A Research on Wormhole Attack in Mobile Ad-Hoc Networks

K Spurthi, T.N.Shankar

Abstract: ***Sensor nodes, when conveyed to shape Wireless sensor networks working leveled out of focal specialist for example Base station are fit for showing intriguing applications because of their capacity to be sent universally in unfriendly and inescapable conditions. Yet, because of same reason security is turning into a noteworthy worry for these systems. Remote sensor systems are helpless against different kinds of outside and inside assaults being restricted by calculation assets, littler memory limit, constrained battery life, handling power and absence of alter safe bundling. This review paper is an endeavor to break down dangers to Wireless sensor networks and to report different research endeavors in considering assortment of directing assaults which focus on the system layer. Especially wrecking assault is Wormhole assault a Denial of Service assault, where assailants make a low-inertness interface between two points in the system. With spotlight on study of existing techniques for distinguishing Wormhole assaults, analysts are in procedure to recognize and delineate the key research difficulties for location of Wormhole assaults in system layer.***

Keywords: Denial of Service, Mobile adhoc network, Security, Wireless sensor network, Wormhole attacks.

I. INTRODUCTION

A social occasion of self-orchestrating compact center point without any exchanges arrange is known as The Mobile Ad-hoc Network (MANET) is [1]. In a Mobile off the cuff framework every center is partner by remote radio interface using remote associations so every center point can permitted to move with no affiliation and with no rhyme with capacity of variable associations with various devices again and again[2]. Because of it is a multi-bounce process, the midway correspondence extent of imperativeness constrained flexible center points and thusly each instrument in framework topology goes about as a switch. Using dynamic nature of framework topology the courses changes snappy and visit along these lines the powerful coordinating traditions accept basic employments in dealing with it. They should be gifted to ensure the movement of packages safely to their objectives. MANETs are furthermore prepared for dealing with topology changes and breakdowns in center points through framework reconfigurations. Models consolidate on-the-fly conferencing applications, arranging adroit sensors or contraptions, etc. Eagerness for such ground-breaking remote frameworks isn't new [3]. It times back to the seventies, when the U.S. Opposition Research Agency, DARPA tackled PRNET and SURAN adventures. They reinforced customized course set up and support in a pack radio framework with palatable flexibility. Energy for such frameworks has starting late grown-up in light of the ordinary openness of remote specific contraptions that can interface PCs and palmtops and work in grant free radio repeat gatherings, (for instance, the Industrial-Scientific-Military or ISM band in the U.S.). In an eagerness to run internetworking traditions on uncommonly named frameworks, another working social occasion for Mobile, Ad hoc Networking (MANET) has been molded inside the Internet Engineering Task Force (IETF), whose agreement fuses developing a structure for running IP based traditions in off the cuff frameworks. Interest has in like manner been to some degree controlled by the progressing IEEE standard 802.11 that fuse the MAC and physical layer conclusions for remote LANs with no fixed establishment [4]. Coordinating traditions in package traded frameworks generally use either interface state or detachment vector guiding estimation. The two figuring's empower a host to find the accompanying hop neighbor to accomplish the objective through the "most restricted way." The briefest way is normally to the extent the amount of bobs; in any case, other suitable cost gauges, for instance, interface utilization or covering deferral can moreover be used. Such most constrained way traditions have been successfully used in various ground-breaking pack traded frameworks. Obvious models join usage of association state tradition in OSPF (Open Shortest Path First) [5] and use of division vector tradition in RIP (Routing Information Protocol) for inside coordinating in the Internet. In spite of the way that, any such tradition would, on a major dimension, work for uniquely selected frameworks, different traditions has been expressly delivered for use with unrehearsed frameworks.

The fundamental motivation is that the most short way traditions, either interface state or detachment vector, take too long to even consider evening consider joining and have a high message unusualness. In light of the obliged transmission limit of remote associations, message multifaceted nature must be kept low. Moreover, possibly rapidly changing topology makes it basic to find courses promptly, paying little respect to whether the course may be defective. A couple of new off the cuff guiding traditions have been made with this crucial thinking. Fragment II gives the information of wormhole strike.

