Trade Collaboration Systems

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ABSTRACT

A Trade Collaboration System (TCS) is a system designed to coordinate the work of supply chain stakeholders involved in the business processes of global logistics. Using the Software as a Service (SaaS) model, the TCS provides a cohesive, process-oriented viewpoint on the stakeholders' collaborative work. The stakeholders supported by these systems include customers and suppliers, carriers, third party logistics providers (3PLs), freight forwarders, customs brokers, and government agencies. The National Institute of Standards and Technology (NIST), through collaboration with the Automotive Industry Action Group (AIAG), is developing an enabling framework for trade collaboration systems. The AIAG Materials Off-Shore Sourcing (MOSS) project performed a pilot investigation of TCS capabilities in cooperation with a software vendor that developed a MOSS-conforming TCS. This chapter reports on the enabling framework, its approach to improving data quality (DQ), and a cost / benefit analysis of trade collaboration systems.[i]

Keywords: inter-organizational information systems, eBusiness, eDocuments, data quality, software as a service, electronic data interchange

INTRODUCTION

This chapter describes an enabling framework supporting the business processes of logistics and order management in international trade. Systems in this area support the activities of a loose federation of stakeholders, starting with a buyer placing an order, and ending with the delivery of the goods. A trade collaboration system (TCS) is an inter-organizational system (Johnston & Vitale, 1988) (Sherer, 1997) that leverages Software as a Service (SaaS) (Chong & Carraro, 2006) technology to coordinate the work of stakeholders involved in the business processes of global logistics. Trade collaboration systems are emerging solutions; currently only a few commercial solutions exist. The stakeholders supported by these systems include customers, suppliers, carriers, third party logistics providers (3PLs), freight forwarders, customs brokers, and government agencies. The scope of processes coordinated by the TCS includes, at least, master order specification, communication of order forecasts, order placement, transportation booking, and customs clearance. The TCS might additionally manage payment processes associated with the order. Trade collaboration systems are easily deployed Software as a Service solutions that are intended to replace the ad hoc mix of paper, fax, phone, email, and Electronic Data Interchange (EDI) messaging typically supporting these activities now.

Significant impediments to the operation of long-distance supply chains arise from the use of error-prone communication channels (fax, email, telephone calls) to coordinate the business processes of the stakeholders. These communication channels, endemic in the typical business process, are implemented extemporaneously and ad hoc, and cannot provide quality operational information ("visibility") necessary for efficient operation of the supply chain. The consequences of this are excessive safety stock inventory, excessive expediting of shipments, and an inability to deploy strategic supply chain initiatives. By providing a cohesive, process-oriented viewpoint on the shipments managed, that is updated through an error-resistant communication channel, the TCS should significantly improve the operation of long-distance supply chains.

The National Institute of Standards and Technology (NIST) of the United States, through collaboration with the Automotive Industry Action Group[ii] (AIAG), has been studying trade collaboration systems since 2005. The AIAG's Materials Off-Shore Sourcing (MOSS) project is an automotive industry effort to reduce the costs, and improve the visibility and performance of transcontinental supply chains of automotive parts bound for US assembly plants. The project is developing an enabling framework for TCS solutions, including a conceptual model of goods order and ocean-going transport, a mapping of EDI messages used to manage shipments to the conceptual model, and software for validating conformance to the EDI message types designed under the project.

The MOSS project performed a pilot investigation of TCS capabilities in cooperation with a software vendor that developed a MOSS-conforming TCS as Software as a Service (SaaS). The pilot investigation involved the shipment of automotive batteries from a Korean supplier to an original equipment manufacturer (OEM) customer. Supporting the pilot process were the 3PL, freight forwarder, ocean carrier, and customs broker supporting the existing supply chain process. The pilot ran “live” data in parallel with the existing process for three months, managing about 20 containers per month. The AIAG has published a cost/benefit analysis of the MOSS solution. (AIAG, 2009) At the time of this writing, the project is preparing publication of its best practice recommendation on the use of TCSs in ocean-going shipments of automotive parts.

This chapter reports on how the requirements of global trade management (GTM) were met using the framework developed under MOSS. The section following this one reviews the challenges of global trade management. Principal challenges to overcome center on data quality (Wang & Strong, 1996) in operational and system design contexts. In the operational context, properties of SaaS deployment are leveraged. SaaS is typically promoted as a means of reducing the cost of managing IT assets. The more interesting property in the context of GTM is its ability to encapsulate both ends of inter-firm communications, and thereby support collaborative processes. The third section describes a solution to data quality problems in a system design context. Specifically, it describes the methodology developed for the design of EDI messages, addressing weaknesses in the prevailing practice. The development activities described in that section are essential to providing the cohesive viewpoint in TCS solutions. The fourth section reports on the MOSS pilot experience and the subsequent cost / benefit analysis performed under the project. The fifth section of the chapter describes a vision for the long-term development of Trade Collaboration Systems, where the TCS can provide effective tools supporting sustainable logistics and more effective interaction with customs authorities. The sixth section reviews related work.

THE CHALLENGES OF GLOBAL TRADE MANAGEMENT

In 2005, the AIAG performed a study of the business practices of intercontinental supply chains of containerized automotive parts inbound to US assembly plants. As part of that study, the AIAG funded a survey of 220 automotive original equipment manufacturers (OEMs) and upper tier manufacturers. (Mixer, 2005) The survey results and subsequent investigation indicated that:

- Visibility into key process milestones is low: Only 20 % of respondents indicated that they have knowledge of when shipments leave a foreign port; only 39 % have knowledge of when goods clear US Customs; only 37 % have knowledge of in-transit movement from customs.
- 15 % of shipments experience delays en route due to errors in the information driving the logistics processes, and 91 % of communication problems are directly attributable to the use of email, phone, fax, and paper. Only 9 % of problems originate with electronic data exchange.
- 79 % of the information driving the process is being entered redundantly into the various stakeholder IT systems supporting the processes.

Each of these problems is discussed in turn below.

Lack of visibility: Visibility is awareness of where goods are, geographically and in terms of their progress through the business process. The lack of visibility into the operation of the supply chain makes the identification of problems difficult. Continuous improvement is only possible when the source of errors is known. Where visibility is lacking, delivery schedules may be set excessively lax, and consequently in-transit inventory and its carrying cost increased.

