ARCHITECTURE DESIGN (CH 11)

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Annoucements

- Exam on Wednesday – take home format
- Project Feedback Survey

Learning Objectives

- Describe the fundamental components of an information system.
- Describe client–server, server-based, and mobile application architectures.
- Describe how cloud computing can be incorporated as a system architecture component.
- Explain how operational, performance, security, cultural, and political requirements affect the architecture design.
- Create a hardware and software specification.

Key Definitions

- Architecture design
  - Plans for how the system will be distributed across computers and what hardware and software will be used for each computer.
- Hardware and software specification
  - Describes the hardware/software components in detail to aid those responsible for purchasing those products.

ELEMENTS OF AN ARCHITECTURE DESIGN

Assigning software components to hardware

Objective of Architecture Design

- Assign the software components of the information system to the hardware devices of the system in the most advantageous way.
- The major *architectural components* of any system are the software and the hardware.

Architectural Components

- Software systems can be divided into four basic functions:
  - Data storage.
  - Data access logic: the processing required to access stored data.
  - Application logic: the logic documented in the DFDs, use cases, and functional requirements.
  - Presentation logic: the display of information to the user and the acceptance of the user's commands.

Architectural Components (cont'd)

- The three primary hardware components:
  - Client computers: Input-output devices employed by users (e.g., PCs, laptops, handheld and mobile devices, smart phones)
  - Servers: Larger multi-user computers used to store software and data.
  - Network: Connects the computers.

Client-Server Architectures

- Client-server architectures balance the processing between client devices and one or more server devices.
- Generally, clients are responsible for the presentation logic, and
- the server(s) are responsible for the data access logic and data storage.
- Application logic location varies depending on the C-S configuration chosen.

Benefits of Client-Server

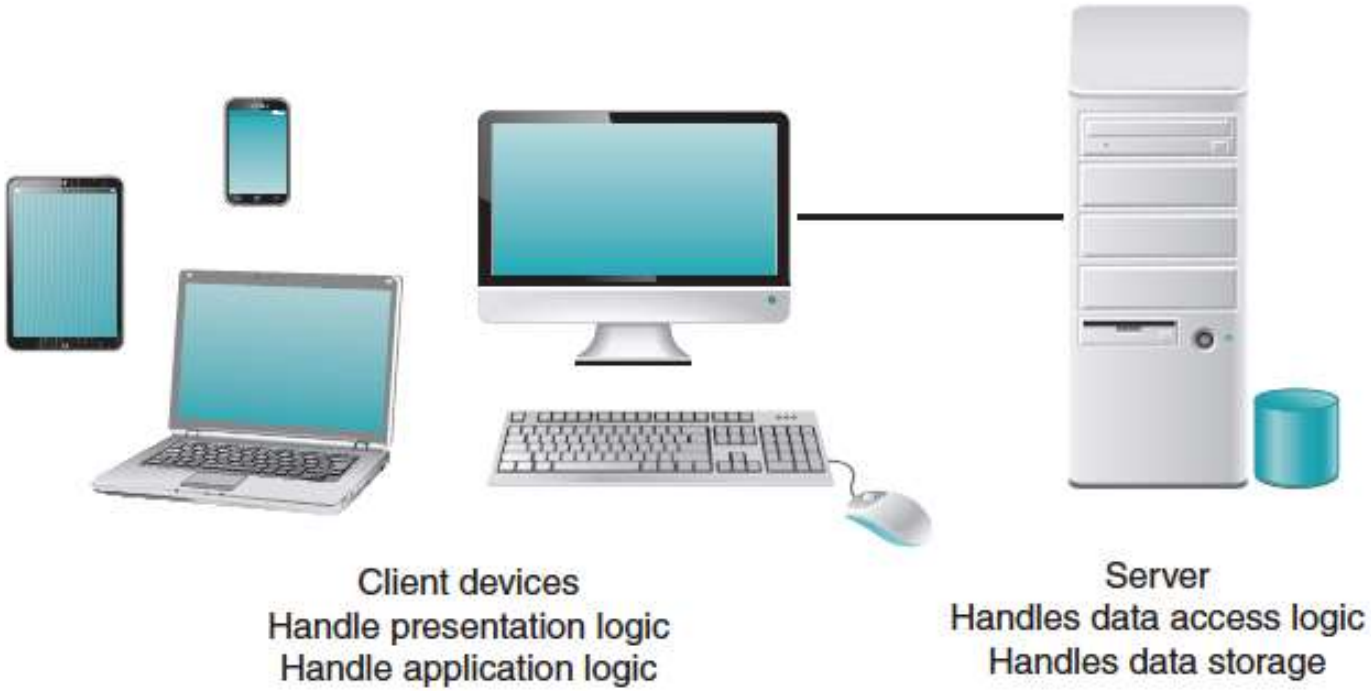
- Scalable
- Can support different types of clients and servers through middleware.
- The presentation logic, the application logic, and the data processing logic can be independent.
- If a server fails, only the applications requiring that server are affected – highly reliable.