In a wormhole attack, two attacker centers solidify. One attacker center point gets packs at one point and "sections" them to another aggressor center through a private framework affiliation, and after that replays them into the framework. Wormhole strike is an exchange based attack that can bother the controlling tradition [6] and thusly resentful or breakdown a framework and as a result of this reason this ambush isn't joking. We can use 4 phases to clear up about a general wormhole attack. An attacker has two

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trusted in center points in two particular regions of a framework with a quick association between the two center points. The assailant records packages at one zone of a framework. The aggressor by then tunnels the recorded bundles to a substitute zone. The aggressor re-transmits those bundles again into the framework region from.

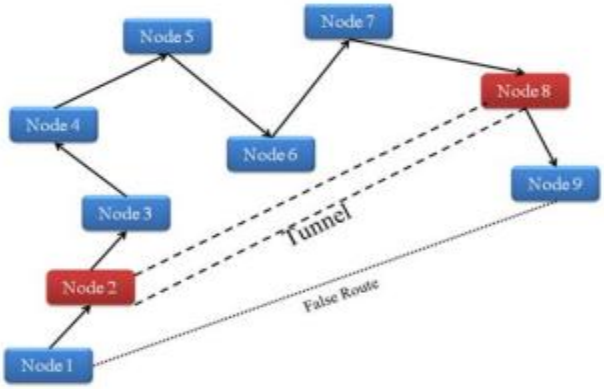

Figure:1: Example of Wormhole.

Figure 1 shows the basic worm opening in the system. Here focus 2 and focus point 8 make the section so as to fill in as a malignant focus. The two focus guides give the dream toward another middle that there is a most limited way. Be that as it may, this most short way does not exist and strike can without a considerable amount of a stretch perform by the attacker. There are three sorts of wormhole ambushes are accessible [7]. There are arranged reliant on its Nodes. There are open wormhole trap, half open wormhole strike and shut wormhole. Open Wormhole Attack: In this kind of snare the two focuses are accessible in the structure so as to finish the correspondence in the system. Here the two focuses can change the information also as show them self in course divulgence path.Half Open Wormhole Attack: In this kind of strike one focus point is open in structure to obliterate the fairness of information. Shut Wormhole Attack: When the section has encompassed then both focus spread then self from the system in any case address changing the information. They demonstrate that the most compelled course to the send the information.

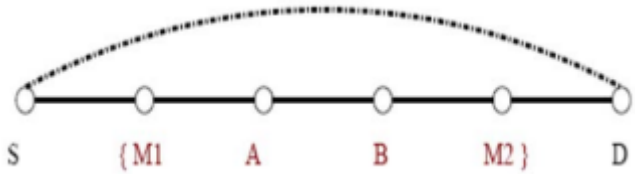

Figure 2: Closed wormhole attack

As indicated by whether the aggressors are sure about the course, wormholes can be depicted into three sorts [8]: shut, half open, and open. The models that join two pernicious focus focuses are appeared in Figure 2, think about M1 and M2, and address the compromising focuses. S and D address the unimaginable focuses as source and objective, and A, B, and so forth as the uncommon focus focuses on the course. The focuses between the wavy props ("{}") are the middle focuses which are going yet elusive to S and D since they are in a wormhole. In the wormhole strike "shut," means, "begin from and join," and "open" suggests, "begin from at any rate disallow" [9]. In (a), M1.and M2. burrow the neighbor divulgence signals from S to D and the an alternate way, and D recognize that they are snappy neighbors to one another. In Figure(b), M1 is a neighbor of S and it burrows its signs through M2 to D, Only one toxic focus point is clear to S and D In an open wormhole, the two assailants are unmistakable to S and D as appeared (c).

