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Subject: Deliverable Number 0022, Service Oriented Architecture (SOA) Reference Model (Task 3.3, 3.4) - Global Transportation Management System Architecture

Reference: Strategic Mobility 21 Contract N00014-06-C-0060

Dear Paul,

In accordance with the requirements of referenced contract, we are pleased to submit this SM21 Deliverable Number 0022, Service Oriented Architecture (SOA) Reference Model (Task 3.3, 3.4) - Global Transportation Management System Architecture for your review.

Your comments on this document are welcomed.

Regards,

Dr. John Hwang
Strategic Mobility 21 Principal Investigator

cc: Administrative Contracting Officer (Transmittal Letter only)
      Director, Naval Research Lab (Hardcopy via U.S. Mail)
      Defense Technical Information Center

Strategic Mobility 21

Service Oriented Architecture (SOA) Reference Model - Global Transportation Management System Architecture

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The GTMS experiment, with the support of Dole Foods, is focused on the development of an integrated System-of-Systems (SoS) solution (that is a combination of different systems). The architecture used will be based on Service Oriented Architecture (SOA). This architecture is basically an approach that provides for the use of the Internet as an Enterprise Service Bus where various systems exchange data using standard protocols. Since the system is targeted for use by multiple commercial and military customers, it will be provided in the form of Software-as-a-Service (SaaS), whereby a vendor can provide the user with the appropriate Internet access to the service, and the service is maintained by a central source. The experiment is meant to be of limited scope in the numbers of shipments, the distribution centers involved, and the number of distribution lanes involved. The data collected throughout the experiment will be processed based on various data messaging formats, which will provide the status of the shipment being monitored.

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ABSTRACT

The Strategic Mobility 21 (SM21) program is currently in the process of developing the Joint Deployment and Distribution Support Platform (JDDSP) concept, which includes the development of a supporting Global Transportation Management System (GTMS). The development of the GTMS, within the context of an experiment, is considered the initial operating capability of the broader JDDSP project. The development of the JDDSP is structured within a multi-phase project designed to evaluate, develop, and implement solutions to challenges facing dual-use distribution networks: that is, transportation networks that are useful for military and commercial sectors.

The GTMS experiment, with the support of Dole Foods, is focused on the development of an integrated System-of-Systems (SoS) solution (that is a combination of different systems). The architecture used will be based on Service Oriented Architecture (SOA). This architecture is basically an approach that provides for the use of the Internet as an Enterprise Service Bus where various systems exchange data using standard protocols. Since the system is targeted for use by multiple commercial and military customers, it will be provided in the form of Software-as-a-Service (SaaS), whereby a vendor can provide the user with the appropriate Internet access to the service, and the service is maintained by a central source. Security would be provided by standard protocols used on the Internet that have been successful with secured applications.

Because development will be incremental, a spiral development model is being used. Development is being performed on an open source platform. This type of platform will provide the optimal flexibility in interfacing with various types of systems.

The experiment with Dole will use separate data sources for:
- Initiating the shipment and customer orders
- Moving the shipment over the ocean
- Moving the shipment through Customs and other regulatory agencies
- Moving the shipment on rail
- Managing inventory in the warehouse.

The experiment is meant to be of limited scope in the numbers of shipments, the distribution centers involved, and the number of distribution lanes involved. The data collected throughout the experiment will be processed based on various data messaging formats, which will provide the status of the shipment being monitored.

Upon completion of the experiment, a lessons learned will be developed and the next phases identified within the GTMS system transition report.

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1 INTRODUCTION

The Strategic Mobility 21 (SM21) program is currently in the process of developing the Joint Deployment and Distribution Support Platform (JDDSP) concept, which includes the development of a supporting Global Transportation Management System (GTMS). The development of the GTMS, within the context of an experiment, is considered the initial operating capability of the broader JDDSP project. The development of the JDDSP is structured within a multi-phase project designed to evaluate, develop, and implement solutions to challenges facing dual-use distribution networks: that is, transportation networks that are useful for military and commercial sectors.

The intent is to develop an integrated solution to solve the most critical issues facing military force deployment and sustainment distribution and commercial intermodal logistics. This integrated solution is being designed to transform logistics networks into agile enterprises through the introduction of information technology-based concepts and capabilities that promote total end-to-end visibility of shipment assets and the individual items inside the asset. Creating this integrated solution requires unprecedented levels of collaboration and data and information sharing, to achieve the required dual-use end states in a secure and scalable environment to mitigate:
- Regional congestion,
- Community environmental impacts, and
- Military-commercial goods movement conflict.

The general concept is based on a System-of-Systems (SoS) approach that will be enabled by information technology based services and capabilities. The goal of SM21 is to alleviate the problems of heterogeneity, interoperability, and requirements volatility. The SM21 architecture will provide a platform for building the next generation of supply chain application services that are loosely coupled, location transparent, and protocol independent.

1.1 Incremental Development – Spiral Model

The nature of the overarching JDDSP project is to provide incremental progress while demonstrating functionality at the end of the various phases. As a result, the GTMS development process will mirror that approach, using a spiral development model.

The spiral development model is a systems development method (SDM) that combines aspects of both design and prototyping for use in large complex projects. There are four (4) basic phases of the spiral development model:
- Determine the Objectives
- Identify and Resolve Risks
- Development and Test
- Planning of the Next Spiral Iteration.

As depicted in the figure below, the spiral development method progresses through several iterations until a release of an operational prototype. The initial increment is a cooperative

endeavor with Dole Package Foods (DPF). This increment is discussed in more detail later in this document.
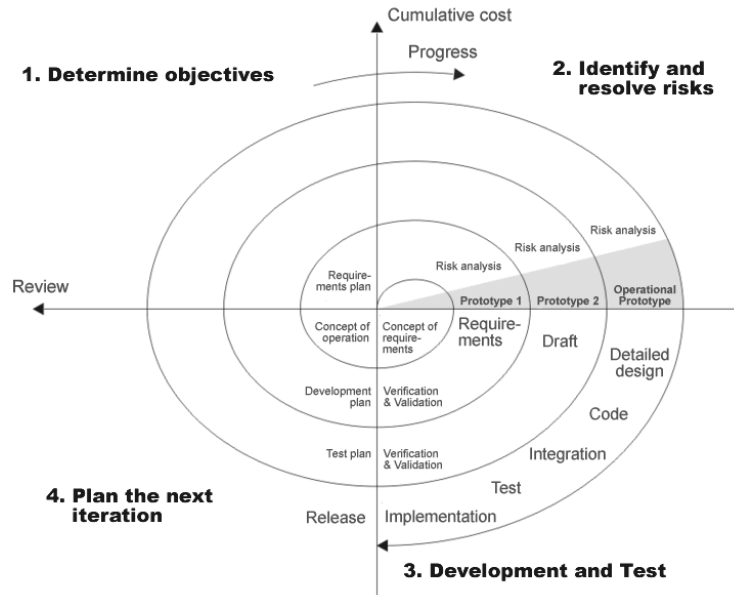
Figure 1: Spiral Development Model

2   SUPPLY CHAIN MANAGEMENT OVERVIEW

The supply chain is the model for the system under development by SM21 program. Figure 2: SCOR Reference Model & presents a general overview of the Supply Chain Operations Reference (SCOR) Reference Model. The current GTMS is focused on the Shipping aspects of the Deliver function as presented by the model. In future releases, the GTMS will include Terminal Operations, Drayage, Transportation Management and Global Trade Compliance.
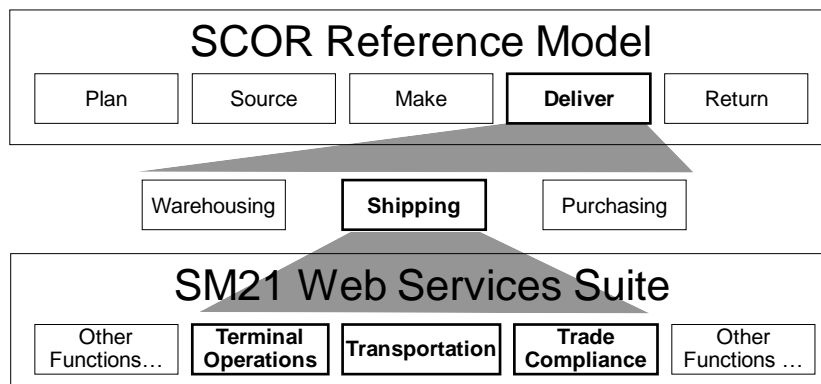
Figure 2: SCOR Reference Model & GTMS

3 GENERAL ENVIRONMENT OF LOGISTICS MANAGEMENT

Figure 3: Social Graph for Global Logistics represents the major aspects of Logistics Management. There is not hierarchy between these three operations. In fact, each of these operations is generally managed independently of each other. However, they share interdependent relationships, since an act in one can affect the operation in the other.
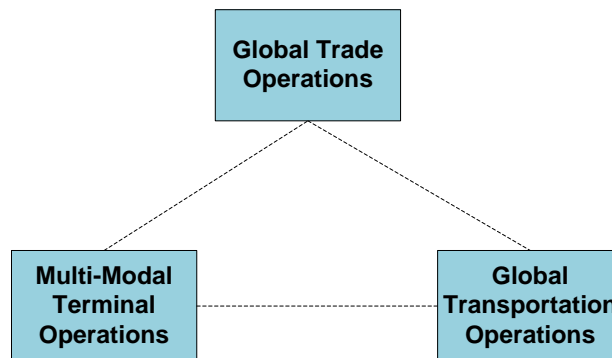
Figure 3: Social Graph for Global Logistics

- **Global Trade Operations** – Those entities interested in the actual trade in goods. Include in this group would be the Doles, International Papers and IBMs of the world who are interested in moving goods because of the acquisition, sale, or production of goods.
- **Multi-Modal Terminal Operations** – These operations consists of the nodes of the transportation system. While the designation may indicate multi-modal, for the purposes of this document, we will include any transportation node, including consolidation, multi-modal (as in sea to land, air to land,…), etc. The emphasis is in the management of an intersection in the transportation network and the need to manage the traffic efficiently and effectively.
- **Global Transportation Operations** – These operations are the legs between the nodes. They represent the companies responsible for the actual movement of the goods. Included are the land, sea, or air conveyors of goods.

Below are examples of some of the considerations for each of the different type operations:

	Global Trade Operations	Multi-Modal Terminal Operations	Global Transportation Operations
Trade Management	Trade Management	-	-
Inventory Optimization	Inventory Optimization	-	-
Container/ Goods Location	Container/ Goods Location	Container/ Goods Location	Container/ Goods Location
Asset Utilization	Asset Utilization	Asset Utilization	Asset Utilization
Warehouse/Distribution Center Management	Warehouse/Distribution Center Management	Warehouse/Distribution Center Management	Warehouse/Distribution Center Management

The problem with today's systems is that there are individual systems for each of these functions. In some cases, there are multiple systems. They vary from organization to organization, even

within the same type organization. In the case of Container/ Goods Location, there are separate systems for Land, Sea, and Air. Furthermore, none of the programs talks to the other. In addition, there is significant manual effort required to work across these diverse applications.

Optimize Sales while Minimizing Inventory (Warehouse and traveling)

Global Transportation Operations

Global Trade Operations

Trade Management

Inventory Optimization

Optimize utilization on vehicles/ minimize wait time

Container/ Goods Location

Asset Utilization

Warehouse/ Distribution Center Mangement

Maximize throughput through terminal

Multi-Modal Terminal Operations

Figure 4: Relative Domain Overlaps

4   THE MILITARY ENVIRONMENT

The military faces all the same complexities of the commercial sector related to logistics and supply chain management with the added complexity of highly dynamic distribution networks and demand patterns. The military is faced with the need to be able to rapidly deploy and sustain large military forces to unknown locations with minimal planning and preparation time. To be truly effective and responsive to the combatant commander, the GTMS operating within the SOA framework will need to be integrated with the primary military systems depicted below in Figure 5.

Currently the combination of incomplete integration with commercial systems and stove-piped military systems prevents and outdated business processes prevent dynamic planning and replanning for force deployment and agile sustainment networks. A graphical example is

provided in Figure 6 of the impact of the current force deployment process on commercial ports as compared to the SM21 GTMS supported Agile Port System modeling results.
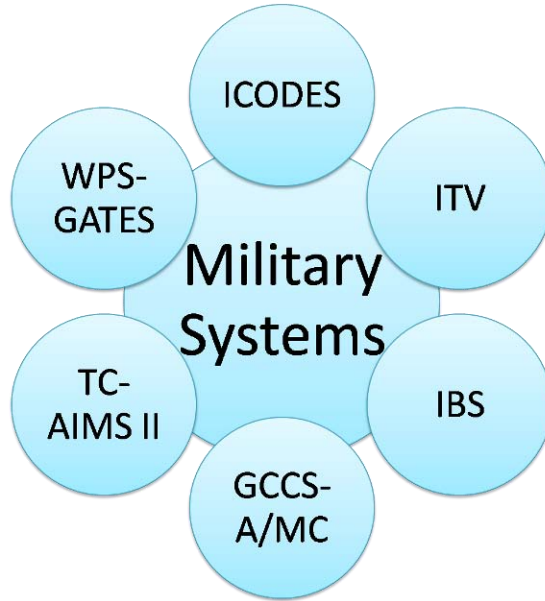
Figure 5: Military Systems – Future Integration

The light blue area in the figure below depicts the actual required buildup of forces on the Port of Savannah's Ocean Terminal over a 14 day period during a deployment to Iraq.
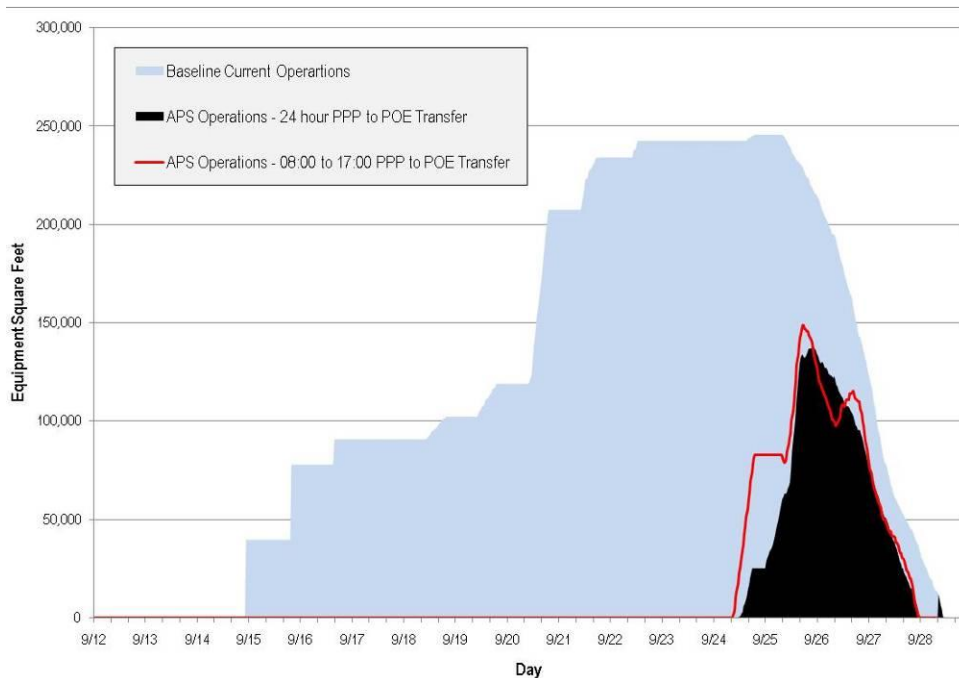
Figure 6: Force Deployment Current Compared to Agile Port System

The current lack of system integration requires that all equipment be physically on the port and seen before ship load planning is completed. This creates a significant impact on both

commercial commerce and the duration of military deployment timelines. Extended deployment timelines increases risks for the combatant commander. Often overlooked in discussions surrounding the current deployment processes and information management systems is the impact on the military members and their families who are about to be deployed, separated, and faced with many challenging moments. Instead of moving equipment and waiting on the next step to take place while information management systems catch up they need all the time they can get for unit team building and preparing their families for the long separation.

The Agile Port System Architecture contained in a separate technical report provides more details on how the GTMS will support both force deployment and sustainment distribution.

5   DEFINING THE PROBLEM

In the brief discussion above on global logistics, some specific parameters develop:

- Overlapping requirements – especially data
- Diverse sources of data
- Diverse needs for services - driven by business needs
- Mature services supporting various operations
- Need to integrate existing services to provide more efficient operations

5.1 Overlapping Requirements – Especially Data

Different companies use different systems, and different types of operations use different types of systems. However, the common theme is that they use the same data. More importantly, where operations work with each other, it would be highly beneficial for them to be seeing the same data at the same time, even if they are looking at the data differently.

5.2 Diverse Sources of Data

For a large organization moving product internationally, the list of potential data sources will include, as a minimum, each sea shipper, each terminal, each rail, each trucking firm as well as customs. As the shipment moves from one mode to the next, the status and sequencing of data needs to be maintained, even if a prior event is reported after the second event. Multiple sources mean multiple formats that need to be reconciled. In addition, this information must be effectively and efficiently available to the various operations of the organization.

5.3 Diverse Needs for Services - Driven by Business Needs

Services are dependent on:
- Type of operation being supported
- Individual organization supporting the operation
- Individual manger of the operation

Each type of operation, global trade, multi-modal terminal operation, or global transportation, focuses on different requirements. But even within these operations, the history of the company, the previous systems, or even the general culture can change the service requirement. Finally, individual mangers, especially at the higher levels will demand to see the information in formats that work for them. A universal approach would assume that there is one best way to do things.

It would assume that there would be no need for improvement. It would deny the individual management differences that provide an edge for the organization.

5.4 Mature Services Supporting Various Operations

In many organizations, there may be systems that have been used over the years or have been developed over time that represent some best practices for that particular operation. While a wish to improve the overall operation may be highly desired, it may not be acceptable to lose specific systems that are considered critical.

5.5 Need to Integrate Existing Services to Provide More Efficient Operations

Many organizations have operations and systems that work well but need enhancing or further "integration". In other cases, there are manual operations that could be replaced with automation, if someone could figure out how to do it. Even if new logistics applications could replace the current applications being used by the company, there may be internal management systems that need to be integrated in some form. At a minimum, the desire to transition gradually may dictate which new applications or services are applied over time.

6 PROPOSED SOLUTION

6.1 Data Integration

If the most common resource across operations is the data, then the first step is to make the data available in a common form. That would mean acquiring the data from the various sources, then normalizing and organizing it. Normalize means pulling the data from the various sources with various formats and making the format of the data consistent so that it can be processed and reviewed efficiently. Organizing means to take the various recorded events for a given shipment and properly sequence and identify the appropriate status of that shipment. While many organizations depend on following a shipment from event to event and mode to mode manually, the ability to consolidate data provides a more efficient and effective approach to managing the process. It also permits the development of metrics and exception reporting that could not be performed under a manual process. Figure 7: Data Integration provides a graphic example of this approach.
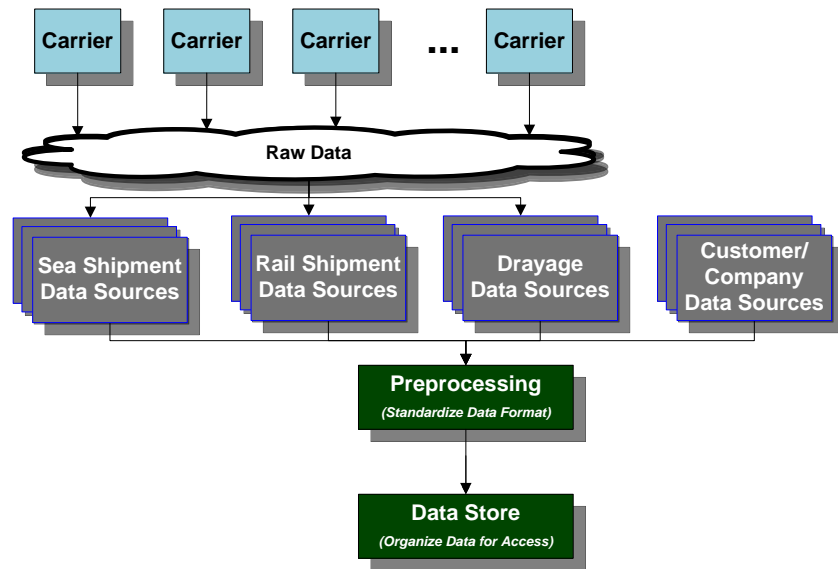
Figure 7: Data Integration

6.2 Service Accessibility

Given a common repository of data, the organization is now in a position to provide services based on that common data. As discussed earlier, services will depend on the type operation being performed, the organization performing the operation, and potentially the manager in charge of the operation. That means there has to be some diversity permitted in the types of services being provided. As a result, the system under consideration should provide a spectrum of data/ information as well as a spectrum of management tools. The individual operations would select the ones that are most advantageous to its operation.

