Journal of Theoretical and Applied Information Technology
30th June 2019. Vol.97. No 12
© 2005 – ongoing JATIT & LLS
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ANALYSIS OF INTELLIGENT INFORMATION SYSTEM FOR V2V AND V2I

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ABSTRACT

Abstract In smart transportation intelligent information systems, it is possible to communicate between car and car or car and intra for data TX/RX. Then, a car density is related to delay of data TX/RX and energy consumption of sensor nodes and has the correlation of distance between cars. In this paper, we analyze the latency and energy consumption in grid topology which is environment between cars and star topology which is environment between car and infra. Communication latency means total time that each car finds their neighbor cars or infra in particular topology. The amount of energy consumption means that cars consumes their batteries during total neighbor finding times. These analysis results are useful in smart transportation intelligent information system when communicating between people and everything.

Keywords: *Sensor Network, Smart Traffic, Neighbor Discovery Protocol, M2M*

1. INTRODUCTION

With the development of science and technology, our lives are getting better, and many device devices are equipped with computing functions. In recent years, device devices are equipped with network functions so that device information can be accessed anytime and anywhere via the Internet. In this way, the environment in which all objects can be accessed via the Internet is called the Internet of things, and the city where information is shared among all buildings or all cities developed in the Internet environment is called smart city [1].

In many studies, the smart city is classified into five such as smart energy, smart water, smart building, and smart government [2] - [15]. Among them, smart transportation is an area of high importance, and many researches have been made recently, and industry-academia-research joint research is actively being carried out. In a smart traffic environment, a computer is mounted on a vehicle from a vehicle of a past transportation means to perform communication with the nearby vehicle or the infrastructure from the analysis of the real-time vehicle condition information and acquire peripheral information, thereby providing a pleasant and safe driving environment to the driver . In addition, the objects around the road are connected to the Internet network, so that the driver can easily provide travel information, traffic information, and surrounding information.

A vehicle existing in a smart traffic environment can communicate with a nearby vehicle or infrastructure because it has a communication function. Generally, in case of vehicles, the real-time position changes because of movement, and in case of infrastructure, it exists in a fixed position and collects and provides information. From a network topology standpoint, vehicles and vehicles have a grid network topology, and vehicles and infrastructure have a star topology.

In order to transmit and receive data between vehicles in a vehicle-to-vehicle (V2V) communication environment, it is necessary to first search for vehicles existing within the communication radius of the vehicle. If the vehicle cannot find a vehicle within the communication radius within a certain time, the network topology cannot be configured. As a result, it is possible to efficiently configure the grid network topology by using a protocol that can quickly find nearby vehicles.

In a vehicle and infrastructure (V2I) environment, a single infrastructure generally forms a vehicle and star topology that is within its communication radius. The infrastructure collects real-time data from the vehicle and stores and analyzes it in the cloud database over the Internet. However, as with V2V, the density of real-time vehicles is changing, so it is important to find

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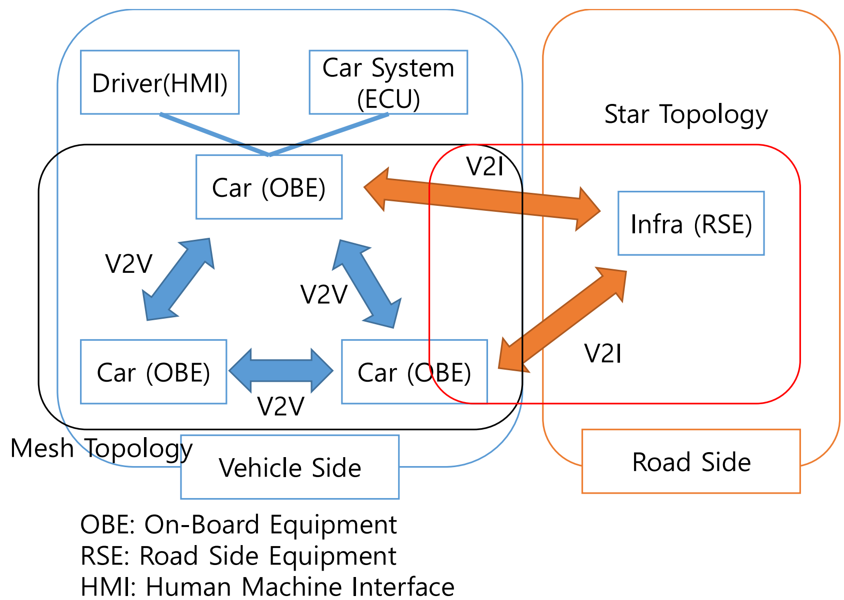

