Chapter 1

An introduction to relational databases

Objectives

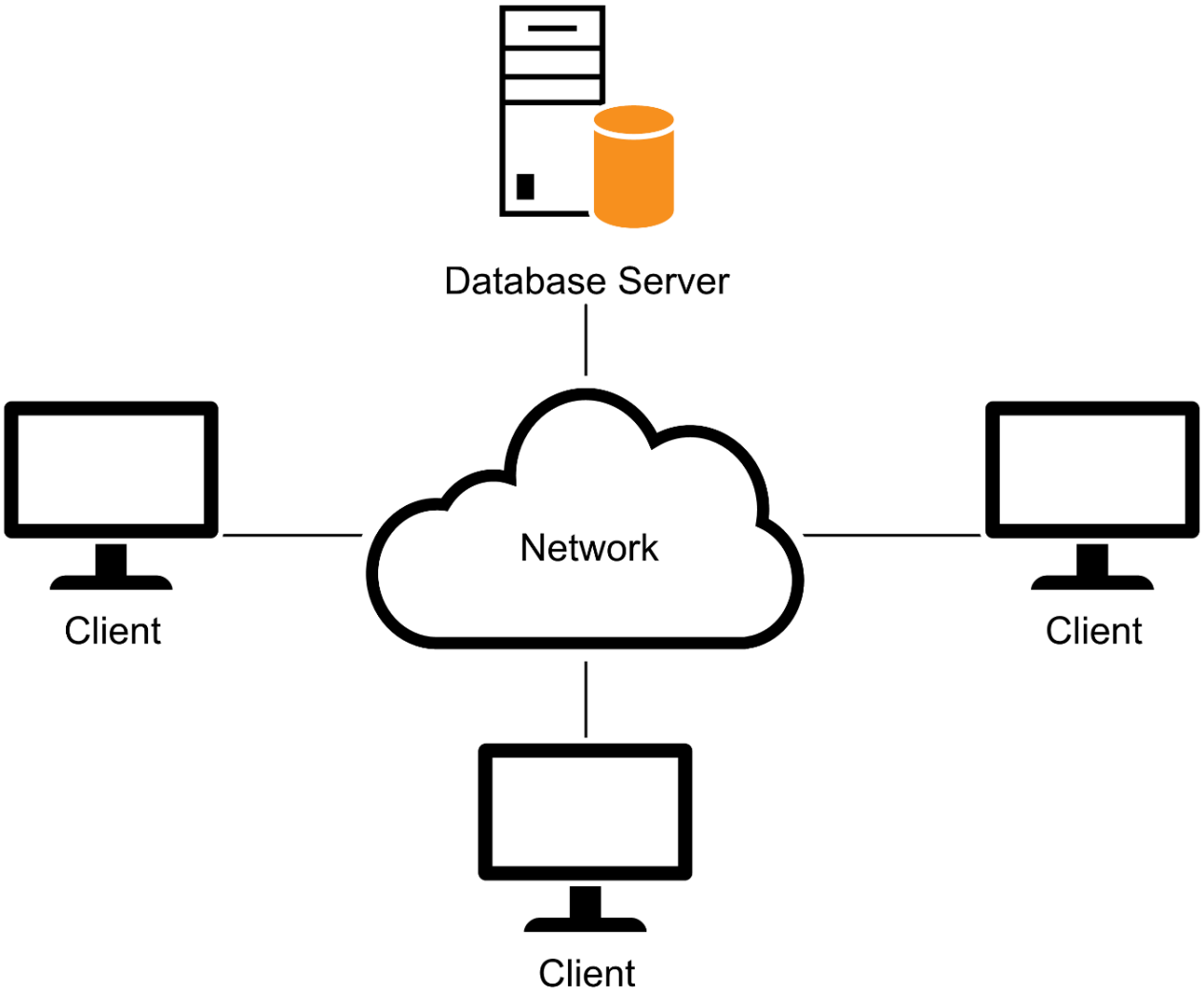
Knowledge

- Identify the three main hardware components of a client/server system.
- Describe the way a client accesses the database on a server using these terms: application software, data access API, database management system, SQL query, and query results.
- Describe the way a relational database is organized using these terms: tables, columns, rows, cells, primary keys, unique keys, and foreign keys.
- Identify the three types of relationships that can exist between two tables.
- Describe the way the columns in a table are defined using these terms: data type, null value, and default value.

Objectives (continued)

- Describe how an entity relationship diagram can show how the tables in a database are defined and related.
- Describe the difference between DML statements and DDL statements.
- List three coding techniques that can make your SQL code easier to read and maintain.
- Describe the use of a database driver.