The next step is to determine how to address the implementation of this approach. There is a significant knowledge base built into the existing transportation systems in the market today. While most generally represent smoke-stack systems (that is, they have not been integrated with each other), it would take a significant investment to build a unified system, not to mention the experience curve the current systems have already been through. As a result, the objective is to provide a solution that can tie these diverse applications together, while providing tools to bridge the gaps between the systems.
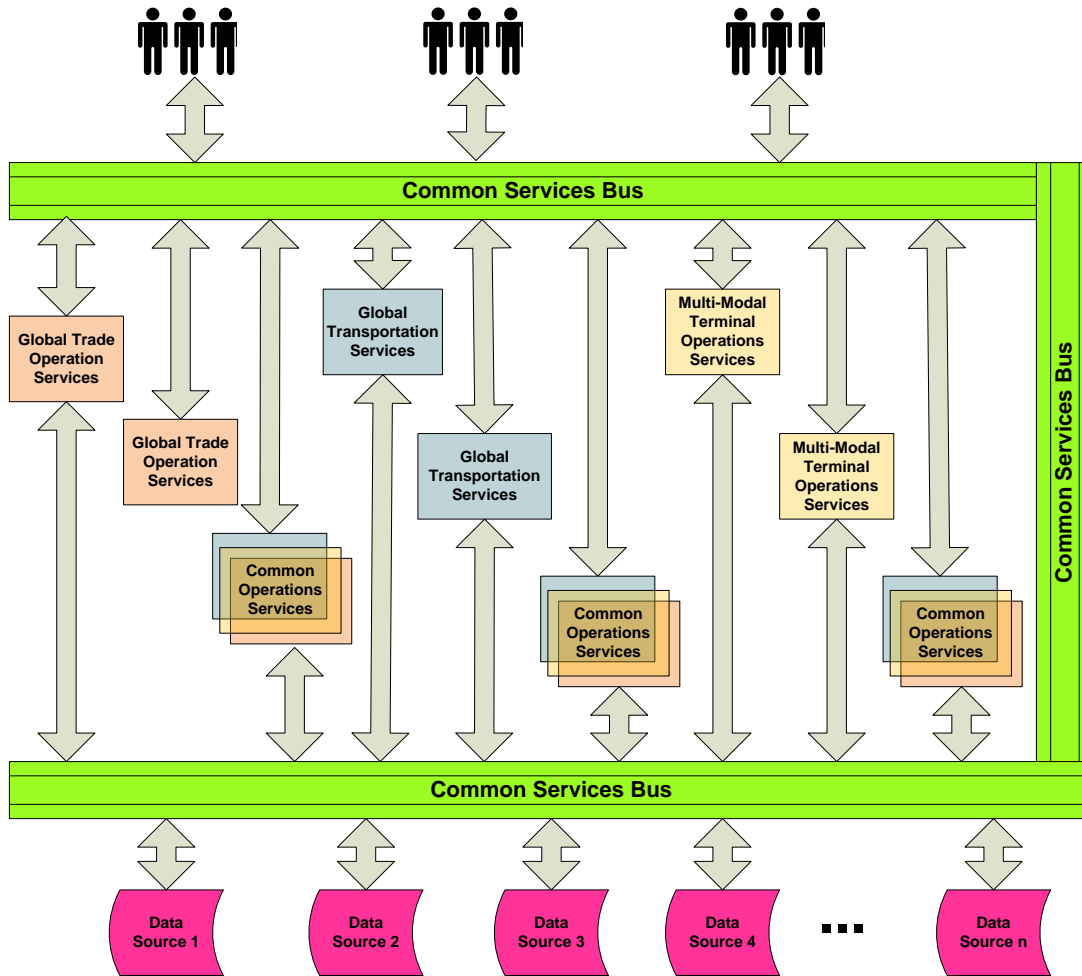
Figure 8: Global Logistics Integrated Management Services

Figure 8: Global Logistics Integrated Management Services shows a high level architecture for implementing an integrated service. This architecture enables any person to access any service. It allows any service to respond to that person, as well as obtain information from the needed data sources. The architecture also permits any service to ask for information from another service. Furthermore, legacy systems can provide their services to the mix as well by wrapping legacy applications in the appropriate message wrappers. This approach is basically a Service Oriented Architecture or SOA.

6.3 Consolidated View

Below is a consolidated view of the data collection and service provision. As has been discussed, the first objective is to obtain the data from the various sources, normalize, and organize it. The next step is to make it available for the various services needed by the operation.
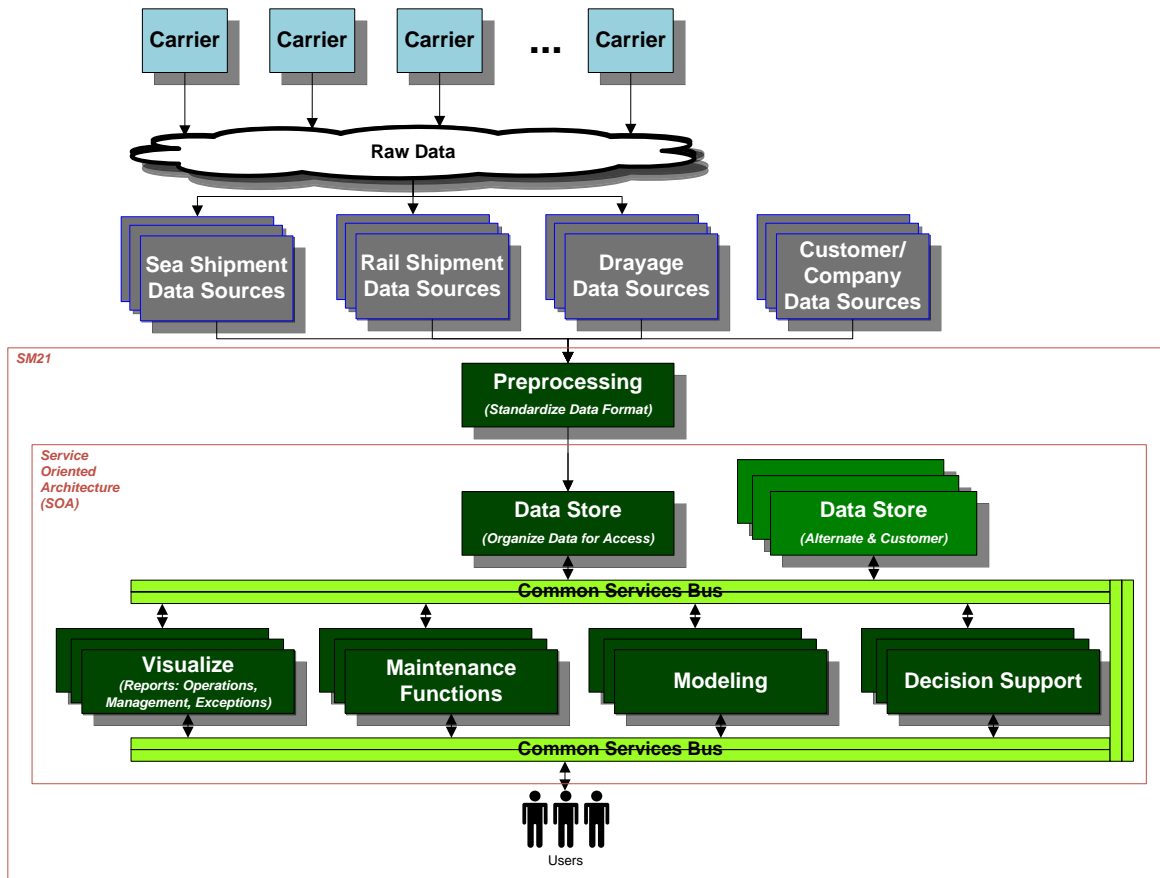
Figure 9: Consolidated View

SECTION B.   ARCHITECTURE

7   SYSTEM OF SYSTEMS (SOS)

The GTMS is being developed as a System of Systems (SoS). This concept takes into account the fact that there are excellent best-of-breed systems that perform selected functions well. In addition, there is a need to combine whatever functionality the GTMS provides with functions in the customer's environment with which the customer would want to integrate. The combination of these various capabilities into a common interface should permit synergies unachievable in other manners. This combination also permits customers to take advantage of an "ABC" philosophy similar to that used by DISA (Defense Information Systems Agency): "Adopt-before-Buy, Buy-before-Create." In general, this means that the customer is taking advantage of well-developed capabilities that already exist, rather than trying to re-invent from scratch and assume the risk of the learning curve that comes with that approach.

8   SOFTWARE AS A SERVICE (SAAS)

Software as a Service (SaaS) is a model whereby customers make use of the application as a service on demand. That means that the service is easily accessible to the customer through a web browser, regardless whether the service is hosted on a vendor web site or the customer's own web site.

The GTMS is designed to use the SaaS model. This approach provides a number of advantages:

- Data collected from various vendors on shipping can be used by a number of different customers, e.g., the multi-modal terminal operators and shippers would use the same data as the supplier in tracking the shipment. This ensures consistency of data across operations, which is especially useful when trying to reconcile shipping issues.
- All services will be provided across the web, permitting suppliers and related vendors to access the information any place or anytime.
- Being a web service, no updates need to be distributed as services are enhanced. This significantly reduces the software coordination needed to support the services.
- As an organization is prepared to add an additional capability, it is available to all appropriate individuals upon release.
- To the degree that closer cooperation is indicated between the shipper and supplier in the future, a platform that can be shared widely will significantly enhance the relationship.

9   SERVICE ORIENTED ARCHITECTURE (SOA)

The GTMS needs an architecture that will support a System of Systems (SoS) and Software as a Service (SaaS). The selected architecture is a Service Oriented Architecture (SOA). It is designed to alleviate the problems of system and operating environment heterogeneity and interoperability as well as the normal requirements volatility that exists in most operating environments.

Think of SOA as a collection of services connected by a communication link –also called a bus (in the GTMS case, the Internet). A user is on the web and from the web interface, requests an action. The request is sent to the proper service, which then provides a response to that request. To facilitate this capability, SM21 has established a single sign-on capability for the user which allows a smooth transition between the services without the user interrupting their thinking with an additional sign-on when crossing applications.

The general capability of the GTMS is obtained by using web-based standards that permit communication in the common environment – the Internet. These standard communication protocols not only let the user communicate with the service, but they allow services to communicate with each other. That permits services to be reused outside the areas they would normally operate. This approach also allows the architecture to interface with any application that can form an interface with the Internet. This capability permits older applications to extend their life while extending their utility. It also permits any platform (mainframe, mid-frame, personal computer, server) and any development environment (Java, COBOL, Microsoft,…) to participate in the operation. The most important elements are the existence of the service, a bus (communication link), and an agreed protocol (messaging format).
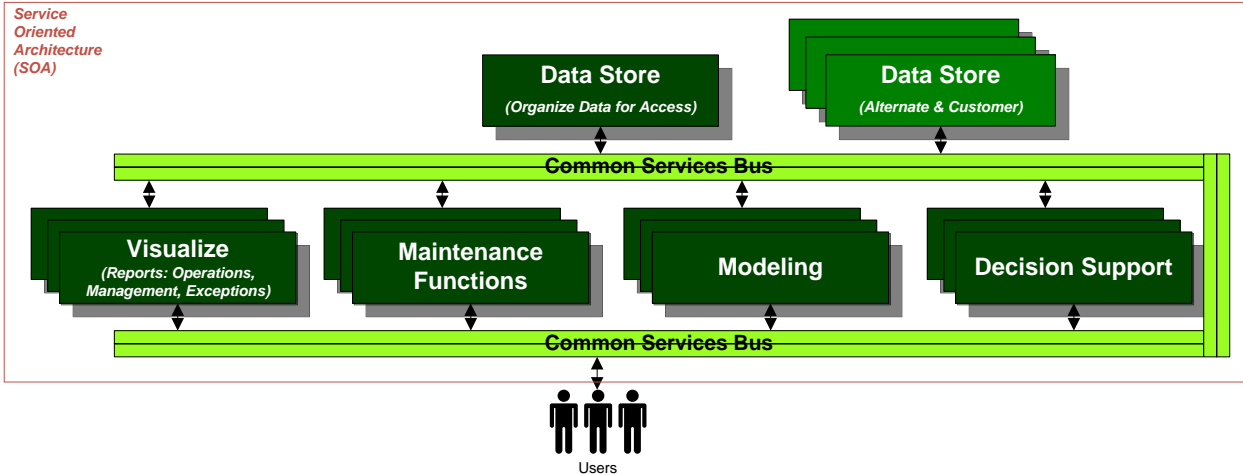
Figure 10: SOA Architecture Example

There are many books and papers written on SOA, and there are many ways to implement it. The foremost characteristic, however, is that the architecture is centered on services. Next, those services can be existing systems that need to talk to each other and have not in the past. In fact, the first step for any development of SOA is to define the requirements, motivation, and goals for pursuing the architecture.[1] That makes it business and process focused. A basic element of SOA is that the services are loosely coupled - a service will be requested via a messaging system and a response will be returned.

In the case of Dole, the first step was to complete a value stream analysis to define the requirements, potential motivation, and goals for developing the initial operating capability of the SOA. After verification of the analysis with Dole and their supply chain partners, five (5)

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[1]Reference Model for Service Oriented Architecture 1.0 – Committee Specification 1,2 August, 2006 OASIS

key capabilities were defined as the initial features of the GTMS IOC, which will support container shipment management:

- End-to-End Shipment Tracking and Visibility
- Integrated Global Transportation Management (GTM)
- Automated Container Pick-up Prioritization and Scheduling
- Exception Based Management
- Extended Supply Chain Management Reporting

The end-to-end shipment tracking and visibility required that all of the major distribution components associated with the Dole Foods Supply Chain Network (Figure 11: End-to-End Supply Chain Network) be seamlessly integrated. The objective was to enable visibility across modes (ocean carrier, rail, and truck) and through the nodes (manufacturing sites, terminals, and warehouses) to allow information from different data sources and systems to be viewed in one system or dashboard.

Figure 11: End-to-End Supply Chain Network

The end-to-end shipment tracking and visibility requirement was the most comprehensive requirement and established the base capability for the remaining four key capabilities. To meet this comprehensive requirement, three existing best-of-breed commercial systems that had not previously exchanged data where integrated within the framework of the SOA as outlined below and depicted in Figure 12.

- GT Nexus – SaaS - Ocean Carrier shipment In-Transit Visibility
- Transentric – SaaS- Rail Carrier Shipment In-Transit Visibility
- One Network Enterprises - SaaS – Transportation Management System
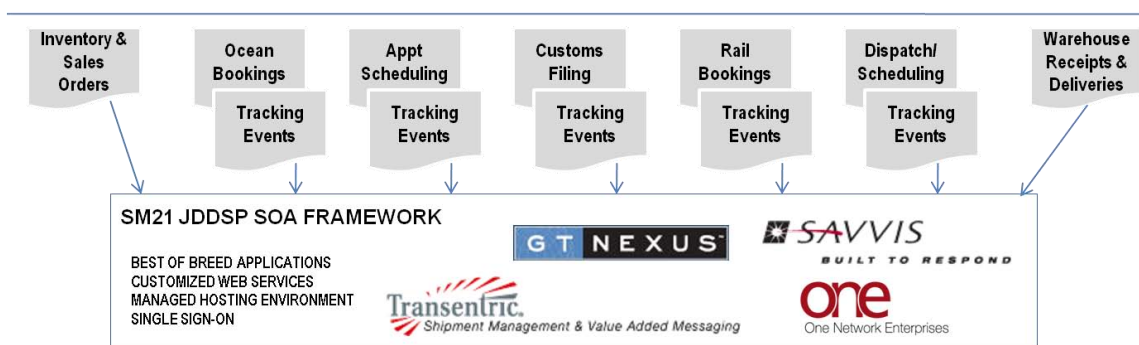
Figure 12: End-to-End Supply Chain Distribution Visibility Systems

After completion of a successful user acceptance test with Dole, to fill in remaining capability gaps or to enhance the fidelity of the initial operating capability of the GTMS, additional existing

systems will be integrated and value added web services will be developed. Drayage tracking is an example of a web service under consideration for development and integration for integration.
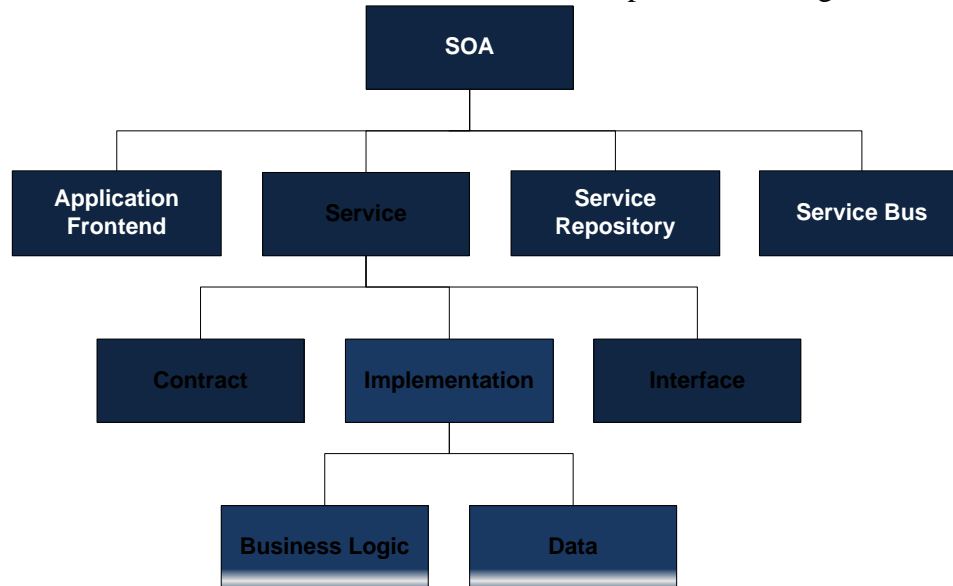
Figure 13: SOA Elements[2]

Here are the elements of a SOA for the most elementary implementation:

- Define the applications front end – the initial starting point. Also the point for establishing single-sign-on (SSO).
- Identify the services to be shared.
- Identify where the services are to reside. They may reside in different places.
- Identify the Service Bus to be used. This is the infrastructure that will transmit the requests and receive the responses. In the GTMS case, that would be the Internet.

In defining the service, the following steps are taken:
- Define the Contract. The contract would be the agreement on the service that is to be provided.
- Implement the service - which includes:
    o Business logic to accomplish the task.
    o Data needed to perform the service.
- Define the interface. The interface would be the messaging used to request the service and the messaging to obtain the result. Since the GTMS is using the Internet, the messaging uses XML and HTML.

Assuming the application exists, the addition of a service requires adding an interface to the application that can receive a request and return an answer using an agreed on messaging protocol.

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[2] Wikipedia, "Service Oriented Architecture" with reference to **Elements of SOA,** by Dirk Krafzig, Karl Banke and Dirk Slama. Enterprose SOA, Prentice Hall, 2005.

10 DEVELOPMENT/ OPERATING ENVIRONMENT

The SM21 development team has designed the operating environment to provide the flexibility for *any* system that can interface with the Internet to be able to provide a service to the GTMS. As a result, the discussion on the Development/ Operating Environment is focused on the SOA frontend. Each of the services is expected to have its own architecture with the capability of interfacing with the Internet.

10.1 General Architecture

The objective of SM21 is to enable the most universal access possible. As a result, the GTMS frontend exclusively uses open standards software in its development. The selected technologies provide SM21 with the security and flexibility required to bring this project through a successful production transition. The components used include:
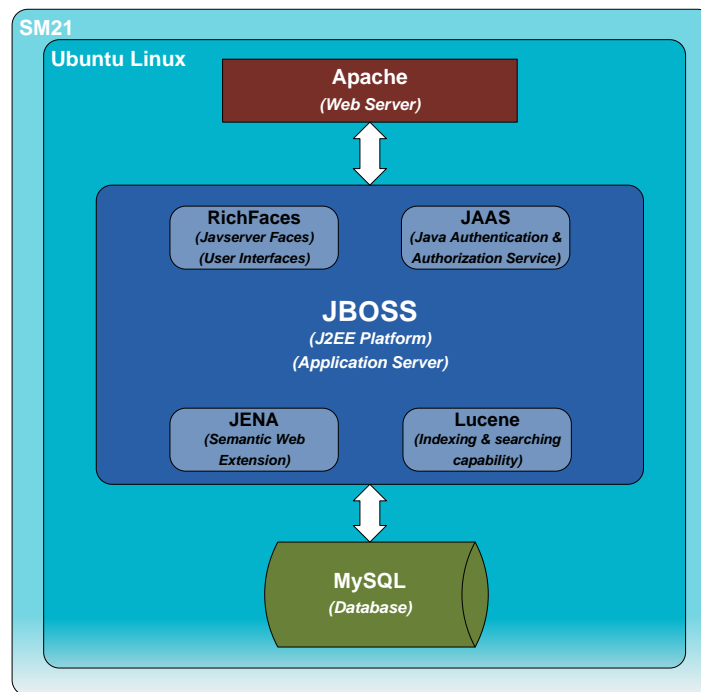
Figure 14: The GTMS Operating Environment

- **Ubuntu Linux** – Linux is an open source operating system. Ubuntu Linux is being utilized as the hosting development environment. Ubuntu provides a very solid Debian (free) based Linux stack that provides all the components needed to insure a secure easily updated environment that can run any open source technology.
- **Apache2 –** Apache2 is a Web Server - The Apache has been the most popular web server on the Internet since about 1996.
- **JBoss –** JBoss is a J2EE (Java 2 Enterprise Edition) Server. - *Lucene* and *Jena* are dependent jar (program) files within JBoss. The open standard-developed software integrates with open standards tools to provide an enterprise solution. JBoss, in

15

combination with ***RichFaces*** and ***Java Server Faces***, provides a unique ability to rapidly develop and deploy user friendly front end***s*** to access and manipulate back end data.

