Chapter 1

An introduction to relational databases and SQL

Objectives

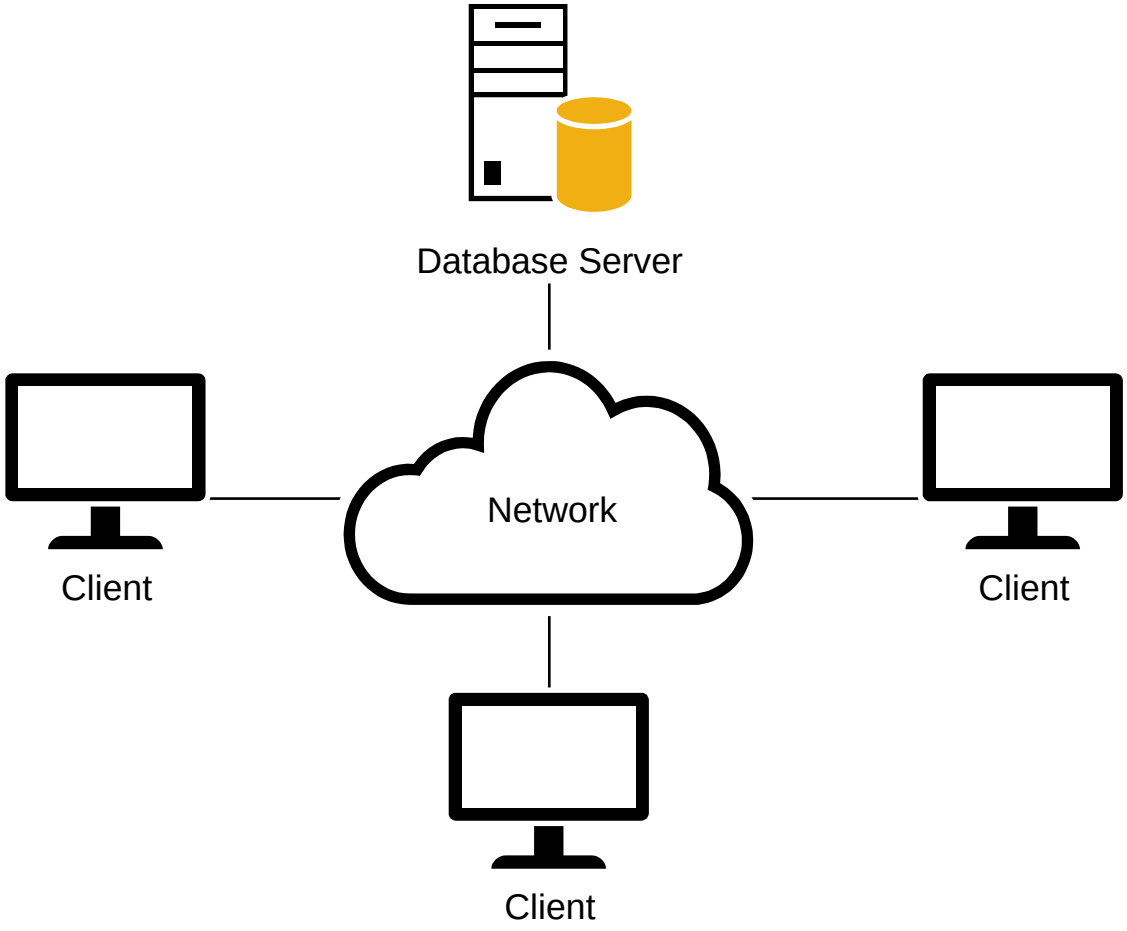
Knowledge

- 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, 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.

Objective (cont.)

