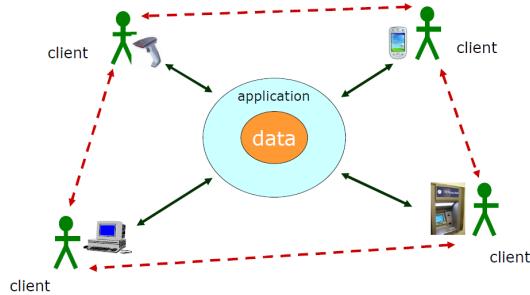
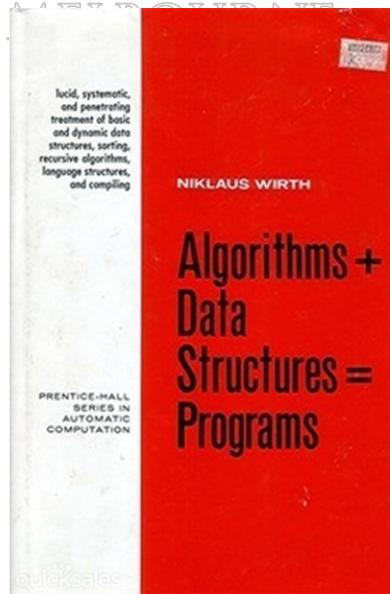




# INFO90002

## Database Systems & Information Modelling

Week 07  
Databases in Applications



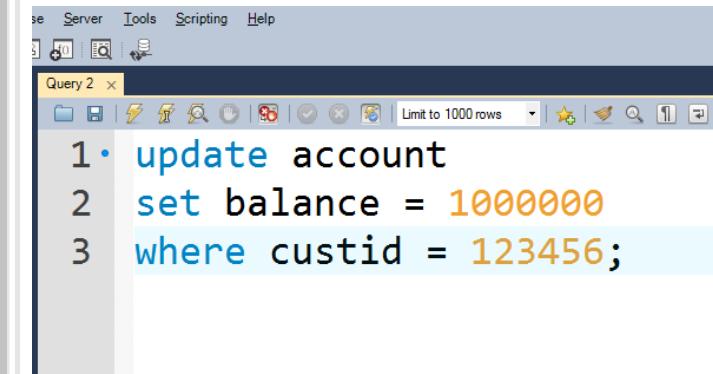
# Today's Session...

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- How end-users access the database
- Business logic
- Stored procedures and triggers
- Embedding databases inside applications
- Application architectures

# Limitations of SQL

- SQL is declarative, intuitive, versatile, but ...
  - cannot express all possible queries in SQL
  - need to enforce business rules beyond domain/ref integrity
  - need procedural constructs such as loops and decisions
  - would you give end-users a query browser? Why not?
  - need a user interface that is both friendly and constraining

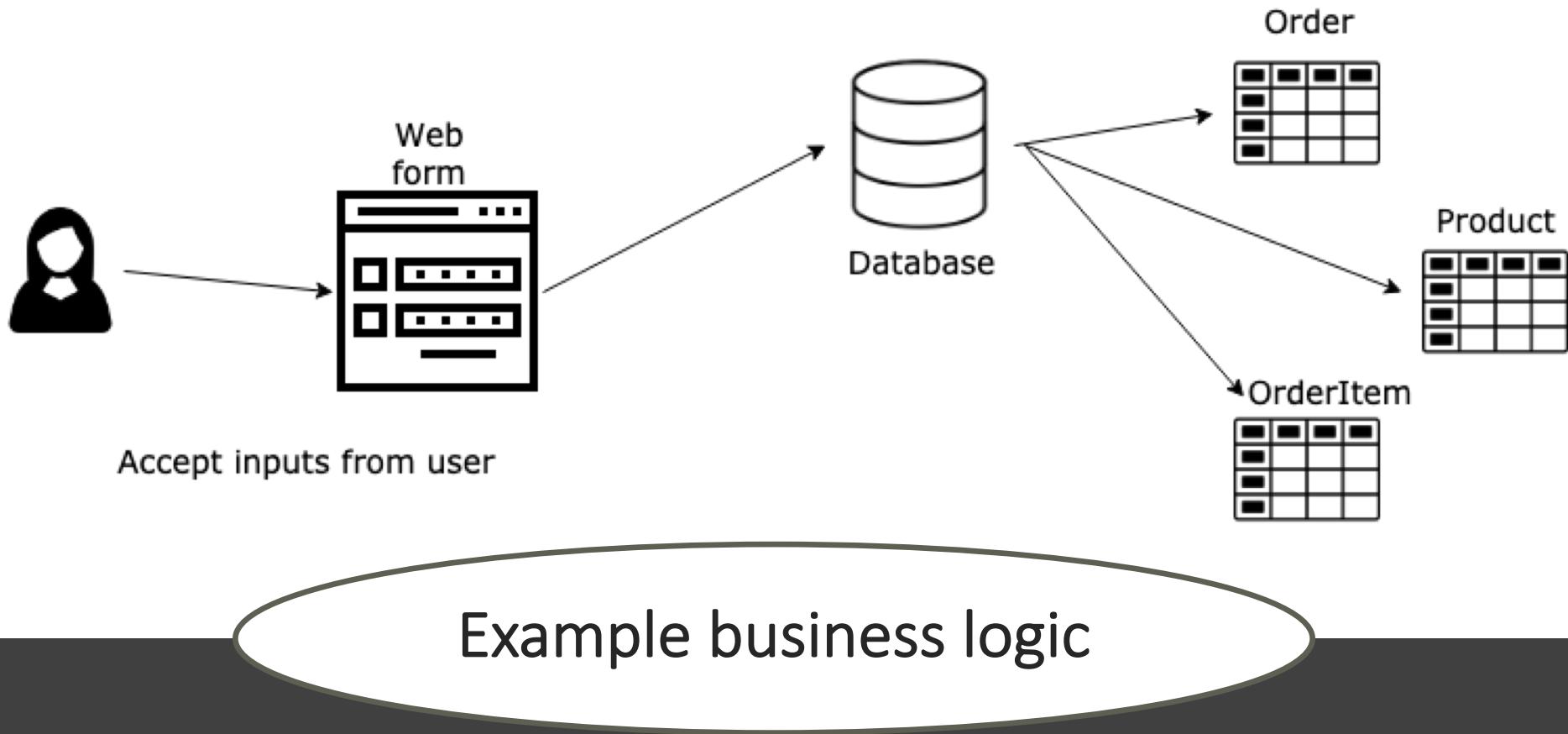


```
1. update account
2. set balance = 1000000
3. where custid = 123456;
```

