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Original Article

Energy Efficient Large-Size Data Block Transmission in VANETs using SD-Kmeans and Th-ANFIS

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Abstract - *Traditional routing-layer-based systems use a substantial percentage of routing pathways to enhance the data link length in a VANET by changing routing paths often while transferring a massive data block, resulting in frequent communication link separation and reconnection. This paper presents a new method for transmitting huge data blocks. Initially, the Swap Displacement and Reversion Fertile Field Algorithm (SDR-FFA) was presented to improve the clustering performance on cluster head selection, where the clusters are formed through the Supremum distance technique in the K-means algorithm. Consequently, the optimal relay node will be selected using Linear Scaling based Red Colobuses Monkey, and efficient features will be selected to improve optimal path discovery using the Threshold based Adaptive Neuro-Fuzzy Inference System (Th-ANFIS) algorithm. Finally, the data file blocks are split and then encoded through the Base64 algorithm to reduce the transmission time. The results show that the proposed system performed well, and the results are compared with several existing techniques.*

Keywords - *VANET, Clustering, Large-size data block, Transmission, Optimisation, ANFIS, Base64.*

1. Introduction

Vehicle Ad Hoc Networks (VANETs) have recently received a lot of attention due to the increase in car ownership and the popularity of onboard apps [1, 2]. Vehicle-to-Vehicle (V2V) [3] and V2-Infrastructure (V2I) [4] links are the most typical VANET connections.

VANET is an emerging network characteristic that enables delivery safety and effective information transit [5-7]. VANET, based on a network with no infrastructure, enables the communication between source and destination. In recent years, the number of cars on the road has expanded dramatically, resulting in an increase in the use of mobile communication [8-12].

Many efforts have been made to increase the VANET's data transmission efficiency, with the most popular study direction being the investigation of effective routing algorithms at the routing layer. Numerous routing algorithms for VANET systems have been put forth so far [13-17].

Due to the intricate routing process involved, Greedy Perimeter Stateless Routing (GPSR) frequently fails to handle complex traffic conditions. The Directional Greedy Routing (DGR) [18-21] method makes constructing a routing path easier by using street maps.

VANET deployment and management are becoming increasingly challenging because of technological advances and the rise of smart cars [26-30]. Creating dynamic routing protocols that can aid in transmitting information from one node (Vehicle) to another is one of the primary difficulties in VANET architecture. VANETs follow the uninterrupted dissemination of messages by allowing a considerable amount of power, energy, and storage, thus eradicating the major challenge of other ad hoc networks. To overcome the drawbacks, this paper proposes an efficient greater-size data block transmission in VANET. As a result of the proposed system, the following objectives will be achieved:

- To improve the cluster performance, the optimal cluster head was selected by using the Swap Displacement and Reversion Fertile Field Algorithm (SDR-FFA).
- To introduce the Supremum distance technique in the K-Means algorithm for improving the clustering accuracy.
- The optimal relay node will be selected using Linear Scaling-based Red Colobuses Monkey to reduce energy consumption.
- The efficient features are selected to improve optimal path discovery using the Th-ANFIS algorithm; additionally, to reduce the transmission time, the split file blocks are encoded using Base64.

The following is the paper's structure: In section 2, recent literature is reviewed; In section 3, the proposed system is described in detail; In section 4, the implementation results and discussions are reviewed; In section 5, the article concludes.

2. Related Works

The Optimised Link State Routing Protocol (OLSR) was introduced by M. Usha and B. Ramakrishnan [31], employing a multipoint relay system. Flooding was the most popular method, which might sometimes cause network congestion. Our method aimed to cover all MPR nodes with two hops. It also took into account the weaker two-hop MPR node set and compensated by offering a countermeasure. The proposed technique aimed to manage transmission control message flooding by assessing the strength of the 2-hop MPR formed before transmission began.

Based on the edge computing idea, Jie Cui et al. [32] developed an effective and privacy-preserving data downloading technique for VANET. A Road-Side Unit (RSU) might detect popular material using the proposed technique by analysing encrypted requests from adjacent automobiles. If a vehicle wants to get popular information, it may get it straight from nearby ECVs. This strategy improved the system's downloading efficiency. The security analysis results showed that the proposed technique could withstand a range of security threats.

