# A Functional Taxonomy of Computer Based Information Systems

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## Abstract.

The increased use of computing facilities and the application of concepts and theories from a wealth of different disciplines have resulted to the development of different types of Computer Based Information Systems (CBIS) with distinct functional characteristics. The reviews and classifications of CBIS found in the literature are usually focusing on one of these types and focus on classes of applications. There is a need for a broad classification with a focus on the functional characteristics for CBIS. The present paper attempts to provide the basic framework for such a functional taxonomy by classifying CBIS on three distinct elemets: information support; decision support; and communication support. The aim is to lead to greater precision in systems categorisation and enhance the usefulness of CBIS research by reducing ambiguity in the attribution of research results. Ten different types of CBIS are examined. The constituent elements of these CBIS types are also analysed.

**Keywords**: computer-based information systems; classification; management information systems; decision support systems; expert systems; database management; model management; knowledge management.

## INTRODUCTION

The increased use of computing facilities and the application of concepts and theories from a wealth of different disciplines (like operational research, management science, artificial intelligence, etc) have resulted to the development of various types of Computer Based Information Systems (CBIS). These types of CBIS exhibit distinct functional characteristics and aim to provide support in separate parts of the organizational environment; e.g. Executive Information Systems focus on the executives of organizations, Decision Support Systems aim at providing support for the decision-making activities, etc.

The reviews and classifications of CBIS found in the literature have two important limitations. First, they are focusing on only one of the various types of CBIS, aiming to limit the scope of analysis into manageable scale; see e.g. Rainer et al (1992) and Watson et al (1991) for reviews of Executive Information Systems. Second, they either focus their analysis on all kinds of applications of a specific type of CBIS [see e.g. Eom and Lee (1990) who review applications of Decision Support Systems] or restrict their scope even more to a particular class of applications (i.e. a particular problem domain); see e.g. Gupta and Chin (1989) for

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applications of Expert Systems in production and operations management.

Although an approach that limits the classification to a particular class of CBIS is useful for gaining insight into specific aspects, it fails to provide a more general framework that would lead to greater precision in the categorisation of systems and to enhance the usefulness of CBIS research by reducing ambiguity in the attribution of research results.

The present paper aims to provide a broad functional classification of alternative types of CBIS. In order to classify the CBIS we use an approach similar to the one adopted by Cotterman and Kumar (1989) in a different context (the classification of end-users). We attempt to classify CBIS on three distinct elements: information process support; decision process support; and communication process support.

Ten different types of CBIS are examined: management information systems; executive information systems; executive support systems; decision support systems; group decision support systems; electronic meeting systems; organizational decision support systems; expert systems; office information systems; and intelligent organizational information systems. The latter category constitutes an attempt to synthesise research towards the goal of competent and intelligent aiding in organizational settings.

The paper examines also the constituent elements of CBIS. The CBIS examined here include the following elements: Database management systems (DBMS); Model Management Systems (MMS); Knowledge Management Systems (KBMS); Cooperation Management Systems (CMS); and Dialogue Systems (DS).

The next section presents the general framework for a functional taxonomy of CBIS and reviews the various types of systems. Next, an attempt is made to map the different types of systems to the taxonomy, identify and discuss their technological elements and characterise the CBIS in terms of the support they provide to the individual, group and organizational level. The final section provides the conclusions and directions for further research.

# CLASSIFYING CBIS

## Elements of the taxonomy

In order to classify the CBIS we use an approach similar to the one adopted by Cotterman and Kumar (1989). We attempt to classify CBIS on three distinct elements:

- information process support, i.e. the provision of on-line support for the extraction, filtering and tracking of data critical to the organization.
- decision process support, i.e. the use of information in order to provide intelligent support for reaching decisions on semi-structured, or un-structured problems.
- communication process support, i.e. the provision of support for sharing and exchange of information between multiple users.

Information process support, decision process support and communication process support are the three key dimensions that allow us to distinguish between the various types of CBIS. Figure 1 provides a convenient way of visualising the various possibilities. In Figure 1 the x-axis is information process support, the y-axis is decision process support and the z-axis is communication process support. The corners or nodes of the cube represent the extremes of each dimension. Node (1,0,0) for example, represents the case of an individual CBIS that provides information process support without explicitly supporting either the decision-making or the communication requirements of an organization.

We need to clarify here that the 0-1 limits of each of the three dimensions of the cube are the end points or limits of a continuum, not a binary classification. The nodes, therefore, are limiting cases. In practice we may find CBIS that are represented by points on any surface of the cube, or even within the cube.

Several types of computer-based systems have been developed; from an analysis of the most-used terms in the literature the following ten types can be identified:

- management information systems (MIS);
- executive information systems (EIS);
- executive support systems (ESS);
- decision support systems (DSS);
- group decision support systems (GDSS);
- electronic meeting systems (EMS);

- organizational decision support systems (ODSS);
- expert systems (ES);
- office information systems (OIS); and
- intelligent organizational information systems (IOIS).

