Ph.D. Research Proposal

Doctoral Program in "Department Name"

SDN Enabled Vehicular Named Data Networking for Secure Emergency Dissemination and Content Retrieval through Evolved Interest Packet

by

<Name of the Candidate>

<Reg. No of the Candidate>

<Supervisor Name>

<Date of Submission (DD MM 20YY>

PHD PRIME YOUR RESEARCH PARTNER

I. INTRODUCTION / BACKGROUND

Vehicular ad hoc network (VANET) has recently become one of the highly active research areas for wireless networking. Since VANET is a multi-hop wireless network with very high mobility and intermittent connection lifetime, it is important to effectively handle the data dissemination issue in this rapidly changing environment. However, the existing TCP/IP implementation may not fit into such a highly dynamic environment because the nodes in the network must often perform rerouting due to their inconsistency of connectivity. In addition, the drivers in the vehicles may want to acquire some data, but they do not know the address/location of such data storage. Hence, the named data networking (NDN) approach may be more desirable here. The NDN architecture is proposed for the future Internet, which focuses on the delivering mechanism based on the message contents instead of relying on the host addresses of the data. Named data networking (NDN) aims at efficient content delivery and reducing the redundancy of data transmission. In NDN, one of the most important issues is how to utilize the cached contents to reduce the user's response delay and improve the utilization of the cache resources.

PHD PRIME
YOUR RESEARCH PARTNER

IP addressing issues presented in traditional network is overwhelmed with the help of Named Data Networking [3]. To attain both network management and IP enhancement, SDN and NDN are combined in VANET [4]. Data dissemination plays vital role in VANET since it includes both emergency message transmission, and delay tolerant packet transmission [11]. Data dissemination to desired numbers of receivers was performed through an approach known as DOVE [13]. Here disseminator selection is not trustworthy and also overhead is high for large number of receivers. In SDN enabled VANET, data dissemination was enabled by including three modules [14] in SDN application layer. This method is not able to transmit emergency transmission even with involvement of three modules. Priority based content forwarding strategies were introduced based on naming scheme [10], and freshness parameter [17]. Major drawback involved in these works is these methods are not able to differentiate emergency packets from high priority packets. Thus emergency packets experiences high delay. eVNDN was designed for the purpose of providing emergency application in VNDN [20]. Increased delay and hop count are limiting the performance of eVNDN. Content or packet forwarding is another important process in NDN based VANET.

Best forwarder vehicle for packet forwarding was selected based on geo-location [12], packet trajectories [16]. Both methods are not considered significant packet metrics for best forwarder selection and overhead is increased at packets. Some approaches dealt with context aware dissemination [18] and PIT entry lifetime maximization [19] for effective content retrieval. However, context aware scheme increases number of retransmissions while lifetime maximization method limits number of interest packets forwarded. Communication between two vehicles was enabled by packet scheduling [15] process which increases transmission delay. In DIFS [5], interest forwarder was selected based on vehicle metrics. The selected forwarder nodes are not always trustworthy and also not vacant for all time. RUFS was attempted to select best forwarder based on interest satisfaction rate of vehicle [6]. If the direction and position of selected forwarder is changed then this method is inefficient. CODIE was an approach to retrieve content by evaluating interest packet [7]. Based on distance metric, optimal path for routing was selected in [8]. Due to absence of significant metrics in optimal route selection, this method increases transmission delay. Controller was responsible for content retrieval in SDN based VANET [9] in which controller transmit interest packet in multiple paths. Thus several responses for same interest packet are arrived at controller similarly resource utilization for routing is increased in all vehicles in all routes.

PHD PRIME
YOUR RESEARCH PARTNER

1.1 Research Outline & Scope

A SDN controlled VNDN architecture that integrates SDN and NDN in VANET is proposed to improve efficiency of VANET. Data dissemination is foremost process in VANET which plays significant role in safety message transmission and delay tolerant transmission.