Delay due to information deficiencies: Typically, an instance (or "occurrence") of a business process must make reference to the particular "individuals" that are to participate in the occurrence. In GTM, these individuals may be, for example, the goods and a container ship voyage. Description of the individuals may not only be logically necessary, but also legally necessary. For example, a description of the contents of a container bound for the US must be reported to US Customs 24 h before the container is loaded onto the ship. When the information that drives a process occurrence is not available, the process occurrence is delayed until that information is provided. Manual intervention may be required to provide it. Unforeseen delays, such as those caused by information deficiencies, increase the variation in transit time and force the customer to carry additional safety stock or pay to expedite delayed shipments.

Redundant and wasteful processes: A study of global trade business practices performed in the MOSS project suggests that 92 % of the data driving the processes is known prior to shipment; only 8 % is created as the goods move. (AIAG, 2009) The 8 % concerns information that cannot be known earlier: seal numbers and actual delivery dates, for example. There should therefore be little need to perform data entry after the goods are prepared for shipment. Study shows, however, that much of the re-entry of information (much of the 79 % mentioned earlier) occurs during movement, and were that redundant processing not to occur, the goods would not move. Typically, it is a lack of automation on one or both sides of a communication that necessitates the re-entry of data. If the system of the receiving agent does not have an interface supporting the form of the message sent, the agent must manually copy the message content into his/her system. To make this process amenable to human labor, the parties involved typically choose to communicate by email and spreadsheets. Associated with the reception of each email and spreadsheet is the manual task of opening the file, reading it, and placing the content in the context of the workflow in which it is to be executed.

The indeliberate emergence of systems supporting global trade

The selection of supply chain partners is often preceded by careful consideration of business strategy. But the ensuing details of what will become the partners' daily interactions in operating the supply chain often are not given equal attention. Sometimes underlying that lack of attention is the presumption that the relationships of a shipper or consignee with its carriers and logistics service providers may be short-term, perhaps lasting a few years or less. Indeed, with each change of logistics service provider there may arise the need to cope with differing procedures and information technology. But the barrier to switching service providers often can be offset by the cost advantage gained in the service provided – the switch may be motivated by changing transportation pricing, or a more advantageous warehousing location, for example. The switching barrier is less if there has been little investment in IT integration with the current provider – arguing for little investment in the IT supporting the partner's operational procedures.

The OEMs of complex products interact with thousands of suppliers, many of whom are overseas. To avoid incurring high costs while interacting with so many suppliers, typically, the OEM will seek uniform adoption of its EDI message types among its suppliers. These EDI message types, described through message implementation guides (MIGs), presumably mirror the requirements for interaction found in the OEM's IT systems. Suppliers, however, might conduct business with several OEMs, each with its own requirements. (Mukhopadhyay, Kekre, & Kalthur, 1995) Further, the supplier may need to interact with the OEM's freight forwarder and 3PL, and the OEM may switch providers of these services as contracts expire. The flux of relationships increases the cost of supporting an automated interface to the OEM's system, and decreases the likelihood that the interface will be maintained.

Like OEMs, ocean carriers interact with thousands of parties, in their case, consignors and consignees. Also like the OEMs, the ocean carriers seek adoption of their EDI messages. A comparison, performed in the MOSS project, of ocean carrier EDI message types for booking processes suggests that there are substantial differences in way information is expressed in the booking message types used by the various ocean carriers. Indeed, a key role of freight forwarders and booking broker services is to cope with these differences. Ocean booking is often performed by phone calls and email to avoid misinterpretation.

The number of relationships, their tendency to be short-lived, the complexity of the information conveyed in interactions, justifiable variation in process, and the multitude of competing choices of transportation mode and other logistics services are all disincentives to the development of a system that might manage the broad scope of processes involved. Additionally, the trajectory of system development in this area has followed two dimensions of activity that are not helpful toward that goal: (1) the extension of capabilities of domestic logistics systems, and (2) the development of web portals for isolated tasks. Taking all this into account, what commonly evolves from the requirement to interact is not a single system integrating the processes but an idiosyncratic arrangement of error-prone point-to-point information flows, conducted as phone calls, faxes, spreadsheets, and email. (See Figure 1). The point-to-point nature of the communication has the additional problem of not alerting parties outside of a communication of its occurrence. This is a principal impediment to visibility, and it persists even under EDI exchange. For example, unless the buyer and 3PL are secondary notify parties of the booking activity between the freight forwarder and ocean carrier (necessitating more point-to-point communications) they will not be informed of its occurrence. Knowledge of these interactions is often obtained second- or third-hand.

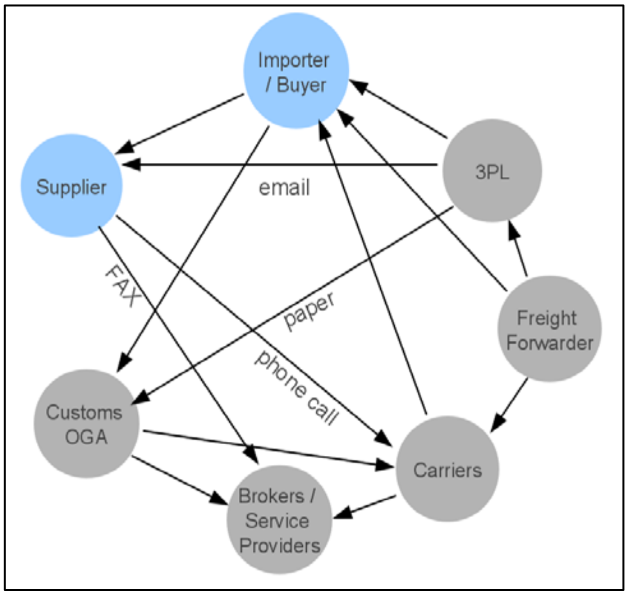

Figure 1: In ad hoc GTM, information is conveyed point-to-point, and is often learned only second- or third-hand.

