Homework 2
1.264, Fall 2004
Requirements, software estimation
Due Monday, September 27th
**Group homework**

## A. Overview

In this homework, you will write the system requirements and estimate the resources required to develop an e-commerce system for a chemical manufacturer. The key aspects of the system are:

1. The chemical manufacturer has a single warehouse in which all the chemicals in the catalog are stocked. It has a warehouse management system that stores inventory data on all the chemicals that are in the warehouse. The system provides the quantity on hand and the price of each product.
2. There is a set of freight carriers that the manufacturer uses to ship the chemicals to chemical distributors.
3. There is a set of customers that buy the chemicals; these are the chemical distributors.
4. You will need to create a mechanism to take orders, which can consist of multiple items. Each chemical product will have a quantity ordered and a price. The distributors will pay for the orders via credit card or purchase order.
5. You will need to track the remaining inventory in the warehouse. You may not ship an item that you do not have in stock. You must decide how to handle backorders.

Your application is fairly small; you will build one or two core parts of what an actual business would use, but you will need to understand all the information technologies and software development steps needed to build a full application.

Over the course of the semester's homeworks, you will design and implement the database, configure middleware to allow Web and other applications to connect to your database, and build a Web site that accesses the database and provides a user interface. The last homework will ask you to assess the software development process that you used.

In this homework you will:

1. Write the requirements (10 pages or less) for the system. Requirements are written from the user's perspective and state **what** the system will do. We will then design each part of the system in following homeworks (in design, we say **how** we will build the system), and also build each part.
2. Estimate the size of the system, the person months and schedule months required to complete it. These should be consistent with the time you and your partner have available for this course.

## B. Requirements

You must write a document, no longer than 10 pages, that describes what your chemical e-commerce system will do. This will be difficult, as it always is at the start of a project, because you won't know all the business and engineering processes that must be supported, and you won't be familiar with all the information technologies required to build the system. This is normal.

In this homework, you will write a text description of what your system will do. In the following homework, you will use models (both a data model and a UML model) to make your description more precise. In this homework you are to document:

- the minimum set of features required to support the chemical business
- the assumed business and engineering processes to be followed by the chemical company
- the way that users will interact with the system: an initial sketch of the user interface

You may do this by:

- writing a brief user manual for the system
- writing a text requirement, describing the features, processes and user interface
- writing a set of scenarios to demonstrate what the system would do to process orders, check status, etc.

These are made more explicit in UML diagrams in the next homework.

## C. Problem Statement

You are a manufacturer of chemicals. You receive orders from chemical distributors who provide them to end-users, such as individual manufacturing or processing plants. The chemicals must be available in your warehouse. They are shipped from your warehouse via freight carriers to the distributor that ordered them.

The orders you receive on your Web site include:

1. Distributor name
2. Distributor address to which the order will be shipped
3. Chemical products and quantities ordered. Your Web site must not allow distributors to order more than the available quantity of a chemical.
4. Container type to be used for each chemical product ordered (drum, cylinder, pail or custom).
5. Means of shipment. Your carrier data contains highway (truck), rail, air and water carriers. Virtually all of your orders will use highway. The distributor will specify the mode (truck, rail, air or water); you will choose the actual carrier.
6. Payment information. Credit card number, expiration date, or purchase order.

When you receive an order on your Web site, you will:

1. Add the price of all the chemicals ordered, to obtain a subtotal.

2. Select a freight carrier to ship the order. You must specify how the decision is made.
3. Add 5% sales tax.
4. Compute the total order price.
5. Assign a unique order number.
6. The order is then shipped; this is outside the scope of the homeworks this term.

The data that is available as your build the system includes:

1. Freight carriers. This file contains freight carriers that are certified to carry hazardous materials. (This is the actual USDOT approved carrier file.) Buyers of chemicals often prefer to use these carriers because their safety and handling standards are high. The file contains:
    a. Certificate number. The USDOT carrier certificate number for the freight company, used as a unique identifier.
    b. Company name, address. The name and address of the freight carrier. Many of the 'carriers' are brokers or forwarders. These fields include street, city, state, zip code, country, contact name and phone number. All carriers are in the US (a simplification of the real data).
    c. Mode. This is a 4 digit field (an awkward format) indicating whether the carrier offers
        i. Highway transportation (1 in column 1)
        ii. Rail transportation (1 in column 2)
        iii. Water transportation (1 in column 3)
        iv. Air transportation (1 in column 4)
    d. Chemicals handled. This is a set of fields that indicate, with a Y or N, whether the carrier can handle certain groups of chemicals:
        i. Group A, corresponds to hazmat class 7 (radioactive)
        ii. Group B, corresponds to hazmat class 1 (explosive)
        iii. Group C, corresponds to hazmat classes 2 (gases), 3 (flammable liquids) and 8 (corrosives)
        iv. Group D, corresponds to hazmat classes 4 (flammable or reactive solids), 5 (oxidizers) and 6 (poisons)
        v. Group E, corresponds to hazmat class 9 (not otherwise defined)

