Designing alternatives in decision problems

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Abstract

Generating alternatives for decision problems is a critical activity regularly underestimated and underdeveloped in the decision analysis literature. We present a survey showing how little this topic has been studied in the last 50 years. We then introduce a general framework under which formalise the design of alternatives. Two examples help to understand our point of view: alternatives are generated through separation of attributes describing the value space of the client/decision maker.

1 Introduction

Most scholar articles as well as textbooks in decision analysis and operational research, when introducing the problem formulation they talk about, start with a claim of the type "given a set A of alternatives" (Barbera, Hammond, & Seidl, 1998; Nemhauser, Rinooy Kan, & Todd, 1989; Ravindran, 2008). Both researchers and practitioners know that in reality the set A is never "'given" ... It is actually often constructed during the decision aiding process and most of the times defined several times during that same process.

Surprisingly enough this topic is almost ignored in the specialised literature. With the notable exception of Keeney (1992), who stated the principle that decision making should start considering "values" (in the sense of attributes) and not "alternatives" the latters derived from the formers (Keeney, 1994; Leon, 1999) very few contributions are available as we will show in the literature survey in the following section.

This is remarkably strange. Practically the mainstream decision analysis literature focuses on how to "choose" an alternative without considering where these alternatives come from and how they can be established. On the other hand it should be obvious: if all the alternatives in the considered set are "bad" we are going to choose a bad option even if it is the best one ... But who decides which are "good" options to include in the set of alternatives and how such a decision is

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taken? While we have very sophisticated methods and algorithms aiming at solving a decision problem we have no formal tools about how to generate solutions before evaluating them. More generally speaking, we have elegant theories and formalisations for a large variety of decision problems, but we have no theories and formalisations as far as the design of alternatives is considered.

The paper develops essentially two claims. The first, based on a literature survey (far from being exhaustive), shows how little the topic of alternative design has been considered as an explicit stand alone problem, although many methods in Operational Research actually contain "routines" generating sets of alternatives. The second claim suggests a general framework allowing handling this topic in a formal way. The topic results as part of the research in conducting decision aiding processes (Tsoukiàs, 2007). We recall that within that framework we will always make the hypothesis that the information used within such a process is the result of the interaction of at least two agents: the client and the analyst. This attempt follows our recent work on defining what a decision problem is (Colorni & Tsoukiàs, 2013) and should include both known procedures which are actually used in order to generate alternatives as well as the basis for defining new procedures of more general validity. Our objective is two-fold:
- show that constructing a set of alternatives is a decision problem itself;
- show which are the conceptual and algorithmic challenges in developing a general theory about alternatives construction, a key topic in conducting decision aiding processes (Tsoukiàs, 2007).

The paper is organised as follows. In Section 2 we present the literature survey, while in Section 3 we introduce our general framework (what is a decision problem) within which we consider the problem of generating alternatives. In Section 4 we show that this problem is a decision problem itself. Section 5 discusses extensively a number of examples showing how existing methods handle the issue of generating "known" alternatives. In Section 6, instead we address the topic of generating "unknown" alternatives when the set of available ones is unsatisfactory.

2 State of the art

Generating alternatives is a relatively "old" subject in decision analysis, but very little developed. Early attempts to address the topic appear in the early 80s and include Arbel and Tong (1982), Ozernoy (1985), as well as Alexander (1979), Gardiner (1977) and Nakamura and Brill (1979), claiming the importance of focusing on how alternatives are generated while structuring a decision problem (the topic is nicely addressed also in Keller & Ho, 1988). It should be noted that Simon (1954) while introducing his famous decision process model, explicitly introduced a “design” part before the “choice” one, however, without any further specification of what “design” operationally implied. The topic has also been considered in the seminal work of Mintzberg, Raisinghani, and Théoret (1976), but once again without further operational hints. The reader should also note that the term “structuring” is not used in the broad sense introduced by “Problem Structuring Methods” (see Rosenhead, 1989), but in a narrow sense addressing the establishment of components of given decision models (define a set of feasible solutions, formulate objectives and/or constraints, elicit preference statements from the decision maker etc.).

