Information systems concepts: a guide for executives

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Abstract

Explains that information technology (IT) applications, especially as reinforcer of competitive advantage, has received prodigious attention. Despite a generous coverage of information systems (IS) concepts, there is still a clear communication gap between line managers and IS managers that is harming the gain of strategic advantage. The lack of understanding between line managers and information specialists can create serious conflicts in interpreting corporate goals and strategic objectives. Presents an easy and user-friendly organization of fundamental IS concepts in order to promote a higher level of communication between the two groups and produce a finer alignment of IT strategy and overall corporate strategy.

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Introduction

Modern firms continuously compete to meet customer special needs better and provide higher quality products and services at a lower price. Firms, however, realize that they can better gain competitive advantage if their competition effort is supported by information technology (IT). This is due to the presence of information resources in all activities of product and service management and the role IT plays in enhancing the value of the firm. The emergence of the information resource management (IRM) concept had changed the firm's habits for investing in information resources and had modified the firm's attitude towards its customers and suppliers (McLeod, 1989).

The rapidly increasing body of literature on IT has established that IT significantly affects the value of an organization (Ahituv and Neumann, 1990; Anthony, 1965; McLeod, 1989). Most researchers confirmed that IT can play either a favourable role or an unfavourable role in enhancing the value of a firm depending on how efficient its utilization is (Cheney and Dickson, 1982; Culnan, 1983). Stories of successes and failures of businesses owing to the adoption of IT are well known in the literature (McKeen, 1983; Oravec and Travis, 1992).

Because the computing behaviour of information consumers cannot be fully explained by the way they adopt IT resources, owing to environmental and organizational constraints, those success factors remain fragile in defining efficient management of IT and may not apply for all categories of information consumers. Also, most discussions about the future of organizations emphasize their increased reliance on IT. Even though organizations rely on IT to reduce uncertainty (objective assessment) and equivocality (subjective assessment) associated with their business processes, organizations now recognize that IT may bring new uncertainty and equivocality to the overall organizational profitability (depending on IT effectiveness). That is, organizations have to cope with the riskful role played by the IT and strive to transform it into their advantages by adopting an effective management of IT, and by continuously evaluating the quality of IT based on an outcome approach.

However, the effectiveness of IT in enhancing the value of an organization is contingent

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on management ability to maintain IT resources efficiently. Executives can do so, first, by continuously identifying IT deficiencies, analysing them, and suggesting immediate corrections; and, second, by synthesizing diverse interpretations obtained from various elements of the IT environment (for example, top management, users, suppliers, customers, world class, etc.) that concern the current IT effects on the organization value. This latter point will enable the executive to build cohesiveness, obtain commitment of all participating elements of the IT environment, and hence prevent potential problems (Hough and Duffy, 1987; Sprague and Carlson, 1982).

The main hindrance to this strategic advantage is the gap between line executives who do not understand IT and IT managers/analysts who do not understand business concepts. The lack of communication between line managers and information specialists can create serious conflicts in interpreting corporate goals and strategic objectives. Even though a higher level of understanding and communication between the two groups is needed for an alignment of IT strategy and overall corporate strategy, a partnership between them will certainly enhance the gain of strategic advantage.

It is very important that line managers be aware of and understand the consequential role IT plays in enhancing the value of the firm. Line managers should distinguish among various types of computer-based information systems (CBIS) and understand their respective roles in enhancing competitiveness.

This article presents minimal IS concepts that executives and line managers need to understand well in order to reduce the communication gap with IS managers and systems analysts that is harming the gain of strategic advantage. The article organizes CBIS using three discrimination subsets of attributes:

(1) the epoch and the main conceptual resources characterizing the IT;
(2) task, management, and feature related attributes; and
(3) system development approaches used in making the technology.

Throughout the article, the terms IS and CBIS are used interchangeably.

Taxonomy of CBIS

CBIS evolved through several epochs known by their areas of concentration aiming at specific conceptual resources as employed by various levels of management in their decision processes. The conceptual resources that have been identified with the CBIS epochs are data, information, decision support, productivity, and knowledge (McLeod, 1989).

