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COMPARISION OF ROUTING ALGORITHMS IMPLEMENTED FOR STREAMING APPLICATIONS IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless sensor network applications require tiny sized sensors with short transmission communication or signaling range which reduce the chances of detection. These size constraints cause limitations on CPU speed, amount of memory, RF bandwidth and battery lifetime. And therefore, efficient communication techniques are essential for increasing the lifetime and quality of data collection and decreasing the communication latency of such wireless devices. In this paper, the performance of a Quality of serviced based routing scheme (QUES) is compared with other existing algorithms and it is proved that QUES algorithm performs better than other existing routing algorithms namely SPIN, PEGASIS and WEED by transmitting different types of movie for experiment. The test results show that QUES algorithm performs better related to the parameters bandwidth, delay, error rate, and percentage of data loss, Connection establishment time and the number of hops used in the communication path.

Keywords: WSN, routing, QoS, SPIN, PEGASIS.

INTRODUCTION

Research aspects of Wireless sensor networks are multifold [14, 16] as major new mission critical applications focus towards the area of monitoring and control which include intrusion detection, target tracking, wildlife habitat control and monitoring, disaster management and climate control.

The technology which drives the emergence of sensor applications is the rapid development in the integration of digital circuitry, which will brings small, cheap and autonomous sensor nodes into work. The rapid development of WSN though may offer new opportunities; it also creates multiple challenges particularly in field of effective communication and error control [2, 5, 19]. As collaboration between mobile nodes is highly required for effective communication, session management with optimal error control is on high priority. Such conflicting objectives provide unorthodox solutions for multiple situations.

Due to wireless nature of WSN, limited resource to be used such as power, memory processing, low node reliability and dynamic network topology had added multiple research challenges. Hence developing real-time applications over WSN should consider available resource constraints, as well the node reliability and communication reliability along with the global time varying network performance. This research work is initially modeled as a non-convex mathematical programming problem whose primary objective is to identify and provide the optimal bandwidth in use. The proposed solution approach is based on data aggregation tree procedure in conjunction with a number of optimization-based heuristics to determine the QoS delay constraints. The objective function includes the "bandwidth in use" [8] of the transmission mode (data transmissions and data retransmissions) as well the bandwidth used by idle node or relay node (to wait for data from downstream nodes in data aggregation tree [4, 6]).

Real time test bed is carried out to identify the behaviour of proposed QUES algorithm using computational experiments, which shows that QUES outperforms existing heuristics that do not take MAC layer retransmissions and the bandwidth consumption in the idle node into account. In view of such challenges [17], it can be understood that error control is a major that enables us to provide robust multimedia communication and maintain Quality of Service (QoS). Despite the existence of some good research works on error control analysis in WSNs, none of them provides a thorough study of error control schemes for multimedia delivery.

This paper also provides the comprehensive performance evaluation of Automatic Repeat Request (ARQ), Erasure Coding (EC), Forward Error Correction (FEC) [16], link-layer hybrid FEC/ARQ, and cross-layer hybrid error control schemes over Wireless Multimedia Sensor Network (WMSNs) [7, 18, 11]. Performance metrics of WSN include frame's Peak Signal-to-Noise Ratio (PSNR), energy efficiency, cumulative jitter, frame loss rate and delay-constrained PSNR which are investigated as part of this work[1,3,9,20]. Analysis of result demonstrates the identification of wireless channel errors which affect the performance of sensor networks and how different error control scenarios can be effective for such networks. The results also provide the required insights for efficient design of error control protocols in multimedia communications over WSNs.

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Motivation and objectives

The integrity of data being transmitted and fault-tolerance issues [4, 10] in WSN has effect on the performance of any data acquisition system. Noise and other external network disturbances can often degrade the information or data transmitted by these systems. Hence the need for devising a fault tolerant communication mechanism in wireless sensor networks is a challenge.

