Collaborative Decision-Making: Concepts and Supporting Information and Communication Technology Tools and Systems

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Abstract

Collaboration means in substance that several entities such as humans, computers, robots, enterprises and so on jointly perform a certain task instead of working individually so that a better result could be obtained. Decision-making is a specific form of activity, commonly carried out by human agents, which is meant to eventually select a certain course of action which is expected to result in attaining a desired result. The chapter is meant to present a concise and balanced view of the basic concepts and main classes of supporting information and communication tools and systems regarding decision-making processes carried out by several collaborating human agents called participants. The reasons for collaboration are briefly explained followed by an exposure of collaboration application in the multi-participant decision-making settings. Having presented the classification of decision problems and decision-making units, the main phases of a specific multi-participant form of Herbert Simon's decision process model are described followed by the presentation of two main forms of close and soft collaboration, namely consensus building and crowdsourcing, respectively. The need for technology support offered to collaborating participants is justified and two main classes of decision supporting systems, namely Decision support systems and the ever more largely used platforms, are addressed. A practical example of an open ended and evolving platform is presented. Open questions about the further role the information and communication tools in multi-participant decision-making processes are eventually formulated from two perspectives, digital humanism and dataism, respectively.

Keywords: consensus building, crowdsourcing, DSS, platform.

1 Introduction

Collaboration is defined by the Merriam-Webster Dictionary [1] as performing a "work with another person or group in order to achieve or do something". The dictionary explains that it comes from the late Latin *collaboratus*, that represents the past participle of the verb *collaborare* (to labour together). In many languages, one can notice the saying „Two heads are better than one", which apparently comes from the Holly Bible (*Ecclesiastes 4;9*), together with the explanation "because they have a good return of their toil". In his recommendation of reading old books [2], Clive Stapleton Lewis, an outstanding English scholar, gives an intuitive justification of the above saying. He stated that the saying was true, "not because either [person] is infallible, but because they are unlikely to go wrong in

the same direction" [3]. Of course, the old saying and Lewis' explanation are true only if the persons involved in a collaborative work do not exhibit an irrational behaviour and act seriously and in good faith.

Collaboration is not restricted to the activities that are carried out by two or more persons who prefer to work together instead of individually acting and may involve other types of entities. For example, Herbert Simon, highlighted the advantages of making AI (*Artificial Intelligence*) tools and MS/OR (*Management Sciences/Operations Research*) models 'collaborate' to solve complex problems [4]. Nof et al [5] explain in their book that, beside persons, other entities such as computers, various automation devices, communication means, machines, and so on may be involved in collaboration. As Camarinha-Matos et al [6] notice, there are several levels of collaboration, such as information exchange, harmonization of objectives, sharing resources and responsibilities, and advanced coordination in decision-making and acting. Consequently, a rather broad definition of collaboration is adopted in [7]:

> Collaboration is a specific class of interactions among several entities, such as organizations, humans, and machines that exchange information and knowledge for mutual benefits, harmonize their major goals and objectives and share resources, action plans, and responsibilities to attain the common goals.

According to the purpose of collaboration, Nof et al [8] identifies two subclasses: a) *mandatory* collaboration, when two or more entities must collaborate, because each one working independently cannot deliver the expected output, such as a product, a service, or a decision, and (b) *optional* (or progressive) collaboration in case the entities might start collaborating because all of them aim at improving the quality of their deliverables or/and to achieve higher values for all of them.

The paper is about *collaborative decision-making*, which is a specific subclass of the more general class of collaborative activities and consists in a series of activities that are carried-out by more than one person that compose a *multi-participant decision unit*. The remaining part of the chapter is organized as follows: Next section contains a review of basic aspects of collaborative decision-making concept, such as decision problems, activities involved, collaborative group definition, and the process of adopting and releasing collaborative decisions. The particular cases of *consensus building* and *crowdsourcing* are described. The third section is about the specific information systems designed to support collaborative decision-making tasks. The need for such systems is explained and a formulation of main requirements and functions to be supported by multi-participant DSS (*Decision Support Systems*) are presented. The section also addresses the platforms which are ever more used nowadays and briefly describes an example.