A simple client/server system



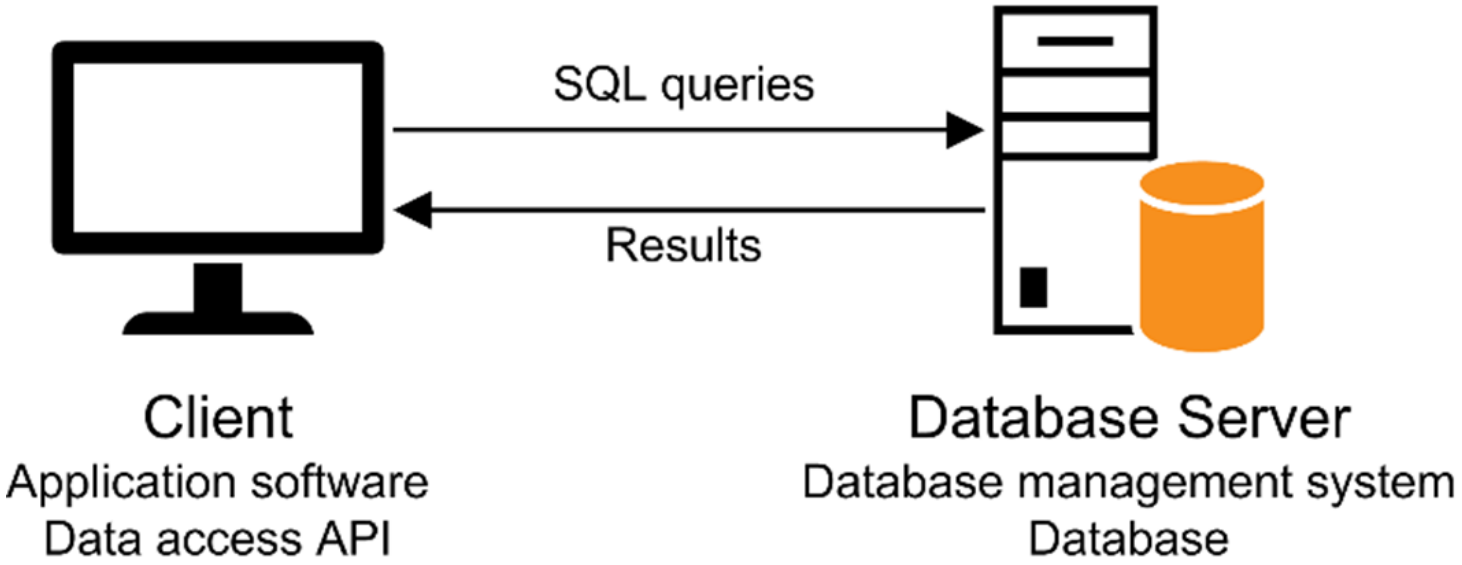
The three hardware components of a client/server system

- Clients
- Server
- Network

Terms to know about client/server systems

- Local area network (LAN)
- Wide area network (WAN)
- Enterprise system

Client software, server software, and the SQL interface



Server software

- Database management system (DBMS)
- The DBMS does the *back-end processing*

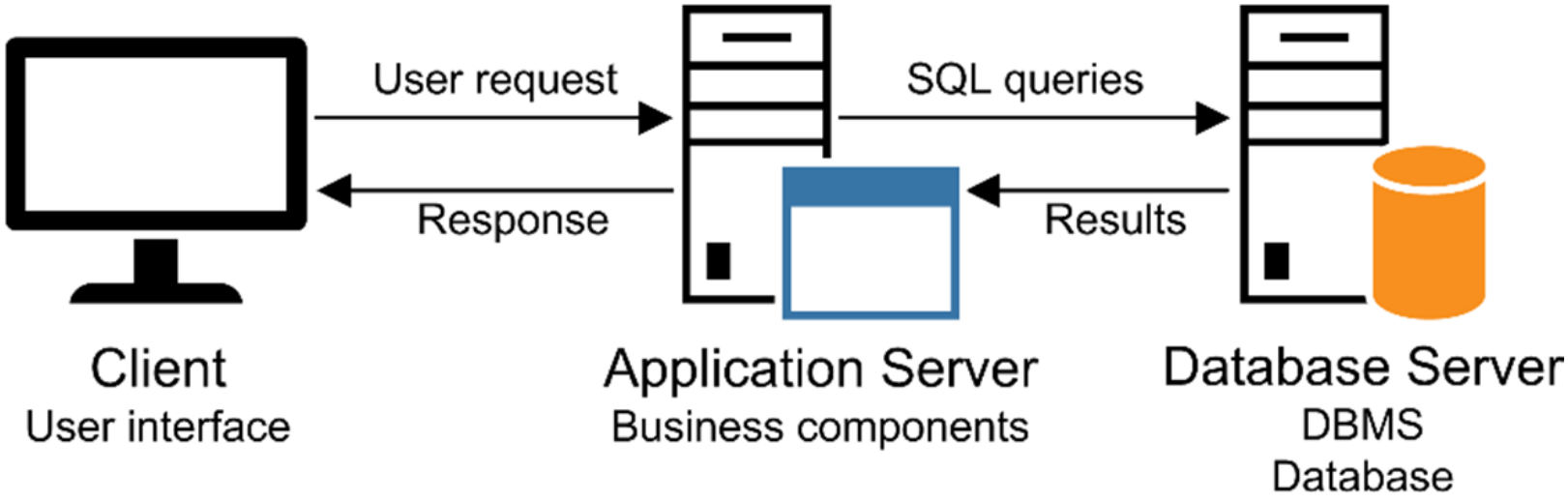
Client software

- Application software
- Data access API (application programming interface)
- The client software does the *front-end processing*