A first systematic approach in order to handle the generation of alternatives has been, in the 80s, the “MGA method” (Modelling for Generating Alternatives), in Brill, Chang, and Hopkins (1982), Chang, Brill, and Hopkins (1983) and Gidley and Bari (1986). The method has been revisited in the 90s in Sprouse and Mendoza (1990) and more recently by De Carolis in (2011) and DeCarolis, Babaee, Li, and Kanungo (2016). The method suggests the use of multi-objective optimisation techniques in order to explore the neighbourhood of a feasible solution, adopting a “distance function”, such that the new solutions are “significantly different” from the starting one. The rationale for this method is that clients/decision makers might not necessarily have a precise idea about the importance of the different objectives and/or constraints used in the model. On the other hand there might be solutions which although “very near” in the objectives space, can be “very different” in the variables space. In the original paper (Brill et al., 1982) the authors claim that exploring the neighbourhood of any given solution can help the client/decision maker to better shape his/her preferences and values before committing to any choice. A very recent application of this technique in the energy planning sector can be seen in Price and Keppo (2017).

A more general and conceptual perspective was discussed during the same period in Teath, White, Berlin, and Park (1987) focussing upon the cognitive aspects of the alternatives generation process and in Norese and Ostanello (1989) where a decision process dimension is explicitly considered (how alternatives are generated within specific types of decision processes). The authors emphasise the specificity of this decision aiding activity showing how this can result in completely different outcomes for the decision maker. The reader should note that the topic of generating alternatives has explicitly been considered in the cognitive sciences literature (an example being Newstead, Thompson, & Handley, 2002).

Not surprisingly, the problem of designing and generating alternatives has been essentially discussed within public policy applications of decision analysis. Already Alexander in (1982) draw the attention upon the design dimension of public policy making processes. Several papers in the 90s describe applications of decision analysis in the public sector focussing on how generation of alternatives is a critical issue: Baetz, Pas, and Neebe (1990); Bayne (1995); Feng and Lin (1999); Guimarães Pereira, Munda, and Paruccini (1994); Netto, Parent, and Duckstein (1996); Quinn and Harrington (1992). Applications beyond public policy include papers discussing alternatives generation processes in Information Systems Requirements Engineering (Fazlollahi & Vahidov, 2001; Jain, Tanniru, & Fazlollahi, 1991) and a first attempt within the broad planning and scheduling literature (Raman, 1995).

However, all such contributions essentially consist in using a multi-objective programming problem formulation where the Pareto frontier allows to establish a large set of interesting alternatives, a set nevertheless smaller than the whole feasible set. The alternatives generation problem consists in computing and exploring appropriately this Pareto frontier.

The first real attempt to propose a more general and systematic approach as far as the alternatives generation problem is concerned is Keeney's "Values Focussed Thinking" (1992); see also Keeney (1994) and Leon (1999). The idea here is that before focussing upon establishing the set of alternatives or considering it as given, decision makers should focus upon what matters for them (their ultimate values) and which are the means to achieve them (their means values). The combinations of such values should describe what the alternatives actions are, allowing for more creative solutions. Under such a perspective decision analysts should conduct the decision aiding process starting from eliciting such values instead of focussing on the alternatives set. A similar idea is suggested in Farquhar and Pratkanis (1993). The reader should note that this journal (the JMCDA) hosted a very interesting discussion around this topic in 1999 (see Wright & Goodwin, 1999). However, this clever idea has not been followed by any further formal development.

Another field where the problem of generating alternatives has been considered from a general methodological point of view, although indirectly, is real options theory (Smit & Trigeorgis, 2004). The idea here is that when facing a decision process under risk and uncertainty, the decision maker might feel uncomfortable with the typical decision process (modelled as a decision tree). The typical "Do/Not Do" binary choice could be a limit obliging him/her to choices for which (s)he might not be ready. In order to increase flexibility in the decision process the decision maker can take "intermediate decisions" such as fixing an option (for a given price) and then decide further on where to continue with realising the option or not. Indirectly this implies generating new alternatives beyond the ones which may look as possible (i.e. to buy or not). The field of real options is continuously expanding, but has never explicitly addressed the topic of how alternatives are generated.

