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Smart Inventory Control System Based On Wireless Sensor Network

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ABSTRACT
A smart Inventory Control based on Wireless Sensor Network (WSN) is working by deployment of sensors for monitoring inventory and providing data for replenishment decisions. In this paper, we proposed an inventory control system using Arduino platform, local server as a base station, and wireless networking of IEEE 802.11 protocol family to build WSN as WIFI. This model can be working in both web-based applications and local network applications using ASP.NET technology. This system implemented on a real WSN environment using Arduino platform focusing on lot sizing in the Material Requirements Planning (MRP) system using L4Llot sizing technique. The aim of this paper is to build a smart inventory monitoringproduction plan and all system based on WSNs to ensure effective monitoring on the and controlling on dependent demand and inventory items.

Keyword: Wireless Sensor Network, lot-sizing, L4L, MRP, ASP.NET, SQL server

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المستخلص
السيطرة الذكية على الخزين باستخدام شبكات الاستشعار اللاسلكية تصمم وتبنى بنشر مجموعة من الحساسات تعمل على مراقبة الخزين للمساعدة على اتخاذ القرار المناسب بشأن تعزيز الدفعة . في هذا البحث قدمنا نظام مقترح يبنى باستخدام جهاز الاردوينو لبناء محطة طرفية تحتوي على جهاز الاستشعار و باستخدام جهاز حاسوب يبرمج للعمل كخادم يكون بمثابة محطة مركزية و يكون الربط بين الخادم و المحطات الطرفية بالاعتماد على مبدأ الشبكات اللاسلكية و كذلك تم تصميم واجهة مستخدم رسومية باستخدام تقنية (ASP.NET) حيث ان هذا النموذ يمكن ان يصمم للاستخدام داخل الشبكة المحل يةاو للاستخدام في الشبكة العنكبوتية (الانترنت).هذا النظام المقترح تم بناؤه للعمل في بيئة حقيقة تستخدم نظام (MRP) كاساس عمل للسيطرة على الخزين و تمت الاستعانة باحدى تقنيات حجم الدفعة التابعة لهذا النظام و هي تقنية (L4L). هدف هذا البحث هو بناء نظام ذكي للسيطرة على الخزين و مراقبة خطة الانتاج باستخدام شبكات الاستشعار اللاسلكية ليضمن مراقبة فاعلة على الخزين وضمان توفره حين الطلب .

I. INTRODUCTION

Wireless Sensor Network (WSN) Technology is used to help more companies to decrease costs, improve productivity, and increase scrutiny within their functional systems. One of the most challenges occurred is the inventory control function which led to different problems such inventory items shortages, high holding costs, unavailability of items when needed, and security problems like theft or damages. Smart inventory control environments are the integration of different techniques and services to achieve automating, monitoring, security, safety, communicating, and cost saving in inventory systems. A smart inventory control system based on WSN is working by deployment sensors to monitoring inventory and provides data that used to make decisions about the quantities and timing of inventory items replenishment[1, 2].

A wireless sensor is a small device with limited computational and power energy uses to translate information from real environment to human over the computer device, as WSN as traditional wireless network designed by using different types of network topologies with network protocols such as UTP, TCP, etc. [3]. Communication is often established with traditional network or other wireless sensor network to exchange information between them [4].

II. SMART INVENTORY CONTROL SYSTEM

WSN works under two main patterns: tracking and monitoring. The former is used in some applications such as enamels tracking, human tracking, etc. And the later also used in some lot applications such as security system, detection, inventory monitoring, etc. This paper focuses on monitoring inventory by deploying sensors, and collecting data from these sensors using WIFI technology of IEEE 802.11protocol family [3]. This system works by using open source device (Arduino)

to give more flexibility to the program righting. The star topology is suitable with this system because it works on indoorprinciples. The system designed by using local server as base station which could manage database using (ASP.NET) technology [5]. The sensors give data as text data, then convert text data to SQL tables, which are suitable with the (ASP.NET), by using SQL server.This model works in both web-based applications and local network applications using ASP.NET technology [6]. All these applications used in WSN to provide the remote monitoring of different systems [7, 8]. Our system is implemented on a real WSN environment using Arduino platform.