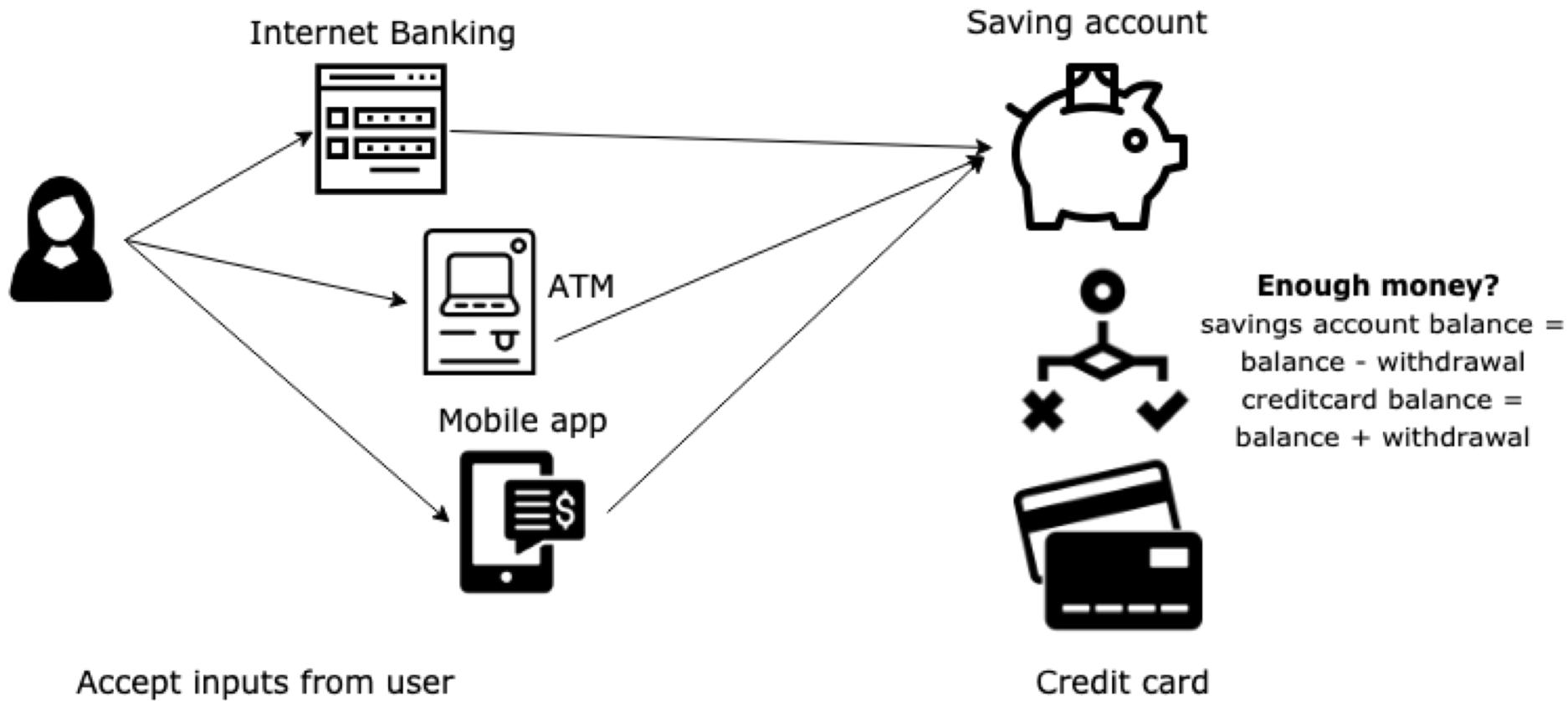


# How to handle business logic?

- **Examples of business logic:**
  - Check name and password. If good, login, if bad, error message
  - Insert one row in ***Order*** table, then several in ***OrderItem*** table
  - Check  $amount < balance$ . If so, subtract amount from one row in bank account table, then add amount to another row
  - For all rows in ***Customer*** table, send out monthly statements
- **Procedural programming languages can do:**
  - Sequence (several steps performed in order)
  - Iteration (loops)
  - Control flow (conditionals, decisions)
  - User interface (accept input and present output for users)
- **SQL is specialized for low-level data access**

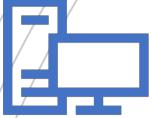


*Customer places an order*



# Example business logic

*Customer moves money from savings to credit card account*



## SQL + Procedural Language

- Different approaches:
  - “**Embedded SQL**”
    - “host language” = C, Fortran, Cobol, Java etc.
    - SQL statements are embedded in code and replaced with library calls during compilation
  - “**Dynamic SQL**”
    - host language sends SQL to DBMS via middleware e.g. ODBC
    - data is passed back to program as record-set
    - host language can handle business and presentation logic
    - example in next lecture “Web Applications”
  - **Stored Procedures, Triggers**
    - procedural code is stored and executed in the DBMS
    - enforce business logic within the database

