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A Comprehensive Survey on Applications and Transport Layer Protocols in Wireless Sensor Networks

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Abstract - *Wireless Sensor Networks are utilized in many kinds of fields which incorporate military, home, disaster relief operation, medical, area monitoring and other commercial programs. With the massive development within the area of embedded computer and sensor technology. The reliability of the data transfer is important for business and enterprise applications of Wireless Sensor Networks. TCP is a time-examined transport layer protocol of an internet that guaranteed reliability, flow control and then congestion control, being a heavy protocol, its miles considered unsuitable for useful resource restrained sensor networks. This paper presents an overview of application, various research issues and transport layer protocols in WSN.*

***Key Words*: General applications, TCP design issues, Transport control protocols, Wireless sensor network.**

1. INTRODUCTION

Wireless sensor network devices can be interacting with the messages through wireless links. Then data can be pass on through multiple nodes with gateway, the data is link to some other wireless network. WSNs is contains with base stations and numbers of nodes. Advancements in industrial, home and automation in transportation represent smart environments. Information for smart environments is obtained through Wireless Sensor Networks (WSN), where multiple sensors are deployed at different locations operating in different modes. A sensor network is efficient of sensing, processing and communicating which aid the base station or command node to observe and react according to the condition in a specific environment (physical, battle field, biological). Sensor network protocols have a differential self-organizing capability. The sensor nodes cooperate with each other in wireless sensor networks. The sensor nodes have some in-built processor for processed the raw data before transmission. These features facilitate wide range of applications of WSNs ranging from military, medical, home, event detection and vehicular telematics. Wireless sensor network gives the services such as monitoring, alerting, information on-demand and actuating. In this paper main focus is to discuss about common applications and research issues in the field of application of wireless sensor network. Also explored the details of Transport control protocols in wireless sensor network. Later how would be possible to select as a list of protocols better in wireless sensor network.

2. GENERAL APPLICATIONS IN WSN

Figure 1 . Architecture of WSN Application

The general applications [1] of wireless sensor network are discussed below.

2.1 Military Applications

A military application [2] is monitoring friendly forces, battlefield surveillance, reconnaissance of opposing forces. Wireless sensor networks are very useful in military operation for hostile motion and also it can be deployed rapidly and self organized. Through the sensor nodes the battlefield supervision can be done to keep a check on everything in case more equipment, forces or ammunitions are needed in the battlefield. The sensor network can be using for discover the chemical, nuclear and biological attacks. The best example for this sniper detection system. The several applications for WSN shown in Figure 1.

2.2 Area monitoring

The location detecting is one of the general software of WSNs [2]. In area tracing, the WSN is deployed over vicinity in which in a few phenomenons is to be supervising. An army instance is the usage sensor detects enemy intrusion. The general example is the geofencing of gas or oil pipelines.

2.3 Disaster relief operation

If a place is stated to have been affected from some type of calamity consisting of wildfire, then drop the sensor nodes on the fire from an aircraft. Observe the information of every node and make a temperature map to concoct proper ways and techniques to overcome the fireplace.

2.4 Medical applications

The health applications [3] preferred for keep on monitoring the patients using WSNs. The animals interior process and movements can keep on supervising. Diagnostics can be done with the help of WSNs. They also assist to keep watch on drug administration in hospitals and in monitoring patients as well as doctors. For instance, an artificial retina is assist to the patients in make out the presence of light and movement of an object. They can be locating the object and count the items alone.

2.5 Home Applications

The advanced technology is making its way in our household appliances [3] for their smooth running and satisfactory performance. We can be finding out these kinds of sensors in refrigerators, microwave ovens, vacuum cleaners, security systems and also in water monitoring systems. And also, can be control the devices locally as well as remotely by the users with the help of WSNs.

2.6 Research Issues in Environmental Applications

Environmental applications can also be supervising the atmospheric parameters, detecting of the movements of birds and animals, forest fire monitoring, habitat surveillance etc.

2.6.1 Greenhouse Monitoring

The automation system is working properly in the greenhouse [4], we just want to make sure about it. This is most important to measure the local climate parameters at discrete points of monitoring in different parts of the big greenhouse. The complete system clumsy and costly if this work is done by wired network. However, a WSN oriented application for the same scope using many tiny size sensor nodes equipped with radio would be a cost effective solution.

