Lecture 2
SQL 1 – Data type, DDL

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Objectives

- Database Models
- SQL Data Definition and Data Types
- Specifying Constraints in SQL
- Schema Change Statements in SQL
- SQL Syntax in SQL Server 20xx

- Ref.: Chapter 6

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Database Models

- A data model comprises
  - a data structure
  - a set of integrity constraints
  - operations associated with the data structure

- Examples of data models include:
  - hierarchical
  - network
  - relational

Flat File Model

	Route No.	Miles	Activity
Record 1	I-95	12	Overlay
Record 2	I-495	05	
Record 3	SR-301	33	

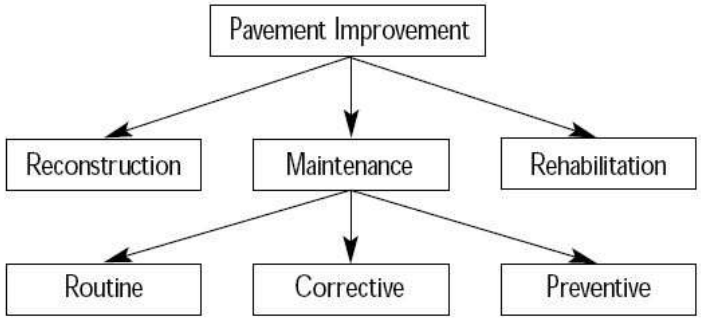
Relational Model

Activity Code	Activity Name
23	Patching
24	Overlay
25	Crack Sealing

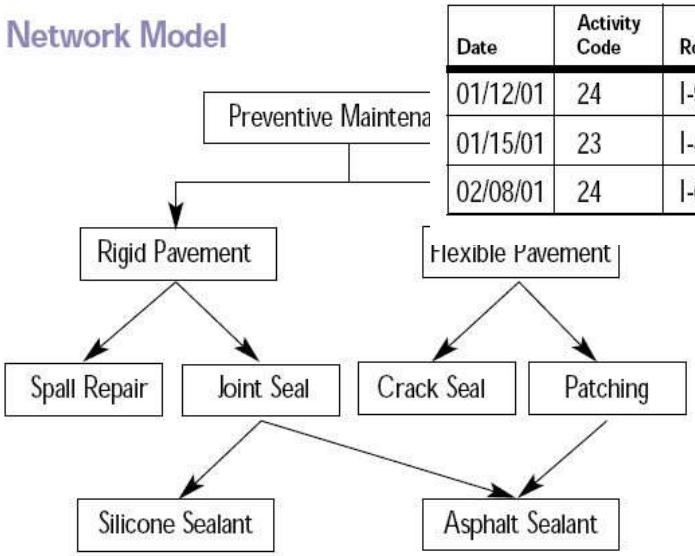
Key = 24

Activity Code	Date	Route No.
24	01/12/01	I-95
24	02/08/01	I-66

Hierarchical Model



Network Model



Date	Activity Code	Route No.
01/12/01	24	I-95
01/15/01	23	I-495
02/08/01	24	I-66

Object-Oriented Model

Object 1: Maintenance Report

Date	
Activity Code	
Route No.	
Daily Production	
Equipment Hours	
Labor Hours	

Object 1 Instance

01-12-01
24
I-95
2.5
6.0
6.0

Object 2: Maintenance Activity

Activity Code	
Activity Name	
Production Unit	
Average Daily Production Rate	

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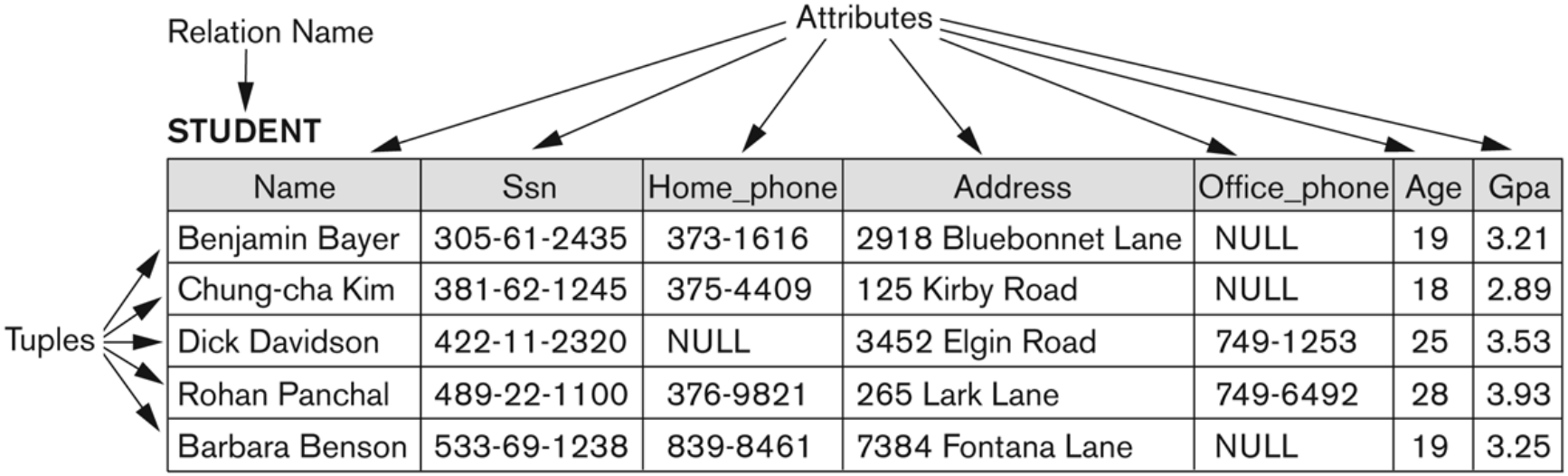
Relational Databases

- The relational data model comprises:
  - relational data structure
  - relational integrity constraints
  - relational algebra or equivalent (SQL)
    - SQL is an ISO language based on relational algebra
    - relational algebra is a mathematical formulation

Relational Data Structure

- A relational data structure is a collection of tables or relations.
  - A relation is a collection of rows or tuples
  - A tuple is a collection of columns or attributes
  - A domain is a pool of values from which the actual attribute values are taken.



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	749-1253	25	3.53
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	NULL	19	3.25

Domain and Integrity Constraints

- Domain Constraints
  - limit the range of domain values of an attribute
  - specify uniqueness and ‘nullness’ of an attribute
  - specify a default value for an attribute when no value is provided.
- Entity Integrity
  - every tuple is uniquely identified by a unique non-null attribute, the primary key.
- Referential Integrity
