

# Towards a Functional GDSS - A New Framework

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## ABSTRACT

One of the deficiencies of most Group Decision Support (GDSS) systems today is that they typically ignore the general processes by which most organizations make decisions. Many purported GDSS systems ignore the decision process almost entirely and function simply as Group Support Systems (GSS) or GroupWare, facilitating group discussion and interaction, but not supporting the whole decision-making process. More well-developed GDSS systems currently available will support a streamlined model of decision-making, but do not account for the many variables involved in organizational decision-making (e.g. accounting for the different types of decisions to be made, variables not considered or evident in the recognition and diagnosis of the problem, and interrupts of the decision-making process).

This paper proposes a framework for a GDSS based upon the decision-making model conceptualized by Mintzberg, Raisinghani, and Theoret. Mintzberg's model considers the different processes involved with making decisions based upon the decision type, reiteration of certain phases of the decision-making process, and the likelihood of interrupts which will disrupt or delay the progression of completing the decision. This framework is also modularized which will allow for the incorporation of many related developments in IT and DSS which will assist the decision makers in each phase of the decision-making process.

## Keywords:

GDSS, Decision Support Systems, Mintzberg, Sprague, Strategic Decisions, Groupware

## INTRODUCTION

Many application categorizations are often included in discussions of GDSS and are sometimes used synonymously: Groupware (which simply supports groupwork & meetings), CSCW (Computer-supported cooperative work), and GSS (Group Support Systems). Most of the application software which is often marketed as GDSS would be more aptly designated as one of these less functional categorizations. Much of the software which has been developed as GDSS focuses principally on assisting brainstorming and mechanizing voting, two components of business decisions which comprise a relatively insignificant part of the decision-making process (Gray and Mandivala, 1999). The misclassification of software in these categories has had the effect of minimizing the pursuit of true GDSS applications as these existing applications generally lack adequate support for complex and significant decisions. The "level" of GDSS support as defined by DeSanctis and Gallupe (1987) is a good measure for determining the quality of support for group decisions within a GDSS. Fjermestad and Hiltz (1997) found after examining 163 papers published relating to controlled experiments on GDSS that 68% of the GDSS systems studied were "level 1" systems, 4% added "level 2" support, and the remainder were simply Computer-Mediated Communications (CMC) systems. None of the systems represented in these studies exhibited "level 3" features.

GDSS has been defined as systems that combine communication, computer, and decision technologies to support problem formulation and solutions in groups (DeSanctis and Gallupe, 1987). Although GDSS software needs to include many of the components found in Groupware, CSCW, and GSS software, it must significantly extend them to fully support the decision process. Indeed, the communications components of a GDSS are secondary to what should be the primary design considerations for an effective GDSS, the decision process.

This research will demonstrate a framework for a generalized GDSS which will incorporate the complex decision-making process utilized by groups in a real-world setting, existing bodies of research relating to DSS, and other technologies designed for aiding individuals and groups in making decisions. In order to better understand the necessity for this framework and its function, we must first understand the research regarding the decision process, how Decision Support Systems have been designed to aid the individual in this process, what has been traditionally incorporated into GDSS research, and a model of how groups make decisions.

## LITERATURE REVIEW

### The Decision Process

To understand how this differentiation impacts our design of a GDSS, we'll need to understand the primary components of the decision process. According to Simon, the decision process is comprised of 3 phases:

1. **Intelligence:** Searching the environment for conditions calling for decisions. Raw data is obtained, processed, and examined for clues that may identify problems.
2. **Design:** Inventing, developing, and analyzing possible courses of action. This involves processes to understand the problem, generate solutions, and test solutions for feasibility.
3. **Choice:** Selecting a particular course of action from those available. A choice is made and implemented (Simon, 1960).

### Variation of Simon's Model

Most research regarding decisions in relationship to DSS development at least acknowledge Simon's model for the decision process. In many instances, however, it may help to partition the Intelligence phase into an Awareness phase and a Search phase. The awareness phase would comprise the activities, data, events, or exceptions which make the decision maker aware that a decision needs to be made. The Choice phase, likewise, can be divided into a Choice and an Implementation phase.

The importance of Simon's model and its derivations can be seen throughout DSS and GDSS research. Any complete Decision Support System must include support for each of these phases of the decision-making process.

