IoT Based Control and Automation of Smart Irrigation System

An Automated Irrigation System Using Sensors, GSM, Bluetooth and Cloud Technology

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***Abstract*—India has a population of more than a billion and its requirement for water increases each year as the demand for food increases hence management of water resources to sustain this massive population is of high importance. The agricultural sector, an important sector of our economy accounts for a good percentage of our nation's GDP and of the exports. With advancement in technology we can establish a system that automates the irrigation process such that there is efficient usage of water and create an ease of work load for the farmers. With embedded technology and Internet of Things, in this work we have designed IoT based automated irrigation system for the Indian scenario. Our system is able to deliver optimal water to the plants based on moisture, light and temperature levels which are obtained through sensors. The farmer will be able to monitor the parameters through the mobile app which is integrated with cloud storage. By analyzing and comparing previous year's data and our current data we are able to efficiently find a way to save water.**

***IndexTerms*—India, water, Irrigation, sensors, Automates, Embedded, Internet of Things, cloud.**

I. Introduction

Water is a vital resource for living creatures, each living creature uses water per its desires, because of this importance of water in our lives, it is highly necessary to use this resource as effectively and optimal as possible. There are several sectors that come under water consumption; the biggest sector is the agricultural sector which amounts to about 70% of the water consumption.

Climate change is a major factor for the unpredictable weather and rainfall patterns. As many of the farmers depend on the monsoons which occur for about four months of the year, changes due to this unpredictable nature of weather harm the crop yield and tend to incur losses. Farmers have stated several times that the monsoon rains have become increasingly unpredictable over the past twenty years, both in the timing of the rainfall and the total amount of rainfall per year. This makes it difficult for farmers to decide which crops are best to plant in which season order to get the highest yields during that particular season. [1]

Technology advancement has played an important role in solving the insufficiency of water, techniques like drip irrigation system, sprinkler systems, automated irrigation systems, network based systems which work on automation of irrigation. Though there are all these different advancements in technology farmers prefer continuing with their traditional irrigation procedures thus this requires some amount of convincing. Efficient system is to be proposed to minimize the water wastage.

Our goal in this project is to help the farmers with their crop yields by using efficient methods for helping them during the drought season due to deficient rainfall, preventing over flooding of the field due to excess rainfall, decreasing the work load for the farmers on a day to day basis, periodically updating the status of soil parameters and any malfunctioning of the mechanical systems like pumps/motors can be pin pointed and finally to help the farmers figure out which crop is best suited for a particular season.

The main of work falls under the following:

a) Sensor Based Automatic Irrigation System

Sensors such as soil moisture, luminosity, temperature and humidity sensors are used to determine the appropriate schedule for irrigation. The sensors are integrated to an Arduino Uno board and this data is used for operating the pump in terms of turning it on when the soil moisture level is less and when the temperature is extremely high, the amount of water let from the pump is more when the temperature is high to compensate for the loss of water due to evaporation.

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b) Internet Of Things

Internet of things is the internetworking of physical devices interacting with each other to collect, control and exchange data. This system is in accordance with collecting real time values from the sensors with the objective of automating irrigation on comparison with the threshold values. The data collected can be stored on Sparkfun, a free web services platform that allocates a user or registrant with 50mB data space. Prototype here developed is programmed to store data on Sparkfun at an interval of 45 seconds, that is, after every sensor reading iteration. Analysis of this data stored can be used to evaluate the water usage per day, per week or per year even.

c) GSM Technology

Integration of the GSM module to the Arduino helps us achieve real time updates on the conditions of the plot of land. Any malfunction in the hardware will be sent via message.

d) Wi-Fi Technology

Wi-Fi technology is used to update our soil parameters to the cloud to keep track of the field status using sensors.[2].

The novelty about our project is the use of the luminosity sensor that senses the light intensity of the surrounding environment and can provide artificial light in case of low intensity, this gives us an upper hand on areas with low sunlight. We have also used sparkfun as a platform to store all the data of the sensors, this is then processed and summarised as to how much more beneficial our system is in terms of water management. The temperature sensor plays an important role in watering the plant as the plants are watered comparatively more when the temperature is higher such that there is a compensation for the high evaporation that occurs. Lastly, we have collected previous years data for the ground nut plant and are currently comparing the monthly data we obtain to it and then come to a conclusion on how much water we have saved.

