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Performance Evaluation of GPSR Routing Protocol for VANETs using Bi-directional Coupling

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Abstract

Routing in Vehicular Adhoc Networks is a challenging task where the nodes themselves are vehicles. The mobility factors such as beacon intervals and vehicles with different velocities may cause inaccuracy in the identification of the vehicle's position. This in turn affects the performance of the position based routing protocols. Further, there is a need to evaluate through simulations performance of the position based routing protocol, especially in urban realistic scenarios for VANETs. The work in this paper evaluates the performance of Greedy Perimeter Stateless Routing protocol (GPSR) for VANETs which is a popular position based protocol especially for routing in MANETs. In order to evaluate realistic simulation environment bi-directional coupling of OMNET++/ INET Framework and SUMO is chosen for Nagarbhavi region in Bengaluru, India. The simulations are done for various scenarios realizing the impact of mobility parameters on routing using GPSR, and performance is measured in terms of packet delivery ratio and throughput.

Keywords: VANET, Bi-directional, GPSR, SUMO, OMNET++.

1. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are an extension of Mobile ad-hoc networks (MANETs). The nodes in VANETs are the vehicles themselves which communicate with each other using wireless technology, without any pre-deployed infrastructure [1]. IEEE 802.11p standard is being used for the Wireless Access in Vehicular Environments [2]. Various applications of VANETs such as safety related and comfort related have been stated in[3] .The main factors effecting routing performance in VANET's are the speed of the vehicles, mobility constraints on the roads and frequent network breakdown. One of the preliminary tasks is in designing routing protocols which can trace the routes between vehicular nodes efficiently. For the same, realistic simulation scenarios are considered for routing protocols from which reliable results can be obtained.

The objective of the work in this paper is to study the performance of GPSR through simulations for routing among vehicular nodes in VANETs particularly in urban areas. Mobility traces are obtained by the real world traffic simulator, these modelled offline traces will give the influence of road traffic on network traffic, but not vice versa. In order to overcome this problem bi-directional coupling of traffic simulator SUMO [traffic simulator, http://sourceforge.net/projects/sumo/], and OMNET++/ INET Framework [network simulator, http://www.omnetpp.org/] are used for realistic simulation scenarios [4].

The work in this paper evaluates the performance of Greedy Perimeter Stateless Routing (GPSR) protocol for VANETs which is a popular position based protocol especially for routing in MANETs. In order to evaluate realistic simulation environment, bi-directional coupling of OMNET++/ INET Framework and SUMO is chosen for Nagarbhavi region in Bengaluru, India.

An overview of position based routing protocols of VANETs is presented in a tabular form in section 2. The comparative analysis is given in Section 3. And the Section 4 discusses on the methodology, simulation setup and its scenarios. Section 5 gives the evaluation metrics as well as an illustration of the acquired results. Further, Section 6 concludes the paper.

2. LITERATURE REVIEW

Routing in VANETs is a challenging task because of the high speed of the nodes (vehicles), frequent topology changes and predictable mobility (constrained by the road topology and traffic regulations). Previous studies showed that the position based routing protocols outperforms non-position based protocols [5][6][7] as modern vehicles are equipped with GPS receivers, digital maps and navigation systems. The position based routing protocols use the geographical information of nodes to route the data packet towards the destination, by beacon packets. These beacon packets along with the node speed may introduce the inaccuracy for position information in the position based routing protocols [8][9].

Table1 shows the comparative study on different position based routing protocols and their functionalities in VANETs. The parameters chosen for comparison are the routing strategies, maps adopted, simulation scenarios and the different simulation tools. The protocols presented adopt multi-hop techniques to transmit the data from source to destination.

As the GPSR protocol is the basic platform in position based routing protocol, it is considered further to evaluate its performance in Indian road network scenarios. GPSR makes greedy forwarding using the immediate neighbour's position information in the network. It consists of two methods for forwarding the data packets. They are greedy forwarding and perimeter forwarding. It works well in a highway scenario because of evenly distributed nodes. GPSR may increase the possibility of getting the local maximum and link breakage because of the high mobility of vehicles and the road specifics in urban areas. It also suffers from link breakage with some stale neighbour nodes in the greedy mode because of the rapidly changing network topology. Packet loss and delay time may occur because the number of hops increases in perimeter mode forwarding.

TABLE 1: Comparison and analysis of different position based routing protocols for VANETs.

