Design & development of secured energy-efficient double-stage cooperative multi-path routing protocol in multi-hop co-operative WSNs to maximize the network lifetime & minimize energy consumption

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Abstract: In this research article, the development of a stable & secured energy efficient cooperative multi-path routing protocols for the WSNs using rejuvenated double stage cooperative multi-path routing protocols for effective transfer of data packets, to increase the network's life-time and minimize the consumption of the energy, which is one of the proposed objectives. Here, design & development of an energy efficient dual stage cooperative routing protocol (DSCR) in multi-hop wireless networks maximizing the network lifetime, increasing the reliability and minimize the energy consumption, is being portrayed. The main objective of this article is to present an improvised / rejuvenated version of the dual stage data transfer scheme that computes the routing path by using cooperative mechanisms using the concept of reduced energies of the nodes. The work done is also compared with the work done by other authors in order to substantiate the effectiveness of the algorithm developed. This objective also demonstrates the various results obtained for all the test cases along with the necessary observations and explanations in the form of discussions and diagrammatic representations.

Keywords : WSN, Sink, Source, Route, Protocol, Data, Packets, Cooperation, Dual, Hop, Simulation, NS-2.

1. Introduction

A wireless based sensor network (briefly abbreviated as WSN) actually is a dedicated sensor monitoring system for recording the state or condition of a network, which consists of a number of parameters called as nodes (source, sink, base station, attackers, transponders, transmitters, receivers, etc…), the recorded data being maintained at a central location [1]-[5]. A The term "*wireless sensor network*" refers to a network of spatial based wirelessly connected devices that use different types of sensors to track the physical parameters or the environmental condition of the parameters [6]-[10]. The work of the WSN is extended to two-stage or dual hop to multi-hop networks in this proposed research work. A typical WSN is shown in the Fig. 1 [40].

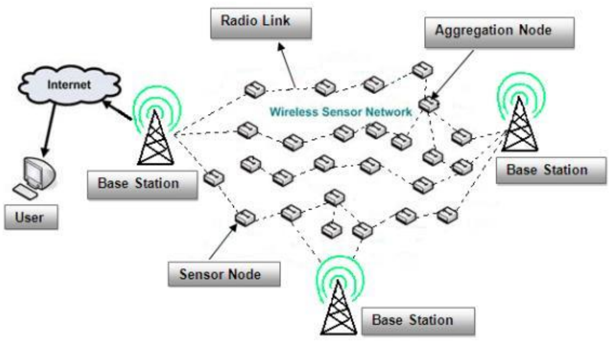

Fig. 1 : A typical WSN with components structural layout

2. Background info about the research article

Then, the two-stage link cost is formulated where *x*, the weight of residual energy, is introduced to be adjusted for different design goals. By selecting the optimal helper set, the two-stage link cost of each link can be optimized [11]-[15]. Finally, based on the designed TSC transmission model and the optimized two-stage link cost, a distributed two-stage cooperative routing (TSCR) scheme or the Dual

Stage Cooperation (DSC) is further proposed to minimize the end-to-end cooperative routing cost. Simulation results evaluate the effect of x on the different performance metrics [40]. When x equals 0, TSCR can achieve the shortest end-to-end transmission delay and highest energy efficiency, while a larger x can achieve a longer network lifetime [16]-[20]. Furthermore, simulation results also show that the proposed TSCR scheme can effectively improve both the energy efficiency and network lifetime compared with the existing schemes along with security transmissions. A dual or two stage or multi hop WSN is shown in the Figs. 2 [40].

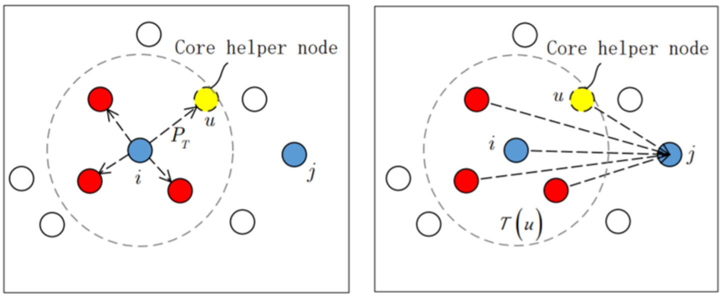

Fig. 2 : S 1: Node i broadcasts data to $T(u)$ & S 2 : $T(u)$ cooperatively beamforms data to node j [40]

3. Mathematical Model in 2 stages

In this paper, the mathematical model of the work related is presented [40]. Suppose that node i has a data X to transmit to node j (i, $j \in V$), in the proposed scheme, the data transmission can be divided into the following two stages, viz. [40],

Stage 1: Node i determines the candidate core helpers $U_{i,j}$ and selects the core helper u from Ui,j . $T(u)$ depends on the selection of core helper u. Then, node i broadcasts the packet X to the helper set T (u) with broadcast power [40].