- **MySQL –** MySQL is an ANSI-99 compliant relational database. Open-sourced, the database can be transplanted at will without licensing concerns. At the same time, it provides the security and flexibility required in business and military environments.
- **JAAS** (Java Authentication and Authorization Service)- provides the security framework for user-centric security
- **Lucene** – Lucene is a text search engine that provides a mechanism for lookups inside each EDI message to include greospatial data.
- **Jena** - The enhanced data is sematically enabled and stored in Jena, the preeminent semantic web tool. This enhanced data is ultimately read and forewarded to One Network[3]. Communication Protocols

As discussed in a previous chapter, the communications bus for the GTMS is the Internet, which means the GTMS will adopt the communications protocols for the Internet. However, it must be understood that after messages are transmitted, the content of the message must also have a format.

The GTMS uses two styles of software architecture for communication across the web:

- REST – Representational State Transfer
- SOAP – Simple Object Access Protocol

Having both capabilities provides the GTMS flexibility to connect with many more systems.

10.2 REST

Representational State Transfer, or REST, in general is a group of networking architectural principles that are used to determine the naming and addressing of resources. REST web services use HTTP to transfer data without an additional protocol such as SOAP. The GTMS accomplishes RESTful interactions by the web application handling RESTful URL's via a URL Rewrite Filter and through a RESTFul web service application. REST also uses Uniform Resource Indicators (URL's are a form of URI's) to access, create, update, and delete data.

The data within a RESTFul interface may appear in a variety of different ways. The data may appear as raw XML interpreted by the browser, or directly handled by HTML style sheets. The data may also appear entirely as a service with no user interface. The form of the data within the message must be well-defined to ensure that the responder can understand the request and that the response sent can be understood by the requestor. This is part of the "contract" discussed in the Service Oriented Architecture (SOA) section.

Some of the proposed advantages of using RESTful applications include:
- Improved response time and reduced server load.
- Reducing reliance on session state information.
- Browser accessible.

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[3] This capability was added on for future development but was not part of the original development request.

- Technology agnostic.

10.3 SOAP

Simple Object Access Protocol, or SOAP, specifies a protocol for exchanging data through web services over networks. Extensible Markup Language, or XML, is the data format and is usually coupled with Remote Procedure Call, or RPC, and HTTP for communications. This directional XML communication can pass data between applications to be interpreted and displayed in any format needed by the end user. The GTMS uses Web Services to automate the data exchange mechanism with any capable enterprise application belonging to organizational partners.

As discussed under REST, the form of the data in the message must be well-defined to ensure that the responder can understand the request and that the response sent can be understood by the requestor. This is part of the "contract" discussed in the section on Service Oriented Architecture (SOA).

11 SYSTEM INTEGRATION

The SOA based architecture connects with services. The GTMS is a System of Systems (SoS), which means that the GTMS is targeted to provide services from any source that meets the business needs. Figure 15: SOA Based Architecture, on the following page, gives an overview of how the various functions might relate. Please be aware that the hardware and communications platforms are not designated here. A reference to a web browser means any web browser that can handle Web 3.0 capabilities. Web servers may be anywhere. The various components of the services layer are very likely to be on different servers provided by different vendors. Also, the databases may or may not need to be accessed through an application layer. Given that the Internet is the main communication bus/ protocols for all of this activity, the connection is now not as important to understand as the services that are being made available.

The SM21 updated experimentation plan outlines future web services related to trade classification, security compliance, and online analytical processing (OLAP) capabilities which will be developed for experimentation and system integration. Likewise, data input in the future will use semantic web tools to more completely automate data integration from the many possible sources and formats. Additional experimentation is being planned for cloud computing, advanced security enhancements, and the integration of real-time sensor feeds that add value to the distribution management process and control of inventory. Finally, planning includes the development of a semantically enabled knowledge management system for shipper use that would be enabled by SM21 developed ontologies in the following initial domains: inventory shipment, trade and security compliance, warehouse management, and transportation asset management.

12 SUMMARY

The GTMS is designed to provide service on the most ubiquitous platform: the Internet. It uses Open Source resources that ensure the ability to move the application anywhere without the need for licensing the underlying platforms.

The GTMS is designed to incorporate any system where a web-interface can be established. This design permits any legacy or web-based system to participate in the activity. The major

advantage to the customer is that their current systems can be incorporated if desired. The value in current systems can be extended by broadening their use. In addition, those systems can be extended with the value of the integration from other services. In general, the SM21 program is focused on building a system around the needs of the customer.
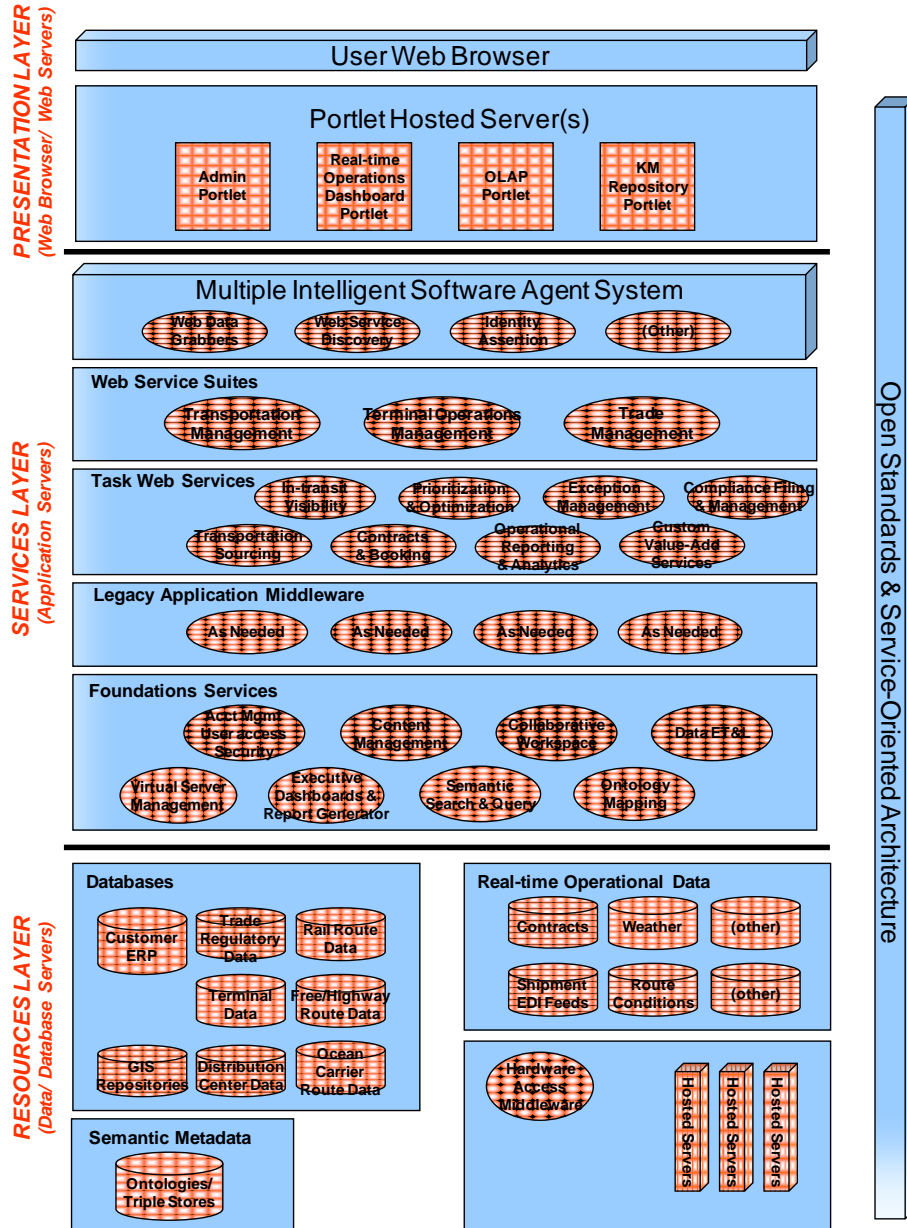
Figure 15: SOA Based Architecture

SECTION C. SYSTEM SECURITY

13 CONSIDERATIONS

In addressing the security aspects of the system, the current state of the art programming for Internet security was considered as well as the standards established in the Orange Book (named after the color of the cover)/ Director of Central Intelligence Directive 6/3 (DCID-6/3) entitled, "Protecting Sensitive Compartmented Information Within Information Systems".

Given the nature of the Internet, the objective is not to secure the entire Internet itself, but to secure the messages being sent, as well as the physical entities at each end. The goal is to get the message from door-to-door safely and uncompromised. Basically, the technology that moves financial transactions across the web is the same as will be used by the GTMS.

Three aspects are involved in security:
1. **Physical** – ensure that the servers and communication links at the service sites are secure.
2. **Communication** – ensure the transmission of the message is secure.
3. **Administrative** – provide an environment for the proper administration of users and their respective roles.

14 PHYSICAL SECURITY

As a system of systems (SoS), the GTMS allows for services to be provided by anyone. As a result, the provider of the service is responsible for ensuring the physical security of their service. Regardless, the characteristics of the security should include:

- **Assurance** - GTMS hardware is located in a protected area where only authorized personnel are allowed entrance. In addition to this physical protection, the GTMS server(s) only allow access to individuals whose system username and password have permissions of an appropriate level to access the servers and code base. A log of user access to the servers is monitored.

- **Continuous Protection** – The GTMS servers are not available to unauthorized personnel. Access to the source code and system configuration is under lock and key. The GTMS system continuously protects against tampering and/or unauthorized changes via password protection.

15 COMMUNICATION SECURITY

15.1 Characteristics
In discussions of information security, these topics are discussed:

- **Confidentiality** – data is secured from others between the sender and designated receiver. The best approach to this issue is *encryption*.

- **Integrity** – data has not been altered between sender and receiver. *Encryption* functions that include the hashing of messages provide a validation that the message has not been altered accidently or on purpose.

- **Authentication** – origin of message can be established. *Passwords* as part of the sign on establish the person which is validated by the application. However, as the message moves from one platform to another, a transport layer security (e.g., the use of the *Secure Socket Layer (SSL)* in HTTPS) sets up a mutual verification that establishes the authentication.

- **Authorization** – managing the access to various functions. In the case of GTMS, the security is *role based* and functions are permitted based on the authentication of the person.

- **Non-repudiation** – sender cannot deny having sent the message. This is a combination of authentication and *transaction logging*. Authentication identifies the individual. Transaction logging provides a record of the activity.

- **Accessibility** – Service is accessible at all times, including from denial-of-service (DOS) attacks, from outside or inside of the system hosting the service. In the case of the GTMS, this is managed through the infrastructure where algorithms identify potential DOS attacks. The other aspect is maintaining redundancy in the infrastructure for servers and power.

15.2 Required Capabilities

Based on the characteristics outlined above, the GTMS will provide a security structure that includes:
1. Encryption
2. User Id & passwords
3. Secured Socket Layer (SSL)
4. Role Based Authorization
5. Transaction Logging

15.3 Security Architecture

The architecture used by the GTMS core is based on the Java Authentication and Authorization Service (JAAS). JAAS is a Java security framework incorporated within the JBoss application server. It includes a wide range of capabilities including cryptography (encryption), public key infrastructure, secure communication, authentication, and access control. The JAAS architecture covers points 1, 2 and 3 in required capabilities. The approach for covering the first three required capabilities includes:

15.3.1 Traditional HTTP Authentication: HTTPS

Secure socket layer (SSL) is a technology which allows Web browsers and Web servers to communicate over a secured connection. The data being sent is encrypted by one side, then transmitted, and decrypted by the other side before processing. This is a two-way process, where both the server and the browser encrypt all traffic before sending out data. The trusted store

provides the handshake between the browser and the http server allowing encrypted communication.

By using J2EE as the target environment, single sign-on is activated, providing single authentication irrespective of how many different web applications a user accesses.

This is traditional web security with some extensions added to prepare for full container security.

15.3.2 J2EE: Enterprise JavaBeans Technology Securing Enterprise Java Beans (EJBs)

Enterprise JavaBeans (EJB) technology is the server-side component architecture for the Java 2 Platform, Enterprise Edition (J2EE) platform. EJB technology enables rapid and simplified development of distributed, transactional, secure, and portable applications based on Java technology.

To secure an Enterprise Bean, the roles used at the web layer are leveraged to provide the same type of role based security just at the EJB method.

15.3.3 Writing the Login Module and Principal

Finally, it is not hard to write a login module. They are typically 50 to 100 lines in modules. Prior to open standards, advanced security required writing hundreds, if not thousands, of lines of software. Using J2EE and JAAS, most of the work is in the definitions contained in the XML files.

16 ADMINISTRATIVE SECURITY

16.1 Security Policy

The GTMS system enforces a well-defined security policy. There is a set of rules that are used by the GTMS to determine whether a subject receives permission to gain access to a specific object. No subject lacking the appropriate clearance level is permitted access to sensitive information. Discretionary rules applied to selected subjects and groups of subjects control access to data. Control of the rule set for system and data access is only allowed for users authorized for such activity.

16.2 Mechanics of the GTMS Security

16.2.1 Marking

Roles are associated with system objects and identify the access level or access limit associated with the object.

16.2.2 Identification

Users of the GTMS system are uniquely identified. Each identified user has person and access level information associated with them. All information pertaining to the user is maintained in a database.

16.2.3 Accountability

The GTMS must maintain audit information so that actions affecting security and information integrity can be tracked to the responsible subject. Auditing levels are set to limit the impact to system performance. The audit date is placed on two redundant password protected systems.

16.3 Role Management

Users, Groups, and Roles are assigned through an administrator's user interface. The authentication described above is used to adjudicate access to altering the Users, Groups, and Roles by requiring any user wishing to change Users, Groups, and Roles to posses the "Administrator" role. An initial Administrative user is available with the caveat that the Administrative password must be changed upon the administrator's first successful login to the application. This user may then be used to create all of the Users and additional Groups and Roles required for the GTMS system authentication and governance.

- Roles consist of a unique name and the relationships with User and Group objects. Roles are associated with Groups and Users by a many-to-many relationship (Groups can have many Roles and Roles may have many Groups).

- Groups consist of a unique name and the relationships between Users and Roles. Groups are associated with Roles and Users by a many-to-many relationship.

- Users consist of a unique username and password combination, and are associated with Roles and Groups by a many-to-many relationship. Users are associated with Person objects by a many–to-one relationship. (A User is related to one Person object but a Person Object may belong to many users.)

- Persons consist of a First Name, Last Name, Gender, Ethnicity, and a Date of Birth. Persons are associated with Users via a one-to-many relationship. (A Person may belong to many users but a user may only have one Person.)

- An Address Object consists of a Type, Address One, Address Two, City, State, Zip, and a unique system assigned integer id. Addresses are related to Persons by a many-to-many relationship.

- Application objects consist of a unique Name, Username Parameter, Password Parameter, and Little Language/script field. Applications share a many-to-many relationship with Users and Roles. Applications share a many-to-one relationship with Application Logins.

- Application Logins consist of an integer id assigned by the system, a Username, and a Password. Application Logins share a many-to-one relationship with Users. Applications Logins have a one-to-many relationship with Applications.
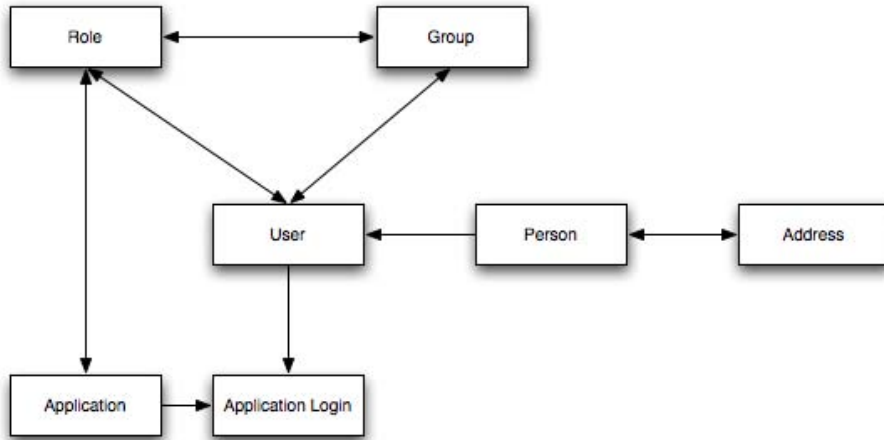
Figure 16: The GTMS Security Data Diagram

Applications configured to work with the GTMS system have access controlled by the security policy. Administrative users have the option to set roles associated with the application.

To control access to Applications, an administrative user is able to assign roles to the application. If a user attempts to access an application or data related to the application assigned to a Role or Group, the user must also be assigned the appropriate role or group in the administrative interface.

Roles and groups are appropriately named to reflect the access levels that possessing the role provides. For instance, if a user is a system administrator, he or she should have the administrative role. The current hierarchy contains only the Basic and Administrator roles. The Basic Role allows access to the system, system pages, and objects with Basic role. The Administrator role will allow access to everything in the system.

Role management can accommodate new roles specifically created for an application. For example, an administrator can add a new application called GT Nexus. To govern the user access to this object, the administrator can create a new role, for example, called "GT Nexus Access" and assign the role to the GT Nexus application. No user without the GT Nexus Access or Administrator role will see the GT Nexus application.

16.4 Transaction Logging

As previously stated, upon attempted entry to the GTMS system, subjects are challenged for a username and password combination. This activity occurs before access to any other part of the system is allowed. Logs are accessible via a user interface in the administrative portion of the system and via text log files for the application server. The logs are then checked to determine who or what changed the data on the system.
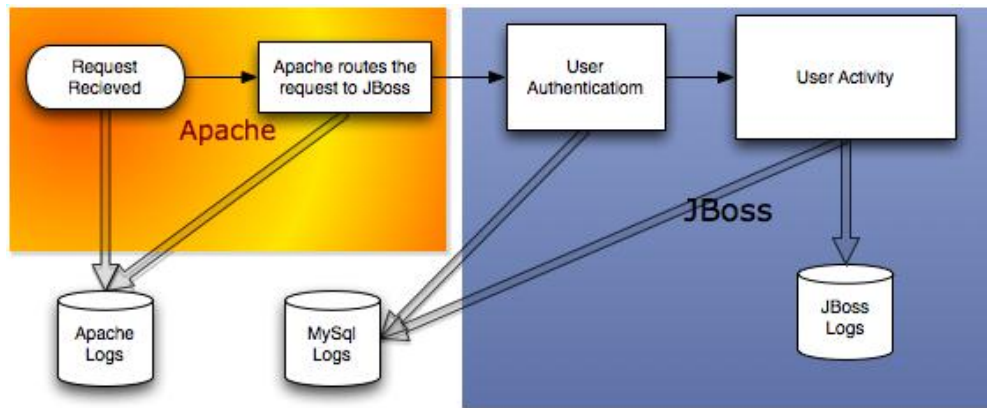
Figure 17 System Logging Diagram

GTMS Administrative users will be able to set the role level which users must have in order to access the logged activity. Logs will not be altered by the system users no matter what role the user is associated with, which insures log integrity.

SECTION D.   DOLE EXPERIMENT

17 1ST EXPERIMENT - DOLE

The first experimentation campaign partner is Dole Corporate Package Foods (DPF) division. Founded in Hawaii in 1851, Dole Foods is the world's largest producer of high quality fresh fruit and fresh vegetables. Dole's geographical reach extends to more than 90 countries, with a line of over 200 products. Figure 18: Dole Shipping Flow demonstrates shipment flows for Dole Foods moving from the Philippines to the Ports of Los Angeles and Long Beach onto further destinations in the US.

Figure 18: Dole Shipping Flow

The purpose of the Dole Foods proof of concept is to demonstrate capabilities that will help Dole improve distribution Center (DC) service levels, reduce inventory, reduce costs, and increase productivity. A subset of Dole Food's supply chain and SKUs are included in this project. The product line SKUs/items include canned pineapple juice and the supply chain network scope are shown below.

There are two primary multi-modal logistics flows represented in the project.
- Ocean to the Port of Los Angeles/Long Beach (LA/LB) and then ground to the Buena Park DC.
- Ocean to the Port of LA/LB and then rail to the Fort Worth and Joliet rail ramps (Joliet freight has since been moved via Hapag, and will not be included in the IOC.)

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18 EXPERIMENT OBJECTIVES

Through the initial requirements spiral, a high-level Value Stream Analysis was performed on DPF's current state regional distribution network for DPF commodities from Dolefil. DPF imports large quantities of these products from the Philippines through the Port of Los Angeles (POLA) or the Port of Long Beach (POLB). The products then move either to their inland distribution center in Buena Park, California or continue eastward by rail to its distribution centers in Dallas Ft. Worth, Texas and Joliet, Illinois. The primary objectives of the Value Stream Analysis (VSA) was to facilitate the identification of capability gaps, to prioritize experimentation areas, and to improve distribution process flows and overall inventory control.

As is typical in this industry, the VSA documented numerous manual processes and various systems used to support shipment movement through the distribution network. For example, DPF manually accesses multiple carrier web sites to check shipment status in order to maintain and distribute spreadsheets to track containers. The expediting of the urgent containers, also a highly manual process, includes several dynamic factors which may impact the overall scheduling of inbound shipment to the Distribution Center (DC). These factors include the amount of free time allowed at the port, carrier transit times, demurrage fees, port fees, operational schedules, and the physical capacity at the ocean port, dray carrier, and distribution center. The tracking of container status is extremely inefficient as the user must constantly check the websites until the container is available for pick-up. The result is that the DPF supply chain can be slow to react to changes in-demand due to reliance on disparate systems and manual processes to manage supply chain and inventory systems. This lack of "real time" visibility of shipments and potential execution failures result in service level impacts and increased inventory buffers.

