INTERNATIONAL JOURNAL OF COMPUTERS COMMUNICATIONS & CONTROL
Online ISSN 1841-9844, ISSN-L 1841-9836, Volume: 18, Issue: 2, Month: April, Year: 2023
Article Number: 4666, https://doi.org/10.15837/ijccc.2023.2.4666

CCC Publications

Cross Layer based Energy Aware and Packet Scheduling Algorithm for Wireless Multimedia Sensor Network

L. Jenila, R. Aroul Canessane

L. Jenila
Sathyabama Institute of Science and Technology,
Chennai, Tamil Nadu, 600119, India
*Corresponding Author: L. Jenila. Email: jenilacse@gmail.com

R. Aroul Canessane
Sathyabama Institute of Science and Technology,
Chennai, Tamil Nadu, 600119, India
aroulcanessane@gmail.com

Abstract

Wireless multimedia sensor networks are used in a variety of applications, including environmental monitoring, industrial automation, and military surveillance. They are well suited to these applications because they can operate independently of a central controller, are highly scalable, and are capable of transmitting large amounts of data over long distances. The scheduling of packets is a crucial issue in wireless multimedia sensor networks because the network's limited resources, such as bandwidth and power, must be carefully controlled to guarantee that data may be transferred effectively and without interference. Algorithms for packet scheduling try to determine the optimal method to distribute these resources in order to maximise network performance. In wireless multimedia sensor networks, a variety of packet scheduling methods may be used, each with its own set of guidelines and goals. The following are some typical goals to improve the network performance in order to increase the quantity of data that can be transferred through the network in a given length of time, the throughput of the network must be maximised. To reduce the time it takes for a packet to be transferred by reducing the network's delay. In order to enhance the entire system's performance, it may also consider the interactions that take place across the physical, data link, and network levels of the network protocol stack. The algorithm's objective is to optimise the trade-off between packet transmission efficiency and energy efficiency in order to enhance the performance and dependability of the wireless multimedia sensor network. The efficiency of the CEAPSA scheme is 23.24% better than the EBJRCF scheme and 34.84% than EAACLS scheme in terms of delivery rates.

Keywords: Semi-Markov process; packet scheduling; Node congestion ratio; Cross layer approach; Wireless Multimedia Sensor Networks.

1 Introduction

A wireless multimedia sensor network (WMSN) is a type of wireless network that consists of a large number of small, low-power devices called "sensors" that are distributed over a wide area. These sensors are equipped with sensors, such as cameras, microphones, and temperature sensors, that allow them to collect data about their environment. Wireless multimedia sensor networks have several key characteristics that distinguish them from other types of wireless networks: Heterogeneity: WMSNs typically consist of a large number of diverse sensors with different capabilities and requirements. Energy efficiency: Sensors in WMSNs are often powered by batteries and must be designed to be energy efficient in order to operate for long periods of time without access to a power source. Quality of service: WMSNs often need to support multimedia applications, such as video and audio streaming, which require high quality of service (QoS) in terms of bandwidth, latency, and reliability. Self-organization: WMSNs are often decentralized and self-organizing, meaning that they do not rely on a central controller to coordinate their activities and can adapt to changes in the network dynamically. To address these challenges, WMSNs often employ specialized protocols and algorithms to optimize the performance and reliability of the network. These may include packet scheduling algorithms, energy-aware routing protocols, and cross-layer optimization techniques. An optimization approach that tries to effectively schedule packets for transmission across the network while simultaneously taking the energy consumption of the wireless devices into account is called a cross-layer based energy aware and packet scheduling algorithm for wireless multimedia sensor networks. Energy efficiency is a major issue in wireless multimedia sensor networks since the devices are often powered by batteries and may need to run for extended periods of time without access to a power source. As a result, in order to reduce energy consumption, the algorithm may take into account variables like the remaining energy levels of the devices, the energy necessary to send and receive packets, and the energy required to process and store data. In order to optimise network effectiveness and guarantee that packets are transported in a timely and reliable way, the algorithm may additionally take into account variables like the data rate, packet size, and bandwidth availability.

2 Related Works

Huge research works had been carried out for multimedia wireless networks in terms of routing, congestion avoidance, security features, packet loss and reducing delay during transmission, etc. Some of them are discussed here to relate the proficiency of our proposed work.

Reliable transport layer protocols are used to improve multimedia transmissions in WMSNs [5]. They comprise of appointing a resources plan of time for sending certain measure of data and evaluating if the channel state permit to finish the transmission or not. If the case is not so, at that point the transmission is ended, consequently it stores significant energy level in the sensors. Differentiated Services (DiffServ) engineering for QoS provisioning in WMSN was introduced [6]. This design separates basic ongoing information from constant mixed media information by characterizing six traffic classes alongside their sending conduct. DiffServ objective is mainly on bandwidth allocation to various traffic classes so as to augment the use of the entire framework.

Greedy Forwarding based on Throughput Energy aware Multi-path routing protocol (GFTEM) [7] which depends on determination of next node that has the most elevated throughput and closer to sink node. Greedy routing structure been intended for scalar information, for example, sensor information; which is little in size contrasted with media information. Delayed inclusion and Non-Delayed Coverage Enhancing Algorithm (DND-CEA) for WMSN was proposed by presenting the model of virtual centripetal power [8]. Here excess sensors are become idle and inclusion of systems can be improved by re-send sensors under the repulse power based virtual centripetal power albeit enormous quantities of repetitive sensors are closed off. Each layer of the protocol stack is monitored and completely engaged with giving QoS ensures and hence cross layer cooperation of various layers was proposed [9]. Here cross layer connections reduces the encoder complexity at each layer of the protocol stack from cutting edge coding methods and accomplishes most extreme pressure to dynamic directing. Cross-layer conspires that consolidate routing and booking components was proposed [10] to improve remote video transmission execution incorporates: a coordinated routing measurement for assessing path quality; traffic task and traffic modification modules are intended to make routing plan adaptable.
Node-level optimal Real-time Priority based Dynamic Scheduling (NRPDS) algorithm [11] was proposed that schedules tasks as indicated by their needs by expanding or reducing the packet repetition, utilizing dynamic voltage repetition scaling and subsequently utilizes energy. Priority based booking helps in accomplishing QoS for delayed traffic. Traffic Congestion Control Algorithm (TCCA) for WMSN was proposed [12]. It utilizes a mix of two distinctive blockage pointers to definitely recognize a congested node. Criticism based rate controller was created to improve the video nature of played streams. Different retransmission tools for various packets are utilized with the goal that the lost packets are spared incidentally and retransmitted when free channel is accessible to eliminate congestion. Problem of losing whole frames for multiview 3-D video transmission over WMSNs can be solved using frame loss concealment method [13]. This system is equipped for managing this

