Transforming Supply Chains by Internet of Things:A Review of Scope and Challenges

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Abstract:

Supply chain of a product is integration of systems used for transforming raw material to finished product and ensuring its availability to end user. Supply chain involves three basic flows of material, money and information. Information flow has become more advanced with respect to application of technology (Information system). Internet has been pivotal in transmission of information in all business decision links. Internet of things (IoT) is advancement in technology and its pattern projected in form ofnetwork of machines, system and toolsconnected one to another other for information sharing. Supply chains are seen as wide area of management where IoT may work as transformative force for advancing performances of supply chains. In present paper we had done a review of scope and challenges in transforming supply chains with help of IoT. This paper discussed how IoT can be used for transforming various supply chain activities like plan, make, source and deliver. Further review of various challenges of privacy and implementation are critically done.

Keywords: Supply Chain, Internet of Things, Security, Information Sharing

1. Introduction

Journey of a product from raw material supplier to customer have several stages which are linked together in a chain called supply chain in management. The supply chain of a product is integration of systems used for transforming raw material to finished product and ensuring its availability to end user. In a supply chain, there are physical, financial, and informational flows among different firms [1]. Efficient supply chain management (SCM) is a potentially valuable way of securing a competitive advantage and improving organizational performance [2].

The growth of usage of information technology (IT) in SCMis reasonforbetter output andgrowth symbols for companies [3]. An Inter-organizational Information System (IOIS) is an application of enterprise level IT. IOIS supports in reframingexchanges with partnering organizations [4]. Involvement of different companies is difficult activity.

IT provides support to management of such complex supply chain processes. There are several IT tools and techniques which sare application for facilitating, streamlining, and increasing the smoothness of communication in supply chain. Lambert & Cooper [5] insisted on integrating external and internal processes. For integration of such processes wide and advanced IT

applications are well known. IT connects internet and things. Today such combination of internet and things is broad term called internet of things (IoT). IoT may be understood as ever-changing worldwide infrastructure of network, which is self-configured, which have standard and cross-operating communication facilities, as suggested by ITU and IERC [6] based on standard [7] and interoperable communication protocols. Here physical and virtual 'things' are identified as different sources or ports and they are connected to each one.

Application potential of IoT is wide across the industries and functions. Present practices of IoT ensure about future applications in all around and will be key enabler for competitive advantages. The case becomes more direct in SCM where IoT technologies give room for wider application [8]. With support of IOT, controlling and monitoring is possible in complex environment also.

IoT amalgamates all needed information for set up of business chain, analyses the mutual dependencies between those parts of information instantaneously, and analytics strongly usage it for optimizing supply chain functions. The internet has helped the world in connecting individuals at very high speed and with high coverage.

The next level of advancement is interconnections of various things for better exchange of information. As it looks that IoT may work as transformative force in making of competitive supply chains; its scope widens all around. But the same there is extreme need to understand how IoT can be utilized well without lesser security and privacy loopholes for organizations.

2. Literature review

Supply chain management is function of operations management which is responsible for all kind of 'supplies' in chain of efforts for satisfying customers. Supply chain is interlinking of different functions like procuring, manufacturing, storing and delivering. SCM is about managing three important flows of material, finance and information within and wide the organizations. There are number of works done in area of SCM, IT and IoT.

We are discussing here important works done in the above areas to understand how IoT can work as transforming force for supply chains:,"Internet of Things" indicates towards future direction of machines, how they are being used for working and automation, and their intelligence and capabilities to receive stimuli and respond to the external situations[9]. Concept of IoT was highlighted when International Telecommunications Union (ITU) presented its first insight IOT [10]. ITU defined IOT as global network of devices and systems which have capacity to interact with one another.

Table 1: Progress of Major IoT Techniques (Projected)

	Up to year 2010	Year 2010- to 15	Year 2015 to 20	Projected after year 2020
Network	Sensor (transducer)base station and nodes-based networks	Self Organizing Networks (SON), Sensor based location visibility-networks with more than one connecting topology (Hybrid)	Dumb network and intelligent computer network	Cognition based networks, learning and healing by system itself
Computer software and Algorithms	Relational database integration for MIS Relational database management system based on And Sensor middleware distance/Localization algorithms	Open semantic software modules, Composable algorithms for interdependent cyber physical system, Next generation internet of things based social software And ERPs	Goal-oriented software, Things-to-things -partnership environments	User-oriented applications, imperceptible IoT Easy to install IoT software, Objects to Human collaborations, Internet of things for all
Hardware	Radio Frequency Identification tags and sensors, -Mobile devices-based sensors -Near field communication in Smartphone, Micro electrochemical systems	Multiprotocol reader such as used in mobiles, sensors and data actuation devices, Advance, low cost sensor-based tags.	Sensors like biochemical with smart features, Tiny sensors	New materials and nanotechnology
Area of Data- Processing	Serial data processing and Parallel data processing for improving service characteristics	Frequency spectrum, Energy and data processing context	Situation specific data processing and data responses	Processing and optimization based on cognition (artificial level)

Source: Adaptation of Sundmaeker, et al. [12] (2010, page 74)

A. Internet of things

Lee and Lee [11] said that IoT may also be termed industrial internet where every object is connected with internet, which has emerged as advancement to technology. IOT is regarded among the most important future technologythe earlier works done reveals that following essentials of IoT technologies. Table 1 Shows projected progress in area of internet of things techniques. IoT techniques have backbone of network supported by structure of algorithms well supported by hardware and the data processing. IoT is supported by wireless communication technology. Wireless communication technology is supposed to be flexible for ease of use.