II. LITREATURE SURVEY

There have been many studies on done on the area of smart irrigation system to provide an easy and efficient method to automate the irrigation process. The different studies done are aimed towards irrigation its inefficient water consumption, absence of remote farm monitoring and lack of useful inference. In this paper we figure out an efficient method to integrate sensors with Arduino and come up with an automated irrigation system. The following are a few studies that we have referred to.

Rajalakshmi.P and Mrs.S. Devi Mahalakshmi developed a system using sensors to monitor the crops. The use of wireless transmission of sensor data from the field and storing it on a database along with control through mobile application proposed a proof of concept to automate the irrigation system. In their system the use of NRF24L01 for wireless transfer of data is different from our system where data is transferred through our Wi-Fi module ESP8266 and then uploaded to cloud. [3]

Joaquín Gutiérrezet. al[4] developed an automated irrigation using solar power for organic that are geographically isolated. Their work on internet controlled duplex communication system holds a good decision making concept for adaptation to several different scenarios. The internet link is provided where access through mobile devices are established. Our system concentrates on cloud storage and GSM technology to water the crops efficiently.[4]

Jia Uddin et. al[6] proposed a system for automated Irrigation System that involves two levels of decision making to turn the motor ON/OFF. The microcontroller has the threshold values embedded in it called secure and unsecure values which are 0cm and 10cm to turn the motor ON or OFF respectively. If the sensor values reach a mid level the farmer or the user intervenes to make the decisions accordingly. This decision is made using a decoder to read the message sent by the owner to turn the motor ON or OFF. The entire system is driven using solar power to overcome the use of electricity as an alternative.[5]
To overcome the drawback of too many decision makers, the threshold values can be made to be operated on different water content levels implemented in our proposed system. This involves coding on the basis of trail and error procedures to build up on moisture levels.

R. Suresh et. al[5] proposed a system for automatic Irrigation prototype wherein the sensor nodes sends sensed values to the microcontroller that operates the solenoid valve. This microcontroller is interfaced to a mobile phone that is in auto answering mode to activate the buzzer that then switches off the motor by sending this activation signal to the microcontroller. This system is based on microcontroller application that results in lower power consumption.
The above system involves interfacing of two communicating devices to turn the motor on and off which can be simplified by letting only the microcontroller turn the motor ON or OFF based on the levels of moisture content and decision embedded in the code as implemented in our system.[6]

III. PROPOSED SYSTEM

Our system consists of three sensors namely, soil moisture sensor, luminosity sensor and the temperature sensor, as shown in figure 1. The soil moisture sensor's value varies according to the moisture level on the field. The temperature sensor records the temperature of the surroundings. The luminosity sensor is used to measure the intensity of light falling on the plant. Each of these sensors are designed to have a threshold value which we obtained on a trial and error basis, these threshold values are divided into different levels in our code. The sensors are interfaced to the Arduino Uno which is a 14 I/O Pin, ATmega328 based microcontroller. The design made such that if the moisture sensor senses moisture less than the set threshold value then the plant is watered. The GSM module is interfaced with the Arduino to establish cellular communication between the system and the user. Live data is sent through the GSM module to the user via text message after insertion of the sim card into the GSM module, The data contains the motor, pump and the sensor conditions, this helps the farmer to keep track of his field and know if there are any malfunctions. We have also established the control of the motor through Bluetooth. A generic application is downloaded and in case of any manual requirement to operate the motor, we can make use of this. The Wi-Fi Module used here is to transmit all the data to the cloud. Sparkfun offers 50mb of cloud storage for a particular user, we use this portal to upload our data at regular intervals of 45 seconds.

As a test case we considered the ground nut crop and obtained the previous year's data through the package of practices in India's farmers' portal. This was an essential part of our study as we compared the collected data and the previous data to obtain the desired threshold values for temperature and moisture such that any overflow or underflow doesn't occur. With this comparison we also could figure out how much millilitres water we saved on a monthly basis.

