Sharing In BitTorrent Can Be Rational
[Extended Abstract]⋆

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1 Introduction: BitTorrent is a Goal-oriented Game

Consider a game played by two mountaineers climbing a mountain. Both are only interested in attaining the summit and can only reach it with help from the other. Over an infinite number of discrete periods they play a symmetric simultaneous game where they may either help the other a fixed distance up the mountain at some cost, or do nothing. Can these mountaineers climb their mountain?

BitTorrent, the popular peer to peer file distribution protocol, is strategically similar to this mountain climbing game. Peers' single goal is to acquire the complete file—to reach the summit—and incomplete files have zero value. Also, like mountaineers, peers can only progress with others' help. Of course, a BitTorrent swarm is more complex than the mountaineering game, containing many peers who can only provide certain pieces of the file to a subset of others. Importantly, however, this metaphor captures BitTorrent's *goal-oriented* nature, an often overlooked but salient feature of BitTorrent.

In our paper we explicitly model BitTorrent as a *goal-oriented game* that has a unique one time payoff for acquiring the complete file. We use this model to obtain novel results about the rationality of sharing in BitTorrent, distinct from previous work on peer to peer networks (e.g. [1] and [3]) and repeated matching games [4]. Only by accurately modeling peers' incentives and understanding their rational strategies can we design maximally efficient file distribution protocols.

2 Summary of Results

We define a *BitTorrent game* to study the rationality of strategies (protocols). We use *rational* in the formal game theory sense of the word, a weak constraint informally requiring that peers act to maximize their utility. While people are not always rational, they are likely to choose "rational" software offering shorter download times and consuming less upload bandwidth.

Result 1: *In the basic BitTorrent game, sharing is not rational.*

The intuition for this negative result is that in the basic BitTorrent game, a rational agent will not provide a peer the last piece of the file it needs. This is because peers that obtain all the pieces of a file immediately leave the swarm— they reach the mountain top and are uninterested in helping you up. This "last

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piece problem" causes a breakdown of collaboration throughout the system, even when the pieces held by other peers are unobserved. In real world BitTorrent swarms, however, some peers are altruists who enjoy providing pieces of the file to assist its distribution. When altruists are present, collaboration can be established:

Result 2: *In the BitTorrent game with altruists, sharing can be rational.*

The presence of altruists allows selfish peers to masquerade as altruists, creating *type uncertainty*. If a peer fails to share with an altruist while it is acquiring the file, the altruist will not provide pieces for free later. With selfish and altruistic peers indistinguishable, sharing becomes rational when peers are more afraid of losing these rewards than providing a single piece without compensation. Even without altruists, however, "cheap pseudonyms" can provide the necessary uncertainty to make sharing rational, too.

Result 3: *In the BitTorrent game with cheap pseudonyms, sharing can be rational.*

Here, cheap pseudonyms allow peers to form groups, each acting as a single entity. Composed of multiple peers and renewed over time with new ones, these entities may persist indefinitely, mimicking the play of an infinitely repeated game between groups. This is in surprising contrast to previous work suggesting cheap pseudonyms are a negative, not useful, feature [2].

3 Future work

In future work, we will extend our model to formally consider piece revelation strategies, preferential attachment, sharing neighborhoods and bandwidth limits. However, we do not expect our current results on rationality to be affected by incorporating these elements, as our current model is sufficiently general to simulate many of the effects of these refinements.

References

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