Supply Chain Modeling with REA

Anders Hessellund

IT University Technical Report Series **TR-2006-80**

ISSN 1600–6100 **January 2006**

ISSN 1600–6100

ISBN 87-7949-119-7

Copies may be obtained by contacting:

IT University of Copenhagen
Rued Langgaards Vej 7
DK-2300 Copenhagen S
Denmark

Telephone: **+45 72 18 50 00**
Telefax: **+45 72 18 50 01**
Web `www.itu.dk`

Supply Chain Modeling with REA

Anders Hessellund

IT University of Copenhagen, Denmark
hessellund@itu.dk
http://www.itu.dk/people/hessellund/

Abstract. Lack of integration between different partners in supply chains prevent companies from reaping the large economic benefits of their collaboration. In this paper, we propose the Resource-Event-Agent (REA) model as modeling tool to capture the complexity of supply chains. By extending previous, simple versions of REA we show that the model can be useful when modeling Vendor Managed Inventory (VMI) which is a subset of the general field of Supply Chain Management (SCM). Our REA-extensions provide a foundation for capturing operational data and supports sophisticated reporting and performance measurements. Specifically, we introduce the concept of Location and Transport in the REA ontology. Finally, we relate our work to previous REA concepts and propose a general taxonomy for REA event types.

1 Introduction

Large economic benefits can be reaped by efficient management of supply chains. The complexity of such supply chain business relationships is unfortunately often overwhelming and general conceptual models are therefore required in order to understand the true nature of the business. This is especially relevant if one is to provide IT support to the interactions between supply chain partners.

Classical double-entry accounting systems are not semantically rich enough to handle the task. The Resource-Event-Agent (REA) model has an extra semantic dimension while still complying to traditional accounting requirements. We propose a set of extensions to REA such that REA models can be used to capture a typical supply chain business concept - Vendor Managed Inventory (VMI). Our extended REA model should serve as *proof of concept* of the general potential of REA as a generic model for supply chain management.

The paper is organized in the following manner: In section 2 we explain the key concepts of the traditional REA model. In section 3 we present VMI which will serve as our concrete SCM problem in this paper. In section 4 we introduce our extensions to REA. Section 5 and 6 relates our work to previous developments in REA and propose a general taxonomy as an important cognitive tool. Finally, we conclude the paper in section 7.

During our initial work we have implemented a C# prototype application that offers operational support for VMI collaborations. The prototype was based on the techniques originally proposed by Johnson and Nakamura [1] and has proved very useful when implementing dynamic and extensible REA systems. We will not discuss the prototype in this paper as our purpose is to introduce new conceptualizations. Interested readers should consult Balthazar et al. [2] for details on the technical implementation of our ideas.

We also refrain from comparing the REA model to other SCM models such as the Supply-Chain Operations Reference-model (SCOR) [3], RosettaNet [4] and proprietary models. These models are complex subjects *per se* and our purpose here is not to prove that REA is better than these models. Our goal is rather to demonstrate that REA is a possible contender in the field of supply chain models. Later work must show how the different models can be compared.

2 The Resource-Event-Agent Model

In this section we will present the REA model that was introduced by William E. McCarthy in 1982 [5]. REA has primarily been used to model accounting phenomena in information systems [5–8]. REA is well-suited for Enterprise Resource Planning (ERP) systems where it provides a simple but generic organizing principle for the operational data of an enterprise. Traditional modeling schemes, such as those found in double-entry systems, are often accounting-specific and are therefore of little use to non-accountants. The generic nature of REA allows both accountants and people from other domains to share operational data and create useful reports [5].

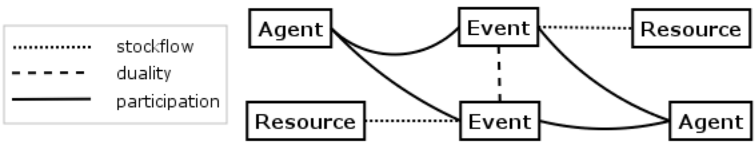

Fig. 1. The Resource-Event-Agent model

REA consist of three basic entities and a set of relations between these entities. Resources are goods, services and other items that can be bought or sold. Agents are individuals, departments or companies that can act as sellers or buyers of resources. Events are the concrete acts of selling, buying or in other ways exchanging resources. These entities are connected by stockflow, participation and duality relations as figure 1 shows.