### Decision Support Systems Research

According to Mallach, "a DSS is a computer-based information system whose primary purpose is to provide knowledge workers with information on which to base informed decisions" (Mallach, 2000). The DSS is not designed to make the decision, but to aid those responsible for making the decision by providing process support, associated information, and possible alternatives. Sprague further develops the objectives for a comprehensive DSS with 6 requirements:

1. A DSS should provide support for decision-making, but with emphasis on semi-structured and unstructured decisions.
2. A DSS should provide decision-making support for managers at all levels, assisting in integration between the levels whenever appropriate.
3. A DSS should support decisions which are interdependent as well as those that are independent. DSS development experience has shown that a DSS must accommodate decisions which are made by groups or made in part by several people in sequence.
4. A DSS should support all phases of the decision-making process.
5. A DSS should support a variety of decision-making processes, but not be dependent on any one.
6. Finally, a DSS should be easy to use (Sprague, 1980).

These requirements not only hold true for DSS, but GDSS as well. Sprague even alludes to GDSS capabilities in his DSS framework.

### Historical Studies in GDSS

In previous studies on GDSS, however, conventional wisdom has primarily led to the following directions in which research has been focused:

- What do groups do
- The effects of GDSS on group work
- The effect of GDSS on organizations
- Effects of hardware performance on GDSS

- Effects of software performance on GDSS
- Cultural effects in GDSS
- Training people to use GDSS (Gray, DeSanctis, Dickson, Johansen, Kraemer, Olfman, and Vogel, 1992)

Of the areas lacking in the historical focus on GDSS, studying how groups traditionally have derived decisions is perhaps the most important. Another facet of GDSS research that has received little attention is the utilization of recent innovations in DSS and their applicability to GDSS. Studying the effects of GDSS without a viable GDSS system being deployed is certainly premature. Advances in technology and communications have also made moot discussions regarding the effects of hardware and software performance. Consequently, for substantial improvements to be made in GDSS development and subsequent utilization, research needs to focus more on the decision-making process, include the technological advances made in DSS systems and models, and applying them to a practical and flexible group decision framework.

The topics which have dominated GDSS research focus on Management Theory, sociology, psychology, Adaptive Structuration Theory, with little relating to other available decision technology. Although these are certainly important topics in the progression of GDSS development, they will not substantially increase the practical body of knowledge in GDSS. The existing body of GDSS research utilizes the social sciences and focuses principally on behavioral aspects of its utilization. Such research can provide insights, but not substantive results (Gray and Mandivala, 1999).

**MINTZBERG’S GENERAL MODEL OF THE STRATEGIC DECISION PROCESS**

To begin the development of an appropriate model for a GDSS, careful analysis of the dynamics of the various decision-making processes needs to be made to better understand how the system is to function. In their 1976 article, The Structure of “Unstructured” Decision Processes, Henry Mintzberg, et al., studied the strategic decision-making processes of 25 organizations (Mintzberg, Raisinghani, and Theoret, 1976). In Mintzberg’s study, they found 9 routines or modules which were utilized in the process of the organizations making strategic decisions. Mintzberg found logic in delineating distinct phases of the strategic decision process, but not in suggesting a simple sequential relationship between them. Not all of the routines discovered were utilized in every decision, but a generalized model of the decision process was developed which incorporated the multiple paths through the different routines (Figure 1). These routines adhered to Simon’s 3 phases of the decision-making process.

