Course Project

This course project was created by professor S.P. Saraswat and is to be completed with Visible Analyst Workbench Computer Assisted Systems Engineering (CASE) tool as announced in the class. Guidelines for completing and submitting different assignments of the project will be provided in the class, and your assignments will be graded for clarity, correctness, detail, organization, and presentation format. You can make any reasonable assumptions to complete these assignments, within the framework of the situation context. These assumptions must be discussed with the instructor and clearly stated in each assignment submitted for grade. The work done by you on each assignment will be needed for the subsequent assignments. It is, therefore, absolutely necessary for you to keep a copy of your work on a floppy disk, as a back-up for your project. THIS PROJECT REQUIRES A CONSIDERABLE AMOUNT OF TIME OUTSIDE THE CLASSROOM.

Only hard copies of diagrams will be accepted for grading.
If you need help on your diagram, please bring it on a floppy disk or bring your laptop with you.

SITUATION CONTEXT:

Nandini Enterprises, Inc., a small mail order supplier of computers and electronic equipment, was established in Natick, Massachusetts, in 1995. In six years, Nandini has acquired a permanent customer base of 1500 corporate and individual customers, and has experienced an average annual sales growth of 34%. Its supplier base, which currently consists of 98 established suppliers, located mainly in New England, has also been growing steadily.

In its basic operations, Nandini orders personal computers and electronic equipment from its suppliers, stocks them in a warehouse, and ships them to its customers located primarily in New England and New York. Customers normally send their orders and related information by phone or fax, but they can also walk in Nandini’s office and place an order. The shipment of items currently in stock is guaranteed within 24 hours after a customer order has been received, registered, and verified. If some items are not available in the stock, the customers are so advised and the unavailable items are ordered from the suppliers immediately. When the items are shipped to the customer, an invoice is sent with the shipment. In case of partial shipment of a customer order, an advisory memorandum is sent to the customer indicating that the items have been ordered by Nandini from its suppliers and will be shipped to the customer within a reasonable period of time. Upon receiving their shipments, customers generally send their payments by check. These payments can also be made by a credit card, in case of telephone orders. Cash or credit cards are accepted for orders directly placed in the office and a receipt is
given to the customer. The receipts for the payments received in the mail are sent to the customers by mail. Nandini’s inventory is continuously monitored and appropriate levels of stock are maintained for items frequently ordered by customers. At the reorder point, orders are sent to the suppliers for various items, and when shipments arrive, the inventory information is immediately updated. Inventory adjustments are also made when the items are shipped to the customers from the warehouse.

Nandini’s enterprise information system is based on personal computers interconnected with a local area network. This system is implemented as a collection of software modules that perform three distinct functions in the organization. The modularized design of the system has made it possible for Nandini to operate and maintain the system satisfactorily with the limited computer expertise currently available in the organization. The Order Processing module contains two processes. The Order Verification process is responsible for registering the order and checking the credit status of the customer. Nandini maintains a comprehensive relational database containing information about customers, suppliers, orders, and inventory. This database is utilized for verification of customer orders and customer credit. Relevant information about new and existing customers is continuously added to this database. The Invoicing process prepares invoices and transmits them to customers, with shipments. This process also prepares and sends to the customer advisory memoranda about partially shipped orders and orders that cannot be shipped due to credit or other problems. Copies of customer invoices are transmitted to the accounts management function for further action. The Accounts Management module of the enterprise information system also contains two processes. The Accounts Receivable process manages the collection of payments from the customers, and the Accounts Payable process is responsible for making timely payments to the suppliers. These processes also update the associated customer and supplier records in the database. The third module of the enterprise information system is Inventory Management. One process in this function, the Purchasing Process, is responsible for sending orders to the suppliers of Nandini. These orders are prepared and sent to Nandini’s suppliers when the stock levels for various items fall below their reorder point, or when a customer orders special items that are generally not stocked in Nandini’s warehouse. This process also updates the database when shipments arrive from Nandini’s suppliers. The Inventory Reporting process of the inventory control module, on the other hand, provides stock-status and other inventory reports to the management of Nandini on a weekly, daily, or as-requested basis.

Although Nandini’s enterprise information system has been functioning without any serious problems, the rapid growth in the company’s sales and other operations has prompted its management to examine whether the existing systems can handle the projected growth for the next five years. Additional modules are planned for implementation in near future, but the management of Nandini is not sure if the existing enterprise information system has the scalability to accommodate the projected needs. You have been hired by Nandini as a systems consultant to analyze the current situation and make some recommendations about the redesign of this system. You have decided to use Visible Analyst Workbench (VAW) as the Computer Assisted Systems Engineering tool for your project. Complete the following assignments according to the guidelines
provided in the class to accomplish your task. Use the stylizing, color, and text enhancement features of Visible Analyst to make your diagrams more readable and attractive.
Assignment 1 (eight sections): [It is important to complete the following sections of the assignment in proper sequence.]

