

# Zippping Transmission for Infrastructure-Assisted Cloud Network Navigation System

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**Abstract**— The usual built-in navigation in a car needs to be upgraded periodically due to the update and change of road conditions. To solve those problems, a cloud network navigation system has been launched which can automatically request the information of roads needed. However sending the information to each user in a specific area individually is very inefficient in the radio resource utilization aspect. In this paper, we model the transmission architecture that can send geographical information to the vehicle using RSUs, and propose a new method called Zippping algorithm. Our proposed algorithm groups the car in efficient way and due to our scheme; the total transmission time will be minimized. To make this possible, we use N times M/M/N which is an extension of M/M/1 model of queueing theory. We show the different traffic congestion of the road depends on the weekdays and weekends. Then, we show the case of car groupings depending on the various Zippping time given. We analyze the above result by simulating the transmission efficiency and compare with the performance of unicast system and that of our proposed algorithm.

**Keywords**— Zippping transmission, V2I communication, N times M/M/1, Cloud Network Navigation system

## I. INTRODUCTION

An important issue in mobile application is to provide updated information rapidly over a network, such as traffic information. The contents of such information are dynamic and its validity may change with time quickly.

The conventional built-in GPS/Navigation in a car needs to be upgraded periodically due to the update and change of road conditions. The problem is that many of users are not aware of dealing with the navigation program and just leave it as an outdated version. This may cause accidents when the user enters unfamiliar area and the navigation gives the old information of roads. It is the best benefit of users if the most recent data can be received by users on time. Updating information which acquires the newly updated version of desired things in the external environment must be done continuously and in a real-time to update the data of the corresponding items in the information servers [1].

To solve those problems, a cloud network navigation system has been launched which can automatically request the information of roads needed. And also studies regarding geo-cast transmission system using road side infrastructure units (RSUs) have been done for the past few years [2]. Those studies gave solutions to the difficulty that needs to upgrade

the navigation system by manually. However sending the information to each user in a specific area individually is very inefficient in the radio resource utilization aspect.

In this paper, we propose algorithm called 'Zippping' which, groups several cars that head the same direction by considering the car's velocity, distance, and time. On the highway, most cars cruise at a similar speed so we can consider them as one group. Even though cars do not keep the similar speed, if they are spaced with acceptable distances, we can group them also. If car requests road information to the RSUs then, the following car may request the same information, when RSUs estimate that those two cars will likely to enter next spot in a same or similar time, they will be grouped one. Multicasting the data to the grouped cars can save the power consumed by the RSUs compare to the unicast system, and also can reduce the transmission delay time. Our proposed algorithm group the car in efficient way and due to our scheme, the total transmission time will be minimized. To make this possible, we use N times M/M/N which is an extension of M/M/1 model of queueing theory [3].

This paper is organized as follows. Chapter II introduces system model used which are M/M/1 and brief introduction of Poisson process. Chapter III presents the procedure of Zippping algorithm, and Chapter IV analyses the performance of the proposed algorithm. Finally Chapter V concludes the paper

## II. SYSTEM MODEL

The M/M/1 queue is of great interest in queueing theory by its simplest form of use among others. It has been widely used in the field of traffic engineering of communication networks.

### A. M/M/1

M/M/1 is the Kendall's notation of a single server queue with a Poisson process arrival and an exponential service time [4]. Here, we will consider queue as cars on the highway and server as RSUs. We assume the car arrival to the queue with rate  $\lambda$ , and the length of cars is exponential distributed with  $1/\mu$ . Define  $\{P_n, n=0,1,2,\dots\}$  as the equilibrium probabilities that the queue contains  $n$  cars. Then they satisfy the following state transition equations [4].

$$\begin{cases} \mu P_1 = \lambda P_0 \\ \mu P_{n+1} = (\lambda + \mu) P_n - \lambda P_{n-1} \end{cases} \quad (n=1, 2, 3, \dots) \quad (1)$$

