A Supply Chain Process Interoperability Demonstration Using the Process Interchange Format(PIF)

Process Interchange Format (PIF)

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Contents

1 Executive Summary **2**

2 Introduction **2**
2.1 Utilising Process Tools . . . 2
2.2 Interlingua, Modelling, Simulation . . . 3

3 Scenario Description **3**
3.1 Supplier Roles . . . 3
3.2 Process Overview . . . 4

4 Detailed Scenario Processes **5**
4.1 Replenish Inventory (Retailer) . . . 5
4.2 Take Delivery (Retailer) . . . 6
4.3 Pay Distributor (Retailer) . . . 6
4.4 Process Order (Distributor) . . . 7
4.5 Place Order (Distributor) . . . 8
4.6 Ship Order (Distributor) . . . 8
4.7 Process Order (Manufacturing) . . . 9
4.8 Ship Order (Manufacturing) . . . 10
4.9 Process Order (Third Party Warehouse) . . . 10
4.10 Process Transport Request (Transportation) . . . 11
4.11 Process Documentation Request (Transportation) . . . 12

5 Supply Chain Objects **12**
5.1 People . . . 12
5.2 Suppliers . . . 13
5.2.1 Departments . . . 13
5.3 General Objects . . . 13
5.4 Dates and Times . . . 13
5.5 Documents . . . 14
5.5.1 Manufacturing Order . . . 14
5.5.2 Packing List . . . 14
5.5.3 Payment . . . 15
5.5.4 Prepare Payment Request . . . 15
5.5.5 Product Replenishment Order . . . 15
5.5.6 Release Payment Request . . . 16
5.5.7 Request for Transport . . . 16
5.5.8 Retail Sales Order . . . 16
5.5.9 Shipping Form . . . 17
5.5.10 Shipping Notice . . . 17
5.5.11 Warehouse Order . . . 18

1 Executive Summary

The goal of the PIF Project is to develop an interchange format to help automatically exchange process descriptions among a wide variety of business process modelling and support systems such as workflow software, flow charting tools, process simulation systems, and process repositories. As an example of such an exchange, a demonstration scenario has been created which describes the use of PIF in the modelling and simulation of an integrated supply chain where different companies co-operate through a global supply chain management procedure to deliver commercial electronic goods. This scenario coordinates the exchange of process knowledge between a business process modelling tool/library (Massachusetts Institute of Technology's (MIT) Process Handbook) and a process simulation package (Knowledge Based System Inc.'s (KBSI) ProSim) with PIF acting as the interlingua.

2 Introduction

The main context for this scenario involves the development and coordination of supply chain processes between a commercial electronics manufacturer, retailer, distributor, warehousing company and transportation company[1]. A supply chain is essentially a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers.

There are supply chains in both service and manufacturing organisations. The complexity of the chain may vary greatly from industry to industry and company to company. Traditionally marketing, distribution, planning, manufacturing, and purchasing organisations along the supply chain operated independently. This independence typically meant that there wasn't a single, integrated plan for the organisation. There were as many plans as businesses. A need existed for a mechanism which integrated these different functions. Supply chain management is now referred to as the strategy through which this integration can be achieved. This has become an important issue for many organisations as they rethink the way they do business. For example, Hammer and Champy pointed out a need for radically changing the processes of a manufacturing logistics supply chain in their pioneering book on Business Process Reengineering.

The overall objective of the supply chain for the scenario described in this document is: to obtain benefits by rapidly getting manufactured commercial electronic products from the production line into retail stores. In order to ensure that this objective is met in an effective way, these processes may need to be modelled and simulated across organisational boundaries. This process may be facilitated by providing a way to help automatically exchange process descriptions between the modelling tool and simulation tool using PIF.

2.1 Utilising Process Tools

We consider the following scenario in order to illustrate interoperability between these tools. A hypothetical consulting firm has been hired to both model and simulate the proposed supply chain activities. The business consulting team would like to utilise MIT's library of business processes found in the Process Handbook (PH) as a basis for process specification. The PH may be used to analyse tradeoffs and alternatives for the supply chain processes. The team would then like to transfer the process descriptions to KBSI's ProSim. As is typically the case, this would require manual rebuilding of the model. Modelling and simulation activities are often part of an iterative cycle and could potentially require significant effort to manually synchronise changes between separate process and simulation models. A shared, common language between these two tools could significantly reduce the consulting team's time and effort in engineering these processes.

[1]This scenario was adapted from the Workflow Management Coalition's (WfMC) workflow interoperability demonstration presented at the 1996 Business Process and Workflow Conference in Amsterdam.

2.2 Interlingua, Modelling, Simulation

PIF is proposed as the interlingua between the consulting team's process modelling tool and process simulator. Both tools are capable of expressing the model in their own linear, declarative format. MIT's Process Handbook uses the Process Handbook Representation Language (PHRL) and ProSIM can accept a generic representation of an IDEF3 model. Translators need to be written between these representations and PIF. ProSIM can then be used to compile a simulation model that will run on Lanner Group, Ltd.'s WITNESS[2] simulator.

