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Modeling Enterprise Information Systems Integration Evaluation as a Dynamic System

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Abstract

With the increasing interoperation of information systems (ISs) within and between companies, the problem of Enterprise Application Integration (EAI) is becoming increasingly challenging and pressing. This is attributed to the dynamic and rapid pace of emerging trends with a diversity of EAI solutions for business domains. Attaining a consummate EAI solution for a specific business domain is still a challenge to enhancing suitability analysis amongst a diversity of correct EAI solutions for specific business domains. Other researchers have established the interdependences between the EAI evaluation criteria factors; however, to the best of our knowledge, what is missing is a method to support feedback analysis between these factors to support complete evaluation of EAI solutions for business domains. In addition, most EAI evaluation methodologies provide insights from one or two evaluation perspectives and yet in reality, evaluation of EAI solutions should arise from an aggregate of various perspectives to enhance a comprehensive EAI solutions evaluation. Therefore, there is still lack of a holistic methodology that supports complete evaluation criteria factor analysis from the different stakeholder perceptives

to realize complete EAI solutions evaluation for specific business domain. In this paper, we identify major sources of problems that make it difficult to evaluate and implement complete EAI solutions for a specific business domain and further give a comparative evaluation matrix to highlight the differences between various EAI technologies, EAI evaluation models and EAI Frameworks. We argue that complete EAI evaluation can only be realized on the basis of the successful accomplishment of EAI adoption Life cycle stages. The analysis to realize a "complete decision" in evaluation of EAI solutions possesses interesting challenges: What evaluation methodology can best represent completeness of an EAI evaluation to suit a specific business domain? A number of evaluation criteria factors for EAI completeness are proposed with particular emphasis on the Dynamic System Modeling approach. The systems dynamics modeling approach proposed extends existing EAI evaluation models based on systems theory; where a number of evaluation criteria factors are considered with their causal inter-relationships and feedback analysis determined to guide comprehensive decision making towards a diversity of correct EAI vendor solutions for a given business domain. The novelty of this model lies with interdependence, dynamic and feedback analysis between evaluation criteria factors from multiple evaluation view points to give a realistic and complete evaluation of EAI solutions rather than from one evaluation perceptive. This model will inter-relate different evaluation criteria factors from a multitude of stakeholder evaluations perceptive in order to have completeness in evaluation amongst diversity of correct EAI solutions in a rapidly changing business environment.

1.0   Introduction

"The integration of enterprise information systems (EIS) represents one of the most urgent priorities to permit intra and inter business process organization to meet increasing organizational and managerial needs" [Bose et al. 2008].   To achieve greater automation of processes, organizations face the challenge of integrating disparate information systems that have produced isolated silos of information. An organization's management system, for example, is considered a silo if it cannot exchange information with other related systems within its own organization, or with the management systems of its customers, vendors or business partners. "Therefore, this may lead to business applications to continuously be locked into inflexible integration infrastructures because an effort to connect them is a costly, time-consuming and risky endeavor "[Lam, 2005; and Kamal et.al 2009]. In addition, the rapid pace and continuous evolution of business enterprises usually implies either: discarding, maintaining, modernizing and reassessing its existing applications, or even overhauling its established business processes than what the enterprise anticipates [Renuka and Srinivas, 2005]. The dynamic nature and business growth necessitates the need to continuously re-evaluate the alignment of existing applications with dynamics and growth of the business enterprise leads to reevaluation of existing enterprise applications for adaptability, flexibility, computability and interoperability   as key non-functional requirements (NFRs) [Benslimane et. al 2007; Glinz 2005, 2007] that may constraint proper functionality of the information systems.

Successful integration of information systems deployment depends not only on the behavior of the new capability itself (functional requirements) but on its interactions with other system components in the business environment and the quality of service of these interactions (NFR). Newly deployed capabilities might generate unexpected contention for shared resources and may end up hindering business operations. "Appropriate evaluation of enterprise information systems (EIS) integration solutions for complex and dynamic business environment is tough" [Popova and Nedeva, 2006; Chappel 2004; Chari and Seshadri 2004]. Enterprise Application Integration (EAI) is a way of addressing this issue [Al Mosawi et. al 2006; Kamal et. al 2009]. "EAI is the unrestricted sharing of information between two or more enterprise applications" [Linthicum 2000; Lam 2005; Themistocleous 2004]. Themistocleous and Irani [2001], Irani et al. [2003]; Kamal et. al , [2008]; Kamal, [2009], analyze and explain the benefits that originate from the use of EAI technology and classify them into: "(a) organizational (b) managerial (c) operational, (d) strategic and (e) technical. Challenges of acquiring EAI solutions include: "technological, business, process and organizational factors" [Purao et al. 2007; Kamal 2009]. Appropriate EAI

solution evaluation is critical for the majority of integration problems [Vasconcelos et al. 2004; Al Mosawi et al. 2006; Kamal et al 2008; Kamal, et al. 2009] and must be performed using a sound and detailed methodical approach. Moreover, we remark on the existence of a market place that is dynamic with a diversity of available EAI technologies for solving different kind of problems. "A mixture of EAI technologies is usually needed to evaluate integrated solutions" [Kamal et al. 2008; Kamal 2009; Bose et al. 2008; Kishore et al. 2006]. In order to achieve complete EAI solutions evaluation to suit a specific business domain, organizations must iteratively and systematically follow EAI life-cycle stages, namely: "Decide, Evaluate, Design and Implement" [Themistocleous et al. 2005]. Therefore, final EAI implementation significantly depends on proper evaluation of the most suitable EAI solution for a specific business domain [Chappel 2004; Wagner 2004; Marijn and Anthony 2005; Sarkis and Sundarraj, 2000].

The analysis to realize a "complete decision" towards the support of evaluation of EAI solutions possesses interesting challenges: What evaluation methodology can best represent completeness of an EAI evaluation to suit EAI requirements for a specific business domain? [AlMosawi et al. 2006; Kamala, et al. 2009; Mantzana et al. 2007; Khoumbati et al. 2006; Chen 2005; Themistocleous, 2004]. The current EAI implementation pitfalls are mostly not due to technical difficulties, but due to management issues [Lam 2005]. EAI problems often emerge from overly ambitious or imprecise requirements resulting from inadequate plans for integrating different systems (legacy or otherwise) [Janssen and Cresswell 2005]. Most enterprises focus on a smaller set of objectives than they ought to, because they are overly influenced by the project or methodological (technical) concerns, and do not sufficiently focus on the non-functional requirements (NFRs) and business goals as a whole [Yusop et al. 2006]. In addition, the high investment costs associated with EAI have caused much concern for many organizations [Chen and Dai 2005; Sanchez et al. 2002]. Although the initial cost of investing in EAI may seem a one-off, the cost of integration is in fact more extensive when EAI solutions are not adopted. In addition, many case studies are simple examples of how the EAI tools work and do not delve into functional analysis for a complex real-world business environment [Themistocleous 2004; Kamal et al 2008; Cysneiros and Leite 2004].

