SYSTEMATIC DESIGN OF ELECTRONIC MARKETPLACES

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Abstract

Electronic Marketplaces have emerged as key information and transaction nodes within the supply chain, which are at the center of the current revolution, of automation at the level of the extended enterprise. In this paper we wish to apply some of the existing tools for manufacturing systems design, such as IDEF models, in the development of electronic marketplaces. The processes involved in the set-up, operation and maintenance of an electronic marketplace are mapped and presented.

1. Introduction

Enterprise automation has progressed through many stages of evolution, as a result of technological advancement in computational and related engineering fields, while being associated with ever increasing efficiency and competitiveness. The focus of companies has slowly moved from factory floor automation to enterprise-level automation and currently to supply chain automation.

The first wave of automation, namely factory floor automation, was typified by control systems managing manufacturing activities and machines. These control system were responsible mainly for efficient manufacturing capacity utilization. This wave was followed by the second stage of innovation saw the wide spread deployment of Enterprise Resource Planning (ERP) packages. These ERP packages automated transaction processing and optimized performance within a single organization, thereby lowering the operating costs of the organization. However, the ERP packages were limited in their ability to foresee and react to the external market environment, on both the demand and the supply side. This meant that even though an organization could optimally plan its internal activities, it would still need to make unnecessary investments in resources to be able to cater to the uncertainties of its supply and demand. This was before the Internet.

The explosive growth of the Internet in the 90s has provided the ideal platform for universal sharing of information and services. The third and current wave of enterprise automation technologies, built to harness the power of the Internet, seek to optimize business processes not only within a single organization, but also across a series of connected organizations in a supply chain network. The current focus of business automation solutions is on the automation of processes across the inter-organizational interfaces, where transactions involving more than one party take place, as shown in Figure 1. The range of Business-to-Business offerings under the umbrella of E-Business characterizes these solutions.
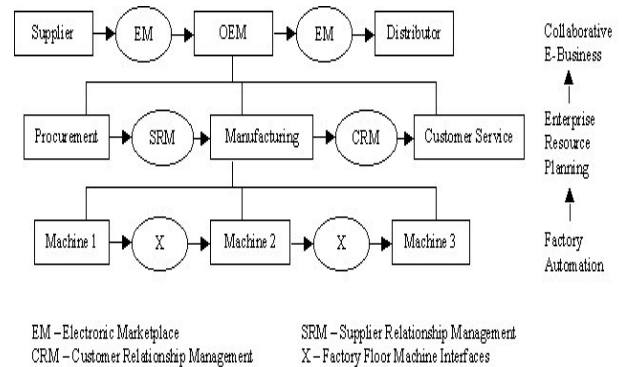

EM – Electronic Marketplace   SRM – Supplier Relationship Management
CRM – Customer Relationship Management   X – Factory Floor Machine Interfaces

Figure 1: Electronic Marketplaces as B2B Interfaces [1]

Electronic Marketplaces

The most important development in business-to-business E-Business has been the proliferation of electronic marketplaces. Electronic marketplaces are similar to physical marketplaces wherein buyers and sellers gather together to transact in goods, services and information. However, unlike traditional marketplaces, all the interaction between the buyers and sellers takes place in a virtual environment, through web-based search, negotiation and collaboration tools.

E-marketplaces are expected to dominate business relationships in the years to come, as highlighted by the AMR Research study, which predicts that Private Trading Exchanges will form the cornerstone for the $5.7 Trillion worth of Business-to-Business commerce that will be conducted online in the year 2004 [2].

The main reason for such a profound impact of these exchanges is that they have revolutionized inter-enterprise business processes and interfaces, by

smoothening out the transactions and information flow between companies, much like what ERP did for processes and interactions across departments in the same organization. This has enabled greater overall efficiency in a supply chain network and made possible completely new business models by formation of new relationships, such as that between manufacturers and end-customers, which were previously unimaginable.

