Java™ DB Performance

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Goal of My Talk

Learn how to configure and use **Java™ DB** to get the best **performance** and the required **durability** for your data.

Agenda

Java DB Introduction

Configuring Java DB for Performance

Programming Tips

Understanding Java DB Performance

Open Source Database Performance

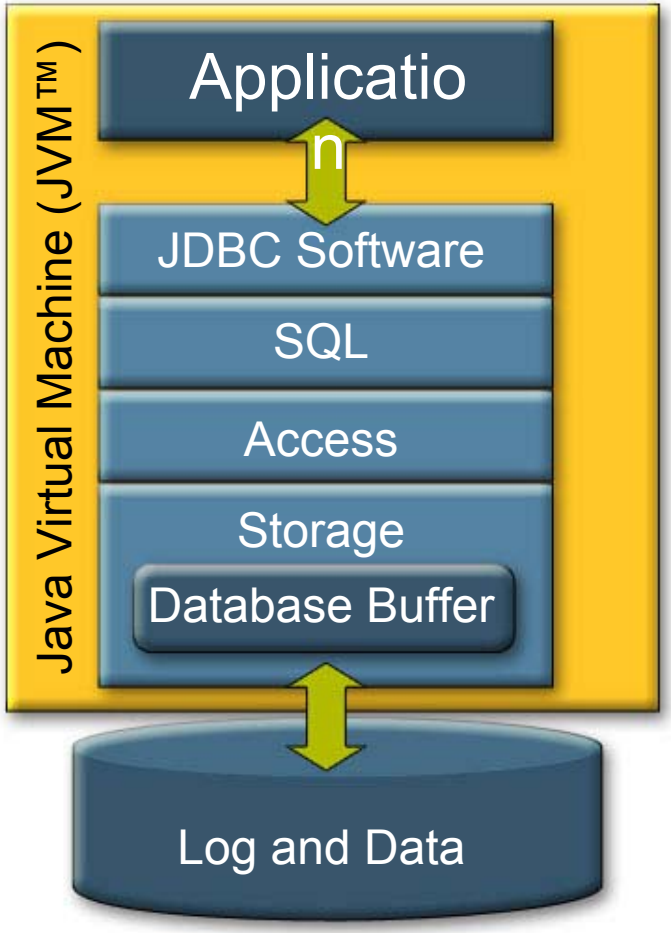
Java DB

- Sun's supported distribution of Apache Derby
  - All development done in the Apache Derby community
- Complete relational database engine
- 100% Java technology
- Bundled in Sun Java Development Kit (JDK™) 6 and GlassFish™ Project
- Supported by NetBeans™ Software, Sun Java Studio Enterprise, Eclipse
- *The database for Java applications* Java DB

Java DB Features

- Complete SQL engine including:
  - Views, triggers, stored procedures, foreign keys
- Multi-user transaction support:
  - All major isolation levels
  - ACID properties
- Security:
  - Data encryption, client authentication, GRANT/REVOKE
- Standard based:
  - Java DataBase Connectivity (JDBC™) 4.0 and SQL92/99/2003/XML

Java DB Architecture: Embedded



- Include derby.jar in your classpath
- Boot the Java DB engine[1)]

```
Class.forName(
  "org.apache.derby.jdbc.
  EmbeddedDriver");
```

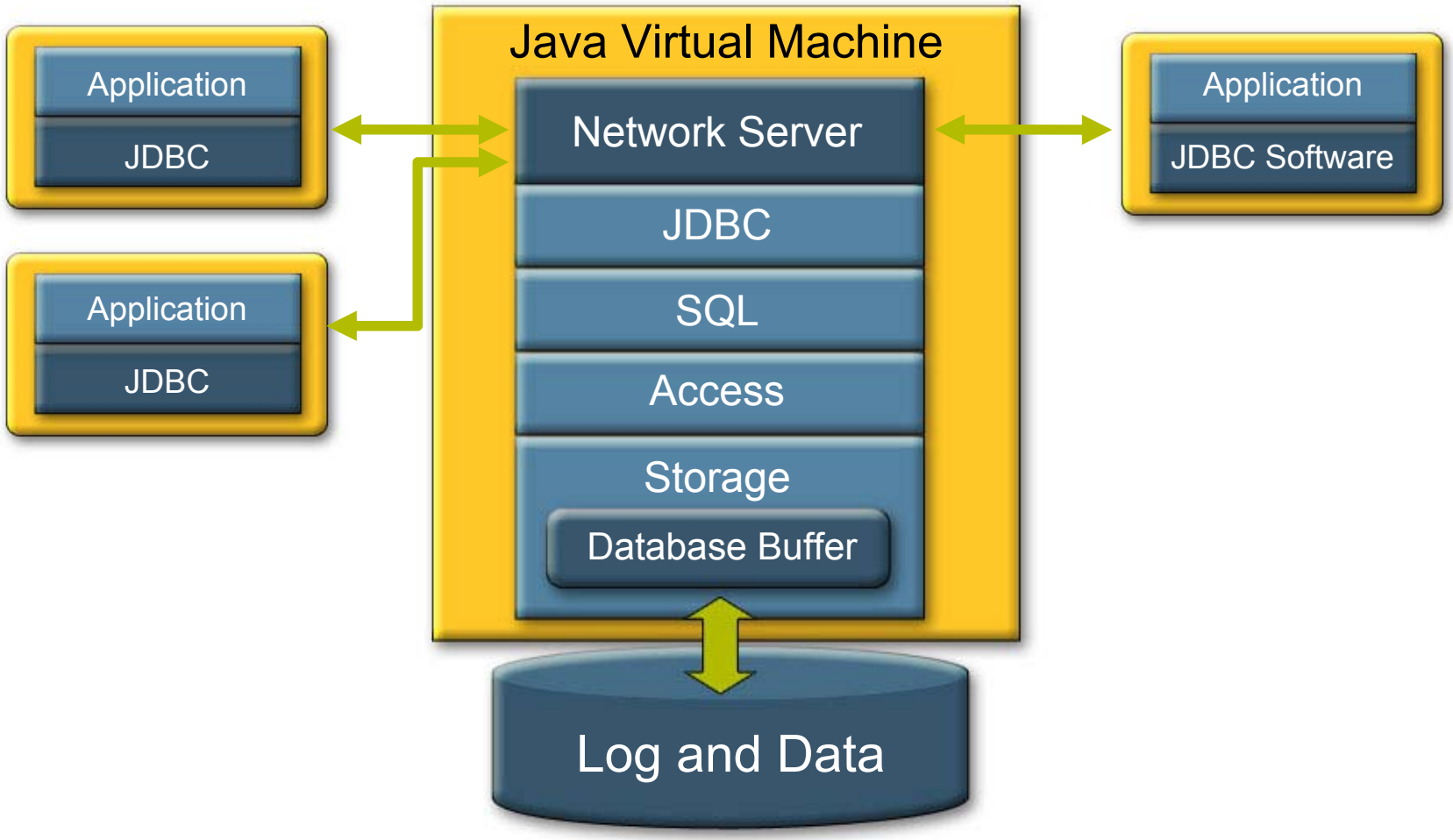
- Create a new database

```
Connection conn =
DriverManager.getConnection(
  "jdbc:derby:dbName; " +
  "create=true");
```

1) Optional when running with JDK version 6

The terms "Java Virtual Machine" and "JVM" mean a Virtual Machine for the Java™ platform.

