Impact of Information Systems on Quick Response Programs

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Abstract A quick response (QR) program is a proven system to deal with the ever changing customer's demand and requirements. Effective information system is one of the backbones to have a successful QR program. This paper discusses how each of the recent technological developments in information technology (IT) has impacted QR program. This paper also discusses the steps that companies need to take in order to take complete advantage of these IT developments, as well as the directions of where IT and QR are heading.

Keywords Information systems · Information technology developments · Quick response

1 Introduction

Rapid technological developments, shorter product life cycles, and increased customer expectations have reshaped how business operates. To survive, it is essential for the firms nowadays to be able to meet the ever changing business situations. Companies need to collaborate with the lower and upper echelons in the supply chain to be able to compete since they have exhausted most of the opportunities to improve internally. With the ever more fragmented customers, companies also need to be able to react quickly to customer's demand and changes. Supply chains simply must be more efficient and effective so that goods, funds, and information can travel fast. Handfield and Nichols (1998) estimated that the costs of the flow of materials through the supply chain are approximately 75% of the total cost.

Companies have for long been relying on quick response (QR) program to deal with various customer's demand and changes. Inefficiencies in the supply chain

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could lead to extra inventories and unnecessary production and long delivery lead times, which may result in lower profit margins and customer satisfactions. QR program is aimed to minimize production and delivery lead times. QR is based on a combination of the just-in-time (JIT) and Information Technology (IT) systems (Birtwistle et al. 2006). Unlike lean concept, which is suitable when demand is relatively stable and customer requirements are more uniform, QR concept is suited well when demand is volatile and customer requirements are more varied (Christopher and Towill 2001). The impact of successful QR in certain industry such as apparel industry could be substantial (Choi et al. 2006).

Mohr and Nevin (1990) described communication as the glue that holds together a channel of distribution. To manage communication flows effectively and efficiently, we need to successfully identify, analyze, and coordinate the interactions among the entities. A study done by the National Institute of Standards and Technology (NIST) found that poor data integration in the supply chain is costing manufacturers billions of dollars each year (NIST 2004). It is clear that an effective coordination throughout the entire supply chain will significantly increase the firm's capability to compete in the market place. SCM systems should be able to facilitate the synchronization of the entire supply chain as they can assist a firm in integrating internal business processes within the corporate boundary so that all internal function areas can operate in synchronization (Tarn et al. 2002).

On these fronts, IT has been a godsend for supply chain management. Schnetzler and Schonsleben (2007) showed that information management has an impact on all target areas of SCM, that is, quality, delivery, reliability, delivery lead times, flexibility, assets, and costs. Hitt and Brynjolfsson (1996) estimated that 40% of the new capital equipment investment in the US is allocated to technology. A survey by Gartner/Dataquest indicates that about 40% of the surveyed companies would increase their spending this year than last year on supply-chain software (Violino 2004). According to ARC Advisory Group, the quest for efficient supply chains led companies worldwide to spend more than $5 billion on supply-chain-management technology last year, which expected to grow to more than $7 billion by 2008. Even during global economic crisis, IT spending is still expected to grow at 2.3% in 2009 (Campbell 2008). Recent developments in IT have significantly reshaped the supply chain behaviors in the last two decades. For example, Sarbanes-Oakley Act introduced in 2002 was affecting the way the firms formulate their supply chain's information technology strategies (Tirschwell 2004).

Much of the current interest in linking information technology to supply chain management research is motivated by the possibilities that are introduced by the abundance of data and the savings inherent in the sophisticated analysis of these data (Sridharan et al. 2005). Information is crucial to the performance of a supply chain because it provides the basis on which decisions are made. The same goes for QR program. QR strategies are dependent on building long-term relationships, sharing information and investment in technology and facilities with suppliers (Birtwistle et al. 2006). A successful QR system has to quickly catch the information from day-to-day transactions, and hence needs to consider IT and non-IT solutions and procedures to improve knowledge sharing, storage, delivery, and application

(Lo et al. 2008). Therefore, IT strategy plays two important components in QR program, namely to facilitate and maintain efficient and timely information sharing across the supply chain. Supply chain's success would then be dependent on the accuracy and velocity of the information provided by the supply chain members.

