Contending Adversity in Urban WSN deployment a sensor based approach.

A Project Thesis Submitted in fulfillment of the requirements for the degree of

Bachelor of Technology
in
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Abstract

The ability of a Wireless Sensor Network (WSN) to monitor and capture real time environmental data invites its use in several application domains ranging from the military to agriculture. Consequently there is a lot of academic and industrial research happening in this field.Low power Wireless sensor networks(WSN) play a very important role in environment monitoring.Communication between low power sensors would be adversely effected by the presence of solid obstacles in the midway of the communication path.Obstruction of data to be communicated would happen too often, in outdoor environments, specially between nodes which are placed on the opposite sides of the roads,which would in turn lead to wastage of huge amount of power due to re-transmission of packets for a considerable amount of time.Work is done on the low power WSN that focus on resolving the cross technology interference issues to mitigate interference from other forms of transmission like wifi ,the communication hazard which arrives from temporary blocking of mobile objects like vehicles is not given much importance.In this report I would like to list the consequences of such obstructions and develop novel ways for tackling the problem in such a way that substantial improvement can be achieved.

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Contents

Chapter 1

INTRODUCTION

1.1 Introduction to Sensor Networks

A sensor is a device that has the capability to detect and respond to some type of input from the physical environment.The input considered can be light, heat, motion,moisture,or any of the many physical environment parameters available.The output is generally a signal that has to be converted into human readable form either at the location of the sensor or can be transmitted to other locations for further processing.

This sensors have real life applications ,for example ;In a mercury based glass thermometer, the input is temperature.The liquid which is present inside,expands and contracts in response,causing the level on the thermometer to be higher or lower which is reflected on the marked gauge and its human readable.

An oxygen sensor in a cars emission control system detects the ration of gasoline to oxygen ,generally through a chemical reaction that generates voltage.A computer present in the engine reads the voltage and if its found that the mixture is not optimal,it readjusts the balance.

Motion sensors in various systems including home security lights, automatic doors and bathroom fixtures typically send out some type of energy, such as microwaves, ultrasonic waves or light beams and detect when the flow of energy is interrupted by something entering its path.

A photo sensor detects the presence of any of these like visible light,infrared rays, ultraviolet rays.

1.2 Its development in recent years

With the accelerated development of internet of things in the recent years,wireless sensor networks have been getting recognition and is gaining importance with an increased momentum in the drastic advancement of information and communication technologies in the recent years, and have been connected and integrated with the Internet in vast industrial applications.But as it is known that most wireless sensor devices are resource constrained and operate on batteries, the communication overhead and power consumption are therefore important issues for WSNs design.
Research on Wireless Sensor Networks (WSNs) have attracted a lot of attention in this current time, and this attention is rising because WSNs promise to be an enabling technology of the future owing to the fact that processors, sensors and wireless radios are becoming extremely small and inexpensive these days. In the near future, the world we live in will be populated by objects that are globally networked such that physical environments are enriched by computational power. A WSN is a network consisting of a large number of wireless radio nodes equipped with sensing devices and are densely distributed for specific applications.Each node is equipped with a transceiver to communicate with another node within its communication radio range.

With the rapid growth in the industrialization of the country, there has also been an increasing responsibility in sensing and protecting the environment for the well being of all. Some novel methods must be proposed for the sake of monitoring the concentration of gases such as CO2, H2S, sound pollution, temperature etc., in the environment.

Wireless Sensor networks, in the recent times, have been one of the most significant technologies. It has its applications in vast areas ,which have been ranging not only from medical to surveillance but also from military to trafficking. Sensor Networks have also developed vastly in the fields of environment monitoring in the recent years.

1.3 Future of sensor networks

Some years ago there used to be talks about things which seamed almost impossible in the near future, a dream in where people can access to services and information into small devices and chips in which we can accesses the information, make calls and watch videos. That far future is not so far, actually the advance of technology involves a more powerful hardware which is converting day to day with a smaller devices with a bigger resources.With the development of the technology,the upcoming development of electronics allows that these devices could be integrated into smart networks and these networks are called Wireless Sensor Networks . These wireless sensor networks do not need physical connections, they use various communication systems such as ZigBEE, WiFi or Bluetooth. These characteristic let emerge the so called Internet of Things (IoT),where everyday objects had network connectivity available, allowing them to send and receive data. Since these days, technology has been showing an exponential advance and hence it has become possible to find devices that permit sophisticated observations in real time. These systems allow to store huge amounts of data, that is collected from devices which are integrated in the concept of Internet of things. This analysis of this big data will be helpful in treatment and finding related solutions in specific areas such as public administration, environment, urban services, etc.

1.4 Contending adversity and need for WSN deployment

The environment we stay in has a large influence among the people and their livelihood hence environmental care has become one of the biggest concerns for almost every country specially in the last decades,but now hopefully current situation is changing towards more environmentally friendly situations. Its highly impossible to monitor these parameters without sensor networks as there must be continuous reception of data and no or very less human intervention

Along with air quality,there are many environmental measures like pollution,humidity,noise,level of carbon dioxide,nitrogen dioxide etc which should be monitored to maintain the equilibrium between healthy environment and human development.For the monitoring of these parameters wireless sensor networks need to be deployed so that we can predetermine the adversities and take respective measures to prevent them.

Chapter 2

MOTIVATION

2.1 Works done in the past

Over the last few decades, we witnessed significant progress in wireless communication. This has led to rapid emergence of heterogeneous wireless technologies that share the RF spectrum in an un-coordinated way. This problem gets significant for technologies operating in the lightly regulated, yet crowded ISM bands.
Hence we use Zig bee channel to avoid Wifi interference .We use mobile wifi analyzer to find such free channel. This problem can be addressed by properly choosing the appropriate Zig bee channel.

Wifi and zigbee both coexist together in the 2.4Ghz band,existing in the exactly same frequency space.when we deploy both of them in the same environment careful planning must be done to see that both of them dont interfere.Operating zigbee and wifi together make them interfere with each other and mostly zigbee will take the hit.

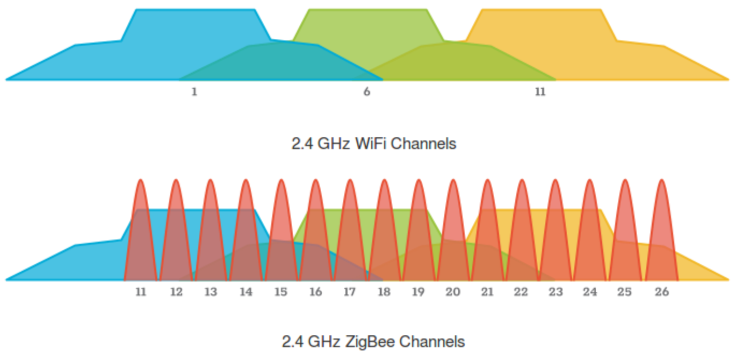


Figure 2.1 [zigbee and wifi channels interference]

If wifi network is on the same channel of the zigbee network then the wifi network is likely to interfere with the zigbee network.

