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IMPROVED INFORMATION COMMUNICATION METHODOLOGY WITH SECURED BACKUP CONFINED NODES FORWSN DESIGN

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ABSTRACT

Wireless Sensor Networks (WSNs) are increasingly utilized in critical monitoring applications, yet their constrained resources and deployment in hostile environments make them vulnerable to security threats and data loss. This paper proposes an Enhanced Secured Data Transmission Methodology (ESDTM) integrated with Backup Protected Nodes (BPNs) to ensure reliable and secure data delivery across the network. The proposed approach incorporates lightweight encryption for secure communication and a dynamic backup node allocation mechanism to mitigate the impact of node failures or malicious attacks. Simulation results demonstrate that ESDTM with BPNs significantly improves packet delivery rate, reduces data loss, and enhances energy efficiency compared to conventional WSN protocols. This methodology is particularly suitable for mission-critical WSN applications, offering improved fault tolerance and security assurance.

INTRODUCTION

Wireless Sensory Associations are made up of geologically isolated autonomous sensory nodes to facilitate keep an eye on environmental or physical conditions and collaboratively send the information they gather to a central base station [01,02]. WSNs require strong, dependable, and secure data transmission systems for a variety of applications, from industrial automation and healthcare to military surveillance and environmental monitoring. However, these networks are vulnerable to security breaches, data packet loss, and node failures because of the intrinsic constraints of sensor nodes—such as their limited processing power, battery life, and memory—as well as their deployment in hostile or unsupervised regions [03].

Designing a secure and fault-tolerant communication infrastructure is essential since traditional routing and data transmission techniques frequently lack robustness against such adversities [04 - 06]. In this research, a proactive Backup Protected Node (BPN) mechanism is integrated into an Enhanced Secured Data Transmission Methodology with Backup Protected Nodes for WSNs. In the event of node failure, the BPNs act as dynamic stand-ins for the primary nodes, guaranteeing continuous data transmission [07, 08]. Furthermore, the suggested approach uses backup protected nodes to protect data confidentiality and integrity without using a large amount of processing power.

The ESDTM with BPNs offers a complete solution for reliable WSN operations by fusing security and dependability to handle both malevolent attacks and system malfunctions. Simulation-based performance evaluation reveals significant gains in resilience, energy consumption, and packet delivery rate, establishing this methodology as a viable strategy for reliable and secure WSN installations.

1. Review of Related Literature

Taha.et.al. With ubiquitous intelligence and calculating potentials to connect massive corporeal things to the Online, wireless statement in contemporary elegant gadget technologies has accelerated the growth of the IoT. The internet of the future is now represented by the IoT, and both industry and academics have a huge opportunity to provide client services in many aspects of contemporary life. The IoT, which is used in manufacturing, finance, logistics, and services, may be used for any industrial activity, including financial transactions, companies, and other entities.

Researchers have described this technology in a variety of ways, which has led to new avenues for study and business. Let's talk about two of the most widely used definitions: First, the Internet of Things is a way for digital worlds and physical elements to interact through a vast variety of sensors and actuators. According to another description, the Internet of Things is a paradigm where any practical thing has networking and computational capabilities built into it. Networking capabilities are used to query the object's state and, if feasible, change its condition. The Internet of Things, in general, describes an innovative humanity where every the gadgets and trimmings are connected to an association in order to do complex activities requiring a high level of intelligence. In order to combine many technologies into one, IoT entities are outfitted with entrenched sensors, processors, actuators and trans-receivers.

As sensors are dispersed throughout wireless sensor networks, a major problem in the intend of association grouping approaches is making sure that the sequences with dispensation energy endure for a lengthy period in order to advance power utilization and prolong the lifespan of the Wireless Sensory Associations. These methods separate the sensory nodes into groups, every one of the which has a distinct group leader. In clustering-based metaheuristics systems, choosing the best CH nodes has recently become dependent on factors like high dependability and low energy usage.

