

Knowledge Sharing, Quality, and Intermediation

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1 Abstract

Informal publishing flourished in the World Wide Web environment, where every user with a sufficient level of access can become a publisher. Although it appears that in such an environment intermediation in the distribution and sharing of information becomes unnecessary, the uneven quality of information and resulting quality uncertainty of information users, together with the increased search efforts, represent a sufficient reason for information and knowledge intermediaries to preserve and even reinforce their roles. Large-scale efforts in knowledge management pursued by industry leaders highlight the need for "new" intermediation.

The paper focuses on economic and business issues in the distribution and sharing of Internet based information and digital products. We address the inefficiency of the pure exchange model in "information markets" that is analyzed based on double coincidence of wants and the lack of discernment on the part of users (many of them occasional users) about the market and intrinsic value of informational and digital products. These inefficiencies can be remedied with the introduction of recognizable currencies, which do not have to be of monetary nature, and the situation can be further improved with intermediation. We conclude that "virtual communities" and intermediation are important in ameliorating the efficiency of the distribution of the electronic information and quality of informational goods. This point of view is supported by the success of the new Internet-based intermediaries, such as Yahoo.

1.1.1 Key Words

Intermediation, Internet, World Wide Web, information exchange, economics of information, knowledge management

2 Introduction

Direct access to information and expertise changed the character of the information seeking. Large masses of

information users became involved in non-mediated access to information resources and digital products. "Digital age" eliminates geographical limitations of the traditional commerce and information distribution as well as software/hardware limitations of the pre-World Wide Web applications. The users of the Internet can locate products, marketing and technical information, technical support, and content without the help of intermediaries. Not surprisingly, "disintermediation" began to be considered as an essential part of the new network based knowledge distribution and sharing paradigm, affecting hardware and software design and market forecasts. Disintermediation, indeed, changed the world of knowledge sharing. Even the supporters of intermediation in information markets recognize that direct access to resources, mediated only by technology, is beneficial:

While it is possible to argue that giving software agents to ordinary end users is a recipe for chaos, resulting in the deskilling of experts, poor outcomes, and loss of efficiency (as end users clumsily attempt to be their own experts), we do not think that human gatekeepers who control access to technology on behalf of end users are desirable or practical [12, p.60]

In the Internet environment, the users carry out independently their information seeking activities, but they have to assume considerable risks for the effects of low quality information. Their concerns about the quality of information and their perceptions of quality of digital products continue to offer strong incentives for the emergence and success of information intermediaries. Intermediaries remain necessary to build and support trusted relationships with information users, carry out quality and price control, and work on increasing the efficiency of the customers' information related activities. The value of intermediation does not need to be at variance with the open information space, non-mediated information seeking, and direct access to resources. Intermediation cannot be fully supplanted by technologies, such as intelligent agents, new market design or a more organized and integrated information space.

The purpose of this paper is to touch upon some intellectual components of knowledge intermediation that appear to become increasingly valuable as electronic repositories and markets grow. Without discounting the evident importance

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of new technologies enabling millions of users to increase the efficiency of their professional and consumer activities, we shall attempt to define two crucial aspects of the role of intermediaries in knowledge distribution and sharing in the Internet environment: support for quality and reduction of search efforts. The reasoning in the paper explains why the value of intermediation will be preserved even as agent and filtering software becomes more pervasive and powerful, and the user audiences with direct access to tools and resources grow.

3 Information Exchange

The Internet first emerged as a community of professional users with similar interests and credentials. This part of the Internet still exists and flourishes, but it is largely relegated to internal networks of companies and organizations. Information and knowledge sharing in a relatively homogeneous environment is often successful, although the drawbacks of such an arrangement have been captured and described in research and empirical literature.

The development and growth of the consumer Internet made information sharing a less predictable and less efficient enterprise. The sheer size of the Internet and, more recently, even the size of the "knowledge warehouses" on Intranets make it impossible to preserve the immediacy and informal character of the early Internet, as well as the trust the first Internet users had in the quality of the Internet-based knowledge bases. Although the level of awareness of an average information user and knowledge worker has grown significantly with the deployment of the Internet and Intranets, the dangers of the uncontrolled information flow and its possibly adverse influences on the decision making become increasingly visible.

3.1 Exchange Economies

The lack of efficiency in knowledge sharing without incentives can be explored from the economic point of view. Although the value of information is difficult and frequently impossible to measure, some general features of goods markets can be extended into the electronic knowledge sharing environment.

Differences between monetary and exchange economies have been a subject of study since last century. Among the factors affecting direct exchange of goods, **double coincidence of wants** can be seen as the core source of inefficiency in direct exchanges. First described by Jevons in 1875 [11], double coincidence of wants relates to the fact that both traders involved in an exchange transaction without a recognizable currency should find the other agent's offering useful and desirable. Instead of simply acquiring what is needed, an agent has to locate another agent that not only has the desirable commodity, but also wants to exchange it for the commodity that the first agent offers. Such situations increase the waiting periods before transactions can occur for all traders, according to Jevons, and therefore make commerce less efficient.

