Extending Variable Importance in Preference Networks

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Abstract

In many application domains we need to find solutions that satisfy, apart from a set of hard constraints, a set of user defined preferences. Ceteris Paribus (CP)-networks have been proposed as an intuitively appealing framework for expressing preference statements. CP-nets have been further extended to incorporate information on the relative importance of the variables, resulting in a formalism called TCP-nets. Despite their high expressive power, TCP-nets do not capture certain types of preference statements that seem to arise naturally in practice.

In this paper we extend TCP-networks with variable importance statements that specify that a variable is more important than its ancestors in the network. These importance statements may induce preference relations on the set of outcomes that contain conflicting pairs. To handle such cases we propose a new semantics that aggregates preference and variable important information in such a way that preferences on more important variables override preferences on less important variables.

1 Introduction

In many application domains we need to find solutions that satisfy, apart from a set of hard constraints, a set of user defined preferences. Such application domains include decision support systems, product configuration software, constraint optimization, planning and scheduling and many others.

Ceteris Paribus networks or CP-nets [Boutilier et al., 1999; Domshlak and Brafman, 2002; Brafman and Dimopoulos, 2004] have been proposed as a powerful yet simple graphical tool for representing preference statements that most people find intuitive and easy to express. In a CP-net the user describes how her preferences for the values of one variable depend on the values of other variables. For example, a user may want to state that her preference between two car manufacturers depends on the car type. She may prefer the first manufacturer if the car is a 4x4 while she may prefer the second if the car is a saloon. This information can be represented in a CP-net by two nodes, one for the car type and one for the manufacturer and an edge that goes from the first node to the second.

Another kind of preferential statements that are useful in practice are relative importance statements. These are statements of the form: "It is more important that the value of $X$ is high than that the value of $Y$ is high" [Brafman and Domshlak, 2002]. This led to the development of TCP-nets [Brafman and Domshlak, 2002], an extension of CP-nets that can capture relative importance statements. In our car domain, we may want to express that safety is more important than speed, meaning that a better value for safety is more important than a better value for speed. TCP-nets allow us to represent conditional relative importance statements that are more useful than simple relative importance statements. For instance, in a TCP-net we can state that in family cars safety is more important than speed, while in sports cars speed is more important than safety.

The semantics of TCP-nets is based on a ceteris paribus [Doyle and Wellman, 1994; Hanson, 1996] comparison of solutions. This means that if the user states that she prefers the value $x_1$ over the value $x_2$ for some variable $X$, this is taken to mean that between two solutions (or outcomes) that assign identical values to all other variables, she prefers the one that assigns the value $x_1$ to $X$ over the one that assigns $x_2$ to the same variable.

Despite their high expressive power and clear semantics, TCP-nets also have limitations. Indeed, the variable importance semantics introduced in [Brafman and Domshlak, 2002] permits information on the relative importance between two variables only if these variables are conditionally independent. There are however situations where there is importance information about variables that are conditionally dependent. Consider the following simple example.

Maria has the following dining preferences. For food she prefers meat to fish, while her preference for wine depends on the choice of food. If the food is meat she prefers red wine over white wine, whereas when fish is served she prefers white wine to red wine. Moreover, wine is more important to Maria than food. This problem situation can not be captured in TCP-nets as this networks contains information that states that the child is more important than the parent.

In this paper we extend TCP-networks with variable importance statements as the one of the previous example, that specify that a variable is more important than its ancestors in...
Given the value assignments we denote that the projection of possible outcomes of \( V \) to the node of variable \( Y \) if \( X \in Pa(Y) \). The notation \( tr(R) \) denotes the transitive closure of a binary relation \( R \).

**Definition 1** [Wilson, 2004]. Let \( s = p : q_i \succ q_j \) be a preference statement. The relation induced by \( s \) on a set of outcomes \( O \) wrt \( s \) is a binary relation \( R_s = \{(o_i, o_j) | o_i, o_j \in O \text{ and } o_i = wq_i \text{ and } o_j = wq_j \text{ and } w \models p\} \). The relation induced by a CP-net \( N = \{s_1, s_2, \ldots, s_n\} \) is the relation \( R_N = tr(R_{s_1} \cup R_{s_2} \cup \ldots \cup R_{s_n}) \).

Therefore, the criteria aggregation method used in the CP-networks is the disjunctive aggregation.