One measure of the price paid by the absence of an available, cohesive body of information is the cost of retrieving information from the prevailing alternative (resembling the idiosyncratic arrangements depicted in Figure 1). The US Importer Security Filing (ISF) is a requirement on importers to provide 10 elements of information on each item imported into the US 24 hours prior to loading the goods onto an ocean-going vessel. The 10 elements are not extraordinary; they include the manufacturer's name and address, the country of origin, tariff schedule number, and the bill of lading number. Yet the US National Association of Manufacturers suggests that implementing the ISF will cost US manufacturers as much as 20 billion USD annually. (Partnership, 2009) It is not hard to see that there can be substantial costs involved in providing the ISF: information has to be collected from the various stakeholders, and the question of who has what elements of it depends on the details of the particular supply chain process. Consequently, the effort required to implement an IT solution is high, and because of justifiable variation in processes, often not shared across supply chains. In the mean time, cost associated with manual intervention and additional in-transit delay is incurred.

Requirements Analysis

Effective supply chain management is only possible when stakeholders are provided with a persistent, cohesive view of the supply chain (its structure, stakeholder roles, principals of operation, and knowledge of goods in transit). In a persistent, cohesive information environment, performance measurement enables continuous improvement, and strategic initiatives can be undertaken. But "cohesion" in the sense intended is not an emergent property of information diffused among stakeholders and buried in faxes, email, and spreadsheets. In the course of the MOSS project, and in subsequent reflection and formalization of the requirements identified

1. The system shall provide a cohesive viewpoint on the supply chain, its resources, participant roles, processes and the status of goods in transit.
    a. The system shall reduce the cost of performing commonplace queries. (ISF, shipment status.)
    b. The system shall enable measurement of supply chain performance parameters.
    c. The system shall facilitate the satisfaction of government filing requirements.
    d. The system shall enforce ontological constraints on the relationships describing supply chain processes and resources.
        i. The system shall ensure that the information it maintains is accurate.
        ii. The system shall provide stakeholders with a schematic representation of the supply chain's processes and resources.
2. The system shall provide flexible methods of information entry (EDI or web).
3. The system shall serve the needs of stakeholders possessing varying degrees of IT infrastructure.
    a. The system shall provide flexible means of reporting (eDocs, web, EDI)
    b. The system shall reliably support processes where paper documents are still required.
4. The system shall facilitate integration with external systems (MRP, scheduling, demand management).
5. The system shall be deployable at a low cost.

Figure 2: An abridged requirements analysis of Trade Collaboration Systems in the context of the MOSS project. In this list of nested sublists, the sublists describe more basic requirements from which the more concrete superlist element is derived.

through the MOSS pilot exercise, a requirements analysis has been performed. This is summarized in Figure 2.

Note that Figure 2 references EDI- and not XML-based exchange. This is because in automotive sector supply chains, EDI is more prevalent than XML by a very large margin. The relative technical advantages of XML-based exchange are not considered in this chapter. MOSS project developers do not believe that the advantages are significant to meeting the requirements enumerated.

A first step in conceiving a solution from the requirements described in Figure 2 is to recognize that effective solutions must *field a system* in the middle of the interactions of global trade management – the requirements cannot be met efficiently by any point-to-point integration of existing backend systems. The requirements for visibility, performance measurement, government filing requirements, and information accuracy are efficiently met only by operation on a cohesive body of information about the business processes. Collecting and formalizing this body of information from the current arrangement, a loose federation of components, is not feasible.

In order to make the system deployable at a low cost, the viewpoint of the business process it presents must be useful to all participants. The viewpoint must be normalized to reflect a common (published) understanding of the objects and relationships in the universe of discourse. With a published viewpoint, the cost of developing interfaces is reduced, and the transparency of operation facilitates business collaboration. In contrast, point-to-point communication is designed to serve the (possibly opaque) purposes of a single recipient. The cost of implementing information flows under the latter must account for the cost of understanding the recipients requirements (perhaps conveyed in a message implementation guide). This cost may be incurred again in providing the same information to other parties – these parties may need the information expressed differently, or may require a differing technical interface.

In summary then (and, for the moment, ignoring the cost of implementing and deploying under the challenges described in the previous section), a solution to the problems of global trade management materializes: the processes of order management and logistics should be guided by a system providing role-based access to a shared repository reflecting the near real-time status of goods in-transit. The system should enable documentation of, and configuration to, a detailed model-based description of the supply chain process that it supports. It should enable the generation, transmission, and publication (to the repository) of key message content such as that contained in an advance ship notice. It should provide reliable production of key trade documents, such as an invoice for customs purposes. Such a system, a trade collaboration system, is depicted in Figure 3.

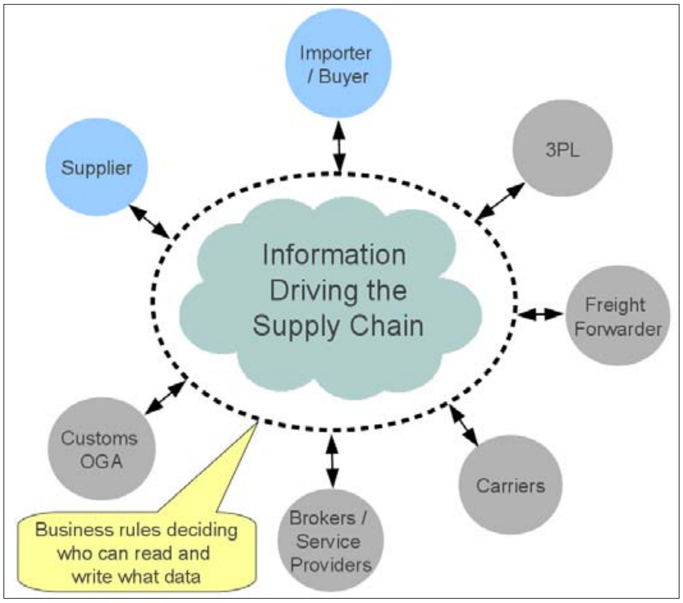

Figure 3: In a Trade Collaboration System, stakeholders of a supply chain share information. Stakeholder interactions are governed by business rules.

