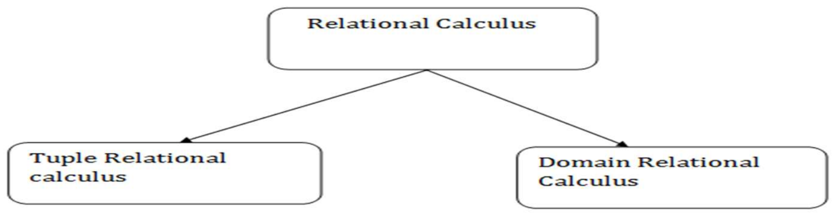
RELATIONAL CALCULUS

- Relational calculus is an alternative to relational algebra. In contrast to the algebra, which is procedural, the calculus is nonprocedural, or declarative, in that it allows us to describe the set of answers without being explicit about how they should be computed.
- The relational calculus tells what to do but never explains how to do.



Tuple Relational Calculus (TRC):

- Tuple relational calculus is used for selecting those tuples that satisfy the given condition.
- A tuple relational calculus query has the form

  {t | P(t)}

- Where t = resulting tuples
- P(t) = known as Predicate and these are the conditions that are used to fetch t
- ✓ Thus, it generates set of all tuples t, such that Predicate P(t) is true for t.

Syntax of TRC Queries:

- Let *Rel* be a relation name, R and *S* be tuple variables, *a* be an attribute of *R,* and *b* be an attribute of *S.* Let op denote an operator in the set {<, >, =,<=,>=,!=}. An atomic (which cannot be further divided) formula is one of the following:

  R ϵ Rel
  R.a op S.b
  R.a op constant

A formula is recursively defined to be one of the following, where *p* and *q* arethemselves formulas and *p(R)* denotes a formula in which the variable *R* appears.

- P(t) may have various conditions logically combined with OR (∨), AND (∧), NOT(¬).
- It also uses quantifiers:

  ∃ t ∈ r (Q(t)) = "there exists" a tuple in t in relation r such that predicate Q(t) istrue.

  ∀ t ∈ r (Q(t)) = Q(t) is true "for all" tuples in relation r.

Bound variables- Sometimes variables are quantified to have specific values. They are called bound variables:
(∃t)(d.Dnumber=t.Dno) (Existential Quantification)
(∀d)(d.Mgr_ssn='333445555') (Universal Quantification)
Free variables: Variables which are not bound are called free variables. ′ Usually, a tuple variable on the left of bar(|) is free and variables on right side are bound

Example:

1. **Find all sailors with a rating above 7.**

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

2. **Find the names of sailors who've reserved boat number 103**

   $\{T \mid \exists S \in Sailors\ (T.name = S.name \wedge \exists R \in Reserves\ (S.sid = R.sid \wedge R.bid = 103))\}$

3. **Find the names of sailors who've reserved any red boat**

   $\{T \mid \exists S \in Sailors\ (T.name = S.name \wedge \exists R \in Reserves\ (S.sid = R.sid \wedge \exists B \in Boats\ (B.color = \text{"Red"} \wedge B.bid = R.bid)))\}$

4. **Find sailors who've reserved a red boat or a green boat**

   $\{S \mid S \in Sailors \wedge (\exists R \in Reserves\ (S.sid = R.sid \wedge \exists B \in Boats(B.bid = R.bid \wedge (B.color = \text{"Red"} \vee B.color = \text{"Green"}))))\}$

Domain Relational Calculus (DRC)

- Domain Relational Calculus uses domain Variables to get the column values required from the database based on the predicate expression or condition.

The Domain realtional calculus expression syntax:

{<x1,x2,x3,x4...> \| P(x1,x2,x3,x4...)} **where,**

- **<x1,x2,x3,x4...>** are domain variables used to get the column values required.
- **P(x1,x2,x3...)** is predicate expression or condition.

- The result of this query is the set of all tuples $(X_l, X_2, \ldots, x_n)$ for which the formula evaluates to true.
- A DRC formula is defined in a manner very similar to the definition of a TRC formula. The main difference is that the variables are now domain variables

Let **op** denote an operator in the set {<, >, =, S,~, i-} and let X and *Y* be domain variables.

An **atomic formula** in DRC is one of the following:

- $(X_1, X_2, \ldots, X_n) \in Rel$, where *Rei* is a relation with *n* attributes; each X_i, $1 \leq I \leq n$ is either a variable or a constant.
- X *op* Y
- X *op constant, or constant op* X.

A **formula** is recursively defined to be one of the following, where *p* and *q* are themselves formulas and *p(X)* denotes a formula in which the variable X appears:

- any atomic formula
- $\neg p$, $P \wedge q$, $P \vee q$, or $p \Rightarrow q$
- $\exists$ *(p(X)),* where *X* is a domain variable
- $\forall X(p(X))$, where *X* is a domain variable

Examples:

(Q1) Find all sailors with a rating above 7.

$\{ \langle 1, N, R, A \rangle \mid \langle I, N, R, A \rangle \in Sailors \wedge R > 7\}$

(Q2) Find the names of sailors who have reserved boat 103.

$\{ \langle N \rangle \mid \exists I,R,A(\langle I,N,R,A \rangle \in Sailors \wedge \exists Ir,Br,D(\langle Ir,Br,D \in Reserves (Ir = I \wedge Br=103))\}$

(Q3) Find the names of sailors who have reserved a red boat.

$\{(N) \mid \exists I,R,A((I,N,R,A) \in Sailors \wedge \exists(I, Br, D) \in Reserves \wedge \exists(Br, BN,\text{'red'}) \in Boats)\}$