1.2 Research Objectives

- For efficient network management under VNDN by SDN
- To avoid transmission interference in SDN & VNDN
- To supports cooperative data dissemination and also minimizes dissemination delay
- To enable cooperative sensing in VNDN and resource utilization for SDN

II. RESEARCH GAPS

2.1 Common Problem Statement

In VNDN, forwarder selection methods was incorporated to select optimal forwarder node. Here forwarder node selection was carried out based on neighbor node inforamtion which was maintained by each node. Here forwarder node selection is not able to determine congestion (or) traffic on the intermediate node. If congestion is high on the selected forwarder node, then dissemination delay also increased rapidly. And also if the selected forwarder is selfish or malicious node, then the interest packet is dropped at the forwarder node.

2.2 Problem Definition

This paper presents an approach [16] to determine optimal forwarder node for interest forwarding. The optimal interest forwarder is selected based on significant metrics. For this purpose, each node maintains neighbor node information such as location, velocity, direction and so on. Based on these metrics distance, velocity, link duration are computed for each node. A node which satisfies all above metrics is selected as interest forwarder and the packet is disseminated through the interest forwarder.

PHD PRIME
YOUR RESEARCH PARTNER

Problems

- Forwarder node selection is not able to determine congestion (or) traffic on the intermediate. If congestion is high on the selected forwarder node, then dissemination delay also increased rapidly.
- And also if the selected forwarder is selfish or malicious node, then the interest packet is dropped at the forwarder node.

Proposed Solutions

- Optimization algorithm also consider traffic density in forwarder node selection to minimize transmission delay
- Graph construction scheme also consider trust value as selection constraint

Forwarder node selection in VNDN is performed [17] based on interest satisfaction rate of each vehicle in the RUFS approach. Interest satisfaction rate is computed based on number of satisfied contents and number of requested contents in the node. In this approach, each vehicle is required to exchange its recent satisfied list with its neighboring vehicles. Upon the received list, vehicles are ranked and a vehicle with high rank is selected as forwarder.

Problems

- In VNDN, network elements and mobility of vehicles are changed over a time. Forwarder node selection without considering these constraints results in poor dissemination.
- Delay for data dissemination increases with increase in vehicle mobility (or) change in vehicle direction.
- There is chances for forwarder node to become selfish or malicious

Proposed Solutions

- Forwarder nodes are selected by optimization algorithm with consideration of multiple significant metrics
- Data dissemination delay is minimized by selecting optimal forwarder vehicles

PHD PRIME
YOUR RESEARCH PARTNER

CODIE is an approach that is presented [18] to control data flooding or broadcast storm in VNDN. Here consumer vehicle includes initial hop count in the interest packet. The intermediate vehicles which receive this interest packet add hop count by increasing the hop count by one. Based on hop count in interest packet, the data packet is sent to consumer node.

Problems

- Not suitable for delay tolerant emergency message dissemination since it introduces high delay in packet transmission.
- Data packet routing through hop count is not effective since the intermediate vehicles can be redirected or rerouted from their path.

Proposed Solutions

- Hierarchy Graph scheme supports emergency message dissemination without increase in delay
- Proposed Geolocation based Search and Rescue Optimization algorithm considers major significant metrics for route selection

This paper presents a scheme which attempts [19] to provide priority for contents in content retrieval. In order provide priority NDN packet is included with a parameter named as “freshness”. Based on name prefix and freshness parameter, priority is given for content in the network. Forwarding decision also dynamically changed upon content priority.

Problems

- This method is only able to provide content retrieval and not able to enable V2V communication in an effective manner.
- Forwarding vehicle selection is not reasonable.

Proposed Solutions

- Proposed RHCS algorithm also support V2V communication in an effective manner
- Forwarding vehicle is selected significantly by RHCS algorithm

PHD PRIME
YOUR RESEARCH PARTNER

This paper proposes a dynamic PIT entry lifetime scheme in [20] which each forwarding vehicle is allowed to compute PIT entry lifetime for different interest packet. This scheme increases the lifetime of interest packet to retrieve content before failure of the packet. This lifetime computation is performed based on interest satisfaction rate and hop count.

Problems

- Computation of PIT entry lifetime for each incoming interest packet increases overhead at vehicle.
- This method limits the number of interest packets supported by a vehicle since lifetime increased packets are kept in PIT for long period of time.

- Since lifetime of interest packets are dynamically changed, this method is not able to support emergency packets which have minimum lifetime.

