Zewail City of Science, Technology and Innovation

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CSAI 202 - Fall 2025

Introduction to Database Systems

Supply Chain Management System

ER Diagram Report

(Final Version)

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Chapter 1

Problem Definition

1.1 Overview

The **Supply Chain Management System** is designed to handle the complete lifecycle of product distribution from suppliers to end customers. The system addresses critical challenges in modern supply chain operations through comprehensive digital management.

The system provides an integrated platform that connects multiple stakeholders in the supply chain ecosystem, including suppliers, warehouse managers, sales representatives, and customers. It enables seamless coordination of inventory, orders, shipments, and payments across distributed warehouse locations.

1.2 Key Problems Addressed

The system addresses the following critical business challenges:

1.2.1 Inventory Management

Centralized real-time tracking of product stock levels across multiple warehouse locations with automated reorder point notifications. The system prevents stockouts while avoiding overstock situations that tie up capital.

1.2.2 Order Processing

Streamlined order lifecycle management from customer placement through payment processing to final delivery with status tracking at each stage. This ensures transparency and improves customer satisfaction.

1.2.3 Supplier Coordination

Efficient procurement management with purchase order creation, supplier communication, and delivery tracking for inbound inventory. The system maintains strong supplier relationships through clear communication and timely payments.

1.2.4 Customer Relationship Management

Role-based access control system enabling personalized experiences for different user types while maintaining security and data integrity. Each user type has specific privileges appropriate to their role.

1.2.5 Financial Tracking

Comprehensive payment processing and transaction management for both customer orders and supplier purchases. The system maintains complete financial records for accounting and auditing purposes.

1.2.6 Logistics Management

End-to-end shipment tracking from warehouse dispatch to customer delivery with real-time status updates. This visibility reduces customer inquiries and improves delivery performance.

1.2.7 Communication

Automated notification system keeping all stakeholders informed about relevant events, order updates, and system alerts. Timely notifications improve operational efficiency and customer satisfaction.

1.2.8 Quality Assurance

Customer feedback collection mechanism enabling continuous improvement through ratings and reviews. This feedback helps identify problems and improve products and services.

1.3 System Benefits

The implementation of this system enables businesses to:

- Optimize supply chain operations and reduce operational costs
- Minimize stockouts and overstock situations
- Improve order fulfillment times and customer satisfaction
- Maintain strong relationships with suppliers through efficient procurement
- Generate actionable insights through comprehensive data tracking
- Scale operations across multiple warehouse locations seamlessly

Chapter 2

System Users and Privileges

2.1 Administrator

2.1.1 Description

Administrators have full system access and are responsible for overall system configuration, user management, and strategic oversight.

2.1.2 Privileges

- Full system access and configuration management
- Manage user roles, permissions, and access controls
- View all orders, payments, and financial transactions
- Manage suppliers, contracts, and procurement agreements
- Configure warehouse locations and inventory policies
- Access comprehensive system-wide reports and analytics
- Manage product categories and catalog structure
- System configuration and business rule management

2.2 Warehouse Manager

2.2.1 Description

Warehouse Managers oversee operations at specific warehouse locations, managing inventory levels, processing shipments, and ensuring efficient warehouse operations.

2.2.2 Privileges

- Manage inventory levels at assigned warehouse location
- Process incoming shipments from suppliers

- Update stock quantities and reorder threshold levels
- Create and track outgoing shipments to customers
- View warehouse-specific performance reports
- Manage product storage locations and organization
- Conduct inventory audits and reconciliation

2.3 Customer

2.3.1 Description

Customers are end-users who purchase products through the system. They interact with the e-commerce interface to browse products, place orders, and track deliveries.

2.3.2 Privileges

- Browse complete product catalog with search and filters
- Place orders and add items to shopping cart
- Track order status and shipment progress in real-time
- View complete order history and past transactions
- Make secure payments for purchases
- Provide feedback, ratings, and product reviews
- Receive notifications for order updates and promotions
- Manage personal profile and delivery addresses

2.4 Supplier

2.4.1 Description

Suppliers are external business entities that provide products to the company. They receive purchase orders and fulfill them by delivering products to warehouses.

