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Large-Scale Cost-Effective Secured Content Distribution in the Cities Using Vehicular Networks

Vinay M Naganur[1], Anand R[2]

[1]M.Tech in Computer Science, CMR Institute of Technology, Bangalore, India

[2]Associate Professor, CMR Institute of Technology, Bangalore, India

Abstract: ***In this paper we have practical and cost-effective approach to construct a fully distributed roadside communication infrastructure to provide the secured content distribution to vehicles in the urban area. In this paper we deploy vehicle to infrastructure and vehicle to vehicle data transmission. The proposed infrastructure is composed of distributed lightweight low-cost devices called roadside buffers (RSBs), where each RSB has the limited buffer storage and is able to transmit wirelessly and vehicle buffers to transmit the information from one area to other. To enable the distributed RSBs working toward the global optimal performance (e.g., minimal average file download delays), we propose a fully distributed algorithm to determine optimally the content replication strategy at RSBs and prioritize the contents such as high priority, average priority and low priority. Where accident messages have high priority are transmitted fast and low priority messages are transmitted later. We secure communication using Trusted Authority which verifies RSU authentication through ECC cryptographic function. The proposed infrastructure is designed to optimize the global network utility, which accounts for the integrated download experience of users and the download demands of files. Using extensive simulations, we validate the effectiveness of the proposed infrastructure and show that the proposed distributed protocol can approach to the optimal performance and secured communication.***

Keywords: Vehicular ad-hoc networks, Road-side buffer, vehicular buffer, Cryptography, security**.**

1. Introduction

In the last couple of years VANETS as shown in fig 1, vehicular networking and communications have been identified as a key enabling technology to make our daily life on the wheel safer, more efficient, and comfortable with ubiquitous broadband services. While being actively pursued for years, the real-world large-scale deployment of vehicular communications, however, is still not practical and fraught with many fundamental challenges. This attributes to the lack of an efficient accessing approach on providing ubiquitous, high-rate, yet low-cost, connections to vehicles. When using traditional third-/fourth-generation cellular networks, the aggregate bandwidth per user is very limited as a large number of users need to share wireless resource concurrently, and also the usage cost per user is high.

An alternative approach is exploring citywide Wi-Fi hotspots for high-rate services at a low price. However, being sparsely distributed in the city with limited coverage individually, Wi-Fi hotspots can hardly provide ubiquitous connectivity to vehicles. Moreover, being originally designed for static indoor applications, Wi-Fi hotspots are not optimized for highly mobile vehicular communications.

Another possible solution is exploring intervehicular communications. While collaborative intervehicular communications can boost the system capacity, purely relying on the vehicle-to-vehicle (V2V) communications is insufficient to provide the reliable and high rate data services to users due to harsh channel conditions and unreliable intervehicular connections