B. IoT in supply chain

Supply chain is inter-linkage of supplier, manufactures, warehouse, dealers and retailers who co-ordinate their functionswith objective of transforming raw material to final products [13]. SCM have objective of ensuring basic flow of information among the different parts of supply chain. Interconnectivity between different supply chain partners is responsibility done by technology, we name as information technology [14].

Concept of supply chain management talks about three basic flows- material, money (finance), and information. Technological developments had led the application of IT widely and vastly across functions and organizations in supply chain management. Organisations are tending towards creating edge over the competitors. Time, cost, quality and delivery are classical examples of competitive advantages. Speed, cost, quality and flexibility are new supply chains features [15]. Time of response and sources in business are considered as newest means of competitive advantages. Nelson [16] talks about empowering organizations with competitive advantages of information technology. While supply chain in formation system has been discussed as new face of competitive advantage. IOT technology implementation widely bring importance of influence of technology, society and completion from market Supply chain functions starting from procurement to distribution require high promptness and efficiency [11]. Value chain analysis and management of company is largely dependent on how efficiently organization is able to manage their flows in supply chain. The speed of linking, faster delivery and lower cost are now determinants of organization efficiency.

IOT for supply chain and other functions include sensing drivers, servers, communication devices, data analytics and lot of artificial intelligence, machine learning and decision-making tools. This all group technology has been successful in interconnecting the objects (Physical) and virtual (information) nodes for purpose of decision making.IOT has function of reconnecting information and objects in the loop. Smart manufacturing is one of the advancements which includes varied system efficiency

method of optimization of flows in chain, tracking and managing real time-based inventory, maintenance schedules on the bases of predictions, assets management base over information systems etc.

Major areas in SCM where IoT is deployed for different objectives are- In the areas of predictive analytics, IOT are being used for simulation modelling in decision support system. Where smart devices connected in loop are able to gather data and are bale in decision making and change in different situations. Supply chain data are most vulnerable in many situations. In such conditions smart technology based IOT is useful in managing the flows in SCs. The SCs which are based on such static data needs to fine-tune them self in real time for the purpose of ensuring high accuracy in information sharing and decision making. Intelligent network of automated systems provides chances of inter-organizational process optimization. But the cost is one factor which need to be given considerations. In IOT based SCM, decision making abilities of system have also impact over supply chain structure. Internet based supply chain restructuring is answer to this problem. Data based supply chain are now days easy to manage. The core supply chain functions like, plan source, make, deliver and return are all such areas where huge amount of data exist and is utilized. Inter-organization information systems are methods to manage such functions efficiently.

C. Scope of IoT in supply chains

In a supply chain, IoT technologies can improve customer service, revenue growth, profitability, and working capital deployment, and asset utilization, time to market, waste reduction, sustainability, equipment/product uptime, security, agility and risk mitigation. All functional and cross functional areas of supply chain management have finer scope of IoT. Most of all advanced technology in management is being used in SCM also. But still it is difficult to find the exact location of product. The IoT finds its scope in making the invisible in to visible [17]. The issue of faster, better and cheaper also creates scope for IoT. But at the same time challenges of magnitude, time and risk are there to determine the value of supply chain. Today information is key to decision makers; same is with supply chain managers also.

Fig. 1. Scope of IoT in SCM functional areas

Beyond these functional areas IoT is also being implemented in customer service performance monitoring, order processing and customer service, supply Chain Management budget forecasting etc. For having such benefits studies finds following essential IoT technologies which have scope in SCM.

Major IoT technologies which [11] are used in now days SCs follows:

a. The technologies which automatically identify and capture data from the target sources are common in usage. These Radio Frequency Identification (RFID) technology uses radio frequency, with a tag and reader.

b. Wireless Sensor Networks (WSN) -: These are made up of spatially distributed autonomous sensors-equipped devices to monitor different conditions. Low power wireless networks supported by advance circuits are being used in SCs [18]. WSN [15] are useful in transportation and logistics of refrigerated products [19]. WSN are further used in cases of tracking of goods and sensing maintenance schedules for the devices.

c. Middleware-: Different in between software embedded in software application are known as middleware. Developers are using these middle wares for the purpose of communicating and input and outputs. Middleware's also features hiding characteristics (hides information from one software which are directly not related with them)

d. Cloud computing-: The huge amount of data has demanded large storage. Cloud computing provides shared pooled, platform different users in this purpose. In case of IoT large amount of data is generated and needs to be shared by different partners of Supply chain. IoT supports as a back end for the purpose of handling, processing of such data.

e. Application for IoT: Different software in form of small applications are installed and used on devices, connected in supply chain. IOT applications are again considerable to effective measuring and evaluation mechanism. Effective monitoring and control mechanism are being used by collecting data on different performances. These applications are for the purpose of facilitating human-to device interface and vice versa. Device to device interactions are also supported by IoT applications in SCs.

f. IoT systems which are embedded with sensors and applications are generating large amount of data and transfer it to data analytics unit. Artificial intelligence tools utilize these all data for decision making.

