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Localization of mobile body by using ZigBee based WSN

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Abstract – *The requirement of next positioning system, ZigBee wireless sensor network by taking help of readily available Received Signal Strength Indicator infrastructure available in the physical layer of 802.15.4.*
Receive Signal Strength Indicator change to the distance providing the basis for using trilateration methods for location estimation. Localization process involves the use of trilateration calculation for intersection of three spheres of which radius to find from the distance estimated from the Received Signal Strength Indicator value ; to work this model requires that the transmitting node have to be inside the intersection of three other receive nodes of which the locations are known.
Wireless tracking and positioning be a member to one of the many applications that can be realized by wireless sensor network.

Key Words: Positioning, Trilateration, Received Signal Strength Indicator (RSSI), ZigBee, Wireless Sensor Network.

1 . INTRODUCTION

Wireless tracking and positioning belongs to many applications that can be fully aware by WSN. Having the small transmission range area of wireless sensor nodes, the setup is applicable to small-scale relative localization, for instance, indoor positioning are sound/sonar, RSSI-based and access point reference.

The implementing node positioning in the ZigBee wireless sensor network on using a readily available Received Signal Strength Indicator framework provided by the physical layer of 802.15.4 network.

In this study Received Signal Strength Indicator is converted to distance providing the basis for using the trilateration method of location estimation.

1.1 RSSI-based Tracking:

Received Signal Strength Indicator is a measurement of the signal power on a radio link.

Received Signal Strength Indicator- based tracking includes two steps

- Range estimation between pairs of nodes based on RSSI measurements.
- Location estimation using geometric or statistical methods applied on the information from all nodes

Simple and cheaper, widely used, low-power consumption, and not suffer from any drift.

The received signal strength can be measured for every packet received, the value indicating the signal strength is provided as part of the Link Quality Indicator (LQI) as a RSSI value and available at PHY layer in IEEE802.15.4 network.

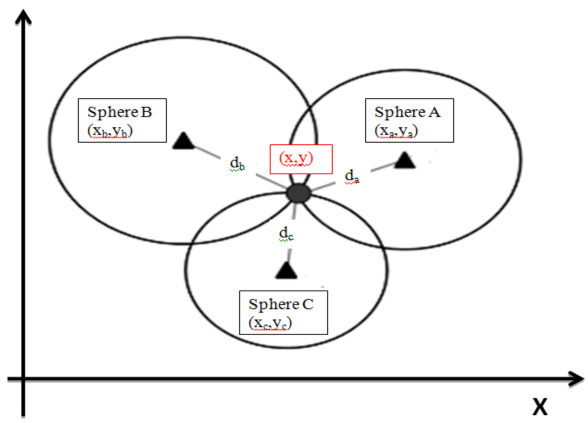
Using RSSI value, a distance to node can be measured and trilateration calculation can be performed against other nodes with known positions.

1.2 Trilateration

Trilateration uses the known locations of two or more reference points and the measured distance between the subject and reference points.

To accurately and uniquely determine the relative distance of a point on a 2D plane using trilateration alone, generally at least 3 reference points are essential. (at least 4 are essential in the 3D plane).

Consider the basic formula for a sphere, given below-



Consider the basic formula for a sphere, given below-

$d^2 = x^2 + y^2 + z^2$............................... (1)

For a sphere centered at a point (x_a, y_a, z_a) , the equation of sphere will be-

$$d^2 = (x - x_a)^2 + (y - y_a)^2 + (z - z_a)^2 \ldots\ldots (2)$$

Since we assume all the nodes span out on the same plane, consider the reference nodes (a, b, and c) that that have distance (d_a, d_b, d_c) to the target node as follows-

The equation for all the above sphere in x-y plane are given by eq. (3), eq.(4) and eq.(5)

