MULTI-OBJECTIVE OPTIMIZATION IN ROAD SENSOR AND ACTOR NETWORKS

W.Kala Belja*

Miss.S.Sumitha**

Abstract

In Road Sensor and Actor Networks, a lot of sensors and actors are arbitrarily deployed on public roads to gather real-time data on traffic and road conditions and ease decision making based on data gathered. Some actors could be put to inactive state to save energy and extend network lifetime. In this paper, the theme of selecting a set of running actors for coordinating data transmission in a road sensor and actor network with least amount communication cost and data error reduction is studied. A modified Non dominated sorting genetic algorithm (NSGA) is proposed. It is used to find which paths are minimizing cost and reducing data error. The usefulness of the proposed algorithms is confirmed using extensive simulations.

* Department of Information Technology, PSN College of Engineering and Technology, Tirunelveli.

** Assistant professor, Department of Information Technology, PSN College of Engineering and Technology, Tirunelveli.

1. INTRODUCTION

Road Sensor And Actor Networks(RSAN), which are composed of a set of sensors and actors are arbitrarily deployed on public roads to gather real-time data on traffic and road conditions and help decision making based on data gathered[3]. Sensors are inexpensive, short-power devices with restricted sensing, and wireless communication capacities. Actors are expensive and prepared with better processing capabilities, very higher transmission power, and longer battery life. In RSANs, sensors and actors work together in data-centric applications with sensors collecting information about the road situation and actors taking suitable actions on the environment. When sensors detect an event (i.e., a passing vehicle), they transmit sensing data (i.e., position, speed and details of the vehicle) to nearby actors, which send out data to the sink through long range communication. The sink processes and analyzes the sensor data and issues action commands to actors. Typical applications in RSANs include vehicle tracking, driver advising, and incident finding, traffic details. For example, if any accident is happened, the sink will identify this and make active the proper actor to take action for that incident. RSANs can also provide more complicated information services such as road-surface condition treatment and traffic information queries. While an abundance of sensors and actors are typically deployed in a road network, such an intense deployment is usually not necessary for actor nodes since actors have higher transmission power and capacities, and a single actor can cover a larger area. To reduce network overhead some actors could be put to inactive state to save energy and extend network lifetime. The method of selecting a set of running sensors and actors and establishing appropriate data paths between them is known as sensor–actor coordination.

II. Related Work

Unlike usual Wireless sensor networks, which are collected of identical nodes and single-sink performing centralized operations [1], RSANs allow heterogeneous nodes to cooperatively execute dispersed sensing and active tasks [2]–[4]. Prepared with more energy and computing resources, the actor nodes can perform more complex functions such as data gathering, coordination, and responses to events.

Efficient data collecting, maximize the actor's coverage, minimize the energy consumption, clustering, energy-efficient routing and data-collecting protocols have been widely studied, and a wide range of special network structures, such as shortest path tree, minimum spanning tree, minimum Steiner tree, clustering, grid, and chain, are utilized to achieve the goal of reducing energy consumption. But these methods cannot be applied directly to RSANs because of the following: First, they work with dissimilar coordination patterns. The sensor–actor network is like a heterogeneous network combining powerful and resource-limited devices performing both long-range and short-range communications. Second, most presented clustering algorithms in sensor networks are topology dependent. In RSANs, the deployment of sensors and actors are restricted in a road network.

To the best of our knowledge, the sensor–actor coordination problem with the explicit intention of both network communication cost minimization and data error reduction in road networks has not been studied in the past.

III. Model

In RSANs, sensor nodes are equipped with power unit, receiver and transmitter, processor and storage, Analog to Digital converter (ADC) and sensing unit. The sensing unit is used to sensing the data such as thermal, optic or acoustic event. The collected analog data are converted to digital data by ADC and then are analyzed by a processor and then transmitted to nearby actors Fig 1a.

