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Energy Efficient Data Aggregation Based Smart Logistics in Wireless Sensor Networks

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Abstract: ***WSN is comprised of a combination of environmental sensors that allows monitoring critical shipment variables such as location, temperature, light, humidity and barometric pressure.WSN based logistic used to provide the safe and security in shipments. The use of WSN in logistic industry is a powerful new central nervous system where easily broken goods, foods and pharmaceuticals can be monitored throughout their shipments in order to avoid quality degradation and spoilage. Propagating data frequently consumes more nodes energy and transmission of such data will create huge database and it also saturates network resources. Data aggregation is an effective technique to reduce the size of the data to be stored in database and it also increase the life time of WSN. The lifetime of the WSN relies upon node's Energy. Proposed Senor enabled logistic (SED) is for raising the energy efficiency of a network. Simulation results indicate that this operation practically will increase the network lifetime.***

Keywords: ***Wireless Sensor Network; Data aggregation; Logistics; WSN;Smart Logistics;Energy efficiency***

I. INTRODUCTION

Wireless sensor networks (WSNs) is composed of one or multiple remote sinks and many tiny, low-power sensor nodes, each equipped with battery, sensing devices, and a wireless transceiver[2]. Due to the technology advances in low-power networked systems and medical sensors, there is an emergence of wireless sensor networks (WSNs) in Logistics.

WSN is comprised of a combination of environmental sensors that monitor a certain phenomena, such as Air pollution, the decay of nuclear waste, forest-fire, Agriculture, Environmental monitoring systems and such. The devices are either deployed physically in a desired stationary structure, or remotely deployed from airplanes depending on application. WSN based logistic used to provide the safe and security in shipments. Easily broken goods, foods and pharmaceuticals can be monitored throughout their shipments in order to avoid quality degradation and spoilage. WSN allows users to monitor critical shipment variables such as location, temperature, light, humidity and barometric pressure, and relays this data to customers.

Sensors provide full visibility inside shipments while they're in movement, helping to ensure they reach their destination in the customer's expected condition. It is a flourishing logistics model in which multiple sensors transmit cargo data. The sensor devices detect current shipment location and environmental variables such as temperature, humidity, light exposure, and barometric pressure, then wirelessly communicate these variables to the shipper and generate alarms when specific events are detected. Additionally, they estimate the remaining ledge life of the perishable goods they travel with. For example the sensors are with GPS technology, used to create customized, location-based alerts to inform them if a shipment deviates from its route, and whether it is planned for timely delivery.

For example, in healthcare and pharmaceutical shipping items that is either very difficult or impossible to replace. Such as tissue specimens need the environmental variables of these packages carefully maintained while in shipment. By monitoring factors such as light exposure, temperature, and humidity could save the specimens from damage.

Data collected from different sensors through out the shipment provides information about Temperature, pressure, humidity, light exposure stored in separate databases and it will create a huge volume of data. Before storing it into the database if the data can be aggregated[6]. lt reduces the storage space and the customer can collect the exact information about the shipment.

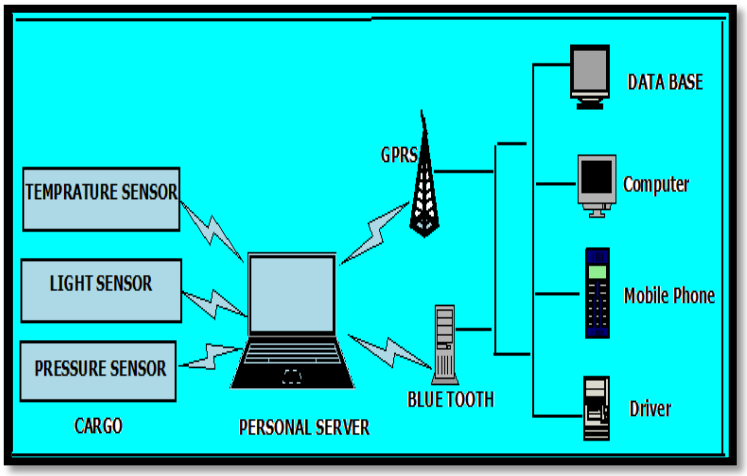

Figure 1: WSN Architecture

II. Related Work

A. Sklorz[1] discussed about IR-Ethylene Concentration Measurement in fruit Logistics smart Systems Integration. L. Evers and P. Havinga[3] proposed flexible sensor network reprogramming for Logistics. L Riz-Garcia and P. Barreriro[4] discussed about Performance of Zigbee-based wireless sensor nodes for real time monitoring of fruit logistics and in [5] they discussed about Review, Monitoring the intermodal, refrigerated transport of fruit using sensor networks. R. Jedermann[8] proposed Intelligent containers and sensor networks –Approaches to apply autonomous cooperation on systems with limited resources in Understanding autonomous cooperation and control in logistics S. Hadimand and N. Mohamed[9] discussed about Middleware Challenges and Approaches for Wireless Sensor Networks. K.P. Shih and S.S. Wang [10] proposed collaborative event detection and tracking in wireless Heterogeneous sensor networks.

