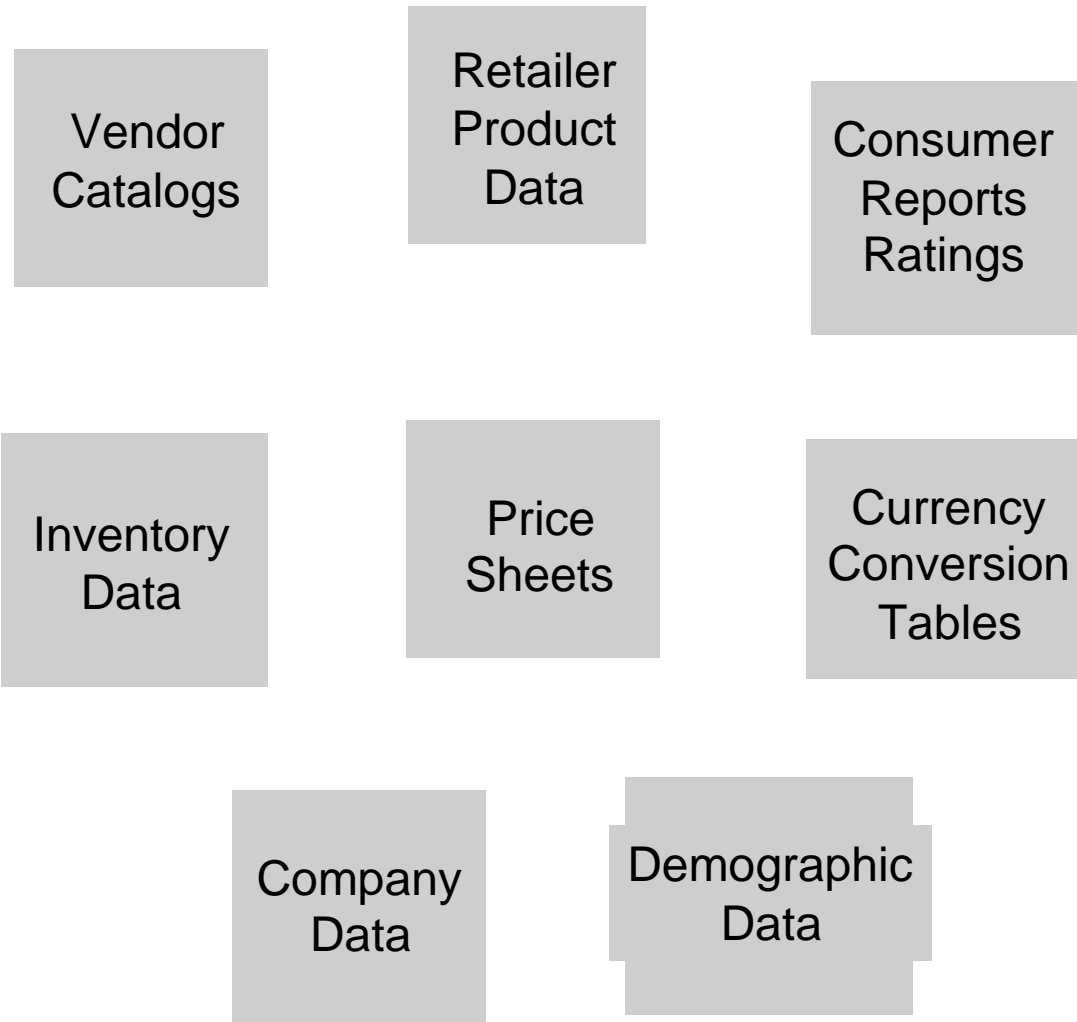


Information Integration

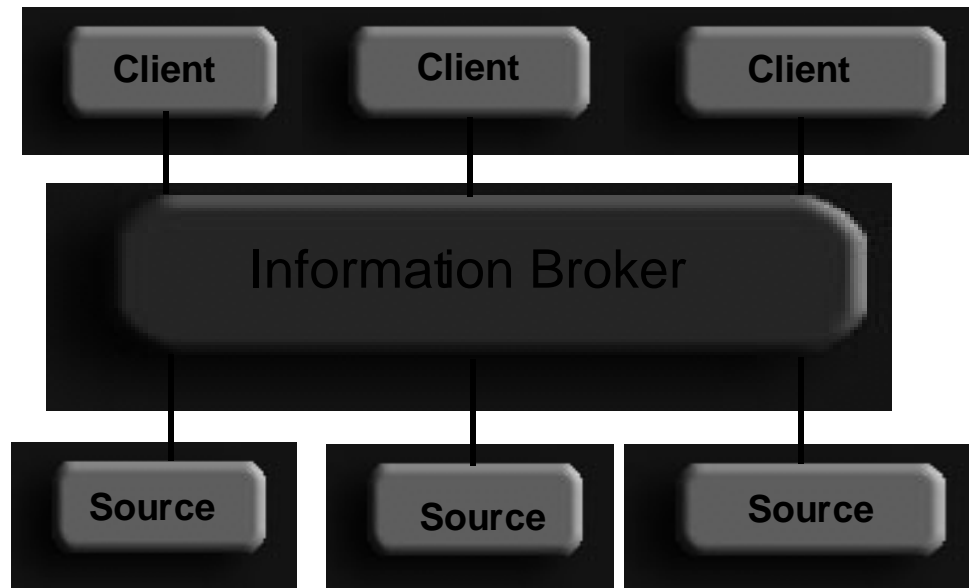
Question

Give me a list of 15 inch aluminum skillets with nonstick coating
rated at least 4 out of 5 by Consumer Reports
that sell for under \$30
and are currently in stock.

Data Sources




Information Integration



Complications

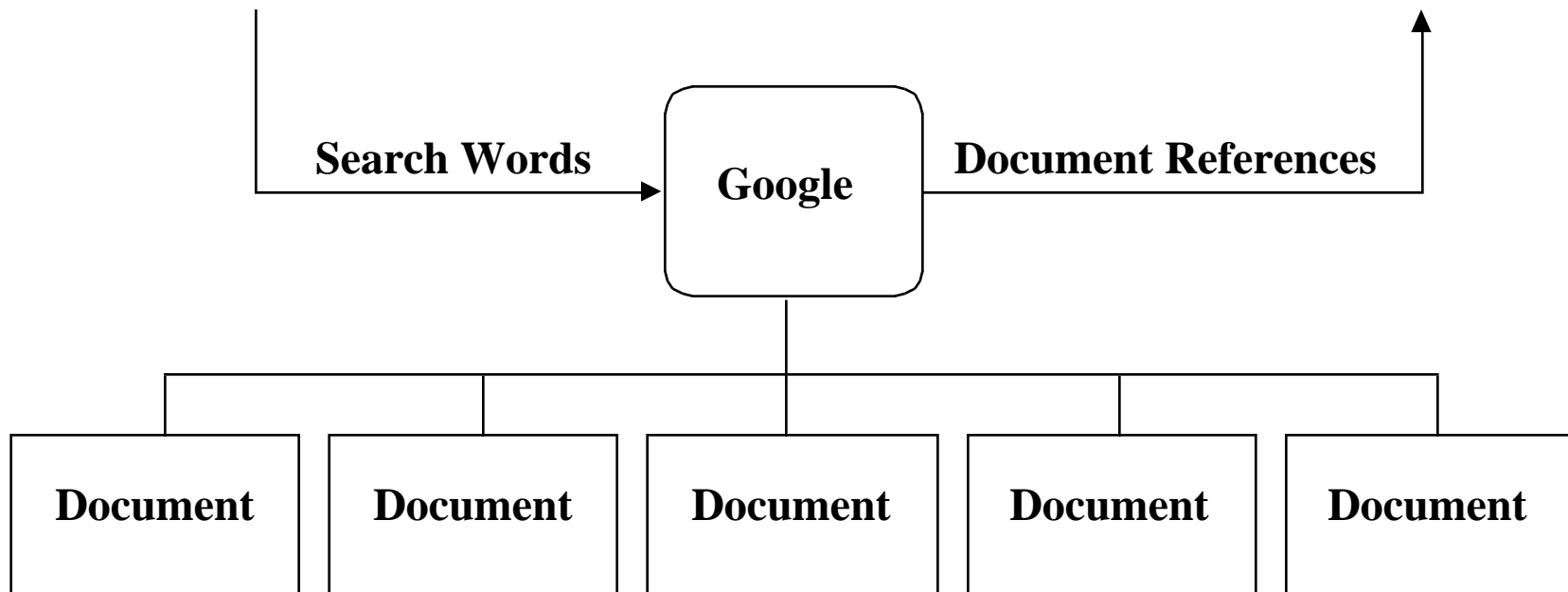
- Difficulties of Using Multiple Sources
 - Distribution
 - Network delays
 - Part-time operation
 - Platform Heterogeneity (dozens)
 - Differences in protocol
 - Differences in format (XML, HTML, spreadsheet, ODBC,...)
 - Conceptual Heterogeneity (thousands)
 - Differences in schema and vocabulary
 - Relative incompleteness
- Life is Change
 - Technological innovation
 - New Buyers, Suppliers, Market Makers



“73% of business managers surveyed said they could not access data in their own corporate databases. “

Gartner Group Report

Syntactic Search Engines



Too Many Results

Query:

Who is older -- Jane or John?