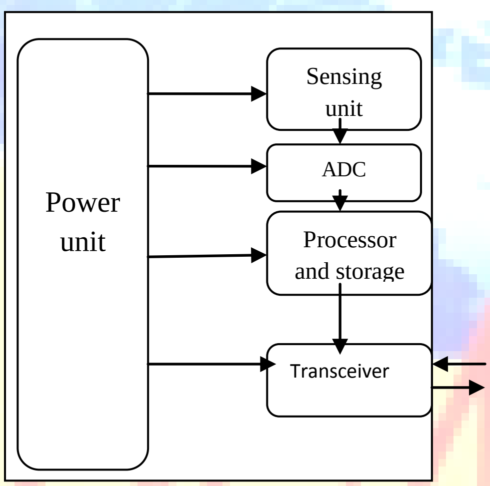

Fig.1a. Sensor node

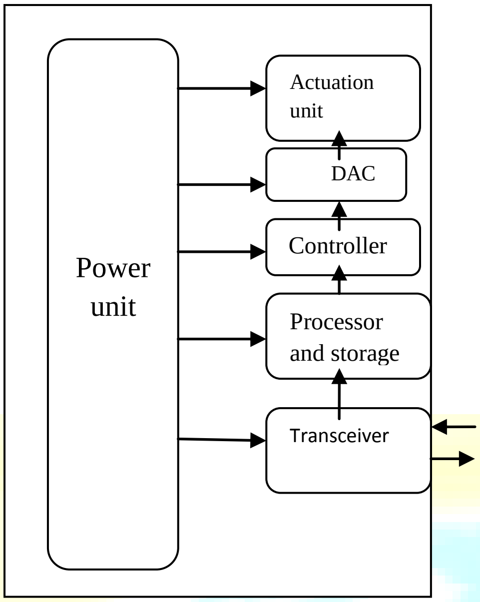

Fig.1b. Actor node

In actor node, the controller functions as a unit that takes sensor readings as input and generates action commands as output. These action commands are then converted to analog signals

by the Digital to Analog Converter (DAC) and

are changed into actions via the actuation unit as shown in Fig. 1b.Fig.2 shows the road sensor–actor network model.. Each actor has two states: *working* or *inactive*. If an actor is in the *working* state, it can sense events, collect data from nearby sensors, and establish long-range communication with the sink. If it is in the *inactive* state, it acts like a normal sensor. Consider the example in Fig.2 ; if sensor *A* as detected an event, the data collected by the sensor need to travel two hops to send to the nearest actor *B*. However, if actor *C* is in

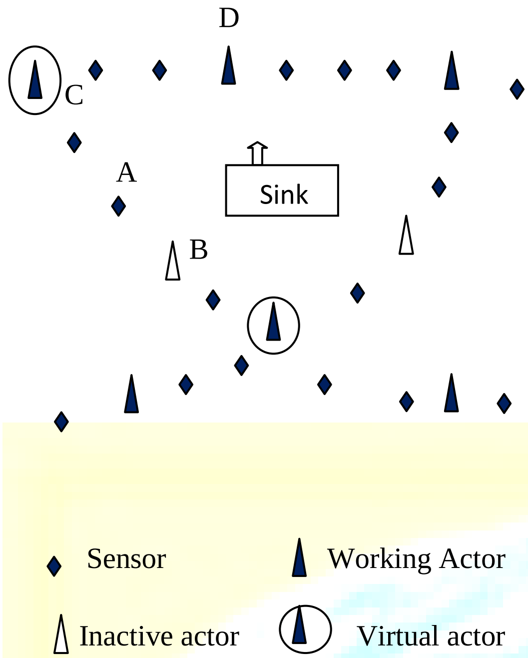

Fig 2.RSAN

the *working* state, it only needs one hop for *A* to communicate with *C*. More working actors clearly improves communication efficiency as the sensor data can be more quickly processed but at the expense of increased communication cost and larger power consumption in the actors. Hence, the selection of a appropriate set of working actors to minimize the total network communication cost is a key design decision in RSANs. In Fig. 2, the actors with dotted circle are virtual actors. The reason behind virtual nodes is that traffic is busier at the intersections and requires careful observation; hence, people tend to deploy actors in these places. In a real road, if no actors are deployed in such areas, the virtual node will redirect the workload to a nearby working actor. For example, in Fig. 2, node *C* is a virtual actor; if there is no real actor deployed in its area, the virtual node will direct its workload to a nearby working actor *D.*

IV. Proposed Methods

Our aim is to minimize the communication cost and data error reduction in Road Sensor and Actor Networks. In this methodology consists four steps. First, defining the Road Sensor and Actor network model. Actors are to be powerful nodes. It is used to collect data and send them to sink. Sensors are low power devices. It used for sensing. Second, initializing the network. It is used to initialize the number of nodes, node energy, data rate, distance of the nodes and bandwidth of the data. Third, minimizing the communication cost. It is essential to minimize network communication in sensor and actor network. Because sensors and some actors are limited battery life time and communication capabilities. Fourth, estimating the data error. It is used to estimate the channel interference, packet delivery ratio. Packet delivery ratio depend on the network traffic, coverage area and node life time.

$$\text{Packet delivery ratio} = \frac{\text{Number of packets received}}{\text{Number of packets Sent}}$$

V . Modified NSGA

The Modified NSGA is a popular non-domination based genetic algorithm for multi-objective optimization. It is a very effective algorithm NSGA is a fast and elitist multi-objective evolutionary algorithm
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A . Path Initialization.

