A Mobility-Predict-based Forwarding Strategy in Vehicular Named Data Networks

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***Abstract*—Named data networking (NDN) is promising for Vehicular Ad hoc Networks (VANETs) owing to its data-centric communication paradigm. However, the existing forwarding strategies for vehicular named data networks (VNDN) cannot handle well the issues of high mobility and broadcast storm. In this paper, we propose a Mobility-Predict-based Forwarding Strategy (MPFS) to tackle these issues in VNDN. First, in order to solve the problem of outdated mobility information in the neighbor table, a lightweight but highly effective approach is proposed to predict the current position in MPFS. Then, the predicted mobility information of the vehicles in the neighbor table is applied to select the next-hop forwarder(s) in both directions (road direction and reverse road direction) of the consumer. Furthermore, the vehicle that is farthest from the current forwarder with a stable link is considered as the next-hop forwarder. Finally, extensive simulations are carried out to demonstrate that MPFS has a less number of Interest packets forwarded, while maintaining a higher ratio of satisfied Interest packets compared with the baseline forwarding strategies.**

***Index Terms*—Named Data Networking, Vehicular Networks, Interest Packet Forwarding, Mobility Prediction, Broadcast Storm**

I. Introduction

Vehicular Ad hoc Networks (VANETs) enable vehicle-to-everything (V2X) to improve driving safety, efficiently manage traffic conditions, and enhance user experience during driving [1]. However, IP-based communication and connection-oriented data transfer hinder vehicular networks from being practical owing to highly dynamic network topology and short intermittent links. Recently, data-centric communication approaches, like named data networks (NDN), have been found to match better with VANET than IP-based communication approaches [2] due to its name-based requesting, addressing, and forwarding. In NDN, the consumer sends Interest packet with the data name rather than the address of the Content Producer or Content Provide (CP) to bring the corresponding Data packet back [3]. In order to adapt typical NDN architecture to VANET, it is necessary to carefully design the forwarding strategy for Interest packets.

Although NDN has been introduced into VANETs, called Vehicular Named Data Networking (VNDN), there still exist the following two issues to be tackled when designing a forwarding strategy. First, the vehicles driving on highways tend to have **high speed and mobility**, so it is difficult to forward interest packets to the CP quickly and take the corresponding data packets back via the reverse path(s). Second, VNDN adopts Flooding strategy to achieve content retrieval and delivery. This flooding brings about well-known **broadcast storm**, which would result in numerous redundant Interest and Data packets, wireless transmission collision, congestion, and delay.

To alleviate the problem of the high mobility and Interest broadcast storm, many forwarding strategies in VNDN have been proposed to select the optimal vehicle(s) as the next-hop forwarder. The link-stability based forwarding chooses the vehicles with stable links as the next-hop forwarder [4], [5]. However, these forwarding policies are inefficient due to more hops being involved. In order to reach the CP faster, the distance-aware forwarding is proposed to select the farthest vehicle from the current forwarder for content delivery [6], [7]. Given the short intermittent links incurred by the high mobility of vehicles, the neighbor-aware forwarding is further designed to select the next-hop forwarder based on the information stored in NeighBor Table (NBT) [8], [9]. In [8], only one optimal vehicle among neighbors of the current forwarder is selected based on multi-criteria. However, it did not consider that the CP may drive to either side of the consumer (front or back). DIFS (Distributed Interest Forwarder Selection) [9] selects two forwarders in both directions of the consumer to forward Interest packets to the farther potential CP. However,

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these NBT-based forwarding strategies do not consider the problem of outdated location information in NBT, which is incurred by the high mobility of the vehicles. This inevitably reduces the success ratio and efficiency of content delivery, because the selected next-hop forwarder may no longer be within the communication range of the previous forwarder or may not be the optimal forwarder.