Sphere A

$$d_a^2 = (x - x_a)^2 + (y - y_a)^2 \ldots\ldots (3)$$

Sphere B

$$d_b^2 = (x - x_b)^2 + (y - y_b)^2 \ldots\ldots (4)$$

Sphere C

$$d_c^2 = (x - x_c)^2 + (y - y_c)^2 \ldots\ldots (5)$$

These equation can be further expanded as-

$$d_a^2 = x^2 - 2x.x_a + x_a^2 + y^2 - 2y.y_a + y_a^2 \ldots\ldots (6)$$

$$d_b^2 = x^2 - 2x.x_b + x_b^2 + y^2 - 2y.y_b + y_b^2 \ldots\ldots (7)$$

$$d_c^2 = x^2 - 2x.x_c + x_c^2 + y^2 - 2y.y_c + y_c^2 \ldots\ldots (8)$$

The equation (6),(7) and (8) are independent non-linear simultaneous equations which cannot be solved mathematically. However using method proposed by Dixon to obtain plane for sphere intersection, subtract the 2 sphere's eq. (8) form eq.(7) we get the following eq.(9)is

$$d_b^2 - d_c^2 = 2x(x_c - x_b) + x_b^2 - x_c^2 + 2y(y_c + y_b) + y_b^2 - y_c^2 \ldots (9)$$

Subtract eq.(6) form eq.(7) we get to eq.(10)

$$d_b^2 - d_a^2 = 2x(x_a - x_b) + x_b^2 - x_a^2 + 2y(y_a + y_b) + y_b^2 - y_a^2 \ldots (10)$$

Re-arranging the eq. (9)to produce a variable V_a

$$x(x_b - x_c) - y(y_b - y_c) = \frac{(x_c^z - x_b^z) + (y_c^z - y_b^z) + (d_b^z - d_c^z)}{2} = V_a \ldots\ldots (11)$$

Re-arranging the eq.(10)to produce a variable V_b

$$x(x_b - x_a) - y(y_b - y_a) = \frac{(x_a^z - x_b^z) + (y_a^z - y_b^z) + (d_b^z - d_a^z)}{2} = V_b \ldots\ldots (12)$$

Resolve the eq. (11) and eq. (12) to gain the intersection point (**x, y**) of these two equation as the following eq. (13) for y-coordinate and eq. (14) for x- coordinate.

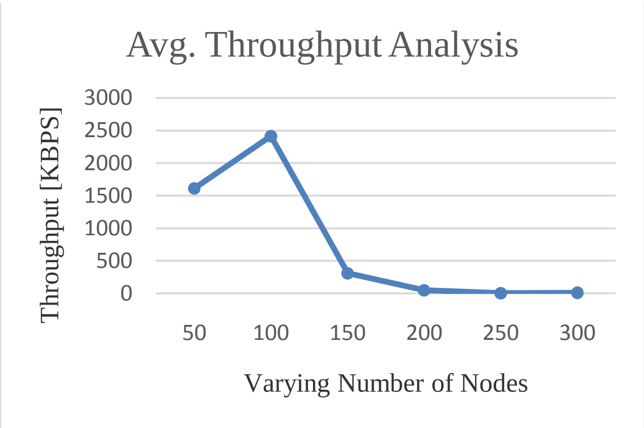
$$y = \frac{V_b(x_b - x_c) - V_a(x_b - x_a)}{(y_a - y_b)(x_b - x_c) - (y_c - y_b)(x_b - x_a)} \ldots\ldots (13)$$

