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Research Article

Increasing the Life Time of the Network by Adjusting the Transmission Power of Nodes Based on Received Signal Strength in Wireless Sensor Networks

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Abstract: Transmission Range Adjustment plays an important role in the data transmission within the wireless sensor networks and enhancing the utility of data collected by enabling sensors. Received Signal Strength (RSS) is used to determine the location from which each data packet is obtained. This study proposes the Range adjustment using Received Signal Strength measurement for two ray ground propagation model. Simulation results validate that the proposed Range Adjustment Protocol significantly outperforms the Link-Aware clustering technique with better packet delivery ratio, better energy consumption and improved Accuracy. Wireless Sensor Networks (WSN) are becoming ubiquitous and their application areas are widening by the day. In wireless sensor networks, by adjusting the transmission power based on received signal strength, we can improve the life time of the network.

Keywords: Clustering, energy efficient, network simulator, received signal strength, routing, wireless sensor network

INTRODUCTION

The Wireless Sensor Networks (WSN) has recently become promising network architecture and is widely used in many applications, including environmental monitoring, object detection, event tracking and security surveillance (Akyildiz *et al*., 2002). WSNs include several different sensors like seismic, temperature, strain and etc., which are used in applications like habitat monitoring, precision agriculture and forest fire detection etc. Sensor networks have provided us with several applications in wireless environments but due of their energy inhabitation; they received increasing attention lately in a way that energy Management has become an important factor in designing the protocols of this network (Sheng-Shih and Ze-Ping, 2013). A Wireless Sensor Networks (WSNs) typically consists of a large number of small, low power communication devices called sensor nodes and one or more Base Station (BS) (Jegadeesan *et al*., 2013). In general, WSNs consist of large numbers of tiny autonomous wireless devices, called sensor nodes, which perform multiple functions such as sensing, computing and communication (Ford, 2001). In typical WSNs, sensor nodes (i.e., source nodes) must report the sensing or monitoring data to a central node, called the sink, when receiving query messages sent by the sink. Because sensor nodes are battery-powered devices, charging batteries for sensor nodes is often difficult. Operations, such as sensing, communication and computation, consume the energy of sensor nodes and data transmission is the major source of energy consumption (Younis and Fahmy, 2004). Thus, it is a serious challenge to design an energy efficient routing scheme for reporting sensory data to achieve a high delivery ratio and prolong the network lifetime (Gerla and Tsai, 1995). In order to improve the life time of the sensor network, the transmission power of node is adjusted based on the received signal strength. I.e., transmission range of the node is adjusted based on received signal strength.

LITERATURE REVIEW

Existing routing protocols for WSNs generally fall into three categories; they are chain-based, tree-based and cluster-based. If a node that is the farthest from the sink becomes a leader, it uses more energy to transmit messages to the sink (Younis and Fahmy, 2004; Wei *et al*., 2011; Tsai and Tseng, 2012). Moreover, if the number of sensor nodes on the chain increases, the chain length also increases. The complication in the methods is Transmission delay and More Energy consumption. The root node becomes a bottleneck for message reporting, thereby quickly exhausting its battery power. The difficulty in the methods is Transmission delay.

The alternative concept is clustering; in this approach it groups all sensor nodes into multiple clusters. In a cluster, one node is elected as the cluster-head, which controls and manages the cluster. Multiple clusters can be connected via gateways (Lin and Gerla,

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1997; Banerjee and Khuller, 2001). The main challenge of clustering is to select proper nodes to act as cluster heads and gateways. Previous researches have proposed many cluster-head election approaches for constructing clusters (Akyildiz *et al*., 2002).

The first type of clustering is active clustering; in this type each node locally exchanges messages with the nodes in its communication range (i.e., neighbors) to determine whether it should become a cluster-head (Kwon and Gerla, 2002).

Another type of clustering is passive clustering; this passive clustering considers three thinks. i.e., predicted transmission count, priority calculation and cluster state transition (Lee *et al*., 2010). In Predicted Transmission Count, Link clustering considers node status and link condition and proposes a metric, called the Predicted Transmission count (PTX). The PTX represents the capability of node for having the persistent transmission to the specific neighbor node. A large PTX value indicates more chance of becoming a CH or GW node.

When node s_i, receives report messages form s_j, it can use Eq. (1) to derive the PTX, q_{ij}:

$$q_{ij\cdot} = \frac{Ej^{res}}{ETX_{ij}.E^{tx}\,(k,d_{ij})} \tag{1}$$

where,

E_i^{res} = The residual energy of s_i

$d_{i,j}$ = The distance between s_i and s_j

E_{tx} (k, d_{ij}) = The energy consumption for s_i to transmit a *k*-bit message over a distance d_{ij}

In priority calculation the LCM evaluates the suitability of CH or GW candidates to determine proper participants to forward data packets. A CH candidate (CH_R node) or a GW candidate (GW_R node), s_i, performs the following steps to determine its priority.

Step 1: Calculate the PTX of each neighboring.

Step 2: Divide Si^{nbr} into two subsets, S_{sat} (i) and S_{sat} (i), where the PTXs of all elements in S_{sat} (i) are greater than or equal to Nreq and the PTXs of all elements in S_{sat} (i) are smaller than Nreq.