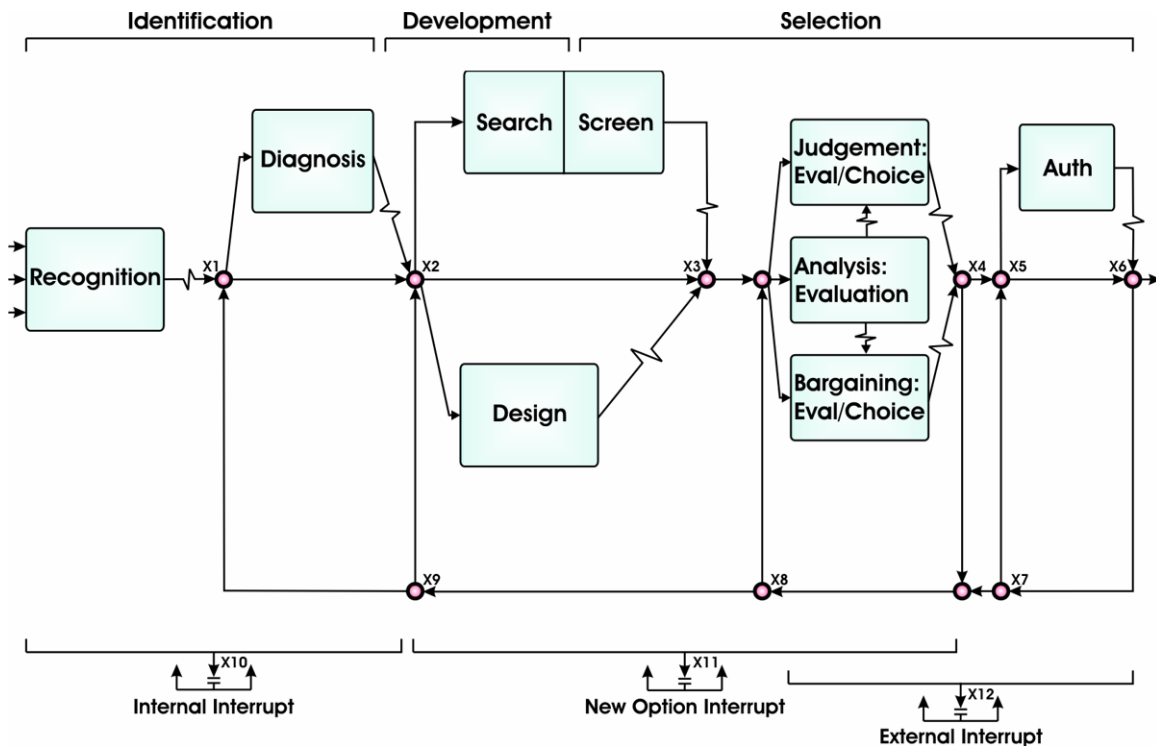


Figure 1: Mintzberg’s Model of a Generalized Group Decision Support Process

## FRAMEWORK FOR A GENERALIZED GROUP DECISION SUPPORT SYSTEM

In developing a new construction for a GDSS, Mintzberg's model was adapted to provide the framework for a generalized GDSS (Figure 2). This framework will also incorporate many of the developments in IT and DSS which will assist the decision makers and participants in certain phases of the process.

### Modularization

Each of the routines in Mintzberg's model can be implemented as a module in the proposed GDSS. By creating a default set of Application Programming Interfaces (APIs) for each of the modules, this will allow them to communicate with one another regardless of which module is interconnecting with which. Each module in itself will also be comprised of multiple modules which are responsible for implementing the steps necessary for completion of the particular routine. There may be additional modules which are loaded dynamically based upon user request or for implementing a particular DSS model. These modules can be added, deleted, and modified on the fly without dramatically affecting the overall decision-making process, although manipulation of the models may initiate an internal interrupt during the development and selection phases of the decision-making process.

### Modeling subsystem

The ability to integrate data access and decision models is an integral part of the development and growth of the GDSS. The modeling subsystem is database driven allowing the integration and communication mechanism between different models. The key capabilities for a GDSS modeling subsystems include:

- the ability to create new models quickly and easily
- the ability to catalog, maintain, and utilize a wide range of models
- the ability to interrelate these models with appropriate routines through the system
- the ability to utilize the models as building blocks for the development of more sophisticated models
- the ability to manage the models with mechanisms for storing, cataloging, linking, and accessing the models (Sprague, 1980)

In adapting Mintzberg's model for utilization in a GDSS framework, the routine modules also incorporate what IT and DSS development have contributed to decision support and automation. Each module must also be capable of logging its status and its contribution to the decision-making process so that the decision makers can better understand the reasoning behind choices that have been proposed.

### The Recognition Module

In Mintzberg's model, strategic decisions presented themselves to the organizations in a variety of ways and could be categorized along a continuum. At one extreme of the continuum are *opportunity* decisions which were initiated voluntarily and sought to improve the organization's situation. At the other end of the continuum were *crisis* decisions in which the organization was forced to make a decision to respond to intense pressures and were typically initiated by a single stimulus. In the middle of the continuum were *problem* decisions which require multiple stimuli and gave the decision makers an opportunity to reflect on the problem before action was required.