Muhammet Ali Karabulut and colleagues [33] developed an Orthogonal Frequency Division Multiple Access system (OFDMA). By lowering the risk of an accident in high-traffic scenarios, throughput was boosted, and delays were reduced. A Cooperative MAC protocol (OEC-MAC) based on OFDMA was predicted for VANET. A Markov chain model-based analytical research was used to assess the performance of the OEC-MAC protocol. Numerical findings demonstrated that the OEC-MAC protocol significantly improved throughput while simultaneously meeting the severe delay constraint of 100 ms in VANETs.

The Moth Whale Optimization Algorithm (MWOA) was created by Shivaprasad More and Udaykumar Naik [34]. The proposed solution was developed by combining the methodologies of MS and WOA. After simulating the VANET, the optimum multipath was chosen using an adaptive geographic routing strategy based on the fitness metric.

For use in dynamic network circumstances, Rajesh Purkait and Sachin Tripathi [35] proposed a multi-criteria fuzzy logic-based intelligence. Fuzzy logic was used to compute node weight based on packet receipt likelihood with variations in the separation between the relay and nearby cars or the RSU, as well as the difference in speeds and the time until the connection expires. Simulation results showed that the suggested approach performed better than existing protocols.

Under sustainable development goals, Wu, Jinsong, et al. [36] discussed the responsibilities and prospects of Information and communication technology in achieving Sustainable Development Goals (SDGs). Researchers conducted extensive literature analyses of IEEE and ACM research communities to discover that SDG contributions primarily focus on technical challenges, leaving out a comprehensive focus on social good.

Lorincz, Josip, et al. [37] discussed different. It has been researched as a potential technology to improve the energy efficiency of wireless networks to use wireless access network paradigms such as millimeter-wave communications, huge multiple-input multiple-output communications, etc.

Wu and Jinsong [38] presented green wireless communication in the view of concept to reality. The author concentrated on energy-efficient cellular wireless communications in this research and some recent advancements in related industries. The global green revolution will significantly influence wireless communications research, development, and applications. It will considerably improve human society's life quality in the near future.

3. Proposed System

Traditional routing-layer-based VANET systems used a high no of routing paths to increase the lifespan of data connections by continually changing routing paths, resulting in frequent communication link severance and reconnection. The vehicular communication network, which allows cars to communicate information, is an important part of an ITS. The creation of dynamic routing protocols can aid in transmitting information from one node to another. VANETs follow the uninterrupted dissemination of messages by allowing a considerable amount of power, energy, and storage, thus eradicating the major challenge of other ad hoc networks. In order to resolve these challenges, a novel system has been developed in this paper, depicted in Figure 1. The proposed system will start from the initialisation of nodes in the VANET. After that, the vehicles are clustered using the clustering technique. In this phase, first, the cluster head will be selected using the Swap Displacement and Reversion-Fertile Field Algorithm (SDR-FFA) with the help of the Vehicle's Minimum Distance. In this case, the cars are gathered as close to the cluster head as possible. The Supremum distance will be added in the K-Means technique to increase clustering accuracy.