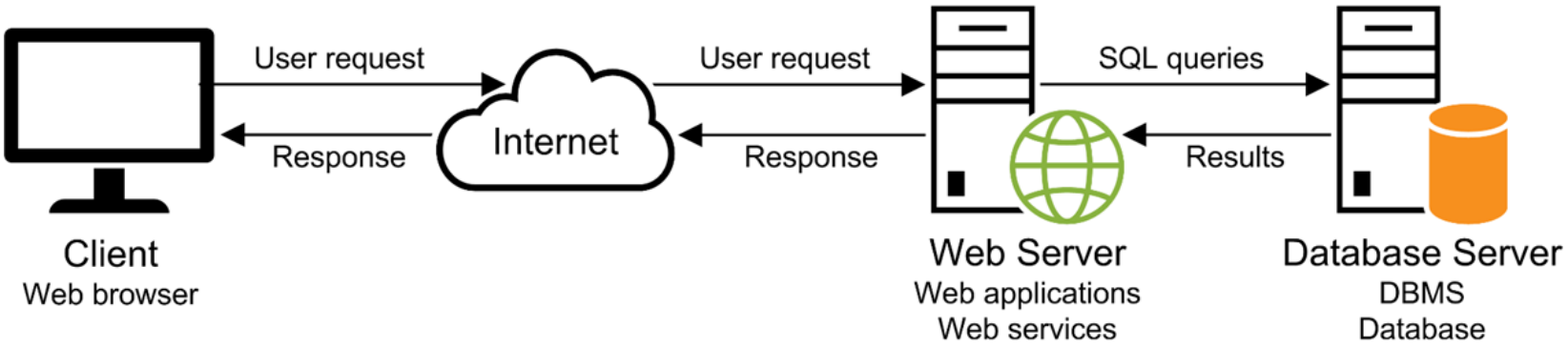
The SQL interface

- The application software communicates with the DBMS by sending SQL queries through the data access API.
- When the DBMS receives a query, it provides a service like returning the requested data (the query results) to the client.
- *SQL* stands for *Structured Query Language*, which is the standard language for working with a relational database.

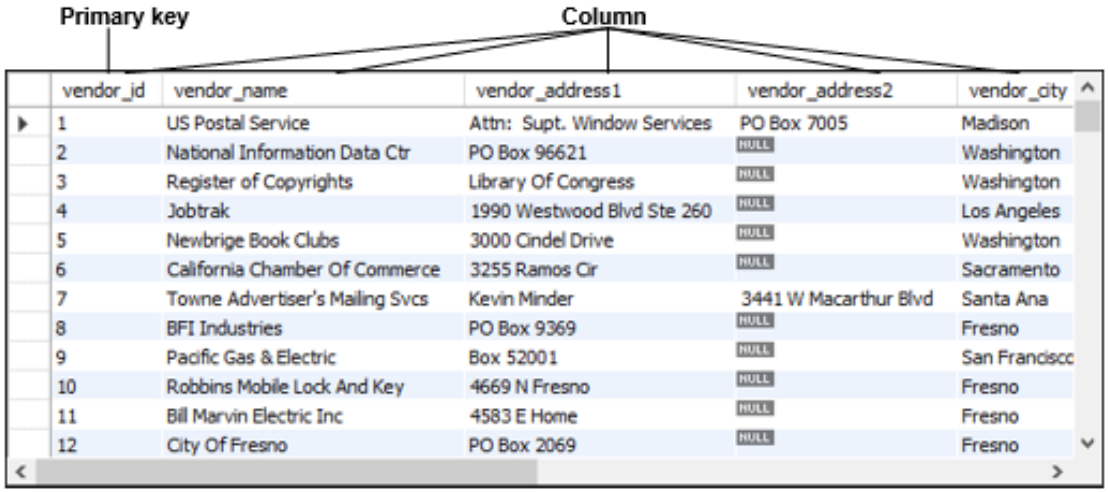
A networked system with an application server