The common rationale in any economic transaction is that two agents agree to give each other one resource in exchange for another. The actual exchange is marked by an event. This economic rationale is expressed in the duality relation that connects the act of giving with the act of taking. If there is no duality then the transaction is pointless. When each part of the exchange occurs, a stockflow relation is established representing the flow of goods. Finally the participation relation between an agent and an event signifies the legal involvement of an agent in a certain transaction.

The generic REA structure which is shown in figure 1 is called the REA template. If concrete models of actual transactions in a given system conforms to the template then the system can be said to be REA compliant. This template is useful not only when constructing new systems but also when analyzing existing systems. O'Leary [9] has for instance shown that SAP systems [10] exhibit a certain degree of REA compliance. The problem of representing different kinds of transactions is handled by typifying the REA entities [11]. Figure 2 shows how two concrete REA compliant models realizes the template.

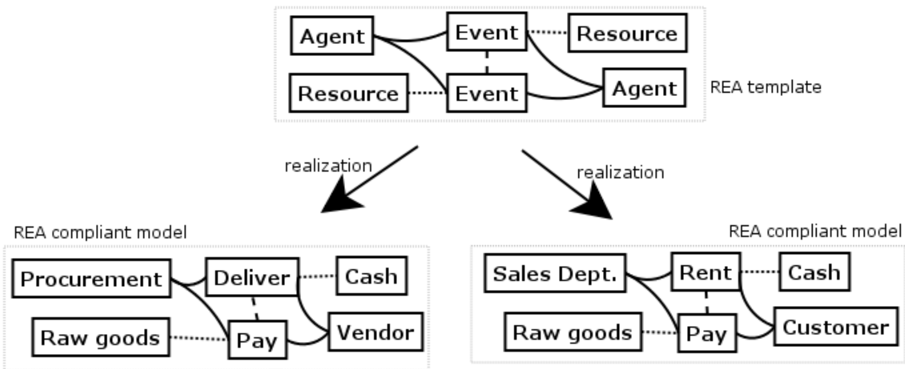

Fig. 2. The abstract REA model and two concrete REA compliant models

REA is typically extended with a contractual layer consisting of the Commitment and Agreement entities [6]. A commitment is similar to an event. The only difference is that it does not represent an actual act but only the promise to perform an act. An agreement is an entity that is used to compose a set of commitments in a contract, such that for instance the promise to deliver goods is related to the promise of compensating this delivery with a payment in cash.

The REA literature (e.g., [7, 8]) has an abundance of examples of how the repeated use of the REA template can provide sufficient concrete models to represent the transactions of an individual company. The single-company perspective that REA offers is called *the trading partner view* [12]. This perspective allows rich report extraction on most intra-company transactions. Exchanges across the company boundary can also be modeled, but external trading partners are only included to make the model comply with the REA template.

Inter-company transactions are more properly represented in global models where the distinction between internal and external partners becomes insignificant [13]. Global models can - as opposed to models based on the *the trading partner view* - represent several companies at once. This allows for more in-depth reporting, such as comparisons of inventory levels in different companies. The ability to represent several companies at once is a key requirement if we are to create models of entire supply chains and thereby manage the complexity of the market today. Integration between agents in such a global model is facilitated by the REA compliance of the individual company models.

3 Vendor Managed Inventory

In this section we will introduce the concept of Vendor Managed Inventory (VMI) [14] which is a subset of Supply Chain Management (SCM). The traditional lack of integration between different partners in the supply chain leads to the Forrester Effect [15]. Demand signals travel slowly through the such chains. The Forrester Effect occurs when small fluctuations in the demand at a downstream partner cause excessive fluctuations in the perceived demand at upstream partners (see fig. 3). Each partner tries to respond to demand by adjusting the safety stock and inventory level based on their perception of the demand. If the inventory level is set too high due to the Forrester Effect and general lack of transparency then unnecessary storage costs are inflicted upon the company.

