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Named Data Networking in VANET: A Survey

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***Abstract*—*Named Data Networking is futuristic data oriented communication model, currently applied to different area of networking. VANET is one area of networking, that named data networking applied on it, to overcome the problem of classically TCP/IP based architecture. As VANET has become a likely area in wireless communication, which can provide a lot of service: traffic efficiency, road safety, and driving comfort. So, Named data networking architecture provide a lot purpose for VANET such as in network caching, security and efficient data distribution between vehicles due to caching capabilities in NDN, this feature make VANET more efficient than TCP/IP network. In existing IP based internet architecture the end points identified by IP addresses but in NDN contents are named with human readable names that provide VANET to retrieve data by sending content name without knowing the location of the provider. This paper also present some research challenge in the VANET via NDN.*

***Keywords*—** *NDN, VANET, Caching, ICN.*

I. INTRODUCTION

Named Data Networking is a new emerging data oriented model, which was extended from Information Content Network (ICN) that is applicable in different area of networking. Specially, NDN is hopeful solution for Vehicular Ad-Hoc Networks (VANETs) by providing a lot of advantage such as in network caching, security, and efficient response time [1], [2]. So, NDN is novel for vehicular ad hoc network (VANET) by providing different service than TCP/IP based vehicular ad hoc network (VANET).

NDN consider the content name as the first class of citizen in NDN communication model, because to access some data on the network, only the required things is data name, thus why the content considered as first class of the citizen. There two type of packet in NDN those are Interest Packets and Data Packets, along with specific data structures in each nodes such as the Content Store (CS), Forwarding Information Base (FIB), and Pending Interest Table (PIT) [3]. Communication in NDN originated by consumer using interest packet for required data.

Vehicular ad hoc network (VANET) is a network of vehicle which is used to communicate between vehicle and other infrastructure. Presently, VANET is based on traditional TCP/IP based architecture, due to this, data forwarding in VANETs faces several challenges dealing with short connectivity and highly dynamic topologies nature of TCP/IP based network [9]. To mitigate this problem NDN come to exist as providing mobility solution to some extent and some built in service such as in network caching, security and data availability. Different protocol are released to support communication between vehicle those are Dedicated Short Range Communication (DSRC) or Wireless Access in Vehicular Environments (WAVE) and Wi-Fi, to collect traffic information [7], [8], [28]. NDN is a likely solution to Vehicular ad hoc network (VANETs) by eliminating the limitations in TCP/IP architecture, however several change to the baseline NDN operations are essential for the VANET environment to increase the performance of VANT in advance.

The remaining of the paper has been arranged as bellows. Section 2 talks about Comparison of TCP/IP with named data networking**.** Section 3 deal about NDN system architecture and working principles. Section 4 discuses about application area of named data networking for VANET. Section 5 deals about open research challenge and Section 6 Conclusion

II. COMPARISON OF TCP/IP WITH NDN

Today's Internet architecture are based on TCP/IP. It has a layered hourglass architecture that share with named data networking communication model (see Figure 1). Individually layer in the communication model offers a specific functionality, lower-layer protocols define interfaces that is used by upper-layer protocols. IP is network layer protocol that is located in the middle of hourglass in TCP/IP network but in NDN communication model IP is replaced by content name [12]. NDN is the prominent communication model recently proposed data centric model for different area of networking. It receives the hourglass shape of IP communication model, but replaces IP with NDN [4, 10].

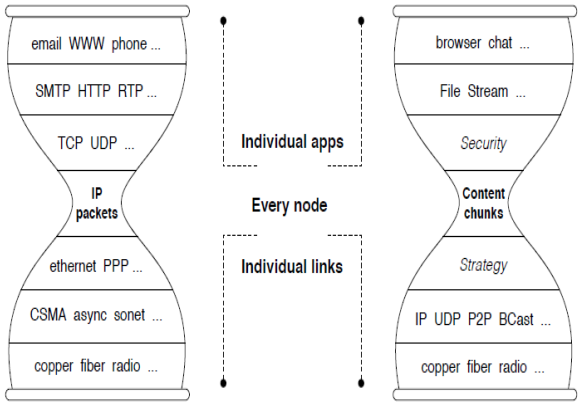

Fig. 1. IP and NDN Hourglass Architecture [4, 12].

