Engineering Socially Intelligent Personal Agents via Norms

Nirav Ajmeri
Department of Computer Science
NC State University
Raleigh, NC 27695-8206, USA
najmeri@ncsu.edu

ABSTRACT

This thesis develops Arnor, an agent-oriented software engineering (AOSE) method to engineer social intelligence in personal agents. Arnor goes beyond traditional AOSE methods to engineer personal agents by systematically capturing interactions that influence social experience. We empirically evaluate Arnor via a developer study, and a set of simulation experiments. We find that (1) Arnor assists developers in engineering personal agents faster, and (2) personal agents engineered using Arnor provide a greater social experience than agents engineered using a traditional AOSE method.

1. INTRODUCTION

A *socially intelligent personal agent* (SIPA) adheres to *social expectations* of multiple *stakeholders*—both *primary* and *secondary*, adapts according to the social context, acts on behalf of its human user, and provides a pleasing social experience to all its stakeholders.

Example 1. *Consider a ringer manager as a SIPA. The ringer manager installed on Alice's phone decides appropriate ringer modes (loud, silent, or vibrate) for incoming calls. Alice, the phone owner is the primary stakeholder of the SIPA. Bob, Alice's friend who calls Alice often, and Charlie and Dave, Alice's coworkers, who are in her vicinity, are some of the secondary stakeholders. Further, the ringer manager's capabilities influencing its social experience include (1) allowing Alice to be tele-reachable, (2) notifying the caller if Alice is not reachable, (3) enabling Alice to work uninterrupted, and (4) not annoying Alice's neighbors.*

Suppose that Bob calls Alice when she is in an important meeting with Charlie and Dave. As a friend, Alice is *committed* (a social norm) to answering Bob's phone calls. Another social norm (*a prohibition*) is to keep one's phone silent during important meetings. Alice's SIPA, understanding that norm and knowing that Bob's calls to Alice are generally casual, puts Alice's phone on silent for Bob's call and notifies Bob that Alice is in a meeting; later when Alice's meeting ends, Alice's SIPA reminds her to call Bob.

Should Alice's phone rings loud during the meeting, privacy implications based on Solove [7] may follow. A loud ring *intrudes* upon Alice's and other meeting attendees' privacy in that call violates the meeting attendees' reasonable expectation to be left alone. It is likely that Alice receives nasty looks from her colleagues attending the meeting (*disapprobation*), and as a result, presumably, Alice may inadvertently blurt out some information about the call's or caller's context. If Bob's call were urgent, Bob's SIPA would communicate the urgency to Alice's SIPA, and Alice's SIPA could have delivered a different social experience, e.g., set phone on vibrate to notify Alice of urgency and yet not annoy other meeting attendees. Should Alice's phone stays silent for Bob's urgent call, it may affect their relationships.

In the examples above, ringer manager SIPA makes nontrivial decisions influencing social experience of its stakeholders. Existing AOSE methods [4, 9, 5] are good starting point to engineer personal agents, however these methods do not guide developers with systematic steps to represent and reason about such scenarios, and thus fall short in supporting agents that adapt to evolving social contexts at runtime.

Social norms inform SIPAs a set of reasonable actions in a social context [8]. Norm compliance in a social context is either achieved by (1) conveyance of norms, where SIPAs are made aware of norms by direct communication, or (2) via (positive and negative) sanctions, where SIPAs learn norms in the form of which actions are appropriate in a context [3].

This research develops Arnor [1], a systematic method to engineer SIPAs. Arnor facilitates developers to model stakeholders' actions and expectations, and how these influence each other. Arnor employs Singh's [6] model of (social) norms to capture social requirements, and incorporates argumentation constructs [2] for sharing decision rationale. Since, testing a SIPA's adaptability in all possible social contexts is logistically challenging and time consuming, Arnor also incorporates a SIPA simulation testbed.

The contribution of this research is the systematic method, Arnor, and its rigorous empirical evaluation via a developer study and a set of simulation experiments on Arnor's SIPA simulation testbed. The novelty of the research is that in spirit, Arnor is a hybrid method that addresses the problem of engineering SIPA's both top-down (by modeling) and bottom-up (via experience or social learning).

2. ARNOR

Arnor is a four-step method that guides developers to systematically engineer SIPA's social experience. Arnor's steps include: (1) goal modeling, (2) environment context modeling, (3) social expectation modeling, and (4) social experience modeling. Figure 1 shows Arnor's conceptual model.

Appears in: *Proceedings of the 16th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2017), S. Das, E. Durfee, K. Larson, M. Winikoff (eds.), May 8–12, 2017, São Paulo, Brazil.*

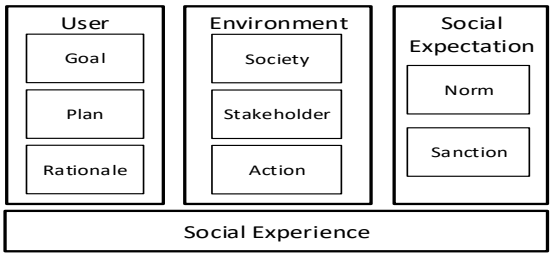

Figure 1: Arnor conceptual model.

