Improving Group Recommendations using Personality, Dynamic Clustering and Multi-Agent MicroServices

Patrícia Alves*
GECAD/LASI, Superior Institute of Engineering of Porto, Polytechnic of Porto, Porto, Portugal, ALGORITMI, University of Minho, Braga, Portugal
pat@isep.ipp.pt

André Martins
GECAD/LASI, Superior Institute of Engineering of Porto, Polytechnic of Porto, Porto, Portugal
1180534@isep.ipp.pt

Paulo Novais
ALGORITMI/LASI, University of Minho, Braga, Portugal
pjon@di.uminho.pt

Goreti Marreiros
GECAD/LASI, Superior Institute of Engineering of Porto, Polytechnic of Porto, Porto, Portugal
mgt@isep.ipp.pt

ABSTRACT

The complexity associated to group recommendations needs strategies to mitigate several problems, such as the group's heterogeinity and conflicting preferences, the emotional contagion phenomenon, the cold-start problem, and the group members' needs and concerns while providing recommendations that satisfy all members at once. In this demonstration, we show how we implemented a Multi-Agent Microservice to model the tourists in a mobile Group Recommender System for Tourism prototype and a novel dynamic clustering process to help minimize the group's heterogeneity and conflicting preferences. To help solve the cold-start problem, the preliminary tourist attractions preference and travel-related preferences & concerns are predicted using the tourists' personality, considering the tourists' disabilities and fears/phobias. Although there is no need for data from previous interactions to build the tourists' profile since we predict the tourists' preferences, the tourist agents learn with each other by using association rules to find patterns in the tourists' profile and in the ratings given to Points of Interest to refine the recommendations.

CCS CONCEPTS

• **Computing methodologies**; • **Multi-Agent systems**; • **Information systems**; • **Clustering; Association rules; Recommender Systems**; • **Computer systems organization**; • **Cloud computing**;

KEYWORDS

Group Recommender Systems, Multi-Agent Microservices, Personality, Dynamic clustering, Affective computing, Leisure tourism

*Corresponding Author

RecSys '23, September 18–22, 2023, Singapore, Singapore

ACM ISBN 979-8-4007-0241-9/23/09.
https://doi.org/10.1145/3604915.3610653

ACM Reference Format:
Patrícia Alves, André Martins, Paulo Novais, and Goreti Marreiros. 2023. Improving Group Recommendations using Personality, Dynamic Clustering and Multi-Agent MicroServices. In *Seventeenth ACM Conference on Recommender Systems (RecSys '23), September 18–22, 2023, Singapore, Singapore.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3604915.3610653

1 INTRODUCTION

The travel and tourism domain is very complex and the emergence of Group Recommender Systems (GRS) [1-5] came to help tourists plan their trips and provide better and more personalized recommendations. Due to that complexity, like the groups' heterogeneity and conflicting preferences (especially in occasional groups), several GRS are being proposed to improve recommendations, using different techniques like preference negotiation, emotions, pairwise preferences, location-based social networks [2, 3, 6-10], or even Multi-Agent Systems (MAS) [11-18]. However, issues like (i) providing the first recommendations independently of the users interaction with the system, negotiation or feedback, (ii) diminishing the group's heterogeinity and conflicting preferences, (iii) providing (explainable) recommendations at a certain destination while caring for the tourists' needs, and (iv) avoiding the emotional contagion phenomenon usual in groups [19, 20] are still open in GRS [4, 19, 21, 22].

Hoping to tackle some of the open issues, we improved our previous work [23], a GRS for tourism prototype, Grouplanner, that beside using Multi-Agent MicroServices (MAMS), introduces three other novelties in GRS: the prediction of the tourists' attraction preference and travel-related preferences & concerns based in their five dimensions of personality, dynamic clustering to group tourists with similar personalities, and association rules to refine the recommendations.