In this paper, in order to solve the problem of broadcast storm and the outdated mobility information of the vehicles in NBT, we propose a Mobility-Predict-based Forwarding Strategy (MPFS) in VNDN. When the next-hop forwarder is selected among the vehicles in NBT, Link Expired Time (LET) and Distance along the Road (DR) are simultaneously considered. However, it should be noticed that the messages in NBT often outdate in vehicular networks. Therefore, the estimated LET and DR based on outdated information in NBT often deviate from their actual values. In order to improve the estimation accuracy, we first predict the current mobility information of vehicles for the consumer or forwarder in NBT, and then computes the LET and DR between the consumer/forwarder and its neighbors. Generally, a vehicle with the longest LET and farthest DR from the current forwarder is considered as the optimal next-hop forwarder. However, a vehicle usually cannot have both the longest LET and farthest DR. In MPFS, the vehicle having both the farthest DR from current forwarder and a larger LET than a threshold (the threshold is large enough for Data packet return), is considered as the optimal next-hop forwarder among all the candidate forwarders. On the one hand, a LET greater than a threshold ensures that the Data packets can return to the consumer before the link connection expires. On the other hand, the maximum DR not only ensures fewer Interest packets, but also guarantee fewer hops to reach the CP quickly. Specifically, we summarize the main contributions as follows:

1) We present a mobility-predict-based forwarding strategy (MPFS) in VNDN to solve the problem of broadcast storm and outdated mobility messages of the vehicles in NBT, which is caused by high mobility of vehicles. The current mobility information of vehicles in NBT are predicted in a lightweight but effective manner to get closer to current real mobility.
2) We propose a novel policy to select the optimal next-hop forwarder with a small number of hops as well as a small number of Interest packets while maintaining high reliability. In order to transfer Interest packets to the potential CP faster, distance along the road instead of Euclid distance is employed to find the optimal next-hop forwarder.
3) Extensive simulations are conducted in ndnSIM [11] with the mobility trace of vehicles generated by SUMO (Simulation of Urban MObility). The results show that our proposed MPFS has a less number of Interest packets forwarded, while maintaining a higher ratio of satisfied Interest packets compared with the baseline forwarding strategies.

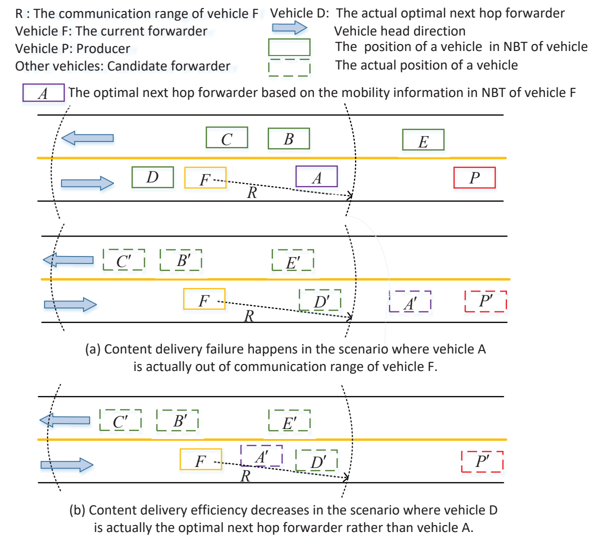


Fig. 1. Diagram of the success ratio or efficiency of content delivery decreases due to outdated mobility information in the NBT of the current forwarder in vehicular networks.

II. Problem Statement

To mitigate the problem of Interest broadcast storm, the next-hop forwarder(s) is selected among neighboring vehicles based on the information in NBT. Moreover, in order to maintain its one-hop NBT, every vehicle is required to exchange beacon messages carrying mobility information with its neighbors periodically. However, sending beacon messages frequently would lead to network resources waste and wireless transmission collision, especially in high density network. If the period of sending beacon messages is too long, the information in the NBT deviates greatly from the true one. A trade-off update frequency (e.g., a few seconds) often causes the mobility information in NBT to become outdated, which would affect the selection of the next-hop forwarder, and then degrade the efficiency and reliability of forwarding strategies.