significant issue without the guide of complexity map. Energy efficient image processing and communication [14] over WSN was proposed; here a solid transmission protocol is utilized at the application layer to guarantee that all media packets are sent and received effectively and organized appropriately.
Reconstruction algorithm for lost frame of multi-view videos based on profound learning method was presented for WMSN [15]. Frame reconstruction scheme is applied to calculate mixed pixels in decoder if video frames are lost during transmission. An epic pixel estimation calculation is created utilizing Multilayer Perceptron Regression (MPR) with the profound learning strategy. The proposed movement planning calculation [16] joins a methodology that empowers every mixed media sensor hubs in WMSN to productively extract its spread sets to guarantee that the basic critical points are checked; therefore the system energy use can be limited viably. The required task for each spread set was done dependent on the connection of visual data from the camera perceptions. Energy-Balanced Joint Routing and Charging Framework (EBJRCF) were proposed [17] to adjust the energy utilization between sensors; here the system is disintegrated into a routing procedure and a charging technique. This routing system is intended to optimize the directing tree comparing to the mobile charge remaining at every sensor hub. Moreover, the proposed charging procedure prefers towards the accusing mode of the best parity of the absolute vitality utilization of sensor hubs during one charging trip.
Energy Aware and Adaptive Cross Layer Scheme (EAACLS) to forward multimedia information through sensor networks was presented [18]. with the goal that it chooses ideal video encoding boundaries at application layer as indicated by current remote channel state, and packet allocations as per its sort through a versatile need video line so less significant parcels are dropped if there should arise an occurrence of system congestion. 3D coverage model is developed [19] with presenting the perceptual range of sensors, while the ideal projection zone of a solitary sensor is concluded. From this point forward, a versatile molecule swarm enhancement is prescribed to smooth out the region information of sensors for diminishing both perceptual covering locales and perceptual outwardly disabled districts in the checking area. At last, to minimize the burden for working nodes a redundant node 'y' is presented.
Problem Identification: The objective of the proposed work is to improve the energy factor and to transmit the data in priority based path scheduling by applying cross layer scheme during routing. In conventional protocols, only sub-optimization energy problem is considered but path aware for data routing is not considered in scheme. In addition path scheduling overheads is not considered which caused due to high congestion exists while routing data. Hence the proposed scheme focuses on energy and path aware scheduling using cross layer scheme.

3 Proposed Mechanism

Cross Layer based Energy Aware Path Scheduling Algorithm (CEAPSA) is proposed to transmit multimedia information efficiently over WSN. Transmitting multimedia information over sensor networks is a challenging task in terms of restricted bandwidth, low powered battery nodes, high congestion rate over transmitting channel etc. CEAPSA scheme consists of three phases such as link estimation between nodes by applying Semi-Markov model, estimation of node congestion rate and path scheduling in which all three phases are linked through cross layer communication. In general cross layer approach is used to connect all the layers virtually to avoid conflictions during transmission.
In cross layer approach the physical, data-link, network and application layers usually communicates with each other directly i.e. each layer is connected with one another and shares their own information with other layers to prevent or avoid unnecessary congestion rate that occurred over high transmitted channel rate. Figure 1 show cross layer approach for CEAPSA over sensor network.

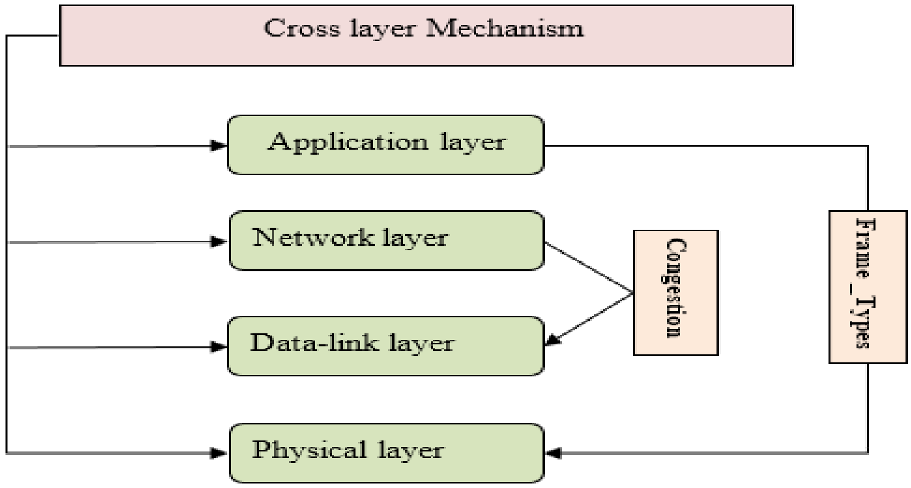

Figure 1: CEAPSA over Sensor Networ

A. Link Estimation process using Semi-Markov model:

In link estimation phase the active nodes are selected for reliable video transmission and optimal routing. Active nodes are chosen from the actual nodes using factors such as Bandwidth Consistency (BC) and Energy Level (EL). By applying semi-Markov process the bandwidth consistent high energy level nodes (active relay nodes) are selected for efficient video transmission with minimum execution time. The node states might jump between three states like Active (A), Idle (I) and Off (O) states and these states are determined utilizing nodes energy factor and bandwidth consistent. Energy level for the node is estimated through node's energy consumption value i.e. by analyzing the energy consumption of previous data transmission of nodes. BC estimation is carried out through link-duration analysis of the transmission channel. BC between the neighbouring nodes is estimated through the number of packets that can be sent in maximum over a channel. Therefore active data transferring nodes are selected through the analysis of BC and EL factor.

Active node 'Ai' selection process is carried out by passing control messages among presented neighbour nodes. Base node 'B' here acts as a source node initially transmits Route reQuest (RQ) to its presented neighbours and active node 'Ai' (acts as a relay or data passing node between base and sink node 'D') with high channel rate sent back Route Reply (RR) message to node 'B'. Now the relay node checks for its EL and BC factors with their threshold value, if the node has high EL and BC value compared to its reference value then the node is chosen as active relay node. Then the path 'B' to 'Ai' and 'Ai' to 'D' is selected as reliable path and video packets gets transmitted successfully without jumping to any other states i.e. $BTx \rightarrow Tx$. If path 'B' to 'Ai' and 'Ai' to 'D' is already connected for data transmission but fails to transmit the sensed video packets for some reasons (insufficient energy or bandwidth), then 'B' broadcasts RQ and tries to retransmit the failed message to 'D' by selecting another active relay node by jumping the states. This active relay node selection process makes the network more reliable and therefore Semi-Markov process plays a major role in detection of active intermediate relay nodes. Figure 2(a) shows node failure 'Ai', figure 2(b) shows the selection process of new active node. Figure 2(c) represents destination node 'D' passes acknowledgement and figure 2(d) shows data retransmission from 'B' to 'D'.

Transmission process (Tx): Node 'B' transmits new packets. 'Active node' is considered to be node$Ai \in \{i, ..., n\}$

Bi: If current B-Ai node accepts data from the base node 'B', and it forwards the same data to node 'D', however this route get failed due to imbalance of EL and BC factor.

