Sustainable Futures 4 (2022) 100069

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures

Warehousing 4.0: A proposed system of using node-red for applying internet of things in warehousing

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ARTICLE INFO

Keywords:
Industry 4.0
Internet of things
Warehouse management system
Supply chain
Node-RED
MongoDB

ABSTRACT

Industry 4.0 has a vital role in supply chain management as it can convert the supply chain to a smart one and make it more agile. One of the main pillars of Industry 4.0 is Internet of Things (IoT). Managing the warehouse the inventory is a very important part of managing the supply chain. In this research a system is proposed to implement the approach of Internet of Things in warehousing management by using Node-RED and MongoDB. The system illustrates how IoT can be implemented in a warehouse to gain benefits and to avoid the drawbacks of traditional warehouse management systems. For illustration, a dataset was used to show how IoT has a great impact on the warehouse operations, especially on the forecasting accuracy. It helps in providing real-time visibility of everything in the warehouse, increasing speed and efficiency, decreasing manual manpower, and preventing inventory shortage and counterfeiting. This research provides an effective roadmap for enterprises to improve their warehouses by using the Internet of Things.

1. Introduction

The main goal of any supply chain management is to achieve coordination and linkage between all processes and entities in the supply chain (SC); i.e. suppliers, customers and the organization itself. The objective is to share information regarding demand to avoid stock out and large amount of inventory buffers, therefore, improving customer satisfaction, empowering competitiveness and profit, and increasing effectiveness and efficiency [1,2]. Warehousing is a main part of managing supply chains as it can provide integration between all the operations in the supply chain. Fig. 1 illustrates the main functions of warehousing [3].

A warehouse is considered as a very necessary part of the supply chain that is involved in achieving optimum and continuous operation of the production and distribution processes. The main keys that help in successful performance of the warehouse are design, layout, and operations of the warehouse [4]. In [5], a new role for warehousing illustrated that the warehouse can make all processes more integrated all over the supply chain not just for storing goods, it provides visibility to avoid a high level of inventory that costs companies more money. So, sharing information all over the supply chain is a critical issue, especially inventory information. Hence, that led to the need for the technologies of the Fourth Industrial Revolution (Industry 4.0).

There are many information-sharing technologies that can be used, but companies need first a good understanding of their Supply Chain to decide which technology will be suitable and how to take advantage of adopting it. One of these technologies is Radio-Frequency Identification (RFID) information technology. In [6], it was found that implementing RFID helps in the coordination of the inventory policies, real-time monitoring for inventory levels that reduces holding and shortage costs and helped in achieving high economic benefits. Internet of Things (IoT) is the new revolution of the Internet, it can be described as smart because it gives everything a unique ID and can make a decision according to the configured process, hence it can convert all the world to a smart one that makes every object talk to each other as it can be applied in all fields; Fig. 2 shows the main applications of IoT [7].

Coordination and information sharing all over the supply chain is the main aim that all enterprises seek to achieve, because that is the first defense against the bullwhip effect. There are many benefits of information sharing over the supply chain as shown in Fig. 3 [1,8].

There are a lot of technologies associated with IoT such as; RFID, barcode, smartphone, WSN, cloud computing, social networks, Internet (IPV6), 3 G/4 G, WiFi and ZigBee [9]. This paper is structured as follows; Section 2 presents the relevant literature and background of the

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https://doi.org/10.1016/j.sftr.2022.100069
Received 20 January 2022; Received in revised form 18 March 2022; Accepted 30 March 2022
Available online 4 April 2022

research. Section 3 explains the research methodology and the flowchart of the proposed system. Section 4 discusses the proposed system by using Node-RED and Mongo DB that illustrates how to implement a numerical example. Finally, conclusions and future work are presented in Section 5.

2. Literature review on using IoT in supply chain

2.1. Publications on IoT in supply chain applications

With the emergence of Industry 4.0, researchers started to explore the potential of using these technologies in several fields. In [10], statistical work was presented to illustrate the fields that used IoT protocol between 2013 and 2018 as shown in Fig. 4. It was obvious that the industrial section was not significant among these fields. Few studies addressed this implementation in the field of supply chain management (SCM).

Industry 4.0 has great impact on several fields such as; smart home, social fields, smart cities, e-health systems, manufacturing and industrial fields and logistics areas [11]. In [12], an interaction system was proposed as a support for education based on IoT. Each student has the system application and a unique account on his device. The system has two databases the first one contains students' information; the second one contains the augmented learning objects. In [13], a systemic dynamic (SD) model was developed to illustrate the impact of Industry 4.0 on supply chains parameters and a framework was presented to illustrate how to implement it in logistics and supply chain management. In [14], the impact of Industry 4.0 on different areas of supply chain was illustrated as it provides real-time information which has an effect on planning and forecasting area, and provides traceability of products all over the supply chain. The author also illustrated how Industry 4.0 technologies can convert a traditional warehouse to an intelligent one. In [15], the impact of big data on supply chain management was studied by making a survey for employees of multinational companies, then a statistical analysis was done, it was found that IoT and big data analytics have great impact on the supply chain as they help in cost savings, operational excellence, reducing gap between demand management and customer satisfaction.