The chart shows an example of data in the dataset; the address and group E are omitted to save space here.

| CERT_NO | COMPANY | MODE | GRP_A | GRP_B | GRP_C | GRP_D |
|---|---|---|---|---|---|---|
| 0621998510 | (GESEACO) | 0010 | N | Y | N | N |
| 0514990080 | 0 J & R | 1000 | N | Y | N | N |
| 0602990050 | 0EIS MARKETS | 1000 | N | Y | N | N |
| 0716990030 | 10-4 | 1000 | N | Y | N | N |
| 0608990030 | 1001 S | 1000 | N | N | Y | N |
| 0701999990 | 1049585 | 1000 | N | N | Y | Y |
| 0708999990 | 1050758 | 1000 | N | N | Y | Y |
| 0603990070 | 1226934 | 1000 | Y | N | N | N |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0607990190 | 123 INC | 1000 | Y | Y | Y | Y |
| 0628990010 | 1243465 | 1000 | N | N | N | Y |
| 0623990040 | 1243480 | 1000 | N | Y | N | N |

2. Customer (distributor) data. This is in the same format as the carrier data and contains:
    a. Certificate number. The USDOT "shipper" certificate number for the distributor, used as an identifier to manage hazardous material shipments.
    b. Company name, address. The name and address of the distributor. These fields include street, city, state, zip code, country, contact name and phone number. All customers are in the US (a simplification of the real data).
    c. Mode. This is a 4 digit field (an awkward format) indicating whether the manufacturer can receive shipments by the following mode:
        i. Highway transportation (1 in column 1)
        ii. Rail transportation (1 in column 2)
        iii. Water transportation (1 in column 3)
        iv. Air transportation (1 in column 4)
    d. Chemicals handled. This is a set of fields that indicate, with a Y or N, whether the distributor can handle certain groups of chemicals:
        i. Group A, corresponds to hazmat class 7 (radioactive)
        ii. Group B, corresponds to hazmat class 1 (explosive)
        iii. Group C, corresponds to hazmat classes 2 (gases), 3 (flammable liquids) and 8 (corrosives)
        iv. Group D, corresponds to hazmat classes 4 (flammable or reactive solids), 5 (oxidizers) and 6 (poisons)
        v. Group E, corresponds to hazmat class 9 (not otherwise defined)

The distributor data has the same format as the carrier data above.

3. You will create your own order and order detail data. The order will contain the 'obvious' data:
    a. Customer
    b. Chemical products, containers and quantities ordered. The quantity cannot exceed the maximum that can be shipped via the selected carrier (see 3.e below). The maximum quantities appear in the Chemical Products dataset below.
    c. Subtotal (price)
    d. Taxes
    e. Total order (subtotal plus taxes)
    f. Freight carrier used to ship the order. You will not include freight charges, a simplification from real life.
    g. Means of payment: a purchase order or credit card number. If a credit card is used, the number and expiration date must be recorded.

4. Chemical products. Your product catalog has the following information:
    a. Product Name: the name of chemical

b. Chemical Class: a number from 1 to 9 (including a decimal subdivision such as 1.1), describing the hazard level of the material. This is the same as the classes used by freight carriers and distributors to define their groups A, B, C, D and E.
c. International Chemical Number. An identifier for the chemical, used to identify it and its emergency handling, coordinated by the United Nations.
d. Passenger Quantity. The maximum quantity of the material allowed to be shipped on a single vehicle that also carries passengers (typically an aircraft, but can be a bus, train or ship). Units are kg or L.
e. Cargo Quantity. The maximum quantity of the material allowed to be shipped on a single vehicle that carries only cargo.
f. Quantity on hand, in kg or L. This is the quantity in stock in your single warehouse. Quantity type (kg or L) is the same as the cargo quantity; if there is no cargo quantity limit, the quantity is in L.
g. Price (US$), per kg or L.

