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Q-BACK-PRESSURE ALGORITHM IN VISUAL SENSOR NETWORKS TO ACHIEVE ENERGY EFFICIENCY THROUGH DELAY REDUCTION

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ABSTRACT

Visual Sensor Networks (VSNs) have emerged its technology in the wireless networking. Because of these advantages over other wireless networks, VSNs are undergoing rapid progress and inspiring numerous applications. Frequent congestion or routing loop is an important issue in Visual Sensor Networks. This is caused due to the node partitioning in the Visual Sensor Networks. This leads to routing problem in the Visual Sensor Network. Adaptive Routing Algorithm is the major cause of this problem. Due to these the VSNs becomes less energy efficient and the throughput gets reduced. To overcome the above drawbacks, Q-Backpressure algorithm is implemented in VSNs. Q-Backpressure algorithm maintains a queue and thus it eliminates the self failure in the link by maintaining the deterministic route. However, to achieve energy efficiency, Autonomous Recovery Scheme (ARS) is implemented. ARS helps in recovering from path failure. The reconfiguration planning technique in ARS identifies local configuration changes for the recovery of path failure.

Keywords: Q-Backpressure algorithm, self failure, path failure, energy efficiency

1. INTRODUCTION

Visual Sensor Networks inherit its characteristics from both Wireless Sensor Networks and more general ad hoc networks. It is an emerging technology which finds application to support many applications in different areas, such as: environmental and habitat monitoring, medical monitoring, industrial monitoring and control, building automation and military applications. A Visual Sensor Networks (VSN) is a network of smart camera devices capable of processing the images of a scene from a variety of viewpoints into some form which is more useful than their real images. The nodes in VSN are inherently resource constrained, since they have limited processing capabilities, storage, communication speeds, and bandwidth. Since, nodes in the VSN have limited power supply, energy efficiency in Visual Sensor Networks is a key area for research and they play a vital role in the performance of the application of Visual Sensor Network.

This area of research Energy Efficiency in VSN includes the different approaches such as: Multi-tier approach, Duty cycles, and Energy Efficient Routing protocols for Routing, Mobile Sinks to track multiple targets in VSN as solutions for the above conflict [1]. The need arises for efficient Routing Protocols which provide an effective trade-off between the QoS and energy efficiency.

In this paper, we present the Q-Backpressure algorithm and the Autonomous Recovery Scheme in VSN to implement Energy Efficiency. In Section 2 we focus the Routing and QoS issues in the VSN, in Section 3, Q-backpressure algorithm is discussed, while in Section 4 ARS Routing is discussed, Section 5 describes the implementation of the System and Section 6 the conclusion is presented.

2. ROUTING AND QOS ISSUES IN VSN

Route Optimisation and QoS in ad-hoc networks is still a complicated topic due to the miniaturization and the battery powered nature of the peer nodes, which join and leave the VSN at anytime. Self organization and auto-configuration are also the important features of VSN.

Figure-1 shows Wireless Visual Sensor Node Architecture by Theodore Zahariadis *et al*. [2]

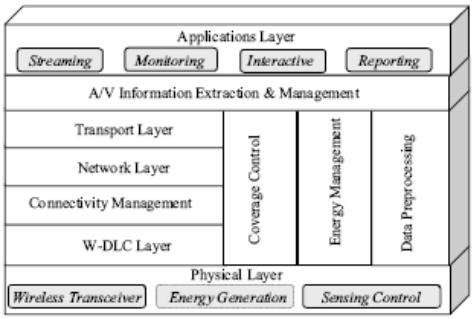

Figure-1. Wireless visual sensor node architecture.

The reference architecture perceives a sensor node as a set of functional requirements. The architecture includes the horizontal and vertical functional layers. Following a bottom up approach, the architecture include the Physical layer, the Communication Protocol Stack comprising the W-DLC Layer, Connectivity Management, Network Layer, Transport Layer, the A/V information extraction and Management Layer, and the Application Layer. The vertical layer includes the Coverage Control, Energy Management and the Data Preprocessing layer [2].

Potential routing protocols that are applied to WVSN are DSR, SSA, AODV, OLSR, LANMAR and ZRP [3].

Theodore Zahariadis *et al.* [2] have generalized that the potential ad-hoc routing algorithms may be organized in three main categories and they are Proactive Routing Algorithm, Reactive Routing Algorithm and the Hybrid Routing Algorithm. He has also listed the Routing Algorithm Evaluation Parameters as the Delivery Ratio, Mean Packet Delay, Routing Overhead, and the Routing Delay.

