SDN Enabled Big Data Analytics and Framework for Sensor Data of Vehicle Health, Safety and Monitoring System

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***Abstract*— Vehicular network enabled vehicle health, safety and monitoring system is gaining attention for its potential application while software defined network (SDN) is supporting vehicular communication for designing core of the network. Vehicular network emits enormous amount of data where most of them are sensor data and that amount of data required to undergo analyzed for productive output. There are two types of sensor data are used in vehicular network, vehicle sensor data (VSD) and infrastructure sensor data (ISD). Flow based SDN controller examines every packet of the network which is responsible of engagement of resources gravely. For vehicular health monitoring and safety applications, SDN doesn't required to check and analyze ISD. In this paper, a framework is proposed that promises to ignore ISD and only consider VSD for vehicle health, safety and monitoring applications. With this connections, this paper proposes big data module along with SDN controller and inside the big data module, a partitioner program is designed. The partitioner program categorize VSD and ISD on the basis of certain parameters like data payload, technology used, packet header and restrict RSD to be processed by SDN controller. A combiner program is designed that bind both VSD and ISD to fed to the application plane of system. Additionally, a big data analytics for vehicle health, safety and monitoring application is derived.**

Keywords—Big data, SDN, Vehicular Network, Framework

I. Introduction

Vehicular network has become a gigantic technology for this modern day world that can proliferate from personal to professional life, smart city to smart home and other aspects. Many other technologies and tools can be incorporated through vehicular network that form a technological ecosystem. Among many vehicular network dependent services, several vehicular monitoring systems have been proposed [1],[2]. Vehicular health monitoring system (VHMS) [3], one of the vehicular monitoring application that is designed with sensors. Sensors play the major role for many applications including vehicular networking.

Big data is designed to handle heterogeneous, huge volume of data and can be incorporated in a real-time system like vehicular network and tremendous volume of sensor data directs researchers towards incorporating big data for vehicular related applications [4]. Software defined network (SDN) proves itself a worthy network infrastructure for implementing vehicular network. Combination of SDN and big data technology can facilitate to implement vehicular network [5].

Applications like VHMS exploits two types of sensor data; the first type is, vehicular health related data or vehicle sensor data (VSD) and network enabled data that are gathered from infrastructure like road side unit (RSU), vehicle etc. The second type of sensor data we can termed as infrastructure sensor data (ISD) that are mostly roadside sensor data. VSD have no involvement in network related issue because it only holds vehicular health related data [6]. However, there is no instruction of segregating VSD and ISD for applications like VHMS where servers can be employed for processing unnecessary data like VSD and uninterrupted services are hampered. Furthermore, big data dimension analysis on sensor data of vehicle monitoring is not determined yet that can reduce the complexity of system.

The main contributions of this paper are scripted as follows,

- Design a SDN based network architecture for vehicle monitoring applications;
- Analyze and determine big data analytics of vehicle monitoring applications;
- Propose a big data analytics framework for big sensor data to decrease probable network load from SDN controller.

II. SDN Architecture for VHMS

SDN facilitates VANET as well as heterogeneous vehicular network with its packet forwarding capabilities and diversified network architectural formation. This paper proposes a SDN for VHMS that collects data from vehicles and send those data to big data platform to process further through SDN network. There is scope to implement VHMS [3] with SDN architecture. The schematic view of the system is shown on Fig.1. Vehicle in the data plane follows hybrid SDN architecture [6] of SDN. The RSU/SDN switches are connected each other through SDN controller with dedicated broadband link and works to convey vehicle generated data to the upper layers. They also hold the ISD of the system. The control plane process the data from data plan and big data analytics platform from this paper resides in this plane. The