The conceptual resource that characterized the first epoch of CBIS was data. CBIS related to this data-based epoch were known by two different names: accounting information systems, and (electronic) data processing systems. This type of CBIS is useful for transactional processing (accounting, operational control). That is, a data processing system is a CBIS that gathers data describing the firm's activities and transforms the data into reports that are distributed periodically to users both inside and outside the firm.

The conceptual resource that characterized the second epoch of CBIS was information (McLeod, 1989). CBIS related to this information-based epoch were known as management information systems (MIS). This type of CBIS is concerned with upper and middle management in various functional units of the company. That is, a MIS is a CBIS that makes information available to users with similar needs.

The conceptual resource that characterized the third epoch of CBIS was decision support (McLeod, 1989). CBIS related to this decision support oriented epoch were known as decision support systems (DSS). This type of CBIS is concerned with various decision processes at all managerial levels. That is, a DSS is a CBIS that supports managers in solving semi-structured (sometimes, more unstructured) and non-routine decision problems.

The conceptual resource that characterized the fourth epoch of CBIS was communication or productivity (McLeod, 1989). CBIS related to this communication oriented epoch were known as office information systems (OIS) or office automation (OA). Since communication is the most important function in an office (sometimes, communication accounts for 80 per cent of the functions performed in an office, while data organization and data manipulation share the remaining 20 per cent of office work), office productivity is considerably related to communication. This type of

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CBIS is concerned with clerical and managerial productivity in various offices of the company. That is, an OIS is a CBIS that integrates all profitable formal and informal OA applications concerned with the communication of information to and from persons both inside and outside the firm.

The conceptual resource that characterized the fifth epoch of CBIS was knowledge. CBIS related to this knowledge-based epoch were known as expert systems (ES) or knowledge-based systems (KBS) (McLeod, 1989; Mockler, 1989; Turban, 1988). This kind of CBIS is concerned with artificial intelligence and knowledge resource management. That is, an ES is a CBIS that attempts to represent the knowledge of human experts in the form of heuristics.

There are three types of CBIS that have not been associated directly to one of the epochs or the areas of concentrations presented above. Those management information systems that are concerned with specific functional units are called functional information systems (FIS). Marketing information systems, manufacturing information systems, human resources information systems, and finance information systems are examples of functional information systems.

A second type of management information system that is concerned with strategic planning is executive information system (EIS). When decision support is also added as feature to the EIS, the resulting CBIS is called executive support system (ESS) (Turban, 1988). EIS relate to the second epoch of CBIS evolution. ESS relate to the second and third epochs and process both information and decision support conceptual resources.

A third type of CBIS is called artificial neural network system (ANNS) and it attempts to simulate the biological system of the human brain and exhibits abilities such as generalization, learning, abstraction, and even intuition. ANNS are useful for defining the associations between a subset of input variables (independent variables) and a subset of output variables (dependent variables) without assuming any prior functional relationship between the dependent and independent variables or any probability distributions for the error terms as it is the case in most parametric statistical techniques. ANNS have been used successfully in modelling non-linear statistical relations in a non-parametric manner and have been especially effective when the number of independent variables is very high.

The above taxonomy of CBIS based on their areas of concentration that aim at a specific conceptual resource attempts to assist line managers to differentiate easily among the CBIS, their usages, and their roles in enhancing the value of the company. For instance, if the managerial task is most concerned with one of the conceptual resources (say, decision support) used earlier to distinguish among various CBIS, then the most appropriate CBIS for this very managerial task is that CBIS concerned with the relevant area of concentration (decision support system).

Discrimination parameters for the design of a CBIS

In order to present a second organization of IS concepts to line managers using task, management, and feature related attributes, this article views IT as any internal information provider which supports specific managerial tasks of a given managerial level while satisfying desired computing features specified in an earlier formal user request. ISs are now organized using their task structure, task frequency, managerial level, processing approach, domain scope, justification feature, uncertainty management feature, and learning capability feature.

