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Polyhouse Automation System

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Abstract*— A Polyhouse is a building where plants are grown. Polyhouses are often used for growing flowers, vegetables, fruits, and tobacco plant. Basic factors affecting plant growth are sunlight, water content in soil, temperature, etc. These physical factors are hard to control manually inside a Polyhouse and a need for automated design arises. Automatically controlling all the factors that affect plant growth is also a difficult task as it is expensive and some physical factors are inter-related, for example, temperature and humidity are related in a way when temperature raises humidity reduces therefore controlling both together is difficult. Because the temperature and humidity of Polyhouse must be constantly monitored to ensure optimal conditions, a wireless sensor network can be used to gather the data from point to point. The data from the Polyhouse will be measured by the sensor and the data that are collected will be sending to the receiver. The data that has been read will be displayed onthe LCD screen. By using this system, the process of monitoring is easier and it is also cheaper for installation and maintenance process.

***Keywords*— FFD, RFD, WSN, Zigbee, PIC.**

I. Introduction

Poly house needs the monitoring of the parameters like temperature, humidity and light. All these real time parameters are measured and sent to coordinator through zigbee [1]. As an open and global standard for wireless sensor network zigbee protocol IEEE 802.15.4 shows advantages on low cost, low power consumption and low data rate. Zigbee's network layer supports three networking topologies; star, mesh, and cluster tree. Star networks are common and provide for very long battery life operation [2]. Zigbee-based wireless monitoring and control system in Polyhouse is composed of a coordinator and end devices including sensor nodes and electrical devices organized as a star network shown in Fig.1

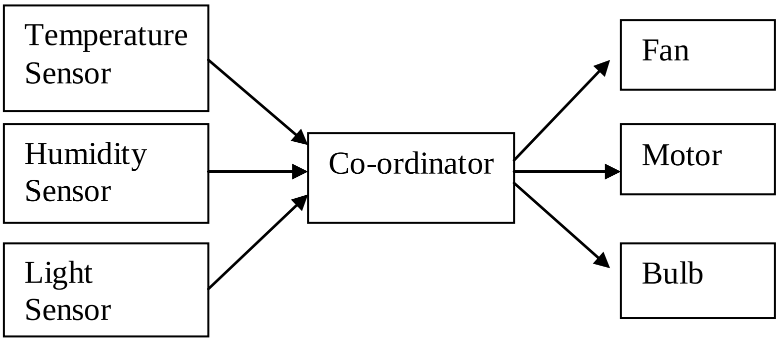

Fig. 1 Star Network Applied in Polyhouse.

II. NECESSITY

It had been identified that the rate of photosynthesis depends on the amount of light energy falling on to the leaves as light intensity reduces the photosynthesis rate reduce and respiration rate increases therefore to get the maximum out of the plants food production the photosynthesis rate needs to be kept high in day time but it is impossible to control if the plant is grown outside a Polyhouse. Moreover it is to be advised that keeping the photosynthesis rates high even at night causes the plants to grow weak therefore photosynthesis needs to be controlled in day time only. Temperature of the atmosphere can drop to values below the optimum temperature and reduce the rates of plants' respiration and photosynthesis rates and when the temperature keeps at a dropped value from the optimum value the yield would be less if the plants are subjected to natural environmental conditions. It is to be understood the terms photosynthesis and respiration. Photosynthesis is the process by which food is made by plants. They absorb CO_2 and H_2O from the atmosphere and uses light energy to convert them to glucose molecules and store as glycogen. Oxygen is formed as a by-product in this process. Respiration is the process by which food (organic molecules) is broken down to release CO_2, H_2O and energy. These processes depends uses enzymes for the operations and the enzymes depend on temperature. At high temperature around 50ºC the enzymes are denatured and at low temperatures they are inactive. Therefore controlling temperature is an essential need in a Polyhouse. Due to the above mentioned processes in a plant a need for a controlled temperature, light intensity and humidity level is required and it is has to done by an automated system.