The utilized load to the queue is  $\rho = \lambda / \mu$ , but only when  $\rho < 1$ , the queue can be stable.  $P_0$  is the probability of system (highway lane in our paper) being empty. By little's law,  $P_0$  can be represented as

$$P_0 = 1 - \rho = 1 - \frac{\lambda}{\mu}. \quad (2)$$

Using the equation (1) and (2), we can acquire the following equations for the number of cars in the queue:

$$\begin{cases} P_n = \rho^n P_0 \\ P_{n+1} = \rho P_n, \end{cases} \quad (3)$$

where  $P_n$  is the Probability that there are  $n$  cars in the highway.

$$L_s = \sum_{n=0}^{\infty} n \cdot P_n = \frac{\lambda}{\mu - \lambda}, \quad (4)$$

where  $L_s$  is the Average number of cars in highway.

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{\rho^2}{1 - \rho}, \quad (5)$$

where  $L_q$  is the Average number of cars in highway before RSUs.

By Little's law, the average number of cars in the highway is the product of arrival rate and average time a car spends in the highway. Average time a car spends in the highway,  $W_s$  can be written as follows:

$$W_s = \frac{1}{\mu - \lambda} = W_q + \frac{1}{\mu} = \frac{1}{\mu(1 - \rho)}, \quad (6)$$

Average time a car spends in the queue;  $W_q$  can be determined by subtracting average service time from  $W_s$ .

$$W_q = W_s - \frac{1}{\mu} = \frac{\rho}{\mu(1 - \rho)}, \quad (7)$$

### B. Poisson process

We use a homogeneous Poisson point process with parameter  $L_s$  ( $L_s$  is the average number of cars) to model car positions. Certainly, for some densities of cars, their positions follow a Poisson point process [5]-[8]. It regards to traffic free flow conditions that each car has its own speed. Basically a point process consists of a sequence of points randomly distributed on the line, with each point representing a car position. A Poisson point process  $N$  with intensity  $L_s$  is defined by the following two properties [9]:

- The number of points in two disjoint intervals of  $\mathbb{R}$  form two independent random variables.

- The number of points in an interval  $[a, b] \subset \mathbb{R}$  with  $b > a$ , denoted  $N([a, b])$  follows a discrete Poisson distribution with parameter  $L_s(b-a)$ , i.e.,

$$P_k = P(N([a, b]) = k) = \frac{(L_s(b-a))^k}{k!} e^{-L_s(b-a)}, \quad (8)$$

where  $P_k$  is the probability of car number is  $k$  in the interval between  $a$  and  $b$ .

The point process is distributed on a line when the car radio ranges become larger than the road width. This is able to model one to several lanes.

### III. ZIPPING ALGORITHM

Zippping algorithm is created by using the characteristics of cars such as speed and distance between them. To make it possible, we need to use  $N$  times M/M/1 system.

#### A. N times M/M/1 System

As explained in chapter II, M/M/1 system constructs single server queue which means it will be single lane for the virtual highway system, but since the real highway has at least three lanes by flow, we used  $N$  times M/M/1 structure. This will generate  $N$  number of M/M/1 system, and will look like Fig.1.

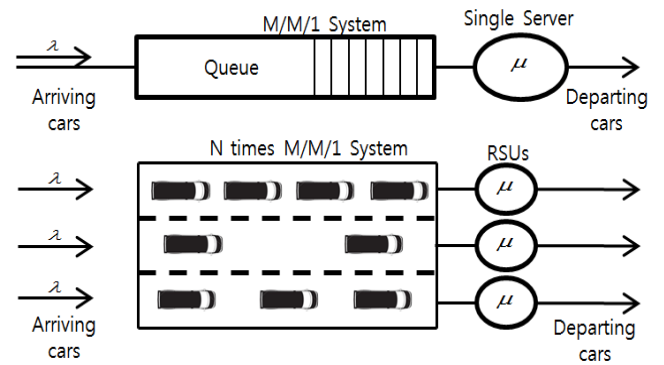


Figure 1. M/M/1 and N\*M/M/1 System

#### B. Zippping algorithm

The Zippping algorithm is the system that will group cars in highway to multicast road information. By multicasting information to group of cars, it will save power spend by RSUs, and also increases the transmission efficiency.

