A survey on security threats and application of wireless sensor network

Anil Kumar Kapil[1], Lokendra Kumar[2]

[1]Professor, Faculty of Mathematics and Computer Sciences, Motherhood University, Roorkee, India
[2]Research Scholar, Faculty of Mathematics and Computer Sciences, Motherhood University, Roorkee, India

Abstract

Wireless Sensor Network over the years have become one of the most promising networking solutions with exciting new application for the near, future. Its deployment has been enhanced by its small, expensive and smart sensor nodes, which are easily deployed, depending on its application and coverage area. In this paper we focus on the Common to special application of wireless sensor network in various domain uses for military operation, monitoring environmental condition, distribution control systems, health care, industrial monitoring and detection of radioactive sources. Not with standing its promising attributes, security in WSN is a big challenge and remains an ongoing research trends. Furthermore the sensor nodes in WSNs are characterized by their resources constraints such as limited power, low bandwidth, short communication range, limited processing, and storage capacity which have made the sensor nodes an easy target. Therefore, in this paper, we present the uses of security aspects of Wireless Sensor Network but we focus on Home Automation, Military Operations, Monitoring Environmental condition like as monitor temperature, pressure, humidity etc.

1. Introduction

A WSN is a wireless network consisting of spatially distributed autonomous devices using sensor to monitor physical or environmental condition. A WSN System in corporate a gateway that provides wireless connecting back to the wired world and distributed nodes. The wireless protocol we select depends on your application requirements. WSN is a heterogeneous system combing thousands to millions of tiny in expensive sensor nodes with several distinguishing characteristics. It has very low processing power and radio ranges, permitting very low energy consumption in the sensor nodes and performing limited and specific sensing and monitoring functions [1-6]. WSN are used for collecting the information needed by intelligent environments in urban and rural construction, smart cities, home and building automation, industrial application or smart hospitals [7-12]. WSN support current requirements related to the deployment of network they cover communication needs and are flexible in time, space and autonomy; they do not require a fixed structure [13-15]. WSN consist of unique challenges, so security techniques used in conventional network cannot be directly applied to WSN due

to its unique characteristics [16]. Security is a vital issue in a wireless sensor network. This is because of the fact that such as network are basically placed in hostile environments like surveillance; it has many military applications also. Security not only deals with protecting the network but also includes detecting of various attacks and their prevention [16]. WSN has been widely used in many areas especially for surveillance and monitoring in agriculture and habited monitoring [17].

1.1 Application of WSN

- Smart buildings eg. indoor climate control
- Smart grids and energy control system
- Industrial application
- Precision agriculture and animal tracking
- Environmental monitoring
- Urban terrain tracking and civil structure monitoring
- Entertainment
- Security and surveillance
- Healthcare health monitoring, medical diagnostics
- Transportation and logistics

Corresponding author: Anil Kumar Kapil
Email Address: anilkdk@gmail.com

WSN is a wireless network that consists of base stations and numbers of nodes (wireless sensors). Sensors are low powered devices and are capable of observing, measuring and communicating data in the network [18].

1.2 Limitation of WSN

- Possess very little storage capacity – a few hundred kilobytes.
- Works in short communication range – consumes a lot of power.
- Have batteries with a finite life time [18].

1.3 Home automation

Home automation system is becoming more and more popular. People want to live in intelligent living spaces equipped with automation system, these system not only provide them convenience, comfort, security but also reduce their daily living cost by energy saving solution [19]. The demand for home automation products has been increased rapidly, which promise a potential market trends in near future. In Europe building are responsible for 40% of total energy consumption [20]. Home automation plays an important role in maintaining these living standards of population by providing a secure and flexible environment. The home automation systems not only maintain the living standards but also help an elderly and disabled people to live their life in convenient way [21].

Home security is a top concern for everyone who owns or rents a home. Moreover, safe and secure residential space is the necessary of every individual as most of the family members are working. Smart home comes into pictures for the purpose of controlling and monitoring the home. It will give a piece of mind, as we can have a close watch and stay connected anytime, anywhere. But is common man really concerned about home security. An investigative study was done by conducting a survey to get the inputs from different people from diverse back grounds. The main motivation behind this survey was to make people aware of advanced Home OS and analysis their need for security [22]. The first thing we desire when we look at our family and our home are their safety. And thus the idea of advanced home security system comes into pictures. The concept of home automation and its safety has been around since late 1970s. But during the course of time with the advancement of technology, our expectation from home has changed a lot and so have the idea of home automation and its security systems. If we look at different home automation system over time, they have always tried to provide efficient, convenient and safe ways for home in habitants to access their homes [23].

