Multiagent Web based Decision Support Systems for Global Enterprises: An Architectural Blueprint

Tagelsir Mohamed Gasmelseid
Assistant professor, Department of Information Systems,College of Computer Sciences and IT, King Faisal University, Al Ahsaa 31982, Saudi Arabia. Tel: +966507858090. E-mail: Tagelsir.gasmelseid@gmail.com

ABSTRACT

Financial institutions are striving to maximize benefits from the emerging digital economy. However, the decision to take such an investment option is contingent upon the "preparedness" of these institutions and the attributes of the infrastructure of global transactions. While the migration to global spaces of operation is being relaxed by the proliferation of information technology infrastructures, the deployment of web based decision support systems is still constrained by many data-specific and decision modeling limitations. To move these systems to a stage of engagement, a paradigm shift in terms problem conceptualization, system analysis and design is looming big. This paper reflects on these limitations with special emphasis on the investment information systems.

Key words: Web based DSS, investment DSS, decision making.

I. INTRODUCTION

On the brink of the 21st century, the impulse of new technologies and flexible forms of organization and management have resulted into a global economy characterized by fragmentation, the transfer of the buying power to the customer, creation of new distribution channels, the development of new marketing and pricing models and reduced number of staff [1]. The recent advancements witnessed in the field of information systems strongly support remote access of data, distributed management of financial resources in an open, electronic financial market and enhanced the availability of on-line and real-time information.

The global integration of markets, processes and operations has been accopmanied with dramatic organizational, social and cultural changes that warrant the attention of global enterprises. Competition from traditional and nontraditional players, the emergence of a multitude of delivery channels, a plethora of regulatory and governmental compliance requirements, and demands for more flexibility and agility, among others, are significantly influencing business design and execution [2]. The resulting new digital global economy is based on global networks of "capital", "information" and "power" and is driven by institutional concepts of "deregulation", "liberalization", and "re-engineering".

II. GLOBALIZATION OF FINANCIAL INSTITUTIONS

A key attribute to the digital global economy is financial globalization in which financial markets are becoming globally interdependent and electronically connected in a global context and the factors of production (labor, capital, knowledge and resources) are being organized around multinational institutions. Being viewed as means for ensuring access to capital resources and value realization, global financial markets are becoming necessarily information-based and valued. Many financial institutions are focusing on overseas operations (e.g. Citibank) and the penetration of international markets [3]. A large number of companies (such as Toyota, General Motors and Merrill Lynch) entered the financial market offering financial services through smart cards. On the other hand, technological infrastructures (such as the internet, electronic data interchange, Object relational databases and multidimensional data analysis) are considerably facilitating financial globalization and are motivating financial institutions to engage in electronic transactions and the provision of an array of services that enable customers to request information; carry out most retail banking services such as balance reporting, inter-account transfer and bill-payment via telecommunication networks [4]-[5]. Despite the variety of motives that bring institutions online, financial institutions adopt electronic transactions in pursuit of leveraging purchasing power, controlling invoice reconciliation activities, increasing market share, retaining customers, maintaining competitive advantage and reducing costs [6]-[7].

Due to the complexities associated with the global economic system many financial institutions in developing countries are planning to explore and involve themselves in global investment transactions especially at a continental level in different areas such as telecommunication and construction sectors. However, they have been faced by the following issues:

1. Growing interest in real time and online information:

Within the context of the digital economy, information-powered networks are emerging as a base for productivity improvement, competitiveness and flexibility at different scales of interaction. The growing need for effective coordination, integration of processes and improved responsiveness increases the demand for real time information in global enterprises. The capacity of financial institutions in developing countries to acquire and use such information is being associated with many downside risks.

2. Improved organizational capacity to manage technology-intensive acquisitions:

Globalization of core activities demands more emphasis on improved enterprise technological capacity (telecommunications, fast transportation, and information systems) and institutional empowerment considerations (networking of business firms and on flexible forms of organization and work management). Therefore, institutions are challenged by the need to improve their capacity to acquire and dynamically manage appropriate mixes of technology-intensive infrastructures. The engagement in global transactions is a function of a combination of "qualitative" variables such as market buying behavior, transactional relationships, communication channels, general decision making approaches, as well as the depth, dynamics and quality of the intellectual and knowledge capital and the capacity of the entire financial institution to operate in a global scale efficiently and meet its obligation [8]. Although the risk ness of global operations can be analyzed by balance sheet data such as bank liquidity and capitalization [9], economic-induced risk originating from economic factors such as trade performance, external debt as well as political-specific variables is difficult to assess and therefore demand a more rigorous institutional capacity to assess downside risks.

3. A change of management styles and undrestanding of organizational objectives:

The diversity of global business activities incorporates significant workforce diversity and cultural differences that affect decision making and decision support tools to be used. Managers of global enterprises are therefore required to differently, perceive, their objectives across global benchmarks and use different critical success factors with regards to the provision of goods and services, the diversity of markets and source their inputs of raw materials, labor and services.

Moreover, financial institutions in developing countries are facing additional challenges in their attempt to engage in global investment transactions such as:

1) Maintaining the appropriate market efficiency form (s) and streamlining the interplay of decision making variables along "integrated" domains and landscapes. The forms of market efficiency range from the weak form (where investors can not use past price and/or volume to forecast future assets prices), through semi-weak (which adds the fact that all publicly available information is reflected in asset prices) to a strong form (where all information both public and private is reflected in the prices of financial goods and services and where managers have no information advantage). Because market valuation, collaboration and integration is becoming information-intensive, the forms of market efficiency to be adopted affects both information availability and the processing capacity of institutions especially for risk averters and investments with temporal trade offs and special circumstances.
2) Pursuing dynamic investment strategies over extended time periods and adjusting the mix of assets by capitalizing on "risk" and "return" and fine-tuning both investment-specific and situational variables. In the global financial market, financial decision making can not be limited to the maximization of investable net worth based on the effective manipulation of money and credit across a wide spectrum of competitive investment options. It is importnt to assess the impact of the risks associated with the type of investment, the amount and timing of expected cash flows and investor's rate of return particularly for multi-asset, multi-stage and dynamically unbalanced investment portfolios.