III. THE PROPOSED SYSTEM REQUIREMENTS AND DESIGN

Many hardware, software, and processing techniquesare required for designing the proposed system as shown in figure(1)

Figure (1): The ProposedSmart Inventory Control SystemLogic.

3.1 Hardware Requirement: -

3.1.1 Central Computer: thecore of the system [9], it works as base station by configure it as server, this server works to:

a) Control the connection between sensors each other.
b) Control the sensor node configuration.
c) Control sending and receiving of data over the local network or over the internet.
d) Control the temporary memory, by work as buffer between the database and WSN system.
e) Control data Conversion from one form to another, because the sensor sends data as text form and the server works with SQL data form.
f) Control the data analysis or data mining to give useful information that benefits the management to make decision.
g) Control data saving.

3.1.2 Access Point (AP): -

AP device isused to ensure connecting between sensor and server over the 2.4 G frequency. This device is very important to connect WSN with server and each other. In the wireless network systems, AP has the same job of hub in wired networks. It sends and receives signals to the computer over the wireless adapter card [9].

3.1.3 Sensor Node: -

The sensor is a device that identifies and translate data frame an environment, it works as converter between real word and computer device to give the human a total picture of what is going on that environment, kind of data relies on upon sensor outline every sensor has info and yield. Information is the manner by which the sensor sorts, for example, light, and weight. Also, yield is making an interpretation of information to human over computer device. The information of sensor is extremely valuable to settle on choice rely on upon application sort and handling sort [10].

3.1.4

Arduino:

It is a device economically accessible electronic board with a microcontroller and some I/O capacities. The colossal accomplishment of Arduino, as for other microcontroller sheets, was because of the way that both equipment and programming were discharged as Open Source ventures. [11]. The Arduino microcontroller is a simple to utilize yet intense single board PC that has increased significant footing in the side interest and expert market. [8].

3.1.5

3.1.6

Single Hop Star Topology:

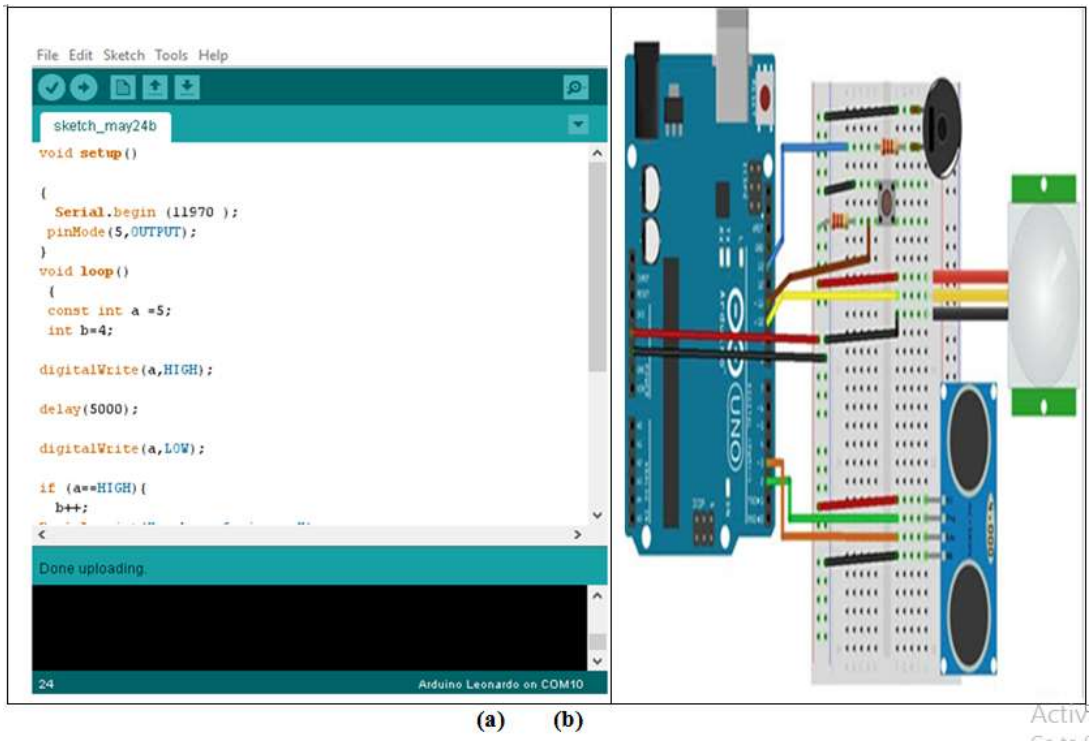
Single hop star topology is the least complex WSN topology. In this topology, each hub discusses straightforwardly with the passage or the information gatherer. The hubs that are at an expansive separation from the passage will have low quality associations with the entryway. Accordingly, this topology regards be utilized just when the quantity of hubs in the system is little and the scope

