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Macro Issues in the Development of Organizational Decision Support Systems

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Abstract

Many tasks in the organization require organization-wide support. This support may be in form of data, model, tools or people. A "seamless" communication environment is needed to facilitate this support. This paper discusses macro issues involved in the development of an Organization Decision Support System (ODSS). Specifically, we address issues like; what factors needs to be considered in developing ODSS? what issues are important in which environment? In addition, we also discuss ODSS architecture and technology that is (un)available to make ODSS feasible.

Introduction

As competition, both domestic and foreign, is growing organizations are looking for different ways to survive and to gain strategic advantage. Organizations are changing structure [2], competitive strategies [40] and merging or expanding overseas to remain competitive [37]. This is changing managerial role. Managerial decision domain is widening requiring broader range of domestic and international knowledge [1, 2, 9]. Managers can no longer make effective decisions based on static local information but need to go beyond organizational and even national boundaries to acquire relevant information [18, 24, 26, 34].

In the 90's information technology will play an important role in providing information support, human expertise and mimicking human brain in a borderless environment. In the 90's system's emphasis will be on "total" organizational support systems due to increasing competition and changing structure of corporate america [36, 43]. More and more decisions are becoming interdependent and team-oriented. Instead of single dimension and local frame of reference managers need multiple dimensions and multiple frame of references in an interactive decision making environment. Considering this trends there is a need for enterprise-wide support systems. However, systems providing such support have only recently gained attention. There appears to be a big gap in the application of information technology to organizational decision support systems (ODSS). This paper focuses on macro issues that must be considered in the development of ODSS. In addition, ODSS architecture is also proposed.

Organizational Decision Support Systems:

The term ODSS was first discussed by Philippakis et. al [33] and A. M. McCosh [32]. Since then many authors have provided their definition of ODSS. George [11, 12] and King et. al [21, 22] have provided an excellent review of the ODSS literature. It is not our intention to repeat these reviews and readers are referred to those papers. In his review George [12] summarized common elements in ODSS definition.

. The focus of an ODSS is an Organizational task or activity or a decision that affects several organizational units or corporate issues;

. An ODSS cuts across organizational functions or hierarchical layers;
. An ODSS almost necessarily involves computer-based technologies, and may also involve communication technologies.

We do not entirely disagree with these common observations, however, we have modified some and added others elements to ODSS definition:

. Single or multiple decision makers
. multiple decisions types
. multiple organization units including **global** units
. ODSS **must** involve some form of communication
. supports multiple organizational processes

In this paper, we define ODSS as, " A computerized system that supports people making enterprise-wide decisions in an interactive environment". Decisions may be independent,

interdependent or pooled; spanning locally or globally; may cut across levels; and may involve single or multiple decision makers. People, themselves, may be locally or globally dispersed. This definition of ODSS **includes** all systems that provide "borderless" and "seamless" decision making support across functional/ divisional/national boundaries. Figure 1 shows different ODSS types.

