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CONTENTS

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A LITERATURE REVIEW OF TECHNIQUES OF CONCEALING SINK NODES IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless Sensor Networks (WSNs) have been used in a variety of applications to observe various objects. The location security of the Base Station is becoming one of the major issues in WSN due to its critical placement. The issue requires great protection. The privacy of the message can be protected through encryption content. This paper formalizes a novel efficient privacy preserving scheme to secure sink node location. The aim is to keep the location security of the base station from being located by using the traffic flow passive analysis. F-CSH is based on the hiding of the location of the main sink using fake sink holes been elected using fuzzy score function. Also, evaluations prove that the F-CSH technique greatly reduces both the delivery time and conservation energy cost as compared to existing strategies. The overall motive of this paper is to make a comparison of the various secured sink based techniques. At the end of the paper, suitable future directions to enhance this work further are provided.

KEYWORDS
F-CSH, multiple path segments, sink privacy.

1. INTRODUCTION

A Wireless Sensor Network (WSN) is a network composed of resource-constrained devices having limited capabilities, and are called the sensors. The sensors are equipped with wireless communications facilities. These sensors send data to the main node in the Wireless Sensor Network (WSN) which is called the Base Station (BS). The Wireless Sensor Networks (WSNs) are deployed in a variety of applications. The applications of Wireless Sensor Networks (WSNs) vary from homeland security to environment sensing, health monitoring, forest fire detection, manufacturing tasks and many more applications.

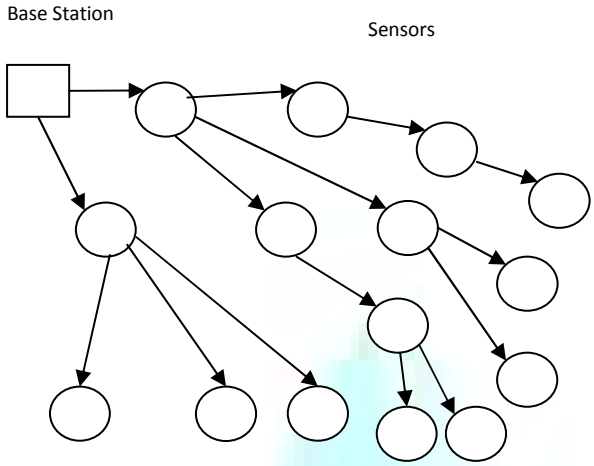
The messages in the Wireless Sensor Network (WSN) are subject to many of the vulnerabilities. The messages may be eavesdropped from the channel and fake messages may be injected into the network without the need of physical access to the network components. The Wireless Sensor Network (WSN) is subject to eavesdropping at the nodes level too. If an opponent gets full access over a node, he may steal the important information from the node, or may change the programming of the node and hence change its behavior, or may physically damage the hardware. In addition, the topology needs to be kept care of. A Wireless Sensor Network (WSN) needs to be secure for its proper functioning. The main features of a secure Wireless Sensor Network (WSN) are the availability, integrity, confidentiality, privacy, authorization, and authentication. A WSN needs to possess these features to work as a secure WSN.

The security of a Wireless Sensor Network (WSN) is challenged by many of the attacks to the WSN. The attacks in the Wireless Sensor Network can be categorized into many of the categories depending upon their intent and the effect. The attacker is an insider or an outsider; the attacks are active or passive; what is the actual purpose of attack, are the main considerations for the categorization of the attacks. Many of the attacks in the wireless sensor network can be categorized as Active Attacks, Passive Attacks, Flood Attacks, Black hole Attack, Denial of service Attack (DoS), Sybil Attack, Information Alteration, Worm Holes, Looping, and Node Replication.