BTx: In state jumping process $\rightarrow$ from one state to other state, it may take two types includes type 1 and type 2 which as follows:

BTx state (Type 1): Base node 'B' retransmits the same data by selecting another active node 'Aj'.

BTx state (Type 2): Data transmitted directly from 'B' to 'D' devoid of choosing any intermediate relay node and this state move is represented to be$BTx \rightarrow BTx$. When base 'B' forwards data to 'D' and intermediate 'Ai' is chosen effectively as the principle state then this state jumps is related as 'DTx' state ($BTx \rightarrow DTx$).

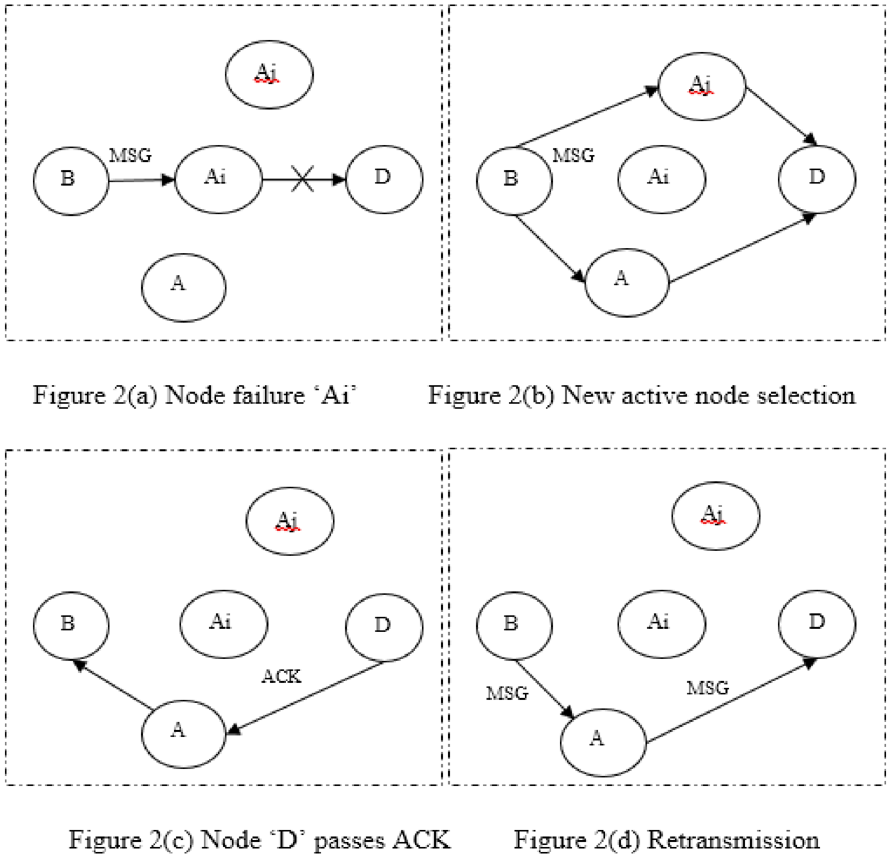

Figure 2(a) Node failure 'Ai' Figure 2(b) New active node selection
Figure 2(c) Node 'D' passes ACK Figure 2(d) Retransmission

DB: Data is transmitted to 'D' once the reliable 'Ai' is chosen then this state is jumped to a separate state from D-B. If selection of 'Ai' is unable to process further, then protocol gives back the DTx state. Now 'B' retransmits data and starts selection of new active node 'Aj' for further transmission process in order to reach destination.

The state transition process takes place from one node to another, for example here we consider three node transition states such as B-D, B-A and A-D and their data channels are obligatory. For the data channel the tuple state is set as 'T_a' which has all proper sets of hidden and observable states$T_a = \left(u^{(a)},\, c^{(a)}_{BD},\, c^{(a)}_{BA},\, c^{(a)}_{AD} \right)$. There are $|T| = 16$ novel tuple sets and each tuple sets have conceivable jumping states in the network structure. The utility factor $u^{(b)} = f\,(T_a)$ that describes about state transitions rules for selecting appropriate active intermediate relay node is defined using equations 1, 2 and 3.

$$U^{(b)}_{(EL,BC)}Tx = \begin{cases} for\;\; U^{(a)}_{(EL,BC)} = BTx,\, C^{(a)}_{BD} = G, \\ or\;\; U^{(a)}_{(EL,BC)} = DTx,\, C^{(a)}_{AD} = G \\ or\;\; U^{(a)}_{(EL,BC)} = NA_i,\, C^{(a)}_{BD}, C^{(a)}_{BA}, C^{(a)}_{AD} = G, \\ \sum_{A=1}^{A=-1} I_G\left(C^{(a)}_{BA}\right) I_G\left(C^{(a)}_{AD}\right) = 0 \end{cases} \tag{1}$$

$$U^{(b)}_{(EC,BL)}A = \begin{cases} for\, U^{(a)}_{(EC,BL)} = Tx, C^{(a)}_{BD} = B, C^{(a)}_{BA} = G, \\ or U^{(a)}_{(EC,BL)} = NA_i, C^{(a)}_{BD} = B, C^{(a)}_{BA}, c^{(a)}_{AD} = G, \\ \sum_{A_i=1}^{A_i=-1} I_G\left(C^{(a)}_{BA}\right) I_G\left(C^{(a)}_{AD}\right) = 0 \end{cases} \tag{2}$$

$$U^{(b)}_{(EL,BC)} = \begin{cases} for\;\; U^{(a)}_{(EL,BC)} = BTx, C^{(a)}_{BA} = B, C^{(a)}_{AD} = B \\ or\;\; U^{(a)}_{(EL,BC)} = A_i, C^{(a)}_{BA} = B \\ or\;\; U^{(a)}_{(EL,BC)} = DTx, C^{(a)}_{AD} = G, \\ \sum_{A=1}^{N} I_G\left(C^{(a)}_{BA}\right) I_G\left(c^{(a)}_{AD}\right) = 0 \end{cases} \tag{3}$$

State jumping probabilities from node to node can be identified using tuple sets T_a to T_b on basis of state transition probability matrix 'P_{ab}'. This also contains a maximum number of state jumping possibilities amongst the tuples. Node jumping state probabilities is computed using equation 4.

$$P_{ab} = \begin{cases} PA\left(C_{BD}^{(b)} \middle| C_{BD}^{(a)}\right) \prod_{A=Ai}^{An} PA_i\left(C_{BAi}^{(b)} \middle| C_{BAi}^{(a)}\right) PA_i\left(C_{AiD}^{(b)} \middle| C_{AiD}^{(a)}\right) \\ \quad for \quad U_{(EL,BC)}^{(b)} = f\left(T_a\right) \\ 0\ ; \quad otherwise \end{cases} \tag{4}$$

If 'Ai' is selected effectively then current state returns to initial transmission state 'Tx' and start to choose the next processing active relay node; hence this process results in effective reliable node identification. Node's utility factor is significant for determining whether it is reliably active or not, with the necessitated considerations of bandwidth consistency and energy level.

