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CREATING AN OPTIMAL AD HOC NETWORK IN INTERNET OF VEHICLES WITH ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Today, the connections between vehicles and their surroundings are limited. However, with the development of the Internet of Things (IoT) and the new technological developments, there have been serious progresses in the Internet of Vehicles (IoV), and vehicle manufacturers have made various studies in this subject. However, these studies generally suggest a link between cars and users. Today, most of the studies do not refer to the connection between vehicles or the vehicle and its environment, so it is necessary to carry out such a study. In this study, it is aimed to establish an ad-hoc network between vehicles and their environments to optimize the number of vehicles to be accommodated in this temporary network. However, it is aimed to share traffic flow and speed information by communicating the vehicles in urban traffic. In this sense, there is no speed and direction limitations in the transient network to be created between vehicles without a specific limitation. Simulation studies have been carried out on the optimization of the network by considering the problems such as; use of the bandwidth efficiently and the removal of the interference problems in the communication between the vehicles and their environments. In order to solve these problems, Artificial Neural Network and Simulated Annealing (SA) algorithms are used to optimize the number of vehicles to be included in the ad-hoc network in the simulations, which performed in MATLAB environment.

Keywords: Internet of Things, Internet of Vehicles, Simulated Annealing, Artificial Neural Network, Ad-Hoc Networks, Optimized Network

1. INTRODUCTION

An ad-hoc network is a type of network used for a temporary solution to a problem. Ad-Hoc networks allow networking between two or more computers / things without using any wireless access point or router. It is not a very reliable network in terms of structure in continuous or mobile communication. For this reason, it is a kind of connection that appeals to the standard users.

Information and communication technologies have become an integral part of our daily lives. Developments in this area are continuing with increasing momentum in the last 30 years. Information sharing, and technological developments have come a long way since the internet has become widespread. Electricity, which is accepted as the greatest invention of the 19th century, has left its place to the internet and information technology. Especially in the last quarter century, great progress has been made in science through the developments in information technologies. The world has taken much more of the steps in the last quarter century than that has taken in the field of science and technology for centuries [1]. In the years, when Information Technology (IT) and the internet are present, development rate differs by seven in comparison with the years when IT and the internet are not available. That is to say, in the year of IT and the active use of the internet, more developments are observed than the seven years that IT and the internet have never been used [2].

In the globalizing world, IT and the internet are now beginning to direct production, consumption and even social life. It has very large effects in the sense of influencing and changing societies.

Digitalization and technology have become a little more integrated with our lives day by day. In this regard, it has been major advances in the areas; such as production, consumption, education, defense and health. In this context, it cannot be said that there is a developed society far away from information and communication technologies. As the advanced technological devices become an indivisible part of our life. However, many words (new research/working area) have entered the literature. Some of these are the Internet of Things (IoT), Machine to Machine Communication (M2M), and the Internet of Vehicles (IoV) [3-4].

IoT, predicts that billions of devices are connected to a common network environment and that data are shared over this network. In order to be able to create such a large network environment, different technologies and platforms need to be used together. The system that will be installed with it will bring many problems. Such as; data traffic, transmission rate, protocols, bandwidth etc. Similar problems arise in IoV, which is within the scope of IoT. In addition, due to the increasing number of vehicles in recent years, the intense of urban traffic is caused time and financial losses.

It is thought that establishing a network between vehicles, having a communication between the vehicle and their environments will prevent both financial and time losses. However, in the solution to solve such a problem, other technical problems such as new protocols for vehicle-to-vehicle communication, a certain bandwidth, etc. are also confronted. In this study, it is aimed to optimize the communication between the vehicles and their surroundings depending on the traffic density in the city centers. In addition, it is aimed to ensure that both using the bandwidth actively and fast / qualified communication between these vehicles and their environments.

1.1. Artificial Neural Network (ANN)

ANN is a computer program, consisting of three layers: input, output and hidden layers, simulates the human brain system. It is a structure that consists of neurons like the human brain and performs operations using the connections between these neurons. These neurons connect to each other in various ways throughout the network. These networks are capable of learning, storing and revealing the relationship between data. In other words, ANNs provide solutions to problems that normally require a person's natural ability to think and observe [5-7].

