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RealNET – Internet of Things in everyday life using Raspberry Pi

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Abstract - *In recent times, the Internet of Things has garnered a lot of importance and is predicted to be more revolutionary than the introduction of computers or even the advent of the Internet. Internet of Things is set to affect the homes of people, their mobility, their neighborhood and their living forever.*

This article explores the applications which Internet of Things finds in everyday life. Raspberry Pi was chosen as the enabler to achieve the same. Raspberry Pi allowed customizing homes and surroundings so as to introduce Internet of Things to the current scenario. The modules in the project (which is named RealNET: Internet of Real Things) automate certain daily activities like acceptance of a courier, incorporate safety features such as notifying gas leaks and burglaries, implement a Smart Trash Can –which empties itself automatically when full and a Tweeting Plant – which waters itself when dry and simultaneously tweets its status. The project as a whole brings about safety and convenience in the lives of people. But more importantly, it is the data generated by the project over a period of time, which will be very useful. This data will help in identifying geography based patterns in safety hazards, burglaries and trash generation which would aid in bringing about necessary process and infrastructure changes.

Our project was implemented, it was fully tested and the performance was found satisfactory.

Key Words: **Home Automation, Internet of Things, Raspberry Pi, Smart City, Smart Home, RFID**

1. INTRODUCTION

1.1 Overview

The Internet of Things (IoT) is an environment in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. [1]Over the next decade, the Internet of Things is poised to change the way we go about our daily lives with projections of over [2] 50 billion connected devices by 2020, compared to the 18 billion devices today. [3]

GitHub Link: https://github.com/akshay-iyer/RealNET

RealNET comprises of 5 system modules:

1. Couriers Automated
2. Smart Plant
3. Door Open Alert
4. Gas Leak Alert
5. Smart Trash

With the rise of e-commerce, the number of couriers and home deliveries have been increasing. But a lot of times, we miss important parcels and deliveries due to various reasons. It would become very convenient if our homes start authenticating and accepting couriers in our absence as it would save us from all the trouble involved in recovering the missed delivery. Couriers Automated is a module in RealNET which satisfactorily performs this task.

There are a lot of times when there isn't anybody at home or there are times when we go on a vacation. During all such times we leave our house and all our precious belongings within, unattended. The concept of the doors of our homes or those of the lockers in the banks, etc. being smart enough to communicate with us whenever they are opened is very unique and will go a long way in protecting thefts. This is the motivation behind the Door Open Alert module which notifies the owner whenever the door, which they choose, is opened.

Internet of Things can be effectively used to save people from potential threats like in the case of a gas leakage and can be used to very easily notify the people, their neighbors and the related rescue officials. Gas Leak Alert is a system module aimed at providing safety to householders and factory workers by lessening the impact of a gas leak.

Social media usage has increased over the past few years and is becoming increasingly common amongst people of all ages. However the objects around us are not yet pulled into this web of social media. Smart Plant is a module, which introduces the plants around us to the world of Twitter. People who are very particular about their plants' health no longer need to worry when they can't directly monitor them The Smart Plant system will take care of the plant autonomously and the plant will post its well-being on Twitter.

In this age of smart phones, smart devices and smart cars, our project aims at making the dumb trash-cans smart. Once a trash-can gets full, it will automatically go to the community

bin and empty itself in it. Once the community bin gets full, it will notify the local authorities to empty it. This would not just be a novelty but would go a long way in improving the aesthetic sense and hygiene of the place and help preventing diseases due to unhealthy surroundings.

The central controller used in the project is Raspberry Pi and it communicates with each of these systems wirelessly via RF433 (radio frequency) transmitter-receiver pair. A single python script runs on Raspberry Pi and manages all the modules. Raspberry Pi has been chosen as the processing unit for the system because of its user friendly features and economic benefits.

The entire system is very compact, robust and easily scalable. Raspberry Pi is connected to the internet via a laptop which is also used as a display (however the laptop could be avoided and a WiFi module could be used for internet connectivity).