The Metropolitan Police Service (MPS) take burglary very seriously [24].

Smart home can be also known as automated home or intelligent home which indicates the automation of daily tasks with electrical appliances used in homes [25].

2. Objectives

- An evaluation of need of security of people from different backgrounds based on different parameters like children and /or aged person staying at home, people living in rural or urban etc. and finding the impact of these parameters on their need of home security system.
- To examine the feasibility of installing advanced security system in rural and urban areas.
- To test the awareness of people for advanced security system.
- To establish the benefits of installing advanced security system.
- Development of possible future advancement home security system using wireless sensor network and biometrics system [22].

3. Home security model review

There are many home security systems for intelligent remote monitoring and controlling which are designed as business related products or under research programs for experiment. It is observed that most of the research carried out fits in following categories.

- Wireless Sensor Network especially for monitoring using Bluetooth, Wi-Fi etc.
- Biometric has various wide range application like Home automation, Home security, Bio medical application, Health monitoring, Agriculture etc.

4. Need of home OS investigative study

According to the survey of Pune police in the city of Pune which is one of the fastest growing cities in India, in the year 2015 alone, there had been 1200 cases of home burglaries in which only 240 cases were solved. Such burglaries amounted to loss property worth rupees 15crore and 72 lakhs out of which is found to be more in the sub urban areas of Pone but even in the heart of the city such incidence are happening. Most of people in Pune stay in flats and thus they are not much informed about their neighborhood. The Criminals take advantages of such situation.

The Pune police suggest that every responsible citizen should take some precautionary steps to avoid the home burglaries. If one is going out of station the neighbor should be informed about the same. All the valuables should be kept at a safe space like bank lockers. The security guards should be appointed only after the strict squirting from the police from respective area. Society should be protected by CCTV Cameras or likewise any advanced home security systems [26].

A home security survey or investigative study is a serious on sight assessment of a property to determine what the present security status is and to find out any scarcities or excess of security. If determines the level of protection needed and give suggestions to improve the overall security of your home, if required.

Traditional techniques of alarms based security have gained much popularity in past decades [27].

5. Military operations

WSN are used in large application from civilian to military so security is very important in WSN. Sensor node use wireless communication that is why it is easy for attacker to inject malicious message into the network [18]. WSN provides potentially low cost solution to a variety of real world challenges they are quickly gaining popularity.

Military application such as tracking and environment surveillance application use these networks. The sensor nodes from sensor network are dropped to the field of interest and are remotely controlled by a user Enemy tracking, security detections are also performed by using these networks [18]. Security mechanism is important in WSN as it provides different levels of security which depends on the resources of sensor network available. Encryption is only way to keep the information secure. Selective Encryption of images is an important mechanism to ensure security in network with resources constraints [28].

Different types of security attacks, their effect and defence mechanism in WSN are vulnerable to security attacks and threat due to its characteristics and limitations. Security attacks are identified and classified from different perspective based on the attacks that occur in network layer [29].

Wireless Sensor have become an excellent tool for military and information application relating intrusion detection, perimeter monitoring and information gathering and elegant logistics support in an unidentified deployed area. Some additional application; location detection, sensor based personal health monitor with sensor network and movement detection [30]. In many important military application is critical to protect a sensor network from malicious attack, which presents a demand for providing security mechanism in the network [31] [32].

6. Most common attacks on WSN

Generally, all the attacks of WSN are aimed at network mal function in interruption of service. Therefore the attacks are executed in several ways.

6.1 Denial of service (DOS)

This types of attack is used against web servers. It invalidates the network using an overload, aiming that consume all the memory and processing capacity of the network, in order to interrupt the services provided by the network [33-35].

6.2 Routing attacks

As the name of attack suggests, the malicious node changes the routing, creating infinite, loops or large deviations between nodes [36-37].

6.3 Jamming attack

A malicious node a powerful transceiver configured to use the same frequency as the sensor nodes, which can occupy the common channel with the noise and prevent the sensor nodes from receiving message [38-40].

6.4 Sybil attacks

A malicious node assumes the pseudonymous identity of one or more legitimate nodes and subsequently executes various types of attacks on the network, including attacks on data aggregation, routing mechanism, resource allocation or distributed storage [41-44].