The space available in the garden also needs to be considered when the user is to buy a Polyhouse. Most of the automated Polyhouses are in large scale and are designed for mass agricultural purposes hence they consume lots of power for heaters cooler fans etc. There are small automated Polyhouses available that are more advanced and used for research work. There are some small automated Polyhouses that control temperature by opening a hatch at the roof but in such Polyhouses more work has to be done in plants like watering them at regular times maybe daily or twice a day depending on the plants grown inside. Due to these reason a control system to suite a small Polyhouse is needed. Many gardeners love to grow various kinds of flower plants but only some really blossom due to the unique conditions in which they prevail. Some seeds require temperatures from 15ºC to 20ºC to germinate and such conditions cannot be provided outside in the normal atmospheric temperature in some areas of the country. Due to the above mentioned various reasons a need for an automated Polyhouse system arises and the Polyhouse system should be cheap, and needs to control the environmental conditions effectively to support efficient plant growth.

Table I Comparison of Wireless Technologies

Parameters	**ZigBee**	**Bluetooth**	**Wi-Fi**
Standard	802.15.4	802.15.1	802.11b
Memory Requirement	4-32 KB	250KB+	1MB+
Battery Life	Years	Days	Hours
Data Rate	250 Kbps	1-3Mbps	11 Mbps
Range	300 m	10-100 m	100 m

III . SYSTEM DESIGN

The hardware unit of the prototype of the system is represented by the block diagram bellow. It contains a PIC16F877A microcontroller as the main processing unit and it gets inputs from the temperature sensor (LM35), LDR (Light dependent resistor) and a humidity sensor. From the data obtained from the sensors the program controls the actuator components (heater, two cooler fans and solenoid valve) to achieve the system requirements. It also uses a LCD display to display the data obtained from the sensors and the data obtained from the user. The heater, cooler fans and light bulb will be connected to the microcontroller using a transistor array and 5V relays (The mechanism used is a normally-open relay switch) since they need an AC power supply to operate. A switch is introduced to manually switch off the light bulbs by cutting off the power supply to the light bulbs.

