A conceptual view of the AGAP system: a GDSS for project analysis and evaluation

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Abstract

This paper presents the AGAP (Aid to Groups of Analysis and evaluation of Projects) system, a distributed GDSS (Group Decision Support System) allowing multiple decision makers to co-operate in the evaluation and selection of investment projects. The system has a state of the art set of economic measures that can be set as criteria for use in several multicriteria decision aid methods. It also tries to enhance the communications and data sharing during asynchronous group meetings. The system is described at a conceptual level, trying to capture and transmit a global view of it. No implementation details or usage operations are presented.

Keywords: GDSS, project analysis and evaluation, multicriteria decision aid.

1 Introduction

The recent development of information and communication technologies enabled the implementation of some classes of applications that are broadly classified as Groupware. Most of these applications try to embody several already developed concepts and non computational techniques and tools with information technologies, in order to attain better communications and new forms of collaboration among people (or organisational units) engaged in some specific task. Among these one can find:

- Computer-Mediated Communication System (CMCS): to use the computer to structure, store, process, and distribute human communications ([Gavish et al. 1995], [Turoff et al. 1993], [Dennis et al. 1988], [Hiltz and Turoff 1985]).

- Group Decision Support System (GDSS): to facilitate the solution of unstructured and semi-structured problems by a group of decision makers working together as a team ([Kersten 1997], [Turban 1995], [Nunamaker et al. 1991], [Jelassi et al. 1990], [DeSanctis and Galuppe 1987]).

Nowadays, both GDSS and CMCS are moving toward providing any time / any place both communication and decision support. Notice that prior GDSS frameworks included the communication’s and meeting’s need of support (level one of group support in [DeSanctis and
Gallupe 1987], for instance) but most GDSS research and development effort did focus on supporting small-groups, single-site meetings in a decision room context. Meanwhile many (perhaps most) CMCS applications were devoted to enhance communications among groups engaged in decision making tasks, but usually on different time and place environments and with large groups.

Conventional meetings are held synchronously: all participants attend the meeting at the same time. In asynchronous sessions each participant can ‘attend’ on the schedule that is most convenient to him/her. The latter kind of sessions poses several problems of synchronisation of communication processes and of understanding the contextual meaning, like who did vote (anonymously), who has not participated but will participate in a near future, when to stop a discussion, when to consider that silence means agreement, etc.

We consider that each participant acts as an individual problem solver and concentrates his or her attention on the specific aspect he or she feels relevant. An underlying assumption is that group members can be concerned with different sets of criteria, with different parameters and with different alternatives. Moreover, they can create and test their own alternatives (which may be hypothetical) just to learn, to better understand or to structure their knowledge. Feedback from the group’s points of view and to the representations of the individuals’ points of view is required. Feedback, in this context, means that a group member changes his or her preferences so that they converge to the other group members’ preferences, as perceived by that member. (See [Vetschera 1991], for a detailed discussion.) Thus, we must consider both individual and group problem solving processes and how they interact. In an asynchronous environment this can be a problem: the designer must create appropriate communication structures and protocols that will bring these two processes into synchronisation.

Having those issues in mind, a distributed GDSS for investment project analysis and evaluation is being developed where both individual and any time/any place group decision processes are considered. This paper presents the description of the first version of the AGAP (Aid to Groups of Analysis and evaluation of Projects) system. The co-operative decision group is small (4 to 6) and may be geographically disperse. No facilitator or ‘chauffeur’ is expected, that is, it is a purely user driven system. Each element of the group has his/her own work station (a PC) connected to a central unit.

Next section presents the fundamentals of project analysis and evaluation. Then the decision group targeted by the system is modeled. Section 4 presents a short description of the AGAP system. This global perspective is then more detailed in the remaining of the paper. Section 5 focuses on the data and model management sub-systems. In section 6 the decision process structure is addressed emphasising individual support and interaction among the decision group. Section 7 details the aspects concerning the communication among the group’s members. Finally, some future developments of the AGAP system are presented.