Mintzberg defined the need for a decision as "the difference between information on some actual situation and some expected standard" (the need to get from point A to point B). The standards sought were based on past trends, projected trends, standards in a comparable organization, expectations of others, and theoretical models.

Of course, the first step in the decision-making process is recognizing or determining that a decision needs to be made. For *opportunity* decisions, the recognition process is typically determined by management within the organization. Consequently, the GDSS must provide the capability for manual initiation of the decision-making process. There are also opportunity decisions that could be triggered by an event (e.g. we can make a lot of money opening a new refinery once the price of a barrel of oil exceeds \$100). *Crisis* and *problem* decisions are typically initiated through one or more actions, events, exceptions, etc. Consequently, the utilization of Intelligent Agents (Hess, Rees, and Rakes, 2000) to trigger the decision-making process must be utilized within this framework in addition to the manual initialization of the process. These agents will operate autonomously and monitor for any events, actions, exceptions, or other activities which could trigger the need for a decision by the organization (e.g. a request for a new customer order is entered through the company's website or a key resource is no longer available from the company's preferred supplier).

## The Diagnosis Module

Mintzberg's model stipulates that once appropriate stimuli are received, the decision process is initiated and the necessary resources are appropriated to deal with it. The issues involved with the decision are then clarified and defined. The decision maker is then tasked with developing a process or finding an existing process to handle the decision.

One adaptation made to Mintzberg's model was to mandate the utilization of the Diagnosis routine. In the modified framework, the diagnosis module is responsible for determining the initial path through the remainder of the GDSS framework or could determine that no additional action or activities are necessary. Interrupts will also result in the decision-making process reverting to the Diagnosis module to determine if a new course of action is required based upon the new situation.

The Diagnosis module is also responsible for determining what personnel are necessary to complete the decision process as well as what organizational and group support are required. Since a GDSS must accommodate decisions which are made by groups or made in part by several people in sequence, the Diagnosis module must be able to determine the decision type to be invoked. Consequently, the "fit" of the personnel utilized, the decision type required, and the path through the decision process must be established by the diagnosis module (Zigurs and Buckland, 1998).

- In an **Independent** decision, the decision maker has full responsibility and authority to make a complete implementable decision. In this type of decision, the GDSS will aid the decision-maker with the appropriate tools incorporated in the module, but may not require utilization of the Selection or Authorization modules.
- In a **Sequential Interdependent** decision, the decision maker makes part of a decision which is then passed on to someone else. In this type of decision, the GDSS will facilitate the progression through each step of the decision-making process. Since, in the Sequential Interdependent decision, each participant is generally responsible for making decisions on their component of the overall decision, after each step, the GDSS will return to the Diagnosis module to determine the next course of action.
- In a **Pooled Interdependent** decision, the decision must result from negotiation and interaction among decision makers. In this, the most complicated form of decision, the Diagnosis module must determine what personnel will be required for the decision-making process and which modules will initially be the most likely to achieve an expedient result (Sprague, 1980).

Consequently, the Diagnosis module is one of the most important components of the GDSS. It also needs to be flexible and capable of determining the correct course of action to follow based upon indeterminate inputs from the Recognition module. The Diagnosis module also needs to be capable of learning the correct course of action based upon feedback from the decision-making process and the decision makers. Therefore, the most appropriate subsystem type to be developed for this module is an Expert System (Aiken, Sheng, and Vogel, 1991). A simple logic tree could be utilized for the development of this module. However, since an Expert System has the capability to learn from its previous decisions, future decision-making processes can take more appropriate courses of action.

## The Development Phase

One of the key components of the decision-making process is the process involved in developing one or more potential solutions to the problem or crisis or the elaboration of the opportunity. Most of the resources involved in the decision-making process are typically consumed in the development phase(s) of the strategic decision process.

Development is typically accomplished in one of two standard routines: **search** or **design**. The Search routine is invoked to find solutions that had already been made. The Design routine is used to develop a custom-made solution or make modifications to an existing solution. In several cases in Mintzberg's study, the Search routine was invoked but was unable to find an applicable solution and the process then diverted to the Design routine to develop a new solution.

Since the functioning of these modules will often, although not always, require group support, there will be common features and components of both modules. Whenever group communications and collaboration are required in the decision-making process, a method of recording the communications for future input into the GDSS will be required. In these cases, Knowledge Acquisition systems will be utilized for the collection, storage, assimilation, and later retrieval of the interactions between the group members (Alavi and Leidner, 2001).