  - rows in different tables are correctly related by valid key values (‘foreign’ keys refer to primary keys).

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Columns or Attributes

- Each column is given a name which is unique within a table
- Each column holds data of one specified type. e.g.
  - integer decimal
  - character text data
    - the range of values can also be constrained
- Some row-column instances may contain no data but instead hold a special null value to indicate that this value is unavailable or inappropriate.

Rows or Tuples

- Each row must be uniquely identifiable with a table
  - one row records a transaction in the bank case
- Columns in a specified row may contain no value
  - a transaction cannot have credit and debit values simultaneously.

Account	Debit	Credit
Cash	300	
Cash		600

- Some columns must contain values for all rows
  - date and source, which make the row unique, in the bank account case.

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Primary Keys

- A table requires a key which uniquely identifies each row in the table-entity integrity.
- The key could comprise more than one column
- A table may have several possible keys, the candidate keys, from which one is chosen as the primary key.
- Primary key implies ‘UNIQUE NOT NULL’. It may be necessary to generate an artificial primary key if no other unique attribute combination is available within the data.

Employee table - column

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

- What is a suitable primary key?
- A suitable key (SSN) must be generated since no other attributes or combination of attributes uniquely identifies each row.

Dependent table – column

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

- The primary key combines **ESSN + Dependent_name** to uniquely identify each row.
- ESSN relates a Dependent row to the corresponding Employee row - it is the primary key in the Employee table and a foreign key in the Dependent table.

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Foreign Keys

- A foreign key is a value held in a table that has exactly the same value as the primary key column of a row in another table.
- A foreign key references the primary key of another table and maintains a relationship between the tables.
- The column ESSN (foreign key) in the Dependent table must have the same value as one of the SSN (primary key) values in the Employee table. This relationship controls referential integrity.

