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RESEARCH ARTICLE

Multi-Channel Multi-Path Video Transmission over Wireless Sensor Networks Using ACDP Technique

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Abstract— Video streaming over wireless networks is compelling for many applications, ranging from home entertainment to surveillance to search-and-rescue operations. Interesting technical challenges arise when the unpredictable nature of the wireless radio channel meets the requirements of high data rate and low latency for video transport. In this paper Quality of Service (QoS) guaranteeing scheme for video transmission over WSN, called the Multi-Channel Multi-Path (MCMP) scheme is proposed. It selects the best paths from the source camera to the gateway based on multiple Quality of Service metrics such as hop-count, aggregated path energy and end-to-end delay. A failure recovery scheme is also provided to cope with link failure. It uses H.264 protocol for video encoding and decoding and can be used as a compressor. Here frames are transmitted based on priorities. Network simulation reveals that this proposed scheme significantly outperforms the existing scheme in terms of channel utilization and delay.

Keywords— WSN, Multi-Channel Multi-Path, H.264, Video Transmission, Quality of Service

I. INTRODUCTION

Wireless Sensor Networks (WSN) has gained a lot of importance in wireless communications. Wireless communication is established by nodes acting as routers and transferring packets from one to another in networks. Wireless Multimedia Sensor Networks (WMSNs) have some distinct features compared to the conventional sensor networks including high rate of data generation from the video sensors and require more power to transmit a multimedia application. This requires larger network bandwidth and more power consumption, and this issue gets more serious if no efficient compression scheme is employed with the transmission. The basic aim of the schemes is to effectively deal with the high bandwidth requirement, prolong the network lifetime, and minimize the delay. Most of the existing schemes use multiple paths with single channel and a single metric is adopted to make a Quality of Service (QoS) decision.

To effectively deal with high bandwidth requirements, in this paper, we propose a composite QoS metric-controlled video transmission scheme for a wireless sensor network, called Multi-Channel Multi-Path (MCMP) video transmission scheme. This scheme uses a two-stage process to find two best paths destined to the gateway, and the H.264 encoded video is transmitted over these paths using alternating orthogonal channels in such a way that the important video part (I-frame) is transmitted over the one of the best path. H.264 is a compression technique that is used only on multimedia applications as they require much higher bandwidth compared to any other regular data such as text, image, audio files. The efficient compression technique used here is H.264 protocol. It is also called as AVC and MPEG-4. It transmits a video data in terms of frames or pictures in a prioritized manner.

The H.264 protocol for video frames is called picture types or frame types. The three major frame types used in the video compression are I, P and B frames. Each group of pictures in a H.264 video sequence consists of I, P, and B frames. I- frames are the least compressible frames but do not require other video frames to decode. The I- frames are intra-coded, coded independent of any other frames, and serve as a reference for the prediction of the subsequent P and B frames. For this reason, the data pertaining to an I-frame is very important to the quality of video data. I-frame is a fully specified picture, like a conventional static image file. P- frame and B- frame hold only part of the image information, so they need less space to store than an I- frame and thus improve video compression rates. I-frames can contain only intra macroblocks. I-frames are coded without reference to any frame except themselves. They can also be generated when differentiating image details prohibit generation of effective P or B-frames. Typically they require more bits to encode than other frame types.

P- frame can use data from previous frames to decompress and are more compressible than I- frame. A P- frame ('Predicted picture') holds only the changes in the image from the previous frame. The encoder does not need to store the unchanging background pixels in the P- frame, thus saving space. P-frames can contain either intra macroblocks or predicted macroblocks. Require the prior decoding of some other pictures or frames in order to be decoded. They may contain both image data and motion vector displacements and combinations of the two and can reference previous pictures in decoding order. P-frame typically requires fewer bits for encoding than I pictures do.

B- frame can use both previous and forward frames for data reference to get the highest amount of data compression. A B- frame ('Bi-predictive picture') saves even more space by using differences between the current frame and both the preceding and following frames to specify its content. B-frames can contain intra, predicted, or bi-predicted macroblocks. This frame includes some prediction modes that form a prediction of a motion region (e.g., a macroblock or a smaller area) by averaging the predictions obtained using two different previously decoded reference regions. In other words, some standards allow two motion compensation vectors per macroblock (biprediction).B- frame typically require fewer bits for encoding than either I or P-frames.

