
Trish Hogan, IBM Corporation

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Overview of Transaction Processing

• Past
• Present
• Future
Past: Pre-TPC TP1 and DebitCredit

- **TP1** – batch debit/credit, no network, no user interaction, no run rules
- **DebitCredit** – April 1985
  - Total System Cost + 5 years Maintenance
  - Scale up rules
  - 95% of transactions complete in 1 second
  - No validation that it was run correctly
Past: TPC-A

- Nov. 1989 TPC-A
  - Based on DebitCredit
  - 90% of transactions complete in 2 seconds
  - Added some ACID requirements
  - Publicly disclosed FDR
- July 1990 first TPC-A results
- ~300 TPC-A results published
Past: TPC-B

• Aug. 1990 TPC-B
  – TPC-A results just started being published
  – Based on TP1 so no end users at a terminal going over a network
  – Mid 1991 first TPC-B result
  – ~ 130 TPC-B results
Past and Present: TPC-C

- July 1992 TPC-C
  - Wholesale Supplier model
  - Started with terminals moved to html
  - Sep. 1992 first TPC-C result
  - Nearly 700 TPC-C results
  - Number of publications beginning to drop
  - Used for engineering work and big splash launches
Present

- End Users on Web, phone, appliance…
- Global access
- More complex transactions
- Bigger databases
- RAID protected
- Database constraints enforced
Present and Future: TPC-E

• Feb. 2007 TPC-E
  • Brokerage house model
  • OLTP Database-centric workload
  • Comparability of results (*)
  • Reduce cost/complexity of running benchmark
  • Enhance schema complexity
• Jul. 2007 first TPC-E result

(*) TPC-E results are intended for OLTP database testing and are not an indicator for past or future market performance, nor should they be used as such.
## Present and Future

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>TPC-C</th>
<th>TPC-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model</td>
<td>Wholesale supplier</td>
<td>Brokerage house</td>
</tr>
<tr>
<td>Number of database tables</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>Number of database columns</td>
<td>92</td>
<td>188</td>
</tr>
<tr>
<td>Minimum columns per table</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Maximum columns per table</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Datatype count</td>
<td>4</td>
<td>Many</td>
</tr>
<tr>
<td>Primary keys</td>
<td>8</td>
<td>33</td>
</tr>
<tr>
<td>Foreign keys</td>
<td>9</td>
<td>50</td>
</tr>
<tr>
<td>Tables with foreign keys</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>Check constraints</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Referential integrity</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Database roundtrips per transaction</td>
<td>One</td>
<td>One or many</td>
</tr>
<tr>
<td>Number of transactions</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Number of physical I/Os</td>
<td>5x</td>
<td>x</td>
</tr>
<tr>
<td>RAID requirements</td>
<td>Database log only</td>
<td>Everything</td>
</tr>
<tr>
<td>Timed database recovery</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>TPC-provided code</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
TPC-E Business Model – Financial Market

Customers

- Customer Request
- Brokerage Response

Brokerage Response

Stock Exchange

- Market Response
- Ticker Feed

Brokerage Request

- Asynchronous Txns
  - B2B Environment
  - Send Trade to Market
  - Receive Trade Result

Brokerage House

- Customer Request
- Brokerage Request

Synchronous Txns
- C2B Environment
- Customer Initiated
- Request a Trade
- Check Status of Trade
- Portfolio Summary
TPC-E Business Model – Financial Market

- Customers
  - Customer Request
  - Brokerage Response

- Stock Exchange
  - Market Response
  - Brokerage Request
  - Ticker Feed

- Brokerage House
  - Customer Request
  - Brokerage Request
  - Ticker Feed
  - Market Response

OLTP Benchmarks
### TPC-E Database Scaling

<table>
<thead>
<tr>
<th>Customer</th>
<th>Broker</th>
<th>Market</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNT_PERMISSION</td>
<td>BROKER</td>
<td>COMPANY</td>
<td>SECTOR</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>CASH_TRANSACTION</td>
<td>COMPANY_COMPETITOR</td>
<td>SECURITY</td>
</tr>
<tr>
<td>CUSTOMER_ACCOUNT</td>
<td>CHARGE</td>
<td>DAILY_MARKET</td>
<td></td>
</tr>
<tr>
<td>CUSTOMER_TAXRATE</td>
<td>COMMISSION_RATE</td>
<td>EXCHANGE</td>
<td></td>
</tr>
<tr>
<td>HOLDING</td>
<td>SETTLEMENT</td>
<td>FINANCIAL</td>
<td>Dimension</td>
</tr>
<tr>
<td>HOLDING_HISTORY</td>
<td>TRADE</td>
<td>INDUSTRY</td>
<td>ADDRESS</td>
</tr>
<tr>
<td>HOLDING_SUMMARY</td>
<td>TRADE_HISTORY</td>
<td>LAST_TRADE</td>
<td>STATUS_TYPE</td>
</tr>
<tr>
<td>WATCH_ITEM</td>
<td>TRADE_REQUEST</td>
<td>NEWS_ITEM</td>
<td>TAXRATE</td>
</tr>
<tr>
<td>WATCH_LIST</td>
<td>TRADE_TYPE</td>
<td>NEWS_XREF</td>
<td>ZIP_CODE</td>
</tr>
</tbody>
</table>

**Legend:**
- **Fixed Tables**
- **Growing Tables**
- **Scaling Tables**
Database – Content

• Populated with pseudo-real data
• Distributions based on:
  – 2000 U.S. and Canada census data (*)
    • Used for generating name, address, gender, etc.
    • Introduces natural data skew
  – Actual listings on the NYSE and NASDAQ
• Benefits
  – Realistic looking data
  – Compressible for backup testing, etc.
  – Closer match to actual customer databases
  – Anticipate usage well beyond benchmark