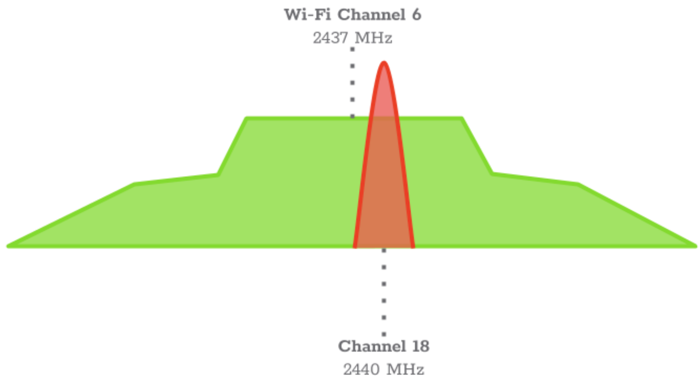


Figure 2.2 [zigbee and wifi channels interference]

There would be unnecessary loss in the data packets if the low power rf signals interfere with the wifi signals, hence care must be taken before hand while selecting the area of the experiment and check(using wifi analyzer) the channel which doesn't interfere with the wifi channels.

2.2 Shortcomings and current project

While studies have been going on about low power wireless sensor networks ,most of them focusing on resolving the cross technology interference issues to avoid interference of the RF signals from other forms of transmission like WiFi, the communication hazard or problem originating from temporal blockage due to mobile objects such as vehicles is not given much importance. When sensor motes mounted on the two opposite sides of the road have to communicate ,vehicles present on the road obstruct the communication.This gets more adverse in urban areas where vehicles obstruction happens more frequently.This movement of vehicles may be due to many reasons such as changes in the traffic signals, congestion or stopping to pickup/drop passengers.

Figure 2.3

IN this project ,we first motivate the problem using actual field measurements to demonstrate the effect of vehicular traffic on link qualities in WSN urban deployment.

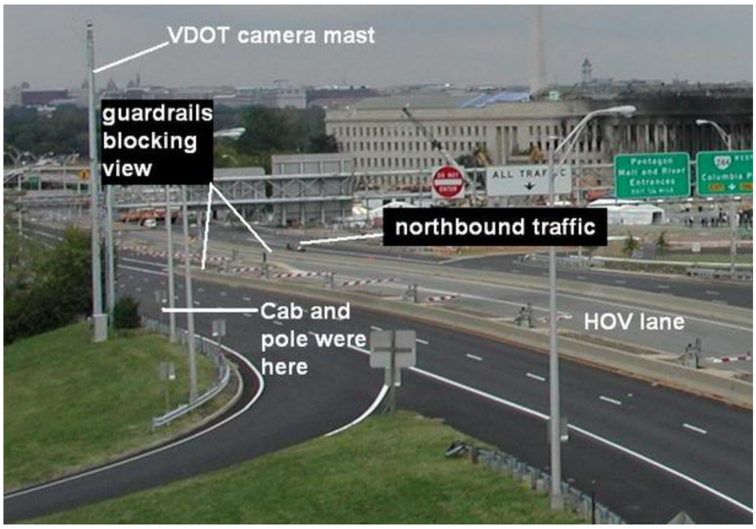


Figure 2.4[General Scenario]

Chapter 3

URBAN WSN DEPLOYMENT

3.1 Project Scope

Compared to wifi signals , the low power RF signals emitted by these motes are also too weak for not being absorbed or highly weakened due to presence of obstacles which results in frequent and constant packet loss.

The usual way of handling packet loss is to first detect the loss through missing acknowledgement (ACK) packet within a certain time and then re-transmitting the packet again. But due to the obstacle, packet loss rate will remain high. Persistent re-transmission over a bad link results in wasting of battery power.

Instead of sending frequent data packets and ACK's which lead to power loss of the battery it is rather better to stop the communication when there is contention.

Now a new challenge pops up of when the communication should be stopped. The bad times when there is high contention should be detected and using that information, we should be able to decide when to carry communication and when not to. This can also be done using the RF signals but it would be expensive to carry on the measurements by RF signals alone. Hence an energy efficient mechanism can thus be developed by exploiting low power sensing to turn on/off the radio at the appropriate time.

3.2 Project Objective

The main objective of the Project is to use different low power solutions to detect contention and switch off the communication between nodes when traffic is detected. RF can be also used for detection, but will consume a lot of power. In this work we use a novel approach to detect the time periods that are not suitable for low power RF communication. Our main target was to employ something else other than RF that can save much energy. It can be observed that the passing of vehicles in a road are often accompanied by a highly and noisy sound. This motivates us to use the microphone. On the other hand, passive infrared sensors (PIR) has been always a standard sensing equipment to detect the presence of moving objects that can emit infrared radiations. Vehicles also fall in this category. Therefore, in this work we experiment with three specific sensors (a) microphone, i.e., sound sensor, and (b) PIR - i.e., passive infrared sensor. (c)RSSI - i.e.,receiver signal strength indicator

Moreover these sensors consume much low power than RF, which is one of the prime reasons behind their use in this work. Apart from this we have sender and receiver mote which sense whether there is a packet loss or not,we have a controller mote which synchronizes all the other motes.

3.3 Project Strategy

Its clear that whenever a vehicle passes in between the motes there is a packet loss happening.Whenever there is packet loss its not suggestible to continue the rf transmissions due to huge power loss. First we must have an idea of how much time the packet loss is happening. We can broadly divide the vehicles passing between the motes into 3 major types. type 1(small vehicles like bike and cars) type 2(medium vehicles like buses and trucks) type 3(heavy vehicles like double Decker buses,dumpers)

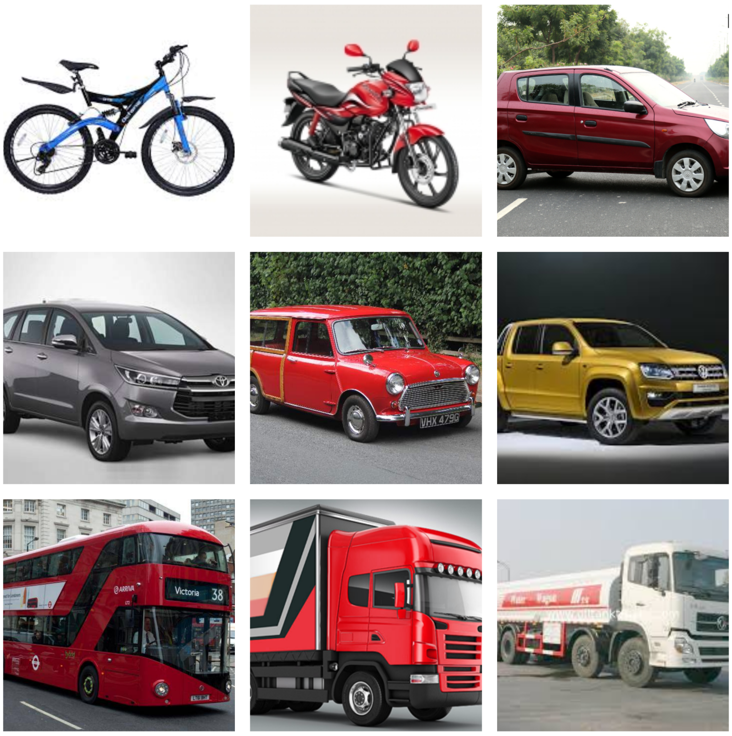


Figure 3.1[Different type of vehicles]