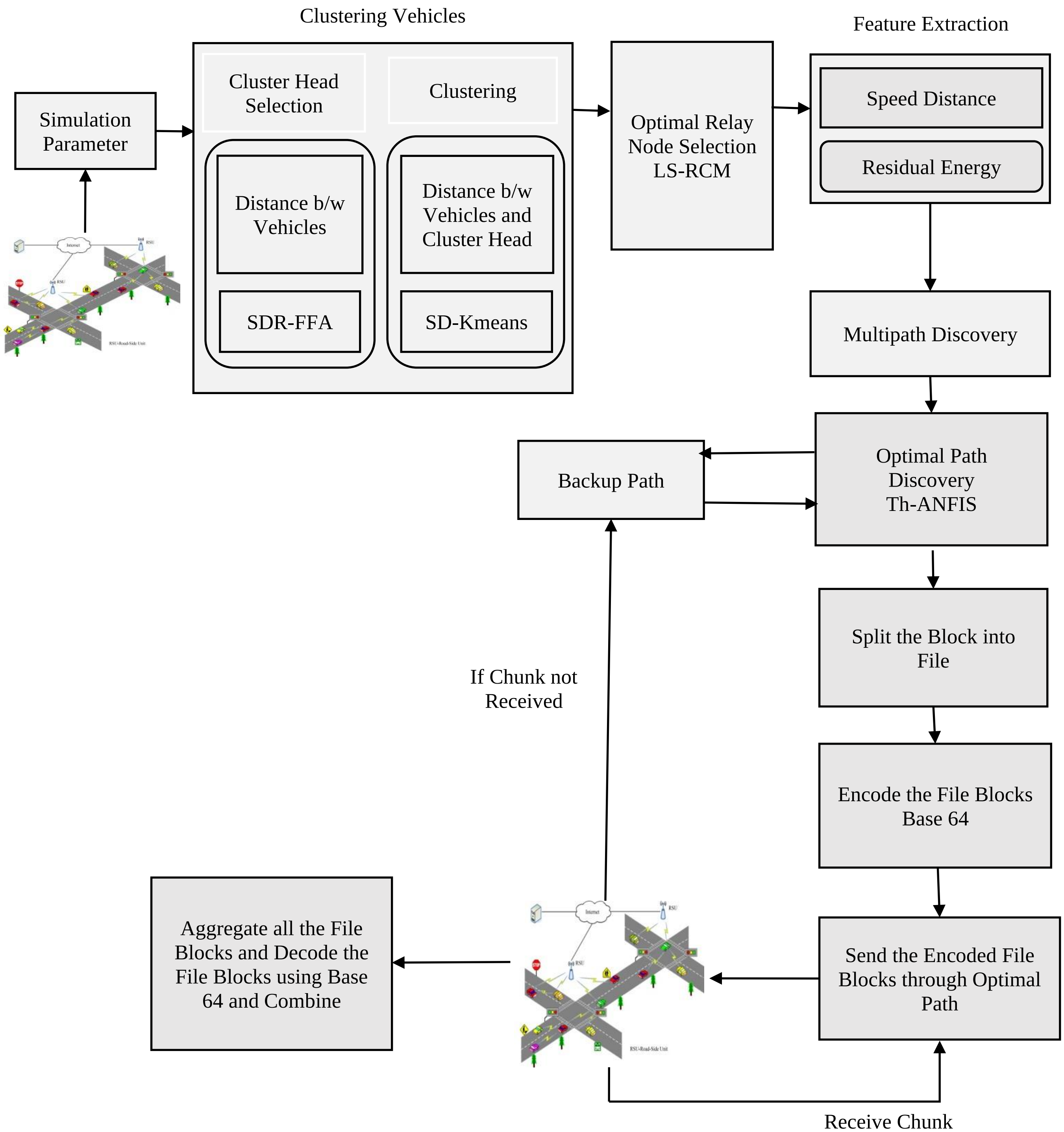


Fig. 1 The proposed framework for the system

The ideal relay node will then be determined using Linear Scaling based Red Colobuses Monkey (LS-RCM) to increase energy efficiency. The Linear Scaling technique will be added to the Red Colobuses algorithm to improve the selection performance. Here, the relay node will be selected from the vehicles. After that, the efficient features, such as Speed, Distance, and Link Residual Energy, will be extracted. Next, the optimal path will be selected by using a rule-based Tanh-ANFIS algorithm. The Tan h activation function will be used in the existing ANFIS algorithm to reduce the training error. Here, the backup path will be selected, and the large files will be split into blocks, and they will be encoded using the Base64 algorithm to improve energy efficiency and transmission time. After sending the encoded blocks, the sender receives a chunk; if the sender does not receive the chunk, that means the connections have disappeared. So, the backup path will be selected for retransmission. Finally, all the split-encoded file blocks are gathered and decoded using Base64.