6.5 Messages modification

A malicious node captures a message and retransmits it in an altered way [45].

6.6 Data negligence and selective forwarding

The intruder node ignores the message that must be sent or retransmitted [46].

6.7 Node capture and compromised node

Most of the WSN are operated in open environments. The small design of the sensors and the distributed nature of their deployments results in many vulnerabilities such as extracting Cryptographic keys, tampering with the associated circuitry, changing the node of the sensors and replacing sensors with malicious nodes that are controlled by the attacker [47].

7. Challenges in security and privacy

WSN are limited in their computation, communication capabilities and energy. In contrast to traditional network, sensors nodes are frequently deployed in accessible areas, presenting a threat of physical attacks. Sensor network interrelated closely with their physical environment and with people, poising extra security problems. Because of their reasons existing security mechanism are inadequate for WSN. These new constraints presence new research challenges on key establish dent, secrecy and authentication, robustness to denial of service attacks, privacy node capture and secure routing to achieve a protected system, security must be included into every component, as component designed without security can become a point of attack. Therefore, security and privacy pervade every feature of system design. Consider one of the most difficult attacks to protect against. Adversaries can severely limit the cost of a wireless sensor network by denial service attacks [48]

In the simplest form of denial of service attack, an adversary attempts to disturb an operation by broadcasting a high energy signal. If the transmissions is strong sufficient, the whole system could be jammed. Additional sophisticated attacks are also possible .the adversary can inhibit communication by

violating the Messages Authentication Control (MAC) protocol, for occurrence by transmitting while a neighbor is also transmitting requesting channel access with Request-To-Send (RTS). New techniques for dealing with this easy yet potentially devoting attack are needed. Various other security related problems need further research [49].

One challenge is how to safe wireless communication links against tampering and eavesdropping. Overall, security is a difficult challenge for any system. The severe demanding and constraints environment of WSN make computer security for these systems even more challenging [50].

WSN is widely used in military application like tracking the Enemy movement and force protection. Security is the major concern and very difficult to achieve due to the unattended nature, limited memory, and limited power of network [51]. WSN are network consisting of numerous small computers equipped with sensor [52-53]. Various types of sensors are used to detect the different events for example infrared sensors are used to detect events like human motion and thermostat sensor is used to determine the temperature [54]. These sensor nodes are equipped with a radio to communicate with each other and to send data to a central computer where this data can be passed and viewed. WSN are quickly gaining popularity due to the fact that they are potentially low cost solution to a variety of real world challenges [52-53]. Their low cost provides a means to deploy large sensor arrays in a variety of conditions capable of performing both military and civilian task [51].

WSN helps in military operation by delivering critical information rapidly and dependably to the right individual or organization at the night time, there by significantly improving the efficiently of combat operations. Here we are using the WSN of monitoring and tracking application in military field. The security is a major concern in this application. First we list the set of application in military field and what are the different types of attacks in this network [51]. Military security is a major applications area of WSN. The major function of the WSN is to monitor the enemy movements and coordinating the activities of the army [51].

8. Monitoring environmental

A WSN consist of specially distributed self-governing sensor to monitor physical or environmental conditions such as temperature, humidity, sound, vibrations, pressure etc. and it also passes the information through network to main location [56]. Today's sensor can monitor temperature, pressure, humidity, soil makeup, vehicular movement, noise levels, lighting, conditions, the presence or absence of certain kinds of objects or substances, mechanical stress levels on attached objects and other properties [57]. In case of WSN the communication among the sensor is done using wireless transceivers. The attractive features of the WSN attracted many researches to work on various issues related to these types of network [58]. These emerging technologies can be used to create smart environments and improve the socioeconomic status of rural areas. The different applications of WSNs in rural environment can include e- services such as learning, e- academic, e-business, e- medicine, and e-

healthcare. Those applications many facilitate an efficient connection between the city and remote rural areas [59].

The use of sensors to detect and monitor fire behaviour has allowed applying new technologies in this area. Sensor used in such system measure static and dynamic variables, like humidity, slope of the land, the type of fuel, the direction, the speed of the wind, smoke, etc. [59].

