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Secure Cluster Head Selection In WSN Integrated With IOT

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ABSTRACT

Internet of Things (IoT) is of great significance in the future and is rapidly developing by connecting heterogeneous devices with several technologies. One of such network is Wireless Sensor Network (WSN) that is integrated with IoT. This interconnectivity of different networks leads to the risk of confidentiality and security of data. WSN routing protocols such as LEACH (Low Energy Adaptive Clustering Hierarchy) is prone to a large number of attacks and one of them is a HELLO flood attack. In this paper, HSRP (Hello flood attack Secure Routing Protocol) an extension to LEACH protocol is proposed for protecting the CH (Cluster Head) against Hello flood attack. HSRP makes data encryption with the help of Armstrong number and decryption with AES algorithm so as to verify CH identity. The proposed technique can be used to protect IoT from HELLO flood attack consisting of various WSNs. The proposed HSRP is implemented by making use of network simulator NS2, the results indicate that the HSRP has a substantial ability to detect flooding attack HELLO for creating the malicious node as CH.

KEYWORDS: Internet of Things, Wireless sensor network, Hello flood attack, Armstrong number, Cluster head.

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INTRODUCTION

Internet of Things (IoT) is a universal network architecture used to provide facilities in the physical world by analyzing and processing data. Wireless sensor network (WSN) composed of low power sensor nodes, along with Big Data and cloud computing led to a great expansion of IoT. Figure 1 shows the integration of WSN and IoT. This combination of various technologies can be used to place multiple sensor nodes everywhere, so that valuable information needed for collection can be obtained. This will help in data collection in places without appropriate infrastructures and communication. The integration of WSN and IoT include a large number of applications including remote patient tracking, medicine, environment monitoring, active volcanoes, toxic vapors industrial sites, radioactive areas, etc. One of the most important issues of this integration is to provide security and confidentiality of the data.

In this paper, an effective protocol for detecting HELLO flood in WSN is proposed when it is integrated with IoT. LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is used for the implementation of WSN. LEACH is used for clustered implementation of WSN making use of Received Signal Strength (RSS) so as to dynamically select Cluster Heads (CHs). LEACH is also exposed to HELLO flood attack in case a malicious node is selected as CH.

Cryptographic methods used for the prevention of a HELLO flood attack are not so supportive and certain non-cryptographic methods for detecting HELLO Flood attack exist but they lack efficiency

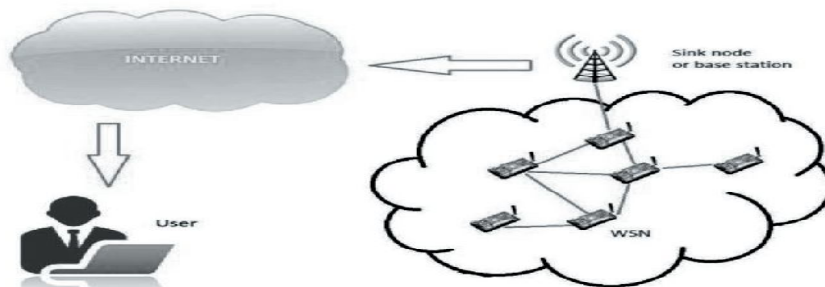


Figure 1: IoT & WSN integration

due to large test packet overhead. In this paper, HSRP (Hello flood attack Secure Routing Protocol) as an extension to LEACH protocol is proposed to protect CH from HELLO flood attack. HSRP makes use of encryption using Armstrong number. The decryption is done with the help of AES algorithm so as to verify the identity of CH. The technique is implemented with the help of NS2 for the implementation of WSN. The results show that HSRP has substantial ability for recognition of HELLO flood attack which is launched for creating CH by the malicious node. The network layer attack Hello flood in WSN initiated when the attacker sent or replay hello packets used

for neighbor discovery with the help of high power of transmission. This is done by creating an illusion of neighborsensor node to other nodes so as to disrupt underlying routing protocol. The attacker makes use of high transmission power to broadcast hello packets so that most of nodes in the network selectattacker as CH in LEACH protocol. The sensor nodes in the network are convinced that their neighbor is the attacker node. The nodes response to HELLO message generated by the malicious attacker and as a result are forced to energy waste, thus resulting in a confused state.

Heinzelman et al.² Introduced LEACH protocol for routing in the sensor networks, whichdivides the network into small clusters in which one sensor node is selected as CH and others as cluster members. The CH after gathering data from nodes send it to the Base Station (BS) and this CH is periodically re-elected. LEACH is divided into Setup and Steady phase used for the formation of the clusters along with CH and sending data to the BS. CHs are randomly changed and it is very hard to spot CHs. If attacker becomes a CH, then the HELLO flood attack can be easily launched. In our previous work¹, a large number of measures to tackle with a Hello flood attackare discussed.In this paper, HSRP as an extension to the LEACH protocol is proposed. HSRP is based on Armstrong number encryption and AES algorithm decryption so as to validate CHfor preventing WSN from Hello flood attack. HSRP can be used with different WSNs integrated with IoT so that secure communication is possible.