As the construction and deployment characteristics of these low powered sensing devices are complex, due to low computation and communication abilities of sensor nodes. Fault tolerant mechanism is inappropriate due to very low computation and overhead of nodes; hence sensor nodes are highly vulnerable to failures. These sensors may lose functionalities at time instance due to energy [13] depletion by harsh environment factors or malicious attack from enemies. Hence error handling and optimal QoS at any time period is important for input /output which also decides the survivability of sensor network.

In WSNs, any sensor node that is within another's interference range trying to transmit simultaneously would result in collisions [17]. When collisions occur, retransmissions are required to ensure that the data be successfully received. These retransmissions [12] result in additional energy consumption. Beside additional energy consumption, extra latency from retransmissions increases the link delay. Because of this extra latency for each link delay, the end-to-end delay from data source nodes back to the sink node will be increased.

Supports for QoS in mobile and WSNs

QoS can be defined as: ''Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service'' E.800 (09/08) -ITU [2].

QoS refers to control mechanisms which monitor and control the resource reservation rather than the provided service quality itself. In practical research aspects, QoS guarantees in WSN can be classified as hard real-time and soft real-time systems [14]. Hard Real Time system focuses on deterministic end-to-end delay bound where the arrival of a message after its defined deadline is considered as failure. A Soft Real Time system can support a probabilistic guarantee with an acceptable or tolerable delay. Hence, supporting the RT QoS in WSN should possess either a deterministic or probabilistic end-to-end delay guarantee in order for the system to function with an optimal QoS support.

Literature survey

Information routing is a very challenging task in highly dense and distributed sensor networks due to its inherent characteristics that distinguish these networks from other wireless or adhoc networks. The sensor nodes deployed in an adhoc manner need to be self-organizing [5, 19] as this kind of deployment requires system to form connections and cope with the resultant nodal distribution. Another important design issue in sensor networks is that sensor networks are application specific. Hence the application scenario demands the protocol design in a sensor network.

The proposed routing protocols for sensor networks should consider all the above issues to be efficient and feasible for implementation. The algorithms developed need to be energy efficient, scalable for error handling as well increase the life of the network in the process[20]. SPIN and LEACH had been considered to be energy effective routing protocols, but neither of these protocols helps in controlling errors while supporting QoS [11, 15]. Both these protocols are better than conventional network protocols, which support direct transmission, adapting to minimum transmission energy, with multi-hop routing, are few major drawbacks which don't allow them to achieve all the desirable properties. Table-1 shows the routing and QoS approaches in WSN which designates.

Table-1. Classification of WSN routing and QoS approaches.

Routing algorithm	Classifi-cation	Scala-bility	Mobility	Energy Usageli	Loca-tion Aware	QoS	Multi-Hop	Data Aggreg ation
Flooding	Flat	Limited	No	High	No	No	Yes	No
SPIN [22]	Data centric	Limited	Limited	Limited	Yes	No	Yes	No
LEACH [23]	Hierarchic al	Good	Fixed BS	Limited	No	No	Yes	Yes
PEGASIS [23]	Hierarchic al	Good	Fixed BS	High	No	No	Yes	Yes

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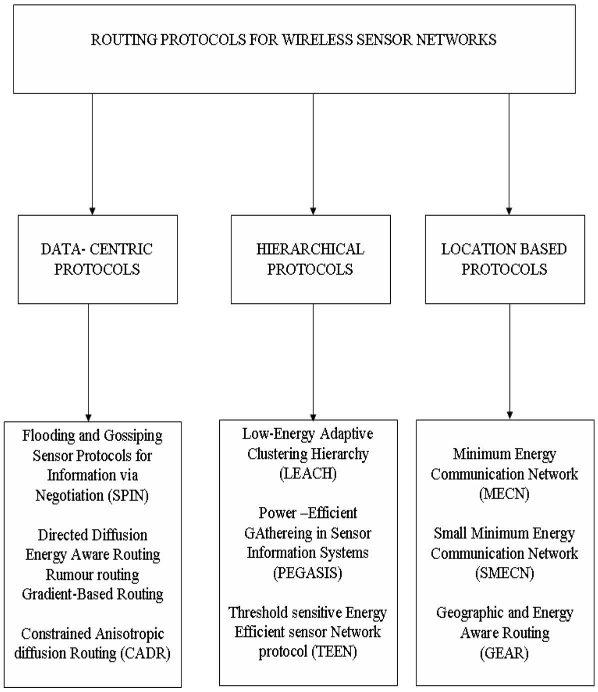

Figure-1. QoS routing protocols for WSN.

