Assignment #4: More Relational Algebra

Release: Feb. 6th, 2020   Due: 8:00pm Feb. 12th, 2020

1. [14 points each] Write the arity, expected min cardinality, expected max cardinality, and the *relational algebra* expression to answer each of the following queries:

   (a) Calculate the *max* duration of phone calls in August 2019, that were originated from Pennsylvania.

   Arity = 1; Cardinality = 1

   $Calls \leftarrow \Pi_{from\_pn,to\_pn,start\_timestamp,duration}(\sigma_{type='call'}(Records))$.

   $People\_PA \leftarrow \Pi_{pn}(\sigma_{state='PA'}(Directory))$.

   $Calls\_from\_PA \leftarrow People\_PA \bowtie_{People\_PA.pn=Calls.from\_pn} Calls$;

   $Calls\_from\_PA\_Aug \leftarrow \sigma_{start\_timestamp>='2019-08-01' \wedge start\_timestamp<'2019-09-01'}(Calls\_from\_PA)$;

   $RSLT \leftarrow \mathcal{F}_{MAX(duration)}(Calls\_from\_PA\_Aug)$;

   (b) Calculate the *average* amount of payments due for the month of November 2019 for each zipcode (i.e., sum up all customers on the same zip code into a single amount for that zip code).

   Arity = 2; Cardinality = [0 .. |r(Customers)|] = [0 .. 50]

   $RSLT(zip, average\_amount\_due) \leftarrow {}_{zip}\mathcal{F}_{AVERAGE(amount\_due)}$
   $(\sigma_{(start\_date \geq '2019-11-01' \wedge end\_date \leq '2019-11-30')}(CUSTOMERS * STATEMENTS))$;

   (c) List the first and last names of customers who have more than one cell phone.

   Arity = 2; Cardinality = [0 .. |r(Customers)|/2] = [0 .. 25]

   $Cell\_Nums(SSN, cell\_count) \leftarrow {}_{SSN}\mathcal{F}_{COUNT(cell\_pn)}(Customers)$;

   $Cust\_Cell \leftarrow Customers * Cell\_Nums$;

   $RSLT \leftarrow \Pi_{fname,lname}(\sigma_{cell\_count>1}(Cust\_Cell))$;

(d) List the last names of customers whom none of their family members is a customer of P_Mobile. That is, customers whose family members are customers in other companies. Recall that people with the same last name are relatives that belong to the same family.

Arity = 1; Cardinality = [0 .. |r(Customers)|] = [0 .. 50]

$PC \leftarrow \Pi_{fname,lname}(CUSTOMERS);$

$NumFM(lname, number) \leftarrow_{lname} \mathcal{F}_{COUNT(*)}(PC);$

$OneFM \leftarrow \sigma_{number=1}(NumFM);$

$FLN(last, first, number) \leftarrow OneFM * PC;$

$CUST \leftarrow FLN \bowtie_{FLN.last=DIRECTORY.lname \,\wedge\, FLN.first<>DIRECTORY.fname} (DIRECTORY);$

$RSLT \leftarrow \Pi_{last}(CUST);$

(e) Find the charges of the customer whose cell phone number is 412-987-6543 in the period between January 1st 2019 until now, assuming a flat rate of 25 cents per minute and 5 cents per SMS (without adding any tax or plan fees).

Arity = 2; Cardinality = 1

$TOTAL\_MIN\_(cell\_pn, type, totmin) \leftarrow_{cell\_pn,type} \mathcal{F}_{SUM(duration)}($
$\quad\quad (\sigma_{start\_timestamp \geq '2019-01-01\ 00:00:00'}$
$\quad\quad\quad\quad {}_{\wedge (from\_pn='412-987-6543' \vee to\_pn='412-987-6543')} (Records));$

$TOTAL\_CALLS \leftarrow \sigma_{type='call'}(TOTAL\_MIN)$

$TOTAL\_SMS \leftarrow \sigma_{type='SMS'}(TOTAL\_MIN)$

$PAID\_MIN(cell\_pn, type, call\_charges) \leftarrow \Pi_{cell\_pn,type,(totmin-free\_min)*0.25}$
$\quad\quad (\sigma_{totmin>free\_min}(TOTAL\_CALLS * CUSTOMERS));$

$NoPAID\_MIN(cell\_pn, type, call\_charges) \leftarrow \Pi_{cell\_pn,type,0}$
$\quad\quad (\sigma_{totmin \leq free\_min}(TOTAL\_CALLS * CUSTOMERS));$

