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Real time Routing Protocols in Wireless Sensor Networks: A Survey

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Abstract- Recent advancements in technology have led to real time applications in wireless sensor networks. The advantages and importance of well timed message delivery in emerging new areas of applications has made real time wireless sensor networks of utmost importance. Due to these applications, many routing protocols have been designed which concentrate on real time design issues. In this paper we present a survey of real-time routing protocols for WSNs, along with the highlights of the advantages and performance issues of every protocol discussing the important parameters on which each depends. In addition, the paper concludes with classification and comparative performance of each real-time routing protocol.

Keywords - Real Time Communication, Routing Protocols, RT systems, Wireless Sensor Networks

I. INTRODUCTION

Due to latest advancements in technology, the production of low cost sensors has become possible both technically and economically. The sensing electronics measure the atmospheric conditions surrounding the sensor and generate electronic signals. Processing such signals reveals about the properties of objects located nearby the sensor. Various groups of sensors can be networked in many applications that require unguarded operations. A Wireless Sensor Network (WSN) consists of a base station, various sensor nodes that communicate with each other directly and also to the base station and the end user [2]. Sensor nodes are used to measure various geographical conditions and their output is wirelessly transmitted to the base station for analysis and collection of data. End users also receive the data from the sensors via websites from long distances[3].

A Wireless Sensor Network consists of spatially distributed autonomous sensors to examine environmental conditions like temperature, pressure, sound etc. The development of these networks has effected the efficiency of various military and civil applications such as weather monitoring, distributed computing, detection of atmospheric conditions such as temperature, sound, light and disaster management[3][4]. There lies wide difference between Wireless Sensor Networks and Real Time Systems based on parameters like wireless nature, low node reliability and dynamic network topology. Therefore, developing real time applications over WSNs considers the timing constraints, and also methods of efficient energy routing,and relay of data from sensor nodes to the sink to maximize the life of the network.

This paper is organized as follows: in Section II, a description of Real time communication in Wireless Sensor Networks is stated. Then in Section III, we have described the Real Time Routing Protocols followed by summary and classification of the Real Time Routing Protocols in Section IV where a comparison between different protocols is shown. Lastly, the conclusions are addressed in Section V.

II. REAL TIME COMMUNICATION IN WIRELESS SENSOR NETWORKS

Routing is an important parameter in sensor networks because of their significance in real time processing and power communications[7]. Real time sensor systems are basically used in intruder tracking, medical health and fire monitoring. For example, a surveillance system alerts intruder authorities within moments of detection. The communication of information from sensor nodes to the base station should be well timed to make the system effective. Another real time application of wireless sensor networks is detection of forest fires.A group of sensor nodes are installed in a forest area to detect when a fire has taken place. These nodes are equipped with sensors to measure humidity,temperature and gases which are produced by fire in the forest area. The early detection is crucial for a successful action but with the help of wireless sensor networks thefire brigade will immediately come to rescue.

Real time routing in sensor networks has become challenging due to its various characteristics which are different from wireless ad hoc networks[3][13]. Firstly, a global addressing scheme is needed which is tough to implement for a certain number of sensor nodes. Secondly, efficient management of resources is important for sensor nodes which are bound in terms of power transmission, processing capacity and on board energy. Thirdly, new designs of real time routings are needed for granting RT QOS which guarantee end to end delivery time.

Wireless sensor networks have gained huge importance for their capability to meet the real time QoS guarantee in time constrained scenarios[1]. Real time communication of a sensor network is directly affected by the choice of routing protocols. In such applications, for positive results the steady delivery of data is very important as out dated data will lead to harmful effects. Real time systems are further categorized as hard real time and soft real time. In hard real time systems, deterministic end to end delay bound is required otherwise catastrophic results will occur while on the other hand in case of soft real time systems some delay is tolerable i.e. probabilistic results are accepted[5].

III. REAL TIME ROUTING PROTOCOLS

The main liability of real time routing is to efficiently maintain the timing of data delivery by aiding transmission delay bound in network layer. To the best of our knowledge, RAP is the first Real Time Routing approach for Wireless Sensor Networks. Admittedly, the SPEED protocol is one of the most important RT routing protocols and has been an inspiration for many other RT routing protocols. RT protocols are broadly classified in this section.

A. RAP

RAP is a real time communication architecture for wireless sensor networks.RAP[1]is the first routing protocol having a detailed study on deadline issues in multi-hop wireless sensor networks. The interaction and sensing of control applications with RAP takes through a set of Query/ Event Service APIs. The function of Query/Event Service layer is to submit the query or event registration to an area. The sensor base communication is supported by a network stack which includes a transport layer namely, Location Addressed Protocol (LAP), Geographic Forwarding (GF) routing protocol also a Velocity Monotonic Scheduling(VMS), and a MAC which is prioritized. RAP works on conditions that the routing layer is aware of geographic conditions. A router determines the location of the destination and forwards the packet in the direction of destination. GF is highly scaled with respect to network diameter, number of nodes, and rate of change in topology. The protocol uses VMS, which supports priority scheduling of packets using speed of transmission[11].