Information, especially electronic information, is reusable, easy to reproduce, and not meant directly for consumption.

The frequency of direct exchanges in this market can be impacted in a greater measure than in non-informational trades, by such factors as the number of "copies" of digital products in circulation. Many informational products, in addition, are time sensitive, and increased waiting periods before the trades can occur are detrimental to their market value.

The activities of the users of digital products on the Internet at any given point may not constitute an exchange transaction. However, the impulse of informal publishers in making their information available on a public network is often connected with their expectation to receive something in return: self-advertising of an individual or increased visibility for a company or its products may be the most important motives behind Internet publishing activities.

However, it is not double coincidence of wants alone that leads to decreased efficiency of exchange markets. In order to correct, to some extent at least, the double coincidence of wants in exchanges, the market can create special places where pairs of products can be exchanged [3]. This method will increase the number of markets and is costly, but it provides an argument in defense of barter and an explanation why, even in monetary economies, pockets of exchange markets continue to exist.

Another argument in support of barter is that even if the agents do not find each other's products mutually acceptable, they may accept them as a medium of exchange, thus increasing the frequency of trades and the efficiency of markets. The attribution of exchange value to a product, however, is an instance of introducing a generic currency, and therefore, the economy ceases to be a true barter economy. In a limited way, inter-business information sharing, typical in today's electronic commerce, is an instance of the introduction of such situational currencies. Indeed, in inter-business communications, when clients or partners participate in information exchange, opening limited mutual access to internal information, the assumption is made that the information mutually acquired by the participants will be equal in value for all the parties involved.

If double coincidence of wants can be remedied, although expensively, there are other reasons why direct exchange of goods and information is inefficient. According to Banerjee and Maskin [3], the main problem of barter resides in asymmetric information, unequal knowledge of buyers and sellers about the value of products. Because of the lack of expertise and ability to recognize intrinsic and market value of products, potential customers assume that they are running a high risk of making a mistake [1]. The results of the research of influences of asymmetric information on markets are fully applicable to the study of informational products. Indeed, asymmetric information is inevitably present in markets for informational products, and their full value can be appreciated only when the product has been acquired and its value transferred to the other party [2]. The impossibility to fully assess the value of an informational product stems from the insufficiency of

their representations available to prospective buyers or exchange partners. Intermediaries therefore perform a valuable social function by ensuring the validity of informational and digital products, protecting the rights of the authors and consumers, and reducing consumer search efforts and costs involved in selling, acquiring, and exchanging information.

3.1.1 *Quality and Validity in Digital Products*

With the millions of electronic documents in many collections, formal and informal, it is impossible for an information user, for whom information related activities often occupy a fraction of his/her time, to form an opinion about the quality and validity of online resources. The growth of occasional audiences of Internet/Intranet users is the most important factor, making the issue of quality of digital products more prominent. In the past, special access privileges and complexity of software precluded most users from familiarizing themselves with multiple heterogeneous applications, but current users tend to access a variety of electronic information systems. This wider exposure to digital resources can increase the efficiency of the users' information seeking, because immediate answers to simple factual questions can be obtained in real time, software tools and other digital products can be downloaded directly, and communities of experts can be queried almost in real time. On the other hand, the multiplicity of systems, even in a more user-friendly environment, means that a large body of users cannot learn any system in-depth for lack of time and specialized experience.

Everybody who watched access levels and usage patterns in organizational settings, [18], realizes how casual the choice of tools, resources, and research methods is in an average case. Although the format and content of queries are very simple, inadequate understanding of Internet/Intranet databases and tools significantly affect the efficiency of knowledge retrieval and quality of answers thus found.

Quality in informational products is a complex and elusive phenomenon. It can be described on the basis of outcomes for their users and potential increase in the efficiency for the tasks they perform [13]. A broader understanding of quality can comprise not only quality proper (e.g. accuracy, currency, reliability, validity, comprehensiveness), but also additional parameters of clearly qualitative nature: reduction of noise, improvement of ease of use, mediation, and user orientation [16]. The recognition of quality in most cases is intellectual and cannot be formalized without over-simplification. Nardi and O'Day [12] who studied libraries to define approaches to the design of intelligent agents stress the complexity of quality control there:

Librarians know about topical coverage of different sources, the kinds of information available ... reliability of sources (fact, rumor or something in between), cost, particular slants or perspectives; breadth of coverage; frequency of update... unique coverage... Librarians know about fields' attributes in each database and use these to good effect. [12, p. 65]

Timeliness of delivery, adequate packaging, and adequate description (catalogs) of documents also have an impact on quality as perceived by the users. Timeliness as a component of quality is variable and depends on the goals of information users. Thus, a consumer using stock market reports for data analysis attaches a different degree of importance to the timeliness of delivery than a stock trader. On the other hand, real-time stock market data has a short-term value only, while a generalization based on the study of its patterns acquires a longer life span and a considerable analytical value. A system administrator will attach a larger importance to the immediate availability of patches than an average user. A user of Linux will not have an immediate interest in the new release of the Macintosh operating system.

