CHAPTER 12
SYSTEM DESIGN
### Chapter Twelve: Systems Design

- Describe the design phase in terms of your information building blocks.
- Identify and differentiate between several systems design strategies.
- Describe the design phase tasks in terms of a computer-based solution for an in-house development project.
- Describe the design phase in terms of a computer-based solution involving procurement of a commercial systems software solution.
System Design

**Systems design** – the specification of a detailed computer-based solution.

– Also called **physical design**.

– Where systems analysis emphasizes the business problem, systems design emphasizes the technical or implementation concerns of the system.
System Design Approaches

• Model-Driven
  – Modern structured design
  – Information engineering
  – Prototyping
  – Object-oriented
• RAD
• JAD
Model-driven strategy – a system design approach that emphasizes drawing system models to document technical and implementation aspects of a system.

Modern structured design – a system design technique that decomposes the system’s processes into manageable components.

- Synonyms (although technically inaccurate) are top-down program design and structured programming.
- Design in a top-down hierarchy of modules
- Easier to implement and maintain (change).
- Modules should be highly cohesive
  - Accomplish one function only
- Modules should be loosely coupled
  - Minimally dependent on one another
Model-Driven Approaches – Information Engineering

Information engineering (IE) – a model-driven and data-centered, but process-sensitive technique for planning, analyzing, and designing information systems. IE models are pictures that illustrate and synchronize the system’s data and processes.

– The primary tool of IE is a data model diagram.
Prototype – a small-scale, incomplete, but working sample of a desired system

The prototyping approach is an iterative process involving a close working relationship between the designer and the users.

Key Benefits:
- Encourages and requires active end-user participation.
- Iteration accommodates end-users who tend to change their minds.
- Endorses philosophy that end-users won’t know what they want until they see it.
- Active model that end-users can interact with.
- Errors can be detected earlier.
- Can increase creativity as it allows for quicker user feedback.
- Accelerates several phases of the life cycle.
Disadvantages and Pitfalls:

- Encourages “code, implement, and repair” life cycle that cause maintenance nightmares.
- Still need systems analysis phases, but so easy to skip.
- Cannot completely substitute a prototype for a paper specification (like architect without a blueprint).
- Numerous design issues are not addressed by prototyping.
- Often leads to premature commitment to a design (usually the first).
- Scope and complexity of the system can expand out of control.
- Can reduce creativity in designs (implementation can drive out analysis).
- Often suffer from slower performance because of language considerations (rapidly becoming a non-issue).
Prototype screen

Members

Status:
- Dropped
- Frozen
- Good Standing
- Inactive
- Probation

Member Number: 100003

Address Information

Name: Jeff Whitten
Street Address: 129 Rural Route 6
City: Fowler
State: IN
Zip Code: 47756-3333
Area Code: 319
Phone: 789-3333

Credit Card Type:
- American Express
- Discover
- Mastercard
- Visa

Card Number: 5424-9981-2919-2912
Expiration Date: 2/2/96

Balance: $495.22
Bonus Balance: 1
Model-Driven Approaches – Object-Oriented Design

**Object-oriented design (OOD)** techniques are used to refine the object requirements definitions identified earlier during analysis, and to define design specific objects.

- Extension of object-oriented analysis
- Attempt to eliminate the separation of concerns about data and process.
User selects “new member order” option
Do until no more member orders
User enters member number
If member number valid
    Get current member order header
    Do until no more ordered products
        Get ordered product information
        Get product information
    Display order
Else
    Display error message
    Clear message
Endif

User selects “new member order” option
Start
Start order process
Request member number
New member number
Validate member number
isMember
reportOrder
reportOrderProduct
reportProduct
Clear
Display error message
Display order
Rapid application development (RAD) – a systems design approach that utilizes structured, prototyping, and JAD techniques to quickly develop systems.

- The merger of various structured techniques to accelerate systems development
  - Data-driven information engineering
  - Prototyping
  - Joint application development
Joint Application Development (JAD) is a technique that complements other systems analysis and design techniques by emphasizing participative development among system owners, users, designers, and builders.