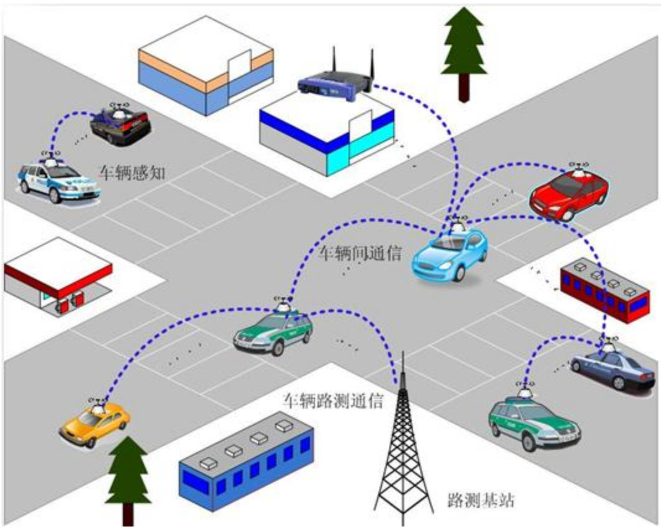

Figure 1: Vehicular Ad-hoc network

The throughput of intervehicular communications is observed to be at most one-fifth of the throughput of vehicle-to-infrastructure communications. In a nutshell, to bring vehicular communications and networking from laboratory concept to commercial reality, a novel, practical, and scalable solution, which offsets the weaknesses of traditional accessing approaches, is desirable. As an effort toward this goal, in this paper, we propose a practical approach on building a low-cost citywide infrastructure to enable content distributions to vehicular mobile users. We argue that a large-scale communication infrastructure that is dedicated to vehicular communications with reserved resources (e.g., storage and communication capacity) is essential to provide reliable and quality-of-service (QoS)-guaranteed services, and finally make vehicular communications an alternative of ubiquitous broadband access. Note that building a large-scale infrastructure is a intimidating task due to the high deployment and maintenance cost. There is a question on how to construct a practical and scalable content distribution infrastructure in the city, which not only bypasses physical installations and investment obstacles but also incurs the minimum monetary wireless bandwidth expense for individual users. To attain this goal, we propose a low cost self-maintained infrastructure.

Many different and sometimes competing design goals have to be taken into account for VANETs to ensure their commercial success. When equipped with WAVE (Wireless Access for Vehicular Environment, a novel type of wireless access dedicated to vehicle-to-vehicle and vehicle-to-roadside communications), in Figure 1 it forms a highly dynamic network. Although, some characteristics of VANETs resembles with the characteristics of MANETs [6, 8] but there are specific features which can be categorized as follows:

- **Highly dynamic topology**
  The high speed of the vehicles along with the avail-ability of choices of multiple paths defines the dynamic topology of VANETs.
- **Frequent disconnected network**
  The high speed of the vehicles in one way defines the dynamic topology whereas on the other hand necessitates the frequent requirements of the roadside unit lack of which results a frequent disconnections.
- **Mobility modeling and Prediction**
  The prediction of vehicle position and their movements is very difficult. This features of mobility modeling and prediction in VANETs is based on the availability of predefined roadmaps models. The speed of the vehicles is again an important for efficient network de-sign.
- **Communication Environment**
  Once we are having a mobility model, yet we are not done. As the mobility model may have different features depending upon road architecture, highways, or city environments. Communicating in these situations has to be taken care.
- **Hard delay constraints**
  At the time of emergency, delivery of messages on time is a critical problem. Therefore, handle such situations rather talking only about high data rates in not sufficient.
- **Interaction with onboard sensors**
  Sensors are the mode of communications. Sensors can read data related to velocity of the vehicle, direction and can communicate to the data center. Thus sensors can be used in link formation and in routing protocols.
- **Unlimited Battery Power and Storage**
  Nodes in VANETs do not suffer power and storage limitation as in sensor networks; therefore optimizing duty cycle is not as relevant as in sensor networks

Applications of Vanets

- **Real-time traffic**: The real time traffic data can be stored at the RSU and can be available to the vehicles whenever and wherever needed
- **Co-operative Message Transfer:** Slow/Stopped Vehicle will exchange messages and co-operate to help other vehicles.
- **Cooperative Collision Warning:** Alerts two drivers potentially under crash route so that they can mend their ways.
- **Traffic Vigilance:** The cameras can be installed at the RSU that can work as input and act as the latest tool in low or zero tolerance campaign against driving offenses.
- **Digital map downloading**: Map of regions can be downloaded by the drivers as per the requirement before traveling to a new area for travel guidance.
- **Route Diversions:** Route and trip planning can be made in case of road congestions.
- **Parking Availability**: Notifications regarding the availability of parking in the metropolitan cities helps to find the availability of slots in parking lots in a certain geographical area.
- **Time Utilization:** If a traveler downloads his email, he can transform jam traffic into a productive task and read on-board system and read it himself if traffic stuck. One can browse the Internet when someone is waiting in car for a relative or friend.
- **Fuel Saving:** When the TOLL system application for vehicle collects toll at the toll booths without stop-ping the vehicles, the fuel around 3% is saved, which is consumed when a vehicles as an average waits normally for 2-5 minutes.

2. Related Work

The survey of existing literature and the related works for the proposed infrastructure. The vehicular content distribution networks can be broadly categorized in two groups: V2V-based systems, where in the content distribution mainly depends on the collaborations among vehicles using the V2V communications only and vehicle-to-infrastructure-based systems, which uses the opportunistic contacts and transmissions of road communication infrastructure to enable content retrievals in vehicles.

