Survey on Intelligent Transportation In The Vehicular Environment Based on Fog Computing

T.Priyanka[1], Dr.D.Ravindran[2]
[1]Dept of Computer Science
[2]Associate Professor, Dept of Computer Science
[1, 2] St. Joseph's College,Truchirappalli-620002 , India.

Abstract- *In today's world ITS applications are becoming more data-intensive and their data are described using the '5Vs of Big Data'. The intelligent transportation system (ITS) was introduced to manage traffic efficiently, increase road safety and preserve our green environment as pollution less. Thus to fully utilize the data big data analytics need to be implied. The Internet of vehicles(IoV) joins the ITS devices to cloud computing centers Data processing for this is done in cloud computing centres. Although transferring large amount of data from geographically distributed devices creates network overhead and bottlenecks and it consumes the network resources. Also following the centralized way to process the ITS big data results in high latency which cannot be tolerated by the delay-sensitive ITS applications. Fog computing is a technology used for real-time big data analytics. Basically the fog technology complements the role of cloud computing and distributes the data processing at the edge of the network which provides faster responses to ITS application queries and saves the network resources. However implementation of fog computing with the lambda architecture for real-time big data processing is difficult in the IoV environment. In this case a novel design architecture for real-time ITS big data analytics in the IoV environment is proposed in this paper. The given proposal merges three dimensions including the real-time big data analytics dimension. Intelligent computing dimension and IoV dimension. Furthermore this paper gives a comprehensive description of the IoV environment the ITS big data characteristics the lambda architecture for real-time big data analytics and several intelligent computing technologies. More importantly this proposal discusses the challenges and opportunities that face the implementation of fog computing and real-time big data analytics in the IoV environment. Finally the critical issues section discusses some issues that should be considered in order to efficiently implement the proposed architecture structure.*

Keywords- Intelligent transportation systems, Vehicular and wireless technologies, data preprocessing, real time systems and Etc..

I. INTRODUCTION

Averagely every year about 80 lakh traffic accidents occur, Injuring about 70 lakh people and death rates of 13 lakh people approximately. Large amount of hours of our time is wasted because of traffic problems (accidents, traffic jams) which causes a drop of 2% in the global total domestic productivity.

More over carbon that are generated by vehicular transportations increases day by day. To improve the performance of transportation systems enhance road safety and preserve the environment the concept of the intelligent transportation system (ITS) was introduced. The emergence of ITS was highly supported by the advancing in sensing and communication technologies and the evolution in the effective integration of networked information systems decision making, and physical infrastructure. Over a decade ago the conceptual idea of Vehicular Ad Hoc Networks (VANETs) was introduced, where vehicles equipped with wireless communication devices can form networks. Basically in a VANET the communication can be among vehicles (V2V) or between vehicles and infrastructure networks (V2I). The main goal of VANETs is to enhance road safety. However to serve the expanding and new requirements of ITSs applications the concept of VANETs evolved into the Internet of Vehicles (IoV). In IoV environment connected vehicles behave as platforms for sensing and monitoring the traffic congestions status the conditions of roads and the environment pollution levels. The ITS big data analytics can be used to reveal trends hidden patterns unseen correlations and achieve automated decision making. Nevertheless big data analytics created not only many opportunities but also several challenges including capturing analysis data processing searching sharing storage transfer visualization querying updating. In particular employing big data analytics in the dynamic environment of IoV is still in an infancy phase and demands new solutions. The ITS big data processing can be centralized or distributed. The centralized approach used in this method utilizes the power of cloud computing. However the requirements of real-time computation are difficult to be met as the centralized approach fail to provide feedback responses quickly. In fact the chance to prevent damages from hazardous events might be missed while waiting to receive a control decision from a centralized center. In addition the centralized processing requires that the ITS big data which are normally geographically distributed be transferred to the cloud center. Such big data collection at a centralized data center generates high network overhead consumes the network resources and creates bottlenecks. As a result extra delays will be experienced while waiting for a feedback from the data center which contradicts the requirements of real-time or latency-sensitive ITS applications. One promising technology that serves the distributed processing of big data is fog computing. In contrast to cloud computing, intelligent data processing with faster responses and higher quality can be provided by fog computing. Basically data processing is parallelized at the network edge by fog computing technologies which fulfil the low latency requirements and reduces the network overhead.