1.2 Advantages

- RealNET is an affordable system, which results in convenience, safety and leads to better quality of life
- Each module is portable and independent of the others. This makes scaling very easy as modules can be smoothly added into /removed from the RealNET system
- It performs satisfactorily even on low internet speeds which is an essential factor for a country like India
- RealNET system modules find applications in a lot of places like homes, industries, nurseries, and smart city initiatives, etc.

2. IMPLEMENTED SYSTEM MODULES

2.1 Couriers Automated:

2.1.1 Description:

Couriers Automated was developed with the aim of resolving the issue of missed couriers with the help of Internet of Things. We miss an important and urgent parcel on multiple occasions, as we are not present at the time of its delivery. Our absence results in multiple visits and varying degrees of trouble to get the parcel back depending on the delivery firm.

Thus Couriers Automated solves this issue of missed delivery by enabling the RealNET system to accept the parcel on behalf of the house owner. The system detects a delivery, authenticates it and only then accepts it. It further notifies the owner of the accepted delivery.

2.1.2 Implementation Setup

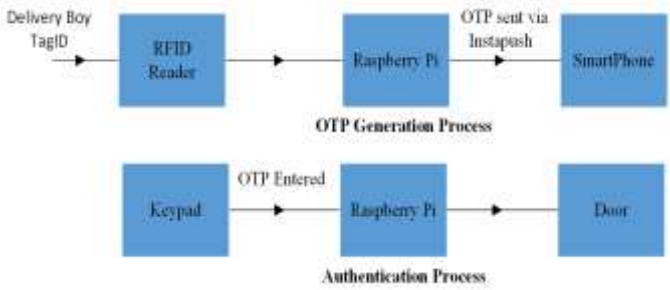

Fig-1: Block Diagram: Couriers Automated

The courier delivery boy scans his authorized Radio Frequency Identification (RFID) tag at the125 KHz RFID reader (EM18) outside the door. Raspberry Pi in return generates a One Time Password (OTP) – a 4 digit number – using python code. Raspberry Pi then pushes the OTP to the Instapush Server. Instapush provides a service to send push notifications to Android and iOS phones. The courier boy receives the OTP on his smartphone as a notification via the Instapush app only if he is signed in the correct account. The boy has to enter the OTP into the numeric keypad present outside the door.

Raspberry Pi verifies the correctness of the OTP and only then opens the slit in the door for 15 seconds and accepts the courier. The opening of the door is enabled by L293d, a 16 pin motor driver connected to the motors of the slit. The delivery boy is allowed 3 attempts to enter the OTP correctly. The OTP adds another layer of security such that even if the Identification card falls in wrong hands, the slit won't open unless the correct OTP is entered.

The entire process is supported by a pre-recorded voice output programmed for all possible outcomes. The voice output helps the courier boy to know when to enter the OTP, whether he entered the OTP correctly and the number of remaining attempts.

It then notifies the owner of the house via Instapush that the courier has been received.

2.1.3 Results

Fig-2: Slit in the door for courier initially closed

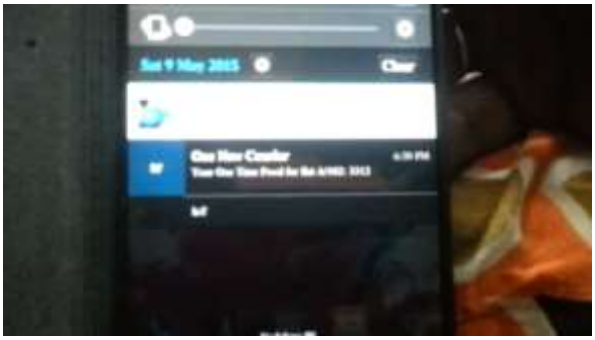

Fig-3: Courier OTP received as notification on smartphone

Fig-4: Slit in the door opens after right OTP is entered

Thus Couriers Automated very satisfactorily solves the troublesome issue of missed couriers. An extra layer of security is ensured by the verification of the OTP. The process is made simpler for the delivery boy by the voice assistance present and it also adds a human touch to the entire process.

