Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-6, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Understanding the Impact of Internet of Things on Logistics Service Supply Chain Architecture

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***Abstract**: The Internet of Things (IoT) opens a large opportunity across industries and customer segments. However, studies on IoT are still limit and just focus on concept, features, and key technology. This article aims to discuss IoT and its applications, consider Logistics Service Supply Chain (LSSC) which provides the customers with integrated logistics service as the research object, analyze the impact of IoT on physical, information, and fund flow of IoT, and finally propose to build up a LSSC architecture based on IoT.*

1. Introduction

When a logistics customer needs an integrated logistics service, and it is not easy for a single logistics enterprise to meet the requirement of logistics service, Logistics Service Supply Chain (called LSSC for short) comes to the tendency of the logistics industry development. LSSC has a demand and supply cooperation chain structure in offering a professional logistics service process. LSSC enables an integrated logistics service to be provided for customers, and logistics service quality becomes the key to success in the LSSC market. LSSC can be considered as a system, and each enterprise can be called one node. The system is made up of several node enterprises whose benefits are split from each other. The system differs from an inventory supply chain, in which the coordination between supplier and buyer is addressed only through the adjustment and optimization of logistics capability [1].

As a typical service supply chain, LSSC has widely attracted the attention of both academics and practitioners. Yet prior studies mainly focused on conceptual model, profit distribution, risk management, order allocation, coordination mechanism, quality coordination, and management control system [2]. Nevertheless, the emergency of the Internet of Things (IoT) has significantly affected logistic service industry and has broadly changed the operation mode and the logistic system architecture. Identifying the impact of IoT on architecture of logistic system, if any, would thus provide important implications for both research and practice. This study considers LSSC as the research object, examines the impact of IoT on logistics service flow, information flow and fund flow in LSSC, and analyzes the influence on the structure of LSSC. By then, grounded on this basis, this research builds the architecture of LSSC based on IoT.

2. IoT and Its Application

2.1. IoT Concept

The term "the Internet of Things" was first used by Kevin Ashton, an expert in RFID in 1999, although the idea was around at least a decade ago. As with many terms in technology, IoT is a loaded term that people interpret in many different ways, depending on their point of view and purpose.

As with many new concepts, IoT's roots can be traced back to the Massachusetts Institute of Technology (MIT), from work at the Auto-ID Center. The Internet of Things is a metaphor for a set of systems in which direct human intermediation is dramatically reduced by equipping distributed systems with sensors that let us acquire information, make decisions, and control things in the physical world. To begin with, *sensors* are used to capture reading from the physical world, and *actuators* to enact metamorphoses in it, devices are deployed in many objects, bouncing from smart transportations to smart buildings and factories. A conceptual overview of the IoT is shown in Figure 1.

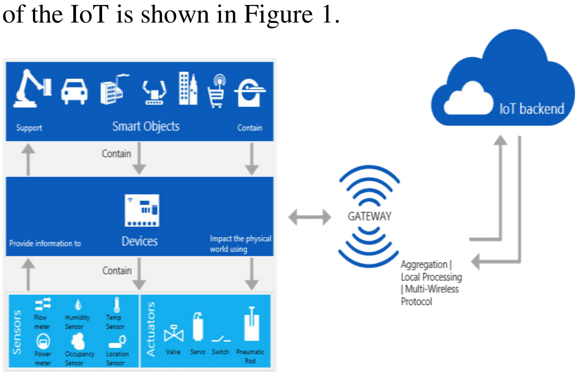

Figure 1. Conceptual overview of IoT.

Source: Hoogendoom and Kottke, 2015

As shown in Figure 1, an IoT solution typically constitutes more than just the software architecture. The figure indicates modalities of IoT including the backend, gateway, sensors and actuators, devices, and the physical systems residing in an IoT system.

Sensors are components that read information from the physical world. These components translate an observation from the physical world into a digital content.

Actuators are components that facilitate influencing the physical world.

Devices are components that support the smart objects by providing information to them or act on their behalf, using Sensors and/or Actuators. These components, including the networked and special-purpose systems, emit telemetry data, request/accept external information, and perform remotely issued commands.