zone does not reach out past the radio transmission scope of around 30 meters in a building [12].

3.2 Software Requirement:

3.2.1 Arduino Programming Language:

A program for an Arduino as in figure (2) is a succession of bits in machine language. The Arduino group has given a high level programming language, a compiler, and a specialized instrument to send the machine code on the Arduino memory. It shows up, the same number of the computer applications, as an apparatus with a menu and a few windows. One of those windows is utilized to alter the program, called a sketch in Arduino language. Sketches are composed in C++, also can write it by using C program language [13, 11]**.**



(a) (b)

Figure (2):(a): Arduino codes and (b): design

3.2.2 ASP.NET Technology Under C# Code:

This technology is used to design dynamic website pages, it works in both windows applications and network applications based on several program languages. ASP.net and C# figure are used to design this system. **3.3.**

3.3.1.

3.2.3 SQL Server Database: -

Structured Query Language (SQL) is a database computer language designed for managing data in Relational Database Management Systems (RDBMS). SQL is an institutionalized coding that was initially created by IBM for questioning, changing and characterizing social databases, utilizing decisive articulations [14]. It used with ASP.net and C# figure to design the proposed system

Data Processing:

Convert Data of Sensor and Text to SQL Server Database

A sensor gives real time data as text as infigure (3).The updatetime and type of data are depend on the purpose of the program.

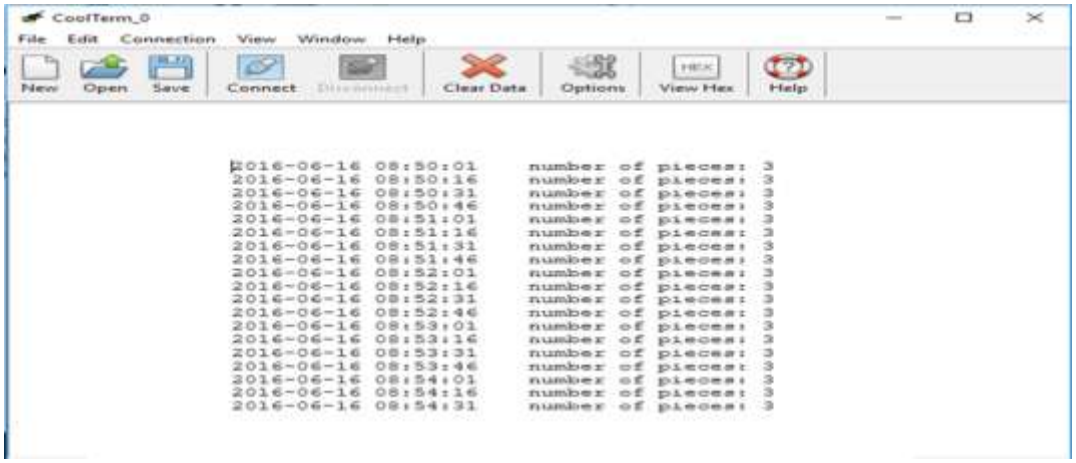


Figure (3) data of sensor

Data of sensor must be converted to tables on the SQL server, to use them on ASP.NET program as in figure (4).