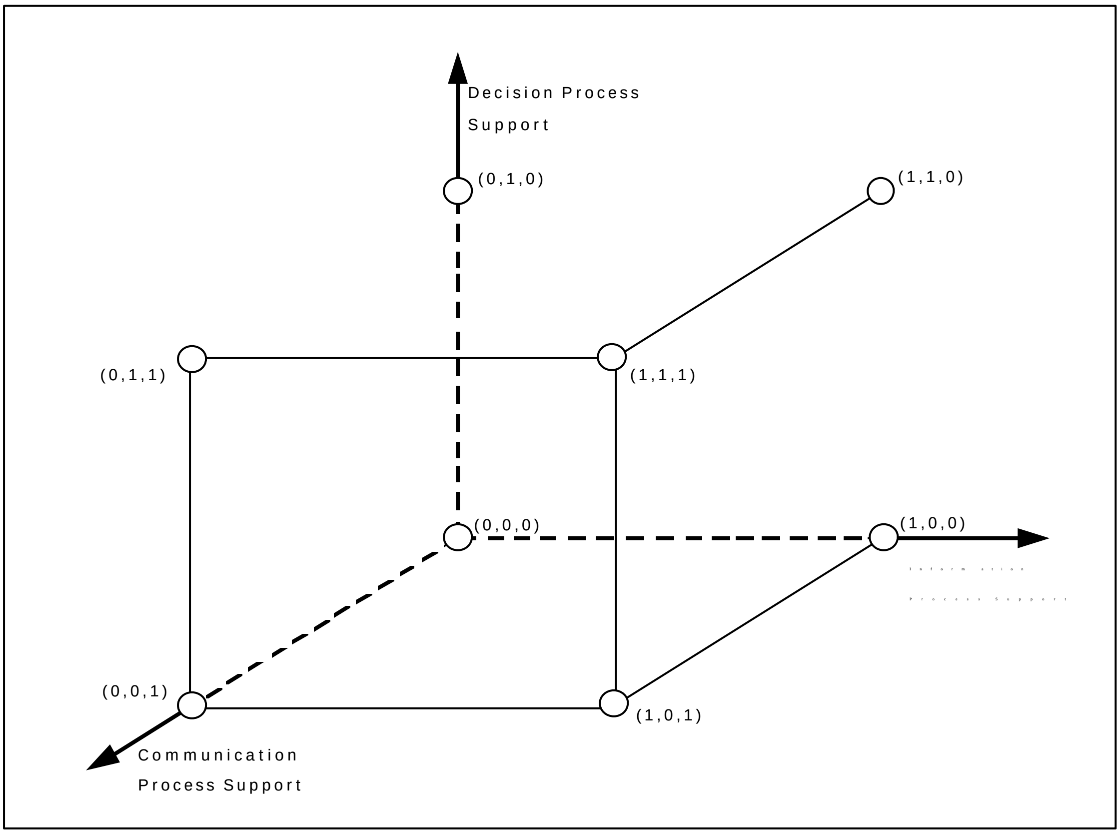


**Figure 1. Classification of Computer Based Information Systems**

| Type of System | Role |
|---|---|
| Management Information Systems (MIS) | Analysis of information, generation of requested reports, solving of structured problems |
| Executive Information Systems (EIS) | Evaluation of information in timely analyses for top-level managerial levels, in an intelligent manner. |
| Executive Support Systems (ESS) | Extension of EIS capabilities to include support for electronic communications and organizing facilities |
| Decision Support Systems (DSS) | Use of data, models and decision aids in the analysis of semistructured problems for individuals |
| Group Decision Support Systems (GDSS) | Extension of DSS with negotiation and communication facilities for groups |
| Electronic Meeting Systems (EMS) | Provision of information systems infrastructure to support group work and the activities of participants in meetings |
| Organizational Decision Support Systems (ODSS) | Support of organizational tasks or decision-making activities that affect several organizational units |
| Expert Systems (ES) | Capturing and organization of corporate knowledge about an application domain and translation into expert advice |

| | |
|---|---|
| Office Information Systems (OIS) | Support of the office worker in the effective and timely management of office objects, the goal-oriented and ill-defined office processes and the control of information flow in the office |
| Intelligent Organizational Information Systems (IOIS) | Assistance (and independent action) in all phases of decision-making, information and communication support in multi-participant organizations. |

**Table 1. Types of Computer-Based Information Systems**

Table 1 summarises the major types of these systems. In the following paragraphs we review the characteristics of these types of CBIS and attempt to map them on the cube.

## Management Information Systems

The literature abounds with accounts of what is, or is not an Management Information System (MIS); see also Parker and Al-Utaibi (1986); the definitions range from the extreme of those who believe that an MIS is a computer-based system that produces an expanded set of reports and has a query capability, to those claiming that an MIS serves all the information needs of an organization.

Keen and Scott-Morton (1978) argue that the main area of impact of MIS on organizations refers to structured tasks where standard operating procedures, decision rules and information flows can be reliably predefined. They argue that MIS improve efficiency by reducing costs and replacing clerical personnel, while the relevance of MIS to decision-making is limited to providing reports and access to data.

Hence, it can be considered that the role played by MIS refers only to the first level of Ackoff's classification [Ackoff (1967)], i.e. MIS have failed to support semi-structured and even unstructured decision-making; see also Watson and Hill (1983) who attribute this failure to the following reasons: MIS personnel are unfamiliar with the decisions that need support; MIS personnel are overworked with backlogs measured in years; managers cannot specify their information requirements except through an interactive process; and managers' information requirements are subject to change with changes in the decision-making environment. The use of computer-based systems that would support and enhance the decision-maker's judgement in areas of unstructured and semi-structured decision-making is where Decision Support Systems come in.

## Executive Information Systems

There is a growing need for timely information needed by senior managers for issues about critical aspects of an organization. Executive Information Systems (EIS) have been created to monitor the decision environment, evaluate the captured information for opportunities and/or problems, and present timely analyses to top-level managers. An EIS can be defined as "a computerized system that provides executives with easy access to internal and external information that is relevant to their critical sucess factors"; see Watson et al (1991).

EIS provide internal and external information in a variety of formats meaningful to the executive user. According to Rainer et al (1992), Turban and Schaffer (1987), Turban (1990) and Watson et al (1991) Executive Information Systems typically: extract, filter, compress and track critical data; provide on-line status access, trend analysis, exception reporting, and "drill-down"; are user-friendly and require minimal or no training; are used directly by executives without intermediaries.

## Executive Support Systems

Both the terms EIS and ESS (Executive Support Systems) appear in the literature. According to Rockar and De Long (1988) an ESS usualy refers to a system with a broader set of capabilites that an EIS, including: support for electronic communications (e.g. e-mail, computer conferencing and word processing, etc); data analysis capabilities (e.g. spreadsheets, query languages, etc); and organizing tools (e.g. electronic calenders, etc). Hence ESS appear to support features not only related to information-support, but also to communication-processs support.