Proposed Solutions

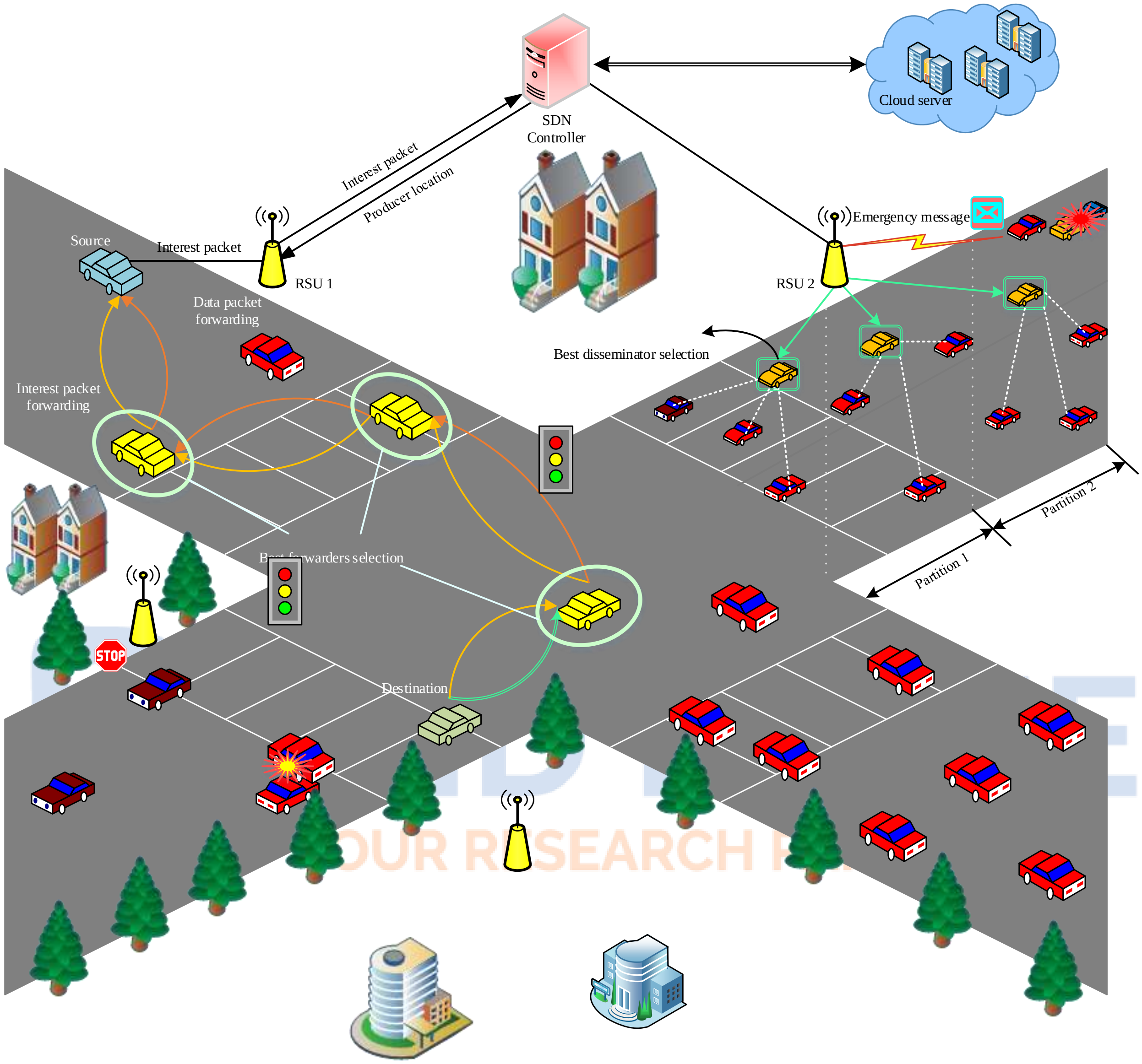
- Packet overhead is relatively small since evolved interest packet is involved with only binary values
- Content dissemination is performed without increasing PIT entry lifetime
- HG scheme supports efficient emergency message transmission without any time delay

III. RESEARCH CONTRIBUTIONS

To overwhelm all above problems, we have designed a novel VANET architecture by integrating SDN and NDN on traditional VANET. Our proposed Controlled-VNDN architecture is comprised with following entities in order to support emergency transmission and content retrieval in an efficient manner: vehicles, Road Side Units (RSUs), SDN controller, and cloud server.