D. Challenges in IoT

IoT faces all kind of challenges as faced by different new technology adoption. There are varied issues related to regulatory frameworks with respect to data collection, transmissions and storage in IoT. Process related challenges are still expanding day by day as we are going to widen the usage. Supply chains are one kind of business function where number of organizations and individuals are related for the business purpose. Inter-organizational relationship issues are still challenging. Technology at different partners level, there strategy, and objectives are

great challenges in deciding over IoT investments. Still organizations feel high level of risk in IoT. In supply chain managers have to consider the process, technology and other functional aspects of partnering organizations. Supply chain coordination (SCC) is one of the trusted methods managing SCs. In case of SCC the observations on parts and processes may be enhanced using IoT. Efficiency of SCM system, with higher productivity and reduced costs are other benefits which may be taken from IoT induction at same level. Challenges in IoT induction has been discussed in report of Gartner [20]. These are discussed as:

Fig. 2. Challenges in IoT deployment

a. Security Challenge-: As IoT has numerous devices are interconnected in a network of processes, so security threat arises. Recent studies show the high percentage of vulnerable and potentials of cyber-criminal for attacking on data and hacking. IoT transfers important data so it becomes important to have high level security protection on network. Security challenges may be handled by incorporating security solutions in different outputs, processes as IoT security measures lime firewall in devices and applications.

b. Data mining challenge-: In case of IoT large data is disseminated and stored so it becomes vital to use data mining tools. Data generated through various devices are streamed about different function like shipping, location, quantity etc. In case of data mining of IoT systems, it should be controlled and analyzed using mathematical and computational methods. For the purpose of capturing video and image data in SCM advanced methods should be used to overcome data mining challenges. Streaming, and mining of SCM sensors data also emerged as a challenge in present scenario.

c. Chaos challenge-: IoT deployment as a hyper accelerated innovation technology. The cycle of innovation in case IoT is speedy. In day to day life as challenges of data security, its transmission is emerging, similar kind of situations in IoT may result into chaos challenges in SCM too. Linking with server

and bandwidth and connecting with too many devices also create chaos.

d. Privacy Challenge-: Privacy has been a challenge in internet and interconnectivity; same is the case with IoT. Data privacy results into heavy cost involvements sometimes. But in case of several party involvements it becomes important to add privacy in system. Data output of different systems is Important in increasing efficiency and decreasing service providers' costs by streamlining operations. Privacy in system design itself is referred as consideration of privacy elements in system at very early and every stage of process [21]. Privacy challenges may be overcome with help of privacy by design.

e. Data management and server technologies-: In IoT sensors and servers interconnected with each other generate high volume of data which needs to manage at all stages. Investing in data management tools is again a challenge in IoT deployment. Server technologies which are used in interconnections are also needs to be modified as per the requirements.

3. Conclusion

IoT has several benefits to supply chain managers. The big part is IoT works on enhanced data collection. Decisions may be done on the basis of real time response. Improvements in devices and control are possible. Overall efficiency is improved with deployment of IoT in supply chains. IoT may be used for increasing output in situations where coordination of different systems is essential to manage the functions [22]. In previous decades SCM was dependent over control functions for reducing variations in different, processes, techniques and methods used for managing the functions of SCM. Now these difficult functions can be controlled and coordinated well with the help of interconnection of different technologies within network of SCs.

IoT enables the supply chain managers to have a watch over the different variation happening throughout the chain. Beside all these benefits there are various challenges too. In SCM, data generation, its collection and storage are a great challenge to data managers. Another vital challenge with data is its ownership, which further leads to privacy issue. When privacy is broken, the issue of security arises with generated data. The challenges of data processing, data warehousing, mining, and ownership need to be addressed [22]. Privacy of data coming out of IoT applications and sensors related with consumers and retailers are another challenge. Privacy of data while using third party logistics (3PL) is great concern. While having interaction of so many organization security and hacking issues needs to be addressed. Issue of privacy with respect to stakeholders needs to be addressed well while designing IoT systems. Fundamental unit of system-based technologies are data its analysis. Data analytics and its application in appropriate manner is important in case of IoT for SCs. The supply chains which have ability to advance analytical skill set will have competitive advantages and they can transform their traditional supply chain to IoT based supply chains.

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