III. Proposed Scheme

In figure 2 Sensors continuously monitor the cargo and propagate the data to the sink. But information is worthless without accurate interpretation. At present, there is no infrastructure to provide these for cargo shipments. Data Aggregation can only do so much. Aggregating monitored data is a great idea [7]. Integrate or aggregate the shipment information into one appealing dashboard, can give actionable information to improve their outcomes.

Data collected from sensors are fed into the database. Before storing it in database if it is aggregated will help to reduce the size of the database as well as customers will take better decision. Abnormal readings, such as dangerously high temperature, pressure, are flagged. It will alert the customers.

Let's think the scenario the vehicle is having 100 cargo each one is having 10 sensors to monitor them. The data collected from the cargo for temperature. Cargo's readings are collected throughout the day for 24 times and it digitally transferred to the database. It will create huge amount of same set of data to be stored in the database.

Cargo =100.

Sensor =10

Data= (10 *100) *24=24000

Aggregated data =100 * 10 =1000

The data is stored in database without aggregation it needs 24000 records. The customer contacts the vehicle driver with this information, but he or she cannot state anything? There would be little time to discuss what it means, why it's dangerous and what the driver should do next.

In Table 1 the data transmitted by the 3 sensors to the database. Data transmitted without aggregation it needs 12 entries with aggregation it needs only 4 entries in the database.

TABLE I: Aggregation Table

Time (Hrs)	Sensor 1	Sensor 2	Sensor 3	Aggregation
1	$19^{\cdot c}$	$19.5^{\cdot c}$	$19^{\cdot c}$	$19.1^{\cdot c}$
2	$18^{\cdot c}$	$18^{\cdot c}$	$19^{\cdot c}$	$18.3^{\cdot c}$
3	$17^{\cdot c}$	$17.5^{\cdot c}$	$17^{\cdot c}$	$17.1^{\cdot c}$
4	$19^{\cdot c}$	$19.2^{\cdot c}$	$19.1^{\cdot c}$	$19.1^{\cdot c}$
5	$20^{\cdot c}$	$20.1^{\cdot c}$	$21^{\cdot c}$	$20.3^{\cdot c}$

This issue can be resolved by Aggregation of data. When the data is aggregated it is stored in the database as one record per cargo. The aggregated data stored as 1000 records database instead of 24000 records database.

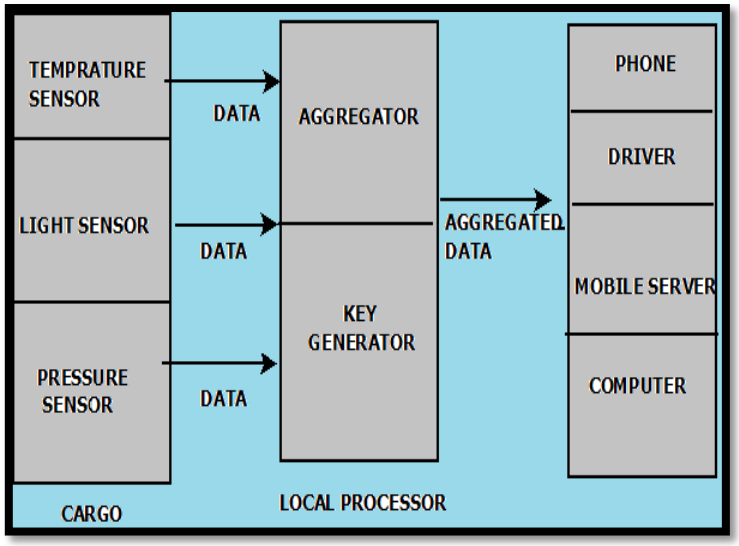

Figure 2: SED Architecture

Data propagation cycle of the sensor consumes more energy. The lifetime of the sensor depends on its energy. Minimizing the propagation of data will improve the energy loss. The Sensor collects the data and the data is compared with the previous values stored in their cache memory. And there is always chance of a security attacks in applications of sensor networks. Here, the attackers can also steal the data by eavesdropping.

The active threats are more harmful than their passive counter parts. This may lead to life threatening situations. To provide security, the data encryption is done before propagation. The sensor node performs its operation based on the energy.

