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Optimization Techniques For High Performance Content Downloading And Data Access In Vehicular Networks

R. M. Kadwe[1], Pradnya Kamble[2], Yogesh Bhute[3]

[1]Research Student,
Nagpur, Maharashtra, India
rooban.kadwe@gmail.com

[2]Professor, Priyadarshini College of Engineering,
Nagpur, Maharashtra, India.
pradnya_kamble@rediffmail.com

[3]Asst. Professor, Abha Gaikwad-Patil College of Engineering,
yog.bhute@gmail.com

Abstract: ***We consider a road scenario where users in vehicles are well-equipped with communication-enabled interfaces in vehicles are requesting for data access or content downloading from the internet servers or roadside Access Points (APs). Here the content that is requested or downloaded is altogether different content (different from that of the other vehicular users). Downloading an altogether different content from the Internet is a topic of increasing interest in vehicular networks due to high demand of mobile users and vehicular networks. We will analyze the technique used for increasing the performance limits of such vehicular communication system for downloading content and accessing data which is unique for the other users by considering the downloading process as an optimization problem, so that can maximize the overall system throughput by leveraging both Infrastructure-to-Vehicle (I2V) and Vehicle-to- Vehicle (V2V) communication. We will see the various methods used to investigate the impact of various factors such as the traffic intensity of vehicular users in the given region, deployment of roadside infrastructure, V2V relaying technique and penetration rate of the system. Our main objective will be to introduce traffic relaying by one or more vehicles creating a multi-hop between the user and the AP along the roadside so that the data flow is maximize across the whole network using a maximum flow algorithm.***

Keywords: Content downloading, roadside Access Points, vehicular communication, optimization problem, performance limits, penetration rate, V2V traffic relaying, multi-ho, maximum-flow.

1. Introduction

The use of fantastic high-end navigation system, information as well as other amazing entertainment related applications is sharply increasing day-by-day which will constantly and definitely lead to a drastic growth in bandwidth usage by the vehicular mobile users. Vehicular Network is a communication system in which vehicular users communicate with the roadside infrastructure units and provide information to each other such as voice or data traffic. Vehicular Networks also compromise of vehicle-to- vehicle communications as well as other examples of applications of vehicular communication abound and that varying from accessing news or weather reports, updating and navigating road maps, updating a software or even downloading some multimedia file, for instantly getting information of traffic conditions of a region or point of interest. This will urge the vehicular user to turn to resource intensive applications equal to the amount as today's cellular mobile customers.

Many observations and studies have agreed that neither the existing nor the upcoming cellular technology will adequately fulfil the increasing demand of high resource applications in wireless network. A recent study reach the inference that the cellular infrastructures have been extremely overloaded by internet traffic and the network is slowing down due to the large growth in mobile data traffic from smartphone users showing that the mobile data traffic has now exceeded mobile voice traffic. This is a major problem for all service providers.

A recent measurement analysis of the internet traffic showing the network resource usage and subscriber behaviour, collected using a large scale data set within a nationwide 3G and 2G cellular data network showed that smartphone and iPhone users currently represent only a few percent of the total subscribers in the network, but surprisingly is draining more than nearly two third of the total network resources [1]. To outline a network model that will support the demand of the increasing number of vehicular users, one possibility is to employ a Dedicated Short-Range Communication (DSRC) and thus divide part of the data traffic as well as voice traffic if required to DSRC through direct communication, (I2V data transfer) as well as V2V data relaying.

In this paper, we will analyze the content downloading process in vehicular mobile networks for data traffic communication and how the works deal with different aspects of the system such as deployment of roadside infrastructure (APs), performance review of I2V transfers, utilization and selection of specific V2V transfer paradigm. We assume ideal conditions from a system engineering point of view, i.e., availability of predefined knowledge of vehicular trajectories and scheduling mechanism to be used for data transmission. We will discuss the impact of important factors in vehicular communication such as AP deployment, selecting I2V or V2V transfer paradigm along with their working and the technology penetration rate. We stress that our objective is to target the general idea of providing user an optimized and high performance best effort downloading of different data content from the internet and not a content of common interest of other users. Our aim is not to study data dissemination or cooperative caching but to investigate the performance of various factors on content downloading and maximize the overall throughput as well as minimizing delays.

This paper is organized in various sections: Section II compromises of some previous related work, which is divided into three parts namely deployment of roadside units or infrastructures (APs), data transfer paradigms, penetration rate of the system. Section III highlights the system model of our proposed work and how it is different from other related works. Section IV enumerates the conclusions of this system.

2. Related Work

Our work basically relates to roadside infrastructures (APs) deployment, efficient optimization of data downloading and performance evaluation of the system, and to increase the overall system throughput, thus minimizing delays.

