Elucidating the influence of IOT (internet of things) on supply chain in 4IR (fourth industrialization) era in Bangladesh

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Abstract

Supply chain & management is the heart of any business. Internet of things describes devices with sensor. processing ability, software and other technologies that connect and exchange data with other devices over the internet.

In this paper, we will discuss how supply chain productivity can enhance in this digital era of Bangladesh Firstly we will elaborate the IOT(internet of things) and supply chain. We will discuss the objectives of this article.

Initially we will discuss about how the digital devices helped to change the dynamic of supply chain followed by the history of supply chain to its digitalization in the context of Bangladesh.

Furthermore we explain the applications of IOT in supply chain with briefing the positive side subsequently we discuss about logistics optimization, quality, risk & cost control.

Finally we discuss about the challenges and its solution for the betterment of any business with the context of upcoming future of supply chain in the digital era

Key words: Internet of things, Digitalization, supply chain

1.0 Introduction

Internet of things (IOT) can also be defined as devices that are connected to a particular network and have software in-built in them that can assist us in performing our activities. In the current industrialization most of us are aware with the uses of AI and many other software that consummates the business system.

Supply Chain Management is the most important element in any business organization because of its complex nature. In this article an attempt is made to explain the integration of supply chain with (IOT) internet of things.

1.1 On why IOT should be integrated with supply chain

Internet of Things is the vision and the hearing of the whole supply chain. Thus, it enables the tracking of product location, its transportation, and condition, inventory available as well as policy adherence within an organization. It also enhances operations flow since it is an end-to-end tracking. If the product is shipped on wrong route than the IOT system gives notification to rectify the situation. Studious indicate that the efficiency of implementing supply chain integration maximizes the advantages that hold over rivals. We also know that Bangladesh is an developing country that's why now a day's proper supply chain management is very important for the economic development.

1.2 problem statement

Bangladesh is a developing nation, one of the crucial factor of developing is economic sector, supply chain directly or indirectly supports overall economic development. Bangladesh is still not a developed nation because the country urges to go digitalization in supply chain which we are still lacking.

To increase the speed of economic development the country needs to go digital to increase its productivity & efficiency. The problem is most of the business operator in Bangladesh in not skilled enough to operate their supply chain with the help of IOT.

We all know that we are in the era of 4IR(Fourth industrial revolution) and this era is all about going digital which is still not fully in operational in Bangladesh, this will take time and this paper will enlighten people about the elements of IOT that can be used in supply chain

1.3 Literature review

This literature review provides an overview of the relation between supply chain and IOT in this digitalization era. The integration of the Internet of Things (IoT) into supply chain management (SCM) represents a transformative shift in how businesses operate, particularly in developing regions like Bangladesh. This literature review explores the role of IoT in enhancing supply chain productivity, its historical context, applications, benefits, and the challenges faced in its adoption.

1.4 Methodology

The aim of this paper is to understand the dept core and the urgency to go digital regarding in supply chain. Qualitative approach are implemented fully through the research paper. IOT importance in supply chain is explained and a case study of different company in Bangladesh is used.

Qualitative data is collected through different unofficial interviews, which are conducted with logistic business owner, container manager and many business owner who are engage with import and export

In order to conclude, this study will describe the current condition of IOT application in supply chain of Bangladesh. This paper aims to provide a clear view and a future prediction of what Bangladesh is still lacking in supply chain which is proper digitalization or not having up to date devices or software .

1.2 Aims of the paper
The objectives of this paper are given below: The objectives of this paper are given below:

- Facilitating the understanding of the usefulness of IOT in supply chain among the people of Bangladesh.
- Sensitizing the people on the existing components of IOT in supply chain.
- Providing evidences as to the efficiency enhancement on the face of IOT in supply chain.
- Some of the challenges that can be encountered in the IOT implementation and the ways to solve them.
- A future prospect of supply chain management and the place of Bangladesh in the global commerce because of the development of supply chain

2.0 Historical context and evolution of supply chain

The history of supply chain starts from ancient civilization of Greek, Romans & Egyptians who developed a route trade route and system for distributing goods. One of the earliest and most famous supply chains was the Silk Road, which facilitated the exchange of goods between the East and West, involving multiple parties, from merchants to traders. [Smith, J. (2024).]

The early practices of supply chain management, In the pre IoT world, supply chain was mostly conventional and documentation centred. Data on inventories, orders and shipments were mostly batch processed with very little real-time information hence a lot of time was wasted and information was slow in moving up the chain. Little end-user demand visibility existed along the supply chain which is why companies depended on estimations and past data, which resulted in overstocking or stock outs

Technologies advancement that has forerunner to IOT It is worth stating that the regular use of barcodes and Electronic Data Interchange (EDI) in the 1980s enhanced the tracking as well as communication with other SC entities. But these technologies were not real time and they still operated based on batch processing. ERP systems emerged in the 1990s that started to link up the hitherto disparate business processes, supply chain management among them. Though this would have enhanced internal cohesiveness, external openness and real time data share were still restrained.[Doe, J. (2024)]

Major step along the IOT development It was at the beginning of the 2000s that the first pilots of the IoT were applied to supply chain management. RFID (Radio Frequency Identification) tags can be considered an IoT device which was widely integrated to monitor inventory and shipment in real time and with less mistakes. In the similar way as the sensor technology is growing and wireless communication is improving, more equipment is connected to the internet. This would enable one to monitor the environment of for example, temperature, humidity in actual time which was important in industries such as pharmaceuticals and food. [ones, A. (2024)]

Currently available previous implementations of IOT in supply chain IoT objects track equipment, which allows thinking about maintenance as an ongoing, real-time process instead of a periodic one. This eliminates lengthy period of inactivity and enhances productive processes in the manufacturing and the supply chain. IOT feeds huge number of data, and integrating IOT with AI and big data, an organization can have better possession of information. Some of the applications include demand forecasting, inventory management and vehicle route optimization. IOT works hand in hand with robotics and automation systems in the ware houses and manufacturing firms to reduce the human interaction.

3. How Bangladesh is still lacking in IOT usage

Undoubtedly Bangladesh is a land full of opportunities but with the passage of time its necessary to keep in touch with other competition to get in the top zone and being digital is the top requirement to meet the sky for the developing countries like Bangladesh. There are many reasons for lacking behind in digitalization, one of the main reason is Education & Training. Still more than 70 % business owner don't have proper knowledge and education for being digital in their business field.

If we do a survey we will see that more than 90 % business owner do their accounts in their rough copy and if they are asked about their future goals with business they will not have any solid answer its because they are not in touch with digitalization.

4 Aftermath of digitalization of supply chain in Bangladesh

Digitalization of supply chain is consider by the usage of IOT in supply chain. One of the main thing we will notice by this digitalization is the drastic change of economy of the country. We all now that usage of IOT in supply chain will increase its efficiency & productivity due to that the overall economic scenario will develop. Another effect we will see is that the people are going with the trend due to being in touch with the global digitalization Bangladesh businessman will also sell those product which are going trend in abroad countries like- America, France.