We select a single-lane road with relative less busy traffic for our experiment in the early stages. TelosB motes and contiki OS are used for all the experiments. We install 2 set of motes on the two sides of the road.One side is designated as the sender side while the other is considered to be the receiver side. In the sender side,the sender mote(transmitter mote) continuously transmits an rf packet every 50ms.In the receiver side,the mote tries to receive the packet and record the reception status of the packet. To understand the reason for the packet loss,we do a little modification in the contiki code to detect whether the packet is completely lost or whether it was due to CRC mismatch.Hence we get a '2' when the transmission is perfect, a '1' when there is CRC mismatch and a '0' when the packet is lost completely.

1	91	2	2	2	2	2	2	2	2	2	2
1	92	2	2	0	0	0	0	0	0	2	0
1	93	2	2	0	0	0	0	0	1	1	0
1	94	2	0	0	0	0	2	2	2	0	0
1	96	1	2	2	1	1	0	0	0	0	2
1	97	0	1	2	1	2	1	1	2	2	2
1	98	2	2	2	2	2	2	2	2	2	2
1	99	2	2	2	2	2	2	2	2	2	2
1	100	2	2	2	2	2	2	2	2	2	2

Figure 3.2[received data]

In order to better understand the scenario we also employed a separate mote which is RSSI logger.Its a Receiver signal strength indicator which indicates the strength of the signal received to log the per-byte RSSI values during the reception of the packets in the receiver side. Finally in order to get a rough idea of the timings of the passage of the vehicle in between the sensors we have another sensor called vehicle logger where one manually enters the type of the vehicle whenever one passes by,as all the motes are synchronized by the controller mote the timings would be automatically saved in the vehicle logger mote too.

Figure 3.3

We should connect all the motes to the laptops for data logging purpose.the vehicle logger mote is manually operated from the attached laptop.The operator in the sender side presses a certain key in the laptop to log in the vehicle

logger mote when he/she observes a vehicle of a particular category passing through.
All sorts of measurements in the experiment are done periodically and at the same time in different motes. Hence time synchronization is a very crucial issue here. We use a simple RF packet reception based single-hop time synchronization for all the motes including the vehicle logger. An iteration of the experiment is divided into a measurement phase and a synchronization phase. Before starting every measurement phase the motes are time synchronized in the synchronization phase by a separate mote (referred to as time-synchronizing mote in figure 2) which transmits 100 RF packets each of size 5 byte. Reception of at least one of these 100 packets by a mote results in a time synchronization among all the motes. To eliminate the possibility of packet drop in our experiment due to WiFi interference, we select a ZigBee channel that is free from any WiFi interference (e.g., channel 26 inside the university campus). We use a mobile app WiFi analyzer to find such a free channel. In our case ZigBee channel 20 was used. We carry out the experiment under different transmission power and different packet sizes. The distance between the sender and the receiver was fixed at about 20 feet. Note that both sender and receiver sides show 4 motes each.
Whenever there is an obstacle,packet loss happens.If transmission is done at this time there is a very high chance that the packets are lost and retransmission should happen which results in loss of power. Hence we have to detect the bad time periods. This can be done in different ways. The major way we can detect whether there is a obstacle or not is through sound.

3.3.1 Sound Sensor

The congestion and hence the frequent packet loss happens only when there is high traffic. Hence when the traffic is high we can off our communication process.
The presence of traffic can be defined by the sound produced by the vehicles (Which is the general property of the vehicles). We must also note that the presence of small vehicles like motor cycles and small cars does not disturb the communication between nodes to a major extent that the heavy vehicles such as double dickers or heavy trucks do. So the bad time period when the communication should be stopped depends also upon the type of the vehicles.which are Type 1 vehicles (Motor cycles, small cars (Light weight vehicles)) ,Type 2 vehicles(big cars, mini buses, vans, etc) and Type 3 vehicles (double dickers, heavy lorries, etc)
Hence Sound sensors are used to sense the traffic, and accordingly we can decide when to shut down the communication of nodes but it has some prob-

lems.
First we need to know how the sound varies when disturbances are created. 70 sound values are received for each iteration in our experiment and their variance is taken as a measure of sound.
To know the characteristics of sound different experimentation's are done and variation of sound with disturbances created are noticed.

This is a graph when there is no sound produced in the surroundings.

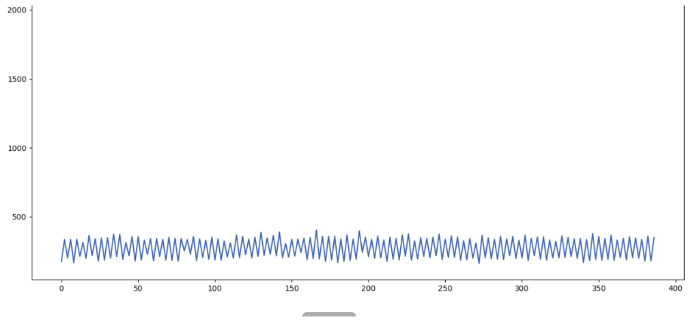


Figure 3.4[standard deviation of sound(y axis) vs time(x axis)]

The figure below shows the standard deviation of sound produced for clap(1st 3 disturbances) and shout(last high disturbance)

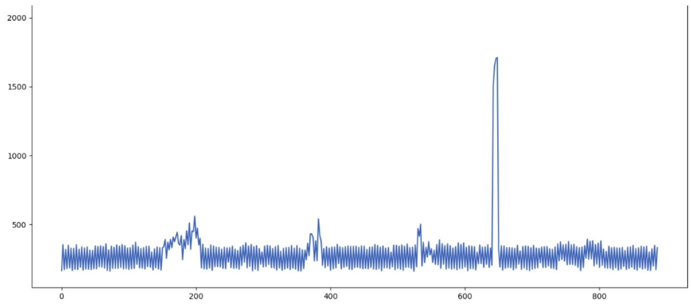


Figure 3.5[standard deviation of sound(y axis) vs time(x axis)]
when there is clap sound and shouting sounds produced in the surroundings

Sound values when there is a vehicle passing by:

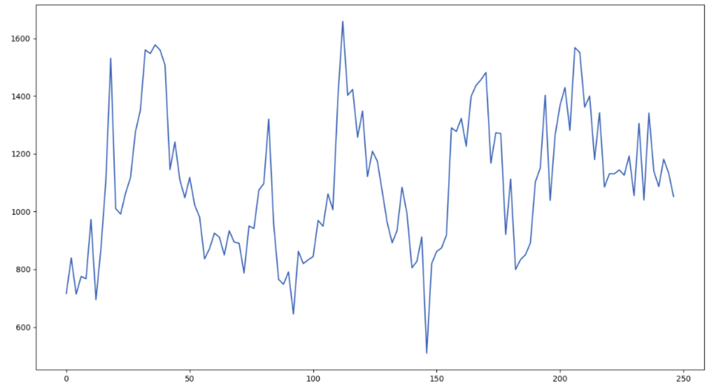


Figure 3.6[standard deviation of sound(y axis) vs time(x axis)]