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EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
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James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

- Employee
  - PK: SSN
- Dependent
  - PK: ESSN+ Dependent_name
  - FK: ESSN

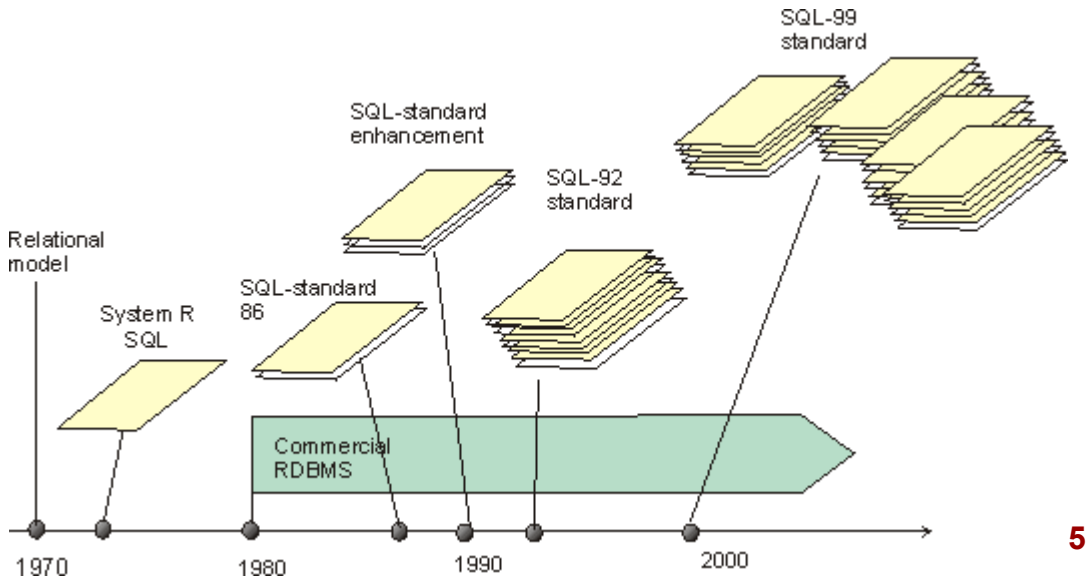
DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

Overview of SQL

- Structured Query Language (SQL)
  - DDL + DML
    - Data Definition Languages
    - Data Manipulation Languages
- SQL: standard language for commercial relation DBMSs.

Evolution
- ANSI and ISO: SQL (ANSI 1986) called SQL-89 or SQL1
- SQL2 (SQL-92)
- SQL3 (SQL-99)



Attribute Data Types - Domains

- Attribute Data Types
  - Numeric:
    - Integer/Int, Smallint,
    - Float/Real, Double Precision
    - Decimal(i,j)/Dec(i,j), Numeric(i,j)
  - Character-string
    - Char(n)/Character(n)
    - Varchar(n)/Char Varying(n)/Character Varying(n)
    - Character Large Object (Clob): large text value (document)

Attribute Data Types – Domains (2)

- Bit-string
  - Bit(n)
  - Bit Varying(n)
  - Binary Large Object (Clob)
- Boolean: True/False – Null (Unknown)

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Additional Data Types in SQL2 and SQL-99

Has DATE, TIME, and TIMESTAMP data types

- **DATE:**
  - Made up of year-month-day in the format yyyy-mm-dd
- **TIME:**
  - Made up of hour:minute:second in the format hh:mm:ss
- **TIME(i):**
  - Made up of hour:minute:second plus i additional digits specifying fractions of a second
  - format is hh:mm:ss:ii...i

Additional Data Types in SQL2 and SQL-99 (2)

- **TIMESTAMP:**
  - Has both DATE and TIME components
- **INTERVAL:**
  - Specifies a relative value that can be used to increment or decrement an absolute value
  - Can be DAY/TIME intervals or YEAR/MONTH intervals
  - Can be positive or negative when added to or subtracted from an absolute value, the result is an absolute value

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Domains

- To specify the data type of each attribute directly
- Syntax:

  CREATE DOMAIN <domain_name> AS <type>

- Example:

  Create Domain Ssn_Type AS Char(9)

Data Definition, Constraints, and Schema Changes

- Used to CREATE, DROP, and ALTER the descriptions of the tables (relations) of a database

Relational Database Schema

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Figure 5.5
Schema diagram for the COMPANY relational database schema.

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CREATE TABLE

- Specifies a new base relation by giving it a name, and specifying each of its attributes and their data types (INTEGER, FLOAT, DECIMAL(i,j), CHAR(n), VARCHAR(n))

- A constraint NOT NULL may be specified on an attribute

```
CREATE TABLE DEPARTMENT (
    DNAME          VARCHAR(10)  NOT NULL,
    DNUMBER        INTEGER      NOT NULL,
    MGRSSN         CHAR(9),
    MGRSTARTDATE   CHAR(9)   );
```

CREATE TABLE (2)

- In SQL2, can use the CREATE TABLE command for specifying the primary key attributes, secondary keys, and referential integrity constraints (foreign keys).