As shown in Fig. 1, the success ratio or efficiency of content delivery decreases due to outdated mobility information in the NBT of the current forwarder. Vehicle F with a communication range of R is the current forwarder and vehicle P is the producer while other vehicles are candidate forwarders. Besides, the solid line car represents the relative position of the vehicles in the NBT of vehicle F, while the dotted cars represent the actual relative location of the vehicles with the same number. Vehicle F considers the information in its NBT comprehensively and regards vehicle A as the optimal next-hop forwarder to reach producer P. However, the outdated mobility information in the NBT of vehicle F is not considered. As depicted in Fig. 1(a), vehicle A which is regarded as the optimal next-hop forwarder is actually beyond the communication range of the current forwarder. So the request fails. As shown in Fig.1(b), content delivery efficiency degrades, because vehicle D is actually the optimal next-hop forwarder rather than vehicle A. It needs more hops to reach the producer. Therefore, in order to solve the problem of outdated NBT, the proposed MPFS first predicts the current

The original field | The appended field

Content Name	Nonce	Selectors	FIRRD	FIRD

Fig. 2. Modified Interest packet format.

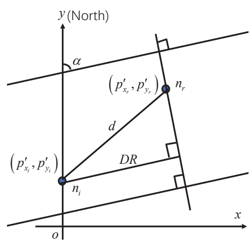


Fig. 3. Diagram of the DR (Distance along the Road) between node n_i and n_r.

position of the vehicles in NBT. On the basis of the predicted position, the next-hop forwarder(s) will be selected accurately.

III. The Proposed Strategy

A. Modified Interest Packet Format

The following two reasons explain why Interest packet format is modified. First, although the location of the content provider is unknown, content providers are distributed along the road in vehicular networks. Therefore, forwarders in both directions of the consumer are selected to reach the provider quickly. Second, only the vehicle(s) identity contained in the Interest packet forwards Interest further in the network while the rest of vehicles drop it, reducing the number of PIT entries, Interest and Data packets. To achieve this, two fields: `FIRRD` (Forwarder Id in the Reverse Road Direction), `FIRD` (Forwarder Id in the Road Direction) are appended to the modified Interest packet, except the original fields such as content name, nonce, selectors (see Fig. 2). Road direction and reverse road direction mean the angle from this direction counterclockwise to the north direction is less than 180°, more than 180°and less than 360°, respectively. They are obtained by a digital map.

B. Information Gathering

Mobility information is gathered to help select the optimal next-hop forwarder. Assume that (P_{x_i}, P_{y_i}), (v_{x_i}, v_{y_i}) are the present position, velocity of vehicle n_i at time t_i, respectively. Also, (P_{x_r}, P_{y_r}), (v_{x_r}, v_{y_r}) are the present position, velocity of vehicle n_r at time t_r, respectively. In the NBT of vehicle n_r, the mobility information of n_i at time t_i is represented as an entry $NBT_r(i, t_i) = (P_{x_i}, P_{y_i}, v_{x_i}, v_{y_i}, t_i)$. Moreover, $NBT_r(r, t_r) = (P_{x_r}, P_{y_r}, v_{x_r}, v_{y_r}, t_r)$. Assume that t is slightly larger than t_i, so the positions of vehicle n_i at time t are predicted as follows.

$$\begin{cases} p'_{x_i} = p_{x_i} + v_{x_i}\left(t - t_i\right) \\ p'_{y_i} = p_{y_i} + v_{y_i}\left(t - t_i\right) \end{cases} \tag{1}$$

Similarly, we get $NBT_r(r, t) = \left(P'_{x_r}, P'_{y_r}, v_{x_r}, v_{y_r}, t\right)$. The optimal next-hop forwarder is selected based on the predicted current positions of the vehicles in NBT instead of outdated information in NBT.