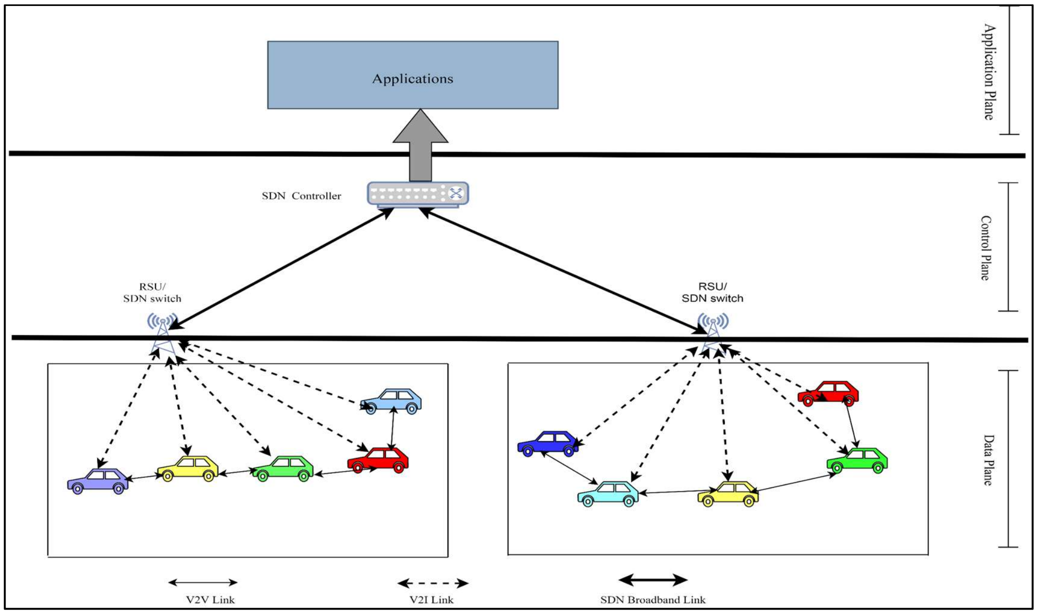

Fig 1. Proposed Network Architecture for VHMS

application plane is dedicated to process further data analysis, data administration and data management.

III. Big Data Analytics on Vehicular health Monitoring System (VHMS)

Big data has become an ultimate choice for any system that handles a large amount of data and this flexibility makes big data a warm of research topics for last several years. Moreover, Associated with SDN architecture, big data experience tremendous performance [7]. VHMS generates mammoth amount of data through sensors in the vehicles and that data need to be process in different layers. To define the characteristics of big data, different literatures depict big data differently. big data characterized by 3Vs (volume, variety, velocity) in [8], in [9] by 4Vs (volume, variety, velocity, veracity), in [10] by 6Vs (volume, variety, velocity, veracity, value, variability) and complexity, in [11] by 8Vs (volume, variety, velocity, veracity, value, variability, volatility, validity) and complexity. The characterizations are proposed based on the specific applications. The characteristics of big data in VHMS would be built on the data generation, data processing, data propagation and other factors. The following characteristics would be viable to define big data for VHMS:

Volume: The size of data for VHMS is immense as sensors would generate primary data of vehicles and the number of vehicles are huge. Moreover, the data propagation to the SDN controller through data plane produce huge amount of network related data. It is certain that, the volume of data in VHMS is mammoth where data needed to be managed by big data system.

Variety: The diversity of data in VHMS plays a big role where sensors, devices and other network nodes generate data. The data generated by the sensors might be formatted or non-formatted. In case of event detection, there might be no data from a specific sensor. The network data is different from that of sensor data. So, there are a lot of varieties in data types.

Velocity: The speed of data in VHMS is continuous as the system is real-time and data need to be processed instantly. The unremitting generation of data in vehicles, in network of VHMS that make responsible big data to function relentlessly.

Value: The value in a big data plays a vital role in VHMS because depending on this, calculations are performed and wrong calculations lead to misleading information. Value in the big data might be inconsistent, incomplete or misinterpreted as the sensor or network related data could be misleading. One or more sensors can generate unrealistic data and network data can be erroneous for any kind of interference or attenuation.

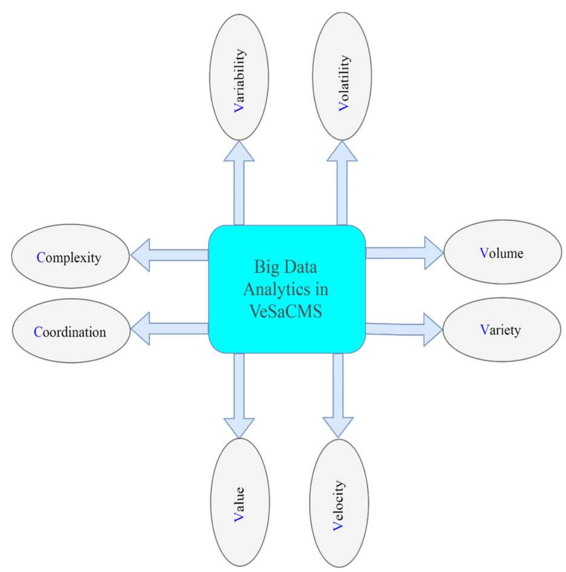

Fig.2. Dimensions of Big Data Analytics

Volatility: It is necessary to define the period of conservation of data in VHMS. Data cannot be stored for infinite period in any system. There must have a mechanism of damping or archiving of old and unutilized data so that the system can function efficiently.