## Decision Support Systems

As Keen (1987) has put it, ".. right from the start of the DSS movement, and even now, there has been no established definition of

DSS...". For example, according to Sprague (1980) DSS are "*interactive* computer based systems, which *help* decision makers utilise *data* and *models* to solve *unstructured* problems". An alternative definition of Decision Support Systems (DSS) is given in Edwards (1992): a Decision Support System is a "system which enables the user to access data and/or models so that he or she may take better decisions". This definition is neutral with respect to issues that are discussed extensively within the DSS field; e.g. whether a DSS must be computer-based, whether it must include a normative model, etc.; see e.g. Sprague and Carlson (1982) and Bonczek, Holsapple and Whinston (1981).

The DSS literature has seen a wealth of research efforts; hundreds of DSS have been constructed, in order to facilitate decision-making in a variety of situations; see e.g. Eom and Lee (1990) for a survey of applications and Eom et al (1993) for an analysis of the intellectual structure of DSS.

## Group Decision Support Systems

It has been argued that group activities are economically necessary, efficient as means of production and reinforcing of democratic values; see e.g. Kraemer and King (1988) and Hatcher (1992). DeSanctis and Gallupe (1987) provide the definition of a GDSS as "an interactive computer-based system that facilitates the solution of unstructured problems by a set of decision-makers working together as a group". Operationally this means increasing the speed at which decisions are reached without reducing, and hopefully enhancing, the quality of resulting decisions. Shaw (1981), for example, concluded that groups produce more and better solutions to problems than do individuals, particularly on judgmental tasks.

The classification of the technology basis for GDSS proposed by Kraemer and King (1988) distinguishes between six "technological systems": electronic boardroom; teleconference facility; group network; collaboration laboratory; information center; and decision conferences. On the other hand, Mentzas (1993a) has identified the following (conflicting) options in the design and development of group systems: specification and implementation of coordination; use of sychronous and asychronous working phases; information exchange and information sharing; support of sequential and concurrent processing; support of negotiation and conflict resolution; support of analytical modelling; and description of the organizational environment.

Research on the support of muti-participant decision-making has been classified by DeSanctis and Gallupe (1987), in a widely accepted scheme, which distinguishes between three levels, based on the degree of support provided to the group. Level 1 systems provide technical functionality aimed at removing common communication barriers and facilitating information exchange; level 2 systems provide decision modeling and group decision process facilitation tools aimed at decreasing uncertainty and ambiguity; finally, level 3 systems provide normative, prescriptive intervention in group processes through structured group process tools, active filtering and structuring of information or communication, and expert systems that perform group roles and functions or advise group leaders/members when appropriate rules are not followed.

Nunamaker et al (1991) argue that group systems should be distinguished based on whether they offer structure or support. According to them, structure would include techniques such as decision modelling, while support would involve providing easy access to a database or allowing parallel communication. Their definition of structure appears consistent with DeSanctis and Gallupe's Level 2 and Level 3 systems, and their definition of support appears consistent with the description of Level 1 system. In a similar vein Pinsonneault and Kraemer (1989) distinguish between GDSS (Group Decision Support Systems) and GCSS (Group Communication Support Systems); the latter aim in reducing communication barriers in a group. This taxonomy is further refined in Teng and Ramamurthy (1993), who distinguish between process support and content support.

Based on the above considerations we consider systems which place emphasis to structure (or content support) as belonging to the GDSS type and systems which place emphasis to support (or process support, or GCSS) as belonging to the Electronic Meeting Systems type, or as McLeod and Liker (1992) put it "low structure environments".

## Electronic Meeting Systems

Electronic Meeting Systems (EMS) provide an information systems infrastructure to support the work of participants in groups and the activities in their meetings; see Martz et al (1992) and Nunamaker et al (1991).

According to McLeod and Liker (1992) the main features of EMS systems are the following: parallel communications (the ability of group members to input and receive ideas simultaneously with other members of the group); anonymous communication (i.e. that group members are not able to attribute ownership to any ideas); shared software (i.e. software that is equally available to all group members); shared view (i.e. all group members have equal access to the same view of their work); decision tools (which refers to software that is designed to support a particular decision task); process tools (software specifically intended to include a particular approach to working on a group's task). Of course, the last two features are expected to be found in GDSS (high-structure environments) rather, than in EMS (low-structure environments).

An example of the tools bundled in EMS systems can be found in Martz et al (1992), in which the tools available include: electronic brainstorming (designed to assist the activity of idea generation by a group); issue analysis (allows the participants to identify, edit and rank a list of focus items in a session); voting procedures (allow the facilitator to initiate a ballot for anonymous voting by the individual participants); and proposal formulation (helps bring a group to agreement on nomenclature and wording for the planning problem domain).

## Organizational Decision Support Systems

The fact that Information Technology has a significant effect on organizational structure has been discussed extensively in the literature. It seems unquestionable that the typical organizational structure has changed in the last decades; see Applegate et al (1988). The organizational tasks or activities that affect several organizational units have been the focus of Organizational Decision Support Systems (ODSS). These systems support people from different groups and provide information which is used across multiple independent activities or decisions, i.e. the range of their users exceeds any specific group; see e.g. Nunamaker (1992), George (1991) and Carter et al (1992).

These systems extend the concepts used in DSS and GDSS in order to cover the whole organizational setting. George et al (1992) identify three emerging changes in organizational structures: downsizing, focus on teams, and outsourcing, and propose different architectures for ODSS, each of which is tailored to one of the changes in structure. They base the architectures to a lesser or greater degree on five types of information technology: communication; coordination; filtering; decision-making; and monitoring technologies.

## Expert Systems

Expert systems (ES) have been defined as systems that embody knowledge, offer intelligent advice or take intelligent decisions about a processing function; see e.g. Edwards (1992) for some definitions. The major issue in expert systems is that they "replace" the human expert, by embodying his/her expertise within an electronic expert; see also Hayes-Roth et al (1983), Turban and Trippi (1989) and Gupta and Chin (1989).