Step 3: If S_{sat} (i) = Ø, set ρi as the PTX of the node, which has the minimum PTX in S_{sat} (i); otherwise, set ρi as the PTX of the node, which has the maximum PTX in S_{sat} (i).

In cluster state transition upon receiving messages, a node uses above Algorithm to determine whether it must change its current state. For the lack of space, this paper uses the IN node as an example to explain the state transition of LCM. If the node becomes a CH or GW node, it then forwards the received message. Stumbling block in this approach is more energy consumption, less accuracy and high transmission delay.

PROPOSED METHODOLOGY

Concept: The Transmission Range of every node from the base station (Sink) can be adjusted using the RSS propagation models, with the goal of accuracy and self-adaptability of model.

Using RSS, the distance of each and every node from the base station can be found and the range can be adjusted according to the distance calculated. Based on the distance we can adjust the transmission power.

Propagation models: There are three types of RSS signal propagation model. The models are free space model, 2-ray ground model and Log-Normal Shadowing Model (LNSM).

Principles of ranging: The principle of RSSI ranging describes the relationship between the transmitted power and received power of wireless signals and the distance among nodes. P_r is the received power of wireless signals and P_t is the transmitted power of wireless signal. d is the distance between the sending nodes and receiving nodes. Transmission factor (n) depends on the propagation environment:

$$P_r = \frac{P_t}{d^n} \tag{2}$$

Modules of proposed method: The proposed methods are divided into different modules; they are Deployment of nodes in WSN, Passive Clustering (CH selection using ETX and CH selection using PTX), Priority Calculation, RSS Measurement and Transmission Range Adjustment.

In Deployment of Nodes in WSN, wireless sensor networks consist of large numbers of tiny autonomous wireless devices, called sensor nodes, which perform multiple functions such as sensing, computing and communication (Banerjee and Khuller, 2001). In typical WSNs, sensor nodes (i.e., source nodes) must report the sensing or monitoring data to a central node, called the sink (Fig. 1).

In Passive Clustering Technique, the cluster-head selection has done by using ETX and PTX methods. In ETX, ETX (Expected Transmission Count) is used to measure the expected bi-directional transmission count of a link. Let ETX_{ij} be the ETX of link e_{ij} and therefore ETX_{ij} can be defined as:

$$ETX_{ij} = \frac{1}{P_{ij}^{f}\,P_{ij}^{r}} \tag{3}$$

where, P_{ij}^{f} and P_{ij}^{r} denote the forward and reverse delivery ratios from node s_i to node s_j, respectively.

In the PTX, Each node in the LCM periodically broadcasts a message to obtain the distance, forward delivery ratio and reverse delivery ratio of its neighbors, thereby making it possible to determine the

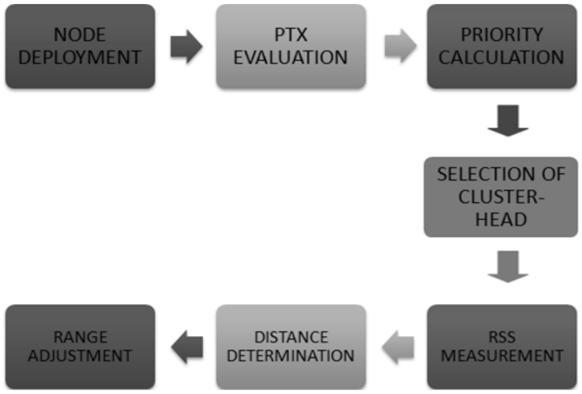


Fig. 1: Block diagram of proposed method

ETX. When node s_i, receives report messages form s_j, it can use Eq. (1) to derive the PTX, q_{ij}.

In the Priority Calculation, it is used to ensure that the high priority node becomes the CH or GW node, the Link clustering uses a random back off approach to defer the transmission of data packets. Let T^w_i be the waiting period of candidate node s_i. Then, T^w_i can be obtained as:

$$T_i^w = \frac{t_{slot}}{P_i} \tag{4}$$

where, t_{slot} is the time slot unit and rounds the value of *x* to the nearest integer less than or equal to *x*.

RSS Measurement is done by the two methods, i.e., free space model and surface bidirectional model. In free space model the transmission power of wireless signal is, the power of received signals of nodes located in the distance of d can be determined by the following formulas:

$$P_r(dB) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^4 L} \tag{5}$$

G_t and G_r are antenna gain and L is system loss factor.

In the Surface Bidirectional Model the received power is determined by the following formulas:

$$P_r(dB) = \frac{P_t G_t G_r h_t h_r}{d^4\, L} \tag{6}$$

where,

P_t = Transmit Antenna Power (Variable)
G_t = Transmit Antenna Gain (1.0)
G_r = Receive Antenna Gain (1.0)
h_t, h_r = Height of antenna (1.5)
L = Antenna loss (1.0)
d = Distance measured (variable)

The distance or range can be calculated using the formula as:

$$\text{Distance (d)} = 10^{\left[\frac{P_{tx} - P_{rx} + G - 20*\log\left(\frac{c}{4\pi f}\right)}{10n}\right]} \tag{7}$$