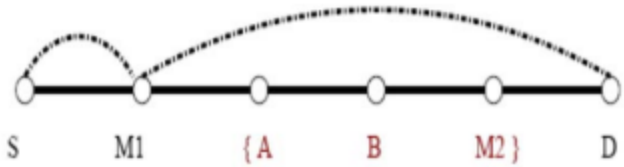

Figure 3: Half open wormhole strike

II. RELATED WORK

Around there exchange about the distinctive evidence and killing movement procedure of wormhole snare in helpful adhoc compose. The dynamic foundation and focus point flexibility regards the different sorts of assault in system. In the midst of the time spent exposure and desire differing methods is proposed by different creators and ace. Some work talk about in this segment for the detestation and affirmation of wormhole assault. [10] In this paper, we evaluate wormholes' stunning risky effect on system coding structure execution through fundamentals. We at first propose a unified figuring to perceive wormholes and demonstrate its rightness inside and out. For the circumnavigated remote structure, we propose DAWN, a Distributed affirmation Algorithm against Wormhole in remote Network coding frameworks, by investigating the refinement in the stream headings of the creative gatherings acknowledged by wormholes.

In this idea totally display that DAWN ensures an OK lower bound of convincing affirmation rate. We perform examination on the limitation of DAWN against game-plan ambushes. We find that the strength relies on the middle point thickness in the structure, and demonstrate an imperative condition to accomplish getting confinement. Dawn does not depend upon any zone data, generally speaking synchronization suppositions or wonderful equipment/middleware. It is just settled on the territory data that can be gotten from standard system coding conventions, and all things considered the overhead of our estimations is sensible. Wide exploratory outcomes have avowed the plentifulness and the reasonability of DAWN. [11] In this paper and adaptable correspondence show is depicted for wormhole spoiled minimal system. The indicated model has given the redesigned parameter adaptable correspondence. Results displays that the work has improved the correspondence throughput and reduced the hardship. This structure for is depicted with confirmation of relative issue so the versatile correspondence is gotten from the work. The custom is additionally depicted with explicit of the correspondence parameter, structure versatile use and the course strategy. The system experiences unmistakable issues

appeared in the structure. The as an issue of first criticalness challenge to the system is the adaptability. The mobiles focus focuses at various speed increment the intrusion amidst the correspondence with the target that the correspondence mishap is common[12].

In this examination paper work, two or three changes has been done in AODV controlling custom to recognize and discharge wormhole snare in clear MANET. Wormhole trap zone and adjusting movement figuring, WADP, has been executed in changed AODV. So also focus endorsement has been utilized to Detect malicious focuses and void false positive issue that may ascend in WADP calculation. Focus point certification evacuates false positive similarly as partners in mapping unmistakable locale of wormhole and is a sort of twofold check for wormhole assault ID. Simulation results shows the theory.

[4] In this paper, we present a countermeasure for the wormhole assault, called MOBIWORP, which helps these hindrances and proficiently mitigates the wormhole strike in versatile systems. MOBIWORP utilizes a guaranteed focal master (CA) for in general after of focus positions. Adjoining checking is utilized to see and confine noxious focus focuses locally. Furthermore, when acceptable vulnerability makes at the CA, it completes a general detachment of the malevolent focus point from the entire system. The impact of MOBIWORP on the information traffic and the consistency of exposure is brought out through far reaching entertainment utilizing ns-2. The outcomes display that as time drives, the information pack drop degree goes to zero with MOBIWORP due the limit of MOBIWORP to see, separate and separate compromising focus focuses. With a fitting decision of structure parameters, MOBIWORP is appeared to completely dispose of keeping of a genuine focus by harmful focuses, to the impediment of a slight enlargement in the drop degree. The outcomes besides display that broadening versatility of the focuses spoils the execution of MOBIWORP.

[5] In this paper, another model is made for revelation and desire for wormholes based weave check metric which we call it BT-WAP. BT-WAP adequately and satisfactorily isolates both wormhole focus and arranging focus point. Our model permits the assessment of focus direct on a pre-pack premise and without the need for more noteworthy noteworthiness use or estimation over the top procedures. We show up by strategies for diversion that BT-WAP suitably abandons getting away hand focus focuses. It is discovered that the BT-WAP show accomplishes an excellent affirmation rate about 99.7% and a disclosure accuracy rate 98.4%. which settles on BT-WAP a connecting with decision for MANET conditions.

