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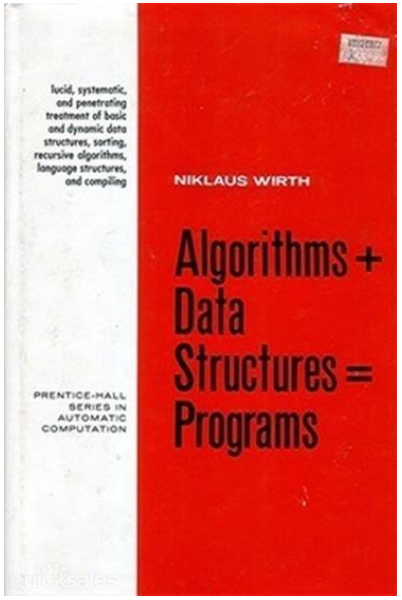
INFO90002 Database Systems & Information Modelling

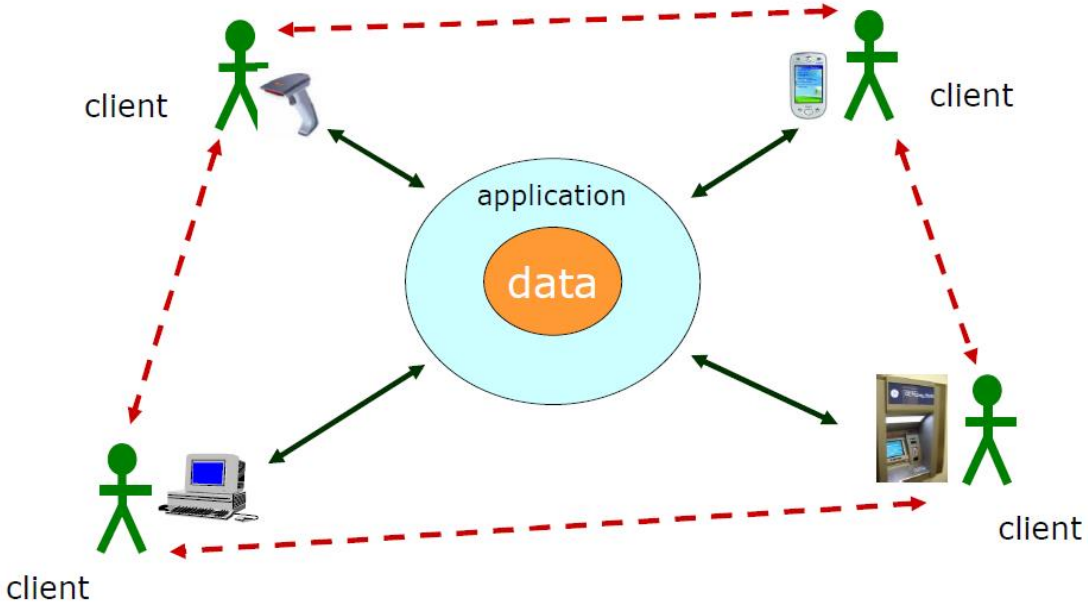
Week 07

Databases in Applications

Today's Session…

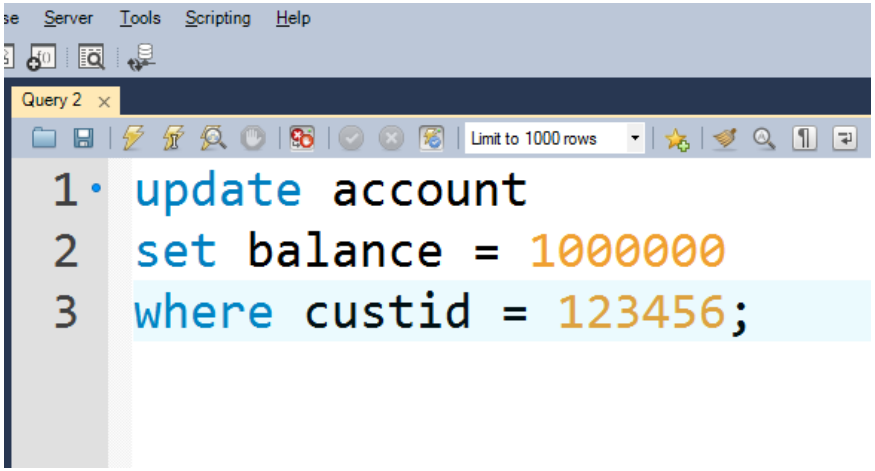
- How end-users access the database
- Business logic
- Stored procedures and triggers
- Embedding databases inside applications
- Application architectures