Propagation of data from the sensor node needs more energy. Energy is efficiently utilized when the number of propagation to be minimized. Instead of sending the same values repeatedly to the database the data of the sensor is like the previous one means the data won't propagate to the sink; otherwise the data value is greater than the threshold (maximum limit) means data immediately transform to the sink and it raises an alarm in figure 3.

Algorithm Propagate (Input: Sensed data, Output: Encrypted data)

Collects data from the sensor
Repeat
If (Data >=Threshold)
Send Data immediately to the sink to raise an alarm
Else
If (Data!+previous value)
Encrypt and propagate the data to sink
Else
Propagation is not done
Until (Node sends data)

Sink does not get any update from the sensor it aggregate the last three values sent by the sensor the result of the currently aggregated value similar to the previously transmitted means the sink does not send the data for updating

Algorithm Aggregate (Input: Sensed data, Output: Encrypted data)

Collects data from the sensor
Repeat
If (No updates from sensor)
Collect the previous three values
Aggregate the data
Else
If (Data! = previous value)
Aggregate the data of nodes
Until (Node sends data)

Sink receives an update from the sensor it aggregates the values and sends it to the database.

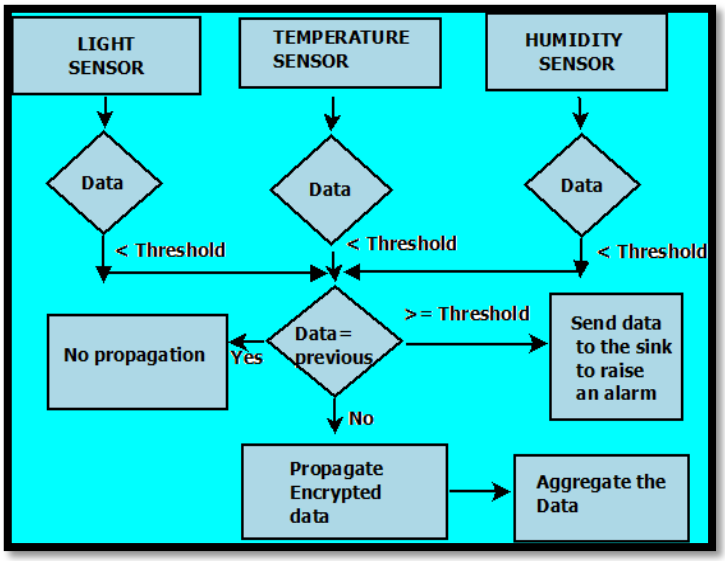

Figure 3: Workflow Model

IV. Simulation Result and Performance Analysis

TABLE II: WSN PROFILE

Parameter	Value
Network Size	600x400m
Nic Type	Nic Csma
Number of Mobile Nodes	5
Mobility Model	Random Way Point
Velocity	5m/S
Radio Sensitivity	-85Mw
Voltage	3V
Simulation Time	60sec
Traffic Type	Periodic
Layer	Sensor Application Layer
Queue Length	10
Bit Rate	2Mbps

The simulations of SED are performed via OMNET simulator shown in Figure 4.

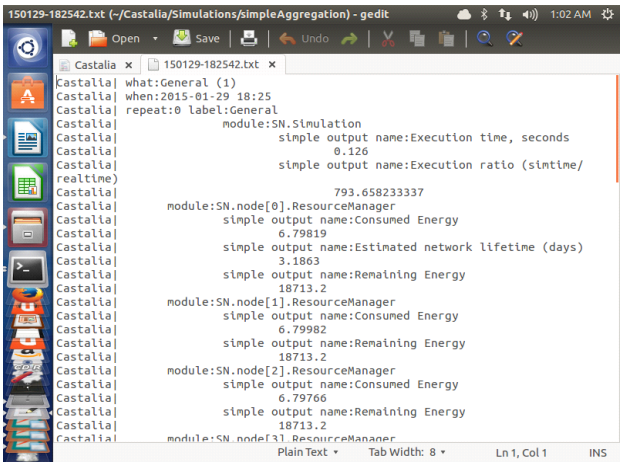

Figure 4: CASTALIA framework Screen shot

Battery residual capacity

Table 3 Shows that the Battery residual capacity of data aggregation using GA and SED. With the increase in the number of iterations, Battery residual capacity of SED is more in figure5.

