Digesting an Open-Source Fair-Use TPC-E Implementation: DBT-5

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Introductions

• Mark Wong
  • Database Performance specialist
  • Previously worked at OSDL (presently, Linux Foundation)

• Rilson Nascimento
  • MSc Candidate in the Federal University of Pernambuco, Brazil
  • Previously worked at Itautec Performance Lab
Question Policy

- Interrupt us if something is unclear
- Keep long generic questions to the end
- Approach us during the conference
- Write us
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  - rilson.nascimento@gmail.com
Why TPC-E?

- http://www.tpc.org/tpce/spec/TPCEpresentation.ppt
- TPC-C is over 14 years old
- Not practical to modify existing workload
- Transaction are too lightweight by today's standards
- CPU performance grew according to Moore's Law
- Disk latency did not
- Reduce cost/complexity of running benchmark
- Encourage DB uses which is more representative of what customer do
TPC-E vs. DBT-5

- TPC-E is a benchmarking specification for generating marketing collateral
- DBT-5 a test kit to help improve PostgreSQL
TPC-E Overview

TPC-E Goals

- OLTP Database-centric workload
- Comparability of results
- Familiar business model – easy to understand
- Reduce cost of running benchmark
- Enhance schema complexity
- Be more representative to what customers do
TPC-E Overview (2)

- Business Model – Financial Market
Business Model – Financial Market
TPC-E Overview (4)

- Business Model – Financial Market

Invoke the following transactions ...

**READ-WRITE**
- Market-Feed
- Trade-Order
- Trade-Result
- Trade-Update

**READ-ONLY**
- Broker-Volume
- Customer-Position
- Market-Watch
- Security-Detail
- Trade-Lookup
- Trade-Status

... against the following data

- Customer Data
- Brokerage Data
- Market Data
Business Model – Comparison with TPC-C

**TPC-C**
- Wholesale supplier
- Organized by
  - Warehouses
    - Districts
  - Customers

**TPC-E**
- Brokerage House
- Organized by
  - Customers
    - Accounts
    - Securities
    - Companies
Database Schema – Comparison with TPC-C

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>TPC-E</th>
<th>TPC-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tables</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td>Columns</td>
<td>188</td>
<td>92</td>
</tr>
<tr>
<td>Min Cols/Table</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Max Cols/Table</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>Data Type Count</td>
<td>Many</td>
<td>4</td>
</tr>
<tr>
<td>Data Types</td>
<td>UID, CHAR, NUM, DATE, BOOL, LOB</td>
<td>UID, CHAR, NUM, DATE</td>
</tr>
<tr>
<td>Primary Keys</td>
<td>33</td>
<td>8</td>
</tr>
<tr>
<td>Foreign Keys</td>
<td>50</td>
<td>9</td>
</tr>
<tr>
<td>Tables w/ Foreign Keys</td>
<td>27</td>
<td>7</td>
</tr>
<tr>
<td>Check Constraints</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Referential Integrity</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
TPC-E Overview (7)

**Database Tables and Scaling**

<table>
<thead>
<tr>
<th>Customer</th>
<th>Broker</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNT_PERMISSION</td>
<td>BROKER</td>
<td>COMPANY</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>CASH TRANSACTION</td>
<td>COMPANY_COMPETITOR</td>
</tr>
<tr>
<td>CUSTOMERACCOUNT</td>
<td>CHARGE</td>
<td>DAILY_MARKET</td>
</tr>
<tr>
<td>CUSTOMERTAXRATE</td>
<td>COMMISSION_RATE</td>
<td>EXCHANGE</td>
</tr>
<tr>
<td>HOLDING</td>
<td>SETTLEMENT</td>
<td>FINANCIAL</td>
</tr>
<tr>
<td>HOLDING_HISTORY</td>
<td>TRADE</td>
<td>INDUSTRY</td>
</tr>
<tr>
<td>HOLDING_SUMMARY</td>
<td>TRADE_HISTROY</td>
<td>LAST_TRADE</td>
</tr>
<tr>
<td>WATCH_ITEM</td>
<td>TRADE_REQUEST</td>
<td>NEWS_ITEM</td>
</tr>
<tr>
<td>WATCH_LIST</td>
<td>TRADE_TYPE</td>
<td>NEWS_XREF</td>
</tr>
</tbody>
</table>

**Legend:**
- Fixed Tables
- Growing Tables
- Scaling Tables
## Transactions

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Weight</th>
<th>Access</th>
<th>Mix%</th>
<th>90% Response Time Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade-Order</td>
<td>Heavy</td>
<td>R/W</td>
<td>10.1</td>
<td>2 sec.</td>
</tr>
<tr>
<td>Trade-Result</td>
<td>Heavy</td>
<td>R/W</td>
<td>10</td>
<td>2 sec.</td>
</tr>
<tr>
<td>Trade-Lookup</td>
<td>Medium</td>
<td>R/O</td>
<td>8</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Trade-Update</td>
<td>Medium</td>
<td>R/W</td>
<td>2</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Trade-Status</td>
<td>Light</td>
<td>R/O</td>
<td>19</td>
<td>1 sec.</td>
</tr>
<tr>
<td>Customer Position</td>
<td>Mid-Heavy</td>
<td>R/O</td>
<td>13</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Broker Volume</td>
<td>Mid-Heavy</td>
<td>R/O</td>
<td>4.9</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Security Detail</td>
<td>Medium</td>
<td>R/O</td>
<td>14</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Market Feed</td>
<td>Medium</td>
<td>R/W</td>
<td>1</td>
<td>2 sec.</td>
</tr>
<tr>
<td>Market Watch</td>
<td>Medium</td>
<td>R/O</td>
<td>18</td>
<td>3 sec.</td>
</tr>
<tr>
<td>Data Maintenance</td>
<td>Light</td>
<td>R/W</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trade-Cleanup</td>
<td>Medium</td>
<td>R/W</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
TPC-E Overview (9)