The Path Initialization is defined how much path is connected from source to destination.

B. Non-Dominated sort

When the path is initialized then the path is sorted based on non-domination into each front.

- The first front being completely non-dominant set in the current population.
- The second front being dominated by the individuals in the first front only and the front goes so on.
- Each individual in the each front are assigned rank (fitness) values or based on front in which they belong to.
- Individuals in first front are given a fitness value of 1 and individuals in second are assigned fitness value as 2 and so on.

C. Crowding Distance

The crowding distance is a measure of how close an individual is to its neighbors. Large average crowding distance will result in better diversity in the path. Crowding distance is assigned front wise and comparing the crowding distance between two individuals in different front is meaningless.

D. Selection

The paths are sorted based on non dominated sort. In this part, select which paths are minimized cost and reduced data error. Then apply cross over mutation. It is used to find the new paths from the selection paths.

VI. Experimental Results

In this section, we conduct simulation experiments to evaluate the performance of the proposed algorithms.

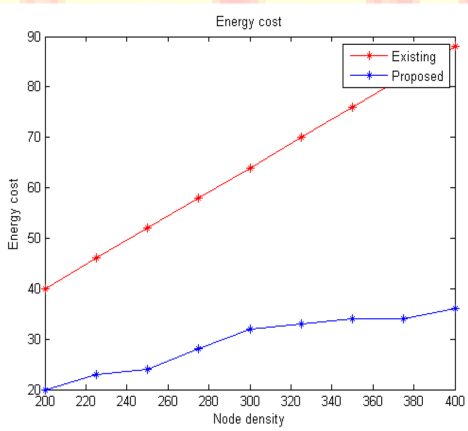

Fig3a.Performance of the Node density Vs Energy cost

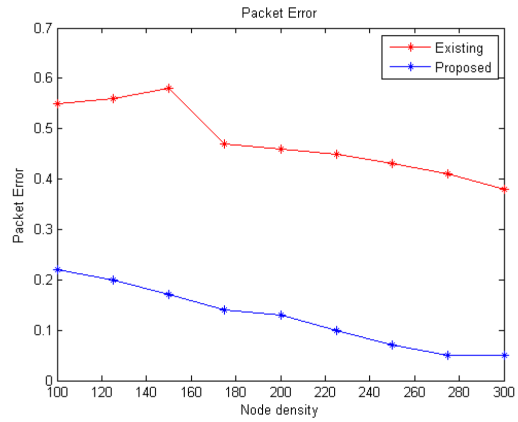

Fig3b.Performance of the Node density Vs Packet error

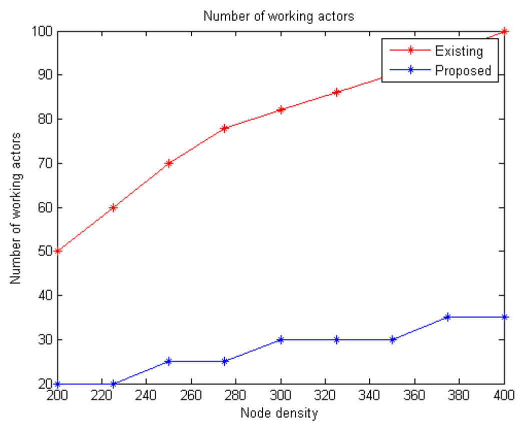

Fig3c.Performance of the Node density Vs Number of working actors

Fig3a. shows performance of the Node density Vs Energy cost. If node density increases, energy cost will also increase. Because the energy cost is dependent on the node density. Fig3a. shows performance of the Node density Vs Packet Error. If node density increases, Packet error will be automatically increased. Fig3c. shows performance of the Node density Vs Number of working actors. If node density increases, we need more number of working actors.

But our algorithm consumes much less energy and reduces data error and minimizes the number of working actors than the other algorithms.

VII. Conclusion

In this paper, we minimized the communication cost and reduced the data error using Non dominated sorting genetic algorithm. The efficient way of communication between sensor and actor node is achieved by Non Dominated Sorting Genetic Algorithm. So NSGA algorithm is used for multi-objective optimization.

VIII .References

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