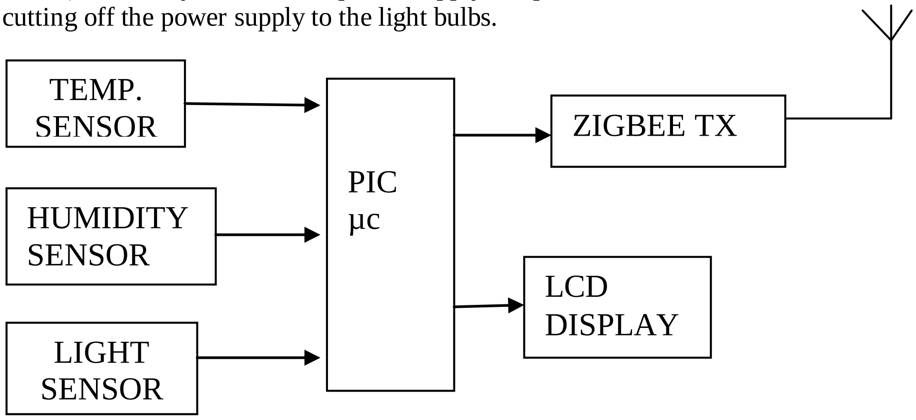

Fig. 2 Block Diagram of Transmitter

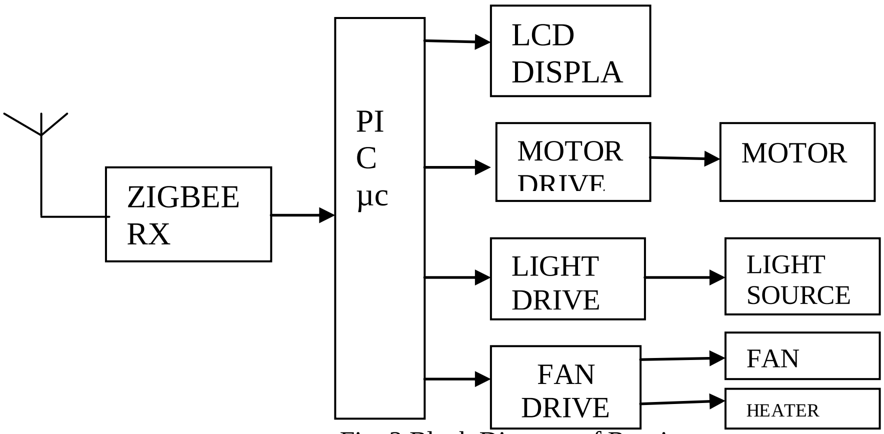

Fig. 3 Block Diagram of Receiver

The requirement of the system is to regulate the temperature to a user defined value and control the amount of light intensity round a defined value in the program and control the humidity around the predefined value in the program while displaying the current temperature value, user set temperature value, humidity value and the light intensity value. The system consists of three subsystems in it and they are,

1] Temperature monitoring and control system

2] Light intensity monitoring and control system

3] Humidity level monitor and control system

The system's temperature monitor and control system works according to the temperature value set by the user. First it gets the value from the user and maintains the temperature around that value. It displays the current temperature in the LCD screen for user reference. The temperature inside is reduced accordingly by the aid of two fans that are placed at the two ends of the greenhouse where one sucks in air from outside and the other sucks out air from the greenhouse thus providing a passage of air through the greenhouse and hence cooling the air inside the greenhouse and therefore the temperature reduces. The temperature of the greenhouse is increased accordingly by using a heater which is placed at the floor of the greenhouse (ideal position needs to be identified by testing). By placing the heater at the bottom it is ensured that the whole Polyhouse is warmed by convectional currents where less dense warm air rises up and dense cold air comes down. The light control system controls the amount of light falling on to the Polyhouse. When there is not enough light the LDR detects this and the microprocessor (PIC16F877A) processes this information send by the LDR and switch on the light bulbs and when there is lighter the bulbs are turned off. But at night the system will automatically switch on the lights and this has harmful effects on the plants therefore a switch is placed to off the lights at times when he feels the lights are unnecessary. The humidity level monitoring system monitors and the current humidity level and maintain it around a predefined value. When the system detects a drop in humidity level it opens a solenoid valve allowing water to flow on to the network of pipelines installed inside the Polyhouse floor. The pipes contain small drilled holes and hence allow water to drip out as a fine jet out into the soil as the water pressure inside the pipe is high. The pipes are placed at the ground level allowing water to reach the soil quickly. When humidity level reaches the correct value the systems shuts the solenoid valve and the flow of water stops. In the temperature monitor and control system an option is given to the user, to set the temperature of the Polyhouse to his/her desired temperature. By this means the user will be able to germinate seeds that require temperatures below the normal atmospheric temperature and grow plants that grow in an ideal temperature as given in the seed packet. But there is a drawback since every time the system is switched on the user needs to get user mode and set the desired temperature value once again but this won't have a big effect since once the system is on the system stays on except till the user offs it or in a power cut. The value of the current temperature and the user defined temperature is displayed on the LCD screen always as a reference for the user and this can be used to check whether the temperature is regulated properly.

Just one LDR is used for the system since light is falling onto the Polyhouse evenly. If the light intensity is high the bulbs are switched off if they are once switched on when the light intensity is low to save power and no attempt is made to decrease the light intensity since more light intensity provokes plant growth. A switch is place to cut off the power supply to the bulbs manually this is because having lights on at night (which happens automatically) will make plants grow weak and consumes more power. The only way the soil inside the moistened significantly is by the watering pipes and not by any other natural means like rain therefore the system is such that it stops the water flow to the pipes when the humidity level reaches the adequate value as defined in the program.

