Approach of BPEL in supply chain activities for managing Bullwhip effect of SCM system

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Abstract—Intending to provide quick, efficient and effective sharing of resources across different organizations with the context of Supply Chain Management, Orchestration Engine and various web services are involved. In this research work, the proposed model using Orchestration Engine for Supply Chain Management supports supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. Existing technologies and tools such as Electronic Data Interchange (EDI) infrastructures and Enterprise Resource Planning (ERP) systems do not provide a flexible and reusable solution to information sharing and application integration. The concept of Orchestration is truly nothing new fangled, however it’s assessment as an enterprise resource is, and it’s obviously the driving force following the value of a Service Oriented Architecture. The orchestration is the capability to organize how information flows and services interrelate to form solutions, processes actually, alive between dozens sometimes hundreds of systems, within and between enterprises. The concept of Business Process Engineering Language (BPEL) is being utilized to design the orchestration engine for the SCM. The Eclipse BPEL designer is being used to construct this engine for the supply chain management systems. Leveraging web service and web portal technologies, that have been developed a prototype web service system to facilitate communication, integration and collaboration among project participants in construction supply chains.

Keywords— BPEL, Bullwhip effect, Supply chain, cloud computing

I. INTRODUCTION

Forrester (1961) has been the first to identify the phenomenon of oscillating and amplifying order behavior upstream of supply chains and its effects on inventories, capacity utilization and other operational parameters [1]. While Lee et al. (1997) first introduced the term “bullwhip effect” to explain this phenomenon; it was first described by Forrester (1961) to demonstrate the demand and variance amplification in an industrial system. His idea has been studied further and illustrated through the “Beer Distribution Game” - a simulation based teaching tool to explain the economic dynamics of stock management problem (Sterman, 1989). Lee et al. (1997) identified the following four reasons for the bullwhip problem: 1) demand forecast updating, 2) order batching, 3) price fluctuation, and 4) the rationing and shortage game [2].

The first time the bullwhip effect was evident in an industrial company in the supply chain of Procter & Gamble’s diaper products. Its sales at retail stores were fluctuating, but the variability’s were certainly not excessive. However, as they examined the distributors’ orders, the executives were surprised by the degree of variability. When they looked at P&G’s orders of materials to their suppliers, such as 3M, they discovered that the swings were even greater. At first glance, the variability’s did not make sense. While the consumers, in this case, the babies, consumed diapers at a steady rate, the demand order variability’s in the supply chain were amplified as they moved up the supply chain. P&G called this phenomenon the “bullwhip” effect. (In some industries, it is known as the “whiplash” or the “whipsaw” effect.) [2].

II. BULLWHIP EFFECT AND ORDER FLUCTUATIONS

The four factors that cause the bullwhip effect are 1) demand forecast updating, 2) order batching, 3) price fluctuation, & 4) the rationing and shortage game.

These will be described briefly in the following:

a) Demand forecast updating: When performing demand forecasts, companies interpret historical order information and update them regularly. This order information from customers, however, does not directly reflect actual demand. This information is used to determine supply requirements as a function of historical demand information, service level policies, and lead times in order to satisfy future demand and safety stocks. The further upstream in the supply chain forecasts are conducted through the more their variability increases, because longer lead times require higher safety
stocks under identical conditions, worsening the bullwhip effect.

**b) Order batching:** Two forms of order batching are identified by Lee, Padmanabhan, and Whang: periodic ordering and push ordering. Most frequently, periodic orders are used. Many such companies run their MRP systems or inventory status periodically and therefore, orders occur periodically as well. Additionally, fixed order costs, such as order processing costs and transportation costs, contribute to larger orders in order to reduce per unit order costs. Push ordering refers to behavioral order distortions. It occurs in cases of budget spending related end-of-year or end-of-period surges. It also contributes to erroneous demand signaling and therefore less reliable forecasts upstream in the supply chain.

c) **Price fluctuation:** Temporary price discounts, promotions, and payment term benefits offered by manufacturers to downstream supply chain members encourages forward buying behavior.

