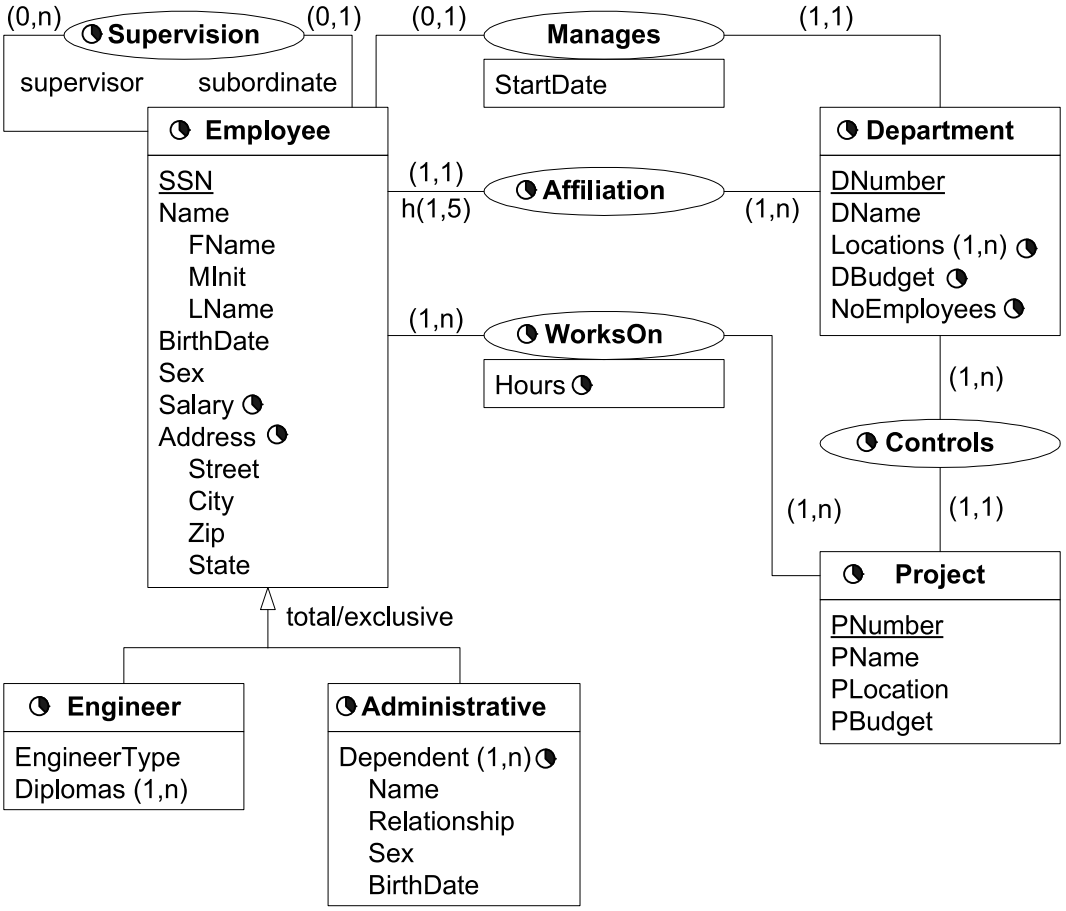
SQL Server
Temporal Databases



Consider the above temporal conceptual schema

- Define a relational schema corresponding to the conceptual schema.
- Write the following queries in SQL:

(1) Give the name of managers living currently in Houston
(2) Give the name of employees working currently in the 'Research' department having a salary greater or equal than 45000
(3) Give the name of current employees who does not work currently in any department
(4) Give the name of the employee(s) that had the highest salary in 1/1/2002
(5) Provide the salary and affiliation history for all employees
(6) Give the name of employees and the period of time in which they were supervisors but did not work in any project during the same period
(7) Give the name of supervisors who had work on a project at some time
(8) Give the name of employees and the date they changed their affiliation
(9) Give the name of employees and the periods they worked on any project
(10) Give the history of the maximum salary
(11) Give by department the history of the maximum salary
(12) Give the history of the number of projects of a department
(13) Give the name of employees and the periods they worked on all projects of their department

- Ensure the following integrity constraints.
  (1) An employee works in at most one department at any point in time.
  (2) At any point in time an employee cannot work more than once in a project.
  (3) The lifecycle of affiliation is included in the lifecycle of employee
  (4) The lifecycle of an employee is equal to the union of his/her affiliations.
  (5) Employees have a contiguous lifecycle.
  (6) The lifecycle of an employee is equal to the union of his/her affiliations, now taking into account that the lifecycle of employees is contiguous.

