

Business Process Modeling for Domain Inbound Logistics System: Analytic Perspective with BPMN 2.0

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ABSTRACT

Among different Business Process Management strategies and methodologies, one common feature is to capture existing processes and representing the new processes adequately. Business Process Modelling (BPM) plays a crucial role on such an effort. This paper proposes a “to-be” inbound logistics business processes model using BPMN 2.0 standard specifying the structure and behaviour of the system within the SME environment. The generic framework of inbound logistics model consists of one main high-level module-based system named Order System comprising of four main sub-systems of the Order core, Procure, Auction, and Purchase systems. The system modeling is elaborately discussed to provide a business analytical perspective from various activities in inbound logistics system. Since the main purpose of the paper is to map out the functionality and behaviour of Logistics system requirements, employing the model is of a great necessity on the future applications at system development such as in the data modelling effort. Moreover, employing BPMN 2.0 method and providing explanatory techniques as a nifty guideline and framework to assist the business process practitioners, analysts and managers at identical systems.

KEYWORDS: computer-aided systems, inbound logistics, BPM, happy flow technique.

INTRODUCTION

Business Process Modeling (BPM) is the main element in Business Process Management at implementation phase [1,2] as well as the activity of representing the processes of an enterprise. It is generally carried out to improve the process efficiency and quality in the change management in areas such as the system engineering and software engineering. A business process is a collection of related and structured activities in a service or task and is categorized into three main types of management, operational, and supporting processes. Business models are being developed to represent the current state of the processes (i.e. As-is) or to what the process should become (i.e. To-be) [3]. Through the analysis between “as-is” and “to-be” models, the need for as low as some minor modifications or as high as the essential re-engineering to correct the problem or improve the efficiency at business process and eventually at the information system design will be revealed [4]. This highlights the importance of the BPM as the main primary step at any effort for the system improvement.

Recent study by MIT, PRTM, and SAP investigated the relationships among information technology strategy, the degree of maturity of business processes, and supply chain performance [5]. The relevant key study finding is that the firms that invested in their supply chain business processes performed better than those firms that invested only in information technology (IT) infrastructure and neglected the relevant business processes. Moreover, several surveys show that the computerization of logistics business processes has been widely acclaimed and concerned [6,7]. Precisely, the Information Technology (IT) plays a key role in supporting the logistics activities [8]. In fact, the Information objects as well as the importance of the flow of information in logistics channels are considered as one main valuable logistics resources. To provide a consistent, low lead-time, and damage-free deliveries, it is absolutely required to maintain an efficient Logistics Information System (LIS) [9].

Several other research have been carried out to analyze the logistics system and database design methodologies for an integrated information system particularly for small to medium-sized enterprises (SMEs) [9-13]. Nonetheless, there are a few conceptual models in different domains of logistics systems and there is not a comprehensive systematic conduction or analysis of the logistics business process modeling which is required at the early stage of the system development and particularly not for small to medium-sized enterprises [14-17].

The aim of this paper is to represent a high-level domain business process model of a complex cooperative and systematic group of activities of the inbound logistics system including the Order, Procure, Auction, and Purchase sub-systems. The generic model is proposed as a reference “to-be” model due to its high-level referential properties and module-based designed for inbound logistics in SMEs. Through accumulated data from case study observations in SME environment in industrial section, the system is modeled which could be of a great beneficial example for business modelers and analysts as well as actual practitioners of logistics activities in the supply chain level. Moreover, the significant explanatory description with easy-to-understand strategy and

technique to accomplish the process modeling is a key feature of the paper to follow on modeling identical cases and systems. Eventually, as a part of larger effort on conducting an extensive modeling for module-based inbound and outbound e-logistics system at the supply chain level, this paper represents the development of BPM using BPMN standard for inbound logistics system as the Order System module. The remainder of the paper is organized as follows. The following section reviews the literature on BPM methods and attributes following discussion on method selection. Next, the inbound logistics business process model is discussed using procedural demonstration of figures and descriptive tables for four main inbound logistics components. Finally, concluding remarks and future research directions are provided.