Several studies show that personality is strongly related to the users' preferences in several domains [24-27], including tourism, which can be a leverage to solve the cold-start problem. Based in our previously proposed models [27], which predict tourist attraction preferences[1] and travel-related preferences & concerns[2]

[1]Adrenaline Activities; Wild Nature Activities; Party, Music & Nightlife; Sun, Water & Sand; Museums, Boat Trips & Viewpoints; Theme & Animal Parks; Cultural Heritage; Sports & Games; Gastronomy Events; Health & Well-being; Natural Phenomena
[2]Previsibility and Safety; Cultural & Learning Experiences; Uniqueness & Exoticness; and Familiarity

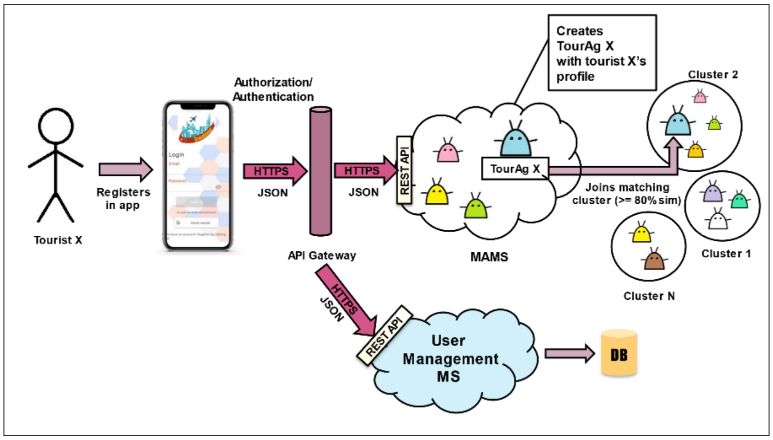

Figure 1: Registering a tourist user in the application with dynamic clustering (simplified diagram)

just by knowing the tourists' five dimensions of personality [28], the developed GRS provides a preliminary list of POI to visit. Besides using the tourists' personality for the referred predictions, the agents use their communication skills to ask for the other tourists' knowledge and travel experience to help improve the recommended list of POI. Using the tourists' personality, the MAMS dynamically creates clusters of tourists with similar personalities which are then used to divide the main excursion group into subgroups of similar personalities and therefore similar tourist preferences, diminishing the group's heterogeinity and conflicting preferences. We believe this can also reduce the time needed to reach a consensus on the final list of POI to visit, the number of interactions and reduce or even eliminate the negotiation phase. This paper briefly describes the referred implemented improvements, more detailed in the demonstration video[3].

2 THE GROUPLANNER PROTOTYPE

The developed GRS prototype is intended to help (occasional) groups of tourists choose which POI to visit at a certain destination based on their profile, mainly their personality, disabilities and fears/phobias. The prototype is fully functional and can be installed and used by any potential users or groups of users to get individual or group recommendations[4].

2.1 The MicroServices architecture

The GRS is based on a microservices architecture, implemented using .NET, composed of five microservices published in a Microsoft Azure server: the User Management MS (UMMS), the Social Network MS (SNMS), the POI MS (POIMS), the Multi-Agent MS (MAMS), and the Recommendation Engine MS (REMS). The MAMS was developed using the ActressMAS [5] multi-agent framework. More details are further described in [23].

2.2 Using MAMS, personality, dynamic clustering and association rules to improve recommendations

2.2.1 User registration with dynamic clustering. When a tourist registers in the app, his profile is first sent in a JSON via HTTPS POST to the UMMS (https://<domain>/gp/user/registerUser), and then to the MAMS, responsible for creating a matching agent (TourAg X) modeled with his initial profile (demographic data, personality, disabilities, fears/phobias). If the tourist is the first person to register in the app, a cluster, using his five dimensions of personality scores as the centroid, is dynamically created (Figure 1). When another tourist registers, her similarity to the center of the existing cluster is calculated (normalized Euclidean distance). If her personality is at least 80% similar to the existing tourist, she is added to the same cluster. If not, a new cluster is created based on her personality, and so on.

