Inducing Cooperation in Peer-to-Peer Television Systems

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Abstract
Peer-to-Peer (P2P) technology is regarded as a good alternative for client-server architectures in the massive distribution of large video files and television streams to a large number of users. But the success of P2P systems depends on the cooperation of users. This paper discusses a PhD project on the inducement of cooperation in P2P-TV systems. It presents relevant mechanisms from state-of-the-art websites and psychological backgrounds. These mechanisms will be applied to the user interface of our P2P-TV system called Tribler and evaluated in a series of remote user experience tests.

Keywords: Peer-to-peer technology, inducing cooperation, user interface design.

1. Introduction

Television and the Internet have shown to be a promising combination for both broadcasters and viewers. Fokker et al. (2007a) explain that users have more dynamic access to an ever increasing amount of content. Moreover, broadcasters and users are no longer limited to fixed broadcast schedules. However, existing client-server architectures face serious bottlenecks when many users try to access the same file or web page simultaneously. A different approach – making use of peer-to-peer technology for the distribution of television content – is introduced for the following reasons:
- Low cost of ownership for content,
- One-click uploading and distribution to a large audience,
- Smart use of existing infrastructure by distributing cost and maintenance over the users, and
- Large video files can be distributed to a larger number of viewers at the same time with increasing efficiency.

Next to advantages, P2P systems face specific challenges as well:
- No central quality control of content and metadata,
- The system can be misused deliberately or unintentionally, but the users remain unseen, and
- Users do no feel responsible to contribute.

However, for any P2P system, success depends on the level of cooperation among users with regards to peer uptime, bandwidth donation, injection, and moderation (Fokker et al., 2007a). Technical enforcement of this cooperation is limited. We present an alternative approach: combining it with the inducement of cooperation. This paper discusses our research based on the question how users can be induced to cooperate massively, positively, and voluntarily in P2P systems. In answering this question, the work presented here is mainly based on the combination of state-of-the-art websites that have succeeded in getting a large number of users to cooperate voluntarily, and 2) relevant theories from (social) psychology that could explain altruistic behavior. The combination of the two inventories leads to a number of possible applications for the user interface of P2P systems.

Section 2 of this paper presents the inventory of state-of-the-art websites. Section 3 discusses the translation of psychological backgrounds about altruistic behavior to user interface design guidelines. Section 4 describes the process of designing and evaluating the evolving user interface of Tribler, our Peer-to-Peer Television (P2P-TV) test case for downloading, video-on-demand and live streaming of television content (Pouwelse et al., 2007).

2. State-of-the-Art Websites

Altruism not only occurs in the real world, but in the virtual one as well. Some websites have proven to be very successful and are contributed to (by usually not more that 10% of the total number of users (Adar & Huberman, 2000; De Valck, 2005;
 Nielsen, 2006) and used by millions. Therefore, it is important to learn how this has been established. 21 State-of-the-art websites, among which YouTube.com, MySpace.com, Amazon.com, Last.fm, and Wikipedia.org were examined for the cooperation inducing mechanisms they apply. This inventory will be updated repeatedly. So far it has been carried out twice: the first in January 2006 and the second in November 2006. It results in the matrix presented in Figure 1 and is meant to clarify the practical context in which each mechanism is applied. Four clusters of cooperation inducing mechanisms that co-occur frequently in the discussed websites could be identified (in Figure 1: read from the right to the left):

1. **User profiling** is a cluster with mechanisms that aim to create trust among users by showing personal information. E.g. registered membership, explicit and implicit profiling, and reputation. All websites use one or more of these mechanisms frequently. Therefore, it is not very discerning. It could be seen as a prerequisite for inducing cooperation among users. This cluster represents mechanisms that induce the most socially passive behavior in the sense that for instance recommendations and reputation are calculated implicitly by the system and do not directly affect other users.

2. **Social visibility** contains mechanisms that show their influence on individual behavior when that behavior is visible to others. E.g. adhering to social norms and obtaining a ranking in a top-n list. Wikipedia and Flickr are two examples of websites that influence individual behavior by making it visible to others.

3. **Social distance** is a cluster with mechanisms based on social networks in which the degrees of separation influence the users’ behavior. E.g. donation, esteem, and social navigation. Especially the social networking websites like Orkut and MySpace are based on these mechanisms. They are the two websites that are represented most frequently in this cluster.

4. **Power of collectivity** contains mechanisms that are based on a network effect; the mass decides what is true or popular and what isn’t. Websites using these mechanisms are mainly the most recent ones based on tagging content: Del.icio.u.s, CiteULike, Technorati, and YouTube. In a previous paper we focussed on applying a tagging mechanism to Wikipedia in the context of video content (Fokker et al., 2006). This cluster involves mechanisms that affect the group the most, even though a user not necessarily recognizes that his actions are beneficial to the group. Tagging for instance, is primarily performed for organizing one’s own content.