In order to benefit from these price reductions, companies buy larger amounts than immediately needed. Depending on inventory holding costs, this might be beneficial for really large amounts. In any case, for upstream supply chain members, it is impossible to derive real customer demand because of this forward buying behavior. Higher direct costs might occur because of overutilization of resources and resulting negative long-term consequences of varying capacity utilization.

d) **Rationing and shortage game:** If supply is limited due to a temporary surge in demand and orders are only partly filled due to this shortage, customers might react by overstating their real demands in order to receive a larger share of the limited supply. When demand returns to normal levels, orders are cancelled or, because of previous more-than-demanded deliveries, simply disappear. This is especially a problem when customers only anticipate a shortage and place multiple orders with multiple suppliers. Then, after the first order is fulfilled, all redundant orders are cancelled. The problem is that it is almost impossible for a manufacturer to tell real orders from fake ones. As Sterman remarked: “Even a perfect forecast will not prevent a manager who ignores the supply line from over ordering” [1].

**Definition disorder in product demand:**

![Figure: 2. Stock Overflow (Wastage of Production cost & inventory)](image)

**III. EFFECT OF BULLWHIP**

In a supply chain, fluctuations affect order streams Figure: 3 the point of sale places quite constant orders to its suppliers, whereas these suppliers place more variable and unpredictable orders. This problem, which is known as the bullwhip effect, leads to unnecessary inventory and decreased customer service because of backorders that is inventory shortages [4]. The bullwhip effect is a coordination problem between autonomous companies which can be considered as agents, therefore we have looked for a coordination technique in multi-agent system and production management fields [4]. Some of the Impact of Bullwhip is as below:

- Customer dissatisfaction
- Market scenario mishandled
- Wastage of Production cost
- Wastage of Inventory

**IV. BRIEF LITERATURE SURVEY**

**Coordination, Collaboration and Integration for Supply Chain Management** (Himanshu S. Moharana, J.S. Murty, S. K. Senapati & K. Khuntia)

Generally, coordination and coordinated decision making refers to separated entities that work together for decision alignment in order to improve overall performance. This has been a major issue of early economic theory that differentiated between the firm and its hierarchies and price mechanisms as forms of coordination. If separate companies coordinate, it is referred as combination or integration. In the context of industrial engineering research and in particular SCM research, the related terms cooperation, coordination, and collaboration are often used interchangeably without clearly distinguishing them from each other. This can cause confusion and ambiguity.

Collaboration is defined as working together or with someone else for a special purpose or simply as working with someone. In the last instance, collaboration is simply defined as a synonym for working together. The other two definitions point out common objectives and efforts. Whereas coordination is mainly conducted by sending the right signals or sharing the right information and the same policies, collaboration indicates a joint, interactive
process that results in joint decisions and activities. By that, it also indicates a higher degree of joint implementation and can be thought of as a teamwork effort. According to this interpretation, coordination alone excludes joint implementation and operational efforts [1].

**Do Electronic Linkages Reduce the Bullwhip Effect? An Empirical Analysis of the U.S. Manufacturing Supply Chains** (Yuliang Yao, Kevin Xiaoguo Zhu)

The bullwhip effect is a major source of supply chain inefficiency. Whereas prior literature has identified a number of potential contributing factors and recommended such remedies as information sharing enabled by information technology (IT) or electronic linkage (EL), few studies have provided empirical support. We use industry-level data to examine whether EL use with buyer and supplier industries helps reduce the bullwhip effect as measured by inventory–demand variance ratio. Our major findings are that 1) EL use with supplier industries reduces the bullwhip effect, whereas 2) surprisingly, EL use with buyer industries increases it, but 3) this adverse effect tends to be mitigated by IT use. These findings point to the possible asymmetric effects of EL use in supply chains and provide a different perspective to the existing conclusions in the literature that EL use improves performance. Combining the above results, we have learned that the use of EL tends to behave differently depending on whether it is used upstream or downstream in the supply chain. This also sheds light on the conditions under which such investment may be more (or less) beneficial [5].