The construction of alternatives has been discussed under the perspective of public policy design as can be seen in Bobrow (2006), further expanded in Howlett (2011) and Howlett (2014). The literature reports several papers where the authors considered the problem of generating alternatives as a help in case studies of supporting public policy making: Abu-Taleb (2000), Ferretti, Pluchinotta, and Tsoukiàs (2019), Fumagalli et al. (2012), Greening and Bernow (2004), Imanirad, Yang, and Yeomans (2016), Margoluis, Stem, Salafsky, and Brown (2009), Öberg, Lundin, and Thelander (2015), Paraguai, Candello, and Costa (2017), Rosenberg (2015). Other application domains where alternatives generation issues are reported include Chakhar and Mousseau (2006), Halim and Srinivasan (2008), Marchand and Walker (2008), Van Aken, Besinovic, and Goverde (2017).

From a general point of view the literature in the most recent years remains focussed on either exploring the Pareto frontier of some multi-objective problem (see Yeomans, 2002 or Zechman & Ranjithan, 2003) or trying to establish a more general perspective (see Gallacher, Martin, & Perrin, 2015; Knudsen & Levinthal, 2007; Nutt, 2005; Tani & Parnell, 2013; Tepper, 2004). However, the only attempts to create a "general theory" result in two previous papers of the authors (see Colorni & Tsoukiàs, 2013 and Colorni & Tsoukiàs, 2018) and the more recent contribution of the design theory group (Hatchuel, 2001; Hatchuel & Weil, 2009; Le Masson, Hatchuel, Le Glatin, & Weil, 2018) and their applications (Pluchinotta, Kazakci, Giordano, & Tsoukiàs, 2019).

3 Concepts and Notation

The general setting is the one considered in Tsoukiàs (2007): a "client" seeking advice to an "analyst" about a decision process in which the client is involved. In Colorni and Tsoukiàs (2013) we introduced a general framework aiming to characterise decision problems on the basis of the information the client in a decision situation can provide. Indeed our framework is independent of any method characterisation: it should instead help defining a decision problem (and thus choosing or constructing any new method) from some minimal information which we call

the primitives. Within such a framework a decision problem is, technically, *"the partitioning of a set A"*; Such a partition can be ordered or not and predefined or not and should satisfy the client's preferential information. The primitives then are:
- the set A described along a set of attributes satisfying separability, in other terms these attributes are the minimal descriptors necessary to make a decision and each one considered alone is sufficient to make a decision;
- the problem statement Π establishing the type of partitioning to perform;
- the preference statements $\mathcal{H}$ provided by the client, to be modelled through appropriate structures and languages.
Let's present these topics with more details.

1. The set A of alternatives which can be described in two different spaces:
   - the variables space, in case the alternatives result as the combination of different variables;
   - the values space where the alternatives are described against a number of attributes representing the consequences which matter for the client;
   We will discuss this in more details at the beginning of section 4.

2. The problem statement Π can be:
   - a ranking: construct a partition of A in ordered equivalence classes which are not defined a-priori;
   - a rating: construct a partition of A in ordered equivalence classes which are defined a-priori;
   - a clustering: construct a partition of A in unordered equivalence classes which are not defined a-priori;
   - an assignment: construct a partition of A in unordered equivalence classes which are defined a-priori.

3. The preference statements $\mathcal{H}$ (the reader should note that we use the term of preference in a very general way: any ordering relation can be considered as a preference relation, see Moretti, Öztürk, and Tsoukiàs (2016), Roubens and Vincke (1985), including similarity and equivalence relations) can be of different types:
   - single or multi-attribute ones;
   - relative (comparing elements of A among them) or absolute (comparing elements of A to some external norm);
   - simple (comparing single elements of A) or extended (comparing whole subsets of A);

- ordinal or more than ordinal (expressing some notion of difference of preference);
- positive or negative (negative preference statements should not be considered as the complement of positive ones);
- first order or higher (preferences about preferences).

