International Journal of Information Technology and Knowledge Management
July-December 2012, Volume 5, No. 2, pp. 413-420

PRIORITIZED REGION SCHEDULING BASED QOS ROUTING OVER WMSN

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Abstract: In this paper we have proposed Prioritized Region Scheduling based Optimal Image Routing (PRSOIR) which optimally transmit image over wireless sensor network. Multiple paths are built and are scored using path conditions based on availability of resources along the paths. The proposed scheme is compared with non-optimal scheme that it transmits the images without calculating the non-overlapping regions and overlapping regions of the original images that are captured and relevant paths are selected according to hop count for routing the image data to sink.

Variant parameters such as free buffer size, energy, hop-count and packet loss. The data is transmitted through highest path score paths. Simulation results have demonstrated the effectiveness of the proposed scheme compared to non-optimal scheme using various metrics.

Keywords: Multipath routing, prioritized region scheduling, multimedia data, QoS routing, reliability, Wireless multimedia sensor network.

1. INTRODUCTION

Advances in wireless sensor networks (WSN) have led to next generation networks that allow retrieving image, video, audio and scalar sensor data from the physical environment, and are called as Wireless multimedia sensor networks (WMSN). WMSN has enabled new applications such as multimedia surveillance sensor networks advanced health care delivery, environmental monitoring etc.. Many of the applications such as environmental monitoring, surveillances, habitat monitoring applications, use of image/ video sensors in WSN can improve the performance. But huge volume of image data may cross the limits of limited resources of WSN which may shorten network lifetime and degrades the performance [1-2]. Many of these applications require mechanisms to deliver multimedia content such as image or video data with a certain level of Quality of Service (QoS). Provisioning sufficient bandwidth and low packet loss rate, while considering energy efficiency, are the main QoS requirements of multimedia data transmission over WMSN. Several features of WMSN such as: resource constraints, unbalanced traffic, and variable channel capacity etc. make provisioning these requirements as a hard problem. This has necessitated providing an efficient way to transmit the image to the receiver while considering energy and bandwidth focusing on features of WMSN. In an application involving images, the important parameters to consider may include a minimum image resolution and size of the data. The routing protocols must provide an optimal data transmission route from sensor nodes to sink to save energy of nodes in the network while achieving application specific QoS. Good surveys of routing techniques are well discussed in [3]. As observed in [4], WMSNs will stretch the horizon of traditional monitoring and surveillance systems by a distributed system of multiple cameras and sensors enables perception of the environment from multiple disparate viewpoints, and helps overcoming occlusion effects. As the Field of View (FoV) of a single fixed camera, or the Field of Regard (FoR) of a single moving pan-tilt-zoom (PTZ) camera is limited. Overlapped cameras can provide different views of the same area or target which enhances the view of scene of interest. The redundancy introduced by multiple, possibly heterogeneous, overlapped sensors can provide enhanced understanding and monitoring of the environment.

In order to deliver a high quality image to sink can be achieved by utilizing prioritization of packets of images and sending them on the more reliable path. In most of the application array of image sensors are deployed and sensed images from these image sensors may overlap with each other consisting of lots of data redundancy. Transmission of such types of images individually may consume more resource such as energy, buffer, bandwidth etc. along the path to reach the sink. The drastic drain of energy for the image transmission efficient network lifetime and also due to packet losses may decrease quality of image recovered at the sink. Hence efficient multimedia routing can be considered as a very challenging problem in WSN. It is found in the literature that single path routing is not an efficient way for transmitting multimedia over WMSN as it

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will cause queuing delay and packet loss in restricted buffers at intermediate nodes and may cause congestion over the network. These problems enforce to use Multipath routing that can provide high end to end bandwidth in WMSNs. Comparing with single path routing, utilizing multiple paths in multimedia transmission will benefit in reducing end to end delay, energy conservation of the node, load balancing etc. Our approach is to select multiple paths based on path conditions and transmit the redundant information acquired from multiple cameras only once.

The rest of the paper is organized as follows. In section II literature works relating to multipath routing in various networks like WSNs, Ad-hoc networks and WMSNs is reviewed. Section III discusses the technique proposed and design of system for the proposed protocol. Section IV describes simulation environment, sample outputs and performance analysis with graphs obtained. Finally, section V summarizes the conclusion drawn and shows the direction for future work.