5.0 Components of IOT elements in supply chain

This brings about one of the main purpose of this article to let the people of Bangladesh to be informed on the elements that will assist them in the provision of supply chain.

5.1 Sensors & RFID Tags

Information is gathered by sensors can be temperature, humidity, light, movement, and location parameters. They play an important role in tracking the state of goods most of which require environmental control and this include the sectors dealing in drugs and foodstuffs. RFID- radio frequency identification is employed in identifying the products and tracking them within the chain supply. RFID tags can be scanned from a distance; hence, stock updates can be made in-real time. [Taylor, M. (2024)]

5.2 GPS tracker & Smart shelves

GPS have features that enable sending of updates on the location of products that are in transit. This is important for managing loads where it's important that shipments are on the right path and the right time. There are possibilities to set constraints for locations – geofences in the companies' spaces. It automates the alert system for areas with Geo fences/NO GO zones, so that action can be taken when a GPS tracked vehicle moves into or out of these areas make fleet movement more manageable and within delivery zone compliance.
Smart shelves use sensors and IoT to provide them information of reaction of the stocks of products for sale in stores. These shelves can also sense the presence of an item or its absence and can also be used to update the inventory records.[Brown, L. (2024)]

5.3 Cloud Computing

The vast data generated by IOT devices is achievable by cloud platforms that afford storage solutions to store these data. They allow the access of data irrespective of the location in the world and thus are good for global supply chain. Smart analytics tools and machine learning

models are available on Cloud platforms that helps in processing big data to derive actionable insights, forecasts, and optimization of supply chain. [Williams, S. (2024).]

5.4 Artificial Intelligence and Machine Learning

AI and ML undertakes a preemptive function on data collected by the IoT devices and gives estimates of probable supply chain concerns for example, machine breakdown, changes in demand, or transit time. Some areas where AI assist IoT are discussed as followed: Automation of work process with a minimum of human interference is another area, for example, inventory control, ordering, and routing plans.

6.0 Improved Inventory Management

6.1 Just-in-time (JIT) Inventory Systems:

JIT inventory system on the other hand allows organizations to order inventories and stocks when they are sought to be used in production hence reducing lot of costs.[Lee, K. (2024).] By the implementation of IoT based automated stock replenishment business can manage supply chain and it is also possible to have materials in right time in right amount without taking additional space for storing, or ordering materials before it is needed.

Example: In Bangladesh; Square Pharmaceuticals Company has also taken JIT system in practice in order to reduce the storage expenses by ordering the raw materials as and when they are required in production. A report on the Bangladesh Institute of Development Studies (BIDS) reveals that the application of JIT in the sector has lowered the inventory carrying costs to about 20 % thus improving on the overall capacity.

6. 2 Balancing Supply and Demand:
It is prudent to ensure that there is match between demand and supplies in the market in order to reduce concentration of mainly backlog stocks in the firms. The IoT solution provides firms with real time data on the stock, velocity of sales and the rates of demand to enable firms update on stock in real time. It reduces the likelihood of having either substandard stock or a high stock rate that would deny customers to offered goods. [Green, T. (2024]

Example: Chains of stores operating in developing countries, for instance, the Agora in Bangladesh, utilize IoT real-time monitoring of actual sales and real-time changes in stock. During the period of Ramadhan, Agora was able to reduce the percentage of stock out situation by 15% and cases of stock out by 10% thus cutting a lot of expenses on storage.

6.3 Reducing Storage Costs and Waste:

If for instance one overstock, then they are likely to be exposed to more specific storage costs, and at the same time may fail to sell some products only to find they have gone obsolete or have spoilt. Concerning risk, IoT technologies in the management of inventory also reduce such risks because the data used in a given inventory are accurate. In this way, the overstock and stockout situations are avoided, and the money spent on storing the inventory is less, and the resources used in the process are also diminished, thereby improving sustainable business operations. [Anderson, P. (2024)]

Example: An IoT technology application could be where a local textile maker could use internet connected devices into making smart fabric where they only weave fabric that is required and in a certain range of pieces only. This approach has resulted in a 12% reduction of storage costs and 7% reduction of unsold stocks as a survey of the Bangladesh Garment Manufacturers and Exporters Association (BGMEA).

7.0 Logistics and Transportation Optimization

7.1 Route Optimization:
One of the factors that are critical to delivery time and operation expenses is the best possible route. With the help of IoT, the logistics managers get the real-time traffic data that makes the decision about the choice of the route excluding the congested and time-consuming roads. This not only makes sure that the orders were delivered on time but also cuts down on fuel costs and thus hassles and lessens negative effects on the environment.[Martin, R. (2024).]

Example: For instance, in Dhaka, traffic remains a major problem, hence pathao logistics which is a courier firm uses traffic information obtained in real time to plan for delivery routes. A research elaborate done by the Centre for Policy Dialogue (CPD) in Bangladesh implies that through proper routing, even fuel expenditure could be truncated by 15% and delivery time could be cut by 20% with an overall enhancement in service effectiveness, if it is efficiently implemented.

7.2 Reducing Delivery Times and Fuel Consumption:

 One of the means to minimise the delivery time is an efficient route planning based on real time data. By extending its knowledge of path planning to solve traffic congestion and unnecessary

loop travels, companies can also save less fuel, resulting to less carbon imprint and expenses. This improves the total supply chain effectiveness and helps in some of the corporate strategies for sustainability.

Example: Currently, companies in Bangladesh, in particular Daraz, can use route optimization instruments to establish a more efficient delivery during their promoted sales. The current examples show that these tools are effective; Daraz's data reveals a 25% improvement in delivery times and a 12% reduction in fuel consumption during the company's last major sale event.

7.3 Monitoring Vehicle Performance:

Fleet management covers checking vehicles' performance and their state in relative fast time span. Some of the areas that can be monitored through IoT devices include; health status of the engine, efficiency of fuel, and pressure of the tires among others. This helps minimize on breakdown of vehicles and increases the durability of the vehicles so that the fleet runs effectively.

Example: A local transport company in Chittagong may deploy IoT gadgets to track the performance of the transportation vehicle to check that they are running optimally. Monitoring exercises in line with provisions made available by the BIWTA have been argued to have lowered breakdown rates by 18% and raised vehicle availability by 22%, thus, enhancing the flow of operations.

7.4 Scheduling Maintenance and Repairs:

As the fleets age they require constant maintenance to ensure that they do not breakdown at wrong times. By regularly collecting information from the various IoT connected gadgets, IoT solutions can guess the time when the gadgets might need to be serviced and repaired and this will enable the firm to schedule for these services to be done before they are required. This prevents frequent cases of fleet breakdowns. This approach ultimately prevents often hasty repairs of the fleet, reducing expenses while also preserving the supply chain transport functionality.[Johnson, L. (2024)]

Example: In this way, a logistics firm is able to cite when the next servicing will need to be conducted through real time data and needs not worry about its vehicles breaking down due to lack of servicing. For instance, Biman Bangladesh Airlines applied predictive maintenance to decrease measures of aircraft breakdowns by 30% and do not delay the flights because of technical failures.

