



Module 31

Partha Pratim
Das

Week Recap

Objectives &
Outline

Application
Programs &
Architecture

Architectures

Classification

1-Tier

2-Tier

3-Tier

n-Tier

Sample Applications

Module Summary

Database Management Systems

Module 31: Application Design and Development/1: Architecture

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Module Summary

- Studied the Normal Forms and their Importance in Relational Design – how progressive increase of constraints can minimize redundancy in a schema
- Learnt how to decompose a schema into 3NF while preserving dependency and lossless join
- Learnt how to decompose a schema into BCNF with lossless join
- Using the specification for a Library Information System, we have illustrated how a schema can be designed and then refined for finalization
- Coding of various queries based on these schema are left as exercises
- Understood multi-valued dependencies to handle attributes that can have multiple values
- Learnt Fourth Normal Form and decomposition to 4NF
- Discussed aspects of the database design process
- Studied the issues with temporal data



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Sample Applications

Module Summary

- What are the Application Programs across various sectors?
- Commonality of architecture across applications
- Understanding the classification and evolution of the architectures
- A look at the architecture for a few sample applications



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Sample Applications

Module Summary

- Application Programs
- Application Architecture with classification and evolution
- Sample application architectures



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Sample Applications

Module Summary

Application Programs and Architecture



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Sample Applications

Module Summary

● Financial:

- Netbanking: SBI, PNB, BoB, Canara, HDFC, ICICI
- Share Market: ICICIDirect, Sharekhan, HDFCDirect
- Insurance & Investment: LIC, PolicyBazaar, NSDL, NPS,
- Payment Gateway: Paytm, GPay, Bhim UPI, PhonePe,
- e-Commerce: Amazon, Flipkart, eBay, BigBazaar, BigBasket,

● Travel & Tourism:

- Travel Reservations: IRCTC, Airlines, MakeMyTrip, Yatra,
- Accommodation: Booking, OYO, AirBnb, Fabhotels, Treebo,
- Transportation: Uber, Ola Cab, Mega Cab, Meru Cab,
- Navigation: Google Maps, MapQuest, Apple Maps,
- Food & Delivery: Zomato, Swiggy, UberEats, Dunzo,

● Communication:

- Live Interaction: Zoom, Google Meet, Teams, Webex, Skype,
- Intermittent Interaction: WhatsApp, Telegram, Signal, Skype
- Mail: Gmail, Yahoo, Hotmail, Rediffmail, [Enterprise Mail](#),
- Social Media: Facebook, Instagram, Twitter, YouTube,

● Knowledge Discovery:

- Static: Google, Yahoo, Bing, Wikipedia, Encyclopedia.com,
- Q&A: Quora, ASKfm, Yahoo Answers, Reddit, Digg,

● Sports:

- Cricket: Cricbuzz, CricViz, Cricket-21, Cricket Exchange,
- Tennis: ATP, ITF, SwingVision, TennisPAL, Tennis Clash,

Database Management Systems

● Software Engineering:

- Issue Tracking: JIRA, BugZilla, Githubs, Gitlab,
- VCS: Githubs, Gitlab, BitBucket, SourceForge,
- Online IDE: OnlineGDB, Codechef, Ideone,

● Library:

- Digital Library: National Digital Library of India,
- Archives: Internet Archive, arXiv, Nextpoint,

● Education:

- eLearning: BYJU's, IGNOU, NIIT, Edukart,
- MOOCs: SWAYAM, edX, Coursera, Udemy,

● Document Processing:

- Editing: Overleaf, Google Docs, Spreadsheet
- Website, Blog: Google Sites, WordPress, Webly,

● Health:

- Telemedicine: MDLIVE, Doctor on Demand,
- National: Aarogy Setu, CoWin, NACO App,

● Organizational ERP: (Intranet)

- Institutions: Students, Faculty, Course
- Hospital: Patient, Doctor, OPD, IPD, Pharmacy,
- Manufacturing: Suppliers, Inventory, Customers,
- Bank: Customers, Accounts, Locker, Deposits,
- Courier: Customers, Parcels, Delivery Agents,

