Information Security

CS3002

Lecture 14

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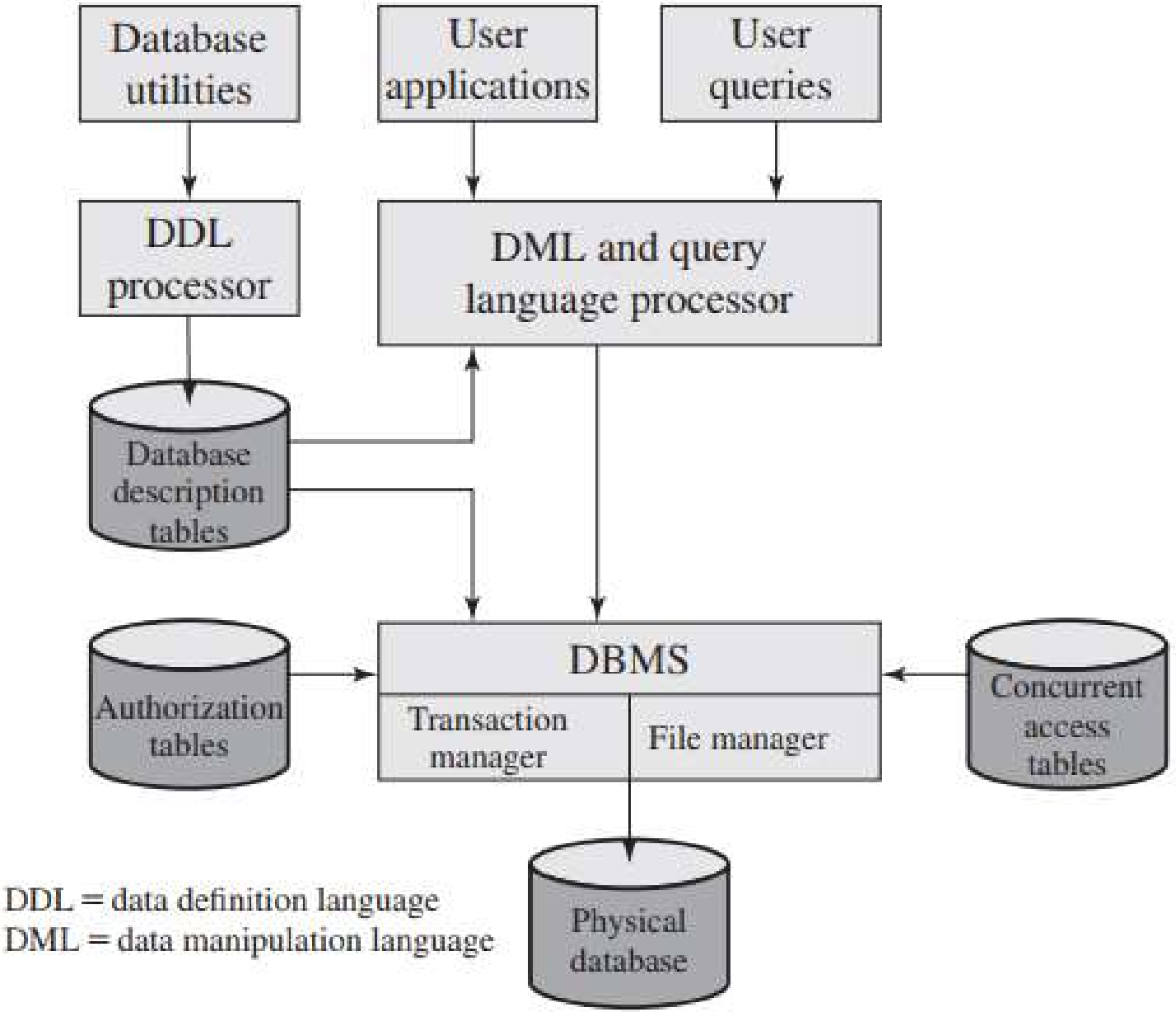
Database Security