Figure 1: Architecture of V2V and V2I

vehicles that are in infrastructure coverage within a certain amount of time.

In a smart traffic environment, V2V and V2I do not exist independently, and data can be transferred through V2I after collecting data between V2V, or through V2V after data is transferred through V2I. Therefore, it is essential to analyze the performance according to the vehicle densities varying with time in order to efficiently share data according to the changes of V2V and V2I environment.

In this paper, we construct network simulator for delay time and energy consumption analysis which are important performance evaluation factors in network. The network simulator that can be constructed is a simulator that can configure star and grid type topologies, and can measure delay time and energy. In this paper, we analyze the delay time and the energy consumption which vary according to the density of the vehicle by using the simulator developed for the performance evaluation of V2V and V2I.

The composition of this paper can be seen as follows. In Section 2, we study the research related to smart vehicles. In Section 3, we analyze V2V and V2I topology. In Section 4, we analyze the car density of V2V and V2I. Section 5 explains the simulator environment and experimental results. The final section summarizes this paper and discusses future research directions.

2. RELATED WORK

The topology of the smart city environment can be a ring type star type linear tree type bus type depending on the network configuration. More specifically, as shown in Figure 1

As shown in Figure 1, V2V [3] forms a star topology for a mesh type V2I. Grid type topology is a network environment in which all devices can communicate with each other with mutual connectivity, so that even if a specific device fails, there is no problem in data transmission. However, it has a disadvantage that it is difficult and expensive to manage because of its high connectivity. There is a risk that all device communication may be paralyzed if the central management device fails, while the star topology has a merit that the specific device is connected to all the devices and is easy to manage.

V2V and V2I in smart traffic environment have been studied extensively. Most of existing researches are based on neighboring node protocol [16] - [25] to focus on data transmission rather than searching for nearby vehicles and determining the data transmission path. In addition, applications such as the Smart Traffic Research Team integration system [12], Drive C2X platform [13], Finland reindeer accident prevention system [14] and Rastu safe operation service [15] Focused.

The neighbor node discovery protocol is a protocol that is executed in the early stage of network construction before carrying out inter-vehicle communication. It is a protocol that can find other vehicles in the range of the vehicle in real time around one vehicle. The connection time of the network communication and the energy consumption of the attached sensor of the vehicle are changed depending on the time of searching for the vehicle in the early stage. Neighboring node finding protocol [16] [17] [18] is a classical research field in sensor network.

Smart traffic environment is an environment in which the density and type of objects change in real time, and density must be considered. In order to communicate with the infrastructure built on the road, consideration is given to star topology that performs communications around the infrastructure. If there is no study of communication between infrastructure and vehicle in advance, it will be difficult to provide accurate service through communication paralysis and inaccurate data sharing due to a long initial network construction time.

In previous paper [27], we analyze traffic flow models in advance to understand the relationship between vehicle density and communication performance, and analyze the density, latency, and energy consumption of vehicles based on the analysis. However, only the analysis based on the vehicle density was performed, and various topology based analyzes were not performed.

In this paper, we compare and analyze the performance of neighboring node protocols to find neighbors as a step for initial network construction in grid and star topology, topology of V2V and V2I in smart traffic environment. In this case, performance is evaluated through delay time and energy consumption.

3. CAR DENCITY ANALYSIS OF VEHICLE TO VEHICLE AND VEHICLE TO INFRASTRUCTURE

Before looking at the topology of the vehicle, we will look at the relationship between vehicle speed and density. Speed and density are factors that closely affect the topology of a vehicle.

There are Greenshield model, Underwood model, Ellis model and Greenberg model.

