An IDEF1x Information Model for a Supply Chain Simulation

Y. Tina Lee
Manufacturing Systems Integration Division
National Institute of Standards and Technology
Gaithersburg, MD 20899-8260, USA
Email: leet@cme.nist.gov **phone: (301) 973-3550 fax: (301) 258 9749**

Shigeki Umeda
Management School
Musashi University
Nerima-ku Tokyo 176-8534, Japan
Email: shigeki@cc.musashi.ac.jp **phone: +81 3 5984 3837 fax: +81 3 3991 1198**

ABSTRACT

This paper describes the scope and configuration of the simulation model that is under development for a manufacturing supply chain. An information model that serves as a neutral interface specification is also presented in the paper. The supply chain simulation model described here is being developed to validate interface specifications as part of the Intelligent Manufacturing Systems (IMS) Modeling and Simulation Environments for Design, Planning and Operation of Globally Distributed Enterprises (MISSION) project [1]. This simulation model is largely based upon the practical business operations of a U.S. power-tools manufacturing company. The information model has been developed using the IDEF1X information modeling language [2]. The information model can ultimately be used to integrate distributed simulation models that are developed by other manufacturers to model their supply chains.

KEYWORDS

Information modeling, simulation, supply chain

INTRODUCTION

The Manufacturing System Integration Division (MSID) of the United States National Institute of Standards and Technology (NIST) participates in the Intelligent Manufacturing Systems (IMS) Modeling and Simulation Environments for Design, Planning and Operation of Globally Distributed Enterprises (MISSION) project [1]. "The goal of MISSION is to integrate and utilise new, knowledge-aware technologies of distributed persistent data management, as well as conventional methods and tools, in various enterprise domains, to meet the needs of globally distributed enterprise modelling and simulation" [1]. Currently, there are three MISSION project teams: the U.S. team, the Europe team, and the Japan team.

A distributed manufacturing simulation architecture has been developed by the NIST MSID to support the MISSION project. The architecture describes the major system modules, data elements or objects, and interfaces between modules [3]. The purpose of the architecture is to identify the software building blocks and interfaces that will facilitate the integration of distributed simulation systems and enable the integration of those systems with other manufacturing software applications. The architecture, however, does not address the detailed design of individual modules and the information models for shared data elements or objects. The emphasis of our current research is to develop an information model and to build a prototype simulation.

A prototype supply chain simulation is being developed as a test case for MISSION by the U.S. project team. In an early planning meeting by the U.S. team, a common interest in the supply chain simulation was expressed by the simulation software vendors participating in the project. A major objective of MISSION is to enable the development of distributed supply chain simulations for globally distributed enterprises. The test case focuses on modules, data structures, and interfaces that require an information model.

The goal of supply chain management is to integrate suppliers, manufacturers, warehouses, and stores efficiently, so that merchandise is produced and distributed in the right quantities, at the right locations, and at the right times [4]. This is done to minimize system-wide costs while satisfying service level requirements. In a supply chain system, an individual member exchanges data with other members to synchronize their business operations. These exchanged data generally include product specification data, planning data, ordering data, and inventory data, among others. These data are often used to control operations in an individual firm, and are also used for negotiation among chain members that form a virtual organization to provide products and services to customers.

There are several different information modeling methodologies, modeling languages, and implementation methods available to support the development of such a communication mechanism [5]. Our approach to developing this communication mechanism and the data specification are listed here:

- Perform a case study to investigate a real supply chain system.
- Identify the scope of the target application.
- Identify core processes of supply chain management.
- Design the prototype supply chain simulation.
- Design the distributed simulation system.
- Analyze communication data flow and identify data requirements.
- Verify the data requirements using the prototype system and the distributed system.
- Layout the data specification.
- Implement the data specification.

This paper first describes the objective and the scenario that are supported by our prototype supply chain simulation. It then presents an IDEF1X [2] information model that describes the data requirements to support data sharing within the simulation.

SUPPLY CHAIN SIMULATION

The U.S. MISSION project team has been working on the development of a supply chain simulation as a test case for evaluating the quality of the supply chain model and validating interface specifications for MISSION. The simulation also allows the validation of the interface specifications defined by the MISSION project. This supply chain simulation will be a prototype, global supply chain system. The objective of the supply chain simulation is to examine issues specific to globally distributed simulation systems through the use of the supply chain simulation.