BUSINESS PROCESS MODELING METHODS

According to Davenport [18] and Hammer [19]. A business process consists of five elements of: 1) customer(s); 2) composition of activities; 3) creating value for customers; 4) operating actors (i.e. humans/machines); and 5) organizational units. Moreover, Kueng et al. [20] grouped process modeling approaches into four general categories:

- (1) Activity-oriented approaches tend to define a business process as a specific ordering of activities (i.e. tasks). They generally offer good support in refining process models.
- (2) Object-oriented approaches are associated with object orientation, such as encapsulation, inheritance, and specialization. The principles of object orientation are applicable to business process modelling.
- (3) Role-oriented approaches suggest that a role to be involved in a set of activities and carry out particular responsibilities [21]. A group of primitive activities can be assigned to a particular role (i.e. actor or agent).
- (4) Speech-act oriented approaches, based on speech act theory under language/action perspective, view the communication process as four- phased loop: proposal, agreement, performance, and satisfaction [22].

Next, main business process modeling methods among others are introduced:

- **IDEF0**: As a part of IDEF family, the (Icam DEFinition for Function Modeling - IDEF0), specifies each by four elements of the input, control, output and mechanism (ICOM) [23-25].
- **RAD**: Role Activity Diagram (RAD) as a role-oriented model assigns the activities to the roles. The process goals are represented by states, activities, interactions, and business roles [26,27].
- **REAL**: As extension of the REA model, it consists of the Resource, Event, Agent, and Location elements [28-30].
- **Petri net**: Place/transition net or P/T net model consists of places, transitions and arcs. Places may contain tokens. Arcs links places to transitions or vice versa [31].
- **EPC**: Event-driven Process Chain (EPC) is a type of flow chart. It consists of Events; Functions; Control flow; Organization units; Resource objects including information or material; Information flow; Logical connector or operators; Process path; three Logical relationship: Branch/Merge, Fork/Join, OR. It is originated and developed by Scheer, Keller and Nüttgens within the framework of Architecture of Integrated Information System (ARIS) [32,33].
- **UML**: Unified Modeling Language (UML) consists of two essential view of a system model: Static and Dynamic including three diagram types of Structural, Behavioral, and Interactional. Basically, the Use case diagrams and Activity diagrams as two classified tools within behavioral diagram types, address the functionality requirements at business process modeling [34].
- **YAWL**: Yet another workflow language (YAWL) functions based on the workflow pattern analysis and is inspired by the Petri net disadvantages [35]. The elements are comprised of three types of conditions, four tasks, three splits, and three joins notations.
- **BPMN**: Business Process Model and Notation (BPMN) is also based on the flow charting technique very similar to UML Activity diagram. It consists of five main components of Events, Activities, Gateways, Swimlanes, and Artifacts [36].

Adopted Modeling Method and Procedure

Business Process Model and Notation (BPMN) is used to represent the functional structure and activities of reference logistics system applicable in SME environment. As introduced by the Object Management Group (OMG) standard Process modeling, BPMN is defined as suitable process modeling standard for business processes in respect to high-level business analytical perspectives in a system [37]. Recent study by Muehlen [38] shows that the combination of BPMN with Simulation Reference Markup Language (SRML) which is a service modeling language provides users with the highest representation power compare to other language pairs. As such, BPMN and UML in some parts are basically used as primary and complementary representation methods to model the whole system.

The architecture of inbound logistics system is organized into smaller parts as sub-systems and analytically developed. Analysis and identification of BPM requirements for logistics system is the first step in the modeling.

This stage identifies and considers all relevant responsible units for domain system using literature review and case study findings. Next the modeling development initiates with an starting point within the Swim lanes that represent the identified roles. Next, all activities are added to the roles based on the identified sequence flow of the processes to reach to the end of the process. “Happy flow” technique which is basically following the “yes” or “default” path at any conditions reaching to the end event is applied. The alternative and extension is added step-by step- to achieve the complete model. The modeling is finalized by adding any required or produced Artifacts associated to the activities (i.e. process and sub-processes). Next, for the identified sub-processes at the domain highest level inbound logistics model, the expanded models are developed in details.

DEVELOPMENT OF INBOUND LOGISTICS BPM

Identification and Classification of BPM Requirements

To model an efficient logistics system, literature findings on the context of BPM requirements and specific SME case study in the car component industry are used to find the modeling requirements. Combination of make-to-order and make-to-stock for a wide variety of metal and plastic washers at a large amount of volume and different sizes is the production system of the case which has been studied. Work orders are taking place either through regular customers or random. Purchased are made generally through regular suppliers unless in a very specific situation made from the bidders base on quality standards, instructions and company regulations. Although the model is inspired from the case study but detail procedures and production and operation specifications of inbound logistics in lower levels are not elaborated to preserve its referential capability.