A simple web-based system



The Vendors table in an Accounts Payable (AP) database

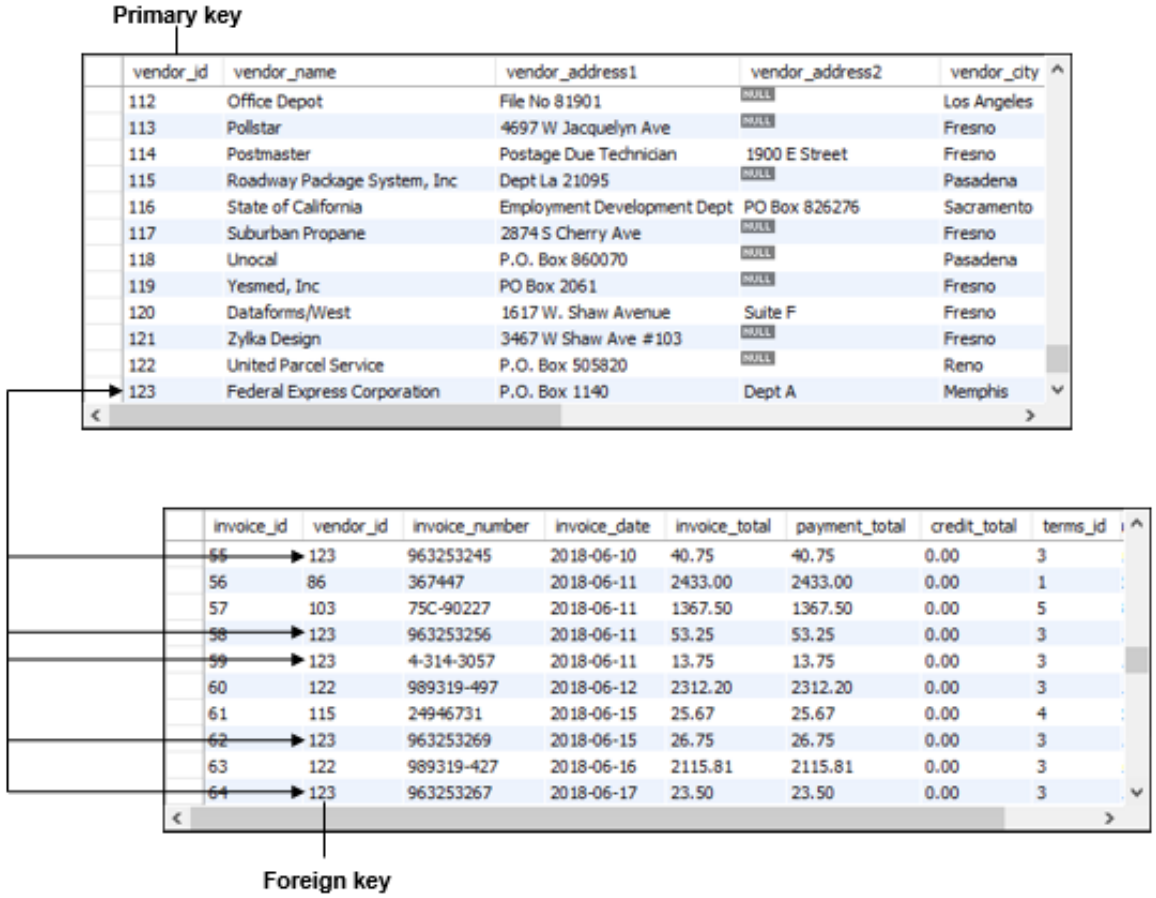


vendor_id	vendor_name	vendor_address1	vendor_address2	vendor_city
1	US Postal Service	Attn: Supt. Window Services	PO Box 7005	Madison
2	National Information Data Ctr	PO Box 96621	NULL	Washington
3	Register of Copyrights	Library Of Congress	NULL	Washington
4	Jobtrak	1990 Westwood Blvd Ste 260	NULL	Los Angeles
5	Newbrige Book Clubs	3000 Cindel Drive	NULL	Washington
6	California Chamber Of Commerce	3255 Ramos Cir	NULL	Sacramento
7	Towne Advertiser's Mailing Svcs	Kevin Minder	3441 W Macarthur Blvd	Santa Ana
8	BFI Industries	PO Box 9369	NULL	Fresno
9	Pacific Gas & Electric	Box 52001	NULL	San Francisco
10	Robbins Mobile Lock And Key	4669 N Fresno	NULL	Fresno
11	Bill Marvin Electric Inc	4583 E Home	NULL	Fresno
12	City Of Fresno	PO Box 2069	NULL	Fresno

Terms to know about database tables

- Relational database
- Table
- Column
- Row
- Cell
- Primary key
- Composite primary key
- Non-primary key (unique key)
- Index

The relationship between two tables



vendor_id	vendor_name	vendor_address1	vendor_address2	vendor_city
112	Office Depot	File No 81901	NULL	Los Angeles
113	Pollstar	4697 W Jacquelyn Ave	NULL	Fresno
114	Postmaster	Postage Due Technician	1900 E Street	Fresno
115	Roadway Package System, Inc	Dept La 21095	NULL	Pasadena
116	State of California	Employment Development Dept	PO Box 826276	Sacramento
117	Suburban Propane	2874 S Cherry Ave	NULL	Fresno
118	Unocal	P.O. Box 860070	NULL	Pasadena
119	Yesmed, Inc	PO Box 2061	NULL	Fresno
120	Dataforms/West	1617 W. Shaw Avenue	Suite F	Fresno
121	Zylka Design	3467 W Shaw Ave #103	NULL	Fresno
122	United Parcel Service	P.O. Box 505820	NULL	Reno
123	Federal Express Corporation	P.O. Box 1140	Dept A	Memphis