To group the cars in a highway, we will consider three parameters such as time, distance, and speed. The Zippping system proceeds as follow:

- The cars request the next road information to RSUs with their maximum allowable time for RSUs to send data (ex. car 1's maximum allowable time is 8 seconds and car 2's is 10 seconds).
- The RSUs compute the starting time of data transmission considering the maximum data transmission time need. (ex. if data transmission time will be 2seconds, then RSUs can transmit within 6 seconds to car 1 and 8 seconds for car 2)

- After that, RSUs set the Zipping time. This will be based on the starting time of transmission for first car (car 1 for this example) to the proceeding cars.
- For example, RSUs set Zipping time to be 4 seconds. Since car 1 need to receive the data within 6 seconds and from that 6 seconds, RSUs count 4 seconds to consider grouping of  $n$  following cars. Therefore RSUs group from car 1 up to the  $n$  cars whose allowable time is within 10 seconds.

The important part of this system is to limit the number of cars to be grouped and also setting the most efficient time for Zipping area. If the time will be too short, RSUs will spend more power to transmit and if the time will be too long, RSUs can't provide proper service to the cars. The Zipping time will vary as the density and speed of cars change.

#### IV. PERFORMANCE ANALYSIS

The performance of the proposed Zipping transmission for infrastructure-assisted cloud network navigation system has been evaluated using the Matlab. We create 3 lanes to follow the general highway condition. The traffic assumed to flow one direction only. We generate the traffic model with Poisson distribution and we set 2 traffic density ( $\lambda$ ) conditions which are weekdays and weekends, 0.02 and 0.07, respectively. For weekends the traffic density gets higher than weekdays.

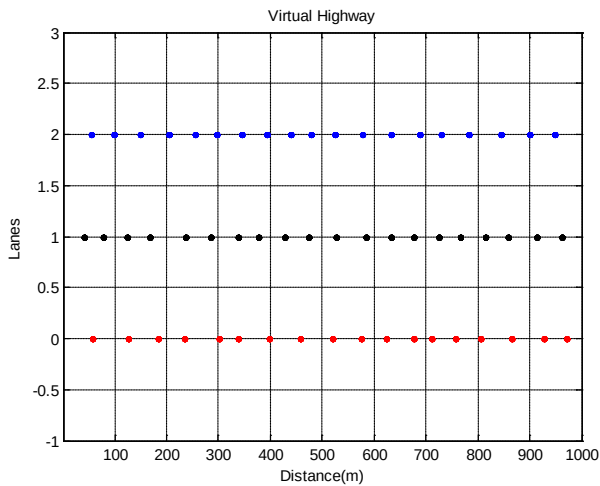


Figure 2. Virtual highway condition

Fig.2 shows the virtual highway condition which applied the parameters explained above. We set the area covered as 1000m.

We give 3 options for Zipping time by 3 seconds, 5 seconds, and 8 seconds to find the most efficient time. We also assume that each transmitter can send data to maximum of 40 cars for the efficient transmission because even if the transmitter can cover more than the number of limited cars, if the transmission rate goes lower than the unicast, it is meaningless.

The simulation result is in time scale since we are dealing with the zipping time. We sorted the order of the cars by time manner that, the fastest car is the car arrives first at the transmitter which is plotted first in the graph. Fig.3 to 4 are the results for the weekdays.