Client-Server Tiers

- There are many ways in which the application logic can be partitioned between the client side and the server side.
- The arrangement in Figure 8-1 is called two-tiered architecture.

Two-Tiered Client-Server Architecture

- Thick client – most of application logic on the client side (shown here)
- Thin client – little application logic on the client side; most shifted to server side

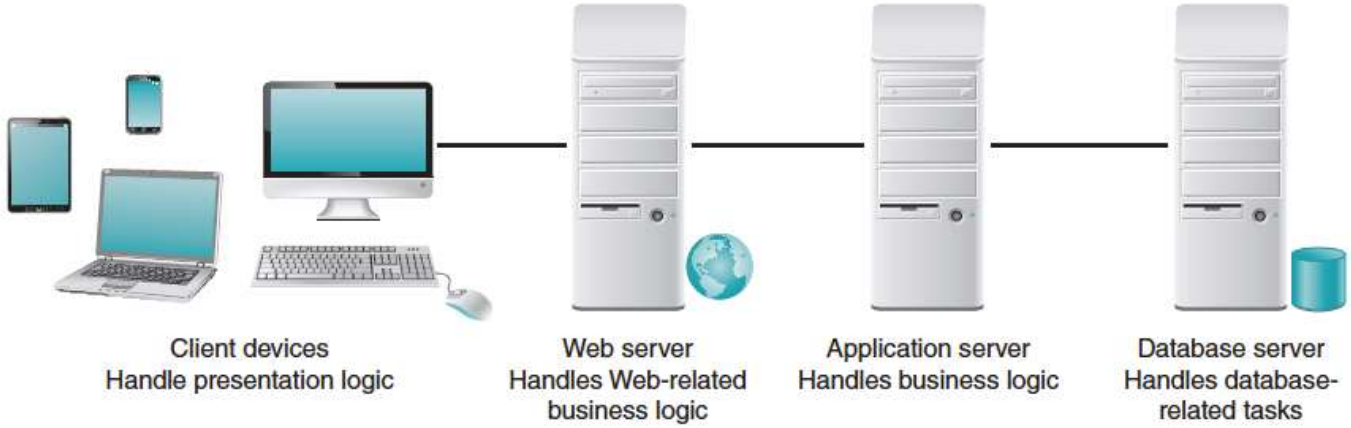


Three-Tiered Client-Server Architecture

- Adds “specialized” servers – one for application logic; one for data base tasks

n-Tiered Client-Server Architecture

- Adds “specialized” servers – one for Web-related business logic; one for application logic; one for data base tasks