The role of Inter-firm SaaS in the solution strategy

A remaining problem in meeting the requirements defined in Figure 2 is alluded to in the phrase above “ignoring the cost of implementing and deploying...”. There is nothing extraordinary about implementing a system with a database repository shared by stakeholders. But the deployment of such a system across the great number of stakeholders, in the many origin / destination pairs in which an OEM or other large enterprise collaborates is infeasible under ordinary client-server technology. In such an arrangement, client software would need to be installed on hundreds of geographically distributed systems maintained by hundreds of parties. Updates would be costly. Further, though it may be possible to use data-driven means to customize the capabilities of those clients to the roles of the party operating the software, providing that capability securely, and providing a means to update it in the field is more difficult. Where anything like this strategy has succeeded, it has required sustained effort from a stakeholder central to many of the processes: a government. Singapore’s TradeNet provides an example. (King & Konsynski, 1990)

Software as a Service is a model of software deployment whereby a provider makes an application and associated computing resources available to a user immediately, through the web, and without requiring explicit action on the user's part to install the application on the hardware on which he/she will use it. The “application” in the context of this chapter is a trade collaboration system configured for the shared use of a buyer and seller, or origin / destination pair, and their supporting logistics service providers. The configured TCS identifies the business process and roles, and provides means for stakeholders to authenticate to those roles.

Not having to install the application and perform version upgrades is an advantage of SaaS common to all of its uses. For many applications this characteristic may be the enabler of economically feasible deployments. A second advantage of SaaS, not realized in all of its usages, but only under certain circumstances where the SaaS application is shared across organizations, is its ability to overcome barriers to interoperability. SaaS simplifies GTM across geographically and culturally diverse stakeholders. Each user of the shared SaaS TCS operates what is effectively a client to a server providing access to a shared viewpoint. But in actuality, the inter-firm SaaS application encapsulates both ends of the interaction, eliminating the need for conformance to a published interface. The user may well have had an efficient interface enabling his/her task execution through point-to-point interactions in an arrangement prior to introduction to the TCS, but just as likely, he/she interacted through inefficient means: spreadsheets, email, fax, and phone calls. In contrast, the TCS, using this SaaS interoperability strategy, provides a baseline user interface for those stakeholders who currently have only inefficient, error-prone means to conduct their role in the business process.

In presentations of the concept of the TCS, MOSS project participants sometimes describe it as “paratrooper software.” Paratroopers are troops that are dropped into a hostile environment to establish a foothold and provide modest capability, on which the capability for greater operations can be built. Similarly, the baseline user interfaces of a TCS establish a modest advance in capability beyond spreadsheets and email (an environment “hostile” to automation). The work of configuring the TCS provides modeling artifacts describing the business process and information flows. These modeling artifacts can be leveraged in engineering more efficient EDI- and XML-based exchange file interfaces.

The MOSS pilot exercise use of a TCS demonstrated the separation of the concern to interact from the ability to generate and read EDI messages. In the pilot TCS, wherever an EDI message type might be used, it was possible to process that message in lieu of manually entering the information through the TCS's web-based interface. Conversely, wherever a web-based manual interaction with the system was possible, it was also possible to generate an EDI message instance mirroring the occurrence of that interaction.

Note also that though it is commonly assumed that the provider of a SaaS application is the vendor of the SaaS software. That need not be the case. Alternatives include having the OEM host the system, or having a third party (a 3PL or industry consortium) host the system. These other approaches may provide the additional benefit of allowing the hosting organization to test software enhancements in an environment closer to its actual usage scenarios. The business model that appears to be emerging for the deployment of trade collaboration systems is one in which the principal revenue stream for the SaaS provider is realized as a small charge for each government filing it performs for its clients. (“Service as a Service” if you will.)

Finally, it should be noted that the use of SaaS as a deployment model of a TCS is distinguished from the now-ubiquitous use of “web portals” in supply chain management. The TCS provides an environment for the close collaboration of many stakeholders in long-running (spanning a few weeks, at least) business processes. By comparison, typical use of web portals in supply chain management concerns only isolated pairs of stakeholders performing limited transactions.

The role of process orientation, shared schema, and the master order

Documenting the process by which a supply chain operates provides immediate value to stakeholders. The simplest documentation is perhaps the routing guide, (Inbound Logistics, 2009) which informally describes the principles of operation of the supply chain's logistics processes, and can be augmented with information about partnering relationships, and business rules of the origin/destination pair. Because many of the stakeholders in a supply chain are involved with many (perhaps hundreds) of supply chains, the existence of an easily comprehended outline in this form provides an efficient reference for decision making.

The publication of a model integrating a process-oriented viewpoint of global trade management with an information-oriented viewpoint should provide significant benefit in trade collaboration systems. Development of this model, the MOSS Conceptual Model, has been an area of focus in NIST's collaboration with the MOSS project. The model should (1) provide business stakeholders a guide to the supply chain's concepts of operation, business rules, logistic partner contact points, and the roles of each in the business process, (2) provide a basis for defining performance metrics, (3) provide a guide, superior to conventional message implementation guides, for constructing EDI interfaces, (4) provide a model for formulating arbitrary queries against a population governed by the schema, for example, a query required to satisfy the ISF, (5) reduce the cost of implementing TCS solutions, and, (6) provide a reference model for advanced functionality, such as for defining protocols that would allow customs authorities to gather targeting information.

A formal process specification provides additional benefit when it is mechanized. Mechanization in the TCS can be used to gate process execution and to identify the parties who should be notified of milestone events and problems. Through its mechanization, the process specification becomes the principal means by which a TCS may be configured for use on the supply chain. Modeling technology relevant to process specification in the TCS includes Unified Modeling Language (UML) activity diagrams (OMG, 2007) and Business Process Modeling Notation (BPMN) (OMB, 2009). An example UML activity diagram depicting the general process flow and responsibilities, but not accounting for exceptional situations, is shown in Figure 4. More detailed diagrams, centered on a single interaction, would describe workflow for exceptional situations and would link tasks to the introduction of key elements of information.

