OPTIMAL SHORTEST PATH SELECTION BASE ON MULTI-CRITERIA DECISION MAKING IN VEHICULAR AD HOC NETWORK

Akmal Shah¹, Tariq Hussain*², Iqtidar Ali¹

Akmalshah253@gmail.com, uom.tariq@gmail.com, iqtidar.perviz@gmail.com

¹Institute of Computer Sciences and IT, The University of Agriculture, Peshawar, Pakistan
²School of Computer science and Information Engineering, Zhejiang Gongshang University Hangzhou, China

Correspondence Email: uom.tariq@gmail.com

ABSTRACT

Vehicular Ad-hoc Network (VANET) is the subtype of Mobile Ad-hoc Network (MANET) where every node is represented as the vehicle. Although, VANETs and MANETs have some common properties still have a difference in their properties and behaviors i.e. nodes of VANETs have unlimited resources in terms of energy, memory, and computational power. Advanced traffic management a vital role in maintaining the flow of traffic, using the latest technologies such as Intelligent Transport System (ITS). The congestion and best Optimal path selection are among the most prominent research issues in VANETs. Different researchers have worked on it and most of them such as Frictional Glow-Warm Swarm Optimization (FGWSO) and Stable CDS-Based Routing Protocol (SCRP) have solved the issue of best-path selection using shortest paths. In this research, we are selecting an optimal shortest path from all available paths through using Analytical Network Process (ANP) analysis and Multi-criteria Decision Making (MCDM) approach. The performance of the proposed Optimal Shortest Path Selection (OSPS) scheme for VANET is being evaluated by super decision-making tool. The parameters such as average speed, end to end delay, shortest path selection, Distance are compared pairwise with each other. The results are derived and shown through the limit matrix by taking four scenarios. These four scenarios are labeled by nodes B, O, K, and node Y, which are optimal nodes respectively, having the highest priority weight. The results show that the proposed OSPS scheme has minimized the end-to-end delay as compared to FGWSO and SCRP schemes.

Keywords: VANETs, AHP, ITS, MCDM, OSPS, ANP.

1. INTRODUCTION

The VANET was first time introduced in 2001 to establish a communication channel between cars, for the safety of the driver, passengers, and roads. This concept is leading to the Intelligent Transport System (ITS) (Abuashour & Kadoch, 2018). In the modern era, the need for Ad-hoc networking and communication is increasing day-by-day and the demand of the future generation. Ad-hoc networks are bringing a lot of facilities, at the same time, they are bringing more challenges to the network as well. In Ad-hoc networks like MANET and VANET, the nodes are constantly changing positions cause of their moving nature. The VANET network allows the vehicles to communicate with other cars and to the roadside units (RSU) for sending and retrieving information about the road conditions (Pu, 2020).

The focus of VANETs is accident avoidance to ensure road safety, they could be classified into the application of safety where they could save millions of lives daily, and for commercial purposes, there has non-safety applications are used (Liang et al., 2014). The reliable end-to-end path between source
and destination is almost impossible to predict and that’s why ad hoc routing protocols are used in VANETs, but routing is not the main challenge in VANETs (Chettiibi, 2020). The main challenge is the cooperation of nodes with each other because if the nodes do not forward data to each other than even the better routing protocols would give poor results (Liang et al., 2014). The IEEE 1609 (WAVE) has been working on a special type of wireless architecture for the lower layers of the protocol stack which is design for VANETs. For the physical and medium access control (MAC) they use the IEEE 802.11p standard. To prioritize the highly relevant safety messages by ensuring these messages can be switched timely in a dense scenario. In VANETs, each vehicle is equipped with a set of wireless sensors and a device called On-Board Unit (OBU) for vehicular communication. There are 4 types of VANETs communication. i. Vehicle-to-vehicle (V2V) communication (Liang et al., 2014). ii. Vehicle-to-road infrastructure (V2I) communication. iii. Vehicle-to-broadband cloud (V2B) communication (Liang et al., 2014). iv. Intra-vehicular communication (Wang et al., 2018). VANETs application can be categorized as a safety-related and non-safety-related application. Safety-related applications can be further subdivided into Collision avoidance, Driver assistance, Alert information, Safety Warning alert. Based on these categories, several potential applications could be developed, such as pre-crash sensing, lane departing alert, traffic signal violation, and others (Ghebleh, 2018). For example, i.e. Life-Critical-Safety-Application. ii. Safety Warning Application. iii. Electronic Toll Collection (ETC) (Qian & Moayeri, 2008). The non-safety application aims to improve traffic efficiency passenger comfort and commercial platform in terms of advertisement and electronic toll collection. These applications can provide weather forecasts, the latest traffic information, and provide various points of intersection. The non-safety-related application can be further subdivided into (Hua et al., 2017). Nearest vacant car park, Convenient store, Shopping mall, Hotel, Hospital, And Petrol station and many more (Cao et al., 2020; R. Hussain et al., 2020).

Shortest path selection is emerging research area in VANET, most of the researcher has worked for finding the shortest path in VANETs, with the focus on different aspects for improving communication between moving vehicle and roadside units, selecting the shortest path and minimizing the delay to reach the destination. The objective of the researchers is mostly to find the shortest path and get rid of traffic congestion that results in congestion because the path is selected by all the most drivers simultaneously. This leads to traffic congestion on the shortest path and so more time is spent to reach the destination.

- In this paper, we proposed a state-of-the-art system for VANET to select the optimal shortest path base on MCDM.
- In the proposed model we decide multi-parameter such as Distance, Speed, Direction, and End to End delay. The vehicle will reach from source to destination with minimum time and minimum End to End delay.

2. LITERATURE REVIEW

In reference (Qian & Moayeri, 2008) the author proposed a secure and application-oriented network framework design for VANETs. This framework consists of two components: an application-aware control scheme and a unified routing scheme. The author discusses several key enabling technologies that are important to practical VANET. In (Raw et al., 2012) proposed the importance of a path time and link interval in VANETs. The connection graph changes, and consecutive mobility affects the performance of VANETs. Therefore, the duration of the path will be used to predict the nature of the node having mobility property in the network. To find the time of the path in VANETs will be the main point to improve the performance of the routing protocol. Finding the path time is a challenge to operate as it focuses on too many parameters which include the density of the node, the range of the transmission, hopes numbers, and the velocity of the node. The comprehensive study shows to find the path duration in VANETs. In (Xie et al., 2018) suggested determined the Modeling and Cross-Layer Optimization of 802.11p VANETs Unicast. They were using the set of IEEE 802.11p unicast model of
the finding of optimal network factors and without sustaining of vehicle monitoring (Evangeline & Kumaravelu, 2020).