Adding “Tiers” in the Architecture

advantages

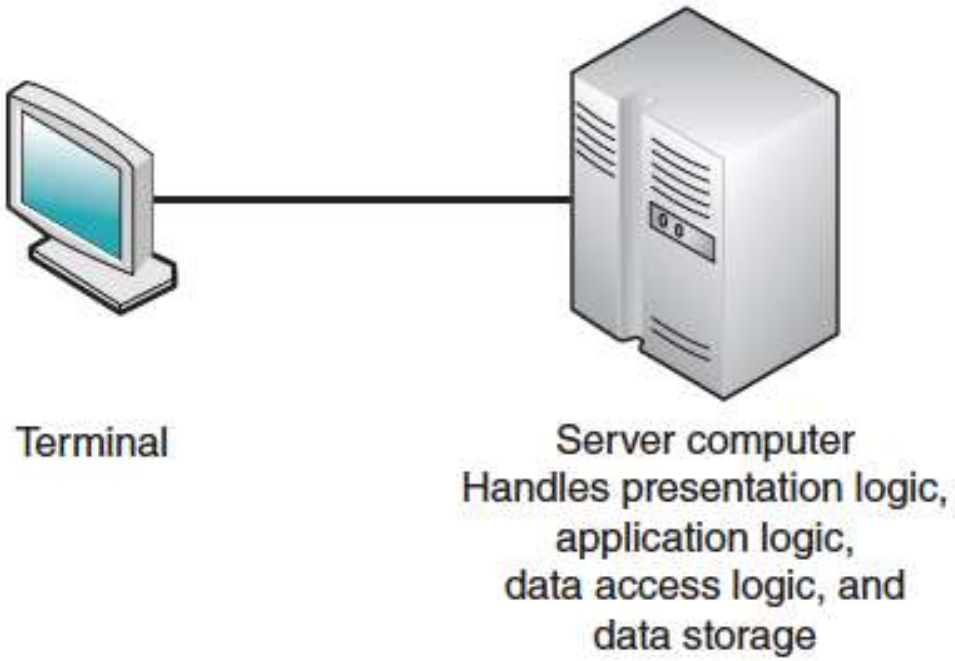
- Modular business logic components are shareable across applications
- Separating the processing among multiple servers makes it possible to balance the server loads efficiently.

disadvantages

- More tiers place a higher load on the network.
- More difficult to implement since the servers must communicate effectively.

Server-Based Architecture

Zero-client used today in virtual desktop infrastructure (VDI)



Mobile Application Architecture

- Rich client – involves processing on the mobile device using its resources. Presentation logic, business logic, and data access logic on the client side.
- Thin Web-based client – business and data access logic on the server side; always connected to server.
- Rich Internet application – browser-based; uses some technologies on client device to provide a rich user interface (e.g., Flash).

Mobile Application Options

- Native app – written to run on specific device with specific operating system.
- Cross-platform frameworks – develop in web-based technologies and use framework to deploy to multiple devices.
- Mobile Web app – browser-based; platform independent. Most limited user experience.

Advances in Architecture Configurations

- Advances in hardware, software, and networking have given rise to a number of new architecture options.
  - Virtualization: Creation of a virtual device or resource.
  - Cloud computing: Computing resources obtained as a service.

Virtualization

- **Server virtualization** involves partitioning a physical server into smaller virtual servers.
- **Storage virtualization** involves combining multiple network storage devices into what appears to be single storage unit.

Cloud Computing

- **Cloud computing** – everything from computing power to computing infrastructure, applications, business processes to personal collaboration can be delivered as a service wherever and whenever needed.

- The "cloud" can be defined as the set of hardware, networks, storage, devices, and interfaces that combine to deliver aspects of computing as a service.

Cloud Computing

Cloud computing is a model for
enabling **ubiquitous**, convenient, **on-demand network access**
to a **shared pool of configurable computing resources**
(e.g., networks, servers, storage, applications, and services)
that can be **rapidly provisioned** and **released**
with minimal management effort or service
provider interaction.

[Source: NIST - National Institute for Standards and Technology - 2011]

Video

Cloud Computing

Cloud computing is a model of **renting** rather than buying resources.

Example:

Perpetual license (on premise)

VS.