Table 1: Identified roles/actors in Order System

<i>Role/Actor</i>	<i>Property</i>	<i>Business Process Descriptions</i>
Customer	Black box	- Place the Customer Order
Supplier		- Regular provider of resources - Receives RFP/RFI - Issues results and feedbacks
Bidder		- Random provider of resources - Receives resource availability requests - Issues feedbacks
Manufacturer	Abstract	- Fulfill the Order
Sales Dept.	Child	- Receives customer order, feedback from suppliers and offers, reproduction requests, purchase arrival notifications, and QC results - Places work order, compensation / rework work order, and purchasing orders - Issues work order, order responses to the customer, RFP/RFI, part availability requests, evaluation of offers, ship available order, and return purchased items notifications - Updates order system including new orders, purchasing, order fulfillments, and compensation/ rework order
Production Dept.	Child	- Receives Work Orders
Quality Dept.	Child	- Issues purchase QC results, Compensation / rework request notifications
Warehouse	Child	- Issues Purchased Items Arrival Notifications - Received Return Purchase Notifications

There are essentially three domain systems which make up the whole logistics system work properly comprising of inbound, production logistics, and outbound logistics system. These systems can be originally as individual or as developed integrated systems. Nonetheless, there would be of no particular consequence on the identification of inbound system BPM requirements. These main recognized systems include inbound logistics (i.e. ordering, procuring, purchasing, etc.), and outbound logistics as (i.e. shipping, warehousing, tracking, tracing, etc.) and production logistics including the whole production system, quality system and inventory controlling system.

Each of these systems engages a group of units/pools or roles/actors and triggers sets of activities and processes to execute toward reaching the goal and output events of the system using and generating numbers of objects and artifacts. The inbound logistics system is explained next named as the Order System. Table 1 illustrates the identified roles/actors for Order System and brief business process descriptions. Next, the discussion on the Shipping system modeling development is presented.

Order System – Explanatory Modeling Technique

Inbound logistics concentrates on inbound movement of material, parts, outsourcings and its associated data generated through the business processes such as ordering, purchasing, procurements, confirmations, and so on. To model the Order system, the Customer, Supplier, Bidder and Manufacturer are identified as the main pools and the Sales Dept., Warehouse, and Quality Dept. as the Manufacturer lanes. Four general components are modeled including Order core, Procure, Auction, and Purchase to address the entire domain highest-level inbound logistics business processes. To respond to customer order, several activities are being performed within

including placing order, registrations and modification, responses to order, and lookups. The procurement, Auction, and Purchasing are as part of the customer order fulfillment leading to events and artifacts required for other systems initiation to launch or interact. In fact, this is the main reason to name the inbound logistics system as the Order System. All business processes are being illustrated throughout the modeling development either as tasks or as sub-processes which used to classify and manage the display of the associated group of sequential or ad-hoc tasks within them. Table 2 shows the main activities of the Order System.

Table 2: Identified Main Activities in the Order System

Activity Name	Type	Specification	Roles	Description
Process order requirement	Task	User	Customer, Sales Dept.	Receiving order requirements and evaluate primary terms and conditions
Place work order	Task	User	Sales Dept.	Registrations of customer order
Registration the orders	Task	User	Sales Dept.	Categorize the customer order to handle properly
Inventory lookup	Task	Service	Sales Dept.	Check for availability of on-hand inventory
Order response	Task	Abstract process type	Customer, Sales Dept.	Respond to customer upon confirmation or rejection of the order as instance
Suppliers' offer evaluation	Task	User	Sales Dept.	Evaluate the output of Procure parts sub-process
Procure parts	Sub-process	Embedded, Multi-instance loop with Parallel ordering	Sales Dept., Supplier	Procure resources
Part auction	Sub-process		Sales Dept., Bidder	Auction for required resources
Purchase process	Sub-process	Reusable	Sales Dept., Supplier, Bidder	Purchasing resources including ordering operations, confirmations, updating, and notifications
Review re-production request	Task	Manual	Quality Dept., Sales Dept.	Review the details of the request received from Quality Dept.
Place compensation /rework work order	Task	User	Sales Dept.	Place new work order associated to the customer order

The next step is to map out the sequential flow of processes through connecting them from a start event up to an end event as it is shown in Fig 1. *Receiving customer order* “Message” start event through a message flow from a “Black box” Customer triggers the Order System to launch. The sequence flow - solid arrow line object – is used to show the flow of processes. The “User” Tasks of *Process order requirement* and *Place work order* are executed and *Updating order system* Task registers the order records into database demonstrated through the data object Artifact of *Database*.

