Average Response Time (ART): Real-Time Traffic Management in VFC Enabled Smart Cities

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Abstract. The extension of Cloud computing with an effective impact is the Fog computing with respect to the edge network which has the capability of identifying location awareness with probable lower latency based on the ever increasing requirements of the ever present connectivity and particularly low latency confront the real time traffic supervision in smart cities which is merely possible by integrating the aspects of “Fog Computing” and “Vehicular Networks” called as the Vehicular Fog Computing (VFC) which is capable of providing the real time position aware network response. In this paper we use the aspects and “use case of VFC” where initially the article develops a “three layer VFC model” which enables us to implement the dispersed traffic organization by reducing the Average Response Time (ART) up to a greater extent and we facilitate the offloading scheme which is clearly based on the optimization problem for leveraging the parked and running vehicles as the fog nodes through with the performance is analyzed by validating the proposed model by providing measures or guidelines towards the challenges such as the VFC enabled traffic management as a whole.

Keywords: Fog computing, Distributed computing, VFC, ART, traffic management, networks.

1. Introduction
In the present day era of urban vehicular network it is clearly visualized that the core components of intelligent transportation systems that covers almost all the regions by considering the traffic safety by localizing and navigating for attaining maximum efficiency by sharing the information over 150 million four wheelers that are yet to be interlinked where each four wheeler generates matterabytes of data per day which has to be processed by handling the wireless bandwidth [1] of four wheelers. In the present era day to day four wheelers are increasing on roads which lead to huge burden in handling the traffic in cellular networks [2] on which intelligent management is to be imposed. Due to escalating number of vehicles on roads the regular ad hoc “Vehicle to Vehicle (V2V)” [3] communication process undergoes issues with intermittent connectivity that leads to attain “Quality of service (QoS)” [4] and particularly reduced latency requires challenging and we have inspected most of the research works performed by most of the researchers in the area with distinct communication and computational requirements for effectively managing the traffic in almost all the smart cities some of the findings are the bandwidth of cellular network is very limited and it is being initially fully controlled by network service providers which can be tackled by majority of the proposed solution is
to implant “Roadside Units (RSUs)” which is economically high and cannot be fully imposed to cover all the roads and routes[5]. And the other solution proposed by the rest of the researchers is to utilize the “Mobile Cloud Computing” which is a time consuming aspect and economically costly when handling the “real time traffic” whose data is to be uploaded into the vehicular networks and these two proposals has brought us to propose a novel platform that tackles both the issues[6][7]. By integrating both the vehicular networks and the cloud computing we propose the “Vehicular Cloud Computing (VCC)” model which aims to fully utilize various network resources very efficiently because vehicles are not the only resources that consumes resource providers but other aspects too[7].

Figure 1: General Architecture of FVC

Due to ever escalating services and the applications over it in the vehicular networks requires greater computing resources as there exists resource limitations and centralized traffic management which is considered to be challenging specially in peak times with more traffic. The Fog computing is more adaptable and most efficient for optimizing the network resources that facilitates communication, processing and networking aspects on nodes based on this in recent the “Open Fog consortium” has released the architecture that comprises of interoperable and scalable development API for fog computing platform which can be intensively used to implement the traffic of vehicular services based on which the fog nodes can be swamped but the major issue lies here is “how to scale up distinct computing resources” using the “fog nodes” is major part of discussion[8][9]. By using the “Vehicular fog computing (VFC)” almost all the vehicular resources are made computationally capable with minimum latency while processing in fog as it is capable of un-exploiting various computing resources that acts as secondary components in a fog node network, and shown as Fig.1. Moving four wheelers have leveraged to enhance the computational capability of cloud computing over the terminals [10] when the cloud becomes overloaded and the resources that are available in four
wheelers can be fully utilized to perform resource consuming which leads to processing and acquiring the process delay as both the parked and moving four wheelers comprises of potential to communicate and compute but we need to analyze the feasibility with respect to security which leads to effective fog assisted traffic control in real time scenario to be acceptable by everyone.

2. Literature review

The following are the remarkable research works done by most of the researchers. As per the reference authors have proposed a framework after careful designing the cumulative data based on the incoming data specifically based on the multimedia streams attained from most of the users whose ability of “Metropolitan Area Networks (MAN)” using the doorway Internet path in the “centralized cloud infrastructure” which canalizes each single bit that is interconnected using privacy security and vulnerable legal implications as the main intent of fog computing is to drastically reduce the network traffic by differentiating the computation capabilities of edge network by initiating the local processing through which privacy preservation is achieved[11].