Packaging is connected to what Taylor [16] defines as "ease of use" and "adaptability." A patent repository including drawings is more useful than a purely textual collection of patent abstracts; but the graphics will be of no value if their format cannot be processed from a standard viewer. An electronic catalog may not generate any sales if the user needs a proprietary network and software to carry out a transaction. A character-based browser is useless when navigation in an information system is based on graphical maps. A browser other than Netscape may not read Netscape javascript correctly, and occasional users will not welcome interfaces based on complex query languages.

Therefore, the quality of digital products is defined by a number of complex inter-related factors, predictable as well as situational.

3.1.2 *Internet Digital Libraries*

In addition to serving as a medium mainly supporting "person to person" communication [15], the Internet is becoming a global online repository of "knowledge"¹. This gigantic digital repository is crucial for education, training, business to business communications, and a variety of research activities. In the World Wide Web environment, any user of information with a sufficient level of access can become an information producer and distributor, creating new concerns for quality and the need for new approaches to information and knowledge management.

The fuzzy boundaries between information producers and information users develop in a situation where new very large audiences of information users become involved in non-mediated information seeking process. Currently, many categories of users, especially in higher education, research, and business, regard the WWW as a helpful and often essential source of heterogeneous up-to-date information as well as a quick way to promote ideas and distribute new resources. A new generation of students in

¹ According to 1997 CommerceNet -Nielsen survey, 73% of North American WWW users have searched the Web for information, mainly on services and products (http://www.commerce.net/work/pilot/nielsen_96/press_97.html).

the U.S. and some other developed countries, has become used to finding course syllabi, required readings, quizzes and exercises on Web servers. They therefore have acquired a perception, carried on into their professional lives, of the World Wide Web as an online library of reliable information resources and source of high quality software and professional advice. In industry and commerce, millions of users begin to draw much of the information necessary to perform their job tasks from a combination of Intranet and public Internet resources. New products and technologies linking legacy applications and repositories to the World Wide Web begin to emerge, making Internet digital repositories more extensive in coverage and scope.

The global nature of Internet-based information sharing and distribution and multiplicity of tasks in which such information is involved make the issue of quality of digital products and information extremely important. Inadequate quality affects the outcomes of the information usage of millions of "patrons" as Internet repositories acquire a very large population of users² and play an increasingly important role in information and knowledge discovery. In addition to access to electronic documents, Internet technologies allow to support more sophisticated ways to manipulate the resources. As a result, directly or indirectly, content is involved in a multitude of complex transactions. More complicated interactions of users and information resources, involving a variety of analysis tools, increase the importance of access to high quality information: non-validated electronic resources may adversely affect not only individual users, but complex "virtual" groups and their output.

As shown by Ackerlof [1], in many cases, the quality of a product is difficult for the buyers to establish. Since low quality goods, although cheaper to produce, are less desirable for consumers, no transactions at all may take place for products and services believed to represent a higher risk relative to their perceived quality and reliability. In the Internet environment, one of the assumptions behind knowledge and information sharing is the mutual character of such activities. However, if the quality of Internet digital libraries is uneven, the producers of higher quality information appear to be at a disadvantage in information exchange: they will exchange access to their high quality resources for access to resources of a lesser value. Intermediaries, by creating "communities" of users and more structured repositories of resources, ensure that producers of higher quality digital product benefit from access to other high quality repositories and increased audiences of users.

² Nielsen -CommerceNet survey found that 23% of North American users have accessed the Internet in the 3 months prior to the survey (up from 10% in 1995) and that 17% have used the Web (up from 8% in 1995). See http://www.commerce.net/work/pilot/nielsen_96/press_97.html for more detail.

4 Intermediaries

The next sections demonstrate the value intermediaries can bring to the information markets, especially in a situation when the quality of digital products and content cannot be recognized by information users.