3 Scenario Description

As stated above, this scenario addresses the processes for managing an integrated supply chain. This section presents some of the central entities and relationships that are involved in this domain. These required elements can be viewed as domain-specific objects which require PIF core extensions in order to express the processes found in this scenario. The following section outlines the processes that are executed using these elements during the enactment of the material and product flow for the supply chain.

3.1 Supplier Roles

These role descriptions provide a high-level summary of the responsibilities of companies which are involved in the modelled supply chain[3]. Detailed descriptions of the supplier activities are given in the following sections.

- The **Manufacturer** produces goods and delivers products from factories based upon orders received from distributors. Delivery is mainly handled through transportation companies which ship products from the manufacturer to the distributor.
- The **Retailer** receives orders for goods. Orders may be translated into a distributor order as the retailer holds limited stock. Distributor orders require payment preparation and release of payment from the retailer to the distributor.
- The **Distributor** takes orders from the retailer and arranges shipment of the ordered products. The distributor has limited inventories of its own. It can rely on a manufacturer's inventories and production for large retailer deliveries.
- The **Warehousing Company** stores supplies of product inventories for the manufacturer which can be shipped directly to distributors when requested from the manufacturer.
- The **Transportation Company** handles most tasks related to transport in an international environment including production of customs documents, shipping forms, etc.

As these responsibilities begin to show, a number of elements can be identified in the supply chain. These objects can be modelled in a simple UML object model to highlight a taxonomy of entities and relations between them. A high-level model is shown in figure 1. This figure outlines both objects that have been introduced by the supplier role descriptions, but also looks ahead towards the objects required for the detailed process descriptions.

Starting toward the top of the model, we can pick out two fundamental classes of entities: company and people. Supply chains are essentially centred around these basic concepts. People involved in these processes may be customers or employees. Looking at companies, we can see that a company is typically composed of zero or more departments. These departments contain one or more employees which carry out the specific

[2]Details on Lanner Group's WITNESS simulator is available at: http://www.lanner.com/product.htm
[3]Descriptions of these roles are based on the previously cited WfMC demonstration document.

tasks. Employee types are usually associated with the nature of the task which they perform (e.g. a driver transports products, a manager manages other employees, etc.) Departments may require specific objects to carry out their tasks. For example, the accounting department requires a specialised record, the purchase ledger, for maintaining the company financial records.

