RELATIONAL CALCULUS AND RELATIONAL ALGEBRA

Consider the following schema:

Suppliers (sid: integer, sname: string, address: string)
Parts (pid: integer, pname: string, color: string)
Catalog (sid: integer, pid: integer, cost: real)

The key fields are underlined, and the domain of each field is listed after the field name. The Catalog relation lists the prices charged for parts by Suppliers. Write the following queries in relational algebra and tuple relational calculus:

1. Find the names of suppliers who supply some red part.
   - RA
     \[ \pi_{\text{name}}(\pi_{\text{sid}}(\pi_{\text{pid}}(\sigma_{\text{color} = 'red'} Parts) \bowtie Catalog) \bowtie Suppliers) \]
   - TRC
     \[ \{ T \mid \exists T1 \in Suppliers(\exists X \in Parts(X.color = 'red' \land \exists Y \in Catalog
       (Y.pid = X.pid \land Y.sid = T1.sid)) \land T\text{name} = T1\text{name}) \} \]

2. Find the sids of suppliers who supply some red or green part.
   - RA
     \[ \pi_{\text{sid}}(\pi_{\text{pid}}(\sigma_{\text{color} = 'red' \lor \text{color} = 'green'} Parts) \bowtie catalog) \]
   - TRC
     \[ \{ T \mid \exists T1 \in Catalog(\exists X \in Parts((X.color = 'red' \lor X.color = 'green')
       \land X.pid = T1.pid) \land T\text{sid} = T1\text{sid}) \} \]
3. Find the sides of suppliers who supply some red part or are at 221 Packer Street.

\[ \rho(R1, \pi_{sid}(\pi_{\text{pid, color}=\text{red}'} \text{Parts}) \bowtie \text{Catalog}) \]
\[ \rho(R2, \pi_{sid} \sigma_{\text{address}=\text{221 Packer Street}'} \text{Suppliers}) \]
\[ R1 \cup R2 \]

4. Find the sides of suppliers who supply some red part and some green part.

\[ \rho(R1, \pi_{sid}(\pi_{\text{pid, color}=\text{red}'} \text{Parts}) \bowtie \text{Catalog}) \]
\[ \rho(R2, \pi_{sid}(\pi_{\text{pid, color}=\text{green}'} \text{Parts}) \bowtie \text{Catalog}) \]
\[ R1 \cap R2 \]

5. Find the sides of suppliers who supply every part.

\[ (\pi_{\text{sid, pid}} \text{Catalog}) / (\pi_{\text{pid}} \text{Parts}) \]

\[ \{T \mid \exists T1 \in \text{Catalog} (\exists X \in \text{Parts}(X.\text{color} = \text{red} \land X.\text{pid} = T1.\text{pid}) \land T.\text{sid} = T1.\text{sid}) \land \exists T2 \in \text{Suppliers}(T2.\text{address} = \text{221 Packer Street} \land T.\text{sid} = T2.\text{sid}) \} \]
6. Find the *sid* of suppliers who supply every red part.

- **RA**
  \[
  (\pi_{sid, pid} \text{Catalog}) / (\pi_{pid \sigma_{\text{color} = \text{red} \text{'}} \text{Parts}})
  \]

- **TRC**
  \[
  \{ T \mid \exists T_1 \in \text{Catalog} (\forall X \in \text{Parts} (X.\text{color} \neq \text{red}') \\
  \lor \exists T_2 \in \text{Catalog} (T2.\text{pid} = X.\text{pid} \land T2.\text{sid} = T1.\text{sid}) \\
  \land T.\text{sid} = T1.\text{sid}) \}
  \]

7. Find the *sid* of suppliers who supply every red or green part.

- **RA**
  \[
  (\pi_{sid, pid} \text{Catalog}) / (\pi_{pid \sigma_{\text{color} = \text{red}' \lor \text{color} = \text{green}' \text{'}} \text{Parts}})
  \]