In this section, the configuration of the supply chain simulation is described. The configuration of the simulation is based on a previous case study of a U.S. power-tools manufacturing supply chain. Figure 1 shows the configuration of this supply chain simulation. Simulation models of the above supply chain components are being developed using the U.S. MISSION partners' simulation tools such as Arena, AutoMod, Microsaint, ProModel, and Quest.

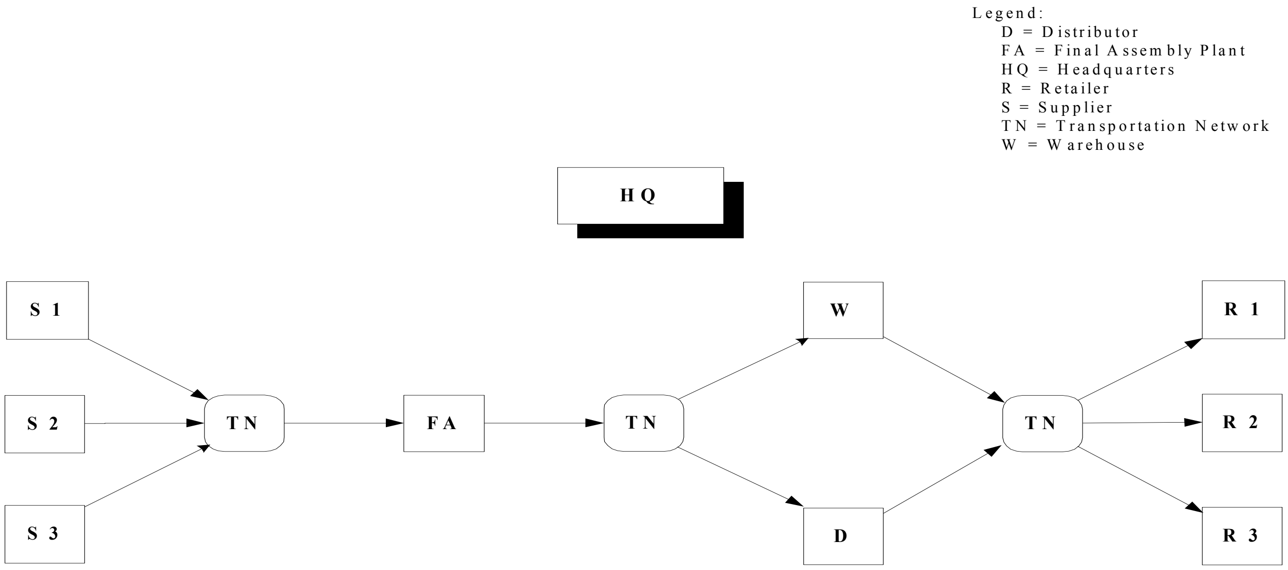
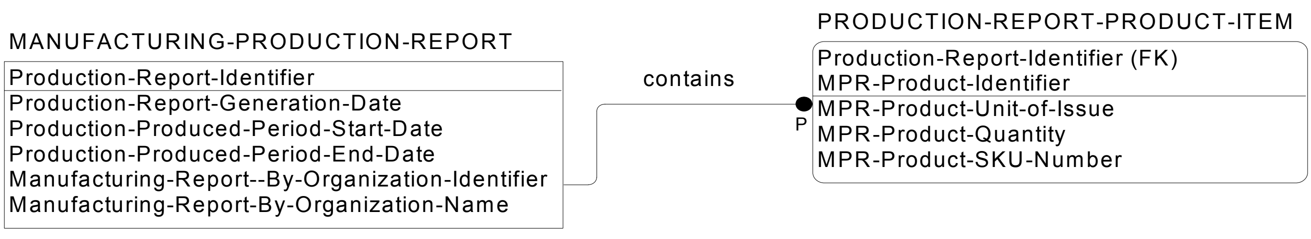
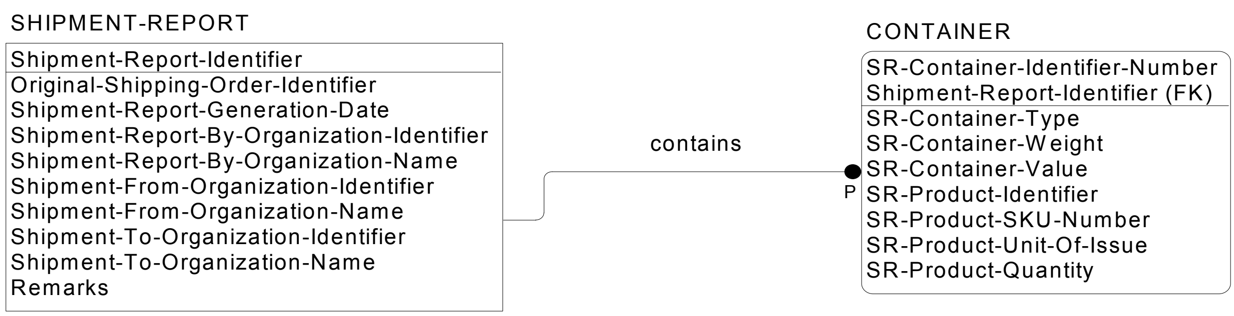