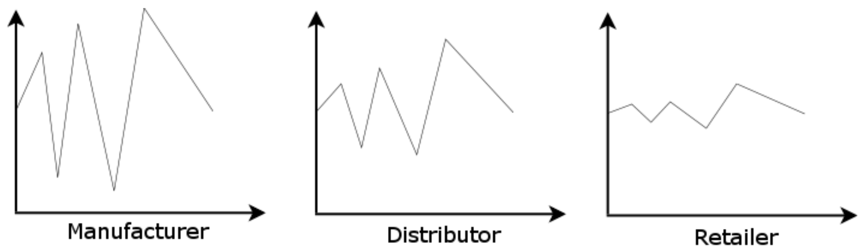

Fig. 3. The Forrester effect

VMI attempts to alleviate the Forrester Effect by integrating the supply chain partners. The manufacturer takes over the responsibility of restocking the inventory at the retailer. In return the retailer supplies the manufacturer with accurate and updated information about the current demand. The manufacturer benefits by being able to decrease his own inventory level and possibly by being able to plan production more efficiently. The retailer benefits by lowering administrative costs and typically also by achieving a better ability to respond to demand - i.e., avoid stock-outs.

In order to represent a VMI collaboration in REA it is necessary to include both manufacturer, distributor and retailer in the model. The model must facilitate report generation - or conclusion materialization as it is called in the REA terminology - about inventory levels at each partner, current and previous demand as well as leadtime between partners. Leadtime is defined as the period from the creation of an order to the delivery of the ordered goods. Since several companies must be modeled the trading partner view have to be replaced by a global model.

4 The Extended REA Model

In this section we will describe two general extensions to the model - Location and Transport. These extensions provides added expressive capabilities to the model and allows us to represent complex global models.

4.1 Location

We will in this section introduce the concept of Location and argue for its necessity in VMI models. To track the movement of goods downstream through the supply chain it is necessary with a well-defined concept of location. The physical location of a resource is traditionally perceived as an intrinsic property of the resource instance or sometimes even as an intrinsic property of the resource type. It is not specified how a REA transfer exchange affects the location of a resource. This prevents us from materializing conclusions about the location of dispatched resources. This is especially problematic in the case of consignment stock where the manufacturer transports goods to the inventory of the retailer but postpones the actual transfer until the retailer sells the goods to the end-customers. Consignment stock in VMI collaborations can not be represented using REA transfers since the movement and transfer of ownership of goods are not directly related.

An extended version of REA called Resource Event Agent Location (REAL) has been proposed by Denna et al. [7]. Unfortunately it is not clear exactly how the location entity is related to the traditional REA entities and why it is needed in that context. The semantics of the location entity have been described in greater detail in the UN/CEFACT Meta Modeling User guide [16] where the site and the destination relations are introduced. We believe that the introduction of location as an independent entity is an important contribution to REA - especially in the supply chain context. In the following, we will present our concept of location which relies UN/CEFACT but extends location with the capacity relation.

The location entity represents a geographical and physical position. A location can be composed of several other locations such as an inventory that is composed of several storage rooms. A location has individual existence independent of any resource hence it is not an attribute of a resource. In modeling terms, a location is related to resource types and events through the following relations: capacity and site.

The storage capacity of an inventory is constrained by both physical and contractual conditions. Take the inventory of a bakery for instance: Physically, there is a natural upper limit to how much bread can be stored in one room.

On the contractual side, there is also an upper limit to how much bread it is feasible to store in one room. It is not a good idea to store too much bread since the retailer will not be able to sell it before it is too old. In our extended REA model, we propose a capacity relation between a resource type and a location to capture this last aspect of storage capacity.

If a bakery act as a manufacturer and collaborates with a retailer in a VMI collaboration the model can have a capacity relation between the Bread type and the retailer's inventory location. This relation specifies the minimum and maximum inventory level of bread. In accordance with the VMI concept, it is the obligation of the manufacturer to keep the inventory level of the retailer within these limits. The VMI contract can specify several capacity relations between the retailer's inventory and different types of products from the manufacturer, such as the cake type, the dough nut type etc. It is possible to verify that the manufacturer complies with the agreement by comparing the capacity relations with conclusions regarding the inventory level at the retailer.

The location entity is related with commitments and events through the destination and site relations [16]. A commitment to deliver bread to the retailer is related to the retailer's location by a destination relation. If the commitment is fulfilled by an event then this event will have a site relation to the retailer's location indicating where the event occurred. The site relation plays a key role in providing track and trace functionality in the model as we will show in the following section.

