**CSIS 2300:**

**Chapter 01: Getting Started**

**Why Use a Database?**

* Store data more complicated than simple lists.
* Keep track of data and relations.

**The Problem with Lists:**

* **Modification problems:** redundancy and multiple themes can create modification problems. The figure bellow illustrates a problem the operations update, delete and insert.

Diagram

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* + Updating the advisor requires the update of all advisor’s related fields.
  + Deleting a row cause a student and advisor data lost.
  + Inserting a row may imply on incomplete data. (Adding NULL)

**Relational Database:**

* **Relational model** is a methodology used as a solution for database design.
* A **relational database** contains a collection of separate tables.
* A **table** holds data about only one *theme*.
* Each **column**,also knownas fields, in a table *stores a characteristic* common to all rows in a table.
* A **row** in a table, also known as a *record*, has data about an *occurrence*.
* The leading technique for data definition and manipulation is **Structured Query** **Languages** (SQL).
* **SQL** is an international standard for creating, processing, and querying databases and their tables. With SQL you can:
  + Reconstruct lists from their underlying tables.
  + Query for specific data conditions.
  + Perform calculations on data in tables.
  + Insert, Update, and Delete data.

**What is a Database System?**

A **Database system** has four components consisting of:

Diagram

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1. Users:
   1. Employ a database application to keep track of things.
   2. Use forms to read, enter, and query data.
2. Database application.
   1. Create and process forms.
   2. Process user queries.
   3. Create and process reports.
   4. Execute application logic.
   5. Control application.
3. Database management system (DBMS).
   1. The purpose of a DBMS is to create, process, and administer databases and are licensed from a vendor. The DBMS enforce the **referential integrity constraints** (rules to ensure values of a column in one table are valid when compared to values in another table).
   2. The function of a DBMS is:
      1. Create databases.
      2. Create tables.
      3. Create supporting structures (e.g., indexes).
      4. Read database data.
      5. Modify (insert, update, or delete) database data.
      6. Maintain database structures.
      7. Enforce rules.
      8. Control concurrency.
      9. Provide security.
      10. Perform backup and recovery.
4. Database:
   1. Self-describing collection of related tables, where **self-describing** means a description of the structure of the database is contained with the database itself.
   2. **Metadata** is a data about the structure of the database.

Diagram

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**Personal Database Systems:**

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**Enterprise-Class Database Systems:**

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**Web Database Applications:**

* A **web database application** is an application with a web user interface that is dependent on a database to store the data needed by the application.
* An **Application Programming Interface** (API) is a programming language such as PHP or JavaScript to connect to a DBMS allowing the sending of SQL commands to the DBMS and then to receive them back

**Data Warehouse and Business Intelligence (BI) Systems?**

* **Transactions** are purchases bought online that are recorded in a company’s database, also referred to as an **Online Transaction Processing** (OLTP) database.
* Data analysis is done on an organization’s **Online Analytical Processing** (OLAP) database and is used for research.
* A **Business Intelligence System** (BI) consists of tools used to analyze and report on company data.

**Chapter 02: The Relational Model**

**Relational Terms:**

* An **entity** is something of importance to the user that needs to be represented in a database.
  + In an entity-relational model, entities are restricted to things that can be represented by a single table.
* A **relation** is a two-dimensional table consisting of rows and columns that has the characteristics shown above:
  1. Rows contain data about an entity.
  2. Columns contain data about attributes of the entity.
  3. Cells of the table hold a single value.
  4. All entries in a column are of the same kind.
  5. Each column has a unique name.
  6. The order of the columns is unimportant.
  7. The order of the rows is unimportant.
  8. No two rows may hold identical sets of data values.

**Relational Structures:**

* When writing out relation structures use the following format:
  + Relation names are written first in all caps (if two words, then use an underscore between them), and they are always singular.
  + A column name is written with the first letter capitalized (if two words, then run them together and capitalize the first letter of each word).
* A **database schema** is the design on which a database and its associated applications are built.

