Fuzzy Management of Participation in Organizations

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Abstract

The Fuzzy Model for Management of Participation in Organizations (FMPO), pretends to be an evolution of the Normative Vroom-Yetton Model (NVYM). It adopts the same decision processes for group problems (AI, AII, CI, CII and GII), and several of the problem attributes defined by Vroom and Jago in the NVYM.

However, there are important differences between NVYM and FMPO philosophies. While the former relies exclusively on linear mathematical equations to evaluate the different decision processes, the later is a fuzzy knowledge based system, with which is possible to express the principles announced by Vroom and Jago´s leadership theory of participation to a greater extent.

FMPO´s philosophy also allows us to spread the model towards more complex fields, which the NVYM ignores or only slightly mentions. The FMPO evaluates the different processes using time and duration criteria, estimates the probability of consulting the subordinates and the probability of convening and conducting a meeting according to possible time constraints, and extends the cost criteria to a level not reached by the NVYM.

Finally, a mention to the fact that unlike the NVYM, FMPO´s output differentiates the decision processes' effectiveness on a qualitative and quantitative basis that can be used to compare different situations.

Keywords: *Decision making; Decision process; Participation; Problem attributes; Fuzzy rules; Fuzzy modeling; Fuzzy sets.*

1. Introduction

In 1973, Vroom and Yetton published a model of leadership that concentrated on the aspects of power sharing by leaders and of participation and influence by those who work with them [1]. In its theory, each problem or decision was thought to represent a distinctive combination of characteristics (situation) that ought to influence the leader's choice of leadership style.

The core of the model was a method for choosing among five decision processes ranging from the autocratic leader decision, to a group meeting with the subordinates in which the decision is the result of a consensus.

The model was (is) quite successful but had its limitations. These limitations led to the development by Vroom and Jago of an ambitious normative model (NVYM) in the mid 80´s [2].

The core of the NVYM is a set of linear mathematical equations which allow the estimation of the relative effectiveness of the five degrees of participation.

Although this method allowed an extension of the possibilities of the first model, a mathematical analysis of the NVYM in [3] showed a few limitations and inaccuracies. This limitations are essentially due to the extreme difficulty of modelling human knowledge with linear mathematical equations. As a result, the NVYM does not follows the principles of Vroom and Yetton´s theory in certain less common situations. However, the biggest problem of the NVYM is the attempt to model the cost and duration of the decision processes. The approach is too simple and quite incorrect, and its effect is often the corruption of the results of the model.

The objective of this work was the development of a fuzzy model that satisfies Vroom´s leadership theory principles and profits from the advances in computer and communication technologies. The model and its integration in a decision support system assumed the existence of these new technologies in organisations allowing the inclusion of mechanisms to estimate the decision processes duration.

The utilisation of a fuzzy rule based system allowed a better definition of the inputs and outputs and a natural modelling of expert knowledge.

2. Decision Processes

The FMPO uses the set of five alternative decision processes for group problems defined in [2]:

AI - Autocratic decision. The leader decides alone.

AII - The leader obtains any necessary information from subordinates (individually), then makes the decision. The subordinates do not provide or evaluate alternative solutions.

CI - Individual consultation. The leader consults each subordinate individually, then makes the decision.

CII - Consultation within a group. The leader shares the problem with the subordinates in a group meeting, then makes the decision.

GII - Consensus. The leader shares the problem with the subordinates in a group meeting. The group agrees on a solution and makes the decision.

3. Inputs

The FMPO uses 16 fuzzy inputs to define each situation (problem attributes). Ten of the inputs are similar to the ones used by the NVYM: **LI** - Leader Information; **SI** - Subordinate Information; **ST** - Problem Structure; **CO** - Conflict; **GC** - Goal Congruence; **CP** - Commitment Probability; **GD** - Geographical Dispersion; **QR** - Quality Requirement; **CR** - Commitment Requirement. Six, are new, and necessary in order to cope with FMPO new objectives: **DL** - Deadline; **CD** - Consultation duration; **Gcost** - Geographical Cost; **LRC** - Leader Relative Cost; **GRC** - Global Relative Cost; **CI** - Cost Importance; **UI** - Urgency Importance.

Gcost is an estimation of the costs of convening a meeting. It might consider travel expenses, or the costs of videoconference equipment, etc. Its value depends on organization resources and the importance of the decision. For a large organization, paying for 5 aeroplane tickets might be acceptable, but for a small organization GC could be Very_High.

GRC and LRC refer to the effective cost of leader and subordinates. If they are involved in other important activities, then their GRC or LRC could be Very_High. If they have a free agenda, it would be Low…GRC refers to both leader and subordinates.