4.2 Transport

In this section we propose a new exchange type called transport to capture the distribution aspect in our model (see fig. 4) and two new event types called Load and Unload. Our transport exchange complies with the traditional REA template [5] by having a dual set of events that affects certain resources and that are initiated by a fixed number of agents. The REA template is extended by the introduction of new event types and integrated with our concept of location. It is necessary to extend REA with this new exchange to be able to represent the fact that resource instances can move through the supply chain.

Dispatch of goods is represented by a load event. The load event moves a resource instance physically away from a location. Receipt of goods is represented by a dual unload event. The unload event delivers a resource instance at a given physical location. Load and unload are related in duality so when we load a set of resource instances it must be expected that these instances will be unloaded at some later stage. The duration of time between load and unload is the transport time.

The load event is related to two agents: a provider and a carrier. Similarly the unload event is related to a receiver and a carrier. The load event physically transfers the resource instances to the carrier. Although the load event is primarily concerned with physical aspects of the exchange it might also transfer liability of the resource to the carrier. We might propose a hypothesis where transfer of liability and the act of physically handing over goods were represented

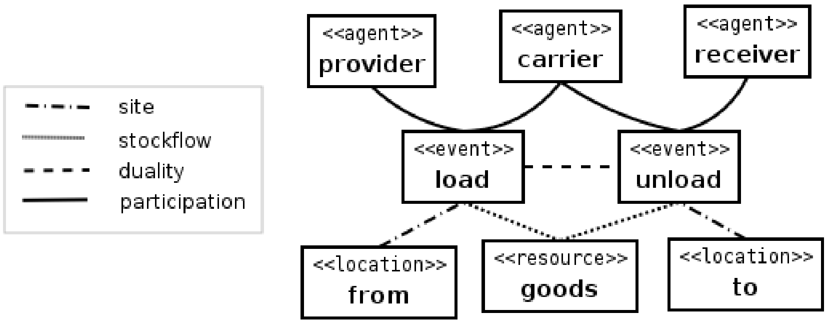

Fig. 4. The transport exchange

by the same event. This would imply that the carrier is responsible for the resource instances even though he does not own them. This liability could be delegated on to the receiver when the unload event occurs. The transfer of liability in load and unload events would be immediate, similarly to the transfer of ownership in traditional transfer exchanges.

An interesting aspect of the transport exchange is its granularity. If a company transports silk from China to Venice[1] we might merely model this as a load event in China and an unload event in Venice. If the silk passes through several partners or carriers on its way then we might model this transport as several load and unload events where the silk is transported in small steps until it reaches its final destination. The granularity of our model should be adjusted in accordance with our requirements for the concrete context.

The precise location of any resource instance with the stated granularity of the model can be derived by examining its load and unload events. Each resource instance has a history of load and unload events which determines the location of it at a given point in time. If the liability aspect is included in our view of the transport exchange then we might also materialize conclusions about liability regarding the resource instance at a given point in time. If a resource instance disappears or is spoiled we could assign blame based solely on transport exchanges and regardless of ownership.

5 Related Approaches

Currently, the generally accepted version of REA [6–8] has two types of exchanges which are used as the cornerstone of every model: transfers and transformations. In the following sections we will briefly sketch these exchanges and explain why they are insufficient as representations of the movement of goods.

[1] This example is called *The Merchant of Venice* and is treated in greater detail in [17, 13]

Transfers deal with the exchange of rights to certain resources. A sale of a bread is best modeled as a transfer since the seller exchanges rights of ownership with a buyer. The buyer receives ownership of the bread and the seller in return receives ownership of an agreed amount of money. Transformations on the other hand deal with changes in the features of certain resources. The production of a bread is an example of a transformation. A set of input resources such as water and flour are consumed in order to produce an output resource such as bread. The baker gives up the raw materials to gain a resource with a new set of features.

Both exchanges are compliant with the basic REA template and exhibits the characteristic simplicity that is the essence of REA. Similar to transport both transfers and transformations consist of a set of dual events that affect the resources involved. In the trading partner view the events either increment or decrement the resources involved. The baker increments his amount of money and decrements his amount of bread each time he takes part in a transfer. If the same exchange is viewed independent of perspective each event is both an increment and a decrement. When the baker hands over bread then this event simultaneously decrements his stock of bread while incrementing the buyer's stock of bread.