In response to these changes, emphasis of decision makers tends to be oriented towards understanding the emerging enterprise decision making processes and decision support systems (DSS), new infrastructure for decision making in organizations and society, the role of web technologies in decision making, and emerging theories and practices for web-based knowledge management [10]-[11].

III. DECISION SUPPORT SYSTEMS

A decision support system can be defined as a computer system that assists decision-makers in choosing between alternative beliefs or actions by applying knowledge about the decision domain to arrive at recommendations for the various options [12]-[13]. They offer a framework within which complex systems can be structurally represented, easily understood and significantly enhanced to allow the acquisition of additional information and new insights through the use of appropriate tools of analysis. It also provides support for integrating (independent and interdependent) decisions across different organizational landscapes because of their ability to represent and manipulate imprecise knowledge which is usually associated with the uncertainty intrinsic to ill-structured problems [14]-[15].

According to [16]-[13], decision support systems fall into five categories: (a) Data-driven DSS which collects and provides real time access to a large operational database necessary for taking structured, semi-structured, and unstructured decisions, (b) Model-driven DSS containing a number of models used for planning and scheduling, (c) Knowledge-based DSS including a small rule-based dispatching system (d) Communication-based DSS providing warnings triggered by pre-specified conditions and sent automatic or manually generated messages to operators before they began processing particular lots to which exceptions applied and (e) Document-driven DSS containing a module for engineering specifications.

Because global enterprises generate data in many operational systems, the use of integrated data-driven decision support systems allow a decentralized access to data and facilitate the provision of queries and management reports. Because it is difficult to share and maintain knowledge, the use of Knowledge-driven DSS expands the base of explicit knowledge in global enterprises and facilitates distribution, access and retrieval of such knowledge. The use of communications technologies (such as LANs, WANs, Internet, ISDN, Virtual Private Networks) and tools (such as groupware, chat, Videoconferencing, and Bulletin Boards) improves the capabilities of communication based decision support systems and their potential to strengthen competitiveness in global enterprises.

Financial institutions in developing countries employ decision support systems to help in:

1. Resource Analysis and assessment of the feasibility of investment projects in pursuit of sustained use of funds by using model-based quantitative estimates of potential returns on investment and operational requirements (i.e., inputs, processes and outputs).

2. Fund use planning and policy formulation based on the feasibility of investment options, available resources, situational change agents and the use of appropriate optimization algorithm wherever necessary.

3. Investment and fund monitoring and evaluation of activities in different sectors to improve the overall financial performance through the identification of constraints and the use of feed back and feed-forwards processes.

4. The provision of proper outputs to enhance the presentation (transfer) of results to policy makers in a manageable and communicable way.

The use of "conventional" decision support systems in investment management tend to be oriented towards building "interfaces" that link "databases" and "model bases" in order to generate management reports as shown in figure (1) below.

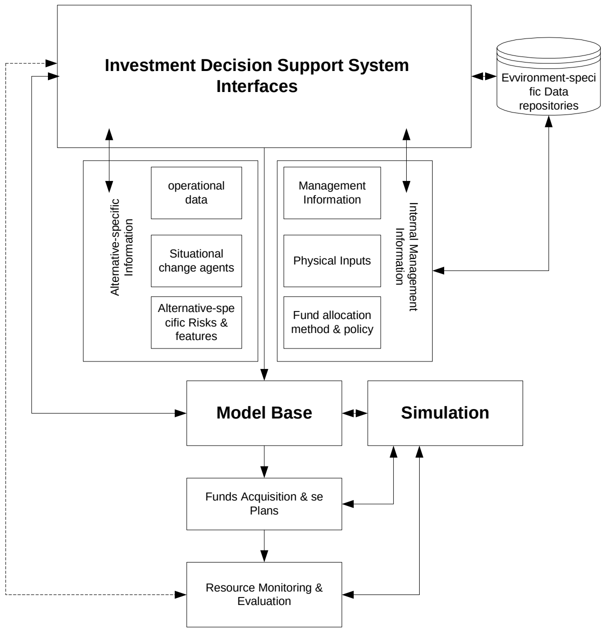

Figure (1): conventional investment DSS

However, most of the existing decision support systems (especially those developed with conventional orientations) are regarded as being not satisfactorily fitting into emerging working practices or organizational environments because decision-making is becoming more pluralistic and increasingly determined by hierarchy considerations and argumentative and evidential value [17]-[18]. According to [19], the development and application of decision support system (DSS) is rather limited due to poor maintainability, in-flexibility and lack of reusability. While this may be applicable to specific applications, the use and adoption of DSS by financial institutions to improve and facilitate investment management in developing countries is being challenged by the following limitations:

(a) Data Specific limitations

1. The financial system at the abstract level of conceptualization incorporates planning, design, coordination, operation and maintenance issues. The complexity of maintaining an integrated view for global enterprises originates from the difficulty to acquire and integrate relevant information. The data making up the physical aspects of the financial system are a part of a complex cause-effect context that is expected, by introducing unexpected variability, to change the swing of the pendulum of decision-making and control. Because of the diversity and complexity of the

processes involved, data availability is significantly affected by the heterogeneity of data sources, focus, methods of collection and analysis, organization and accessibility. As a result, especially under conditions of risk, the capacity of decision makers to have an integrated view and acquire relevant decision data to conceptualize interdependencies and model relevant phenomenon (e.g., investment patterns) remains questionable.

2. Sectoral investment processes involve a large amount of business metadata (describing investment processes, entities and actors, attributes and relationships, and technical implementation of investment information) and technical metadata, both static and dynamic, (describing the physical implementation of the business metadata). However, despite the use of Semantic Webs and Metadata Management Systems for understanding and interpreting information stored by the various systems, the entire metadata of conventional DSSs does not contain semantics on what DSS is and how to use it.