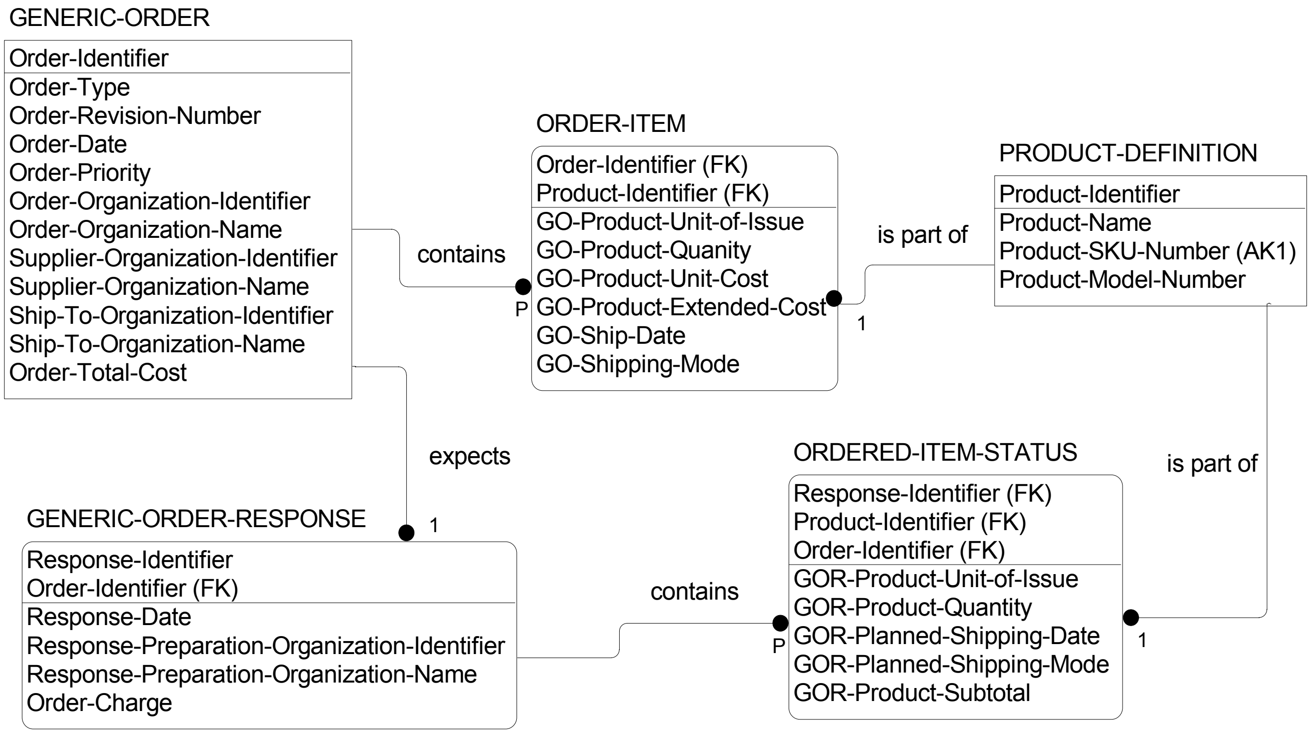
Figure 1. The configuration of the supply chain simulation