I. RELATED WORKS

In this section of the paper, the proposed work regarding selecting and securing CH's using the LEACH protocol in WSN is discussed.

LEACH protocol was proposed by Heinzelman et al.²in which each of the sensornode has equal probability to be elected as CH. This protocol extendsthe lifetime of the network by allowing every sensor node to play role as CH. In LEACH protocol, sensor nodes with high remaining energy declare themselves to be CHs so that other nodes join as cluster members. LEACH assumes that there are no compromised nodes in the network, and therefore has no method for protecting cluster formation. F-LEACH³ was one of the extensions to LEACH proposed to defend the clusterformation from malicious nodes in the network. F-LEACHmakes use of common keys that are shared with BS in case a sensor node wants to become a CH, so as to check the authenticity of the node to become CH. The sink broadcast secure authentication for CHs using μ TESLA is proposed in⁴. Normally nodesin the network join one legitimateCH, this methodprovide no way to validatesensor nodes which join any one of the clusters. For resolving this issue, Oliveira et al.⁵ proposedSecLEACH. In this proposed work, BS is used to authenticate CH nodes while the CHs are further used to authenticate joining of sensor nodes. Both SecLEACH and F-LEACH requires nodes to be assigned

pre-assigned keys for the purpose of verification before deployment. LEACH and SecLEACH only help the network in external attack prevention from the attackers before joining of cluster formation process, i.e. these protocols are not able to protect CHs from internal attacks.

Various extensions⁷⁻¹¹ to LEACH protocol in the past have been proposed, but the majority of these focus on energy consumption balancing over all the available nodes so as to extend the network lifetime. Few of these⁸ extensions deal with secure election of CH. However, most of these extensions are not able to prevent malicious nodes from CH declaration as it can cheat other sensor nodes pretending having short distance with large residual energy. Liu¹³ proposed a method of cluster formation in which pre-determined sensor nodes only can be declared as CHs. Other sensor nodes are allowed to join any cluster either via a relay node or directly. Any CH allocation or cluster joins is done by some pre-assigning of polynomial share, therefore this method protects network from any external attacker during the process of cluster formation. The method proposed avoids a compromised relay node from invoking a DoS (Denial of Service) attack by the process of removing CH and its serving nodes connection. Sun et al.¹⁴ in the work proposed a protected method for cluster formation which is used for checking protocol conformity of nodes so as to discriminate malicious nodes. In this work, physical network transformation is done into cliques so that members can be connected openly to each other in a clique. After clique is formed, each node in the clique checks whether every member has the similar clique membership view or not. The methods of¹⁹ have enhanced¹⁴ safety, but with the assumption that during cluster formation no collisions are possible. This type of assumption used is very difficult to implement without using special measure like TDMA schedule assignment along with separation code. Nishimura et al.²¹ in the work, proposed a method by allocating a trust value to every cluster node of CH in which most trusted are allowed as CH. The limitation of this work is that it produces a lot of overhead communication for trust evaluation system and is not appropriate in the case of resource-constrained sensor network.

Rifa-Pous et al.²⁰ based on the public key cryptography in the paper proposed a protected cluster formation method. The proposed method contains three phases; the phase of cluster discovery, the phase of CH designation, and the phase of cluster maintenance. In the first phase of cluster discovery, every node in a cluster is given same view as far as membership is concerned with other nodes in the cluster. In the second phase of the cluster designation, election of CH is considered on the basis of a number of times already elected as CH in the past including number of its neighbors. In the cluster maintenance phase, CH that has been elected to provide a certificate of authorization to each cluster member. The limitation of this method is that it assumes no node departs from participating of cluster discovery. Crosby et al.²¹ in the paper proposed a CH election based on trust where each of the node provides trust values to another on the basis of behavior and trust so that

trustworthy nodes are elected as CHs. A node behavior is counted by occurrence of successful and unsuccessful node transmissions. The more a node is successful in its transmission, the more superior reputation it has. During the process of electing new CH, nodes having more reputation value are suggested by cluster members for role of CH so that one of them is elected as a new CH.

Buttayan et al.²² proposed a CH selection scheme using cryptographic which hides the election process from outside nodes. But, the proposed work of concealment tackles with only external attackers. A compromised node in the network can expose the selection result with no trouble. The malicious node in the network can declare itself as a CH without having the eligibility. Sirivianos et al.²⁴ proposed SANE (Secure Aggregator Node Election) protocol. In this protocol all the legal CH members of a cluster contribute in producing random value so that CH may be elected based on this random value. SANE is further divided into three sub-schemes based on the generation and distribution of random value. The scheme makes use of Merkle's puzzle, commitment scheme, and scheme based on seeding. Dong et al.²⁵ in the work proposed scheme for preventing attackers from participating in the process of election by making use of ID assignment scheme, which binds ID of the node, its polynomial shares and commitments. In this method, nodes not broadcasting participation message are not allowed for participating in CH election and are excluded from the process of electing CH candidates. The CH is selected among one of the rest of the candidates, but still attacker may change election result of CH by escaping distribution of participation message. Although, this method provides recovery system by combining various election results into one, but there is requirement of co-operation of CH candidates.