4. Let's recall finally that in order to choose or to construct a "resolution" method what we strictly need is the set A (minimally described), a problem statement Π and enough preference statements where we need to check (wrt to $\mathcal{H}$):
   - how differences of preferences are considered on each single attribute;
   - how differences of preferences are considered among the different attributes;
   - whether preferences are conditional/dependent from other preferences;
   - whether negative preferences should be considered explicitly or not.

4 Constructing A as a recursion

Let's start talking about the set A in more details. The reader should note that our task is not to have a complete description of what the alternative options of action are for the client, but that description which matters for her/him. As already mentioned the set A can be described in two different spaces: the variables one and the values one.

1. The variables space is the product space of all the variables which might be used in order to describe an alternative. We consider n independent variables $x_i \;\; i \in \{1 \cdots n\}$. If $\forall i \; x_i \in \mathbb{R}$ then A is a subset of a vector space ($A \subseteq \mathbb{R}^n$). If $\forall i \;\; x_i \in \mathbb{Z}$ then A is a combinatorial structure ($A \subseteq \mathbb{Z}^n$). Without loss of generality we will only consider the case where $Z = \{0, 1\}$ since any other combinatorial structure can be obtained from that one. There is of course always the case where the set A is an enumeration of "objects" (a list). In this case we will consider that each alternative corresponds to a single variable. Hereafter we will represent a generic element of A as $< x >$.

2. The values space where each element of A (independently from how it has been described in the variables space) is mapped against a set of attributes D. Each D_j $(j \in \{1 \cdot m\})$ should be seen as a function $D_j : A \mapsto E_j$ where

E_j is the set of all possible values an object can take under that attribute (often the domain E_j is called the scale of the attribute D_j). Of course each E_j can be either an interval of the reals or of the integers. There is however, a special case where the domain E_j is composed by nominal labels (for instance colours: $E_j = \{$red,yellow,green...$\}$). Without loss of generality we will associate to this set a set of integers, paying attention not to consider the underlying ordering structure of the numbers.

3. There might be connections between the two spaces. More precisely it is often the case that each single variable (used in order to compose the set A) can be itself assessed against the attributes D. In other terms we may have that $D_j(\langle x_1 \cdot x_n \rangle) = F(D_j(x_1) \cdot D_j(x_n))$, F being an aggregation function, not necessarily linear.

4. The important concept to bear in mind is that the set D should satisfy "separability". There might be infinite different dimensions under which the elements of A can be described and assessed. What we are interested in are the ones which are relevant for the client. The way to check it is whether the client would use that precise attribute in order to discriminate two alternatives (for the rest identical) in case of a decision to be taken. If yes, it means that this attribute matters to the client and is separable, otherwise it remains a potential descriptor of A, for the moment irrelevant for the client and the decision process.

Example 4.1 *Let's discuss the above through a very well known example: the "knapsack problem". There are n different objects, each of which can be chosen in order to be carried within a container (the knapsack). It turns natural to associate to each such object a variable $x_j \in \{0, 1\}$ representing the choice to carry or not that specific object. The set $A \subseteq \{0, 1\}^n$ is thus described in the variables space by the 2^n possible "packages" of objects. Let's consider now three attributes: value, weight and colour to be used in order to assess the different possible packages (alternatives). Let's make the hypothesis that we know the value, weight and colour of each single object: we will represent them as $v(x_j)$, $w(x_j)$ and $c(x_j)$. It is natural to consider that $\forall < x > \in A \; w(< x >) = \sum_j w(x_j)$ (the weight of each package will result as the sum of the weight of the objects composing it). It is equally easy to understand that we cannot use such a linear aggregation as far as the colour is concerned. The value attribute could be linear ($\forall < x > \in A \; V(< x >) = \sum_j v(x_j)$, but only if there are not "absorbing values among objects" (if I pick x_1 is useless to pick x_2). Last, but not least, the* *discussion with the client could reveal that finally the colour is not a separable attribute, in the sense that she/he would not make any decision just because two packages have a different colour.*

Remark 4.1 *The reader may note that, in the above example, we could consider each single variable as an evaluation variable (possibly using sub-attributes). For the time being we are not going to explore this modelling option which requires further specifications. However, the reader should remember that this option exists and implies unifying the two spaces within which we describe the set A.*

We are now able to introduce our first and fundamental claim.