A managerial task structure parameter takes three values: structured, unstructured, and semi-structured (Culnan, 1983; Leonard-Barton, 1987; Mintzberg *et al.*, 1975). A task is structured when the manager knows the steps and the decision rules required to plan, analyse, and solve the task. A task is unstructured when the manager does not know the steps and the decision rules needed to plan, analyse, and solve the task. A task is semi-structured if it is not fully structured and not fully unstructured.

A managerial task also belongs to an organizational level: low, middle, or top management. Upper management is concerned with strategic planning. Middle management is involved with functional control. Lower management is concerned with operational control.

At the top management level, the literature recognizes three types of IT: DSS, ES (or KBS), and EIS (or ESS). In broad terms, a KBS may be regarded as an ES with a more

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general domain. Both DSS and ES support semi-structured, unstructured, and non-routine decision tasks. In rare occasions, DSS and ES have also been used to support structured decision situations; they are in this case called institutional decision support systems and decision expert systems respectively (Turban, 1988).

This manager should comprehend a DSS as an IT resource that provides information concerning some semi-structured or unstructured and non-routine decision problems. The DSS generates messages that are apprehended by the decision maker, then interpreted and transformed into DSS-based decisions. The DSS does not explain its reasoning; nor does it provide a certainty factor associated with its messages.

In contrast, an ES can deal with less unstructured decision situations and use symbolic processing in addition to computational programming. Furthermore, an ES generates recommendations that do not require managerial interpretations. The ES also explains its reasoning process and assigns certainty factors to its recommendations.

At the functional and operational organizational level we identify functional information systems (marketing, finance, and manufacturing information systems, etc.), OIS, and EDP systems. Functional information systems (FIS) are information systems especially designed for single functional units. Information systems that analyse management information using FIS information are called management information systems (MIS). On the other hand, OIS are those information systems that use electronic and electromechanic devices to organize, transform, and communicate office information in order to enhance managerial and clerical productivity. On the other hand, the EDP term is used, in the literature, to refer to those traditional data processing systems dealing with operational data like accounting information systems and transactional information systems.

There are many other criteria useful in determining the IS that is most appropriate for a given managerial task. These criteria include task frequency, processing approach, domain scope, justification feature, uncertainty management, and learning capability.

The task frequency parameter takes two values: routine and non-routine. A task is a routine one if the task is performed periodically. A non-routine task is one that is not performed periodically.

The processing approach takes two values: numerical processing and symbolic processing. While the objective of numerical processing is to design efficient algorithm-based application procedures, symbolic processing tends to design efficient knowledge representation so that an inference mechanism can automatically generate efficient procedures (Gallagher, 1988).

The domain scope parameter takes two values: specific or general. A decision domain is specific if the problem area is characterized by a limited number of input variables. The decision domain is general if it is not specific.

The justification parameter takes two values: present or absent. A CBIS may or may not possess a justification subsystem that demonstrates the reasoning process that produces system output.

The uncertainty management parameter takes three values: deterministic, probabilistic, or possibilistic. A CBIS may not be capable of processing uncertainty and hence employs deterministic models. A CBIS may be capable of processing uncertainty. Uncertainty may be processed using additive probabilistic models or possibilistic (non-additive probabilistic) models.

The learning capability parameter takes two values: present or absent. A CBIS is capable of learning if it can treat new decision situations.

Table I shows how the CBIS types fit into the design parameters.

Development approaches

When the development process is considered, information specialists view CBIS as traditional or non-traditional. Traditional CBIS apply numerical processing. Non-traditional CBIS employ symbolic processing. Because functional systems specifications of traditional CBIS may be obtained from users, systems requirements may be organized through a top-down decomposition process. A reductionistic approach is therefore appropriate for the development of traditional CBIS (Gallagher, 1988).

