EXPERIMENTATION MANAGEMENT KNOWLEDGE SYSTEM

Information Systems Integration for DoD Network-Centric Operations

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Abstract: A current major focus in the DoD involves the integration of information across the different military branches for operations. Network-centric information methods will enable efficiencies through the integration of best-of-breed software and hardware from each branch of the military, together with the latest advances from government laboratories and the private sector. Information merging will promote synergy and expand effective use of the enterprise infrastructure to realize improved operational and organizational processes. Research to date has focused on core network and infrastructure capabilities but has not fully addressed strategic organizational objectives in the context of systems integration. A model is advanced that establishes variables for enterprise analysis to assess strategic technical objectives enabled or hindered through new network-cen-tric capabilities. Examples are derived from operational experimentation in network-centric warfare but presented generically to apply to any organization seeking to assess the effectiveness of organizational strategy as enabled or hindered through network-based communications and enterprise-level systems integration.

1 INTRODUCTION

DoD systems integration problems are similar to those encountered in the private sector. However, the complexity of relationships in military exchanges and the inherent uncertainties of dynamic environmental variables make DoD systems integration problems much more difficult.

Warfare in the past was mainly laying ordnance on targets. Today we are in a systems-based environment with network-centric operations and the management of knowledge as a top priority. Various techniques are being advanced to help integrate distributed databases and legacy information systems into virtual enterprise architecture. Data types, sources, taxonomy, ontology, and XML schemas are being mapped to enable information exchange.

Key to military operations is the sequence of processes: information development, information sharing, knowledge development, situation assessment, shared situation understanding, and collaborative action—herein achieved as a facet of enterprise-level integration of large-scale databases and database driven systems.

It is worth noting that knowledge development is needed for more than military operations. Management processes such as budget and procurement decisions must also be supported. These decisions are even more complex in the new environment because they involve more than hardware design and acquisition. Someone has to decide how much a "pound" of information management is worth.

2 INFORMATION INTEGRATION

Networked enterprises are becoming a new organizational paradigm, creating challenging opportunities in terms of management (Azevedo and Sousa, 2000). Technological analysis needs to incorporate organizational context as well as application and data sources (Ericsson, 2001). Enterprise systems integration, in the system discussed, addresses technological, organizational, and information [context] variables to improve management decision-making. The referenced KM enterprise system was developed to interface with and assess systems and systems integration initiatives and make recommendations based on experimentation results.

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2.1 Objective Integration

QoS issues generally involve the effectiveness and/or efficiency of the systems integration initiatives. For example, the recent Trident Warrior 2004 experiment considered the effectiveness of individual networks,

interfaces between information systems, coherence to emerging standards for enterprise architecture (i.e., Web Services, Global Information Grid), the viability of specific components of the infrastructure and the information they produced, human-systems integration, and organizational decision processes supported or hindered by the systems integration initiative(s).

A sponsor provides experimentation objectives for the particular systems integration initiative. This is the top-level definition of the experiment. At the next level, the experiment's physical structure is chosen to meet those objectives, including the operational forces, the processes to be used by operational personnel, and the systems that will support those processes. The next level is concerned with situations to be run, measures to be produced , data to be captured, and analysis techniques. All of this information is integrated in the KM system with appropriate relationships for reference, to establish fitness across components, and to construct and make available a data capture plan.

A key to experimentation is development of experiment threads. For each thread, specific data elements are identified, generally as pass-through from system to system and increasingly as a web service or XML-based exchange. Data that is captured during the experiment are input into the KM system. The result is development of an automatic association from top-level objectives down through data, analysis, and results. The KM information can be entered at any point of experimentation and relationships to all associated information examined.

Results reporting follows a similar structure. Data is archived with a relationship to experiment threads. Measures resulting from analyses are filed in the KM system with the correct relationship to the data from which they are produced. The final step in the results production process is interpretation of meaning by subject-matter-experts (SMEs). A form-based process in the KM system is used to file both interpretation results (interpretation is with respect to the experiment's original sponsor objectives) and the context within which the experiment was carried out. The relationships between results and objectives are made transparent in the system, as are references to all levels of planning and analysis.