To coordinate the communications process, the GDSS should utilize DeSanctis' "Level 3" mode of interaction (DeSanctis and Gallupe, 1987). In this method of information exchange, the system will suggest a method of interaction by selecting and arranging the rules to be applied during the meeting and these patterns of communication will be imposed on the group

through the system. Additional rules could be applied to change the communications method depending on the content, timing, or other factors occurring during the discussion. The GDSS should also provide the facilities for the group to select or build rules for the group discussion. Samples of potential rule sets to be employed are located in Table 1.

Preferences	Rule set
Desire to enforce formalized decision procedures	Automated Parliamentary Procedure or Robert's Rules of Order
Desire to select and arrange an array of rules for discussion	Rule base; facility for rule selection and application
Uncertainty about options for meeting procedures	Automated counselor, giving advice on available rules and appropriate use
Desire to develop rules for the meeting	Rule-writing facility

**Table 1: Sample GDSS Communications Rules**

### Search and Screen Modules

The Search module's primary function is to collect potential solutions from decisions that have been previously made. The Search module can also be utilized within a group to brainstorm for novel ideas to solve the problem without necessarily fully developing the idea and without fear of being ridiculed because of the anonymous nature of the system. The Screen module is then utilized to evaluate those potential solutions to determine their fitness for the decision at hand.

The advantage of implementing the framework as independent modules is most prevalent in the Search and Design processes of the GDSS framework. The modularization of the various DSS models allows for the seamless integration and utilization of these utilities within the GDSS. If the participants in the GDSS wish to utilize a particular DSS model, they just invoke the tool from within the framework. Any constructs which must be input into the model can be derived from the GDSS or input by the participants. Modules can be created from Data Mining, Case-Based Reasoning (CBR), Expert Systems, Neural Networks, etc. The ability to create new modules based upon existing or forthcoming Decision Support models allows the GDSS to remain current and grow as new methods become available.

Particularly useful in the Search module, CBR allows the users to retrieve equivalent or similar solutions from a broad database of previous decisions. A Case-Based Reasoning model can be invoked by the participants in the Search module to aid in the exploration of solutions based upon past experiences stored in a database. This DSS model is particularly effective at combining past experiences in order to formulate a unique solution to problems that are similar to what the organization had experienced previously. In particular, CBR allows the users to develop better decisions by increasing the number of alternatives examined, time and cost savings in searching for previous solutions, provides new insights to the existing case by looking at how similar cases had been previously solved, and allows the organization to make better use of existing data. CBR allows the users to use complete solutions from previous cases as well as combining solutions from previous cases to form a similar, but unique, solution to the current problem (Sinha and May, 1994).

Once the Search routine generates the possible alternatives to the solution of the problem, they are each evaluated in the Screen routine. This routine is more likely to focus on eliminating solutions that are infeasible, rather than determining which solutions are most appropriate. This process is important, however, in order to reduce the alternatives to a manageable number that can then be evaluated by the decision maker.

### The Design Module

The Design process is potentially the most intensive and expensive component of the decision-making process. When ready-made solutions are not available, this module has the capability of potentially bringing in engineers, consultants, and other experts. Therefore, the Design module will generally only be executed when there are no pre-made solutions that will accomplish the current task.

It is also in the Design module where the application of various DSS models is likely to have the greatest impact. The modeling subsystem referenced earlier will be utilized to its greatest extent in this module.

### **The Evaluation Modules**

The selection phase is generally considered to be the final part of the decision-making process. However, there are frequently sub-decisions which each require a selection step and consequently, a single decision process could involve multiple selection phases.

The evaluation-choice routines typically use one of 3 different modes for coming to a decision: judgment, bargaining, or analysis. The judgment mode involves an individual making the choice, many times based on intuition. The bargaining mode involves a selection made by a group of decision makers each of who exercise their own judgment. The analysis mode involves factual evaluation by experts followed by managerial judgment or bargaining.

Additional utilities may also be incorporated in the Evaluation modules to aid in the analysis of the available choices. In cases where there are multiple decision makers, a technique for voting among the participants is utilized in the Judgment: Eval/Choice module.