We employ a composite QoS metric, comprising hop-count and remaining energy. The high bandwidth requirement is dealt with by using the Alternating Channel Duo Path (ACDP) technique. Two best paths are selected by gateway node based on hop cont and remaining energy which is composite QoS metrics. The recovery path which is used as a backup if any of the links goes down during the video transmission is dynamically selected by gateway node. Computer Simulation reveals that the proposed scheme significantly outperforms the existing scheme on channel utilization and delay. We proposed multi-channel multi-path video transmission technique to transmit a multimedia application and multiple QoS metrics are used for best path selection decision making.

II. Literature Survey

Video streaming of news and entertainment clips to mobile phones is now widely available. For surveillance applications, cameras can be cheaply installed, if a wireless network provides connectivity. A wireless Local Area Network (WLAN) might connect various audiovisual entertainment devices in a home. WMSNs have some distinct features compared to the conventional sensor networks including high rate of data generation from the video sensors. Various existing solutions developed for multimedia communication in wireless and internet environment cannot be directly applied to sensor network due to the unique characteristics and resource constraints [1].

A wireless video sensor network interconnects low-cost and low-power sensor nodes with limited data processing capabilities, which are equipped with miniature cameras and wireless transceivers. Typically, video sensors are small in size and communicate over short distances. Each video sensor node captures video scenes and transmits them to a central base station or data sink. A heterogeneous sensor network may consist of both video sensors and conventional sensors to gather video as well as other sensory data. For high-rate video traffic in video sensor networks, throughput and delay are important quality of service (QoS) metrics. A video sensor is generally battery-operated; therefore, energy consumption (and hence network lifetime) is a fundamental issue associated with QoS provisioning in wireless video sensor networks [2]. In an environmental monitoring application scenario, video sensors will need to collect, store, and transmit only the most important video sensory data. Power for sensors is mostly generated dynamically via solar panels or wind-powered generators [3].

Yunfeng Chen, Nidal Nasser propose a novel mechanism to find multiple-paths between one sink and multiple-sources with the consideration of reducing collision occurred at nodes that are receiving and forwarding packets on behalf of the source nodes [4]. The Video data encoded with H.264 protocol is inherently composed of prioritized data. Each group of pictures in a H.264 video sequence consists of I, P, and B frames. The I-frames are intra-coded, i.e., coded independent of any other frames, and serve as a reference for the prediction of the subsequent P and B frames [5].

Chen and Nasser have proposed Secure and Energy-Efficient Multipath Routing Protocol (SEEM) . SEEM consists of three phases, and uses multipath alternately as the path for sharing between two nodes. Quality of Service Multipath Routing Protocol (QOSMR) provides QoS guarantees that have a potential impact on the performance of the network in terms of throughput and network lifetime. The major focus is to eliminate congestion in the intermediate nodes [6]. Link-layer encryption and authentication, identity verification, bidirectional link verification, and authenticated broadcast can protect sensor network routing protocols against outsiders, bogus routing information, Sybil attacks, HELLO floods, and acknowledgement spoofing, and it is feasible to augment existing protocols with these mechanisms [7]. The Multipath multi-SPEED protocol (MMSPEED) has been proposed in. It uses multipath forwarding by transmitting duplicate copies of the packets, where a detour path of more hops is also taken rather than using only the shortest path. The protocol offers QoS guarantees on timeliness and reliability. Here the end-to-end delay requirement is supported in a localized way, which is desirable for large-scale dynamic sensor network with respect to scalability and adaptability [8].

Moreover, the routing schemes proposed ***so*** far in the context of ad **hoc** networks employ single-path routing which might not ensure optimal end-to-end delay. However, once a set of paths between ***s*** to d is discovered, in some cases, it is possible to improve end-to-end delay by splitting the volume of data into different blocks and sending them via selected multiple paths from **s** to d, which would eventually reduce congestion and end-to-end delay [9].

Ye Ming Lu and Vincent W. S. Wong propose a distributed, scalable and localized multipath search protocol to discover multiple node-disjoint paths between the sink and source nodes. We also propose a load balancing algorithm to distribute the traffic over the multiple paths discovered[10].Ad hoc On-demand Distance Vector (AODV) were proposed to improve the energy efficiency of ad hoc networks by reducing the frequency of route discovery[11].

