An Information System Design Product Theory for Integrated Order, Transportation and Warehouse Management Systems

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Abstract

Globalization, lead time reduction and cost pressures, and other factors make it nontrivial for most companies to devise and manage effective logistics services to meet client requirements. They are better off using the services of specialized third party logistics service providers. These providers compete fiercely and need to develop and improve their services continuously to gain competitive advantage. Integrating the logistics process for improving communication and coordination is the most feasible way for third party logistics providers to deal with these pressures. Yet, the extant literature provides little theoretical guidance for integrating the logistics life-cycle, including ordering, transportation, and warehousing.

This paper develops an Information System Design Product Theory for the class of integrated Order, Transportation and Warehouse Management Systems based on a case study and a literature review. The theory helps clients and service providers to acquire and design information systems for designing, managing and controlling transparent and seamless logistics processes that improve service effectiveness.

1. Introduction

Logistics provides organizations with time and space utilities such as the necessary quantity of right cargo in the right place at the right time [2, 11, 18]. As part of the supply chain services, logistics has to be fulfilled efficiently and effectively to meet client requirements [3, 16] such as globalization, lead time reduction, and client orientation [8, 23]. Meeting these requirements with own logistics services is nontrivial for most organizations. They should focus on core business and source logistics processes to specialized logistics service providers to improve their competitiveness. Third-party logistics (3PL) providers are companies managing, coordinating, and delivering logistics services for the clients’ value chains [8, 16]. The most important benefits clients gain from using 3PL services are the improved expertise in and efficiency of logistics [9, 19].

3PL providers need to establish close relationships with clients and offer comprehensive logistics services to enhance their competitiveness [17]. For example, providing clients with more value-added services (such as sharing the logistics information in a timely manner among business partners for better planning, reducing inventory, and shortening the delivery time) can improve competitiveness. These services and associated benefits can be achieved by designing and deploying integrated logistics information systems [8, 22].

Logistics information systems facilitate logistics management and allow clients to acquire logistics services and conduct business transactions via the internet [16]. Some of the main purposes of logistics information systems integration are to achieve real-time capturing and sharing of key information along the logistics service processes, process unexpected coordination breakdowns quickly, and make logistics decisions [18].

Investments in IT may fail to produce expected benefits unless clients and 3PL providers are willing to share logistics information [6]. Effective logistics can typically be achieved only when companies exchange not only transactional data (e.g., material or product orders) but also strategic logistics information helping stakeholders to make important decisions in their operations [14]. For example, the sales history information helps providers to forecast demand, improving service quality and efficiency. Real-time inventory information helps providers to plan their replenishment and delivery schedules, improving service quality and reducing inventory costs [13, 20]. Effective knowledge sharing necessitates frequent and intense communication between clients and providers and contributes to establishing cooperative relationships between partners. High degrees of symmetrical flows of strategic information between partners are likely to result [10].

A number of studies have demonstrated various benefits from information sharing with logistics partners in terms of inventory management [1, 13, 26, 28], improved agility and flexibility [24], and the reduced bullwhip effect (that causes supply chain participants...
far from the end consumers to experience greater demand variations than participants close to the end consumers) [4]. Knowledge sharing significantly impacts the planning and delivery of logistics services [29]. Providers’ IT capabilities and knowledge sharing affect the integration of logistics systems directly and the organizational performance indirectly [15]. The integration of logistics systems is a crucial way to realize these benefits and gain competitive advantage. Information should flow seamlessly and the 3PL life-cycle should be transparent for clients and providers.

3PL providers most commonly offer warehousing, transportation, and customs brokerage services [12]. Traditional core competencies of 3PL providers also include (1) booking services for air and sea freight forwarding services and (2) preparing tailored documentation [16]. In sum, the most important logistics practices include freight forwarding services, warehousing services, and transportation services. Usually, forwarding services are based on specific order management services. Therefore, order management is also important for the integrated logistics systems.

Most 3PL providers in China are small or medium-sized. They subcontract parts of their operations to other supply chain partners [16]. Furthermore, poor communication channels (e.g., fax, phone, and email) lead to service breakdowns (e.g., service delays, human errors) and high operating costs. Due to these limitations, Chinese 3PL providers are often unable to obtain up-to-date status information from their supply chain partners in real time for making timely decisions.