During the JAD sessions for systems design, the systems designer will take on the role of facilitator for possibly several full-day workshops intended to address different design issues and deliverables.
System Design Tasks For In-House Development
<table>
<thead>
<tr>
<th>System Design Tasks For In-House Development (Build)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Design the Application Architecture</td>
</tr>
<tr>
<td>– Defines the technologies to be used by (and used</td>
</tr>
<tr>
<td>to build) one, more, or all information systems.</td>
</tr>
<tr>
<td>– Revise models as physical models (e.g. Physical</td>
</tr>
<tr>
<td>Data Flow Diagram)</td>
</tr>
<tr>
<td>• Design the System Databases</td>
</tr>
<tr>
<td>– Database schema</td>
</tr>
<tr>
<td>– Optimized for implementation DBMS</td>
</tr>
<tr>
<td>• Design the System Interface</td>
</tr>
<tr>
<td>– Input, output, and dialogue specifications</td>
</tr>
<tr>
<td>– Prototypes</td>
</tr>
<tr>
<td>• Package Design Specifications</td>
</tr>
<tr>
<td>– Specifications to guide programmers</td>
</tr>
<tr>
<td>• Update Project Plan</td>
</tr>
</tbody>
</table>
## Member Response to Video Title Selection of the Month

### Table of Member Responses

<table>
<thead>
<tr>
<th>Category</th>
<th>Potential Orders</th>
<th>Selection of the Month</th>
<th>Alternate Selection</th>
<th>Selection of Month + Alternatives</th>
<th>Number of Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Adventure</td>
<td>6342</td>
<td>2410</td>
<td>634</td>
<td>241</td>
<td>2916</td>
</tr>
<tr>
<td>Animated</td>
<td>3577</td>
<td>1538</td>
<td>644</td>
<td>154</td>
<td>1241</td>
</tr>
<tr>
<td>Comedy</td>
<td>964</td>
<td>181</td>
<td>33</td>
<td>18</td>
<td>716</td>
</tr>
<tr>
<td>Documentary</td>
<td>1436</td>
<td>677</td>
<td>45</td>
<td>60</td>
<td>477</td>
</tr>
<tr>
<td>Drama</td>
<td>540</td>
<td>388</td>
<td>54</td>
<td>30</td>
<td>56</td>
</tr>
<tr>
<td>Western</td>
<td>104</td>
<td>9</td>
<td>54</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>Horror</td>
<td>900</td>
<td>99</td>
<td>23</td>
<td>40</td>
<td>2501</td>
</tr>
<tr>
<td>Musical</td>
<td>2019</td>
<td>43</td>
<td>73</td>
<td>289</td>
<td>103</td>
</tr>
<tr>
<td>Science Fiction</td>
<td>4590</td>
<td>2011</td>
<td>699</td>
<td>2200</td>
<td>5329</td>
</tr>
<tr>
<td>Sports</td>
<td>208</td>
<td>208</td>
<td>277</td>
<td>121</td>
<td>387</td>
</tr>
</tbody>
</table>

- **Sum of Potential Orders:** 19010
- **Sum of Selection of the Month:** 17812
- **Sum of Alternate Selections:** 2956
- **Sum of Selection of the Month + Alternatives:** 3510
- **Total Number of Orders:** 13719
Dialogue Interface Prototype Screen

Welcome to the Soundstage Entertainment Club

Today's Statistics
Number of users: 4
Orders Processed: 1956
Customers: 2509

Member Services System

File  Edit  Reports  Operations  Maintenance  Help

User  Rick
Privileges  Manager

Operations
- Orders
- Memberships
- Video Titles
- Audio Titles
- Game Titles
- Promotions
- Clubs

Maintenance
- Backup Database
- Restore Database
- System Users

System Options
- Help
- Exit and Logoff

7/10/96 9:48 AM
 Context Of System Design For “Buy” Solutions To Projects
Tasks for Procurement Phase
• *Magazines and journals*

• *Internal standards* may exist for hardware and software selection.

• *Information services* are primarily intended to constantly survey the marketplace for new products and advise prospective buyers on what specifications to consider.

• *Trade newspapers and periodicals* offer articles and experiences on various types of hardware and software that you may be considering.
Solicit Proposals (or Quotes) From Vendors

Request for Proposals (RFP) – used to communicate requirements and desired features to prospective vendors. Several different vendors and/or products are candidates. They will respond with a proposal.