III. THE PROPOSED MCMP SCHEME

During the survey of different algorithms and schemes proposed to transmit multimedia content over WSN, it has been observed that most schemes use multiple paths and single channel. In addition, only a single metric is adopted to make a QoS decision. It is thus necessary to develop a scheme that uses multiple QoS metrics in making a decision.

The Multi-Channel Multi Path (MCMP) video transmission scheme uses multiple paths and multi-channel for transmission of multimedia content over WSN. Multiple metrics are adopted to make QoS decision. The Multi-Channel Multi Path (MCMP) video transmission scheme considers channel diversity as well as space diversity to obtain maximum data rate and assign separate path to each camera for collision-free transmission. Furthermore, appropriate decisions are made by employing various QoS metrics. At the time of deployment, every sensor node is assigned a unique ID for identification and tuned to a common control channel.

The proposed MCMP scheme consists of two stages as explained later. The Alternating Channel Duo Path (ACDP) technique used in the MCMP scheme is explained first.

A. ACDP Technique

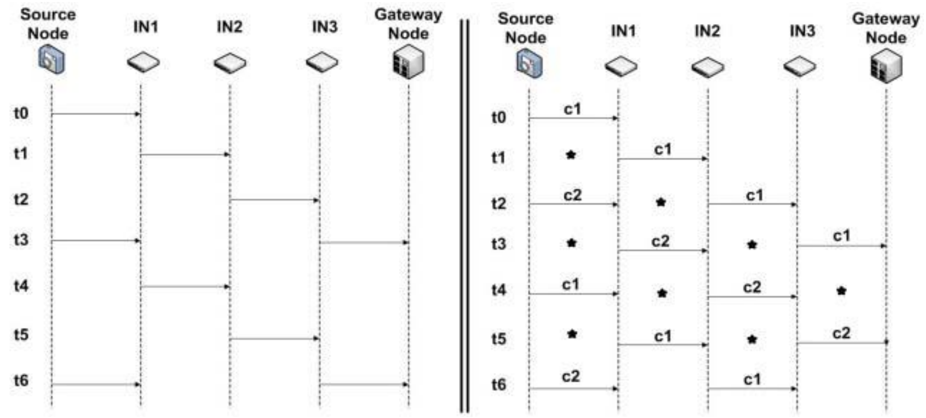

Figure 1. (a) Single channel transmission. (b) Transmission using alternating channels.

In the existing single channel transmission system the sequence of events that taking place are listed below. Here the nodes are assumed to be half-duplex. Spectral efficiency of traditional single path transmission is low mainly because of overhearing caused by neighbouring nodes. As shown in Figure 1(a), at timeslot "*t*1", the source node cannot send the next packet to intermediate node-1 (IN1) because it is busy in transmitting the first packet to intermediate node-2 (IN2). Here the nodes are assumed to be half-duplex. Similarly, at Timeslot "*t*2", the source node still cannot transmit Packet 2 because the transmission from IN2 to IN3 is being overheard by IN1. Therefore, the source node has to wait for three timeslots before transmitting the next packet.

The existing Single channel system uses AODV protocol as a routing protocol. AODV is mainly a reactive protocol where path is established on demand. It works on control messages such as Route Request (RREQ) and Route Reply (RREP). It takes sequence number as a parameter along with other parameters like scr add, dest add, hop count and broadcast id. Source node broadcasts RREQ in a network Each neighbor either satisfy the RREQ, by sending back a routing reply (RREP), or rebroadcast the RREQ to its own neighbors after increasing the hop_count by one.

On the other hand, if two channels (c1 and c2) are scheduled in such a way that the nodes tune their radios in every node can transmit the packet at the third timeslot as shown in Figure 1(b). Moreover, in order to further increase the packet transmission rate, the intermediate vacant timeslots (marked as *****) need to be utilized. This is achieved by utilizing another pair of channels (c3 and c4) to transmit the packets in the same manner through a secondary path towards the destination. By using the ACDP technique, the data can be transmitted at every available timeslot towards the next hop, allowing maximum throughput.