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Sample Applications

Module Summary

- **Diversity:** These applications widely differ in their
 - *Domain, functionality, user base, response time, scale, daily hit* and many more
- **Unity:** Yet, these have a lot in common
 - Most use an RDBMS like Oracle, DB2 MySQL, PostgreSQL, etc. for managing data
 - Applications are functionally split into *frontend layer, middle layer, backend layer*
 - ▷ **Frontend or Presentation Layer / Tier**
 - Interacts with the user: Display / View, Input / Output
 - *Choose item, Add to cart, Checkout, Pay, Track order*
 - Interfaces may be, *Browser-based, Mobile App*, or *Custom*
 - ▷ **Middle or Application / Business Logic Layer / Tier**
 - Implements the Functionality of the Application: Links front and backend
 - *Authentication, Search / Browse logic, Pricing, Cart management, Payment handling (gateway), Order management (mail / SMS / internal actions), Delivery management*
 - Support functionality based on frontend interface
 - ▷ **Backend or Data Access Layer / Tier**
 - Manages persistent data, large volume, efficient access, security
 - *User, Cart, Inventory, Order, Vendor databases*



Characteristic of Application Programs (2): Architecture

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1-Tier

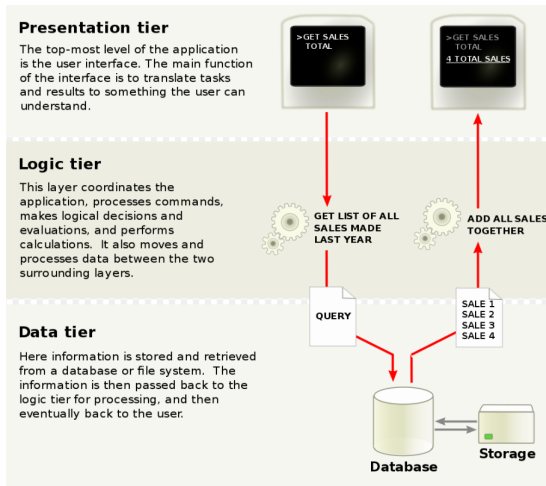
2-Tier

3-Tier

n-Tier

Sample Applications

Module Summary



Source: https://en.wikipedia.org/wiki/Multitier_architecture



Application Architectures: Layers

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Sample Applications

Module Summary

- **Presentation Layer / Tier**
 - **Model-View-Controller (MVC)** architecture
 - ▷ **model**: business logic
 - ▷ **view**: presentation of data, depends on display device
 - ▷ **controller**: receives events, executes actions, and returns a view to the user
- **Business Logic Layer / Tier**
 - provides high level view of data and actions on data
 - ▷ often using an object data model
 - hides details of data storage schema
- **Data Access Layer / Tier**
 - interfaces between business logic layer and the underlying database
 - provides mapping from object model of business layer to relational model of database
 - *Already discussed and studied in depth*



Application Architecture (2): MVC

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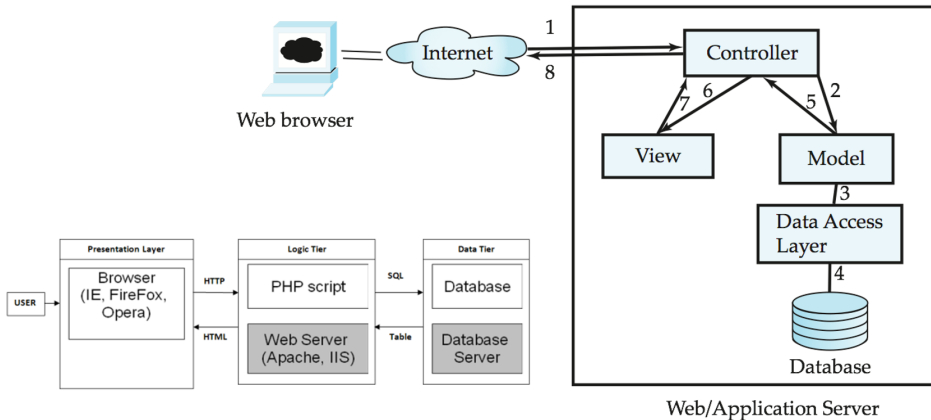
2-Tier