II. INTERNET OFVEHICLES

An Internet of Vehicles(IoV) is defined as a platform that realizes in-depth the integration and the information exchange between humans vehicles things and the environment. The main goal of IoV is to strengthen the efficiency and safety of transportation improve the service level of cities improve the environment and ensure that humans are happy with the transportation systems services. The basic idea of VANETs takes vehicles as mobile nodes that can interact to create a network. Basically due to mobility constraints VANETs are considered as conditional networks where their performance is affected by the vehicular density and distributions and various other factors such as bad drivers behaviours and tall buildings. In addition, the vehicles are considered as unstable temporary and random nodes. Thus VANETs cannot guarantee the sustainability of applications and services for customers on large scale areas, the evolution of the conceptual idea of VANETs resulted in the introduction of the concept of Internet of Vehicle (IoV). Thus as a special case of IoT and IoV has peculiar characteristics and special requirements to serve the intelligent transportation systems.

III. CURRENT EXISTING IoV ARCHITECTURE

A architecture model of IoV was introduced in which it integrates humans vehicles things and the environment. A three layer architecture was identified and in that it describes the different IoV environment technologies interactions. The 1stlayer consists of all the vehicle's sensors that collect environmental data and detect certain events such as driving patterns, vehicles situations and the conditions of surrounding environment. The 2nd layer is for communications which assists different modes of wireless communications such as Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P), Vehicle- to-Vehicle (V2V), and Vehicle-to-Sensor (V2S). Through the communication layer smooth connectivity is ensured to many networks. The 3rdlayer has the IoV intelligence resources and is completely responsible for making decisions in tough situations. This layer contains statistics tools and also the collected big data resources and processing resources. A4 layers IoV architecture was proposed by CISCO. The end users layer includes V2V communications vehicles and required software. All technologies that are necessary for communications between IoV components are defined in the infrastructure layer. Afterwards for the management and monitoring the policy enforcement the operation layer was introduced so that it can be done flow-based. In the end the services given to drivers through the cloud computing are differentiated through a service layer. Although the a fore mentioned IoV architectures suffer the following disadvantages network problems may occur due to transmitting collected data without preprocessing specially in high vehicular density situations limited interaction with car users that uses car devices to provide notifications only and they do not provide a clear integration between communication and intelligence.

In a multiples even layered model architecture for IoV is introduced and the layers are user interface data acquisition filtering and preprocessing communication control and management processing and security. An user-vehicle interface is supported by the seven-layer architecture to administrate the interactions between the driver and the vehicle. Also a communication interface was newly given for optimal transmission network selection. By checking the existing IoV architectures, it is clear that there was no consideration for the real-time Big data processing requirements. Also, all the previous architectures assume that all the collected information must be sent to the data centers for processing and analysis

Therefore such models are not suitable for many of the ITS applications that require real-time big data analytics. High latency and communication network over loading are the expected outcomes of performing any of the previous architectures.

IV. INTELLIGENT TRANSPORTATION SYSTEMANALYTICS

The evolution of sensing and communications technologies and the advances in intelligent data processing are the driving forces for realizing the intelligent transportation systems concept which is a main component of smart cities. Similar to many modern life ways transportation management and control is also now became more data-driven. The applications of ITSs are data intensive complex and the Big Data's 5V's are Volume Variety Velocity Veracity and Value. One of the specific characteristic of ITS big data is the geographically distributed data sources and consumers. In fact the relevant ITS data have many source classes which are classified in to four main classes and they are data obtained from roadways data obtained through vehicles data obtained from travellers and data obtained from wide geographical area.

