

IMPROVED ENERGY EFFICIENCY USING ROUTING ALGORITHM IN WIRELESS COMMUNICATION

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Abstract: The availability of Global Positioning System GPS is not always possible. For military field and mining field which completely relies on GPS has to come up different technology for navigation as their work mostly relies in the GPS denied region. One such technique is discussed in this paper for a reliable navigation. WPAN is used to navigate based on the cell phone triangulation method and different approaches are done to get more accurate location navigation. The RSSI values of the WPAN is measured and based on the triangulation method the nearest node location is calculated and is communicated to the display mote. The effective distance between the nodes in which it has to be placed and a new algorithm is also return to make the idle nodes to go to sleep in order to get maximum efficiency and life time is discussed in this paper.

Index Terms: GPS, WPAN, RSSI, Signal Triangulation method, Transceiver.

1. Introduction

The Introduction to the Global Positioning System (GPS) made a huge impact in the day to day life. GPS is also widely used in military, exploring and mining fields. Using GPS, the location is determined by receiving signal from four different satellite. But during the intervention of bad weather or blizzard receiving all the four signals from different satellite is not possible [5]. Also the anti-GPS systems or GPS jammers imposes a threat during war times. Hence sooner or later an alternate method has to be adapted as a navigation system or as a backup in case of GPS failure.

Different navigation systems and methods have been devised for navigation in the GPS denied system. They are classified under two basic methods. They are location based system and direction based system[1].

Location based system is based either on time difference of arrival method or angle of arrival method. Time difference of arrival is based on the time difference between the signal transmitted and the time at which the

signal is received. The difference in time gives the distance between the transmitter and the receiver.

Angle of arrival method is based on the difference in phase angle or phase shift occurred while transmitting and thus distance is calculated. In both the method, the transmitter and receiver should be already pre-determined and distance should be known to locate the person.

In direction based systems, the person is located by detecting the direction of the signal received. Therefore this type of systems should be equipped with special directional antennas.

The use of location based system can give accurate location but requires complex equations and programs to determine the location and also the location of the nodes and its distance. Hence a simpler and more efficient way of navigation can be achieved using direction based system.

GPS, WiFi triangulation, Cell Phone triangulation or combination of all the three are based on location based system [4]. GPS is based on receiving the signals from four satellite and comparing them. The signals transmitted has time stamp on it and the receiver can note the time it received the signal and the difference gives the location of the user. WiFi triangulation and cell phone triangulation is based on the signal transmitted from base stations. WiFi triangulation gives reasonable accuracy when compared to the other two techniques. Cell phone triangulation gives the least accurate result.

Hence a direction based system is adopted and the location is determined. The Proposed system consist of two sections- Reference motes or nodes and Display motes or nodes. The reference motes will be placed along the tracks travelled towards or away from the camp site. Display motes will be given to individuals when they are out on the mission. The individuals can track their way back to the camp when they are lost using this display mote.

The display mote will communicate with the reference mote and depending upon the signal received will compare and decide the path to be taken by the

person. This method is not only suitable for satellite signal denied region but also for navigation within the building or complex where GPS lacks line of sight and also magnetic devices which uses earth magnetic field reading is also unreliable[6-9].

2. Wireless channel models

Radio propagations involve loss of signal strength with respect to the distance or termed as path loss. Let P_T be power transmitted, P_R be power received and R be the distance between transmitter and receiver, there are three basic models used widely for wireless sensor network.

i) Free propagation model- Considering that the transmitter and receiver is placed where there is no obstacles between them and are in the line of sight, following equation is derived.

$$P_R \times R = C_f \frac{P_T}{R^2}$$

Where C_f is the constant depending on the transceiver.

ii) Two-Ray ground model- The equation is derived introducing reflection to the above model where receiver receives a direct communication signal and reflected signal.

$$P_R \times R = C_t \frac{P_T}{R^4}$$

The equation is simplified considering the distance R is much greater than the height of the transceiver. C_t is the constant depends on the transceiver of two ray ground model.

iii) Long distance model- The equations are derived from the analytical and empirical method.

$$P_R \times R \propto \frac{P_T}{R^\alpha}$$

Where α is defined as the distance power gradient.

These models are used in the simulation process to calculate the values theoretically. The practical model relies much on the two values. RSSI and LQI.

RSSI- Received signal strength indicator is the received power measured. Depending on the RSSI value the distance is calculated and the person is navigated. Strong signal gives high RSSI value where weak signal gives low RSSI value.

LQI- Link quality indicator is used to determine the quality of the link that is established between the transmitter and receiver. It depends on the how easy it is for the receiver to modulate the received signal in addition to the noise that gets added up in the link. Low noise gives high LQI value and high noise gives low value of LQI.

3. Hardware setup

The system consists of reference nodes and display nodes. The transceiver in the display node should be able to communicate with transceivers in the reference nodes. Different transceivers were implemented and observed. The RSSI value of the MiWi MRF24J40 and CC2420 fairly remains constant with respect to the distance i.e., the loss of signal is constant.