Smart objects are the real objects that derive value from an increased amount of contextual decision logic, sensing capabilities, and control.

Regarding technology, IoT is the outcome of deepened Internet application. Iot is an application involving three types of technology, that is, perception, transmission and intelligent processing. Regarding the development, however, the basic theory and key technology of IoT are still at initial stage. IoT is anticipated to spread sharply over the coming years and this convergence will unleash a new dimension of services that improve the quality of life of consumers and productivity of enterprises. The potential impact of the IoT is considerable, and a concerted effort is required to move beyond this early stage.

2.2. IoT Features

While the Internet of Things ultimately has an enormous impact on consumers, enterprises and society as a whole, it is still at an early stage in its development. Several distinctive features of IoT have been identified in the literature. According to Wang (2012), the main features of IoT are self-feedback architecture, 3C integration (computer technique, control technique, and communication technique), privacy, complex networks and ecosystem [5]. Miorandi et al. (2012) suggested the key system level features that IoT needs to support, those are, scalability, devices heterogeneity, uniquituos data exchange through proximity wireless technologies, localization and tracking capability, energy-optimized solutions, embedded security and privacy-preserving mechanisms, data management [4]. A common understanding of the distinctive nature of this nascent opportunity should help hasten the development of this market. The five distinctive features are:

First, the IoT can enable the next wave of life-enhancing services across several fundamental sectors of the economy. As the IoT evolves, the proliferation of smart connected devices supported by mobile networks, providing pervasive and seamless connectivity, will unlock opportunities to provide life-enhancing services for consumers while boosting productivity for enterprises.

As can be seen in Figure 2, thirteen industry sectors are likely to show significant adoption of IoT services.

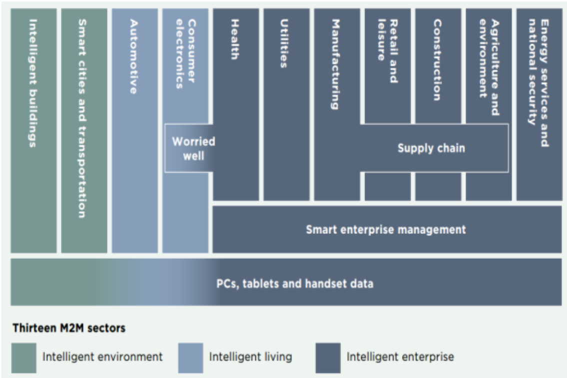

Figure 2. IoT industry sector categories.

Second, meeting the needs of customers may require global distribution models and consistent global services. The modern age of business and consumerism is increasingly driven in a global fashion with international brands in many vertical industries. In order to support the development of a viable service ecosystem, i.e. one that meets customer expectations in an economical manner, globally consistent service enablers will be a key requirement. For companies in vertical industries, the ability to deploy their services across several countries by partnering with a single mobile operator, or an operator partnership or alliance, not only helps guarantee a consistent end customer experience but also allows for the centralization of manufacturing and planning processes while also leveraging common management systems for consistent policy controls (e.g. for provisioning, customer care, security, data protection, privacy, billing and reporting). This in turn allows the service partners to benefit from economies of scale for service delivery that helps accelerate speed and quality of deployment for the market as a whole. Furthermore, the resulting economies of scale also enable service delivery in markets where the cost of creating a bespoke local service would make serving the market economically unviable.

Third, IoT presents an opportunity for new commercial models to support mass global deployments. In order to bring new services to market, mobile operators are partnering with adjacent industry organizations and jointly developing innovative IoT services targeted at the end consumer. A variety of commercial models are becoming more prominent, such as business to business to consumer (B2B2C) propositions where the end service is marketed by the adjacent industry partner who owns the end customer relationship. In addition to this structural distinction, there is a fundamental difference in the nature of customer charges. While customer charges underpinning traditional telecommunication services are typically usage-based, often tied to data consumption, those supporting IoT services will be linked to service value (of which connectivity will be an indistinguishable component).

