

Economic Model Based on Micro-Payment in P2P Systems

Wang Qingjie, YU Jian, YU Mei*, Zhang Jie, Zhao Zheng

School of Computer Science and Technology

Tianjin University, Tianjin, China

qingjiawang@sina.com,

Corresponding Author *: yumei@tju.edu.cn

Abstract—At present the problem of free-riding is serious in P2P network. Free-riding behaviors not only reduce the network scale but only severely restrict the advantage of P2P system. In this paper, an economic model of currency exchange which based on the micro-payment platform with an incentive mechanism is proposed. In the platform, the resources and the services provided by nodes are priced as virtual currency; the excess cost are stored into the node account and paid services can be achieved. The implement of the model is described. This model can effectively solve the problem of free-riding.

Keywords- Peer to Peer(P2P); Free-riding; Economic Model; Micro-payment Platform

I. INTRODUCTION

P2P systems are paid more and more attention. An important objective of P2P network is that all users in the system can share their resources, but the current network is based on the basic assumption that the node is willing to share the resources. However, the mode which individuals provide resources to the public and node acts are not limited leads to serious free-riding in P2P networks, that is, node only consumes resources provided by other nodes without sharing their own resources. Free-riding behaviors not only seriously constraint the advantages of P2P, but also caused a series of other issues such as the tragedy of public goods, the collusion etc.

Since the free-riding phenomenon in P2P networks are found in [1], some researchers began to come up with the solution to this problem. At present, these solutions can be roughly divided into two categories: trust models based on probability theory and incentive model of game theory-based. In [2] the summary of both technologies is performed and the differences in performance are compared. Most of the trust models is based on probability theory, and introduce the concept of reputation or trust, which the conduct of the node is judged by the reputation value.

In the incentive mechanism model based on game theory, [3] [4] used the game theory for P2P networks the first time, [5] provided incentive compatible mechanism to solve the issue of free-riding, and [6] proposed a pricing mechanism based on the quality of service. The above mechanisms can not be used for many-to-many situation, but one-to-many, that is a service provider to a number of service requester. It does not adapt to the majority of P2P applications.

II. ECONOMIC MODEL BASED ON MICRO-PAYMENT

A P2P system can be regarded as an economic system under the market, and each node is an economic entity which can be a provider or a consumer. Services are provided each other between the nodes, and services may be shared documents, CPU time, storage space, network bandwidth and so on.

P2P system has experienced several different business models in the course of its development. Early P2P systems did not provide an incentive mechanism, which the node provided sharing services in accordance with the principle of voluntary and the services that can be seen as public goods is free of charge. With the same as economic society, this kind of business model is bound to lead to the emergence of the phenomenon of Tragedy of Commons[7], so that on the one hand the network congestion has been caused in nodes which voluntarily provide services, on the other hand no other nodes are willing to share the network load. Therefore, it is necessary to change the public services in system to private services and establish a set of criticism standards with the clear powers and responsibilities and measurement systems.

Most of the current P2P systems are the barter market system, such as BitTorrent, eMule and other file-sharing system. Such applications force nodes provide the file segment upload to the other node when download file. In the download process the rate of sharing of the download node which directly impact on the download speed is calculated according to the upload amount. In some applications, the rate of sharing is not long-term preserved, and it is only in a file download process. It is recalculated when downloading another file next time. In addition, this model seems only to apply to file-sharing and not be implemented in other applications.

In this paper, a currency exchange economic model is presented. when services are provided between nodes, the excess cost will be recorded under the asymmetry of the cost of the services, and is stored into account of this node as a virtual currency so as to the next exchange service. This mode can be used in many application fields including file-sharing, such as collaborative work, distributed computing, distributed e-commerce and so on. The next questions are how to price services and how to store the account information of node in a distributed environment.

In this economic model, the resources of the nodes will eventually be transformed into the form of currency and stored. In this process, there are three steps: packaging, pricing, and clearing, shown in Figure 1. Packaging is a process of program level; the local resources will be packaged into a unified service interface by application. Through an incentive compatible pricing mechanism, the services are transited into the valuable data packet being transmitted. At the same time the update results of account information of all nodes are recorded after clearing by their respective account management system.

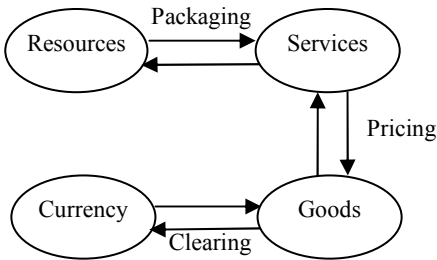


Figure 1. Transformation Steps from resources to currency

In Figure 2 the level of functional components in the services between nodes is described in detail. Logically they can be classified roughly four layers:

- (1)Application layer, in this layer the services directly apperceived by the user is provided, such as instant messaging, collaborative work, data sharing.
- (2)Below the application layer is the middleware level including incentive mechanism, such as the former trust model or the micro-payment platform with packaging, pricing, and clearing mechanisms.
- (3)The next is the P2P overlay network layer, a variety of messages are forwarded and transmitted by the P2P routing protocol.
- (4)The bottom is the Internet by connecting various physical networks, using TCP/IP interconnection protocol.