SYSTEM ARCHITECTURE

PHD PRIME
YOUR RESEARCH PARTNER



Emergency message dissemination is performed by dividing RSU coverage range into multiple regions based on communication range of vehicle. Initially evolved interest packets are classified at RSU with the help of Convolutional Classifier (CC). Here packets are classified into emergency packets, and normal packets based on significant features involved in evolved interest packets. After classification, emergency packets are disseminated to best disseminator in each region. Best disseminator selection is carried out by Hierarchy Graph. Here each vehicle is provided with a load value based on multiple significant metrics such as velocity, number of neighbors, trust value, traffic density, etc. When a consumer requires content from producer, the consumer sends interest packet to nearest RSU. Then RSU retrieve the content if the content is available in CS. Otherwise RSU checks it's PIT for interest, if the interest is available in PIT, then it add an entry to the PIT. Otherwise RSU forward the interest packet to controller which has overall network view. Controller detects the producer vehicle with location and transmits this information to requested RSU. Upon received producer's location, RSU find a route with best forwarders for the interest using a novel Geolocation based Search and Rescue Optimization Algorithm. Through this optimal route content is retrieved and also support route selection for V2V communication. In any network, scalability evaluate the efficiency of the algorithms involved in the network with the changes in network size (i.e.) scalability measures the ability of proposed architecture to support increasing network size.

Performance Evaluation

Finally our proposed work is evaluated based on following performance metrics,

- Interest Satisfaction Rate
- Interest Satisfaction delay
- Average hop count
- Number of forwarded packets
- Gain of scalability

PHD PRIME
YOUR RESEARCH PARTNER

IV. RESEARCH NOVELTIES

- Effective forwarding vehicle is selected for both content retrieving and emergency message transmission
- Transmission delay is small due to involvement of best forwarder nodes.
- Evolved interest packet doesn't increase the overhead since binary values only involved
- Optimal forwarding vehicles are selected by RHCS algorithm

V. PREVIOUS WORKS & LIMITATIONS

Paper 1

Title: DENA: An Intelligent Content Discovery System Used in Named Data Networking

Concept

In this paper, an intelligent content discovery system to fully utilize the cache resources, called DENA, is proposed, which encompasses the deep exponential network-based cache announcement and cache exergy-based cache replacement algorithms. DENA provides shortcut paths for interest packets to access targeted data packets under instructions of AT (announcement table) constructed by a precision cached content announcement algorithm with low communication overhead. In the meantime, a cache replacement algorithm to assist the cache announcement is also proposed.

Paper 2

Title: A comprehensive survey on vehicular Ad Hoc network

Concept:

PHD PRIME
YOUR RESEARCH PARTNER

In this paper, author surveyed VANET architecture and applications to provide clear view about VANET. According to author, Vehicle Ad-hoc Network (or) VANET is an application of Mobile Ad-hoc Network (MANET). A typical VANET architecture is comprised with On Board Unit (OBU), Application Unit (AU), and Road Side Unit (RU). In VANET two different communications such as Vehicle to Vehicle (V2V) communication and Vehicle to Infrastructure (V2I) communication are involved. But routing and emergency data transmission is critical in VANET due to mobility of vehicles.

Paper 3

Title: DOVE: Data Dissemination to a Desired Number of Receivers in VANET

Concept

In this paper, data dissemination problem is converted into processor scheduling problem in which roads are treated as processor. Optimal workload assignment strategy is involved in this work in order to minimize data dissemination delay in the network without increasing overhead. For this purpose road layout and traffic information of road are utilized. Here workload reassignment process is performed to deal with real time cases.

Limitations

- Best disseminator selection is not trust worthy.
- This method increases overhead with increase in number of desired vehicles. Thus emergency messages which are to be disseminated to multiple receivers are suffered from high latency.

Paper 4

Title: Boosting Named Data Networking for Efficient Packet Forwarding in Urban VANET Scenarios

Concept:

PHD PRIME
YOUR RESEARCH PARTNER

This paper introduces geo-location location information based data forwarding in urban VANETs with the assist of NDN. Here best forwarder selection and forwarder decision processes are involved in communication. The interest packet which has lower latency is provided with higher priority in order to serve the request. Best forwarder is selected based on geo-location and decision is made based on wireless channel characteristics.