3. The problems associated with the discovery and management of database inclusion dependencies are affecting the semantics of databases, relational database design and maintenance, database reverse engineering, semantics query optimization, and efficient view maintenance in data warehouses. The discovery of the suitable inclusion dependencies is a complex process because it is impractical to discover all non-trivial inclusion dependencies satisfied by a particular instance especially when testing multiple relational schemas. Inclusion dependency should not be regarded as a process of “duplicating attributes that are used to link together the relational schemas in a database schema” but instead, it should reflect processes at a single functional system (such as investment) as well as cross-system linkages in a way that promotes information sharing and the development of learning value-adding networks.

(b) Decision modeling Limitations

1. The globalization of financial markets has been accompanied with difficulties with regards to decision modeling especially in hierarchical domains and multi phased investment processes where decision makers tend to face considerable difficulty in conceptualizing “problem domains” and envisioning “solution spaces” as “global decision configurations. The types of models to be used, the nature of model sharing and coupling practices, the degree of accessibility and the extent of privileges to be offered for decision partners are emerging as limiting factors. When managing global investment systems, decision making is viewed as a multi phase process in which decision needs are translated into a number of optional decision scenarios, which are then analyzed and used to make recommendations within a distributed domain of functionality.

2. The financial system (with its large number of stakeholders) is regarded as a legacy system in which the process of decision modeling can be threatened by the lack of standards to integrate different legacy systems in a way that enables sharing and validating different decision making models.

Meeting these challenges calls for two important shifts:

a) A paradigm shift in the “pattern” of financial decision making in order to reflect the change exhibited in the "domain" and "context" of integrated "global" decision making which is expanding beyond “organizational boundaries” towards a wider “market reach” and “diversified content”. Such a transformation can’t be met through the migration from “conventional” to “integrated” decision making styles but it also demands a new mind set to incorporate the new array of issues and concerns.
b) A transformation in the way information systems are conceptualized and “adopted” because it is “information utilization” not “information supply” which makes a difference. Within the context of electronic, networked and integrated financial systems, the success of the entire information systems adopted in global enterprises is contingent upon on the capacity of such systems to facilitate the achievement of corporate and shared goals associated with global operations rather than upon the maintenance of mountains of operational, non-operational and meta data or the entire system and organizational architectures.

IV. WEB ABSED DECISION SUPPORT SYSTEMS

The complexities associated with the management of global “investment” activities have increased the interest in the use of web technologies and intelligent techniques. Web used technologies are used to improve the capacity of decision support systems through decision models, On-line Analysis Processing (OLAP) and data mining tools that allow "standardized" publishing and sharing of decision resources on the Internet [31]. In a web-based decision support system, all decision support related operations are performed on a network server n order to benefit from platform independence, shorter learning curves for users already familiar with web tools and web navigation, lower software distribution costs, ease of performing system updates and "reusability" of decision modules and information on the Internet through standardized protocols and formats [16] - [20]-[21]-[22]-[23].

According to [24], the importance of using web based DSS originates from the growing amount of available information that should be identified, controlled and accessed remotely using web based tools to support reusability of integrated decision modules. Using such systems, an enterprise can create survey software, Web based forms, build document-driven DSS for requests and approvals [25]-[15]. They help global enterprises manage and improve decision processes through improved efficiency, better process control, improved customer service, more flexible re-design, and streamlining and simplification of business processes. Using web based DSS decision-makers can share open decision modules on the Internet using standardized protocols such as HTTP, and a standardized format like XML or DAML [26].

According to [27], web-based systems are regarded as "platforms of choice" for delivering decision support while taking into account many technical, economic and social considerations. The migration towards web based DSS denotes a shift from DSS generators (that allow users to develop specific applications characterized with limited deployment, inflexibility) to integrated cross-application orientations that emphasize the reuse of applications and components [28]-[29]. By deploying web capabilities, multiple knowledge bases and knowledge processing techniques can be used. The design of decision support systems has been affected by the availability of a wide range of web based tools, techniques and technologies. The use of web tools are reshaping the description of relations between information components and decision modules in a way that affects both the physical and logical design of the DSS, model visualization, sharability of decision modules and the development life cycle of DSS. As a result, the underlying architecture for Web-based DSS has moved from main frames, to client–server systems, to Web- and network technology-based distributed systems that enable the integration of large amounts of data and decision support tools originating from heterogeneous multidisciplinary sources for the provision of value-added information using knowledge discovery and data mining tools.

With the advent of web-based DSS, the user community expands to include, in addition to the managers and experts working on business-related problems, customers, suppliers and financers who shape the firm's policies and decisions. On the other hand, the problem domain is no longer limited to taking structured and/or unstructured decisions but turned into a wider context of information production and use. The transformation into distributed, open, interoperable, and scalable decision making environment has been facilitated by the wide of range of internet-based tools and technologies (such as parallel processing, solver server technology and cluster computing) in a way that reduces computational load and enables efficient use of models to solve a wide variety of problems.

V. RELATED WORK

Web based applications are being widely used by global enterprises for online shopping because goods are becoming increasingly easy to deliver, cheaper, and easier to choose [30]. These applications are seen as vehicles for improving customer interest, improving product perception, shopping experience, customer service and customer risk in considering shopping mall design [34] - [32]. Within this context, emphasis tend to be made on developing business-to-customers shopping malls that promote customer interest in the form of super stores, promotional stores, product lists, plain sales stores, and a one-page store [31]-[32]-[33]-[34]-[35]. The approaches used for the development of such online malls continued to be oriented towards the maintenance of appropriate merchandise, provision of reliable services, allowing for promotions, ensuring convenience, enabling enhanced interface, and facilitating checkout and store navigation [33]-[36]. Other efforts are done to develop web-based applications to assist customers configure product and service according to their needs by allowing individual customers to design their own products by choosing from a menu of attributes, components, prices, and delivery options [44]. Within this context, emphasis tend to be made on the alternative use of web based applications for searching databases, standardizing models, and conducting comparisons using multiple pre-specified attributes. The approaches for developing web based applications in the health care industry, have been concerned with facilitting service provision and improving awareness. The drug checker application that helps asceratin the medications a person takes, and health calculators on topics such as stress, nutrition, and fitness are also examples of web based systems.