In reference (Rewadkar & Doye, 2018) recommended Fractional glowworm swarm optimization for traffic-aware routing in urban VANETs. They were making the protocol with the combination of fractional theory and GSWO known as FGWSO. (Abuashour & Kadoch, 2018) Control Overhead Reduction in Cluster-Based VANETs Routing Protocol. They were making a plane for the reduction of overhead known as the Control Overhead Reduction Algorithm (CORA). The main objectives of the plan are decreasing the overhead controlled messages in a cluster topology. Furthermore, they have also developed a new device for updating and calculation the optimal time. In (Farman et al., 2017) suggested that too in large the previous work of grid-based hybrid network deployment approach in which split and merge method has been analyzed for network topology. Through this technique the construction of topology, there have used the analytical process model to choose the head of the cluster in the wireless sensor network. Five parameters, i.e. Distance from a node, distance from the centroid, residual energy level, and the number of times that a node has been selected as cluster head and merge node for cluster head selection. The cluster head is selected on the base of the multi-criteria decision system for ANP method. The main contribution of this work is the applicability of ANP for cluster head in wireless sensor networks.

In reference (Shahidi & Ahmed, 2018) examined the analytical calculation of the distribution probability of an end to end delay in a two-way highway VANETs. The literature has shown those two-way multi-lane highways by taking into concern vehicles traveling in both directions. The calculated end-to-end delay in this probability distribution depends on the system factors, such as the distribution of speed in two ways route, range of communication, and analyzing vehicle density. The best union between the analytical calculation and the results of the simulation has led to the rightness of the proposed model. (Farman et al., 2018) discuss the objective to choose the trusted node which is optimal that has the privacy of the location of the source node in the VANETs. A different parameter is taken from the phantom node such that acceleration, speed, distance, trust, and direction make a multi-criterion for decision problems. For this problem, there is used ANP. The criteria, alternatives, and goals are identified first and then each element is compared pairwise with all the alternative elements and it’s vice versa. So the whole process of ANP is concluded in matrix limits which gives us the good and important criteria. (Liao et al., 2018) proposed that the ANP is too flexible as compared to AHP(Shrivastava et al.) to handle the MCDM issues in which the criterion dependent on each other, this problem attracted many researchers, and this consideration has been applied to many scenarios. So, it gives the low power of the intuitionistic fuzzy set in representing a positive way. The examine of ANP framework for the MCDM issues in which the comparison judgment of pairwise information over the objects are shown in the intuitionistic fuzzy number (Xu et al., 2020). First, it explains the method to decay the MCDM issues into a holarchy and the structure of the network based on which the intuitionistic fuzzy relations will be constructed with the help of pairwise comparison over the aim, conditions and clusters, and the elements. Consider that not all the IFPRs are reliable, then propose a new method to originate the priorities from the IFPRs that it is reliable or not. making a super matrix for those elements which are not dependent. To check whether the applicable and efficient of IFANP there will be implementing a method to a concern study of brand management of six golden flowers.

In reference (Kumar et al., 2018) suggested an efficient traffic control system with the help of Internet of Vehicular (IoV) technologies. The street is segmented into many maps. The algorithms which are applied to every map to find the optimal route is the Ant Colony Algorithm. Before there were used fuzzy logic for traffic intensity and calculation functions. To compare the IoV based route selection with the shortest path selection algorithms i.e. Kruskal algorithm and Prime algorithms. So, the results show that IoV has a good result for route selection. With the increasing population around the world, it has paramount, to build a Smart Grid that aims to improve the management of urban flows trusted on effective information technologies. For effective operation of smart cities Vehicular Sensing Network (Al-Turjman & Lemayian, 2020; T. Hussain et al., 2020) (VSNs) play a dangerous rule to maintain the operation of the cities. There are too many issues to solve before the introduction of VSNs which also include the concept of accurate topological analysis methods during sharing their information. VSN
based smart city model which will be intelligent applications for both public and urban flow management.

3. MULTI-CRITERIA DECISION MAKING

Thomas L. Saaty introduces the MCDM model (Chettibi, 2020) to tackle decision making for many real-world problems that can’t be constructed in the hierarchy. MCDM is used for multiple conditions decision making as shown in Figure 2. This method is used for node selection when multiple nodes in the network and we want to select a specific function node. A different technique used for research such as ANP and Analytical hierarchy Process (AHP) (Xu et al., 2020). To derive a relative priority scale of absolute numbers from individuals ANP decision-making tool. Higher-level elements depend on lower-level elements see Figure 1. ANP is a generalized form of AHP due to the dependence on hierarchy elements. ANP involves loops within the same cluster and the cycle between clusters. It also shows that concerning common property loop in a component indicates the inner independence of element (Farman et al., 2017).

![Analytical Network Process model](image1)

![Comparison of criteria and Alternatives](image2)

**Figure 1:** Analytical Network Process model

**Figure 2:** Comparison of criteria and Alternatives
3.1 COMPARISON OF CRITERIA AND ALTERNATIVES

ANP method has some steps which are given below. To achieve the optimal shortest path selection and average speed of the vehicle and analysis of the model. In the Network scenario the selection of the best suit, there will be used many applications for the decision making, such as Shortest Distance, Average Speed, and end to end delay (Farman et al., 2017). In this research, we used the ANP method for optimal path selection in VANETs within urban environments. ANP compare pairwise comparisons of nodes as well as parameters such as distance, speed, delay, and density. It will calculate the fitness function for every node on the base of the parameter to achieve their goals.

Quantitative Scale of selection: Table 1 shows the list of the different available paths. The best path will be shown in different categories.