Theodore Zahariadis *et al.* [3] have specified the QoS requirements are of two groups such as the AV related set of QoS requirements and the networking group of QoS requirements. The former is related to the probability that an event is detected and or reported and the confidence level and the accuracy about the captured and retrieved data and the latter is related to the wireless networking characteristics and the streaming capability of the WVSN. He has also summarized the networking QoS characteristics by the following parameters such as the Response Time, Reaction latency, and Deployment Lifetime. Response time composed of the transmission latency, the forwarding latency, and the processing latency. Reaction latency is the latency from the time an event is detected to the time the relevant data are available to the end-user of the application. Deployment lifetime in VSN includes the summary of the energy to perform the following tasks such as Communication, to schedule, forward, store or retrieve information, Routing maintenance, to maintain the routing topology graph among nodes, Connectivity maintenance, to maintain a connected network topology, Time/ Location, to achieve time synchronization and location awareness per node and Computation, for in-network data processing.

3. Q-BACKPRESSURE ALGORITHM

Visual Sensor Network experience frequent congestion or routing loop due to the node partitioning in the network. These problem lead to severe performance degradation in VSN or require expensive manual network management for their recovery. Adaptive routing algorithm is the major cause of these problems. Adaptive routing algorithm is a type of dynamic routing. This algorithm dynamically changes route as the function of the current state of network. Dynamic Source Routing is one of the examples of Adaptive routing algorithm. During the transmission in the VSN, each node exchange more information with its neighboring node. Even though this exchange of information improves the routing decision and it introduces traffic and any of the node may get partitioned in the network. Due to this partitioning various routing problem occurs. Finally this leads to the routing loop. Thus it affects the topology of the entire network and it also increases the overhead in the network and degrades the performance of the network.

The disadvantages of DSR in VSN are as follows:

- Due to node partitioning it leads to routing loop.
- It is difficult to maintain a deterministic route.
- It also leads to link failure.
- The transmission is blocked and it leads to delay in routing the packet.
- Finally the throughout is reduced, the performance and efficiency is degraded.

4. AUTONOMOUS RECOVERY SCHEME

In addition to the Q-Backpressure Algorithm, Autonomous Recovery Scheme (ARS) is proposed in VSN to help in recovering from path failure [4]. ARS allows the VSN to autonomously reconfigure its local network settings such as channel and route assignment for real-time recovery from path failures. ARS is equipped with a reconfiguration planning technique that identifies local configuration changes for the recovery while minimizing changes for healthy network settings. ARS also includes a monitoring protocol that enables a VSN to perform real-time failure recovery in conjunction with the planning technique [5]. The accurate link-quality information from the monitoring protocol is used to identify network changes that avoid propagation of QoS failures to neighboring links. The monitoring protocol periodically sends its local channel usage and quality information for all outgoing links through the control gateway. Then the control gateway generates reconfiguration plan to recover from link failure. Finally the packet is transmitted in an energy efficient manner.

A. Advantage of Q-Backpressure algorithm and ARS

- Q-Backpressure algorithm maintains a queue which helps in maintaining a deterministic route.
- ARS improves the overall channel efficiency.
- It also helps in maintaining the network connectivity.
- Finally the performance is improved and energy efficiency is achieved.