If \( N \) is an acyclic CP-net the relation \( R_N \) is a strict partial order, ie. it is irreflexive, asymmetric and transitive. The next theorem proves the first two properties of \( R_N \) as transitivity follows from its definition.

**Theorem 1** Let \( N \) be an acyclic CP-net. Then, the relation \( R_N \) is irreflexive and asymmetric.

If \( N \) is an acyclic CP-net we say that the outcome \( o_i \) is strictly preferred to outcome \( o_j \) wrt \( N \), denoted by \( o_i \succ_N o_j \), if \( (o_i, o_j) \in R_N \). We drop \( N \) form \( \succ_N \) when the CP-network to which we refer is clear from the context. The following example illustrates the ranking relation imposed on the set outcomes by the CP-networks.

**Example 1** Let \( N \) be the CP-network defined on the variables \( X, Y, Z \) as follows:

\[
\begin{align*}
  s_1 &=: x_1 \succ x_2 & s_2 &=: y_1 \succ y_2 \\
  s_3 &=: x_2 \succ y_1 & s_4 &=: y_1 \succ z_2 \\
  s_5 &=: y_2 \succ z_1
\end{align*}
\]

The relation induced by each of the above statements are the following:

\[
\begin{align*}
  R_{s_1} &= \{(x_1, y_1 z_1), (x_1 y_1 z_2, x_2 y_1 z_2), (x_1 y_2 z_1, x_2 y_2 z_1), (x_1 y_2 z_2, x_2 y_2 z_2)\} \\
  R_{s_2} &= \{(x_1 y_1 z_1, x_1 y_1 z_2), (x_1 y_2 z_2, x_1 y_2 z_2)\} \\
  R_{s_3} &= \{(x_2 y_2 z_1, x_2 y_2 z_2), (x_2 y_2 z_1, x_2 y_2 z_2)\} \\
  R_{s_4} &= \{(x_1 y_1 z_1, x_1 y_1 z_2), (x_2 y_1 z_2, x_2 y_1 z_2)\} \\
  R_{s_5} &= \{(x_1 y_2 z_2, x_2 y_1 z_2, x_2 y_2 z_2)\}
\end{align*}
\]

The ranking induced by the relation \( R_N = U_{i=1}^5 R_{s_i} \) specifies that \( x_1 y_1 z_1 \succ x_1 y_1 z_2 \succ x_1 y_2 z_2 \succ x_1 y_2 z_1 \succ x_2 y_1 z_1 \succ x_2 y_2 z_2 \). Note that the outcomes \( x_1 y_2 z_1 \) and \( x_2 y_2 z_2 \) are incomparable.

TCP-networks [Brafman and Domshlak, 2002] extend CP-networks with relative variable importance statements. A relative variable importance (or relative importance) statement is of the form \( p: X \triangleright Y \) where \( X, Y \subseteq V \), and the sets \( Pa(X), \{X\}, \{Y\} \) are pairwise disjoint. Intuitively, the meaning of such a sentence is when \( p \) is true we prefer a good value for \( X \) over a good value to variable \( Y \). A variable importance statement induces a binary relation on the set of possible outcomes.

**Definition 2** Let \( v = p : X \triangleright Y \) be a variable importance statement of a TCP-net \( N \). The relation induced by \( v \) on a set of outcomes \( O \) is a binary relation \( R_v = \{(o_i, o_j) | o_i, o_j \in O, o_i = w_{x_i} y_a, o_j = w_{x_j} y_b, x_i \triangleright x_j, \text{ and } wz \models p\} \), where \( x_i, x_j \in dom(X) \) and \( y_a, y_b \in dom(Y) \). The relation
induced by a TCP-net $N$ that contains the preference states $s_1, s_2, \ldots, s_m$ and the variable importance statements $v_1, v_2, \ldots, v_n$ is $R_N = tr(R_{s_1} \cup R_{s_2} \cup \ldots \cup R_{s_m} \cup R_{v_1} \cup R_{v_2} \cup \ldots \cup R_{v_n})$.

We can extend the notion of the graph $G_N$ associated with a CP-nets to the graph associated with a TCP-net $N$, also denoted by $G_N$, by adding to the graph an edge from the node that corresponds to $X$ to the node that corresponds to $Y$ for every variable importance statement of the form $p : X \succ Y$. We can now extend theorem 1 and show that for a TCP-network $N$ with an acyclic graph $G_N$ the relation $R_N$ is a strict partial order.

