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Token-based Accounting and Distributed Pricing to Introduce Market Mechanisms in a Peer-to-Peer File Sharing Scenario

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Abstract

This paper presents a token-based accounting mechanism that alleviates the free riding problem in P2P networks. The approach is complemented by distributed pricing as a flexible and viable scheme to incite users to share valuable content and to efficiently balance requests among all peers based on economic decisions.

Keywords: Peer-to-Peer, File Sharing, Accounting, Pricing, Charging

1. Introduction

Peer-to-peer systems are based on the assumption that participating peers share their own resources with other peers, while they can benefit from resources that are shared by others. The practical experience has shown that in today's P2P file sharing systems this ideal situation cannot be achieved due to the free-rider problem. Consequently, in the absence of economically efficient mechanisms (which balance the utilization and provisioning of resources) these systems operate at a heavily reduced performance. Moreover, a commercial use of P2P technology is currently not possible, as reliable and efficient accounting mechanisms are missing. In comparison with other solutions a token-based accounting mechanism has a good scalability and offers a high trustworthiness. Complemented by a distributed pricing scheme (which enables flexible price determination and efficient price dissemination) the presented approach supports a complete set of mechanisms being necessary to build a market for the exchange of files in a P2P network.

2. Token-based Accounting

The token-based accounting system assumes that users can clearly be identified through a permanent ID, e.g. through a private/public key pair issued by a certification authority. Each peer holds an account with a specific number of tokens, each token clearly issued to it. A peer spends a token by sending it to its transaction partner in order to receive a service. Accordingly, when a peer provides a service it collects tokens from other peers. Peers cannot spend foreign tokens. Using the *token aggregation process* peers exchange the collected foreign tokens against new ones issued to it. Further, tokens contain a unique identifier and are signed with the peer-to-peer system's private key. The system's private key is shared among selected peers of the system. A quorum of super-peers is able to sign new tokens (partially) with the system's private key using threshold cryptography [1].

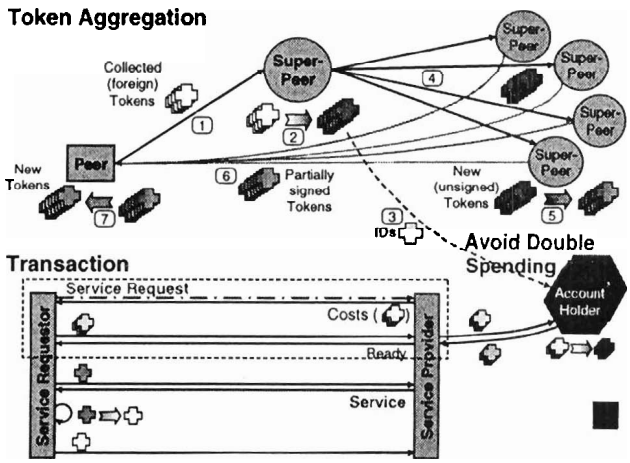

Figure 1: Token-Accounting-System

To avoid *double spending* of tokens, for each peer an additional account exists on a remote peer. This account contains a list of tokens issued to the account owner. The list of token IDs is sent to the account holding peer during Token Aggregation. Prior to each transaction the customer peer informs the providing peer which tokens it intends to spend. The providing peer checks with the account holder

whether these tokens are valid. In the token list valid tokens will now be marked as spent and finally be removed from the list when exchanged in an aggregation process. This way the accounting system supports a trustworthy way for the exchange of content and tokens. Tokens are sent in two parts. Before the service is provided, a token is sent without the owner's signature. When the service worth one token was delivered the signed token is sent. Both peers loose their incentive to cheat.

3. Distributed Pricing

The presented token-based accounting system offers two degrees of freedom: the amount of tokens that need to be spent per file and the rate at which peers can exchange received tokens for new ones. While token exchange rates are not further discussed here, pricing deals with the variable amount of tokens that are charged for a file.

The proposed distributed pricing scheme comprises three main mechanisms, namely *price determination*, *price valuation*, and *price dissemination*, which are detailed below. The presented mechanisms discuss different strategies how peers can calculate the amount of tokens and evaluate an offered price. In addition, it is described how prices can be communicated between the peers.

Price Determination. Peers have the flexibility to adopt their own pricing strategy from a set of built-in price determination mechanisms which are outlined below. The different strategies can be combined and customized based on a peer's current situation.

Demand-based pricing calculates the prices dynamically based on current local demand which can, *e.g.*, be determined by the request rate. Using demand-based pricing peers can increase prices during peak times to avoid congestion. *Market-based pricing* determines the prices based on price quotes from other peers. By offering competitive prices, peers can attract more requests in order to increase their own revenue. *Value-based pricing* takes into account the quality of the content itself. Value-based pricing calculates prices for files based on peer's utility of the content, which can, *e.g.*, be determined using aggregated content ratings. *Cost-based pricing* is probably the fairest approach as prices are calculated based on the costs for creation, provisioning and distribution of the content. However, due to high metering effort, this approach seems technically hardly feasible. *Rule-based pricing* can be used in addition to the above strategies to constrain allowed price ranges in order to increase the social welfare. However, enforcement of such rules is difficult to achieve.

Price Valuation. To evaluate an offered price, peers need to assess the expected utility of a file. Since a peer does usually not know the nature of a file in advance, it has to rely on information provided by other peers. The proposed pricing scheme uses *content ratings* to determine the quality of a file. Peers can rate the content they examined and share their ratings with other peers. Every rating is weighted according to a peer's trustworthiness and its experience in a specific field of interest. Using distributed aggregation, content ratings can be averaged in an efficient and scalable manner [3].

Price Dissemination. In order to guarantee authenticity and integrity of a price offer, peers create price messages that are signed by their private key. The dissemination of such price messages determines a typical search problem for which there are a number of possible solutions. While *flooding* is obviously not a scalable solution, its efficiency can be improved by *caching*. However, caching has the drawback of price validity and selfish behavior of peers. The same holds for *price-based routing* which directs requests towards the best offer. Alternatively, price messages can be stored in a *distributed hash table*. This approach scales well and seems to be trustworthy, since many peers independently provide the same information.

4. Summary and Conclusions

This paper presented the concept of a P2P file sharing scenario, which offers efficient price determination and dissemination capabilities. Basis for the proposed market mechanisms is a token-based accounting system, which determines a trustworthy and scalable approach. The presented accounting system is very flexible and can be adapted to a broad variety of P2P scenarios.

In the next step, the remaining issues will be solved and delivered to prove the concepts.

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