invoice_id	vendor_id	invoice_number	invoice_date	invoice_total	payment_total	credit_total	terms_id
55	123	963253245	2018-06-10	40.75	40.75	0.00	3
56	86	367447	2018-06-11	2433.00	2433.00	0.00	1
57	103	75C-90227	2018-06-11	1367.50	1367.50	0.00	5
58	123	963253256	2018-06-11	53.25	53.25	0.00	3
59	123	4-314-3057	2018-06-11	13.75	13.75	0.00	3
60	122	989319-497	2018-06-12	2312.20	2312.20	0.00	3
61	115	24946731	2018-06-15	25.67	25.67	0.00	4
62	123	963253269	2018-06-15	26.75	26.75	0.00	3
63	122	989319-427	2018-06-16	2115.81	2115.81	0.00	3
64	123	963253267	2018-06-17	23.50	23.50	0.00	3

Terms to know about table relationships

- Foreign key
- Referential integrity
- One-to-many relationship
- One-to-one relationship
- Many-to-many relationship

The columns of the Invoices table

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
invoice_id	INT(11)	☑	☑	☐	☐	☐	☐	☑	☐	
vendor_id	INT(11)	☐	☑	☐	☐	☐	☐	☐	☐	
invoice_number	VARCHAR(50)	☐	☑	☐	☐	☐	☐	☐	☐	
invoice_date	DATE	☐	☑	☐	☐	☐	☐	☐	☐	
invoice_total	DECIMAL(9,2)	☐	☑	☐	☐	☐	☐	☐	☐	
payment_total	DECIMAL(9,2)	☐	☑	☐	☐	☐	☐	☐	☐	'0.00'
credit_total	DECIMAL(9,2)	☐	☑	☐	☐	☐	☐	☐	☐	'0.00'
terms_id	INT(11)	☐	☑	☐	☐	☐	☐	☐	☐	
invoice_due_date	DATE	☐	☑	☐	☐	☐	☐	☐	☐	
payment_date	DATE	☐	☐	☐	☐	☐	☐	☐	☐	NULL
		☐	☐	☐	☐	☐	☐	☐	☐	

Column Name:

Charset/Collation:

Comments:

Data Type:

Default:

Storage: ○ Virtual ○ Stored

☐ Primary Key ☐ Not Null ☐ Unique

☐ Binary ☐ Unsigned ☐ Zero Fill

☐ Auto Increment ☐ Generated

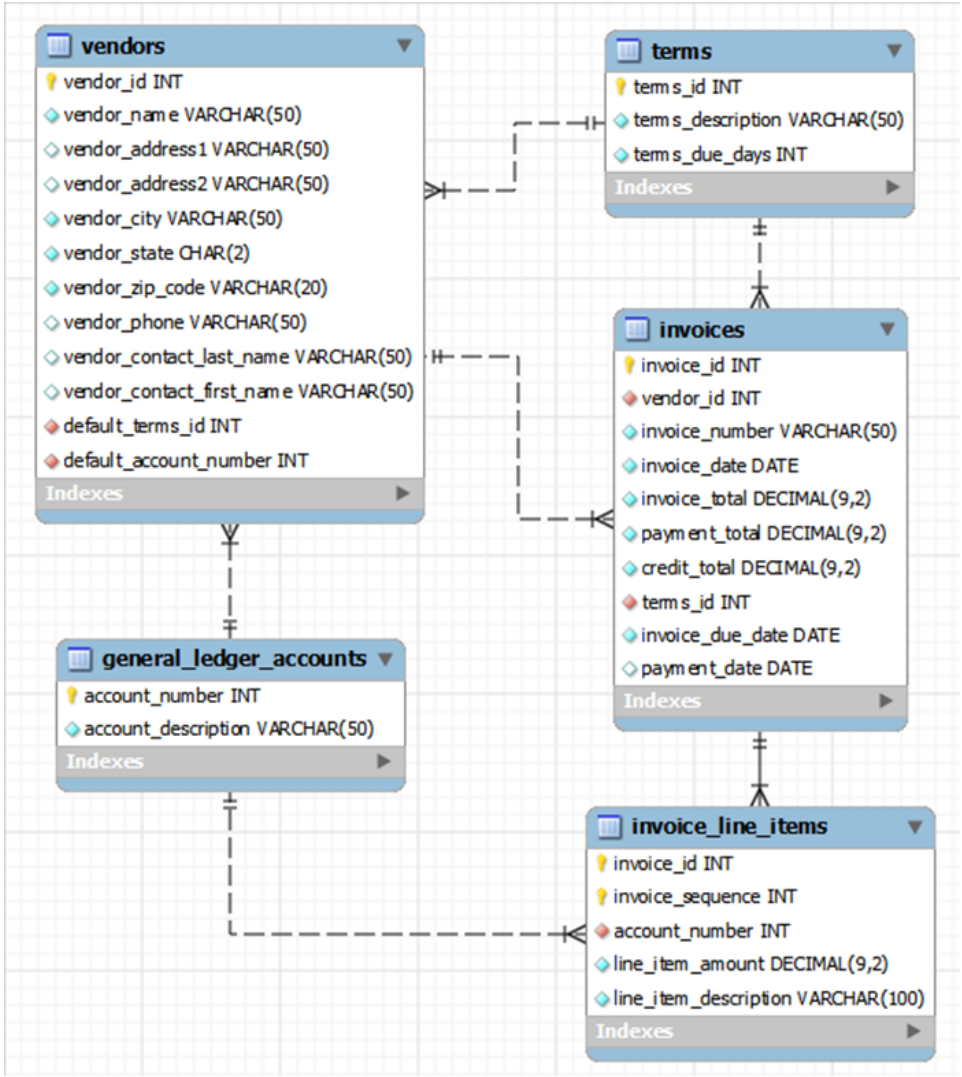
Common MySQL data types

```
CHAR, VARCHAR

INT, DECIMAL

FLOAT

DATE
```

