Multi-Enterprise Collaborative Enterprise Resource Planning and Decision Support Systems

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Abstract

Enterprise Resource Planning (ERP) and Decision Support Systems (DSS) have independently evolved and prospered in the marketplace as well as in academia. More recently, ERP and related systems such as Customer Relationship Management (CRM) and Supply Chain Management (SCM) are incorporating decision support tools and technologies. These include Business Intelligence, Customer Intelligence, Supply Chain Intelligence, and Business Analytics. At the same time, DSS are taking advantage of the data resident in ERP systems.

This emerging convergence has motivated us to look at the integration of ERP and DSS. The integration of ERP and DSS provides firms with a number of advantages. First, they are able to maximise their Intelligence Density. Second, they are able to improve the quality and visibility of their information. Finally, they can form a solid foundation from which they can achieve multi-enterprise collaboration. Over the years, researchers and practitioners have proposed frameworks and architectures for ERP and DSS exclusively. However, there is little in the way of academic literature, frameworks, architectures, and implementations that integrate ERP and DSS in a coherent fashion.

We address this area of research by first conducting a review of the independent and combined literature in the fields of ERP and DSS. This literature review paves the way for the proposal of a Multi-Enterprise Collaborative conceptual ERP-DSS framework that considers SCM, Enterprise Management, and CRM as components. This framework brings together the ERP and DSS integrated solutions offered by a host of well-known vendors in the marketplace. We then combine our own insight with respect to multiple-enterprise collaboration via the integration of ERP and DSS to propose a set of high-level and medium-level system frameworks. These system frameworks depict the mechanisms behind the integration of ERP and DSS both within the firm, and in a Multi-Enterprise Collaborative context.

1. Introduction

Over the last three decades, researchers and practitioners in the fields of ERP and DSS have played their part in helping these fields of research to develop and flourish independently. More recently, this has led to research and practice that places attention on the significant value that the integration of these fields of research generate.

Traditionally, ERP systems have provided firms with limited analytical capabilities, but have made up for this limitation via strong data storage, access, scrubbing, and integration capabilities. Conversely, DSS have provided firms with strong data transformation, discovery, and knowledge-gaining capabilities, but have not been able to provide this functionality at an enterprise-wide level. The capabilities provided by each of these systems, combine to increase Intelligence Density. Dhar & Stein (1997) use this term to characterise the degree of intelligence provided by a decision support tool. They describe Intelligence Density as representing the amount of useful 'decision support information' that a decision maker gets from using the output from some analytic system for a certain amount of time [3]. Thus, the integration of ERP and DSS can play a significant role in allowing firms to maximise the potential of their Intelligence Density, thereby taking care of their internal environments. In addition, by using integrated ERP and DSS such as CRM and SCM, firms can achieve multi-enterprise collaboration by reaching beyond the confines of their boundaries and forming valued relationships with all their partners.

Over the past few years, the marketplace and the trade press has recognised the value derived via the integration of ERP and DSS. However, academic literature, frameworks, architectures, and application implementations that coherently integrate ERP and DSS in a complimentary fashion are scarce. The discussion, analysis, and framework design conducted within this paper aims to fill this gap and provide a fresh perspective in this combined area of research.

The weaknesses in stand-alone DSS and ERP motivate us to look at their integration in the next section. We then use the ideas put forward in this discussion to propose a Multi-Enterprise Collaborative conceptual ERP-DSS framework that considers SCM, Enterprise Management, and CRM as components. This conceptual framework allows us to propose a Multi-Enterprise Collaborative System ERP-DSS Framework that depicts the mechanisms behind the integration of ERP and DSS both within the firm, and in a Multi-Enterprise Collaborative context.

2. Integration of ERP & DSS

As defined earlier, Intelligence Density provides a measure from which we can decipher the degree of intelligence provided by a decision support tool. Formally, Intelligence Density equals the 'utiles of decision making power gleaned (quality)' divided by 'Units of analytic time spent by the decision maker' [3]. The lower the unit of time spent by the decision maker to retrieve their desired output, the higher the Intelligence Density of the system. Dhar et al. (1997) describe six steps of processing to transform data into knowledge (Figure 1).

In our research, we use Intelligence Density as construct to define the value generated by the integration of ERP and DSS. By using this Intelligence Density construct, we can understand the relative value of various DSS tools and technologies and their integration with ERP systems, in order to provide better decision support for decision makers.

A firm can integrate an ERP system with a DSS in one of several ways. First, extend the functionality of current DSS so that they can easily access the data stored in an ERP system. Second, integrate existing DSS that currently sit on top of a firms' ERP system. Third, integrate existing DSS that currently sit on top of a firms' ERP system across multiple firms. Finally, build a single, flexible, and comprehensive DSS that sits on top of an ERP system.