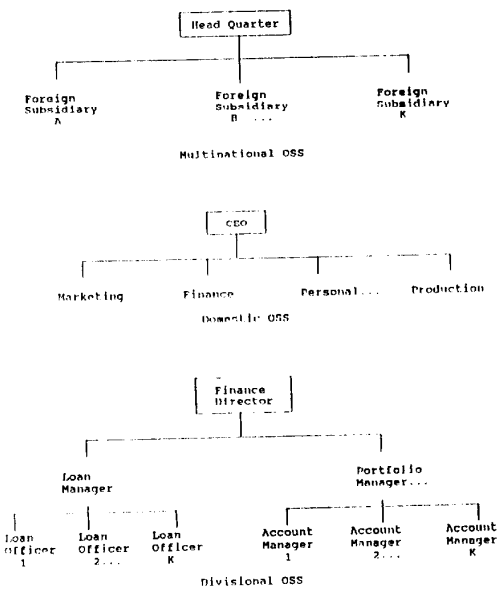

Figure 1: Examples of ODSS

Since 1988, many authors have reported applications that could be classified as ODSSs. El Sheriff [8] discusses an institutional DSS that synthesizes various model-based systems for the Egyptian Cabinet. This system supports multiple cabinet ministers and multiple tasks in a computer supported environment. Though he did not call it an ODSS but it has many of the ODSS features discussed above. Bowker et al [3] and Walker [41] have also reported systems that have some of the ODSS features. Rathwell and Burns [35] discuss the concept of distributed decision making (DDM) systems, which they describe as a mechanism for integrating a number of separate DSS's that coexist in the organization. These systems facilitate group cooperation between several DSSs in a distributed environment and meet the specific needs of group planning and group decision making. Rathwell et. al. [35] have used the concept of DDM to develop Distributed Decision Support Systems (DDSS). Chung et al [4] have taken DDSS a step further by discussing various factors that should be considered in designing an DDSS. It addition, they discussed the trade-off between flexibility and rigidity in designing DDSS. We take the factors discussed by Chung et al. [4] a step further both in dimension and context. In this paper we will discuss macro issues (factors) that must be considered before developing an ODSS within the context of our broader definition of an ODSS. These issues are macro issues because they address concerns at the **organizational** level.

Issues In ODSS:

Issues relating to ODSS can be grouped as: general, global and local. General issues are applicable to all ODSSs, global issues are applicable to multinational ODSSs and local issues are applicable to domestic ODSS, i.e., systems that span within one country. However, for the purpose of discussion we are not distinguishing between different types of ODSSs and issues are discussed in the context of general ODSS with differences noted wherever applicable.

1. **Scope** : Scope is defined as the number of decision makers, decisions, units, departments, functions and processes an ODSS supports. Higher the number the more enterprise-wide an ODSS will be. Architecture of ODSS will be influenced by the scope of ODSS.

Since ODSSs cover broad range of organizational decisions, it does not imply ONE big integrated system that can support **all** decisions and/or decision makers in the organization. Scope of ODSS will depend on the decisions and people they support. ODSS may cover decisions that span horizontal and/or hierarchical levels within functions, departments or units. For multinationals it may cover units across nations. Organizational structure will also play an important role in influencing the architecture and scope of ODSS. Organizations with centralized decision making will result in vertical (pyramid) shaped ODSS. Since decision making is concentrated in centralized organizations, vertical integration is a necessicity to channel filtered information upward. ODSS for such organizations will support fewer decision makers, cut through hierarchical levels reducing the scope of ODSS. On the other hand decentralized organizations will result in horizontal (matrix) shaped ODSS supporting many decision makers, decisions, cutting through fewer levels but supporting more levels resulting in more complex ODSS.

Intuitively, the more divisions/departments/functions an ODSS includes the more compatibility and connectivity problems it will have. Based on the scope, ODSS can be classified as:

Pyramid ODSS: These ODSSs support centralized organizations and closely follow organizational structure. Their architecture is function-oriented and decision-making emphasis is more at the higher levels. They cut across levels, but rarely across departments or units.

Matrix ODSS: These ODSSs support decentralized

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organizations. Their architecture is process and team-oriented and most decisions are made at local levels. They cut across departments and units but fewer levels.

ODSSs described above, in turn, can be a combination of any of the following ODSSs.

Base ODSS: These ODSSs support day-to-day operational decisions of the organization. They provide transaction-oriented information to support routine reports and day-to-day supervisory planning and control. These ODSSs support many users, fewer decisions, rarely cut across hierarchical levels, departments or units and address "local" issues.

Middle-Level ODSS: These ODSSs support decisions involved in medium-term functioning of the organization. They provide filtered information to support planning, control, monitoring and projections. These ODSSs support more decisions than base ODSS, fewer users and cut across hierarchical levels, departments but rarely across units.