There are few studies on small and medium-sized 3PL providers in the Chinese logistics market [7, 16]. However, these 3PL providers have become increasingly important, because there has been a trend for 3PL providers to participate in clients’ supply chains for providing logistics management [16]. Therefore, it is necessary for small and medium 3PL providers to improve their communication and operations to offer services more effectively.

This paper proposes that integrated Order, Transportation and Warehouse Management Systems (hereafter, OTWMS) should be designed to help the 3PL providers to manage the 3PL life-cycle from the service initiation phase through ordering, transportation execution, and warehouse tracking and management to service closure. Each OTWMS instance leverages repositories to store automated, OTWMS-generated logistics orders; schedule, transportation, warehouse and inventory information; and other relevant information produced during the 3PL life-cycle. OTWMS instances use the repositories to help reuse logistics plans from previous services and manage newly created logistics plans. OTWMS instances also support logistics team members’ work and help the clients capture and track the logistics service information. Clients and 3PL providers can obtain real-time information from OTWMS instances, making the 3PL life-cycle transparent and seamless.

To achieve such integration, there are several factors to consider. Client requirements need to be transformed to a detailed and executable logistics plan. Specific transportation management and warehouse management services must meet client requirements and deal with unexpected service breakdowns, necessitating quick but effective creation and sharing of knowledge within and between clients and 3PL providers. Clients and 3PL providers may be globally distributed, making it difficult to conduct face to face meetings with clients. Changing client requirements or service breakdowns may require revising contracts between clients and 3PL providers and raise service risks.

There is little theory-based guidance to help 3PL providers and clients design and leverage such integrated systems. This paper draws upon a case study to create an information system design product theory (hereafter, design product theory) for the class of OTWMS. A complete information system design theory (ISDT) prescribes both the product and process aspects of a class of information systems, that is, what are the meta-requirements and the meta-design for all the products instantiating the class; which kernel theories from reference disciplines are vital to determine what the products should do, and how the products should be built [27]. ISDTs make the development of products more tractable for application developers by focusing their attention and restricting their options and help organizations to source products and components from commercial and open source markets.

This paper focuses on prescribing the product aspects for the class of OTWMS because the existing literature does not provide such a theory. Moreover, OTWMS instances can be built in many ways and it is thus not as fruitful to prescribe the process aspects as the product aspects. The design product theory addresses the following research question: What are the meta-requirements and the meta-design of the design product theory for the class of OTWMS in order to enable comprehensive 3PL life-cycle management?

This paper is organized as follows. Section 2 presents the research methodology and the case company. Section 3 presents the meta-requirements for OTWMS, that is, the specific practices and involved stakeholders and tasks in each phase of the 3PL life-cycle that must be supported by the OTWMS instances. Section 4 describes the meta-design for the class of OTWMS. The last section concludes the paper and suggests topics for future research.
2. Research methodology, kernel theory, and the case company

This research was conducted in the context of the Chinese 3PL logistics services market offering services for international and domestic clients that leverage information and communication technology enabled sourcing (eSourcing) of logistics services. The research is part of a larger project that investigates various classes of information systems facilitating the end-to-end eSourcing service provisioning life-cycle for markets such as software products and services eSourcing and business process eSourcing.

The eSourcing Capability Model for Service Providers (eSCM-SP) has been chosen as the reference theory of the larger research project to understand the eSourcing life-cycle holistically from providers’ viewpoint and to ensure the comparability of various subprojects. eSCM-SP has been demonstrated to help various types of providers in different industries to improve their capabilities related to both ongoing, phase-specific, and engagement-specific sourcing practices throughout the eSourcing service provisioning life-cycle [25]. The life-cycle involves three phases from the provider’s viewpoint: initiation, delivery, and completion. Ongoing practices are run throughout the life-cycle to perform management functions. The three phases and the ongoing practices cover ten capability areas (e.g., knowledge management, threat management, and performance management).

3PL services are widely delivered by Chinese providers. This research investigates the end-to-end eSourcing service provisioning life-cycle (hereafter “life-cycle”) using a single qualitative case study to provide a holistic, systemic understanding of the phenomenon [5]. The case company was selected because it is a leader in 3PL business in China and its practices are likely to create an adequate baseline for design product theory creation. In 2012, it had more than 2200 employees and offices in more than 80 cities. The collected data covers the 3PL life-cycle, including the practices, the cooperation between logistics team members involved in these practices, the people responsible for logistics engagements as a whole, and the design and use of information systems that structure and are structured by these practices. Practices of the case company were compared to eSCM-SP based on the three phases and specific practices.

