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A negotiation framework for heterogeneous group recommendation

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ABSTRACT

Over the last years, some remarkable recommender systems for group of users have been developed. When using most of these systems, each group member communicates his/her preferences to the system, which obtains a group profile as the result of an equal weighting of the individual preferences. This way, no member is particularly dissatisfied with the recommendations. However, this is not a realistic situation, given that not all the members in a group act in the same manner. This paper deals with the problem of recommendation for a group of users, where, besides his/her own preferences, each user may have different expectations about the result of the recommendation and may exhibit a different behaviour with respect to the other group members. Moreover, all this information is private and may be revealed under certain circumstances. In this context, we have opted for building a multi-agent system, where an agent acts on behalf of one group member. We have implemented a *UserAgent* that can be configured in order to exhibit the behaviour desired by the corresponding user. Then, different *UserAgents* negotiate with the aim of building a group profile that satisfies their particular minimum requirements, while preserving some privacy. Moreover, we have designed a *NegotiatorAgent*, which governs the negotiation and may act as a mediator in order to facilitate the agreement. Finally, we have performed some experiments that show that this mechanism is able to give a response in this heterogeneous environment.

1. Introduction

A *Recommender System* (RS) (Resnick and Varian, 1997) is a personalization tool that attempts to provide people with lists of items that best fit their individual tastes. A RS infers the user's preferences by analyzing the available user data, information about other users and information about the environment. While many RSs are focused on making recommendations to a single user, many daily activities such as watching a movie or going to a restaurant involve a group of users (Boratto, 2011), in which case recommendations must take into account the tastes and preferences of all the users in the group (Ardissono et al., 2003). This type of system is called a *Group Recommender System* (GRS). Over the last few years, GRSs have been an active area of research within the field of RS. As a result, some remarkable GRSs have been developed. For example, *Polylens* (O'Connor et al., 2001) recommends movies, as an extension of the MovieLens recommender; *MusicFX* (McCarthy and Anagnost, 1998) selects a radio station among 91 stations; *Intrigue* (Ardissono et al., 2003), *The Collaborative Advisory Travel System* (McCarthy et al., 2006) and *Travel Decision Forum* (Jameson, 2004; Jameson et al., 2004) deal with a tourist domain; *GRSK* (Garcia et al., 2012; Garcia et al., 2011) is a generic GRS that can be used with any application domain.

The main issue in group recommendation is to identify the items that are likely to satisfy all the group members adequately (Jameson, 2004; Plua and Jameson, 2002). Most of the GRSs lately developed are based on the aggregation of the preference models of individual users into a group model that is then used to elicit a recommendation that is satisfactory for the whole group (Jameson, 2004; Plua and Jameson, 2002). This *centralized* view has two main implications:

- Most GRSs tend to favour an equal weighting of the individual preferences when recommending an item for the group such that no member is particularly dissatisfied with the decisions. However, some authors criticize these aggregation strategies because the ratings are combined always in the same way without considering how the members in the group interact with each other (Chen et al., 2008; Recio-Garcia et al., 2009). For example, we can find a person that wants to favor a specific user or that feels more comfortable when accepts the others' proposals instead of trying to impose his/her preferences over the other group members. That is, new trends in GRSs

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(Masthoff, 2005; Recio-Garcia et al., 2009) argue that it is more realistic to capture the different attitudes of each member in the group with respect to the others.
- Centralized systems need that the user communicates his/her preferences to the system in order to provide a recommendation. However, not all the users feel comfortable in this situation, given that they consider that preferences are delicate information which should not be revealed to everybody. That is, a GRS can be also considered as a *distributed system*, where each user has private information and the system only knows the information that the user wishes to make public.

In summary, the problem we are facing in this work has the following characteristics:

- It is a *group recommendation* problem, where a group of users want to obtain a recommendation of a list of items that match their preferences as a whole.
- Each group member has his/her own preferences and may exhibit a *different behaviour*. For example, different users may have different expectations about the resulting group profile, may want to impose their preferences over the other users' preferences or may like better to agree with the others' proposals.
- Both the preferences and the user expectations are *private information* to each user, who decides which information he/she wants to share with the other users at any given moment.

Therefore, the task of the GRS is to manage, joint with the individual preferences, some other aspects of the users' behaviour to come up with a common group profile, only taking into account the information provided by the users until this moment. This may imply, for example, that the final list of recommended items in our case may contain more items suitable for a user than for another and both can be equally satisfied.