Database Systems

- Structured collection of data stored for use by one or more applications
- Contains the relationships between data items and groups of data items
- Can sometimes contain sensitive data that needs to be secured
- Query language: Provides a uniform interface to the database

Database Architecture



Relational Databases

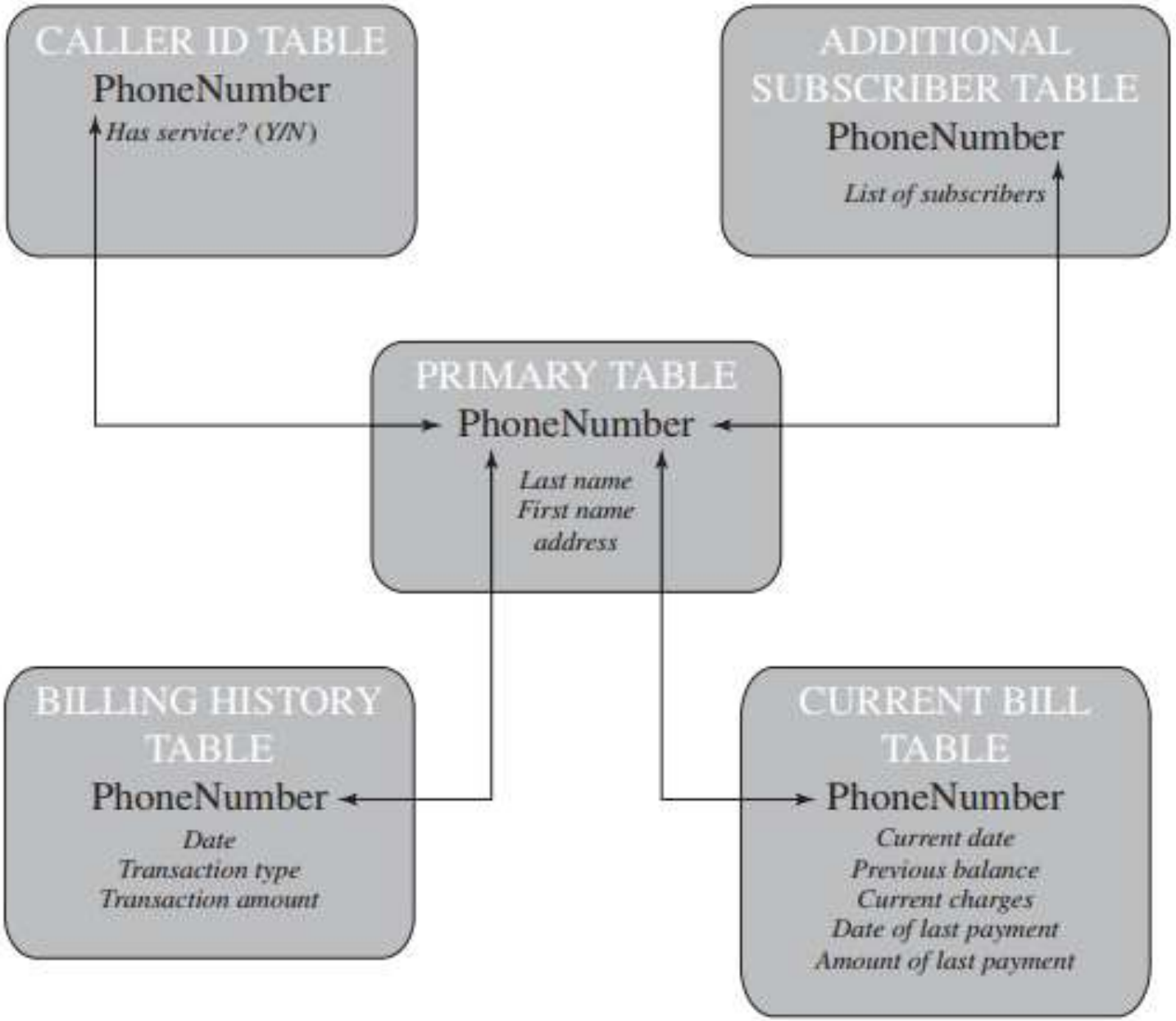
- Table of data consisting of rows and columns
  - Each column holds a particular type of data
  - Each row contains a specific value for each column
  - Ideally has one column where all values are unique, forming an identifier/key for that row