2 Collaborative Decision-Making: Basic Aspects and Special Cases

2.1 Decision problems and participants

A *decision problem* is associated with (a) a perceived or anticipated situation that requires action and (b) several possible courses of action, called *alternatives*. The decision is defined in [9] as "the result of a series of human conscious activities that aim at choosing a course of action with a view to attaining a certain objective (or set of objectives)". It consists in processing information and knowledge by an empowered person or set of persons who have to make the choice and are accountable for the quality of the solution adopted to solve a particular problem or situation. *Making* (solving the decision problem) and *taking* (assuming the solution), releasing, and deploying the decision normally imply allocating the necessary resources such as people, time, information, and supporting technical means. The decision problems and activities can be classified in accordance with several attributes as follows:

- The *pursuit objectives* that may be a) to obtain the result that is optimal in accordance with a single criterion or set of criteria, b) to maintain the supremacy over competitors or to reduce the distance to the leader, c) to mitigate and recover from losses in case of disaster or crisis situations, and d) attaining a mutually accepted settlement in the case of negotiations of the parties who have conflicting objectives;

- The *number of decision units* that take part in decision-making and taking; one can distinguish *individual and multi-participant (collaborative)* units;

- The *number of people* that compose a decision unit; there may be a single person that makes and takes decisions, or there are several people that work together to make and take the decision;

One can identify two subclasses of the more general class of multi-participant decision units as follows:

- *Collectivity*, which is characterized by an episodic composition of the unit and it is commonly met in a) negotiations when the parties typically pursuit different, sometimes conflicting, objectives [10], and b) crisis management situations [11];

- *Collaborative groups* that are characterized by several attributes such as: a) *congruence* of goals and methods of group constituents with respect to the adopted objectives, activities and procedures of the group as a whole, b) *effectiveness* that measures the degree to which the objectives of group are attained, c) *efficiency* to measure the savings individual resources to attain the group goals, d) *cohesion* of group members that are willing and ready for further collaboration [12].

2.2   Multi-participant decision-making

The general model of decision-making activities was proposed by Herbert Simon [13]. It is a process composed of several phases such as: a) intelligence, b) design of alternatives and models, and c) choice of a solution to be released for implementation. A fourth phase, the evaluation of the decision implementation impact and possibly to re-start the process, was later added to model. In collaborative decision-making, the Simon's process model can be adapted to multi-participant settings. A possible model consists in the following phases [14]:

- *Preparation* meant for a) defining the problem characteristic aspects, such as: purpose, the domain, current context, criteria, and possible constraints, and b) empowering the decision unit;

- *Collective understanding* of problem which can be viewed as a natural extension of the preparation phase and consists in activities such as: sharing a common vision of the problem with all the participants and agreeing on how to implement the designed process;

- *Solution generation* meant to identify or design alternatives and applicable models to solve the problem;

- *Negotiation and confrontation* of viewpoints to enable participants to elaborate their contributions and present them in order to win the support of the greatest number of other parties;

- *Decision* for selecting, according to the criteria previously agreed, the ideas which have been voted by most of participants, or which have received the consensus within the group;

- *Monitoring* phase which covers the entire decision-making process so that any problem can be solved in the allocated time period. It includes generating a report on the decision-making process and ensures the implementation of the adopted and assumed solution.

2.3   Collaboration forms and methods

In [15], the following forms of collaboration forms were identified:

- *close* collaboration established among the members of the decision group who exchange information to make and take decisions;

- *asymmetric* or skew collaboration, which is a particular form of the previous one and it is established among the decision takers and their own human support team of assistants or/and hired consultants;

- *soft* collaboration of the decision takers with commonly anonymous members of a crowd. There are several approaches and methods that can be used in collaborative decision-making. Chapter 3 of the monograph dedicated to computer supported collaborate decisions [7] contains a review of the most commonly used methods. Among the methods for aggregating individual preferences, the chapter addresses social choice (including voting mechanisms), its axioms and paradoxes, and several extensions, such as: judgement aggregation, resource allocation, group argumentation, and collaboration engineering.