Strategic ODSS: These ODSSs support decisions having long range impact on the organization. They provide statistical information to support planning, projections and strategy formulation. They have fewer users, cut across many levels, departments, and units and support "global" issues.

In summary, issues of interest are:

. Domain (narrow, broad) of ODSS
. Number of departments/functions/units involved
. Dimensions (horizontal and vertical) of ODSS

2. **Managerial Levels:** We will use Keen and Morton [20] managerial classification, strategic, control and operations to discuss this issue. It has been well established that computerized systems developed for senior executives will have very different requirements than the systems developed for control or operation level managers [20, 38]. Since an ODSS may cut across several hierarchical levels its design will have to provide broad range of support for differences in user's cognitive styles, computer experiences, aspirations/goals and decision making styles. For ODSSs covering multinational units, "culture" will play an important role in ODSS development [13]. It is well established that decision-making styles are influenced by the social structure and the culture of the society. For example, decision making style of a manager of a Nigerian subsidiary will be very different than the one for US. Issues of interests are:

. Types of users (levels) supported
. Number of users supported
. Individual Differences
    . Decision making style of users
    . Users experience with computers
    . Users aspirations/goals
. Cultural Differences

3.**Decision Types**: Decision type will influence the technology needed to support ODSS. Decisions can be grouped as structured, un-structured and semi-structured. By definition, structured tasks have known procedures and algorithms and their data and models requirements are known, whereas for unstructured tasks data or models requirements are unknown or fuzzy. In addition, decisions may be independent, interdependent or pooled [15]. Since interdependent decisions may span horizontally and/or vertically across levels, i.e., from structured at one level to unstructured at another level, ODSS requirements may also change from known at one level to fuzzy at another level. ODSS that support multinational units, typically, will require support for ill-structured interdependent tasks, whereas local ODSSs will require support for structured pooled independent or interdependent tasks. Issues of interest are:

. Range of decisions (structured, unstructured) supported
. Number of decision supported
. Types of decisions (independent, interdependent) supported
. Nature of decisions (repetitive, one-of-a-kind, ad-hoc) supported

4. **Locus of Control**: Locus of control influences the scope and development of ODSS. A locus of control (LOC) is defined as an individual, group, department or unit that has the ultimate decision making authority in that environment. The environment consists of decisions that span across or within functions, processes or hierarchical levels. LOCs are important in the sense that nothing can be done without their input or approval.

In many instances, especially for multinational ODSS, it is necessary to know who is in charge? or who is the locus of control? This is due to the fact that multinational ODSS spans across nations where decision environment is uncertain and national and local politics play important role. Recognition of LOCs can be very helpful in such cases since local LOCs can guide ODSS development within local and national constraints. Many authors have discussed locus of controls in some form or the other. Porter [34] suggested multidomestic and multinational global business strategy related to locus of control. Along similar lines Barlett and Ghoshal [2] has distinguished between multinational, global and international organizational structure based on business strategy which in turn identifies locus of control. Negandhi [30] defines three different locus of decisions, home office, home office and overseas subsidiary and at subsidiary level. ODSS supporting different locus of controls will have different configuration. It is almost a necessicity to support LOCs and in some cases in addition to LOCs it may be necessary to support stakeholders in the home office, units and functions that are not part of LOCs. Issues of interest are:

. nature of interaction between locus of control and home office
. composition of locus (individual, group)
. goals/aspirations of each locus of control

5. **Cultural Diversity**: For multinational ODSSs and to

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some extent domestic ODSSs cultural diversity is an important issue. Many researchers have found significant differences between the US and other parts of the world in terms of users attitudes, [7, 23, 28] user characteristics [25] and decision making styles [16]. In addition to these differences there are other differences in terms of usage (left-hand drive vs. right hand drive for autos), specifications (110 volts vs 220 volts electronic appliances) and styles (left-to-right vs right-to-left reading labels). It is intuitive that users need information support related to cultural diversity to market their product and to develop competitive strategies [14]. Cultural issues become the guiding or the focal issues in such ODSSs. Issues of interest are:

