Approximating user preferences in online store systems

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ABSTRACT

In many online systems, shoppers are usually overwhelmed by a huge number of outcomes and choices. In practice however, they usually have interest in only some of these choices. While these online shopping systems allow the users to provide some keywords and other information in order to filter and get only what they need, these latter feel that what they get does not necessarily meet their satisfaction. In this paper, we propose a new shopping system that enables the customers to express what they want when buying a product online. More precisely, the users are given the ability to provide their requirements and desires in a friendly and interactive way. The system will then provide a list of suggestions meeting the users' requirements and maximizing their desires. Requirements and desires are managed, in a unique model, respectively as a set of hard constraints and preferences where these latter can be quantitative (numerical), qualitative (ordinal) or both. The branch and bound method is then applied in order to provide the users with a list of best outcomes.

***Index Terms*—** E-commerce, Constraint Optimization, Preferences, Artificial Intelligence.

1. INTRODUCTION

Many online systems involve some interaction with the users in order to understand and answer their needs. In order to succeed, these systems should maximize the user experience with the system. Maximizing user satisfaction can be done by taking his/her desires/preferences into consideration when he/she is looking for a given item. This will result in making the system more popular and earning more reputation among customers. In order for the systems to handle user desires, they should have a proper way to represent, elicit and evaluate user preferences. Thus, reasoning about preferences is a core concept for systems involving a relatively large space of interaction with the user. Moreover, many of these systems exist in a constrained environment. For example, in an online PC configuration system, the user cannot choose two different parts that are incompatible with each other. Therefore, we should consider the situation where constraints and preferences co-exist together. In the current shopping systems, shoppers might face a difficult time to get an appropriate product among a huge set of possibilities of outcomes. Moreover they have the impression that their preferences and needs are not taken into consideration by the system. This has motivated us to develop an online shopping system taking into account the problem requirements and maximizing the users desires. Requirements and desires are managed, in a unique model, respectively through a set of hard constraints and preferences where these latter can be quantitative (numerical), qualitative (ordinal) or both. Hard constraints correspond here to both user and problem requirements and are managed with a Constraint Satisfaction Problem framework (CSP) [1]. We use the C-semiring [2] and the CP-net [3, 4] to represent the set of quantitative and qualitative preferences respectively. The branch and bound method is then applied in order to provide the users with a list of outcomes satisfying the hard constraints and optimizing the preferences. To the best of our knowledge there is no existing interactive system handling problem requirements as well as user preferences expressed in both a qualitative and a quantitative way. Moreover, our system is the first real attempt to cope and use both the C-semiring and the CP-net into the same interactive system.

The rest of the paper is structured as follows. The next section provides a brief background respectively about CSPs, CP Nets, soft constraints and the approximation method. Then, we will discuss the representation of qualitative and quantitative preferences in our online system as well as the approximation process as described in [5]. Our solving method based on the branch and bound algorithm is then presented in Section 4. Finally, in Section 5 we list some concluding remarks and promising future works.

2. CSPS, CP-NETS, SOFT CONSTRAINTS AND THE APPROXIMATION METHOD

A Conditional Preferences network (CP-net) [3, 4] is a graphical model to represent qualitative preferences statements including conditional preferences such as: "I prefer A to B when X holds". A CP-net works by exploiting the notion of preferential independency based on the ceteris paribus (with all other things being without change) assumption. Ceteris Paribus (CP) assumption gives us a clear way to interpret the user preferences. For instance, I prefer A more than B means I prefer A more than B if there was no change in the main properties of the objects. A CP net can be represented by a directed graph where nodes represent features (or variables) along with their possible values (variables domains) and arcs represent preference independencies among features. Each variable X is associated with a ceteris paribus table (denoted as CPT(X)) expressing the order ranking over different values of X given the set of parents Pa(X). An outcome for a CP-net is an assignment for each variable from its domain. Given a CP-net, the users usually have some queries about the set of preferences represented. One of the main queries is the best outcome given the set of preferences. We say outcome o_i is better than outcome o_j if there is a sequence of worsening flips going from o_i to o_j [6]. A Worsening flip is a change in the variable value to a less preferred value according to the variable's CPT.