Limitations

- Best forwarder selection is not efficient since the traffic density on the forwarder is not considered.
- Here all packets with low latency are considered as high priority packets which makes complex the transmission of emergency packets.

Paper 5

Title: SDN Coordination for CCN and FC Content Dissemination in VANETs

Concept

This paper deals with routing for content retrieving in CCN based VANET by incorporating SDN. Here an initial path is found between consumer and data provider by controller. If the content is not available in the path, then the controller detect several paths and send the interest packets in all possible paths at the same time. From these paths, controller retrieve requested content and forward it to the consumer.

Limitations

- Here for an interest controller requests data from several paths this results in several responses.
- Similarly energy consumption and resource utilization in each intermediate vehicle in all paths is high for same interest.

Paper 6

Title: Named Data Networking for Software Defined Vehicular Networks

Concept

In order to overcome issues in IP based communication, this paper provides a way to build NDN on VANET architecture. The presented architecture utilizes advantages in both SDN and NDN technologies. Thus this architecture is able to overcome IP communication issues with efficient network management. In this architecture each NDN enabled node is comprised with content store (CS), forward information base (FIB), and pending interest table (PIT). This provides the summarization on SDN and NDN enabled VANET and highlights issues to be overcome.

Paper 7

Title: Named Data Networking

Concept:

This paper provides the brief introduction to NDN which is a new paradigm. NDN is an evolved architecture of content centric networking. NDN enables new way to look at the networking in which data name is used to fetch data instead of destination address in the network. Here interest packet supports data request and data packet provides required data for that interest packet. Consumer is one who requires data and starts interest packet. Similarly data producer is one who carries the data for interest packet. Communication in NDN is carried out through exchanging interest and data packets.

Paper 8

Title: Overcoming the Key Challenges to Establishing Vehicular Communication: Is SDN the Answer?

Concept

This paper deals with integration of SDN in VANET in order to utilize advantages of SDN. Author states that SDN simplifies the network management in VANET since it decouples data plane and control plane. Integrating SDN and VANET also requires flexibility, interoperability, security, connectivity and so on. In this paper, author also compares the existing software defined VANET architectures and highlights their advantages.

Paper 9

Title: Named Data Networking for Priority-based Content Dissemination in VANETs

Concept

This paper deals with forwarding of priority contents in VANET. To achieve this, a prioritized vehicular NDN is designed with a naming scheme and timing algorithm. In naming scheme, VANET applications are divide into high and low categories. Then a common name is provided with respect to the category. These named interest packets are sent into the network and corresponding data packets are retrieved. Here data packet rebroadcast timer is designed in order to ensure the data delivery.

Limitations

- Interest packet drop occurs since forwarders are not optimal forwarders and also rebroadcast timer is designed for data packets only.
- Emergency packets are suffered from dissemination delay since other packets also categorized as high priority packets.

Paper 10

Title: A survey on data dissemination in vehicular ad hoc networks

Concept

Data dissemination in VANET plays vital role in two kinds of transmissions such as safety message transmission and delay tolerant transmission. This paper surveys the works held on data dissemination in VANET. These works considered following metrics for data disseminations: means dissemination delay, average number of nodes receive high priority messages, average delay, data deliver ratio, and data delivery delay. Author outlined that most of these works are not able to support data dissemination requirements such as scalability, security, trust, traffic characterization, node cooperation.

Paper 11

Title: Cooperative Data Scheduling in Hybrid Vehicular Ad Hoc Networks: VANET as a Software Defined Network

Concept

This paper presents a strategy to schedule vehicles for V2V communication in SDN based VANET. In this work, RSU which is involved in VANET also act as SDN controller. RSU is responsible for scheduling of vehicles in order to enable route between them. Communication between vehicles held only on allocated time slot. For multi hop communication, each vehicle is scheduled to next hop vehicle by considering as single hop routing.

Limitations

- Scheduling alone not able to result in efficient packet forwarding in VANET
- Though queuing delay is minimized by scheduling, but transmission delay is high due to inefficient forwarding nodes.