In general bandwidth estimation is done by analysing the amount of data rate that can be passed over a channel and it is given in equation 5. Calculating the average bandwidth utilisation is significant for a set of data transmission. In case of normal image packet transmissions it is enough to take lesser bandwidth rated nodes but for video transmissions it is necessary to use higher bandwidth or data channel rate. Bandwidth threshold is set for all nodes (either active or idle), BC value which is greater than the reference value 'B_{Th}' is finally chosen for data transmission. Therefore this node factor analysis improves better achievable data rates.

$$BC_{a,b} = \frac{Max\, pkts\, sent}{T} \ \ (bps) \tag{5}$$

Bandwidth threshold is set by estimating the typical packet size used to communicate by the node and it is given in equation 6. This BC estimation includes nodes channel rate from the base node (N_B) to the destination node (N_D) as well as overall control overheads.

$$B_{Th} = \sum_{N_B \to BA_i,\, A_i D}^{N_D} BC \tag{6}$$

The bandwidth consistent rate $\Omega_{ab}\,(a,\, b\, \in \{1,\, 2, ..., \,16\})$is determined for the node's state transitions using the equation 7.

$$\Omega_{ab} = \begin{cases} 1\ ; \quad for\, U_{(BC)}{}^{(ab)} = Tx,\ C_{BD}^{(ab)} = G, \\ \quad\quad or\, U_{(BC)}{}^{(ab)} =\ A_i,\ c_{A_iD}^{(ab)} = G \\ 0\ ; \quad otherwise \end{cases} \tag{7}$$

Therefore it is stated that each time a node state transition $A_i \to Tx$exists, the bandwidth consistent rate Ω_{ab} is settled to '1' that covers half of all the jumping transitions.

In parallel to BC factor higher residual EL node factor is also considered for the selection of active intermediate relays in the link quality estimation phase. Since node's energy is important for processing and transmitting the data and the node's EL is identified by computing node's energy drain rate. Evaluation of node energy drain rate gives the optimal residual energy value of the particular node. Therefore computed low energy level nodes are kept 'idle' and extracted from the selection list of active relay nodes. Energy threshold is maintained for all the nodes which lie in the network and this energy reference value decides whether the node can be selected as active node or not in order to participate in data routing. Energy consuming rate (E_{CR}) for a particular node is estimated by taking the variations between its initial energy E_I and present energy E_P of the node with respect to time. Equation 8 describes about computing E_{CR}.

$$E_{CR} = \frac{E_I - E_P}{T_c} \tag{8}$$

Reference energy value 'E_R' is set for each and every node in regarding of overall network's E_{CR}. Therefore E_R is evaluated by considering the average consumption of node's energy rate using equation 9.

$$E_R \ = \ \sum_{i=0}^{n} Avg\ \ (E_{CR}) \tag{9}$$

The energy consumed 'E_{ab}' during the time of node's tuple state transition $T_a \to T_b$is given in equation 10.

$$E_{ab} = \begin{cases} E_{Tx} + E_{Rx}\left(I_G\left(C_{BD}^{(a)}\right) + \sum_{A=1}^{N} I_G\left(C_{BA}^{(a)}\right)\right)\ for\, u^{(a)} \in \{Tx,\, BAi\}\,, \\ \quad\quad\quad\quad U_{(EL,BC)}{}^{(b)} \in \{Tx,\, A\}\,, \\ E_{Tx} +\ I_G\left(C_{AD}^{(a)}\right) E_{Rx} \quad\quad for\, U_{(EL,BC)}{}^{(a)} = A, \\ E_{Tx} +\ I_G\left(c_{BD}^{(a)}\right) E_{Rx} \quad\quad for\, U_{(EL,BC)}^{(a)} = U_{(EL,BC)}^{(b)} = BD, \\ 0\ ; \quad\quad\quad\quad otherwise \end{cases} \tag{10}$$

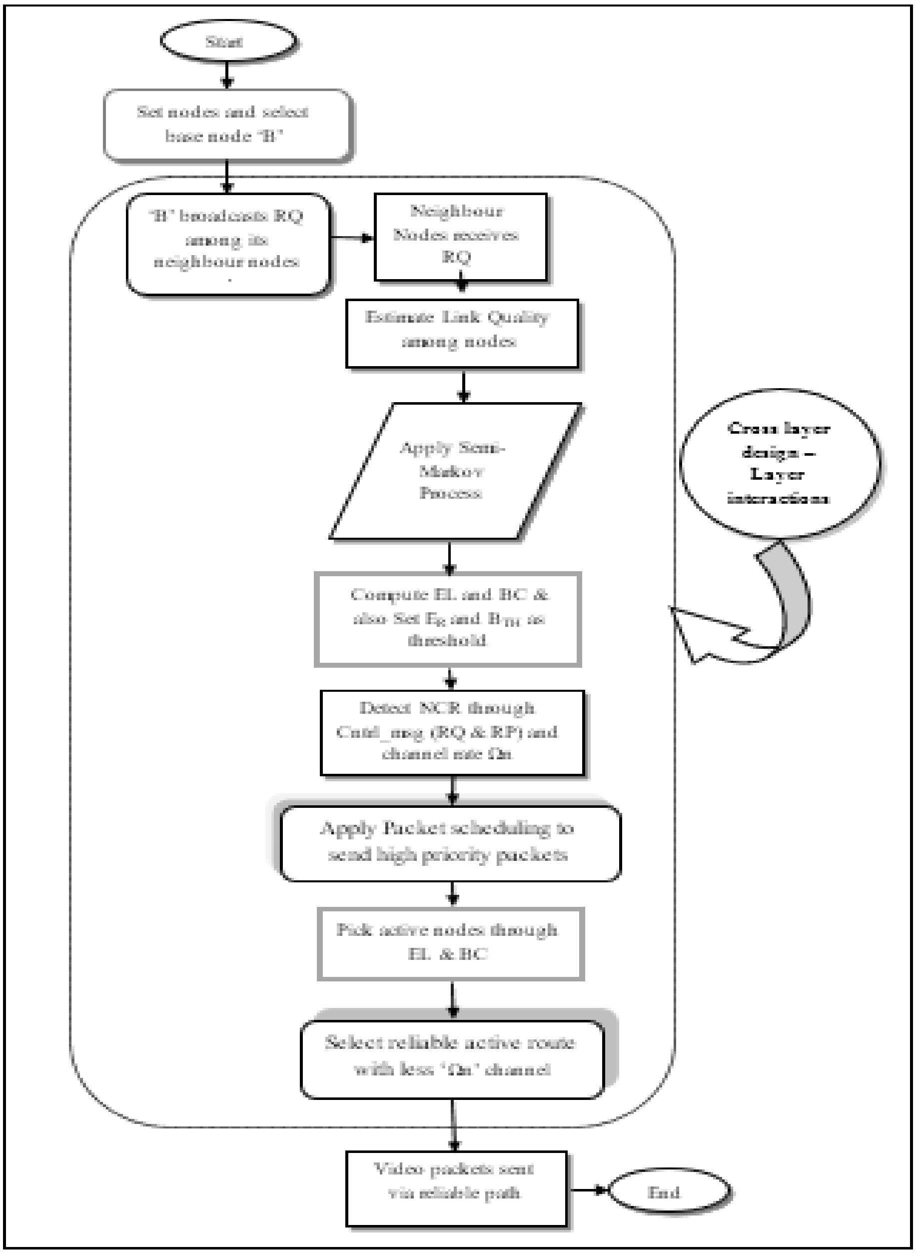

Figure 3: Flow diagram of CEAPSA Scheme

On basis of flow of radio channels, effective bandwidth rate and active energy intermediate relay node assortment is made in regard of time-associated channels. The node utility factors such as BC and EL is updated during each state transition are done between the nodes. The flow diagram of CEAPSA in depicted in figure 3.

