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Machine Monitoring on Cloud using Raspberry Pi and Internet of Things

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Abstract: This paper demonstrates a novel approach in industrial machine monitoring on cloud server using Internet of Things implemented on Raspberry Pi. The raspberry pi is a small credit card sized computer which can directly send data to the cloud server. Any kind of CNC or industrial machine can be connected to Raspberry pi giving logical inputs and can be monitored on the internet based server so that the real time production data, the work currently going on, the employee who is working on a particular machine, the rate of production, causes of delays and downtimes everything can be monitored by the supervisory or authorities sitting at a remote location almost anywhere in the world. Moreover the system is very simple which can be operated by unskilled workman working on the floor.

Keywords: Raspberry Pi, Machine monitoring, IOT.

I. INTRODUCTION

There are various types of processes which are controlled by different machines in any kind of manufacturing industries. Considering a small industry to a large industry everywhere in production scenario, it is required to keep a track of entire production line up and the daily targets as well as failures for effective production monitoring. In companies which employ mass production daily, the record of daily production is done manually by using a production line counter. And about monitoring of CNC machines, most recording of machine performance, the operation, the number of jobs produced/worked upon are entirely drafted on paper. The reports generated are also manual which are either written on paper or generated on computer by manually entering the data. This data can be like machine running for 8 hours, manufacturing 10 pieces and failing to do 5 pieces. Likewise the report generation if done manually is a time taking job and highly erroneous. This also leads sometimes to data manipulation as well as misinterpretation. In such cases some automation of CNC machine performance becomes very important for effective monitoring of the entire production. This automation should include as many parameters of machine as possible to be continuously recorded mostly on some sort of local storage as well as a remote storage. This remote storage can act as effective monitoring tool for the supervisory persons. If the remote storage is on internet, the data monitoring can even be done sitting almost anywhere in the world.

The proposed work aims at providing solution to above mentioned issue by providing a solution using Raspberry Pi Computer in the most cost effective way. Here the approach used is very simple and can be adapted to any kind of industries by little or no modifications at all. The Raspberry pi with digital opt coupled inputs and active internet connection can read all the values given by the machine easily and log them on the cloud server effectively. The cloud server can be custom created or any freely available open cloud server can also be used. Raspberry Pi computer can be connected to internet using either Ethernet based connection using RJ45 cable connected to local Ethernet switch or it can be connected to internet using USB wifi dongle if WIFI internet connection is available. The board runs on Linux operating system which can support many programming languages like C, C++, Python, Java etc… for our job, we've selected to use python as our programming language.

II. WHAT IS IoT

The internet of things is becoming an increasingly growing topic of conversation both in workplace and outside of it. Broadband internet connection has become more widely available almost everywhere in the world. The costs involved in broadband internet connection are reducing almost every day and hence the cost of connecting to the internet has drastically being reduced [3]. Additionally more devices are being connected using Wi-Fi technology removing the wired complexity and costs involved giving wireless freedom for internet connectivity. So hence, more and more devices are being built everyday with capability to connect to the internet, share and send some data to internet and receive any data coming from internet. Thus, IoT is a concept of basically connecting any device with an On and Off switch to the internet. This device can be anything from cell phone, coffee vending machine, water geyser, microwave oven, lamps, room lights and anything we can think of. It's going to be beyond the connected computers term which is in use for so long term. IoT is going to be a giant network where every device imaginable would be connected to internet.

Now the benefit of this IoT term is beyond simple discussion. There are numerous applications from household appliance control to industrial process controls. Embedded Devices connected to internet can accept On Off commands from internet; share all the data available with them to the internet. The user of system can be sitting anywhere in the world and control his home appliances or industrial processes by just looking on his computer

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screen where he can open a web browser and put address of his device. The embedded device may serve an HTML page of its own just like a web site page loads where user can see any data related to the device. Similarly there are large numbers of applications where data analysis can be done in a much smarter way. In many cases, the embedded device connected to internet does not serve HTML page, but simply send the parameters that are sensed using HTTP requests to the server and it's up to the server side programming to analyse data properly and arrange in a way where user can effectively read and observer the data.
Internet of Things, is in use already and there are many implementations of it. To implement IoT on embedded system, the system needs to have a programmable element and internet connection through either Ethernet interface or through Wi-Fi Interface and send data to a web based service. Nowadays there are many Cloud Service providers for IoT application where user can subscribe to a cloud service, take some user name, password and API key from them and send data to his own cloud space. This way eliminates the user from the complex programming and networking related to the server side and focus on embedded applications. There are many such examples of available cloud services e.g. www.kaaproject.org, dataplicity.com, www.nearbus.net, www.teleduino.org. Most of these cloud service providers also provide their own mobile OS app also where user can see his data on mobile app and can also control some devices directly through mobile App. The devices used for embedded platform building can be any small microcontrollers. If smart devices with sufficiently more computing power are used, the IoT applications run smoother. There are many Linux powered boards available today which makes developing IoT applications very easy.