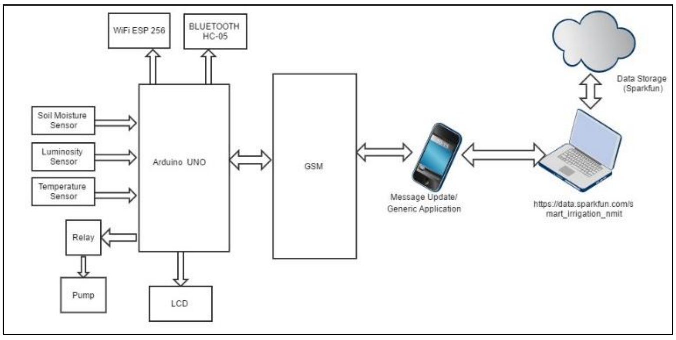


Fig. 1. Block Diagram

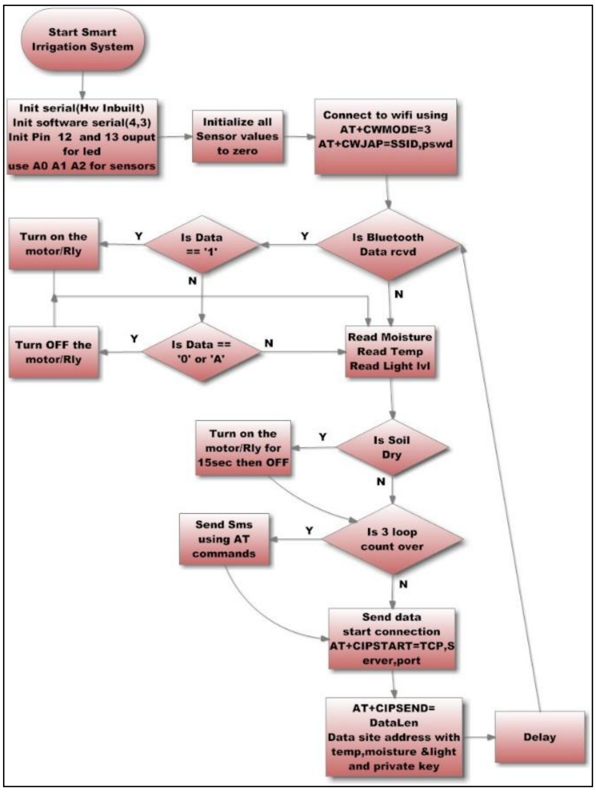


Fig 2. Flow Chart

IV. REQUIREMENTS

In order to build the proposed framework for the automated irrigation system, we have used following hardware and software components:

a) Soil moisture sensor:

A soil moisture sensor measures the amount of moisture content that is present in the soil, this is of great importance for the irrigation system. [7]

A generic soil moisture sensor operating at 3.3v-5v, consisting of an on board LM393 comparator is used here. The volumetric content of the soil is represented in percentages which we have then converted to four levels L0-L3, Zero being driest and three being flooded. When the soil moisture happens to be L0, the motor turns on and the water is pumped to the plant.

b) Temperature sensor:

The LM35 is an integrated circuit temperature device with an output that is linearly proportional to the Centigrade temperature. The LM35 device does not require any external calibration or trimming to provide accuracy of ±¼°C and ± 3/4 °C at room temperature and externally respectively. [8]

c) Luminosity sensor:

The LDR sensor is a photo resistor whose resistivity works on EMR. These are made up of semiconductor materials having high resistance sensitivity to light. The resistance of the LDR decreases when light falls on it and is increased when the light is low. [9]

d) Arduino uno:

The Arduino uno is a microcontroller board based on the ATmega 328P datasheet. It has 14 digital I/O pins, 6 analog pins, a power jack, USB connection, reset button, and an ICSP header[10]. The main purpose of the usage of Arduino here is to interface all the sensors and actuators conveniently. The Arduino is where all the code is dumped.
The Arduino is interfaced with the Wifi module and Bluetooth Module.

e) Relay and pump:

The relay is used to turn on and off the pump according to the moisture level of the soil. It is controlled by interfacing it to a microcontroller, in this case the Arduino uno. The pump is triggered on and off by the relay.

f) GSM module:

The GSM Module used works with the SIM900 Quad-band solution which is embedded in the customer applications. In india we use 900MHz for communication of SMS, Data and Fax. The GSM module consumes low power and hence is widely used. The GSM Module is interfaced to the Arduino Uno and transmits the sensor data to the user via text message and any malfunction observed will also be sent.