Table

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**Types of Keys:**

* A **key** is one or more columns of a relation that is used to identify a row.
  + A key can be unique (primary key) or nonunique (foreign key).
* A **composite key** contains two or more attributes.
* **Candidate keys** are the keys that uniquely identify each row in a relation.
* A **primary key** is a candidate key that is chosen as the key that the DBMS will use to uniquely identify each row in a relation.
  + The primary key in a relation will be underlined.

**Surrogate Keys:**

* A **surrogate key** is a column with a unique, DBMS-assigned identifier that has been added to a table to be the primary key.
  + The ideal surrogate key is short, numeric, and never changes.
* Suppose we have the following table: ***PROPERTY (Street, City, State, ZIP, OwnerID)***
  + Notice that it takes the street, city, state, and zip to uniquely identify a row in a table.
* Now let’s use a surrogate key as a unique identifier! ***PROPERTY (PropertyID, Street, City, State, ZIP, OwnerID)***

**Foreign Keys:**

* A **foreign key** is a primary key of another relation that has been placed in the current relation to represent a relationship between two tables.
  + It is represented in a relation by italics as seen in the example bellow.

**EMPLOYEE (EmployeeNumber, FirstName, LastName, Department, EmailAddress, Phone)**

**DEPARTMENT (DepartmentName, BudgetCode, OfficerNumber, DepartmentPhone)**

**Referential Integrity:**

* A **referential integrity constraint** states that every value of a foreign key must match a value of an existing primary key.
* In the relationship between EMPLOYEE and DEPARTMENT seen in the **Foreign Keys** section, the department attribute located in the EMPLOYEE table is the foreign key and whatever value is placed in that column, the same value MUST exist in the Department attribute in the DEPARTMENT table.

**The NULL value:**

* A **null value** is a missing value in a cell in a relation.
* The problem with null vales is that it is ambiguous:
  + Is it that no value is appropriate?
  + Is it known, but not entered?
  + Is it unknown, thus not entered?
* You can eliminate null values by requiring an attribute value.

**Functional Dependencies:**

* A functional dependency occurs when a candidate key determines all the other attributes in a relation.
  + In other words, all the attributes in a relation are functionally dependent on the candidate key.
  + A dependency is shown with the determinant on the left and then an arrow showing the attribute(s) that depend on it, as shown: ***CustomerNumber-> (CustomerLastName, CustomerFirstName, Phone)***

**Normalization:**

* **Normalization** is the process of (or a set of steps for) breaking a table or relation with more than one theme into a set of tables such that each has only one theme.
* Relational design principles for a well-formed relation:
  + Every determinate must be a candidate key.
  + Any relation that is not well formed should be broken into two or more relations that are well formed
* A relation is in first normal form (1NF) if it:
  + Has characteristics listed below:
    - Rows contain data about an entity.
    - Columns contain data about attributes of the entity.
    - Cells of the table hold a single value.
    - All entries in a column are of the same kind.
    - Each column has a unique name.
    - The order of the columns is unimportant.
    - The order of the rows is unimportant.
    - No two rows may hold identical sets of data values.
  + Has a defined primary key.
  + No repeating groups.

**Algorithm (Normalization Process):**

1. Identify the candidate keys of the relation.
2. Identify all the functional dependencies in the relation.
3. Examine the determinants of the functional dependencies. If any determinant is not a candidate key, the relation is not well formed. In this case:
   1. Place the columns of the functional dependency in a new relation of their own.
   2. Make the determinant of the functional dependency the primary key of the new relation.
   3. Leave a copy of the determinant as a foreign key in the original relation.
   4. Create a referential integrity constraint between the original and the new relation.
4. Repeat step 3 until every determinant of every relation is a candidate key.

