A voting procedures recommender system for decision-making.

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Abstract. Facilitation is a critical element in decision-making using the tools of new technology. Voting is a tool commonly used in decision making. The choice of a voting procedure is not easy for a novice facilitator. So it is interesting to propose a recommendation system that assists novice facilitators in their voting procedures choice.
There are several voting procedures, some of which are difficult to explain and which can elect different options or alternatives. The best choice is one whose election is easily accepted by the group.
Voting in social choice theory is a widely studied discipline whose principles are often complex and difficult to explain at a decision-making meeting. So, a recommendation system can alleviate the facilitator on his work in finding adequate voting procedure to be applied in a group decision.

Keywords: Recommendation system, Recommender, voting procedures, decision-making, facilitation tools, GRECO,

1 Introduction and Background

Collective decision-making often generates conflict situations due to differences in views and interests of decision-makers about the same set of objects, hence the need for decision-support systems. Making a decision is choosing from a set of alternatives that can solve a problem in a given context (ADLA, 2010)

Group Decision Support Systems (GDSS) are developed to help decision makers and are most often based on computer platforms that provide decision-makers with a formal framework for reflection, and investigative skills to express the preferences and parameters of each, to evaluate them, and to provide the relevant elements for the decision-making.

This type of system consists in offering tools for group decision (KOLFSCHOTEN, et al., 2007). A particular actor stands out in the process of group decision making. This is the facilitator. This actor's role is to support the group decision making. This assistance can be defined not only on the technical level, but also on the content or the decision-making process (BRIGGS, et al., 2010). Among the tasks provided by a facilitator are:

- preparation of the agenda;
- technology integration;
- technical support;
- seeking information;
- coordination of the decision-making meeting;
- recording comments and voting results;
- timing the session duration.

A usual step in these group decision-making processes is to allow each member of the group to vote. There are different voting procedures (BRAMS, et al., 2012) that the facilitator can propose to the decision-makers. These voting procedures do not necessarily lead to the same results, provoking resistance in their acceptances. The difference in voting results depends on several factors such as the method of vote calculation, the voters number, the candidates, number, the votes way presenting.

Our goal with this work is to propose a voting system with recommendation mechanism able suggesting which procedures can be used depending the decision context.

In this paper, we will briefly introduce the recommendation systems and mention some facilitation tools. In addition, we are interested in certain parameters that can influence a voting procedures results. Then our article approaches the voting theory in order to understand the procedures and the different paradoxes that can arise. We will try to understand the design of a recommendation system. As scientific contribution, we will propose a voting recommender system for a facilitator to help him in his task.

2 Related Work

2.1 Recommendation system

Recommendation systems (RS) are software tools and techniques that provide suggestions for articles that are useful to the user (RICCI, et al., 2015). Suggestions focus on various decision-making processes, such as which articles to buy, which music to listen to, which online news to read, which method to choose, etc. They therefore have the potential to support and improve the quality of decisions made by users. There are four main families of recommendation systems:

Collaborative filtering is a method of making automatic predictions about the interests of a user by collecting preferences or taste information from many users. The assumption of the collaborative filtering approach is that if a person A has the same opinion as a person B on an issue, A is more likely to have B's opinion on a

different issue than that of a randomly chosen person. The techniques of this approach are grouped into two subgroups: Memory-based, Model-based. (FELFERNIG, et al., 2006)

Content-based recommendation systems analyze item descriptions to identify items that are of particular interest to the user. This kind of system is composed of three main components: A Content Analyzer, that give us a classification of the items, using some sort of representation, A Profile Learner, that makes a profile that represents each user's preferences and A Filtering Component, that takes all the inputs and generates the list of recommendations for each user. But this method also has disadvantages. To make recommendations in relation to user preferences, the user must be familiar with the system. Thus during the initialization step of the preferences of the user, the system will not be able to make recommendations or these will be irrelevant

Knowledge-based recommenders are a specific type of recommender system that are based on explicit knowledge about the item assortment, user preferences, and recommendation criteria (i.e., which item should be recommended in which context). These systems are applied in scenarios where alternative approaches such as collaborative filtering and content-based filtering cannot be applied.
A major strength of knowledge-based recommender systems is the non-existence of cold-start (ramp-up) problems. A corresponding drawback is a potential knowledge acquisition bottleneck triggered by the need to define recommendation knowledge in an explicit fashion. (BURKE, 2000).