Appropriate evaluation is critical and important during an Enterprise Application Integration (EAI) project. The evaluation process has been hindered by the variance in underlying EAI approaches, frameworks and adoption models with different terminology and concepts [Kamal et al. 2009]. Several researchers have proposed EAI adoption models and evaluation frameworks that are based on: "(a) diversity of EAI evaluation criteria factors, (b) a specific business domain (c) simple qualitative

descriptions of various factors, d) identification casual inter-relationships among EAI adoption factors by highlighting the importance of each factor and its inter-relationship with other factors and (e) based on mappings of EAI adoption factors to the phases of the EAI lifecycle" [Irani et al. 2003; Kamal 2006; Themistocleous 2004; Kamal et al. 2008; Kamala et al. 2009; Khoumbati et al. 2006].To the best of our knowledge no methodology to support comprehensive decisions on how the interdependence evaluation criteria factor analysis affects appropriate evaluation of EAI solutions for a specific business domain and how in turn it affects existing business operations has been proposed. This paper promotes the idea that appropriate evaluation of EAI solutions to be based on holistic analysis of functional requirements (FRs), Non-functional requirements (NFRs) and business goals to comprehensively evaluate EAI solution effects in a specific business domain. FRs realize functionality of the EAI system such as: data integration, application integration, platform integration and business process integration whilst NFRs constrain the FRs of the system and hence the interdependence between them will definitely affect business operations. In order to systematically elicit the impact of a specific solution in a specific business domain; "NFRs, FRs and business goals must be treated together" [Glinz 2005, 2007]. This paper focuses on the potential application of systems dynamics (SD) modeling for holistic analysis of factors to support appropriate evaluation of EAI solutions for complex and dynamic business environments. System dynamics modeling methodology is based on systems theory that has the ability to model problems in a dynamic state [Sice & French, 2006]. System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. "System dynamics is a tool to help address complex issues involving delays, feedback, and nonlinearities" [Sterman, 2000]. The very nature of EAI is dynamic and requires dynamic project managers to manage their implementation. Despite the increasingly sophisticated EAI suites, enterprise integration still remains difficult. Technical, business and political challenges require EAI implementations to be carefully planned and be adaptable to inevitable change. Agile enterprise application integration evaluation methods are needed for proper adaption to inevitable changes in business environments. The novel nature of this research is the development of an EAI evaluation model based on interdependence and feedback analysis between different evaluation criteria factors from various evaluation's perceptive.

In section 2, we present the state of art technologies and methodologies for enterprise integration. In section 3, we present various decision support systems for enterprise application integration (EAI) evaluation approaches, a taxonomy of EAI evaluation criteria for sophisticated EAI vendor suites and a comparative evaluation on various evaluation frameworks and models. In section 4, we present various issues in using

Enterprise Application Integration (EAI) solutions, the proposed system dynamics framework for evaluation of EAI is discussed and several challenges reviewed and in section 5, we present our conclusion and future research directions.

2.0   State of the Art

Despite the new emerging developments in enterprise application integration (EAI), "the application of proposed technological solutions is still tough given the lack of methodological foundations, skill and knowledge" [Kamal 2009]. We review the state of the art in the field considering: levels of Integration, Middleware and EAI architectures. There are different types of integration levels in EAI systems explaining the various dimensions of integration tasks and these include: platform, data, and business process [Jinyoul et al. 2003; Crouch 2003]. Platform integration which is the lowest level of integration is concerned with the integration of the underlying infrastructure, like operating systems, database management systems, server and network [Themistocleous and Irani, 2003]. Data integration level means that applications can exchange data between one another seeminglessly [Schmidt and Buschmann 2003]. Application-to-Application integration of cross-platform applications over a network [Chappell, 2004] can be achieved via various techniques such as the use of application program interfaces (API's), web services and distributed objects based on e.g., CORBA or COM+. Business process integration is the highest level of integration at the business processes level and it involves diverse enterprise business systems which can only be achieved by realization of underlying integration levels [Themistocleous and Corbitt, 2006].

 To achieve the three levels of integration for business domains, middleware a computer software that connects software components or applications, network services and business processes. Middleware which consists of a set of services that allows multiple processes running on one or more machines to interact in a distributed computing system while hiding lower layers heterogeneities and making coordination possible [Chappell, 2004]. Message-oriented middleware (MOM) is designed specifically to handle the complexities of exchanging information within a distributed environment based on guaranteed message delivery [Schmidt and Buschmann 2003].Two messaging architectures, message queuing and publish/subscribe, are the most common in present EAI solutions[Schmidt and Buschmann 2003].

Enterprise Application Integration (EAI) architectures define the elements that compose the system and how they interact with one another. Enterprise Application Integration (EAI) enables automated communication and interoperability between different applications and business processes within the corporation and between

trading partners [Kamal et al. 2008]. There are three major types of EAI architectures reviewed below: the accidental architecture, hub- and –Spoke architecture, Federated and Enterprise Service Bus [Chappell 2004]. The accidental architecture is a de facto integration approach that develops over time, as a result of not having a coherent corporate-wide strategy for integration [Chappell, 2004]. Therefore not every organization unit is connected as required. Such a situation leads to business applications continuously locked into inflexible integration infrastructure [van den Heuvel, 2002]. The major strengths are that much point to point integration already exists and no major up front investment is required [Cormella-Dorda, et al. 2000]. The biggest drawback is hindrance of operation consistency as new changes are added to the architecture resulting from continuous evolution of the enterprise. In Hub- and Spoke architecture, every application has to be connected only once to provide integration with the centralized hub, which reduces the integration complexity. However, most hub-and-spoke- architectures for EAI products are monolithic, expensive systems, based on proprietary standards. In a federated architecture, corporate information systems that origininally have been running as independent units are often required to work together to permit access and sharing of data or processes, particularly in organizations that are the result of going through, mergers or takeovers [Chappell, 2004]. In this case the existing systems have been designed for different corporate needs, and the resulting enterprise will have to face information inconsistency, heterogeneity and incompatible overlap. The federated architecture distinguishes itself from the others by not having a centralized EAI-server. "Federation" circumvents the hub-and-spoke drawbacks: avoidance of a single-point-of-failure increases the reliability of the system, no performance bottleneck due to the lack of a central component, and no huge investments in hardware clusters [Chappell 2004]. The biggest drawback of this architecture is that it is suited for only smaller integration projects and as needs increase for a specific organization, it becomes a very inefficient and ineffective approach to use towards integration. ESB architecture has one central EAI server that manages all the workflows and data transformations. A drawback of this architecture is that there has to be a module installed on every integrated system [Chappell, 2004]. The advantages of this topology are as follows: Scalability, high performance, distributed architecture and centralized management [Chappell, 2004].