- 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



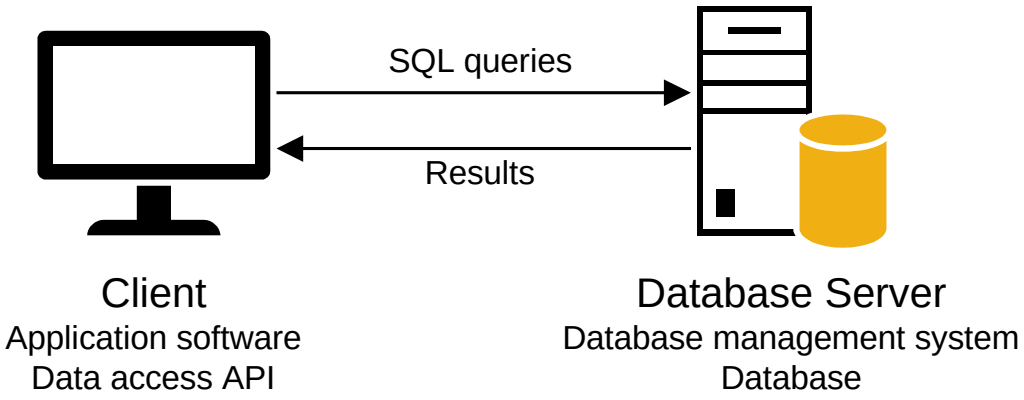
The three hardware components of a client/server system

- Clients
- Server
- Network

Terms to know

- 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.

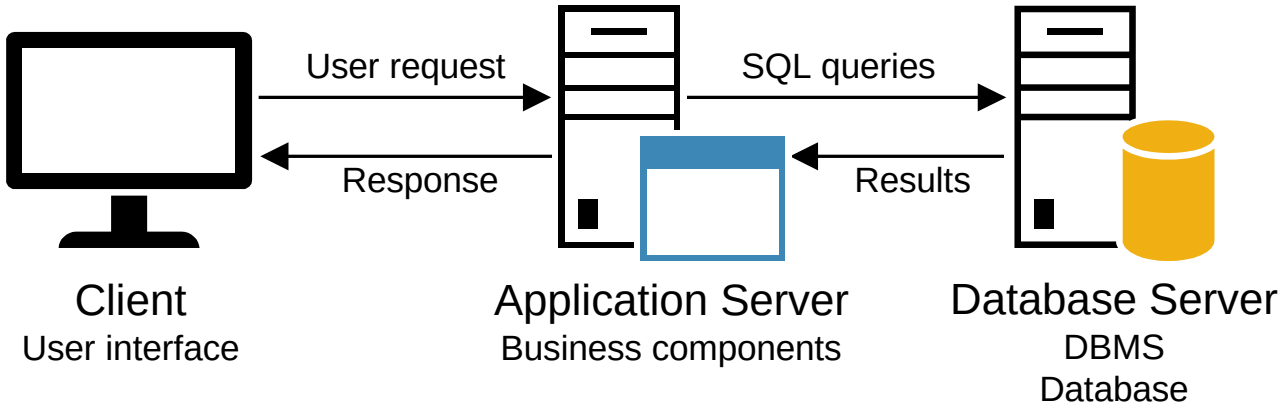
Client/server system

- Processing is divided between client and server.