2.4.2 Privileges

- View purchase orders from the company
- Update order status and shipment tracking information
- Manage supplied product information and specifications
- Receive notifications for new purchase orders

- View payment status for delivered goods
- Update contact and business address information
- Access supplier performance metrics

2.5 Sales Representative

2.5.1 Description

Sales Representatives assist customers with orders, handle inquiries, and provide customer support. They serve as the human interface between the company and customers.

2.5.2 Privileges

- Process customer orders on behalf of clients
- View customer information and purchase history
- Handle customer inquiries and support requests
- Generate sales reports and performance analytics
- Update order statuses and resolve issues
- Access product catalog, pricing, and availability
- Manage customer relationships and communications

Chapter 3

Entities and Descriptions

3.1 User Management Entities

3.1.1 User

Represents all individuals who interact with the system, including administrators, warehouse managers, customers, and sales representatives. This central entity stores authentication credentials, basic user information, and links to role assignments. Each user must have unique login credentials and be assigned to exactly one role that determines their system privileges.

3.1.2 Role

Defines different user types in the system with specific permission sets that determine what actions users can perform. Roles provide a flexible access control mechanism, allowing the system to enforce security policies and ensure users only access features appropriate to their responsibilities. Common roles include Administrator, Warehouse Manager, Customer, Supplier, and Sales Representative.

3.1.3 Customer

Represents end customers who purchase products through the system. This entity extends the User entity with customer-specific information such as delivery addresses, contact preferences, and purchase history. Customers are the primary revenue generators and interact with the system through the e-commerce interface to browse products, place orders, and track shipments.

3.2 Product Management Entities

3.2.1 Product

Represents items available in the supply chain system. Each product contains comprehensive details including name, description, pricing information, and specifications. Products are the core inventory items that flow through the supply chain from suppliers through warehouses to customers. The system tracks each product's availability, location, and movement throughout its lifecycle.

3.2.2 Category

Organizes products into logical groups for easier navigation and management of the product catalog. Categories create a hierarchical structure that helps customers find products efficiently and enables administrators to manage similar products collectively. Examples include Electronics, Clothing, Food Items, etc. Each product belongs to one or more categories.

3.3 Warehouse and Inventory Entities

3.3.1 Warehouse

Represents physical storage locations where inventory is maintained. Each warehouse has a unique identifier, location information, and associated management staff. The system supports multiple warehouses distributed geographically, enabling regional fulfillment and optimized shipping costs. Warehouses serve as the physical nodes in the supply chain network.

3.3.2 Inventory

Tracks the quantity of each product available at specific warehouse locations. This critical entity maintains real-time stock levels, reorder points, and availability information. Inventory records enable the system to prevent stockouts, trigger automatic reordering, and optimize stock distribution across warehouses. Each inventory record links a specific product to a specific warehouse with quantity information.

3.4 Supplier Management Entities

3.4.1 Supplier

Represents external vendors who provide products to the company. Suppliers are business entities that fulfill purchase orders and replenish inventory. The system maintains supplier contact information, business details, supplied products, and performance metrics. Strong supplier relationships are essential for maintaining adequate inventory levels and ensuring product quality.

3.4.2 Purchase Order

Represents orders placed with suppliers to procure products. Purchase orders are formal requests for suppliers to deliver specific quantities of products. The system tracks purchase order status from creation through supplier confirmation, shipment, receipt, and payment. This entity is crucial for managing procurement processes and maintaining inventory levels.

3.5 Order Processing Entities

3.5.1 Order Details

Represents customer orders placed through the system. Each order contains information about products purchased, quantities, pricing, customer details, and order status. Orders flow through multiple stages from placement through payment processing, warehouse fulfillment, shipment creation, and final delivery. This entity is central to the revenue generation process.

3.5.2 Payment

Tracks financial transactions for customer orders. Payment records include transaction amounts, payment methods (credit card, bank transfer, etc.), payment dates, and processing status. The system ensures that orders are only fulfilled after successful payment verification. Payment tracking provides financial accountability and enables reconciliation with bank statements.

3.6 Logistics Entities

3.6.1 Shipment

Represents the delivery of products from warehouses to customers. Shipments connect orders to specific warehouse locations and track the physical movement of goods. The system maintains shipment dates, carriers, tracking numbers, and delivery status. Real-time shipment tracking enhances customer satisfaction by providing visibility into delivery progress.

