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Using Supply Chain Management Approach for Message Forwarding for Internet of Things (IoT)

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Abstract: Kevin Ashton, an expert in RFID in 1999, first used the word "the Internet of Things (IoT)". As per the terms of technology, IoT is an environment that people understand in many different ways, depending and based on their requirement, point of view and purpose. This paper discusses the supply chains and its possible applications for job scheduling in the IoT framework. The supply chain management (SCM) is a means of providing facilities for delivery of services with the purpose of transporting materials for distribution to end of the chain or customers. SCM has the property of delivery tracking at every time while using the best possible path which augurs well with IoT resembling the dynamic route conditions. The study is further encouraged by the fact with Radio Frequency for Identification (RFID) being the assistive tracking technology for both SCM and IoT.

Keywords: Internet of things (IoT), Supply chain management (SCM), Response time

Introduction

IoT is a network connection spanning from computers, automobiles, homes etc. to realize a smart world. These objects works with the backbone of internet and Cloud to accomplish everywhere, everything and any time computing. IoT is also mentioned as the Internet of Everything (IoE) to represent the next innovation of the Internet modifying the human machine and machine-to-machine interaction in a new way. IoT goes to connect and cover everything useful in this world any place and time using a wired and wireless network devices which is used to make easy in our daily life like 4G-LTE, RFID, Bluetooth and Wi-Fi [1-8]. The efficiency of the system can be rated by analyzing the various Quality of Service (QoS) parameters considered in the process.

Supply Chain Management (SCM) is responsible for planning and execution of the objective of monitoring goods and services from one place to the other in the best possible time with the tracking information being updated at every moment. IoT, on the other hand refers to the network of wired or wireless objects working under some control. SCM ensures tracking and recordkeeping of the movement of goods in the chain starting from the supplier to the end retailer or customer. In IoT terms, it translates as the transfer of messages from the source node to the destination node (Cloud). SCM thus serves the purpose of efficiency improvement with a timely delivery of goods and services. With these advantages, the organization (IoT world) benefits both structurally (Qos) and financially (computational cost) and that too with customer satisfaction. The movement of goods at every step is timestamped for effective monitoring and rerouting, if necessary. This is realized using the support of Radio Frequency Identification (RFID) and Global positioning system (GPS) [9, 10]. A typical representation of Flow of Goods in SCM in IoT environment has been presented in Figure 1 [10].

The word "things" refers to the idea, which deals with the manufactured products and it will be a neighborhood of the extended net since they are going to be labelled and indexed by the makers throughout production. Customers read these tags information for updating their products every time and everywhere over wired and wireless technologies or mobile applications. Similarly, the IoT objects too can be equipped with identification and sensing in order to be known on the network in a safe way while

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communicating with the other objects. As of now, applications of IoT are covering various areas like transportation, power consumption, or even medical aid or healthcare to name a few. This is bound to increase in the future with more penetration of technology in our everyday life [11].

In SCM, there are three modules viz. supplier, container and distributor. Supplier is used to supply the various types of products to customers or users with the help of container and distributor unit. Synchronization between supplier and distributor is possible with the help of Internet of things (IoT). Global Positioning System (GPS) is used for monitoring the location of transported object's location and sending this information to the supplier for updating. When the object reaches the supplier, it can access these products using some authentication mechanism e.g. the open and close mechanism of door is controlled by relay. RFID tags therefore can be used for identification. The message of product delivery will be send to distributor regarding delivery of product as acknowledgement from distributor to supplier and the same updates can be relayed to the customer too[12].

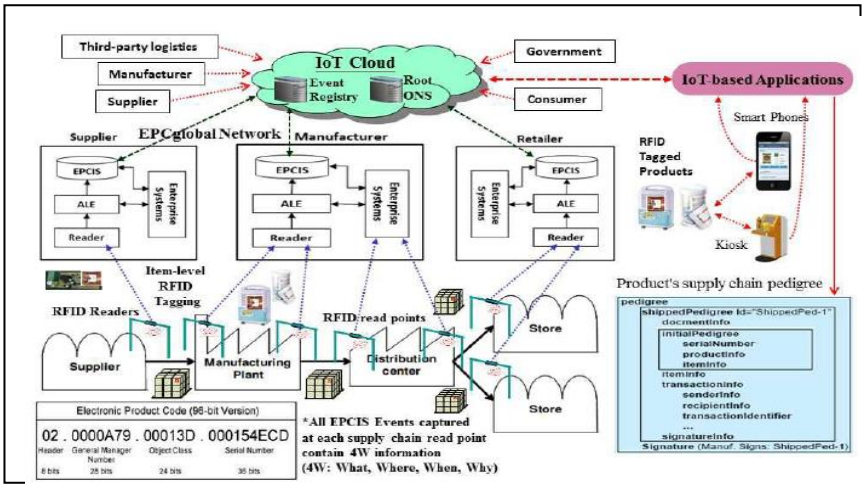

Fig. 1. Conceptual Flow of Goods in SCM in IoT Network

The information of products or materials is updated automatically through the internet so that supplier and distributor can use this information at any time for keeping the records. Supply chain management using IoT satisfies the supplier and distributor requirements. The objectives of Supply Chain Management using IoT are given below [12]:

- To satisfy the customers' requirements.
- To increase sale of products.
- To provide better service to customers.
- To enhance visibility of product delivery along with the supply chain.

Job scheduling and message forwarding in IoT environment is more complicated than performance optimization in SCM. The reason for the same being the dynamic and heterogeneous resources and environment. Therefore, a study of the mechanisms to schedule the jobs same as SCM with dissimilar workload features and QoS parameters gains vital importance. Finding fastest path between the source and the destination is one such problem qualifying the QoS optimization requirement [8, 13-14].

Related Work

In SCM and IoT environment, wireless and wired sensor networks data is a mixture of energy efficiency and sensing services abilities. A well-organized resource scheduling approach is will increase the total network lifetime; during which it selects a collection of wired and wireless sensing element devices/nodes to produce the desired sensing services in an exceedingly periodic manner. SCM using IoT is a very robust synergy implying significant contribution to our future economy. The constantly linked world of IoT opens new experiences into running supply chain tasks, with never before seen methods and applications with the ability to learn and correct the decisions dynamically.

M. Tu [10] is proposed the mixed research strategies to investigate the acceptance goals of SCM in IoT. The study explores the vulnerabilities and issues like reliability of the method, firm's expectations and benefits to the

providers to assess various features of IoT and SCM. H. Machado et. al. [15] proposed supply chain utilizing the advanced technologies to enhance industrial plant workflow, increase material following, and optimize distribution to maximize revenues. R. B. Dhumale et. al. [12] proposed RFID technology and the significant impact on the supply chain from the point of view of combination and execution. AT&T Internet for Business [16] suggested that in SCM, wearables and pallet sensors are always connected to the vehicles, resulting in the real-time data to dynamically improve the productivity and performance with live monitoring of shipments (computationally important messages in IoT). M. Wilson [17], K. Lee [18], P. Tadejko [19] and B. Cortés et. al. [20] suggested and explored the opportunity that the IoT brings with SCM. They pointed out the outcome that will help the manufacturer and the end user client with wealthier information and profound knowledge exploiting the supply network. SCM will keep using these propelled innovations to enhance production and work process. This will result in the improved quality of gadgets. Further, it will ensure the sources to be utilized viably too in real time by adapting to the changes rapidly. Vinod N. Sambrani et. al. [21] used Geographic information system (GIS) as a tool for mapping various constituents in the supply process being very important for SCM. Y. Rashed [22] proposed to provide a hypothetical premise on how organizations can utilize IoT to permit simpler access for data all through the association with negligible exertion. M. Merino et. al. [23] studied that the current management disciplines focusing on SCM seeking to optimize the performance by considering various parameters like time, cost, information and sequence of services. W. Liu et. al. [24] introduced the idea of SCM into a hybrid information spread structure for WSNs. This is very important with WSN being a core constituent of IoT. M. Z. Arokhlo et. al. [25] investigated the efficiency of the model of the ecological conditions considering multi-specialist framework for a road transportation network for SCM. J. Lee et. al. [26] proposed the supply chain network strategy issues e.g. position and distribution of facilities, and their routing choices to propose a heuristic for the SCM routing framework.

This work tries to explore the amalgamation of SCM with IoT in order to find the appropriate shortest path as QoS for the IoT network.

Problem Statement and Proposed SCM Basen IoT Message Scheduling

This section we discuss about the problem statement followed by an insight into the using SCM approach in IoT message scheduling in the work and the job model considered.

The Need: SCM and IoT

Due to the continuous advancements in the technology and massive research efforts, the affordability of mobile devices is being witnessed like never before. This is further aiding the growth of IoT with mobile devices being added continuously with the applications ranging from computational ones to smarter world including components like transport, finance, health care to governance. Gartner has predicted that the growth of IoT devices will "significantly alter supply chain leaders' information access and cyber-risk exposure." Michael Burkett, managing vice president at Gartner, takes this further: "It is important to put IoT maturity into perspective because of the fast pace at which it is emerging, so supply chain strategists need to be looking at its potential now" [18].