Electronic marketplaces primarily provide a platform for companies to locate, manage and collaborate with their partners, thereby reducing the effort expended in sourcing for reliable products and suppliers and coordinating with them. Additionally, they incorporate convenient, cheap and well-administered processes that cut down on procurement costs of companies. Consequentially, the direct benefits accruing for an organization by participation in an electronic marketplace are Search Cost Reduction, Transaction Cost Reduction, Workflow cost reduction and Fulfillment cost reduction as listed below in Table 1.

Table1: Cost Reductions

Search Costs	Costs associated with sourcing for and identifying potential trading partners and the required products. Can be very significant in a fragmented market with large number of product offerings. E-markets eliminate this cost by aggregating information on all the industry players and products in a central searchable location.
Transaction Costs	Transaction costs are related to the inefficient coordination processes involved in bilateral trading. These processes are often paper and telephone based, labor and time intensive and error-prone. Instead of relying on asynchronous telephone and fax communications, buyers and sellers can at their convenience readily access information relevant to them on their respective web-based marketplace consoles.
Workflow Costs	The administrative costs involved in the internal product selection, approval and procurement process. These costs can be easily eliminated by the digitization of the documents and automation of the workflow in a marketplace.
Fulfillment Costs	The costs incurred due to the lack of visibility into the supply chain. Increased visibility of the fulfillment status, through information sharing in a marketplace, allows businesses to better react to unforeseen delivery problems more effectively, allowing them to lower buffer stock requirements and hence saving on the inventory holding costs.

The above listed cost savings are no doubt very attractive to all industries. However, depending upon the nature and characteristics of the industries the significance of the various benefits may differ. Accordingly the architecture of the marketplace will vary as well. Nevertheless, the basic architecture and functionalities of an electronic marketplace are pretty standard and is presented below in Figure 2.
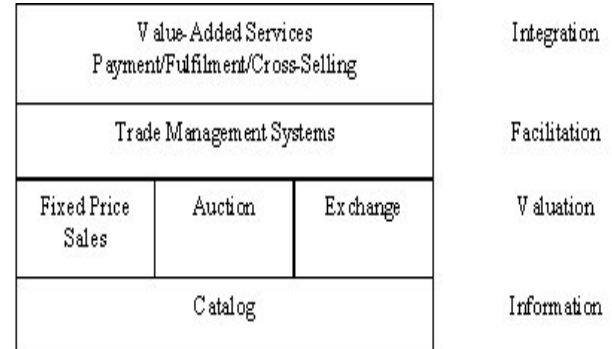

Figure 2: Architecture of an electronic marketplace

The four main functions of an electronic marketplace are information, valuation, facilitation and integration. Information in the form of searchable industry product catalogs or supplier directories is the most basic functionality offered by an electronic marketplace and is the foundation on which electronic marketplaces are built. Valuation tools such as fixed-price based shopping carts, auction engines or negotiation based exchange services allow transactions for products and services. Transaction facilitation through automation of the business processes such as credit checking and shipment scheduling is also offered by some trading exchanges. However, the most significant benefit results from the integration of the marketplace with the enterprise systems of the buyers and sellers and third-party service providers, thereby allowing automation of the entire inter-organization interaction. As may be expected, the architecture and the value adding services offered by the electronic marketplace will differ significantly depending on the characteristics of the industry that it serves.

Literature Survey & Motivation

There is quite a bit of literature relating to the design of automation technologies for factory-floor automation and for business process reengineering and automation in companies. However, there has not been any attempt to extend these concepts to the design of supply chain networks and e-business systems. In particular, given the importance of electronic marketplaces and their unique design requirements for each separate industry, there is a need to develop a methodology to map the characteristics of the industry to the specific functionalities required from the electronic market. We hope to bridge the gap through our approach of using IDEF models to map the various business and technical processes involved in the setting up an electronic market. Our effort we hope will

aid business and technical decisions for companies wishing to set-up or join an electronic marketplace.