Effective information systems allow not only the collection of data across the supply chain, but also the analysis of decisions that maximize supply chain profitability. Gunasekaran and Ngai (2004) argued that it is not possible to achieve an effective supply chain without IT, as it enables the management and exchange of information as well as the integration of the trading partners along the supply chain. The primary function of information technology in the supply chain is to seamlessly link the points of procurement, production, and delivery. This gives a significant benefit to the firm by greatly easing the ability to share information (such as point-of-sale data, inventory, forecast data, order change, and sales trends) in a relatively quick and inexpensive manner. For example, with the adoption of EDI, web service, service-oriented architecture (SOA), RFID, etc., the supply chain partners can communicate and conduct business with downstream and upstream partners electronically, and thus realize zero information latency and full supply chain visibility. This also allows planning, tracking, and estimating lead times based on real-time data. By improving their information systems, Longs Drug Stores' inventory at its distribution centers has decreased to 65% since 1997, which translates to $36 million annual savings (Lee 2004). These improvements in turn help upstream partners to respond to the downstream partner's requirements quickly and enhance value-adding services to customers (Au and Ho 2002). All these efforts are expected to streamline, integrate, and speed up the business processes from production to delivery.

In this paper, we wish to accomplish two main objectives. First, we would like to detail how each of the recent technological developments in IT have impacted QR. Second, we would like to review the steps that companies must take in order to take complete advantage of these IT developments. This will also raise some important issues that we feel researchers should address. We will conclude this paper by discussing the directions in which the interaction between IT and QR is heading.

2 Recent IT Developments and Their Impacts on QR

Popular information systems that have had a significant impact on the day-to-day supply chain operations include electronic data interchange (EDI) and point of sales (POS), RFID (radio frequency identification), enterprise resource planning (ERP), customer relationship management (CRM), and collaborative planning, forecasting, and replenishment (CPFR). The following subsections detail on how each of these developments has affected QR performance.

2.1 Electronic Data Interchange and Point of Sales

Electronic data interchange (EDI) software is designed to automate inter-organizational communication and thus improve the effectiveness of QR program. EDI is the use of standard electronic formats for the creation, transmission, and storage of documents, such as requisition, quotation, purchase orders, and invoices (Owens and Levary 2002). According to Giga Research, 88% of larger enterprises used EDI for supply chain communications because of the fewer errors and lower cost per transaction over manual processing methods (Brockmann 2003). Boyson et al. (2003) argued that electronic information exchange leads to reduction of errors and increased efficiency of processes. EDI connects the databases of different companies. For example, order placed by a company is transmitted directly from the company's system to its supplier's system. Supplier's system then transmits the billing information directly to the ordering company's system.

In its early use, EDI allowed companies to utilize material requirements planning (MRP) to inform suppliers of the upcoming orders by providing them with access to the database of planned orders. Although this approach was innovative at that time, it still represented only a limited sharing of information between the supply chains. In supply chain management, EDI is a means of sharing information among all members of a supply chain. Additionally, shared databases can ensure that all supply chain members have access to the same information, providing visibility to everyone and avoiding problems such as the bullwhip effect. Moreover, EDI system contributes to cutting lead times by reducing the portion of the lead time that is linked to order processing, paperwork, stock picking, transportation delays, and so on.

Cash and Konsynski (1984) discussed the impact of electronic links such as EDI to the inter-organizational system. They argued that electronic links, in addition to improving efficiency, would change the power balance between supplier and buyer relationship, and in most instances, shift the competitive position of intra-industry competitors. Clemons and Row (1993) studied the impact of EDI on manufacturer and retailer relationship in the consumer packaged goods industry. They concluded that resistance by the expected adopters limits the potential strategic benefits of EDI. Dearing (1990) studied the strategic benefits of EDI in the supply chain. He classified the benefits into three major categories, namely direct, indirect, and strategic benefits. Mukhopadhyay et al. (1995) studied the cost effectiveness of implementing EDI at Chrysler Corporation. They found that Chrysler successfully lowered the operating costs associated with carrying inventories, obsolescence, and transportation. They estimated that by implementing EDI, Chrysler saved $220 million annually. Chatfield and Yetton (2000) examined the strategic payoff of EDI. They argued that EDI impact on strategic performance depends on the level of EDI embeddedness by moderating the impact of EDI adopter use on initiator strategic benefits.