**Table 1. Quantitative Scale of Absolute Number**

| Intensity of Importance | Definition                  | Explanation                                                                 |
|-------------------------|-----------------------------|-----------------------------------------------------------------------------|
| 1                       | Weak                        | Two actives contribute equally to the objective                             |
| 2                       | Slightly weak               | Judgment and Experience slightly favor one activity over another            |
| 3                       | Reasonable importance       | Judgment and Experience strongly favor one activity over another            |
| 4                       | Moderate                    | An activity is favored very strongly over each other its dominance in practice |
| 5                       | Strong importance           | The evidence favoring one activity over another is of the highest possible order of affirmation |
| 6                       | Very Strong                 |                                                                            |
| 7                       | Excellent                   |                                                                            |
| 8                       | Outstanding                 |                                                                            |
| 9                       | Extreme importance          |                                                                            |

Consistency Measurement: The first step in making a consistency analysis. The CM vector is input for consistency index (CI) and Consistency Ratio (CR) calculated by equation 1 and 2. The average CM vector is \( \lambda_{\text{max}} \) in Eq (2), n and RI are taken from Table 1. In Eq (1) CR is a consistency ratio, RI is a random index.

**Consistency Ratio:** To check the reliability of pairwise comparisons, it is very important to ensure the consistency between the pairwise comparisons made.

\[
\text{CR} = \frac{\text{CI}}{\text{RI}} \tag{1}
\]

**Random index:** RI is the consistency index of the random reciprocal matrix generated from the quantitative 9-point scale in table 2.

\[
\text{CI} = \frac{\lambda_{\text{max}} - n}{n - 1} \tag{2}
\]

The consistency measurement vector is input for consistency index (CI) and Consistency Ratio (CR) calculated by equation 1 and 2 (Chettibi, 2020). The average CM vector is \( \lambda_{\text{max}} \) in Eq (2), n, and RI is taken from table 1. In Eq (1) CR is a consistency ratio, RI is a random index.

**Table 2. Random consistency**

| N  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
|----|----|----|----|----|----|----|----|----|----|
| R1 | 0  | 0  | 0.52 | 0.89 | 1.11 | 1.25 | 1.35 | 1.40 | 1.45 |

3.9 Algorithms for OSPS: This is the last stage of ANP. In this stage the high priority component or element is gained by computing all the pairwise comparisons, consistency ratio, weight matrix, un-weight matrix, and super limit matrix.
Algorithm

Step 1. Initialization nodes
Step 2. each node broadcast Hello packet
Step 3. send their distance and speed
Step 4. pairwise comparison of the data of each node
Step 5. for each node
   i. if consistency ratio = > 0.1
   ii. repeat step 5
   iii. else
   iv. calculates the un-weighted matrix
   v. weighted matrices
   vi. limit matrices
   vii. then selects the best path

4. STATE-OF-THE-ART PROPOSED MODEL

The proposed model analysis and all the requirements carried on Multiple Criteria Decision Making (MCDM). The proposed system choosing an optimal, shortest, and ultimately fastest path base on MCDM in VANETs. The technique we will use in this system will be MCDM. The decision will be taken according to the parameters. The choice of path or path selection will be according to the parameters we choose and define. For example, if we choose average speed, shortest distance & lower traffic density as a parameter, then the path with the best average speed, lower traffic density, and shortest distance will be selected. Our goal is to get to the destination through the optimal path in the shortest time & with minimal traffic possible. The role of MCDM will be to analyze and rank all the paths using the information from VANETs and then a decision will be made according to those values. We will also use the Analytical Network Process (ANP). ANP is a decision-making method that is used to make decisions in very complex environments.

Table 3: Parameters for Mathematical Model

| Parameter     | Range      | Values          | Explanation                                    |
|---------------|------------|-----------------|------------------------------------------------|
| Distance      | 1m-9m      | 1m= 10m         | 1 for low distance                             |
|               |            |                 | 9 for long distance                            |
| Average Speed | 1km-9km    | 1km=10km        | 1 is of minimal value for low speed            |
|               |            |                 | 9 is the maximum value for high speed          |
| Delay         |            | 1sec= 0.5 Sec   |                                                |
| Direction     |            | 1 to 9          | 1 to 5 is the same direction and 6 to 9 in     |
|               |            |                 | the opposite direction                          |

4.1 Simulation scenario

The instrument used for simulation of MCDM will be Sd mod which is a multi-criteria decision-making numerical calculating setting. as shown in Table 4, therefore around one million handlers are using throughout academia and industry. Sd mod is generally used in all fields of applied mathematics, also use in learning and for research purposes in universities. Sd mod users initiated from numerous education, engineering, science, economics, and many more.

Table 4: Simulation Parameters

| Parameters          | Values       |
|---------------------|--------------|
| Simulation time     | 1000 second  |
| Simulation area     | 1000m x 1000m|
| No of vehicles      | 20-80        |
| Range of transmission| 300-400m    |
| Bandwidth           | 2 Mbps       |
| Average speed       | 40-90 km/h   |
### Table 1: Frequency, Speed, and DSRC Protocol Range

| Minimum-Maximum speed | 10-90 km/h |
|------------------------|------------|
| Frequency (Sourav 2013) & Cheng (2007) | 5.9 GHz |
| DSRC protocol range | 1000 |

4.1.1. **Average Speed:** The average speed will be taken from the node which is the forwarder node in the current time as shown in eq 3.

\[
(Average \ Speed) = \frac{Distance}{Time} \tag{3}
\]

4.1.2 **Shortest Path Selection:** The shortest path will be selected in all available paths on which have high speed and the shortest distance from the source to destination. In the shortest path, we select the next-hop node, which is the shortest distance to the destination and delivers a smaller number of hops. Likewise, in the less remaining distance forwarding, select the next-hop node, that is nearest to the destination and has a less remaining distance to the destination (Raw et al., 2012).

4.1.3 **End to End Delay:** The concern delay will use for the time taking, which moves the vehicles from the source to destination nodes. The single router End-to-end delay, explore the total delay between the sender and receiver. To become manage on the opinion; assume there are N-1 routers amongst the source and destination host (Rewadkar & Doye, 2018).

\[
(EED = (\text{start time} - \text{ended time}) \tag{4}
\]

4.1.4 **Distance:** It will show the length of choosing the way for the vehicles which will reach the destination. The equation for a distance as given below (Rewadkar & Doye, 2018). As we know that in physic the distance formula is

\[
(S = VT) \tag{5}
\]

\[
(S = \text{distance}, V = \text{velocity and } T = \text{time}) \tag{6}
\]

4.1.5 **Traffic Direction:** The node in the opposite direction will have low priority as compared to the one in the same direction. This approach uses direction priority instead of a pre-select path to forward packets toward a destination. It selects the next hop based on the preferred direction and location information in the current situation. It predicts the directions of vehicles’ movement. But it doesn’t predict the future environment change (Rewadkar & Doye, 2018).

