The Information Market: Its Basic Concepts and Its Challenges*

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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 re-position it as a market where demand for information meets supply for information. The paper starts by exploring the notion of a market in general and is followed by a specialization of these considerations in the information market, where we will also position some of the existing work[1].

1 Introduction

Our modern day western societies are dominated by computerized information systems. Despite being incredibly useful for many tasks, computers have not (yet) solved the problem of dealing with large collections of information. The apparent rise of the Web has resulted in a in a multiplication of the information available to people around the globe. Even more, this information is available in many forms and formats which makes life rather difficult for the average user who shops around to discover information resources that fulfill his or her information needs. These developments have shifted the attention of information retrieval research away from "stand alone" collections to information retrieval on the Web [1].

When the Web matured it, on its turn, 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 brings us to the focus of this paper. 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, this paper aims to mark a transition from a traditional view on information retrieval to an *Information Market Paradigm*.

This paper is not concerned with developing yet another approach to match demand and supply of information, but rather with an attempt of fundamentally

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[1] An extended version of this paper can be found http://osiris.cs.kun.nl/~basvg/pubBvG.php

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understanding the workings of the *Information Market*. We focus on the elaboration of *Information Market*, which we regard as a follow up to *Information Retrieval*.

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 will, however, adopt the point of view that markets deal with *exchange* in general. As such, we consider economic markets to be a specific class of markets dealing with the trading of goods, services and *money*. Economic markets assume the existence of some form of currency to serve as a universal trading unit. In our study of markets, we generalize from these requirements. Nevertheless, our considerations are indeed inspired by literature on economic theories. Our considerations are primarily based on [2, 3, 4] 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* and *Execution of services* (which can be split further into *transformation of entities* and *reduction of uncertainty*). Even though one may hold the position that in the case of markets dealing with physical goods, it are the physical goods which are the entities being traded, we take the view that what is *actually* traded is the *ownership* of these entities. Trading entities on a market can, in our view, only be discussed if these entities can be regarded as being *owned* by some participant in the market. Trading an entity involves a *change* of ownership. In the next section we will discuss some information market pendants of these classes of services. Let us now explore markets in more detail.

2.2 Transactions

Let p_1 and p_2 be two participants of the market, and let a_1 and a_2 be two assets that are on offer by these two respective participants. The participants may decide to trade these assets, leading to a *transaction*.

In economic markets, one is used to referring to participants as either being a *selling* or a *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. In the example given above, one could state that participant p_1 sells asset a_1 to participant p_2, making p_1 the selling and p_2 the buying party. By the same token, however, one could state that participant p_2 sells asset a_2 to p_1. We argue that there is nothing wrong with this duality.

It is only our day-to-day use of the terms *sell* and *buy* in the context of the *economic markets* that have lead to a uni-directional view on selling and buying. The "pre-occupation" of economic market with the role of *money* as a universal means of trading has produced this default interpretation of seller and buyer.

The sales of an asset by a participant to another participant, will be referred to as a trans*actand*. 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 $\mathsf{Participants}(t) = \{s, b\}$. Similarly, the buyer and seller 'role' within a transactand are given by $\mathsf{Buyer}(t) = b$ and $\mathsf{Seller}(t) = s$ respectively. A transaction can now be regarded as being a set of transactands. If T is a transaction, then we can define: $s \xrightarrow{a} b \in T \triangleq \exists_{t \in T} \left[t : s \xrightarrow{a} b \right]$. The set of participants involved in a transaction are defined as: $\mathsf{Participants}(T) \triangleq \bigcup_{t \in T} \mathsf{Participants}(t)$. As a rule we will require:

[IM1] $t_1, t_2 \in T \wedge t_1 : s \xrightarrow{a} b \ \wedge \ t_2 : s \xrightarrow{a} b \ \Rightarrow \ t_1 = t_2$

In other words, the involved participants and asset uniquely determine the transactand in a transaction. Even more so, a participant can not play the buyer and seller role in one single transactand:

[IM2] $\forall_{t \in T} [\mathsf{Seller}(t) \neq \mathsf{Buyer}(t)]$

There is usually some *benefit* to the participants of a transaction, even though this may be an *'artificial'* benefit such as holding on to one's life in the case of a *you're money or your life* situation. As such, a transaction is not just any set of transactands; each participant in a transaction must both receive and pay an asset:

