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A Survey on Different WSN Transport Layer Protocols for Congestion Control and Reliability

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***Abstract*— Protocol stack of Wireless Sensor Network (WSN) contains five layers. These are also called standard protocol layers. In this transport layer protocols plays an important role in handling the congestion and maintaining the reliability. This layer mainly provides these both functionalities: congestion control and reliability. Transport layer helps in connect to other system and provide connectivity goals. There are so many protocols already exist to handle the congestion and provide the reliability. In this paper we are representing a review on transport layer protocols of reliability and congestion control. We also give a brief introduction of WSN networks. Later we separately described the protocols and disadvantage of UDP and TCP traditional protocols of transport layer protocol.**

***Index Terms*— Wireless sensor network, Transport layer, Protocols, Reliability, Congestion**

I. INTRODUCTION

Sensor network gives a communication infrastructure that utilizes a system of circulated sensors and sensor nodes to procure information and hand-off it central or diverse monitoring location. Generally monitoring parameters are pressure, wind direction and speed, illumination intensity, sound, vibration intensity, power-line voltage, temperature, humidity, chemical concentrations, pollutant levels etc. For different purpose there are different sensors available. Sensor network can be wired or wireless. Here we are focusing on wireless sensor network.

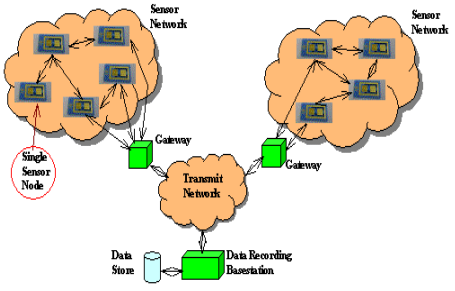

Fig 1: WSN Architecture

The architecture of WSN follows five layers same as OSI model named as: application layer, transport layer, network layer, data link layer and physical layer. Other than this there are three cross plane layers named as: power management plane, mobility management plane and task management plane.

Wireless Sensor network has a wide research area, its rapidly increasing. There are so many application of wireless network. Sensor network is a collection of nodes which interact with each other and for transmission of information we need a reliable protocol. Here transport layer protocol comes in frame. Using transport layer protocol we can provide the congestion control and reliability.

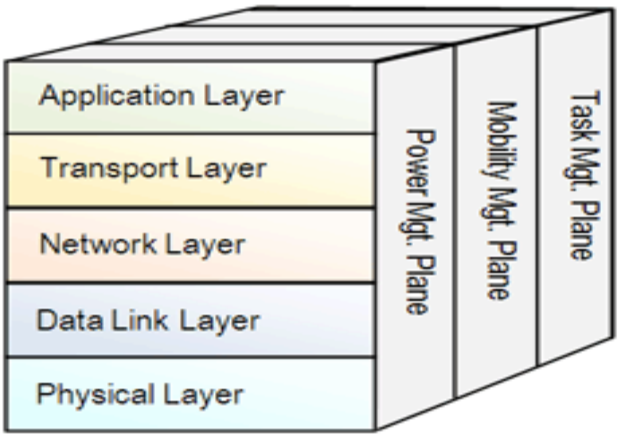

Fig 2: WSN Layers Stack

Basic Services Provided by Transport Protocols are:

Reliability: Reliability refers to delivering each segment of information data or packet successfully from source node to destination node. Reliability can be explained in two classes.

- Packet reliability or hope to hope: packet should be delivered to destination from source or sink node.
- Event reliability: every event should be detected, nut it is enough to get one notification message at sink node.

Congestion Control: Congestion can be referred as traffic. Whenever bandwidth is insufficient or the load capacity of receiver network does not fulfill by the sender there is a possibility of occurrence of congestion. Congestion control leads to packet loss, delay in network and low throughput.

Flow Control: Flow control is managing the data packet flow between the nodes. Congestion control is used for managing the flow control between the source and sink.

Allocation of bandwidth: Transport layer protocols play an important role in allocation of bandwidth. It allocates the unbiased or fair bandwidth to all nodes in the network, which helps in maintaining the flow control.