3.1. Clustering Vehicles

The very dynamic topology of large-size data block transmission leads to rapid changes in connection; therefore, the link between two cars might soon vanish. The reliability and scalability of routing protocols in big metropolitan significant research is now being done on VANETs. In VANETs, clustering can be chosen to increase routing scalability and reliability by dispersing hierarchical network topologies based on connected geographic distribution and relative velocity. Cluster head selection is a critical issue in clustering due to the dynamic nature of vehicle motion. As a result, the best cluster head was chosen using the SDR-FFA to increase cluster performance.

3.1.1. Cluster Head Selection

In the proposed system, the SDR-FFA was developed for cluster head selection. To improve the fertility evaluation, the positions will be updated using this Swap Displacement and Reversion Technique. The fertile field method is a nature-inspired optimisation approach driven by plant survival, with the fertility function accurately stated as the objective function of the optimisation problem. The ideal cluster head selection is treated as an optimisation issue in the proposed system.

Algorithm 1. The proposed SDR-FFA algorithm

Set $k = 0$
Initialise the algorithm parameters $S_0,\ N_p, S, m_1, m_2$
Initialise seed population X_i $(i = 1,2, \dots n)$
while $(k \leq Max\ number\ generations)$
    Evaluate points through fertility functions (swap, displacement, reversion)
    Sort points based on the fertility in $R(X_i) = j$
    Growth of plants proportional to the fertility rank of points (R)
    Update the best point with most fertility $(X^* = X_i)$
    Update convergence data
        if$(stoping\ criteria\ satisfied)$
            End of program
            Return X^*
End if
if$\left(k > \frac{Max\ number\ generations}{2}\right)$

$$m_1 = 100m_1$$
$$m_2 = 100m_2$$

End if
    Regenerate the seeds from plants
    Generate the random direction for wind dispersion
    Stochastic dispersal of seeds by wind
    Stochastic dispersal of seeds by animals

$$k = k + 1$$

End while
    Return X^*

Algorithm 1 describes the suggested SDR-FFA algorithm's method. Initially, both the optimisation problem and the input algorithm parameters should be entered into the algorithm. The parameters include the starting population of animal (k) set to zero or the number of initial seeds (S_0), the number of plants (Np), the number of seeds formed in each cycle (S), and the wind speed dispersion percentage (w). The percentage of seed dispersal by wind might range between 0 and 1—the probability parameters for seed dispersal by wind (PW) and animals (PA). The first seed population is generated and spread at random. The rank function (R) ranks and evaluates points.

In the proposed cluster head selection algorithm, the swap, displacement and reversion operations are considered the objective functions for fertility evaluation. The most fruitful point is designated as X* and is saved as the point with the highest rank (R = 1). The necessary data is updated in order to evaluate the convergence criterion. The wind and animals' seed dispersion systems create new points, which are used to update the population. Depending on the number of generations, the technique might be done in two stages to improve the accuracy of the results. When the basic parameter value is utilised, runs are performed until half of all generations have been finished. Finally, the optimisation method is terminated, and the global optimum point is provided if the convergence requirements have been met, and the optimum point is selected as the optimal cluster head.

3.1.2. Clustering

In the proposed system, the clusters formed by the supremum distance K represent the clustering algorithm. The supremum distance was included in the k-means clustering method, in this case, to increase the grouping accuracy based on the cluster head.

The supremum distance was adopted for the k-means clustering algorithm's distance measurement. Supremum distance, sometimes referred to as maximum value distance, is calculated as the magnitude in absolute terms of the differences between the coordinates of two vehicles.

$$D_{XY} = max_k \left| V_{ik} - V_{jk} \right| \tag{1}$$

The procedure of the proposed supremum distance K-means clustering algorithm is given as follows.

Let $V = \{V_1, V_2, \dots V_n\}$ be the set of vehicles and $X^* = \{X_1, X_2, \dots\ X_n\}$ cluster heads set selected by the proposed SDR-FFD algorithm.