B. SPEED

It is a QoS routing protocol which supports soft real time routing in sensor networks which is based on feedback controls on stateless algorithms [1][6]. SPEED uses geographic location to make localized routing decisions. In addition, SPEED secures a speed for every packet in the whole network so that every application can make an estimation of the end-to-end delay for the packets by having the division of the distance to the sink by the packet's speed before making the decision of admission. Also, SPEED avoids all the congestion in the network and carefully handles all the voids with minimum control overhead.

SPEED uses a routing module called Stateless Geographic Non-Deterministic forwarding (SNFG) which works with other four modules at the network layer. The beacon exchange mechanism collects information about the nodes and their location. Delay estimation at every node is done by calculating the lapsed time when an ACK is received by a neighbour node which is a response to a transmitted data packet. SNGF selects only those nodes which meet speed requirements, based on delay values. When such node does not exist,the relay ratio is checked. The function of Neighbourhood Feedback Loop (NFL) is used to provide the relay ratio that is calculated by examining the miss ratios of the neighbours of a node which are led to SNGF module. If the relay ratio lies between 0 and 1, the packet is discharged. Lastly, backpressure rerouting prevents voids when a node fails to find the next hop node and thus eliminates congestion in the network[10].

C. MMSPEED

It is a Multi Path and Multi-SPEED Routing Protocol which provides an extension to the work of SPEED Protocol and thus supports probabilistic QoS guarantee by considering QoS in two domains, reliability and timeliness [8]. To address QoS in terms of timeliness, MMSPEED works on multiple network wide speed packet delivery options rather than single network wide speed options. To address QoS in terms of reliability, MMSPEED uses the concept of probabilistic multipath forwarding. MMSPEED supports multiple network wide speed packet delivery through two techniques which are virtual isolation and dynamic compensation that compensates for inaccurate local decisions as packet moves towards its destination.

MMSPEED needs the support of IEEE 802.11e at the MAC layer to provide distributed prioritization which is based on Differentiated Inter Frame Spacing(DIFS). Each speed level has their certain definition in the MAC layer. To support service reliability, probabilistic multi path forwarding is used which controls the number of delivery paths based on meeting end to end deadlines. To provide service differentiation to enhance reliability, MMSPEED uses the concept of redundancy i.e. the packet reaches the destination with higher probability if it has more paths. The performance of MMSPEED shows that its results are very good in terms of reliability and timeliness but energy parameters are not considered in its design.

D. RPAR

Real-time Power-Aware Routing protocol (RPAR) [9] was proposed to provide energy-efficiency in real time communication in WSNs. This protocol works by adapting transmission power and routing decisions relatively according to packet deadlines. RPAR is based on the proposition that there should be a balance between transmission power and communication delay. To control communication delays under light workloads, transmission power control is used which works by improving the link quality and simultaneously reduces the number of transmissions required to deliver a packet.

So an adjustment can be made between energy consumption and communication delay by defining packet deadlines. As RPAR automatically adjusts transmission power to meet the requirements of end to end delays, so it is not needed to predefine various delivery speeds like Set Speed Layers as in MMSPEED.

In RPAR, a neighbourhood management mechanism is proposed which reduces energy consumption in comparison to beacon exchange scheme like in SPEED and MMSPEED[12]. The neighbourhood manager is called when there is no forwarding choice in the neighbour table for forwarding a packet. Various simulations have proved that neighbourhood management of RPAR can significantly reduce energy consumption and thereby achieve real time guarantees.

IV. SUMMARY AND CLASSIFICATION OF REAL TIME ROUTING PROTOCOLS

Without loss of generality, we categorize the aforementioned RT routing protocolsbased on RT types, location, scalability, energy efficiency and link reliability as shown in Table 1. We think the classification is reasonable and can clearly display the characteristics of each protocol. We have also shown the parameters of the protocols in figures below as illustrated under.

Table I Classification & Comparison Of Real Time Routing Protocols In Wireless Sensor Networks

Routing Protocol	**Type**	**Location Based**	**Scalability**	**EnergyEfficiency**	**LinkReliability**	**Band width**	**DeadlineMissRatio**	**Power Consumption**
Rap	SRT	Yes	Good	N/A	N/A	200 kbps	Less	Limited
Speed	SRT	Yes	Good	N/A	Moderate	200 kbps	Less	Average
MMSpeed	SRT	Yes	Good	N/A	Good	200 kbps	More	Good
Rpar	SRT	No	Good	High	Excellent	N/A	More	High