Java DB Architecture: Client-Server



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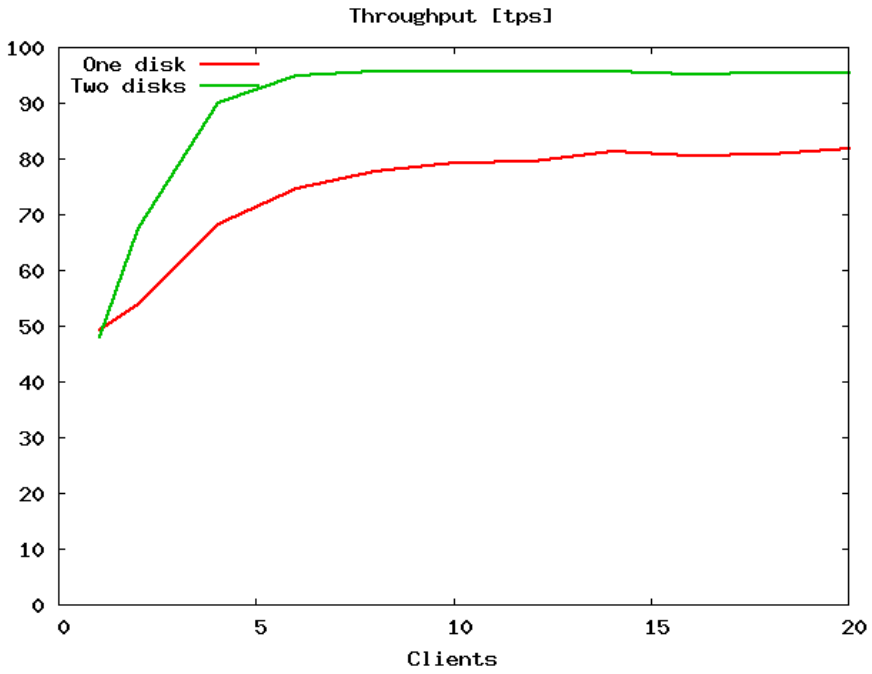
Performance Tip 1:
Separate Data and Log Devices

Log on separate disk:

- Utilize sequential write bandwidth on disk
- Configuration:

  JDBC driver connection url:

  `logDevice=<path>`



Performance tip:

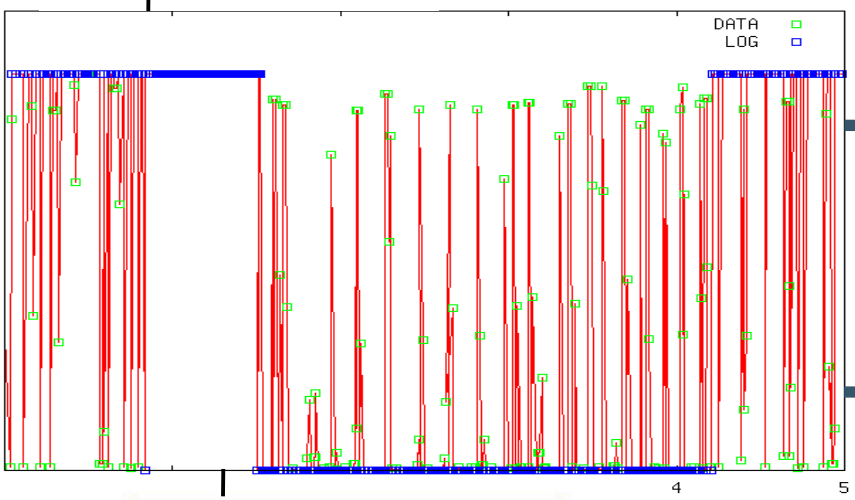
Use separate disks for data and log device

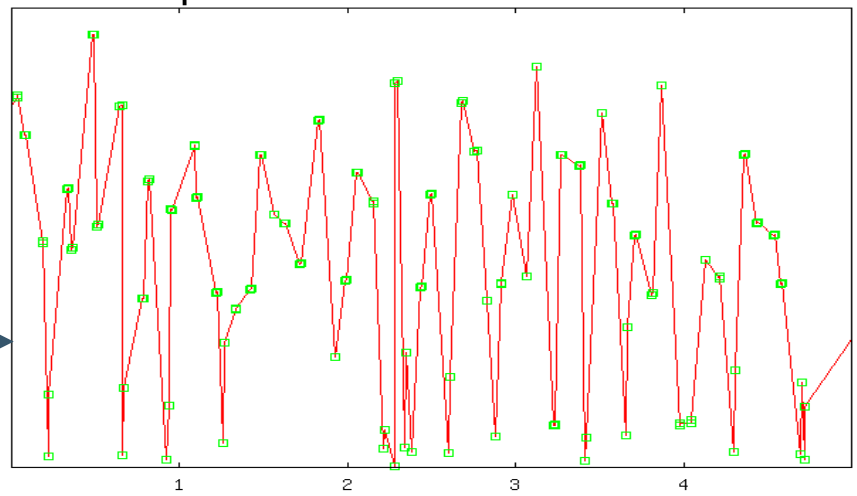
JDBC Driver = a driver supporting the JDBC™ API