2.2 Smart Plant

2.2.1 Description

Smart Plant is a system which augments the natural capabilities of a plant and adds the ability to water itself when needed and post its status on Twitter. The current scenario in everyday homes and nurseries requires some or complete manual supervision to water the plants. While this is fine as long as there is someone to do it every day, it becomes an issue when the members of the house or the caretakers of the nursery have gone for a vacation or are away for several days.

Smart Plant enables the plant to water itself on its own without any supervision and in addition to has the feature of keeping the owners updated of its well-being using Internet as the medium. The plant is now a part of the fabric of Twitter with its own account, followers and tweets.

2.2.2 Implementation Setup]

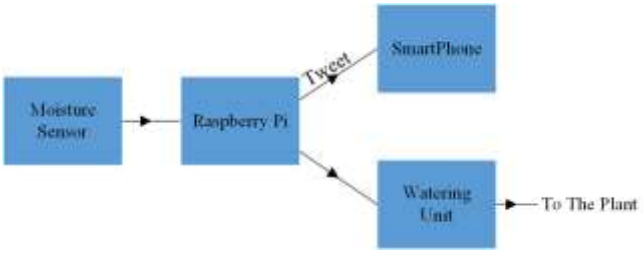

Fig-5: Block diagram – Smart Plant

Smart Plant employs a moisture sensor- called the Soil Humidity Moisture Detection Sensor Module to measure the moisture content of the soil of the plant, a water pump along with Atmega 8 and L293d motor driver to water the plant, RF433- an RF transmitter/receiver pair for wireless communication with Raspberry Pi, all powered at 3.3V.

The moisture sensor can function both in analog and digital modes. In the analog mode, we can calibrate the output voltage as per the moisture content whereas in the digital mode, it produces a 3.3V (high) output when the soil is dry and produces a 0V (low) output for a wet soil. We used the digital mode for proving the concept but analog mode can be used if we require amount of watering to vary according to the level of moisture

Considering the case of the soil being dry, the moisture sensor produced a 3.3V output on detecting that the soil of the plant is dry. This information is appended with the unique ID of the Smart Plant system by HT12E encoder and transmitted wirelessly via RF433 transmitter. The RF433 receiver and HT12D decoder combination at Raspberry Pi helps it to understand the condition of the plant. The python code in Raspberry Pi is integrated with Twython API to enable it to post to Twitter. The code then posts to Twitter on behalf of the plant 'I am currently running dry and need watering'. Raspberry Pi then signals the watering system consisting of Atmega8, L293d motor driver and the water pump to water the plant for a defined but programmable time period customized as per the plant.

The process is similar for a plant which is well watered, the differences being: Raspberry Pi does not signal Atmega 8 to water it and posts "I am well-watered, hale and hearty!" on Twitter. The code is programmed such that it continuously checks for the moisture content. It posts to Twitter as soon as the soil becomes dry whereas it posts at programmable, defined intervals when the soil is wet.

2.2.3 Results

Fig-6: Plant is initially dry (Sample of soil is chosen as a substitute for a full plant as we are concerned with the moisture content of the soil)