Terms to know about columns

- Data type
- Null value
- Default value
- Auto increment column

An EER diagram for the AP database



How knowing “standard SQL” helps you

- Basic SQL statements are the same for all *dialects*.
- Once you know one dialect, you can easily learn others.

How knowing “standard SQL” does not help you

- Most applications require modification when moved to another database.

First database releases

Oracle	1979
DB2	1985
SQL Server	1987
MySQL	2000

Primary platforms

Oracle	Unix OS/390 and z/OS
DB2	OS/390 and z/OS Unix
SQL Server	Windows
MySQL	Unix Windows Mac OS

SQL DML statements

```
SELECT
INSERT
UPDATE
DELETE
```

SQL DDL statements

```
CREATE DATABASE, TABLE, INDEX
ALTER TABLE, INDEX
DROP DATABASE, TABLE, INDEX
```

A statement that creates a new database

```
CREATE DATABASE ap
```

A statement that selects the current database

```
USE ap
```

A statement that creates a new table

```
CREATE TABLE invoices
(
  invoice_id         INT                PRIMARY KEY
                     AUTO_INCREMENT,
  vendor_id          INT                NOT NULL,
  invoice_number     VARCHAR(50)        NOT NULL,
  invoice_date       DATE               NOT NULL,
  invoice_total      DECIMAL(9,2)       NOT NULL,
  payment_total      DECIMAL(9,2)                  DEFAULT 0,
  credit_total       DECIMAL(9,2)                  DEFAULT 0,
  terms_id           INT                NOT NULL,
  invoice_due_date   DATE               NOT NULL,
  payment_date       DATE,
  CONSTRAINT invoices_fk_vendors
    FOREIGN KEY (vendor_id)
    REFERENCES vendors (vendor_id),
  CONSTRAINT invoices_fk_terms
    FOREIGN KEY (terms_id)
    REFERENCES terms (terms_id)
)
```

A statement that adds a new column to a table

```
ALTER TABLE invoices
ADD balance_due DECIMAL(9,2)
```

A statement that deletes the new column

```
ALTER TABLE invoices
DROP COLUMN balance_due
```

A statement that creates an index on the table

```
CREATE INDEX invoices_vendor_id_index
  ON invoices (vendor_id)
```

A statement that deletes the new index

```
DROP INDEX invoices_vendor_id_index
```

The Invoices base table

invoice_id	vendor_id	invoice_number	invoice_date	invoice_total	payment_total	credit_total	terms_id
1	122	989319-457	2018-04-08	3813.33	3813.33	0.00	3
2	123	263253241	2018-04-10	40.20	40.20	0.00	3
3	123	963253234	2018-04-13	138.75	138.75	0.00	3
4	123	2-000-2993	2018-04-16	144.70	144.70	0.00	3
5	123	963253251	2018-04-16	15.50	15.50	0.00	3

A SELECT statement that retrieves and sorts selected columns and rows

```
SELECT invoice_number, invoice_date, invoice_total,
    payment_total, credit_total,
    invoice_total - payment_total - credit_total
    AS balance_due
FROM invoices
WHERE invoice_total - payment_total - credit_total > 0
ORDER BY invoice_date
```

The result set defined by the SELECT statement

invoice_number	invoice_date	invoice_total	payment_total	credit_total	balance_due
39104	2018-07-10	85.31	0.00	0.00	85.31
963253264	2018-07-18	52.25	0.00	0.00	52.25
31361833	2018-07-21	579.42	0.00	0.00	579.42
263253268	2018-07-21	59.97	0.00	0.00	59.97
263253270	2018-07-22	67.92	0.00	0.00	67.92

A SELECT statement that joins data

```
SELECT vendor_name, invoice_number, invoice_date,
       invoice_total
FROM vendors INNER JOIN invoices
    ON vendors.vendor_id = invoices.vendor_id
WHERE invoice_total >= 500
ORDER BY vendor_name, invoice_total DESC
```

