

: *What is a decision system?*

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A decision system is a collection of information-processing components that interact to make decisions. Decision systems may solely involve people components or may include components like computer-based applications, routines, and technologies. Decision systems have a variety of purposes including making routine decisions, monitoring and controlling processes, and assisting decision makers in semi-structured or unstructured decision situations. This umbrella term includes both decision automation and decision support system technologies and applications. In general, a decision system is a set of interacting people, methods, procedures and routines for making decisions or supporting decision processes. Organizational decisions are made by simple or complex decision systems.

Gerrity (1970), in his Ph.D. dissertation at MIT Sloan School of Management, defined a man-machine decision system (MMDS) “as involving the interaction of three main components: 1. man - the decision maker (one or more); 2. machine - meaning a computer, plus associated information technology necessary to support man-computer interaction; and 3. decision task - the problem, plus related environment and information sources. (p. 11)”

Promotional materials about the *Journal of Decision Systems* (JDS) note “decision systems refer to computer-based applications that can replace (partially or totally) or help individuals or groups in their decision-making tasks, cf., https://www.researchgate.net/journal/1246-0125_Journal_of_Decision_System .

In the business and organization research literature, a complex decision process with multiple decision makers has been described as a decision system. For example, Cyert and March (1963) explained conditions that determined when a decision system is viewed as adaptive. In their analysis, a firm or organization is a decision system. Cyert and March developed two computer models of business decision-making and compared results from the models with actual results. The models had good predictive power.

In the corporate governance literature, a decision system is defined as the system by which corporate decisions are distributed between the annual shareholder meeting, the board of directors and the management. It also covers issues in the corporate charter of relevance for the distribution of control, such as the existence of staggered boards and stocks with differential voting rights, cf. Fama and Jensen, 1983; 1985. Decision systems are hypothesized to influence financial

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performance. For example, separation of control between a team of executives and a board of directors may increase financial performance by mitigating the possibility of self-dealing among the firms' top management.

Ackoff (1967) prescribed analysis of the decision system in designing management information systems. He considered failure to analyze the decision system as a contributing factor in providing misinformation and creating information overload. Pfiffner (1960) argued "the information system and the decision system are interdependent and both are circular and multi-dimensional."

In an influential, ground-breaking conceptual article, J. C. R. Licklider (1960) envisioned a man-computer symbiosis "to enable men and computers to cooperate in making decisions." Licklider explained "one of the main aims of man-computer symbiosis is to bring the computing machine effectively into the formulative parts of technical problems. The other main aim is closely related. It is to bring computing machines effectively into processes of thinking that must go on in 'real time,' time that moves too fast to permit using computers in conventional ways. ... men will handle the very-low-probability situations when such situations do actually arise. ... the computer will serve as a statistical-inference, decision-theory, or game-theory machine to make elementary evaluations of suggested courses of action whenever there is enough basis to support a formal statistical analysis. Finally, it will do as much diagnosis, pattern-matching, and relevance-recognizing as it profitably can, but it will accept a clearly secondary status in those areas."

In a 1963 Engineering Management article, Andrew Vazsonyi used the Program Evaluation and Review Technique (PERT) with an on-line man-machine system to help a manager examine a wide array of alternative solutions. Vazsonyi concluded that with the aid of a special keyboard a user "could direct a computer to execute computer routines whereupon the machine would immediately respond by visually displaying results" and a manager would arrive at a better decision.

In the mid-1960s, actually developing computer-based decision systems became more feasible with technology advances. Miller, Kaplan, and Edwards (1967; 1969) reported evaluations of a computer-assisted decision technique called JUDGE (Judged Utility Decision GENERator) written using the SIMSCRIPT language (Markowitz, Hausner, and Karr, 1962). The JUDGE system was "designed to dispatch aircraft on non-preplanned close air support missions, the number dispatched depending on judgments of target values made by experts at the times when targets appear." The results confirmed the superiority of the computer-assisted decision system, JUDGE, over a conventional system in dispatching close air support missions.