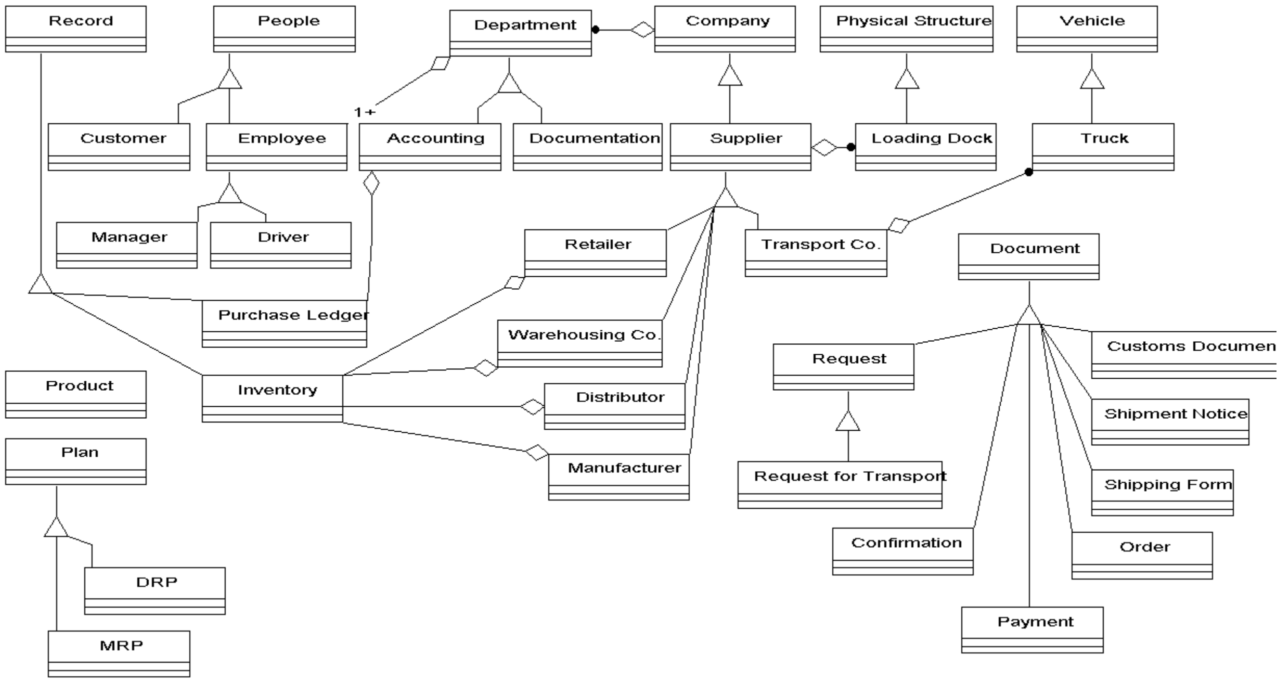

Figure 1: High-level UML Object Model of the Supply Chain Entities

Companies involved in supply chain management are referred to as suppliers. In this domain, there are 5 supplier types or roles as described above. Suppliers require objects such as trucks, loading docks, and records of current stock (i.e. inventory). Suppliers communicate and perform various transactions by using a variety of document types. Knowledge of a variety of other objects may be necessary, such as products and plans. This overview of the objects involved in the supply chain is revisited in more detail in section 5.

3.2 Process Overview

A high-level model of the current cross-organisational supply chain process is shown the UML activity diagram in figure 2. This diagram has a "swim lane" layout which identifies the temporal ordering of the processes across all of the companies. Each process identified in this diagram is broken down and described in the subsequent sections.

The flow of supply chain activities stem from a "replenish inventory" process which is initiated at the retailer. This leads to a cross-organisational activation of a process at the distributor. A key decision taken by the distributor at this point has been highlighted. This decision involves either satisfying the order via existing stock or by requesting products from the manufacturer. While the former simply requires a shipment to the retailer, the latter involves placing an order with the manufacturer. The manufacturer, in turn, makes a couple of important decisions while processing an order. These decisions are to either request stock to be sent from a third party warehouse or to satisfy the order via a scheduled production run. For orders completed at the factory, a decision is made as to how the product will be shipped to the distributor. The manufacturer typically requests pickup and delivery from a transportation company, but it also has a limited capacity to deliver products on its own (usually only performed for smaller orders). The transportation company handles the documentation for product shipment along with providing the transport service. Once the distributor receives the products, they are sent along to the retailer. The retailer completes the modelled process by sending payment for the goods to the distributor.

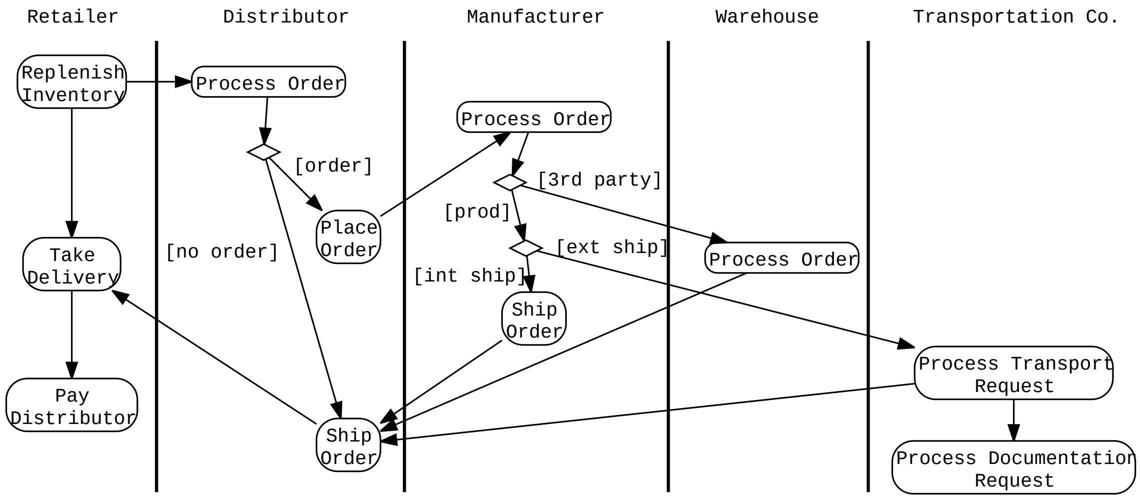

Figure 2: High-level UML Activity Model of the Supply Chain Processes

4 Detailed Scenario Processes

This section details the supply chain processes identified in figure 2. Each process is described in a paragraph of text. This description is then modelled using a UML activity notation and a brief description of the analysis. Activities in this notation are represented via a rounded box (as in figure 2). A solid dot and a dot enclosed in a circle represent the begin and end points of the overall process, respectively. Arrows represent a simple ordering of the activity execution. A decision is modelled with a diamond and labelled arcs which indicate the nature of the alternate path. A solid horizontal line represents an “and” split or join in the activity network.

4.1 Replenish Inventory (Retailer)

Scenario Text

Inventory replenishment is triggered at the Retailer based on a balance between sales volume and inventory. An order from a customer may generate a request from the Retailer to the Distributor to supply a quantity of product on a given date. The Retailer next starts a sub-process with the Accounts department to prepare a payment for the Distributor. Inventory is updated and payment is released when the goods have been received and checked.

