Beyond Rows and Columns: Is the Fourth Time the Charm?

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The Birth of Today’s DBMS Field

• In the beginning was the Word, and the Word was with Codd, and the Word was Codd...
  – 1970 CACM paper: “A relational model of data for large shared data banks”
• Many refer to this as the first generation of (real?) database management systems
This is a SQL/NoSQL History Talk

- The pre-relational era
- The relational DB era
- Beyond rows and columns?
  1. The object-oriented DB era
  2. The object-relational DB era
  3. The XML DB era
  4. The NoSQL DB era
- Reflections & challenges

The First Decade B.C.

- The need for a data management library, or a database management system, had actually been well recognized
  - Hierarchical DB systems (e.g., IMS from IBM)
  - Network DB systems (most notably CODASYL)
- These systems provided navigational APIs
  - Systems provided files, records, pointers, indexes
  - Programmers had to (carefully!) scan or search for records, follow parent/child structures or pointers, and maintain code when anything physical changed
The First Decade B.C. (cont.)

Order (id, custName, custCity, total)

Product (sku, name, listPrice, size, power)

Item-Order

Item-Product

Item (ino, qty, price)

Enter the Relational DB Era

Order (id, custName, custCity, total)

Product (sku, name, listPrice, size, power)

Item (order-id, ino, product-sku, qty, price)

- Be sure to notice that
  - Everything’s now (logical) rows and columns
  - The world is flat; columns are atomic \((1\text{NF})\)
  - Data is now connected via keys (foreign/primary)
As the Relational Era Unfolded

• The Spartan simplicity of the relational data model made it possible to start tackling the opportunities and challenges of a logical data model
  – Declarative queries (Rel Alg/Calc, Quel, QBE, SQL, ...)
  – Transparent indexing (physical data independence)
  – Query optimization and execution
  – Views, constraints, referential integrity, security, ...
  – Scalable (shared-nothing) parallel processing

• Today’s multi-$B industry was slowly born
  – Commercial adoption took ~10-15 years
  – Parallel DB systems took ~5 more years

Enter the Object-Oriented DB Era

• Notice that:
  – Data model contains objects and pointers (OIDs)
  – The world is no longer flat – the Order and Product schemas now have \texttt{set}(Item) and Product in them, respectively
What OODBs Sought to Offer

- Motivated largely by late 1980s/early 1990s complex applications (e.g., mechanical CAD, software CAD, ...)
  - Rich schema with inheritance, complex objects, object identity
  - Methods (behavior) within the DBMS
  - Tight bindings with (O-O) programming languages
  - Fast navigation, some declarative querying
- Ex: Gemstone, Ontos, Objectivity, Versant, Object Design, O2, also DASDBS (sort of)

Why OODBs “Fell Flat”

- Too soon for another (radical) DB technology
  - Also technically immature relative to RDBMSs
- Tight PL bindings were a double-edged sword
  - Data shared, outlives programming languages
  - Bindings led to significant system heterogeneity
  - Also made schema evolution a major challenge
- Systems “overfitted” in some dimensions
  - Inheritance, version management, ...
  - Focused on thick clients (e.g., CAD workstations)
Enter the Object-Relational DB Era

Order (id, customer, total)

<table>
<thead>
<tr>
<th>Order</th>
<th>Customer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>Fred</td>
<td>25.97</td>
</tr>
</tbody>
</table>

Item (order-id, product-sku, qty, price)

<table>
<thead>
<tr>
<th>Order</th>
<th>Product SKU</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>401</td>
<td>2</td>
<td>9.99</td>
</tr>
<tr>
<td>123</td>
<td>544</td>
<td>1</td>
<td>3.99</td>
</tr>
</tbody>
</table>

• Be sure to notice:
  – “One size fits all!” (:flex) [emoji]
  – UDTs/UDFs, table hierarchies, references, ... 
  – But the world got flatter again...
  (Timing lagged OODBs by just a few years)

What O-R DBs Sought to Offer

• Motivated by newly emerging application opportunities (multimedia, spatial, text, ...) 
  – User-defined functions & aggregates
  – Data blades (UDTs/UDFs + indexing support)
  – OO goodies for tables:
    – row types, references, ...
  – Nested tables (well, at least Oracle added these)
• Back to a model where applications were
  – loosely bound to
    – SQL/ODBC/JDBC
• Ex: ADT-Ingres, Postgam, Starburst, UniSQL, Illust, DB2, Oracle

Third-Generation Database System Manifesto

The Committee for Advanced DBMS Systems
Michael Stonebraker, Lawrence A. Rowe, Bruce Lindsay, Jannes Gray, Michael Carey, Michael Braddor, Philip Bernstein, David Beech
ACM SIGMOD Recop, Sep 1990
Why O-R DBs “Fell Flat”

- Significant differences across DB vendors
  - SQL standardization lagged somewhat
  - Didn’t include details of UDT/UDF extensions
  - Tough to extend the innards (for indexing)
- Application issues (and multiple platforms)
  - Least common denominator vs. coolest features
  - Tools (e.g., DB design tools, ORM layers, ...)
- Also still probably a bit too much too soon
  - IT departments still rolling in RDBMSs and creating relational data warehouses

Then Came the XML DB Era

```xml
<Order id="123">
  <Customer>
    <custName>Fred</custName>
    <custCity>LA</custCity>
  </Customer>
  <total>25.97</total>
  <Items>
    <Item ino="1">
      <product-sku>401</product-sku>
      <qty>2</qty>
      <price>9.99</price>
    </Item>
    <Item ino="2">
      <product-sku>544</product-sku>
      <qty>1</qty>
      <price>3.99</price>
    </Item>
  </Items>
</Order>

<Product sku="401">
  <name>Garfield T-Shirt</name>
  <listPrice>9.99</listPrice>
  <size>XL</size>
</Product>

<Product sku="544">
  <name>USB Charger</name>
  <listPrice>5.99</listPrice>
  <power>115V</power>
</Product>

Note that
- The world’s less flat again
- We’re now in the 2000’s
What XML DBs Sought to Offer

- One `<flexible/>` data model fits all (XML)
  - Origins in document markup (SGML)
  - Nested data
  - Schema variety/optionality
- New declarative query language (XQuery)
  - Designed both for querying and transformation
  - Early standardization effort (W3C)
- Two different DB-related use cases, in reality
  - *Data storage:* Lore (pre-XML), Natix, Timber, Ipedo, MarkLogic, BaseX; also DB2, Oracle, SQL Server
  - *Data integration:* Nimble Technology, BEA Liquid Data (from Enosys), BEA AquaLogic Data Services Platform

Why XML DBs “Fell Flat” Too

- Document-centric origins (vs. data use cases) of XML Schema and XQuery made a mess of things
  - W3C XPATH legacy (nowledgment)
  - Document identity, document order, ...
  - Attributes vs. elements, nulls, ...
  - Mixed content (overkill for non-document data)
- Two other external trends also played a role
  - SOA and Web services came but then went
  - JSON (and RESTful services) appeared on the scene
- *Note:* Likely still an important niche market...
To Be Continued...

- Tune in to “Friday Night With Databases” for the exciting conclusion....