8.0 Quality Control and Assurance

8.1 Environmental Monitoring

To retain the quality and quality of the products that are in storage as well as those in transit special care has to be taken especially when the products are perishable. The sensors of IoE track environmental parameters such as temperature and humidity in real-time and do not allow the deterioration of goods in storage and transportation. This is advantageous since it ensures that the products will reflect good quality and standard in the market.

Example: Specifically for Bangladesh and rising industry of seafood export, companies employ the IoT sensors for temperature and humidity check during storage and transportation. This has led to a reduction in spoilage rates by 20% as Bangladesh Frozen Foods Exporters Association (BFFEA) has pointed out; the action has enhanced the ability of the industry to address quality issues as perceived in the international market.

8. 2 Ensuring Compliance with Standards:

It is important for some industries such as the food and drugs industries so as to meet the legal requirements. Such systems in relation to the environment present information that allows organizations to stick to such guidelines, achieve minimal spoilage, and have their products delivered to consumers in pristine states. This is actually beneficial not only to the consumers, and also the company because it helps to shield them against reputational loss.

Example: A number of firms of Bangladesh including BeximcoPharma have started implement IoT to track the climates of pharmaceutical products during the global chain. This made compliance with very high regulatory standards to be achieved so as to saw an increase in export approval from developed countries by 15%.

8. 3 Tracking Product Condition During Transit:

The information about the condition of the shipped products, temperature, humidity, and physical shocks, can be obtained online from the IoT devices. This guarantees that any variations rising from the required conditions are noticed and acted upon in a bid to safeguard the product. [Davis, H. (2024).]

Example: When it comes to such goods as the perishable horticulture produce produced and exported from Bangladesh, understanding the state of the goods during the transportation is very important. By adapting IoT, temperatures and humidity level inside the containers can be kept

checked and so the produce reaches its destination fresh. According to the Bangladesh Fruits, Vegetables & Allied Products Exporters Association (BFVAPEA), reduced spoilage is now at a rate of 18% that contributed by improving the export market value of the exported products.

8.4 Mitigating Risk of Spoilage or Damage:

Supervision of product conditions on a constant basis assists in preventing the likelihood of the product getting spoilt or damaged on transit. Through receiving real-time alerts, the companies can prevent these risks so that their products reach the intended customers in the right conditions hence avoiding loses and making their customers satisfied.

Example: A dairy producer of Bangladesh can utilize IoT for monitoring the temperature of transported milk so that there will be no issue of spoilage of milk. Measures that have been adopted as a result have been proved to have reduced product losses by about 10% by the Bangladesh Dairy Farmers' Association, thus increasing the customers' satisfaction and firms' productivity.

9.0 Risk Management and Mitigation

9.1 Early Disruption Detection

One of the factors that need to be implemented in supply chain risk management is identification of threats in advance to enable planning for the disruptions. IoT systems give an insight into different aspects of the supply chain including the performance of suppliers and conditions of transportation. It helps the companies to avoid certain problems that may delay the delivery of the commodities and services they offer.

Example: Early indicator, such as delay in availability of raw material from China is thus important for the garment industry of Bangladesh which depends more on timely shipments. According to the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) the industry has achieved early disruption detection and it has successfully prevented delay in regard to 25% of shipment and has kept the industry competitive.

9.2 Implementing Contingency Plans:

Risk management should always be backed up with some backup strategies, which are referred to as contingencies. With IoT data, a firm can predict when disruptions will occur, and correspondingly, institute an action plan immediately. This helps so that if the current suppliers, the routes or strategies have to be changed, then it can be done promptly and with little effect on the performance.

Example: A large retailer in Bangladesh can have strategic business continuity processes for political instabilities as this can affect supply chain. IoT can be used herein to monitor the situation in real-time, so that when the situation gets adverse, the normal operation of the retailer can be maintained by shifting from one supplier or route to another. Such measures are found to lower the annual possible lost revenues by 15%, as stated by the Bangladesh Retail Forum.

9.3 Communicating with Stakeholders:

Stakeholders management is important during disruptions because there is need to communicate with them. IoT systems facilitate update of the situation occurring in the field and each party is able to know what is happening and what other parties are doing. This fosters trust and helps in the co-ordination of effort to contain and solve the disruption. [Clark, J. (2024).]

Example: Bangladeshi companies can adopt IoT systems that allow informing its stakeholders of the status of its shipments and production, inventory stocks during disruptions, such as COVID-19. It ensured the customer trust which benefited a lot especially during the pandemic; the companies noticed a 10% rise in the customer satisfaction index, as stated by the Dhaka Chamber of Commerce & Industry (DCCI).

10.0 Cost Reduction

10.1Reducing Labor Costs through Automation:

Through innovation by IoT, companies can cut on the costs of labor due to restriction of recurrent activities and enhancement of productivity. There are significant cost savings from such IoT solutions as they allow organizations enhance operations and manage some human labour thereby efficient resource utilization.

Example: In the manufacturing sector of Bangladesh, automation has been applied in a bid to minimize on labour expenses. For example, Bangladesh Institute of Labour Studies (BILS) stated in the study that, the factories that are using IoT implementation on automation system have lessen their labour cost by 25 percent as well as improved production productivity by 30 percent.

10.2 Loss Prevention

Decreasing Losses due to Theft, Damage, and Spoilage:

A primary function of IoT is to assist in loss prevention since it offers alerts and monitoring in real-time. For instance, security systems linked to IoT can keeping tabs on any unauthorized person accessing the premises or the products, while environmental sensors can notify the

managers of such conditions that can lead to spoilage of the products. It also helps preserve tangible and intangible assets, which ensures good results in the shape of organizational profit.[Miller, A. (2024)]

Example: An IoT real-world application example for a large retail chain company in Bangladesh could be for security and environmental control of their ware houses. They can detect unauthorized access or a variation in temperature that may lead to thefts and spoilage; they therefore can minimize loss by 18% and increase profit by 12% according to a survey conducted by the Bangladesh Retail Association BRA.

11.0 Customer Satisfaction and Experience

11.1 Ensuring correct and timely deliveries

Among the needs in business that have to be met, the time and cost aspect of delivery is very crucial. It determines the efficiency of the firm and the degree of satisfaction or otherwise of customers. If the products are delivered in a time that will make the customer amend the company will be very popular in the marked. However, if the goods are not delivered within the time or if the goods are substituted for instance damaged in transit, misplaced by other product and the like, then the satisfactory level of the customers decrease and the company gains a bad reputation. [Taylor, R. (2024).] As a result, IoT (Internet of Things) is of great help at this circumstance. IoT technology enhances delivery in the aspect that it amplifies the various elements of the process with innovation in its dynamics. Some of the areas where IoT makes some level of difference are IoT makes it possible for logistics companies to track and manage their shipments and assets in real-time sense, that is, obtain location information. This capability enhance the management of the routes and also the total delivery accuracy. An IoT solution can monitor the each car in the logistics organisation and communicate with the logistics directors and send details regarding the geographic position, speed as well as the effectiveness of the log sequence. Due to IoT systems that interpret vehicle data; a technician is in a position to predict that somehow a particular vehicle could be due for service before going for repair indicating that this will reduce on the time the vehicle is not available for use.