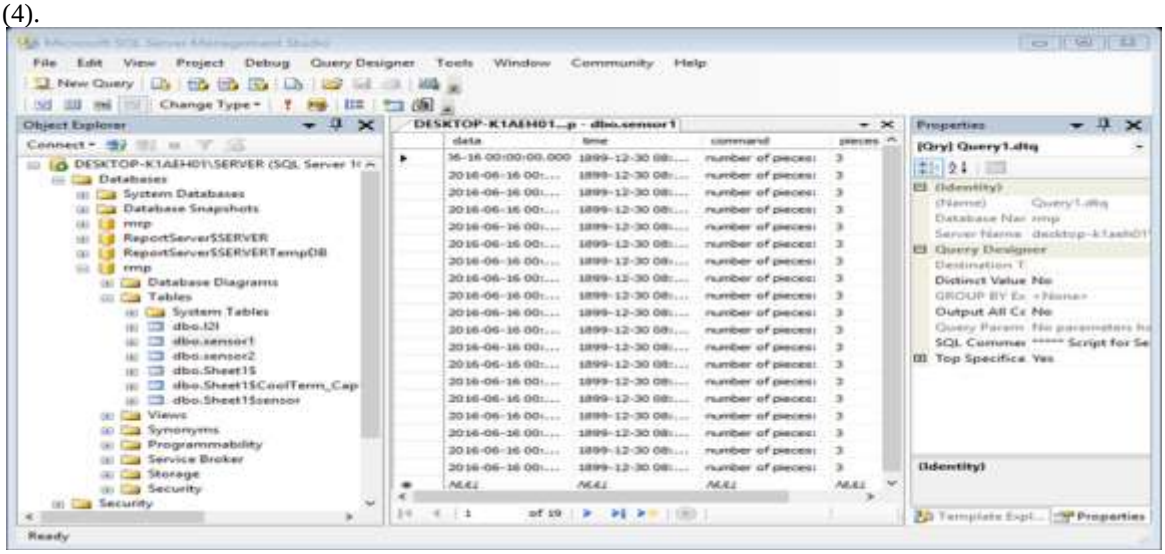


Figure (4): Convert data to tables in SQL server.

3.3.2. Display Data of Sensor: -

To controlling and monitoring the inventory, the designed system is possible to use the converted data to make several procedures using (ASP.NET). Thiscontrolling system allows making right decisions to replenishing inventory items. Many advantages are achieved bydisplay data of sensor:

1. Make the right decisions.
2. Reduce costs.
3. Minimizing risks.
4. Enhance the inventory control performance.
5. Remote Monitoring and Control over local network or internet.

3.4. Material Requirements Planning System:

In order to implement the proposed system to make rational decisions especially in the field of inventory control, a production planning system is considered called Material Requirements Planning system (MRP). MRP is a computerized production planning system developed specifically to help manufacturers manage dependent demand inventory items and to schedule replenishment orders [15].

The major objectives of MRP system are:

1- Guarantee the availability of materials, parts, and sub-assemblies items.

2- Keep up the least conceivable level of stock,

3- Determine the economic order quantity [16].

3.4.1. MRP Inputs:

The key inputs of MRP are Bill of Materials Database (BOM), Inventory record Database (IR), and Master Production Schedule (MPS).

BOM is a record of all the components of an item, the parent-component relationships, and the usage quantities derived from engineering and process designsas in figure (5) [15].

MPS is a part of the material requirements plans that details how many end items will be produced within

specified periods of time called planning horizon as intable (2). [16]

IR Inventory records include information about the inventory status for each item by time period or time buckets. This file may contain gross requirements, scheduled receipts, and expected on hand inventory. It also includes other details for each item, such as supplier, lead time, and lot size policy. Changes due to stock receipts and withdrawals, cancelled orders, and similar events are also recorded in this file. [17]

MPS depends on the following equations:

Gross Requirement (GR):

$GR_T = TQ_T * QR$ …. (1)

Where TQ: total quantity, T: time period, and QR: quantity required of each part to produce one item of the final product.

Scheduled Receipts (SR):

$SR_T = GR_T + SS - POH_{T-1}$…. (2)

Where SS: safety stock and POH: projected on hand inventory.

Projected On Hand Inventory (POH):

$POH_T = (POH_{T-1} + SR_T + PR_T) - GR_T$…. (3)

Where PR: planned receipts.