To assist in the transformation of the DPF supply chain into a competitive advantage by influencing the supply chain and not reacting to it, three (3) main components for an agile distribution network were identified:

- Early sensing of potential problem areas in the distribution network can lead to a more timely response and resolution.
- Near-term and future objectives will be dependent on timely, complete, and accurate data.
- The high number of transactions across the distribution network can only be managed effectively by exception.

After verification with DPF and their supply chain partners, five (5) key capabilities were defined as the initial features for GTMS IOC which will support container shipment management:

- End-to-End Shipment Tracking and Visibility
- Integrated Global Transportation Management (GTM)
- Automated Container Pick-up Prioritization and Scheduling
- Exception Based Management
- Extended SCM Reporting

As the Dole Foods experimentation VSA targeted specific DPF product lines of pineapple products, the IOC will focus on a subset of transportation carriers and lanes which provide service to DPF. The transportation carriers and lanes defined below will assist with the validation of the IOC.

- Port of General Santos, Philippines to Port of Los Angeles/Long Beach, U.S.A.
  Ocean carriers selected for experimentation are Maersk, NYK, and CMA.
- Port of Los Angeles/Long Beach to Distribution Center in Buena Park, CA
  Dray carrier selected for experimentation is JAC Trucking.
- Port of Los Angeles/Long Beach to Rail Intermodal Ramps in Ft. Worth, TX and Joliet, IL
  Rail carriers selected experimentation are BNSF and UP.

Keys to the success of the SM21 IOC will be:

- Cooperation among the technology solution vendors and supply chain partners.
- Full understanding of each partner's capabilities and limitations.
- Collection of the most accurate and timely data available in the industry.
- Availability and responsiveness of the supply chain partners for detailed requirements gathering and experimentation participation.

19 SHIPMENT DATA FLOW

Figure 19: Dole Data Flow shows the data flow that will be used for this experiment.

As described in the previous sections, the GTMS will collect all shipment details, in-transit events, and inventory balance across DPF's supply chain partners for the IOC. These incoming shipment messages will be processed and stored into a centralized semantic database. Based upon the information consumed, business processing logic will be applied, which will generate the appropriate normalized data feeds from the GTMS to One Network

The following strategic technology partnerships are being incorporated into the GTMS IOC:

- GT Nexus – SaaS - Ocean Carrier shipment In-Transit Visibility.
- Transentric – SaaS- Rail Carrier Shipment In-Transit Visibility.
- One Network Enterprises – SaaS - Distribution & Transportation Management Solution.

19.1 GT Nexus

In this first iteration of services implementation, GT Nexus will provide the GTMS ocean shipment visibility for the Dole Experimentation Campaign. GT Nexus is an established on-demand ocean visibility solution that has established connectivity and relationships with the top twenty (20) ocean carriers and exchanges over 500,000 messages a day.

This solution will include collecting and standardizing near-real-time
- EDIX12 315 - Ocean Carrier Shipment Status

- Full in-gate at Ocean Terminal
- On-board vessel at Port of Origin
- Vessel departed Port of Origin
- Vessel estimated Time of Arrival (ETA)
- Customs Released
- Vessel arrived Port of Discharge
- Container Available Notice
- Full out-gate from Ocean Terminal
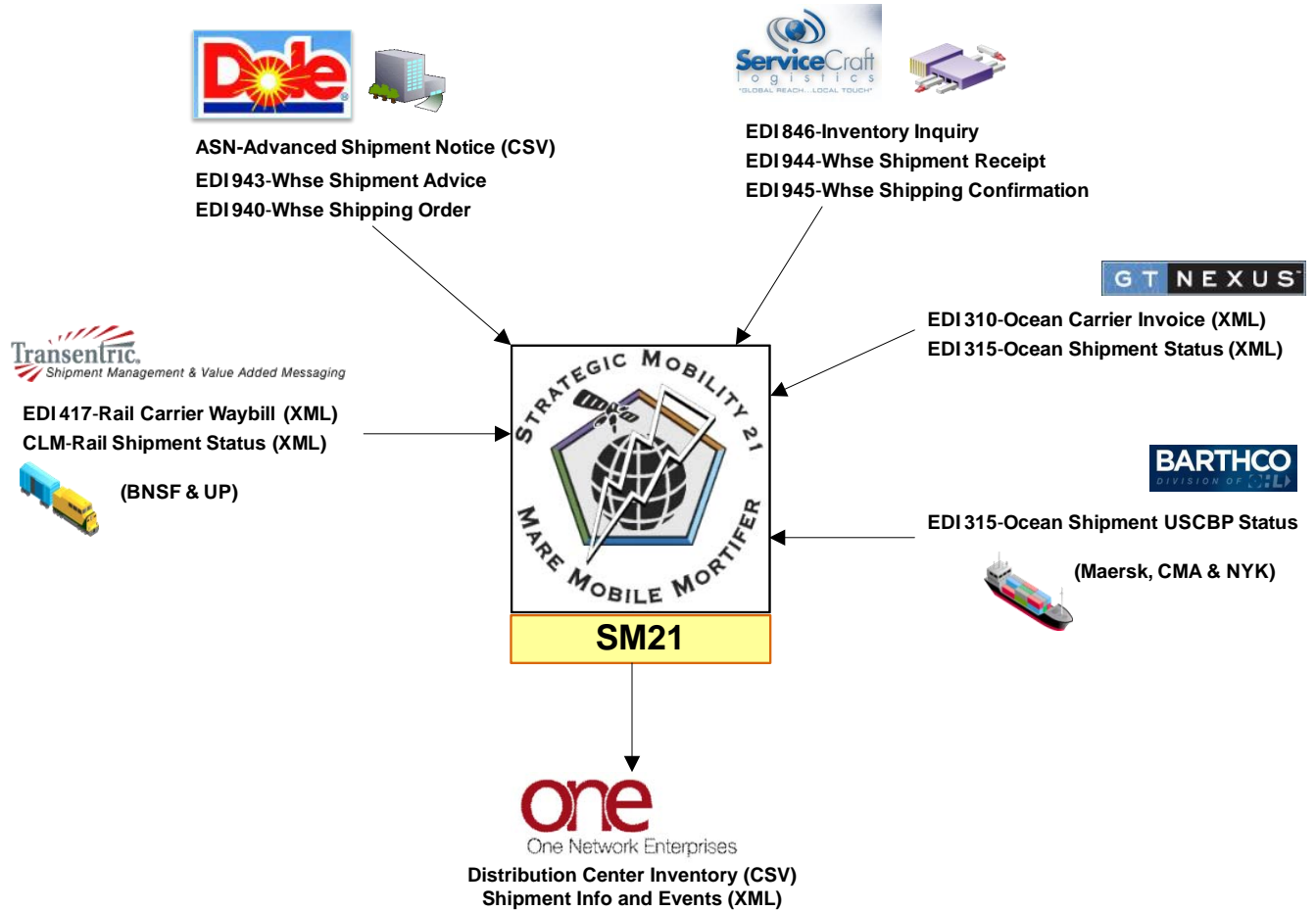
Figure 19: Dole Data Flow

- Full container delivery
- Empty container returned

- EDIX12 310 - Ocean Carrier Freight Receipt

Initially, GT Nexus will synchronize the ocean carrier integrations and normalize the data across the selected carriers identified for the IOC (Maersk, NYK and CMA). Through a standard XML

interface process, the ocean data will be sent to the GTMS to be processed and loaded into the semantic data store. The following is a short list of expected ocean events provided by the 315 that will be collected across the IOC ocean carriers.

Shipment Detail	Container Detail					Help ?

Container	MWCU6220332		**Other Reference**	091363	
Container Type	40' RE			280769	
Booking #	598903046			MSK	
B/L instruction	N/A			V0781553149	
B/L	MAEU598903046			V0781553149	
Vessel/Voyage	MAERSK ALFIRK 0905			V0781553149	
	MAERSK BROOKLYN 0905			V0781553149	
				V0781553149	

Shipper	DOLE THAILAND LTD
Carrier	Maersk Line
Consignee	Dole Foods Co.
Notify	BARTHCO INC-LOS ANGELES
Also Notify	MADISON WAREHOUSE, DOLE PACKAGED FOODS INC

Place of Receipt	Bangkok, Thailand	03/28/2009	(Actual)
Port of Load	Laem Chabang, Thailand	03/30/2009	(Actual)
Port of Discharge	Los Angeles, CA, United States	04/18/2009	(Actual)
Place of Delivery	Fort Worth, TX, United States	04/24/2009	(Actual)

Report a Data Quality Issue

Event	Vessel	Voyage	Location	Date	Time
Empty Container Returned	MAERSK ALFIRK	0905	Fort Worth (Place of Delivery)	04/27/2009	12:00 PM CST
Full Container Delivery	MAERSK ALFIRK	0905	Fort Worth (Place of Delivery)	04/27/2009	08:06 AM CST
Full Out Gate at Inland or Interim Point (Destination)	MAERSK BROOKLYN	0905	Fort Worth (Place of Delivery)	04/27/2009	08:01 AM CST
Full In Gate at Inland or Interim Point (Destination)	MAERSK BROOKLYN	0905	Fort Worth (Place of Delivery)	04/22/2009	02:52 PM CST
Off Rail (Destination)	MAERSK ALFIRK	0905	Fort Worth (Place of Delivery)	04/22/2009	10:14 AM CST
Carrier Released	MAERSK ALFIRK	0905		04/22/2009	02:34 AM PST
On Rail (Destination)	MAERSK ALFIRK	0905	Los Angeles (Port of Discharge)	04/20/2009	01:55 PM PST
Full Container Discharged at Port of Discharge	MAERSK ALFIRK	0905	Los Angeles (Port of Discharge)	04/18/2009	03:57 PM PST
Vessel Estimated Time of Arrival		0905	Los Angeles	04/17/2009	06:00 PM PST
Vessel Arrived at Port of Discharge	MAERSK ALFIRK	0905	Los Angeles (Port of Discharge)	04/17/2009	04:36 PM PST
Vessel Departed from Transship Point	MAERSK ALFIRK	0905	Hong Kong	04/06/2009	07:30 AM Asia/Hong_Kong
Full Container Loaded for Transshipment	MAERSK ALFIRK	0905	Hong Kong	04/06/2009	01:56 AM Asia/Hong_Kong
Full Container Discharged for Transshipment	MAERSK BROOKLYN	0905	Hong Kong	04/04/2009	09:21 AM Asia/Hong_Kong
Vessel Arrived at Transship Point	MAERSK BROOKLYN	0905	Hong Kong	04/03/2009	09:24 PM Asia/Hong_Kong
B/L Processed by Carrier	MAERSK BROOKLYN	0905		03/31/2009	09:57 PM PST
Vessel Estimated Time of Departure		0905	Laem Chabang	03/31/2009	11:00 AM Asia/Bangkok
Vessel Departed from Port of Loading	MAERSK BROOKLYN	0905	Laem Chabang (Port of Load)	03/31/2009	06:20 AM Asia/Bangkok
On-Board Vessel at Port of Loading	MAERSK BROOKLYN	0905	Laem Chabang (Port of Load)	03/30/2009	10:08 PM Asia/Bangkok
Full In Gate at Ocean Terminal (CY or Port)	MAERSK BROOKLYN	0905	Laem Chabang (Port of Load)	03/28/2009	09:58 PM Asia/Bangkok

If a specific location is not mapped to a time zone in the application, the governing country time zone is used and this may result in a difference of a few hours. If time is not provided to the application by the carrier, the default setting is 12 Noon UTC.

Add Event

Figure 20: The GT Nexus Shipment Screen

19.2 Transentric

As defined in the IOC transportation lanes, a portion of the shipments will move by rail once it arrives at the POLA. Transentric's Rail Visibility Platform was ranked among the highest for rail visibility services, and selected as the second visibility product to be integrated into the GTMS. Transentric is an established on-demand visibility solution in the Rail Industry that has

connectivity to all Class I Railroads in North America, and exchanges over 2.5 million messages a day.

Transentric will provide the GTMS rail shipment visibility for the Dole Experimentation Campaign. This will include collecting and standardizing near-real-time Rail Carrier Car Location Messages, (CLMs), and Rail Carrier Waybill Interchange, EDIX12 417, data for all of Dole Foods' rail shipments into a unified platform. Initially, Transentric will synchronize the rail carrier integrations, normalize the data across the selected carriers identified for the IOC (UP and BNSF), and provide dynamic in-transit ETAs. The CLMs will be provided by the IOC rail carriers in an AAR/NITL Format G, which includes the railcar initial and number and the location represented as a SPLC (Standard Point Location Code). The SPLC is designed to provide each point originating freight and each point receiving freight in North America with a unique code number. The code number is constructed to identify the point with its geographic location, and is maintained by National Motor Freight Traffic Association (NMFTA).

Transentric will also provide dynamic rail in-transit ETAs providing up to date visibility for "when" the shipment will arrive. Through a standard XML interface process, the rail data will be sent to the GTMS to be consumed and loaded into the semantic data store. The following is a short list of expected rail events provided by the CLM that will be collected across the IOC rail carriers.

- Waybill Processed
- Loaded on Flatcar
- Departure from Location
- Arrival at Destination
- Unloaded from Flatcar
- Constructively Placed (Container Available Notice)
- Ramp Departure (Full out-gate from Intermodal Ramp)

Shipment ID: MWCU622033		Historical Umler	
Rpt Origin:	LAHARAPMT CA	Rpt Destination:	ALLIANCE TX
Start Date:	04/17/2009 10:36	End Date:	04/22/2009 10:31
Total Days in Std:		Total Transit Days:	5
Detention Days:			
Current ETA:	04/22/2009 10:31	Original ETA:	04/22/2009 05:00
Fleet 1:		Fleet 2:	
Break Event:	L/E:	Location:	Date:
Comment:			

▷ Additional Comments

▷ Billing Details

L/E:	L	Assign Code:	T
UPT Car Kind:		AAR Car Kind:	
Fleet 1:		Fleet 2:	
Weight:	00048325		
Bill of Lading:	LGB090408292	Pro Number:	
Delivery Date:			
Shipper:	MAERSK INC	Consignee:	MAERSK INC
Origin:	LAHARAPMT CA	Destination:	ALLIANCE TX
Care of:			
Route:	BNSF		
Commodity:		STCC Code:	4611110
Content:	2,860 CASES UPC. NO. 38900-03008 DOLE MIXED F		
Customer Area 1:		Customer Area 2:	
Customer Area 3:		Customer Area 4:	

Event	City/State	Train	Carrier	Time	Delay Time	Reason Code	BO Minutes
WAYBILL	LAHARAPMT CA	WBMSG	BNSF	04/17/2009 10:36			
LOAD ON FLATCAR (CONTAINTER) -	LAHARAPMT CA		BNSF	04/18/2009 21:41			
LOAD ON FLATCAR (CONTAINTER) -	LOSANGHAR CA		BNSF	04/18/2009 21:41			
DEPARTURE	LAHARAPMT CA	QLC118	BNSF	04/19/2009 07:48			
DEPARTURE	BARSTOW CA	QLC118	BNSF	04/19/2009 13:48			
DEPARTURE	NEEDLES CA	QLC118	BNSF	04/19/2009 17:51			
DEPARTURE	WINSLOW AZ	QLC118	BNSF	04/20/2009 02:55			
DEPARTURE	BELEN NM	QLC118	BNSF	04/20/2009 09:33			
TRAIN ARRIVAL	CLOVIS NM	QLHACL	BNSF	04/20/2009 16:20			
DEPARTURE	CLOVIS NM	QSA119	BNSF	04/21/2009 14:27			
DEPARTURE	CHILDRESS TX	QSA119	BNSF	04/21/2009 22:22			
DESTINATION ARRIVAL	ALLIANCE TX	QSA119	BNSF	04/22/2009 03:55			
UNLOAD OFF FLATCAR(CONTAINER)-"DE-RAMP"	ALLIANCE TX		BNSF	04/22/2009 10:14			
CONSTRUCTIVE PLACEMENT	ALLIANCE TX		BNSF	04/22/2009 10:31			
RAMP DEPARTURE (CONTAINER)	ALLIANCE TX	NCOC	BNSF	04/22/2009 14:14			

Figure 21: GTMS -Transentric Shipment Screen

19.3 Barthco

Besides collecting the standard shipment events from the IOC carriers, the GTMS will consume U.S. Customs & Border Protection (CBP) status data provided by Barthco. Barthco, which acts as DPF's Customs Broker, will transmit the data received from CBP Automated Broker Interface (ABI) in an Ocean Carrier Shipment Status, EDIX12 315 format. This data feed will provide additional visibility into CBP, FDA (Food and Drug Administration) and USDA (United States Department of Agriculture) shipment holds.

19.4 ONE Network Enterprises

The next technology component provides key Transportation Management System (TMS) planning and execution capabilities that will leverage the consolidated in-transit shipment data collected and normalized by the GTMS in a standard XML interface. Using the same evaluation process, ONE Network (ONE) was considered to have one of the more advanced technology strategies among the vendors, and was selected to provide the base set of TMS services for the IOC. ONE provides a flexible Business Process Platform (BPP) which enables the ability to rapidly compose new business processes and expand the core TMS feature-set to adapt to the challenges facing dual-use distribution networks. ONE currently has over 3,200 trading partners on existing commercial networks, and manages over $1B in annual trade under management.

ONE TMS components include:

Demand Driven Distribution Network Optimization & Planning
- Demand Management and Continuous Incremental Re-planning
- Multi-Enterprise Inventory Management
- Enterprise-wide Order, Shipment, Transaction and Capacity Management
- Multi-Enterprise Collaboration and Exception Management

Constraint Based Demand Driven Transportation Management & Appointment Scheduling
- Transportation Planning, Optimization and Execution
- Electronic Load Tendering
- Transportation Visibility and Tracking
- Synchronized Demand Driven Appointment Scheduling

31

Sense and Respond Framework
- Predictive Issue Identification and Proactive Resolution

ONE will provide an exception driven user interface for transportation planning and execution. This solution has the ability to sense exceptions in real time and the appropriate action across all parties in the network. This platform also provides a dynamic virtual environment that enables predictive supply chain performance modeling in a controlled off-line representation of the real-world network. The end user will have access to ONE through a Single Sign-On (SSO) process provided by the GTMS. SSO provides centralized access and control to the various technology solutions integrated within the GTMS.

Under the IOC, the GTMS will first and foremost provide global container visibility, status information, and monitoring across the multiple carriers and modes. Shipment and tracking events will be collected and normalized by the GTMS, and then transmitted to ONE. For example, Dole Foods will be able to search for a specific container and see that it is in-transit from the Philippines to the Port of LA. Additionally, alerts will be provided when certain exception based rules occur, such as a container that is scheduled for pickup at the Port of LA but is not in "Ready for Pickup" status.

Figure 22: GTMS-One Network Shipment Screen

The second IOC capability which will be provided by ONE is container prioritization at the Port of LA for containers destined to the Buena Park DC. Since demand changes have occurred since the orders were released from Dole Philippines, the container prioritization and schedule is created to address Buena Park DC's needs based upon several factors such as the following:

- Inventory priority for inbound orders for the Buena Park DC;
- Port and Carrier Costs (i.e. detention costs, terminal fees);
- DC receiving capacity.

19.5 Service Craft

In order to provide inbound container prioritization to the Buena Park DC, the GTM will collect inventory transfer and balance data directly from Dole Package Foods and Service Craft, which manages and operates the Buena Park DC. For incoming product into the DC, Dole Foods provides an EDIX12 943, Warehouse Stock Transfer Shipment Advice to Service Craft. The EDIX12 943 will be provided roughly 5-7 days prior to shipment arrival at the port of discharge. The source and timeliness of the data is driven by a manual process between DOLEFIL (Dole Philippines) and DOLEUSA which supplies shipment information to Dole Foods' ERP (Enterprise Resource Planning) system. Upon physical receipt of the shipment, Service Craft will generate an EDIX12 944, Warehouse Stock Transfer Receipt Advice. A similar data exchange happens for product shipping out of the DC. Dole provides an EDIX12 940, Warehouse Shipping Order to Service Craft, which will generate an EDIX12 945, Warehouse Shipping Advice, upon physical shipment of the product. Service Craft also provides Dole Foods with an EDIX12 846, Inventory Inquiry, to provide a daily inventory balance. These data exchanges will be consumed by SM21 then transformed into the appropriate data elements for ONE. ONE will use this inventory data to automate the planning and execution of containers out of the port and into the DPF Distribution Center at Buena Park.

For extended visibility of shipment details, typically an ASN (Advanced Shipment Notice), EDIX12 856, is used to augment the carrier waybill (ocean or rail) to provide line item/order information specific to each container shipment. The ASN message will be used to associate shipment details such as the UPC (Universal Product Code) and quantity to an actual container shipment. However, DPF's version of an ASN is an Excel file which is e-mailed to DOLEUSA from DOLEFIL on a weekly basis. The Excel file will be manually provided to SM21 roughly 2-3 weeks prior to shipment arrival at the port of discharge. This data feed will provide the IOC visibility down to the line-item level for ocean shipments inbound to the DCs.

20 DOLE EDI FLOW

The GTMS System-of-Systems Service (SoS) Service Oriented Architecture (SOA) is fundamentally in line with the DISA (Defense Information Systems Agency) commitment to the "ABC" philosophy: "Adopt-before-Buy, Buy-before-Create." SM21 is leveraging existing and evolving logistics and transportation technical capabilities. The key to ABC is the adaptation of commercial best practices, architectures, and standards.