- Enables the creation of multiple tables linked together by a unique identifier that is present in all tables

- Use a relational query language to access the database
  - Allows the user to request data that fit a given set of criteria

Formal Name	Common Name	Also Known As
Relation	Table	File
Tuple	Row	Record
Attribute	Column	Field

A Relational Database Example



Relational Database Elements

Department Table

Did	Dname	Dacctno
4	human resources	528221
8	education	202035
9	accounts	709257
13	public relations	755827
15	services	223945

Primary key

Employee Table

Ename	Did	Salarycode	Eid	Ephone
Robin	15	23	2345	6127092485
Neil	13	12	5088	6127092246
Jasmine	4	26	7712	6127099348
Cody	15	22	9664	6127093148
Holly	8	23	3054	6127092729
Robin	8	24	2976	6127091945
Smith	9	21	4490	6127099380

Foreign key

Primary key

(a) Two tables in a relational database

Dname	Ename	Eid	Ephone
human resources	Jasmine	7712	6127099348
education	Holly	3054	6127092729
education	Robin	2976	6127091945
accounts	Smith	4490	6127099380
public relations	Neil	5088	6127092246
services	Robin	2345	6127092485
services	Cody	9664	6127093148

(b) A view derived from the database

Relational Database Creation

```
CREATE TABLE department (
    Did INTEGER PRIMARY KEY,
    Dname CHAR (30),
    Dacctno CHAR (6) )
CREATE TABLE employee (
    Ename CHAR (30),
    Did INTEGER,
    SalaryCode INTEGER,
    Eid INTEGER PRIMARY KEY,
    Ephone CHAR (10),
    FOREIGN KEY (Did) REFERENCES department (Did) )
```

```
CREATE VIEW newtable (Dname, Ename, Eid, Ephone)
AS SELECT D.Dname E.Ename, E.Eid, E.Ephone
FROM Department D Employee E
WHERE E.Did = D.Did
```

Structured Query Language

- Structured Query Language (SQL)
  - originally developed by IBM in the mid-1970s
  - standardized language to define schema, manipulate, and query data in a relational database
  - several similar versions of ANSI/ISO standard