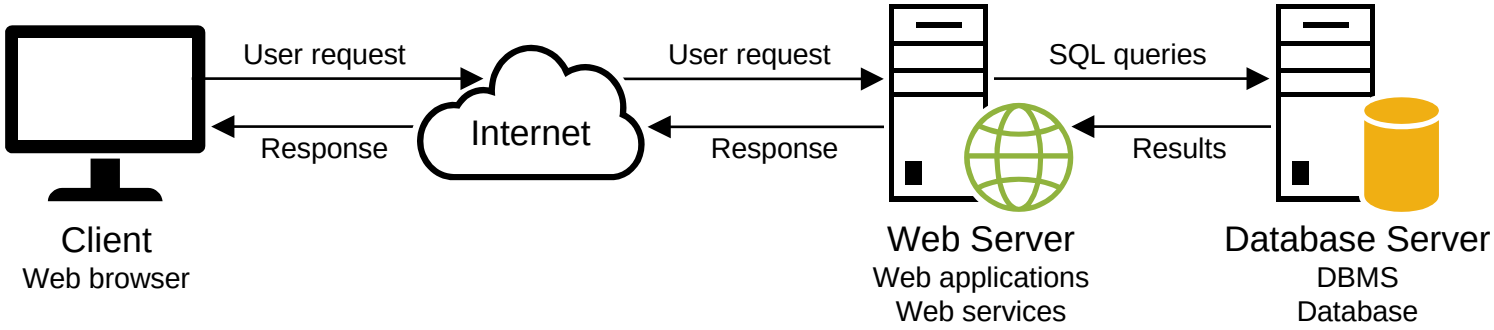
File-handling system

- All processing is done on the clients.

A networked system that uses an application server



A simple web-based system



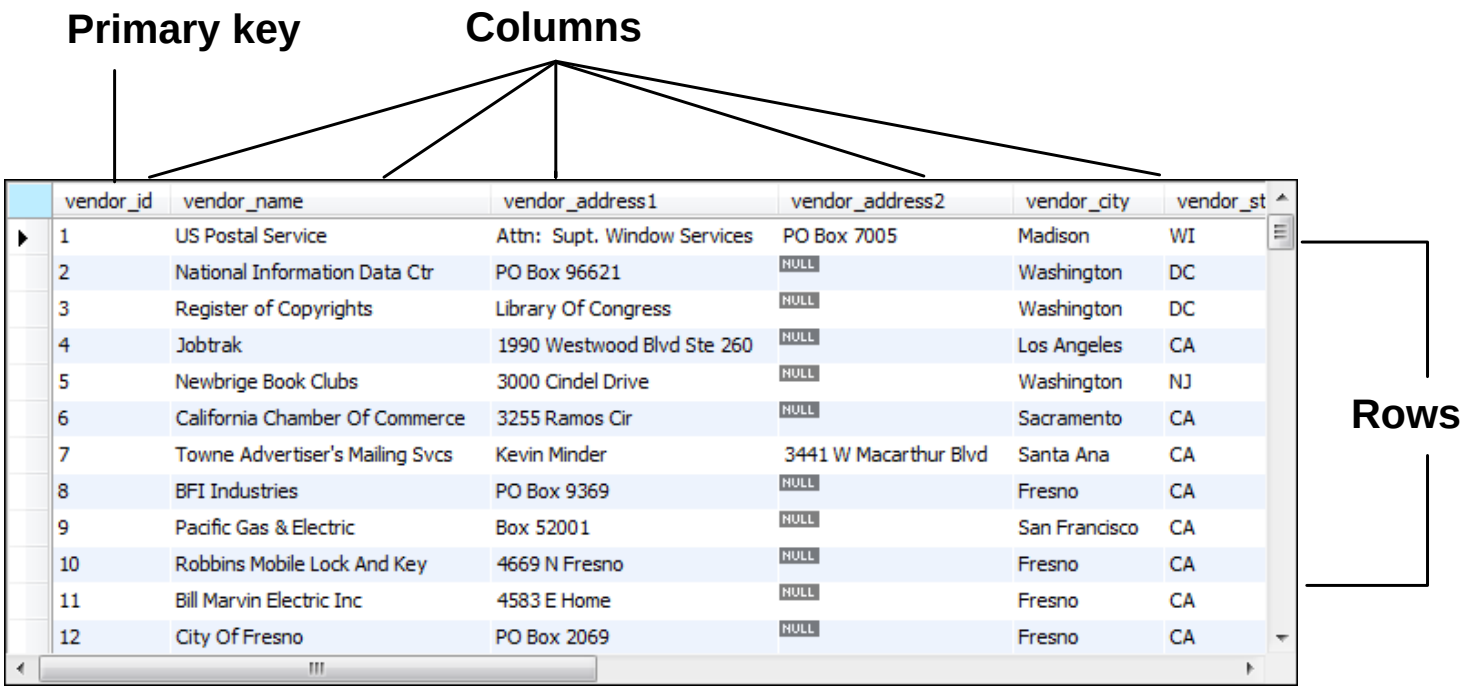
Other client/server components

- Application servers store business components
- Web servers store web applications and web services

