

# Towards an Information Market Paradigm

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**Abstract.** This paper discusses the concept of information market. The authors of this paper have been involved in several aspects of information retrieval research. In continuing this research tradition we now take a wider perspective on this field, and position it as a market where demand for information meets supply for information.

## 1 Introduction

Our modern day western societies are dominated by information systems. This is not a new phenomenon, as there were information systems playing important roles in cultures and empires long since gone. The problem of managing large volumes of *information* is also not new. The first institutional libraries appeared in Athens during the 4th century BC. Around that time in the library of Alexandria the first catalogs were used. The Romans later introduced classification and in the 18th century Dewey elaborated on that with the *Dewey Decimal System*. These days we use computers to assist us in managing these large volumes of information, either stored in a physical bricks and mortar library or on the Web. Hand in hand with the increased amounts of information that needed processing, the problem of *information overload* started to surface. As more and more data accumulated in information systems, it became harder and harder to find those bits of data that really mattered. This has led to the introduction of the field of information retrieval [1]. The development of the Internet provided our society with the opportunity to interconnect computers, leading to networked information systems. As the Internet matured it gave birth to the World-Wide-Web (the Web). This resulted in a multiplication of the information available to people around the globe and gave birth to e-commerce. Given the abundance of information available via the Web, an important part of the commodities traded on the Internet are actually *carriers* of information. This paper proposes to look at the exchange of information on the Internet as an *Information Market*, where demand and supply of information meet. As such, our aim is to mark a transition from a traditional view on information retrieval to an *Information Market Paradigm*. A traditional perspective on information retrieval is provided in the *Information Retrieval Paradigm* [2]. On one side, there are information resources that are at our disposal. These resources, which may be aggregated,

are characterized in some way to facilitate their discovery. Facing the information carriers is the user with an information need. The user expresses this need in terms of an information request; a query. The query will usually only be a crude description of the actual carrier(s) needed to fulfill the given information need. The need for information will most often be due to some *gap* in the user's knowledge. Relevant information is discovered and then absorbed by the user to fill the knowledge gap. In our research we are not concerned with developing yet another approach or strategy to match the demand and supply of information, but rather with an attempt at fundamentally understanding the workings of the *Information Market*.

## 2 Markets

Our generalized perspective on markets as presented here, is partially based on the concept of economic markets, in particular on the field of micro-economics. We consider economic markets to be a specific class of markets dealing with the trading of goods, services and *money*. Our considerations are indeed inspired by literature on economic theories primarily based on the work reported in [3, 4, 5], as well as introspection.

### 2.1 Traded assets

In our view, two main classes of *assets* can be traded on a market. *Ownership of entities*, such as physical goods, bank notes, part of an organization, land, etc. The second class, *execution of services*, pertains to services that may be applied on/to/over entities that are regarded by some participant as value adding, for example treatment of an illness, management of a stock portfolio, etc. In markets dealing with trading of physical goods (i.e., *entities*) we take the view that what is *actually* traded is the *ownership* of these entities. The class of *executable services* could be split further into *Transformation of entities* and *Reduction of uncertainty*. Let us now, however, first explore markets in more detail. We will do so by discussing four core concepts: transactions, cost/benefits, preference and value addition.

### 2.2 Transactions

If  $p_1$  and  $p_2$  are two participants of a market that decide to trade two assets,  $a_1$  and  $a_2$ . This trading of assets is a *transaction*. In economic markets, transaction participants are said to be either a *selling* or *buying* participant. In our view, the notion of selling and buying can only be defined relative to a specific asset that is involved in the transaction. The sales of an asset by one participant to another participant, will be referred to as a *transactand*. Let  $t$  be a transactand, then we will use  $t : s \xrightarrow{a} b$  to denote the fact that in transactand  $t$  participant  $s$  sells asset  $a$  to participant  $b$ . The (two) participants in a transactand are given by the function  $\text{Participants}(t) = \{s, b\}$ . Similarly, the buyer and seller 'role'

within a transactand are given by  $\text{Buyer}(t) = b$  and  $\text{Seller}(t) = s$  respectively. A transaction can now be regarded as being a set of transactands. If  $T$  is a transaction, then we can define:  $s \xrightarrow{a} b \in T \triangleq \exists t \in T [t : s \xrightarrow{a} b]$ .

