

Multiagent Systems for Privacy-Aware Social Computing

Nirav Ajmeri

(Under the guidance of Professor Munindar P. Singh)

Department of Computer Science
North Carolina State University

July 2017

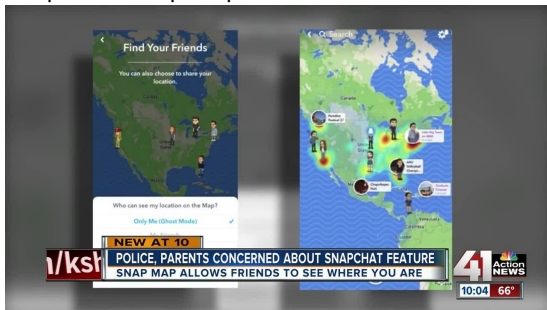
Outline

- 1 Introduction
- 2 Contributions
 - Arnor
 - Poros
- 3 Proposed Works
 - Valar and Gimli
- 4 Conclusions
 - Plan

Examples of Privacy Concerns

Location sharing

Snapchat: Snap map



Messenger: Live location



Make Meeting Up Easier

Share your location to make meeting up with friends easier. When you choose to share, Live Location continues sharing your location even when you're not using the app.

OK

Not Now

Share your location to make meeting up with friends easier. When you choose to share, Live Location continues sharing your location even when you're not using the app.

Concepts

Social norm as defined by Singh [2013], is a relation between two parties, a subject and an object, and involves an antecedent (which brings a norm in force) and a consequent (which brings the norm to satisfaction or violation)

Social context is the circumstance under which an agent takes an action [Dey, 2001]

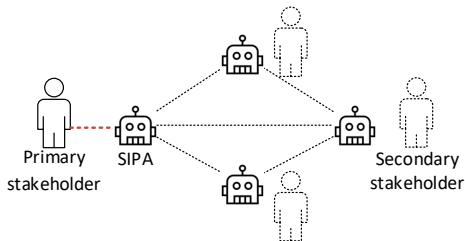
Deviation is a perceived violation of a norm

Values are “socially constructed concepts of right and wrong that we use to judge the goodness or badness of concepts, objects, and actions and their outcomes” [Ramos et al., 2002]

Research Objective

To help software developers in engineering personal agents that deliver a privacy-respecting social experience to their stakeholders via (1) *modeling social intelligence in terms of social norms*, (2) *understanding contextually-relevant social norms*, and (3) *reasoning about values*

Socially Intelligent Personal Agent (SIPA)



- Adapts to social context and adheres to social expectations of multiple stakeholders:
 - Primary stakeholder, the user who interacts directly with the agent
 - Secondary stakeholders, the users who are affected by the agent's actions
- Acts on behalf of the primary stakeholder

Research Questions

RQ Social intelligence: How can modeling social intelligence in a SIPA help deliver a social experience and respects its stakeholders' privacy?

- Arnor, an Agent-Oriented Software Engineering Method

RQ Context: How can SIPAs share and adapt to deviation contexts, and learn contextually relevant norms?

- Poros, a context reasoning framework

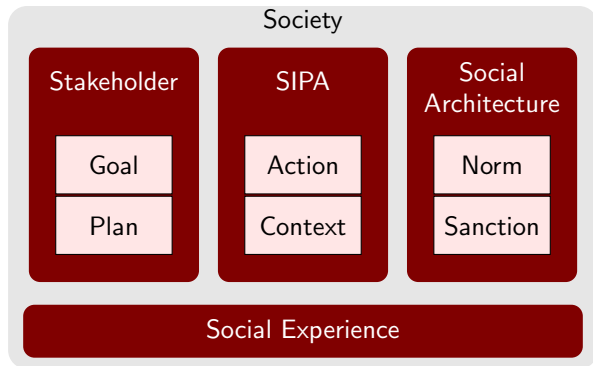
RQ Values: Does a SIPA's ability to reason about values that its actions promote or demote help enrich the social experience delivered to its stakeholders?