The analysis of the available choices may also lead the decision makers to conclude that more work needs to be done and revert the decision back to one of the earlier modules for additional effort. In order to aid in the evaluation of the potential solutions, the decision makers will also be able to rely on the feedback component of the prior modules to gain a better understanding of the reasons these solutions were recommended.

### **The Authorization Module**

When the individual or group making the choice does not have the authority to approve the course of action, the decision must seek approval from one or more people hierarchically. This routine may be repeated multiple times without interaction with the other routines as it progresses up the hierarchy of the organization. Authorization can also occur in intermediary phases within the decision process if it becomes necessary to gain approval for the continuation of the process.

Depending on the complexity and cost of the selected decision and the complexity of the hierarchy in the organization, the decision may have to seek multiple approvals of management prior to implementation. During this process, the management may endorse the proposed decision, deny the decision (terminating the process), or refer the decision back to one of the earlier modules with suggestions for modification or requests for additional detail.

### **Interrupts**

Another important aspect of Mintzberg's model is the concept of interrupts. Interrupts are events or modifications to the premise of the decision that can occur at any time during the decision-making process causing disruption, escalation, or termination of the process. The three most common classifications of interrupts are internal or political interrupts, new option interrupts, or external interrupts. Internal or political interrupts are those that come from within the organization and may lead to returning to the recognition routine, resolving the disagreement through bargaining, or delay until the resistance subsides or is removed politically. New option interrupts typically occur late in the development or during the evaluation routines and either lead the process back to the design phase to work with the new option or directly to the evaluation routines to select or reject it immediately. External interrupts exist where outside forces block the selection of a completed solution. These interrupts will typically lead either to modification in the design or complete redevelopment of a new solution.

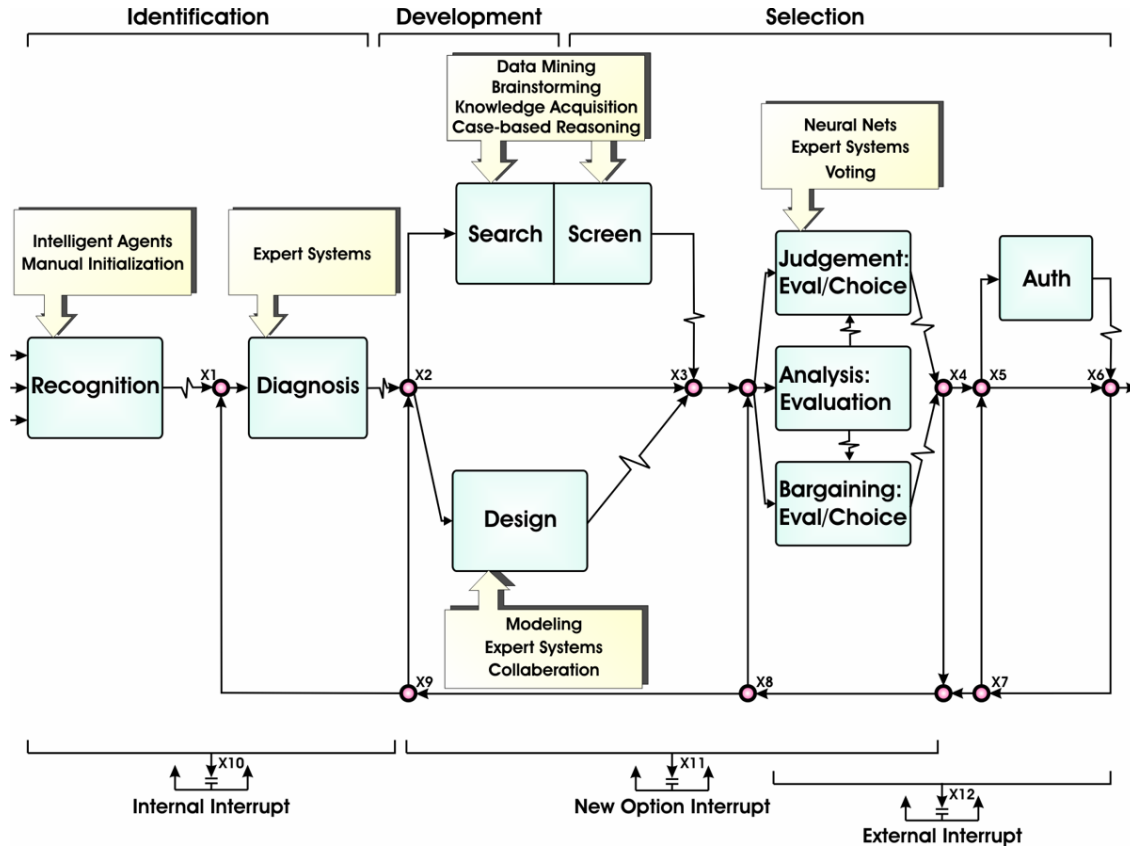


Figure 2: Mintzberg's Adapted Model of a Generalized Group Decision Support Process