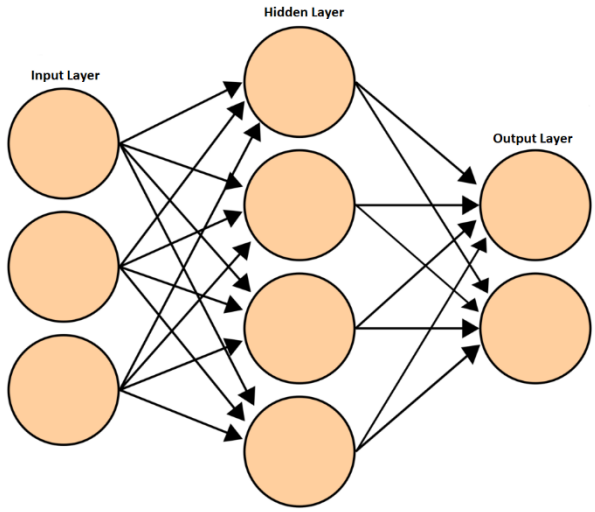

Figure 1. Structure of Artificial Neural Network (ANN)

1.2. Simulated Annealing Algorithm (SA)

Simulated Annealing (SA) algorithm, is a probabilistic approach for optimization problems, aims to produce the best solution as soon as possible for the problems. So, it is used especially in combinational

optimization problems which are costly to solve with mathematical models. The solution of combinational optimization problems due to the size of the search space requires the use of optimization methods. The use of requisite methods in a large search space is almost impossible. Because it takes a lot of time to find the best solutions in this search space. Local search methods can also be stuck in the smallest local solution in the search process, preventing a better solution value from being reached. In the face of this situation, which is considered a disadvantage for search algorithms, search methods that perform more detailed searches have been developed. The simulated annealing algorithm is one of these methods [8-10].

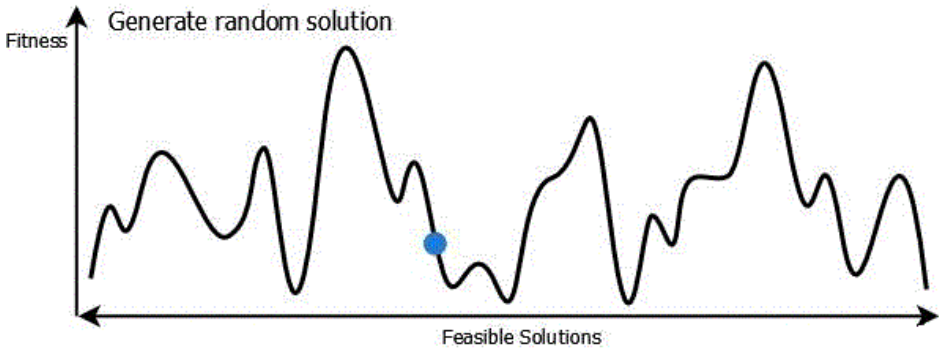

Figure 2. Feasible Solutions via Simulated Annealing Algorithm [11]

2. **RELATED WORKS**

IoT transforms traditional vehicle networks into the Internet (IoV) of cars. With the rapid development of computing and communication technologies, IoV promises a great deal of commercial interest and research value, and thus it becomes the focus of interest for many companies and researchers. IoV mediates to integrating vehicles, environment, intelligent systems, sensors, mobile devices and various cyber-physical systems in cities into a global network. Routing of the message packages depends on a number of factors such as the speed, intensity and direction of motion of the vehicles in IoV [12].

Yanmaz [13] has worked on the connectivity of a static wireless network and the effect of topology changes caused by node faults, to use better the current network. In the study, possible failure patterns are introduced and it has been shown that the connection of a static wireless network with a common organization and mobile overlay network can be significantly improved.

In recent years, IoV has become one of the most active research areas in networking and intelligent transport systems. Because IoV plays an important role in solving various driving and transport problems with advanced information and communication technology [14]. The rise in traffic congestion causes a loss of time for those in traffic. It also affects energy consumption. Existing technologies that support vehicle movements, such as wired sensors, surveillance cameras, observe a vehicle in a stationary position. In addition, these technologies are both expensive and require high maintenance costs. In addition, the accuracy of these devices also depends on ambient conditions, changing traffic flows and densities of the traffic and also depends on the traffic light control system [15].

Over the past few years, interest in automotive automation has increased, as evidenced by several announcements from Google and some automobile manufacturers. For decades, automotive vehicles have been built on different driving environments built on the development of vehicles such as safety, mobility and driving convenience. In fact, many cars today have "partial automation" features such as anti-lock braking systems, electronic skid protection (ie positive traction control), adaptive cruise control and lane protection [16]. In addition, there are also various workshops and conferences that outline a range of issues related to automation vehicles, beyond the technology challenges. For example, in 2013, the latest Transport Research Board Workshop on Road Vehicle Automation identified the latest technology in terms of automated vehicle demonstrations, while addressing definitions, security, responsibility, confidentiality, security, reliability, human factors, human machine interfaces, licensing and insurance [16].