Relational Schema

- Employee(SSN, FName, MInit, LName, BirthDate, Sex)
- EmployeeLifecycle(SSN, FromDate, ToDate)
  SSN references Employee(SSN)
- EmployeeSalary(SSN, Salary, FromDate, ToDate)
  SSN references Employee(SSN)
- EmployeeAddress(SSN, Street, City, Zip, Country, FromDate, ToDate)
  SSN references Employee(SSN)
- Engineer(SSN, EngineerType, FromDate, ToDate)
  SSN references Employee(SSN)
  In this table the lifecycle of Engineer is kept as well as the attribute EngineerType. There will be redundancy if the lifecycle of Engineer is not continuous.
- EngineerDiplomas(SSN, Diploma)
  SSN references Engineer(SSN)
- AdministrativeLifecycle(SSN, FromDate, ToDate)
  SSN references Employee(SSN)
- AdminDependent(SSN, Name, Relationship, Sex, BirthDate, FromDate, ToDate)
  SSN references AdministrativeLifecycle(SSN)
  It is supposed that an employee does not have two dependents of the same name and the same relationship. An alternative will be to put BirthDate instead of Relationship as part of the key.
- Supervision(SSN, SuperSSN, FromDate, ToDate)
  SSN references Employee(SSN)
  SuperSSN references Employee(SSN)
- Affiliation(SSN, DNumber, FromDate, ToDate)
  SSN references Employee(SSN)
- Department(DNumber, DName, MgrSSN, MgrStartDate, FromDate, ToDate)
  MgrSSN references Employee(SSN)
  It is supposed that the lifecycle of departments is continuous. In this case an additional table for the lifecycle is not necessary.
- DeptLocations(DNumber, Location, FromDate, ToDate)
  DNumber references Department(DNumber)
- DepartmentBudget(DNumber, DBudget, FromDate, ToDate)
  DNumber references Department(DNumber)
- DepartmentNbEmp(DNumber, NbEmp, FromDate, ToDate)
  DNumber references Department(DNumber)
- Project(PNumber, PName, PLocation, PBudget, FromDate, ToDate)
  It is supposed that the lifecycle of Project is continuous.
- Controls(PNumber, DNumber, FromDate, ToDate)
  PNumber references Project(PNumber)
  DNumber references Department(DNumber)
- WorksOn(SSN, PNumber, Hours, FromDate, ToDate)
  PNumber references Project(PNumber)
  SSN references Employee(SSN)
  It is supposed that the temporality of attribute Hours is the same as the lifecycle of the association. In this case two different tables are not necessary. To obtain the lifecycle of the association independently of the attribute hours a temporal projection is needed.

Example Database

Partial schema where not all entities and attributes are taken into account.

Employee

SSN	FName	MInit	LName	BirthDate	Sex
123456789	John	B	Smith	09-05-1955	M
333445555	Franklin	T	Wong	08-12-1945	M
999887777	Alicia	J	Zelaya	19-07-1958	F
987654321	Jennifer	S	Wallace	20-06-1931	F
666884444	Ramesh	K	Narayan	15-09-1952	M
453453453	Joyce	A	English	31-07-1962	F
987987987	Ahmad	V	Jabbar	29-03-1959	M
888665555	James	A	Borg	10-11-1927	M

EmployeeLifecycle

SSN	FromDate	ToDate
123456789	01-01-1985	01-01-2079
333445555	01-01-1982	01-01-2079
999887777	01-01-1985	01-01-2079
987654321	01-01-1982	01-01-2079
666884444	01-01-1985	01-01-2079
453453453	01-01-1985	01-01-2079
987987987	01-01-1985	01-01-2079
888665555	01-01-1980	01-01-2079

EmployeeSalary

SSN	Salary	FromDate	ToDate
123456789	30000	01-01-1985	01-01-2079
333445555	40000	01-01-1982	01-01-1983
333445555	45000	01-01-1983	01-01-2079
999887777	25000	01-01-1985	01-01-2079
987654321	43000	01-01-1982	01-01-2079
666884444	38000	01-01-1985	01-01-2079
453453453	25000	01-01-1985	01-01-2079
987987987	25000	01-01-1985	01-01-2079
888665555	55000	01-01-1980	01-01-1981
888665555	58000	01-01-1981	01-01-2079

