

Retransmission and Congestion Control of Hop-By-Hop Protocols and End-To-End Protocols in Wireless Sensor Networks



P.Geetha Mageswari, R.Jayakarthish, M.S.Nidhya

Abstract-Wireless Sensor Networks serene of number of nodes, which monitors the environment. Monitored data is send to the base station by a sensor node. Information may be lost at the sender side or in intermediate node itself. This lost information can be rectified by number of protocols. Generally loss recovery is done by hop-by-hop and end-to-end in WSN. This paper analyses and compares shop-by-hop protocol and end-to-end in wireless sensor networks (WSNs). We examine and compared hop-by-hop and end-to-end protocols based on some constraints such as retransmission and reliability. We classify the transport protocols into two groups such as hop-by-hop and end-to-end. Hop-by-hop protocol and end-to-end protocols are compared based on the parameter such as retransmission and congestion control, time delay and energy efficiency. We finalized that hop-by-hop protocols are best suited for retransmission and time delay; end to end protocols are suited for congestion control and energy efficiency.

Keywords: protocols, end-to-end, hop-by-hop, WSN, reliability, retransmission.

I. INTRODUCTION

Wireless Sensor Networks are applied in military, forest fire monitor, climate monitoring, habitat monitoring, health monitoring and so on. Information is passed to sink node by a monitoring node. User can accumulate the data from base station. The significant benefit of sensors is it accesses the environment where human cannot reach. A sensor is a small device that is proficient of monitoring, processing and communication capabilities. Based on the application sensors can be used to sense temperature, fire, water level, soil moisture. The processing unit of a sensor can manipulate the detected value and also expected values from neighbors. The communication unit in a sensor node is used to transmit and receive the information. Transport layer protocol handle transmission between base station and sensors in two ways 1) upstream 2) downstream. Upstream means communication is from sensors to base station. Downstream means

communication is from sink to sensor. In critical environment, event data are monitored by the sensor nodes. Then sensors reliably forwarded to the sink. So major challenge of WSNs is, it should reliably transfer data from sensor nodes to the sink in the presence of error in wireless links. Reliable transfer of data is the guarantee delivery of packet to the target. In WSNs, reliability can be divided into various levels, one is packet reliability another one is event reliability. Generally reliability is evaluated by time delay and energy factor of each node[4]. Packet reliability guarantees reliable transfer of all sensed data to the sink node, collected from the sensor node. However, event reliability guarantees that the sink only gets sufficient data about an assured event happening in the network as a substitute of transferring all the sensed packets.

To achieve reliability the lost packets has to be recovered through retransmission of lost packets. As we said earlier that end-to-end and hop-by-hop are two ways to achieve retransmission. In end-to-end, lost packet can be retransmitted by source node only. Whereas in hop-by-hop, lost packet is recovered from intermediate nodes by their local buffer. In a multi-hop WSNs, reliability in the basis of retransmission can be attained by acknowledgement mechanism. On the way to sink node the sender node have to receive acknowledgement from the neighboring node for its data packets. The major types of acknowledgements are ACK- Explicit acknowledgement, NACK -Negative acknowledgement and iACK-Implicit acknowledgements. The eACK technique ensures the complete reliability for each packet transferred. After successfully packet received a receiver node will send a special message eACK to the sender about the message received. NACK also sends special message like eACK, missing sequence of packet can be retransmitted by the sender if it is required by the destination. ACK and NACK mechanism leads to high communication overhead and energy wastage which may not be achievable for most of the WSN applications. But iACK technique, avoids transmission overhead and reduces energy wastage. Using iACK a sender can overhears the next node about the message send by it. In this paper section 2 explains hop-by-hop supported protocols, section 3 explains end to end protocols, section 4 illustrates the comparison between the protocols, and section 5 depicts the conclusion.

II. HOP-BY- HOP

Guaranteeing the reliable communication of packet to the endpoint i.e. the sink node is responsible of next hop. Hop-by-hop supported protocols are ERP, SWIA,ERTP, RMST. End to end supported protocols are STCP, ART, LTRES, RTMC.