Stage 2 : Every node $t \in T$ (u) can successfully receive the data packet X. Then, T (u) becomes a cooperative transmitting set ($|T(u)| = n$) and cooperatively transmits the packet X to node j using a joint beamforming vector $w = (w_1, w_2, \cdot\cdot\cdot, w_n)$ [40].

4. Simulation Results & Discussions

In our work, we have used the Network Simulation-2 (NS-2) as it has got a lot of advantages over the other, main being the stages of simulation can be seen, which is not possible in some of the other languages such as the Matlab [21]-[25]. The flow chart for the development of the proposed algorithm & for the efficient transfer of the data from the source to the sink is best realized in the form of a generalized data flow diagram or the flow chart in spite of terror attacks, thus securing the data packet transmissions. Once the main file, *main.tcl* is run, few files are generated in which the datas will be stored starting from the node deployment until the data is being transferred to the end point [26]-[30]. The files that are developed during the process of writing the script & during the execution of the program are large in numbers. Once the developed program is being run (*main.tcl*), the following files are generated which will help us to study the various characteristic features of the WSN. These additional files are shown in the Fig. 3 [31]-[40].

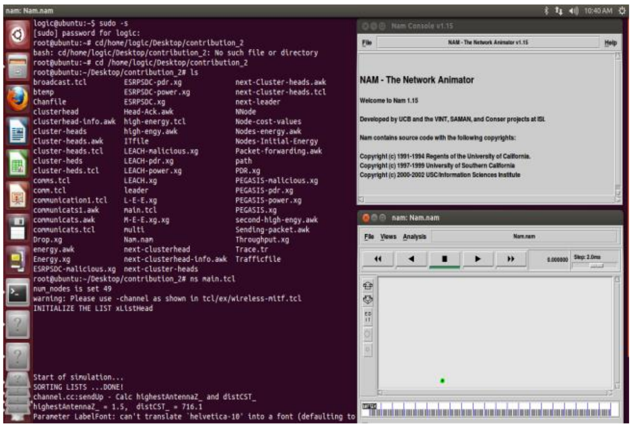

Fig. 3 : Terminal in which the NAM window & the commands are used for execution of the simulation of the 2-stage multi-hop network showing the list of files in the simulation and also indicating the start of the simulation process @ the command prompt & the program written in the NS2 command window

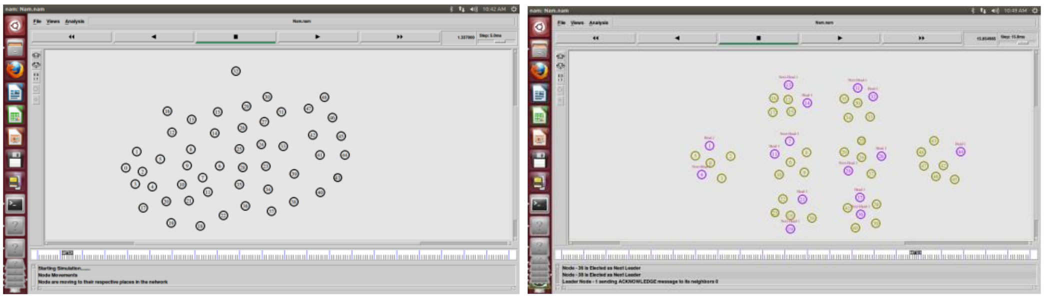

Fig. 4 : Deployment of the sensor nodes (49 in no.) starts immediately & reorganization of the groups with 2 heads, main & deputy head

