Extensible Query Processing in Starburst

Michael DiBernardo
September 26th, 2006

Motivation

- It's 1989
- Databases are hard to use for domain-specific applications

Motivation

- e.g. If I want to build an app for biological data mining
  - I have to write my own predicates for sequence similarity
  - I have to convert VARCHARs to DNA/RNA representations in the application
  - This results in lots of “glue code” and data selection logic spread across db and application layers

Motivation

- Secondary motivation:
  - Authors desire an arena in which they can invent many facetious names for things

Proposed Solution

- Make the system extensible, and allow “database customizers” with domain-specific knowledge to tailor
- Extensibility was a hot topic because of emergence of OO databases

Proposed Solution

- Extensions:
  - Language extensions (new datatypes and operations)
  - Data management extensions (access and storage)
  - Processing extensions (new joins, query transforms)
- To support all these, need a powerful language processor

Anatomy of Starburst

- Design of query language
- Internal representation of a query
- Query rewriting
- Cost-based optimization

Outline

- Design of query language
- Internal representation of a query
- Query rewriting
- Cost-based optimization

Query language

- Derivative of SQL called "Hydrogen"
- Add hooks for language extensions
- Increases orthogonality
  - Emphasize table as fundamental unit
  - Views are tables
  - Expressions evaluate to tables

Query language

- Keeps language simple, but there are many ways to describe the same query
  - Makes optimization difficult
  - Makes understanding queries difficult
- Also implies that queries can be verbose

Query language

- Keeps language simple, but there are many ways to describe the same query
  - Makes optimization difficult
  - Makes understanding queries difficult
- Also implies that queries can be verbose

Outline

- Design of query language
- Internal representation of a query
- Query rewriting
- Cost-based optimization

Representation

- Goal is to have a flexible representation that
  - Is easily extensible
  - Sufficiently expressive
  - Easy to operate on