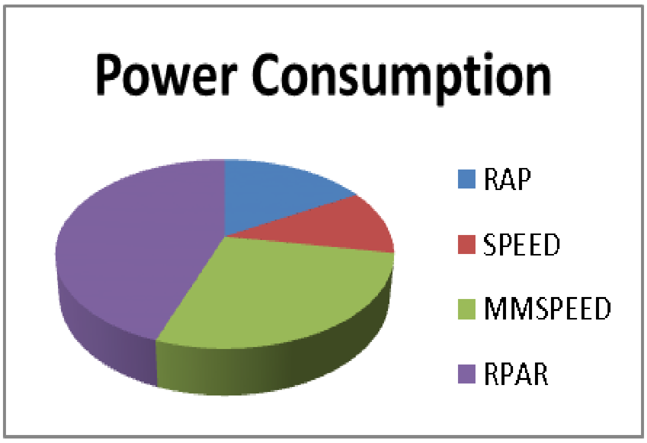

Figure 1: shows that RPAR has maximum capability of Power Consumption

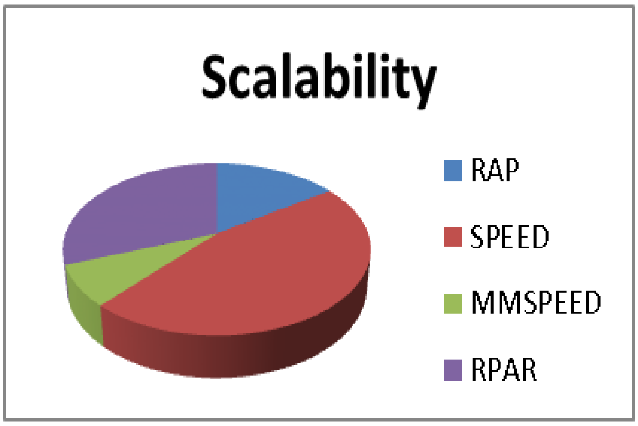

Figure 2:shows that SPEED protocol has best scalability

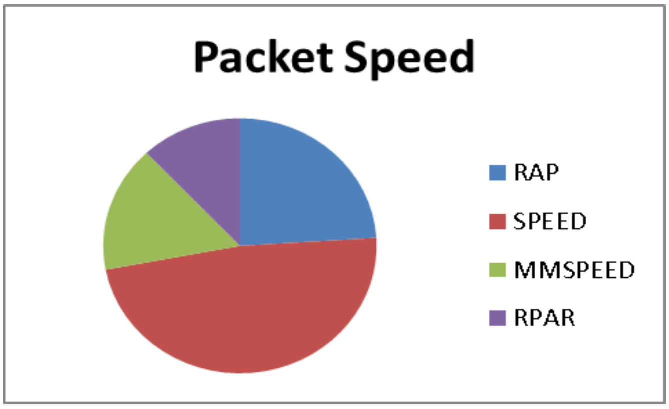

Figure 3: shows that Speed Protocol has maximum Efficient Speed of sending packetsin terms of their efficiency

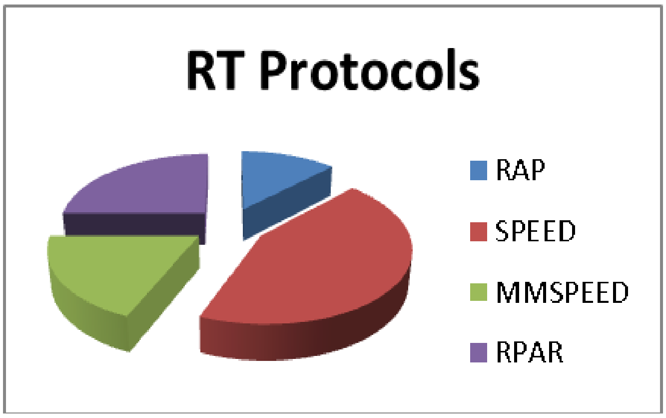

Figure 4: shows the final analysis of all protocols

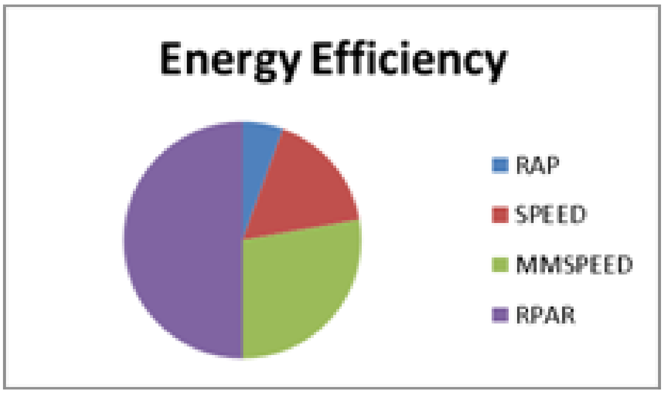

Figure 5: shows the optimal energy distribution of all the protocols

V. CONCLUSION

Real-time communication is an important parameter for future sensor networks to provide distributed micro-sensing in physical environments .The common objective is to provide timeliness guarantee for resource constrained wireless sensor systems and scalability to large scale of deployment.This paper provides a detailed analysis of the real time routing protocols for WSNs andhighlights the advantages and comparison of every protocol. From the analysis we have learned that SPEED, which guarantees soft real time communication and hence is very much suitable for real time communication in wireless sensor networks. Finally, we pinpoint future research directions investigating more parameters about the real time protocols.Security and reliability aspects of the protocols are also important research directions.

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