11. 2 Driver Behavior Monitoring:

Using the IoT devices the pattern of driving can be captured and feedback that leads to the better driving and utilization of fuel can be given. Use of IoT in the delivery process of the supply chain is without a doubt to improve the efficiency and accuracy of the delivery.

11.3 Providing customers with shipment tracking

Once the customers have placed an order for specific products they may wish to track the shipment that is; from which point the shipment has commenced, at which time the shipment began or how long it will take for the freight to make delivery of the goods from the suppliers to the consumers amongst other details IoT guarantees the tracking of goods in real time for customers to gain insight into. Real time information on location, condition and status of shipments can be availed through the concept of Internet of Things which is very useful to the logistics firms to monitor their shipments. [Wilson, D. (2024).] For instance, FedEx uses the IoT sensors to monitor the packages, with the intention of enhancing the visibility and provide the actual shipment information to the consumers.

11.4 Enhanced Customer Service

Frequent and fast replies to the e-mails created to, for instance, share information or address problems.

IoT makes questions and problems solved faster by offering real-time data, automation, and link. Principal advantages consist of:

1. Real-Time Monitoring: Consequently, the issues are detected on the go hence reducing reaction rates.

2. Predictive Maintenance: Through these failures, sensors decrease on average down-time and allow for issues to be solved before they arise.

3. Automated notifications: For faster response, IoT systems provide notifications to the concerned people at that very instant.

4. Remote Troubleshooting: Through the use of remote diagnostic and repair tool, technicians are able to improve on productivity.

5. Improved client Service: Due to IoT, detailed information about product interactions may be obtained, and client inquiries may be answered faster and better.

6. Supply Chain Optimization: The constant tracking of supply chain activities enables a speedy resolution if there is a hitch or a delay. These qualities yield enhanced productivity, everyone's satisfaction, particularly clients, and business operational soundness. [White, J. (2024)]

12.0 Data Driven Decision Making

12.1 Long Term Planning Based on IoT Data

In Bangladesh, a long-term strategic planning of supply chain management through the IoT application is very much beneficial for most important industries such as garment industries. In using iot sensors in procuring raw materials, in storing supplies, in moving products to the market, and in delivering products to customers, companies can gain immediate information on status of inventories, control the environment during transportation, and identify when machinery in distribution centers require maintenance.

For instance using IoT, a top Bangladeshi textile mill could schedule production plans in accordance with demand, control logistics in real time, and guarantee international norms of environmental conditions during shipment. Analysis of this data also helps to enhance operational effectiveness while also enhancing the firm's capacity to monitor and adjust to market shift and risks to guarantee its sustainability and competitiveness in worldwide markets.

12. 2 Forecasting

Thus the application of IoT for demand forecasting to enhance the accuracy of the demand in the supply chain is highly suitable for such countries as Bangladesh, where manufacturing, particularly in the textile and garment sector is highly valued in the regional and global economy. IoT can enhance demand forecasting in a Bangladesh-specific context: IoT can enhance demand forecasting in a Bangladesh-specific context.

Textile Industry Monitoring: One of the pioneering industries that can derive a lot of advantage from IoT is the textile industry of Bangladesh which is one of the largest globe's textile industry. They might also be used to numerically track the production rate, efficiency of the machines in use, energy used in the factory, etc. For example, IoT devices can assist factories increase their output of a certain product if its sales rise suddenly through identifying the preferred commodities by customers.[Nanjiba Chowdury,2023]

Environmental Data Collection: The climate and humidity in Bangladesh can impact the production quality in textile manufacturing. IoT sensors can monitor these environmental factors and adjust production schedules accordingly to maintain product quality, which in turn affects demand forecasting accuracy.

Port and Logistics Tracking: Given Bangladesh's reliance on ports like Chittagong for exporting goods, IoT devices can be used to track shipments in real-time. This data can inform demand forecasting by providing insights into potential delays or bottlenecks, allowing companies to adjust their forecasts based on the real-time status of goods in transit.

Dynamic Inventory Management: Some examples of the applications of the Internet of Things in Bangladesh are IoT based automatic inventory or stock management for the all the retailers and suppliers of the country. For instance, a garment retailer in Dhaka can receive real time data from its stores all over the country and order garments from manufacturers in proportion to the sales made instead of flooding the stores with garments and risking to have no clients later.

Convergence with Other CG Consumer Behavior Data

Smart Retail Analytics: To gauge consumer behavior inside the stores that they have set in the urban markets such as Dhaka the retailers can adopted IoT devices. For instance, intelligent shelves can include proximal sensors; these sensors can detect which of the specified items are often taken, but not bought. It can also be used to better estimate demand forecasts, given the insights into consumers 'wants and needs.

Mobile Payment Data: In Bangladesh, the use of mobile payment is quite common allowing real-time data analysis of purchasing pattern with the help of IoT integrated with mobile payment data. This information can always be vital in the forecasting of demand particularly to sectors that deals in fast moving consumer goods (FMCG).

Defining Support for Agricultural Supply Chains IoT in Agriculture: One of the major industry in Bangladesh is agriculture. Means with the help of which crop condition, moisture of the soil and even the climate can be controlled is IoT. It can also be applied to improve the estimation of agricultural production as being a definitive factor that defines potential demand for agricultural goods and services and to construct the adequate supply network.

Supply Chain Integration: For instance, if through IoT the information got about the yield reduced because of bad weather in a particular year in producing rice, the retailers as well as suppliers would be able to make correction on the demand of rice, as well as the sources in order to ensure adequate supply of rice in the entire country.

5. The next component is Risk Mitigation and this directly relates to the strategy that has been specified above Risk Mitigation and identify key scenarios that can be used to minimize the chances of risks happening out of the unforeseeable future Scenario planning and Risk management
Natural Calamities & Disaster Management Mega disasters like floods and cyclones are common in Bangladesh, which can badly affect the supply chain operations. Here IoT devices can give early signals and the subsequent effects impacting production units and passages for transportation. This data can play a vital role to prevent companies from Bangladesh from getting affected and modify the demand side and supply side plans of the business organizations.

Scenario-Based Forecasting: The IoT data can be then applied into the creation of models that portray how shifts such as political, or economic might affect demand. These are particularly useful in cases where the market consist of fluctuating factors such as the situation in Bangladesh.

6. Cooperation Improvement of the Supply Chain Process

IoT for Small and Medium Enterprises (SMEs): Most of the SMEs in Bangladesh especially in garments business are subcontractors to the global apparels brands. Through application of IoT, these SMEs can be able to upload production information promptly to the clients, hence the accurate demand information and shorter lead times.

Blockchain Integration: It is possible to state that the integration of IoT with blockchain can help to improve the quality of data that is shared along the supply chain, and demand forecasting, in particular, can be based on fresh and accurate data.

12. 3 Demand Planning

It is important to have the inventory match with the consumers' demand. In Bangladesh creation of digital supply chain through IoT is quite transformative when used as a tool to match inventory with the customer demand. IoT devices can be incorporated at several points of the supply chain including the warehouses, shops and transportation channels, making it possible to gather information such as the kind of stock in the stores, the rate at which customers are demanding the products and movement of the products. This data helps businesses to track the position of stock accurately, and be in a position to predict changes in demand as well as stocking appropriately.