Subscription-based license (cloud)

- Some plans also allow the on-premise version of Office to be installed for the duration of the subscription on several machines

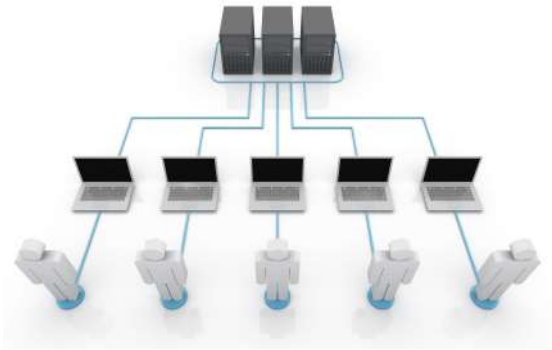
Cloud Computing Essential Characteristics

- **On-demand self-service**
  - A consumer can **unilaterally** provision computing capabilities (server time, network storage, applications, etc.) **as needed** automatically without requiring human interaction with each service provider.

- **Broad network access**

Cloud Computing Essential Characteristics

- **Resource pooling**
  - Provider's computing resources are pooled to serve multiple consumers
  - **Multi-tenancy model** (multiple users sharing one resource or infrastructure) - different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
    - **Virtualization** – allow resources on one computer to be broken into multiple "virtual" minicomputers (many boxes in a box) inside which applications can be run separately
  - **Location independence** – customers generally have little or no control or knowledge over the exact location of the hardware supporting the provided resources (think about Gmail)



Cloud Computing Essential Characteristics

- **Measured Service**
  - Resource usage can be monitored, measured (according to various metrics), controlled / optimized (sometimes automatically), and reported providing transparency for both the provider and consumer of the utilized service

- **Rapid elasticity (scalability)**
  - Resources can be
    - rapidly and elastically provisioned, (sometimes automatically) to quickly **scale out** (expand) when needed
    - rapidly released to quickly **scale in**
  - To the consumer, the resources available for provisioning often appear to be unlimited and can be purchased in almost any quantity at any time.