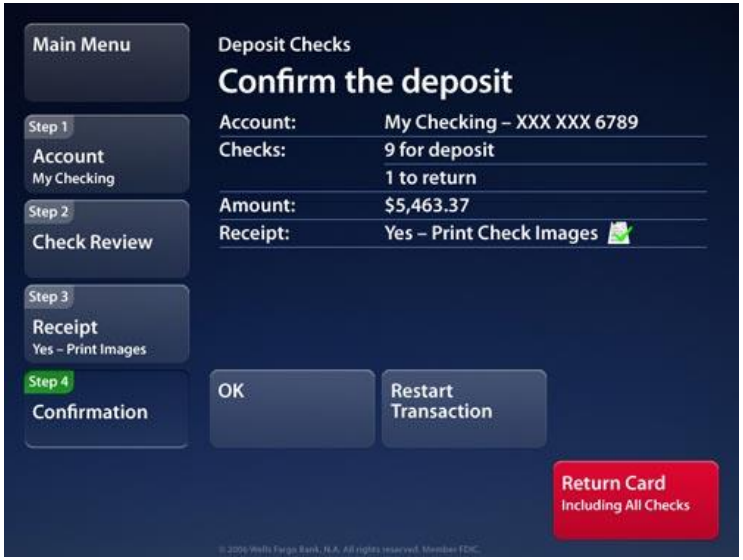




Limitations of SQL

- 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





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

Example business logic

- Customer places an order
  - Accept inputs from user (e.g. via web form)
  - Insert row into Order table
  - Repeat for each product ordered:
    - Check Product table shows sufficient quantity in stock. If so:
      - Insert one row into OrderItem table
      - Change Product table in-stock, Customer table amount-owing
  - If no errors encountered, end successfully
- Customer moves money from savings to credit card account
  - Accept inputs from user (via ATM, internet banking or mobile app)
  - Select balance from savings account
  - Is there enough money to withdraw? If so:
    - Update savings account balance = balance – withdrawal
    - Update credit card balance = balance + withdrawal
  - If no errors encountered, end successfully

SQL + Procedural Language

- Need to combine data manipulation with the ability to handle sequence, iteration, decision. 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
    - in SQL-92 standard, but implemented differently in different DBMS

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

1. accept person details as inputs
2. check whether the person is already in the database
3. if yes, return error
4. 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.