CI indicates how important is to minimise the decision making process cost. UI defines how important is to make the decision as soon as possible.

Each input can assume a continuous value between 0 and 100 and is associated with several linguistic terms.

4. Outputs

The system gives the following outputs: the evaluation of each decision process (final and intermediate); the possibility of utilisation of consultation and group processes (if there is a deadline); an estimation of the duration of CII and GII.

The FMPO evaluates each decision process on a qualitative basis ranging from Very_Bad to Very_Good according to the situation. Unlike the NVYM, the FMPO allows an absolute evaluation of each decision process. The results of the NVYM are always relative to the situation: a higher output on a given situation does not mean that we should expect better results than with a lower output on a different situation. On the FMPO, a decision process that is evaluated as Good, should conduct to better results than a process evaluated as Average/Good on a different situation.

The answers of the FMPO to the possibility of consulting and/or convening a meeting with the subordinates, range from Yes to No, with several degrees of Maybe.

The system expresses the estimation of the duration of a decision process as an imprecise time interval. Examples of possible results are: *About 2 days, 2-3 hours, Almost a week,* etc.

5. Structure of the FMPO

The FMPO consists of six large subsystems. Four of them evaluate each decision process according to a criteria: Quality, Commitment, Urgency and Cost. The fifth subsystem deals with the problem of estimating the duration of the decision processes according to the situation, in order to evaluate their cost and possibility of application. The last subsystem joins the information from each criteria and produces the final decision, i.e., an evaluation of each decision process for the given situation. Figure 1 represents the structure of the FMPO.

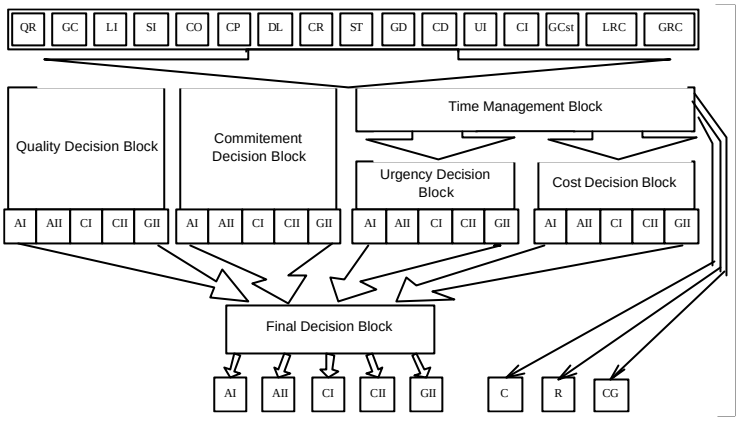

Figure 1 - FMPO structure

In figure 2 and figure 3 we can see the inputs and outputs of each subsystem and the interaction among them. Each subsystem contains at least one Fuzzy RuleBase that only uses the pertinent inputs.

Some rulebases are subdivided internally in order to reduce the complexity of the problem and the number of necessary rules. This subdivision is possible due to the relation between inputs: some inputs depend on one or more other inputs, but others are independent.

