Peer-to-Peer Electronic Commerce: A Taxonomy and Cases

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Abstract

Peer-to-peer electronic commerce (P2P EC) is a technical (or architectural) alternative (or complement) to Web-based EC. P2P EC may be defined as a class of electronic commerce that takes advantage of resources available at the edge of the Internet. A taxonomy of P2P EC based on the features of the edge resources is suggested. Among the five categories based on the taxonomy, we introduce the emerging P2P EC cases in physical product marketplace, digital product marketplace, and digital casting marketplace. For each case, we discuss the motivations of the P2P EC, the status of the real world business, technical issues to be solved, business issues, and future prospects.

Keywords

electronic commerce, business models, peer-to-peer

1. Introduction

The emergence of Napster and its impact to Internet users and music industry have attracted much attention to the so called P2P (peer-to-peer) paradigm on e-business. The academic and industrial interests in P2P have been amplified by the recent technological developments of Gnutella [1, 2], Freenet [3, 4], and SETI@Home [5] etc., and the early research projects are becoming rapidly commercialized into SUN's JXTA Project, centrata.com, and Groove Networks etc.

However, we have not seen the commercially viable business models of P2P-based or P2P-embedded Internet businesses. It can be explained by the fact that the P2P business itself is in a very early stage of its evolution. We guess many researchers and practitioners are deliberating on the right business models of P2P businesses and technology integration. The recent establishment of academic conferences and business forums on P2P support this guess.

P2P is one of network computing paradigms. P2P architecture can be contrasted with client-server architecture, especially the popular World Wide Web architecture in Internet computing. P2P applications can be simply defined as a class of applications that takes advantage of resources - storage, cycles, content, human presence - available at the edge of the internet [6].

We contrast the two views on P2P: sharing vs. commerce. The sharing perspective regards the P2P technology as sharing platform that is an alternative to existing client-server architecture [7]. Most of current P2P applications such as Napster, Gnutella, Freenet, and Groove Networks seem to have only the function of the information sharing though they might pursue ultimately the realization of commercial transactions using their applications. On the other hand, the electronic commerce view considers P2P as an electronic commerce platform that can overcome the limitation and the drawback of existing client-server based electronic commerce platform. This paper takes the electronic commerce view on P2P and tries to investigate the technical and business issues towards P2P EC.

2. Peer-to-Peer Architecture for EC

2.1. Taxonomy of P2P Applications

Kant, Iyer & Tewari [8] provides a framework for classifying current and future P2P technologies and discusses the unresolved issues in each case. In approaching the classification, they identify the following dimensions of the problem as follows:

1). Resource (or data) storage: organized or scattered.
2.) Resource control: organized or scattered.
3.) Resource usage: isolated or collaborative.
4.) Consistency constraints: loose or tight.
5). QoS constraints: loose (e.g., non real-time), moderate (e.g., online query/response), or tight (e.g., streaming media).

The main motivation for the taxonomy is to identify basic characteristics of peer to peer applications so that the infrastructure to support peer to peer computing can concentrate on these basic characteristics.

On the other hand, Krauter, Buyya, and Maheswaran [9], develops an abstract model and a comprehensive taxonomy for describing GRID resource management architectures.

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They classify the Grid systems into the three categories: computational Grid, data Grid, and service Grid. The computational Grid is divided into 'high throughput' category and 'distributed supercomputing', and the service Grid is refined into 'on demand', 'collaborative', and 'multimedia' category. Such taxonomy is used to identify approaches followed in the implementation of existing GRID resource management systems for very large-scale network computing systems known as Grids. The taxonomy and the survey results are used to identify architectural approaches and issues.
In this paper, we try to develop a taxonomy for P2P EC, which will be explained in the next section.