**Theorem 2** Let $N$ be an acyclic TCP-net. Then, the relation $R_N$ is irreflexive and asymmetric.

As in the case of acyclic CP-networks we say that the outcome $o_i$ is strictly preferred to outcome $o_j$, denoted by $o_i \succ_N o_j$, if $(o_i, o_j) \in R_N$. The next example illustrates the semantics of TCP-networks.

**Example 2** Consider the CP-network of example 1 extended with the variable importance statement $v \equiv X \succ Z$. The associated binary relation is $R_v = \{(x_1y_1z_1, x_2y_2z_2), (x_1y_2z_1, x_2y_1z_2), (x_1y_2z_2, x_2y_1z_1)\}$. Note that the relation $tr(R_{s_1} \cup R_{s_2} \cup R_{s_3} \cup R_{s_4} \cup R_{s_5} \cup R_{s_6})$ is antisymmetric and that the new relation includes the pair $(x_1y_2z_2, x_2y_1z_1)$, i.e. outcomes that were previously incomparable now become comparable.

### 3 Cyclic TCP-Networks

The work of [Brafman and Dimopoulos, 2004] extends the semantics of CP-networks from acyclic to cyclic networks. The semantics of a cyclic CP-network $N$ is defined again by the relation $R_N$, which is now not a strict partial order, as it needs not be irreflexive or asymmetric. Instead, in order to be able to capture the semantics of cyclic CP-networks the relation $R_N$ is required to be a pre-order, that is, a reflexive and transitive binary relation. We can easily turn the induced by a TCP-network $N$ into a pre-order by defining it as $R_N = tr(R_{s_1} \cup R_{s_2} \cup \ldots \cup R_{s_m} \cup R_{v_1} \cup R_{v_2} \cup \ldots \cup R_{v_n}) \cup \{(o, o) \mid o$ is a value assignment to all variables of $N\}$. In the following we omit pairs of the form $(o, o)$ from the relations.

Following [Brafman and Dimopoulos, 2004] we define the semantics of cyclic CP-networks as follows. Given a TCP-network $N$ and two outcomes $o, o'$ we say that $o$ is weakly preferred to $o'$, denoted by $o \preceq o'$ if $(o, o') \in R_N$. We say that $o$ is strongly preferred to $o'$, denoted by $o \succ o'$ if $(o, o') \in R_N$ and $(o', o) \not\in R_N$. Finally, we say that outcomes $o$ and $o'$ are equally preferred, denoted by $\sim$, if $o \preceq o'$ and $o' \preceq o$. The next example illustrates the new semantics.

**Example 3** Consider the CP-net $N'$ on the variables

\[ \text{STATER} = \{\text{sope, salat}\} \]
\[ \text{MAIN} = \{\text{fish, meat}\} \]
\[ \text{WINE} = \{\text{white, red}\} \]

with the following preferences:

\[ \text{salat} \succ \text{sope} \]
\[ \text{fish} \succ \text{meat} \]
\[ \text{red} \succ \text{white} \]
\[ \text{white} \succ \text{red} \]

The ranking on the outcomes of $N'$ induced by the relation $R_N$ is given below, where each variable value is represented by its initial (sa stands for salad and so for soup):

\[ \{(sa, m, r) \succ (sa, m, w), (sa, m, w) \succ (sa, f, w) \succ \{(sa, f, r), (so, f, w) \succ (so, m, r) \succ (so, m, w)\} \}

We extend $N'$ into a TCP-net $N$ by adding the variable importance statement $v = \text{WINE} \triangleright \text{STATER}$. This statement induces the binary relation $R_v = \{\{(sa, m, r), (sa, m, w)\}, (\{sa, m, w\}, \{so, w, \{sa, f, r\}, (\{sa, f, w\}, \{so, f, r\})\} \}$, whereas the relation induced by $N$ is $R_N = R_N \cup R_v$. The outcome $\{sa, m, r\}$ is strictly preferred over all other outcomes, whereas the outcomes $\{sa, m, w\}$, $\{sa, f, w\}$, $\{so, f, r\}$, and $\{so, m, r\}$ are equally preferred.

The simple extension of the semantics of TCP-networks described above captures a wide class of cyclic TCP-networks, but not all. Consider for instance the simple example presented in the introduction.