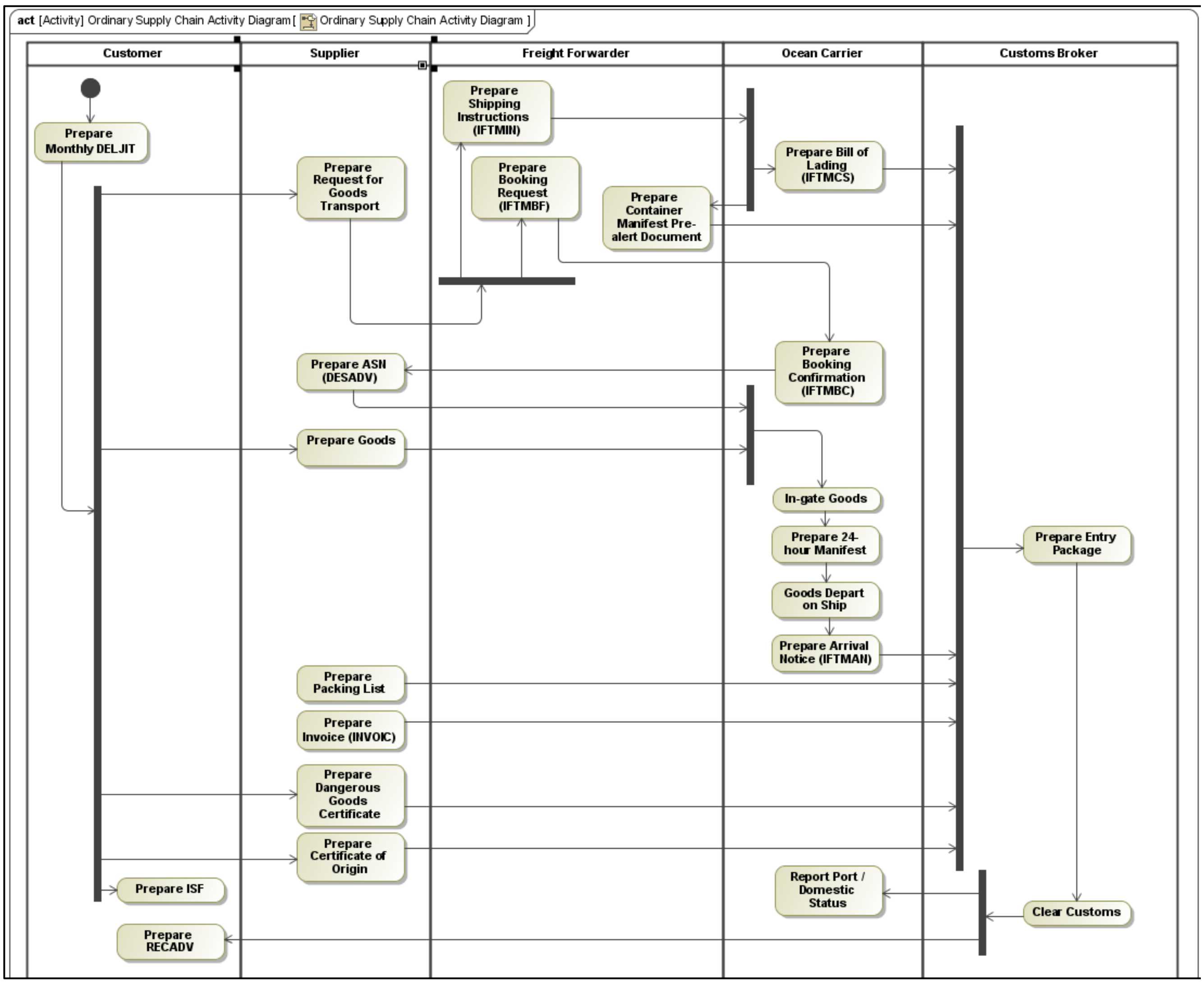

Figure 4: A supply chain process specification providing basic information for configuring a TCS.

Whereas the history of IT development supporting GTM suggests that it has not been possible to formulate an information schema that anticipates all business needs, it should at least be possible to map the requirements of a single origin/destination pair into a common form sufficient for the operation of its supply chain – this is the goal of a TCS. Additionally, it should be possible to map elements of a population managed by the TCS into exchange forms (EDI and XML, for example) where interaction with external systems is required.

The master order is a document describing a long-range (perhaps one year) plan to buy certain items. It is a key document in configuring the TCS, since it populates key information elements, including perhaps part numbers, quantities, prices, tariff numbers, hazardous goods designation, and country of origin information. Combined with information from the goods order, the two documents can be referenced to make transportation bookings, define shipping instructions, and complete the advanced shipping notice (ASN) and invoice. In the MOSS project, a study of current practices suggests that a large portion of errors delaying shipments originate with the production of the ASN and invoice. A TCS can provide the OEM's suppliers with a consistent web-based means to complete the ASN and generate an eDocument invoice. This was demonstrated in the MOSS pilot exercise.

The MOSS CONCEPTUAL MODEL AND EDI MESSAGE MAPPING

The MOSS project performed a bottom-up study of 16 EDI messages used in the automotive sector processes of cross-border materials management. The study identified about 400 business information elements and mapped these to 1400 EDI data elements. (Typically 3 or 4 EDI elements are required to encode a business element.) The work product of this study is the MOSS Data Matrix, a spreadsheet of about 1400 rows and 160 columns with about 35% of its cells populated. In the case of 6 of the 16 message types, the mapping of the information to EDI structures was based upon previous work of a joint automotive industry effort of the AIAG, the Japanese Automotive Manufactures Association (JAMA) the Japanese Automotive Parts Industry Association (JAPIA) and ODETTE, a European automotive industry association. That work was adapted for use in the cross-border supply chains that are the concern of the MOSS project. The improvements are being fed back into the message implementation guides of the joint industry effort.

By virtue of the fact that the MOSS message data is organized as a single spreadsheet, it is possible to identify where consistent mapping of information can be enforced, and it is possible to follow the “lifecycle” of a property – the message and task in which it is introduced, and the messages and tasks in which it is reused. Indeed, three of the principal weaknesses of the current method of developing message implementation guides are that the method does not ensure that (1) the EDI encoding of information across the message types is consistent where possible, (2) EDI structures that are interpreted to the same business concept are associated with a single property used across message types, and, (3) the origin of a property (in what process it is introduced) can be documented. In MOSS, items (1) and (2) are achieved through use of the data matrix and automated tools that operate on it. Item (3) is work-in-progress, part of an effort to define formal mappings from the EDI message structures to a conceptual model of the domain, and to process models.

