Infomaster

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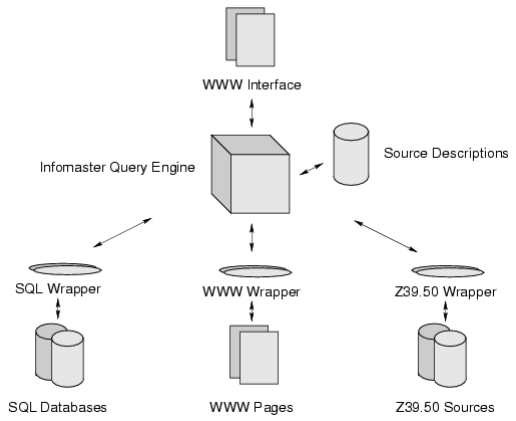
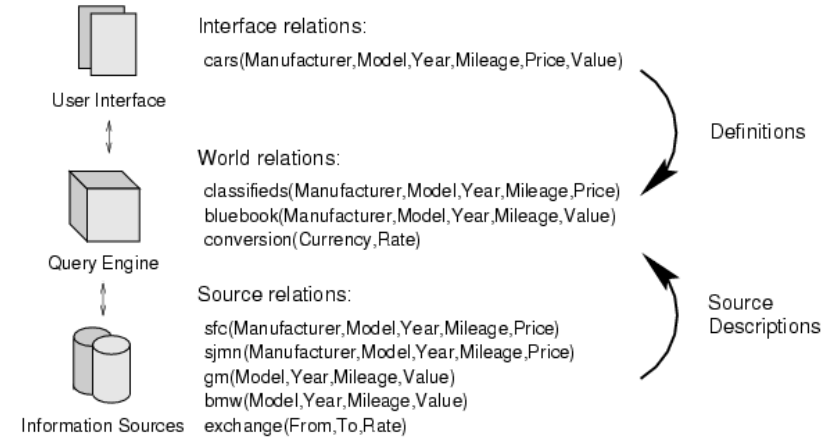
Infomaster -- Duschka



Interface, World, & Source Relations



Description of the Interface in Terms of the World Relations

$$cars(Manufacturer, Model, Year, Mileage, Price, Value) :-$$
$$classifieds(Manufacturer, Model, Year, Mileage, Price),$$
$$bluebook(Manufacturer, Model, Year, Mileage, Value)$$

Description of the Sources in Terms of the World Model

$$sfc^{l}(Manufacturer, Model, Year, Mileage, Price) :- classifieds(Manufacturer, Model, Year, Mileage, Price)$$

$$sjmn^{l}(Manufacturer, Model, Year, Mileage, Price) :- classifieds(Manufacturer, Model, Year, Mileage, Price)$$

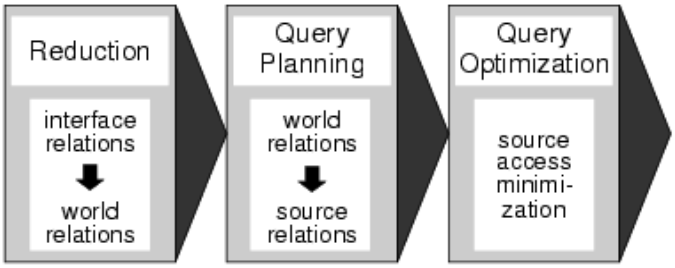
$$exchange^{e,l}(From, dollar, Rate) :- conversion(From, Rate)$$

Description of Sources in Terms of the World Model

$$gm^{e,l}(Model, Year, Mileage, Value) :- bluebook(gm, Model, Year, Mileage, Value)$$

$$bmw^{e,l}(Model, Year, Mileage\_in\_km, Value\_in\_DM) :- bluebook(bmw, Model, Year, Mileage, Value), conversion(dm, Rate), Mileage = Mileage\_in\_km * 1.6, Value = Value\_in\_DM * Rate$$

Infomaster Query Processing



Example Query

Retrieve the model, mileage, and price of BMWs built in 1996
That are for sale for a price below their average market value:

$$q(Model, Mileage, Price) :-$$
$$cars(bmw, Model, 1996, Mileage, Price, Value),$$
$$Price < Value$$

Reduction

$$
\begin{aligned}
q(Model, Mileage, Price) :- \\
&classifieds(bmw, Model, 1996, Mileage, Price), \\
&bluebook(bmw, Model, 1996, Mileage, Value), \\
&Price < Value
\end{aligned}
$$