Hybrid recommendation is a combination of content-based, collaborative and Knowledge-based recommendations. The aim is to eliminate the disadvantages of the tree approaches. There are different hybridization designs: Monolithic (exploiting different features), Parallel (use of several systems) and Pipelined (invocation of different systems)

For more details on the recommendation systems I can consult the works (RESNICK, et al., 1997) (JANNACH, et al., 2010) (FELFERNIG, et al., 2006)

2.2 GDSS tools

Facilitation is an important and difficult task in making a decision, so the use of computer tools is advisable. Currently several solutions exist ie **Stormz[1], Mentimeter[2], Sli.do[3], SessionLab[4], Howspace[5],** etc ...

Some offer voting tools that only use plurality as a method of calculating votes. Our approach is to offer a tool with several procedures (such as Condorcet, Borda, etc.) accompanied by a recommendation depending on the context to accompany a facilitator.

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[1] https://stormz.me/en/stormz-application
[2] https://www.mentimeter.com/
[3] https://www.sli.do/
[4] https://www.sessionlab.com/
[5] https://www.howspace.com/

2.3 Voting theory

A voting procedure consists of determining from a method the winner of a vote. This gives voting procedures the character of decision-making tools in a context of social choice; whose purpose is, not only to elect a winner(s) but to build objectively a collective choice (CRAID, 2016). There are several voting procedures that have emerged based on specific situations. In the literature we can group these procedures into two groups namely the non-ranked (Plurality Voting, plurality with Runoff Voting, Approval Voting) and ranked procedures. Ranked procedures can also be divided into two subgroups: Not Condorcet–Consistent (Borda's count, Alternative vote, Coombs' method, Bucklin's method, Range voting, majority Judgement) and Ranked Condorcet–Consistent (Minimax, Dodgson, Nason, Copeland, Black, Kemeny, Schwart, Yong). (FELSENTHAL, et al., 2018). A procedure is called Condorcet-consistent(RCC) if, as soon as there is a Condorcet winner[6] for a profile, the rule designates him as the sole winner of the election. And, it says Not Condorcet–Consistent (RNC), if it can designate other winners besides that of Condorcet. Thus all procedures derived from the Condorcet method are RCC

We designate the set of voting procedures by VP_i

$$VP_i = \{i|\ i \in [Copeland, Borda, Approval \ldots . MJ]\ \}$$

All these procedures have shown their limit in a given situation, called paradox in the voting theory (NURMI, 2012) (FELSENTHAL, et al., 2018). We define the "voting paradox" as an undesirable result that a voting procedure may produce and which may at first glance be seen, at least by some people, as surprising or counterintuitive. These paradoxes have been well studied for decades. The conclusions reached by its various studies have allowed to distinguish between two types of voting paradoxes associated with a given voting procedure: 'Simple or Straightforward' paradoxes and 'Conditional' paradoxes.

Relevant data that may influence the results of a vote are: the number of voters, the number of candidates, the number of candidates that must be elected, the preference ordering of every voter among the competing candidates, the amount of information voters have regarding all other voters‘ preference orderings, the order in which voters cast their votes if it is not simultaneous, the order in which candidates are voted upon if candidates are not voted upon simultaneously, whether voting is open or secret, and the manner in which ties are to be broken (NURMI, 2012).

The five best–known ‘simple ‘paradoxes that may afflict voting procedures designed to elect one out of two or more candidates are the following: Condorcet Winner, Absolute Majority Winner, Condorcet Loser or Borda Paradox, Absolute Majori-

[6] http://www.whydomath.org/node/voting/impossible.html

ty Loser, Pareto (or Dominated Candidate). for more information, see (FELSENTHAL, et al., 2018) (CHENG, et al., 2012).