The result set defined by the SELECT statement

vendor_name	invoice_number	invoice_date	invoice_total
Federal Express Corporation	963253230	2018-07-07	739.20
Ford Motor Credit Company	9982771	2018-07-24	503.20
Franchise Tax Board	RTR-72-3662-X	2018-05-25	1600.00
Fresno County Tax Collector	P02-88D77S7	2018-05-03	856.92
IBM	Q545443	2018-06-09	1083.58
Ingram	31359783	2018-06-03	1575.00
Ingram	31361833	2018-07-21	579.42
Malloy Lithographing Inc	0-2058	2018-05-28	37966.19

Terms to know about SQL

- Query
- Base table
- Result table (result set)
- Calculated value
- Join
- Inner join
- Outer join

A statement that adds a row to the Invoices table

```
INSERT INTO invoices
  (vendor_id, invoice_number, invoice_date,
   invoice_total, terms_id, invoice_due_date)
VALUES
  (12, '3289175', '2018-07-18', 165, 3, '2018-08-17')
```

A statement that changes the value of a column for one row

```
UPDATE invoices
SET credit_total = 35.89
WHERE invoice_number = '367447'
```

A statement that changes the value of a column for multiple rows

```
UPDATE invoices
SET invoice_due_date
    = DATE_ADD(invoice_due_date, INTERVAL 30 DAY)
WHERE terms_id = 4
```

A statement that deletes a selected invoice from the Invoices table

```
DELETE FROM invoices
WHERE invoice_number = '4-342-8069'
```

A statement that deletes all paid invoices from the Invoices table

```
DELETE FROM invoices
WHERE invoice_total - payment_total - credit_total = 0
```

A SELECT statement that's difficult to read

```
select invoice_number, invoice_date, invoice_total, payment_total,
credit_total, invoice_total - payment_total - credit_total as
balance_due from invoices where invoice_total - payment_total -
credit_total > 0 order by invoice_date
```

A SELECT statement that's easy to read

```
SELECT invoice_number, invoice_date, invoice_total,
    payment_total, credit_total,
    invoice_total - payment_total - credit_total
    AS balance_due
FROM invoices
WHERE invoice_total - payment_total - credit_total > 0
ORDER BY invoice_date
```

A SELECT statement with a block comment

```
/*
Author: Joel Murach
Date: 8/22/2018
*/
SELECT invoice_number, invoice_date, invoice_total,
    invoice_total - payment_total - credit_total
    AS balance_due
FROM invoices
```

A SELECT statement with a single-line comment

```
-- The fourth column calculates the balance due
SELECT invoice_number, invoice_date, invoice_total,
    invoice_total - payment_total - credit_total
    AS balance_due
FROM invoices
```