As a rule we will require:  $t_1, t_2 \in T \wedge t_1 : s \xrightarrow{a} b \wedge t_2 : s \xrightarrow{a} b \Rightarrow t_1 = t_2$ . In other words, the involved participants and asset uniquely determine the transactand in a transaction. This will allow us to denote the initial transaction between  $p_1$  and  $p_2$  as:  $\{p_1 \xrightarrow{a_1} p_2, p_2 \xrightarrow{a_2} p_1\}$  and a more complex set of transactions involving  $p_3$ ,  $p_4$  and  $p_5$  as:  $\{p_3 \xrightarrow{a_3} p_5, p_5 \xrightarrow{a_4} p_4, p_4 \xrightarrow{a_5} p_3\}$ . The set of participants involved in a transaction are defined as:  $\text{Participants}(T) \triangleq \cup_{t \in T} \text{Participants}(t)$ . This leads us to the question why do the transactions take place in the first place? There is usually some *benefit* to the participants of a transaction, therefore a transaction is not just any set of transactands. Each participant in a transaction must both receive and pay an asset:

$$p \in \text{Participants}(T) \Rightarrow \exists_{t_1, t_2 \in T} [\text{Seller}(t_1) = p \wedge \text{Buyer}(t_2) = p]$$

Also, transactions are assumed to be ‘singular’ in the sense that participants of a transaction play the buyer and seller role exactly once. Even more so, a participant can not play the buyer and seller role in one transactand:

$$t \in T \Rightarrow \text{Seller}(t) \neq \text{Buyer}(t).$$

We presume the participants of the market to behave in a goal-driven manner. These goals might be explicit in the reasoning of the participants, but may also be more implicit and based on emotions. For the moment we presume  $\mathcal{G}$  to be the set of possible goals. Let furthermore,  $\mathcal{PA}$  be the set of participants on the market and  $\mathcal{ST}$  be the set of states a participant may hold. A state, in this context, is defined to be the present satisfaction (of a searcher) with regard to the goals in  $\mathcal{G}$ . We presume the function:  $\text{ld} : \mathcal{ST} \rightarrow \mathcal{PA}$  to identify which states belong to which participant. Given the state  $s$  of a participant  $\text{ld}(s)$ , we can view the satisfaction of the goals which the participant (in a certain state!) may have as a function:  $\text{Satisfaction} : \mathcal{ST} \times \mathcal{G} \rightarrow [0..1]$ . For each goal, the level of satisfaction is expressed as a number between 0 and 1. The consumption of some asset by a participant in a transaction, will result in a change of state of that participant. If  $T$  is a transaction, and  $s$  is a participant state, then  $s \times T$  is the state which results after the participation of  $\text{ld}(s)$  in transaction  $T$ . We require the resulting state to belong to the original participant:  $\text{ld}(s) = \text{ld}(s \times T)$  and the participant to indeed be a participant of the transaction:  $\text{ld}(s) \in \text{Participants}(T)$ . On closer consideration, our statement:  $p_1 \xrightarrow{a} p_2$  as an abbreviation for: “Participant  $p_1$  sells asset  $a$  to participant  $p_2$ ” is not specific enough. An actual transaction will take place between participants who hold a specific *state*. For our considerations in the next subsections, we will need this more refined view. We will therefore use  $t : s_1 \xrightarrow{a} s_2$  as an abbreviation for: “In transactand  $t$ , participant  $\text{ld}(s_1)$  in state  $s_1$  sells asset  $a$  to participant  $\text{ld}(s_2)$  in state  $s_2$ ”. We do require:

$$t : s_1 \xrightarrow{a} s_2 \Rightarrow t : \text{ld}(s_1) \xrightarrow{a} \text{ld}(s_2)$$

such that the set of states involved in a transaction is identified as:

$$\text{States}(T) \triangleq \left\{ s_1 \mid \exists_{s_2, a} [s_1 \xrightarrow{a} s_2 \in T \vee s_2 \xrightarrow{a} s_1 \in T] \right\}$$

## 2.3 Costs and benefits

The actual benefit of an asset is difficult to measure and defining a measurement for a certain type of phenomenon is often difficult. Consider the following historical example as described in [6]. Ken Alder writes “Our methods of measurement define who we are and what we value”. In his book, he describes the quest for a universal measure for distance in the late 1790’s by two astronomers. Their task was to establish this new measure – *the meter* as one ten-millionth of the distance from the North Pole to the equator. Where the astronomers Delambre and Méchain’s quest was to find a measure for distance, the “quest” for markets in general is to present a measure for value (cost/benefits) of assets.

We presume that the benefits of an involvement in a transaction can be defined as the positive impact on the satisfaction levels of a participant:

$$\text{Benefit}(s, T) \triangleq \lambda_{g \in \mathcal{G}\mathcal{L}} \cdot \text{MAX}(\text{Satisfaction}(s \times T, g) - \text{Satisfaction}(s, g), 0)$$

We have employed the Lambda calculus notation to denote a function ranging over  $\mathcal{G}\mathcal{L}$ . The costs of an involvement in a transaction can be defined as the negative impact on the satisfaction levels of a participant:

$$\text{Cost}(s, T) \triangleq \lambda_{g \in \mathcal{G}\mathcal{L}} \cdot \text{MAX}(\text{Satisfaction}(s, g) - \text{Satisfaction}(s \times T, g), 0)$$