B. Node Congestion Rate (NCR):

Once the node utility factors are determined and the active relay nodes are selected then the second phase NCR is carried out. Network congestion occurs if the route is loaded with more number of information packets to deliver to the destination. This excess amount of data might cause packet loss or unnecessary delay in delivering the packets or frames. If the path 'B' to 'Ai' and 'Ai' to 'D' is selected as reliable then the cross layer scheme is applied here to check the data status whether the route has the ability to send the whole data packets successfully. To avoid data loss, NCR is calculated by passing control message RQ using equation 11,

$$NCR = \sum_{i=1}^{n} \left(\frac{RQ - RP}{RQ} \right) \times 100 \tag{11}$$

NCR Algorithm:

Begin

Set node Ni

Get Sent RQ count & received RP count

Calculate NCR

if NCR > 80%

Ni → low channel rate
Else if, 45% < NRV < 80%
Ni → average channel rate
Else NCR < 45%
Ni → high channel rate
End

NCR is calculated and the split ratio is set between 45% and 80%. If NCR is found to be greater than 80% for the data path 'B' to 'D', then the data path has low channel rate and routing data through this channel leads to high data loss. If NCR of the path 'B-D' lies between 45% and 80% then the path has average channel rate and the data passed through the channel have low data loss. If the obtained NCR value is less than 45%, then the path is highly suitable for transmitting the video packets and the loss rate will be very low or null at sometimes.

The evaluation of NCR is necessary to monitor the channel status and therefore channel rate is considered for evaluating the node's congestion rate. The availability of bandwidth for each node is determined by base 'B' which passes RQ message, and the neighbour nodes that are elected as active intermediate relay nodes 'Ai' gives bandwidth availability information through RP message, therefore the efficient data channel rate nodes can be identified from the available active nodes presented towards the destination 'D'. Here the channel rate is directly proportional to the total bandwidth rate. Channel rate can be defined as the rate in which the data can be sent to the receiver reliably. The sum of whole available bandwidth for transmitting maximum data packets through the channel is calculated using equation 12,

$$\Omega\,(n) \;=\; \varphi \;-\; \left(\frac{\sum_{n(B,\,D)}^{Path} (\beta + \Theta)}{\theta} \right) \tag{12}$$

Bandwidth calculation includes node's own video sensing information i.e. data generation rate β and control overheads Θ. The control message that takes maximum time to reach the neighbour node is represented as Θ.

C. Packet Scheduling Process:

Third phase of CEAPSA scheme is packet scheduling process in which queue scheduler component is applied for replacing the higher priority packets with the normal packets. Through the cross layer communication design approach the layers can communicate together, PHY layer focuses on highly prioritized packets and shares the information to other layers, application layer detects the packet type that is going to be transmitted by communicating with network layer. To avoid or reduce the congestion ratio the packet types are categorised in to two kinds such as high priority packets and low priority packets or frames. The higher priority packets are enqueued in the selected reliable path (path selection done on basis of energy level, bandwidth consistent and congestion ratio). Path count is calculated to identify the number of times that the path used for data transmission and it is given in equation 13,

$$P_{count} \;=\; \frac{No.of\; hop\_counts}{Total\; no.of\; paths} \tag{13}$$

Each node will update the path count with their corresponding node_ID. The path that has higher leftover energy level , high bandwidth consistent and low congestion ratio is selected as reliable path for transmitting the higher priority packets and it should be equivalent to '1' considered to be a weight factor given in equation 14.

$$P_{count} \;=\; \alpha + \beta + \gamma \approx 1 \tag{14}$$

Lower priority packets are enqueued after the higher priority packets, once the higher priority packets or frames are sent to the sink then the lower priority packets are dequeued over the reliable path in order to reach the sink node. Low priority frames can also be transferred over low reliable paths (over average EL and BC nodes) since the packet may reach with little delay will not affect the network reliability. By selecting the active relay processing nodes and passing the data by applying packet scheduling algorithm, the scheduling overheads can be controlled reliably and the network lifetime can be maximized.

4 Results and Discussion

The network simulator tool (NS2) is used to simulate the proposed CEAPSA scheme and the comparative existing protocols such as EAACLS and EBJRCF schemes. The simulation parameters taken into consideration are defined in the table 1.

By taking link connectivity among nodes, their energy level and the amount of data traffic can be sent over the channel are the metrics taken here to identify the active intermediate reliable nodes by using cross-layer approach interaction among all the layers. This model results in identifying the reliable and efficient route for data forwarding process with low congestion and less delay.

Table 1: Simulation Parameters

Parameter	Value
No. of. Nodes	100
Simulation time	250sec
MAC layer	IEEE802.11
Traffic source	CBR
Packet size	512 bytes
Routing protocol	AODV
Communication Range	250m
Area Size	1000m X 1000m

The simulation of wireless network is performed with 200 nodes using the IEEE 802.11 MAC layer and the AODV routing protocol. The simulation runs for 250 seconds and shall involve Constant Bit Rate (CBR) traffic with 512-byte packets. The communication range of the nodes is 250 meters and the area size of the simulation is 1000 meters by 1000 meters. The Ad Hoc On-Demand Distance Vector (AODV) routing protocol is a reactive routing protocol, which means that it only establishes a route to a destination when it is needed by a source node. AODV has the advantage of low overhead and fast route discovery and It is commonly used in ad hoc wireless networks, where nodes are free to move and there is no fixed infrastructure.