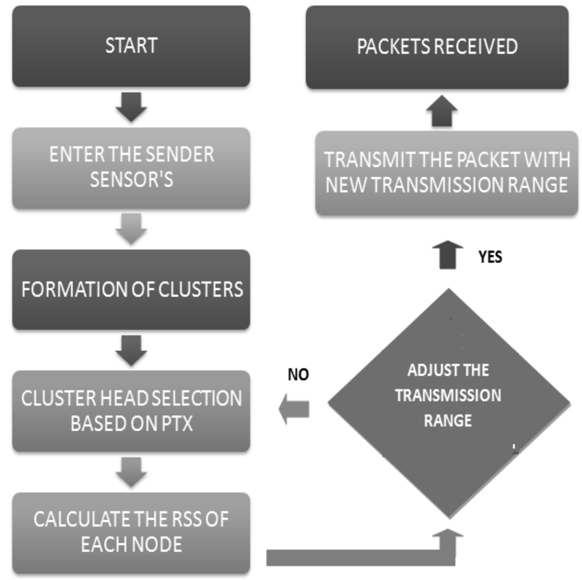


Fig. 2: Simulation flow chart of TRAP

Table 1: Simulation parameters and values

Simulator	NS 2
Channel	Wireless
Simulation run time	30 sec
Coverage area	600*600 m
Packet size	1024 bytes
Speed	1 to 10 msec
Routing protocol	AODV
Propagation model	Two ray ground
Queue type	Drop tail

Finally the Transmission Range Adjustment based on RSS measurement, the Transmission range of each and every node can be found and it is adjusted by means of increasing or decreasing the voltage supplied to every node. Thus saving the energy by means of increasing or decreasing the voltage supplied to every node according to the distance from its neighbor:

$$\text{Transmit Power} = \frac{\text{Initial Energy given to the Node}}{\text{Time taken to transmit}} \tag{8}$$

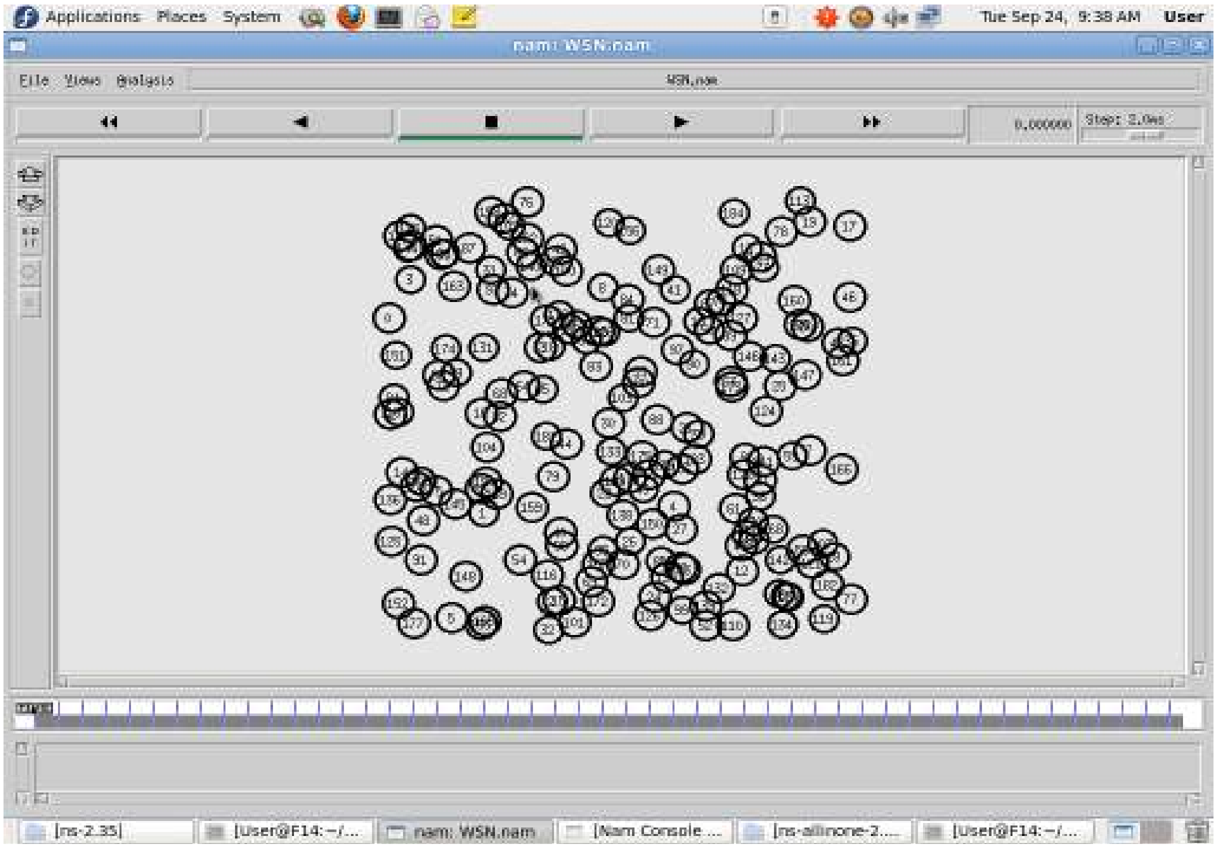
The outperforms of the proposed method are better packet delivery ratio, better energy consumption, accuracy improvement and self-adaptability.

Performance evaluation: The performance of proposed method is evaluated by using the simulator tool Network Simulator-2 and Fedora-Linux (Fig. 2). The evaluation result, i.e., the simulation parameters and values are tabulated in Table 1.