3.7 Communication and Feedback Entities

3.7.1 Notification

Stores system-generated messages sent to users for various events. Notifications keep stakeholders informed about order updates, shipment tracking, low inventory alerts, payment confirmations, and system events. The notification system supports multiple channels and ensures timely communication with all parties. Notifications enhance user engagement and operational efficiency.

3.7.2 Feedback

Captures customer reviews and ratings for products or orders. Feedback enables quality improvement, helps other customers make informed decisions, and provides valuable insights into product performance and customer satisfaction. The system collects ratings, written reviews, and other feedback metrics that drive continuous improvement initiatives.

Chapter 4

Relationships and Descriptions

4.1 User Management Relationships

4.1.1 assigned (User to Role)

Cardinality: Many-to-One (M:1)

Connects User to Role, representing the assignment of specific roles to users. Each user must be assigned to exactly one role at any time, which determines their access privileges and allowed operations in the system. Roles can be assigned to multiple users. This relationship is fundamental to the system's security model and access control mechanism.

4.2 Order Processing Relationships

4.2.1 places (Customer to Order Details)

Cardinality: One-to-Many (1:M)

Represents a customer placing orders for products through the system. Each customer can place multiple orders over time, but each order is associated with exactly one customer. This relationship tracks the customer's purchase history and enables personalized marketing and customer service.

4.2.2 has (Purchase Order to Payment)

Cardinality: One-to-Many (1:M)

Connects Purchase Orders to Payment records. Each purchase order can have multiple payment installments, while each payment is associated with one specific order. This relationship tracks the financial settlement of procurement transactions with suppliers and ensures proper accounting and reconciliation.

4.2.3 Shipped Via (Order Details to Shipment)

Cardinality: Many-to-Many (M:M)

Represents orders being fulfilled through specific shipments. An order might be split into multiple shipments if items come from different warehouses, and a shipment might consolidate multiple orders going to the same region. This relationship enables flexible logistics management and optimized delivery routing.

4.3 Feedback and Communication Relationships

4.3.1 has (Customer to Feedback)

Cardinality: One-to-Many (1:M)

Connects customers to their feedback submissions. Each customer can provide multiple feedback entries for different orders or products, but each feedback is authored by one customer. This relationship enables tracking of customer satisfaction over time and identification of product quality issues.

4.3.2 has (Feedback to Notification)

Cardinality: One-to-Many (1:M)

Links customer feedback to notification records for tracking and response purposes. When feedback is submitted, notifications may be sent to relevant staff members for review and action. This ensures timely responses to customer concerns and facilitates quality improvement processes.

4.3.3 Receives (User to Notification)

Cardinality: Many-to-Many (M:M)

Represents users receiving system notifications about various events and updates. Multiple users can receive the same notification (e.g., all warehouse managers notified of low stock), and each user receives many notifications over time. This relationship ensures all stakeholders stay informed about relevant system events.

4.4 Product and Inventory Relationships

4.4.1 categorizes (Category to Product)

Cardinality: One-to-Many (1:M)

Represents the classification of products into specific categories. Each product belongs to one primary category, while each category can contain multiple products. This hierarchical organization facilitates product discovery, catalog management, and reporting by product type.

4.4.2 contains (Category to Product)

Cardinality: Many-to-Many (M:M)

Alternative categorization allowing products to belong to multiple categories simultaneously. For example, a smartphone might be in both Electronics and Communication Devices categories. This flexible classification supports multiple navigation paths and improves product discoverability.

4.4.3 stocked in (Product to Warehouse)

Cardinality: Many-to-Many (M:M)

Represents products being stored at specific warehouse locations. The same product can be stocked in multiple warehouses to enable regional fulfillment, and each warehouse stocks many different products. This relationship is materialized through the Inventory entity which tracks quantities.

4.4.4 contains (Warehouse to Inventory)

Cardinality: One-to-Many (1:M)

Represents the inventory records maintained at each warehouse location. Each warehouse has many inventory records (one per product stocked), and each inventory record belongs to one warehouse. This relationship enables warehouse-specific inventory management and stock level monitoring.