Analysis

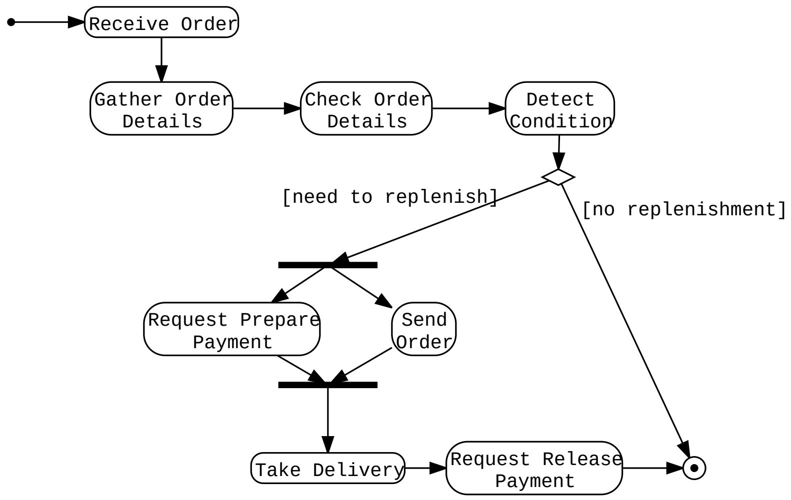

Figure 3: Replenish Inventory (Retailer) Diagram

Figure 3 illustrates the current structure of the modelled "replenish inventory" process. This process contains eight activities (e.g. Receive Order, etc.). The decision represents a conditional flow of activities based on an evaluation of current sales volume and inventory given the retail order details. "Request Prepare Payment" and "Send Order" may be executed in parallel. The "Take Delivery" activity is actually a composite activity which is further defined in section 4.2.

4.2 Take Delivery (Retailer)

Scenario Text

Inventory is updated at the Retailer when the goods have been received. The delivery must be verified first though in order to ensure that it properly meets the requirements of the order.

Analysis

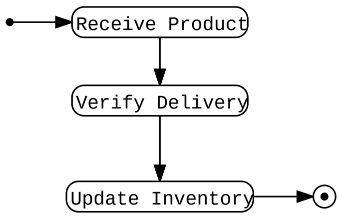

Figure 4: Take Delivery (Retailer) Diagram

"Take Delivery" is modelled as a simple three-step process in which the goods are received and checked and inventory updated.

4.3 Pay Distributor (Retailer)

Scenario Text

When an order is being sent from the Retailer to a Distributor the Retailer will request to have the payment for the Distributor prepared. Payment preparation also involves an update of the purchase ledger. Payment to the Distributor is issued at the time that the goods are received either directly from the Distributor or being part of a "drop shipment" from another supplier. Released payments are recorded in the purchase ledger as well.

Analysis

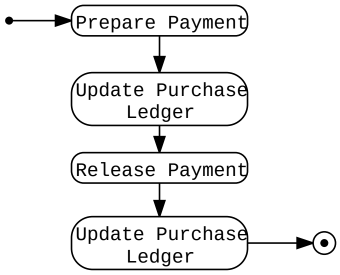

Figure 5: Pay Distributor (Retailer) Diagram

This process is ultimately comprised of two phases. The first phase involves the preparation of payment along with an appropriate updating of the ledger. The second phase releases the payment to the distributor and again, updates the ledger. This is illustrated very simply as a linear sequence of four separate activities.

4.4 Process Order (Distributor)

Scenario Text

The Distributor accepts orders from retailers. Once these orders have been validated they are used to update the Distributor Planning process/plan. The DRP is then used to determine whether an order can be shipped from existing inventories or whether it will require a shipment from a manufacturer. If the products will be shipped from the Distributor's existing stock then the replenishment shipment is scheduled. The truck is loaded as an advance shipment notice is sent. The goods are shipped directly from the distributor. On the other hand, if a manufacturer is required, an order is sent out. Either way, the inventory is updated when the order is sent and the Distributor Planning Process is amended to reflect the situation.

Analysis

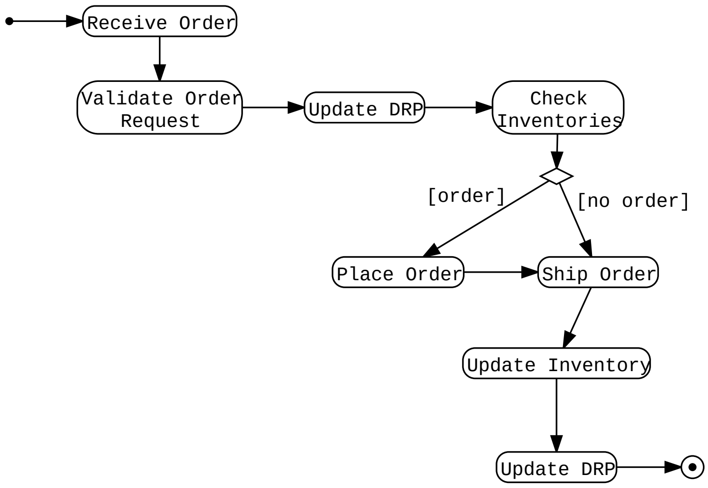

Figure 6: Process Order (Distributor) Diagram

This process represents the flow of activities at the distributor when an order arrives. The decision indicates that the distributor may satisfy the order via existing stock or it may need to communicate with the manufacturer. The “Place Order” and “Ship Order” activities are non-primitive and they are further elaborated in sections 4.5 and 4.6, respectively.