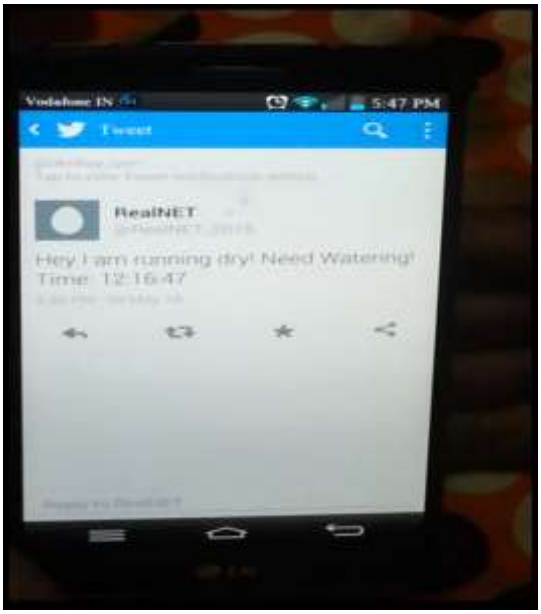

Fig-7: Plant tweeting its status of being dry

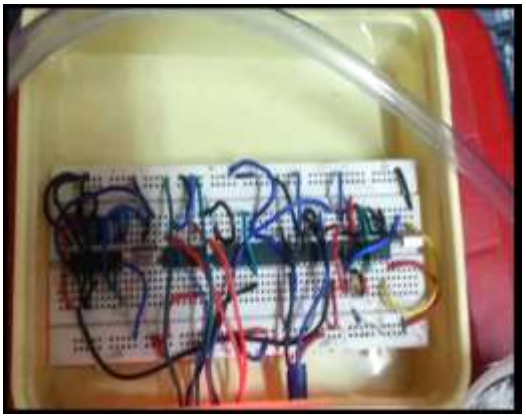

Fig-8: Setup for moisture detection and plant watering

Fig-9: Plant watering itself on its own

Thus Smart Plant enables the plant to water itself unsupervised and would go a long way in the preservation of plants while there is nobody to take care of it. Moreover it brings in the concept of a tweeting plant which is an innovative solution using Internet of Things.

2.3 Door Open Alert

2.3.1 Description:

Door Open Alert is a very important system which, as the name suggests, will alert the owner of the house/ shop if it detects if the designated door is opened. This system will always remain critical as it ensures safety.

2.3.2 Implementation Setup:

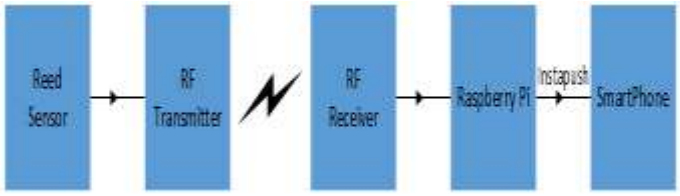

Fig-10: Block Diagram – Door Open Alert System

Door Open Alert system uses a magnetic reed switch placed at the top of the door. Whenever the door is opened, the circuit gets broken and this information is appended with the unique ID of the Door Open Alert system using the HT12E encoder and transmitted wirelessly using the RF433 transmitter. The decoder-receiver combination at Raspberry Pi helps it to receive the information of the door getting opened.

Raspberry Pi runs the part of the code responsible for pushing the 'Door Open!' alert to Instapush Server. The owner of the house hence receives an alert whenever the specific smart door of his house gets opened and may take the necessary action.

2.3.3 Results

Fig-11: Door gets slightly opened

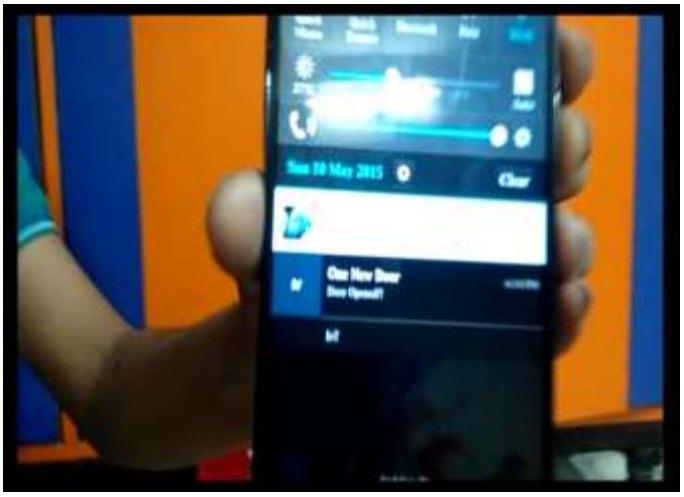

Fig-12: User gets notified of the security breach on his phone

Door Open Alert system thereby provides an efficient method to alert users whenever there is a possible security breach. This module will find wide-scale adoption in homes/ jewelry showrooms as well as expensive shops. Existing systems for intruder alerting have been implemented using GSM but RealNET makes use of internet making it cost effective as low speed internet is sufficient for message transmission using Instapush

2.4 Gas Leak Alert

2.4.1 Description

There have been numerous incidents in the past where lives and precious property have been lost due to unnoticed gas leaks. These gas leaks, if noticed at the very initial stages would have saved many precious lives and property. The situation is worse if there is no one present to notice when the leak occurs, since then it would not be detected and it could become a terrible disaster.