- Valar, a framework grounded on a crowdsourcing study
- Gimli, a tool that recommends actions based on values

Outline

- 1 Introduction
- 2 Contributions
 - Arnor
 - Poros
- 3 Proposed Works
 - Valar and Gimli
- 4 Conclusions
 - Plan

Arnor's Concepts Schematically



Arnor: A Method to Model Social Intelligence

Goal, context, social expectation, and social experience modeling

Goal modeling includes identifying a SIPA's stakeholders, their goals, and relevant plans

Context modeling includes identifying the main social contexts in which the stakeholders of a SIPA interact

- Context helps in deciding which goals to bring about or plans to execute

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

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

Evaluation: Developer Study

Participants: 30 developers

Study Unit: RINGER SIPAs

Mechanics: One factor two alternatives

- Two groups (Arnor and Xipho) balanced on skills developed RINGER SIPAs in six weeks
 - Modeling
 - Implementation
 - Testing

Deliverables:

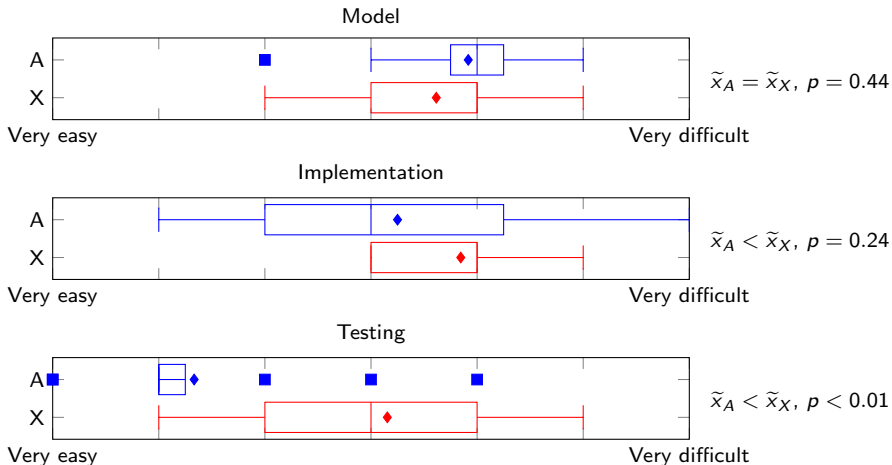
- Models
- SIPA implementation source code
- Time and effort survey (after each work session)
- Post survey

Metrics:

- Coverage and correctness
- Time, difficulty, and effort to develop

Developer Study

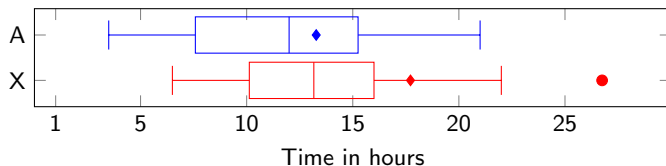
Result: Developers who follow Arnor feel it is easier to develop a SIPA, than those who follow Xipho (a previous approach)



Developer Study

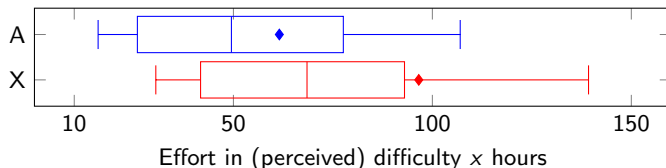
Result: Developers who follow Arnor spend less time and less effort to develop a SIPA, than those who follow Xipho (a previous approach)

Development Time



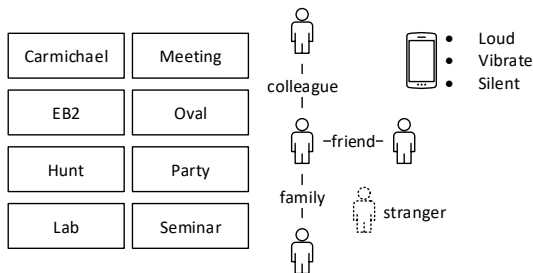
$$\mu_A < \mu_X, p = 0.39$$

Development Effort



$$\mu_A < \mu_X, p = 0.31$$

Evaluation: User Study (Simulations)