EmployeeAddress

SSN	Street	City	Zip	State	FromDate	ToDate
123456789	731 Fondren	Houston	1000	TX	01-01-1985	01-01-2079
333445555	638 Voss	Houston	1000	TX	01-01-1982	01-01-2079
999887777	3321 Castle	Spring	1000	TX	01-01-1985	01-01-2079
987654321	291 Berry	Bellaire	1000	TX	01-01-1982	01-01-2079
666884444	975 Fire Oak	Humble	1000	TX	01-01-1985	01-01-2079
453453453	5631 Rice	Houston	1000	TX	01-01-1985	01-01-2079
987987987	980 Dallas	Houston	1000	TX	01-01-1985	01-01-2079
888665555	450 Stone	Houston	1000	TX	01-01-1980	01-01-2079

Supervision

SSN	SuperSSN	FromDate	ToDate
123456789	333445555	01-01-1985	01-01-2079
333445555	888665555	01-01-1982	01-01-2079
999887777	987654321	01-01-1985	01-01-2079
987654321	888665555	01-01-1982	01-01-2079
666884444	333445555	01-01-1985	01-01-2079
453453453	333445555	01-01-1985	01-01-2079
987987987	987654321	01-01-1985	01-01-2079

Affiliation

SSN	DNumber	FromDate	ToDate
123456789	1	01-01-1985	01-01-1986
123456789	5	01-01-1986	01-01-2079
333445555	4	01-01-1982	01-01-1984
333445555	5	01-01-1984	01-01-2079
999887777	4	01-01-1985	01-01-2079
987654321	4	01-01-1982	01-01-2079
666884444	5	01-01-1985	01-01-2079
453453453	5	01-01-1985	01-01-2079
987987987	4	01-01-1985	01-01-2079
888665555	1	01-01-1980	01-01-2079

Department

DNumber	DName	MgrSSN	MgrStartDate	FromDate	ToDate
1	Headquarters	888665555	19-06-1980	01-01-1980	01-01-2079
4	Administration	987654321	01-01-1982	01-01-1981	01-01-2079
5	Research	333445555	22-05-1984	01-01-1982	01-01-2079

DepartmentNbEmp

DNumber	NbEmp	FromDate	ToDate
5	4	01-01-1980	01-01-2079
4	3	01-01-1980	01-01-2079
1	1	01-01-1980	01-01-2079

DeptLocations

DNumber	DLocation	FromDate	ToDate
1	Houston	01-01-1980	01-01-2079
4	Stafford	01-01-1980	01-01-2079
5	Bellaire	01-01-1980	01-01-2079
5	Sugarland	01-01-1980	01-01-2079
5	Houston	01-01-1980	01-01-2079

Project

PNumber	PName	PLocation	FromDate	ToDate
1	ProductX	Bellaire	01-01-1980	01-01-2079
2	ProductY	Sugarland	01-01-1980	01-01-2079
3	ProductZ	Houston	01-01-1980	01-01-2079
10	Computerization	Stafford	01-01-1980	01-01-2079
20	Reorganization	Houston	01-01-1980	01-01-2079
30	Newbenefits	Stafford	01-01-1980	01-01-2079

Controls

PNumber	DNumber	FromDate	ToDate
1	5	01-01-1980	01-01-2079
2	5	01-01-1980	01-01-2079
3	5	01-01-1980	01-01-2079
10	4	01-01-1980	01-01-2079
20	1	01-01-1980	01-01-2079
30	4	01-01-1980	01-01-2079

WorksOn

SSN	PNumber	Hours	FromDate	ToDate
123456789	1	32.5	01-01-1985	01-01-2079
123456789	2	7.5	01-01-1985	01-01-2079
333445555	1	10	01-01-1982	01-01-2000
333445555	2	10	01-01-1982	01-01-2002
333445555	3	20	01-01-2005	01-01-2079
453453453	1	20	01-01-1985	01-01-2079
453453453	2	20	01-01-1985	01-01-2079
666884444	3	40	01-01-1985	01-01-2079
888665555	20	30.0	01-01-1983	01-01-2079
987654321	10	5.0	01-01-1982	01-01-2000
987654321	20	15.0	01-01-1982	01-01-2001
987654321	30	20.0	01-01-1982	01-01-2002
987987987	10	35.0	01-01-1985	01-01-2079
987987987	30	5.0	01-01-1985	01-01-2079
999887777	10	10.0	01-01-1985	01-01-2079
999887777	30	30.0	01-01-1985	01-01-2079