Claim 1 *A decision problem exists if there is at least one separable attribute describing the set A.*

Remember that a decision problem corresponds to a partitioning of the set A (using one among the four fundamental problem statements). However, such a partitioning can occur if there is at least one attribute considered relevant by the client, to be used in order to discriminate the objects among them: a separable attribute. We can now state the first result of our paper.

Proposition 4.1 *Constructing the set A is itself a decision problem.*

Proof. Suppose a decision situation for which the client claims that the set A is totally unknown. If this is to be considered as a decision problem then exists at least one separable attribute which is able to discriminate and assess the (unknown) set A. We already know that for each such separable attribute exists a set E of values (representing the domain of the attribute). Without loss of generality we can assume that $A = E$ (the alternatives are abstract objects represented by the values of that attribute). In other terms we assume that exists a decision variable having as domain E. This automatically establishes a set A_0 upon which we can apply a partitioning procedure aiming at satisfying the client's requirements. There are two cases:
1. The partition is satisfactory. The procedure stops, since the client is satisfied.
2. The partition is unsatisfactory. We have again two, non exclusive, cases:
2.1. Add further separable attributes, under which we can refine further the partitioning of A_0.
2.2. Add further decision variables enriching the set A_0.
In both cases we generate a new set A_1, using the partition of A_0 and the new

attributes and/or variables introduced. We can now apply upon A_1 a new partitioning procedure.
Consider now the generic step i of this procedure where $A_i = \bigcup_i [A_{i-1}]_i$. If this partitioning is satisfactory then we end, otherwise we repeat the procedure. This will end when the client declares to be satisfied.

■

Discussion. The case where the set A is totally unknown is rather unrealistic. In most of the cases the client comes with a vague idea of what this set should look like and we are able to establish some decision variables describing the composition of A and some separable attributes assessing it. However, most of the times this set will result to be "unsatisfactory" and the way through the client (and the analyst) realise it is that, whatever the partitions generated out of this set, the client is unsatisfied with the result.

There is a special case to consider due to the fact that the decision maker is really interested in solutions which are feasible, potential alternatives which can be realistically implemented. While this is true, it does not affect our framework, since "feasibility" can be expressed upon any of the attributes describing and valuing the alternatives. In other terms constructing a set of feasible alternatives is once again a decision problem.

What the theorem practically tells us is that the construction of the set A is a process (part of the whole decision aiding process) combining two activities: one, creative, consisting in identifying new attributes and/or variables and one, technical, consisting in solving a decision problem generating new partitions of the incumbent set A_i (at step i of the process). This process is subjectively driven by the client's satisfaction (as always in a decision aiding process).

5 Examples of alternatives generation

In the following we present two examples in order to allow the reader better understand the theory we presented in the previous section.

Example 5.1 ***Location problem***

1. Suppose the following problem situation. A client demands the analyst an advice about where to locate a number of facilities in order to cover the demand of the population of a given city. The convention is that the city is divided in districts $\{1 \cdots n\}$ and that locating a facility at a district covers also the adjacent ones (we obviously know the adjacency matrix $\mathcal{A}$). The demand is to cover the whole city with as less as possible facilities.

This is a very well known archetypal problem in location theory (Drezner & Hamacher, 2002). The typical modelling is straightforward. We associate to each district a binary variable x_j $j \in \{1 \cdots n\}$ ($x_j = 1$ if we open a facility at district j and 0 otherwise). We then formulate the well known ILP:

$$\begin{aligned} \min \sum_j x_j \\ \text{st} \\ \forall i \quad \sum_j a_{ij} x_j \geq 1 \\ x_j \in \{0, 1\} \\ a_{ij} \in \mathcal{A} \end{aligned}$$

Discussion. The reader will note that there is only one attribute that matters for the client: the number of openings. This is the reason for which we only need the decision variables representing the openings. We just need to count them.