Net Requirement (NR):

$NR_T = (GR_T + SS) - (SR_T + POH_{T-1})$ …. (4)

Planned Receipts (PR):

PR=L4L Quantity …. (5)

Planned Order Releases (POR):

$POR_T = PR_T - L.T$ …. (6)

Where L.T. : lead time

3.4.2. MRP outputs:there are several outputs for MRP system such as:

1- Planned orders to be released at a future time.
2- Order release notices to execute the planned orders.
3- Changes in due dates of open orders due to rescheduling.
4- Cancellations or suspensions of open orders due to cancellation or suspension of orders on the master production schedule. [18]

3.4.3. Lot Sizing Rules

The problem of lot sizing is determining the economic order\production quantitiesto minimize holding and setup costs. A variety of lot sizing rules has been proposed in literature [19]. This paper focuses on Lot-for-Lot (L4L) technique due to its easiness and suitability with different systems. It is most applicable to expensive items with small ordering or setup costs. It is the only rule that can be used for low-volume items. It can also approximate the small-lot inventory levels of a lean system. [15]

4. The Proposed System Implementation

Toachieve the aim of ensuring an effective monitoring and controlling on dependent demand and inventory items, the proposed system implemented using its hardware and software components as shown in figure (6) throughinstalling the sensor system to sends different types of message when the value is less than a threshold determined by L4L role.The proposed system is was implemented on a case study instance.

Case Study

A company is producingitem (A). The parts, sub-assemblies, and required items areas shown in BOM in figure (5). SS is 50units, L.t=1 week,POH_{t-1}=0, SR = 200 at week 1. The production plan of product (A) is in table (1).

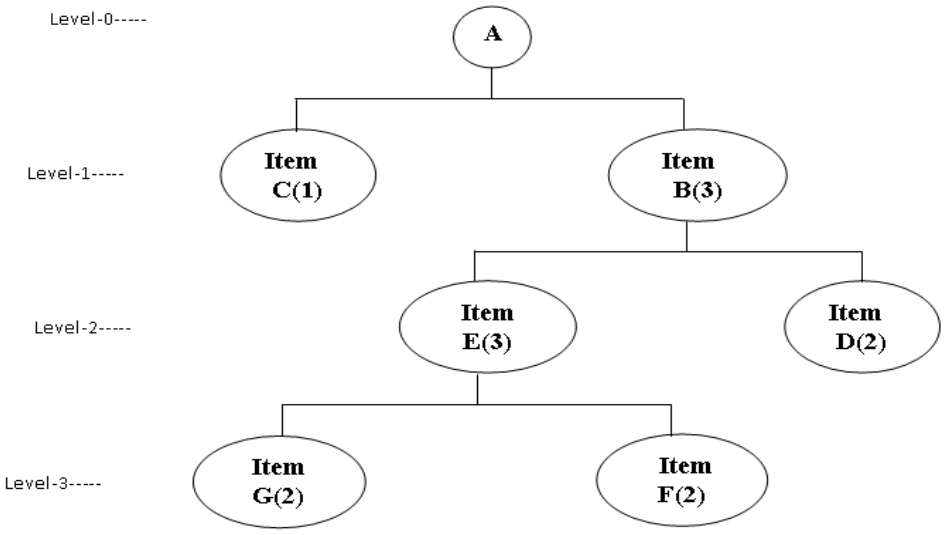


Figure (5):BOM of product A

Table (1) Aggregate Production Plan for Item B

Weeks	1	2	3	4	5	6	7	8	9	10
GR	0	50	60	0	60	45	25	30	30	10
POR	50	60	0	60	45	25	30	30	10	0