g) Bluetooth Module:

The HC-05 is an easy Bluetooth device working designed for transparent wireless serial connection setup. Serial port has a data rate of 3mbps with complete 2.4GHz radio transreciever and baseband. [11]

h) Wi-Fi Module:

The ESP8266 is a low cost Wi-Fi module which ads functionality to the existing Arduino unovia the UART serial connection. This module is reprogrammed in such a way that the data from the sensors are transmitted to the cloud storage provide by sparkfun every 45 seconds.

i) Arduino IDE:

The Arduino Software is an open source software that can be downloaded from the Arduino website, this is used to write codes and upload it on to the board. The Arduino software supports Windows, Linux, and Mac etc and is written in Java. All sensors and actuators are controlled by varying the code.

j) Sparkfun:

Sparkfun is a free open source service which pushes all the data of the sensors to cloud. Sparkfun provides 50mb of space to store and analyse data. To access this, one must create a stream and after receiving the public and private key on the hardware we have created a string with the data obtained from the sensors.

V. IMPLEMENTATION

In this section we will discuss about the different modules that make the project a whole.

A. Integration of Moisture, Temperature and Luminosity sensors with the Arduino Uno:

The soil moisture sensor records the moisture level of the soil, we have categorized the moisture content in four levels namely L0 for Dry soil, L1-L2 for moderately wet soil and level L3 for flooded soil. When the soil moisture is of level 0, the pump is turned on. The temperature sensor records the temperature of the environment in a resolution of 5/1024 ADC, this needs to be incorporated retrieve the data in a digital form, according to how high the temperature is and the water through the pump is increased by 20ml to compensate for the loss of water through evaporation. The luminosity sensor has levels ranging from L0-L10 where L0 is dark and l10 is high, the main function of the luminosity sensor is to send a signal in case there is an overly cloudy day such that artificial light can be used on certain crops to improve their growth. All the sensor values are displayed on the LCD. The Arduino board is powered by the laptop or an external adapter of 9V, Arduino IDE is used to edit, write and upload the code. Whenever the moisture is less the relay turns on and the pump is turned on for about 10-20 seconds. As only 1 UART is present in Arduino board second UART is emulated using software serial function, mySerial object is created and it inherits all the function of Serial object.

B. Sending a message to smartphone using GSM:

The GSM HC-05 is powered by 12V supply, the TX and RX pins are responsible for transmitting the message to the user. Currently an SMS is sent every 3rd cycle which is approximately 3 minutes but this can be altered according to convenience as shown in figure 3.

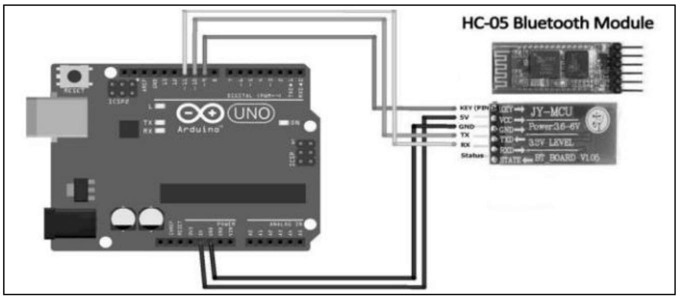


Fig 3. Arduino Uno and HC-05 connection

C. Control of motor through Mobile application:

We use a generic application to turn on and off the motor, this is a safety unit in case any malfunction occurs during the process of automation. After pairing the Bluetooth of the system to our smartphone, the motor can be turned on and off according to convenience.

D. Send sensor data to the cloud:

The sensors detect and measure changes in the parameters such as temperature, humidity, light and moisture content in the soil. These parameters are in electrical and numerical values. ESP8266 is Wi-Fi module that works with UART serial communication pin, via this, AT commands are sent to the Wi-Fi module, first at commands are to connect the Wi-Fi spot and later to send the data to internet using HTTP GET request. In our project we use sparkfun to store the data on cloud. This allows the sensors, instruments and websites to communicate the data in cloud. [12]

E. Collection and Comparison of data to obtain threshold value:

As a test case we considered the groundnut crop and used it for our studies. We collected data from the years 2015-2016 through our government website for farmers i.e. Farmers portal: Package of practices as shown in figure 5, 6 on how much the temperature and moisture level changes throughout each season such that we could determine the threshold temperature and moisture values for each season. In this way we can efficiently know if a particular plant is favorable for the given weather conditions. By collecting our monthly data as shown in figure 5, 6 we were able to determine how much water is saved on a monthly basis as compared to an average groundnut crop.

