# Performance of Cooperative Transmission Schemes in Industrial Wireless Sensor Network Using S-AODV Protocol

**R. Janaki, R. Hemalatha, T. Janani, M. Kavipriya, S. Srinithi**

***Abstract--- In this paper, we investigate the impact of propagation channel conditions including both line of sight (LOS) and non line of sight(NLOS) environment. The major issue identified in wireless sensor network is data transmission rate redundancy which is resolved by proposing a new protocol namely S-AODV (Statistical Adhoc On-demand Distance Vector routing) protocol. This protocol is designed to improve the AIDV protocol by developing adaptive methods by considering the statistical parameters. The coorelation coefficient is the prominent parameter used for selection of routes in S-AODV protocol. The routing algorithm is designed by considering the propagation environment, energy efficiency, outage probability and throughput efficiency.***

***Keywords--- cooperative communication, industrial wireless communication, adaptive methods, energy efficiency, outage probability, throughput performance.***

## I. INTRODUCTION

Industrial wireless sensor networks (IWSNs) have gained much attention due to their low cost, small geometry, low heat dissipation and low-power sensors. These nodes are tiny and compact, and operated using battery sources and they can be operated for many years.

But battery replacement is difficult or even impossible in some specific cases. Furthermore, the computational capacity and wireless throughput gain have significantly increased in the last decade, whereas the capacity of batteries has achieved a modest increase. Consequently, the demand for minimizing the energy consumption is a serious concern in IWSNs. The performances of short-hop and long-hop routing strategies were analyzed in terms of energy consumption under stringent outage constraints. Besides, the overall energy consumption is affected by multi-path fading in a harsh industrial environment. Thus, it leads to increased energy consumption owing to multiple retransmissions. Cooperative communication has emerged as a potential technique by exploiting the additional spatial degrees of freedom to combat multi-path fading and increase energy efficiency because it significantly enhances the signal-to-noise (SNR) ratio at the receiver as compared to that of a single antenna (single-input single-output, SISO) system.

By exploiting relay techniques, spatial diversity can be achieved. The cooperative protocols are defined based on the specific behavior of the relay nodes. For example, in amplify and-forward (AF) strategy, the relay nodes simply amplify the signal received from the source node at the first phase, and subsequently forward the amplified version of the received signal at the second phase. In the compress-and-forward (CF) protocol, the relay nodes compress the signal received from the source node, and forward it to the destination . In decode-and-forward (DF) scheme, the relay nodes decode the overheard signal from the source node at the first time slot, re-encode, and forward the re-encoded version at the second time slot.

In the SDF scheme, the relay nodes forward the signal to the destination whenever it is successfully decoded from the source node. Otherwise, the source node retransmits the signal. Specifically, the relay nodes utilize the measured channel state information (CSI) between the source and the relay nodes. Thus, IDF scheme could obtain adaptive protocol. In the IDF scheme, the relay node may overhear the signal that is transmitted from the source node to the destination node owing to the broadcast nature of wireless medium. Subsequently, the relay node only forwards the frame at the second time slot in case of failure of decoding at the destination node. This mechanism is provided by the feedback channel.

Thus the above mentioned shortcomings were evaluated by energy consumption, transmission power, throughput performance, and outage probability of the six transmission schemes, single-hop, multi-hop, SDF, IDF, AF,IAF. In previous reference paper, they presented the performance comparison under NLOS and LOS environment. Furthermore, the relay location is also investigated under these conditions. Our main contribution is,

- To minimize the data redundancy rate in AODV protocol and to improve the QoS parameters, Statistical Ad-hoc On demand Distance Vector(S-AODV) protocol is proposed in this paper by considering the scattering parameters.
- In order to maximize energy consumption savings, minimize the transmission power of each transmission scheme since the internal hardware power consumption of the transmitter and receiver circuitry is fixed.

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This solution significantly reduces the computational complexity since it involves only elementary functions. This is a practical solution since modern industrial wireless sensor network (WSN) nodes can adjust the transmission rate and power consumption to achieve the required quality of service (QoS).