IDEF1X INFORMATION MODEL

This section first specifies the information required for communicating among the supply chain simulation. It then presents an information model that describes, with the IDEF1X methodology, the data requirements. A communication data flow analysis of the supply chain simulation was performed. This analysis focuses on the minimal set of data that needs to be exchanged between members of the supply chain. As a result, a set of data requirements used to communicate among the supply chain members has been identified. Local data required by supply chain members is not contained within the requirements list. These data requirements are a set of messages or entities; they are grouped into 9 units of functionality: Generic Order, Generic Order Response, Shipping Order, Shipping Order Response, Product Forecast, Product Forecast Response, Manufacturing Production Report, Truck Dispatch Order/Log, Shipment Report, Transport Request, and Transport Request Response. The information model is presented in the IDEF1X diagrams.



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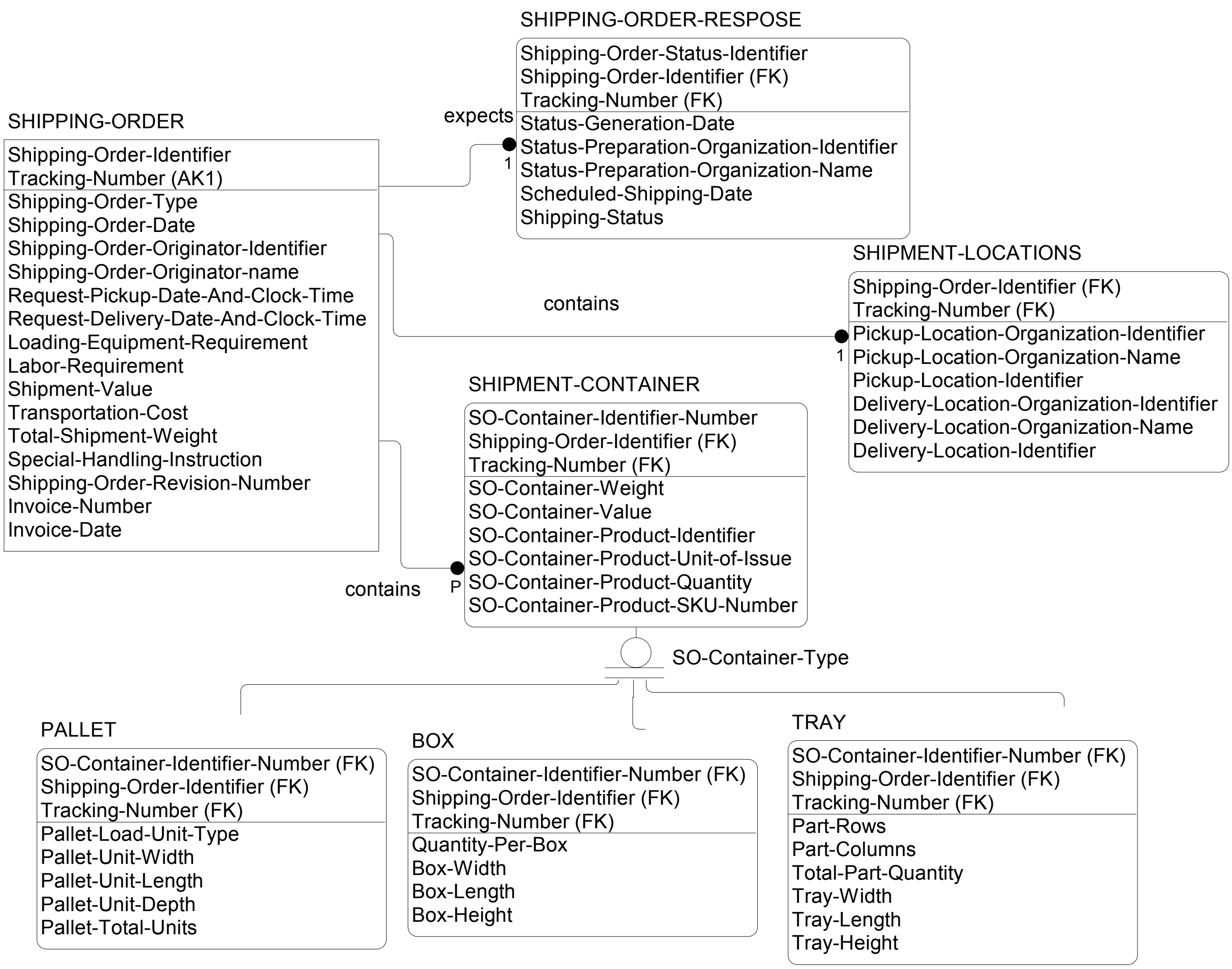
Order-Identifier
Order-Type
Order-Revision-Number
Order-Date
Order-Priority
Order-Organization-Identifier
Order-Organization-Name
Supplier-Organization-Identifier
Supplier-Organization-Name
Ship-To-Organization-Identifier
Ship-To-Organization-Name
Order-Total-Cost
contains
P
ORDER-ITEM
Order-Identifier (FK)
Product-Identifier (FK)
GO-Product-Unit-of-Issue
GO-Product-Quanity
GO-Product-Unit-Cost
GO-Product-Extended-Cost
GO-Ship-Date
GO-Shipping-Mode
is part of
1