2. RELATED WORK

Routing in WMSN is more challenging task because not only because of the scarcity of the resources of the WSN but also it should consider unique characteristic of multimedia data. Most of the earlier protocols were based on single path routing which constructs a single energy-efficient path between a source and a destination node. In [5], authors described that single path are not suitable for supporting multimedia transmission in WSN. Performance of data transmission gets enhanced with efficiently with the use of Multipath protocols in WMSN than the single path routing protocols. The optimized node-disjoint multiple paths between source and destination provide load balancing function in WSN to achieve reliable data transmission. The key challenge is to find effective approach to establish multiple paths which provides reliability, balances the load among multiple paths and thus increase the network lifetime. There are numerous multi path routing protocols are presented in the literature of adhoc network, WSN, and WMSN. In [6], authors described AOMDV which shares several characteristics of AODV. The core of the AOMDV protocol lies in ensuring that multiple paths discovered are loop-free and disjoint, and in efficiently finding such paths using a flood-based route discovery. In [7], authors proposed multipath routing protocol for network lifetime maximization in ad-hoc networks which is based on AOMDV. Here the protocol sets energy threshold to optimize the forwarding mechanism. It builds energy cost function and uses the function as the criterion multiple path selection. But this protocol does not consider end to end delay. In [8], authors proposed an energy efficient adaptive multipath routing technique which utilizes multiple paths between source and the sink. This protocol is intended to provide a reliable transmission environment with low energy consumption, by efficiently utilizing the energy availability and the received signal strength of the nodes to identify multiple routes to the destination. In [9], authors proposed an energy efficient multipath routing protocol called REER. REER uses the residual energy, available buffer size, and Signal-to- Noise Ratio (SNR) to predict the best next hop through the paths construction phase. REER examines two methods of traffic allocation; the first method uses a single path among the discovered paths to transfer the data message, when this path cost falls bellow a certain threshold, it then switches to the next alternative path. The second method is to split up the transmitted message into number of segments of equal size and then transmit it across multiple paths simultaneously to increase the probability that an essential portion of the packet is received at the destination without incurring excessive delay. In [10], authors designed novel QoS aware routing protocol to support high data rate for WMSN. The routing decision is made according to the dynamic adjustment of the required bandwidth and path length based proportional delay differentiation for real time data. The proposed protocol works in a distributed manner to ensure bandwidth and end to end delay requirements of real time data. In [11], authors presented multi-path transmission of video based on packet and path priority scheduling over WMSN. Here the objective is to provide a transmission mechanism to improve the video quality perceived at the receiver while considering energy, bandwidth and delay constraints of the network. Video packets are classified according to their types and more important packets are transmitted through paths with better conditions. Path conditions are evaluated by a score mechanism using variant parameters such as free buffer size, energy, hop count and packet loss. The network-adaptive transmission mechanism is proposed in [12] that decompose the source bit stream into segments of unequal importance and reserves the most reliable paths to transmit the segments with the highest importance. Moreover, unequal segment loss protection with erasure codes of different strengths is used to maximize the expected quality at the destination and propose a fast algorithm that finds nearly optimal transmission strategies.

Finding the exact object location is one of such traditional problems which have been well studied in the past. Authors in [13] proposed an object localization scheme for WMSNs which can be run on a single camera sensor by only using the sensor's location information. First it extracts the detected object using frame differencing. To reduce the processing cost of this operation, each frame size is reduced with some video pre-processing. The location of the object can then be estimated using the distance of the object to the camera and camera/frame size properties. In addition to being energy-efficient, since a single camera sensor is involved, the required time for localization is reduced immensely as opposed to approaches which involve multiple camera sensors. Authors in [14] present a vision-based solution to the problem of topology discovery and localization of WSNs. In this proposed model, a robot controlled by the network is introduced to assist with localization of a network of image sensors, which are assumed to have image planes parallel to the agent's motion plane. The localization algorithm for the scenario where the moving agent has knowledge of its global coordinates is first studied. This baseline scenario is then used to build more complex localization algorithms in which the robot has no knowledge of its global positions. Two cases where the sensors have overlapping and non-overlapping fields of view (FOVs) are investigated. In order to implement the discovery algorithms for these two different cases, a forest structure is introduced to represent the topology of the network. The collection of sensors with overlapping FOVs as a tree in the forest is considered. The robot searches for nodes in each tree through boundary patrolling, while it searches for other trees by a radial pattern motion.