# Stored Procedures and Triggers



- **Advantages**

- Compiled SQL statements
- Faster code execution
- Reduced network traffic
- Improved security and data integrity
- Business logic under control of DBA
- Thinner clients

- **Disadvantages**

- Code is not under the control of the application programmer
- Proprietary language
  - e.g. MySQL SP's can't be used in Oracle or SQL Server

# Example stored procedure

- accept person details as inputs
- check whether the person is already in the database
- if yes, return error
- if no, add to database

source: Hoffer chapter 8

```
CREATE OR REPLACE PROCEDURE p_registerstudent
(
    p_first_name IN VARCHAR2
    p_last_name IN VARCHAR2
    p_email      IN VARCHAR2
    p_username   IN VARCHAR2
    p_password   IN VARCHAR2
    p_error      OUT VARCHAR2
)
IS
    l_user_exists NUMBER := 0;
    l_error      VARCHAR2(2000);

BEGIN
    BEGIN
        SELECT COUNT(*)
        INTO l_user_exists
        FROM users
        WHERE username = p_username;
    EXCEPTION
        WHEN OTHERS THEN
            l_error := 'Error: Could not verify username';
    END;

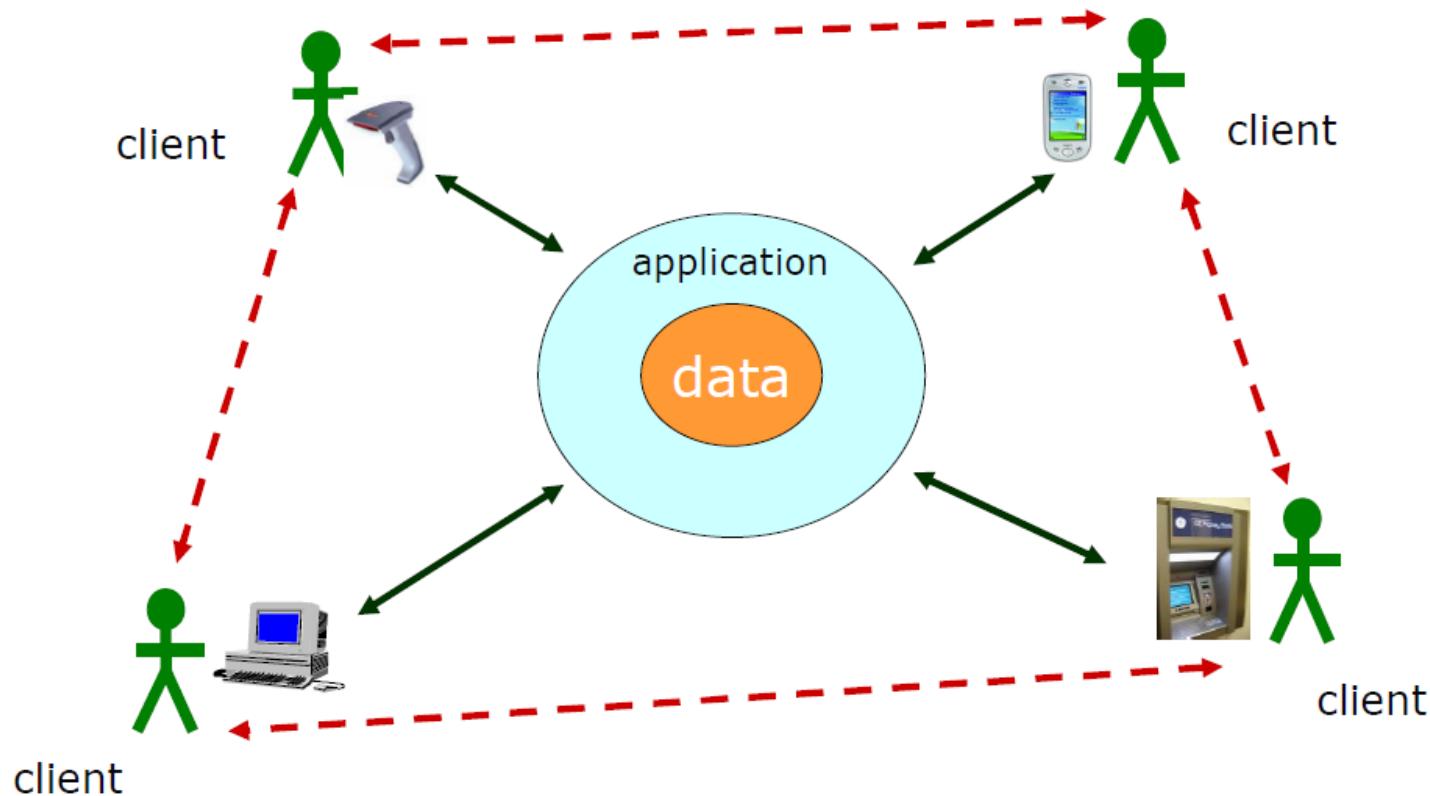
    IF l_user_exists = 1 THEN
        l_error := 'Error: Username already exists !';
    ELSE
        BEGIN
            INSERT INTO users VALUES(p_first_name,p_last_name,p_email,p_username,p_password,SYSDATE);
        EXCEPTION
            WHEN OTHERS THEN
                l_error := 'Error: Could not insert user';
            END;
        END IF;
    p_error = l_error;
END p_registerstudent;
```