How web applications work

- A web browser on a client sends a request to a web server.
- The web server processes the request.
- The web server passes any data requests to the database server.
- The database server returns results to web server.
- The web server returns a response to the browser.

The Vendors table in an Accounts Payable (AP) database

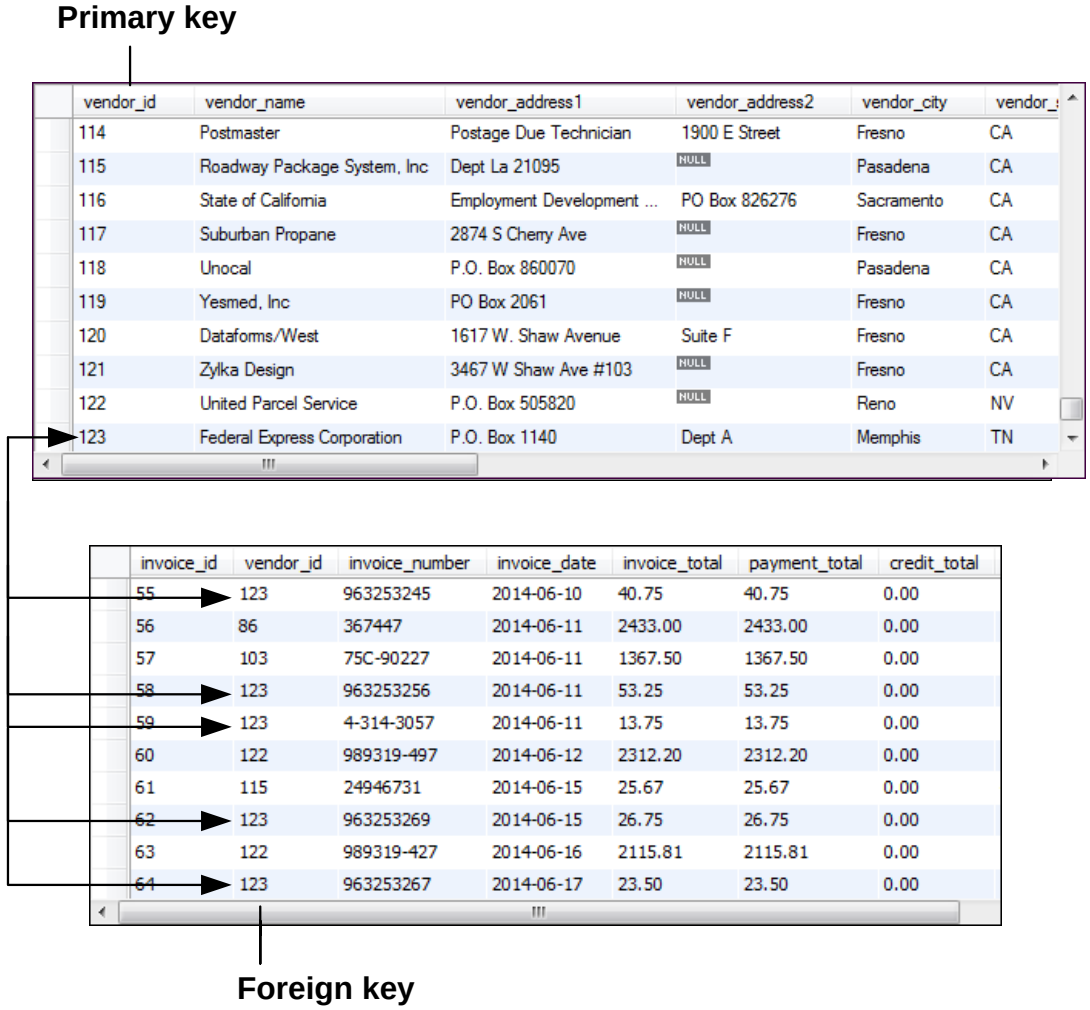


vendor_id	vendor_name	vendor_address1	vendor_address2	vendor_city	vendor_st
1	US Postal Service	Attn: Supt. Window Services	PO Box 7005	Madison	WI
2	National Information Data Ctr	PO Box 96621	NULL	Washington	DC
3	Register of Copyrights	Library Of Congress	NULL	Washington	DC
4	Jobtrak	1990 Westwood Blvd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

Terms to know

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

The relationship between two tables



Terms to know

- 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	BIN	UN	ZF	AI	Default
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: Data Type:

Collation: Default:

Comments:

☐ Primary ☐ Not Null ☐ Unique

☐ Binary ☐ Unsigned ☐ Zero Fill

☐ Auto Increment

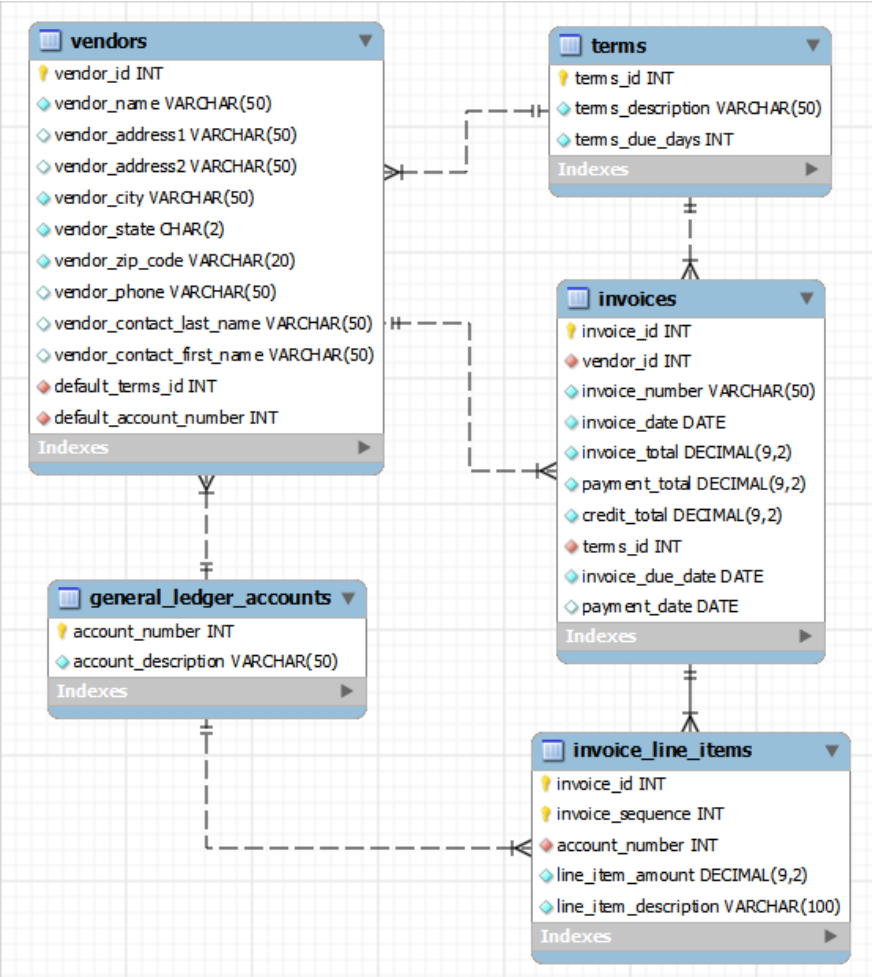
Common MySQL data types

- CHAR, VARCHAR
- INT, DECIMAL
- FLOAT
- DATE

Terms to know

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

An EER diagram for the AP database



Important events in the history of SQL

Year	Event
1970	Dr. E. F. Codd developed the relational database model.
1979	Relational Software, Inc. (later renamed Oracle) released the first relational DBMS, Oracle.
1982	IBM released their first RDBMS, SQL/DS (SQL/Data System).
1985	IBM released DB2 (Database 2).
1987	Microsoft released SQL Server.
1989	ANSI published the first set of standards (ANSI/ISO SQL-89, or SQL1).
1992	ANSI revised standards (ANSI/ISO SQL-92, or SQL2)
1995	MySQL AB released MySQL for internal use.
1999	ANSI published SQL3 (ANSI/ISO SQL:1999).

Important events in the history of SQL (continued)

Year	Event
2000	MySQL became an open-source database.
2003	ANSI published SQL4 (ANSI/ISO SQL:2003).
2008	Sun Microsystems acquired MySQL.
2010	Oracle acquired Sun Microsystems and MySQL.

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, Windows, Mac OS OS/390 and z/OS
DB2	OS/390 and z/OS Unix, Windows, Mac OS
SQL Server	Windows
MySQL	Unix, z/OS 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	invoice_du
1	122	989319-457	2014-04-08	3813.33	3813.33	0.00	3	2014-05-08
