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IMPLEMENTATION OF PRIVATE GSM NETWORK FOR DISASTER MANAGEMENT AND DETECTION OF HAZARDOUS GASES IN SEWAGES AND MANHOLES

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ABSTRACT - *In the twenty-first century, communication has become as important as oxygen for the survival of humankind. The communication is an essential part of our day to day life, however during the advent of any natural disaster such as an earthquake, Tsunami or floods the conventional base transceiver station (BTS) suffers from a sudden breakdown and hence loses its wireless connectivity resulting in a communication loss leading to miserable scenarios. The aim of the project is to establish a low powered, highly dynamic, cost-efficient and compact sized small-scale private GSM Network. The BTS system has the following components it requires a host processor to run the telephony engine for which a raspberry pi model 3B/2B would be highly ideal. The Telephony Engine which is being used here is the YATE Software which stands for Yet Another Telephony Engine, which is an open source software used to interface with the various layers of GSM. The system also consists of a Software Defined Radio which acts as the transceiver. The project is not only aimed at building such a network alone it also involves the detection of hazardous methane gas in the sewage and the man-holes with the help of a conventional methane gas sensor such as MQ4 and constantly transmitting the methane levels via our network. The BTS System using such above components is able to create a network and place a call to a distance of about 150 meters without any power amplifier/antennas and constantly detects the values of methane and provides a detailed graphical report.*

1. INTRODUCTION

The main aim of the project is to create a network in which communication can be possible even during disaster time and which can be easily transported to disaster-hit areas to provide a communication to a range of at least 150 meters in order to provide communication between the rescue team and the victim.

The core of the project is the USRP, an abbreviation for Universal Software Radio Peripheral, the software defined radio is used as a transceiver. There is a variety of SDR available depending upon the cost and the range, but for our project having the cost in mind, we use the "NUAND BLADE RF X-40" which is a low-cost SDR costing around 57,000 INR.

2. A BRIEF OVERVIEW OF THE BTS SYSTEM

The BTS System consists of the following components namely:

RASPBERRY PI which acts as a Linux server and also as the host processor to drive the commands of the YATE

It also consists of an SDR which acts as a transceiver and conventional power amplifiers and antennas in order to enhance the range of communication.

2.1 Software Defined Radio

The Advancements in technology have significantly changed the concepts of software radio techniques .with the advent of emerging digital signal processing techniques the conventional hardware parameters such as the amplifiers, mixers, and filters can be easily implemented as a software. The origins of the software defined radio date back to late 1980's initially used for the military purposes but due to the reduced cost, it's made easily available to research enthusiasts. The Nuand's Blade RF X-40 is a low-cost SDR which has the following specifications provided by the manufacturer

FREQUENCY RANGE 300MHZ-3.8GHZ

FPGA Altera Cyclone IV 40 KLE

Blade RF can be configured on both Windows and Linux platforms, however, configuring using Linux is highly recommendable. A constant update is being provided by the manufacturer which can be achieved by using a command bladeRF-client.

2.2 Raspberry Pi

The Raspberry Pi is a small credit card sized single board computer. The Processor uses the ARM Processor which stands for the advanced risk machine the processor at the heart of the Raspberry Pi is a Broadcom BCM2835 System on chip multimedia processor and also includes USB 2.0 peripherals, one Ethernet Port and a Wireless adapter-Wi-Fi Bluetooth.

A comparative analysis of the different versions of the pi model are listed below:

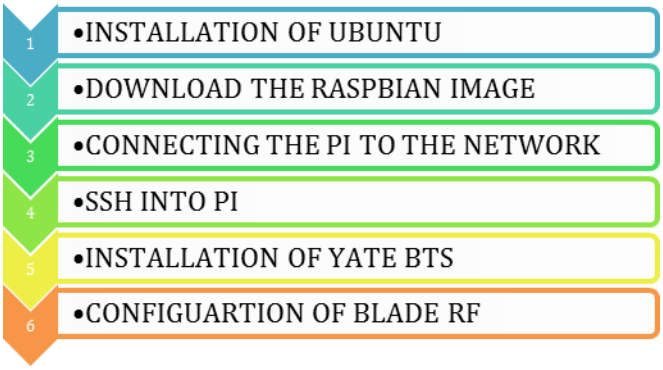
Specs	Pi 3 Model B	Pi 2 Model B
SoC	BCM 2837	BCM 2836
CPU	Quad Cortex A53 @ 1.2GHz	Quad Cortex A7 @ 900 MHz
RAM	1GB SDRAM	1GB SDRAM
Wireless	802.11n / Bluetooth 4.0	None

2.3 YATE AND YATE BTS

YATE-BTS is the software implementation of the GSM Radio network. YATE is one of the commonly used telephony engines which stands for Yet Another Telephony Engine is an open source communication which supports a routing engine for voice, data, video and instant messaging features. It is an extensible GPL Licensed PBX. Yate BTS is generally written the C++ but also can be written in other programming and scripting languages such as the PHP, Perl etc.