**Example 4** Maria prefers meat to fish. When the food is meat she prefers red wine over white wine, whereas when fish is served she prefers white wine to red wine. Moreover, wine is more important to Maria than food. The TCP-network $N$ that represents Maria’s preferences will contain the variables \text{FOOD} and \text{WINE} with \text{dom(FOOD)} = \{\text{meat, fish}\} and \text{dom(WINE)} = \{\text{white, red}\}. Network $N$ contains the variable importance statements $s_1 = \text{meat} \succ \text{fish}$ $s_2 = \text{meat} : \text{red} \succ \text{white}$ $s_3 = \text{fish} : \text{white} \succ \text{red}$ The variable importance statement $v = \text{WINE} \triangleright \text{FOOD}$, which is not an acceptable statement in the language of TCP-nets, as it violates the restriction that $P_{\text{WINE}}(\text{WINE})$ and $\{\text{FOOD}\}$ must be disjoint, whereas $P_{\text{WINE}}(\text{WINE}) \cap \{\text{FOOD}\} = \{\text{FOOD}\}$.

In order to be able to handle TCP-networks with cycles of length two, as those of the previous example, we need to extend the the semantics of variable importance statements. This is accomplished by the following definition.

**Definition 3** Let $v = p : X \succ Y$ be a variable importance statement of a TCP-net $N$. The relation induced by $v$ on a set of outcomes $O$ is a binary relation $R_o = \{(o_1, o_2) \mid o_1, o_2 \in O, o_1 = \text{w}_{x_1}y_1, o_2 = \text{w}_{x_2}y_2, x_1 \succ_{x_2} x_2, \text{Z} \setminus \{Y\} = \emptyset, \text{and } \text{wz} \models p\} \cup \{(o_1, o_2) \mid o_1, o_2 \in O, o_1 = \text{w}_{x_1}y_1, o_2 = \text{w}_{x_2}y_2, \exists x' \in \text{dom(X)} \text{ such that } x \succ_{x_1} x' \text{ and } x' \succ_{x_2} x, \text{ with } \text{wz} \models p\}$.

The variable importance statement $v = \text{WINE} \triangleright \text{STATER}$ of network $N$ of example 4 induces the relation $R_v = \{\{(\text{meat, red}), (\text{fish, red})\}, (\{\text{fish, white}\}, \{\text{meat, white}\})\}$. The induced relation is $R_N = \{\{(\text{meat, red}), (\text{fish, red})\}, (\{\text{meat, white}\}, \{\text{fish, white}\}), (\{\text{fish, white}\}, \{\text{meat, red}\}), (\{\text{fish, white}\}, \{\text{meat, white}\})\}$. The relation $R_N$ renders the outcomes \{\text{meat, white}\} and \{\text{fish, white}\} equally preferred. The reason is that there are two criteria, one that postulates that meat is preferred over fish and ranks the outcome \{\text{meat, white}\} higher than the outcome
a variable importance statement of the form \( S_v = R_v - \{(a,b)|(b,a) \in tr(\cup_{k \in F} S_k)\} \). Similarly, if \( v \) is a variable importance statement of \( N \), define \( S_v = R_v - \{(a,b)|(b,a) \in tr(\cup_{k \in F} S_k)\} \).

It is easy to see that \( S_v = R_v - tr(\cup_{k \in F} S_k^{-1}) \) and \( S_v = R_v - tr(\cup_{k \in F} S_k^{-1}) \). We now define the relation induced by a TCP-network.

Definition 7 Let \( N \) be a TCP-net that contains the preference statements \( s_1, s_2, \ldots, s_n \) and the variable importance statements \( v_1, v_2, \ldots, v_m \). The relation induced by \( N \) is \( S_N = tr(s_1 \cup s_2 \cup \ldots \cup s_n \cup v_1 \cup v_2 \cup \ldots \cup v_m) \).

Example 5 Consider the TCP-network \( N \) of example 4. It holds that \( D_{s_1} = \{\text{WINE}\} \) and \( D_{s_2} = D_{s_3} = D_v = \emptyset \). Moreover, \( F_{s_1} = \{s_2, s_3, v\} \) and \( F_{s_2} = F_{s_3} = F_v = \emptyset \).