The system development life cycle is a sequential process of constructing a CBIS that performs the planning, analysis, design, and implementation of the system prior to its delivery. This process is a reductionistic way

Table I Design parameters versus CBIS types

Design parameters	Types of computer-based information systems DP/AIS	MIS/FIS	DSS/GDSS	OIS	ES/KBS	EIS/ESS	ANN
Epoch	1st	2nd	3rd	4th	5th	3rd	5th
Conceptual resource	Data	Information	Decision support/ communication	Communication	Knowledge	Information and decision support	Knowledge
Task structure	Structured	Structured	Semi-structured	Structured	Unstructured	Unstructured	Unstructured
Task frequency	Routine	Route	Non-routine	Routine	Non-routine	Non-routine	Non-routine
Managerial level	Lower level	Middle level	Middle level	Middle/lower	All levels	Upper level	Upper/middle
Processing approach	Numerical	Numerical	Numerical	Numerical	Symbolic	Numerical	Symbolic
Domain scope	Specific	General	General	General	Specific	General	Specific
Justification feature	Absent	Absent	Absent	Absent	Present	Absent	Absent
Uncertainty management	Deterministic	Deterministic	Probabilistic/ deterministic	Deterministic	Possibilistic	Deterministic/ probabilistic	None
Learning capability	Absent	Absent	Absent	Absent	Present (partially)	Absent	Absent

to adopt the systems approach to CBIS development.

On the other hand, non-traditional CBIS have no functional system specifications. Hence, a top-down decomposition process is impossible. The development of non-traditional CBIS requires a holistic approach that is characterized by a rapid prototyping, short and efficient feedback loop, and a strong proof-of-concept tool (Gallagher, 1988). The reductionistic approach which is based on a detailed functional analysis and characterized by a top-down, structured approach to systems development is not appropriate for non-traditional CBIS.

While prototyping is compulsory in the development of non-traditional CBIS, it is only optional for most of the traditional CBIS. Because prototyping is necessary for developing non- traditional CBIS, users are expected to be continuously and heavily involved until the final version of the system is introduced (Gallagher, 1988). Users are, however, expected to participate strongly in the preliminary study phase and in the testing activities of traditional CBIS.

Table II provides an easy reference for line managers to help them identify the alternative development approaches they can adopt in building a desired CBIS.

Components of CBIS

The subsystems or the main components constituting the system are important determinants of CBIS types. Line managers may express their needs by identifying several components of a CBIS or they may recognize one by its components. The most common components that are usually related to the design of a CBIS are database, knowledge base, inference engine, development engine, reporting software, analytical models, simulation models, user interface, input and output subsystems, integration subsystem, justifier, input and output layers, and hidden layer. Before proceeding further, it is important that these terms are defined.

Table II Development approaches versus CBIS types

Development approaches	Types of computer-based information systems DP/AIS	MIS/FIS	DSS/GDSS	OIS	ES/KBS	EIS/ESS	ANN
Prototyping	No	No	Yes	No	Yes	Yes	Yes
Reductionistic approach	Yes	Yes	Yes	Yes	No	Yes	No
User involvement	Partial	Partial	Partial	Partial	Full	Partial	Full
System development life cycle	Yes	Yes	No	No	No	May be	No
Holistic approach	No	No	No	No	Yes	No	Yes

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- A *database* is a collection of data files, integrated and organized to minimize redundancy, enhance consistency, ease information retrieval, and enforce data independence.
- A *knowledge base* contains facts concerning objects in a specific domain and their relationships. It can also hold concepts, useful procedures, and their associations. It is usually constituted through knowledge elicitation from a human expert.
- An *inference engine* contains practical procedures to search the knowledge base and produce recommendations and solutions to domain problems.
- A *development engine* is a subsystem or a user interface designed to assist the user in developing his/her own CBIS.
- *Reporting software* is a computer program that is incorporated in the CBIS in order to prepare information reports periodically or when exceptions occur.
- An *analytical model* is any mathematical or statistical model used to analyse a business process.
- A *simulation model* is any quantitative model that uses multiple scenarios to anticipate the effects of a potential solution on the business process.
- A *user interface* is a dialogue generation management subsystem or a computer program that organizes the dialogue between a user and a CBIS.
- An *input subsystem* is any function, process, or a CBIS that generates data to the database of CBIS.
- An *output subsystem* is any function or process that extracts specific information from the database of a CBIS.
- An *integrated subsystem* is a module that resolves information conflicts among various output subsystems of a CBIS.
- A *justifier* is a subsystem that explains the CBIS reasoning that produces a system recommendation.
- An *input layer* is the collection of input neurons or the interface through which a neural network receives its input data.
- An *output layer* is the collection of output neurons or the interface through which a neural network generates its output information.
- A *hidden layer* is the collection of neurons used by the neural network to simulate the relationships between input and output patterns.