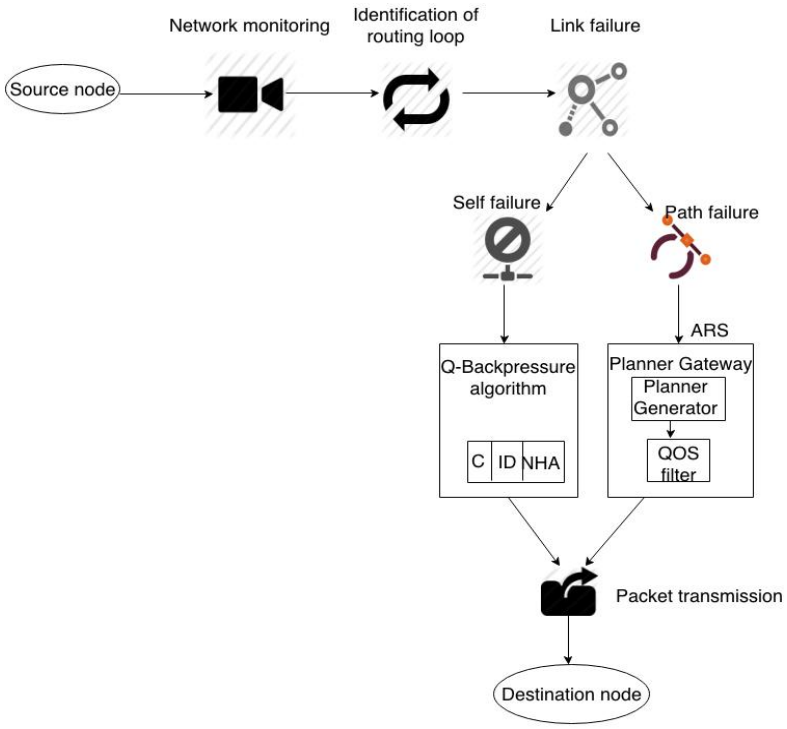

Figure-2. The overall system model.

5. SYSTEM IMPLEMENTATION

A. Creation of visual Sensor nodes

When a new node enters into a sensor network the node itself registers within the network. This helps the node for easy communication within the network. Each node consists of the cameras that are dynamic in nature. It captures the behaviour of each node in the network and is used for some local image processing communication in which the image data from multiple cameras is further processed and fused. The network consist of the source nodes and the destination nodes. The node details include IP address, connection status and time of node creation. The connection status often gets changed according to the bandwidth and the delay in the network.

B. Identification of routing loop in VSN

The camera in each node is used to sense the transmission in VSN. In a dynamic Visual Sensor Network any node may get partition or leave the network. The main reason of partitioning is due to heavy traffic, speed range exceeded, bandwidth demand. Due to this partitioning, routing problem occurs. This leads to routing loop. In [4] routing loop is defined as when a packet is forwarded from source node to some other node in the network, it eventually returns to that source node itself. It is an important pathology which must be prevented. This is the major cause of the congestion which leads to two types of link failures. They are self failure and path failure [5]. In self failure, the node itself has failed due to a crash, re-boot, bug in software code, or connectivity issue. In path failure, a node along the path fails, causing other nodes to fail or there are collisions along the path. It ultimately results in packet loss and increases the overhead and delay in the network.

a. Recovering from self failure using Q-Backpressure algorithm

Q-Backpressure algorithm is used to recover from self failure which occurs due to congestion. Initially it identifies the node where self failure occurs. It maintains a queue which helps in maintaining a deterministic route[6]. Queue contains three fields. They are counter, packet id, and next hop address. The counter gets incremented or decremented upon the arrival or departure of the packet. Packet id is the respective id of the current packet. Next hop address contain the address to route the packet to the next node. Due to routing loop, if the packet eventually comes to the same node it can be easily identified with the help of packet id maintained in the queue. As a remedy, with the help of the counter and next hop address the packet are routed in a sequential order to the destination node. This prevents congestion and avoids the occurrence of self failure. Finally the delay in transmission is reduced and throughput is increased.

C. Recovering from path failure using ARS

During the transmission of the packet, path failure may occur. The path failure is detected and

recovered using Autonomous Recovery Scheme (ARS) [5]. It is used to generate reconfiguration plan technique in the failure path. A reconfiguration plan is defined as a set of links configuration changes necessary for a network to recover from a path failure. One of the node among the path failure acts as a gateway. ARS detects the necessary changes in the local path so that the path failure can be avoided. Also ARS maintains the existing connectivity of the network.

However, the further challenges of ARS are as follows:

- Avoiding a faulty channel.
- Maintaining network connectivity and utilization.
- Avoiding cascaded link failures.

ARS is implemented in four steps

- Calculating monitoring period using monitoring protocol.
- Detection of failure and measurement of group formation period.
- Measurement of planning period.
- Reconfiguration port.

In calculating monitoring period using monitoring protocol, the ARS in every node monitors the quality of its outgoing wireless links using monitoring protocol and reports the results to a gateway through management message.

In the detection of failure and measurement of group formation period, once the ARS detects path failure, ARS in the detector nodes trigger the formation of a group among the VSN that use a faulty channel. After the group formation one of the group members is elected as a leader using election algorithm for coordinating the reconfiguration.

In measurement of planning period, after the selection of the leader, if the leader node is node other than gateway then it sends a planning-request message to a gateway. Otherwise if the leader is a gateway then the gateway synchronizes the planning requests and generates a reconfiguration plan for the request.

In reconfiguration port, the gateway sends a reconfiguration plan to the leader node and the group members. Finally, all nodes in the group execute the corresponding configuration changes, if any, and resolve the group [5]. Finally ARS makes the packet transmission in efficient manner. So the performance is improved and energy is conserved since the path failurs are detected and eradicated improving the energy efficiency of the network.