The development of the Data Matrix was supported by software tools that used a model of EDIFACT directory message types that was constructed by parsing the UN/CEFACT EDIFACT 05B directory (UN/CEFACT, 2005), a collection of HTML files, into an in-memory relational representation. The in-memory relational representation was used in the development of (1) tools to create EDIpath expressions (see Figure 5) (ISO, 2002), (2) tools to provide a web-based presentation of the UN/CEFACT directory message structures (UN/CEFACT, 2005), (3) tools to provide a web-based presentation the MOSS-defined EDI message structures (Denno, 2009), (4) tools to assess conformance of software vendor-produced EDI message instances to the MOSS message types, and (5) tools designed to identify quality problems in the Data Matrix. The quality checking tools check such things as:

- Consistent naming of properties – Names of properties that are associated with line items, shipments, dates, and quantities should follow the naming conventions established for those types.
- Consistent organization of structures – For example, if a property is associated with a line item-level concept, it must be associated with the EDI structures for the description of line item detail. If a property is associated with a shipment-level concept, it must not be associated with a line item-level EDI structure.
- Existence, in the message type definition, of required structures – Certain structures are required, to enable unambiguous parsing, for example.

- Uniqueness of EDIpaths – Each property must is represented by a unique EDIpath in the message structure.

The EDIpath:

DELJIT.SG2[NAD.3035=SF].NAD.C082.3039(90:20:1)

is associated with the Data Matrix's encoding of the EDIFACT DELJIT message "Ship From Party ID" property.
This EDIpath is interpreted as follows:

- **DELJIT** – refers to the EDIFACT "Delivery Just-in-Time" message type.
- **SG2** – refers to the second "segment group" in the message definition. Segment groups are hierarchically nested units of information in the EDI message structure. In the case of the DELJIT message, this segment group is used to identify parties.
- **[NAD.3035=SF]** – is a condition identifying a particular instance of Segment Group 2. This instance has a NAD (Name and Address) element whose 3035 element must have the value 'SF'. 3035 refers to an element of the UN Technical Data Element Dictionary (UN/TDED). The 3035 element is defined in that dictionary as "Party Function Code -- a code giving specific meaning to a role of a party."
- **NAD** – indicates that the "Ship From Party ID" is mapped to a Name and Address Element.
- **C082** – indicates that the "Ship From Party ID" is mapped to the EDIFACT "composite data element" by that name, used inside the NAD.
- **3039** – indicates that the "Ship From Party ID" is mapped to the UN/TDED element 3039 inside the C082, inside the NAD. The 3039 element is defined in that dictionary as "Party Identifier – a code specifying the identity of a party." Another element of the NAD in which this element is embedded identifies the agency responsible for maintaining the code list for which this value (the value of the 3039 data element) is a term. For example, the agency "16" is Dun & Bradstreet indicating that the ship from party is identified by the DUNS identifier.
- **(90:20:1)** – this describes an alternative method of describing the path (but not constraints) to which "Ship From Party ID" is mapped. 90 is an index into the DELJIT message type (identifying the NAD). 20 is an index into a NAD (identifying the C082 composite element). 1 is an index into the C082, (identifying the 3039 element).

Figure 5: Interpretation of an example EDIpath expression. The EDIpath notation is similar in purpose and form to XML XPath. The complete syntax is described in ISO 20625. The MOSS Data Matrix contains thousands of these EDIpaths, each describing how a conceptual property is mapped to an element of an EDI message type structure.

The MOSS Conceptual Model is a conceptual model of order management and logistics of ocean-going freight, defined as a collection of UML class diagrams. The model currently defines about 200 classes; it is expected that when complete, these class diagrams will describe about 300 classes. A NIST initiative associated with the MOSS project has sought to define formal mappings of the MOSS message structure elements with this conceptual model. The mapping is intended to provide:

- Better message implementation guides – When elements of information in message types are linked to objects and relationships in a conceptual model, their purpose is more easily understood.

- Ontology-based validation tools – NIST is investigating the ability of first-order logic reasoning technology in the capacity of assessing semantic interoperability among software tools managing supply chain processes. The mapping would allow the development of automated tools to generate, from message instance content, populations conforming to the conceptual model. (Denno, Barkmeyer, & Neuhaus, 2009)

- Reduced cost in implementing a TCS – The class definitions of the MOSS conceptual model suggest implementation forms, and the mapping indicates how these forms would be populated from EDI message instances.

Exploratory work to implement the mappings has been performed using a mapping engine intending to conform to the Object Management Group (OMG) Queries, Views and Transformations (QVT) specification. The QVT mapping engine was developed in the scope of NIST's participation in the MOSS project. Experience suggests, however, that the QVT mapping notation is excessively complex, considering the simple hierarchical organization of the EDI messages. At the time of this writing, an alternative approach to mapping is being investigated. This approach would leverage the EDIpath notation.

THE MOSS PILOT EXERCISE AND COST / BENEFIT ANALYSIS

The investigation reported in this chapter was performed as part of a four-year program by the AIAG to define best business practice procedures and supporting EDI message types for the management of supply chains of inbound (to the US) automotive parts to US assembly plants. Early development work in the project included a study of automotive supply chain logistics business processes, and the bottom-up development of the MOSS Data Matrix, and conformance validation tools. These efforts were followed by a proof-of-concept exercise of the MOSS EDI message types. In this exercise, participating software vendors were invited to test the ability of their software in reading and generating messages conforming to the MOSS EDI message type specifications. Although there were a few software technology providers contributing significantly to the project throughout the first two years, only one completed the proof-of-concept exercises. The software of that provider, a TCS, was subsequently used in the pilot exercise, which as stated earlier, concerned the management of 20 containers of automotive batteries per month, for three months, from a Korean supplier to the warehouse of an automotive OEM in the US. A second pilot exercise, involving less-than-container-load shipments of production parts consolidated in Europe and deconsolidated in the US has been planned, but not yet performed.