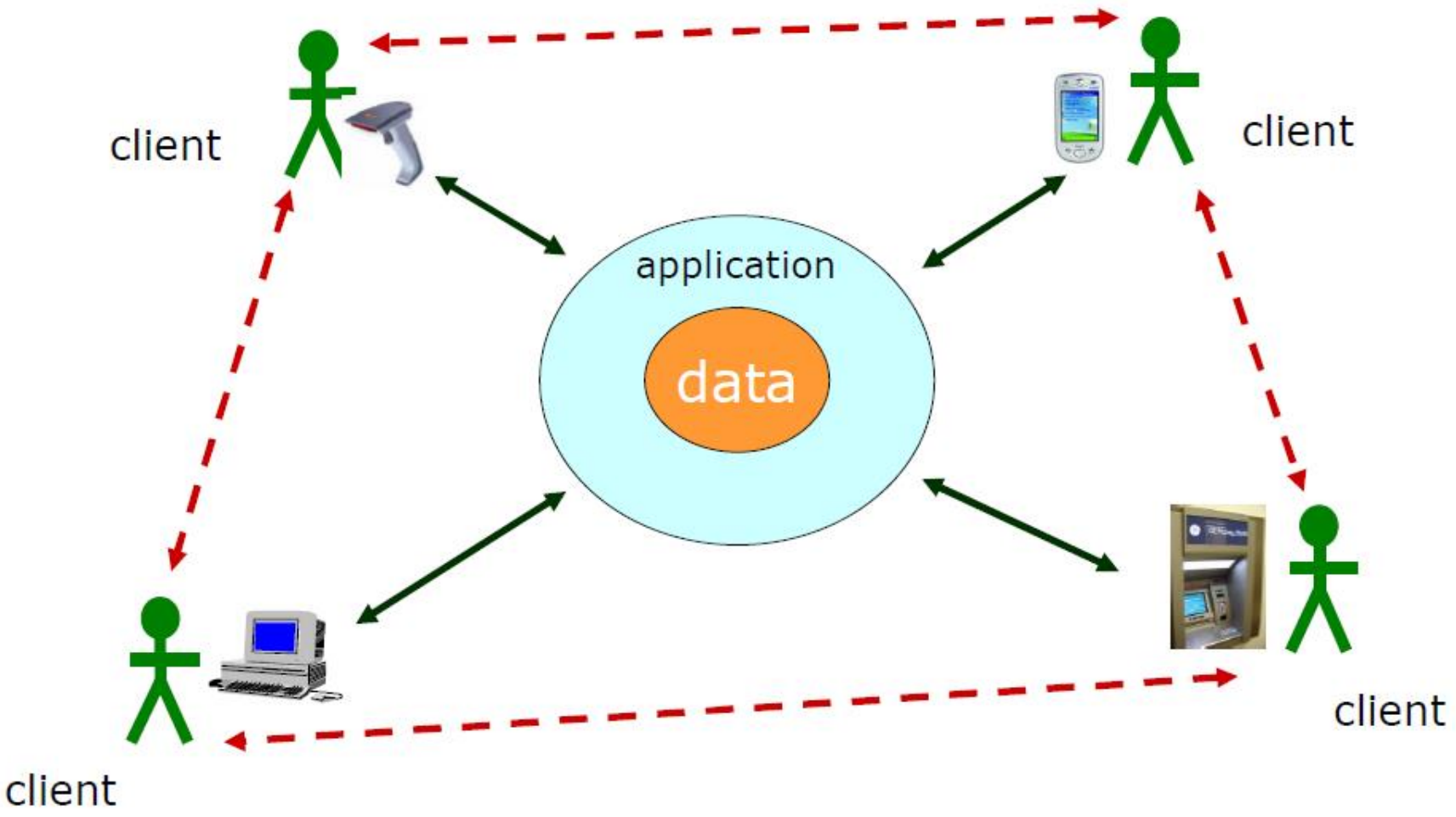
If the username does not exist in the database, the data entered are inserted into the database.

Application Architectures

system architecture = “fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution“

- ISO/IEC/IEEE 42010:2011
Systems and software engineering — Architecture description

System architecture



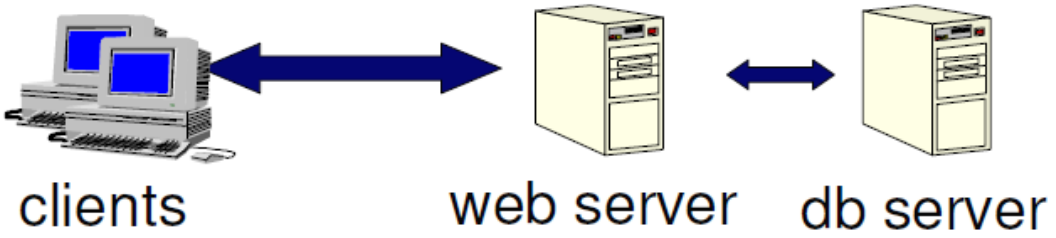
System architecture

- An information system must provide
  - 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