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n-Tier

Sample Applications

Module Summary





Application Architecture (3): User Interface

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Sample Applications

Module Summary

- Web browsers have become the de-facto standard user interface to databases
 - Enable large numbers of users to access databases from anywhere
 - Avoid the need for downloading / installing specialized code, while providing a good graphical user interface
 - ▷ Javascript, Flash and other scripting languages run in browser, but are downloaded transparently
 - Examples: banks, airline and rental car reservations, university course registration and grading, and so on.
- Use in Mobile Devices are getting popular
 - Mobile Apps or Browser in Mobile
 - These are similar in architecture and workflow with web, but have significant differences with their smaller (but wide range of) form factor, and extremely low resources
 - *Will be discussed later*



Application Architecture (4): Business Logic Layer

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Sample Applications

Module Summary

- Provides abstractions of entities
 - For example, students, instructors, courses, etc
- Enforces **business rules** for carrying out actions
 - For example, student can enroll in a class only if she has completed prerequisites, and has paid her tuition fees
- Supports **workflows** which define how a task involving multiple participants is to be carried out
 - For example, how to process application by a student applying to a university
 - Sequence of steps to carry out task
 - Error handling
 - ▷ For example, what to do if recommendation letters not received on time



Application Architecture (5): Object-Relational Mapping

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Sample Applications

Module Summary

- Allows application code to be written on top of object-oriented data model, while storing data in a traditional relational database
 - alternative: implement object-oriented or object-relational database to store object model
 - ▷ has not been commercially successful
- Schema designer has to provide a mapping between object data and relational schema
 - For example, Java class *Student* mapped to relation *student*, with corresponding mapping of attributes
 - An object can map to multiple tuples in multiple relations
- Application opens a session, which connects to the database
- Objects can be created and saved to the database using `session.save(object)`
 - mapping used to create appropriate tuples in the database
- Query can be run to retrieve objects satisfying specified predicates



Application Architecture (6): Data Access Layer

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Sample Applications

Module Summary

- Issues of modeling and design of databases have already discussed in depth through the previous module
- Issues of accessing and updating data from application will be discussed later this with through the interactions of native languages and SQL



Architecture Classification

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Sample Applications

Module Summary

- Database architecture uses programming languages to design a particular type of software for businesses or organizations.
- Database architecture focuses on the design, development, implementation and maintenance of computer programs that store and organize information for businesses, agencies and institutions.
- A database architect develops and implements software to meet the needs of users.
- The design of a DBMS depends on its architecture. It can be
 - centralized
 - decentralized
 - hierarchical
- The architecture of a DBMS can be seen as either single tier or multi-tier:
 - 1-tier architecture
 - 2-tier architecture
 - 3-tier architecture
 - n-tier architecture



Architecture Evolution

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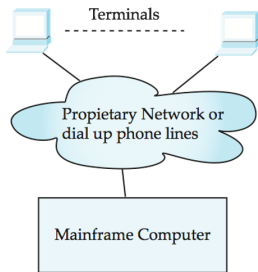
3-Tier

n-Tier

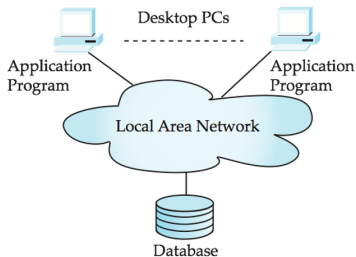
Sample Applications

Module Summary

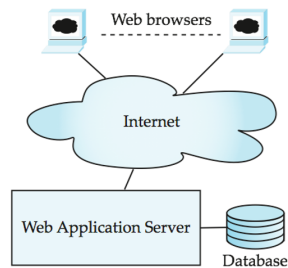
- Three distinct eras of application architecture
 - Mainframe (1960's and 70's)
 - Personal computer era (1980's)
 - Web / Mobile era (1990's onwards)



(a) Mainframe Era



(b) Personal Computer Era



(c) Web era



1-tier Architecture

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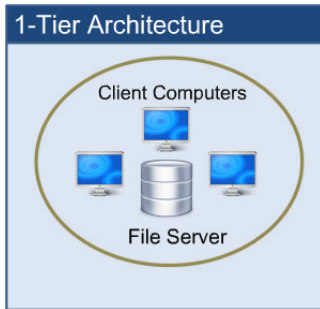
3-Tier

n-Tier

Sample Applications

Module Summary

- One-tier architecture involves putting all of the required components for a software application or technology on a single server or platform



- Basically, a one-tier architecture keeps all of the elements of an application, including the interface, Middleware and back-end data, in one place
- Developers see these types of systems as the simplest and most direct way