The first author conducted two rounds of investigation in the case company. A subsidiary of the corporate entity was investigated on-site in Beijing. It delivers logistics services based on the Total Order Management (TOM) information systems instance developed by the case company. The instance includes three main subsystems: Order Management System (OMS), Warehouse Management System (SMS), and Transportation Management System (TMS), enabling the offering of an integrated solution for clients’ supply chain management. They support service delivery and proactively help to avoid service breakdowns in order to meet client requirements. SMS offers basic warehouse management functionality. To meet complex requirements, the case company bought another Warehouse Management System (WMS).

“SMS just has the basic functions of warehouse management. We have developed it ourselves to meet the general warehousing requirements. However, our business is growing and large international enterprises demand more complex warehousing services, so we bought the WMS. We will choose either SMS or WMS based on the client’s warehousing requirements. SMS and WMS are also able to share information during the logistics services.” - A warehouse manager

The investigation developed an understanding about (1) ways the workers in the company use the subsystems for providing logistics services and (2) the types of breakdowns occurring. The second round of data collection was conducted in December 2011 and January 2012 by visiting the headquarters of the company on-site in Guangzhou to probe how TOM’s subsystems supported each service phase of eSCM-SP. For example, TOM can combine and optimize orders from clients. The introduction of TOM in 2002 enabled the company to reduce its logistics costs by 20% and the logistics costs of its clients by 2-4% and to improve service effectiveness by raising order processing speed from 50 orders per hour to 150 orders per hour.

Logistics teams are responsible for specific logistics services. Usually the most important services are delivered by three sub-teams: order management team, transportation management team, and warehouse management team (Table 1). These teams need to work together seamlessly to process orders, analyze client requirements, and draft logistics plans. In order to trace the service engagements initiated by orders, the 3PL life-cycle should be transparent for clients.

The design product theory for OTWMS has been created based on a literature review and the analysis of the design and use of the innovative TOM system of the case company. eSCM-SP has been chosen as the kernel theory of the design product theory because it takes the life-cycle view and the OTWMS instances must support the 3PL life-cycle.

The design product theory for OTWMS has been designed to be abstract and generic enough so 3PL providers can use it to improve their processes and information systems regardless of their current practices and systems. It may be possible for 3PL providers to benefit from the theory for OTWMS even
without replacing any existing systems. Providers can thus use even separate order management systems, transportation management systems, and warehouse management systems and use the theory to better integrate and organize these systems for enabling the end-to-end life-cycle. For example, an OTWMS instance can track the order execution process against the logistics plan and report execution results and breakdowns. It does not need to help execute specific logistics tasks but it needs to trace and report the results of the tasks. A specific task can be run by using other logistics management tools. Therefore, the analysis of the practices and information systems of the case company has helped us to scope the design product theory for OTWMS appropriately.

<table>
<thead>
<tr>
<th>Title</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order management team</td>
<td>Team is responsible for order validation, entry, and processing. It makes the logistics plan for the order together with a transportation team and a warehouse management team. During the delivery phase, it also coordinates with the transportation and warehouse management teams. It is solely responsible for communicating with clients. During order completion, it documents the services and the lessons learnt.</td>
</tr>
<tr>
<td>Transportation management team</td>
<td>Team defines the most efficient transportation schemes according to client requirements and drafts the logistics plan with the order management team. It executes the delivery service and reports any transportation breakdowns (e.g., delays, accidents, and non-forecasted stops).</td>
</tr>
<tr>
<td>Warehouse management team</td>
<td>Team uses SMS or WMS to manage the cargo and support the transportation team (e.g., ensuring the cargo is ready for delivery when the transportation team arrives).</td>
</tr>
</tbody>
</table>