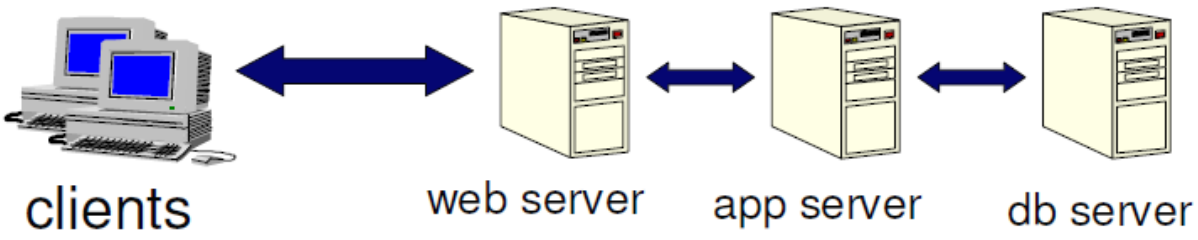
Multi-tiered architectures

- 2 tiers

- 3 tiers

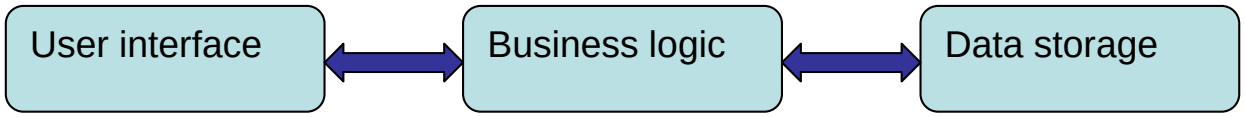


- 4 tiers



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



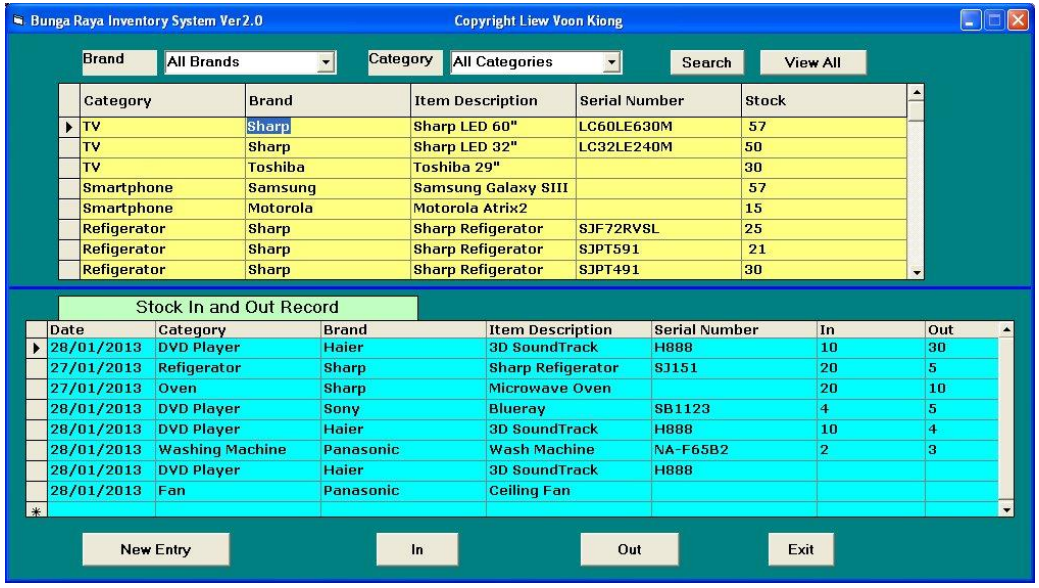
Mainframe ("1Tier")

- Mainframes and mini-computers
- Dumb terminals (no processing at client end)
- Entire application ran on the same computer
  - Database
  - Business logic
  - User interface