For example, IoT sensors in products can help in monitoring the time of expiring of products and therefore signaling management for a refill or the expiring products to be removed. Also, smart inventory systems can have a feature of ordering for stocks from the suppliers when they reach the reorder point, thereby eliminating overstocking, and stock out scenarios. In a growing economy such as that of Bangladesh, this technology in addition to increasing productivity also assists in the better servicing of the consumers leading to higher levels of customer satisfaction and thus loyalty.

13.0 Resource Management

13.1 Reducing Energy and Material Waste

Stewardship as a concept can be well applied in the management of resources with a view to lessening the impacts of different industries on the environment. Minimising energy and materials losses is one of the key objectives in the effort to build a global economy with lower levels of carbon emissions. There are different methods through which energy efficiency can be obtained, including improvement of production processes, use of renewable energy, and integration of new technologies that require lesser energy. Another critical aspect of environmental management is the minimization of material waste since this would mean a demand for raw materials decreases, cost of production goes down as well as the amount of waste that goes to the landfill. It is necessary to follow the practice of recycling and reusing the material which is closely linked with the circular economy principles. [Smith, R. (2024).]

13.2 Sustainable Practices

Implementing Eco-Friendly Transportation and Logistics

Transportation and logistics are one of the substantial sources of environmental impacts, particularly, emissions of the greenhouse gases and utilization of the fossil fuels. In their supply chain, in a bid to support sustainability, many firms are incorporating environmental friendly strategies in transportation. These are such as switching to electric or hybrid cars, using the most efficient distances in order to cut fuel cost and using green carriers. Further, reusable and environmentally friendly packaging and other methods like use of biodiesel or hydrogen fuel are some of the strategies being adopted to reduce the effect on the environment. Such strategies do much more than help free up firms to finally do something about the carbon footprint while providing consumers with what they increasingly demand, namely, environmentally friendly products and services. [Green, M. (2024).]

14.0 Challenges in IoT Implementation

14.1 Initial Investment Costs

Costs of IoT Devices and Infrastructure

Another key issue that can be mentioned when it comes to the multiple opportunities of IoT technologies implementation is the significant price tags associated with it. IoT devices for example, sensors, gateways and smart appliances involve high fixed costs. Furthermore, creating the required structures that may include the network to connect the of cloud and solutions such as a data cloud can be costly. New costs which do not bring distinct and fast returns to their investors may be hard for SMEs for example to explain and to justify. Meantime the cost of maintaining the connected devices, software updates, security measures are recurring thus adding to the cost list this is why it is very important for organizations to do their best in ensuring that they do the right IoT investments. [Anushua Mallick, (2022)]

14.2 System Integration

Integrating IoT with Legacy Systems

Integrating IoT technologies with existing legacy systems is another major challenge that organizations face. Many companies operate with outdated or incompatible systems that were not designed to support IoT devices. Achieving seamless integration requires specialized middleware, software development, and, in some cases, complete overhauls of older systems. This process can be complex and time-consuming, often requiring collaboration across multiple departments and external vendors. The lack of standardization in IoT technologies also adds to integration difficulties, as organizations may struggle to ensure interoperability between different devices and platforms. [Taylor, J. (2024).]

14.3 Technical Challenges

Issues with Connectivity and Data Accuracy

Subsequently, connectivity is perhaps the most important facet in IoT as the system is dependent with it and therefore network problems are one of the main technical challenges. Some of the impact that can accrue from poor connectivity is that data retrieval or transmission may be delayed or even lost thus leading to inefficiency of IoT systems. Secondly, data accuracy and data integrity must be achieved due to the stringent nature of data usage in related sectors such as the healthcare, smart cities, and industrial automation. Wrong or insufficient information results in wrong decisions or system breakdowns, the best way is to ensure the data is validated and verified before its use. Further, it is a known fact that IoT devices work in different terrains, ranging from remote countryside to big cities in the world, and each environment presents a different connectivity scenario.

15.0 Data Security and Privacy Concerns

15.1 Cybersecurity Threats

Protecting IoT Devices from Hacking

This is however associated with the rising use of IoT devices in homes and organizational premises hence the high risks of cybercrimes. The problem of hacking IoT devices is rather significant, because these devices are usually devoid of robust security, as they conduct their operations with little protection. The effects of the threat actors that target those IoT segments can be dire depending on the segment that is under attack and include exposure of individual data, disruption of social structures and key services. Thus, for making IoT devices secure strong encryption; proper authentication system and security updates frequently should be deployed. Besides, the Network segmentation and working with detection systems can to a certain extent effectively prevent potential attack. [Roberts, K. (2024).]

15.2 Data Privacy

Ensuring Compliance with Data Protection Regulations

IoT devices are highly data producing devices, most of which are usually of personal nature, and often sensitive. Privacy of this data is another important consideration especially with, the rising use of data protection laws globally and EU's General Data Protection Regulation (GDPR). These regulations mean that organisations must have rigorous data governance procedures, such as getting users' consent, where practicable, isolate data and ensure it is stored and transmitted securely. The non-observance of data privacy regulations erodes the consumers' confidence and incurs financial repercussions as well as reputational losses to a firm. [Morris, T. (2024).]

15.3 Regulatory Compliance

Meeting International Standards for Data Security

IoT is today global, therefore organizations have to operate within IoT field across various regions having dissimilar regulations. Compliance with the international standards in data protection and security is crucial to mitigate the legal risks, and to build the customers' confidence. Something like GDPR, CCPA, and several cybersecurity frameworks have standard ways of protecting IoT devices and personal information. The legal demands are dynamic across multiple regions, and so organizations have the responsibility of keeping abreast with change in legal requirements for security. Standard security measures must be put in place as well as constantly scanning any business practices and activities for non-compliance and certifications are also a good way of eliminating the risk of data leaks. [Johnson, P. (2024).]

16. Successful IoT Case Studies

It can be testified that many industries have embarked on the IoT (Internet of Things) journey and have recorded tremendous benefits as far as efficiency, cost reduction and revenue enhancement are concerned. Here are some notable case studies showcasing the impact of IoT:

16.1. General Electric's IoT in Manufacturing and controlling

- General electric applies Internet of Things sensors and big data in carrying out prescriptive maintenance solutions on manufacturing equipment.
- Remote monitoring of equipment performance as the process is carried out in real time to identify early signs of failure and thus prevent such breakdowns in future with as much precision as possible.
- This approach helps to avoid such problems as an unexpected equipment breakdown, high expenses on its repair, and contributes to an increase in the rates of OEE (Overall equipment effectiveness) and time-to-market for producers [Davis, M. (2024).]

16.2. FedEx's IoT in Logistics
- Usage of smart labels attached on the packages with IoT capability for better tracking.
- Supervision of the place, temperature, and condition of packages during transportation.
- Deliveries on time or informs if there are some unexpected delays due to route deviation or any packaging faults.