. local customs
. local usage
. local perceptions
. local expectations and values
. local political climate
. local laws

6. **Proximity**: Proximity is defined as the distance between decision makers. As organizations diverge and expand proximity becomes an important issue. For multinational ODSS, proximity becomes even more important on two counts, distance and time. Questions like, can we provide support for same time and different location, or for different time different location? This becomes even more important when locus of control is shared by home office and overseas subsidiaries or when an organization works around the clock. For example, concept of 24-hour trading on different world exchanges will require continuous ODSS support at different locations at different time to facilitate around-the-clock global stock portfolio management.

Proximity has been discussed in context of pooled decisions [17, 19, 31], i.e., how does proximity affects group decision making? However, proximity also plays an important role in ODSSs since there are multiple decision makers who may or may not be in same location at the same time. This raises technical issues that must be addressed during the development of ODSS. Issues of interest are:

. distances between departments/divisions
. distances between users

7. **Communication:** Nothing is feasible without appropriate and effective communication. This is probably one of the most critical issue for ODSS. It facilitates data access, co-operation, coordination and discussion among decision makers. Nature and mode of communication will dictate type and accessibility of data, model and software tools in ODSS. Data can be in the form of video, voice, image, text, animation or sound. Is it necessary or required to communicate verbally, through written documents or through computerized communication channels? Communication is a function of time and place. There are four possible communication environments: same time same place, same time different place, different time, same place and different time different place.

For same-time same-place verbal face-to-face communication may suffice, whereas written or electronic communication may be needed for other environments. For multinational ODSS with various locus of controls, different place same time and different time different place communication will be of utmost important. How do we provide "seamless" communication in such an environment? Network architecture becomes crucial during development and design phase of ODSS. Important issues are:

. Modes of communication
. Place of communication
. Timing of communication
. Type of communication

8. **Stakeholders Politics:** ODSS involves integration. This may result in realignments, rightsizing and loss of power causing resistance and power struggle between units, people and departments. The dissatisfaction may come from stakeholders who are losing power in terms of data ownership, project priorities, fear of diversion of resources and/or job elimination. A powerful stakeholder may not agree to standardize its processes or may not be interested in giving up data ownership. A powerful unit may want to dictate level of integration. Scope and level of integration will be dictated by relative power of stakeholders.

Integration is even more complex for international ODSSs. Not only organizational politics but country politics, relations within countries and local politics impact integration. Local or country laws may require local control and local majority ownership. In such cases ODSS must be sensitive to local needs, culture and autonomy requirements. ODSS can not be successful unless political implications of realignment, stakeholder's ambitions and data ownership issues are considered.

Though we have discussed several key issues that should be considered in ODSS development, it should be noted they are not mutually exclusive. In fact, in most cases dependency is quite evident. For example, if an ODSS is to be developed for interdependent decisions that span across units that are geographically (globally) dispersed, then proximity, cultural diversity, type of communication, locus of control, organizational politics and hierarchical levels will dictate the scope of ODSS.

In this case proximity is long distance and face-to-face communication between LOCs (with current technology) may not be cost effective or even feasible.

Architecture of ODSS:

Many authors have suggested ODSS architecture (see George [12] for complete review). Whitehair et al [42] describe a probot that can communicate across organizational lines to achieve fixed set of goals. Swanson [39] describes

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ODSS in the context of distributed systems. Rathwell et. al [35] use the concept of integrating existing DSSs to develop ODSS. Chung et al. [4] use the concept of decision nodes which they define as a single or group decision making unit. We take this notion a little further and describe ODSS as integration and linkage of various locus of controls (LOCs). Linkage provides coordination and Integration provides communication. As already mentioned, a locus of control has the ultimate authority to make decisions and may consist of group(s), a function, or a unit. At any given time, a locus of control could be part of several decision types and the constitution of locus of control may change over time. LOC are dynamic unlike decision nodes that are static. LOCs cover broader range and types of decisions. A decision nodes as described by Chung et al can be a part of an LOCs but rarely an LOC itself. We chose LOCs because they are complete and relatively stable in the organization.