The new age transportation requires the efficient linking between the customers and their needs while considering the various constraints. SCM is an example of the planning based efficient routing mechanism for the efficient and timely delivery of data. SCM improves the resource availability for the reliable transport considering order, timeline, cost and safety for delivery of goods/messages in a secured manner between consumer and producers [23, 27-28]. The resemblance between the requirements of SCM and IoT is quite overlapping. Like SCM, IoT also needs the services/messages to be delivered in time with the essential QoS requirements like minimization of the response time and shortest path selection to realize the same inviting the research to exploit the features of SCM to be used in realizing smart world as promised by IoT.

SCM and IoT: Shortest Path Selection

Some serious issues associated with SCM while travelling across a road transport network could be stated as the accessibility, economic feasibility, geographic feasibility and energy consumption to name a few. The category of route is dependent on the physical circumstance of the devices in the route. A proper route selection in SCM and IoT ensures a good trip time thus reducing the wastage, energy consumption and wastage. This also has a

long-term effect on the company reputation reflecting on its efficiency. In IoT, it has prime importance as it optimizes the very important QoS parameter being the response time or the message delivery time. On the other hand, a poor decision in route selection destroys the company reputation in SCM and hampers the performance of the IoT scheduler with inferior realization of QoS parameters and possibly violated SLAs. When route has good condition then vehicles have reduced trip time. This demands the use of a Traffic Management Architecture (TMA) for SCM, which translates into Job scheduler for IoT. Both serves the same use of planning, management, information sharing and backbone infrastructure support for the underlying network. The traffic can be analyzed both using the greedy approach with looking at the neighboring area or the global approach with GPS based routing. Greedy approach augurs well with the dynamic IoT environment being true with SCM too by allowing the selection of the best path currently available. A recommendation system can be used to even accommodate the secured data transfer as per the pre agreed SLA. This may include the past performance matrices of the routes to assess and evaluate the parameters like speed (type) of the vehicle traffic translating to speed of the forwarding node, density variations or may be the weather dependence thereby including the geographical dependence [25, 29-31].

The main aim of this work is to present the similarity and appropriateness of SCM and IoT to work out the shortest and safest path in the SCM structure for the transfer of products or update/messages to and from the base/source node (working as a Cloud server) to the final end/destination node (working as a Client server) along the *N* stages. These stages can even be analyzed using the queuing network of *N* stages with the appropriate routing decision taken at each layer. The network can even be considered with a clustered approach with the routing decisions made by various cluster heads. However, both the methods have their own advantages and limitations. One such scenario of IoT message forwarding is presented in Figure 2.

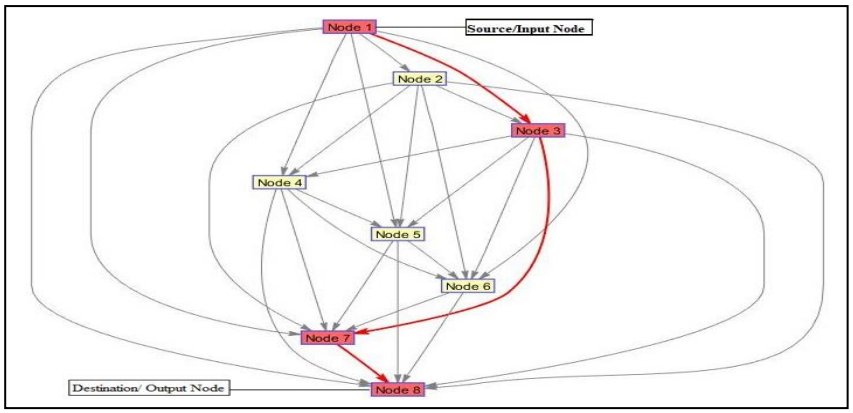

Fig. 2. Conceptual route selection in IoT Network

In SCM and wireless sensor networks (WSN), too there are a lot of components or functions bearing similarities. As an example, the data collection feature of sensors resembles the warehouse component of SCM where the goods are stored as a repository or to serve as the storage in transit. Just like energy conservation problem in WSN, SCM too requires the minimum efforts model for timely delivery of goods aiding the company's performance and reputation in longer terms. The cost minimization in SCM too is synonymous to the transmitting of data in the sensor networks [24].