As conditional paradoxes that can influence the results of a voting procedure we can quote: Additional Support (or Lack of Monotonicity or Negative Responsiveness), Reinforcement (or Inconsistency or Multiple Districts), Truncation, no–Show, Twin, Violation of the Subset Choice Condition (SCC), Preference Inversion, Dependence on Order of Voting (DOV) see (FELSENTHAL, et al., 2018) (NURMI, 2012) for more information.

We designate the set of paradoxes by Pdx_j,

where $Pdx_j = \{j \mid j \in [Condorcet\ winner, .. DOV]\}$

3 GRECO (Group vote RECOmmendation)

Our goal is to provide a hybrid recommendation engine, using voting procedures characterization for the content based approach. After also doing collaborative filtering when the information will grow. As shown in the following ***Figure1*** (Inspired by work (JANNACH, et al., 2010))

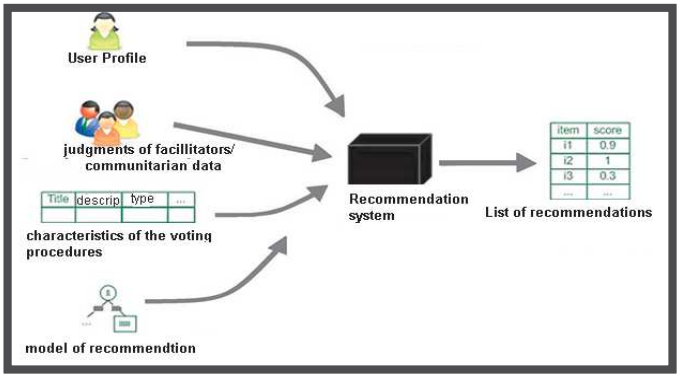

***Figure 1**: GRECO recommendation logic*

Currently, we have implemented voting procedures such as Borda, Condorcet, plurality, Black and Copeland methods.

3.1 Characterization of voting procedures

Based on the characterization of voting procedures on the following work (SUITT, et al., 2014), (NURMI, 2012), (DURAND, 2000) (KONCZAK, et al., 2005) (FELSENTHAL, et al., 2018), and taking into account that our system aims at a reduced work group environment, we have established a matrix characteristic of the implemented procedures. For a small group, we have established the following crite-

ria: $C1$: Condorcet Winner Criterion, $C2$: Absolute Majority Criterion, $C3$: Pareto Criterion, $C4$: Loser Criterion, $C5$: Participation Criterion, $C6$: Monotony Criterion, $C7$: Coherence Criterion.

Thus, we obtain the following characterization matrix

Characteristic→ Procedures	Type	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Plurality	RNC	1	2	0	2	0	0	0
Borda	RNC	1	2	0	0	0	0	0
Condorcet	RCC	1	0	0	0	1	0	1
Black	RCC	0	0	0	0	1	0	1
Copeland	RCC	0	0	0	0	1	0	1

***Table 1**: voting procedures characterization matrix: M_P*

Considering the following scoring scale, 0: the criterion does not affect the voting procedure, 1: the criterion affects the voting procedure and 2: the criterion has a significant impact on the procedure.

3.2 Voting procedures scoring

In GRECO, as feedback, the facilitator has the possibility to assign or evaluate the voting procedures used in a decision making process. They can use the following ratings.

Rating	Poor	Not enough	Fair	Satisfying	Good	great
Note	0	1	2	3	4	5

***Table 2** : Rating scale*

We have the following scenarios for scoring the different voting procedures:

Scenarios 1: The facilitator may decide to apply a given procedure, i.e. manual selection. This choice implies that the procedure is known and appreciated by the facilitator. If the facilitator confirms his choice, the system assigns a **'Good'** rating to the chosen procedure. This mechanism allows the system to avoid the start-up problem in issuing recommendations known as 'Cold-Start'.