Practically, it is important to take into account that these ERP and DSS integration options may be achieved via an emerging class of integration technologies called Enterprise Application Integration (EAI). EAI efficiently and effectively integrates functionality from a variety of Information Systems resulting in flexible and maintainable Information Technology infrastructures. The ability of EAI to integrate all combinations of enterprise applications (e.g. legacy, custom, packaged) [9] makes it a viable choice for integrating ERP and DSS both within a firm and in a multi-enterprise level.

2.1. Benefits of integration

The integration of ERP and DSS brings about a number of significant benefits. These include the ability to improve the quality and visibility of information, increase Intelligence Density, and achieve multi-enterprise collaboration. We now move on to discuss each of these benefits in more detail.

2.1.1. Improving the quality and visibility of information. In 1998, Deloitte Consulting, in association with Benchmarking Partners, Inc. conducted a survey that they labelled as 'ERP's Second Wave' [2]. This survey consisted of in-depth interviews with 164 individuals at 62 Fortune 500 firms in manufacturing and consumer industries. The survey found various technological and operational motivations for implementing an ERP system. Seventy percent of the respondents expected that their ERP system would provide them with improved quality and visibility of information, ultimately leading them to better decision-making. However, only 16% of the respondents realised that an ERP system actually improved the quality and visibility of their information.

Once a firm correctly implements an ERP system, among the core capabilities provided is its ability to provide its decision makers with real-time access to data. However, one of the fundamental and driving forces behind the ability for these decision makers to fulfil their level of responsibility is their ability to have this data transformed into information, and ultimately turned into knowledge. Minimising the time taken by the decision makers to progress through all these tiers of data, sets the platform for correct and timely decisions to be made. Firms must also take into account the increasing trend towards competing firms (mainly medium to large) making parallel evaluations for their need of the core capabilities provided by an ERP system. As a result, firms need to look beyond and extend upon their intentions to invest in ERP systems, and look to establish other avenues for competitive differentiation. Hence, we are seeing a market that is gradually moving towards doing more with the large amounts of data resident in ERP systems.

2.1.2. Increasing Intelligence Density. The integration of ERP and DSS increases the Intelligence Density of a firm. As can be seen in Figure 1, ERP systems provide firms with the ability to gain access to their data through a common GUI, made possible through client/server technology. The presence of this common database helps to eliminate dirty data, redundancies, missing records and inconsistencies through data scrubbing techniques. ERP systems are also able to achieve integration by bringing together data from different sources within the firm. This may include disparate databases that exist across different functional units, thus helping the firm to gain a more complete and realistic picture of all the data they hold. However, as the figure illustrates, ERP systems have traditionally not been able to provide satisfactory support for transforming data, and enabling decision makers to discover and learn, ultimately turning this data into knowledge. This is where DSS have been able to give strong support. Though DSS have the ability to perform the first three steps of increasing

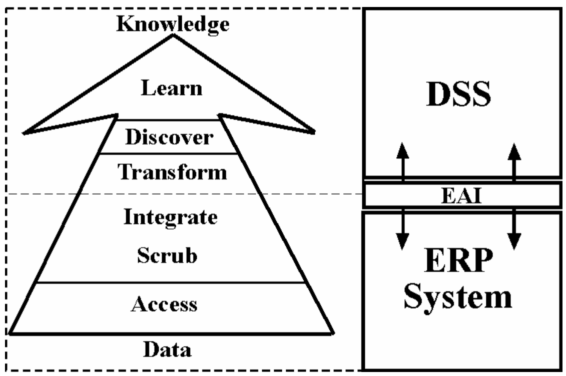

Figure 1. Integration of ERP and DSS increases the Intelligence Density of firms

Intelligence Density, they do not support accessing, scrubbing, and integrating data well enough at an enterprise-wide level. They do however provide substantial support the final three steps for increasing the Intelligence Density. Once a common database is in place with an ERP system, DSS have the ability to take the integrated data stored within this database and transform it, through various analysis techniques. The transformation of data allows decision makers to gain a higher-level view of the data, thus providing them with the ability to discover trends, patterns, and relationships in the data. Furthermore, once decision makers make discoveries, DSS support them through a period of learning. Decision makers gain insight and understanding, thereby setting the platform for making accurate, timely, and knowledgeable decisions.

Hence, as we look at Figure 1, we can see that the integration of ERP and DSS is an imperative and necessary path that firms should take, if they are to equip and provide their decision makers with the necessary support for increasing the Intelligence Density of the firm.

2.1.3. Multi-enterprise collaboration. Previously, we have discussed the need to integrate ERP and DSS within the context of a single firm. That is, one or more decision support tools extracting data from a single ERP system and turning that data into relevant and useful information within one firm. However, another benefit of the integration of ERP and DSS can extend to include the collaboration of multiple enterprises.

Firms face a variety of demands from an increasingly competitive marketplace. These demands are forcing decision makers to share information beyond the confines of their internal environment. In order to stay competitive, firms need to address a number of areas. First, firms need to share information with their supplier-facing partners. Second, they need to gather information from their customer-facing partners (i.e. retailers, customers). Finally, they need to increase Intelligence Density through the various DSS tools and technologies integrated with their respective ERP systems. By doing this, they provide their decision makers with the opportunity to make more informed decisions because they are able to make their decisions based on the information viewed across the entire extended value chain. Figure 2 illustrates our representation of multi-enterprise collaboration with respect to the integration of ERP and DSS.