4.1 Roles of Intermediaries

Marketing theory views intermediaries as "organizations that support exchanges between producers and consumers, increasing the efficiency of the exchange process by aggregating transactions to create economies of scale and scope" [14]. Some economic models assume that trade can be transacted without friction, because it allows the researchers to highlight more prominently various components of commercial activities. In reality, however, heterogeneous agents participate in commerce, and friction is inevitable. According to Bose and Pingle [6], the main function of intermediaries is to eliminate friction in markets. They write: "...intermediation can be profitable - and thus be expected to arise endogenously - if the set of agents is heterogeneous in a certain sense. This is true even if intermediaries do not have superior information, or the benefit of increasing returns to scale." [6, p. 251]. Intermediaries are also instrumental in shortening the length of time necessary for a transaction to complete, therefore decreasing the "search" efforts in a market. Bhattacharya and Hagerty [4] see the role of intermediaries as "price setters," serving as regulators between buyers and sellers, and price stabilization is extremely important in information markets³. The benefits to consumers can increase through the competition of intermediaries, according to Bose and Pingle [6], since it often results in driving down prices, a phenomenon that can be observed in prices for digital products⁴. Williamson [20] contends that a very important role of intermediaries consists in increasing the quality of goods and services. We also consider this activity essential in information markets

³ Case studies of information intermediaries conducted within the scope of this research indicate that prices represent the most variable aspect of the operations of intermediaries. Thus, the role of knowledge intermediaries as price setters appears to be of a lesser importance.

⁴ A good example of such competition is the reduction of prices for tools necessary to index information located on distributed Web servers. Initially, such providers as Verity, Inc. or Open Text, Inc. based their pricing model on the number of servers and documents to be indexed, making the prices prohibitively expensive for distributed and decentralized larger customers. Because of the competition between providers, the prices were revised. Subsequently, as the demand grew, size-based pricing schemes were re-instated. Similarly, information brokers, such as Dialog Corporation, IAC, and Questel/Orbit begun to offer flat fee pricing for some databases in order to deal with lower prices from smaller information brokers.

because most users have no expertise to assess independently the quality of information resources and digital products.

The acceptance or lack of support for some electronic commerce technologies indirectly confirms the need for intermediaries. Although microtransactions were predicted to be crucial for digital commerce, since they promote the “unbundling” of intrinsically redundant informational products, their adoption by the information users has been slow. According to *The Economist*’s “Survey on Electronic Commerce” (May 10th - 16th 1997),

The digital-money business is built on the premise that electronic commerce will bring a boom in “microtransactions” for information goods and services: buying a newspaper article for a quarter, ... paying a few cents a day to see a favorite comic strip, or renting software by the hour. ... Unfortunately... the psychology of microtransactions is all wrong. Individual consumers... dislike paying for information and positively hate meters. [10, p. 13-14].

Based on past experiments and reports on digital commerce, today one has to agree that “[...] consumers want to avoid wasting their money, but more importantly, they want to minimize their risk” [10, p. 14⁵]. Intermediaries, therefore, can be instrumental in increasing the consumers’ trust by offering validation services. Validation services are important in information markets. For example, Yahoo (www.yahoo.com) that provides a more structured access to the WWW information resources and is somewhat selective in its coverage, consistently ranks as the most used Internet resource, confirming the users’ need for intermediation and a resulting more structured, although not restrictively structured, information space.

Reliance on intelligent technologies and delivery methods as an alternative to human intermediation in information distribution does not fully take into consideration the psychology of information users and non-market qualities of informational products. If the avoidance of risks in engaging in electronic transactions is important for the consumers of electronic informational products, they will have to continue to rely on intermediaries.

Technologists who studied the work of human “information intermediaries” recognize that, although technologies can make information production, distribution, and retrieval more efficient, some of the intermediation activities for knowledge products are intellectual in nature and cannot be substituted by software. Nardi and O’Day who observed

librarians in corporate libraries, while working on design principles for intelligent agents, conclude:

The assumption on the part of many... that intelligent agents or other software programs will replace librarians is gravely misguided in our opinion. ... The notion of a “librarian in a box”, a reference we have frequently heard in talks on digital libraries, is utterly wrong-headed to us. Rather than seeing human agents and software in competition, ... the wiser course is to leverage the strength of each, deliberately designing work practices and institutional arrangements that reflect and exploit the possibility of collaboration between human and software agents [12, p. 83].

4.2 Activities of Information Intermediaries

Case studies of knowledge intermediaries, conducted within the framework of this research⁶, highlight the roles that all intermediary organizations share. The intermediaries are instrumental in promoting trusted relationships with customers, through individualized support, active mediation in research, or helpdesk assistance. In addition to forming trusted relationships with customers, the intermediaries promote trust with primary information providers, by extending the intellectual property protection to all the products they distribute.

All the intermediaries exercise active quality control of the informational products they distribute. They use reputable publishers as primary providers and monitor their performance for timeliness of delivery and other qualitative parameters. They screen and categorize new information sources. They are willing to add new high quality sources of information or tools in order to make their repositories more comprehensive. Where relevant, they incorporate domain expertise into their products and services and are able to assess the validity and importance of the information resources in specialized fields.

Work to increase the quality of resources offered to the end users goes hand in hand with work aimed at augmenting the efficiency of the users’ information seeking. Many intermediaries use their own technologies to enhance and improve information management, processing, and indexing. When the emphasis is on direct access of end users to the information, the intermediaries provide consistent interfaces and unified query languages as well as extensive search assistance. Most intermediaries carry out customization and focusing of their products.