A. Zigbee Module

There are various wireless technologies available in the market that fulfills similar needs, and each of them has its own pros and cons. The oldest one is "Infrared technology", whose power consumption in transferring the collected data is low but the number of units that can be controlled or monitored by this technology is only 1. The transfer rate for data is also very low i.e. 38 Kbps. Another wireless technology, which can fulfill the requirements of transferring the data, is "Bluetooth Technology". The power consumption of this technology for transferring the data is on the higher side but it can control 7 devices at a time. Moreover, the data transfer rate is as high as 1 Mbps. However, a new technology known as "Zigbee Technology" is superior to both technologies mentioned above. ZigBee has been developed to meet the growing demand for capable wireless networking between numerous low-power devices. In industry ZigBee is being used for next generation automated manufacturing, with small transmitters in every device on the floor, allowing for communication between devices to a central computer. This new level of communication permits finely-tuned remote monitoring and manipulation. In the consumer market ZigBee is being explored for everything from linking low-power household devices such as smoke alarms to a central housing control unit, to centralized light controls [4].

The specified maximum range of operation for ZigBee devices is 250 feet (76m), substantially further than that used by Bluetooth capable devices, although security concerns raised over "sniping" Bluetooth devices remotely, may prove to hold true for ZigBee devices as well. Due to its low power output, ZigBee devices can sustain themselves on a small battery for many months, or even years, making them ideal for install-and-forget purposes, such as most small household systems. Predictions of ZigBee installation for the future, most based on the explosive use of ZigBee in automated household tasks in China, look to a near future when upwards of 60 ZigBee devices may be found in an average American home, all communicating with one another freely and regulating common tasks seamlessly Zigbee is a low cost, low power, wireless mesh networking standard. Zigbee can control 254 devices at a time and has the data transfer rate of 250kbps. Because of Zigbee's low cost, low power consumption and ability to connect large number of devices, it could be considered the best option to be used in wireless control and monitoring applications.

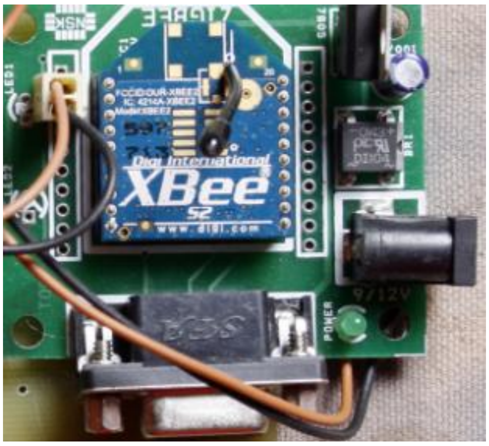

Fig. 4 Zigbee Module

The Zigbee, the RF module, is heart of the Wireless Sensor Node. The Zigbee shown in figure, from Digi International, is a wireless transceiver supporting the IEEE802.15.4 protocol. Low-Rate Wireless Personal Area Network protocol (LR-WPAN) for Wireless Sensor Networks (WSN) or for mesh networking use ZigBee or DigiMesh. This allows addressable communications between nodes. Data may be sent to individual nodes (point- to-point) or to all nodes in range (point-to-multipoint) using a broadcast address.By default, the modules are configured from the factory to be a wireless serial line replacement.

B. Features of Zigbee module

The salient features of Zigbee are as follows.

1] Power output 63 mW (+18 dBm) North American version
2] Indoor/Urban range: Up to 300 ft (90 m)
3] RF data rate: 250 Kbps
4] Interface data rate: Up to 115.2 Kbps
5] Operating frequency: 2.4 GHz
6] Receiver sensitivity: -100 dBm

The ZigBee standard is built on top of the IEEE 802.15.4 standard. The IEEE 802.15.4 standard defines the physical and MAC (Medium Access Control) layers for low-rate wireless personal area networks. The physical layer supports three frequency bands with different gross data rates: 2,450 MHz (250 kbs-1), 915 MHz (40 kbs-1) and 868 MHz (20kbs-1). It also supports unctionalities for channel selection, link quality estimation, energy measurement and clear channel assessment. ZigBee standardizes both the network and the application layer. The network layer is in charge of organizing and providing routing over a multi-hop network, specifying different network topologies: star, tree, peer-to-peer and mesh. The application layer provides a framework for distributed application development and communication.

C. Types of Zigbee Devices

C I. Zigbee Coordinator

This acts as the building block of the Zigbee communication. Zigbee coordinator forms the root of the various topologies like mesh, star, tree topology network etc. and communicates from one device to other. There is only one Zigbee coordinator in the whole Zigbee environment.