SQL – Background

- SQL
  - Widely used database query language
  - Fetch a set of records

    SELECT * FROM Person WHERE Username= ‘Vitaly’
  - Add data to the table

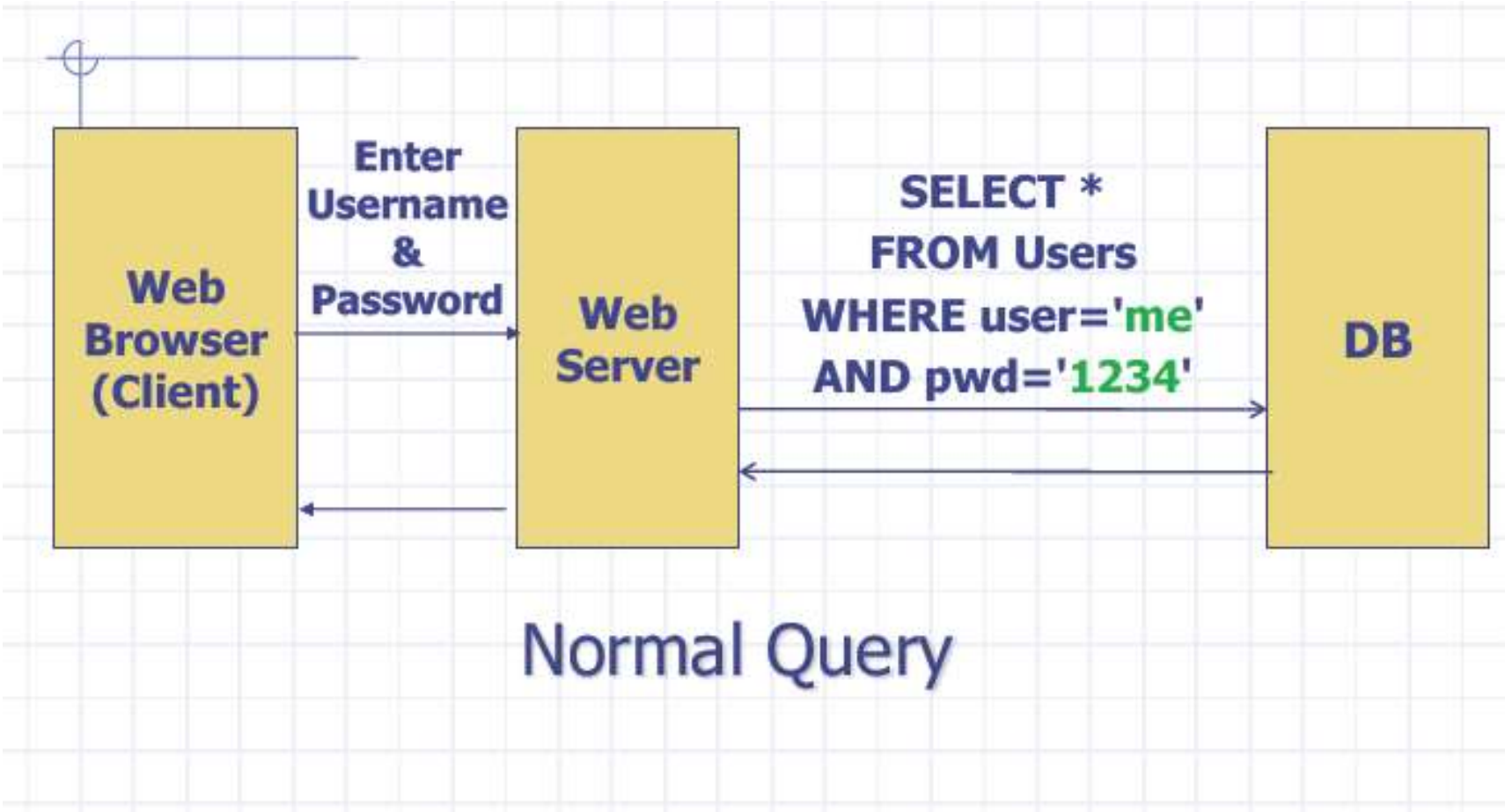
    INSERT INTO Key (Username, Key) VALUES (‘Vitaly’ , 3611BBFF)
  - Modify data

    UPDATE Keys SET Key=FA33452D WHERE PersonID=5
  - Query syntax (mostly) independent of vendor

SQL – Background

- Typical Login Prompt

SQL – Background



SQL – Background

```
set ok = execute( "SELECT * FROM Users
      WHERE user=' " & form("user") & " '
      AND   pwd=' " & form("pwd") & " '" );

if not ok.EOF
      login success
else  fail;
```

SQL Injection Attacks

- One of the most prevalent and dangerous network-based security threats
- Sends malicious SQL commands to the database server
- Depending on the environment SQL injection can also be exploited to:
  - Modify or delete data
  - Execute arbitrary operating system commands
  - Launch denial-of-service (DoS) attacks

SQL injection (SQLi)