Developing an ODSS that can provide integrated support for all locus of controls is a complex undertaking. Questions addressed are very similar to ones faced by database designers [5]. Should we develop a centralized or distributed database? How can different database be combined? What design approach (top-down, bottom up) should be taken? Similar questions face ODSS. For example:

- Should it be one big integrated ODSS, or several small ODSSs integrated together?
- Should we develop a completely new ODSS(s) or integrate existing systems?

LOCs are the building blocks for ODSS. For design purposes, we can compare a locus of control to an "object" as in object-oriented databases (OODB). It compares, in the sense that an "object" is encapsulation of data and operations performed on that data and ODSS is encapsulation of data, models and tools and operations performed on that data and models. Just as in OODB various objects can be combined to develop applications, various LOCs can be combined to develop an ODSS.

One big integrated ODSS that integrates all locus of controls, though theoretical possible, is not desirable or even feasible with current technology. It faces same problems as a centralized corporate database [6]. However, in future with better processing hardware and communication technology a large ODSS may be feasible. Another approach is to develop an ODSS as a combination of different LOCs. Figure 2 shows examples of Hierarchical, Process and Function LOCs based ODSS. A hierarchical ODSS integrates LOCs within a given level and links across levels. A process based ODSS integrates within a process and provides links across processes and a function based ODSS integrates within a function and provides links among functions. A unit-based ODSS based LOCs integrates and links units.

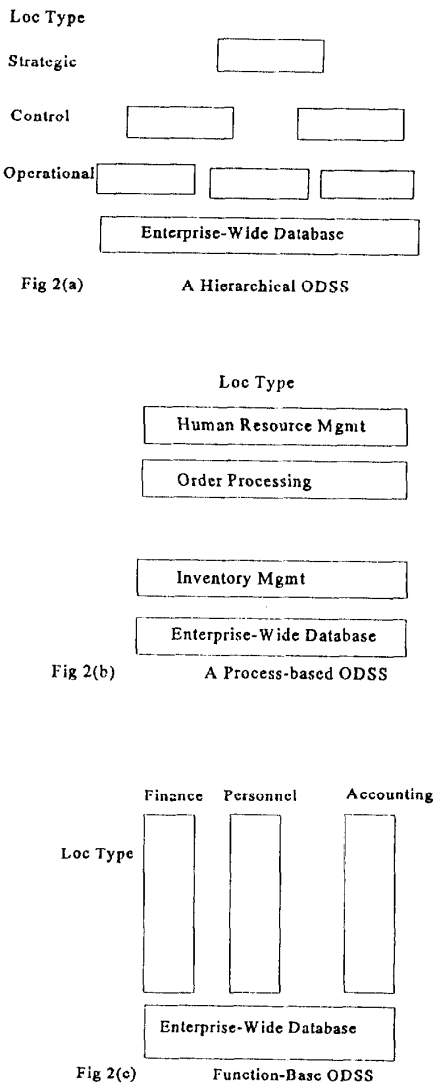

Figure 2: LOC Based ODSS

Another question in the development of ODSS is whether to build an entirely new system that integrates and links various LOCs or to integrate existing systems. For multinationals, building an altogether new system will be time consuming and even counter productive as locus of controls may be suspicious of change and may not be willing to give up their existing system for an 'outside' system. It is possible that

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local LOCs may be less resistant or suspicious of 'integrating' their existing system into host (outside) system.

Next, we present ODSS architecture in terms of its components data-model-dialog-communications and the tools needed to operate on the components. In all our discussion key words are integration and linkage. Figure 3 shows the components of an LOC.