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A. EVENT RELIABILITY PROTOCOL (ERP)

Event Reliability Protocol (ERP) [1] is an upstream hop-by-hop transmit the details about event to the sink reliably. It works on the basis of spatial temporal correlation. It suppresses the redundant information in a packet. That is if an event is happened in an environment that will transmitted to sink node. Repeated information is transmitted over the network, due to this energy will be lost for nodes in the network. ERP saves energy of a node by reducing the redundant packet transmission and reduce traffic by using implicit acknowledgement (iACK). Generally data flow is controlled by sink node but ERP controls traffic, saves energy of a node and controls congestion also. The ERP process is based on Region-based selective retransmission mechanism in which the sensor node behaves in store and forward manner. A sensor node sense an event from an environment, event data has to be send to the next node, the next node store the event information then it forward the information to next node. ERP uses implicit acknowledgement that is a node will over hears that the message passed by it is transmitted successfully to the next node [1]. That node then erases the packet information from the queue end and the next packet in the queue is processed. Data about the event from each region is adequate for the sink. Sink node does not require event details from all the nodes present in the region. ERP uses selective retransmission process. Hence if a node lost any packet information or not receives a packet at prescribed amount of time then that specified packet will be retransmitted. It will retransmit a packet only if the unrecognized packet will not be in the node's queue. Advantages of ERP are an energy efficient and low traffic overhead by minimizing the retransmission of duplicate events. Disadvantage is it decline network coverage when density of a node increases.

B. STOP-AND-WAIT-IMPLICIT ACKNOWLEDGEMENT (SWIA)

Stop-and-Wait Implicit Acknowledgement (SWIA) method is used by Directed Flood-Routing Framework (DFRF) [2] for packet recovery in wireless sensor networks. In SWIA, receiving ACK for previous packet then only the node will send another packet. It efficiently use implicit acknowledgement (iACK)[3]. This denotes that before sending a packet, a sender sense the channel and check if the receiver has any pending packet to forward. In a firm time limit the source has to receive iACK, it means that the destination has receives the packet; else, the sender undertakes that the packet is lost. The benefit of SWIA is without any additional packet overhead, iACK creates effective use of the transmission nature of the wireless channel. SWIA retransmits every lost packet. During congestion retransmission of each lost packet create a channel contention problem. Retransmission of each lost packet may reduce the reliability of the network. The SWIA protocol, transfer the next packet only if it got ACK packet for the previous transmitted packet [5]. An iACK mechanism reduces network traffic; a node has to check the channel after transferring a packet. Advantages of SWIA are traffic minimized and there is no additional packet overhead. Disadvantage of SWIA is using of iACK technique cause delay in the network performance.

C. ENERGY-EFFICIENT AND RELIABLE TRANSPORT PROTOCOL(ERTP)

Energy-efficient and reliable Transport Protocol (ERTP) [6], is an energy effective transport protocol providing end-to-end arithmetical reliability for a WSN application producing streaming data. It strongly-minds only the amount of data acknowledged by the sink relatively than the reliability of each data from sensor to sink. To recover the lost packet ERTP uses Stop-and-Wait Implicit Acknowledgement [1] whereas end-to-end reliability is attained by proving the reliability at each node and use of ACK to approve packet response at the sink. To reduce the energy consumption ERTP dynamically decreases the number of rebroadcasts. A retransmission timeout estimation mechanism is introduced in which the node's coming up time for iACK at each node is energetically attuned based on time taken by the downstream nodes to forward the packet. This results in major reduction in energy consumption. This is the one of the main advantage of ERTP. One of the disadvantage is, low percentage of network congestion occurrence stage it use low power listening (LPL) MAC protocol for implied acknowledgements. Inadequate number of retransmissions effects in loss of packets. Network congestion may occur but it is not detected and controlled efficiently.

D. RELIABLE MULTI-SEGMENT TRANSPORT (RMST)

Reliable Multi-segment Transport[7], packets are divided into number of segments then it will be transferred to the sink node (Destination). Reassemble is done at receiver side. It is mostly suitable for sending a large size of multimedia files. This protocol sends similar data from other nodes to destination, in which missing segments are also retransmitted even though it does not collect data inaccurate. For sending control messages RMST uses NACK but it does not respond for a downstream node NACK request about detection of holes in the non-caching mode. It also does not efficiently use NACK; it can work only if the destination obtains at least one packet from the source. Reliability is not assured for particular messages.

