# “Liquid” Electronic Marketplaces

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**Abstract**. “Neutral” electronic marketplaces fail because their structure and mode of operation does not allow for the effective accommodation of multiple business models that could serve the interests of a critical mass of adopters. We propose a fresh approach for the creation of economically viable “neutral” electronic marketplaces showing that this can be accomplished through the ability to transcend taxonomical classifications with a generic agent-mediated ontology and, simultaneously, through the provision of flexible and active decision support. Taxonomies may stifle innovation by imposing artificial boundaries through categorization schemes and levels of abstraction. The proposed architecture addresses this issue underlying a “liquid” e-hub that may mutate from one taxonomical classification to another.

## 1 Introduction

The phenomenal growth of Internet-based information services and infrastructure in the recent years has provided a new technological basis for enabling and expanding the electronic execution of commercial transactions both on a business-to-business (B2B) and on a business-to-consumer (B2C) level. According to the Economic Review of the Federal Reserve Bank of Kansas City in the second quarter of 2004, B2C e-commerce sales grew at an annual rate of 34 percent from 1999 to 2003 while, between 1999 and 2002, B2B e-commerce sales grew at an annual rate of 5.5 percent in the United States [1].

Electronic Marketplaces were mainly single-vendor sites at the onset of the e-Commerce revolution but since the end of the nineties they have increasingly played the role of an aggregator that merges potentially thousands of vendors and customers either as B2C virtual malls or as B2B electronic hubs. Kaplan et al. have introduced in [2] a well-referenced taxonomy that classifies B2B e-hubs based on 4 dimensions: what businesses buy (i.e. horizontal vs. vertical – operating supplies vs.

manufacturing inputs), how businesses buy (i.e. systematic sourcing vs. spot sourcing), source of value creation (i.e. aggregation vs. matching), and bias of e-Hubs (i.e. neutral vs. biased). Notwithstanding the short history of electronic marketplaces, several studies have identified a number of key success factors including: development of a critical mass of transactions, maintenance of a balance among the conflicting interests of participants, maximization of participants' benefits and implementation of features that create advantage and loyalty [3]. Albeit the substantial growth of the e-Commerce sector, some analysts have noted that many "neutral" e-hubs are shutting down because of an insufficient number of adopters [3].

This paper endeavors to propose a novel approach for the creation of economically viable "neutral" e-hubs based on the success factors that have been identified in the literature. Our approach is twofold:

- On the one hand, based on the work of Kontolemakis et. al [4], we suggest that "neutral" e-hubs must be characterized by openness and flexibility with respect to other taxonomical classification dimensions in order to achieve and sustain a sufficient volume of transactions in an unstable market environment as well as to be capable of maintaining a balance among the participants.
- On the other hand, we advocate the provision of intelligent services that will assist buyers and sellers in the course of their decision making processes as a feature that will help to enhance their satisfaction and loyalty taking into account what Herbert Simon noted as early as 1971: "What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it." [5]

## 2 "Neutral" e-Hubs: Viability Issues

Kaplan and Mohanbir [2] have identified bias as an important dimension along which an e-Marketplace is described. "Neutral" e-Hubs have been defined in their paper as marketplaces that do not favor buyers over sellers and vice versa (in opposition with "biased" e-Hubs). "Neutral" e-Hubs are true "market-makers" attempting to aggregate many buyers with many sellers. By definition, e-Marketplaces of this type face a "chicken and egg" problem: buyers will not participate unless an adequate number of sellers exist and vice versa.

E-Hubs are categorized to ones that work under pre-negotiated contracts (systematic sourcing) and to ones that function under direct negotiation (spot sourcing). For the first, the conditions are not favorable for small participants since they cannot achieve the same terms and discounts as large users who buy large quantities through the E-Hub. For the second, the conditions are not favorable for large clients since even if they buy a lot from the E-Hub they sometimes during the auction may end up buying to a steeper price than a small business. Accordingly, an E-Hub offering both spot and systematic sourcing may help to avoid the appearance of phenomena that relate to the 'chicken-and-egg' problem. Thus, "neutral" e-hubs require two-sided liquidity.