3. **Psychological Backgrounds**

In our paper (Fokker et al., 2007a) on psychological backgrounds of altruistic behavior we list 13 relevant theories that can possibly explain altruism and we discuss their usefulness in the context of P2P-TV systems. They are mostly taken from (social) psychology and evolutionary biology. Mapping these theories to possible mechanisms resulted in the clustering as shown in Figure 2. It is meant to translate the theories into new possibilities for cooperation inducing mechanisms. Some observations of this clustering:

- The mechanisms based on the process of exchange (e.g. tit-for-tat fairness and share ratio) are frequently found in the theories of reciprocal altruism, social exchange, and equity.
- Esteem is a mechanism that is important in more than half of the theories and refers to personal appreciation of for instance a peer’s reliability and trustworthiness. It’s not the same as the mechanism ‘reputation’ as shown in Figure 1. In that setting reputation refers to the position and prominence of a person within the group.
- The right half of the mechanisms (‘group size’ and onwards) are hardly found in the listed theories. This can be explained by the fact that most of these mechanisms are more economical and/or individual than social.
- The mechanisms based on different relationship strengths (e.g. cost/benefit ratio, degrees of separation, and donation) are frequently found in the theories of kin selection, group selection, and social balance.

From the combination of theory and practice, we have suggested a number of generic applications to the user interface (Fokker et al., 2007a) based on their applicability to P2P-TV systems:

- Make behavior publicly visible,
- Show contributions in respect to a user’s total resources,
- Make user-to-user moderation possible,
- Use different return-on-investment times for different relationship types,
- Exploit the need to belong as well as to stand out, and
- Make use of the degrees of separation.
Figure 1 Two-way hierarchical clustering of cooperation inducing mechanisms (columns) in 21 state-of-the-art websites (rows).

Figure 2 Two-way hierarchical clustering of 13 theories from (social) psychology (rows) and cooperation inducing mechanisms (columns).
Some mechanisms have already been applied to the user interface design of Tribler, as will be discussed in the next section.

4. Tribler User Interface Design

Knowledge from both inventories presented in section 2 and 3 will be operationalized over the coming releases of Tribler. The visibility of behavior was recognized as a strong motivation from both inventories. Therefore, the mechanisms to be applied first are based on this visibility: reputation, esteem, sharing ratio, friends, and communities. The design of Tribler 4.0 is shown in Figure 3 (Tribler, 2007). The user interface gives access to all discovered content and users in the network, but also provides the means to browse personalized content with the distributed recommendation engine (Wang et al., 2007) and the advanced social network each user creates implicitly and explicitly.

Remote User Experience Tests

Gathering data on the individual use of Tribler is difficult in P2P systems, and is usually limited to general statistics on the ratio of new and active users (Fokker et al., 2007b). Therefore, to test the effectiveness of the mechanisms we will apply to the coming releases of Tribler, a series of remote user experience tests (Vermeeren & Kort, 2006) will be performed in collaboration with the TUMCAT project (2007).

The level of cooperation on six essential usage-related issues will be tested: downloading, seeding, moderation, social reach, injection, and peer uptime (Fokker et al., 2007b). Moreover, we want to learn what the user experience for all issues is. To this end, TUMCAT provides the means to 1) log actions, like starting a download from the recommendations, 2) sense contextual information, like the user’s list of Tribler friends, 3) collect user generated content (e.g. spontaneous feedback to the testing team), and 4) transfer data to a remote server for further data analysis. A pilot study was carried out with Tribler version 3.5.0 from December 6 2006 to January 10 2007 with 28 participants. It was set up to create a benchmark for testing future versions of Tribler and the effectiveness of applied mechanisms.

![Figure 3 User interface of Tribler version 4.0, to be released on May 23rd 2007 containing a) an overview of all discovered users in the network, b) information about a user’s overall sharing ratio, c) information about a user’s reputation, and d) a user’s most often used tags.](image-url)
The pilot study was regarded as useful and fit for its purpose, because it clarified what actions were taken by each individual, their reasons for doing so, as well as how the interaction with Tribler was valued.

5. Conclusions and Future Work

Human cooperation is essential for the success of any P2P-TV system. This paper presented ongoing work on the inducement of massive, positive, and voluntary cooperation in P2P-TV systems. It is the first recipe for addressing this topic with a profound theoretical and practical background.

Knowledge about possibly successful cooperation inducing mechanisms is taken from inventories of 21 state-of-the-art websites and 13 (social) psychological theories that can explain altruistic behavior. The new version of Tribler contains mechanisms that are based on the visibility of behavior: reputation, esteem, sharing ratio, friends, and communities.

The success of applied mechanisms will be tested in a series of remote user-experience tests of future versions of Tribler, the main research vehicle of this PhD project. A pilot study was carried out to set a benchmark for future tests. We will continue to systematically operationalize and evaluate new cooperation inducing mechanisms in P2P-TV systems. By doing so, we will find successful (combinations of) cooperation inducing mechanisms and identify the mechanisms that conflict in a peer-to-peer system.

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