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Cloud Manufacturing Framework for Controlling and Monitoring of Machines

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Abstract

Due to the development that occurs in the technologies in information systems, many techniques were introduced and played an important role in the connection between machines and people through the internet, it is also used to control and monitor machines. These technologies are called cloud computing and the Internet of Things. With the replacement of computing resources with manufacturing resources cloud computing named converted into cloud manufacturing.

The problem is that there are some materials that are not safe to keep workers in touch with it, or the manufacturing process needs the place to be kept clean, such as IC manufacturing, and these processes must be remote controlled and manufactured.

In this research, cloud computing was used in the field of manufacturing to automate the process of selecting the G-code that the computer numerical control machine works with, this process was applied by using this machine with the radio frequency identification and some AWS Cloud services and some of the python libraries such as PAHO (the library that was used with the MQTT protocol) to establish the connection between devices.

A present sensor value (A sensor called DHT sensor) was used in this research to measure temperature and humidity in clouds to help the operator make decisions. This technology was used to eliminate paperwork, provide a real time monitoring of the machines, and allows the upper level of management to make their decisions about the products and its status to begin the shipping to the costumer.

Technology called “ethernet” over internet protocol has been used to control and monitor machines through a remote by using a Mikrotik router device, and a virtual private network (VPN) was used to make a unique IP address for each machine**.**

This research will solve the availability of worker mobility and the monitoring of the machines of a difficult machining material that is dangerous to workers life during the process.

Keywords: *Internet of Things, Cloud Manufacturing, CNC machine, RFID sensor.*

1. Introduction

Cloud computing is coming into development step by step recently. On the off chance that we supplant the "figuring assets" with the "producing assets", the activity of the executive methods of the cloud computing can be acquired in the assembling field, which can be an original thought for the information development for the assembly ventures, therefore the idea of the cloud manufacturing is placed forward. Based on the network with manufacturing and cloud computing, the cloud manufacturing is characterized as a server. The cloud manufacturing is a novel arranged assembling mode which uses the internet and the cloud

manufacturing stage, sorts out different sorts of manufacturing assets (to be specific the manufacturing cloud web), and gives clients a wide range of services for their requests. It combines the current innovations of the organized assembling and administration with cloud computing, superior processing, the internet of things, and so on, to give each manufacturing action high quality and low-cost services whenever and anyplace on demand[1].

Recently, researchers have been focusing on the cloud manufacturing and its capabilities, below there are many of researches:

Lihui Wang intends to build up an internet and web-based administration situated framework for machine accessibility, checking, and process arranging. This paper especially proposes layered and capacity obstructs for the model. This framework engineering presents the IEC 61944 execution. By interfacing with a wise-shop floor system, it empowers continuous machine accessibility and execution status observing during metal-cutting activities[2].

Caggiano et al. proposed a research that used the cloud to monitor the materials that are difficult to machine, the system consists of multi sensors that are used to collect data from machines, according to a service oriented approach to review cloud capability, advance signal processing, and decision making was assigned to the cloud server. Data that is taken from sensors gives the status of tool condition and the local servers are used to send commands to the machines. This research concludes that clouds are very important to enhance computing process and data storage that are collected from different resources to help decision making and increase the efficiency of tool condition diagnostics[3].

Perez et al. proposed new assembling worldview called "cloud dexterous assembling". The primary goal for this work is to offer mechanical mechanization. It works as an administration to empower the clients in more elevated amounts to get to accessible functionalities of the computerization framework with the least unpredictability[4].

Jan-Peer Rudolph and Claug Emmelmanna presented the additive manufacturing that is a part of industry 4.0 that is used to increase industrial production and how it was used to manufacture parts that are out of their CAD data, these were accomplished by using cloud based platform that presents as a manufacturing services provider and also as an interface to the costumers. The point of convergence of the stage is on a mechanization of the request acknowledgment, the offer estimation, and the part screening for the distinguishing proof of fitting AM parts [5].

