An Improvised Hierarchical Black Hole Detection Algorithm In Wireless Sensor Networks

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Abstract: Due to the specific characteristics, Wireless Sensor Networks (WSN) are severely unsafe and are open to malicious attacks. One of the most malicious threats to WSN is in the form of black hole attack that target the routing protocols. This genre of attacks can have a very serious impact on hierarchical routing protocols. A variety of security solutions have been put forth to safeguard WSNs from black hole attacks. However, a majority of the solutions are cumbersome and vitality inefficient. In this paper an improvised hierarchical vitality efficient intrusion detection system is proposed, to protect sensor Network from black hole attacks. Our proposed approach is simple and is based on exchange of control packets between sensor node and base station. The results show that our proposed algorithm is effective in detecting and preventing efficiently the black hole attacks.

Keywords: Black hole, Security stacks, Wireless Sensor Networks, Cluster head

I. Introduction

A WSN comprises of spatially dispersed sensor nodes, which are unified deprived of the use of any wires [1, 2]. In a WSN, sensor nodes intell...
H. et al.[10] have developed a Weighted Trust Evaluation (WTE) mechanism for ordered sensor network architecture. This mechanism is applied to Cluster Head at each sequence to detect unspecified activity.

Virmani D. et. al. [11] recommended an exponential trust based mechanism to identify malicious node. Trust factor droops down exponentially with each successive packet being dropped which aids in sensing the adversary. Janani C et. al. [12] introduced TARF a strong trust aware routing framework for WSNs mainly protects a WSN against the replay attacks and also, demonstrated to be potent against several strong attacks. A hierarchical secure routing protocol called HSRBH, has been put forth in [14] to identify and discover a secure path against black hole attacks. Symmetric key cryptography is used to determine an innocuous route against black hole attacks. Most of black hole attacks except the group leader collude with other nodes to mark black hole attack. So, it is much quicker in identifying the black hole attacks, and the message overhead is very low.

III. Proposed Method

Our simple idea is to detect and prevent black hole attacks, by implementing an intrusion detection system based on a simple strategy. In our proposal, each sensor node sends a control packet to one of agents and the Cluster Head [CH] among them at the end of transmission phase. Each control packet contains the node identifier [id], and the number of packets sent to CH [Nbrpk]. Then, base station compares the Nbrpk of each node with the amount of packets received from its agent and the CH. The mismatch in Nbrpk allows base station to detect an eventual black hole attack.

In this case, base station will broadcast an alarm packet to all network nodes. The alarm packet contains identifier of black hole node [detected CH]. All sensor nodes maintain a black hole table, which contains identifiers of detected black hole nodes. Then, each sensor node checks its black hole table before the selection of its next CH, which prevents that attacker node from being selected one more time as Cluster Head. The node with the maximum vitality backup and neighbor to more number of nodes will be selected as a second CH.

3.1. Phases

1. Selection of Agent Node
2. Determination of Neighborhood Nodes
3. Choosing a Cluster Head
4. Transmission of Control Packets
5. Detection and Elimination of Black Hole Node

3.1.1. Selection of Agent Node

The agent node is selected centered on its aloofness to the base station. The agent with least distance to the base station is selected or preferred than agent with maximum distance to the base station. The foremost aim of our work is to conserve vitality resources. The vitality consumed by the node to transfer a packet depends on the distance. Hence we conserve large amount of vitality by minimizing the distance between the agent and base station.

3.1.2. Determination of Neighborhood Nodes

The neighborhood nodes are designated based on the coverage. The nodes are considered to be the neighbor to each other when they are in a particular coverage area or range to the other.

3.1.3. Choosing a Cluster Head

Cluster Head is nominated based on the residual vitality. The node with maximum residual vitality and neighbor to more number of nodes is nominated as the Cluster Head. The role of cluster head is vitality consuming since it is continuously switched on and in control for the far-off transmissions. If a fixed node has this role, it would lose its vitality rapidly, and after it died, all its adherents would be “headless” and so useless. If the Cluster Head is detected as a black hole node then the Cluster Head is discarded.