It has been argued that expert system development is quite different from that of conventional systems; the reasons for this difference can be summarized in the following: conventional programs deal with problems that have been solved beforehand, hence they try to change know procedures or algorithms into code in an efficient manner, while ES determine and encode expert knowledge, based upon knowledge acquisition with repeated interviews of human experts; see Williams (1986).

The introduction of expert systems was accompanied with the use of artificial intelligence techniques that refer to knowledge acquisition, knowledge structuring, inference mechanisms, search strategies, symbolic representation and truth maintenance.

Early ES were focused on modular knowledge bases in conjunction with efficient logical inference strategies. Partridge (1987) claimed that the major assumptions upon which expert systems rest are: the fact that necessary knowledge can be represented as a collection of more or less independent rules; and that intelligent decision making can be implemented as a logical, truth-derivation mechanism. He argues that these assumptions are true in domains of abstract, technical expertise, such as mathematics, geology, chemistry, configuring computer systems, medical diagnosis, game playing and puzzle solving. However, these assumptions are weak in the following domains: natural language processing; intelligent tutoring; self-explanation of behaviour; and advanced robots. In addition, knowledge in ES is static; learning, adaptation and uncertainty mechanisms are not always included.

## Office Information Systems

Office Information Systems (OIS) aim at supporting the document-related, procedural and communication issues of office work; see Ellis and Nutt (1980). They have been modelled as encompassing three domains: passive office objects; office procedures; and office tasks; see Nierstrasz and Tsichritzis (1989) and Mentzas (1991).

Office objects are the primitive office elements; examples of office objects are documents, files, printers, etc.; hence, office objects provide metaphors that represent their actual counterparts in the physical office. Office procedures can be considered a set of mappings among office objects; office procedures are routine sequences of operations that are used to manipulate office objects. They model the event-driven behaviour of office work and are triggered upon completion of some awaited event, e.g. the arrival of a message, the completion of a form, or the modification of a document. Finally, office tasks are goal-directed and cannot necessarily be encoded to a precise procedure to be followed. Their intention is to model cooperation among many office agents, negotiation among parties, confrontation and argumentation, and the abilities to learn and reach goals.

## Intelligent Organizational Information Systems

Two are the main problems facing all of the above types of systems. First, none of them satisfies in an adequate manner all the decision-, information-, and communication-related processes of an organization. The second major problem of existing systems is that none of them covers explicitly the needs of large-scale organizations; e.g. support of parallel work; intelligent assistance in group communication; negotiation and conflict; distribution of processing and reasoning facilities; techniques for multi-participant planning; organizational learning facilities; etc. Hence, there is clearly a need for systems that would support in an intelligent manner the whole spectrum of organizational activities; we call such systems intelligent organizational systems; see also Mentzas (1993b).

| Information System | Information support | Decision Support | Communication Support |
|---|---|---|---|
| MIS | High | Low | Low |
| EIS | High | Low | Low |
| ESS | High | Low | Medium |
| DSS | Medium | High | Low |
| GDSS | Medium | High | High |
| EMS | Medium | Low | High |
| ODSS | Medium | High | High |
| ES | Medium | High | Low |
| OIS | High | Low | High |
| IOIS | High | High | High |

**Table 2. Types of support in computer-based information systems**

**Note**. The abbreviations of the various types of information systems are as follows: MIS: Management Information Systems; EIS: Executive Information Systems; ESS: Executive Support Systems; DSS: Decision Support Systems; GDSS: Group Decision Support Systems; EMS: Electronic

Meeting Systems; ODSS: Organizational Decision Support Systems; ES: Expert Systems; OIS: Office Information Systems; IOIS: Intelligent Organizational Information Systems.

With the term Intelligent Organizational Information Systems (IOIS) we label the research direction towards systems of intelligent software entities, that are organised in loosely-coupled, distributed architectures, and include communication, control, and task-sharing facilities, with the addition of effectuation and advanced modelling capabilities. Intelligent Organizational Information Systems aim to relieve the burdens and assumptions imposed within other types of CBIS. Elsewhere we claim that recent advances in the fields of distributed artificial intelligence and object-oriented computing facilitate the design and development of IOIS; see Mentzas (1993b) and argue that the modelling features of these systems can be separated in two groups that correspond to the two different levels of the system designed: the level of the single, independent element (i.e. the internal structure of the object), and the system level (i.e. the system architecture of IOIS). The features referring to the internal structure are: specialisation; representation; effectuation; learning; adaptability; planning; and intentionality. The features of the system architecture are: parallelism; distribution; modularity; heterogeneity; communication; organization; and human interaction. Mentzas (1993c) gives an analysis of these features in CBIS applications in the office and factory environments and Papazoglou et al (1992) present a framework for intelligent cooperative information systems that aim to satisfy the same requirements.

## MAPPING CBIS TO THE TAXONOMY

Although all ten types of computer-based systems try to cover the information, decision and coomunication-process support activities represented on the cube of Figure 1, they exhibit varying degrees of coverage. Table 2 presents a qualitative analysis of the the degree to which each type of system attempts to cover these activities.

It appears that information management support has reached relatively high scores in the MIS, and EIS types of systems. These systems cover an area of the cube of Figure 1 close to the (1,0,0) node, while ESS extend (to a lesser degree) the scope to support the needs of communicatiation support. Office information systems, since they are expected to provide information support to the office workers together with communication and coordination facilities, are expected to be near the (1,0,1) node, since they do not usually include decision-support aids.

Given that the main objective of Decision Support Systems is to assist in solving semi-structured and un-structured decision-making problems, they are expected to cover the area close to the (0,1,0) node. Since Expert Systems are usually considered to provide intelligent advice or to take intelligent decisions they are expected to cover the same area (this of course does not represent the fact that they are made up of different components, or the fact that ES are focusing on problem-solving and not on decision-making; see the next section for a discussion on this subject).

Electronic Meeting Systems place emphasis on providing communication-, and information support (with more emphasis on the former); therefore, they are expected to be close to the (0,0,1) and (1,0,1) nodes of the cube. Communication support can be also found in Group Decision Support Systems; these systems however, also provide the basic functionalities of DSS; hence they are expected to cover the area close to the (0,1,1) node. The same area is covered by Organizational Decision Support Systems; however, ODSS focus on supporting the needs of more than one group in an organization, while GDSS are limited to the support of one team of participants.