- **Active Attacks** are the attacks in which the attacker causes physical damage in the network like destruction of resources, change of data, changing traffic direction or restriction of data to sink nodes.
- **Passive Attacks** are another types of attacks in which the attackers only observe various activities on the network, extract private information but don't cause any physical destruction or any change of information. Passive attackers can launch active attacks.
- In **Flood Attacks**, Hello messages are flooded in the network. The attacker pretended that the sender of the packet is in their neighbor, therefore when the sender node want to send any sensed information to a sink node, then they forward it towards the attacker node.
- In **Black Hole Attacks**, the attacker nodes act like a black hole, where the attacker node sees the route request packets from its neighbors and replies them back using fake information about shortest route toward sink node. Therefore, any node which wants to send data to a base station will forward it towards attacker.
- In **Denial of Service (DoS) attack**, the attacker sends extra packets in the network without any need and keeps the route as well as the base station busy. So the legitimate users are unable to send data, access resources and get services.
- In **Sybil Attacks**, a node changes its ID continuously and attacker nodes using multiple identities of the legitimate sensor nodes at the same time.
- In the **Information Alteration Attack**, an attacker may spool the data in the middle of communication, and he may alter the complete message or a part of it to misguide the base station.
- In the **Worm Holes Attack**, the whole traffic of the network is sent in a particular direction at a distant place, which causes restriction of data receiving in the other parts of the network.
- In **looping attack**, few nodes in the network cause the circulation of data in a restricted region which stops the data to send to the destination node.
- In the **Node Replication Attack**, the attacker adds a new sensor node in the network, which is using the ID of a trusted user and can attack any node or sink node by pretending himself as a trusted user.

F-CSH is a fuzzy based scheme for concealing sink node with fake holes. The scheme uses the traffic flow passive analysis for concealing sink node. The algorithm works in three phases. The three phases are Network Discovery Phase, Fake Sink Holes Announcement Phase and, Data Delivery Paths Phase. In the Network Discovery Phase, the sink node broadcasts the identification message holding the id. Each node estimates how far it is from the sink node using the RSSI (Received Signal Strength Indication) of this message. Each node broadcasts this message to every other node. During the Fake Sink Holes Announcement Phase, nodes calculate their fuzzy score based on the residual energy of the node, connectivity factor and the centrality factor of the node. The nodes with the highest fuzzy function are selected as the fake sink holes of the current round. In the Data Delivery Phase, nodes send multi-casted packet holding the address of its fake sink hole and randomly one of the nearest neighbors to the target real sink node. This method is repeated by the intermediate nodes on the path from the source node to the real sink.

FIG. A: WIRELESS SENSOR NETWORK



2. LITERATURE SURVEY

Since the location privacy of the sink node is an important issue in wireless sensor networks (WSNs), it requires great protection. A. Din et al. [1] proposed an original and capable privacy protecting method to protect the sink node location. The scheme keeps the location privacy of the sink node from being known. The method uses the traffic flow passive analysis. The method elects fake sink holes for concealing the location of the main sink. The election of the fake sink holes is based on the fuzzy logic.

Black hole attack occurs when a mediator investigates and re-programs some of the nodes in the network. The mediator blocks/drops the packets and generates false messages towards the base station. B. Mishra et al. [2] studied the techniques proposed for the identification and prevention of black hole attack in wireless sensor network. These identify the black hole attack and provide the successful delivery of data to the base station. It is observed that the techniques suffer from very little false positives. A number of security algorithms like AES, DES, XXTEA have been proposed to deal with the black hole attack. The features of each of the algorithms has been studied and compared.

R. Banerjee et al. [3] proposed a new scheme for optimal energy utilization. The scheme is based on cluster based routing protocol. The sink node is considered to be mobile. The cluster head is selected by using the fuzzy function. Agent node selection algorithm is also used for selecting cluster head and Agent node. In addition to the node's energy, the node's distance to Base Station and node's distance to other members is also considered while calculation the fuzzy score. The new protocol is compared with the traditional LEACH protocol. The Simulation results show that the network lifetime improves by an average of 50% in comparison to the traditional LEACH protocol.

Black Hole presents a shortest path to the destination node but in reality it drops all packets. So, security is threatened. G. Pathak et al. [4] proposed a new protocol to protect against the Black Hole attack in Wireless Sensor Networks (WSNs). The protocol uses the Hierarchical Cluster Topology. The proposed protocol has been compared with one of the existing approach in terms of packet delivery ratio, throughput and end-to-end delay using Network Simulator Tool NS2. The new protocol is robust against both single and cooperative Black Hole attacks in a dynamic environment.