3.1.4. Transmission of Control Packets

First the control packets are transmitted from all the nodes to the Head of the Cluster and the agent node. Then the agent node and Cluster Head will send those control packets to the base station for detection of black hole attack.

3.1.5. Detection and Elimination of Black Hole Node

When the packets are sent from the agent and Head of the Cluster to the base station the comparison of number of packets is done by base station. If there is a black hole attack then number of packets sent by the agent and the Cluster Head will differ. In case of absence of black hole then number of packets sent by the
agent and the number of packets sent by the Cluster Head will be equal. In case of detection of black hole node, the CH is discarded from the network. Fig 3.1 shows the scenario of proposed work.

![Fig 3.1 Scenario of proposed work](image)

The proposed model is explained in the flow chart as shown in fig 3.2

![Fig 3.2 Flow Chart of Proposed Algorithm](image)

3.2. Vitality Calculation

3.2.1. Vitality Equations for our work

A main task in constructing a WSN is to enhance the network life time. Nodes in a WSN are usually highly vitality-constrained and estimated to operate for longer periods. Accurate prediction of sensor network lifetime requires an accurate vitality-ingesting model. In this paper, a comprehensive vitality model is adopted [15] that includes sensing, logging and switching energies apart from the processing and communication vitality values. The network set up shown in consumes vitality by transmitting packets, receiving packets, overhearing, switching vitality, and sensor logging. The nature of the sensor nodes determine the processes involved in consuming vitality. For example, the sink node need not involve in overhearing and hence, it does not consume vitality in overhearing of packets from neighbouring nodes.

Sensor logging consumes vitality used for reading ‘b’ bit packet data and writing it into memory.

\[
E_{\text{log}}(b) = E_{\text{write}} + E_{\text{read}} = b \cdot (E_{\text{write}} + E_{\text{read}}) \tag{1}
\]

where, \(E_{\text{write}}\) is vitality consumption for writing data, \(E_{\text{read}}\) is vitality consumption for reading ‘b’ bit packet data, \(I_{\text{write}}\) and \(I_{\text{read}}\) are current for writing and reading 1 byte data.

Communication of neighboring sensor nodes is enabled by a sensor radio. Vitality dissipation by a sensor node can be attributed to transmitting and receiving data. According to [8], the vitality dissipation due to transmitting ‘b’ bit packet, in a distance \(d\) from sensor node to the neighbor is given by (2)
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\[ E_{\text{trans}}(b, d_j) = b \times E_{\text{elec}} + b d_j^\gamma \times E_{\text{amp}} \]  

(2)

where, \( E_{\text{elec}} \) is the vitality dissipated to transmit or receive electronics, \( E_{\text{amp}} \) is the vitality dissipated by the power amplifier, and \( n \) is the distance-based path-loss exponent. Here, free space spading is assumed and so \( n \) takes the value 2. Vitality dissipation due to receiving ‘b’ bit packet from the sensor node is given by:

\[ E_{\text{recv}}(b) = b \times E_{\text{elec}} \]  

(3)

The switching vitality component [17] is the vitality consumed for switching the radio state between states, including normal, power down and idle modes. The following equation determines the vitality consumed for switching the radio from sleep mode to active mode:

\[ E_{\text{switch}} = \left( I_{\text{active}} - I_{\alpha} \right) \times T_{\text{active}} \]  

(4)

where \( I_{\text{active}} \) is the current draw of the radio in active mode, \( I_{\alpha} \) is the current draw of the radio in sleep mode \( \alpha \), and \( T_{\text{active}} \) is the time required for the radio to go from sleep mode to active mode.

In the vitality model [16] that incorporates overhearing, the total vitality expenditure due to a transmission from node \( i \) to \( j \) is given by,

\[ E_{\text{trans}}(b, d_j) = b \times E_{\text{elec}} + b d_j^\gamma \times E_{\text{amp}} + \lambda^j \times E_{\text{recv}}(b) \]  

(5)

Hence, the total vitality consumed by a node is given by,

\[ E_{\text{total}} = E_{\text{elec}} + E_{\text{switch}} + E_{\text{active}} + E_{\text{recv}} + E_{\text{log}} \]  

(6)

\( E_{\text{total}} \) is the total vitality consumed by each and every node, \( E_{\text{elec}} \) is the vitality consumed due to processing of packets, \( E_{\text{switch}} \) is the switching vitality.