| PROD_NAME | CLASS | UN_NUM | PASS_QT | CARG_Q | QUANT | PRICE |
|---|---|---|---|---|---|---|
| Accumulators, | 2.2 | NA1956 | No limit | No limit | 5000 | 5.00 |
| Acetal | 3 | UN1088 | 5 L | 60 L | 200 | 0.47 |
| Acetaldehyde | 3 | UN1089 | Forbidden | 30 L | 500 | 0.33 |
| Acetaldehyde | 9 | UN1841 | 200 kg | 200 kg | 400 | 5.22 |
| Acetaldehyde | 3 | UN2332 | 60 L | 220 L | 2000 | 8.00 |

5. Emergency response. Your system must be able to generate the correct emergency response information if there is an accident involving a chemical shipment. There are three files that contain this data. The first is the emergency response file, which provides, for each international chemical number (see 4.c above), a guide number for the emergency instructions contained in file 6 below. The data is:
    a. Name of chemical. Descriptive only; may not match product name exactly.
    b. International Chemical Number. Unique identifier. There may be multiple entries per chemical number, but the guide number and isolation values are the same for each (alternate chemical names are given in the multiple entries)
    c. Guide Number. Reference to data in Emergency Detail (see below)
    d. Isolation. If value is T (true), there is an entry in the Isolation dataset (see below)

| MATERIAL | UN_NUMBE | GUIDE_NU | ISOLATION |
|---|---|---|---|
| Air, refrigerated liquid | 1003 | 122 | F |
| Air, refrigerated liquid | 1003 | 122 | F |
| Ammonia, anhydrous | 1005 | 125 | T |
| Ammonia, anhydrous, liquefied | 1005 | 125 | T |
| Ammonia solution, with more | 1005 | 125 | T |
| Anhydrous ammonia | 1005 | 125 | T |
| Anhydrous ammonia, liquefied | 1005 | 125 | T |
| Argon | 1006 | 121 | F |

| | | | |
|---|---|---|---|
| Argon, compressed | 1006 | 121 | F |
| Boron trifluoride | 1008 | 125 | T |
| Boron trifluoride, compressed | 1008 | 125 | T |
| Bromotrifluoromethane | 1009 | 126 | F |
| Refrigerant gas R-13B1 | 1009 | 126 | F |

6. Emergency Detail. This dataset contains the details for emergency response:
    a. Guide Number. This is the reference from the Emergency Response dataset.
    b. Sequence. This puts the rows of this dataset in proper order to be printed on orders and shipping documents.
    c. Sentence. These are the emergency response instructions.

| GUIDE_NU | SEQUENCE | SENTENCE |
|---|---|---|
| 111 | 1 | GUIDE 111 - MIXED LOAD/UNIDENTIFIED CARGO |
| 111 | 2 | POTENTIAL HAZARDS |
| 111 | 3 | FIRE OR EXPLOSION |
| 111 | 4 | · May explode from heat, shock, friction or |
| 111 | 5 | · May react violently or explosively on contact with air, |
| 111 | 6 | · May be ignited by heat, sparks or flames. |
| 111 | 7 | · Vapors may travel to source of ignition and flash back. |
| 111 | 8 | · Containers may explode when heated. |
| 111 | 9 | · Ruptured cylinders may rocket. |

7. Isolation. This file contains the chemicals for which there are isolation or protective distances in case of an accident. The data is:
    a. International Chemical Number. The “UN number” as identifier.
    b. Chemical name. Descriptive; may not match other names exactly.
    c. Small spill. Isolation distance, in feet, with small spill.
    d. Large spill. Isolation distance, in feet, with large spill.
    e. Shipment hazard. If T (true) indicates inhalation hazard.
    f. Water hazard. If T (true) indicates material is water-reactive.

| UN_NU | MATERIAL | SMALL_ | LARGE_ | SHIP_ | WATE |
|---|---|---|---|---|---|
| 1005 | Ammonia, | 100 | 300 | F | F |
| 1005 | Ammonia, | 100 | 300 | F | F |
| 1005 | Ammonia solution, | 100 | 200 | F | F |
| 1005 | Anhydrous | 100 | 300 | F | F |
| 1005 | Anhydrous | 100 | 300 | F | F |
| 1008 | Boron trifluoride | 200 | 600 | F | F |
| 1008 | Boron trifluoride, | 200 | 600 | F | F |
| 1016 | Carbon monoxide | 100 | 300 | F | F |
| 1016 | Carbon monoxide, | 100 | 300 | F | F |
| 1017 | Chlorine | 200 | 600 | F | F |

8. You will create your own order files. (No salesperson data is included; this is a simplification.) The order will contain the 'obvious' data: customer, chemicals and quantities ordered, total price, taxes, and freight carrier used to ship the order. We assume all orders are shipped the next business day if the parts are in stock. The order also contains the means of payment: a purchase order or credit card number. If a credit card is used, the number and expiration date must be recorded.