Received Signal Strength (RSS): The Received Signal Strength is calculated by measuring the transmit and receive power of the antenna used, transmit and receive

Gain the distance in meters and Signal Strength in dbm can be evaluated, the variation of RSS over distance has been observed (Fig. 3).

Packet delivery ratio: Ratio of number packets received by the sink none to the number messages send by the source node.



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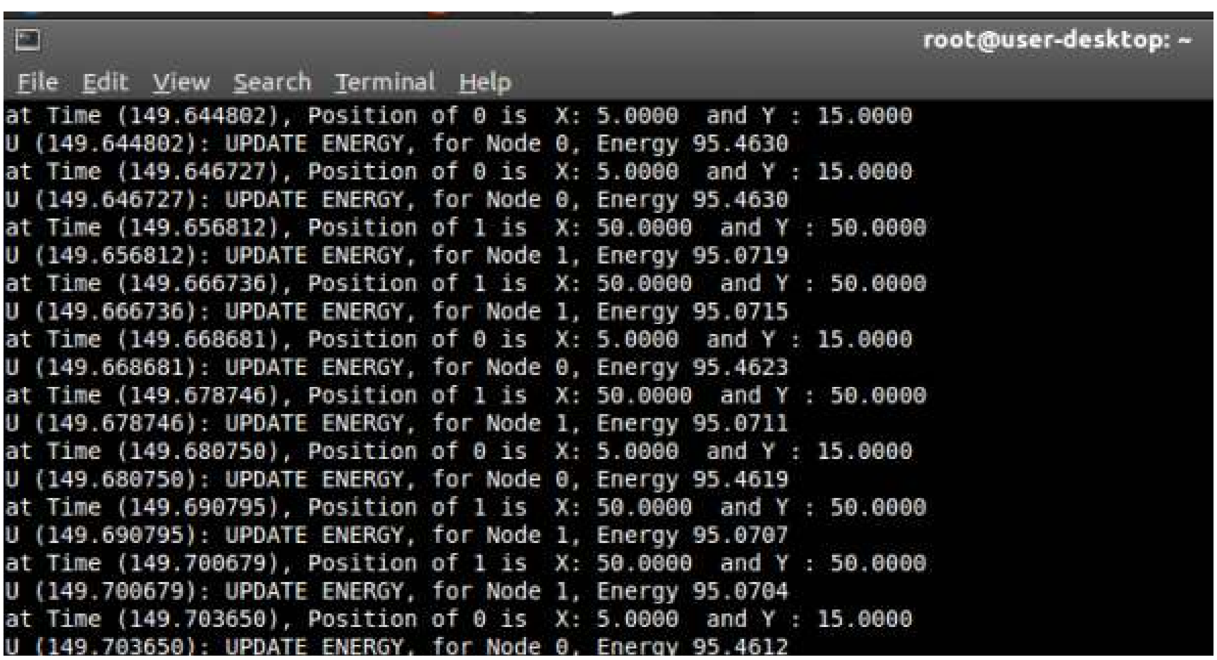

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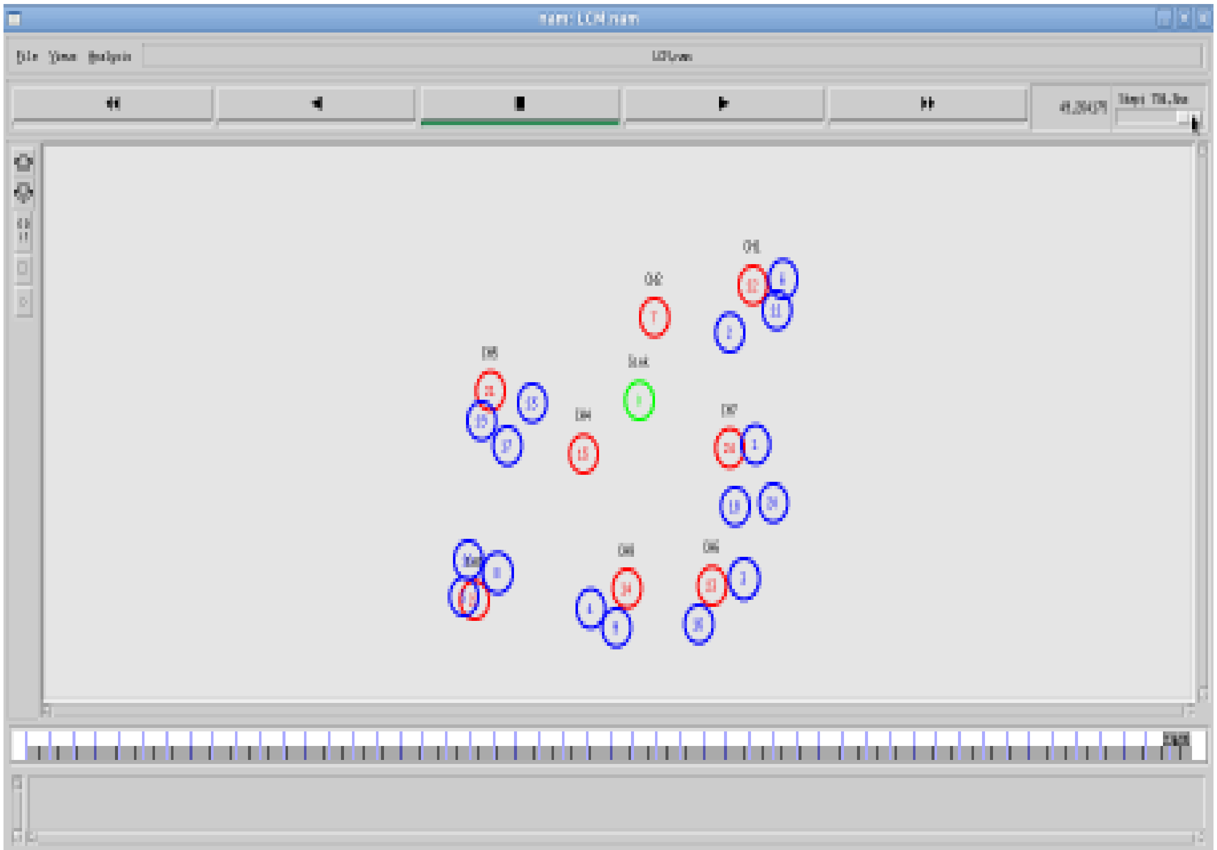