As per the reference authors have proposed the results attained based on the metropolitan traffic which have maximum “spatial” and “temporal” data which merely relies on the specific point of time in a day and specific location attribute where one of the example considered in the literature is hourly traffic data recorded at various centers and assessing the peak hours where there is more traffic specifically in college and office timings [12].

As per the reference authors have proposed a framework which comprises of a networking perspective where the probable “Vehicular Fog Node”[13][14] is totally operational with most of the available network interfaces that are further connected to internet using the cellular connectivity using the WLAN access point using which the “vehicles can be further connected” using the “Vehicular Fog Node” using “Dedicated Short Range Communications (DSRC)” for identifying the nearby vehicles for creating a fog node network when nodes are available and ready to communication within the specific range.

As per the reference authors have proposed a mobility framework based on “fog nodes” and the “Dynamic Vehicular Network Topology” which comprises of novel “security and privacy challenges” whose major issue is to attain the security of authentication in a “distributed environment where fog nodes” are implemented as “gateways” in a “Probable Hybrid Cloud” that comprises of central cloud nodes [13][15].

3. Problem Formulation

In the smart cities the communication of vehicles and traffic network create huge data in the network. So that the smart cities technology upgraded with Cloud computing, fog computing and Software Defined Network. Here V2V communication can do by directly with dedicated short-range communications (DSRC) or RFID signals. This process create node to node direct link between vehicles .Vehicle wants to communicate to other Vehicle in cloud association then the communication is called V2V[16]. Subsequently due Fog technology advance each vehicle arranged with fog technology to create more availability of services of cloud and fog which designed to called as VFC-enabled architecture[17].

The communication among the Cloud ,Fog and other devices in the networks create reliable transmission of data. In each platform different services provided irrespective of type of the data. Whenever a request raised by one of edge device to cloud for response, the cloud System response time laps the time from cloud to fog ,fog to edge device and sometimes response pass in other network support devices .Here response time calculated from cloud to edge device. Initially cloud system responded data entered into fog system via Cloud-Fog interface and entered into Fog system[18]. The response time from cloud to fog calculated based on data pre-processing time, Queuing time, Service time, travel time and average delay. Here the end devices are the running vehicles and parked vehicles as part of the communication[19]. The response time from the cloud to parking vehicle difference to
the running vehicle because the running vehicle moves from one network region to other network region and their address value change from one point other point. The entire network region divided into sub regions where the cloud and fog technologies interface one to each other continuously to provide service to the end devices. The devices raise the request to cloud for service requirement in action[20]. The Cloud response to the device as a service which occupies some time interval to reach that service or response to the end devices [21-23]. The response time from the cloud to device passing from the cloud interfaces, fog devices and other network devices to reach edge device. So that the total response time for a Running vehicle or parking vehicle is depended on mainly four parameters such as Cloudlet response, fog response and running or parking vehicle response.

Response time for the cloud: Response time of cloud depends upon pre-processing of data, queuing time, service time, travel time in the network and average delay in each process.

\[
E(\delta_C^k) = \sum_k (\delta_k^{pre} + \delta_k^{que} + \delta_k^{ser} + \delta_k^{tr} + \delta_k^{dlly})
\]  

(1)

In the above principle \( \delta_k^{pre} \) represents the pre-processing of message at each cloud device, \( \delta_k^{que} \) represents the queuing time, \( \delta_k^{ser} \) cloud service time, \( \delta_k^{tr} \) travel time and \( \delta_k^{dlly} \) represents the average delay. The service rate of the cloud from a server calculated by two parameters one is service and flow process the data. The cloud service rate given as:

\[
\rho^C = \frac{\gamma^C}{b\mu_s}
\]