POS, on the other hand, is an integral part of EDI system. POS data transfer system provides a distributor/manufacturer with real-time information on what is selling at the retailers. Weber and Kantamneni (2002) examined the benefits and barriers of adopting POS and EDI in retailing business. They concluded that the retail managers see the adoption of POS technology as an operational and tactical decisions, while the adoption of EDI technology as a strategic decision. Retailers, on average, carry 2 months of inventory of their suppliers' products (Aiyer and Ledesma 2004). At that rate, companies must look at more accurate and efficient ways to create reliable forecasts and manage inventory in the system. POS data are viewed by many as the answer. The major benefit of using POS data is that it reflects the true sales. This leads to a more efficient inventory replenishment, which ultimately leads to customer-driven replenishment (CDR). POS also allows companies to employ more responsive and real-time pricing strategy. The Beer Store, for example, is using POS data to automatically alert their system to modify their pricing for in-stock brand or package configuration of beers when particular item is out of stock (Gentry 2004). Ko and Kincade (1997) studied the impacts of various QR technologies on time/availability, store environment, and value-added service for apparel retailers. They found that POS improves the retailer's performance although the effect is being moderated by the size and type of the store.

The effect of sharing POS data among supply chain members is, however, not clear. Lee et al. (2000) study the effect of information sharing when the demand is nonstationary AR(1). They showed that the manufacturer will benefit significantly when retailer shares their POS data. Using an experimental study, Croson and Donahue (2003) investigate whether sharing POS data among supply chain members reduce the bullwhip effect when the demand distribution is known. They showed that when demand is stationary and stable, sharing POS data can help reduce the bullwhip effect by helping upstream suppliers to better anticipate the customer's demand. When the demand is nonstationary and unknown, in contrast to Lee et al. (2000), they showed that sharing POS data can bias upstream player's demand forecast. This finding is also consistent with that of Raghunathan (2001). He found that the parameters of the demand are known, and sharing POS data is insignificant since the manufacturer can utilize available order history to forecast the demand.

EDI implementation is expensive and complicated; therefore, it typically is applicable for larger companies with huge initial investment. Nowadays, many companies along a supply chain have adopted SOA, which allows for widespread sharing of services (e.g., real-time information) among trading partners. SOA can be implemented by the internet-based languages and protocols such as extensible markup language (XML), universal description, discovery, and integration (UDDI), web services description language (WSDL), and simple object access protocol (SOAP).

2.2 Radio Frequency Identification

One technology that will increase a firm' supply chain visibility is radio-frequency identification (RFID). RFID is a wireless technology that identifies objects without having either contact or sight of them (Levary and Mathieu 2004). RFID is basically a chip bearing a unique serial number affixed to, for example, a container, a pallet. The reader receives a signal from RFID tag carrying the item's serial number, which logs the item's location and time in an online database, creating a detailed history of each item's movement. The data obtained from RFID could be fed directly into ERP system, allowing company to track and operate on a real time basis. The tag of RFID can be active, passive, or semipassive. Active tag broadcasts information and require a power source, while passive tag just responds to queries without power source. SAP and PeopleSoft (now Oracle) had made a significant investment to modify their existing system software for RFID to prepare applications for collecting more data more frequently (Bacheldor 2004).

Firms are expecting RFID to bring improvements on inventory status, tracking and management of assets, and responsiveness and customer service. The technology is deemed to be so important that some large retailers require their vendors to employ RFID. In 2003, chain store giant, Wal-Mart, decreed that its 100 leading suppliers should all be RFID equipped by January 2005 (Holland 2004). Bednarz (2004) reported that United Parcel Service (UPS) is under the gun to begin tagging cases and pallets with RFID labels to comply with mandates from Wal-Mart, Target, Albertsons, Best Buy, and other retailers. The number of firms that are using the technology is also increasing. Aberdeen survey revealed that 5% of the companies – primarily in the consumer goods sector – planned to deploy RFID by June, 11% within 6 months, 34% within 12 months, and 39% within 2 years (Violino 2004). RFID has also been adopted in the apparel industry. Jones Apparel Group is pioneering a program to assess the benefits of applying passive RFID technology (O'Connor 2008). Chow et al. (2007) reported an integrated logistics information management system case study among supply chain players. They found that by integrating RFID and IT companies can significantly improve their logistics functions performance. They showed that companies can reduce their average inventory by 27%, out-of-stock frequency by 68%, and average delivery time by 32%. de Kok et al. (2008) studied the impacts of RFID implementation in the situation where inventory is sensitive shrinkage. They found that break even prices of the RFID implementation are highly related to item's value, shrinkage percentage, and remaining shrinkage. With the implementation of RFID technology, the visibility and velocity of a supply chain can be dramatically improved; furthermore, with the combination of RFID and POS data, the true demand information can be determined since the retailer can estimate the lost sale (Simichi-Levi et al. 2008).