2. IDEF Models

IDEF (Integrated Computer Aided Manufacturing (ICAM) DEFinition) is a standard modeling language developed by the US Air Force for Integrated Computer Aided Manufacturing (ICAM) in the 1980s and has been successfully used in a variety of scenarios since then. The basic approach in the development of IDEF was to develop and apply structured system engineering methods for manufacturing system analysis and design.

IDEF diagrams are based on simple rules that govern the graphical representation of a system or process. IDEF uses functional decomposition thereby providing a mechanism wherein only relevant amount of detail is presented at a given level. This allows a general higher-level understanding and also a detailed view of the process being analyzed through as many levels of low-level details as necessary. The above-mentioned functionality allowing easy mapping of processes and drill-down to lower-level details makes the IDEF methodology ideal for analysis and design in business process reengineering. So far, IDEF diagrams have been used to model a variety of systems and processes such as Computer Integrated Manufacturing Information Systems Design [3], evolutionary development of enterprises [4], and processes to complexity management [5].

3. Design of an Electronic Marketplace

The process of designing, implementing and operating an electronic marketplace comprises of a series of complex and inter-dependent activities, which are directed not only by the technical requirements of the task but also by the associated people and management issues.

On a very high-level the Design and Operate an Electronic Marketplace Process, as shown in Figure 3, describes the inputs and outputs the creation of an electronic marketplace. Specifically, the presentation and functionalities of an electronic marketplace will depend on environmental factors such as the IT infrastructure of the country and region being served and the tax regulations, laws and languages of the region. More importantly, the characteristics of the market and the domain knowledge of the marketplace owner or operator in the particular market influence the variety and the usefulness of the functionalities offered by the market. Apart from these factors, the technology familiarity of the marketplace implementer is another crucial input as shown in Figure 3. This process in return produces an operating marketplace with fulfilled transactions and cost-savings to the participants.

The overall design and operate process can be broken down into sub-processes dealing with gathering of design

requirements, implementation of the system and operation of the system as shown in Figure 4. The process begins with an attempt to narrow down the scope of the electronic marketplace, based on the market and regional information, to the regions and industries, which are ready for adoption of electronic marketplaces. The designer of the marketplace then needs to collect information of the needs of the participants using the marketplace. This information goes into the technical design process, which generates the functional specifications that are implemented and tested before the marketplace operations are launched. Additionally, the marketplace owner needs to continuously seek and form alliances with partners who can add value to the marketplace.
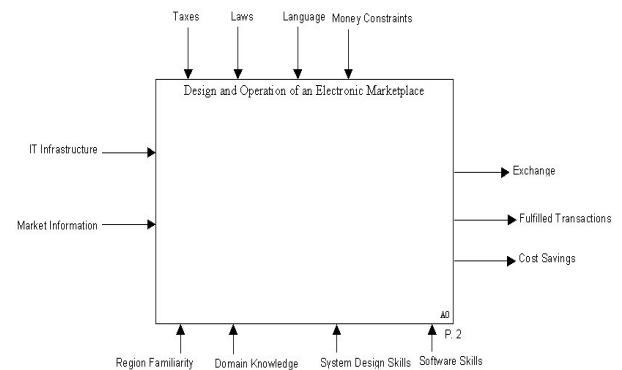
Figure 3: Design and Operate an Electronic Marketplace.
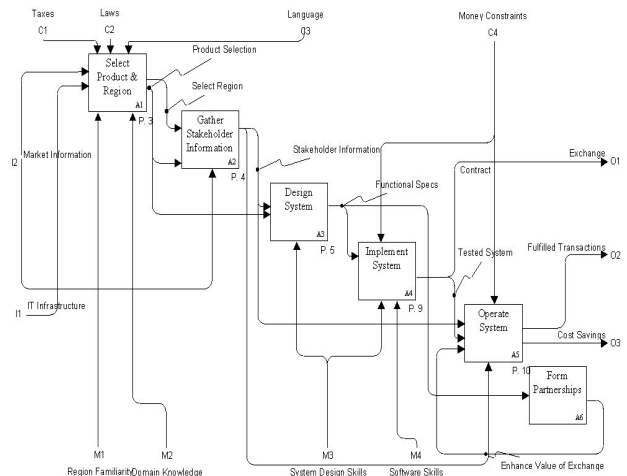
Figure 4: Sub-processes in the Design and Operate Electronic Marketplace process.