1) V2V-Based System

To enable the cooperative content retrieval and sharing among vehicles, Nandan introduced the first V2V-based content distribution protocol, which is named as swarming protocol for vehicular adhoc networks . In SPAWN, a file is first chopped into multiple pieces and then these pieces are swapped among vehicles in a BitTorrent style to facilitate the collaborative download. Lee et al. proposed CodeTorrent , which uses the network coding to maximize the mutual differences of content pieces stored in the nearby vehicles, and accordingly reduces the search delay and coordination of each piece transmissions. Unlike SPAWN and CodeTorrent, this paper mainly focuses on the design of the infrastructure and development of distributed content replication protocols. As the infrastructure-based content distribution serves as a complement to the V2V content distribution. Li et al. proposed CodeOn for efficient content distribution over vehicular networks in a highway. Yan et al. developed an analytical model to evaluate the multihop transmission rate of the network-coding-based content distribution in the highway. Ye et al. investigated the highway content distribution using network coding and developed an analytical model to evaluate the completion probability of content dissemination in the Rayleigh fading channel. Zhang et al. developed a platoon-based content distribution protocol, which would optimally replicate the contents in a vehicle platoon based on the diverse mobilities of platoon members. In contrast to CodeOn, this paper considers the content distribution in urban areas. Unlike that on highways, the V2V communication in urban areas grows to be much more dynamic due to the complicated street layout and diverse motion of vehicles. Due to the intense interference within densely located nodes and shadowing and fading effects caused by complex building environments, the V2V communication in urban areas has much lower capacity and smaller coverage. Hence it is desirable to explore the infrastructure for content distribution. However, the approach to deploy distributed infrastructure, as proposed in this paper, can also be applied in the highway vehicular networks

2) Vehicle-to-Infrastructure-Based System

For service differential content distribution Zhang et al. developed a scheduling algorithm at distributed roadside units (RSUs) to manage the vehicle-to-roadside (V2R) access of vehicles. Nandan et al. proposed AdTorrent to facilitate the advertising of contents relevant to a local area. In AdTorrent, static wireless digital billboards are deployed on the roadside, which continually push the advertisements like hotel virtual tours, movie trailers, etc., to the vehicles in the connection area. Among vehicles, the flyers are then swapped in a BitTorrent style similar to SPAWN. Zhang et al. mainly focused on the content schedule and service provision at a single RSU, and Nandan et al. investigated on the content distribution over a small region without considering the collaborative caching between wireless digital billboards and vehicles. In contrast, we target to support the content distribution infrastructure over a large region with a large-scale node population. Intelligent and full utilization of the buffer resource of the distributed infrastructure devices is necessary of this purpose. Trullols-Cruces et al.explored opportunistic contacts and cooperative download among vehicles to enhance the content delivery rate. This paper differs in three aspects. First, the work in assumes that the mobility trajectories of vehicles are given and used for determining the content replications accordingly.

3. Proposed System

The infrastructure is composed of a multitude of roadside buffers (RSBs) -wireless buffer devices deployed on the roadside. Each RSB consists of a wireless transceiver operating on the dedicated short-range communication radio and can communicate with nearby vehicles using the vehicle-to-infrastructure communications. The RSB are capable of selectively retrieving content files from the vehicles which drive through its coverage and disseminating the cached files to vehicles upon their requests. The distributed deployments of the infrastructure are motivated by the following features of RSBs.

- Cheap and easy to install. The RSBs are cheap and lightweight devices consisting of a wireless transceiver and a small buffer which can be wirelessly configured and managed, requiring no complex and expensive cabling work. They need not be necessarily connected to the Internet as RSBs are deployed to distribute the local contents generated by their owners,. As such, once deployed, RSBs incur no bandwidth cost to their owners.
- Easy to manage. The content distribution and buffer management of RSBs are purely self-organized, which individually adapt to the time-varying network conditions like the density of vehicle traffic and buffer availability and are designed to meet the file download demands. So the owners need not get involved in any further operation except for using wireless connections,.
- Profitable. By distributing the advertisements or other any useful information to the public the RSBs can bring commercial benefits to their owners .