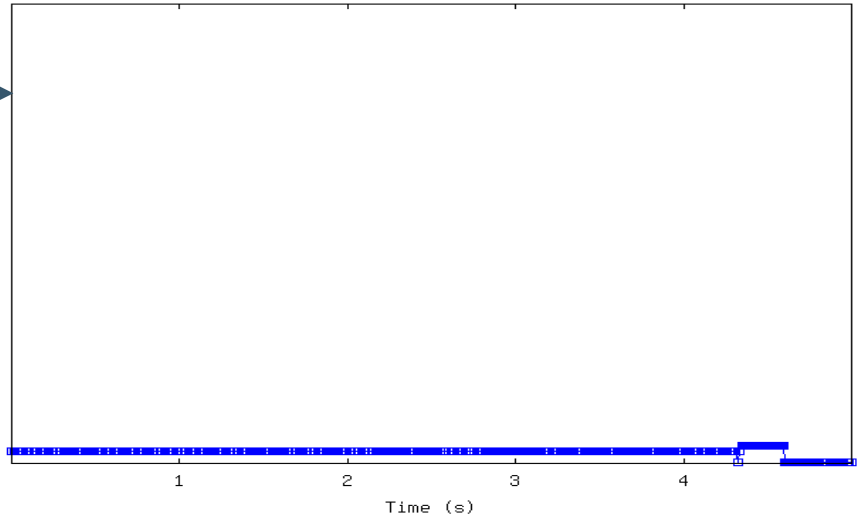
Disk Activity

Data and log on separate disks

Data and log on same disk



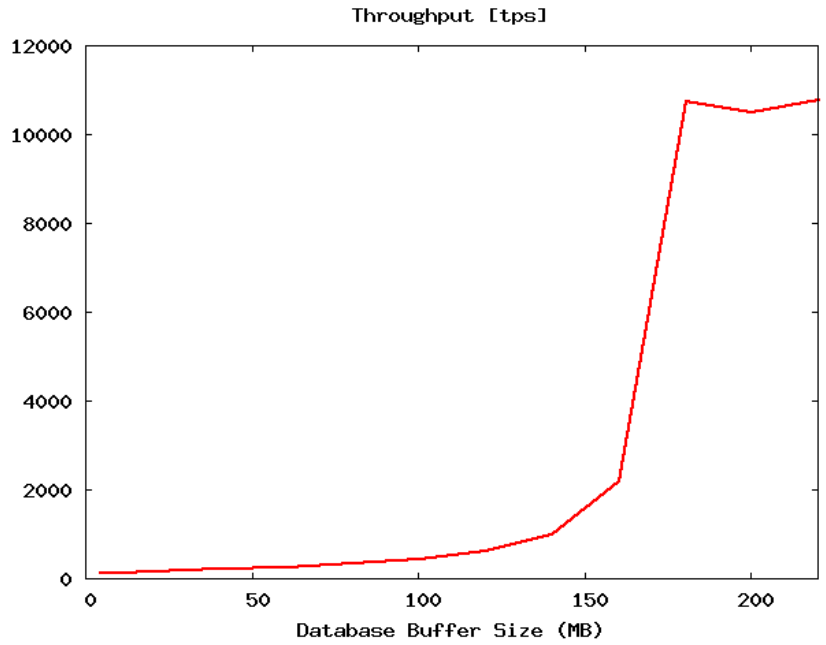




Disk head movement for 5 seconds of database activity

Performance Tip 2:
Tune Database Buffer Size

- **Cache of frequently used data pages in memory**
- **Cache-miss leads to read from disk**
- **Size:**
  - **default 4 MB**
  - `derby.storage.pageCacheSize`



Performance tip:

Increase the size of the database buffer to get frequently accessed data in memory

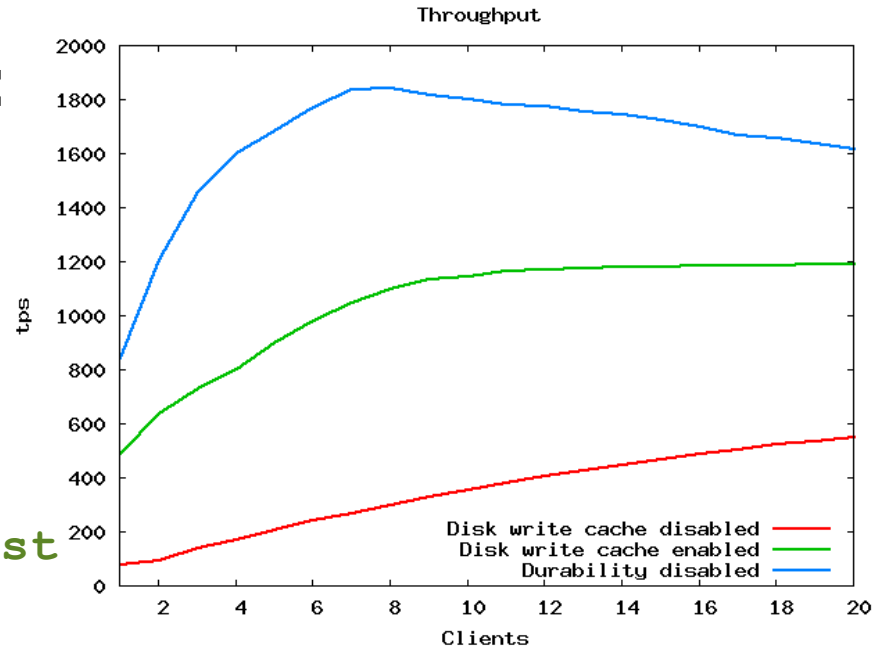
Performance Tip 3:
Trade Durability for Performance

Log device configuration:

- **Disk's write cache:**
  - **Disabled**
  - **Enabled**
- **Disable durability:**

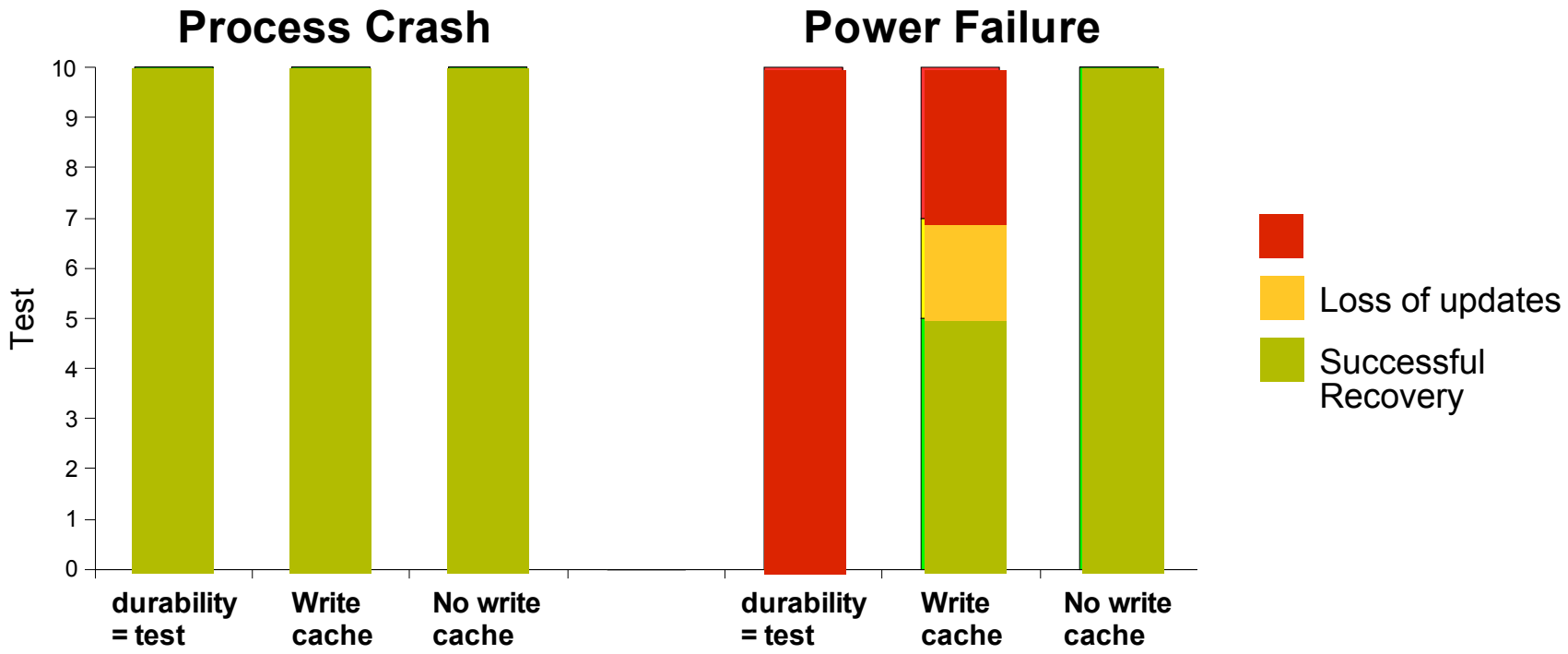
```
derby.system.durability=test
```

  - **log flushed to disk *after* commit**



WARNING: Write cache reduces probability of successful recovery after power failure