In the proposed alternating channel method sequence of events that taking place are listed below. Here nodes are assumed to be half duplex and data transmission takes place through two channels channel 1 indicated as c1 and channel 2 as c2 in figure 1(b). Two channels (c1 and c2) are scheduled in such a way that the nodes transmit packets in an alternative way. The intermediate vacant timeslots (marked as *) are utilized as channel 3 in order to further increase the packet transmission rate. Using the ACDP technique, the data can be transmitted at every available timeslot towards the next hop, allowing maximum throughput.

B. SELECTION OF TWO BEST PATHS

After the network deployment, the path search algorithm is run. The AODV which is routing algorithm is configured to work as a path search algorithm. Instead of taking a sequence number as a parameter it takes hop count and remaining energy of nodes as a parameters.

1) The AODV is a reactive algorithm. It creates routes on-demand and reduce as much as possible the acquisition time .It uses symmetric links between neighbouring nodes. It does not attempt to follow paths between nodes when one of the nodes cannot hear the other one. Nodes that have not participate yet in any packet exchange (inactive nodes), they do not maintain routing information. They do not participate in any periodic routing table exchanges.
2) The source camera broadcasts the GSM (Gateway Search Message) which is a RREQ to all neighbouring nodes. These messages pass through all the nodes in network carrying QoS information of each node such as hop count and remaining energy.
3) Gateway node selects two best paths based on the QoS information. Path which has least hop count and maximum remaining energy are selected as two best paths and is acknowledged to source node by sending BPM (best Path Message) acts as a RREP along the two paths
4) The source camera starts transmitting frames along the two best paths.

C. FAILURE RECOVERY AND NETWORK MAINTENANCE

During transmission of data, if one of the links goes down, the gateway instructs the source camera to transmit data through the recovery path. The recovery path is selected dynamically. As soon as a link goes down internally the AODV protocol path search algorithm is run. RREQ and RREP Signals or messages are exchanged among source and gateway node based on which it selects the recovery path. The interrupted transmission is resumed by transmitting the frames on the recovery path.

D. ADVANTAGES OF PROPOSED SYSTEM

1) The proposed scheme uses Multiple QoS metrics while making a decision of transmitting video over WSN.
2) The header of each video frame is appended with a frame number and source camera ID for identification purposes.
3) Every node can frequently switch between the assigned orthogonal channels in the round robin fashion in order to transmit the packets as per the ACDP technique.

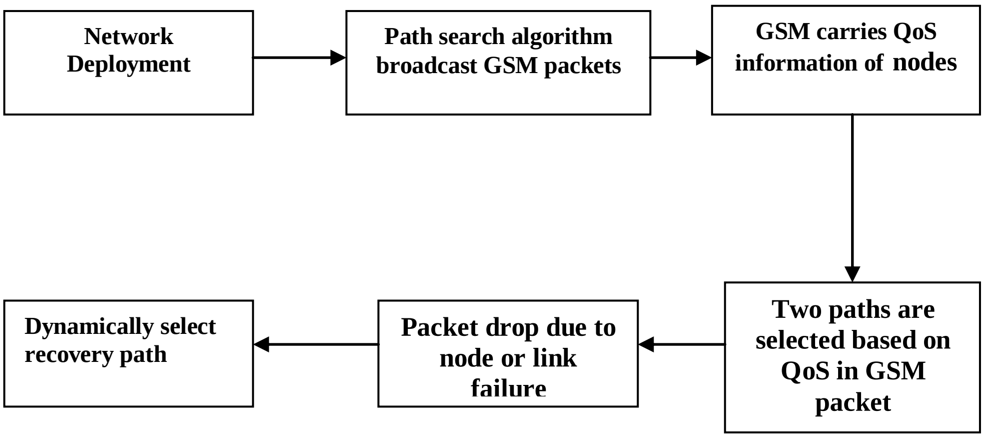

Figure 2: Block Diagram of a System

IV. PERFORMANCE EVALUATION AND DESIGN

A) Simulation Model

We run the simulation in Network Simulator (NS-2) accepts as input a *scenario file* that describes the exact motion of each node and the exact packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. The detailed trace file created by each run is stored to disk, and analysed using a variety of scripts, particularly one called *file *.tr* that counts the number of packets successfully delivered and the length of the paths taken by the packets, as well as additional information about the internal functioning of each scripts executed. This data is further analysed with AWK file and Microsoft Excel to produce the graphs.