Fourth, the majority of revenue is derived from the provision of value added services and operators are building new capabilities to address these new service areas. An area in which there has been recent innovation is the capability for the remote provisioning of IoT devices. In some connected devices or equipment, the module with the SIM card needs to be inserted in the machine and hermetically sealed during the production process. Examples include tamper-proof security or alarm systems. Other pieces of connected equipment are located in remote or hazardous locations, such as weather, pipeline or geology sensors, or equipment in chemical plants, meaning it is difficult or impossible to access the module after deployment.

Fifth, device and application behavior will place new and varying demands on mobile networks. The IoT will increase the range of services, each requiring varying levels of bandwidth, mobility and latency. For example, services that are related to public safety or personal safety will generally require low latency, but not high bandwidth per se. alternatively, services that provide surveillance might also require high bandwidth. Due to the differing level of service demand, mobile networks may need the ability to identify the service which is generating traffic and meet its specific needs.

The IoT promises to deliver a step change in quality of life of individuals and productivity of enterprises. Through a broadly distributed, locally intelligent network of smart devices, the IoT has the potential to enable extensions and enhancements to fundamental services in transportation, logistics, security, utilities, education, healthcare and other areas, while providing a new ecosystem for application development.

2.3. IoT applications

Over the last few years, the evolution of markets and applications, and thus their economic potential and their impact in addressing societal challenges and trends for the next decades has changed sharply. Societal trends are grouped as: health and wellness, security and safety, energy and environment, transport and mobility, communication and e-society. These trends create significant chances in the markets of customer electronics, automotive electronics, medical applications, communication, etc. The applications in these areas benefit directly by the More-Moore and More-than-Moore semiconductor technologies, communications, networks and software developments.

The IERC described the main IoT applications, which span numerous applications domains: smart health, smart industry, smart energy, smart buildings, smart transport, and smart city.

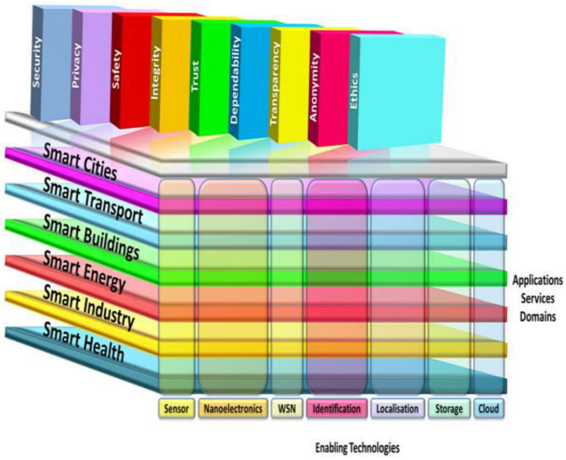

Figure 3. IoT applications.

The applications areas include as well the domain of Industrial Internet where intelligent devices, intelligent systems, and intelligent decision-making represent the primary ways in which the physical world of machines, facilities, fleets and networks can more deeply merge with the connectivity, big data and analytics of the digital world. Manufacturing and industrial automation are under pressure from shortened product life-cycles and the demand for a shorter time to market in many areas. The next generation for manufacturing systems will therefore be built with flexibility and reconfiguration as a fundamental objective. [3]

Prior studies have documented mixed evidence on the combination of the IoT and the supply chain and the decision-making modals of adopting the IoT by enterprises, and put forward recommendations from government and enterprises perspectives.

In summary, the study on IoT still concentrates on concept, key technology and features and the study on IoT application is still at discussion stage. This study takes LSSC as the object of the research, analyzes the effect of IoT on logistics service flow, information flow and fund flow in LSSC and the effect on the structure of LSSC, and on this basis, builds the architecture of LSSC based on IoT.

3. Impact of IoT on LSSC

LSSC provides the customer with integrated logistics service. Logistics service quality can be measured from three aspects: accessibility, operation performance (speed, flexibility, consistency) and service reliability, in which reliability is the core of logistics service quality which logistics customer can be perceived, and directly affects core service benefit of logistics enterprise. With integrity and complexity increase of the logistics service outsourcing, the logistics enterprises set customers' logistics needs as a starting point, form a complete supply and demand process of the logistic services after a service process of mutual relationship between supply and demand.