Queries

(1) Give the name of the managers living currently in Houston

```
select E.FName, E.LName
from Employee E, EmployeeAddress A, Department D
where E.SSN = A.SSN and E.SSN = D.MgrSSN
and A.City = 'Houston'
and A.FromDate <= getdate() and getdate() < A.ToDate
and D.FromDate <= getdate() and getdate() < D.ToDate
```

(2) Give the name of employees working currently in the 'Research' department and having a salary greater or equal than 45000

```
select E.FName, E.LName
from Employee E, EmployeeSalary S, Affiliation A, Department D
where E.SSN = S.SSN and E.SSN = A.SSN and A.DNumber = D.DNumber
and D.DName = 'Research' and S.Salary >= 45000
and S.FromDate <= getdate() and getdate() < S.ToDate
and A.FromDate <= getdate() and getdate() < A.ToDate
```

(3) Give the name of current employees who do not work currently in any department

```
select distinct E.FName, E.LName
from Employee E, EmployeeLifecycle L
where E.SSN = L.SSN
and L.FromDate <= getdate() and getdate() < L.ToDate
and not exists (
    select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate <= getdate() and getdate() < A.ToDate )
```

(4) Give the name of the employee(s) that had the highest salary on 1/1/2002

```
select E.FName, E.LName
from Employee E, EmployeeSalary S
where E.SSN = S.SSN
and salary = ( select max(salary) from EmployeeSalary
               where FromDate <= '2002-01-01' and '2002-01-01' < ToDate )
and S.FromDate <= '2002-01-01' and '2002-01-01' < S.ToDate
```

(5) Provide the salary and affiliation history for all employees

```
create function minDate
  (@one smalldatetime, @two smalldatetime)
returns smalldatetime as
begin
  return CASE WHEN @one < @two then @one else @two end
end
go
create function maxDate
  (@one smalldatetime, @two smalldatetime)
returns smalldatetime as
begin
  return CASE WHEN @one > @two then @one else @two end
end
go
select E.FName, E.LName, D.DName, S.Salary,
  'Start Date' = dbo.maxDate(S.FromDate,A.FromDate),
  'End Date'= dbo.minDate(S.ToDate,A.ToDate)
from Employee E, EmployeeSalary S, Affiliation A, Department D
```

```
where E.SSN = S.SSN and E.SSN = A.SSN and A.DNumber = D.DNumber
and dbo.maxDate(S.FromDate,A.FromDate) <
  dbo.minDate(S.ToDate,A.ToDate)
order by E.FName, E.LName
```

(6) Give the name of employees and the period of time in which they were supervisors but did not work in any project during the same period

```
--Case 1
select S.SuperSSN, S.FromDate, W1.FromDate as ToDate
from Supervision S, WorksOn W1
where S.SuperSSN = W1.SSN
and S.FromDate < W1.FromDate and W1.FromDate < S.ToDate
and not exists ( select * from WorksOn W2 where S.SuperSSN = W2.SSN
    and S.FromDate < W2.ToDate and W2.FromDate < W1.FromDate )
union
--Case 2
select S.SuperSSN, W1.ToDate as FromDate, S.ToDate
from Supervision S, WorksOn W1
where S.SuperSSN = W1.SSN
and S.FromDate < W1.ToDate and W1.ToDate < S.ToDate
and not exists ( select * from WorksOn W2 where S.SuperSSN = W2.SSN
    and W1.ToDate < W2.ToDate and W2.FromDate < S.ToDate )
union
--Case 3
select S.SuperSSN, W1.ToDate as FromDate, W2.FromDate as ToDate
from Supervision S, WorksOn W1, WorksOn W2
where S.SuperSSN = W1.SSN and S.SuperSSN = W2.SSN and W1.ToDate < W2.FromDate
and S.FromDate < W1.ToDate and W2.FromDate < S.ToDate
and not exists ( select * from WorksOn W3 where S.SuperSSN = W3.SSN
    and W1.ToDate < W3.ToDate and W3.FromDate < W2.FromDate )
union
--Case 4
select SuperSSN, FromDate, ToDate from Supervision S
where not exists ( select * from WorksOn W where S.SuperSSN=W.SSN
    and S.FromDate < W.ToDate and W.FromDate < S.ToDate )
```

(7) Give the name of supervisors who had work on a project at some time

```
select distinct E.FName, E.LName
from Employee E, Supervision S, WorksOn W
where E.SSN = S.SuperSSN and E.SSN = W.SSN
```

(8) Give the name of employees and the date they changed their affiliation

```
select distinct E.FName, E.LName, A1.ToDate
from Employee E, Affiliation A1, Affiliation A2
where E.SSN = A1.SSN and E.SSN = A2.SSN
and A1.ToDate = A2.FromDate and A1.DNumber <> A2.DNumber
```