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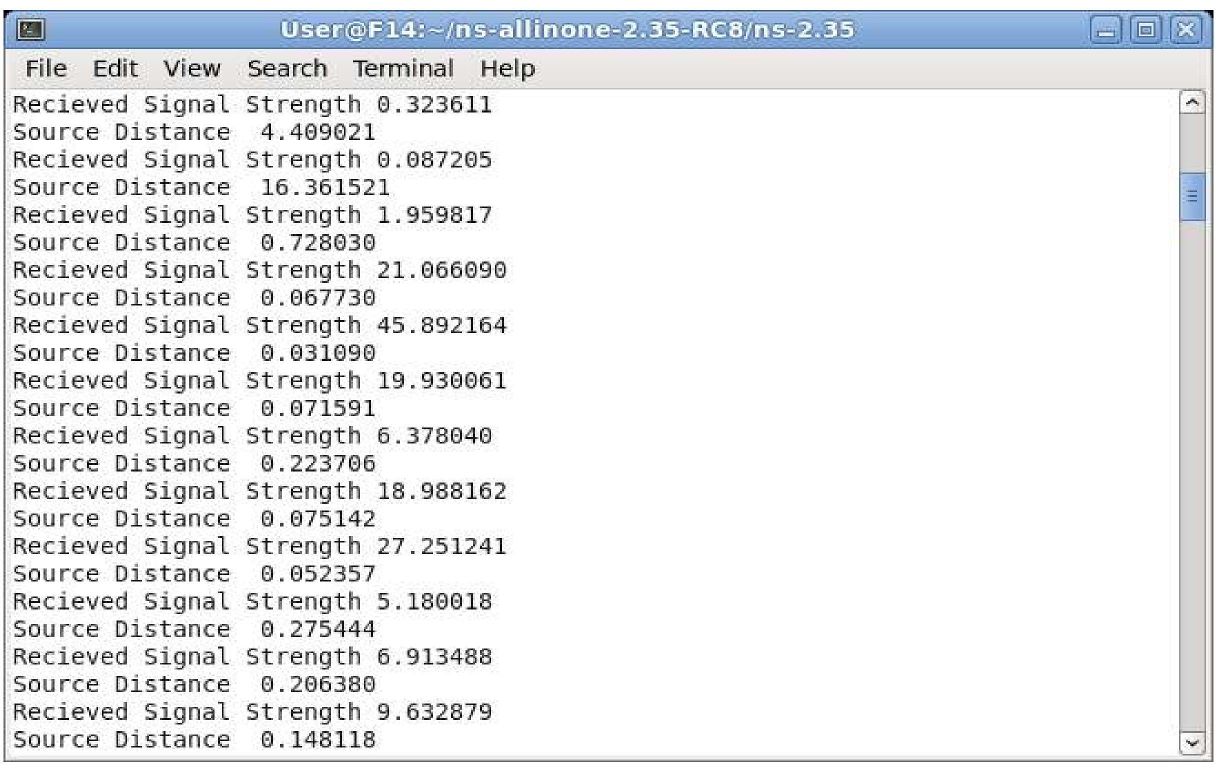
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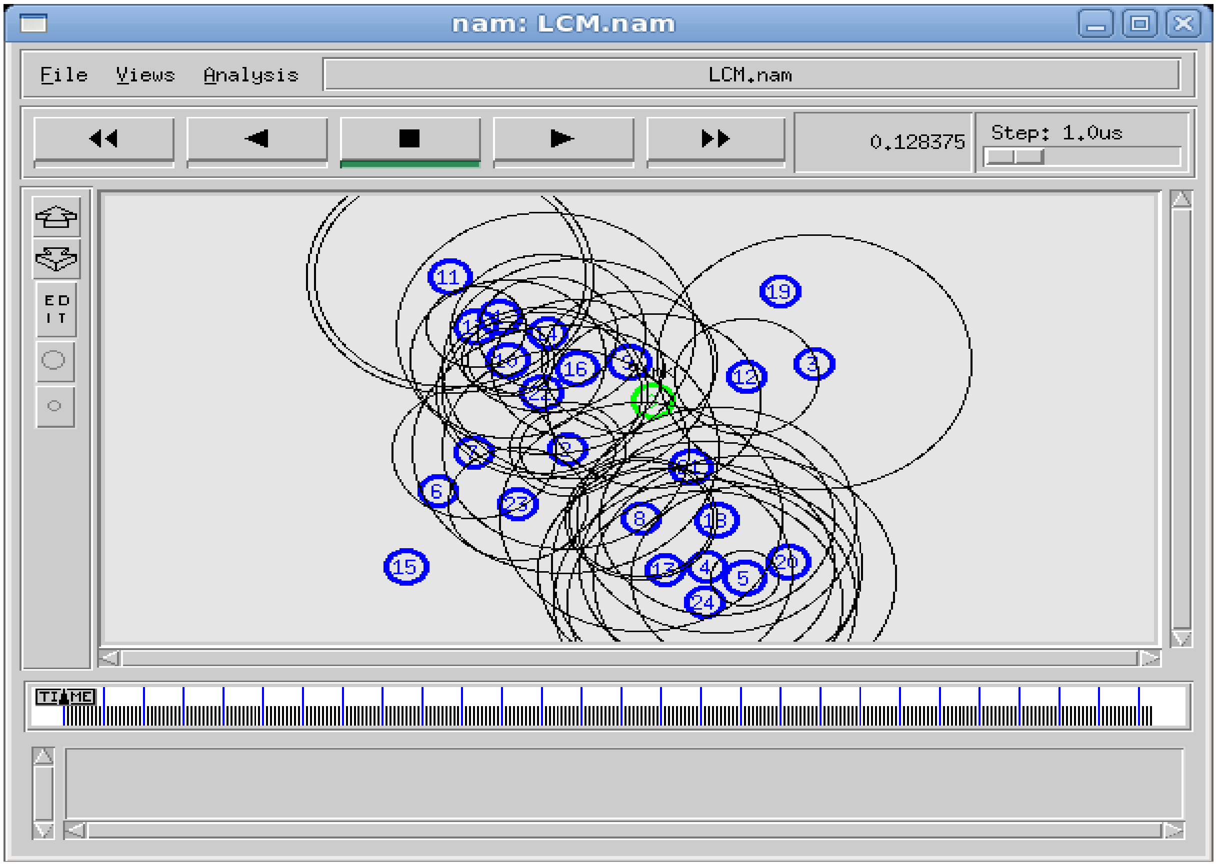
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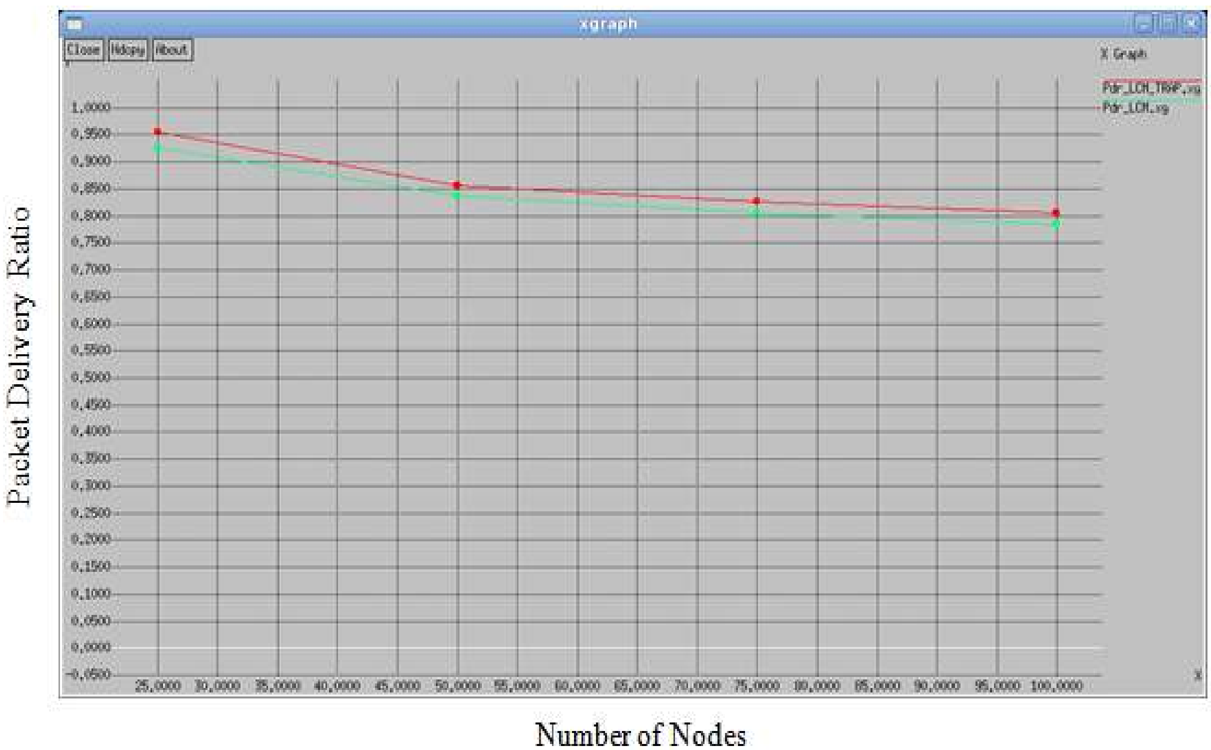
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Packet Delivery Ratio
Number of Nodes