3.2. Optimal Relay Node Selection

In the proposed system, the Linear Scaling based Red Colobuses Monkey (LS-RCM) algorithm was proposed, and it integrated with the Red Colobuses Monkey algorithm. The Red Colobuses Monkey (RCM) optimisation algorithm is a nature-inspired algorithm that mimics the Red Colobuses Monkey behaviour.

When monkeys are organised into teams (clusters), each has one male. Nevertheless, the choice of the leader depends on the physique and combat capability since the stronger monkey will seek food spots at a distance, while the lesser animal will be outside the scope of conventional eyesight. Furthermore, male Cercopithecus mitis and juvenile Cercopithecus mitis have little interaction.

Young males must move out early due to the territorial trait associated with Cercopithecus mitis, as they compete with dominant males from other groups. If they succeed in defeating that guy, they will become family leaders, providing somewhere to live, food, and socialisation for the children.

Each red monkey in a group's position is updated based on the position of the group's best red monkey; this behaviour was discovered using the following formulas:

$$PB_{i+1} = (PA_i \times PB_i) + (W_{leader} - W_i) \times rand \times (X_{best} - X_i) \quad (2)$$

Where, PB denotes the monkey body power, PA denotes the monkey combat power, W_{leader} shows the leader's weight, W_i denotes the monkey's weight, X denotes the position of the red monkey, X_{best} shows the position of the leader.

The following equations have been used to update the position linked to the children of the red monkey:

$$PBch_{i+1} = (PA_i \times PBch_i) + (Wch_{leader} - Wch_i) \times rand \times (Xch_{best} - Xch_i) \quad (3)$$

In the above equations (3), the addition of ch represents the child red monkey. It is worth noting that all RCM parameters may be determined either through trials or by the nature of the issue that has to be solved. Thus, the presented linear scaling procedure in the Red Colobuses Monkey algorithm can avoid slow convergence. RCM can also balance between the exploitation and exploration phases.

3.3. Optimal Path Selection

A large-size data block transmission must be conducted once the proposed system has selected the optimal relay node. In order to do that, several efficient and discriminate features such as speed, distance, and link residual energy were extracted for all vehicle points. In the end, multiple paths have been created with the efficiently extracted features. For optimal path selection, the rule-based Tanh-ANFIS algorithm has been introduced in the proposed system. In which the tangent hyperbolic (tanh) activation function has been incorporated with the ANFIS.