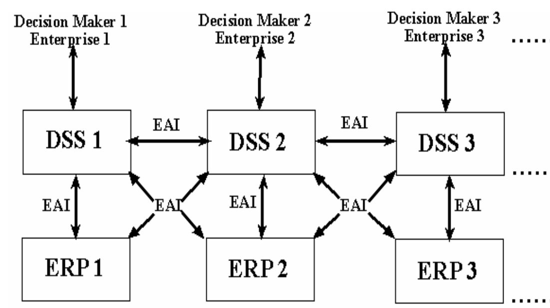

Figure 2. Multi-enterprise collaboration

SAP, a market leader in the ERP vendor market, shares similar views on the trend to extend beyond the confines of the firm. SAP has shown that firms are attempting to reach beyond the confines of their firm. They develop relationships with their partners through systems such CRM, SCM, Business-to-Business (B2B) Procurement, and Online Stores. By using the SAP Business Warehouse (BW) (SAP's term for a Data Warehouse), firms are able to provide their decision makers with analytical capabilities. Strategic Enterprise Management (SEM) and the Knowledge Warehouse (KW) extend beyond the analysis of the data from ERP systems via the BW. They move towards providing highly dense information for decision makers across the extended enterprise.

2.2. Current trends

The fields of ERP and DSS have slowly evolved independent of each other since the 1950s. This evolution has now come to a point of confluence, where we are reading about terms such as Customer Intelligence, Supply Chain Intelligence, ERPII, and Enterprise Commerce Management (ECM) (Figure 3). Here, we introduce and briefly discuss these ERP and DSS related trends.

The introduction of DSS in the early 1970s provided more extensive and better analytical support for decision makers compared to the limited analytical capabilities offered by TPS, and later MIS. In the 1980s and until the 1990s, DSS evolved to include Executive Information Systems (EIS) in order to serve the needs of senior managers and executives in the firm. During the same time these DSS advancements were taking place, the field of ERP was making concurrent advancements. The introduction of ERP systems in the early 1990s stemmed from the continuous enhancements made to BOM processors,

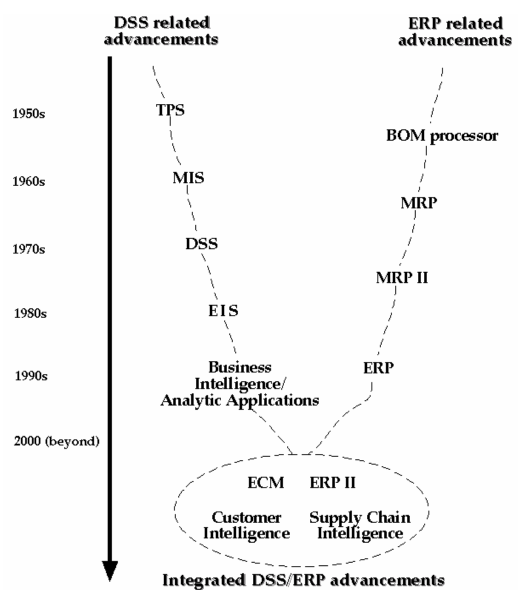

Figure 3. The convergence of ERP and DSS

MRP systems, and MRPII, between the 1950s and 1980s. While ERP systems solved the problem of centralising disparate data and streamlining business processes, over time they made firms rich in data. This placed demands on the field of DSS to introduce applications that could integrate with ERP systems. This integration was to serve the purpose of taking this data, turning it into information, and eventually creating knowledge. This brought about the introduction of Business Intelligence (BI) and Analytic Applications in the 1990s. These applications enabled decision makers to obtain enterprise-wide data more easily. Among the many possible sources of data for these Business Intelligence and analytic solutions are ERP systems. What BI and Analytic Applications intended on doing was to provide more enhanced decision support than that provided by traditional DSS, EIS, and the basic reporting capabilities provided by ERP systems. All this made possible by making use of tools, technologies, and techniques such as Data Warehouses, Data Marts, Online Analytical Processing (OLAP), and Data Mining.

We now go on to discuss the integrated ERP/DSS related advancements in more detail. First, we discuss the ERP related trends by looking at ERP II and ECM. We then look at the DSS related trends, namely, Supply Chain Intelligence and Customer Intelligence.