2.6.2 Habitat Surveillance

WSNs discover widespread application [4] in habitat surveillance compared to other tracing methods due to high deployment density and self-organization of the sensor nodes. The invisible placement of sensor nodes in habitat wont leave any noticeable mark which might affect the behaviour pattern of the inhabitants. This is the main advantage of WSNs.

2.7 Research Issues in Commercial Applications

Wireless sensor networks include a few economic applications such as vehicular tracking, cultural property safety, event detection and structural fitness monitoring. In this issues lets we explored about a few commercial applications.

2.7.1 Event Detection

Monitoring is the general characteristics of Wi-Fi sensor networks [4], particularly for fast tracing of context. Most of the work has been performed in WSN, because of sensor nodes having equal sensing devices. Howsoever, the utilization of several varieties of sensor nodes is a place but to be discussed. For event detection and tracing in wireless, heterogeneous sensor networks has been available. However, replies to sensor node utility, records dissemination and routing in Wireless Heterogeneous Sensor Networks are the nuisance but to be address.

2.7.2 Structural Health Monitoring

The technique of detection the damage for civil, aerospace and various engineering structures is called Structural Health Monitoring (SHM). In this system if any changes present interior of fabric or geometric house due to inner factors or outside elements is termed as harm. The habitual operation of an SHM machine contains the low energy, lengthy-term tracing of a figure to offer periodic updating of its fitness condition. However, in the course of critical proceedings along with earthquakes band other natural failures, real-time quick structural conditional screening may be accomplished the use of SHM gadget.

3. TCP FOR WIRELESS SENSOR NETWORKS

Taieb et al. [5] proposed TCP layer is the good choice for WSNs. The low-level layers can be issued the rich and useful information to the transport layer in the wireless sensor networks and also increases the badly needed system performance. TCP is a connection-oriented protocol. The number of sensed data is for event-based applications are usually very small in WSNs. The three-way handshake process is required for TCP. The window-based flow and congestion control might be triggering potentially the segment loss in TCP. It will decrease the transmission rate unnecessarily while packet loss may have occurred as a result of link error and there may be no congestion. This demeanor will lead to low throughput, especially under multiple wireless hops, which are prevalent in WSNs. An end-to-end process used in TCP for congestion control. Due to longer response time segment loss will be occurring, so energy wastes in the transmission. And also, TCP uses end-to-end ACK and retransmission when its to be needed. In most of the WSNs, lower throughput and longer transmission time will be performing when RTT is long.

4. TRANSPORT PROTOCOL DESIGN ISSUES

Taieb et al. [5] proposed the transport protocol designs. WSNs be supposed to design [5] with congestion control, reliability in data dissemination, security, eye to energy conservation and management. This kind of issue enters single or multilayer of the hierarchical protocols. For example, the congestion control involved at transport layer only and energy conservation might be involved in to the physical, data link, network, and perhaps all other high layers. TCP design has two major functions congestion control and loss recovery. In congestion control set of congestion can be detect by someone and also resolve when and where it is occurred. The link load or monitoring node buffer occupancy can be making out the congestion in transport control protocol. The traditional internet is consisting of two methods to control the congestion. One is active queue management (AQM) schemes used for adjust the rate at source node and another one is additive increase multiplicative decrease (AIMD) use of routing techniques. For WSNs, sensors having the limited resources so only one should be consider to detect and overcome the congestion. These kinds of protocols consider simplicity and scalability, to save energy ways to prolong the life of sensor batteries. It has two approaches such as hop-by-hop and end-to-end, then it uses for discover the congestion quickly and that result provide in less additional network traffic.