3.1. IoT and the integration in LSSC

LSSC is an essentially service supply chain based on ability cooperation. Here's ability cooperation may be due to the shortage of the capacity of logistics service integrators itself, it is also possible that service integrators itself did not have this ability and need to buy the logistics service capacity with functional logistics service provider. The logistics capability has a variety of operational type, such as transport capacity, storage capacity, etc. There are two kinds of circumstances, one is that logistics capability provided by the functional logistics service provider may be the same type, such as all capacity are transport capacity; the other is that logistics capability provided by the functional logistics service provider is not the same type, such as some are transport capacity and some others are storage capacity.

If logistics capability type provided by functional logistics service provider is the same, functional logistics service providers exist competition between them, so the subsystem structure is parallel-connection one from the point of reliability block diagram theory, the connection between this subsystem and logistics service integrators constitute a series one, the system reliability block diagram is a parallel-series structure. If logistics capability type provided by functional logistics service provider is not the same, the relationship of operation provided by them is cohesive one, cannot substitute mutually, connection structure of node enterprise is series from reliability block diagram. These two kinds of structure as the basic structure of LSSC, any complex structure of LSSC systems can be decomposed into these two kinds of structure.

So as to increase the links in LSSC, to improve the LSSC's operation efficiency, to develop the physical flow, information flow, and fund flow in LSSC, enterprises built LSSC management information platform based on IoT and connected this system to the net of node enterprises in LSSC.

Designing logistic and supply chain solution: This is the beginning of full logistic service process. The quality of this solution affects the logistic service quality as well as the performance and reputation of IoT. It mostly illustrates in three following aspects: first, making it more rapid to identify and innovate; second, making it more reachable to communicate among subcontractor, integrated supplier and consumers; third, qualifying the satisfaction to solutions greatly.

Purchasing logistics capability: The logistics demand analysis is the beginning of logistics capability purchasing. After IoT is applied, LSSC can do an intelligent analysis, make plans of logistics capability demand relied on logistics demand, ensure the betimes of save manpower and logistics capability supply.

Logistics service progress: This is essential to entire logistics service supply and demand. Its quality directly associates with the customer satisfaction and the reputation of LSSC. LSSC information platform is able to monitor the operation of transport link, storage link and other links momentarily and insure the betimes, safety, reliability and satisfaction after IoT is applied.

Logistics service feedback: Logistics service feedback is the critical link that improved logistics service. Node enterprises got the comments which logistics demander made on service, communicate with customers and develop the logistics service progress and solution from IoT platform which results the improvement of logistics service.

3.2. IoT and the physical flow in LSSC

There are three major flows in a supply chain including the physical flow of goods and services, the information flow, and the fund flow. All are necessary in case a supply chain is to function and flourish. The most visible flow is that of the goods and services. In manufactured products, they originate in the extraction (mining) industries and farms, and flow toward the consumer through fabricators, assemblers, distributors, and retailers. Although not yet perfect, this flow is improving rapidly. For the most part, it receives major management attention and resource commitment. Of the three supply chain flows, this flow is in the most advanced state of development. Modern logistics contains all links in supply chain, not only means transportation and storage, grated service for supply chain that embedding LSSC into manufacturing supply chain. IoT enables the service provided by LSSC more intelligent, convenient and rapid, flexible and visualize.

3.3. IoT and the information flow in LSSC

Activities in the logistics field, which are closely referred to other activities of management, require information collected, obtained, and processed within the entire information system in the enterprise. The used information systems might contribute to improve or delay the process of decision-making at different stages of management.

Difficulties to define proper information support for corporate governance in public companies originate from problems with determination of fundamental mission of the company – is it supposed to consist in maximization of shareholders value or to realize social and economic policies. States can strive for realization of both goals, which is often difficult to compromise. Proper corporate governance must be clearly defined, which is possible to be achieved through adherence to good disclosure standards. Performance of these tasks is possible through employing external auditing firms with good reputation to attract attention of shareholders to individual aspects connected with risk and poor results. Audits should be carried out according to international auditing standards.