Developed RINGER SIPAs simulated in varying adaptation scenarios:

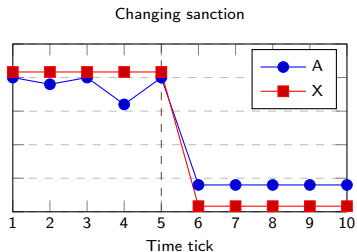
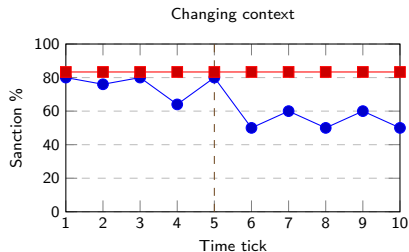
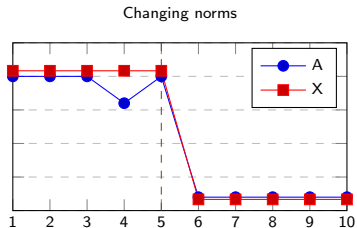
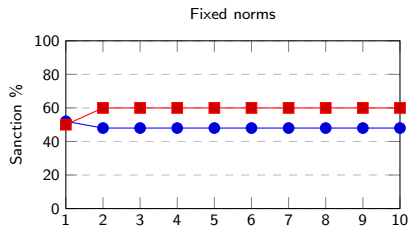
- Fixed norms
- Changing norms
- Changing context
- Changing sanction

Metrics:

- Adaptability coverage and correctness
- Norm compliance
- Proportion of positive sanctions

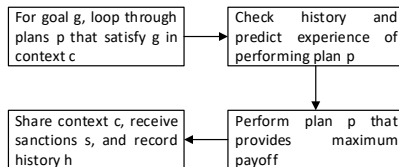
Simulation Experiments

Result: SIPAs developed using Arnor yield lower sanction proportions than SIPAs developed using Xipho (a previous approach)



~~“Without deviation from a norm, progress is not possible.”—Frank Zappa (American Musician)~~
“Deviations from a norm hint toward a contextually relevant norm.”

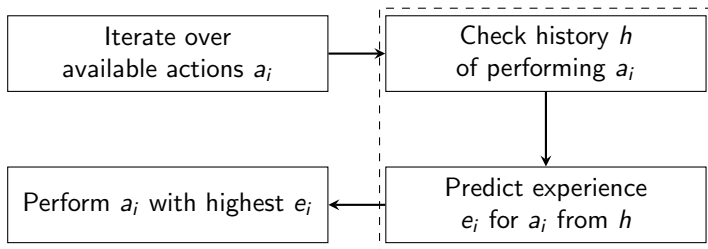
Interaction and Learning in Poros



Selecting Actions

Input: c : context, h : history

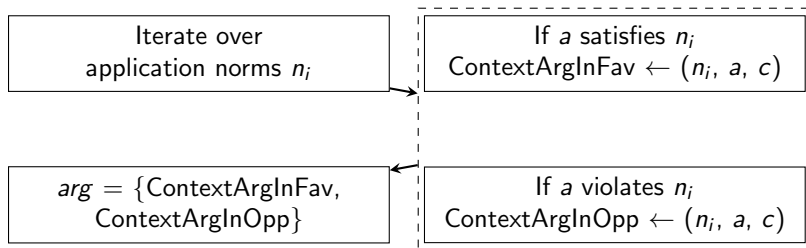
Output: a : action



Sharing Deviation Context

Input: N : norms, a : action, c : context

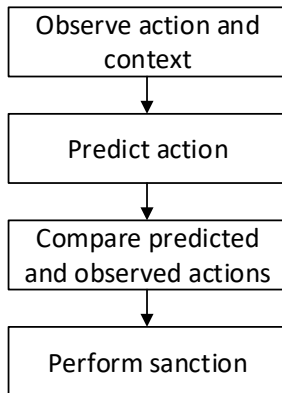
Output: arg : deviation context argument