V. REAL-TIME BIG DATA PROCESSING BY LAMBDAARCHITECTURE

A real-time big-data processing architecture called lambda architecture was introduced and the premise behind this is that ad hoc queries can be employed against all the data to get results , however, such queries are very expensive in terms of resources. The architecture contains 3 layers. The lambda architecture is independent from different technologies that can be used to implement the three layers. Actually, there are many technologies that are useful in creating a processing system for real-time big-data. Implementing the Lambda architecture for real-time big-data analytics in IoV environment faces many difficulties. Implementing this model in the cloud center is won't going to serve the real-time applications due to the large latency of cloud-based processing. So, the implementation need to be done at the network edge and it should be distributed to match the geo distributed nature of ITS big-data.

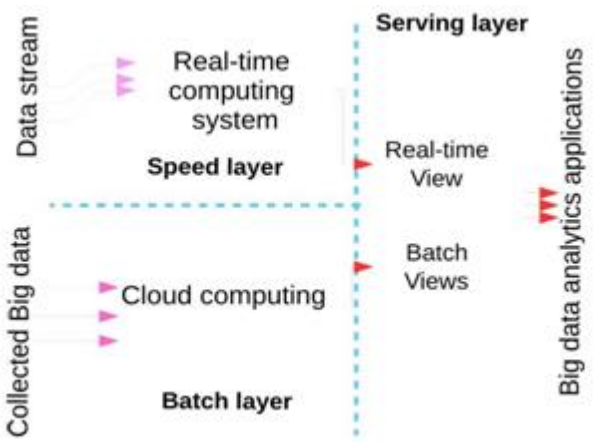

Figure-1 Generic Lambda architecture

VI. INTELLIGENT COMPUTING PLATFORMS FOR ITS BIG DATAANALYTICS

This section compares the definitions, functionalities, advantages and disadvantages of cloud and edge computing. Moreover, it highlights the important role that fog computing can play in real-time big data analytics.

CLOUD COMPUTING

As one of the most significant improvements in modern data storage and computation technologies cloud computing provides a powerful platform to perform complex and large-scale computing. The cloud computing is a model for allowing universal convenient and on-demand network access to a number of configured computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. The main advantages are security virtualized resources parallel processing and the data services integration with data storage

MOBILE EDGE COMPUTING

The increasing popularity of wireless networks and mobiles has made cloud computing to new dimension due to the limited battery lifetime processing capability and storage capacity of such many devices. Mobile edge computing is a new technology that provides an IT environment and cloud-computing abilities at the edge of the mobile network in range of the Radio Access Network and in closeness to mobile subscribers given by ETSI. Compared to cloud computing, MEC is characterized by advantages of low latency proximity high bandwidth and real-time insight into radio network information and location awareness.

FOG COMPUTING

Another technology of edge computing is known as fog computing, which was initiated by Cisco in 2012. Fog computing is an architecture that uses edge devices to carry out a substantial amount of computation, storage and communication locally and routed over the internet backbone.

Fog computing is entirely different from other edge technologies as it gives tools for distributing, orchestrating managing and securing resources and services across networks and between devices that reside at the edge. Not like the cloud computing which is a centralized deployment and management to its physical resources that are mostly homogeneous fog extends and complements the cloud through distributingheterogeneousresourcesatthenetworkedgeandmana gingresourcesinaopenway.Byusing fog computing not only latency sensitive application can be supported at the network edge but also latency-tolerant tasks can be performed and done efficiently at the intermediate network nodes as they have more powerful computing abilities than many technologies.