For example, a recent evaluation of a web services implementation in a distributed environment tested the ability of a portal to dynamically assemble web services under various network conditions. Of particular interest was that one of the tested services was itself a compilation of XML feeds from several different servers, and another was processing metadata input from distributed sources (also encapsulated and passed as a web service). Additional tested systems included networks, routers, and communication technologies employed in the process (various configurations of optical, Ethernet, satellite, and wireless). The thread used by the KM system to analyze such a process involved a live event (MSEL) to stimulate an operational scenario (terrorist attack). The thread was the means to tie together the systems, the information output, and the results of the test within context.

The experimentation and analysis KM system therein has two primary objectives: the creation of knowledge through the experimentation process, and the retrieval of knowledge as results or recommendations that are forwarded to decision-makers and/or into subsequent experimentation. Information and knowledge is drawn from the distributed systems and integration initiatives, plus reach-back into supporting systems and archives.

Knowledge retrieval is essentially a reversal of creation. The objective is not the usual meaning of information retrieval via a search or a relational SQL query, although both of these techniques, plus some additional AI-based means, are used to help sort experimentation results. Rather, the focus of information or knowledge output from the KM system is to answer a question.

At the lowest level, system logs and network data are assessed to determine the performance of tested systems against various integration scenarios and network loading conditions. The advent of web services and service-oriented architectures have added increased emphasis to comprehensive evaluation that includes the context in which the tested system operated and communicated. Results are derived at technical and operational levels. Together it is possible to judge system performance and interoperability within the tested context.

2.2 Application Integration

Enterprise integration is the study of an organization, its business processes, and resources, understanding how they are related to each other so as to efficiently and effectively execute the enterprise goals, focusing on organization, process, application, data, and network (Nunez, Giachetti, Truex, and Arteta, 2004). Modern knowledge management must go beyond data mining and search to provide collaboration as an intrinsic part of any business process (Hawryszkiewycz, 2001).

Economies of scale are also realized, as data no longer needs to be moved from independent systems or data marts into the warehouse. As Belo (1999) noted, significant effort involving enterprise functional and operational analysis processes is necessary in the migration of data into a warehouse.

Figure 1 provides a use-case of technical and operational integration around high-level system objectives, focusing on user requirements and specifications for information retrieval. Generally, data output from higher-level systems and databases are summarized or encapsulated for the next level. At the lower level additional database (systems) information is integrated with the higher-level information.

Previous research has noted that information systems too often require specialized managerial skills to interpret data and derive useful conclusions and where the data volume is large a decision support capability can help structure relationships (Malhotra, 2001). In addition, cross-domain enterprise architectures must support information flows between internal and cross-enterprise processes with a high level of automation while remaining flexible and integrated (Martakos, Kanellis, and Alexopoulou, 2004). Satisfaction concerns were a driving force for the development of the KM experimentation management system and, we believe, effectively addressed.

Similar to the private sector, in the military different information systems satisfy different information needs. For example, a field sales person may access specific product data for a sales call and this may be represented in a sector of the corporate enterprise system. Upon completion of the sale, and similar sales from peer sales persons, a mid-level or tactical information system [or sector in the enterprise system] would synthesize and represent these results for mid-level management. Sales across a region would similarly be derived for top management. Middle and top managers are cognizant of the importance of information resources to assure decision effectiveness (Carneiro, 1999).

Military systems have this same information flow but in addition there are specialized systems at each level. For example, a warfighter in the field would require situational awareness specific to his or her immediate surroundings (operational) while a mid-level manager may require tactical data and situation assessment at the theater level. At the strategic level a commander's situational assessment would require understanding of issues at the tactical and operational levels but not necessary the types of information required at those levels. Thus, a difference between military and corporate systems is not only the additional specialized information technologies at each level that still need to be integrated but also the filtering mechanisms to refine the output for appropriate audiences at each level, and in each environmental context. The addition of highly dynamic context is an additional variable.

The use-case therein establishes the necessary systems integration relationships and in an information-driven network-centric environment the types of queries and linkages necessary for efficient information retrieval. Each of the use-cases represents one or more systems and the output of those systems the information needed by both the actor/user and the other systems employed at that level (operational, tactical, strategic).

