

# SQL Server

## Integrity Constraints

Consider the following database schema

- Employee(SSN, FName, MInit, LName, BDate, Address, Sex, Salary, SuperSSN, DNo, HireDate)  
SuperSSN references Employee(SSN)  
DNo references Department(DNumber)
- Department(DNumber, DName, MgrSSN, MgrStartDate, NbrEmployees)  
MgrSSN references Employee(SSN)
- DeptLocations(DNumber, DLocation)  
DNumber references Department(DNumber)
- Project(PNumber, PName, PLocation, DNumber)  
DNumber references Department(DNumber)
- WorksOn(ESSN, PNo, Hours)  
ESSN references Employee(SSN)  
PNo references Project(PNumber)
- Dependent(ESSN, DependentName, Sex, BDate, Relationship)  
ESSN references Employee(SSN)

Define in SQL Server a set of CHECK constraints or triggers that ensure the following constraints.

- (1) The age of employees must be greater than 18
- (2) The supervisor of an employee must be older than the employee
- (3) The salary of an employee cannot be greater than the salary of his/her supervisor
- (4) The manager of a department must be an employee of the department
- (5) The location of a project must be one of the locations of its department
- (6) The hire date of employees must be greater than their birth date
- (7) A supervisor must be hired at least 1 year before every employee s/he supervises
- (8) The attribute Department.NbrEmployees is a derived attribute from Employee.DNo
- (9) The attribute Employee.SuperSSN is a derived attribute computed as follows. Department managers are supervised by the manager of the Department 1 (Headquarters). Employees that are not managers are supervised by the manager of their department.
- (10) An employee works at most in 4 projects
- (11) An employee works at least 30h/week and at most 50 h/week on all its projects
- (12) Among all employees working on a project, at most 2 can work for less than 10 hours.
- (13) Only department managers can work less than 5 hours on a project
- (14) Employees that are not supervisors must work at least 10 hours on every project they work
- (15) The manager of a department must work at least 5 hours on all projects controlled by the department
- (16) The supervision relationship defined by Employee.SuperSSN must not be cyclic. (It is supposed that attribute Employee.SuperSSN is not derived as stated above).

# Database loading

Employee

FName	MInit	LName	SSN	BDate	Address	Sex	Salary	SuperSSN	DNo	HireDate
John	B	Smith	123456789	09-05-1955	731 Fondren, Houston, TX	M	30000	333445555	5	01-01-1985
Franklin	T	Wong	333445555	08-12-1945	638 Voss, Houston, TX	M	40000	888665555	5	01-01-1982
Alicia	J	Zelaya	999887777	19-07-1958	3321 Castle, Spring, TX	F	25000	987654321	4	01-01-1985
Jennifer	S	Wallace	987654321	20-06-1931	291 Berry, Bellaire, TX	F	43000	888665555	4	01-01-1982
Ramesh	K	Narayan	666884444	15-09-1952	975 Fire Oak, Humble, TX	M	38000	333445555	5	01-01-1985
Joyce	A	English	453453453	31-07-1962	5631 Rice, Houston, TX	F	25000	333445555	5	01-01-1985
Ahmad	V	Jabbar	987987987	29-03-1959	980 Dallas, Houston, TX	M	25000	987654321	4	01-01-1985
James	A	Borg	888665555	10-11-1927	450 Stone, Houston, TX	M	55000		1	01-01-1980

Department

DName	DNumber	MgrSSN	MgrStartDate	NbrEmployees
Research	5	333445555	22-05-1978	4
Administration	4	987654321	01-01-1985	3
Headquarters	1	888665555	19-06-1971	1

Project

PName	PNumber	PLocation	DNumber
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

Dependent

ESSN	DependentName	Sex	BDate	Relationship
333445555	Alice	F	05-04-1976	Daughter
333445555	Theodore	M	25-10-1973	Son
333445555	Joy	F	03-05-1948	Spouse
987654321	Abner	M	29-02-1932	Spouse
123456789	Michael	M	01-01-1978	Son
123456789	Alice	F	31-12-1978	Daughter
123456789	Elizabeth	F	05-05-1957	Spouse

DeptLocations

DNumber	DLocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WorksOn

ESSN	PNo	Hours
123456789	1	32.5
123456789	2	7.5
333445555	1	10
333445555	2	10
333445555	3	20
453453453	1	20
453453453	2	20
666884444	3	40
888665555	20	30.0
987654321	10	5.0
987654321	20	15.0
987654321	30	20.0
987987987	10	35.0
987987987	30	5.0
999887777	10	10.0
999887777	30	30.0

## Answers

- (1) The age of employees must be greater than 18

```
alter table Employee
add constraint employee_Age18
check ( BDate <= dateadd(year,-18,getdate()) )
```