2.1 Roadside Units or Infrastructures (APs)

A deployment of roadside units (APs) is a crucial aspect for data communication in vehicular networks, its impact and placement scenario are discussed in other works as well. Infrastructure deployment strategies are proposed up-to-date that can be able to maximize the amount of time a vehicular user remains within the radio range of an access point.
It is obvious that longer duration of time instances within AP coverage can surely support the downloading mechanism of vehicular users. The conception of non-continuous coverage for vehicular user called α-coverage, which provides worst-case guarantees on the interconnection gap at the same time using fewer APs than needed for normal coverage [2], thus guarantying a minimum coverage requirement.

As the popularity of high-resource services is increasing, Wireless LANs (WLANs) is gaining popularity but they are expensive only after opportunistic services without any guarantee on short-term throughput. Deployment of roadside WiFi is economically scalable and can be presented to design an efficient deployment method that maximises the worst-case contact opportunity [3]. A random distribution of roadside units (APs) over a road layout can not help routing data in urban vehicular networks being highly populated with vehicular users because such type of scheme is only suitable for scenario where APs are to be employed as static cache for content items that need to be delivered to the vehicles visiting the AP at different times irrelevant of their position.

An infrastructure deployment strategy favouring content downloading with the help of vehicle-to-vehicle relaying in vehicular networks is introduced in [4] which explain cooperative downloading in dense vehicular network region. In this scenario, a vehicle downloads a part of the required content from one AP that is in its radio range and the relay downloads the other remaining part of the same content from another AP in its radio range. Later on when the two vehicles meet or encounter each other at some point, the relay transfers the data carried to the user, i.e., the target downloader. This type of system requires the pre-emptive knowledge of the vehicles that acts as downloader and relays as well as the candidate APs must be in contact communication of one another to help coordinate with each other and informing the other AP of about the location, required content and other scheduling parameters. This scheme aims at maximizing the use of V2V communication but it could not avoid the mutual interference caused among concurrent traffic transfers.

Another relevant work related to roadside unit deployment or AP placement is briefly stated in [5] where the objective is dissemination of data or information in shortest possible time where as our concern is different content downloading in vehicular environment.

2.2 Data transfer Paradigms

We are discretely outlining a general case where every vehicular user wants to access or download a resource-rich file or application that is of uncommon nature of interest among other users. The downloader can either communicate through direct communication with the AP, if possible, or be able download it by being assisted by another vehicles acting as relays. One of the studies focuses on accessing the web search and makes it highly efficient using the pre-fetching mechanism of the scheduling technique. The work in [6] points out the pre-fetching with traffic scheduling techniques. Its objective is to maximise the content downloading amount by vehicular users through APs that form a wireless mesh network. But here the knowledge of vehicle trajectory over the road space needs to be known and most importantly multi-hop data transmission with the help of relays was not investigated [6].
The cooperative downloading can be used in this scenario as well where the vehicular trajectory of the user and the relay must be known beforehand. In this context the work in [7] aims to establish a swarming protocol for Vehicular Ad Hoc Networks (VANETs) called as SPAWN, which is economic and scalable for peer-to-peer content delivery mechanism or file sharing protocol that makes the use of parallel downloading among a mesh of cooperating peers in the VANET. But this is

restricted to allow vehicle to share a content of common interest only.

Some of the important data transfer paradigms that are established using I2V or V2V communication are 1) Direct transfer which is the direct link between the roadside unit (AP) and a downloading user vehicle, 2) Connected forwarding, i.e., traffic relaying with the help of one or more vehicle that will form a multi-hop path between the AP and the downloading user vehicle, 3) Carry-and-forward, which is similar to connected forwarding but relays store and carry the data, ultimately delivering it to the destination downloader or to another relay vehicle to meet the downloader sooner.