Routing protocol	**Forwarding Strategy**	**Digital Map**	**Traffic-aware**	**Scenario**	**Recovery Strategy**	**Intersection Based**	**Mobility Model**	**Simulation Tool**
GPSR	Greedy	No	No	Highway	Perimeter Forwarding	No	Random Way Point	NS2
GyTAR	Improved Greedy	Yes	Yes	Urban	Carry and Forward	Yes	Realistic Mobility Model	QualNet

GSR	Greedy	Yes	No	Urban	Carry and Forward	Yes	Obtacle Model	Daimler Chrysler
GPSR-L	Greedy	No	No	Highway	Perimeter Forwarding	No	Manhatta n	NS2
CAR	Advanced Greedy	Yes	No	Urban& Highway	Node Awareness	Yes	MTS	NS2
A-STAR	Greedy	Yes	Yes	Urban	Recompute d Anchor Path	Yes	M-Grid	NS2
SAR	Greedy	Yes	No	Urban	Flooding	No	RWP	NS2
GPCR	Greedy	No	No	Urban	Right hand rule	Yes	Obstacle Model	Vanet Mobisim
MDBG	Greedy	Yes	No	Urban	Carry & Forward	Yes	MOVE	NS2
JBGR	Greedy	Yes	Yes	Urban	Carry & Forward	Yes	Vanet Mobisim	Vanet Mobisim
IBRP	Greedy	yes	No	Urban	Carry & Forward	Yes	Manhatta n	NS2
GTLBR	Greedy	Yes	Yes	Urban	Carry & Forward	Yes	SUMO	NS2/SU MO
E-GyTAR	Greedy	Yes	Yes	Urban	Carry& Forward	Yes	Vanet Mobisim	GLOMO SIM
BACRP	Trajectory	Yes	Yes	Urban	Carry & Forward	No	Manhatta n	NS2
IBGRP	Greedy	Yes	No	Urban	-unknown-	Yes	- unknown-	MatLab/ SIMULIN K

3. COMPARATIVE ANALYSIS

Alsaqour et. al. analyzed the effect of position information inaccuracy caused by node speed and beacon packet interval time. Their work also identified that the network performance metrics can be affected by position information inaccuracy in GPSR routing protocol, in terms of end-to-end delay and routing loop in MANETs [26]. Yongjin et. al. and Shah et.al had also identified that the location errors degrade the performance of perimeter forwarding strategy in terms of data packet drop, optimal route and routing loop rate in dense networks and may lead to power consumption of nodes due to sub-optimal path [27,28]. Further, the link connection problem with neighboring nodes and routing loop due to inaccurate location information are also identified as shown in [29, 30].

4. SIMULATION ENVIRONMENT

In the present study, analysis is carried out for network performance metrics, affected by position information inaccuracy in GPSR routing protocols, in term of PDR and Throughput. The speed of vehicular nodes and beacon packet interval time are the two main mobility parameters, which causes the position information inaccuracy in VANETs. Inaccurate location information caused by node mobility is also shown.

4.1 Simulation Model

Network topology and route information on Nagarbhavi region in Bengaluru covering an area of 25 km^2 are selected and downscaled from Open Street Map for the study. The information of network topology (net.xml) and Route files (rou.xml) are obtained using Net converter and Duarouter in SUMO. In a real time scenario, inter vehicle communication is necessary among the vehicle's for the distribution of the information on traffic, where the vehicles position depends on the received information. In order to handle such interactions, bi-directional coupling is required. Therefore, a TCP connection is used between Traffic and Network simulators to communicate bi-directionally using Traffic Control Interface (TraCI) [10], as shown in the figure 1. The bi-directional communication is initiated by sending the synchronization message and simulation results (vehicles position) to each other (figure 3).