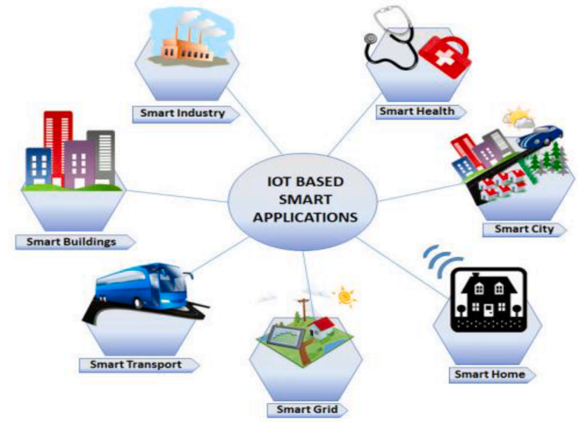

Fig. 2. IoT applications [7].

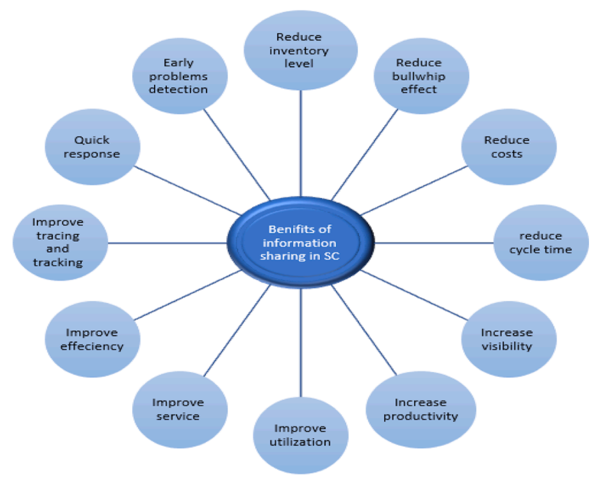

Fig. 3. Benefits of information sharing in SC.

2.2. Impacts of IoT on supply chain processes

In [16], the impact of real-time data generated by IoT system on demand forecasting was studied. It was found that it plays a critical role in the quantitative methods of forecasting as real-time data help in achieving agility, strategic advantage, revenue growth, cost saving and high accuracy. In [17], a framework for implementing IoT in warehousing was presented and the expected results from this framework were illustrated. The authors argued that Industry 4.0 technologies help in providing real-time visibility of everything that increase speed and efficiency of supply chain and make it more agile. In [18], a conceptual framework of applying IoT in warehouse management system was proposed and the impact of the framework on the supply chain was studied. It was found that IoT helps in having more control and monitoring on all the warehouse operations. In [19], an application of IoT-based warehouse management system for smart logistics was designed with an advanced data analytical approach by using computational intelligence, it was found that Industry 4.0 techniques increases warehouse productivity, picking and packing accuracy, efficiency and robust order variability.

As it obvious there are no publications in the industrial sector until 2018, lack of development frameworks that provide guidance for IoT adoption in a context with clear guidelines and roadmaps, there is no researches in the areas of demand forecasting, marketing, transportation. So this research aim to provide a valuable insight about IoT and present a detailed system that considered as a very useful roadmap

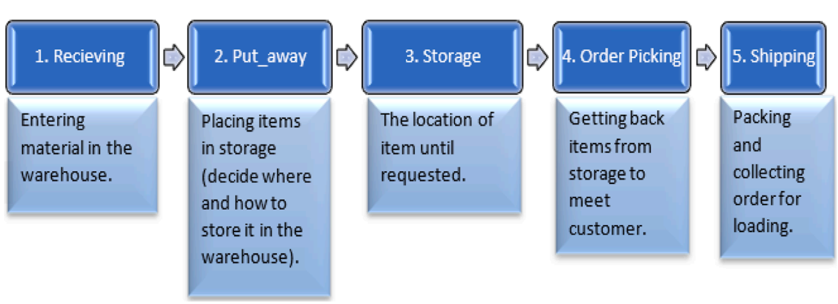

Fig. 1. Main functions of warehousing.

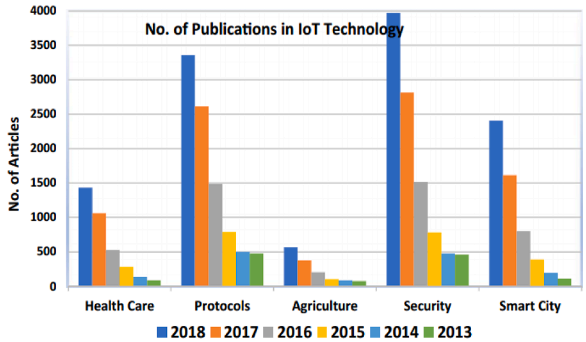

Fig. 4. Number of publication of IoT in several fields [10].

for academics and practitioners to show how they can implement ioT in supply chains and gain more benefits from it then present a numerical example to illustrate how real time data affect forecast accuracy.

3. Research methodology

3.1. Internet of things (IoT)

IoT is considered as one of the main pillars of Industry 4.0 that helps organizations build and strengthen their competitiveness in the market; and it has an increasing impact on the modern economy transformation [20]. Architecture layers of IoT vary depending on the application where IoT is used; different architectures have been proposed by researchers. According to [21], IoT architecture could be identified with four basic layers:

1. Devices: (devices connected to sensors or RFID) that can monitor measure and collect information.
2. Connectivity: wireless sensor networking that provides connectivity to exchange data between the devices.
3. Cloud: All the process occurs under the cloud (Internet) to exchange, analyze and store theses data on databases.
4. Application interface: that provides real-time monitoring and controlling the system.

According to [22], the most popular IoT architecture consisted of three layers: sensor, middleware and application layer, the first one is sensor layer in which uniquely identify objects in the IoT ecosystem using sensors or RFID tags to collect information about them. The second one is middleware layer that provides a network support and protocols for IoT that can receive and send data. The last one is application layer the purpose of this layer is to carry out application specific functionalities. These layers were shown in Fig. 5.