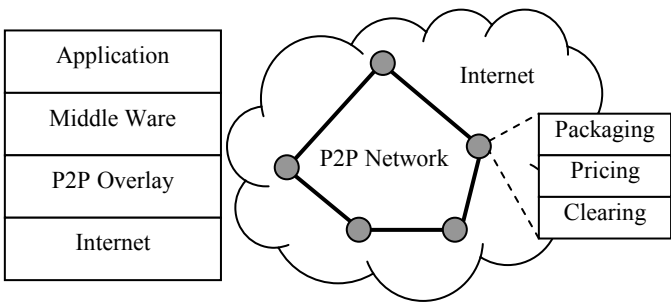


Figure 2. Logical Structure of Economic Model

In this model, applying the mechanism design theory in micro-economics to the P2P network, we design a many-to-many service pricing model, and prove that the model is the incentive compatible and encourage the each node in the P2P

network to report their true valuation of the services. This model can adapt to many-to-many environment in P2P network.

The model based on game theory has been pointed out that the lack of practicality [8] [9], the most important reason for this is that all these models have the assumption of have being a practical micro-payment platform, but the current research in micro-payment platform were very little. The model proposed in this paper realized clearing platform on the basis of the structured P2P routing protocol Pastry, which is fully distributed. The contribution of the node to whole system can be quantified as virtual currency, and then the currency account balances of node are stored and updated in accordance with the remote, distributed, redundant way.

In next section, the implement of the packaging mechanism in micro-payment platform is described in detail.

III. PACKAGING MECHANISM IN P2P MODEL

In P2P system a relationship of servicing and being serviced is provided between nodes, service is the ultimate manifestation of the local computer resources. The form of the local resources is various, including CPU's computing power, storage space on the memory or external memory, network connection or upload and download bandwidth, share files such as music or movies, and remote resources that the node can access to, etc., which is shown in Figure 3.

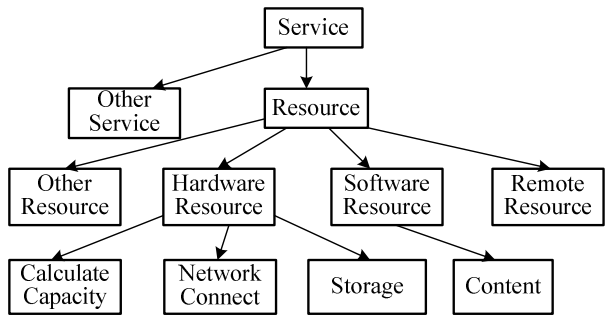


Figure 3. Services and Resources

These services are self-included, namely, they can contain a number of hardware and software resources, and even includes a wide range of services. Abstract class services with well-defined interfaces can provide access to the upper application, so that the transparency of resources to the application can be achieved. Services can be provided directly to other network nodes, but also through the pricing and clearing mechanism can be further provided to the other network nodes in the form of a fee paid. Figure 4 is the deployments diagram of a packaging mechanism of the nodes.

The key of packaging mechanism is the concept of service, which makes a variety of resources to achieve a loose coupling between components. It has brought a lot of technical advantages, such as higher operating consistency, a higher rate of code reuse, dynamic construction of on-demand applications, etc. The key points of the loose coupling between service providers and service consumers is that service interfaces act as a separate entity from services. It is required

that service interfaces with a coarse-grained must be designed in application development. Most methods with loose coupling rely on the messages based on service interfaces. The interface based on messages is compatible with a wide range of transmission such as HTTP, JMS, TCP/IP, MOM etc., which can use synchronous and asynchronous protocols.