Search Words:

John

Jane

older

Document Fragments:

..John is older than Jane...

Jill wants to know whether John is older than Jane...

*..John is older than Jill...
...Jim is older than Jane...*

Too Few Results

Query:

Is it the case that John is older than Jane?

Document fragments:

..John is more advanced in years than Jane...

..Jane is younger than John...

...John is the father of Jane...

No Integration

Query:

Is it the case that John is older than Jane?

Documents:

...John is older than Jill...

...Jill is older than Jane...

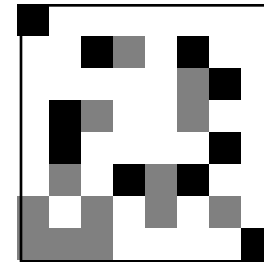
Content vs. Form

Semantic View



*Those who will not reason
Perish in the act;
Those who will not act
Perish for that reason.*

Syntactic View



Those who will not reason
Perish in the act;
Those who will not act
Perish for that reason.

Structured Data

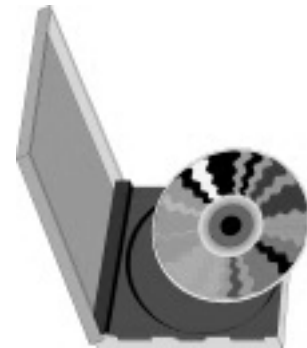
Free Form Text

Easy to Use but limited capability
Too Few answers, too many answers
Impossible to Aggregate effectively



Structured Data

Taxonomy, Attributes, Typed Values
Powerful search possible
Aggregation possible



Adding tags allows machine to understand so we can search and integrate.

Potential Application Areas

Corporate Logistics - Enterprise Resource Directories

Personnel, locations, organizations, equipment, orders

Electronic Commerce - Integrated Product Catalogs

Catalogs, inventories, product ratings, contracts

Health Care - Consolidated Patient Records

Doctors, nurses, lab technicians, administrators, patients

Multidisciplinary Engineering - Concurrent Engineering

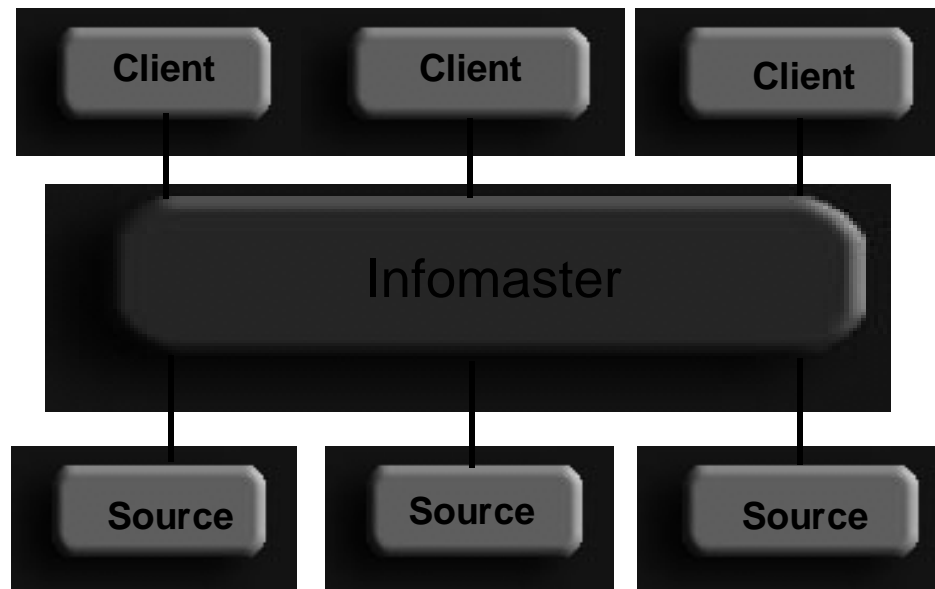
Architects, engineers, construction planners

Command and Control - Situation Assessment

Commanders, intelligence, field officers, consultants

Semantic Integration in Infomaster

Data Integration System - integrated access to heterogeneous data sources giving the illusion of a homogeneous data management system



"Infomaster creates an environment that makes it easier for information consumers to get the information they need to answer their questions, while making it easier for owners to publish and share their databases."

Dennis Rayer, Manager, Data Warehouse,
Stanford University

Databases

name	manager	office	phone
John	Jill	MJH222	38086
Jane	Jerry	Cedar12	57493
Jill		MJH222	
Jerry		420-032	56777

Fragmentation

Horizontal fragmentation

name	manager	office	phone
John	Jill	MJH222	38086
Jane	Jerry	Cedar12	57493

name	manager	office	phone
Jill		MJH222	
Jerry		420-032	56777

Vertical Fragmentation

name	manager
John	Jill
Jane	Jerry
Jill	
Jerry	

name	office	phone
John	MJH222	38086
Jane	Cedar12	57493
Jill	MJH222	
Jerry	420-032	56777

Conceptual Heterogeneity

name	manager	office	phone
John	Jill	MJH222	38086
Jane	Jerry	Cedar12	57493
Jill		MJH222	
Jerry		420-032	56777

name	employee	location	telephone
John		MJH222	7238086
Jane		Cedar12	7257493
Jill	John	MJH222	
Jerry	Jane	420-032	7256777

“The biggest problem facing anyone who wants to search multiple structured databases. . .is that many organizations use different words to describe the same thing.”

Martin Marshall, *Communications Week*

Relational Logic for Mapping

name	employee	location	telephone
John		MJH222	7238086
Jane		Cedar12	7257493
Jill	John	MJH222	
Jerry	Jane	420-032	7256777

employee(X,Y):-manager(Y,X).

name	manager	office	phone
John	Jill	MJH222	38086
Jane	Jerry	Cedar12	57493
Jill		MJH222	
Jerry		420-032	56777

Rules in Epilog

Safe, Horn Rules

```
grandparent(X,Z) :- parent(X,Y), parent(Y,Z).
```

Existential Variables

```
parent(X,f(X,Z)) :- grandparent(X,Z).
```

Disjunction/Classical Negation

```
father(X,Y) | mother(X,Y) :- parent(X,Y).
```

```
father(X,Y) :- parent(X,Y), ~mother(X,Y).
```

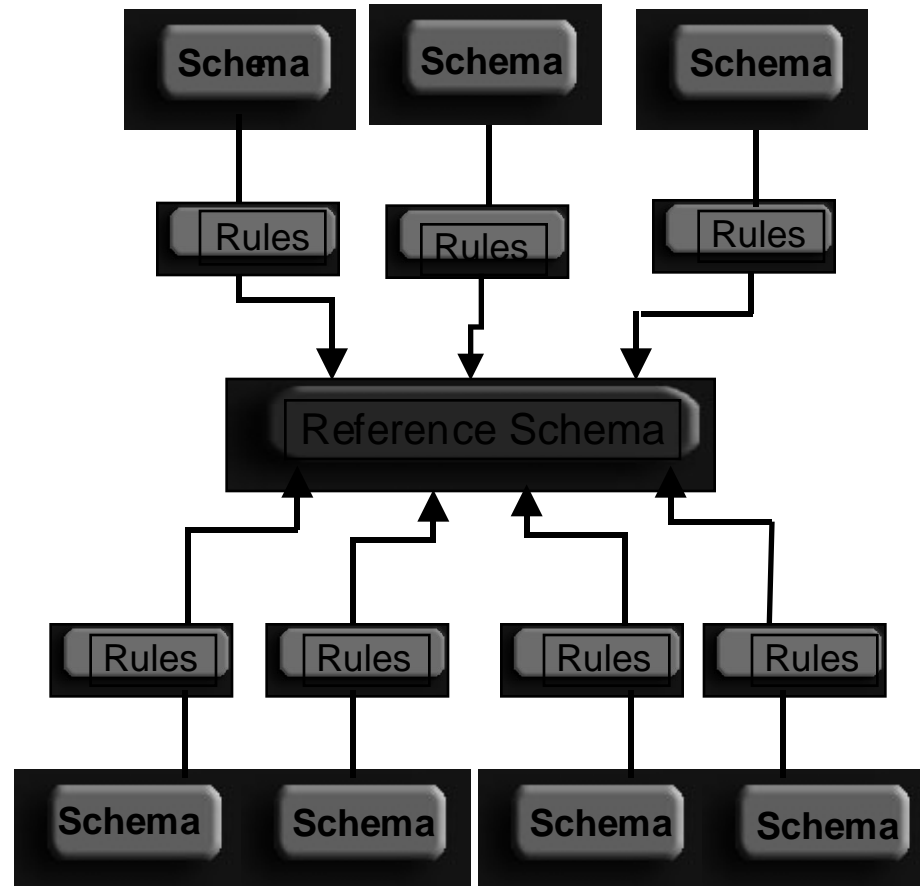
```
mother(X,Y) :- parent(X,Y), ~father(X,Y).
```