In today's world, the internet is a global phenomenon. With the devices being controllable over the internet, traffic management over the internet is facilitated in transportation. However, as the number of vehicles increases exponentially, more traffic management problems arise. It is also reasonable that speed limits, environmental pollution checks and monitoring of emergency response to road accidents are necessary to facilitate life. There are many methodologies [17] recommended in wireless sensor networks for traffic management. However, IoV stands out as a next-generation technology. It mainly focuses on the discussion of methodology, advantages and obstacles in IOV creation. The study identified the potential advantages of the IoV concept over loT in traffic management. In addition, it recommends an efficient method for traffic management and a better journey for everyone. It can also be used to create better architectures and strategies for onroad traffic management and to influence the effectiveness of monitoring and emergency response to traffic accidents [18].

3. **PROPOSED METHOD**

Figure 3. Internet searches of IoT, IoV and bandwidth in the last five years

As seen in Figure 3 over the last five years, related works and interest on bandwidth is more than IoT and IoV. The new generation of technology is one of the biggest problems of almost every new method / technology that integrates with daily life. For this reason, in this work, the idea of allocating the frequency in order to effectively use the bandwidth in the ad-hoc network which will be formed between the cars has not been found sufficient. Because in an environment with a large number of vehicles, it is not possible to give a certain frequency to a vehicle each time, as the available frequency range will not be enough.

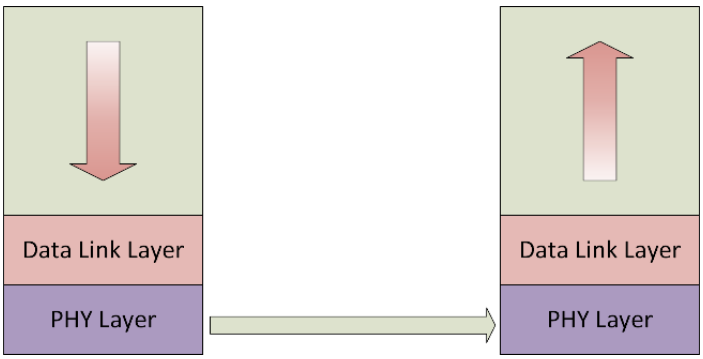

Figure 4. Data transmission between OSI layers

As shown in Figure 4, data transmission occurs from the physical layer of the source object towards the physical layer of the target object. By giving each vehicle a MAC address, any confusion or attempt at communication will be avoided.

In order to solve this problem, OSI architecture, which is network architecture, is taken as a basis. The signal, which comes from the physical layer, comes to the data link layer of the target object. For this reason, interference will be avoided by giving each vehicle a different MAC address, just like on mobile phones. In addition, the problems of using the frequency range will be blocked.

Another problem we encounter when solving this problem is the Doppler Effect. As the vehicles are mobile, we also solve the problem of late receipt of signals sent or received from vehicles by Doppler Effect. Doppler Effect is a phenomenon that the frequency and the wavelength of any physical entity that exhibits a wave characteristic are perceived differently by the moving observer at different times or positions. Accordingly, if the frequency of the signal from a vehicle is known, it is possible to find the average speed of the vehicle and decide whether or not to include it in the ad-hoc network.

4. **CONCLUSION**

In the proposed system, based on the direction and speed of the vehicles, the vehicle-related data is sent via vehicle sensors, road side sensors and via the navigation systems on the vehicles are taken and the results are evaluated in the temporary network. The data link layer will be linked to the MAC address, so that the received signals will not be able to interfere.