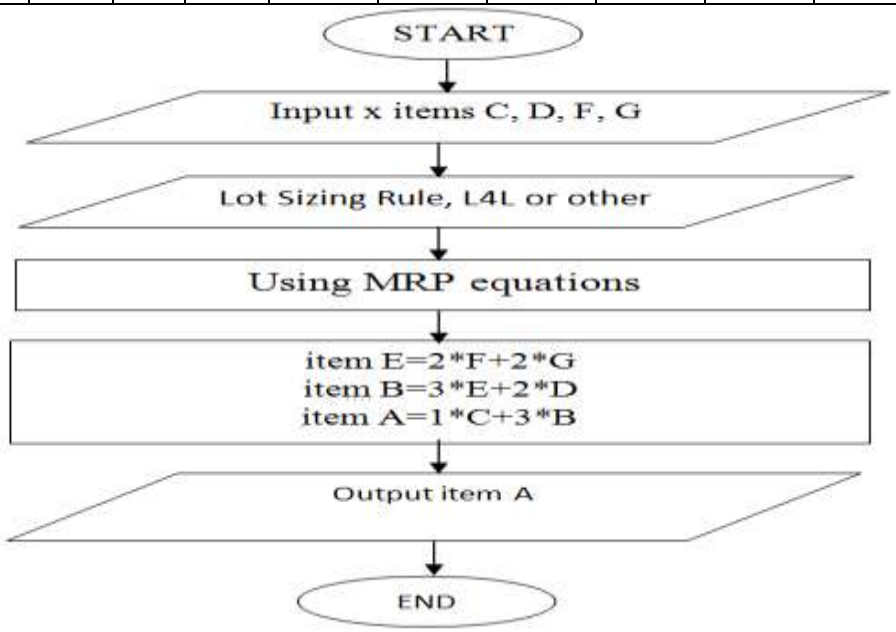


Figure (6). General algorithm to produce item A

Table (2) below represents the application of MRP logic to determine the planned orders release for item (B). the data about safety stock, scheduled receipts, and items replenishment are obtained using the deployed sensors and the proposed system as illustrated in figure (7).The WSN technology can work with any part within the smart inventory control system.The sensor sends text messages to the central computer; the management uses these messages by read it over the internet page. The internet page was designed by using ASP.NET technology as in figure (8). Data will be inserted to the ASP.NET to display it over a local network.

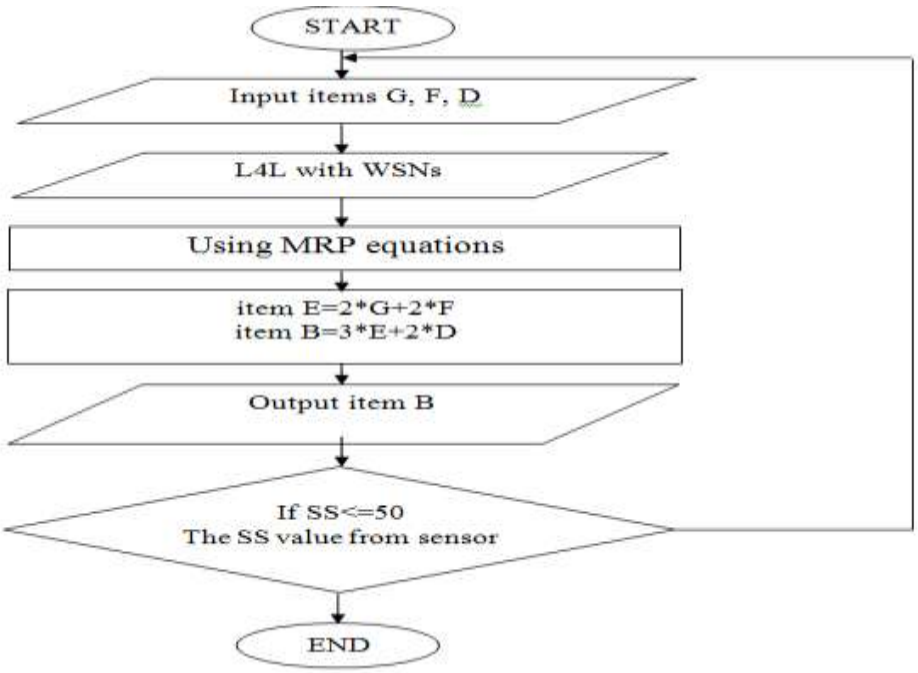


Figure (7). Algorithm to produce item B

Table (2) MRP Record for Item B

Lot size technique: LOT FOR LOT Item: B											
Safety stock (SS)=	50										
L. t = 1											
Weeks		1	2	3	4	5	6	7	8	9	10
Gross requirements		150	180	0	180	135	75	90	90	30	0
Scheduled receipts		200	0	0	0	0	0	0	0	0	
Projected on hand	0	50	50	50	50	50	50	50	50	50	
requirementsNet		0	180	0	180	135	75	90	90	30	
Planned order receipts		0	180	0	180	135	75	90	90	30	
Planned order releases		180	0	180	135	75	90	90	30		