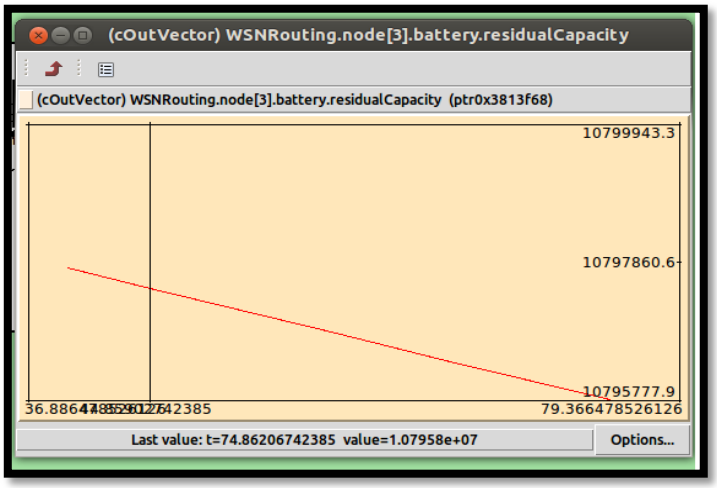

Figure 5: Battery Residual Capacity

Table III Battery Residual Capacity

Nodes		Batttery capacity(amp) after 5 hours		% Energy Utilized	
	Default	*Trad GA*	*SED*	*GA*	*SED*
1	10	7	9	30	10
2	9	3	7	60	20
3	8	2	7	50	10
4	9	2	8	70	10

Throughput

After applying algorithm SED the data transmitted as aggregated data. Throughput means the packet is delivered to the sink with minimum energy. The throughput of SED and GA is highlighted in Figure 5.

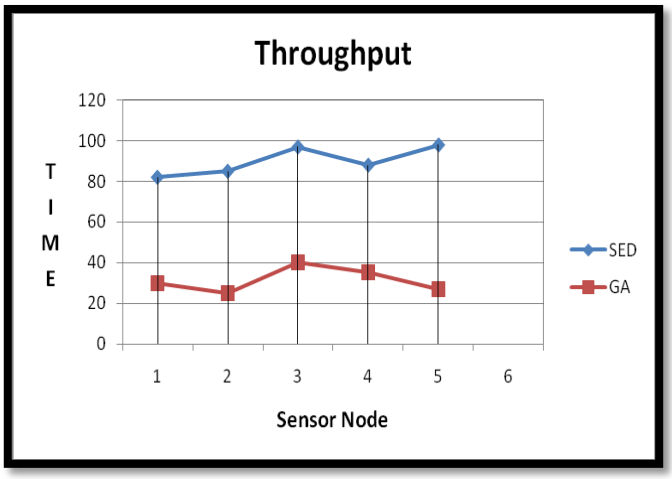

Figure 5: Node Vs Time

C. Energy Utilized

Figure 6 Shows that energy utilized ratio between GA based data aggregation and SED. Energy utilized means the energy used for the packets are delivered from node to sink. With the increase in the number of iterations, Residual energy is more for SED than GA.

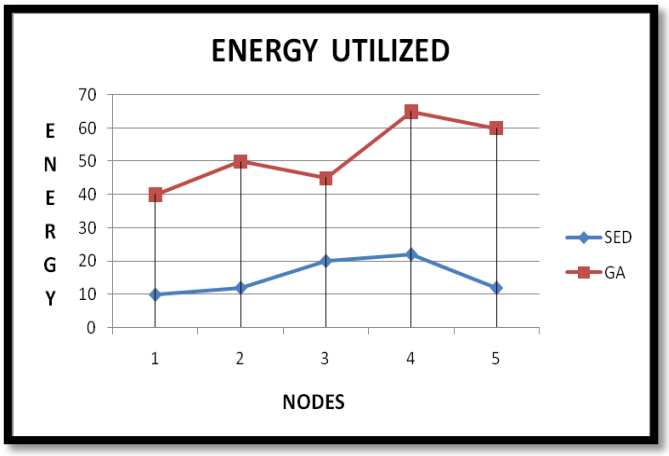

Figure 6: Node Vs Residual Energy

V. CONCLUSION

An innovative Energy efficient data aggregation for Logistics based algorithm was introduced which improves the lifetime of WSN effectiveness. Simulation results show that this method is more efficient in extending the lifetime of sensor node with data aggregation than Genetic algorithm method. Further investigations may include the use of intelligent algorithms for data aggregation.

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He is an Associate Professor at the Department of Computer Science, Madurai Kamaraj University, Madurai. His research interests are in the area of Data Semantics, Networks and Wireless Sensor Networks. At MKU additionally, he is also a Resource Executive of many academic councils. He has worked on much Government sponsored UGC projects that involve innovation and Domain specific benefits. He has over two decades of experience in the field of Information Technology. He specializes in setting up Global Research and Development and innovation. He is an expert in the area of developing strategies for innovation.

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