The figure illustrates a motivating scenario in which a grocery store intends to distribute its recent flyers to maximum customers in the city. For this purpose, first the flyers are to be uploaded to one or multiple RSBs near the store. The RSBs are then responsible for distributing the content files (flyers) on the fly to vehicles driving through the area and let the vehicles distribute the flyers to other RSBs and vehicles across the city

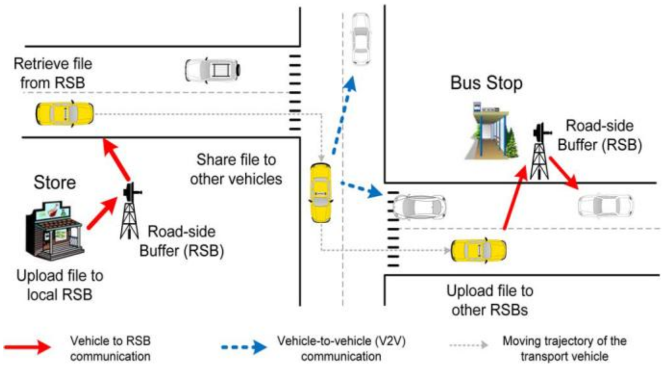

Figure 3:.Architecture

Figure 2: Content distribution through the proposed infrastructure

The infrastructure here (i.e., RSBs) is distributed, deployed, owned, and managed by separate individual entities. For example, a grocery store or a shopping mall may deploy the RSB in its parking lot to advertise i.e, broadcast periodically the advertisements, as in Fig. 1. A movie theater may also deploy a similar RSB to distribute the new movie trailers to the public. The distributed RSBs deployed by separate entities collectively form the infrastructure network. The RSBs deployed in a distributed manner across the city can provide dedicated storage and communication capacity to enable content distributions to vehicles. Moreover, relying on fast vehicles to transport contents among RSBs and making RSBs selectively retrieve contents from vehicles to cache and redistribute, makes the entire infrastructure achieve a global optimal goal in a fully distributed manner.

3.1 System Model

1) Model of RSBs: Consider the city as a bounded region where a set R of RSBs are randomly deployed. RSBs at different locations would have different radio coverage, given the different building environments and diverse communication capabilities. Within their communication coverage, we consider RSBs to have the same data transmission rate to vehicle nodes, which is denoted by CV2R. In this paper, we allow vehicles to disseminate cooperatively and distribute the downloaded contents to each other by communicating with each other . Let CV2V denote the data transmission rate of V2V communications. Each vehicle is equipped with a single-radio transceiver and communicates to only one node at each time. We make CV2R > CV2V, then vehicles prefer to download from RSBs in case RSB connections are available. Due to the ample power energy and better channel conditions when mounted high, RSBs tend to have a higher transmission rate than V2V communications which is a working assumption.

2) Model of Node Mobility: The mobility of each vehicle node is represented by an ON/OFF process based on its connectivity to RSBs. If a vehicle node is outside the coverage of any RSB it is in state 0; otherwise, it is in state 1.

3) Model of Files: Let F denote the integrated set of content files available for download in the region of interest. Throughout this paper, a distinct owner is assumed to manipulate each RSB the contents to its RSB are uploaded at periodic intervals by the owners following the exponential distribution with mean Δ. RSBs have homogeneous buffer size,1 which is denoted by L. When the buffer of RSBs overflows with excessive file being uploaded from vehicles, the oldest files stored in the RSB are to be eliminated. Throughout this paper, the focus is on the design of RSBs and assume that the buffer management at vehicle nodes are predefined and out of control. Specifically, the vehicles could have heterogeneous and limited-sized buffer storage, and randomly select files to eliminate from the buffer if their buffer overflows. The pattern of a V2V content swap is also predefined, which could follow existing schemes, such as SPAWN. With new files being continually uploaded at distributed RSBs and old files being eliminated from the network, F changes dynamically over time. In the network, each file is characterized by a three-tuple, including file blocks, popularity, and availability, defined as follows.