In order to increase network lifespan and lower power consumption, the authors provide a unique improvement technique that uses Aquila Optimizer to improve power equilibrium in groups among sensory nodes throughout association communications. In a wireless sensor network, existence and power-efficiency grouping algorithms—specifically, genetic algorithms, Coyote Optimization Algorithm, Aquila Optimizer, Harris Hawks Optimization, and the less-power adaptive grouping hierarchy procedure as a conventional procedure —are assessed. The study comes to the conclusion that the recommended AO algorithm executes enhanced than alternative algorithms in provisions of energy usage and alive nodes analysis [9].

Boban.et.al. WSN, which are utilized in numerous aspects of everyday life, including calamity reprieve, intention tracking, ecological organize, elegant cities, medication, and physical condition concern, are made up of spatially dispersed sensor nodes that are able to intellect, evidence, and allocate corporeal and ecological parameters. Many inexpensive, multipurpose sensor nodes that are usually powered by a small battery and placed to monitor a specific region of interest make up a typical wireless sensor network. The network's lifespan is directly impacted by the sensor nodes' limited energy supply.

Energy-efficient protocols and algorithms are thus being thoroughly researched in order to accomplish the aim of extending the network lifetime, which makes energy-efficient modes of operation of WSNs crucial. An examination of earlier studies on wireless network security and enhancing the energy efficiency of wireless sensor networks identifies issues with individual node lifetime, network dependability and data transmission security, and the best way to divide the network into clusters.

By combining pre-existing solutions and implementing original limitations for a sustainable company representation and power competence enhancement of WSN in the digital era, each of the aforementioned protocols improved energy conservation while also creating new opportunities for improvement, which the authors will examine and present in their research article [10].

Chouhon.et.al. Over the past 20 years, academics have thoroughly investigated the problem of prolonging the lifespan of WSNs intended for the IoT. Real-time IoT applications are needed for complicated analysis and monitoring. Sensor nodes in the Internet of Things rely on battery backup power, which is regarded as an energy constraint for carrying out different tasks. It is now difficult to maximize the network lifespan of network nodes.

Researchers have previously concentrated on using guarantee life-time protocols to increase the network lifespan of nodes; however, some problems including scheduling, sensing exposure, and association connectivity have not been taken into account. In order to obtain a better packet delivery ratio, prolong network lifespan, and optimize network energy consumption, an energy-efficient routing method is suggested in this work for duty-cycled nodes by taking into account snooze/wakeful method and enhanced information rates. Sink nodes regularly allocate sleep/awake modes to nodes based on the node's remaining power, exposure region, with overall active occasion [11].

Alshammri.et.al. One important technical development that might fuel the industrial revolution is a wireless sensor network. Battery power powers the sensory nodes that construct up Wireless Sensory Associations. Since batteries cannot be replaced or recharged, power is the most important source for Wireless Sensory Associations. A number of methods have been developed and applied over time to conserve WSNs because they are a limited resource. This study will offer a practical approach for Cluster Head choices to increase the longevity of WSNs. To choose the best Cluster Head, several studies are using the swarm-based optimization technique. The best CH selection in WSN is chosen in this revise using the Squirrel Search Algorithm.

The precise need for CH choosing in WSNs has been addressed in this work by modifying the generic SSA. A number of improvements are incorporated into the Improved Squirrel Search Algorithm with the goal of improving solution quality and speeding convergence. Notably, we have enhanced the SSA's exploration and exploitation capabilities by including a Local Search Algorithm, Adaptive Population Initialization, and Dynamic Step Size Control. Together, these improvements improve the algorithm's capacity to efficiently traverse the search space, leading to more effective junction towards ideal explanations.