II. MATERIALS AND METHODS

The proposed HSRP to be used for detecting and isolating Hello flood attack in sensor network is discussed in this section of the paper. The WSN model along with assumptions is discussed first, followed by working of the proposed protocol.

A. WSN Model

The WSN considered to be a clustered network having N static sensor nodes. The network includes special sensor nodes called CH and BS along with member nodes. CHs collect information from their clusters and then pass them to the BS for the purpose of making decisions/judgments. LEACH protocol is used for the formation of clusters in which every sensor node has a unique identity (ID). HSRP makes use of the following assumptions for the WSN.

- 1) Hello flooding attack sensor node is the compromised CH.
- 2) The attacker sensor node has a high power transmission.

- 3) All the sensor nodes in the network other than malicious nodes have same initial energy, power of transmission, power of computing, internal structure of storage, etc.
- 4) Nodes are allocated ID's that cannot be changed.
- 5) The Unique Armstrong number is allocated to each sensor node.
- 6) All the nodes in the network consume the same amount of energy for working on the same stage.

B. Implementation of HSRP

The HSRP is used as an improved extension to LEACH protocol with more security, therefore the proposed protocol make use of features of clustering used in the LEACH protocol. The working of LEACH protocol is divided into the steps of set-up and stable phase. In the first phase of set-up, all the nodes in the WSN follow the guidelines of fairness criterion along with randomness criterion. In first and fairness criteria every sensor node in the WSN has equal probability of becoming a CH. While in the second randomness criterion, random way is used for the election of CH. The chance of a node to be elected as CH entirely depends on two things. First whether the node is elected as CH in past recent rounds. Second, percentage of CH's IN the WSN. After the election of CH's in the WSN, each member chooses a cluster to join it on the basis of maximum RSS (Received Signal Strength) till the completion of all clusters.

Each cluster sensor node member has the responsibility of sensing surrounding of it, i.e. environment so as to forward data to CHs respectively. The CH's after collecting this information from member nodes forward the information to the BS. The LEACH protocol is vulnerable against Hello flood attack because of these characteristics. Hello flood attack is one of the common routing attacks used in the WSN in which the malicious node broadcasts a huge number of hello messages to the sensor nodes with very higher transmission power in the WSN. The sensor nodes receiving such a hello message will consider malicious node as their CH. After becoming the CH, malicious node may create damage in WSN by modifying or discarding data received from cluster members.

C. Malicious CH determination

The BS of the WSN makes use of registration table in order to maintain records of created CHs and members of clusters along with malicious nodes as different sets. These set values are regularly updated as per the changes made in the CHs and clusters. The following are the initial values for these sets

Set $CH_{node} = \{null\}$, to store CHs in the WSN.

Set $CH_{member} = \{null\}$, to store members of clusters in the WSN.

Set $CH_{malicious} = \{null\}$, to store detected malicious nodes in the WSN.

Each of the sensor nodes in the WSN tries with a definite probability (p) to become CH following the criterion of both randomness and fairness. The nodes that are able to become CH broadcasts hello message for clustering so as to attract sensor nodes to join it. The CH(i) is selected with the level of RSS so as to join in a specific area range. The members calculated by CH for the cluster are included in the set CH_{member} .

a) Unique ID allocation

The BS is used to allocate a unique ID number to each of the sensor nodes in the WSN. The request of any sensor node for becoming CH is accepted only if it provides allocated unique ID to the BS in order to fulfill node validation.

b) Unique Armstrong number allocation

The BS is also given the responsibility of allocating a unique Armstrong number for each ID to the sensor node in WSN. Armstrong number is defined as m (digit) base n no. so that sum of its (base n) digits raised to the power m is no. itself. For example, $371 = 3^3 + 7^3 + 1^3 = 27 + 343 + 1$ is an Armstrong number. Any sensor node can become CH by sending an Armstrong number, encrypted hello message to the sensor nodes in the WSN. Table 1 displays a sample registration table which is maintained at BS.

The flowchart of figure 2 represents the working of HSRP for the purpose of authenticating CH by the BS. HSRP is a more secure version of the LEACH protocol as only authenticated sensor nodes in the WSN are allowed to become CH's. It becomes very difficult for a malicious node to become CH by only having high transmission power. Therefore, HSRP provides a secure network for the purpose of communication in the WSN.