(9) Give the name of employees and the periods they worked on any project

```
select distinct E.SSN, E.FName, E.LName, F.FromDate, L.ToDate
from Employee E, WorksOn F, WorksOn L
where E.SSN = F.SSN and F.SSN = L.SSN and F.FromDate < L.ToDate
and not exists ( select * from WorksOn M
    where M.SSN = F.SSN
    and F.FromDate < M.FromDate and M.FromDate <= L.ToDate
    and not exists ( select * from WorksOn T1
        where T1.SSN = F.SSN
        and T1.FromDate < M.FromDate and M.FromDate <= T1.ToDate ) )
and not exists ( select * from WorksOn T2
```

```
    where T2.SSN = F.SSN
    and ( ( T2.FromDate < F.FromDate and F.FromDate <= T2.ToDate )
       or ( T2.FromDate <= L.ToDate and L.ToDate < T2.ToDate ) ) )
```

(10) Give the history of the maximum salary

```
-- First step: Construct intervals during which no salary change occurred
WITH Instants(Instant) AS (
  select distinct E.FromDate from EmployeeSalary E
  union select distinct E.ToDate from EmployeeSalary E ),
Intervals(FromDate,ToDate) AS (
  select distinct I1.Instant, I2.Instant
  from Instants I1, Instants I2
  where I1.Instant < I2.Instant
  and not exists ( select * from Instants I3
                   where I1.Instant < I3.Instant
                   and I3.Instant < I2.Instant ) ),
-- Second step: Compute the maximum salary for these intervals
TempMax(SalaryMax, FromDate, ToDate) AS (
  select max(E.Salary), I.FromDate, I.ToDate
  from EmployeeSalary E, Intervals I
  where E.FromDate <= I.FromDate and I.ToDate <= E.ToDate
  group by I.FromDate, I.ToDate )
-- Third step: Coalescing the above table
select distinct F.SalaryMax, F.FromDate, L.ToDate
from TempMax F, TempMax L
where F.FromDate < L.ToDate and F.SalaryMax =  L.SalaryMax
and not exists ( select *
    from TempMax M
    where M.SalaryMax =  F.SalaryMax
    and F.ToDate < M.FromDate and M.FromDate <= L.FromDate
    and not exists ( select *
        from TempMax T1
        where T1.SalaryMax =  F.SalaryMax
        and T1.FromDate < M.FromDate and M.FromDate <= T1.ToDate ) )
and not exists ( select *
    from TempMax T2
    where T2.SalaryMax = F.SalaryMax
    and ( ( T2.FromDate < F.FromDate and F.FromDate <= T2.ToDate )
       or ( T2.FromDate <= L.ToDate and L.ToDate < T2.ToDate ) ) )
order by F.FromDate
```

(11) Give by department the history of the maximum salary

```
-- First step: Construct by department the intervals during
-- which the maximum salary must be calculated.
WITH Aff_Sal (DNumber, Salary, FromDate, ToDate) AS (
  select distinct A.DNumber, S.Salary,
    dbo.maxDate(S.FromDate,A.FromDate),
    dbo.minDate(S.ToDate,A.ToDate)
  from Affiliation A, EmployeeSalary S
  where A.SSN = S.SSN
  and dbo.maxDate(S.FromDate,A.FromDate) <
      dbo.minDate(S.ToDate,A.ToDate) ),
SalChanges(DNumber, Instant) AS (
  select distinct DNumber, FromDate from Aff_Sal
  union select distinct DNumber, ToDate from Aff_Sal ),
SalIntervals(DNumber, FromDate, ToDate) AS (
  select distinct P1.DNumber, P1.Instant, P2.Instant
```

```
  from SalChanges P1, SalChanges P2
  where P1.DNumber=P2.DNumber and P1.Instant<P2.Instant
  and not exists ( select * from SalChanges P3
    where P1.DNumber = P3.DNumber and P1.Instant < P3.Instant
    and P3.Instant < P2.Instant ) ),
-- Second step: Compute the maximum salary for the
-- above periods.
TempMaxDep(DNumber, MaxSalary, FromDate, ToDate) AS (
  select P.DNumber, max(Salary), P.FromDate, P.ToDate
  from Aff_Sal A, SalIntervals P
  where A.DNumber = P.DNumber
  and A.FromDate <= P.FromDate and P.ToDate <= A.ToDate
  group by P.DNumber, P.FromDate, P.ToDate  )
-- Third step: Coalescing the above table
select distinct F.DNumber, F.MaxSalary, F.FromDate, L.ToDate
from TempMaxDep F, TempMaxDep L
where F.DNumber = L.DNumber and F.MaxSalary = L.MaxSalary
and F.FromDate < L.ToDate
and not exists ( select *
    from TempMaxDep M
    where F.DNumber = M.DNumber and F.MaxSalary = M.MaxSalary
    and F.ToDate < M.FromDate and M.FromDate <= L.FromDate
    and not exists ( select *
        from TempMaxDep T1
        where F.DNumber = T1.DNumber and F.MaxSalary = T1.MaxSalary
        and T1.FromDate < M.FromDate and M.FromDate <= T1.ToDate ) )
and not exists ( select *
    from TempMaxDep T2
    where F.DNumber = T2.DNumber and F.MaxSalary = T2.MaxSalary
    and ( ( T2.FromDate < F.FromDate and F.FromDate <= T2.ToDate )
       or ( T2.FromDate <= L.ToDate and L.ToDate < T2.ToDate ) ) )
order by F.DNumber, F.FromDate
```