Some approaches are also being used for developing web based applications to facilitate collaborative product development systems that enable multidisciplinary team members to share design knowledge, manage projects and their data and monitor the status of a working design environment and the design process [37]-[38]-[39]-[40]-[41]-[42].

Despite the spreeding deployment of web based applications, little has been done to develop appropriate system architectures that guide their implementation. Several frameworks have been proposed for web-based applications but most of them are either to support fundamental aspects of collaborative design or still under proof-of-the-concept prototype development [43]. They majority of them lack the concept of "integartion" that allow them to interact with each other or cause an adverse reaction.

The real challenge is how to develop architectures for problem that are different from conventional activities as they are based on new concepts of online and webbased concepts in pursuit of narrowng the gap between online customers and traditional market customers [45]-[46]-[32].

Because of the lack of an integrated view, the frameworks used to reflect the dynamics of web based applications have resulted into "dash boards and websites" rather than integrated systems that incorporate decision support functionalities [31]. There has also been a considerable failure to incorporate many situational (organizational, social and economic) considerations [47]. According to [48] most web-based spatial decision support systems essential for global financial decision making, for example, are either simple spatial query systems or map-building programs, while access to more resource and data intensive GIS functions such as spatial analyses is limited. The technical challenges of managing the transfer of large volumes of spatial data between sites and the management of spatial data which is being used, created or changed by multiple users in a stateless web-based system are limiting the adoption of an integrated approach. The lack of reliable network algorithms designed to exploit the computing resources and bandwidth characteristics of computer networks [49] is another limiting factor. Such limitations have increased the cost of developing web based tools and limited their use to generic minimum cost network problems and being highly specialized for use within particular industries [50]-[51].

The contribution of this paper lies into its emphasis on developing an integrated approach and framework for the development of web absed decision support systems that are adaptable to the needs of global enterprises. The use of multiagents technologies and concepts allows for more flexibility and coverage. On the other hand, the framework is easy to expand to incorprate additional "players", "functions" and "attributes" or "re-visit" the model base". Modification of the system is no longer dependent on the source code to be written by the programmer, but the conceptualization of functionalities as well as the maintenance of the entire system can also be done from remote place. On the other hand, the famework shows some degree of modularity where different agent modules and functionalities can be viewed and implemented seperately (and collectively) in accordance with the domain of problem and decision maker preferences.

VI. MULTIAGENT DSS FOR INVESTMENT MANAGEMENT

The use of agent-based systems technology is growing in different domains because of their ability to offer modularity and abstraction necessary for facilitating the management of real, complex, large, and unpredictable problem domains. Their deployment in electronic commerce, traffic control, health care provisioning, portfolio management and telecommunications, proved their relevance to handle complex, distributed problems involving a multiplicity of interconnected processes whose solutions demand the allocation of fusion of information and expertise from demographically distributed sources [52]-[53]. The incomplete information and capabilities possessed by individual agents limit their potential to handle complex decision-making problems especially within distributed environments where decision making data tend to be decentralized and the need for global control of the entire system increases. These capabilities require that agents be able to interoperate cooperate and coordinate with each other in peer-to-peer fashion to increase their problem-solving scope through the use of multiagent mechanisms. Multiagent systems approach problems through the development of functionally specific, and possibly heterogeneous specialized modular components (agents) to solve particular problems by using their own most appropriate problem solving paradigms and interact in order to reach an overall goal and support different people (using different information sources and communication links), at different times, with different software tools and techniques. They generate approximate solutions by dividing the necessary knowledge into subunits, associating an intelligent independent agent to each subunit, and coordinating the overall agents' activity.

The aim of coupling DSS with web software agents' technologies is to enhance global investment management processes. The use of multiagent systems improves the capacity of decision makers to represent complex systems, global interactions among dynamic and autonomous entities, assessment of alternative scenarios and negotiation. Their use can also provide support in terms of finding and filtering information, customizing views and automating work to reduce entry requirements and removing technical barriers to ensure involvement in a wider decentralized decision making environments. In addition to their ability to represent spatially and temporally distributed systems, multi agent systems support decentralized management of global enterprises through the delegation of tasks and management of complexity.

The use of multiagent technologies and associated techniques (such as data mining) relaxes the challenges faced by global enterprises with regards to improving the availability and accessibility of online information and turning enterprises into learning organizations by improving their capacity to effecively manage integrated systems and dynaically adjust their organizational patterns. Their efficiency in adopting web based multiagent systems significantly improves their ability to maintain market efficiency and global investment strategies. Moreover, coupling agent and other web based technologies relaxes both data specific and decision modeling limitations through the appropriate sharing of "reusable" decision data and models.

The architecture of the entire web-based multi agent system, the number and type of agents, functionalities and potential organizational and decision support depend exclusively on the complexity of the entire problem domain. The development of suitable architectures that support the process of managing investment and improving investment intelligence in global enterprises has been based on the use of multiple methodologies. The architecture shown in figure (2) below follows a resource oriented approach which emphasizes three basic activities: (a) resource acquisition (b) resource use and application and (c) resource planning and monitoring. The framework is also based on a process-centered approach which focuses on agent functionalities and privileges. The framework includes two basic types of agents: superior and subordinate. Superior Agents act in "line" capacity to perform tasks in their own capacity or on behalf of their subordinate agents. Subordinate agents act in a "staff" capacity to support access to data sources, process verification and validation and subtasks implementation especially for data mining and database tuning. The incorporation of multiple approaches enables further consideration of agents as "task" and "interface" agents.