2.2.1. ERP II. In the 1990s, ERP systems provided firms with a large step forward in terms of a single point of data storage and the ability to optimise their internal resources. However today, we are seeing a shift in focus and needs not only from the perspective of the firm itself, but also from all its associated partners. Firms are looking more and more at collaborating with multiple external partners across their supply chains. The result is what Gartner terms as 'ERP II'. Traditionally, ERP systems focused on the optimisation of the firm itself. ERP II expands to include the participation of all relevant partners of the firm across its supply chain, and thus enables collaborative-commerce. ERP systems primarily cater for the Manufacturing and Distribution industries. ERP II incorporates all sectors and segments of the marketplace. ERP II aims at being open and externally connected to the marketplace. Finally, traditional ERP systems have treat company data as an internally generated and consumed commodity. ERP II on the other hand considers data as a tier that needs to be looked at both internally and externally. With this type of data scope, the integration of ERP and DSS is more effective. Decision makers have the opportunity to identify, collect, and analyse more relevant and accurate information on which to base their decisions.

2.2.2. Enterprise Commerce Management. While ERP II is Gartner's view of extending the scope of firms beyond the confines of their boundaries, ECM is the way AMR Research presents the same issue. ECM is a blueprint that enables firms to plan, manage, and maximise the potential of applications, business processes and technologies they need to support their supply chains. ECM allows firms to evaluate and map their Information Technology infrastructure and business issues against a customised architectural, operational, and business process plan. Using the ECM methodology, AMR Research works with companies to assess how existing systems could work together. A relevant example of this is assessing how an ERP system integrates with existing or new DSS applications in order to generate optimal value for the firm and its decision makers.

2.2.3. Supply Chain Intelligence. The supply chain of a firm consists of a complex, dynamic, and data-driven set of relationships. Information has been, is, and will continue to be one of the key drivers of this supply chain. However, the abundance of information threatens to disintegrate these supply chains. Firms all over the world have invested large amounts of their resources on ERP and SCM systems, with the intention of controlling and mastering their supply chains. Firms applying Supply Chain Intelligence systems seek to go further, by providing their decision makers with knowledgeable decision support.

According to Probert and O'Regan (2002), Supply Chain Intelligence systems complement the capabilities of ERP systems, and SCM applications, and build on them with respect to three key areas. These include:

- Rich and deep analytical capabilities on cross-functional supply chain areas.
- The integration of information from cross-functional supply chains, as well as legacy and back office applications.
- User-friendly Key Performance Indicator (KPI) dashboards that provide the decision maker with knowledgeable decision support on the areas of the firm that need attention.

A Supply Chain Intelligence system makes use of many of the tools and technologies that the BI and Analytic Applications use, one of which includes ERP systems. Supply Chain Intelligence systems also provide built-in functionality. Two defining characteristics differentiate Supply Chain Intelligence systems with the systems offered in the 1990s. First, Supply Chain Intelligence systems have the ability to provide both breadth and depth of information for the decision maker. Second, Supply Chain Intelligence systems not only provide a snapshot view (breadth) of the KPI's selected by the decision makers, but also have the ability to examine the underlying detail (depth) from which this snapshot view originated. This type of flexibility provides a platform for decision makers to generate success for their firms in the marketplace.

2.2.4. Customer Intelligence. Firms are becoming more aware of the fact that customers are one of the major driving forces of their supply chain. Therefore, attracting them and keeping them is a key consideration for all firms. Firms must ensure they are able to identify, collect, and analyse all the relevant information pertaining to their customers and other relevant partners along their supply chains. With such information, firms will have the ability to determine the value of each customer to their firm. They are able to do this by analysing the past, present, and future status of their customers in terms of their spending with the firm. Customer Intelligence therefore, is the identification, collection, and analysis of this type of information.

Traditional BI, Analytic Applications, and ERP systems provide limited capabilities for the firm to interact with its customers. Customer Intelligence leverages the capabilities of these tools and technologies via CRM decision support applications. According to Liautaud and Hammond (2001), the following are the primary goals of Customer Intelligence via CRM applications with respect to maximising the lifetime value of customer relationships. **Acquire:** Attracting new customers through segmentation techniques, correct and timely marketing campaigns, following up leads through sales efforts, closing the loop on the effectiveness of the whole process. **Build:** The process of building the value of customers over time. The firm must work hard to build relationships with new customers and measure their achievements over time. **Care:** The ability of the firm to provide the best level of service to its customers. This builds high customer retention levels. By leveraging ERP systems and the tools and technologies associated to BI and Analytic Applications, firms can build a solid infrastructure of information and better understand customer needs, thus providing them with the best care.

We now combine the literature reviewed and the ideas discussed in this part of the paper with our own insights to propose a Multi-Enterprise Collaborative conceptual ERP-DSS framework. Our conceptual framework paves the way for the proposal of a set of high-level and medium-level system frameworks that illustrate the mechanisms behind the integration of ERP and DSS.

3. Multi-Enterprise Collaborative ERP-DSS conceptual framework

Our Multi-Enterprise Collaborative conceptual framework introduces and categorises the ERP and DSS related solutions offered by a host of well-known vendors. These solutions support firms in dealing with their internal environments. In addition, they aid firms to reach beyond their internal boundaries, in order to achieve multi-enterprise collaboration. The solutions presented in this framework are categorised into three well-known areas. These areas not only support the way the firm collaborates with its supplier-facing and customer-facing partners, but how it also handles its internal environment. We refer to these areas as components in our framework. These components include SCM, Enterprise Management, and CRM. Within each component, we identify the solutions that vendors offer firms. These solutions help firms to take care of their internal environments and achieve multi-enterprise collaboration.