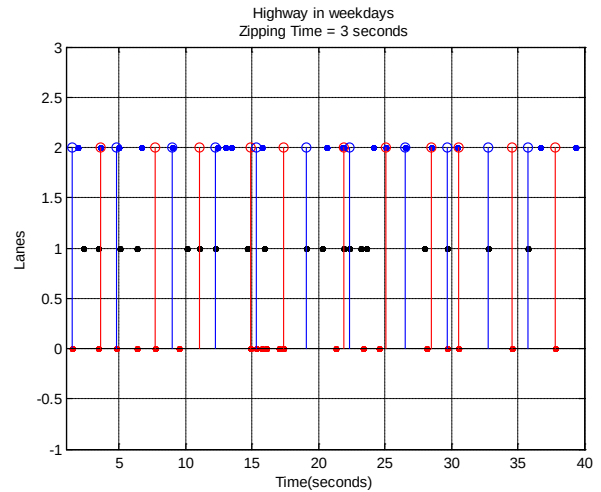


Figure 3. Zipping time 3 seconds for weekdays

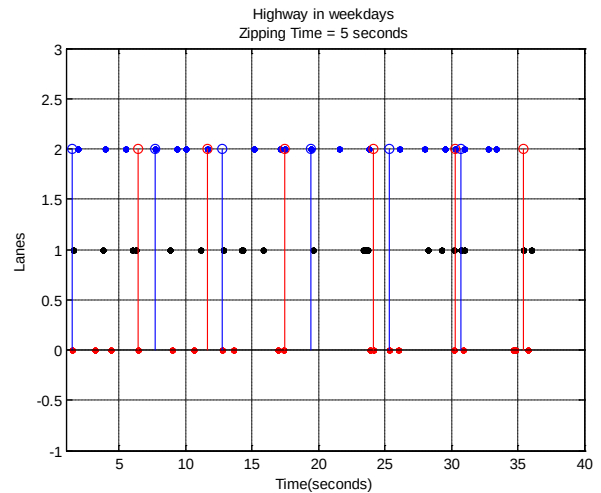


Figure 4. Zipping time 5 seconds for weekdays

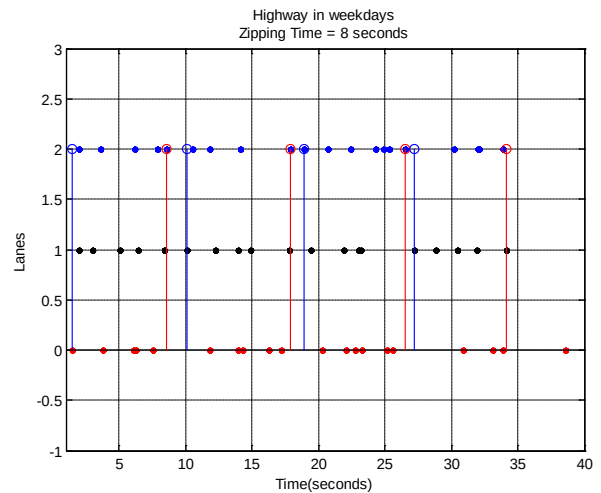


Figure 5. Zipping time 8 seconds for weekdays

The blue bar indicates the start point of group and the red bar indicates end point of the group. As we can see, the areas covered by each group are getting wider when Zipping time

increases. It means that as we increases the Zipping time, transmitter can cover more cars in each group. This is the reason that we give 3 inputs of Zipping time to observe whether which of the Zipping time will be suitable for the different traffic conditions. As we mentioned earlier that even if we could group the cars as many as we want, if the limit transmitter capacity exceeds, the transmitter will provide poorer performance than the unicast so it is important for us to find out the best Zipping time depending on the traffic density.

After grouping the cars in virtual highway, we simulate for the efficiency of Zipping transmission by getting the ratio of number of cars presented in highway, to the number of group the transmitter assigned. In this paper we assume that the number of resources is same with the number of cars present in a highway. Originally, unicast has to transmit data to every car present in highway but Zipping transmission only needs to send data to number of groups formed which is a way less than the number of unicast. Table 1 shows the result that needed for the computation of transmission efficiency.