[6] In this paper, we propose another thought for neighbor revelation process by indicating prehand shaking methodology. A prehandshaking strategy will isolate the exercises of neighboring focus point and help to decrease influence amidst information transmission and help to achieve each pack to the right beneficiary without dropping. The wormhole assault is a boss among the most exceptional ambushes in WANET which can on a fundamental dimension shock the exchanges over the system. Likewise, It is a sort of replay snare and affected by something like one dangerous focus point. The difficulties of this assault is difficult to shield against and simple to figure it out. This paper exhibits a novel technique for neighbor disclosure and coordinating the impact of wormhole strike. The proposed framework does not require any exceptional apparatus or costly instruments added to the remote focuses.

[7] In this paper, we build up a powerful strategy called Wormhole Attack Prevention (WAP) without utilizing explicit equipment. The WAP perceives the phony course similarly as gets preventive measures against activity wormhole focus focuses from returning amidst the course revelation compose. Expansion results display that wormholes can be recognized and isolated inside the course divulgence arrange.

[8] In this paper, wormhole assault induced by mishandling AODV custom in MANET, is seen and disposed of in two stages. The pivotal stage in the midst of the time spent seeing wormhole snare is done, in context on timing examination and jump check. In the wake of suspecting the strike, a Clustering based framework is utilized to demand the vicinity of assault, what's more to perceive the aggressor focuses. The whole system is disconnected into various groups and each social affair will have a Cluster Head, which controls the majority of the middle focuses in the get-together and anticipate the movement of a controlling expert in MANET.

[9] In this work, we present a novel system for seeing wormhole assaults. The proposed tally is totally limited and works through searching for clear affirmation that no assault is occurring, utilizing just arrange data as concluded by the hid correspondence framework, and full scale nonattendance of coordination. Rather than many existing strategies, it doesn't utilize a particular equipment, making it incomprehensibly pleasing for realworld conditions. In particular, in any case, the calculation can generally imagine worm-gaps, paying little regard to the thickness of the structure, while its benefit isn't influenced even by determined framework changes.

III. RESULTS & DISCUSSIONS

Obvious arranging traditions are existing for WSN. A pinch of the routinely used arranging traditions are considered here and the threat of wormhole ambushes to such traditions is depicted. These organizing traditions are depicted into two sorts: proactive/table driven traditions and open/demand driven traditions [13]. AODV, DSR and Ariadne are responsive controlling traditions and OLSR, DSDV and SEAD are proactive arranging traditions.

a) OLSR (Optimized Link State Routing)

It is a proactive controlling custom in which information of the topologies get exchanged occasionally. Hi messages are transmit to pick single influence neighbors. To circulate hailing traffic, flooding structure is use. In this structure each inside point progresses overpowered message that was not sent by them in advance. The topology messages contains the majority of the information about alliance bestows that are sent to each

other center point. With the help of this information, fragmentary topology layout are procured by each inside in the wake of learning the most limited way using symmetric relations. Clearly this system is available to wormhole strike [14]. Bound center centers can send hey and topology manage messages are available at its planning center concentrations to its own neighbors for broadcasting fake information into the structure. This will make two far away concentrations to wrongly trust in themselves as neighbors, that lead to the mistake of organizing custom.

b) DSDV (Destination Sequenced Distance Vector)

It is a proactive sorting out tradition, in which all the estimation, target courses, approach number made by the objective concentration and next ricochet to each objective are kept up in a table. Each inside in the structure goes about as a switch and the table gets fortified sporadically to the extent master business of messages among neighboring switches. This tradition is available to wormhole catch [14]. By using an entry, the plotting center centers beat message between two far away center centers, recognize X and Y which will results X and Y to consider themselves to be neighbors and they will push a ricochet consider of one as a touch of each other. In light of this scam information, in case the elective course has skip count mutiple, by then all other insisted center centers will intend to send the messages through X to target Y.

c) DSR (Dynamic Source Routing)