In general, intermediaries help the users to extract the best outcomes from the information resources with minimal effort. Therefore, the main roles of information intermediaries in the Internet environment lie in improving quality of information resources and efficiency of information seeking as well as promoting trusted

⁵ As an example of such attitudes that are not justified from the economic point of view, the *Economist*’s report refers to AT&T attempt to introduce a variable scale of payments for local call in the 70s. This pricing scheme was rejected by the telephone customers who would benefit from such a system; instead, they preferred to pay a stable, although more substantial, fee [10, p. 14].

⁶ The case studies are not presented here because of the space limitations, but are available from the authors upon request.

relationships with primary information vendors and customers.

5 Economic Factors in Electronic Commerce for Content & Knowledge Sharing

Having reviewed the essential roles of information intermediaries, we shall now illustrate various situations relating to information distribution using a set of stylized models. We understand that the interaction of users and producers of digital products are not limited to the direct exchange and that sometimes the levels of access and usage of such resources represent an incentive in themselves. For example, access levels are connected to advertising revenues. However, the simple models below allow us to formalize and highlight the important aspects of the Internet-based knowledge sharing⁷, and provide a framework that can be used for the analysis of the user acceptance of information systems.

The following notation is used for all models in this section:

V_t - payoff at the end of period t

m - probability of finding an exchange partner or conducting a transaction

p_i - relevance of product i (probability that it will be relevant to an agent selected at random)

p_j - relevance of informational product j to an agent selected at random

θ - probability that the quality of a product is recognized. Some agents will not have competency in the area where informational products are offered.

$1-\theta$ - probability that its is not recognized, and, according to Akerlof's model, the agent assumes that the quality is low.

$\alpha < 1$ - depreciation coefficient (when an item is exported, a copy stays with the original owner) and only a part of the value is transferred

x_i - real value of informational product i

$x'_i < x_i$ - perceived "low" value of informational product i when it's quality is not recognized, and the agent (consumer) assumes it is low.

y_i - cost of production (or primary "acquisition") for product i

z - search coefficient (an average effort necessary to locate a relevant knowledge product)

Comparisons of exchange economies, "monetary economies" with fiat currencies and economies with intermediation are presented below.

5.1 Exchange economy & fiat currency

The pay-off when informational products are exchanged depends not only on the desirability or relevance of products i and j , but also on the probability of the meeting of two agents that are mutually interested in the products offered on exchange (due to double coincidence of wants). Since there is no currency, an agent holding product i and wishing to exchange it for product j will need not only to find a holder of product j , but also to locate such a holder that also needs product i . Therefore, the probability of 2 agents meeting mutually acceptable partners is m^2 . The payoff function for period t for two agents can be described as follows:

$$V_t = m^2 \left\{ \sum_{i \neq j}^n p_i p_j (x_j - y_i) + \sum_{i \neq j}^n p_i p_j (x_i - y_j) \right\} \quad (1)$$

A few examples illustrate the model. In order to open an information channel, two companies should be mutually interested in such a partnership. Since not all the eligible companies will have incentives to participate, the task of locating a partner is more difficult, and the probability of establishing such a connection is smaller. In another example, in order to obtain a meaningful evaluation of a software package or information repository, the product owners are interested only in evaluators that represent potential customers or possess a certain combination of knowledge and skills. On the other hand, the eligible evaluators are interested in expending time and effort for an evaluation only if they perceive a value to them in the arrangement. As a result, the probability of finding a match can decline.

However, the most important obstacle to the development of pure exchange economies may be the lack of competency of buyers and sellers in discerning the value of products in an exchange market. This argument applies even more strongly to informational markets where all the products contain private information (their true value and quality cannot be discerned until the value is transferred) and where the intellectual component and specialization are highly developed. The lack of discernment can apply to the inherent characteristics of a product or its market features [3]. Using our previous example, the user volunteering to provide feedback in exchange for a beta version of a software product may have made a wrong commitment because the software package is not able to perform the desired operations in his/her computer environment. The same mistake can occur also because comparable product is offered by another company free of charge. Similarly, an individual contracting to fill a survey in exchange for a trial access to a database may not know that the database contains low quality outdated content (intrinsic qualities of a product) or that similar documents are available through other providers free of charge (failure to discern market qualities).