In a sinkhole attack, an attacker compromises a node or introduces a fake node inside the network and uses it to commence an attack. J. Chaudhry et al. [5] described the problems in investigating sinkhole attacks in WSNs. Many approaches such as the anomaly-based, rule-based, statistical, cryptographic and hybrid approaches are available for the sinkhole attack detection and prevention. The choice of the approach depends on the particulars of the WSN in question. For example, WSNs where new nodes are not added after initial setup are suited for a rule based approach. A WSN where the sensor nodes are difficult to challenge and have sufficient power are suited for a cryptographic approach.

In a WSN, a large number of sensor nodes are identified to spread out in a geometric region, with close by nodes communicating with each other directly. W. Wei et al. [6] studied the topology discovery with boundary recognition in a wireless sensor network. The scheme detects the holes in the topological architecture of sensor nets only by connectivity information. PPA (Poincare-Perelman Theorem) has been designed to decide whether there are holes in WSNs-monitored areas. The theorem can detect holes on the topological surfaces. These surfaces can, then, connect into meaningful boundary cycles. The method has been proved to be suitable for continuous geometric domains as well as for discrete domains. The algorithm even gives good results in networks with low density.

Coverage holes have become an important problem in Wireless Sensor Networks (WSNs). Coverage is an important pointer to measure if the wireless sensor networks' performance is good or bad. J. Yang et al. [7] proposed two algorithms based on the traditional VOR algorithm to develop the coverage holes recovery. The simulation results establish that these algorithms make holes recovery more effective than the traditional algorithm. The proposed algorithms are the VORP and VORCP algorithm. The results show the betterment of the proposed algorithms in terms of both performance and efficiency.

A wide variety of attacks are known that the wireless sensor networks could suffer. The attacks affect the power consumption and performance of these networks. P. Sanchez et al. [8] simulated the most familiar and dangerous attacks that a WSN can experience. NS-2 and OMNET++ are the simulators that have been used to model WSNs. The simulation technique used is the native HW/SW Co-Simulation. The proposed virtual platform includes a HW node, embedded SW, a RTOS, a wireless sensor network and attack models. The simulations show that three types of attacker nodes have been identified: link-noise, fake-packet injection and direct attack nodes. The affect of these attacks on power utilization and software execution time are also studied. The results show that the given technique is able to investigate the functional and power utilization impact of attack on WSNs.

Security is of major concern in Wireless Sensor Networks (WSNs). M. Khan et al. [9] identifies different challenges and necessities for security of wireless sensor networks. A number of security methods for wireless sensor networks had been proposed. The weaknesses of existing methods have been identified. Different security threats and possible attacks have been analyzed. Different security protocols like the SNEP protocol, TESLA with Instant Key Disclosure (TIK), REWARD have been discussed. The existing security approaches proposed by different researches with their basic characteristics have also been analyzed. However attack identification and prevention has been abandoned.

L. Feng et al. [10] proposes a multi-path energy hole avoidance routing algorithm based on genetic algorithm (GA). The algorithm uses the Genetic Algorithm to select numbers of next-hop nodes and allocate suitable magnitude of data to be transmitted. The proposed algorithm redefines the code, operations and policies of searching optimal solution for the genetic algorithm. The algorithm can not only be applicable to flat networks. It would also be applicable to hierarchical networks, if improved. The algorithm can provide global optimal routing approach for energy balance without assuming the topology structure of network. The simulated experiments show the accuracy of the algorithm. But, there is deficiency of centre optimization device.

Since energy is a limited resource in Wireless Sensor Networks (WSNs), techniques need to be developed which save energy. One such technique is data aggregation. Data aggregation is a collection of data readings that represents a joint view of a set of nodes. Although data aggregation reduces collisions due to

interference and eliminates redundancy, it makes data integrity verification more complex since the received data is distinctive. Bagaa et al. [11] presented a new protocol called SEDAN (Secure and Efficient Data Aggregation protocol for wireless sensor Networks) that provides control integrity for aggregation in wireless sensor networks. It is based on a two-hop verification mechanism of data integrity. It allows us to avoid referring to the base station for data integrity verification. Therefore, SEDAN minimizes the blind rejection of sensed data. In addition, SEDAN saves many useless transmissions between sensors and the sink, and thus minimizes energy consumption. Simulations and comparisons of different techniques and SEDAN using the TinyOS environment show that SEDAN saves energy and minimizes blind rejection while providing the same level of security for aggregated data. In addition, the mean time to bogus data detection (MTTD) in SEDAN is less than in other techniques.