2	123	263253241	2014-04-10	40.20	40.20	0.00	3	2014-05-10
3	123	963253234	2014-04-13	138.75	138.75	0.00	3	2014-05-13
4	123	2-000-2993	2014-04-16	144.70	144.70	0.00	3	2014-05-16
5	123	963253251	2014-04-16	15.50	15.50	0.00	3	2014-05-16

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	2014-07-10	85.31	0.00	0.00	85.31
963253264	2014-07-18	52.25	0.00	0.00	52.25
31361833	2014-07-21	579.42	0.00	0.00	579.42
263253268	2014-07-21	59.97	0.00	0.00	59.97
263253273	2014-07-22	30.75	0.00	0.00	30.75

A SELECT statement that joins data from the Vendors and Invoices tables

```
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	2014-07-07	739.20
Ford Motor Credit Company	9982771	2014-07-24	503.20
Franchise Tax Board	RTR-72-3662-X	2014-05-25	1600.00
Fresno County Tax Collector	P02-88D77S7	2014-05-03	856.92
IBM	Q545443	2014-06-09	1083.58
Ingram	31359783	2014-06-03	1575.00
Ingram	31361833	2014-07-21	579.42
Malloy Lithographing Inc	0-2058	2014-05-28	37966.19

Terms to know

- 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', '2014-07-18', 165, 3, '2014-08-17')
```

A statement that changes the value of the credit_total column for a selected row

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

A statement that changes the values in the invoice_due_date column for all invoices with the specified terms_id

```
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 coded with a readable style