III. RASPBERRY PI

Raspberry Pi is a Linux powered computer and definitely is a natural choice for IoT applications. The reason for raspberry pi being a preferred IoT device is because it runs a complete Linux Kernel and has direct interfaces such as Ethernet for wired internet as well as USB ports to connect to wifi. The operating system of raspberry Pi supports modern programming languages like python which makes IoT application development easier. Moreover, raspberry pi also has GPIOs so it can directly connect with devices, sensors and many real world devices.
The Raspberry Pi is having a 40-Pin GPIO header, 4 x USB ports, 1x LAN port, 1x CSI and 1x Touch Screen interface, 1xhdmi port, 1xintegrated audio and video output port. The board runs on single +5v power supply for which there is a microUSB female connector provided.

IV. HARDWARE REQUIREMENT

Currently proposed system is supposed to be used in an industrial application. A system is connected to a CNC machine where manually various job are manufactured. This system takes inputs from the machine in the form of logical inputs and pushes that data to a dedicated web server on the internet. To do so, the system uses wifi connection for internet connection. The system made up of raspberry pi is to be connected to a CNC machine along with a keyboard and mouse. The workflow of the system is as follows-
The operator when comes first in the company, turns on the machine and at the same time, turns on the Raspberry Pi based system. The system takes some 2 minutes to boot up completely. Once booted up, the operator has to open a web browser and enter the IP address of the Cloud Server. Once the IP address of the cloud server is entered, the web application opens. Here the operator has to login using his given username and password. Once logged in, user has to select the machine he is working on and the job he is going to perform and then start the job. Once he starts the job, there will be a number of sensors from which the raspberry pi will accept digital inputs and will simultaneously post it on to the web server. This data will be updated in real time. The operator if wishes to take any kind of break, he has to mention so in the web application as well as if there is any failure in the job being produced, then he has to be mention the reason for failure. This way, the company supervisor can get complete information about all the jobs going on in real time and can monitor them all by having a bird eye view of the entire system.

V. SYSTEM DEVELOPMENT

System consist of raspberry pi model B+ with an 8 GB SD Card. Below is the system block diagram-

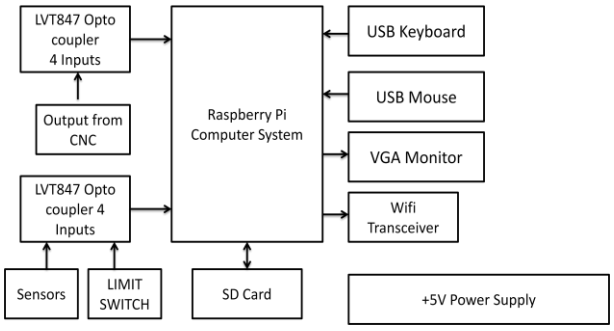

Fig. 1 System block diagram

Above figure shows block diagram of the system. The raspberry pi is having 8 GB SD card with Raspbian Operating system installed. We're using LTV847 Opto coupler which is 4-in one optocopuler IC. Optocopuler IC is used to accept high voltage DC inputs to the raspberry pi. The inputs coming from the CNC machines are coming from PNP Proximity sensors and limit switches all of this work on 24v DC. If 24v DC is directly given to raspberry Pi, it will damage the GPIO pins. The 24v DC can be dropped down to 3v using Resistors but that does not give any kind of isolation. Hence we've used optocouplers to give complete isolation from 24v supply system. The optocoupler part is so designed that it can accept any dc voltage from 5v up to 100v dc. The outputs coming from sensors are given as input to the optocouler its output transistor switches 3.3v to the input of raspberry Pi. To accept 8 digital inputs, 2 LVT847 optoupler IC's are used. The optically isolated signal goes to the GPIO of raspberry

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pi where the software can analyse signals and do further processing. While raspberry pi supports a variety of different programming languages, for this system, we've used python. Python is the officially supported language for raspberry pi. There are numerous different libraries available for raspberry pi to be used with python. Python is a perfect mix of easy to use as well as powerful programming features such as audio/video processing, internet and email connectivity likewise. Python works as interpreter hence the syntax of python is minimal. On Raspberry pi the Python 2.7 is installed by default and for all our experiments, we've used python 2.74 with additional libraries. With Raspberry Pi, Linux operating system, any required software can be installed directly from internet through lxterminal. We've used the RPI.GPIO library for python on raspberry pi for interfacing with the optocouplers and read the inputs. For the internet part, python's built in HTTPLIB is used which can effectively send GET requests. Python code can be run directly from command prompt or an IDE called IDLE can be used to run python codes.

Raspberry pi, being a computer system does not work as microcontroller. At the same time, it can run many different programs along with this system program. But these programs are needed to be run by giving command manually every time the system starts. Hence to run the program automatically, we've to add the program in the raspberry pi's start up routine. This can be easily done by adding the CRON job. cron is the time-based job scheduler in Unix-like computer operating systems. CRON enables users to schedule jobs (commands or shell scripts) to run periodically at certain times or dates. It is commonly used to automate system maintenance or administration. Once the program is added to CRON, it runs automatically in the background.