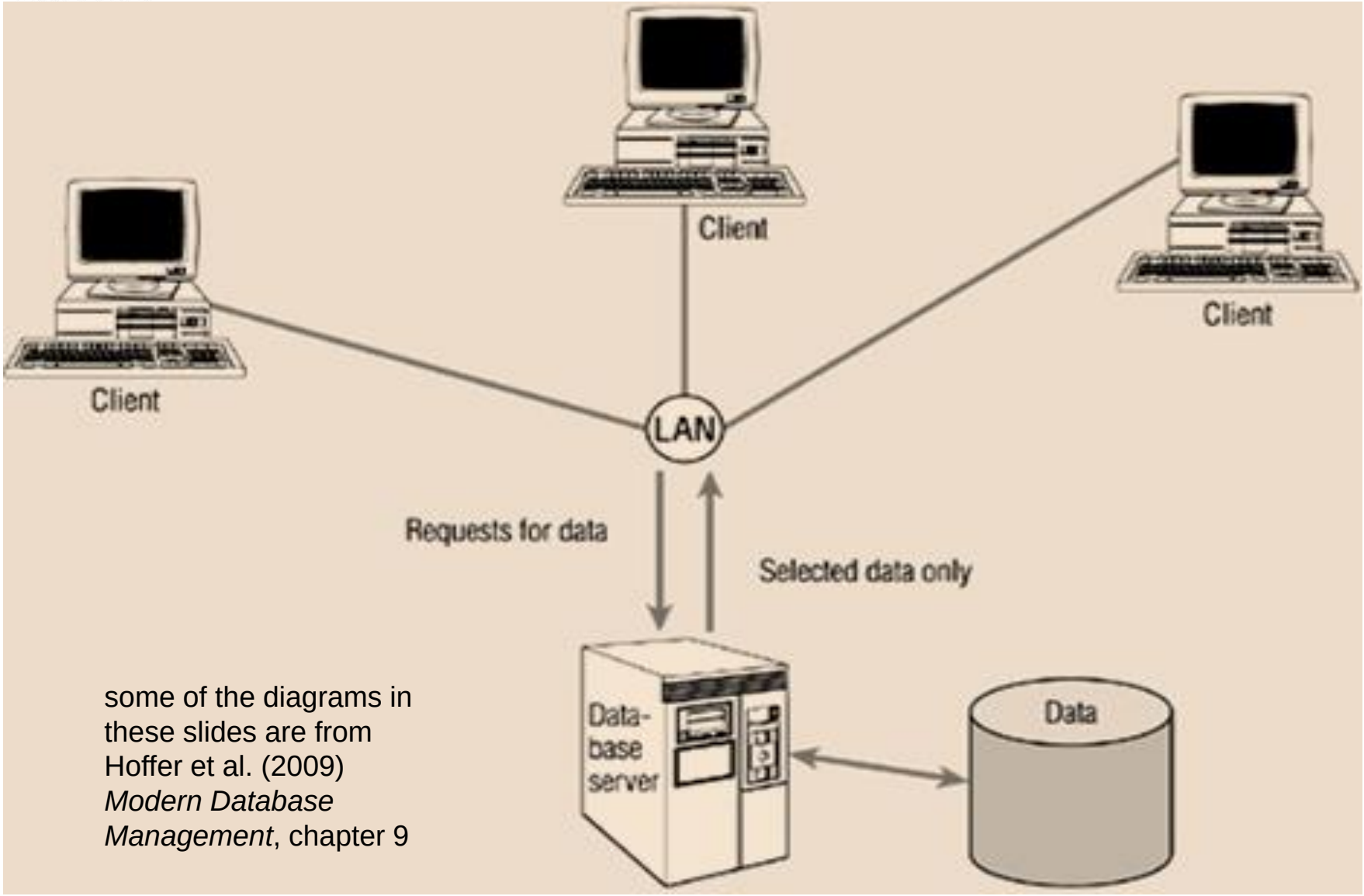
- Enabling technologies included:
  - Embedded SQL
  - Report generators

