Content Storage and Retrieval for Vehicular Delay Tolerant Network

Chetana T. Baviskar[1] , Nilima P. Patil[2]
chetnabaviskar10@gmail.com np_1234@rediffmail.com
Computer Science & Engineering Department
S.S.B.T. College of Engineering & Technology, Bambhori, Jalgaon

Abstract- Delay Tolerant Network (DTN) is an approach which has been developed to build architecture models to tolerate the disconnected network partitions or long delays in delivery of data to the destinations. Vehicular Delay Tolerant Network (VDTN) do not consist of end-to-end or direct connectivity so the nodes carries the messages until the next hop becomes available. Therefore small sized buffers are not suitable for such conditions. Instead, the nodes are equipped with large sized buffer to achieve data delivery. The storage capacity and message retrieving of intermediate nodes directly affects the network performance. So the Content Storage and Retrieval (CSR) mechanism is used for efficient and robust caching and forwarding contents over the network. In this way, though the connection between the mobile nodes may not be always available, the packet can reach the destination by hopping over the mobile nodes.

Index Terms- Vehicular Delay-Tolerant Network (VDTN), Bundle, Caching, Forwarding, Mobile Ad-hoc Networks (MANETs), Vehicular Ad-hoc Networks (VANETs), Fragmentation.

1. INTRODUCTION

Nowadays, all-time and unlimited connectivity to the internet seems to be fairly common for a great number of mobile and fixed devices. However, the truth is that persistent connectivity is not present everywhere or even in certain circumstances not necessarily mandatory. Delay Tolerant Networks (DTNs) are networks that enable communication where connectivity issues like sparse and intermittent connectivity, long and variable delay, high latency, high error rates, highly asymmetric data rate, and even no end-to-end connectivity exist. Vehicular Delay-Tolerant Networks (VDTNs) are based on DTN concept and characterized by opportunistic contacts. VDTN network assumes three types of nodes viz., terminal nodes, relay nodes and mobile nodes. Terminal nodes act as VDTN access points providing several services such as exchanging emails, documents, voice mails, movies, music, images, among others. Relay nodes are the VDTN store-and-forward agents that allow bypassing mobile nodes to store and forward data. Mobile nodes physically carry and relay data in the network (e.g., vehicles).

In DTN-based network, nodes allow data storage when there is no contact opportunity with other nodes to carry it until having contact with other nodes. At a contact opportunity, data are forwarded to the new contact. In VDTN, mobile and fixed nodes interact with each other to provide data dissemination and routing. VDTN appear as a new approach for vehicular communications, gathering some contributions from the store-carry-and-forward paradigm of DTNs. Therefore storing and forwarding are the key issues in data dissemination.

These content storage and retrieval (CSR) mechanism helps to improve the performance of network through data dissemination and routing in opportunistic vehicular networks.

2. RELATED WORK

This section describes caching mechanisms in various networks. These mechanisms have the similar network architectures as the VDTN network architecture, offering several contributions to refine the content storage and retrieval mechanism for VDTNs.

2.1. *Caching in wireless network*

Wireless network nodes consist of cooperation to forward traffic between themselves addresses. The energy constraints and network congestion problems are addressed by a cooperative cache protocol [1]. The cooperative cache protocol consist of three distinct cache protocols, CachePath, CacheData, and HybridCache. In the CachePath protocol, when two nodes communicate they exchange requester's node identification related to data that they carry CachePath protocol also caches the path (distance) between themselves and the source and destination of the requested data whereas in CacheData protocol, instead of paths, router nodes frequently caches accessed passing-by data for future requests. The HybridCache protocol is the combination of both CacheData and CachePath protocols. That is The

HybridCache protocol use both CacheData and CachePath protocols.

2.2. *Caching in mobile ad-hoc networks*

Mobile ad-hoc networks (MANETs) are autonomous ad-hoc networks where mobile hosts are connected by multi-hop wireless links. A cooperative caching service for MANETs [3] addresses two important issues in cooperative caching - cache resolution and cache management. Cache resolution concerns the decision mechanisms of the mobile device to find the requested data from the user. For this purpose, historical profiles and forwarding nodes are used to induce less communication cost. Cache management determines which data will be placed on or purged from the local cache.

2.3. *Caching in vehicular ad-hoc networks*

Vehicular Ad-hoc Networks (VANETs) are a subset of MANETs, where vehicles deliver and propagate data throughout the network. The Drive-thru internet project [4] is a caching proposal for VANETs. This project uses IEEE 802.11 access points that provide several Internet services for moving vehicles, in challenged environments with intermittent connectivity. To resolve the disconnection problem, this approach introduces the concept of Performance Enhancing Proxies (PEPs) which are usually network agents designed for improving end-to-end communication protocols, by breaking one connection into multiple connections. Drive-thru proxies are placed in a fixed network that is managed by a Drive-thru service provider. Drive-thru proxies are used as fixed points that relay mobile node requests to and from the Internet, and waits for a new communication opportunity to forward the requested data.