(12) Give the history of the number of projects of a department

```
-- First step: Construct intervals during which the number of
-- projects of a department does not change
WITH Instants(DNumber, Instant) AS (
  select distinct DNumber, FromDate from Controls
  union
  select distinct DNumber, ToDate from Controls ),
Intervals(DNumber, FromDate, ToDate) AS (
  select distinct I1.DNumber, I1.Instant, I2.Instant
  from Instants I1, Instants I2
  where I1.DNumber = I2.DNumber
  and I1.Instant < I2.Instant
  and not exists ( select * from Instants I3
                   where I1.DNumber = I3.DNumber
                   and I1.Instant < I3.Instant
                   and I3.Instant < I2.Instant ) ),
-- Second step: Compute the number of projects for these intervals
TempCountDep(DNumber, NbProjects, FromDate, ToDate) AS (
  select I.DNumber, count(C.PNumber), I.FromDate, I.ToDate
  from Controls C, Intervals I
  where C.DNumber = I.DNumber
  and ( C.FromDate <= I.FromDate and I.ToDate <= C.ToDate)
  group by I.DNumber, I.FromDate, I.ToDate )
-- Third step: Coalescing the above table
select distinct F.DNumber, F.NbProjects, F.FromDate, L.ToDate
```

```
from TempCountDep F, TempCountDep L
where F.DNumber = L.DNumber and F.FromDate < L.ToDate
and F.NbProjects = L.NbProjects
and not exists ( select *
    from TempCountDep M
    where M.DNumber = F.DNumber and M.NbProjects = F.NbProjects
    and F.ToDate < M.FromDate and M.FromDate <= L.FromDate
    and not exists ( select *
        from TempCountDep T1
        where T1.DNumber = F.DNumber and T1.NbProjects = F.NbProjects
        and T1.FromDate < M.FromDate and M.FromDate <= T1.ToDate ) )
and not exists ( select *
    from TempCountDep T2
    where T2.DNumber = F.DNumber and T2.NbProjects = F.NbProjects
    and ( ( T2.FromDate < F.FromDate and F.FromDate <= T2.ToDate )
       or ( T2.FromDate <= L.ToDate and L.ToDate < T2.ToDate ) ) )
order by F.DNumber, F.FromDate
```