2.1 Decision Support for Enterprise Application Integration (EAI) Evaluation
What distinguishes one architecture from another one is not only the relationship of their components, but its overall performance with respect to the requirement that it tends to address. To assess this, a precise evaluation of the architecture is essential. Evaluation is thus an essential component of decision- making [Delone and McLean, 2003] that needs proficiency to realize the ultimate value, effectiveness and relevance

to a specific business domain integration problem. Kamal et al. [2008] point out that EAI adoption, evaluation frameworks and models should clearly show which factors influence the decision making process for EAI adoption lifecycle phases. Several researchers have indicated that EAI product evaluation involves a sequence of phases an organization passes through before taking the final decision to adopt and implement a specific technological integration solution [Kamal 2006; Frambach and Schillewaert 2002; Gallivan 2001; Darmawan 2001]. On the contrary, in the context of EAI implementation, several researchers put forward different phases in their EAI implementation process e.g. [Lam and Shankararaman 2004; Themistocleous and Irani 2006; Reiersgaard et al. 2005]. Technology adoption involves a sequence of phases an organization passes through before taking the decision for adoption [Frambach and Schillewaert 2002; Gallivan 2001]. [Rogers 1995] explains that adoption is the process through which an individual or another decision-making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. Several researchers proposed adoption lifecycle phases for EAI, e.g. [Kamal 2006] proposed a novel taxonomy of Information Technology (IT) innovation adoption with the highest number (eight) of phases for private sector organizations through exploration of several factors that impact its adoption optimistically and pessimistically. Most authors include: innovation, motivation, adoption, and implementation as the common EAI adoption lifecycle phase [Gallivan 2001; Darmawan 2001; Kamal et al. 2008; Kamal 2006]. Researcher, [Darmawan 2001] also considered evaluation phase whilst researcher [Kamal et al. 2008] working in a slightly different domain (local government Authority) included: conceptualization and proposal as key adoption lifecycle phases for EAI. Kamal et al., [2008] also modified most existing adoption lifecycle phases by addition of an external driver and / or driving force phase prior to the motivation phase; discussion and research phase between the conception and proposal phases; investment (to consist of new phase and alternative name) after the final adoption decision is taken as shown in Figure 1 below:
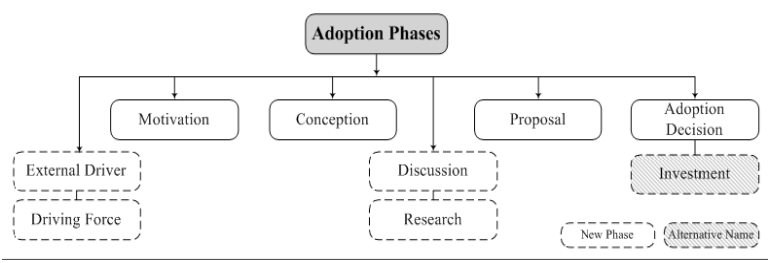

Figure 2: Revised Adoption Lifecycle Phases Adapted from Kamal et al. 2008

Decision support for any new information technology emerges when an organization realizes a problem may be solved by a specific technology; the organization is motivated to attain knowledge about how the technology may resolve their problem. [Frambach and Schillewaert 2002; Darmawan 2001] have described this state as the initiation phase in their respective models. Motivation signifies the circumstance when a business becomes aware of a specific technology and attempts to acquire knowledge about the technology, further leading to motivating the organization in ascertaining an attitude towards its adoption [Kamal, 2006; Becker and Whisler, 1967]. Conception phase refers to a plan of action that the organization should pursue and it is exhibited by a number of organizational members such as creating an attitude towards technology adoption [Kamal, 2006; Becker and Whisler, 1967). [Rogers 1995] refers to this stage as persuasion that occurs when an individual (or a decision-making unit) forms a favorable or unfavorable attitude towards innovation adoption [Rogers 1995]. Thus, it appears that the conception phase is directly related to the motivation phase. The proposal phase refers to making a formal proposition for technology adoption to the rest of the organization [Kamal 2006; Becker and Whisler, 1967]. Proposing the innovative idea to the rest of the organization is critical for making technology adoptive decisions such as which EAI toolkits or packages may be best suited in a constrained business environment[Irani et al. 2002]. Adoption Decision is the actual phase where organizations take the decision to adopt a specific technology [Kamal 2006; Frambach and Schillewaert, 2002]. Darmawan [2001], analyzed adoption phase at two levels: (a) at organizational level i.e. when an organization begins to realize the need for strategic change and decides to adopt technology, thus, the decision ends with the acquisition of technology, and (b) the individual level where adoption commences with the acquisition of technology, and finishes when technology is utilized. Therefore, the state of utilization of the technology will greatly depend on the quality of the decisions made in the aforementioned phases.

For example, if a business enterprise is motivated to invest in Enterprise application Integration (EAI) solutions, the decision makers may indeed attempt to acquire the details i.e. first to develop some views as to how EAI may assist them in solving their problems. Secondly, decision makers will be interested in high quality decision making. In considering various EAI technological solution alternatives for a given business enterprise, decision makers must evaluate the impact of each chosen alternative from a diversity of evaluator perceptive such as: end-users of the EAI system, top management, business operations and continuity, and EAI expert and chief information officers (CIOs) rather than from a single point of view such as the technical characteristics. In addition, EAI evaluation methodology should be founded on the concepts of holistic analysis rather than piecewise analysis of key evaluation criteria factors [Williams 2002].

2.2 System Dynamics Modeling Methodology for Evaluation Enterprise Information Systems Integration

System dynamics modeling methodology is a computer-aided approach to policy analysis and design that applies to problems arising in complex, social, managerial, economic, or ecological systems [Williams 2002]. The approach is appropriate for any dynamic system characterized by interdependence, mutual interaction, information feedback, and circular causality. The classic dynamic system process involves: Indentifying a problem or issue or evaluation question, developing a dynamic hypothesis explaining the cause of the problem, building a model of the system at the root of the problem, ensuring that the model reflects the behavior seen in the real world, or exploring similar models that have already been tested, play around with the model to see what insights it gives you about the issue, problem, evaluation question or puzzle and drawing conclusions from these insights [Harris and Williams 2005]. Therefore the evaluation question for this research is: Does holistic analysis of criteria EAI evaluation factors lead to complete decisions to guide suitable business enterprise information systems integration?