## 2 Project analysis and evaluation

Analysis and evaluation of investment projects are fundamental activities in most businesses. Their prosperity depends upon the correct allocation of the capital they raise - if many unprofitable investments are made, the survival of the companies can be in danger. In this section we will try to present what managers want to accomplish when evaluating projects, without using an over-technical ‘language’.

The best way of judging a decision is probably ten years after it has been made. The judgement ‘that was a good decision’ will show the best decisions as those where the future was correctly predicted. This prediction could had been no more than a coincidence or ‘good luck’, nevertheless, it is due to it that a ‘good decision’ had been made. The retrospective judgement of a good decision has been summarized by asking: ‘has the economic performance of the project
been good, and was there scope for corrective actions when the unexpected arose?” ([Rose, 1978, pp147]). This means that the objectives (nowadays the words ‘economic performance’ must be understood as a set of different objectives that are connected to several aspects of a company’s performance) should be well attained for the most likely set of future conditions. Moreover, to have a good decision, the less likely outcomes should have been investigated, the necessary corrective actions determined and the resulting less likely effects determined. It is also usual to have a fall-back plan, particularly on large projects. In the last stages before making a decision, it is discussed by the board of directors. These discussions are, in part, to assess the possibilities of global losses and the company’s resilience to unexpected changes. This is an informal attempt of creating a strategy.

Projects can go through several decision stages, depending on their nature. Without being exhaustive, one can list the following different types of projects: financial (bonds, stocks, futures, etc.), industrial, distribution nets, public (not for profit), research and development, etc. It is pointless, for instance, to compare an industrial process designed optimally with another using highly unsuitable operating conditions. That is, for some project types it is necessary to undertake a first decision stage where each alternative is analysed and planned to achieve individual optimal conditions, regardless of the other alternatives. Another decision stage consists in comparing all the alternatives and choosing one or more of the alternatives, or classifying them (bad, good, very good, for instance), or ranking them all. This stage can be difficult because a good decision cannot be defined by a single criterion. It is not the one with the highest profit or the lowest risk. Generally it is some combination of these two with other criteria such as prestige, power, ethical concerns, company’s technological know-how, ‘versatility’, etc. Accepting a project with a lower expected profit, because it has a better potential if the future turns unfavorable (or it can be easily adapted to several possible scenarios) is a normal insurance against an unpredictable future. The insurance premium is the difference in the expected profits. These kind of alternatives are rarely evaluated with rigor, but are usually considered at a very subjective level.

Having chosen an alternative, or a set of alternatives, the next decision stage can be (if applicable to the type of project) to present them more carefully as a capital investment. This stage is to show that a project makes sense as a company’s investment possibility. It is necessary to re-evaluate the projects considering not only their absolute value, but also their value in the context of the company. In some cases it may be that the company is short of capital (or that capital has a high cost to the company), or that the project is very big, imposing intolerable pressures upon management, or that the project needs technical know-how that is difficult to obtain, etc. It is also in this decision stage that one must take care of synergy (bad or good) among the projects already undertaken by the company and the new projects. This opens the subject of portfolio analysis and the idea of risk diversification.

A large number of economic or financial methods can be used in order to measure both the profitability and the risk of a project or a project portfolio. There are also several other quantitative methods (from the operations research field) that can be used in order to analyse, measure or combine, risk with profitability and other criteria.

If some decision stages (usually the first ones) or part of them can be complete by just one decision maker, it is not conceivable to have all the decision process performed by just one or two decision makers. There are several global aspects of a company, as explained before, that must be considered in projects’ evaluation processes. Only in very small companies it is possible to find one or two persons having the necessary knowledge and power to make a decision. Usually several chief managers from the different company’s units (financial, operation, stocks, etc.) must incorporate their knowledge and preferences on the first stages of the decision process, where each alternative is optimized per se and compared against the others. On the last stages of the process, the board of directors, the ones having the global
picture of the company and its operating environment, must re-evaluate the projects considering their interactions with the state of the company, and take the final decisions.

In conclusion, one can consider that the activity of analysis and evaluation of investment projects is essentially a group decision activity.