5. **EXPERIMENTAL RESULT**

The above-mentioned chapter defines a technique for optimal path selection in VANETs. VANETs are the combination of vehicle devices which is a peer to peer connection to each other. All the vehicles were connected and share their information with each other. There are four types of communication V2V, V2I, V2B (Rehman et al., 2020; Sateesh & Zavarsky, 2020), and intra-vehicular communication (Mishra et al., 2020). This is briefly discussed in chapter number 1. In today's era, the need for Ad-hoc networking and communication is increasing day by day and is also the demand of the time. Ad-hoc networking is bringing a lot of facilities to us, but at the same time, they are bringing more challenges to the network as well. In Ad-hoc networks like MANET and VANET, the nodes are constantly changing their position because of their moving nature. This results in constantly changing scenarios.

The VANET was first introduced in the year 2001 for communication between cars for the safety of the driver, passengers, and roads. This concept is leading to the Intelligent Transport System (Quessada et al., 2020) (ITS). The VANET network allows the vehicles to communicate with other cars and to the roadside units for sending and retrieving information about the road conditions. In this research study, we proposed a technique for optimal path selection in VANETS. The proposed technique considers V2V and V2I Network. They will select the path which has minimum distance, high average speed, and
takes less time to reach from source to destination. So that path will be considered as an optimal path in the current network. If the path has a low distance from the source to destination and they have less average speed and high delay so that path will not consider as an optimal path. Because they didn’t satisfy our criteria. In this section, we are going to discuss the analysis and its result based on our parameter. Which as distance, average speed, delay, and direction. The basic data is consisting of 26 nodes. All the data will be compared with each other based on MCDM and ANP. After the analysis they will show the optimal path which has low distance, having high average speed, minimum delay, and the same direction.

5.1 PROPOSED MODEL FOR OPTIMAL SCENARIO

The proposed model is using for optimal path selection from source to destination in complex environments in VANETs. The source node will broadcast a hello packet to very nodes which is near to source nodes. The other vehicle devices give a reply which will show the distance, average speed, delay, and direction. This thesis proposed to use a multi-criteria decision making (MCDM) tool called Analytical Network Process (ANP) to efficiently select the optimal path. the ANP is a multi-criteria method used for decision making and selecting a suitable choice in a complex environment. In the proposed network scenario as shown in Figure 3, it is considered when a source node going to their destination and they have multi-paths. So, they send a beacon message to all vehicles to check their distance, direction, delay, and speed of the particular vehicle.

![Figure 3: a proposed scenario for optimal path selection](image-url)
• Node values
Once the parameter weight was decided the step by step ANP process for optimal path selection followed. The process model has used the given value in table 5. So, the make N*N matrix for pairwise comparison. The relative weight of the parameters and nodes are shown as $C_{ij}$, where “i” represent rows and “j” for the column. If the relative importance of component $c_i$ is equal to component $C_j$ then $C_{ij}=1, C_{ji}=1$. As shown in Table 5 the weight at diagonal is 1 represents the same importance.

| Nodes | Speed | Distance | Direction | Delay |
|-------|-------|----------|-----------|-------|
| A     | 7     | 8        | 5         | 8     |
| B     | 8     | 5        | 3         | 7     |
| C     | 6     | 5        | 6         | 9     |
| D     | 5     | 6        | 8         | 8     |
| E     | 8     | 8        | 4         | 9     |
| F     | 5     | 6        | 8         | 8     |
| G     | 6     | 5        | 5         | 9     |
| H     | 8     | 7        | 2         | 9     |
| I     | 7     | 5        | 6         | 8     |
| J     | 6     | 2        | 8         | 9     |
| K     | 8     | 5        | 5         | 9     |
| L     | 6     | 3        | 7         | 9     |
| M     | 5     | 3        | 4         | 7     |
| N     | 5     | 2        | 5         | 5     |
| O     | 6     | 4        | 5         | 8     |
| P     | 3     | 2        | 3         | 8     |
| Q     | 6     | 3        | 2         | 8     |
| R     | 2     | 3        | 1         | 5     |
| S     | 2     | 2        | 2         | 2     |
| T     | 3     | 3        | 3         | 4     |
| U     | 5     | 2        | 6         | 9     |
| V     | 6     | 3        | 5         | 7     |
| W     | 5     | 3        | 4         | 8     |
| X     | 6     | 3        | 5         | 4     |
| Y     | 6     | 4        | 3         | 9     |
| Z     | 3     | 6        | 1         | 2     |

5.2 GRAPHICAL REPRESENTATION OF ANP
Once the parameter weight was decided the step by step ANP process for optimal path selection followed. The process model has used the given value in table 3 on to N×N matrix for pairwise comparison. The relative weight of the parameter and nodes are shown as $C_{ij}$, where “i” represent rows and “j” for the column. If the relative importance of component $c_i$ is equal to component $C_j$ then $C_{ij}=1, C_{ji}=1$. As shown in table 3 the weight at diagonal is 1 represents the same importance.

5.3 N×N MATRIX PAIRWISE COMPARISON
In pairwise comparison, all the parameter values will be compared with each other, but the same parameter will be equal to 1. As we know that delay compares with a delay so they will be equal to 1 and so on. As shown in the metric.

Matrix 1: N×N pairwise comparison

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     |           |          |       |
| Direction | 1         |          |          |       |
| Distance |          | 1        |          |       |
| Speed   |          |          | 1        |       |

5.3.1 Pairwise Comparison of the parameter concerning Node A
In these metrics, the alternative value compared concerning criteria and add all value of each column. After this, each value of the cell will be divided by its total value of the column as shown in the below table. So, they will come to the normalization form, as shown in Matrix 2 to Matrix 27.

Matrix 2. Normalization process

|       | Delay     | Direction | Distance | Speed     |
|-------|-----------|-----------|----------|-----------|
| Delay | \( \frac{1}{2.75} = 0.3636 \) | \( \frac{4}{12} = 0.3333 \) | \( \frac{1}{2.75} = 0.3636 \) | \( \frac{2}{5.333} = 0.375 \) |
| Direction | 0.25 | 0.0909 | 0.25 | 0.0909 |
| Distance | 2.75 | 1 | 2.75 | 1 |
| Speed | 2.75 | 0.1818 | 2.75 | 0.1818 |
| CR    | 0.007747 |

5.3.2 Pairwise Comparison of the parameter concerning Node B its reciprocal value which shows in the form of decimal and the consistency ratio. The consistency ratio must be less than 0.1.