In this figure we can clearly see that there is an increase in the standard deviation of sound at regular intervals of time that is when a vehicle passes by. This is when vehicle acts as an obstacle and the communication doesn't happen properly. Its reflected in the figure below:

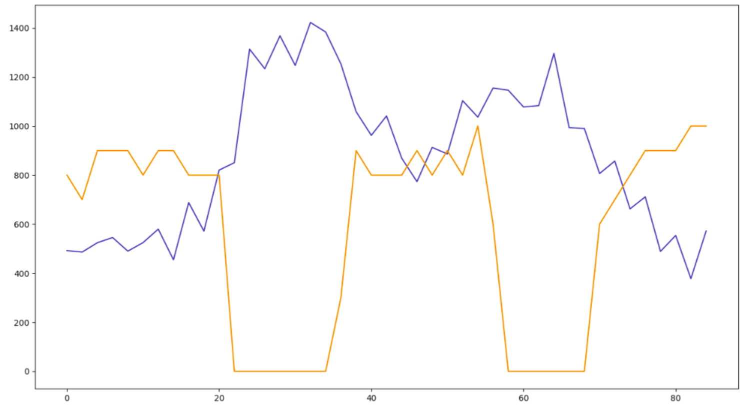


Figure 3.7[standard deviation of sound(y axis) vs time(x axis)]

By the figure above it can be concluded that whenever there is an increase in the sound it implies that an obstacle has come and packet loss is going to happen.From this we can find a particular threshold of standard deviation of sound value above which there is a high packet loss and it can be considered as a bad time period where the communication has to be stopped.

3.3.2 Challenges

We had a common assumption that larger the vehicle more is the sound produced and hence more is the packet loss but it is not the case every time. As some motor bikes and cars produce large noise, the sound sensors misinterpret these vehicles to be Type 2 or Type 3 sensors. Hence relying on just the sound sensors would lead to incorrect results. The graph given below is the plot with Packet reception Ratio(PRR) on the x axis and standard deviation of sound values on the y axis. Our assumption is true that larger vehicles produce more sound and as the PRR increases the standard deviation of sound would decrease. Its probably happening but the plot doesn't clearly indicate it, due to the changes in the surroundings.The blue dots in the first 3 plots indicates when there is no vehicle passing.Unexpectedly there are some points whose standard deviation is on par with that of the heavy vehicles.This might be errors or external factors while experimenting or the vehicle might have just passed by,hence one must be very careful while carrying out the experiment.

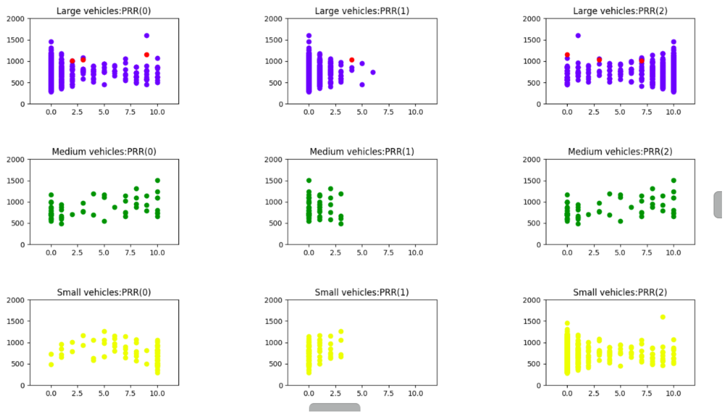


Figure 3.8[standard deviation of sound(y axis) vs time(x axis)]

Sound alone is not sufficient to find the bad time period hence it must be clubbed with other factors for the proper functioning of it.

3.3.3 Passive infrared sensors(PIR)

Passive infrared sensors are used to detect the objects which produce infrared radiations within its scope or view up to around 10m from the sensor. As vehicles also come into the category of objects that generate infrared rays these passive infrared sensors can be used to detect the movement of the vehicles.

We find that PIR sensor is heavily sensitive to the passive infrared waves. Therefore, even a human passers by resulted in a high reading of the PIR value.We find that the variance or the standard deviation of the raw values shows the necessary pattern that can indicate the passage of a vehicle. Specifically the standard deviation values are quite proportionate with the

the loudness or the level of noise created by the passing vehicles.
Thus, the higher value should indicate higher the drop in the PRR.It can be observed that PIR does not show any pattern. This is due to its very high rate of false positives. If the PIR reading is low then for sure the path is not blocked by any obstacle. However, if PIR says the road is blocked then this should be cross checked through sound reading.

3.3.4 Challenges

As human beings also produce infrared rays, PIR also detects human beings even though there are no vehicle.
The first thing noticeable is that the PIR shows many false positive cases, i.e., high reading when there was no vehicles passing which makes it alone unreliable in defining a bad time period.

3.3.5 RSSI logger

Received signal strength indicator is another indicator which is used to denote the strength of the signal received. RSSI is an indication of the power level being received by the receive radio after the antenna and possible cable loss. Therefore, the higher the RSSI number, the stronger the signal.
This graph below indicates the relationship between RSSI values and the packet reception ratio.Therefore it can be told that if RSSI is less than a particular value there would be significant packet loss happening.

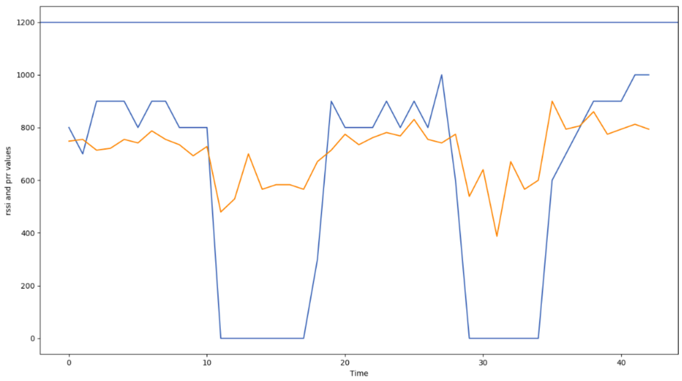


Figure 3.9[standard deviation of RSSI and PRR(y axis) vs time(x axis)]

The blue line shows PRR while the orange graph denotes the receiver signal strength ratio(RSSI). From the graph it can be observed that when there is a vehicle passing through,there is a packet loss and it is also reflected in the RSSI values.(Dint use Link Quality indicator(LQI).)

3.4 Other Motes

Apart from the RSSI, PIR and the sound sensors we have the controller mote which is used for synchronization of all the motes.Sender mote is used to send the data while the receiver mote receives the data sent by the sender mote.