They are important for weather monitoring and optimal use of fertilizers in the field. An important feature of WSNs deployed in a setting is that they can collect heterogeneous data from different environments. The goal of this approach is to provide a smart environment able to make decisions and efficiently manage resources. [59]. recently, the development of environmental monitoring system has been applied in many applications in order to assist people in their job and reduce cost and time. The applications of environmental monitoring have grown rapidly in agriculture monitoring, habitat monitoring, indoor monitoring, greenhouse monitoring, climate monitoring, it is a good effort and brings advantage because the community has realized the importance of the wireless sensor network technologies in their life. [55].

8.1 Agricultural monitoring

Agricultural monitoring always focuses mostly on farming area. Some studies define animal monitoring as animal tracking [60] but the concept in the same. These are methodologies to be implemented in order to get through each phases well-defined for the entire life cycle [61]. The interaction between animals and human has been developed and recognize for decades. The contribution of animals love, true-hearted and continuity live can provide positive impact on human physical and mental [62] [63].

However, nowadays many animals lack proper treatment and there are also cases where these animals' diseases are not detected. Therefore, it is important to have a monitoring system to monitor animal behaviour and produce a report regarding their health or behaviour in real-time system.

There are many identification methods in monitoring animal health, but some of them either fail or lacking in and efficiency and also not user-friendly. The design of RFID-based mobile monitoring system [64] helps users control animal behaviour and movement. Monitoring system for poultry also contributes a big advantage to user especially farmers [65].

8.2 Habitat monitoring

Habitat monitoring is one of the essential parts in environment monitoring. Habitat means a place in which an animal or plant naturally grows or lives. Therefore, habitat monitoring is important to make sure their species autonomies and prevent and ecological disturbance for animals and plants. Pollution can cause negative impact to health and ecological balance. Therefore, it is important to manage a system that can monitor pollution so that it is under controlled [66] develop a web-based graphical user interface to manage the data of pollution efficiently. The sensor nodes are used to read current sensor reading. At the end of the study, they manage to improve the

performance of the sensor technology by gaining a stable communication even through the average lifetime of sensor has declined due to the requirement of latency.

8.3 Indoor living monitoring

Sensor technologies for security in living monitoring have become one of the main options for people for safety indoor environment. It has provided many benefits to the user in terms of security [67]
There are also studies on fire detection in building [68]. The system provides real-time monitoring and alarm in the presence of fire, and also informs the exact location of that fire. It also distributes direction by continuously collecting, analyzing, and keeping real time information.

8.4 Greenhouse monitoring

The greenhouse effect occurs when solar radiation which is sun heat, is trapped by the gases in the earth's atmosphere and reflected back from the earth. Thus, it will heat the surface of earth and leads to global warming. Therefore, greenhouse monitoring system is important to ensure the stabilization of the environment [69] develop greenhouse monitoring system using TinyOS as the based platform to measure and monitor environmental parameters including temperature, light and humidity. The system collects sends and controls the parameters information automatically and it is proven that the performance of the system is efficient as the user can collect high precision data of the environment without any disturbance.

8.5 Climate monitoring

The climate change of the world nowadays have brought many effects such as the breaking of sea ice, increasing in sea water level, heat waves, glacier melting, lake temperature warming, and many more. Thus, in an effort to control and monitor the climate change [70] develop a monitoring system that manages and keeps data in real time and focuses on the processing of spatiotemporal query. The incoming data is kept as a segment and labelled with timestamp of changes occur in the value of item.

8.6 Forest monitoring

Forests are important sources for biodiversity and ecological balance. They provide many benefits and it is the main function for water and soil conservation, genetic resources for plant and animal, and also source of wood supply and other forest goods. However, recently the green forest environment has been interrupted by non-ethical activities such as illegal logging and also country development activities that decrease the benefits of the forest contribution.

9. Conclusion

We draw attention some of the important areas where WSN is

widely used. In military application like tracking the Enemy movement and force protection the WSN is very beneficial. The development of environmental monitoring system has been applied in many applications in order to assist people in their job and reduce cost and time. This survey will be helpful to those researcher who wants to do research to improve the quality of services and security aspects of the Wireless Sensor Network.