2.2. Taxonomy of P2P Electronic Marketplace

The phrase 'peer-to-peer' in P2P EC represents a technological feature in electronic commerce rather than an interaction between participants in electronic commerce. Its level of discussion differs from that of the phrases 'B2C (business-to-consumer)' or 'B2B (business-to-business)', which represent the interaction between electronic commerce participants. Therefore, the expression 'P2P B2B EC' or 'P2P B2C EC' is possible.
Simply put, P2P EC is a technical (or architectural) alternative (or complement) to Web-based EC. For example, Napster users do not have to use Web browser for sharing and downloading music files from the Internet. This shows the feature of P2P as an alternative to Web architecture. However, Napster uses its Web-based homepage for its business. In this aspect, P2P coexists with Web technology. Using the Shirky[6]'s definition of P2P applications, P2P EC may be defined as a class of electronic commerce that takes advantage of resources available at the edge of the Internet. In the definition, the edges can have the commercial resources as physical products and their catalogs, digital products, casting contents, or computing powers. According to the features of the edge resources we classify P2P marketplace into the two types: physical delivery required marketplace and digital delivery possible marketplace. The digital delivery possible marketplace includes digital product marketplace, digital casting marketplace, computing power marketplace [10], and virtual storage marketplace (e.g. www.i-drive.com). The main difference between digital product marketplace and digital casting marketplace is whether the digital delivery cost can be assumed to be zero or not. The delivery cost in digital product marketplace can be assumed to be zero, but the delivery cost in digital casting marketplace cannot be ignored. From the view point of duplicability, physical product marketplace is similar to computing power marketplace and virtual storage marketplace. In the marketplaces, the edge resources such as physical products, computing powers, and virtual storages cannot be duplicated because their values are all based on the physical reality, so the ownership of the resources are explicit. However, in the digital product marketplace and the digital casting marketplace, the edge resources such as digital products and digital contents are duplicable, so the ownership of such resources is not clear without a proper mechanism like digital rights management [11]. From the volatility aspect of edge resources, the physical product marketplace and digital product marketplace are similar because their products are not volatile over time. However, both computing power and virtual storage are time-dependent resources. If they are not used at a time, then the value of the resources disappear for nothing during the time. In the digital casting marketplace, realtime casting contents are volatile and offline casting contents are not volatile. The summary of the above discussions is in Table 1.

Table 1. Classification of P2P EC based on Edge Resource

	Deliverability	Duplicability	Volatility
PPM	Physical delivery required	Non-duplicable	Non-volatile
DPM	Digital delivery cost is zero.	Duplicable	Non-volatile
DCM	Digital delivery cost is not zero.	Duplicable	Volatile or Not
CPM	Digital delivery possible	Non-duplicable	Volatile
VSM	Digital delivery possible	Non-duplicable	Volatile

PPM: Physical Product Marketplace
DPM: Digital Product Marketplace
DCM: Digital Casting Marketplace
CPM: Computing Power Marketplace
VSM: Virtual Storage Marketplace

2.2. Essential Features of P2P EC Applications

Shirky suggested a litmus test for a peer-to-peer application. He claimed that a P2P application should allow for variable connectivity and temporary network addresses, and it should give the nodes at the edge of the network significant autonomy. In this paper, we identify four essential features of P2P EC applications by adapting his suggestion.

1) Peer program with autonomy: Most evident and important feature of P2P applications different form Web-based applications is the existence of the peer program. P2P EC needs a specialized peer program as well as a Web browser. Especially, the peer program has some level of autonomy and plays the following basic functions: (1) providing contents and information without human prevention, (2) automatically processing the requests from servers or other peers, and (3) integrating with internal information system of the peer users.

2) Communication and transaction with unspecified peers: One of important characteristics of P2P applications different from usual distributed computing applications is that the peer programs communicate or transact with other peers without predetermined relationship. The current SETI@Home is not really a P2P computing because its

client programs communicate with only the server computers. On the other hand, P2P applications can exist with or without servers. Though P2P applications neither assume nor exclude the existence of servers, server architecture is main variable that affects the architecture of a P2P electronic commerce. The server architecture is typically classified into the three ones: (1) no-server architecture, (2) one-server architecture, and (3) multi-server architecture. Each architecture has pros and cons in its performance [12]

3) Application-level naming space and ontology: One of revolutionary features of P2P applications different from existing networking applications is that a P2P application has its own naming space independent of the existing IP addresses and therefore can support variable connectivity and temporary network addresses. A P2P application defines an open or proprietary naming space which includes the meta data to represent a edge resource and the edge itself and a peer-to-peer communication ontology [13]. According to [14], understanding and managing namespaces and other forms of metadata becomes central to peer-to-peer applications and is also the key to many peer-to-peer business models.