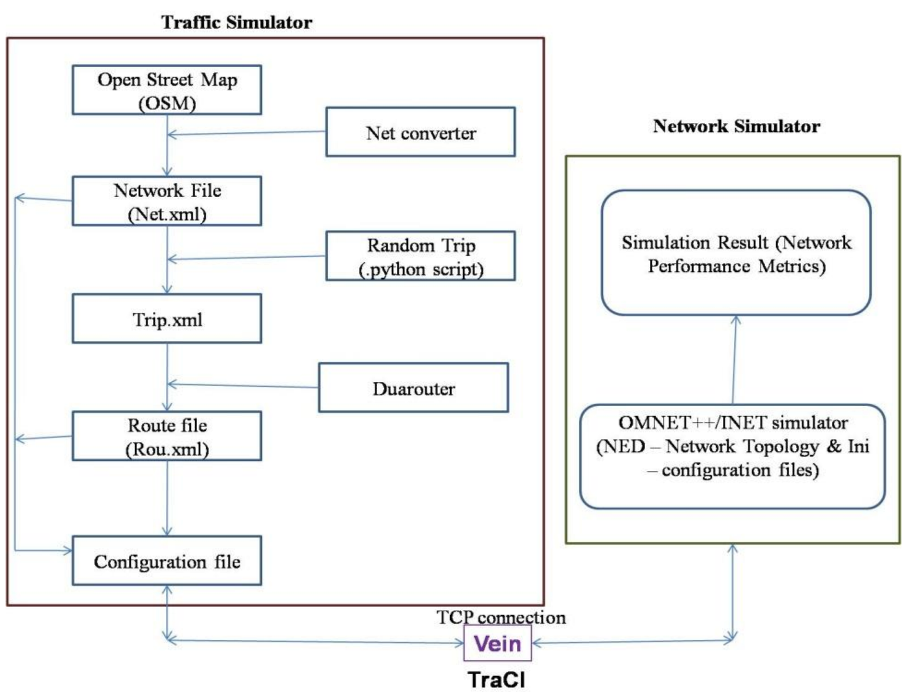

FIGURE 1: Methodology for calculating the Network performance metrics.

By considering the urban scenario, vehicle speed (m/s) [in rou.xml] is modified during the generation of trace files in traffic simulator, which will be used further in network simulator. The beacon intervals in seconds and number of traffic sources [in .ini file] is varied for the communication between nodes. The moving vehicles on the obtained road network are given in figure 2a &b.

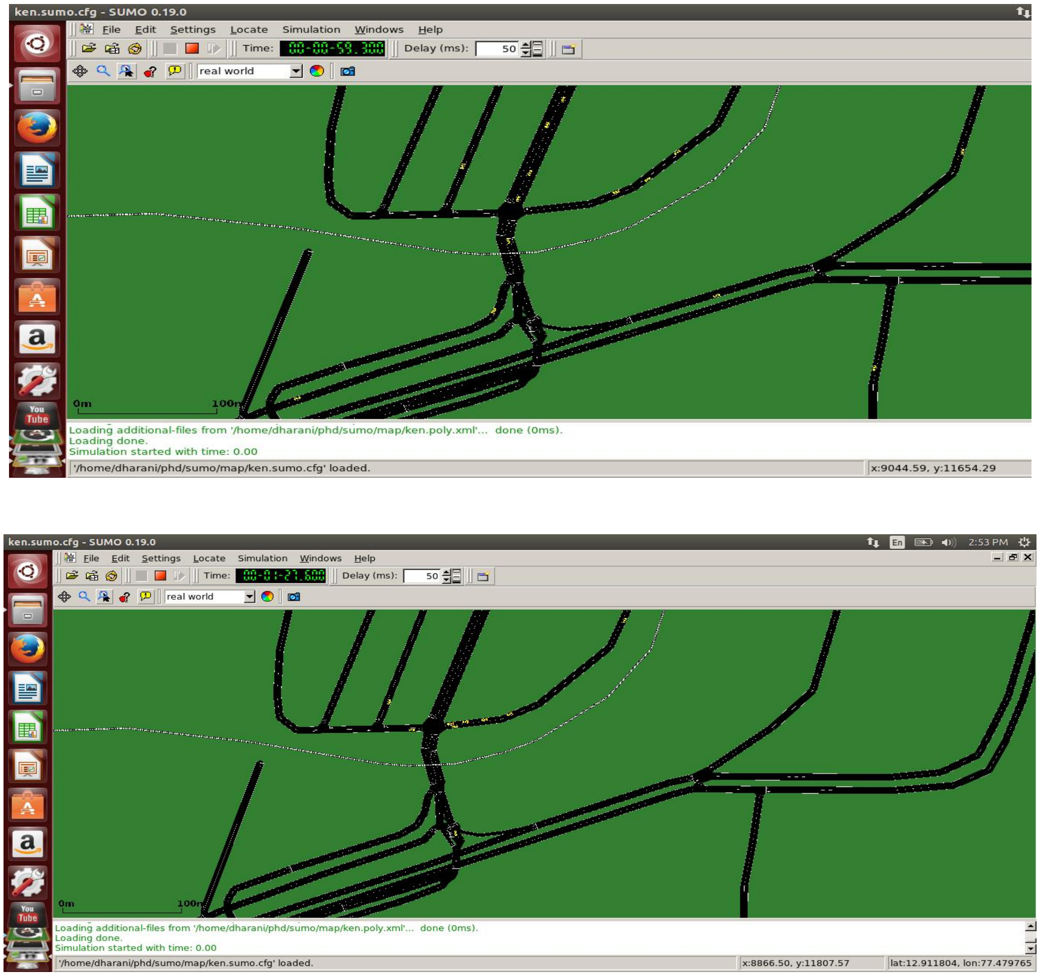

FIGURE 2 a & b: Road network of Nagarbhavi [urban area] showing the simulation of Nodes in SUMO [Traffic simulator].