Vehicle logger is needed to record the time when the vehicle passes by.Its done manually.We pressed '1' for small vehicle,'2' for vehicles of medium size and '3' for larger vehicles.

While sender and receiver communicate among each other we have to take care of the power of the transmission,channel through which the communication is taking place and the packet size of the packets that are being communicated. these value of channel,power and data packet size can be determined in the controller.All the modes are resetted. To change channel we use "c 14" To change power we have "p 32" To change packet size we have "d 62" only when all sensor motes are turned on and the data transfer is not yet started,we use these above commands to change the channel ,power and data packet size and then press the user button in the controller so that all the others start transmission in a synchronous fashion.

3.5 Project Requirements

We have to do the experiment in a single-lane with relatively less busy traffic. TelosB motes and Contiki OS are needed. Vehicle recorder is also needed to record the vehicles along with the sound sensor, Passive infrared sensor, receiver and transmitter motes. A synchronized mote is needed along with the above mentioned motes as all the measurements must be time synchronized and carried at the same time. Initially experiment is done connecting to the laptop which should be at both the sides of the road hence we need 2 laptops for the experimentation.

3.6 Project Inferences

We can infer that for a sufficiently high transmission power and narrow width of the road ,there is no effect in the passage of any type of vehicles .It could be more strongly stated if the signal strength received is high(higher than -65 dBm).But this may not be the case if the signal strength decreases. Where as when the signal strength is less than -90 dBm and packet size is very high all type of vehicles incur a packet loss and hence a loss in the energy. For a moderate Received signal and a moderate packet size , obstruction of communication path between nodes by type X vehicles would not effect the communication between them while obstructing the path by type Z vehicles would adversely effect the communication between the nodes. While type Y nodes behave differently in different cases.

3.7 Related work

Wireless sensor networks have been a really big promise in the recent years but a lack of real applications makes it difficult in the establishment of the technology. The environmental care has become one of the biggest concerns for almost every country in the last few years. Even though the industrialization level has been increasing without any control in the last decades, the current situation is clearly changing towards more environmentally friendly solutions. Water and air quality are essential to maintain the equilibrium between human development and a healthy environment. Due to the reasons above, the necessity of monitoring production processes and environmental parameters has become an essential task for the industrial community. The solution proposed in this text is an environmental monitoring system based on a wireless sensor network (WSN hereafter) platform called Cookies, to measure both gas emissions and waste water quality in an instant coffee factory in Spain. Even though there are myriad other approaches that are now being used, WSNs can offer a cheaper solution while having data acquisition in real time, working in an unattended way. Typically, the environmental data acquisition in factories is carried out manually and occasionally or using wired systems that are normally expensive and not flexible. This solution is not the best in terms of security, as it is necessary to hire workers to take measurements in dangerous places such as chimneys or waste water pipes. In this way, if a catastrophic discharge occurs, the factory will not notice it until next measurement, which can be several weeks later.

3.8 Future Work

The bad time periods have to be detected and the communication process shouldn't be carried out when a bad time period occurs.Continuously sensing the medium using RF signals and re-transmitting if there is a packet loss will waste a lot of power.Using sound sensors to continuously sense the environment hugely decreases the power loss but its not trustworthy as packet loss and sound are not always linear. We use curve fitting to fit the probability distribution curve and find the bad time period but more novel and energy efficient techniques have to be developed to detect the bad time periods.

Chapter 4

RESULTS and PLOTS

Firstly we need to prove that smaller vehicles do not result in sufficient packet loss compared to packet loss incurred by medium and heavy size vehicles.

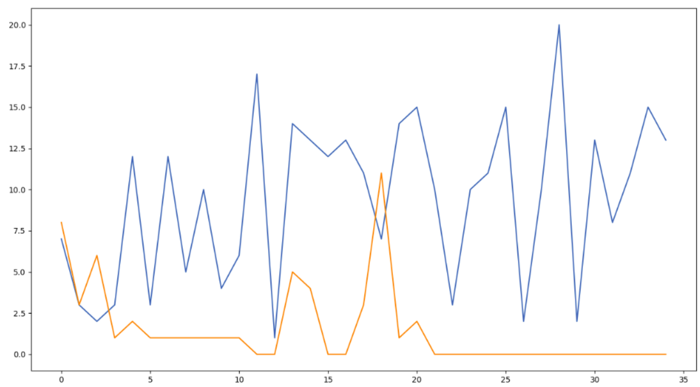


Figure 4.1 [Packet-Reception-Ratio(y-axis) vs time(x-axis)]

Orange graph is for type 2 vehicles(car) while blue graph is for vehicles of type 1(bikes).It can be inferred from this that the packet reception is lower for larger vehicles. The same can be shown for different powers and different packet sizes. The experiments are conducted in many places like jatni,khandagiri,Bhubaneswar ,SES and LBC.
We can plot Sound,RSSI and packet reception ratio with respect to time so that we can see how the sound and RSSI effect the PRR.

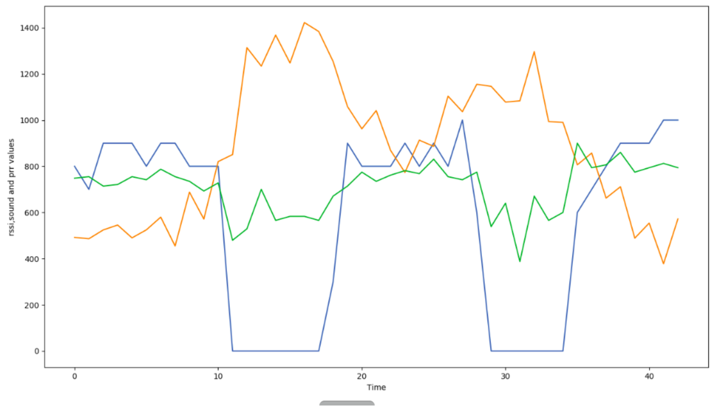
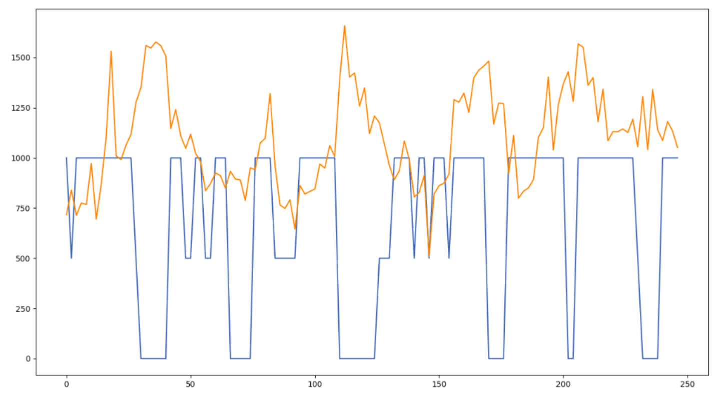
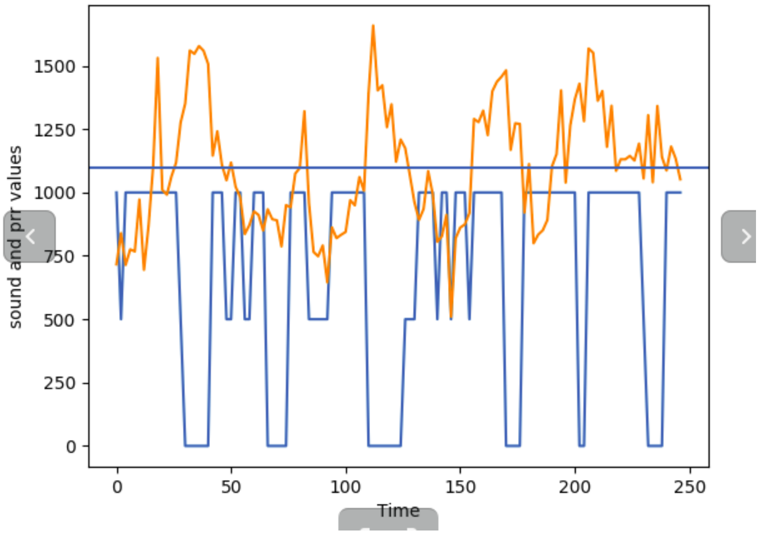