- Key attributes can be specified via the PRIMARY KEY and UNIQUE phrases

```
CREATE TABLE DEPT (
  DNAME            VARCHAR(10)    NOT NULL,
  DNUMBER          INTEGER        NOT NULL,
  MGRSSN                CHAR(9),
  MGRSTARTDATE     CHAR(9),
  PRIMARY KEY      (DNUMBER),
  UNIQUE           (DNAME),
  FOREIGN KEY (MGRSSN) REFERENCES EMP   );
```

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DROP TABLE

- Used to remove a relation (base table) and its definition

- The relation can no longer be used in queries, updates, or any other commands since its description no longer exists

- Example:

```
DROP TABLE   DEPENDENT;
DROP TABLE   DEPENDENT CASCADE;
```

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ALTER TABLE

- Used to add an attribute to one of the base relations
  - The new attribute will have NULLs in all the tuples of the relation right after the command is executed; hence, the NOT NULL constraint is not allowed for such an attribute

- Example:

```
ALTER TABLE EMPLOYEE ADD JOB VARCHAR(12);
```

- The database users must still enter a value for the new attribute JOB for each EMPLOYEE tuple.
  - This can be done using the UPDATE command.

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Features Added in SQL2 and SQL-99

- Create schema
- Referential integrity options

Create Schema

- Specifies a new database schema by giving it a name
  - Authorization identifier
  - Descriptors
- Schema elements: tables, constraints, views, domains, …
- Statement create a schema:
  - **CREATE SCHEMA** COMPANY
    AUTHORIZATION Jsmith;

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Drop Schema

- If a whole schema is no longer needed.
- Syntax:

  Drop Schema <schema_name> Cascade|Restrict

  - Cascade: remove the database schema and all its table, domains, and others elements
  - Restrict: the schema is dropped only if it has no elements in it.
- Example:

  Drop Schema COMPANY Cascade;

Constraints in SQL

- Primary Key
- Foreign Key
- Null – Not Null
- Default <value>
- Check

- Example:

```
Dnumber Int Not Null Check (Dnumber > 0 And Dnumber < 21)
Or
Create Domain D_Num as Integer Check (D_Num > 0 And D_Num <
  21)

...
Dnumber D_Num Not Null
...
```

Referential Integrity Options

- We can specify restrict: CASCADE, SET NULL or SET DEFAULT on referential integrity constraints (foreign keys)

```
CREATE TABLE DEPT (
   DNAME          VARCHAR(10)   NOT NULL,
   DNUMBER        INTEGER       NOT NULL,
   MGRSSN         CHAR(9),
   MGRSTARTDATE   CHAR(9),
   PRIMARY KEY (DNUMBER),
   UNIQUE (DNAME),
   FOREIGN KEY (MGRSSN) REFERENCES EMP
  ON DELETE SET DEFAULT ON UPDATE CASCADE);
```

Referential Integrity Options (2)

```
CREATE TABLE EMP(
 ENAME VARCHAR(30)   NOT NULL,
 ESSN  CHAR(9),
 BDATE DATE,
 DNO   INTEGER  DEFAULT 1,
 SUPERSSN  CHAR(9),
 PRIMARY KEY (ESSN),
 FOREIGN KEY (DNO) REFERENCES DEPT
  ON DELETE SET DEFAULT ON UPDATE  CASCADE,
 FOREIGN KEY (SUPERSSN) REFERENCES EMP ON DELETE
 SET NULL ON UPDATE CASCADE);
```

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SQL Server 20xx: Data types(1)

- Integer

Name	Bytes	Range
bigint	8	-2^{63} (-9,223,372,036,854,775,808) to $2^{63} - 1$ (9,223,372,036,854,775,807)
int	4	-2^{31} (-2,147,483,648) to $2^{31} - 1$ (2,147,483,647)
smallint	2	-2^{15} (-32,768) to $2^{15} - 1$ (32,767)
tinyint	1	0 to 255

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Data types (2)

- Exact numeric

Name	Bytes	Range
decimal[p[,s]]	5 – 17	$-10^{38}+1$ to $10^{38}-1$.
numeric[p[,s]]	5 – 17	$-10^{38}+1$ to $10^{38}-1$.