Figure-1 shows the list of WSN protocols that are used for establishing communication path over multi-hops of session established. Well known common protocols identified by the researching community include SPIN, LEACH [12] and PEGASIS. These protocols support in providing QoS between multiple sensor nodes engaged in communication as well as in establishing reliable transfer of the data.

Specific protocols such as MECH, SMECH and APTEEN help in controlling energy efficiency as well as in providing support for QoS during transfer. Protocols such as LEACH, PEGASIS and TEEN support in threshold based energy conservation. These protocols are effective in controlling consumable energy but fails in controlling service based tasks for differing applications or real time situations.

Directed diffusion routing algorithms proposed by [21] belong to the class of localized algorithms. Diffusion adopts the form of broadcast routing which does not specify the destination node address to communicate. The packets being forwarded by neighboring nodes follows the direction or gradient being overlaid to control the broadcast or forwarding of packet, which finally reaches the destination node. Diffusion routing approach, relies upon information gathered at neighboring WSN nodes, decides the way to address the information-theoretic capacity of a spatially distributed wireless network. An important design issue in the investigation of system parameters such as network size and approach to understand how the density of nodes per square mile affect the tradeoffs between latency, reliability and energy is a challenge to be attended.

QUES algorithm

Procedure 1: to Create route

{Route_Create (Route_ID, Route_Next, QoS_value)}
Route Request (QUES_SREQ) and Route Reply (QUES_SRLY) for any node Fi
Variables:
S, D: Identity of source and destination WSN nodes
Route [ ]: Array route consisting of all temporary WSN node
Route_OPT, TempRoute: Optimal route and temporary routes from S to D
η: WSN Node priority
|Hopk|: ‘k’ number of hops between S to D, where ‘k’ being the radio propagation length
Ri (Li, Fi): Route segment where neighboring WSN node Fi is located
Ii = Route Interference
τ: Route update Time Wait (TW) parameter
QUES_SREQ: Route request packet
QUES_SRLY: Route reply packet
QUES_OPT: Optimal Route
Upon receiving QUES_SREQ (S, D, TempRoute) from any Fi
1: if (S == D) and (|TempRoute| ∈ Route) then
2: Route_OPT = TempRoute
3: Send QUES_SRLY(S, D, Route_OPT)
4: return Route_OPT
5: else
6: send QUES_RER (0)
7: end if
8: if QUES_SREQ ≠ θ
9: if (Ri (Fi) ≠ Ri (Fj) and (Ri(Fi) ⊂ TempRoute) then
10: add Ri (Fi) to Route [ ]
11: end if
12: set Hop k = distance (Fi, Fj) * τ
13: increment Hopk
14: endif
15: if Ri (S) == Rj(D) then
16: stop Hopk / * Fi is a better broadcast node */
17: end if
18: set η = 0
19: QUES_BCS Route (S, D, TempRoute) /* broadcast route */
20: receive QUES_SRLY (D, S, Route_RPL(Fj-1,Fi-1,-1)) from Fj
21: if η ≠ -1 then goto step 8
22: else
23: continue
24: if (Fi == S) then
25: Store Route_RPL in Ii
26: Forward QUES_SREQ (S, Fi, ROUTE_RPL (Fi+1, Fj+1, D, η))
27: end if

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Optimal route discovery and route update

Identifying an optimal route for a service between source and destination defines the process of satisfying the QoS on demand as per QUES metrics. Any service can be effectively accomplished if a best possible route or an optimal route among the available links is selected. The “capability” of defining an optimal route is based on the communication effectiveness for expected service in terms of logistic policy measure. Any node or link which is not “capable” to communicate as per optimality condition is defined as 'Worst'. Optimization helps in providing an adaptive service for services which demand QoS consistently such as streaming media delivery, content management feed, media conference. Optimization is provided to (a) assigning route with required bandwidth, (b) maintaining and monitoring QUES metric on delay, packet loss, no of hops, radio propagation range.