Therefore, we introduce the "competence" coefficient (θ), the probability that the quality of the informational products will be recognized. Akerlof [1] demonstrated that

⁷ More details on stylized models can be supplied upon request.

if buyers and sellers have asymmetric information about the quality of products (i.e. the quality is not recognized), the buyers are inclined to pay only the low quality price. Accordingly, we designate $x'_i < x_i$ as perceived low exchange values of informational products when their quality is not recognized (i.e the agent is not competent in the informational product offered by the other agent). The model taking these issues into consideration is presented below:

$$V_i = m^2 \{ (\theta \sum_{i \neq j}^n p_i p_j (x_j - y_i) + (1 - \theta) \sum_{i \neq j}^n p_i p_j (x'_j - y_i)) + \theta (\sum_{i \neq j}^n p_i p_j (x_i - y_j) + (1 - \theta) \sum_{i \neq j}^n p_i p_j (x'_i - y_j)) \} \quad (2)$$

Unlike commodities that are used directly for consumption, electronic informational products are copied when they are exchanged and transferred. When a user retrieves an electronic news story from RBA (Reuters Business Alerts), he/she copies the file into their desktop. The initial copy on the RBA server remains intact. Almost no expense is incurred in copying the file; the cost mostly concerns the infrastructure, not the information vendor and distributor. At the same time, the market value of an electronic informational product is reduced if there are many copies in circulation. In an exchange economy with n agents, when there are n copies of a certain knowledge product in circulation, the value of this item will be 0, since it will not be accepted on exchange by any of the agents. We introduce therefore a "copying" or "depreciation" coefficient ($\alpha < 1$) to denote how the value of an informational product will be reduced by copying and the number of copies in circulation.

$$V_i = m^2 \{ ((\theta \sum_{i \neq j}^n p_i p_j (x_j - y_i) + (1 - \theta) \sum_{i \neq j}^n p_i p_j (x'_j - y_i)) - \sum_{i=1}^n \alpha p_i x_i) + ((\theta \sum_{i \neq j}^n p_i p_j (x_i - y_j) + (1 - \theta) \sum_{i \neq j}^n p_i p_j (x'_i - y_j)) - \sum_{j=1}^n \alpha p_j x_j) \} \quad (3)$$

Let us now examine a different case where agents have knowledge products and recognizable currency. If currency is always accepted in exchange for a product, the probability of two agents performing a trade will be m (the agents have to locate another agent who has the required piece of information for sale, rather than an exchange partner). The market becomes more efficient with the introduction of a recognizable currency, by eliminating double coincidence of wants.

The recognizable currency does not need to be represented by money or electronic cash: all kinds of "tokens" can play the role of currencies. In some bibliographic databases, for example, the users are rewarded with credits for searching when they create unique records that other participants can reuse. Recognizable currencies can be also substituted with authentication, signaling that certain users come from certain organizations, such as educational institutions, with

authorized access to electronic resources. Similarly, group subscriptions can be authenticated by domain addresses, serving as "passwords" to information repositories. In general, the notion of recognizable currency or fiat money may simply mean that the information-holding agents will be recognized or compensated for their efforts in some form. The payment does not need to be direct, similarly to the situation in public libraries where, in most cases, patrons are not paying directly for access to information, but share the costs indirectly through taxes or student fees. Nor does the compensation have to be monetary: in many cases, broad access to resources without any direct payment is a sufficient incentive for the providers because it represents a source of advertising revenues or increase in funding. In short, there should be sufficient and visible incentives for the information holders to ensure that the information is made available and prominent, and is not under-used.

Let us now explore more closely a situation where there is a recognizable currency that is accepted by all the agents. In this case, the probability of finding an agent holding the needed product will be m , not m squared. The agents will exchange their products for their value, or perceived low value, in terms of this recognizable currency. The formula for transactions including a recognizable currency can be written as follows:

$$V_i = m \{ (\theta \sum_{i=1}^n p_i (x_i - y_i) + (1 - \theta) \sum_{i=1}^n p_i (x'_i - y_i)) - \sum_{i=1}^n \alpha x_i p_i \} + m \{ (\theta \sum_{j=1}^n p_j (x_j - y_j) + (1 - \theta) \sum_{j=1}^n p_j (x'_j - y_j)) - \sum_{j=1}^n \alpha x_j p_j \} \quad (4)$$

The value of the payoff function will be greater in (4) than in (3).

5.2 Users' Quality Uncertainty and Intermediation

Without the possibility to inspect digital products prior to the transfer of value, the information about informational products (catalogs) is always insufficient for decision making. An experienced user searching Dialog Select, the consumer service of Dialog Corporation, will not be able to form a competent opinion about the relevance and quality of the articles based on the limited information displayed prior to committing to buy the resources. The users' perception of risks in this case may be high because, unlike the goods market, the user of information will have to pay for resources that did not suit his/her needs and goals: informational products are not returnable.