3.1. Motivation behind conceptual framework

Firms need to control and manage their supply chains with the additional consideration of multi-enterprise collaboration. This factor has come about due to major shifts in business rules and operations experienced by firms from the mid to late part of the 1990s. These include shifts such as the movement from nationally driven business environments to internationally oriented environments and from producer-defined markets to markets defined by end-users. The collaboration of key areas such as SCM, CRM, and Enterprise Management provides the basis for firms to achieve better results along their integrated supply chains. For example, Gartner's ERP II package incorporates ERP systems, CRM, and SCM, and provides firms with the ability to support any activity from the initial logging of the activity, right through to applying the payment.

3.2. Components of conceptual framework

3.2.1. Enterprise Management. In order to define Enterprise Management we refer to Anthony's (1965) classic hierarchical taxonomy. This taxonomy presents three broad categories that encompass all the activities with which management is associated. Figure 4 depicts Anthony's hierarchical taxonomy in conjunction with Scheer's view of Integrated Information Systems within a firm. Strategic planning is defined as "the process of deciding on the objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources" [1]. Management Control is defined as "the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives" [1]. Finally, operational control is "the process of assuring that specific tasks are carried out effectively and efficiently" [1]. Scheer (1998) adapted his view of Integrated Information Systems within a firm from these definitions provided by Anthony. This view shows the support the firm obtains by Information Systems at various levels of Anthony's taxonomy. Long-term planning & DSS, as well as Analysis and Information Systems support the strategic planning layer of the firm, while Reporting & Controlling Systems support the management control layer of the firm. Finally, Value-Oriented Job Accounting Systems and Quantity-Oriented Operative Systems support the operational control layer of the firm. Hence, with this integrated view of Information

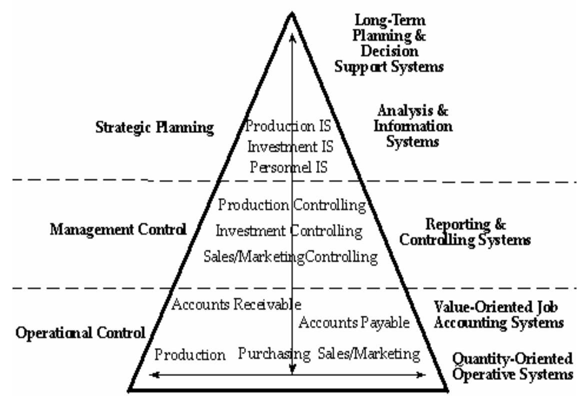

Figure 4. A convergence of views [1, 5]

Systems seen from the lens of Anthony's hierarchical pyramid-like taxonomy, we can attempt to define Enterprise Management as being: "the Information Systems support that a firm gives to its decision makers in order to support their decision-making efforts at the operational control, management control, and strategic planning level of the enterprise".

3.2.2. Supply Chain Management. Stadtler (2000) provides a synthesised definition of SCM stating that it is a process of integrating organisational units along a supply chain and coordinating materials, information and financial flows in order to fulfil customer demands with the aim of improving competitiveness of a supply chain as a whole. Considering his definition, we define SCM as the collaboration and cooperation of firms across the entire supply chain in order to improve operational efficiency and market competitiveness, via the coordination of all forms of activities, information, and materials from the initial source to the end-user (customer).

3.2.3. Customer Relationship Management. Although there are a number of perspectives on the definition of CRM, the underlying motives behind this concept are similar across all these perspectives. All definitions seem to include the actions of first creating a customer base, then retaining or maintaining the relationships formed within it, and finally attempting to expand these relationships.

The Data Warehousing Institute provides a specific and comprehensive definition of CRM that is perhaps the most relevant to our conceptual framework. They state that CRM is "any application or initiative designed to help your company optimize interactions with customers, suppliers, or prospects via one or more touchpoints – such as a call centre, salesperson, distributor, store, branch office, Web, or email – for the purpose of acquiring, retaining or cross-selling customers" [4].

3.3. The complete conceptual framework

We now present a depiction of our Multi-Enterprise Collaborative conceptual framework (Figure 5) with respect to the vendors that offer solutions in each of its components. Though we have named this part of our paper a 'complete' conceptual framework, it is important to mention that the range of vendors and solutions we identify in our framework is not a 'complete' and comprehensive reflection of all the vendor solution offerings in the marketplace today. Rather, it is a snapshot of the most widely recognised vendors and solutions in the marketplace today. As can be seen, well-known vendors in the marketplace offer a range of solutions that assist firms in their quest to achieve multi-enterprise collaboration via the three components of the framework. Within the Enterprise Management component, vendors offer a range of solutions that assist firms at the operational, management, and strategic levels such as SAP's R/3 ERP system and JD Edwards' One World ERP system, iBaan Business Intelligence and Siebel Analytics 7.5, PeopleSoft's Enterprise Performance Management (EPM) and SAP's SEM. Similarly, these vendors offer CRM and SCM solutions that allow firms to reach out and form solid relationships with all their partners along their supply chain.