4.5 Place Order (Distributor)

Scenario Text

When the Distributor sends out an order to a Manufacturer, one of two things may occur. The Manufacturer may either confirm or refuse the order. If the order is confirmed then the distribution plan should be updated (schedule receipt). If, on the other hand, the order is refused then an alternative supplier needs to be found. Products are then reordered from the alternative supplier. When notification of the shipment is received, the product quantities and expected arrival dates on the notification are used to confirm that a loading dock will be available. The goods are subsequently received at the dock and verified against the order details.

Analysis

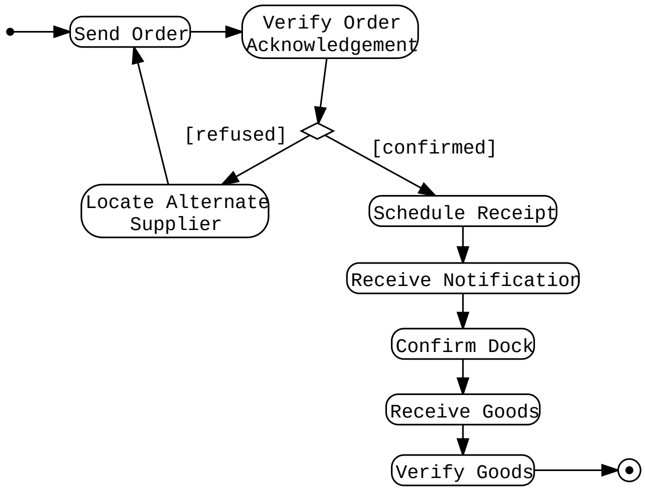

Figure 7: Place Order (Distributor) Diagram

The place order process is defined with a loop which is executed when the selected manufacturer is unable to meet the distributors demands. This loop allows recovery via selection of another supplier. Once confirmed, the distribution plan is updated. The process is ultimately considered complete when the goods have been received and verified at the distributor.

4.6 Ship Order (Distributor)

Scenario Text

When the products will be shipped from the Distributor’s existing stock the replenishment shipment is scheduled. The truck is loaded as an advance shipment notice is sent. The goods are shipped directly from the distributor.

Analysis

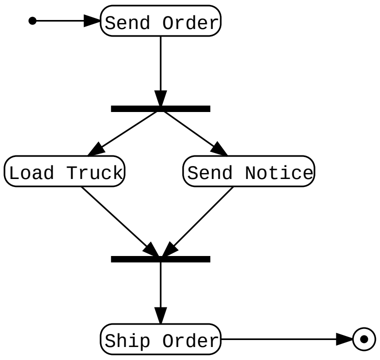

Figure 8: Ship Order (Distributor) Diagram

This process is initiated by a scheduled shipping order. Parallel activities address the preparation for this shipping order. Once these preparations have been made the order is physically transported to the retailer.

4.7 Process Order (Manufacturing)

Scenario Text

Orders received at the Manufacturer are first checked. Valid orders are treated as production schedule requests. A request is checked against the current manufacturing requirements plan (MRP). The ability to ship on time is assumed since there are a variety of transportation companies that can be accessed and there is also limited backup shipping capabilities at the Manufacturer. It is possible that the order could be rejected based on the current plan and available inventories though. Orders can be fulfilled out of a production run or from current inventories. If it is decided that the order will be fulfilled from current inventories then the order is forwarded to a Third Party Warehousing Company that holds product inventory. Orders to be fulfilled via production are entered into the manufacturing requirements plan. The manufactured products are inspected to assure product quality before they are matched to outstanding orders. Completed orders are then shipped to the Distributor.

Analysis

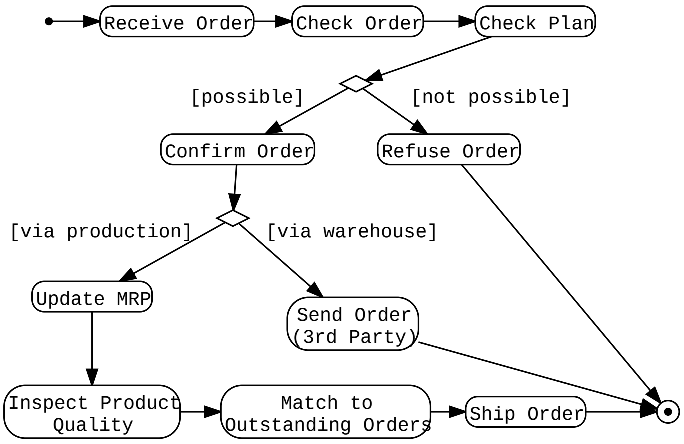

Figure 9: Process Order (Manufacturing) Diagram

Orders received by the manufacturer may be deemed “possible” based on the order details and the current MRP, otherwise the process terminates with a communication of order refusal. Possible orders may then be met via production or the warehouse stock. The "Ship Order" process that results from a production run is defined in section 4.8.