It is a responsive controlling custom since it finds the required courses basically after it has gatherings to transmit to the objective. It needs source course upkeep in light of the course that in the midst of the utilization of the course, it is fundamental to check the errand of the route and to report the sender concerning the screws up. It is in hazard to wormhole ambush and renouncing of affiliation trap at the objective [15]. This custom ensures sending of essentially the first RREQ that it will got and will reject all other RREQ packs for a for all intents and purposes indistinguishable course. This RREQ pack contains the extensively captivating center concentrations and the bounce check information. The course by then set up is used to send data social events. As wormhole catch ensures a practical channel for sending messages, so when risen up out of various ways RREQ group through them will got together at objective speedier. This will result in simply the wormhole approach to manage be found as the course to objective. The wormhole attacker discards the data isolates or deficiently that results attempting to guarantee thoughtlessness of affiliation strike at the objective.

d) SEAD (Secure Ad-hoc Distance Vector)

This tradition depends upon single bearing hash ties instead of hilter kilter cryptograph and shields the framework from clumsy attacks and DoS ambushes. A few center centers can check each and every other part of the chain. This requires affirming the estimation of the sorting out table and the get-together number. The recipient should in like manner check the sender. Therefore, an enemy can't send controlling message without exchanging off an inside point, as it doesn't give affirmation code to its neighbors. Despite the way in which that SEAD acceptably handles replay strike, it is unfit to manage the wormhole catch [16] by an unsafe center point that is replaying the message from an unauthenticated center point as a repeater.

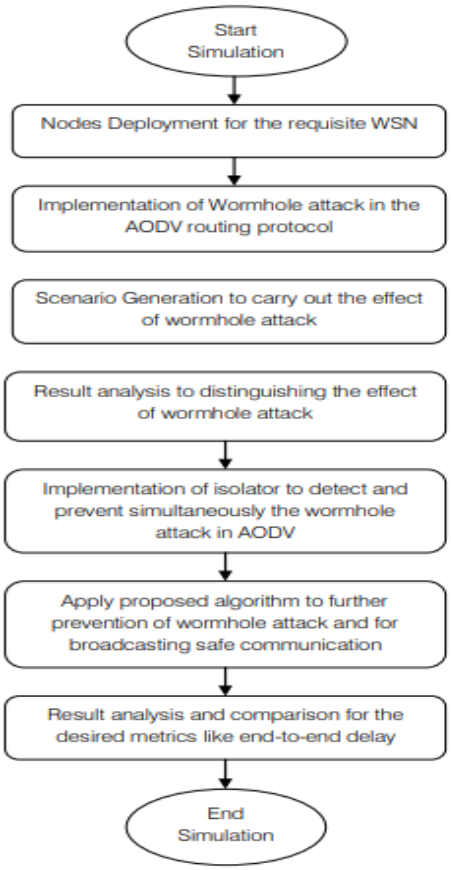

FIG 4: The Prevention of Wormhole attack in AODV using WSN

e) AODV (Ad-hoc On-demand Distance Vector)

It is an on-demand guiding tradition which offers RREQ messages to its fast neighbors for sending messages to positive target and from now on these neighbors rebroadcast them to their neighbors. This whole procedure continues with adjacent to if until the RREQ message accomplishes the objective. On getting the key RREQ message from the source, the objective center point sends a RREP to the source center point through a for all intents and purposes indistinguishable switch way. All the amidst centers in like manner moved course domains in their particular table. The neighboring concentrations forward course mess up message to most of its neighbors coming to fruition to seeing blemish in any interface with a center. This will again start a course disclosure procedure to change the broken alliance. This AODV controlling tradition is also in hazard to wormhole strike. As wormhole catch ensures a practical channel for sending messages, so when risen up out of various ways RREQ pack through them will got together at objective snappier. In this custom, the objective rejects all the later on RREQ packs got, yet they are from embraced center. Along these lines the objective picks the fake path through wormhole for RREP [17].

f) Ariadne (A Secure On-Demand Routing Protocol for Ad-hoc Networks)

This tradition depends on symmetric cryptography and ensures that the source can insist each nearly the entire path center in the course and the objective center supports the source. All transitional center point out take out or install center concentrations in the blueprint of center motivations behind the course request. It uses the key affiliation custom known as TESLA that bases on the clock synchronization to insist controlling messages. TESLA uses per-sway hashing system. A request done at each center does not simply depend upon the information contained in the RREQ group yet adjacent to depends the confirmation code of the past center point. Ariadne custom is free from over flooding of RREQ trap in light of how the attacker is kept from replaying the message in context on the structure wide shared puzzle key. It is key for each center to insert underwriting code to each RREQ group that it moves. By then the source can almost certainly support the beginning period of each individual datum field in the RREP pack [14]. It is protected from flooding strike wormhole and ambush [20] while historic course winding requires RREQ to be extraordinarily organized carefully.