(a) Prepare a functional decomposition diagram (FDD) showing all the functions and processes of Nandini’s enterprise information system. Each software module identified in the situation context constitutes a function in the diagram.

(b) Analyze this diagram and save the error or warning messages generated by VAW.

(c) Create the top-level [Level 0] data flow diagram (DFD) for the system showing only one process. Show only one input, and one output data flow connected to each external entity in the diagram and give appropriate names to these flows indicating their comprehensiveness. [Do not include any data stores in this diagram].

(d) Explode the process in your top-level (level 0) data flow diagram (DFD) to generate the next level of data flow diagram (level 1). Show three processes in this diagram but DO NOT CONNECT the net data flows to the process symbols. Analyze this diagram and print out the error messages. [There is no need to correct the errors at this stage since the diagram is not complete].

(e) Spawn each of the three functions at level 2 in your functional decomposition diagram (FDD) to create new sets of data flow diagrams. Select your level 1 DFD created in the previous step as the parent of the data flow diagrams created in this step. Update your diagrams with each selection.

(f) Again analyze your functional decomposition diagram (FDD), and note down the errors or warnings generated by the system. There should be no errors or warnings if you have successfully completed these steps.

(g) Explode each process shown in your level 1 data flow diagram as follows:

   Explode a process, select the most appropriate existing diagram from the three diagrams spawned in step (e) above, and use the selected diagram as the child diagram for the process you are exploding.

(h) Decompose the process shown in your top-level data flow diagram and create an unstructured process decomposition diagram.

Submit a printed copy of all the diagrams you have created as a report with a title page. Include in your report a printout of the errors and warnings found in steps (b) and (d) above. Attach the diagrams in your report in proper order and identify each diagram with a title on the top.
A detailed examination of the existing order processing operations at Nandini Enterprises revealed the following facts:

**[Hint: use the information in the following paragraph to model the second level data flow diagram. Show only LOCAL data stores in each diagram.]**

All the relevant information for order processing is stored in three data-stores in the relational database. One of these data stores, the Inventory data-store, is used by two modules in the organization. The Inventory Management module accesses this database to update inventory when shipments arrive from the suppliers. On arrival, these shipments are verified against the supplier invoices, which arrive at the Inventory Management module. After the verification and adjustment of inventory, the supplier invoices are sent to the Accounts Management function for payments. A copy of the invoice is also sent to the Order Processing function. Information from the inventory database is also obtained by the Customer Order Processing function to verify the availability of items in the inventory. Orders arriving from Nandini’s customers at the Customer Order Processing function are verified and two copies of customer invoice are prepared. One copy is sent to the customer, and the second copy is sent to the Inventory Management function for inventory updates and shipping of the order. After shipping the order, the Inventory Management function sends a verified copy of the invoice to the Accounts Management function for billing adjustments. The Inventory Management function is responsible for shipping the items to the customers. This function makes appropriate adjustments in the inventory database to reflect the sale and shipment of the items. If the items ordered by a customer are not immediately available, customer orders are partially shipped and an advisory memorandum is sent to the customer by the Customer Order Processing function indicating that the remaining items will be shipped as soon as possible. A purchase requisition is sent by the Order Processing function to the Inventory Management function so that it can order the out-of-stock items from Nandini’s suppliers. The Inventory Management function sends Stock Status reports and Inventory Order Recommendations reports to the managers of Nandini when requested. This function also generates orders sent to Nandini’s suppliers for replenishing the inventory as needed. Payments received from Nandini’s customers directly go to the Accounts Management function, and the payments to Nandini’s suppliers are also directly sent by this function. The Bills of Lading are prepared by the Customer Order Processing function and sent to the shippers. The shippers send their bills to the accounts management process of Nandini for payment.

**[Hint: use the information in the following paragraphs to model the Level 2 (final level) data flow diagrams. Show only LOCAL data stores in each diagram.]**

The two processes of the Customer Order Processing function, order verification and invoicing, perform separate tasks. The orders sent by Nandini’s customers are first received at the order verification process. This process interacts with the customer database to add new customers to it and verify the credit status of existing customers.
From the inventory database, this process receives information about items available in the stock. From this information, the order verification process prepares an advisory memorandum if any items ordered by a customer are not immediately available, and send these memoranda to customers. A purchase requisition is sent by the order verification process to the inventory function to obtain the items not immediately available. The verified order is now transmitted to the invoicing process, which prepares two copies of the invoice as explained in the previous section. The invoicing process prepares the bills of lading and transmits them to the shippers.