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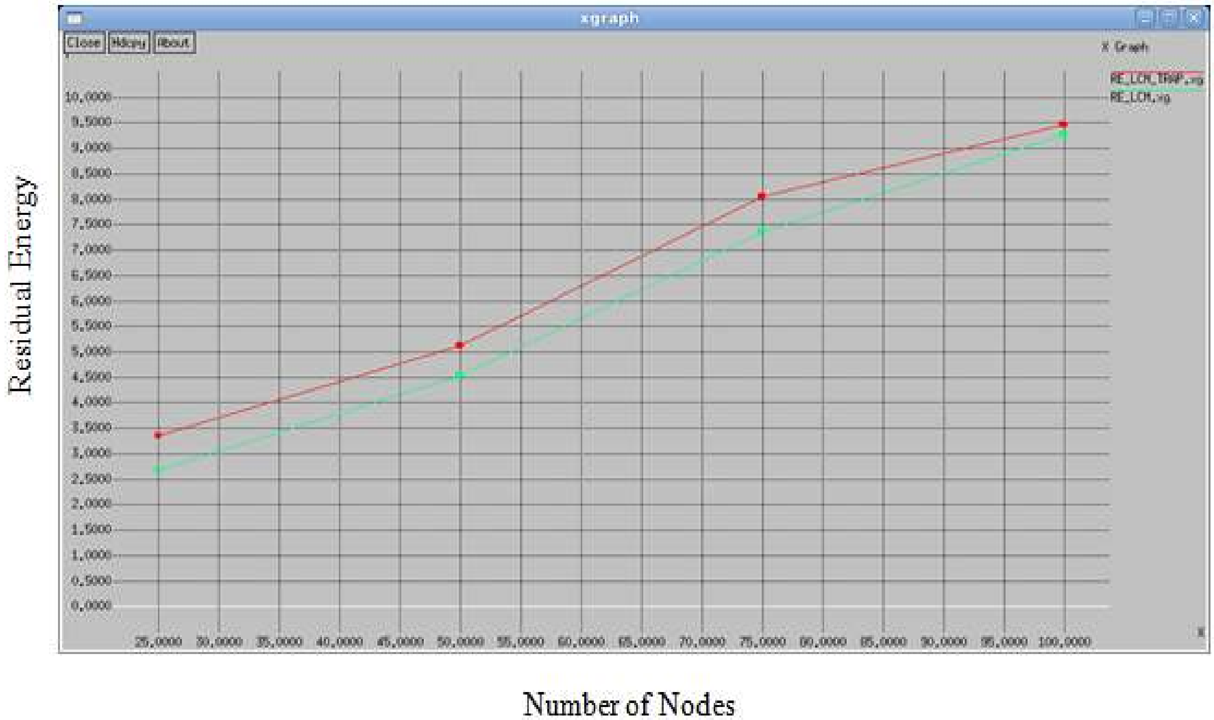