2.3 Information Systems (IS) Evaluation Approach

Evaluation theory is used to measure the effectiveness of different aspects of practice [Chen and Dai 2005] and is entrenched in the twin ideas of accountability and social enquiry [Alkin and Christie 2004]. Cronholm and Goldkuhl [2003] categorize information system (IS) evaluation approaches into, formal rational, interpretive or criteria based, using respectively goal based, goal free and criteria based evaluation strategies. Formal rational evaluations are largely quantitative processes, usually concerned with technical and economic aspects, employing goal based strategies that focus on intended services and outcomes, to achieve goals which can be phrased in quantitative or qualitative terms. Interpretive approaches view IS as social systems with well-established information technology (IT). In the same light, Walsham [1993] argues that IS evaluation should consider not only the purpose for conducting the evaluation and associated factors, but also social context and process, and stress the need to consider evaluation as a learning process for all involved. Goal free strategies are appropriate in an interpretive approach, performed with limited evaluator involvement. In contrast criteria based evaluation use selected general qualities for evaluation where scores from multiple criteria are combined into an overall weighted sum [Walsham 1993]. The most appropriate evaluation approach depends largely on its context Cronholm and Goldkuhl[2003] and [Akin and Christie 2004] argue that whatever the approach adopted, evaluation models must consider methods, valuing and use. Methods focus on knowledge construction because they deal with how the assessment is to be done. Valuing concerns the role of the evaluator in assigning criteria while use focuses on the purpose of the evaluation.

These factors can be seen as the process, people and purpose that [Ballantine et al. 2000] identify as drivers of IS evaluation. In summary, IS evaluation is considered as a multi-stage process occurring at diverse points, in diverse ways during the technology adoption life-cycle. However, the majority of IS literature is directly associated with the technical project development cycle. For example, Kamal et. al [2008] propose a Enterprise application integration (EAI) adoption based on mapping factors influencing EAI adoption on four phases of the adoption life cycle and simply deal with strategic, formative, summative approaches, and post mortem analysis - which is not relevant to the comparative enterprise application integration system evaluation being investigated here.

Enterprise Information System (ISs) integration is taken as systems of systems that are dynamically related in time and each of these integrated system components can positively and negatively impact on the operation of the whole integrated system. To permit seamless sharing and exchange of information in a heterogeneous business environment, enterprise ISs must be integrated together, basing on systemic attributes that can be holistically evaluated against user requirements for the benefit of entire business operations. The difference between enterprise application integration (EAI) systems and general IS is arguably the dynamics, scope and complexity of the environment within which they must work. The dynamics leading to new evolutions within various corporations has led new IS trends in web enabled applications since majority of organizations rely on a on a myriad of applications [Sice and French, 2006] . Therefore, the ability to evolve and integrate existing applications in such dynamic and complex environment becomes significant. Enterprises frequently find themselves having to merge with other enterprises, reorganizing their internal structure, and adopting new technologies and platforms as they strive for competitive advantages. The vast amounts of data and information of business enterprises require adoption of appropriate enterprise application integration technologies. It is not a simple matter for an enterprise to discard its existing applications, or even overhaul its established business processes, to effect a change in its business model. Many enterprises cannot afford to make such changes or discard existing systems. Thus, it is critical for enterprises to be able to leverage their investments in their existing enterprise infrastructure and applications. In these situations, EAI assumes a great importance because it enables an enterprise to integrate its existing applications and systems and to add new technologies and applications to the mix. EAI also helps an enterprise to model and automate its business processes.

In a comparative evaluation of EAI systems as IS for a given domain, where the assessor is neither the proposed user, nor a formal rational, an interpretative approach seems as appropriate as a criteria-based approach in which the user's requirements

motivate the evaluation criteria. Such an approach can be undertaken in a strategic, formative or summative evaluation. The resultant EAI evaluation model must achieve model objectives that should be measured.

2.4 Taxonomy of Enterprise Application Integration Technologies and Evaluation Criteria

Themistocleous and Irani [2005] classify integration technologies into: database oriented middleware (e.g. ODBC, JDBC); message oriented technologies (e.g. message brokers, MOM, RPC, XML); object oriented technologies (e.g. CORBA, COM, DCOM, EJB, etc.); and transaction based technologies (e.g. transaction process monitors, applications servers). There exists a diverse set of integration technologies in today's marketplace with each technology claiming to solve integration problems Themistocleous [2004].In addition, there is no single integration technology that can support all levels of enterprise integration problems, as each technology was designed to address a broad category of integration issues. Hence, a combination of integration technologies is required to achieve inter and intra organizational integration [Linthicum, 2000; Ruh, et al. 2000]. To further illustrate the capabilities of each EAI product, comparative evaluation taxonomy, shown in Table 1, adapted from Themistocleous and Irani, [2003] summarizes the differences between them. Considering the fact that the five packages assessed represent the elite of EAI solutions, Ring and Ward-Dutton [1999], it appears that there is no single EAI package that addresses all integration problems. This finding is in accordance of other research conclusions [Linthicum, 2000b; Ruh et al., 2000; Linthicum, 2001].

In table 1 below, the major columns are: EAI vendors, EAI products, Integration Layer and various evaluation criteria such as (integrated, toolkit, loosely, tightly, customer, packaged, intra-organization and inter-organizational) that are used for each specific product from a specific vendor. The rows provide details about strengths (□) and weakness or gap (×) for each specific product from a particular EAI vendor. For, example in row one, BEA systems is an EAI vendor and Elink is one of its major products. The integration layer evaluation criterion has four layers which are: connectivity, transportation, translation and process automation and BEA systems (Elink) uses the following technological approaches respectively to achieve enterprise integration: third party, information broker (Message based Transaction Processing (TP) Monitor), Mercator (Message Broker) and Mercator Adapters and InConcert (Process Modeling Tool). Considering, the Elink product from BEA system on other evaluation criteria factors, it has the following strong points as evaluation criteria factors: toolkit, loosely, tightly, customer and intra-organization . Its weak points are integrated, packaged, and inter-organization.

IBM MQ Series is classified as a middleware and third party toolkit used for the messages brokering and has custom and packaged as distinguishing evaluation

criteria factors. BEA elink system provides third party connectivity, uses an information broker to transport information between different applications and has an automatic process modeling tool. BEA elink toolkits can support tightly and loosely coupling for intra-organizational integration. In addition, all three products (IBM MQ series integrator, BEA Elink systems and level 8 systems) can be used as toolkit applications and individual packages. In a nutshell, Table 1 allows decision makers to understand which integration layers an EAI package supports as well as to realize the integration technologies that are used. Also, based on Themistocleous [2002]; Themistocleous and Irani [2003], decision makers can evaluate EAI packages using the eight criteria identified as: integrated product, toolkit product, loose type of integration, tight type of integration, custom systems integration, packaged systems integration, intra-organizational integration and inter-organizational integration to further clarify the differences among EAI packages. However, the EAI evaluation framework presented, only gives summarized technical evaluation highlights and lacks interdependence, feedback analysis of evaluation criteria factors to enhance complete EAI evaluation for a complex and dynamic business domain.