4.8 Ship Order (Manufacturing)

Scenario Text

Shipping is scheduled in compliance with a delivery date constraint. An external transport firm may be chosen or the product may be shipped via the Manufacturer. When the order needs to be shipped from the Manufacturer, the order is released. The truck is loaded and the shipping notice is sent prior to shipping the product. If the external transport partner will be used, then a request for transport must be submitted. If the transport is confirmed, the order is released and the shipping notice is sent. If the transport was refused then an alternative transport firm is selected and transportation is re-requested.

Analysis

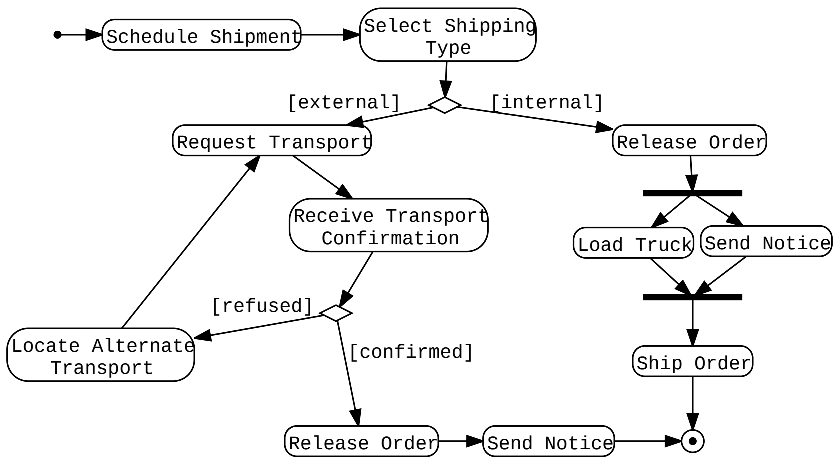

Figure 10: Ship Order (Manufacturing) Diagram

The manufacturer decides whether the products will be sent via an external company or by using internal resources. Internal processing is similar to the distributor's shipping process in section 4.6. External transportation may involve a loop when the manufacturer searches for a transport supplier. Confirmed shipment results in the release of the order and a shipping notice being sent to the distributor.

4.9 Process Order (Third Party Warehouse)

A Warehousing company receives orders from Manufacturers to supply Distributors with products. When products are ordered, the inventory count is updated and the products are shipped to the requested location. The Warehousing company registers the movement of the products.

Scenario Text

Analysis

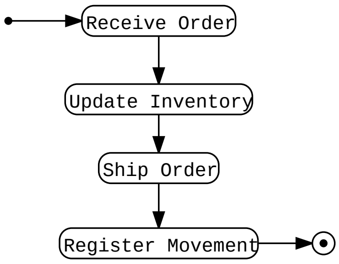

Figure 11: Process Order (Third Party Warehouse) Diagram

The warehouse process is defined as a very straight-forward set of activities in which the order is received, inventory is updated and the products are sent.

4.10 Process Transport Request (Transportation)

Scenario Text

Shipping orders are received at the transport company. The company validates the request against available vehicles and staffing for the requested date. If it is a cross-border shipment, a sub-process is initiated to prepare documentation. While documentation is being completed (if it was necessary), dispatch is requested at the required date and time. Once transport has been confirmed and the documentation has been completed, the truck is dispatched.

Analysis

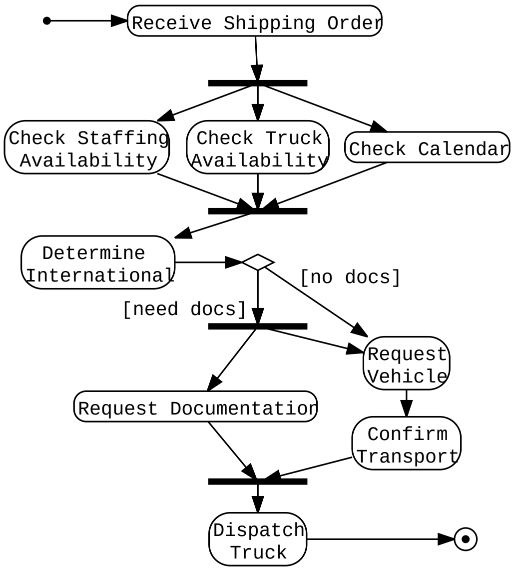

Figure 12: Process Transport Request (Transportation) Diagram

Initial processing of a transport request consists of three activities which may be performed in parallel. Once all of these data gathering activities have been completed, the order is inspected for possible documentation requirements. Required documentation is handled concurrently with the acquisition of a vehicle and the confirmation of transport. Documentation request handling is defined in section 4.11. Finally, the truck is dispatched.