Among the various traffic flow models, the existing vehicle density analysis paper [27] analyzed the relationship between speed and vehicle density using the Greenberg model, which deals well with complexity and accuracy. In this paper, a revised vehicle model is used to prevent the speed from infinitely increasing in the low vehicle densities, which is a disadvantage of existing vehicle models. The basic traffic flow model uses equation (1) to find the relationship between speed and vehicle density.

$$u = u_m \cdot ln\left(\frac{k_j}{k}\right) \tag{1}$$

In equation (1), u includes the vehicle speed (km / h), u_m the critical speed (km / h), k_j the congestion density (vehicle / km) and k the vehicle density (vehicle / km). In this case, the critical speed means the speed when the vehicle is congested on the road, and the congestion density means the density when the traffic congestion occurs. However, in the case of the basic traffic flow model, the value of congestion density increases as the value of denominator k becomes smaller. As a result, the vehicle speed increases in the traffic flow model. In order to solve these drawbacks, the existing traffic flow model uses the method of determining the maximum speed of the vehicle at a vehicle density below a certain level as shown in Equation (2).

$$\mathrm{u} = \begin{cases} u_q \quad if\ k \leq 10 \\ u_m \cdot ln\left(\frac{k_j}{k}\right) \quad if\ k > 10 \end{cases} \tag{2}$$

In equation (2), u_q means the maximum speed of the vehicle and the remaining parameters are the same. In Equation (2), if the vehicle density is less than or equal to 10 on the basis of 10, the speed value is the highest speed of the vehicle or the existing traffic flow model is used.

In addition to the traffic flow model, the cargo distance is generally considered. The headway distance can be obtained from Eq. (3), which means the distance from the front end to the front end of the vehicle body.

$$s = \frac{1000}{k} m \tag{3}$$

In Equation (3), k is the density of the vehicle and s is the headway distance.

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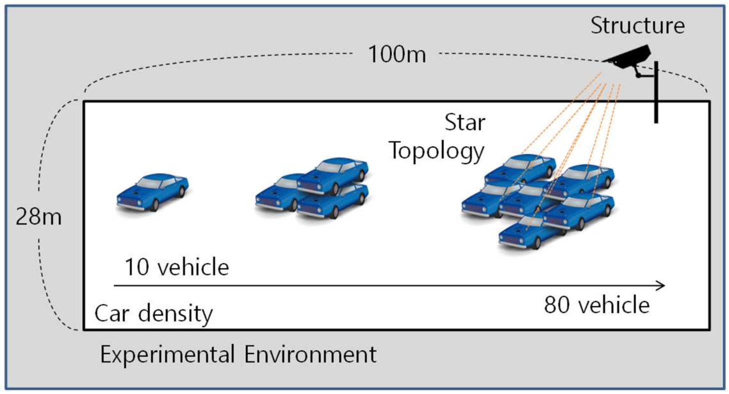

Figure 2: Experimental Environment in Smart Traffic

In order to show the model described above through experiments, we constructed the following experimental environment and found the relationship between vehicle speed and density.

Small sensors are attached to vehicles in smart traffic environment. And the sensor attached to each vehicle carries out communication by using CC1000 communication module. Each sensor uses CSMA / CA method to prevent data collision. Consider a situation where an infrastructure such as VDS is installed on a wide road using a star network topology. It is assumed that the network coverage performed at this time is 28 * 100 m between the infrastructure and the vehicle. In the experimental environment, the density of the vehicle is assumed to be between 10 and 80 densities based on the analysis on the whole field.

Figure 2 shows an example of the experimental environment for the experiment in this paper. In Figure 2, the total experiment size is 28 * 100m. And the density of the vehicle is between 10 and 80. In addition, it can be seen that communication is performed by constructing a star topology between the right structure and the vehicle.