Consensus mechanism. One of the approaches used in close collaborative decision-making, with or without moderator's support, that has received, from academia cercles, a lot of attention over the last decades is based on *consensus building* [16]. According to Merriam-Webster Dictionary [1], the consensus term means "a general agreement about something: an idea or opinion that is shared by all the people in a group". An example for *consensus* desideratum is a quotation from President Abraham Lincoln, who, before issuing the *Emancipation Proclamation*, wrote in his message to Congress:" We can succeed only by concert. It is not 'can any of us imagine better?' but, 'can we all do better?'" [17]. The process of aggregating participants' individual preferences is composed of two main sub-processes: a) consensus building, and b) selecting a recommended solution [16] [18]. During consensus building, the participants might need to revise their opinions with a view to making them closer to one another in an interactive process, so that an acceptable level of consensus could eventually be reached. The process is viewed as composed, at each iteration, of several activities, such as: a) collecting from each participant his/her individual preference, b) aggregating individual preferences by using one of the available methods c) measuring the consensus level expressed as a distance of individual preferences either to the calculated collective one, or as the result of comparing pairs of preferences, d) implementing a revising scheme for the individual preferences with a view to improving the consensus level based either on identifying the participants whose further contribution to consensus reaching could be neglected or minimizing the number of preference revisions. Other methods based on the fuzzy approach have recently been proposed [19].

Crowdsourcing. There are a few recently reported results concerning *large scale decision-making processes* [20] possibly using AI (*Artificial Intelligence*)–based methods and tools. However, an implicit assumption in many schemes for collaborative decision-making based on consensus building consists in limiting the number of participants involved, so that various methods proposed could be technically applicable. In addition, the expertise of the participants might not be appropriate or sufficient for the faced decision situation, or/and the problems could be too complex, or persistent. In such situations, a larger number of people could provide with the necessary information and knowledge for solving the problem. Such a soft collaboration form can be effective in many domains. A particular form of soft collaboration which has got traction over the last decades is *crowdsourcing*. Howe [21] coined the concept as "the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call". Crowdsourcing means, in substance, that an individual or collective initiating agent (called *crowdsourcer*) does not assign a certain known person or group of persons to work on a specific task, but he/she will hand over the task to the crowd composed of anonymous *crowdworkers* who will complete it. Having carried-out an extensive study of systems that had claimed to support crowdsourcing solutions, Estelles Arolas and González-Ladrón [22] proposed a rather broadly accepted definition as follows:

> Crowdsourcing is a type of participative online activity in which an individual, organization, or company with enough means proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken.

Crowdsourcing is deployed in many various domains and its usage is nowadays facilitated by

the mobile computing [23]. In the particular setting of collaborative decision-making through using crowdsourcing the following steps are carried-out [24] [7]:

- Identification of the decision problem to be solved by using the opinions collected from the crowd, and defining the corresponding task. The activity basically corresponds to the *Intelligence* phase of Simon's process model;

- Broadcasting the task to the crowd, commonly in the form of an open call;

- Idea generation by the crowd members in the form of various action alternatives or/and evaluation criteria. It basically corresponds to the *Design* phase of Simon's process model.

- Evaluation of collected ideas by the same members of the crowd that generated them or by another crowd or limited group of hired experts who may pursue the process of reaching the consensus, as described above;

- Choosing the solution through a voting mechanism or based on expert views [25].

3 Information and Communication Technology for Collaborative Decision-Making

3.1 The need for technology support

The multi-participant decision units, in case they are not supported by technology, may face a series of problems [12] [7] such as: a) *groupthink* caused by an authoritarian leader or a very vocal participant, time or/and external pressure, high homogeneity of the group, when the participants have similar interests, b) cognitive overload caused by excessive interactions, c) the fear for possible negative consequences, d) possible misunderstanding in case the participants possess different cultural or technical backgrounds or speak different native languages, e) high costs or sanitary restrictions to organize the meetings, and so on. At present, all collaboration forms can be enabled and supported by modern I&CT (*Information and Communication Technology*) tools, systems, and platforms. A review of several technologies and tools, such as AI (*Artificial Intelligence*), social networks, Data Science, web technology, mobile and cloud computing, the biometric tools, and serious games, and their relevance for supporting collaborative decision-making can be found in the third chapter of [7]. The MADM/MCDM (*Multi-attribute decision-making/multi-criteria decision-making*) methods [26] [27] and their computerised versions, possibly combined with *AI* and *Big Data* methods and technologies [28], are very useful tools for solving the problems characterized by several aspects to be taken into account.