The simulation models are built using the Network Simulator tool (NS-2) version 2.35.The experiments use a fixed number of packet sizes (512-bytes). The mobility model used is a radio propagation model. Simulations are run for 500 simulated seconds. Identical mobility and traffic scenarios are used across protocols to gather fair results.

B) Performance Metrics

The project focuses on 3 performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running in NS- 2 simulation. The performance metrics are:

1. Average end-to-end delay of data packets — there are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. The thesis use Average end-to- end delay. Average end-to-end delay is an average end-to-end delay of data packets. It also caused by queuing for transmission at the node and buffering data for detouring. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

$$Avg\_End-to-End\_Delay = \frac{\sum_{1}^{n}(CBRsentTime - CBRrecvTime)}{\sum_{1}^{n} CBRrec} \text{.....Equation2}$$

2. Throughput -The ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput. It is expressed in bits per second or packets per second. Factors that affect throughput include frequent topology changes, unreliable communication, limited bandwidth and limited energy. A high throughput network is desirable.

3. Energy consumption - Usually, energy consumption can be divided into three domains: sensing, communication, and data processing. Of the three domains, a sensor node expends maximum energy in data communication. This involves both data transmission and reception and transmission and reception energy costs are nearly the same.

C. Simulation Result

The simulations were performed using Network Simulator (Ns-2), which is popularly used for ad hoc networking community. The simulation is done in the Ns-2.34 simulator installed on Linux Operating System. One part of the ns-allinone package is 'xgraph', a plotting program which can be used to create graphic representations of simulation results.

The AODV implementation is used in ns2 downloaded from web site, using IEEE 802.11 as the MAC layer protocol. The radio propagation model is the two ray ground model. The application traffic is CBR (Constant Bit Rate). The source destination pairs (connections) are chosen randomly. The parameters considered for performance analysis are:

1. End to End Delay
2. Energy Utilization
3. Throughput

a) End to End Delay

The average end to end delay of data packets includes all possible delays caused by buffering during routing discovery, queuing at the interface queue, propagation, and transfer time.

Here no of nodes are taken along X-axis and delay along Y-axis. By increasing the no of nodes we can see that delay also increases in both existing and proposed system. The existing single channel delay is indicated by red line and proposed multi channel delay by green line in a graph.

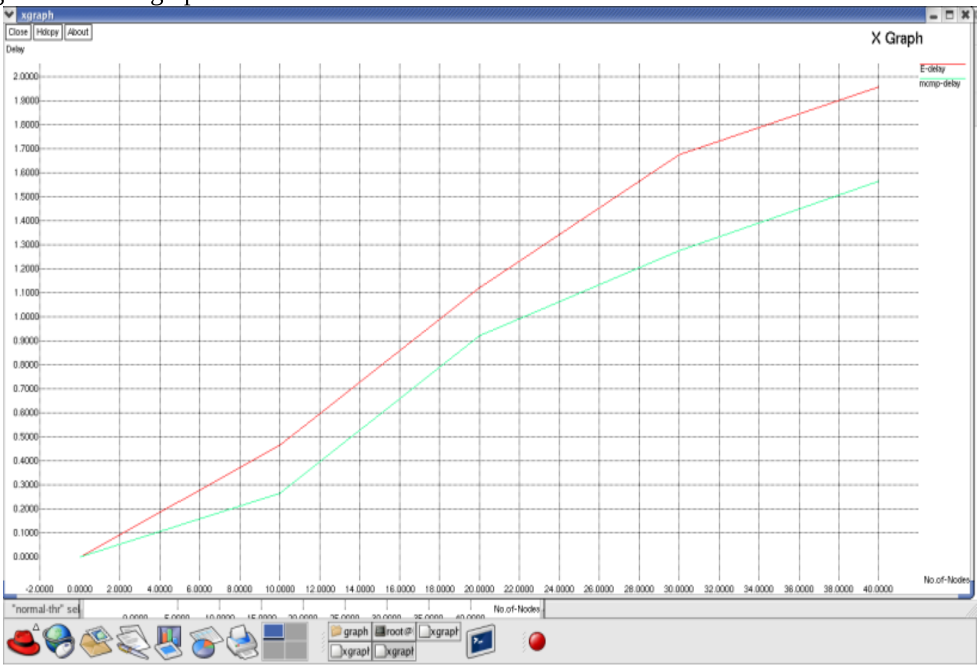

Figure 3 :Plot for End to End Delay

As it can be seen from the above result, end to end delay is higher in the existing single channel multi path video transmission compared to proposed MCMP Scheme. Existing system uses only single channel to transmit the video frames, so the delay is more. The proposed method uses two channels to transmit the same video frames, from which delay can be reduced.