4.5 Supplier Relationships

4.5.1 Supplies (Supplier to Product)

Cardinality: Many-to-Many (M:M)

Represents suppliers providing specific products to the company. Suppliers typically offer multiple products, and products may be sourced from multiple suppliers for reliability and competitive pricing. This relationship tracks the supplier catalog and enables procurement decisions based on pricing, quality, and delivery terms.

4.5.2 Receives (Supplier to Purchase Order)

Cardinality: One-to-Many (1:M)

Represents suppliers receiving purchase orders from the company. Each supplier receives multiple purchase orders over time, and each purchase order is sent to one supplier. This relationship manages the procurement process and tracks order fulfillment by suppliers.

Chapter 5

ER Diagram

5.1 Entity-Relationship Overview

This section shows all entities and their relationships without displaying entity attributes. Relationship attributes (if any) are shown on the relationship lines. This provides a high-level view of the system structure and how different components interact.

5.1.1 Simplified Overview (No Attributes)

This diagram shows only the entity names and their relationships, providing a clear view of the system architecture.

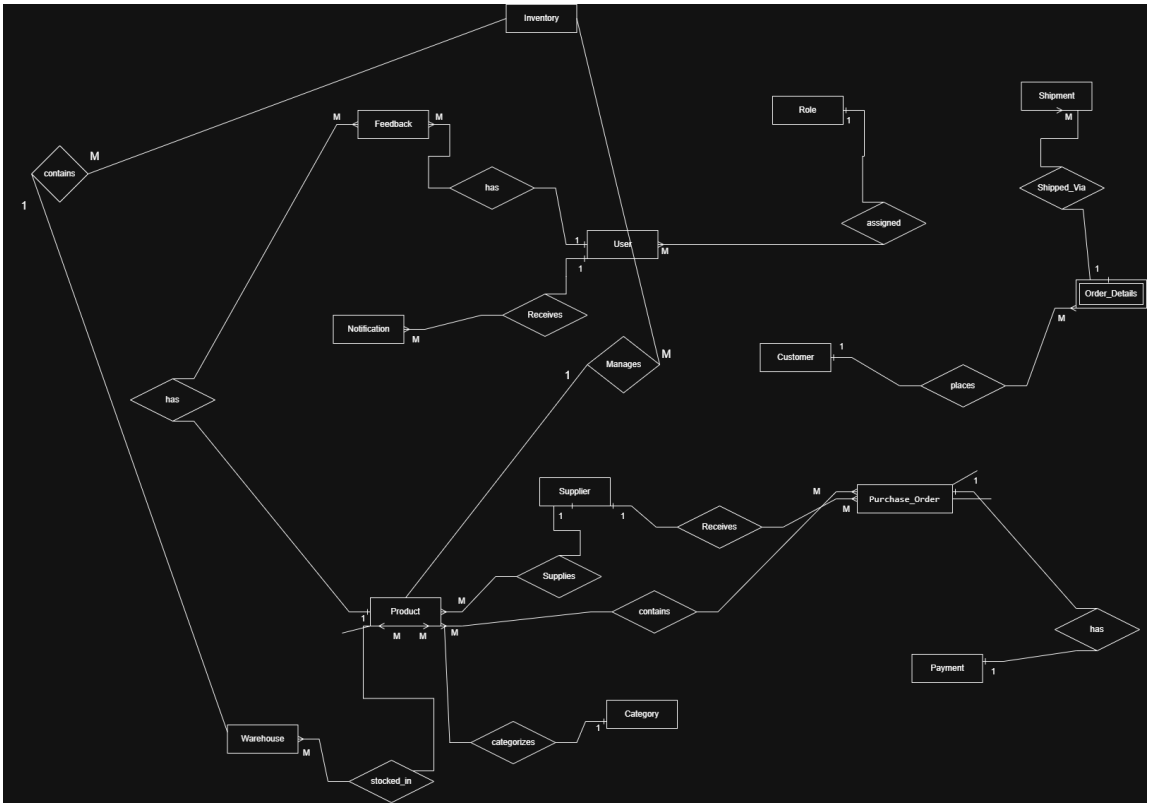

Figure 5.1: Entity-Relationship Diagram - Simplified Overview (Entities and Relationships Only)

5.1.2 Complete Diagram (With Attributes)

This diagram shows the complete entity-relationship model including all entity attributes, providing detailed insight into the data structure.