Figure 3 is a graph showing the relationship between the density of the vehicle and the speed and headway distance using the modified traffic flow model. In graph X-Y-Y graph, the X axis is the density of the vehicle, the left Y axis is the vehicle speed, and the right Y axis is the distance between the cars. There is no change in vehicle speed and distance between vehicles in the early 0-10 vehicle / km segment of the graph. The speed of the vehicle is fixed at 100 m for a distance of 120 km / h. However, when the density of the graph exceeds 10, it can be

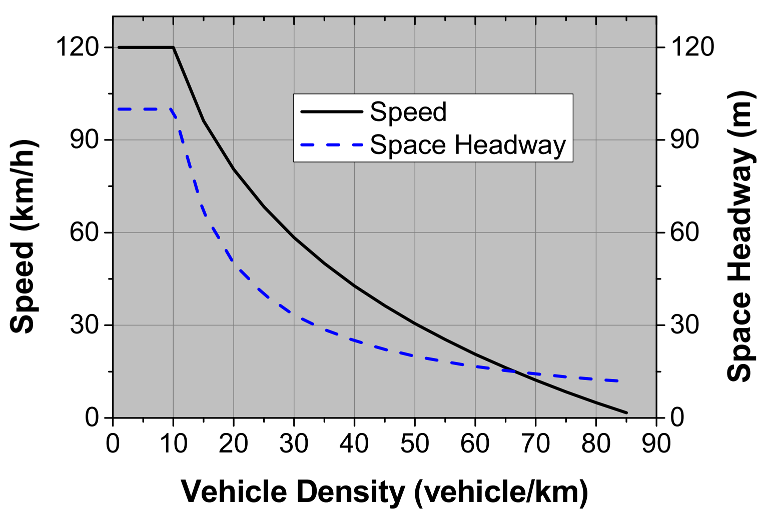

Figure 3: Experimental Environment in Smart Traffic

Journal of Theoretical and Applied Information Technology
30th June 2019. Vol.97. No 12
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

seen that the speed of the vehicle is reduced. More specifically, it can be seen that the vehicle speed is linearly reduced, but the headway spacing is exponentially reduced. It can also be seen that the vehicle's speed and density are crossed at the vehicle's starting point of 65 vehicles / km. In conclusion, the speed of the vehicle is reduced even though there is little change in the headway interval. Using these correlations, dynamic communication can be performed efficiently. In the next section, we analyze the topology relationship of the vehicle

4. TOPOLOGY ANALYSIS OF VEHICLE TO VEHICLE AND VEHICLE TO INFRASTRUCTURE

In a smart traffic intelligent information system, vehicles and vehicles (V2V) generally communicate in a grid-like topology configuration, while vehicles and infrastructure (V2I) communicate in star topology configuration. Therefore, a network can be constructed as shown in Figure In a grid-like network configuration, all vehicles can communicate directly with each other. In the star topology configuration, communication is performed with all vehicles in a centrally controlled infrastructure.

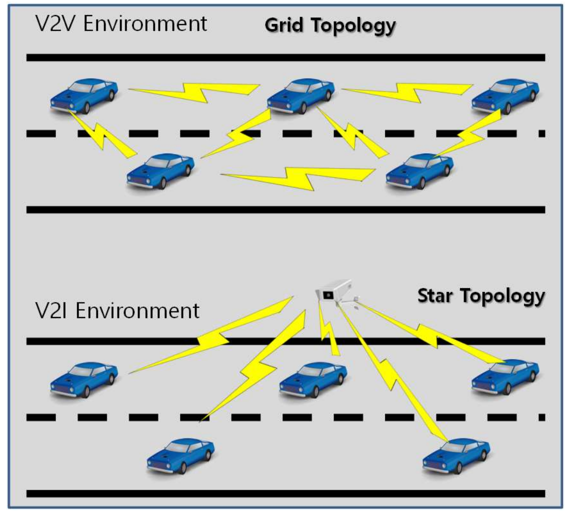

Figure 4: Example of V2V and V2I

Therefore, in case of grid type topology, 2N (N-1) links become one when the vehicle is increased by one, and N links become in case of star topology. Therefore, it can be seen that the grid type increases exponentially in the correlation between the vehicle density and the number of links. That is, for the same number of vehicles, the grid type topology has a greater number of links. Figure 5 shows the relationship between number of links and vehicle density. The higher the density of the vehicle, the more linear the number of links in the star topology, while the exponential increase in the mesh topology.

