**RFID and ZigBee Technology to automate Supply Chain Management**

# **Introduction**

With the advent of industrial revolution, the way in which businesses operate has undergone a major shift and automation has become core aspect of business operations, with an aim of enhancing efficiency of businesses. The supply chain management is one of the core areas which need automation by seeking benefit of Information Technology (IT) enablers, of which RFID and Zigbee technology are considered as most prevalent (Narayanaswami et al., 2019). In order to deal with abruptly changing demands of consumers, as witnessed during the recent pandemic, retail stores have faced huge pressure in smooth management of its supply chain (Mekruksavanich, 2020). The panic buying of consumers and rapid sales of inventory items from stores is one instance of the factors, which could cause shortage of inventory in store. The flexibility and structural adaptability are considered as core aspects of contemporary supply chain management (Neelakandan, Tyagi and Nagalkar, 2019). In order to develop needed resilience and flexibility, manual supply chain has higher associated cost, as it requires commitment of additional resources. Some instances of this cost are associated with management of buffer inventory, development of extra capacity and high level of coordination needed between personnel and sales activities (Strassner, 2005). Firms can balance the needed resilience and cost by ensuring higher level of visibility throughout the supply chain, as well as improved speed to respond to the changes.

In order to improve efficiency of supply chain management, RFID integrated with Zigbee technology can help to obtain real time status of the products in stores. Hereby, RFID technology will serve as the way of data collection system, whereas Zigbee network will be a wireless communication network that will allow to transmit the same information to various stakeholders throughout the supply chain. It has been mentioned by Angeles (2005) that both the RFID and Zigbee will act as feedback link and thus monitoring of material and items become easy. The large retail stores like Woolworth and Coles are found to struggle with the tracking of inventory, and huge personnel involvement is needed to ensure that material tracking is carried out in efficient manner (Ahmed and Bakhsh, 2017). In order to solve this issue, RFID technology and Zigbee technology network are considered as attractive solution, whereby time consumed in manual tracking of inventory can be saved and automation can be used for enhancing efficiency of supply chain (Oghazi et al., 2018).

## **RFID and ZigBee Network Technology**

Radio Frequency Identification (RFID) is a type of wireless technology which is widely used in industry 4.0 for carrying out automatic tracking, locating as well as identification of an object or an item, without requiring any specific line of contact. RFID tags are slightly different from barcode tags, as it does not require any line of sight and tags can be scanned and identified even from a distance (Alyami, Campion and Atkins, 2016; Van Hoek, R., 2019). RFID is also recognized as intelligent form of bar code, which allows the items to be tracked in the supply chain and thus makes supply chain operations more easy and efficient.

ZigBee on the other hand is recognized as advanced wireless communication protocols, which is based on IEEE 802 standard and makes use of small and low power digital radios (Van Hoek, R., 2019). ZigBee communication network is used for transmitting data and information over a long distance, whereby data travels from intermediate devices with an aim of approaching the distant devices. These characteristics make ZigBee adhoc network, which gives it limited centralized control (Podduturi et al., 2019). The use of ZigBee is considered as less expensive, secure and simple in contrast to other WPAN applications. ZigBee uses pool of technologies to ensure scalability and self-organization, which can manage number of different data traffic patterns and thus it makes networking possible across low power devices. It has been noted by Attaran (2012) that ZigBee serves as the way of assuring fine communication between devices and thus it is one of the most effective wireless network for carrying out monitoring and analysis across different business operations.

Both the RFID and ZigBee are considered as emerging technologies which have been substantially applied in large number of industries including; logistics, supply chain management as well as asset tracking process (Wu et al., 2016; Sharma and Sharma, 2016). The shorter time lags and error free ID entries are considered as key factors for contributing in success of the system (Zelbst et al., 2019). Moreover, the readability of RFID from remote distance and ability to read numerous tags in specific time are benefits of the anti-collision technology which are realized by many industries and departments.