- Metrics
  - Performance (throughput), expressed in tpsE
  - Price/Performance, expressed in price/tpsE
  - Availability Date, when all products necessary to achieve the stated performance will be available
TPC-E Overview (10)

- Sample Test Configuration
Sample Test Configuration, Variation I
TPC-E Overview (12)

- Sample Test Configuration, Variation II
● Sample Test Configuration, Variation III
TPC-E Overview – Highlights and Benefits

- Financial business model
- Rich transaction set
- Diverse, realistic schema

- Server-centric workload with DB focus
- Realistic application model
- Rebalanced hardware configuration
- Specification provides code where sponsor creativity is not being tested
DBT-5 Architecture
Database creation is vendor specific, but...
Database population can be vendor neutral
TPC-E includes a data generator for database loading
  • C++ code to generate data
  • Flat file generation is provided
  • Sponsor is free to create to customize interface
Libpqxx: C++ API for PostgreSQL
Experimental Results

- **Test bed**
  - Processor: Intel(R) Xeon(TM) CPU 2.80GHz w/HT
  - Memory: 3 GB
  - Disk: 14 disks in hw RAID 0 (data)
  - Operating System: Linux 2.6.20-gentoo-r4
  - Database Engine: PostgreSQL 8.2.3
  - Database Size: 2806 MB (1000 customers, 50 ITD)
Experimental Results – DBT-5 Report

Database Test 5 Report

Fri May 11 11:11:06 BRT 2007

Results Summary

Trade Result Transactions per Second (trtps): 2.02
Scale Factor: 1000
Test Duration (min.): 30.00
Ramp-up Time (min.): 0.02
Total Unknown Errors: 20

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Mix %</th>
<th>Total</th>
<th>Response Time</th>
<th>Rollbacks</th>
<th>Charts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mix %</td>
<td>Total</td>
<td>Average (s)</td>
<td>90th %</td>
<td>Total %</td>
</tr>
<tr>
<td>Trade Order</td>
<td>10.11</td>
<td>3831</td>
<td>0.02</td>
<td>0.04</td>
<td>38.99</td>
</tr>
<tr>
<td>Trade Result</td>
<td>9.60</td>
<td>3635</td>
<td>0.04</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Trade Lookup</td>
<td>8.09</td>
<td>3063</td>
<td>0.35</td>
<td>0.94</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Charts:
- Response Time
- Time Distribution
### Experimental Results

#### Response Time (s)

<table>
<thead>
<tr>
<th>Transaction</th>
<th>%</th>
<th>Average : 90th %</th>
<th>Total</th>
<th>Rollbacks</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Order</td>
<td>10.21</td>
<td>0.021 : 0.043</td>
<td>3869</td>
<td>38</td>
<td>0.99</td>
</tr>
<tr>
<td>Trade Result</td>
<td>9.59</td>
<td>0.040 : 0.083</td>
<td>3635</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Trade Lookup</td>
<td>8.08</td>
<td>0.346 : 0.945</td>
<td>3063</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Trade Update</td>
<td>1.96</td>
<td>0.313 : 0.677</td>
<td>743</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Trade Status</td>
<td>19.03</td>
<td>0.006 : 0.010</td>
<td>7212</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Customer Position</td>
<td>12.89</td>
<td>0.005 : 0.009</td>
<td>4885</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Broker Volume</td>
<td>4.84</td>
<td>0.003 : 0.004</td>
<td>1835</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Security Detail</td>
<td>14.43</td>
<td>0.014 : 0.018</td>
<td>5467</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Market Feed</td>
<td>0.96</td>
<td>0.055 : 0.090</td>
<td>363</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Market Watch</td>
<td>17.99</td>
<td>0.009 : 0.017</td>
<td>6817</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Data Maintenance</td>
<td>n/a</td>
<td>0.036 : 0.122</td>
<td>9</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

2.02 trade-result transactions per second (TRTPS)

30.0 minute duration

20 total unknown errors

1 second(s) ramping up
Experimental Results – Response Time Plots

- Trade Result Transaction Response Time
- Trade Lookup Transaction Response Time
- Trade Update Transaction Response Time
Experimental Results – System Statistics
Research

- A scientific article portraying DBT-5 was accepted in the 27th Brazilian Computer Society Conference, that will be held in Rio de Janeiro in June 2007

- Rilson's Master's dissertation is employing DBT-5: Synthesizing Representative I/O Workloads for TPC-E
Future Work

- Update the workload to the latest TPC-E specification
  - EGen
  - Functions
- Write the Functions in C (in progress)
- Tune indexes/functions
- Support other databases
Resources

- **DBT-5**
  svn co https://osdldbt.svn.sourceforge.net/svnroot/osdldbt/trunk/dbt5 dbt5

- **libpqxx: C++ API for PostgreSQL**
  http://pqxx.org/

- **TPC-E Specification**
  http://www.tpc.org/tpce/spec/TPCE-v0.32.2g.pdf (PDF)
  http://www.tpc.org/tpce/spec/TPCE-v0.32.2g.doc (DOC)
Bibliography

- TPC BENCHMARK™ E Standard Specification-Version 1.0.0
- TPC Site - www.tpc.org
Thank you! :)

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