Log Device Configuration: Effect on Durability



Durability tip:
Disable the disk's write cache on the log device

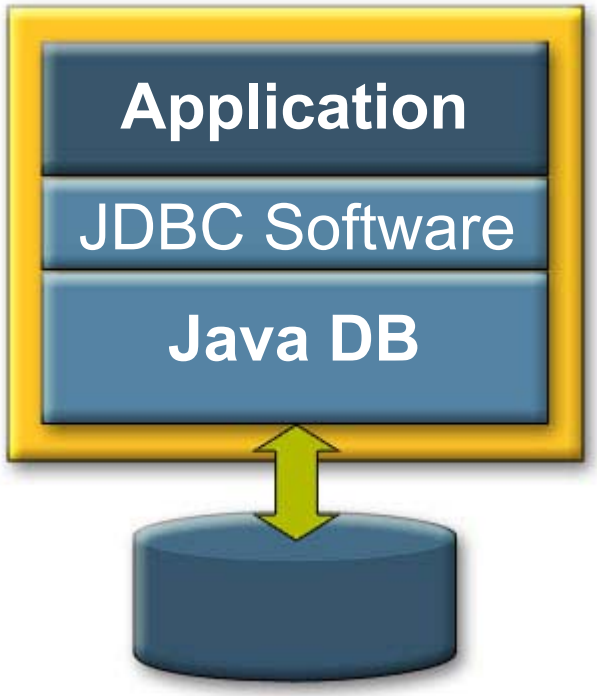
Performance Tip 4:
Use Embedded Java DB

Performance advantages:

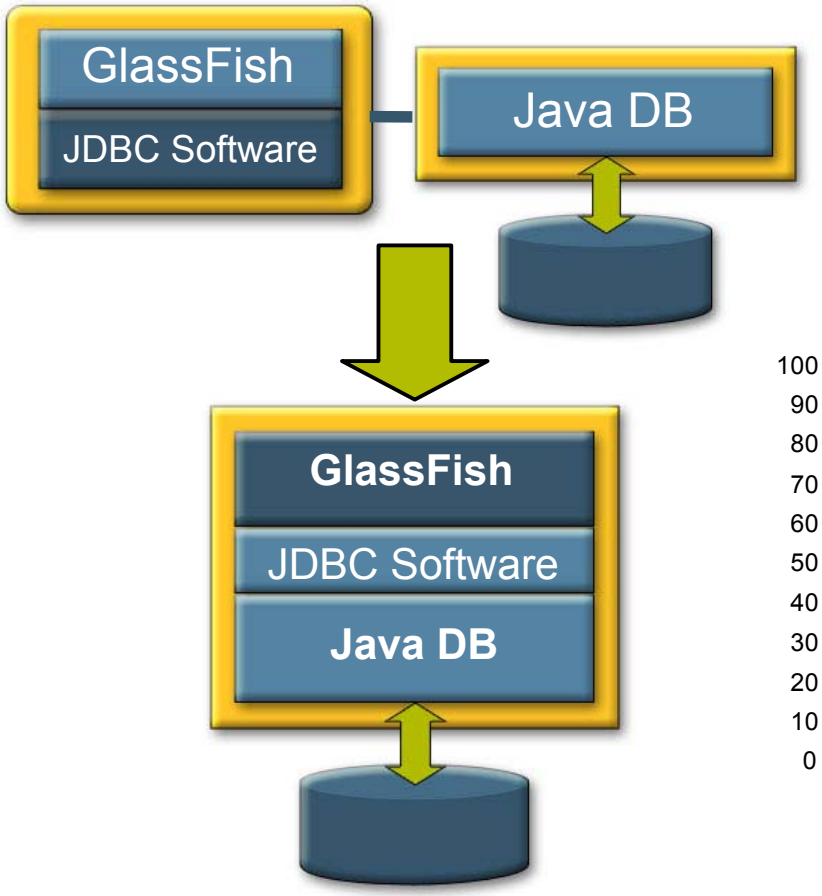
- Saves inter-process or server communication
- Reduces CPU usage
- Reduces hardware cost

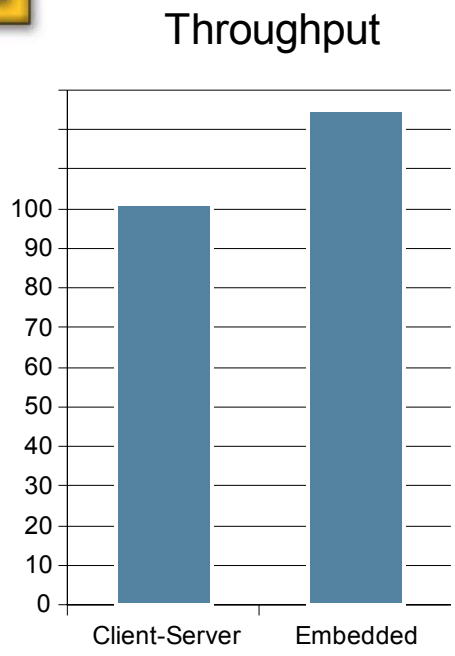
Potential issues:

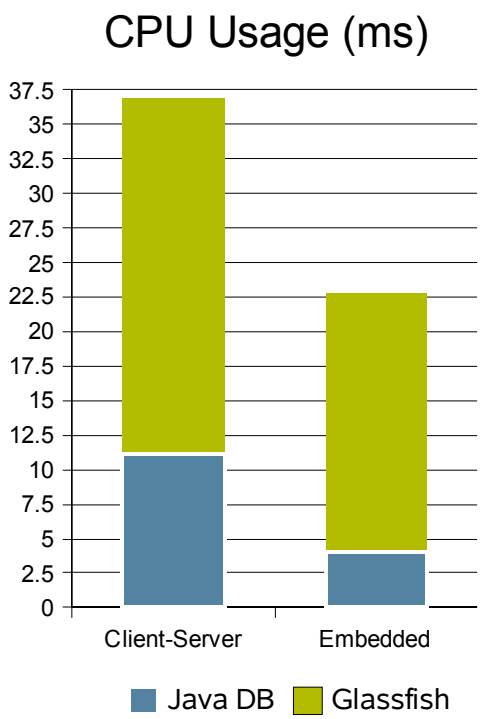
- Scalability (one machine)
- JVM software configuration



Client-Server vs. Embedded: Example







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Performance Tip 5:
Use Prepared Statements

- Compilation of SQL statements is expensive:

```
Statement s = c.createStatement();
while (...) {
   s.executeQuery("SELECT * FROM t WHERE a = " + id);
}
```