The objective function of the proposed formulation considers the intra-cluster distance, sink distance residual energy, factor, and Cluster Head balance average. A range of conditions are used to perform the simulations. The suggested code of behavior A Metaheuristics Optimized Cluster head selection-based Routing Algorithm for WSNs, Multi-agent path finding using Ant Colony Optimization, Grey Wolf Optimization, SSA, Chernobyl Disaster Optimizer, Sperm Swarm Optimization, and Energy-Efficient Weighted Clustering are the protocols that are compared to SSA-C. the ISSA-C approach outperformed MAP-ACO, SSA, and GWO. It demonstrated better bit error rates and used less energy than other approaches [12].

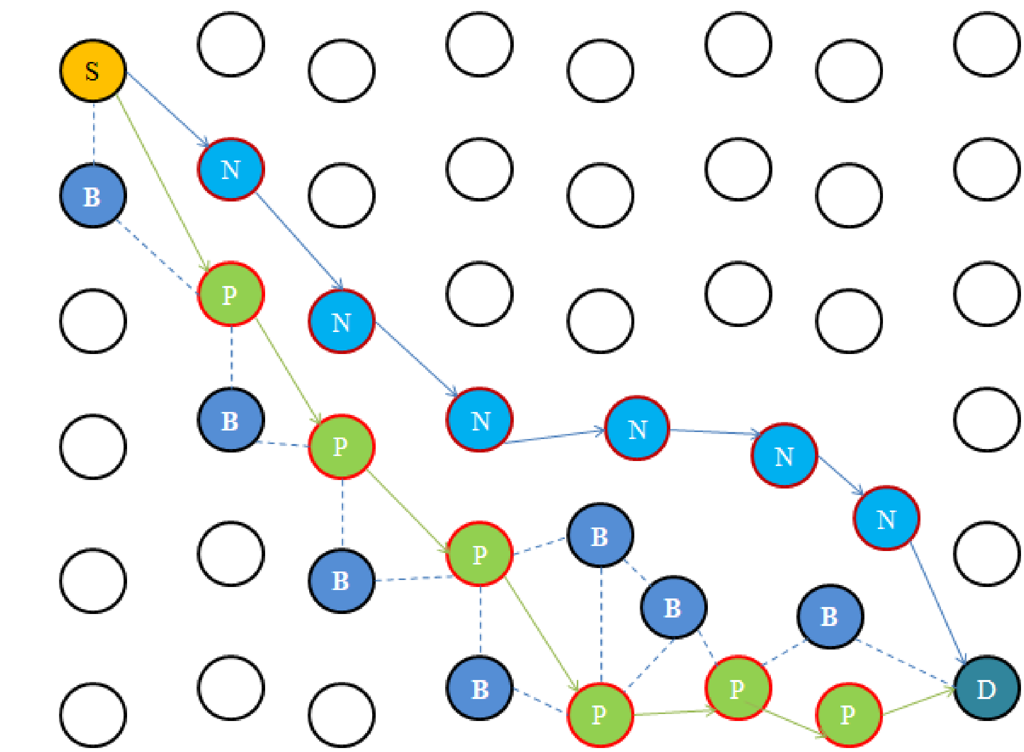
2. Enhanced Secured Data Transmission for WSN

To convey data exactly and accurately without encountering any transmission flaws, the WSN architecture is frequently utilized. However, in order to maintain long-term route accessibility, the current methods to WSN design mostly concentrate on energy efficiency and increasing the node's active time to increase or extend its lifetime.

While most research concerns were on data transmission, this study proposal focuses on communicating the data between the nodes in a secure way with the least amount of time and energy usage. To improve data transmission fault tolerance during information transmission from the resource node to the objective node, backup protected nodes were added to the current model. The design of the Enhanced Secured Data Transmission Method with Backup Protected Nodes for WSN Architecture is shown in figure 1. Table 01 below provided a description of the working method:

Table.01. Working Methodology of Enhanced Secured Data Transmission Backup Protected Nodes for WSN