Wang et al. [6] proposed some of the design issues in wireless sensor networks, packet loss is usually due to the quality of the wireless channel, sensor failure, and/or congestion. Some critical applications required trust worthy transmission of each packet, so packet-level reliability is important. Other applications required only a proportionately trustworthy transmission of each packet. To detect the packet loss for wireless sensor network by packed switched network. The best example is each packet contain piggyback sequence number and receiver can detect the packet loss through sequence number. Once completion of the packet loss detection ACK and/or NACK can be used to recover missing packets based on an end-to-end or hop-by-hop control. In WSNs transport protocols designs by following factors

1. An execute the congestion control and delivery the reliable data. Thereafter most the data travel from sensor nodes to sink and congestion might be occurring inside the sink. Though MAC protocol can be recover the packet loss as a conclusion bit of error. For recovery the packet loss, wireless sensor network is important such as ACK as well as selective ACK used in TCP. For example, in some of the sensor applications WSNs only receive the packets exactly from fraction of sensors in that area. It cannot receive the packets from each sensors node at a time in that area. This monitoring result of input is more important for design the WSN transport protocols. This effective hop-by-hop approach used for congestion control and loss recovery, it may be reducing the packet loss and conserve energy.

2. Transport layer protocols for WSN must be condense the primary connection establishment process or use a connectionless protocol to speed up improve throughput, connection process, and lower transmission delay. WSNs applications are more reactive, which is monitor passively and holding for events to occur before forwarding data to sink.

3. Transport protocols for WSNs should be exclude packet loss as possible thereafter loss translate to energy waste. The transport protocol must use an active congestion control(ACC) for abstained the packet loss at the cost of marginally lower link usage. ACC triggers to exclude the congestion before it happens. For instance, client might be decrease the forwarding rate while buffer size exceeds a few commencements.

4. The transport control protocols should ensure reasonableness for an assortment of sensor nodes.

5. Once routing algorithm intimate the route failure, the protocols able to deduce that packet loss is from route failure not from congestion. For this situation, the sender may keep up its present rate.

5. TRANSPORT CONTROL PROTOCOLS

5.1 CODA

Wan et al. [7] proposed congestion detection and avoidance protocols. CODA is an upstream congestion control approaches that includes three factors: congestion detection, open-loop hop-by-hop backpressure, and closed-loop end-to-end multisource regulation. CODA regulates a multisource rate through a closed-loop end-to-end technique, as follows (1) When a sensor node exceeds its theoretical rate, it units a regulation bit in the event packet (2) If the event packet obtained by using the sink has a regulation bit set, the sink sends an ACK message to the sensor nodes and informs them to decrease their rate and (3) if the congestion is cleared, the sink will send an immediate ACK control message to the sensor nodes, informing them that they could grow up their rate. CODA drawbacks are its unidirectional control, only from the sensors to the sink; there is no reliability attention; and the replying time of its closed-loop multisource control increases beneath heavy congestion thereafter the ACK issued from the sink will probably be lost.

5.2 ESRT

Aka et al. [8] proposed event-to-sink reliable transport protocol. ESRT is offers reliability and congestion control, belongs to the upstream. This reliability figure indicates the rate of packets which is obtained successfully with in the interval time. ESRT assuming the needed sensor reporting frequency(f) since reliability figure(r) expression as f=G(r). ESRT uses an end-to-end technique to guarantee a preferred reliability figure through adjusting the sensors reporting frequency. The main drawback of ESRT advertises the same reporting frequency to every sensor and it can be considering main attributes are reliability and energy conservation as performance measures.

5.3 RMST

Stann, and Heidemann et al.[9] proposed reliable multisegment transport protocol. RMST ensures effective transmission of packets in the upstream direction. The middle ware nodes cache all the packet to enable hop-by-hop recovery or it can be operating non-cache mode, where final nodes cache the transmitted packets for end-to-end recovery. This protocol support cache and noncache modes and also it uses selective NACK and timer-driven mechanism mainly for notification and packet loss. An end packet is recovered hop-by-hop through the middleware sensor nodes in the cache mode. Is suppose the middleware nodes get fails to locate the end packets or the middleware node works in non cache mode, it will be send it to NACK upstream. RMST provides reliability for every application. The main problem of RMST is lack of congestion control, energy efficiency and application level reliability.