  - generates Java bytecode and loads generated classes

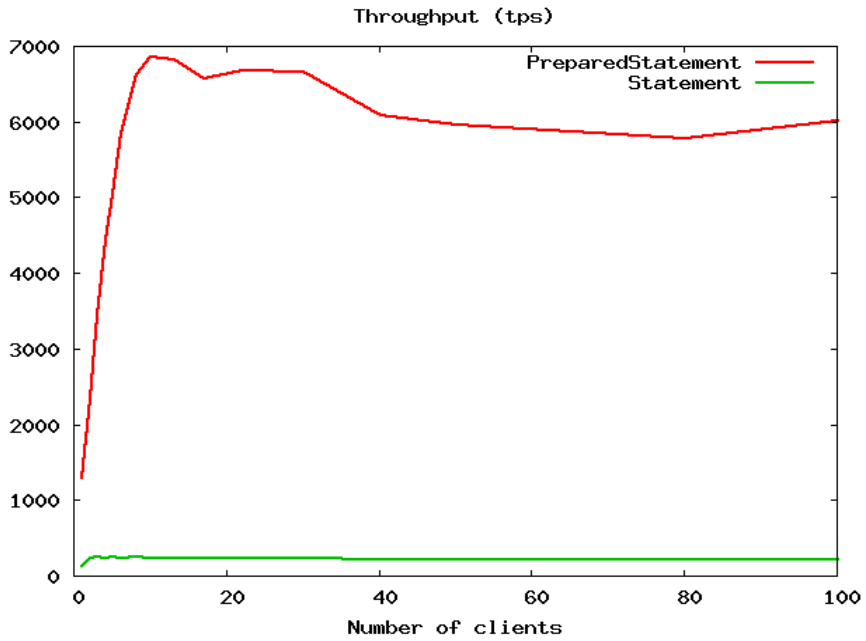
- Prepared statements eliminate this cost:

```
PreparedStatement s =
   c.prepareStatement("SELECT * FROM t WHERE a = ?");
while (...) {
   s.setInt(1, id);
   s.executeQuery();
}
```

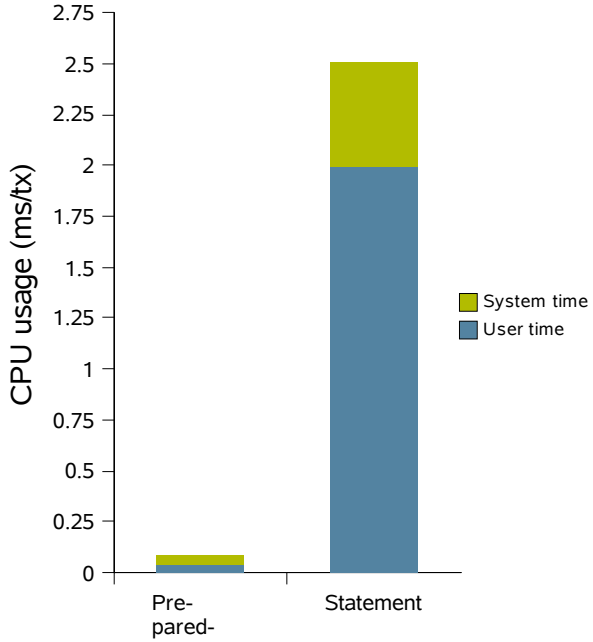
  - generated Java bytecode can be JIT compiled

Use Prepared Statements: Example

CPU Usage



Throughput



Performance tip:
USE prepared statements—and **REUSE** them

Performance Tip 6:
Help the Database to Perform

- Use indexes to optimize frequently used access paths:

```
CREATE INDEX indexName ON tableName (column)
```

  - Table scan: reads the entire table
  - Index: finds the data by reading a few blocks
- Close JDBC software objects after in use
  - Connections, Statements, ResultSets, Streams
- Use transactions—do not rely on auto-commit
  - Particularly for insert/update/delete operations

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Performance Tip 7:
Know the Load

- Know the load on the database:
  - `derby.language.logStatementText=true`
  - **All executed queries written to derby.log**
- Know how the queries are executed:
  - `derby.language.logQueryPlan=true`
- Use OS and Java tools to find resource usage:
  - CPU, memory, disk IO for log and data device

Performance tip:

Use the available tools to understand what the database is doing and where resources are spent

Performance Tip 8:
Query Plan and Run-time Statistics

- Enable/disable tracing of query plan:
  - `SYSCS_UTIL.SYSCS_SET_RUNTIMESTATISTICS(1)`
  - `SYSCS_UTIL.SYSCS_SET_RUNTIMESTATISTICS(0)`
- Enable/disable timing information in query plan:
  - `SYSCS_UTIL.SYSCS_SET_STATISTICS_TIMING(1)`
  - `SYSCS_UTIL.SYSCS_SET_STATISTICS_TIMING(0)`
- Retrieve query plan for individual queries:
  - `SYSCS_UTIL.SYSCS_GET_RUNTIMESTATISTICS()`

Example: Query Plan and Run-time Statistics

```
// enable run-time statistics
Statement s = c.createStatement();
s.executeUpdate("CALL SYSCS_UTIL.SYSCS_SET_RUNTIMESTATISTICS(1)");
s.executeUpdate("CALL SYSCS_UTIL.SYSCS_SET_STATISTICS_TIMING(1)");

// execute query
ResultSet rs = s.executeQuery("SELECT T1.c2 from T1, T2
                               where T1.c2 = T2.c2 and T1.c2 < 800");
while (rs.next()) {}
rs.close();

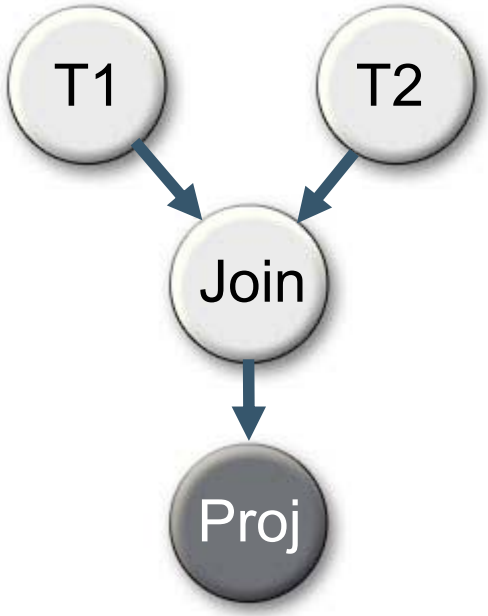
// retrieve query plan and run-time statistics
rs = s.executeQuery("VALUES
                     SYSCS_UTIL.SYSCS_GET_RUNTIMESTATISTICS()");
rs.next();
String str = rs.getString(1);
System.out.println("Query Plan: " + str);
```