A further breakdown of the sub-processes in Figure 4 is presented in Figures 5-10. A detailed process map for the Select Product and Region process is presented in Figure 5 and describes the environmental and market data inputs to this process that generate the product and region focus for the marketplace. The Gather Stakeholder Information process, described in Figure 6 involves the identification of participants in the marketplace based on some criteria, determined from market research, and obtaining information on their processes and systems.

The Design System process forms the core of the electronic marketplace design process. This process

gathers the stakeholder information, the information on the product characteristics and the industry characteristics to generate the system design as shown in Figure 7. In this process a variety of characteristics such as the level of information sharing between partners, the IT capabilities of the participants, the presence of existing digital content, the use of preferential agreements in relationships, the differentiation of product offerings, perishability of products, fragmentation of the market, information-disparity in the market, certification requirements, payment terms, volatility of price and stock in the market and vendor search costs are determined and considered for the system design.
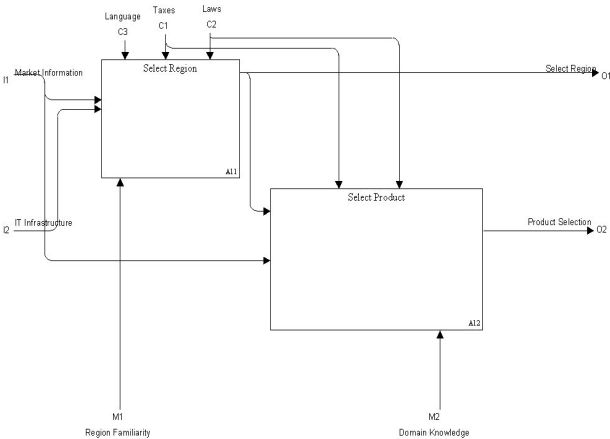

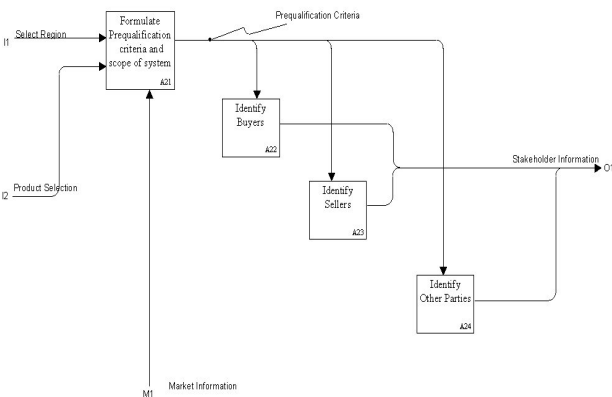Figure 5: Product and Region Process
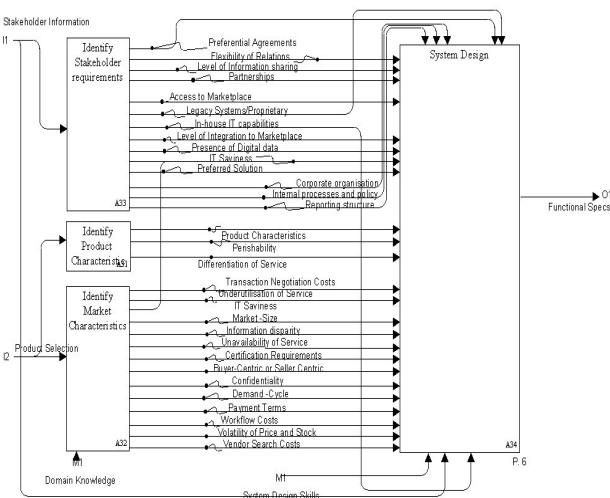