II. END TO END

End points (i.e. merely the sender and receiver nodes) are accountable for confirming the effective communication. End to end delivery supported protocols are STCP, ART, LTRES, RTMC.

A. SENSOR TRANSMISSION CONTROL PROTOCOL (STCP)

Sensor Transmission Control Protocol (STCP) [8] is an (sensor-to-sink) end-to-end transport protocol which controls congestion and provides reliability also. Sink node is a central processing for this protocol. Congestion in a network is detected by intermediate node and notified to sink node and set the notification bit in header. Sink node instructs the affected sender nodes in the congested path about the congestion and insist them to change the path for reliable packet transmission. STCP offers different levels of reliability for various types of applications.

To provide reliability, it knobs different type of data flows for event-driven and different type data flow for continuous. ACK technique is used for event-driven applications, to acquire a confirmation of packet response from the sink; source nodes use end-to-end retransmissions. On the other hand, the sink node use NACK based end-to-end retransmissions for continuous data flow. Based on the queue length congestion is detected by the intermediate node and notified to the sink node. To sustain reliability, sender node retains the data in its cache, until it receives an acknowledgement from the sink. Some times this may cause inactivity and store excess, long waiting of sender node for an acknowledgement.

B. ASYMMETRIC AND RELIABLE TRANSPORT (ART)

Asymmetric and Reliable Transport (ART) [3] that selects some essential nodes (E-nodes) from network then exertion organized as cluster heads to offer end-to-end reliability and query reliability. End-to-end reliability is an upstream and query reliability is downstream. Bidirectional reliability is provided by ART. To provide a congestion control ART regulate the data flow of intermediate nodes. This process may save energy in an efficient way. E-nodes are used in this protocol. Communication overhead will not be occurred in this protocol because of E-nodes. E-nodes are nominated by the residual energy level of a node. ART achieve upstream reliability by transmitting ACK between E-node and the sink. E-node send first event message to sink node by setting the event notification bit and start timer. It waits for an ACK to be received. However, the sink is imposed to send an ACK, if it accepts a message with its event notification bit enabled. Within the timer E-node should receive the ACK or else if the timer finishes, E-node once more permits the event notification bit, rebroadcast the message and returned the timer. Using NACK mechanism, ART performs reliable query propagation. E-node receives query from sink node to check the sequence order of fragment. If E-node detects query fragment loss the sends back a NACK to sink node. As a final point, with the help of E-nodes congestion is also controlled. E-node assumes network is congested, if it does not receive any acknowledgement from sink node within specified time duration. Then E-nodes control the data flow by controlling its neighboring non E-nodes for transferring any data till the congestion is unoccupied. In this protocol E-nodes are efficient that non E-nodes because congestion control and event reliability are efficiently handled by E-nodes. During congestion packet loss at non-essential nodes are not recovered by ART. ART provides reliability and congestion control only for the essential node, however the reliability for non-essential nodes are ignored which is the major portion of network.

C. LOSS-TOLERANT RELIABLE EVENT SENSING (LTRES)

Loss-Tolerant Reliable Event Sensing transport protocol (LTRES) [9] is the end-to-end transport reliability protocol. This protocol can be applied in heterogeneous sensing environment. LTRES [10] reports event-to-sink reliability and guarantee end-to-end transport reliability. LTRES requires an event area as an alternative of each sensor node's information. In adding to that it provides sources rate alteration based on the network capacity. This network size is