One of the main obstacles in the evolution of current and future E-Hub implementations is that not all companies are eligible to participate in them no matter how big or small they are if they don't abide to the 'laws' of the E-Hub that controls what to present and how to present it. This stems from the fact that every company has different types of products and services and a different customer base to deal with. Even if they have the same product categories, they may present them differently to their clients emphasizing on special attributes that they only amongst the other hub participants choose to provide (such as a 3 year guarantee plan, etc.). In addition, the taxonomy differentiates E-Hubs to those that deal with manufacturing and to those that deal with operating products. Simply stated, if a company transcends these categories in the physical world, it cannot do it in the virtual.

In addition, we are accustomed to 'seeing' two main types of information systems - B2C *or* B2B. Usually, a system that fall into either one of these categories is largely autonomous without blending in some of the functionality of the other one. Virtually every hub or marketplace created focuses on either B2B or B2C business transactions. An integration of both categories would yield a generic e-hub that caters for all stakeholders across the process flows and covers every step of the way from production to consuming. It is important to note that the taxonomy proposed by Kaplan et al [2] only covers B2B E-Hubs. By importing the "C" parameter to an open and generic E-Hub renders any differentiation – and hence any taxonomy – that distinguishes between B2B and B2C categories largely artificial. The usual method market makers employ for attracting participants is the offering of ancillary services that provide additional value [3]. We propose an integrated approach to face the above issues according to the success factors that, as we mentioned in the previous section, have been identified by several studies as most important:

(1) Development of a critical mass of transactions
(2) Maintenance of a balance among the participants
(3) Maximization of participant benefits
(4) Implementation of features that create advantage and loyalty.

We argue that factors (1) and (2) may be satisfied if the architecture of an electronic marketplace permits mutation from one taxonomy classification to another: support of both vertical and horizontal markets (what businesses buy), support for both systematic and spot sourcing (how businesses buy), support for both aggregation and matchmaking as sources of value creation.

Furthermore, as we mentioned above, we argue that factors (3) and (4) may be satisfied with the provision of flexible and "active" decision support mechanisms that will assist buyers and sellers in the course of their decision making processes, promoting their satisfaction and loyalty by helping them maximize their turnover. Software agents play a crucial role in order to achieve this transcendence of the taxonomy. Their characteristics like situatedness, autonomy, intelligence, social ability, reactivity and pro-activeness would help an "active" DSS to monitor the user actions and proactively provide advice, provide negative and positive critique to the actions of the user, give explanation for its feedback if requested, adapt its feedback to the user profile, based on knowledge captured about the domain and the user profile, handle different business models and present them to the interested user.

A sample listing of current operating "neutral" marketplaces that are financially healthy simultaneously by serving customers in diverse industries and by providing intelligent services assisting buyers and sellers in their decision making processes (e.g. spend analysis, supplier assessment, etc.) is shown in Table 1 [6].

The research described in this paper proposes an agent-based architecture for an open and truly flexible "liquid" electronic marketplace that may mutate from one taxonomy classification to another [2, 4] with emphasis on an agent-based active DSS system that handles different business models.

**Table 1.** Successful "neutral" e-marketplace examples

| *Name* | *Intelligent Services* | *Industries/Segments* |
|---|---|---|
| **Ariba** | Supplier Discovery/Assessment, Sourcing Decision Support, Spend Analysis, Bid Optimization | Consumer Products, Energy, Financial Services, Healthcare, High Technology, Manufacturing, Pharmaceutical, Public Sector/Education, Telecom, Transportation |
| **Emptoris** | Supplier Discovery/Assessment, Sourcing Decision Support, Spend Analysis, Bid Optimization | Financial Services, Telecom, Retail, Energy, Technology Hardware, Healthcare, Capital Goods, Food and Drink, Media, Pharmaceutical, Other |
| **Verticalnet** | Supplier Discovery/Assessment, Sourcing Decision Support, Spend Analysis, Bid Optimization | Consumer Goods, Healthcare, Manufacturing, Retails, Services/Media |
| **Global eProcure** | Supplier Discovery/Assessment, Sourcing Decision Support, Spend Analysis, Bid Optimization | Retail, Manufacturing, Financial Services, Consumer Products, Energy, Entertainment, Food, Gas, Public Sector, Publishing, Real Estate, Transportation, Other. |
| **Perfect Commerce** | Supplier Discovery/Assessment, Sourcing Decision Support, Spend Analysis, Bid Optimization | Chemicals, Retail, Energy, Financial Services, Food, Health, Hospitality, Manufacturing, Technology, Transportation |