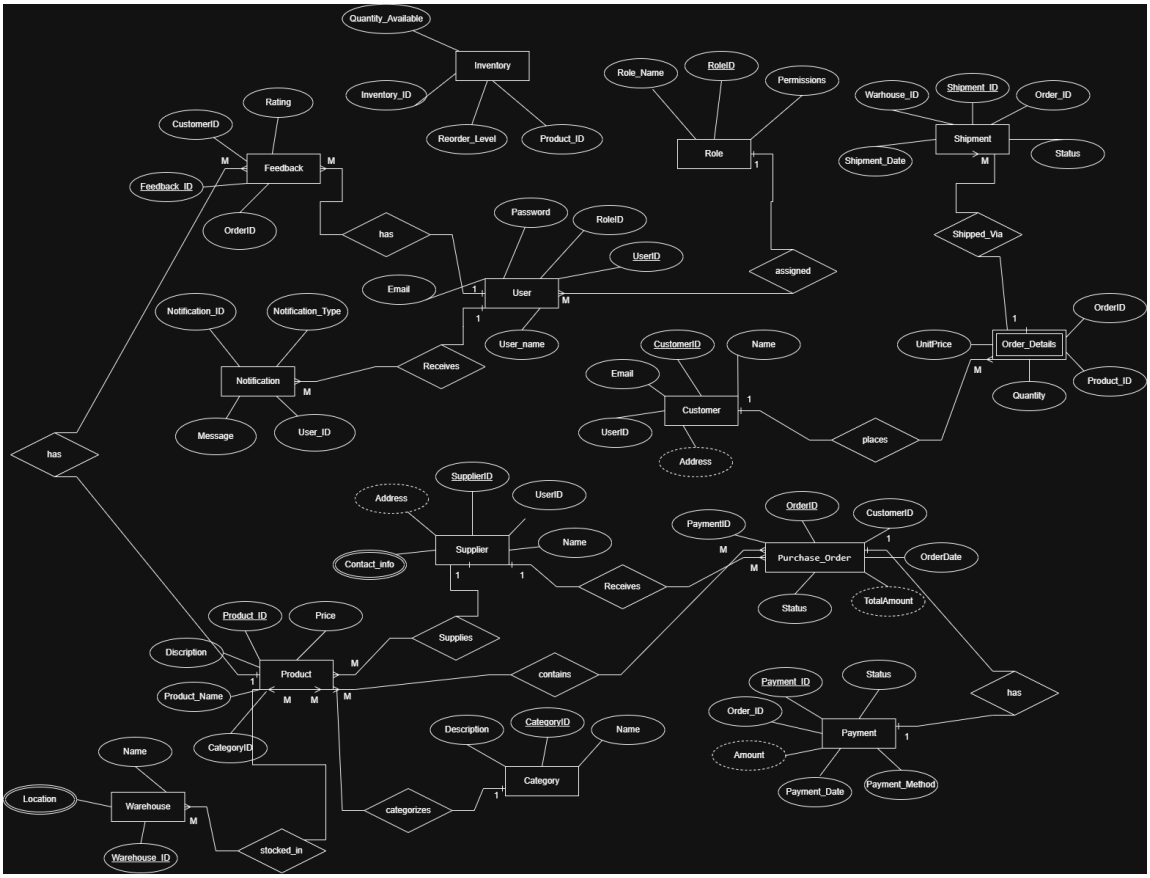

Figure 5.2: Entity-Relationship Diagram - Complete with Attributes

5.2 Entity Attributes

The following sections detail the attributes of each entity in the system.

5.2.1 User Management Entities

Attribute	Type	Description
User Entity		
UserID	Integer	Primary Key, unique identifier
User_name	Varchar(100)	Display name for the user
Email	Varchar(150)	Unique email address
Password	Varchar(255)	Encrypted password hash
RoleID	Integer	Foreign Key to Role table

Role Entity		
RoleID	Integer	Primary Key, unique identifier
Role_Name	Varchar(50)	Name of the role
Permissions	Text	JSON or serialized permission list

Customer Entity		
CustomerID	Integer	Primary Key, unique identifier
UserID	Integer	Foreign Key to User table
Name	Varchar(100)	Customer full name
Email	Varchar(150)	Contact email
Address	Text	Delivery address