References

[1] Shio Kumar Singh, M.P.Singh and D.K.Singh,"A Survey Of Energy-Efficient Hierarchical Cluster-based Routing in Wireless Sensor, Network", International Journal Of Advanced Networking and - Application (IJANA): Vol.02, Issue. 02, 570-580, 2010.
[2] Shio Kumar Singh, M.P.Singh and D.K.Singh, "Energy Efficient Homogenous Clustering Algorithm for WSN", International Journal Of Wireless & Mobile Networks (IJWMN), Vol. 02, Issue. 03, 49-61, 2010.
[3] Shio Kumar Singh, M.P.Singh and D.K.Singh, "Applications, Classification and Selection of Routing Protocols for WSN", International Journal Of Advanced Engineering Sciences and Technologies (IJAEST), Vol. 01, Issue. 02, 85-95, 2010.
[4] Shio Kumar Singh, M.P.Singh and D.K.Singh, "Routing Protocols in WSN – A Survey", International Journal Of Computer Sciences and Engineering (IJCSES): Vol.01, Issue. 02, 63-83, 2010.
[5] Shio Kumar Singh, M.P.Singh and D.K.Singh, "Performance Evaluation and Comparison of Energy- Efficient Routing Protocol for WSN", Global Journal of Computer Application and Technology (GJCAT): Vol.01, Issue.01, 57-65, 2011.
[6] Shio Kumar Singh, M.P.Singh and D.K.Singh, "Energy-Efficient Transmission Error Recovery for WSN", International Journal of Grid and Distribution Computing (IJGDC): Vol.03, Issue.04, 89-104, 2010.
[7] B.Rashid and M.H.Rahmani, "Application of WSN for Urban Areas: A Survey", Journal of Network and Computer Application: Vol.06, 192-219, 2016.
[8] D.Li, J.Cao and Y.Yao, "Big data in Smart Cities", In Science China Information Sciences, Vol.58, Issue.12, 2015.
[9] L.D.Xu., W.He and S.Li, "Internet of things in Industries: A Survey", IEEE Transaction on Industrial Information, Vol.10, Issue.04, 2014.
[10] C.S.Nandyala and H.K.Kim, " From Cloud to fog and IoT based real time U-healthcare monitoring for Smart Homes and Hospitals", International Journal of Smart Homes, Vol.10, Issue.02, 187-196, 2016.
[11] A. Holziger, C.R., M.Ziefie and C.Rocker, "From Smart Health to Smart Hospitals in health", Inform Smart Health to Smart Hospitals in smart health, 20.2015.
[12] A.Gonzblez-Briones, J.Prieto, De.La Prieta, F.E.Herrera-Viedma, J.M.Corchado and A. Gonzalez-Briones, "Energy Optimization using a case based Reasoning Strategy", Sensors, Vol.18, Issue.03, 865, 2018.
[13] D.Jiary, Z.Xu, W.Li and Z.Chen, "Network Coding based Energy Efficient Multicast Routing Algorithm for Multihop Wireless Network", The Journal of System and Software, Vol.104, 152-165, 2015.
[14] G.Hackmann, W.Guo, G.Yan, Z.Sun, C.Lu and S.Dyke, "Cyber physical code sign of distributed structural health monitoring with Wireless Sensor Network", IEEE Transaction on Parallel and Distributed System, Vol.25, Issue.01, 63-72, 2014.
[15] D.I.Tapia, R.S.Alonso, O.Gracia, J.M.Corchado and J.Bajo, "WSN real time locating system and multi-agent system: the perfect team", In proceeding of the 16th International Conferences of Information Fusion, 2013.
[16] Dr. Maninder Singh, Meena Pundir, "Analysis of DoS Attack in WSN", International Journal of Engineering Research & Technology (IJERT) : Vol.03, Issue.09, 2014.
[17] Mohd. Fauzi Othman, Khairunnisha Shazali, "WSN Application: A study in Environmental Monitoring System", International Symposium on Robotics and Intelligent Sensors (IRIS), 1204-1210, 2012.
[18] Prof. Sagar Thakre, Manusha Nimbalkar, Richa Nabar, "A Survey on External, Security Threat with Defence Mechanism for WSN", International Journal of Innovative Research in Computer and Communication Engineering, Vol.05, Issue.05, 2017.

[19] R.Aswani, Mrs. Pooja Mohnani, "Application of WSN in Home Automation", International Journal of Computer & Organisation Trends, Vol.09, Issue.01, 2014.

[20] D.Culler, D.Estrin and M.Srivastava, "Overview of Sensor Network", IEEE Computer Magziner, 41-49, 2004.

[21] Bhagyashri, R.Wankar, Prof.Vidya Dhamdhere, "Application of WSN to Intelligent Home Automation and Power Monitoring using Android Smart Phone- A Survey", International Journal of Computer Sciences and Mobile Computing, Vol.04, Issue.01, 242-245, 2015,

[22] Sudhir Chitnis, Neha Deshpande, and Arvind Shaligram,"An Investigative Study for Smart Home Security: Issues, Challenges and Home Countermeasures", Wireless Sensor Network, 8, 61-68, 2016.