Finally, Intelligent Organizational Information Systems as they have been defined earlier, attempt to cover the whole spectrum of information, decision and communication-process support; hence attempts towards the development of such systems is directed to the (1,1,1) node of the cube.

Nevertheless, it should be mentioned here that the above discussion and the classification presented in Table 2 is only indicative of the general characteristics of the different types of systems, while specific applications which may claim to be of the one or the other type may present different characteristics. In addition, we emphasize that the functional classification presented here is nor meant to be a research framework to encompass a multitude of factors. Research frameworks have been proposed for specific types of CBIS; see e.g. Pinsonneault and Kraemer (1989) for such a framework for the GDSS type of CBIS.

In order to extend the classification framework and take into account the technological basis of CBIS, in the following we examine their basic components and examine the positioning of types of CBIS in relation to the inclusion of these components.

## Analysis of Components

The CBIS examined here include a number of constituent elements, which in turn are built using fundamental theoretical techniques drawn from such fields as operations research, computer programming, artificial intelligence, etc. We can distinguish among five such constituents: Database management systems (DBMS); Model Management Systems (MMS); Knowledge Management Systems (KBMS); Cooperation Management Systems (CMS); and Dialogue Systems (DS).

*Database management systems* provide mechanisms for information storage, retrieval and processing. Various types of data bases have been used in CBIS; any database adhering to the hierarchical, CODASYL-network, relational, or object-oriented data model can be candidate for inclusion in such a system. Nevertheless, databases designed with the more semantically oriented postrelational data models, can provide enhanced storage and retrieval mechanisms. Two major problems arise in DBMS. The first deals with the provision of a unifying framework for covering the multiplicity of database representations; see Reiter (1985), Li (1985) and Kim (1990) for related efforts. The second problem deals with the need to represent and manipulate descriptive knowledge in the form of text, image, etc; hence the need arises for support of multi-media information; see Akscyn et al (1988).

*Model management systems* use modelling languages, which when coupled to a variety of algorithms, are capable of representing and evaluating multiple mathematical abstractions of a given system. The typical model management system should support the following tasks: model formulation (i.e. gathering of information for building up a new model); model representation (i.e. representation of model structure, input and output information, overall characteristics, relations to other models, etc); and model processing (i.e. application of suitable algorithms, support of sensitivity and what-if analyses, etc); see Baldwin et al (1991) for a recent survey in model management research. In general, research in this area has been partial, in the sense that its aims were in supporting specific phases of the modelling life-cycle. Only recent efforts have been directed toward an integrated support of mathematical modelling. On the other hand, the idea that model management systems can contribute to organizational intelligence has been recently proposed; see Blanning (1993).

*Knowledge management systems* capture the knowledge of experts in a field and possess inference procedures capable of searching the state-space of available knowledge and solving problems that are difficult enough to require significant human expertise for their solution. Six types of knowledge have been identified, irrespectively of the specific techniques for knowledge representation and processing; descriptive knowledge; procedural knowledge; presentation knowledge; assimilative knowledge; linguistic knowledge; and reasoning knowledge; see also Holsapple and Winston (1989). In the case of reasoning knowledge the representation schemes used include: production rules; semantic networks; and frames. Inference engines in knowledge-based systems perform control tasks using: forward reasoning; reverse reasoning; blackboards; pattern-directed; etc, see Altenkrueger (1990).

*Cooperation management systems* facilitate conflict resolution and negotiation support when two or more decision makers are involved in the process of decision. Recent advances in information technology, communications and management science techniques have enhanced the performance of systems that support multiparticipant processes; see Applegate et al (1991). An important issue in multiparticipant processes deals with the assignment of quantitative values from group members as collective inputs to models which then help arriving at a solution; multi-attribute value analysis and calculation of preferences are techniques based on input collected in a group context. Methods used for deciding among alternatives include optimisation techniques, payoff matrices, utility curves, decision trees, game theory, ranking and statistical inference.

*Dialogue systems* are request and response mechanisms, which support human-machine interactions as two-way message passing activities. Woods and Roth (1986) provide three design metaphors for man-machine systems: man as cooperating participant of a problem solving/decision making system; man as a supervisor of a technical system that is partly automatically controlled; man as a user of tools, this includes the use of communication tools which could be any type of technology-mediated human-human interaction. These methaphors can be regarded as orthogonal design dimensions. Research efforts in Human-Computer Cooperative Work would involve the cooperation dimension (with the development of intelligent interfaces), the supervision dimension (i.e. in association with control applications involving human and system agents) and the tool dimension (for facilitating human-human cooperative work with intelligent tools); see e.g. deGreef et al (1991).

## Classification based on components

Table 3 attempts an analysis of the CBIS regarding their constituents. Some elements are considered '*basic*' for a system, since they provide the fundamental mechanisms for a system to be classified in a specific category, while some others are considered '*optional*', in the sense that although they are not necessary for the system, some implementations found in the literature include them.

It should be mentioned here that the classification presented in Table 3 is only indicative of the general characteristics of the different types of systems, while specific applications which may claim to be of the one or the other type may present different characteristics.

| Information System | DBMS | MMS | KBMS | CMS | DS |
|---|---|---|---|---|---|
| MIS | Basic | | | | Basic |
| EIS | Basic | Optional | | | Basic |
| ESS | Basic | Optional | | Basic | Basic |
| DSS | Basic | Basic | Optional | | Basic |
| GDSS | Basic | Basic | Optional | Basic | Basic |
| EMS | Basic | Optional | Optional | Basic | Basic |
| ODSS | Basic | Basic | Optional | Basic | Basic |
| ES | Basic | Optional | Basic | | Basic |
| OIS | Basic | | Optional | Basic | Basic |
| IOIS | Basic | Basic | Basic | Basic | Basic |

**Table 3. Elements of computer-based information systems**

**Notes**

1. The abbreviations of the various types of information systems are as follows: MIS: Management Information Systems; EIS: Executive Information Systems; ESS: Executive Support Systems; DSS: Decision Support Systems; GDSS: Group Decision Support Systems; EMS: Electronic Meeting Systems; ODSS: Organizational Decision Support Systems; ES: Expert Systems; OIS: Office Information Systems; IOIS: Intelligent Organizational Information Systems.