Matrix 3. Comparison of Parameter concerning Node B

|       | Delay     | Direction | Distance | Speed     |
|-------|-----------|-----------|----------|-----------|
| Delay | 1 | 5 | 5 | 2 |
| Direction | 0.2 | 1 | 0.1666 | 0.1666 |
| Distance | 0.2 | 6 | 1 | 1 |
| Speed | 0.5 | 6 | 1 | 1 |
| CR    | 0.013726 |

Matrix 4. Pairwise Comparison of Parameter concerning Node C

|       | Delay     | Direction | Distance | Speed     |
|-------|-----------|-----------|----------|-----------|
| Delay | 1 | 4 | 5 | 4 |
| Direction | 0.25 | 1 | 0.1666 | 1 |
| Distance | 0.2 | 6 | 1 | 2 |
| Speed | 0.25 | 1 | 0.5 | 1 |
| CR    | 0.040218 |

Matrix 5. Pairwise Comparison of Parameter concerning Node D

|       | Delay     | Direction | Distance | Speed     |
|-------|-----------|-----------|----------|-----------|
| Delay | 1 | 1 | 3 | 4 |
| Direction | 0.25 | 1 | 0.5 | 4 |
| Distance | 0.3333 | 0.3333 | 1 | 2 |
| Speed | 0.25 | 1 | 0.5 | 1 |
| CR    | 0.007755 |

Matrix 6. Pairwise Comparison of Parameter concerning Node E

|       | Delay     | Direction | Distance | Speed     |
|-------|-----------|-----------|----------|-----------|
| Delay | 1 | 6 | 2 | 2 |
| Direction | 0.1666 | 1 | 0.2 | 0.2 |
| Distance | 0.5 | 5 | 1 | 1 |
| Speed | 0.5 | 5 | 1 | 1 |
| CR    | 0.012314 |
**Matrix 7. Pairwise Comparison of Parameter concerning Node F**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 1         | 3        | 4     |
| Direction    | 1     | 1         | 3        | 4     |
| Distance     | 0.3333| 0.3333    | 1        | 2     |
| Speed        | 0.25  | 0.25      | 0.5      | 1     |
| CR           | 0.007755|

**Matrix 8. Pairwise Comparison of Parameter concerning Node G**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 5         | 5        | 4     |
| Direction    | 0.2   | 1         | 1        | 0.5   |
| Distance     | 0.2   | 1         | 1        | 2     |
| Speed        | 0.25  | 2         | 0.5      | 1     |
| CR           | 0.072757|

**Matrix 9. Pairwise Comparison of Parameter concerning Node H**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 8         | 3        | 2     |
| Direction    | 0.125 | 1         | 0.16666  | 0.142857|
| Distance     | 0.3333| 7         | 1        | 2     |
| Speed        | 0.5   | 7         | 0.5      | 1     |
| CR           | 0.084917|

**Matrix 10. Pairwise Comparison of Parameter concerning Node I**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 3         | 4        | 2     |
| Direction    | 0.3333| 1         | 0.5      | 0.5   |
| Distance     | 0.25  | 2         | 1        | 0.3333|
| Speed        | 0.5   | 2         | 3        | 1     |
| CR           | 0.058981|

**Matrix 11. Pairwise Comparison of Parameter concerning Node J**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 2         | 8        | 4     |
| Direction    | 0.5   | 1         | 7        | 3     |
| Distance     | 0.125 | 0.142857  | 1        | .2    |
| Speed        | 0.25  | 0.3333    | 5        | 1     |
| CR           | 0.045888|

**Matrix 12. Pairwise Comparison of Parameter concerning Node K**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 5         | 5        | 2     |
| Direction    | 0.2   | 1         | 1        | 1     |
| Distance     | 0.5   | 1         | 1        | 1     |
| Speed        | 0.5   | 1         | 1        | 1     |
| CR           | 0.040122|

**Matrix 13. Pairwise Comparison of Parameter concerning Node L**

|              | Delay | Direction | Distance | Speed |
|--------------|-------|-----------|----------|-------|
| Delay        | 1     | 4         | 5        | 3     |
| Direction    | 0.25  | 1         | 0.5      | 0.5   |
| Distance     | 0.2   | 2         | 1        | 0.3333|
| Speed        | 0.3333| 2         | 3        | 1     |
| CR           | 0.062451|
Matrix 14. Pairwise Comparison of Parameter concerning Node M

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 3         | 7        | 4     |
| Direction | 0.3333 | 1         | 5        | 2     |
| Distance | 0.14285 | 0.2       | 1        | 0.25  |
| Speed   | 0.25  | 0.5       | 4        | 1     |
| CR      | 0.039428 |

Matrix 15. Pairwise Comparison of Parameter concerning Node N

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 1         | 4        | 1     |
| Direction | 1     | 1         | 4        | 1     |
| Distance | 0.25  | 0.25      | 1        | 0.25  |
| Speed   | 1     | 1         | 4        | 1     |
| CR      | 0.000 |

Matrix 16. Pairwise Comparison of Parameter concerning Node O

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 3         | 4        | 3     |
| Direction | 0.3333 | 1         | 0.5      | 1     |
| Distance | 0.25  | 2         | 1        | 2     |
| Speed   | 0.3333 | 1         | 0.5      | 1     |
| CR      | 0.054431 |

Matrix 17. Pairwise Comparison of Parameter concerning Node P

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 6         | 7        | 6     |
| Direction | 0.01666 | 1         | 0.5      | 1     |
| Distance | 0.14285 | 2         | 1        | 2     |
| Speed   | 0.1666 | 1         | 0.05     | 1     |
| CR      | 0.034477 |

Matrix 18. Pairwise Comparison of Parameter concerning Node Q

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 7         | 6        | 3     |
| Direction | 0.142857 | 1         | 0.5      | 0.2   |
| Distance | 0.166667 | 2         | 1        | 0.25  |
| Speed   | 0.33333 | 5         | 4        | 1     |
| CR      | 0.037451 |