Variability: In a day, data flow to VHMS may vary time to time. For example, during peak hour or office hour, the number of vehicles is more which consequence is more data flow to VHMS. The opposite scenario happens during off-peak hour that make the VHMS less burden with data flow.

In this way, VHMS encounters with variability in data flow depending on different time slot in a day.

Complexity: The processing of different types of data from different sources where dimensions of data are large and it is a challenging task. This makes VHMS more complex where the data sources are different and amount of data is huge as well as other factors are involved in the processing. Since, complexity becomes a concerning issue for VHMS, it needs big data to resolve with proper measures.

Coordination: As one of the main mottos of VHMS is to share information with other stakeholders, big data needs to intervene on data exchange. Big data must have the capability to manage the data exchange session with stakeholders so that appropriate data can be send and trustworthiness could be attained.

Big data challenges encountered in applications like VHMS can be categorized as 6Vs and 2Cs (complexity, coordination) or 6V+2C as summarized in Fig.2. To vanquish 6V+2C challenges regarding big data, VHMS needs to embrace a big data analytics method that derive covert, valuable patterns from the data and brings fruitful information for the system [11]. Traditional analytics process such as gathering, feature selection, preprocessing, data reduction, transformation, data mining, evaluation and other methods are applicable to process big data analytics [12]. There are several frameworks and tools such as Haddop, Spark, Stream and others are exploited for big data [13].

IV. SDN BASED BIG DATA FRAMEWORK

The big sensor data related to vehicular health has no significance on vehicular communication while sensor data from RSU/SDN switches have impact on communication. platform can be further processed that are ready to be shared with stakeholders like Government agencies, research fraternities, companies and so on. SDN capability to incorporate AI based techniques [14] are out of the scope of discussion of this paper. SDN based network is feed with data to improve network functionalities specially routing by big data platform. VSD and ISD couldn't not be segregated and classified in SDN platform because this platform is solely for network purpose. Moreover, SDN network primarily designed for dealing data transmission, not the processing of data. This action can be implemented by big data platform that classify the network data, vehicle related data. This enabling technique can send network related data to SDN network platform for further process and exploit data to improve network performances. In this point, it is obvious to have some discussion on VSD and ISD.

A. Big data and vehicle sensor data (VSD)

Data generated in vehicles are from sensors and for VHMS, generated data are related with vehicular health related data like crankshaft vulnerability, engine overheating issue, misfires issues etc. [2]. Besides that, VHMS can have different kinds of sensors like speed sensor, position sensor, pressure sensor, temperature sensor etc. [6]. The challenging thing is that some sensors can function as both VSD and ISD like position sensor. So, this challenge motivates to introduce a procedure that can efficiently identify and segregate VSD and ISD.

For managing and maintaining in-vehicle sensor, different wireless sensor technologies are introduced inside vehicle. Among them radio frequency identification (RFID), Bluetooth, Wifi , Zigbee are commonly used for intra-vehicular wireless sensor network (IVWSN) [15], the in-vehicle sensor network. The data generated by IVWSN are propagated with suitable network technology of vehicular network either through V2V (vehicle-to-vehicle) or V2I (vehicle-to-infrastructure) communication.

Table I has highlighted some features [16], [17], [18], [19], [20] of commonly used IVWSN that would be helpful to identify VSD at upper layer including SDN controller.

TABLE I. FEATURES OF SENSOR TECHNONLOGY

Sensor Technology	RFID	Zigbee	Bluetooth
Standard	IEEE 802.15.4 e	IEEE 802.15.4	IEEE 802.15.1
Frequency band	2.4 GHz	868/915 GHz; 2.4 GHz	2.4 GHz
Coverage Range	0.1-10 m	10-100m	1-10 m
MAC Header length	0-20 bytes, Shorter MAC Frame	0-20bytes, Super-frame	54 bit header

B. Big data and Infrastructure sensor data (ISD)

Data generated in roadside infrastructure usually not build on structured network unlike in vehicle. The data generated by infrastructures are immediately propagate using communication technology or radio access technology. In smart city, roadside sensors can facilitate with traffic management, environment monitoring, smart warning, urban planning and so on [21]. To transfer RSD vehicular network exploit short-range V2V or long range V2I communication. Some features [22],[23],[24],[25] of different V2V and V2I communication technologies are tabulated below.