2. The abbreviations used for the elements of the systems are as follows: DBMS: Data-base Management System; MMS: Model Management System; CMS: Cooperation Management System; KBMS: Knowledge Based Management System; DS: Dialogue system.

## Level of Organizational Support

An important issue that is neither represented in the functional taxonomy presented in Figure 1, nor analysed in the examination of components refers to the degree of support to individuals, groups of individuals and large-scale organizations.

Table 4 examines the support provided by the CBIS reviewed to these three levels. Although MIS, EIS, ESS, DSS and ES types of systems provide substantial support to the individual user, they fail to support teams and organizations. On the other hand, GDSS and EMS are directed mainly to group support and present restricted support to the needs of individual users, as well as to large-scale organizations. It seems that from the existing systems only the ODSS and OIS categories are able to satisfy to an adequate degree the requirements posed by organizations, while IOIS aim at fulfilling the requirements of all types of users from the individual to the whole organization.

Table 5 attempts to represent in a simple, yet synthetic, form the information presented in Tables 2 and 4. Some types of systems are classified in more than one cells of the table, since they explicitly aim to aid more than one processing dimension and/or more than one type of organizational element.

| Information System | Support of individuals | Support of groups | Support of organizations |
|---|---|---|---|
| MIS | High | | |
| EIS | High | | |
| ESS | High | | |
| DSS | High | | |
| GDSS | Medium | High | |
| EMS | Medium | High | |
| ODSS | Low | Medium | High |
| ES | High | | |
| OIS | Low | | High |
| IOIS | High | High | High |

**Table 4. Degree of support to the individual, group and organization-level**

**Note:** The abbreviations of the various types of information systems are as follows: MIS: Management Information Systems; EIS: Executive Information Systems; ESS: Executive Support Systems; DSS: Decision Support Systems; GDSS: Group Decision Support Systems; EMS: Electronic Meeting Systems; ODSS: Organizational Decision Support Systems; ES: Expert Systems; OIS: Office Information Systems; IOIS: Intelligent Organizational Information Systems.

| | **Support of Information process** | **Support of Decision process** | **Support of Communication process** |
|---|---|---|---|
| **Support of Individuals** | MIS, EIS, ESS | DSS, ES | ESS |
| **Support of Groups** | EMS | GDSS, ODSS | GDSS, EMS |
| **Support of organizations** | OIS, IOIS | ODSS, IOIS | OIS, IOIS |

**Table 5. Classification of CBIS relative to the degree of support to the individual, group and organization-level and the three processes**

**Note:** The abbreviations of the various types of information systems are as follows: MIS: Management Information Systems; EIS: Executive Information Systems; ESS: Executive Support Systems; DSS: Decision Support Systems; GDSS: Group Decision Support Systems; EMS: Electronic Meeting Systems; ODSS: Organizational Decision Support Systems; ES: Expert Systems; OIS: Office Information Systems; IOIS: Intelligent Organizational Information Systems.

## CONCLUSIONS

The taxonomy presented allows the classification of existing and feature CBIS in a three-dimensional scale. The three dimensions include: information process support; decision process support and communication process support.

Based on the taxonomy, more precision and control can be introduced in the development and use of CBIS systems and the attribution of research findings can be more easily traced to specific system functions. In addition, the taxonomy identifies the relative lack of systems that cover all different processes in an organizational setting, i.e. while different CBIS cover adequately the support of the three processes for individuals and groups, there seems to be a lack for consistent support for all three dimensions for large-scale organizations.

Two are the main further research directions that arise from the work presented here. The first refers to an effort to refine the classification presented above. In order to accomplish such a refinement we aim to define in a more rigorous manner alternative levels of support for the three classification dimensions. Specifically, by defining three levels of support (e.g. no support, structured support and intelligent support) for each dimension, the cube of Figure 1 can be broken down to 27 cubes, each representing a specific category of CBIS which satisfies one of the three levels of information process support, one of the three levels of decision process support, and one of the three levels of communication process support; see Figure 2.

A second direction refers to the consistent testing of the power and validity of the classification scheme presented here. Our framework must be tested by applying it to examine existing CBIS and see if they can be classified accordingly. The systems mapped currently upon the cube are only types of CBIS; specific "instances" of CBIS (i.e. specific systems) were not mapped here. Characteristic examples of specific CBIS products should be examined and mapped to the three dimensions of the cube.