Grouplanner allows tourists to register visited POI and rate them from 1 to 5 stars, as well as define if they want to visit the same POI again. These functionalities, along with the tourists' profile, are important to improve the recommendation process, i.e., an agent can learn from the other agents' travel experience and profile.

2.2.2 Group Recommendations. When a tourist creates an excursion group (group owner), a JSON containing the group's data is sent via HTTPS POST to the MAMS (https://<domain>/mams/agents/groups/registerGroup), which then creates a Travel Agent Y (TrvAg-<GroupID>) representing the group. When the group owner requests a group recommendation, an HTTPS request is sent to the respective TrvAg (https://<domain>/mams/agents/groups/<groupID>/requestRecommendation). At the moment a group recommendation is received, to help minimize the group's heterogeneity and conflicting preferences, if at least three tourists belong to the same cluster, a subgroup with the agents belonging to that cluster is created, with a centroid based in their average personality scores, as well as a Subgroup Travel Agent (TrvAg-<GroupID>Sub<clusterID>) responsible for the subgroup members communication (Figure 2). Using the previously proposed models [27], each subgroup's tourist attractions preference and travel-related preferences & concerns are predicted by the subgroup's centroid score in the five dimensions of personality, and posteriorly sent to the REMS to build the first recommendations.

[3]Accessible at https://youtu.be/up0A3B_e6zU
[4]Available at http://www.gecad.isep.ipp.pt/grouplanner/dissemination.html as an installable Android APK. The API can be provided on request.

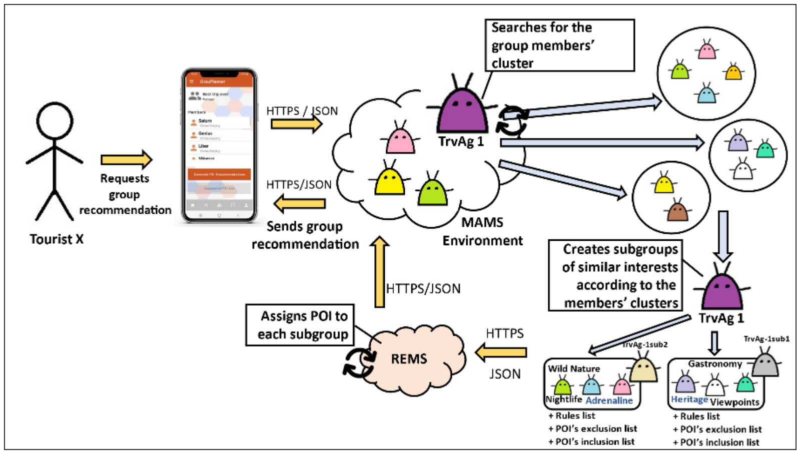

Figure 2: Simplified diagram for the group recommendation process

The Subgroup TrvAg then asks the subgroup's cluster members for their travel history (visited POI, respective rating, revisit intention, and rating preference for unvisited POI), if available, and searches for positive and negative association rules in the respective cluster using the apriori algorithm, adding them to a list of rules. If 50% or more tourists in a subgroup match a certain rule for a POI, that POI is added to a POI exclusion or inclusion list, whether it is a negative or positive rule, respectively, so that and other similar POI are (not) included by the REMS in the recommendation list for that subgroup. Also, if a POI in the subgroup's members travel history has a mean rating of less than 3 stars, that POI is added to the subgroup's POI exclusion list. If all tourists have similar personalities, the main group will prevail, and the recommendations will be for the whole group. In case there are tourists from different clusters that were not enough to create a subgroup, they are compared to the existing subgroups and added to the most similar one, but without changing the subgroup's centroid. The same applies to tourists with a similarity below 80%. After creating the subgroups, the TrvAg sends a JSON via HTTPS POST to the REMS containing the subgroups characteristics and their POI lists.