Information is very important which identifies whether or not the operation of LSSC is success since information is the decision basic of node enterprises. Information symmetry affects the whole operation performance of LSSC directly. Information flow is the LSSC media, the basis of logistics capability purchasing and logistics service progress. This flow integrated all links and participants in LSSC. The application of IoT met the requirements of participants for information.

Achieving the high speed for the transmission of information flow: Compared to a traditional LSSC, LSSC embedded with IoT helps transmit the information faster and obtains the diversification and automation of information collection. It enables to share information with IoT easily and to overcome the bullwhip effective of LSSC.

Achieving the intelligence for processing information flow: LSSC allows to process logistics information intelligently, including information measurement, information perception, information identification, information acquisition, etc.

Achieving the networking for the dissemination of information flow: The traditional information dissemination in LSSC was linear, yet, after applying IoT, information dissemination has been networked owing to the information exchange of different participants. The high degree of sharing information, the flat mode of transmission levels, and the great decrease of information distortion overcome the bullwhip effective, help decrease recourse waste and improve the satisfaction of customers, and enable every component of LSSC be able to get accurate logistics capability requirement information.

3.4. IoT and fund flow in LSSC

Funds flow, or the flow of money, is required in a supply chain. The money flows from the consumer upstream in a supply chain until all suppliers have received payment for the goods and services they provided. Although there are other funds flow in a company, such as for equipment purchases and payroll, we will only be concerned with the flow along the supply chain, which affects the working capital of a company – its accounts receivable, inventory and accounts payable. While the flow of funds is mandatory if a supply chain is to exist, it is still an uncoordinated and sub-optimized flow in most supply chains.

Applying IoT in LSSC accelerates the turnover of the fund, improved the transparency of fund flow and reduced financial risks of node enterprises, makes the process of LSSC shorter and accelerated the turnover of current assets and fixed assets so that the capital turnover of node enterprises is accelerated. Besides, IoT helps to insure the safety of fund flow. Although the financial decision of node enterprises should be independent, IoT helps to reduce financial risks and not to breaches the agreement of LSSC and influence the operation of entire LSSC in some degree. IoT can provide effective capital flow information to node enterprises in time and real-time monitor the condition of registered bank account in every unit of LSSC through integrating internet recourses of enterprises in LSSC. Each company can monitor its own fund condition according to authorization. IoT makes the system practical and improving safety and utilization of fund.

Furthermore, applying IoT reduces financial risks for node enterprises. IoT accelerates logistics and fund flow of node enterprises and reduced liquidity risks. Enterprises obtain more actual information through IoT. Applying IoT intelligent algorithm can reduce investment risks in some degree, make communication between node enterprises more smooth and enhance the confidence of investor and demander.

3.5. Building up the LSSC architecture based on IoT

The most important and international acknowledged result of our study is the setup of the multi-centre architecture of logistics service suppliers, and the creation of its establishment-methods. A complex model has been elaborated that proposes an algorithm, by which the formation of logistics centres can be supported involving small and medium sized companies. The initial input of the model is based on a survey exploring the existing regional logistics capacity, transport infrastructure and demand. Comparing supply and demand deficit a possible development concept can be determined.

As mentioned above, three elements of enterprise are physical flow, information flow and fund flow. Applying IoT expands information sharing and integrates the information flow, goods/service flow and capital flow. Information flow is the key of LSSC management. “Three flows” interacts with each other to be an organic unity, to improve logistics service capability and operation performance.

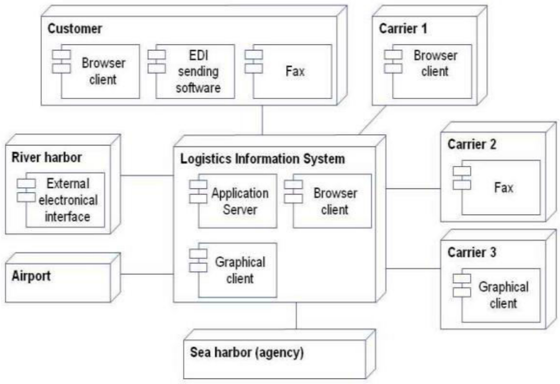

Figure 4. Architecture of LSSC based on IoT.