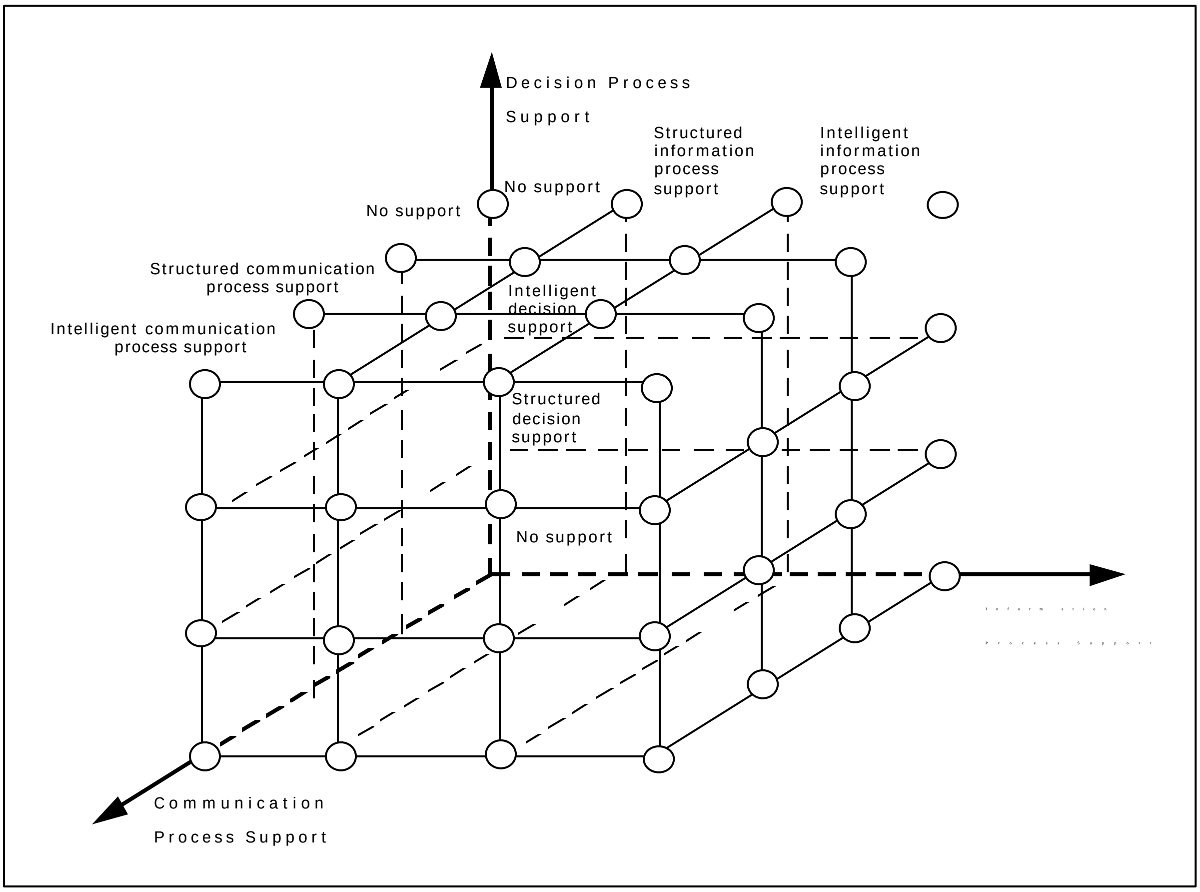


**Figure 2. A refinement of the classification of CBIS**

## REFERENCES

**Ackoff, R.L. (1967)** Management Misinformation Systems, *Management Science*, 11 (4), pp. 147-156.

**Akscyn, R.M. et al (1988)** KMS: A Distributed Hypermedia System for Managing Knowledge in Organizations, *Communications of the ACM*, Vol. 31, No, 7, pp. 820-835.

**Altenkrueger, D.E (1990)** KBMS: Aspects, Theory and Implementation, *Information Systems*, Vol. 15, No 1, pp. 1-7.

**Applegate, L. (1991)** Technology Support for Cooperative Work: A Framework for Studying Introduction and Assimilation in Organizations, *Journal of Organizational Computing*, Vol. 1, No 1, pp. 11-39.

**Applegate, L., C. Ellis, C. Holsapple, F. Radermacher, and A. Whinston (1991)** Organizational Computing: Definitions and Issues, *Journal of Organizational Computing*, Vol. 1, No 1, pp. 1-10.

**Applegate, L., J.I. Cash and D.Q. Mills (1988)** Information Technology and Tommorow's Manager, *Harvard Business Review*, pp. 128-136.

**Baldwin, A.A., D. Baldwin and T. Sen (1991)** The Evolution and Problems of Model Management Research, *Omega*, Vol. 19, No. 6, pp. 511-528.

**Blanning, R. (1993)** Model Management Systems: An Overview, *Decision Support Systems*, Vol. 9, No. 3-4, pp. 9-18.

**Bonczek, R.H., C. Holsapple, A.B. Whinston (1981)** *Foundations of Decision Support Systems,* Academic Press, NY.

**Carter, G.M., M.P. Murray, R. Walker and W. Walker (1992)** *Building Organizational Decision Support Systems*, Academic Press.

**Cotterman, W. and K. Kumar (1989)** User Cube: A Taxonomy of End Users, *Communications of the ACM*, 32 (11), Nov.

**deGreef, P., D. Mahling, M. Neerincx, S. Wyatt (1991)** Analysis of Human-Computer Cooperative Work, Technical Report No. 4, Esprit Project 5362, Leiden University.

**DeSanctis, G. and R.B Gallupe (1987)** A Foundation for the Study of Group Decision Support Systems, *Management Science*, Vol. 33, pp. 589-606.

**Edwards, J.S. (1992)** Expert Systems in Management and Administration - Are they really different from Decision Support Systems?, *European Journal of Operational Research*, Vol. 61, pp. 114-121.

**Ellis, C.A and G.J. Nutt (1980)** Office Information Systems and Computer Science, *ACM Computing Surveys*, Vol. 12, No 1, March, pp. 27-60.

**Eom, H., S. Lee and J. Kim (1993)** The Intellectual Structure of Decision Support Systems (1971-1989), *Decision Support Systems*, pp. 19-35.

**Eom, S.B. and S.M. Lee (1990)** Decision Support Systems Applications Research: A Bibliography, *EJOR*, 46, pp. 333-342.

**George, J.F. (1991)** The Conceptualization and Development of Organizational Decision Support Systems, *Journal of Management Information Systems*, 8 (3), pp. 109-125.

**George, J.F., J.F. Nunamaker and J. Valacich (1992)** ODSS: Information Technology for Organizational Change, *Decision Support Systems*, pp. 307-315.

**Gupta, Y.P. and D.C. Chin (1989)** Expert Systems and their applications in Production and Operations Management, *Computers and Operations Research*, 16 (6), 567-582.

**Hatcher, M.E. (1992)** Group Decision Support Systems: Decision Process, Time and Space, *Decision Support Systems,* 8 (2), pp. 83-84.