Step 01:	Start the process
Step 02:	Receive the data sending request from source node
Step 03:	Identify the data receiver node
Step 04:	Identify the nodes between the dispatcher node and beneficiary node along the power range
Step 05:	Using the protected nodes, confirm and generate the undeviating path route between the resource and recipient nodes for data transfer.
Step 06:	Verify the power range of the created route with protected nodes
Step 07:	Complete and verify the data transmission route with those protected nodes if the power of those path protected nodes' range exceeds 90%, then move on to Step 9.
Step 08:	Else again begin from the process from the Step 05
Step 09:	Prepare the backup path protected nodes for the path protected nodes and keep active those backup path protected nodes while from the data transmission begins and up to its transmission ends successfully
Step 10:	Start the data transmission between the sender and receiver using the protected route
Step 11:	If any path protected node crashed at the time of transmission, re-route that path with the help of backup path protected nodes which is nearest backup path protected nodes to the crashed path protected node
Step 12:	Verify the data transmission completed between the sender and receiver
Step 13:	Stop the process



S = Source Node, D= Destination Node, P=Protected Nodes, N = Normal Nodes, -> = Data Transit
B = Backup Protected Nodes, --- = Data Transmission Back Path for Protected Nodes

Figure.01. Enhanced Secured Data Transmission Method Backup Protected Nodes in WSN Architecture

3. Results and Discussions

To evaluate the efficiency of the projected Enhanced Secured Data Transmission Methodology (ESDTM) integrated with Backup Protected Nodes (BPNs), simulations were conducted using a custom-built network simulation environment.

Average Latency

Network latency is a well-known barrier to communication across groups of connections. It illustrates the time it takes for data to move between networks of connections. Compared to low latency networks, which counter quickly, high latency networks have a bigger obstacle or insulation. When manipulative the typical latency of the information statement from reserve to the objective node, the quantity of occasion that must intervene between starting at the resource and incoming at the intention is taken into report. It is crucial to minimize the delay occurrence as much as feasible.

Packet Delivery Rate

The PDR is calculated by dividing the whole numeral of packets resourcefully delivered to the intended nodule by the numeral of packets sent originally. The whole numeral of packets sent divided by the entirety numeral of packets constructively acknowledged yields the packet delivery rate. Next, multiply the result by 100 to get a percentage. The packet delivery ratio must be as high as is practically possible and still acceptable for a typical routing system.

Packet Loss Rate

PLR is a crucial performance indicator used in networking to assess the efficacy and dependability of data transfer, especially in wireless and MANETs. It is the proportion of the numeral of information packets transmitted by the source to the numeral of information packets that are successfully delivered to the destination.

Energy Efficient Analysis

The design, implementation, and upkeep of network infrastructures and practices with the aim of reducing the power consumption of information centers and association equipment is known as energy-efficient networking. A device's energy efficiency may be assessed and calculated by comparing the amount of productivity it generates with the amount of power it consumes during production. The power consumption of the sensory nodes is estimated based on the simulation's duration. The quantity of power, expressed in joules, that is tranquil present in the sensory nodes subsequent to a specific number of events.

Network Life Time Analysis

The "network lifetime" of a network is the amount of time that passes between its deployment and decommissioning. If the overall outstanding power level in the set of connections is greater than the power collapse in a single node, the lifetime can be defined as the total outstanding power of all the nodes in the set of connections. The network lifespan specification determines the most effective method of improving energy efficiency. The endurance of the association is evaluated as a function of the simulation time. As the lifespan of the sensor rises, the set of connections will have more time to function as planned. When the entire number of nodes that have been in operation for a definite episode of occasion is totaled up, the lifetime of the network remains constant. The more complete zip nodes there are in the collection of linkages, the higher the lifelong competency.

The publication's Table 02 and Figure 02 contrast the anticipated representations with the average delay model that was previously made available. It demonstrates how the projected representation outperforms the aforementioned technique in terms of average latency.