Xi (Vincent) Wang aimed to make a progress on the cloud manufacturing solution, called an interoperable cloud-based manufacturing system (ICMS), to create a fabrication platform that combines production services from the design to the manufacturing. In the ICMS environment, clients can submit production requests for as far as cloud service queries through a remote, via the network, with the help of the SCM mechanism[6].

This research differs from the previous research in the use of cloud computing in the automation of CNC machines work by the use of RFID sensor that are attached to the product and has an ID for each product to send this ID to the cloud, telling the CNC to work a specific g-code and also to monitor the temperature of the CNC tool, and to send this information to an application to review it.

2. Cloud Manufacturing

The cloud manufacturing is characterized as a novel arranged assembling mode which uses the internet and the cloud manufacturing stage, composes different sorts of assembling assets (specifically the assembling cloud) on the internet, and gives clients a wide range of administrations on their request. It combines the current advances of the arranged assembling and administration with cloud computing, superior processing, the internet of things, and so forth, to give each assembling movement high-caliber and minimal effort administrations whenever and wherever on interest.

Cloud manufacturing comprises of different assets, administrations, and answers for tending to an assembly task. Any assembling ventures can utilize these assets, capacities, and learning to complete its assembling activities. Inside a cloud assembly scene, an assembly endeavor doesn't have to have the whole assembling condition, for example, machines, IT framework, and work force, or even programming, is engaged with assembling activities, for example, the plan, generation, the board, and strategic applications. An assembling organization can require the assets and administrations in the cloud fabrication stage alongside a compensation as-you-go evaluating approach[7].

3. Internet of Things

The IoT idea was authored by an individual from the radio frequency identification (RFID) advancement network in 1999, and it has lately turned out to be increasingly pertinent to the handy world generally in light of the development of cell phones, inserted and omnipresent correspondence, distributed computing, and information investigation.

Envision a reality where billions of articles can detect, impart, and share data, all interconnected over open or private internet protocol (IP) systems. These interconnected articles have information routinely gathered, broke down, and used to start an activity, giving an abundance of insight to arranging the board and basic leadership. This is the universe of the internet of things (IOT)[8].

The web of things can be characterized as an interconnection between individuals, or articles that trade information over systems without including human-to-human or human-to-PC collaboration. IOT offers different sorts of networks from gadgets, frameworks, and administrations that work inside machine-to-machine interchanges (M2M), and spread with applications, spaces, and conventions.

4. Message Queue Telemetry Transport

MQTT is an open-sourced protocol for passing messages between multiple clients through a central broker. It was designed to be simple and easy to implement. The MQTT architecture is broker-based, and uses long-lived outgoing TCP connections to the broker. MQTT also supports hierarchical topic (e.g., "subject/sub-subject/sub-sub-subject") file system structures [8].

MQTT can be used for two-way communications over unreliable networks where the cost per transmitted bit is comparatively high. It is also compatible with low power consumption devices. The protocol is light-weight (simple), and therefore well suited for constrained environments. MQTT has a mechanism for asynchronous communication and for communicating disconnected messages when a device has disconnected. The most recent message can also be stored and forwarded. Multiple versions of MQTT are available to address specific limitations.

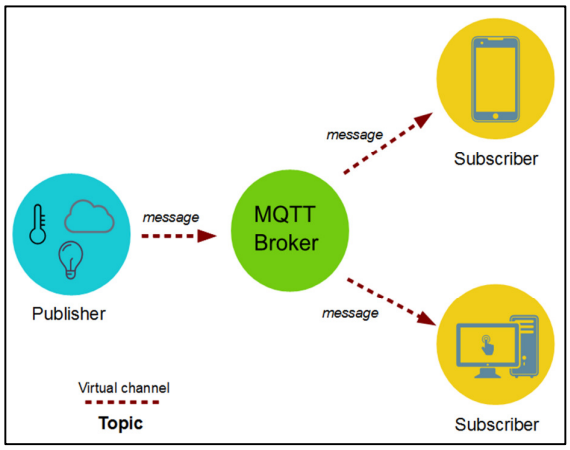

Fig. 1. MQTT Protocol.