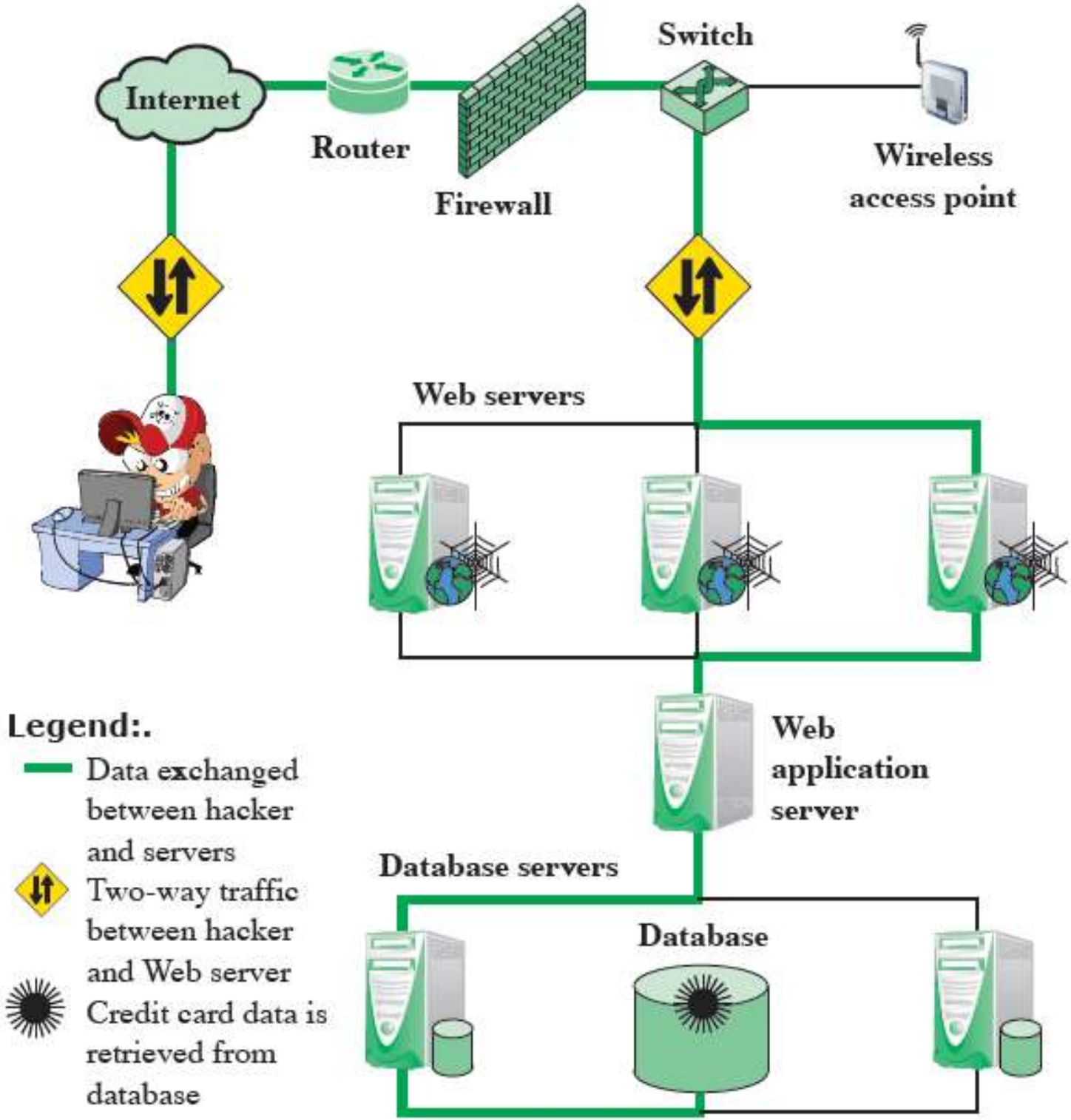
- An application security weakness that allows attackers to control an application's database Access or delete data
- Change an application's data-driven behavior and do other undesirable things – by

- Method: Sending unexpected SQL commands.