### 3 The model of the decision group

In this section a model of the decision group is presented. The design of the AGAP system has this model as a reference. The activities to support, both individual and collective, and the interactions between decision makers were considered to evolve in a similar way to this model. Therefore, the general architecture and functionality of the system were shaped according to it. This theoretical model identifies several sensitive points that are essential to the effectiveness of the system. These points or issues are emphasized in this section, alerting to the difficulties and preparing the reader to the design solutions implemented in the AGAP system. These design solutions are thoroughly explored in the next sections.

Research in group decision making has shown that collaborative decision making tasks encompass three distinct types of information processing, corresponding to different reference levels: individual, interpersonal, and collective ([Nadler, 1979]). Grounded in theories of interpersonal information processing from [Brehmer 1976] and of collective decision making from [Ono and Davis 1988], [Sengupta and Te’eni 1996, pp 120] consider that a group decision situation incorporates three iterative levels of information processing (see fig. 1):

- “At the individual level, group members process information individually, concentrating on their own decision processes.”
- “At the interpersonal level they learn about the thoughts and opinions of other members, and incorporate them in their own decision processes to arrive at an individual decision.”
- “At the collective level, the group exchanges and processes information as a collective entity in order to arrive at a joint decision.”

![Three iterative levels of information processing](image-url)

**Figure 1** – Three iterative levels of information processing.
Even though these levels are intertwined in any collaborative situation, it is important to draw a conceptual distinction among them because each level needs distinct modes of interaction and requires different levels of support.

At the individual level, users need to concentrate on their own thoughts. A basic assumption is that group members are interested only in a subset of criteria. This assumption can be justified from an organizational point of view: organizations often delegate decisions about projects’ evaluation because individual group members have specialized knowledge of different particular areas that otherwise cannot be brought together in a decision process. In contrast, information processing at the interpersonal level entails assimilating the views of others. This requires interactive facilities that enable users to compare, contrast and integrate the views of others. Feedback, in our context, means that a group member changes his or her preferences so that they more closely reflect the other group members’ preferences, as perceived by that member. Such a change can be made in several distinct ways:

- the group member changes the structure of his/her evaluation system (e.g. changing the attention paid to the criteria); and/or
- the group member alters his/her own set of criteria, adding or deleting some criteria (it is also possible to create a criterion named ‘group’s opinion’); and/or
- the group member adjusts his/her assumptions and predictions (subjective or not) according to some extra information provided by the other group’s elements; and/or
- the group member uses another method or process of aggregating the criteria that he or she considers relevant.

Following from the need for multiple modes of interaction is the problem of supporting easy transition from one level to the other. When individuals revise their respective strategies to take into account the thoughts of others, they can lose control over the revised versions of their strategies. There is a dual need to support: discrimination and integration ([Sengupta and Te’eni, 1996]). Individuals need to discriminate their own views from those of others, and integrate ideas from multiple views in order to enrich their perspectives. It is considered ([Vetschera, 1991]) that one criterion representing the ‘group’s evaluation’ will cause less cognitive strain then dealing with all the attributes. This criterion can be easily interpreted by each group member as an aggregation of all the members’ special knowledge that warrants another distinction between the alternatives.

At the collective level there is the need to support activities such as communicating, creating common views by voting, extracting common factors, amalgamating, etc. This level can be viewed as an extension of the interpersonal level to all members with an increase of different perspectives (some of them may be antagonistic) requiring processes to achieve a common decision and allowing some members to explicitly disagree with it.

A transition from the individual to the interpersonal or collective level is accompanied by a loss of context. This loss is more notorious when arriving at the collective level. At the individual level, context is present in an implicit fashion. However, this context is often lost in the act of sharing representations. The effectiveness of a system can be enhanced if it is designed to provide and maintain context ([Herrman et al. 1996]).

The next section presents a global view of the AGAP system.

4 AGAP’s conceptual model and a short description

The AGAP is a GDSS that is being developed as a distributed system allowing multiple decision makers to co-operate in order to evaluate and eventually select investment projects. The system has a state of the art set of economic measures that can generate multiple criteria for
the evaluation of projects. Non economic criteria can also be incorporated whenever a decision maker (DM) feels necessary. Furthermore, multiple criteria decision aid methods are available to the decision group.

