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Content distribution in VANETs

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ABSTRACT

Advances in vehicular communications technology are making content distribution to vehicles more effective and increasingly more popular. This paper presents state of the art technologies and protocols for content distribution in VANETs. Major challenges are Internet access spectrum scarcity, mobility, connectivity intermittence and scalability. Aspects covered in this paper include: coexistence of WiFi and LTE; application of network coding; protection from pollution attacks; incentive design for cooperation enforcement; QoS support for video streaming applications. Simulation and testbed results are presented to support the findings. Critical issues that will determine future directions in this area are identified and discussed.

1. Introduction and background

Navigation safety has been the main driver of VANETs in the early years. With the improvement of technology and the increase in popularity of mobile phone applications, new interests have emerged that are related to location aware information and entertainment. Among these, content downloading is probably the most important trend. Beside music, movie trailers, games and restaurant menus, there is a proliferation of location-cognizant data such as virtual tours to local attractions or snapshots of nearby resort areas. Downloading of video camera streams from vehicles facing an accident or a road emergency (flood, fire, etc.) also falls in the local content distribution category, albeit for safety rather than entertainment purposes. A mobile user can download content from access points (APs) that connect to the Internet, using a strategy called Wardriving (www.wardriving.com). Unfortunately the traditional client/server type download will not work because the contact time is insufficient. For example, with a WiFi radio range of 300 m, at 45 mph, the contact time is less than 30 s, and the useful download time is even less if one accounts for the overhead required to set up the Internet connection. Moreover, installing access points every 300 m is too costly. Expecting to find friendly open APs within comparable intervals is unrealistic. Unless the driver is willing to stop in front of the AP when he finds it, one must conclude that in practice, multimedia content downloading at vehicular speed from WiFi APs is not feasible. The only solution that will work in a VANET environment is peer-to-peer "file swarming", enabling users far away from the APs to complete their downloads by exchanging pieces with other interested drivers.

The prime example of P2P file swarming is BitTorrent, where a file is segmented into chunks. Peers discover what chunks the neighbors have that they are missing and promptly exchange them to complete the download. One immediate advantage is to reduce the "flash crowds" load on the content provider. The availability of the pieces is increased because of users' cooperation, and the downloading process is expedited. BitTorrent on wireless however will not work directly as it was designed for the Internet. In the Internet overlay a one hop neighbor may be several physical hops away, requiring a major expense of resources (spectrum and energy). Instead of using overlays, it makes more sense to use physical neighbors for the chunk exchange [1,2]. One such P2P scheme is SPAWN, which uses proximity (instead of the conventional rarity measure) for piece selection and was shown to outperform the "rarest first" criterion of Internet schemes.

By extending SPAWN [1], CarTorrent was born. CarTorrent is a BitTorrent-style file swarming protocol applied to the vehicular environment. CarTorrent clients use k-hop limited scope gossiping to disseminate their chunk availability. Gossip messages are propagated up to k hops from the originator. This allows peers to collect information about piece availability as well as local topology. Topology and availability info is used to select the piece to request next. For example, if A and B own a rarest piece that C desires, and A is at a shorter hop distance than B, the query is sent to C.

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