To address the distribution visibility capability gap, SM21 program technical management team evaluated the available best-of-breed products and services to support the experimentation and the development of the GTMS IOC. These common visibility platforms augmented with DPF

distribution supply chain partners will provide the required processing and movement data that action level systems and resources will need in order to achieve the objectives in further spirals and experimentation campaigns. **Figure 23** below depicts the Systems View (SV) of the SM21developed GTMS IOC and the overall Dole Foods EDI flow. The following sections of this document will explain the IOC feature capabilities and interfaces of the GTMS.

Product evaluations were conducted to determine the initial best-of-breed global visibility services to be included in the GTMS Service Oriented Architecture (SOA). A standardized evaluation process was developed to assist with the selection of the top rated In-Transit Visibility (ITV) and Transportation Management System (TMS) solutions that can support the various modes of delivery. Each criterion received a weight factor representing the overall importance of the feature within the GTMS architecture. The evaluation criteria consisted of several categories including the established relationships with multiple carriers and partners; the ability to provide accurate and reliable shipment data; it enables the customer to access exception management reports and notifications of existing or potential issues with shipments; the key technology components of the system and adherence to open standards; the platform is provided as a Software as a Service (SaaS)-based offering; and the ability to adapt to the dual-use capability objective.
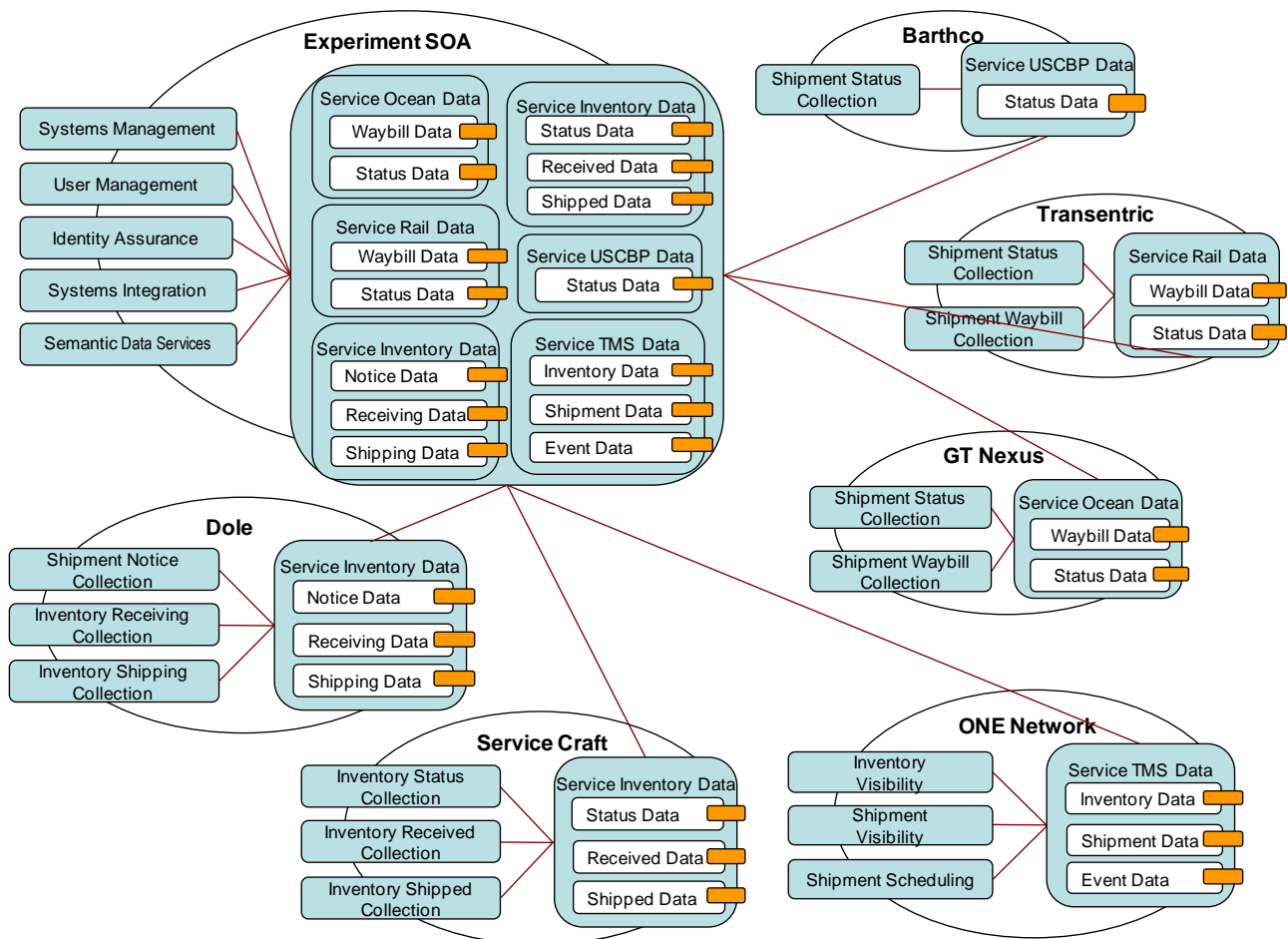
Figure 23: Dole EDI Flow

After applying the weighting, a rating was developed for each criterion based upon product demonstrations, phone conversations, vendor provided documentation, strategic partnerships, customer base, product and market vision, pricing model, SM21 SOA adaptability, and collective team judgment. Using this rating system, the GT Nexus Ocean Visibility Platform was ranked among the highest for ocean visibility services, and selected as the initial visibility product to be integrated into SM21.
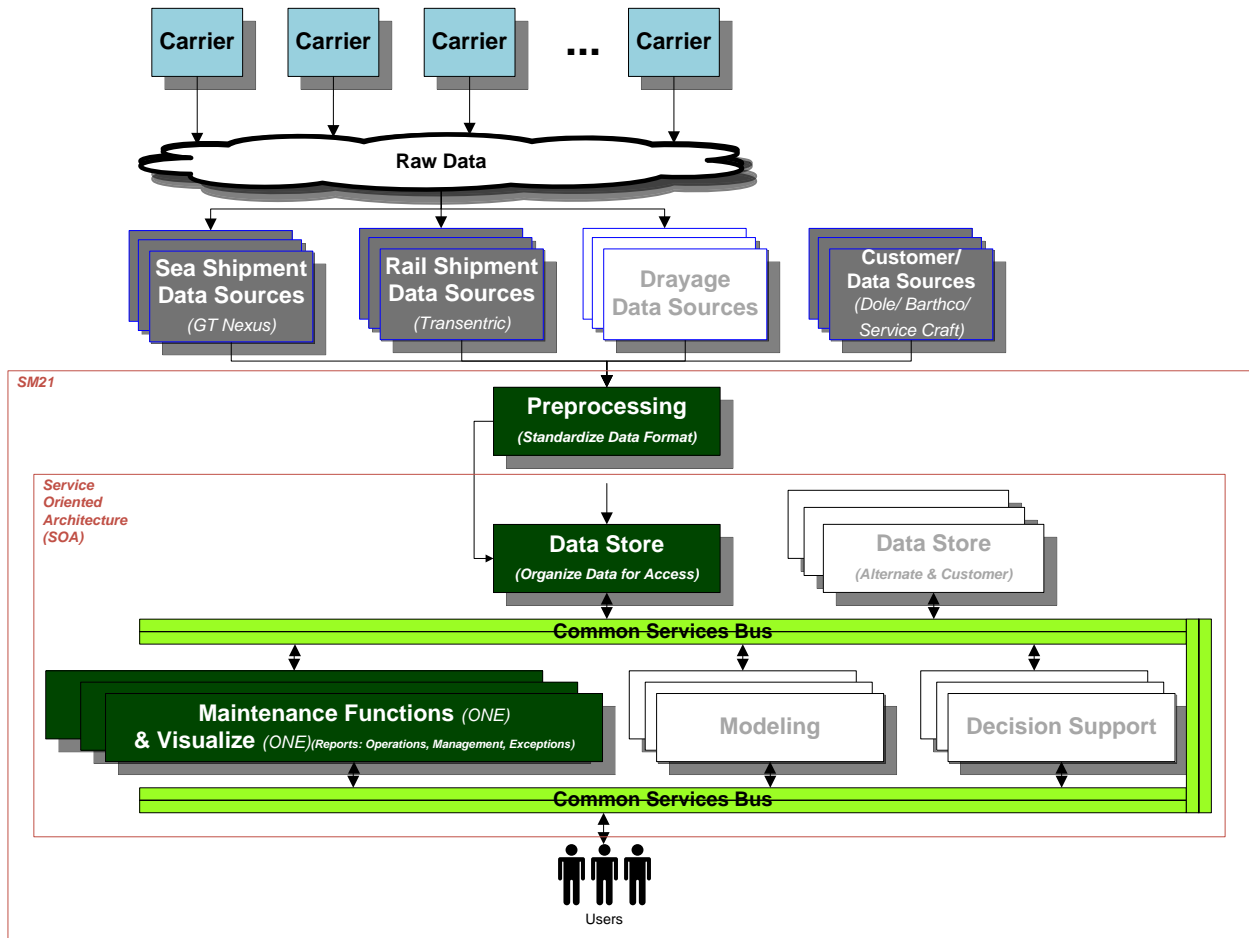
Figure 24: Activated Parts of System

SECTION E.   SYSTEM FLOWS

These next chapters address the underlying rules that drive the system that has been provided for this experiment. It should be remembered that the focus was to demonstrate the functionality of combined data sources to provide an improved Global Trade Management System.

21 PROPOSED DATA SOURCES & INFORMATION FLOWS

This section is intended to summarize the previous discussion into a form that will allow the reader to proceed to the near term design of the system. It takes each player and graphically depicts the roles they play. This document will then move onto the basic rules for managing the events of the system.

The following summary slides provide an overview of the shipment flows as well as expected data sources.

Figure 25: Dole, GTNexus and Barthco Shipment Data Flow

Proposed Data Sources and Information Flow – POC Phase (cont'd.)

Data Source	Transentric Shipment Management & Value Added Messaging			ServiceCraft logistics "GLOBAL REACH...LOCAL TOUCH"		
Milestones	Booking Confirmation from Rail Carrier	Rail Loading and Transit	Rail Unloading and Constructive Placement	TPL Warehouse Receipt Confirmation (Inbound)	Customer Order Processing (Outbound)	Inventory Updates
EDI Files	**Rail Waybill EDI 417**		**Rail Sightings CLM**	**Shipment Receipt EDI 944**	**Shipping Confirmation EDI 945**	**Inventory Status EDI 846**

Rail Waybill EDI 417

The Ocean Carrier will send a 404 Bill of Lading to the Rail Carrier informing them of the rail shipment. A 417 rail waybill is sent to Transentric soon after the vessel arrives at the port. The 417 file will contain the following info:

- Container Number
- Rail Carrier
- Bill of Lading No.
- Destination ETA
- Train
- STCC (product)
- Weight
- Route (interchange points)

Rail Sightings CLM

The following milestones will be tracked once the trip is initiated.

- Waybill Issued
- Load on Rail Car
- Departure
- Reads on Intermediate Points
- Train Arrival
- Unload on Rail Car
- Constructive Placement (Container Available)

Each sighting event message will include an updated ETA to rail destination.

Shipment Receipt EDI 944

Once the warehouse receives and unloads the container, their Warehouse Management System (WMS) generates an EDI 944 and sends it out to Dole to update its ERP system. A duplicate copy of the EDI file will be sent to SM21.

Shipping Confirmation EDI 945

As customer orders are fulfilled, the warehouse WMS generates an EDI 945 to notify Dole that the order is processed and inventory is reduced accordingly. A duplicate copy of the EDI file will be sent to SM21

Note: The EDI 944 and 945 files are received by SM21 as soon as the warehouse clerk enters the transaction in the WMS system.

Inventory Status EDI 846

Daily inventory status is sent to Dole to update their ERP system. SM21 will receive a duplicate copy to adjust the inventory count accordingly.

Figure 26: Transentric and ServiceCraft Shipment Data Flow

This next graphic provides the information flow that occurs around the shipment. Please pay attention to the legend that explains where the shipment flow exists. The Dole Foods box basically initiates the action. The flow follows the "slides" in the earlier sections. You can then see where the players obtain their information and how that information flows through the process.
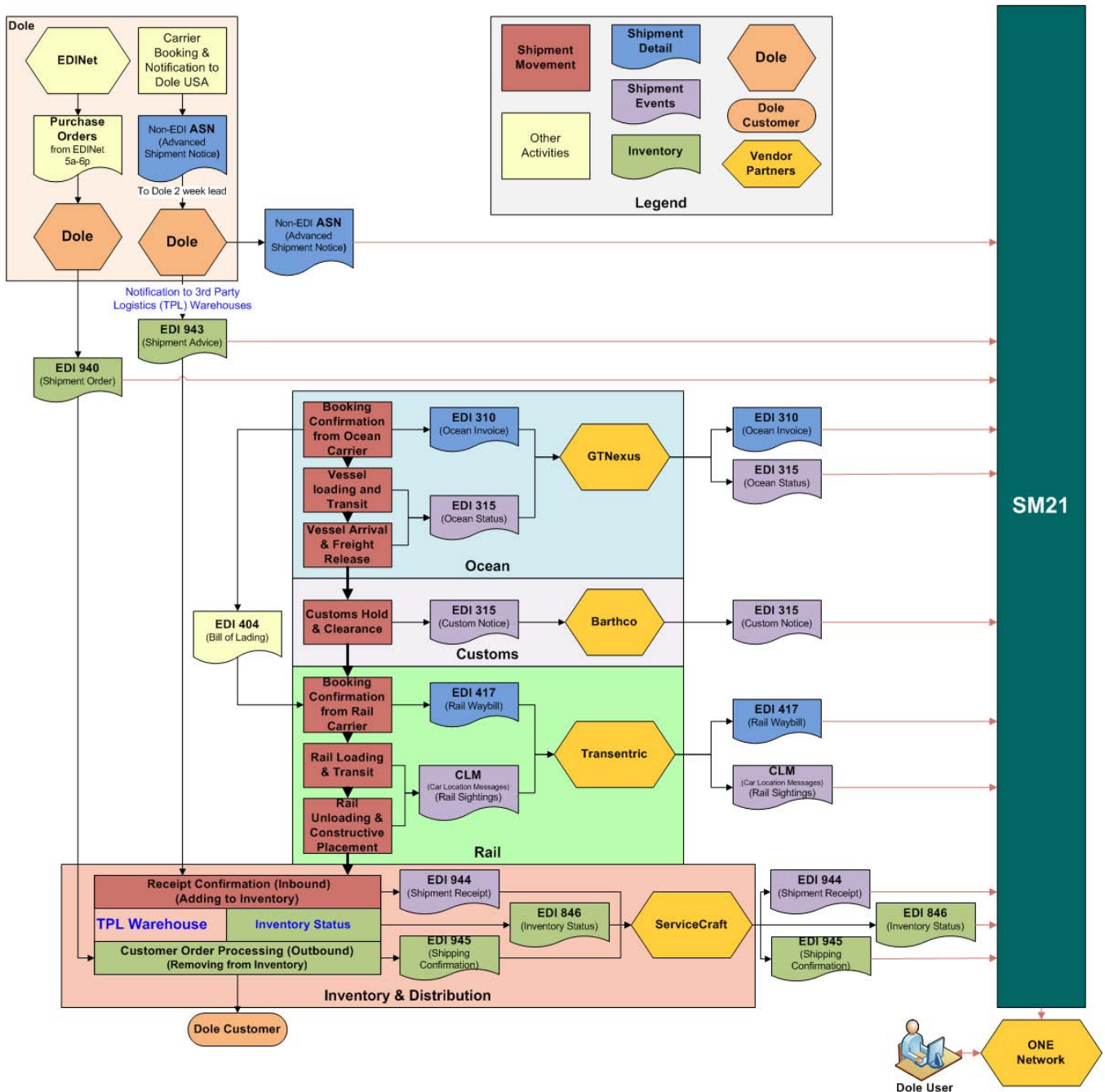
Figure 27: Shipment, Process & Information Flows

How the Different Data Sources Will Be Used

The EDI files will be processed and provide what is need for shipment tracking (from ocean carrier to dray) and prioritization for the DC:
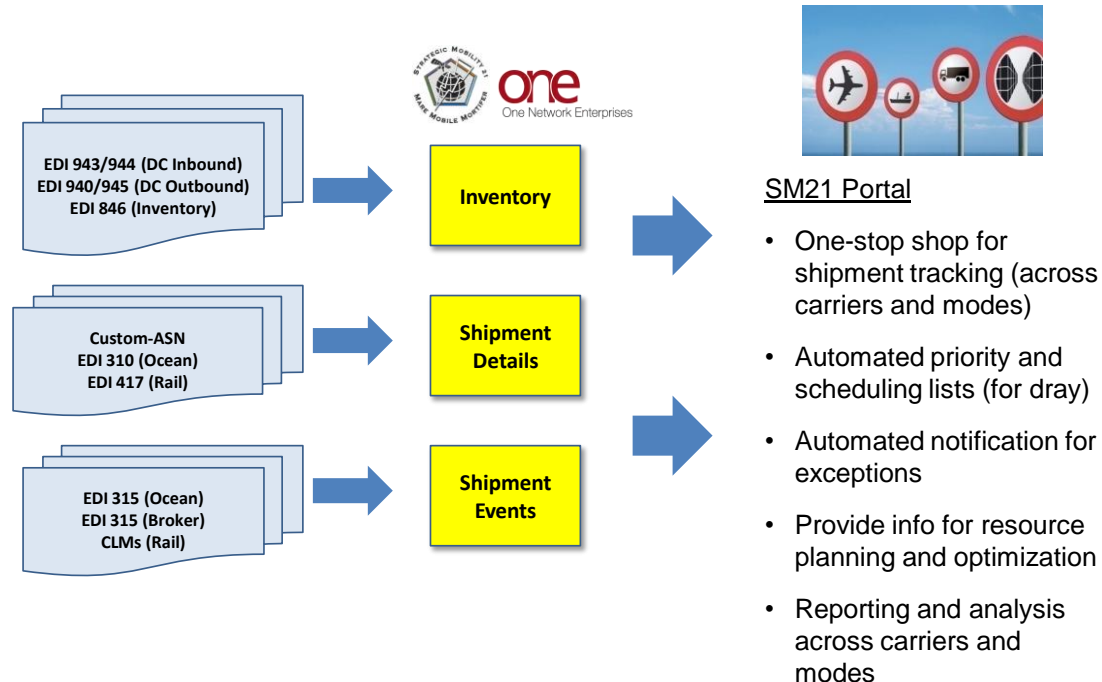
Figure 28: Data Source Functions

While the EDI 944 (Shipment Receipt) is shown as an inventory item message, it also represents the final message indicating the completion of the shipment.

Assumptions

- Dole will send the Custom ASN file via email every Monday morning.

- We will only be needing EDI files from Dole for ServiceCraft warehouse (SER) shipments. Tracking of data to MCH and MFW will only include up to the rail.

- Transentric messages will only apply for Madison warehouses in Texas and Chicago (MFW and MCH).

- Real-time dray tracking for JAC will not be includes during the POC. JAC dispatcher will use the system to confirm scheduling of container pick-up at the port.