IV. DIFFERENT DETECTION METHODS

Two or three specialists have handled distinctive verification of wormhole assault in MANET.

4.1 Hop Count Analysis Method

Shang, Laih and Kau[4] showed a framework called jump check examination for region of wormhole. This strategy does less see the wormhole in any case just keeps away from the course that is suspected to have wormhole and picks a substitute course. The producer presented a multipath planning custom that depends upon weave tally examination procedure. The considering is to utilize part multipath course in this manner the information is in like way part. With this the attacker can't totally get the information.

4.2 Location Based Approach

Location based framework is huge where the area of neighboring focuses and transmission go are known. In this structure the focuses share their district data with one another. Creator of [5] proposed a phenomenal method called the geological chain to see wormhole. A chain is a couple of data which is attached to a group intended to control the most ludicrous permitted transmission free. This geographic chain guarantees that the beneficiary of the pack is inside the degree of sender. At first all inside focuses know their very own domain. The middle point while sending a bundle combines time when the gathering was sent, time when pack was gotten and its zone. The beneficiary focus point starting at now separates this data and its own one of a kind zone and time when the group was gotten. In region based strategy remarkable equipment is utilized. Locale based is equipped with either GPS or some orchestrating advancement. This improvement flops without GPS framework.

4.3 Time Based Approach

Time based system proposed by Hu et al [5][6] depends upon specific time estimation. This procedure requires the inside focuses to keep up steadily synchonized clock. The producer has proposed a procedure called short lived rope. In this methodology extremly accurate clock synchonization is depended upon to bound propogation time of pack. In [7], the producer has proposed a method called transmission time based mechanism(TTM). This strategy separates wormhole amidst beginning time clearly set up by figuring the time of transmission between two unique focus focuses. On the off chance that the transmission time between two focuses is high, by then wormhole is recognized. It does a not require any extraordinary hardware like GPS structure.

4.4 Digital Signature Based Approach

In [18] creator has proposed a framework utilizing impelled imprint. Every inside point in system contains mechanized normal for each uncommon focuses in a tantamount structure. A believed way is made between the sender and the gatherer utilizing motorized imprint. In the event that a middle point does not have true computerized imprint, it is perceived a noxious focus point. 4.4 Neighbor Node Monitoring Author of [9] has proposed a system dependent on a reaction time of answer message. This reaction time is utilized for endorsement reason. Every inside point keep up table for verifying the suitable reaction time. On the off chance that the suitable reaction time isn't right, by then there is a risky focus in the structure. Examination is done on reaction time and rehashed until goal is come to.

4.5 Round Trip Time Based Approach

The Round Trip Time (RTT) based rationality proposed by Zaw Tun and Thein [10] considers the round trek time (RTT)[19] between two powerful focus focuses. In context on transmission time between two focus focuses wormhole is perceived. Here the transmission time between two false focus focuses is viewed as higher than others. This system does not require any sort of unprecedented apparatus for its distinctive verification technique.

V. CONCLUSION

In this paper shows the overview of wormhole attack distinguishing proof and neutralizing activity procedure. Similarly talk about the arrangement of wormhole strike in remote framework. The attack methodology is executed similar to close strike and open ambush. The purpose of wormhole ambush is theft of information from source place. The ambush of wormhole next with no impact on the execution of remote framework. The execution of framework premise is troublesome. Amid the time spent area process distinctive counts is proposed by different estimation, for instance, reference based figuring, clock synchronization and framework bundle coding methodology.