The Job Model

The ultimate goal of the scheduling model is the selection of the appropriate web service in IoT and distributing the messages/jobs in turn from the source to the destination. Thus, one important consideration becomes that of selecting suitable web services among the feasible ones considering their appropriateness, QoS and SLA obedience. The jobs for such a system is considered either the computational jobs or the streaming messages generated from the sensors. The former case is handled by considering the job to be made up of either independent or dependent sub tasks represented in the form of a DAG. In the latter case, the job will be a stream of messages coming as packets that are to be analyzed for some QoS optimization and may be required to be delivered to either a Cloud datacenter or a destination node. Intermediate data filtering and processing can be done either considering the Fog or Edge computing or the Cloud. If the selected web service is closer to the current one, will result in lesser waiting time to eventually consume less power. The greedy approach further supports the dynamic behavior of the IoT network with short-term decisions taking place. Therefore, each job or update

information message is distributed into sub jobs/tasks, which depends on the priority of jobs and the sequence of data messages. Figure 2 presents a small scenario for selecting source to destination Nodes/Server paths in the *N*-stage IoT environment. A sample shortest path is shown between source base stations to destination base station using SCM approach considering minimizing the service delivery or the response time. A probabilistic path selection model can be considered as proposed in. Accordingly, the performance measurement of SCM in terms of the shortest path and other parameters like waiting time and the average queue length can then be performed. It can be assumed that each server follows the M/M/1 queuing model with some arrival rate and service rate [8].

The Challenges

The integration of SCM and IoT proposes an efficient way of scheduling the data on the IoT network. However, there are a number of issues that should be considered while adapting the same [32]. These issues are primarily the ones emanating from core IoT, Big data handling and WSN issues varying from both internal and external factors. There are challenges faced due to macro issues like globalization and connectivity to micros like optimizing the efficiency and operating cost for SCM translating to heterogeneous objects, networks and management policies and QoS optimization under the SLA framework in IoT [33]. To start with, security and privacy issues of the data while moving from one stage of the SCM network to the other is a big concern due to the unreliable nature of the platforms. Big data itself is a big issue because of the massive streams of data being generated that demands action. Due to a significant number of things communicating with one or the other object in the Big Data environment, the potential for the loss of security and data information increases enormously. It should be noted that there is a huge investment both in the terms of money and manpower to control the cost of logistics and operations in streamlining the activities in SCM translating into scheduling issues for the IoT. The job scheduling policy itself varies with the varying QoS considerations. Being an NP Hard problem opens up a number of ways to address the same depending on the requirements. WSN constitute the major portion of IoT with RFID sensors being placed for goods/data tracking. This issue also brings security as a concern due to the integrity of the SCM with RFID for a possible monitoring by unauthorized sources. The current computing scenario has a focus on the Service Oriented Architecture (SOA), which also requires a collaboration and interaction with the SCM information structure [34].

Conclusion and Future Work

This work presents a study of obtaining the optimal path from any source to any destination using the SCM within IoT environments. The same may be over the requirement of some QoS parameter optimization other than only minimizing the response time. It is always desired of any scheduler to result in the message transfer with average response time. For a heterogeneous environment like IoT, it is very important to identify and club together similar objects to form a group. This group can then be used for optimized message forwarding. In this paper work, an analysis of SCM on response time aware IoT scheduler has been presented. It is observed that SCM works effectively in the IoT environment by providing a good path from the source to the destination thereby average the overall response time of message forwarding from the source to the destination, which is very important for context aware SCM scheduling.

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References

H. Kai, G. C. Fox, J. J. Dongarra “Distributed and Cloud Computing from Parallel Processing to the Internet of Things,” China Machine Press, Singapore, 2012.

Harald S, Patrick G, Peter F, Sylvie W “Vision and Challenges for Realising the Internet of Things,” Cluster of European Research Projects on the Internet of Things (CERPIoT), Belgium, 2010.

Dieter U, Mark H, Florian M “Architecting the Internet of Things,” Springer, London, 2011.

G. Jayavardhana, B. Rajkumar, M. Slaven, P. Marimuthu, “Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions,” Future Generation Computer Systems 1645–1660, 2013.

L. Atzori, A. Iera, G. Morabito, "The Internet of Things: A survey," The International Journal of Computer and Telecommunications Networking, Vol. 54. Issue 15, 2787-2805, 2010.

Z. Andrea, B. Nicola, V. Lorenzo, Z. Michele," Internet of Things for Smart Cities," IEEE Internet of Things Journal, Vol. 1. No. 1, 2014.

G. Bin, Z. Daqing, W. Zhu, "Living with Internet of Things: The Emergence of Embedded Intelligence," International Conferences on Internet of Things and Cyber, Physical and Social Computing, 2011.

S. Kumar, Z. Raza, "Using clustering approaches for response time aware job scheduling model for internet of things (IoT)," International Journal of Information Technology, June 2017, Volume 9, Issue 2, pp 177–195.