When Relating TCP/IP architecture with NDN communication model NDN have fundamentally new features those are stated below [13].

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- ✓ It use the content name to initiate the communication and also use name for routing instead of IP address in TCP/IP network.
- ✓ It provide caching in every intermediate node, which is used for availability of content and reduce response rate of packets [15, 17].
- ✓ It provide data centric security rather than communication channel [14].
- ✓ Compared to IP networks, NDN does not require DNS services, subnet masks, and gateways, neighbor lists and other features [19]

III. NDN WORKING PRINCIPLES

NDN is a novel communication model, which a lot of researcher give attention on it. Named data networking (NDN) access data by data names, where naming is applied for each and every data that is accessed in one communication range. This simplify data search or retrieval and to sophisticate the communication. Naming structures are based on application-specific and independent of the network. The name used to access global data it must be globally unique [5].

3.1 Naming

In NDN each packet is attached to unique name to uniquely identify that packet in one communication range. The naming of data is same with DNS that is hierarchically structured name. In order to access exact data, a user will type related keywords that associated with required. Consumer initiate communication in NDN by sending interest packet for required data (see Fig. 3(a)). As soon as an interest packet reaches to content producer or a node having the required content that is Data packet (see Fig. 3(b)) is delivered for requested interest packet [6]. Whenever a node neither produce data for requested interest packet nor it is able to forward interest packet upstream, it sends interest NACK to its downstream [16].

In this paper, the node which send interest for is required data termed as 'consumer ', and the node produce the content is termed as 'producer' as well as the node forward interest packet or data packet is termed as 'provider'.

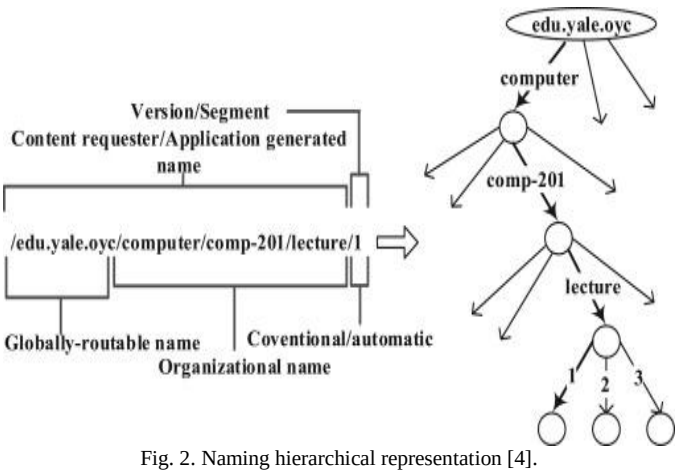

Fig. 2. Naming hierarchical representation [4].

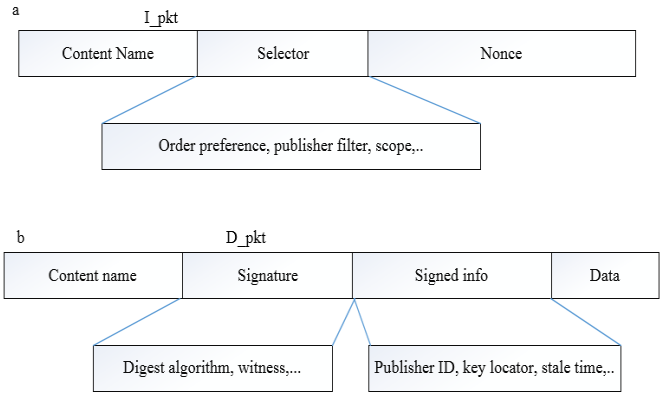

Fig. 3. Shows interest packet and Data packet [4].