**Hayes-Roth, F., D.A. Waterman and D.B. Lenat (1983)** *Building Expert Systems*, Addison-Wesley, Massachusetts.

**Holsapple, C. and A.B. Winston (1989)** Knowledge Representation and Processing in Economics and Management, *Computer Science in Economics and Management,* Vol. 2, No 1, pp. 37-48.

**Keen, P.G.W. (1987)** Decision Support Systems: The next decades, *Decision Support Systems*, 3, pp. 253-265.

**Keen, P.W.G., and M.S. Scott-Morton (1978)** *Decision Support Systems: An Organizational Perspective*, Addison-Wesley, Reading, MA.

**Kim, W. (1990)** Object Oriented Databases: Definitions and Research Directions, *IEEE Transactions on Knowledge and Data Engineering*, pp. 327-340.

**Kraemer, K.L. and J.L. King (1988)** Computer-based Systems for Cooperative Work and Group Decision Making, *ACM Computing Surveys*, 20 (2), pp. 115-146.

**Li, Y.P. (1985)** On Data Modelling Through Logic, Research Paper, Graduate School of Management, UCLA, February 8.

**Martz, W.B., D. Vogel, and J.F. Nunamaker (1992)** Electronic Meeting Systems: Reesults from the Field, *Decision Support Systems*, Vol. 8, No 2, pp. 141-158.

**McLeod, P.L. and J.K. Liker (1992)** Electronic Meeting Systems: Evidence from a Low Structure Environment, *Information Systems Research*, 3 (3), pp. 195-223.

**Mentzas, G. (1991)** A Review of Object Orientation and Knowledge Processing in Office Models, *European Journal of Information Systems*, 1 (3), pp. 193-203.

**Mentzas, G. (1993a)** Coordination of Joint Tasks in Organizational Processes, *Journal of Information Technology*, 8, pp. 139-150.

**Mentzas, G. (1993b)** Towards Intelligent Organizational Information Systems, *International Transactions on Operational Research*, forthcoming issue.

**Mentzas, G. (1993c)** Object-based Intelligence in Office and Production Processes: A View on Integration, *Information and Decision Technologies*, forthcoming issue.

**Nierstrasz, O.M. and D. Tsichritzis (1989)** Integrated Office Systems, in W. Kim and F. Lochovsky (ed.): Object-Oriented Concepts, Databases and Applications, ACM Press, Adison-Wesley, New York, pp. 199-215.

**Nunamaker, J. F. (1992)** Organizational Decision Support Systems (ODSS), in E.A. Stohr and B.R. Konsynski (eds) *Information Systems and Decision Processes*, IEEE Computer Society Press.

**Nunamaker, J., D. Vogel and B. Konsynski (1989)** Interaction of Task and Technology to Support Large Groups, *Decision Support Systems*, Vol. 5, No 2, pp. 139-152.

**Nunamaker, J.F., A.R. Dennis, J.S. Valacich, D.R. Vogel and J.F. George (1991)** Electronic Meeting Systems to Support Group Work", *Communications of the ACM*, Vol. 34, pp. 40-61.

**Papazoglou, M.P., S.C. Laufmann and T.K. Selis (1992)** An Organizational Framework for Cooperating Intelligent Information Systems, *International Journal of Intelligent and Cooperative Information Systems*, Vol. 1, No. 1, March, pp. 169-202.

**Parker, B. and G. A Al-Utaibi (1986)** Decision Support Systems: The Reality that Seems Hard to Accept?, *Omega*, Vol. 14, No. 2, pp. 135-143.

**Partridge, D. (1987)** The Scope and Limitations of First Generation Expert Systems, *Future Generation Computer Systems*, Vol. 3, pp. 1-10.

**Pinsonneault, A. and K. Kraemer (1989)** The Impact of Technological Suport on Groups: An Assessment of the Empirical Research, *Decision Support Systems*, Vol 5, No 2, pp. 197-216.

**Rainer, R.K., C. Snyder and H. Watson (1992)** The Evolution of Executive Information System Software, *Decision Support Systems*, pp. 333-341

**Reiter, R. (1985)** Towards a Logical Reconstruction of Relational Database Theory, in Brodie et al (eds) *On Conceptual Modelling*, Springer-Verlag.

**Rockar, J.F. and D.W. De Long (1988)** *Executive Support Systems: The Emergence of Top Management Computer Use*, Dow Jones - Irwin.

**Rockart, J.F. and DeLong (1988)** *Executive Support Systems*, Irwin, Homewood.

**Shaw, M.E. (1981)** *Group Dynamics: The Pychology of Small Group Behavior*, third edition, McGraw Hill, New York.

**Sprague R. H. and Carlson, E. D. (1982)** *Building Effective Decision Support Systems*, Prentice-Hall, NJ.

**Sprague, R.H. (1980)** A Framework for the Development of Decision Support Systems, *MIS Quarterly*, 4, pp. 1-26.

**Teng, J., and K. Ramamurthy (1993)** Group Decision Support Systems: Clarifying the Concept and Establishing a Functional Taxanomy, *INFOR*, 31, No 3, pp. 166-185.

**Turban, E. (1990)** *Decision Support and Expert Systems: Management Support Systems*, MacMillan, New York.

**Turban, E. and D.M. Schaffer (1987)** A Comparative Study of Executive Information Systems, *DSS 87 Transactions*, pp. 139-148.

**Turban, E. and R. Trippi (1989)** The Utilization of Expert Systems in OR/MS, *Omega*, 17 (4), pp. 311-322.

**Watson, H.J. and M.M. Hill (1983)** Decision Support Systems or what didn't happen with MIS, *Interfaces*, 13(5), pp. 81-88.

**Watson, H.J., R.K. Rainer, C. Koh (1991)** Executive Information Systems, *MIS Quarterly*, Vol. 15, No 2, pp. 13-33, March.

**Williams, C. (1986)** Expert Systems, Knowledge Engineering and AI Tools - An Overview, *IEEE Expert*, Winter, pp. 66-70.

**Woods, D.D. and E.M. Roth (1988)** Cognitive Engineering: Human Problem

Solving with Tools, *Human Factors*, 30, pp. 415-430.