Query Planning

$$
\begin{aligned}
&q(Mo_1, Mi_1, Pr_1) :- classifieds(Ma_1, Mo_2, Ye_1, Mi_2, Pr_2), \\
&\qquad bluebook(Ma_2, Mo_3, Ye_2, Mi_3, Va_1), less(Pr_3, Va_2), \\
&\qquad e(Mo_1, Mo_2),\ e(Mo_2, Mo_3),\ e(Mi_1, Mi_2),\ e(Mi_2, Mi_3), \\
&\qquad e(Pr_1, Pr_2),\ e(Pr_2, Pr_3),\ e(Ma_1, bmw),\ e(Ma_2, bmw), \\
&\qquad e(Va_1, Va_2),\ e(Ye_1, 1996),\ e(Ye_2, 1996) \\
&classifieds(Ma, Mo, Ye, Mi, Pr) :- sfc(Ma, Mo, Ye, Mi, Pr) \\
&classifieds(Ma, Mo, Ye, Mi, Pr) :- sjmn(Ma, Mo, Ye, Mi, Pr) \\
&bluebook(gm, Mo, Ye, Mi, Va) \quad :- gm(Mo, Ye, Mi, Va) \\
&bluebook(bmw, Mo, Ye, f_1(Mo, Ye, Mi\_km, Va\_DM), f_2(Mo, Ye, Mi\_km, Va\_DM)) \\
&\qquad :- bmw(Mo, Ye, Mi\_km, Va\_DM) \\
&conversion(dm, f_3(Mo, Ye, Mi\_km, Va\_DM)) :- bmw(Mo, Ye, Mi\_km, Va\_DM) \\
&times(f_1(Mo, Ye, Mi\_km, Va\_DM), Mi\_km, 1.6) :- bmw(Mo, Ye, Mi\_km, Va\_DM) \\
&times(f_2(Mo, Ye, Mi\_km, Va\_DM), Va\_DM, f_3(Mo, Ye, Mi\_km, Va\_DM)) \\
&\qquad :- bmw(Mo, Ye, Mi\_km, Va\_DM) \\
&conversion(From, Rate) \quad :- exchange(From, Dollar, Rate) \\
&e(Y_1, Y_2) :- conversion(X_1, Y_1),\ conversion(X_2, Y_2),\ e(X_1, X_2) \\
&e(X_1, X_2) :- times(X_1, Y_1, Z_1),\ times(X_2, Y_2, Z_2),\ e(Y_1, Y_2),\ e(Z_1, Z_2) \\
&e(Y_1, Y_2) :- times(X_1, Y_1, Z_1),\ times(X_2, Y_2, Z_2),\ e(X_1, X_2),\ e(Z_1, Z_2) \\
&e(Z_1, Z_2) :- times(X_1, Y_1, Z_1),\ times(X_2, Y_2, Z_2),\ e(X_1, X_2),\ e(Y_1, Y_2) \\
&e(X, Y) \quad :- e(X, Z),\ e(Z, Y)
\end{aligned}
$$

Query Optimization

$$
\begin{aligned}
&q(Model, Mileage, Price) :- \\
&\quad (sfc(bmw, Model, 1996, Mileage, Price) \\
&\quad \vee \ \ sjmn(bmw, Model, 1996, Mileage, Price)), \\
&\quad bmw(Model, 1996, Mileage\_in\_km, Value\_in\_DM), \\
&\quad exchange(dm, dollar, Rate), \\
&\quad Mileage = Mileage\_in\_km * 1.6, \\
&\quad Value = Value\_in\_DM * Rate, \\
&\quad Price < Value
\end{aligned}
$$

Query Planning Details

Planning for Information Gathering: A Tutorial Survey [Lambrecht & Kambhampati, 1997]

- World Model Relations
  - Name(Name)
  - Phone-of(Name, Area, Phone)
  - Phone(Area, Phone)
  - Phone-company(Name, Company)
- Sources
  - WHITEPAGES(Name, Area, Phone, Co)

Relating Sources to the World Model

Complete information:

$$\text{WHITEPAGES}(Name, Area, Phone, Co) \Leftrightarrow name(Name) \wedge phone\text{-}of(Name, Area, Phone) \wedge phone(Area, Phone) \wedge phone\text{-}company(Name, Co)$$

Partial information:

$$\text{WHITEPAGES}(Name, Area, Phone, Co) \text{ :- } name(Name) \wedge phone\text{-}of(Name, Area, Phone) \wedge phone(Area, Phone) \wedge phone\text{-}company(Name, Co)$$