The above three features are the components of P2P applications as well as P2P EC. The next component is the unique feature of P2P EC.

4) Implementation of a commercial transaction mechanism: P2P EC is different from P2P sharing applications in that it implements a commercial transaction mechanism. Design of revenue stream in P2P EC shapes the architecture of P2P EC. The revenue model is typically classified into the three ones: (1) Solution model (with free service), (2) Service model with P2P network participation fee, and (3) Service model with fee per transaction on P2P network.

3. Motivations of P2P Architecture in EC

P2P EC models are emerging from the demand of current EC businesses and customers ('Demand Pull') as well as the technological breakthrough ('Technology Push'). Especially P2P EC model emerges as both an alternative and a complement to the current Web-based B2B exchange model [15]. The realities of the current early B2B EC are characterized by the shut down of some major B2B exchanges such as Chemdex.com and Promedix.com etc. The possible explanations on the gloomy realities include as follows:

1) Limitation of the current Internet itself as a medium: B2B EC needs much more information than B2C, including implicit knowledge as well as explicit but complex information. The current Internet has still limits in transferring such implicit knowledge [16], so the diffusion of B2B EC has been much slower than many people expected.

2) Lack of trust: The lack of trust on the new commerce platform prevents active processing the B2B EC transactions that are large in volume and size.

3) Lack of incentives to participants (esp. sellers): According to [17], the current B2B exchanges deliver little benefits to sellers. Suppliers have access to more buyers with only a modest increase in marketing cost, but that benefit is overwhelmed by pricing pressures. B2B EC needs to offer strong incentives to both buyers and sellers.

4) Lack of killing business models: Wise & Morrison [17] claimed that the business models of most B2B exchanges are immature. The exchanges have used off-the-shelf software to set up simple auctions, but the software is readily available and relatively cheap, so the barriers to entry are low, and the resulting proliferation of new exchanges is undermining the margins of all players. In addition, the role of B2B exchange and its revenue model have conflicted with each other. Most of revenue model of B2B exchange comes from the intermediation, which matches the buyers and the sellers. To collect a matching fee from the participants, they should hide important information, however it prevents the frequent use of the B2B exchange by the participants. The current B2B exchanges need to change their revenue model from the intermediation to the meta-mediation [18], which is a process that goes beyond aggregating vendors and products and includes services required for facilitating transactions.

5) Lack of seamless integration of facilitating services: Though the role of meta-mediation of B2B exchanges is important, the facilitating services such as transaction support, negotiation support, and payment etc. have not been seamlessly integrated yet.

Though the above explanations do not doubt the appropriateness of the client-server or Web architecture as the major technical platform of EC, in this paper, we pay attention to the inherent limitation of the Web-based architecture in some types of B2B EC.

We claim that World Wide Web, the client-server architecture in Internet computing, is suitable to the so called 'asymmetric' electronic commerce. In B2C EC, the businesses are mainly the producers of information and the consumers are just consumers of information. Technically speaking, Web server side is good for provider of information and Web client side, i.e. Web browser, is good for consumer of information. Web browser is not good for heavy and frequent provider of information because it is not easy for a Web browser to cooperate with the internal information system of the browser's user.

In B2C EC, business sides use (i.e. operate) Web server and consumer sides use Web browser. Therefore, B2C EC fits well with the Web architecture, which has inherently the client-server architecture. The good fit applies to some asymmetric B2B EC where the larger businesses operate Web server and the smaller businesses use Web browser.

For example, an e-procurement Web site is the typical example where a large buyer operates Web server and small

sellers participate in the site using Web browser. In such an e-procurement situation, which is a typical asymmetric B2B EC architecture, the support of long-term relationship by information sharing such as VMI (Vendor Managed Inventory), IOIS (Interorganizational Information System), negotiation support functionality, seller selection support functionality etc. are important issues to be solved. An e-seller site operated by a large seller such as Cisco is another example of asymmetric B2B EC, which fits well with the Web architecture. In this context, strong seller operates its Web server and the small buyers participate in the Web site using their Web client programs, i.e. Web browsers. This situation is very much similar to B2C e-commerce. The important issues of this type of e-commerce include buyer support functionality such as automatic configuration, recommendation services, trouble shooting, and flexible transaction mechanisms etc.