Contextual information such as the information regarding whether, when, and where the data is collected cannot be protected using only native techniques (e.g., encryption). Contextual information can be protected against global eavesdropper who can monitor the entire network traffic by periodic packet transmission combined with dummy traffic filtering at proxy nodes. Bicakci et al. [12] used a Linear Programming (LP) framework to characterize the network dynamics and energy dissipation trends. PFS (Proxy based Filtering Scheme) and TFS (Tree based Filtering Scheme) schemes proposed earlier have been modeled. PFS scheme uses a single level proxy architecture, where data packets pass through a single proxy at most. Both ordinary nodes and proxy nodes always generate data at a steady rate. In TFS scheme, proxies are organized in a tree structure; proxies at higher levels in the tree aggregate the packets coming from lower level proxies. Bicakci et al. proposed and modeled a new scheme called OFS (Optimal Filtering Scheme). PFS is suitable for small-size WSNs. As network size grows, the OFS becomes more significant for use than the PFS.

Data trustworthiness is a fundamental requirement in a Wireless Sensor Network (WSN). Location-aware sensors are becoming the reality standard in WSNs. The trustworthiness about the node position information and the privacy conformity are used for evaluating data trustworthiness. Trustworthiness, security of localization information and privacy are the fundamental requirements in WSN. Porisini et al. [13] presented an approach, named Cross Layer Protocol (CLP), for improving data quality based on an integrated solution that considers a sound privacy management policy along with a secure localization protocol. The approach is largely independent from the adopted routing protocols, the verification localization algorithm and the used encryption technique. CLP relies on cross-layer evaluation to assess the overall quality of the collected information. CLP combines verification of localization information and the identification of privacy violations and, thus, evaluates nodes reputation and therefore data quality. The simulations were carried out using Omnet++. The obtained results from the simulations prove that besides guaranteeing anonymity, CLP provides secure node localization and the capability to identify malicious behaviors.

Two-tier architecture has been widely adopted for Wireless Sensor Networks (WSNs) because it can save power and storage consumptions for sensors and improve the efficiency of query processing. In a two-tiered wireless sensor network, resource-constrained sensor nodes act as the lower layer and sense data, and resource-rich storage nodes act as the upper layer and store data and process queries from the sink. But, the storage nodes may be attacked in an unfriendly environment and violate privacy of sensor data. Yao et al. [14] proposed a privacy-preserving protocol specializing for MAX/MIN query that prevents eavesdroppers from gaining sensitive information from sensor collected data.

One way of hiding the sensor nodes' detectability is by limiting the transmission power of the nodes that eavesdroppers cannot detect the existence of the WSN unless they are within the sensing range of the WSN. The network is said to be operating in the stealth mode. Position dependent transmission power adjustment enables the network to maintain its level of secrecy while allowing nodes farther from the network boundary to use higher transmission energy levels. In order to mitigate the irregular energy dissipation characteristic, nodes that cannot disperse their energies on communications reduce the amount of data they generate through computation so that the relay nodes convey less data. Compression/decompression techniques can be used to reduce the amount of data generated. Dynamic data compression/decompression strategies achieve better energy savings when compared to static compression/decompression of data in which the data is always compressed independently of the power transmission strategy. Incebacak et al. [15] employed contextual privacy measures through a novel mathematical programming framework. Five data compression strategies are employed which are No Compression (NC) strategy, Always Compression (AC) strategy, Optimal Compression (OC), Optimal Single Level Compression (OSLC), and Limited Compression (LC). Inceback et al. [15] also investigated the effects of Optimal Single Level Compression (OSLC) and Limited Compression (LC) strategies through Mixed Integer Programming (MIP) models. The impact of node density and limited transmission range due to contextual privacy scenarios are explored.