Table 5.1: User Management Entity Attributes

5.2.2 Product Management Entities

Attribute	Type	Description
Product Entity		
Product_ID	Integer	Primary Key, unique identifier
Product_Name	Varchar(200)	Name of the product
Description	Text	Detailed product description
Price	Decimal(10,2)	Unit price
CategoryID	Integer	Foreign Key to Category

Category Entity		
CategoryID	Integer	Primary Key, unique identifier
Name	Varchar(100)	Category name
Description	Text	Category description

Table 5.2: Product Management Entity Attributes

5.2.3 Inventory and Warehouse Entities

Attribute	Type	Description
Warehouse Entity		
Warehouse_ID	Integer	Primary Key, unique identifier
Location	Varchar(200)	Physical address

Attribute	Type	Description
Name	Varchar(100)	Warehouse name or identifier

Inventory Entity		
Inventory_ID	Integer	Primary Key, unique identifier
Product_ID	Integer	Foreign Key to Product
Warehouse_ID	Integer	Foreign Key to Warehouse
Quantity_Available	Integer	Current stock quantity
Reorder_Level	Integer	Minimum stock threshold

Table 5.3: Inventory and Warehouse Entity Attributes

5.2.4 Supplier Management Entities

Attribute	Type	Description
Supplier Entity		
SupplierID	Integer	Primary Key, unique identifier
Name	Varchar(150)	Supplier company name
Contact_Info	Varchar(200)	Phone or email contact
Address	Text	Business address
UserID	Integer	Foreign Key to User

Purchase Order Entity		
OrderID	Integer	Primary Key, unique identifier
SupplierID	Integer	Foreign Key to Supplier
CustomerID	Integer	Foreign Key to Customer
OrderDate	DateTime	Date order was placed
Status	Varchar(50)	Current order status
TotalAmount	Decimal(12,2)	Total order value
PaymentID	Integer	Foreign Key to Payment

Table 5.4: Supplier Management Entity Attributes

5.2.5 Order and Payment Entities

Attribute	Type	Description
Order Details Entity		
OrderID	Integer	Primary Key, unique identifier
CustomerID	Integer	Foreign Key to Customer
UnitPrice	Decimal(10,2)	Price per unit
Quantity	Integer	Number of items ordered
Product_ID	Integer	Foreign Key to Product

Payment Entity		
Payment_ID	Integer	Primary Key, unique identifier

Attribute	Type	Description
Order_ID	Integer	Foreign Key to Order
Amount	Decimal(12,2)	Payment amount
Payment_Date	DateTime	Date of payment
Payment_Method	Varchar(50)	Method used (card, bank, etc.)
Status	Varchar(50)	Payment status

Table 5.5: Order and Payment Entity Attributes

5.2.6 Shipment and Communication Entities

Attribute	Type	Description
Shipment Entity		
Shipment_ID	Integer	Primary Key, unique identifier
Order_ID	Integer	Foreign Key to Order_Details
Warehouse_ID	Integer	Foreign Key to Warehouse
Shipment_Date	DateTime	Date of shipment dispatch
Status	Varchar(50)	Current shipment status

Notification Entity		
Notification_ID	Integer	Primary Key, unique identifier
User_ID	Integer	Foreign Key to User
Message	Text	Notification message content
Notification_Type	Varchar(50)	Type of notification
OrderID	Integer	Related order (if applicable)

Feedback Entity		
Feedback_ID	Integer	Primary Key, unique identifier
CustomerID	Integer	Foreign Key to Customer
Rating	Integer	Rating score (1-5)
OrderID	Integer	Foreign Key to Order_Details

Table 5.6: Shipment and Communication Entity Attributes

Chapter 6

Assumptions and Restrictions

6.1 System Assumptions

1. **User Role Assignment:** Each user must be assigned to exactly one role at any given time. Role changes are tracked through audit logs but users cannot simultaneously hold multiple roles.

2. **Supplier-Product Relationship:** Products can be supplied by multiple suppliers to ensure competitive pricing and supply reliability. Similarly, suppliers can provide multiple products from their catalog.

3. **Warehouse Distribution:** A warehouse can store multiple products, and the same product can be stored in multiple warehouses to enable regional fulfillment and reduce shipping times.