With a number of vehicles with high mobility in vehicular networks, it is hard to forward Interest to reach producer fast and send Data back to the consumer based on the reverse path(s). The vehicle farthest from the current forwarder with a stable link among the vehicles in NBT is selected. Also, the LET and DR between every two neighboring nodes can be estimated based on the predicted current positions. The LET between node n_i and n_r at time t is estimated as follows [10].

$$L\left(n_i, n_r\right) = \frac{-\left(ab + cd\right) + \sqrt{\left(a^2 + c^2\right) r^2 - \left(ad - bc\right)^2}}{a^2 + c^2} \tag{2}$$

Where $a = v_{x_i} - v_{x_r}, b = p'_{x_i} - p'_{x_r}, c = v_{y_i} - v_{y_r}, d = p'_{y_i} - p'_{y_r}$. As depicted in Fig. 3, The DR between node n_i and n_r is estimated as follows.

$$\begin{aligned} D\left(n_i, n_r\right) &= d\left(n_i, n_r\right) cos\left(\alpha - \arctan\left|\frac{{p'}_{x_r} - {p'}_{x_i}}{{p'}_{y_r} - {p'}_{y_i}}\right|\right) \\ &= \sqrt{\left({p'}_{x_i} - {p'}_{x_r}\right)^2 + \left({p'}_{y_i} - {p'}_{y_r}\right)^2} cos\left(\alpha - \arctan\left|\frac{{p'}_{x_r} - {p'}_{x_i}}{{p'}_{y_r} - {p'}_{y_i}}\right|\right) \end{aligned} \tag{3}$$

Where $d\left(n_i, n_r\right)$ is the Euclidean distance between vehicle n_i and n_r. Road direction (α) is obtained by a digital map. The DR rather than Euclidean distance between vehicles is adopted to spread Interest to reach the provider fast. We can obtain LET and DR between every two neighboring vehicles in NBT according to (2) and (3), respectively.

C. Forwarding Strategy

In order to achieve both efficiency and reliability for packet delivery, the vehicle whose DR is farthest from the current forwarder with a stable link is selected as the next-hop forwarder in MPFS. That is, the selected vehicle has LET larger than the threshold, which is large enough for Data packet return. On one hand, a stable link is selected to complete the exchange of Interest packet and Data packet. On the other hand, the vehicle whose DR is farthest from the current forwarder is selected to disseminate Interest packet as far as possible, so as to reach producer faster with fewer hops and fewer Interest packets. What is more, in case of low vehicle density, when no vehicle has LET greater than the threshold, the vehicle with the longest LET is selected as the next-hop forwarder. However, the estimated LET and DR based on outdated messages in NBT usually deviate from the true ones, owing to high mobility of vehicles. To address this problem, when a vehicle sends or forwards Interest packet, it first predicts the current mobility information of the vehicles in its NBT. And then forwarder(s) is selected based on the predicted messages of vehicles in NBT.

When a consumer vehicle sends an Interest packet at time t_0, two next-hop forwarders located in both directions are selected. Fig. 4 depicts the process that the consumer selects two next-hop forwarders when receiving Interest. The details of the steps are as follows.

Step 1. Predict current neighbor table NBT'_c based on outdated neighbor table NBT_c , according to (1).

Step 2. According to the predicted neighbor table NBT'_c, some vehicles which satisfy (4) are selected to the decision

Algorithm 1 Pseudo-code for Interest packet received at intermediate vehicles in MPFS

Input: An Interest packet [Name, Selector(s), Nonce, n_p, n_q] is received by current vehicle r.