In order to deal with this problem, we have opted for *building a multi-agent system (MAS)* (Wooldridge, 2002), where multiple agents work together in order to obtain a recommendation for the whole group. That is, ours is not a centralized system responsible of computing the group preference model; instead, the users themselves (i.e. the agents that represent the users), coordinated by another agent acting as a host, are responsible of obtaining the group profile by means of a negotiation process. Specifically, the tasks performed by these agents are: (1) building the individual preferences model, (2) reaching an agreement about the group profile and (3) selecting the recommended items for all the group members according to the obtained group profile.

The group profile is built by means of a negotiation process (Jennings et al., 2001; Lenar and Sobecki, 2007), whose goal is to reach an agreement about the preferences that are included in the group model, that is, an agreement about the preferences that are shared by all the group members and at which degree. If the negotiation process has been successful, these preferences are then used to select the list of recommended items for the whole group, which is then shown to the real users. The negotiation process in our GRS is a variation of the model of *alternating offers* (Kraus, 2001) in a multi-party setting. Each agent that represents a real user in the MAS (named *UserAgent*) knows the preferences of this user, but may share only some information with the other agents. In this paper, we introduce an example of UserAgent that can be configured by the real user for exhibit a certain behaviour during the negotiation. This different behaviour can be implemented as different utility functions, different agreement thresholds or different criteria to accept or reject the proposals from other users. Apart from the agents representing the real users, there is a *host agent* that is in charge of controlling the negotiation process, collecting the user proposals and creating a common proposal to all the users. Moreover, this agent may also participate in the negotiation as a mediator to help the agents to reach an agreement.

The advantages of our solution for the resolution of the group recommendation problem are:

1. The fact that each user may exhibit a different behaviour is easily captured by the behaviour of each agent, who decides which proposals are accepted or rejected. This results in a more flexible system.
2. Negotiation is a method that captures well the group dynamics when the agents involved have different behaviours.
3. Users do not need to communicate all their preferences to the system, so that privacy is preserved (at some extent).

The paper is organized as follows. Section 2 summarizes the state of the art on the use of MAS in recommender systems and the management of the particular behaviour of each user in group recommendation. Section 3 gives an outline of the MAS and the agents that participate in the recommendation process. Section 4 introduces the negotiation framework for obtaining the group profile and all the components (protocol, messages, etc.). Section 5 details the strategy of the host agent and Section 6 gives an example of strategy for a user agent. Section 7 shows an example of a negotiation process, summarizes some experiments performed to test our distributed approach and analyzes how different settings for the agents may affect to the result of the recommendation. We finish with some conclusions in Section 8.

2. Background

The main issue in GRS is to identify the items that are likely to satisfy all of the group members adequately (Jameson, 2004; Plua and Jameson, 2002). Some GRSs build a group profile that considers the tastes and preferences of the whole group by using aggregation methods to elicit the group profile, associating a weight or degree of interest to each preference in the group profile. There are many remarkable GRS based on the elicitation of preferences; examples include *Intrigue* (Ardissono et al., 2003), *Polylens* (O'Connor et al., 2001), *MusicFX* (McCarthy and Anagnost, 1998), *Let's Browse* (Lieberman et al., 1999), *The Collaborative Advisory Travel System, CATS* (McCarthy et al., 2006) and *GRSK* (Garcia et al., 2012). A description of these GRSs joint with a classification upon different features can be found in Boratto (2011), de Campos et al. (2009), Garcia et al. (2012) and Masthoff (2011).

As explained above, these systems collect the preferences of all the group members and combine them in order to obtain a recommendation that equally satisfies the group as a whole. This implies that every individual is considered as equal to the others and, therefore, how the members in the group interact with each other is ignored. Besides, it can be very difficult to obtain a single recommendation that satisfies every member for heterogeneous groups. Moreover, the general group satisfaction is not always the aggregation of the satisfaction of its members as different people may have different expectations (Recio-Garcia et al., 2009). In summary, the decision of a group member whether or not to accept a given recommendation can depend not only on his/her evaluation of the content of the recommendation but also on his/her beliefs about the evaluations of the other group members and about their motivation (Jameson et al., 2003).

Recently, some GRSs that consider the different behaviours and attitudes of the group members have appeared. For example, Recio-Garcia et al. (2009) proposes a GRS that takes into account the personality of each group member to weight the influence of his/her ratings during the recommendation process. A *conflict*