4. **Order Composition:** Each order is placed by one customer but can contain multiple products with different quantities. Orders are atomic transactions processed as single units.

5. **Payment Processing:** Payments are processed per order with one payment record per order. Partial payments and payment plans are not supported in the current system design.

6. **Shipment Origin:** Shipments are dispatched from a single warehouse per order. If products come from multiple warehouses, the system creates separate shipments.

7. **Notification Distribution:** Notifications can be sent to multiple users for the same event (e.g., low inventory alerts sent to all warehouse managers).

8. **Feedback Timing:** Customers can provide feedback only after receiving their orders and the order status is marked as "Delivered."

9. **Inventory Management:** Inventory levels are maintained separately for each product at each warehouse. Stock transfers between warehouses are tracked as separate transactions.

10. **Automatic Reordering:** When inventory falls below the reorder level threshold, the system automatically generates purchase order recommendations for warehouse managers to review and approve.

11. **Order Status Workflow:** Orders follow a sequential status workflow: Pending, Confirmed, Processing, Shipped, Delivered. Each status change triggers appropriate notifications.

12. **Data Retention:** Historical data including past orders, payments, and shipments are retained indefinitely for reporting and audit purposes.

6.2 System Restrictions

1. **Unique Identifiers:** UserID, CustomerID, ProductID, and all primary keys must be unique and auto-incremented. No duplicate identifiers are permitted.

2. **Email Uniqueness:** Email addresses must be unique across all users in the system to prevent authentication conflicts and ensure proper communication.

3. **Positive Values:** Product prices, payment amounts, and order totals must be positive decimal values greater than zero.

4. **Non-Negative Inventory:** Inventory quantities cannot be negative. The system prevents orders that would result in negative stock levels.

5. **Date Validity:** Order dates, payment dates, and shipment dates must be valid dates and cannot be in the future relative to the transaction time.

6. **Payment Matching:** Payment amounts must exactly match order total amounts. Partial payments require order splitting into multiple orders.

7. **Chronological Ordering:** Shipment dates must be on or after order dates. Delivery dates must be on or after shipment dates.

8. **Rating Range:** Feedback ratings must be within a defined scale of 1 to 5 stars. Ratings outside this range are rejected.

9. **Referential Integrity:** A user cannot be deleted if they have associated orders, payments, or other transactions. Cascading deletes are restricted to maintain data integrity.

10. **Warehouse Prerequisites:** Warehouse locations must be specified and activated before inventory can be added to that warehouse.

11. **Authentication Requirements:** All users must have valid authentication credentials (username and password) meeting minimum security requirements.

12. **Order Minimum:** Orders must contain at least one product with a quantity of at least 1. Empty orders are not permitted.

13. **Supplier Verification:** Suppliers must be verified and approved by administrators before they can receive purchase orders.

14. **Product Activation:** Products must be marked as "active" before they can be included in customer orders. Inactive products remain in the system for historical reference.

15. **Concurrent Modification:** The system implements optimistic locking to prevent concurrent modification conflicts when multiple users update the same records.

Chapter 7

Conclusion

7.1 System Summary

The Supply Chain Management System provides a comprehensive database solution for managing the complete product lifecycle from supplier procurement through warehouse storage to customer delivery. The entity-relationship model captures all essential business entities and their relationships, ensuring data integrity and supporting complex business operations.

7.2 Key Design Decisions

The following design decisions were made to ensure system effectiveness:

- **Role-Based Access Control:** Flexible user management through role assignments enabling appropriate access controls for different user types.
- **Multi-Warehouse Support:** Distributed inventory management across multiple locations to enable regional fulfillment and optimize shipping costs.
- **Supplier Integration:** Comprehensive procurement tracking with multiple supplier support to ensure supply reliability and competitive pricing.
- **Order Lifecycle Management:** Complete tracking from order placement through delivery with status updates at each stage.
- **Real-Time Communication:** Notification system keeping stakeholders informed about relevant events and system updates.
- **Quality Assurance:** Feedback mechanism supporting continuous improvement through customer ratings and reviews.
- **Financial Tracking:** Comprehensive payment processing and transaction management for accountability and auditing.
- **Scalability:** Database design supports business growth through distributed warehouses and flexible product catalog management.

End of Report