Matrix 19. Pairwise Comparison of Parameter concerning Node R

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 5         | 3        | 4     |
| Direction | 0.2 | 1         | 0.25     | 1     |
| Distance | 0.3333 | 3         | 1        | 2     |
| Speed   | 0.25  | 2         | 0.5      | 1     |
| CR      | 0.019189 |

Matrix 20. Pairwise Comparison of Parameter concerning Node S

|        | Delay | Direction | Distance | Speed |
|--------|-------|-----------|----------|-------|
| Delay  | 1     | 1         | 1        | 1     |
| Direction | 1 | 1         | 1        | 1     |
| Distance | 1 | 1         | 1        | 1     |
| Speed   | 1 | 1         | 1        | 1     |
| CR      | 0.0000 |
Matrix 21. Pairwise Comparison of Parameter concerning Node T

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 2         | 2        | 2     |
| Direction | 0.5   | 1         | 1        | 1     |
| Distance  | 0.5   | 1         | 1        | 1     |
| Speed   | 0.5   | 1         | 1        | 1     |
| CR      | 0.0000|

Matrix 22. Pairwise Comparison of Parameter concerning Node U

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 4         | 8        | 5     |
| Direction | 0.25  | 1         | 5        | 2     |
| Distance  | 0.125 | 0.2       | 1        | 0.25  |
| Speed   | 0.2   | 0.5       | 4        | 1     |
| CR      | 0.051022|

Matrix 23. Pairwise Comparison of Parameter concerning Node V

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 3         | 5        | 2     |
| Direction | 0.3333| 1         | 3        | 2     |
| Distance  | 0.2   | 0.3333   | 1        | 0.25  |
| Speed   | 0.5   | 0.5       | 4        | 1     |
| CR      | 0.065797|

Matrix 24. Pairwise Comparison of Parameter concerning Node W

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 5         | 6        | 4     |
| Direction | 0.2   | 1         | 0.5      | 0.5   |
| Distance  | 0.1666| 2         | 1        | 0.3333|
| Speed   | 0.25  | 2         | 3        | 1     |
| CR      | 0.065517|

Matrix 25 Pairwise Comparison of Parameter concerning Node X

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 0.5       | 2        | 0.3333|
| Direction | 2     | 1         | 3        | 0.5   |
| Distance  | 0.5   | 0.3333   | 1        | 0.25  |
| Speed   | 3     | 2         | 4        | 1     |
| CR      | 0.011625|

Matrix 26 Pairwise Comparison of Parameter concerning Node Y

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 4         | 6        | 4     |
| Direction | 0.25  | 1         | 3        | 1     |
| Distance  | 0.1666| 0.3333   | 1        | 0.3333|
| Speed   | 0.25  | 1         | 3        | 1     |
| CR      | 0.022793|

Matrix 27 Pairwise Comparison of Parameter concerning Node Z

|       | Delay | Direction | Distance | Speed |
|-------|-------|-----------|----------|-------|
| Delay | 1     | 6         | 5        | 2     |
| Direction | 0.1666| 1         | 0.5      | 0.2   |
| Distance  | 0.2   | 2         | 1        | 0.25  |
| Speed   | 0.5   | 5         | 4        | 1     |
| CR      | 0.022826|
The proposed model used value given in Table 5 into n × n matrix for pairwise comparison relative weights of parameter and nodes are shown as $C_{ij}$, where “i” represents the row and “j” is for the column. If the relative importance of component $C_i$ is equal to component then $C_{ij} = 1$, as shown in table 3 the weights at diagonal, are 1 representing the same importance. The below comparison of the parameters concerning Nodes. And it’s reciprocal.

5.4 COMPARISONS CONCERNING "DIRECTION" IN "ALTERNATIVES" NODES
All nodes are compared concerning the direction and its reciprocal. We have 26 nodes which are started from A and ending with Z. as shown in Table 5. The nodes compare with has self they will be equal to 1. Where “i” represent rows and “j” represents a column. As we know that the “B” value is 3 in 1st row so we divide 1 on 3 so the reciprocal value is equal to (0.3333 ) and so on in this process, they will apply to each node.

5.5.1 PAIRWISE COMPARISON OF NODES CONCERNING PARAMETER DELAY
Figure 4 shows the pairwise comparison of all nodes concerning “Delay” this is an important parameter in this research work. All 26 nodes will be pairwise comparing with each other. 1st they will compare and after the comparison, they will go to the next step which is the unweight supermatrix. Then they were going to the weighted supermatrix after they will go to the last step which has to limit the supermatrix there are calculated a weighted matrix and take a power of 2k to achieve stable values which make a limit matrix, where k is any arbitrary numbers. In this table nodes B, K, O, and Y are optimal nodes that have low End to End delay concerning other nodes in the present topologies.

![Figure 4: Pairwise comparison of Nodes with respect to parameter "Delay"](image)

5.5.2 PAIRWISE COMPARISON OF NODES CONCERNING PARAMETER DIRECTION
Figure 5 shows the pairwise comparison of all nodes concerning direction. All 26 nodes will be pairwise comparing with each other. 1st they will compare with each other give us their reciprocal values. And after the comparison, they will go to the next step which is the unweight supermatrix. Then they were going to weight the supermatrix after that go to the last step limit supermatrix where are calculated a weighted matrix and takes a power of 2k to achieve a stable value which makes a limit matrix, where k is any arbitrary numbers.
5.5.3 PAIRWISE COMPARISON OF ALL NODES CONCERNING DISTANCE

Figure 6 shows the relation of every node with each other. They will show which node is optimal. The node will be optimal which have the highest value. As we know that node B, K, O, and Y is optimal nodes in the present topology. Our first topology consists of 6 nodes which are a, b, c, d, e, f. The next 6 nodes are the 2nd topology. In 3rd topology has consisted of the next 6 nodes and the last topology have 7 nodes,

5.5.4 PAIRWISE COMPARISON OF NODES CONCERNING SPEED

In Table 5 the all nodes were pairwise comparing with each other, based on speed and it’s all steps of ANP which also mention in the above section 5.5.1, as shown in figure 7.
5.6 PAIRWISE COMPARISON OF NODES CONCERNING OPTIMAL

In figure 8 show a combination of all parameters and nodes. They show which nodes are optimal. Values of figure 8 have come from the combination of all parameter which is average speed, distance, direction, and delay. After the completion of the whole process of ANP so these values are the output values of our topology the following values have come from the power of 2k and k is an arbitrary number. The number which makes the value stable. So that is the stable value of the following nodes. They show the priority values. If the value is high so its priority will be high and vice versa. In this research, we proposed four Topologies. We need four optimal nodes to reach from source to destination. So, in the first Topology, 6 nodes are A, B, C, D, E, and F. As we know that in this Topology the B node is optimal because they have a high priority value as compare to the other 5 nodes. In Topology second have G, H, I, J, K, and L. So in this Topology nodes k have high priority. In third Topology M, N, O, P, Q, and R. So in this Topology o is an optimal node and the last topology we have seven nodes S, T, U, V, X, and Y. In last Topology node Y have high priority value so node Y is an optimal node. The path on which node B, K, O, and Y is traveling so that path will consider is an optimal path.