5. Sensors

Sensors are an important thing in reading the changes in machine parameters such as tool temperature, spindle speed, and they order the object to select a code that is related to its shape, for this, an RFID sensor was used to sense the object and a DHT sensor was used to sense its temperature.

6. Radio Frequency Identification

A radio frequency reader (RFID reader) is a gadget used to take data from an RFID tag, which is utilized to follow individual articles. Radio waves are utilized to move information from the tag to a reader.

The RFID is an innovation comparable in principle to standardized tags. Notwithstanding, the RFID tag doesn't need to be examined straightforwardly, nor does it require an observable pathway to the peruser. The RFID label must be inside the scope of an RFID peruser, so as to be perused. RFID innovation enables a few things to be immediately checked and empowers quick distinguishing proof of a specific item, in any event, when it is encompassed by a few different things. Figure 3 shows the RFID sensor components (tags and reader).

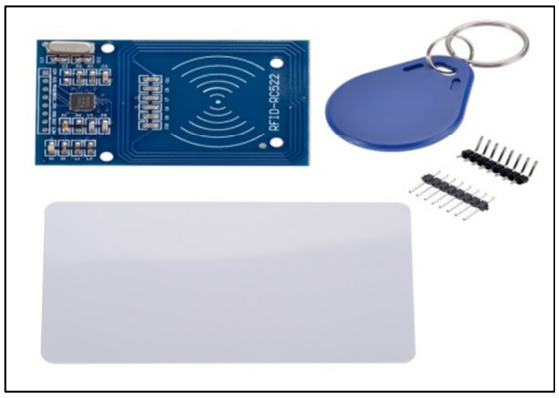

Fig. 2. RFID sensor component (tags and reader).

7. DHT Sensor

DHT is a sensor that is used to measure both humidity and temperature by the use of two-part capacity for humidity, and a thermistor for temperature, it spits out a digital signal because of the chip inside of the sensor that converts analog signals into digital signals, so it is easy to read with any controller. Figure 4 shows the DHT sensor.

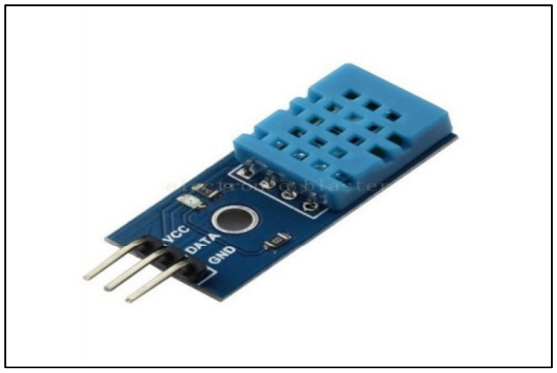

Fig. 3. DHT Sensor.

8. Mini CNC Machine

A mini CNC milling machine was used in this research to machine non-metal materials such as wood and acrylic. Its controlled by a controller called “Grbl 0.9j” and has 3 axis motions (x, y, z) controlled by a stepper motor (NEMA 17) working at 12 V with 1.8 step size and has a spindle motor with a voltage of 12-24 V[9]. The figure below shows the CNC milling machine.

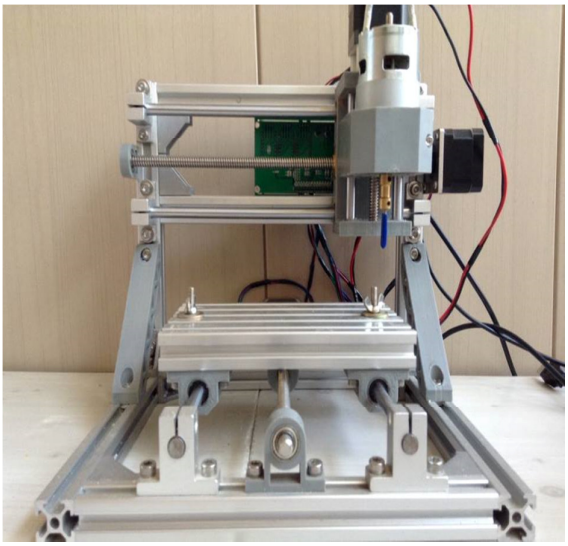

Fig. 4. CNC milling machine.