Many Sensor applications such as monitoring and Surveillance may require image sensor array to conduct collaborative image transmissions in WSN. The large size image transmissions cause bottlenecks in WSN due to the limited energy resources and network capacity. In [15], authors proposed a collaborative transmission scheme for image sensors to utilize inter-sensor correlations to decide transmission patterns based on transmission path diversities, which achieves minimal energy consumption, balanced sensor lifetime and required image quality. This optimization scheme not only allows each image sensor to transmit optimal fractions of the overlapped images through appropriate transmission paths in energy-efficient way, but also provides unequal protection on the overlap image regions through path selections and resource allocations to achieve good transmission image quality. In [16], authors proposed an effective approach where the data redundancy among correlated image sensors can be considerably reduced. The communication overhead for data exchange is relatively small to exploit the correlations in the proposed approach. Furthermore, it is investigated and considered both source sensor image transmission schemes and routing patterns together in WSN assuming that image sensors are installed in various locations of a large size sensor network to monitor or track objects. These sensed images may overlap with each other. The sensors have limited capability and resource to process the images; therefore, images have to be sent to base station (sink) for more sophisticated processing. To save communication energy, it would be important for each source sensor to send its own Non-overlapping region (NOVR) and not to send the overlapping region. As the base station may be far away from the image sensor, the images then have to be transmitted by multiple hops through relay sensors to the base station. It requires an effective image transmission pattern, to handle large-size image data. Further this uses MLRR routing scheme achieving energy efficiency and longer network lifetime, based on residual energy level at each of the nodes rates are determined at each of the node. It will choose the next hop node in next level whose rate is same as that of its. So that lower transmission rate is assigned to nodes which have less residual energy.

The proposed protocol "Energy Efficient Prioritized Region Scheduling based Optimal Image Routing (EE-PRSOIR)" finds OVR and NOVR as presented in [16] to exploit the redundancies among the correlated large size images from image sensors falling in same FOV which reduces the amount volume of data actually sent to the destination. And then it uses Multipath routing scheme which considers not only the residual energy at nodes but also buffer size and hop count to get increased throughput. We use prioritized region scheduling to get improved image quality, higher packet delivery and hence throughput with minimum packet loss. In [16] only energy efficiency was the main concern. The path with the highest score has the best condition for transmitting high priority packets is used to send OVR. This causes more important packets to be transmitted through more reliable paths and therefore it could increase image quality at the receiver. The proposed protocol being an optimal scheme calculates OVR and NOVR of the images captured from same scene of interest, so that transmission of redundant data is reduced. These classified data is transmitted from source to sink with low energy consumption through multiple paths which can considerably reduce the total energy consumption and extend the network lifetime for WSN.

3. PROPOSED TECHNIQUE

3.1 Working Scheme

The proposed protocol Prioritized region scheduling based Optimal Image Routing (PRSOIR) uses Multipath based approach to transmit image over WSN. In order to build multiple paths we have considered features of AOMDV [6]. We consider a camera based WSN where image data is to be sent to sink from source node. Source node can be an aggregation node that collects the data from the multiple image sensors. The image sensors are installed in various locations of a large size sensor network to monitor a scene of interest or track objects. These sensed images may overlap with each other and have some regions in common (overlapped) and some are not (non-overlapping). So image is separated into overlapping ad non-overlapping region of original image. We use an approach to classify each image as consisting of $P1$ = OVR, NOVR1 and $P2$ = OVR, NOVR2. OVR of both the images have the redundant information and hence can be transmitted only once to reduce energy consumption and also is the important region because the two original images can only be recovered by the reliable reception of this OVR at the sink. We use prioritized region scheduling. When the correlated images among cameras considered, after classification of image into OVR and NOVR not all the packets in all the regions have the same effect on the image quality, so it is better to give priority to packets belonging to OVR because these packets are most important to reconstruct the images as they carry information of both the images and loss of such packet degrades the picture quality and hence a most reliable path is searched among the multipaths to send the OVR packets. The data is scheduled for transmission through multiple paths according to the path scores. Multiple path scores are calculated by considering the hop count, minimum residual energy, and minimum buffer size. The data is transmitted through highest path score paths. The optimal scheme provides high throughput and low packet loss.