Data component is a function of scope of LOC, i.e., how does locus of control spans in the context of process, function, unit and hierarchy? What kind of decisions are being supported? independent or interdependent, strategic, control or operational? Database will consist of at least three different types of data: Internal, External and Private. Internal data consists of two data types, organizational data external to LOC and data within LOC. External data consists of data external to the organization and private data consists of data personal to each stakeholder in LOC.

go with client/server architecture? or distributed databases? Which stakeholder has what data ownership and responsibility within which LOC? Are they willing to share this data? Data security and ownership become problems in a distributed environment.

In addition to usual design questions [6], following also need to be addressed:

. data security at LOC level and ODSS level
. data ownership
. data extraction procedures
. data location

For multinational LOCs, possibilities of wire-tapping, data interception and sabotage are also important issues. There are rules and regulations that govern what data can be transported across nations and cultural issues must be considered while standardizing data, i.e., should data be presented in dollar, yen or franc; are there any special local or national requirements that necessitate local ownership or local format (metric vs lb).

Component	Data	Model	Dialog	communication	end-user tools	others
Organization-wide Tools	.Query Language .Knowledge Base .Org. Database .Distributed Data	.Linear Prog. .Statistical .Distributed Model .Modeling Language .Expert systems .Optimization Models	.Mouse .Touch screen .Voice-input .Icons to build models .Key board .GUI	.E-mail .Bulletin Board .Voice-mail .EDI .Video .FAX .Video Conferencing .Multimedia	.Graphics .Spreadsheet .4GL .Multimedia Appl. Generator .Project Management .GDSS tools .CASE tools .database software	.Virus Control .Triggers .Auto Backups .Filters .CAI .Security

Specific LOC Components

Communication	Type:	.Voice .Data .Image .Video .Animation .Text	Domain:	Same Time Same Place Same time Different Place Different Time Same Place Different Time Different Place	Nature: .Localized Processing .Distributed Processing .Private Processing .Integrated Processing
Dialog		.Group Windows .Natural Language Interface .Menu-driven .Image Scanners			
Model		.Heuristics .Ad-hoc .Symbolic .Atomic .Forecasting .Planning			.Model Generation .Interrogation .Interpretations .Recommendations
Data		.External		.National .International .Rules/Regulations .Competitors .Political	.Filteration .Extraction .Synthesis .Interpretation
		.Internal Org. data Local LOC data		.Strategic .Control .Operational	
		.Personal		.Rule of Thumb .Gossip .Heard on the Street	

Figure 3: An Architecture for a Locus of Control

Enterprise-wide data modelling techniques can be used to model organizational data and internal data can be extracted from this. Miller and Nilakanta [27] have suggested ways of extracting data from organization data to facilitate data-model communication. Several questions related to data and network architecture will have to be addressed. Should we

For multinational LOCs, additional questions need to be considered:

. transborder data flow rules and regulations
. data standardization across nations.
. data security at local level

Model component is a function of nature of tasks, i.e.

strategic, control, operation; independent or interdependent and decision making style, i.e., analytical, satisfying etc [20] performed at the LOC. In general, model will consist of Internal and Private models. Internal models will consist of generic organization-wide models and models internal to a given LOC. Private models are models developed by stakeholder(s) for their use and are generally not available to others.

Basic models like optimization and statistical may be part of organization-wide models that provide 'what-if' and 'goal-seeking' capabilities. Specific models may be needed for within LOC analysis. In addition, each stakeholder may have their own models to perform 'private' analysis. For example, strategic level LOCs may contain heuristic models that are specific to that LOC and some stakeholders may develop their own symbolic/rule-of-thumb models.

LOCs that support interdependent or distributed tasks may desire distributed model building and consolidation capabilities. For rational stakeholders it may be necessary to provide atomic models and/or modeling language [10] that allow them to build model as necessary. This is one area which is still developing and management scientists are working to make atomic modeling feasible.