However, when the participating businesses are not just consumers of information but also producers of information, we need a technology for the prosumers. We expect peer-to-peer networking to fit well the prosumer-to-prosumer EC situation. For example, Napster is a typical prosumer-to-prosumer application. In B2B context, most of B2B exchanges have targeted symmetric EC situation where there are not dominant market players in the market. In this aspect, B2B exchanges should consider P2P architecture as its new EC platform. McAfee claimed in his article 'Napsterization of B2B' that the need for centralized exchanges decreases dramatically through peer-to-peer networks [15]. According to him, the advantages of P2P over exchange-based model include 1) avoidance of the fees charged by exchanges, 2) reduction of complexity and expense of networking, 3) easiness to integrate its internal information systems with a single P2P program, and 4) boundless scalability of P2P networks. He expected all the technical requirements to shift B2B onto peer-to-peer networks would be in place shortly.

From the IOIS (Inter-Organizational Information System) perspective, P2P EC can be called as 'Dynamic Electronic Dyad". Choudhury [19] proposes a typology of three different types of IOISs: electronic monopolies, electronic dyads, and multilateral IOISs. An electronic monopoly is an IOIS that supports a sole source relationship for a product. The asymmetric B2B EC sites such as e-procurement and e-seller belong to the electronic monopoly category. A multilateral IOIS allows a firm to communicate with a large, potentially unlimited, number of trading partners over a single logical inter-organizational link. Thus a multilateral IOIS effectively serves as an intermediary between a firm and its trading partners. Most of e-malls and e-auction sites belong to multilateral IOISs. On the other hand, electronic dyads are bilateral IOISs, where a buyer/seller establishes individual logical links with each of a selected number of sellers/buyers for a product. EDI links are common examples.

The reason why we call P2P EC as 'Dynamic Electronic Dyad' is that in P2P EC a buyer/seller 'dynamically' establishes individual logical links with each of a 'dynamically' selected number of sellers/buyers for a product. In this respect, P2P EC calls for a research on the new type of IOIS. The unique feature of P2P EC as a 'Dynamic Electronic Dyad' is that both the depth and the breadth of IOIS are high [20]. Generally speaking, electronic monopoly has a deep depth of IOIS relationship and narrow breadth of IOIS relationship while multilateral IOIS has shallow depth of IOIS relationship and wide breadth of IOIS relationship. Electronic dyad is considered as having middle depth and breadth of IOIS relationship. From the emergence and the advancement of the open, global, and low-cost digital network Internet, we now can have a new form of IOIS 'Dynamic Electronic Dyad' that has both deep depth and wide breadth of IOIS relationship. Adapting the figure in [19], we may position the 'Dynamic Electronic Dyad' as in Figure 1.

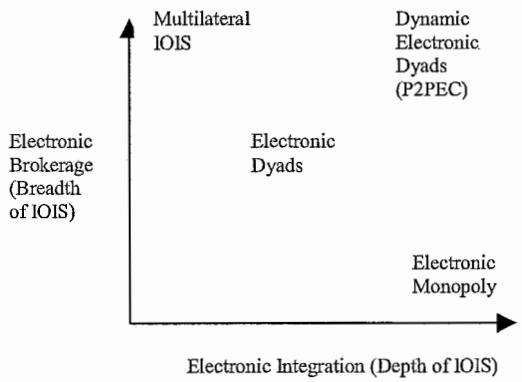

Figure 1. P2P EC from IOIS perspective

For the small and medium companies, we will need a 'Dynamic Electronic Dyad' with peer-to-peer style connection and messenger-style application. The main issues in this architecture will be the update, maintenance and search mechanism of the company database. Metadata like UDDI (www.uddi.org) and search scheme like Gnutella-like search (e.g. SUN's JXTA search, www.jxta.org) should be developed. The e-marketplace operator should play a role of meta-mediation [18] such as escrow, banking, logistics, and inspection as well as the usual intermediary function such as matching between buyers and sellers. In the next section, we give a case study of its realization in Korea.