There are two “Data-based Exclusive” and “Inclusive” gateways identified namely as *Sufficient capacity* and *Inventory enough* which are employed respectively. Based on the “happy flow” technique used following the routine flow of tasks and events with no exceptions and alternatives, only one control flow of *Sufficient capacity* gateway is modeled for now which can also be called as default flow. *Inventory lookup* is a “Service” Task while *Order confirmation* is a “Send” Task and generalizes the *Order response* Task as one instance. The output decision over the *Inventory enough* “Inclusive” Gateway includes two conditional paths of *Yes* leading to end of the flow with a “Message” end event named as *Ship available order* that initiates another system (i.e. Outbound Logistics System) to launch.

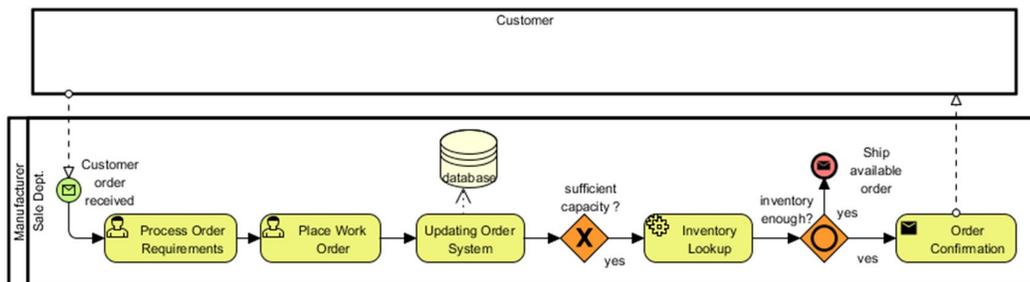


Fig 1: Initial Order System BPM Using “Happy Flow” Technique

Next step is to add the alternative paths and exceptions into the initial happy flow model. Each activity is double checked for exception as well as the gateways for alternative paths. Fig 2 illustrates the model with alternative path with *No* condition for *Sufficient capacity* gateway. In this case, the *Order rejection* task will send rejection of the order to Customer though a message flow and system updated through *Updating order system*

task. Data object artifacts of *Database* is updated and annotation artifact as *Modify order record* is used for readability and instructive purposes followed by the End event to end this flow.

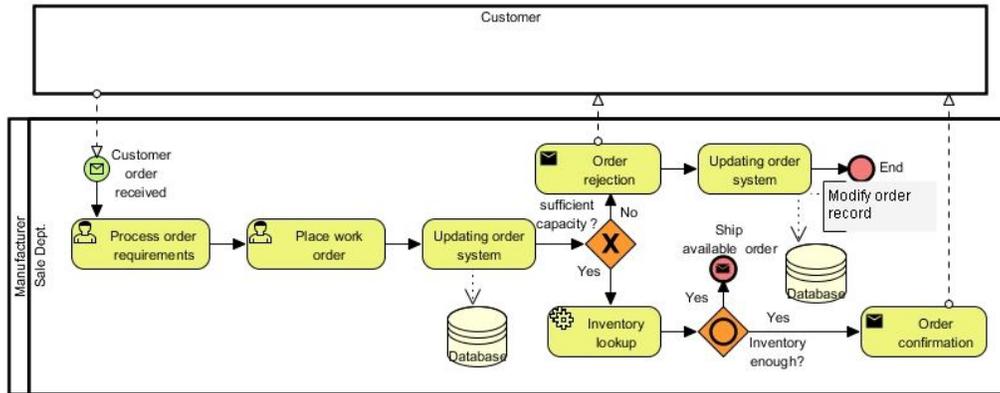


Fig 2: Alternative Flows at Insufficient Capacity Gateway

Identifying alternative paths continues with focusing on the *Inventory enough* Gateway and alternative flow with *No* condition as it is shown in Fig 3. The *Procure part-(RFP/RFI)* Sub-process and *Suppliers' evaluation offer* Task are executed. In order to demonstrate the simultaneous requisition of *Suppliers' proposals*, the *Procure part-(RFP/RFI)* Sub-process is specified with "Multi-instance loop" and as "Parallel ordering" type.

Moreover, another data object artifact is also added for a better readability named as *Available inventory*. Yet another "Inclusive" Gateway named as *Can be obtained by supplier* with three diverging paths with the *Yes* condition is recognized. In *Yes* condition, one flow initiates the Production Logistics System to run through the *Work order* end event, another flow triggers the *Order confirmation* Task again, and the last one triggers the *Purchasing process* "Reusable" Sub-process to get activated. The model reaches to an end event with default flow condition type. However, there is another possible scenario for new Gateway as well as exception flow of *Purchasing process* Sub-process which introduced next.