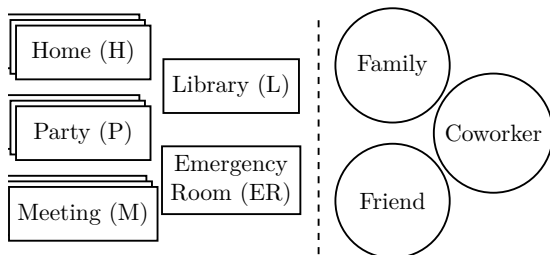
Reasoning about Context

Input: a : action, c : context, h : history

Output: s : sanction



Evaluation: Simulation



- Pragmatic agents with varying network types
- Considerate agents
- Selfish agents

Metrics

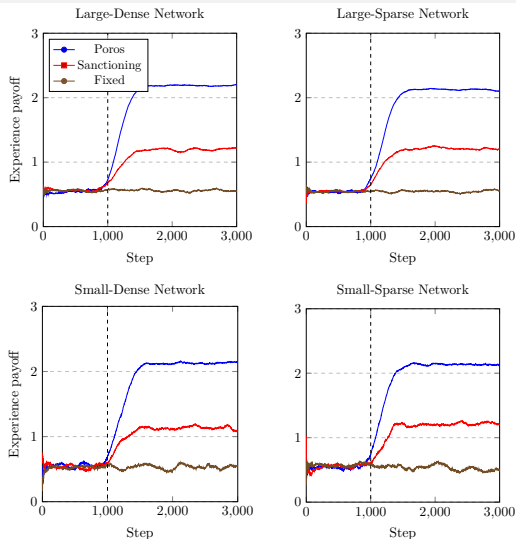
Happiness measures the proportion of agents that perceive actions as norm compliant

Experience-payoff measures the social experience delivered by an agent

- computed by aggregating payoffs for all stakeholders

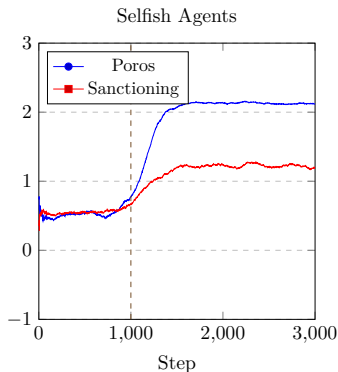
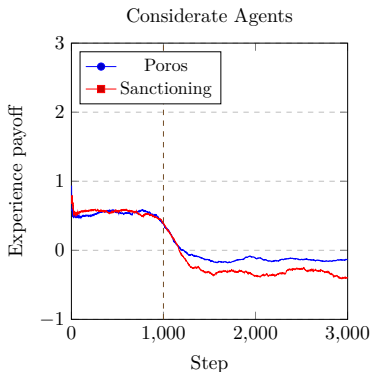
Experiments on Pragmatic Agents, and Varying Network Types

Result: Happiness and experience payoffs offered by Poros agents are significantly greater than those offered by Fixed and Sanctioning agents



Experiments on Considerate and Selfish Agents

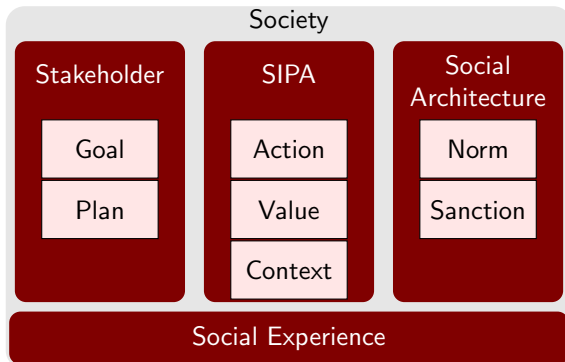
Result: The average experience payoff drops for considerate Sanctioning and Poros agents after they have gained enough confidence. Plots for selfish agents are similar to those in the experiment with pragmatic agents, but with slightly lower stabilized values