# **Literature Review**

The development of RFID network along with integration of Zigbee communication network is likely to benefit supply chain management in significant way. For instance, the flow of material can improve substantially along with flow of equipment and personnel. The analysis and monitoring of logistic can be carried out in real time by seeking benefit of applications, such as real time locating systems (RTLS), which can enhance efficiency of supply chain management. It has been highlighted by Coltman and Michael (2008) that RTLS can improve quality of service through utilization of time critical processes and optimization of emergency management. By using RFID, the physical tags are connected with the items which are needed to be identified. RFID applications can then read the tag from a physical distance without line of sight and signals are then transmitted through antenna (Narayanaswami et al., 2019). The same information is then transferred to communication infrastructure that helps in updating the supply chain information (Dash et al., 2019). Continual and real time monitoring of tagged objects through RTLS allows to obtain critical information about supply chain items. For instance, date of expiry, rate of sales, physical location of items in stores as well as cost and stock requirements for the items (Sharma and Sharma, 2016). It indicates that automatic identification of stock requirement is enabled through RFID, as ZigBee enabled RFID transmits all data in real time and suppliers are atomically notified about the needed stock. The involvement of sales personnel to request for the restock of inventory thus reduced substantially and time is saved through RTLS based supply chain management.

## **Need of Retail Supermarkets to automate Supply Chain**

Automation is considered as one of the most desired aspects of the retail super markets, as mentioned by Ghadge et al., (2020) That in order to survive in retail industry it is highly needed to approach customers with goods in fastest possible way. Major supermarkets retailers of Australia, such as Coles have recently strike a deal with British based group of retailers to assure that its warehouse is effectively managed and capacity of operations is increased (Mekruksavanich, 202; Musa and Dabo, 20160).

This is only one instance of the push in high tech zone by retailers with the purpose of managing their supply chains in efficient manner along with reducing costs to substantial level (Musa and Dabo, 2016). Woolworth has also recently announced that in order to meet the enormous demand of online consumers, its existing supply chain management has proven to be overburdened (Podduturi et al., 2020). For instance, during the recent pandemic, volume of online sales has increased rapidly and in order to assure smooth supplying of goods in such situations, automation of supply chain is considered as one attractive option (Podduturi et al., 2020). It is being mentioned by Gaukler (2004) that most complicated aspect of managing demand of consumers in retail supermarkets is to keep track of items in stock and assuring that shelves never get empty. The human involvement for tracking and ordering the inventory is exposed to many errors. Additionally, there is high level of associated cost and time with manual supply chain management, as tracking and tracing of goods is complicated process, requiring continual human input and involvement (Khan, Asim and Manzoor, 2020). Therefore, implementation of RFID for automatic tracking and monitoring of goods and Zigbee for communicating demand for stock to suppliers in real time, is considered as an effective solution for managing supply chain in effective manner.

The understanding regarding implementation of RFID and ZigBee technology to automate supply chain can be best generated through recognition of process centric view of supply chain (Sharma and Sharma, 2016). According to this process, supply chain is divided into different activities including; source, make, deliver and return. In terms of sourcing, automation through RFID and ZigBee technology can enable virtual control over supply chain, whereby real-time tracing and tracking of good leads to efficient sourcing of goods to retail stores (Musa and Dabo, 2016). For instance, the data obtained through RFID and communicated through ZigBee provides real time visibility to suppliers and thus enables efficient planning of product assortment. The next step in supply chain management process is to use big data obtained through RFID for support smart manufacturing, whereby suppliers can efficiently meet the demand of business and retail stores will never go out of stock (Narsing, 2005). Subsequently, the deliver stage is core of logistics, whereby decisions regarding storing of inventory and delivery of goods are made. RFID can solve the issue of incompatibility existing between supply partners (Lin et al, 2006; Narayanaswami et al., 2019). The data shared in real time allows all supplying partners to get on the same page and thus use the opportunity of predictive modelling and smart decision making. End to end visibility thus supports synchronization among different supply chain activities and delays are substantially reduced (Sharma and Sharma, 2016). One instance of smart delivery is the use of programmable automated guided vehicles, which allows to automatically store RFID tagged items in inventory. Finally, it is noted that RFID also supports smart returning, by support e-reverse logistic framework. It has been noted by Narayanaswami et al., (2019) that product life cycle integrity is enhanced by use of RFID and with automation of return, any environmental hazards are controlled (Neelakandan, Tyagi and Nagalkar, 2019). These evidences clearly highlight that use of RFID and ZigBee networks to automate supply chain management can smoothen the whole process of supply chain management from sourcing to production, delivery and return (Coltman and Michael 2008). The retail supermarkets are likely to seek substantial advantage from this automation, as they can control cost, can minimize time of supply chain processes and can limit any delays in supply chain activities (Van Hoek, R., 2019).