Table 1: BS registration table

Sensor number	Allocated unique ID	Allocated Random Armstrong Number
001	S0001	153
002	S0002	407
.	.	.
.	.	.
N		54748

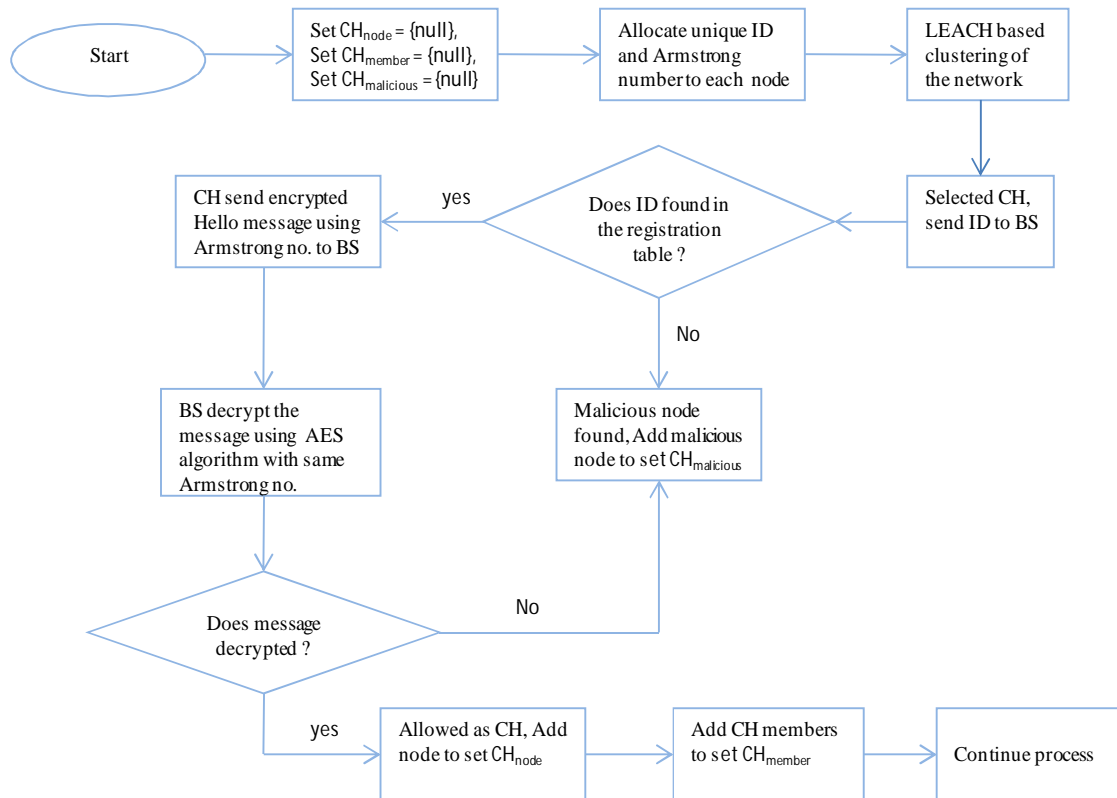


Figure 2: Proposed HSRP

III. RESULTS AND DISCUSSION

This part of paper presents results produced with the help of the simulation carried out in NS 2.35 to show HSRP effectiveness. The parameters of the simulation are shown in table 2.

A. Throughput

Network throughput is defined as the average rate of effectively delivered packets. Throughput calculation is done as:

$$\text{Throughput} = (\text{Total no. of packets delivered}) / (\text{Simulation time});$$

The figure 3 displays throughput for WSN with, without, and under Hello flood attack. The figure also displays implementation of proposed HSRP. The proposed protocol after isolating Hello flood attack increases throughput.

Table 2: Parameters of Simulation

Parameter	Value
Simulator	Network simulator 2.35
Area in meters	800X800
Nodes	50
Routing protocol	LEACH
Type of Channel	Wireless
Size of Packet	512 byte
Model for Mobility	Two ray ground propagation model

B. Packet delivery ratio

Packet delivery ratio (PDR) of WSN is the ratio of total packets received to total packets generated. PDR is defined as

$$\text{PDR} = (\text{Packets received at destination} / \text{packets generated by source}) * 100$$

Figure 4 displays PDR analysis for without attack, under attack, and implementation of HSRP. The figure 4 indicates that HSRP results in the increase of PDR.

C. Delay

Delay is the average time required to deliver the packet at the destination, including the process of route discovery and queue time for packet transmission. Delay is calculated as:

$$\text{Delay} = \sum (\text{arrive time} - \text{send them}) / \sum (\text{Number of connections})$$

Figure 5 provide end-to-end delay in WSN without attack, under attack, and HSRP implementation. The figure indicates that HSRP results in the decrease in delay.