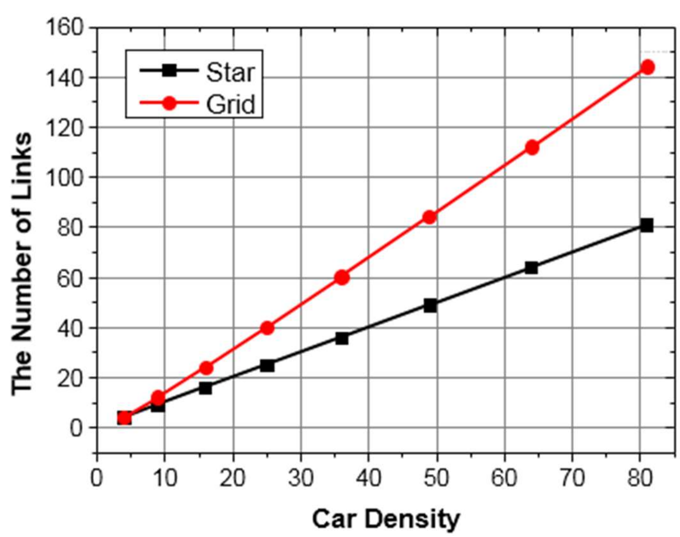

Figure 5: The number of Links of Star and Grid Topology according to Car Density

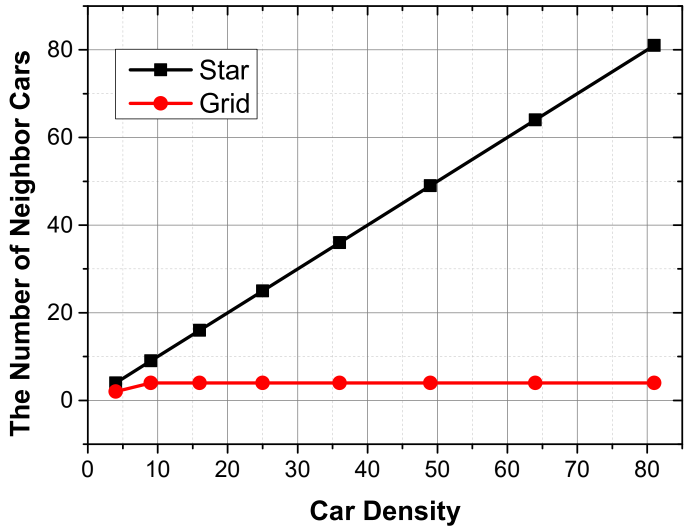

Figure 6: The number of Neighbor Cars of Star and Grid Topology according to car density

Therefore, it can be seen that as the density of the vehicle increases, the number of links in the star topology is smaller than the number of links in the grid topology.

However, the relationship between the vehicle density and the number of neighboring vehicles in Figure 6 shows that even if the density of the vehicle increases, the maximum number of neighboring vehicles is the same, while in the case of star type, the number of neighboring vehicles increases linearly with density. The reason for this is that in the case of star type, since one infrastructure communicates with all vehicles, if one vehicle is increased, the effect is the same as that of one neighboring vehicle. On the other hand, in the case of grid type topology, the number of nearby vehicles does not increase even if the density of the vehicle increases because one vehicle only communicates with neighboring vehicles near itself without performing communication with all vehicles. Therefore, the grid type topology is more advantageous than the star type topology in terms of searching time for neighboring vehicles. In terms of energy consumption, grid type topology is also advantageous. However, since there are many cases where the system is linked with external organizations or communicates with the infrastructure, it is necessary to construct a flexible topology according to the situation.

5. EXPERIMENTAL RESULT

In order to construct the experimental environment, the space size was set considering the actual sensor network environment and vehicle density. The size of the time slot was set to 15ms for the sensor module CC1000. In this case, the density of the vehicle is in the range of 10 ~ 80, and since the number of vehicles placed in the grid environment increases by the square of the number, the density is determined in the form of 4, 9, 16, 25, 36, 49, The delay time is defined as the time taken until all the vehicles find their neighbors, and the energy consumption is measured based on the CC1000 Active and Sleep Data Sheet.