Figure 4.2[RSSI,Sound and PRR(y axis) vs time(x-axis)]

In this case orange is sound and green is RSSI. Using these 2 plots we can tell when the packet loss is happening and hence detect the presence of the vehicles.
We see that when packet loss occurs, sound increases a little from the average value and RSSI decreases a little from its average value as shown in the figure.We observe that when sound value exceeds a particular value the packet reception drastically falls down.This particular value is told to be the threshold.
Threshold is fixed to a certain value . Its value is considered in such a way that if sound crosses this threshold value the PRR should be drastically low.





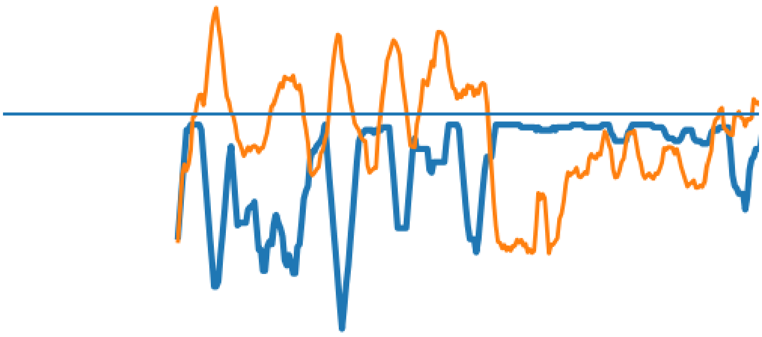


Figure 4.3,4.4,4.5 [Sound and PRR(x-axis) vs time(y-axis)]

Thus, these initial experiments show the fact that the passage of vehicles along the roads can temporarily make a link across the road unusable for low communication. In the next section we show how such time periods can be detected and subsequently avoided.

This time period is considered to be the bad time period where the packet loss occurs. A perfect threshold must be selected in such a way that as soon as the sound crosses a certain value the PRR must drop drastically as seen in the figures. Now we would define the bad time period as the period for which the sound is above the threshold.These time periods are isolated.

Consider the example below:

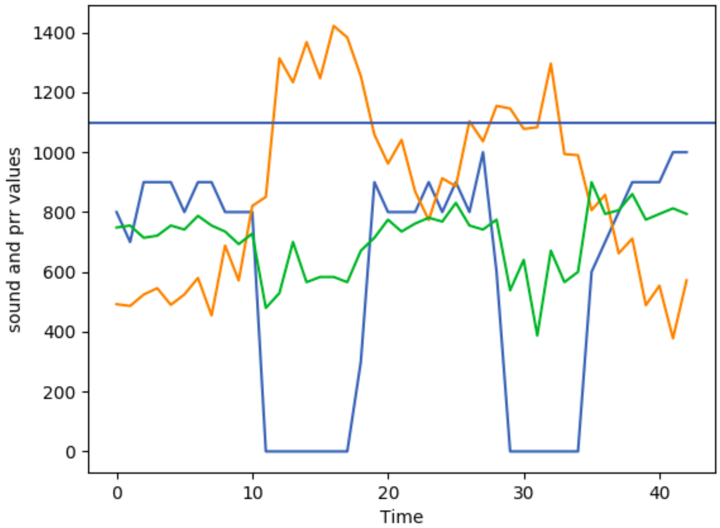


Figure 4.6[Sound and PRR(x-axis) vs time(y-axis)]

We have assumed the threshold value to be 1100. We can calculate the points at which the sound crosses the threshold value.

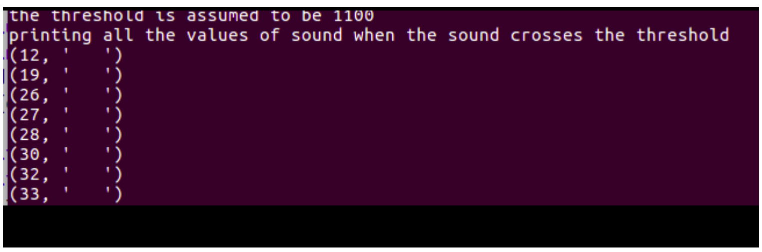


Figure 4.7[Time period at which sound crossed the threshold.]

```python
        #sums=0
        #line=fp.readline()
        line1=fp1.readline()
r=[]
i=0
while i<(len(b)):
        while i<len(b) and b[i]<1100:
                i+=1;
        if i<len(b) and  b[i]>1100:
                r.append(i)
        while i<len(b) and b[i]>1100:
                i+=1;
        if i<len(b)  and b[i]<1100:
                r.append(i)
                while i<len(b) and b[i]<1100:
                        i+=1;
print('the threshold is assumed to be 1100')
print('printing all the values of sound when the sound crosses the threshold')
i=0
while i<len(r):
        print(r[i],'   ')
        i+=1
t=[]
i=0
print('The bad time periods are the periods when the sound first became less than the threshold -the first
time it crossed the threshold')
while i<(len(r)/2):
        t.append(r[2*i+1]-r[2*i])
        i+=1;

print("printing bad time periods")
```

Figure 4.8

```python
g=[]
for i in range(6):
        g.append(0)
for i in range(len(t)):
        if t[i]<2:
                g[0]+=1
        elif t[i]<4:
                g[1]+=1
        elif t[i]<6:
                g[2]+=1
        elif t[i]<8:
                g[3]+=1
        elif t[i]<10:
                g[4]+=1
        elif t[i]<12:
                g[5]+=1
objects=('0-2','2-4','4-6','6-8','8-10','10-12')
y_pos=np.arange(len(objects))
plt.bar(y_pos,g,align='center',alpha=0.5)
plt.xticks(y_pos,objects)
plt.xlabel('time periods')
plt.ylabel('probability distribution')
plt.title('probability distribution of time periods')
plt.show()
print("printing probability distribution")
for i in range(4):
        print(g[i])
#print(len(r))
#for i in range(len(r)):
#       print(r[i])
```

Figure 4.8

Based on this we can find the bad time periods that is (time when sound got down the threshold)-(time when the sound just crossed the threshold) and then we find the probability distribution of how many times the bad time period was lying between certain intervals.