Enforcing the constraint using a trigger

```
create trigger age18 on Employee
after insert, update as
if exists ( select * from Inserted where BDate > dateadd(year,-18,getdate()) )
begin
    raiserror 13000 'Constraint Violation: The age of an employee must be greater than 18'
    rollback
end
```

- (2) The supervisor of an employee must be older than the employee

```
create trigger supervisorAge on Employee
after insert, update as
if exists ( select * from Inserted I, Employee E
    where ( I.SuperSSN = E.SSN and I.BDate > E.BDate )
    or ( E.SuperSSN = I.SSN and E.BDate > I.BDate ) )
begin
    raiserror 13000 'Constraint Violation:
The age of an employee must be less than the age of his/her supervisor'
    rollback
end
```

- (3) The salary of an employee cannot be greater than the salary of his/her supervisor

```
create trigger supervisorSalary on Employee
after insert, update as
if exists ( select * from Inserted I, Employee E
    where ( I.SuperSSN = E.SSN and I.Salary > E.Salary )
    or ( E.SuperSSN = I.SSN and E.Salary > I.Salary ) )
begin
    raiserror 13000 'Constraint Violation:
The salary of an employee cannot be greater than the salary of his/her supervisor'
    rollback
end
```

- (4) The manager of a department must be an employee of the department

```
alter table Employee
add constraint UN_Employee_SSN_DNo
unique (SSN,DNO)
alter table Department
add constraint FK_Employee_SSN_DNo
foreign key (MgrSSN,DNumber)
references Employee(SSN,DNo)
```

- (5) The location of a project must be one of the locations of its department

```
alter table Project
add constraint FK_Project_DeptLocations
foreign key (DNumber,PLocation)
references DeptLocations (DNumber,DLocation)
```

- (6) The hire date of employees must be greater than their birth date

```
alter table Employee
add constraint HireDate_BDate check ( HireDate > BDate )
```

- (7) A supervisor must be hired at least 1 year before every employee s/he supervises

```
create trigger hireSuperv on Employee
after insert, update as
if exists ( select * from Inserted I, Employee E
  where ( I.SuperSSN = E.SSN and datediff(year, I.HireDate, E.HireDate) < 1 )
  or ( E.SuperSSN = I.SSN and datediff(year, E.HireDate, I.HireDate) < 1 ) )
begin
  raiserror 13000 'Constraint Violation:
A supervisor must be hired at least 1 year before every employee s/he supervises'
  rollback
end
```

- (8) The attribute Department.NbrEmployees is a derived attribute from Employee.DNo

```
create trigger derived_Department_NbrEmployees on Employee
after insert, update, delete as
begin
  update Department
  set NbrEmployees = ( select count(*) from Employee where Employee.DNo = DNumber )
  where DNumber in ( select DNo from Inserted )
  or DNumber in ( select DNo from Deleted )
end
```

#### Incremental version

```
create trigger derived_Department_NbrEmployees_1 on Employee
after insert, update, delete as
begin
  update Department
  set NbrEmployees = NbrEmployees +
    ( select count(*) from Inserted I where DNumber=I.DNo ) -
    ( select count(*) from Deleted D where DNumber=D.DNo )
  where DNumber in ( select DNo from Inserted )
  or DNumber in ( select DNo from Deleted )
end
create trigger derived_Department_NbrEmployees_2 on Department
after insert, update as
if exists ( select * from Inserted where NbrEmployees <>
  ( select count(*) from Employee where Employee.DNo = DNumber ) )
begin
  raiserror 13000 'Constraint Violation:
The attribute Department.NbrEmployees is a derived attribute from Employee.DNo'
  rollback
end
```

- (9) The attribute Employee.SuperSSN is a derived attribute computed as follows. Department managers are supervised by the manager of the Department 1 (Headquarters). Employees that are not managers are supervised by the manager of their department.

```

create trigger derived_Employee_SuperSSN_1 on Department
after insert, update as
if update(MgrSSN)
begin
    update Employee
    set SuperSSN = ( select MgrSSN from Inserted I where I.DNumber = DNo )
    where SSN not in ( select MgrSSN from Inserted )
    and DNo in ( select DNumber from Inserted )

    update Employee
    set SuperSSN = ( select MgrSSN from Department where DNumber = 1 )
    where SSN in ( select MgrSSN from Inserted )
end
create trigger derived_Employee_SuperSSN_2 on Employee
after insert, update as
if update(DNo)
begin
    update Employee
    set SuperSSN = ( select MgrSSN from Department where DNumber = DNo )
    where SSN in ( select SSN from Inserted )
end

```

- (10) An employee works at most in 4 projects

```

create trigger empNbrProj on WorksOn
after insert, update as
if exists ( select * from WorksOn group by ESSN having count(*) > 4 )
begin
    raiserror 13000 'Constraint Violation: An employee works at most in 4 projects'
    rollback
end