Goal modeling enables SIPA to be aware of its stakeholders, their goals, and relevant plans. Arnor uses Xipho [5] constructs for goal modeling.

Context modeling includes identifying the social contexts in which the stakeholders of a SIPA interact. The context plays a decisive role in which goals to bring about or which plans to execute during inconsistencies.

Social expectation modeling includes identifying social norms and sanctions that govern stakeholders' goals and plans.

Social experience modeling includes identifying SIPA's actions that promote greater social experience, i.e, choosing which plans to execute, which goal states to accomplish, and which norms to satisfy.

2.1 Evaluation

We evaluated Arnor (A) against Xipho (X) via a developer study in which 30 developers engineered ringer manager SIPAs, and a set of simulation experiments on the SIPAs engineered during the developer study.

Developer Study. We hypothesize that the developers who follow Arnor (1) produce better models, (2) expend less time, (3) feel it is easier to develop a SIPA, and (4) expend less effort, than those who follow Xipho.

We found that developers using Arnor spent less time and effort, and overall felt it is easier to engineer a SIPA using Arnor. No significant difference was found in the model quality. Figure 2 summarizes the time and effort results.

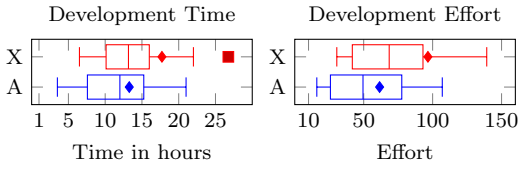

Figure 2: Arnor vs Xipho's development time and effort.

Simulation Experiments. We hypothesize that SIPAs developed using Arnor (1) have better adaptability features, and (2) provide richer social experience, than SIPAs developed using Xipho.

We found that SIPAs engineered using Arnor had greater adaptability correctness, and were prone to lesser sanctions. Figure 3 summarizes the simulation results for sanction proportion for various adaption environments.

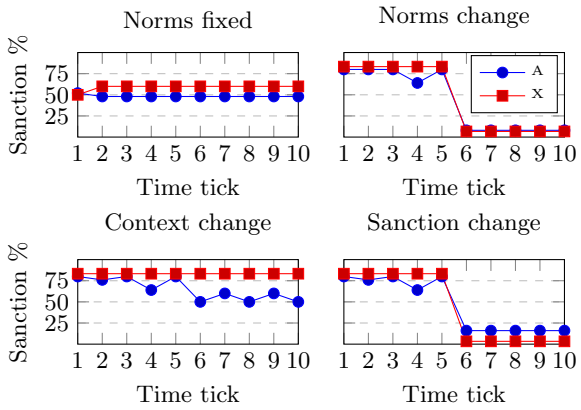

Figure 3: Arnor vs Xipho's sanction proportion.

3. DIRECTIONS

A natural future direction is to develop a computational framework over Arnor that recommends SIPA of actions that promote richer social experience. Next, we seek to address the following challenges.

Privacy. How much contextual information a SIPA should disclose to promote greater social experience?

Emotional basis. How do a SIPA reason about an affect and emotional basis of social norms?

REFERENCES

[1] N. Ajmeri, H. Guo, P. K. Murukannaiah, and M. P. Singh. Arnor: Modeling Social Intelligence via Norms to Engineer Privacy-Aware Personal Agents. In *Proc. AAMAS*, pages 230–238, 2017.

[2] N. Ajmeri, C.-W. Hang, S. D. Parsons, and M. P. Singh. Aragorn: Eliciting and maintaining secure service policies. *IEEE Computer*, 50(12):50–58, Dec 2017.

[3] G. Andrighetto, J. Brandts, R. Conte, J. Sabater-Mir, H. Solaz, and D. Villatoro. Punish and voice: Punishment enhances cooperation when combined with norm-signalling. *PLoS ONE*, 8(6):1–8, 06 2013.

[4] P. Bresciani, A. Perini, P. Giorgini, F. Giunchiglia, and J. Mylopoulos. Tropos: An agent-oriented software development methodology. *JAAMAS*, 8(3):203–236, May 2004.

[5] P. K. Murukannaiah and M. P. Singh. Xipho: Extending Tropos to engineer context-aware personal agents. In *Proc. AAMAS*, pages 309–316, 2014.

[6] M. P. Singh. Norms as a basis for governing sociotechnical systems. *ACM TIST*, 5(1):21:1–21:23, Dec. 2013.

[7] D. J. Solove. A taxonomy of privacy. *University of Pennsylvania Law Review*, 154(3):477–564, 2006.

[8] M. B. van Riemsdijk, L. Dennis, M. Fisher, and K. V. Hindriks. A semantic framework for socially adaptive agents: Towards strong norm compliance. In *Proc. AAMAS*, pages 423–432, 2015.

[9] M. Winikoff and L. Padgham. *Developing Intelligent Agent Systems: A Practical Guide*. Wiley, Chichester, UK, 2004.