1: **if** Content Not in Content Store (CS) **then**
2:   **if** Name Not in Pending Interest Table (PIT) **then**
3:     **if** $r = n_p$ **then**
4:       Add [Name, Nonce, Face] in PIT.
5:       Predict current neighboring table using (1).
6:       Decision list in the reverse road direction $DL_{RRD}(r)$ is created using (4).
7:       Compute LET $L(n_r, n_i)$ and DR $D(n_r, n_i)$ between vehicle r and the vehicles in $DL_{RRD}(r)$, according to (2) and (3).
8:       Select n'_p as FIRRD among the vehicles in $DL_{RRD}(r)$ using (6).
9:       Forward Interest [Name, Selector(s), Nonce, n'_p, N], where N is not any vehicle id in the network.
10:     **else if** $r = n_q$ **then**
11:       Add [Name, Nonce, Face] in PIT.
12:       Predict current neighboring table using (1).
13:       Decision list at road direction $DL_{RD}(r)$ is created using (5).
14:       Compute LET $L(n_r, n_i)$ and DR $D(n_r, n_i)$ between vehicle r and the vehicles in $DL_{RD}(r)$, according to (2) and (3).
15:       Select n'_q as FIRD among the vehicles in $DL_{RD}(r)$ using (7).
16:       Forward Interest [Name, Selector(s), Nonce, N, n'_q], where N is not any vehicle id in the network.
17:     **else**
18:       Drop Interest.
19:     **end if**
20:   **else**
21:     Drop Interest.
22:   **end if**
23: **else**
24:   Return DATA [Name, MetaInfo, Content, ...].
25: **end if**

list in the reverse road direction $DL_{RRD}(c)$. Similarly, some vehicles which satisfy (5) are selected to the decision list in the road direction $DL_{RD}(c)$.

$$DL_{RRD}(c,i) = \left\{ i \in NBT'_c \,\middle|\, P'_{x_i} < P'_{x_c} \,\&\, d\left(P'_{x_i}, P'_{x_c}\right) < R \right\} \quad (4)$$

$$DL_{RD}(c,i) = \left\{ i \in NBT'_c \,\middle|\, P'_{x_i} > P'_{x_c} \,\&\, d\left(P'_{x_i}, P'_{x_c}\right) < R \right\} \quad (5)$$

Step 3. The LET $L(n_c, n_i)$ and DR $D(n_c, n_i)$ between the consumer and vehicles in the decision list of the reverse road direction $DL_{RRD}(c)$(or vehicles in the decision list of the road direction $DL_{RD}(c)$) are calculated according to (2) and (3), respectively.

Step 4. The forwarder in the reverse road direction n_p is selected according to (6). Namely, if the vehicle in $DL_{RRD}(c)$, whose LET with consumer c $L(n_c, n_i)$ is larger than the local threshold μ, exists, the farthest vehicle along the road n_p is selected as the forwarder in the reverse road direction. Otherwise, the vehicle with largest LET is selected as the next-hop forwarder. Similarly, according to (7), n_q is selected as the forwarder in the road direction.

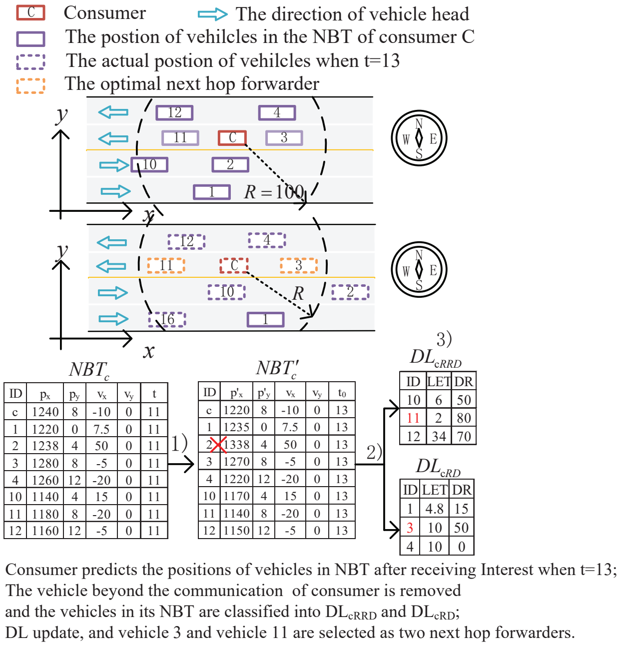


Fig. 4. The process that consumer selects two next-hop forwarders, when receiving Interest