Detecting gas leaks as soon as they occur and informing the owners and the required authorities would be a life savior. The Gas Leak Alert system detects the slightest of the leaks and informs the owner and the authorities.

2.4.2 Implementation Setup

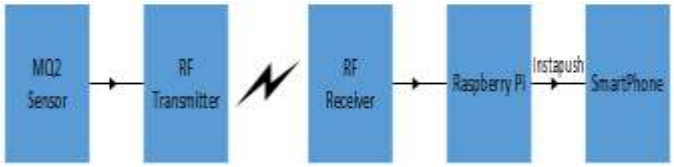

Fig-13: Block Diagram – Gas Leak Alert System

Gas Leak Alert uses a MQ2 Gas sensor along with HT12E encoder and RF433 transmitter to enable wireless communication with Raspberry Pi. Whenever a gas leak occurs (simulated using the gas from a cigarette lighter), the sensor produces an active low signal which is inverted using an inverter (7400 NOT gate). This information is appended with the unique ID of the Gas Leak Alert system using the HT12E encoder and sent wirelessly using the RF433 transmitter. The decoder-receiver combination at Raspberry Pi helps it to receive the information of the gas leak.

Raspberry Pi runs the part of the code responsible for pushing the 'Gas Leak!' alert to the Instapush Server. The owner of the house hence receives an alert whenever there is a gas leak in the house and may take the necessary action.

2.4.3 Results

Fig-14: Gas sensor to detect gas leak

Fig-15: Owner and the neighbors are alerted of the gas leak

Thus Gas Leak Alert is a potential life-saver and introduces an effective way to prevent or lessen the damage

due to a gas leak. There are not many existing systems to alert people of gas leaks and hence this module would very quickly experience large scale adoption. It is a compact and robust system and is easily portable due to the wireless communication capability. It can also be used effectively in factories where thousands of lives are at stake apart from costly machinery. At such places if the staff is informed of a leak before it turns into a mishap then timely and appropriate measures can be taken.

2.5 Smart Trash

2.5.1 Description

Smart Trash is a system which, as the name suggests, makes trash cans take intelligent decisions. Trash cans overflowing with litter is a common scenario which spoils the aesthetic sense of the place in addition to spreading diseases. Smart trash aims at solving this issue. The trash-can detects if it has become full and moves towards the community bin. A proximity sensor is placed on the trash-can so that it can avoid colliding with obstacles. The mechanical arm on the community bin empties the trash-can into itself and the trash-can retraces the path it took. Once the community bin becomes full, it notifies the local authorities using the push notification service provided by Instapush.

2.5.2 Implementation Setup

Fig-16: Block Diagram – Smart Trash

Smart Trash consists of a line following robot over which the trash can is placed, a mechanical arm on the community bin which will lift the trash can and various bump switches. The line following mechanism is carried out by a board containing an Atmega 16 microcontroller and IR sensors for path detection.

A bump switch is placed at the inner side of the lid of the trash-can which gets pressed when the trash-can gets full. This switch is connected to the Atmega 16 on the line-following robot, which thus receives information of the trash-can getting full. The line following robot then drives the trash can on the programmed path to the community bin. The proximity sensor is placed on the front of the trash-can which is an Infra-red (IR) transmitter-receiver pair. The IR transmitter continuously transmits IR rays, whenever any obstacle comes in front of the trash-can, the IR rays get reflected and fall on the receiver which gives a 5V signal to the micro-controller board which stops the robot till the obstacle moves away.