Figure 29: Assumptions
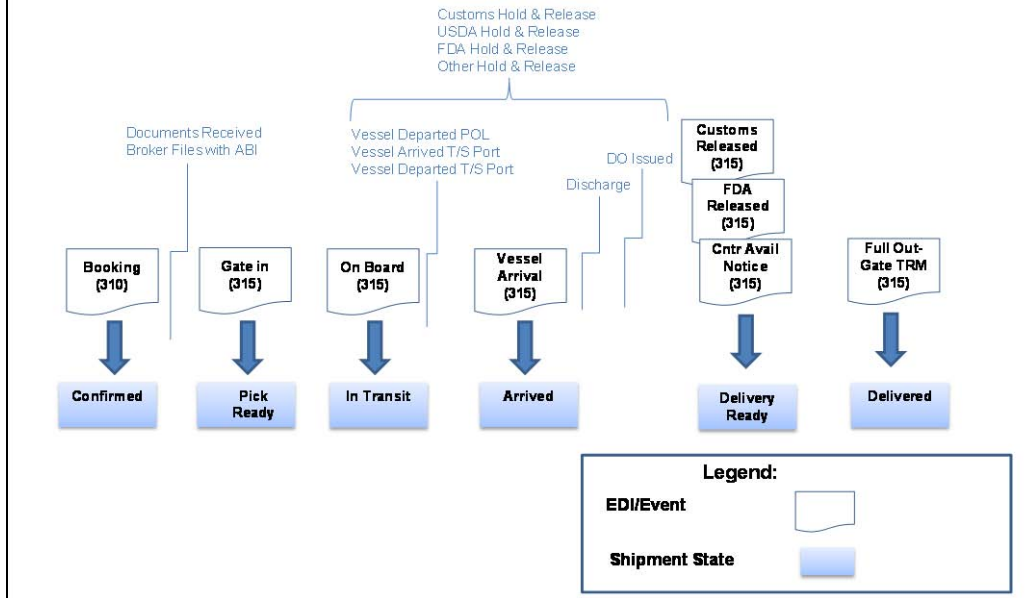
Figure 30: Ocean Movement State Transition Triggers
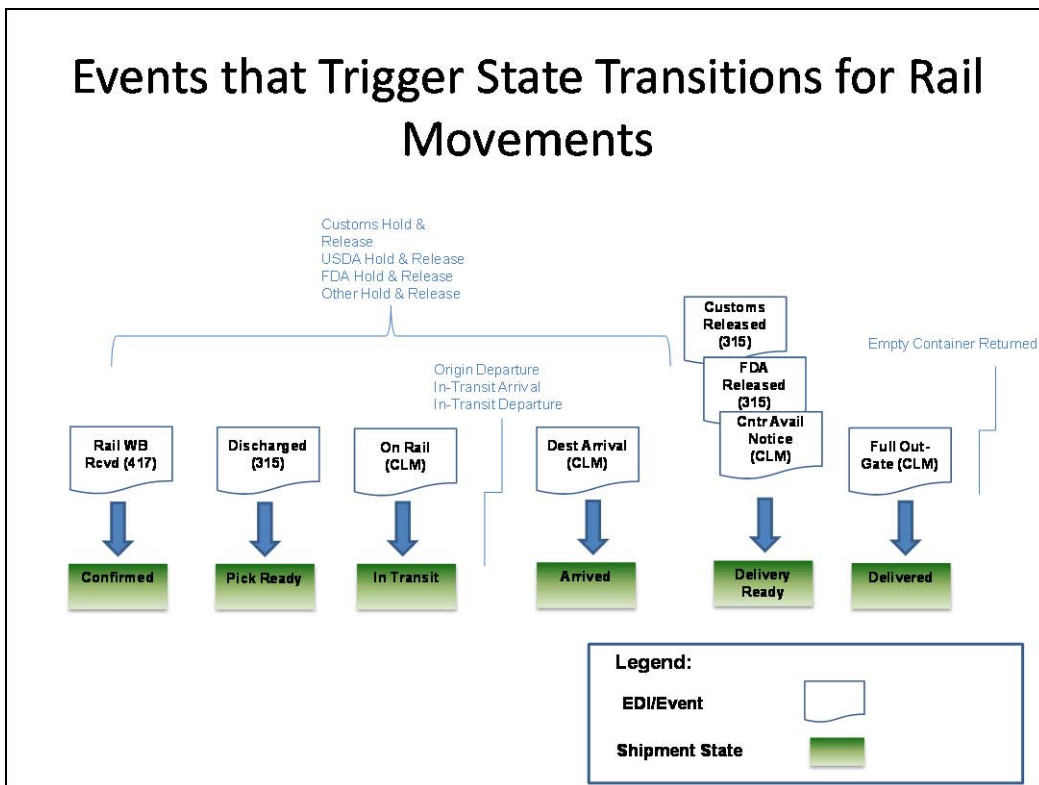
Figure 31: Rail Movement State Transition Triggers
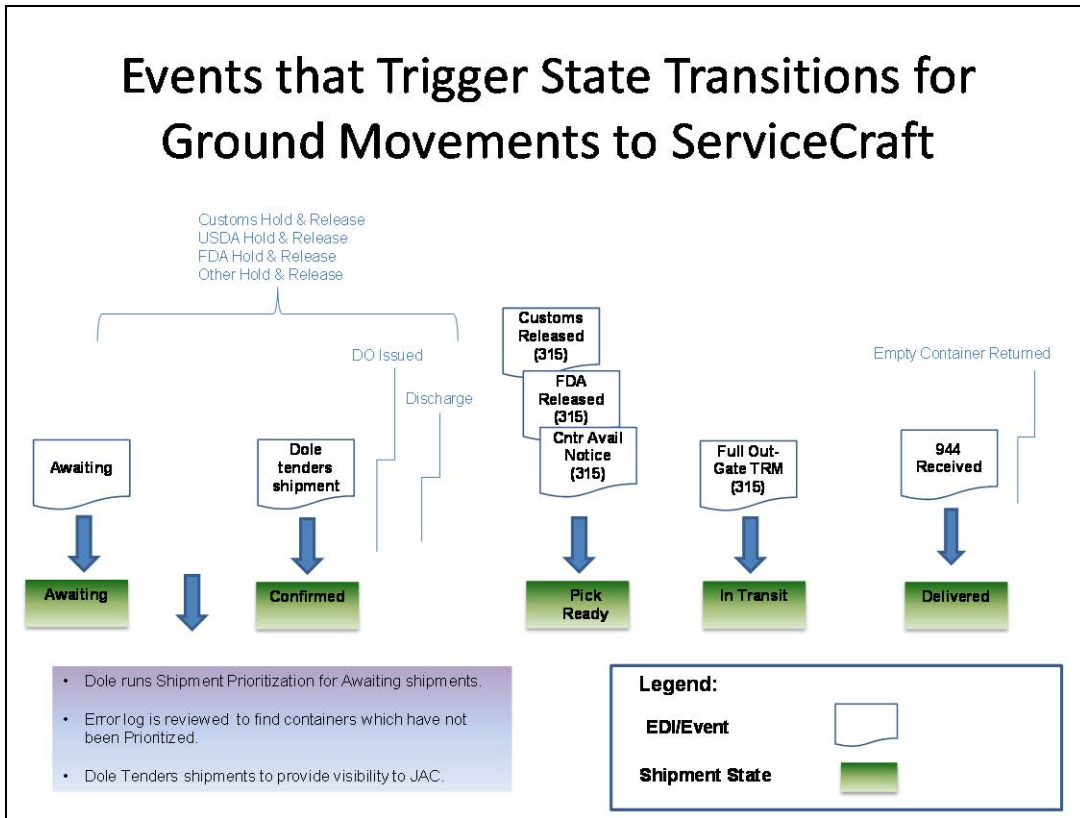
Figure 32: Ground Movement State Transition Triggers

The next two diagrams show how this flow process looks going end-to-end from booking to receipt for each of the two destinations being used.
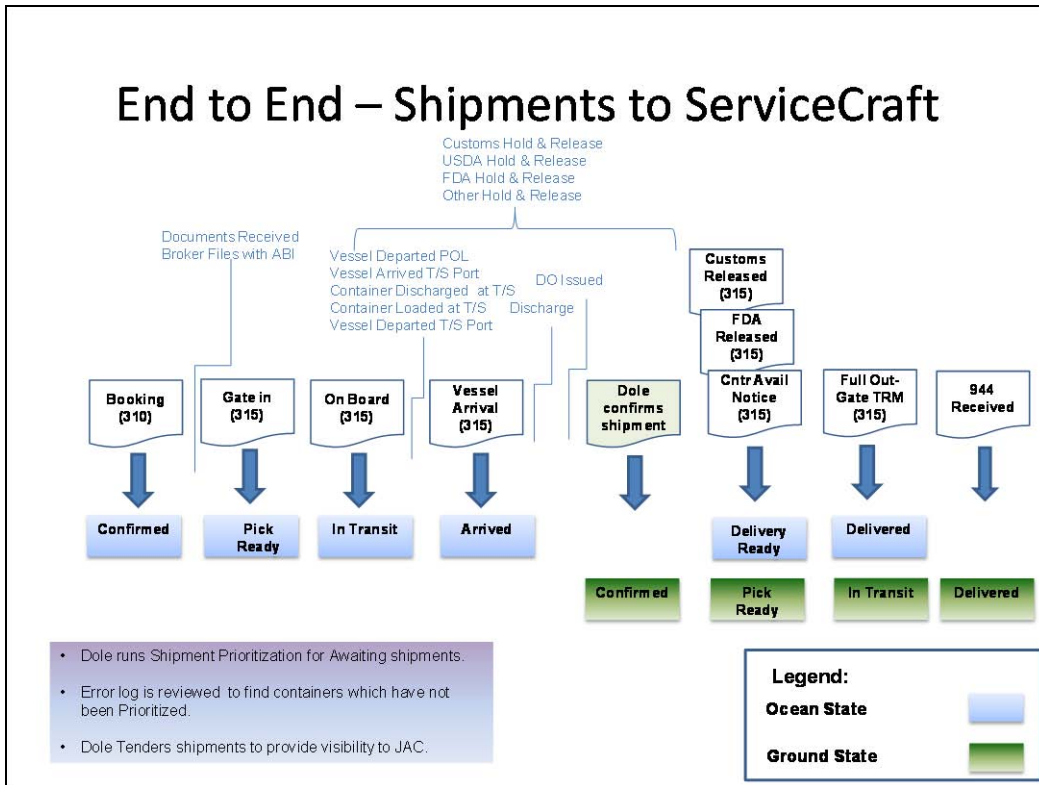
Figure 33: End-to-End ServiceCraft
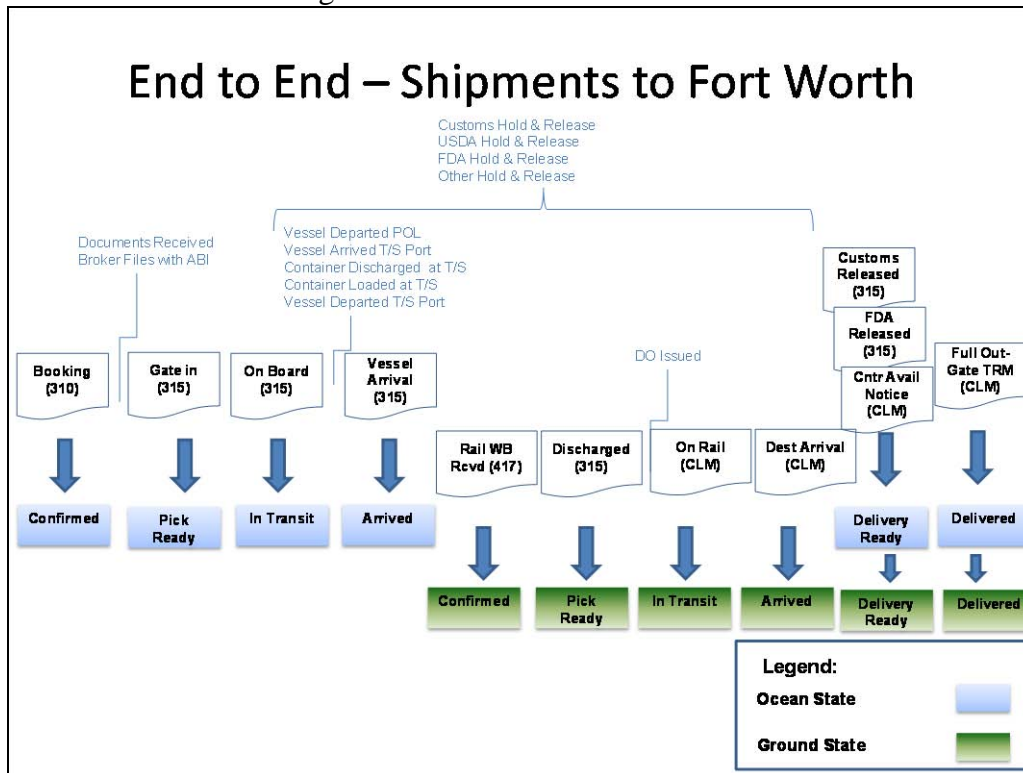
Figure 34: End-to-End Fort Worth

22 PROGRAM FLOW

Figure 35: IDEF0 Model – JDDSP-OS IOC Data Processing provides a higher level approach to system process while Figure 36: Program Flow provides more detail of the various modules used to produce the process. Files (messages) are received and stored in individual directories. A Java utility polls the directories to see if there are any new items. It then transfers control to the appropriate message handler for processing. The message handler processes the information and passes the information to the type of transaction to be generated for transmission or file transfer to ONE Network.
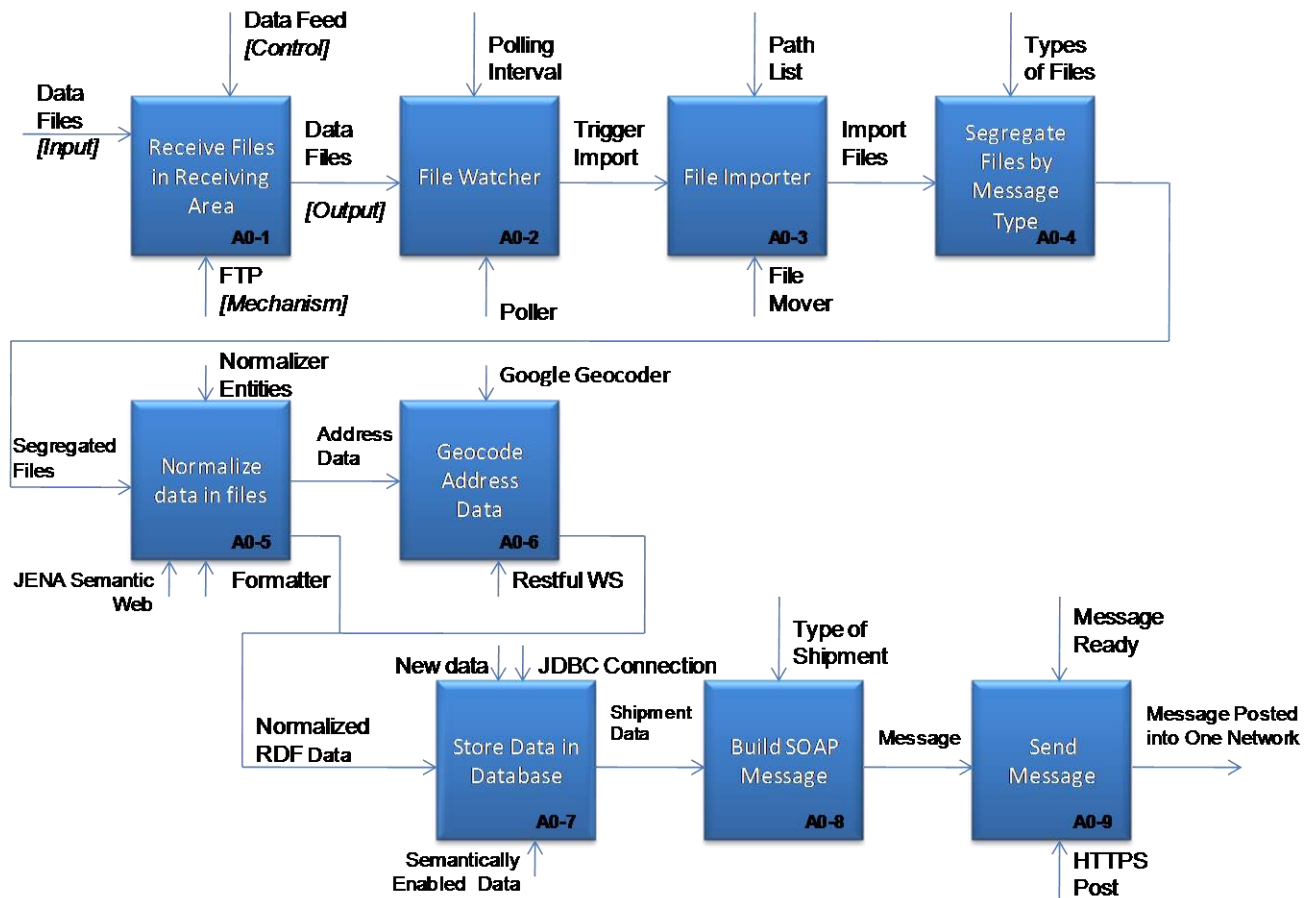
Figure 35: IDEF0 Model – JDDSP-OS IOC Data Processing
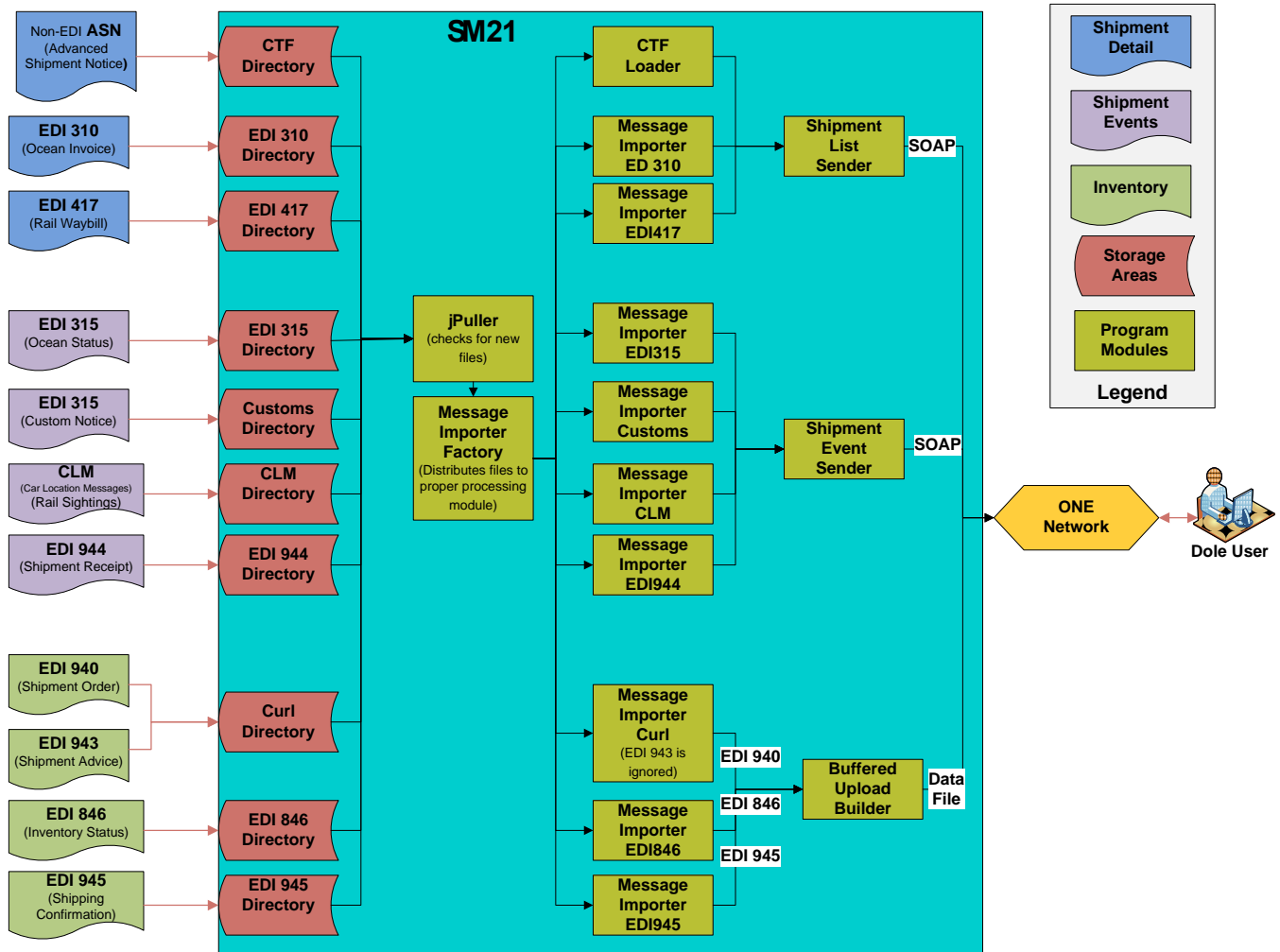
Figure 36: Program Flow

There are three types of messages prepared for ONE:
- Shipment List – provides contents of the shipment.
- Shipment Event – provides a status of the shipment.
- Buffered Upload – provides inventory available as well as potential lost sales from an identified inventory deficiency.

22.1 Shipment List (Detail)

As the shipment moves from one mode of transportation to another, consolidation or reorganization of the shipment can occur. As a result, the relevant information needs to be updated as the shipment goes from Advanced Shipment Notification (ASN as seen on the CTF file) to the ocean mode (EDI 310 – Ocean Invoice) to the rail mode (EDI 417 – Rail Waybill).

22.2 Shipment Events

Shipment events are basically a translation of the various EDI into shipment events. The charts below provide the correlation. Except for the EDI 310, which causes a shipment list to be generated and that ONE then also translate into an event, each of the EDI messages is analyzed and then causes state changes (i.e., events) to be communicated to ONE. The charts below provide the translations for the various legs of a shipment.