The relations defined by the preference statements \( s_2 \) and \( s_3 \) of \( N \) are \( s_2 = R_{s_2} = \{(\text{meat, red}), (\text{meat, white})\} \) and \( s_3 = R_{s_3} = \{(\text{fish, white}), (\text{fish, red})\} \). The variable importance sentence \( s \) induces the relation \( S_v = R_v = \{(\text{meat, red}), (\text{fish, red})\} \). The relation induced by the preference statement \( s_1 \) is \( s_1 = R_{s_1} = R_{s_1} - tr(s_1^{-1} \cup s_3^{-1} \cup s_1^{-1}) = \{(\text{meat, red}), (\text{fish, red})\} \). The relation induced by the network \( N \) is \( S_N = s_1 \cup s_2 \cup s_3 \cup s_v = \{(\text{meat, red}), (\text{meat, white})\} \).

The new semantics is illustrated better in the next, more complicated example.

Example 6 Let \( N_1 \) be the TCP-network on the variables \( \text{COCKTAIL} = \{\text{rum, vodka}\} \), \( \text{STARTER} = \{\text{salat, soup}\} \), \( \text{FOOD} = \{\text{meat, fish}\} \), \( \text{WINE} = \{\text{red, white}\} \) with the following preferences
\( s_1 = \text{rum} \succ \text{vodka} \)
\( s_2 = \text{rum} : \text{salat} \succ \text{soup} \quad s_3 = \text{vodka} : \text{soup} \succ \text{salat} \)
\( s_4 = \text{salat} : \text{meat} \succ \text{fish} \quad s_5 = \text{soup} : \text{fish} \succ \text{meat} \)
\( s_6 = \text{salat}, \text{meat} \succ \text{red} \succ \text{white} \)
\( s_7 = \text{soup} : \text{fish} \succ \text{red} \succ \text{white} \)
\( s_8 = \text{soup}, \text{meat} \succ \text{white} \succ \text{red} \)
\( s_9 = \text{salat}, \text{fish} \succ \text{white} \succ \text{red} \)

The variable importance statements are \( v_1 = \text{STARTER} \succ \text{COCKTAIL} \), \( v_2 = \text{FOOD} \succ \text{STARTER} \) and \( v_3 = \text{WINE} \succ \text{FOOD} \). As before, we represent each variable value by its initial (\( s \) stands for salat, so for soup, \( r \) for rum, and \( w \) for red).

The relations induced by the preference statements \( s_6, s_7, s_8, s_9 \) are \( S_{s_6} = R_{s_6} = \{(\text{ru, sa, m, re}), (\text{ru, sa, m, w}), (\text{v, sa, m, re}), (\text{v, sa, m, w})\} \), \( S_{s_7} = R_{s_7} = \{(\text{ru, so, f, re}), (\text{ru, so, f, w}), (\text{v, so, f, re}), (\text{v, so, f, w})\} \), \( S_{s_8} = R_{s_8} = \{(\text{ru, so, m, re}), (\text{ru, so, m, w}), (\text{v, so, m, re}), (\text{v, so, m, w})\} \), \( S_{s_9} = R_{s_9} = \{(\text{ru, sa, f, w}), (\text{ru, sa, f, re}), (\text{v, sa, f, w}), (\text{v, sa, f, re})\} \).
The relation $R_{v_3}$ is $S_{v_3} = R_{v_3} =$
\begin{align*}
&\{(ru, sa, m, re), \ (ru, sa, f, re), \ (v, sa, m, re), \\
&\{v, sa, f, re), \ (ru, sa, f, w), \ (ru, sa, m, w), \\
&\{v, sa, f, w), \ (v, sa, m, w), \}
\end{align*}

The preference statements $s_4$ induces the relation $S_{v_4} = R_{v_4} - \text{tr}(S_{v_4}^1 \cup S_{v_4}^2)$, where $R_{v_4} =$
\begin{align*}
&\{(ru, sa, m, re), \ (ru, sa, f, re), \\
&\{v, sa, m, re), \ (v, sa, f, re), \\
&\{vu, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \\
&\{v, sa, m, w), \}
\end{align*}

Therefore $S_{v_4} = R_{v_4} - \{(ru, sa, m, w), \ (ru, sa, f, w), \\
{v, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \}}$

The preference statement $s_5$ induces the relations $S_{v_5} = R_{v_5} - \text{tr}(S_{v_5}^1 \cup S_{v_5}^2)$, where $R_{v_5} =$
\begin{align*}
&\{(ru, sa, m, re), \ (ru, sa, f, re), \\
&\{v, sa, m, re), \ (v, sa, f, re), \\
&\{vu, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \\
&\{v, sa, m, w), \}
\end{align*}

Therefore $S_{v_5} =\{(ru, sa, m, re), \ (ru, sa, f, re), \ (v, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \}$. 