![Figure 7 Pairwise comparison of Nodes concerning parameter “Speed”](image1)

![Figure 8: Pairwise comparison of Nodes concerning parameter “Optimal”](image2)
### Table 6: Un-Weighted table

| Alternative | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|-------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delay       | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 |
| Direction   | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Distance    | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Speed       | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

### Table 7: Weight Super Matrix

| Alternative | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|-------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delay       | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 |
| Direction   | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Distance    | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Speed       | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

### Table no 8: Limit matrix of OSPS

| Alternative | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|-------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delay       | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 |
| Direction   | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Distance    | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Speed       | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
• TOPOLOGY NUMBER 1

This section discussed the scenario numbers, we have a “Z” vehicle that wants to reach from source to destination with minimum time. mentioned some criteria for this if they satisfy our criteria so they will be considered as an optimal path and they will be reached from source to destination. Our criteria such as average speed, minimum distance, direction, and delay. So, node “Z” will send a hello message to all nodes which are present in its range. So, all the present node gives reply message in this message they will send their speed distance delay and direction. So, node “Z” will find the optimal node and all present nodes. So, the following graph shows the 1st scenario. There are 6 nodes which as nodes (A, B, C, D, E, and F). Node “Z” have sent a hello packet to all node and they give a reply message. Node A value is 0.017, node B value is 0.022, node C value 0.016, node D value 0.017, node E value is 0.021 and node F value 0.017. The values are come after doing all the processes of ANP. The above value calculated a weighted matrix and take a power of 2k to achieve a stable value which makes a limit matrix, where k is any arbitrary numbers. The limit matrix is a resultant matrix where priority is the weight. So, in this scenario, node B is an optimal node and the path on which node B is traveling so that path is optimal because they have a high priority value as shown in Figure 9.

![Figure 9: Resultant table for Topology number 1](image)

• TOPOLOGY NUMBER 2

In the 2nd Topology when the node “Z” covers the distance on which the B nodes are traveling. So, when they reach the next intersection so they send again hello packet to the next nodes which are present in its range. So now the present nodes are G, H, I, J, K, and L. so the nodes “Z” will send a hello packet so the receiver nodes will send a reply message as we discuss in scenario number 1. So, node G value is 0.014, node H value is 0.018, node I value is 0.014, node J value is 0.019, node K value is 0.028 and node L value is 0.017. So, we know that this table shows the k node is optimal also this path will consider is optimal because they have high priority as shown in Figure 10.

![Figure 10: Resultant table for Topology number 2](image)
- **TOPOLOGY NUMBER 3**

In the 3\textsuperscript{rd} Topology when the node “Z” covers the distance on which the K nodes are traveling. So now the present nodes are M, N, O, P, Q, and R. so the nodes “Z” will send a hello packet so the receiver nodes will send a reply message as we discuss in scenario number 1. So, node M value is 0.007, node N value is 0.006, node O value is 0.014, node P value is 0.006, node Q value is 0.008 and node R value is 0.003. So, we know that this table shows that the O node is optimal also this path will consider is optimal because they have high priority as shown in Figure 11.

![Figure 11: Resultant table for Topology number 3\textsuperscript{th}](image)

- **TOPOLOGY NUMBER 4**

In the 4\textsuperscript{th} Topology when the node “Z” covers the distance on which the O nodes are traveling. So, when they reach the next intersection so they send again hello packet to the next nodes which are present in its range. So now the present nodes in S, T, U, V, W, X, and Y. the nodes “Z” will send a hello packet so the receiver nodes will send a reply message as we discuss in scenario number 1. So, node S value is 0.002, node T value is 0.004, node U value is 0.013, node V value is 0.009, node W value is 0.008, node X value is 0.007 and node Y value is 0.015. So, we know that figure 12 shows the Y node is optimal also this path will consider is optimal because they have high priority.

![Figure 12: Resultant table for Topology number 4\textsuperscript{th}](image)
Figure 13: Pairwise comparison of nodes concerning parameter Delay

Figure 13 shows the pairwise comparison of all nodes concerning “Delay” this is an important parameter in this research work. All 26 nodes will be pairwise compared with each other. 1<sup>st</sup> they will compare and after the comparison, they will go to the next step which is the unweight supermatrix. Then they will go to the weighted supermatrix after they will go to the last step limit supermatrix there is calculated a weighted matrix and take a power of 2<sup>k</sup> to achieve a stable value which makes a limit matrix, where k is any arbitrary numbers.

### 5.6.5 PAIRWISE COMPARISON OF NODES CONCERNING OPTIMAL

In figure 4 is the combination of all parameters and all nodes. They will show which nodes are optimal. The values of this figure come from the combination of all parameter which is average speed, distance, direction, and delay. They show the priority values. If the value is high so its priority was high and vice versa. In this research, we have four scenarios. We need four optimal nodes to reach from source to destination. So, we have in the first scenario 6 nodes which are A, B, C, D, E, and F. as we know that in this scenario the B node is optimal because they have a high priority value as compare to the other 5 nodes. In the scenario, the second has G, H, I, J, K, and L. so in this scenario nodes K have high priority. In the third scenario M, N, O, P, Q, and R. so in this scenario O is an optimal node and in the last scene, we have seven nodes S, T, U, V, W, X, and Y. in last scenario node Y have high priority value so node Y is an optimal node. The path on which nodes B, K, O, and Y is traveling so that path will consider is an optimal path.