The REMS then searches for the N best matching POI for each subgroup in a POI ontology, considering the respective POI lists, the preferred predicted tourism categories and travel related preferences & concerns, and possible disabilities and fears/phobias. Then, it answers the requesting TrvAg with the list of POI suggested for each subgroup. The TrvAg then answers to the GRS app, which creates the suggested subgroups and presents them in the subgroup's interface along with their respective POI recommendation list, allowing each subgroup's members to anonymously rate the recommended POI. If at least 50% of the members in a subgroup rate a POI below 3 stars, it is added to the subgroup's POI exclusion list and to the respective rater and cluster's members POI history. If the group owner asks for new recommendations, all POI rated below 3 will be replaced by new POI.

2.2.3 Individual Recommendations. The prototype also allows requesting individual recommendations. The recommendation process is the same as for the group recommendations, but the recommendation request is directly asked to the tourist's agent (https://<domain>/mams/agents/tourists/<username>/requestRecommendation). If the tourist rates (un)visited POI that were never rated by tourists in his cluster, the rating is replicated for those tourists and replaced by the real rating if the tourist visits and rates them.

3 CONCLUSIONS

In this demonstration, we briefly described Grouplanner, a GRS for tourism prototype, that can be used by individuals or (casual) groups of tourists to obtain recommendations of POI to visit. The microservices architecture allows requests from any HTTP client, namely: tourist registration, request of individual recommendations, creation of excursion groups, request of group recommendations, and rating of the recommendation lists and visited POI.

The first POI recommendations are provided without the need for the users interaction, negotiation or feedback, solving GRS open issue (i); the dynamic clustering and division of the main group into subgroups of similar personality tourists diminishes the group's heterogeinity and conflicting preferences, tackling issue (ii); all presented recommendations consider the tourists' travel-related preferences & concerns, disabilities and fears/phobias, are accompanied by a description of the tourism category they belong to, and the 3 top tourism categories that characterize each subgroup (or the main group) are presented to the tourists, solving issue (iii); and finally, the emotional contagion phenomenon, issue (iv), is mitigated by dividing the main excursion group into subgroups of similar tourists and forcing the tourists to anonymously rate the recommended POI lists, only presenting the (sub)groups overall rating when all tourists have individually rated the suggested POI.

To test the prototype, a simulation with real users (n = 35) was performed. The results are currently in a work that is under peer review, but the dataset used can be consulted at the Grouplanner website.[5].

[5]Under the "Simulations" tab at http://www.gecad.isep.ipp.pt/grouplanner/dissemination.html

ACKNOWLEDGMENTS

This work was supported by the smarTravel Project under the European Regional Development Fund POCI-01-0247-FEDER-179946, and by national funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within the Projects UIDB/00319/2020 and UIDP/00760/2020.

REFERENCES

[1] Ardissono, L., Goy, A., Petrone, G., Segnan, M. and Torasso, P. Intrigue: personalized recommendation of tourist attractions for desktop and hand held devices. *Applied artificial intelligence*, 17, 8-9 (2003), 687-714.

[2] Garcia, I., Sebastia, L., Onaindia, E. and Guzman, C. A group recommender system for tourist activities. In *Proceedings of the International conference on electronic commerce and web technologies* (2009). Springer, 2009.

[3] Nguyen, T. N. and Ricci, F. A chat-based group recommender system for tourism. *Information Technology & Tourism*, 18, 1-4 (2018), 5-28.

[4] Alves, P., Carneiro, J., Marreiros, G. and Novais, P. *Modeling a mobile group recommender system for tourism with intelligent agents and gamification.* Springer, 2019.

[5] Leon, F. ActressMAS, a. NET Multi-Agent Framework Inspired by the Actor Model. *Mathematics*, 10, 3 (2022), 382.

[6] Park, M.-H., Park, H.-S. and Cho, S.-B. Restaurant recommendation for group of people in mobile environments using probabilistic multi-criteria decision making. Springer, 2008.

[7] Álvarez Márquez, J. O. and Ziegler, J. *Hootle+: A group recommender system supporting preference negotiation.* Springer, 2016.