Table 1: Block Combinations With Near 1% Duty Cycle

Properties	Values
Topology	Star, Grid Topology
Area Size	100 × 100m
Radio Chip	CC1000
Car Density	9,16,25,36,49,64,81
Slot Time	15ms
Packet Length	53 bytes
Duty Cycles	42%

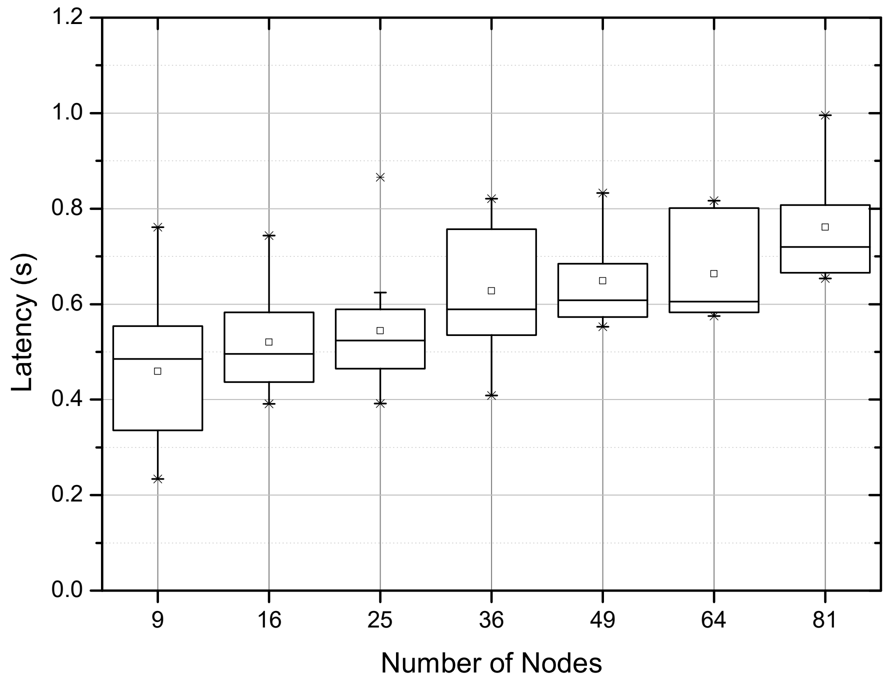

Figure 7: Latency of Grid Topology

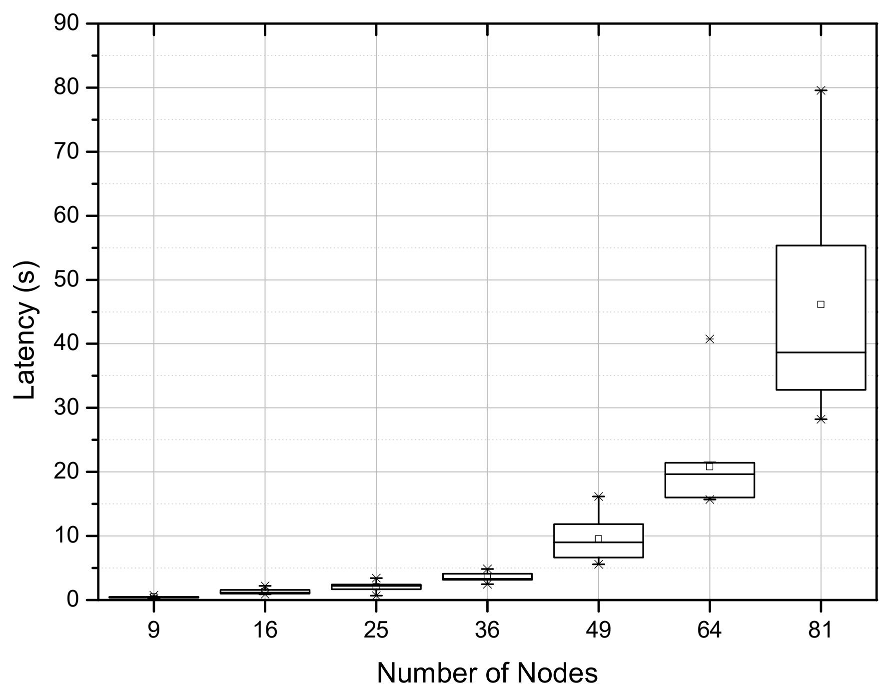

Figure 8: Latency of Star Topology

Figure 7 shows the delay time box graph in a grid topology environment. The X-axis of the box graph represents the number of sensor nodes and the Y-axis represents the delay time. As the number of