D. Overhead

Overhead is a measure of excess time by a protocol for delivering packets to the destination. Hello flood attack results in increase of overhead in WSN. Figure 6 display overhead for WSN without attack, under attack, and for HSRP. The HSRP decreases overhead for WSN as shown in figure 6.

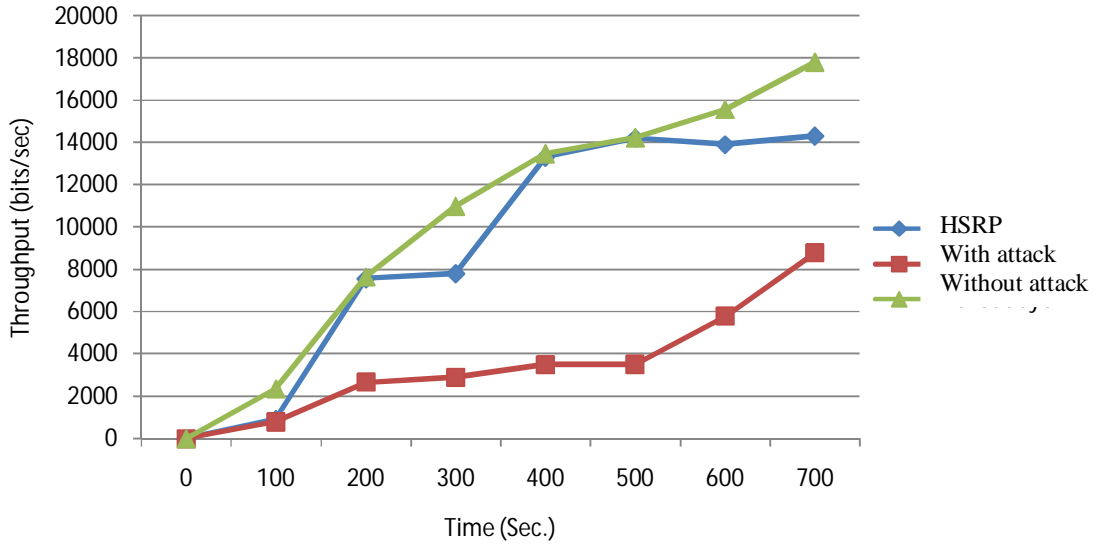


Figure 3: Throughput

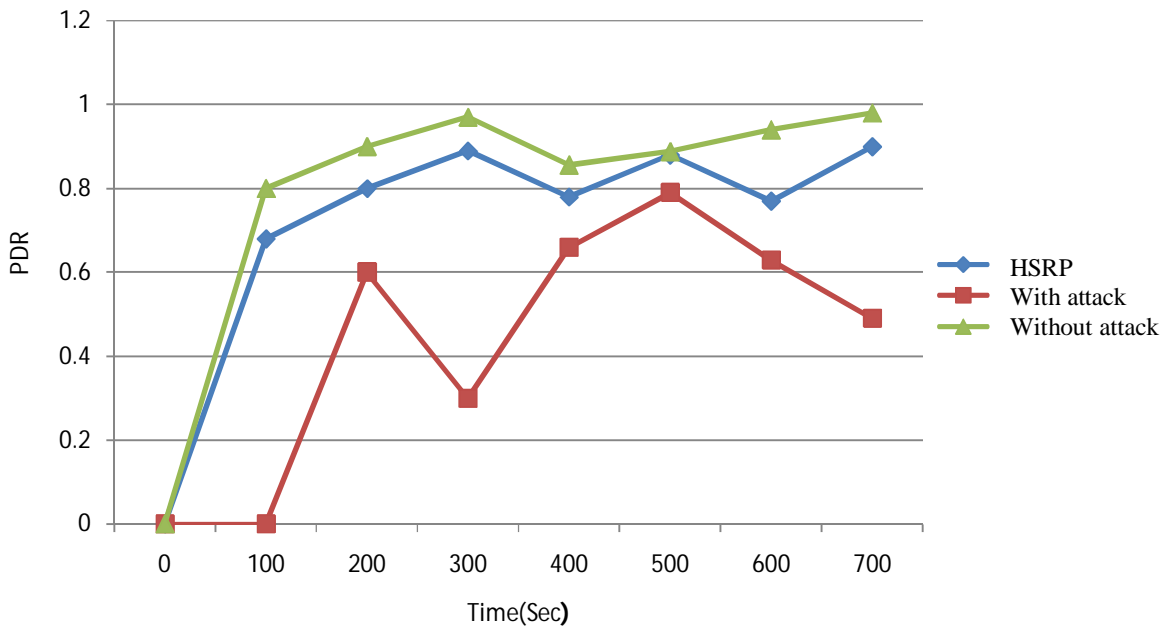


Figure 4: PDR

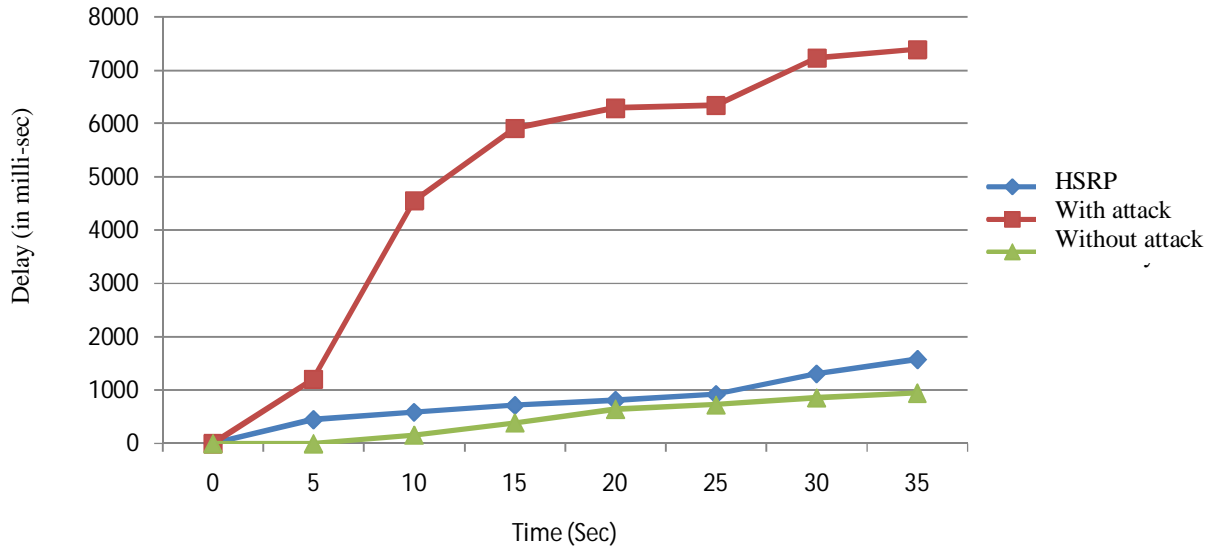