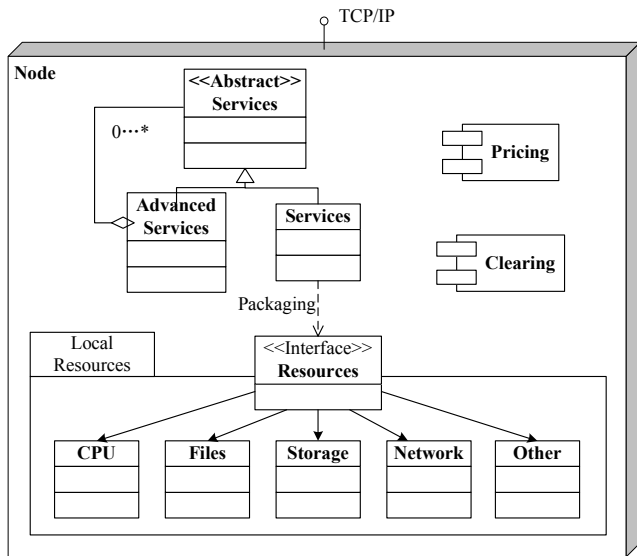


Figure 4. Deployments Diagram of the Node

How to design a coarse-grained service interface with a good scalability and reusability may refer to the current research results on SOA (Service-Oriented Architecture). In recent years, the main research results of interface standardization are XML and Web services technology which add new important functions to a higher level of SOA, and significantly enhanced the value of SOA. In the prototype of micro-payment platform in this paper, a unified service interface has already achieved in the sharing of content and storage space and network bandwidth.

IV. EXPERIMENT ANALYSIS

In this experiment, the total number of nodes is set to 2000, the number of providers is 100, the percentage of the malicious fraud node m is gradually increased from $m = 0\%$ to $m = 90\%$. Malicious nodes always report high price than other ordinary consumer node, and request greater bandwidth than the upload bandwidth of providers. But after receiving a reply from the provider they never really distribute their own download bandwidth to any provider. Other acts of malicious nodes are as ordinary nodes. In the experiment the changing process with time of the total amount of money of providers is recorded.

The experimental results are shown in Figure 5. X-axis is the number of query cycles; y-axis is the total amount of money. $m = 0\%$ is the income of providers under normal circumstances, which increase linearly with time. The existence of malicious nodes increases the difficulties of providers finding the right consumers, which results in a "slow start" and a delay of time. But with the process of time, after providers began to find the right consumers, the revenue curve will become linear. When there are many malicious nodes in

the system, such as $m = 90\%$, the provider spend a long time to look for real consumers at the beginning of time, and real earnings will begin until built a co-operation relationship.

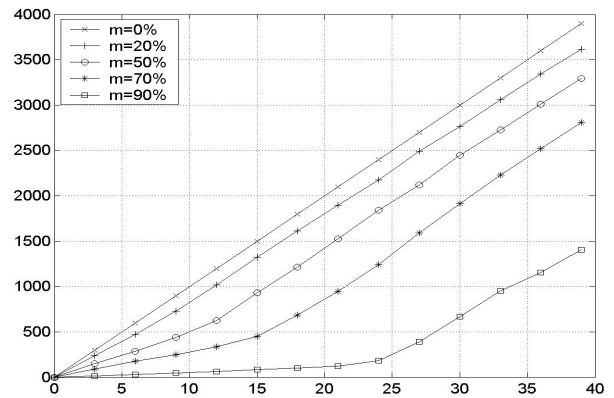


Figure 5. The Impact of Fraud

V. CONCLUSION

In this paper, first of all, the reason of free-riding in the current P2P networks is analyzed from the point of market economics. And then the incentive mechanism based on currency exchange is presented when P2P network as a market economic social system. Node resources are transformed into universal and lastingly-preservative virtual currency through packaging, pricing, clearing. These three segments form the micro-payment platform. Finally, it is explained how to design services interface so as to realize the packing relations from resources to services.

REFERENCES

- [1] E. Adar, B. Huberman, Free riding on Gnutella, Tech. Rep. Xerox PARC, 2000.
- [2] Z. Despotovic, K. Aberer, P2P reputation management : Probabilistic estimation vs Social networks, Elsevier: Computer Networks, 2006, 50(4): 485~500.
- [3] M. Feldman, C. Papadimitriou, J. Chuang etc, Free-riding and whitewashing in peer-to-peer systems, Proceedings of the 3rd Annual Workshop on Economics and Information Security, 2004.
- [4] M. Feldman, K. Lai, I. Stoica etc, Robust incentive techniques for peer-to-peer networks, Proceedings of the 5th ACM conference on Electronic commerce, ACM Press New York, NY, USA, 2004, 102~111.
- [5] S. Sanghavi, B. Hajek, A new mechanism for the free-rider problem, ACM Press New York: Applications, Technologies, Architectures, and Protocols for Computer Communication, NY, USA, August 2005, 122~127.
- [6] R. Jurca, B. Faltings, Reputation-based pricing of P2P services, ACM Press New York: Applications, Technologies, Architectures, and Protocols for Computer Communication, NY, USA, August 2005, 144~149.
- [7] G. Hardin, The Tragedy of the Commons, Science, 1968, 3859 (162): 1243~1248.
- [8] J. Sabater, C. Sierra, Review on Computational Trust and Reputation Models, Artificial Intelligence Review, 2005, 24(1): 33~60.
- [9] J. Feigenbaum, C. Papadimitriou, R. Sami etc, A BGP-based mechanism for lowest-cost routing, Springer: Distributed Computing, 2005, 18(1): 61~72.