Procedure p\_registerstudent accepts first and last name, email, username, and password as inputs and returns the error message(if any).

This query checks whether the username entered already exists in the database.

If the username already exists, an error message is created for the user.

If the username does not exist in the database, the data entered are inserted into the database.



# System architecture

# System architecture

## ➤ Presentation logic

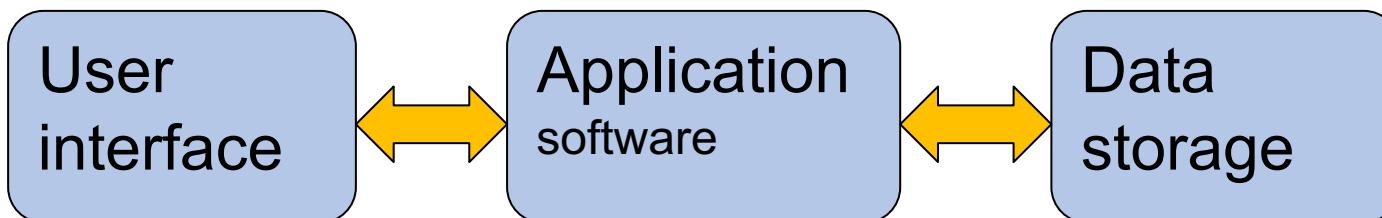
- input (keyboard, touchscreen, voice, sensor etc.)
- output (large screen, printer, phone, ATM etc.)