## **Limitations of using RFID and ZigBee network for Supply chain automation**

Although, RFID enabled and integrated with ZigBee has numerous benefits for managing supply chain of retail supermarkets, yet it has been mentioned by researchers and practitioners that there are some associated drawbacks as well (Oghazi et al., 2018). The key issue which is being identified by researchers in general for Internet of Things (IoT) is internet scalability. The scalability refers to the capability of networks and internet of things to handle the load of data, as businesses grow (Khan, Asim and Manzoor, 2020). It is generally accepted that there is not the case of one size fit all situations. Internet of things might slow down as data burden enlarges followed by growth of business. The supermarket retailing is expanding rapidly and scalability is crucial for automating supply chain management (Strassner, 2005). This aspect is relatable to both RFID and ZigBee technology, yet the advanced RFID applications are highly scalable, as they can process larger amount of data in real time. The new platforms and protocols are constantly introduced to further enhance scalability of RFID integrated with ZigBee communication network.

On the other hand, security and privacy have also been regarded as significant issues which have specific association with RFID integrated with ZigBee. It is noted that data in RFID based applications is being transferred by making reliance on unsecure wireless channels, such as ZigBee communication network, which lowers the security and privacy of data being identified and transmitted through RFID (Srivastava, 2010). Moreover, in order to enhance scalability of RFID system technology, linear search is mainly used to identify tags and it creates serious security and privacy concerns. Some of the solutions have proposed to use tree structure to store keys, but they can only provide a weaker level of privacy (Van Hoek, R., 2019). For instance, the tree protocols are highly vulnerable of attack, as one adversary including tag might also reveal the secret of other tags (Coltman and Michael 2008). It is noted that although efforts are made continuously to develop protocols for improving privacy and security of RFID, yet mean while the practitioners are highly concerned about the existing privacy provisions of RFID (Neelakandan, Tyagi and Nagalkar, 2019). The limited privacy aspect might be considered as threatening by retail supermarkets while automating their supply chains and thus data protection and security features are needed to be improved further (Wang, Lin and Lin, 2007).

Finally, the aspect of resource efficiency with respect to cost and energy capacity is also an important concern for both researchers and practitioners while implying RFID and ZigBee. It has been noted that in contrast to barcode technology, RFID has higher level of associated cost, which makes it a difficult option to adopt. The cost of redesigning the organization to imply RFID and ZigBee networking is considerable, yet it is mentioned by Wu et al (2016) that in long RFID substantially contributes in lowering the cost of supply chain management. The wastage of material and goods throughout the supply chain processes reduces with the use of RFID, thus indicating that in long run this solution is highly efficient for controlling the resource utilization in supply chain (Narsing, 2005). On the other hand, the questions are raised regarding energy capacity and environmental impact of RFID technology in supply chain (Zelbst et al., 2019). Some researchers argue that energy capacity is high for implying RFID in supply chain management. On the other hand, it is maintained by practitioners that RFID based architecture supports energy efficient products and logistics. For instance, higher capacity utilization is enabled in transportation, while using RFID technology. Likewise, stocks are reduced, reliance on paper is minimized and electronic transmission of data assures that positive impacts are brought on environment (Wang, Lin and Lin, 2007). In conclusion, it is noted that although there are some limitations of RFID and ZigBee networks, yet improvements are made to minimize any potential limitations and to assured enhanced efficiency of supply chain management.

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