Table.02. Average Latency Comparison

File Size	64 kb	128 kb	256 kb	512 kb	768 kb
CS	16	19	23	24	25
CS+HS	11	13	15	17	20
FR	8	9	10	11	15
RP	6	8	9	10	11
ESDTM	5	7	8	9	10
ESDTMBN	5	6	7	8	9

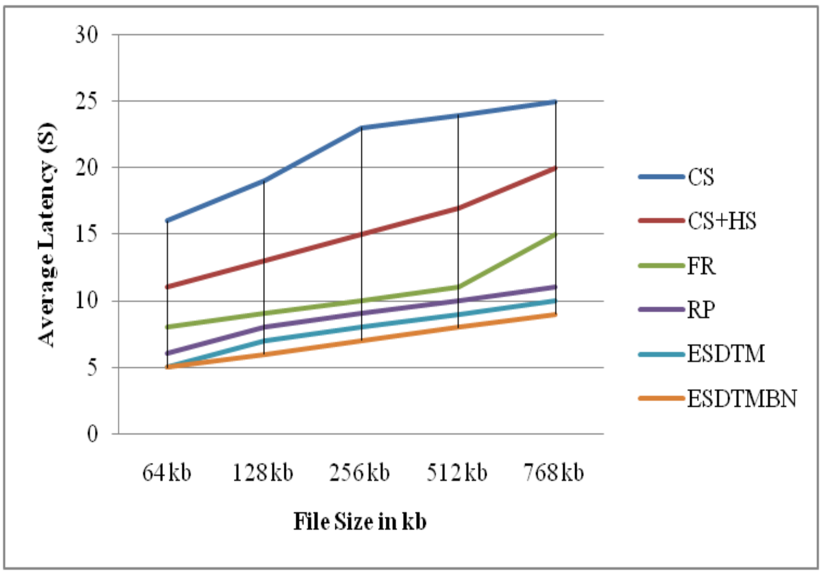


Figure.02. Average Latency Comparison

A comparison between the projected representations and the previously provided PDR model is shown in Table 03 and Figure 3. It shows that the predicted representation is superior than the previously suggested packet delivery rate technique.

Table.03. PDR Comparison

File Size	64 kb	128 kb	256 kb	512 kb	768 kb
CS	88	87	87	86	81
CS+HS	94	92	91	89	86
FR	98	96	94	93	91
RP	99	97	96	95	94
ESDTM	99	98	97	97	96
ESDTMBN	99	99	98	97	97

Figure.03. PDR Comparison

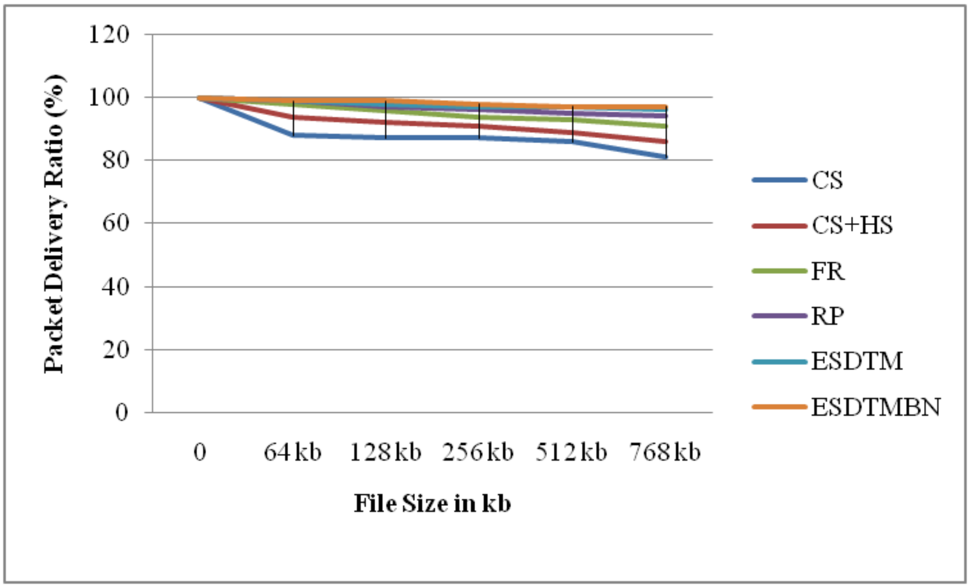


Table.04. PLR Comparison

File Size	64 kb	128 kb	256 kb	512 kb	768 kb
CS	12	13	13	14	19
CS+HS	6	8	9	11	14
FR	2	4	6	7	9
RP	1	3	4	5	6
ESDTM	1	2	3	3	4
ESDTMBN	1	1	2	3	3