[IM3] $\forall_{p \in \mathsf{Participants}(T)} \exists_{t_1, t_2 \in T} [\mathsf{Seller}(t_1) = p \wedge \mathsf{Buyer}(t_2) = p]$

Also, transactions are assumed to be 'singular' in the sense that participants of a transaction play the buyer and seller role exactly once. 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. We assume $\mathcal{GL}$ to be the set of possible goals a participant may have, and $\mathcal{PA}$ of participants on the market and $\mathcal{ST}$ 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 $\mathcal{GL}$. Let the function: $\mathsf{Id} : \mathcal{ST} \rightarrow \mathcal{PA}$ identify which states belong to which participant. Given the state s of a participant $\mathsf{Id}(s)$, we can view the satisfaction of the goals which the participant (in a certain state!) may have as a function: $\mathsf{Satisfaction} : \mathcal{ST} \times \mathcal{GL} \rightarrow [0..1]$.

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 $s \ltimes T$ is the state which results after the participation of $\mathsf{Id}(s)$ in transaction T. We require the resulting state to belong to the original participant and the participant to be a participant of the transaction:

[IM4] $\mathsf{Id}(s) = \mathsf{Id}(s \ltimes T)$

[IM5] $\mathsf{Id}(s) \in \mathsf{Participants}(T)$

We will use $t : s_1 \xrightarrow{a} s_2$ as an abbreviation for: "In transactand t, participant $\mathsf{Id}(s_1)$ in state s_1 sells asset a to participant $\mathsf{Id}(s_2)$ in state s_2":

[IM6] $t : s_1 \xrightarrow{a} s_2 \;\Rightarrow\; t : \mathsf{Id}(s_1) \xrightarrow{a} \mathsf{Id}(s_1)$

The set of states involved in a transaction is identified as:

$$\mathsf{States}(T) \triangleq \left\{ s_1 \;\middle|\; \exists_{s_2,a} \left[s_1 \xrightarrow{a} s_2 \in T \;\vee\; s_2 \xrightarrow{a} s_1 \in T \right] \right\}$$

2.3 Costs and Benefits

The actual benefit of an asset is difficult to measure. This also makes it hard for participants to assess whether they wish to purchase/consume the resource or not: the only way to assess the true benefit is by consuming it! 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:

$$\mathsf{Benefit}(s, T) \triangleq \lambda_{g \in \mathcal{GL}}.\mathrm{MAX}(\mathsf{Satisfaction}(s \ltimes T, g) - \mathsf{Satisfaction}(s, g), 0)$$

The costs of an involvement in a transaction can be defined as the negative impact on the satisfaction levels of a participant:

$$\mathsf{Cost}(s, T) \triangleq \lambda_{g \in \mathcal{GL}}.\mathrm{MAX}(\mathsf{Satisfaction}(s, g) - \mathsf{Satisfaction}(s \ltimes T, g), 0)$$

Given a relative prioritization of the different goals, a weighed level of satisfaction could be computed. Let $\mathsf{Priority} : \mathcal{ST} \times \mathcal{GL} \rightarrow [0..1]$ therefore be a function which identifies 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:

[IM7] $\forall_{s \in \mathcal{ST}} \left[\sum_{g \in \mathcal{GL}} \mathsf{Priority}(s, g) = 1 \right]$

With this weighing function, we can define the overall satisfaction as follows: $\mathsf{Satisfaction}(s) \triangleq \Sigma_{g \in \mathcal{GL}}\, \mathsf{Satisfaction}(s, g) \times \mathsf{Priority}(s, g)$. The (micro)economic assumption of rational behavior can now be reformulated as follows: if two people are in the same *state* (i.e. have the same level of satisfaction) and the same goal, then actually executing a transaction will have the same cost/benefit for these players. An increment in satisfaction does not have to be a *hard* goal such as the quantity of possession, but could also be a *soft* goal such as social esteem or appreciation by friends. It seems sensible to presume that the level of satisfaction of all participants of a transaction should not decrease:

[IM8] $\forall_{s \in \mathsf{States}(T)} [\mathsf{Satisfaction}(s) \leq \mathsf{Satisfaction}(s \ltimes T)]$