$PAID\_SMS(cell\_pn, type, sms\_charges) \leftarrow \Pi_{cell\_pn,type,(totsms-free\_sms)*0.05}$
$\quad\quad (\sigma_{totsms>free\_sms}(TOTAL\_SMS * CUSTOMERS));$

$NoPAID\_SMS(cell\_pn, type, sms\_charges) \leftarrow \Pi_{cell\_pn,type,0}$
$\quad\quad (\sigma_{totsms \leq free\_sms}(TOTAL\_SMS * CUSTOMERS));$

$ALL\_C(cell\_pn, type, charges) \leftarrow PAID\_MIN \cup NoPAID\_MIN \cup PAID\_SMS \cup NoPAID\_SMS;$

$RSLT(phone, balance) \leftarrow_{cell\_pn} \mathcal{F}_{SUM(charges)}(ALL\_C);$

(f) List the first name, last name and phone number of all customers who owe more than \$90. Note that people may have skipped more than one payment.

Arity = 3; Cardinality = Cardinality = $[0 \ .. \ |\text{r(Customers)}|] = [0 \ .. \ 50]$

$DUE(cell\_pn, due\_amount) \leftarrow {}_{cell\_pn}\mathcal{F}_{SUM(amount\_due)}(STATEMENTS);$

$PAID(cell\_pn, paid\_amount) \leftarrow {}_{cell\_pn}\mathcal{F}_{SUM(amount\_paid)}(PAYMENTS);$

$DUE\_PAID \leftarrow DUE * PAID;$

$BALANCE(cell\_pn, amount) \leftarrow \Pi_{cell\_pn,(due\_amount-paid\_amount)}(DUE\_PAID);$

$CUSTDUE \leftarrow \sigma_{amount>90}(BALANCE);$

$RSLT \leftarrow \Pi_{fname,lname,cell\_pn}(CUSTDUE * CUSTOMER);$

(g) ⋆ Find the first and last name of the customer(s) who made the longest phone call between June 1st, 2019 and August 31st 2019.

Arity = 2; Cardinality = $[0 \ .. \ |\text{r(Customers)}|] = [0 \ .. \ 50]$

$CALLS(cell\_pn, start\_timestamp, duration) \leftarrow \Pi_{from\_pn,start\_timestamp,duration}(\sigma_{type='call'}(Records)).$

$MAXCALL(maxduration) \leftarrow \mathcal{F}_{MAX(duration)}($

$\sigma_{(start\_timestamp\geq'2019-06-01' \ \wedge \ start\_timestamp\leq'2019-08-31')}(CALLS));$

$RSLT \leftarrow \Pi_{fname,lname}(CUSTOMERS* (CALLS \bowtie_{duration=maxduration} MAXCALL));$

2. [10 points each] Provide

- an instance of relation R:

A	B	C	D
a1	b1	c1	d1
a2	b2	c2	d2
a3	b3	c3	d3
a4	b4	c4	d4
a5	b5	c5	d5
a6	b6	c6	d6
a7	b7	c7	d7
a8	b8	c8	d8
a9	b9	c9	d9
a10	b10	c10	d10
a11	b11	c11	d11
a12	b12	c12	d12
a13	b13	c13	d13

- An instance of relation S:

D	E	F
d1	e1	f1
d3	e2	f2
d3	e3	f3
d4	e4	f3
d4	e5	f2
d16	e5	f5
d20	e11	f11

- an instance of relation *R full-outer-join(R.D = S.D) S*:

R.A	R.B	R.C	R.D	S.D	S.E	S.F
a1	b1	c1	d1	d1	e1	f1
a2	b2	c2	d2	null	null	null
a3	b3	c3	d3	d3	e2	f2
a3	b3	c3	d3	d3	e3	f3
a4	b4	c4	d4	d4	e4	f3
a4	b4	c4	d4	d4	e5	f2
a5	b5	c5	d5	null	null	null
a6	b6	c6	d6	null	null	null
a7	b7	c7	d7	null	null	null
a8	b8	c8	d8	null	null	null
a9	b9	c9	d9	null	null	null
a10	b10	c10	d10	null	null	null
a11	b11	c11	d11	null	null	null
a12	b12	c12	d12	null	null	null
a13	b13	c13	d13	null	null	null
null	null	null	null	d16	e5	f5
null	null	null	null	d20	e11	f11