Place of Delivery: Fort Worth, TX — ONE Tracking Events that force a State Transition

Legend: G = GROUND (TL), O = OCEAN

Event	CLM	G:Confirmed	G:Ready for Pickup	G:Picked Up	G:Arrived	G:Ready for Delivery	G:In-Gate	G:Delivered	O:Confirmed	O:Equipment Booked	O:Documents Received	O:Customs Submitted	O:In-Gate	O:Ready for Pickup	O:Equipment Loaded	O:Picked Up	O:ETA	O:Departed	O:UpdateCurPos	O:Customs Cleared	O:Clearance Removed	O:USDA Clearance	O:Arrived	O:Freight Released	O:FDA Clearance	O:Customs Hold	O:Hold Removed	O:Unloaded	O:Ready for Delivery	O:Out-Gate	O:Delivered
310 GTNexus																															
310 Ocean Waybill Received	-	-							-	x																					
315 Barthco																															
Documents Received by Broker											x																				
Documents Submitted to US Customs (ABI)												x																			
315 GTNexus																															
Full In-Gate at Ocean Terminal (CY or Port)							x	x					x	x																	
On-Board Vessel at Port of Loading															x	x															
Vessel Departed from Port of Loading																		x													
Vessel Estimated Time of Arrival																	x														
Vessel Arrived at Transship Point																			x												
Full Container Discharged for Transshipment																			x												
Full Container Loaded for Transshipment																			x												
Vessel Departed from Transship Point																			x												
Carrier Released																								x							
315 Barthco																															
Customs Released																															
US Customs Clearance (ABI)																				x		x									
417 Transentric																															
417 Rail Waybill Received	WB																														
315 GTNexus																															
Vessel Arrived at Port of Discharge																							x								
Full Container Discharged at Port of Discharge																												x	x		
315 Barthco																															
US Customs Clearance Removed (ABI)																					x										
US Customs Hold Placed																										x					
US Customs Hold Removed																											x				
FDA Hold Placed																										x					
FDA Clearance																									x		x				
USDA Hold Placed																										x					
USDA Hold Removed																											x				
Other Agency Hold Placed																										x					
Other Agency Hold Removed																											x				
315 GTNexus																															
Full Out-Gate from Ocean Terminal (CY or Port)																														x	
Full In-Gate from Inland or Interim Point																															
CLM Transentric																															
On Rail (Destination)	RP																														x
Origin Departure	DP																															
In-Transit Arrival	AR																															
In-Transit Departure	DP																															
Destination Arrival	DA																															
Off Rail (Destination)	DR																															
Container Available Notice	CP																															
Delivery Order Issued																																
Full Out-Gate from Inland or Interim Point	RD																															
944 Warehouse Stock Receipt Received																																
315 GTNexus																															
Empty Container Returned																																

45

Figure 37: Ground & Ocean Message Translation

Place of Delivery: Fort Worth, TX	CLM	RAIL														GROUND (TL)								
shipment leg:		Confirmed	Equipment Booked	Ready for Pickup	In-Gate	Equipment Loaded	Picked Up	Departed	UpdateCurPos	Arrived	Unloaded	Ready for Delivery	Out-Gate	Delivered	Confirmed	Ready for Pickup	Delivery Order Issued	Out-Gate	Picked Up	Arrived	Ready for Delivery	Delivered	Equipment Returned
310 GTNexus																							
310 Ocean Waybill Received															-								
315 Barthco																							
Documents Received by Broker																							
Documents Submitted to US Customs (ABI)																							
315 GTNexus																							
Full In-Gate at Ocean Terminal (CY or Port)																							
On-Board Vessel at Port of Loading																							
Vessel Departed from Port of Loading																							
Vessel Estimated Time of Arrival																							
Vessel Arrived at Transship Point																							
Full Container Discharged for Transshipment																							
Full Container Loaded for Transshipment																							
Vessel Departed from Transship Point																							
Carrier Released																							
315 Barthco																							
Customs Released																							
US Customs Clearance (ABI)												x				x							
417 Transentric																							
417 Rail Waybill Received	WB	-	x																				
315 GTNexus																							
Vessel Arrived at Port of Discharge																							
Full Container Discharged at Port of Discharge				x																			
315 Barthco																							
US Customs Clearance Removed (ABI)												!				!							
US Customs Hold Placed																							
US Customs Hold Removed																							
FDA Hold Placed																							
FDA Clearance												x				x							
USDA Hold Placed																							
USDA Hold Removed																							
Other Agency Hold Placed																							
Other Agency Hold Removed																							
315 GTNexus																							
Full Out-Gate from Ocean Terminal (CY or Port)																							
Full In-Gate from Inland or Interim Point					x																		
CLM Transentric																							
On Rail (Destination)	RP					x	x																
Origin Departure	DP						x																
In-Transit Arrival	AR							x															
In-Transit Departure	DP							x															
Destination Arrival	DA									x													
Off Rail (Destination)	DR										x												
Container Available Notice	CP											x				x							
Delivery Order Issued																	x						
Full Out-Gate from Inland or Interim Point	RD												x	x					x	x		x	
944 Warehouse Stock Receipt Received																							
315 GTNexus																							
Empty Container Returned																							x

Figure 38: Rail & Ground Message Translation

22.3 Buffered Upload

The buffered upload provides the inventory on hand as well as the net open orders that cannot be serviced by the inventory on hand at the given distribution center (DC).

- The inventory on hand is provided by the EDI 846 transaction.
- The open orders are the total of the EDI 940's (shipment orders) minus the total of EDI 945's (Shipping Confirmation).
- The amount of this overall difference is compared with the inventory on hand and the net deficiency is reported as potential lost sales.

23 DEPLOYMENT MODEL

Figure 39: Deployment Model shows the general deployment model for the application.
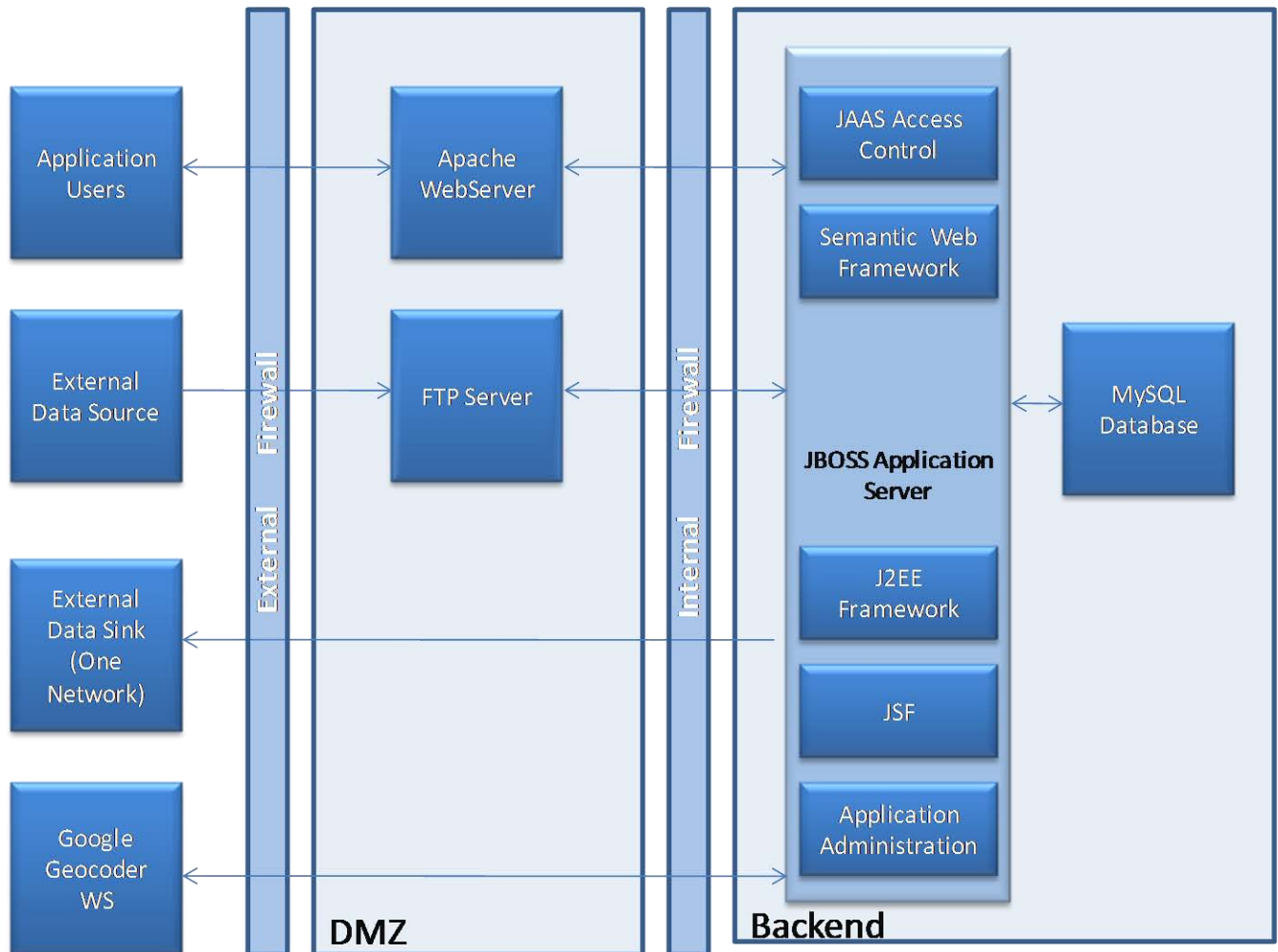
Figure 39: Deployment Model

SECTION F. FUTURE STATE

24 DOLE FUTURE STATE

The SM21-Dole experimentation campaign will be completed with a demonstration of the GTMS IOC. However, further analysis with Dole Foods is expected to continue beyond the bounds of the GTMS IOC by extending further into the distribution supply chain and spiraling into the next deployment iteration based on a defined set of capability improvements. It is envisioned that these future capabilities will either be developed under Level 6 Logistics LLC, the identified JDDSP-OS (Joint Deployment and Distribution Support Platform-Operations System) transition organization, or transition to an interim entity for continued development. Future capabilities will most likely include:

- Enhanced ocean and rail shipment visibility by way of
    - o On-boarding the remaining Dole product lines, business units, transportation carriers and partners,
    - o Source in-transit events from the terminal/port to augment the carrier shipment status, and
    - o Source in-transit events directly from transportation carriers to enhance data redundancy and accuracy.
- Expand end-to-end inventory visibility by starting at sales order then ending at the retailer's shelf.
- Provide drayage tracking and Fleet Management capabilities to enhance visibility and management of shipments moving between the ocean and rail terminals to the DCs.
- Implement Global Trade Compliance Management capabilities to assist with compliance for all areas of Customs rules and regulations, such as Importer Security Filing (ISF) "10+2" and Customs-Trade Partnership Against Terrorism (C-TPAT), including Free Trade Agreements and related agencies such as USDA and FDA.
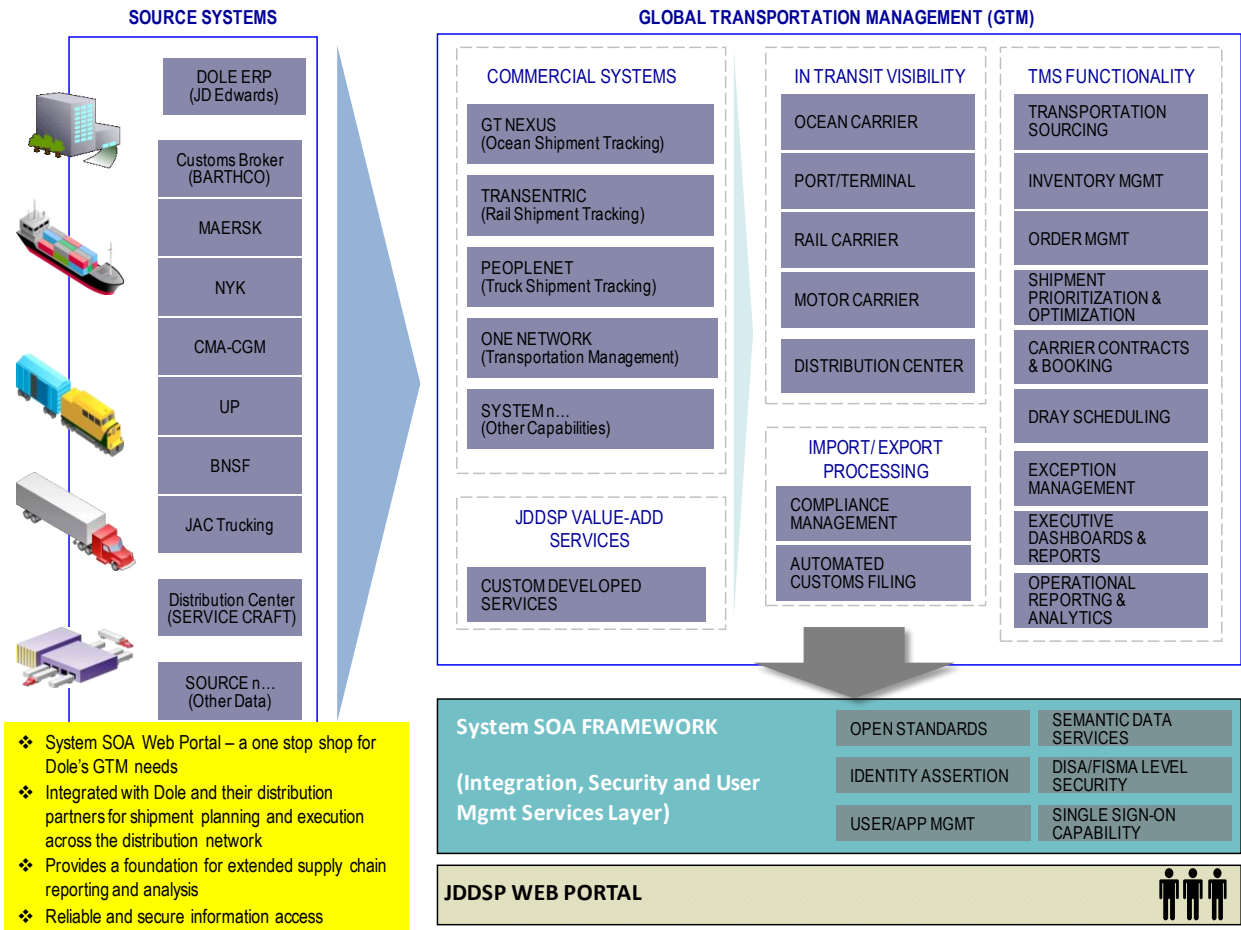
Figure 40: Dole Future State

SECTION G. APPENDICES

APPENDIX A - GLOSSARY

Terminology	Definition
3PL	Third Party Logistics
AAR	Association of American Railroads
ABI	Automated Broker Interface
ABox	Assertion component
ASN	Advance Shipment Notice
B1	Multi-level secure Definition also from the Orange Book
DoD	Department of Defense
DoDAF	Department of Defense Architectural Framework
DPF	Dole Package Foods
EDI	Electronic Data Interchange
EJB	Enterprise JavaBean
ERP	Enterprise Resource Planning
ETA	Estimated Time of Arrival
FDA	Food and Drug Administration
FCS	Future Combat System
GTM	Global Transportation Management
HTTP	Hypertext Transfer Protocol
IOC	Initial Operating Capability
J2EE	Java Platform Enterprise Edition
JAAS	Java Authentication and Authorization Service
JDDSP	Joint Deployment and Distribution Support Platform
JDDSP-OS	Joint Deployment and Distribution Support Platform-Operations System
NITL	National Industrial Transportation League
NMFTA	National Motor Freight Traffic Association
OWL	Web Ontology Language
PO	Purchase Order
POLA	Port of Los Angles
POLB	Port of Long Beach
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
REST	Representational State Transfer
RPC	Remote Procedure Call
SCLA	Southern California Logistics Airport
SDM	Systems Development Method
SKU	Stock Keeping Unit
SM21	Strategic Mobility 21
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SoS	System of Systems
SPLC	Standard Point Location Code
SSL	Secure Sockets Layer
SV	System View

TBox	Terminological component
TMS	Transportation Management System
UP	Union Pacific
UPC	Universal Product Code
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USDA	United States Department of Agriculture
W3C	World Wide Web Consortium
XML	Extensible Markup Language
XSD	XML Schema Definition

APPENDIX B – SECURITY INTERFACE

1   PROCESS WITHIN THE GTMS

To access the GTMS web application a user first opens a web browser and types in the URL of the GTMS domain. This request is immediately routed from an Apache Web Server to an SSL connection with the JBoss Web Application Server. JBoss immediately challenges the requester for a username and password either via a browser dialogue or directly through the browser.

Figure 41: Administrative Login Page

JBoss container authentication in combination with JBoss, the web module and the underlying custom JAAS module handles the authentication steps. The data is available via a web service interface which adheres to both popular protocols – namely REST and SOAP. Configuration of a custom JBoss JAAS Module authenticates the user based on the information in the database and provides the opportunity to manipulate the GTMS systems connections to other outside databases.

The JAAS Module discussed above checks a username and password combination against stored user information in a database. If the username exists in the database and the password entered by the user matches, a user object is built and the roles and group roles associated with this user object are assembled and stored in the requested context.

If a login attempt fails the user is informed on the login page where they can attempt to login again.

Figure 42: Denial for Failed Login Attempt

The use of JAAS authentication allows easy protection for access to individual pages on the site by mapping a page to a Role. When attempting to access data in the system, the assembled roles are checked against roles assigned to the accessed object. If access is allowed the system acts normally. If access is not allowed the user is taken to an error page.

An authenticated user object is stored on the session as a principal. This principal is added to the session during user authentication. When a user attempts to access data on the GTMS system, the session identity provides access to roles associated with the authenticated user, and these roles are checked against the access levels related to system objects and actions.

2 TIMESTAMPS

A timestamp, user, activity, and activity status are recorded for each event. When a new authentication or logout event occurs, the requester specifics are logged also. For deletion and creation of events, the deleted or created item's id is logged. Logs are filtered by the timestamp, user, activity, activity status, requester information, and object information. Logs are associated with users, Applications, and Application Logins in a many-to-one fashion.

Figure 43: Logs Page

A set of automated unit and functional tests thoroughly subject the code base to security tests to insure the application handles all security measures.

GTMS code base is stored in a Subversion repository that is accessible via a secured Apache server or by accessing the box using an authorized user on the server. Subversions architecture tags each change to the code base and provides access to versions of code previous to any changes. Subversion is subject to an independent backup to insure that files are not lost due to any issues.

APPENDIX C - SEMANTIC WEB

This application capability was added for additional functionality in the future. It was an add-on and not originally part of the requested capabilities of the system.

The Semantic Web provides an automated way of enhancing the collection of the characteristics of data as it is gathered so that a more flexible use of the data can occur at a later stage. This capability is achieved by, among other things, setting up additional relationships with the data as it is collected. The advantage comes at a later time when the data needs to be referenced in the context of its intended use, rather than how it is collected. More information on this will be provided later.

1   SEMANTIC CAPABILITIES

1.1 Semantically Enabling Data Through RDF, RDFS and OWL

Semantically enabling data means being able to enhance the data with characteristics when the data is collected. This is accomplished using RDF, RDFS, OWL and the Vocabulary. The next diagrams demonstrate the Semantic relationship.
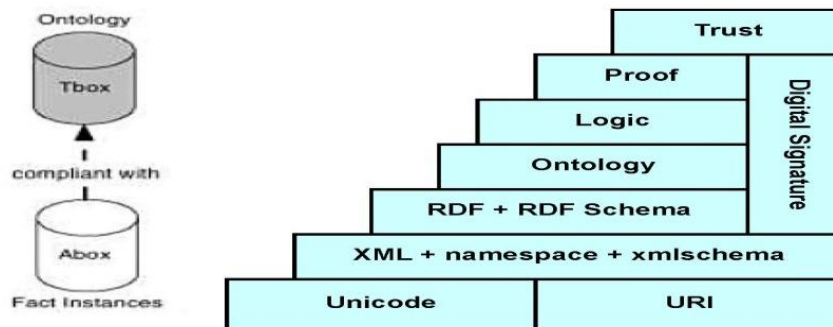
Figure 44: Semantic Web Definitions

The terms Abox and Tbox are used to describe two different types of statements in ontologies. Tbox statements describe a system in terms of controlled vocabularies, for example, a set of classes and properties. Abox are Tbox-compliant statements about that vocabulary. Tbox statements are sometimes associated with object-oriented classes and Abox statements associated with instances of those classes. Together Abox and Tbox statements make up a knowledge base.

Figure 45: Semantically Enabling Data

- **RDF** - The Resource Description Framework (RDF) is the W3C standard for encoding knowledge. RDF provides the ability to express any fact in small, structured pieces. It is able to represent knowledge as a network graph, as a set of statements, or even as XML. The design of RDF is suited to meshing distributed knowledge sources together. Applications use RDF files from different sources to derive new facts. The RDF standard enables this process by providing logical descriptions of inferences between facts and instructions on how to search for facts in other RDF documents. These facts may occur in the local document, external document, or a combination of both. RDF easily learns new facts by being remarkably flexible. The RDF standard not only links documents together by a common vocabulary, but it also allows any document to use any vocabulary.

- **RDFS** - RDF Schema (RDFS) provides the ability to type. RDFS determines which terms from the vocabulary are classes and which are properties.

- **OWL** - OWL (Web Ontology Language) is the top layer that says much more about the vocabulary. OWL allows the system to place more restrictions, and with these restrictions, a more sophisticated level of reasoning on the data. Additionally, it places the simple terms from the vocabulary into an object model.

As a result:
- RDF, RDFS, OWL and the Vocabulary are layers on top of each other.
- RDF provides a format to express a fact, in the form of Subject, Predicate, and Object.
- The vocabulary places terms in the RDF format.

A user performs a text search against all available data sources, including those available through Web Services. Text searches search for matching values in the database. For example, if a text search is for "Smith," the results may be for a person with the same surname or for a street named "Smith Street." The results from a text search bring back the URI of the RDF document.

1.2 Semantic Extensions

As the types of data sources evolve, the GTMS can be modified to accept them. Like browsers, Wiki's can be a front-end to the GTMS. Wiki's can also be a data source. Semantic features can be enabled through the utlizlation of Wiki extensions.

2   PERFORMANCE MEASURES

From an input perspective, the processing must keep pace, meaning messages must be processed at a rate higher than they are received. The initial production work firmly establishes this ability as a mitigated risk. Data appears at a rate more than 10 orders of magnitude slower than the processing of the EDI files. The returning of data must occur to fill a web screen within 10 seconds. Current processing occurs in less than two seconds.

The SM21 team looks to take the RDF and build a consensus across carriers, vendors and shippers. It will vet and take feedback from real shippers, clients and carriers.

3 BLACKBOOK

Blackbook, which is multi-level secure, will run on the same SOA as the GTMS. This is a standard best of breed approach. Blackbook is a semantic web processor which may process all incoming data. At this point, incoming data is stored in an RDF store. Downstream processing occurs by querying data from the RDF store.