Procedure 2: Optimal route

QUES_OptimalRoute(NodeID_send(j), NodeID_recv(j), QUES_metric, Link_ID(j), β, μ)
where j is set of route links identified between 1 to n
Variables:
S, D: Identity of source and destination WSN nodes
Route [ ]: Array route consisting of all temporary WSN node
Route_OPT, TempRoute: Optimal route and temporary routes from S to D
μ: Service priority
| Hopk |: ‘k’ number of hops between S to D, where k being the radio propagation length
Ri (Li, Fi): Route path where WSN node Fi is located
τ: Route update Time Wait (TW) parameter
QUES_SREQ: Route request packet
QUES_SRLY: Route reply packet
QUES_OPT: Optimal Route
Upon receiving QUES_SREQ (S, D, Temp Route) from any Fi
1: if ((S == Fi) || (D==Fj)) and (|TempRoute| ∈Route[ ]) then
2: Route_OPT = TempRoute
3: send QUES_SRLY(S, D, Route_OPT)
4: return
5: else
6: send QUES_SREQ(S, D, TempRoute, μ, β)
7: set Hopk = distance (Fi, Fj) τ /* hop count between nodes */
8. set β = High || Low || Normal
9: set μ = High || Low || Normal
10: set τ = 0
11: if QUES_OPT = θ
12: if (Ri (Fi) ≠ Ri (Fj) and (Ri (Fi) ⊂ TempRoute) and QUES_SREQ (Fi+1, Fj+1, μ) then
13: add Ri (Fi) to Route_OPT /* add the best route to Optimal Route */
14: end if
15: increment Hopk
16: if Ri (S) == Rj(D) then
17: stop Hopk / * Fi is a better broadcast node */
18: end if
19: send QUES_OPT (S, D, TempRoute, β) /* Optimal route */
20: receive QUES_SRLY (D, S, Route_RPL(Fj-1,Fi-1, -1)) from Fj
21: increment QUES_OPT
22: if β > 1 then goto step 10
23: else
24: continue
25: endif
26: if (Fi == S) then
27: store QUES_OPT in Ci and Ri
28: forward QUES_SREQ (S, Fi, ROUTE_RPL (Fi+1, Fj+1, D, β))
29: end if
30: endif

The step by step explanation of the algorithm is discussed. Steps 1 to 6 explains the optimal route identified if the route is found to be shortest between the source and destination, with no other possible routes found in *TempRoute* list. Step 7 to 10, assigns default values for QUES_OPT metrics, Step 11 checks whether an optimal route is available in list QUES_OPT, else the process of adding the possible links based on the service request is added to QUES_OPT as explained in Step 12 to 14.

Experimental test bed

The parameters analyzed by real time implementation are bandwidth, delay, error rate, no. of hops, % of data loss and connection establishment time. For evaluating the node behaviour and route efficiency MATLAB software is used. The network test bed topology is random and also desirable nodes with dynamic topology. Figure-2 shows the nodes in mobility. There are ‘N’ sensor nodes are located randomly within a square border of 10*10 m^2, where N is fixed as 20. The initial communication range of nodes is considered as 0.1cm. The connective range of nodes is 50 to 60 meters, which considers that each 2 nodes being located at a distance of less than 60 m are considered as neighbours hence can exchange data. Events are sensed periodically such that for each period an event occurrence is observed. Value of route selection for update of selection probability of a node is taken 0.001s.