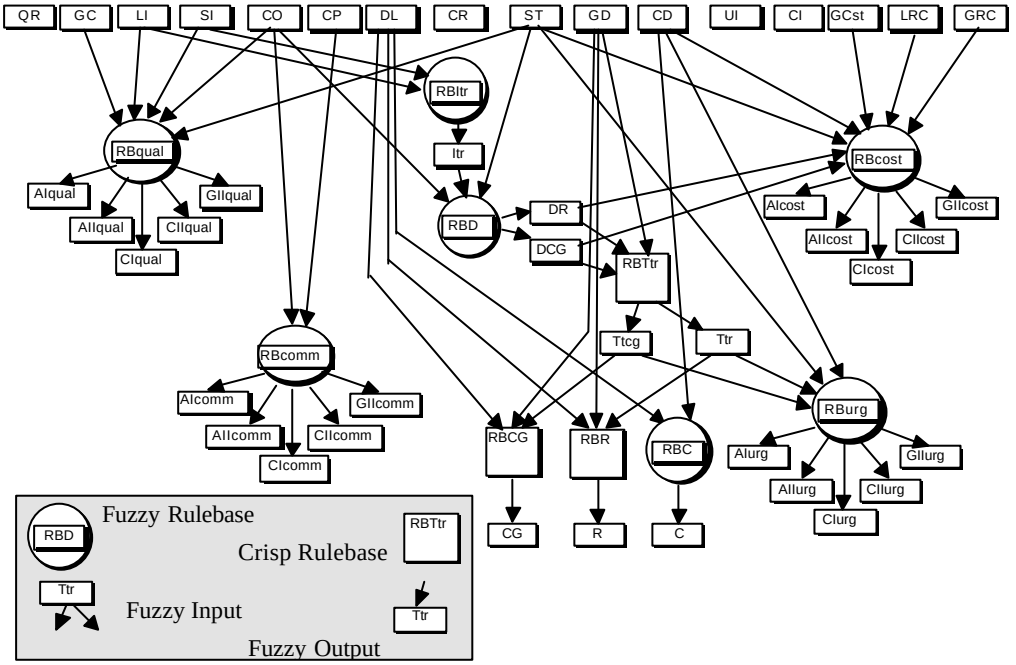

Figure 2 - FMPO, Block diagram

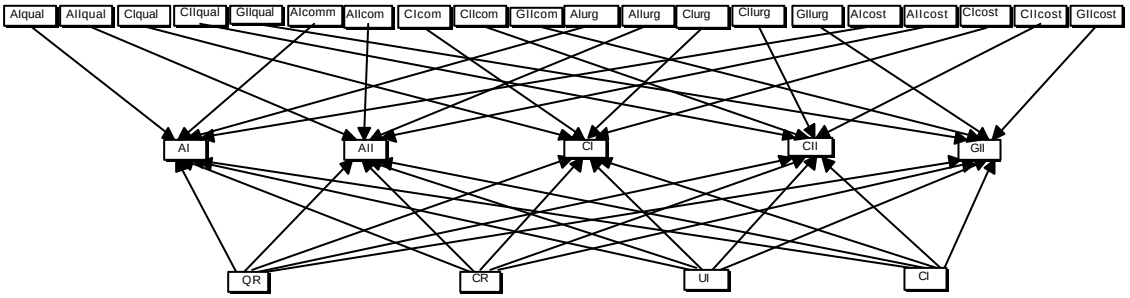

Figure 3 - FMPO, Final Decision

In [2], Vroom and Jago analyse the importance of each input for each criteria, and present linguistic rules that express the relationship among inputs. However, the independence of several inputs is often overrated, probably due to the

difficulty of expressing this relations in mathematical equations. For instance, the NVYM considers LI and SI independent (in Decision Quality), but the knowledge that LI is High is not sufficient to say which of the decision processes is better. If I know that LI is High, and SI is Low, then I can say that CIIqual will be probably better than GIIqual. Each rule in the FMPO includes one or more inputs according to its relation with other inputs. The explicit inclusion of relationships among dependent variables, improved the flexibility of the FMPO, allowing it to adapt to rather uncommon situations.

Usually, a rulebase has several independent groups of rules. Associated with each group is a weight that defines its importance in the criteria.

Figure 4 represents RBqual. It has two groups of independent inputs - LI/SI (weight = 100) and GC/CO(w = 70), each with 25 rules, and 4 rules involving ST and other inputs (w = 40).

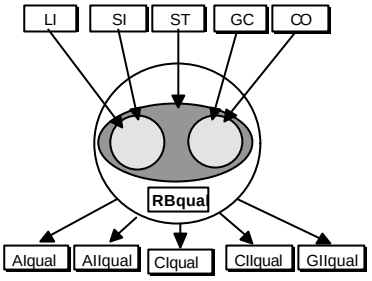

Figure 4Decision Quality Rulebase

Usually a rule has the following structure:

If *LI* **is** *High* **and** *SI* **is** *Low* **and** *ST* **is** (*PN* **or** *No*) **Then**

AIqual **is** *Bad*, *AIIqual* **is** *Acceptable*, *CIqual* **is** *Very_Good*, *CIIqual* **is** *Good*, *GIIqual* **is** *Bad*

The current version of the FMPO uses 386 fuzzy rules and 12 crisp rules to evaluate a situation.

6. Estimating the Duration of Decision Processes. Integration of the FMPO in a Decision Support System

A more participative process does not last necessarily longer than a less participative one. In certain situations it's faster to convoke a meeting and make a decision with all subordinates, than to consult each subordinate individually. If the leader's knowledge is very low, and the problem is complex, it's probably faster to collect information with the subordinates, than to make an autocratic decision. The duration of each process depends highly on the situation.