Scenario 2: The system can automatically propose to the facilitator a list of voting procedures to be applied. If the facilitator confirms his choice, the system assigns a 'Good' rating to the chosen procedure.

Scenario 3: After a voting procedure has been applied in a given context, participants in decision-making can address the group's overall level of satisfaction to the facilitator. This makes it possible to note the procedure used. This note is very critical and important because it comes from the group of decision-makers.

The various facilitators' notes make it possible to draw up an M_n matrix, containing voting procedures scoring as shown in ***Table 3***.

Procedure→ Facilitator	$Borda$	$Condorcet$	$Black$	$Pluralité$	$Copeland$
Fac_1	5	5		3	
Fac_2			3		5
Fac_3		4			
.....					
Fac_n	3				4

Table 3: *M_n, voting procedure scoring matrix*

3.3 GRECO's Content-based implementation algorithm

We used the Django framework to develop our solution. This framework is based on python and closes libraries such as Pandas[7], nump[8], scipy[9] which facilitate the implementation of the various desired functionalities. The following algorithm explains the draft of our content-based recommendation.

Algorithm

Data: M_P: Voting procedures characterization matrix

M_n : Voting procedures scoring matrix

Begin

1. build a user profile based on the voting procedures already used in past meetings using M_P and M_n
   1.1-Center the score matrix to get $M_c \leftarrow M_n$
   1.2 Calculation of the coordinates for each characteristic
2. search for the k voting procedure profiles most similar to the user profile
   2.1- Index each voting procedure by its characteristics
   2.2- Look for the **k** profiles of the voting procedures most similar to the user profile using the vector model (Cosine similarity[10])

End

[7] https://pandas.pydata.org/

[8] http://www.numpy.org/

[9] https://www.scipy.org/

[10] https://en.wikipedia.org/wiki/Cosine_similarity

3.4 Using Greco: Practical test

An example will allow us to discover the current state of GREO. For example, a committee of five (5) decision-makers wants to choose a place to celebrate the annual board of directors. Tree (3) hotels (Azalaï, Grand Micasa, Radison Blu) have been proposed. The meeting used GRECO to determine the elected hotel according to the table containing the preferences issued by the committee.

Nb DM→	**2**	**2**	**1**
Rank	Radison Blu	Grand Micasa	Radison Blu
	Azalaï	Azalaï	Grand Micasa
	Grand Micasa	Radison Blu	Azalaï

***Table 4**: Voters preferences*

The vote creation on GRECO is done in three essential steps:

Step 1: Vote creating (see ***Figure 2***)

a. All the basic information of the vote is provided: title, description, start and end dates of the vote and status.
b. The different candidates from the list of alternatives proposed during the meeting are added.
c. The voters who are participating in the meeting are designated and click on the button "Create the vote".