Packet Loss Recovery: Here packet loss recovery means packet retransmission and reach-ability of packets.

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Transport Layer Protocols for WSN:

In transport layer there are two most known protocols are TCP and UDP. But we cannot use them for WSN's. Both are not well suitable for the wireless sensor network. TCP and UDP both used for internet and many other transmission applications.

For WSN we need reliability and congestion controls both functionalities. Where TCP is a reliable but when gives low throughput because whenever a packet drops it believes that it happened because of congestion and it slow down the transmission speed which leads to low throughput. On the other side UDP is a fast processing protocol but it is a connectionless protocol. It does not provide the reliability and congestion control.

So for WSN's different protocols of transport layer have been designed which are categorized into three ways:

- Provides reliability
- Provides congestion control
- Provides both functionalities

II. LITERATURE SURVEY

Wireless network is collection of nodes that is embedded with computing devices and sensors. As to provide reliability and congestion control in the distributed environment we need to follow some transport layer protocol methods. Kanchan Kaushal, Taranvir Kaur, Jaspinder Kaur [1] represented a survey on the WSN reliability protocols. They explained the architecture of WSN network and the different protocols for reliability and congestion check. Chonggang Wang, Mahmoud Daneshmand, Bo Li, Kazem Sohraby [2] discussed about the current issues in WSN protocols and represented a comparative study among protocols. Nilima Rani Das1, Rashmi Rekha Sahoo and Debashree Mishra Sar [8] described about the congestion control and avoidance algorithms. As the WSN network scale and scope is increasing day by day we need to implement more relevant methods. Vasilis Michopoulos, Lin Guan, George Oikonomou, Iain Phillips [9] they represented their views on RDC (Radio Duty Cycling) can drastically influence the performance of congestion detection. Ahmad Abed Alhameed Alkhatib, Gurvinder Singh Baicher [10] represented a survey on wireless network architecture. They explored every layer of WSN architecture according to OSI model. Further they explained the protocols and ideas of best design of WSN network. Almir Davis, Hwa Chang [11] represented a comparative study among existed WSN architecture on basis of network lifetime, scalability, modularity, and ease of latency, reliability, quality of service (QoS), fidelity, deployment. Ekaterina Dashkova and Andrei Gurtov[3] presented a Survey paper on on Congestion Control Mechanisms for Wireless Sensor Networks.The fundamental objective of this paper is to consider all the techniques of congestion control for compelled enviornment and propose a requirement for improvement through new adaptable paper. The new solution which is suitable for congestion control and other protocols. Raheleh Hashemzehi, Reza Nourmandipour, Farokh koroupi [4] presented a paper on Congestion in Wireless Sensor Networks and Mechanisms for Controling Congestion in which they basically describe characteristics and contents related to different congestion scenarios. Swastik Brahma and Mainak Chatterjee Kevin Kwiat [7] presented a paper on Congestion Control and Fairness in Wireless Sensor Networks in which they proposed a new algorithm for a dispersed congestion control calculation for tree based internetworking in remote sensor arranges, that tries to adaptively relegate a reasonable and productive transmission rate to every hub.

III. RELIABILITY PROTOCOLS

Reliability in transport layer means that each segment should be properly delivered from source to destination. Reliability could be maintained by keeping up-to-date information of dropped packet and again transmitting packet to its particular (relevant) point.

I. Reliability Direction

There are basically two directions in WSN in which information is send and write.

1) Upstream Reliability

When information flows from the start point to the end point perfectly without any errors it is called Upstream Reliability, mainly this type of flow is one direction communication. Example is ESRT[1] which only assure about the event reliability and consistency of the event stream. While packet reliability is provided by RMST(Reliable Multi-Segment Transport) [2] and RBC(Reliable Bursty Convergecast)[3]. The GARUDA and PSFQ do not have upstream reliability.

2) Downstream Reliability

The transmission of control packets and problems that are successfully transferred from the end point to the start point is known as downstream reliability; mainly this type of flow is one to many communications. Both GARUDA [4] and PSFQ [5] follow downstream reliability.

