

Adapting BitTorrent to Wireless Ad Hoc networks

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Abstract—BitTorrent is one of the Internet’s most efficient content distribution protocols. In wireless ad hoc networks, many constraints appear as the scarcity of resources and their shared nature, which make running BitTorrent with its default configuration not lead to best performances. To these constraints it adds the fact that peers are both routers and end-users and that TCP-performance drops seriously with the number of hops. We show that the neighbor selection mechanism in BitTorrent plays an important role in determining the performance of the protocol when deployed over a wireless ad hoc network. We propose an enhancement to BitTorrent which aims to minimize the time to download the content and at the same time to enforce cooperation among peers. Our solution considers a restricted neighborhood to reduce routing overhead and to improve throughput, while establishing few connections to remote peers to improve diversity of pieces. With the help of extensive NS-2 simulations, we show that these enhancements to BitTorrent significantly improve the file completion time while fully profiting from the incentives implemented in BitTorrent to enforce fair sharing.

I. INTRODUCTION

The P2P paradigm aims to establish large scale distributed services without the need for any infrastructure. Within this paradigm, users have symmetric roles. The global service is ensured thanks to their collaboration. In the case of a wireless ad hoc network, the network is a set of wireless nodes with no central administration or base station. Nodes in such a network operate both as routers and hosts. Multi-hop routing approaches are used to ensure connection between distant nodes. For P2P file sharing applications, peers collaborate in downloading data. Each peer shares some of its upload capacity by serving other peers. The global capacity of the system grows then exponentially with the number of peers.

Both P2P file sharing applications and wireless ad hoc networks are mature fields of research. They have been studied heavily but separately in the literature. Only few works try to study how they perform together (e.g., [2] [3]). These works focus on the content lookup problem in wireless ad hoc networks without studying the efficiency of the content sharing itself. Studying the performance of file sharing applications over wireless ad hoc networks is challenging because of the diverse constraints imposed by the use of wireless channels. Indeed, as nodes are both routers and end-users, the routing overhead must be taken into consideration. Furthermore, the performance of transport protocols such as TCP drops seriously when multi-hop paths

are used. That is why current topology-unaware P2P file sharing applications are not expected to perform well when deployed over wireless ad hoc networks. Designing efficient file sharing solutions for such networks is an important area of research.

In this work, we investigate how well a P2P file sharing solution developed for the wired Internet performs over a wireless ad hoc network. Our aim is to come up with a solution that minimizes the content download time while at the same time improving collaboration by enforcing fair sharing among peers. As efficient and fair content sharing is targeted, we choose to adapt BitTorrent [1] as a file sharing protocol given its large usage and its known close to optimal performances in the wired Internet [4]. In a first effort to understand this problem, we consider the particular case when every ad hoc node is interested in downloading the content. In this case, the underlying topology has a big impact on the performance of BitTorrent. We aim at well understanding this case and proposing an efficient solution for it before moving into less loaded scenarios in future work namely the scenario where only a part of the nodes are peers. The performance evaluation is done through extensive NS-2 simulations using regular modules for the ad hoc routing and wireless medium and our implementation of BitTorrent in NS-2.

The main scenario is described in Section II. Section III studies the impact of the scope of the neighborhood. Section IV presents our enhanced variant of BitTorrent.

II. THE MAIN SCENARIO

We consider a network of 40 nodes distributed in a plane following a grid topology (10 nodes per row). The distance between two physical neighbors is set to 40 m for a range of wireless transmissions equal to 50m. At the beginning of each simulation, node 0 located at the top left is the seed and the other nodes are leechers. The file size is set equal to 10 Mbytes. All peers start downloading the file at the same time $t=1500s$ by first looking for each other then sharing the pieces of the file according to the BitTorrent algorithms. The bitTorrent choking algorithm period is taken in our simulations equal to 40s. A piece is subdivided into blocks of size 1KB. Concerning the underlying layers, the nodes connect to each other using the 802.11 MAC Layer with the RTS/CTS-Data/ACK mechanism enabled. The data rate is set to 1 Mb/s. We use DSDV as a routing protocol.

⁰This work was supported by the Expeshare ITEA project. The stay at INRIA of the third author was supported by the PURPURA COLOR action.