A Constraint Satisfaction Problem (CSP) [1] is a well-known framework for constraint problems. More formally, a CSP consists of a set of variables each defined on a set of possible values (variable domain) and a set of relations restricting the values that each variable can take. A solution to a CSP is a complete assignment of values to variables such that all the constraints are satisfied. Unlike hard constraints, soft constraints are associated with degrees of satisfaction [7] and the goal is to find the optimal outcome or solution. In Soft CSPs (SCSPs) [2], an optimization problem is investigated where the optimal solution is one solution with the best objective function according to the soft constraints. An SCSP is a generalization of the classical CSP where constraints have several levels of satisfiability that are totally or partially ordered according to the C-semiring structure [2]. The C-semiring is a mathematical model based on the semiring formalism with which to handle different soft constraint problems and extensions. Using the c-semiring, different constraint problems in a unified framework can be represented. More formally, a C-semiring is a tuple (A,+,x, 0, 1) where [8]: A is a set and 0, 1 are elements of A. + is the additional operation defined over a set of elements of A and 0 is the unit element. x is the multiplication operation and 1 is the unit element and 0 is the absorbing element. + is an idempotent operation. That is a + a = a and this can be used to find partial order over A. The partial order over A can be found as a $<$ b iff b is better than a (that is, a + b = b). Using the C-semiring definition, different CSP extensions can be represented, in a unified framework, by giving different semantics to the addition and the multiplication operations [9]. A Weighted CSP (WCSP) is an instance of the C-semiring where the associated value for each tuple represents the cost of that tuple in the final solution. Therefore, the optimal solution in a WCSP is the solution where the associated value is the minimum and the ultimate goal is to minimize the global cost of the problem. In adding two constraints, a WCSP takes the constraint with the minimum tuple value and the total cost could become more than 1. When given a CP-net N, it can be approximated to a soft constraint problem SCSP [5]. This approximation is favorable in many domains, specifically those domains where there is heavy interaction with the user as in online configuration problems [5]. Another advantage of approximating a CP-net to an SCSP is to overcome the complexity of reasoning with CP-nets. Approximation aims to convert the preference statements in the CP-net to soft constraints and reflect the ordering for each statement by giving a higher value to the preferred instantiations for the tuples. Test dominancy ("*is a given outcome better than another*") is known to be computationally difficult in CP-nets. However, an SCSP provides a linear time in response to dominance testing between two outcomes [8, 5].

The main characteristic with which to distinguish different approximations for a particular CP-net is the information preserving property [10]. Information preserving simply means what is already preferred in the CP-net must also be preferred in the approximated SCSP. The process of approximation can be completed in two steps by creating the constraint graph and by calculating the preference values for each variable in the constraint graph. One final step to be completed in order to make the approximated SCSP compatible with the C-semiring framework, is to reflect the weights of the variables to the constraint tuples. This can simply be done by multiplying the weight for each variable X to the set of constraints where X is mentioned.

3. REPRESENTATION OF PREFERENCES IN AN ONLINE SHOPPING SYSTEM

We propose a system with which the user is able to specify his/her preferences and constraints. The system then looks for the optimal item maximizing the preferences and satisfying the constraints. Following the approximation method we introduced in the previous section, our approach approximates the set of qualitative and conditional qualitative preferences to quantitative preferences as an instance of SCSP. It then incorporates the new induced SCSP with the quantitative part of the problem. It is assumed that the customer is capable to state the preferences, and it can be either quantitatively or qualitatively, as it shows in Figure 1. The constraints can be a global constraint; for instance, budget or price limit for the amount of money that the customers are going to spend or local; for instance, incompatibility between different components of the laptop. In this instance, the constraint is the price or the budget of the customer. It is measured when the customer considers the qualitative and quantitative preferences as shown in Figure 2.

The set of qualitative preferences are approximated to SCSP to overcome the computational complexity associated with CP-net. The set of quantitative preferences along with the approximated SCSP forms a SCSP network. This network is implemented with the approximated and quantitative preferences shown in Figure 3. The problem can be solved like any other WSCSP problem where the optimal solution is the solution whose associated value is a minimum. Figure 3 shows

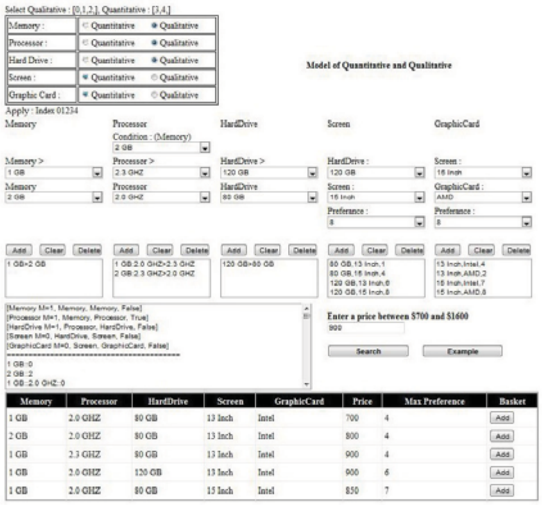

Fig. 1. GUI of our Online Shopping System.