EAI Vendor	EAI Product	Connectivity	Transportation	Translation	Integration layer Process Automation	Integrated	Toolkit	Loosely	Tightly	Custom	Packaged	Intra-Organization	Inter-organizational
												Evaluation Criteria	
BEA Systems	Elink	Third Party	Information Broker (Message based TP Monitor)	a) Mercator (Message Broker) b) Mercator Adapters	InConcert (Process Modeling Tool)	X	√	√	√	√	X	√	X
Cross-worlds	United Application Architecture	Object Request Brokers (Java), APIs	Interchange Server (Java ORB)	a) Interchange Server b) Adapters	Third Party	√	X	X	√	X	√	√	√
IBM	MQ Series Integrator	a) Middleware b) Third Party	MQSeries (MOM)	a) MQSeries Integrator (Message Broker) b)Adapters	MQ Workflow (Work Flow Modelling tool)	X	√	√	X	√	X	√	X
Level 8 Systems	Enterprise Integration Template	Unified View Engine (OBDC, CORBA,COM)	Third Party	Geneva Enterprise Integrator (Message Broker)	Geneva Enterprise Integrator (Message Broker)	X	√	√	√	X	√	√	X
Mercator Software	Mercator	a) Middleware b)ThirdParty	b) Third Party	a) Mercator (Message broker) b) Mercator Adapters	a) Mercator (Message broker)	X	√	√	X	√	S A P	√	√

Table 1: Novel Framework for Evaluating EAI Packages adopted from (Themistocleous & Irani, 2003)

Legend:
☐= Strength and × = Weakness (gap)

2.5 Enterprise Application Integration (EAI) Evaluation Frameworks and Models
Themistocleous and Irani [2002] present a detailed description of an evaluation framework based on the classification of enterprise application integration which include: inter-organizational, application integration, intra-organizational integration and hybrid application integration. Other authors like [Schelp and Schwinn 2005; Puschmann and Alt 2001; Ring and Ward-Dutton 1999] evaluate the capabilities of EAI packages to support the integration of system types (intra organizational (custom,

packaged) and inter-organizational (e-business)); type of integration (loosely coupled and tightly coupled) and the availability of EAI packages that can be configured individually or used as a toolkit by users. This evaluation criterion indicates that EAI packages consists of a set of tools that are based on specific integration technologies and tests whether packages allow integrators to customize these technologies tools (e.g. adapters) based on their own needs. [Puschmann and Alt 2001] further illustrate, using a case study example, the problems arising when a company decides to evaluate a set of EAI tools to integrate systems such as enterprise resource planning (ERP), supply chain management (SCM) and customer relationship management (CRM), ecommerce, and legacy systems. The evaluation criteria framework suggested used four types of evaluation criteria factors: integrated vs. toolkit application, tight vs. loose coupling, individual vs. standard applications integration, and intra- vs. inter-organizational integration. Themistocleous and Irani [2003] extend the frameworks proposed by [Puschmann and Alt 2001; Ring and Ward-Dutton, 1999] by adding an evaluation criteria; 'considering the technical requirements of the different enterprise technologies'. Despite the fact that the classic applications are constructed based on concrete business requirements, enterprise application integration (EAI) tools must be built considering the technical requirements of the different enterprise technologies by also thinking about technical requirements, depending on the different technologies used by the enterprise. EAI tools attempt to connect the great amount of different types of software products and to maintain this functional integration in spite of the independent evolution that these products have. While acquiring a single business application depends on the evaluation of its own characteristics and the functional needs of the enterprise, including integration needs, the acquisition of an EAI tool does not only depend on the evaluation of its characteristics, this acquisition is highly constrained by the technologies and the characteristics of the enterprise applications that the organization has implemented.

2.5.1 Enterprise Application Integration (EAI) Adoption and Evaluation Models

Research work on EAI adoption and evaluation models has been the object of several researchers e.g. Themistocleous [2004] proposed EAI adoption models in multinational organizations, [Khoumbati 2005] evaluated and proposed a model for EAI adoption in healthcare organizations, Mantzana; Kamal et. al [2006] utilized Khoumbati [2005] EAI adoption model and extended the research area in healthcare sector, by identifying the healthcare actors involved in EAI adoption process and the causal relationships among the healthcare actors and factors that influence EAI adoption. In the area of the local government authorities, Kamal and Themistocleous [2006, 2007] proposed and validated an EAI adoption model. Chen's [2005] model differs from other existing EAI adoption models, identifying

the significant differences in the way small and medium Enterprises (SMEs) and large companies approach integration technologies but not specific to EAI evaluation criteria factor analysis.

These models mainly focus on a number of different evaluation criteria factors that influence the decision making process for EAI adoption. (e.g. benefits, barriers, costs) In addition, these influencing factors differ from one type of organization to another depending on among other things, the nature and size of the organization [Kamala et al. 2009], for instance, one set of factors is used to support EAI adoption in SMEs and another in large organizations, whereas there are differences among influential factors that are used in private sector, healthcare organizations and the local government authorities (LGAs). Kamal et al. [2008] extended work done in LGAs by mapping factors influencing EAI adoption on four phases of the adoption life cycle, thus providing sufficient support to the decision makers for speeding up the decision making process for EAI adoption in LGAs.

Silveira and Pastor [2006], further argue that a model for the evaluation of EAI tools is essential for mitigating risks of investment in unsuitable tools and the probable operational losses that arise by poor or inefficient operation of unsuitable integration tools. Silveira and Pastor [2006], contribution is provision of a quality model for EAI tools evaluation that contributes to identify quality criteria, which can be useful in the evaluation and selection processes that an enterprise must make to decide which EAI tools are most suitable to implement. Khoumbati et al. [2006], evaluated enterprise application integration in healthcare organizations using fuzzy cognitive mapping (FCM) simulation to demonstrate the causal inter-relationships between the EAI adoption factors. FCM simulation provides insights into better understanding about the interdependences of the factors that influence EAI adoption in health care organization. This enhances the quality of the evaluation process, and shows the importance of each factor and its inter-relationship with other factors. However, the FCM simulation model merely demonstrates the causal inter-relationships between the EAI adoption evaluation criteria factors and does not provide an interpretation of the mappings of the factors on the adoption lifecycle phases Khoumbati and Themistocleous [2007]. According to [Sice and French 2006], systems theory proposes the study of the unified whole as a self organizing systems which is based on the idea that the whole is different from the sum of the individual parts. System theory stresses the interdependent and interaction nature of the relationships that exist among all the parts of the system [Sice and French 2006]. Therefore there should be a holistic analysis of how all the fourteen factors affect the adoption of EAI solutions in health care organization.