3 IMPLEMENTATION OF THE PRIVATE GSM NETWORK

With the above components and requirements, we are able to build a network to a radius of around 150 metres and place a call and send messages without any distortion. The system is a full duplex and works on the back of 2.5G. The process flow is as follows, it begins with the configuration of Raspberry Pi with a suitable OS. The preferred Operating System is UBUNTU 16.04 LTS which is a Linux kernel. The operating system for the Raspberry Pi is downloaded and it is etched in the memory card of the Pi. The next step is to include the SSH for security reasons and for the remote login. Now with all the above prerequisites in hand, we can boot the SDR with the help of the Raspberry Pi. The SDR as said above works on the software of YATE Technology and hence, the YATE software is dumped into the SDR via the Raspberry Pi device. The Process flow is as follows,



4. METHODOLOGY

The system works on Global System for Mobile Communication Railways band, for testing purpose. All of the GSM Bands are licensed and hence the testing must be done only under a faraday cage. The GSM-R Band is chosen in order to avoid interference with the existing carriers being used for the commercial purposes. The GSM-R band in India works under the range of 900 MHZ Frequency with the following specifications

Uplink: 907.8–909.4 MHz

Downlink: 952.8–954.4 MHz

The following values are to be dumped in the NIB Web Interface

Radio.Band=900

Radio.C0=91

Identity.MCC=YOUR_COUNTRY_MCC(001)
Identity.MNC=YOUR_OPERATOR_MNC(01)
Identity.ShortName=yateBTS
Radio.PowerManager.MaxAttenDB=10

Radio.PowerManager.MinAttenDB=10

Any Mobile Phone can be connected to our network by accessing their settings option and by manually connecting to our network, disabling the automatic option in the network preference is highly preferred which would tune to 2.5G automatically, since our network is not the home network of the SIM Card it will consider it to be as a roaming, moreover the modern day phone's which we are using today are built with the ability to connect automatically to faster networks such as 3G and 4G, during Resets.

4.1 Range Testing

The Range Testing Which is done with the help of suitable Antenna's and Amplifiers have resulted in the following Tabulation. By using a small Antenna, there was distortion after 150 metres. Exceeding which the phone was expected to be in a LOS Component with the Antenna.

When a Big Antenna was used, the coverage up to 200 metres has no issues in two way communication. However, Beyond 200 m the phone is expected to be in LOS with respect to the antenna.

Setup	Radio RSSI Target (dBm)	Max. Call distance	Distance up to which call quality is good	RSSI values (dBm)
Small Antenna at Tx, Rx	-26	150m	120m	-105 at 150m -98 at 120m
Big Antenna at Tx	-26	330m	250m	-95 at 250m -105 at 330m
Big Antenna at Rx	-26	150m	150m	-105 at 150m

4.2 Detection of Methane gas

The nature of the Gas Detector is to sense the level of hazardous gas in that area, the origin of the gas detector's dates back to 1815 during the industrial era, invented by Sir Humphry Davy to detect the presence of methane gas in the coal mines. Even today coal miners at certain parts of the rural area use a canary bird, a canary bird is highly sensitive to Methane gas, depending upon the level of impact the methane gas had on the canary bird the miners have an idea about the level of Methane gas present and plan to abort the entry into the mines. Thanks to the Development of Science and Technology. We have a highly safe and cost-efficient Semiconductor based Gas Sensors which are available in the form of MQ Sensors. MQ sensors are special sensors designed to have sensitivity to detect some gas like LPG, CO, Propane, butane etc.

4.3 Methane gas and its impact on environment

The Methane is a colorless, odorless, the highly flammable gas being one of the major constituents of the Natural gas, is emitted as a result of both natural and manmade sources, represented by the Molecular Formula CH4. They are released from coal deposits during mining, and also during the decomposition of agricultural and animal wastes which is found mainly in the Sewage and the Man-holes. Everyone is exposed to Methane, but the level varies, the release of methane is high in coal fields and sewage, as a result of the inhalation of methane gas leads to Death. Methane Gas is itself not a killer gas, however, it displaces the level of oxygen we need to inhale for survival and converts the oxygen into as the highly fatal Carbon-monoxide which leads to lack of oxygen and it leads to Death. Reports say that more than 1000 sewage cleaners have died in the last two years due to the release of a high level of methane gas in the sewage that has been left unnoticed.

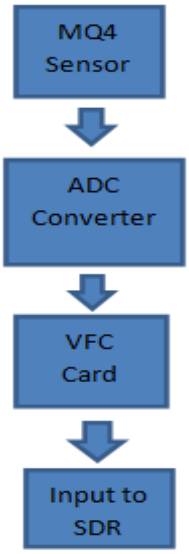
4.4 Detection using MQ4 gas sensor

The Detection of Methane Gas can be done with the help of a semiconductor-based Gas Sensor namely the MQ4 sensor, there is a variety of a series of MQ Gas Sensors which are used to detect the other hazardous gases such as propane carbon mono-oxide etc. The list of MQ sensors and their comparative study has been listed below:

Sensor	Detects
MQ-2	Methane, Butane, LPG, smoke
MQ-3	Alcohol, Ethanol, smoke
MQ-4	Methane, CNG Gas
MQ-5	Natural gas, LPG
MQ-6	LPG, butane gas
MQ-7	Carbon Monoxide
MQ-8	Hydrogen Gas

4.5 Transmitting via private network

The MQ sensor is controlled with the help of an Arduino controller. The value which we get via the controller is being converted into a voltage with the help of an ADC converter. The Voltage value which thus arrived is converted into a frequency with the help of a voltage to frequency converter. The Frequency is being provided as an input to our private network and constantly being monitored for any sudden increase in the rise of methane level. When such a phenomenon is founded, a warning alert is sent to all the users connected to our network.



5. CONCLUSION

Based on the above configuration and the on the readings, the mobile phone can remain connected to our network to a distance of about 150 metres, this doesn't imply that calls can't be made after 150 metres, calls can be made even beyond 150 metres with the help of range improving Antenna's supplied with the power amplifiers. With the inclusion of Power

Amplifiers a two-way communication can be extended to a distance more than 350 metres, but however after which the RSSI falls down suddenly making the device disconnected from the network.

The conclusion that has been arrived is as follows:

Network Coverage

1 Without any Antenna and power Amplifier: 150m

2 With the Big Antenna and power Amplifier: 350m

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