The MiWi is selected as the transceiver in both reference nodes and display nodes due to large coverage area because of the availability of the folded PCB antenna and also external 50 Ohm antenna [10-14]. Zigbee enhanced network analyzer, ZENA can also be used but the signal loss is not constant with respect to the distance though the receiver is sensitive [15-19].

Wireless RF, Physical Layer baseband and MAC layer baseband are integrated in the MRF24J40. It can be widely used in the applications like home automation, consumer electronics, robotic toys, industrial automation, PC peripherals and more. The low radio power consumption in MiWi is very suitable for this system as the typical current consumption is 18mA in receive mode, 22mA in transmit mode and 2 μ A in sleep mode[20-24].

The transceivers signals are controlled, monitored and compared by the controller. PIC microcontrollers are suitable for this system as they have reduced instruction set RISC processor and MiWi are compatible with PIC controllers.

MRF24J40 are connected to Serial peripheral interface SPI of PIC18F45J11. The result is read in the LCD or any display unit. Thus the hardware is kept minimal in order to carry out to places with ease and budget minimal[25-27].

4. Estimation model

Theoretical calculations can be obtained for the distance-RSSI relationship but when practical scenario is considered the RSSI value does not hold good. The fluctuation that occurs in the RSSI value is suitable for practical calculations but still many attempts are made to derive one and to get more approximate value of the distance from the RSSI value.

Multiple sensor values are considered for the calculation in order to avoid the variation in RSSI value. The calculation involves RSSI ratio denoted as P . The estimation is done as given in the following steps
The user node collects the reference nodes values in its communication range. It calculates the least hop count, the steps referred as hop count, from the values received and decides the reference node as the next destination and the user makes a move towards a random direction.
 P is calculated after each step is taken at the end of the step and compared with the predetermined threshold P value. If the calculated P is greater than the threshold

value then the user continues to move towards the same direction. Else the user takes a clockwise turn by $(-1)^n \times (n+1) \times 90^\circ$ for the next turn, where n is the number of turns made previously.

iii) After each step if the user mote detects lesser hop count other than the current reference mote then the user mote will change its current reference mote to the lesser hop count mote and follows from the step one.

Navigation scheme performance is determined by the ratio of the path taken by the user to the destination in the straight line [28-30]

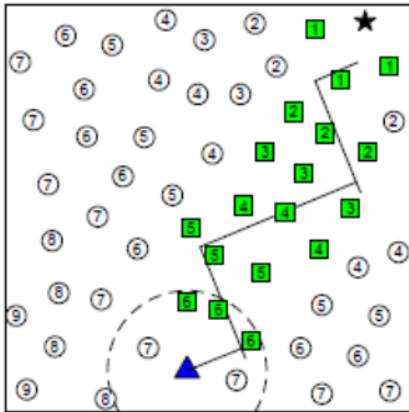


Figure 1. An example network shown. i) star-Destination. ii) Triangle- Display node. iii) Rectangle-Reference node. iv) Dashed circle- in the coverage area of display node.

To the actual path taken by the user to the destination using the system. For the ideal system the ratio should be unity. The practical system should give value more close to unity. The system performance is calculated by taking RSSI samples. The samples are calculated using the following equation.

$$RSSI_d = RSSI_0 - 10 \times \beta \times \log(R/R_0) + X$$

Where $RSSI_d$ is the RSSI value at distance R and $RSSI_0$ is the value at distance R_0 , β is the path loss factor and X is the zero mean Gaussian noise, R_0 is the short distance between transmitter and receiver.

The distance between the user and the mote determination for indoor navigation can approximately calculated with the help of the following equation.

$$D = \frac{10^{[(p_0 - f_m - p_r - 10 \times n \times \log_{10} f + 30 \times n - 32.44) / (10 \times n)]}}{10^{[(p_0 - f_m - p_r - 10 \times n \times \log_{10} f + 30 \times n - 32.44) / (10 \times n)]}}$$

Where p_0 and p_r are the power from distance zero and test distance respectively. F_m is the fade margin, f is the signal frequency and n is the path loss factor.

Fade margin is the difference between the sensitivity of the receiver and the received signal. The values obtained are approximate values only. With the implementation of more hardware to cancel the noise,

more sensitive antenna, filter and more iterations to get more accurate values which is left to the future works.

5. Test Prepration

The motes are designed according to the above specified specification and microcontrollers are programmed according to the designed algorithm. The motes are placed close to each other and readings are noted. Then the motes are gradually separated and different readings are noted in order to observe the noise variation in the signal. The maximum distance in which the motes can be placed is determined and good LQI can be achieved. In this distance the presence of informative signal becomes much lesser than the noise in the signal. The signal extraction becomes difficult further from this distance.