The accounts receivable and payable processes of the Accounts Management function interact with the Transaction Database. The accounts payable process obtains information about Nandini’s supplier related transactions from this database, and adjusts the database, in turn, for the payments sent to the suppliers or other entities. This process receives the verified supplier invoice from the Inventory Management function and sends payments to the suppliers. The accounts receivable process, interacts with the transaction database to obtain information about the customer related transactions, and adjusts the database for the payments received from customers. This process receives payments from Nandini’s customers and provides receipts to the customers for their payments.

The purchasing process of the Inventory Management function receives invoices from suppliers and purchase requisitions from the Customer Order Processing function. It prepares and sends orders to Nandini’s suppliers, and verified supplier invoices to the inventory reporting process. The inventory reporting process updates the inventory database with this information and with the copies of the customer invoices received from the Customer Order Processing function. This process also provides inventory related reports to the management of Nandini Enterprises. After adjusting the inventory database, the inventory reporting process sends the verified supplier invoice to the Accounts Management function for appropriate action. It also sends the verified customer invoices to the Accounts Management function after shipping the items to the customers.

Six entities of significance have been identified in the organization, from the point of view of information processing and data management. These entities are: (1) customer, (2) supplier, (3) manager, (4) order, (5) inventory item, and (6) inventory report. A customer can send one or more orders at a time to Nandini Enterprises. An order can contain more than one inventory items, and an inventory item can be listed on more than one order. A supplier can supply many inventory items to Nandini, and an inventory item can be ordered from many suppliers. Each order is sent to only one supplier but a supplier can receive more than one order at the same time from Nandini Enterprises. Managers of Nandini can request one or more reports at the same time, and each report can be provided to many managers.
Assignment 2 (Five sections): [It is important to complete the following sections of the assignment in proper sequence.]

[Hint: For each process in your data flow diagrams, identity the incoming and outgoing data flows from the description in the situations context. Include only those data flows in your diagram that are mentioned in the situation context; do not add any EXTRANEOUS data flows to the diagram.]

(a) With the additional information provided in the situation context, update your Level 1 (next to context level) data flow diagram created in assignment 1. Add appropriate data store(s) to this diagram, split the net data flows, and add appropriate local data flows to model the situation more realistically. Analyze your diagram for inconsistencies, and correct all errors before submitting the assignment.

(b) Modify all Level 2 (the last level for the project) data flow diagrams created in assignment 1 with the additional information in the situation context. Add appropriate data flows and data stores to your model in each of the three levels of diagrams. Analyze your diagrams for inconsistencies and correct all errors before submitting the assignment.

(c) Create an appropriate Entity Relationship Diagram showing all the entities and relationships between them. Analyze your diagram for syntax and normalization, and record the errors generated by VAW. Make some suggestions to correct the inconsistencies identified by VAW?

(d) Submit a printed copy of all data flow diagrams and the entity relationship diagram with your assignment.

(e) Create two repository reports as follows:

Report 1: This report should contain a split flows listing from the data flow diagrams, for the entire project, showing all entry characteristics, with multiple entries per page.

Report 2: This report should contain a detailed listing of only PROCESS entities in the Level 1 (next to the context diagram) data flow diagram, in the alphabetical order, with multiple listings per page.

Attach your reports with the assignment and submit it on the due date with a title page.
...SITUATION CONTEXT ...

When the entity relationship diagram containing the data model was presented to the management of Nandini, it was pointed out that that the model was too complex because too many entities were included in it. Since the entity relationship diagram is a realistic data model, only those entities should be included in it that have corresponding databases either currently existing or planned for future. Only five database entities currently exist in the enterprise. These entities are: Customer, Supplier, Inventory, Transaction, and Price. Among these, the Price entity is actually an associative entity between Supplier and Inventory. It was created to normalize the many-to-many relationship between Supplier and Inventory entities. Since one supplier can supply many inventory items and an inventory item can be supplied by more than one supplier of Nandini, a many-to-many relationship exists between supplier and inventory entities. These relationships are difficult to implement and should be decomposed into one-to-many relationships by introducing associative entities. The customers and suppliers of Nandini are identified by account numbers, and the transaction database contains these number as a foreign key to establish a connection between the transaction database and the supplier and customer databases. Consequently, transaction is also treated as an associative entity in the data model. As usual in business organizations, customers and suppliers can generate many transactions but each transaction is unique to a customer or supplier.

The purchasing process of the inventory management function accesses the supplier database to verify supplier information before sending orders, and update information after receiving shipments. The price database is also frequently used by the inventory management function - both processes. Prices of various items are obtained from the price database by the purchasing process to prepare supplier orders. On the other hand, information in the price database is modified by the inventory reporting process. The order verification process of the customer order processing function uses the customer database to verify customer information.