Figure 5: Delay

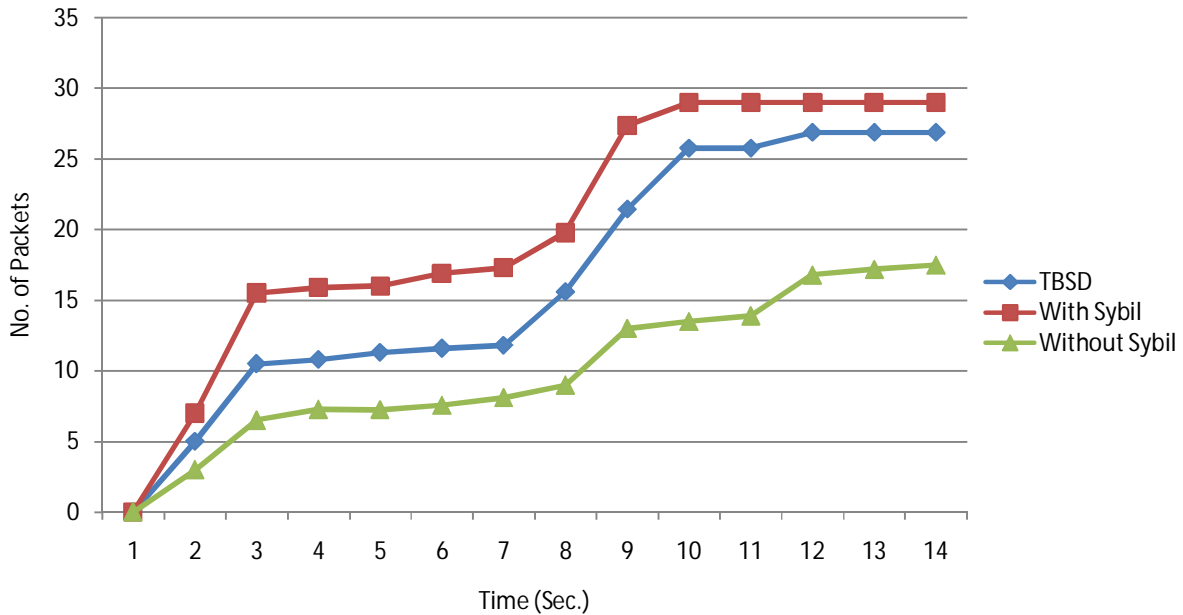


Figure 6: Overhead

IV. CONCLUSION

IoT make use of various network technologies for communication of physical objects. IoT also make use of different wireless sensor networks connected together so as to gather data present at separated locations. The huge progress in the services of IoT needs authentic security mechanism. The selection of cluster head in a secure way in wireless sensor network is important as all the