Recursion

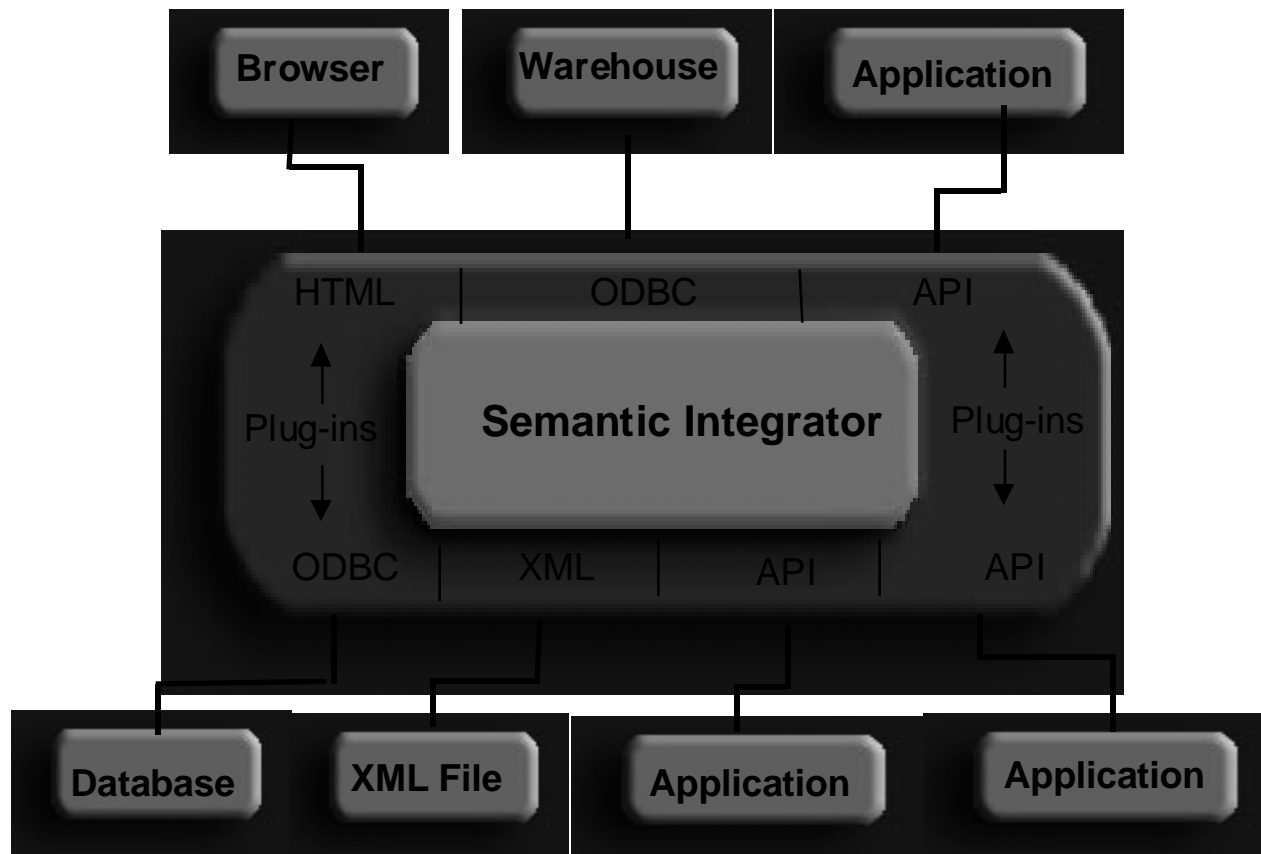
```
ancestor(X,Y) :- parent(X,Y).
```

```
ancestor(X,Z) :- parent(X,Y), ancestor(Y,Z).
```

Reference Schema

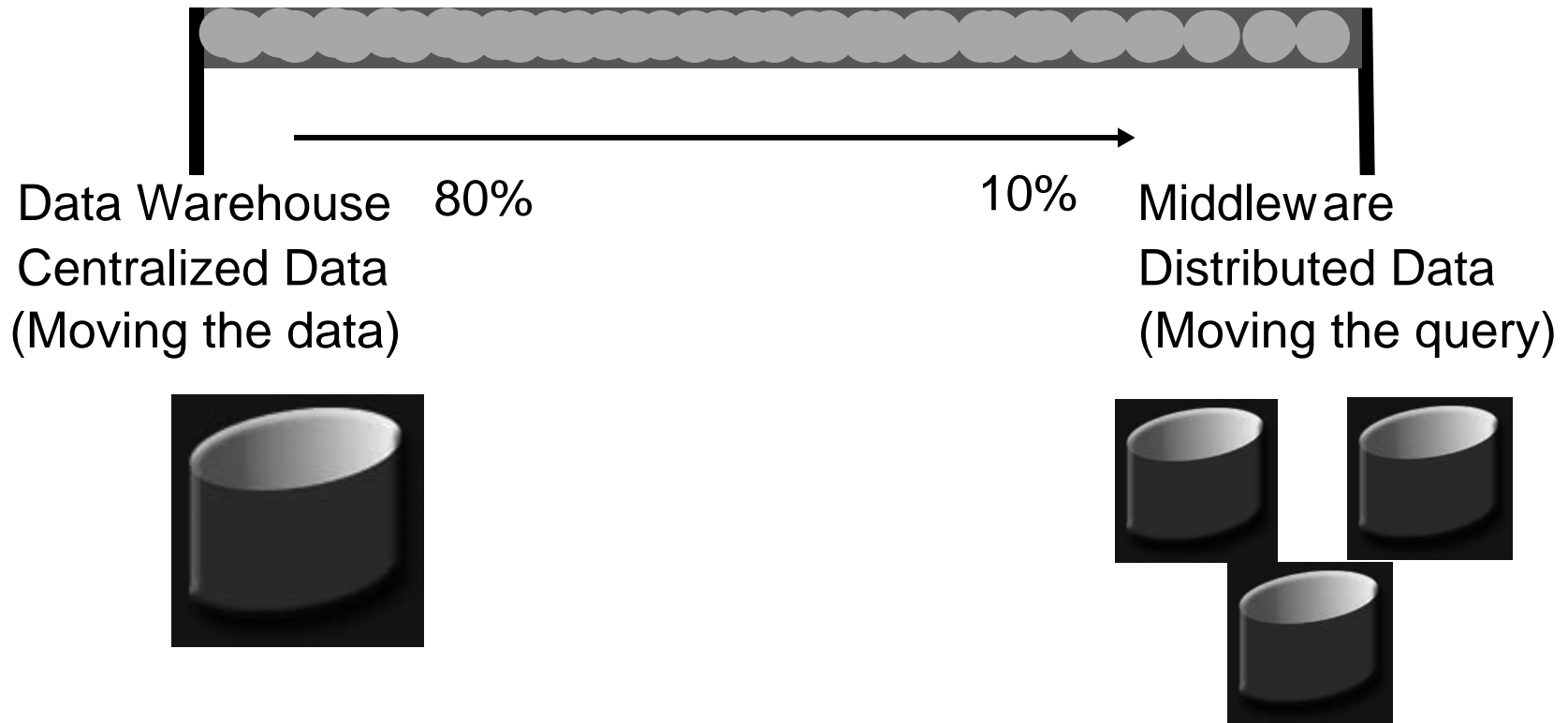


Plug-in Architecture



Selective Materialization

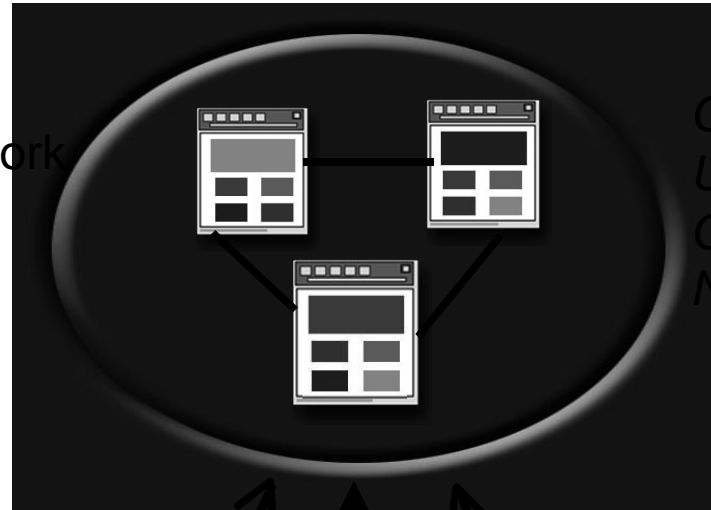
Spectrum of Data Management Strategies



Dataweb User Interface

DataWeb

Virtual information network
Hyperlinked Concepts
(one entity, one page)



Click-through Browsing
Update (single entry principle)
Cross Category Search
Notification (smart push)