Client Server - 2 Tier

- 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, business logic is handled in client application
- Platforms like Visual Basic (1990s into 2000s)



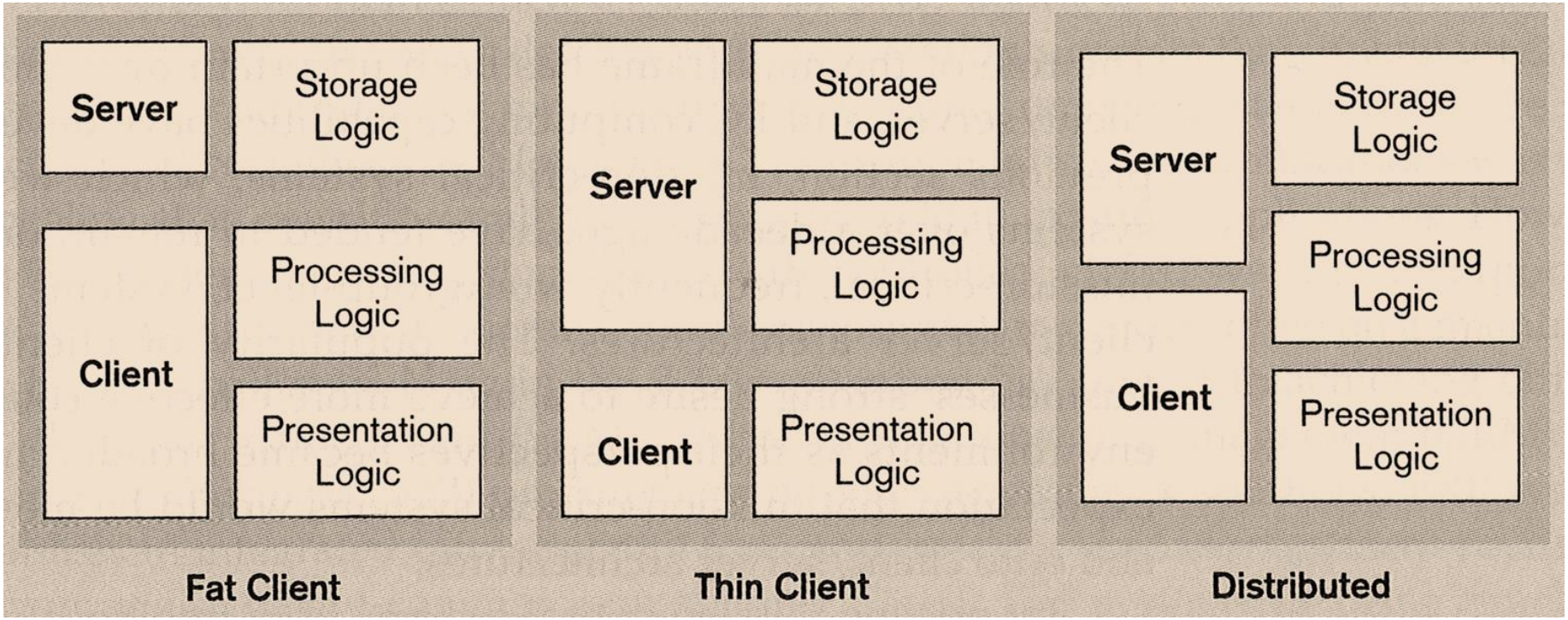
2 Tier Example



some of the diagrams in these slides are from Hoffer et al. (2009) *Modern Database Management*, chapter 9