2.3 Enterprise Resource Planning

An enterprise resource planning (ERP) system is a broadly used industrial term to describe the multi-module application software for managing an enterprise's suppliers, customers, and functional activities. ERP software systems are designed to link and integrate the various business processes of enterprises. An ERP system uses a single database and a common software infrastructure to provide a broader scope and up-to-date information. This allows the ERP system to integrate all aspects of the company, such as financial, production, supply, and customer order information. Companies can keep track of materials, orders, and financial status efficiently and coordinate manufacturing and inventory across different locations and business units. The industry views ERP system as a tool that enables them to have higher efficiency by enabling them to move financial and other data speedily from one department to another department (Holt 1999). ERP software can also be used to integrate internal business activities of a multi-facility organization, or enterprise, to ensure that it was operating under the same information system to achieve better coordination across the supply chain. Furthermore, ERP software can also support operations functions such as production scheduling to enable company to quickly respond to customers' demand, high quality of product, reliable delivery, etc. (Metaxiotis et al. 2003). For example, Microsoft Window's client-based and object-oriented QR tool was designed to "augment ERP applications with more precise and constraint-based scheduling of both materials and resources" (Hickey 1999).

Although the system promises significant benefits, this, however, comes with big costs and risks. ERP implementation requires flexibility and risk tampering as the project cannot be completed within a short period of time; in fact, it is an ongoing process. ERP systems are complex, and implementing the system can be a difficult, time-consuming, and expensive project for companies. Implementation can take many years to complete and cost tens to hundreds of millions of dollars. Moreover, even with significant investments in time and money, there is still no guarantee of the outcome. Cliffe (1999) quoted that 65% of executives believe that ERP systems have at least a moderate chance of hurting their businesses because of the potential for implementation problems, which may disrupt the day-to-day operations. Davenport (1998) argued that ERP system is difficult to implement and expensive. He also argued that most ERP system projects fail during the implementation stage. Umble and Umble (2002) discussed ten factors that may lead to implementation failure. In the survey that they quoted, 77% of respondents believe that poor planning and management are major contributors for the implementation failure. It then follows by change of business goals during the project (75%) and lack of business management support (73%). Umble et al. (2003) presented empirical findings on the implementation and critical success factors of ERP projects. Barker and Frolick (2003) examined the failure of ERP implementation at a soft drink bottler company. They argued that this company undermined the importance of involving, supervising, recognizing, and retaining those who work or will work with the system. O'Leary (2002) offered a discussion on when is it appropriate to use heterogeneous expert opinion as a basis for research on ERP systems.

ERP systems have continued to evolve in the twenty-first century. ERP systems are also designed to take advantage of Internet technology, and users are able to share information and communicate via the Internet. By the second generation of ERP (ERP II), vendors had learned to create Web-centric systems by consolidating data and allowing dynamic access from various clients. One of the latest developments is the integration of e-business capabilities to use the internet to conduct business transactions, such as sales, purchasing, inventory management, and customer service. ERP systems provide vast amounts of data for analysis. Software vendors have developed powerful new analytic tools and applications that capitalize on ERP's central repository of data. Examples of such software systems are customer relationship management (CRM), supplier relationship management (SRM), advanced planning and optimizer (APO), and collaborative commerce (CPC). Capgemini's recent survey revealed that the top five investments in supply chain technology for 2005 were CRM (38%), demand planning (35%), warehouse management system (33%), supplier integration (32%), and ERP (31%), indicating a slight shift away from traditional transaction data systems towards those that link supply and demand more closely (Capgemini 2004)