Today, several organizations and services seeks applying IoT in their systems as they can gain massive benefits that incur a positive impact on their business such as improving utilization, reducing human

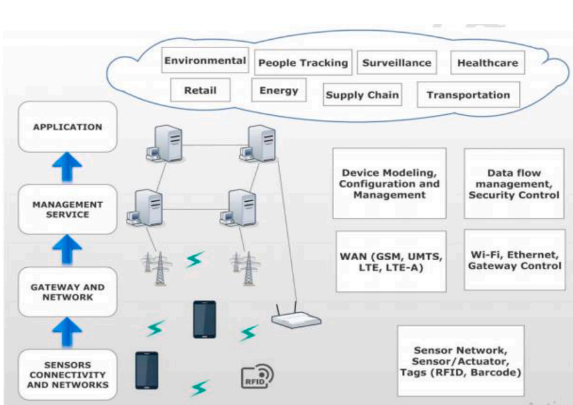

Fig. 5. Architecture layers of IoT [22].

interaction, proactive maintenance and reducing costs. IoT can have a significant role in improving various functions of SCM. Fig. 6 summarizes some potential benefits of this implementation [23].

IoT provides a solution based on hardware and software that can receive, retrieve, process, and store data according to the configured processes using some technologies and protocols such as:

RFID which is one of the most important technologies used when applying IoT. It is used for identifying objects with a unique ID and it can be used for storing data about the products attached.

Wireless Sensor Network (WSN) that is considered as an important advantage of IoT. It depends on sensors that can be attached to any object and has the ability to collect, monitor and analyze data. These technologies and sensors can be used in inventory management to monitor, track, trace and provide real-time visibility of all objects. Hence it provides more control, accuracy and competitive advantages to enterprises [24].

3.2. Inventory management and demand forecasting

Forecasting helps enterprises to expect how much inventory they should hold in their warehouses. Holding inventories more than needed causes loss of money, because the goods may be exposed to damage, obsolescence or shrinking and, hence the holding cost increases as it is related to other costs as shown in Fig. 7. But it is important to hold inventories for enterprises for some reasons shown in Fig. 8 [25].

All organizations strive to keep their inventory at an optimal level, in this regard, they use forecasting methods and real-time data to avoid loss and uncertainty. Demand forecasting is considered as an essential and important activity in any organization. The main purpose of forecast is to reduce uncertainty and forecast errors. Organizations can perform long-term or short-term forecast and they can apply both. In general, short-term forecasting is more accurate than the long-term one. This is mainly due to the fact that short-term forecasts include fewer uncertainties [25].

There are two categories of forecasting methods [26]:

Quantitative methods; these methods are time-series based, as they depend on the historical data from past events, future demand is estimated from the past actual data only. The components of this time series data may be (trend, seasonality, cycles or random).

Qualitative methods; these methods are used when historical data are not available, and applying quantitative methods involves a high uncertainty so these methods require high skilled employees or experts.

Fig. 9 Time-series components [26].

One of the quantitative methods that will be used in this research is the weighted moving average method. This method is used when a trend is present. Weights are based on experience and intuition. It is calculated by using the formula in Eq. (1) [26].

$$M = \sum_{t=1}^{n} W * D \Big/ \sum_{t=1}^{n} W \tag{1}$$

Where M is the average value, D is demand value, W is the weighing factor and n is the number of periods in the weighting group. After calculating forecast data, error is calculated by using Eq. (2):

$$ForecastError = |Actual - - Forecast| \tag{2}$$

The aim of any forecasting method is to make the error value at the minimum level. When the data has a seasonal variation (ups and downs in a time-series) the seasonal model can be applied. Fig. 9 represents the steps for calculating it [26].

4. Proposed system

It is obvious that the traditional Warehouse Management System (WMS) has many problems that need to be fixed, such as the mismatch between data of the actual inventory and the inventory data on