3.0 Sources of Problems in using Enterprise Application Integration (EAI) Solutions

Enterprise Application Integration (EAI) solutions are not problem free and challenges arise. This is attributed to the fact that many business integrations have tended to address EAI in an ad-hoc manner resulting in incomplete evaluations of EAI solutions for a specific business domain. Therefore, some organizations are now realizing the value of adopting a more strategic and systematic approach to IS integration evaluation and implementation, and are therefore turning to the Enterprise Application Integration (EAI) tools being marketed by a number of integration vendors. EAI initiatives, however, not only involve technical challenges, but also significant business and organizational challenges. EAI challenges differ significantly, in terms of their level of technological support, administrative and technological restrictions, ability to integrate with other systems, and exposure to low-level system details as pointed out below:

~ Scope of Integration: Sharif et al. [2005, 2004] point out that because of the heterogeneous environments and scope of integration, software vendors offer enterprise application integration (EAI) suites that provide: "cross-platform, cross-data, and cross-language integration as well as the ability to interface with many popular packaged business applications" [Endries 2003]. However, the technical infrastructure presents only a small portion of the problems in enterprise integration Kaisler et al. [2005].

~ Complexity and dynamics of business enterprises: emerging business requirements prompt for implementations that are "extensible and modular to allow for future changes "[Chari and Seshadri 2004; Lam, 2005].

~ Emerging diverse and dynamic proprietary vendor Enterprise Application Integration (EAI) solutions: the EAI market is dynamic with a diversity of integration technologies for solving different kinds of integration problems and has caused some functionality spillover or overlap, making it is tremendously difficult to select from more than one correct solution for a specific business problem domain. [Kamal et al. 2008; Themistocleous 2004].

~ Majority of business enterprises still operate legacy systems: maintaining and upgrading legacy systems is one of the most difficult challenges that any chief information officer (CIO) faces today because many were not designed for new quality-attribute requirements [Warfield 2007; Themistocleous 2004; Reussner et al.2004].

~ High costs of acquisition and mergers: Enterprise integration tools such as EAI tools are expensive in the acquisition and also require expertise [Kaisler, Armour and Valivullah 2005].

~ Lack of knowledge and resources on adoption and evaluation of EAI solutions: Enterprise chief information officers (CIOs) and organizational decision makers lack knowledge on proper and strategic adoption of EAI solutions [Kamal, Themistocleous, & Elliman, 2008] and therefore in most cases rely on good collaborations with EAI vendor, consultants and expertise.

~ No immediate quantifiable metrics on Return on Investments (ROI) on enterprise application integration (EAI) adoption: According to Kamal et al. [2009], it is very difficult to establish the extent and viability to invest in EAI solutions.

~ Comparative evaluation of EAI approaches: all integration approaches have strengths and weaknesses and must be correctly evaluated for a specific business and it does not imply necessary that an EAI solution with a lot of strength is the most beneficial for a specific business enterprise. "Most of the approaches show very technical standards and lack concrete evaluation mechanism for their deployment" [Kamal 2008; Kamal et al. 2008].

~ Multiplicity of diverse EAI adoption and evaluation criteria factors: that makes it difficulty to indentify which factors influence EAI adoption and evaluation for a specific business domain. In addition there exist few EAI evaluation frameworks and models that focus on descriptive evaluation criteria factors and therefore do not support comprehensive end to end analysis [Themistocleous and Irani 2002; Silveira and Pastor 2006; Kamal et al. 2008].

~ Lack of Knowledge and resources on adoption and evaluation of EAI solutions: Enterprise chief information officers (CIOs) and organizational decision makers lack knowledge on proper and strategic adoption of EAI solutions (Kamal, Themistocleous, & Elliman, 2008) and therefore in most cases rely on good collaborations with EAI vendor, consultants and expertise.

~ Lack of sufficient business enterprise governance models to support EAI projects through out the adoption lifecycle phases [Kamal et al. 2008].

~ Lack of EAI architecture focus, standards and processes leading to sub-optimal solutions which are difficult to manage [Kamal et al. 2008].

~ Frequent EAI system downtime due to insufficient monitoring and problem resolution framework.

3.1 The challenges of using system dynamics framework for EAI evaluation

The rapid pace of change of business and the need for an enterprise to communicate and share information with other enterprises means that enterprise integration is an on-going challenge that every enterprise will face. In this context, the outcome of any change to the system (such as new adoption of enterprise application integration (EAI) solution investment decision arising from the dynamics of an evolving business enterprise) cannot always be predicted. This is attributed to the fact that EAI is a complex and dynamic task involving technological, political and business

challenges [Kamala et al. 2009]. In addition, the evaluation of a suitable EAI for complex and dynamic business environment is tough and usually a nightmare [Popova and Nedeva 2006; Chappell, 2004; Chari and Seshadri 2004] and therefore requires comprehensive evaluation mechanism prior to deployment. System dynamics (SD) modeling is the technique of constructing and running a model of an abstract system in order to study its behavior without disrupting the environment of the real system [Williams 2002]. SD is a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations. For example systems dynamics modeling can be used to evaluate an EAI project, specifically concerning vendor EAI solutions for a specific organization. The evaluation of EAI vendor solutions constitute a number of criteria factors such as: organizational (managerial capability, barrier, benefits, formalization and size), pressure, technological, support, and financial. Most important to the evaluation of EAI solutions for a specific organization is the consideration of functional requirements (FRs), Non-Functional Requirements (NFRs) and business goals that are to be achieved from the EAI solution for the organization.

However, both the technical requirements and business requirements for EAI solution evaluation pose interdependence and feedback effect between themselves. An example for realization of EAI evaluation of a NFR through FR is an authentication FR realizing a Security NFR but in turn could constrain or realize the business goals for a particular vendor EAI solution. Therefore SD modeling will be used to see the simulated behavior of causal-interrelationships of EAI evaluation factors for a specific business domain and will help in answering our research evaluation question which is, whether holistic analysis of criteria evaluation factors leads to better decisions for enterprise information systems integration. And, how holistic analysis is guiding comprehensive decision making when evaluating enterprise integration solutions for an organization. However, effective and efficient management of complex and dynamic enterprise systems such as enterprise application integration (EAI) remains a challenge. The acquisition of an EAI solution does not only depend on the evaluation of its characteristics, this acquisition is highly constrained by the technologies and the characteristics of the enterprise applications that the organization has already implemented. Business enterprises still struggle to integrate disparate systems to permit communication and sharing of information in a heterogeneous environment. They often resort to adoption and implementation of EAI technological solutions, yet experiences show that technology alone is seldom the answer. What is needed is the conscious design of an effective and efficient EAI evaluation mechanism based on interdependences and feedback between multiple evaluation criteria factors Kamal et al. [2008] to accurately establish suitability of the EAI solution to a specific business domain.