D. Performance evaluation of Q-Backpressure algorithm ARS and Adaptive routing

Figure-3 shows that in adaptive routing algorithm due to path failure there is a delay in transmission. So that packet delivery ratio is not increased and performance is not improved. But ARS recovers from path failure by generating reconfiguration plan technique in the failure path. This increases the packet delivery ratio and improves the performance. Finally the energy efficiency is achieved due to the remedy for the path failure.

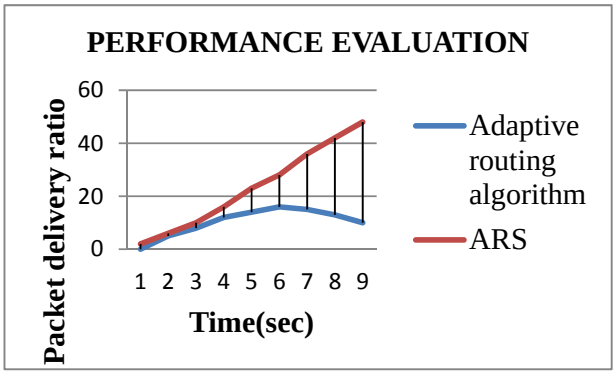

Figure-3. Comparison of performance.

Figure-4 shows when Q- backpressure algorithm is implemented in VSN the throughput is increased. This is because a queue is maintained which helps in maintaining a deterministic route and congestion and self failure is reduced. So the transmission is performed efficiently and in a faster manner. Figure-5 shows that finally energy efficiency is achieved and reduces the energy consumption.

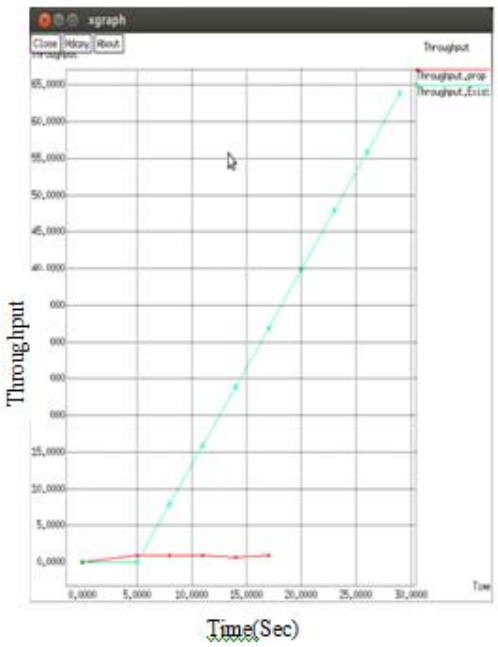

Figure-4. Performance analysis on throughput.

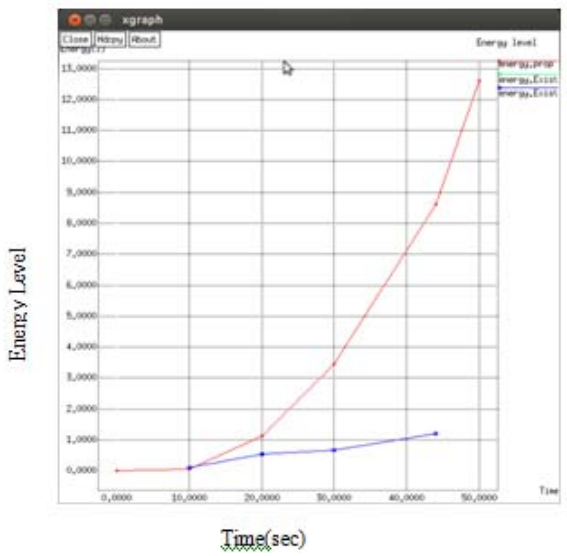

Figure-5. Simulation result for achieving energy efficiency in VSN.

6. CONCLUSIONS

The proposed system introduces the Q-backpressure algorithm which maintains a deterministic route to prevent self failure in the network. It also has queue which has three fields. This algorithm mainly helps in routing the in packet transmission in an efficient manner. Hence the delay in routing the packet is reduced and the throughput is increased. Next, ARS is implemented. It helps in recovering from path failure. ARS is equipped with a reconfiguration planning technique that identifies local configuration changes for the recovery of path failure. Finally the throughput is increased and energy efficiency is achieved in Visual Sensor networks.

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