- Appropriate numeric

Name	Bytes	Range
Float[(n)]	n	$-1.79E^{+308}$ to $-2.23E^{-308}$, 0 and $2.23E^{-308}$ to $1.79E^{+308}$
real	4	$-3.40E^{+38}$ to $-1.18E^{-38}$, 0 and $1.18E^{-38}$ to $3.40E^{+38}$

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Data types (4)

- Monetary

Name	Bytes	Range
Money	8	-922,337,203,685,477.5808 to 922,337,203,685,477.5807
smallmoney	4	- 214,748.3648 to 214,748.3647

- Date and Time

Name	Bytes	Range
datetime	8	January 1, 1753, to December 31, 9999
smalldatetime	4	January 1, 1900, to June 6, 2079

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Data types (6)

- Characters

Name	Bytes	Comments
char[(n)]	0-8000	non-Unicode
varchar[(n)]	0-8000	non-Unicode
varchar(max)	0-2 GB	non-Unicode, 16 bytes pointer on row, preferred over text data type
text	0-2 GB	non-Unicode, 16 bytes pointer or in row, obsolete, varchar(max) prefered

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Data types (7)

- Characters (contd.)

Name	Bytes	Comments
nchar[(n)]	0-8000	max 4000 unicode characters
nvarchar[(n)]	0-8000	max 4000 unicode characters
nvarchar(max)	0-2 GB	16 bytes pointer or in row, preferred over ntext data type
ntext	0-2 GB	16 bytes pointer, obsolete, nvarchar(max) prefered

Data types (8)

- Binary

Name	Bytes	Comments
binary[(n)]	0-8000	
varbinary[(n)]	0-8000	
varbinary(max)	0-2 GB	16 bytes pointer or in row, preferred over image data type

Data types (9)

- Image

Name	Bytes	Comments
Image	0-2GB	16 bytes pointer, obsolete, varbinary(max) prefered

- Global identifier

Name	Bytes	Comments
uniqueidentifier	16	

- XML

Name	Bytes	Comments
xml	0-2GB	16 bytes pointer

SQL server 20xx: Create table command

```
CREATE TABLE
    table_name
        ( column_name data_type [ NULL | NOT NULL ]
[ ,...n ] )
 [ ; ]
GO
```

Creating Employee table

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

Field Name	Data Type	Null
FName	varchar(15)	NOT NULL
MInit	varchar(1)	NULL
LName	varchar(15)	NOT NULL
SSN	char(9)	NOT NULL
BDate	datetime	NULL
Address	varchar(30)	NULL
Sex	char(1)	NULL
Salary	numeric(10, 2)	NULL
SuperSSN	char(9)	NULL
DNo	numeric(4, 0)	NULL

```
CREATE TABLE Employee(
  FName varchar(15) NOT NULL,
  MInit varchar(1) NULL,
  LName varchar(15) NOT NULL,
  SSN char(9) NOT NULL,
  BDate datetime NULL,
  Address varchar(30) NULL,
  Sex char(1) NULL,
  Salary numeric(10, 2) NULL,
  SuperSSN char(9) NULL,
  DNo numeric(4, 0) NULL)
GO
```

Creating Department table

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

Field Name	Data Type	Null
DName	varchar(15)	NOT NULL
DNumber	numeric(4, 0)	NOT NULL
Mgrssn	char(9)	NULL
MgrStartdate	datetime	NULL

Creating Dept_Location table

DEPT_LOCATIONS

Dnumber	Dlocation

Field Name	Data Type	Null
DNumber	numeric(4, 0)	NOT NULL
DLocation	varchar(15)	NOT NULL

Creating Project table

PROJECT

Pname	Pnumber	Plocation	Dnum

Field Name	Data Type	Null
PName	varchar(15)	NOT NULL
PNumber	numeric(4, 0)	NOT NULL
PLocation	varchar(15)	NULL
DNum	numeric(4, 0)	NOT NULL

Creating Works_on table

WORKS_ON

Essn	Pno	Hours

Field Name	Data Type	Null
ESSN	char(9)	NOT NULL
PNo	numeric(4, 0)	NOT NULL
Hours	numeric(4, 1)	NULL

Creating Dependent table

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Field Name	Data Type	Null
ESSN	char(9)	NOT NULL
Dependent_Name	varchar(15)	NOT NULL
Sex	char(1)	NULL
BDate	datetime	NULL
Relationship	varchar(8)	NULL

Creating Primary key

ALTER TABLE *table_name*
  ADD CONSTRAINT *constraint_name*
    PRIMARY KEY (*column_name* [*,...n*])
[;]
GO

Ex:

```
ALTER TABLE Employee
  ADD Constraint pk_Emp PRIMARY KEY (SSN)
GO
```

Creating Primary key

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Figure 5.5
Schema diagram for the COMPANY relational database schema.