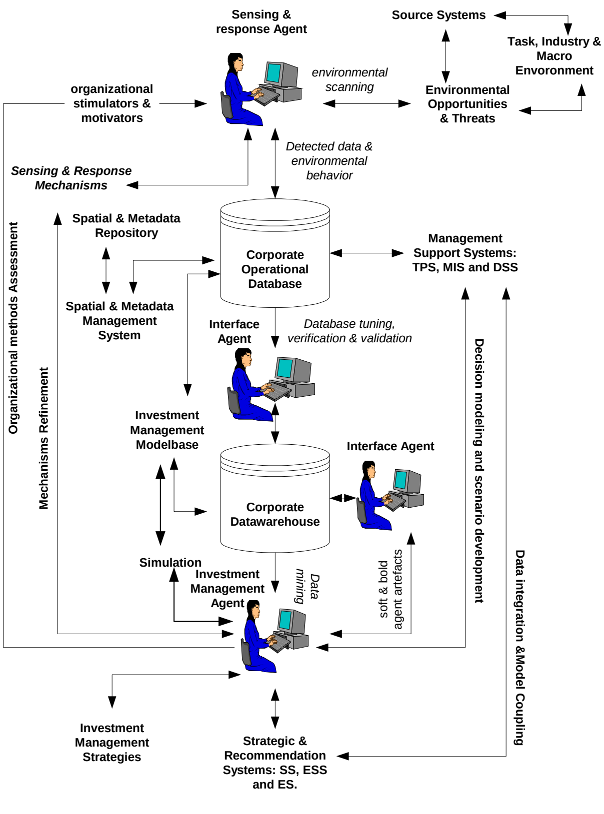

Figure (2): AWBDSS Architecture

The process starts at the desk of the Sensing and Response Agent (S&RA) which aims at improving investment intelligence and management through environmental scanning directed towards the crystallization of all potential opportunities and threats in the "investment" environment based on the dynamics of source systems interacting in it. Successful management of global enterprises demands an increasingly sophisticated ability of their senior managers to promptly understand and adapt to rapidly changing external environment. Environmental scanning aims at the collection of external information in order to reduce downside risks and provide an early warning context for decision makers with regards to changes in the environment and possible consequences through scanning, monitoring, forecasting and assessment. The environment to be scanned ranges from the task to be performed through the industry shaping up functionalities to the macro environment. Within the context of the digital economy and global enterprises, the feasibility of traditional models and methodologies that focus on historical internal data for forecasting and understanding environmental change and consequences remains questionable. The capacity of such kind of models is endangered with downside risks associated with global transactions and the growing number of social, technological, economic, and political implications that significantly affect both problem domains and solution spaces.

The data and signals of behavior detected by the (S&RA) are the main inputs to the operational database reflecting current or forecasted transactions. The (S&RA) adopts a set of sensing and response mechanisms to govern the functionality of the enterprise with regards to the existence of sensed data including and associating senses, detections, and responses with the over all global policy. The mechanisms in use should be subject to continuous refinement to accommodate changes that take place in the environment. The (S&RA) facilitates the acquisition of appropriate and update of data acquired to enable continuous organizational assessment of the sensing and responding methods. Because sensed data constitutes a driving decision component for the Investment Management Agent (IMA), linkages of the functionalities of the (S&RA) are done through a set of organizational simulators or motivators reflecting all environmentally-induced and organizationally-articulated variables that indicate the need for response to opportunities and threats that exist in the external environment through the design and use of appropriate adaptation and intervention options. Such options include the development of new projects, developing customer relations management programs that target advanced customer loyalty, and drawing strategies that make remarkable breakthrough in the global market in areas related to the five forces model (i.e., the power of the customer, suppliers, new market entrants, rivalries, and substitute products and/or services).

Both the (S&RA) and the (IMA) interact with each other as well as with other source and client systems. Source systems represent all possible information sources in the environment as well as other internal systems that provide data and methods. Internal source systems are represented by On-line Transaction processing (OLTP) applications (that support the operational activities of the investment process) and also by existing data archives or external data sources. Client Systems are represented by departmental data marts, enterprise wide information systems (e.g. web portals), local reporting systems, and other On-line Analytical Processing (OLAP) components. Client systems can use the interface agent to access data from the operational database, the corporate data warehouse or from both of them simultaneously. They range from management support systems geared towards internal functionalities (TPS, MIS, DSS, OAS, and KWS) to strategic recommendation systems ensuring linkages between the entire global enterprise and its environment (ESS). However, the dynamics of the investment process significantly affects the capacity of such systems to interact with each other throughout the landscapes of the multiagent organization. The more effective the interactions being built the more will be the support provided for global decision makers and their respective task agents with regards to decision modeling, scenario development, data integration and model coupling.

The corporate operational database represents the bridge between OLTP and (OLAP) environments. The data structure of such database must be designed in a fashion that allows accessibility to all client systems with the possibility of having basic cleansing and integration processes preformed on loaded data to be integrated and consolidated from disparate operational systems. The interface agent undertakes all activities necessary for database tuning and verification to update the enterprise data warehouse. In addition to "sensed" data, the corporate operational database includes a repository of spatially business and technical metadata. Business metadata describes the context of investment (i.e., investment style definitions, investment processes, entities involved, relevant attributes and relationships, implementation mechanisms and departmental information components). Technical metadata, on the other hand, describe the physical implementation of the business metadata. The static technical metadata describes rarely-changing objects in terms of their data dictionaries descriptions and structures, attributes and physical definition, unique identifiers, indexes of access and sharing and corresponding entities relationships. The dynamic technical metadata describes the metrics governing data load volume and quality quantifiers, overall data statistics, data flows, data usage patterns and other information about the usage of the static structures. The Spatial and Metadata Management System is the logic and semantic layer of understanding and interpreting the information stored by the various systems. The importance of using such SMMS is to facilitate spatial analysis and data geo-referencing by allowing users to create, edit, view and publish standardized spatial metadata and combines the most advanced corporate metadata editor with an innovative data, metadata search and analysis tool that enhance incorporating use, search, evaluation and management reporting capabilities.

The enterprise corporate data warehouse contains integrated enterprise-wide detailed and summarized data, stored in a corporate integrated and consolidated view with the basic aim of maintaining consistency, enabling data sharing and strengthening accessibility among source and clients systems. The process of database tuning aims at streamlining the performance of the entire database by focusing on cohesive tasks (using single or multiple procedures to model operations using the appropriate core abstract method components within the context of relevant activities and disciplines) and services performed on them in a wide multi agent organization and domain of analysis. Such tuning coincides with the process centered and resource oriented approach adopted for the development of this architecture in which emphasis is being made on agent functionality and modeling and integration of them to serve other agents or decision makers. The (IMA) uses the services of the interface agent to access the corporate data warehouse.