S. Yuvaraj, M. Sangeetha, "Smart Supply Chain Management using Internet of Things (IoT) and Low Power Wireless Communication Systems," IEEE WiSPNET Conference, 2016.

Mengru Tu, "An exploratory study of Internet of Things (IoT) adoption intention in logistics and supply chain management - a mixed research approach", International Journal of Logistics Management, https://doi.org/10.1108/IJLM-11-2016-0274.

L. Zhou, A. Chong, E. Ngai "Supply chain management in the era of the internet of things," International Journal of Production Economics 159:1-3 · January 2015.

R. B. Dhumale, N. D. Thombare, P. M. Bangare " Supply Chain Management using Internet of Things," International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 06 June - 2017.

U. A. Al-Haddad, G. Aldabbagh "A Classification and Comparison Between Clustering Algorithms for Wireless Networks," International Conference on Wireless Networks |ICWN'15|, 2015.

S. Ghosh, S. K. Dubey "Comparative Analysis of K-Means and Fuzzy C-Means Algorithms," International Journal of Advanced Computer Science and Applications," Vol. 4. No.4, 2013.

M. Harry, S. Kartik "Internet of Things (IoT) impacts on Supply Chain," International Journal of Applied Mathematics, Electronics and Computers, Special Issue-1, pp. 104-110, December 2016.

AT&T Internet for Business, "A Supply Chain Manager's Guide to the Internet of Things", https://www.business.att.com/content/whitepaper/supply-chain-mgr-guide-to-iot.pdf.

Wilson M., https://www.afflink.com/blog/how-does-the-internet-of-things-influence-the-supply-chain.

K. Lee, "How the Internet of Things will change your world", http://www.supplychainquarterly.com/topics/Technology/20150331-how-the-internet-of-things-will-change-your-world/.

P. Tadejko "Application of Internet of Things in logistics–current challenges," Economics and Management, Volume 7, Issue 4, pp. 54-64, 2015.

B. Cortés, A. Boza, D. Pérez, L. Cuenca "Internet of Things Applications on Supply Chain Management," International Journal of Computer and Information Engineering, Vol:9, No.12, 2015.

https://www.geospatialworld.net/article/routing-analysis-in-supply-chain-management-scm-a-managers-perspective/.

Y. Rashed " Internet of Things and Modern Supply Chain Management," Tampere University of technology, October 2017.

M. Merino, P. Mariño, "Supply Chain Management in International Logistics – RFID Applications", Business Dynamics in the 21st Century, DOI: 10.5772/2279, May 2012.

W. Liu , Y. Zhang, W. Lou and Y. Fang, "Managing Wireless Sensor Networks with Supply Chain Strategy", International Conference on Quality of Service in Heterogeneous Wired/Wireless Networks (QSHINE'04), IEEE, 2004.

M. Z. Arokhlo, A. Selamat and S. Z. Mohd Hashim, "Route planning model of multi-agent system for a supply chain management", Elsevier, 2012.

J. H. Lee, K. Moon, J. H. Park " Multi-level supply chain network design with Routing," International Journal of Production Research, Vol. 48, No. 13, pp. 3957–3976, July 2010.

S. Abdullah, K. Yang "A QoS Aware Message Scheduling Algorithm in Internet of Things Environment," IEEE Online Conference on Green Communications (Online Green Comm), 2013.

J. H. Abawajy, M. U. Chowdhury, B. R. Ray, "Secure Object Tracking Protocol for the Internet of Things", IEEE Internet of Things Journal, Vol. 3, NO. 4, August 2016.

R. Laver, D.Schneck, D. Skorupski, S. Brady, L. Cham, B. A. Hamilton, "Useful life of transit buses and vans", U.S. Department of Transportation Federal Transit Administration, 2007.

Y. Kovalchuk, "A Multi-agent decision support system for supply chain management", University of Essix, Innsbruck, Austria, July, 2009.

S. Srinivasan, D. Kumar, V. Jaglan, "Multi-Agent System Supply Chain Management in Steel Pipe Manufacturing", International Journal of Computer Science Issues, 7(4), 30–34, 2010.

S. Kumar, Z. Raza "Internet of Things: Possibilities and Challenges," International Journal of Systems and Service-Oriented Engineering, Volume 7, Issue 3, July-September 2017.

Deloitte "Continuous Interconnected Supply Chain Using Blockchain & Internet of Things Supply Chain Traceability," 2017.

Li Da Xu "Information architecture for supply chain quality management," International Journal of Production Research, November 2010.

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