The vehicular mobility is controlled by SUMO and Vehicular nodes by OMNET++/INET, where IEEE 8011p is used for the communication. The position and radio wave transmissions between the vehicular nodes are shown in the figure 3.

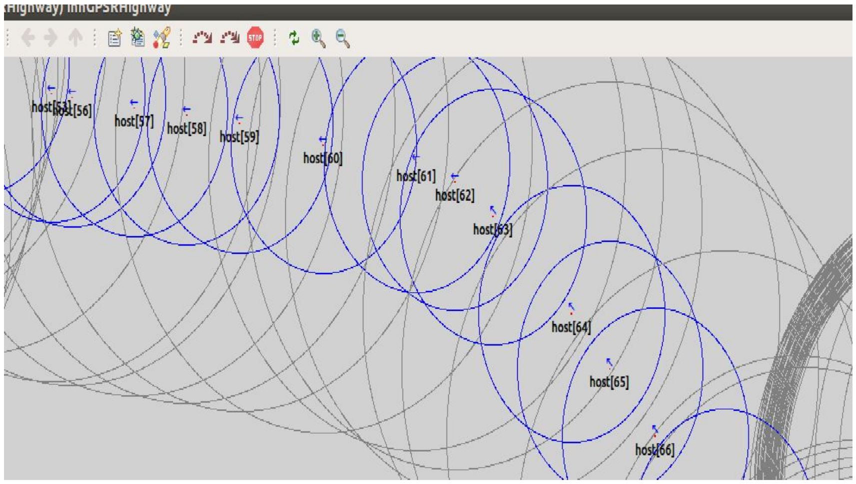

FIGURE 3: Communication among the vehicles in motion [OMNET++/INET].

Table 2 indicates the parameters used for network operation, where the parameters of Physical and MAC layers are configured to IEEE 802.11p.

TABLE 2: Configuration parameters used in the simulation process.

Parameter(s)	Value(s)
Simulation Area	5000m*5000m
Simulation Time	300s,600s
Number of traffic Sources	10,20,50,70,100
Vehicle Speed	5m/s,10m/s,15m/s,20m/s
Data Packet Length	512 Byte
Vehicle Beacon Interval	1s,2s,3s,4s,5s
Carrier Frequency	5.8GHz
Transmission Range	250m
Physical Layer	IEEE802.11p
Data Bitrates	27Mbps
Transmission Power	10mW
Packet Type	UDP
Mobility Model	TraCIMobility
Routing Protocol	GPSR

5. RESULTS AND DISCUSSION

The performance of chosen GPSR routing protocol is evaluated for different parameters which includes beacon intervals, vehicles with different velocities and numerous traffic sources. The PDR and throughput are the two different network performance metrics evaluated for the comparison of GPSR protocol performance. Packet Delivery Ratio (PDR) gives the ratio of the number of data packets received at the destination vehicle to the number of data packets sent by the source vehicle. The throughput is the total number of bits delivered successfully from the source to the destination every second. The results obtained through simulation are discussed below.

5.1 Varying Beacon Packet Interval

Figure 4 show the simulation results on the effect of using different beacon intervals. It shows the performance metrics, PDR and Throughput of GPSR routing protocol for Beacon packet intervals varying from 1 second to 6 seconds keeping the maximum velocity of a vehicle as constant to 5m/s. The result indicates the degradation of the protocol performance when the time gap for beacon packet increases. The result also shows an inverse relation between PDR, Throughput and Beacon Packet Intervals due to the inaccuracy on the delivery of position information of neighbors.

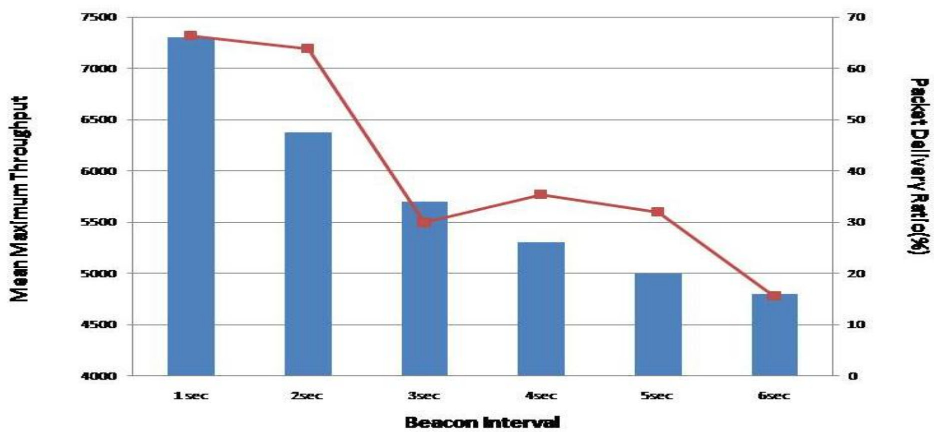

FIGURE 4: The relationship between PDR, Throughput and Beacon Intervals.