Conventional schemes taken here to analyse the transmission process with the proposed CEAPSA scheme are EAACLS and EBJRCF. The metrics taken for the analysis of proposed CEAPSA and conventional schemes EAACLS and EBJRCF are Frame delivery rate, Data Loss Rate, Peek Signal-to-Noise Ratio (PSNR), energy consumption of nodes, End-to-End Delay, and scheduling overheads.

a. Frame Delivery Rate

Frame Delivery Rate (FDR) is defined as the amount of packets that can be delivered successfully to the sink node with respect to the total amount of packets sent by base node. FDR is measured using equation 15,

$$FDR = \frac{\sum_0^n No.of\ Frames(Pkts)\ Received}{Time} \tag{15}$$

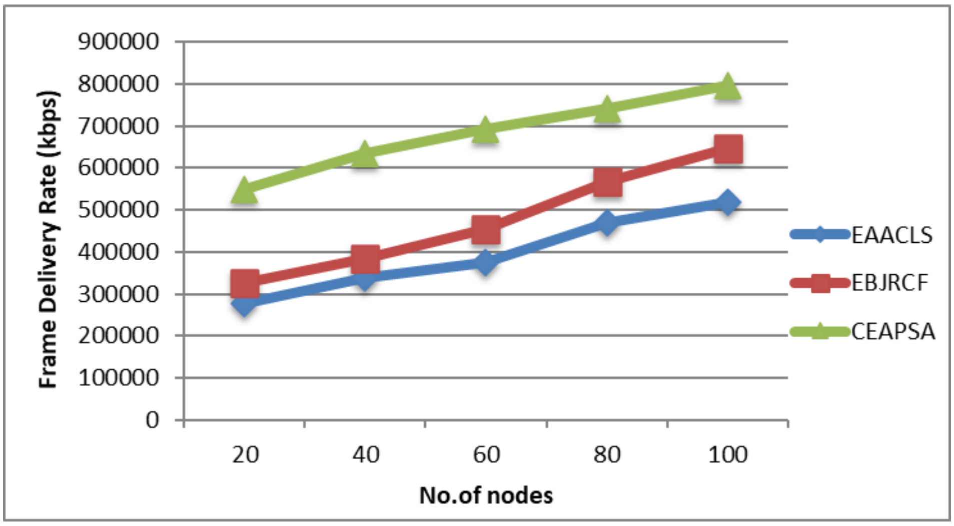

Figure 4: Frame Delivery Rate

Figure 4 shows graphical representation of FDR for both the proposed scheme CEAPSA and conventional schemes EAACLS and EBJRCF. It is clearly shown that the CEAPSA scheme has better packet or frame delivery rates at receiver side compared to conventional methods.

b. PSNR

PSNR is taken for analysis of obtained video quality of the sensed and processed video series. The achieved multimedia quality is highly basis on path scheduling in which high priority packets are scheduled through selected reliable routes. Proposed CEAPSA method obtains the video quality range of 33.6 dB and it is comparatively a better quality while comparing with the schemes EAACLS and EBJRCF. Figure 5 shows obtained PSNR of CEAPSA, EAACLS and EBJRCF.

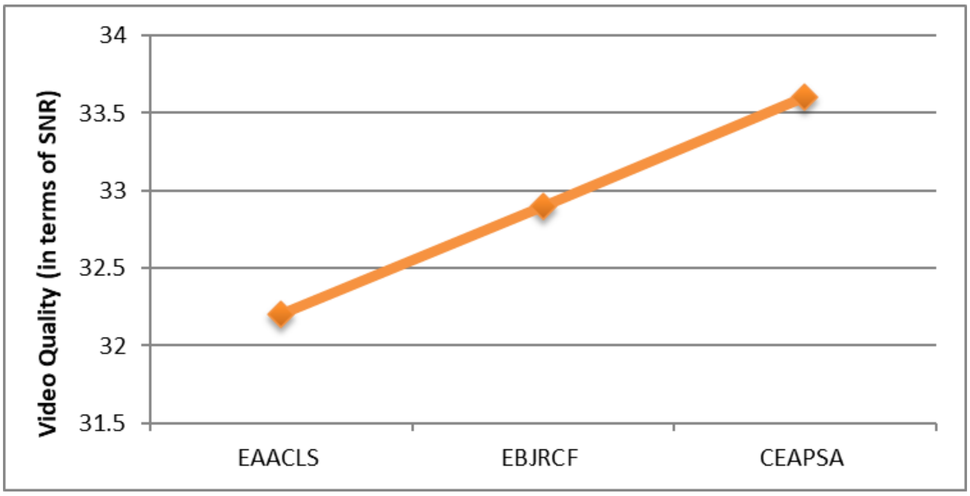

Figure 5: PSNR

c. Scheduling Overheads:
Path scheduling and packet scheduling process greatly reduces the data overheads (congestion) also decreases unnecessary delays in receiving the packets of cost metrics.

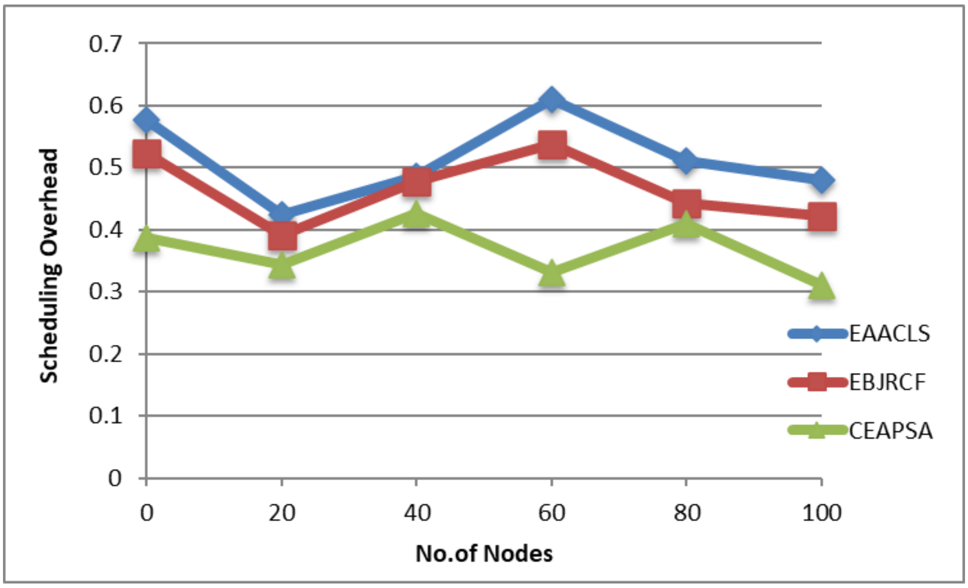

Figure 6: Scheduling Overheads

By transferring high prioritised frames through the selected reliable routes; the congestion rate can be greatly reduced. It also reduces the path scheduling cost in regards to the number of participates nodes while routing. The obtained scheduling costs results of CEAPSA, EAACLS and EBJRCF are compared and proposed CEAPSA got better result compared to other two algorithms. Figure 6 shows the graphical representation of scheduling overheads for both proposed CEAPSA method and conventional schemes.

d. Energy Consumption
Relative energy level for each and every node should be calculated in the network that also used for data transmission process. Nodes energy consumption value (E_{CR}) that is used for transferring the frames and to maintain the node in active role is calculated using nodes energy drain rate (using equation 8 that is mentioned in prior).