```

- (11) An employee works at least 30h/week and at most 50 h/week on all its projects

```

create trigger workson_30_50 on WorksOn
after insert, update, delete as
if exists ( select * from WorksOn
            group by ESSN having (sum(Hours) < 30) or (sum(Hours) > 50) )
begin
    raiserror 13000 'Constraint Violation:
An employee works at least 30 h/week and at most 50 h/week on all its projects'
    rollback
end

```

- (12) A project can have at most 2 employees working on the project less than 10 hours

```

create trigger worksonLess10h on WorksOn
after insert, update as
if exists ( select * from WorksOn where Hours < 10 group by pno having count(*) > 2 )
begin
    raiserror 13000 'Constraint Violation:
A project can have at most 2 employees working on the project less than 10 hours'
    rollback
end

```

- (13) Only department managers can work less than 5 hours on a project

```
create trigger worksonLess5h_1 on WorksOn
after insert, update as
if exists ( select * from Inserted where Hours < 5 and ESSN not in (
    select MgrSSN from Department where MgrSSN is not null ) )
begin
    raiserror 13000 'Constraint Violation:
Only department managers can work less than 5 hours on a project'
    rollback
end
create trigger worksonLess5h_2 on Department
after update, delete as
if exists ( select * from Deleted where MgrSSN not in ( select MgrSSN from Department )
    and MgrSSN in ( select ESSN from WorksOn where Hours < 5 ) )
begin
    raiserror 13000 'Constraint Violation:
Only department managers can work less than 5 hours on a project'
    rollback
end
```

- (14) Employees that are not supervisors must work at least 10 hours on every project they work

```
create trigger workson10h_1 on WorksOn
after insert, update as
if exists ( select * from Inserted where Hours < 10 and ESSN not in (
    select SuperSSN from Employee where SuperSSN is not null ) )
begin
    raiserror 13000 'Constraint Violation:
Employees that are not supervisors must work at least 10 hours on every project they work'
    rollback
end
create trigger workson10h_2 on Employee
after update, delete as
if exists ( select * from Deleted where SuperSSN not in (
    select SuperSSN from Employee where SuperSSN is not null )
    and SuperSSN in ( select ESSN from WorksOn where Hours < 10 ) )
begin
    raiserror 13000 'Constraint Violation:
Employees that are not supervisors must work at least 10 hours on every project they work'
    rollback
end
```

- (15) The manager of a department must work at least 5 hours on all projects controlled by the department

```
create trigger mgrProj_1 on Department
after insert, update as
if exists ( select * from ( Inserted I join Project P on I.DNumber = P.DNumber )
    left outer join WorksOn on MgrSSN = ESSN and PNumber = PNo
    where ( Hours is null or Hours < 5 ) )
begin
    raiserror 13000 'Constraint Violation:
A manager must work at least 5 hours on all projects controlled by his/her department'
    rollback
end
```

```

create trigger mgrProj_2 on Project
after insert, update as
if exists ( select * from ( Project P join Department D on D.DNumber = P.DNumber )
  left outer join WorksOn on MgrSSN = ESSN and PNumber = PNo
  where P.PNumber in ( select PNumber from Inserted )
  and ( Hours is null or Hours < 5 ) )
begin
  raiserror 13000 'Constraint Violation:
A manager must work at least 5 hours on all projects controlled by his/her department'
  rollback
end
create trigger mgrProj_3 on WorksOn
after update, delete as
if exists ( select *
  from ( Department D join Project P on D.DNumber=P.DNumber) left outer join WorksOn
  on MgrSSN = ESSN and PNumber = PNo
  where D.MgrSSN in ( select ESSN from Deleted )
  and ( Hours is null or Hours < 5 ) )
begin
  raiserror 13000 'Constraint Violation:
A manager must work at least 5 hours on all projects controlled by his/her department'
  rollback
end

```

- (16) The supervision relationship in Employee.SuperSSN must not be cyclic

```

create trigger noncyclic_subordinates on Employee
after insert, update as
begin
  create table #Supervision ( SSN char(9), SuperSSN char(9) primary key (SSN,SuperSSN) )
  insert into #Supervision select SSN, SuperSSN from Employee where SuperSSN is not null
  while @@rowcount != 0 -- while previous operation affected some rows
  begin
    if exists ( select * from #Supervision where SSN=SuperSSN )
    begin
      raiserror 13000 'Constraint Violation: The supervision relationship is cyclic'
      rollback
    end
    insert into #Supervision
    select distinct S1.SSN, S2.SuperSSN from #Supervision S1 join #Supervision S2
    on S1.SuperSSN = S2.SSN
    where not exists ( select * from #Supervision S where
      S.SSN=S1.SSN and S.SuperSSN=S2.SuperSSN )
  end
end

```