With the help of the interface agent, the (IMA) uses soft and bold artifacts for data mining to explore patterns of behavior and trends shown by detected data. Emphasis on data mining stems from the growing volume of resulting data and the need for maintaining linkage between transaction and analytical systems to facilitate open-ended user queries. Moreover, the process is motivated by the need to explore data through some activities including data gathering (data warehousing and web crawling), cleansing (eliminating errors), feature extraction and discovery (obtaining only the interesting attributes of the data and extracting patterns) and the development, validation and deployment of the appropriate models in pursuit of explaining variability and producing stable results using techniques like bagging (averaging and voting), boosting, stacking (stacked generalizations) and meta-learning.

Using its linkages with other agents, source and client systems and databases, the (IMA) carries out simulation tasks in accordance with the nature and magnitude of trends exhibited in the investment environment and the set of decision making models at its disposal (such as return on investment, net present value and payback period. The result of such process is a set of investment management strategies that reduces the risk of global operations based on improved "investment intelligence".

VII. DISCUSSION

The integration of agent and web technologies with decision support systems remains of significant importance and value to global enterprises and financial institutions in developing countries willing to engage into global investment. The problems cited in this paper with regards to the “usability’ and "dependability" of conventional DSS reflects two basic concerns:

1. Architectural and development concerns:

DSS are usually developed and used to support users with different decision frequencies (ad hoc and institutional), to approach problems with different structures (semi structured and unstructured) taking place at different decision making levels. However, the effectiveness of the entire DSS depends upon the architectural ad development approach used and the capacity of making clear linkage between "functionalities" and "problem domains".

The emphasis on architectural concerns stem from the fact that multiagent web based DSS incorporate a wide range of “user and service mobility”, “context-awareness” and “spatial” dimensions. However, while some current agent oriented software engineering methodologies are “expanding” the application of existing “conventional” software engineering methodologies (especially object oriented) to agent oriented domains, others are focusing on defining a number of models that guide the process of designing agent oriented applications in accordance with the basic guidelines of agent theory [54]-[55]-[56]. Some of these methodologies are been criticized for their limited deployment due to the lack of maturity [57] and their failure to capture the autonomous and proactive behavior of agents, as well as the richness of the interactions [57]. Current agent-oriented methodologies focus mainly on multi-agent systems analysis and design, but without providing straightforward connections to the implementation of such systems [58]-[59]. They are characterized with a fundamental mismatch between the concepts used by object-oriented developers and the agent-oriented view [60]. As a result, they fail to adequately capture an agent's flexible, autonomous problem-solving behavior, the richness of an agent's interactions, and the complexity of an agent system's organizational structures. Most of these methods feature a technology-driven, model-oriented and sequential approach and assumes (in advance) the suitability of multiagent technology for the development of multiagent applications which may not always be the case in different problem domains. Because model orientations of these methodologies are obvious, the process of model coupling and integration process does not explicitly reflect the links between models [61]. Besides the main issues (known as agent qualities) to be addressed by agent oriented software engineering methodologies (such as autonomy, reactivity, proactive-ness and social ability), the concern for mobility have been growing over time [62]. In spite of the growing diffusion of mobile agent technology, little research has been done to settle “design” directions to be followed in order to determine when mobile agents are convenient to be used or not. However, the current agent oriented software engineering methodologies used for developing multi agent systems do not provide methods to determine in which cases mobile agents should be used. Many of the existing methodologies intentionally do not support intelligent agents; rather, they aim for generality and treat agents as black boxes [63].

The use of conventional database-and-model oriented architectures falls short to provide necessary support in decentralized decision making contexts. The use of web and agent technologies must be guided by a thorough understanding of the "context of global transactions" and appropriate software engineering methodologies. Highlighting architectural concerns enables the description of potential system functionalities as web services within the context of service oriented architecture, figuring out mobility indicators in accordance with network-specific, user-oriented and third-party-based functionalities and the articulation of context awareness to be incorporated in pursuit of improved performance. Because of these considerations, the process of coupling DSS with web and agent technologies must be based on systematic change and situation analysis, otherwise the whole process will result into a "technically sound" but "operationally-defeated" DSS.

2. Organizational concerns:

The adoption of a multiagent web based DSS incorporates a wide range of intelligent and data visualization considerations. The "augmentation" of potential benefits demands critical organizational changes that convert the entire enterprise into" learning" global body in which continuous improvements assumes paramount priority in pursuit of the provision of quality services and prompt response. To have that enabling and conducive environment the organizational structure, patterns of decision making, regulations, standard operating procedures and work flow system must be revisited and reengineered.

VIII CONCLUSIONS

The migration of enterprises operating in developing countries to electronic transactions in general is challenged by institutional, organizational and technical limitations. The success in managing such limitations significantly affects their capacity to maintian approriate market efficiency forms, develop investment strategies and effectively respond to customer and business needs. The operational and functional ability of global enterprises in developing countries to use decision support systems for the management of their investment processes has been challenged by data specific and decision modeling limitations that warrant a paradigm shift in both the pattern of financial decision making and the way decision support systems are being developed and used. The adoption of multiagent web based DSS provides global financial institutions in developing countries with added capabilities in terms of data access and sharing, prompt response, and partnership. However, their deployment calls for the resolution of many organizational and technical limitations, undertaking a paradigm shift to take care of architectural concerns and ensuring an organizational transformation that converts the entire enterprise into a globally learning platform. Maximizing the benefit from the use of intelligent web based technological developments and emerging agent oriented software engineering methodologies, deserves thorough situational analysis and continuous environmental scanning.

REFERENCES

[1] Weeks, A & d. Frisone, "E-commerce: What Legal Issues Does it Present?" *Commercial Law Bulletin* 14(4), 1999, pp. 13-14.

[2]L. Cherbakov, G. Galambos, R. Harishankar, S. Kalyana, and G. Rackham, "Impact of service orientation at the business level". IBM Systems Journal 44 (4), 2005, pp. 653:668.