TABLE II. FEATURES OF VEHICULAR COMMUNICATION TECHNOLOGY

Communication Technology	DSRC/WAVE (V2V communication)	LTE (V2I Communication)
Standard	IEEE 802.11p	3GPP
Frequency Band	5.9 GHz	700–2690 MHz
Coverage Range	1 km	Up to 30 km
Communication Method	Physical and MAC layer controlled	3GPP physical and MAC format

The propoerties of each technology mentioned in Table I and Table II can enable big data analytics framework to identify appropriate type of sensor data.

C. SDN Platform

SDN network is consist of two major parts; SDN controller and open flow enabled switches.

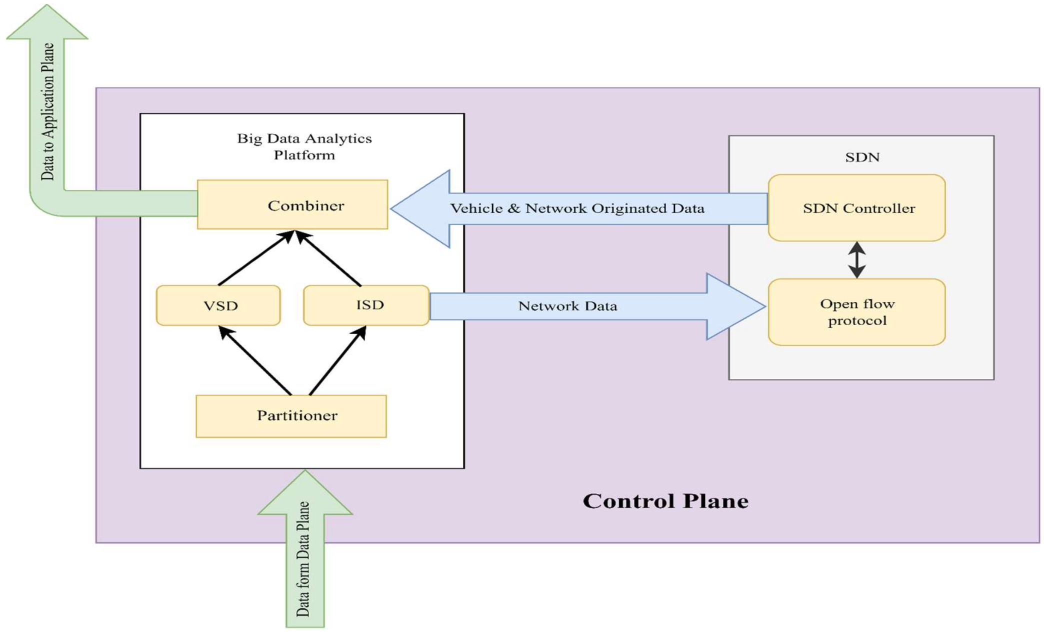

Fig 3. Big Data Analytics Framework

Open flow switches can be installed as RSU for vehicular communication that act as a gateway for vehicle to communicate with outside network. On board unit (OBU) of a vehicle is designed to establish V2I radio communication with RSU.

SDN controller works as the brain of the network that determines data flow in data plane with devices and controls the data flow to application layer. It constitutes a centralized system and data communication on data plane is controlled from SDN controller.

In SDN platform, vehicles originated VSD are sensory data and ISD data that are mostly network data is circulated to SDN controller through open flow switches.

D. Big Data Analytics Platform

Big data analytics platform proposed in this paper exploited partitioner and combiner to process the data from SDN platform [26].

The data form SDN platform is received by big data platform where network and sensor data from vehicles are ready to be processed. These data then carried to partitioner module where VSD and ISD are segregated. The extraction logic is based on the data collected from table 1 and table 2

of this paper. The physical layer and MAC (media access control) layer properties and header data are analyzed so that exact data could be extracted. Moreover, data field of header like type can be utilized to identify characteristics of VSD or ISD. From this module, the ISD data is sent to the SDN platform for network related usage. In next stage, the combiner module adjoins both ISD and VSD for the upper application layer utilization.

V. Futere Directions and Conclusion

The Big data techniques explored in this paper can support the network functionality to immense extent. The usability of this technique could be analyzed through implementation with appropriate big data platform. The experiment on different network functionalities like routing, handover, data offloading etc. can be performed by exploiting this method. Also implementations of various AI based algorithms are feasible to perform the proposed analytics. Vehicular monitoring applications including VHMS could utilize the big data analytics framework for successful implementation.

The topics discussed in this paper is supported by the authentic literatures and is ready to be deployed with necessary datasets.

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