VI. SOFTWARE REQUIREMENT

The raspberry pi's raspbian operating system is preloaded with the GCC compiler suite. This GCC compiler is not needed to be installed separately and hence raspberry pi directly run C programs without installing anything extra. But the embedded coding requires access to the Raspberry Pi GPIO's and for that sake; it's a must to install additional libraries. In the short time that the Raspberry Pi has been around, a considerable number of programming languages have been adapted for the Raspberry Pi, either by the creator of the language, who wanted to support the Pi by porting their creation or by enthusiastic users who wanted to see their language of choice available on their platform of choice. The Raspberry Pi Foundation recommends Python as a language for learners. Any language which will compile for ARMv6 can be used with the Raspberry Pi, though; so you are not limited to using Python. C, C++, Java, Scratch, and Ruby all come installed by default on the Raspberry Pi.

VII. PYTHON

Python is considered to be the simplest of all programming languages by many. This is the reason why many people prefer using python on the raspberry pi. As python was being preferred by the raspberry pi foundation itself, later on, it happened so that many people who wanted to write device drivers, firmware and sample codes for various GPIO interfaces to raspberry pi, began naturally to write all these things in python only. This leads to a wave of programming stuffs and material being done in python. The gitbuh.com contains loads of different user contributed libraries to make working on raspberry pi using python a delight.

Python is a much high-level, interpreted, interactive and object-oriented programming and scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation. Python was developed by Guido van Rossum in the late eighties and early nineties at the National Research Institute for Mathematics and Computer Science in the Netherlands.

VIII. RESULTS AND CONCLUSION

For Final programming, along with the Python as our main programming language, we need to use some additional libraries for using with python basic programming software. These additional libraries are RPI GPIO library which gives access to raspberry PI's GPIO's and the HTTPLIB which can access the working internet connection of raspberry pi through programming and post the data to the server present on the internet. The data posting through the python programming can be timed at suitable intervals so as to not to clot the sever with incoming streams of data continuously. We can also do a provision in raspberry pi to write the data on to a separate Text file if internet connection is not available. As soon as the internet connection becomes available, raspberry pi first starts posting data from the text file and then starts updating the real time data which is coming at the moment. In the final program, we've to handle most of the error exceptions which can occur due to the internet connectivity or GPIO errors. If the exceptions are not handled properly, then it can hang/stop the python program which is not desired in any condition.

Parameter	**Different models of Raspberry Pi**		
	Model B	**Model B+**	**Model 2**
Operating voltage	+5v	+5v	+5v
Current Consumption	600mA	600 mA	700mA
GPIO's	26	40	40
Boot Time	17 sec	17 sec	10 sec
Speed	700 MHZ	700 MHZ	900 MHZ
Processor	Single Core	Single Core	Quad Core
No of USB ports	2	4	4

The system when installed on a demo machine runs smooth for more than 24v continuously. The raspberry pi system is fully hardware optimized so that even if it runs

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24x7 there is no problem. There can be only some issues if there is no internet connectivity, the program is kept lightweight and we've handled the internet connectivity exception, so that the program does not hang or automatically stop after such exception, rather it skips the exception and tries to POST the data again on the internet. Whenever there is connectivity, the data posting starts again. There are though some significant feature changes observed with different hardware configurations of raspberry pi.

There are different sensors which we are using to accept input to raspberry pi which are limit switch, proximity sensors, and sometimes push buttons. Each of these sensors does include some of their own de-bounce in the system as shown below input comparison table-

Sensor type	Allowed Voltage	Actuation	Denounce	Response time
Limit switch	12v	Automatic	High	1 sec
Snitcher	24v	Automatic	High	1 sec
Paddle switch	24v	Manual	High	2 sec
Pusher	24v	Automatic	Medium	1 sec
Sensor	24v	Automatic	Low	500 ms

IX. FUTURE SCOPE

The future of this system is very wide open. As the Internet of Things is just opening its arms, there are endless fields where the same system can be applicable without any significant modifications. Though the sensors that were used in this system were all digital inputs, we can also sensors with analog inputs by using a suitable A-D Converter. With the addition of a simple USB web camera, periodically, images can be taken and sent on the internet. E-mail sending is also possible easily on raspberry pi using the smtplib function present already. By combining all these features, this can be a complete production monitoring system or can be used as a building automation and control system. The applications are literally limitless. Wherever, data monitoring, remote sending and remote controlling is required, the same system is applicable directly with little modifications.
Thus, such a system can be readily implemented using a low cost computer like Raspberry Pi which can function like a complete computer. The said system can run for 24 hours a day 7 days a week continuously for satisfying the most demanding application also. With the latest advancements of technology and new boards coming every day, it apparent that all embedded applications and systems will be implemented as IoT application.

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