Most traditional CBIS use databases. If the traditional CBIS provide decision support then a model base is usually expected in the system configuration. An interface is required for any interactive CBIS whether it is traditional or non-traditional. A functional information system is usually equipped with a database, input subsystems which generate data to the database, output subsystems which extract information from the database, and an integration subsystem that plays the role of a moderator who resolves conflicts in output subsystems information. If a non-traditional system has the capability to process knowledge, then a knowledge base and an inference engine will be expected. However, if it utilizes a neural model, then an input layer, an output layer, and one or many hidden layers are usually found in the system design.

DSS are usually equipped with a database, a reporting software, and a model base that consists of analytical and simulation models. While DSS do not provide a justification of their results nor do they give estimates of the levels of confidence associated with their information, ES have justifiers that explain the reasoning that produces the conclusions and provide certainty factors with their recommendations.

Table III provides an easy reference for line managers to know how to associate main system components they need for their business process with various types of CBIS.

Conclusion

The article organized IS applications using their supported managerial level, task attributes, development approaches, and constituting components. Executives can view an IS from four different angles and have a better comprehension of its appropriateness, requirements, construction, usage, and management. The article produced tables summarizing the organization of IS applications with respect to selected discrimination criteria in order to provide easy reference for executives and line managers.

Executives' cognizance of fundamental IS concepts and their appreciation of IS benefits will ease their involvement in the development of IS applications and enhance their communication with IS analysts. In addition to a maximization of IS success, reducing the gap between line managers and IS managers will

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Table III Main system components versus CBIS types

	Types of computer-based information systems						
Main components	**DP/AIS**	**MIS/FIS**	**DSS/GDSS**	**OIS**	**ES/KBS**	**EIS/ESS**	**ANN**
Database	Yes	Yes	Yes	May be	No	Yes	No
Knowledge base	No	No	No	No	Yes	No	No
Inference engine	No	No	No	No	Yes	No	No
Development engine	No	No	May be	No	Yes	No	Yes
Reporting software	May be	Yes	Yes	May be	Yes	Yes	No
Analytical models	No	No	Yes	No	No	Yes	May be
Simulation models	No	No	Yes	No	No	May be	Yes
Justifier	No	No	No	No	Yes	No	No
User interface	No	May be	Yes	No	Yes	Yes	Yes
Input subsystems	No	Yes	No	No	No	May be	No
Output subsystems	No	Yes	No	No	No	May be	No
Integration subsystems	No	Yes	No	No	No	May be	No
Input layer	No	No	No	No	No	No	Yes
Output layer	No	No	No	No	No	No	Yes
Hidden layer	No	No	No	No	No	No	Yes

refine the alignment of IT strategies and overall corporate strategies and consequently boost organizational performance.

The article's organization of IS applications is also very useful in assisting management in their effort of auditing IS effectiveness. While management involvement in IS design, a consequential requirement for IS development, can ease the IS continuous improvement process which is essential to maintain organizational competitive advantages, auditing activities have to be well planned and periodically performed. IS auditing activities can be design-centered, process-centered, or resource-centered, for which Tables I, II, and III are useful, respectively. The principal objective of the auditing process which is established by upper management will determine the auditing approach and the appropriate audit parameters.

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