3) *Bidirectional Reliability*

This is the best possible reliability as it is achieved in both directions, downstream and upstream. For any protocol, reliability is better when it is bidirectional example ART.

II. Reliability Level

This field basically tells about the height of reliability sustained by the protocol. There are three levels of reliability as follows.

1) *Packet Reliability*

Packet reliability is the conveyance of the considerable number of packets effectively to the destination. It is important in certain control driven application situations, e.g. consistent dampness checking for a control process, and so on. Each detected data is of essential nature and any loss of data might bring about procedure breakdown.

2) *Event Reliability*

Event reliability introduced the perfect event reorganization. For instance, if more than one sensor in the field detects the temperature and outlines to the end point, it is normal that no less than one packet will be conveyed and the successful delivery of each and every packet is not necessary. Only PORT, ART provides event reliability.

3) *Destination Reliability*

This worries to send the message effectively just to the

particular hubs or a chosen bunch in whole WSN system. This protocol GARUDA offers end point reliability with the packet dependability. All in all, the packet fidelity is much better than event fidelity as it promises the conveyance of every last piece of data. Be that as it may, then again, packet level fidelity quality includes more vitality usage. Hence the convention outline ought to be more adaptable to adjust both event and packet reliability relying upon the focused on application. Some Reliability conventions are portrayed as takes after:

A. PSFQ

PSFQ (Pump Slowly Fetch Quickly) was motivated due to 2 reasons.

- There is a rising need to be able to re-assignment or reconstruct clusters (groups) of sensors in remote (high fallacy rate) sensor systems on the fly.
- Because of the application-particular nature of sensor systems, it is hard to outline a solitary solid transport framework that can be enhanced for each application.
- The crucial idea after designing PSFQ is to design consistent, light protocol to spread data from start point at very low speed –that is called Pump Slowly Fetch the missing data from the nearest neighbors – that is Fetch Quickly. PSFQ [6] is downstream reliable protocol. PSFQ is outlined.
- It is recognized when a higher grouping number than anticipated is gotten at a hub setting off the fetch operation.
- Minimize the quantity of transmissions for lost discovery and redemption operations with least flagging
- Operate effectively even in a situation where the environment is extremely poor
- Provide free defer limits for information conveyance to all the planned receivers

PSFQ follows three functions.

1) *Pump*

Hub telecasts a parcel to its neighbors each Tmin. Collectors checks for gaps in arrangement number .On the off chance that this is another packet (diminish TTL => TTL==0) and there is no crevice in seq# then a dispatch is planned.

Limitation: Tmin< Ttransmit < Tmax ,(Tmin,Tmax clocks)

2) *Fetch*

Fetch operation solicitation to retransmit the missing bundles from neighbor.

3) *Report*

Details to user are provided by third function.

B. GARUDA

GARUDA is a legendary winged animal that moved divine beings dependably. GARUDA gives information conveyance from a solitary point to the different focuses from sink bit to the sources. Subsequently we can say that GARUDA guarantees downstream reliability. Reliability can be characterized into four sections:

- Assures conveyance to the entire field,
- Assures conveyance to a sub district of the sensors,
- Assures conveyance to an insignificant arrangement of sensors and
- Assures conveyance to an expect subset of sensors.

GARUDA make utilization of an out-of-request sending way to deal with overcome the issue of less use in the demonstration of packet misfortunes. Out-of-request sending permits back to back parcel to be sent even when the packet is lost.

GARUDA utilizes two stage misfortune recuperation forms. [1] In first stage, packet recuperation is finished by the center hubs [7]. At the point when a packet touches base at central hub which is not agreeing the succession, it advises to central hub in upstream course that some packet is absent. Another is called noncore recuperation [1] stage in which no central hubs solicitations to transmit bundles again from center hubs.

C. RBC

The Remote Building Control Protocol (RBC) is an application layer convention for disseminated, communitarian, hypermedia data frameworks. The configuration of RBC depicts a nonexclusive, stateless, convention which can be utilized for some undertakings past its utilization for building knowledge; RBC is Reliable Bursty Convergent convention. In RBC, middle of the road hubs stores each part they get. On the off chance that a part is recognized, it is erased from the store, else it is rehashed n times. RBC actualizes a unique store lining model able to do proficiently conveying unordered pieces, which is valuable for bursty communication. The convention utilizes numerous (square) ACKs.