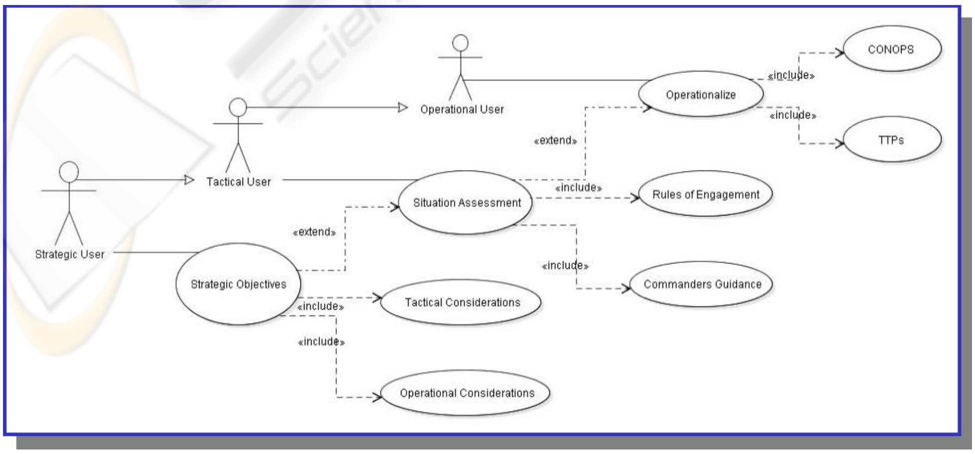

Figure 1: Use-case of information and systems integration showing levels of usage, data requirements and pertinent databases (systems) for each level of usage

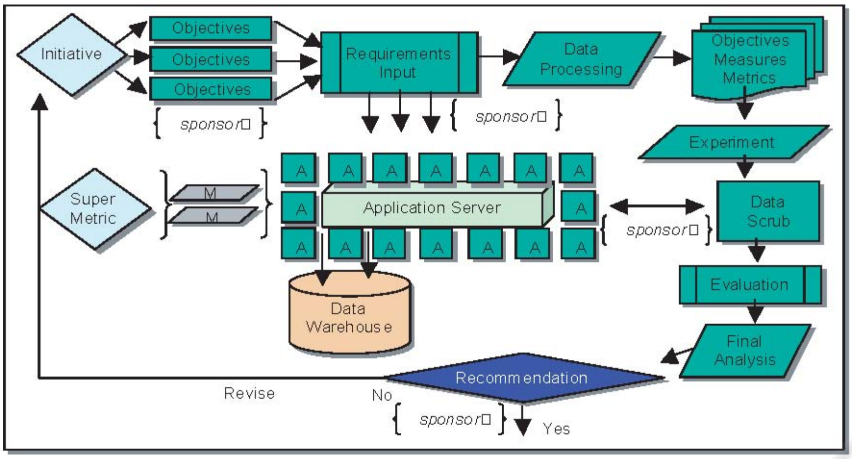

Figure 2: Application server and repository for system and application integration

2.3 Data Integration and Analysis

Finally is the data processing for integration. Data maintained in operational systems is not commonly arranged for analytical needs or management perspectives (Gonçalves, Lourenço and Belo, 2001). Figure 2 represents a process through which the previously discussed efforts achieve fruition. Experimentation processes are mapped from initiatives through to end-user or sponsor objectives. This includes delineation of requirements and specifications that lead to the initial series of applications designed to aid in data processing. These applications help structure the measures and metrics that govern the systems integration testing and evaluation. The KM system processes operate in tandem to help assess processes and collect pertinent data. This occurs throughout the experiment.

Next represented in the figure is the data scrub that occurs after an experiment. Increasing much of the initial processing is occurring parallel to experimentation phases.The scrub provides structure and contextualization that maps repository metadata to the systems, projects or business areas (Ramírez, Merayo, and Baizán, 2003). A significant number of applications are employed to help in this process. These applications are served to experimentation and sponsor participants through an application server with a portal interface and secured Internet connection.

Finally is the evaluation process that leads to a recommendation on the effectiveness of a particular system or the efficiency of a systems integration initiative. If successful the tested system [or system of systems] is forwarded for possible inclusion in upcoming acquisition cycles, if unsuccessful dropped from consideration, if partially successful returned to the experimentation cycle for follow-on tests. The experiments generally evaluate for timeframes 5-8 years into the future and the tested environments simulate those time periods and the technologies that will exist at those dates.

3 CONCLUSION

This paper presented a systems integration scenario and supporting KM-based enterprise-class experimentation management system operational in military network-centric technology experimentation. The discussion addressed both the environment through which systems integration is addressed and also the evaluation systems used to monitor and assess the functioning of the systems and initiatives. This led to an overview of output processes for various levels of decision makers, use-cases for the information requirements, and an operational diagram of the knowledge management systems and processes supporting the use-cases. Comparisons were drawn between military and corporate systems integration.

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