**Example 01:**

Both the prescription and its customer details are in the same table.
The data from the table are,
1. 
Prescription Number,  P10001
Date,  10/17/2019
Drug,  Drug A
Dosage,  10mg
Customer Name,  Smith, Alvin
Customer Phone,  575-523-2233
Customer Email Address,  ASmith@somewhere.com

2.
Prescription Number,  P10003
Date,  10/17/2019
Drug,  Drug B
Dosage,  35mg
Customer Name,  Rhodes, Jeff
Customer Phone,  575-645-3455
Customer Email Address,  JRhodes@somewhere.com

3.
Prescription Number,  P10004
Date,  10/17/2019
Drug,  Drug A
Dosage,  20mg
Customer Name,  Smith, Sarah
Customer Phone,  575-523-2233
Customer Email Address,  SSmith@somewhere com

4.
Prescription Number,  P10007
Date,  10/18/2019
Drug,  Drug C
Dosage,  20mg
Customer Name,  Frye, Michael
Customer Phone,  575-645-4566
Customer Email Address,  MFrye@somewhere.com

5.
Prescription Number,  P10010
Date,  10/18/2019
Drug,  Drug B
Dosage,  30mg
Customer Name,  Rhodes, Jeff
Customer Phone,  575-645-3455
Customer Email Address,  JRhodes@somewhere.com

**Normalized CUSTOMER and PRESCRIPTION relations and data:**

The prescription and drug data and the customer details are in separate tables. 
The columns in the Customer table are Customer Email Address, Customer Name and Customer Phone.
The data in the sequence of columns is,
• ASmith@somewhere.com; Smith, Alvin; 575-523-2233
• JRhodes@somewhere.com; Rhodes, Jeff; 575-645-3455
• MFrye@somewhere.com; Frye, Michael 575-645-4566
• SSmith@somewhere.com; Smith, Sarah; 575-523-2233
The columns in the Prescription table are Prescription Number, Date, Drug, Dosage, Customer Email Address. The data is as below.
1. 
Prescription Number,  P10001
Date,  10/17/2019
Drug,  Drug A
Dosage,  10mg
Customer Email Address,  ASmith@somewhere.com

2.
Prescription Number,  P10003
Date,  10/17/2019
Drug,  Drug B
Dosage,  35mg
Customer Email Address,  JRhodes@somewhere.com

3.
Prescription Number,  P10004
Date,  10/17/2019
Drug,  Drug A
Dosage,  20mg
Customer Email Address,  SSmith@somewhere com

4.
Prescription Number,  P10007
Date,  10/18/2019
Drug,  Drug C
Dosage,  20mg
Customer Email Address,  MFrye@somewhere.com

5.
Prescription Number,  P10010
Date,  10/18/2019
Drug,  Drug B
Dosage,  30mg
Customer Email Address,  JRhodes@somewhere.com

**Example 02:**

Few sample data from the table are,
1.
Employee Number, 101
 First Name, Mary
 Last Name, Jacobs
 Department, Administration
 Email Address, Mary.Jacobs@ourcompany.com
Department phone, 360-285-8100

2.
Employee Number, 102
 First Name, Rosalie
 Last Name, Jackson
 Department, Administration
 Email Address, Rosalie.Jackson@ourcompany.com
Department phone, 360-285-8100

3.
Employee Number, 103
 First Name, Richard
 Last Name, Bandalone
 Department, Legal
 Email Address, Richard.Bandalone@ourcompany.com
Department phone, 360-285-8200

4.
Employee Number, 104
 First Name, George
 Last Name, Smith
 Department, Human Resources
 Email Address, George.Smith@ourcompany.com
Department phone, 360-285-8300


5.
Employee Number, 105
 First Name, Alan
 Last Name, Adams
 Department, Human Resources
 Email Address, Alan.Adams@ourcompany.com
Department phone, 360-285-8300

6.
Employee Number, 106
 First Name, Ken
 Last Name, Evans
 Department, Finance
 Email Address, Ken.Evans@ourcompany.com
Department phone, 360-285-8400

**Normalized EMPLOYEE and DEPARTMENT relations and data:**

Few sample data from the first table are,
1.
Employee Number, 101
 First Name, Mary
 Last Name, Jacobs
 Department, Administration
 Email Address, Mary.Jacobs@ourcompany.com