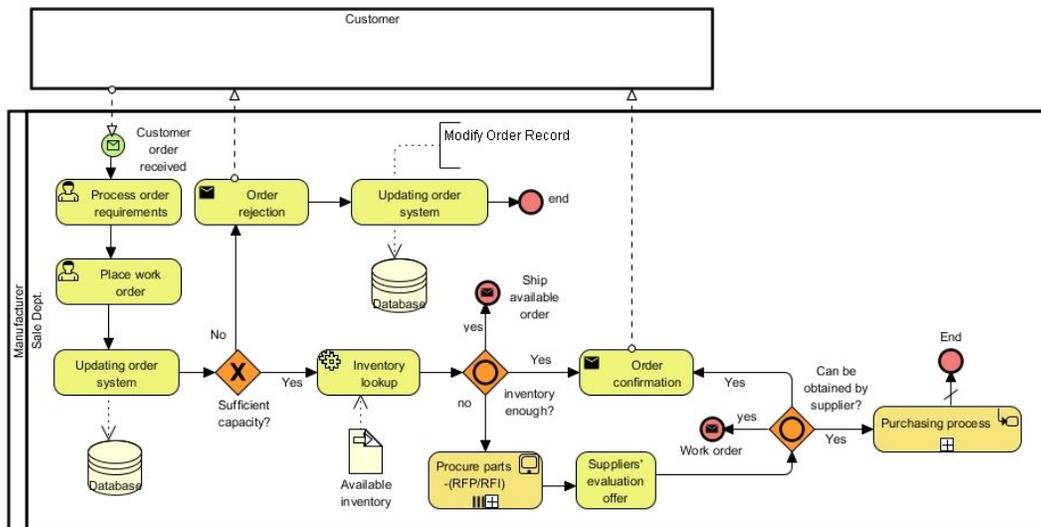


Fig3: Alternative Flows at Insufficient Inventory Result Gateway

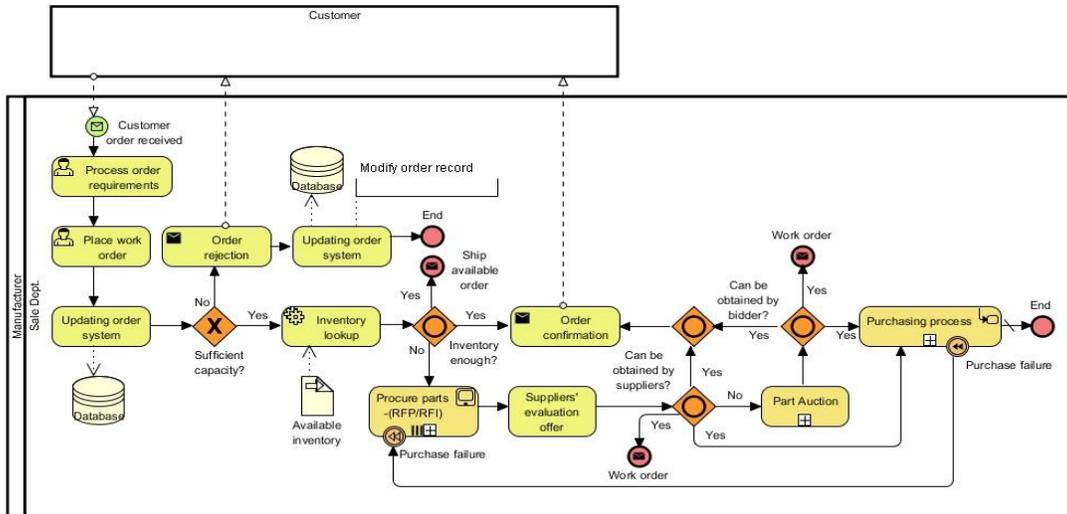


Fig 4: Alternative Flows for the *Part Auction* Sub-process

As it is shown in Fig 4, the *Part auction* Sub-process is the activity that is executed upon the *No* condition of *Can be obtained by supplier* Gateway. New “Inclusive” Gateway of *Can be obtained by bidder* is recognized before *Purchasing process* Sub-process with three possible *Yes* condition flows. First reaches to the *Part Auction* sub-process, the second points to the *Work order* end event and the third reaches to another “Inclusive/Merge” Gateway. The “Inclusive/Merge” gateway with “Converging” direction is used to merge two incoming flows and is connected to the *Order confirmation* Task.