4. Multi-Enterprise Collaborative ERP-DSS system frameworks

We now consider the ideas brought forward in our conceptual framework in order to propose a number of high-level and medium-level system frameworks. These frameworks attempt to provide a more detailed look at the mechanisms behind multi-enterprise collaboration via the integration of ERP and DSS.

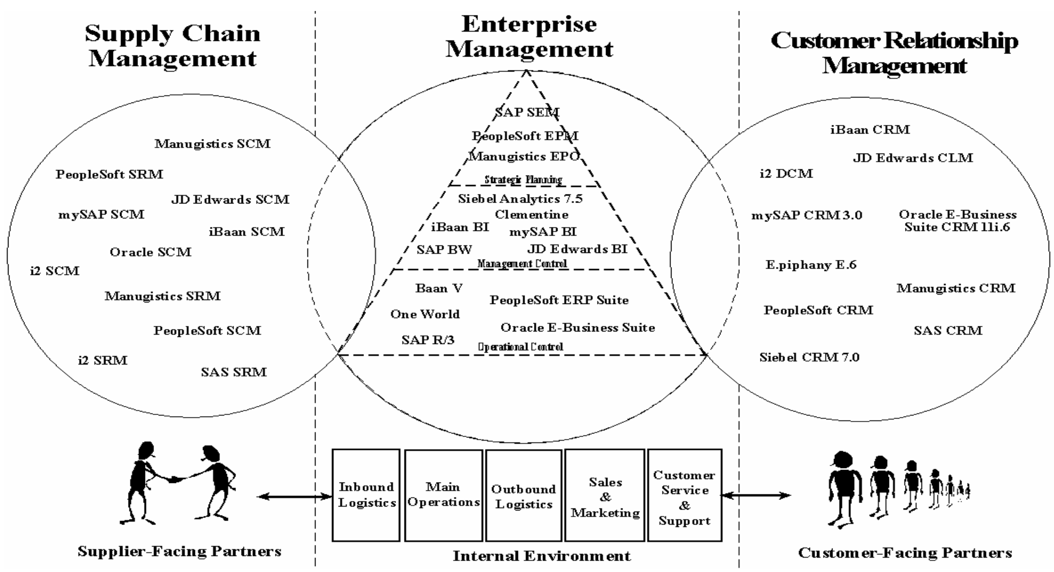

Figure 5. Complete depiction of Multi-Enterprise Collaborative conceptual ERP-DSS framework

4.1. High-level system framework

We propose our high-level system framework by considering the conceptual framework proposed earlier (Figure 5). Our high-level system framework aims to add a new perspective on how firms are able to achieve multi-enterprise collaboration via the integration of ERP and DSS. Figure 6 illustrates this new perspective, showing how the existence of an ERP system within the firm is the central data platform for Multi-Enterprise Collaboration.

Data from the main ERP system feeds into both the CRM and SCM data warehouses. The main DSS also uses the data from this main ERP system. Each of these systems has their own specific CRM and SCM DSS. Decision makers from within the firm, as well as across the extended value chain, are provided with data access, scrubbing, integration, transformation, discovery, and knowledge gaining capabilities. This provides firms with the opportunity to maximise their Intelligence Density, and lays the foundation for achieving multi-enterprise collaboration.

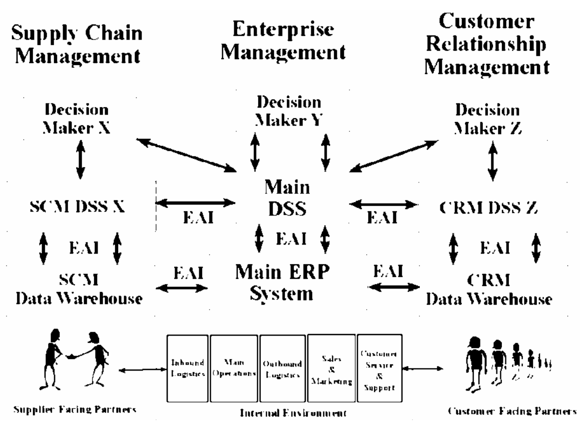

Figure 6. Multi-enterprise collaboration via the integration of ERP and DSS

We next propose a more detailed version of this integration, both within the boundaries of the firm, as well as in a Multi-Enterprise Collaborative context.