Outline

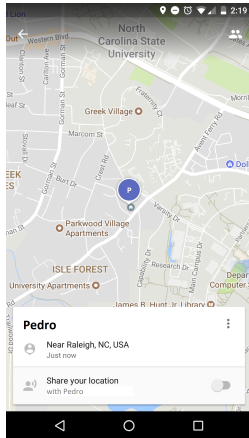
- 1 Introduction
- 2 Contributions
 - Arnor
 - Poros
- 3 Proposed Works
 - Valar and Gimli
- 4 Conclusions
 - Plan

Valar Concepts Schematically



Norms and Values

Naviterier: A Navigation Assisting SIPA

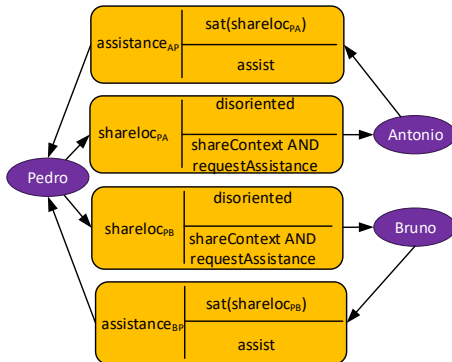


- Pedro, a visually impaired masseur, uses Naviterier
- Antonio and Bruno are in his trust circle

Values here:

- Freedom
- Privacy
- Relation
- Security
- Trust

Norms and Values: Norms in Naviterier



- $\text{sat}(C_{assistanceAP}) \vee \text{sat}(C_{assistanceBP}) \uparrow$ safety
- $\text{sat}(C_{assistanceAP}) \wedge \text{sat}(C_{assistanceBP}) \downarrow$ resource

Norms and Values: Privacy Example

- Rodrigo, Pedro's visually impaired roommate, is also a Naviterier user
 - Shares his context with his brother Carlos at all times
 $C_{shareLocRC}: C(\text{Rodrigo}, \text{Carlos}, \top, \text{shareContext})$
 - Request assistance when only disoriented
 $C_{reqAssistRC}: C(\text{Rodrigo}, \text{Carlos}, \text{disoriented}, \text{shareContext} \wedge \text{requestAssistance})$

Pedro and Rodrigo are out together

- $\text{sat}(C_{shareLocRC}) \uparrow \text{safety} \wedge \text{freedom}_{\text{Rodrigo}}$
- $\text{sat}(C_{shareLocRC}) \wedge \text{awareofFriendship} \downarrow \text{privacy}_{\text{Pedro}}$
- $\text{vio}(C_{shareLocRC}) \downarrow \text{freedom}_{\text{Rodrigo}}$

Probable solution:

- $\text{shareAbstractContext} \uparrow \text{safety} \wedge \text{freedom}_{\text{Rodrigo}} \wedge \text{privacy}_{\text{Pedro}}$

Research Questions and Hypotheses

RQ Values (a) How can we enable a SIPA to reason about values that its actions promote or demote?

RQ Values (b) How can we build a decision module to recommend actions for a SIPA to perform?

Hypotheses

- Valar SIPAs that reason about values provide a privacy-respecting social experience than SIPAs that do not reason about values
- Gimli SIPAs produce recommendations that are more accurate than the ones produced by the baseline approaches

Experimental Setup: Crowdsourcing Study

Design

Participants: Crowdworkers on MTurk

Study mechanics: One factor two alternatives

Multi-phase immersive study:

- Phase 1. Seeding for values
- Phase 2. Pairing workers with people of different attitudes
 - Provide situations with context and applicable norms
 - Ask preferred action

Control group: Based on the situation, respond with the preferred action

Treatment group: Understand what they value and what others value

Experimental Setup: Crowdsourcing Study

Deliverables

Study Design

- Presurvey
 - Demographics
 - Privacy and risk attitudes (DOSPERT Scale) [Blais and Weber, 2006]
 - Personality (Mini-IPIP Scale) [Donnellan et al., 2006]
- Immersive survey: Situations where participants are immersed
 - Context (place, stakeholders, social relationship, preferences)
 - Applicable norms

Responses collected for:

- Preferred action
 - Willingness of violate a norm
 - Sanctions
 - Willingness to make adjustments
 - Confidence in preferred action
- Post survey