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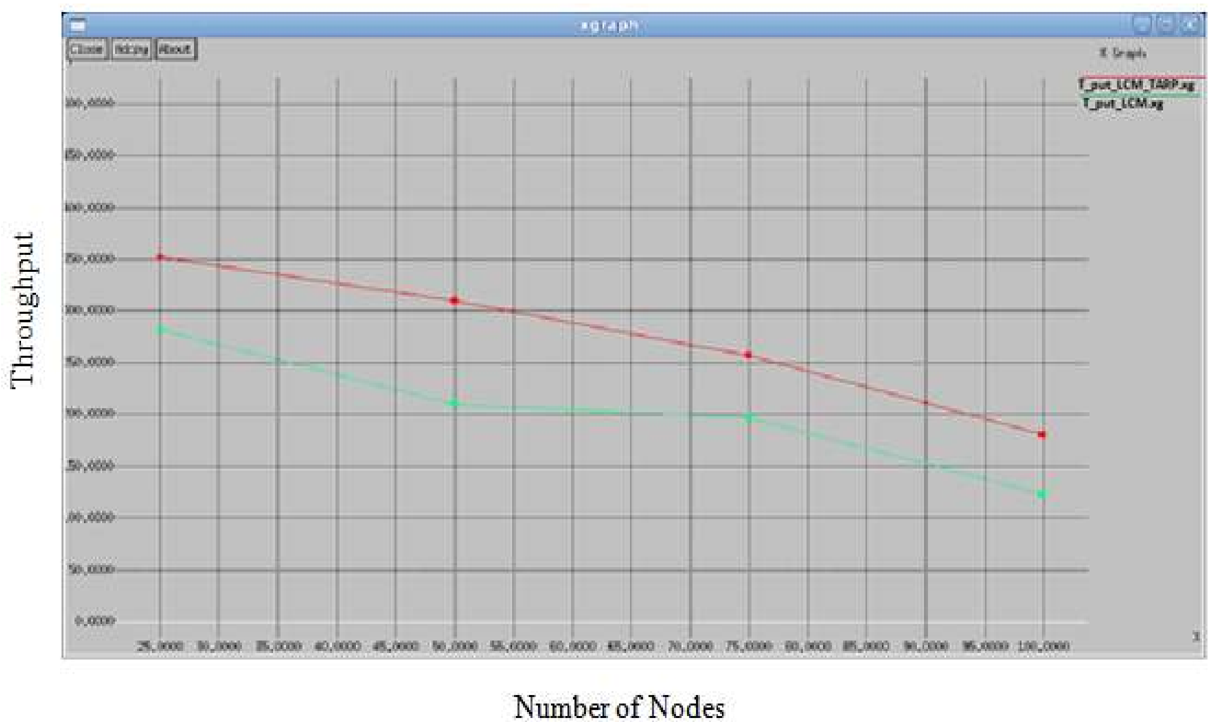