## 3 Proposed E-Marketplace architecture

In Figure 1, we show how the three basic components of an E-Market (Ontology, Negotiation, and Decision Support) come together and interact defining as a whole the functionality of the system. The first component is the Generic Product Ontology which is an ontology created so as to cover every possible product or input combinations which can be stored in the systems database. The second one is the Negotiation Agent, who is responsible for managing the negotiation process between the buyer and seller using ontology attributes and for reaching a mutually acceptable promise which is then fulfilled. The third one refers to flexible and "active" decision support system. Flexible, in the sense, that it will accommodate all the diverse needs of the actors in the context of taxonomy classification transcendence and "active" in the sense that it will act proactively to support the decision making processes of the actors (in contradiction with the traditional "passive" Decision Support Systems that required from their users to possess full knowledge of their capabilities and exercise initiative, something that has been criticized since the late eighties [7, 8]).

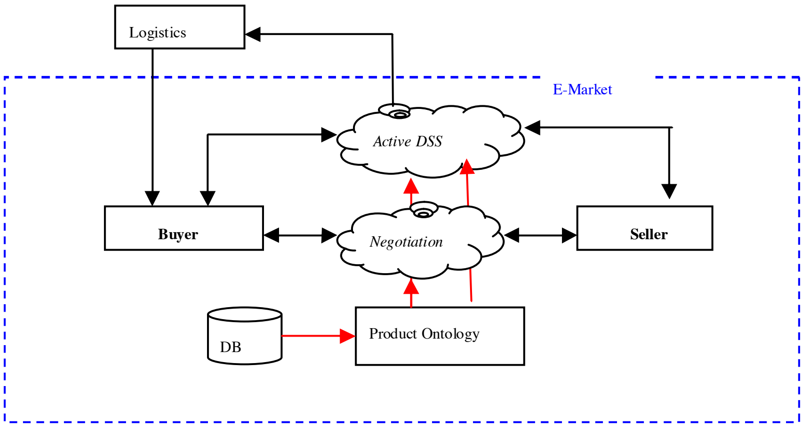


**Fig. 1.** Generic and Agent-Mediated E-Marketplace Architecture

## 4 Ontology design

Our research falls under the design-science paradigm in information systems research [9] where knowledge and understanding of a problem domain and its solution are achieved by engaging in the actual process of building the desired artifact and applying or putting it into use. Two instantiations of the final product have been created and are being tested in a laboratory environment. These are the generic product ontology and the negotiation part of the E-Hub as described in the following paragraphs. The Decision Support System is the next instantiation to be presented in this paper and the final prototype will be created out of the testing of those three.

A flexible and generic E-Hub architecture can mutate from one taxonomy classification to another. In order to achieve this, a generic and thus reusable product ontology is deemed necessary and was created. We have expanded and build upon the model presented in [4] so as to cover every aspect of a modern electronic hub with the addition of 2 components that interact with the DSS presented in the following section whilst striving to keep it as simple and hence as reusable as possible. In Figure 2 the expanded product model is depicted. The **Identifier** is the

ID of the product along with the characteristics that define it. The **Physical** property corresponds to one material when we talk about manufacturing inputs or to a collection of raw materials or other products so that when synthesized an operating input is created. So both manufacturing and operating products are supported by the ontology. The **Functional** property refers to the possible applications of the product, i.e. what this product is used for best. The **Presentational** property is related to the manner and form in which the product is represented to the user. This can be in a form of an image, video [10] or any other 3D-representation. As described in [11], the latter is accomplished by creating a 3D model from images taken as inputs. The **Product Category** property provides the vendor with the ability to classify his product into a broader category. To each category specific properties can be assigned that are derived from the product and are called Special Attributes. The **Special Attributes** property includes alternate characteristics or meta-attributes of a product. This property contributes to producing a flexible system since additional product attributes are not predefined by the ontology, but can be created at run-time by appropriately configuring the Product Category. This property in conjunction with the physical one provides an ontology of such generality and with any special characteristics providing the flexibility to the user to promote his product or service in any way that he see fit. **Strategy** is a property that helps the user to define his deal-making tactics based on the products' negotiable attributes. The **Domain Model** varies according to the taxonomy classification of the e-Hub and type of product. A product belongs to at least one domain model and it is treated as a part of this model following the rules and tasks according to the domain model stored in the database. The **User Model** comprises of user attributes and user preferences represented in terms of hard and soft constraints corresponding to a specific product so that a matching of product-user can be effectively achieved.