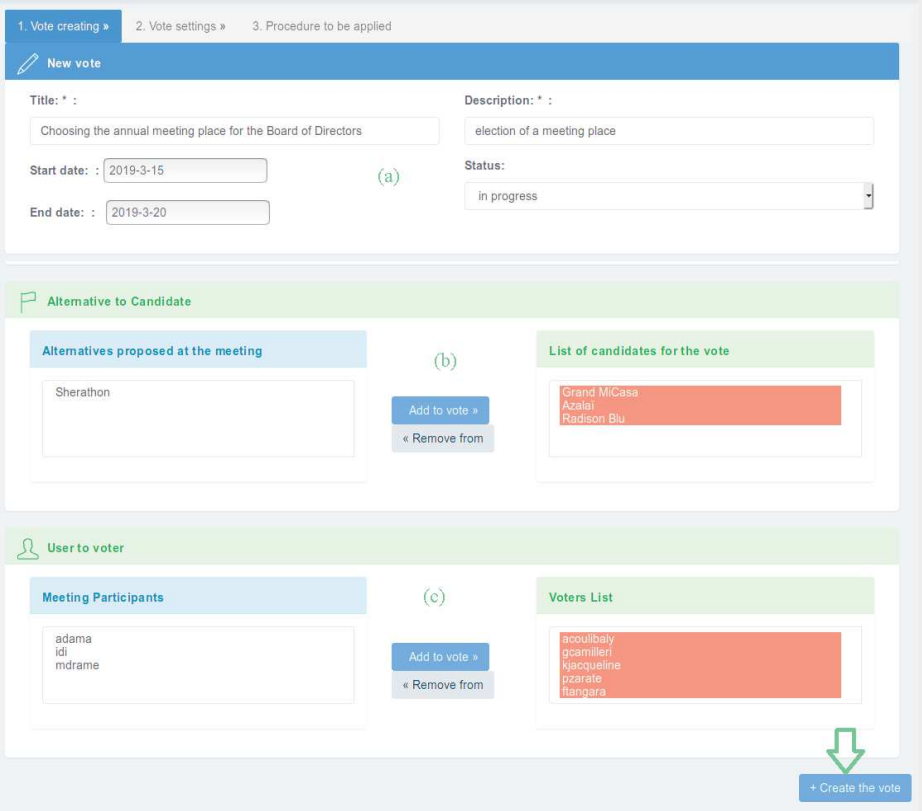

***Figure 2:** Vote creating*

Step 2: Vote settings (See ***Figure 3***)

a. We continue with a summary of the voting data during the creation process. (voting data)

b. The parameters for the recommendation are defined:
The type of procedure which is a list composed of three values (no matter, Condorcet-Consistent and Not Condorcet -Consistent). This parameter allows us to define the rank of similarity search for recommendation result. In this example, we chose 'Condorcet-Consistent'.
The parameter of choice methods takes two possible values (automatic or manual) and allows to refine the result of our recommendation because the similarity can give us a list of procedures corresponding to the user's profile. In this example we choose 'Automatic'

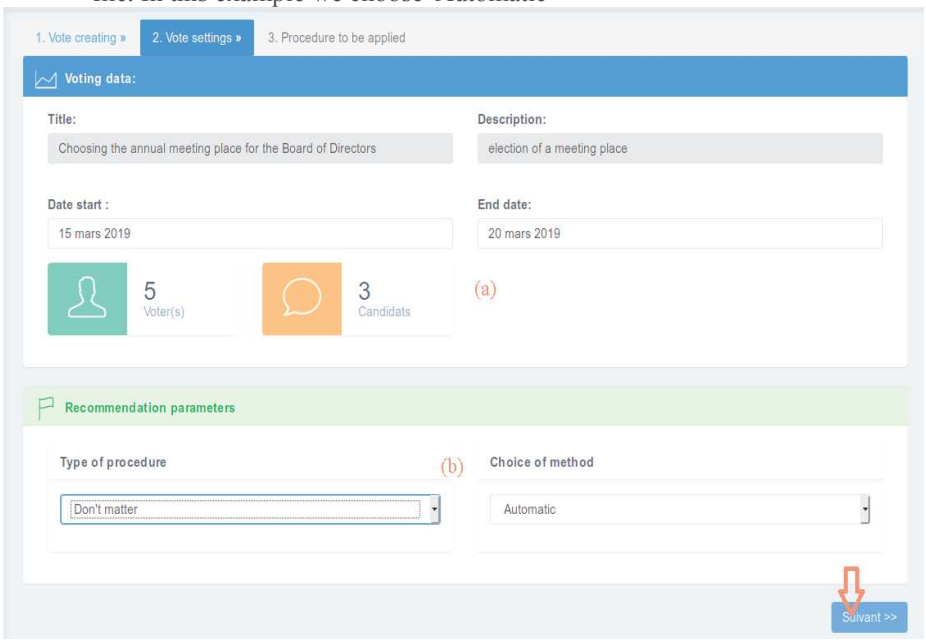

Figure 3: *Voting setting: Recommendation parameters*

Step3: choosing procedure to be applied:

This is the final step in creating the vote. It confirms the recommended procedure by associating it with the vote being created. In this example the recommendation suggested the Condorcet procedure. The "Finish" button allows you to finalize the voting creation process.