## ➤ Business logic

- input and command handling
- enforcement of business rules

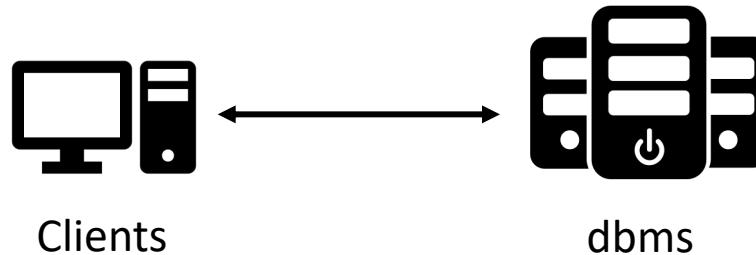
## ➤ Storage logic

- persistent storage of data
- enforcement of data integrity



# Multi-tiered architectures

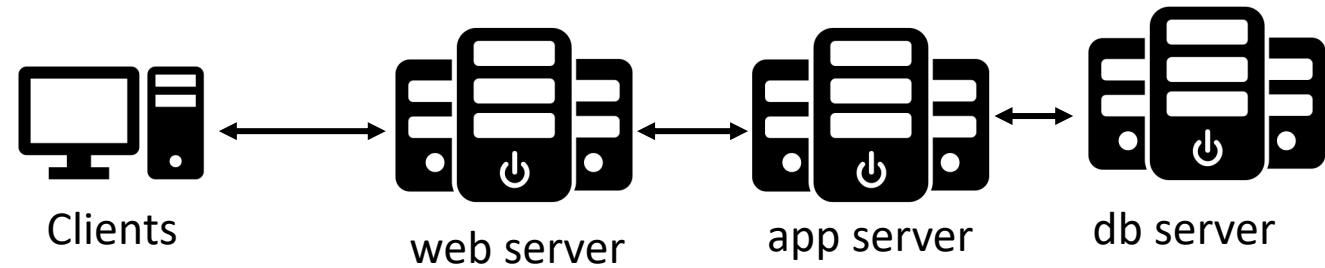
- 2 tiers



- 3 tiers

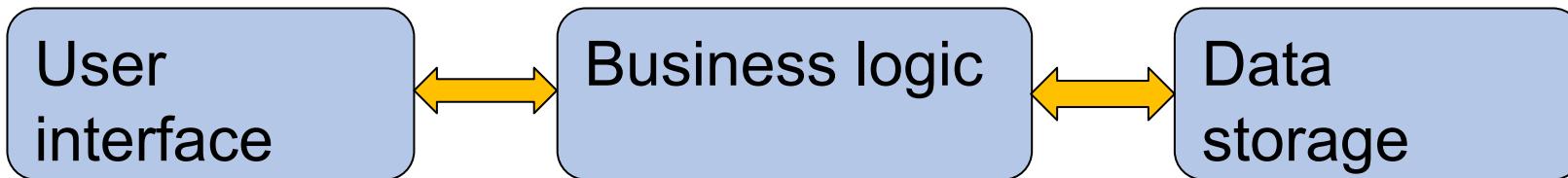


- 4 tiers



# Evolution of application architectures

- **Mainframe / dumb terminal**
  - One large computer handles all logic
  - Problems: doesn't scale with number of users
- **Client-Server architecture**
  - 2-tier: e.g. file server, database, web
  - 3-tier: separation of Presentation, Processing and Storage logic
- **Web architecture**
  - a particular form of 3 or 4 tier architecture





# Mainframe (“1Tier”)

- Mainframes and mini-computers
- Dumb terminals (no processing at client end)
- Entire application ran on the same computer
  - Database
  - Business logic
  - User interface
- Enabling technologies included:
  - Embedded SQL
  - Report generators



- Server is a relational DBMS
  - data storage and access is done at the DBMS
- SQL queries sent to DB server, which returns raw data
- Presentation and business logic is handled in client application
- Platforms like Visual Basic (1990s into 2000s)