**Factors causing reversed bullwhip effect on the supply chains of Kenyan firms** (Tom Obondi Otieno, Gerald Ochieng Ondiek, Odhiambo Odera)

Reverse bullwhip effect refers to the variability of supply downstream the supply chain thereby depicting inadequate supply in the face of adequate demand. Reverse bullwhip effect is multifaceted and can occur between the producers and wholesalers, wholesalers and retailers and between retailers and end user customers. With regards to the supply chain elements, influence is reciprocal and behavior is erratic during periods of supply disruption which compound the problem into a chaotic chain. However with regards to the supply chain facilities, variability’s are localized but the impacts are system wide. As firms successfully streamline their operations, the next opportunity for improvement is better coordination with suppliers and customers in order to receive or get their products to end users within the place, time and form of need. Budiman (2004) notes that this depends on complex tasks that require several companies working together as a supply chain or network to eliminate all supply chain inefficiencies. In attempting to effectively coordinate the supply activities, firms are faced with intermittent supplies, mutating consumer tastes and preferences, advancements in technology and a threatening competition. According to Tang (2006), as supply chains become more global, supply uncertainty becomes a more striking issue. Kumar et al. (2004) observe that while pipelines are one of the safest modes of transporting bulk energy and have failure rates much lower than rail road or highway transportation, failures do occur and sometimes with catastrophic consequences [6].

**A state-space based study of stability, bullwhip Effect and total costs in two-stage supply chains** (Chong Zhang and Haiyan Wang)

The main focus of this work is to apply the state-space method used in modern control theory to study the stability/instability of a two-stage supply chain controlled by the order policy called Automatic Pipeline, Variable Inventory and Order Based Production Control System (APVIOPBCS). Because product returns are not permitted, the supply chain may turn out to be an autonomous switched system according to the retailer’s order pattern. The stability of each subsystem is examined by analytic method and numerical analysis. The relationship between the supply chain stability/instability and bullwhip effect at different values of input parameters is then examined through simulation. Finally, the impacts of the decision variables on the relationship between the supply chain stability and the chain-wide total cost are analyzed, and the implications for demand forecasting, inventory control, and supply process for improving the supply chain operations are identified [7].

**V. PROBLEM STATEMENT**

Stability of supply chain is one of the major concerns to make the company moving forward and to attain the energetic behavior that describes transforms of inventory into orders over time. The bullwhip effect reveals the magnification of inventory and orders compared to consumer demand. The strategy of control has effects on the stability and bullwhip effect in supply chain system. Managing Supply Chain is very complex as it is a set of connections which involves multiple entities such as suppliers, manufactures, distributors, and retailers, encompassing their activities of moving goods and adding value from the raw material stage to the final delivery stage [10].

**Figure: 4. Supply Chain Challenges**

The bullwhip effect is a vibrant phenomenon in supply chains. It refers to the tendency of the variability of supply chains. It refers to the tendency of the variability of orders...
rates to increase as they pass through the stratum of a supply chain towards producers and raw material suppliers. The bullwhip effect reveals that there is a mild tremor in the supply chain management (SCM). It may be a mismatch between order and demand and thereby inventory becomes uncontrollable. If actions are not taken, it leads to a bigger problem over the supply chain. There are various measures of the bullwhip effect proposed in the literature. The most common measure is the ratio of the variance of the order rate to the variance of the demand rate, see equation [10].

\[
\sigma^2_{\text{order}} \quad \text{var} \{\text{orders}\} \\
\sigma^2_{\text{demand}} \quad \text{var} \{\text{demand}\}
\]

Bullwhip = \frac{\sigma^2_{\text{order}}}{\sigma^2_{\text{demand}}}

Figure: 5. (Bullwhip Equation)

Bullwhip creates unbalanced production schedules. These unstable productions schedules are the cause of a range of needless costs in supply chains. Companies have to invest in extra capacity to meet the high variable demand.

Multi Agent Based SCM has a drawback of no efficient coordination between agents. These agents are entities like suppliers, manufactures, distributors, and retailers and customers. Due to lack of coordination Multi Agent Based SCM have to suffer many problem regarding market demand and supply of product. That can be harmful to the company.

VI. PURPOSED SOLUTION

To reduce the effect of Multi based agent SCM, we will use an approach, that is call Orchestration Cloud Computing. Our research is to design a new approach to make a better automated arrangement, coordination, and management of complex computer systems. Which will reduce the total cost and the bullwhip effect can be considered. It is assumed that the supply chain echelons are committed to share their information completely. This assumption can be criticized and suspended in real world cases. Design of a new MAS which is capable of reducing the bullwhip effect in such environments, can be considered as another future research subject [8].

Orchestration describes the automated arrangement, coordination, and management of complex computer systems, middleware, and services. It is often discussed as having an inherent intelligence or even implicitly autonomic control, but those are largely aspirations or analogies rather than technical descriptions. In reality, orchestration is largely the effect of automation or systems deploying elements of control theory [9].