Once the vote has been created, all voters can participate by making their preference list as shown in ***table 4.***

Finally, the ***Figure 4*** shows the voting result using the Condorcet procedure, and the candidate hotel '*Radison Blu'* is the winner.

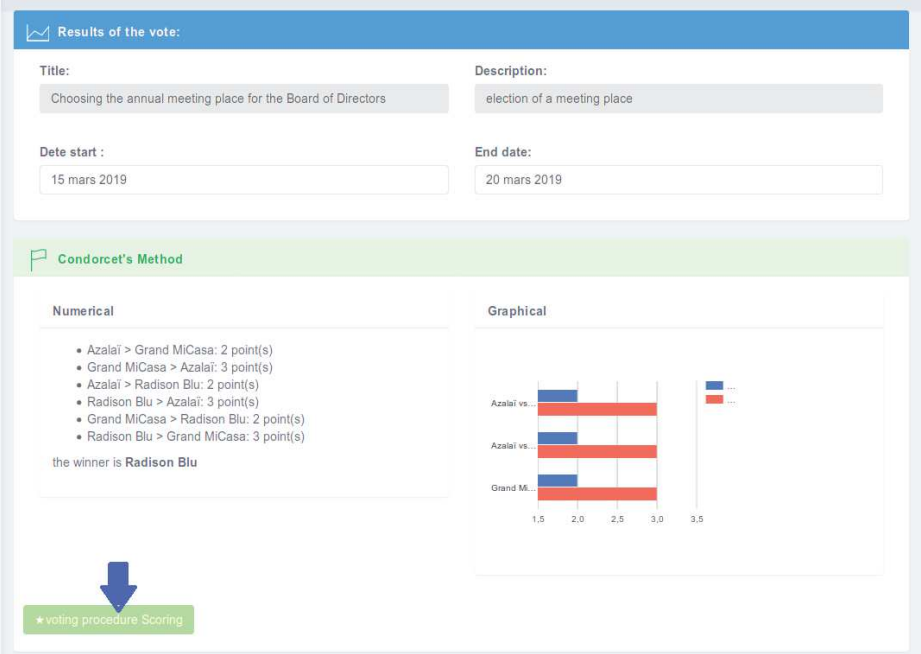

***Figure 4**: Voting result*

By clicking on the ***"voting procedure scoring***" button, the facilitator can express the level of satisfaction of participants in the decision-making process with the voting procedure used by entering one note and a comment as shown in ***Figure 5***.

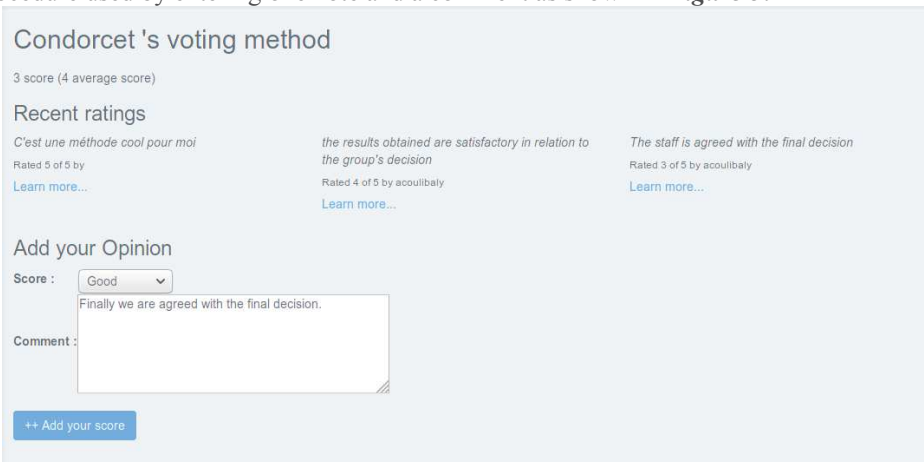

***Figure 5:** Voting procedure scoring*

4 CONCLUSIONS

With the use of new technologies, the role of a facilitator is crucial in decision-making. There are few tools that can recommend voting procedures in a decision-making meeting. **GRECO** comes to fill one this rarity. At current state, Condorcet, Borda, Black, plurality, Copeland voting procedures are implemented in **GRECO.**

We can conclude that the voting procedures the paradoxes and recommender system operations, especially hybrid approach, allowed us to build our solution proposal. As future work, we continued to improve the part of collaborative filtering that requires usage information in the system.