The purpose of Blackbook is to provide GTMS users with an easy-to-use tool to access valuable data. The tool federates queries across data sources. These data sources are databases or applications located either locally or remotely on the network. Blackbook's architecture fits well within the GTMS system. Blackbook is a J2EE server-based data integration framework which relies on open standards to promote robustness and interoperability, including Jena, June, Lucene, JAAS, D2RQ. It is based on semantic web technologies (I.e., RDF, RDF Schema, OWL, SPARQL). It is vocabulary agnostic, meaning that it can leverage any existing vocabulary 'for free', so users need not build everything from scratch (a vocabulary is a set of consistently used and carefully defined terms). Vocabularies construct RDF statements that conform to the RDF format. Blackbook provides a default web application interface, and uses SOAP and RESTful interfaces. It also provides a high level of security 'baked in' (PL3 Appendix E certified) with access to data controlled to the individual user, as will be shown below. The data processing for the GTMS may be One Network, Blackbook, or components of both.

Blackbook implements the layers in the 'semantic stack' that are now most technology mature—i.e., up to the ontology level using OWL -- and, along with its implementation technologies for indexing, converting data to RDF, and querying data and work flow, it allows analysts to make logical inferences across the data sources, to add their own knowledge and share that knowledge with others using the system.

APPENDIX D - SEMANTIC WEB TREATMENT FOR XML FORMATTED EDI MESSAGES FOR AIR, OCEANIC, RAIL, AND TRUCK TRANSPORT

Basic metadata about the system occurs in three areas, each having their own data store:

- The workspace/workflow module maintains definitions of processing for users and groups of users.
- The security module maintains access controls.
- The metadata manager modules maintain metadata on data sources themselves, including EDI data sources.

1 SEMANTIC WEB METHODOLOGY

Step 1
Describe the initial, most difficult requirements in conversational, informal English. Leverage any existing diagrams or formalisms.

Step 2
Decompose the problem into domain components. Pick the most difficult domain as a starting point. Add in any "for free" completed domains.

Step 3
Look for opportunities of abstraction to lessen the number of components.

Step 4
Research existing vocabularies and ontologies in similar domains to use in composition.

Step 5
If a preexisting vocabulary does not exist, model it yourself creating Tbox entries.

Step 6
Take an instantiation of the data and prove it can work on paper.

Step 7
Use a semantic web implementation, like Jena, to build a Tbox vocabulary.

Step 8
In a semantic web implementation, instantiate the vocabulary by creating instances and output the instances as RDF/XML.

Step 9
Iterations - repeat steps 1 through 8 until complete.

2 SHIPPING VISIBILITY CASE STUDY

Partners will send SFTP EDI XML event messages to a secured server. These messages will then be consumed and stored in a semantic data store. This data will be searched, and the messages will be editable via a web based user interface and will be available for analysis via dashboards and reports.

The EDI XML needs to be transformed into logically formatted RDF XML that takes the messages and information contained within into account.

2.1 Step 1. Describe Requirements

Goal: Describe the initial, most difficult requirements in conversational, informal English. Leverage any existing diagrams or formalisms.

Since the customer wants to track shipments, the problem must be extruded down to developing a vocabulary for a shipment.
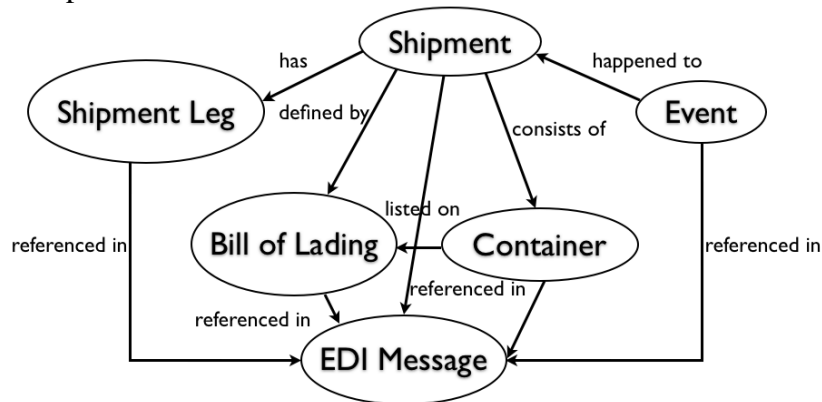
Figure 46 Shipment

2.2 Step 2. Decompose Problem into Domain Components

Goal: Decompose the problem into domain components. Pick the most difficult domain as a starting point. Figure 47 presents the problem in a simpler form and separates it into its domain components.
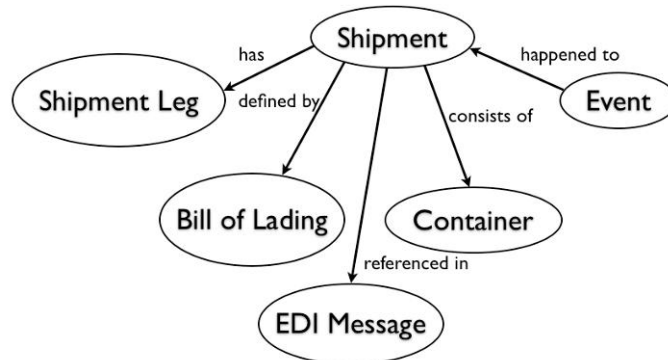
Figure 47 Decomposed Shipment

2.3 Step 3. Look for Opportunities of Abstraction

Goal: Look for opportunities of abstraction to lessen the number of components.

The number of components pretty much fits what is needed to display, but it is important to take a closer look at what composes each domain object.

1. Shipment - The Shipment will have a Shipment Id literal composed of the Bill of Lading Id and Container Number. The shipment will reference the Container object, Bill of Lading object, Event object, Shipment Leg objects, and EDI Message objects.

2. Shipment Leg - The Shipment Leg object will consist of a literals representing location, an estimated time, and an actual time. Shipment legs will reference a Shipment object and an EDI Message object.

3. Bill of Lading - The bill of lading will have a bill of lading number literal. Bill of ladings will have references to Container objects, EDI Messages objects, and Shipment objects.

4. EDI Message - The EDI Message will have a literal for the EDI Message, Message ID, and Message Set. The EDI Message will have references to Shipment object, Shipment Leg object, Bill of Lading object, Event objects, and Container objects.

5. Container - The Container object will have literals representing the Container Number which is a composite of a prefix and number. Container Objects will have references to Shipment objects, Bill of Lading objects, and EDI Message objects.

6. Event - The Event object will have literals for Event Id, Location, and Time Stamp. Event objects will reference Shipment objects and EDI Message objects.

2.4 Step 4. Research Existing Vocabularies

Goal: Research existing vocabularies and ontologies in similar domains to use in composition.

The existing VCard:ADR ontology and the XSD can be leveraged for date/time to cover both location and date/time. VCARD:ADR provides a defined locality to store the location information. Latitude and longitude will be stored using the Geo Point Ontology at http://www.w3.org/2003/01/geo/wgs84_pos#. A custom TBox for Shipment, Shipment Leg, Bill of Lading, EDI Message, Container, and Event will have to be created.

2.5 Step 5. Create TBox Entries

Goal: If a preexisting vocabulary does not exist, model it yourself creating Tbox entries.

Shipment TBox
- ID
- Container TBox
- Shipment Leg TBox
- Bill of Lading TBox
- Event TBox
- EDI Message TBox

Shipment Leg TBox
- ID
- Mode
- VCARD: ADR
- Estimated Arrival Time Stamp (XSD)
- Actual Arrival Time Stamp (XSD)
- Estimated Pickup Time Stamp (XSD)
  a. Actual Pickup Time Stamp (XSD)
  b. Shipment TBox

c. EDI Message TBox

Bill of Lading TBox
- ID
- Payment
- Shipment Id
- Container TBox
- EDI Message TBox
- Shipment TBox

EDI Message TBox
- Message
- ID
- Message Set
- Sent Time Stamp (XSD)
+ Container TBox
+ Shipment Leg TBox
+ Bill of Lading TBox
+ Event TBox
+ Shipment TBox

Container TBox
- ID
- Equipment Type
- Quantity
- Package Type
+Shipment Leg TBox
+Bill of Lading TBox
+EDI Message TBox

Event TBox
- ID
+ VCARD: ADR
- Time Stamp (XSD)
- event code
- container status
- location function
- carrier scac
- unique character data
+ reference to Tbox

2.6 Step 6. Instantiate Data

An example EDI 310 XML message from GT Nexus (See Appendix A.) is the starting point.
From the XML the container and status information can be determined.
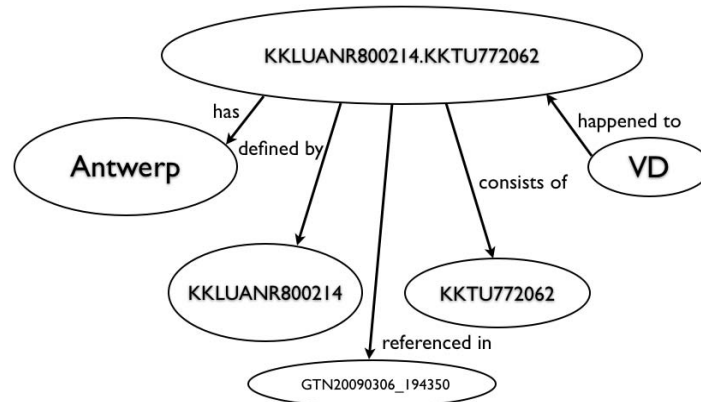
Figure 48 Container KKLUANR800214.KKTU772062

2.7 Step 7. Implement using Semantic Web Technologies

```java
package sm21.jena;
import com.hp.hpl.jena.ontology.DatatypeProperty;
import com.hp.hpl.jena.ontology.ObjectProperty;
import com.hp.hpl.jena.ontology.OntClass;
import com.hp.hpl.jena.ontology.OntModel;
import com.hp.hpl.jena.ontology.OntModelSpec;
import com.hp.hpl.jena.rdf.model.ModelFactory;
import com.hp.hpl.jena.rdf.model.Resource;
import com.hp.hpl.jena.shared.PrefixMapping;


/**
 * The Shipping Vocabulary for tracking containers and their related information.
 *
 * @author Rich Brassell
 * @version 1.0
 */
public class Shipping {
   /* General Ontology Information Start */
   /** <p>The ontology model that holds the vocabulary terms</p> */
   private static OntModel m_model = ModelFactory.createOntologyModel(
OntModelSpec.OWL_MEM, null );

   /** <p>The namespace of sm21 the vocabulary as a string</p> */
   public static final String NS = "http://domains.intervise.com/shipping/1.0#";

   /** <p>The namespace of the vocabulary as a resource</p> */
   public static final Resource NAMESPACE = m_model.createResource( NS );

   /**
    *  <p>The namespace of the vocabulary as a string</p>
    *  @see #NS
    */
```

65

```java
   public static String getURI() { return NS; }
   /* General Ontology Information End */

   /* Bill of Lading Start */
   /**
    * <p>This class represents a Bill Of Lading containing information about
    * containers being tracked.</p>
    */
   public static final OntClass BillOfLading = m_model.createClass( NS + "BillOfLading" );
   /* Bill of Lading End   */

   /* Container Start */
   /** <p> Containers are represented by the Container object.</p> */
   public static final OntClass Container = m_model.createClass( NS + "Container" );

   /** <p>A container is listed on a Bill of Lading.</p> */
   public static final ObjectProperty listedOn = m_model.createObjectProperty( NS + "listedOn"
);
   /* Container End */

   /* EDI Message Start */
   /** <p> EDI Messages are represented by the EDIMessage object.</p> */
   public static final OntClass EDIMessage = m_model.createClass( NS + "EDIMessage" );

   /** <p>EDI Messages have the raw message associated with them.</p> */
   public static final DatatypeProperty message = m_model.createDatatypeProperty( NS +
"message" );

   /** <p>EDI Messages have the message set associated with them.</p> */
   public static final DatatypeProperty messageSet = m_model.createDatatypeProperty( NS +
"messageSet" );

   /** <p>EDI Messages have a sent time.</p> */
   public static final DatatypeProperty sentTime = m_model.createDatatypeProperty( NS +
"sentTime" );
   /* EDI Message End */

   /* Event Start */
   /** <p> Events are represented by the Event object.</p> */
   public static final OntClass Event = m_model.createClass( NS + "Event" );

   /** <p>Events have a time they occurred.</p> */
   public static final DatatypeProperty eventTime = m_model.createDatatypeProperty( NS +
"eventTime" );
   /* Event End */
```

```java
   /* Shipment Start */
   /**
    * <p>This class represents a Shipment containing information about
    * containers being tracked.</p>
    */
   public static final OntClass Shipment = m_model.createClass( NS + "Shipment" );

   /** <p>A shipment consists of containers.</p> */
   public static final ObjectProperty consistsOf = m_model.createObjectProperty( NS +
"consistsOf" );

   /** <p>A shipment is defined by a Bill Of Lading.</p> */
   public static final ObjectProperty definedBy = m_model.createObjectProperty( NS +
"definedBy" );

   /** <p>A shipment has Shipment Legs. </p> */
   public static final ObjectProperty happenTo = m_model.createObjectProperty( NS +
"happenTo" );

   /** <p>A shipment has Shipment Legs. </p> */
   public static final ObjectProperty has = m_model.createObjectProperty( NS + "has" );

   /** <p>An id for objects.</p> */
   public static final DatatypeProperty id = m_model.createDatatypeProperty( NS + "id" );

   /** <p>A shipment is referenced in EDI Messages </p> */
   public static final ObjectProperty referencedIn = m_model.createObjectProperty( NS +
"referencedIn" );
   /* Shipment End   */

   /* Shipment Leg Start */
   /** <p> Shipment Legs are represented by the ShipmentLeg object.</p> */
   public static final OntClass ShipmentLeg = m_model.createClass( NS + "ShipmentLeg" );

   /** <p>An actual time of arrival for a shipment leg will be represented by actualArrivalTime
for objects.</p> */
   public static final DatatypeProperty actualArrivalTime = m_model.createDatatypeProperty(
NS + "actualArrivalTime" );

   /** <p>An estimated time of arrival for a shipment leg will be represented by
estimatedArrivalTime for objects.</p> */
   public static final DatatypeProperty estimatedArrivalTime =
m_model.createDatatypeProperty( NS + "estimatedArrivalTime" );
   /* Shipment Leg End */

   // Geo points are created using the following.
```

```
/** <p>I need to create a representation for geo points.  This is the geoNS</p> */
public static final String geoNS = "http://www.w3.org/2003/01/geo/wgs84_pos#";

/** <p>Map the prefix fro the geo tag</p> */
public static final PrefixMapping geoPM = m_model.setNsPrefix("geo", geoNS);

/** <p>The geo has a point.</p> */
public static final ObjectProperty Point = m_model.createObjectProperty( geoNS + "Point" );

/** <p>The Point has a latitude value.</p> */
public static final ObjectProperty lat = m_model.createObjectProperty( geoNS + "lat" );

/** <p>The Point has a longitude value</p> */
public static final ObjectProperty longitude = m_model.createObjectProperty( geoNS + "long"
);
}
```

2.8 Step 8. Develop RDF/XML Representations of Instances

```
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:owl="http://www.w3.org/2002/07/owl#"
   xmlns:vcard="http://www.w3.org/2001/vcard-rdf/3.0#"
   xmlns:geo="http://www.w3.org/2003/01/geo/wgs84_pos#"
   xmlns:Shipping="http://domains.intervise.com/shipping/1.0#">
 <rdf:Description
rdf:about="http://domains.intervise.com/shipping/1.0#Shipment/KKTU772062.KKLUANR800214">
   <Shipping:consistsOf>
    <rdf:Description
rdf:about="http://domains.intervise.com/shipping/1.0#Container/KKTU772062">
     <Shipping:id>KKTU772062</Shipping:id>
     <Shipping:listedOn>
      <rdf:Description
rdf:about="http://domains.intervise.com/shipping/1.0#BillOfLading/KKLUANR800214">
       <Shipping:id>KKLUANR800214</Shipping:id>
       <Shipping:referencedIn>
        <rdf:Description
rdf:about="http://domains.intervise.com/shipping/1.0#EDIMessage/GTN20090306_194350">
         <Shipping:id>GTN20090306_194350</Shipping:id>
         <Shipping:message>&lt;BlMessage&gt;
 &lt;TransactionInfo AcknowledgementRequested="false"&gt;
  &lt;MessageSender&gt;GTNEXUS&lt;/MessageSender&gt;
  &lt;MessageRecipient&gt;INTERVISE&lt;/MessageRecipient&gt;
  &lt;MessageID&gt;GTN20090306_194350&lt;/MessageID&gt;
```

<Created>2009-03-06T19:43:50.463-08:00</Created>
<FileName>INTERVISE20090306_194352932.xml</FileName>
</TransactionInfo>
<BL BLNumber="KKLUANR800214" BillType="SeaWaybill" CarrierScac="KKLU"
MoveType="CYPToCYP" Payment="Mixed" Purpose="Completion"
Sequence="1" ServiceType="NoCFS" ShipmentId="90406">
<References>
<Reference referenceType="BookingNumber">KKLUANR800214</Reference>
<Reference Description="SERVICE CONTRACT"
referenceType="ContractNumber">GSN00083</Reference>
</References>
<Voyage>
<VoyageNumber>17E</VoyageNumber>
<Vessel Code="9302619" Country="LR" Qualifier="Lloyds">
<Name>YM UNITY</Name>
</Vessel>
</Voyage>
<Parties>
<Party Code="10013959" Type="Shipper">
<Name>DHL GLOBAL FORWARDING (BELGIUM) NV</Name>
<Address>
<AddressLine>ANTWERPSEBAAN 56</AddressLine>
<AddressLine>2040</AddressLine>
<AddressLine>ANTWERPEN</AddressLine>
</Address>
</Party>
<Party Type="Consignee">
<Name>FANCHENG INTERNATIONAL TRANSPORTATION SERVICE CO
LTD</Name>
<Address>
<AddressLine>8-9F. 218 WU SONG ROAD</AddressLine>
<AddressLine>SHANGHAI</AddressLine>
<AddressLine>P.R. CHINA</AddressLine>
</Address>
</Party>
<Party Type="Forwarder">
<Name>DHL GLOBAL FORWARDING</Name>
<Address>
<AddressLine>(BELGIUM) NV/SA</AddressLine>
<AddressLine>ANTWERPSEBAAN 56</AddressLine>
</Address>
</Party>
<Party Type="Notify">
<Name>DANZAS Z.F. FREIGHT AGENCY CO.LTD.</Name>
<Address>

```
        &lt;AddressLine&gt;14FLR,ORIENT INTERNATIONAL
FINANCE&lt;/AddressLine&gt;
        &lt;AddressLine&gt;PLAZA. NO. 318 SOUTH ZHONGSHAN
ROAD&lt;/AddressLine&gt;
        &lt;AddressLine&gt;200010 SHANGHAI, P.R. CHINA&lt;/AddressLine&gt;
      &lt;/Address&gt;
    &lt;/Party&gt;
   &lt;/Parties&gt;
   &lt;Locations&gt;
    &lt;Location Country="BE" Function="OperationalOrigin"
     Identifier="BEANR" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;ANTWERP&lt;/Name&gt;
    &lt;/Location&gt;
    &lt;Location Country="BE" Function="ContractualPlaceOfReceipt"
     Identifier="BEANR" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;ANTWERP&lt;/Name&gt;
     &lt;DateTime Qualifier="Actual" TimeCode="LocalTime"&gt;
                  2009-03-03T16:26:00.000-08:00
          &lt;/DateTime&gt;
    &lt;/Location&gt;
    &lt;Location Country="BE" Function="OperationalPortOfLoading"
     Identifier="BEANR" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;ANTWERP&lt;/Name&gt;
     &lt;DateTime Qualifier="Estimated" TimeCode="LocalTime"&gt;
            2009-03-03T16:26:00.000-08:00
          &lt;/DateTime&gt;
    &lt;/Location&gt;
    &lt;Location Country="CN" Function="OperationalPortOfDischarge"
     Identifier="CNSHA" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;SHANGHAI&lt;/Name&gt;
     &lt;DateTime Qualifier="Estimated" TimeCode="LocalTime"&gt;
            2009-03-26T12:00:00.000-07:00
          &lt;/DateTime&gt;
    &lt;/Location&gt;
    &lt;Location Country="CN" Function="ContractualPlaceOfDelivery"
     Identifier="CNSHA" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;SHANGHAI&lt;/Name&gt;
     &lt;DateTime Qualifier="Estimated" TimeCode="LocalTime"&gt;
            2009-03-26T12:00:00.000-07:00
          &lt;/DateTime&gt;
    &lt;/Location&gt;
    &lt;Location Country="CN" Function="OperationalFinalDestination"
     Identifier="CNSHA" Qualifier="UNLOCODE"&gt;
     &lt;Name&gt;SHANGHAI&lt;/Name&gt;
    &lt;/Location&gt;
    &lt;Location Country="BE"
```

Function="OperationalBillOfLadingReleaseOffice" Qualifier="UNLOCODE">
    <Name>ANTWERP</Name>
   </Location>
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EDIDP</DescriptionLine>
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C</DescriptionLine>
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PALLETS</DescriptionLine>
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     <DescriptionLine>
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     <DescriptionLine>R HARMLESS GLUE HS: 35069100
PLASTI</DescriptionLine>
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2.9 Step 9 Repeat Steps 1 to 8

Execute loop until all business entities have been mapped.