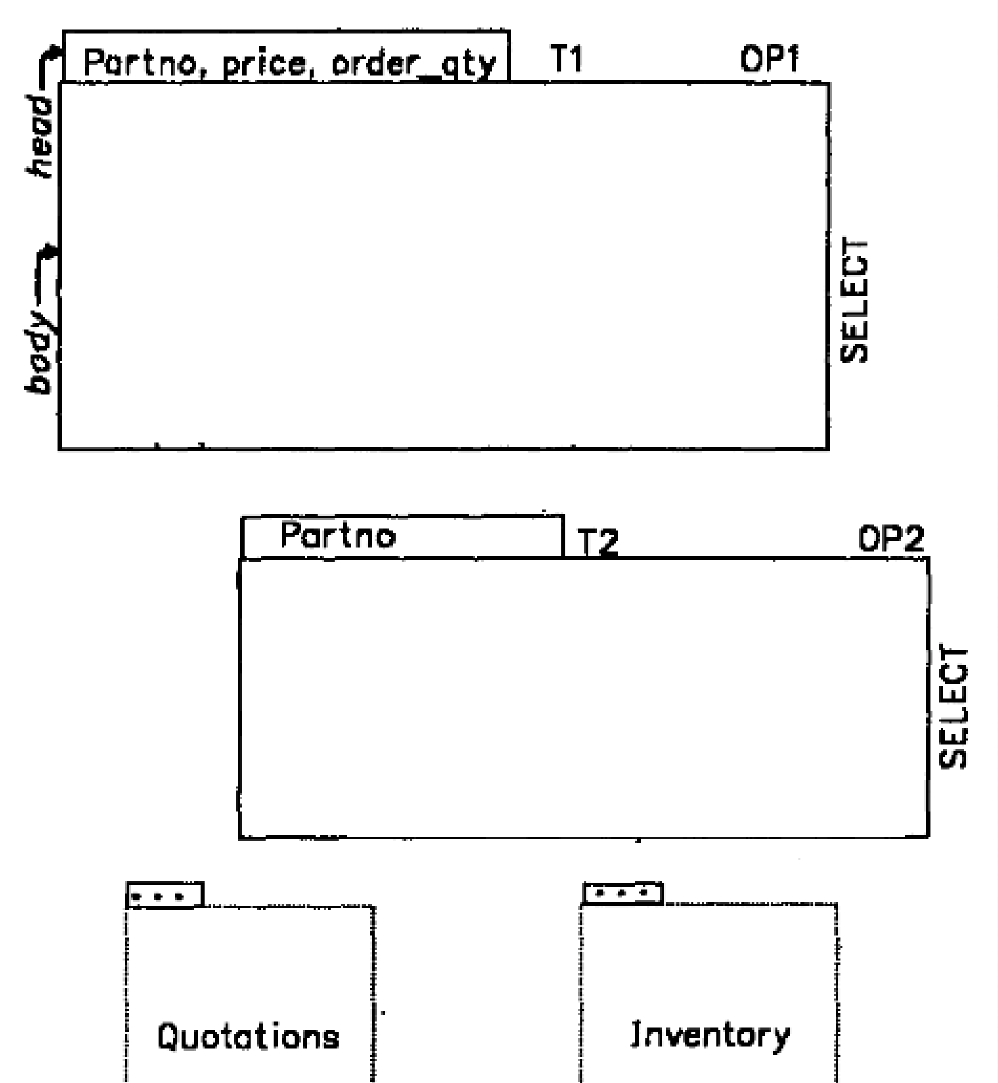
Query Graph Model

- Tables (normal and derived) are boxes with heads
- Table accesses are vertices
- Predicate applications are edges (with rectangles, for some reason)

Example

```
SELECT partno, price, order_qty
 FROM quotations Q1