(13) Give the name of employees and the periods they worked on all projects of their department

```
-- First step: Construct intervals during which the number of projects
-- of an employee does not change
WITH Aff_Cont(SSN, DNumber, PNumber, FromDate, ToDate) AS (
  select distinct A.SSN, A.DNumber, C.PNumber,
    dbo.maxDate(A.FromDate,C.FromDate),
    dbo.minDate(A.ToDate,C.ToDate)
  from Affiliation A, Controls C
  where A.DNumber = C.DNumber
  and dbo.maxDate(A.FromDate,C.FromDate) <
      dbo.minDate(A.ToDate,C.ToDate) ),
Aff_Cont_WO(SSN, DNumber, PNumber, FromDate, ToDate) AS (
  select distinct A.SSN, A.DNumber, W.PNumber,
    dbo.maxDate(A.FromDate,W.FromDate),
    dbo.minDate(A.ToDate,W.ToDate)
  from Aff_Cont A, WorksOn W
  where A.PNumber = W.PNumber and A.SSN = W.SSN
  and dbo.maxDate(A.FromDate,W.FromDate) <
      dbo.minDate(A.ToDate,W.ToDate) ),
ProjChanges(SSN, DNumber, Instant) AS (
  select distinct SSN, DNumber, FromDate from Aff_Cont
  union select distinct SSN, DNumber, ToDate from Aff_Cont
  union select distinct SSN, DNumber, FromDate from Aff_Cont_WO
  union select distinct SSN, DNumber, ToDate from Aff_Cont_WO
  union select SSN, DNumber, FromDate from Affiliation
  union select SSN, DNumber, ToDate from Affiliation ),
ProjIntervals(SSN, DNumber, FromDate, ToDate) AS (
  select distinct P1.SSN, P1.DNumber, P1.Instant, P2.Instant
  from ProjChanges P1, ProjChanges P2
  where P1.SSN = P2.SSN
  and P1.DNumber = P2.DNumber and P1.Instant < P2.Instant
  and not exists ( select * from ProjChanges P3
    where P1.SSN = P3.SSN and P1.DNumber = P3.DNumber
    and P1.Instant < P3.Instant and P3.Instant < P2.Instant ) ),
-- Second step: Compute the number of projects for these intervals
TempUnivQuant(SSN, FromDate, ToDate) AS (
  select distinct P.SSN, P.FromDate, P.ToDate
  from ProjIntervals P
  where not exists ( select * from Controls C
```

```
        where P.DNumber = C.DNumber
        and C.FromDate <= P.FromDate and P.ToDate <= C.ToDate
        and not exists ( select * from WorksOn W
          where C.PNumber = W.PNumber and P.SSN = W.SSN
          and W.FromDate <= P.FromDate and P.ToDate <= W.ToDate ) ) )
    -- Third step: Coalescing the above table
    select distinct F.SSN, F.FromDate, L.ToDate
    from TempUnivQuant F, TempUnivQuant L
    where F.SSN = L.SSN and F.FromDate < L.ToDate
    and not exists ( select *
        from TempUnivQuant M
        where M.SSN = F.SSN
        and F.ToDate < M.FromDate and M.FromDate <= L.FromDate
        and not exists ( select *
            from TempUnivQuant T1
            where T1.SSN = F.SSN
            and T1.FromDate < M.FromDate and M.FromDate <= T1.ToDate ) )
    and not exists ( select *
        from TempUnivQuant T2
        where T2.SSN = F.SSN
        and ( ( T2.FromDate < F.FromDate and F.FromDate <= T2.ToDate )
           or ( T2.FromDate <= L.ToDate and L.ToDate < T2.ToDate ) ) )
    order by F.SSN, F.FromDate
```

Constraints

(1) An employee works in at most one department at any point in time.
In other terms SSN is a sequenced primary key for Affiliation.

```
create trigger Seq_PK_Affiliation on Affiliation
  after insert, update  as
if exists ( select * from Inserted A1
  where 1 < ( select count(*) from Affiliation A2
    where A1.SSN = A2.SSN
    and A1.FromDate < A2.ToDate and A2.FromDate < A1.ToDate ) )
begin
  raiserror 13000
    'An employee works in at most one department at any point in time'
  rollback transaction
end
```

(2) At any point in time an employee cannot work more than once in a project.
In other terms (SSN,PNumber) is a sequenced primary key for WorksOn

```
create trigger Seq_PK_WorksOn on WorksOn
  after insert, update as
if exists ( select * from Inserted W1
  where 1 < ( select count(*) from WorksOn W2
    where W1.SSN = W2.SSN and W1.PNumber = W2.PNumber
    and W1.FromDate < W2.ToDate and W2.FromDate < W1.ToDate ) )
begin
  raiserror 13000
    'At any point in time an employee cannot work more than once in a project'
  rollback transaction
end
```

(3) The lifecycle of affiliation is included in the lifecycle of employee.
In the following triggers it is assumed that the table EmployeeLifecycle is coalesced.
Therefore, every line in Affiliation must be covered by one line in EmployeeLifecycle.

```
create trigger Seq_FK_Affiliation_EmployeeLifecycle_1 on Affiliation
  after insert, update as
if exists ( select * from Inserted A
  where not exists ( select * from EmployeeLifecycle E
    where A.SSN = E.SSN
    and E.FromDate <= A.FromDate and A.ToDate <= E.ToDate ) )
begin
  raiserror 13000
    'The lifecycle of affiliation must be included in the lifecycle of employee'
  rollback transaction
end

create trigger Seq_FK_Affiliation_EmployeeLifecycle_2 on EmployeeLifecycle
  after update, delete as
if exists ( select * from Affiliation A
  where A.SSN IN ( select SSN from Deleted)
    and not exists ( select * from EmployeeLifecycle E
    where A.SSN = E.SSN
    and E.FromDate <= A.FromDate and A.ToDate <= E.ToDate ) )
begin
  raiserror 13000
    'The lifecycle of affiliation must be included in the lifecycle of employee'
  rollback transaction
end
```