4.2. Medium-level system frameworks

Here we present several medium-level system frameworks that represent the integration of ERP and DSS. Figure 7 illustrates a perspective on the mechanisms behind the integration of ERP and DSS within the boundaries of a firm. This integration occurs via the connection of many technological layers that may already exist in the firm. Though our framework resembles the infrastructure of a large firm, many small and medium-sized firms are also part of our framework. The database layer sets the platform for the collection and maintenance of the raw data received by the firm. Typically, a firm (depending on its size) will have a number of databases that are responsible for collecting and maintaining different forms of data. For example in a large firm, a CRM system database may deal strictly with the customer-facing data, a SCM system database may handle the supplier-facing data, and an ERP system may handles the general business transaction data. The platforms used by these databases may vary in the firm.

For example, the ERP system database may be running under a Microsoft SQL Server environment, while the CRM and SCM databases work under Oracle. Finally, there may be instances where some small to medium sized firms have not incorporated transactional systems or data warehouses. In these cases, the database layer has the flexibility of connecting with proprietary DSS already in place.

The transactional system layer resides on top of these databases. A firm that has CRM, SCM, and ERP system databases will typically have CRM, SCM, and ERP transactional systems. These systems interact, integrate, and to a certain extent analyse, the data that these databases hold. For example, when a user posts a production order through an ERP system, the system feeds this transactional data into the ERP system database. The database then updates the relevant functional units and automatically and all at once. It is also worthwhile mentioning that firms have come to realise that these transactional systems alone, do not provide them with the information processing and analysing capabilities they need. As a result, firms have the opportunity to integrate their transactional systems with proprietary DSS that provide their decision makers with comprehensive analytical and decision support capabilities.

Each of these transactional systems may have their own data warehouse, illustrated on the data warehouse layer. These data warehouses provide yet another information processing option for the firm, as they are able to extract data from their respective transactional systems and provide decision makers with more relevant, accurate, and multi-faceted analytical information. These data warehouses also have the capability to connect with proprietary DSS, thereby providing specific analytical capabilities. For example, there may be proprietary DSS, like an EIS, for the strategic decision makers of the firm. Integrating these applications with a data warehouse provides strategic decision makers with analytical capabilities more suited to their role. This is in comparison to the uniform analytical capabilities a data warehouse may provide.

The DSS component and proxy pool, DSS component mapping layer, and the DSS application layer (includes the Flexible Enterprise Decision Support System (FEDSS)), are shown as separate layers in our framework. However, we may consider these as a set of technological layers that are dependant on one another for a number of reasons. First, the DSS component and proxy pool acts as a library that collects and stores the components (i.e. data, visualisations, models, solvers) and proxies needed to present decision makers with the information they request via the FEDSS. Data components typically have a direct connection to a database in the database layer, from which it collects the objects that the decision maker may specify via the FEDSS. A model illustrates the structure of a real-life problem. A model is the central component that sets the structure for the interactions between itself and all the other components. Solvers take these models and treat them as their inputs, from which they perform