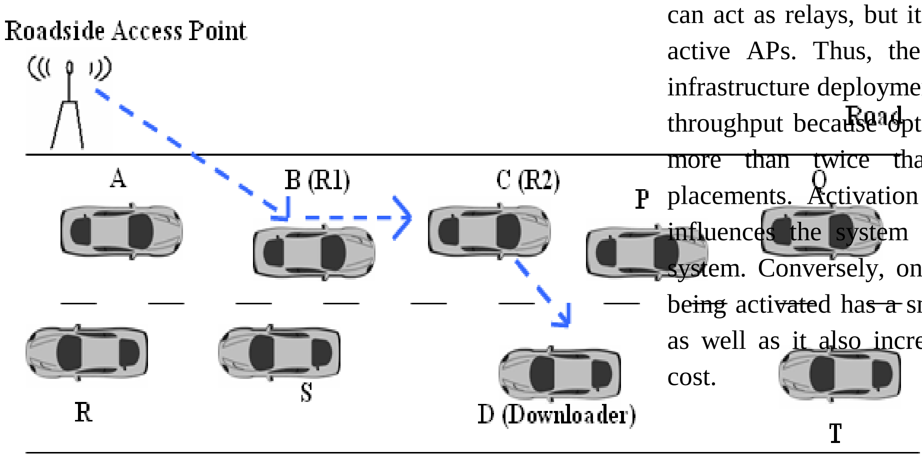

Figure 1: Vehicular Network Scenario showing the use of V2V relaying for content downloading. Vehicle D wants to download some content from the internet, vehicle B and C act as relays R1 and R2 respectively, as they are idle. Vehicle A, R, S cannot act as relay as they are not in idle state.

A vehicle can act as an intermediate relay needs to be the state of ideal condition, that is, it must not be itself downloading any data or using the network resources or internet services at the time of data transmission

2.3 Penetration Rate of the System

Penetration rate of the particular system in the context of a vehicular network environment can be defined as the fraction of vehicles that are well equipped with communication interfaces and are willing to participate and get involved in the content downloading process possibly as relays. We need to evaluate the effect that this penetration rate, p, has on the system performance and how it impacts the overall system throughput as well as the per-user throughput. Per-user throughput is the ratio of the amount of data received to the complete downloader trip duration.

Delay in data transfer is another important effect of the penetration rate. The higher the penetration rate, the higher will be the delay due to the more frequent V2V transfer taking place in a communication process. We also calculate the fairness in the system, that is, to obtain an analysis of how the system throughput is shared among the individual downloaders in the network.

The higher the penetration rate of the system, the higher is the chances that the technology uses the V2V data transfer paradigm thus causing a large number of hops that are used for a single transmission leading to delayed transmission. The lower the rate of penetration of the technology the higher is the amount of I2V communication taking place, thus having to deploy APs with maximum coverage capacity.

In a low penetration regime, the AP placement in early stages is quiet crucial as it can change a lot of factors. Lower penetration is not only observed when there are few numbers of users who can act as relays, but it also occurs when there are only a few active APs. Thus, the policy that is selected for roadside infrastructure deployment has a dramatic impact on the per user throughput because optimal AP deployment yields throughput more than twice than that obtained with random AP placements. Activation of few more or less APs drastically influences the system throughput, delay and fairness of the system. Conversely, on the other hand, large number of APs being activated has a small impact on the system performance as well as it also increases the deployment and maintenance cost.

3. System Model

The existing Model is quite different from the proposed model as the main goal of the existing system is data sharing or downloading content of common interest using peer-to-peer communication. The system working of this proposed system is carried out by initially considering the most dramatically influential factor that affects the network performance.

The foremost important factor is the region's traffic intensity to start with. The amount of user that have Internet-enabled interfaces in their vehicles or are either are requesting for data access or wanting to download some content from Internet, such users can act as relays or downloaders respectively, this defines the traffic intensity of the given road segment. The user intensity of vehicular traffic will be drastically different at different road segments because the roads are static but traffic varies according to timing and its placement in the town. We will measure the traffic intensity for different places like the urban region, rural region and a suburban area and this will help us for respectful deployment of APs according to the demand in the region.

When the vehicular user requests for some content to access or download, the nearest AP is first activated and then the AP unit finds out the number of vehicles that can act as intermediate relays at that point of time. These APs, downloaders and relays are considered in various positions in different time frames considering the locations as imaginary points of locations over the space. Using these imaginary frame and positional locations a Dynamic Network graph is created using the vehicular mobility frame instances. Vehicles can be continuously added or removed from these graphs because the vehicles are moving at a fixed speed and different vehicles move in and out of that road segment very fastly.

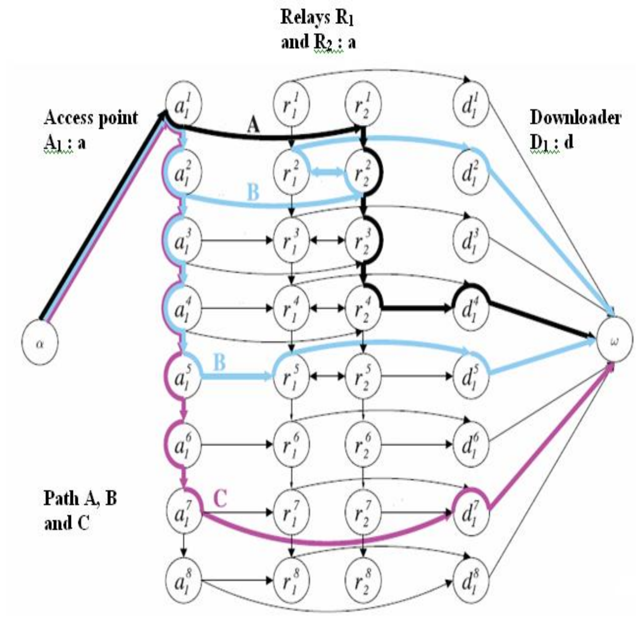

Figure 2: Dynamic Network topology graph showing the imaginary positions of AP, relays and the downloader at different time instances.