$$n_p = \begin{cases} \max\limits_{n_i} \left[D(n_c, n_i) \,|\, L(n_c, n_i) > \mu \right], \exists L(n_c, n_i) > \mu, \\ \quad n_i, n_p \in DL_{RRD}(c) \\ \max\limits_{n_i} \left[L(n_c, n_i) \right], \ \nexists L(n_c, n_i) > \mu, n_i, n_p \in DL_{RRD}(c) \end{cases} \quad (6)$$

$$n_q = \begin{cases} \max\limits_{n_i} \left[D(n_c, n_i) \,|\, L(n_c, n_i) > \mu \right], \exists L(n_c, n_i) > \mu, \\ \quad n_i, n_q \in DL_{RD}(c) \\ \max\limits_{n_i} \left[L(n_c, n_i) \right], \ \nexists L(n_c, n_i) > \mu, n_i, n_q \in DL_{RD}(c) \end{cases} \quad (7)$$

Step 5. Consumer broadcasts the Interest packet [Name, Selector(s), Nonce, n_p, n_q].

When an Interest packet [Name, Selector(s), Nonce, n_p, n_q] is received by current vehicle r (except consumer), the pseudo-code for the forwarding process is illustrated in algorithm 1. only the vehicle(s) contained in the Interest packet forwards the Interest packet, while the rest of vehicles drop it. Also, only one vehicle in the road direction (or reverse road direction) farthest with a stable link is selected by the current vehicle to forward Interest packet to farther potential producer. However, in the case of low vehicle density, since perhaps no vehicle has LET larger than the threshold with the current forwarder, the vehicle with the longest LET is selected as the next-hop forwarder. To be precise, if $r = n_p$, n'_p is selected as the next-hop `FIRRD` (see lines 4-9 in Algorithm 1). If $r = n_q$, n'_q is selected as the next-hop `FIRD` (refer to lines 11-16 in Algorithm 1). If $r \neq n_p$ and $r \neq n_q$, vehicle r does nothing but to drop the Interest.

IV. Performance Evaluation

A. Simulation Environment

Our proposed algorithm is implemented in ndnSIM [11] and evaluated with the mobility trace of vehicles generated

TABLE I
SIMULATION PARAMETER

Parameter	value
Simulation scene	Highway with 10 km
Number of vehicles	50, 100, 150, 200 and 250
Number of Interest that consumers send	200, 400, 600 and 800
Initial vehicle speed	25, 35 and 40 m/s
Simulation time	20 s
Number of runs	3
Data message size	1 kb
Bit rate	24 Mbps
Transmission power	40 mW
Max transmission range	500 m
Carrier frequency	5.9 GHz
Communication technology	IEEE 802.11p
Additional data structures	NBT

by SUMO (Simulation of Urban MObility) [12]. In our simulation, a highway segment with a length of 10 km is considered. For a fair comparison, an identical simulation parameter and mobility model are used in the simulations, which is illustrated in Table I.

We consider different vehicle densities by varying the total number of vehicles in 50, 100, 150, 200, and 250. In addition, we consider different network traffic by varying the total number of Interest that all consumers send in 200, 400, 600, 800. We assume that every vehicle has different contents in the cache (become producer). Moreover, every vehicle randomly generates Interest packet (become consumer) for random contents, which differs from the contents at CS. And there is no fixed time slot for generating any Interest, thus ensuring like real scenario. What is more, the retransmission time of Interest is set to 3 seconds. Every vehicle shares its mobility information with its neighbors through beacons with a rate of 0.5 beacons/s. All nodes are equipped with IEEE 802.11p interface operating in ad hoc mode. We configure the transmission rate of 24 Mb/s and transmission power of 40 mW. The transmission range of 500 m is considered.

The performance of MPFS was compared to that of DIFS [9], and the basic Flooding strategy. Simulation results were averaged from three independent 20s long runs. For comparisons, the following performance metrics are introduced.