Internet/Intranet

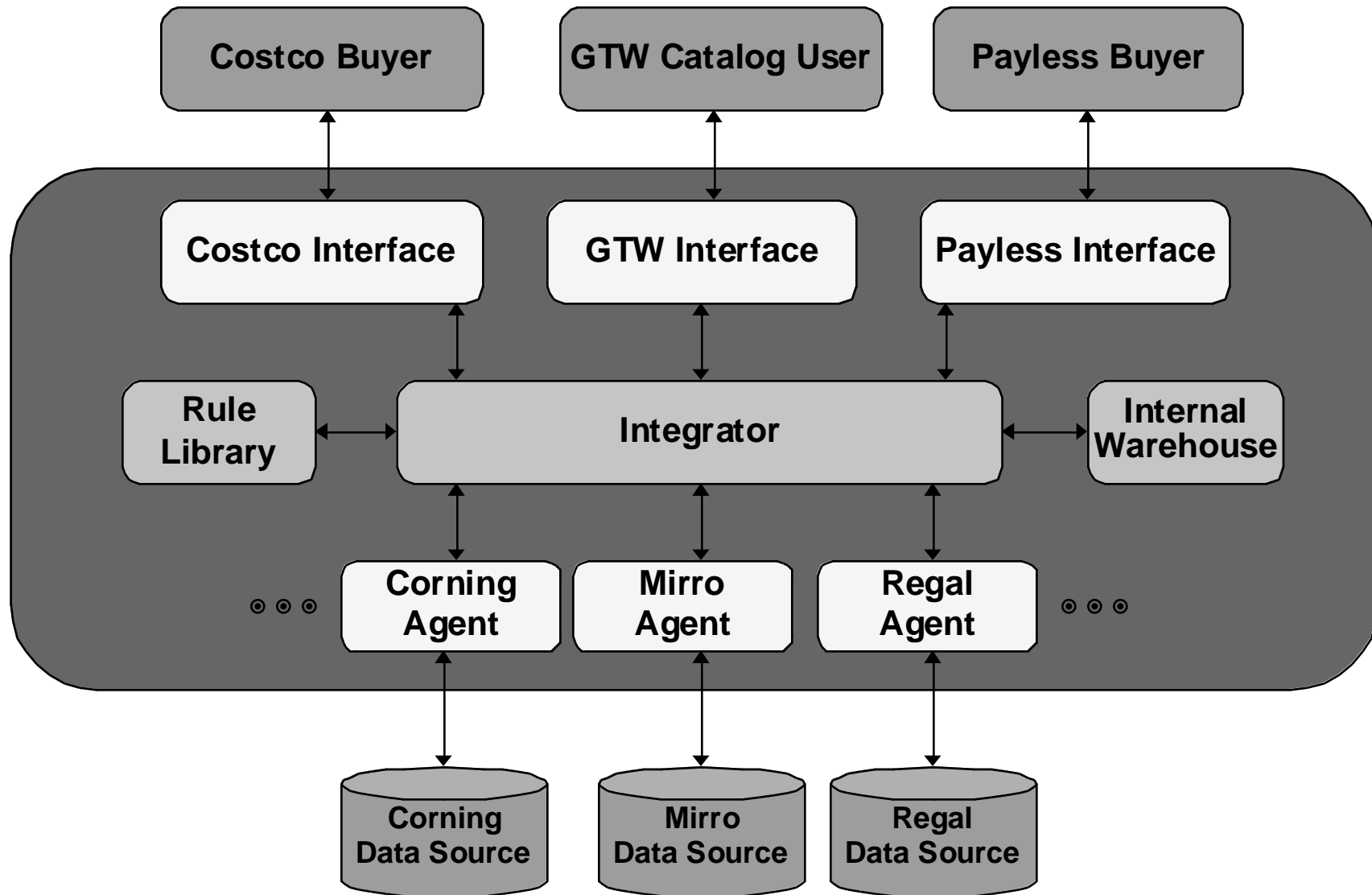
Physical Network
Hyperlinked Databases and
Documents



*"This is one of the most useful
applications I've seen on the net."*

Matt Brown, Tandem Computers

Demonstration Architecture





Location: http://0.0.0.0:3000/

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- ▶ [Service](#)
- ▶ [Organization](#)
- ▶ [Company](#)
- ▶ [Location](#)

Search for

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- ▶ [31 - Manufacturing Components and Supplies](#)
- ▶ [32 - Electronic Components and Supplies](#)
- ▶ [43 - Communications, Computer Equipment, Peripherals, Components and Supplies](#)
- ▶ [44 - Office Equipment, Accessories and Supplies](#)
- ▶ [45 - Printing, Photographic and Audio/Visual Equipment and Supplies](#)
- ▼ [52 - Furniture, Furnishings, Domestic Appliances and Consumer Electronic Products](#)
 - ▼ [5215 - Domestic kitchenware](#)
 - ▶ [521518 - Domestic cookware](#)
- ▶ [53 - Apparel, Luggage, and Personal Care Products](#)
- ▶ [55 - Published Products](#)

- ▶ [Service](#)
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Search for

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Location: <http://0.0.0.0:3000/gtw/SEARCH?Class=UNSPSC.521518>

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Unspsc.521518.Type

-
- Accessory
 - Baking Dish
 - Bowl
 - Cup
 - Dish

Unspsc.521518.Material

-
- Aluminum
 - Ceramic
 - Glass
 - Iron
 - Stainless

Unspsc.521518.Interior

-
- Ceramic
 - Enamel
 - Glass
 - Metal
 - Porcelain

Unspsc.521518.Exterior

-
- Ceramic
 - Enamel
 - Glass
 - Metal
 - Porcelain

Unspsc.521518.Color

-
- Black
 - Grey
 - Silver
 - Clear
 - White

Unspsc.521518.CapacityAt least and at most quarts**Unspsc.521518.Diameter**At least and at most inches**Unspsc.521518.Msrp**At least and at most dollars**Unspsc.521518.Manufacturer**

-
- Boisecascade
 - Corning
 - Mirro
 - Officedepot
 - Regal

[Compare](#)**20 of 266 items**

[3500971 1.5qt Sauce Pan](#)
[3500954 2qt Sauce Pan](#)
[3500952 3qt Sauce Pan](#)
[3500938 1.5qt Pouring Sauce Pan](#)
[3500936 2.5qt Pouring Sauce Pan](#)
[3500937 3.5qt Pouring Sauce Pan](#)
[3500950 8in Skillet](#)
[3500949 10in Skillet](#)
[3500948 12in Skillet](#)
[3500983 8in Nonstick Skillet](#)
[3500982 10in Nonstick Skillet](#)
[3500985 12in Nonstick Skillet](#)
[3500947 4.5qt Dutch Oven](#)
[3500955 6qt Stock Pot](#)
[3500946 8qt Stock Pot](#)
[3500945 10qt Stock Pot](#)
[3500986 2.25qt Tea Kettle](#)
[3500953 2qt Steamer Insert](#)
[3500957 4qt Steamer Insert](#)
[3500944 2qt Double Boiler Insert](#)

...More...

Location: <http://0.0.0.0:3000/gtw/SEARCH?Class=UNSPSC.521518>

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Unspsc.521518.Type

-
- Roaster
-
-
- Sauce Pan
-
-
- Skillet
-
-
- Stock Pot
-
-
- Tea Kettle

Unspsc.521518.Material

-
- Aluminum
-
-
- Ceramic
-
-
- Glass
-
-
- Iron
-
-
- Stainless

Unspsc.521518.Interior

-
- Ceramic
-
-
- Enamel
-
-
- Glass
-
-
- Metal
-
-
- Porcelain

Unspsc.521518.Exterior

-
- Ceramic
-
-
- Enamel
-
-
- Glass
-
-
- Metal
-
-
- Porcelain

Unspsc.521518.Color

-
- Black
-
-
- Grey
-
-
- Silver
-
-
- Clear
-
-
- White

Unspsc.521518.CapacityAt least and at most quarts**Unspsc.521518.Diameter**At least and at most inches**Unspsc.521518.Msrp**At least and at most dollars**Unspsc.521518.Manufacturer**

-
- Boisecascade
-
-
- Corning
-
-
- Mirro
-
-
- Officedepot
-
-
- Regal

[Compare](#)**20 of 59 items**

[3500950 8in Skillet](#)
[3500949 10in Skillet](#)
[3500948 12in Skillet](#)
[3500983 8in Nonstick Skillet](#)
[3500982 10in Nonstick Skillet](#)
[3500985 12in Nonstick Skillet](#)
[Solutions 9in Skillet](#)
[3514480 8in Skillet](#)
[3514507 10in Skillet](#)
[3514527 12in Skillet](#)
[3500795 12in Chicken Fryer](#)
[3500879 12in Sauteuse](#)
[Revere Copper Clad Stainless Steel 9in Skillet](#)
[3520527 12in Skillet](#)
[3500793 12in Chicken Fryer](#)
[3500882 12in Sauteuse](#)
[Revere Aluminum Disc Bottom Stainless Steel 9in Skillet](#)
[3500115 8in Skillet](#)
[3500116 10in Skillet](#)
[3500117 15in Skillet](#)

... More ...