This leads us to conclude that the semantics of events are not necessarily identical in the trading partner view and independent of perspective. Where transfer events are either increments or decrements in the trading partner view they can potentially be both when viewed independent of perspective. We call such events bidirectional events since they are related to both an ingoing and an outgoing stockflow.

The dual events in transformations (consume and produce) are different since they are always either increments or decrements. When the baker consumes water and flour in a consume event then this is a decrement of his stock both in the trading partner view and independent of perspective. The duality of the transport exchange is similar to transformation in this respect since the load event is decrementing and the unload event is incrementing both in the trading partner view and global view.

In the following two sections we will show why neither transfer nor transformation are sufficient to represent the VMI concept.

5.1 Transfer

Is transfer suitable as a representation of the VMI model? Transfer seems an obvious choice since it can be used to model how the ownership of goods is transferred downstream through the supply chain. The vendor transfers goods to the customer. The duality in transfer is always between flow of goods and flow of cash. These transfers must keep the inventory level at the customer within an agreed range. Apart from the special contractual obligations of the vendor this model would be similar to ordinary REA models for sale. It is possible to materialize conclusions about previous and current demand on the basis of such a model.

The transfer exchange suffers from two related problems: First of all the model can not be used to materialize conclusions about leadtime. Having detailed information about the leadtime of different types of goods is necessary to guarantee a high service degree. In order to be able respond to demand the vendor has to know average time span from the transfer of a resource until it is available in the next partner. Since transfer events are instantaneous by nature it is not clear whether the event signals a dispatch of goods from the vendor or the receipt of goods at the customer. In other words it is only in legal and accounting terms that a transfer event immediately affects two different inventories. The transfer exchange does not represent the actual physical state of the inventories.

Second, the transfer exchange does not affect the location of resources. The site of a transfer event is in contrast to that of transformation and transport events rarely relevant in ordinary business contexts. Since the transfer exchange is concerned with purely legal and accounting issues it can be signed basically anywhere and still retain validity. A transformation or transport event on the other hand directly affects the physical state of the involved inventories. These exchanges are therefore dependent on the location to a higher degree than transfers.

5.2 Transformation

An alternative solution is to use transformation exchanges as the cornerstone in a VMI model. Transformations do not deal with cash flows so we will leave out the flow of money for the time being. Since transformations by definition affect the features of resources this can possibly solve the problem of tracking and tracing the individual resources. Furthermore, the special duality in transformations is also suitable for materializing conclusions about the duration of the process since consume and produce events does not necessarily occur at the same point in time.

Transformation traditionally relies on one of the following location concepts: First, a location can be considered a property of the resource type. In this case, bread at the manufacturer and bread at the retailer are two different resource types. Alternatively if location is considered a property of the resource instance, then bread at the manufacturer and at the retailer are resources of similar type but with different features. In both cases the transformation exchange can be used to represent the movement of resources from manufacturer to retailer. Bread at the manufacturer is consumed or dispatched and at a later stage it is produced or received at the retailer. The duration of time between consume and produce event can be used to materialize conclusions about the leadtime of bread.

The transformation exchange can account for movement of goods between inventories both within the same company and in different companies. It solves the previous problem of consignment stock because goods can be moved from vendor to customer without transferring rights of ownership.

This VMI model would not solve our problem, though. It suffers from problems that in our view renders it unqualified. Since transformation by definition changes its resources it is not possible for a resource instance to retain identity through a series of transformations. Every transformation consumes the resources involved and produces a new set of resources based on this input. This implies that we cannot directly relate goods at the manufacturer with goods at the retailer through a serial number for instance. The relation has to be derived on the basis of the transformation events. This is not the case in transports where the resource at the manufacturer is identical with the resource at the retailer after a transport.

A second problem concerns the balance between input resources and output resources in transformations. If the baking process consumes 20 kilograms of flour then this does not automatically imply that the product will be 20 pieces of bread. There is no general way of relating the quantity of input goods with the quantity of output goods in transformations. This balance might vary from resource type to resource type and even vary for each concrete production. Transport exchanges does not face this problem. If the manufacturer dispatches 20 pieces of bread then the duality can only be balanced if the retailer receives 20 pieces of bread. This direct correlation stems from the fact that transport exchanges primarily deals with the physical state of things and are subject to the laws of nature.