The FMPO assumes the use of new technologies available in organizations to estimate the duration of group decision processes. In a near future, an organization will be able to guarantee the permanent availability of any subordinate (anywhere, anytime) for consulting, trough the use of cellular phones, laptop computers and a way to exchange documents (Fax, e-mail, etc.). The use of office automation software and electronic planners will allow the immediate access to the agendas, location and availability of subordinates. The expansion of the Internet and WWW, and the use of databases and search engines will allow us to know how much time will be necessary for a subordinate to reach a place where he can participate on a group decision (GD is the time necessary to guarantee the presence of all subordinates). The subordinate doesn't need to be physically present. The meeting can use videoconference equipment or a computer network. The estimation will always be inaccurate, since factors like aeroplane delays are always unforeseeable and unexpected.

The necessary time to make a group decision includes the time to convene and start the meeting (GD), and the time to effectively make the decision (the duration of the meeting). The FMPO estimates the duration of a meeting according to the situation. It considers the structure of the problem, leader and subordinate's knowledge and experience with similar situations, and the existence of possible conflicts. It assumes that the organization has access to means of dealing with meetings with a large number of participants (special equipped rooms, specialists in meeting conduction,...) in order to diminish the importance of this factor in the duration of the meeting. The estimated duration for the meeting ranges from half hour to 1 week.

The Time Management Subsystem and the model for the integration of the FMPO in a decision support system details are available in [4] and [5]

7. Simulation Results and Conclusions

The application of the FMPO and the NVYM to the case studies presented in [2], reveals similar behaviours for their common criteria, Quality and Commitment[1]. Figure 5 shows the results of both systems for the New machines decision problem.

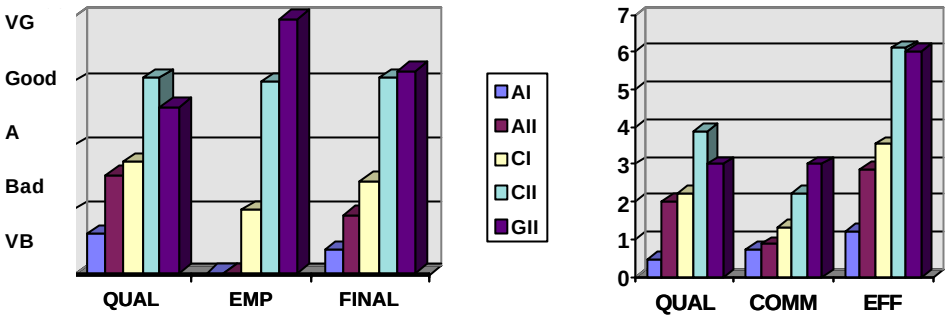

Figure 5 - New machines decision problem. FMPO and NMVY results

This similarity of behaviours in cases that were used to validate the NVYM can be used to validate the FMPO. There are minor differences in the results which are justified by the differences in philosophy followed in the implementation of the rules. It's quite easy to alter the rules in order to follow Vroom´s ideas faithfully. It's even possible, and quite easy due to the nature of the model, to adapt the rules to different styles of leadership. This possibilities are obviously not present in the NVYM. It is impossible to reproduce FMPO´s current philosophy using linear mathematical equations.

The NMVY is a tested and valid model in a large number of situations. However, it's not difficult to find certain situations in which its behaviour it's not completely satisfying. For instance, the NMVY ignores certain important inputs (like ST and CO) when LI is very high; or, it ignores GC when conflict is absent. Once again, it would be quite difficult to modify and adapt the NMVY to every situation. FMPO´s simulation results shows that its fuzzy rule based system copes quite well in odd situations [4].

The Time Management subsystem exhibits the intended behaviour. The estimation of the duration of the most participative processes is situation dependent and the results are quite promising, although extensive field test results are not yet available. Given enough real-life data, optimisation of the model is possible, expected, and not a difficult task, due to model nature and internal architecture.

In the NVYM, cost evaluation depends heavily on the assumption that most participative processes are longer, which is not always correct. In the FMPO, Cost and Urgency subsystems results are quite dependent of Time Management outputs. FMPO also includes a better characterisation of the situation in these criteria. Assuming that Time management outputs are valid, Urgency and Cost become useful criteria in decision process evaluation.

The application of both models to certain particular situations, shows that FMPO results are more reliable. NMVY´s time penalty (Dtp), and Dcost can invalidate other criteria evaluation. [4] presents some examples of these not so uncommon situations.

Detailed simulation results, analysis and conclusions can be found in [4].

8. References

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[3] João Paulo Carvalho, *Uma análise crítica ao Modelo Normativo de Vroom-Yetton*, INESC technical report, 1995

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[5] João Paulo Carvalho, *Estimating the Duration of Decision Group Processes*, INESC technical report, to be published, 1997

[1] Since the author considers that NMVY´s results for cost criteria is not valid, its results are obviously different.