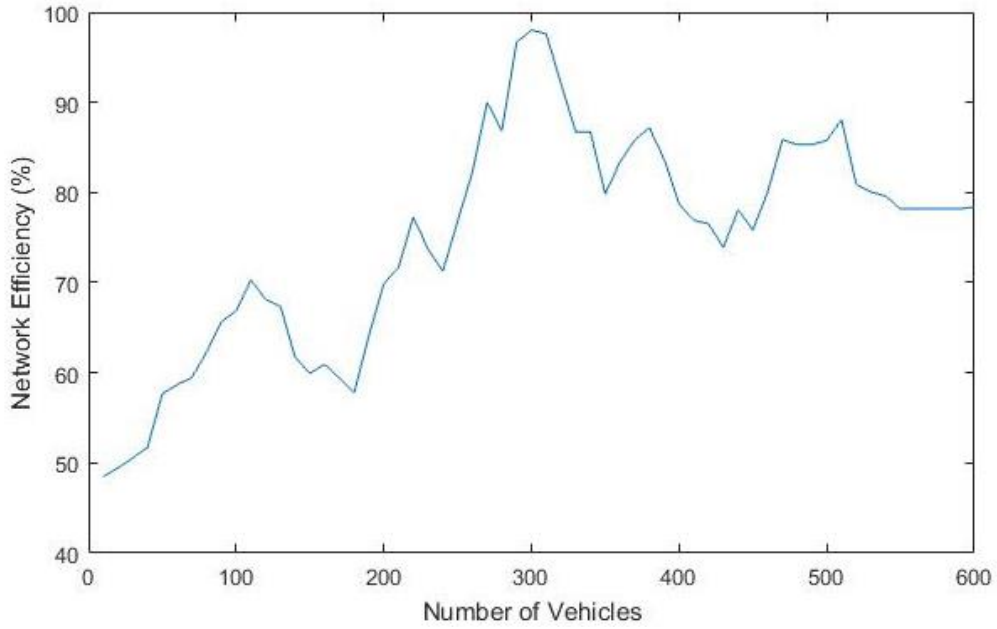

Figure 5. Number of vehicles and the network efficiency via Simulated Annealing(SA) algorithm

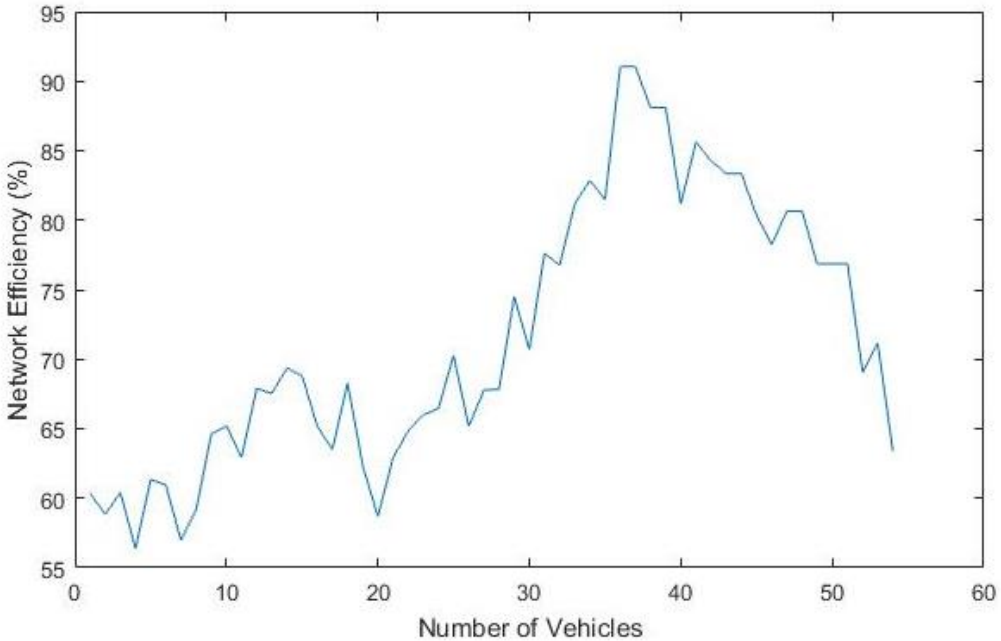

Figure 6. Number of vehicles and network efficiency via Artificial Neural Networks(ANN)

As shown in Figures 5 and 6, a simulation study was performed for the proposed method. In this study, two different algorithms were used; Simulated Annealing and Artificial Neural Network algorithms. Simulated annealing algorithm was used to optimize the number of vehicles in the network. ANN was also used to test the operability and flexibility of the proposed model. In this study; for the simulated annealing algorithm, a 1000-vehicle string on the same road and intersection was considered. It is intended that 1000 vehicles will be able to share the road information and other data about the environment with each other. However, in this case the network must be fast because the vehicles are mobile. Therefore, it is necessary to optimize the number of vehicles to solve this problem. While optimizing the number of vehicles, speed, number of packets to be sent, vehicle type and route information are regarded. Due to the changes in the data transmission rate depending on density of the traffic, it is essential to have the optimum number of vehicles. As a result of the simulations made over 1000 vehicles, it has been observed that the number of vehicles required for the optimum network should be taken as 600. Though, for these cars the network efficiency was observed via simulated annealing algorithm, hereat the number of vehicles to send the maximum number of packets determined as 300. After this point, the increase in the number of vehicles due to slowdown problems in the network has been observed to adversely affect the system. Again, with ANN algorithm, this situation has been tested and shown in Figure 4. It was observed that the network activity and efficiency had decreased while the number of vehicles increased excessively. However, it is observed that the network activity is lower in both algorithms because of the higher vehicle speeds, when the number of vehicles is low. Because limited number of vehicles means that the road is empty, and the vehicles increase their speed accordingly.

As a result, a network based on the number of vehicles was designed, using two different algorithms and the number of vehicles in this network were optimized. The data sharing rate in the optimized network was tested on MATLAB environment with Artificial Neural Network and Simulated Annealing algorithms.

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