**Table 1.** Maximum Number of Cars Covered in a Group for Weekdays

| Zipping time | Number of groups | Maximum Number of cars covered in a group | Total cars in highway |
|--------------|------------------|-------------------------------------------|-----------------------|
| 3 seconds    | 10               | 7                                         | 20                    |
| 5 seconds    | 6                | 11                                        | 20                    |
| 8 seconds    | 4                | 15                                        | 20                    |

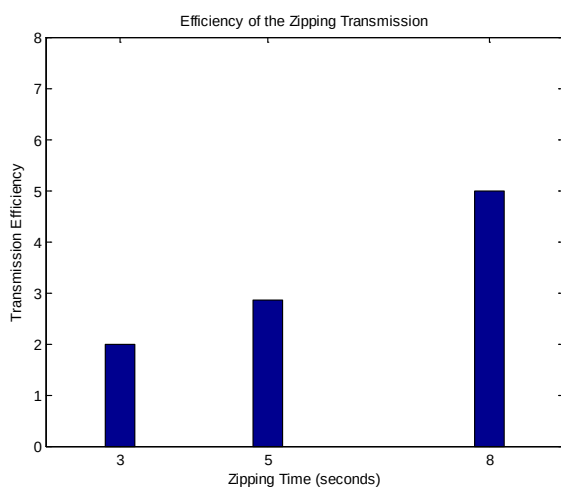


**Figure 6.** Efficiency of the Zipping Transmission for weekdays

According to the Fig.6, by using Zipping transmission, we come up with 2 times, 3 times, and 5 times efficiency than unicast, for Zipping time of 3 seconds, 5 seconds, and 8 seconds, respectively. Since we assumed the maximum number of cars can cover by each transmitter in a group is 40 cars, all of the groups are under the limitation. In that case, it will be more efficient to have smaller number of groups to reduce the redundant transmission, which contains same information, to the several groups. Therefore when there are

few cars in highway like in weekdays, it is better to set longer Zipping time.