4.11 Process Documentation Request (Transportation)

Scenario Text

Shipping orders are received at the documentation department by a manager. The manager delegates the task to an employee. The delegated employee completes the shipping forms and the customs documents and returns them to the manager for approval. The manager then approves the form and sends a notice of completion.

Analysis

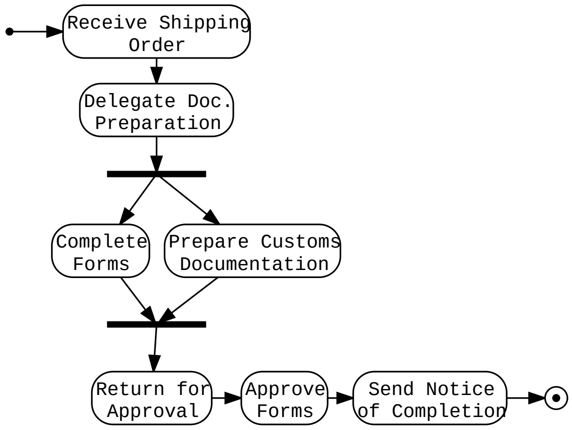

Figure 13: Process Documentation Request (Transportation) Diagram

Managers delegate the documentation work once a shipping order request has been sent. The documentation process may involve concurrent preparation of the shipping forms and customs documents. Once both activities are complete, the documents are returned and the manager approves them.

5 Supply Chain Objects

This section summarises many of the objects which play a role in the supply chain processes. These objects were initially presented at a high level in section 3. Knowledge of these elements should be capable of being "shared" between a process modelling and process simulation tool.

5.1 People

Supply chain processes are enacted by people or computer systems. In this scenario, some of the roles played by people have been identified. These roles are

- Customer - The customer places orders at the retailer for some quantity of goods.
- Employee - Employee is a general role that refers to anyone working for any of the supplier companies.
- Manager - Some employees are specialised to perform certain tasks. The manager is responsible for overseeing the work of other employees.
- Driver - Driver is also a specialisation of employee. A driver performs a specific task of transporting goods using a transportation vehicle.

5.2 Suppliers

The suppliers involved in the supply chain were described in section 3.1. They included: manufacturer, retailer, distributor, warehousing, and transportation companies. A supplier can be thought of as a specialisation of a company. These companies contain various objects that are used during the enactment of the supply chain processes. These objects are discussed in greater detail in the following section.

5.2.1 Departments

Companies are typically partitioned into departments. A department performs a specific set of related tasks. In this scenario, two departments were mentioned. The retailer has an **accounting department** which, among other things, is responsible for preparing and releasing payment to a distributor. Also, the transportation company has a **documentation department** that is responsible for completing shipping forms and customs documents (if needed).

5.3 General Objects

A number of general objects are created, required, used, and modified throughout the enactment of the supply chain processes. A list of these objects is presented here. While documents are considered part of this general collection, they have been listed in a separate section for presentation purposes.

- Products - Products are items created by the manufacturer. The supply chain is centred around the production, storage, shipping, etc. of these items. A collection of products is sometimes referred to as a shipment, delivery, goods, or order.

- Vehicles - Some vehicles are objects that can used to transport products. A **truck** is a specilized vehicle that is used to do all of the transportation in this scenario.

- Physical Structures - Some companies are required to have particular physical structures that permit the performance of some activities. In this scenario, the distributor is required to have an available **loading dock** which can be used when a shipment arrives.

- Plans - Both the distributor and the manufacturer maintain plans that specify future and current activities for their company. The Manufacturing Requirements Plan (**MRP**) describes when individual orders will be started and finished during the manufacturer's production runs. The Distribution Requirements Plan (**DRP**) maps out the activities needed to supply retailers with products.

- Records - Records are general structures which are used to store information related to various quantities. The retailer has a **purchase ledger** which is used to record payments (among other things). All of the suppliers, except for the transportation company, also maintain a count of the number of products they currently possess. This is referred to as the **inventory**.

5.4 Dates and Times

Many activities within the supply chain processes are temporally dependent. These activities may reference a specific calendar date (e.g. Jan 1, 1998, Every 2nd Wed. of the month), a specific time of the day (17:00:00 hrs EST) or both. These dates and times appear on most of the documents that are manipulated throughout the process as well (e.g. due date, shipping date, expected arrival date and time, etc.).

Various subprocesses in the supply chain contain a loop to indicate the repetition of a set of activities until a condition is achieved. For instance, the manufacturer may need to repeat the steps involved in identifying and securing a transportation supplier for a shipment. The specification of these processes should be flexible enough to allow this loop to be expressed alongside the fact that timepoints will be attached to various activities as well.

5.5 Documents

Documents are used to perform various transactions between companies as well as to communicate requirements and occurrence of events between people/departments/companies. Documents may be in paper form or they may be an electronic artifact. The documents used in this supply chain are listed below along with the elements that are contained within them. Next to each element is a specification of the type needed to express the value of the document entry.