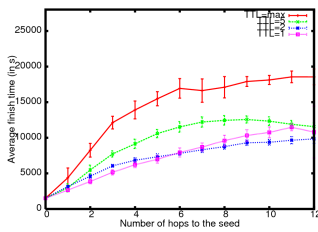


Fig. 1. Average finish time as a function of number of hops to seed for different flooding scope

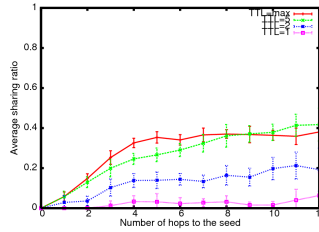


Fig. 2. Average sharing ratio as a function of number of hops to seed for different flooding scope

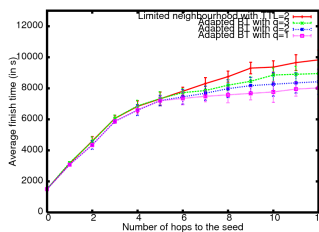


Fig. 3. Average finish time for our enhanced BitTorrent

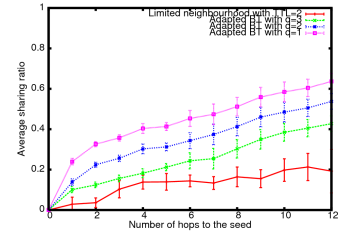


Fig. 4. Average sharing for our enhanced BitTorrent

III. IMPACT OF THE SCOPE OF THE NEIGHBORHOOD

In this section, we study the impact of reducing the scope of the neighborhood on both the finish time and the sharing ratio. We run several simulations on the topology described in II changing each time the flooding scope (TTL) of HELLO messages destined to peer discovery. Figure 1 compares the finish time for TTL=max, 5, 2 and 1. Interestingly, the finish time improves when the neighborhood scope is decreased. This is mainly due to better TCP performance over short paths and to smaller routing overhead. Figure 2 plots the average sharing ratio as a function of the number of hops to the seed for the different values of TTL. Unfortunately, we can see that the improvement in finish time when reducing the neighborhood comes at the expense of a lower sharing ratio. The diversity of pieces in the network decreases and the file propagates more or less as a wave in a unique direction from the seed to the farthest nodes. Hence, distant peers can not participate in the replication of pieces, they only wait for pieces to arrive to their physical neighbors to obtain them. Clearly, this is bad for cooperation among peers. An optimal solution should improve the finish time while preserving large values for the sharing ratio.

IV. ADAPTING BITTORRENT TO WIRELESS AD HOC NETWORKS

Ordinary BitTorrent establishes TCP connections with neighbors independently of their location. This choice of neighbors can lead to slow TCP connections due to long multi-hop paths and routing overhead. Sharing can also be bad when using large pieces since complete pieces cannot be sent too far to be reused later by other peers. To recover from these impairments, we propose an enhanced variant of BitTorrent, tuned to ad hoc networks, which considers a restricted neighborhood to diminish routing overhead and to improve throughput, while establishing few connections to remote peers to improve diversity of pieces. To implement this, we modify the choking algorithm and add a new piece selection strategy. To this end, we tuned BitTorrent to support the distinction between remote and close peers. The new choking algorithm is aware of the location of peers. It distributes optimistic unchokes between close and far peers following a quantum q .

To study the performance of our solution, we run several NS-2 simulations over the previously described topology. We vary the values of the quantum q and observe the behavior of the download finish times of peers and their sharing ratios. Figure

3 compares finish time of ordinary BitTorrent with limited neighborhood (TTL = 2) with our version of BitTorrent using different values of the quantum q ($q=3, 2$ and 1). Each curve presents the average finish time as a function of the number of hops to the seed. The larger the q , the smaller the number of unchokes to remote peers. The finish time for our solution is better and more equally distributed since far nodes can receive pieces from the beginning of the session and can replicate them in their close neighborhoods. Our solution limits the number of pieces sent to far nodes in order to reduce the routing overhead. This creates parallel areas of activity in the network. Far nodes do not need to wait for pieces to arrive to their neighborhoods to download them. Hence, pieces propagate in the network in all directions. This observation is illustrated in Figure 4 which compares sharing ratios of ordinary BitTorrent with limited neighborhood (TTL=2) with our variant of BitTorrent using different values of the quantum. Each curve presents the average sharing ratio as a function of number of hops to the seed. Figure 4 shows that the strategies used in our solution increase considerably the sharing ratios of all peers. So, sharing incentives work well in this context and the distribution is less vulnerable to the selfishness of some nodes.

V. CONCLUSIONS

There is a high potential for P2P file sharing applications but unfortunately, the wireless nature of the network imposes many constraints to be taken into consideration before using regular applications tuned for the wired Internet. Solutions that reduce neighborhood scope allow better finish time than those with random graphs of communications. Nevertheless, limiting the neighborhood is shown, in this paper, to be dangerous in terms of reducing sharing ratios between peers. A final solution must be a trade-off between good finish time and good sharing opportunities. The solution we propose in this paper finds a good management of neighbor and piece selection that reduces finish time and encourages sharing. A peer concentrates on its nearby peers with some connections to far ones. Simulation results show a decrease in service time and a significant improvement in sharing ratios.

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