- **TRC**
  \[
  \{ T \mid \exists T_1 \in \text{Catalog} (\forall X \in \text{Parts} ((X.\text{color} \neq \text{red}') \\
  \land X.\text{color} \neq \text{green}') \lor \exists T_2 \in \text{Catalog} \\
  (T2.\text{pid} = X.\text{pid} \land T2.\text{sid} = T1.\text{sid}) ) \land T.\text{sid} = T1.\text{sid}) \}
  \]

8. Find the *sid* of suppliers who supply every red part or supply every green part.

- **RA**
  \[
  \rho(R1, ((\pi_{sid, pid} \text{Catalog}) / (\pi_{pid \sigma_{\text{color} = \text{red} \text{'}} \text{Parts}}))))
  
  \rho(R2, ((\pi_{sid, pid} \text{Catalog}) / (\pi_{pid \sigma_{\text{color} = \text{green} \text{'}} \text{Parts}}))))
  
  R1 \cup R2
  \]

- **TRC**
  \[
  \{ T \mid \exists T_1 \in \text{Catalog} ((\forall X \in \text{Parts} \\
  (X.\text{color} \neq \text{red}' \lor \exists Y \in \text{Catalog} (Y.\text{pid} = X.\text{pid} \land Y.\text{sid} = T1.\text{sid})) \\
  \lor \forall Z \in \text{Parts} (Z.\text{color} \neq \text{green}' \lor \exists P \in \text{Catalog} \\
  (P.\text{pid} = Z.\text{pid} \land P.\text{sid} = T1.\text{sid})) ) \land T.\text{sid} = T1.\text{sid}) \}
  \]
9. Find pairs of \( sids \) such that the supplier with the first \( sid \) charges more for some part than the supplier with the second \( sid \).

- **RA**

\[
\rho(R1, Catalog) \\
\rho(R2, Catalog) \\
\pi_{R1.\text{sid}, R2.\text{sid}}(\sigma_{R1.\text{pid}=R2.\text{pid} \land R1.\text{sid} \neq R2.\text{sid} \land R1.\text{cost} > R2.\text{cost}}(R1 \times R2))
\]

- **TRC**

\[
\{T \mid \exists T1 \in Catalog(\exists T2 \in Catalog \\
(T2.\text{pid} = T1.\text{pid} \land T2.\text{sid} \neq T1.\text{sid} \\
\land T2.\text{cost} < T1.\text{cost} \land T.\text{sid} = T2.\text{sid}) \\
\land T.\text{sid} = T1.\text{sid})\}
\]

10. Find the \( pids \) of parts supplied by at least two different suppliers.

- **RA**

\[
\rho(R1, Catalog) \\
\rho(R2, Catalog) \\
\pi_{R1.\text{pid}, R2.\text{pid}}(R1 \times R2)
\]

- **TRC**

\[
\{T \mid \exists T1 \in Catalog(\exists T2 \in Catalog \\
(T2.\text{pid} = T1.\text{pid} \land T2.\text{sid} \neq T1.\text{sid} \\
\land T.\text{pid} = T1.\text{pid})\}
\]
11. Find the *pids* of the most expensive parts supplied by suppliers named Yosemite Sham.

- **RA**

\[
\rho(R1, \pi_{sid} \sigma_{sname='YosemiteSham'} Suppliers) \\
\rho(R2, R1 \bowtie Catalog) \\
\rho(R3, R2) \\
\rho(R4(1 \rightarrow sid, 2 \rightarrow pid, 3 \rightarrow cost), \sigma_{R3.cost < R2.cost}(R3 \times R2)) \\
\pi_{pid}(R2 - \pi_{sid,pid,cost} R4)
\]

- **TRC**

\[
\{T \mid \exists T1 \in Catalog(\exists X \in Suppliers \\
(X.sname = 'YosemiteSham' \land X.sid = T1.sid) \land \neg(\exists S \in Suppliers \\
(S.sname = 'YosemiteSham' \land \exists Z \in Catalog \\
(Z.sid = S.sid \land Z.cost > T1.cost))) \land T.pid = T1.pid)\}
\]