9. Experimental Work

The proposed research was presented as a prototype of the manufacturing shop floor, it was designed to fit the communication between machines in the industry, and also to support the remote controlling of machines.

The system design contains several things, first, two machines named as “computer numerical control" (CNC) that connects to a personal computer (PC) that works as a controller of the CNC (local server store CNC program and takes orders from the cloud). Second, sensing devices that contain two sensors for Radio Frequency Identification (RFID) and DHT 12, the third one is the cloud service that is called “brochure” that used the message queuing telemetry transport (MQTT), and a dashboard was used to monitor the status of machines and monitor the message between machines. Figure 5 shows the parts that work.

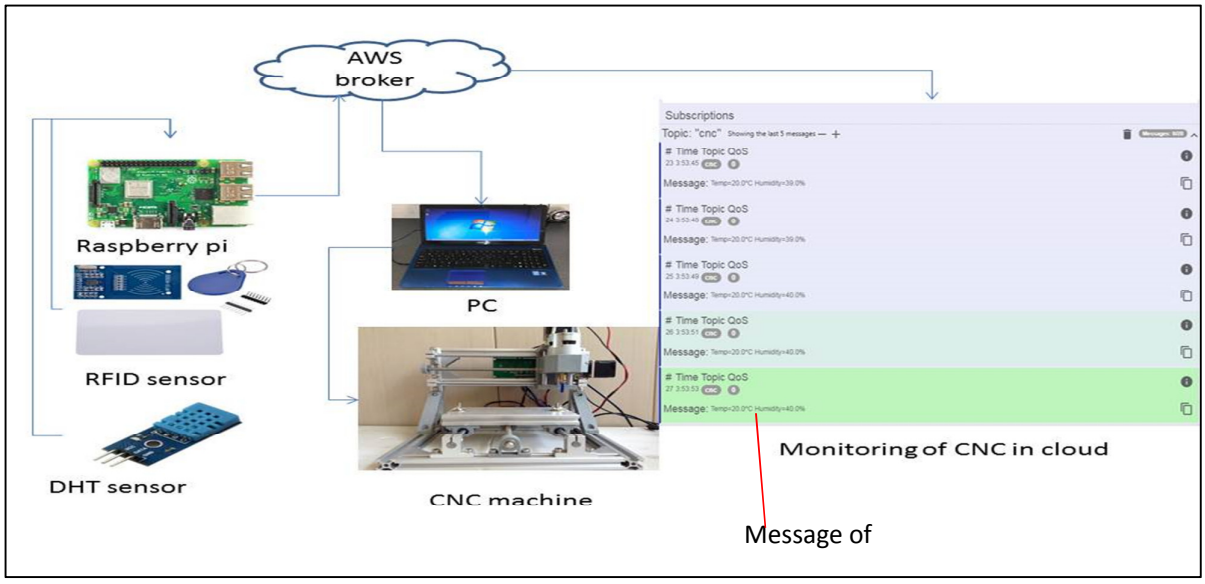

Fig. 5. Work diagram.

The connection between the sensors and the raspberry pi will be shown in table (1) for the RFID sensor, and table (2) for DHT sensor.

Table 1,
Connection of RFID with raspberry pi.