The variable importance statement $v_2$ induces the relation $S_{v_2} = R_{v_2} - \text{tr}(S_{v_2}^1 \cup S_{v_2}^2 \cup S_{v_2}^3 \cup S_{v_2}^4)$, where $R_{v_2} =$
\begin{align*}
&\{(ru, sa, m, re), \ (ru, sa, f, re), \\
&\{v, sa, m, re), \ (v, sa, f, re), \\
&\{vu, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \\
&\{v, sa, m, w), \}
\end{align*}

Therefore $S_{v_2} =\{(ru, sa, m, re), \ (ru, sa, f, re), \ (v, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \}$. 

The variable importance statement $v_1$ induces the relation $S_{v_1} = R_{v_1} - \text{tr}(S_{v_1}^1 \cup S_{v_1}^2 \cup S_{v_1}^3 \cup S_{v_1}^4)$, where $R_{v_1} =$
\begin{align*}
&\{(ru, sa, m, re), \ (ru, sa, f, re), \\
&\{v, sa, m, re), \ (v, sa, f, re), \\
&\{vu, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \\
&\{v, sa, m, w), \}
\end{align*}

Therefore $S_{v_1} =\{(ru, sa, m, re), \ (ru, sa, f, re), \ (v, sa, m, w), \ (v, sa, f, w), \ (ru, sa, m, w), \}$. 

The relation defined by network $N_1$ is $S_{N_1} = R_1 \cup S_{N_1}^1 \cup S_{N_1}^2 \cup S_{N_1}^3$. The ranking induced by this relation on the outcomes of the network is depicted in figure 1.

Figure 1: Ordered Outcome Classes for the example 6

4 Conclusions and discussion

In this paper we extended TCP-networks with variable importance statements that assert that a variable is more important than some of its ancestors in the network. We introduced a new semantics for such cyclic networks of length two, and a new method for preference aggregation.

The work described in this paper can be also seen as a first attempt to bring together TCP-networks and work from decision theory. When we move from TCP-nets with relatively simple structure to more complicated ones, as those presented here, there is a need for aggregation methods that are stronger than disjunctive aggregation. In decision theory there are several methods which can be used for solving complex preference aggregation problems.

One possibility is a majority based preference aggregation procedure. However, the result of such aggregation procedures is not guaranteed to be an acyclic outcomes graph [Bouyssou, 1996]. Depending on whether we are looking for a ranking or just for the best choice among the outcomes there exist several procedures which allow to find a result from such a graph [Vincke, 1992].

Clearly all such procedures satisfy some properties, but not others. Basically they all require at some point of the procedure to make some arbitrary hypothesis (for instance some require to reduce cycles into equivalence classes). Unfortunately there is no universal procedure solving this problem and there will never exist one [Vincke, 1992]. For each specific problem it is necessary to take into account [Bouyssou et al., 2005]:

- the type of outcome the procedure is expected to provide;
- the properties the procedure has to satisfy or not to satisfy;
- the complexity of each such procedure wrt to the available resources;
- the intuitive correspondence between the procedure and the
client’s requirements.
This will result in an ad-hoc procedure the validity of which
is strictly bounded to the specific problem.

References

Hoos, and D. Poole. Reasoning with conditional ceteris

[Bouyssou et al., 2005] D. Bouyssou, T. Marchant, M. Pir-
ilot, P. Perny, A. Tsoukiás, and Ph. Vincke. Evaluation and
decision models: stepping stones for the analyst. Kluwer

they have special properties? Journal of Multi-Criteria

[Brafman and Dimopoulos, 2004] R. Brafman and Y. Di-
mopoulos. Extended semantics and optimization algo-
rithms for CP-networks. Computational Intelligence, 20,
2004.

[Brafman and Domshlak, 2002] R. Brafman and C. Domsh-
lak. Introducing variable importance tradeoffs into CP-

[Domshlak and Brafman, 2002] C. Domshlak and R. Braf-
man. CP-nets - reasoning and consistency checking. In
Proc. of UAI’02, 2002.

AAAI Spring Sym. on Decision-Theoretic Planning, 1994.

[Hanson, 1996] S. O. Hanson. What is a ceteris paribus pref-

[Vincke, 1992] Ph. Vincke. Exploitation of a crisp relation in
a ranking problem. Theory and Decision, 32(3):221–240,

conditional preference statements. In Proceedings of