- FIP: The average number of Interest packets forwarded per vehicle when retrieving Data.
- SIR: Ratio of the number of Satisfied Interest packets to the total number of Interest packets that consumers send.
- ISD: The average Interest Satisfaction Delay. The time elapsed from the instant when a consumer sends an Interest packet for the first time to the Data packet received by it.
- HCN: The average Number of Hops for Content retrieval.

B. Results and Discussion with Different Vehicle Densities

With a certain total number of Interest packets sent by consumers, the performance of MPFS, DIFS, and Flooding are investigated and compared using different numbers of vehicles.

First of all, it can be inferred from Fig. 5 that SIR and HCN of all strategies first increase and then remain stable, while the total number of Interest packet forwarded by all vehicles in the network increases, when the number of the vehicles in the network increases. This expected trend happens due to the increment of vehicle density. When the number of vehicles is 50, frequent partitions often occur in the vehicular network. As a result, the Interest packet could not reach farther producer, as a consequence of low total FIP, low SIR, and low HCN, refer to Fig. 5(a), Fig. 5(b), Fig. 5(d). Moreover, low SIR leads to much Interest packet retransmission, bringing to high ISD, refer to Fig. 5(c).

As can be seen from Fig. 5 (a), with the increase of vehicle density, FIP of MPFS and DIFS decreases, while FIP of Flooding strategy first increases and then remains stable. For Flooding strategy, every vehicle receiving an Interest packet will forward it, hence always maintaining high FIP. In addition, owing to unreliable wireless transmission, more than one node among neighboring nodes or none of them may be the next-hop forwarder in DIFS. However, only one vehicle among its neighbors is selected to forward Interest received further in the network in MPFS. This explains why the FIP of MPFS and DIFS decreases with the increasing number of vehicles, and the FIP of MPFS is less than that of DIFS.

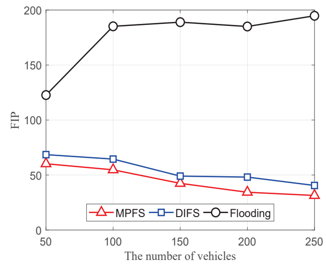
When compared with Flooding strategy, the proposed MPFS brings about less HCN and less FIP, while maintaining similar SIR, whatever vehicle density is. Although more Interest packet forwarded at each hop helps improve content delivery, it leads to higher contention for the use of wireless channel, which causes transmission failure and delay, especially with the increasing vehicle density. When the number of vehicles is 250, Flooding strategy forwards 5.2 times Interest packet more than MPFS, and 3.81 times more than DIFS. That explains why SIR of Flooding strategy drops slightly while ISD of Flooding is more than that of other strategies, when the number of vehicles is 250.

When compared to DIFS, the proposed MPFS induces less FIP, less ISD, and higher SIR while maintaining similar HCN, whatever vehicle density is. It is verified that MPFS reaches farther producer than DIFS with the same hop, gaining higher SIR. Moreover, because of retransmission times incurred by transmission failure, MPFS gains less ISD.

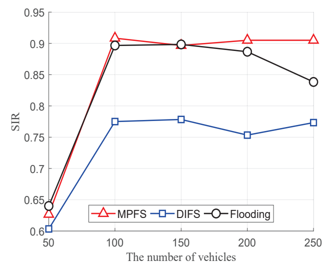
C. Results and Discussion with Different Network Traffic

With a certain number of vehicles in the network and different numbers of Interests sent by consumers, the performance of MPFS, DIFS, and Flooding are investigated and compared.

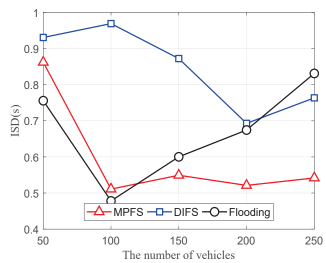
It can be seen from Fig. 6 that SIR and HCN decrease, meanwhile FIP and ISD increase, when the number of Interest packets that consumers send increases. That is due to higher contention for the use of wireless channel due to more overhead occasioned by more Interest or Data packet transmission. Therefore, not only Interest can't reach farther vehicles for content retrieval, leading to low SIR and low HCN, but also more Interest packets retransmissions for consumers and longer queue per vehicle result in high ISD. Moreover, the