[8] Abolghasemi, R., Engelstad, P., Herrera-Viedma, E. and Yazidi, A. A personality-aware group recommendation system based on pairwise preferences. *Information Sciences*, 595 (2022), 1-17.

[9] Sojahrood, Z. B. and Taleai, M. Hybrid POI Group Recommender System based on group type in LBSN. *Expert Systems with Applications* (2023), 119681.

[10] Bekkerman, P., Kraus, S. and Ricci, F. *Applying cooperative negotiation methodology to group recommendation problem.* 2006.

[11] Borràs, J., Moreno, A. and Valls, A. Intelligent tourism recommender systems: A survey. *Expert Systems with Applications*, 41, 16 (2014), 7370-7389.

[12] Ravi, L., Devarajan, M., Sangaiah, A. K., Wang, L. and Subramaniyaswamy, V. An intelligent location recommender system utilising multi-agent induced cognitive behavioural model. *Enterprise Information Systems*, 15, 10 (2021), 1376-1394.

[13] Selmi, A., Brahmi, Z. and Gammoudi, M. *Multi-agent recommender system: State of the art.* 2014.

[14] Neto, J., Morais, A. J., Gonçalves, R. and Coelho, A. L. *Multi-Agent-Based Recommender Systems: A Literature Review.* Springer, 2022.

[15] Julian, V. and Botti, V. *Special Issue on Multi-Agent Systems.* Multidisciplinary Digital Publishing Institute, 2023.

[16] Batet, M., Moreno, A., Sánchez, D., Isern, D. and Valls, A. Turist@: Agent-based personalised recommendation of tourist activities. *Expert Systems with Applications*, 39, 8 (2012), 7319-7329.

[17] Lorenzi, F., Loh, S. and Abel, M. *Personal Tour: A Multi-Agent Recommender System of Travel Packages.* IGI Global, 2012.

[18] Wallinger, S., Grundner, L., Majic, I. and Lampoltshammer, T. J. *Agent-Based Modelling for Sustainable Tourism.* Springer, 2023.

[19] Delić, A., Nguyen, T. N. and Tkalčič, M. Group decision-making and designing group recommender systems. *Handbook of e-Tourism* (2020), 1-23.

[20] Delic, A. and Masthoff, J. Group Recommender Systems. In *Proceedings of the Proceedings of the 26th Conference on User Modeling, Adaptation and Personalization* (2018). ACM, 2018.

[21] Masthoff, J. *Group recommender systems: aggregation, satisfaction and group attributes.* Springer, 2015.

[22] Ricci, F. *Recommender systems in tourism.* Springer, 2022.

[23] Alves, P., Gomes, D., Rodrigues, C., Carneiro, J., Novais, P. and Marreiros, G. *Grouplanner: A Group Recommender System for Tourism with Multi-agent MicroServices.* Springer International Publishing Cham, 2022.

[24] Tkalcic, M. and Chen, L. *Personality and recommender systems.* Springer, 2015.

[25] Cantador, I., Fernández-Tobías, I. and Bellogín, A. *Relating personality types with user preferences in multiple entertainment domains.* Shlomo Berkovsky, 2013.

[26] Martijn, M., Conati, C. and Verbert, K. "Knowing me, knowing you": personalized explanations for a music recommender system. *User Modeling and User-Adapted Interaction* (2022), 1-38.

[27] Alves, P., Martins, H., Saraiva, P., Carneiro, J., Novais, P. and Marreiros, G. Group Recommender Systems for Tourism: How does Personality predict Preferences for Attractions, Travel Motivations, Preferences and Concerns? *User Modeling and User-Adapted Interaction* (2023), 1-70.

[28] Costa, P. T. and MacCrae, R. R. *Revised NEO personality inventory (NEO PI-R) and NEO five-factor inventory (NEO-FFI): Professional manual.* Psychological Assessment Resources, Incorporated, 1992.