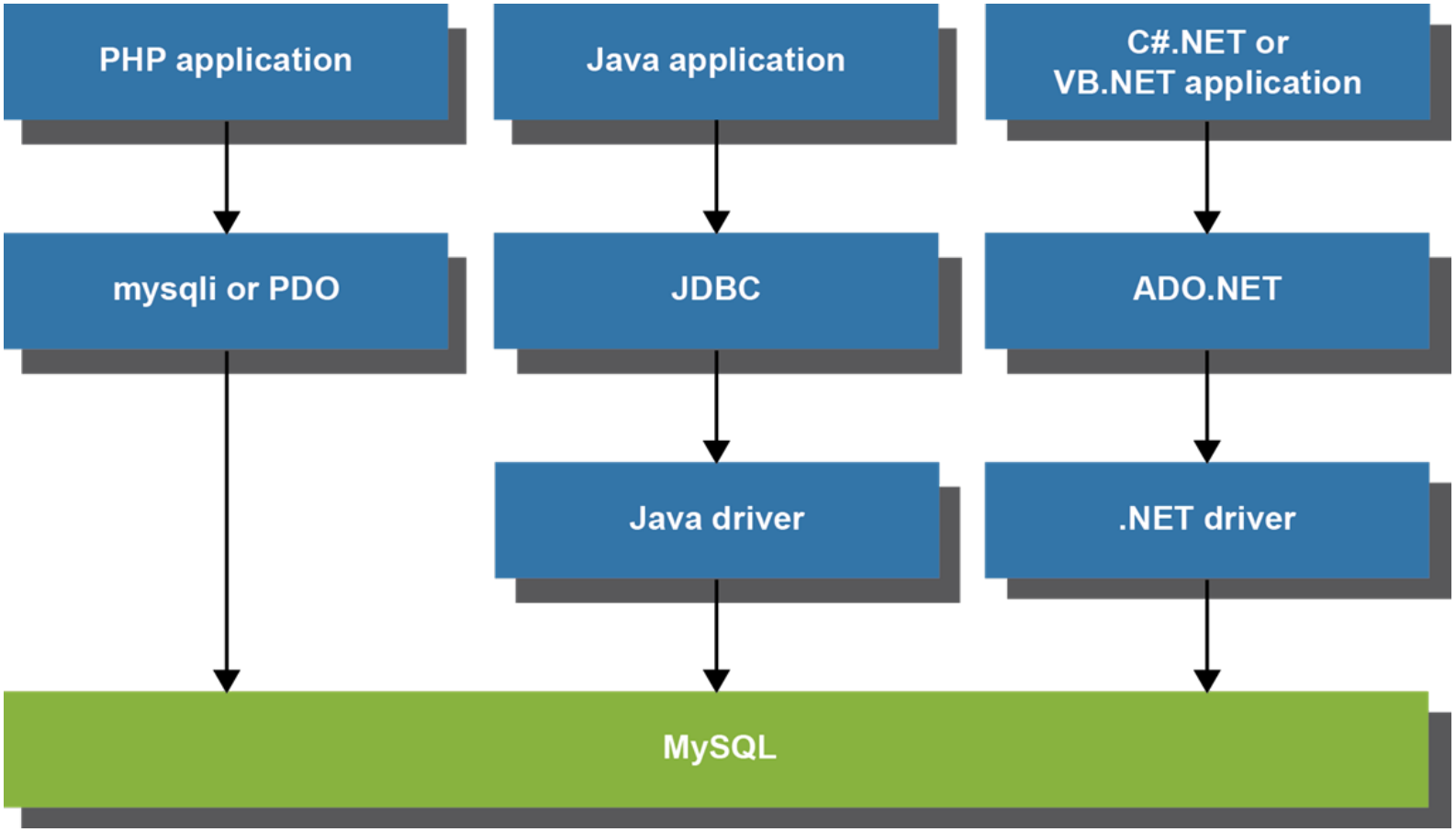
Coding recommendations

- Capitalize all keywords.
- Use lowercase for the other code.
- Separate the words in names with underscores.
- Start each clause on a new line.
- Break long clauses into multiple lines.
- Indent continued lines.
- Use comments only for code that is difficult to understand.
- Make sure that the comments are correct and up-to-date.

Note

- Line breaks, white space, indentation, and capitalization have no effect on the operation of a statement.

Common options for accessing MySQL data



Two commonly used MySQL drivers

- Connector/J
- Connector/Net

Terms to know about accessing MySQL data

- Data access API
- mysqli API (for PHP)
- PDO API (for PHP)
- JDBC API (for Java)
- ADO.NET API (for .NET languages)
- Database driver

PHP code that gets data from MySQL (part 1)

```
<?php
  $query =
       "SELECT vendor_name, invoice_number, invoice_total
        FROM vendors INNER JOIN invoices
            ON vendors.vendor_id = invoices.vendor_id
        WHERE invoice_total >= 500
        ORDER BY vendor_name, invoice_total DESC";
  $dsn = 'mysql:host=localhost;dbname=ap';
  $username = 'root';
  $password = 'sesame';

  try {
       $db = new PDO($dsn, $username, $password);
  } catch (PDOException $e) {
       $error_message = $e->getMessage();
       echo $error_message;
       exit();
  }

  $statement = $db->prepare($query);
  $statement->execute();
  $rows = $statement->fetchAll();
?>
```

PHP code that gets data from MySQL (part 2)

```
<!DOCTYPE html>
<html lang="en">
  <head>
      <title>DB Test</title>
  </head>
  <body>
    <h1>Invoices with totals over 500:</h1>

    <?php foreach ($rows as $row) : ?>
    <p>
        Vendor: <?php echo $row['vendor_name']; ?><br/>
        Invoice No: <?php echo $row['invoice_number']; ?>
        <br/>
        Total: $<?php echo
            number_format($row['invoice_total'], 2); ?>
    </p>
    <?php endforeach; ?>

  </body>
</html>
```

Java code that gets data from MySQL (part 1)

```
import java.sql.*;
import java.text.NumberFormat;

public class DBTestApp
{
    public static void main(String args[])
    {
        String query =
            "SELECT vendor_name, invoice_number, invoice_total " +
            "FROM vendors INNER JOIN invoices " +
            "ON vendors.vendor_id = invoices.vendor_id " +
            "WHERE invoice_total >= 500 " +
            "ORDER BY vendor_name, invoice_total DESC";

        String dbUrl = "jdbc:mysql://localhost:3306/ap";
        String username = "root";
        String password = "sesame";

        try (Connection connection =
                DriverManager.getConnection(
                    dbUrl, username, password);
             PreparedStatement ps =
                connection.prepareStatement(query);
             ResultSet rs = ps.executeQuery())
```

Java code that gets data from MySQL (part 2)

```
{
            System.out.println("Invoices with totals over 500:\n");
            while(rs.next())
            {
                String vendorName = rs.getString("vendor_name");
                String invoiceNumber =
                    rs.getString("invoice_number");
                double invoiceTotal = rs.getDouble("invoice_total");
                NumberFormat currency =
                    NumberFormat.getCurrencyInstance();
                String invoiceTotalString =
                    currency.format(invoiceTotal);
                System.out.println(
                    "Vendor:      " + vendorName + "\n" +
                    "Invoice No: " + invoiceNumber + "\n" +
                    "Total:      " + invoiceTotalString + "\n");
            }
        }
        catch(SQLException e)
        {
            System.out.println(e.getMessage());
        }
    }
}
```