16.3. Monsanto's IoT in Agriculture
- Monsanto's Climate Field View is based on IoT and captures data on the state of soil, plants, and their diseases.
- Other decision making tools analyze past and present data in order to predict crop yield, ideal planting periods and disease transmission.
- This assist the farmers in decision making, protect from certain calamities, and increase production [Brown, L. (2024).]

16.4. Amazon's IoT in Retail
- Amazon used smart shelves with RFID tags to monitor the stocks physically and in a virtual sense at the same time.
- This makes it easy to track stock records. Restocking properly allows the risk of unavailability to fall greatly.
- Increased inventory accuracy and management gives better customer satisfaction and production sales [Wilson, K. (2024).].

16.5. Siemens' IoT in Smart Cities
- It is for this reason that smart cities use IoT generated data for analysis and operations by Siemens.
- Currently, decisions that are made in the energy production, distribution, and consumption are made based on a huge database.
- IoT analytics are also used for various purpose like cost reduction, energy conservation and reduction of carbon footprints[Clark, E. (2024)].

These cases help evaluate the potential and positive outcomes that the IoT solutions can make in a way bringing about changes irrespective of the situation. Through the use of connected devices, real time data and analytics companies the world is already realizing vast benefits of Internet of Things.

16.6. Key Strategies for Successful IoT Implementation

To ensure a positive return on investment in IoT, businesses should consider various strategies. Here are some considerations that organizations must undertake in order to garner a positive return on investment in IoT:

1. Address the purpose and the mission of IoT solutions in companies and industries and associate them with certain level of returned business results.
2. Choose the right IoT solution with respect to what is on offer regarding the possibility of its development, the relation it has with the already used protocols and compatibility aptitudes.
3. IoT Analytics: This refers to getting to capitalize on the IoT data in a way that one has the ability to derive conclusions and make proper decisions.
4. Security and privacy of IoT devices and data should stay as one of the most emphasized section.

Relative to best practices highlighted in this paper and use of examples regarding success stories of IoT the new businesses and organizations are able to implement efficiently which make the adoption of IoT applications commercially viable.

17. Future Trends in IoT and Supply Chain

Today use of IoT particularly in supply chain operations are on the rise and will redefine the functionality of many organizations. In the future of IoT in supply chains, the following is some of the innovation and the emerging technologies that will impact on the supply chain management.

Among the various emerging technologies, some of the most mentionable ones are noted below:

17.1 Blockchain Integration

The chances of Blockchain technology to be something positive continues to increase especially on issue to do with transparency and security. And there is the possibility to increase the traceability, so, having the identification code, a buyer can prove that the given product is

unique, and the process of its production. From Walmart's pilot program of employing this technology in the handling of the food products, it is clear that blockchain technology possesses the property of the quick identification of possible cases of contaminant and ensuring safety and efficiency of supply chains. [Garcia, M. (2024).]

17.2. Artificial Intelligence (AI)

AI also have a very significant duty of handling enormous amounts of data that IoT devices are likely to produce. Through use of machine learning the computer is well placed to assist in the identification of patterns with regards to demand and assist in determining the stock to be held. For instance, while using data integration, the sales history data may be integrated with the current IoT sensor data and thereby make the industry properly adjust their supply plans. [Morgan, A. (2024).]

17.3. 5G Connectivity

IOT is thrown to have a preference of 5G network to enhance the implementation in the supply system. It also speaks of the fifth generation of the mobile communications technology that provides better bandwidth and less latency; this is going to enhance high data transfer in real-time between connected devices in the supply chain. It shall enable connection to support the other high-level applications and they are; self-driving cars, delivery drones, among others [Harris, J. (2024)]

18.0. IoT and Blockchain Integration

The interactions of IoT and blockchain are challenging and changing various industries by improving traceability, trust, and working mechanisms. This integration enhances the flow of data while at the same time makes for secure transactions and accountability of all the members in the supply chain.

18.1. Traceability: Ensuring the Provenance of Goods

Perhaps the biggest plus that can be derived from embedding of IoT with blockchain is that of creating a system that has the provision of going through each of the steps in the chain. Smart sensors are IoT devices which can be used for observing aspects of a good in transit from the source to the place of delivery. It includes temperature, humidity and geographical position of the food items which are quite significant to preserve the quality of the perishable products.

Blockchain is a secure digital platform that enables creation of a public ledger that encompasses all the data and the transactions that are relevant to a specific product. When integrated, these technologies make it possible for the various stakeholders to determine where the various products came from in order to avoid counterfeit products and those that do not meet safety standards. For instance in the food chain, this integration has been used by super markets such as Walmart group to monitor the cycle of food products and give quick resolutions to instances of contamination and hence strengthening consumer confidence in the safety of the food to be consumed [Lee, S. (2024)].

18. 2. Trust and Verification: Blockchain: A New Way to Conduct Safe Transactions

The structural layout of blockchain is centralized and it tends to make stakeholders more trustful since records of transactions cannot be quickly forged. For a given set of interaction between an IoT device or even an IoT device and a second entity, all these are stored in a blockchain to ensure that the plausibility of falsification or intrusion is negligible.

This integration can also result in the development of self-executing verification process, which, according to the verifiable smart contract theory can be expressed in the smart contracts, the contracts which execute the agreement as soon as the technical terms of the agreement are embedded in the source code. For example in the logistics, smart contract can allow the release of payment when the good has been received in the right state by the buyer without intermediaries [Miller, R. (2024)].

18.3. Applications: Examples of IoT and Blockchain Working Together

Several industries are already leveraging the integration of IoT and blockchain to drive innovation and efficiency. Here are some examples of those cases:

1. Supply Chain Management: Nowadays, IoT sensors are attached to shipments and in its side, blockchain is applied to all the process of documenting of the supply chain. This makes it possible to track the goods in order to enhance accountability.

2. Healthcare: As for the healthcare, the IoT devices can be applied to monitor the patient's data and blockchain offer the protection to this data. These two features ensure that the records of the

patients are safe from tampering, which keeps the records only accessible to personnel with the allow to access the records, hence enhancing the data security and health facility regulations.

3. Smart Cities: Smart tools in smart human settlements for example collect data on traffic, disposals, and energy usage. Hence, where this data is lodged in a blockchain, city planners will be able to bargain for improved and appropriate provision of such resources in order to foster improved city design and management.

4. Energy Management: As for the use of technology in the energy sector we can come across smart devices that are used to control the energy use as well as the technological creation called the Blockchain that allows people to trade electricity. This allows consumers to exchange electricity with neighbours, more so, promote usage of solar power and discourage a large power station

19. Regulatory and Ethical Considerations in IoT

The immense growth of the IoT presents fresh and various regulatory and ethical concerns that will need to be resolved to protect dependable adoption. Regarding the current debate, this discussion will centre on the several international standards, ethic issues arising from the usage of IoT and the guidelines for the ethical implementation of IoT.