3.2 Data structure of NDN

In NDN communication model each node must maintain three data structure those are FIB (see Table 2), PIT (see Table 1) and CS. When interest packet is received by NDN node it search the requested packet in CS. If NDN node obtain match data for requested packet it send to the consumer else the interest packet will be checked in the PIT [10]. If interest packet is an exactly-matching PIT entry, then interest packet is discarded and arrival face is added in the PIT entry [18]. If not**,** PIT creates new face for not satisfied interest packet, then routed upstream based on FIB information to find requested content from upstream potential data source. A response data packet will be directed downstream and cached in the CS if interest packet requested data is available in PIT table. (See Fig. 4 for NDN communication process)

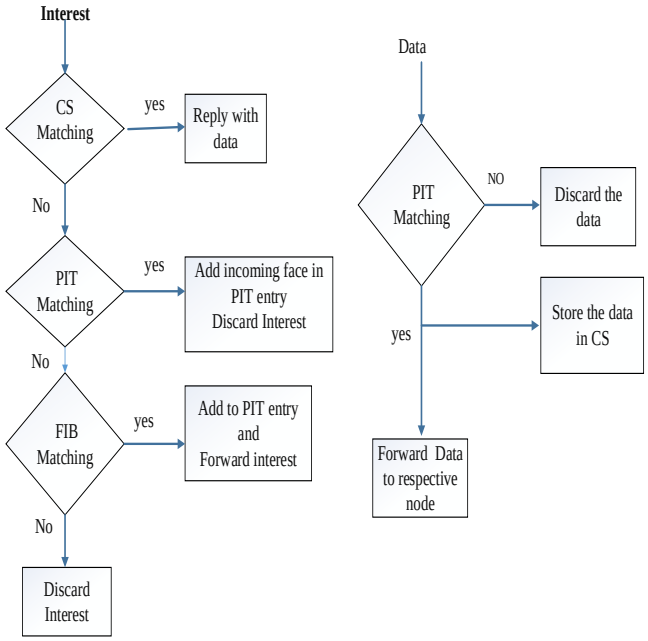

Fig. 4. Named data communication process [25].

PIT is a table in NDN node, which helps to store pending interest packet, that provide data packet come back to the node in order to cache the data by verifying PIT table. Each PIT

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entry has five fields (Table I) those are nonce, incoming and outgoing interface, content name and timer.

TABLE I. Pending Information Table (PIT) [27]

Name	List of Nonce	List incoming Interface		List out coming Interface	
Content Name	Nonce	Interface Id	Lifetime	Interface id	Send time

FIB is NDN data structure used to route interest packet. FIB contain the following fields (Table II) FIB contain the following field those are routing preference, RTT, stale time, status, and rate limit.

TABLE II. Forwarding Information Base (FIB) [27]

Name prefix	Stale time	Interface ranked by forwarding policies				
Name prefix	Time	Interface Id	RTT	Routing preference	Status	Rate limit

IV. Purpose of NDN for VANET

NDN is likely solution for VANET [9, 10, and 20]. NDN permits vehicles to produce content using different sensor equipped in the vehicle. The generated content is response for requester. Currently different functionalities is added to VANET those application supporting the emerging of a new applications including gaming on the go and real time video streaming, which need greater performance when associated to outdated VANET applications such as traffic and accident condition warnings [19]. As the advanced feature added to VANET it need advance communication model that increase the performance of VANET. NDN likely future internet architecture, which can provide a lot purpose for VANET such us in network caching, security, mobility support and provide efficient data distribution.

4.1 In Network Caching

NDN provide in-network caching, that decrease the needless retrieving of content from the central server or producer that increase availability of data at every intermediate node to improve the user response time [17, 21]. Due to this functionality, vehicular ad hoc network (VANET) are more advantages to retrieve content from the neighboring node because each node cache the content. However, due to distributed storage in every node of the network and lesser cache space which decrease the success rate of data and overhead is introduced in cache management. To overcome this caching problem a lot of researcher proposed some solution to curve this problem that is HCC methods by groping network in to different cluster, for each cluster one clusterhead is selected for all cluster this clusterhead mange all decision in one cluster [17]. This methods improve in-network caching and increase performance of network.

