CHAPTER 5

ACTOR NODES FOR ENERGY EFFICIENCY IN VISUAL SENSOR NETWORKS

5.1 INTRODUCTION

WSN continue to gain tremendous popularity due to the increasing number of applications through these networks. This work focuses on ways to maximize the network lifetime of Visual Sensor Networks (VSN) and improve the energy efficiency through the actor node in VSN. The higher demand for the network’s resources is due to QoS requirements. VSNs have unique camera sensing capabilities. In VSN, the real-time images and video streams are routed through over multiple routing algorithms. In this chapter, the implementation of actor nodes in VSN is proposed to provide energy efficiency as well as Quality of Service through the Carry-Disseminate-Store–and–Forward algorithm of the EMD (Energy-Efficient Message Dissemination) protocol. The EMD protocol implemented from WSN and WSAN is also extended to VSN to achieve energy efficiency. Visual Sensor Networks (VSN) can be defined as a special type of multi-hop ad-hoc networks (MANETs) since they show a number of common characteristics.

Visual sensor networks do not use fixed infrastructure since the participating nodes in these networks are typically considered as battery-operated, and they have only a limited amount of energy. Visual sensor networks are wireless networks. Multi-hop routing is one of the preferred routing methods in WSN’s due to its energy efficiency. However, multi-hop routing may result in increased delays, due to queuing and data processing at
intermediate nodes. Thus, the total delay from the data source to the sink increases with the number of hops on the routing path.

The research direction in visual sensor networks is interdisciplinary and the research directives are numerous and diverse. Visual sensor networks inherit the characteristics from both wireless sensor networks and ad hoc networks. Due to the unique features of image sensors, the increased needs for the network resources and more strict QoS are requirements, not all protocols developed for traditional sensor networks can be used directly in visual sensor networks. Visual sensor networks provide users with large amount of information, which makes them extremely resource demanding. The right sensor management policy, in terms of sensor selection and scheduling, is essential in order to provide persistent monitoring. In many applications of visual sensor networks, the goal is to fully cover the entire monitored 3D space with the cameras. Network layer is responsible for routing and routing should be energy efficient and stable. Routing in VSN should also support various QoS requirements.

Energy consumption is important for most applications such as the self-configuring visual sensor networks since they are envisioned to last for months or even years. The replacement of the batteries for a large number of sensor nodes is often not an option, so in order to last longer, sensor networks must have a low-power profile, achieved through the coherent design of both hardware and the networking stack, providing a tradeoff between energy consumption, functional fidelity and lifetime of sensor network. There are several factors that affect the energy consumption of sensor nodes.

The predominant applications of visual sensor networks include military applications and security. Visual sensor networks and wireless sensor networks have been used for military purposes for a long time. Wireless sensors can be deployed easily to collect various data from battlefield, and to
collect data about the enemy. Camera-based networks have been used for security applications such as security monitoring and surveillance for a long time. VSN differs from WSN in terms of the amount of energy consumed, and the volume of information extracted by visual sensors.

Since visual sensor networks are used for monitoring both the remote and inaccessible areas over a long period of time, it is important that the operation should be energy efficient. They should prolong monitoring over a long period of time. In order to achieve energy efficiency in VSN, actor nodes and EMD protocol implemented in WSN are extended to VSN.

Section 5.2 deals with the advantages of actor node and the extension of actor node from WSN to VSN to implement VSAN (Visual Sensor Actor Network). Section 5.3 deals with the advantages of EMD protocol extended from WSN to VSN to achieve energy efficiency. Section 5.4 deals with the simulation results and Section 5.5 concludes with the summary.

5.2 ACTOR NODE

![Figure 5.1 Components of actor node](image)

Figure 5.1 Components of actor node
Figure 5.1 depicts the components of the actor node. Shibo He et al. (2013) have presented that actors possess rich resource nodes ready with improved processing potential, high transmission powers and a long battery life. In particular, the sensor-actor coordination provides the transmission of event features from the sensors to actors. The actors have to manage with each other in order to make decision on the most suitable way to perform the action after getting the event information.

The important characteristic of communication between the sensor and the actor communication is to provide less communication delay due to the nearness of sensors and actors. The main problems of the sensor-actor coordination are: 1) communication and 2) communication realization.