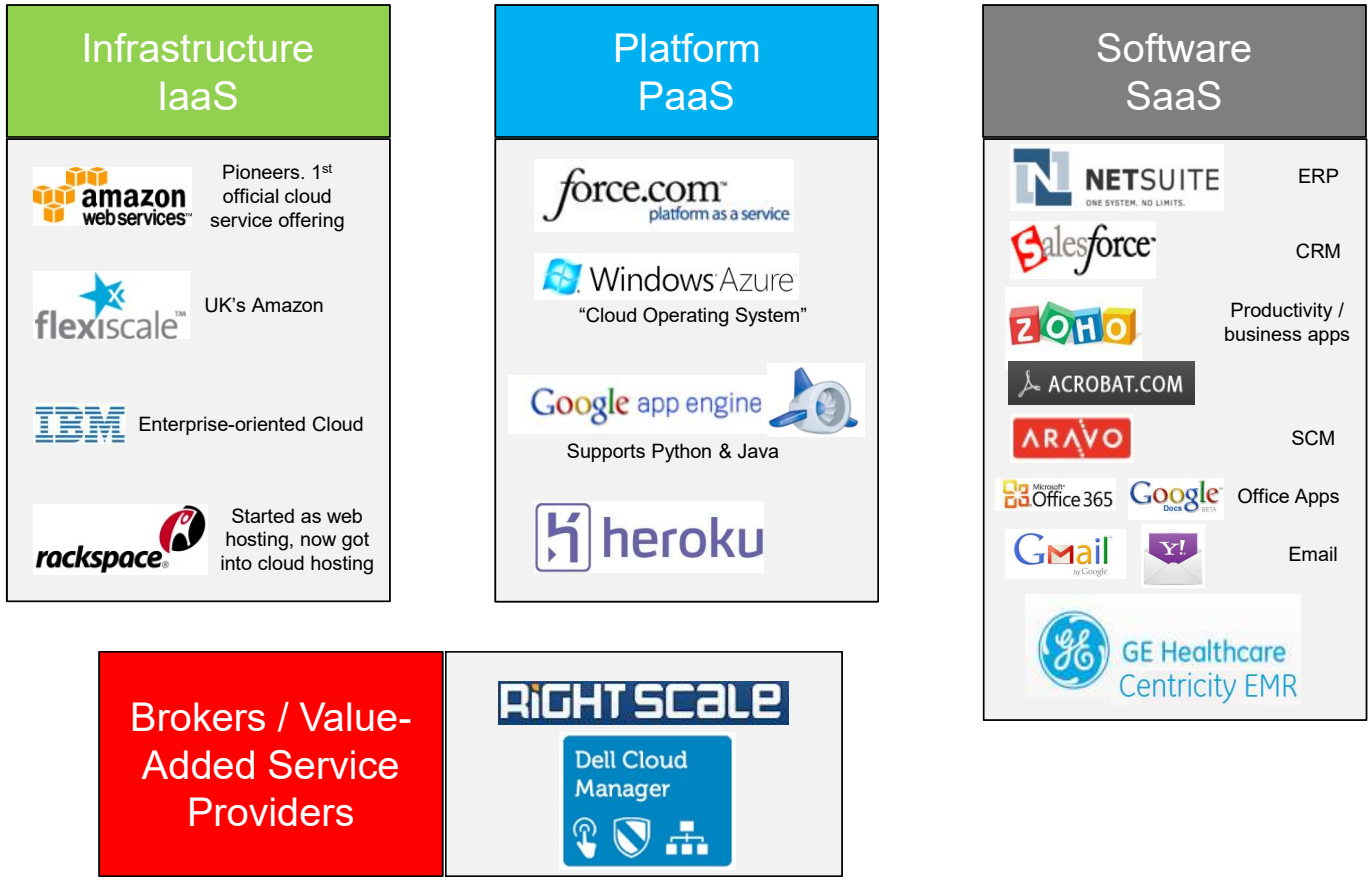
Cloud Computing Deployment Models

- **Public clouds:**
  - The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
  - Examples: Amazon EC2, Rackspace, etc.
- **Private clouds:**
  - The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.
- Others: community, hybrids, etc.

Cloud Computing Service Models

Software as a Service SaaS	software applications (e.g., email) accessed by a user via a thin client interface (e.g., web browser, mobile app).
Platform as a Service PaaS	provides a platform (an environment with pre-installed software) allowing customers to develop, run and manage Web applications without the complexity of building and maintaining their own infrastructure typically associated with developing and launching an app.
Infrastructure as a Service IaaS	raw processing power – ability to rent server instances – users get a lot of control over the environment.
Brokers / Value-added Service Providers	Provide support tools to manage deployment and operation in the cloud. They do not own the infrastructure..

Cloud ComputingService Models



Advantages of Cloud Computing

- Elasticity: the resources allocated can be increased or decreased quickly, based on demand.
- Cloud customers can obtain cloud resources in a straightforward fashion.
- Cloud services typically have standardized APIs (application program interfaces).
- Customers are billed for resources as they are used.

Disadvantages to Cloud Computing

- **Lock-in**
  - Interoperability among clouds is not yet at a mature stage
    - Several cloud brokers offer various cross-cloud services (e.g., Dell Cloud Manager)
  - Large amounts of data can be hard to move very efficiently out of the cloud or between cloud vendors
  - Software may be platform-specific
    - until 2011, Google's App Engine only worked with proprietary BigTable non-relational databases (support for SQL added in Oct 2011)
- **IT Strategy**
  - A firm may simply not need a cloud service
  - Government policies may not allow data to be stored abroad

Comparing Architecture Options

- Most systems are built to use the existing infrastructure in the organization, so often the current infrastructure restricts the choice of architecture.
- Each of the architectures discussed has its strengths and weaknesses.
- Client-server architectures are strongly favored on the basis of the cost of infrastructure.
- Cloud computing deserves consideration today.