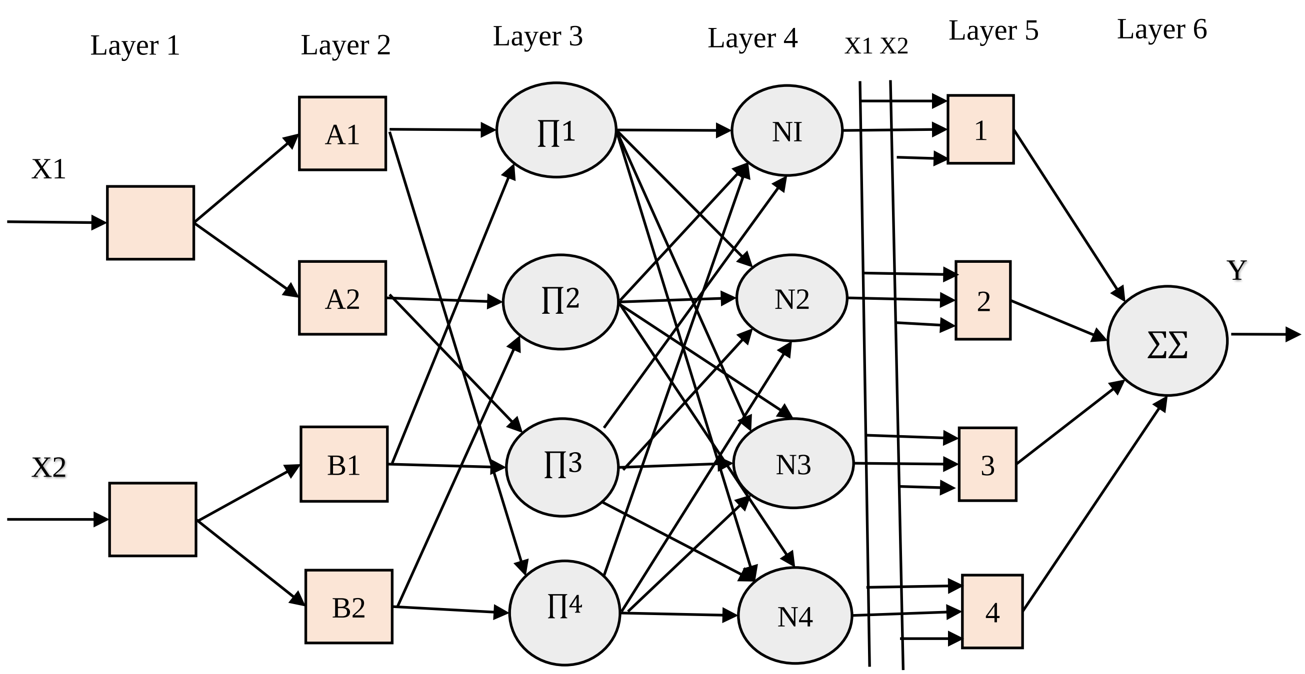


Fig. 2 ANFIS layers architecture

The membership function parameters in ANFIS define the system's behaviour. The system's parameters are adjusted in response to a specific error circumstance. The rule-based ANFIS algorithm was adopted in the proposed system, which is based on the IF-THEN condition having two rules.

Rule 1: If x is A_1 and y is B_1 then $f_1 = p_1x + q_1y + r_1$
Rule 2: If x is A_2 and y is B_2 then $f_2 = p_2x + q_2y + r_2$

The ANFIS system has five layers consisting of neurons that the tanh activation function has activated, illustrated in Figure 2. The formula for the tanh activation function is given as follows:

$$tanh = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \quad (4)$$

As mentioned earlier, the activation function of the proposed algorithm adopts the tangent hyperbolic function (tanh), which further reduces the training error. In addition, it selects the backup path to compensate for the errors at the time of transmission.

3.4. Data Block Transmission

The proposed system was developed to transmit the large size data blocks efficiently. In order to do this, the large files will be split into blocks, and they will be encoded using the Base64 algorithm to improve energy efficiency and transmission time.

The Base 64 encoding method entails:

- Divide the incoming data stream into three-byte segments as part of the Base64 encoding procedure.
- Divide each 3-byte block's 24 bits into four sets of 6 bits.
- Using the Base64 character set map, depending on the 6-bit value, map each set of 6 bits to one printed character.
- If the last three bytes of input data only contain one byte, pad it with two zeros. Replace the final two letters with two equal signs (==) after encoding it as a standard block. Decoding recognises that two bytes of zero padding were used.
- Pad the final 3-byte block with a zero if the input data is only represented by two bytes. Replace the final character with one equal sign (=) after encoding it as a standard block, and the decoding process will begin.

After sending the encoded blocks, the sender receives a chunk. If the sender does not receive the chunk, the connections have disappeared. So, the backup path will be selected for retransmission. Ultimately, all the split-encoded file blocks are gathered and decoded using Base64.

4. Result and Discussion

The proposed solution's implementation information and outcomes are provided in this section. The system has been presented. Also, a comparative analysis was provided to ensure the effectiveness of each part of the proposed system.

4.1. Experimental Setup

4.1.1. Hardware and Software Requirement

The proposed work is implemented in the PYTHON working environment. Python is a well-known high-level programming language.

This programming language allows for the quick and effective integration of systems. The virtual environment utility builds a separate Python environment from the system-wide Python environment (in the form of a directory). The required hardware is an Intel i5/core i6 processor running at 3.20 GHz with Windows 7 as the operating system.