PRODUCT-DEFINITION
Product-Identifier
Product-Name
Product-SKU-Number (AK1)
Product-Model-Number
expects
1
GENERIC-ORDER-RESPONSE
Response-Identifier
Order-Identifier (FK)
Response-Date
Response-Preparation-Organization-Identifier
Response-Preparation-Organization-Name
Order-Charge
contains
P
ORDERED-ITEM-STATUS
Response-Identifier (FK)
Product-Identifier (FK)
Order-Identifier (FK)
GOR-Product-Unit-of-Issue
GOR-Product-Quantity
GOR-Planned-Shipping-Date
GOR-Planned-Shipping-Mode
GOR-Product-Subtotal
is part of
1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Shipping-Order-Status-Identifier
Shipping-Order-Identifier (FK)
Tracking-Number (FK)
Status-Generation-Date
Status-Preparation-Organization-Identifier
Status-Preparation-Organization-Name
Scheduled-Shipping-Date
Shipping-Status
expects
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SHIPPING-ORDER
Shipping-Order-Identifier
Tracking-Number (AK1)
Shipping-Order-Type
Shipping-Order-Date
Shipping-Order-Originator-Identifier
Shipping-Order-Originator-name
Request-Pickup-Date-And-Clock-Time
Request-Delivery-Date-And-Clock-Time
Loading-Equipment-Requirement
Labor-Requirement
Shipment-Value
Transportation-Cost
Total-Shipment-Weight
Special-Handling-Instruction
Shipping-Order-Revision-Number
Invoice-Number
Invoice-Date
SHIPMENT-LOCATIONS
Shipping-Order-Identifier (FK)
Tracking-Number (FK)
Pickup-Location-Organization-Identifier
Pickup-Location-Organization-Name
Pickup-Location-Identifier
Delivery-Location-Organization-Identifier
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Shipping-Order-Identifier (FK)
Tracking-Number (FK)