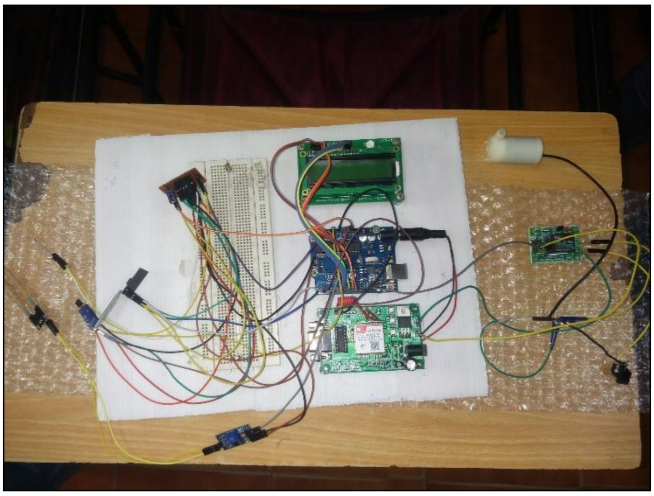


Fig 4. Implemented Project

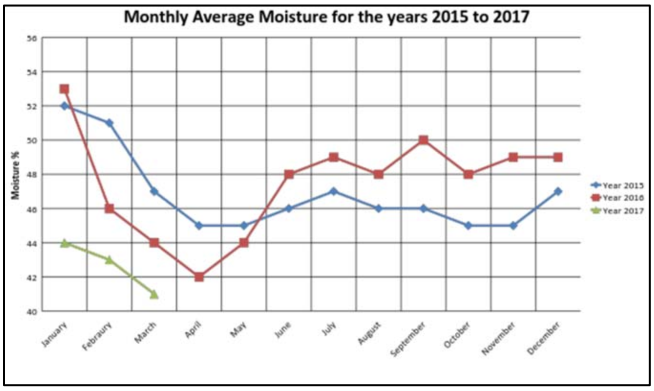


Fig 5. Monthly Average Moisture for the years 2015 to 2017

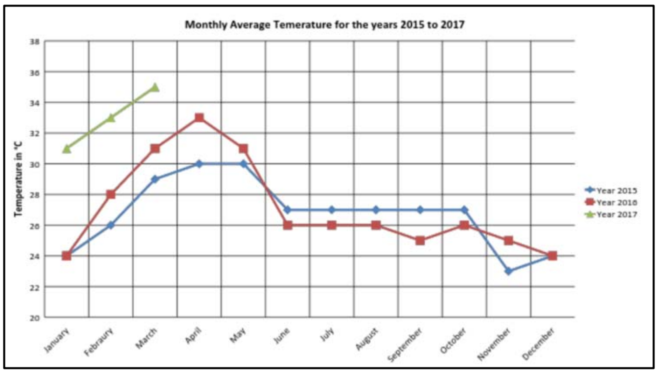


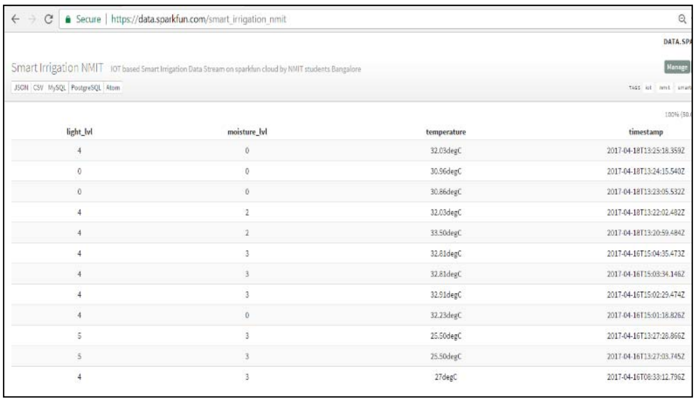
Fig 6. Monthly Average Temperature for the years 2015 to 2017

VI. RESULT

Through this project we have been able to control the motor according to the soil moisture level and control the amount of water being pumped according to the temperature of the environment to compensate for the loss of water due to evaporation. We have made it such that the pump is turned on whenever the moisture level goes below the threshold value(L0). In case of any error, the motor can be manually controlled through the app. All sensor values are uploaded on a real time basis on the cloud and can be accessed anytime through the URL specified:

http://data.sparkfun.com/smart_ittigation_nmit.