2. Suppose we solve the above ILP and we provide the client with our suggestion: the minimum number of openings covering the city is k and there are several combinations of k openings which are for the moment indifferent among them. At this point the client's reaction is "NO! That's too much! I cannot afford opening k facilities".

Discussion. Whatever solution we suggest to the client involving opening k facilities is not satisfying her. Clearly the client has not been clear with us, since (s)he never talked about budget constraints, but this is how it happens. Clients are never crystal clear about their problems and often it is only when they realise that all admissible solutions of the problem as they described it are unsatisfactory that they make the effort to clarify further what they are looking for. In our case we clearly need to look for other alternatives.

3. There are two different attributes that matter now for the client. The first one remains the "openings": the client nevertheless desires minimising the number of "openings", actually we could now consider associating to each potential opening a cost (c_j). However, there is a second attribute which now needs to be considered: "covering". Since we cannot cover the whole city, we need to consider how much each solution covers: the client is nevertheless motivated to maximise the covering of the city. At this stage we introduce new binary variables y_i $i \in \{1 \cdots n\}$ ($y_i = 1$ if district i is covered and 0 otherwise (possibly considering different weights w_i for each district). We then formulate the well known ILP:

$$\min \sum_j c_j x_j$$
$$\max \sum_i w_i y_i$$
$$\text{st}$$
$$\forall i \ \sum_j a_{ij} x_j \geq y_i$$
$$x_j, y_i \in \{0, 1\}$$
$$a_{ij} \in \mathcal{A}$$

Discussion. We can stop the presentation here, since it is not important for our discussion how this bi-objective problem will be solved and how the solutions will be discussed with the client. For the time being we only need to focus our attention on what has been the modelling action which enabled us to generate further alternatives: separating the "covering" attribute allowed to expand the solution space and to formulate a new decision problem, possibly with satisfying solutions for the client.

Remark 5.1 *The reader will note that the attribute "covering" was already there. However, it was not separable. This is visible at the first problem formulation, at the logical constraint* $\forall i \ \sum_j a_{ij} x_j \geq 1$*. Actually* 1 *is the value which we give to all covering variable* y_i *when we make the hypothesis that the whole city has to be covered. If we relax this constraint, then the attribute becomes separable and the variables can also take the value* 0*.*

Remark 5.2 *For this precise problem there are no more than* 2^n *potential solutions which is the whole set of possible combinations of the* x_j *opening variables. The different problem formulations we presented here only change the part of the combinatorial structure which makes sense to explore for the client. Thus is expressed through the feasibility constraints. Under such a perspective we did not really gave an example of how to generate "new" alternatives, but rather an example on how to revise/expand the set of solutions to explore in order to satisfy the client's demand.*

Example 5.2 ***Real options***

1. Alice just submitted a paper to a prestigious conference. Actually, being so prestigious the acceptance rate is less than $a\%$ (a rather small). The decision problem of Alice concerns the flight ticket. She could buy a ticket today at a reasonably low price (l), but in case the paper is not accepted her department will not reimburse her. She could wait until she knows whether the paper is accepted or not and then buy the ticket, but the price will be unreasonably high (h) and the department could refuse to pay due to funds restrictions (and for herself would be also impossible). This is a typical problem of decision under risk which we can represent using a decision tree (see figure 1), where V is the reward for attending, l and h are the prices (low and high respectively), a being the prior probability to be accepted and b representing the decision to buy now the ticket.

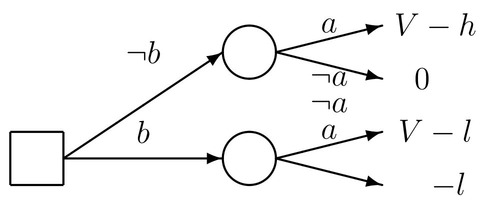

Figure 1: Decision Tree 1

Obviously Alice is unsatisfied with both options and she would like to have other new ones before making any decision.