2.4. *Caching in delay tolerant network*

Caching mechanisms plays a vital role in DTNs since end-to-end path between client and server may not exist. Authors in [2] [5] proposes a distributed caching scheme for DTN which includes application hints to messages in order to perform content intelligent caching, acting as distributed storage or forward content. This approach presents a distributed caching strategy in DTN nodes. In order to improve this distributed caching scheme there exists a logic module for storage and retrieval operations [6]. This module allows cache lookups for stored resources in the queue and cache retrieval for passing requests. Such procedures require additional information about their payloads. For this purpose, application-hints extension blocks for the bundle protocols were also introduced. The application-hint contains several cache control fields. Application protocol field explicit the application protocol to perform proper resource matching; resource field identifies the carried resource for matching operations; operation type field indicates if the resource is a request, a response, an unconfirmed event, or an unknown operation type, and whether the bundle contains a resource.

3. MECHANISM FOR CONTENT STORAGE AND RETRIEVAL

For the intermittent connectivity, network nodes carry messages in their buffers, relaying them only when a proper contact opportunity occurs. The storage capacity and message retrieving of intermediate nodes directly affects the network performance. So there exists Content Storage and Retrieval (CSR) mechanism which manages the node buffers, deciding, which data will be sent, stored or dropped [7].

3.1. *Control labels for content storage and retrieval*

The CSR mechanism assumes the inclusion of CSR control labels attached to every bundle of aggregated network traffic (data bundles) as shown in Figure 1.

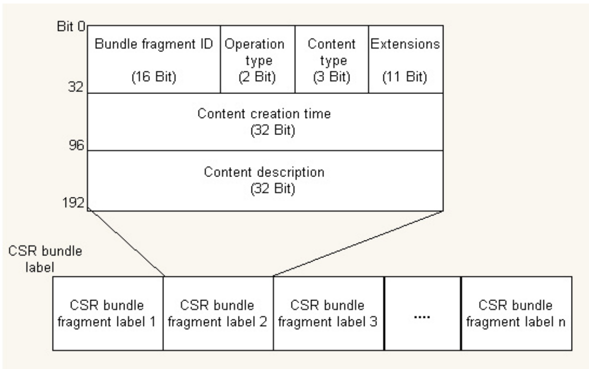

Fig. 1. Content storage and retrieval labels for VDTN

Each label contains specific CSR control fields that define if the content is to be cached or forwarded. The main purpose of these labels is to define cacheable contents, and apply caching and forward restrictions in order to improve network performance.

- **Bundle fragment ID**: It identifies the bundle fragment label.
- **Content creation time:** It includes the data and the time of creation or last modification of the respective content.
- **Operation type:** It specifies the operation for the respective content (i.e., request, response, storage).
- **Content type:** It identifies the type of the respective content (i.e., request, response, storage).
- **Content description:** It describes the bundle content.

When communication between a relay node and mobile node is established they exchange control information. In this control information the CSR bundle labels from all stored bundles are exchanged in order to start the CSR mechanism. Cacheable and forwarding bundles to be sent and received from the other node are selected by CSR matching operations. This data bundles are exchanged when the data plane is connected and ready to exchange data.

3.2. *Algorithm for content storage and retrieval*

(1) Relay node and mobile node exchanges a control information.
(2) In order to start the CSR mechanism the CSR bundle labels from all stored bundles are exchanged.
(3) CSR matching operations selects cacheable and forwarding bundles as aggregated network traffic.
(4) Bundle containing fragments that have, ‘Storage’, ‘Response’, and ‘Request’ as operation will be process by a node.

(i) If the bundle has fragments with storage type
Then,
compare with the ‘Content description’ field to check for the bundle is not already stored.
OR

(ii) If the bundle has fragments with response or request type
Then,
compare with the ‘Content description’ and ‘Content type’ field to check if a possible request or response is stored.

If so,
then bundle is selected to be cacheable.

(5) All selected bundles are sent in the list of cacheable data.
(6) Corresponding contents are forwarded along with their respective CSR bundle labels.

After exchanging CSR bundle labels, each node has access to the list of bundle fragments that the other node is carrying. A bundle that will be considered to be cacheable and forwarded is then selected by node. Bundle containing fragments that have, ‘Storage’, ‘Response’, and ‘Request’ as ‘operation type’ will be process by a node. If the bundle has fragments with storage type then, it is compared with the ‘Content description’ field to check for bundle is not already stored if so then bundle will automatically be selected for being cacheable. If the possible content is already stored then with the help of ‘Content creation time’ field it verifies that the content is the most recent one.