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nodes exponentially increases, the delay time increases linearly. It can be seen that the interval between the deviations is 0.1 ~ 0.2s in total, and the increase is 0.35s, and the worst case is more irregular than the best case and irregular regardless of the number of sensor nodes.

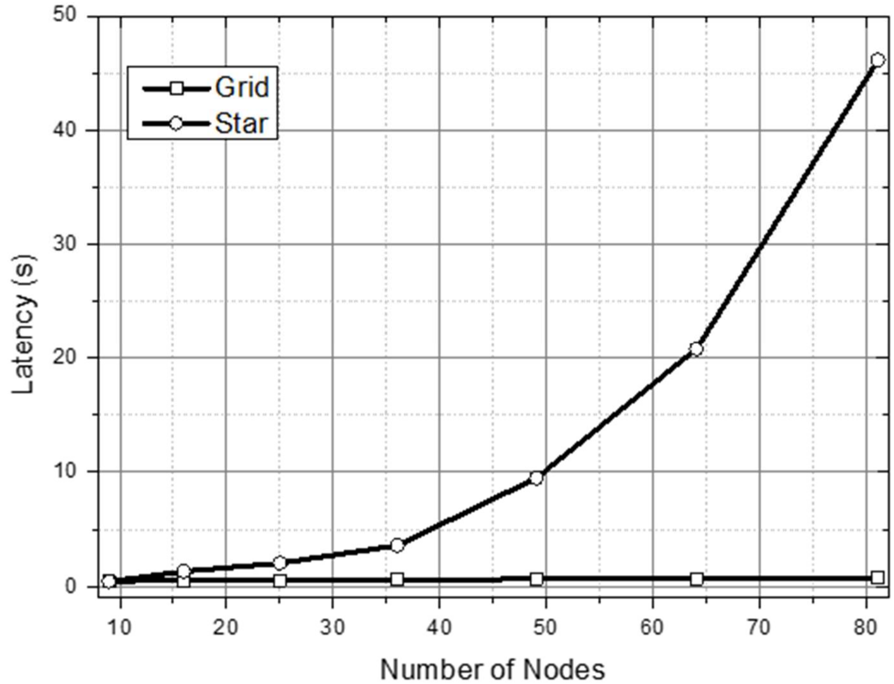

Figure 9: Latency of Grid and Star Topologies

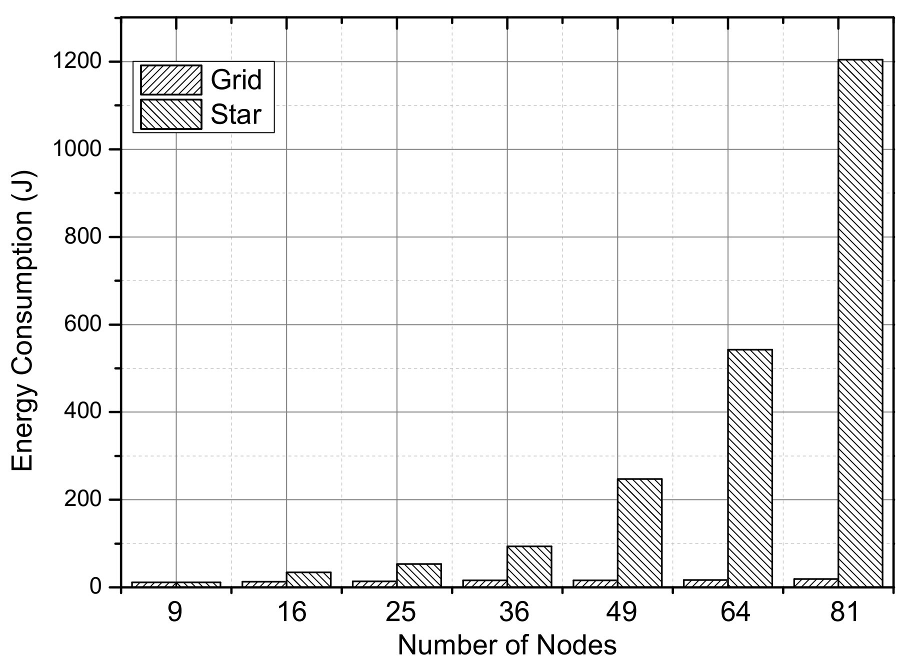

Figure 10: Energy Consumption of Cars at Star and Grid Topology

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Figure 8 shows the delay time graph of the star topology in V2I topology form. It can be seen that the increase of the delay time of the star topology is large and increases exponentially rather than linearly. In addition, the star topology differs from the grid topology in that the average standard deviation increases with the number of sensor nodes. This result shows that, in the case of the grid type topology, the number of neighboring vehicles of one vehicle is kept constant at a maximum of 4. However, since the number of neighboring vehicles of the infrastructure in the star topology increases as the number of vehicles increases, . That is, since a large number of cars attempt to communicate with one infrastructure at the same time, they cause various problems such as communication collision and packet loss. This increases the delay time and increases the deviation.

Figure 9 shows a graph of delay time comparison between the star and grid types. It can be seen that the delay time of the grid type does not substantially increase the delay time regardless of the increase of the sensor node. The reason is that the maximum number of neighboring vehicles in a vehicle is limited and delay time does not affect the vehicle growth since each vehicle has nearly the same neighboring vehicle. On the other hand, in the star topology, the increase of the vehicle is the same as increasing the number of communication attempts of the infrastructure and the number of neighboring vehicles because one infrastructure must try to communicate with all the vehicles. Therefore, in star topology, the delay time increases as the vehicle increases, and the delay time increases exponentially because the communication collision increases as the number of vehicles increases.