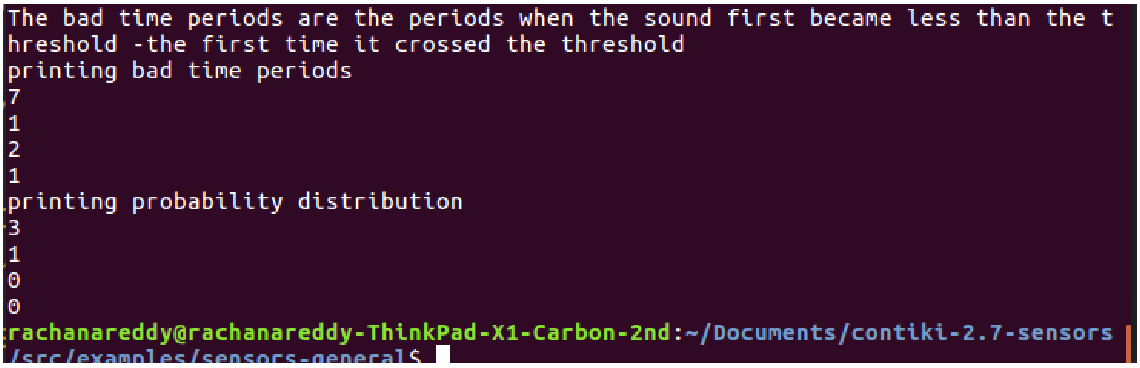


Figure 4.10[Bad time periods and probability distribution.]

The probability distribution values define the number of bad time periods in the interval of 5sec. The curve can be plotted as follows:

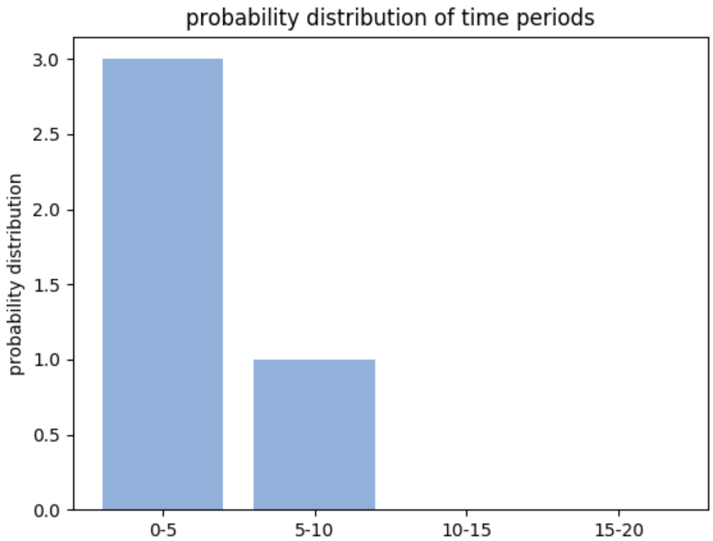


Figure 4.11[probability distribution curve]

This curve dosen't give much information to infer from it so we can decrease the interval to 2sec.Even then we dont get a good graph.So we had to consider for a larger data. Consider the following graph below:

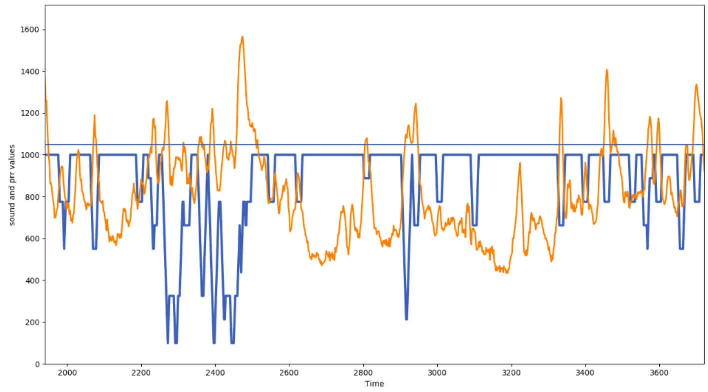


Figure 4.12[Sound and PRR(x-axis) vs time(y-axis)]

The threshold is considered to be 1050. The probability distribution curve looks something like:

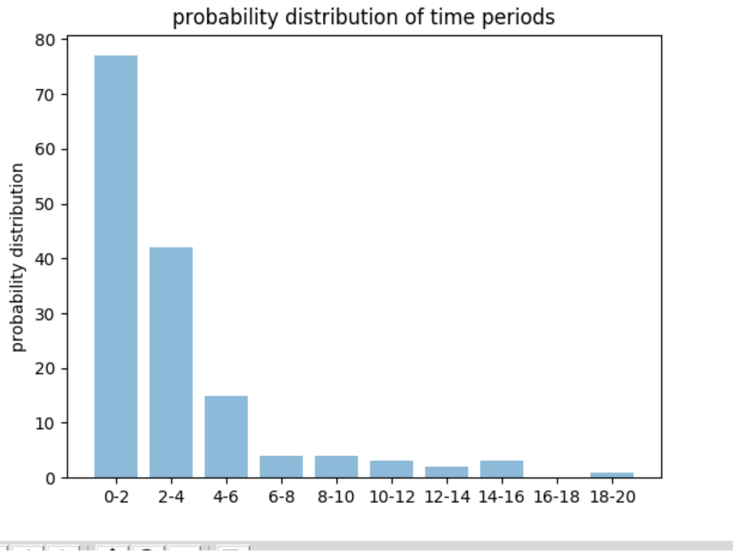


Figure 4.14[probability distribution curve]

The probability distribution curve changes with the change in the threshold value too. In the previous case if the threshold value is taken as 1000 and 1150 graph looks like:

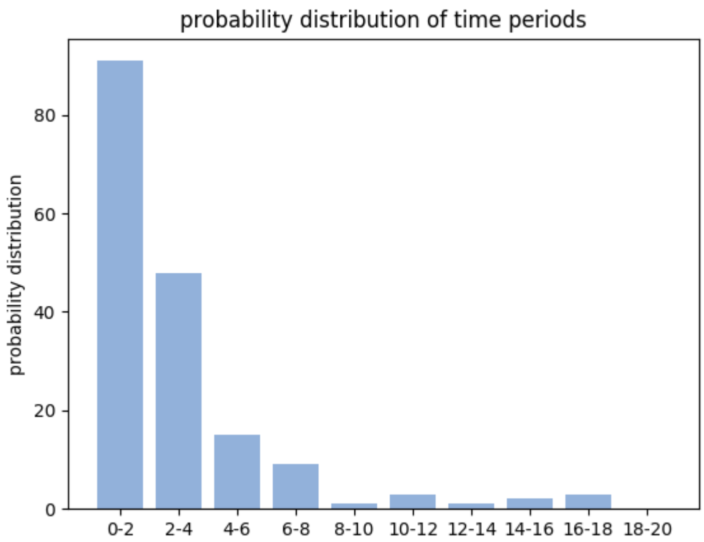


Figure 4.15[probability distribution with threshold sound 1000]