```
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: 8/22/2014
*/
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
```

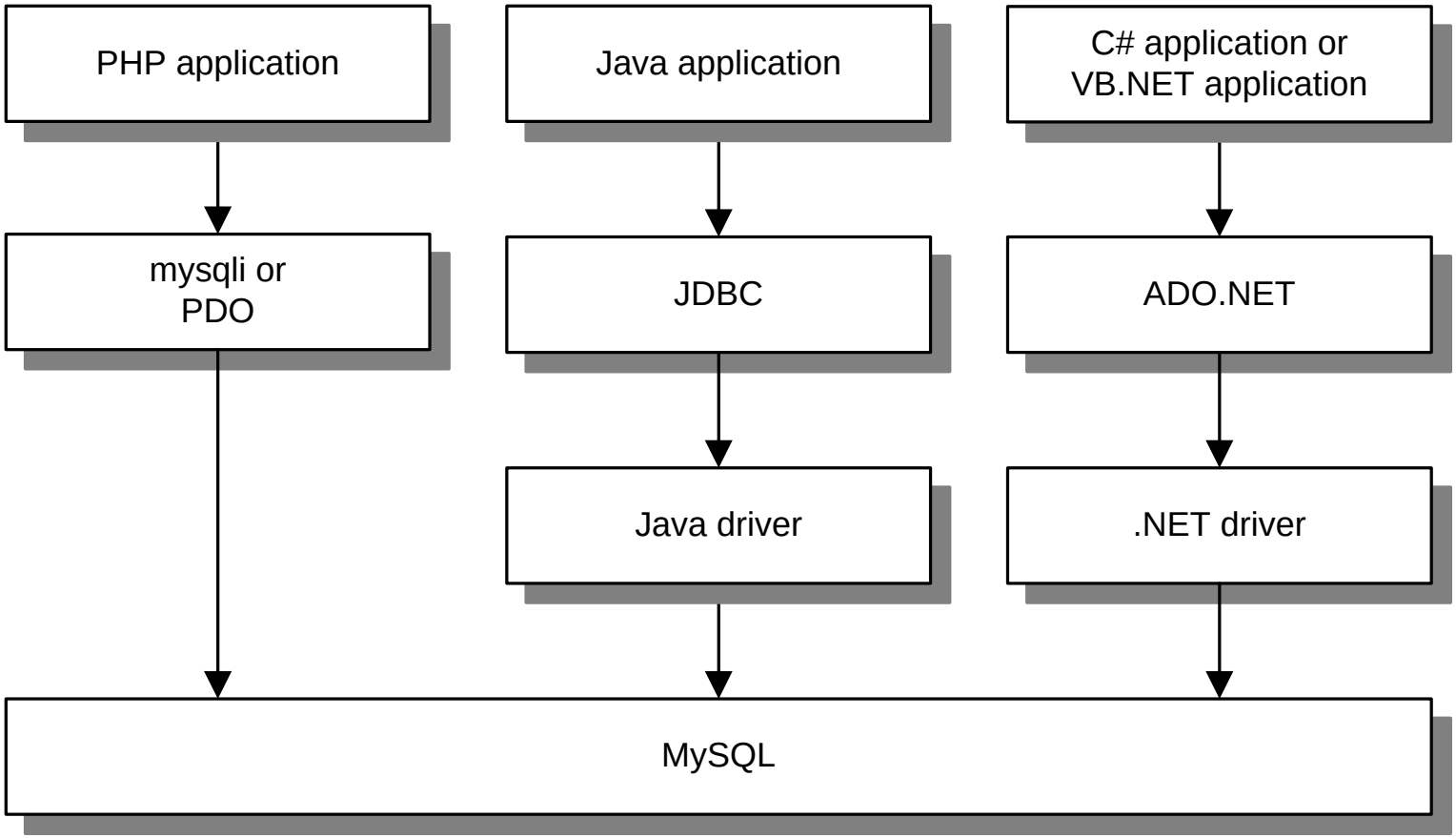
Coding recommendations

- 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

- 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

```
<?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 = 'ap_tester';
    $password = 'sesame';

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

PHP code that gets data from MySQL (cont.)

```
<!DOCTYPE html>
<html>
    <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

```
package murach.ap;

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 = "ap_tester";
        String password = "sesame";
```

Java code that gets data from MySQL (cont.)

```
// define common JDBC objects
try (Connection connection =
        DriverManager.getConnection(
            dbUrl, username, password);
     Statement statement =
         connection.createStatement();
     ResultSet rs = statement.executeQuery(query)) {

    // Display the results of a SELECT statement
    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");
```

Java code that gets data from MySQL (cont.)

```
                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());
        }
    }
}
```