- Furthermore, the trade-off between throughput performance and energy efficiency is considered in this paper. Our results show that incremental cooperative schemes can outperform other cooperative and non-cooperative schemes. A comparative study reveals that the proposed protocol performs better than the present AODV protocol.

## II. LITERATURE SURVEY

**1)**In 2011, Martin Suchara, Dahai Xu, Robert Doverspike, David Johnson published a paper on Network Architecture for joint failure recovery and traffic engineering. In this they propose a mechanism that combines path protection and traffic engineering to enable reliable data delivery in the presence of link failures.

**2)**In 2014, Jing Liu, Jie Li, Guochu Shou, Yihong Hu, Zhigang Guo, Wei Dai published a paper on SDN based load balancing mechanism for elephant flow in data center network. It explains about framework enables adaptive multipath routing of elephant flows to efficiently spread the load in accordance with the changing load conditions.

**3)**In 2015,Haidlir Achmad Naqvi, Sofiya Naning Hertiana, Ridha Mulidina Negara published a paper on enabling multipath routing for unicaste traffic in ethernet network. Here the system is considered scalable since it can run on many topologies such as mesh, grid, clos, and ring with various number of switches; and the results show that convergence time is below 5 seconds. The system also yields better performance since it adopts multipath routing, indicated by either lower latency or packet loss rate compared to spanning tree protocol.

**4)**In 2016,Wen Wang, Wenbo He, Jinshu Sut, Yixin Chen published a paper on Cupid: Congestion-free Consistent Data Plane Update In Software Defined Networks. In this paper, we focus on updating flow tables in data plane consistently and efficiently while preserving throughputs of flows. To reduce the overhead of finding a feasible updating order, we firstly partition the rerouted path into independent segments, and then divide the global dependency among updates into local dependencies among critical nodes.

## III. HARDWARE DESCRIPTION

*PIC16F877A*

The PIC, or Peripheral Interface Controller, is the name given by Microchip Technologies to its single – chip microcontrollers. PIC micros have grown to become the most widely used microcontrollers in the 8- bit microcontroller segment. The PIC16F877A CMOS FLASH-based 8-bit microcontroller is compatible with PIC16C5x, PIC12Cxxx and PIC16C7x devices. It contains 200 ns instruction execution, 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

**Fig. 1: PIC Microcontroller**

*Temperature Sensor*

The temperature sensor used here is LM35.It is used to measure the temperature for a particular region. This sensor can measure the value more accurately when compared with others. They also has additional features namely, it posses low self heating and in still air they does not cause more than 0.1 degree celsius.

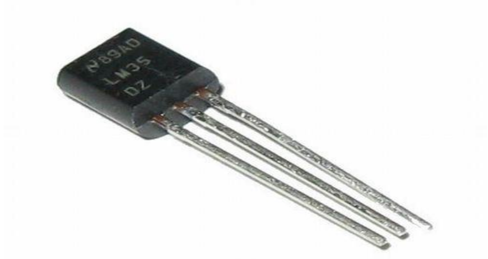



**Fig. 2: Temperature Sensor**

*Humidity Sensor*

A humidity sensor is used to measure, senses, report both moisture and air temperature. This humidity sensor is also known as hygrometer. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. For a comfort zone, Relative humidity plays a major role.

*Voltage Regulator*

The voltage regulator used in our project is LM7805.The voltage level is regulated by using voltage regulator. It is preferred when the steady, reliable voltage is needed as it maintains the output voltage at constant value. It acts as a buffer to protect the components from damages.

*Liquid Crystal Display*

LCD is a flat panel display which is used to display the visible image. Liquid crystal do not emit light directly but instead, it uses a backlight or reflector to produce the images on the display either in color or monochrome.

*Crystal Oscillator*

The crystal oscillator is used to obtain very high frequency of oscillations with stability. High frequency of operation is made. The crystal oscillator used here is of 10MHZ.