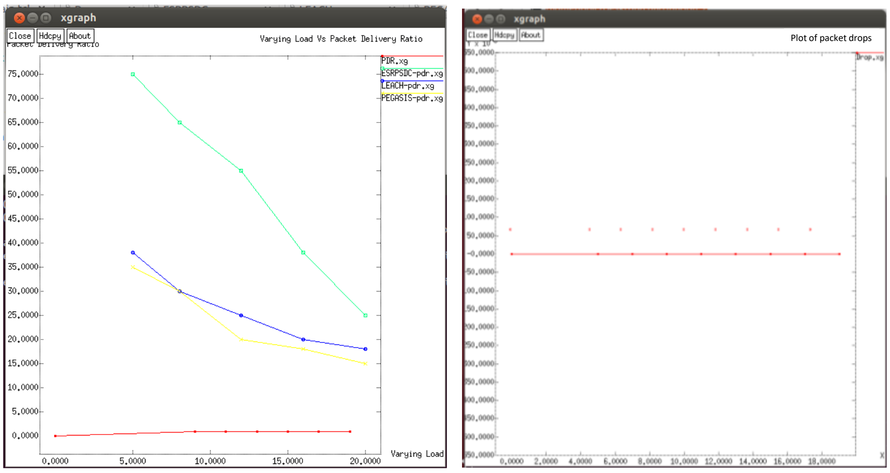

Fig. 5 : Plot of varying load v/s PDR & comparison of the proposed work with others & the plot of drop in packets showing that no packets are dropped from the sending end to the receiving end (sink)

The plot of varying load v/s PDR & comparison of the proposed work with others is graphically displayed in the Fig. 5, which shows that the proposed method (red colour) is more effective than the others (blue & green colour), thus showing the effectiveness of the methodology that was developed. The graph shows that as the load is varying, the PDR is zero compared to the existing methods such as the LEACH, ESRPSDC, PEGASIS methods [1]-[10]. In the sense, the loss exists in the other methods during the transmission of the data packets from the 2nd stage head to the sink, thus, our proposed method is more efficient compared to the others. The plot of drop in packets is graphically displayed in the Fig. 5, which shows that the proposed method (red colour) no packets are dropped, i.e., if at the sending end, 10 packets are sent and all the 10 packets are received at the receiving end, then the packet drop index will be 10 – 10 = 0, i.e., along the *x*-axis, thus, our proposed method is more efficient compared to the others [11]-[20].

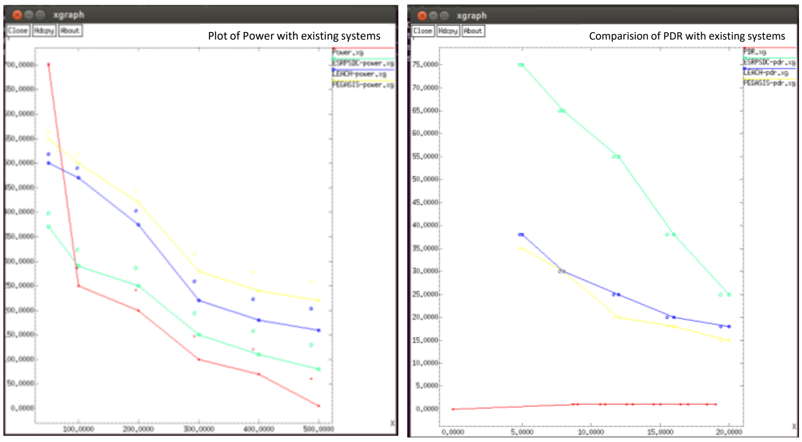

Fig. 6 : Plot of power of the proposed system & the comparision with the existing systems & plot of comparision of PDR with existing systems

The plot of throughput v/s time is graphically displayed in the Fig. 6, which shows that the proposed method (red colour), throughput is very high, thus, our proposed method is more efficient. The plot of PDR v/s time & the comparison of the proposed work with others is graphically displayed in the Fig. 6, which shows that the proposed method (red colour) is more effective than the others (blue & green colour), thus showing the effectiveness of the methodology that was developed. The graph shows that as the load is varying, the PDR is zero compared to the existing methods such as the LEACH, ESRPSDC, PEGASIS methods [21]-[30]. In the sense, the loss exists in the other methods during the transmission of the data packets from the 2nd stage head to the sink, thus, our proposed method is more efficient compared to the others. The plot of power / energy consumed & comparison of the proposed work with others is graphically displayed in the Fig. 6, which shows that the proposed method (red colour) is more effective than the others (blue & green colour), thus showing the effectiveness of the methodology that was developed. The graph shows that as the time is consumed, i.e., as $t \rightarrow \infty$, the energy of power consumed by the proposed method is very less compared to the existing methods, thus, our proposed method is more efficient compared to the others and is energy/power efficient [31]-[40]. Fig. 7 & 8 gives the plot of malicious nodes v/s end to end delay & plot of varying loads v/s packet delivery ratio & the plot of varying loads v/s end to end delay & plot of varying power consumption v/s no. of nodes.

