Collaborative Privacy Management in Online Social Networks

(Doctoral Consortium)

Onuralp Ulusoy
Bogazici University
Istanbul, Turkey
onuralp.ulusoy@boun.edu.tr

ABSTRACT

Online Social Networks (OSNs) are widely used media for users to share various types of contents with their connections. These contents tend to contain private information of users. In most cases, the extent of privacy might not just include the publisher of the content, but also other OSN users that are related to it. Satisfying all privacy requirements of the related users for a content is an important but difficult task, since these requirements might be in conflict. Hence, resolution of the privacy disputes in such cases is essential. Accordingly, we propose a collaborative privacy management system with an agent-based model, where agents represent users and manage their privacy requirements with a modified version of Clarke-Tax mechanism that achieves fair handling of privacy settings and taxes the agents whose privacy settings are chosen.

KEYWORDS

Privacy; Online Social Networks; Auctioning

ACM Reference Format:

Onuralp Ulusoy. 2018. Collaborative Privacy Management in Online Social Networks. In *Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), Stockholm, Sweden, July 10–15, 2018,* IFAAMAS, 3 pages.

1 INTRODUCTION

Online social networks are widely used systems by a large number of users [1]. Most of these users share contents over OSNs and the shared contents might reveal personal information about the user that owns the content, as well as others that are affiliated with it. Therefore, preservation of privacy must not just take the uploader of a content into consideration, but also other users whose privacy requirements might be affected from sharing of the content. This leads to the concept of *collaborative privacy management* [6], where all related users should be able to submit their opinions about if and how a content is to be shared.

Collaborative privacy management is challenging, since the privacy requirements of users are not always coherent, which might result in conflicts over shared content over OSNs. Resolution of these conflicts is a hard task, mainly because it requires human effort and time. Most of the OSN users would not be able to spend much time on conflict resolution for every piece of shared content they are related with. Current OSNs only allow options for uploaders to adjust privacy settings. For example, a person tagged in a photo cannot request a friend of an uploader to be removed from the audience over the network. In real life, users deal with these conflicts offline, through personal communication [7]. In order to be able to handle them online, decision mechanisms should be in place. Recently, multi-agent agreement techniques have been used to address collaborative privacy management. Kekulluoglu *et al.* [4] and Such and Rovatsos [9] propose negotiation-based approaches that enable users to reach a consensus on how to share a content. Kokciyan *et al.* [5] use argumentation to enable one user to persuade the other into sharing with her own privacy constraints. These approaches have been successful but require heavy computations; that is, they can only be used when the entities can reason on its privacy policies and communicate with others intensively.

On a different line, Squicciarini *et al.* [8] propose a model where users enter auctions for deciding on a policy that requires collaborative management over a content, based on Clarke-Tax mechanism [2, 3]. However, with its current state, the system is open to abuse by the users, such that a single user's privacy can be ignored repeatedly when all others collaborate strongly.

In this thesis, we propose an agent-based collaborative privacy management system called PANO with three main contributions to the field. Our first contribution is the employment of the agents to reduce user involvement in decisions. The second one is a fair reward mechanism, which aims to both prevent privacy violations and encourage more content sharing in OSNs. Our third main contribution is a group-wise currency system for auctions with a goal to prevent abuse by malicious users in the environment.

Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), M. Dastani, G. Sukthankar, E. André, S. Koenig (eds.), July 10–15, 2018, Stockholm, Sweden.

2 AUCTIONING PRIVACY

Auctions are mechanisms that can be used for many purposes, such as decision making, buying/selling goods etc. The outcome of an auction is affected by the conflicts between participants, and the result is in favor of the parties that bid successfully. Collaborative privacy management is yet another area that auctions can be beneficial. An auction mechanism for deciding which actions for content sharing to be taken, where participants bid according to their privacy constraints; is suitable for this context. In our model, we employ Clarke-Tax mechanism with an agent-based approach.

2.1 Background: Clarke-Tax Mechanism

Clarke-Tax mechanism [2] provides an auction mechanism, similar to English auctions where participants bid for different, possible actions in the environment. The action that receives the highest total bids from the participants wins and is executed. Different from an English auction, participants who aid in the winning action to be chosen, i.e., that bid towards it, are taxed according to the value they put on it. This is achieved by subtracting the bid values of every single user from the overall values. If the subtraction of a single user's bid changes the overall decision, it shows that the user's bid on this action had a *decisive* value. Thus, the user is taxed with the difference of the actual action's score and the score of action to be taken if that user was not present in the auction.

Table 1: Three User Bids for Sharing an Image

Users	No Share	Limited Share	Public Share
Alice	15	5	0
Bob	0	5	10
Carol	0	0	8

In the context of collaborative privacy, Clarke-Tax mechanism is used to decide on how an image is going to be shared. Squicciarini *et al.* [8] consider three types of sharing actions: *no share*, *limited share*, and *public share*. We follow the same scheme here. When an image is about to be shared, all the relevant participants bid on these three possible actions. Table 1 shows an example of biddings of three users for deciding to share or not share a content. Users decide based on their own importance of the three actions. According to the example, Alice bids the most for *no share* action, while Bob and Carol bids mostly for *public share* action.