Several privacy-preserving techniques for Wireless Sensor Networks (WSNs) are available. There are two main categories of privacy-preserving procedures for protecting two types of private information, data-oriented and context-oriented privacy. First is privacy concern on information being collected, transmitted, and analyzed in a Wireless Sensor Network (WSN) and that of sensitive queries executed. Second is the protection of contextual information such as the location of a sensor initiating data communication and the base station as well as the timing of the generation and transmission of sensitive data. Effective countermeasure against the disclosure of both data and context-oriented private information is an indispensable prerequisite for the broad application of WSNs to real-world applications. Li et al. [16] provided a state-of-the-art survey of privacy-preserving techniques for WSNs. Privacy protection has been extensively studied in various fields related to WSN such as wired and wireless networking, databases and data mining. Li et al. attempted to compare the existing techniques in terms of such metrics as privacy, accuracy, delay, and power consumption. A number of important open challenges are discussed for future research.

Securing surveillance wireless sensor networks (WSNs) during Base Station (BS) failure is challenging. BS is a critical part of a WSN and the whole WSN can be made useless by taking down its BS. The eavesdroppers can make the network useless by only destroying the BS as the required efforts to destroy the BS is much less than that is needed to destroy the network. Megahed et al. [17] proposed a novel security architecture called Surveillance Security (SurvSec) for efficient network recovery from single BS failure of surveillance WSN with single BS. The new designed security architecture will detect the BS failure, monitor the network sensitive security issues to store security data in multiple replicas, and send the stored data to the new Base Station after it is authenticated. SurvSec employs a set of sensor nodes to work as Security Managers for management and storage of the security concerned data of all sensor nodes. SurvSec has three components: (1) Sensor nodes serve as Security Managers, (2) Data Storage System, and (3) Data Recovery System. Megahed et al. evaluated the designed security architecture for reliable network recovery from BS failure. The evaluation showed that the proposed security architecture can meet all the desired specifications and the provided Security Managers are capable of network recovery from BS failure.

Concealing the locations and the identities of the nodes, especially the sink node or the Base Station in a wireless sensor network (WSN) is challenging. Nezhad et al. [18] explained that appropriate solutions for this problem depend on the nature of the traffic generated in the network and the capabilities of the eavesdropper that must be resisted. Nezhad et al. proposed a DCARPS anonymous routing protocol that can support location privacy against a global eavesdropper. The protocol is based on label switching. Layered cryptography has been used to make a packet look randomly different on consecutive links. To have energy conservation, the Destination-Controlled Anonymous Routing Protocol for Sensornets (DCARPS) for abundant traffic situations use only modest symmetric cryptography. In addition, the sink is responsible for all routing calculations while the sensors only perform simple label swapping actions when forwarding packets. Another advantage of labels is preventing unnecessary cryptographic operations. DCARPS is suitable for abundant traffic networks but two variations of this protocol called Probabilistic DCARPS are also available for scarce traffic networks.

Pietro et al. [19] addressed the problem of preserving the location privacy of the sensors of a wireless sensor network when they send reply to a query broadcast by the Base Station. These queries focus on obtaining aggregate features such as SUM, AVERAGE, or MAX/MIN of data readings. These values are provided by the sensors to the sink. Therefore, preserving location privacy is an important aspect in such situations. In addition, resilience is another important feature to be met which assures that assures that the overall computation is not disturbed by a subset of sensors compromised by eavesdropper. A probabilistic and scalable protocol is provided in the paper. The protocol has the following features: (i) it ensures the location privacy of the sensors replying to the query (ii) it is resilient to an active eavesdropper willing to change the readings sent by the sensors; and, (iii) it allows to trade-off the accuracy of the result with (a small) overhead increase [19].The protocol ensures that even an adversary that can monitor the whole network, it cannot extract any information about the sensors that have the value queried by the Base Station. The protocol is lightweight and expandable; communication overhead is evenly distributed among sensors.