This position paper proposes to adopt systems dynamics methodology to enhance holistic evaluation of EAI solutions based on different evaluation perceptives to guide optimal appraisal of EAI solutions for specific business domains. The different stakeholder evaluations' perceptive for EAI solutions for a specific business domain may include several view points that range from the technical EAI experts perceptive (system analyst, integration experts and chief information officer), end users of the integrated system perceptive, and top management perceptive (Chief executive Officers, Directors and managers) that will be concerned about how the EAI solution will enhance strategic business development in liaison standard organization policies. For example, the EAI technical experts will be interested in the goals and functions (functional requirements) of the EAI solution and end-quality of the integrated system (non- functional equipments) [Hess 2005; Kamal and Themistocleous 2006; 2007]. The end-users will be interested in an easy to use and friendly integrated system that meets their business functional requirements. The executive policy makers will be interested in an efficient and effective system that meets business goals. An allocation of most appropriate set of evaluation criteria factors for each of the user evaluation perceptives will be indentified. Interdependence and feedback between these evaluation criteria factors will be established in their specific evaluation perceptive and how they end up affecting the quality of decision regarding EAI evaluation for a specific business domain will be determined. Thus, there is a need to develop an EAI evaluation model that permits feedback and dynamic analysis of functional requirements (FRs), non-functional requirements (NFRs) and business goals as key parameters in order to evaluate effectiveness and efficiency of the EAI solution from various perceptives in a specific business domain. The EAI system significance and quality to different stakeholders must be assessed. The key parameters will be measured based on both qualitative and quantitative approaches using the appropriate data scales of measurement such as nominal, ordinal, ratio and interval. The complexity of the model will involve interdependence analysis between different evaluation criteria factors within and across specific user evaluation perceptives to provide an effective evaluation of EAI solutions for the whole business.

4.0 Proposed System Dynamics Framework for Evaluation of Enterprise Application Integration (EAI)

Most research provides an explanatory view on the evaluation criteria factors that can be used to aid decisions on adoption and deployment of EAI solutions [Al Mosawi et al. 2006; Kamala et al. 2009; Kamal and Themistocleous 2006, 2007]. "Some authors have attempted to establish causal inter -relationship between the various factors Khoumbati, et al. [2006], in particular stating the importance of each factors in evaluation of EAI and the degree of relationship with other factors. However,

literature is still lacking in regard to holistic analysis of EAI adoption and evaluation criteria factors from multi-evaluation view points, and how in turn they affect the quality of decision for specific business domains (feedback analysis). Experts who take a systems view of policy problems know that the behavior generated by complex organizations cannot be well understood by examining the parts. By taking this holistic view, models capture time delays, amplification, and information distortion, as they exist in organizations" [Williams 2002]. The omission of holistic evaluation criteria factor analysis of EAI for specific business domains gives only limited insights into decision making. Appropriate evaluation of EAI for specific business domains must be based on holistic analysis of evaluation criteria factors rather than piecemeal analysis which hinders comprehensive decision making [Chen and Dai, 2005; van den Heuvel 2007; Younes et al. 2007; and Liu et al. 2007]. For efficient and effective evaluation, the whole integrated system in line with business goals must be evaluated rather than solely basing on piecewise evaluation criteria factors such as FRs, NFRs and business goals.

A diversity of EAI evaluation options must be taken into account and their final effect on quality of the decision of EAI adoption evaluated. This will provide a more systematic and comprehensive approach for adoption and evaluation of EAI for a diversity of integration problems that exist for complex and dynamic business enterprises. As pointed out by Kamal et al. [2009] due to unavailability of a systematic, approach for adopting, selecting and evaluating EAI solutions for a diversity of business integration problems, business enterprises officials are reluctant to proceed with EAI. This systematic and comprehensive approach will enable diverse set of business domains adopt EAI solutions with some level of acceptable certainty about the costs, benefits, risks, and any disadvantages the EAI solution might cause to the entire business as a whole [Janssen and Cresswell 2005; Irani, et al. 2005; Chen and Dai 2005].

Figure 1 below shows a schematic data and control flow diagram of how the system dynamic modeling methodology would help the EAI evaluation process. It shows the steps of the overall process that are followed to build evaluation models for EAI products. The steps involve:

Step1: Define your EAI evaluation goals and priorities specific to a business domain. The order of their importance is very important to building an EAI evaluation model;
Step 2: Identify various evaluation perceptives from various participants and their roles in EAI product evaluation;
Step3: Determine EAI evaluation requirements This will set initial goals for EAI

evaluation The list of EAI evaluation requirements should be updated as the EAI project proceeds. Some of the typical deliverables for this stage is identification of evaluation perceptives, evaluation criteria factor and causal loop diagram to guide comprehensive causal effect analysis between the different criteria factors in their evaluation perceptive ;

 Step 4: Gather EAI project and system information: data will be collected from subject matter experts (both internal and external to the organization) which will concern evaluation and documentation of key business processes and information for reengineering requirements for EAI evaluation for a specific domain.

 Step 5: Develop EAI evaluation 1st iteration using the data and information gathered in step 4. This will aid the development of the first draft of the most significant EAI evaluation model.

Step 6: Review and improvement of the first EAI evaluation iteration models should be done with the parties identified in step 2 above, and

 Step 7: Present final deliverables of the EAI evaluation model how it assists complete evaluation of EAI products based on causal-interrelationships and feedback loop analysis between the criteria variables in respect to evaluation perceptive, to guide suitability analysis for a specific business domain.