The switch is placed on the community bin gets pressed when the trash-can comes near enough. A mechanical arm situated at the community bin will lift the trash can and dump the trash in the former.

A bump switch is placed on the base of the line-following robot which gets pressed when the trash-can is placed on it again. The trash can (line-following robot) then retraces its path to its initial position.

Once the community bin becomes full, this information is appended with the unique ID of the Smart Trash system using the HT12E encoder and transmitted using the RF433 transmitter. The decoder-receiver combination at Raspberry Pi helps it to receive the information. Raspberry Pi runs the part of the code responsible for pushing the 'Trash-Can Full!' alert to Instapush Server. The local authorities hence receive an alert whenever the community bin gets full and may take the necessary action.

2.5.3 Results

Fig-17: Trash-can on a line following robot

Fig-18: Trash-can held by the arms (which are fitted on the community bin)

Smart Trash is an innovative system which is a necessity nowadays due to the increasing trouble caused due to excessive litter. Cities will become a lot cleaner when this system is installed. The small trash-cans placed outside parks, on the roads, etc. will detect when it is full and follow a pre-defined, non-intrusive path to the community bin. The community bin will be able to notify the authorities whenever

it becomes full, hence ensuring close to zero-litter spread and thus useful to be a very useful as well as innovative application of Internet of Things.

3. COMPARATIVE ANALYSIS

Table -1: Comparison between current scenario and RealNET

Application/ Use-case	Current Scenario	RealNET
Accepting couriers	• Manually accepted • Recovery is manual and painful • Wastes time and effort	• Acceptance is automated and with proper authorization checks • No missed courier hence no need of recovery • Saves time and effort
Watering of plants	• Requires human intervention • No way to remotely track the plant status	• Plant autonomously watering itself considerably removes human intervention • Status of the plant can be tracked from anywhere, where there is internet connectivity
Notifying burglaries	• Few upcoming automated systems • Use SMS as a way to notify events thereby increasing the cost involved	• Quickly and efficiently notifies the event via Internet thereby reducing the cost compared to SMS
Notifying gas leakages	• Very few automated systems • Notify events via SMS thereby increasing cost	• Quickly and efficiently notifies the event via Internet thereby reducing the cost compared to SMS
Emptying of trash-cans	• No tracking of amount of trash to prevent litter spread • No automation in this area of waste tracking and maintenance	• Trash-can can notify when it is close to getting full • Real-time intimation and collection of trash will minimize litter spread • Improves the aesthetic sense of the place by reducing litter around

4. CONCLUSION AND FUTURE WORK

4.1 Conclusion

Present paper provides a low cost, scalable as well as modular system involving Raspberry Pi which controls five independent modules. The Couriers Automated module provides an easy as well as secure way of enhancing and increasing the efficiency of the e-commerce and logistics industry. Smart Plant enables self-watering based on environmental conditions which can also be scaled to large nurseries increasing their efficiency. The Gas Leak alert and Door Open Alert module provides protection from impending disasters and security to our homes respectively. The Smart Trash module enables timely disposal of trash cans which will aid in making our environment clean. Apart from making the homes smart, this project also aids in development of smart cities as the future development plans of cities could incorporate modules like Smart Trash and Gas Leakage Alert in their development plans and these modules can also be easily integrated into the current city plan.

Thus successful implementation of this project shows the utility of Internet of Things in everyday life and how it impacts the homes, cities and the lives of people.

4.1 Future Work

The data generated from this system can help the government make important decisions. For example, the gas leakage alert module will help the government identify areas in which occurrences of gas leak is high, which may aid in identifying fraudulent distributors. Similarly door open alert module can help identify places where robbery attempts are high so as to increase police protection.

The project can be upgraded to include energy consumption monitoring, healthcare, agriculture etc. and the data generated can be used to plan future decisions pertaining to the society.

As also the current smart homes can get more interactive rather than just properly execute commands issued by the user. Natural language processing along with Internet of Things can be explored to fill in the deficiency of engagement between homes and users. Making the system more aware of the surroundings will make the experience of a smart home even more seamless.

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BIOGRAPHIES

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