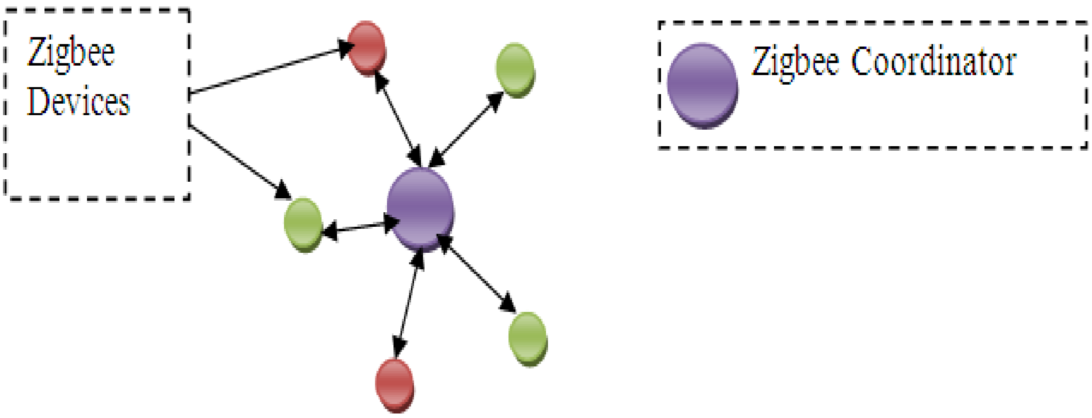

Fig. 5 Zigbee Co-coordinator

C II. Full Function Device

Full function devices support all IEEE 802.15.4 functions and features that are defined by the standard. They can also function as a Zigbee coordinator. More memory and computing power availability helps them to work as router also, which helps in transmitting data to longer distances through different networks.

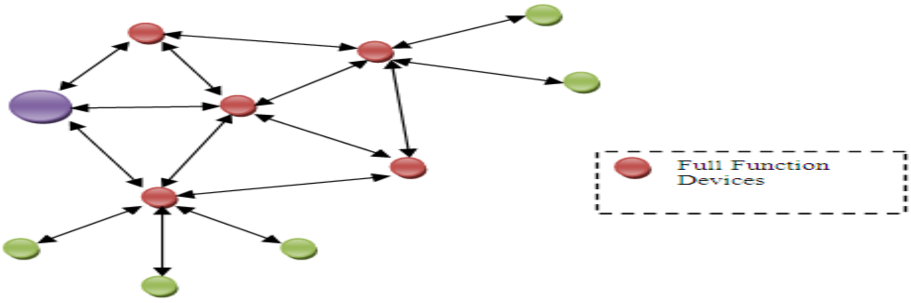

Fig. 6 Full Function Devices

C III Reduced Function Device

Reduced function devices just talk to the Zigbee coordinators or Full function devices. They cannot perform the functions of a router or coordinator.

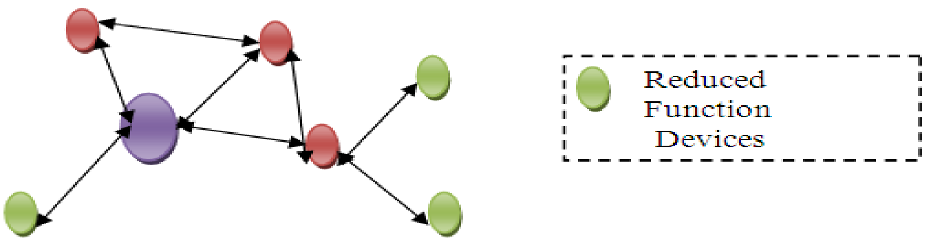

Fig. 7 Reduced Function Devices

D. Temperature Sensor

Various types of temperature sensors are available in the market and sensor depending upon the use can be implemented. The LM358 is a commonly used temperature sensor which has temperature range of −55° to +150°C. It can be used with single power supplies, or with plus and minus supplies. The LM35 output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry easy. The LM35 series are precision integrated-circuit LM35 temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 sensor thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling [5]. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°Cover a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies.