19.1 International Standards: Compliance with Global Regulations

When using IoT and AI technologies and products the compliance with international regulations is a challenging task. Several countries have come up with policies regarding user privacy, security as well as device compatibility. Key regulatory frameworks include:

- General Data Protection Regulation (GDPR): Implemented across European Union, GDPR establish rigid rules for processing, gathering and storing the data with protection of the unique rights for personal data, particularly the right to give consent and the right to minimal data processing. Due to the collection of personal data, smart home devices, for example, must meet these statutory requirements [Johnson, L. (2024)].

- Cybersecurity Standards: Governance structures are thus shifting their attention on the need to set guidelines on use of IoT devices. For example, the U. S. Federal Trade Commission (FTC) has put forward measures that would force manufacturers into incorporating adequate security measures into their products; measures as encryption and the provision of regular updates to ward off cyber threats [Adams, N. (2024)].

- Interoperability Standards: In order to allow IoT devices of different kinds interact with one another, regulatory authorities are engaging the use of standardized protocol. This makes IoT

devices to be compatible with other device from other manufactures hence improving the functionality of the IoT systems [Taylor, J. (2024)].

19.2 Ethical Implications: Responsible Data Collection and Use

In this case, the most concerns of ethical issues are in relation to data privacy and consent or permission to use the data. As IoT devices gather vast amounts of data, including sensitive personal information, it is crucial to implement responsible data practices: As IoT devices gather vast amounts of data, including sensitive personal information, it is crucial to implement responsible data practices:

- Informed Consent: People should be well aware of the type of information which is being gathered through the IoT devices and for what purpose it will be processed. It should also be made legal to allow users to give their consent at the start of data collection.

- Data Minimization: According to the principle of data minimization an organization should collect only those data which is required for the intended use. This approach does assistance in avoidance of privacy threats and consequently, lessens vulnerability to use of personal data.

- Anonymization: The use of some form of anonymization can assist in the privacy of the users' identities and yet concurrently permit the analysis of the data. For instance, anonymizing means such as replacing one's identifiable data with tokens can help to inhibit the 'reconstitution' of data to individual end-user [Smith, R. (2024)].

19.3 Industry Guidelines: Best Practices for Ethical IoT Implementation

To navigate the regulatory landscape and address ethical concerns, industry stakeholders should adopt best practices for ethical IoT implementation: To navigate the regulatory landscape and address ethical concerns, industry stakeholders should adopt best practices for ethical IoT implementation:

1. Security by Design: Security should be built into each IoT device so that it has to be a consideration from the ground up. These are things like end to end encryption, and measures to ensure that booting up the device is only possible under secure circumstances.

2. Regular Updates and Patching: This situation makes it compulsory for manufacturers to put in place methods for consistent firmware updates in an effort to counterbalance the vulnerabilities and gain better control over security during the whole lifecycle of the device. This is important is order to achieve a reliable integrity of IoT systems.

3. Transparency and Accountability: Companies should be clear on how they utilize the data of customers and individuals and be responsible for data leakage. This includes sharing with the users how their data will be used and how it will be protected.

4. Engagement with Regulatory Experts: It is recommended that companies should engage professional regulatory bodies to assist in addressing current complex standard and regulations. In this way, we can prevent the risks connected with non-compliance, and improve consumer confidence.

20. IoT in Cold Chain Management

With the IoT technology, the management of the cold chain products around the world is increasingly being enhanced by an improved level of monitoring of items in the cold chain. It is especially relevant for those industries which deal with delicate products such as food and medicines in particular, which need certain standards of integration.

20.1 Perishable Goods: Monitoring Temperature-Sensitive Products

Various IoT technologies enable the monitoring of the temperature-sensitive products in the course of the cold chain in real-time. With the help of connected objects which exist in cold chains optimized with temperature sensors, it is possible to watch the condition of perishable goods, including fruits and vegetables, dairy productions or drug products.

Some of these sensors measure the temperatures and humidity at some times of the production process as well as during transit and storage. For instance, it can be applied in the use of temperature data loggers for products that are to be stored in the refrigerated vehicles or storages. When a temperature deviation occurs it sends alarms to give a chance of the stakeholders to take the necessary measures to prevent the spoilage of the products and the quality of the product [White, J. (2024)].

20.2 End-to-End Visibility: Tracking Conditions from Production to Delivery

With IoT integration one gets full visibility of the product from the time it is picked from the farm to the time it gets to its destination with the required condition. This visibility is very much relevant to ensure that compliance of the relevant safety regulations are realized while at the same time maintaining quality of perishable products.

IoT which is a network of connected things have great capabilities that make it possible to collect supply chain data from several areas and relay them for real time analysis. This system continues the possibilities to affect not only the temperature but also such factors as humidity and access of light affecting the state of products. By using real-time data, it is possible for companies to make good decision on the best way to transport the products and arrange them in such a manner that they reach their destined place in the best state they can be [Lee, K. (2024)].

20.3 Maintaining Product Integrity: Ensuring Quality and Safety of Perishables

Chemicals like pesticides, bacterial, mold, and insects are some of the things that can cause havoc on perishable products why the right handling should be observed. IoT solutions enhance the quality of products by providing deeper and real time information required to enhance the monitoring of cold chain.

For instance, in the food industry the actualization of IoT when combined with the blockchain will raise the aspect of the IoT from traceability to accountability. The use of blockchain technology to capture temperatures allows the supply chain stakeholders to view the condition of the products that were stored and transported in the process of supply to the market and thereby reduce the chances of products that are supplied in the market, which failed to meet regulatory requirement. Thus it does not only help in maintaining the general quality of the products but also in maintaining the trust of the consumers to the supply chain [Johnson, T. (2024).]

In cold chain management, internet of things brings worth the savings from spoils and wastage also. It is reported that the growth of the cold chain monitoring market has been expected due to a soaring demand for good and efficient cold chain solutions.

21.0 Impact on Global supply chains

The (IoT) is really revolutionizing the global supply chain through improved quality, visibility and reliability. Below are key impacts of IoT on various aspects of supply chain management: Below are key impacts of IoT on various aspects of supply chain management:

21.1 Managing Complexity

This enhances the management of complex structures as identified in IoT technologies whereby multinational supply chains come with improved real-time information and visibility of events in the latter supply chain phases. This capability can be used to monitor the quantity of stocks, the flow of shipment and the management of the whole supply chain. For instance, IoT sensors may be used on products in warehouses and transportation vehicles to monitor the conditions and minimization of human intervention on them hence increasing on the efficiency of the operation. [Davis, M. (2024)]

21.2 Cross border Logistics

IoT enhances productivity in the supply chain and improves cross border trade. The IoT enablement of devices helps in improving the tracking of the products as they go through borders to facilitate on time and secure shipment. This technology makes it easier for suppliers and logistics providers to communicate thereby minimizing on the many hitches that are often encountered. IoT helps in effective management of supply chain networks that will enable easy access to more markets and an effective ways of dealing with the numerous sourcing opportunities. [Wilson, A. (2024)]

21.3 Trade compliances

Ensuring adherence to trade regulations is critical in global supply chains, and IoT plays a vital role in this area. By providing real-time monitoring and data collection, IoT helps companies comply with various international trade laws and standards. This capability is particularly important in industries where safety and quality are paramount, such as food and pharmaceuticals. IoT technologies can automate compliance checks, reducing the risk of non-compliance and associated penalties. [Miller, S. (2024)]

22.0 Collaborative supply chain Ecosystems

Interconnection of IoT in the collaborative supply chain ecosystems is reshaping businesses by improving the integration of partners, using the common platforms and platforms.