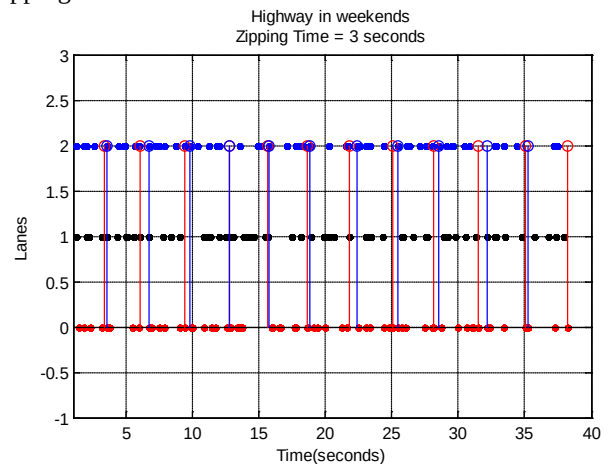


**Figure 7.** Zipping time 3 seconds for weekends

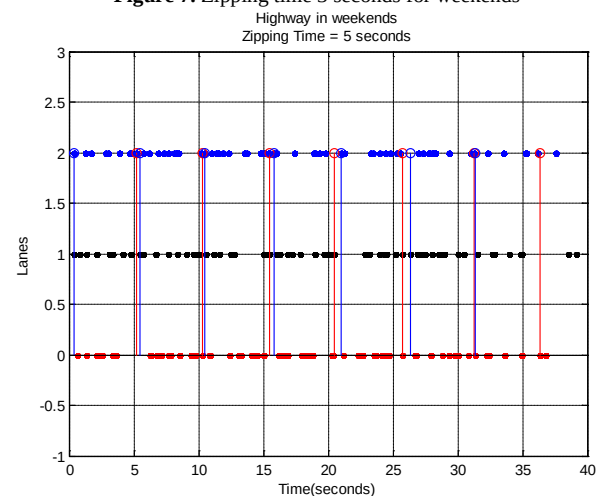


**Figure 8.** Zipping time 5 seconds for weekends

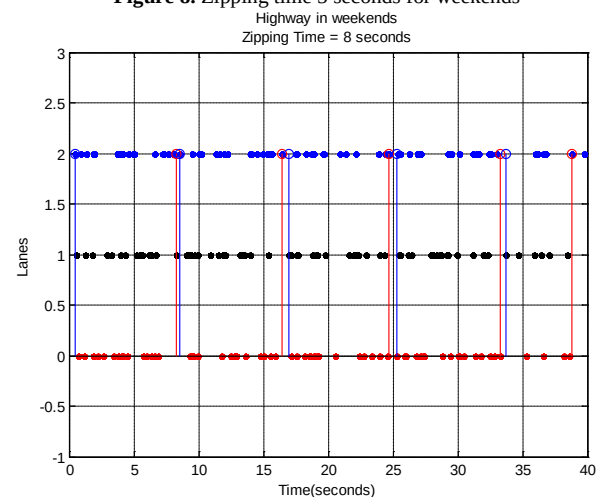


**Figure 9.** Zipping time 8 seconds for weekends

Finally, we simulate the traffic condition of the weekends. From Fig.7 to 9 seems similar with the weekdays result but in each group, it contains more cars than weekdays' group. Table 2 shows the simulation result of the number of groups and cars.

**Table 2.** Maximum Number of Cars Covered in a Group for Weekends

| Zipping time | Number of groups | Maximum Number of cars covered in a group | Total cars in highway |
|--------------|------------------|-------------------------------------------|-----------------------|
| 3 seconds    | 13               | 20                                        | 75                    |
| 5 seconds    | 7                | 33                                        | 75                    |
| 8 seconds    | 5                | 48                                        | 75                    |

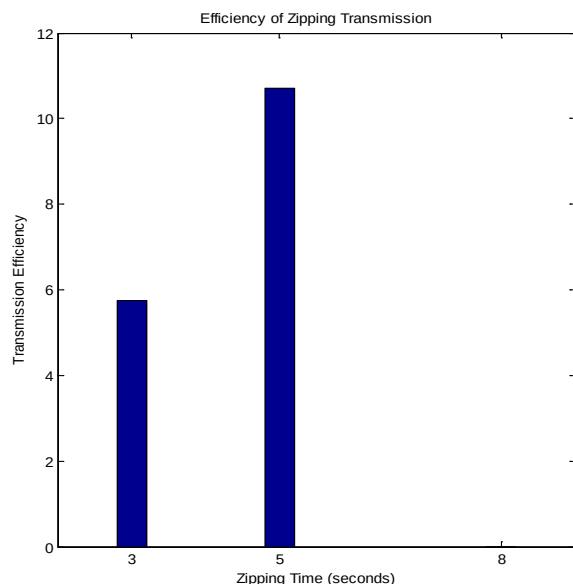


**Figure 10.** Efficiency of the Zipping Transmission for weekends

Same with the case of weekdays, we also simulate transmission efficiency. As we can see in Fig.10, For the Zipping time 8 seconds, it's actually value of efficiency was 15 but we marked it as 0 because based on our assumption, the transmitter's maximum number of car coverage is 40 cars. Even though it could cover many cars in a group and may transmit the data, if the limit exceeds, the rate of transmission decreases. Therefore Zipping time of 8 seconds is no better than unicast.

## V. CONCLUSIONS

In this paper, an algorithm for Zipping transmission for infrastructure-assisted cloud network navigation system was proposed. We briefly explain the concept of M/M/1 system and N times M/M/1 which is the base of our algorithm environment. Also Poisson process was presented which is included in the concept of N times M/M/1 system. Based on this algorithm, steps to simulate the grouping of cars in a highway to perform efficient multicasting of geographical data was provided. These results verified by computer simulations showed the performance of Zipping transmission and also efficiency compared to unicast. With these results, we conclude that to increase the transmission efficiency and to save transmission power from the transmitter, short Zipping time is qualified for high traffic density conditions, and long Zipping time for low traffic density conditions. With this result, we found that when there is capacity limitation on

transmitter, the best Zipping time does exist depending on the density of cars. Our approach and results will be extended by considering more practical traffic flow models.

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