VII. FOG COMPUTING VEHICULARCONCEPT

Fogcomputingwhichtargetsondynamiccomputingresourcestotheedgeofnetworksaccompaniescloud computing by solving the latency constraints and reducing incoming traffic to the cloud. Although the IoV environment vehicles are looked as huge under utilized resources. Vehicular fog computing (VFC) which uses vehicles as part of the fog computing resources makes the best use of the vehicular computational and communications resources. More accurately VFC is an architecture that is based on association among near-user edge devices and end-user clients to perform an essential amount of computations and communications. VFC is differentiated from other computing technologies for its high mobility support dense geographical distribution and high proximity to end-users. More accurately fog computing models consider smart devices and vehicles as end users, and in between the cloud and these end-users the fog layer exists. On the other hand the VFC architecture consider the smart devices and vehicles as part of the fog.

VFC can harness a huge computational power through the resource aggregation of individual vehicles and other ITS smart devices. With the evolution of vehicular communications technologies and equipment's clusters of moving vehicles can act as fog infrastructure and they become perfect candidates for providing on wheels data centers. As a result both computational and communications capacity can be highly improved in urban environment when vehicles share tasks processing and contribute to the fog computing system.

As an extension of fog concept the VFC and fog computing have many similar characteristics such as low-latency communications and the wide geographical distribution. However VFC concept highlights the new features of exploiting the resources of the collaborating near-located vehicles. Actually many of the ITS applications are distributed and location-based. Thus they do not require the collection of information at remote servers from a wide geographical scope this significantly reduces deployment cost and time delay. However the main challenge in VFC is the adhoc nature of fog nodes (vehicles) which makes the VFC layer highly dynamic and requires efficient management of collaboration computation storage and communication among vehicles and moving devices.

VIII. FOG COMPUTING BASED SYSTEMARCHITECTURES

In fog computing the main component is the fog nod which can be a facility or infrastructure that provides resources for network edge services. A fog node might be a resource poor device such as an end device a base station a switch a router and an access point or machines with rich resources such as IOx which is a fog device produced by Cisco. The input and output buffers received data is queued in input buffer where as processed data is pushed to the output buffer. The physical resources they comprise storage computational control and communication resources such as routers servers and physical channels that are associated to the fog node. The bank of Virtual Processors (VPs) where the assigned workload is processed on behalf of the served devices. The virtualization layer manages the available physical resources among the running VPs in real-time. The Virtual Switch sustains an end-to-end based inter VP TCP/IP transport connections. The Adaptive Load Dispatcher over the available group of VPs it dispatches the input workload in a balanced way in order to meet the QoS requirements of serviced devices and minimize the consumed energy.

A general hierarchical system architecture based on fog computing is shown in Figure-3. There are often three tiers in a fog computing system but more tiers can be allowed for special application scenarios. At the network edge fog nodes are typically focused on sensor data acquisition collection data normalization and command/control of sensors and actuators. This layer is designed for Machine-to-Machine (M2M) interactions through Internet inter connections which gives the ability to react and make decisions in real-time.

At second tier, fog nodes are focused on data filtering, compression, and transformation. At the higher tiers or near to the back-end cloud, fog nodes are focused on aggregating data to create knowledge out of data. Basically, the second and third tiers deal with visualization and reporting, as well as systems and processes. The time scales of these interactions over the fog platform range from milliseconds to minutes (real-time analytics), up todays (transactional analytics). Therefore, fog must support multiple types of storages, from transient at the lowest tier to semi-permanent at the highest tier. Structurally fog nodes at the edge may have less communications, processing and storage abilities than nodes at high levels. With the increase in the number of tiers, each tier would be sifting and extracting meaningful data to create more intelligence.