Request for Quotations (RFQ) – used when you have already decided on a specific product that can be acquired from multiple sources. They respond with a price quotation.
Typical Outline for Request For Proposal (RFP)

I. Introduction
   A. Background
   B. Brief summary of needs
   C. Explanation of RFP document
   D. Call for action on part of vendor

II. Standards and instructions
   A. Schedule of events leading to contract
   B. Ground rules that will govern selection decision
      1. Who may talk with whom and when
      2. Who pays for what
      3. Required format for a proposal
      4. Demonstration expectations
      5. Contractual expectations
      6. References expected
      7. Documentation expectations

III. Requirements and features
   A. Hardware
      1. Mandatory requirements, features, and criteria
      2. Essential requirements, features, and criteria
      3. Desirable requirements, features, and criteria
   B. Software
      1. Mandatory requirements, features, and criteria
      2. Essential requirements, features, and criteria
      3. Desirable requirements, features, and criteria
   C. Service
      1. Mandatory requirements
      2. Essential requirements
      3. Desirable requirements

IV. Technical questionnaires

V. Conclusion
Validate Vendor Claims and Performances

- Review vendor proposals and eliminate any that does not meet all mandatory requirements.
- Validate the vendor claims and promises against validation criteria.
  - User References
  - Technical Manuals
  - Demonstrations
Evaluate and Rank Vendor Proposals

• Feasibility assessment
• Scoring system
  – **Hard-dollar costs** – you will have to pay to the selected vendor.
  – **Soft-dollar costs** – additional costs you will incur if you select a particular vendor (to overcome a shortcoming, etc.)
Award Contract and Debrief Vendors

- Negotiate contract with selected vendor.
- Debrief vendors that submitted losing proposals.
  - Not to offer a second chance.
  - But to inform them of precise weaknesses in their proposals and/or products.
Impact of Buy Decision on Remaining Life-Cycle Phases

- Must integrate or interface the new system to other existing systems.

- Decision Analysis
  - Make revisions in models to reflect purchased solution.
  - Implement purchased solution.
  - Integration problems lead to revised business requirements statements.

- Design
  - Technical specification for a subset of programs to integrate purchased and built solutions.
CHAPTER

13

APPLICATION ARCHITECTURE AND MODELING
Chapter 13  Application Architecture & Modeling

- Define an information system’s architecture in terms of KNOWLEDGE, PROCESSES, and COMMUNICATION—the building blocks of all information systems. Consistent with modern trends, these building blocks will be distributed across a network.
- Differentiate between logical and physical data flow diagrams, and explain how physical data flow diagrams are used to model an information system’s architecture.
- Describe both centralized and distributed computing alternatives for information system design, including various client/server and Internet-based computing options.
- Describe database and data distribution alternatives for information system design.
- Describe user and system interface alternatives for information system design.
- Describe various software development environments for information system design.
- Describe strategies for developing or determining the architecture of an information system.
- Draw physical data flow diagrams for an information system’s architecture and processes.
Application Architecture – a specification of the technologies to be used to implement information systems. The blueprint to communicate the following design decisions:

- The degree to which the information system will be centralized or distributed.
- The distribution of stored data.
- The implementation technology for software developed in-house.
- The integration of commercial off-the-shelf software.
- The technology to be used to implement the user interface.
- The technology to be used to interface with other systems.
Physical data flow diagram (DFDs) – a process model used to communicate the technical implementation characteristics of an information system.

- Communicate technical choices and other design decisions to those who will actually construct and implement the system.
- Recall from Chapter 9 that DFDs are a type of process model.
Sample Physical Data Flow Diagram

This diagram is intentionally incomplete and oversimplified.
Physical Processes

**Physical process** – either a *processor*, such as a computer or person, or a technical implementation of specific work to be performed, such as a computer program or manual process.