## Client Server - 2 Tier

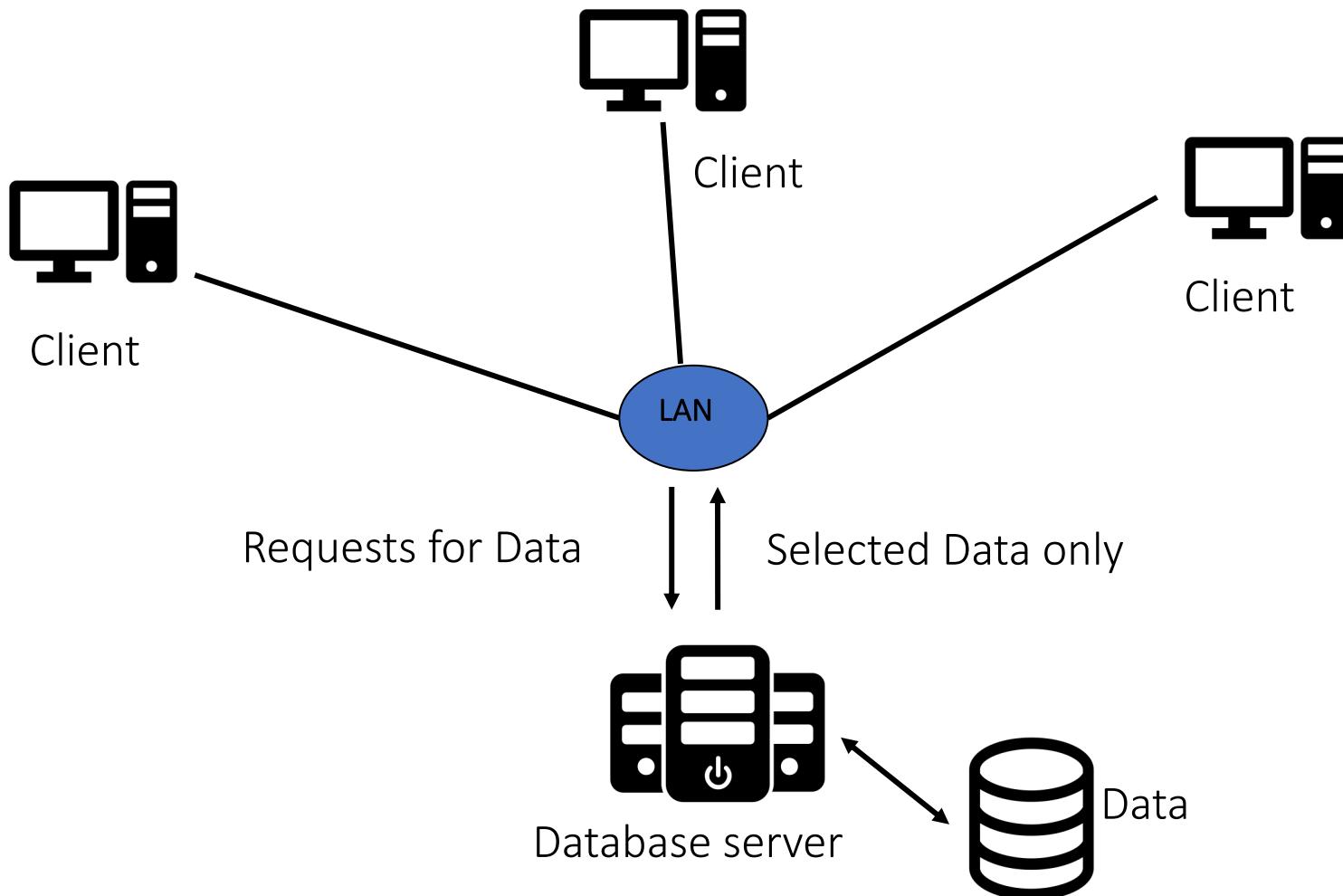
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	Category	Brand	Item Description	Serial Number	Stock	
▶	TV	Sharp	Sharp LED 60"	LC60LE630M	57	
	TV	Sharp	Sharp LED 32"	LC32LE240M	50	
	TV	Toshiba	Toshiba 29"		30	
	Smartphone	Samsung	Samsung Galaxy SIII		57	
	Smartphone	Motorola	Motorola Atrix2		15	
	Refigerator	Sharp	Sharp Refigerator	SJF72RVSL	25	
	Refigerator	Sharp	Sharp Refigerator	SJPT591	21	
	Refigerator	Sharp	Sharp Refigerator	SJPT491	30	