REFERENCES

1. ShiyuJi, Tingting Chen, Sheng Zhong “Wormhole

Attack Detection Algorithms in Wireless Network Coding Systems" IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL-14, 2015. Pp 660-674.
2. Amit Kumar "A Parameter Estimation Based Model for Worm Hole Preventive Route Optimization" International Journal of Computer Science and Mobile Computing, 2015. Pp 80-85.
3. JuhiViswas, Ajay Gupta, Dayashankar Singh" WADP: A Wormhole Attack Detection Andprevention Technique in MANET using Modified AODV routing protocol" IEEE, 2013. Pp 376-381.
4. Issa Khalil, SaurabhBagchi, Ness B. Shroff "MOBIWORP: Mitigation of the wormhole attack in mobile multihop wireless networks" Elsevier ltd. 2007, Pp 344-362.
5. BadranAwad, TawfiqBarhoom "BT-WAP: Wormhole Attack Prevention Modelin MANET Based on Hop-Count" IJARCCE, 2015. Pp 600-606.
6. Rakhil R, Rani Koshy "An Efficient Algorithm for Neighbor Discovery and Wormhole Attack Detection in WANET"2015 International Conference on Control, Communication & Computing India (ICCC) 19-21 november 2015.
7. Sun Choi, Doo-young Kim, Do-hyeon Lee, Jae-il Jung "WAP: Wormhole Attack Prevention Algorithm in Mobile Ad Hoc Networks" IEEE, 2008. Pp 343-348.
8. AnjuJ,Sminesh C N,"An Improved Clustering-based Approach for Wormhole Attack Detection in MANET" 3rd International Conference on Eco-friendly Computing and Communication Systems 2014.
9. TassosDimitriou and AthanassiosGiannetsos "Wormholes no more?Localized Wormhole Detection and Prevention in Wireless Networks" 2012. Pp 1-14.
10. S. Choi, D. Kim, J. Jung. "WAP: Wormhole Attack Prevention Algorithm in Mobile Ad Hoc Networks". In International Conference on Sensor Networks, Ubiquitous and Trustworthy Computing, 2008.
11. J. Eriksson, S. V. Krishnamurthy, M Faloutsos "Truelink: A practical countermeasure to the wormhole attack in wireless networks" 2006, Pp 75–84.
12. W. Wang, B. Bhargava, Y. Lu, X. Wu "Defending against wormhole attacks in mobile ad hoc networks: Research articles" Wireless. Commun.Mob.Comput. 2006, Pp 483–503.
13. Kamanshis Biswas, Md. Liakat Ali. "Security Threats in Mobile Ad Hoc Network". Paper submitted to the Department of Interaction and System Design, School of Engineering at Blekinge Institute of Technology, 2007.
14. Y.-C. Hu, D.B. Johnson. "Ariadne: A Secure OnDemand Routing Protocol for Ad Hoc Networks", Wireless Networks, 11(1-2), 2005.
15. Bounpadith Kannhavong, Hidehisa Nakayama, Abbas Jamalipour. "A Survey of Routing Attacks in Mobile Ad Hoc Networks", IEEE Wireless Communication, 2007.
16. Hu, Y.-C.; Perrig, A.; Johnson, D.B.; "Packet leashes: a defense against wormhole attacks in wireless networks,". Twenty-Second Annual Joint Conference of the IEEE Computer and Communications. IEEE Societies, April 2003.
17. Lazos, L.; Poovendran, R.; Syverson, P.; Chang, L.W.; "Preventing wormhole attacks on wireless ad hoc networks: a graph theoretic approach," Wireless Communications and Networking Conference, March 2005.
18. Honglong Chen, Wei Lou, Zhi Wang, A secure localization approach against wormhole attacks using distance consistency, EURASIP Journal on Wireless Communications and Networking, April 2010.
19. R. Graaf, I. Hegazy, J. Horton. "Detection of wormhole attacks in wireless sensor networks," Springer book chapter Ad Hoc Networks, 2010.
20. A.Vani, D. Sreenivasa Rao, "A Simple Algorithm for Detection and Removal of Wormhole Attacks for Secure Routing In Ad Hoc Wireless Networks", International Journal on Computer Science and Engineering (IJCSE), June 2011.

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