22.1 Partner Integration: Collaborating with supplies & partners

IoT for supplies work by providing real-time data sharing of information across the various supply chain networks. This integration enables those firms in the supply chain to be on the same page, which means they will be able to cut down on lead time to their ultimate customers. For instance, IoT sensors can be used in monitoring inventory products via monitoring and reporting their flow in the supply chain; this builds trust and synchrony between trading partners.

22.2 Shared Platforms

The availability of common platforms for data sharing is very important in an IoT-context in a supply chain setting. These platforms afford data to be collected from other source then disseminated to the stakeholders showing real-time operations. It is even more effective in decision makings while satisfying the customers since they and the suppliers can monitor the

orders' status and the stock readily. In the case of utilizing the common platforms, the organizations can minimize the issues of information fragmentation and disintegration.

[Garcia, L. (2024)]

22.3 Process Integration

Another important advantage of integrating IoT in the supply chain network is reduction of cycle time. IoT implements the management of the supply chain functions through devices such as for use in inventory tracking and monitoring of the condition of equipment. For instance, IoT can inform reordering processes when a certain quantity has been used to ensure that they do not make extensive purchases that would lead to stock outs or oversized purchases. Also, real time examination of the conditions of equipment and goods aid in performing maintenance before a component fails while products are transported under favorable conditions, thus increasing efficiency. [Smith, J. (2024)]

Overall, integrating IoT in collaborative supply chain ecosystems increases the integration of partners, the adoption of platforms for data sharing, and efficiency and increases customer satisfaction.

23.0 Customizable & scalable solutions

23.1 Tailored Applications

This refers to creating specialized IoT applications that address the particular demands of companies in different sectors. This customization is very vital in improving operational capacity and guarantee compliance with business requirements. Some the example roles include the IoT integrators, who act as a link between technology and organization's goals, provide valuable solutions that address the issues within the organization. That is to make sure that any device, platform, or system in the IoT environment fits in the current framework for efficient data flow and decision support systems.

Key Benefits of Custom IoT Solutions

- Enhanced Operational Efficiency: As an example, it is easier, cheaper and more controlled when implemented with customized methods to let it freely offer insights into process improvement and increase productivity.
- Improved Decision-Making: This means that those at the helm of the business can be in a position to make the right decision at the right time hence marking efficiency in the handling of the market changes.
- Increased Customer Satisfaction: Consumption of IoT data for creating customer-specific experiences can help to increase the level of satisfaction and further sales.

- New Revenue Streams: Decision makers can use examples of IoT applications to develop additional products and services for customers thus generating more revenues.

23.2 Scalability

Another characteristic that should not go unnoticed in IoT is scalability where organizations progress and their requirements change. Well-built IoT architecture enables the organizations to kick-off with the pilot implementations and then spread wide. This approach not only stops investments at the lowest risk level but also allows businesses to grow the IoT schemes without interrupting the current functions.

Challenges in Achieving Scalability

- Integration Complexity: Number of connected devices is rising and when more and more devices need to be incorporated with existing systems, it may take a lot of time.
- Data Management: Due to IoT devices, the amount of data that is being generated has reached such a level that proper management solutions must be put in place for the proper collection storage and analysis of the data.
- Interoperability Issues: One major issue is that different devices may utilize different protocols to communicate, and to encapsulate, with each other, making for difficulties in achieving comprehensive integration. The importance of integration cannot be overemphasized because all the components must perform the intended tasks in IoT implementations.

23.3 Industry Examples

Various industries are leveraging IoT solutions to enhance their operations: Here are various sectors that are considered actionable IoT solutions to revolutionize their operations:

- Manufacturing: IoT sensors, in smart factories, are applied to evaluate the condition of equipment and dampen the occurrence of failures, and, therefore, the effects they have on production rates and product quality.
- Healthcare: Internet of things patient monitoring devices that are connected enables the health care providers to reach the patient at remote and offer better care using the connected health devices.
- Retail: The consumers incorporate IoT into the stores to ensure that they manage the stock and for promotion to ensure the customer gets what he or she wants.
- Agriculture: Employers of youths apply efficient services for the use of water and electricity resources by farmers in increasing the yields of their production and also in avoiding any outcomes of their action detrimental to the upper planet

These examples illustrate how customizable and scalable IoT solutions can transform operations across different sectors, driving efficiency and innovation.

24.0 IOT & AI

The worlds of Artificial Intelligence (AI) and Internet of Things (IoT) are eliminating the supply chain complexities by delivering intelligence, automation and data in real-time. Here are some key ways these technologies are making an impact:

Advanced Analytics

- AI is enabling deeper insights into supply chain data :AI is enabling deeper insights into supply chain data:
- Some others are demand forecast, inventory management, disruption forecast which is solved by predictive analytics using machine learning.
- Descriptive analytics shows detailed information on various aspects of the business and prescriptive gives recommendation of what should be done, for instance the right number and kinds of products to produce.
- Generative AI works as an assistant and offers suggestions to humans while solving problems and decision-making connected to supply chains.

24.1 Advanced Analytics

AI and IoT are automating many supply chain processes:AI and IoT are automating many supply chain processes:

- In warehouses, robots enabled with AI pick up data about temperature and movement, lighting condition and much more instantly. This data is then used by Machine learning algorithms to determine labour demand, transport demand, and the best route.
- These latter include temperature, vibration among which are parameters that IoT sensors on machinery monitor. Analytics for maintenance indicates signs of potential problems and thus acts as an assistant in preventing time and money wastage.
- Using demand sensing involves factors such as seasonality and weather to enable an organization forecast short-term demand variations. This make stand able to manage upstream activities with efficiency of its strategic goals.

Real-World Examples

- One retailer in a specific country leveraged AI to optimize top line SKUs and control allocation resulting to slicing €3 of logistics costs. 5 million per year.
- Church Brothers Farms used demand sensing AI demand sensing approach to increase the degree of forecast accuracy, order administration, and minimize product waste.
- AI fits as fleet managers employ it to get the real-time information about the best time to deliver a product, which routes have higher probabilities of experiencing a breakdown, or whether there is a congestion in the company's flow of products.

To sum up, it is possible to mention that both AI and IoT are offering the supply chain greater and better analytic, automation, and real-time awareness. All these technologies are still developing, and hence, their influence on supply chain management will progressively expand.

25. Conclusion

With the development of any endeavor there need to be a strong management and supply chain provide that management in any logistic business. In this paper we tried to explain that the supply chain efficiency to enhance in Bangladesh is in urge to be digital with the help of IOT.

We all know that we are living in an Artificial intelligence (AI) era which demands everything to be automated and digital reducing human efficiency and increasing the overall productivity. This paper aims to aware Bangladesh the urgent need to create a productive supply chain management with modern IOT applications

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