6 Future Directions

We will in this section show how our concepts of location and transport can be combined with elements from the related approaches above. Specifically we introduce the idea of exchange coupling as an organizing principle for the complex contractual structure which are typically found in supply chains. Next we introduce a general taxonomy of events. This taxonomy classifies both the existing and new event types in one common framework and can be extended when further event types are discovered/invented.

6.1 Exchange Coupling

In this section we will discuss the idea of coupling exchanges together in order to represent transactions in a more complete way. As we have now argued that the standard transfer and transformation exchange are not suited for the VMI scenario one might raise the question whether the proposed transport exchange is sufficient. We have argued that transport accounts for the physical aspects of the flow of goods through the supply chain. This is actually sufficient to provide operational support for a wide variety of VMI applications since these are often merely concerned with the flow of goods. In order to get to the full benefit of REA in the VMI context we think that it is necessary to add the aspect of cash flow and orders.

We propose a coupling of different exchange types by the means of the agreement entity in REA [6]. The agreement entity is composed of a set of commitments and encapsulates one or more interactions between manufacturer and retailer. If the manufacturer agrees to restock the retailer's inventory then this collaboration covers two important areas: flow of goods and flow of cash. The flow of goods is represented by a transport exchange that shows when and where resource instances are located. The flow of cash is represented by a traditional transfer exchange such that there is duality between the transfer of ownership of bread and the transfer of ownership of cash. These two exchanges are tied together in a agreement between manufacturer and retailer.

This set of coupled exchanges are important in our leadtime calculation. The leadtime equals the duration between the creation of the transfer commitment and the occurrence of an unload event. In other words, the leadtime is the time from the retailer requests a bread until it is physically delivered. It is only possible to materialize such a conclusion based on our coupled exchange.

We might imagine a concrete scenario where the manufacturer agrees to restock inventory of the retailer. Since the manufacturer assumes responsibility of the inventory level, he has to create an order at the correct time such that the inventory level never goes below the safety stock. The order, which is an agreement in REA terms, specifies that the manufacturer has to dispatch bread Monday night and deliver bread at the retailer Tuesday morning. A third-party distributor transports the bread. From the loading of the bread at the manufacturer until the unloading at the retailer the distributor is liable for the bread. This is the physical part of the order, that is, the transport exchange.

When the bread arrives at the retailer, the liability of the bread is also transferred to the retailer. The ownership of the bread still belongs to the manufacturer. Depending on the specific agreement, the manufacturer may choose to collect his payment at delivery, or in the case of consignment stock, when the retailer sells the bread. The transfer of ownership is performed in the transfer exchange where ownership is exchanged for ownership of cash. This transfer exchange does not necessarily have to coincide with the transport exchange. They are related through the agreement, and fulfillment of this agreement happens when the dual events in each exchange has occurred.

6.2 Event Taxonomy

In Balthazar et al. [2] we have proposed a taxonomy for REA events (see table 1). This taxonomy makes it possible to compare different event types in a general way. Each type is classified by name and the way it affects resource instances. The characteristics that we were interested in during our VMI work were ownership, liability, location and direction of the related stockflow. Direction is defined as the direction of the related stockflow of an event type independent of perspective.

We believe that future extensions to REA should take this classification scheme into consideration. If a new event type is added on the vertical axis then it should be determined how it compares with other types with regard to ownership, liability, location and direction. One might also extend the taxonomy in the horizontal axis by adding new characteristics and re-classifying existing events. We might for instance propose insurance liability as a new characteristic and determine for each event type whether it changes insurance liability or not.

	changes ownership	changes liability	changes location	changes existence	stockflow direction
transfer	yes	no	no	no	bidirectional
consume	yes	yes	yes	yes	outgoing
produce	yes	yes	yes	yes	ingoing
load	no	yes	yes	no	outgoing
unload	no	yes	yes	no	ingoing

Table 1. Taxonomy for events and commitments

The taxonomy will also be useful when extending REA with new exchanges. A new exchange will be composed of new or existing events and the taxonomy can be used to highlight the cumulative effect of this composition. Our introduction of the Transport exchange can be seen as a concrete example of extending REA's portfolio of exchange types.