Table 1. Responsibilities of Key Logistics Teams

3. Meta-requirements of the design theory for OTWMS

This section describes the meta-requirements for the design product theory of OTWMS, that is, what services integrated order, transportation, and warehouse management systems must provide to enable stakeholders to streamline the end-to-end 3PL life-cycle (Figure 1). OTWMS shall offer three categories of services: (1) order management, (2) transportation management, and (3) warehouse management (Table 2). Order management deals with, for example, order prioritization and management. Prioritization refers to establishing priorities for orders according to client requirements (e.g., lowest transportation costs, fewest possible stops to improve quality and to shorten lead-times). Order management is responsible for a variety of issues such as arranging interrelated orders (e.g., having the same final destinations and priorities) to optimize the resource usage of transportation services, informing clients on product availability and order status, and enabling clients to trace cargo information. For example, whenever breakdowns occur during warehouse management or transportation execution in the case company, the responsible teams must inform the order management team that will then communicate with the client(s) as necessary. OTWMS instances record breakdowns and send information to stakeholders. Warehouse management is responsible for the goods in warehouses, for optimizing the usage of the warehouse space, and for processing transactions such as receiving and picking goods. Transportation management is responsible for delivering cargo based on orders, client requirements, and the locations of ordered items in available warehouses. The most efficient transportation schemes are determined based on the orders’ priorities and the availability information provided by warehouse management.

<table>
<thead>
<tr>
<th>Order management</th>
<th>Transportation management</th>
<th>Warehouse management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Prioritize an order based on business priorities and risks</td>
<td>1 Monitor the transportation progress against the logistics plan</td>
<td>Identify storage locations of cargo, track cargo from initial phase to completion phase, and report real-time information about the status of cargo</td>
</tr>
<tr>
<td>2 Collect orders from previous similar services to reduce duplication</td>
<td>2 Report execution results and transportation breakdowns (e.g., delays, accidents, and unexpected stops)</td>
<td></td>
</tr>
<tr>
<td>3 Manage independencies between orders and align order, transportation, and warehouse teams.</td>
<td>3 Generate a transportation results report</td>
<td></td>
</tr>
<tr>
<td>4 Provide clients with order status.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. A framework for categorizing the services of the design product theory for OTWMS

3.1. Initiation

In the initiation phase, a client provides a request for proposal (RFP) and documented logistics requirements, including specific transportation requirements, warehousing requirements, expected arrival time, expected number (quantity), types, volumes (to determine the physical spaces needed during transportation and warehousing), and destinations of the cargo to be delivered. The 3PL providers need to analyse the proposal and requirements to create a business case for estimating the profitability of the service. If the service is profitable, the providers will draft logistic plans to bid. Clients will analyse the plans, choose the providers, sign the contracts, and send
formal orders to selected providers. Providers will establish unique identifiers for the orders to trace and manage the orders during the end-to-end life-cycle. Whenever clients have special requirements, their orders will be marked as special orders. For example, in the case company, the orders that must be delivered to clients after normal working hours are considered special orders.

Order analysis and management are the main activities throughout the 3PL life-cycle. The order database enables an OTWMS instance to manage multiple order types and provides real-time visibility of order status and associated transportation and warehouse information to evaluate service quality and business risks. Furthermore, bidirectional traceability is supported between order, transportation, and warehouse information artifacts across the 3PL life-cycle.

3.1.1. Prioritizing the orders based on business priorities

Providers will analyze the RFP and client requirements. The involved teams need to work together to analyze the priorities of logistics requirements, check the availability of appropriate warehouse space (if necessary), and define the most efficient transportation schemes. The OTWMS instance helps them prioritize orders based on business priorities and risks.

3.1.2. Collect and analyze orders from previous service engagements to reduce duplication

The OTWMS instance collects order, logistics plan, transportation, warehouse, and other relevant artifacts from each engagement between a provider and a client. Providers analyze the client requirements and search for relevant artifacts to reduce the time and costs involved in creating a suitable logistics plan and to estimate the service price and the needed time and resources based on previous experiences. After that, they draft the logistics plan and bid. Clients review the bids, including logistics plans, from several providers and select the proper providers. After contracting has been completed, clients will send formal orders to the providers who will schedule, resource, and execute the transportation and warehousing services.

3.1.3. Assign order to the suitable transportation team and prepare the delivery services

After the order management team receives the formal order, it needs to validate the order to ensure all the required information is included, schedule the service, send the order to the proper transportation team to execute the services, and inform the warehouse management team to prepare for offering storage or picking services. After that, the transportation team knows the destination of the cargo, checks the availability of necessary vehicle(s) and other resources, and prepares to deliver services. In the case company, OTWMS instances are used to assign people for the specific service delivery, making it easy for relevant stakeholders to hold these people accountable and to communicate with them in real time. When transportation teams need to pick cargo from clients, the order management team communicates with clients first to make appointments and then informs transportation teams the exact times and places for picking the cargo. Order management teams also communicate with clients whenever breakdowns occur.