Source: [Concepts of Database Architecture](#)



2-tier Architecture

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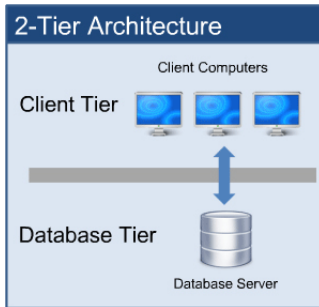
3-Tier

n-Tier

Sample Applications

Module Summary

- The two-tier is based on Client Server architecture
- It is like client server application



- The direct communication takes place between client and server
- There is no intermediate between client and server

Source: *Concepts of Database Architecture*



3-tier Architecture

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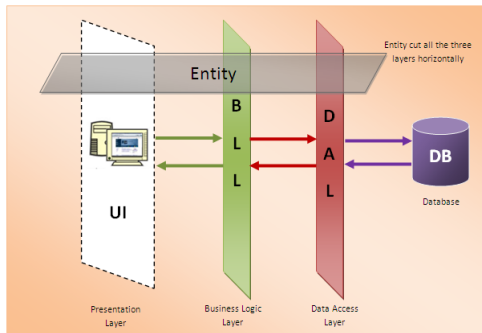
3-Tier

n-Tier

Sample Applications

Module Summary

- A 3-tier architecture separates its tiers - *Presentation*, *Logic* and *Data Access* - from each other based on the complexity of the users and how they use the data present in the database
- It is the most widely used architecture to design a DBMS



Source: *Concepts of Database Architecture*

Database Management Systems

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n-tier Architecture

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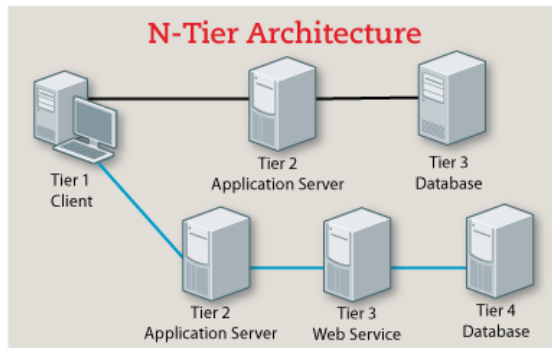
3-Tier

n-Tier

Sample Applications

Module Summary

- An n-tier architecture distributes different components of the 3 tiers between different servers and adds interfaces tiers for interactions and workload balancing



Source: [Concepts of Database Architecture](#)



Sample Applications in Multiple Tiers

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Sample Applications

Module Summary

Application	Presentation	Logic	Data	Functionality
Web Mail	<ul style="list-style-type: none"> Login Mail List View <ul style="list-style-type: none"> Inbox Sent Items Outbox Trash Mail Composer Filters 	<ul style="list-style-type: none"> User Authentication Connection to Mail Server (SMTP, POP, IMAP) Encryption / Decryption 	<ul style="list-style-type: none"> Mail Users Address Book Mail Items 	<ul style="list-style-type: none"> Send / Receive Mails Manage Address Book
Net Banking	<ul style="list-style-type: none"> Login Account View Add / Delete Account Add / Delete Beneficiary Fund Transfer 	<ul style="list-style-type: none"> User Authentication Beneficiary Authentication Transaction Validation Connection to Banks / Gateways Encryption / Decryption 	<ul style="list-style-type: none"> Account Holders Beneficiaries Accounts Debit / Credit Transactions 	<ul style="list-style-type: none"> Check Balance and Transactions Transfer Funds
Timetable	<ul style="list-style-type: none"> Login Add / Delete Courses, Teachers, Rooms, Slots Assignments: <ul style="list-style-type: none"> Teachers → Course Allocations <ul style="list-style-type: none"> Course → Room, Slots Views 	<ul style="list-style-type: none"> User Authentication Timetable Assignment Logic Encryption / Decryption 	<ul style="list-style-type: none"> Courses Teachers Rooms Slots Assignments Allocations 	<ul style="list-style-type: none"> Manage timetable for multiple courses taken by multiple teachers



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Sample Applications

Module Summary

- Had a glimpse of Application Programs across various sectors
- Understood the typical architecture for an application
- Studies the classification and evolution of the architectures
- Glimpsed at architecture for a few sample applications

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