7 Conclusion

Our work has shown that it is possible to capture the central operational aspects of a VMI collaboration in an extended REA model. By introducing the location entity with well-defined semantics we can lay the foundation for a completely new exchange type. The transport exchange which consist of two new events - load and unload - is ideal for representing the flow of goods through supply chains. Our VMI model enables conclusion materialization about inventory levels at each partner, current and previous demand as well as leadtime between partners. Taken together these parameters allows us to represent and measure performance in any given VMI collaboration.

We have furthermore shown how the new transport exchange can be coupled with the classical REA exchanges - transfer and transformation. This coupling allows us to express complex contracts in VMI- and possibly also general SCM-settings. We have classified the event types involved in these exchanges in a general taxonomy that provides an important cognitive tool for REA modelers. This taxonomy will especially be useful when extending the model since it offers advice on how to integrate new types with the existing type system.

Acknowledgements

This work was conducted under the Next project at the IT University of Copenhagen, Denmark. I would like to thank my project partners Stine Balthazar and Ali Chohan for valuable cooperation. Furthermore, I would like to thank the following people who offered advice, reviews and useful comments: Kasper Østerbye, Peter Sestoft, Jesper Kiehn, Pavel Hruby, Thomas Jensen, Mette Jaquet, Signe Ellegård Borch, Steen Brahe, Anker Helms Jørgensen and Poul Erik Christiansen.

References

1. Nakamura, H., Johnson, R.E.: Adaptive Framework for the REA Accounting Model (1998) OOPSLA'98 Workshop on Business Object Design and Implementation IV.
2. Balthazar, S., Chohan, A., Hessellund, A.: Supply Chain Integration. Master's thesis, IT University of Copenhagen, Denmark (2005) In Danish. Supervised by Kasper Østerbye. Not published yet due to a non-disclosure agreement.
3. Supply Chain Council: http://www.supply-chain.org/.
4. RosettaNet: http://www.rosettanet.org/.
5. McCarthy, W.E.: The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment. The Accounting Review **LVII**(3) (1982)
6. Geerts, G., McCarthy, W.E.: The Ontological Foundation of REA Enterprise Information Systems. http://www.msu.edu/user/mccarth4/Alabama.doc (2000)
7. Denna, E.L., Cherrington, J.O., Andros, D.P., Hollander, A.S.: Accounting, Information Technology, and Business Solutions, 2nd. Irwin McGraw-Hill (1996)
8. Dunn, C., Cherrington, J.O., Hollander, A.: Enterprise Information Systems: A Pattern-based Approach. McGraw-Hill Publishing Co (2004)
9. O'Leary, D.E.: On the relationship between REA and SAP. International Journal of Accounting Information Systems (5) (2004) 65–81
10. Knolmayer, G., Mertens, P., Zeier, A.: Supply Chain Management Based on SAP Systems. Springer (2002)
11. Geerts, G., McCarthy, W.E.: Type-Level Specifications in REA Enterprise Information Systems. 'http://www.msu.edu/user/mccarth4/UTS-seminar-/Type%20paper%20final%20submission.doc (2003)
12. Pavel Hruby et al.: Business Patterns. Springer Verlag (2006) to be published.
13. Jaquet, M.: REAlistic - En REA-model uden perspektiver. Master's thesis, IT University of Copenhagen, Denmark (2003) In Danish. Supervised by Kasper Østerbye.
14. Holmstrom, J.: Implementing Vendor-Managed Inventory the efficient way: A case study of partnership in the supply chain. Production and Inventory Management Journal **3**(39) (1998) 1–5
15. Forrester, J.W.: Industrial Dynamics. Pegasus Communications (1961)
16. UN/CEFACT: UN/CEFACT Modeling Methodology (UMM) User Guide 5 - CEFACT/TMG/N093. Technical report, UN/CEFACT (2003) http://-www.unece.org/cefact/umm/umm_userguide.pdf.
17. David, J.S.: Three "'Events"' That Define a REA Methodology for Systems Analysis, Design, and Implementation. Proceedings of the Annual Meeting of the American Accounting Association (1997)