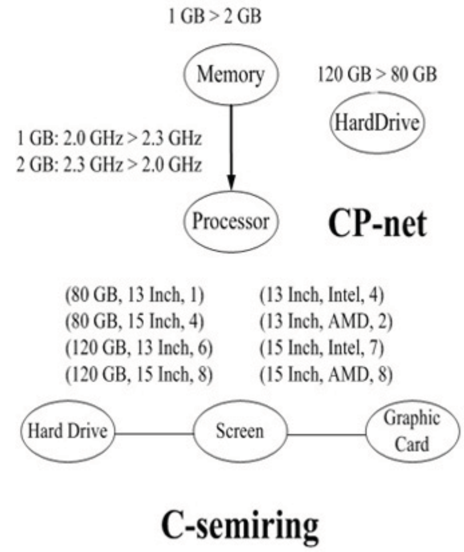

Fig. 2. An example of the CP-net and the SCSP.

the whole network for the quantitative preferences and the approximated CP-net. The variable Memory has a soft unary constraint with the following two tuples: (1, 0) and (2, 2), and also the variable Hard Drive has a soft unary constraint with the following two tuples: (120, 0) (80, 1). The bottom of figure 1 shows more than one optimal solution of the customer, and the first optimal solution for this network is Memory =1 GB, Processor=2.0 GHZ, Hard Drive=80 GB, Screen=15 Inch and Graphic Card=Intel with 4 as the total cost or preference, and the price is $700. Figure 4 presents the architecture of our online system. New customers first need to register and create a new account. They can then log in and choose a brand name and one of the possible ways of inputting their preferences: quantitative (numerical), qualitative (ordinal) preferences or mixed. They can then provide their preferences and ask the system to return the solutions maximizing their desires.

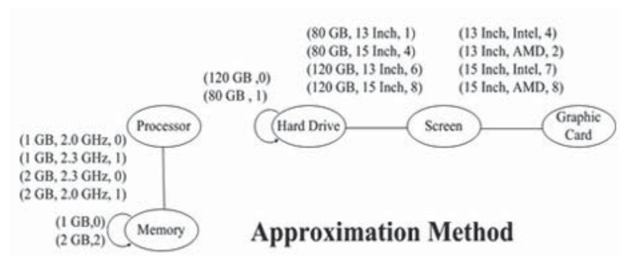

Fig. 3. Approximated (SCSP).

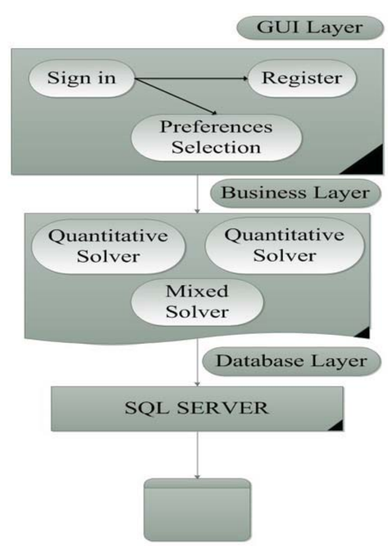

Fig. 4. Software Architecture of our online system.

4. MANAGING PREFERENCES AND CONSTRAINTS: THE SOLVING METHOD

The branch and bound algorithm is a systematic search method for discovering the best solutions to optimization problems. It considers the problem of choosing an optimal laptop according to a set of quantitative preferences in addition to a set of hard constraints. It is assumed that the user is able to specify her/his preferences quantitatively as shown in Figure 1, with a budget of $900. Therefore, the system is constrained to choose the laptops that are less than or equal to $900, and lists all the results as shown at the bottom of Figure 1. The budget is considered here as a global hard constraint. After the list of results suggested to the user are displayed, this latter can save them in his/her basket for further use.

5. CONCLUSION AND FUTURE WORK

In this paper, we proposed an online shopping system based on user preferences and constraints. We considered the case where user preferences can take qualitative, quantitative or both forms. We used the C-semiring and the CP-net to represent the set of quantitative and qualitative preferences respectively. The user specifies his/her preferences then the system looks for the optimal outcome satisfying the set of requirements expressed as hard constraints and optimizing the user preferences. Here we focused upon the online shopping system, however, our work can be generalized to any interactive system where the user is involved in the process of choosing an item among a set of others. Another future work is to manage preferences in the presence of dynamic hard constraints where the user can add or remove some hard constraints and see the effect of these changes on the solutions returned. In this case, we can use a dynamic variant of the constraint solving techniques [11, 12, 13]. While our branch and bound technique is in general capable of returning the optimal solution in a reasonable amount of time, we will investigate several variable and value ordering heuristics [14] that allow this backtrack search algorithm to return the solution in a better running time. We will also explore other techniques based on parallel genetic algorithms[15], ant colony optimization [16] and stochastic local search [17]. While these techniques do not guarantee the best outcome, they are in general very efficient in terms of response time needed to reach the optimal (or near to optimal) solution.

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