BatTorrent: A Battery-Aware BitTorrent for Mobile Devices

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Abstract
BitTorrent has been shown to be an effective and energy-efficient means to distribute digital content. Typically, however, BitTorrent swarms are composed of immobile peers (i.e., desktop computers) with no concerns for loss of power. In the mobile realm this concern becomes a reality. Due to the upload-in-order-to-download nature of the tit-for-tat mechanism, mobile devices must consume battery life to remain viable members of the swarm. We propose a novel solution which takes into account the variability of available battery life in a mobile BitTorrent swarm and attempts to minimize the strain on low battery clients while retaining the benefits of "download in parallel" BitTorrent provides.

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Introduction
BitTorrent depends on a tit-for-tat mechanism of resource sharing to ensure fast and dependable content distribution. In short, peers involved in a BitTorrent transfer receive data at a rate proportional to the amount of data uploaded, treating bandwidth as the only shared resource.

While this works well for immobile peers, a mobile peer is also concerned with battery usage. As transmission of data necessarily consumes more energy than reception of data, a mobile BitTorrent peer is faced with a conundrum: maximize upload bandwidth to receive the reciprocal download bandwidth and drain battery or limit the rate of data upload and suffer the consequences of the tit-for-tat enforcement. Further, any action the peer takes, whether it attempts to minimize download time or battery consumption, can have far reaching effects on the swarm as a whole.

BatTorrent

BatTorrent is our proposed system for dealing with BitTorrent swarms composed of battery-constrained peers. Our primary contribution is an adjustment to the exclusively bandwidth-based rate measure used by BitTorrent. The main insight of our solution relies on the observation that mobile clients share two resources: bandwidth and battery. Each bit uploaded consumes not only bandwidth but also battery life. The consumption of battery life is arguably more important than that of bandwidth. Saturating upload capacity certainly prevents many operations from succeeding, but draining battery life can result in a mobile device becoming an expensive, shiny paperweight.

BatTorrent introduces a new message, BATT. The payload of this new message is the remaining battery capacity of the peer sending the message (over the interval (0, 1]). This payload is used by receiving peers during the choking algorithm. BatTorrent peers scale the rate measure of other peers via the function *f*(r, batt) = r * 1/batt, where r is the standard BitTorrent rate measure. The result is that peers with less battery life remaining are able to scale down their upload rate down in proportion to remaining battery life and not suffer choking that would normally occur.

As there is no reliable means to externally determine the remaining battery capacity of a connected peer, BatTorrent relies on a social trust network to determine the veracity of BATT messages. In short, we assume that friends are unlikely to game each other and thus BATT messages received from them are likely to be legitimate. For complex swarms involving more than binary social relationships the function *f* can be scaled further via a trust level. Peers with strong social connections will receive greater benefit than those with weak social connections.

As BatTorrent deliberately reduces the bandwidth contribution of low capacity peers, the question of fairness arises. For the case of battery-constrained devices, we determine that fairness is a function of the bandwidth contribution with respect to the risk of functionality loss of a peer. I.e., a peer with low battery is contributing more to the swarm for every bit it uploads than a corresponding peer with high battery.

Finally, while we expect the ubiquity of mobile, battery-constrained devices to increase dramatically in the future, it is unreasonable to expect non-constrained devices to vacate the scene completely. BatTorrent makes use of non-constrained devices to offload energy consumption where possible. While this is the obvious solution to the trivial case where non-constrained devices are able to fully saturate the download capacity of constrained devices, we have observed Wi-Fi speeds on mobile devices that would indicate a shrinking gap between non-constrained and constrained device speeds thus strengthening the case for BatTorrent.

BatTorrent is implemented on the Android mobile platform and will be demonstrated during the poster presentation. The social trust network that BatTorrent uses (GeoS) has also been submitted as a poster for UbiComp 2009. Our poster will include preliminary results comparing download time and battery consumption of standard BitTorrent vs. BatTorrent showing that BatTorrent enabled swarms allow low battery peers to download in a reasonable time while minimizing impact on battery life.