The GSM module sends updates to the mobile phone (as shown in figure 8) as to when the soil moisture is low and when the pump is turned on along with the present values of the luminosity sensor and the temperature sensor.The monthly updates of soil parameters are then compared with the previous year's data and observed that the moisture level required for the ground nut plant is lesser than what had been used in the years 2015-2016 as shown in figure 5 and 6. The comparison can be used for data processing and analysis to predict which crop is well suited for a particular season.


https://data.sparkfun.com/smart_irrigation_nmit

Smart Irrigation NMIT IOT based Smart Irrigation Data Stream on sparkfun cloud by NMIT students Bangalore

light_lvl	moisture_lvl	temperature	timestamp
4	0	32.03degC	2017-04-18T13:25:18.359Z
0	0	30.96degC	2017-04-18T13:24:15.540Z
0	0	30.86degC	2017-04-18T13:23:05.532Z
4	2	32.03degC	2017-04-18T13:22:02.482Z
4	2	33.50degC	2017-04-18T13:20:59.484Z
4	3	32.81degC	2017-04-16T15:04:35.473Z
4	3	32.81degC	2017-04-16T15:03:34.146Z
4	3	32.91degC	2017-04-16T15:02:29.474Z
4	0	32.23degC	2017-04-16T15:01:18.826Z
5	3	25.50degC	2017-04-16T13:27:28.866Z
5	3	25.50degC	2017-04-16T13:27:03.745Z
4	3	27degC	2017-04-16T08:33:12.796Z

Fig 7. Sparkfun Data Storage [http://data.sparkfun.com/smart_irrigation_nmit]

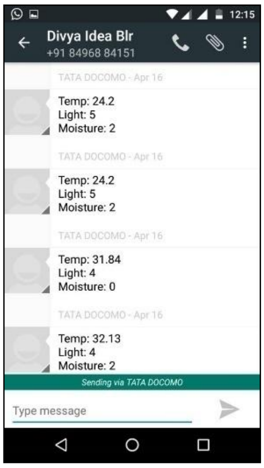


Fig 8. Sensor status received through SMS

VII. CONCLUSION

The irrigation system on automation uses optimal resources to improve the efficiency of the irrigation. This system can be implemented in places that face water shortage to improve agricultural sustainability. In this project a prototype includes sensing element node and data storage. The sensing element node is deployed on the field for sensing the soil parameters such as temperature, moisture, luminosity and humidity. According to the soil parameters the automation is achieved by turning the motor on and off using the threshold values embedded in the code. The status for the same is alerted to the users through messages using GSM. The same principle is also extended to access the data from cloud using sparkfun. Collecting the data of the groundnut crop from 2015-2016 and comparing it to the 2017 data obtained from our test groundnut plant we can see that the required moisture content to water the plant decreases and hence we can say that we have successfully conserved water.The functionality of the system on various tests is said to be successful and can be used to analyse different crops.The extension of this project can be the use of solar panels in the project to run the motor to save energy, which we are working on now.

VIII. FUTURE ENHANCEMENTS

*a) Alarm System can be used to alert the Farmer/Land Owner in case of any Unusual activities on the field:*this can be obtained by having sensors around to monitor the Field of by installing a live surveillance which can detect unusual movement by image processing.

*b) Installation of a solar panel for providing electricity instead of a Pump:*As solar energy is a renewable source and is in abundance, this can be used to save energy.

c) Providing Different types of Irrigation according to crops: Not limiting ourselves to one type of watering method but using Drip irrigation, sprinklers etc as different crops need different type of watering system.

*d) Taking weather into account:*To be able to control the irrigation according to the weather such that we can predict when to water the crops and when not to according to when the next rainfall would be, this prevents over flooding.

IX. ACKNOWLEDGEMENT

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