Given a relative prioritization of the different goals, a weighed level of satisfaction could be computed. Let  $\text{Priority} : \mathcal{S}\mathcal{T} \times \mathcal{G}\mathcal{L} \rightarrow [0..1]$  therefore be a function which identified the level of priority a participant (in a specific state) gives to the specified goal. We presume the priority function to be a distribution totaling to one for each of the states:  $\forall_{s \in \mathcal{S}\mathcal{T}} [\sum_{g \in \mathcal{G}\mathcal{L}} \text{Priority}(s, g) = 1]$ . With this weighing function, we can define the overall satisfaction as follows:

$$\text{Satisfaction}(s) \triangleq \sum_{g \in \mathcal{G}\mathcal{L}} \text{Satisfaction}(s, g) \times \text{Priority}(s, g)$$

It’s sensible to presume that the level of satisfaction of all participants of a transaction should not decrease:  $\forall_{s \in \text{States}(T)} [\text{Satisfaction}(s) \leq \text{Satisfaction}(s \times T)]$

## 3 Particularities of the Information Market

This section is concerned with a specialization of the ideas presented in the previous section to the context of the information market. It will also position some of the pre-existing research relative to the notion of the information market.

### 3.1 The assets

In accordance to [7, 8] the entities traded on the information market are dubbed *information resources*, or *resources* for short. In the context of the Web, an information resource can be defined as [9]: any entity that is accessible on the Web, and which can provide information to other entities connected to the Web. Even though the trading is about information resources, there are actually different levels of ownership/usage rights being traded. One could distinguish between four main classes. The *right to read/consume* the information resources for a fixed period of time. The *right to show the contents* of the information resources to other parties. The *right to redistribute* i.e. produce copies. Finally the *full*

*transfer of ownership*. In addition to trading of ownership/usage of information sources, services pertaining to these information sources are traded as well. Such services may include; the transformation of an information resource's storage format, the translation of an information resource from one language to another, the transfer of information resources from one location on the Internet to another location. Information resources and related services are not the only assets traded on the market. Producers (and transformers) of information resources will only do so if they have a reason. In other words, there must be some flow of assets back to the producers. This backward flow will have to originate from the consumers of the information resources. This flow could consist of money, but could equally well deal with intangible assets such as intellectual esteem, personal achievement, social standing, etc. Quantifying the backwards flow on an information market is also a major issue in the field of knowledge management [10]. One of the major challenges in the field of knowledge management seems to be the willingness of people to freely share knowledge. This sharing without any form of payment or return of benefits creates a major problem when trying to answer the question, "what will people get in return?"

### 3.2 Transactions

Transactions on the information market as such, will not differ dramatically from markets in general. However, in the case of the information market, we can elaborate more on the goals which drive the consumers of information resources. A future consumer of an information resource will have a need for information. This need for information can be caused by a number of reasons. At the moment we distinguish between two types of goals: *increment of knowledge* and *change of mood*. The former corresponds to a situation where someone finds that they are lacking some information/knowledge. This *knowledge gap* [9] could pertain to something fairly specific such as learning *the latest price of 19 micron wool*, to the very broad such as learning about the *theory of relativity*. When a consumer aims to achieve a *change of mood*, then this probably indicates a situation where an information resource is needed such as music or a movie to influence the mood. This can be music that is uplifting, a movie that is relaxing, etc. Collectively, one can refer to these two types of goals as *cognitive goals*. In addition to a cognitive goal, a consumer of information will have some *operational goal* as well. This latter goal relates to the tasks the consumer has/wants to perform. These tasks may put requirements (such as timeliness) on the information consumption process. An important characteristic of transactions in the information market is that they are *asynchronous*: there may be a (large) gap in time between the moment of publishing a resource on the web by the supplier and the actual downloading of it by the consumer.

### 3.3 Costs and benefits

The costs and benefits of an information resource are particularly difficult to measure. We shall adopt a multi-dimensional view on measuring the potential

benefit of a resource; *Utility* - dealing with the information that may be provided by a resources and the timeliness, *Structure* - concerned with the form (report, painting, movie, audio) and format (PDF, MP3) of a resource, *Emotion* - dealing with the emotional effect (pretty/inspiring) that a resource may have when it is *consumed*.

## 4 Conclusion

At the start of this paper we have discussed how an evolution can be observed moving beyond the traditional information retrieval paradigm to an information market paradigm. We have provided a discussion on the general notion of a market where assets are traded. This was then specialized to information resources, leading to an information market. At present, we are working on a more fundamental understanding of markets in general and information markets in particular. Based on these insights, we will evolve our existing theories for different aspects of information retrieval. We expect that models for goal-driven reasoning of participants in the information market will in particular be fruitful in improving the workings of the information market. Most importantly, we expect this to be most helpful in the retrieval of relevant information by searchers in the information market.

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