SQL injection (SQLi)

- Control application behavior that's based on data in the database, for example by tricking an application into allowing a login without a valid password
- Alter data in the database without authorization, for example by creating fraudulent records, adding users or "promoting" users to higher access levels, or deleting data
- Access data without authorization, for example by tricking the database into providing too many results for a query

A Typical Injection Attack



Injection Attack Steps

1. Hacker finds a vulnerability in a custom Web application and injects an SQL command to a database by sending the command to the Web server. The command is injected into traffic that will be accepted by the firewall.
2. The Web server receives the malicious code and sends it to the Web application server.
3. The Web application server receives the malicious code from the Web server and sends it to the database server.
4. The database server executes the malicious code on the database. The database returns data from credit cards table.
5. The Web application server dynamically generates a page with data including credit card details from the database.
6. The Web server sends the credit card details to the hacker

Technique of SQL Injection

- Union Operator: can be used when the SQL injection flaw happens in a SELECT statement, making it possible to combine two queries into a single result or result set.
- Boolean: use Boolean condition(s) to verify whether certain conditions are true or false.
- Error based: this technique forces the database to generate an error, giving the attacker or tester information upon which to refine their injection.
- Out-of-band: technique used to retrieve data using a different channel (e.g., make a HTTP connection to send the results to a web server).
- Time delay: use database commands (e.g. sleep) to delay answers in conditional queries. It is useful when attacker doesn't have some kind of answer (result, output, or error) from the application.

SQL Injection Attacks – Bad Input

- Suppose user = " 'or 1=1 -- " (URL encoded)
- Then scripts does:

```
ok = execute( SELECT ...
          WHERE user= ' ' or 1=1  -- ... )
```

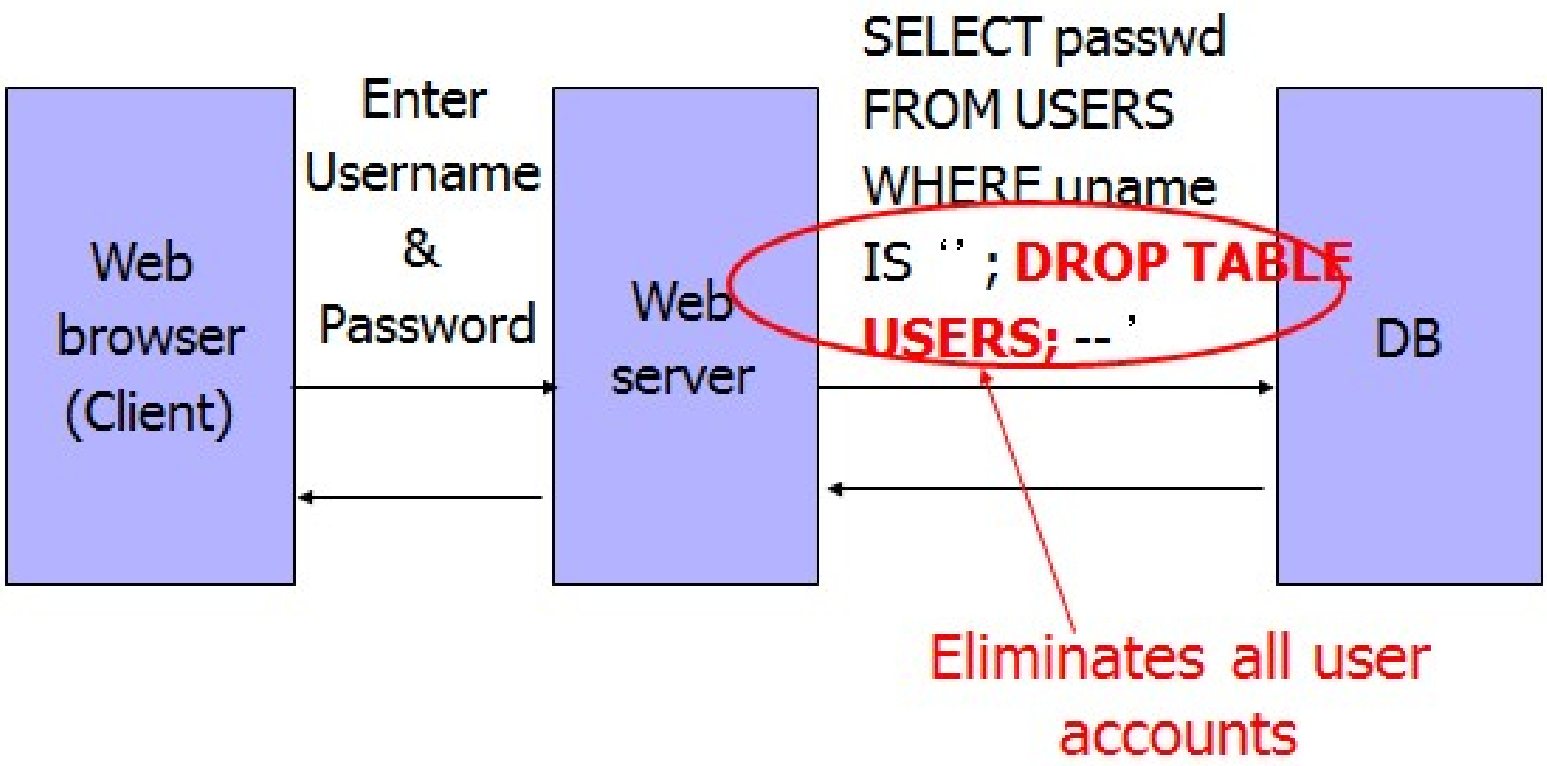
  - The "--" causes rest of line to be ignored.
  - Now ok.EOF is always false and login succeeds.