The following is a listing of some important data items in these data-stores:

(i) **Customer data-store:**

Customer account number (Primary key)
Customer name
Customer address
Credit limit

(ii) **Supplier data-store:**

Supplier account number (Primary key)
Supplier name
Supplier address
(iii) **Transaction data-store**

Transaction number (Primary key)  
Customer account number (Foreign key)  
Supplier account number (Foreign key)  
Transaction date

(iv) **Inventory data-store**:  

Item number (Primary key)  
Item name  
Unit price  
Quantity on hand

(v) **Price data-store**:  

Item number (Primary key; Foreign key)  
Supplier account number (Primary key; Foreign key)  
Supplier price
Assignment 3 (Seven sections): [It is important to complete the following sections of
the assignment in proper sequence. ]

[Hint: In defining database entities in the entity relationship diagrams, the length of key
items should not exceed ten characters.]

(a) Update your data flow diagrams with the additional information provided to you.
Show the supplier, price and other data stores in appropriate diagrams, with properly
labeled data flows connecting them to purchase, reporting and other relevant
processes.

(b) Update your entity relationship diagram with the additional information (showing
only five entities) and create a GLOBAL view of your modified database.

(c) Create a NEW (local) view of your database containing the price entity and all its
associated relationships.

(d) Define all your databases in the repository and enter the data items for each
database in the composition field of the repository. Enter the name, type, length,
and null value possibilities for key fields only.

(e) Perform key analysis to check the consistency of your design, and perform key
synchronization to migrate all the foreign keys to appropriate databases.

(f) Submit a printed copy of your modified diagrams with a one page summary of your
experience.

(g) Create a repository report from your entity relationship diagram, containing a
detailed listing, including all entity types from your main entity relationship diagram
(a single diagram), showing all entry characteristics, sorted by entity type, with
multiple entries per page. Attach your report with the assignment.

The systems analysis team has now created two models of Nandini’s enterprise
information system: a process model and a data model. The process model consists of
the data flow diagrams, and the data model contains entity relationship diagrams. In order
to ensure the correctness of the entire model, the systems analysis team has decided to
“balance” these models for data flows and other requirements. Also, it has been
suggested that an experimental structure chart should be created. This chart will be used
later as a guide to create detailed structure charts for all the processes included in the data
model.

The process selected for the experimental structure chart is the order verification process.
This process contains four subordinate modules. The first module, called customer status
check, receives the customer name from the invoking process and returns the customer account number and a control flag indicating whether the customer is an existing or new customer. After this verification, one of the next two modules is invoked depending on the status of the customer. In the case of the existing customers, the customer account number and order amount are sent to the existing customer module. This module returns a control flag indicating whether the order is approved or not. In the case of new customers, however, the new customer module is invoked. This module adds the customer information to the customer database. Information about new customers is sent to this module by the order verification process and a control flag indicating that the information is added to the customer data base is returned by the new customer module to the order verification process. Finally the fourth module is invoked to check the availability of items. The invoking process passes a list of item numbers to this module and receives a list of the unavailable item numbers in return. Two times a day, the management of Nandini examines all the received orders and approves the orders from new customers. Consequently, it is decided that the order verification process should execute continuously till all the orders in a batch are verified.

With the additional information available in the situation context, complete the following assignments:

Assignment 4 (Four sections):

(a) Create a structure chart from the description provided in the modified situation context; analyze this diagram to ensure its correctness.

(b) Define appropriate length and type (physical characteristics) for each data item in the model.

(c) From the repository menu, run the model balancing option and modify your diagrams to ensure that the model is correctly balanced. The primary keys and other composition of the data stores should match the entities in the ERDs. Set your ERD balancing rules to specify that all fundamental elements must be used on a DFD, and every entity must correspond to a data store.

(d) Submit a printed copy of your (a) structure chart and (b) analysis results (errors or warnings) for grade.

ENHANCEMENTS TO THE SYSTEM:

Nandini Enterprises has decided to modify its operations to include the evolving technologies of electronic commerce and web-based business in its order processing operations. Major modifications need to be made in the existing system to include these technologies. Your task is to redesign this system by including additional functions, processes, entities, data-flows and data-stores in the system.
Based on your findings in the analysis phase as completed in the first three assignments, recommend at least four major design changes and discuss them with your instructor. After the discussion, modify your diagrams by including (in addition to existing items) at least one process at level 2, one external entity, one data-store, and a minimum of two additional data flows in your model. You do not need to modify the existing structure chart or create new structure charts. Show your modifications in the model in a different color, for presentation.

**ASSIGNMENT 5 (Class Presentation):**

Submit a printed copy of all the diagrams (after modifications) with a report containing detailed information about all entities in the model listed separately in alphabetical order.

Make a comprehensive presentation to the class as follows:

- Analyze the entire project to show that no errors exist in the model.
- Display each diagram and explain it.
- Indicate the changes you have made in each diagram and explain how they will improve the system.
- Show that your model properly balances – after modifications.
- Submit a one-page single-spaced written summary of the changes you are recommending in your design.