3.2. Delivery

During the delivery phase, transportation teams are responsible for preparing and executing specific transportation services. Clients and providers can trace the transportation process and get the cargo status information timely through OTWMS. The process includes various stakeholders. The execution of the process involves coordination of the flow of information, services and finances among these stakeholders [21]. Therefore, it is important to manage the life-cycle effectively to meet the delivery performance expectations of the stakeholders.

OTWMS enables clients and providers to communicate effectively and seamlessly throughout the delivery phase. For example, logistics information such as order status and inventory reports can be shared with clients and providers to reduce the inventory and speed up the overall fulfillment process. In addition, OTWMS enables clients and providers to deal with breakdowns quickly. For example, when a transportation team of the case company arrives on time to pick cargo from a client, but the client is not ready, the team must inform the order management team responsible for dealing with the breakdown together with the client. Whenever transportation teams notice discrepancies between the cargos and the original orders, they must also inform the order management team about such breakdowns. OTWMS instances record all the breakdowns to help both clients and providers to improve their performance in future.

3.2.1. Transportation execution

OTWMS must support all physical and administrative operations regarding transportation. For example, it can trace each delivery event by event (shipping from A, arrival at B, customs clearance, etc.) and send transportation breakdown (e.g., delay or accident)
reports and real time transportation status information to order management teams. Whenever clients refuse to receive the cargo due to breakdowns, the respective orders may have to be refunded. When the providers are not responsible for the breakdowns, transportation teams need to inform order management teams responsible for communicating with clients. OTWMS must also collect metrics to measure the transportation performance such as transport cost per distance (e.g., per mile or kilometer) and carrier rate acceptance.

3.2.2. Warehouse management

Warehouse management primarily aims at controlling the movement and storage of materials within a warehouse and processing the related transactions, including shipping, receiving, storing and picking. Warehouse management monitors the flow of cargo and optimizes stock based on real time information provided by technologies such as barcode scanners, mobile computers, and radio frequency identification. Once data has been collected, it is typically transmitted to a central database through either asynchronous batch processing or real time wireless transmission. OTWMS uses the database to provide useful reports about the status of goods in the warehouse for order management teams and clients.

Warehouse management teams prepare for service after providers receive the formal orders. They check numbers, types, required spaces, and arrival times of cargos from orders. In the case company, they also check the arrived cargos and the associated information together with the transportation teams. The validated information is stored in OTWMS.

3.2.3. Service breakdowns

Whenever service breakdowns happen, OTWMS will send relevant information to order management teams that need to communicate with clients and adjust transportation schemes as necessary. Clients will estimate the influence of breakdowns and decide whether to change their requirements. If they change requirements, they typically have to form and send new orders to providers. Service breakdowns can be caused by clients or providers. For example, if the client is not ready to receive cargo when the transportation team of the case company arrives, the transportation team reports the breakdown to the order management team that will communicate with clients and arrange redelivery or other solution. In the case company, stakeholders can generally obtain clear instructions for proceeding with the delivery within an hour after reporting breakdowns to the order management team.

"Without the help of OTWMS, it would be impossible to deal with breakdowns in one hour. This system helps us communicate with all stakeholders including clients in real time, which is crucial to deal with breakdowns effectively." - An order manager

3.3. Completion

The completion phase starts when providers have transported cargo to final destinations. Clients need to check the services and cargos to determine whether they meet the service closure conditions. If the conditions are met, the logistics engagement between the client and the provider can be closed. The client needs to pay for the services according to the original agreement and realized service quality (e.g., taking into account integrity and possible delays). When the provider’s financial department will receive the payment, the provider can close the order, summarize the services, and compare the performance during the engagement with earlier measurements to improve their service capabilities. For example, OTWMS should be able to benchmark the transportation performance with industry standards and previous performances and report the results to transportation management teams and other stakeholders.

OTWMS stores relevant information and artifacts to the order database for further reuse. The artifacts to be stored include logistics requirements and optimized logistics plans and schedules, which can help the provider to improve their transportation and warehouse management in future.