 WHERE Q1.partno IN
   (SELECT partno
     FROM inventory Q3
     WHERE Q3.onhand_qty < Q1.order_qty
            AND Q3.type = 'cpu')
```

Example



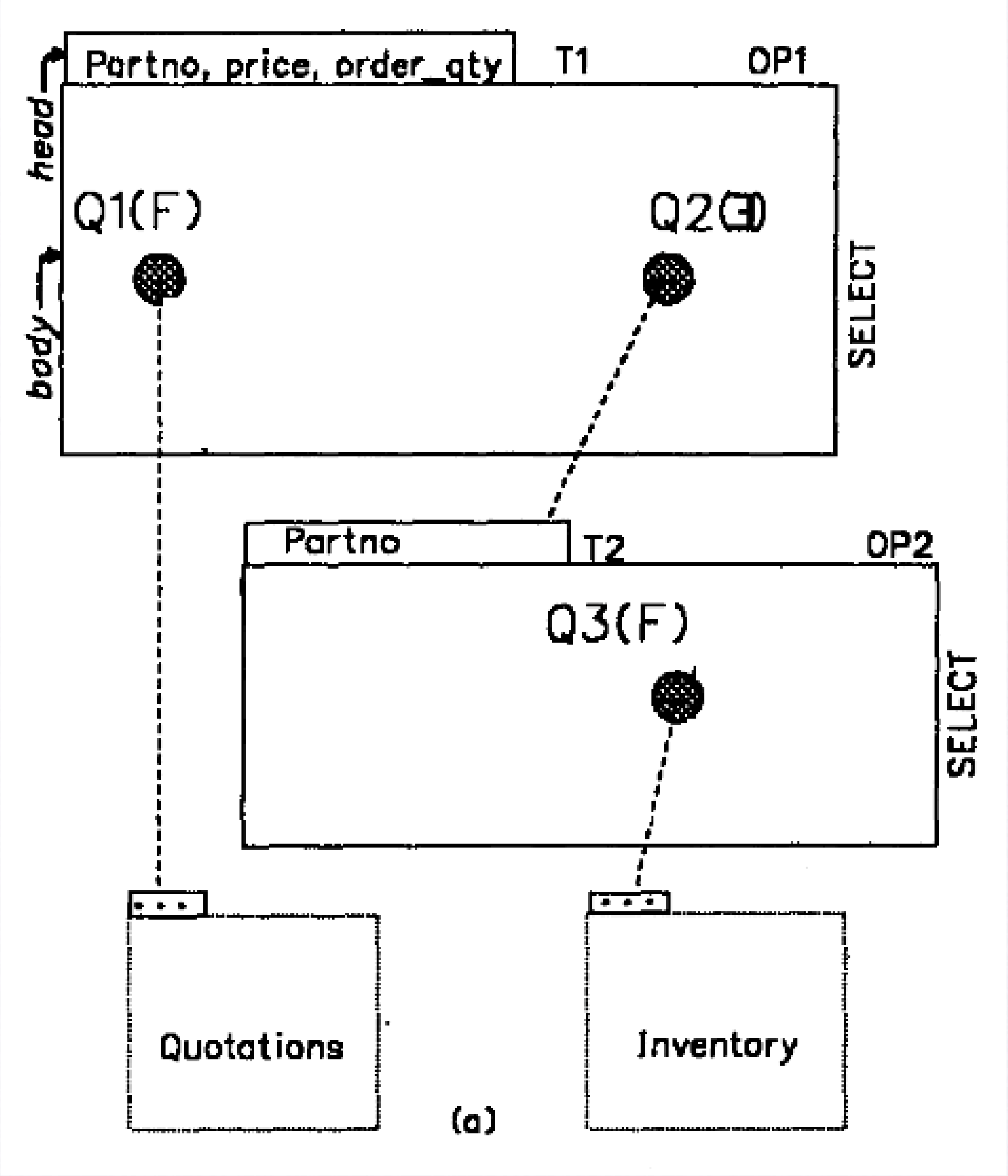
Partno, price, order_qty
T1
OP1
head
body
SELECT
Partno
T2
OP2
SELECT
Quotations
Inventory