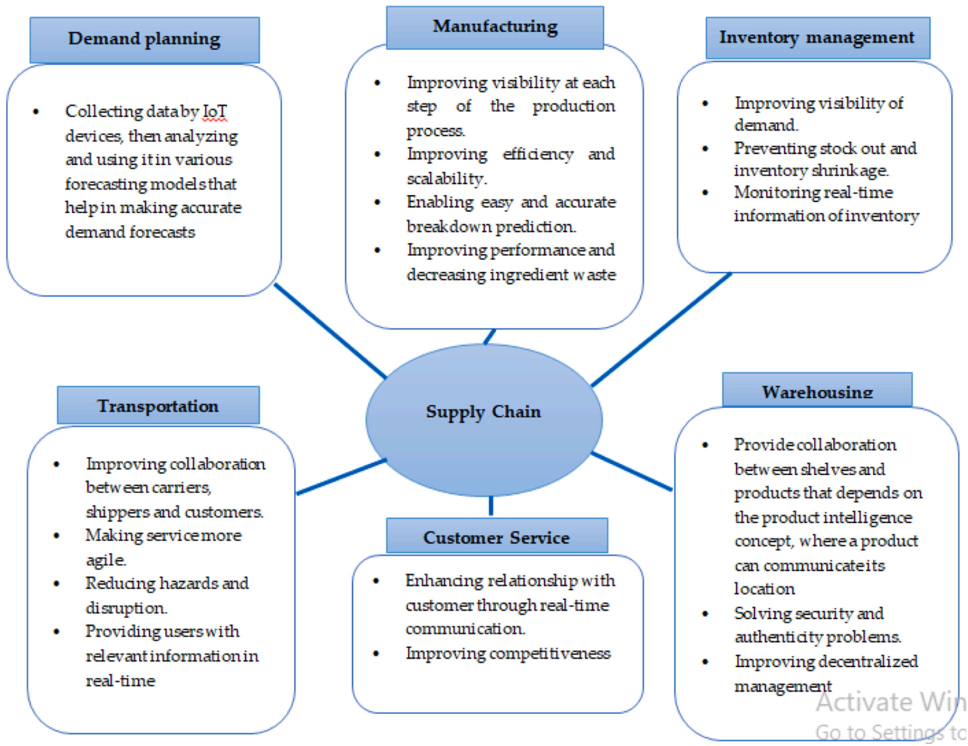

Fig. 6. Benefits of using IoT in SCM functions [23].

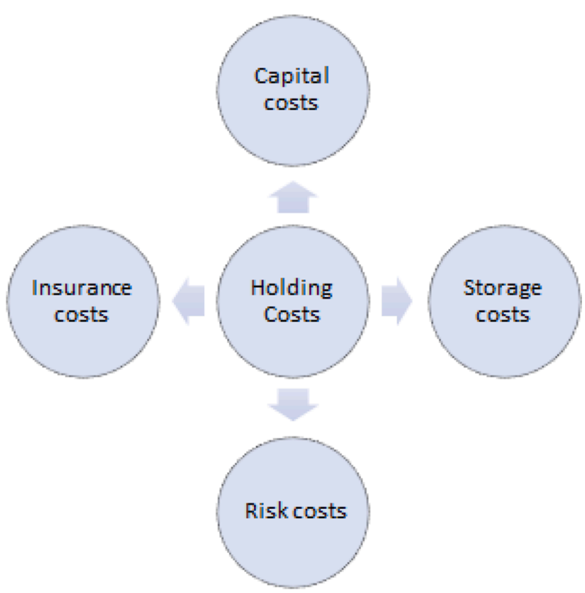

Fig. 7. Inventory holding cost components.

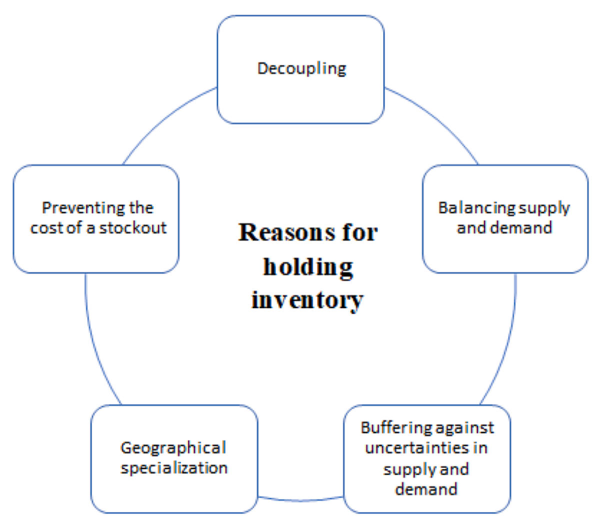

Fig. 8. Reasons for holding inventory.

Enterprise Resource Planning (ERP) system, the long duration of picking and packing processes, the lack of controlling space allocation that results in waste in the warehouse space, more costs and efforts due to manual labor, and mistakes in orders that would have bad impact on the business. Most of these problems can be fixed by adopting IoT. A system of using IoT technology in a warehouse is proposed in this paper to address those problems and make the warehouse smarter. Two software packages were used:

(a)Node-RED [27]: an open-source flow-based and event driven programming tool programming tool that enables a real connection of hardware and Application Programming Interfaces (APIs). Node-RED is represented as a flow or network of nodes that can communicate to each other and exchange information. These nodes may be hardware like a sensor or software like a service. It helps developers and designers to understand all the interactions in an IoT system.

(b)MongoDB [28]: a tool used to store data; it is a database engine that has the ability to respond to a large number of queries in a short time.

In the proposed system, every product is attached to an RFID tag before entering the warehouse, the tag contains its information (product name, production date, expiry date, its location in warehouse and weight). Fig. 10 gives a flowchart that illustrates the steps after entering from the gateway for the proposed system.

4.1. Pseudo code for the proposed system

Variables:

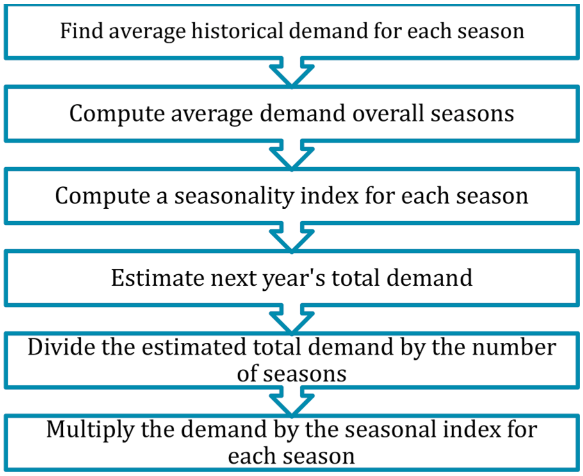

Fig. 9. Steps for calculating seasonal index method.