Valar and Gimli

Valar. Generalize Arnor and Poros to a broader framework incorporating values

- From the crowdsourced data, identify
 - contexts and values influencing decision making
 - preferences and tradeoffs between factors and value pairs
- Build models based on identified contexts and values

Metrics:

- Willingness to make adjustment
- Confidence in preferred action

Gimli. Test with real data from stakeholders (end-users)

- Classifier to recommend actions

Metrics:

- Accuracy of recommendations

Threats to Validity

Limited set of values. Multiphase study to first collect a larger set of values

Lack of attention. Employ attention-check questions

Participant confusion. Select participants with high success rates

Unreliability of self-reported attitudes. Employ situations where participants are immersed in situations

Limitations (because of logistical reasons):

- Limited set of predetermined situations
- Limited set of actions

Outline

- 1 Introduction
- 2 Contributions
 - Arnor
 - Poros
- 3 Proposed Works
 - Valar and Gimli
- 4 Conclusions
 - Plan

Conclusions and Directions

- Seeking to advance the science of privacy by tackling nuanced notions of privacy in personal agents
- Developed
 - Arnor, an AOSE method to model social intelligence in privacy-aware personal agents
 - Poros, a framework that enables personal agents to reason about contexts
- Envision
 - Valar, a framework that enables personal agents to reason about values
 - Gimli, a tool to recommend actions to a SIPA based on context and values

Plan

	Task	Status	Timeline
1.	Arnor	Complete	
2.	Poros	Almost Complete	Aug 2017–Sep 2017
3a.	Valar	Ideation	Sep 2017–May 2018
3b.	Gimli	Ideation	Sep 2017–May 2018

Thank You

Acknowledgments:

- Adviser
- Past and present collaborators

Engineering privacy in social applications with PK Murukannaiah and H Guo [IC 2016, AAMAS 2017], and MB van Riemsdijk and P Pasotti (ongoing);

Reasoning about normative conflicts with J Jiang, R Chirkova, and J Doyle [IJCAI 2016; HotSoS 2016];

Sanctions and cybersecurity with H Du, BY Narron, S Al-Amin, E Berglund, and J Doyle [HotSoS 2015, ACySe 2015];

Norms and sociotechnical systems with Ö Kafalı [IS 2016, AAAI 2017];

Sanction typology with LG Nardin, T Balke-Visser, AK Kalia, and JS Sichman [KER 2016];

Incorporating an emotional basis of norms in social agents with AK Kalia, KS Chan, JH Cho, and S Adali [TRUST 2014, CHB (in review)]

Argumentation and secure service policies with CW Hang and SD Parsons [Computer 2017];

Analytic workflow with G Yuan, C Allred, PR Telang, and M Wilson [RCIS 2015];

Creativity, personality, crowdsourcing, and teamwork with PK Murukannaiah [RE 2016, RE 2017];

Collective intelligence with AK Kalia, PK Murukannaiah, R Pandita, and H Du (ongoing);

Analysis of privacy news with K Sheshadri and J Staddon [PST 2017]

- Science of Security Lablet at North Carolina State University

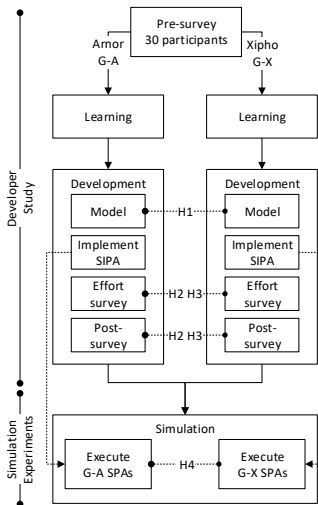
Appendix

Taxonomy: Solove

- Information Collection
 - Surveillance
 - Interrogation
- Information Processing
 - Aggregation
 - Identification
 - Insecurity
 - Secondary Use
 - Exclusion
- Information Dissemination
 - Breach of Confidentiality
 - Disclosure
 - Exposure
 - Increased Accessibility
 - Blackmail
 - Appropriation
 - Distortion
- Invasion
 - Intrusion
 - Decisional Interference