- The bad news: easy login to many sites this way.

SQL Injection Attacks (cont.)

- Malicious User Input

SQL Injection Attacks (cont.)



SQL Injection Attacks (cont.)

- Then script does:

```
ok = execute( SELECT …
    WHERE user= ' ' ; DROP TABLE Users … )
```

- Deletes user table
  - Similarly: attacker can add users, reset pwds, etc.

SQL Injection Attacks – Even Worse

- Suppose user =

```
'; exec cmdshell
        'net user badguy badpwd' / ADD --
```

- Then script does:

```
ok = execute( SELECT …
        WHERE username= ' ' ; exec …  )
```

If SQL server context runs as "sa", attacker gets account on DB server

Types of Attack

- In-band Attack
- Out-of-band Attack
- Inferential or Blind Attack

1. In-band Attacks

Data is extracted using the same channel that is used to inject the SQL code. This is the most straightforward kind of attack, in which the retrieved data is presented directly in the application web page.

- **Tautology**: This form of attack injects code in one or more conditional statements so that they always evaluate to true
- **End-of-line comment**: After injecting code into a particular field, legitimate code that follows are nullified through usage of end of line comments
- **Piggybacked queries**: The attacker adds additional queries beyond the intended query, piggy-backing the attack on top of a legitimate request

2. Out-of-bound Attack

- In an **out-of-band attack**, data are retrieved using a different channel (e.g., an e-mail with the results of the query is generated and sent to the tester).
  - This can be used when there are limitations on information retrieval, but outbound connectivity from the database server is less strict

3. Inferential Attack (gathering info)

- There is no actual transfer of data, but the attacker is able to reconstruct the information by sending particular requests and observing the resulting behavior of the Website/database server
  - Illegal/logically incorrect queries: lets an attacker gather important information about the type and structure of the backend database of a Web application
    - The vulnerability leveraged by this attack is that the default error page returned by application servers is often overly descriptive.
  - Blind SQL injection: Allows attackers to infer the data present in a database system even when the system is sufficiently secure to not display any erroneous information back to the attacker
    - The attacker asks the server true/false questions to observe the functionality in each case.