5.2 Vehicles with Varying Velocities

Figure 5 shows the effect of node speed on the performance of GPSR routing protocol in term of PDR and Throughput for node velocities starting from 5m/s to 20m/s in steps of 5m/s. The beacon interval is set as 1.5 second in network simulator. Due to the network disconnection and path instability the performance of GPSR decreases as the speed of the node increases. Vehicle speed influences the accuracy in receiving the geographical information of nodes which effect the performance of GPSR.

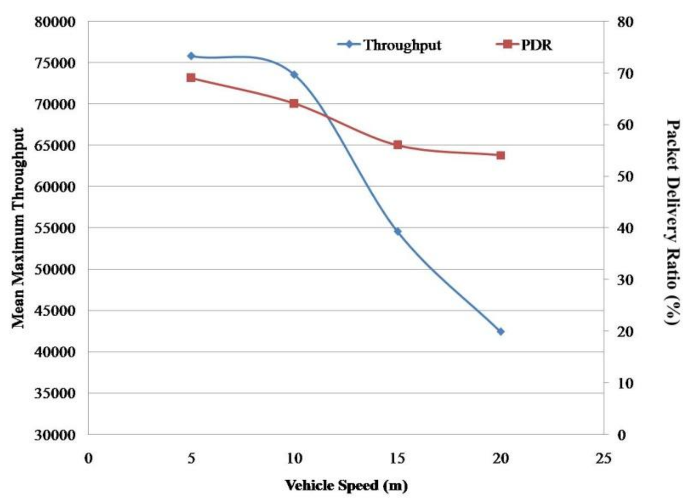

FIGURE 5: The impact of vehicle Speed on PDR and Throughput.

5.3 Traffic sources (nodes transferring the data packets)

The levels of Throughput and PDR relies on the number of traffic sources. As the traffic sources increases, the throughput increases because of the increase in transmission rate of data packets. This helps in the improvement of connectivity between traffic sources. In the meantime, the PDR decreases as there is a lack of scalability. Also, drastic changes can be observed in PDR due to node buffer overflow, as shown in the figure 6.

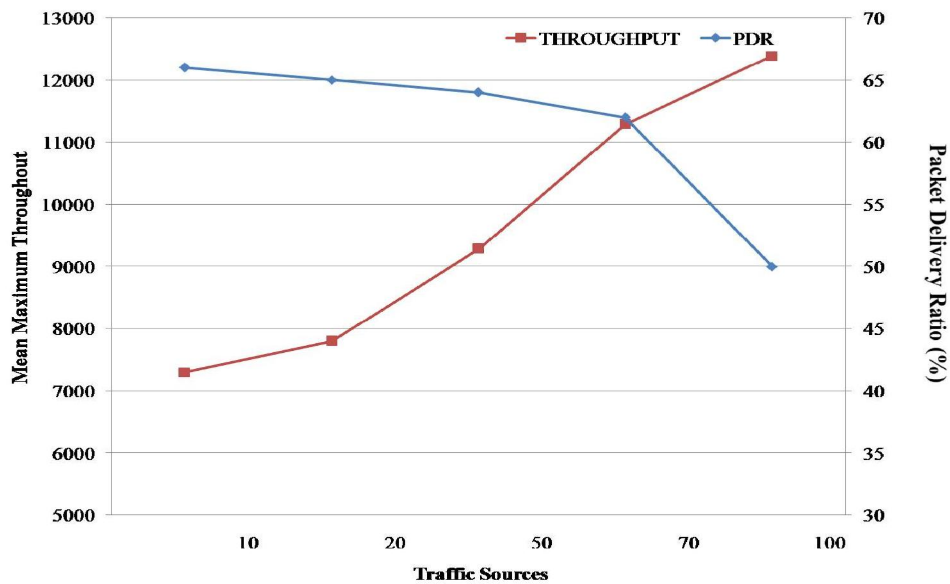

FIGURE 6: Influence of Traffic Sources on PDR and Throughput.