Pins	Raspberry pi pins
VCC	Pin 1 3.3v
RST	GPIO 25
GND	Pin 6 (GND)
MISO	GPIO 9
MOSI	GPIO10
SCK	GPIO 11
SS	GPIO 8

Table 2,
Connection of DHT with raspberry pi

Pins	Rpi Pins
VCC	Pin 2 (5v)
GND	Pin 14(GND)
DATA	GPIO 4

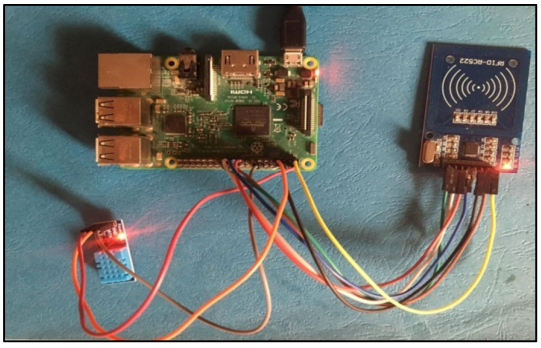

Fig. 5. Sensors connection with raspberry pi.

The connection between the cloud, CNC, and the sensor will be used a graphical user interface to make the connection, the same as figure 6.

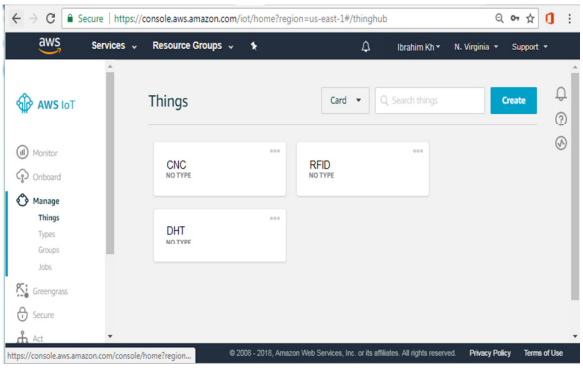

Fig. 6. AWS cloud connection with CNC and sensors.

Monitoring process of the messages between devices will be as figure 7:

Fig. 7. Application of monitoring messages

10. Result

The system shown in figure 8 runs smoothly depending on several experiments, thus the RFID sensor sensing the product whenever it comes through it, works as a publisher, then publishes a message to the AWS IoT broker that streams this message to the CNC machine that works due to the g-code that is saved in its controller when it comes a message published that CNC completes its work. A DHT sensor was used to monitor the status of CNC. The main result from this process is to show the ability of cloud computing to be applied on manufacturing processes in monitoring and controlling, so it can save time to operate transportation between machine and save the cost of labor.

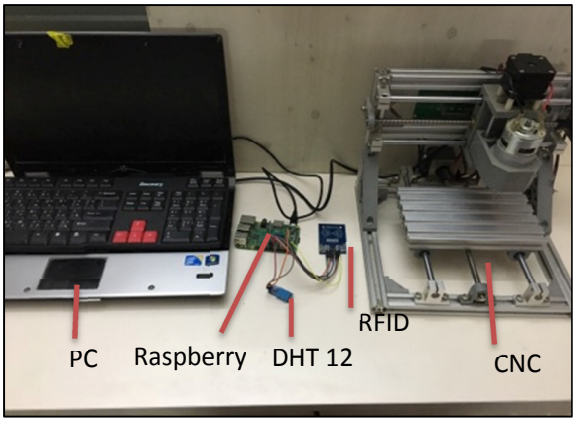

Fig. 8. System prototype.

The part that are produced from the process of automation shown in figure 9, it has a drilling and milling process performed by the mini CNC machine.

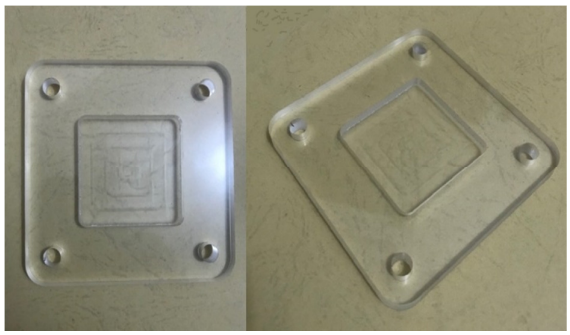

Fig. 9. Final part produced by CNC machine.