Ferguson and Jones (1969) developed an on-line, real-time, time-sharing model of a job shop so users could explore various combinations of heuristics and programmed decision rules for production planning. In their study, over 300 managers and academicians assumed the role of

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managers and participated in experiments with the prototype system that demonstrated its practicality to aid in decision making and problem solving. Janssen (1970) described and explained a project to develop an information-decision system for bank reserve management. The system integrated a forecasting model and a dynamic programming decision model.

In 1971, Sprague published a conceptual description of a planning model that was central to an integrated computer-based planning system. The planning model used a linear programming algorithm "to optimize 'balance sheet management' decisions within liquidity and capital adequacy constraints."

Another early example of a computer-based decision system is explained by Seaberg and Seaberg (1973). They describe the efforts of Xerox of Canada Limited (XCL) to use time shared models to link the functional areas for communication, planning, and control purposes. "Using the approaches of statistical forecasting, heuristics, and simulation, the XCL Decision System assists and guides management all the way from deriving product demand forecasts to simulating the day-to-day operations of the firm to formulating divisional financial statements to preparing corporate operating and medium-range plans."

Simulation can also help understand decision systems in firms. Bonini (1963) developed a simulation of a hypothetical business firm. The complex and detailed model was programmed in FORTRAN and run on an IBM 7090 computer, a second-generation transistorized scientific computing system. The simulation involved defining decision centers, information centers, and decisions rules. Bonini explains "A decision system is the sum total of all the decision rules in the organization. Thus a specific decision system means a specific set of decision rules (including specified decision parameters) (p. 18)." Bonini specified complex behavioral decision rules for the simulation. The firm in the simulation had three major areas: manufacturing, sales, and an executive committee for planning and control of the whole firm.

Decision systems often involve groups of interacting people. In the 1980s, DeSanctis and Gallupe (1987) extended the boundary of computerized support to include an information-exchange perspective. While traditional DSS were conceived to help individual decision makers, GDSS were targeted at supporting groups of senior management and professional groups to reach consensus in complex group decision making scenarios (Gray, 1987). GDSS technology ranged in complexity from group communication and collaboration features, including option selection functionality, to "sophisticated rule-based systems that enable a group to pursue highly structured and novel decision paths" (DeSanctis and Gallupe, 1987). At that time, GDSS were explored mostly in decision laboratory and experimental environments (Nunamaker et al., 1987). GDSS technology enabled enhanced collaboration across geographically dispersed teams. In the 1990s, the terms computer-mediated communication (CMC) and computer supported cooperative work systems (CSCW) were introduced to characterize technologies used to support group communication in virtual teams and face-to-face group decision making. In the academic literature, GDSS, CMC and

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CSCW are sometimes used interchangeably, and arguably all of these components can be included in decision systems.

Another approach in decision systems for making routine decisions is deploying rule-based knowledge decision systems. A decision automation system (DAS) or automated decision system (ADS) is a rule-based knowledge system that makes a choice among predefined solutions using specified inputs for a specific, repetitive decision task. The rules and analytical, especially predictive, models provide the decision logic for an ADS. In many ADS, forecasting and optimization algorithms provide inputs to rules based upon external inputs. ADS may automate pricing decisions, approve loans, or make stock trades. Newell, Shaw and Simon's (1959) General Problem Solver (GPS-I) was the first useful AI program, cf., Newell and Simon, 1972. Work on the DENDRAL expert system began in 1965, cf., Feigenbaum and Buchanan, 1993. Taylor (2012) explains that Decision Management Systems, unlike Decision Support Systems, are focused on taking or recommending action.

Davenport and Harris (2005) argue "automated decision systems are best suited for decisions that must be made frequently and rapidly, using information that is available electronically. The knowledge and decision criteria used in these systems need to be highly structured, and the factors that must be taken into account must be well understood. If experts can readily codify the decision rules and if high-quality data are available, the conditions are ripe for automating the decision. Bank credit decisions are a good example: They are repetitive, susceptible to uniform criteria and can be made by drawing on the vast supply of consumer credit data that are available." Also, they explain a number of automated decision system technologies including data mining and rule engines -- "Data mining allows people to use sophisticated algorithms and search engines to find patterns and correlations in large, preexisting databases. Rule engines process a series of business rules using conditional statements to solve nonalgorithmic problems."