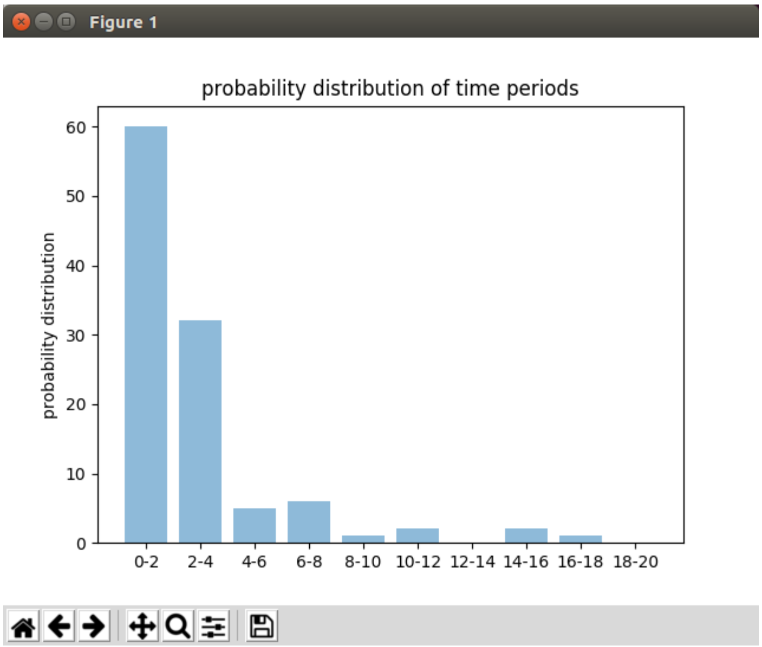


Figure 4.16[probability distribution with threshold sound 1150]

From this probability distribution using curve fitting we can hopefully find out the estimated bad time period.

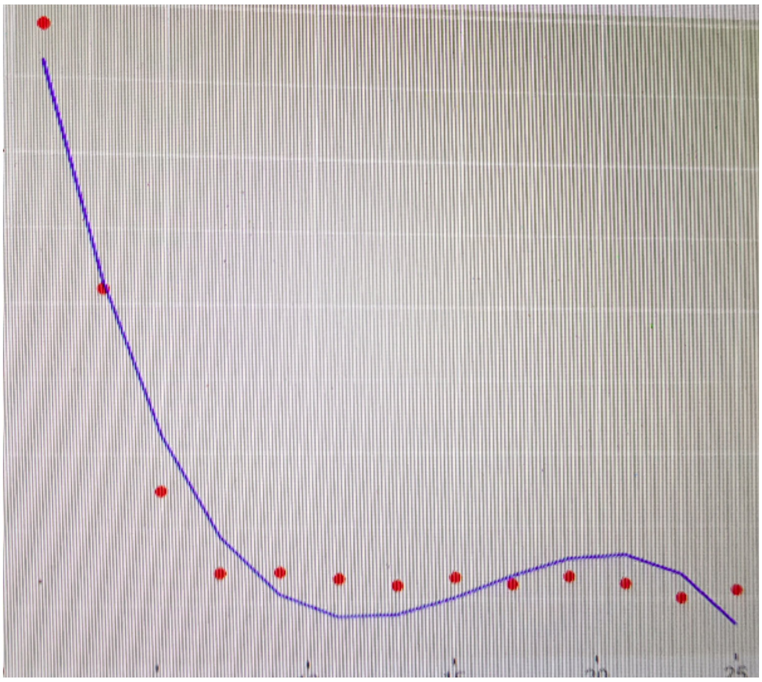


Figure 4.17[probability distribution of bad time periods]

Once we know the estimated bad time period we can switch off the communication process for that time period using a timer and then continue the transmission.

Chapter 5

DISCUSSIONS AND CONCLUSION

5.1 Discussion

As we must correctly understand the effect of different kind of vehicles for obtaining proper results,we generally avoid wide roads with multiple lanes and heavy traffic in each lane in each direction and constrain ourselves to roads with single lane and not much traffic as it is necessary that the noises of vehicles in the opposite lane must not obstruct the experimentation in our lane . We expect the sensors to be mounted high on the lamp post so that the vehicles wont effect the communication between nodes, but not even too high that the motes can not even sense the gases and the surroundings(eg: smoke ,dust .CO2 ,etc.;). Our main aim is to avoid the RF packet transmission in the bad time periods so that the energy is conserved.So we must use the sensor reading to avoid RF communication.We can use the sensors in many ways to avoid the bad time periods.A simplest possible way can be to read the sensor before doing every RF communication instead of the RF transmissions directly which would incur great loss if packet loss happens. But from the previous knowledge sound standard deviation and packet loss are non-linear.We find that above a particular threshold of standard deviation of sound there is a drastic packet loss happening. However, deciding this threshold is usually a non-trivial task since it is usually dynamic and changes with the traffic status. Actual energy saving depends on various factors such as how frequently we use the sensors, the threshold value, how many samples we use to calculate the sound standard deviation, whether both PIR and sound are used,and most importantly the rate at which the vehicles that can block the transmission crosses the link.Therefore,we would like to see that how much percent of the failed rf transmission is properly detected through the experimentation. Note that in the simulation of the simple and sort of blind protocol, for every threshold value certain cases of successful transmissions will also get blocked. The rate of this false positive increases with decrease in the threshold value. We find that in our experiment conducted with our data set collected in bhubaneswar for 1 hr in a less busy single lane road for a threshold value of 1050 we get an avoidance of 86 percent of the transmissions ,blocking the remaining 14 percent and considering this 14 percent of successful transmission as a bad time periods.

Thus in a nutshell we can tell that the sensor assisted approach has a potential to bring down huge power consumption leading to power savings which can be used during the safe periods to convey the remaining data with more frequent communication.

5.2 Conclusion

Large vehicles are considered to be a potential cause of loss of data and ACK packets in urban deployment of low power network. Our main aim is communication between nodes .Which is found using the PIR and sound sensors .Standard deviation of sound measurement above a threshold can successfully detect the passing of vehicles that can block the low power transmissions.

IN order to understand the basic problem, in our initial experiments we avoid wide roads having multiple lanes and heavy traffic in each lane and in each direction and use single The use of sensors also consumes certain power, although much lower than RF. Therefore, clever use of the sensors are also necessary to optimize the power consumption. Our further analysis on the collected dataset of sound reading shows that the the duration of the time periods above a certain threshold value as well as the gaps in between such periods follows exponential distribution.This fact can also be used to derive sophisticated algorithm such as probabilistic decision making to avoid the periods and also the time when its necessary to do the sensor sampling once again.

Chapter 6

REFERENCES

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