SO-Container-Weight
SO-Container-Value
SO-Container-Product-Identifier
SO-Container-Product-Unit-of-Issue
SO-Container-Product-Quantity
SO-Container-Product-SKU-Number
contains
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SO-Container-Type
PALLET
SO-Container-Identifier-Number (FK)
Shipping-Order-Identifier (FK)
Tracking-Number (FK)
Pallet-Load-Unit-Type
Pallet-Unit-Width
Pallet-Unit-Length
Pallet-Unit-Depth
Pallet-Total-Units
BOX
SO-Container-Identifier-Number (FK)
Shipping-Order-Identifier (FK)
Tracking-Number (FK)
Quantity-Per-Box
Box-Width
Box-Length
Box-Height
TRAY
SO-Container-Identifier-Number (FK)
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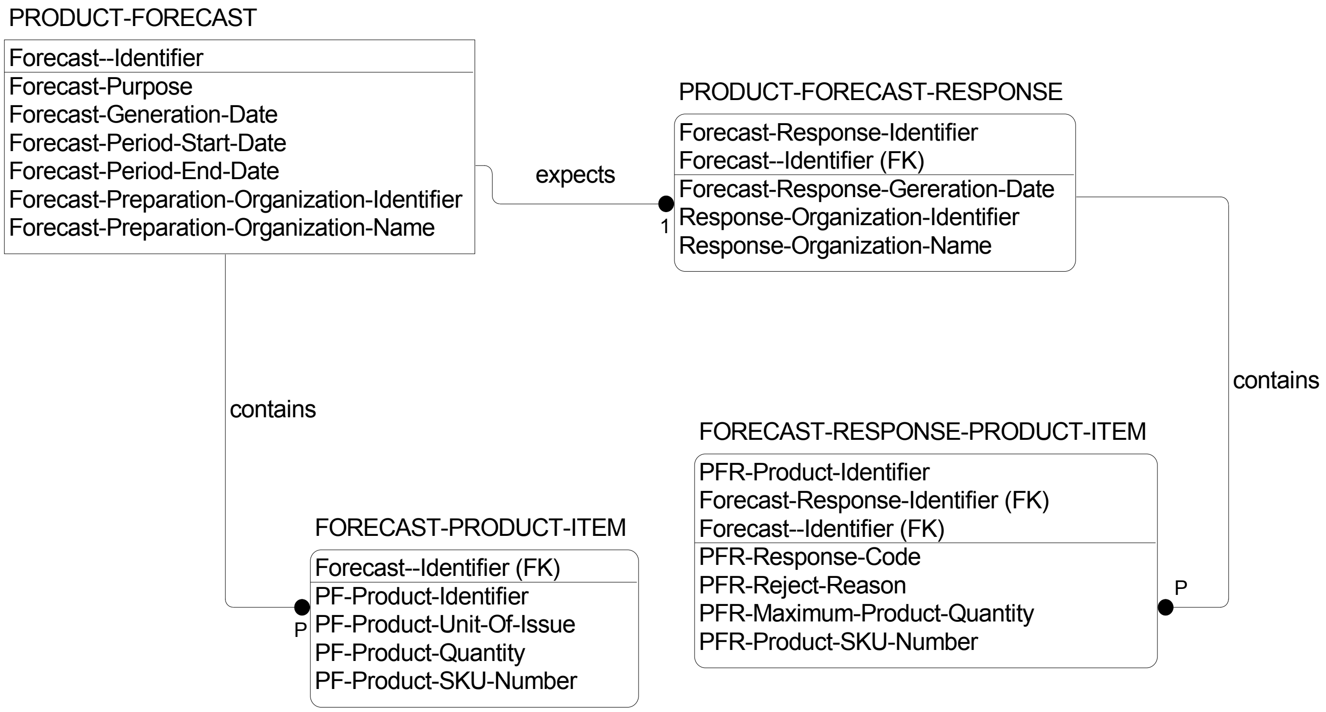
Tracking-Number (FK)
Part-Rows
Part-Columns
Total-Part-Quantity
Tray-Width
Tray-Length
Tray-Height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Forecast--Identifier
Forecast-Purpose
Forecast-Generation-Date
Forecast-Period-Start-Date
Forecast-Period-End-Date
Forecast-Preparation-Organization-Identifier
Forecast-Preparation-Organization-Name
expects
1
PRODUCT-FORECAST-RESPONSE
Forecast-Response-Identifier
Forecast--Identifier (FK)
Forecast-Response-Gereration-Date
Response-Organization-Identifier
Response-Organization-Name
contains
contains
FORECAST-RESPONSE-PRODUCT-ITEM
PFR-Product-Identifier
Forecast-Response-Identifier (FK)
Forecast--Identifier (FK)
PFR-Response-Code
PFR-Reject-Reason
PFR-Maximum-Product-Quantity
PFR-Product-SKU-Number
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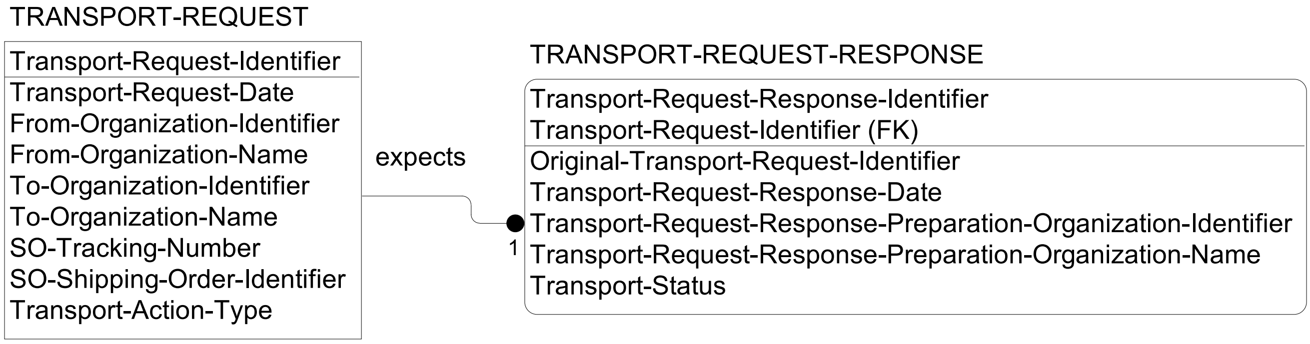
FORECAST-PRODUCT-ITEM
Forecast--Identifier (FK)
PF-Product-Identifier