Figure-2. TinyNode testing for QUES on mobility.

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The area of testbed is 100sqm, 20 nodes are used for real time test bed, the initial energy is 0.01s, frequency is of 700khz, connectivity range is 60m, sensing range is 30 and the sink is placed at the position (300, 300). All the nodes are distributed randomly with reliable mobility.

Performance analysis

Figure-3 shows the packet delivery ratio for SPIN and QUES algorithm. The data transfer rate is 54Mbps and data packet size is 1000 bytes. From the graph when the message interarrival period increases the packet delivery ratio also increases thus avoiding latency in the communication. Higher the packet delivery ratio, the network packets are routed very efficiently from source to destination. By comparing the QUES with SPIN, the proposed algorithm performs better than SPIN.

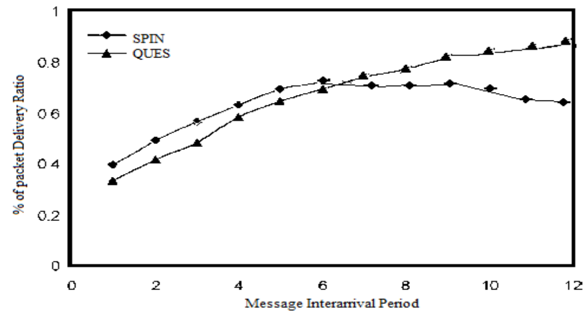

Figure-3. Packet delivery ratio comparison between SPIN and QUES.

Table-2. Comparison of various parameters using real time test bed.

Movie For Experiment	Average B/W required Mbps	Average B/W used Mbps	B/W load balancing Mbps	Delay in ms	Error Rate %	No. of Hops	% of data loss	T_{CE} in ms
Chat 180Mbps	200							
SPIN		110	120	37.0	10	6	46	62
PEGASIS		190	100	35.4	14	6	51	80
WEED		130	110	35.0	9	8	31	50
QUES		155	90	33.3	6	6	26	43
File transfer 200Mbps	200							
SPIN		145	170	49.6	7	7	42	52
PEGASIS		170	162	43.5	5	5	68	50
WEED		126	160	39.8	9	5	44	42
QUES		120	152	37.7	2	6	34	28
Remote file access 220MBPS	250							
SPIN		232	246	31.0	6	6	45	50
PEGASIS		240	240	34.4	6	5	58	47
WEED		234	240	29.1	7	5	42	50
QUES		210	235	28.8	5	4	37	32
Remote file access 200Mbps	250							
SPIN		240	245	36.6	5	7	38	51
PEGASIS		245	245	39.0	4	6	47	46
WEED		220	238	34.2	4	5	30	31
QUES		214	220	31.0	3	5	21	24

T_{CE} - Connection establishment time, B/W- bandwidth

Table-2 shows the comparision of various parameters using real time test bed by varying the movie for experiment. It is evaluated in terms of routing load balancing and bandwidth overhead (β) used in low

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mobility 'γ' (static and mobility within room) over a small-scale network '∂' (<20 nodes). However, its performance deteriorates slowly when the number of nodes 'n' is slowly increased and its bandwidth usage gets overloaded, as well 'γ' and '∂' increase. This issue attributes to the aggressive usage of source routing cache in node.

During an error discovery process, source node indicates the error to neighboring nodes which neglects the error. It also helps in identifying the source to discover multiple routes to its destination. This enables the source node to switch to cached routes in case of the currently using route break up. In case of error, it significantly reduces the possibility to restart a route discovery process in case of error. However, under stressful situations, the cached routes are considered as invalid status which thus reduces unnecessary delay and handles network traffic effectively.

WEED algorithm adopts weighted voting method for detection of faulty sensor reading and thus avoids routing the erroneous data. This algorithm does not rely nodes on relative distance alone, but also considers the confidence or reliability level of node based on error. It efficiently removes the erroneous decision based on near by but faulty sensor nodes.