Different caching policies is also proposed by different researcher see fig 5.

The figure 5 shows classification of caching strategies in named data networking. It divide caching in to two categories those are cache placement and cache replacement and each this categories have their own division. Cache placement is the categories of caching that is leaving copy of data in every path based on some criteria.

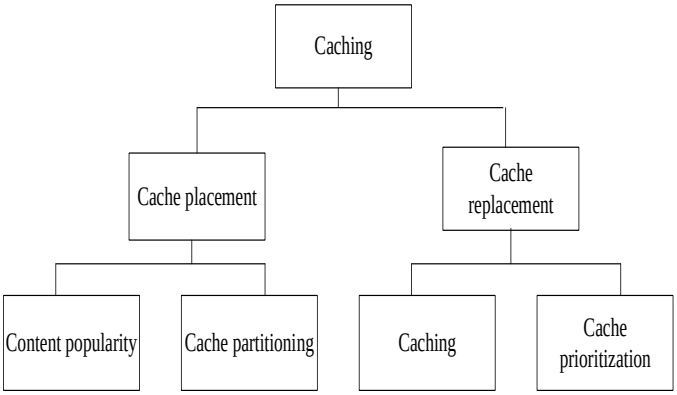

Fig. 5. Classification of different caching strategies [4].

The performance of in network caching is measured by four metrics those are: success ratio, content delay, average number of hops traversed. Other helpfully performance metrics of cache can be dissemination speed, which measures content distributing time for to respective network node [4].

4.2 Security

NDN share the same hourglass model with TCP/IP communication model, but in the middle of hourglass leverages NDN instead of IP addresses for initiating communication for delivery of packet [4].

NDN provide high security than TCP/IP communication model by providing security at data level this is provided by security layer dedicated for securing data in NDN.

Content integrity and authentication made in NDN by producer signature and different authentication information (e.g., producer public key) in every Data packet. As shown in fig. 1, security and strategy are two new layer added on named data networking architecture. Security layer offers security to every content in named data networking unlike securing communication channel in TCP/IP network [16]. Strategy layer provide forwarding interest/data packet between nodes and control forwarding in each node.

4.3 Mobility

In vehicular ad hoc networking (VANET) the mobility of vehicle disrupt the communication of vehicle in TCP/IP architecture but this is improved to some extent in named data networking due to the availability of data on different intermediate node rather than the producer. Different technique is used to achieve this mobility such data mulling physical carries of data in case intermittent. This technique mainly used for sparse vehicle and the other technique is multi hop technique mainly used for dense vehicle.

4.4 Efficient Data Dissemination

In-network caching and name-based communication make NDN a likely solution for data distribution in VANET [22]. So, different Named Data Networking packet forwarding technique have been planned for VANET by different researcher to improve predefined named data networking

forwarding strategies (See Table III). The built in forwarding strategies in NDN is flooding strategies that distribute packet to all neighbor.