PF-Product-Unit-Of-Issue
PF-Product-Quantity
PF-Product-SKU-Number
P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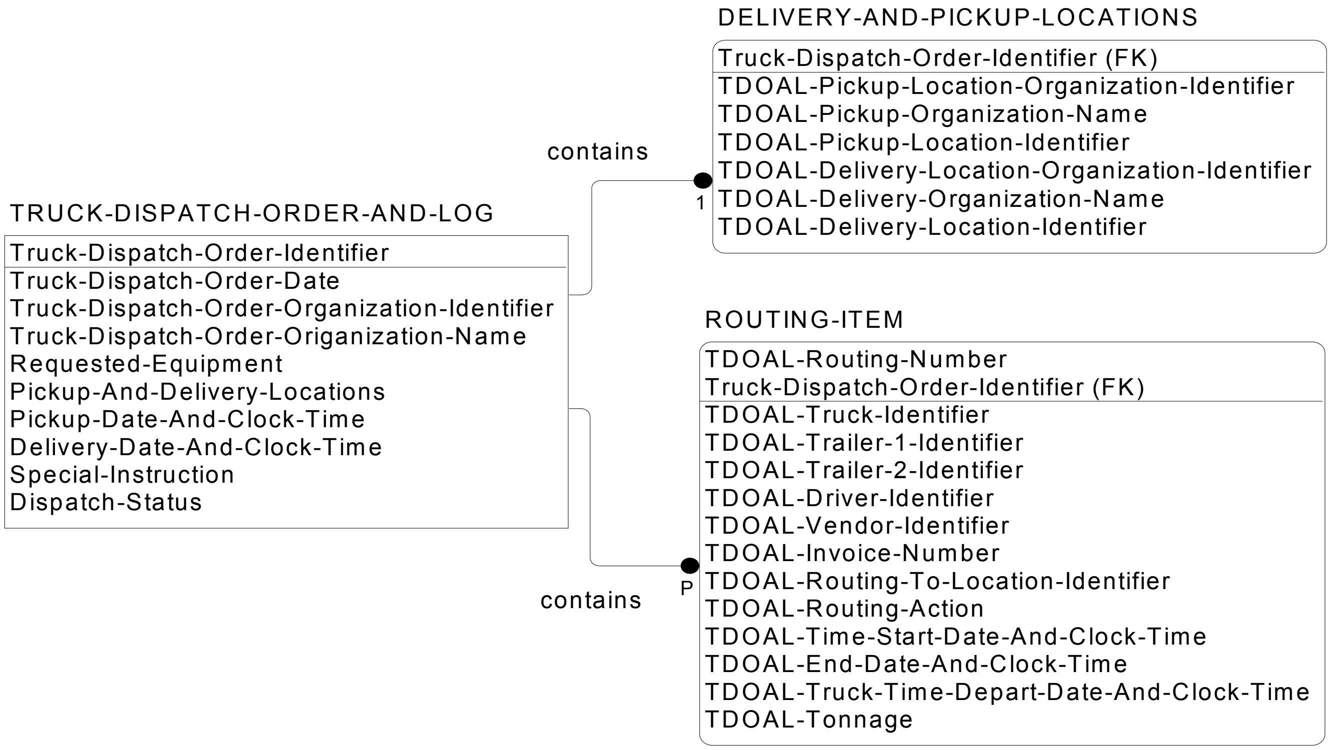
Transport-Request-Date
From-Organization-Identifier
From-Organization-Name
To-Organization-Identifier
To-Organization-Name
SO-Tracking-Number
SO-Shipping-Order-Identifier
Transport-Action-Type
expects
1
TRANSPORT-REQUEST-RESPONSE
Transport-Request-Response-Identifier
Transport-Request-Identifier (FK)
Original-Transport-Request-Identifier
Transport-Request-Response-Date
Transport-Request-Response-Preparation-Organization-Identifier
Transport-Request-Response-Preparation-Organization-Name
Transport-Status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TDOAL-Pickup-Location-Identifier
TDOAL-Delivery-Location-Organization-Identifier
TDOAL-Delivery-Organization-Name
TDOAL-Delivery-Location-Identifier
contains
1
TRUCK-DISPATCH-ORDER-AND-LOG
Truck-Dispatch-Order-Identifier
Truck-Dispatch-Order-Date
Truck-Dispatch-Order-Organization-Identifier
Truck-Dispatch-Order-Origanization-Name
Requested-Equipment
Pickup-And-Delivery-Locations
Pickup-Date-And-Clock-Time
Delivery-Date-And-Clock-Time
Special-Instruction
Dispatch-Status
ROUTING-ITEM
TDOAL-Routing-Number
Truck-Dispatch-Order-Identifier (FK)
TDOAL-Truck-Identifier
TDOAL-Trailer-1-Identifier
TDOAL-Trailer-2-Identifier
TDOAL-Driver-Identifier
TDOAL-Vendor-Identifier
TDOAL-Invoice-Number
TDOAL-Routing-To-Location-Identifier
TDOAL-Routing-Action
TDOAL-Time-Start-Date-And-Clock-Time
TDOAL-End-Date-And-Clock-Time
TDOAL-Truck-Time-Depart-Date-And-Clock-Time
TDOAL-Tonnage
P
contains