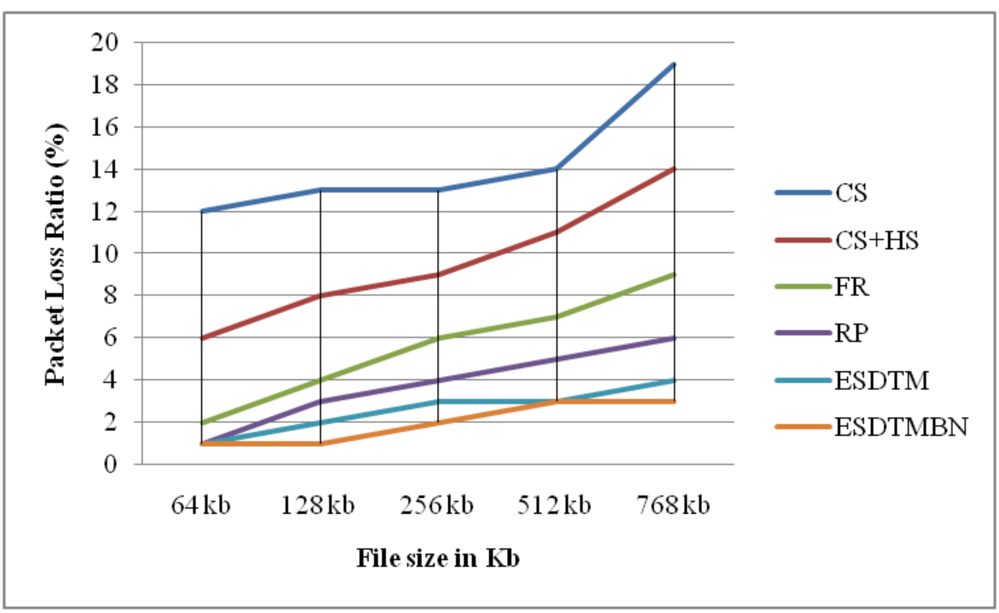


Figure.04. PLR Comparison

A comparison between the projected representations and the previously provided PLR model is shown in Table 04 and Figure 4. It proves that the projected representation is superior to the packet loss rate method that was previously suggested.

The projected representations are contrasted with the previously published model for energy-efficient analysis in Table 05 and Figure 05. It illustrates how the proposed representation is better than the one that was provided in the Energy Efficient Analysis.

Table.05. Energy-Efficient Analysis Comparison

File Size	64 kb	128 kb	256 kb	512 kb	768 kb
CS	0.43	0.42	0.44	0.46	0.48

CS+HS	0.32	0.36	0.39	0.41	0.46
FR	0.28	0.27	0.26	0.27	0.34
RP	0.27	0.25	0.25	0.26	0.31
ESDTM	0.25	0.23	0.24	0.25	0.29
ESDTMBN	0.24	0.22	0.22	0.24	0.27