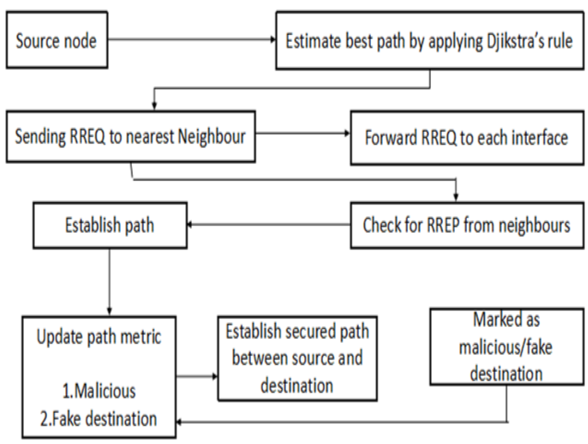
**Fig. 3(a)**

**Fig. 3(b)**

**Fig.3(a), 3(b): Photography of prototype**

## IV. SOFTWARE DESCRIPTION

In this we are using the cygwin work station and TCL language for the simulation purpose. They may consist of the various procedures and hence they are well explained in the below flow diagram. Here in order to send the data to the receiver, the sender sends the rreq to the receiver. If the receiver is free and in case of accepting the data, reply rrep is send and hence the data is transmitted between the two nodes. If the node is busy, they send the data to neighbour by node and hence it will forward to the destination node.




**Flow diagram**

The simulation is carried out by the below procedures. PDR (Packet Delivery Ratio) is the proportion to the total amount of packets reached the receiver and amount of packet sent by source. If the amount of malicious node increases, PDR decreases. The higher mobility of nodes causes PDR to decrease. As the node density decreases, this rate gradually goes down to about 60%. In constract, AODV's PDR ranges between 60% and 80% for dense networks. There are two reasons for the PDR penalty for AODV to operate in sparse networks. First, data packets are forwarded using traditional IP forwarding in AODV. When channel quality varies, a packet may be lost at the link layer. After a few failed retransmits, it will be dropped by the network layer. The proposing S-AODV protocol improvise the existing AODV protocol by considering the statistical parameters. The computation of Correlation Coefficient (CC) and regression are the prominent parameters in the algorithm for selecting the routes in S-AODV protocol.

| **Parameter** | **Range of values** |
|---|---|
| Energy used for transmission | 50-81 mW |
| Energy used for listen | 30-35 mW |
| Energy used for sleep | 0.003-0.005 mW |
| Packet size | 100-1000 bits |
| Packet transmission speed | 500-1000 kbps |
| Average node's minimum energy consumption level | 10-50 J |
| Receiving power strength | 200-750 kbps |
| Learning rate | 0.5 -1 |
| Discount factor | 0.5-5 |
| Gradient step size | 0.0001-0.1 |
| Average time to live value | 8-15 ns |

**Fig. 4: Table including ranges**

In simulation, following sequential steps occur. All the nodes are in sleep mode before communication starts and preserving energy level. Tx – Node - 0 starts communication with destination node - 22 vi active neighbor node . Tx- 0 starts communication with active neighbor node(AN) Node – 91. Active neighbor node (AN) Node - 91 starts communication with other AN node – 6.Active neighbor node(AN) Node - 6 starts communication with other AN node – 28.Licensed primary node - 38 starts recovering the secondary neighbor node – 28.Secondary neighbor node - 28 recovered and ready for communication .Active neighbor node (AN) node - 28 starts communication with other AN node – 25.Active neighbor node (AN) node - 25 starts communication with other AN node – 94.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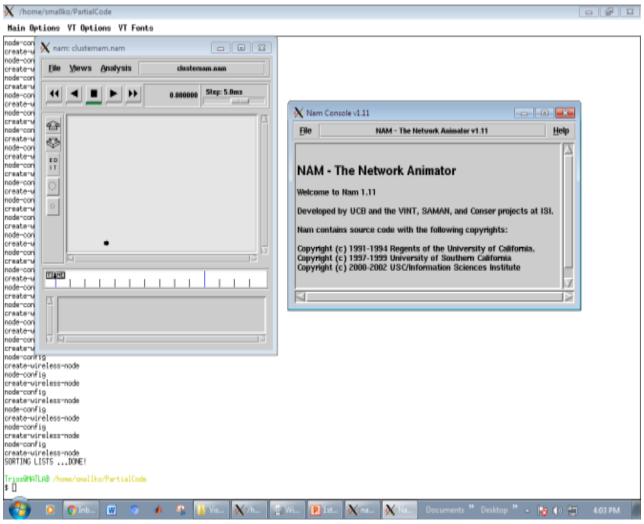