Distribution of Processing Logic

- 2-tier distributions
  - Processing logic could be at client, server, or both



2-Tier advantages and disadvantages

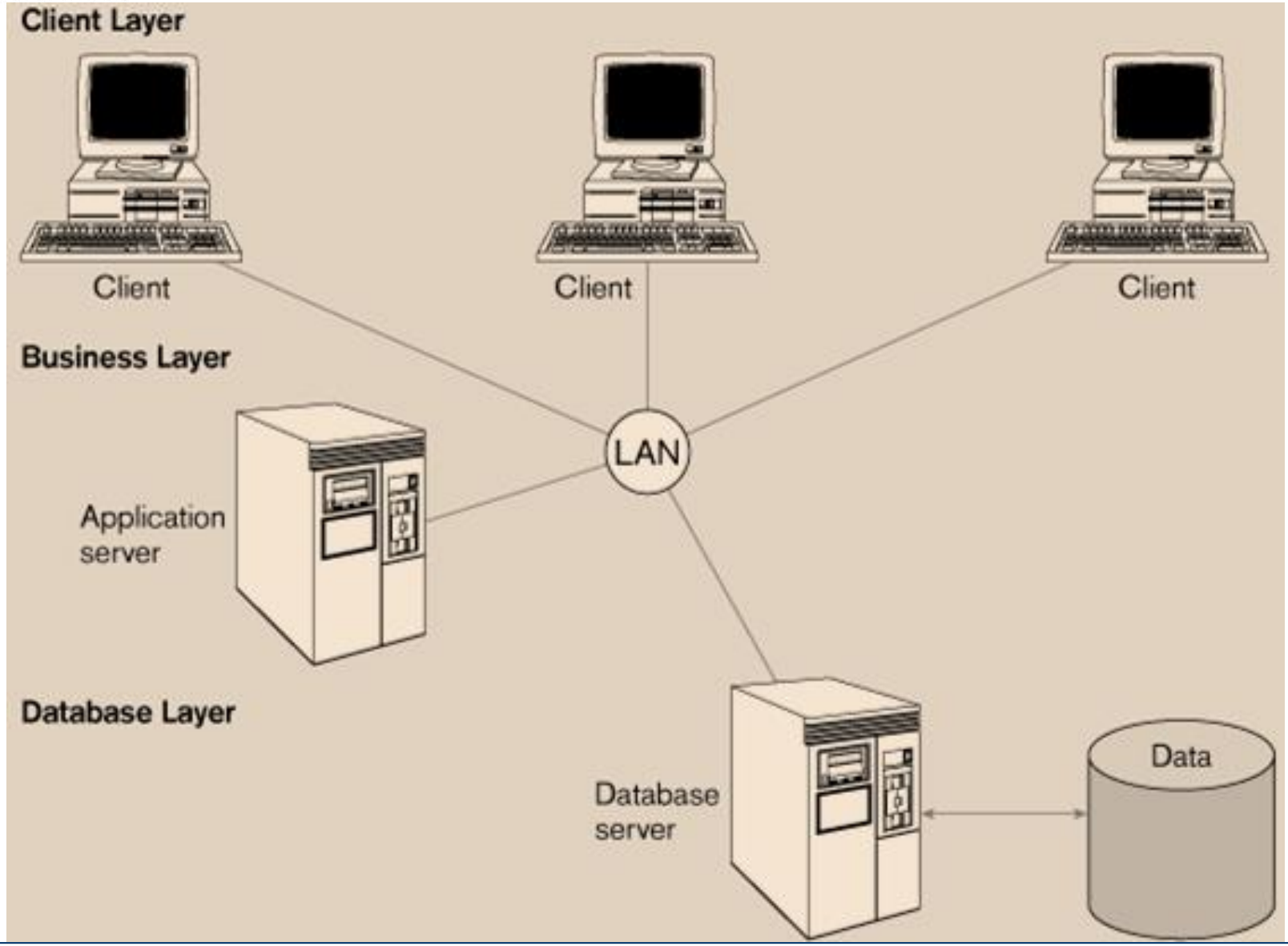
- Advantages
  - Clients and server share processing load
  - Good data integrity since data is all processed centrally
  - Stored procedures allow some business rules to be implemented on the database server
- Disadvantages
  - Presentation, data model, business logic are intertwined at client
  - If 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

3-Tier (web based – see next lecture)

- 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)

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

Example web applications