SPAWN: A Swarming Protocol For Vehicular Ad-Hoc Wireless Networks

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ABSTRACT

Future vehicular networks are expected to deploy short-range communication technology for inter-vehicle communication. In addition to vehicle-to-vehicle communication, users will be interested in accessing the multimedia-rich Internet from within the vehicular network. This motivates a compelling application of Co-operative Networking in the Vehicular Ad-Hoc network where the Ad Hoc network *extends* and *complements* the Internet. The broadcast nature of the wireless medium drives us to explore different design paradigms from the ones used in typical wired settings.

A new paradigm in content delivery on the Internet using peer-peer swarming protocols is emerging [1, 2]. We propose *SPAWN*, a simple cooperative strategy for content delivery in future vehicular networks. We study the issues involved in using such a strategy from the standpoint of Vehicular Ad-Hoc networks. Several enhancements to a popular swarming protocol (BitTorrent) are discussed including a gossip mechanism that leverages the inherent broadcast nature of the wireless medium, and a piece-selection strategy that uses proximity to exchange pieces quicker. Preliminary results show that *SPAWN* increases the perceived performance of the network, resulting in faster downloads for popular files.

Categories and Subject Descriptors

C.2.m [**Computer-Communication Networks**]: Miscellaneous

General Terms

Management, Performance, Design

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Keywords

Vehicular Networks, Wireless, Peer to Peer, Content Delivery, Cooperative strategies

1. THE SPAWN PROTOCOL

SPAWN has the same generic structure of any swarming protocol. Peers downloading a file form a mesh and exchange pieces of the file amongst themselves. However the wireless setting of *SPAWN*, characterized by limited capacity, intermittent connectivity and high degree of churn in nodes requires it to adapt in specific ways. As we shall see, this particular scenario provides a compelling incentive for individual nodes to *cooperate* while accessing the Internet. Figure 1 describes the basic operation of the *SPAWN* protocol.

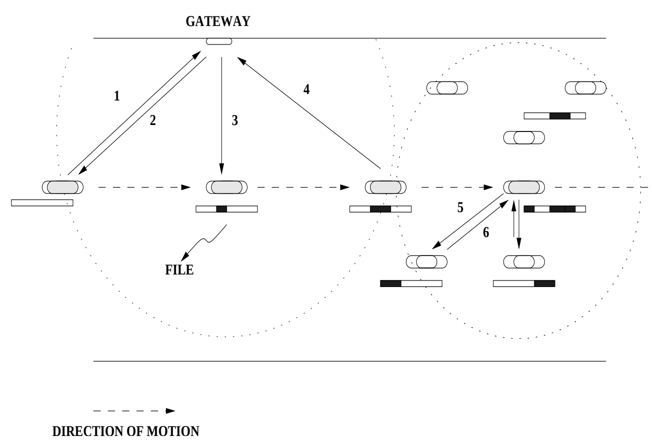

Figure 1: Evolution of a file in a node using the SPAWN protocol.
(1) A car arrives in the range of a gateway,(2) initiates a download (3) downloads a piece of the file. (4) After getting out of range, (5) starts to gossip with its neighbors about content availability and (6) exchanges pieces of the file, thereby getting a larger portion of the file as opposed to waiting for the next gateway to resume the download

1.1 Peer Discovery

There are several components to the operation of the *SPAWN* protocol, but for brevity we just focus on Peer Discovery. We propose a *decentralized* mechanism for peer discovery. We utilize the broadcast medium of the wireless channel to *gossip* information about the content availability at neighbors. In a mobile environment, gossiping provides a way to incorporate location awareness into the peer discovery scheme [3]. Since TCP over multiple-hops suffers quite

TorrentID	ChunkList			Timestamp
n1	n2	n3	n4	n5

Figure 2: Gossip Message Format, here ni denotes the address of the i^{th} node in the path that the gossip message traversed

dramatically in the ad-hoc wireless scenario [4], a node is better off using unicast TCP connections with near-by peers. Gossiping helps here in constructing overlapping meshes of physically close peers for exchanging pieces of the file. Figure 2 shows the structure of a Gossip message in SPAWN.

1.2 Gossiping Schemes

We evaluate various gossiping schemes which we describe in this section.

1.2.1 Probabilistic Spawn

Spawners not interested in the particular file listen to gossip messages of that file and forward them with a low probability. *Interested Spawners* listen to those gossip messages and forward them with a higher probability after stamping the route-list of the packet with their own id. An *Interested spawner* who is currently downloading a file will generate Gossip messages on completion of downloading a new piece.

1.2.2 Rate-Limited Spawn

Each *Spawner* maintains two caches, a Non-Interested cache of gossip messages about files that it is not interested in, and an Interested cache. Periodically, gossip messages are picked up from one of the caches and re-broadcasted (without updating the origination time-stamp). Interested cache messages are selected at a higher frequency. The decision about which message to select from a particular cache can be made in different ways.

- **Rate-Limited-Recent Spawn:** The gossip message with the most recent origination time-stamp is forwarded.
- **Rate-Limited-Random Spawn:** The gossip message is selected at random from the relevant table.

2. PRELIMINARY RESULTS

We implemented the gossip schemes in *Nab* a network simulator written in *Ocaml*. *Nab*[5] is a fast, flexible and scalable simulator for ad-hoc networks. We incorporated our mobility model, and a simple traffic model into the simulator. The mobility model simulates a simple picture of a freeway scenario. The car arrival process at the access point follows a poisson distribution. When a car comes within range of the gateway, it starts downloading random pieces

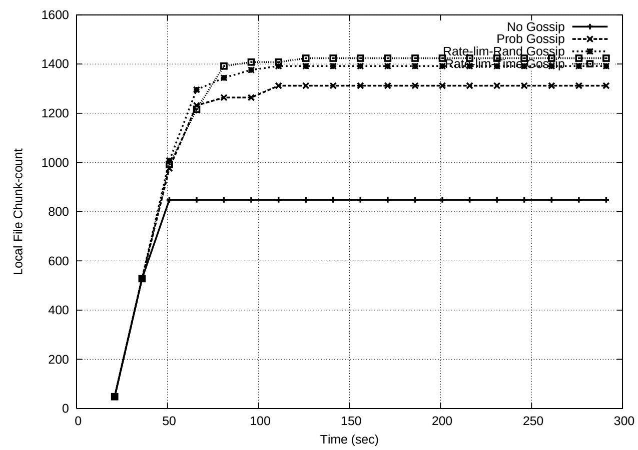

Figure 3: *Local File-Piece Evolution*

of the file. The tracker running on the gateway bootstraps the car with a set of 6 peers who last crossed that gateway and were interested in the same file. Each car possesses an initial speed which is varied at random by a small amount every 5 seconds. Cars maintain the same direction throughout and are not affected by the speeds of cars around them.

3. CONCLUSIONS

We proposed and investigated simple gossiping schemes at the application layer for a cooperative swarming protocol in a vehicular ad-hoc wireless network. We simulated a few gossiping schemes and our proposed strategies for piece selection to show that gossiping helps in embedding location-awareness into the peer selection resulting in better perceived performance.

4. ACKNOWLEDGMENTS

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