Understanding the Query Plan (1)

```
CodeStatement Text:
        SELECT T1.c2 from T1, T2
        where T1.c2 = T2.c2 and T1.c2 < 800
Parse Time: 1
Bind Time: 5
Optimize Time: 16
Generate Time: 3
Compile Time: 25
Execute Time: 52

Project-Restrict ResultSet (4):
Number of opens = 1
Rows seen = 800
Rows filtered = 0

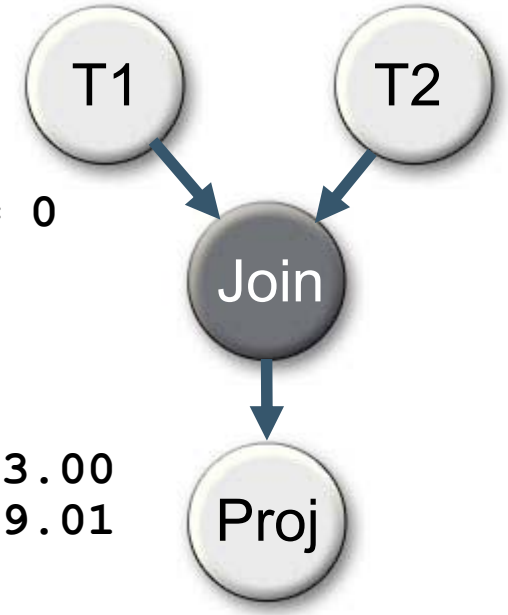
optimizer estimated row count:      753.00
optimizer estimated cost:           349.01
```



Understanding the Query Plan (2)

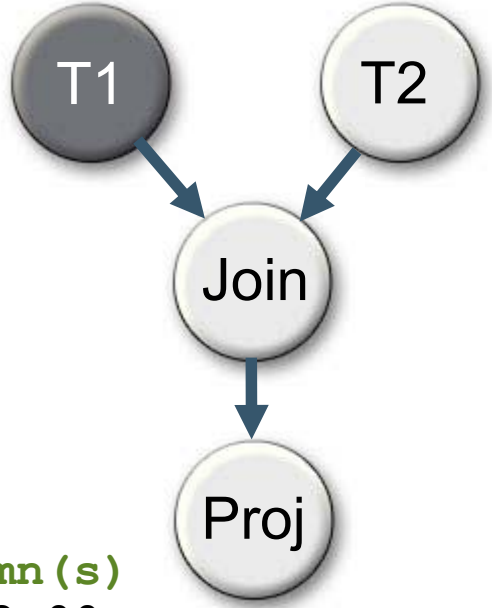
```
Source result set:
    Hash Exists Join ResultSet:
    Number of opens = 1
    Rows seen from the left = 800
    Rows seen from the right = 800
    Rows filtered = 0
    Rows returned = 800
        constructor time (milliseconds) = 0
        open time (milliseconds) = 31
        next time (milliseconds) = 21
        close time (milliseconds) = 0

    optimizer estimated row count:      753.00
    optimizer estimated cost:           349.01
```



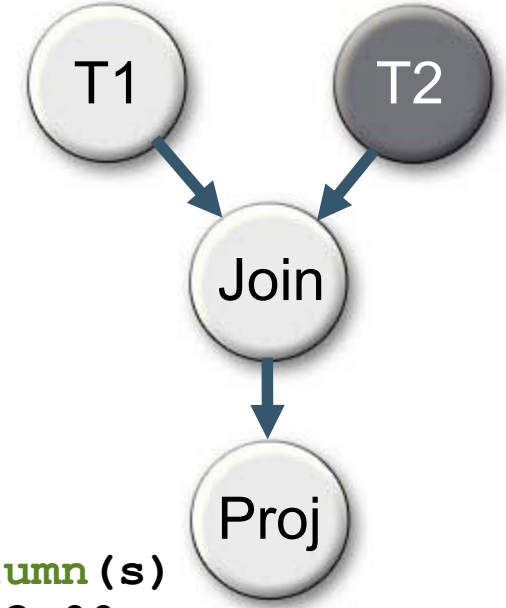
Understanding the Query Plan (3)

```
Right result set:
    Hash Scan ResultSet for T1 using index T1_i2 at read
committed isolation level using instantaneous share row
locking:
    Number of opens = 800
    Hash table size = 800
    Rows seen = 800
    scan information:
        Number of columns fetched=1
        Number of pages visited=6
        Number of rows qualified=800
        Number of rows visited=801
        Scan type=btree
        start position: None
        stop position: >= on first 1 column(s)
    optimizer estimated row count:      753.00
    optimizer estimated cost:           186.27
```



Understanding the Query Plan (4)

```
Left result set:
    Index Scan ResultSet for T2 using index T2_i2 at read
committed isolation level using instantaneous share row
locking chosen by the optimizer
    Number of opens = 1
    Rows seen = 800
    Rows filtered = 0
    scan information:
        Number of columns fetched=1
        Number of pages visited=6
        Number of rows qualified=800
        Number of rows visited=801
        Scan type=btree
        start position: None
        stop position:  >= on first 1 column(s)
    optimizer estimated row count:      753.00
    optimizer estimated cost:           162.74
```



Performance Tip 9:
Optimizer Overrides

- Override execution strategy selected by optimizer
- Force use of specific index:

```
SELECT * FROM t1 --DERBY-PROPERTIES index=t1_c1
WHERE c1=1
```

- Force use of constraint:

```
SELECT * FROM t1 --DERBY-PROPERTIES constraint=c
WHERE c1=1 and c2=3
```

- Force specific JOIN order and JOIN strategy:

```
SELECT * FROM --DERBY-PROPERTIES joinOrder=FIXED
t1,t2 --DERBY-PROPERTIES joinStrategy=NESTEDLOOP
WHERE t1.c1=t2.c1
```

  - **Join strategies: HASH and NESTEDLOOP**

Optimizer Overrides Example

- ```
  SELECT t1.c2 FROM --DERBY-PROPERTIES joinOrder=FIXED
  t1, t2 --DERBY-PROPERTIES joinStrategy=NESTEDLOOP
  WHERE t1.c2 = t2.c2
  ```

Optimizer overide	Estimated cost	CPU (ms)
None	2311	12.0
joinOrder=FIXED	2505	12.0
joinStrategy=NESTEDLOOP	3404	14.7
FIXED and NESTEDLOOP	3404	14.4

Performance tip:
Use optimizer overrides—**but only** when needed
  ```

Performance Tip 10: Understand Locking Issues

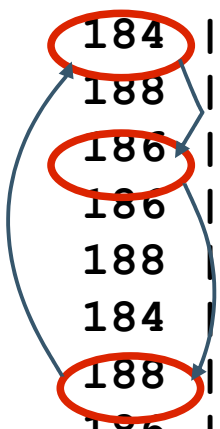
- Lock-based concurrency control
- Isolation level:
  - Reducing isolation level increases concurrency
- Lock escalation:
  - Default: escalation from **row locks** to **table locks** when 5000 locks are set on the table
  - `derby.locks.escalationThreshold=100`
  - `LOCK TABLE t1 IN {SHARE|EXCLUSIVE} MODE`
- Deadlock tracing:
  - `derby.locks.monitor=true`
  - `derby.locks.deadlockTrace=true`

Understand Locking Issues

Retrieve lock information:

```
SELECT * FROM SYSCS_DIAG.LOCK_TABLE
```

XID	TYPE	MODE	TABLENAME	LOCKNAME	STATE	INDEXNAME
186	ROW	X	T2	(1,9)	GRANT	
184	ROW	S	T2	(1,9)	WAIT	
188	ROW	X	T1	(1,11)	GRANT	
186	ROW	S	T1	(1,11)	WAIT	
186	ROW	S	T1	(1,1)	GRANT	SQL070425023
188	ROW	S	T1	(1,1)	GRANT	SQL070425023
184	ROW	X	T1	(1,7)	GRANT	
188	ROW	S	T1	(1,7)	WAIT	
186	TABLE	IX	T2	Tablelock	GRANT	
184	TABLE	IS	T2	Tablelock	GRANT	



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Performance Improvements

Java DB 10.3

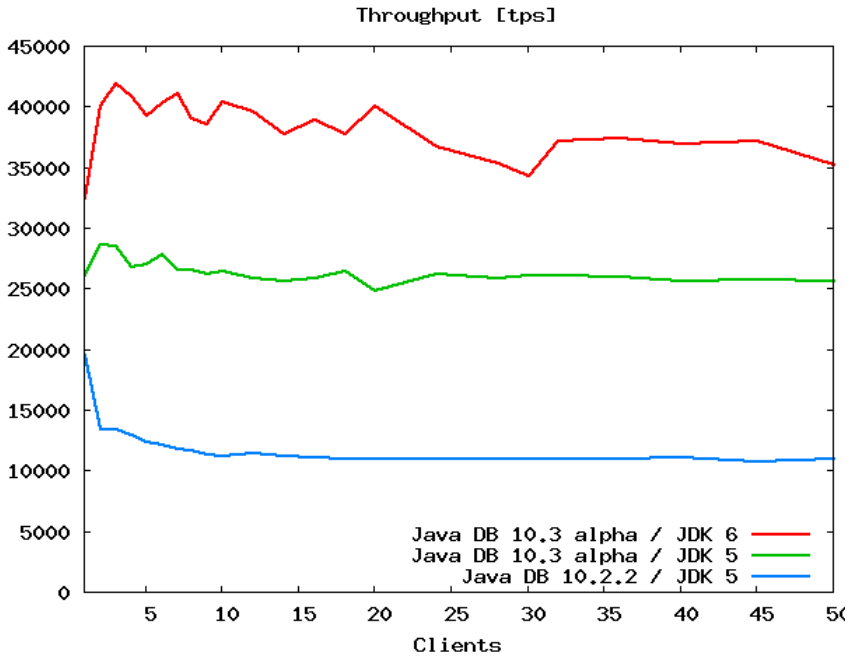
- Embedded:
  - Reduced synchronization and context switches
  - Reduced CPU usage
  - Reduced number of disk updates to log device
  - Concurrent read/writes on data device
- Client-server:
  - Improved streaming of LOBs
- SQL Optimizer:
  - Improved optimization

30–150% increased throughput on simple queries

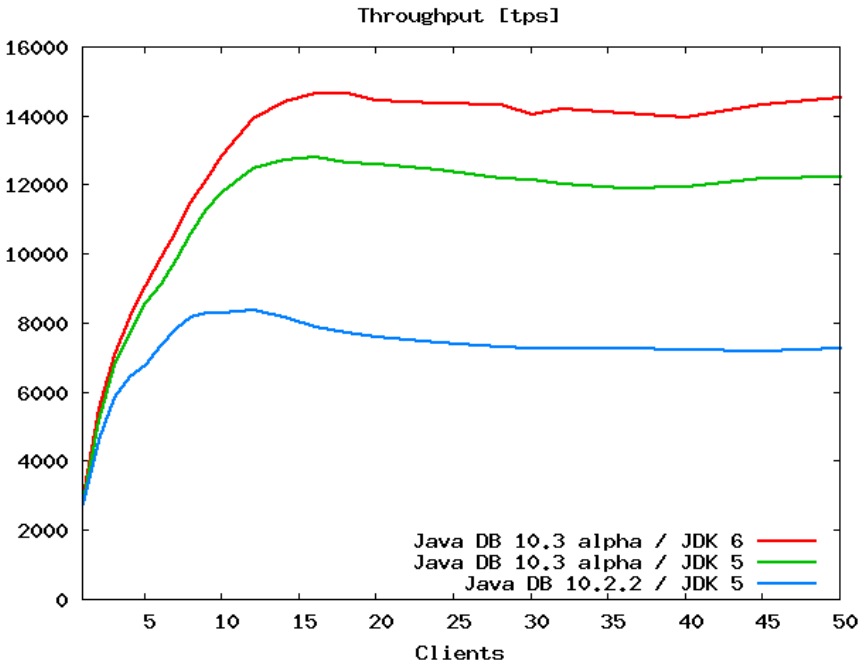
Performance Improvement: Example

Upgrading to Sun JDK version 6 and Java DB 10.3 alpha

Java DB embedded:



Java DB client-server:



Load: Select one record in a table

Comparing Performance

Open-Source Databases

Databases:

- **Java DB 10.3 alpha**
  - **Embedded**
  - **Client-server**
- **PostgreSQL 8.1.8**