ERP aims to improve internal efficiency by integrating the different parts in the organization. The proliferation of ERP systems forces companies to provide communication and information flow between supply chain agents, overcoming natural boundaries (Tarn et al. 2002). Therefore, integration of ERP and QR is a natural and necessary process as their successes rely on a very similar framework that is the accuracy and velocity of the information flow. Actually, ERP systems help support a variety of QR manufacturing by providing real-time information access, improving responsiveness and shortening lead time along a supply chain. The future of ERP is to improve the supply chain and foster greater collaborating across many different locations and business units, and hence more responsive QR. For example, coordinated with other components such as product lifecycle management, CRM, procurement, SCM, the Oracle ERP system has become an integral part of Oracle E-business suite.

2.4 Customer Relationship Management

Customer relationship management (CRM) plays a very important role in QR program as it connects company with its customers. CRM is software that plans and executes business processes that involve customer interaction, such as sales, marketing, fulfillment, and customer service. CRM allows real-time order submissions, which results in an improved customer service. As soon as a customer places the order, the system confirms adequate inventory, verifies order receipt, and goes immediately to the warehouse for delivery. CRM changes the focus from managing products to managing customers. In CRM, all data go into a data warehouse, where it is analyzed for hidden patterns (called data mining) and from which predictions of future behavior are made. For example, in apparel and footwear industry, it was found that 34% of men purchasing shoes were republicans (Jordan 2004). MedicalDispatch adopted Sendia's WorkSpace CRM wireless software to shorten the company's sales cycle by around 50% (from 61 days to the average of 31), which leads to the company's QR to the market (Beasty 2006). CRM allows firms to integrate database marketing strategy to their organizations to achieve better customer segmentation (Weinberger 2004). In addition to collecting and analyzing data, CRM provides decision support for forecasting demand, demand management, pricing products and services, quoting order delivery dates, and planning for customer service needs. The apparel retailers can use data mining to analyze POS data, and then to forecast size, color, and consumer's purchasing habits (Suzette 1998).

2.5 Collaborative Planning, Forecasting, and Replenishment

Collaborative forecasting and replenishment (CPFR) is a web-based standard that empowers vendor-managed inventory and continuous replenishment by making joint forecasting (Simchi-Levi et al. 2007). It enables firms in the supply chain to plan, forecast, and replenish inventories in a collaborative manner. With CPFR, parties exchange electronically sales trends, scheduled promotions, and forecast. This allows the participants to coordinate joint forecasts by working on their forecast differences. Sharing forecasts with other partners can result in a significant decrease in forecast errors and inventory levels. As a result, CPFR could take QR to the next level (Margulis 1999).

Latest CPFR model comprises four major iterative collaborative activities: strategy and planning, demand and supply management, execution, and analysis. Each activity also includes two tasks. The CPFR model is applicable to different scenarios. For example, collaborative assortment planning, one of the CPFR scenarios, is suitable for apparel and seasonal goods. Internet-based CPFR can coordinate the requirements planning prices among upstream and downstream supply chain partners for demand creation and order fulfillment activities, and thus to shorten the lead time (Bowersox et al. 2010).

3 How Should Companies Respond to Advances in IT?

It is not an exaggeration to say that QR has not fully exploited to the changes in information technology. By using the available information in a superficial manner, the companies are not taking full advantage of the information available to them. The main reasons for such an incomplete use of information are as follows:

Supply chain design: The strategic design of a supply chain (e.g., location and number of facilities, operating policies) has been determined long before the information was available. Now that the information is available, to make the best use of it, it may be necessary for the supply chain to be redesigned. Many companies have failed to recognize this need for redesign and have instead decided to stay with the old design while trying to make the best use of the available information. As a result, QR captured only a fraction of the IT benefits.

Decision making process: It is reasonable to say that most of the decision making in the current supply chains is very much manual as well as subjective, and makes very little use of a rigorous and automated decision making process. As a result of this manual interaction, the voluminous data that has recently become available cannot be analyzed, interpreted, and incorporated into the decision making process. This in turns hinders a speedy decision making on new customer's demand and requests.