E. Humidity Sensor

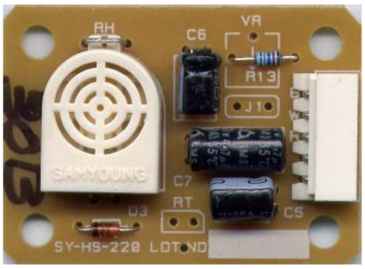

Fig. 8 Humidity Sensor

To measure humidity, amount of water molecules dissolved in the air of Polyhouse environments, a smart humidity sensor module SY-HS-220 is opted for the system under design [6],[7]. The photograph of humidity sensor SY-HS-220 is shown in the figure 8. On close inspection of photograph, it is found that, the board consists of humidity sensor along with signal conditioning stages. The humidity sensor is of capacitive type, comprising on chip signal conditioner. However, it is mounted on the PCB, which also consists of other stages employed to make sensor rather smarter. The PCB consists of CMOS timers to pulse the sensor to provide output voltage. Moreover, it also consists of oscillator, AC amplifier, frequency to voltage converter and precision rectifiers. Incorporation of such stages on the board significantly helps to enhance the performance of the sensor. Moreover, it also helps to provide impediment to the noise. The humidity sensor used in this system is highly precise and reliable. It provides DC voltage depending upon humidity of the surrounding in RH%. This work with +5 Volt power supply and the typical current consumption is less than 3 mA. The operating humidity range is 30% RH to 90% RH. The standard DC output voltage provided at 250C is 1980 mV. The accuracy is ± 5% RH at 250C. As shown in the figure 8, it provides three pins recognized as B, W and R. The pin labeled W provides the DC output voltage, whereas the pin labeled B is ground. The VCC of +5V is applied at the pin R. The humidity dependent voltage is obtained and subjected for further processing.

F. Light Sensor

A simple LDR with proper light arrangement can be used to operate as a light sensor. A photo resistor or light dependent resistor or cadmium sulfide cell is a resistor whose resistance decreases with increasing incident light intensity. It can also refer as a photo conductor. A photo resistor is made of a high resistance semiconductor. If lightfalling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough

energy to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering resistance. A photoelectric device can be either intrinsic or extrinsic. LDR is a cost effective light sensor which can be implemented in Polyhouse.

IV. Conclusion

Polyhouse prevents the plant from the effects of climate; inspect and so on, which makes great sense for agricultural production. The automation and high efficiency on Polyhouse environment monitoring and control are crucial. Applying ZigBee-based WSN technologies to Polyhouses is a revolution for protected agriculture which overcomes the limits of wire connection systems. Such a system can be easily installed and maintained.

In this we discussed the wireless solution of Polyhouse monitoring and control system based on ZigBee technology, and designed the wireless nodes, network establishment and control system. With the capabilities of self-organizing, self-configuring, self-diagnosing the ZigBee based monitoring and control system provides nearly unlimited installation flexibility for transducers, increases network robustness, and considerably reduces costs. We therefore, conclude that the ZigBee based monitoring and control system can be a good solution for Polyhouse monitoring and control.

The sensor positions and the cooler fans and heater positions needs to be identified by testing for the appropriate positions. It also depends on the size of the Polyhouse as the size of the Polyhouse increase the temperature will not be constant and therefore more than one sensor needs to be used. The same applies to humidity level sensor. In the prototype made it is still possible to add two more sensors to the system along with two more fans and a solenoid valve and still display the temperature and soil humidity level detected from the added sensors in the LCD display. But by this means the Polyhouse would have two temperature and soil water level control systems and these two systems can be used to monitor and control the temperature and soil water level in two sectors of a large Polyhouse. Using one LDR sensor for the whole Polyhouse is much suitable since light is falling equally into the Polyhouse and the sensor needs to be placed in a place where it is directly subjected to light from the sun and as well as from the light bulbs Currently the temperature, light intensity and humidity is regulated around a particular value. But when implementing practically it is more efficient to regulate these parameters around a range of values even though the values do no frequently change.

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