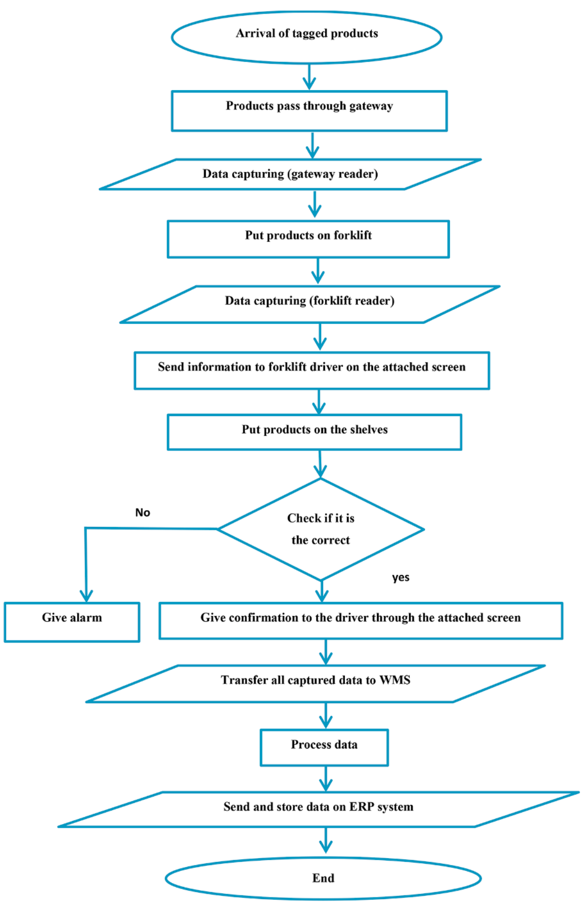

Fig. 10. Flowchart for the proposed system.

T= {T1, T2, T3,….Tn}: set of RFID tags that contains product information PI.

PI: set of information about product {product name, number entered, production date, expiry date, product location number in the warehouse, weight per one product}.

R= {R1, R2, R3}: R1 gateway readers, R2 forklift reader, R3 shelve reader.

S= {S1, S2}: S1 shelve weight sensor, S2 humidity sensor.

FS: screen attached to forklift.

SI: shelve information {location number, product name, weight per one product, shelve weight limit}

Algorithm:
Initialize tags Ti for products Pi.
Initialize readers Ri positions and sensors Si positions in the warehouse.
System initialization
Pass products through gate way and Read PI using R1.
Put products on forklift
R2 send PI to forklift man through FS.
Define forklift movement according to PI.
Move to shelve and put products.
IF (PI =! SI)
Send alarm ("error")
Else
If (S2 reading > shelve weight limit)
Send alarm ("weight exceeded")
Else
Send confirmation ("this is the correct place")
End if
Transfer all captured data from Ri and Si to WMS.
Process data
If (PI captured == PI existed in database)
Update
Else
Insert new product
End if
Send data to ERP and SCM systems.
Store data.
End.

4.2. Using node-red and MongoDB for applying the proposed system

To verify and run the proposed system, data from warehouse of an Egyptian factory was used. As shown in Fig. 11, once the batch arrives at the warehouse gateway that represented by ProductEnteringWarehouse node, the scanners read these tags and the program starts to check the products database in MongoDB (CheckFindResult node). The system checks if the same product name with the same expiry date exists or not. If it already exists, it will be updated (PrepareDataUpdate node); and if not, it will be added as a new product (InsertUpdateIntoMongo node) as shown in Table 1.

Once the products are put on a forklift, the forklift reader sends a message to the forklift driver on the attached screen with the product location. Once the products are put on the shelves, it will give a confirmation that this is the correct location; if there is an error it will give an alarm. If the weight exceeds the weight limit that calculated in CalculateWeight node, it will give alarm and a message to the driver as shown in Fig. 12. Also, humidity and heat sensors exist on the shelves and give alarm if any off-limits occurrence happened in order to assure product quality and warehouse safety.

The second function implemented in Node-RED is for making an order from the warehouse. Assume that 100 pieces of product A2 are required to be picked from the warehouse. As soon as the order is entered to the system, the program starts to search for the product in the products database (in MongoDB) with the earliest expiry date and send a message on the forklift screen; as shown in Fig. 13 with the location of the products required. The Node-RED flow of ordering from the warehouse is shown in Fig. 14.

Once the products are picked from the shelves, the inventory level in the products' database is updated immediately table 2 and the sales data are stored on the Sales.Data database at the same time Table 3. All the data sharing is executed in the cloud.

In Fig. 15, Node-RED generates an excel report to enable searching for products and exporting the entire database as shown in Table 4.

After exporting data, data can be easily sorted and analyzed online. Providing real-time data can solve several problems that exist in

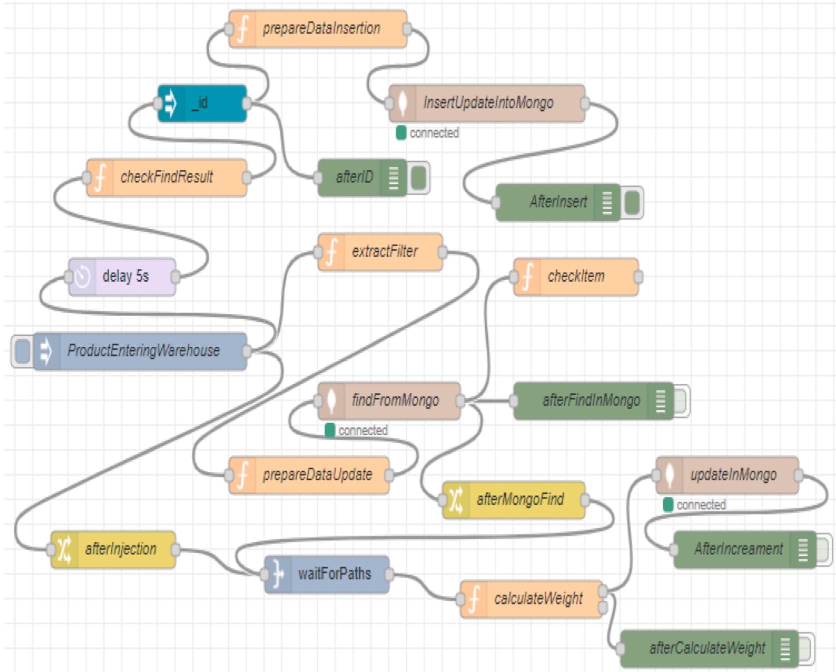

Fig. 11. Node-RED flow (scanning and storing products).