5.4 PSFQ

Taieb et al. [5] proposed pump slowly, fetch quickly protocol. This protocol is apportioning the data from sink to sensor node by using pacing data at relatively slow speed, however allowing sensor nodes that are experience collections of information loss to recover any missing segments from instant neighbour. This protocol provides downstream reliability. PSFQ includes three operations: fetch, pump, and report. This is the way PSFQ works: Sink broadcasts a packet to its neighbors each T time units until all of the data fragments had been sent out. A sequence number gap is find out once, the sensor node going into fetch mode and recovers the missing fragment by issues a NACK in the reverse path. The NACK is not transmitting by the neighbor nodes except the number of times that the NACK is dispatched exceeds a predefined inception. The main drawback of PSFQ is, it cannot be find out the packet loss for single packet transmission. It uses a slow pump, this result will make a large delay and and hop-by-hop recovery with cache necessitates mega buffer sizes.

5.5 GARUDA

Taieb et al. [5] proposed this protocol to performing under downstream reliability group. It depends on a two-tire node architecture; nodes with 3i hops from the sink are chosen as core sensor nodes (i is a integer). The rest of the nodes are (noncore) referred as second-tier nodes. Every noncore sensor node selects a nearby core node as its core node. Noncore nodes utilize core nodes for lost packet recuperation. For loss detection and notification GARUDA uses a NACK message. The loss recovery is consisting of two categories: It is among core sensor nodes and between noncore sensor nodes and their core node. Hence, transmission to recover lost packets seems like a hybrid scheme among hop-by-hop and end-to-end. The drawback of GARUDA is lack of reliability in the upstream direction and lack of congestion control. The various TCP protocols for WSN shown in TABLE 5.1

5.6 ATP

Taieb et al. [5] proposed Ad Hoc transport protocol to works based totally on receiver-and network-assisted end-to-end feedback control algorithm. For packet loss recovery it is using selective ACKs. In ATP Middle ware network nodes process the aggregate of exponentially issues packet queuing and transmission delay is known as D. The expected end-to-end rate is set as the inverse of D. All the packets are computed by the values of D that can be traverse in the sensor node which is given, then if it exceeds the value is piggybacked in each outgoing packet, before forwarding the packet it will be update the field. The receiver calculates the needed end-to-end rate and feeds it return to the sender. Thus, the sender can intelligently alter its sending rate depends up on the received value from receiver. To ensure reliability, ATP using selective ACKs (SACKs) as an end-to-end mechanism for loss detection. ATP decouples congestion control from reliability and as a result, achieves sublime fairness and higher throughput than TCP.

Table 5.1: Various Transport Protocol for WSNs

Protocols	Direction	Congestion Support	Open or closed-loop	Reliability Support	Loss detection	ACK or NACK	Energy conservation
CODA	Upstream	Yes	Both	No	-	-	Good
ESTR	Upstream	Sleepy	No	Yes	No	ACK	Fair
RMST	Upstream	No	-	Yes	Yes	NACK	-
PSFQ	Downstream	No	-	Yes	Yes	NACK	-
GARUDA	Downstream	No	-	Yes	Yes	NACK	Yes
ATP	Both	Yes	-	Yes	Yes	SACK	-

6. CONCLUSION

This paper presents a survey of applications and transport layer protocols in general wired-cum-wireless and in wireless sensor networks. The application of the WSN in the area of military, disaster relief operation, medical, area monitoring, home applications have been briefed. These exciting applications are possible because of the flexibility, fault tolerance, low cost and fast deployment characteristics of sensor networks. A review on the several research issues involved in WSN applications has been outlined. The WSNs applicationsis not restrained to the areas stated on this paper. The future possibilities of WSN applications are notably promising to revolutionize our everyday lives. The WSN characteristics are which might be low cost, low power resource constrained end devices called sensor nodes very low link bandwidths and ad-hoc network topology make application of TCP even more challenging in these networks. We identify these issues in WSN and represented the several approaches followed by using researchers a good way to implement reliability in WSNs. These techniques are classified as making TCP appropriate for WSN by several methods like parallel TCP, link layer retransmissions, splitting TCP throughout proxy, issued TCP caching and retransmissions and designing new transport layer protocols for WSNs consistent with the features and restrictions of these networks. This survey is useful for researchers project the mission of exploring transport layer problems in both general wired-cum-wireless networks and specifically in WSNs.

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