- ▶ [Product](#)
- ▶ [Service](#)
- ▶ [Organization](#)
- ▶ [Company](#)
- ▶ [Location](#)

Unspsc.521518.Type

- Roaster
- Sauce Pan
- Skillet
- Stock Pot
- Tea Kettle

Unspsc.521518.Material

- Aluminum
- Ceramic
- Glass
- Iron
- Stainless

Unspsc.521518.Interior

- Enamel
- Glass
- Metal
- Porcelain
- Teflon

Unspsc.521518.Exterior

- Ceramic
- Enamel
- Glass
- Metal
- Porcelain

Unspsc.521518.Color

- Black
- Grey
- Silver
- Clear
- White

Unspsc.521518.Capacity

At least and at most quarts

Unspsc.521518.Diameter

At least 15 and at most inches

Unspsc.521518.Msrp

At least and at most dollars

Unspsc.521518.Manufacturer

- Boisecascade
- Corning
- Mirro
- Officedepot
- Regal

[Compare](#)

5 items

- [3500117 15in Skillet](#)
- [27069 Saute](#)
- [27199 Grillpan](#)
- [92732 Saute](#)
- [J5817 15 In Fry Pan](#)

Location: <http://0.0.0.0:3000/gtw/COMPARE?>

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ID	3500117 15in Skillet	27069 Saute	27199 Grillpan	92732 Saute	J5817 15 In Fry Pan
Type	Skillet	Skillet	Skillet	Skillet	Skillet
Material	Aluminum	Aluminum	Aluminum	Aluminum	
Interior	Teflon	Teflon	Teflon	Teflon	Teflon
Exterior	Aluminum	Porcelain	Porcelain	Porcelain	Teflon
Color	Silver	Black	Blue	Black	Grey
Capacity					4
Diameter	15	15	15	15	15
MSRP	33	49	48	44	92
Manufacturer	Corning	Mimo	Mimo	Mimo	Regal
UPC	050035001176	071108270695	071108271999	071108927322	078008018563
Image					

Location: <http://0.0.0.0:3000/gtw/INSPECT?Object=REGAL>

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Regal is an object of type **Company**.

Name Regal Ware Inc.

Nationality [Uk](#)

Supplier

this Company.

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- ▶ [Product](#)
- ▶ [Service](#)
- ▶ [Organization](#)
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Silver
Clear

Capacity At least and at most

Diameter At least and at most

MSRP At least and at most

Manufacturer an object of type company

Name Exact?

Company.Nationality a country that satisfies the following criteria

- Country.Capital**
 Abu Dhabi
 Abuja
 Accra
 Addis Ababa
 Algiers

- Country.Continent**
 Asia
 Australasia
 Europe
 North America
 South America

- Country.Corporation**
 Boisecascade
 Corning
 Mirro
 Officedepot
 Regal

- Supplier**
 Boisecascade
 Corning
 Mirro
 Officedepot

4 items

- [3500117 15in Skillet](#)
- [27069 Saute](#)
- [27199 Grillpan](#)
- [92732 Saute](#)

- ▶ [Product](#)
- ▶ [Service](#)
- ▶ [Organization](#)
- ▶ [Company](#)
- ▶ [Location](#)

Silver
Clear

Capacity At least and at most

Diameter At least and at most

MSRP At least and at most

Manufacturer an object of type company

Name Exact?

Company.Nationality a country that satisfies the following criteria

Country.Capital

- Abu Dhabi
- Abuja
- Accra
- Addis Ababa
- Algiers

Country.Continent

- Asia
- Australasia
- Europe
- North America
- South America

Country.Corporation

- Boise Cascade
- Corning
- Mirro
- Officedepot
- Regal

Supplier

- Boise Cascade
- Corning
- Mirro
- Officedepot

1 item

[J5817 15 In Fry Pan](#)

Location: <http://0.0.0.0:3000/gtw/INSPECT?Object=J5817-15-IN-FRY-PAN>

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J5817 15 In Fry Pan is an object of type 521518 - Domestic cookware.

Type [Skillet](#)
Material
Interior [Teflon](#)
Exterior [Teflon](#)
Color [Grey](#)
Capacity 4
Diameter 15
MSRP 92
Manufacturer [Regal](#)
UPC 078008018563

Image



this Unspec.521518.

Netscape: Inspect J5817 15 In Fry Pan

Location: <http://0.0.0.0:3000/gtw/INSPECT?Object=J5817-15-IN-FRY-PAN>

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J5817 15 In Fry Pan is an object of type **521518 - Domestic cookware**.

Type [Skillet](#)

Material

Interior [Teflon](#)

Exterior [Teflon](#)

Color [Grey](#)


Capacity 4

Diameter 15

MSRP 92

Manufacturer [Regal](#)

UPC 078008018563


Image 

this Unspsc.521518.

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Netscape: Inspect J5817 15 In Fry Pan

Location: <http://0.0.0.0:3000/regaldataserver/INSPECT?Object=J5817-15-IN-FRY-PAN>



J5817 15 In Fry Pan is an object of type **Regal**.

Regal.Type [Fry Pan](#)

Regal.Gauge [8 Ga](#)

Regal.Interior [Arc Sprayed](#)


Regal.Exterior [Arc Sprayed](#)

Regal.Height 2

Regal.Diameter 15

Regal.Price 60

Regal.Upc 078008018563

Regal.Picture 

this Regal.

Netscape: Inspect J5817 15 In Fry Pan


Location: http://0.0.0.0:3000/gtw/INSPECT?Object=J5817-15-IN-FRY-PAN

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J5817 15 In Fry Pan is an object of type **521518 - Domestic cookware**.


Type	Skillet
Material	
Interior	Teflon
Exterior	Teflon
Color	Grey
Capacity	4
Diameter	15
MSRP	92
Manufacturer	Regal
UPC	078008018563
Image	

this Unspsc.521518.

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Netscape: Modify J5817 15 In Fry Pan

Location: http://0.0.0.0:3000/regaldataserver/MODIFY?



Update succesful. Use the following form to make changes.

J5817 15 In Fry Pan is J5817 15 In Fry Pan **Regal** with the following profile.

Regal. Type	<input type="text" value="Fry Pan"/>
Regal. Gauge	<input type="text" value="8 Ga"/>
Regal. Interior	<input type="text" value="Arc Sprayed"/>
Regal. Exterior	<input type="text" value="Arc Sprayed"/>
Regal. Height	<input type="text" value="2"/>
Regal. Diameter	<input type="text" value="15"/>
Regal. Price	<input type="text" value="60"/>
Regal. Upc	<input type="text" value="078008018563"/>
Regal. Picture	<input type="text" value="

this item.

this item.

Netscape: Inspect J5817 15 In Fry Pan


Location: http://0.0.0.0:3000/gtw/INSPECT?Object=J5817-15-IN-FRY-PAN

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J5817 15 In Fry Pan is an object of type **521518 - Domestic cookware**.


Type	Accessory
Material	
Interior	Teflon
Exterior	Teflon
Color	Black
Capacity	4
Diameter	15
MSRP	153
Manufacturer	Regal
UPC	078008018563
Image	

this Unspsc.521518.

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Netscape: Modify J5817 15 In Fry Pan

Location: http://0.0.0.0:3000/regaldataserver/MODIFY?



Update succesful. Use the following form to make changes.

J5817 15 In Fry Pan is J5817 15 In Fry Pan **Regal** with the following profile.

Regal. Type	<input type="text" value="Steamer Inset"/>
Regal. Gauge	<input type="text" value="8 Ga"/>
Regal. Interior	<input type="text" value="Arc Sprayed"/>
Regal. Exterior	<input type="text" value="Durscote"/>
Regal. Height	<input type="text" value="2"/>
Regal. Diameter	<input type="text" value="15"/>
Regal. Price	<input type="text" value="100"/>
Regal. Upc	<input type="text" value="078008018563"/>
Regal. Picture	<input type="text" value="

this item.

this item.

Netscape: Inspect J5817 15 In Fry Pan


Location: http://0.0.0.0:3000/gtw/INSPECT?Object=J5817-15-IN-FRY-PAN

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J5817 15 In Fry Pan is an object of type **521518 - Domestic cookware**.


Type	Skillet
Material	
Interior	Teflon
Exterior	Teflon
Color	Grey
Capacity	4
Diameter	15
MSRP	92
Manufacturer	Regal
UPC	078008018563
Image	

this Unspsc.521518.

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Netscape: Modify J5817 15 In Fry Pan

Location: http://0.0.0.0:3000/regaldataserver/MODIFY?



Update succesful. Use the following form to make changes.

J5817 15 In Fry Pan is J5817 15 In Fry Pan **Regal** with the following profile.

Regal. Type	<input type="text" value="Steamer Inset"/>
Regal. Gauge	<input type="text" value="8 Ga"/>
Regal. Interior	<input type="text" value="Arc Sprayed"/>
Regal. Exterior	<input type="text" value="Durscote"/>
Regal. Height	<input type="text" value="2"/>
Regal. Diameter	<input type="text" value="15"/>
Regal. Price	<input type="text" value="100"/>
Regal. Upc	<input type="text" value="078008018563"/>
Regal. Picture	<input type="text" value="

this item.

this item.

Location: <http://0.0.0.0:3000/COORDINATOR/>

GTW Catalog Coordinator

Expand	Find	Create	Change
Buyer	1 Find	Create	Change
Seller	0 Find	Create	Change
Exchange	0 Find	Create	Change
Fileserver	1 Find	Create	Change

Enter substring:

Location: http://0.0.0.0:3000/coordinator/CREATE?Class=FILESERVER

GTW Catalog Coordinator

Create as a **Fileserver** with the following profile.