calculated by evaluating the event throughput at the sink. LTRES is based on light weight congestion control and information about congestion occurrence is reported by the sink node instead of sensor node. Then the congestion is controlled by the sink node by destroys the communication of the violent nodes based on the data it receives. On the basis of current network LTRES sustains a convinced level of loss tolerant reliable (LTR) data transport necessities. It provides best services where prescribed level of reliability is not attained. Event area is called as monitoring area in where the sink access events from E-nodes then it measure required level of reliability from the observed level of reliability. Reliability measure is sending to set of E-nodes. Using this reliability measure packet loss rate at each E-node is premeditated by the sink node in a periodic manner. In this protocol congestion detection and avoidance is carry out sink node. The sink observes if the packet loss rate is high then routing path is called to be congested. It sends congestion notification to a congested E-node, and then E-node avoids congestion by reducing their source rate. The sink directs session close packet to the E-nodes if an event is not occurred then LTRES task completed. LTRES is entirely hooked on the sink, because the sink node transmits the re-organised sender nodes to the downstream E-nodes, but it cannot provide reliability or congestion control for non-essential nodes. Absence of loss recovery and reliability attentions for the non-essential nodes is the disputes of this protocol. Advantages of LTRES are it achieves traffic control, compared with LSR protocol fast and reliable event sensing. The disadvantage of LTRES is a reduced amount of energy efficient due to source rate adaptation mechanism.

D. RELIABLE TRANSPORT WITH MEMORY CONSIDERATION (RTMC)

Reliable Transport with Memory Consideration (RTMC)[11] is a reliability oriented transport protocol contemplates restricted memory of sensors and unreliable links also. RTMC splitting up the files then it will be communicated; the node can transfer the files only if the memory of the next node gets free. Moreover, it assures that sink has received all the segments reliably. In this protocol, information about memory is stored in the header of the packets then it will be shared among the neighbours. Due to this memory overflow is prevented. In RTMC uses relay node for transmission. Sender node can transmit the parts of a file to receiver node, till the memory of an intermediate node is full. The communication rate at the sender is dynamically adjusted to tackle the relay node situation. A node currently receives the segment which is not approved by the next neighboring node. Then it request the previous node to send packet if that node's memory is empty. Transmission finished information is informed to intermediate node by the source node if all the segments are sent. One of the restrictions in this protocol is, more memory space is requires when huge amount of nodes transferring the data at the similar time. It leads to vast time delay. This protocol cannot work properly if many sources sending the segments to the sink node. Explicit congestion control techniques are not available.

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| Reliability level | Protocols | Retransmission | Energy/time delay | Congestion |
|-------------------|-----------|----------------|---------------------------|--|
| Hop-by-hop | ERP | iACK | Energy consume | Congestion controlled. |
| | SWIA | iACK | Energy consume | Delay in network performance |
| | ERTP | iACK/ACK | Reduce energy consumption | Congestion occurs |
| | RMST | NACK | Time delay | No explicit congestion control mechanism |
| End to end | STCP | ACK/NACK | Time delay | Congestion controlled. |
| | ART | ACK/NACK | Energy efficient | Congestion controlled. |
| | LTRES | ACK/NACK | Less energy efficient | Congestion controlled. |
| | RMTC | NOT ACK | Time delay | No explicit congestion control mechanism |

IV. RESULTS AND DISCUSSION

Hop-by-hop protocols and end to end supported protocols are analyzed based on retransmission, congestion control, energy consumption and time delay. From overall analysis of congestion control hop-by-hop protocols are less efficient than end-to-end protocols. But in the point of retransmission hop-by-hop protocols are best one because it supports implicit acknowledgement iACK. Generally iACK avoid transmission overheads and energy is wasted by the transmission of control messages (eACK/NACK). In the basis of time delay, end to end protocols are delay in transfer when compared with hop-by-hop protocols. Hop-by-hop protocols are less energy efficient than end to end protocols. In end to end protocols, Asymmetric and Reliable Transport (ART) provides energy efficiency when compared with other protocols. In this paper we analysed eight protocols which are grouped into two categories one is hop-by-hop and another one is end to end. In our point of view, end to end protocols are most suited for congestion control and energy efficiency it is shown in the table 1.1. Hop-by-hop protocols are efficient in retransmission and time delay.

V. CONCLUSION

In this paper we analyzed reliable transport layer protocols, on the base of four limitations such as retransmission and congestion control, time delay and energy efficiency. We grouped the transport layer protocols into two categories, end to end protocols and hop-by-hop protocols. In the basis of our analysis end to end protocols are most suited for congestion control and energy efficiency; hop-by hop protocols are efficient in retransmission technique and time delay. In future efficiency in dynamic wireless sensor networks.

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