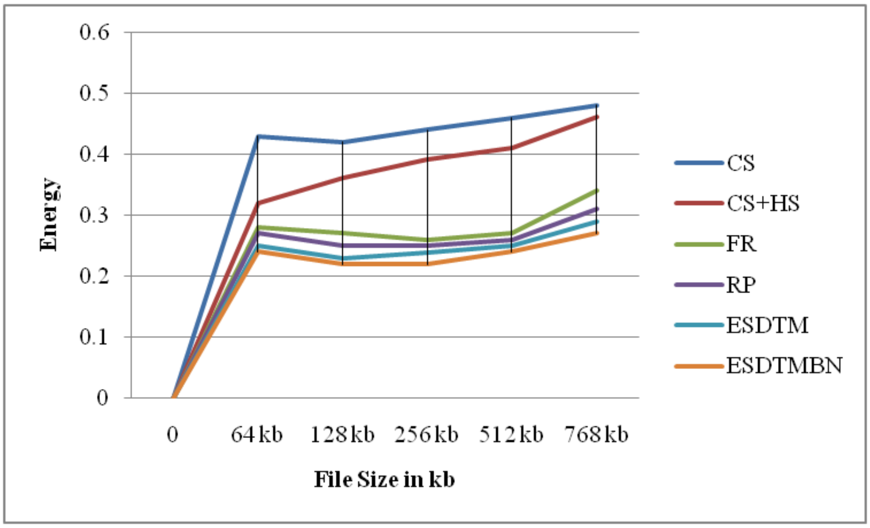


Figure.05. Energy-Efficient Analysis Comparison

Table.06. Network Life Time Analysis Comparison

File Size	64 kb	128 kb	256 kb	512 kb	768 kb
CS	195	193	191	189	187
CS+HS	196	195	194	192	190
FR	197	196	195	194	192
RP	198	197	196	195	193
ESDTM	199	196	195	194	194
ESDTMBN	199	198	197	196	195

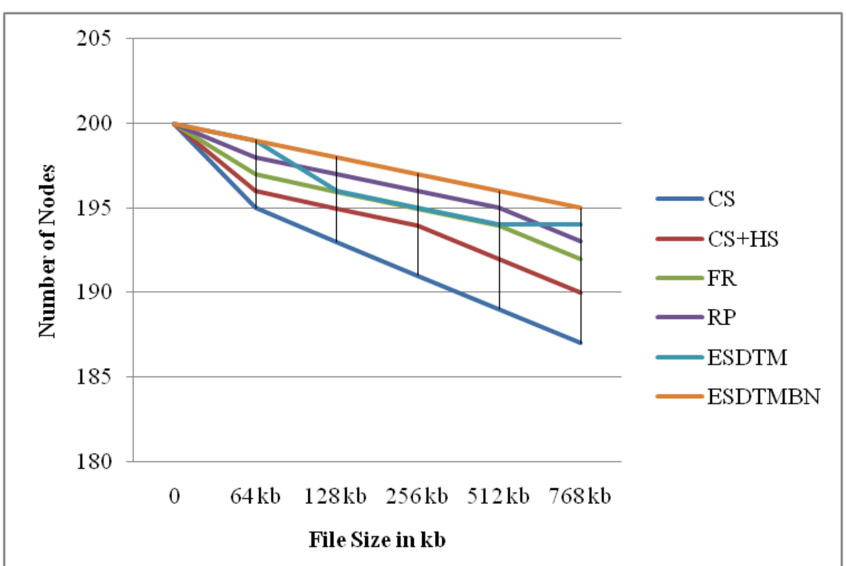


Figure.06. Network Life Time Analysis Comparison

Table 06 and Figure 06 compare the projected representations with the previously released Network Life Time Analysis model. It proves that the strategy that was previously covered in the Network Life Time Analysis is inferior to the projected representation.

4. Conclusion and Future Enhancement

This research concentrate on the crucial issues of security, dependability, and fault tolerance in Wireless Sensor Networks (WSNs) by proposing an Enhanced Secured Data Transmission Methodology (ESDTM) coupled with Backup Protected Nodes (BPNs). In the container of node malfunction or malicious assaults, the approach maintains data flow continuity through dynamic backup node assignment while guaranteeing safe communication through backup path protected nodes. The success of the suggested strategy is confirmed by simulation results, which show considerable gains in packet delivery rate, energy efficiency, and network resilience over conventional protocols. ESDTM is a strong option for mission-critical and real-time WSN applications because it combines security measures with redundancy techniques.

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