Agentcapability

Extractmetadata

Filename

Format

Interest

Specialty

Rootclass

Noncreateableclass

Nonchangeableclass

Rootrelation



Location: <http://0.0.0.0:3000/coordinator/CREATE?>

GTW Catalog Coordinator

New object succesful. Use the following form to make changes.

Rdb is Rdb **Fileserver** with the following profile.

Agentcapability	<input type="checkbox"/>	<input type="checkbox"/>	Indexed	<input type="button" value="Expand"/>
Extractmetadata	<input type="checkbox"/>	<input type="checkbox"/>	Dynamic	<input type="button" value="Expand"/>
Filename	<input type="checkbox"/>	<input type="checkbox"/>	gullible:catalog:cookware:renfrew:renfrew	
Format	<input type="checkbox"/>	<input type="checkbox"/>	Semanticxml	<input type="button" value="Expand"/>
Interest	<input type="checkbox"/>	<input type="checkbox"/>	<pre>+ + / < =< > >=</pre>	
Specialty	<input type="checkbox"/>	<input type="checkbox"/>	<pre>Renfrew.Unspsc.521518.Cid Renfrew.Unspsc.521518.Diameter Renfrew.Unspsc.521518.Hue Renfrew.Unspsc.521518.Manufacturer Renfrew.Unspsc.521518.Material Renfrew.Unspsc.521518.Pid Renfrew.Unspsc.521518.Price Renfrew.Unspsc.521518.Surface Replicate.Host</pre>	
Rootclass	<input type="checkbox"/>	<input type="checkbox"/>	Renfrew.Unspsc.521518	<input type="button" value="Expand"/>
Noncreateableclass	<input type="checkbox"/>	<input type="checkbox"/>		<input type="button" value="Expand"/>
Nonchangeableclass	<input type="checkbox"/>	<input type="checkbox"/>		<input type="button" value="Expand"/>
Rootrelation	<input type="checkbox"/>	<input type="checkbox"/>	*	

Location: <http://0.0.0.0:3000/coordinator/Run?>

GTW Catalog Coordinator

Run action **Integraterules** on the following arguments.

Integraterules.Source Rdb

Integraterules.Target Library

ID	R11	R12	R13	R14	R15	R16
Type						
Material	Aluminum	Aluminum	Aluminum	Iron	Iron	Iron
Interior						
Exterior						
Color						
Capacity						
Diameter	12	12	12	12	12	12
MSRP						
Manufacturer	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew
UPC						
Image						

Infomaster

ID	R11	R12	R13	R14	R15	R16
Renfrew.Unspsc.521518.Manufacturer	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew
Renfrew.Unspsc.521518.Price	32	40	48	32	40	48
Renfrew.Unspsc.521518.Pid	000011	000012	000013	000014	000015	000016
Renfrew.Unspsc.521518.Cid	079043	079043	079043	079043	079043	079043
Renfrew.Unspsc.521518.Diameter	12	12	12	12	12	12
Renfrew.Unspsc.521518.Hue	Ebony	Charcoal	Pumice	Teal	Aqua	White
Renfrew.Unspsc.521518.Surface	teflon-aluminum	teflon-aluminum	teflon-aluminum	teflon-iron	teflon-iron	teflon-iron
Renfrew.Unspsc.521518.Material	Aluminum	Aluminum	Aluminum	Iron	Iron	Iron

Infomaster™ is a data integration system developed by the Logic Group at Stanford University.

Location: http://0.0.0.0:3000/Library/QBE?

GTW Catalog Library

Unspsc.521518.Upc

?product ?upc

Renfrew.Unspsc.521518.Cid

?product ?cid

Renfrew.Unspsc.521518.Pid

?product ?pid

Stringappend

?cid ?pid ?upc

Save Rule

Convert to SQL

Add Condition *

Drop Rule

Convert to KIF

Delete Selection

Update Rule

Reverse Rule

The GTW Catalog is an application of Infomaster.

Location: <http://0.0.0.0:3000/GTW/COMPARE?>

GTW DIRECTORY

SEARCH THE GLOBAL TRADING WEB


[Directory Home](#)
[Go To Commerce One](#)
[Go To Commerce One.net](#)
[About the GTW Catalog](#)
[Simple Search](#)
[Administrator](#)
[Help](#)

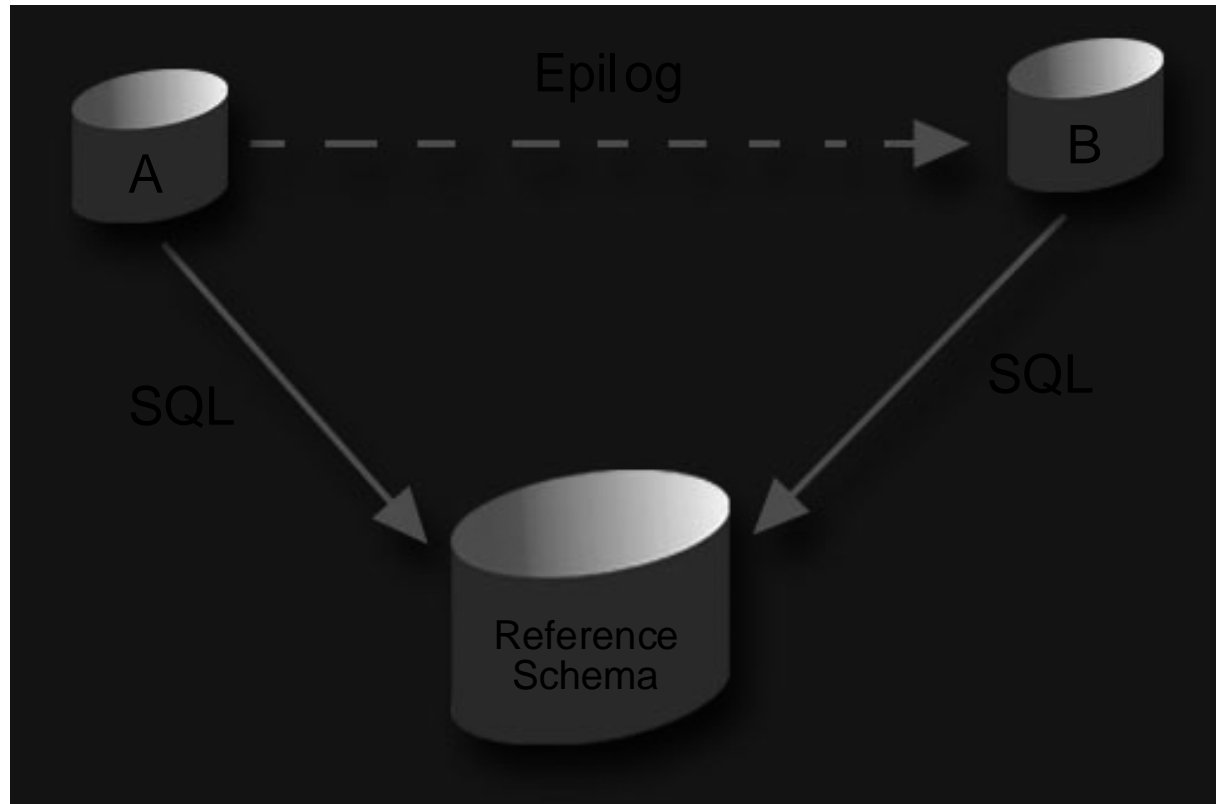
ID	R11	R12	R13	R14	R15	R16
Type						
Material	Aluminum	Aluminum	Aluminum	Iron	Iron	Iron
Interior						
Exterior						
Color						
Capacity						
Diameter	12	12	12	12	12	12
MSRP						
Manufacturer	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew
UPC	079043000011	079043000012	079043000013	079043000014	079043000015	079043000016
Image						

Infomaster

ID	R11	R12	R13	R14	R15	R16
Renfrew.Unspsc.521518.Manufacturer	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew	Renfrew
Renfrew.Unspsc.521518.Price	32	40	48	32	40	48
Renfrew.Unspsc.521518.Pid	000011	000012	000013	000014	000015	000016
Renfrew.Unspsc.521518.Cid	079043	079043	079043	079043	079043	079043
Renfrew.Unspsc.521518.Diameter	12	12	12	12	12	12
Renfrew.Unspsc.521518.Hue	Ebony	Charcoal	Pumice	Teal	Aqua	White
Renfrew.Unspsc.521518.Surface	teflon-aluminum	teflon-aluminum	teflon-aluminum	teflon-iron	teflon-iron	teflon-iron
Renfrew.Unspsc.521518.Material	Aluminum	Aluminum	Aluminum	Iron	Iron	Iron

Infomaster™ is a data integration system developed by the [Logic Group](#) at [Stanford University](#).