Figure 6: Gather Stakeholder Information

Figure 7: Design System Process

The process of System Design presented in Figure 8 matches the characteristics of the marketplace to the functional specifications of the electronic marketplace software. The System Design involves the Algorithm Design for matching within the marketplace, Design Features process for design of critical and value-adding services, Design Backend Integration process for design of the software modules for backend integration with enterprise systems, Workflow Automation Design process, Design User Interface process and the Gather Data Objects Requirements process for design of the data structures needed to support the implementation of the system.
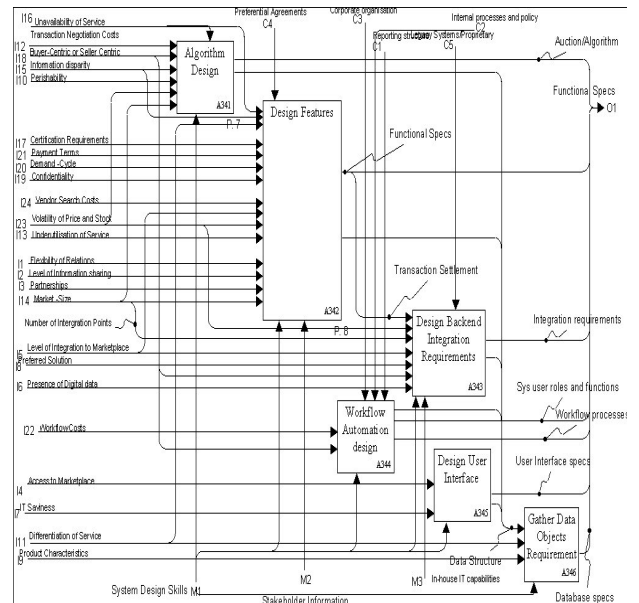

Figure 8: Sub-processes in the Design System Process

A brief description of some of the above mentioned sub-processes in the System Design process is presented below, while the Algorithm Design and Design Features processes are discussed in the subsequent paragraphs.

1. The Design Backend Integration process generates the integration requirements based on the level of integration needed to the marketplace and the number of and flexibility of the required integration module.
2. The Workflow Automation Design process is a critical process where workflow costs in an electronic buying process are significant, such as in the case of E-procurement of indirect materials.
3. The design of the user interface will depend on the characteristics of the Internet link through which the marketplace is accessed and the IT saviness of the users.
4. The critical activity of designing the database driving the marketplace will depend on the properties of all the services offered by the marketplace, as generated by the various sub-processes in the System Design process.

Unavailability of Service
C1

Transaction Negotiation Costs
I1
Information disparity
I3
Perishability
I4
Volatility of Price and Stock
I5