6. CONCLUSION

In this paper, an attempt has been made to study the effect of node speed and beacon intervals on GPSR protocol performance. Network topology and route information about Nagarbhavi region, Bengaluru urban area is obtained using OpenStreetMap (http://www.openstreetmap.org/). The bi-directional coupling of OMNET++/INET and SUMO had been used to create a realistic scenario. The results indicate that:

- The levels in beacon intervals have an impact on the delivery of position information degrading the performance of GPSR.
- High mobility of vehicles causing network disconnection and path stability problem influences the network performance metrics.
- As the number of traffic sources increase the PDR decreases due to scalability issue in GPSR.

The present study on the performance of GPSR routing protocol indicates the potential to improve the performance for VANETs in urban scenarios considering the real time parameters such as vehicles velocity, direction and vehicle density for further work.

7. ACKNOWLEDGEMENT

The authors would like to thank the web sources for SUMO (http://sourceforge.net/projects/sumo/), Vein (http://veins.car2x.org/) and OMNET++/INET (http://www.omnetpp.org/) software's. We would also like to express our gratitude to our colleagues and management for the overall support.

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9. ANNEXURE

1. Greedy Perimeter Stateless Routing Protocol (GPSR) [11]
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Storage Virtualization: Towards an Efficient and Scalable Framework

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Abstract

Enterprises in the corporate world demand high speed data protection for all kinds of data. Issues such as complex server environments with high administrative costs and low data protection have to be resolved. In addition to data protection, enterprises demand the ability to recover/restore critical information in various situations. Traditional storage management solutions such as direct-attached storage (DAS), network-attached storage (NAS) and storage area networks (SAN) have been devised to address such problems. Storage virtualization is the emerging technology that amends the underlying complications of physical storage by introducing the concept of cloud storage environments. This paper covers the DAS, NAS and SAN solutions of storage management and emphasizes the benefits of storage virtualization. The paper discusses a potential cloud storage structure based on which storage virtualization architecture will be proposed.

Keywords: Storage Virtualization, Cloud, Tiered Storage.

1. INTRODUCTION

To overcome critical storage issues faced by organizations, the need for a storage management solution arises. Storage architectures have been proposed which efficiently manage data in an environment. Intelligent storage systems distribute data over several devices and manage access to data [1]. Storage solutions are hence the top priority for organizations, considering integrity, availability and protection of data. With a plethora of options available, the most prevalent and traditional solutions have been direct-attached storage (DAS), network-attached storage (NAS) and storage area networks (SAN).

The storage components of the three traditional solutions namely DAS, NAS and SAN will be discussed. Various factors affect data storage selection such as performance, scalability, capacity, availability and reliability. Data protection operations such as backup and recovery are the backbone of any storage environment.

This paper focuses on a storage virtualization technology that creates logical abstractions of physical storage. Storage virtualization offers a number of benefits including reduction in management overheads and administration complexity [2].

Storage clouds on the Internet can be created using virtualization. The cloud storage system accommodates various storage sizes ranging from small storages to colossal devices. This paper discusses the cloud storage concept and a layered cloud storage structure. Virtual storage architecture will be advocated and analyzed.

Increasing the scalability and capacity of data is the inclination and goal of this work. Storage virtualization is the concept which encourages this purpose; improving data management in a storage environment.

2. INFORMATION STORAGE REVIEW

2.1 Direct Attached Storage (DAS)

DAS refers to a storage system attached directly to a server without the involvement of a network system. It is a non-networked storage solution, which does not provide access to other devices in the storage environment. This concept uses the server as the center for data transmission purposes. The main protocols used in DAS connections are ATA, SATA, SCSI, SAS and Fiber Channel [3].

The DAS solution for storage management, with its simple architecture is easy to understand and works well for small scale storage systems. It ensures security and efficiency of the highest order in such environments.

Deployment in large scale systems made the limitations of DAS clear. Since all data access transactions require transfer through a server, the performance of DAS storage method is affected in large scale storage systems such as an enterprise environment. When the performance of a system gets worse, it leads to a performance bottleneck. Moreover, disabling a server can make the whole system invalid, which is referred to as single point failure [4].

Other shortcomings of the DAS solution were issues pertaining to complex data sharing and high costs of data management. Large amounts of uncontrolled data meant wastage of system resources, which would lead to data inconsistency. The aforementioned are considered major disadvantages of the DAS architecture.

2.2 Network Attached Storage (NAS)

NAS is another primary solution for data storage. It is a file-level data storage which utilizes the built-in server as central data storage. NAS systems are normally networked and may be comprised of multiple logically or RAID arranged storage devices. Using file sharing protocols like AFP, NFS, and CIFS/SMB, file access is provided [4].

NAS appliances are storage units directly attached to a local area network (LAN). Where DAS architecture relied on link to a single server, NAS appliances can be accessed by any client on the network without server involvement. One solution to the problems suffered by DAS is to connect NAS appliances directly onto the network. These appliances only present/transfer data as files facilitating file sharing between users and servers across multiple operating systems.