5. Conclusions

Finally, to conclude, the proposed objective of multi-hop scenarios in the wireless sensor networks is presented. In this contributory work, we have developed an energy efficient dual stage cooperative routing protocol in multi-hop wireless networks with enhancement in their life times with parallel processing concepts and reduced energies of the nodes. The main objective of this contribution is to present an improvised version of the dual stage data transfer scheme that computes the routing path by using cooperative mechanisms using the concept of reduced energies of the nodes which could be observed from the simulated results. Algorithms were developed using NS2 tools in the Ubuntu environment, results were observed & conclusions were drawn after comparing the work done with others to show the efficacy of the proposed dual stage methodology. As a result, we can conclude that our protocol of dual hop saves more energy and can extend the network lifetime (increase lifetime) for the same number of nodes as other under-consideration schemes. Finally, the primary objective of this research was to present a dual hop concept in the WSN taking the security features into consideration, a efficient routing algorithm that computes the routing path based on energy consumption and channel efficiency, which was accomplished.

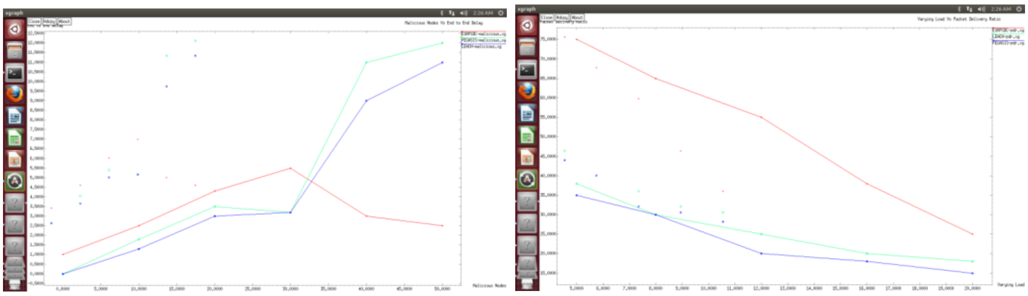

Fig. 7 : Plot of malicious nodes v/s end to end delay & plot of varying loads v/s packet delivery ratio

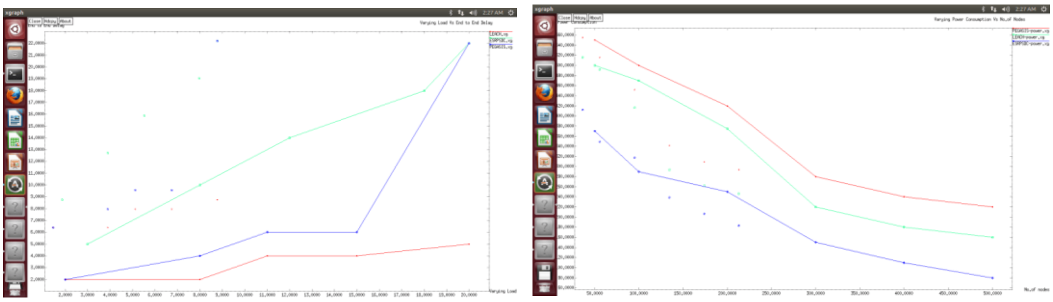

Fig. 8 : Plot of varying loads v/s end to end delay & plot of varying power consumption v/s no. of nodes

From the Figs. 3 to 8, it could be observed that the proposed dual hop routing protocol characteristics are better compared to the other ones, which shows the efficacy of the methodology that is being developed. Also, the plot of malicious nodes v/s end to end delay is more effective as the curve droops down at the delivery point, which shows that the effect of malicious nodes on the actual nodes is ineffective, which shows that the methodology developed is more secured in nature [1]-[40].

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