4. A meta-design of the design product theory for OTWMS

This section outlines a generic meta-design for OTWMS based on the analyses of interview transcripts, the 3PL life-cycle, the literature review, and the OTWMS instance developed by the case company. The meta-design covers the entire 3PL life-cycle outlined in Section 3 and visualized in Figure 1. The section concludes by explicating the linkages between order management, transportation management, and warehouse management subsystems to validate the meta-design and to justify its scope.

Order, transportation, and warehouse artifacts are managed by OTWMS instances. Orders are associated with the transportation and warehouse management artifacts. The relationships between these artifacts are explained next. Orders are based on client requirements and RFPs; each order needs at least one transportation service and zero or more warehousing services to complete it; each warehouse links with at
least one order; and each transportation service delivers at least one order.

This section introduces generic structures and attributes of the three classes of artifacts presented above. According to the design product theory, OTWMS instances should include at least these structures and attributes to be effective.

4.1. Order

Table 3 presents the generic structure of order artifacts. In the following, each class within the structure is explained.

*Description* describes what an order is about, the purpose of the order, and the deadline for its delivery. If there are service breakdowns that lead to change requirements, clients may form a new order to execute the services. *Name* and *ID* are used for identification and traceability.

*Origin* describes the client requirements the order is based on. One order should cover all the client requirements.

*Analysis* is used to probe the implications of the order. *Priority* is used to rank orders and arrange suitable resources and efforts. During the service delivery phase, *status* can be used to check the order status (e.g., shipping or waiting for picking).

*Workflow* describes what should be done next to this order and by whom. Order management teams need to allocate each order to one or more transportation and warehouse management services.

*History* is used to provide information about the responsible managers and all prior edits of various order attributes. As a result, the stakeholders can be held accountable for their actions and unexpected service breakdowns can be dealt with effectively. Changed requirements may necessitate unexpected revisions of logistics plans and raise service risks. History information helps logistics teams to proactively eliminate many breakdowns and to recover from breakdowns to continue service execution.

4.2. Transportation

Table 4 presents the generic structure of transportation artifacts.

*Description* describes the destination of transported goods. *Route* indicates the stops needed for the transportation service, including the final destination. *Origin* describes the order(s) the transportation service refers to. One order may need more than one transportation service.

*Analysis* is used to probe the implications of a transportation service. *Priority* describes the priority of the transportation service and *status* refers to the transportation progress. Required effort describes the transportation costs, time, and resources, which can be used to calculate the total service cost of an engagement. This information can be reused to estimate the profitability and feasibility of future engagements.

<table>
<thead>
<tr>
<th>Class</th>
<th>Questions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>What is the order about?</td>
<td>Name, ID, Description, Required date and time of delivery, Rationale</td>
</tr>
<tr>
<td>Origin</td>
<td>Which client requirements does the order refer to?</td>
<td>Author, Source, Date of creation</td>
</tr>
<tr>
<td>Analysis</td>
<td>What are the implications of the order?</td>
<td>Status, Required effort, Priority, Scheduled date and time of delivery</td>
</tr>
<tr>
<td>Workflow</td>
<td>What should be done to this order next? By whom?</td>
<td>Assigned Transportation services, Assigned Warehousing services, Responsible person, Realized order closure date and time</td>
</tr>
<tr>
<td>History</td>
<td>What has been done to the order artifact? When?</td>
<td>Information about all prior edits, editors, and changes</td>
</tr>
</tbody>
</table>

Table 3. Generic Structure of Order Artifact

<table>
<thead>
<tr>
<th>Class</th>
<th>Questions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>What is the transportation service about?</td>
<td>Name, ID, Description, Rationale, Route, Required date and time of delivery</td>
</tr>
<tr>
<td>Origin</td>
<td>Which order does the transportation service refer to?</td>
<td>Author, Source order, Date of execution</td>
</tr>
<tr>
<td>Analysis</td>
<td>What are the implications of the transportation service?</td>
<td>Status, Required effort, Priority, Scheduled date and time of delivery</td>
</tr>
<tr>
<td>Related transportation vehicles</td>
<td>Which vehicles and transportation methods are involved in this transportation service?</td>
<td>IDs of vehicles to be used</td>
</tr>
<tr>
<td>Workflow</td>
<td>What should be done to this transportation service next? By whom?</td>
<td>Allocation to transportation team members, Responsible person, Realized date and time of delivery</td>
</tr>
<tr>
<td>History</td>
<td>What has been done to this transportation artifact? When?</td>
<td>Information about all prior edits, editors, and changes</td>
</tr>
</tbody>
</table>

Table 4. Generic Structure of Transportation Artifact
Related vehicles provides traceability links to the vehicles (e.g., cars, ships) that are involved in the transportation services.