Pilot Exercise Stakeholder Training

The battery supply chain involved an OEM customer in the US, a supplier in Seoul, Korea, a freight forwarder in Singapore, and a 3PL and customs broker, both in the US. Through discussions with the supply chain stakeholders, the MOSS project participants gained a basic understanding of the supply chain's operation, which was summarized in an activity diagram similar to Figure 4, and verified in conference calls with the participants. Stakeholders provided examples of the spreadsheets that were being used in the current process to communicate order details (part numbers and quantities). The project participants used master order information from the OEM customer to load the TCS with part numbers, annual quantity forecasts, and prices. The TCS was configured with a process specification using a visual tool (part of the TCS), and roles were defined, describing capabilities to be available to each participating organization. The TCS provided role-based authentication to the system, and provided each authenticated user with a user interface configured to its role in the business process. A 50-page user's guide was written, detailing the use of the system for each role and process task, and providing screen shots of the system in the performance of those tasks. However, on-going input from the stakeholders in consultation with the project participants entailed on-going, time-consuming editing of the user guide; its maintenance was eventually abandoned, replaced by screen recordings augmented with annotations elaborating upon the operation displayed.

The MOSS project participants held at least one (and no more than two) web conferences with each stakeholder representative prior to going live with the pilot exercise. The screen recordings and activity diagrams were used in these meetings. Web conferencing provided significant value in training stakeholder representatives. In these sessions, stakeholder representatives gained hands-on experience with the TCS with the help of project participants. Witnessing the stakeholder representative's early interactions with the system provided developer participants with insight into the representative's intuitions about the system. This understanding could be fed back into system improvements. At times, the stakeholder representative suggested improvements to the user interface and workflow that were implemented during the web conference, as customizations.

Leveraging web conferencing as it did, the training experience suggested that, notwithstanding time zone differences and some language barriers, it should be possible to cost-effectively deploy trade collaboration systems with geographically and culturally diverse partners. It should be noted, however, that conversations with the stakeholders, particularly with the supplier, revealed opportunities for improvements in the pilot supply chain that went beyond the introduction of the TCS technology, and were not strongly associated with it. Though our discussion of the cost / benefit analysis suggest that the financial incentives for the TCS are strong, as is so often said about supply chain management, much of what can be achieved is a matter of cooperation, not technology. (Mentzer, Foggin, & Golicic, 2000)

Pilot Exercise Technical Detail

Since the pilot exercise was run in parallel with the existing process, it was important to ensure that the execution of the two parallel processes did not result in duplicate container bookings. An application statement 2 (AS2) connection was established between the TCS and the system of the ocean carrier. In order to acquire a booking number, the TCS sent a "update" EDIFACT booking request to the system of the ocean carrier. The message contained no consequential updating information, but the response from the system of the ocean carrier provided the original booking number.

One of the key advantages of the TCS, in the pilot and generally speaking, is the degree to which it can make use of existing information. The principal activity in preparation of the ASN, for example, is the description of the goods, quantities, packaging, and the container number in which the goods will be stuffed. Typically, as was the case of the pilot, all but the container number and the exact time of shipment is known from the upstream booking process, and goods detail for preparation of the booking can be referenced from the pre-loaded master order. At no point in the pilot exercise was it necessary to re-enter information that was stated earlier.

The information content of the invoice is similar to that of the ASN, but the invoice additionally includes prices and legal clauses pertaining to the payment. Further, the invoice is structured by line-item, whereas the ASN is structured by packaging. Customs clearance processes often require a paper or paper image of the invoice. In the MOSS project, an Extensible Style Language (XSL) file with formatting objects (XSL-FO) (W3C, 2006) was defined for a paper invoice similar in structure to the UN/CEFACT invoice eDoc. The *xsl:value-of* element is commonly used in XSL to populate a template with data from a non-local reference. Typically, the *select* attribute of the *xsl:value-of* would supply an XPath expression. In the case of the MOSS work, however, the *select* attribute value is an EDIpath referencing the MOSS EDIFACT INVOIC message. The NIST EDI validation tooling, for example, is able to generate a completed invoice from a MOSS EDIFACT INVOIC message instance uploaded to the system using a pre-processor that replaces the *xsl:value-of* element with data from the uploaded EDI message instance. The pre-processed XSL is then sent to Apache FOP (Apache Foundation, 2009) to generate a Portable Document Format (PDF) invoice document. The pilot TCS system used the MOSS XSL-FO document in a similar process. By these means a paper invoice can be generated as needed, and attached to the shipment.

It should be noted in passing that attaching scanned and eDoc generated documents (invoice, certificates of origin, and dangerous goods certificate) to the TCS managed shipment information was found to be a valuable information organizing strategy. A view of the typical cross-border supply chain process, apparent also from the activity diagram of Figure 4, is that many tasks provide information required for the custom broker's customs clearance task.

A Cost / Benefit Analysis of the MOSS TCS

The pilot exercise provided input to an analysis of the costs and benefits of Trade Collaboration Systems to automotive supply chains. (AIAG, 2009) However, the pilot exercise ran in parallel to the existing process; the physical goods were managed by the original process, not the pilot process. Due to that limitation, the short (3 month) duration of the exercise, and the relatively small number of containers involved, certain potential differences between the two processes cannot be known with certainty. Perhaps the most significant measurements not available for analysis were TCS-managed transit time and transit time variation. Nonetheless, it was evident that, like many other cross-border supply chains, there was excessive dwell built into the pilot chain at the port of loading and the port of discharge. Keeping in mind that earlier analysis indicated that 15% of shipments are delayed due to errors in the information driving the process, and that export clearance, Importer Security Filing, and import clearance are three processes where a lack of the required information will certainly delay processing, it was postulated that the TCS-managed process could save 4.85 days of in-transit inventory and 7 days of safety stock. These appeared to be rather conservative figures, leaving ample time for processes at the port to occur. However, in order to support analyses where other values for in-transit and safety stock inventory might be used, the cost / benefit analysis also provided costs for 1 day of in-transit and safety stock inventory each. These are called the “unit” values below. On an import value of $55,277,000 (all values are in USD), the cost / benefit analysis of the pilot supply chain calculated the following (AIAG, 2009):

- Freed working capital : $1,840,000
- Freed working capital (unit) : $310,000
- Ongoing annual savings : $392,000
- Ongoing annual saving (unit) : $228,000

The ongoing annual savings calculations are largely based on the cost of financing the reduced inventory. (a 6% cost of capital was assumed) but several other considerations were also taken into account.