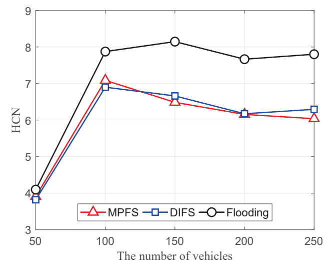
(a) Number of Interest packets forwarded per vehicle



(b) Ratio of satisfied Interest packets

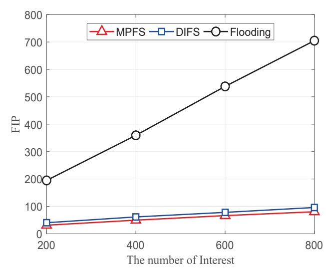


(c) Average Interest satisfaction delay

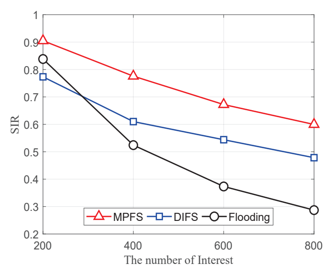


(d) Average hop count for content retrieval

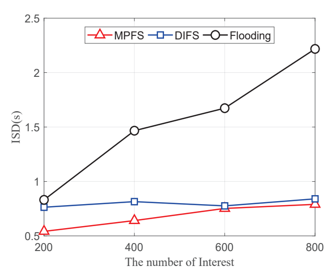
Fig. 5. The performance of different forwarding strategy with different network densities, when the total number of Interest packets is 200.



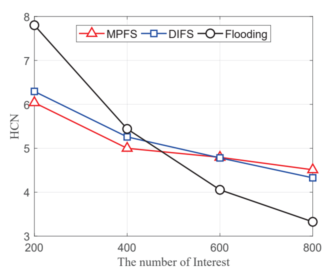
(a) Number of Interest packets forwarded per vehicle



(b) Ratio of satisfied Interest packets



(c) Average Interest satisfaction delay



(d) Average hop count for content retrieval

Fig. 6. The performance of different forwarding strategy with different network traffic, when the number of vehicles in the network is 250.

performance of Flooding strategy declines faster than MPFS and DIFS, owing to its rapid increase in FIP.

When the total number of Interest that consumers send is 200, 400, 600, 800, MPFS maintains more 45.96% SIR with less FIP to 87.3%, less ISD to 55.97% in average than Flooding strategy. This can be explained by that MPFS needs less overhead, such as FIP and fewer nodes involved in the Interest packet process, for content delivery.

MPFS maintains more 22.74% SIR with less FIP to 17.4%, less ISD to 14.71% on average than DIFS. Owing to unreliable wireless transmission, more than one vehicle at each hop may be forwarder in DIFS, leading to DIFS more FIP than MPFS. In addition, it is verified that MPFS can reach farther producer to gain higher SIR than DIFS. Because the next-hop forwarder(s) is selected based on predicted mobility messages in NBT in MPFS. Therefore, the proposed MPFS outperforms the strategies of Flooding, DIFS in terms of FIP, SIR, ISD.

V. Conclusion

In order to mitigate the problem of Interest broadcast storm and the outdated information in NBT, we propose a mobility-predict-based forwarding strategy in vehicular named data networks in this paper. After the current position of vehicles is predicted, the vehicle that is farthest from the current forwarder with a stable link among neighbors is selected as the next-hop forwarder to fetch content fast with fewer hops. Also, with provider location unknown, Interest is forwarded in both directions of the consumer to reach potential providers. Because only the vehicle(s) contained in Interest forwards it, MPFS has a small number of FIP. Simulation results show that MPFS gains higher SIR with less FIP than Flooding, DIFS. We mainly consider network partitions caused by high mobility in this paper, and we will further consider producer mobility to improve the success ratio of content delivery when designing a forwarding strategy in the future.

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