4.2. Analysis of Simulation Results

The proposed system has been implemented in the Python platform, whereas the cluster head was selected with the SDR-FFA algorithm, and the clustering has been formed with the SD-K means clustering algorithm. Both algorithms are performed in lesser selection time and clustering time, and the cluster head was selected optimally with fewer numbers. The performance of the clustering algorithm is shown in Table 1.

Table 1. Performance of clustering algorithm

Parameter	Value
Number of optimal CH	39
CH selection time (ms)	2013
Clustering time (ms)	1660

Finally, the data blocks are encoded with the Base64 algorithm and sent to the destination. The sample encoded data is depicted in Figure 3.

Fig. 3 Encoded data with Base64 algorithm

4.3. Comparative Analysis

In this section, the proposed SDR-FFA cluster head selection algorithm has been compared with the existing algorithms such as Chimp Optimization Algorithm (ChOA), Butterfly Optimization Algorithm (BOA), Rider Optimization Algorithm (ROA), and Fertile Field Algorithm (FFA). The SDR-FFA algorithm comparison is shown in Table 2.

Table 2. Comparison of the SDR-FFA algorithm

Techniques	Optimised CH	CH Selection Time (ms)
ChOA	51	10004
BOA	47	8005
ROA	43	6014
FFA	41	4012
SDR-FFA	39	2013

Finally, the performance parameters of the optimal path selection (Tanh-ANFIS) algorithm have been compared with the existing Artificial Neural Network (ANN) and ANFIS algorithms.

The parameters such as latency, load balancing, throughput, response time, processing time, and average waiting time are compared. It is depicted in Table 3.

The comparative analysis results show that the cluster head selection algorithm, clustering algorithm, optimal path selection and transmission techniques have outperformed the existing techniques.

Figure 4 (a, b) depicts the percentage-wise security of both models in which both SD-Kmeans and Th-ANFIS are more secure enough to transmit data where intruders can be negotiated.

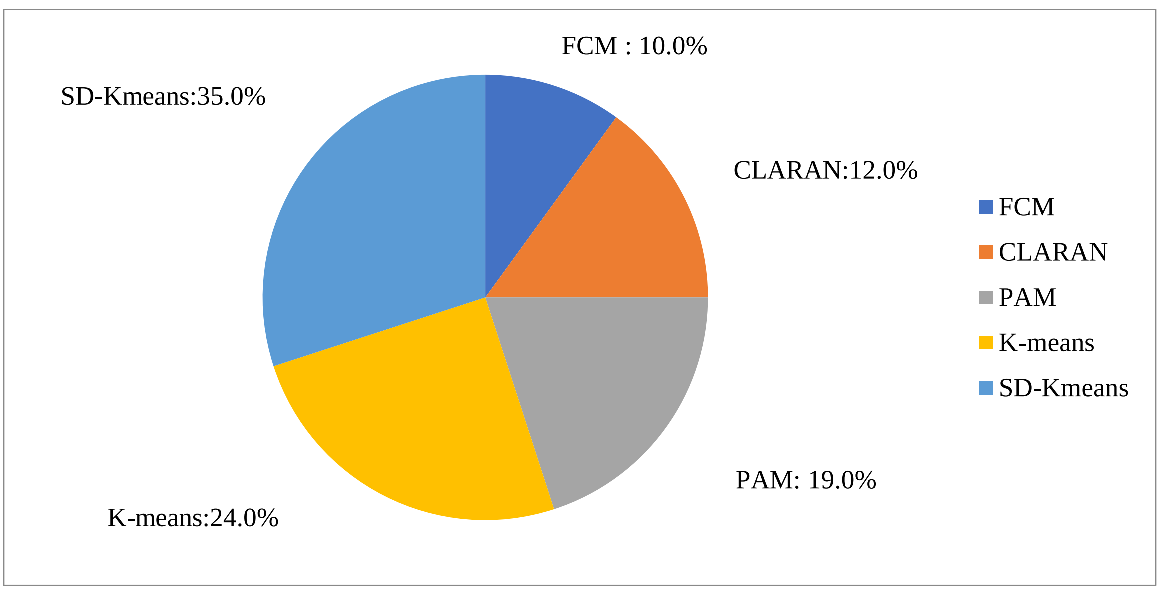
Table 3. Comparison of Th-ANFIS algorithm