(*) only names of 2000 census have been used – all other data are fictional and any similarities are purely coincidental
### OLTP Benchmarks

**Database – Content**

- Sample data from TPC-C CUSTOMER table

<table>
<thead>
<tr>
<th>C_FIRST</th>
<th>C_MIDDLE</th>
<th>C_LAST</th>
<th>C_STREET_1</th>
<th>C_CITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>RONpTGcv5ZBZO8Q</td>
<td>OE</td>
<td>BARBARABLE</td>
<td>bR7QLfDBhZPHlyDXs</td>
<td>OmWmlzJ0GeP kYM</td>
</tr>
<tr>
<td>e8u6FMxFLlt6p Q</td>
<td>OE</td>
<td>BARBARPRI</td>
<td>eEbgKxoIzx99ZTD S</td>
<td>4Vlt1VmdVcXyoTOMwpPz</td>
</tr>
<tr>
<td>bTUkSuVQGdXLjGe</td>
<td>OE</td>
<td>BARBARPRES</td>
<td>QCGLjWnsqSPQnP D S</td>
<td>jVHBwlGFh2k oTOMwpPz</td>
</tr>
<tr>
<td>18AEf3ObueKvubUX</td>
<td>OE</td>
<td>BARBARESE</td>
<td>JnBSg4RtZbALYu S</td>
<td>5g8XMnlegn oTOMwpPz</td>
</tr>
<tr>
<td>mFFsJYeYE6AR bUX</td>
<td>OE</td>
<td>BARBARANTI</td>
<td>MLEwwdy3dXfqngFcE</td>
<td>yVVR4iEtj0ADEwe wpPz</td>
</tr>
</tbody>
</table>

- Sample data from TPC-E CUSTOMER table

<table>
<thead>
<tr>
<th>C_TAX_ID</th>
<th>C_L_NAME</th>
<th>C_F_NAME</th>
<th>C_M_NAME</th>
<th>C_GNDR</th>
<th>CDOB</th>
<th>C_EMAIL_1</th>
</tr>
</thead>
<tbody>
<tr>
<td>757FI2006HD923</td>
<td>Mexicano</td>
<td>Courtney</td>
<td>T</td>
<td>F</td>
<td>1997-11-30</td>
<td><a href="mailto:CMexicano@hotmail.com">CMexicano@hotmail.com</a></td>
</tr>
<tr>
<td>922SN3775RQ823</td>
<td>Udley</td>
<td>Judith</td>
<td>F</td>
<td>F</td>
<td>1954-09-27</td>
<td><a href="mailto:JUdley@earthlink.com">JUdley@earthlink.com</a></td>
</tr>
<tr>
<td>006GT3444BE624</td>
<td>Buchanan</td>
<td>John</td>
<td>R</td>
<td>M</td>
<td>1971-06-13</td>
<td><a href="mailto:JBuchanan@msn.com">JBuchanan@msn.com</a></td>
</tr>
<tr>
<td>181UZ4114LR434</td>
<td>Soloman</td>
<td>Clinton</td>
<td>D</td>
<td>M</td>
<td>1938-02-27</td>
<td><a href="mailto:CSoloman@rr.com">CSoloman@rr.com</a></td>
</tr>
<tr>
<td>355IE4773VF335</td>
<td>Orner</td>
<td>Harry</td>
<td>P</td>
<td>M</td>
<td>1974-11-15</td>
<td><a href="mailto:Horner@attbi.com">Horner@attbi.com</a></td>
</tr>
</tbody>
</table>
# Transactions - Overview

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Access</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broker-Volume</td>
<td>BV</td>
<td>RO</td>
<td>DSS-type medium query</td>
</tr>
<tr>
<td>Customer-Position</td>
<td>CP</td>
<td>RO</td>
<td>“What am I worth?”</td>
</tr>
<tr>
<td>Market-Feed</td>
<td>MF</td>
<td>RW</td>
<td>Processing of Stock Ticker</td>
</tr>
<tr>
<td>Market-Watch</td>
<td>MW</td>
<td>RO</td>
<td>“What’s the market doing?”</td>
</tr>
<tr>
<td>Security-Detail</td>
<td>SD</td>
<td>RO</td>
<td>Details about a security</td>
</tr>
<tr>
<td>Trade-Lookup</td>
<td>TL</td>
<td>RO</td>
<td>Look up historical trade info</td>
</tr>
<tr>
<td>Trade-Order</td>
<td>TO</td>
<td>RW</td>
<td>Enter a stock trade</td>
</tr>
<tr>
<td>Trade-Result</td>
<td>TR</td>
<td>RW</td>
<td>Completion of a stock trade</td>
</tr>
<tr>
<td>Trade-Status</td>
<td>TS</td>
<td>RO</td>
<td>Check status of trade order</td>
</tr>
<tr>
<td>Trade-Update</td>
<td>TU</td>
<td>RW</td>
<td>Correct historical trade info</td>
</tr>
</tbody>
</table>
Sample Implementation
TPC-E Summary - Highlights

• Financial business model

• Rich transaction set

• Major components provided

• Diverse, realistic schema
  • Extensive use of non-primary key access
  • Foreign key relationships
  • Complex DML
  • Referential integrity

• Availability requirements
  • Storage media must be fault tolerant
  • Practical implication: RAID-1 or RAID-5
TPC-E Summary - Benefits

- Server-centric workload with strong DB focus
- Broader coverage: database functions, schema, features
- Realistic application transaction model
- Ease of benchmarking: quicker startup, lower cost
- Reduced I/O requirements
- Comparability of results
- Realistic database schema, population, and transactions
- Specification provides code where sponsor creativity not being tested
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