1) File Blocks. Each content file in the network is divided into multiple non-overlapping file blocks for delivery. A vehicle node must collect all blocks of the requested file from either RSBs or other vehicles which has the file stored in order to complete the download of a file. A file can be redistributed by a vehicle node to the others only after it has the entire file downloaded and recovered.

2) File Popularity and Availability. In addition to the number of file blocks, each content file in the network is characterized by another two parameters, namely popularity and availability.

3.2 Network Utility Function

For each content file I in the network, we assume that there is an underlying utility function Ui(τi) which specifies the satisfaction of vehicular users on downloading file i given the download delay τi. Moreover, it is nature to assume that U(τi) is a monotonically decreasing function of τi, i.e., reducing the download delay τi would monotonically increase the user's utility of file i. The proposed infrastructure is designed to maximize global network utility function U, which represents the integrated utilities of all vehicles under consideration. The network utility can be adapted to achieve different design goals, with different concerns, as in the following examples.

1) User-centric content distribution: In this scenario, by tuning the weighing factor of each file equal to the corresponding file popularity, the proposed infrastructure targets to optimize the user's download experience by maximizing the average user satisfaction on the file dissemination.

2) Content-centric content distribution: The weighting factor wi can be set to a predefined value that symbolizes the importance of file i. For example, breaking news, important software update, etc., can be assigned with the large weighing factors and accordingly be assigned high priorities to be stored in RSBs. This ensures vast storage and ubiquitous availability of those important files .

3) Cost-centric content distribution: A practical concern of the proposed infrastructure is the hardware cost of RSBs. More files can be cached in each RSB, rendering reduced download delay to users provided the larger buffer storage of RSBs; However, it increases the cost of RSB hardware accordingly.

3.3 Distributed Content Replication

Here, we design a distributed algorithm to enable RSBs to select the appropriate files in a fully distributed manner. We adopt a random-walk-based algorithm over a file graph as follows to enable RSBs select file I from the network in a distributed manner.

1) File Graph: The file graph refers to a graph connecting all the content files stored in distributed vehicle. As shown in Fig. 2, each vertex in the graph represents a file that is stored in a vehicle node. Additionally, each vehicle has an anchor file, e.g., file j, which is selected from the locally stored files in vehicles, which has the largest value of pj [κjμ(λ + μ) + δ(μ − λ)] among all the other buffered files in the file graph of a vehicle node. Each vehicle node periodically advertises its anchor file information, including availability aj and popularity pj , to the neighbor vehicles. In the file graph, all files stored in the same vehicle node are fully connected, and the anchor files among neighboring vehicles are fully connected, as shown in Fig 2.As the top tier connects the anchor files of vehicles and the underlying tier connects all the files inside a vehicle to its anchor file, the file graph of a vehicle node has a two-tier architecture.

2) Random-Walk-Based File Selection: The file selection is realized by a random-walk algorithm over the file graph. Specifically, to determine the files which are to be stored in RSBs, an RSB first issues a number n of random walkers to separate vehicles which are within its communication range. Each vehicle that receives a walker from the RSB will then initiate the random-walk process starting from its anchor file. The walker is stochastically forwarded on the file graph from one vertex (file) to another vertex (file), following the

Metropolis–Hasting algorithm. Once the walker is forwarded to the anchor file, it may then be forwarded to other anchor files stored in different vehicles. In this case, the walker is forwarded to other vehicles and proceeds the random-walk algorithm. After being relayed for time-to-live (TTL) hops among files on the file graph including self-loops, the walker stops at a file. The file thus selected is to be uploaded to RSBs.

4. Random-Walk Algorithm

To compute the transition probability of the walker, each vehicle needs to know the availability and popularity of the files stored in its buffer. RSBs three modes of operation:

1) File Publication: Whenever a new file is published at RSB A which is uploaded by its owner, the RSB A issues n walkers to separate vehicles within its coverage. Each walker is relayed among files over the file graph embedded in the vehicular networks following Algorithm, and results in one file being selected after the Time to leave Hops. The vehicles with the selected files will then upload the file to the RSBs that they drive through. As such, RSBs are dynamically refreshed with new contents being continuously uploaded and this process is triggered by the publication of new files. In this phase, RSB A is only responsible to issue walkers to the vehicular network upon the publication of new files to the RSB A. The files selected by the walkers will be uploaded to RSBs in the communication range of the vehicles hosting the selected file, which may not necessarily be RSB A.