D. RMST

RMST is Reliable Multi-Segment Transport [8] was displayed to cross dependability at the transport layer [7]. RMST is a convention in light of specific NACK which might be arranging for in network reserving and repair. RMST was intended to work in synchronicity with coordinated dissemination. RMST i.e. Dependable Multi-Segment Transport [7] was intended to understand the activity of in network preparing for the dependably exchange the information. RMST is valuable over dissemination steering, since it includes insignificant extra control movement. All the more so while numerous bounces show higher rates of blunder the RMST ensures the conveyance. Conveyance request is straightforward to the customers of RMST yet request is not ensured. RMST does not guarantee any insurance at constant.

In RMST, collectors are in charge of identifying if a section should be re-sent or not. Here the "beneficiary" does not as a matter of course mean sink. In the non-storing mode, just sinks screen the trustworthiness of a RMST element with respect to got sections. In storing mode, a RMST hub gathers parts and is fit for starting recuperation for missing pieces to the following hub along the way toward the source.

IV. CONGESTION CONTROL PROTOCOLS

Congestion can be explained as traffic occurs in the network. When the sender side producing the more data compare to the capacity of the receiver side, then there is a packet drop. Some information might be dropped while reaching at destination node. It can't be acceptable. Sometimes we need to retransmit the data to recover from the loss. How to control the

congestion control? We can control congestion using transport protocols. There are five transport layer protocols we can use: Congestion Detection and Avoidance (CODA), SenTCP, Fusion, Priority-based Congestion Control Protocol (PCCP) and Congestion Control and Fairness (CCF). This can be described as:

A. CCF (Congestion Control and Fairness)

It provides simple congestion and fairness mechanism based on the packet service time calculated at MAC layer. Congestion controlled in hop-by-hop manner with simple fairness. By using packet service time we can find the congestion rate in the network on every intermediate node. When congestion occurs in network, it sends the updates to the respective nodes to the downstream to slow down the sending process.

B. PCCP (Priority-based Congestion Control Protocol)

Priority based congestion control handles the congestion based on the priority mechanism. It calculates the degree of congestion as a ratio of packet arrival rate. We fix some priority for each sensor node according to requirements. Nodes near the destination have more priority than to nodes away. Nodes adjust their congestion by themselves by slowing down the sending speed of node. This protocol is suitable for the single path and multipath routing.

C. Fusion

Fusion congestion control works on stop-and-start manner. In this method whenever congestion occurs on a node it sends the congestion information to the next node and next will sent it to next to next node and process followed. There is a CN (congestion notification) field in the packet header where previous node mention about the congestion. With the help of this packet header every node gets to know about the congestion in the network and they stop forwarding the packets. That's how we manage to control the congestion.

D. ARC

Adaptive rate control mechanism not generates any congestion notification. Instead of that it uses two function values alpha and beta to fix some threshold value. A intermediate node is continuously increased by a packet rate to check the failure point or point where congestion occurs. This point defines as alpha α. If it is successfully forwarded to sink node from parent node than fix a constant value. Otherwise, the intermediate node multiplies its sending rate by a factor beta β, where $0 < \beta < 1$. Alpha and beta factor used to provide the fairness in the network.

E. Siphon

Here the concept of VS (virtual sink) and redirection bit come into frame. When congestion is increases and it is difficult to handle, we redirect the congestion to the virtual nodes. Virtual sinks are randomly distributed across the network to control the congestion. When we redirect the congestion we have to change the redirection bit in the network header to acknowledge the information about the redirection. When the congestion is in the hand again we transfer data from virtual sink to the original sink.

V. CONCLUSION

As the WSN network plays an important role in getting high performance in data transmission and better life of a network. We should provide some mechanism towards the reliability and congestion control.

In this paper we explored the different protocol of transport layer providing congestion control and reliability. There are three types of protocols first, which provides only congestion. Second, which provides only reliability and third, which provides both congestion control and reliability. Here we discussed only first two types.

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