Bestwick (2016) at Oliver Wyman explains: "Automating decisions is like automating any other business process — you codify a set of rules that create a connection between the data and how the decision gets made. As you see how well the rules work (or not), you fine-tune the process to improve efficiency and accuracy. And you create a feedback loop that constantly analyzes the rules against the results they create to build a self-learning, self-correcting system. Finally, you identify the special cases and exceptions that need special review by the human experts who are best placed to make the most difficult judgement calls."

An example of a modern decision system is credit and loan software. The Kumaran Systems website (<https://kumaran.com>) explains its Credit Decision System banking application. The Credit decision system enables an efficient loan approval process i.e., automated and instant credit decisions based on information provided. The system provides an overview of a credit application that is being assessed and provides many options and helps reach a decision on viability of a credit application. Loan departments in bank and other financial institutions receive many loan applications

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and the credit review process is similar in every institution. "In view of the volume of loan applications there is a need to automate the decision making process." Peldec Decision Systems offers credit management solutions. It offers ProFile, a commercial credit management software that support reviewing, analyzing, collaborating, and decision-making on commercial credit applications by incorporating workflow, document management, account aggregation, risk rating, automated credit write-ups, and relationship management. CRIF Lending Solutions (<https://www.criflendingsolutions.com/>) also provides a Credit Decisioning System, decision analytics, Loan Origination Software, and credit decision system.

A context aware decision system for a smart home is an emerging use of the term decision system in the literature. This computer-based system provides voice control of a home, cf., Chahuara, Portet, and Vacher (2012).

Donovan and Madnick (1977) distinguished among 1) structured decision systems, that assess routine, recurring, well-structured decision situations, 2) institutional DSS, that assess less-structured decisions of a recurring nature, and 3) ad hoc DSS, that assist with unanticipated or non-recurring decisions. They defined the term decision support system (DSS) as a subset of management information systems that truly support decision-making processes. DSS only included ad hoc and institutional applications.

Eom (2004) identified at least 12 terms used in the academic literature that refer to the same or similar computerized systems as those termed decision systems, including the widely used term decision support systems. This article creates a modern context for understanding historical developments in decision systems, including automated decision systems and decision support systems.

In recent years, the interaction of people with computers has become widespread. Also, many decision tasks can be performed by algorithms and computer programs. Decision support has also expanded its reach of applications and range of use. With wireless networks a computerized decision system may be embedded in an Internet of Things (IoT) device, may be part of an Ambient Intelligence (AmI) environment, or may accompany a person who is using a wearable or hand-held device. Also, evidence suggests that certain kinds of human-AI combinations will perform better than humans and AI working alone (Wladawsky-Berger, 2017 quoting Pentland).

A decision system is a general concept for activities and processes that may include no technology to very extensive use of computer-based decision technologies and applications. Computer-based decision tools may make a decision or support decision making as part of a more complex, multi-component decision system.

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Future research related to decision systems can follow many paths from design science for innovative decision system capabilities using quantitative models or machine learning to a wide variety of experimental and descriptive research comparing systems or quantitative models and tools. Qualitative research related to in situ organization man-machine decision systems may lead to development of complex simulations of actual functioning decision systems, cf., Bonini, 1963. Computational organization theory can help understand organization decision systems and decision making. As Bonini (1962) explained there is a need "for a model or framework that the theorist can use to study the effects of information and related organizational factors upon decision-making in the whole firm." More descriptive research and theory related to decision systems (cf., Duncan, 1972; Mintzberg, Raisinghani, & Théorêt, 1976) can improve processes, automation, and augmentation. Smart organizations and effective Human-AI decision system show promise (Wladawsky-Berger, 2017). Overall, more knowledge about and innovation related to decision systems, especially automated decision systems, can help create more productive operations in organizations.

Pentland (2017) asserts "Perhaps the most critical function of any organization or society is its decision systems." Decision systems of various designs have become increasingly important and strategically important.

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