Paper 12

Title: A Data Dissemination Strategy in SDN Enabled Vehicular Networks

Concept

This paper introduces a data dissemination strategy in SDN based VANET which involved in SDN application layer. This architecture is comprised with three modules such as content management module, content cutting module, and pre cache module. Involvement of these three modules allows a vehicle to retrieve required content. The data is divided into different segments in content cutting module and pre cache module disseminates the data through appropriate route.

PHD PRIME
YOUR RESEARCH PARTNER

Limitations

- Emergency message transmission is not efficient
- Route selection is not effective

Paper 13

Title: A Multi-Pronged Approach to Adaptive and Context Aware Content Dissemination in VANETs

Concept

This paper investigates the performance and research challenges in SDN based content centric enabled VANET in different scenarios. Here author outlined that mobility of vehicles and network density are major constraints for content dissemination in VANET. To this end, author presents an approach for content retrieving in which interest message carry the type, name, and location of requested content. In the case of content is not available in any intermediate nodes, then the interest packet is eventually reach the intend destination.

Limitations

- Here content forwarders are not selected as efficiently which results in multiple interest packet retransmissions.
- Emergency or safety data dissemination also follows the same approach which increases the delay and results in severe performance degradation in the network.

Paper 14

Title: A Geographic Opportunistic Forwarding Strategy for Vehicular Named Data Networking

Concept:

In this paper, a geographical opportunistic routing protocol (GOFP) is introduced in order to support geo-tagged name based content retrieval in VNDN. Forwarding decision is made based on three critical parameters such as opportunistic forwarding strategy, position of vehicles, and trajectories. In each packet multiple trajectory information are included. Some of these trajectories are position, near degree of vehicle, nearest time, nearest distance, and comprehensive nearest metric. Based these trajectory information, content is retrieved.

Limitations

- Here incorporating multiple trajectories increases packet overhead.
- Without knowledge of significant metrics of forwarding vehicle results in performance degradation

Paper 15

Title: SDN-Based Routing for Efficient Message Propagation in VANET

phdprimehelp@gmail.com
+91-97 91 62 64 69

Concept:

This paper presents a routing strategy in VANET based on SDN. Here each vehicle is considered as able to act as SDN switches and can communicate with the SDN controller. Through vehicular switches, controller collects network topology information. In each vehicle initial route is searched on local trace in which recent routes are maintained. These route entries are maintained for predefined amount of time then discarded. If the route is not detected in local search, then controller find a new route based on minimum optimistic time (distance) metric.

Limitations

- In local search predefined (or) previous route is selected for routing. Here if the route is congested or vehicles in the route are moved then that route is not feasible.
- Considering distance metric alone for route selection increases delay for packet transmission.

PHD PRIME
YOUR RESEARCH PARTNER

BIBLIOGRAPHY

Zhang, H., Xie, R., Zhu, S., Huang, T., & Liu, Y. (2016). DENA: An Intelligent Content Discovery System Used in Named Data Networking. IEEE Access, 4, 9093–9107.

Saif Al-Sultan, Moath M.Al-Doori, Ali H.Al-Bayatti, Hussien Zedan, “A comprehensive survey on vehicular Ad Hoc network”, Journal of Network and Computer Applications, Elsevier, 2013.

Tan Yan, Wensheng Zhang, and Guiling Wang, “DOVE: Data Dissemination to a Desired Number of Receivers in VANET”, IEEE Transactions On Vehicular Technology, Vol. 63, No. 4, pp. 1903-1916, 2014.

Chaoyi Bian, Tong Zhao, Xiaoming Li and Wei Yan, “Boosting Named Data Networking for Efficient Packet Forwarding in Urban VANET Scenarios”, IEEE International Conference on Local and Metropolitan Area Networks, 2015.

PHD PRIME
YOUR RESEARCH PARTNER
phdprimehelp@gmail.com
+91-97 91 62 64 69

Ridha Soua, Eirini Kalogeiton, Gaetano Manzo, Joao M. Duarte, Maria Rita Palattella, Antonio Di Maio, Torsten Braun, Thomas Engel, Leandro A. Villas, and Gianluca A. Rizzo, “SDN Coordination for CCN and FC Content Dissemination in VANETs”, Springer, 2016.