[23] Cyril Jose, A. and R.Malekian, "Smart Home Automation Security: A literature Review", Smart Computing Review, 5, 269-285, 2015.

[24] "Metropolitan Police", Adaptive on Burglary Prevention, 1-26.

[25] Bangali J. And A.Shaligram, "Design and Implementation of Security System for Smart Home based on GSM Technology", International Journal of Smart Home, 7, 201-208, 2013.

[26] Kolhe S.," Average of Robbery Cases in Pune City: Three per day", (English Translation of Marathi News) Maharastra Times Marathi News Paper, 1-2, 2016.

[27] Hasan R., Khan M.M, Ashok A. and Rumpa D., " Microcontroller based Home Security System With GSM Technology", Open Journal of Safety Science and Technology, 5, 55-62, 2015.

[28] Danilo de Oliveira Goncalves, Danniel G.Costa, "A Survey of Image Security in WSN", 2015.

[29] Suparna Biswas, Subhajit Adhikari, "A Survey of Security Attacks, Defence and Security Mechanism in WSN", Vol.131, 2015.

[30] I.F. Akyildiz, W.Su, Y.Sankarasubramaniam and E.Cayirci, "A Survey on Sensor Network", IEEE Communication Magazine, Vol.40, Issue.08, 102-114, 2002.

[31] Jun Zheng and Abbas Jamalipour, "WSN: A Networking Perspective", A Book published by A John & Sons, Inc. and IEEE, 2009.

[32] Shio Kumar Singh, M.P.Singh and D.K.Singh, "A Survey on Network Security and Attack Defence Mechanism for WSN", International Journal of Computer Trends and Technology, Article-2011.

[33] K.Pelechrinis, M.Iliofotou and S.V.Krishnamurthy, "Denial of service attacks in Wireless Network: The case of jammers," IEEE Communication Survey Tut., Vol.13, Issue.02, 245-257, 2011.

[34] M.Eian and S.F.Mjolsnes, "The modelling and comparison of wireless network denial of service attacks," Presented at 3rd ACM SOSP workshop on networking systems and application on mobile handhelds, 2011.

[35] K.Sharma and M.Ghose, "WSN: An overview on its security threats," IJCA, Special Issue on MANETs, 42-45, 2010.

[36] M.Prabhu, et al.," DOS Attacks and Defences at the Network Layer in ADHOC and Sensor Wireless Networks, Wireless AD-HOC Sensor Networks: A Short Survey," EJAS, Vol.07, Issue.02, 80-85, 2015.

[37] C.Taylor and T.Johnson, "Strong authentication countermeasures using dynamic keying for sinkhole and distance spoofing attacks in smart grid networks," Presented at IEEE WCNC 2015.

[38] M.Tiloca, et al., "SAD-SJ: A self-adaptive decentralized solution against Selective Jamming attack in WSN," Presented at IEEE 18th Conferences on ETFA 2013.

[39] G.Han, et al.,"Secure Communication for underwater acoustic sensor networks," IEEE Communication Mag., Vol.53, Issue.08, 54-60, 2015.

[40] K.Gai, et al., "Spoofing-Jamming Attack Strategy Using Optimal Power Distributions in Wireless Smart Grid Networks," IEEE Trans. Smart Grid, 2017.

[41] C.Karlof and D.Wagner, "Secure Routing in WSN: Attacks and Countermeasures," Ad Hoc Netw., Vol.01, Issue.02, 293-315, 2003.

[42] J.Newsome, et al., "The Sybil attacks in sensor networks: analysis & defences," in Proc.3rd IPSN ACM 2004.

[43] E.Shi, and A.Perrig, "Designing secure sensor Networks," IEEE Wireless Communication Lett., Vol.11, Issue.06, 38-43, 2004.

[44] Q.Zhang, et al., "Defending against Sybil attacks in sensor networks," Presented at 25th IEEE ICDCS 2005.

[45] S.Ghildiyal, et al., "Analysis of denial of service attacks in WSN," IJRET, Vol.03, 2319-1163, 2014.

[46] M.R.Rohbanian, et al.,"watchdog-leach: a new method based on LEACH protocol to secure clustered WSN,"arXiv: 1310.3637, 2013.