IX. PROPOSED REAL-TIME INTELLIGENT TRANSPORTATION SYSTEM BIG DATA ANALYTICS (RITS-BDA) ARCHITECTURE

Designing a layered architecture in the IoV domain which comprises heterogeneous devices and networks is a significant task. Optimizing the number of layers identifying the different functionalities of each layer and defining the relations among layers are serious challenges of the layered architecture design. In addition various network characteristics such as interoperability and scalability must be considered. The proposed real-time intelligent transportation system big data analytics (RITS-BDA) architecture is to efficiently utilize the fog computing facilities in order to provide real-time ITS big data analytics in the context of IoV. The design of RITS-BDA architecture should consider three different perspectives which are: the real-time big data analytics the IoV and the intelligent computing(i.e. fog and cloud computing). Due to the fact that the research in the field of real-time big data processing in IoV is in initial stage, especially in research projects and industries, to the best of our knowledge this effort is the first towards designing an architecture for real-time ITS big data processing based on fog computing in the IoV environment. A multi-dimensional layered architecture is designed including the intelligent computing dimension the real- time big data analytics dimension, and the IoV dimension. The layers components and organizations of each dimension are described below in details. Figure-4 shows an abstract view of the proposed architecture where the blue color blocks represent the IoV dimension the green color blocks represent the real-time big data analytics dimension and the red color blocks represent the intelligent computing dimension (i.e. cloud and fog computing).

X. SECURITY AND PRIVACY ISSUES

IoV fog Computing and ITS big data analytics technologies are still in their infancy stages. Many serious research problems have not yet been addressed. This section discusses various challenges facing the integration of these three technologies and introduces future research directions.

As the intelligent transportation system is developing continuously collecting big data is becoming more intensive through IoV various communications technologies which leads to increasing number of security attacks and privacy violations. Nowadays there exist some related works which focus on security of big data. A key exchange scheme for secure scheduling of big data applications was proposed in. For collecting big data in the large scale IoV environment a secure mechanism is proposed in, where vehicles need to register in the big data center to connect into the network. Afterwards vehicles connect with big-data center via mutual authentication and single sign-on algorithm for the further process.

Some big data analytics security requirements in IoV environment which are listed in the following Authentication to identify the big data center sink node and vehicle node To protect messages against destructions or modifications, integrity is required To protect the data sent to specific entity confidentiality is highly important Nonrepudiation to prevent deny afterward To ensure that only an authorized node accesses the resources authorization is necessary.

However, the available protocols cannot be applied directly to secure the big data collection, storage and processing in large scale IoV fog based environment. This is because, the existing solutions do not consider the fog related security and privacy vulnerabilities in the IoV environment. Basically as fog computing utilizesnetworkedgeandend-userdevicestocollectandprocessdatamanysecurityandprivacyco ncerns may arise. Moreover the security and privacy requirements of real-time ITS big data applications are not addressed in the existing studies. The following points summarizes important security and privacy issues thatneedintensiveresearchintheareaoffogcomputingbasedIoVfo rreal-timebigdataanalyticsSecurity issues Privacy preservation techniques Trustworthiness of IoV systems and The security and privacy of the VFC network are extremely critical issues.

XI. CONCLUSION

The ITS concept was introduced to increase road safety improve transportation systems efficiency and preserve our environment. However as most of the ITS applications are becoming data-intensive applications there is a need to fully utilize the power of big data analytics in ITSs. Never the less employing big data analytics in the conventional way by depending on cloud computing services is not sufficient for ITS applications in the environment of IoV. This is because many ITS applications are delay-sensitive and processing the data at the cloud centers creates long delays. Recently the fog computing technology is introduced as a promising solution to support real time big data applications. Fog computing complements the cloud computing by providing distributed intelligent and fast data processing at the network edge. Real-time big data analytics consists of three main stages including batch, speed and serving. However performing these three stages in the cloud is not going to serve the latency-sensitive applications. On the other hand the fog platform can not handle the batch processing stage. Therefore big data analytics stages need to be distributed among the cloud and fog computing layers. Furthermore, the IoV environment must provide the required coordination and communication between the different layers and components.

Finally, the proposed architecture presents a good basement for future research in this field and it can be used as part of the intelligent transportation systems to enable the real-time applications such as collision avoidance, hazardous warning, advanced driver assistance systems, autonomous driving. As a result, many people lives will be saved by using more safe transportation systems. In addition, transportation systems will become more efficient and environmental friendly.

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