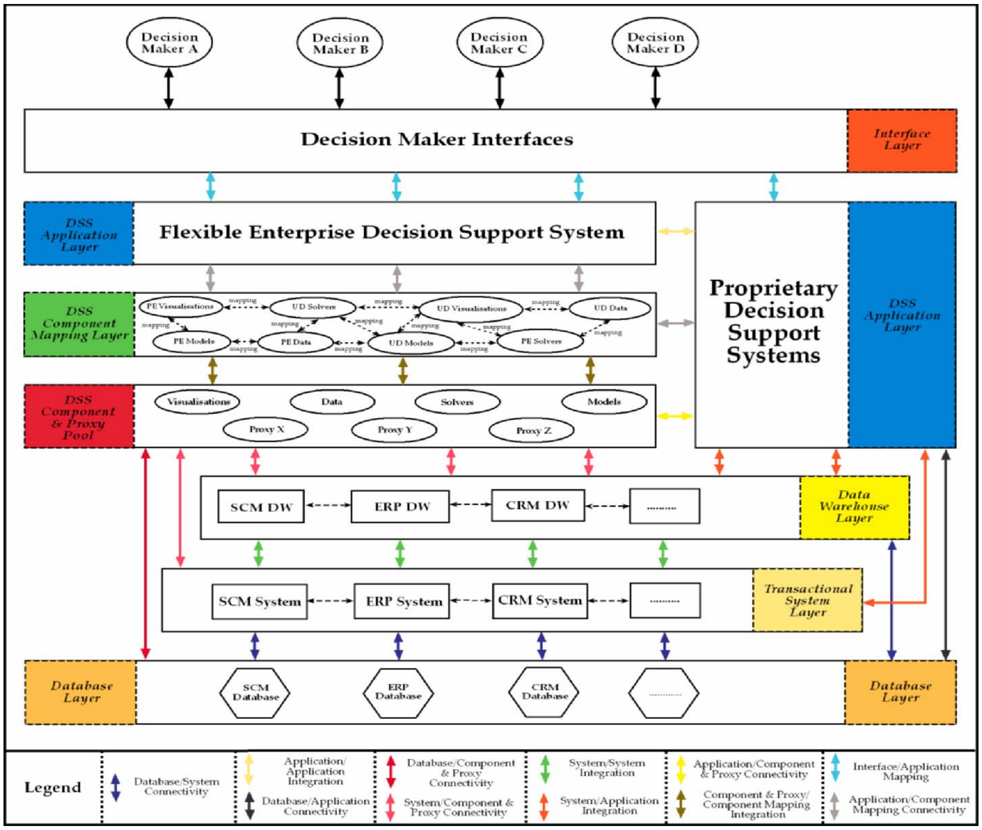

Figure 7. Integration of ERP and DSS within an enterprise

transformational analysis, and return the necessary output. Visualisations are similar to solvers in that they return an output requested by the decision maker. However, instead of only returning an output in text or numerical format, these components presents the output in a visual format. A proxy is an object that acts on behalf of another object. The inclusion of proxies in our DSS component and proxy pool enables more transparency in terms of the mechanisms of the FEDSS from the perspective of the decision maker. This is because the decision maker can view and manipulate components without needing to refer to the database, transactional system, or data warehouse layers, where the real components may be residing. This helps to reduce the time that it takes to perform routine component request operations, such as requesting the display of a simple graph because the proxies can act on behalf of the real data, solver, model, and visualisation components. In addition, the framework shown in Figure 8 has been setup in such a way that allows the DSS component and proxy pool to collect its components and proxies from a variety of sources. Second, without the presence of the DSS component-mapping layer, these components and proxies would not be able to communicate with each other. In addition, they would not be able to validate the request of the decision maker via the FEDSS. The final piece of the puzzle in our dependent set of technological DSS layers is the FEDSS. This layer is dependent on the operations performed by the DSS component and proxy pool and the DSS component-mapping layer. The requests of decision makers move through the FEDSS and feed into these other layers. The FEDSS provides decision makers with several important capabilities. This includes the opportunity to create or select models that best represents the problem at hand, instantiate these models with dates, execute them with solvers, and visualise the results using various visualisation formats. This type of flexibility means that decision makers are able to make more effective business decisions for their firms. This is because the information presents itself in a manner that they can clearly understand, thus increasing the possibility of augmenting the Intelligence Density of their firms. In addition, the FEDSS may also integrate with proprietary DSS in order to provide decision makers with customised decision support capabilities.

With a discussion of the mechanisms behind the integration of ERP and DSS within a firm in mind, we can now move on to discuss how this framework assists firms to collaborate. Figure 8 illustrates our perspective on how firms can achieve multi-enterprise collaboration via the integration of ERP and DSS. A firm takes care of its internal environment via the ERP and DSS integration framework discussed previously. To collaborate at a multi-enterprise level, the firm connects with its partners through EAI technologies. The open and flexible nature of this framework enables firms to integrate their technology, processes, and information with all their partners along their extended value chains. These partners in turn may also integrate their respective technologies, processes, and

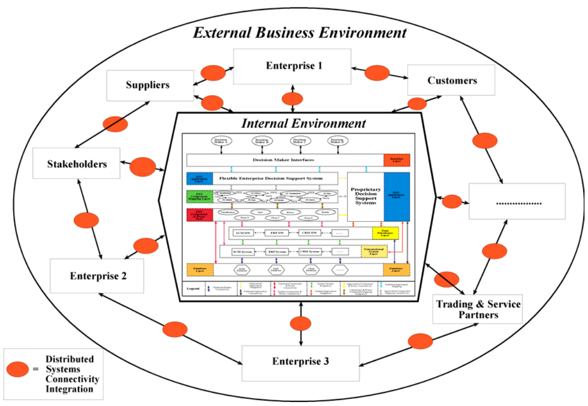

Figure 8. Multi-Enterprise Collaborative network

information, thus creating a network like multi-enterprise collaborative structure. The presence of such a network increases the Intelligence Density of the firm as all its decision makers (internal and external) have access to all the relevant and detailed information to base their business decisions on.

5. Conclusion

Firms need to provide their decision makers with timely and effective support from Information Systems. This support needs to first focus on providing capabilities to increase the Intelligence Density of the firm. Second, it needs to improve the visibility and quality of information that decision makers handle. Finally, these Information Systems have to aim to not only assist the internal environment of the firm, but also set the foundation for the firm to achieve multi-enterprise collaboration with their partners along their extended value chains. ERP systems together with DSS provide this kind of support. Decision makers have the ability to maximise the Intelligence Density of their firms by providing them with the capabilities to access, scrub, integrate, transform, discover, and gain knowledge.

The proposal of a Multi-Enterprise Collaborative ERP-DSS conceptual framework allowed us to portray the existing range of quality solutions from a host of well-known vendors in the areas of SCM, Enterprise Management, and CRM. These solutions can assist firms to manage their internal environments, while laying a good foundation for achieving multi-enterprise collaboration. The presence of this conceptual framework allowed us to investigate the way we may implement the integration of ERP and DSS by proposing a number of high-level and medium-level system frameworks. These system framework proposals introduced a fresh perspective on the integration of ERP and DSS, and their role in supporting firms in their quest to obtain and maintain valued relationships with their partners.

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