2.4 Value Addition

Given some tradable asset, it may be possible to increase the value of this asset by means of a transformation. From the perspective of some participant (state) the transformation may, or may not, be value adding. If a is an asset, and $S(a)$ is the asset which results after performing some transformation S to it, then the added value of performing S to a, in the *context* of a participant in state s and a

transaction T, can be defined as: $\mathsf{AddedValue}(S,a)[s,T] \triangleq \mathsf{Satisfaction}(s \ltimes T) - \mathsf{Satisfaction}(s \ltimes T^a_{S(a)})$, where $T^a_{S(a)}$ is the transaction which differs from T *only* in that all transactands involving a have been changed to involve $S(a)$. More formally:

$$R^a \triangleq \left\{ s_1 \xrightarrow{a} s_2 \;\middle|\; s_1 \xrightarrow{a} s_2 \in T \right\}$$
$$A^a_{a'} \triangleq \left\{ s_1 \xrightarrow{a'} s_2 \;\middle|\; s_1 \xrightarrow{a} s_2 \in T \right\}$$
$$T^a_{S(a)} \triangleq (T - R^a) \cup A^a_{S(a)}$$

An obvious example is the market for antiquities such as paintings. It is unlikely that intermediaries will 'transform' the painting itself. They do, however, add value in the sense of an appraisal, insurrance etcetera.

3 Particularities of the Information Market

3.1 The Assets

In accordance to [5] 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 [6]: any entity that is accessible on the Web and which can provide information to other entities connected to the Web. A definition which truly supports the open character of the net. Examples of information carriers included are: web pages free text databases, traditional databases and people's e-mail addresses. Note that even though the trading is about information resources, it are actually different levels of ownership/usage rights that are traded. Quite often, the resources will actually be available for free. That is to say, the amount of Euros one has to hand over in exchange is close to zero. As we will see below, the costs/benefits of information resource involves more than the amount of money that is handed over. In addition to trading of ownership/usage of information sources, services pertaining to these information sources are traded as well. Such services may include transformation of an information resource's storage format or translation of an information resource from one language to another. 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.

3.2 Transactions

A future consumer of an information resource should 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.

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 (and searching!) process. For example, timeliness is a good reason for turning to a (good) search engine when searching for some specific information.

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. The utility domain deals with the information that may be provided by a resources and the timeliness. The structure domain is concerned with the form (report, painting, movie, audio) and format (PDF, MP3) of a resource. Lastly, the emotion domain deals with the emotional effect (pretty/inspiring) that a resource may have when it is "consumed". This benefits-taxonomy can be used to explore the potential benefits of resources in diverse situations. For instance, in case of art the emotional benefit is likely to be more important than in the case of technical reports, for searchers using a WAP or I-mode based connection the structural aspects are likely to be of high importance.

The costs associated to a resource also fits the above discussed multi-dimensional domain. For a searcher these costs would, for example, include: *Utility*: the costs of actually obtaining the resource such as search costs (time and money), costs for the Web-connection etc; *Structure*: the amount of disk space needed to store the information resources at a convenient location, computing capacity needed to display the information resource, etc; and *Emotion*: the costs associated to actually conceiving the resource (i.e. the cognitive load associated with interpreting and understanding the resource. These are costs from the informational domain. For a publisher these costs would, for instance, include: *Utility*: the costs associated to creating the resource such as time and effort; *Structure*: the costs associated to storing the resource such as disk space, as well as required computing power in creating the resource; and *Emotion*: Intellectual energy needed to create the contents of the resource. This may also be referred to as cognitive load [7].

3.4 Value Addition

Value addition on the information market may be achieved by the earlier discussed services, such as: (1) transformation of an information resource's storage format, (2) translation of an information resource from one language to another,

(3) aiding searchers in articulating/formulating their specific need for information, and (4)matching demand for information to supply of information. Traditionally, information retrieval focuses on (4) with extensions towards (3). In our opinion, theories are needed to underpin all services that enable the working (value addition) of the information market. Such theories will need to take the goals of all participants of the market into consideration.

4 Conclusion

At the start of this paper we 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 narrowed down 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 on the information market will in particular be fruitfull in improving the workings of the information market. Most importantly, we expect this to be most helpful in the retrieval of relevant information by by searchers in the information market. This, however, requires a thorough and fundamental understanding of the goals of the participants on the market and how the traded information resources may contribute towards these goals, i.e. what their costs/benefits are with regards to these goals.

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