Decide between auction, exchange & catalog
A3411

Auction Type/Exchange/Catalog

Data Structure
O2

Decide M21 or 121 or M2M
A3413

Auction/Algorithm
O1

Market -Size
I6

Additional Features
A3414

Auction Selection

Proxy Bidding & Auto-Extension

Buyer-Centric or Seller Centric
I2

Reverse Auction or Std Auction
A3412

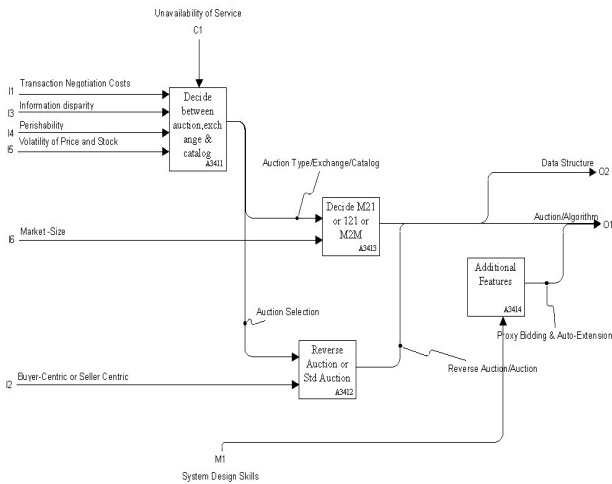Reverse Auction/Auction

M1
System Design Skills

Figure 9: Algorithm Design Process

The matching algorithm of the marketplace will very much depend on the characteristics of the product chosen and the market as shown in Figure 9. Based on transaction negotiation cost, the information disparity in the market, the perishability of the product and the volatility of the price and stock the matching algorithm might be a fixed price sale, an auction or a negotiated exchange. For example, if the product is highly perishable or rare or if there is an information disparity in the market, the preferred mode of sale would be an auction. If the transaction negotiation cost is significantly high the buyers and sellers will prefer to trade on a fixed price sale thereby removing the cost of negotiating. Also if the price and stock of the product being traded is highly volatile the preferred mode of transaction will be a negotiated exchange. Furthermore, depending on the number of buyers and sellers in the market the algorithm will need to be designed for a one-to-one, many-to-one or many-to-many matching. Additionally, in the case of an auction-based electronic marketplace the buyer-centric or the seller-centric nature of the electronic marketplace will determine if the auction is a standard auction or a reverse auction. Features such as proxy-bidding and auto-extension of the auction in case of last-minute bids can also be incorporated into the matching algorithm based on the business requirements.

C1 Preferential Agreements

Differentiation of Service
I3
Level of Information sharing
I13

Comparison Features
A3421

Comparison Features

Information disparity
I2
Level of Integration to Marketplace
I9
Volatility of Price and Stock
I10

Search Features
A3423

Vendor Search Costs
I8

Certification Requirements
I4
Confidentiality
I7

Security & Privacy
A3424

Search Features

Functional Specs
O1

Security Features

Demand -Cycle
I6
Unavailability of Service
I1
Underutilisation of Service
I11

CRM Features
A3425

Data Structure
O2

Collaboration features
A3422

Feedback, Recommendation, Notification system, Previous histroy

Flexibility of Relations
I12
Market -Size
I15
Partnerships
I14
Payment Terms
I5

Collaboration Features, Consolidation Service

Design Transaction Settlement
A3426

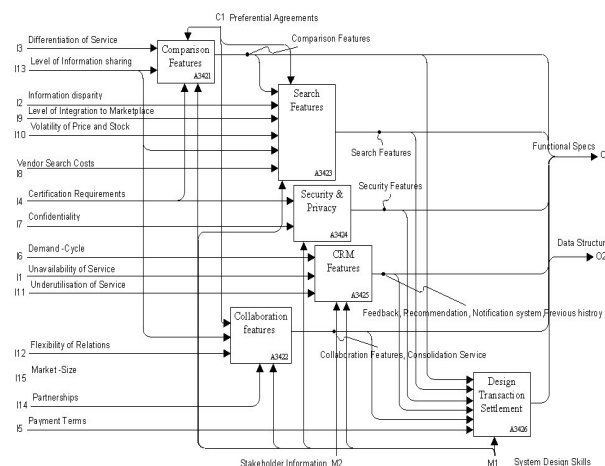Stakeholder Information M2

M1 System Design Skills

Figure 10: Design Features Process

The second critical aspect of the System Design process, described in the Design Features process presented in Fig 10, relates to the design of critical features and value adding services such as the product and supplier comparison feature, search features and collaboration features. A description of some of the sub-processes in the Design Features process is listed below.

1. Based on the level of information sharing, the differentiation of the product offerings and the presence of a standard certifying procedure, the Design Comparison Features sub-process generates the functional specifications for the product and supplier comparison features offered by the marketplace.
2. The functionality of the search feature in the marketplace is determined by the Design Search Feature sub-process which is influenced by the level of integration of the marketplace with the enterprise systems of the participants, the volatility of the price and stock, information disparity in the market and level of information sharing. In markets where the vendor search costs are high, the search feature is a very critical service that is absolutely necessary for the success of the marketplace.
3. The Design Security Features process determines the level of security and the security techniques to be considered in the design of the system, based on the requirement for confidentiality and certification.
4. One of the key value-adding services that can be incorporated into an electronic marketplace is a Customer Relationship Management Service, which will provide recommendations and feedback to the customers based on their previous history.
5. Collaboration features in the marketplace will depend on the level of information-sharing between participants and partners and the flexibility of relations. If relationships in the chosen market are easily formed and broken it may be assumed that trust between partners would be lower and hence collaboration tools will not be a critically required.
6. The transaction settlement process will depend on the standard terms of agreement between buyers and sellers in the chosen market and will need to be designed in such a manner as to support all the other features designed in the Design Features process.