We are planning additions to other methods to have a lot of possibilities at the time of the recommendation. We recommend doing several tests to validate the results of our recommendation system.

Our recommendation engine is based essentially on the relationships that exist between the voting procedures and the mentioned paradoxes, some of which are circumstantial. In perceptive, we propose to do a study showing a ranking of the importance of their influence in the voting results. This will make it possible to reduce the number of variables in the similarity calculations thus making the recommendation faster.

References

ADLA, Abdelkader. 2010. *Aide à la Facilitation pour une prise de Décision Collective : Proposition d'un Modèle et d'un Outil.* Université de Toulouse. Toulouse : Thèse doctorat, 2010.

AGGARWAL, Charu C. 2016. Recommender Systems: The Textbook. *Springer.* 2016.

BENOUARET, Idir. 2017. Un système de recommandation contextuel et composite pour la visite personnalisée de sites culturels. 2017.

BRAMS, Steven J. and KILGOUR, D. Marc. 2012. Narrowing the field in elections: the next-two rule. 2012, Vol. 24, 4, pp. 507-525.

BRIGGS, Robert O., KOLFSCHOTEN, Gwendolyn L. and DE VREEDE, Gert-Jan. 2010. Facilitator in a Box: Computer Assisted Collaboration Engineering and Process Support Systems for Rapid Development of Collaborative Applications for High-Value Tasks. 2010.

BURKE, Robin. 2000. Knowledge-based Recommender Systems. *Encyclopedia of library and information systems.* 2000, Vol. 69, 32, pp. 180-200.

CHENG, Kung-E and DEEK, Fadi P. 2012. Voting tools in group decision support systems: theory and implementation. 2012, Vol. 12, 1.

CRAID, Gordon. 2016. «Si la tendance se maintient... le théorème d'Arrow, les mathématiques et les élections». 2016, Vol. LVI, 3, pp. 11-26.

FELFERNIG, Alexander, FRIEDRICH, Gerhard and JANNACH, Dietmar. 2006. An integrated environment for the development of knowledge-based recommender applications. *International Journal of Electronic Commerce.* 2006, Vol. 11, 2, pp. 11-34.

FELSENTHAL, Dan S. and NURMI, Hannu. 2018. *Voting Procedures for Electing a Single Candidate - Proving Their (In)Vulnerability to Various Voting Paradoxes.* s.l. : Springer, 2018.

FOMBA, Soumana. 2018. *Décision Multicritère: Un système de recommandation pour le choix de l'operateur d'agregation.* Toulouse : s.n., 2018.

FOMBA, Soumana, et al. 2017. A Recommender System Based on Multi-Criteria Aggregation. 2017.

JANNACH, Dietmar, ZANKER, Markus and FELFERNIG, Alexander. 2010. Recommender systems: an introduction. *Cambridge University.* 2010.

KOLFSCHOTEN, Gwendolyn L, DEN HENGST-BRUGGELING, Mariëlle and DE VREEDE, Gert-Jan. 2007. Issues in the Design of Facilitated Collaboration. 2007, Vol. 16, pp. 347-361.

NURMI, Hannu. 2012. On the Relevance of Theoretical Results to Voting. *Electoral systems.* Springer, 2012, pp. 255-274.

RESNICK, Paul and VARIAN, Hal R. 1997. Recommender systems. *Communications of the ACM.* 1997, Vol. 40, 3, pp. 56-59.

RICCI, Francesco, ROKACH, Lior and SHAPIRA, Bracha. 2015. Recommender systems: introduction and challenges. *Recommender systems handbook.* springer, 2015, pp. 1-34.