4. A B2B2C EC: OPEN4U Case

OPEN4U is the Korea-based start-up company running a P2P e-commerce network for consumers and small and medium companies. This Korea-originated company is thought to be the world-first company in P2P E-commerce.[1]

[1] Why is the world-first P2P ecommerce model emerging in Korea?. The rapid diffusion of high-speed Internet such as ADSL is one of the answers. The high-speed Internet environment of Korea plays a role of fertilizing newly

Buyers and sellers in OPEN4U (the acronym of Open P2P E-commerce Network for you) download a peer program (not a 'client program') named as 'OPENER' and install it into their PCs. When buyers specify their wanted products on the 'OPENER' and push the 'SEND' button, then the information goes to its server. Then the OPEN4U server returns the IP addresses of prospective sellers of the wanted products. Using the IP addresses, buyer's OPENER sends the RFP (request for proposal) to the OPENERs that the sellers have, the sellers' OPENERs alarm and the sellers send a bid to buyers' OPENER. The reason why it can be called 'peer-to-peer' is that the bid is directly sent to buyer's OPENER without intervention of OPEN4U server. Among the bids from sellers, buyer selects the best considering seller's location, delivery terms, and price etc. Buyers are also be able to refer to the detail description of products by clicking the URLs included in the bid sellers send. In addition, OPEN4U helps buyers and sellers negotiate with each other through video-chatting interface of OPENER. After selecting a seller and pushing the 'ORDER' button on the OPENER, then the transaction is settled. Through the whole process, OPEN4U does not intervene the transaction but only collects the information on the final terms of transaction. Figure 2 shows an example screen of the OPENER.

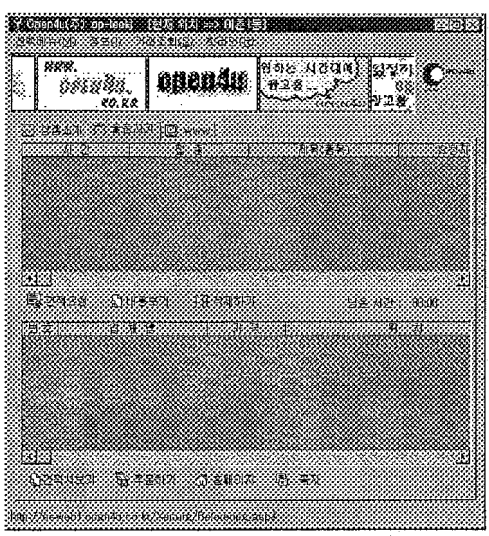

Figure 2. OPENER: The peer program of OPEN4U

While OPEN4U does not play a role as an intermediary, but it works as a peer-to-peer networking company. It neither intervenes between buyers & retailers, nor between retailers and wholesalers. Instead, it just forms peer-to-peer supply chains among the ecommerce participants. OPEN4U shows an integration of B2C and B2B e-commerce because sellers can also buy items using their OPENER since sellers are usually also both the buyers of products other than their business items and the buyers who buy products from their upper-level suppliers. This is the hidden point of OPEN4U's business model and revenue model, which composes a B2C and B2B network among buyers, retailers, and suppliers through P2P technology.

OPEN4U is a buyer-driven commerce similar to reverse auction. It is also a negotiation-supported electronic commerce. It not only includes the typical features of electronic commerce such as disintermediation and buyer-driven commerce, but also solves many real world hassles of ecommerce such as burden of commission fee, entry cost to EC, price dilemma and channel conflict etc. The remaining challenges to this new emerging company are: how to diffuse this new business model to current industry, how to attract the participants into its network, how to make profit from the role of networking, and how to cope with the competitors which will mimic its business model.

OPEN4U has not succeeded yet as a profitable business since established one year ago. In the case of Napster, its impact lies in its rapid growth in the number of subscribers. The subscribers had the benefit of downloading freely quality music files from Napster network. The growth of the number of subscribers raised both the quantity and the quality of the music file services. Therefore, the size of the network and the attractiveness of the network formed a virtuous cycle of growth. On the other hand, the OPEN4U network is still in infant stage. How to reach the critical mass, how to exploit the network effect, whether to attract customers or suppliers are the important decision problems of OPEN4U management. Standard formation strategy is also important. The management should decide 'open' or 'proprietary' strategy on the forming the standard of the metadata ontology, communication ontology, and message format.