(4) The lifecycle of an employee is equal to the union of his/her affiliations. It is supposed that the previous trigger is activated, therefore it is sufficient to monitor that an employee must be affiliated to a department throughout his/her lifecycle.

```
create trigger Seq_FK_EmployeeLifecycle_Affiliation_1 on Affiliation
  after update, delete as
if exists ( select * from EmployeeLifecycle E
  where E.SSN in ( select SSN from Deleted )
  and not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate <= E.FromDate and E.FromDate < A.ToDate )
  or not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate < E.ToDate and E.ToDate <= A.ToDate )
  or exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and E.FromDate < A.ToDate and A.ToDate < E.ToDate
    and not exists ( select * from Affiliation A2
      where A2.SSN = A.SSN
      and A2.FromDate <= A.ToDate and A.ToDate < A2.ToDate ) ) )
begin
  raiserror 13000
    'An employee must be affiliated to a department throughout his/her lifecycle'
  rollback transaction
end

create trigger Seq_FK_EmployeeLifecycle_Affiliation_2 on EmployeeLifecycle
  after insert, update as
if exists ( select * from Inserted E
  where not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate <= E.FromDate and E.FromDate < A.ToDate )
  or not exists ( select * from Affiliation A
    where E.SSN = A.SSN
```

```
    and A.FromDate < E.ToDate and E.ToDate <= A.ToDate )
  or exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and E.FromDate < A.ToDate and A.ToDate < E.ToDate
    and not exists ( select * from Affiliation A2
      where A2.SSN = A.SSN
      and A2.FromDate <= A.ToDate and A.ToDate < A2.ToDate ) ) )
begin
  raiserror 13000
    'An employee must be affiliated to a department throughout his/her lifecycle'
  rollback transaction
end
```

(5) Employees have a contiguous lifecycle.

```
alter table EmployeeLifecycle
drop constraint PK_EmployeeLifecycle
alter table EmployeeLifecycle
add constraint PK_EmployeeLifecycle primary key (SSN)
```

(6) The lifecycle of an employee is equal to the union of his/her affiliations, now taking into account that the lifecycle of employees is contiguous.
It is necessary to ensure that (1) the affiliations of an employee define a contiguous history, and (2) an employee must be affiliated to a department throughout his/her lifecycle.
The following trigger ensures that the affiliations of an employee define a contiguous history.

```
create trigger Contiguous_Hist_Affiliation on Affiliation
  after insert, update, delete as
if exists ( select * from Affiliation A1, Affiliation A2
  where A1.SSN = A2.SSN and A1.ToDate < A2.FromDate
  and not exists ( select * from Affiliation A3
     where A1.SSN = A3.SSN
     and ( ( A3.FromDate <= A1.ToDate and A1.ToDate < A3.ToDate )
        or ( A3.FromDate < A2.FromDate and A2.FromDate <= A3.ToDate ) ) ) )
begin
  raiserror 13000
    'The affiliations of an employee define a contiguous history'
  rollback transaction
end
```

The following two triggers replaces those of question (4).

```
alter trigger Seq_FK_EmployeeLifecycle_Affiliation_1 on Affiliation
  after update, delete as
if exists ( select * from EmployeeLifecycle E
  where E.SSN in ( select SSN from Deleted )
  and not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate <= E.FromDate and E.FromDate < A.ToDate )
  or not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate < E.ToDate and E.ToDate <= A.ToDate ) ) )
begin
  raiserror 13000
    'An employee must be affiliated to a department throughout his/her lifecycle'
  rollback transaction
end
```

```
alter trigger Seq_FK_EmployeeLifecycle_Affiliation_2 on EmployeeLifecycle
  after insert, update  as
if exists ( select * from Inserted E
  where not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate <= E.FromDate and E.FromDate < A.ToDate )
  or not exists ( select * from Affiliation A
    where E.SSN = A.SSN
    and A.FromDate < E.ToDate and E.ToDate <= A.ToDate ) ) )
begin
  raiserror 13000
    'An employee must be affiliated to a department throughout his/her lifecycle'
  rollback transaction
end
```