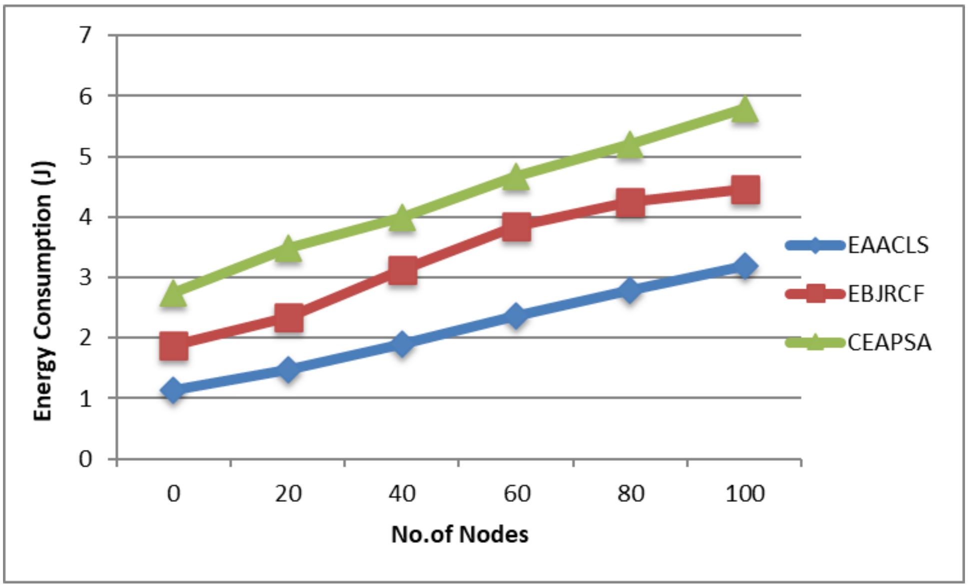

Figure 7: Energy Consumption

Figure 7 shows the consumption of value of energy in terms of joules for both proposed CEAPSA and existing schemes EAACLS and EBJRCF. CEAPSA protocol consumes less energy since it selects the active intermediate relay node routing (highly reliable) for transferring the packets or frames of video sequences.

e. Data Loss Rate

Data Loss Rate (DLR) can be computed by calculating by taking the difference between the numbers of packets dropped at the receiver side and the number of packets sent by the base node. DLR is computed using equation 16,

$$DLR = \sum_{0}^{n} Packets\,Dropped - \sum_{0}^{n} Packets\,Sent \tag{16}$$

DLR of both proposed scheme and existing schemes are compared with each other and the graphical representation is shown in figure 8. It is clearly shown that the proposed CEAPSA scheme has lower data loss in terms of packets compared to the other conventional schemes EAACLS and EBJRCF that simultaneously indicates the better service quality and higher performance of the network.

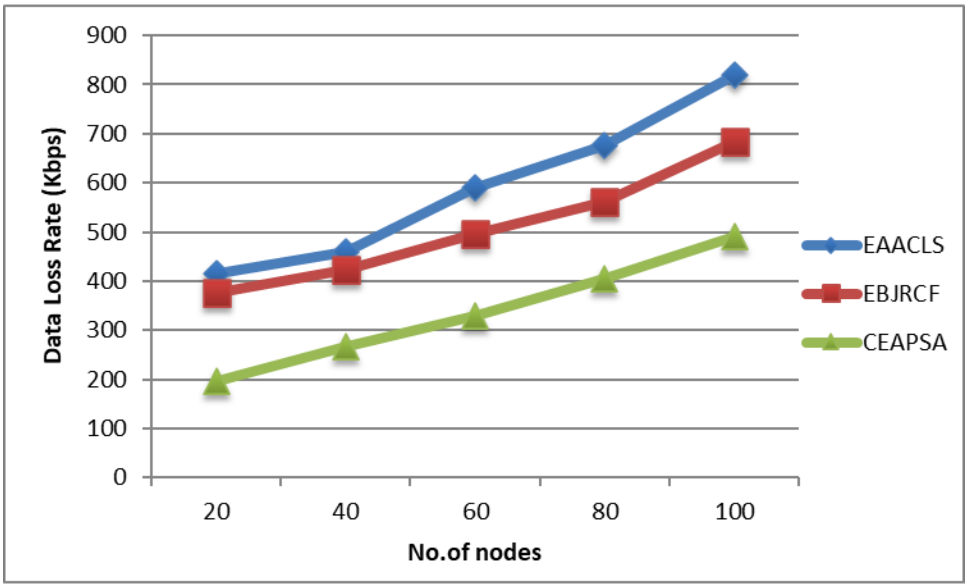

Figure 8: Data Loss Rate

f. ETE Delay

End-to-End (ETE) delay is measured to calculate the overall time that is taken for a set of data transmission process. It is defined as the time difference between the packets received by the receiver node and the packets sent by the base node. ETE delay is measured using equation 17,

$$ETE\_Delay = \frac{\sum_{0}^{n} Pkt\,Rcvd\,Time \; - \; Pkt\,Sent\,Time}{n} \tag{17}$$

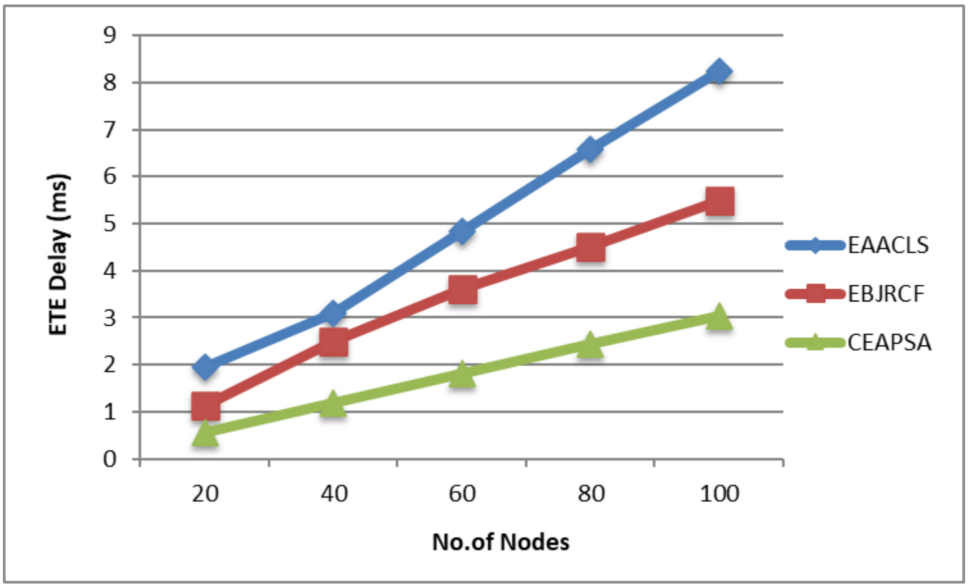

Figure 9: ETE Delay

Figure 9 shows graphical representation of ETE delay for both the proposed and existing schemes. The data processing delay is reduced at the channel for the proposed scheme CEAPSA due to path scheduling process and the obtained delay value is low compared to the conventional schemes EAACLS and EBJRCF. Getting lowered delay value signifies that the achievement of higher system throughput.