❖ Comparison of OSPS with FGWSO and SCRP

- **FGWSO**: Fractional Glowworm Swarm Optimization
- **SCR: Stable CDS-Based Routing Protocol**
- **OSPS**: Optimal Shortest Path Selection

| Table 9: Comparison of OSPS with the other FGWSO and SCRP methods (step 1) |
|---------------------------------------------------------------|
| Name of the Method | Average End-to-End Delay | Average Distance |
|---------------------|--------------------------|------------------|
| FGWSO               | 6.6953 seconds           | 18.65m           |
| SCRP                | 12.4355 seconds          | 54.8400m         |
| OSPS                | 1.5 seconds              | 50m              |
Setup 1: The Average end to end delay and average distance for simulation setup 1. During this step, the average end-to-end delay values in the optimal path selected by the existing methods, FGWSO and SCRP are 6.6593 and 12.4355 seconds respectively shown in figure 9, whereas the proposed OSPS method attained the average end to end delay value of 1.5 seconds. Likewise, for average distance, the existing methods FGWSO and SCRP selected the path with average distance values of 18.65m and 54.8400m, respectively, whereas the proposed OSPS resulted in selecting the average distance value of 50m. Similarly, for the entire time considered for the experimentation, the proposed OSPS selected the optimal route path with minimal end to end delay and with a high average distance. As we know that when we find End to End delay is per meter so the delay will be divided by the total distance. So, FGWSO has 0.35 per meter, SCRP has 0.226 and OSPS has 0.03 End to End delay per meter as shown in Table 9.

| Name of the Method | Average End-to-End Delay | Average Distance |
|--------------------|--------------------------|------------------|
| FGWSO              | 8.41 seconds             | 17.76m           |
| SCRP               | 12.008 seconds           | 53.0092m         |
| OSPS               | 0.5 seconds              | 50m              |

Setup 2: The Average end to end delay and average distance for simulation setup 2. During this step, the average end to end delay values in the optimal path selected by the existing methods, FGWSO and SCRP are 8.41 and 12.008 seconds respectively, whereas the proposed OSPS method attained the average end to end delay value of 0.5 seconds. Likewise, for average distance, the existing methods FGWSO and SCRP selected the path with average distance values of 17.76m and 53.0092m, respectively, whereas the proposed OSPS resulted in selecting the average distance value of 50m. Similarly, for the entire time considered for the experimentation, the proposed OSPS selected the optimal route path with minimal end to end delay and with a high average distance. As we know that when we find End to End delay is per meter so the delay will be divided by the total distance. So, FGWSO has 0.473 per meter, SCRP has 0.226 and OSPS has 0.01 End to End delay per meter as shown in Table 10.

| Name of the Method | Average End-to-End Delay | Average Distance |
|--------------------|--------------------------|------------------|
| FGWSO              | 9.72 seconds             | 17.39m           |
| SCRP               | 12.88 seconds            | 53.67m           |
| OSPS               | 3 seconds                | 40m              |

Setup 3: The Average end to end delay and average distance for simulation setup 3. During this step, the average end to end delay values in the optimal path selected by the existing methods, FGWSO and SCRP are 9.72 and 12.8810 seconds respectively, whereas the proposed OSPS method attained the average end to end delay value of 3 seconds. Likewise, for average distance, the existing methods FGWSO and SCRP selected the path with average distance values of 17.3962m and 53.6730m, respectively, whereas the proposed OSPS resulted in selecting the average distance value of 40m. Similarly, for the entire time considered for the experimentation, the proposed OSPS selected the optimal route path with minimal end to end delay and with a high average distance. As we know that when we find End to End delay is per meter so the delay will be divided by the total distance. So, FGWSO has 0.529 per meter, SCRP has 0.223 and OSPS has 0.075 End to End delay per meter shown in Table 11.

| Name of the Method | Average End-to-End Delay | Average Distance |
|--------------------|--------------------------|------------------|
| FGWSO              | 9.72 seconds             | 17.39m           |
| SCRP               | 12.88 seconds            | 53.67m           |
| OSPS               | 3 seconds                | 40m              |

5.5 DISCUSSIONS

we used MCDM and ANP method for the selection of an optimal path from source to destination based on a parameter such as average speed, distance, direction, and delay. The main objective of the research is optimal path selection. The path will be considered optimal which fill our criteria. The main point in this research is the selection of paths that have high speed, minimum distance, low delay, and have the
same direction on the base of V2V in VANETs. So, the ANP has main steps, 1st one is the goal (Optimal path Selection) the 2nd one is criteria which means (parameter) and the last section is alternatives means (Nodes. In the above network, which is design for optimal path selection, the alternative is compared pairwise concerning all nodes as well as to the 9-point scale as shown in table 1. All the parameters are dependent upon each other and compare concerning others. On the base of the Saaty scale, we will check the consistency ratio, whether the comparison is consistent or not. An un-weighted super matrix is generated consisting of the outcome of all Eigenvector obtained from pairwise comparisons. The un-weight super matrix shown in Table 6, is transformed into a weighted super matrix see in Table 7, by making each column stochastic. The weighted super matrix see in Table 8, is raised to the power of 2k to get stable values to form the limit matrix. Where k is an arbitrary number. The limit matrix is a resultant matrix having the final priority weights. Resultant graph of different Scenarios concerning Nodes. The path in which the optimal node is traveling so this path is the optimal path because they have high speed and low distance. We have 4 Scenarios so they will show 4 optimal nodes. Each Scenario has its optimal node in the simulation time.

6. CONCLUSION

In this research, the main idea of the research work is to select the optimal path in VANETs under the condition of parameter and its criteria which we define in sections 3 and 5 that are MCDM and ANP. In this research, the main problem of selecting the optimal shortest path selection in all available paths in VANETs using the ANP analysis for selecting the best path. ANP is a multi-criteria decision tool that selects the path under the base of multi-parameter such as average speed, distance, direction, and delay, where criteria are considered for selection. All the nodes and parameters will be pairwise compared with each other using saaty9 points quantitative scale. The result shows through the limit matrix, that node k is the optimal node that having high priority weight. In topologies, we have 4 scenarios from source to the destination and 4 interactions. So, when the node “Z” is traveling from source to destination, they were passed from these intersections. In this case, one path is optimal from source to destination which followed by node B, node K, node O, and the last node is Y. according to simulation result B, K, O, Y are the optimal path.

Future Direction: After the complete study of VANETs and ANP, the future work in this research is that this idea can easily implement in MANETs and Body area networks. Security is the other direction to secure the whole network.

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