AGAP is being implemented in Delphi as an MS-Windows (95 or NT) based distributed system using TCP/IP, consisting of a central unit and several (4 to 6) work stations (one for each user). A user cannot directly access the data stored at another group element’s computer. The AGAP supports structured communication organised as “documents” of related data as well as unstructured communication (such as messages) and voting. Access permissions to data can be stipulated by the group element (the owner) that originates that data or that communication. All of this is controlled by the central unit.

![Figure 2 – AGAP’s conceptual model.](image)

Fig. 2 presents the system’s conceptual model. Note that there is not a perfect match between the hardware and the conceptual model: part of the group support is placed at the work stations. Two points are to be stressed in fig. 2. First, the group information block represents a more restrict concept than the concept of ‘group memory’ as defined in [Hoffer and Valacich 1993]. To them, group memory includes almost all the memory of the system (data, models, processes, historical uses, etc.). At the AGAP system the group information block is only the record of the group meetings, as in formal meetings: it registers whatever any element of the group wants to be stored for future recall in other meetings or for recording his/her position about the issues under discussion. The second point is that the data blocks and the model blocks are only conceptually different, since the structure of some models or methods is also stored as data (see the next section for an extended discussion).

The system provides the support usually found in decision support systems planned for a single DM. Therefore, a DM can create his/her evaluation process to analyse the group’s problem as if he/she was the only DM. Furthermore, the DM can create multiple evaluation processes to test several hypotheses. By doing this the DM can learn individually before discussion starts or while the group's discussion takes place. The system allows strict confidentiality concerning this individual analysis, which is done locally at the DM's work station.
Figure 3 – Sequence of the tasks to perform. Several loops (omitted from the schema) can be performed among the tasks.

Figure 3 presents a schema of the task sequence to perform in order to come out with the final result. This sequence must be performed regardless of the number of decision makers (one or more) and of the detours or even restarts that may be needed to improve the results and the decision makers’ confidence on them. To know more details about the system usage and the results of some tests, refer to [Costa et al. 1999].

Firstly, it is necessary to define the alternatives and to set an evaluation process. The alternatives are defined by setting their performances on several attributes that are considered relevant and establishing the scenario assumptions (economic macro-indicators, for instance) that affect them.

After defining the alternatives, it is necessary to set an evaluation process: to choose and characterize the criteria, to choose a sub-set of alternatives to evaluate and to apply a multicriteria aggregation method, according to the type of decision at stake (to select a project, to rank or to classify the projects). The criteria are selected among the attributes characterizing the project cases (alternatives), and more than one multicriteria method can be applied in the same evaluation process. All the data are stored by the system.

The data structure storage uses relational databases' concepts and is distributed. The way data are distributed is essential for the security of the system and therefore is managed by the central unit. The database structure is replicated on all the workstations but each workstation only
stores information of the DM or information that the DM has access to (granted by the information owner).

The data concerning the decision alternatives has a 'project-case' structure. An investment project originates cases representing alternative ways of characterising / implementing it.

For instance, imagine a project to enhance a textile production line. A zero case is created. This case has all the raw data needed to characterise the project. Several cases can then be derived from the zero case. These other cases of the same project can have drastic differences among them or just minimal differences. For instance: 'Should we enhance the textile production line through purchasing a machine?', or 'Should we buy the services of that machine from other company?'. Another example could be just to have different concepts about the reinvestment of cash flows. This means that the system supports not only project's selection, but also project's planning and scenario analysis.

The project’s cases are characterised by attributes. The AGAP system is quite flexible: there are several pre-defined attributes at the system but the users can define new ones. Moreover, the users can define the new attributes based on other attributes defined earlier. These new attributes can sometimes be defined as syntactic expressions involving other attributes that are computed by the system whenever needed. Hence, simple models, based on syntactic expressions, are stored as data.