2) Retrieve Files from Vehicles: Whenever a vehicle with a selected file in the random-walk algorithm comes into the coverage of RSB A, it will retrieve the file immediately from the vehicle. During this period, the channel of RSB A is exclusively used for the file retrieval. If there are simultaneously multiple uploads from different vehicles to RSB A, RSB A can only process one retrieval at one time until this retrieval completes. Once the selected file in a vehicle is uploaded, the vehicle will not upload this file to other RSBs unless this file is selected again in the random-walk algorithm. In the case that a vehicle moves out of the coverage of RSB A before it accomplishes the retrieval, RSB i would proceed the file retrieval again from other driving-through vehicles, which has the unfinished file stored. If its buffer is full, RSB A depletes the buffer by evicting the file that has been stored for the longest time.

3) Upload File to Vehicles: In the idle phase of RSB i, when it does not need to issue walkers to the network or to retrieve files from vehicles, it uploads the cached file to the vehicles driving-through the RSBs upon their requests. Each RSB in the network thus works in the three modes in a fully distributed manner.

Security of the data transmission:
We propose Trusted Authority, where the user is provided login and unique key is generated. The trusted authority verifies the data from RSBs and sends to vehicles. When the RSB is attacked by the malicious user the trusted authority drops all the packets using ECC cryptographic function.

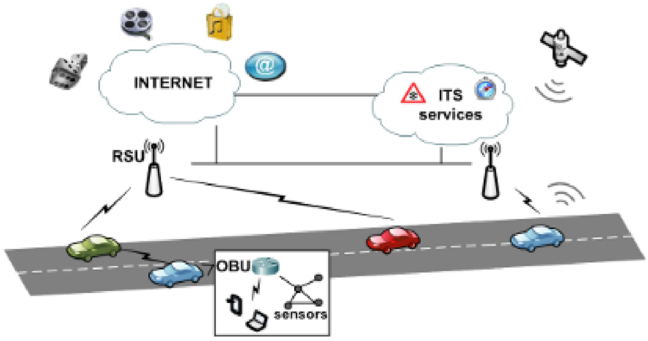

Figure 3: Security in VANET's

5. Simulation Results

Scenario 1:

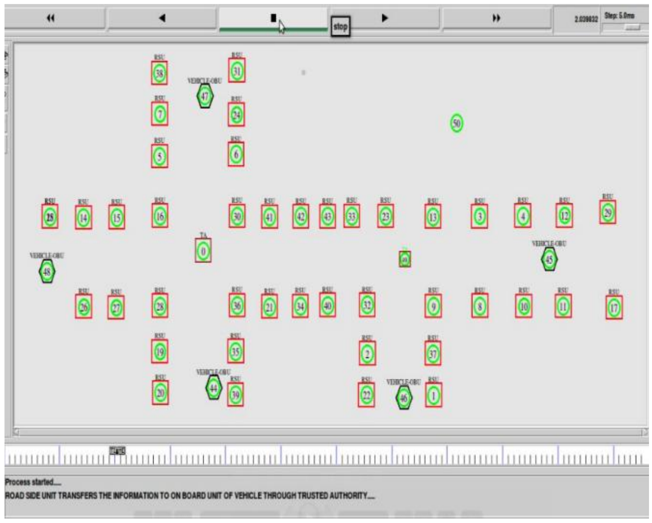

Figure 4: Initial RSB and Vehicle

In the above scenario we shown there are set of Road side buffers, Information sender, Trusted authority and vehicles.