Expertise, in knowledge and information management, or specialized domains of knowledge, can alleviate the perceptions of risks that information users will otherwise be exposed to. Intermediaries use expertise as well as a notion of stability and repeated business as tools to improve the information users' discernment of the quality of digital products. Due to trusted relationships with users that the intermediaries promote, and to their continued quality control activities, the quality of the resources is recognized more frequently with intermediation. As a result, the users

are willing to pay high quality prices more frequently, or otherwise endorse the digital products. We assume that in a mediated information space the users more frequently discern the quality of resources. The special coefficient for the users' competence with intermediation is $\theta_i > \theta$, leading to higher pay-offs.

$$\theta_i > \theta$$

$$\begin{aligned} V_i = & m\{(\theta_i \sum_{i=1}^n p_i(x_i - y) + (1 - \theta_i) \sum_{i=1}^n p_i(x_i' - y_i - z)) \\ & - \sum_{i=1}^n \alpha x_i p_i\} + m\{(\theta_i \sum_{j=1}^n p_j(x_j - y_j) + (1 - \theta_i) \sum_{j=1}^n p_j(x_j - y_j - z)) \\ & - \sum_{j=1}^n \alpha x_j p_j\} \end{aligned} \quad (5)$$

Additionally, in the case of intermediation, the distribution of products is centralized, and we can assume that all the matches are available for information seeking agents. Therefore $m=1$. This factor further increases the value and maximum of the payoff function as the value of formula (5a) is greater than the value of formula (5).

$$\theta_i > \theta$$

$$\begin{aligned} V_i = & (\theta_i \sum_{i=1}^n p_i(x_i - y) + (1 - \theta_i) \sum_{i=1}^n p_i(x_i' - y_i - z)) - \sum_{i=1}^n \alpha x_i p_i \\ & + (\theta_i \sum_{j=1}^n p_j(x_j - y_j) + (1 - \theta_i) \sum_{j=1}^n p_j(x_j - y_j - z)) - \sum_{j=1}^n \alpha x_j p_j \end{aligned} \quad (5a)$$

5.3 Search Efforts and Intermediaries

When several informational products are needed, the information-seeking agents may have to perform the research operations sequentially. In a situation where search applications available on AT&T, IBM, MCI, Nortel, and Xerox public World Wide Web sites are queried sequentially to locate available software packages for speech recognition, the users may need to access each of the servers. In each of the cases, they will need to formulate their queries, taking into consideration different search engines, and compare the output from all the repositories. These activities will involve at least four steps for each of the sites, to the total of 20 steps, as well as the synthesis stage.

The efficiency of the research is increased when the users can instead query one of the Web search services, such as Excite, Altavista, or Infoseek that include information from all of the five primary servers as well as some additional resources. However, because of the technologies used for data collection, the coverage provided by different search services will be different. Therefore, in order to achieve broad and conclusive results, the users will need to query several search services. A new option open to the users now is to search the primary search services in parallel, with the help of one of the emerging meta search services, thus achieving the desired results in one step.

Similarly to aggregating search efforts using meta search, intermediaries can reduce Internet traffic and save the users' research efforts. Already the first critics of the WWW as a global information system considered the lack of structure as a factor leading to under-use of Web based information. The first developers of Web based information management systems turned to library science for help assuming that the "work of stabilizing and maintaining digital collections will involve much systematic human activity" [22, p. 195]. However, the sheer volume of the World Wide Web made such techniques prohibitively expensive. SGML seemed an appropriate method to use one technical protocol for record keeping and information retrieval, and XML may finally fulfill this goal. SGML continues to be labor intensive and complex and, therefore, not appropriate for large-scale projects involving heterogeneous data sets. For similar reasons (complexity), Z39.50 protocol that offered the promise of interoperability to diverse information retrieval applications and elicited a lot of interest from the researchers and developers in 1995, proved to be too specialized for global deployment.

Since it appears to be impossible to ensure accessibility of a large body of information resources through manual/semi-manual cataloging only, automatic approaches began to emerge, and WWW search services arose. A strong feature of these applications is that documents are processed in their initial formats, without preliminary editing. These retrieval tools were designed for non-professional users with little time to learn new query languages, protocols, and database design. They allow the users to retrieve relevant information using unconnected keywords and free syntax.

In order to improve search efficiency, efforts to create meta-search engines, combining the output of several search utilities, are under way, and several implementations, for both server and client sides, are fully operational. Agent technologies can serve as delayed meta search engines, optimizing the users' queries and formatting the output.

Although Web search services are instrumental in bringing "information about information" to the Web users' desktops and their usage is growing⁸, they capture only a fraction of Web digital repositories. Although the largest of the search services have indexed tens of millions of pages, their indices reflect only a part of available information. The current automatic Web indexing model, where "spiders" (automatic http clients) follow the links found on HTML pages and eventually retrieve documents referenced, leaves out large areas. Pages that are connected

⁸ Spring '97 CommerceNet/Nielsen Media Research Study of Internet Demographics and Electronic Commerce reports that 71% of users recur to search engines the most often to find new information. Press release and findings are available at:
http://www.commerce.net/work/pilot/nielsen_96/

only among themselves and not to any other collections are likely to be left out; password protected services are often excluded as well as millions of pages generated on the fly as a result of a query. Not only are the searchable collections incomplete, but information included in them often is not meant for public presentation at publication time. Although robot exclusion standard offers a way to eliminate non-public areas from global indexing, robots.txt files are too technical to be set up by thousands of amateur Web publishers. As a result, the quality of information that reaches the end users remains unpredictable and uneven.