- Logical processes may be assigned to physical processors such as PCs, servers, mainframes, people, or devices in a network. A physical DFD would model that network structure.
- Each logical process requires an implementation as one or more physical processes. Note that a logical process may be split into multiple physical processes:
  - To define those aspects that are performed by people or computers.
  - To define those aspects to be implemented by different technologies.
  - To show multiple implementations of the same process.
  - To add processes for exceptions and internal control (e.g., security).
<table>
<thead>
<tr>
<th>ID (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Verb</td>
</tr>
<tr>
<td>+</td>
</tr>
<tr>
<td>Noun or Object Phrase</td>
</tr>
<tr>
<td>Implementation</td>
</tr>
</tbody>
</table>
### Samples of Physical Processes

<table>
<thead>
<tr>
<th>Logical Process</th>
<th>Sample Physical Process Implementations</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td>Acct Clerk</td>
<td>COBOL/CICS</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Check Customer Credit</td>
<td>Check Customer Credit</td>
</tr>
<tr>
<td></td>
<td>Quickbooks</td>
</tr>
</tbody>
</table>
Possible Computer Process Implementations

• A purchased application software package
  – Also called *commercial off-the-shelf (COTS) software*

• A system or utility program
  – Such as an e-mail/message server or third-party framework

• An existing application program from a program library
  – May require modification

• A program to be written
### Physical Data Flows

A physical data flow represents any of the following:

- The planned implementation of an input to, or output from a physical process.
- A database command or action such as create, read, update, or delete.
- The import of data from, or the export of data to another information system across a network.
- The flow of data (variables and parameters) between to modules or subroutines (represented as physical processes) in a program.
## Sample Physical Data Flows

<table>
<thead>
<tr>
<th>Logical Data Flow</th>
<th>Implementation</th>
<th>Sample Physical Data Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order</td>
<td>Computer Input (Keyboard)</td>
<td>WIN 2000 GUI: Order Form</td>
</tr>
<tr>
<td>Order</td>
<td>Computer Input (Internet)</td>
<td>HTML: Order Form</td>
</tr>
<tr>
<td>Product Sold</td>
<td>Computer Input (Keyless)</td>
<td>BAR CODE: Product UPC</td>
</tr>
<tr>
<td>Hours Worked</td>
<td>Computer Input (Batch File)</td>
<td>KEY-TO-DISK: Hours Worked</td>
</tr>
<tr>
<td>Salary Equity Analysis</td>
<td>Computer Output (Printed)</td>
<td>PRINTOUT: Salary Equity Report</td>
</tr>
<tr>
<td>Account History</td>
<td>Computer Output (On-Line)</td>
<td>WIN 2000 GUI: Account History</td>
</tr>
<tr>
<td>Create Order</td>
<td>Create a record in a database</td>
<td>SQL Insert: New Order</td>
</tr>
</tbody>
</table>
Sample Physical Data Flows (continued)

- Unfilled Orders → Read records in a database → SQL Select: Unfilled Orders
- Update Credit rating → Update a record in a database → SQL Update: Credit Rating
- Delete Employee → Delete a record in a database → SQL Delete: Employee
- Insurance Accident Claim → Import a data file → IMAGE FILE: Insurance Accident Claim
- Schedule of Classes → Export a data file → Comma Delimited File: Schedule of Classes
- Extended Cost → Pass data between modules of a program → Extended Cost
- Course Request → Pass a manual form → Form 23: Course Request
Physical External Agents and Data Stores

Physical external agents are carried over from the logical DFD models.

– If scope changes, the logical models should be changed before the physical models are drawn.

A physical data store represents the planned implementation of one of:

– A database
– A table in a database
– A computer file
– A tape or media backup of anything important
– A temporary file or batch
– Any type of noncomputerized file
Physical Data Store Notation

<table>
<thead>
<tr>
<th>ID (opt)</th>
<th>Implementation Method: Data Store Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data Store Name (Implementation Method)</td>
</tr>
</tbody>
</table>
## Physical Data Store Implementations

<table>
<thead>
<tr>
<th>Logical Data Store</th>
<th>Implementation</th>
<th>Physical Data Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resources</td>
<td>A database (multiple tables)</td>
<td>Oracle: Human Resources DB</td>
</tr>
<tr>
<td>Marketing</td>
<td>A database view (subset of a database)</td>
<td>SQL Server: Northeast Marketing DB</td>
</tr>
<tr>
<td>Purchase Orders</td>
<td>A table in a database</td>
<td>MS Access: Purchase Orders</td>
</tr>
<tr>
<td>Accounts Receivable</td>
<td>A legacy file</td>
<td>VSAM File: Accounts Receivable</td>
</tr>
<tr>
<td>Tax Rates</td>
<td>Static data</td>
<td>ARRAY: Tax Table</td>
</tr>
<tr>
<td>Orders</td>
<td>An off-line archive</td>
<td>TAPE Backup: Closed Orders</td>
</tr>
<tr>
<td>Employees</td>
<td>A file of paper records</td>
<td>File Cabinet: Personnel Records</td>
</tr>
<tr>
<td>Faculty/Staff Contact Data</td>
<td>A directory</td>
<td>Handbook: Faculty/Staff Directory</td>
</tr>
<tr>
<td>Course Enrollments By Date</td>
<td>Archived reports (for reuse and recall)</td>
<td>REPORT MGR: Course Enrollment Reports</td>
</tr>
</tbody>
</table>
Distributed versus Centralized Systems