Syed Hassan Ahmed, Safdar Hussain Bouk, Dongkyun Kim, Danda B. Rawat, and Houbing Song, “Named Data Networking for Software Defined Vehicular Networks”, pp. 60-66, IEEE Communications Magazine, 2017.

Lixia Zhang, Alexander Afanasyev, Jeffrey Burke, Van Jacobson, kc claffy, Patrick Crowley, Christos Papadopoulos, Lan Wang, and Beichuan Zhang, “Named Data Networking”, ACM SIGCOMM Computer Communication Review, Volume 44, Number 3, July 2014.

Ibrar Yaqoob, Iftikhar Ahmad, Ejaz Ahmed, Abdullah Gani, Muhammad Imran, and Nadra Guizani, “Overcoming the Key Challenges to Establishing Vehicular Communication: Is SDN the Answer?”, IEEE Communications Magazines, pp. 128-134, 2017.

Marica Amadeo, Claudia Campolo, Antonella Molinaro, “Named Data Networking for Priority-based Content Dissemination in VANETs”, IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications, 2016.

Moumena Chaqfeh, Abderrahmane Lakas, Imad Jawhar, “A survey on data dissemination in vehicular ad hoc networks”, Vehicular Communications, Elsevier, 2014.

Kai Liu, Joseph K. Y. Ng, Victor C.S. Lee, Sang H. Son, and Ivan Stojmenovic, “Cooperative Data Scheduling in Hybrid Vehicular Ad Hoc Networks: VANET as a Software Defined Network”, IEEE/ACM Transactions on Networking, Vol. 24, No. 3, pp. 1759-1773, 2016.

Yao-Hua Ho, Chun-Han Lin, and Shih-Jie Sun, and Ling-Jyh Chen, "Emergency Application for Vehicle-to-Vehicle Communication using Named Data Networking (eVNDN)", IEEE Conference on Ubiquitous and Future Networks, 2016.

Joao M. Duarte, Eirini Kalogeiton, Ridha Soua, Gaetano Manzo, Maria Rita Palattella, Antonio Di Maio, Torsten Braun, Thomas Engel, Leandro A. Villas, Gianluca A. Rizzo, "A Multi-Pronged Approach to Adaptive and Context Aware Content Dissemination in VANETs", Mobile Networks and Applications, Springer, 2017.

Xuejie Liu, M. João Nicolau, António Costa, Joaquim Macedo, Alexandre Santos, "A Geographic Opportunistic Forwarding Strategy for Vehicular Named Data Networking", Intelligent Distributed Computing, Springer, 2015.

Ming Zhu, Jiannong Cao, Deming Pang, Zongjian He, and Ming Xu, "SDN-Based Routing for Efficient Message Propagation in VANET", Springer, pp. 788–797, 2015.

Syed Hassan Ahmed, Safdar Hussain Bouk, Muhammad Azfar Yaqub, Dongkyun Kim, and Houbing Song, "DIFS: Distributed Interest Forwarder Selection in Vehicular Named Data Networks", IEEE Transactions on Intelligent Transportation Systems, 2017.

Syed Hassan Ahmed, Safdar Hussain Bouk, and Dongkyun Kim, "RUFS: RobUst Forwarder Selection in Vehicular Content-Centric Networks", IEEE Communications Letters, Vol. 19, No. 9, pp. 1616-1619, 2015.

Syed Hassan Ahmed, Safdar Hussain Bouk, Muhammad Azfar Yaqub, Dongkyun Kim, Houbing Song, and Jaime Lloret, "CODIE: Controlled Data and Interest Evaluation in Vehicular Named Data Networks", IEEE Transactions on Vehicular Technology, 2016.

Marica Amadeo, Claudia Campolo, and Antonella Molinaro, "Priority-Based Content Delivery in the Internet of Vehicles through Named Data Networking", Journal of Sensor and Actuator Networks, Vol. 5, No. 17, 2016.

PHD PRIME
YOUR RESEARCH PARTNER

Safdar Hussain Bouk, Syed Hassan Ahmed, Muhammad Azfar Yaqub, Dongkyun Kim, and Mario Gerla, "DPEL: Dynamic PIT Entry Lifetime in Vehicular Named Data Networks", IEEE Communications Letters, 2015.

PHD PRIME
YOUR RESEARCH PARTNER