[3] The Economist, Emerging Market Indicators: Foreign Banks, November 4, 2000, p. 118.

[4] Bielski, L, "E-Business Models Stress putting the Customer First", *ABA Banking Journal*, July 2000, pp. 67-76.

[5] Courchane, M; N. David & S. Richard, "Investment in Internet Banking as a real Option: Theory and Tests", *Journal of Multinational Financial Management*, 12(4-5), 2000, pp. 347-363.

[6] Beans, K, "Internet Banking is the Future of Community Banks", *Journal of lending and Credit Risk Management*, 81 (11), 1999, pp. 47-49.

[7] Ore, W, "ABAecom Poised for e-commerce Growth", *ABA Banking Journal*, 91(10), 1999, pp. 84-88.

[8] Simpson, J, "The Impact of the Internet in Banking: Observations and Evidence from Developed and Emerging markets", *Telematics & Informatics* 19(4), 2002, pp. 315-330.

[9] Foster, G (1986). Financial Statements Analysis, Prentice Hall. Englewood Cliffs, NJ.

[10] D.J Power, "What is involved in providing decision support for global enterprises?", DSS *News*, Vol. 7 (3), January 29, 2006. Available online at: http://www.dssresources.com.

[11] [IBM] Global CEO Study 2004, IBM Corporation, *http://www-1.ibm.com/services/us/index.wss/xs/bcs/a1001708*.

[12] Fox. J. and S. Das, Safe and sound. *Artificial Intelligence in Hazardous Applications*, AAAI Press/the MIT Press, 2000.

[13] J.P. Shim, M. Warkentin, J.F. Courtney, D.J. Power, R. Sharda and C. Carlsson, "Past, present, and future of decision support technology", *Decision Support Systems* 33, 2002, pp. 111–126.

[14] Kung-Jeng Wang and Chen-Fu Chien, "Designing an Internet-based group decision support system", *Robotics and Computer-Integrated Manufacturing*, **19** (1-2), 2003, pp. 65-77.

[15] Bijan Fazlollahi, Rustam M. Vahidov, and Rafik A. Aliev, "Multi-Agent Distributed Intelligent System Based On Fuzzy Decision Making", *International Journal of Intelligent Systems*, **15** (9), 2000, pp. 849-858.

[16] Huaiqing Wang, Stephen Liao and Lejian Liao, "Modeling constraint-based negotiating agents", *Decision Support Systems*, 33(2), 2002, pp. 201-217.

[17] Huaiqing Wang, Stephen Liao and Lejian Liao, "Modeling constraint-based negotiating agents", *Decision Support Systems*, **33** (2), 2002, pp. 201-217.

[18] Yong Xie, Hongwei Wang and Janet Efstathiou, "A research framework for Web-based open decision support systems", *Knowledge-Based Systems* 18 (7), 2005, pp. 309-319.

[19] Julian J. Ray, "A web-based spatial decision support system optimizes routes for oversize/overweight vehicles in Delaware", *Decision Support systems*, doi:10.1016/j.dss.2005.07.007, Available online 15 August 2005.

[20] C. Rinner, "Web-based spatial decision support: status and research directions", *Journal of Geographic Information and Decision Analysis*, 7 (1), 2003, p. 15.

[21] V. Sugumaran and R. Sugumaran, "Spatial decision support systems using intelligent agents and GIS web services", Proceedings of the Americas Conference on Information Systems, 2003. pp. 15-26.

[22] Dursun Delen, Ramesh Sharda and Prajeeb Kumar Movie forecast Guru, "A Web-based DSS for Hollywood managers", *Decision Support Systems.* doi:10.1016/j.dss.2005.07.005 Available online 15 August 2005.

[23] O. Byung Kwon Meta web service, "Building web-based open decision support system based on web services", *Expert Systems with Applications*, 24 (4), 2003, pp. 375-389.

[24] Friedman, T. L, The World Is Flat: A Brief History of the Twenty-First Century, Farrar, Straus and Giroux, 2005.

[25] H.K. Bhargava and D.J. Power, "Decision support systems and web technologies: a status report", Proceedings of the Americas Conference on Information Systems, 2001.

[26] Shifeng Zhang and Steve Goddard, "A software architecture and framework for Web-based distributed Decision Support Systems", *Decision Support Systems* doi:10.1016/j.dss.2005.06.001 Available online 11 August 2005.

[27] N.G. Shaw, A. Mian and S.B. Yadav, "A comprehensive agent-based architecture for intelligent information retrieval in a distributed heterogeneous environment", *Decision Support Systems* **32** (4), 2002, pp. 34-42

[28] Sycara, K.P, "Multiagent Systems", *AI Magazine* 19 (2), 1998, pp. 79-92.

[29] Jennings, N. and M. Wooldridge, "Intelligent Agents: theory and Practice". *Knowledge Engineering Review*, 70 (2), 1995, pp. 115 – 152.

[30] Kun Chang Lee and Namho Chung, "A web DSS approach to building an intelligent internet shopping mall by integrating virtual reality and avatar", *Expert Systems with Applications, 28(2)*, 2005, pp. 333-346.

[31] A.R. Dennis, Lessons from three years of web development, *Communication of the ACM* **41** (7), 1998, pp. 112–113.

[32] S.L. Jarvenpaa and P.A. Todd, "Consumer reactions to electronic shopping on the World Wide Web", *International Journal of Electronic Commerce* **1** (2), 1997, pp. 59–88.

[33] G.L. Lohse and P. Spiller, "Electronic shopping", *Communications of the ACM* **41** (7), 1998, pp. 81–87.

[34] R.M. O'Keefe and T. Mceachern, "Web-based customer decision support systems", *Communications of the ACM* **41** (3), 1998, pp. 71–78

[35] P. Spiller and G.L. Lohse, "A classification of internet retail stores", *International Journal of Electronic Commerce* **2** (2), 1998, pp. 29–56.

[36] G.L. Lohse and P. Spiller, "Quantifying the effect of user interface design features on cyberstore traffic and sales", *Proceedings of the Computer Human Interaction'98, April* (1998), pp. 211–218.