**A Simple Case**

Consider the case of a construction company utilizing a GDSS for determining an appropriate bid on a project. The construction company has a website which allows the customer to input their specifications for the proposed structure or select from a collection of sample structures. The company also receives requests for proposals directly from its customers and other intermediary organizations. The GDSS is responsible for determining the plan for the structure, its cost, the price quoted to the customer, and potential schedules for construction.

In a simple case, a potential customer selects a structure from one of the samples provided on the website. The Intelligent Agent in the Recognition module of the GDSS accepts the event and sends the data to the Diagnosis module. Since the solution for this project has already been determined, it's a simple matter of incorporating the current pricing of the components and availability of the construction crews. Once this is determined, the Diagnosis module just needs to send the plan, cost, price, and possible schedules on to the Evaluation modules where the decision makers finalize the proposal and send it to the customer; completing the implementation of the decision (no authorization is required since this is a simple, pre-authorized solution).

In a slightly more complex case, the customer submits a request for a proposed structure with his own layout and dimensions. At this point, the Diagnosis module will determine that the Search module will need to evaluate the problem to see if similar problems had already been solved. The team involved in the Search module finds several similar structures that had been previously constructed and screens them. Again, the decision makers pick an appropriate solution in the Evaluation modules. Since this was based upon a previously completed project, only a single level of authorization is necessary prior to sending the proposal to the customer.

In a more extreme case, the potential customer calls the sales representative at the construction company and requests a proposal for a structure which includes certain components and is suitable for a particular task. The sales representative then manually invokes the GDSS with the information from the customer. The Diagnosis module sends the request to the Search module where the team attempts to find a possible solution, but determines that nothing in their experience will fulfill the request. The team then invokes the CBR module to see if combining the results of other successful projects will fulfill the



customer's request. The CBR comes up with a possible solution, but the decision makers are not satisfied with the solution and send it back to the Diagnosis module along with what the CBR module had come up with. The Diagnosis module then sends the request on to the Design module where the engineers work together to accomplish the task using other models at their disposal to implement different components of the task. While the engineers are working on the solution, the customer requests a modification to their request. This causes New Option Interrupt which reverts the decision process back to the Diagnosis module. From there it goes back to Search/Screen along with what the engineers had already developed, and then back to the Design module where the engineers complete the solution, the decision makers accept the solution, and it goes through multiple levels of authorization and finally is delivered to the customer.

## CONCLUSION

Not every decision can be made in a vacuum and may need input from a group. Just because a decision is to be made in a group, however, is no reason to discard the DSS tools that are readily available. Incorporating Mintzberg's framework into a GDSS allows the system to be flexible and comprehensive, while still allowing for a variety of DSS models to be utilized in the decision-making process.

Finally, a DSS should be easy to use. This characteristic has been described by a number of terms including flexibility, user friendliness, non-threatening, etc. The importance of this characteristic is accentuated by the type of people likely to utilize this tool (e.g. non-technical managers). Any DSS must "earn" its users' dedication by being valuable AND convenient (Sprague, 1980).

## FUTURE RESEARCH

Most prior GDSS research has typically focused on a single element of the decision-making process (typically interaction among group members). The framework suggested in this essay seeks to expand the traditional view of the GDSS to cover the complete decision-making process and its inherent fluctuations while incorporating much of the technology available today. To be implementable, the modules described must be more fully developed, especially in regards to the Diagnosis Module. In order for the Search and Screen modules to fully utilize the capabilities of existing DSS systems, methods for incorporating the modeling subsystem into the GDSS and implementation of the various DSS technologies into this subsystem will likewise require some additional research. Subsequent to the completion of the Analysis and Design of the GDSS, implementation of the communications between the modules and the module implementation can commence.

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