Figure 10 shows the sensor energy consumption graph of the vehicle according to the number of star and grid sensor nodes. Energy consumption graph Similar to the delay time graph, it can be seen that the energy consumption increases exponentially in the case of the star type topology while the increase in the energy consumption is small in the case of the grid type. The reason for this is that in the case of the grid type topology, the search time of the neighboring vehicle is short, so the on / off time of the vehicle sensor is short so that the star topology exponentially increases the searching time of the neighboring vehicle. Because other vehicles also consume energy during the time it takes to find them.

In this paper, the topology of V2V and V2I is analyzed in terms of delay time and energy consumption. As a result, the overall delay time and energy consumption were found to be good at V2V. However, since V2I, which is directly connected to the central control center, is necessary, a topology in which V2V and V2I are appropriately mixed should be configured in a smart traffic environment. For example, in a high-density area of a vehicle, if you configure a network topology in which data is transmitted via V2V to a vehicle near the infrastructure and then a vehicle near the infrastructure sends data to the central control center via V2I, It will have much better performance than a topology with V2V and V2I. In addition, since the number of neighboring vehicles changes in real time in a smart vehicle environment, it is necessary to consider a structure capable of dynamically communicating.

6. CONCLUSIONS

This paper is a cornerstone study for topology analysis that varies according to V2V and V2I in smart traffic intelligent information systems. Each topology is analyzed through the number of vehicles, delay time and energy consumption. As a result of the analysis, it can be confirmed that the grid type has little change in the delay time and the energy consumption regardless of the increase of the vehicle. In the star topology, the delay time and the energy consumption are exponentially increased. The result of this experiment is that the topology of V2V and V2I should be composed of a topology that is not a separate but dynamically converged type, which means that communication can be performed quickly in a smart traffic environment without any communication trouble.

Future research will be carried out in consideration of the smart traffic environment considering the dynamic environment in which the number of neighboring vehicles changes in real time rather than in a static environment.

ACKNOWLEDGMENTS:

This work was supported by Kyonggi University Research Grant 2018.

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