[37] Ying Daisy Wang, Weiming Shen and Hamada Ghenniwa (2003). WebBlow: a Web/agent-based multidisciplinary design optimization environment, Computers in Industry, 52(1), September 2003, pp. 17-28.

[38] G. Toye, M. Cutkosky, L. Leifer, J. Tenenbaum, J. Glicksman, SHARE: a methodology and environment for collaborative product development, in: Proceeding of the Second Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises, Morgantown, WV, USA, 1993, pp. 33–47.

[39] M.R. Cutkosky, J.M. Tenenbaum and L. Glicksman, "Madefast: collaborative engineering over the Internet". *Communications of the ACM* **39** (9), 1996, pp. 78–87.

[40] U. Roy and S.S. Kodkani, "Product modeling within the framework of the World Wide Web". *IIE Transactions* **31** 7 (1999), pp. 667–677.

[41] J. Numata, Knowledge Amplification: An Information System for Engineering Management, Sony's Innovation in Management Series 17, Sony Corporation, Japan, 1996.

[42] W. Shen, J.P. Barthès, DIDE: a multi-agent environment for engineering design, in: Proceedings of the First International Conference on Multi-Agent Systems (ICMAS'95), San Francisco, CA, 1995, pp. 344–351.

[43] W. Shen, Web-based infrastructure for collaborative product design: an overview, in: Proceedings of the Sixth International Conference on Computer Supported Cooperative Work in Design, Hong Kong, 2000, pp. 239–244.

[44] Pratyush Bharati and Abhijit Chaudhury, "An empirical investigation of decision-making satisfaction in web-based decision support systems", *Decision Support Systems*, 37 (2), May 2004, pp: 187-197.

[45] Albayrak, S., Meyer, U., Bamberg, B., Fricke, S., & Tobben, H., "Intelligent agents for the realization of electronic market services", proceedings of the 1st international conference and exhibition on the practical application of intelligent agent and multi-agent technology'96, 1996, pp. 11–23.

[46] O.B. Kwon and K.C. Lee, MACE: Multi-agents coordination engine to resolve conflicts among functional units in an enterprise, *Expert Systems with Applications* **21,** 2002, pp. 9–21.

[47] Julian J. Ray, "A web-based spatial decision support system optimizes routes for oversize/overweight vehicles in Delaware", *Decision Support Systems*, doi:10.1016/j.dss.2005.07.007.

[48] D. Green and T. Bossomaier, Online GIS and Spatial Metadata, Taylor & Francis, London (2001).

[49] J.-C. Thill, Geographic information systems for transportation in perspective. In: J.-C. Thill, Editor, *Geographic Information Systems in Transportation Research*, Pergamon Press, Oxford (2000).

[50] R.W. Hall, Change of direction, *OR/MS Today* **29** (1), 2002, p. 1.

[51] H. Miller and S.-L. Shaw, Geographic Information Systems for Transportation: Principles and Applications, Oxford University Press, New York, NY (2001).

[52] D. J. Power (2000). Web based and Model Driven decision support systems: concepts and issues, proceedings of the Americas Conference on information Systems.

[53] Iglesias, C., Garrijo, M., Gonzalez, J, A survey of agent-oriented methodologies. In Muller, J. P.,, Singh, M. P., and Rao, A. S., editors, *Intelligent Agents V – Proceedings of the 1998 Workshop on Agent Theories, Architectures and Languages.*

[54] Wooldridge, M., N. R. Jennings, D. Kinny, The Gaia Methodology for Agent-Oriented Analysis and Design, in *Journal of Autonomous Agents and Multi-Agent Systems*, **3** (3), 2000, 285—312.

[55] Odell, J., Van Dyke Parunak, H., Bauer, B, Extending UML for Agents. Proc. Of the Agent-Oriented Information Systems Workshop at the 17th National Conference on Artificial Intelligence, Wagner, G., Lesperance, Y., and Yu, E. (Eds.), 2000.

[56] Khanh H. Dam and Michael Winikoff, Comparing Agent Oriented methodologies, Agent-Oriented Information Systems (AOIS-2003), Melbourne, Australia, 2003, www.cs.rmit.edu.au/**agent**s/Papers/aois2003.pdf .

[57] Zambonelli, F., Jennings, N., Omicini, A, Wooldridge, M. "Agent-Oriented Software Engineering for Internet Applications", In Coordination of Internet Agents. Eds. A. Omicini, F. Zambonelli, M. Klusch and R. Tolksdorf. Springer Verlag, 2001, pp. 326-346.

[58] Mercedes Amor, Lidia Fuentes and Antonio Vallecillo "Bridging the Gap Between Agent-Oriented Design and Implementation Using MDA*". In: Agent-Oriented Software Engineering V, James Odell, Paolo Giorgini, Jörg P. Müller (Eds.), Lecture Notes in Computer Science, Volume 3382, Chapter 3, 2005, Springer-Verlag GmbH**,** pp: 93-108.

[59] DeLoach, S. A., M. F. Wood, C. H. Sparkman, "Multiagent System Engineering", in *International Journal of Software Engineering and Knowledge Engineering*, **11** (3), 2001, pp. 231-258.

[60] Wooldridge M. J. and Jennings N. R., "Software Engineering with Agents: Pitfalls and Pratfalls". *IEEE Internet Computing*, **3**(3), 1999, pp. 20-27.

[61] Lind, J, A review of Multiagent Systems Development Methods. Technical report, British Telecom, Adastral Park Labs, Martlesham Heath, Suffolk, 1999.

[62] Pablo Villarreal, Maximiliano Alesso, Sebastián Rocco, María Rosa Galli and Omar Chiotti, "Approaches for the Analysis and Design of Multi-Agent Systems", *Inteligencia Artificial, Revista Iberoamericana de Inteligencia Artificial. No.21, 2003, pp. 73-81 (*http://www.aepia.org/revista).

[63] Lin Padgham and Michael Winiko, „Prometheus: A pragmatic methodology for engineering intelligent agents", proceedings of the OOPSLA 2002 Workshop on Agent-Oriented Methodologies, November 2002, pp. 97-108, Seattle.