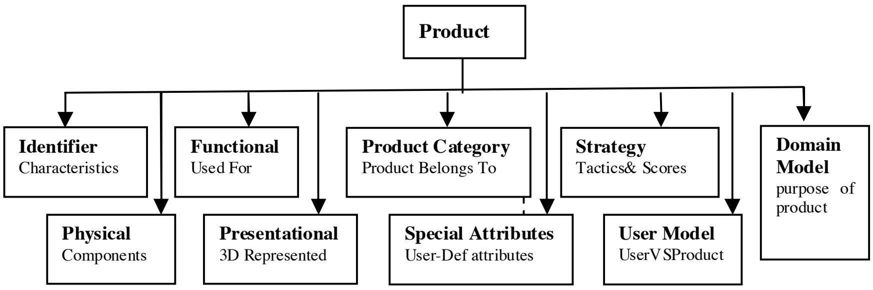

**Fig. 2.** Generic Product Ontology

## 5 Decision support

The dominant approach adopted for human decision making in traditional DSS by the research community has been Simon's phase model [7, 12, 13]. Decision making is perceived in this model as a choice from a number of alternative options to achieve the best outcome from a set of all possible consequences. This model incorporates three phases – Intelligence, Design, Choice – that are used both to describe and explain the decision making process and as a roadmap for building DSS supporting each of the phases [14]. The Intelligence phase is defined as the identification and listing of a subset of all the alternatives which the decision maker will consider; the Design phase is defined as the determination of the consequences of each of the identified alternatives, i.e. the calculation of the pay-off function; finally, the Choice phase is defined as the comparison of the efficiency of the consequences of each alternative resulting to a selection among them. Sprague and Carlson [5] formulated a set of tools as the building blocks for DSS according to these 3 phases: (1) storage, manipulation and access of data tools, (2) tools supporting fitting this data into formal models, and (3) tools incorporating methods and algorithms used to "solve" models in order to reach a decision.

The old-fashioned way of business points out that when a customer becomes a regular client of a shop, the seller offers him better conditions in terms of price, time of delivery, etc. Current E-hubs offer either systematic or spot sourcing according to pre-negotiated or not contracts. With the help of the active DSS system and the agents in it, the spot sourcing oriented E-Hub can easily be mutated into systematic sourcing for a specific buyer. This, for example, can be accomplished when the customer buys a lot from a) a specific seller that can provide him with better terms relating, for example, to price, etc. and b) from not a specific seller but from the same hub where for example having met predefined sales levels, better prices quotes can be offered regarding fulfilment services, etc. The advisor agent of the proposed DSS architecture (Figure 3) keeps track of the buyers' movements and acts accordingly.

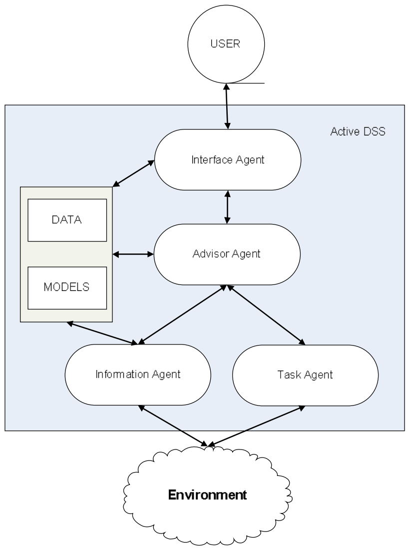


**Fig. 3.** Decision Support Mechanism Architecture

For the first case the agent informs the seller for the specific customer and proposes him to contract the customer with better terms. If the seller agrees, the discount is applied every time the two sides come to a mutually accepted agreement through negotiation. This mechanism favors the vendor in the sense that he receives all the orders and the buyer in the sense that he enjoys better terms. If the contracts that take place consider a discount percentage on the upper or lower limit of the negotiation ranged space attributes and the negotiation is still used then the buyer will still receive lower prices. But if something unexpected happens causing the product's negotiable attribute (usually price) to rise, then the seller would have a chance to apply hard utility factors and functions on the product in the negotiation part of the E-Hub that will enable him not to loose money and to keep his client happy since he/she will still buy cheaper than the others.