Fig. 5: Simulation output

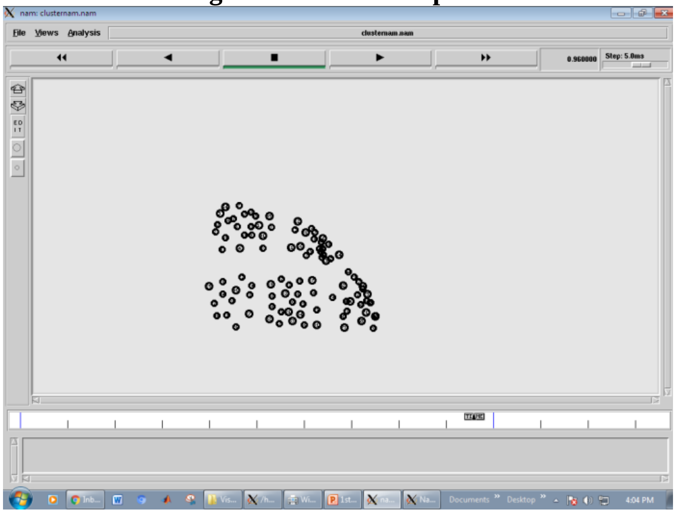

Fig. 6: Formation of nodes

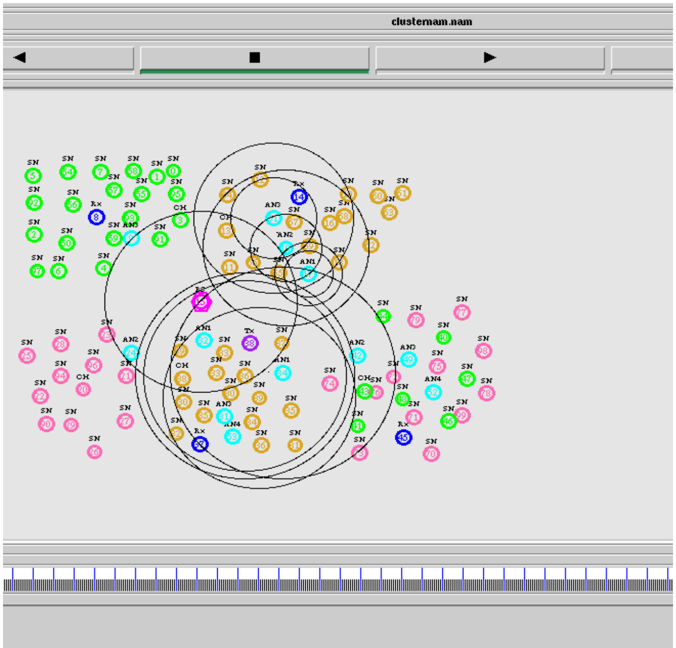


Fig. 7: Transmission of data between 100 nodes

## V. SIMULATION RESULTS

For evaluation of the performance of the proposed system, throughput for both AODV and S-AODV is also calculated. Throughput is the amount of data delivered per unit time. From the figure, it is understood that the throughput of S-AODV is higher when compared with that of AODV.

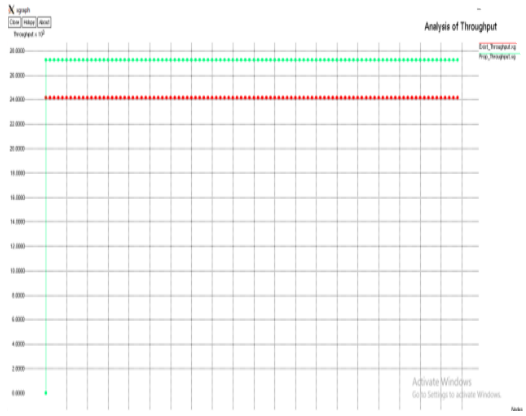


Fig. 8: Throughput efficiency graph

For evaluation of the performance of the proposed system, network delay for both AODV and S-AODV is also calculated .Network delay is the time taken by data to get delivered per unit time. From the figure, it is understood that the throughput of S-AODV is higher when compared with that of AODV.