(2)

where \( \gamma^C \) is the flow to be processed and \( \mu_s \) is the service rate. The minimum expected service provide by cloud given as: \( E(\delta_C^k) = 1/\mu_s \). Response time for fog nodes: Fog devices provides interface between clouds to edge devices to speed up the data processing. The cloud data offloading and responding depended on the pre processing, queuing, transmission time and average delay. Fog virtualization implemented in vehicle network only. So the response time of the fog vary from running vehicle to parking vehicle. The service rate of the fog and cloud calculation is similar but the flow of processing is different. So that the fog service rate for the parking vehicle given as: \( \rho^F = \frac{\gamma^F}{b\mu_s} \). The response time of Fog nodes from parked vehicle calculated based on the pre-processing of the data, fog service from a node \( b \), minimum service rate, travel time and average delay given as:

\[
E(\delta^F) = \sum_k (\delta_k^{pre} + f(b, \rho^F) + 1/\mu_s + 2d_{ri-fog} + \delta_k^{dlly})
\]

(3)

The fog response time for the running vehicle has difference with parking vehicle. The other road side unit’s connections change within a small period of time when the vehicle moves. The service rate by the fog in a running vehicle given as: \( \rho^R = \frac{\gamma^R}{b\mu_s} \). The response time by the fog for running vehicle depended on the time of pre-processing, service time, travel time and average delay given as:

\[
E(\delta^R) = \sum_k (\delta_k^{pre} + \rho_i^R [y(\rho_i^R)] + 1/\gamma + 2d_{ri-fog} + \delta_k^{dlly})
\]

(4)

The response time for a message calculated for parking vehicle and moving vehicle with associated of Fog technology. The result of each scenario depended on the cloud response and fog response time with other IoT network devices such as road side units because they also part of the network and occupy the sometime intervals to process the data and response according to the network instructions.

The average response time for the parked vehicle associated fog device given as:

\[
E(\delta) = xE(\delta_C^k) + yE(\delta^F) + \frac{\delta_{loff}}{N}
\]

(5)

The average response time for the running vehicle associated fog device given as:

\[
E(\delta) = xE(\delta_C^k) + zE(\delta^R) + \frac{\delta_{loff}}{N}
\]

(6)
Where $\delta_{\text{off}}^N$ describes the offloading data and processing time of other IoT devices and $N$ is number of road side devices in the network. The $x,y$ and $z$ are binary variable denote the message processing by cloud, or running vehicle or parking vehicle.

4. Performance Evaluation

In the smart vehicle system, vehicles implemented with local cloud also called as fog computing which supported to reduce the delay of real time traffic management. The fog node communicates with nearby access points surrounded by those areas and other road side devices. This fog nodes also have direct interfaacing communication with cloud computing. The average response time from any node which implemented with fog technology is very less spam compared to the normal networks. The average response time (ART) inclusion of response time from the cloud and response time of parked or running vehicle and time delay by other road side devices. The performance of the ART depended on the number vehicles and messages. The messages generated from the vehicle then obviously create traffic and queuing at cloud systems as well at fog and access point. Compared randomized strategy the performance of the proposed ART is very feasible and provided accuracy in the result or running vehicles and parking vehicles. The Table 1 shows the list of parameters that we included into our execution of proposal. Figure 2 experimental results of ART for different messages arrival rate at two different cases. Figure 3 experimental result of ART with the number of parked and running vehicles.

| Parameters                  | Value                      |
|-----------------------------|----------------------------|
| Number of vehicles          | 20–100                     |
| Number of Access Points     | 15                         |
| Area                        | $1200 \times 1200$ m      |
| Number of Tasks             | 100-1000                   |
| Number of Fog Nodes         | 5                          |
| Simulation time             | 300 s                      |
| Average Task Size           | 450KB                      |
| Transmission range          | 450 m                      |
| Vehicles speed (min)        | 0–4 m/s                    |
| Vehicles speed (Max)        | 5–25 m/s                   |
| Wireless Channel Bandwidth  | 20MHz                      |
| Receiver sensitivity        | $-71.65$ dBm               |
| Traffic type                | User datagram protocol     |
| Antenna type                | Omni-directional           |
| Simulation scenario         | roads with various intersections |
5. Conclusion
In this paper we discussed about response time in the distributed network and traffic management. The IoT network decentralized with fog technology divided into many regions. The integration of fog with cloud system reduced the time of offloading and network burdens. In this paper we proposed the average response time from the cloud to vehicle which associated with fog technology. The ART time need to be implementing in the real time scenarios by following the network constraints and traffic. Our research will continue to identify the less response from the cloud to device without lost the data.

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