The total vitality consumed by the Cluster, CH\( j \) per round is given by equation (7).

\[ E_{\text{CH}}(j) = E_1 + E_2 + E_3 + E_4 + E_5 + E_6 + E_7(7) \]

where,

\[ E_1 = h_2 \times b \times V_{\text{sup}} \times I_{\text{sense}} \times T_{\text{sense}} \]

stands for vitality due to sensing,

\[ E_2 = h_4 \times b \times V_{\text{sup}} (I_{\text{write}} \times T_{\text{write}} + I_{\text{read}} \times T_{\text{read}}) \]

is the data logging vitality,

\[ E_3 = h_1 \times b_1 \times N_{\text{cy}} \times C_{\text{cug}} \times V_{\text{sup}}^2 (n_j + 1) \]

is the vitality spent due to switching,

\[ E_4 = h_1 \times b_1 \times V_{\text{sup}} (I_0 \times e^{(V_{\text{sup}}/N_{\text{cy}} T)}) \left( N_{\text{cy}} / f \right) (n_j + 1) \]

stands for the leakage vitality

\[ E_5 = h_2 \times b_2 \times (1 + \gamma) \times d_j^\gamma \times E_{\text{amp}} \]

is the transmitting vitality consumed by the nodes to the CH,

\[ E_6 = T_{\text{CH}} \times V_{\text{sup}} [C_{\text{CH}} \times I_{\text{A}} + (1 - C_{\text{CH}}) i_5] \]

is the vitality spent during transient

\[ E_7 = E_{\text{actu}} \times N_{\text{actu}} \]

is the actuation vitality.

**IV. Experimental Results And Comparisons**

We assume a network of 12 nodes to recognize the black hole attack. The simulation is done in c++. The vitality spent for transmission, reception of packets is also calculated.

4.1 Neighbourhood Node Detection

The neighbourhood node detection phase include two steps one is coordinate generation and the distance calculation.
Fig 4.1. Coordinate Generation for all the Nodes

Coordinate generation includes the generation of the coordinates for each and every node in the network. Our simulation results produce coordinates for all the nodes. Fig 4.1 shows the coordinates for a network of 12 nodes. Distance calculation is an important metric in the neighbourhood detection. The nodes which are in a particular coverage are said to be the neighbour nodes. Fig 4.2 shows the distance of each node from other nodes. This distance calculation of each node to other nodes is helpful to find the neighbourhood nodes.

Fig 4.2. Distance calculation of neighbourhood nodes

The Fig 4.2 shows the number of neighbour nodes to a particular node and indicate their node name along with them. From the it is known that the number of neighbourhood nodes for node 1 is 8.
4.2. Selection Of Agent Node

The selection of agent node phase includes the distance calculation and comparison. The agent node selection will be centered on their aloofness to the base station. Hence it is the first and foremost reason to calculate the distance between each and every node and the base station.
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4.3. VITALITY CONSUMPTION
The vitality required for transmission, reception of packets is calculated for all the nodes and the Cluster Head. The Fig 1.8 shows the result of comparing both existing algorithm and proposed algorithm for different number of nodes. It is proved that the proposed algorithm provides a large amount of vitality consumption. Hence our proposed work is said to be vitality efficient.

![Fig 4.5. Cluster Head Detection](image)

![Fig 4.6. Vitality Consumed for Different Number of Nodes](image)

V. Conclusion
In [13] they recommended an intrusion detection mechanism to detect the black hole attack which is vitality inefficient. We proposed an intrusion detection system which is vitality efficient, to secure network nodes from black hole attacks. Our approach is simple and is based on the exchange of control packets between sensor nodes and base station. Therefore, BS takes the part of monitor node to detect any black hole attack. Our proposal mitigates significantly the effect of the black hole attack. Simulation effects show that the recommended methodology has a improved performance in the IDS in terms of security and vitality consumption. As a future work, sensor nodes can also be simulated as black hole nodes along with the CH and an efficient mechanism can be devised.

References
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