The current technical challenges of OPEN4U represent the general technical issues of P2P EC. They include the optimal performance architecture of peer-to-peer networking architecture [21, 22], data security and system security [23, 24], reputation building mechanism [25], catalog representation, distribution/payment/logistics integration, customer information sharing, mobile service integration, and user friendly interface etc.

From the supply chain management perspective, OPEN4U is an example of P2P-based supply and demand chain network. The problems of Web-based SCM can be summarized as follows. Web-based system has inherent limitation in effective sharing of large amount of information among businesses. Web-based system is good for asymmetric information sharing architecture where one party is mainly the producer of information and other are mostly the consumers of information. However, Web is not good for sharing information among similar-size businesses and we do not have a standardized Web architecture for the information sharing. In addition, the stateless HTTP protocol does not well support the seamless interaction of the supply chain partners. For example, to support the automated interaction of the web-based supply chain using tools such as software agents, we need another layer of

growing P2P businesses in this country.

Web-Agent interaction. However, the Web is designed for appealing human's eyeball, but not good for machine understanding. Therefore, the Web-based SCM cannot be easily automated or integrated with internal information systems of each participant.

The required functionality of P2P SCM includes 1) well-scoped ontology for a specific supply chain, 2) well-designed communication and interaction protocol, 3) intelligent information filtering capability for filtering out irrelevant partners and products, 4) preferably standardized negotiation message, 5) automated bidding capability , 6) time-bounded negotiation functionality [26], 7) anytime scheduling and decision making capability for autonomous response [27], 8) matrix auction problem solving for deciding optimal task set, 9) MCDM (Multi-Criteria Decision Making) capability, and 10) negotiation support functionality etc.

5. P2P EC for Digital Product Marketplace

Digital product marketplace is a place where electronic transaction of digital products (e.g. software, e-book, and digital contents etc.) occurs. In a web-based digital product marketplace, creators of a digital product upload their products on the Web, then the prospective buyers visit the Web site and download some digital products by paying the prices. The current Web-based digital product marketplace has some problems as follows:
1) Upload hassles: In a web-based marketplace, the digital product providers should upload their product on the Web. If the number of products is large and the uploading occurs frequently, then the uploading process can be a hassle to the providers.
2) Consistency maintenance: Whenever the contents of the uploaded products need to be changed, the providers should upload the new products on the web.
3) Vendor trust: The major difference of digital products from physical products is that they can be duplicated easily without much cost. Therefore, the digital goods are called 'nonrival' goods [28]. If the nonrival goods are stored in a third-party marketplace, then it cannot be assured that a digital product is not duplicated or used for other purpose. The providers of the digital products should trust vendors, i.e. the marketplace operators., without proper method.

One of companies to overcome the above problems of the Web-based digital product marketplace is Lightshare.com. Through Lightshare, individual consumer or business can sell products and information directly from their local computer, without the presence of a website or server. The Lightshare claims to offer an inherent advantage over traditional, Web-based commerce. If a person buys an MP3 from a vendor on Lighshare's network, that person can then resell the track to another one over the p-to-p network. Each time the track is resold, the original vendor collects a royalty payment [29]. The CEO of Lightshare says:

We've developed a copyright filter technology so that any material that's potentially copyrighted cannot circulate on our network. Another thing we do has to do more with tracking. Let's say you've created a document and I purchase it from you. We're able to track the flow of that document within the network. Let's say I try to resell it to four other people. You'll know exactly whom I sell it to . . . and you're able to receive revenues from that [30].

As we see in the above, Peer-to-peer digital product marketplace has advantages over the existing Web-based marketplace. However, its realization needs a technology for both compensating the digital products creators and supporting seamless commercial transaction between buyers and suppliers. The right development of the digital rights management technology and the business model based on the technology will be the critical success factors of the P2P digital product marketplace.

6. P2P EC for Digital Casting Marketplace

Digital casting is one of promising areas for applying peer-to-peer technologies because both businesses and users feel some problems on the current Web casting architecture. Web casting business inherently suffers from one of the most well-known axioms of streaming: The more popular your content; the more it will cost you. The costs of streaming are such that every new viewer and every new listener adds to the overall costs [31]. The significance of the streaming cost makes the digital casting marketplace different from the digital product marketplace explained in the previous section. In short, the contents delivery cost in digital contents marketplace is not zero while the cost in digital product marketplace can be assumed to be zero. The fact enables the various business models in digital casting marketplace.