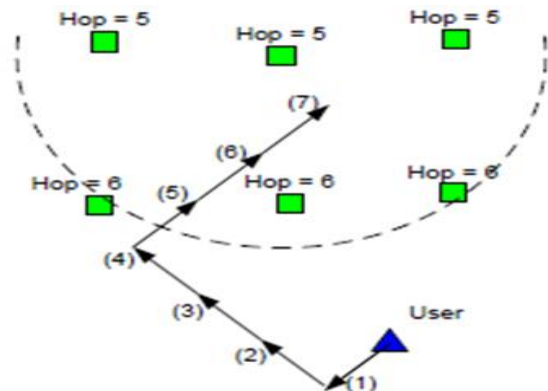


Figure 2. Zoom in view of the display node. Display node then switches to the next set of reference sensors. More number of motes are employed which helps in getting more RSSI samples to improve the navigation performance. The RSSI values that can be measured is stored in the specified register given in the data sheet in 2's complement. Hence the power is calculated from the following equation by considering the 2's complement of RSSI value.

$$P = RSSI[VAL] + RSSI[OFFSET] \text{ [dBm]}$$

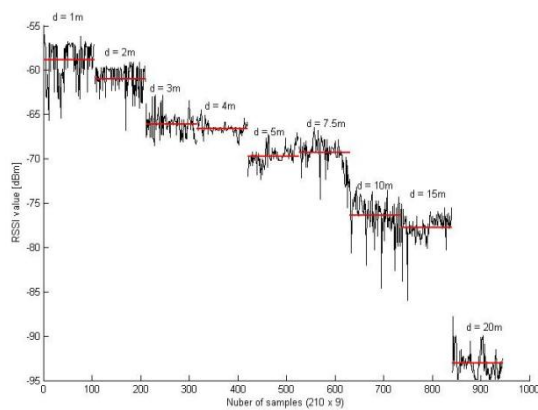


Figure 3. Reading RSSI on MRF24J40

The RSSI values to the number of RSSI samples are plotted in graph and shown in fig 1. As the number of samples increases the distance R is also increased and the coverage area can also be increased.

The deviation from the actual distance to the distance noted is calculated using the standard deviation formula.

$$\sigma = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\frac{1}{(n-1)} \sum_{i=1}^n (x_i - \bar{x})^2}$$

The readings are noted and standard deviations are calculated and compared. The table shows the values noted.

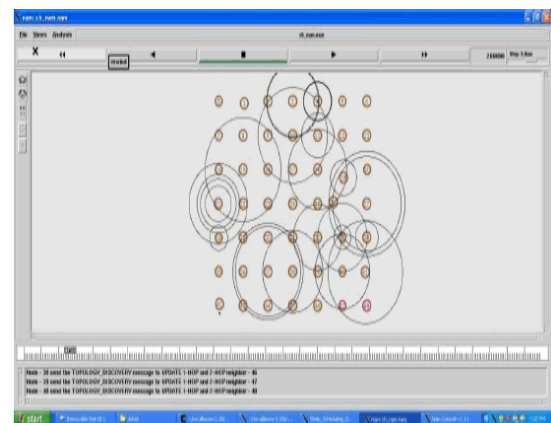
Table 1. Distance (m), average RSSI (dBm) and standard deviation using MRF24J40

DISTANCE	RSSI	ST.DEVIATION
1m	-58.89	2.23
2m	-60.73	1.41
3m	-66.09	1.31
4m	-66.58	0.63
5m	-70	1.03
7.5m	-69.5	1.62
10m	-76.4	2.0
15m	-77.7	1.5
20m	-93.14	1.4

5. Idle Nodes To Sleep Nodes

Transmission of data between a sender to a Receiver

through a network is done using intermediate nodes. Since all the nodes are battery operated power will be wasted in order to avoid it a new concept is proposed i.e. usually all the intermediate nodes will be waiting to receive the packet transferred by the head node and only a particular node will be given the data, the remaining nodes will not be taken into account so there will be wastage of power, here we organize the nodes into groups and give a head node for it and it will select the particular node in the group and make the remaining node to go to sleep. This idea will reduce the power wastage and also improve the efficiency.



6. Conclusion

In this system, the navigation to the destination using RSSI is studied and implemented. The system with MiWi shows a gradual deviation in the reading noted from the actual distance. Distance calculation using RSSI value is discussed and derived but implementation of the above is difficult in practical cases with the above devices. Due to the high irregularity in the RSSI values more number of sensors are implemented and also this plays a major role in distance calculation.

The problem that occurred was the microchip documentation and RSSI value calculation. The RSSI value is defined in the datasheet but the actual calculation of RSSI in dBm is not defined, in regards to the RSSI value given in MRF24J40.

The navigation using this system with the help of RSSI is done but the accuracy and distance calculations cannot be obtained clearly with the above values. The Time of arrival and angle of arrival methods can give more accurate result in the cost of complex algorithms and system implementation whereas this system serves the basic purpose of navigation with simple implementation of hardware as well as software.

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