Meeting the ever increasing demand of storage space requires adding extra capacity to NAS appliances. Eventually, when the limit is reached, the only solution is to deploy additional appliances. Servers need direct attached storage for high speed block based access. This creates a fragmented data environment. Data backup operations are also conducted on the LAN in the NAS storage method.

NAS provides solutions to a number of business requirements including solving the problems of DAS. However, as data requirements grow, NAS may become inefficient and/or inadequate. Increased dependency on the NAS controller means that all data will be funneled through the NAS appliance, which may result in a bottleneck. Limited backup functionality can also be a disadvantage of the NAS architecture.

2.3 Storage Area Network (SAN)

SAN is the most popular solution, which has been rapidly spreading across organizations. This concept involves moving networked storage from its traditional position to a separate location, which is a network of its own. Storage devices can be connected directly to this network by a fabric which contains switches and hubs to connect any storage to the servers as if they were local. SAN is a dedicated high speed network, specifically created to facilitate data transfer not only between servers and storage devices but also between multiple storage devices. SANs depend heavily on a high-speed fiber channel technology to provide flexible connectivity requirements. Introduction of a storage fabric resolved some connectivity issues found in DAS architectures. This storage method helps achieve high speed data backup without any impact on LAN performance. SAN contributed to solve the scalability issues of DAS and NAS by allowing servers and storage devices to scale independently [4] [5].

The major disadvantages of SAN storage systems are that SAN upgrades may cost more than the initial installation and are not easy to merge/integrate with existing technologies or other vendor equipment. Users usually have to stick to a single vendor, which results in isolated pockets/islands of SANs. Storage virtualization offers a viable solution to the problems faced by SAN storage systems.

3. VIRTUALIZATION OF STORAGE

Virtualization involves abstracting or isolating internal functions of storage systems or general network resources to enable network independent data/storage management. According to [1], virtualization of storage is technically the pooling of physical storage from various storage devices, disguised to be a single storage device which can be administered centrally.

Storage virtualization increases performance of various tasks involved in storage administration, such as backup, recovery, archiving, etc. in a timely and cost effective manner. Provisioning and managing distributed storage as a consolidated resource promotes simplicity. Storage virtualization automates storage expansion, reducing manual provisioning and hence decreasing downtime.

Digital storage in a home storage environment has been growing steadily. The use of storage devices, including external hard drives, has become a common practice for the average consumer. These devices have a limited lifetime and therefore with age, they may fail. While the size and complexity are significantly less, the management of home digital storage can be improved by adopting techniques used in large scale datacenters [6].

Datacenters in an enterprise storage environment consist of a collaboration of storage devices and systems that are created by aggregating storage devices. These storage systems are networked together to improve data efficiency and movement in the network. Enterprises also deal with content stored on multiple types of storage systems, referred to as “storage tiering” [7]. This storage architecture is a common characteristic of large-scale storage systems such as those in a datacenter.

3.1 Cloud Storage

Clouds consist of numerous storage devices grouped by network, file systems and various storage components. Since clouds are presented as a service, they are referred to as a storage service system. Cloud storage architectures may be comprised of network devices, storage pools, file systems, service-level interfaces and common access interfaces, etc. It is made up of distributed resources, but acts as a single resource, hence providing high fault tolerance through data redundancy and distribution.

Cloud storage components can be categorized by their functions as physical and logical so as to provide more scope for interactions and compatibility. Figure 1 shows a potential cloud storage structure which is presented as a generalized and layered architecture.

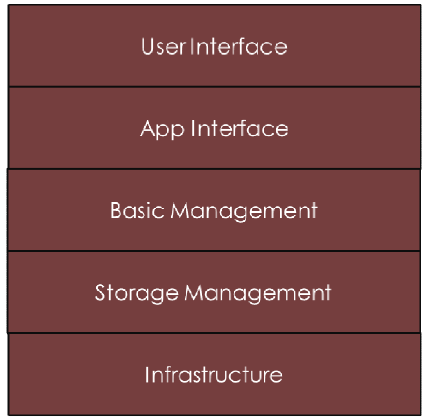

FIGURE 1: Cloud Storage Structure.

The structure from bottom to top consists of infrastructure, storage management, basic management, app-service interface and the user interface.

The infrastructure of a cloud storage system mainly consists of storage components such as storage devices, servers, and storage networks (NAS, SAN, FC, iSCSI, SCSI, SAS, etc.). It also comprises of wired/wireless networks.