Assets Leveraged

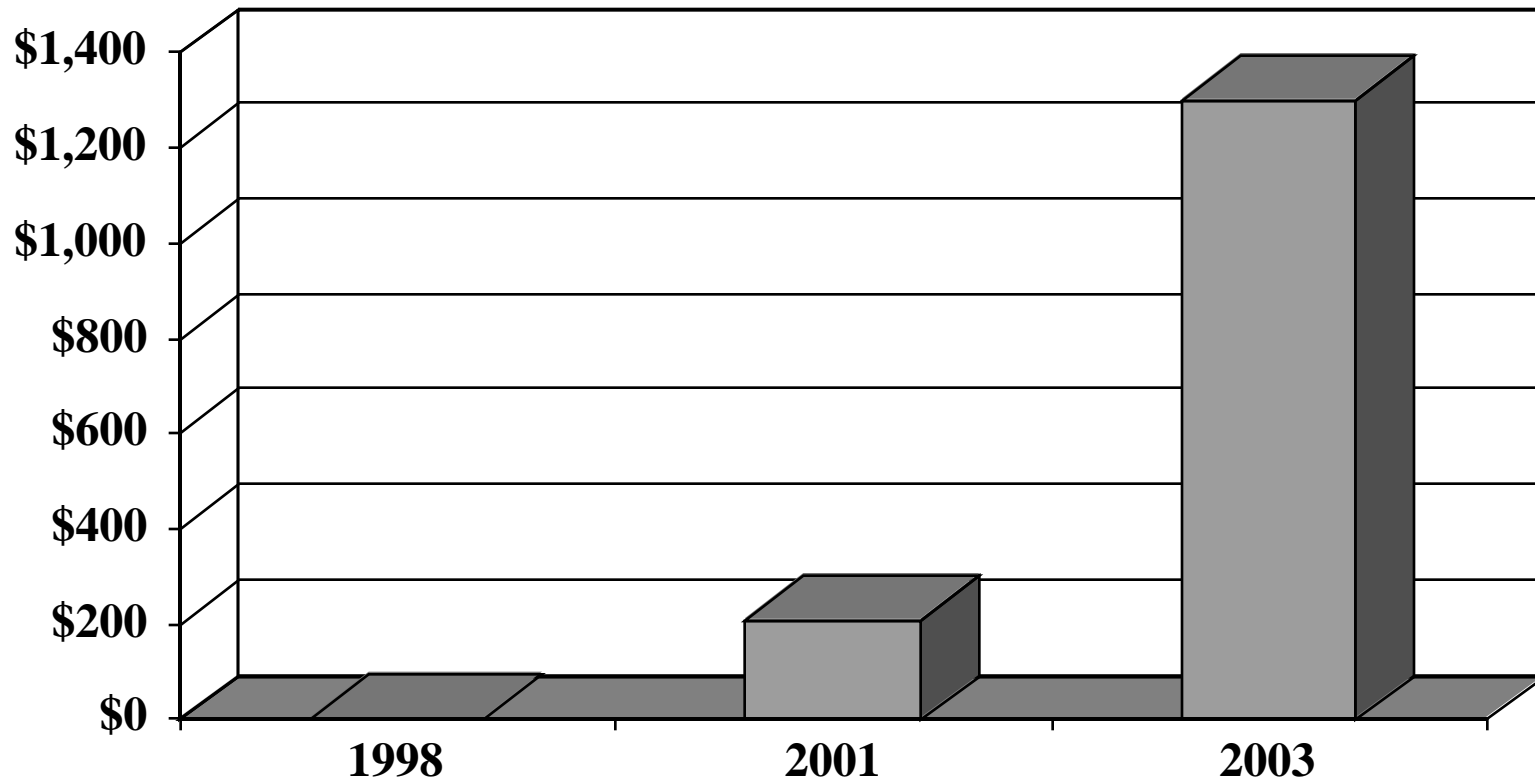


Complexity hidden

SQL Skills and Code preserved

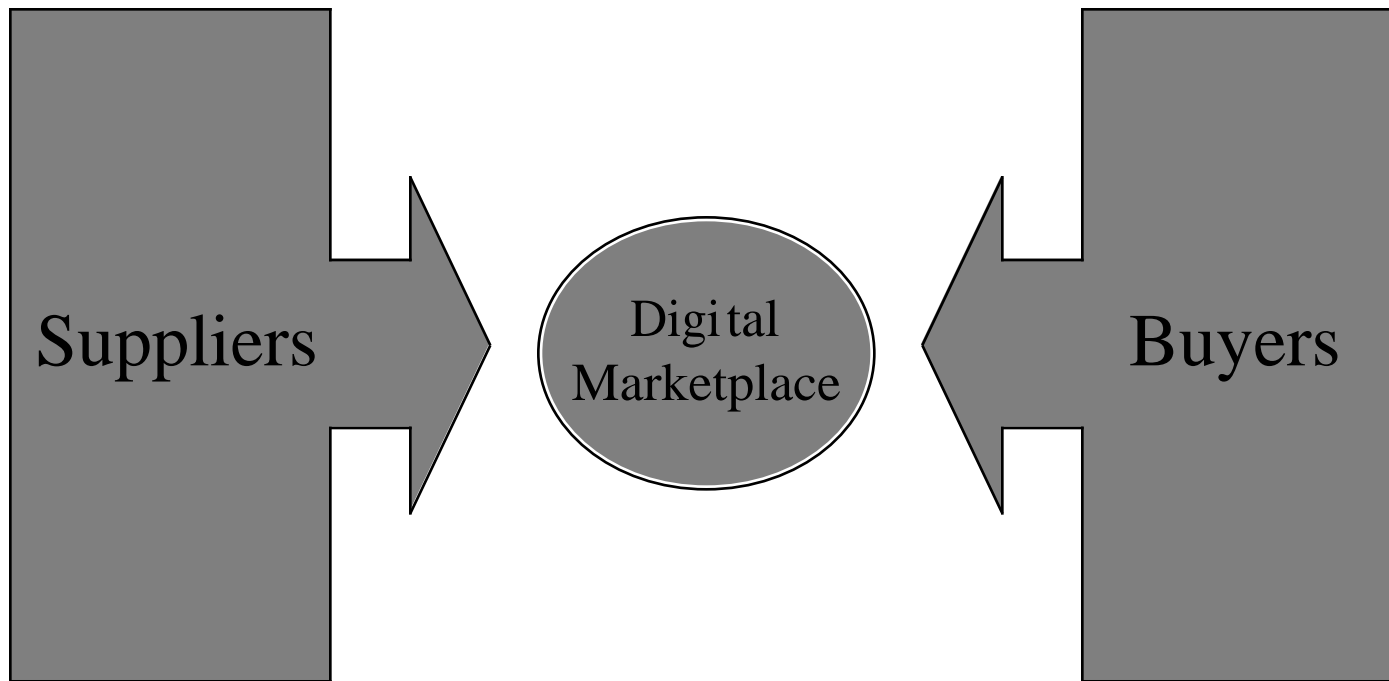
Business to Business Net Commerce

\$Billions



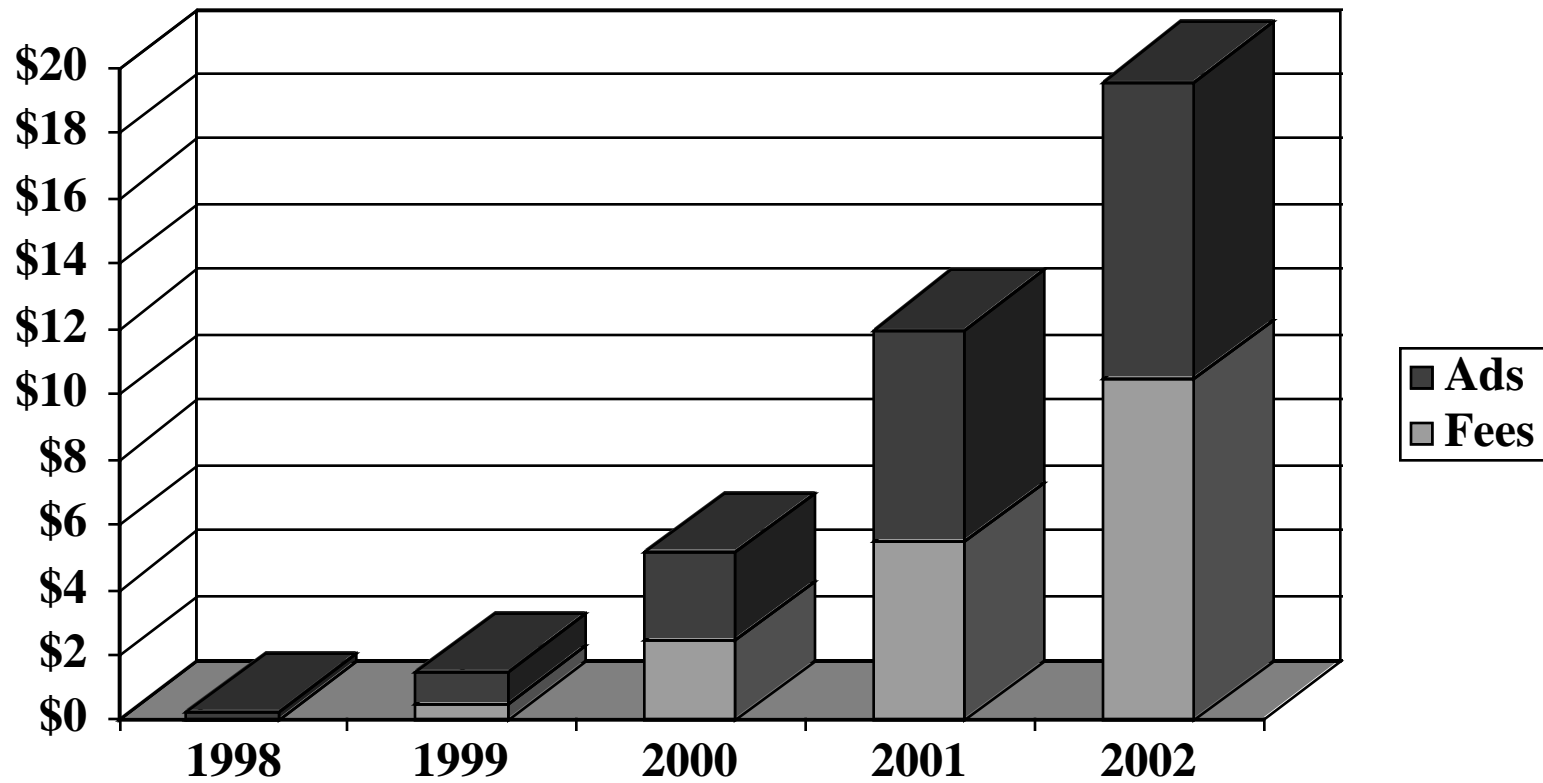
Source: Forrester Research, 1999

Market Makers



The Infomediaries Market

\$Billions



Source: Volpe Brown Whelan

Components of Digital Marketplace

Transaction execution

Order taking, tracking, payment, auction,...

Order Fulfillment

Requisition, approval process, budget, pricing

Product Information Management

Aggregation of Product Information

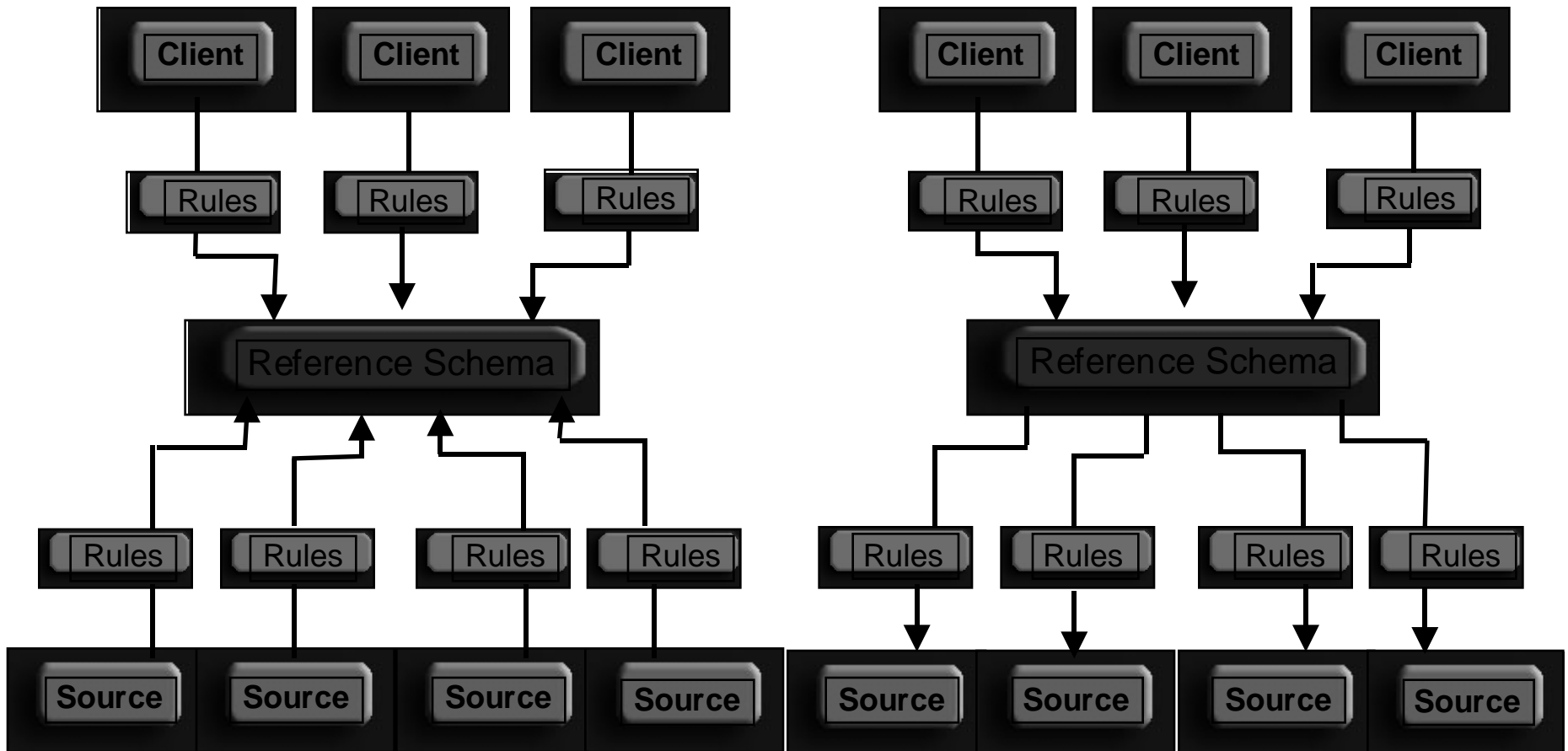
Search and Update

Quote

“The catalog ... is what I believe is blocking the growth of Internet commerce today...”

Geoffrey Moore, Author of *Crossing the Chasm*, RedHerring, February 1999.

View Inversion



View Inversion

Example

`employee(X, Y) :- manager(Y, X).`



`manager(Y, X) :- employee(X, Y).`

Automated View Inversion

Predicate Completion on relations in Reference Model
Simplification within and across rules using Model Elimination

Correct (all answers justified by data)
Complete (all such answers)

Best newcomer paper award at PODS 97
US Patent pending

Example of Complete Inversion

```
father(X,Y):-parent(X,Y),gender(X,m).
```

```
mother(X,Y):-parent(X,Y),gender(X,f).
```



```
parent(X,Y):-father(X,Y).
```

```
parent(X,Y):-mother(X,Y).
```

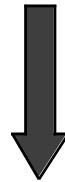
```
gender(X,m):-father(X,Y).
```

```
gender(X,f):-mother(X,Y).
```

Examples of Semi-complete Inversion

Existential Variables

```
grandparent(X,Z) :- parent(X,Y), parent(Y,Z).
