at http://www.cse.iitb.ac.in/infolab/dbridge
  - Email: karthiksr@cse.iitb.ac.in

Transformation Walk-through

Input: A Java Program which uses JDBC

```
PreparedStatement stmt = con.prepareStatement(
    "SELECT COUNT(p_partkey) AS itemCount
       FROM newpart
     WHERE p_category = ?");

while(category != 0){
    stmt.setInt(1, category);
    ResultSet rs = stmt.executeQuery();
    rs.next();
    int itemCount = rs.getInt("itemCount");
    sum = sum + itemCount;
    category = getParent(category);
}
```

Transformation Walk-through

Step 1 of 5: Identify candidates for set-oriented query execution:

```
PreparedStatement stmt = con.prepareStatement(
    ”SELECT COUNT(p_partkey) AS itemCount
       FROM part
     WHERE p_category = ?");

while(category != 0){
    stmt.setInt(1, category);
    ResultSet rs = stmt.executeQuery();
    rs.next();
    int itemCount = rs.getInt("itemCount");
    sum = sum + itemCount;
    category = getParent(category);
}
```

Iterative execution of a parameterized query

Intention: Split loop at this point

Transformation Walk-through

Step 2 of 5: Identify dependencies that prevent loop splitting:

```
PreparedStatement stmt = con.prepareStatement(
    "SELECT COUNT(p_partkey) AS itemCount
       FROM part
     WHERE p_category = ?");

while(category != null){
    stmt.setInt(1, category);
    ResultSet rs = stmt.executeQuery();
    rs.next();
    int itemCount = rs.getInt("itemCount");
    sum = sum + itemCount;
    category = getParent(category);
}
```

Iterative execution of a parameterized query

A **Loop Carried Flow Dependency** edge crosses the query execution statement

TRANSFORMATION WALK-THROUGH

Step 3 of 5: Reorder statements to enable loop splitting

```
PreparedStatement stmt = con.prepareStatement(
"SELECT COUNT(p_partkey) AS itemCount
       FROM part
    WHERE p_category = ?");

while(category != null){
     int temp = category;
     category = getParent(category);
     stmt.setInt(1, temp);
     ResultSet rs = stmt.executeQuery();
     rs.next();
     int itemCount = rs.getInt("itemCount");
     sum = sum + itemCount;
}
```

Move statement above the Query invocation

Loop can be safely split now

Transformation Walk-through

Step 4 of 5: Split the loop (Rule 2)

```
LoopContextTable lct = new LoopContextTable();
while(category != null){
    LoopContext ctx = lct.createContext();
    int temp = category;
    category = getParent(category);
    stmt.setInt(1, temp);
    stmt.addBatch(ctx);
}
stmt.executeBatch();

for (LoopContext ctx : lct) {
    ResultSet rs = stmt.getResultSet(ctx);
    rs.next();
    int itemCount = rs.getInt("itemCount");
    sum = sum + itemCount;
}
```

To preserve split local values and order of processing results

Accumulates parameters in case of batching; submits query in case of asynchrony

Query execution statement is out of the loop and replaced with a call to its set-oriented form

Process result sets in the same order as the original loop

TRANSFORMATION WALK-THROUGH

Step 5 of 5: Query Rewrite

```
SELECT COUNT(p_partkey) AS itemCount
       FROM part
    WHERE p_category = ?
```

Original Query

```
CREATE TABLE BATCHTABLE1(
paramcolumn1 INTEGER, loopKey1 INTEGER)
```

Temp table to store Parameter batch

```
INSERT INTO BATCHTABLE1 VALUES(..., …)
```

Batch Inserts into Temp table

```
SELECT BATCHTABLE1.*, qry.*
FROM BATCHTABLE1 OUTER APPLY (
SELECT COUNT(p_partkey) AS itemCount
   FROM part
 WHERE p_category = paramcolumn1) qry
ORDER BY loopkey1
```

Set-oriented Query