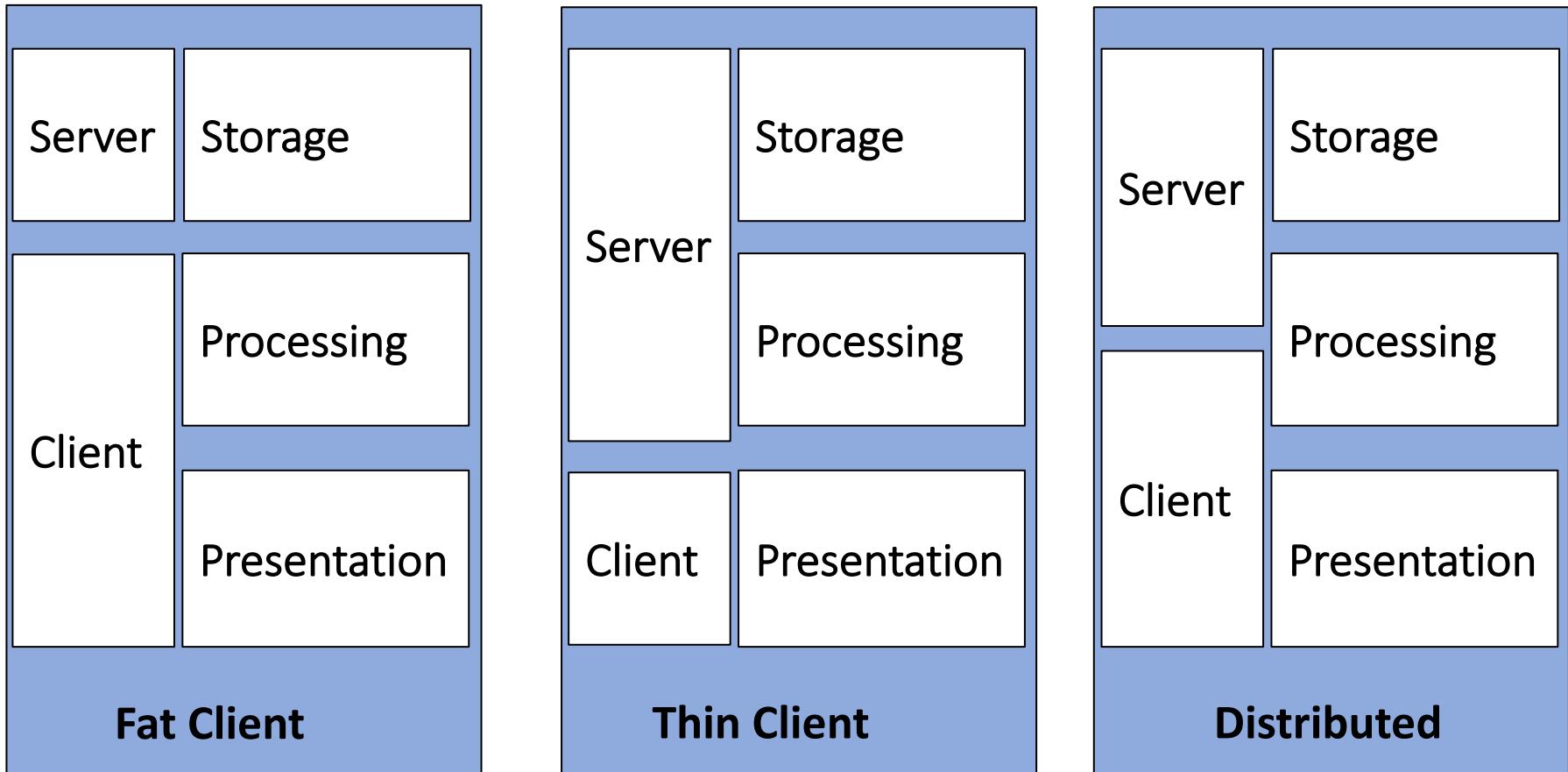
Stock In and Out Record							
Date	Category	Brand	Item Description	Serial Number	In	Out	
▶ 28/01/2013	DVD Player	Haier	3D SoundTrack	H888	10	30	
27/01/2013	Refigerator	Sharp	Sharp Refigerator	SJ151	20	5	
27/01/2013	Oven	Sharp	Microwave Oven		20	10	
28/01/2013	DVD Player	Sony	Blueray	SB1123	4	5	
28/01/2013	DVD Player	Haier	3D SoundTrack	H888	10	4	
28/01/2013	Washing Machine	Panasonic	Wash Machine	NA-F65B2	2	3	-15
28/01/2013	DVD Player	Haier	3D SoundTrack	H888			
28/01/2013	Fan	Panasonic	Ceiling Fan				



## 2 Tier Example



# Distribution of Processing Logic



# 2-Tier advantages and disadvantages



- **Advantages**

- Clients and server share processing load
- Good data integrity since data is all processed centrally
- Stored procedures allow some business rules to be implemented on the database server

- **Disadvantages**

- Presentation, data model, business logic are intertwined at client
- If DB schema changes, all clients break
- Updates need to be deployed to all clients
- DB connection for every client, thus difficult to scale
- Difficult to implement beyond the organization (to customers)

# 3-Tier architecture

Client program <-> Application server <-> Database server

Presentation logic

- Client handles interface
  - Thinner clients
  - Limited or no data storage (possibly no hard disk)