3.2 Equations

Path Score Calculation

In [18-19] authors have proposed a mechanism for achieving most reliable path.The path with the highest score has the best condition for transmission of important packets and path score is calculated as follows:

$$\text{Path score} = \alpha + WE + \beta * WQ + \gamma * WH \tag{1}$$

Where, $\alpha + \beta + \gamma = 1 \quad 0 \Leftarrow \text{path score} \Leftarrow 1$

WE = min E res in the path /$E0$,

WQ = min ABS in the path/$B0$,

WH = (1 + max hop count-hop count)/max hop count,

Where, $B0$ is the initial buffer size of the intermediate node and Hop count is the number of hops traversed by a packet all over the network to reach the sink.

Energy model

We adopted the energy model of [17] for communication.

- The consumed energy for transmission of a n-bit message is given by,

$$ET = n * \text{Eelec} + n * \text{Eamp} * r2 \tag{2}$$

“To receive a n-bit message, a sensor consumes the energy

$$ER = n * \text{Eelec} \tag{3}$$

Where, Eelec is the energy consumed in the nodes electronic apparatus,

Eamp is the energy requirements for the signal amplification,

‘r’ is the distance between the transmitting and receiving node.

- Residual energy ‘Eres’ of each node is computed based on:

$$Eres = E0 - ER - ET \tag{4}$$

Where, $E0$ is the initial energy of the node, ER = energy consumption for receiving n-byte,

ET = energy consumption for transmitting n-byte,

- The count of available buffer space ‘ABS’ of each node is computed based on

$$ABS = BS - j \tag{5}$$

Where, Buffer size ‘BS’ is maximum capacity of the buffer to store the packets and ‘j’ is a counter that shows the no of packets in each intermediate node buffer.

3.3 Algorithm

The proposed protocol Energy Efficient Prioritized Region Scheduling based Optimal Image Routing (EE-PRSOIR)” works as follows.

Step1: Image sensors (IS) are randomly selected from the array of sensors deployed. Calculate overlapping and non overlapping region of the images captured from the image sensors.

Step 2: In Path Discovery phase, the source will find the number of valid multiple node disjoint paths that are calculated based on minimum hop count towards forwarding nodes from source sensor to sink. Each IS sends RREQ to find neighbor nodes of IS until it reaches sink. From IS it finds all available paths based on maximum hop count which is considered as two more than the network size ($N + 2$). From all available paths find valid paths based on minimum hop.

Step 3: A method is used to score the paths according to their properties and QoS requirements of multimedia applications. We used control packets for collecting path conditions periodically. Score mechanism is on following metrics: Free buffer size, residual energy, and hop count. Paths that have better conditions get higher scores using the equations (1-5).

Step 4: The multipaths are sorted based on their path score and stored in valid path list.

Step 5: Once the multiple paths are found Data is transmitted towards sink over three selected paths simultaneously. We are using prioritized region scheduling to avoid fast depletion of energy in the sensor nodes. i.e the overlapping region is sent on the first highest path score path and then non-overlapping regions of two images are sent on the other two paths which are selected among all valid paths. The path with the highest score is considered as the most reliable and packets that have higher priority can be sent on these paths to improve the image quality at the sink.

Step 5.1: Select first three highest path scored paths.

Step 5.2: Assign first highest path for transmission of important OVR packets of the images.

Step 5.3: Assign next two highest paths to NOVR of the two images.

Step 6: The images are reconstructed at the sink.

The proposed protocol is compared with non-optimal scheme where classification of packets is not performed. The non-optimal scheme transmits the images on the relevant paths selected according to hop count. The packet loss, throughput, Peak Signal to noise ratio (PSNR), Packet Delivery Ratio (PDR) is evaluated.

4. SIMULATION AND PERFORMANCE ANALYSIS

We present and discuss in this section the simulation results for the performance study of proposed multipath routing protocol along with sample outputs, parameters used for simulation, and performance analysis with the help of graphs obtained. The proposed scheme is implemented using Matlab [20-21] to simulate packet transmission over WSN. We simulate image transmission using optimal scheme and non-optimal scheme with path scheduling. Here non-optimal scheme approach is that it transmits the images without calculating the OVR and NOVR of the original images that are captured and relevant paths are selected according to hop count for routing the image data to sink, then data obtained are compared with optimal scheme.