(a)

Example

```
SELECT partno, price, order_qty
 FROM quotations Q1
 WHERE Q1.partno IN
   (SELECT partno
     FROM inventory Q3
     WHERE Q3.onhand_qty < Q1.order_qty
             AND Q3.type = 'cpu')
```

Example

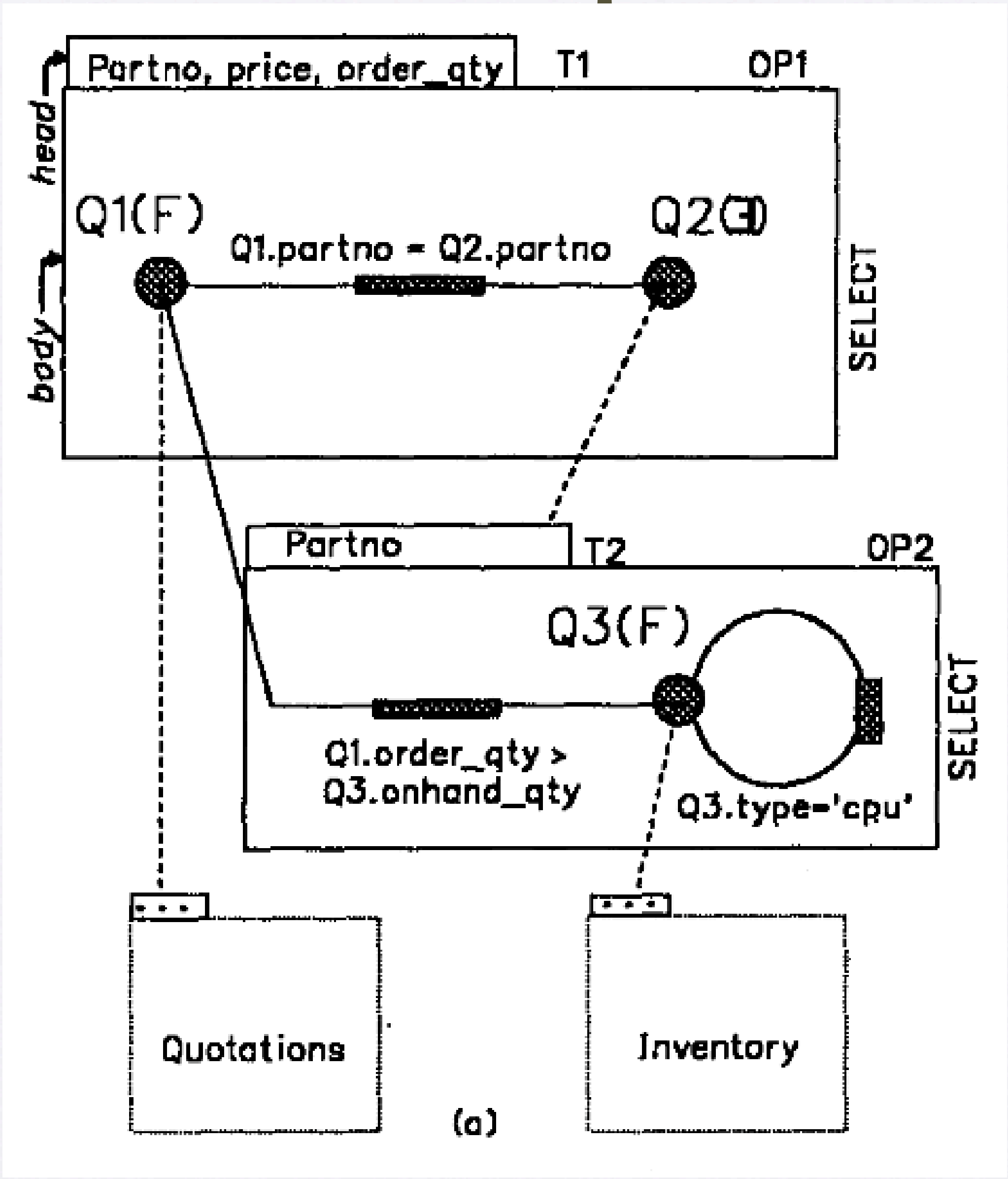


Partno, price, order_qty
T1
OP1
head
body
Q1(F)
SELECT
Partno
T2
OP2
Q3(F)
SELECT
Quotations
Inventory
(a)

Example

```
SELECT partno, price, order_qty
 FROM quotations Q1
 WHERE Q1.partno IN
   (SELECT partno
     FROM inventory Q3
     WHERE Q3.onhand_qty < Q1.order_qty
             AND Q3.type = 'cpu')
```

Example


Partno, price, order_qty
T1
OP1
head
body
Q1(F)
Q2
Q1.partno = Q2.partno
SELECT
Partno
T2
OP2
Q3(F)
Q1.order_qty >
Q3.onhand_qty
Q3.type='cpu'
SELECT
Quotations
Inventory
(a)

Outline

- Design of query language
- Internal representation of a query
- Query rewriting
- Cost-based optimization

Query Rewriting

- First component of ‘optimization’
- Basic idea:
  - Maintain a set of rules that recognize a condition and perform a transformation on QGM
- e.g. If you have two SELECTs (boxes) and they handle dups the same, merge them into one box

Query Rewriting

- Three classes of rules
  - Predicate migration
  - Projection push-down
  - Operation merging
- DBC can add to or create new classes

Query Rewriting

- “Rule engine” applies rules
  - Selects rule to apply based on some ordering (sequential, statistical, priority)
  - Uses forward chaining to generate rewrites
  - Has a “budget” to prevent it from running too long

Query Rewriting

- What if there's more than one rule that works?
  - We don't have a notion of cost here
  - So generate all alternatives and push them forward
  - Maintains modularity at expense of performance

Outline

- Design of query language
- Internal representation of a query
- Query rewriting
- Cost-based optimization

Cost-based estimation

- The general framework we're familiar with:
  - Generate a space of plans from the QGM
  - Estimate the cost of each plan
  - Search the space
- Each operation is optimized independently

Plan generation

- Build a plan using a grammar-driven approach
- Terminals are “low level plan operators” (LOLEPOPS)
    - i.e. relational algebra primitives implemented as functions that operate on and produce tuples
- Nonterminals are “strategy alternative rules” (STARs
    - i.e. higher-order functions that combine nonterminals and LOLEPOPS

Plan costing

- Each table (normal or derived) has a set of properties
- Properties are modified on the fly as LOLEPOPS are applied to them
- Three kinds:
  - Relational (e.g. tables joined, columns accessed)
  - Operational (e.g. ordering of tuples)
  - Estimated (e.g. cardinality)

Search Strategy

- Nothing especially exciting here
  - Alternative STARs are ranked for pruning
  - Change queueing to implement different searches
  - Other parameters
    - e.g. Turn off bushy trees

Wrapup

- Starburst =
  - Orthogonal and extensible query language
  - Generic query representation (QGM)
  - Rule-based query rewriting
  - Plan optimization w/ grammar-driven generation
  - Lots of silly subcomponent names

Discussion