If the bundle has fragments with response or request type then, it is compared with the ‘Content description’ and ‘Content type’ field to check if a possible request or response is stored if so, then the bundle is selected to be cacheable. If not , then at least one of the communicating node is mobile and the destination node is matched with the mobile node route information and in this case the bundle is selected to be cacheable. At the last as shown in Figure 2, all selected bundles are sent in the list of cacheable data and corresponding contents are forwarded along with their CSR bundle labels.

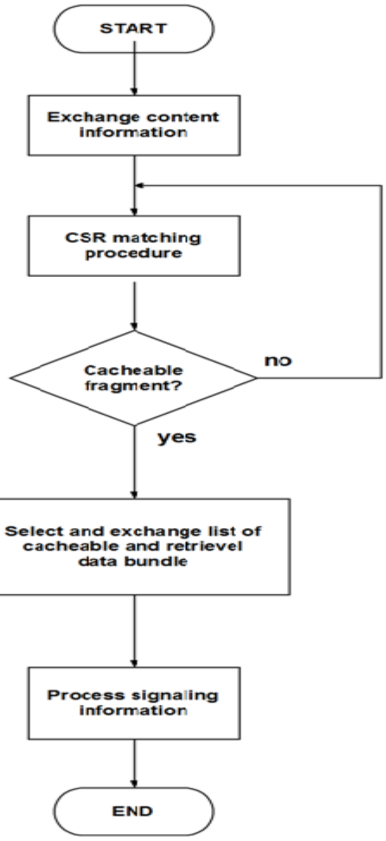

Fig. 2. Content storage and retrieval flowchart

4. DISCUSSION

The Content Storage and Retrieval (CSR) mechanism manage the node buffers, deciding which data will be sent, stored or eliminated and hence provides a fast, safe and reliable data transfer and storage management. The creation of suitable storage-and-forward mechanisms improves the performance of VDTN network. The main difference between VANETs and VDTNs is that VANETs assume that end-to-end connectivity exists through some path, while VDTNs do not. So, VANETs concepts are more appropriate for dense networks, while VDTNs accept also sparse networks through its store-carry-forward paradigm. The store-carry-forward paradigm kept the target and the relaying vehicles to have continuous communications in the uncovered areas. Large bundles may require more transmission time than available in short vehicle contacts. This may require fragmentation, which causes additional overhead. So, a compromise in bundle size may prove more efficient.

5. CONCLUSION

A store-carry-forward paradigm introduced in DTN performs better and uses fewer resources than end-to-end protocols, as each hop is optimized individually. By providing DTN capabilities to vehicular networks, new challenging situations typical of vehicular networks may be overcome, such as sparse and intermittent connectivity, variable delays, high error rates and nonexistence of an end-to-end path. CSR mechanism improve the average bundle delivery probability, the average bundle delay and the average contact time between nodes. The performance of VDTN networks improves significantly as CSR mechanism provides an efficient and feasible caching and forwarding of contents.

References

[1] Cao G.; Yin L.; Das C. (2004). *Cooperative cache-based dataaccess in ad hoc network.* Computer **37**(2), pp. 32-39.

[2] Cerf V.; Burleigh S.; Hooke A.; Torgerson L.; Durst R.; Scott K.; Fall K.; Weiss H. (2007). *Delay-Tolerant Networking Architecture*, RFC 4838 (Informational), Internet Engineering Task Force, [Online]. Available: http://www.ietf.org/ rfc/rfc4838.txt

[3] Du Y. and Gupta S. K. S. (2005). *Coop - a cooperative Caching service in manets.* Autonomic and Autonomous Systems and International Conference on Networking and Services, ICAS-ICNS. Joint International Conference. pp. 23- 28.

[4] Ott. J. and Kutscher D. (2004). *The "drive-thru" architecture: Wlan-based internet access on the road*. In Vehicular Technology Conference, **5**, pp. 2615-2622.

[5] Ott J. and Pitkanen M. J. (2007). *Dtn-based content storage and retrieval.* In World of Wireless, Mobile and Multimedia Networks. pp. 1-7.

[6] Pitkanen M. J. and Ott J. (2007). *Redundancy and distributed caching in mobile dtns.*In Proceedings of 2nd ACM/IEEE international workshop on Mobility in the evolving internet architecture, pp. 8:1-8:7.

[7] Silva B.; Farahmand F. and Rodrigues J. (2010). *Performance assessment of caching and forwarding algorithms for vehicular delay tolerant networks.* GLOBECOM, pp. 1-5.