A decision process can have several evaluation processes. Each evaluation process can belong to an element or to a sub-group of elements within the group. Related to each evaluation process we have the project's cases under analysis and evaluation, the chosen criteria, the methods

![Figure 4 – The architecture of the AGAP system. The large arrows represent data and the thin ones represent control.](image-url)
(usually multicriteria) of evaluation used and the results obtained. This structure allows for lots of tests and comparisons of results.

Figure 4 presents the fundamental blocks of the AGAP structure. The next sections present a more detailed description of some of the blocks depicted there.

5 Data and model management sub-systems

The key structural element of information is the ‘case’. A case includes relevant data characterising an investment project, reference to some environmental data for scenario analysis (which can be common to several cases even if they derive from different projects - exogenous characteristics at fig. 5) and the identification of the group elements associated to that case.

The data of an investment project are introduced in the system as a so-called zero case. This zero case has all the raw data of the project, and several cases can be derived from it. These new cases are identified as case n, n>0, from that project. The group elements (one or more) that build a case are its owners and they can define permissions (read, write and copy) to the other elements of the group. It is not necessary to repeat all the information of the zero case in the cases based on it, it is only necessary to store the differences. This means that the cases inherit the characteristics of the zero case and that the zero case cannot be altered whenever there are cases based on it.

One of the fundamental activities in project analysis and evaluation is planning. AGAP’s problem solving support is not only about choosing the best project among several, choosing a certain amount of projects to build a portfolio, or classifying projects into money makers or money loosers, but also the important and often forgotten aspect of selecting the best way of implementing a project. This can be considered planning.

Some interdependencies among the cases of projects can also be modeled (fig. 5). The system is prepared to deal with mutual exclusivity, synergy and technical constraints among projects. This is particularly important when building and evaluating project portfolios.

The structural element of information, that is the case, is characterised via ‘attributes’. Each attribute has its own identification and definition. The project cases have performances on the attributes. Notice that not all the available attributes must be used to characterise the project cases, and that a user can define new attributes. Consider, for example, that there is a pre-defined attribute in the system, the attribute A, and the user defines another attribute B. Then,
this user can build an attribute C, that is based on attribute A and B. For instance \( C = \frac{(A - B)}{2} \). Whenever the attribute C is used by the system, an expression evaluator is triggered to obtain the respective performance. Note that if a project case characterisation includes attribute C, it must also include attributes A and B.

The AGAP system offers several functions that can be used to build the syntactic expression defining an attribute. Among these functions there are the most important and the most widely used measures for economic evaluation of investment projects as well as utility-based multicriteria methods. Following [Remer and Nieto 1995a, 1995b] the most common measures for economic evaluation of investment projects can be divided in five classes: equivalent worth, rate of return, ratio, payback and accounting. To know more details about the economic methods implemented in the system refer to [Afonso et al. Accepted].

6 Decision process structure

The characterisation of the projects, eventually through alternative cases, can be inserted in the system independently from any decision process. However, when project cases have to be compared to select some of them, to rank them or to assign them to pre-specified categories (e.g. "interesting", "not interesting" or "more research needed"), then a decision process has to be defined. In the AGAP system a decision process is like an umbrella that encapsulates the statement of the problem (a short description), the identification of the participating members (i.e. the decision group, chosen among the users with access to the system), the communication among these members and all the evaluation processes performed to support decision making.

An evaluation process is performed whenever some method is executed on a set of alternatives (project cases or portfolios) to yield a result. It is always concerned with some decision process. In AGAP every evaluation process has an "owner", who may be a single DM, a set of DMs within the decision process' group or the entire group of members. It may also encompass a reference to the method that was run (which is usually a multicriteria analysis method), a reference to the criteria that were used, the values chosen for all the parameters needed, a reference to the alternatives considered and the method's results. Access to the input or output of a decision process is restricted to its owner plus whoever its owner grants the necessary permissions, thereby assuring the privacy of the evaluation.