The idea that intermediation reduces consumer search efforts can be formalized introducing a search coefficient ($z > 0$), relating to every instance of an information seeking activity, and a coefficient $k=1,2 \dots k$, denoting the number of times the activity has to be repeated in order to locate the needed knowledge product. While m indicates the probability of finding the holder of relevant knowledge products (and therefore, the difficulties involved in locating the needed trading/exchange partners), search coefficient z relates to the effort that an agent needs to expend when attempting to locate the information he/she needs after the relevant "collection" was found. The resulting equation for barter markets can be written as follows:

$$V_i = m^2 \left\{ \theta \left(\sum_{i \neq j}^n p_i p_j (x_j - y_i - kz) \right) + (1 - \theta) \left(\sum_{i \neq j}^n p_i p_j (x'_j - y_i - kz) \right) \right. \\ \left. - \sum_{i=1}^n p_i \alpha x_i \right\} + \theta \left(\sum_{i \neq j}^n p_i p_j (x_i - y_j - kz) \right) + (1 - \theta) \left(\sum_{i \neq j}^n p_i p_j (x'_i - y_j - kz) \right) \\ - \sum_{j=1}^n p_j \alpha x_j \quad (6)$$

With intermediation, $m=1$, and $k=1$ (and since $z > 0$, $kz > z$), because instead of researching a number of information resources sequentially, the users are able to consolidate their research efforts. Although multiple queries are often necessary to obtain the needed information, they are posted to a smaller number of online databases (one "database" in the case of our simplified model). In the case of intermediation, the value and maximum of equation (7) are greater than the respective values in (6), indicating greater payoffs achieved with intermediation. $\theta_i > \theta$

$$V_i = (\theta_i \sum_{i \neq j}^n p_i p_j (x_j - y_i - z) + (1 - \theta_i) \left(\sum_{i \neq j}^n p_i p_j (x'_j - y_i - z) \right) \\ - \sum_{i=1}^n p_i \alpha x_i) + (\theta_i \left(\sum_{i \neq j}^n p_i p_j (x_i - y_j - z) \right) + (1 - \theta_i) \left(\sum_{i \neq j}^n p_i p_j (x'_i - y_j - z) \right) \\ - \sum_{j=1}^n p_j \alpha x_j) \quad (7)$$

If we assume that the intermediaries accept only products with quality higher than a certain threshold, select primary providers with lower production costs, and their multi-

product repositories do not experience the effects of the "copying discount", the payoff will increase further.

6 Summary

The Internet greatly increased the body of information available to end users, providing many of them with the rights of publishers and drawing millions of new users in non mediated information seeking process. Although the idea of the knowledge sharing is attractive and many Internet users are accustomed to free content and other digital products, the "pure" knowledge sharing model may be flawed because, when no additional incentives are offered to higher quality information producers, they are at a disadvantage in an information market. As a result, information and knowledge exchange without intermediation or outside of distinct communities, with an authorization and reward system ("recognizable currencies") may lead to the deterioration of quality in the Internet digital repositories. Intermediaries are instrumental in keeping the quality of digital repositories high, offering both quality monitoring and incentives to qualified "suppliers."

Information and knowledge exchange, as any barter economy, is also rendered less efficient by double coincidence of wants when only mutually acceptable transactions of pairs of agents are possible, since no recognizable currency is available. But, as we attempted to explain in this paper, the efficiency of information markets can be improved with recognizable currencies.

The recognizable currency does not need to represent a direct payment of the users of knowledge products to their producers or to intermediaries, but may be achieved through automatic authentication of authorized users as members of virtual communities.

Another weakness of exchange economies is the inability of most users to reliably assess market and intrinsic values of products. These restrictions apply in full measure to informational products because their quality and content cannot be fully described without transferring their value. When the quality of digital products is not recognized, the users are willing to pay lower prices, or show lower commitments through lower levels of usage, assuming that the quality is inadequate. Intermediaries, through monitoring of levels of quality by the primary information providers, can increase the confidence of users and lead to additional increases in the efficiency of digital markets by augmenting the population of consumers who trust the sources of their digital products.

Yet another intermediation activity that brings greater efficiency to the information seeking and knowledge sharing resides in the ability of intermediaries to aggregate search efforts necessary to locate the needed information. Intermediaries offer multi-product access to repositories and catalogs, put in place more sophisticated information filtering, and provide human assistance as well as a variety of analytical services.

The World Wide Web did not eliminate the need for intermediation in information markets, both consumer and organizational, but modified its character: the new populations of end-users became responsible for direct information seeking, while the intermediaries remained in charge of the information systems design and quality control. The importance of intermediaries in increasing the users' trust and the efficiency of information markets remains unchallenged in the Internet environment.

7 Bibliography

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