communication between the sensor nodes and base station is done via the cluster head. Hello flood attack can be launched in sensor network so as to make cluster head compromised. In this paper, HSRP (Hello flood attack Secure Routing Protocol) as an extension to LEACH protocol in sensor networks is proposed. HSRP is based on Armstrong number encryption and AES algorithm decryption. HSRP can be used to increase performance by timely detection of malicious nodes and avoiding the sensor nodes from such a mean cluster head. The IoT make use of different sensor networks connected together via different network technologies so as to share the information gathered. The proposed HSRP can be used to protect different WSNs from Hello flood attack in IoT. The proposed HSRP is implemented with the help of NS2 and show the efficiency for parameter packet delivery ratio, throughput, overhead, and delay. The results of simulation show HSRP expels compromised nodes in the clusters. Further, simulation with more parameters will be done to increase number of sensor nodes in future.

REFERENCES

1. Singh R, Singh J, and Singh R. Hello flood attack Countermeasures in Wireless Sensor Networks. *International Journal of Computer Science and Mobile Applications* 2016;4(5), 2016;1-9.
2. Heinzelman W. R., Chandrakasan A., Balakrishnan H. Energy-efficient communication protocol for wireless microsensor networks. In the proceedings of the 33rd Annual Hawaii International Conference on System Sciences. 2000.
3. Ferreira A. C., Vilaca M. A., Oliveira L. B., Habib E., Wong H.C., and Loureiro A. A. On the security of cluster-based communication protocols for wireless sensor networks. *Proc. of 4th IEEE Int'l Conf. on Networking*, Reunion Island, France. 2005; 17-21.
4. Perrig A. et al. SPINS: Security Protocols for Sensor Networks. *Wireless Networks*. 2002; 8(5):521-534.
5. Oliveira L. B. et al. SecLEACH-a random key distribution solution for securing clustered sensor networks. *Proc. of 5th IEEE Int'l Symp. on Network Computing and Applications*, Cambridge, Massachusetts, USA., 2006.
6. Shen Y., Liu S., Zhang Z. Detection of Hello Flood Attack Caused by Malicious Cluster Heads on LEACH Protocol. *International Journal of Advancements in Computing Technology*. 2015; 7(2).
7. Kang S. and Nguyen T. Distance Based Thresholds for Cluster Head Selection in Wireless Sensor Networks. *IEEE Communications Letters*. 2012; 16(9):1396-1399.

8. Han Y., Park M., and Chung T. SecDEACH: Secure and Resilient Dynamic Clustering Protocol Preserving Data Privacy in WSNs. Proc. of the 2010 Int'l Conf. On Computational Science and Its Applications. 2010; 6018(1): 142-157.
9. Katiyar V., Cand N., Gautam G. C. and Kumar A. Improvement in LEACH Protocol for Large-scale Wireless Sensor Networks. Proc. of Int'l Conf. On Emerging Trends in Electrical and Computer Technology. 2011;1070-1075.
10. Saadat M., Saadat R. and Mirjality G. Improving Threshold Assignment for Cluster Head Selection in Hierarchical Wireless Sensor Networks. Proc. of Int'l Symposium on Telecommunications. 2010; 409-414.
11. Ren P., Qian J., Li L., Zhao Z., and Li X. Unequal Clustering Scheme based LEACH for Wireless Sensor Networks. Proc. of Fourth Int'l Conf. on Genetic and Evolutionary Computing. 2010;90-93.
12. Devi G., Sankar R., and Sahoo N. Hello Flood Attack Using BAP in Wireless Sensor Network. International Journal of Advanced Engineering Research and Science. 2015; 2(1).
13. Liu D. Resilient Cluster Formation for Sensor Networks. Proc. of 27th Int'l Conf. on Distributed Computing Systems. 2007; 40-48.
14. Sun K. et al. Secure Distributed Cluster Formation in Wireless Sensor Networks. Proc. of 22nd Annual Computer Security Applications Conference. 2006; 131-140.
15. Mayur S., Ranjith H. D. Security Enhancement on LEACH Protocol From HELLO Flood Attack in WSN Using LDK Scheme. International Journal of Innovative Research in Science, Engineering and Technology. 2015; 4(3).
16. Rawan S., Suhare M., Manal A. Intrusion Detection of Hello Flood Attack in WSNs Using Location Verification Scheme. International Journal of Computer and Communication Engineering. 2015; 4(3).
17. Kaur D., Singh R. Energy level based Hello Flood attack Mitigation on WSN. International Journal of Embedded Systems and Computer Engineering. 2015.
18. Jyoti, Bansal A. Detection of Hello Flood Attack on Leach Protocol Based on Energy of Attacker Node. International Journal of Innovations & Advancement in Computer Science, 2015; 4(1).
19. Wang G., Kim D., and Cho G. A Secure Cluster Formation Scheme in Wireless Sensor Networks. Int'l Journal of Distributed Sensor Networks. 2012.
20. Rifà-Pous H. and Herrera-Joancomartí J. A Fair and Secure Cluster Formation Process for Ad Hoc Networks. Wireless Communications. 2011; 56(3): 625-636.

