A Survey on Geographic location routing and forwarding strategies of VANET and WSN based on NDN

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Abstract. Named-data Network (NDN) is a new network architecture, and its purpose is to achieve network architecture from the host-centric to the data-centric. NDN uses the data name of the application to communicate directly. Since the data name is defined by the application and unrelated to the connection, it relieves the need for IP address configuration, so as long as the physical connection exists, data exchange can occur. The NDN-based forwarding mechanism is very important for effective communication in Vehicle Ad-hoc Network (VANET) and Wireless Sensor Network (WSN). Location-based routing and forwarding utilizes the location information of neighboring nodes or destination nodes to improve the efficiency of routing search. The paper mainly discusses the geographical routing and forwarding strategies of NDN-based VANET and WSN and the existing problems, and proposes future challenges for NDN routing and forwarding.

1. Introduction

The mobility, traffic pressure, and security problems faced by IP-centric network systems now need to be solved urgently, and NDN is a new type of network architecture based on these requirements[1]. NDN aims to adapt to this increasingly complex network, from the user’s point of view, and NDN uniquely names each piece of information within a certain range, maintaining the narrow features of the IP architecture[2], but turning the information name into the core of the network. NDN provides a new way to think about future network architecture. It is a powerful architecture that supports Internet application services. NDN is one of the research projects of the future Internet architecture funded by the National Science Foundation[3]. It originated from an early project-Content-Centric Network (CCN). NDN was an example of ICN at the very beginning.

VANET, or, the vehicle ad-hoc network, is a self-organizing network composed of mobile vehicles[4]. The creation of VANET is based on the principle of Mobile Ad-hoc Network (MANET). VANET has the basic characteristics of MANET, but because of the particularity of the vehicle environment, it is endowed with different characteristics. Due to the network characteristics of VANET itself, such as high dynamic topology, strict delay requirements, high node movement speed, and mobility constraints, traditional IP-based networks cannot perform well in the vehicle environment[5]. NDN architecture is suitable for multiple users requesting the same or different data at the same time or at different times, and there is no requirement for continuous connections between users. The applications in VANET are often related to time and location. This is exactly the scenario where NDN is applicable. Combining the advantages of NDN, it can just solve the problem of VANET information transmission. Wireless Sensor Network (WSN), composed of a large number of sensors deployed in the monitoring area in a self-organized and multi-hop way, is a wireless network that cooperatively senses, collects, transmits and processes the information of monitored objects in the
network coverage area. Wireless sensor network systems usually include sensor nodes, sink nodes and management nodes. NDN provides a comprehensive solution for the entire Internet and IoT. NDN adopts a receiver-based service model to change the communication paradigm from a traditional host-centric communication method to a named data-centric communication method, which can naturally meet the requirements of WSN and IoT.

The combination of many scenarios (including VANET and WSN) with the NDN architecture has been extensively studied, and some efforts have been made to study how to apply the NDN architecture to scenarios such as VANET and WSN. NDN provides them with feasible solutions, but at the same time, the original NDN faces new challenges such as naming schemes, security, routing and forwarding. Inspired by the extensive research on NDN-based VANET and WSN scenarios, this paper will give a detailed system overview of VANET and WSN under the NDN architecture. More specifically, the paper makes a comprehensive statement of the geographical location aware forwarding strategies in the NDN-based VANET and WSN scenarios proposed in various literatures. At the same time, this paper will describe the challenges faced by NDN-based VANET and WSN scenarios and future research directions.

2. NDN VS IP

2.1 Architecture and routing/forwarding of NDN

The NDN architecture is a brand new paradigm architecture, but it can be based on current practice in terms of operation. The design of the NDN architecture represents our understanding of the limitations and advantages of the currently implemented Internet architecture (ie, TCP/IP). NDN maintains the same hourglass architecture as the original Internet[1], as shown in Figure 1.

NDN uses flooding to carry out routing announcements of content, content sources and cache nodes advertise content name prefix announcements in the network, and nodes that receive the announcement establish and update their own FIB tables. NDN communication is driven by data consumers, and it has two types of packets: Interest and Data packets[6]. Each router node maintains three data structures: Forwarding Information Table (FIB), Pending Interest Table (PIT) and Content Store (CS). In NDN, the requester-driven communication mode is adopted, that is, the content requester sends the Interest request content, and the content provider sends Data to respond after receiving the request.