Application Interaction with DB

- The first step in this test is to understand when the application interacts with a DB Server in order to access some data. Typical examples of cases when an application needs to talk to a DB include:
- Authentication forms: when authentication is performed using a web form, chances are that the user credentials are checked against a database that contains all usernames and passwords (or, better, password hashes).
- Search engines: the string submitted by the user could be used in a SQL query that extracts all relevant records from a database.

The **Common Vulnerabilities and Exposures** (**CVE**) system provides a reference-method for publicly known information-security vulnerabilities and exposures.

CVE Details

The ultimate security vulnerability datasource

(e.g.: CVE-20

og In Register

Switch to https://
Home

Browse :
Vendors
Products
Vulnerabilities By Date
Vulnerabilities By Type

Reports :
CVSS Score Report
CVSS Score Distribution

Search :
Vendor Search
Product Search
Version Search
Vulnerability Search
By Microsoft References

Top 50 :
Vendors
Vendor Cvss Scores
Products
Product Cvss Scores
Versions

Other :
Microsoft Bulletins
Bugtraq Entries
CWE Definitions
About & Contact
Feedback
CVE Help

Security Vulnerabilities (SQL Injection)

CVSS Scores Greater Than: 0 1 2 3 4 5 6 7 8 9
Sort Results By : CVE Number Descending CVE Number Ascending CVSS Score Descending Number Of Exploits Descending
Copy Results Download Results

#	CVE ID	CWE ID	# of Exploits	Vulnerability Type(s)	Publish Date	Update Date	Score	Gained Access Level	Access
1	CVE-2017-1002028			Sql	2017-09-14	2017-09-15	0.0	None	???
Vulnerability in wordpress plugin wordpress-gallery-transformation v1.0, SQL injection is in ./wordpress-gallery-transformation/ga into an SQL query.									
2	CVE-2017-1002022	89		Sql	2017-09-14	2017-09-18	7.5	None	Remote
Vulnerability in wordpress plugin surveys v1.01.8, The code in questions.php does not sanitize the survey variable before placing i									
3	CVE-2017-1002021	89		Sql	2017-09-14	2017-09-18	7.5	None	Remote
Vulnerability in wordpress plugin surveys v1.01.8, The code in individual_responses.php does not sanitize the survey_id variable b									
4	CVE-2017-1002019	89		Sql	2017-09-14	2017-09-18	7.5	None	Remote
Vulnerability in wordpress plugin eventr v1.02.2, The edit.php form and event_form.php code do not sanitize input, this allows for									
5	CVE-2017-1002018	89		Sql	2017-09-14	2017-09-18	7.5	None	Remote
Vulnerability in wordpress plugin eventr v1.02.2, The edit.php form and attendees.php code do not sanitize input, this allows for bl									
6	CVE-2017-1002015			Sql	2017-09-14	2017-09-14	0.0	None	???
Vulnerability in wordpress plugin image-gallery-with-slideshow v1.5.2, Blind SQL Injection in image-gallery-with-slideshow/admin_									
7	CVE-2017-1002014			Sql	2017-09-14	2017-09-14	0.0	None	???
Vulnerability in wordpress plugin image-gallery-with-slideshow v1.5.2, Blind SQL Injection in image-gallery-with-slideshow/admin_									
8	CVE-2017-1002013			Sql	2017-09-14	2017-09-14	0.0	None	???

SQLi Countermeasures

- Defensive coding: Stronger data validation
  - type checking, to check that inputs that are supposed to be numeric contain no characters other than digits
  - pattern matching to try to distinguish normal input from abnormal input
- Detection
  - Signature based
  - Anomaly based
  - Code analysis
- Runtime prevention: Check queries at runtime to see if they conform to a model of expected queries