Your Web site must contain pages to implement the following processes and information display:

a. Describe the manufacturer: general description of products and services, and a description of the company.
b. Marketing information. Information about the firm, its founders (you), why a customer should do business with you, etc.
c. Browse chemicals and freight carriers available and, if you so choose, emergency information.
d. Place an order: Select a set of parts, specify quantities, have the system total the order and accept payment information. (We will not actually implement the credit card interface.) Your system will assign a unique order number. You must decide the process to choose a transportation mode or a specific carrier.
e. These processes are supported by the database you will build in homeworks 2 and 3. You do not need to write any requirements for the database itself; we will address those in homeworks 3 and 4.

Your system must also support the following general processes:

a. Customer login to site.
b. Customer update of its address, contact or other information.
c. Display and confirmation of orders, including carrier chosen to ship the part(s). Distributors should be able to check the status of their orders.
d. Optionally, you may allow a distributor to change or cancel orders. Beware: changing orders can be very complex!
e. Customers may not be in the customer database. Your system should allow new customers to be created.
f. You should discuss the following awkward issues:
    - What to do if items are out of stock
    - Must a single carrier be used for each order, or can more than one carrier be used? How do you select the carrier(s)?
    - Must the shipment go to a single address? (Hint: yes)
    - What happens if prices change?
    - What statuses can an order have?
    - What error handling will you implement? (Hint: minimal, but describe it)
    - And you will probably encounter a few other messy questions…

There are several processes you do not need to consider:

- You do not have to support the processes of updating chemical inventory when new shipments are received, or adding/deleting/changing chemicals when the items change.
- You do not have to support adding, deleting or changing freight carriers, or emergency instructions

## D. Assignment

1. You are to write the requirements for the system to support the manufacturer. You may choose one of the following 'minimal' formats, described in McConnell (pages 323-325). All must be 10 pages or less. Please keep your homework concise. Longer homework won't get more credit.
    a. Short paper specification. A text description.
    b. User manual. Sketch (draw) the user interface and general functions the system will perform.
    c. Scenarios. Define the 5 or 10 key scenarios (sets of steps or processes) that the system will support. This can be a storyboard, in which the steps are drawn, with minimal text.

2. Estimate the size of the effort. We will cover this in class. The key steps are:
    a. Count the function points for each of the systems functions that you will implement. (McConnell, pp 174-177). You will need to estimate the number of database tables, even though you have not designed it yet. While this seems and is unfair, it is also typical in real projects. 20 is a good guess for this project.
    b. Estimate the lines of code for your system, using McConnell, page 519.
        i. While you would normally use the Oracle numbers for the database function points, use 10 lines of code per function point instead. You will only do straightforward queries when you implement your system, and you will omit most of the more complex queries.
        ii. While you would normally use the perl numbers for the Web application, again you should use 10 lines of code per function point. Perl is the closest match to html and Active Server Pages/ASP.NET, which you will use to implement the Web app. In your homework, you will be given code examples to follow, so that the amount of code you write will be minimal.
    c. Once you have the lines of code, estimate the person months and schedule months. Extrapolate from tables 8-8 to 8-10 to make the estimate. Your project is smaller than 10,000 lines, and the relationships are nonlinear. A very approximate estimate is sufficient; don't spend time fitting curves, etc. Justify your choice of table (8-8, 8-9, or 8-10) and type of software.
    d. Assign a confidence range to your estimates, based on figure 8-2 (page 168). Never use a point estimate without a range!

e. Briefly comment on any other factors that affect the estimates or ranges that you have prepared.

3. Hand in hardcopy and electronic copy. See course Web site for how to turn in the electronic copy.

Note: This data is based on the actual USDOT and USEPA hazardous materials database. It has been simplified substantially and some data has been invented.