Therefore, new protocols must be developed for wireless SANs with the following objectives such as to endow with real-time services with agreed delay limits according to the application constraints. They also should make sure energy efficient communication between the sensors and actors, ensure ordering between different events when they are reported to the actors, and provide synchronization among different sensors reporting the same event. The new protocols developed should track and report the sensed phenomena to a different set of actors that are not necessarily based on proximity or energy limitations for the case when the events take place in different locations. Actor nodes are yet another approach through which the energy efficiency can be achieved.

Wireless SANs actors communicate with each other in addition to communicating with sensors. Actor to actor communication occurs in the following situations: (1). The actor that receives the sensor data may not operate on the incident area owing to the operation range or inadequate energy. (2). One actor is not sufficient to operate the required action and thus the additional nearby actors should be triggered. (3). If many actors obtain the
similar event information and there is a threshold for the action, these actors “talk” to every added node in order to make a decision which one of them should execute the action.

In certain applications, if multiple actors are needed to cover the entire event region, it may be necessary to ensure that these entire regions are non-overlapping in the network or mutually exclusive in order to ensure uniform acting behavior over the entire region. If the present multiple actors receive information from multiple sensors for the same event, then it is necessary to ensure that the multiple actors act on the environment at the same time. Ian F. Akyildiz et al. (2004) have presented that this synchronization requirement between actors and sensors in the execution of the task is required in applications where partial execution of the events or task alters the state of the event in the region where it has not been executed. In case of simultaneously occurring multiple events, task assignment can be done via actor to actor communication. Also, it may be desired that the events or tasks are executed sequentially. This constraint is referred as ordered execution of tasks (Ian F. Akyildiz et al.2004). The actor node receives the event information and if the event is diffusing to the other actor’s acting areas, the present actor node transmits the data or action command to those actors node. In this way, there will be no need for sensor node in those areas to send information to the nearby actors as they forward by initial set of actors (Ian F. Akyildiz et al. 2004).

Abdulla et al. (2012) have presented that actor–actor coordination should be handled with insight into the sensor-actor coordination problem. C. Bettstetter et al. (2005) have presented that the routing problems should also be investigated between the sensor node and actor nodes. However, no coordination problems in sensor-actor node or in actor–actor communications are considered in the study.
Shibo He et al. (2013) have presented that while travelling in $\Omega$, an actor may spontaneously have a message. That message may be a piece of critical information collected from sensors, to share with the other actors. The message has a delay bound, $T$, which implies that it remains effective only within the next $T$ time slots. An actor is referred to as an original source actor (SA). For simplicity, it is assumed that there is only one original SA in the network and denote the original SA’s message by $M$. The actors that have not received $M$ are called target actors (TAs). A TA becomes an SA (to differentiate from original SA, refer to as common SA when needed) as soon as it receives $M$. The goal of this work is to design an energy efficient message dissemination protocol in VSN.

5.3 ENERGY EFFICIENT MESSAGE DISSEMINATE PROTOCOL

In EMD, message routing takes place at the beginning of each time slot when common SAs request the original SA for a dissemination strategy (upward routing) for the current time slot, and the original SA transmits the strategy to common SAs (downward routing). As the connection is not maintained among actors, a scheme is designed to enable upward routing and downward routing, which is based on the routing protocol OLSR. Burns et al. (2005) have presented that OLSR is designed to update a common mobile destination’s location to all the sensors in the network and dynamically maintain a routing path from each sensor to the destination, and is proven to guarantee delivery. Though multi-hop routing is the preferred routing method in WSN’s due to its energy-efficiency, they may result in increased delays, due to queuing and data processing at intermediate sensor nodes. Thus, the total delay from the data source (camera node) to the sink node increases with the number of hops on the routing path.
When a source actor travels in a sub region, it transmits its message to sensors in a local area. Sensors receiving the message store it in memory and forward it to other actors when they come into contact. An actor becomes a source actor once it receives the message (Akyildiz et al. 2005). Different sub regions have different probabilities of being visited by actors. Source actors disseminate data to sensors in the sub regions with high probabilities of being visited by destination actors such that a pre-set dissemination coverage rate (the percentage of actors obtaining the message) is met, a given delay bound is satisfied, and the total communication cost is minimized. The “Carry-Disseminate-Store-and-Forward” principle is intrinsically different from the concept of “Store Carry and Forward method” in opportunistic networks, which exploits the meeting probabilities of nodes and forwards data to the nodes with high probability of meeting the destination.