TABLE III. Named data networking forwarding strategies

Scheme	Architecture	Contribution in forwarding strategies	Simulation tools	Mobility
Simple inter-vehicle one-hop large-size content distribution mechanism [23].	NDN	(i). It enables multiple functions including nearby request, multisource supply, intelligent response and breakpoint resume	ndnSIM	Urban mobility using SUMO
geo-based forwarding strategy[25]	NDN	(i). geographically based forwarding and data retrieval (ii). Addition field is added to FIB	ndnSIM	Urban mobility using SUMO
Navigo[24]	NDN	(i).Additional field in interest/Data packet to add geo based routing in NDN (ii). Use data naming design to add geolocation to the packet	ndnSIM	Urban mobility using SUMO
Push based critical data dissemination [9]	NDN	(i). It relies on beacon message - no interest forwarding for critical data	ndnSIM	Urban mobility using SUMO
Density-Aware Delay-Tolerant(DADT)[30]	NDN	(i).It use Delay Tolerant Networking (DTN) (ii).It use two communication phase : ✓ Rebroadcast ✓ Retransmission.	ndnSIM	Urban mobility using SUMO
Prefix-based prioritized technique[22]	NDN	(i). it add "name-prefix" to priorities different application. -Then it send data based on priorities.	ndnSIM	Urban mobility using SUMO
RUFS[29]	CCN	(i). data structure is added on it, apart three data structure in CCN (ii).new parameter for forwarder selection.	NS 2.35	Urban mobility using SUMO
Neighborhood-Aware Interest Forwarding (NAIF)[18]	NDN	Additional data structure (i) Distance table Eligibility of an intermediate node based on: ✓ Data retrieval rate ✓ Distance to the consumer.	ndnSIM	-
Provider-aware forwarding (PAF)[18]	NDN	Additional data structure (i) Distance table Additional packet fields (i) Provider–identifier, (ii) Distance	ndnSIM	-
Blind forwarding (BF)[18]	NDN	(i) Nonce data structure and packet field added	ndnSIM	-
Next-hop awareness:[18]	NDN	-use beacon to discover the neighbor and some additionally field is added to it.	ndnSIM	-

V. Open Research Challenge

Even if, NDN is likely solution for vehicular ad hoc network (VANET) "there are two side for every coin" some challenge is there that is road map of the researcher. As named data networking (NDN) is drawn lots of attention presently, it offer plenty of open research challenge such as naming, caching ,mobility, security and forwarding strategies.

5.1 Naming

Naming is an important in named data networking (NDN) as content delivery is based on data name rather than IP based, so NDN require globally unique name, human readable and secure naming. Currently, naming hierarchical are used by different researcher but not satisfies all requirement. In [25] naming is designed for geo-location for content distribution between vehicle. Consequently, the major challenge is to develop naming design that can fulfill all requirement in Vehicular Ad hoc Network (VANET) scenarios.

5.2 Mobility

In NDN mobility problem is solved to some extent. NDN minimize hand off delay when switching from one information source to other, as result of replicated copies of content, which hosted on intermediate node between the consumer and producer of the content. Nevertheless, the key problem is many real time communication has less use of caching (e.g., video streaming). As a result, real time communication that support NDN is a major research challenge. In VANET, most of the time the vehicle get information from crow-sourcing, so authenticating data without revealing provider identity is a major open research challenge.

5.3 Forwarding

NDN forwarding process depends on three data structure, namely, pending interest table (PIT), content store (CS), forwarding information base (FIB). There can be many entries that are entered, removed within these data structure, so efficient data structure that support memory consumption, high speed lookup are still open research area. In [7] dynamic pending interest table (DPIT) is proposed to overcome the problem of storing every broadcast interest packet in vehicular named data networking (NDN) but not considering the other data structure.

5.4 Interest Flooding

In [24, 25] interest forwarding is improved to some extent, but there is still possibility for further improvement. However, these solution are also challenging due to dynamics nature of vehicular ad hoc network.

VI. CONCLUSION

NDN is upcoming content oriented communication model that provide hopefully solution for vehicular ad hoc network (VANET) than traditional TCP/IP based VANET, those service provided by NDN are in network caching, security and efficient data distribution, due to availability of data in different intermediate node rather than the content producer. This paper also present some comparison of TCP/IP with NDN, naming hierarchical, named data networking(NDN) communication process , as well as discussing some efficient data distribution scheme applied on NDN such as : Simple inter-vehicle one-hop large-size content distribution mechanism, geo-based forwarding strategy, Navigo, Density-Aware Delay-Tolerant(DADT), Prefix-based prioritized technique, Neighborhood-Aware Interest Forwarding and robust forwarding selection(RUFS). Lastly, some open research challenge in named data network (NDN) via vehicular ad hoc network (VANET) were discussed.

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