From the user side, we could find more problems in Web-based casting. To find some digital contents that a user likes, the user should search many Web casting sites. Such situation is inconvenient for a passive user who wants to just sit down doing nothing in front of PC or digital TV. Even an active user who searches many Web casting sites and gets the contents from multiple sites have experienced hassles of paying the fees in different ways to different companies at different times. As such, both businesses and users are demanding a new solution to solve these problems and the peer-to-peer technology is one of the candidates.

In this paper, we propose an agent-based architecture of P2P-based digital casting marketplace. In this architecture, users have an agent-based peer program that can both communicate with human users and intelligently communicate with other peer programs and contents provider. The peer programs are actually an interface agent that learns the preference of human principals and gets the orders from the human users. In addition, the peer programs

should have multiagent communication functionality to cooperate and negotiate with other peer programs and contents providers.
In the digital casting marketplace, the marketplace operator does not provide digital contents, but distribute peer programs and may optimize the overall performance and QoS of the casting marketplace. Companies such as vTrails.com have the P2P-based casting technology, which can be used for the marketplace operator. Vtrails.com uses the client programs of user side as casting servers. In multicast literature, there have been researches on application-level multicasting [32].

According to vTrails.com, End-users download the vTPass (Peer Program) in order to join the peer-to-peer network. VTCaster (Casting Network Operator) automatically creates a tree structure based on end-user network location and connection type as in Figure 3 (A similar technique is introduced in [33]). The tree is dynamically optimized in order to serve those with high-speed connections first and connect end-users who are close, network-wise (within the same ISP network, same company, etc.). The first tier of end-users receives content via a downstream connection while broadcasting to additional end-users via an upstream connection. This second tier then serves the next in turn. vTCaster collects packet-level information from each end-user, automatically adjusting the tree structure in real-time to reflect better connections and disconnected machines. All transactions are monitored to maintain a high level of quality of service. By serving only a fraction of the end-users directly and turning them into edge stations, a tremendous quantity of bandwidth is saved and network bottlenecks are eliminated.

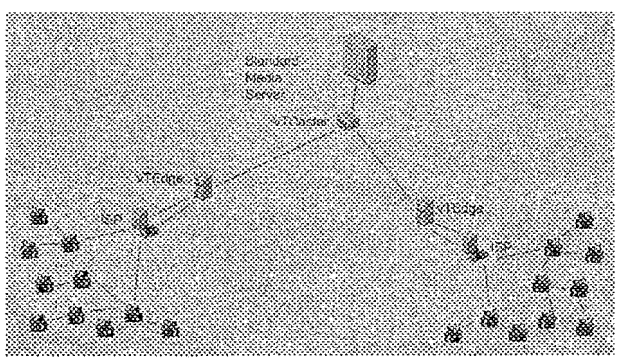

Figure 3. Casting tree generation in vTrails.com

AllCast.com also provides a similar solution that uses streaming media listeners/viewers themselves to intelligently determine the best network strategy. The applications retransmit data packets to the nearest neighbors. AllCast provides passive conduit functions necessary to ensure content delivery in a quality fashion to the user. The AllCast software-based platform ensures peer-to-multipeer content distribution for the content webcaster and allows the content owner to maintain a cascading environment as in Figure 4.