11. Transferring G-code to CNC machine

File transfer protocol "FTP" is an open protocol used for sharing files through the net. Files transferred from the "CAD/CAM" center to the CNC machine using "FTP" in this technique will sent a g-code from the workstation to the CNC machine using a war-ftpd 1.55 program. This method was applied to C-tek KM-80D milling machining, as shown in figure 10, and the product that results from this operation is shown in figure 11.

Fig. 10. Transfer of g-code to machine.

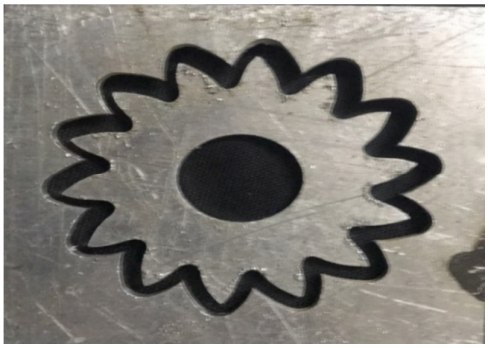

Fig. 11. Final product of machining process.

12. Conclusion

1. The automation process of the production lines can be applied by the use of cloud manufacturing, and it can also be monitored by using sensors.
2. The use of cloud manufacturing in the automation process will reduce labor force, help in decision making, and improves work efficiency.
3. Cloud manufacturing can be used in the manufacturing process to increase system efficiency and productivity by reducing the time and cost that is required to make the system more reliable and robust.
4. The wireless transferring of G-Code to CNC will reduce downtime for program transfer, machine data collection and analysis and will reduce the interaction between user and machines.

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إطار التصنيع السحابي للتحكم في الآلات ومراقبته

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الخلاصة

نظرًا للتطور الذي يحدث في التقنيات في نظم المعلومات، تم إدخال العديد من التقنيات ولعبت دورًا مهمًا في الاتصال بين الآلات والأشخاص عبر الإنترنت ، كما أنها تستخدم للتحكم في الآلات ومراقبتها. تسمى هذه التقنيات الحوسبة السحابية وإنترنت الأشياء. مع استبدال موارد الحوسبة بالحوسبة السحابية لموارد التصنيع المسماة محولة إلى التصنيع السحابي.

تكمن المشكلة في وجود بعض المواد غير الآمنة لإبقاء العاملين على اتصال بها ، أو أن عملية التصنيع تحتاج إلى المكان الذي يجب الحفاظ عليه نظيفًا، مثل التصنيع باستخدام IC ، ويجب التحكم في هذه العمليات وتصنيعها عن بُعد.

في هذا البحث، تم استخدام الحوسبة السحابية في مجال التصنيع لأتمتة عملية اختيار رمز G الذي تعمل معه آلة التحكم العددي بالكمبيوتر ، تم تطبيق هذه العملية باستخدام هذا الجهاز مع تحديد تردد الراديو وبعض خدمات سحابة AWS وبعض مكتبات الثعبان مثل PAHO (المكتبة التي تم استخدامها مع MQTT بروتوكول) لتأسيس الاتصال بين الأجهزة. تم استخدام قيمة مستشعر حالية (مستشعر يسمى مستشعر DHT) في هذا البحث لقياس درجة الحرارة والرطوبة في السحب لمساعدة المشغل على اتخاذ القرارات. تم استخدام هذه التقنية للقضاء على الأعمال الورقية، وتوفير مراقبة آنية للآلات، وتسمح للمستوى الأعلى من الإدارة باتخاذ قراراتهم بشأن المنتجات وحالتها لبدء الشحن إلى الزبون.

تم استخدام تقنية تسمى "ethernet" عبر بروتوكول الإنترنت للتحكم في الأجهزة ومراقبتها من خلال جهاز تحكم عن بعد باستخدام جهاز توجيه Mikrotik، وتم استخدام شبكة خاصة افتراضية (VPN) لإنشاء عنوان IP فريد لكل جهاز.

سيحل هذا البحث مدى امكانية تنقل العمال ومراقبة آلات مواد التصنيع الصعبة والتي تشكل خطورة على حياة العمال أثناء العملية.