CONCLUSION

The manufacturing industry has become much more interested in supply chain management over the past several years. At the same time information technology becomes an important enabler for effective supply chain management. With appropriate information models that support information sharing among supply chain members, the supply chain can be integrated seamlessly. Thus, communications among chain members may go directly, and better customer value performance, shorter lead time, and even lower production and manufacturing costs can be expected.

The paper specifies a prototype system of a supply chain simulation. It also presents an information model that provides a framework of communication data in the prototype supply chain simulation. The prototype system is developed to support the international MISSION project to demonstrate the feasibility of a globally distributed virtual enterprise. The prototype system and information model specified in this report has been implemented using an NIST-developed Distributed Manufacturing Systems Adapter [3]. It is anticipated that the implementation of this prototype system will be carried out at multiple geographical locations simultaneously.

The prototype system is intended for the MISSION project only and will not be generic enough for the general purpose application. NIST is currently working on the design and development of a simulation model for a virtual supply chain enterprise. The goal of this model is to support the users to make strategic decisions for improving the performance of the supply chains. This decision support will serve many supply chain activities, such as physical distribution, physical supply, and manufacturing planning and control.

REFERENCES

[1] MISSION Consortium, “Intelligent Manufacturing System (IMS) Project Proposal: Modelling and Simulation Environments for Design, Planning and Operation of Globally Distributed Enterprises (MISSION), Version 3.3,” Shimuzu Corporation, Tokyo, Japan, March 1998.

[2] D. Appleton Company, Inc., “Integrated Information Support System: Information Modeling Manual, IDEF1 – Extended (IDEF1X),” ICAM Project Priority 6201, Subcontract #F33615-80-C-5155, Wright-Patterson Air Force Base, Ohio, December, 1985.

[3] McLean Charles and Riddick, Frank, “The IMS Mission Architecture for Distributed Manufacturing Simulation,” Proceedings of the 2000 Winter Simulation Conference, Orlando, Florida, December, 2000.

[4] Simchi-Levi, David, Kaminsky, Philip, and Simchi-Levi, Edith, “Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies,” Irwin McGraw-Hill, 2000.

[5] Lee, Y. Tina, “Information Modeling: From Design to Implementation,” Proceedings of the Second World Manufacturing Congress, International Computer Sciences Conventions, Canada/Switzerland, September 27-30, 1999.