For the second case, the task agent informs the corresponding logistics department for the discount in shipping fees as well as the buyer through the interface agent for the discount taken place. Every time the task agent places an order for the specific client it sends the shipping company the reduced fee that should be retrieved from his/her account. This favours the buyers since the E-Hub lowers its transaction/fulfilment costs. Sellers can also be favoured in this E-Hub. When a specific seller completes a lot of transactions he may enjoy a reduction in the rental space of the marketplace. Here the information agent keeping track of all the transactions within the marketplace can decide whether a specific seller can enjoy a reduction in the rental space of the marketplace. This decision is taken by considering not only the value of the goods sold but also the frequency of sales. If the reduction is decided, the seller is informed and a new contract must be signed for the changes to take effect. So the proposed architecture could prompt us to classify it as neutral but offering at the same time the flexibility to become forward, reverse or biased – hence liquidity.

In the context of B2B electronic commerce a Business Transaction Model (BBT) may help the decision maker to move from the abstract goal of profit maximization to specific, tangible sub-goals, by splitting the process in concrete stages, namely: (1) Partnership Formation (i.e. to find collaborators), (2) Brokering (i.e. matchmaking buyers and sellers), (3) Negotiation (i.e. to find agreements), (4) Contract Formation (i.e. to legally contract), (5) Contract Fulfillment (i.e. delivery and payment), (6) Service Evaluation (i.e. transaction feedback). He et al. argue in [15] that only stages (1), (2) and (3) involve complex issues related to decision making, information search and matchmaking and, thus, are candidates for the employment of agent technology facilitating decision support and automation. Based on this analysis, we argue that a "neutral" e-hub striving to be economically viable should provide intelligent decision support in each of these stages. We should also note that the "Service Evaluation" phase may produce valuable data that could be employed by a DSS for the "Intelligence" phase of the subsequent decision making processes. Silverman et al. have identified in [16] the existence of data warehouse technology that may be used by suppliers and aggregators in order to track customer transactions and build descriptive and predictive models of buying patterns, as well as to provide personalized customer services with the help of business rules, collaborative filtering and other matchmaking algorithms (albeit in a B2C context). In a B2C environment stages (2), (3), (4), (5), and (6) are the ones that are used by the marketplace in order to fulfill the process.

Based on the work of Angehrn and Dutta in [17] and of Vahidov in [12], we propose, a decision support architecture for "liquid" B2B electronic marketplaces that extends the traditional "roadmap" defined by Sprague and Carlson in [18] by incorporating: (1) the use of "stimulus" agents that act as advisors providing alternatives or as "devil advocates" challenging the actions of decision makers in the course of the decision making processes related to the aforementioned stages of the BBT model, (2) "situating" decision support systems within the problem environment through the use of information and task agents that will act respectively as sensors and effectors and (3) interface agents effectively employing novel methods in human computer interaction with emphasis on conversational methods to capture knowledge from the decision makers [19].

The architecture we propose is comprised of the following components: Interface Agent; Data and Models; Advisor Agent; Information Agent; and Task Agent (Figure 3).

The "**Data and Models**" compartment contains data and models relevant to decision making: (1) The Domain Model, captures knowledge of one particular domain, i.e. pharmacological ontology, or printer ontology. It comprises of a hierarchical task representation of the respective e-commerce process along with the knowledge base (rules, cases, relevant information sources) pertaining to the decision making process. These ontologies-models provide detailed description of the domain. Domain ontologies use the whole set of modeling primitives, like (multiple) inheritance, numerous slots and relations, etc. They are complex in structure and are usually constructed manually. As stated in [20] it is not feasible to think of knowledge needs of all foreseeable domain applications. Hence, in our case, the domain ontology serves as many reusable knowledge entities that can be shared across the e-market domain [20]. Each new entity is stored in the DB and relations are created with existing entities. In this way any model whether it originates from B2C or from B2B domain, from vertical or horizontal markets and so on can be stored in the ontology. The demanding task of extracting or importing domain models accordingly is left in the Information Agent component of the DSS mechanism. In this way the taxonomy of Kaplan et al [2] can be transcended since our proposed e-marketplace comprises of all possible markets stored in the ontology and used by the Decision Support Multi-Agent System accordingly. (2) The User Model, captured by the Interface Agent, comprising of user attributes and user preferences represented in terms of hard and soft constraints. User attributes are domain specific characteristics of the user (e.g. annual turnover of a company, customer salary, etc). User preferences may be modeled as a Utility Function that associates criteria with weights or as a Vector pay-off function with satisfactory aspiration levels for each criterion according to the behavioral model of rational choice introduced by Simon [21]. This will be accomplished through the use of a Constraint Satisfaction Formalism: hard constraints (limits for specific criteria beyond which pay-off become zero) correspond to the aspiration levels of the behavioral approach; soft constraints (limits for specific criteria beyond which pay-off is diminished) correspond to the preference statements in a multi-attribute utility function.