Binding Restrictions

White pages must be queried with a name:

$$\text{WHITEPAGES}(\$Name, Area, Phone, Co) \text{ :- } name(Name) \wedge phone\text{-}of(Name, Area, Phone) \wedge phone(Area, Phone) \wedge phone\text{-}company(Co)$$

Valid Query:

$$\text{WHITEPAGES}(Name, Area, Phone, Co) \wedge Name = \text{“}Eric\ Lambrecht\text{”}$$

Invalid Query

$$\text{WHITEPAGES}(Name, Area, Phone, Co) \wedge Co = \text{“}USWest\text{”}$$

Soundness & Completeness

- A plan is *sound* if each of the tuples returned by a plan satisfy the query
- A plan is *complete* if all tuples are returned that satisfy a query
  - A plan is ***operationally complete*** if it returns all tuples from the available information sources
  - A plan is ***conceptually complete*** if it is exactly the set of tuples that would be returned from a database
  - Conceptual completeness implies operational completeness
- A plan is minimal if it is not subsumed by any subplan

Reasoning About Plan Completeness

- Each phone book has all of their own customers and some of the other:

$$\begin{aligned}
\text{USWEST}(Name, Area, Phone, Co) \;\text{:-}\; & name(Name) \wedge \\
& phone\text{-}of(Name, Area, Phone) \wedge \\
& phone(Area, Phone) \wedge Area = 602 \\
& phone\text{-}company(Name, Co) \\
\text{ATT}(Name, Area, Phone, Co) \;\text{:-}\; & name(Name) \wedge \\
& phone\text{-}of(Name, Area, Phone) \wedge \\
& phone(Area, Phone) \wedge Area = 602 \\
& phone\text{-}company(Name, Co)
\end{aligned}$$

LCW – Local Closed World

- LCW Statement – Source contains the phone numbers of all people in Phoenix served by USWest

$$name(Name) \wedge phone\text{-}of(Name, Area, Phone) \wedge phone(Area, Phone) \wedge Area = \text{“602”} \wedge phone\text{-}company(Name, Co) \wedge Co = \text{“USWest”} \;\text{:-}\; \text{USWEST}(Name, Area, Phone, Co)$$

Building Inverse Rules

Inverting the rules (without binding patterns):

$\text{MOVIE-MANIA}(Movie) \;\text{:-}\; movie(Movie) \wedge reviewed\text{-}by(Critic, Movie)$

we can convert it into the following reformulation rules:

$$movie(Movie) \;\text{:-}\; \text{MOVIE-MANIA}(Movie)$$
$$reviewed\text{-}by(f(Movie), Movie) \;\text{:-}\; \text{MOVIE-MANIA}(Movie)$$

Using the rules:

$query(X) \;\text{:-}\; movie(X)$

it can be transformed (by applying the rules above) into

$query(X) \;\text{:-}\; \text{MOVIE-MANIA}(X)$

Building Inverse Rules for Sources with Binding Patterns

$$\text{WHITEPAGES}(\$Name, Area, Phone, Co) \text{ :- } name(Name) \wedge phone\text{-}of(Name, Area, Phone) \wedge phone(Area, Phone) \wedge phone\text{-}company(Co)$$

- Binding pattern on $Name needs to be addressed in the rules
- Add one of the conjunctions that provides Name to the new rules

Example Inverse Rules

$$\begin{aligned}
name(Name) &\text{ :- } name(Name) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
name(Name) &\text{ :- } phone\text{-}of(Name, Area, Phone) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone\text{-}of(Name, Area, Phone) &\text{ :- } name(Name) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone\text{-}of(Name, Area, Phone) &\text{ :- } phone\text{-}of(Name, Area, Phone) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone(Area, Phone) &\text{ :- } name(Name) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone(Area, Phone) &\text{ :- } phone\text{-}of(Name, Area, Phone) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone\text{-}company(Co) &\text{ :- } name(Name) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)\\
phone\text{-}company(Co) &\text{ :- } phone\text{-}of(Name, Area, Phone) \wedge \text{WHITEPAGES}(Name, Area, Phone, Co)
\end{aligned}$$

Query Planning

- Given a query,
  - Search through the space of inverse rules
  - Apply the rules to the world model relations
  - Terminate when query is completely rewritten in term of source relations
- Resulting query is the plan for retrieving the data