The difficulty of concentrating information is caused by the large number of service providers utilizing different transportation modes. The information is owned by the service providers. Because of the lack of a universally accepted, specific and complete communication standard it is not possible to implement automated computer to computer communication between each of these providers. An IT architecture must be created which can integrate as many providers as possible, because this - along with several intelligent elements - is the foundation for the competitiveness of a logistics centre.

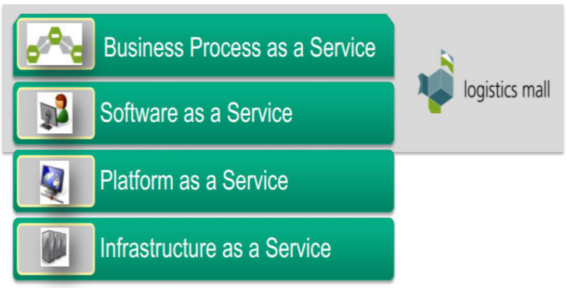

Figure 5. Service layers concerning logictics mall.

Applying IoT makes the logistics service demander, logistics service integrated provider and logistics service subcontractor exchange information through IoT platform, the transmission between LSSC and customers smooth and help enterprises to make decisions independently. It helps to smooth fund flow between LSSC and customers and to insure the fund security. It helps to improve the security and service quality of LSSC progress that the whole LSSC progress can be monitored and visible after IoT is applied. Applying IoT integrates the material flow, fund flow and information flow between customers and LSSC and makes profit for enterprises participated.

4. Conclusions

IoT creates opportunities to achieve efficient solutions in the retail sector by addressing the right person, right content at the right time and right place. Adapting to the tastes and priorities of changing populations will be a critical task for retailers worldwide. To keep up with all these changes, retailers must deploy smart, connected devices throughout their operations.

In the future, the number and types of IoT devices will increase, therefore inter-operability between devices will be essential. More computation and yet less power and lower cost requirements will have to be met. Technology integration will be an enabler along with the development of even lower power technology and improvement of battery efficiency. A similar trend can be expected for embedded computing using similar technology over the next 10 years. Furthermore, batteries will be recharge from radio signals, cell phones will recharge from Wi-Fi. Smaller cells (micro, pico, femto) will result in more cell sites with less distance apart but they will be greener, provide power/cost consumers to manage their energy, media, security and appliances.

Informal mechanisms do not distribute funds directly among channel members, but they offer incentives indirectly to encourage cooperation. These have to do with power and trust. Large firms may use coercive power to force other channel members to comply with their wishes. Reward and referent power are less straight forward and offer benefits to cooperation through such mechanisms as training or use of a valued name, such as Intel Inside. Trust has to do with sharing information among members so that they can be in a better position to make decisions benefiting all channel members in the coalition.

Collaboration among LSSC members is at the heart of supply chain management and will be the key to its future success. The essence of channel collaboration has several identifiable features. First, it is about managing a supply channel of vertically-related but legally separate firms. Second, it represents an untapped opportunity because channel members often work at cross purposes. Third, cooperation and trust are the keys to realizing the benefits from collaboration. Fourth, the benefits may "pool" with one or a few channel members, thus creating the need for sharing the benefits. Fifth, redistributing the benefits requires metrics to identify and measure potential benefits, information sharing among the members to build trust, and sharing methods for a fair benefits distribution. To summarize, collaboration in LSSC will require information sharing and a spirit of cooperation, a boundary-spanning information system, inter-organizational metrics, a means for benefits identification, and ways for sharing the spoils of cooperation. A particular need is for an information system that is inter-organizational in scope and is directed toward providing relevant information so that channel members can "see" the opportunities for

LSSC improvement and can track the flow of the benefits from cooperation.

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