The “Carry-Disseminate-Store-and-Forward” and the “Store-Carry-and-Forward” are the two algorithms implemented in the EMD protocol. Through extensive simulations, it is found that EMD has good performances in terms of energy efficiency and time delay using the “Carry-Disseminate-Store-and-Forward”. Actors can seldom communicate with other actors directly, and the approach of building an overlay at the application layer does not work. “Carry-Disseminate-Store-and-Forward” is totally different from Store-Carry-and-Forward approach in opportunistic networks because “Carry-Disseminate-Store-and-Forward” focuses on how to disseminate data to sensors upon contact to ensure energy-efficient data dissemination among actors within a delay bound.

The drawback of “Store-Carry-and-Forward” process in WSN is used to send data from one region to the other region with more energy consumption. In this method, the node information is stored in local repository, and when it moves from one region to another that node
information will be deleted. It leads to delay and energy loss. J.Chen et al. (2010, 2011, 2012) have presented that delay leads to degradation in the network performance.

The problem of the delay in “Store-Carry-and-Forward” is overcome with the Carry Disseminate Store and Forward Algorithm implemented in VSN. EMD Protocol implemented in the method of “Carry-Disseminate-Store-and-Forward” achieves both energy efficiency and provides better Quality of Service to satisfy the real-time application requirements in wireless network such as VSN for a longer period of time.

5.3.1 Store and Forward

Frey et al. (2009) have presented that in store and forward method, after reading an input port of a packet, the router saves the packet in a row. At the same time, according to the head of the queue it also sends a packet from the router to the appropriate output port. This technique is relatively easy to implement, but the packet in a network has to wait to be stored in the internal packet at each hop time. A dead lock situation may occur in this technique due to the delay of transferring data. Every packet is routed individually so the sending time will be elapsed. The entire packet is copied from the input buffer to the output buffer. They have presented that the input buffer is completely buffered and the routing decisions are only made after each intermediate router. This leads to the poor performance in the dissemination of data.

Considering the above constraints, to enhance the performance of VSN, in this work, actors are introduced along with the efficient message disseminate protocol using algorithm named Carry -Disseminate-Store-and-Forward method. Thus, VSN is used to transfer data and image with limited energy and delay tolerant with quality of service using the above techniques,
protocols and methods. The quality of service is achieved in visual sensor networks using the EMD protocol because it is mainly used to send real-time audio and image and it is used to support real-time application. The main criteria affecting network performance ratio is delay, and the delay is minimised using the EMD protocols.

5.3.1.1 Carry Disseminate Store and forward algorithm

The Carry Disseminate Store and Forward algorithm divides the region into more number of sub regions. When the actor moves from one region to the other region, it disseminates the message to the other region. Gerkey et al. (2002) have presented that actor to actor node co-ordination requires only less time compared with the sensor to sensor communication. The main advantage is that it maintains the energy level because it stores each node information to the primary storage memory when it comes into contact. If the same node comes for another transmitting process, it just refers only to the storage memory so that the energy will be saved. 100 sensors working process is equal to 1 actor. Sensor sensing range is less when compared with the actor. Actor sensing range is 300m/s.

Figure 5.2 depicts the flow chart for the actor nodes in VSN.
Figure 5.2 Provides the flow-chart for the actor nodes in VSN
The algorithm for the actor nodes in VSN is as follows:

For each actor camera node ACN ∈ ACNs do
ACNs is the subregion of the Actor Camera Node

Begin

Broadcast message $M_{ACN} = \{ID_{ACN}, ID_{ACNs}\}$

// The actor camera send broadcast message for long range transmission.

$ID_{ACN}$ is the Id of the actor camera node, $ID_{ACNs}$ is Id of the sub region’s actor camera node.

End

For each camera actor node $s ∈ S$ that a received a message $M_{ACN}$ from actor node ACN

Do

Mark itself as an actor camera node

Set $D= \{(all,Null,∞)|\{ ID_{ACNs},Null, 0\}\}$

//D is the distance vector from source to actor

End For

For each actor camera node ACN ∈ ACNs do

Broadcast the message $M_{ACN} = \{ID_{ACN}, ID_{ACNs},0\}$ // The actor node send broadcast message for small range transmission. 0 represents the hop count of actor to actor set.