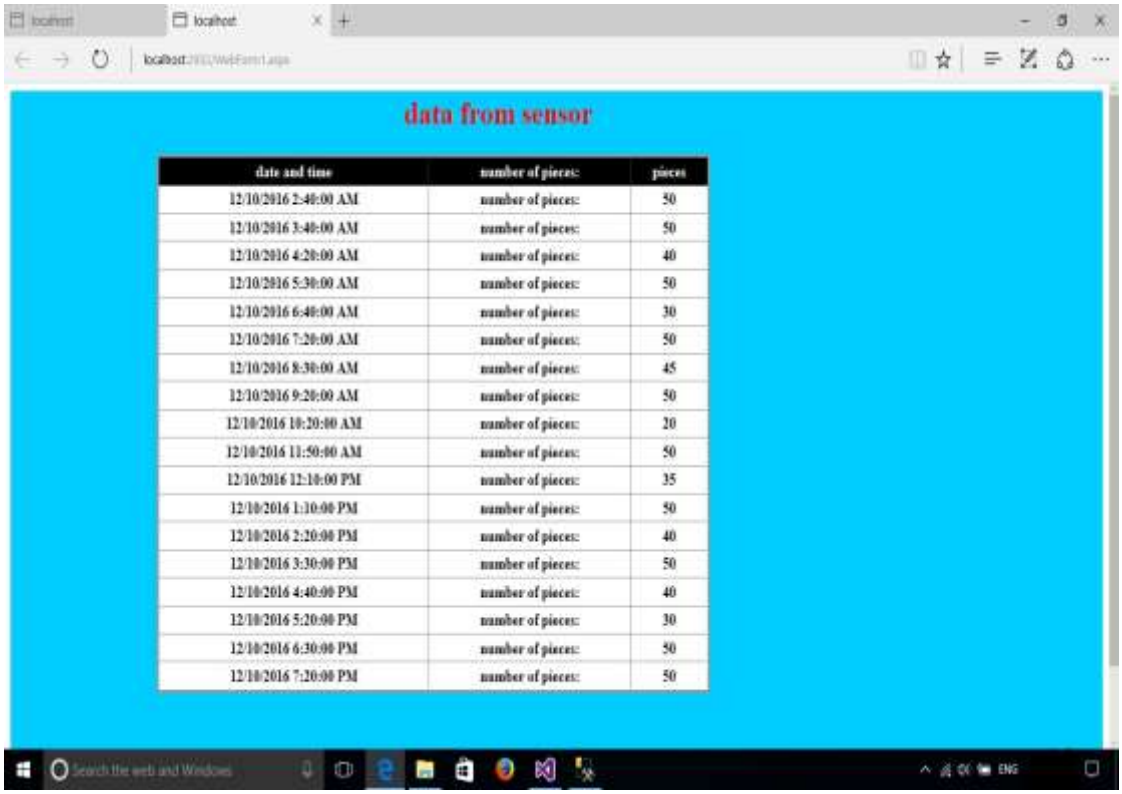


Figure (7):. Display data of sensor on asp.net form.

IV. CONCLUSION

Smart inventory control system based on wireless sensor network by deployment different types of sensors in different places to monitor the production plan, that gives more comprehensive vision to help system to give accurate results, this system builds by using open source micro controller device that is means development software is free. More systems can be using WSN technology to be smart system. To build the smart warehouse system can take from SQL server to build it database. Real time monitoring over internet by using ASP.NET technology. The data of sensor are very useful to make decision, that is depend on an application type and processing type. (SS) is very important part of the L4L technique to ensure that no sudden stop in the production line, by install WSN in this part. Also, can avoid sudden stop in the production line when using another Lot Sizing Rules.

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