Business logic

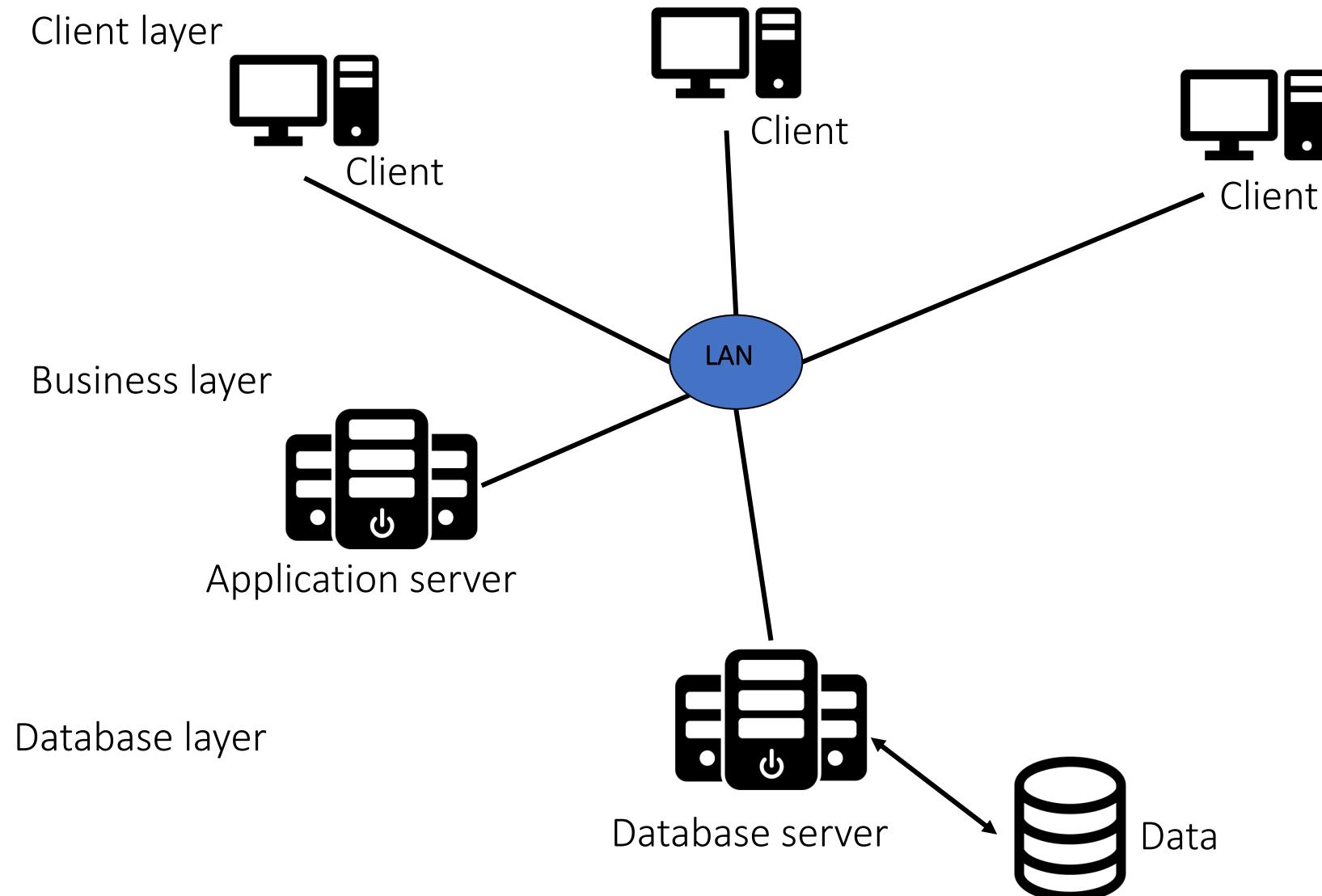
- Application Server deals with business logic

Storage logic

- Database server deals with data persistence and access



# A Three-tier architecture - Example





# 3-Tier advantages and disadvantages

- **Advantages**
  - Scalability
  - Technological flexibility (can change business logic easily)
  - Can swap out any single component fairly easily
  - Long-term cost reduction
  - Improved security – customer machine does presentation only
- **Disadvantages**
  - High short-term costs
  - Tools and training
  - Complex to design
  - Variable standards



Browser handles presentation logic



Browser talks to web server via simple, standard protocol



Business logic and data storage handled on server(s)



### Pros

Everyone has a browser

No need for install and maintain client software

HTML and HTTP are simple standards, widely supported

Opens up the possibility of global access to database



### Cons

Even more complexity in the middle-tier

Simple standards = hard to make complex application

Global access = potential security nightmare (next page)

3-Tier (web based – see next lecture)

# Security in multi-tier applications

Network environment creates complex security issues

Security can be enforced at different tiers:

- **application password security**
  - for allowing access to the application software
- **database-level password security**
  - for determining access privileges to tables
- **secure client/server communication**
  - via encryption



# Create an account

It's free and always will be.

First name  Surname

Email or mobile number

Re-enter email or mobile number

New password  (with 8+ characters)

Birthday  
Day  Month  Year  Why do I need to provide my date of birth?

Female  Male

Sign in to continue to Gmail

Email \*

Password \*

Stay signed in [Need help?](#)

Start Over University Login Guest Login Discovery BONUS+ Interlibrary Loans Search Other Libraries Program Calendar

Start Over Modify Search Another Search (Search History)

KEYWORD SQL Search Entire Collection

Limit search to items available for borrowing or consultation 438 results found. Sorted by relevance | [date](#) | [title](#).

Result page: 1 2 3 4 5 6 7 8 9 10 11 ... 37 Next

Save Marked Records Save All Records Save Marked Records to List

KEYWORDS (1-12 of 438)

SQL found in main title of entries 1-195

1	Beginning Oracle SQL : for Oracle Database 12c / Lex De Haan, Tim Gorman, Inger Jønson, Melanie Caffrey. Berkeley : Apress, Third edition. 1 online resource.	2014.
2	Oracle PL/SQL programming [electronic resource] / Steven Feuerstein, Bill Pribyl. Sebastopol, Calif. : O'Reilly Media, 6th ed. 1 online resource (1 v.) : ill.	c2014.

BONUS+ Discovery Trove CARM

Personal customers Business customers Help ?

Enter your customer ID (Using your keyboard)  \*

Enter your password (Using the buttons below)

[Forgotten your password?](#)

# Example web applications