The Design Features process will generate the functional specifications and the data structure designs for the various modules implementing the required features.

Once the functional specifications of the system are generated they need to be converted into the technical specifications for the system in the form of hardware and software requirements and design, from which the system can be implemented as shown in the Implement System process in Figure 11. Some of the hardware issues to be considered include the response time of the system,

internet connection speeds required, the need for clustering of the servers, the need for call-centers and integrated voice response systems. The software considerations on the other hand include the requirements of the programming environment, the database requirements, the encryption levels, etc. At the resolution of these issues the system can be assembled together and tested. The electronic marketplace should now be ready for operation.
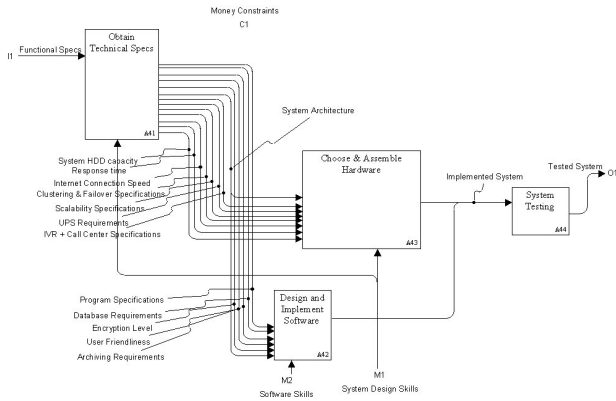

Figure 11: Implement System Process

The Operate System process, presented in Fig 12, describes the activities involved in the operation of an electronic marketplace. Accounts need to be issued to all the stakeholders allowing them access to the system. The system also needs to be continually maintained and upgraded to add greater value to the users. Furthermore, in an operational electronic marketplace, the marketplace owners are required to ensure fulfillment of all the transactions going through the system and need to collect revenue for the services offered by them. The value added by the marketplace needs to be benchmarked so as to quantify the cost savings from the electronic marketplace to the marketplace users.
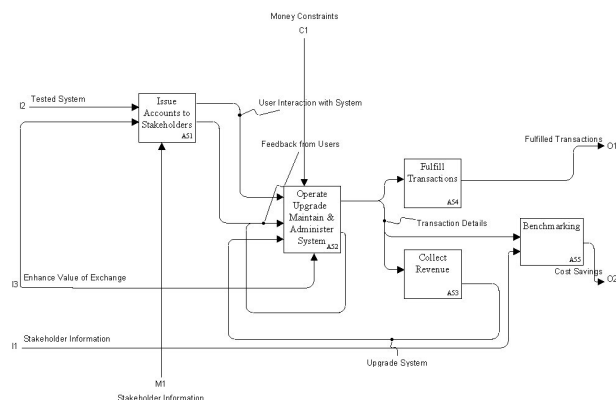

Figure 12: Operate System Process

Hence, the process of setting up an electronic marketplace involves a series of closely related activities that need to be thought about and well managed in order to establish a successful marketplace.

4. Conclusions

Electronic marketplaces are emerging as key information and transaction nodes in the integrated supply chains of the future. The emergence of electronic markets is a major trend in the next-level of business automation namely inter-enterprises processes. Given the significance of electronic marketplaces a systematic design process needs to be developed to facilitate the creation of these marketplaces. An attempt has been made in this paper to describe such a process using IDEF models. We hope that the process presented herein will aid companies in their E-Business programs by listing out for them the issues to consider and the roadmap to follow when they embark on their electronic marketplace initiatives.

5. References

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