The concept of evaluation process provides a framework to support the individual DM (or a set of DMs within the group) and information exchange among the members of the group. There will be at least one evaluation process (probably incomplete) shared by the whole group involved in the decision situation, which will gather consensus among all of its members. Each DM may use information from such processes to build his/her private evaluation processes, where confidential data, values and beliefs may be incorporated. In turn, the results of these private evaluations may be transmitted to some other group members or to the whole group. This may occur when voting, when sending messages or when disclosing (possibly only part of) the evaluation's input or output.

The interaction framework of AGAP provides solid grounds for discussion within the group. It allows the DMs to share and compare alternatives (e.g. new ideas on how to implement a project), concerns (e.g. the urge to include some forgotten criteria or scenarios) and values (e.g. the relative importance of the criteria), having results to support their arguments. This fosters co-operation and individual learning while not assuming that the DMs will disclose all of their information and preferences, which would be unrealistic. Moreover, this interaction is consistent with the any time / any place usage of AGAP and allows DMs to work in parallel.

The methods offered in AGAP are available to all its users. Apart from the economical evaluation methods referred in the previous section, the current version of AGAP offers some multicriteria evaluation methods. These methods consider a set of alternatives (either project
cases or alternative portfolios), a set of criteria (chosen among the attributes that characterise the projects) and some parameters that allow the DM to express his/her values to produce a result. Depending on the method, this result may be a global value for each alternative, a set of preference relations among the alternatives or an assignment of the alternatives to pre-specified categories ([Keeney and Raiffa 1976], [Roy and Boyssou 1993]).

7 Data sharing and communications

The fundamentals of the communications of the AGAP system are the following:

- Communications always use the central unit. A member’s work station does not have direct access to the work station of another member of the decision group.

- If a work station has something to communicate, it places it at the central unit. When a work station is connected to the group system it checks the central unit for communications having it for destination. From time to time, a work station already connected to the system repeats the operation in order to receive information. This enables asynchronous communications.

- There are three kinds of communications: message passing, voting processes and document sharing.

The communication structure of the messages is very close to the structure of the electronic mail tools that are used nowadays. Anonymity and pseudo-anonymity (when a message is identified by a pseudonym that remains unchanged until the end of the communication process, including replies and replies to replies) are supported. The channels of communication can be multipoint and several levels of authorisation (reading, replying, anonymity, etc.) can be defined. The message passing tool can be used not only for usual electronic mail purposes but also for supporting several group techniques such as brainstorming.

Any member of the decision group can start a voting process, characterising it (who votes, type of voting, type of counting system, several types of user information disclosure, who receives the results and in what way), defining the object of voting and sending a special message (with all this information) requesting an answer until a certain date. The voting members of the group then reply via another special message according to the characterisation of the voting process. The voters are not allowed to change their vote on this first version of the AGAP system. Hence, the central unit terminates the voting process when all the voters have voted or when the deadline has expired regardless of the number of votes. Afterwards the central unit processes the votes and transmits the results according to the characterisation of the process. Several voting and counting systems are supported by the AGAP system.

For technical details about the communications in the AGAP system refer to [Melo and Costa 1999].

8 Future developments

This paper describes the current version (version 1.0) of the AGAP (Aid to Groups of Analysis and evaluation of Projects) system, a distributed GDSS, which is still under development. Several points are being addressed, namely:

- the development of a Human/machine interface that best suits the decision makers. Some sensitive points have been identified: the management of the project case structure, the introduction of new attributes, the support on choosing evaluation criteria and the presentation of results to the decision group and their discussion.
- the study and development of support to the structuring phase, bringing together economical theory and project analysis and evaluation methods, the concept of a coherent family of criteria from decision theory and the theory underlying the relational database model.
- the incorporation of other methods of considering the risk associated to the investment projects, other measures of projects’ economic profitability and other multicriteria decision aid methods.
- the refining of the architecture of the system in order to enhance the support to collective tasks of the decision group, namely in what concerns enabling all the group members to change a common working area, keeping stored an history of what happened.
A new version of the system is being prepared in order to incorporate these new developments, tools and features.

Acknowledgements:
The present version of the AGAP system was implemented by António Ricardo Afonso, João Paulo Trindade and Secundino Lopes.
This work was supported by PRAXIS/PCSH/C/CEG/28/96.

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