According to the biddings of all users, Clarke-Tax auction mechanism decides on which action to take. Based on the bids from Table 1, *no share* action receives a total of 15, all coming from Alice, while *limited share* receives a total of 10 from both Alice and Bob. *public share* has the total amount of 18 with bids from Bob and Carol. Since the highest sum of bids is for *public share*, this action is selected. Table 2 shows the resulting decision and applies the taxes according to the Clarke-Tax algorithm. Since both Bob and Carol's presence affects the final decision, they are both taxed. Bob's tax is more than Carol's because his bid is greater, therefore his bid in the final decision has more effect than Carol's

2.2 Challenges

Auctioning with Clarke-Tax Mechanism is an efficient way of negotiation, since it has been shown that truthfulness is the best strategy for bidding [8]. The bidder who overvalues a decision to get its way can be taxed with a greater amount, because it changes the group decision by spending system currency way more than the other participants of the auction. This results in the participants bidding with truthful values, while trying to establish its own decision and not get taxed with a greater amount. Even with the notion of truthfulness, the approach used in [8] still has some limitations that can result in abuse by the bidders or inflation in the currency used.

Another drawback of Squicciarini *et al.* [8] is that it requires user involvement for every single auction. This could be necessary for some cases, but it could become a tedious task for greater number of contents. Also, unavailability of some users in auctions who are related to a content that has privacy conflicts could make the method get stuck, or decide on a semi-successful policy. To resolve these issues, an automated auction process where software agents represent the users and act on their behalf can be implemented.

Table 2: Clarke-Tax Mechanism Example - Decision and Taxes

Values	No	Limited	Public	Taxes
Overall	15	10	**18**	
Without Alice	0	5	**18**	0
Without Bob	**15**	5	8	7
Without Carol	**15**	10	10	5

3 AGENT-BASED BIDDING

3.1 Privacy Policy

PANO makes use of policies for the agents to compute the bidding evaluations. Agents have multiple policies that correspond to different actions, and in an auction, they correspond to these policies to place bids accordingly. In PANO, a policy P is a 5-tuple $P = \{a,n,p,q,i\}$, where a is the agent that the policy belongs to, n is the set of users in the network the policy is applied to, p is the conditions for the content types that the policy will be applied, q is the action of sharing or not sharing the contents when the policy is applied and i is the importance of the policy, which is a value between 0 and 1. An example policy of Alice wanting to share photos that contain scenery tag with friends, with 0.6 importance can be represented as *P = {Alice,friends,photo[scenery],share,0.6}*.

3.2 Preventing Abuses in the Auction Mechanism

The economic system and the global currency in Clarke-Tax mechanism can allow abuses, as shown in Section 2.2. We propose the group-wise bid scoring and boundaries of the bids for the auctions to overcome possible malicious behavior by the users.

Group-wise Spending: With group-wise spending, the currency earned from auctions with some co-owners can only be spend in the future auctions with the same co-owners. Hence, a user can't abuse an auction with currency obtained from previously shared contents that are unrelated to the other auction participants.

Boundaries: We propose minimum-maximum bid boundaries in order to help a participant to have a clear opinion about what others might bid. This approach can also be beneficial to prevent users that are richer in the currency from dominating the decisions.

4 FUTURE DIRECTIONS

Our approach is currently being implemented as a software simulation, where no human interaction is available. One of our goals to improve our work is to represent real-life scenarios, possibly with human evaluation. We plan to achieve this with a user study, where OSN users can evaluate the bidding strategies of the agents within the simulation.

Another future goal we plan to reach is implementing agents that can learn from the opposition in the auctions and adapt their bidding strategies accordingly. In order to achieve this, we are currently implementing agents that contain a reinforcement learning module, where the agents can increase/decrease their bids according to past auction outcomes, content contexts and opponent categorizations. We aim to evaluate the performance of learning agents against other learning agents with several strategies and OSN users.

REFERENCES

[1] Dave Chaffey. 2017. Global Social Media Research. (2017). http://www.smartinsights.com/social-media-marketing/social-media-strategy/new- global-social-media-research.

[2] Edward Clarke. 1971. Multipart pricing of public goods. *Public Choice* 11, 1 (1971), 17–33.

[3] Eithan Ephrati and Jeffrey S. Rosenschein. 1991. The Clarke Tax As a Consensus Mechanism Among Automated Agents. In *Proceedings of the Ninth National Conference on Artificial Intelligence - Volume 1 (AAAI'91)*. AAAI Press, 173–178.

[4] Dilara Kekulluoglu, Nadin Kökciyan, and Pinar Yolum. 2018. An Argumentation Approach for Resolving Privacy Disputes in Online Social Networks. *ACM Transactions Internet Technology* (2018). To appear.

[5] Nadin Kökciyan, Nefise Yaglikci, and Pinar Yolum. 2017. An Argumentation Approach for Resolving Privacy Disputes in Online Social Networks. *ACM Trans. Internet Technol.* 17, 3, Article 27 (June 2017), 22 pages.

[6] Jan Kolter, Thomas Kernchen, and Günther Pernul. 2009. Collaborative Privacy – A Community-Based Privacy Infrastructure. In *Emerging Challenges for Security, Privacy and Trust*, Dimitris Gritzalis and Javier Lopez (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 226–236.

[7] Airi Lampinen, Vilma Lehtinen, Asko Lehmuskallio, and Sakari Tamminen. 2011. We're in It Together: Interpersonal Management of Disclosure in Social Network Services. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 3217–3226.

[8] Anna C. Squicciarini, Mohamed Shehab, and Federica Paci. 2009. Collective Privacy Management in Social Networks. In *Proceedings of the 18th International Conference on World Wide Web (WWW '09)*. ACM, New York, NY, USA, 521–530.

[9] Jose M. Such and Michael Rovatsos. 2016. Privacy Policy Negotiation in Social Media. *ACM Trans. Auton. Adapt. Syst.* 11, 1, Article 4 (Feb. 2016), 29 pages.