The **Interface Agent is** responsible for interaction between the user of the e-Hub and the decision support mechanism. Its aim is to capture user's attributes, preferences, objectives, hard and soft constraints in order to elicit a user model supporting the decision making process. The method employed for capturing user needs follows a conversational approach based on inference according to rules applicable in the domain model (different for each taxonomy classification of the e-Hub and/or user role). Conversations as a method for eliciting user preferences have the advantage that they provide control over the process to the user, incorporate intelligence that make easier for the user to specify his requirements in an iterative way and also may provide feedback about the progress of the process [22, 19]. Moreover, the Interface Agent is responsible to convey advice generated from the Advisor Agent to the user. In order to perform these tasks the Interface Agent accesses Data and Models. There are several issues to be taken into account in the design of the Interface Agent as far as presentation and interaction are concerned. First, it must be ensured that the look-and-feel of the advice will be aesthetically appealing and functional. Interaction design should meet requirements posed by the intent of the advice (e.g. influencing timing of the advice) as well as regarding the desired level of intrusiveness [22].

The **Information** Agent is responsible to gather information from the environment and store it in the Data and Models compartment. The Information Agent is invoked by the Advisor Agent to retrieve necessary data for decision support from an information source specified in the knowledge base. For example, it may access the Data Warehouse of the e-Hub to capture past transactions of a specific buyer after a command from the advisor agent, in the course of providing decision support to a seller.

The **Task Agent** is responsible for the execution of a user decision, e.g. to enforce a specific pricing policy after a relevant decision made by the seller in the context of the previous scenario.

Last but not least, **the Advisor Agent** which is the core of the decision support system. The Advisor Agent dynamically influences the decision making process of the user by assuming three different roles: Proposer, Proponent and Opponent. These roles are based on the scientific community metaphor introduced by Kornfeld and Hewitt [23] in machine problem solving. The proposers suggest solutions to the problem, e.g. specific product recommendations, the opponents criticize the proposed solutions while the proponents defend, explain and extend the proposed solutions. In the proposer role, the Advisor Agent provides suggestions for the decision making process according to: condition-action rules pertaining to the Domain Model and its respective task hierarchy, case based reasoning based on similarity analysis of cases stored in the Domain Model. In the opponent role, the Advisor Agent critiques the suggestions of the proposer or the actions of the user based on his/her preferences, objectives and constraints. In the same manner, in the proponent role the Advisor Agent provides positive feedback stressing the strengths of the suggestions of the proposer or the actions of the user.

This architecture incorporates agents that may:

- support each of the phases of Simon's model (Information Agent, Advisor Agent),
- provide positive and negative critique to the actions of the user allowing him/her to reformulate the problem,
- situate the DSS within the problem environment (Information Agent, Task Agent),
- employ novel methods of human computer interaction (Interface Agent).

On the other hand, it encompasses knowledge structures that may:

- support taxonomical transcendence of the electronic marketplace (Domain Models),
- support evaluation and comparison of alternatives according to both classical and behavioral theory (User Model).

## 6 Conclusions and Further Research

The aim of this paper has been to propose a novel architecture for the creation of economically viable "liquid" e-hubs. We have argued that this can be accomplished through the ability of a "neutral" electronic marketplace to transcend other taxonomical classification dimensions and, simultaneously, through the provision of flexible and "active" decision support that will enhance the satisfaction of buyers and sellers by assisting them in the course of their decision making processes.

We have introduced a generic agent-based e-marketplace architecture and expanded the product ontology as was introduced by Kontolemakis et al. in [4], by adding factors that support the DSS part of the proposed e-marketplace. We showed how this architecture transcends the proposed taxonomy of Kaplan and Mohanbir [2] and moved one step down by describing concepts and techniques for the design and implementation of decision support systems that operate in a flexible and proactive manner. We referred to certain principles of decision-making as presented in research literature; described how they can be employed in our context and proposed a simple and reusable agent-based architecture facilitating decision support in a "liquid" E-Hub capable of mutating from one taxonomy classification to another. Our future research will focus on the implementation of a prototype and its subsequent evaluation following the design research paradigm as described in [9].

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