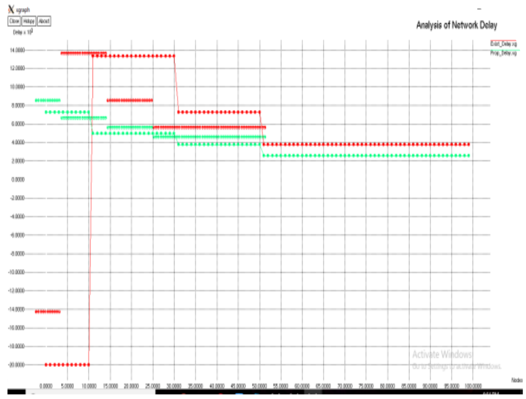


Fig. 9: Analysis of network delay graph

For evaluation of the performance of the proposed system, network lifetime for both AODV and S-AODV is also calculated .Network lifetime is the overall comparison between the AODV and S-AODV. From the figure, it is understood that the throughput of S-AODV is higher when compared with that of AODV.

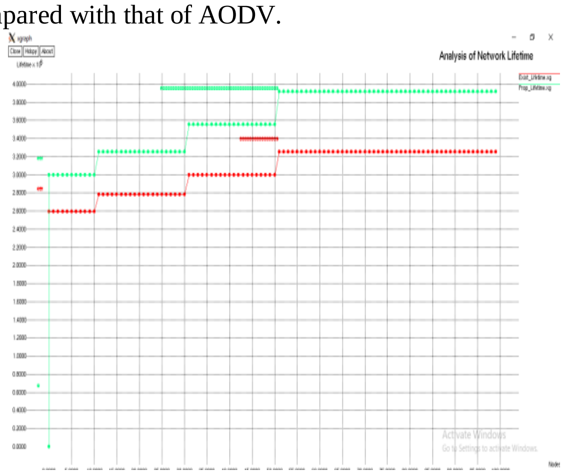


Fig. 10: Graph on network lifetime



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For evaluating the performance of the proposed system, the energy consumption also plays a major role and hence the energy consumption between the AODV and S-AODV protocol is also calculated. From the below figure, it is understood that energy consumption of the S-AODV protocol is less when compared with AODV protocol.

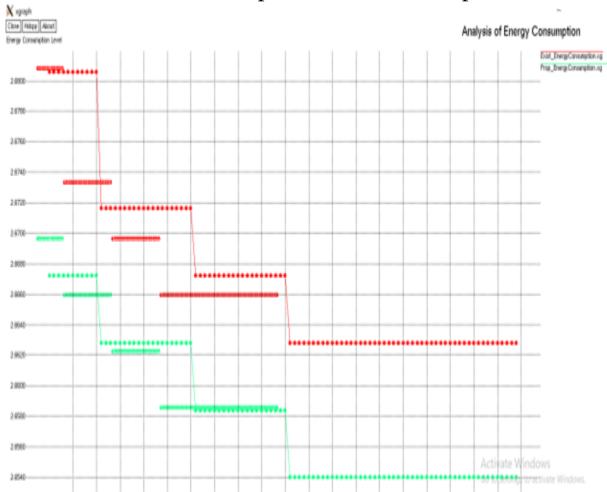


**Fig. 11: Energy consumption graph**

## VI. CONCLUSION

Though many protocols are existing in the present technology, we have found a new protocol for the data transmission which leads to reduced energy consumption, high efficiency, etc., when compared to other routing protocols. Since it is based on the statistical parameters which may include mean, standard deviation, coorelation coefficient, etc., they have a good scope for transmission of data by avoiding major loss of data transmission.

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