Table 1
MongoDB products database.

Products								
	_id ObjectId	productName String	quantity Int32	productDate String	ExpiryDate String	LocationInWarehouse String	weightPerProduct Int32	AllWeight Int32
1	254f857s214j95w182ft87sg	"A1"	140	"1–5–2019″	"15–05–2020″	"L"	15	2100
2	5214l48d752e841a851g36r5	"A2"	150	"1–5–2020″	"15–05–2021″	"M"	10	1500
3	541 g547q28g1r852p94s145	"S2"	150	"1–5–2020	"15–05–2021″	"S"	10	1500

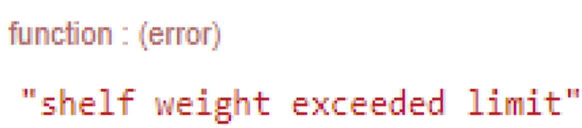

Fig. 12. Error message.

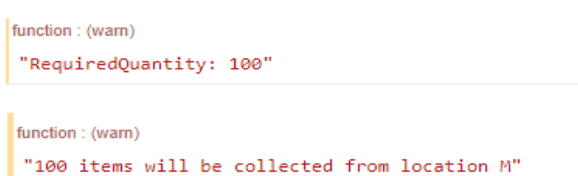

Fig. 13. Forklift message.

traditional WMSs, and can have a direct impact on the accuracy of demand forecasting as real-data is available.

Numerical example

Accurate forecasts play a vital role to support the managers for correct decision making. The accuracy of a forecast increases with the usage of real time data collected automatically by the IoT system. A numerical example is presented to show the impact of using forecasted data (A) and real time data generated from IoT system (B) on the forecasting accuracy. A dataset published online is used [29] the data is given in Table 5. It provides the number of monthly sales (per carton) of champagne for eight years.

The data was plotted in Fig. 16, some observations were taken; first, the data has seasonality, second, the trend increases over time, and third, no outliers exist.

The dataset was used to test how the data collected through the IoT system will affect the forecasting accuracy. In this section, two methods were used to make a forecast for year 8. a.Weighted moving average: The first step is calculating 3 months moving average. Forecast A is calculated by using the forecasted data (traditional method), Forecast B is calculated by using the actual sales data (IoT data). Weighted moving average is calculated by using Eq. (1). The monthly moving average weights are 3 for the last month, 2 for two months ago and 1 for one month ago. The forecasting results are given in Table 6.

After that, error analysis is performed by calculating Forecast error and Mean Absolute Deviation (MAD) by applying Eq. (3). The results are given in Table 7.

$$MAD = \sum_{t=1}^{n} |Actual - Forecast| \Big/ n \tag{3}$$

MAD for Forecast A = 71,564.72656 / 12 = 5963.727213
MAD for Forecast B = 31,522.33333 / 12 = 2626.861111

The data used has seasonality; hence the second method of forecasting is applied to calculate the demand forecast for year 8.

Seasonality index method: This method was applied for 3 years 5, 6, and 7; the results are given in Table 8. The first step is to calculate the average demand for the three years for every month from Eq. (4) [26].

$$Average\ demand = \sum_{t=1}^{3} D \Big/ n \tag{4}$$

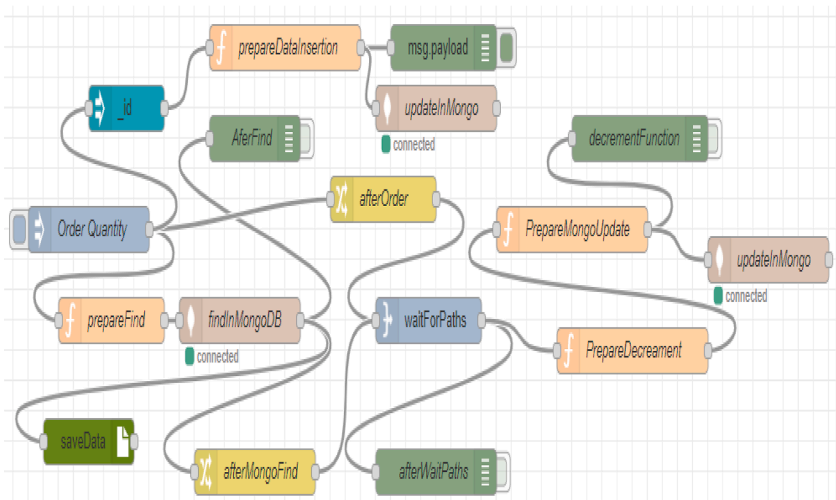

Fig. 14. Node-RED flow (when making an order from warehouse).

Table 2
Products database after ordering 100 unit from product A2.