5.5.1 Manufacturing Order

Also called a production schedule request. This document reflects a transaction between the distributor and manufacturer to fulfill a distributor's request. This document may be translated to a Warehouse Order in order to have it satisfied from a 3rd party's existing stock.

- Order Number (String)
- Manufacturer Number (String)
- Distributor Number (String)
- Date Needed (Date:YYYY/MM/DD)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
  - Cost Per Unit (Money: US Dollars)
  - Cost (Money: US Dollars)
- Total (Money: US Dollars)
- Sub-Total (Money: US Dollars)
- Tax (Float)

5.5.2 Packing List

A packing list is created by the transportation company's documentation department to accompany an order. This list is used by the retailer when the take delivery activity is performed.

- Order Number (String)
- Customer Name (String)
- Customer Address (String)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
- Shipping Date (Date: YYYY/MM/DD)

5.5.3 Payment

A payment represents a monetary transaction between two companies. For example, the retailer prepares this payment and releases it to the distributor for providing the required goods.

- Payment Number (String)
- Date (Date: YYYY/MM/DD)
- Payee (String)
- Total (Money: US Dollars)

5.5.4 Prepare Payment Request

This request is issued within the retailer and is handled by the accounting department. This document is used in order to authorise the creation of a payment which may subsequently be released to the distributor.

- Date (Date: YYYY/MM/DD)
- Requesting Employee Number (String)
- Distributor Number (String)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)

5.5.5 Product Replenishment Order

A product replenishment order represents a transaction between the retailer and the distributor. The retailer initiates the request to have a product list delivered. The order may be translated into a Manufacturing Order based on decisions made at the distributor.

- Order Number (String)
- Retailer Number (String)
- Distributor Number (String)
- Date Needed (Date: YYYY/MM/DD)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
  - Cost Per Unit (Money: US Dollar)
  - Cost (Money: US Dollar)
- Total (Money: US Dollar)
- Sub-Total (Money: US Dollar)
- Tax (Float)

5.5.6 Release Payment Request

The payment release request is generated within the retailer and is handled by the retailers accounting department.

- Date (Date: YYYY/MM/DD)
- Requesting Employee Number (String)
- Payment Number (String)

5.5.7 Request for Transport

A Request for Transport is submitted to a transportation company by a supplier to determine whether the transportation company is capable of shipping an order to a specified destination. This request may be accepted or rejected based on the availability of vehicles and drivers.

- Date (Date: YYYY/MM/DD)
- Required Date (Date: YYYY/MM/DD)
- Required Time (Time: HH:MM)
- Transport Request Number (String)
- Source Manufacturer Number (String)
- Distributor Destination Address (String)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
  - Cost Per Unit (Money: US Dollars)
  - Cost (Money: US Dollars)
- Transportation Company Number (String)

5.5.8 Retail Sales Order

The retail sales order represents a transaction between a customer and a retailer. The order is initiated by a customer due to a purchase of some list of products. This order may be translated by the retailer into a Product Replenishment Order in order to receive the products from a distributor which will satisfy the request.

- Order Number (String)
- Customer Number (String)
- Sale Date (Date: YYYY/MM/DD)
- Sale Time (Time: HH:MM)
- Required Date (Date: YYYY/MM/DD)
- Item List (List)

- Product Number (String)
- Quantity (Integer)
- Cost Per Unit (Money: US Dollars)
- Cost (Money: US Dollars)

- Total (Money: US Dollars)
- Sub-Total (Money: US Dollars)
- Tax (Float)
- Shipping and Handling Cost (Money: US Dollar)

5.5.9 Shipping Form

A shipping form is produced by a transportation companies' documentation department for a specific product delivery. This form is used by the driver in order to enact the transportation of the shipment.

- Shipping Number (String)
- Shipping Address (String)
- Order Number (String)
- Date (Date: YYYY/MM/DD)
- Expected Arrival Date (Date: YYYY/MM/DD)
- Expected Arrival Time (Time: HH:MM)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
- Shipping and Handling Cost (Money: US Dollars)

5.5.10 Shipping Notice

A shipping notice represents an exchange of information between two suppliers (e.g. a transportation company and a distributor). In particular this informs the supplier of the time that a particular shipment will be delivered.

- Shipping Number (String)
- Order Number (String)
- Expected Arrival Date (Date: YYYY/MM/DD)
- Expected Arrival Time (Time: HH:MM)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)

5.5.11 Warehouse Order

A warehouse order represents a transaction between a manufacturer and a 3rd party warehousing supplier. The order is initiated by the manufacturer as a request to fulfill a distributor's order based on the stock held at the warehouse.

- Order Number (String)
- Manufacturer Number (String)
- Distributor Number (String)
- Warehousing Number (String)
- Date Needed (Date: YYYY/MM/DD)
- Item List (List)
  - Product Number (String)
  - Quantity (Integer)
  - Cost Per Unit (Money: US Dollar)
  - Cost (Money: US Dollar)
- Total (Money: US Dollar)
- Sub-Total (Money: US Dollar)
- Tax (Float)