Workflow describes who is responsible for transportation processes and the realized time of delivery.

### 4.3. Warehouse

Table 5 presents the generic structure of warehouse artifacts. Description explains which logistics requirements are met by the warehouse.

Origin describes which orders are linked with the warehouse, when, and using which transportation services.

Analysis probes the availability and convenience (e.g., distance from the final destination) of the warehouse and the profitability of using it in order to prioritize and schedule the transportation service. This information can also be reused in future to help providers and clients optimize schedules and improve service effectiveness.

Workflow describes the processes that should be taken to use the warehouse and the responsible stakeholders. The transportation team needs to communicate with the warehouse team and form a reasonable store and pick schedule.

<table>
<thead>
<tr>
<th>Class</th>
<th>Questions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Which logistics requirements does the warehouse meet?</td>
<td>Name, ID, Description, Rationale</td>
</tr>
<tr>
<td>Origin</td>
<td>Which orders are linked with the warehouse? Which transportation artifacts are linked with the warehouse?</td>
<td>Author, Source order, Source transportation, Scheduled dates and times of transportation</td>
</tr>
<tr>
<td>Analysis</td>
<td>What are the availability and convenience of the warehouse?</td>
<td>Status, Priority, Risk, Required warehouse space</td>
</tr>
<tr>
<td>Workflow</td>
<td>What should be done to use this warehouse next? By whom?</td>
<td>Allocation to transportation team and warehouse management team, Information about responsible person</td>
</tr>
<tr>
<td>History</td>
<td>What has been done to this warehouse artifact? When?</td>
<td>Information about all prior edits, editors, and changes</td>
</tr>
</tbody>
</table>

Table 5. Generic Structure of Warehouse Artifact

### 4.4. Validating and scoping the design product theory for OTWMS

OTWMS instances help 3PL providers to prioritize and valuate logistics requirements. The requirements and their interdependencies can be stored in the order database. The prioritization and valuation methods are beyond the scope of this paper.

Most logistics resources are allocated to deal with the highest priority requirements. OTWMS instances make it easy to trace orders and transportation services, because transportation and warehouse management artifacts are bidirectionally linked to orders. In the case company, all the stakeholders involved in the service engagement record their actions and relevant information to OTWMS, helping the order management team to manage service provisioning and to effectively communicate with clients.

For each logistics service engagement between a client and a provider, the used OTWMS instance indicates which orders provide the purpose for the transportation and which warehouses are leveraged. Moreover, all actions can be traced to responsible staff members, improving accountability and service quality. Version management helps to identify the stakeholders involved with different versions of various artifacts and the actions the stakeholders have taken. Therefore, order management teams can analyze and control the impacts of order changes and revise the schedules and logistic plans as necessary to meet the most important requirements and recover from service breakdowns.

### 5. Conclusions and future research

This research established the meta-requirements and the meta-design of the design product theory for OTWMS. The theory helps 3PL providers design, acquire, and use OTWMS instances for providing logistics services. The validity of the theory was enhanced by a case study, which involved a leading Chinese 3PL provider, and the analysis of an OTWMS instance, which has been developed and used by the case company for about ten years.

OTWMS instances are expected to enforce standardized processes for 3PL providers and the implementation of best practices across services. Order management, transportation management, and warehouse management teams can share and reuse artifacts from the order database to raise productivity and quality. Clients can share logistics knowledge across service engagements to increase efficiency and reduce risks. 3PL providers and clients can aggregate quality metrics across service engagements.

This research is limited to one case study. The case company is not only a leader in its field in China but also the first Chinese company to use modern logistics concepts to provide clients with integrated logistics services. Its key staff members interviewed for this study have more than ten years of work experience in
logistics services. The generalizability of the design product theory is thus expected to be significant. Future research needs to validate the theory using more case studies and help providers to better reuse logistics artifacts. New case studies and action research are thus necessary to make the theory even more credible for 3PL providers, information systems designers, logistics professionals, and researchers.

6. References

Figure 1. A Meta-Design for Integrated Order, Transportation, and Warehouse Management Systems enabling the Third-party Logistics Services Life-Cycle