21. Crosby G. V and Pissinou N. Cluster-based Reputation and Trust for Wireless Sensor Networks. Proc. of the 4th IEEE Consumer Communications and Networking Conference. 2007; 604-608.
22. Buttyan L. and Holczer T. Private Cluster Head Election in Wireless Sensor Networks. Proc. of the Fifth IEEE Int'l Workshop on Wireless and Sensor Network Security, IEEE. 2009;1048-1053.
23. Magotra S., Kumar K. Detection of HELLO flood Attack on LEACH Protocol. IEEE International Advance Computing Conference. 2014.
24. Sirivianos M. et al. Non-manipulable Aggregator Node Election Protocols for Wireless Sensor Networks. Proc. of Int'l Sympo. on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks. 2007;1-10.
25. Dong Q. and Liu D. Resilient Cluster Leader Election for Wireless Sensor Networks. Proc. of IEEE 6th Annual Comm. Society Conf. on Sensor, Mesh and Ad Hoc Communications and Networks. 2009;108-116.
26. Nishimura I., Nagase T., Takehana Y., and Yoshioka Y. Secure Clustering for Building Certificate Management Nodes in Ad-Hoc Networks. Proc. of 14th Int'l Conf. On Network-Based Information Systems, Tirana, Albania. 2011.
27. Steffi J., Priyanka A., Tephillah S., and Balamurugan A. M. Attacks and countermeasures in WSN. International Journal of Electronics & Communication. 2014; 2(1).
28. Saini S. K., Gupta M. Detection of Malicious Cluster Head causing Hello Flood Attack in LEACH Protocol in Wireless Sensor Networks. International Journal of Application or Innovation in Engineering & Management. 2014; 3(5).
29. Dubey A., Meena D., Gaur S. A Survey in Hello Flood Attack in Wireless Sensor Networks. International Journal of Engineering Research & Technology. 2014; (1).
30. Singh V. P., Aishwarya S., Ukey A., and Jain S. Signal Strength based Hello Flood Attack Detection and Prevention in Wireless Sensor Networks. International Journal of Computer Applications. 2013; 62(15).
31. Fatema N, Brad R. Attacks and counterattacks on wireless sensor networks. International Journal of Ad hoc, Sensor & Ubiquitous Computing. 2013; 4(6).
32. Wanjari A., Dhamdhare V. Evading Flooding Attack in MANET Using Node Authentication. International Journal of Science and Research (IJSR). 2014; 3(12).
33. Haghighi M. S., Mohamedpour K., Varadharajan V., and Quinn B. G. Stochastic Modeling of Hello Flooding in Slotted CSMA/CA Wireless Sensor Networks. IEEE transactions on information forensics and security. 2011; 6(4).

34. Singh V. P., Jain S., and Singhai J. Hello Flood Attack and its Countermeasures in Wireless Sensor Networks. *International Journal of Computer Science Issues*. 2010; 7(3).
35. Venkata C., Singhal M., Royalty J., and Varanasi S. Security in wireless sensor networks. *Wireless communications and mobile computing* Published online in Wiley Inter Science. 2006.
36. Khozium M. O. Hello Flood Counter Measure for Wireless Sensor Network. *International Journal of Computer Science and Security*. 2(3).
37. Hamid A., Rashid M., Hong C. S. Defense against laptop class attacker in wireless sensor network. *The 8th International Conference Advanced Communication Technology*. 2006.
38. Thiago H. et al. Malicious Node Detection in Wireless Sensor Networks. *18th International Parallel and Distributed Processing Symposium*. IEEE. 2004.
39. Singh J., Gupta S. and Kaur L. A MAC Layer Based Defense Architecture for Reduction-of-Quality (RoQ) Attacks in Wireless LAN. *International Journal of Computer Science and Information Security*. 2010; 7(1).
40. Singh J., Gupta S. and Kaur L. A Cross-Layer Based Intrusion Detection Technique for Wireless Networks. *The International Arab Journal of Information Technology*. 2012; 9(3).
41. Kumar, Alampalayam S., Vealey T., and Srivastava H. Security in internet of things: Challenges, solutions and future directions. *System Sciences (HICSS)*. 2016.
42. Khalil N., Abid M. R., Benhaddou D., Gerndt M. Wireless Sensors Networks for Internet of Things. *IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) Symposium on Public IoT*. 2014.
43. Zorzi M., Gluhak A., Lange S., Bassi A. From Today's Intranet of Things to a Future Internet of Things: A Wireless and Mobility-Related View. *IEEE Wireless Communication*. 2010; 43–51.