4.1 Simulation Environment

The Figure 1 shows sample output where N^2 ($N = 7$) of uniformly distributed sensors over an area of 1000×1000 m^2. We assume that the sensor nodes are stationary for their lifetime. In addition, we assume that each sensor is able to compute its residual energy, available buffer size. The source sensor senses the image and stores in it, then the OVR and NOVR of the original image is calculated. Quality scalable source encoders such as JPEG 2000 [22] can be used which offer flexibility in choosing the size of the information bit stream to be transmitted. In [23], authors proposed a system for JPEG-2000 with multiple descriptions coding of image and video data, image transmission over WSNs that minimizes energy consumption which is based on encoding the information bit stream using assumption while satisfying QoS guarantees. The input image is encoded using standard JPEG format. Both gray scale image and color images can be used. Although a JPEG file can be encoded in various ways, most commonly it is done with JFIF encoding.

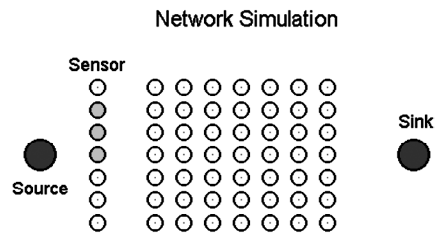

Figure 1: Network Topology

4.2 Simulation Settings

The simulation scenario was set up according to Table 1.

Parameter Name	*value*
Channel Type	Wireless channel
Radio-Propagation model	Propagation / Two Ray Ground
Network Dimension	1000mx1000 m2
Number of nodes	25 to 400
Sensor transmission range	50m
Sensor initial energy	10 joules
Node placement	Uniformly distributed
Traffic	One node sends image to the base station.
Buffer size	50 packets
Bandwidth	250kbps
Packet Size	1024bytes

4.3 Example Domain

It is found in the literature of WMSN, that they are used in Wildlife monitoring to study the behavior of animals by being programmed to detect and react in a proper way to pre-specified conditions, with almost no human intervention. The distributed structure of these systems allows deploying them to cover wide territories and to capture data from different modalities in response to events in real time, e.g., capturing image data only animals are active and by using motion sensors event can be generated to capture the image. WMSN are used in the forest where mammals lives in, the higher the number and diversity of species, body sizes and diet types. Some mammals seem more vulnerable to habitat loss than others: Insect-eating mammals-like anteaters, armadillos and some primates are the first to disappear-while other groups, like herbivores, seem to be less sensitive. The results of the study are important in that they confirm what suspected: habitat destruction is slowly. For monitoring of endangered species hierarchical routing can be used. At the low level motion sensors can detect the motion and inform about the same to image sensors at the top level to take into part and send the images to the sink for necessary action.

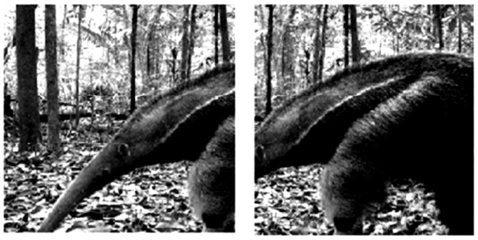

Figure 2: Original image 1 Original image 2

The images shown Figure 2 are of anteater are taken as input to source sensor and then OVR and NOVR are calculated, by comparing block of image1 with image2 if they are same, then it's considered as OVR of the images otherwise NOVR. The generated images are as shown Figure 3.

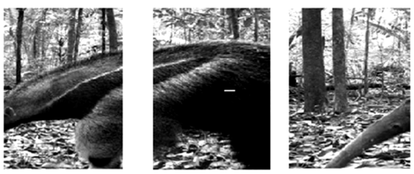

Figure 3: NOV1 NOVR2 OVPR1

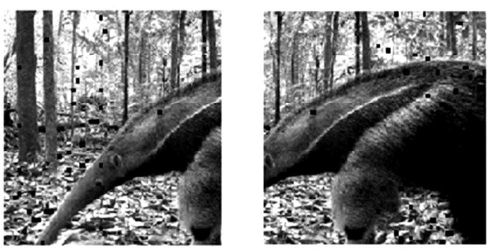

Figure 4: Reconstructed Image1 Image2

4.4 Performance Metrics

To evaluate the performance of the proposed protocol, the following performance metrics are used:

- **Packet loss:** Packet loss is the failure of one or more transmitted packets to arrive at their destination.
- **Throughput:** Throughput is the measure of number of packets passing through the network in a unit of time. Network throughput is the average rate of successful message delivery over a communication channel.
- **Packet Delivery Ratio:** It is defined as the ratio of number of packets sent by source to the number of packets received at the sink.
- **Peak Signal to Noise Ratio:** The peak signal-to-noise ratio (PSNR) is the measure of required image quality and is usually expressed in decibels.

