

Relational Calculus

- An alternative to relational algebra.
- **Declarative**
 - describe the set of answers
 - without being explicit about how they should be computed
- One variant is called: **Tuple Relational Calculus (TRC)**.
- Another variant: **Domain Relational Calculus (DRC)**
- Calculus has variables, constants, comparison ops, logical connectives and quantifiers.

Tuple Relational Calculus

- A TRC query has the form $\{T \mid p(T)\}$
 - T is a tuple variable
 - $p(T)$ is a formula that describes T
- Result: set of all tuples t to which $p(T)$ evaluates to true when $T = t$
- Example: $\{S \mid S \in \text{Sailors} \wedge S.\text{rating} > 7\}$

Tuple Relational Calculus

(Q11) Find all sailors with a rating above 7.

$$\{S \mid S \in \text{Sailors} \wedge S.\text{rating} > 7\}$$

(Q12) Find the names and ages of sailors with a rating above 7.

$$\{P \mid \exists S \in \text{Sailors} (S.\text{rating} > 7 \wedge P.\text{name} = S.\text{sname} \wedge P.\text{age} = S.\text{age})\}$$

the form $P \in \text{Relname}$. The result of this query is a relation with two fields, *name* and *age*. The atomic formulas $P.\text{name} = S.\text{sname}$ and $P.\text{age} = S.\text{age}$ give values to the fields of an answer tuple P . On instances $B1$, $R2$, and $S3$, the answer is the set of tuples $\langle \text{Lubber}, 55.5 \rangle$, $\langle \text{Andy}, 25.5 \rangle$, $\langle \text{Rusty}, 35.0 \rangle$, $\langle \text{Zorba}, 16.0 \rangle$, and $\langle \text{Horatio}, 35.0 \rangle$. PURUSHOTHAM

(Q13) Find the sailor name, boat id, and reservation date for each reservation.

$$\{P \mid \exists R \in \text{Reserves} \exists S \in \text{Sailors} \\ (R.sid = S.sid \wedge P.bid = R.bid \wedge P.day = R.day \wedge P.sname = S.sname)\}$$

<i>sname</i>	<i>bid</i>	<i>day</i>
Dustin	101	10/10/98
Dustin	102	10/10/98
Dustin	103	10/8/98
Dustin	104	10/7/98
Lubber	102	11/10/98
Lubber	103	11/6/98
Lubber	104	11/12/98
Horatio	101	9/5/98
Horatio	102	9/8/98
Horatio	103	9/8/98

Figure 4.20 Answer to Query Q13

(Q1) Find the names of sailors who have reserved boat 103.

$$\{P \mid \exists S \in \text{Sailors } \exists R \in \text{Reserves}(R.sid = S.sid \wedge R.bid = 103 \wedge P.sname = S.sname)\}$$

(Q2) Find the names of sailors who have reserved a red boat.

$$\{P \mid \exists S \in \text{Sailors } \exists R \in \text{Reserves}(R.sid = S.sid \wedge P.sname = S.sname \\ \wedge \exists B \in \text{Boats}(B.bid = R.bid \wedge B.color = 'red'))\}$$

(Q9) Find the names of sailors who have reserved all boats.

$$\{P \mid \exists S \in \text{Sailors } \forall B \in \text{Boats} \\ (\exists R \in \text{Reserves}(S.sid = R.sid \wedge R.bid = B.bid \wedge P.sname = S.sname))\}$$

(Q14) Find sailors who have reserved all red boats.

$$\{S \mid S \in \text{Sailors} \wedge \forall B \in \text{Boats} \\ (B.\text{color} = \text{'red'} \Rightarrow (\exists R \in \text{Reserves}(S.\text{sid} = R.\text{sid} \wedge R.\text{bid} = B.\text{bid})))\}$$

Domain Relational Calculus

- **Query** has the form:

$$\left\{ \langle x_1, x_2, \dots, x_n \rangle \mid p(\langle x_1, x_2, \dots, x_n \rangle) \right\}$$

- **Answer** includes all tuples $\langle x_1, x_2, \dots, x_n \rangle$ that make the formula $p(\langle x_1, x_2, \dots, x_n \rangle)$ be true.

Example: Find all sailors with a rating above 7

$$\{ \langle I, N, T, A \rangle \mid (I, N, T, A) \in \text{Sailors} \wedge T > 7 \}$$

Giving each attribute a variable name

Ensures that I, N, T, and A are restricted to be fields of the same tuple

(Q11) Find all sailors with a rating above 7.

$$\{\langle I, N, T, A \rangle \mid \langle I, N, T, A \rangle \in \text{Sailors} \wedge T > 7\}$$

condition $\langle I, N, T, A \rangle \in \text{Sailors}$ ensures that the domain variables I , N , T , and A are restricted to be fields of the *same* tuple. In comparison with the TRC query, we can say $T > 7$ instead of $S.\text{rating} > 7$, but we must specify the tuple $\langle I, N, T, A \rangle$ in the result, rather than just S .

(Q1) Find the names of sailors who have reserved boat 103.

$$\{\langle N \rangle \mid \exists I, T, A (\langle I, N, T, A \rangle \in \textit{Sailors} \\ \wedge \exists D (\langle I, 103, D \rangle \in \textit{Reserves}))\}$$
$$\exists (I_r, B_r, D) \in \textit{Reserves}.$$

(Q2) Find the names of sailors who have reserved a red boat.

$$\{\langle N \rangle \mid \exists I, T, A (\langle I, N, T, A \rangle \in \text{Sailors} \\ \wedge \exists \langle I, Br, D \rangle \in \text{Reserves} \wedge \exists \langle Br, BN, 'red' \rangle \in \text{Boats})\}$$