Existence of supply chain metrics: One of the major issues associated with any supply chain collaboration project is the manner in which the benefits will be shared among the participants. To achieve a mutually agreeable sharing of the benefits, one must be able to exactly compute the benefits associated with a particular strategy. In the current state of affairs, the financial picture at most companies is so muddled (with significant time lag) that it is almost impossible to determine the improvements realized from a supply chain collaboration endeavor. If the information-based collaboration is to proceed, the issues associated with QR and SCM metrics must be adequately addressed.

Based on the observations detailed above, it is imperative that companies address some or all of these issues before we can say that the IT-based revolution is complete. In the presence of information, it is necessary for companies to change the design and management of their supply chain to better support the QR program. As such they should obtain the ability to evaluate alternative supply chain strategies available, pick the one that is most information compatible. The companies must also develop a user-friendly, automated, rigorous decision making process with as little human or subjective involvement as possible. Such an approach will be better able to handle the voluminous data that is being transmitted across the supply chain. The in-built algorithms should be able to automatically incorporate the information and produce the appropriate decisions. In addition, they must be in a position to accurately and in a timely manner calculate their financial position.

4 The Existing Problems and Direction for Potential Future Research

Although the aforementioned information systems have been widely implemented, there is a significant disagreement over the actual benefit they have provided. It has been reported that a large percentage of QR and supply chain IT projects have failed to recoup their investments. To understand why it is so, it is necessary to look at how supply chains are managed in the presence of information. In addition, one needs to be able to compute the benefits of such endeavors and be in a position to estimate an ROI. A lot of work has already been done in this direction and more needs to be done.

The ability to access information across the supply chain and use it in real time provides various opportunities. Inventory requirements for buffer stocks are likely to be lower, because the uncertainty in forecasts and demand can be reduced across the supply chain. Allocation of inventory to different retail outlets or customers as part of order fulfillment can be done more effectively when there is visibility about the number and type of inventory located at the different sites in the supply chain.

As more supply chain execution information becomes available, firms can plan for future operations using advanced planning and optimization (APO) tools. The ability to share information creates an opportunity for firms to have collaborative planning and design, which removes the inefficiencies in these processes.

A number of papers have dealt with this type of information flow in the QR and supply chain and the effect of that on its performance. Palmer and Markus (2000) studied the relationship among business process change, degree of new information technology, and firm performance. They found that QR technology adoption at a minimal level is associated with higher performance. Cachon and Fisher (2000) showed that timely information sharing helps speed up decision making and often results in shorter lead times and smaller batch sizes. Russell and Hoag (2004) argued that the most significant challenge in implementing IT is not the technical portion but the human portion. A number of social and organizational factors, such as user perceptions, culture, communication, and leadership, affect the success of an implementation. Sparks and Wagner (2003) compared four retailing concepts that promote supply chain efficiencies: QR, ECR, CPFR, and Retail Exchange. They overviewed the fundamental IT differences between the four concepts. Brown and Buttross (2008) studied the financial impact of a QR program. They found that QR adopters did not benefit as expected in terms of their profitability, cost efficiency, and inventory level performances.

A lot more needs to be done before one can rest be assured that supply chains are making the best use of information systems. Here we list three of them: (1) The information systems are usually imposed on the existing supply chain setups. If one wants to maximize the impact of the information systems, there needs to be a significant redesign of the supply chain structure or operational policies; (2) It is necessary to capture the strategic/competitive behavior of the participants. If the gaming tendencies of the participants are ignored, the policies developed could result in inferior performance; (3) Information in the real world is often inaccurate and this has to be incorporated into the analysis. To have the most impact, it is necessary for the QR researchers to incorporate these complexities in the models they study. For example, supply chain partners can adopt recent IT technology standards such as RosettaNet or ebXML to manage their business process. Furthermore, enterprises have to rely on business analytics to improve their decision making process (Davenport 2006).

5 Conclusions

It is fair to say that this is the start of a fruitful relationship between IT and QR, and the interaction could be mutually beneficial for a long time. To improve demand predictability and supply chain coordination in more volatile environments, it is more cost efficient to invest in IT than in manufacturing flexibility (Khouja and Kumar 2002).There will be new developments in information technology, and QR programs will evolve to incorporate these developments and improve their operation. On the other hand, QR could demonstrate a need, and an appropriate technology will be developed to address it. Thus the interaction should be a bi-directional one. In recognition of the mutual benefit, it behooves that the researchers in IT and QR work collaboratively on these issues.

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