- **MySQL 5.0.33**
  - **With InnoDB**

Load clients:

1. Select load:

1 single-record select

2. Update load:

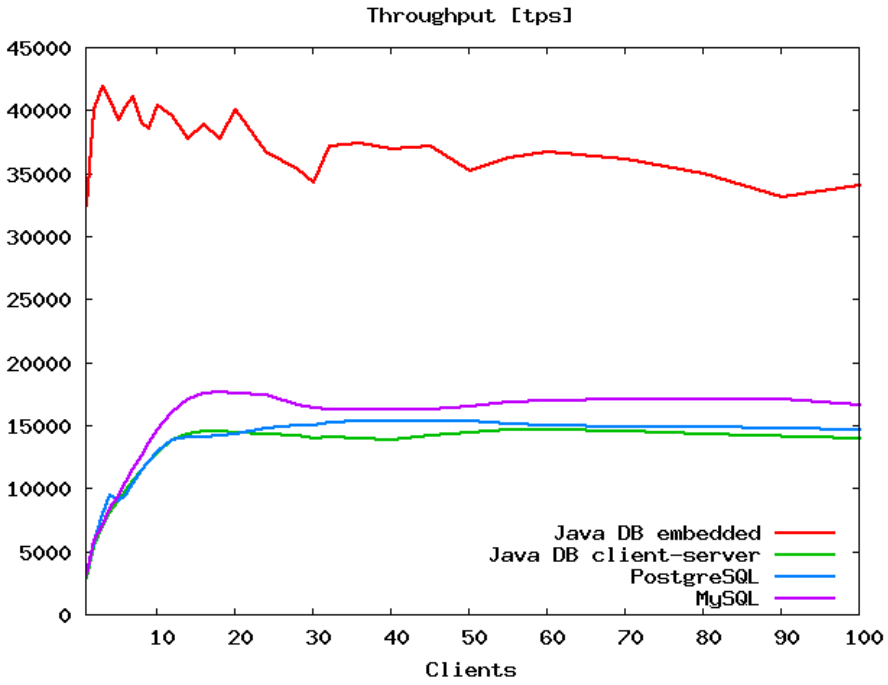
3 updates, 1 insert, 1 select

Test Configuration:

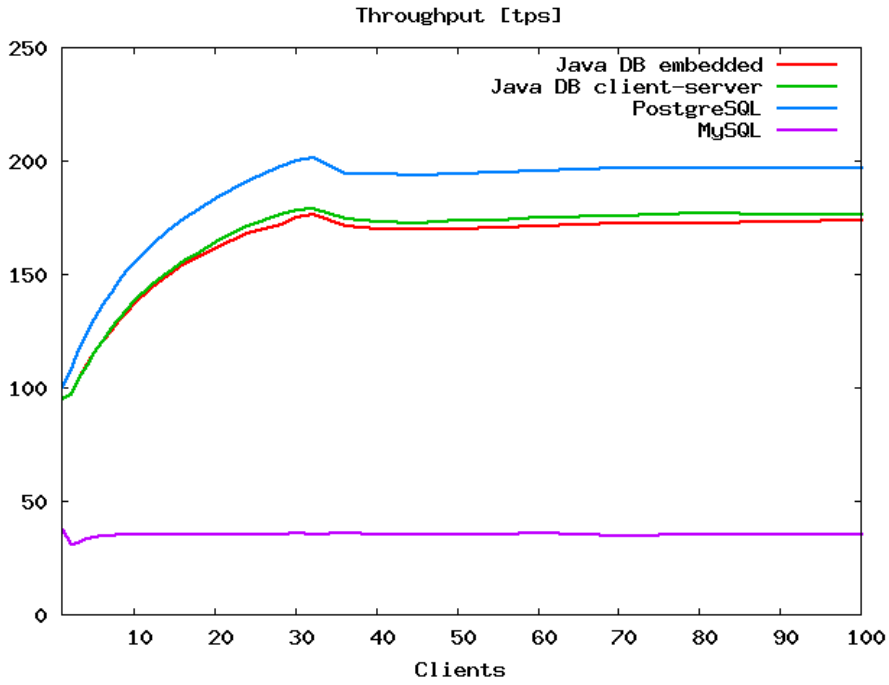
- **“Out of the box”**
- **50 MB database buffer**
- **Log and data on separate disks**

Throughput: Single-record Select

Main-memory database (10 MB):

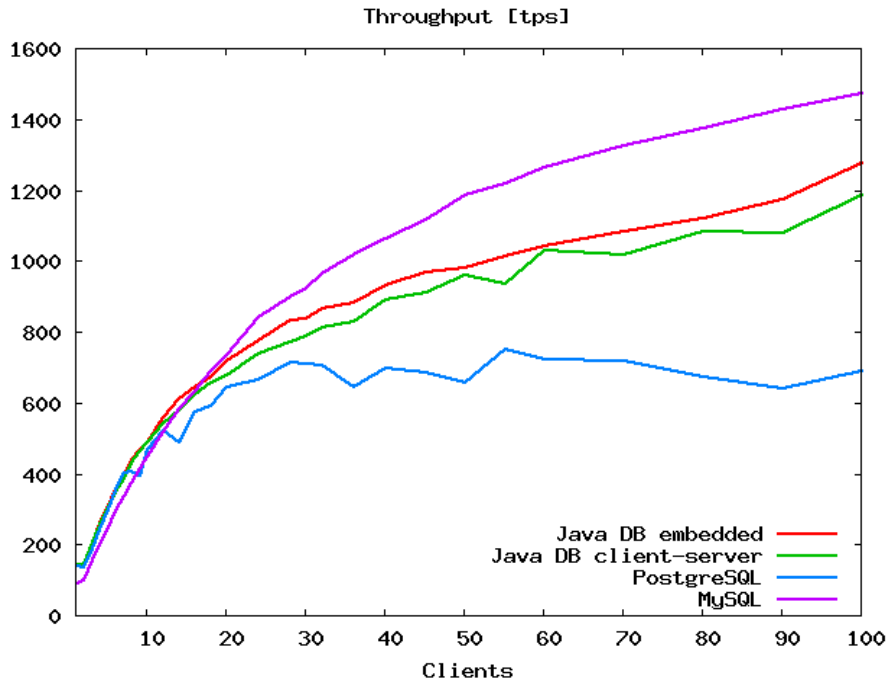


Disk-based database (10 GB):

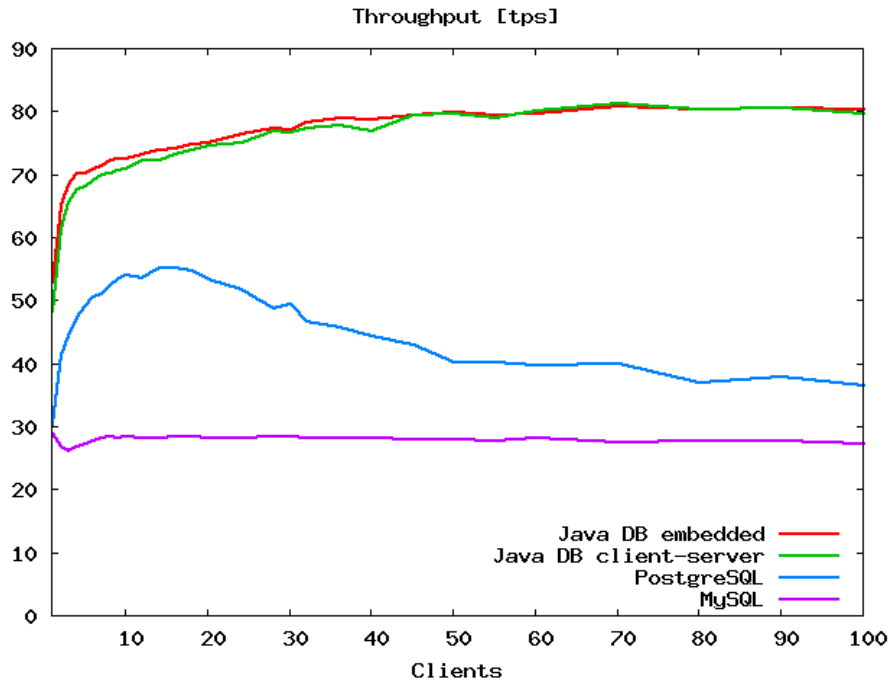


Throughput: Update Load

Main-memory database (10 MB):



Disk-based database (10 GB):



Summary

- Trade-offs between durability and performance
  - Know your requirements and select carefully
- Know what influences performance
  - Java DB configuration
  - User application
- Tips and tools to find and solve performance bottlenecks

Java DB Performs!—Comparable to competition

For More Information

- Java DB: http://developers.sun.com/javadb/
- Apache Derby: http://db.apache.org/derby/
- derby-user@apache.org
  - Discuss experiences, get help, give feedback
- derby-dev@apache.org
  - Discuss developer issues

Q&A

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