2.
Employee Number, 102
 First Name, Rosalie
 Last Name, Jackson
 Department, Administration
 Email Address, Rosalie.Jackson@ourcompany.com

3.
Employee Number, 103
 First Name, Richard
 Last Name, Bandalone
 Department, Legal
 Email Address, Richard.Bandalone@ourcompany.com

4.
Employee Number, 104
 First Name, George
 Last Name, Smith
 Department, Human Resources
 Email Address, George.Smith@ourcompany.com

5.
Employee Number, 105
 First Name, Alan
 Last Name, Adams
 Department, Human Resources
 Email Address, Alan.Adams@ourcompany.com

6.
Employee Number, 106
 First Name, Ken
 Last Name, Evans
 Department, Finance
 Email Address, Ken.Evans@ourcompany.com

The Department and Department Phone of the second table are,
1. Administration, 360-285-8100
2. Finance, 360-285-8400
3. Human Resources, 360-285-8300
4. Legal, 360-285-8200

**Eliminating Anomalies from Multivalued Dependencies:**

1. When modification problems are due to functional dependencies and we then normalize relations to BCNF, we eliminate these anomalies.
2. Anomalies can also arise from another kind of dependency – the multivalued dependency.
   1. A **multivalued dependency** occurs when a determinant is matched with a particular set of values as seen below.

The Employee_Degree holds data for Employee Name and Employee Degree.
1. Chau, BS
2. Green, BS
3. Green, M S
4. Green, P h D
5. Jones, A A
6. Jones, B A
The Employee_Sibling holds data for Employee Name and Employee Sibling.
1. Chau, Eileen
2. Chau, Jonathan
3. Green, Nikki
4. Jones, Frank
5. Jones, Fred
6. Jones, Sally
The Partkit_Part holds data for Partkit Name and Part
1. Bike Repair, Screwdriver
2. Bike Repair, Tube Fix
3. Bike Repair, Wrench
4. First Aid, Aspirin
5. First Aid, Bandaids
6. First Aid, Elastic Bands
7. First Aid, Ibuprofin
8. Toolbox, Drill and drill bits
9. Toolbox, Hammer
10. Toolbox, Saw
11. Toolbox, Screwdriver
12. Toolbox, Wrench

**First Normal Form: (1NF)**

1. Each cell has only one value, and all entries in a column are of the same kind.
   1. Removes repeating groups from the table.
   2. Create a separate table for each set of related data.
   3. Identify each set of related data with a primary key.

Table

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**Second Normal Form: (2NF)**

1. Each table is in 1NF and all non-key attributes are determined by the entire primary key.
   1. Usually used in tables with a multiple-field primary key (composite key).
   2. Each non-key field relates to the entire primary key.
   3. Any field that does not relate to the primary key is placed in a separate table.
   4. MAIN POINT – eliminates redundant data in a table and create a set of values that apply to multiple records.
2. Table also should not contain partial dependency.

Table

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**Third Normal Form: (3NF)**

1. Each table is in 2NF and no non-key attributes are determined by another non-key attribute.

Table

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**Boyce-Codd Normal Form: (BCNF)**

1. Each table is in 3NF and all determinants are candidate keys.
2. Most 3NF relations are also BCNF relations.
3. A **3NF** relation is **NOT** a **BCNF** if:
   1. Candidate keys in the relation are composite keys.
   2. There is more than one candidate key in the relation.
   3. The keys are not disjoint.
   4. A table is Boyce-Codd normal form if every determinant in the table is a candidate key. (A determinant is any attribute whose value determines other values with a row).
   5. If a table contains only one candidate key, the 3NF and the BCNF are equivalent.

* 1. BCNF is a special case of 3NF.

**Chapter 03: Structured Query Language**

**Structured Query Language:**

* Is not a complete programming language; rather, it is a data sublanguage.

**SQL Statement Categories:**

* Data definition language (DDL).
  + Statement used to create a database structure.
* Data manipulation language (DML).
  + Statements used to query, insert, modify, and delete data.
* SQL/Persistent stored modules (SQL/PSM).
  + Statements to extend SQL by adding procedural programming capabilities.
* Transaction control language (TCL).
  + Statements used to mark transaction boundaries.
* Data control language (DCL).
  + Statements used to grant and revoke database permissions.