**Distributed system** – a system in which components are distributed across multiple locations and computer networks.

- Accordingly, the processing workload is distributed across multiple computers on the network.

**Centralized systems** – a system in which all components are hosted by a central, multi-user computer.

- Users interact with the system via terminals (or a PC emulating a terminal).
- Virtually all the actual processing and work is done on the host computer.
Why the Trend Toward Distributed Systems?

• Modern businesses are already decentralized (distributed).
• Distributed computing moves information and services closer to the customers and users who need them.
• Distributed computing consolidates the power of personal computers across the enterprise.
• Distributed computing solutions are in general more user-friendly because they use the PC as the user interface processor.
• Personal computers and network servers are less expensive than mainframe computers
  – Though total cost of ownership is at least as expensive
Computing Layers

• **Presentation layer**—the user interface

• **Presentation logic layer**—processing that must be done to generate the presentation, such as editing input data or formatting output data.

• **Application logic layer**—the logic and processing to support business rules, policies, and procedures

• **Data manipulation layer**—to store and retrieve data to and from the database

• **Data layer**—the actual business data
Types of Distributed Computing

- **File Server Solution**: Stored on the File Server
- **Client/Server Solutions**:
  - Distributed Presentation (2 Tier): Stored on the Database Server
  - Distributed Data (2 Tier): Stored on the Database Server
  - Distributed Data & Application (N Tier): Stored on the Database Server
- **Network Computing Solution**: Stored on the Database Server

- **Data Layer**
  - Executed on the Client
  - Executed on the Database Server

- **Data Manipulation Layer**
  - Executed on the Client
  - Executed on the Database Server

- **Application Logic Layer**
  - Executed on the Client
  - Executed on the Server

- **Presentation Logic Layer**
  - Executed on the Client
  - Executed on the Client

- **Presentation Layer**
  - Displayed on the Client
  - Displayed on the Client
  - Displayed on the Client
  - Displayed on the Client
  - Displayed from the Web Server
File Server Architecture

Local area network (LAN) – a set of client computers (PCs) connected over a relatively short distance to one or more servers.

File server system – a LAN in which a server hosts the data of an information system.

- All other layers are implemented on the client computers.
- Frequently excessive network traffic to transport data between servers and clients.
- Client must be fairly robust ("fat") because it does most of the work.
- Database integrity can be compromised.
**File Server Architecture**

1. Presentation

2. Request to create, read, update, or delete 1 or more records

3. Entire tables

4. Table Locked Until Client Returns Table

5. Response to request returns entire tables

6. Entire Tables with any Updated Records

7. Updated Tables

8. Unlock Tables

**User**

**Client PC**

**File Server**

**File Server Database** (e.g., MS Access)
Client/Server Architecture — Clients

**Client/server system** — a distributed computing solution in which the presentation, presentation logic, application logic, data manipulation, and data layers are distributed between client PCs and one or more servers.

**Thin client** — a personal computer that does not have to be very powerful because it only presents the user interface to the user.

**Fat client** — a personal computer, notebook computer, or workstation that is typically powerful.
**Client/Server Architecture — Servers**

- **Database server** — a server that hosts one or more databases.
  - Executing all data manipulation commands at the server.

- **Transaction server** — a server that hosts services which ensure that all database updates for a transaction succeed or fail as a whole.

- **Application server** — a server that hosts application logic and services for an information system.

- **Messaging or groupware server** — a server that hosts services for e-mail, calendaring, and other work group functionality.

- **Web server** — a server that hosts Internet or intranet websites.