Besides, another exception flow is identified for the *Purchasing process* Sub-process. The compensation intermediate event namely *Purchase failure* is recognized in case of failure in process of purchasing the resources from the Supplier or the Bidder. One sequence flow connects this compensation intermediate event to another compensation intermediate event attached to the *Procure part-(RFP/RFI)* Sub-process to compensate the process. Since the *Purchase failure* compensation intermediate event is triggered from the *Purchasing Process* Sub-process, it is set as “Throwing” attached to “Catching” through the sequence flow.

Next, as illustrated in Fig 5, other possible sequence flow with *No* condition is identified for *Can be obtained by bidder* gateway to which through a link intermediate event is connected to the *Order rejection* Task. Two other links of intermediate events, named as *B*, and *Care* added for better readability and to avoid confusion that might be cause due to crossing sequence flow notations considering the “Throwing” and “Catching” properties for the senders and the receivers. As it is seen the “Inclusive/Merge” converging Gateway is now depicted with a “Data-based exclusive” gateway named as *Confirmation already sent once* with two labeled flows with *Yes* and *No* conditions. This change is made upon compensation intermediate event triggered by the *Purchasing process* Sub-process which causes to pass in an already once passed flow.

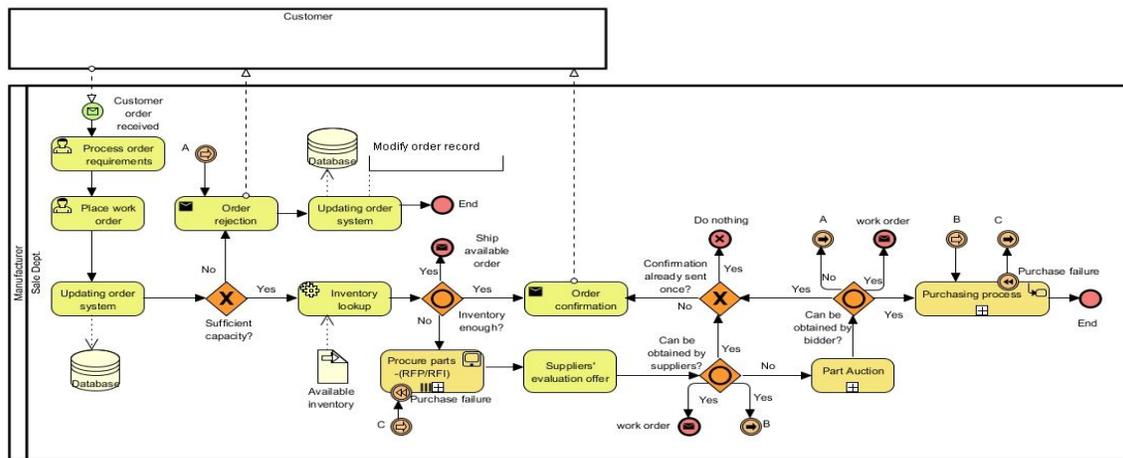


Fig 5: Alternative Flows of the Bidder and Confirmation Gateways and All Intermediate Links

Eventually, the completed domain business process model for the Order System with all alternative and exception flows aiming to fulfill the customer order is illustrated at Fig 6. As it can be seen, new identified system initiation is added to the model. The Quality Dept. triggers the Order System with the *compensation/rework production notification* “Message” compensation start event. This is due to quality rejections that might happen during the production process which initiates the compensation or rework processes starting from the re-ordering. The *Review re-production request* “Manual” Task followed by the *Place compensation/rework work order* Task are executed. Next, the Order System is updated with new records associated with the original customer order and the procedure of the order fulfillment is continued by flowing the routine path same as for one new order fulfillment through connecting the sequence flow to the *Sufficient capacity* Gateway. Moreover, the three identified Sub-processes of Procure, Auction, and Purchase process are expanded which the Purchase Process explained next.