Parameters	Methods		
	ANN	ANFIS	Th-ANFIS
Latency (ms)	6035	5813	2158
Load balancing	0.9862	0.7132	0.3125
Throughput	305	812	2412
Response time (ms)	4312	5581	6125
Process time (ms)	7264	6362	3812
Average waiting time (ms)	2581	2151	789

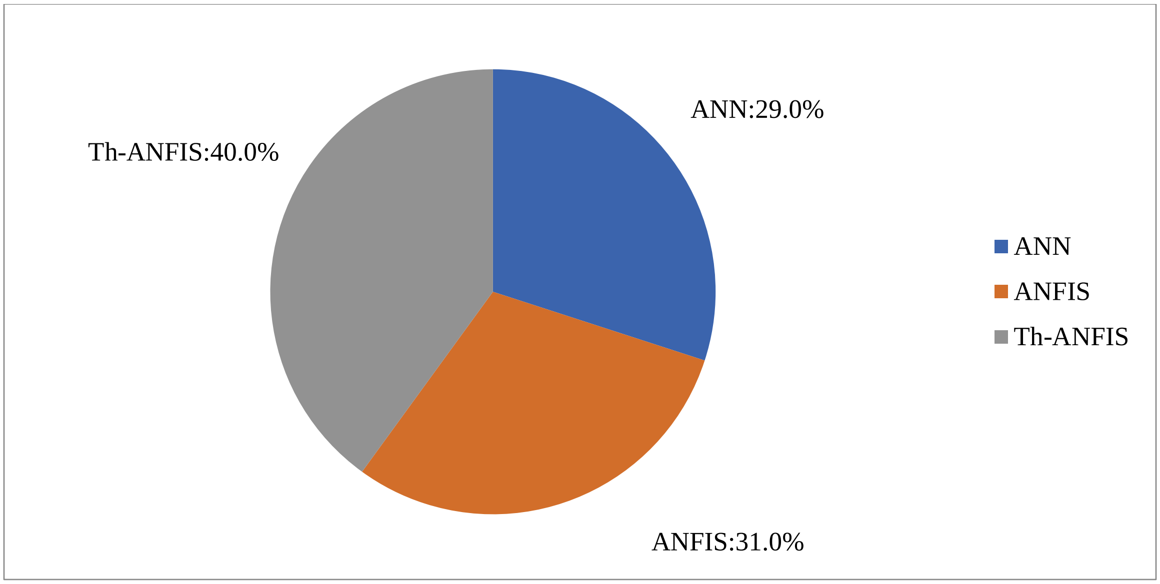
When compared to SD-Kmeans and Th-ANFIS, it is more secure due to its fuzzy structure, and it is complex enough to negotiate attacks. Table 4 compares Th-ANFIS and other models under measures like reliability, effective communication, and success rate. Table 4 depicts the fitness of models for effective routing in VANET.

Table 4. Overall comparison using reliability, effective communication and success rate

Models	Reliability	Effective Communication	Success Rate
ANN	0.79	200	0.96
ANFIS	0.84	300	0.98
Th-ANFIS	0.95	305	1



(a)



(b)

Fig. 4 (a) SD-Kmeans vs Models over security, (b) Th-ANFIS vs Models over security.

5. Conclusion

VANET transmission of large-size data blocks is proposed in this paper. The cluster head selection was performed with the novel swap, displacement, and reversion-fertile field algorithm, followed by the clustering, formed in minimal time with the supremum distance K-means clustering algorithm. Then, the optimal relay node was selected by integrating linear scaling with the Red Colobuses Monkey optimisation algorithm. Consequently, the rule-based tanh-ANFIS algorithm was adopted for optimal path selection among multiple paths, which also selects the backup path for accurate data transmission. Finally, the large-size data block is encoded by the Base64 algorithm and transmitted in the VANET network. The results show that the proposed system's performance outperforms several existing techniques in terms of clustering time, latency, throughput, and waiting time.

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