In the storage management layer, there can be a storage manager or a management system which administers or advocates the management of storage in the infrastructure layer. Its most important role is data management. This layer collaborates between multiple domains to ensure data redundancy, fault tolerance, load balance and storage maintenance.

The basic management layer furthers the collaboration among storage devices by incorporating technologies such as cloud computing, distributed file system, etc., to enable data access. It is the central layer of a cloud storage structure which is the medium of interaction between the above and below layers.

App interface supplies a platform/link between applications and users for interaction. It supports various applications and platforms to help bundle applications under the cloud storage environment and be provided as a service to the users.

Finally, the user interface is the front end of the cloud storage structure. This layer is the point of interaction with the end users.

4. A PROPOSED VIRTUAL STORAGE ARCHITECTURE

For easy and dynamic data allocation, the end user has to have access to storage space without hindrance. To achieve this goal, this paper proposes a virtual storage structure in Figure 2.

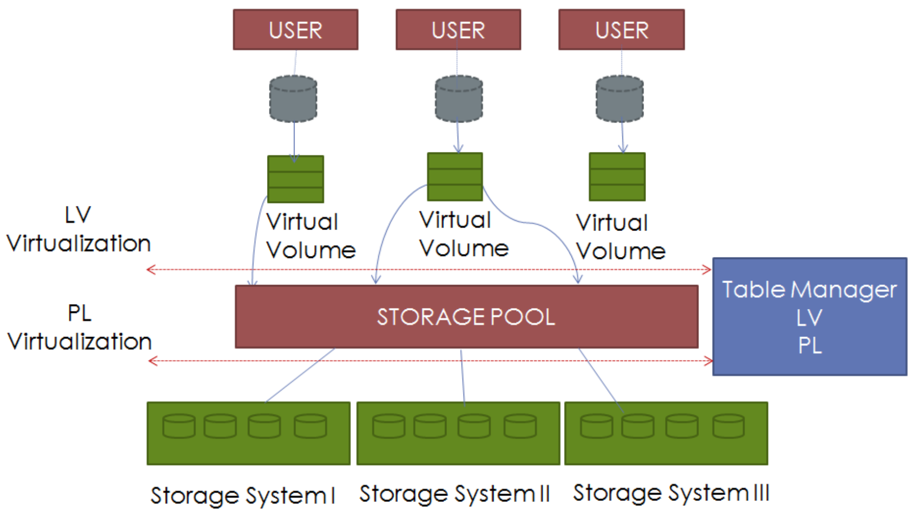

FIGURE 2: Proposed Virtual Storage Architecture.

As seen, storage systems are virtualized by storage virtualization techniques. The end users are provided with a logical volume of storage. This volume of storage will have a size as specified by the end user. There is a mapping table between the logical and virtual storages for each user. These tables record/preserve data on mapping relationships among users and storage pools. The user will be able to see enough space to meet its storage needs.

To manage mapping tables, a table manager is devised. This table manager manages logical-virtual virtualization and physical-logical virtualization. Separate managers can also be setup for independent logical-virtual/physical-virtual virtualizations.

The most severe problem virtualization can help solve is management of storage, considering the heterogeneous nature of a storage environment consisting of file systems, operating systems, management consoles, storage systems, management software, etc. Coping with the exponentially increasing demand for storage space both physical and virtual environments poses a major challenge. Data protection in scenarios such as server overload, server recovery, failed backups and service interruption is essential since critical data is present in a SAN.

In the proposed architecture of virtual storage, since the logical volume has been made virtual, users can be allocated virtual spaces of any size. Even if the allocated size exceeds the physical storage space, the user is unable to see the physical storage space. This helps in increasing simplification of storage administration, storage capacity and data utilization [6].

Since the data is virtualized into storage pools, storage space can be expanded as users need more storage space. Both the physical and logical spaces can be expanded dynamically according to the users' needs. Users can have huge virtual storage spaces.

However, since the proposed architecture involves the introduction of mapping tables and mapping managers, there is a possibility of increased complexity of the storage environment [6].
To increase productivity and meet consumer demands, valuable data has to be secured both internally and externally [9]. Virtualizing the physical space to logical volumes and the logical volumes to virtual volumes can make the system prone to malicious attacks. This architecture will be investigated further to ensure efficiency and scalability. Future work will include incorporation of encryption/decryption protocols in the proposed framework for assurance against malicious attacks.

5. CONCLUSION

This paper discussed various components of the three traditional storage topologies, namely direct-attached storage (DAS), network-attached storage (NAS) and storage area networks (SAN). The concepts of cloud storage and storage virtualization have been focused upon, following which a layered cloud storage structure has been discussed. Finally, considering the efficiency and scalability of data utilization as focal points, a virtual storage architecture has been proposed for future consideration.

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