4.5 Simulation Results

In this section the performance of the proposed optimal routing scheme in wireless multimedia sensor network is compared with non-optimal scheme.

It is found that packet loss can be caused by a number of factors including signal degradation over the network medium, channel congestion, corrupted packets rejected in-transit, faulty networking hardware, faulty network drivers etc.. Figure 5 shows packet loss in the proposed WMSN. Packet loss is more in case of optimal method when the network size is small due to the less number of non interfering available paths when compared to increasing network size. As the network size increases more number of paths becomes available. The packet loss is more in non-optimal scheme when compared with optimal scheme.

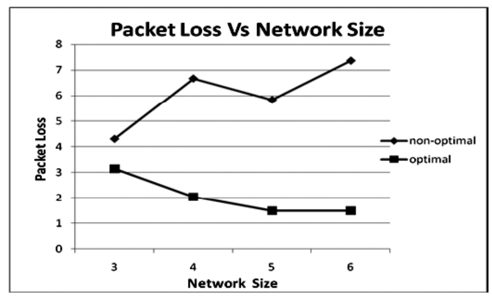

Figure 5: Packet Loss Versus Network Size

Figure 7 shows Throughput as a function of Network size of the compared protocols. It shows that the throughput of optimal scheme is better than non-optimal scheme because packet loss is more in non-optimal when compared with proposed optimal scheme. As the network size increases performance degrades in non-optimal scheme as it is not considering the path conditions as well as more number of packets are sent which consumes more energy.

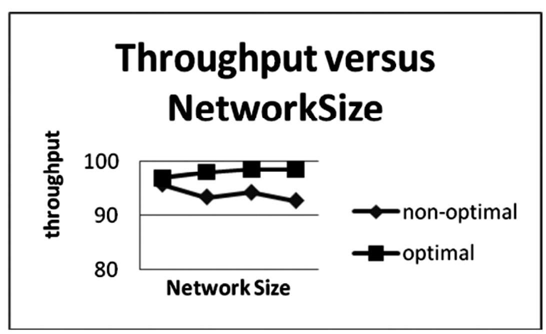

Figure 6: Throughput Versus Network size

Figure 7 shows PDR versus network Size. As the network gets large, there are more available nodes and hence more routes to forward data resulting in increasing the delivery ratio. The proposed scheme outperforms Non-optimal schemes in packet delivery capability. This is due to the selection of multiple paths. As the packet drops are less in optimal scheme and hence increase the packet delivery ratio.

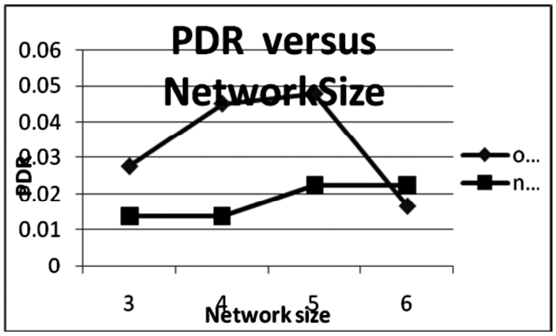

Figure 7: PDR Versus Network Size

5. CONCLUSIONS

Transmitting the large size image with high quality over resource constrained WSN is the bottleneck. To solve this problem, we proposed a optimal multipath routing, where the images are processed within WSN can transmit appropriate overlap regions over multiple paths found from source to sink based on path metrics like hop count, residual energy, buffer size, so that less energy is consumed by efficiently utilizing the resources of network. We use prioritized region scheduling to get improved image quality, higher packet delivery and hence throughput with minimum packet loss. The proposed protocol Prioritized Region Scheduling based Optimal Image Routing (PRSOIR)" uses Multipath based approach to transmit image over WSN. The protocol classifies the images into OVR and NOVR of each image and then transmits it over multiple paths simultaneously to increase that an essential and important packets to reach the sink. For evaluating our proposed protocol we compared it with non-optimal transmission scheme.

Simulation results show that the proposed mechanism could improve image quality at the receiver by decreasing packet loss and distributing image traffic over network more efficiently, which shows high throughput when compared to Non-optimal scheme.

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