(h)

Fig. 3: Simulation results of proposed protocol, LCM with TRAP (a) deployment of nodes, (b) energy measurement, (c) cluster head selection, (d) distance measurement between the nodes, (e) simulation output of proposed protocol, (f) Packet Delivery Ratio (PDR) of LCM with TRAP and LCM (no units), (g) residual energy of LCM with TRAP and LCM for different number of sensor nodes, (h) throughput of LCM with TRAP and LCM for different number of sensor nodes

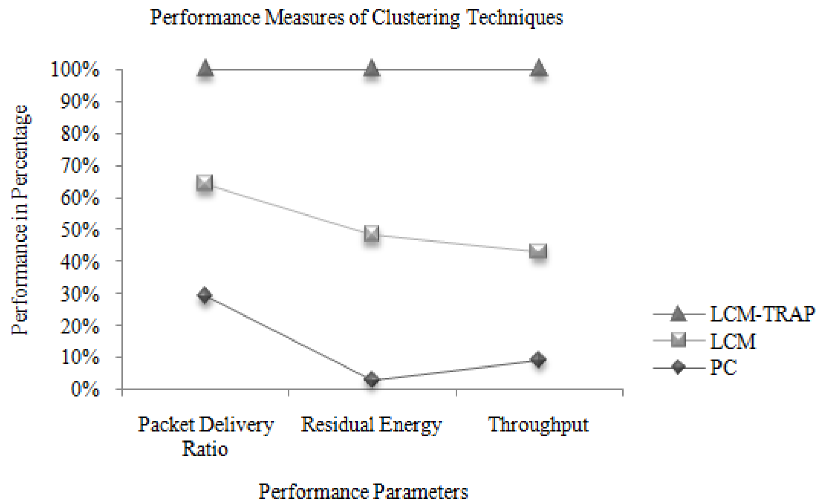

Fig. 4: Performance measures of clustering techniques

Table 2: Adjusting the power supplied to each node based on RSS

Range	1 m	10 m	25 m	40 m	50 m
P_t	0.000192278	1.92278e^{-06}	3.07645e^{-07}	5.5872e^{-04}	7.69113e^{-08}
Range	200 m	225 m	250 m	500 m	1000 m
P_t	8.91754e^{-10}	5.56717e^{-10}	3.65262e^{-10}	2.28289e^{-11}	1.42681e^{-12}

Table 3: Comparison of performance measures for three clustering techniques

Clustering techniques	Packet delivery ratio	Residual energy	Throughput
No of nodes	50	50	50
LCM-TRAP	0.8552	5.12683	351.29
LCM	0.8363	4.52689	209.10
PC	0.6971	0.30479	57.27

Delivery latency: Time taken by the data to travel from source node to the sink node.

Residual energy: Measures the value of the residual energy of all sensors in the network when the simulation terminates.

RESULTS AND DISCUSSION

The Received Signal Strength is calculated by measuring the transmit and receive power of the antenna used, transmit and receive Gain the distance in meters and Signal Strength in dbm can be evaluated, the variation of RSS over distance has been observed (Fig. 3).

Figure 1 shows the block diagram of proposed method, it shows the range adjustment of each node based on the received signal strength. Figure 2 shows the simulation flow chart of proposed protocol TRAP and it shows the transmission range adjustment based on the distance and received signal strength. Transmission power adjustment based on the received signal strength with respect to distance is calculated and tabulated in Table 2. From the Table 2 it is clear that, if the distance increases between the source and sink node, the transmission power also increases exponentially. If the distance between the source and sink is very short, then very small amount of energy only required to transmit data from source to sink. The result of LCM with Transmission Range Adjustment Protocol (TRAP) is compared with LCM and PC protocols. The LCM with TRAP having better packet delivery ratio than LCM, i.e., the packet delivery ratio PC is 0.6971, the packet delivery ratio of LCM is 0.8363 and the packet delivery ratio of proposed LCM with TRAP is 0.8552. As no. of nodes increases packet delivery ratio decreases.

The throughput of PC protocol is 57.27, the throughput of LCM is 209.10 and the throughput of proposed LCM with TRAP protocol is 351.29 (Fig. 4).

The residual energy of node is compared for the three protocols, in this proposed LCM with TRAP protocol consumes minimum energy when limited number of nodes used. The comparisons of performance measures for three clustering techniques are tabulated in Table 3.

CONCLUSION

This paper has proposed a link-aware clustering mechanism with Transmission Range Adjustment Protocol called LCM-TRAP, to provide energy-efficient routing in wireless sensor networks. The key concept is to find the signal strength of every node and determines its distance from the specific neighborhood node. Thus by means of adjusting the power supply of each node based on its distance from the neighbor prevents the nodes to transmit with its full transmission range all the time, thus reducing the wastage of Energy leading to the extension of Network Lifetime.

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