As it is shown in Fig 7, based on the decisions made at *Suppliers’ offer evaluation* Task explained earlier for purchasing method, the Purchasing Process starts and *Place purchase order* as a “Send” Task either to the Supplier or the Bidder through message flows and *Receive Reply* from either. Next, the Purchase system is updated and Quality Dept. will be notified with *Notify Purchase Order* “Send” Task for QC preparations for new resources. The process flow is held at “Attached Time” intermediate event to the *Purchased items arrival notification* “Receive” Task from the Warehouse. Next the process flow is held again at “Attached Time” intermediate event to the *Receive QC results* “Receive” Task from the Quality Dept. Next, the *QC OK* Gateway with two *Yes* and *No* conditions determines the next sequence flows. If *Yes*, the system is updated and it ends with an end event. If *No*, the *Return purchased items notification* “Send” Task is issued to the Warehouse, the system is updated and ends.

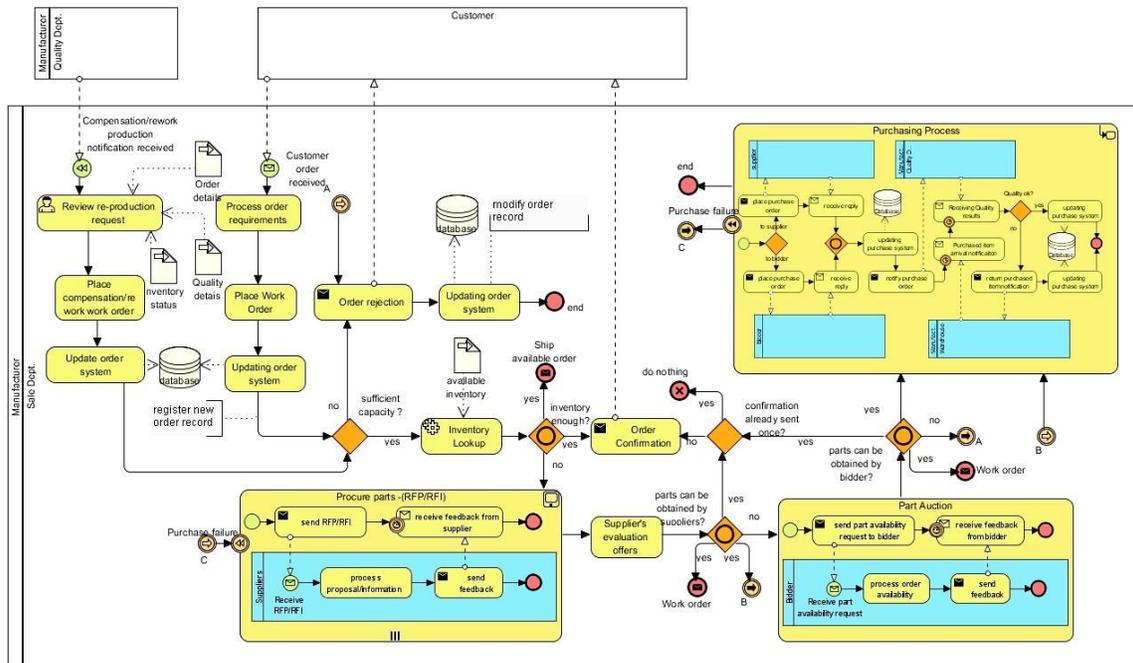


Fig 6: Final View of the Domain Business Process Model for Inbound Logistics System

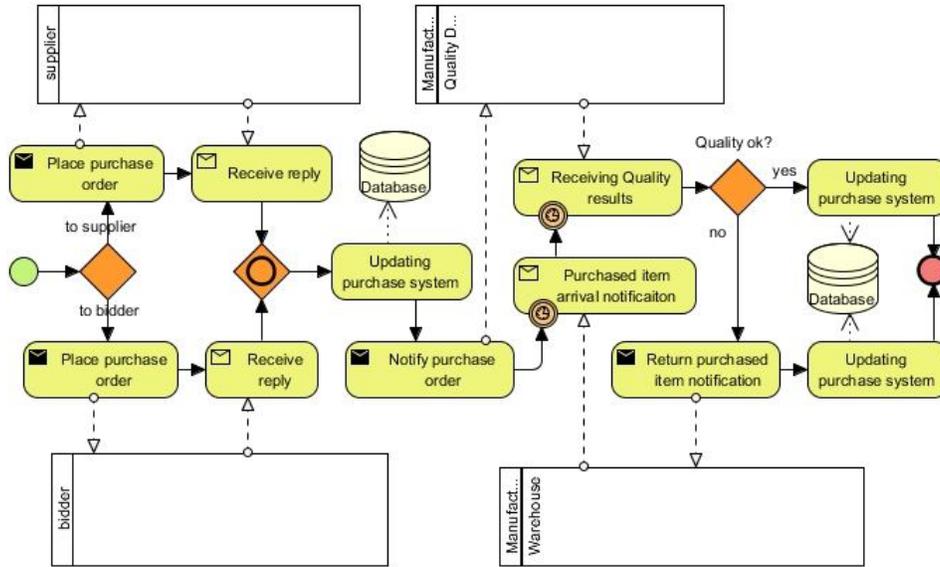


Fig 7: Expanded Purchasing Sub-process

Description of every element properties and specifications introduced in the Order system business process model are listed into Table 3 including relationship matrix and connectivity types.