Figure 1: Schematic Data Control Flow Diagram for Evaluation Process Model

Table 2 below illustrates the evaluation criteria factors that influence complete decision making for suitable EAI for a specific domain. Table 2 summarises results of existing Enterprise Application Integration (EAI) evaluation models based on case studies. The major columns are: evaluation criteria factors and EAI evaluation models based on case studies. The evaluation criteria factors column consists of sub columns; major factors, sub factors and elements. The EAI evaluation models based on case studies consists of sub columns of recent literature reviewed that contributed to the body of research through development of EAI evaluation frameworks and models. The rows provide a comparative evaluation results for each of the EAI evaluation models based on case studies to highlight the strengths (□) and gaps (x) with each based on the evaluation criteria factors , sub factors and elements with a given sub factor. Results from table 2 justify the fact different business enterprises or EAI domain application areas required different evaluation criteria factors suited to that specific EAI application domain. Therefore complete evaluation of EAI to support suitability to a particular business domain depends on structural characteristics of the business domain and only same business context organizations can use similar evaluation criteria factors for EAI Evaluation. In, summary, business enterprises are unique depending on the mission, vision, values, business goals and objectives and therefore each one of them depending on the situation analysis for EAI, will use different criteria factors to attain completeness in evaluation of EAI. Again as seen from table 2 below, currently we could not indentify any literature supporting multi-evaluation perceptive and holistic analysis in the context of feedback analysis. This regeneration process will prompt for refinements and improvement in areas where there is a negative response and incase of positive response, organizations will reuse the EAI evaluation model in similar business domains for a specific integration problem need. Thus, there is need to develop an EAI evaluation model that permits feedback and dynamic analysis of evaluation criteria factors based on multiple evaluations perceptive to attain completeness in evaluation of EAI solution is appropriateness of a an EAI solution to a business domain is paramount. The EAI systems' significance and suitability to different stakeholders must be assessed. Nicholson [2004] urges that FRs, NFRs and business goals must be treated together.

Evaluation Criteria Factors			ENTERPRISE APPLICATION INTEGRATION EVALUATION MODELS- based on Case Studies							
Factors	Sub-Factors	Elements	The Case of e-Government Services in a Welsh Authority (Kamal, et al 2009)	Mapping Factors Influencing EAI Adoption in the Local Government Authorities on Different Phases of the Adoption Lifecycle (Kamal et al, 2008)	Identifying healthcare actors involved in the adoption of information systems (Mantzana et al 2007)	A Model for Enterprise Application Integration Tools Evaluation (Silveira and Pastor, 2006)	Application of Fuzzy Simulation for Evaluating EAI (Khoumbati, et al 2006)	Developing E-Government Integrated Infrastructures: A case Study (Themistocleous, et al 2005)	Justifying the decisions for EAI implementations: a Validated proposition of influential factors (Themistocleous, 2004)	Proposed Holistic Enterprise Application Integration (EAI) Evaluation Model
Technological Factors	Relative Advantage	Investment costs	√	√	x	x	√	√	√	√
		Benefits	x	√	x	x	√	x	√	
		Direct impact	√	√	x	x	√	x	√	
		Indirect impact	x	√	x	x	x	x	√	
		Barriers	√	√	x	x	√	x	√	
		Risks	√	√	x	x	x	x	√	
	Compatibility	Value systems	√	x	x	x	x	x	x	√
		Business Needs	√	√	x	x	√	x	√	
		Organizational	√	x	x	x	√	x	x	
		Technological	√	x	x	x	√	x	x	
		Legacy systems	√	√	x	x	√	√	x	

Category	Subcategory	Sub-subcategory								
	Complexity	*Organizational*	x	x	√	x	x	x	x	√
		Technological	x	x	x	x	x	x	x	
	Goals	*Functional Requirements*	√	x	x	√	x	x	x	√
	System Quality	*Non-functional requirements*	x	x	x	√	x	x	x	√
	Technology potential for integration (IT capabilities)	*IT infrastructure* / *Personnel IT Knowledge* / *IT sophistication*	√	x	x	x	x	x	√	√
Support	Top Management	*Financial (ROI and Cost)*	√	√	x	x	√	x	√	√
		Managerial capability(knowledge of EAI, Innovativeness and motivation)	x	√	√	x	√	x	√	
	IT Support	*consultant*	x	√	x	x	√	x	√	
		Vendor	x	√	x	x	√	√	√	
		Customer	x	x	x	x	√	x	√	
	Higher Administrative authority	-	√	√	√	x	√	x	√	
Pressure Factors	Project Champion / Citizen's Satisfaction / Critical Mass / Market Knowledge	-	x	√	x	x	√	x	x	√
Multi-Evaluation Perceptive (Stakeholders view points)	Novice/end Users / Technical experts / Management		×	×	×		×	×	×	×
Holistic Evaluation	Feedback		x	x	x	x	x	x	x	√
	Interdependence		x	x	x	x	√	x	x	
	Casual effect		x	x	√	x	√	x	x	
Dynamism	*Business dynamics*		√	x	√	x	√	x	x	√

Table 2: Comparative Evaluation of Recent EAI Framework and Models
Legend
□= Strength   X= Gaps

5. 0 Conclusion and Future work.

Enterprise Application Integration (EAI) allows organizations to simplify interactions among organizational applications by adopting a standard approach to integration and replacing a multitude of ad-hoc integration efforts [Khoumbati et al. 2006; Lam 2005; Themistocleous 2004; Linthicum 2000]. However, there exists a diversity of proprietary EAI vendor products that can suit a specific class of integration problems for a specific business domain. This makes evaluation of most suitable EAI solutions from a diversity of rightful EAI needs very difficult. It is a great challenge to achieve complete evaluation of EAI for complex and dynamic environments, thus hindering the selection of an appropriate and effective solution. As seen from table 2 above, only a few of EAI evaluation models support : dynamism, interdependence and casual effect as holistic evaluation criterion and none of them support feedback analysis and a multiple evaluation perceptive as a criterion [Themistocleous and Irani 2002; Silveira and Pastor 2006; Kamal et al. 2008]. In this paper, we identify major sources of problems that make it difficult to evaluate and implement EAI for a specific domain and further give a comparative evaluation matrix to highlight the differences between various EAI technologies, EAI evaluation models and EAI Frameworks as shown in table 1 above. We propose a model based on System dynamics modeling approach that in figure 1: Schematic Data and Control Flow Diagram for EAI Evaluation Process Model. It extends existing EAI evaluation models based on systems theory; where a number of evaluation criteria factors are considered with their causal inter-relationships and feedback analysis determined to guide comprehensive decision-making towards attaining complete evaluation of EAI vendor solutions to suit a specific business domain. The novelty of this model lies with interdependence, dynamic and feedback analysis between evaluation criteria factors from multiples evaluation view points to give an overall (complete) realistic evaluation of EAI solutions rather than from one evaluation perceptive. This model will relate different evaluation criteria factors in multiple evaluations perceptive in order to have a holistic view of evaluation of EAI solutions in a rapid changing business environment. The model will be used as a decision tool to aid EAI practitioners, end-users and management into comprehensive evaluation of EAI for complex and dynamic business enterprises. Future work involves using a case study based approach to identify key evaluation criteria factors in multiple evaluations perceptive and establish the interdependences and feedback loops between them to aid comprehensive decision making towards complete evaluation of EAI for complex and dynamic environments using causal loop diagrams.

Acknowledgements

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