The cost side of the analysis consisted of an estimate of one-time costs and ongoing costs. The one-time costs covered supply chain analysis, system configuration and training, and came to $32,000. The on-going costs were based on information provided by the pilot exercise software vendor. These covered connectivity to the system and transaction handling, and came to $94,000. These values concerned all interactions between a buyer and a seller over any number of origin / destination pairs. The $32,000 cost of deploying this SaaS system appears to be quite low when compared to conventional software deployments. Also of note, was that about 1/3 of the on-going cost was attributed to a fixed fee per transaction charged for processing the US Customs Importer Security Filing and other customs documents.

Finally, using values of the costs and benefits, the net present value (NPV) was calculated to be $323,000.

FUTURE RESEARCH DIRECTIONS

This section envisages two possible applications built on a foundation of a TCS, the MOSS conceptual model, and the Data Matrix mapping to it: (1) the use of the TCS in allowing customs authorities to do more effective targeting of high risk cargo (to identify counterfeiting or other illicit activity), and (2) the use of the TCS in evaluating the environmental impact of logistics choices.

Customs Shipment Targeting

Federal enforcement agencies make effective use of targeting systems to identify for inspection shipments that fit patterns of illicit activity. These systems make use of information provided to the government about the nature of the goods, their movement through the supply chain, trading partners, and logistics service providers. The information currently provided to the government, “business-to-government” (B2G) information flows, such as the Importer Security Filing, manifest, and entry are used for enforcement targeting. Confidence in the information's integrity and veracity would be enhanced through corroboration with the parallel “business-to-business” (B2B) information flows that are implemented in the TCS and used to manage the intercontinental movement of goods, raw materials and equipment. Conversely, contradiction with the parallel flows would provide evidence of an anomaly relevant to risk assessment.

From the viewpoint of customs authorities, the TCS effectively provides a “single window” into the transactions of the origin / destination pair's business process. The use of the term “single window” here reverses the viewpoint described by the World Customs Organization (WCO, 2009); instead of a single window consolidating the complexity of needs of the various government agencies, this single window consolidates the complexity of needs of the various stakeholders involved in the transportation logistics (and possibly payment processes) for the benefit of those stakeholders. Work in this area would leverage the MOSS conceptual model to gain consensus on the content of TCSs, and seek to define protocols that would provide customs authorities with information in the B2B information flows.

Metrics for Sustainable Logistics

The TCS and especially MOSS conceptual model could be leveraged to develop an assessment of the environmental impact of logistic choices. Toward this purpose, the conceptual model would be extended to provide greater detail of the various legs of the journey from the supplier to the customer. A broadly adopted program in this area is currently administered through the US Environmental Protection Agency, called SmartWay Transport (EPA, 2009). That program however does not currently address ocean freight, and calculation of the impact involves copying information into a spreadsheet developed by the program. In a TCS implementation, the calculations would be made using queries against the process model.

RELATED WORK

This chapter describes a technical solution to the challenges of providing an effective inter-organizational information system to stakeholders in global trade business processes. As the process flow in Figure 4 may suggest, a great deal of the activity performed by the stakeholders is motivated by requirements to communicate certain information to government entities. Deficiencies in business-to-government information flows are a common cause for delay in cross-border supply chains. (Mixer, 2005) It seems reasonable to ask then whether it might be more effective to have a government maintain the cohesive body of trade information, rather than managing it in a stakeholder-sponsored system with (possibly complex) interfaces to various government systems. In such an arrangement the government would provide a “single window” (WCO, 2009) for the entry of information it requires, and the details of distributing that information to the systems of the various government agencies would be the responsibility of the sponsoring government. Singapore’s TradeNet (King & Konsynski, 1990) is an example of such a government-sponsored system. All indications suggest that it is a very effective solution. TradeNet, however, does not currently support business-to-business information flows. The follow-on initiative called TradeXchange is intended to support a scope of processes similar to the TCS. (Sathasivam, 2009)

This chapter considers an approach to electronic business interoperability that stresses the need for information modeling that integrates considerations from the full scope of business processes that rely on the information. A study of EDI data quality by Vermeer (Vermeer, 2000) emphasizes the need for “context alignment” and maintains that failures in the deployment of EDI often can be attributed to a lack of it, which leads to operational errors. The MOSS methodology of information modeling, leveraging the MOSS Data Matrix, is a strategy to ensure context alignment in the sense intended by Vermeer. It provides means to track the life cycle of information elements and resolve issues of context and representation in a setting that best captures the intended use of the information. The method should apply as well to XML-based exchange technology as it does to EDI.

CONCLUSION

Trade collaboration systems fielded as SaaS show promise in meeting the challenges of managing global trade. The use of SaaS and the SaaS interoperability strategy make the deployment of the TCS economically feasible. The AIAG MOSS project, in collaboration with NIST, developed an enabling framework for the development of Trade Collaboration Systems. The framework provides a method for life-cycle integrated information exchange, and grounding in a conceptual model of the domain. The success of the MOSS pilot exercise suggests that the benefits, costs, and risks associated with deployment are favorable.

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Definition of Terms

supply chain – an organized assembly of inter-firm resources and procedures regulated by interaction and interdependence to deliver a product or service to a customer

systems integration – engineering that enables system components to work jointly toward a shared goal

semantic integration – that part of systems integration that concerns whether or not messages, correctly received and parsed, in fact serve to direct the recipient to perform the desired behavior

inter-organizational information system (IOS) – an information system that supports the joint work of several organizations toward a shared goal

SaaS interoperability strategy – a software system design strategy that leverages the ability of an IOS SaaS application to encapsulate both ends of a communication flow, and thereby improve the likelihood of semantic integration

trade collaboration system – an IOS that uses a SaaS interoperability strategy to support the operation of a supply chain

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[i] Certain commercial software products are identified in this paper. These products were used only for demonstration purposes. This use does not imply approval or endorsement by NIST, nor does it imply these products are necessarily the best available for the purpose.

[ii] The Automotive Industry Action Group (AIAG) is a not-for-profit consortium of automotive industry stakeholders