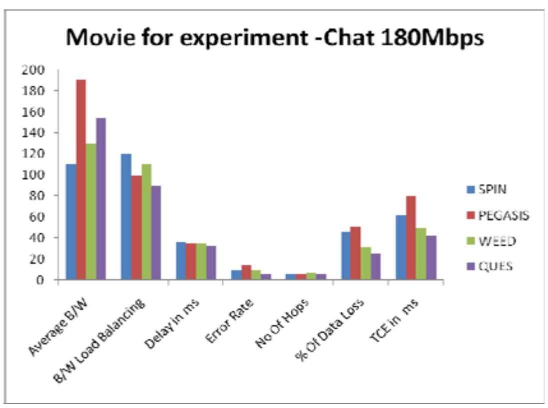

Figure-4. Chat movie for experiment with 180Mbps.

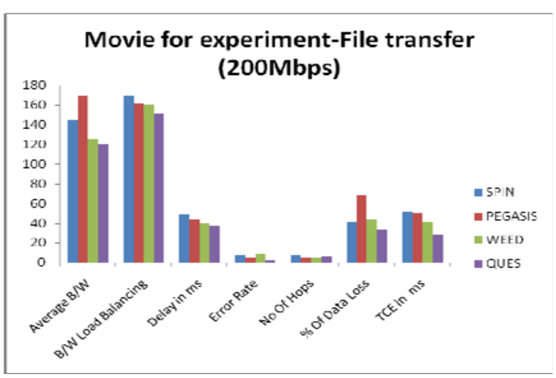

Figure-5. File transfer movie for experiment with 200Mbps.

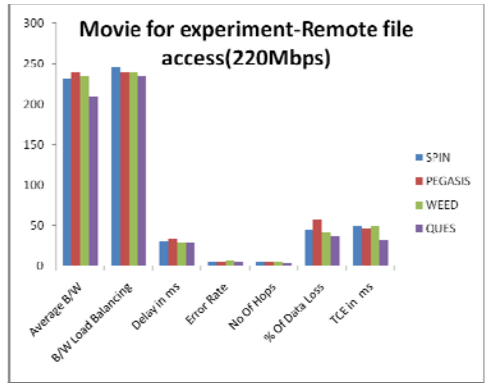

Figure-6. Remote file access movie for experiment with 220Mbps.

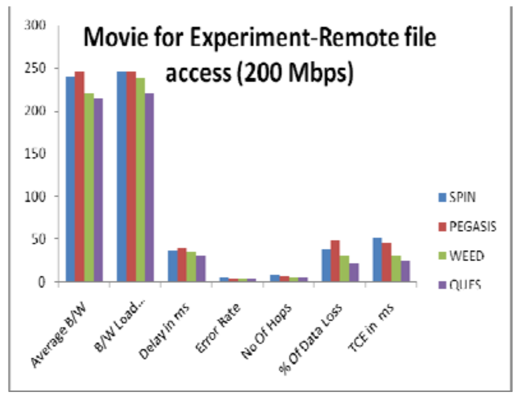

Figure-7. Remote file access movie for experiment with 200Mbps.

Figures 4-7 shows the various movie used for real time experiment and shows the comparison of QUES with SPIN, PEGASIS and WEED.

From the Figures it is concluded that QUES performs better than other algorithms as the erroneous routes are avoided and a new route is established with the help of catched route rather than searching a new routes.

6. CONCLUSIONS

In this paper, the behaviour of the QUES algorithm is analyzed in terms of the parameters bandwidth,delay, error rate,no.of.hops, connection establishment time, packet delivery ratio and error rate. QUES support routing for each variable service sessions on policy control rules in order to control transmission errors for different applications such as streaming content delivery over WSN using route metrics. It is concluded that the QUES routing algorithm performs better when compared with the other algorithms such as SPIN, PEGASIS and WEED. In future the aspects on node degradation behaviour should be considered for designing of delay bond routing protocols, since carry and forward are the missing approaches to deliver packets.

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