3.2 Multi-Participant Decision Support Systems

A *decision support system* (DSS) is defined in [9] as "an anthropocentric and evolving information system which is meant to implement the functions of a human support system [the team of assistants and possible external consultants] that would otherwise be necessary to help the decision-maker to overcome his/her limits and constraints that he/she may encounter when trying to solve complex and complicated decision problems that that matter". In the multi-participant setting, in order to overcome the problems that could be encountered by the decision unit as enumerated earlier, the specific subclass of collaborative (or multi-participant) DSS should possess the characteristic attributes of a collaborative [information] systems. The list of attributes includes: a) parallelism, in order to avoid the waiting time of participants who want to intervene by enabling all of them to simultaneously input into the system their ideas and views, b) *anonymity*, so that an idea could be accepted based on its value only no matter the proposer's professional reputation or social position, c) *memory of the group*, to accurately record the ideas and views expressed by individual participants and the solutions that were adopted, d) *unambiguous* and faithful presentation on participants' computer screen of the ideas and views of other attendants of the decision-making process [12]. Practical experience has witnessed that the DSS are continuously evolving under the influence of several factors such as

the changes in business environment, available technology and methods, and developments in users' knowledge, skills, and willingness to use the system [29].

3.3   Platforms

The platforms have been traditionally representing a specific subclass of the more general class of I&CT means used to support various collaborative activities, including multi-participant decision-making, characterized by large numbers of people commonly working in different locations and organized in virtual teams [30]. The platforms are necessary enabling means for carrying out crowdsourcing and *crowdwork*. Nowadays, the pandemic and the associated sanitary restrictions have made the usage of platforms one of the most common styles of work and the *platform economy* is spreading and growing as a wild fire all over the world. When one intends to use crowdsourcing, a decision problem is choosing the most appropriate platform. In the specific setting of collaborative decision-making based on crowdsourcing, a methodology inspired from [31] is proposed in [15] for choosing the platform. The following criteria (and derived subcriteria) are proposed and used to compare several available platforms: a) adequacy to the envisaged applications (informational transparency, accuracy of expected results, robustness to errors and low quality uncertain input data, response time), b) quality of implementation: (scalability, flexibility, functional transparency, documentation completeness), and c) delivery quality (price, service delivery time, provider's general reputation, easy adaptation, degree of independence on the technical assistance from the provider's specialists for implementation and usage).

3.4   Example

iDS (intelligent Decision Support) is a family of platforms developed by Ropardo, a Romanian company located in Sibiu. The family members have been designed over one and half decade with a view to supporting individual as well as multi-participant decision-making activities carried out in universities, local public administration and digital factory milieux [32] [7]. The family comprises a series pf successive versions developed under the influence of three main factors, such as: a) new I&CT tools, b) users' evolving needs and skills, and c) evaluation of results obtained in practical applications. The latest version is characterized by the following aspects: a) usage of web 3.0 technologies and social networks to support collaborative work, b) the possibility to integrate additional third-party modules via API (*Application Program Interface*) together with its own standard set of tools which includes a forum-like discussion list, a voting module, an electronic brain-storming, and c) facilitating asynchronous decisions through web 2.0 clients or dedicated mobile clients.

4   Conclusions

In the chapter, the presentation of collaborative decision-making has been restricted to the process consisting in the interactions among several human agents possibly supported be I&CT tools and systems. At present, one may already notice the availability of *digital cognitive systems* which have evolved from simple information tools to *digital clones* of human advisers, consultants, and even mediators meant to augment human intelligence so that better capabilities and performances could be attained [33]. At the same time, there are initiatives, research efforts, and reported results in AI domain aiming at making the artifacts ever more intelligent and even able to autonomously make decisions and act. Consequently, the result of future developments in I&CT and their impact on human well-being are not too easy to predict [34]. Shall the *Digital humanism* [35] trends prevail and the future possibly augmented humans will take on board, in a recommended service-oriented scheme, the AI based artifacts as collaborators and additional participants in the future decision-making activities, or the people shall become mere data feeders of algorithms as in the *Dataism* anticipations [36]?

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