CREATING AN ARCHITECTURE DESIGN

Applying the nonfunctional requirements

Selecting an Architecture Design

- Lower costs often used to justify choice of client-server

- Recommended selection process:
  - Expand nonfunctional requirement details
  - Base architecture selection on the detailed nonfunctional requirements
    - Operational,
    - Performance,
    - Security, and
    - Cultural/political

Operational Requirements

Requirement	Definition	Example
Technical Environment	Special hardware, software, and network requirements imposed by business requirements	All office locations have always-on network connection permitting real-time database updates
System Integration	The extent to which the system will operate with other systems	The system will read and write to the main inventory database
Portability	The extent to which the system will need to operate in other environments	The system must operate with mobile devices (Android and iOS)
Maintainability	Expected business changes to which the system should be able to adapt	The system must accommodate new manufacturing plants

Performance Requirements

Requirement	Definition	Example
Speed	Time within which the system must perform its function	Network transaction response time <= 4 seconds
Capacity	Total and peak number of users and the volume of data expected	Maximum of 2000 simultaneous users at peak use times
Availability and Reliability	Extent to which the system will be available to the users and the permissible failure rate due to errors	99% uptime performance

Security Requirements

Requirement	Definition	Example
System Value Estimates	Estimated business value of the system and its data	A complete loss of all system data would cost $20 million
Access Control	Limitations on who can access what data	Inventory item changes can be made only by managers for items in their own department
Encryption and Authentication	Defines what data will be encrypted where and whether authentication will be needed for user access	Data will be encrypted from the user's computer to the Web site to provide secure ordering
Virus Control	Controls to limit viruses	All uploaded files will be checked for viruses before being saved in the system

Cultural/Political Requirements

Requirement	Definition	Example
Multilingual	The language(s) the system users will need	The system will operate in English, French, and Spanish
Customization	Specification of what aspects of the system can be changed by local users	Country managers will be able to define new fields in the product database to capture country-specific information
Making Unstated Norms Explicit	Explicitly stating assumptions that differ from country to country	All weights will be stated in pounds and in kilograms
Legal	The laws and regulations that impose system requirements	Personal customer information cannot be transferred from European Union countries to US

Designing the Architecture

- Technical environment requirements, driven by business requirements, often define the application architecture.

- If not, other nonfunctional requirements become important.

Nonfunctional Requirements and the Architecture Design

Requirements	Server-Based	Thin Client-Server	Thick Client-Server
Operational Requirements			
System Integration Requirements	✓	✓	✓
Portability Requirements		✓	
Maintainability Requirements	✓	✓	

HARDWARE SOFTWARE SPECIFICATION

Outlining needs in new system

HW/SW Specification Purpose

- Used if new hardware or software must be purchased
- Communicates project needs
- Actual acquisition of hardware and software may be done by a purchasing department -- especially in larger firms.

Sample HW/SW Specification

	Standard Client	Standard Web Server	Standard Application Server	Standard Database Server
Operating System	• Windows 7 Pro	• Linux	• Linux	• Linux
Special Software	• Real Audio • Adobe Acrobat Reader	• Apache	• Java	• Oracle
Hardware	• 500-GB disk drive • Intel®-Core™ i3-4130 dual core processor • 22-inch LCD Monitor	• 500-GB disk drive • Quad-core Xeon	• 500-GB disk drive • Six-core Xeon	• 1-TB disk drive • RAID • Eight core Xeon
Network	• Always-on Broad-band, preferred • Dial-up at 56 Kbps, possible with some performance loss	• Dual 100 Mbps Ethernet	• Dual 100 Mbps Ethernet	• Dual 100 Mbps Ethernet

DEMONSTRATION DRAWING NETWORK DIAGRAMS

- A chain of sporting goods stores has its headquarters is in Las Vegas with has 27 locations throughout Nevada, Utah, and Arizona. Stores will be linked to one of three regional servers, and the regional servers will be linked to corporate headquarters in Las Vegas. The regional servers also link to each other. Each retail store will be outfitted with similar configurations of two PC-based point-of-sale terminals networked to a local file server.