Products								
	_id ObjectId	productName String	quantity Int32	productDate String	ExpiryDate String	LocationInWarehouse String	weightPerProduct Int32	AllWeight Int32
1	254f857s214j95w182ft87sg	"A1"	140	"1–5–2019″	"15–05–2020″	"L"	15	2100
2	5214148d752e841a851g36r5	"A2"	50	"1–5–2020″	"15–05–2021″	"M"	10	500
3	541 g547q28g1r852p94s145	"S2"	150	"1–5–2020	"15–05–2021″	"S"	10	1500

Table 3
Sales data database in MongoDB.

SalesData				
	_id ObjectId	productName String	quantityOrdered String	month String
1	254f85758214856182ft87sg	"B2"	"10″	"1″
2	54285uhk88g1r852p94s145	"A2"	"100″	"6″

Calculate average monthly demand Eq. (5) [26].

$$Average\ Monthly\ demand = \sum_{t=1}^{n} Average\ Demand \Big/ n \tag{5}$$

Calculate the seasonal index Eq. (6) [26], the results are shown in Table 8.

$$Seasonal\ index = Average\ Demand / Average\ Monthly\ Demand \tag{6}$$

Calculate the expected demand by using Eq. (7) [26] for year 8. The deseasonalized demand is given in Table 9, by using the data from the first method (weighted moving average):

$$Expected\ Demand = Seasonal\ index * Forecasted\ value \tag{7}$$

Table 10 shows the calculations of forecast Error and MAD by using Eq. (3).

MAD for Forecast A = 69,290.0996/ 12 = 5774.174967

MAD for Forecast B = 23,848.30905 / 12 = 1987.359087

It is obvious that there is a huge difference in the accuracy of the forecasted data when using the traditional method compared with when using the data from IoT system and how real-time data affects the

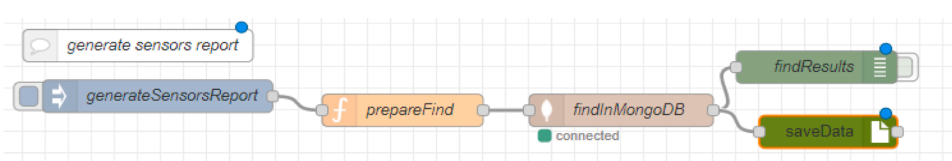

Fig. 15. Node-RED flow (generating an excel sheet).

Table 4
Data as exported on excel.

	A	B	C	D	E	F	G	H
1	_id	productName	quantity	productDate	ExpiryDate	LocationInWarehouse	weightPerProduct	AllWeight
2	254f857s214j95w182ft87sg	A1	140	01/05/2019	15/05/2020	L	15	2100
3	5214148d752e841a851g36r5	A2	50	01/05/2020	15/05/2021	M	10	500
4	541g547q28g1r852p94s145	S2	150	01/05/2020	15/05/2021	S	10	1500

Table 5
Sales data of champagne.

Month Year	1	2	3	4	5	6	7	8
Jan	2815	2541	3113	5375	3633	4016	2639	3934
Feb	2672	2475	3006	3088	4292	3957	2899	3162
Mar	2755	3031	4047	3718	4154	4510	3370	4286
Apr	2721	3266	3523	4514	4121	4276	3740	4676
May	2946	3776	3937	4520	4647	4968	2927	5010
Jun	3036	3230	3986	4539	4753	4677	3986	4874
Jul	2282	3028	3260	3663	3965	3523	4217	4633
Aug	2212	1759	1573	1643	1723	1821	1738	1659
Sep	2922	3595	3528	4739	5048	5222	5221	5951
Oct	4301	4474	5211	5428	6922	6872	6424	6981
Nov	5764	6838	7614	8314	9858	10,803	9842	9851
Dec	7312	8357	9254	10,651	11,331	13,916	13,076	12,670

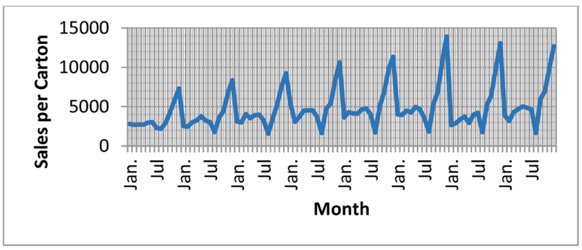

Fig. 16. Champagne sales plot.

Table 6
Forecasting results by using weighted moving average.

Month Year	7	Actual Sales 8	Using Forecasted data Forecast A (8)	Using Actual data Forecast B (8)
Jan	2639	3934	10,889	10,889
Feb	2899	3162	11,444	7966
Mar	3370	4286	11,531	5072
Apr	3740	4676	11,395	3853
May	2927	5010	11,448	4294
Jun	3986	4874	11,444	4778
Jul	4217	4633	11,437	4886
Aug	1738	1659	11,442	4776
Sep	5221	5951	11,441	3186
Oct	6424	6981	11,440	4301
Nov	9842	9851	11,441	5751
Dec	13,076	12,670	11,441	8244

Table 7
Calculating forecast error and MAD.

A |Actual-Forecast|	B |Actual-Forecast|	(A-F)^2 [A]	(A-F)^2 [B]
6955	6955	48,376,662	48,376,662
8282	4804	68,586,003	23,078,416
7245	786	52,489,220	617,272
6719	823	45,143,841	677,878
6438	716	41,452,792	513,133
6570	96	43,169,128	9216
6804	253	46,300,427	64,178
9783	3117	95,698,457	9,716,728
5490	2765	30,136,224	7,644,303
4459	2680	19,886,397	7,184,187
1590	4100	2,527,095	16,812,733
1229	4426	1,511,452	19,586,525
71,565	31,522	495,277,699	134,281,232

forecasting accuracy, MAD has improved by 56% after using the real-time data which helps increasing competitive situation and increasing the revenues.