A Maximum Flow Problem is formulated to perform an action of letting the flow from the AP to the downloader through the relays be maximized for better system throughput. This is applicable to more than one downloading user and huge number of relays that are involved in respective communications and a given time instance.

Using the dynamic network graph and the max-flow problem, the graph is then sub-divided into smaller sub-graphs which are called as sample graphs. Using these sampled graphs, the sub-graph in which the flow from AP to downloader is maximum with faster downloading speed indicated by lesser time frames for complete download to take place, is selected. Such sub-graphs are plotted and the candidate location helps to decide the appropriate placement of the roadside Access Point. This method of sampling helps to deploy APs at optimal location that can provide best coverage and easier allocation of relays over the given road segment.

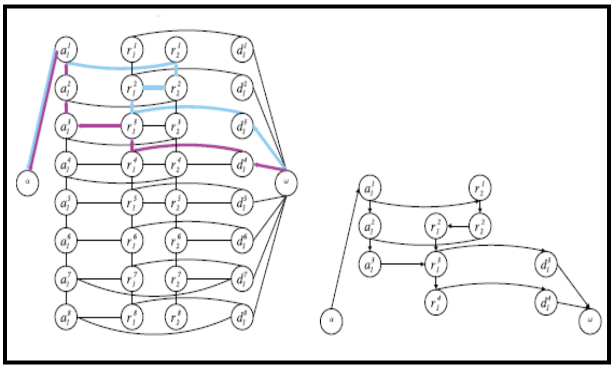

Figure 3: Example of sampled graph.

Once APs are deployed at the roadside and are activated, we need to evaluate the performance of the system in order to calculate the overall throughput, delay, V2V data transfer fraction and fairness of the network with respect to all parameters. Penetration rate of the technology and the user density is considered to formulate the performance graph because it causes a drastic change in the calculations. Depending on the location of the downloader, relay vehicles and AP locations, the system must be able to transfer the content to the target user using the appropriate transfer paradigm, i.e., the I2V or V2V transfer. If the penetration rate is high then most of the transfer of data will take place by the assistance of one or more relays thus creating a denser multi-hop communication network, leading to delays but gives increased fairness and per-user throughput. In case of low penetration rate, data communication will mostly take place through direct communication (I2V) between the infrastructure and the downloader, thus needing to increase the coverage capacity of the APs and hence accurate AP deployment is crucial at low penetration regimes.

4. Conclusion

Downloading internet application, files and services that are different in terms of its content is a topic of increasing attention due to the high amount demand for the resource-intensive files, applications and other services in vehicular networks. So we proposed a framework that is based on time-expanded graph that also allows us to capture the space and time dynamics of the network. Our system not only enhances the overall system throughput as well as it minimizes the delays but it also helps to give a high performance limits and optimized vehicular network model.

The two regimes, that is, high and low penetration rates, are characterized by different performance and impact of the system settings. The penetration rate, obtained by the vehicular intensity, has a major impact on the performance of the system as it helps to decide the correct locations for the deployment of APs that will give better coverage to the users as well as the relays.

In a low penetration regime AP deployment is very crucial for obtaining higher throughput, whereas, in high penetration regime even a random deployment of roadside infrastructures can work appropriately as maximum data transfer distance is covered by traffic relaying. V2V traffic relaying plays the most important role to evaluate performance of the system as it can enhance as well as slow down the network to great extent. The knowledge of vehicular trajectories is vital before designing the network model of this kind since most of V2V traffic relaying takes place using carry-and-forward data transfer paradigm, where the relay carries, stores and simultaneously transfers the data to the downloader.

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Author Profile

R. M. Kadwe completed Engineering in Computer Technology from Priyadarshini College of Engineering, Nagpur, Maharashtra, India in year 2010. She is a full-time Lecturer in Tulsiramji Gaikwad-Patil college of Engineering and Technology, Nagpur, Maharashtra, India in Computer Science and IT department. She is doing research on Wireless Networks and Relay Communication. Her area of interests are Wireless Communications and Computing, Vehicular Ad-Hoc Networks, Distributed Computing and Satellite Communications.