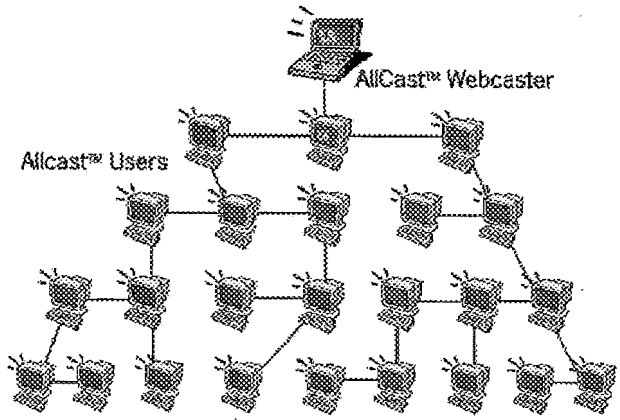

Figure 4. Cascading structure in Allcast.com

VTrails.com and allcast.com both emphasize the new way of digital casting from provider's perspective. However, we need to note that P2P-based digital casting means the radical change of user environment as well as the change in the way of contents providing. User's peer program will be used for the user-oriented virtual integration platform of digital casting contents as well as only for casting contents. Using the peer program, users do not have to visit various Web casting sites. Kontiki.com is planning to provide such a personal delivery service for video, software, audio and other digital media. It claims the following benefits:
1) Convenience: Kontiki automatically manages delivery of digital media in three ways: streaming, in the background or overnight. Kontiki then provides anytime access to digital media from PC whether or not users are connected to the Internet.
2) Simplicity: Kontiki has a clean, easy-to-use interface for finding, delivering and managing users' digital media.
3) Quality: Kontiki enables a high-quality viewing experience with TV or DVD resolution video on PC.
4) Speed & Reliability: Kontiki gets digital media several times faster than streaming, a typical web download or a file sharing transfer. Interrupted or paused deliveries are automatically resumed.
5) Personalized Experience: Kontiki delivers only the digital media users request, allows users to organize their favorite places to find content and gives users complete control over their participation in the network.

Kontiki aggregates underutilized Internet capacity through Time Shifting (which smoothes historically spiky bandwidth consumption patterns), through efficient distribution of content by means of high-performance Adaptive Rate Multiserving (ARM) and by caching content at the outer edge of the network. It contains built-in self-healing capabilities as well as an automatic switch-over to fault-tolerant origin servers to guarantee reliable delivery of digital media. It maintains the integrity of all network communications and deliveries through a Secure Distributed Network Management Protocol as well as through integrated Digital Rights Management. Kontiki's

Large Scale Network Simulator is constantly deployed, optimizing the network and anticipating needs. The Kontiki Delivery Network uses current standards and is compatible with existing assets, formats and players to ensure low-cost delivery and simple deployment. It works with a content provider's existing web site, content management system and network. Moreover, Kontiki has been developed with a lightweight modular architecture that enables the system to be rapidly developed and enhanced [34].

vTrails.com and Kontiki.com show the future of digital casting. However, they do not contain the intelligent agent features in the digital casting applications. For the P2P-based digital casting to be a killer application, we believe that the peer program must have an intelligent agent capability that can learn user preferences such as in [35, 36, 37] and communicate and negotiate with other peer programs (i.e. intelligent agents). In addition, there should be a business model for digital casting marketplace.

To implement such a marketplace, we have been developing a business model for the marketplace and multiagent communication ontology by extending KQML [38] to P2P digital casting environment [39]. The core of the business model of P2P-based digital casting marketplace lies in the separation between contents price and contents delivery price. We expect that many economic entities in digital casting marketplace will negotiate with each other on the contents price and contents delivery price. In such environment, the peer programs of each entity should play a role of automated agents negotiating with other agents on behalf of their principal users. To do a good job, the agents should also have a user-learning capability. This application area is expected to be a good test bed for the applying the literatures on the multiagent automated negotiation and intelligent agents.

7. Conclusions

Peer-to-peer electronic commerce (P2P EC) is a technical (or architectural) alternative (or complement) to Web-based EC. We defined P2P EC as a class of electronic commerce that takes advantage of resources available at the edge of the Internet. We gave a taxonomy of P2P EC based on the features of the edge resources, including the categories such as physical product marketplace, digital product marketplace, digital casting marketplace, computing power marketplace, and virtual storage marketplace. We introduced OPEN4U as the case of P2P EC in physical product marketplace, Lightshare as the case in digital product marketplace, and vTrails, Allcast, and Kontiki as the cases in digital casting marketplace. For each case, we discussed the motivations of the P2P EC, the status of the real world businesses, technical issues to be solved, business issues, and future prospects. Summing up the cases, we may conclude that there are many things to be done to realize P2P EC in each area. Especially, we would like to emphasize that P2P EC needs to integrate intelligent agent technologies in its all areas to support the autonomous service provision, automated and efficient peer-to-peer communication, and learning of user preferences and behaviors.

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