$$x = \frac{y(y_a - y_b) - V_b}{(x_b - x_c)} \ldots\ldots (14)$$

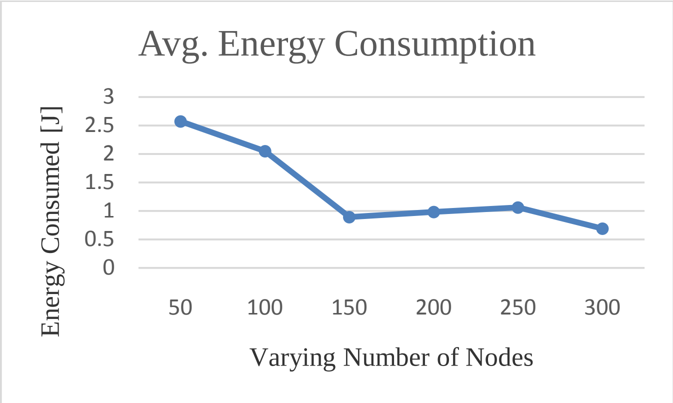
By using these equation, unknown coordinates of the unknown node P(x, y) can be calculated by using $(\boldsymbol{d_a}, \boldsymbol{d_b}, \boldsymbol{d_c}, \boldsymbol{d_d})$ values.

2. Simulation Results for Trilateration Algorithm

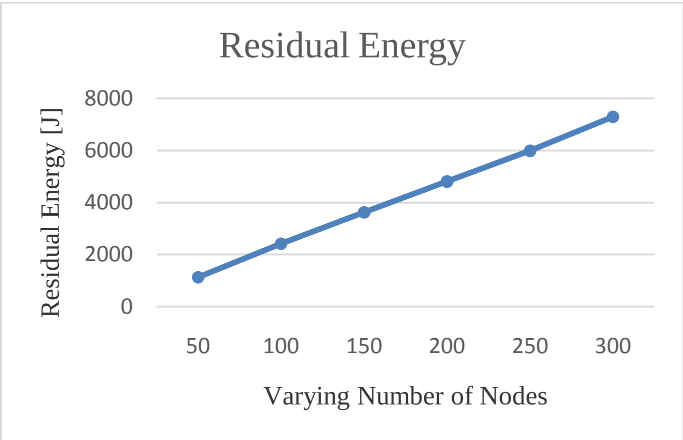
2.1. Avg. Throughput vs. Number of ZigBee Nodes



2.2 Avg. Energy Consumption vs. Number of ZigBee Nodes



2.3 Residual Energy vs. Number of ZigBee Nodes



2.4 Network Lifetime vs. Number of ZigBee Nodes

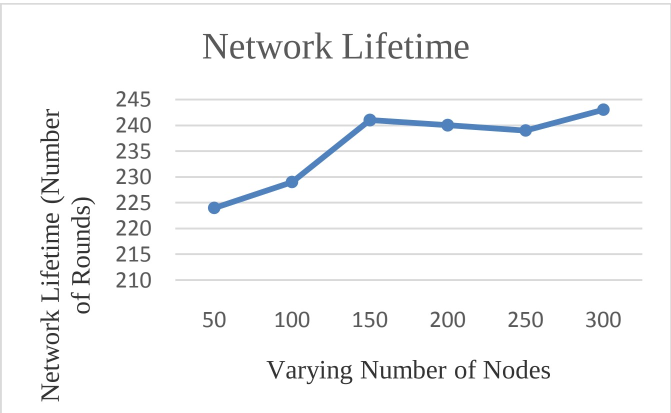


Table -1: Network Scenario Configuration

Number of Sensor Nodes	50/100/150/200/250/300
Traffic Patterns	CBR
Network Size	100 X100
Mobility Speed	5m/s
Simulation Time	100s
Transmission Packet Rate Time	10 m/s
Pause Time	1.0s
Localization Methods	RSSI/Hybrid RSSI
MAC Protocol	802.15.4
Transmission Protocol	CBR
Number of Flows	10, 12, 14, 16, 18, 20
Type of Networks	ZigBee

3. CONCLUSIONS

Many LBS application require the incorporation of sensors and automation. ZigBee provides both location management and integration with any type of sensor. E.g. access control applications. Mobile phone can be used as an I/O channel to send or receive data based on the position of the associated ZigBee tag.
In other cases the ZigBee tag will operate to locate objects in indoor while outdoors, us may be located by cell/GPS or Wi-Fi using their mobile phone. ZigBee is the right choice for many cases where safety and reliability in communications and it does not require high data transfer.

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