5. Conclusion

Cross layer based energy aware path scheduling algorithm is proposed here to reduce congestion ratio and to improve link quality between the routing nodes. Semi-Markov process is applied for estimating link quality among nodes as well as its durability. Path scheduling process determines the highly prioritized packets and selects the active node through link quality process then transmits the packets to the destination based on prioritize level. Simulation analysis is carried out through network simulator tool and the proposed mechanism efficacy is compared with the conventional schemes. Proposed scheme shows better results with improved performance. The efficiency of the CEAPSA scheme is 23.24% better than the EBJRCF scheme and 34.84% than EAACLS scheme in terms of delivery rates.

In future, the network may be enhanced with QoS, improved scalability. Future enhancements could focus on improving the security of the algorithms and making them more resistant to these types of attacks in wireless multimedia sensor networks.

Acknowledgement

There is no acknowledgement involved in this work

References

[1] Rosário, Denis, Rodrigo Costa, Aldri Santos, Torsten Braun, and Eduardo Cerqueira. "QoE-aware multiple path video transmission for wireless multimedia sensor networks." In Proc. Simpósio Brasileiro de Redes de Computadores e Sistemas Distribuídos (SBRC), pp. 31-44. 2013.

[2] Farooq, Muhammad Omer, Thomas Kunz, and Marc St-Hilaire. "Cross layer architecture for supporting multiple applications in wireless multimedia sensor networks." In 2011 7th International Wireless Communications and Mobile Computing Conference, pp. 388-393. IEEE, 2011.

[3] Alikhani, Shafagh, Thomas Kunz, Marc St-Hilaire, and Fei Richard Yu. "A central-networked cross-layer design framework for wireless sensor networks." In Proceedings of the 6th international wireless communications and mobile computing conference, pp. 301-305. 2010.

[4] Mendes, Lucas DP, and Joel JPC Rodrigues. "A survey on cross-layer solutions for wireless sensor networks." Journal of Network and Computer Applications 34, no. 2 (2011): 523-534.

[5] Mingorance-Puga, Jose F., Gabriel Maciá-Fernández, António Grilo, and Nestor MC Tiglao. "Efficient multimedia transmission in wireless sensor networks." In 6th EURO-NGI Conference on Next Generation Internet, pp. 1-8. IEEE, 2010.

[6] Farooq, Muhammad Omer, Thomas Kunz, and Marc St-Hilaire. "Differentiated services architecture for QoS provisioning in wireless multimedia sensor networks." In 2011 IFIP Wireless Days (WD), pp. 1-3. IEEE, 2011.

[7] Hussein, Wael Ali, Borhanuddin M. Ali, M. F. A. Rasid, and Fazirulhisyam Hashim. "Design and performance analysis of high reliability-optimal routing protocol for mobile wireless multimedia sensor networks." In 2017 IEEE 13th Malaysia International Conference on Communications (MICC), pp. 136-140. IEEE, 2017.

[8] Jing, Zhao, and Zeng Jian-Chao. "Delayed and non-delayed coverage-enhancing algorithm for wireless multimedia sensor networks." In 2012 International Conference on Computing, Measurement, Control and Sensor Network, pp. 187-190. IEEE, 2012.

[9] Hamid, Zara, and Faisal Bashir Hussain. "QoS in wireless multimedia sensor networks: a layered and cross-layered approach." Wireless personal communications 75, no. 1 (2014): 729-757.

[10] Wan, Zheng, Naixue Xiong, and Laurence T. Yang. "Cross-layer video transmission over IEEE 802.11 e multihop networks." Multimedia Tools and Applications 74, no. 1 (2015): 5-23.

[11] Jamshed, Muhammad Ali, Muhammad Farhan Khan, Khalid Rafique, Muhammad Imran Khan, Kashif Faheem, Syed Muslim Shah, and Anum Rahim. "An energy efficient priority based wireless multimedia sensor node dynamic scheduler." In 2015 12th International Conference on High-capacity Optical Networks and Enabling/Emerging Technologies (HONET), pp. 1-4. IEEE, 2015.

[12] Abbas, Nasim, and Fengqi Yu. "A Traffic Congestion Control Algorithm for Wireless Multimedia Sensor Networks." In 2018 IEEE SENSORS, pp. 1-4. IEEE, 2018.

[13] Zhou, Yuan, Wei Xiang, and Gengkun Wang. "Frame loss concealment for multiview video transmission over wireless multimedia sensor networks." IEEE Sensors Journal 15, no. 3 (2014): 1892-1901.

[14] Aziz, Syed Mahfuzul, and Duc Minh Pham. "Energy efficient image transmission in wireless multimedia sensor networks." IEEE communications letters 17, no. 6 (2013): 1084-1087.

[15] Karthik, A., MazherIqbal, J.L. Efficient Speech Enhancement Using Recurrent Convolution Encoder and Decoder. Wireless Pers Commun 119, 1959–1973 (2021). https://doi.org/10.1007/s11277-021-08313-6

[16] Lin, Ting-Lan, Hua-Wei Tseng, Yangming Wen, Fu-Wei Lai, Ching-Hsuan Lin, and Chuan-Jia Wang. "Reconstruction algorithm for lost frame of multiview videos in wireless multimedia sensor network based on deep learning multilayer perceptron regression." IEEE Sensors Journal 18, no. 23 (2018): 9792-9801.

[17] Osamy, Walid, Ahmed M. Khedr, Ahmed Salim, and Dharma P. Agrawal. "Sensor network node scheduling for preserving coverage of wireless multimedia networks." IET Wireless Sensor Systems 9, no. 5 (2019): 295-305.

[18] Liu, Fang, Hang Lu, Ting Wang, and Yuanan Liu. "An Energy-Balanced Joint Routing and Charging Framework in Wireless Rechargeable Sensor Networks for Mobile Multimedia." IEEE Access 7 (2019): 177637-177650.

[19] El, Mohamed Ezz El Dien Abd, Aliaa AA Youssif, and Atef Zaki Ghalwash. "Energy aware and adaptive cross-layer scheme for video transmission over wireless sensor networks." IEEE Sensors Journal 16, no. 21 (2016): 7792-7802.

[20] Jiao, Zhenghua, Lei Zhang, Miao Xu, Changxin Cai, and Jie Xiong. "Coverage Control Algorithm-Based Adaptive Particle Swarm Optimization and Node Sleeping in Wireless Multimedia Sensor Networks." IEEE Access 7 (2019): 170096-170105.

Member since 2012
JM08090

This journal is a member of, and subscribes to the principles of,
the Committee on Publication Ethics (COPE).
https://publicationethics.org/members/international-journal-computers-communications-and-control

Cite this paper as:

Jenila, L.; Aroul Canessane, R. (2023). Cross Layer based Energy Aware and Packet Scheduling Algorithm for Wireless Multimedia Sensor Network,*International Journal of Computers Communications* & *Control*, 18(2), 4666, 2023.

https://doi.org/10.15837/ijccc.2023.2.4666