2.2 The limitations of IP

The hourglass architecture of today's Internet realizes the minimum functions necessary for global interconnection on the general network layer of IP[7]. The thin waist structure enables independent innovation of upper and lower layers of technology, thereby exploding the number of Internet. But IP data packets are only named at the communication endpoints, so IP represents two things, one is the identity of the host, and the other is the location of the host. IP-centric networks face the following problems:

- The allocation and management of IP addresses. The huge number has led to the demand for IP addresses and the management of IP difficult;
3. Forwarding strategies

3.1 Location routing/forwarding strategies of VANET based on NDN

The Vehicle Ad Hoc Network (VANET) is a sub-domain and application running under the Mobile Ad Hoc Network (MANET). Literature[4] developed a named data vehicle network (V-NDN) prototype in VANET through a named data network. Sometimes, the information from the source node is very critical (ie, accidents, road conditions). Therefore, the communication between the source node and the target node is very challenging. The challenge of using NDN in VANET is the flooding of Interest and Data packet forwarding, and due to the high mobility of vehicles in VANET, data distribution will encounter interruption problems.

In order to solve these problems, literature[8] introduced the DTN mode into the packet forwarding process, and proposed a hybrid geographic routing solution that combines restricted greed, greed, perimeter and DTN modes to improve packetization forwarding in VANET in urban areas; Literature[9] proposed Navigo, a brand-new method to solve the frequent connection interruption and sudden network changes in VANET. Navigo uses geographic information instead of routing protocols to guide Interest packet forwarding; and literature[10] also proposed a Geographic Opportunistic Forwarding Strategy (GOFP) for vehicle named data networks to solve the problem of data distribution interruption by selecting the best relay node, It requests Interest data packets from POI, and can uses the nearest and fastest response vehicle as the best relay node; In order to improve the performance of the entire network and reduce overhead, A reliable VANET forwarding strategy based on NDN proposed in [11], RFS only uses beacons to share information about neighboring nodes and is a lightweight and no-topology protocol. During the content search, in order to deal with the interest broadcast storm problem, [12] proposed an Interest Packet Forwarding Protocol for content requests based on link stability (LISIC). This protocol controls the transmission of interest packets by giving prioritize neighbor vehicles with a more stable link for the current sender; and [13] proposed a location-based content distribution protocol (LOCOS), which uses the location of the recently discovered vehicle content source to control the transmission of interest packets to the area where the content source is located, the idea is to perform a search for the required content in the neighboring area of the known content provider; [14] proposed a preliminary design to support traffic in VANET Information retrieval. The design adopts an information-centric communication model and a probabilistic forwarding strategy based on name and geographic location to improve traffic information retrieval in VANET.

Location forwarding strategies of VANET based on NDN are summarized as Table 1.

| Name of strategies | Description | Problems to be solved                                                                 | characteristic                                                                 |
|--------------------|-------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Navigo[9]          | Binding of name to geographic area                                                   | Connection interruptions and network changes                                    | Mapping data name to data location and forwarding packets along optimal path    |
| GeoDTN-NDN[8]      | Hybrid geographic routing solution                                                    | Interest packet’s flooding and Data packet’s forwarding disruption               | Forwarding Interest packets to the destination in different modes according to location information |
| GOFP[10]           | Geographical opportunistic                                                            | High mobility of vehicle and selection of available relay                       | Forwarding Data and Interest packets with different strategies based on POI’s location |
4. Open challenges

NDN accelerates the communication speed between nodes, which is of great help to the improvement of network performance. At the same time, it explains network security issues and data redundancy issues. The potential of the CCN/NDN paradigm applied to VANET and WSN networks remains
challengable.

In general, there are many problems that need to be solved to better apply NDN to VANET and WSN, but the following difficulties are the most concerned:

- Naming scheme. As an information-centric network, NDN must have a unique name to identify each content, otherwise it will lose its original advantages. In order to make each VANET’s and WSN’s content have a uniquely identifiable name, it is necessary to thoroughly analyze the characteristics of VANET’s and WSN’s applications;

- Caching mechanism. Universal caching is simple and easy, but the premise is under the assumption that storage space is infinite. Considering that there are geographical and time constraints on the content of VANET’s and WSN’s applications, we should try to combine this feature to select the cache and delete it according to the timeliness, so as to reduce the existence rate of the same copy and outdated messages, and increase the use of cache space rate.

5. Conclusion

The paper discusses the NDN architecture and routing/forwarding strategies, as well as the role of NDN in VANET and WSN. The main focus is on the NDN-based geographic location routing and forwarding strategy. The geographic location routing and forwarding strategies in VANET and WSN scenarios are separately and comprehensively summarized in order to gain a broader understanding. In order to better understand NDN, this paper briefly compares NDN and IP. The challenges related to NDN forwarding and possible future research directions are also discussed. In conclusion, the research in the paper shows that there is enough space in VANET and WSN scenarios to design smarter and more enhanced forwarding strategies.

Acknowledgments

We thank the anonymous reviewers for their insightful feedback. This work was supported by National Key R&D Project of China under grant 2019YFB1802505.

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