Step	Arnor Task	Example
Goal Modeling	Identify all actors	Alice, Bob, Charlie, Dave, Erin, and strangers in the theater
	Abstract actors as primary and secondary stakeholders, as appropriate	Phone user is a primary stakeholder; friend, coworker, stranger in the vicinity of phone users are secondary stakeholders
	Identify goals of each actor	Phone user's goals <i>to be tele-reachable</i> , and <i>to be not disturbed</i>
	Identify all actions, and abstract them as appropriate	<i>Phone users do not answer phone calls during meetings; phone users answers their coworkers' urgent phone calls</i>
	Identify plans for abstract actions	<i>Set ringer mode as loud</i> for the action <i>phone user answers a phone call</i>
	Associate goals with plans	Phone user's goal of <i>tele-reachable</i> can be realized by the plan of <i>setting ringer mode as loud</i>
Context Modeling	Identify the contexts in which each actor's goals and plans are relevant	Coworker's goal <i>to be not disturbed</i> is relevant in the <i>meeting</i> context
	Identify conflicting goals (and inconsistent plans)	Phone user's goal of <i>tele-reachable</i> conflicts with the goal <i>to not disturb neighbors</i> in the <i>meeting</i> context
Social Expectation Modeling	Identify norms relevant to social and privacy expectations	<i>The phone user is committed to answering urgent phone calls from family</i>
	Identify possible conflicts between norms	<i>Phone user's commitment toward friend to answer phone calls</i> conflicts with <i>phone user's commitment to keep phone on silent during meeting</i>
	Resolve conflicts by capturing contextual preferences between norms	In the <i>meeting</i> context, prefer <i>phone user's commitment to keep phone on silent during meeting</i> over <i>phone user's commitment toward friend to answer phone calls</i>
Social Experience Modeling	Identify effects of stakeholders' actions on social expectations Promote actions that enhance social experience	A norm that is consistently being violated, e.g., <i>phone users always answering calls during meeting</i>

Arnor: Study Design



Threats to Validity

- Skill difference
- Failure to report information
- Contamination

Limitations:

- Results based on development of only one kind of SIPA
- SIPAs reflect participants privacy attitudes and not general attitudes
- Limited set of scenarios in simulation

Empirical Results on Effectiveness of Poros Agents

Large-Dense			
Agent Type	Experience [#]	Happiness ^{##}	$p^{###}$
Fixed	0.56	52.7%	< 0.01
Sanctioning	1.21	63.5%	< 0.01
Poros	2.19	83.2%	–
Large-Sparse			
Agent Type	Experience [#]	Happiness ^{##}	$p^{###}$
Fixed	0.55	52.5%	< 0.01
Sanctioning	1.21	63.5%	< 0.01
Poros	2.19	83.2%	–
Small-Dense			
Agent Type	Experience [#]	Happiness ^{##}	$p^{###}$
Fixed	0.53	52.1%	< 0.01
Sanctioning	1.11	61.2%	< 0.01
Poros	2.14	82.0%	–
Small-Sparse			
Agent Type	Experience [#]	Happiness ^{##}	$p^{###}$
Fixed	0.54	52.5%	< 0.01
Sanctioning	1.22	63.7%	< 0.01
Poros	2.14	82.1%	–

Personality and Privacy

- The Influence of Personality Traits and Information Privacy Concerns on Behavioral Intentions, Melinda L. Korzaan and Katherine T. Boswell, 48.4, 2008
“Agreeableness was found to have a significant influence on individual concerns for information privacy while neuroticism was found to have a significant influence on computer anxiety.”
- Personality traits and concern for privacy: an empirical study in the context of location-based services, Junglas et al., EJIS, 17.4, 2008
“Agreeableness, conscientiousness, and openness to experience each affect the CFP.”
- Personality Traits and Information Privacy Concern on Social Media Platforms, Babajide Osatuyi, JCIS, 55.4, 2015
“Individuals that score highly on agreeableness and conscientiousness were found to be concerned about the privacy of their information on social media platforms.”

Value List of Milton Rokeach (1973)

Terminal values

Value List of Milton Rokeach (1973)

Instrumental values