The no of nodes are varied from 0 to 40. There is a change in delay after 10, 20 and 30 nodes in both the systems. The existing system has a delay of 0.45 msec for 10 nodes. While the proposed system has 0. 25msec, which is comparatively half of existing system. This reduction in delay in multi channel system is due to use of alternating channels.

b) Energy consumption

The amount of energy used by a node to transmit a data is called energy consumption.

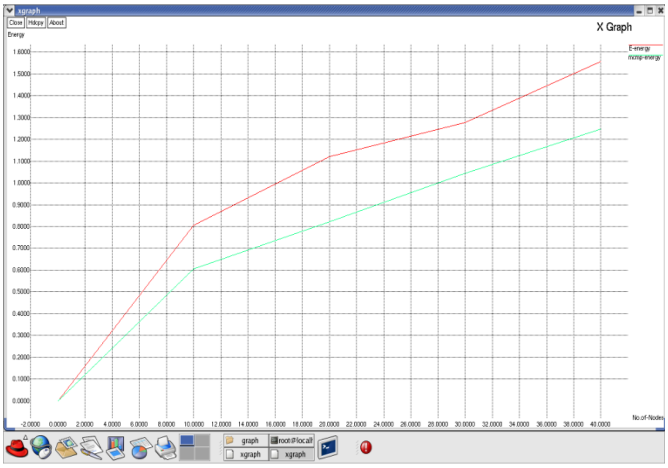

Fig 4: Plot for Energy Consumption

Here no of nodes are taken along X-axis and energy consumption along Y-axis. As we can clearly observe from the graph, energy consumption in MCMP is less when compared to existing system. The existing single channel energy consumption is indicated by red color line and proposed multi channel energy utilization by green line in a graph.

c) Throughput

The amount of data transferred from one place to another or processed in a specified amount of time. Data transfer rates for disk drives and networks are measured in terms of throughput. Typically, throughputs are measured in kbps, Mbps and Gbps.

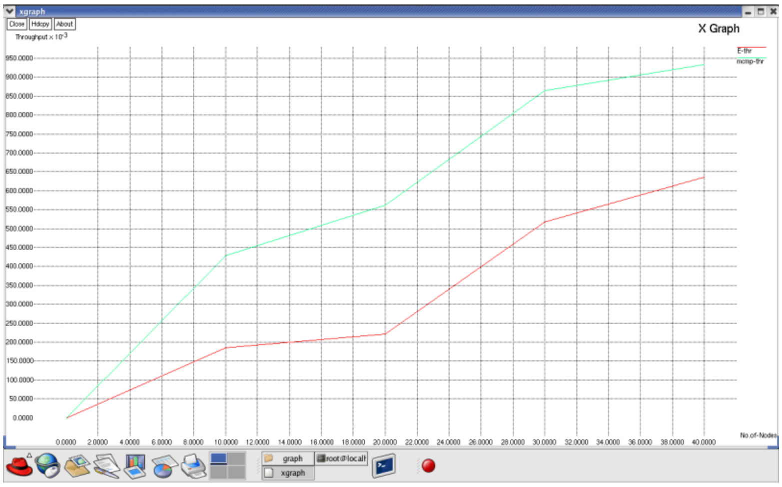

Fig 5: Plot for Throughput

V. CONCLUSION AND FUTURE WORK

The implemented MCMP scheme uses the H.264 encoder and decoder protocol, where video can be effectively transmitted through the sensor network by considering multiple QoS parameters. Here it splits the video in to prioritized and non prioritized data like" I" frames and" BP" frames respectively. A failover scenario has also been incorporated into this scheme. The third path selected in Stage-1 is termed as a recovery path, which takes over a failed path during transmission. This implemented scheme makes use of multiple paths and Quality of Service (QoS) metrics like throughput and delay in performance analysis.

In future it can be used to transmit real time data rather than stored data, considering more no of QoS metrics.

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