Scenario 2:

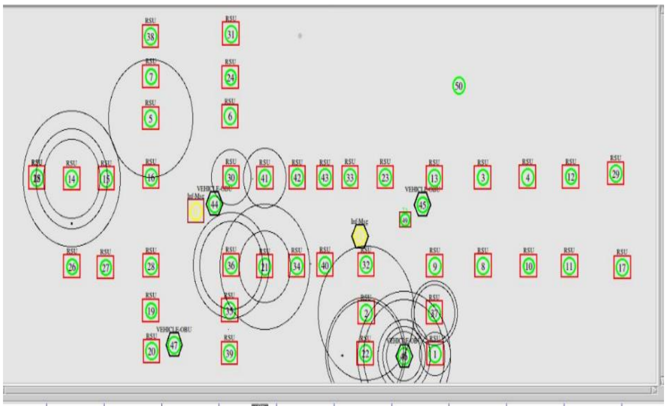

Figure 5: Communication between RSB's and between Vehicle and RSB's

In above scenario we shown the transfer messages from RSB to RSB, RSB to vehicle and Vehicle to Vehicle.
Scenario 3:

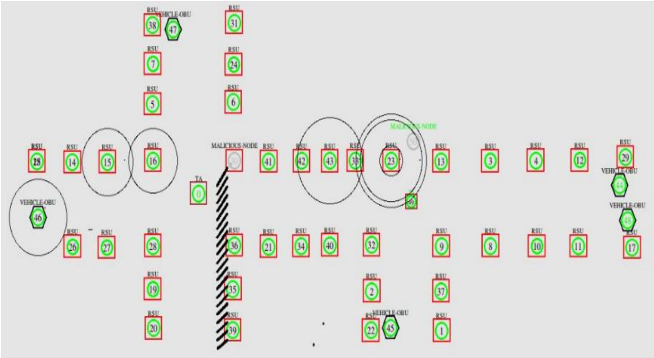

Figure 6: Trusted Authority drops packets

In above scenario if any virus or unwanted information in the transmission trusted authority authenticates and drops the packets.

Scenario 4:

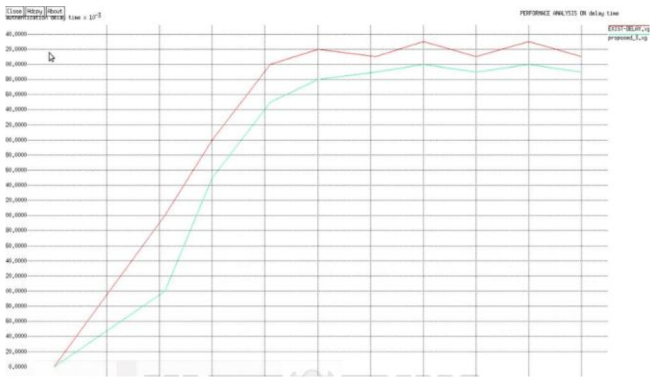

Figure 7: Performance graph

In above graph we shown that proposed scheme has less delay time than the traditional scheme.

6. Conclusion and Future Work

The proposed infrastructure is composed of distributed lightweight low-cost devices called roadside buffers (RSBs), where each RSB has the limited buffer storage and is able to transmit wirelessly the cached contents to fast-moving vehicles. To enable the distributed RSBs working toward the global optimal performance (e.g., minimal average file download delays), we propose a fully distributed algorithm to determine optimally the content replication strategy at RSBs and prioritize the contents where accident messages have high priority and information messages like advertisements have low priority . We secure communication using Trusted Authority which verifies RSU authentication through ECC cryptographic function. The proposed infrastructure is designed to optimize the global network utility, which accounts for the integrated download experience of users and the download demands of files and provides security to the system. In future work we take different cryptographic function for the security of the data transmission in VANET and provide internet enabled RSBs.

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Author Profile

Vinay M Naganur received the B.E. degree in Computer Science and Engineering from KLEIT, Hubli in 2013 and pursuing M.Tech in Computer Science and Engineering from CMRIT, Bangalore.

Mr. R. Anand is pursuing Ph.D. in Visvesvaraya Technological University, Belgaum. He completed his M.E(CSE) from Jayam College of Engineering & Technology Coimbatore in 2009. He is presently working as Associate Professor, CMR Institute of Technology, Bangalore. He presented nearly 10 papers in national and international conferences. His research areas include Mobile Adhoc networks.