End-to-end data integrity is an important concern in Wireless Sensor Networks (WSNs). Whenever the number of messages in the transmission buffer increases than a given threshold, messages are aggregated to eliminate the buffer overflow. The messages in the transmission buffer are aggregated as soon as the

transmission queue starts increasing in length. Sicari et al. [20] presented an approach for dynamic secure end-to-end data aggregation with privacy function, named DyDAP. It is an innovative and integrated solution for dynamic data aggregation with privacy solution. DyDAP introduces an original aggregation algorithm that uses a discrete-time control loop and is able to dynamically handle data fusion inside the network which reduces the communication load. The protocol has been designed starting from a UML model. Computer simulations have been provided showing that DyDAP avoids network congestion. It improves WSN estimation accuracy; and guarantees anonymity and data integrity.
DyDAP is a building block of several secure Internet of Things (IoT) scenarios.

TABLE 1

Ref No.	Year	Authors	Techniques	Features	Sink Privacy	Source Privacy	Soft Computing	Tools
1	2014	A. Din et al.	F-CSH	Fuzzy logic	Yes	No	Yes	MATLAB
2	2014	A. Mishra et al.	Security against Black Hole Attack	Black hole attack is identified	No	No	No	NA
3	2014	R. Banerjee et al.	Cluster Based Routing Protocol	Energy Hole is by-passed	Yes	No	No	NA
4	2014	G. Pathak et al.	Hierarchical Cluster Topology	Black Hole Attacks are detected and prevented	No	Yes	No	Network Simulator Tool NS2
5	2013	J. Chaudhry et al.	Dealing Sinkhole Attacks	Sinkhole attacks are detected and neutralized	Yes	No	No	NA
6	2012	W. Wei et al.	Poincare-Perelman Theorem	Detects holes by connectivity information	No	No	No	NA
7	2013	J.Yang et al.	VOR, VORP, VORCP algorithm	Coverage holes are detected	No	Yes	No	MATLAB
8	2013	P.Sanchez et al.	Security Simulation	Security and Performance Analysis is perfomed	No	No	No	NA
9	2011	M.Khan et al.	Security Protocols	Security techniques are discussed	Yes	Yes	No	NA
10	2008	L.Feng et al.	Multi-path routing Genetic algorithm	Provides global optimal routing approach	No	Yes	Yes	NA
11	2011	M.Bagaa et al.	Data aggregation	Efficient data aggregation is provided	No	Yes	No	TinyOS
12	2011	K. Bicakci et al.	Life Maximization	Linear Programming (LP) framework is used	No	No	No	NA
13	2012	A. Porisini et al.	Cross Layer Protocol	Data quality is improved	No	No	No	Omnet++
14	2013	Y.Yao et al.	HMAC-MD5 DES algorithm	Two-tier WSN is used	No	No	No	NA
15	2014	D.Incebacak et al.	Optimal Data Compression	Contextual privacy is provided	Yes	Yes	No	NA
16	2009	N.Li et al.	Privacy Preservation	A Survey	Yes	Yes	No	NA
17	2011	M. Megahed et al.	Surveillance Security (SurvSec)	Base Station Failure Recovery is provided	Yes	No	No	Matlab
18	2008	A.Nezhad et al.	DCARPS protocol	Symmetric Cryptography is used	Yes	Yes	No	OPNET
19	2011	R.Pietro et al.	Location Privacy and Resilience	Location Privacy and Resilience	Yes	Yes	No	
20	2012	S. Sicari et al.	DyDAP privacy function	End-to-end data aggregation is provided	Yes	Yes	No	

3. CONCLUSION AND FUTURE WORK

A novel privacy-preserving scheme applying intelligent fake sink node topology to protect the location security of BS has been considered in this paper. In this paper, F-CSL based on the hiding of the main sink using fake sink nodes has been elected using fuzzy score function. The sink location could be replaced with dummy sink nodes. The analysis has evaluated the performance of the new technique and found that the scheme can effectively secure the sink location. The energy utilization and delivery time is also more efficient as compared with others. In near future, I will extended F-CSL further in order to improve sink privacy with multiple path segments using mobility control. My work will also consider the dual membership function to minimize the energy utilization more.

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