**Wedgewood Pacific Relations:**

The following information is given in the image:
Line 1: DEPARTMENT open parenthesis DepartmentName, BudgetCode, OfficeNumber, DepartmentPhone close parenthesis.
Line 2: EMPLOYEE open parenthesis EmployeeNumber, FirstName, LastName, Department, Position, Supervisor, OfficePhone, EmailAddress close parenthesis.
Line 3: PROJECT open parenthesis ProjectlD, ProjectName, Department, MaxHours, StartDate, EndDate close parenthesis.
Line 4: ASSIGNMENT open parenthesis ProjectlD, EmployeeNumber, HoursWorked close parenthesis


* A referential integrity constraint is used to link (or reference) relations. This means that a foreign key in a relation must also exist in the relation in which it serves as the primary key. WP’s referential integrity constraints.

**The following information is given in the image:
Department in EMPLOYEE must exist in DepartmentName in DEPARTMENT Supervisor in EMPLOYEE must exist in EmployeeNumber in EMPLOYEE Department in PROJECT must exist in DepartmentName in DEPARTMENT ProjectID in ASSIGNMENT must exist in ProjectID in PROJECT EmployeeNumber in ASSIGNMENT must exist in EmployeeNumber in EMPLOYEE.
**

**The columns of Department table are,
• Department Name with a primary key
• Budget Code
• Office Number
• Department Phone
The columns of Employee table are,
• Employee Number with a primary key
• First Name
• Last Name
• Department, 
• Position
• Supervisor
• Office Phone
• Email Address
The columns of Project table are,
• Project ID with a primary key
• Project Name
• Department
• Max Hours
• Start Date
• End Date
The columns of Assignment table are,
• Project ID with a foreign key
• Employee number with a foreign key
• Hours Worked
Below are relations between the tables:
1. A one-to-many relationship on Department Name from Department to Employee.
2. A one-to-many relationship on Department Name from Department to Project.
3. A one-to-many relationship on Employee Name from Employee to Assignment.
4. A one-to-many relationship on Project ID from Project to Assignment.**

**Data Definition Language (DDL):**

* CREATE
  + Create database objects.
* ALTER
  + Modify the structure and/or characteristics of database objects.
* DROP
  + Delete database objects.
* TRUNCATE
  + Delete table data while keeping the structure.

**SQL CREATE TABLE Statement:**

The following information is given in the image:
Line 1: CREATE TABLE NewTableName open parenthesis
Line 2: ColumnName DataType OptionalColumnConstraints,
Line 3: ColumnName DataType OptionalColumnConstraints,
Line 4: ColumnName DataType OptionalColumnConstraints,
Line 5: optional table constraints
 Ellipsis
 Close parenthesis semicolon


The three SQL statements specifies the column name, data type, null or not null column and primary key, if any. The SQL statements are,
CREATE TABLE DEPARTMENT
( Department Name Char(35) PRIMARYK EY, 
Budget Code Char(30) NOT NULL, 
Office Number Char(15) NOT NULL, 
Department Phone Char(12) NOT NULL );

CREATE TABLE EMPLOYEE 
  ( Employee Number Int PRIMARY KEY, 
First Name Char(25) NOT NULL,  
LastName Char(25) NOT NULL, 
Department Char(35) NOT NULL DEFAULT 'Human Resources', 
Position Char(35) NULL, 
Supervisor Int NULL, 
Office Phone Char(12) NULL, 
Email Address VarChar(100) NOT NULL UNIQUE );

CREATE TABLE PROJECT 
(Project ID Int PRIMARY KEY, 
Project Name Char(50) NOT NULL, 
Department Char(35) NOT NULL, 
Max Hours Numeric(8,2) NOT NULL DEFAULT 100, 
Start Date Date NULL, 
End Date Date NULL );

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