Dialog component is a function of stakeholder in the LOC and the nature of LOC. For example, a strategic level LOC will require user-friendly graphical user interface (GUI) environment. In general, dialog component will consist of internal and personal dialog capabilities. Internal diagonal capabilities may include organization wide capabilities like windows, mouse, touch screens and internal LOC capabilities may include group work areas, special editors and multi-media capabilities. For example, in an interdependent task, windows should be able to capture and display different user's perspective in on-line real-time mode, i.e., one window may show local analysis, second window may show analysis at an overseas subsidiary and a third window may show analysis at another unit and a fourth window may show consolidated effect. This will provide LOCs multi-perspective analysis in an interactive environment. However technology for uploading/downloading and consolidating data (multimedia) from various sources is currently lacking and vendors are working to meet this challenge.

Communication Component is the **key** component of LOC. A seamless communication with other LOCs is not only desirable but necessary. Without appropriate communications nothing can be read, seen, or heard. Of course communication is necessary but not sufficient by itself. Integration and linkage becomes utmost important. Current technology is not able to link different sites in different place at a **reasonable cost**. Videoconferencing is an attempt in that direction. For multinational, communication becomes even harder because of varying transmission standards for data, images and voice across nations. Work has already begun on integration and the concept of converging technology (integration of computer and communication technology) is already emerging [29]. It is expected that international standard will emerge that will allow LOCs to connect and transmit data, text, video, voice and image over a single medium. For ODSS to be effective it is necessary to provide localized, distributed and consolidated processing. Localized processing is needed for local LOCs, distributed processing is needed for geographically dispersed LOCs and consolidated processing is needed for linking functional, process or hierarchical based LOCs.

Tools are software that support data-model-dialog-communications, end-user computing and other functions needed to make effective decisions in an LOCs. Tools can be organization-wide, Internal to LOC or personal. Organization-wide tool provide generic capabilities like word processing, graphics, CASE analysis, spreadsheet etc. LOC and personal tools will be function of decision made and stakeholders involved. LOC tools as a minimum will include a query language, a database system that can handle local and distributed data, knowledge base and a model base.

Current state of technology in this area still lacks many desirable features. Currently ODSS tools are not integrated. Though database systems are available but knowledge and model management systems are not fully developed. For model traditional optimization and statistical modes are available but model generation languages that can generate and consolidate models are still in their infancy. On-screen model building is available only for Linear Programming (LP) models. Domain oriented expertise is available in certain cases but consolidation of expertise is still lacking. Mimicking a human brain is (neural nets) also in development phase.

Tools that automate and integrate control and processing at locus of control are also needed, i.e., virus programs, automatic backups, triggers, filters (intelligent programs that will filter messages), Computer Assisted Learning (CAI). Though many desirable features are not currently available at a reasonable cost, advances in information technology is making LOC and ODSS more of a reality.

Summary

Expansion and globalization will necessitate systems that can integrate heterogenous environments. Managerial roles and their decision domain is changing and continuous learning is needed to survive in this environment. Key words are **interdependency** and **coordination** which is achieved through **integration** and **linkage (communication)**. Organization decision Support Systems are the systems that can handle these changes.

In this paper we have tried to elaborate on macro issues that should be considered in designing a generic ODSS

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and noted differences for special cases wherever appropriate. We also presented an LOC based ODSS architecture and discussed some of the components of a **typical** locus. The next research step is to derive micro issues from these macro issues as they relate to LOCs. Research questions related to the architecture of enterprise-wide data, model and tool as they relate to LOC and ODSS need to be addressed. Further research efforts will be directed towards a framework that relates current technologies like OODB and Client/server to enterprise-wide issues within the context of LOCs.

Some of the technology needed to make these systems feasible is not currently available. However researchers in the areas of management science, computer science, electrical engineering and social sciences are working to make this technology commercially viable.

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