```



```
parent(X,f(X,Z)) :- grandparent(X,Z).
```

```
parent(f(X,Z),Z) :- grandparent(X,Z).
```

Disjunction

```
parent(X,Y) :- father(X,Y).
```

```
parent(X,Y) :- mother(X,Y).
```



```
father(X,Y) | mother(X,Y) :- parent(X,Y).
```

Disjunctive Source Description

Sources (non-Recursive Datalog):

```
s1(X,Y) :- virgin(X,Y), major(X), major(Y).
```

```
s2(X,Y) :- united(X,Y), major(X), major(Y).
```

```
s3(X,Y) :- virgin(X,Y).
```

```
s3(X,Y) :- united(X,Y).
```

Query:

```
query() :- virgin(X,Y), united(Y,Z).
```

Partial Query Plans (infinitely many):

```
query() :- s1(X,Y), s2(Y,Z).
```

```
query() :- s1(X',X), s3(X,Y), s2(Y,Z).
```

```
query() :- s1(X'',X'), s3(X',X), s3(X,Y), s2(Y,Z).
```

```
...
```

Query Plans

After Inversion:

```
query() :- virgin(X,Y),united(Y,Z)
~virgin(X,Y) :- ~query(),united(Y,Z)
~united(Y,Z) :- ~query(),virgin(X,Y)

virgin(X,Y) :- s1(X,Y)
virgin(X,Y) :- s3(X,Y),~united(X,Y)

united(X,Y) :- s2(X,Y)
united(X,Y) :- s3(X,Y),~virgin(X,Y)
```

After Simplification (recursive Datalog):

```
query() :- virgin(X,Y),united(Y,Z)

virgin(X,Y) :- s1(X,Y)
virgin(X,Y) :- virgin(X',X),s3(X,Y)

united(X,Y) :- s2(X,Y)
united(X,Y) :- s3(X,Y),united(Y,Y')
```

Complexity Results

		User Query			
		conjunctive	disjunctive	recursive	first-order
Source Description	conjunctive	PTIME	PTIME	PTIME	undecidable
	disjunctive	co-NP	co-NP	co-NP	undecidable
	recursive	co-NP	co-NP	undecidable	undecidable
	first-order	undecidable	undecidable	undecidable	undecidable

Data complexity to decide whether a tuple is in the answer.

Table of results courtesy of Oliver Duschka [Ph.D. dissertation 1997].