Creating Foreign key

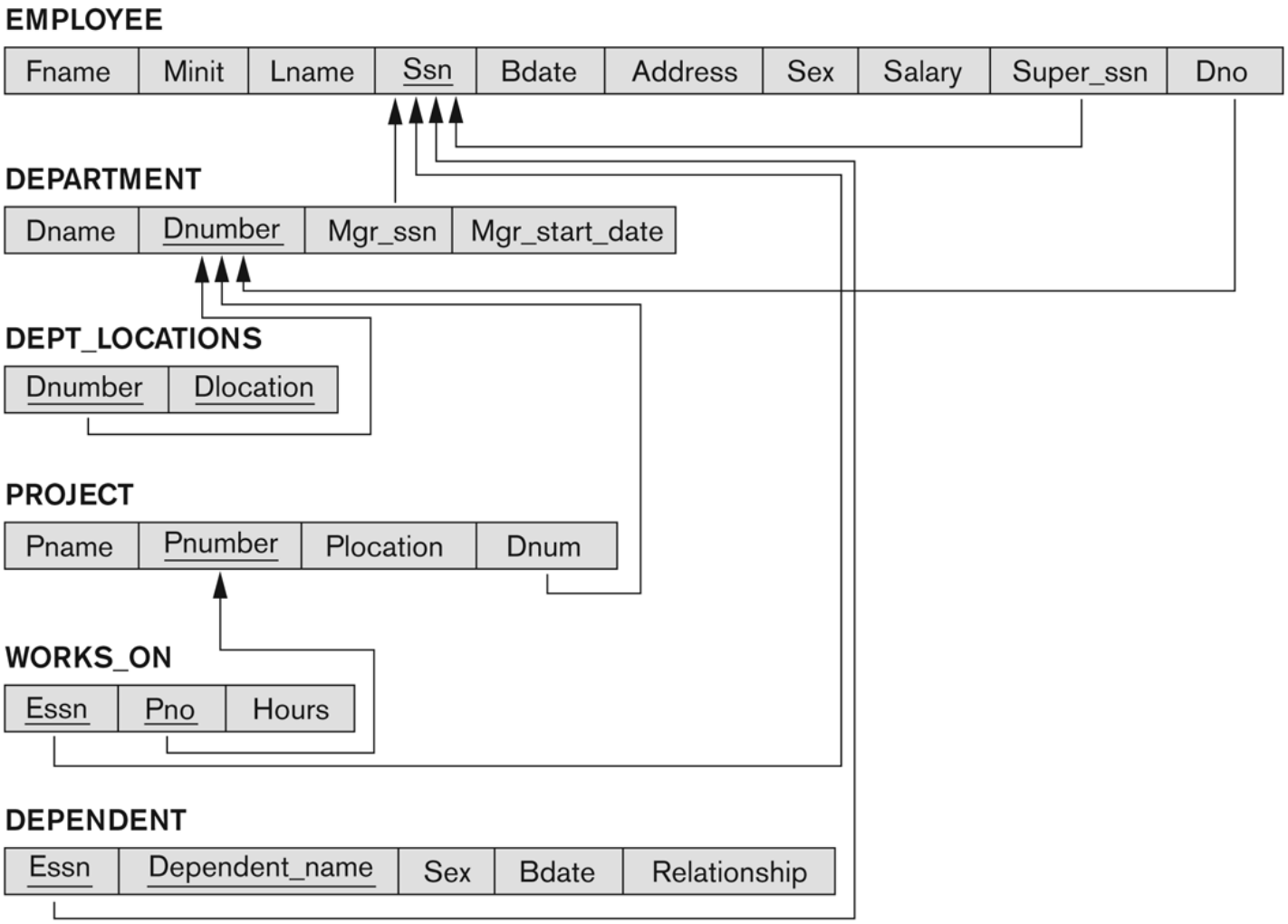
ALTER TABLE *table_name*
ADD CONSTRAINT *constraint_name*
FOREIGN KEY (*column_name* [,...*n*])
REFERENCES *table_name_ref*(*column_name* [,...*n*])
[;]
GO

Ex:

```
ALTER TABLE Employee
  ADD Constraint fk_EmpDNo FOREIGN KEY(DNo)
  REFERENCES Department(DNumber);
 GO
```

Creating Foreign key

Referential integrity constraints displayed on the COMPANY relational database schema.