[47] H.M.A.Fahmy, "WSN," Springer, 2016.

[48] A.wood and J.Stankovic, "Denial of Service in Sensor Networks," IEEE Computer, Vol.35, Issue.10, 54-62, 2002.

[49] A.Perrig, J.Stankovic and D.wagner, "Security in WSN," paper, CACM, Vol.47, Issue.06, 53-57, 2004.

[50] Rajkumar, Dr.H.G.Chandrakanth, et al., "Research Challenges and Characteristics Features in WSN," International Journal Advanced Networking and Applications, Vol.09, Issue.01, 3321-3328, 2017.

[51] Arun Madhu, A.Sreekumar, "WSN Security in Military Application using UnmannedVehicle," IOSR Journal of Electronics and Communication Engineering, 51-58.

[52] Tufan Coskun Karalar,"Implementation of a Localization System for Sensor Networks, University of California, Berkeley 2002.

[53] Guoqiang Mao, Barys, Fidan and Brian D.O.Anderson, "WSN Localization Technique," In 2003.

[54] Lynch J.P.,"Overview of Wireless Sensors for Real-time Health Monitoring of Civil Structures," In Proceeding of the 4th International Workshop on Structural Control, 2004.

[55] Mohd Fauzi Othman, Khairunnisa Shazali, "WSN Applications: A Study in Environment Monitoring System," International Symposium on Robotics and Intelligent Sensors, 2012.

[56] Neha Singh, Kamakshi Rautela, "Literature Survey on WSN," International Journal of Engineering and Computer Science, Vol.05, Issue.08, 17544-17548, 2016.

[57] Pathan, et al., "A Framework for Providing E-Services to the Rural Areas using Wireless Ad Hoc and Sensor Networks," to appear in IEEE ICNEWS, 2006.

[58] Al-Sakib Khan Pathan, et al., "Security in WSN: Issues and Challenges," Conference paper 2016.

[59] Alfonso Gonzalez-Briones, et al., "A Framework for Knowledge Discovery from WSNs in Rural Environments: A Crop Irrigation Systems Case Study," Handawi Wireless Communications and Mobile Computing, Vol. 2018.

[60] R.Kays, et al., "Tracking Animal Location and Activity with an Automated Radio Telemetry System in a Tropical Rainforest," The Computer Journal, Vol.54, Issue.12, 1931-1948, 2011.

[61] S.E.Diaz, J.C.Perez, A.C.Mateos, M.C.Marinescu and B.B.Guerra,"A novel methodology for the monitoring of the agricultural production process based on WSN," Computers an Electronics in Agriculture, Vol.76, Issue.02, 252-265, 2011.

[62] S.Hemsworth and B.Pizer,"Pet ownership in immune compromised children - a review of the literature and survey of existing guidelines," Eur Joncol Nurs, Vol.10, Issue.02, 117-127, 2006.

[63] L.Spencer, "Pets prove therapeutic for people with AIDS." Journal of the American Veterinary Medical Association, Vol.201, Issue.11, 1664-1668, 1992.

[64] J.S.L.Ting, et al., "A Dynamic RFID-based Mobile Monitoring System in Animal Care Management over a Wireless Network," 2085-2088, 2007.

[65] M.Murad, K.M.Yahya, and G.M.Hassan," Web Based Poultry Monitoring System using WSN," 2009.

[66] S.Roy, "Testbed Implementation of a Pollution monitoring System using WSN for the Protection of Public Spaces," 263-276.

[67] S-hwan Choi, et al., "An Implementation of WSN for Security System using Bluetooth," Vol.50 Issue.01, 234-244, 2004.

[68] S.Bhattacharjee, et al., "WSN based fire detection, alarming, monitoring and prevention system for Bord and Piller coal mines," Journal of System and Software, Vol.85, Issue.03, 571-581, 2012.

[69] R.Gao, "A Wireless Sensor Network Environment Monitoring System Based on TinyOS," International Conference on Electronics and Optoelectronics, 497-501, 2011.

[70] Y.K.Lee, Y.J.Jung and K.H.Ryu, "Design and Implementation of a System for Environmental Monitoring Sensor Network," 2007.

Cite this article as: Anil Kumar Kapil, Lokendra Kumar, A survey on security threats and application of wireless sensor network, International Journal of Research in Engineering and Innovation Vol-3, Issue-3 (2019), 217-222.