<u>Discussion</u>. Apparently the options Alice has are fixed independently from any attributes describing or assessing them: either she buys the ticket now or not. However, let's try to have a closer look on how these two options are established. There are two fundamental dimensions to consider: the two scenarios of acceptance or rejection of the paper. However, in order to give a value for each option we need to consider precisely the costs and rewards: let's call V the reward in case the paper is accepted and l and h the low and high price respectively of the ticket (see figure 1). Considering that the reward is a consequence independent from any action of Alice we get two attributes (the scenarios) with two possible values (h and l) which results in exactly two options.

Let's now focus more on how the monetary consequences are calculated. For the time being we consider the moment in which Alice decides to make a buy commitment and the moment in which she actually buys the ticket the same. What happens if we keep these two moments separated? The reward and the ticket price do not change. However, if there is a time lapse between the commitment to buy and the acquisition itself we can expect that the vendor will add a cost remunerating the time he waits, since Alice could end not buying the ticket ... On the other hand Alice could extend this time lapse until she knows if the paper is accepted ... In other terms if we separate the attribute "time to buy" from the attribute "price of the ticket" and we compute the possible outcomes we end with three possible actions (commit and buy now, commit now and buy later, commit and buy later).

2. With this new idea in mind we can now design a new decision tree (see figure 2). Besides the two branches (alternatives) b (buy now) and $\neg b$ (buy when the paper acceptance decision is taken) we introduce a third branch w: pay a fee (k) fixing the price to l, but allowing to decide whether to actually buy the ticket when the paper acceptance decision is taken. In case the paper is rejected then Alice will lose k, while in case the paper is accepted Alice will pay $l + k$ instead of h. Readers interested in solving the decision tree will note that the branch b is preferred to the branch $\neg b$ for unlikely to occur likelihoods, while the branch w will be preferred to b and to $\neg b$ for more much more likely to occur likelihoods (thanks to a presumably low value of k).

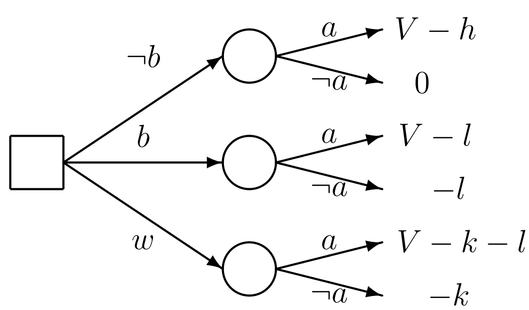

Figure 2: Decision Tree 2

Remark 5.3 *The careful reader will recognise in the above example the ideas behind real options theory. What we present here is current practice both in finance (buy options upon the stock market before any real acquisition of stocks) and is largely used in flexible management under risk and uncertainty (see Brealey & Myers, 2000; Kulatilaka & Trigeorgis, 1994).*

Remark 5.4 *The reader will also note again that what triggers the process for which we generate new alternatives is the client's subjective "insatisfaction".*

6 Conclusions

Our paper is based upon a common knowledge within the Decision Analysis community: for any given decision problem we consider the set of alternatives as "given", but we all know that in reality it is never the case. Alternatives are constructed during the decision aiding process.

In the paper we present a survey of the existing literature showing how little this topic has been considered in the past, despite being considered as crucial. With most papers considering applications to the public sector, the essential proposal consists in trying to explore the neighbourhood of a solution in order to help the decision maker to improve it. Noticeable exceptions include the general framework introduced in Value Theory and the more recent attempts within the Formal Design Theory Community.

Besides the survey, our contribution is twofold. On the one hand we show that constructing a set of alternatives is itself a "decision problem" (in the sense of our generic definition of decision problem), establishing a design recursion to be ended by subjective satisfaction. On the other hand we show that the revision (possibly expansion) of the set of alternatives occurs through separation of attributes describing the values space relevant for the client/decision maker.

Several topics remain obviously open. Among the most interesting ones are naturally the practical ones: how to minimally revise the last decision model (which includes a set of alternatives) in order to generate an improved one with possibly satisfying alternatives? A more general topic concerns the connections, yet to be studied, with Formal Design Theory as well as with existing "change frameworks" (after all we make decisions because we expect to "change" something).

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