End For
Update flag=false

For camera actor nodes receiving a message $M_j$ Do

   For $j=0$, $j\leq M_j$.Length, $j++$
      
      $h_1=$GetheopcountfmID$_{ACN}(M_j, j)$
      
      // Determine hopcount between actor camera and $j^{th}$ node message
      
      $h_2=$GetheopcountfmID$_{ANS}(M_j, j)$
      
      // Determine hopcount between sub region actor nodes and $j^{th}$ node message
      
      ID$_{ACN}=$GettheActorfm($M_j, j$)
      
      // Determine the Id of the actor from $j^{th}$ node message
      
      ID$_{ANS}=$GetActorfm($M_j, j$)
      
      // Determine the Id of the actor set from $j^{th}$ node message

      If Getheopcount($RT_s$, ID$_{AS}$) > $h_1+1$
         
         set $v=$\{ID$_{ACN}$, GetId($M_j$), $h_1 +1$\} | ()
         
         update $RT_s$ with $v$ //$RT_s$ is routing table of sensor node.
         
         update flag=true
      
      End If

      If Getheopcount($RT_s$, ID$_{AS}$) > $h_2 +1$
         
         set $v=$\{() | ID$_{ACN}$, GetId($M_j$), $h_2 +1$\} 
         
         update $RT_s$ with $v$ //$RT_s$ is routing table of sensor node.
         
         update flag=true
End If

End For

End For

If update flag=true

Sensor node broadcast a packet

End if

5.4 SIMULATION RESULTS

Actor nodes along with EMD protocol is implemented in VSN with the same parameters implemented as in Q-back pressure algorithm and autonomous recovery scheme, G-AODV and AODV in VSN respectively. The performance of VSAN with EMD protocol in VSN is measured in terms of the energy, throughput and packet loss.

Figure 5.3 shows the comparison of the energy drained between AODV, G-AODV, Q-back pressure algorithm with autonomous recovery scheme in VSN and the actor nodes with EMD protocol in VSN. The graph reveals that energy drained with actor nodes with EMD protocol in VSN is less than the Q-back pressure algorithm with autonomous recovery scheme in VSN, G-AODV and AODV in VSN. The consumed energy is expressed in terms of milli joules versus the message interval time in terms of seconds.
Figure 5.3 Energy drained in VSN through VSAN with EMD protocol

Figure 5.4 depicts the comparison of the energy consumed between AODV, G-AODV, Q-back pressure algorithm with autonomous recovery scheme in VSN and the actor nodes with EMD protocol in VSN. The graph reveals that energy consumed with actor nodes with EMD protocol in VSN is less than the implementation of Q-back pressure algorithm with autonomous recovery scheme in VSN, G-AODV and AODV in VSN. The consumed energy is expressed in terms of milli joules versus the message interval time in terms of seconds.
Figure 5.4 Energy consumed in VSN through VSAN with EMD protocol

Figure 5.5 depicts the performance of VSN in terms of throughput for the proposed protocols AODV, G-AODV, Q-back pressure algorithm with autonomous recovery scheme and actor nodes with EMD protocol in VSN. The graph reveals that actor nodes with EMD protocol outperforms Q-back pressure algorithm with autonomous recovery scheme, G-AODV and AODV in terms of throughput in VSN respectively. The throughput is expressed in terms of kilo bits per second versus the time in terms of seconds.
Figure 5.5 Throughput in VSN through VSAN with EMD protocol

Figure 5.6 depicts the performance of VSN in terms of packet loss. The graph reveals that actor nodes with the EMD protocol in VSN outperforms Q-back pressure algorithm with autonomous recovery scheme, G-AODV and AODV in terms of packet loss in VSN respectively. The packet loss is expressed in terms of kilo bits per second versus the time in terms of seconds.
5.5 SUMMARY

Visual sensor networks are used to send real-time image, audio, and video in real-time application. In this work, the technique for enhancing the energy efficiency in visual sensor networks using the actor node and the EMD protocol is highlighted. The significant parameters of Visual Sensor Networks such as: energy efficiency, packet delivery ratio, and throughput have been analyzed. Furthermore, the experimental results show that network lifetime can be increased by the inclusion of actor nodes and the EMD protocol. Also, the throughput is increased through the actor nodes and the EMD protocol in VSAN. In future, energy efficiency in VSN can be increased using compression, decompression and noise removal techniques.