This usage of orchestration is often discussed in the context of service oriented architecture, virtualization, provisioning, Converged Infrastructure and dynamic datacenter topics. The orchestration in this sense is about aligning the business request with the applications, data and infrastructure. It defines the policies and service levels through automated workflows, provisioning, and change management. This creates an application-aligned infrastructure that can be scaled up or down based on the needs of each application. The orchestration also provides centralized management of the resource pool, including billing, metering, and chargeback for consumption. For example, orchestration reduces the time and effort for deploying multiple instances of a single application. And as the requirement for more resources or a new application is triggered, automated tools perform tasks that before could only be done by multiple administrators operating on their individual pieces of the physical stack [11].

VII. TOOLS

Business Process Execution Language (BPEL), short for Web Services Business Process Execution Language (WS-BPEL) is an OASIS standard executable language for specifying actions within business processes with web services. Processes in BPEL export and import information by using web service interfaces exclusively.

BPEL design goals

There were ten original design goals associated with BPEL:

- Define business processes that interact with external entities through web service operations defined using WSDL 1.1, and that manifest themselves as Web services defined using WSDL 1.1. The interactions are “abstract” in the sense that the dependence is on portType definitions, not on port definitions.
- Define business processes using an XML-based language. Do not define a graphical representation of processes or provide any particular design methodology for processes.
- Define a set of Web service orchestration concepts that are meant to be used by both the external (abstract) and internal (executable) views of a business process. Such a business process defines the behavior of a single autonomous entity, typically operating in interaction with other similar peer entities. It is recognized that each usage pattern (i.e., abstract view and executable view) will require a few specialized extensions, but these extensions are to be kept to a minimum and tested against requirements such as import/export and conformance checking that link the two usage patterns.
- Provide both hierarchical and graph-like control regimes, and allow their use to be blended as seamlessly as possible. This should reduce the fragmentation of the process modeling space.
- Provide data manipulation functions for the simple manipulation of data needed to define process data and control flow.
- Support an identification mechanism for process instances that allows the definition of instance identifiers at the application message level. Instance identifiers should be defined by partners and may change.
- Support the implicit creation and termination of process instances as the basic lifecycle mechanism. Advanced lifecycle operations such as “suspend” and “resume” may be added in future releases for enhanced lifecycle management.
- Define a long-running transaction model that is based on proven techniques like compensation.
actions and scoping to support failure recovery for parts of long-running business processes.

- Use Web Services as the model for process decomposition and assembly.
- Build on Web services standards (approved and proposed) as much as possible in a composable and modular manner.

VIII. Conclusion

BPEL is an orchestration language, and not a choreography language. The primary difference between orchestration and choreography is excitability and control. An orchestration specifies an executable process that involves message exchanges with other systems, such that the message exchange sequences are controlled by the orchestration designer. Choreography specifies a protocol for peer-to-peer interactions, defining, e.g., the legal sequences of messages exchanged with the purpose of guaranteeing interoperability. Such a protocol is not directly executable, as it allows many different realizations (processes that comply with it). A choreography can be realized by writing an orchestration (e.g., in the form of a BPEL process) for each peer involved in it. The orchestration and the choreography distinctions are based on analogies: orchestration refers to the central control (by the conductor) of the behavior of a distributed system (the orchestra consisting of many players), while choreography refers to a distributed system (the dancing team) which operates according to rules (the choreography) but without centralized control.

BPEL’s focus on modern business processes, plus the histories of WSFL and XLANG, led BPEL to adopt web services as its external communication mechanism. Thus BPEL’s messaging facilities depend on the use of the Web Services Description Language (WSDL) 1.1 to describe outgoing and incoming messages.

In addition to providing facilities to enable sending and receiving messages, the BPEL programming language also supports:

- A property-based message correlation mechanism
- XML and WSDL typed variables
- An extensible language plug-in model to allow writing expressions and queries in multiple languages: BPEL supports XPath 1.0 by default
- Structured-programming constructs including if-then-else-if-else, while, sequence (to enable executing commands in order) and flow (to enable executing commands in parallel)
- A scoping system to allow the encapsulation of logic with local variables, fault-handlers, compensation-handlers and event-handlers
- Serialized scopes to control concurrent access to variables.

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