5. Discussion and implications

In any supply chain, the aim is to get the right item, at the right time, in the right place with the right quantity, in the right condition, and at low cost. This could be accomplished with adapting IoT to address today's customer demands. 75% of retailers and manufacturers describe online data as a key for effective supply chains, but most of them still insist on sharing the information via fax and phone [30] that indicates that there still exists a huge gap between what organizations expect to have of Digitalization and their preparedness for participation. According to [31] Organizations with DSC and highly digital operations can expect 4.1% annual efficiency gains while boosting revenue by 2.9% per year. This digitization of supply chains enables companies to have an effective and efficient integration between personnel, processes, equipment, and products, providing efficiency, flexibility, and visibility [32–35]. Shown that information visibility due to regular RFID use has led supply chains to achieve a 40–70% reduction in inventory costs alone, reduce risk and increase real-time decision making and efficiency by saving communication time, setting rules and regulations This research presented a valuable insight about supply chain and supply chain management then defined one of the main pillars of Industry 4.0 IoT, its definitions, components and its architecture is presented then a valuable system for how we can implement IoT in warehousing using Node-Red and Mongodb illustrated in detail that considered a roadmap for academic and practitioners. Then a numerical example illustrated to show how real time data can affect the accuracy of forecasting that impacts on all the supply chain.

6. Conclusions and future work

One of the functions of planning in supply chain is to develop demand forecasting that leads to developing sales plans, inventory plans and financial plans. A Warehouse management system is responsible for maintaining accurate inventory level, picking, packing, shipping, and ensuring safety for workers and products. In this paper, a proposed system that uses the Internet of Things in the warehouse is used. The proposed framework can improve the warehouse management system positively; hence the supply chain in the following ways:

Ensuring safety of labor and goods,
Reducing operational time,
Increasing efficiency,
Reducing accidents,
Minimizing the number of workers,
Increasing reliability and accuracy of packing and picking processes,
Decreasing counterfeiting, fraud and theft,

Table 8
Forecasting results by using seasonality method.

Month				Actual Sales	(5–7)		
Year	5	6	7	8	Average Demand	Average Monthly Demand	Seasonal Index
Jan	3633	4016	2639	3934	3429	5364	0.639380176
Feb	4292	3957	2899	3162	3716	5364	0.692827585
Mar	4154	4510	3370	4286	4011	5364	0.747890847
Apr	4121	4276	3740	4676	4046	5364	0.754292107
May	4647	4968	2927	5010	4181	5364	0.779462108
Jun	4753	4677	3986	4874	4472	5364	0.833779592
Jul	3965	3523	4217	4633	3902	5364	0.727444106
Aug	1723	1821	1738	1659	1761	5364	0.328266533
Sep	5048	5222	5221	5951	5164	5364	0.962737005
Oct	6922	6872	6424	6981	6739	5364	1.256511314
Nov	9858	10,803	9842	9851	10,168	5364	1.895705045
Dec	11,331	13,916	13,076	12,670	12,774	5364	2.381703584

Table 9
Deseasonalized forecasting for year 8.

Seasonal Index	Using Forecasted data Forecast A (8)	Using Actual data Forecast B (8)	using forecasted data (A) Expected Demand [A]	using actual data (B) Expected Demand [B]
0.639380176	10,889	10,889	6962	6962
0.692827585	11,444	7966	7928	5519
0.747890847	11,531	5072	8624	3793
0.754292107	11,395	3853	8595	2906
0.779462108	11,448	4294	8924	3347
0.833779592	11,444	4778	9542	3984
0.727444106	11,437	4886	8320	3555
0.328266533	11,442	4776	3756	1568
0.962737005	11,441	3186	11,014	3067
1.256511314	11,440	4301	14,375	5404
1.895705045	11,441	5751	21,688	10,902
2.381703584	11,441	8244	27,248	19,636

Table 10
Forecasting error analysis.

A	B		
|Actual-Forecast|	|Actual-Forecasst|	(A-F)^2 [A]	(A-F)^2 [B]
3028	3028	9,171,351	9,171,351
4766	2357	22,719,407	5,555,753
4338	493	18,817,271	242,997
3919	1770	15,359,311	3,132,772
3914	1663	15,316,122	2,766,399
4668	890	21,790,615	792,458
3687	1078	13,594,703	1,163,088
2097	91	4,396,909	8307
5063	2884	25,637,353	8,314,915
7394	1577	54,671,429	2,487,445
11,837	1051	140,118,405	1,103,693
14,578	6966	212,520,736	48,519,002

Helping companies improve forecasts due to the availability of accurate data,

Real-time data of inventory helps in accurate decision making,

Enhancing the overall performance of companies.

All those benefits will improve the profit and the reputation of the organization. But there are some challenges such as; security issues due to the large amount of data generated, integration of new technology equipment with the existing ones, interoperability, and return of investment of the new technology. So enterprises must be aware about these challenges before adapting the proposed system.

More work could be carried out in the following directions:

(a) Implementing this system on a real warehouse and compare the benefits expected from this proposal with the actual results;

(b) Making an online dashboard that is connected to Node-RED and MongoDB to provide real-time visualization of the inventory level, the forecasted data, and all the related data that help organizations to improve their competitiveness.

(c) Designing an interface application for the proposed system.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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