Table 3: Elements Description and Matrix Relationship in OrderSystem

Swimlanes and Artifacts																						
No #	Name	Swimlane Element and Type					Data Object					Relationships (SF: sequence flow, Mf: message flow, A: artifact)										
		Pool	lane	Black box	Parent	Child	Parent #	Data	Input	Output	Datastore	Sf	Mf	A	Name	From	To					
1	Customer	✓		✓												17,18	6					
2	Manufacturer	✓			✓																	
3	Sales Dept.		✓				2															
4	Available inventory								✓					✓			19					
5	Database										✓			✓			16					
Events																						
No #	Name	Element Type			Trigger	Type		Attached		Quantity	Relationships											
		Start	Intermediate	End		T	C	yes	No		Sf	Mf	A	Name	From	To						
6	Customer order received	✓			Message		✓		✓	1	✓	✓				1	14					
7	Ship available order			✓	Message	✓			✓	1	✓			Yes		25						
8	Work order			✓	Message	✓			✓	2	✓			Yes		26,27						
9	Do nothing			✓	Cancel					1	✓			Yes		28						
10	Purchase failure		✓		Compensation	✓	✓	✓		1	✓					23,13	13,21					
11	A		✓		Link	✓	✓		✓	1	✓					27	17					
12	B		✓		Link	✓	✓		✓	1	✓					26	23					
13	C		✓		Link	✓	✓		✓	1	✓					10	10					
13.1	End			✓	End				✓	2	✓					16,23						
Task																						
No #	Name	Element Type										Loop Type	Ordering #	Quantity	Relationships							
		Sv	Sd	Rc	U	M	B	S	R	P	R				M-I	S	P	S	Sf	Mf	A	Name
14	Process order requirement				✓										3	1	✓				6	15
15	Place work order				✓										3	1	✓				14	16
16	Updating order system	✓													3	2	✓	✓			15	24,5, 13.1
17	Order rejection			✓											3	1	✓	✓	No		11,24	1,16
18	Order confirmation			✓											3	1	✓	✓	Yes,No		25,28	1
19	Inventory Lookup		✓												3	1	✓	✓	Yes		24,4	25
20	Suppliers' offer				✓										3	1	✓				21	26

evaluation																			
Sub-process																			
	Name	Element Type					Ad-hoc	orderi ng		Loop type			ordering		Parent #	Relationships			
		Em	I	E	R	F		P	S	M-I	S	P	S	S		M	A	Name	Fro m
21	Procure parts - (RFP/RFI)	✓								✓		✓		3	✓		No	25	20
22	Part auction	✓												3	✓		No	26	27
23	Purchasing process		✓											3	✓		Yes	27, 12	10, 13.1
Gateways																			
	Name	Element Type					Process		Direction			Parent #	Relationships						
		DBE	EBE	I	C	P	Decisi on	Me rge	Co nv	D i	Mixed		S	M	A	Name	Fro m	To	

CONCLUSION

This paper is focused on the business process modeling as a key role and requirement to capture and analyze the existing processes at early phase of system development. The Inbound logistics as an actual real-world industrial system is modeled for the SME environment using BPMN 2.0. The literature review on the main modeling methods and tools were elaborately studied and described. BPMN standard as the main tool for modeling the system was selected due to the prominent feature of providing a high-level analytical perspective that is required for a system analysis, management, and development. Logistics is a process-oriented business constituting numerous processes linked together to perform different logistics operations. Inbound logistics activities are basically classified as the Order Systems covering all activities in respect to the inbound movement of the resources and information including the ordering, procurement, auction, and purchasing processes. The model is addressing the module-based design by categorizing the processes into these system components and since the model is considered as referential “to-be” BPM, the identified actors can be merged depending to the implementing actual case structure. Moreover, the explanatory easy-to-understand strategy and technique is employed to describe the domain analytical high-level business process modeling development supporting the referential applicability for lower-level developments.

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