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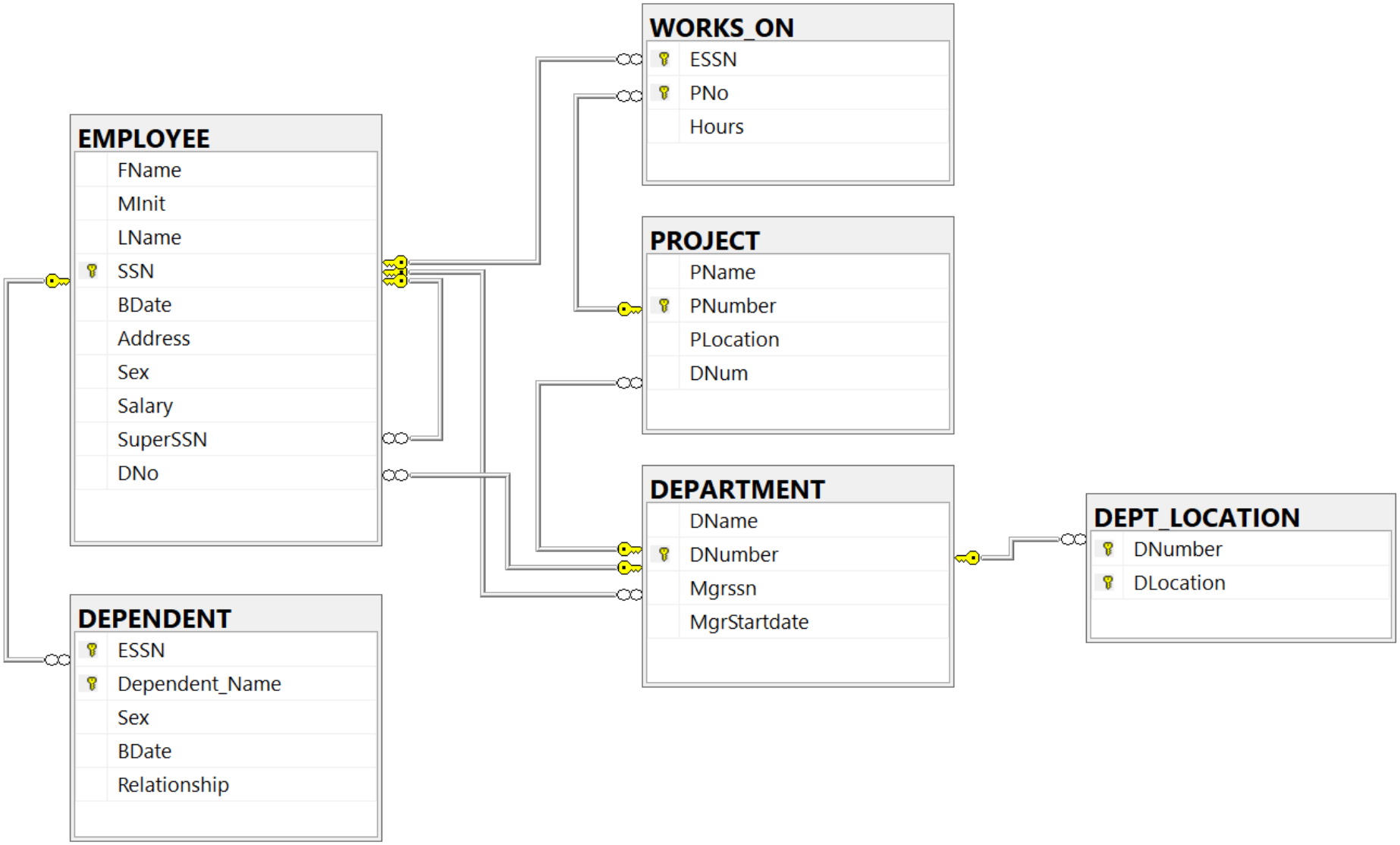

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